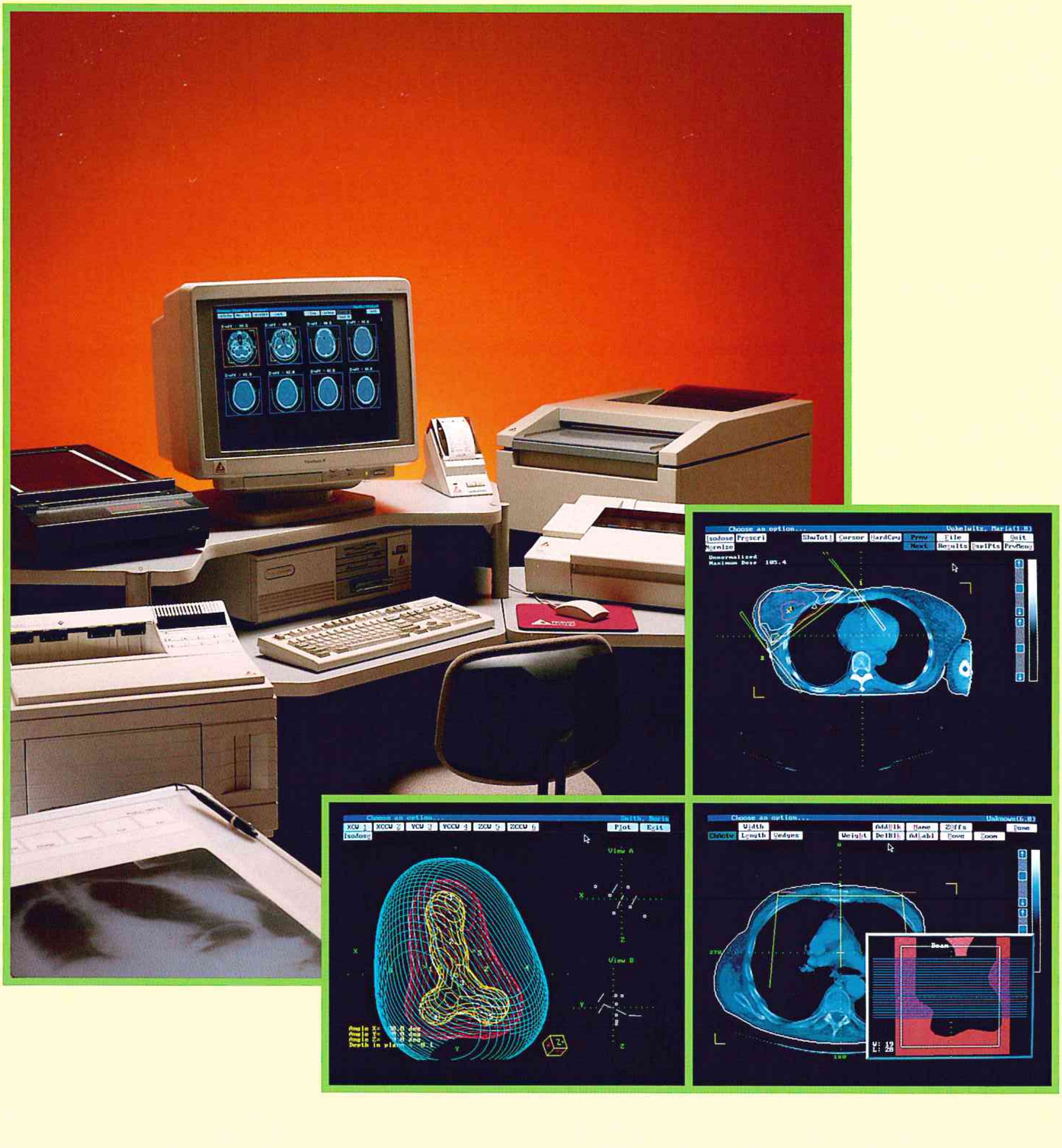
PROWESS 3000

CT Treatment Planning



PROWESS
SYSTEMS

RADIOTHERAPY TREATMENT PLANNING

USER'S MANUAL

May 1995

SSGI
1370 Ridgewood Dr., Ste. 20
Chico, California 95926
TEL: (916) 898-0660
FAX: (916) 342-8966

PROWESS SYSTEMS

Radiotherapy Treatment Planning

Welcome to the SSGI select group of software users. You have purchased a product designed with your patients and support staff in mind. All Prowess Systems products have been designed to be accurate, fast, and easy to learn and use. All procedures come with detailed documentation. SSGI is dedicated to providing you with continuous support for your product and quick response to your questions, concerns, and comments.

This manual is under constant revision, as is the software. Therefore, you may be receiving periodic inserts for this manual. Until a full manual update is released, you may notice various dates located in the footers of this manual. Although the footers may reflect an earlier date, all information in this manual is current at your time of purchase.

Retain any and all communications with SSGI within this manual binder or in a separate file. You may be contacted at any time for this documentation.

SSGI disclaims all responsibilities for any inaccuracies in calculations by Prowess Systems. All data entered is the responsibility of the user and all calculations must be checked by a responsible radiation oncologist or physicist before implementation. Prowess Systems are not to be connected directly to any patient or x-ray source and cannot be held liable for such. All data used by Prowess is to be entered only by trained operators under the direction of a qualified radiation oncologist or physicist.

Written by Philip Heintz, Paul King, & Dave Childs.

Book design by Lillian Heintz & Debra McElroy.

To Bret and Robert

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

INTRODUCTION TO PROWESS

I. SYSTEM OVERVIEW

Prowess is a multislice, two-dimensional radiotherapy treatment planning system. It is organized in a modular manner and consists of a set of independent programs each of which provides a specific capability. The Main Menu provides access to all of the programs.

The programs are highly interactive and use a mouse and/or keyboard-driven graphical user interface (GUI) developed specifically for this application. An on-screen button bar provides access for up to 20 operations at any given time. Various on-screen icons provide additional user control. All buttons and icons can be accessed using either the keyboard or mouse.

The on-screen status bar is continuously updated to provide constant feedback on the current process. Pop-up boxes are used to provide and solicit supplemental information.

The programs included allow entry and editing of patient data, treatment data, treatment unit, implant, and brachytherapy source characteristics. Every effort has been made for the use of these programs to be as intuitive as possible.

Every effort has also been made to achieve product modularity and high-speed calculations. However, calculation accuracy has not been sacrificed to achieve these benefits. Prowess calculations are based almost exclusively on measured and precalculated data.

II. SYSTEM HARDWARE

Prowess is a software system. The hardware selected to run the software is standard, commercially available equipment. Interfaces between the different hardware components use standard cabling (either parallel or EIA RS232 serial connections). The hardware components include:

80486 or Pentium based personal computer
Super VGA Graphics Display
Keyboard
Digitizer
Color Plotter
Laser Printer
Diskette Drives
Hard Disk Drive
Mouse
Magnetic Tape Drive (optional)
Film Scanner (optional)
Label Printer (optional)

III. USERS' MANUALS

Prowess Systems are provided with the following manuals:

- Prowess Systems User's Manual
- MS-DOS™ Reference Manual
- Microcomputer User's Guide
- Graphic Plotter Operation and Interconnection Manual
- Digitizer Operator's Manual
- Printer Operator's Manual
- Magnetic Tape Drive Reference Manual (Optional)
- 6FS Film Scanner Operator's Manual (Optional)
- 14FS Film Scanner Operator's Manual (Optional)
- Label Printer Operator's Manual (Optional)

SYSTEM HARDWARE AND SOFTWARE

I. OVERVIEW

This section describes the basic hardware, system software, and the software design philosophy and organization. For information about the features and operation of each hardware component, consult the appropriate user's manual. Prowess programs are described in the succeeding sections.

II. HARDWARE

A. General

Before discussing the Prowess *1000*, *2000*, and *3000* software products, it is important to become familiar with the system hardware.

The major hardware components include the computer, keyboard, enhanced graphics display, diskette drives, hard disk drive, printer, plotter, digitizer, mouse, tape drive, and film scanner. Each of these systems are described briefly and the salient points of operation are discussed. Read all hardware system manuals before using Prowess.

B. Computer System

Prowess programs operate on an MS-DOS™ computer system using either an Intel 80486 or a Pentium microprocessor with a minimum of 8 MB of RAM. The display must be a Super Video Graphics Adaptor (SVGA) with at least 1 MB of memory that allows up to 43 lines of color text displayed on the screen. The color monitor must use an SVGA display of at least 256 colors from a palette of 2,000,000 different colors. The SVGA graphics resolution mode is 640 x 480 pixels using all 256 color palettes. MS-DOS Version 5.0 or higher must be installed as the operating system.

The computer must have at least two RS232 serial ports and one parallel port. If the plotter is an HP PaintJet™ or other printer/plotter, then one serial and two parallel ports are required. These are used to interface the printer, digitizer, and plotter, respectively. Mouse support is usually provided through a bus interface card. Please read the appropriate sections of the computer manual to learn how to operate the computer.

C. Keyboard

The standard keyboard for the computer has the traditional QWERTY arrangement for the alpha keys. In addition to the numbers across the top of the keyboard, there is a numerical keypad on the right side. The two sets of numbers have exactly the same function. Included in and/or to the left of the numeric keypad are a set of arrow keys. Across the top of the keyboard (or to the left) are the function keys which are labeled F1 through F10.

ESCape: This key is usually located in the upper left corner of the keyboard and marked with the letters ESC. This key is used extensively in Prowess programs to move from one part of the program to another.

ALTernate: This key is important in the operation of Prowess. Many operations are activated by pressing the ALT key along with a key letter in the function name.

DELete: This key is located at the bottom of the numeric keypad on the 84 key keyboards and in the center cursor control area of the 101 key keyboards.

The combination of CTRL, ALT, DEL is used to reboot (i.e., restart) the computer without having to shut off the power. Rebooting destroys all the information not saved on your hard disk.

D. Mouse

A mouse can be used as a pointing device. Operate the mouse by sliding it along a flat surface. There are two or three buttons on the mouse. The left button usually acts like the **Enter** key on the keyboard. The right button usually acts like the **ESC**ape key.

To select a button on the screen, move the mouse to the area of interest and click the left button once. To choose an item from a list, move the arrow to the item and click the left button twice.

E. Hard Disk Drive

The computer uses an internal hard disk generally designated as C:. To protect the hard disk, place the computer in a location that is stable and free of vibration.

A software package is provided with the system for hard drive maintenance. These programs are easy to use and can assist with most problems. Refer to the software manufacturer's manuals for complete instructions.

F. Diskette Drive

Diskette drives are used for installation of new programs and data, backup of the hard disk, and archival storage of patient data.

Four types of diskette drives are supported:

5.25"	1.2 MB	HD
5.25"	360 KB	DSDD
3.5"	1.44 MB	HD
3.5"	760 KB	DSDD

Read the computer manual for instructions on operating the diskette drive. Do not leave diskettes in the drives when the power is turned off.

For optimum life, keep each diskette in an envelope when not in use. Never touch exposed diskette surfaces. Never fold or bend diskettes. Keep diskettes and all magnetic media away from magnetic fields and protected from temperature extremes. Diskettes are not suitable for long term storage of critical data. Always keep a backup copy of critical data along with a printed hard copy. Diskettes must be formatted before use. Formatting a diskette destroys all previously stored data. Refer to the MS-DOS™ and computer manuals for details.

G. Backup

It is important to periodically back up the contents of the hard disk to protect against computer failure. There are several methods to back up data stored on the hard disk. If the computer fails, all the files created or changed since the last backup may be lost. Most systems include a cartridge tape backup system. This is the easiest and fastest back up system available. For systems without cartridge tape backup, the commercial program Fastback Plus™ is provided for fast and convenient system backup. The MS-DOS™ program BACKUP can also be used for backing up your hard disk. If your system has a 9 track magnetic tape, it may be used for back up.

1. Fastback

To use FASTBACK, it will take up to ten, 5¼" or 3½" high density diskettes depending upon the contents of the disk. Have these ready before starting. They do not have to be pre-formatted. Label the diskettes with the date and volume number.

Start FASTBACK from the main menu
Choose BACKUP
Using the cursor keys, choose: INCLUDE FILES
Enter \PROWESS for directories
. for files
Y for subdirectory
Press ESCape to exit editing the Include Files
Choose START BACKUP. A new screen appears
Insert your first diskette
Choose START BACKUP and press **Enter**
If you choose ESTIMATE this will give an estimate of the number of floppy disks needed
  (divide number by two for a better estimate)
Answer any questions the program prompts
Insert diskettes as requested

When the backup is finished, exit the program by pressing ESCape, then Quit. You are now ready to install the update. For further details, refer to the manufacturer's manual.

2. Cassette tape backup

To back up with the cassette tape drive, select **Tape Backup** from the main menu. Ensure the date and time are correct. Load a tape into the tape drive. (Be sure it is formatted. If it is not, select **Utilities** and format tape. This process takes approximately one hour per tape).

If the tape is not new and overwriting the existing data is acceptable, select **Utilities** and **Quick Erase**.

Once the tape is ready, select **Backup**, then wait for completion. Give the tape a name.

H. Digitizer

A digitizer is used to enter the location of a point into Prowess. The digitizer is used by the external beam program for patient contour and block outline entry, by the irregular field program for beam outline entry, by the brachytherapy program for source localization, and by the machine data entry program for %DD and OCR curve entry.

A digitizer consists of four components: the stylus, tablet, receiver, and control unit. The digitizer can be operated in either a point or continuous entry mode. To operate in the point entry mode, press the point of the stylus against the surface of the tablet until it clicks, then release. To operate in the continuous entry mode, click the stylus to the tablet and, while maintaining pressure, trace the outline of the curve or contour.

The surface of the tablet is covered with a protective plastic sheet and marked as shown in Figure 2.1.

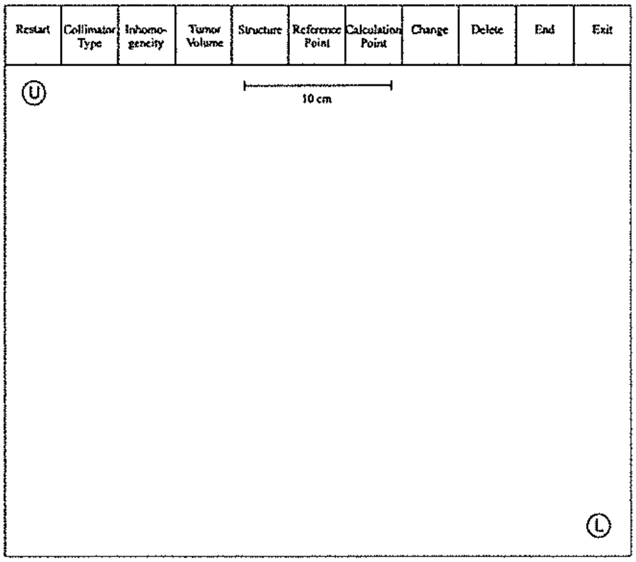


Figure 2.1 - Active Area of the Digitizer

The features of this tablet surface include a large open area for placing contours, plots and films; two points "U" and "L" which are used for calibration, and eleven square regions marked as buttons. To select one of the options indicated by the button name, digitize a point inside the button.

For the most accurate results, always keep the digitizer stylus perpendicular to the tablet surface. The active area of the tablet is indicated by backlighting and points cannot be digitized outside the active area. Since positions are digitized by interpretation of the signal detected by the receiver, it is important that nothing interfere with the signal as it is transmitted from the stylus to the receiver. An acoustic digitizer's receiver (microphone pair) is located on the periphery of the tablet. Ensure that the blue stripe on the stylus points in the general direction of the receiver and that nothing blocks the path from stylus to receiver. Accurate results cannot be assured when the stylus of an acoustic digitizer is within 5 cm of the receiver. An electromagnetic digitizer's receiver (wire grid) is located just below the surface of the tablet. It is important to keep metal objects out of the general vicinity of the stylus.

I. Plotter

Prowess products use the Hewlett Packard DeskJet 1200 C/PS™, the Lexmark PS4079™, the HP PaintJet XL™ with HPGL cartridge, the HP PaintJet XL300™ with Post Script, the HP 7475A™, the HP 7550A™, or most HPGL compatible 6-8 pen color plotters to produce color plots on standard paper. Read the plotter manufacturer's manual before using Prowess. See Appendix C for further configuration information. For metric paper size plotters, the switches must be set from US to Metric.

J. Printer

The standard text printer for Prowess products is the Hewlett-Packard LaserJet 4m™. This printer also can print CT hardcopy and can produce black and white HPGL plots.

Read the manufacturer's manual to become familiar with the features of this printer. This guide describes the set up procedures, use, and maintenance of the printer.

K. Image Printer

The preferred device for CT hardcopy printing and plotting is the Hewlett Packard DeskJet 1200 C/PS™. The Lexmark PS4079™ with postscript or the HP PaintJet XL300™ with postscript are also supported. These printers not only allow you to print CT image using gray scale, but they also overlay color coded isodose lines. The beams and contours are outlined in black.

These printers' paper trays hold up to 100 sheets of paper. Both 8½"x11" and 11"x17" sizes of paper trays are available on the HP PaintJet XL300™ and the Lexmark PS4079™.

These devices will print and plot, however, to print text-only documents, it is recommended that you also have an HP LaserJet 4m™ printer.

L. Magnetic Tape Drive

The reel-to-reel magnetic tape drive option can be used to read CT tapes from various imaging equipment. The unit reads ½" wide, 9 track tape at 800, 1600, 3200, and 6400 bits/inch.

The read/write heads on a magnetic tape unit get dirty quickly with use. Clean the head every 2-3 tape readings. To clean the head:

Turn the power OFF.
Wipe the head with a cotton swab dipped in high grade ethyl alcohol.
Let the head dry.
Turn the power ON.

A tape unit can also be used to back up a hard disk. Refer to the manufacturer's manual.

To load a manual unit, place the magnetic tape on the lower hub and lock the hub. Thread the tape around the rollers and through the heads. Wrap the tape around the take-up wheel (upper hub) and spin the upper hub to be sure the tape sticks. Press the load button and remove the write-protect option. Select the correct speed (H for AK Systems drive).

To load an automatic unit, pull down the load cover, slip the tape reel into the unit, and locate it on the hub. Close the front cover and press **Load**. When loaded, press **On Line**.

M. Film Scanner

There are two film scanners available to read CT or MRI images, the Prowess 6FS film scanner and the Prowess 14FS film scanner.

1. Prowess 6FS

The Prowess 6FS is an 8½"x14" flatbed transmissive film scanner. One side is open to allow placement of wide films.

When using the film scanner, be sure the power is on. Both the green and yellow lights must be lit before scanning a film. The scanner has a calibration strip at the top of the scanner bed. Ensure that this strip is not obstructed.

Warm up the scanner for at least 15 minutes before making the first scan. The bulbs have a finite lifetime and will need to be replaced every six months with normal use.

2. Prowess 14FS

The Prowess 14FS film scanner is a large scanner capable of reading a 14"x17" film. Warm up the scanner for a minimum of 15-20 minutes for normal use. For absolute stability, warm up for two hours (film dosimetry). The film is placed against the rollers on the front of the scanner. The scanner will grab the film and pull it through the unit as it reads the film. Once scanned, the film is fed back out the front.

N. Label Printer

The daily calculation program can use a label printer for hardcopy. Before using the printer, turn it on by pressing the left button which is marked with a ϕ. Use the right button to advance the labels.

Only use labels approved by the manufacturer. Load the labels by dropping the roll into the hopper and feeding the leader through the front roller. Advance to the first perforation. The label printer must be attached to a serial port for operation.

O. Power Protection

A power protection device should be used to protect the computer from surges on the power line. If power failures and sags are common, then an uninterruptable power supply is recommended.

III. TESTING THE SYSTEM

Many simple diagnostic tests may be performed to evaluate the operation of the computer and peripherals. The computer runs its own self-test at the time of power up. The self-tests for the printer and the plotter are described in the user's manual. Prowess Systems have a program called **Device Testing**. If problems occur with the system, it is helpful to run these tests before calling a service representative. This should be run after installation or when there is any question of a hardware problem. The operation of this program is described later in this chapter.

IV. INSTALLATION NOTES

Before Prowess can be installed, data must be collected for each energy of every therapy machine in the department. The data required is discussed in Section 10. The hardware must be installed according to the manufacturer's specifications. Refer to the appropriate user's manuals for details.

After installation, perform the following procedures: (a) Turn the system on and check the start up files for completeness, (b) format patient floppy diskettes for archival storage, and (c) create machine characteristics for each therapy machine and mode of operation. Store these machine characteristics in the machine directory and back up onto floppy diskette.

V. DAILY START UP AND SHUT DOWN

Turn the equipment on according to the original manufacturer's recommendations. Refer to the appropriate user's manuals whenever necessary. Before power is supplied to any of the units, be sure that all cable connections are tight. Where possible, screw the cable connections into place.

The magnetic tape device must be turned on after the computer has reached the Main Menu. Turning on the power to the other units does not require a particular sequence. Switches are located near the power cord on most units. At the time the power to the computer is turned on, be sure there are no diskettes in drive A:. If a common power controller has been included for all components, simply turn on the main power switch.

When all units are on, the computer displays the Prowess Main Menu. This menu may differ at each installation, depending upon the ancillary or the support programs operational on the computer. To activate one of the programs, simply select the desired program such as **Treatment Planning** by using either the cursor keys or the mouse.

Exit from the program that is operating and return to the main system menu before turning off the power to all units.

VI. OPERATING PROWESS

Operating Prowess has been made easy, as the software has made full use of the hardware features of the microcomputer. Every effort has been made to minimize your movement between the digitizer and the keyboard.

The basic flow in Prowess System are shown in Figures 2.2, 2.3, 2.4, 2.5, and 2.6. Upon completion of a program the system will return to the treatment planning Main Menu. The second page of the treatment planning menu provides the utility functions for editing machine characteristics. To reach these programs, touch the "C" for **Configuration/Data Entry**.

Once the desired program is chosen, it will request information from either the keyboard or the digitizer. Beam outlines and patient contours may be entered from the digitizer. Brachytherapy source locations may be entered from the digitizer or the keyboard. Results are displayed on the screen and can be transferred to the printer and plotter. The printed copy should be put in the patient's chart along with a manual calculation to verify the accuracy of the results.

All programs, system modules, and machine data are stored on the hard disk of the computer. Patient data is kept on the hard disk in one subdirectory, the machine data and radiation source data in another, and the program modules in an additional subdirectory. A cassette or 9 track tape should be used for long term archival storage of patient data files. As a patient directory is built, it may be transferred to a tape for permanent storage.

A maximum of 500 patient files can be stored in a directory. Periodically review your patient directory and archive inactive patient files.

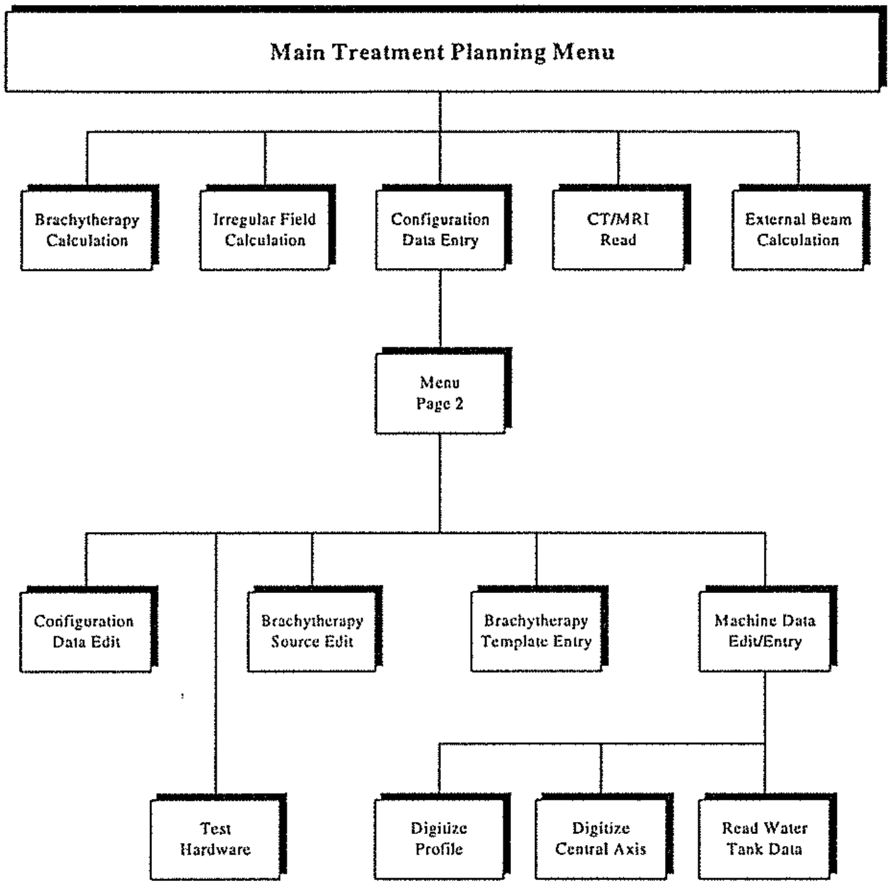


Figure 2.2 - Main Prowess Menu

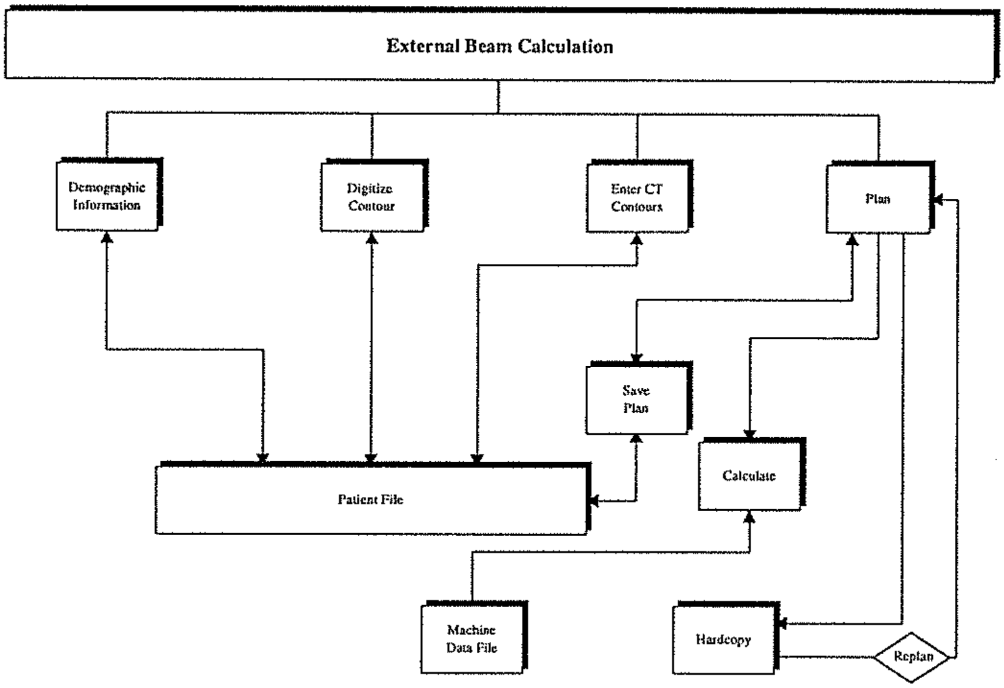


Figure 2.3 - External Beam User Interface

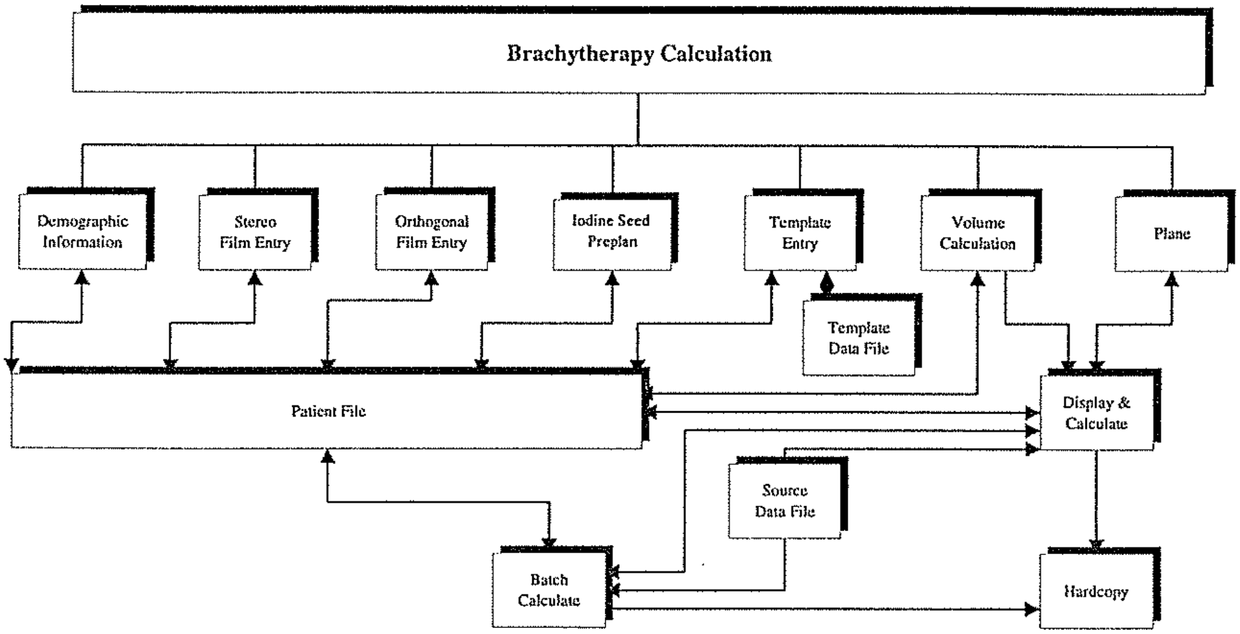


Figure 2.4 - Brachytherapy User Interface

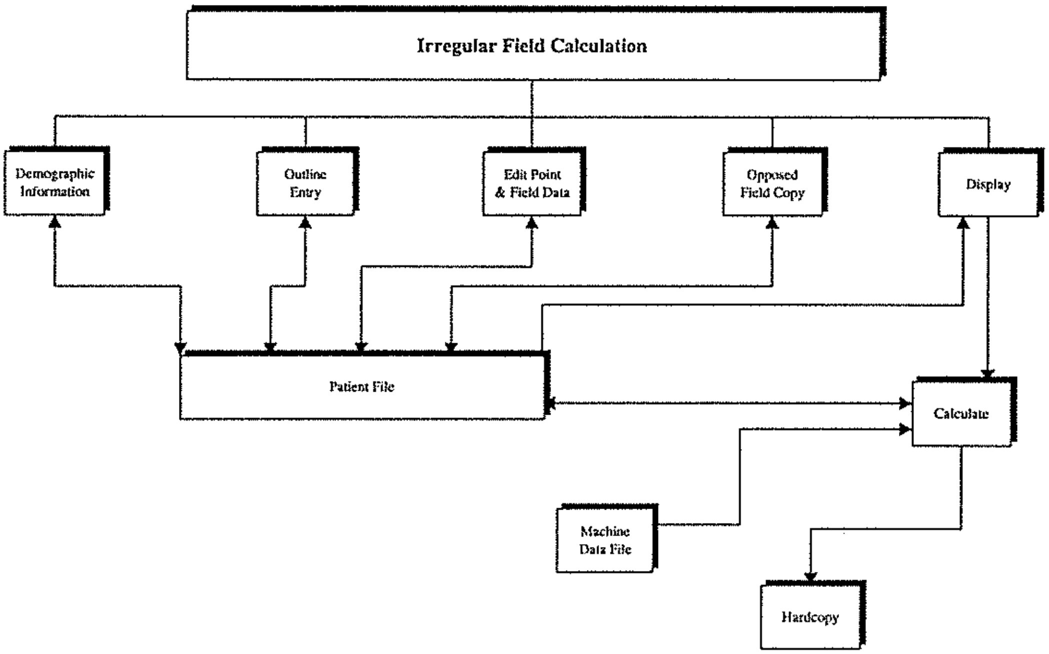


Figure 2.5 - Irregular Field User Interface

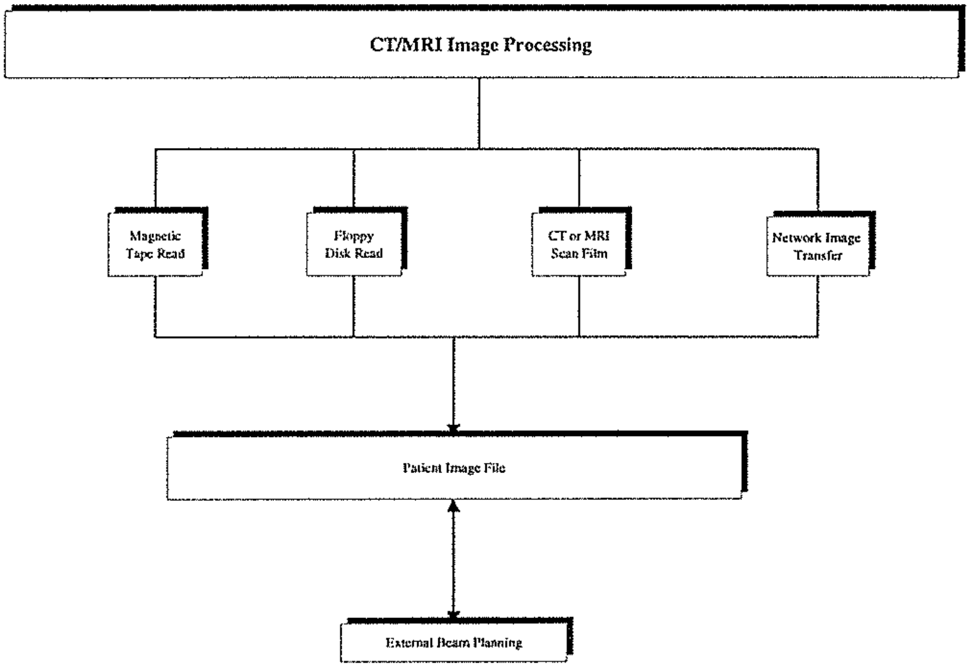


Figure 2.6 - Image Entry User Interface

VII. STARTING PROWESS

Following initial start-up, you may reach the treatment planning menu from the main menu by selecting TPS. From this menu, select the appropriate treatment planning program.

To choose the desired option, move the UP or DOWN arrow keys to highlight the desired program and press **Enter** or press the key of the first letter such as B for Brachytherapy Calculation.

External Beam Planning
Brachytherapy Calculation
Irregular Field Calculation
Daily Calculation
Read CT/MRI Images
Scan CT/MRI Images
Configuration/Data Entry
Quit or ESCape exits Menu

Edit Configuration
Machine Data Entry
Brachytherapy Source Entry
Template Entry
Device Testing
File Management
Quit Configuration Menu
Units

A. Units

Standard units are used throughout the program. All linear dimensions are specified in centimeters unless otherwise documented. Doses are specified in cGy and dose rates in cGy/hr. Units of activity vary, but are shown on the screen. They may be in mCi, mgRadeq., Bq, or U. Densities are specified as relative to water unit density.

B. File Manipulation

Programs, patient data, and machine data are stored as files. Each file has a unique name consisting of 1-8 letters followed by a period and a 3 letter extension. The files are organized or grouped on the disk drive in a directory or subdirectory. A directory can hold any number of files.

MS-DOS™ uses certain file label restrictions. Read the manufacturer's manual for further information.

The hard disk has a number of directories which are used by Prowess. The following list describes the directory tree used by Prowess:

\PROWESS - main treatment planning directory
    \BIN - executable (*.EXE) programs and the compiled control file (TPSCTL.CTL)
    \FONTS - fonts (*.FNT) used for screen display
    \IMAGE - images (*.PCX) used for screen display.
    \PATIENT - patient files (*.EXT, *.IRG, *.BCY)
    \MACHINE - machine data files (*.MCH), brachytherapy source file (LINESEED.SRC), and brachytherapy template files (*.BTX).
    \CATIMAGE - film densitometry images (*.FS2)

Patient files can be copied and deleted using MS-DOS™ commands or the file management option. This option utilizes a program called Pop-Up DOS™. The user's manual for these programs are included in the reference documentation. Appendix C is a summary of the Pop-Up DOS™ commands needed to manipulate Prowess files.

VIII. HARDWARE TEST

The **Device Testing** option in the **Configuration/Data Entry** menu is used to test the digitizer, mouse, printer, plotter, magnetic tape drive, and scanner.

Use this program, after installation, after repair, and periodically The program can also be used to help troubleshoot hardware and software problems.

From the test menu, choose each hardware device and take any action requested by the program. The results of each test are displayed on the screen. Should a device fail the test, check the device to be sure that it is plugged in and turned on.

If, after taking all appropriate correctional measures, the device still fails, please contact the closest Prowess Systems representative for assistance.

IX. UPDATING PROWESS

The update diskettes are 5¼", 1.2 MB format or 3½", 1.44 MB format.

Before installing any update, back up your current system software. Follow the directions starting on Page 2-3 regarding Backup.

To exit the Main Menu, press "F10" twice. The MS-DOS™ Prompt (**C:**) should appear.

Before installing the update program, please run **CHKDSK/F** to check the integrity of the hard disk. Put Disk #1 in drive A: (or B:). Invoke the install program by typing **A: INSTALL.** Answer the questions and put the diskettes in drive A: as requested. After the update is installed, type **C:** and press Enter. If there are any questions about the update call the SSGI Technical Support office at (916) 898-0660 between 8:00 am and 5:30 pm Pacific Coast Time.

EXTERNAL BEAM PATIENT ENTRY

I. GENERAL

The external beam treatment planning process consists of three steps. The first step is to enter a set of anatomical and geometric data which describes a patient. This step is the topic of this section. The second step is to specify and position a set of beams on the patient and calculate the resulting dose distribution (see Section Four). The third step is to save and make a hardcopy print of all planning results (see Section Five).

There are two types of patient data which may be entered for external beam planning. These are anatomical image data and geometric contour data. Each patient is divided into a set of patient slices.

As shown in Figure 3.1, each patient slice is divided into a contour slice and an image slice.

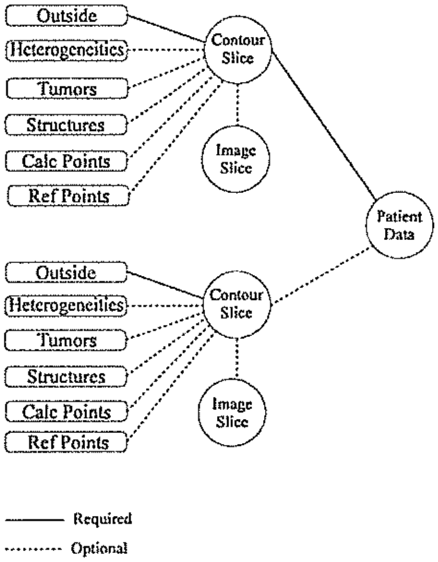


Figure 3.1 - Structure of Patient Data

Image slice is a feature of Prowess *2000* and Prowess *3000* systems only.

Image data is not used in dose calculations. The contour slice is required and the image slice is optional for each patient slice. Any images in a patient field without associated contours cannot be used for external beam planning. Each patient slice is parallel and offset from all other patient slices. Each contour slice is required to have an outside contour and may have internal contours and points. Thus, the simplest patient data set might contain only one outside contour, whereas, a complex data set could contain much more information.

Image slices can be entered from a film scanner, magnetic tape, network, or diskette. Contour slices can be entered from the digitizer, mouse, or can be generated from image slices. Keyboard entry is required for demographics entry as well as parts of the contours and image slices. This is illustrated in Figure 3.2.

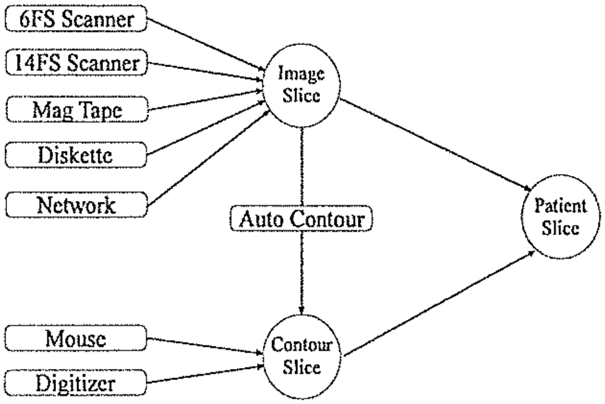
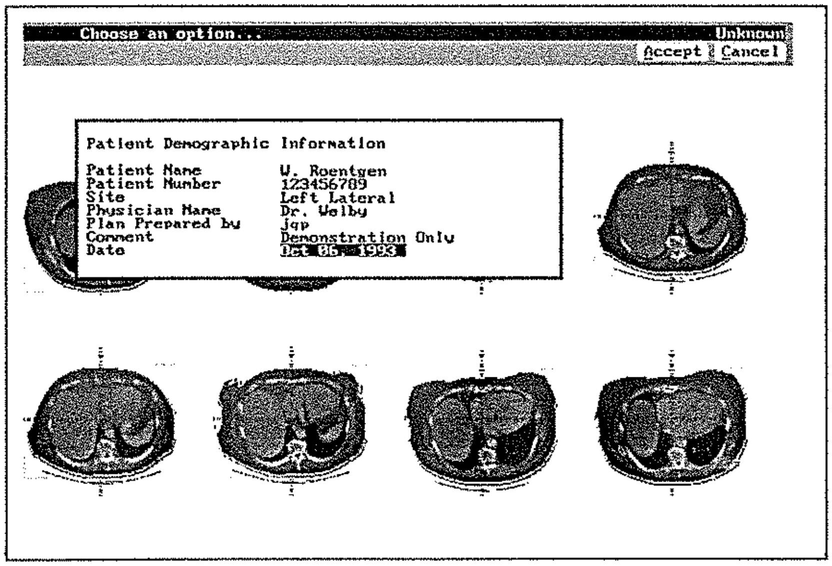


Figure 3.2 - Patient Data Entry Flow

Image slice and Auto Contour are features of Prowess *2000* and Prowess *3000* systems only.

II. DEMOGRAPHIC ENTRY

When a patient is first entered, the demographic data is prompted for as shown in Figure 3.3. To modify this data from the main external beam planning window, select Demogr.



Patient Demographic Information

Patient Name	W. Roentgen
Patient Number	123456789
Site	Left Lateral
Physician Name	Dr. Welby
Plan Prepared by	jqp
Comment	Demonstration Only
Date	Oct 06, 1993

Figure 3.3 - Demographic Data Entry

III. IMAGE ENTRY

Image Entry does not pertain to Prowess *1000*.

A. From Magnetic Tape

To enter CT images from a magnetic tape, load the magnetic tape into the tape unit. Choose **Read CT/MRI Images** from the main treatment planning menu. Be sure the load light is ON and the correct density is selected (e.g., 1600 bpi). Check that the correct CT scanner is shown on the screen when you start the program. The program reads the tape header and displays the patients, procedures, and number of slices on the tape. Choose the patient desired and press **Enter**. As each image is read and formatted, the slice number is displayed on the screen. When the transfer is complete, the total number of slices is displayed. Press **ESCape**, choose another patient for transfer, or choose Process.

B. From Diskette

To read CT images from a diskette, place the diskette in the appropriate drive. Choose the image file source (e.g., Siemens, Varian, Kermath, or Nucletron) to Prowess Convert selection from the main treatment planning menu. The program displays the files on the diskette. Enter or edit the demographic data. Then, choose Transfer. As each image is read and formatted, the slice number is displayed on the screen. When the transfer is complete, the total number of slices are displayed. Choose another patient or another diskette. When finished, choose Process.

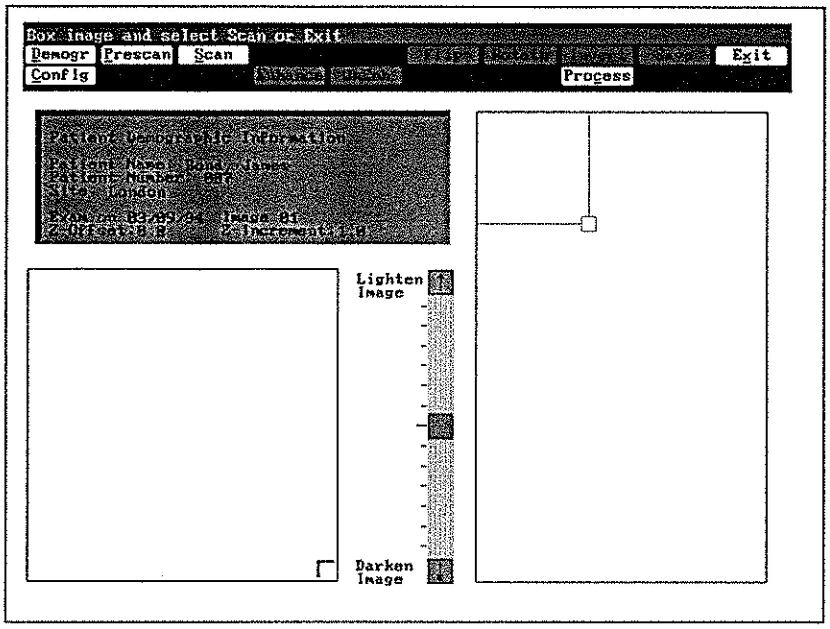
C. From Network

To read CT images from a network, choose the image file source (e.g., Siemens, Varian, Elscint, ACR NEMA, or DICOM) to Prowess Convert from the main treatment planning menu. Each image (and associated contours) are read and formatted. When the transfer is complete, the main menu returns for further planning.

D. From 6FS Scanner

Before scanning, install the light source so that it shines down on the film and remove the scanner cover. Use the scanner manual as a reference.

Turn the power on, and verify that both green and yellow lights on the front panel of the scanner are lit. Position the CT images on the scanner without covering the calibration strip at the head of the scanner. Choose ScanCT from the main treatment planning menu. Enter the demographic information and Accept. The options are presented as shown in Figure 3.4.



Box image and select Scan or Exit

Patient Demographic Information

Patient Name: Bond, James
Patient Number: 007
Site: London

Exam on 03/09/94 Image 01
Z-Offset 0.0 Z-Increment 1.0

Figure 3.4 - 6FS Film Scanner Entry Window

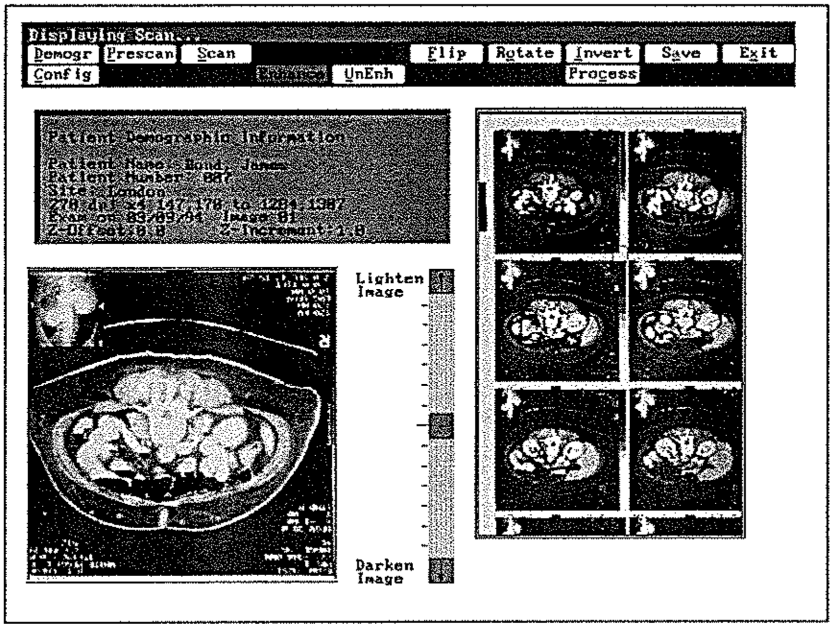
Select Prescan. A scan is made of the entire active area. A large square box appears in the prescan image area to the left on the screen with a small box in the lower right corner. This large box is the area which will be selected to be scanned. The area to be scanned appears on the right of the screen as a blue box with a small box in the lower right corner.

Use the mouse to move, stretch, or shrink the box. To move the box, place the mouse into the center of the area, hold the left mouse button down and drag the box. Release the mouse button to release the box. To change the size of the box, move the mouse to the small box, hold the left mouse button down and drag the mouse. The square box now changes size. The fastest way to get the area you want covered is to move the large box and set the upper left corner in place. Then, change the size to cover the region of interest.

When the box is released, a low resolution image of the area to be scanned is shown in the small scan box. Use this image as a guide to be sure the area selected covers the area to be scanned.

Once the area is chosen, select Scan to scan the area. Following the scan, the small scanned area is replaced with the high resolution image. New features become active on the menu as shown in Figure 3.5.

It is strongly recommended, once the image acquisition size is chosen, that it not be changed for the subsequent slices. This allows all slices to have the same scale so that only one scale factor is needed which applies to all slices.



Patient Demographic Information

Patient Name: Bond, James
Patient Number: 007
Site: London
270 dpi x4 147,178 to 1284,1387
Exam on 03/09/84 Image 01
Z-Offset:0.0 Z-Increment:1.0

Figure 3.5 - 6FS Film Scanner Processing Window

You may manipulate the image by inverting, flipping, and/or rotating until it appears in the correct orientation on the screen. You may also re-scan if necessary. Be sure the image orientation is correct. These functions are not available in external beam planning.

The image is digitally enhanced during scanning. If necessary, choose UnEnh to remove this enhancement.

After each image has been scanned and accepted, choose Save. The images will be saved in the order scanned, incremented by the offset. This offset can be edited later, but the orientation cannot.

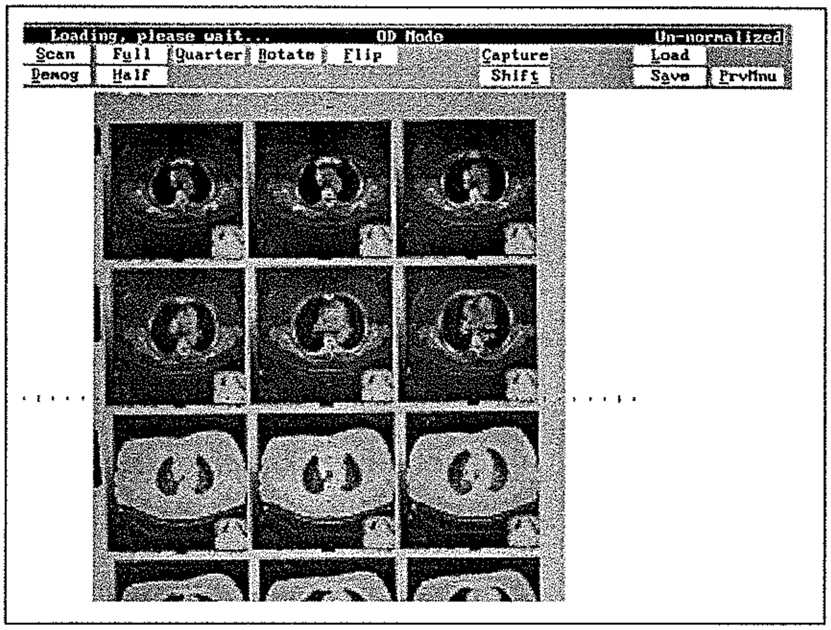
Multiple images may be scanned before leaving the module. Move the image scan box to the new area of interest and scan it again. Each of these images are sequentially labeled. Enter the images in increasing section numbers to make it easier to keep track of the selected images. Choose Process to continue to marking up and planning the scanned images.

E. From 14FS Scanner

Warm up the scanner for at least two hours before scanning. Position the film in the scanner bed against the rollers. Choose **Scan CT Images** from the main treatment planning menu.

If acquiring images from the film densitometer program, choose CT Acquisition. Enter the demographic information.

Choose Scan to read the entire film. Once the film is read and displayed on the screen, a new series of menu items appears as shown in Figure 3.6.



Loading, please wait...

Figure 3.6 - 14FS Film Scanner Image Acquisition Window

Select the appropriate zoom box to acquire the image. Move the box with the mouse to cover the image. Choose the correct orientation and then Capture to store the image. Move the box to the next image and choose Capture if more than one image is required. This image cannot be changed while using external beam planning.

The whole film image can be stored for future reprocessing by choosing Save to store the 1024 x 1024 12-bit image on the hard disk. To recall a saved file, choose Load and select from the list.

When all the images have been captured, choose Process to start planning or Quit to exit.

IV. SLICE MANAGEMENT

Choose Slices to view all available patient slices. The slices are displayed in order of z-offset with no two slices having the same z-offset. Choosing this option brings up the following menu items:

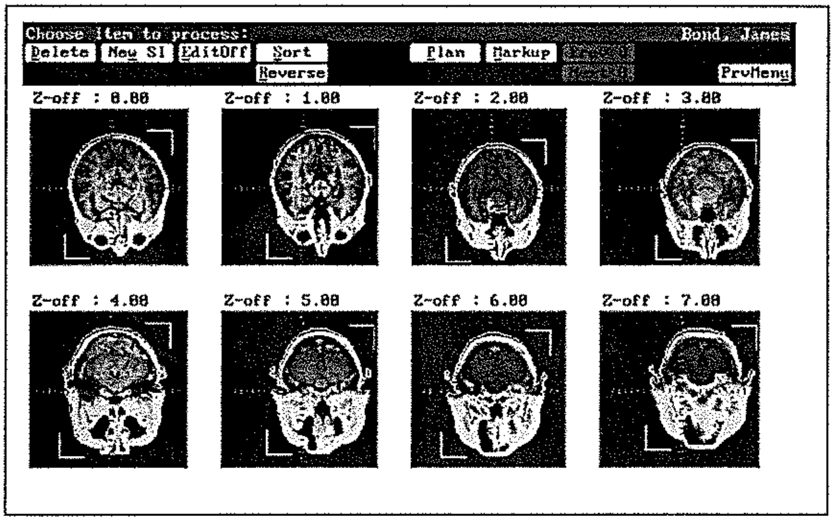


Figure 3.7 - Slice Management Window

The active slice is highlighted in red. It may be chosen by clicking the mouse on that image or using the arrow keys.

If entering a new patient using the digitizer, start with only one blank slice. Create all the slices for this patient before proceeding. Choose NewSl. Be sure to enter the z-offsets for the new slices. Changing the z-offset of a slice will remove any existing beams from a current plan. Change offsets by selecting EditOff. After changing the z-offset, re-arrange the order of the slices in increasing z-offsets by selecting Sort. If more than eight slices are entered for a patient, the slices not shown on the screen can be displayed by choosing Next8 or Prev8 from the menu.

Select Delete to delete a slice or image from the slice manager screen. Before deleting the slice, confirmation is requested. The Reverse function changes the sign of each slice's offset, thereby reversing the order of the slices.

V. IMAGE WINDOWING

The window and level of the image can be changed throughout the planning process. The controls are shown on the right side of the screen. The top bar is the window and the lower bar is the level. Use the mouse to change the values by grabbing the slider. You can also use the arrow keys to change these functions. The up/down keys change the window and the left/right keys change the level.

When the beam movement is available during the planning process, the arrow keys move the beam and not the window and level. You can still use the mouse to change the image.

The image may be doubled or halved by selecting Zoom. The image is always displayed in the 256 x 256 format, only the magnification is changed.

Select Origin to change the default of the image. Place the cursor where the new origin is to be located and click the left mouse button. Once the origin is located, select "Yes" or "No" to indicate if all origins are to be changed.

VI. IMAGE PROCESSING

Image Processing does not pertain to Prowess *1000.*

Choose Tools to process the image further. The image tools window is shown in Figure 3.8.

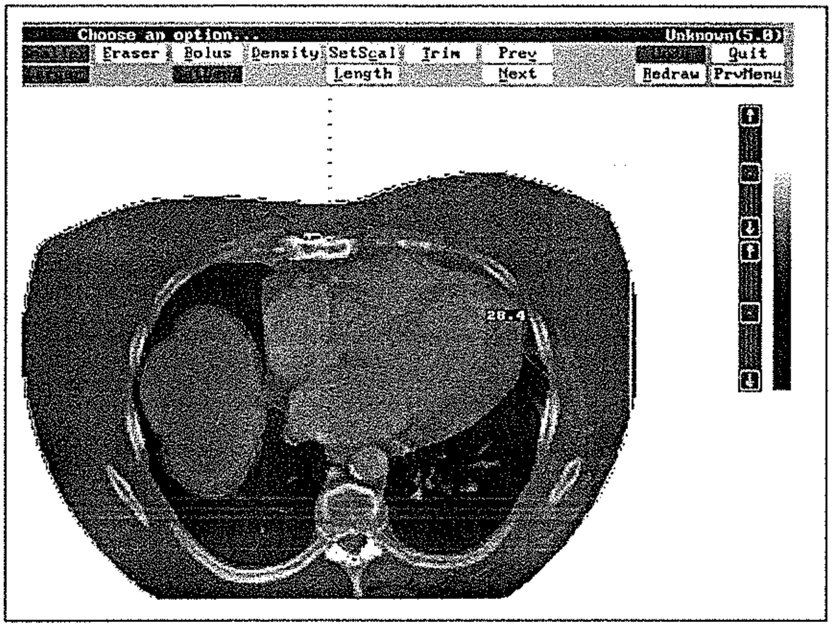


Figure 3.8 - Image Tools Window

Select Eraser to erase part of the image. A square eraser box will appear on the screen. The box may be made Larger or Smaller. Move the box over the area to be erased and press the left mouse button. Holding down the left mouse button while moving the mouse gives continuous erasing. Choose Undo to correct mistakes and Accept to save changes.

Use erase to clean up a scanned image before autocontouring. Sometimes the scout views overlap the image and produce a strangely shaped patient when contoured. To eliminate overlapping, erase the unwanted image adjacent to the patient image.

The image may be repaired or bolus may be added by choosing Bolus. The function adds a uniform density image within the box. Choose SetDens and enter a density from -2000 to +2000 to change the bolus density.

Select Density to find the average CT density inside a square area. As in Eraser, the box may be changed in size by choosing the appropriate function menus. Move the box and press the left mouse button or the **Enter** key to produce the average image density numbers inside the box. **ESC**ape exits this function.

After the outside contour has been entered, all of the scan information outside this contour may be deleted. Select Trim to clear the area outside the contour.

If the image becomes corrupted, undo or redraw the image. Undo removes all changes and Redraw redraws the image.

To perform accurate multi-slice plans using a scanner, all slices must be scaled correctly and have a common origin. When the image is acquired during scanning, be sure all slices are scanned with the same magnification. Select the appropriate zoom box on the first scan and retain that size for all succeeding scans. Be sure that all scans have the correct orientation. After scanning is complete and planning is started, choose Slice. Set the offset for each image correctly and sort the images. The scale must be set on all the slices. To do this, select the first slice and choose **Set Scale** from the Tools menu. Use the 5 cm scale on the image or a true anatomical distance to set the appropriate scale on the CT image. Finally, to set a common origin, choose Origin and move the cursor to a common point on the first slice such as the tip of "R" or "L" on the image. Choose that point as the origin. Repeat the process on each slice. Once all slices are processed, move the origin to the desired anatomical location on one slice. This now sets a common origin on all slices at the desired location inside the patient.

VII. CONTOUR ENTRY

To enter contours, choose Markup, then Contour from the main external beam planning window. The screen will appear as shown in Figure 3.9.

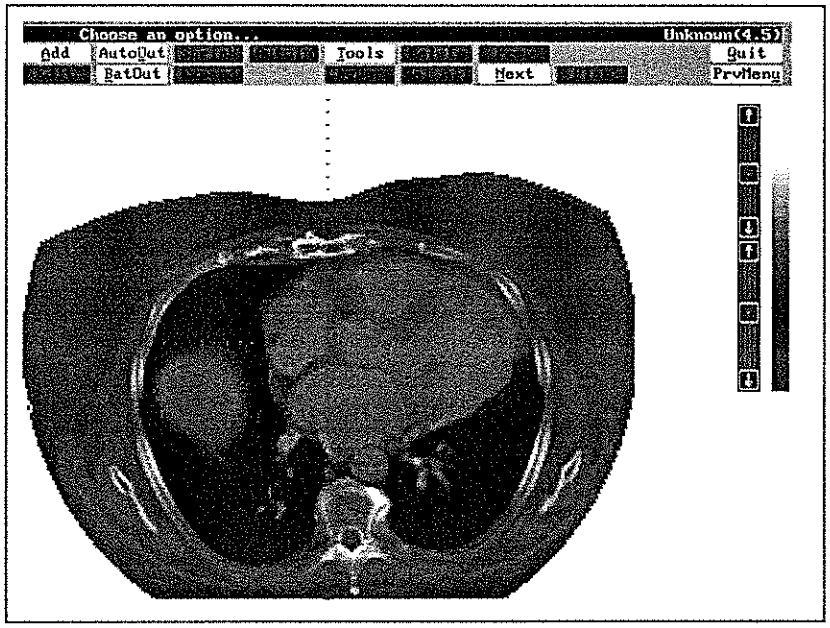


Figure 3.9 - Contour Entry Window

To delete contours, choose either Delete or DelAll. Select Add to add a new contour. When prompted, select the entry mode as the digitizer or the mouse.

A. Digitizer Entry

In the digitizer entry mode, first digitize the bitpad calibration points U and L. Then, either enter the contour magnification factor or the length of a reference line on the contour. Figure 3.10 shows the layout of the digitizer.

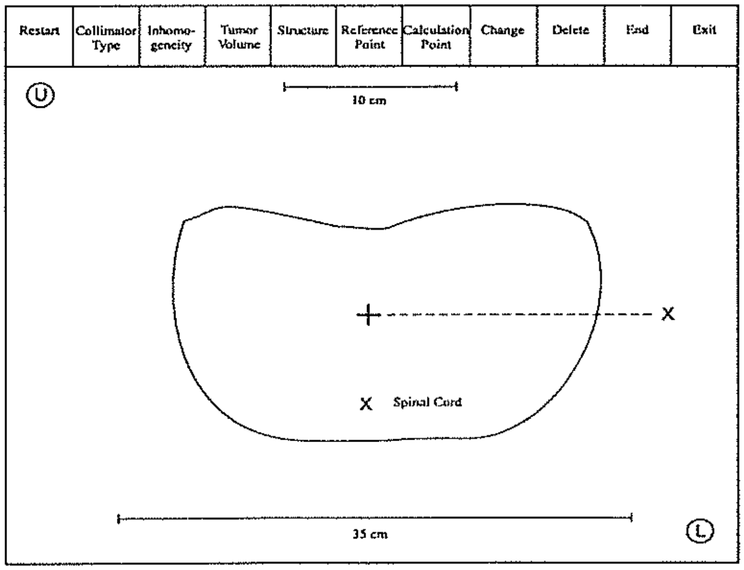


Figure 3.10 - Digitizer Entry of Patient Contours

After digitizing the image origin and a point on the right horizontal axis, begin tracing the outline of the contour or the point locations. Enter contours in either continuous or point mode. If, at any time during the entry process, you need to clear all entries and start over, select **Restart**. If you enter erroneous points, select **Delete** as many times as needed. After completion of contour, select one of the options (**Calculation Point**, etc.) and enter with the digitizer. Select **End** and then **Restart** for another option (the deletion of unwanted points is done with the keyboard in **Markup**). If no further entry is needed, select **Exit**.

B. Mouse Entry

Contour or point entry with the mouse functions similar to digitizer entry. The same toggling cursor and tracking marks appear on the screen except under the control of the mouse. No calibration or scaling is required for mouse entry as the on-screen coordinate axes are used for position reference. Contours and points can only be entered in the point mode. Use the mouse and entry type by selecting the on-screen button bar. Note that in mouse mode, by selecting Label, a text label can be attached to the contour slice.

During contour entry with the mouse, a left mouse click inserts a new point, a right mouse click deletes the last point, and a middle mouse click closes the contour. A two-button mouse accomplishes a middle click by clicking the right mouse button while the left is depressed.

From the keyboard, **Insert** can be used to insert or point out the current mouse location, **Delete** deletes the last point, **End** closes a contour, and **ESC**ape terminates entry.

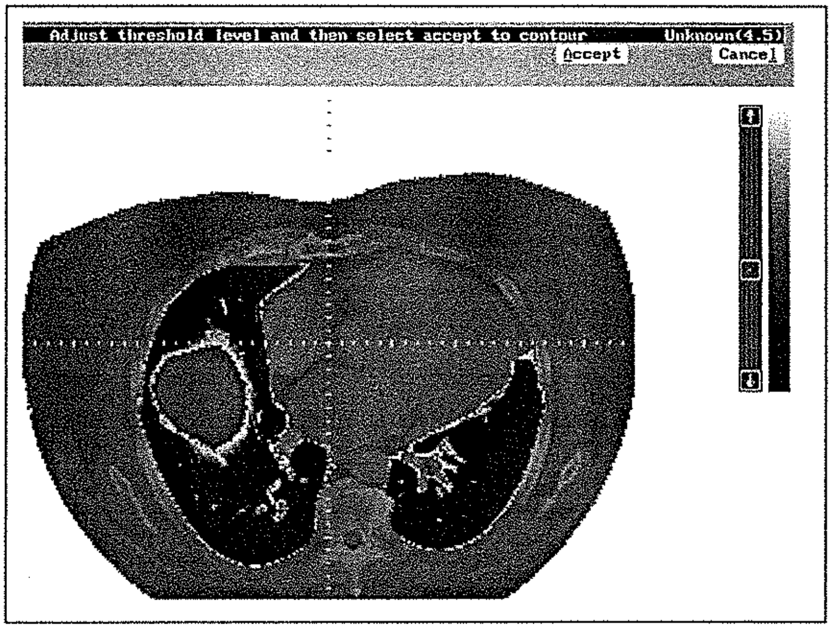
During contour entry, a crosshair cursor appears on the screen which tracks entry. To toggle this cursor between an open-centered mini-crosshair and a full screen crosshair, use the "+" key on the numeric keypad. A pair of alignment markers track the projection of the cursor onto the coordinate axes.

C. Automatic Contour Entry

Automatic contour entry does not pertain to Prowess *1000.*

If there are image slices entered for the current patient, then in addition to Add, some combination of the following options will be enabled.

AutoOut: Automatic outside contouring is enabled for uncontoured image slices. Select this option to initiate a threshold-based image analysis process and set an adjustable threshold for the part of the image to be contoured. All image pixels which are to be contoured are turned to blue on the screen. See Figure 3.11.



Adjust threshold level and then select accept to contour

Figure 3.11 - Auto Outside Contour Entry Window

Proper selection of the threshold or blue/gray interface is critical. The outside contour will follow the outside of the blue image. Use the slider to the right of the screen to change the blue level threshold. The default setting is a good starting point for an image. Scanned images may require some adjustment.

The contouring threshold is indicated on the threshold bar on the right side of the screen. There are several ways to modify the threshold: Click on the up/down arrows at the top/bottom of the threshold bar, click and drag the threshold button in the threshold bar, press the up/down arrow on the keyboard or, for coarse adjustment, set the increment using the "+/-" keys on the keyboard and change the threshold with the Shift-up arrow and Shift-down arrow.

Some adjustment of the image threshold may be required before contouring. Set the threshold so that the entire contour is turned blue, but there is no connection to any blue object in the background. Practice is helpful in order to use this tool effectively. Select Accept to draw the contour or Cancel to abort the process.

BatOut: Batch automatic outside contouring is enabled if there are multiple uncontoured image slices. This option works in a manner identical to AutoOut until Accept is calculated. At this point, instead of contouring the current slice, the current threshold is used to contour all slices for the patient. If you select BatOut and there are existing contours, you will be prompted on how to handle this case. The process can be aborted, all existing contours can be overwritten, or all contours can be retained. Use the default option to prompt each existing contour as encountered.

AutoIn: Automatic inside contouring is enabled if the current slice has an outside contour. After selecting AutoIn, specify the type of internal contour from the button bar. The same image analysis process is used as for AutoOut. Adjust the threshold until the structure of interest is either completely blue or lacks blue altogether and is not connected to another structure in the same condition. Select Accept when the threshold is correct. You will be prompted to click on the structure of interest. For best results, click near the edge of the structure and far from complicated image features. See Figure 3.12.

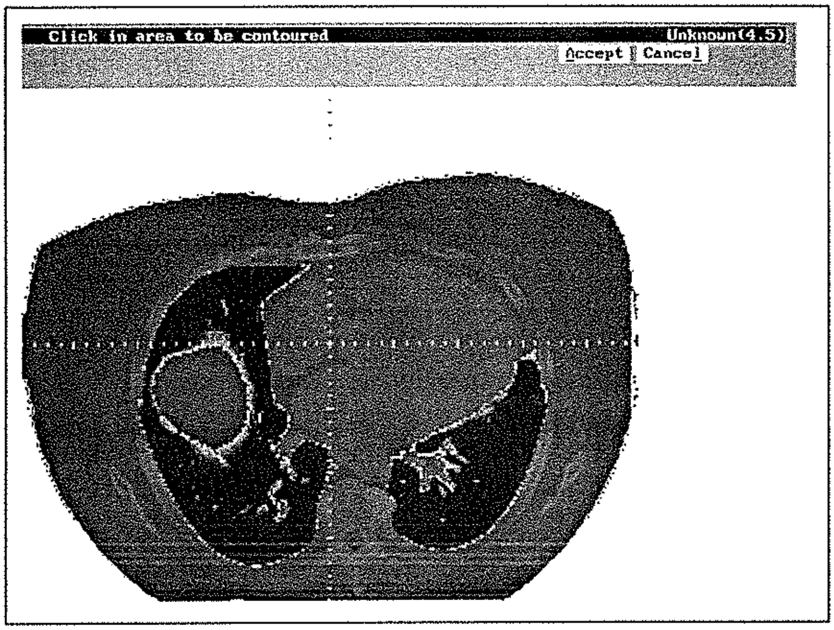

Click in area to be contoured

Figure 3.12 - Auto Inside Contour Entry Window

In Figure 3.12, a region of liver appears inside a region of lung. To contour the liver, click inside or near its edge. To contour the lung, click close to the edge of the lung. After the contour has been drawn, select Accept or Cancel.

Shrink: The outside contour shrink option is enabled if an outside contour has been entered on the current patient slice. It uses the same thresholding technique previously described, except instead of drawing around the blue contour, it shrinks an existing contour down to the threshold.

Expand: The inside contour expand option is enabled if an inside contour has been entered on the current patient slice. It uses the same thresholding technique described above except instead of drawing around a structure, it expands an existing contour out to the threshold.

VIII. CONTOUR EDITING

All contours can be edited using the mouse. The Edit option from Figure 3.9 becomes active if contours have been entered for the current patient slice. After selecting this option, a box appears around the outside contour. Use Next and

Prev to step the box through each contour until the contour to be edited is indicated. Choosing Accept causes the selected contour to change color which indicates that it is editable.

Click the mouse at one end point of the region of the contour to be modified. A small circular marker appears on the contour. As you move the mouse around the contour, the selected region of the contour changes color. Click the mouse twice to remove the undesired segment of the contour and begin contour entry. Enter contour points and terminate by clicking the middle mouse button.

IX. CONTOUR MANAGEMENT

The Prev and Next options are available in the window of Figure 3.13, as well as most other windows, when multiple patient slices exist. These buttons allow you to move between slices.

The ChgDens option is available when heterogeneities or calculation points have been entered. Use this option to modify calculation points, heterogeneity names, and heterogeneity densities. Heterogeneity names and densities are prompted for at the time of entry, but this option is required for specifying calculation point names.

Selecting Tools opens the window shown in Figure 3.13. This option provides a group of image slice and contour slice utilities.

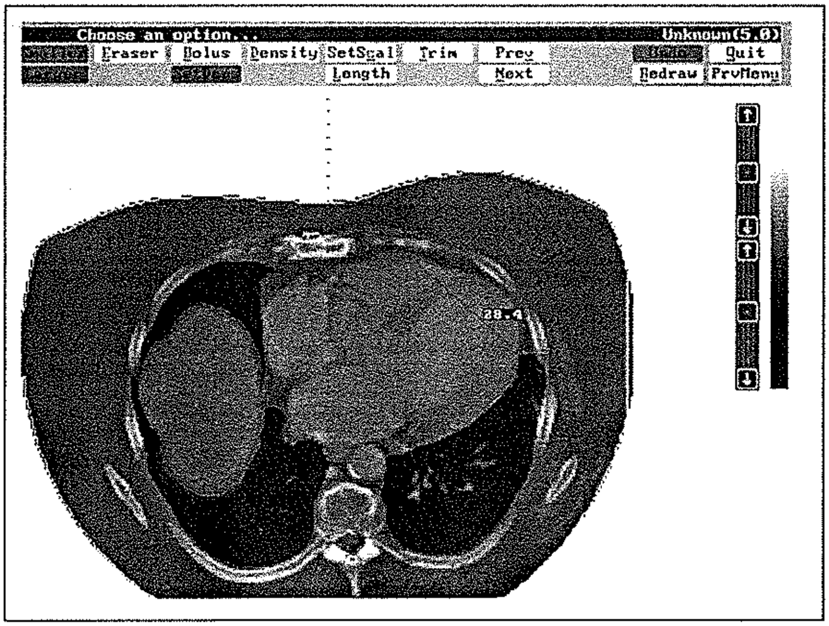


Figure 3.13 - Contouring Tools Window

Length is used to measure the distance between two points. This measurement can be attached to the contour. In Figure 3.13, a length measurement between the medial and lateral breast margins has been attached to the contour slice.

SetScal is used to rescale a contour slice. This option is generally needed when contours are drawn over film scanned images. Selecting this option prompts for entry of two vertically and horizontally displaced points separated by a known distance. Since the horizontal and vertical scales are frequently the same, the option is provided to copy the vertical scale to horizontal.

Warning: Changing the contour through markup by editing a contour, adding a calculation point, etc. changes your calculated plan. Therefore, all calculated plans are deleted after such changes. Beam placement or definitions may be affected. Accept these changes or the program deletes all beams entered. This is a safety feature.

EXTERNAL BEAM PLANNING

I. GENERAL

The external beam calculation module calculates the dose distribution on a set of patient slices from a set of teletherapy beams.

This section describes the techniques for creating an external beam treatment plan, calculating the dose distribution, and calculating machine settings.

As many as 40 beams from different machines may be entered into a single plan as isocentric, SSD, or rotational beams. The results of all plans may be stored for later retrieval.

Rotational calculations are performed by integrating over stationary isocentric fields. The default increment is 10 degrees with a minimum of six increments for each integration of a rotational field. The increment can be changed during the planning process.

Reference points and calculation points are specified during patient entry. The dose at each calculation point is explicitly calculated and printed on the summary sheet. Additionally, the dose contribution of each beam to the calculation point is calculated.

All of the slices with an outside contour are available for planning. Planning starts with the active slice or the last slice used for the last plan.

II. EXTERNAL BEAM PLANNING AND CALCULATING

The Plan menu option (from the main External Beam Planning Menu) only becomes available when a contour has been entered. If a plan has already been entered for this patient, the plan is recalled. Select NewPlan from the Main Menu to clear the existing plan. Select File if a saved plan is desired, then retrieve the appropriate plan.

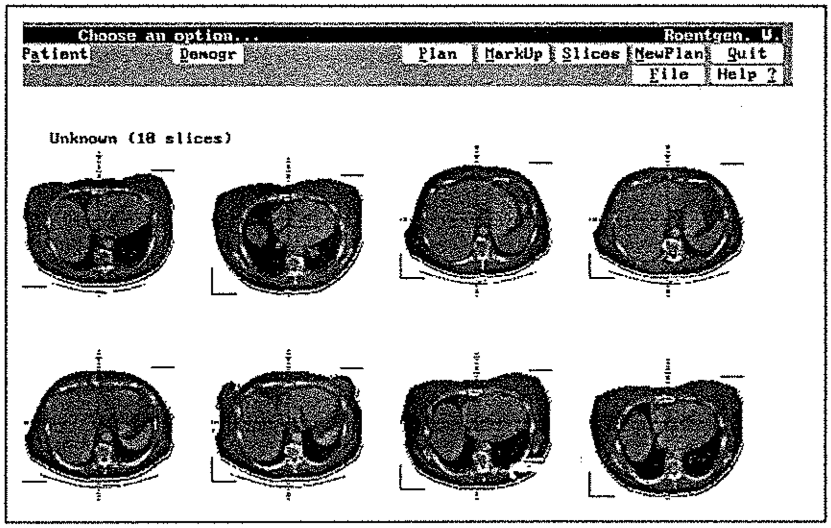


Figure 4.1 - Main External Beam Planning Window

Once planning is entered, only those slices with an external patient contour will be available. To start a new plan, choose Beam and select a new beam.

III. NEW BEAM ENTRY

Choosing Beam from the main external beam planning menu opens a pop-up window requesting beam selection information. Select a machine from the list of machines.

Enter all of the information requested in the window to define the beam. Edit entries using the arrow keys or the mouse. Enter the effective field width and effective length (or delete the beam). Choosing Accept accepts the beam. All entries may be edited later.

If at least one beam is already present in the plan, it may be copied by selecting Copy. CopyInv copies the mirror image of any previously entered beam. Be sure to enter a unique name for each beam.

If the default type of the beam is not correct, it may be changed by selecting BmType.

A. Machine Selection

Choose Machin from the new beam window to display a list of the available machines. Use the arrow keys or the mouse to select a different machine. Select the machine by pressing Enter or exit with no change by pressing ESCape. If changing from one machine to another, where there are different block type numbers, verify that there are corresponding block type and wedge numbers.

B. Beam Type Selection

Choose BmType to change the type of beam. The beam type may be isocentric, rotational, or SSD. Use the arrow keys or mouse to select the type and press Enter or **ES**Cape to exit without any change. An SSD beam is a special case of an isocentric beam with the isocenter on the skin surface.

C. Beam Deletion

To delete a beam, select the beam from the list, then choose DelBm.

D. Beam Size Selection

Specify the beam size by entering the collimator width and length and the effective width and length. Effective size is the blocked beam size that is projected onto the patient, whereas, collimator size is the actual setting of the machine collimator. The effective size is always less than or equal to the collimator size. Specifying effective field size (equivalent square) is one method to allow for custom cast blocking of the field which reduces the effective size of a field. The program will automatically calculate the effective field size, from the beam's eye view, if blocks are entered.

The collimator field size is the field size set on the treatment unit and the effective field size is the blocked field size seen by the patient. Both are projected to the nominal SSD or SAD for that treatment machine. The effective field size is used to look up the TMR for the calculation. The collimator field size is used to determine the OCR and output factor for the beam. The output factor is corrected for blocking by using the Peak Scatter Factor (PSF) of the effective field size.

If the collimator field size entered is outside the bounds of the OCR data, it is set to a field size that is just inside its maximum or minimum limits. It is important to know what the range of maximum and minimum field sizes are in each data file. If the beam is an electron beam, it must be specified as an SSD beam. Rotational and isocentric electron beams are not supported.

E. Beam Weighting

The weight of a beam, the weight point, total weight value, and the number of fractions can be specified. The weight point can be the isocenter of the beam (if it is isocentric), depth of dose maximum (d_{max}) on the central axis, monitor units, or a calculation point. Isocenter and d_{max} points are defined on the central axis slice only. If you weight to a calculation point, it can be any calculation point defined on any slice as long as that point is inside the beam. The weight is the total dose in cGy to be delivered by that beam to the weight point. The number of treatment fractions can be entered.

Normalization and prescription may change the actual machine settings, therefore, the weights can also be relative. For sets of isocentric fields, it is preferable to choose beam weight so that they total 100.

F. Weighting all Beams

Select AllWt to change the weights of all beams. Selecting this option shows a window with the weights of all the beams. Edit any weight value using the keyboard. Use NextBm and PrevBm or the arrow keys to move around the table. Select Accept or Exit to terminate entry with or without saving.

G. Selecting Collimation

The jaws may be symmetric or asymmetric. Choosing IJOn turns the independent jaw feature on. Likewise, choosing IJOff makes the beam symmetric. The collimator for each jaw setting must be set with the independent jaw option on. For example, an independent jaw entry requires 5 cm to be entered for a 10 cm wide field. Whereas, for a symmetric beam, only the 10 cm need be entered.

H. Beam Acceptance

Accept the beam by selecting Accept after all the beam descriptions have been entered or press **ESC**ape to reject the beam. The beam, once accepted, becomes the active beam.

IV. ALTERING BEAMS

Once a single beam has been entered, the planning menu is updated as shown in Figure 4.2. The beam may be moved or changed by this new set of functions.

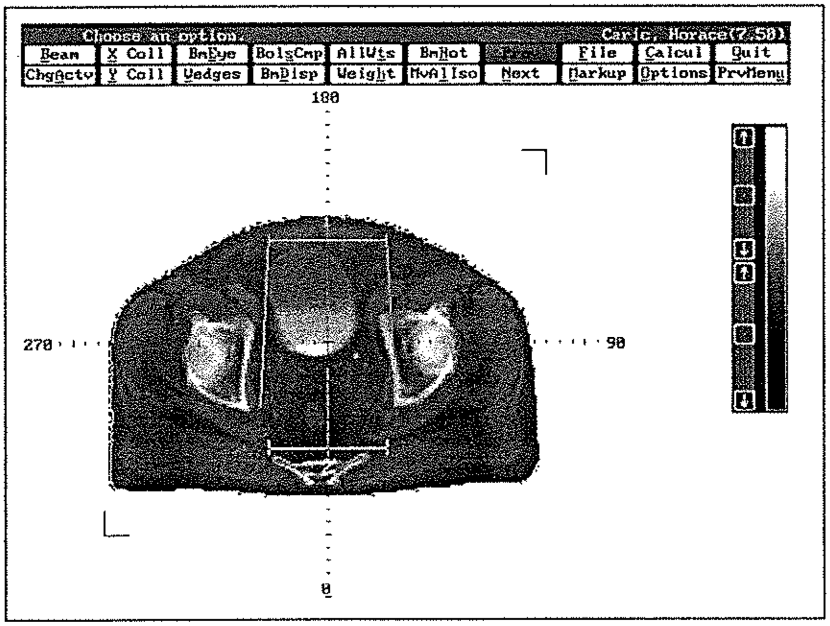


Figure 4.2 - Beam Specification Window

V. BEAM DESCRIPTION

There are three different types of beams available for planning: SSD, isocentric, and rotational. In Figure 4.3, hot regions are indicated by dashed lines.

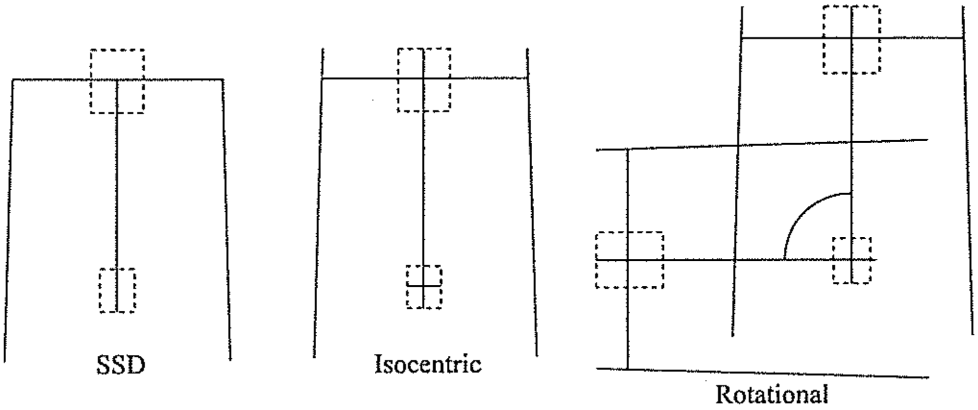


Figure 4.3 - Beam Icons

A. SSD Beam

The boxes indicated by dashed lines indicate "hot" regions on the beam icon. They can be grabbed by clicking on them with the mouse. The top hot region is used to position the beam and the bottom one is used to rotate the beam. The middle vertical line indicates the central axis of the beam and the peripheral lines indicate the diverging beam edges. The lateral line crossing the central axis is at the beam nominal SSD point. Note that an SSD beam can only be moved on the slice where it is defined.

B. Isocentric Beam

Isocentric and SSD beams are different. The bottom hot region now indicates the beam isocenter and is used for positioning. Thus, the top hot region is used for rotation.

C. Rotational Beam

A rotational beam's icon is presented as a pair of isocentric beams with a common isocenter connected by an arc through which the beam rotates. A rotational beam has two rotation hot regions used for specifying the initial and final gantry angles.

D. Beam Modifiers

A beam which is modified by a wedge has the wedge indicated on its beam icon. There are four types of wedges available: open beam, standard wedge, split field, and split wedge. The open beam is shown in Figure 4.3.

Presentation of wedges on beam icons is the same for isocentric beams. For rotational beams, the wedges are presented only at the initial angle.

If a bolus and/or compensator are present, a "B" or a "C" will appear as shown in Figure 4.4.

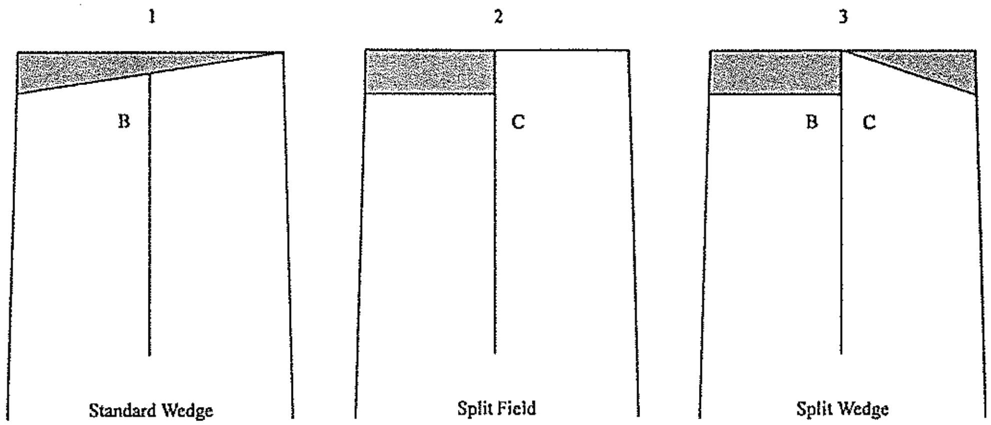


Figure 4.4 - Wedge Icons

VI. MOVING BEAMS

A. Moving a Beam with the Mouse

You may use the mouse to move a beam. Move the mouse pointer to the hot region, depress and hold the left button down. Move the beam. Release the button to fix the beam. An SSD beam will automatically attach itself to the contour. The coordinates of the beam will appear in the status bar during movement. To rotate the beam, click on the hot region and move the mouse left or right. Release the button to fix the angle. The angle of the beam will appear on the status bar during rotation. For rotational beams, both the initial and final angles may be fixed.

B. Move all Isocentric Beams with the Mouse

Select MvAlIso and activate a large crosshair on the screen. Move the crosshair to the new isocenter. Release the button and all isocentric beams move the same offset as the active beam. If all beams have the same isocenter, then they will all move together.

C. Moving a Beam with the Keyboard

In addition to the mouse, an isocentric or rotational beam may be repositioned with the arrow keys. However, when the window and level slider bars are on the screen (i.e., during mark-up and after calculation) the arrow keys control the window and level. SSD beams are moved around the outline. The angle of a beam may be changed from the keyboard by selecting BmRot and a new menu appears as shown in Figure 4.5.

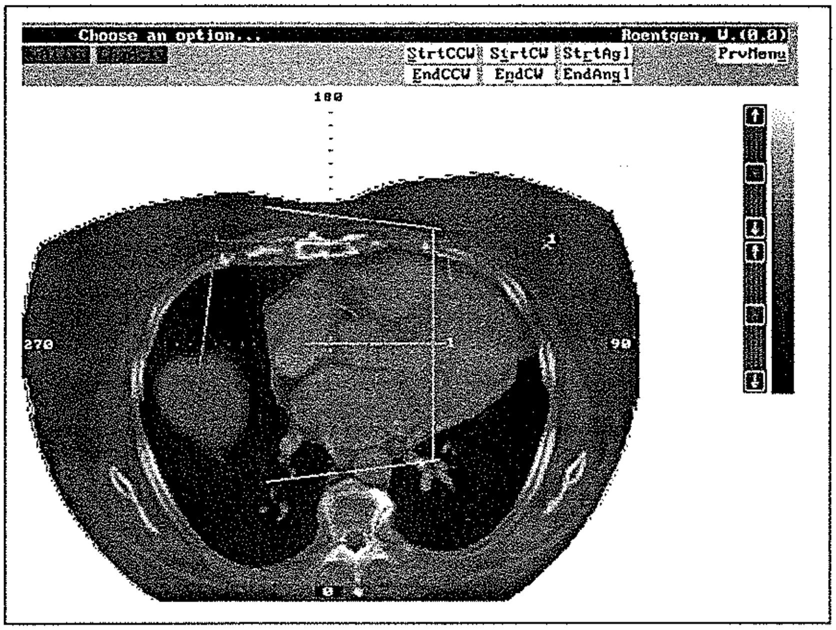


Figure 4.5 - Beam Rotation Windows

When beam movement is possible, the ability to window and level the image is only possible with the mouse function. To window the image, move the image sliders located on the right of the screen.

In the case of a fixed beam, StrtCCW/EndCCW would be replaced by RotCCW; StrtCW/EndCW would be replaced by RotCW; and StrtAgl/EndAngl would be replaced by ChgAngl.

The default step increment for changes in position is 1 cm and angle is 10 degrees. This may be changed by using the + or - keys (+ increases the increment and - reduces the increment by a factor of 2). ChgAngl allows entry of a gantry angle from the keyboard.

VII. EXTENDED SAD

Sometimes it is useful to specify an isocenter for a patient's treatment independent of that specified for the treatment machine. To do this, choose Beam from the external beam menu. Then, choose ChgSAD to redefine the isocenter. Return to save the value and press **Return** again to save the beam. Since Prowess uses the same calculation approach for SSD and SAD beams, this is equally applicable to SSD treatments.

Redefining a treatment SAD does not change the treatment machine calibration, machine data, or collimator calibration. Thus, beam dimensions are scaled and inverse square corrections are made between the machine isocenter and beam isocenter.

VIII. CHANGING ACTIVE BEAMS

After entering several beams, it is sometimes necessary to change one of the previously entered beams. Use the Page Up and Page Down keys to select another beam. Choose CngActv to increment the active beam. Notice the display changes to the new active beam after pressing this button.

Choose Beam to enter another beam. Enter all of the information or copy the beam as described in the New Beam Entry section. The active beam is denoted by the long geometric edges displayed in green as well as the T bar, whereas, the inactive beams are denoted by a T bar only and are shown in white.

IX. MULTI-SLICE CALCULATIONS

Multi-slice calculations are a feature of Prowess *3000* systems only.

When the Calcul option is selected, the plan calculates all slices which have, at least, the outside contours entered. Single-slice calculations can be selected by choosing Option, then MPlane. Set it to "No" so that only the active slice will be calculated.

Multi-Slice calculation first calculates the weight for a particular beam, then the dose to all the slices from that beam. The process is repeated for all beams. The calculation is done by using the difference in the Z-offset of each slice in relation to the central axis slice Z-offset. For a beam on a slice at 50.0 cm, the calculation on a slice at 53.0 cm would have an offset of 3 cm from the central axis.

X. COMPOSITE PLANS

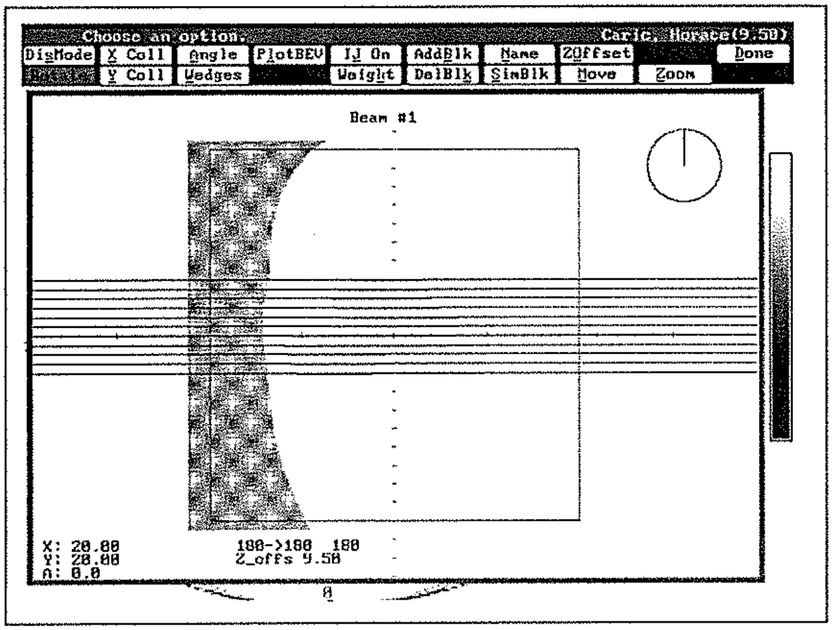
When calculating a composite plan, you may have a patient contour and multiple sets of beams, each treated with a specified number of monitor units for a specified number of days. Each beam is weighted to monitor units and assigned a weight equal to the total number of monitor units administered. In this case, one fraction is entered. The plan is then calculated and the resulting isodose distribution has units of total dose in cGy.

Composite planning does not treat every beam each day. For example, suppose one is treating with an isocentric opposed pair and wedges every other day. Four beams are actually treated whose weights total 100%. The plan calculated is actually an integral plan over a two-day period. Thus, the prescribed dose entered must also reflect a two-day period (twice the fraction dose). If only a single fraction dose were entered, the monitor units calculated would be half that desired.

XI. BEAM'S EYE VIEW

Beam's Eye View is a feature of Prowess *3000* systems only.

The active beam can be viewed in a transverse projection as though you are looking down the beam. This projection is called the Beam's Eye View (BEV). Choosing BmEye produces a pop-up window showing the BEV. In this projection, the collimator, blocks, and wedges are shown. See Figure 4.6.



X: 20.00
Y: 20.00
A: 0.0

180->180 180
Z_offs 9.50

Figure 4.6 - Beam's Eye View Window

Blocks can be entered using the mouse or the digitizer. To enter a block, choose AddBlk or SimBlk, specify the type, then use the mouse or digitizer. Enter the desired block. Close the block by choosing the digitizer **End** menu item or holding the left mouse button while clicking the right button. The block will appear as a closed contour, shaded in red. Press **ES**Cape on the keyboard to end block entry.

The field size or collimator may be changed by choosing XColl or YColl and typing in the desired field size. Set the mouse on the collimator to be changed, then click and drag the collimator to the desired size.

Select SimBlk to enter a simple or bar block. A line will appear on the screen. Choose the starting position for the block and check once. Choose the ending position and click again. A filled block will appear on the screen.

Select Angl to rotate the collimator and type in the desired collimator angle or grab the corner of the beam and rotate it with the mouse.

Choose DelBlk to delete a block. Pick the desired block by selecting Prev/Next until the desired block is found. Choose Accept to delete the block.

The location of the BEV window can be moved into any of the four quadrants by selecting Move. To enlarge the window, select Zoom. To return to the small window, reselect Zoom.

The primary slice for the active beam can be changed by selecting ZOffs. Once selected, a list of the available slices is shown on the screen. Click on the desired slice. The screen is updated with the new center slices.

All patient contour projections are shown in the beam's eye view. To view the contour projection through a rotating beam, select Rotate. Gantry angle is tracked by the icon in the upper right corner of the BEV window. You must select a rotating beam machine to use Rotate in BEV.

Select Done to return to the normal planning display. If blocks or wedges have been entered, a cross section of the block/wedge will appear on the beam.

A. Block Entry Restrictions

Block entry in beam's eye view is subject to various restrictions due to the processing algorithm which is used to determine intersections of entered polygons and the collimator bounds. There is usually no problem with simple case blocking, however, deep nesting of blocking patterns as well as floating blocks within floating blocks, etc. may cause problems. Trouble in resolving blocking patterns into area and perimeter of the open field has been noted in even what appears to be the most simple of cases. Blocks which "float" in the center of the open field are now supported and will produce valid results in the area over perimeter equivalent square calculations. Figure 4.7 shows some examples of valid block patterns.

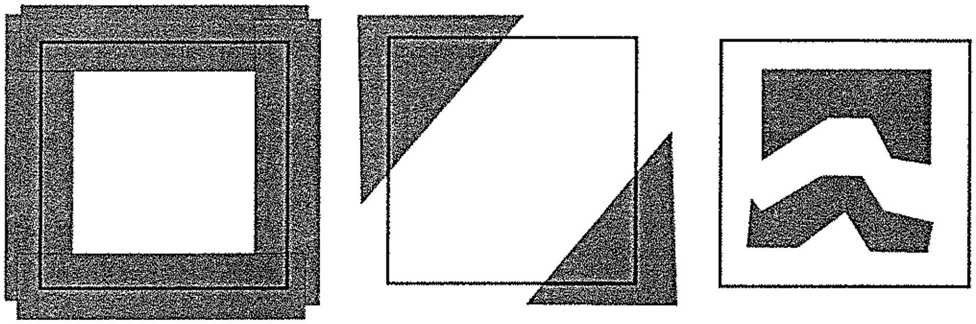


Figure 4.7 - Three examples of valid block patterns for BEV

Figure 4.8 shows some invalid block patterns which produce incorrect results.

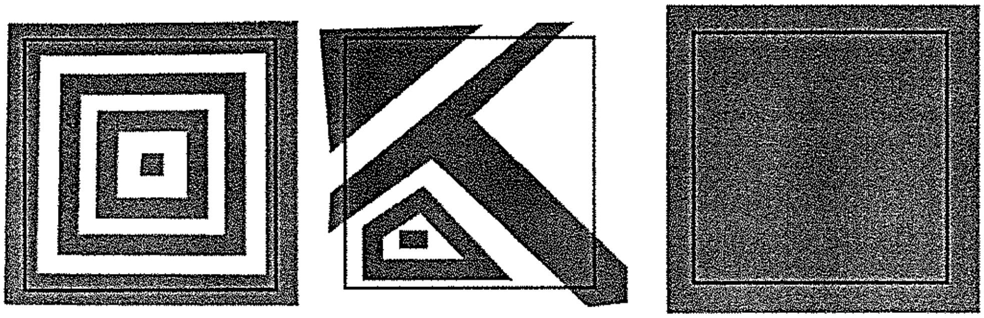


Figure 4.8 - Three examples of invalid block patterns for BEV

Invalid blocking patterns typically involves multiple nesting of floating blocks.

B. Resolving Problems with Block Intersections

Problems in faulty intersection will be flagged by an error message upon exiting the beam's eye view window. This error message is indicative of a failure in the calculation of area over perimeter. Problems can occur in even the most benign looking blocking patterns. If a problem is detected, there are two available options. The first option is to calculate the effective field size length and width by hand and enter into the Current Length and Current Width fields in the Blocked Field Size entry window. The second option is to try to correct the intersection problems by changing the arrangement of the blocks in the beam's eye view window.

Possible corrective entry may include entering multiple overlapping blocks as one single block, correcting any collinear condition of blocks with the collimator or blocks with blocks, or removing one block at a time until the offending block is detected, re-entering the offending block and changing its orientation slightly.

It is a good idea to check the block intersection calculations intermittently when entering a number of complicated blocks. Doing this will ensure that problematic block entries will not be detected after many blocks have been entered, causing loss of time and input.

If problems are detected, results will not be produced, so it is impossible to get a faulty calculation based on a faulty intersection calculation of block patterns. As a final recourse, if a complicated block pattern cannot be resolved by the Prowess software, a hand calculation of the effective field size is the only way to produce a valid effective field.

C. Calculated Quality Factor

The Calculated Quality Factor, as presented in the Blocked Field Size window, is a measure of the confidence you can have in the effective field sizes calculated. It is determined by calculating a percent difference of the effective field size based on the area over perimeter model vs. the effective field size based on equal area. For a square collimator with no blocking, this value will be 100%. As the collimator is elongated and blocked, the area over perimeter effective field size and the equal area effective field will diverge, thus causing the calculated quality factor to decrease. When the Calculated Quality Factor falls below 80 percent, the percentage number will turn red, alerting the user that the area over perimeter approximation has degraded and should be hand calculated.

XII. BEAM DISPLAY

Select BmDisp for a text description of the beams. The information is displayed at the bottom of the screen. The active beam is shown in green, the others in blue. Each beam is described by its number, machine type, its X and Y position in centimeters with respect to the origin, angle in degrees, wedge number, collimator width and length in centimeters, and weight. The weight is shown as the dose to a specific point shown in parentheses, where (0) is the isocenter, (-1) is the dose at d_{max} and (-2) is weight to monitor units. The parameters displayed on the bottom of the screen are continuously updated as the beams are changed.

XIII. ADDITIONAL FUNCTIONS

Selecting Options enables a set of functions to change matrix size, contour names and densities, calculation window, display window, and toggle between heterogeneity correction on and off during calculation.

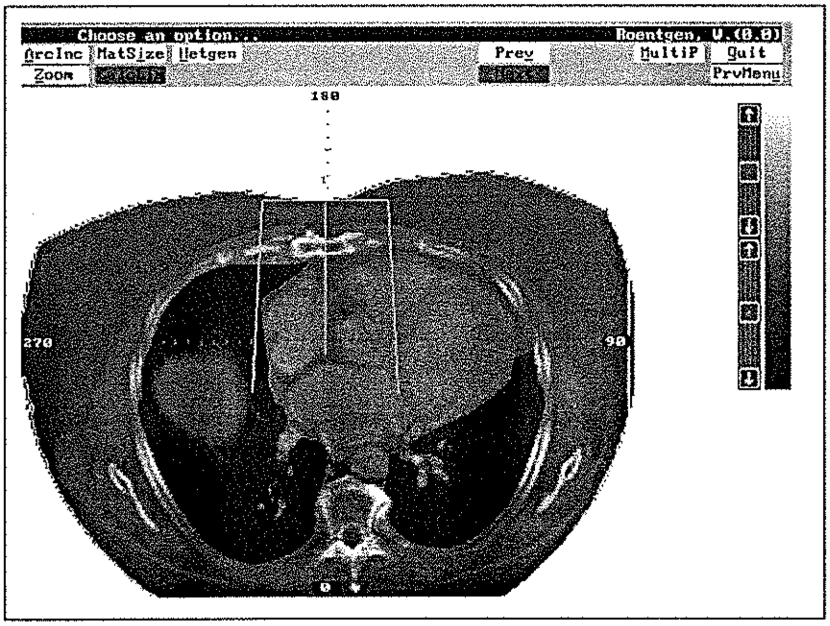


Figure 4.9 - External Beam Options Window

Choosing ArcInc and MatSize requires entry of a numeric value. ArcInc allows you to change the arc increment of the gantry angle for rotating beams. MatSize allows selection of a matrix size for calculation. 1024 is the default. The maximum matrix size is 16,384.

Select Hetgen and heterogeneity corrections can be enabled or disabled. Select "Yes" or "No" and ESCape to exit Prowess.

Prowess supports two heterogeneity models: effective path length and Batho power law. Only one model is supported at a time. The model chosen is selected in the control file and this selection should be made by the responsible physicist.

Multi-Slice Calculation is a feature of Prowess *3000* systems only.

Multi-Slice calculations can be enabled or disabled using the MPlane option. By default, the option is enabled, but may be changed by choosing "No". If disabled, only the active slice will be calculated.

XIV. WEIGHTING

Each beam must have an associated weight and weighting method. One way to weight a beam is by monitor units. When a beam is weighted to monitor units, its weight indicates the number of monitor units to be delivered.

Another way to weight a beam is by the dose it delivers to a point. The point must be specified. If the weight point is specified as d_{max}, then (for a stationary beam) this is equivalent to weighting by giving doses with blocking and wedges in the beam on the central slice. For example, if a pair of beams are weighted to d_{max} and assigned equal weights, they will deliver equal doses to their respective d_{max} points. A beam that is weighted to d_{max} and has a bolus chooses the d_{max} depth inside the patient contour, not at d_{max} from the bolus surface.

"Given dose" weighting is similar to d_{max} weighting except, instead of weighting to what the d_{max} dose is, it weights to what the d_{max} dose would have been without blocks or wedges.

A beam can also be weighted to isocenter. In this case, the weight value specifies the dose contribution from a beam to isocenter. Alternately, it can be weighted according to its contribution to a specified calculation point. This option is useful when a beam is blocked at or near midline. Any calculation point on any slice can be used as a weight point.

When specifying a weight point ensure that the point is not under or near a block, outside the beam, or outside the patient.

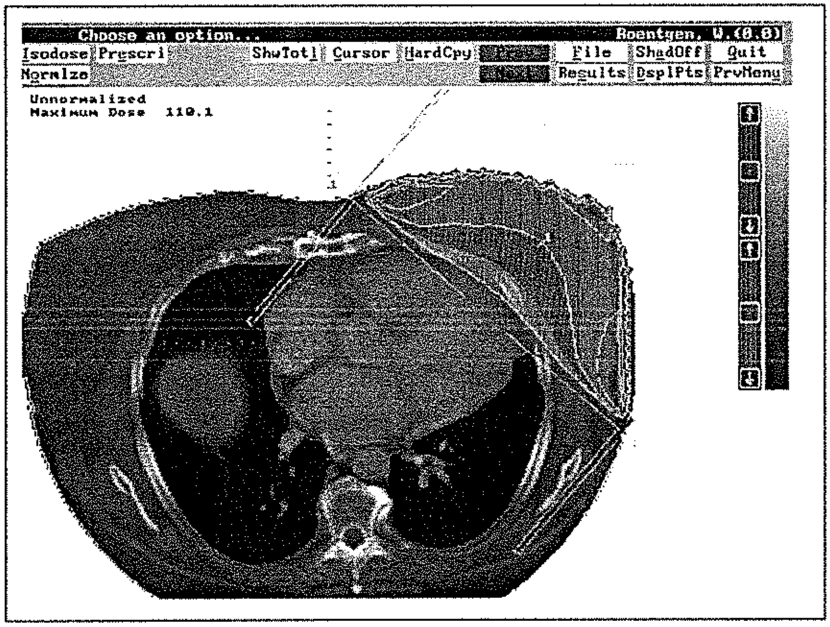
XV. BEAM CALCULATION

Select Calcul to calculate the external beam plan. During calculation, the beam number, its angle, and the slice being calculated are shown. Press the **ESCape** key to stop the calculation.

The algorithms used to calculate this plan depend on the options selected in the system control file. These options are shown on the printed hardcopy for reference and they cannot be changed within the program.

XVI. THE FINAL PLAN

Following calculation, the screen shows the completed plan. The isodose curves may be displayed by selecting the desired values from the pop-up window. Edit or enter new values as desired. **ESCape** completes isodose entry and displays the window shown in Figure 4.8.



```
Unnormalized
Maximum Dose  110.1
```

Figure 4.10 - Post Calculation Window

A. Normalization

The calculated dose distribution can be normalized in five different ways. By selecting Normalz, the default normalization is displayed. The default can be changed in the program control file. Typically, normalization to the isocenter or unnormalized is used as the default. When the Normalz option is selected, the following menu items appear on the screen:

Point - Normalizes to any calculation point in any slice.
IsoCntr - Normalizes to the isocenter of the first isocentric beam.
Max - Normalizes to the maximum dose in the dose matrix.
Line - Assigns the dose specified to the line specified.
Unnorm - Unnormalizes the dose distribution.

B. Prescription

Select Prescri to enter a prescription before printing, plotting, or examining the results. Enter the dose and the isodose line to which the dose is specified. The prescription applies to the dose as displayed on the screen. The default prescription is 100 cGy to the 100% dose line.

C. Display Points

Choose DisplPts to view the dose to the calculation points. The dose to the points of calculation are displayed on the screen in a window. The contribution to each point from each beam is not displayed, but is shown on the printout.

D. Cursor

Choose Cursor to display the dose to any point inside the patient external contour. When the function becomes active, a cursor is displayed, controlled by the mouse. Its position is displayed at the top of the screen. When the cursor is positioned at the desired location, press Enter or click the left mouse button to obtain the dose at that point.

Exit the cursor mode by selecting Done or ESCape.

E. Results

Select Results to obtain a summary of the calculated results. A pop-up window shows all of the beams entered, the calculation SSD, TMR, output factor, and machine setting for each beam. The printout shows more detailed results. The total dose to the plan can be shown by selecting ShwTotl. This option displays a window with the total dose in cGy for each isodose line.

F. File

To save or retrieve a completed plan, select File. Selecting this option allows you to save or retrieve a completed or partially completed plan. You may also list or delete the saved plans. Choose the option you desire from the pop-up window. If you decide to save the current plan, give it a unique and descriptive name.

Warning: Do a hand calculation to verify the monitor units calculated by the computer. If the hand calculation differs by more than 2%, *do not* implement the plan until the problem has been resolved.

G. Hardcopy

The printed copy activated by Hardcopy is discussed in Section 5. Keep the printout and the color plot in the patient's chart as a permanent record.

EXTERNAL BEAM PLAN MANAGEMENT AND HARDCOPY

I. PLAN MANAGEMENT

After an external beam plan has been entered and calculated, the plan and its calculation results are automatically saved as the active plan. Any modification made during planning is automatically reflected on the active plan. To clear the active plan, select NewPlan from the main external beam planning window.

Save multiple plans for a single patient independently. To select File from the main external beam planning window or from the planning window, choose Plan and then File. Select File from the main external beam planning menu for a list of existing plans, then retrieve or delete a plan from that list. Choose File from the planning window to select one of these options or to add the current plan (if one exists) to the list of saved plans.

All contours and images entered into the patient file are automatically saved. All entered data is assumed to belong to one patient and all plans are applied to the entered patient data. It is not possible to enter multiple sets of contours or image data into one patient file.

II. HARDCOPY

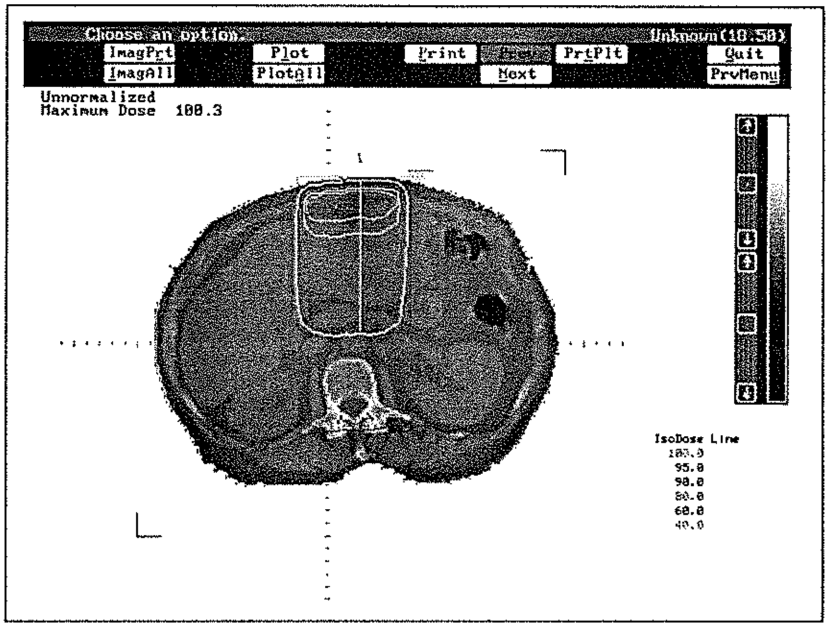
After an external beam plan has been entered and calculated, print the plan and calculation results for a permanent record. There are four types of hardcopy results which can be produced during external beam planning: BEV plot, external beam plot, external beam image print, and external beam results.

A. BEV Plot

To plot the BEV of the current beam, select BmEye and then PlotBEV. Using ChgActv, this process can be repeated for all beams. The plotted BEV will show the locations of the collimators and the blocks, and the projection of all contours into the BEV.

B. External Beam Plot

After an external beam plan has been calculated and a prescription has been entered, the Hardcpy option becomes active. Select Hardcpy to enter the hardcopy window. See Figure 5.1.



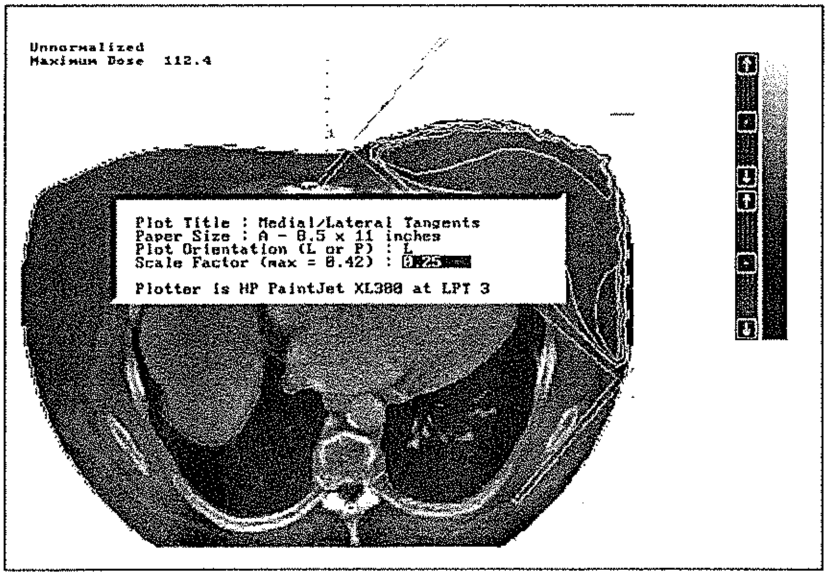
```
Unnormalized
Maximum Dose  100.3
```

```
IsoDose Line
  100.0
   95.0
   90.0
   80.0
   60.0
   40.0
```

Figure 5.1 - Hardcopy Window

Select Prev and Next to choose the slice you want to plot. Select Plot and enter the plot title, paper size, orientation, and scale to plot the current slice as shown in Figure 5.2.

To batch plot all or selected slices, choose PlotAll.

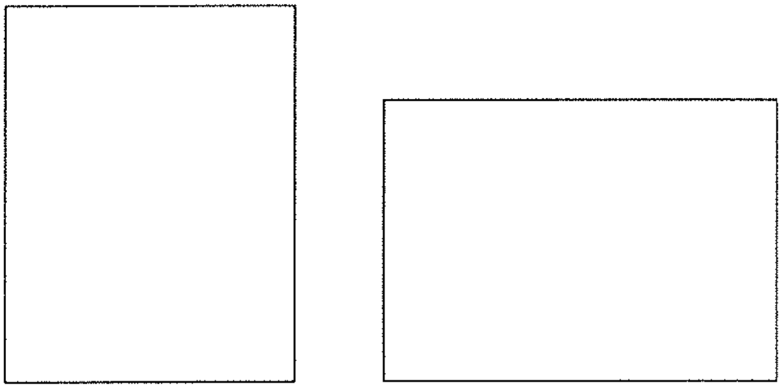


```
Unnormalized
Maximum Dose  112.4
```

```
Plot Title : Medial/Lateral Tangents
Paper Size : A - 8.5 x 11 inches
Plot Orientation (L or P) : L
Scale Factor (max = 0.42) : 0.25

Plotter is HP PaintJet XL300 at LPT 3
```

Figure 5.2 - External Beam Plot Options

The two choices of plot orientation are portrait and landscape. See Figure 5.3 for an illustration of the plot orientation.



Portrait Landscape

Figure 5.3 - Plot Orientations

C. Image Print

External beam plotting and image printing function almost identically. To print an image, select ImagPrt from the hardcopy window. The only difference in the hardcopy options is that the image print overlays all isodose and contour information with the grey scale image on the page. The window and level settings are reflected on the printed image. The isodose shading option shown on the screen is only supported on the screen. It is not a hardcopy feature.

To batch print all or selected CT slices, Choose ImagAll.

D. Print

Select the Print option from the hardcopy window to print the complete treatment plan description and calculation results. Demographic information is printed at the top of the page followed by the prescription data and a beam listing.

Each beam entry contains a complete beam description, all physics parameters, and calculated machine settings. If entered, calculation point doses and tumor dose statistics will be printed on a second page. All information needed to independently calculate the machine settings are included in the print.

The Prt/Plt option functions the same as Print and Plot.

DAILY CALCULATIONS

I. GENERAL

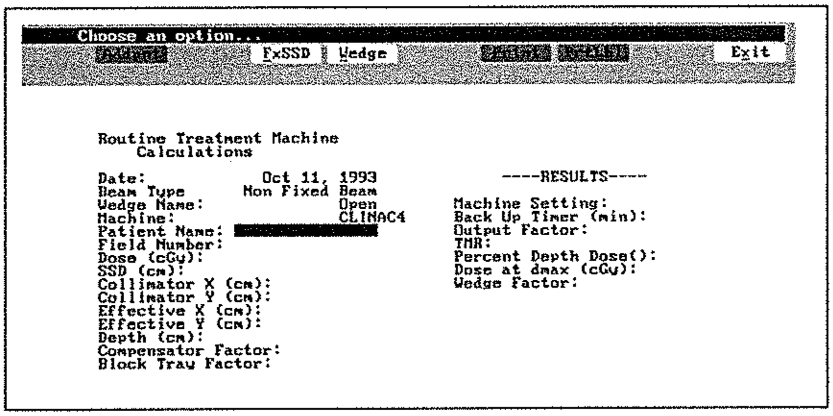
The Daily Calculation program has the capability to calculate point doses and machine settings, Nominal Standard Doses (NSDs), and interfield gaps.

After selecting Daily Calculations from the main treatment planning menu, there are several options to choose from as shown in Figure 6.1.

Figure 6.1 - Daily Calculation Window

II. MACHINE SETTINGS

The MU/Time option enables you to calculate the machine setting for a teletherapy beam. The machine setting calculation window is shown in Figure 6.2.

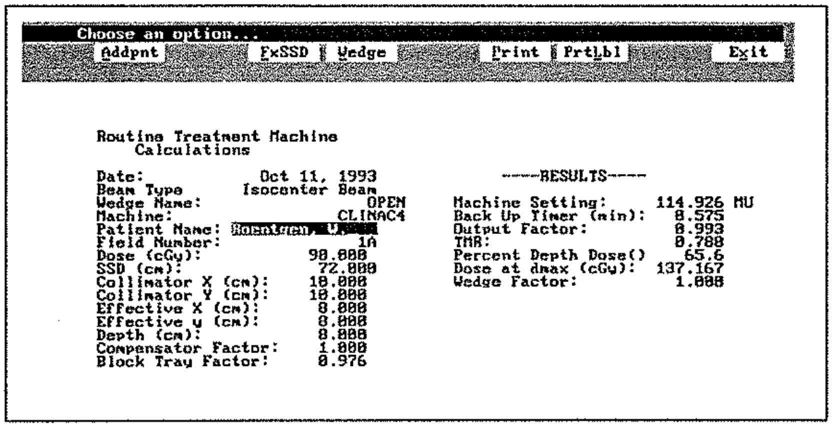


```
Routine Treatment Machine
    Calculations

Date:               Oct 11, 1993          ----RESULTS----
Beam Type         Non Fixed Beam
Wedge Name:                 Open       Machine Setting:
Machine:                    CLINAC4    Back Up Timer (min):
Patient Name: [redacted]               Output Factor:
Field Number:                          TMR:
Dose (cGy):                            Percent Depth Dose():
SSD (cm):                              Dose at dmax (cGy):
Collimator X (cm):                     Wedge Factor:
Collimator Y (cm):
Effective X (cm):
Effective Y (cm):
Depth (cm):
Compensator Factor:
Block Tray Factor:
```

Figure 6.2 - Machine Setting Calculation Window

There are two active buttons on the button bar. The one on the left causes the beam type parameter to rotate through its three values while the button rotates through its three values. Selecting FxSSD sets the beam type to an SSD beam and forces the beam SSD to be the nominal SSD. Selecting FxSAD sets the beam type to an isocentric beam and forces the beam SSD to be the nominal SSD minus the depth. Selecting NoFxSAD sets the beam type to non-fixed beam and allows the SSD to be freely specified.

Selecting the Wedge option allows you to select from the list of available wedges. Use the keyboard to enter the treatment field parameters in the upper left part of the window. After the last parameter is entered, the machine setting results are calculated and presented in the upper right corner of the window as shown in Figure 6.3.

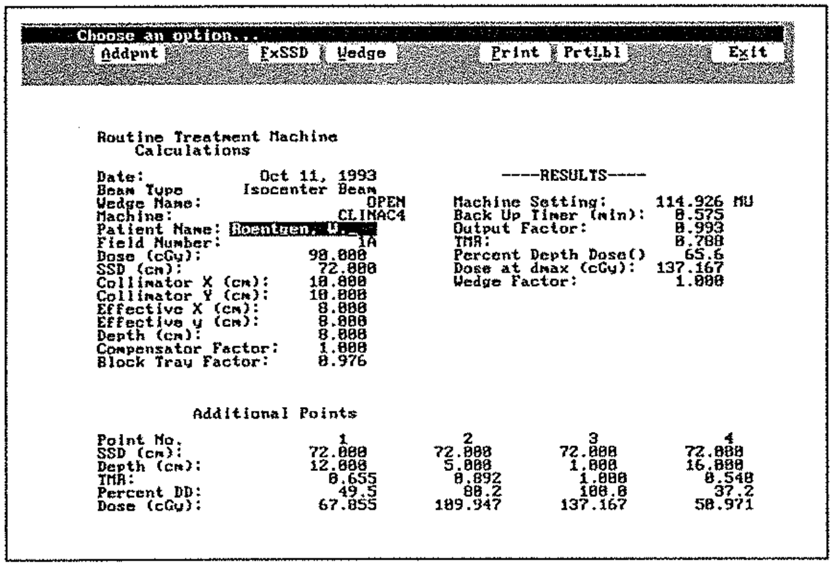


```
Routine Treatment Machine
    Calculations

Date:              Oct 11, 1993          ----RESULTS----
Beam Type        Isocenter Beam
Wedge Name:                  OPEN    Machine Setting:      114.926 MU
Machine:                  CLINAC4    Back Up Timer (min):    0.575
Patient Name: Roentgen, W.           Output Factor:          0.993
Field Number:                  1A    TMR:                    0.788
Dose (cGy):               98.000     Percent Depth Dose()     65.6
SSD (cm):                  72.000    Dose at dmax (cGy):   137.167
Collimator X (cm):        10.000     Wedge Factor:           1.000
Collimator Y (cm):        10.000
Effective X (cm):          8.000
Effective y (cm):          8.000
Depth (cm):                8.000
Compensator Factor:        1.000
Block Tray Factor:         0.976
```

Figure 6.3 - Machine Setting Calculation Results

The collimator field size reflects the jaw settings on the treatment unit. The effective field size reflects the field size seen by the patient with all forms of blocking which include secondary blocks and patient flash. The collimator settings are used to look up the machine output factor and the effective field size is used to look up the TMR and PSF correction. Both field sizes are as projected to the machine isocenter. The output factor reflects the machine output factor reported times the PSF (unlike the external beam program that separates the two parameters).

After calculating the machine setting, you have the option of changing any of the treatment parameters. The calculation results will be automatically updated. You have the additional options of Print and PrtLbl to print to a page or to a label. Before printing, you may enter up to four secondary calculation points using AddPnt. An example is shown in Figure 6.5.



```
Routine Treatment Machine
    Calculations

Date:              Oct 11, 1993          ----RESULTS----
Beam Type        Isocenter Beam
Wedge Name:                  OPEN    Machine Setting:      114.926 MU
Machine:                  CLINAC4    Back Up Timer (min):    0.575
Patient Name: Roentgen, W.           Output Factor:          0.993
Field Number:                  1A    TMR:                    0.788
Dose (cGy):               98.000     Percent Depth Dose()     65.6
SSD (cm):                  72.000    Dose at dmax (cGy):   137.167
Collimator X (cm):        10.000     Wedge Factor:           1.000
Collimator Y (cm):        10.000
Effective X (cm):          8.000
Effective y (cm):          8.000
Depth (cm):                8.000
Compensator Factor:        1.000
Block Tray Factor:         0.976


          Additional Points

Point No.                  1          2          3          4
SSD (cm):              72.000     72.000     72.000     72.000
Depth (cm):            12.000      5.000      1.000     16.000
TMR:                    0.655      0.892      1.000      0.540
Percent DD:              49.5       80.2      100.0       37.2
Dose (cGy):            67.855    109.947    137.167     50.971
```

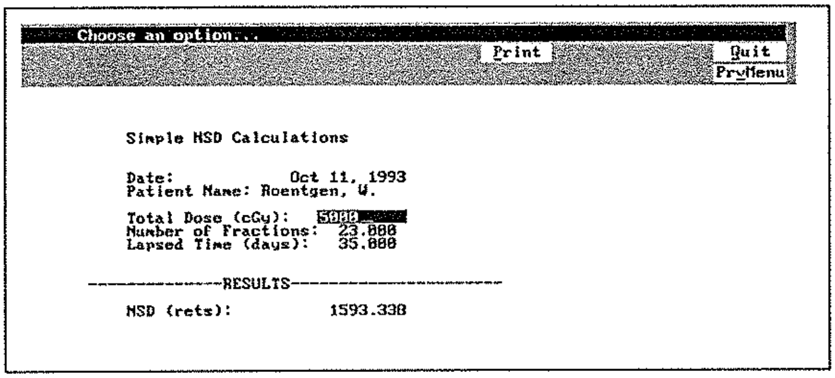
Figure 6.4 - Secondary Calculation Point Entry

III. NSD CALCULATION

This program performs a single Nominal Standard Dose (NSD) calculation on a patient's treatment. The program uses the standard Ellis[1] formula of:

$$\text{NSD (Ret)} = \text{Total Dose (cGy)} * \text{Time}^{-1.11}\,\text{(days)} * \text{Fraction}^{-0.24}$$

Select NSD from the daily calculations menu. A new screen appears as shown in Figure 6.5.



```
Simple NSD Calculations

Date:            Oct 11, 1993
Patient Name: Roentgen, W.

Total Dose (cGy):   5000
Number of Fractions:  23.000
Lapsed Time (days):   35.000

--------------RESULTS----------------------

NSD (rets):          1593.338
```

Figure 6.5 - Nominal Standard Dose Calculation Window

Enter all of the information requested on the screen. Once enough information has been entered, the results will be displayed at the bottom of the screen. At this time, the Print option appears. To edit any of the items use the arrow keys, and the program will automatically recalculate the results.

Once the results are satisfactory, select Print to print the screen.

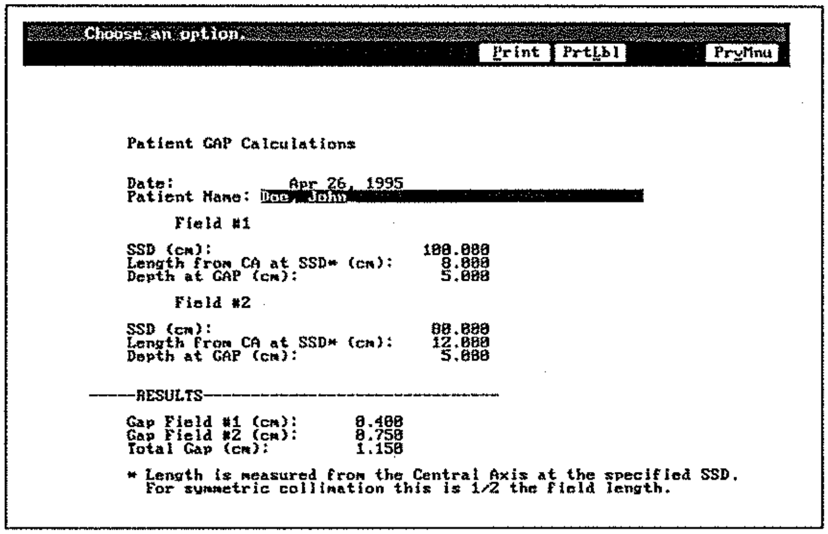
To end the program, select Quit or **ESC**ape from the keyboard.

IV. GAP CALCULATION

The Gap Calculation program performs a calculation to determine the gap needed between two adjacent fields in order to prevent geometric overlap at depth. The program uses the following geometric formula:

$$\text{Gap} = \text{Length} * \frac{\text{Depth}}{\text{SSD}}$$

To begin the program, select GAP from the Daily Calculations menu. A new screen appears as shown in Figure 6.6.



```
Choose an option.

Patient GAP Calculations

Date:              Apr 26, 1995
Patient Name: Doe, John
     Field #1

SSD (cm):                             100.000
Length from CA at SSD* (cm):            8.000
Depth at GAP (cm):                      5.000
     Field #2

SSD (cm):                              80.000
Length from CA at SSD* (cm):           12.000
Depth at GAP (cm):                      5.000

-----RESULTS---------------------------------

Gap Field #1 (cm):        0.400
Gap Field #2 (cm):        0.750
Total Gap (cm):           1.150

* Length is measured from the Central Axis at the specified SSD.
  For symmetric collimation this is 1/2 the field length.
```

Figure 6.6 - Gap Calculation Window

Enter all of the information requested on the screen. Once enough information has been entered, the results will be displayed at the bottom of the screen. At this time, the Print and PrtLbl menu items appear. To edit any of the items, use the arrow keys and the program will automatically recalculate the results.

This value must include any blocks at the gap end of the field. The depth required is the depth at the point where the two fields abut. A second depth for non-coplanar beams can be entered. The default for the second depth is that of the first field.

Once the results are satisfactory, select Print or PrtLbl to print the screen. To end the program, select Quit or ESCape.

IRREGULAR FIELD CALCULATION

I. CALCULATION DESCRIPTION

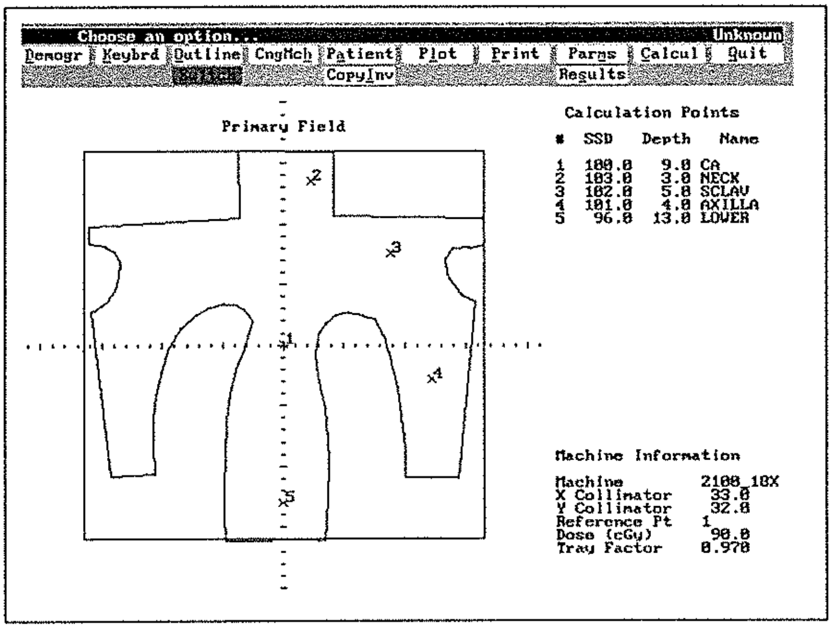
The irregular field calculation determines the dose to a set of calculation points from an arbitrarily shaped beam which irradiates a homogenous patient. It uses a modified version of the Clarkson integration technique.

In calculating the TMR seen at each calculation point, an adjusted zero area TMR is added to an average SMR as seen at that point. The zero area TMR at the depth of the calculation point is modified by an energy and profile correction. It is then modified by a block edge profile factor which depends on its proximity to the nearest field-defining block edge.

To determine the average SMR, the beam outline is approximated by 72 pie-slice shaped regions, each of which encompass a 5 degree arc. The SMR associated with each radius is determined and then averaged. For further explanation of this calculation, see Section 11.

II. CALCULATION COMPONENTS

To view the irregular field plan of an existing patient, choose **Irregular Field Calculation** from the main treatment planning menu. See Figure 7.1 for an illustration of an irregular field calculation window. The status bar and button bar are seen as in all Prowess Systems products The irregular field plan is made up of six components: demographics, beam outline, calculation points, beam parameters, optional opposed field, and calculation results.



Choose an option...

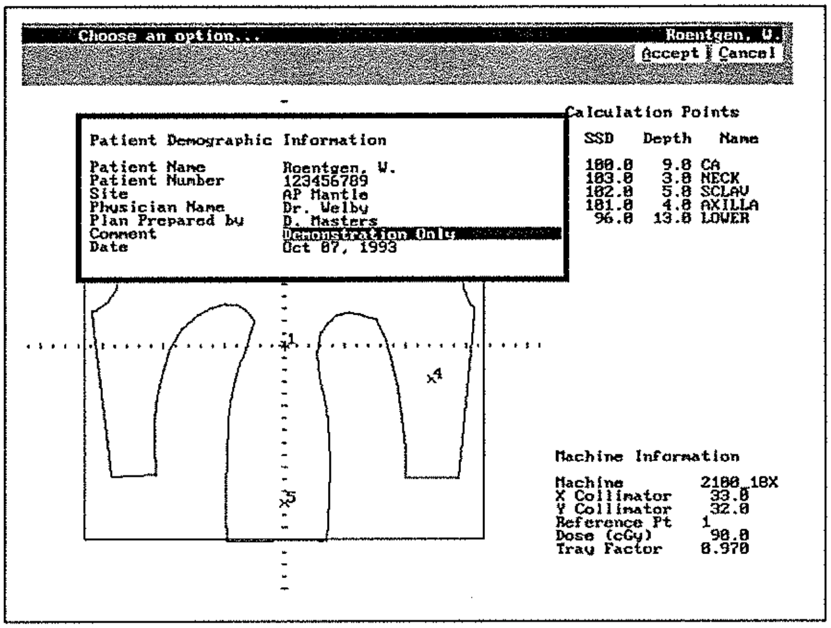
```
Calculation Points

#  SSD    Depth  Name

1  100.0   9.0 CA
2  103.0   3.0 NECK
3  102.0   5.0 SCLAV
4  101.0   4.0 AXILLA
5   96.0  13.0 LOWER
```

```
Machine Information

Machine        2100_18X
X Collimator    33.0
Y Collimator    32.0
Reference Pt   1
Dose (cGy)      90.0
Tray Factor    0.970
```

Figure 7.1 - Irregular Field Calculation Window

A. Demographics

Select Demogr to enter the patient's demographic data. Enter the data by using the keyboard. Select Accept to save the entries, or Cancel to discard them. The patient's name appears in the status bar. See Figure 7.2.



Patient Demographic Information

Patient Name	Roentgen, W.
Patient Number	123456789
Site	AP Mantle
Physician Name	Dr. Welby
Plan Prepared by	D. Masters
Comment	Demonstration Only
Date	Oct 07, 1993

Calculation Points

SSD	Depth	Name
100.0	9.0	CA
103.0	3.0	NECK
102.0	5.0	SCLAV
101.0	4.0	AXILLA
96.0	13.0	LOWER

Machine Information

Machine	2100_10X
X Collimator	33.0
Y Collimator	32.0
Reference Pt	1
Dose (cGy)	90.0
Tray Factor	0.970

Figure 7.2 - Demographics Entry Window

B. Beam Outline

The beam outline appears in the center left of the screen. A blue rectangle indicates the collimator settings. A green set of coordinate axes indicate the beam's central axis and orientation. Color differences around the beam outline indicate differences in blocking type.

To replace the existing beam outline, select Outline. All outline entry is done through the digitizer. See Figure 7.3.

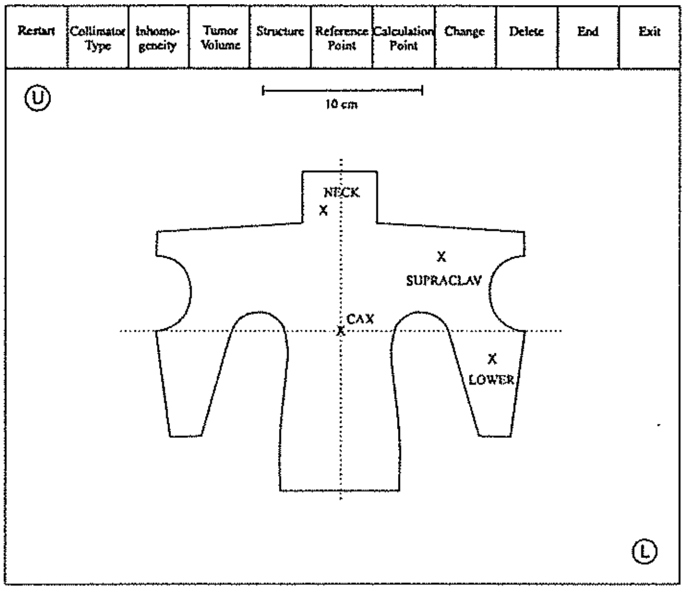


Figure 7.3 - Digitizer Entry of Irregular Field

After selecting the beam outline option, digitize the calibration points "U" and "L" and to A) enter the outline scale or B) digitize both ends of a reference mark. Next, digitize the central axis location and the location of some point along the positive X axis.

Begin digitizing the beam outline either clockwise or counter-clockwise. Only a single connected field region can be entered. To close the beam outline, select **End**. Enter up to 20 calculation points at the prompt. Select **Exit** to terminate entry.

The scale of the beam outline must be as projected to the plane of the machine isocenter. During outline entry, select **Delete** to delete outline points or calculation points.

C. Calculation Points

The calculation points are shown in the upper right corner of the screen overlaid on the beam outline. Each calculation point has a name, depth, and SSD which are entered by you. The depth is the depth of the calculation point below the patient surface and the SSD is defined to be the central axis SSD plus the vertical gap between the central axis SSD point and the projection of the calculation point to the surface. The gap can be positive or negative. Figure 7.4 shows a projection of one of the calculation points from the beam through the patient.

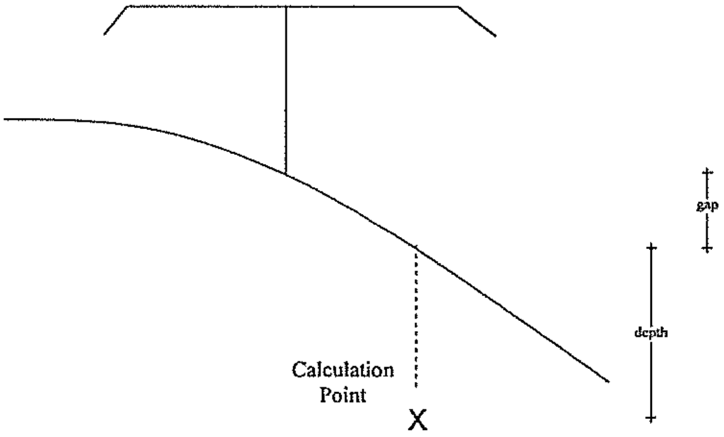
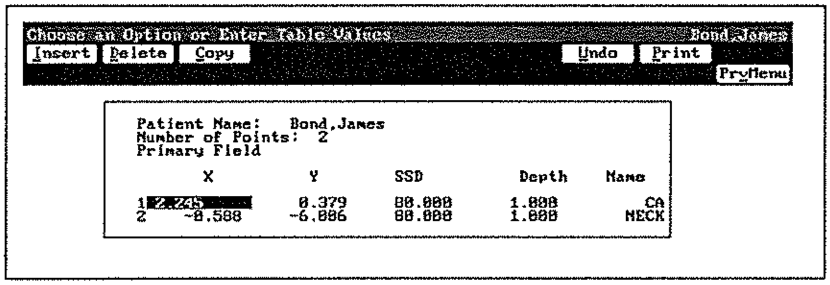


Figure 7.4 - Calculation Point Geometry

Select Keybrd to edit the calculation points. An example of the point list is presented in Figure 7.5.



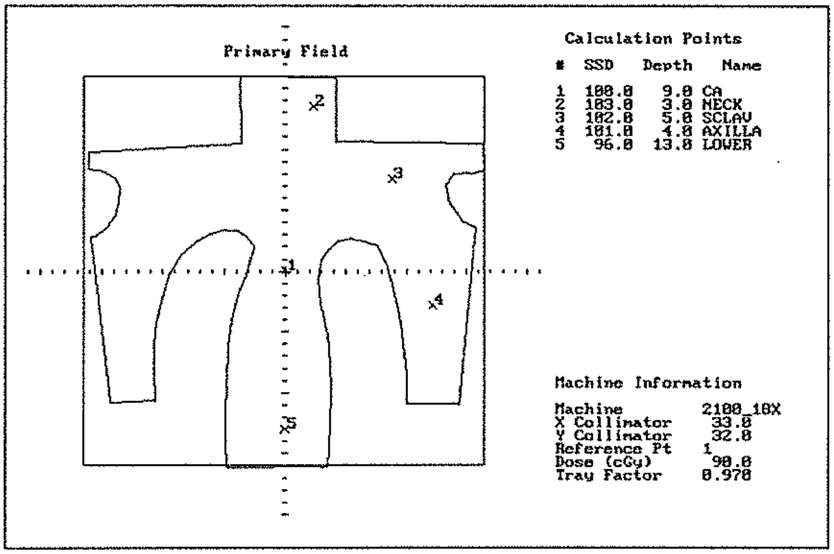
```
Patient Name:   Bond,James
Number of Points:  2
Primary Field
        X          Y        SSD         Depth    Name

1  2.245        0.379     80.000      1.000        CA
2    -0.500    -6.006     80.000      1.000      NECK
```

Figure 7.5 - Irregular Field Keyboard Mode

Use the arrow keys to move to any entry in the table. All entries, including X and Y location, can be edited with the keyboard. All positions are referred to the plane of the machine isocenter. Select Insert or Delete to create new or remove existing calculation points. Choose Copy to make a copy of an existing point. Select Print to make a hardcopy print of the list. Select PrvMenu to exit and to save. Alternately, to undo changes, select Undo, then PrvMenu.

D. Beam Parameters

The beam parameters are shown in the lower right corner of the screen. These parameters include treatment machine name, X and Y collimator settings, prescription reference point number, prescribed dose, and tray factor. Select Parms to edit these values. The values are presented as shown in Figure 7.6 and may be edited using the keyboard.



```
Calculation Points

#  SSD     Depth    Name

1  100.0    9.0 CA
2  103.0    3.0 NECK
3  102.0    5.0 SCLAV
4  101.0    4.0 AXILLA
5   96.0   13.0 LOWER
```

```
Machine Information

Machine           2100_10X
X Collimator       33.0
Y Collimator       32.0
Reference Pt      1
Dose (cGy)         90.0
Tray Factor       0.970
```

Figure 7.6 - Irregular Field Calculation Window

E. Optional Opposed Field

If an opposed field is present in a specific treatment calculation, select CopyInv and the Switch option becomes active. The Switch option can be used to toggle between the primary and opposed fields.

F. Calculation Results

Select Calcul to obtain calculation results. Calculation results consist of a dose delivered at each point from each beam, machine settings required to deliver the prescribed dose to the reference point, and the physical parameters leading to the doses and machine settings. After selecting Calcul, summarized results are shown on the screen. Any calculation points under or near a block edge are shown in red and should not be used for weighting. To see the complete results, select Print and Plot to print hardcopy calculation results and plot the beam outline.

III. CALCULATION PROCESS

If you enter a new patient name after entering the irregular field calculation, a new patient will be created. Enter the patient demographics as prompted. Select Outline and enter the outline, calculation points, and parameters as previously described. When this is complete, you can create and edit an opposed beam, if needed, and Print and Plot the results.

BRACHYTHERAPY CALCULATION

I. GENERAL

The brachytherapy program is used to calculate the dose distribution resulting from implants of seed and/or line sources.

Implants can be entered from the keyboard, a template, orthogonal films, stereo films, or axial contours. A maximum of 500 line sources or 1000 seed sources may be entered. The sources may be mixed in any combination of activity and type.

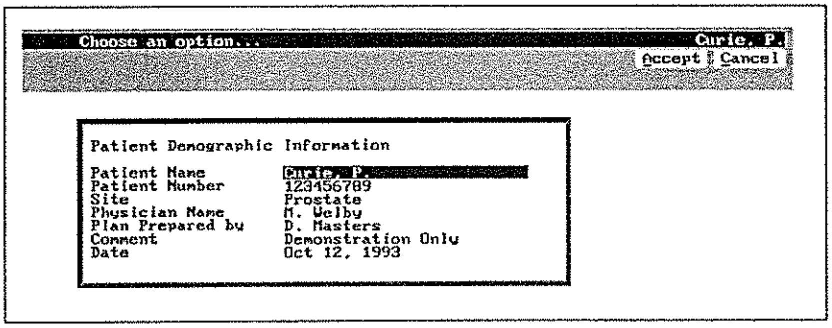
A number of different types of dose results can be calculated. The dose to a point can be calculated. The dose distribution on a plane or a series of planes can also be calculated and displayed. In addition, the volumetric dose distribution can be calculated and analyzed.

Select **Brachytherapy Calculation** from the main planning menu.

Enter a patient file name comprised of any combination of characters except blanks. The file name should contain at least three, but no more than eight characters. If the file name is unique, a new patient file is created. If the file already exists, it is retrieved for planning.

If you need to search for an existing patient file, press the down arrow key or click on **List Patients**. A list of all available patient files will appear in a scrolling listbox. Up to 10 patient file names are shown in alphabetical order at a time. Use the arrow keys or mouse to select one of these patients. If the patient is not shown in the window use the arrow key or the mouse to locate the desired name. Once you have selected the desired patient, press **Enter**.

If a new patient file is created, you will next be prompted to enter demographic data for this patient through the Demographic Data Entry Window as shown in Figure 8.1.



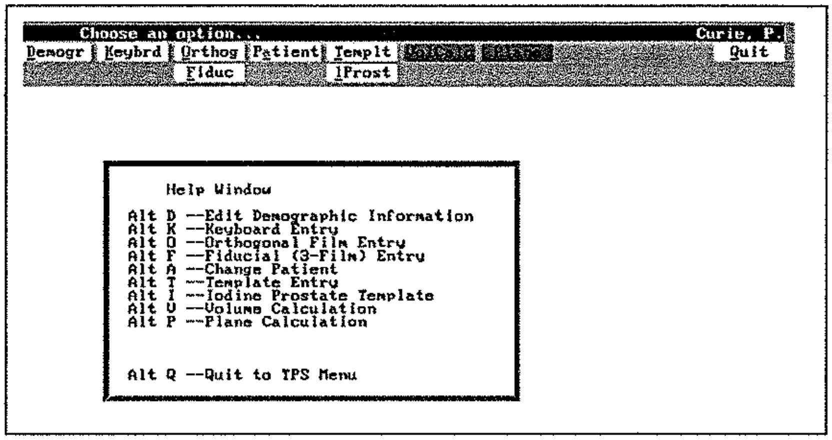
Patient Demographic Information

Patient Name	Curie, P.
Patient Number	123456789
Site	Prostate
Physician Name	M. Welby
Plan Prepared by	D. Masters
Comment	Demonstration Only
Date	Oct 12, 1993

Figure 8.1 - Demographic Data Entry Window

Use the arrow keys to access and edit any entry. Selecting Accept saves this information and Cancel aborts entry.

The Main Brachytherapy Planning Window is presented as shown.



```
    Help Window

Alt D --Edit Demographic Information
Alt K --Keyboard Entry
Alt O --Orthogonal Film Entry
Alt F --Fiducial (3-Film) Entry
Alt A --Change Patient
Alt T --Template Entry
Alt I --Iodine Prostate Template
Alt V --Volume Calculation
Alt P --Plane Calculation


Alt Q --Quit to TPS Menu
```

Figure 8.2 - Brachytherapy Planning Window

Patient demographic data may be updated at any time during the planning process by selecting Demogr from the Brachytherapy Planning Window.

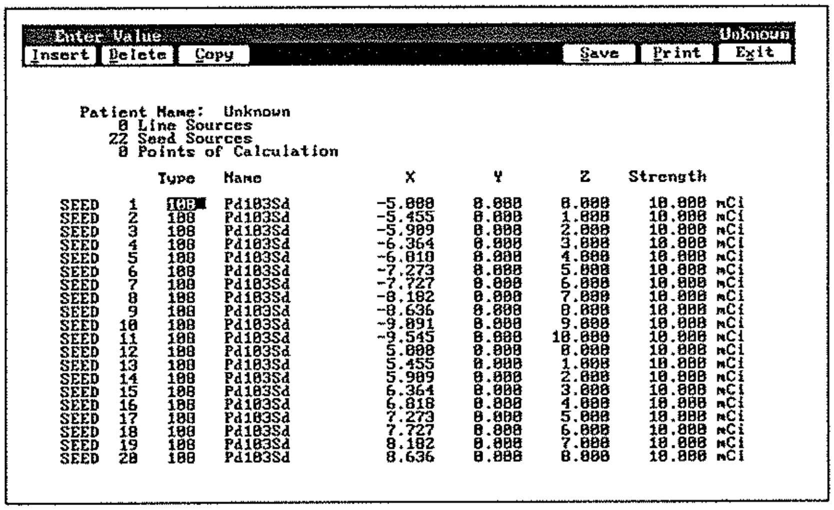
To enter an implant, select an entry technique from the button bar, To enter an implant from the keyboard or to edit an existing implant, select Keybrd. Use Templt to enter an implant using a template. To reconstruct an implant from orthogonal views, use Orthog. Fiduc is used to reconstruct implants from stereo projections. The IProst option is used to pre-plan prostate images from axial contours.

II. IMPLANT ENTRY

A. Keyboard

To enter an implant from the keyboard, select Keybrd from the Brachytherapy Planning Window.

The Keyboard Entry Window is presented as shown.



```
Patient Name:  Unknown
     0 Line Sources
    22 Seed Sources
     0 Points of Calculation

            Type   Name                  X         Y         Z     Strength

SEED    1   100    Pd103Sd            -5.000     0.000     0.000     10.000 mCi
SEED    2   100    Pd103Sd            -5.455     0.000     1.000     10.000 mCi
SEED    3   100    Pd103Sd            -5.909     0.000     2.000     10.000 mCi
SEED    4   100    Pd103Sd            -6.364     0.000     3.000     10.000 mCi
SEED    5   100    Pd103Sd            -6.818     0.000     4.000     10.000 mCi
SEED    6   100    Pd103Sd            -7.273     0.000     5.000     10.000 mCi
SEED    7   100    Pd103Sd            -7.727     0.000     6.000     10.000 mCi
SEED    8   100    Pd103Sd            -8.182     0.000     7.000     10.000 mCi
SEED    9   100    Pd103Sd            -8.636     0.000     8.000     10.000 mCi
SEED   10   100    Pd103Sd            -9.091     0.000     9.000     10.000 mCi
SEED   11   100    Pd103Sd            -9.545     0.000    10.000     10.000 mCi
SEED   12   100    Pd103Sd             5.000     0.000     0.000     10.000 mCi
SEED   13   100    Pd103Sd             5.455     0.000     1.000     10.000 mCi
SEED   14   100    Pd103Sd             5.909     0.000     2.000     10.000 mCi
SEED   15   100    Pd103Sd             6.364     0.000     3.000     10.000 mCi
SEED   16   100    Pd103Sd             6.818     0.000     4.000     10.000 mCi
SEED   17   100    Pd103Sd             7.273     0.000     5.000     10.000 mCi
SEED   18   100    Pd103Sd             7.727     0.000     6.000     10.000 mCi
SEED   19   100    Pd103Sd             8.182     0.000     7.000     10.000 mCi
SEED   20   100    Pd103Sd             8.636     0.000     8.000     10.000 mCi
```

Figure 8.3 - Keyboard Entry Window

This window can be used to enter an implant or to edit an implant which has already been entered. Use the arrow keys to move from cell to cell within the table. All entries are editable using the keyboard.

Select Insert to insert a new source at the cursor, Delete to delete the current source, or Copy to make a copy of the current source.

When editing is complete, Print can be used to print the source table, Save will save all changes, and Exit will terminate keyboard entry. All unsaved changes will be lost when you exit.

B. Template

One technique common to interstitial brachytherapy[1] is the use of templates to guide needle placement during implantation.

The template entry option can be used as a technique for entering the source coordinates for a template guided implant. This is done by specifying the template geometry, template loading, and implant coning.

1. Preparation

The template geometry is entered using the Template Edit Program. The template loading will be specified from the keyboard.

Implant coning is specified by four coning factors which are taken from two orthogonal radiographs. A coning factor is defined as the implant width as at one end of the implant expressed as a proportion of the template width. Coning factors are required at both ends of the implant in both the vertical and horizontal directions.

The projected orthogonal views of a template implant appear as shown in Figure 8.4. This implant shows no coning.

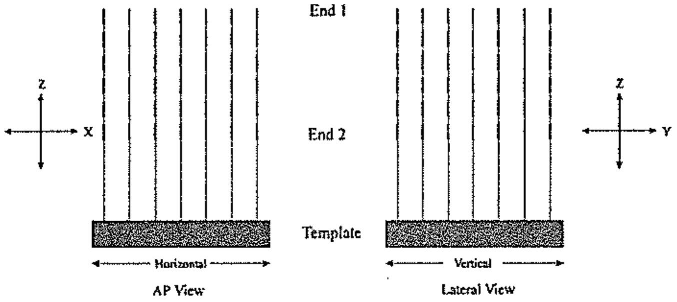


Figure 8.4 - Template Implant Projections

To determine the coning factors, measure the width of the implant at each end and in each view and divide these values by the width of the template. This is demonstrated in Figure 8.5.

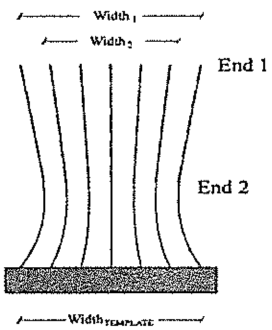


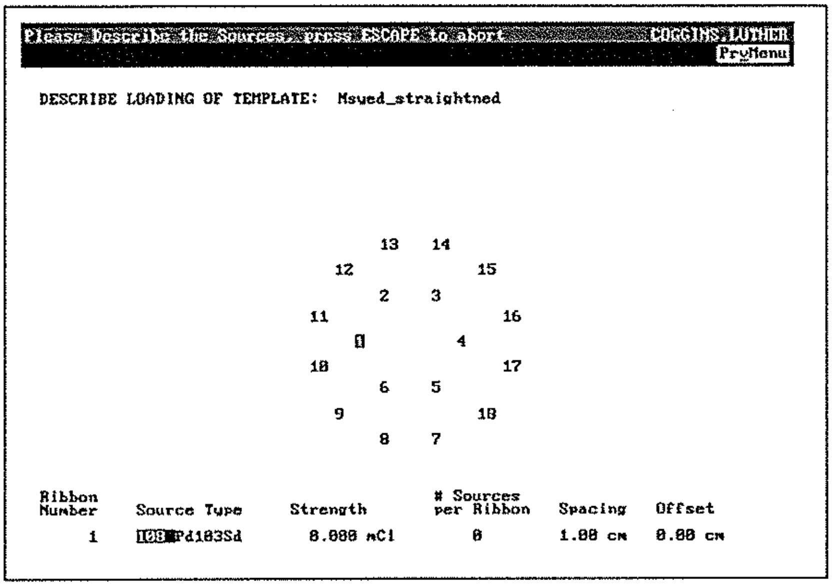
Figure 8.5 - Measurement of Coning Factors

$\text{Coning Factor}_1 = \text{Width}_1/\text{Width}_{\text{TEMPLATE}}$
$\text{Coning Factor}_2 = \text{Width}_2/\text{Width}_{\text{TEMPLATE}}$

2. Entry

To specify an implant using template entry, select Templt from the Brachytherapy Planning Window. Select a template type from the scrolling listbox.

The Template Loading Window is shown in Figure 8.6.



DESCRIBE LOADING OF TEMPLATE: Msyed_straightned

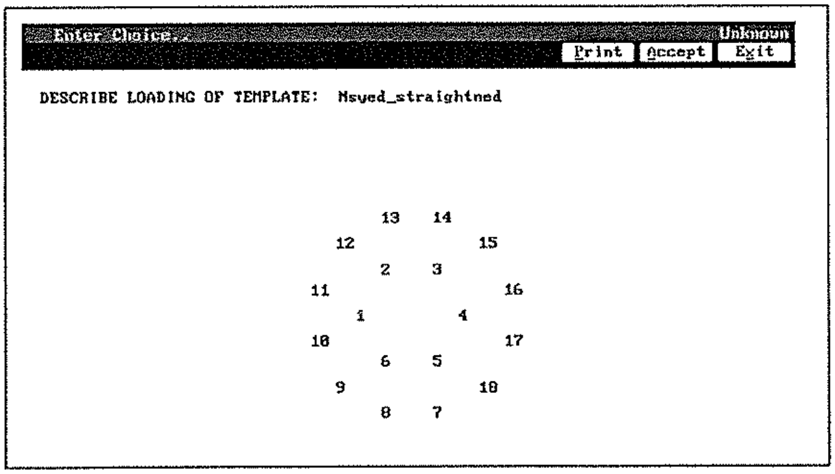
Ribbon Number	Source Type	Strength	# Sources per Ribbon	Spacing	Offset
1	100 Pd103Sd	0.000 mCi	0	1.00 cm	0.00 cm

Figure 8.6 - Template Loading Window

Enter the source number, source strength, number of seeds per ribbon, interseed spacing and offset from the keyboard for ribbon Number One. To see the source library, select seed type zero. To leave a needle unloaded, enter zero sources in the ribbon. After entering the offset, press Enter to progress to ribbon Number Two. The default for ribbon Number Two will be the values entered into ribbon Number One.

The left and right arrow keys can be used to move from item to item and the up and down arrow keys can be used to move from ribbon to ribbon. In the template diagram, loaded ribbons are indicated in red and unloaded ribbons are indicated in green. After all ribbons have been edited, enter the coning factors from the keyboard.

The screen will then appear as shown in Figure 8.7.



DESCRIBE LOADING OF TEMPLATE: Msyed_straightned

Figure 8.7 - Template Loaded Window

Select Print to print a template loading diagram and Accept to save the source positions. Selecting Exit does not save the source positions.

C. Orthogonal Films

1. Preparation

Before entering source coordinates, a pair of orthogonal projection radiographs must first be exposed, developed, and prepared.

Taking care to prepare good radiographs can greatly simplify and improve the process of source localization. Be sure to select exposure factors which will provide sufficient contrast and detail that each source can be clearly seen in each image. It is sometimes[2] easier to make a single exposure with two films in the cassette. This can make it easier to simultaneously visualize sources in both high and low density regions.

It is also important to be able to correlate sources between projections. Selecting good projection angles can make this process easier. The projections must be made at right angles to each other, but there are no other restrictions on what these angles may be. Use of dummy sources with identifying markers and radio-opaque spacers can also assist in source reconstruction.

A teletherapy simulator is very useful in making localization radiographs. Its isocentric construction is helpful in establishing and identifying a unique origin. The gantry readout can be used to ensure a 90 degree rotation between projections and fluoroscopy can be used to select the best gantry angles.

After exposing and developing a pair of acceptable images, you will need to align the images to each other. Do this by identifying the common y axis in both images and rotate the films such that the y axis is vertical in each. See Figure 8.8.

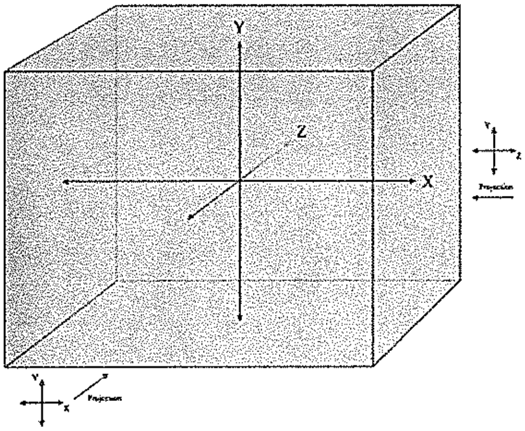


Figure 8.8 - Orthogonal Projection Geometry

After aligning the films, correlate the sources between the films. Identify and mark each source as seen in each projection. Calculation points will also need to be marked. For line sources, correlate each end of each source.

2. Entry

To begin entry from orthogonal films, select Orthog from the Main Brachytherapy Menu. As prompted, enter the first source type and activity to be used.

The next step will be to enter each source projection. The magnification of the image can be entered either from the keyboard or from an object of known size in the projected image. If you opt not to enter the magnification from the keyboard, you will need to type in the length of the magnification object.

Next, digitize points **U** and **L**. These points are used to confirm correct calibration of the digitizer before point entry. If you opted to enter the magnification from the digitizer, you must next digitize each end of the magnification object and confirm the magnification factor.

After that, digitize the origin of the implant coordinate system and a point to the right of the origin (i.e., in the +x direction). These two points will be used to calculate the angle by which the film is rotated on the digitizer. For this reason, these two points should be well-separated so that this angle can be accurately calculated.

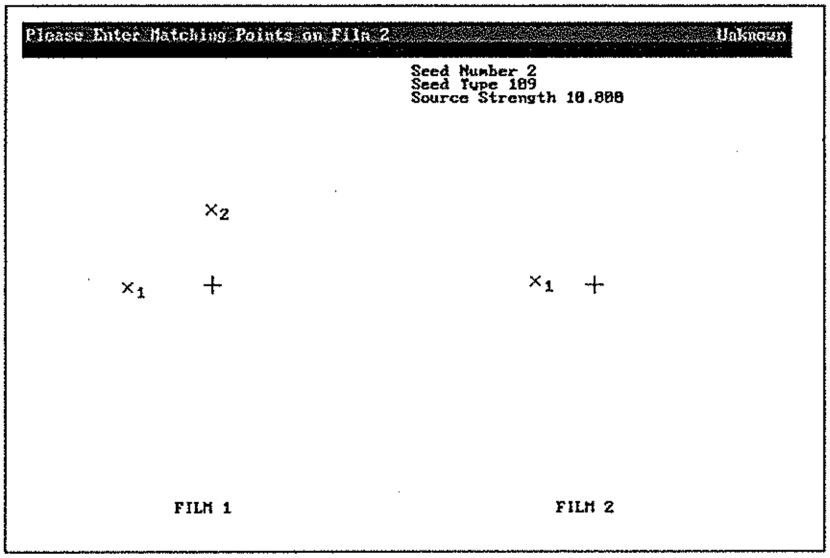
Once the implant coordinate system has been specified, enter each source point in order using the digitizer. To change to a different source type or activity, select **Change** using the digitizer. To digitize a point source, simply click on the point. To digitize a line source, click on each end of the source. Sources can be mixed in any way desired.

Warning: Do not mix sources to be implanted temporarily with those to be implanted permanently. The dosimetric results will be difficult to interpret.

After all sources have been entered, select either **Calculation Point** to begin entry of calculation points or **End** to end entry. **End** is also used to end entry of calculation points.

After entry of source and calculation points is complete, remove the first film from the digitizer and replace it with the second. Digitize points **U** and **L**, the ends of the magnification object if appropriate, the origin, and a point to the right of the origin (i.e., the +Z direction). The origin digitized must correspond with that digitized from the first film.

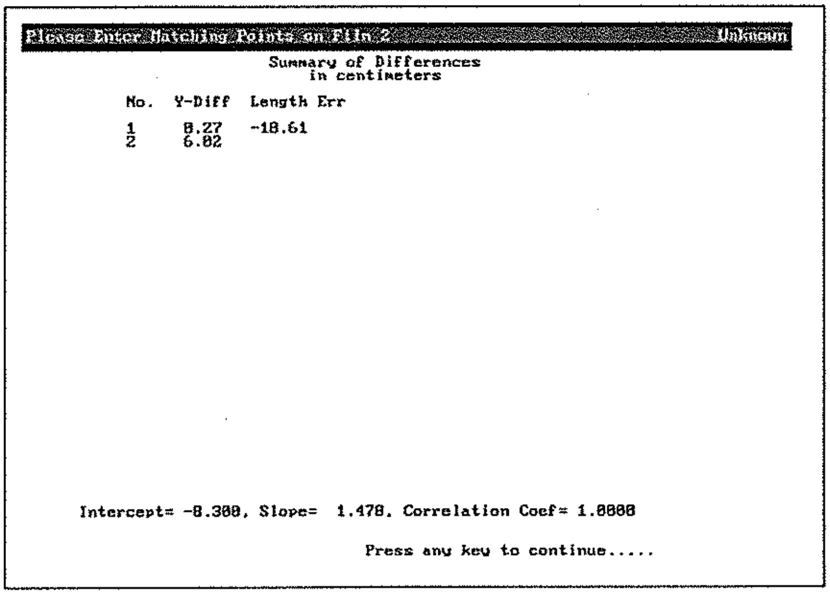
Next, digitize each of the source and calculation points as projected into the second image. These points must be entered in the same order as they were in the first image. There is no need to select **Change, Calculation Point**, or **End** from the digitizer as the activity, type, and order of the points is fixed. See Figure 8.9.



```
Please Enter Matching Points on Film 2                    Unknown
                              Seed Number 2
                              Seed Type 109
                              Source Strength 10.000
```

Figure 8.9 - Orthogonal Entry Window

After each of the source coordinates have been entered, an error analysis is made of the implant entry and the results are presented as shown in Figure 8.10.



```
Please Enter Matching Points on Film 2                    Unknown
                    Summary of Differences
                        in centimeters

   No.  Y-Diff  Length Err

   1     0.27   -10.61
   2     6.02




Intercept= -0.300, Slope=  1.470, Correlation Coef= 1.0000

                         Press any key to continue.....
```

Figure 8.10 - Orthogonal Entry Error Analysis Window

If line sources have been entered, the right column indicates the length error of these sources. The length error is calculated as the difference in length between the entered source and the physical length of the source type specified.

The rest of the analysis focuses on the y coordinate of each point. The y coordinate of each point is entered twice—once from each projection. Ideally, both values should be equal. The extent to which they are equal is an indication of the accuracy of the reconstruction. The left column shows the difference in the y values on a point-by-point basis. Points which show substantial error are color keyed.

In addition, the (y_1, y_2) values are used to calculate a best fit line. Ideally, y_1 should equal y_2 in all cases and the best fit line should be $y_1 = y_2$. The slope value should very rarely be 1.00, the intercept value should very rarely be 0.00, and the correlation coefficient should very rarely be 1.00.

Incorrect seed entry can result in all of these values being wrong. If the intercept differs greatly from 0.00, it can indicate incorrect origin placement. If the slope differs greatly from 1.00, it can indicate incorrect magnification.

D. Stereo Films

In the reconstruction of an implant from stereo projections, a set of points of known position[3] are used to calculate the exact imaging geometry. These parameters are then used to determine the seed locations.

These fixed points are called fiducial points. These points are indicated by radio-opaque markers in a fiducial jig. The locations of these points are stored in C:\PROWESS\MACHINE\SPFID.TXT and the fiducial jig appears as shown in Figures 8.11 and 8.12.

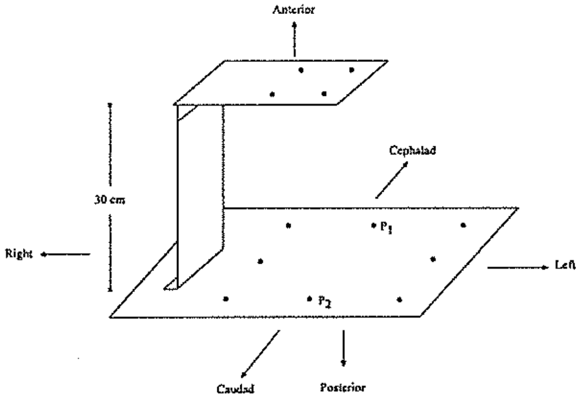


Figure 8.11 - Perspective View of Fiducial Jig (not to scale)

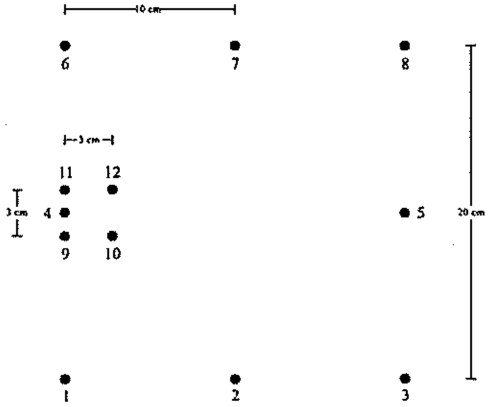


Figure 8.12 - Vertical View of Fiducial Points

1. Preparation

In making the localization images, use 14"x17" films. Place the patient on the table with the arm of the jig positioned on the patient's right side as shown in Figure 8.11. The arm of the jig should be on the patient's right side. Be sure the patient does not lean against the arm of the jig, because it will alter the geometry of the lead shot.

Using a target-to-film distance of approximately 100 cm, make the first exposure with the central ray passing through point P_1. Shift 20 cm in the caudad direction and make the second exposure with the central ray passing through point P_2. Do not allow the patient to move between exposures.

Since fiducial points are used, the geometric relationship of the x-ray source and the films is not critical. From the data given, the computer calculates the actual target-film distance and the shift distance used. Record the distance between the lower plate of the fiducial jig and the cassette. This value should be between 5 and 12 cm.

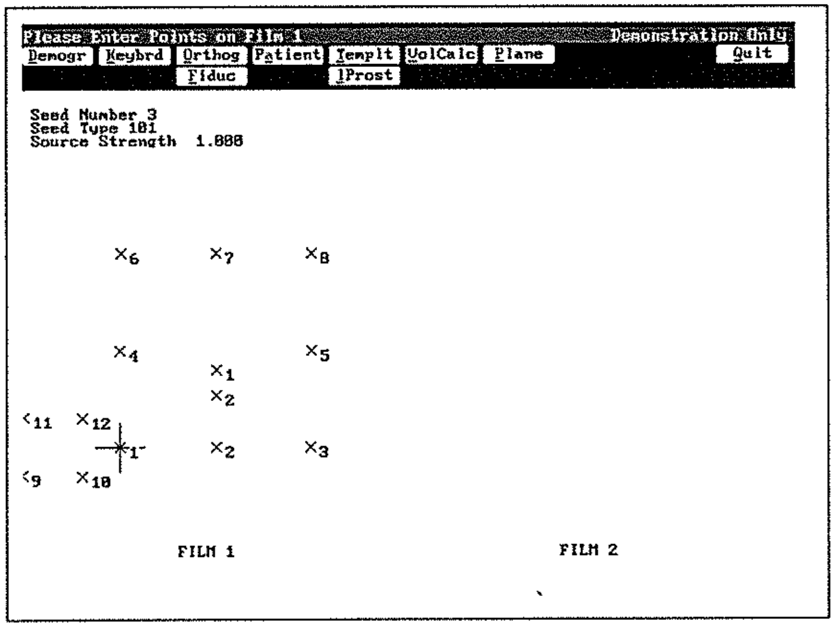
Align the two films such that the caudad part of each image is at the top of each film. The source and calculation points must be matched between films.

2. Entry

To begin entry from stereo films, select Fiduc from the Brachytherapy Planning Window. Next, enter the source type and the source strength.

Digitize points U and L. Then digitize fiducial Point 1 as the origin and fiducial Point 3 as a point to the right of the origin.

A stereo film entry window is shown in Figure 8.13.



```
Seed Number 3
Seed Type 101
Source Strength  1.000
```

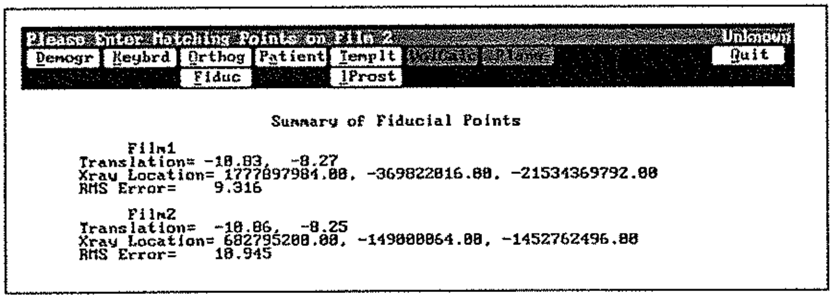
Figure 8.13 - Stereo Film Entry Window

Digitize the 12 fiducial points and then digitize the sources. To change the source type or strength, select **Change** from the digitizer.

To enter points of calculation, select **Calculation Points** from the digitizer. Up to 20 points may be entered.

After all points have been entered, select **End** from the digitizer. Enter the fiducial and source coordinates for film two.

When all of the sources have been entered, the program displays the location of the x-ray source and the errors in the entry of the source coordinates. An RMS error of greater than 0.05 is indicative of bad data entry. Figure 8.14 shows an example of poor implant entry.



```
                 Summary of Fiducial Points

     Film1
Translation= -10.03,  -8.27
Xray Location= 1777097984.00, -369822016.00, -21534369792.00
RMS Error=    9.316

     Film2
Translation=  -10.06,  -8.25
Xray Location= 682795200.00, -149000064.00, -1452762496.00
RMS Error=    10.945
```

Figure 8.14 - Stereo Shift Error Analysis Window

E. Axial Contours

1. Preparation

Line up all of the equally spaced scans on the digitizer in order of depth. Be sure the two points called **A1** and **G1** (6 cm to the right of A1) are marked on each scan. These points will be used to align and scale each scan.

2. Entry

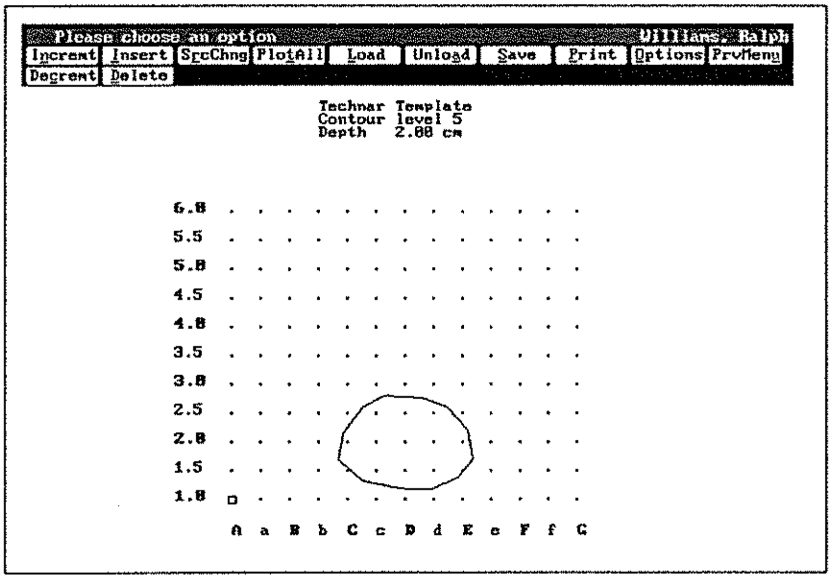
To enter an implant using axial contours, select IProst.

From the keyboard, enter the vertical (z) distance between contours. Next, digitize points **U** and **L**. at the upper left and lower right corners of the digitizer. Digitize all of the contours in order from top to bottom.

To enter a prostate contour, first digitize the two template reference points. These are points **A1** and **G1** for the Technar template and points **A0** and **G0** for the GE template. Next, trace out the prostate contour with the digitizer stylus. Select **End** from the digitizer tablet to close the contour. After digitizing the last contour, select **Exit** to terminate entry.

Specify the source type and source strength to be used. Note that a true source strength (e.g., mCi) will lead to a dose rate distribution which has units of cGy/hr. An implant time scaled source strength (e.g., mCi x 1.44 x isotope's physical half life in hrs) will lead to a dose distribution which has units of cGy.

The IProst Planning Window appears as shown in Figure 8.15.



```
Technar Template
Contour level 5
Depth   2.00 cm
```

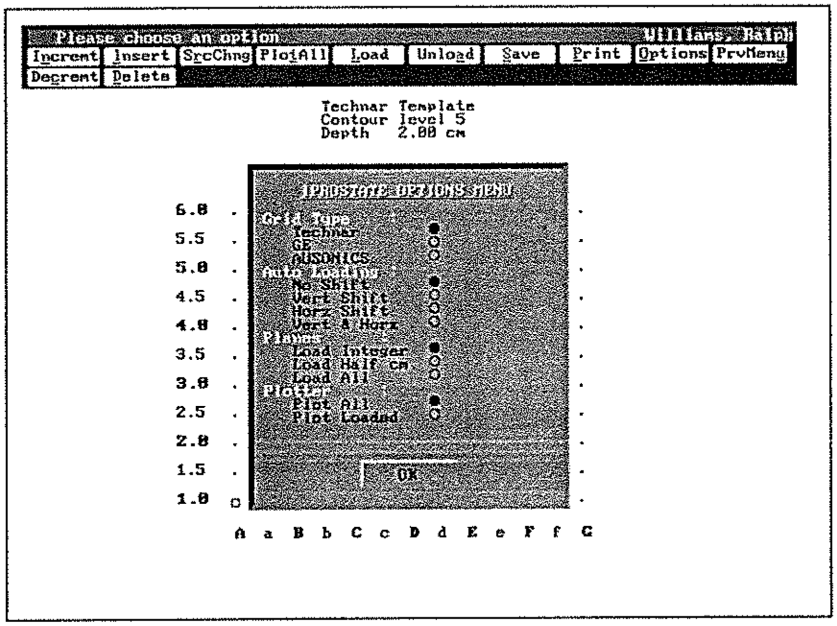
Figure 8.15 - IPROST Planning Window

At the center of the screen is the first prostate contour with the template pattern overlaid and the template axes marked.

Select Load to load all template points inside the prostate volume according to the Options. Select Unload to remove all loaded sources.

To insert a source into a specific template location, click on the grid point with the mouse. Clicking on it again removes the source. Another technique is to use the arrow keys to move the cursor. Use Insert and Delete to insert and delete sources at the current cursor location. The Return key will toggle sources in and out.

The Options button is used to control other functions inside IProst. The IProstate Options Menu is shown in Figure 8.16.



Technar Template
Contour level 5
Depth 2.00 cm

IPROSTATE OPTIONS MENU

Grid Type
- Technar ●
- GE ○
- AUSONICS ○

Auto Loading
- No Shift ●
- Vert Shift ○
- Horz Shift ○
- Vert & Horz ○

Planes
- Load Integer ●
- Load Half cm ○
- Load All ○

Plotter
- Plot All ●
- Plot Loaded ○

Figure 8.16 - Planar Implant Display Window

Select **Grid Type** to specify either a Technar, GE, or Ausonics grid. The **Plotter** options specify whether all slices or only loaded slices are plotted when PlotAll is selected.

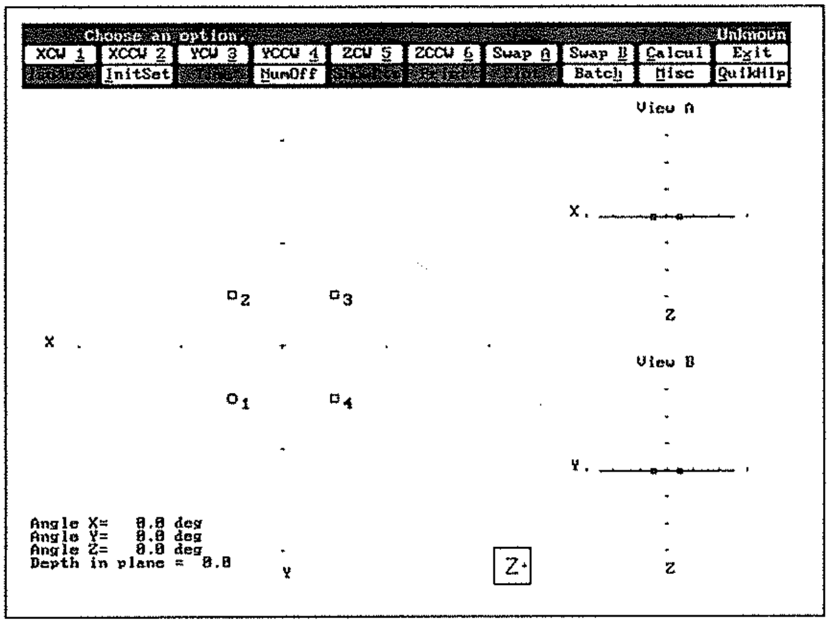
The **Auto Loading** and **Planes** options are used to control the function of the Load button. When **Load Integer** is selected, seeds are loaded into integer slices only. When **Load half cm** is selected, seeds are loaded into the half cm slices only. **Load All** causes all slices to be loaded.

With a slice, seeds are loaded one a 1 cm grid. The **Auto Loading** options allow for a 0.5 cm shift in either the X direction, the Y direction, neither, or both.

Use Incremt and Decremt to move from slice to slice. After all sources have been loaded, select Save and Exit.

F. 2D Planar Planning

Select Plane from the Brachytherapy Planning Window to begin planar planning. The planar Implant Display Window is presented as shown in Figure 8.17.



```
Angle X=   0.0 deg
Angle Y=   0.0 deg
Angle Z=   0.0 deg
Depth in plane =  0.0
```

Figure 8.17 - Planar Implant Display Window

The implant is presented from three orthogonal perspectives. On the left is the active (x, y) plane. To the right are the orthogonal (x, z) and (y, z) planes. These are designated View A and View B.

The active plane coincides with the calculation matrix and "what you see" here is "what you get" when the dose distribution is calculated.

Since it can be difficult to think in three dimensions, a number of on-screen tools are provided to aid with visualization. First, the depth of the active plane appears as a horizontal line indicating the depth of this plane in the orthogonal projections. The size and color of sources in the active plane also provides depth cueing. Sources above the calculation plane (Z>) are green and large. Sources below the calculation plane (Z<) are red and small. Sources within 0.5 cm of the calculation plane are white.

In the lower left corner of the window are the three angles by which the implant is rotated relative to the coordinate axes and the depth of the active plane relative to the orthogonal projections. In the lower right section of the window is an alignment cube which indicates the rotation of implant relative to the coordinate axes. In Figure 8.1 that the implant is viewed from along the +Z axis.

G. Calculation Matrix

The calculation matrix can be adjusted using the options selectable from the Misc button.

The **Change Limits** option is used to change the size of the calculation plane. Enter the number of centimeters by which you want the plane to change. A positive number increases the size of the plane. A negative number decreases it.

Use **Move Windows** to shift the calculation window in the x, y, and/or z direction. Enter the number of centimeters by which to move the window in each direction.

Select the **Matrix Size** option to change the number of calculation points in the calculation matrix. This number can be adjusted between 100 and 4,096. A larger matrix will produce a more precise calculation.

H. Plane Offset

Two keys are used to translate the calculation point relative to the implant.

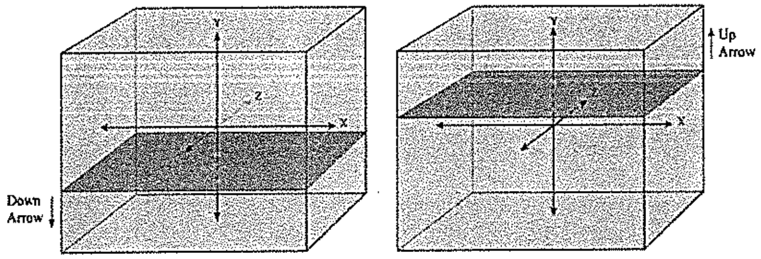


Figure 8.18 - Calculation Plane Translation Directions

The up arrow key moves the plane up and the down arrow key moves it down.

Under the Misc button, select **Offset Increment** to change the distance by which the up and down arrows move the calculation plane. The default value is 0.5 cm.

I. Implant Rotation

Six buttons are used to rotate the implant relative to the coordinate axes. The XCW1 and XCCW2 are used to rotate the implant around the X axis. The YCW3 and YCCW4 are used to rotate the implant around the Y axis. The ZCW5 and ZCCW6 keys are used to rotate the implant around the Z axis. This is illustrated in Figure 8.17.

At any time, select InitSet to return to the starting offset and angles.

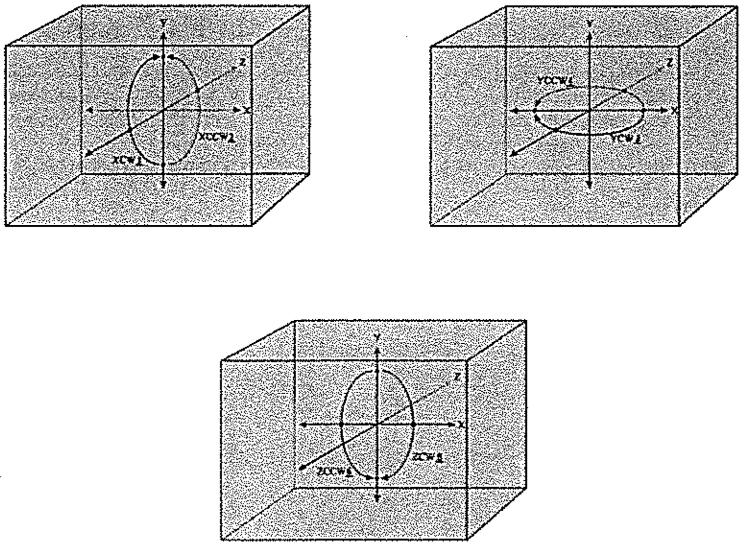


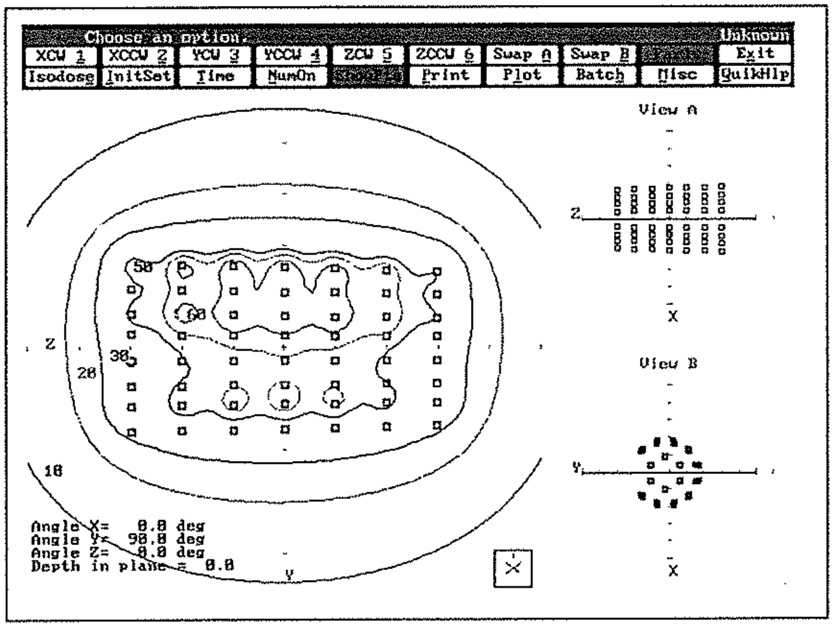
Figure 8.19 - Implant Rotation Directions

Under the Misc button, select the **Angle Increment** to change the angle by which these buttons rotate the implant. The default value is 10 degrees.

At any time, select InitSet to return to the starting angles and offset.

J. Dose Calculation

Select Calcul to calculate the dose distribution in the current plane. After the dose distribution is calculated, the isodose selection box is presented with a set of default values. To display the default isodose lines, press the **ESC**ape key. Each time the Enter key is pressed, a new isodose line from the default list is displayed. The default values can be edited from the keyboard during selection. Up to 17 isodose lines may be displayed. After isodose lines have been selected, the Planar Dose Display Window will appear as shown in Figure 8.20.



```
Angle X=   0.0 deg
Angle Y=  90.0 deg
Angle Z=   0.0 deg
Depth in plane =  0.0
```

Figure 8.20 - Planar Dose Display Window

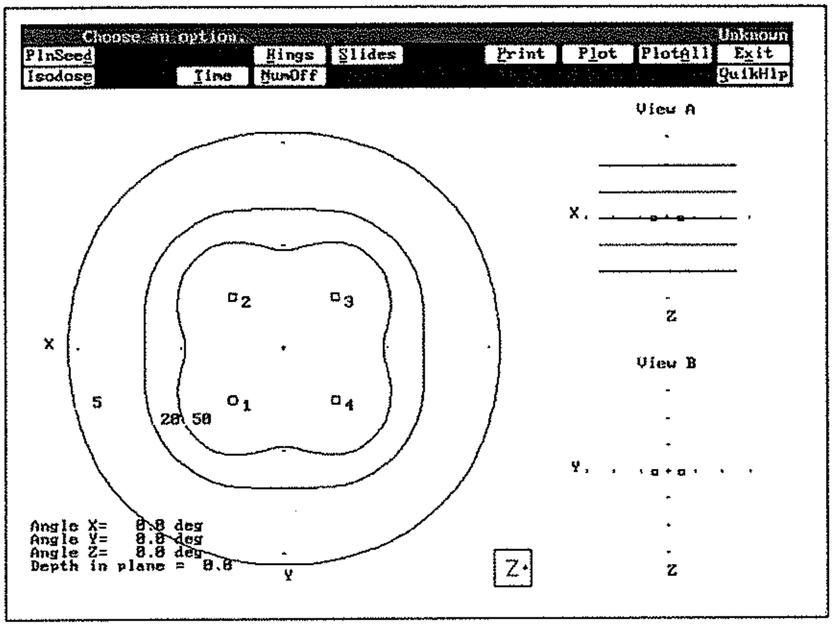
As calculated, the iso-lines display dose rate are in units of cGy/hr. To scale the value to dose, enter the implant time in hours. Select Time to do this.

Select ShoPts to display the dose to all calculation points. This option is disabled if no calculation points are entered.

If the Paris[3] system normalization has been made active in the control file, the Paris button replaces Calcul after dose calculation. Select Paris to normalize the dose distribution according to the Paris system. Use the up and down arrow key to select the calculation point whose dose is the basal dose. Use the Enter key to toggle from NO to YES. If multiple points are selected, their average is used as the basal doses. The Paris dose is reported as 85% of the basal dose and all doses are normalized to the basal dose. Select DONE after selecting the basal dose points.

III. 2D MULTISLICE PLANNING

To calculate a set of parallel planes, select Batch. Enter the range of the planes to be calculated. After calculation, the isodose curves are displayed for the lowest plane. Use the arrow key to step through the planes. The Batch Processing Window appears as shown in Figure 8.21.


Choose an option.

Angle X= 0.0 deg
Angle Y= 0.0 deg
Angle Z= 0.0 deg
Depth in plane = 0.0

Figure 8.21 - Batch Processing Window

Exit batch processing by selecting Quit.

A. Slides Display

Choose Slides to simultaneously display all of the planes. The Slides Display Window is shown in Figure 8.22.

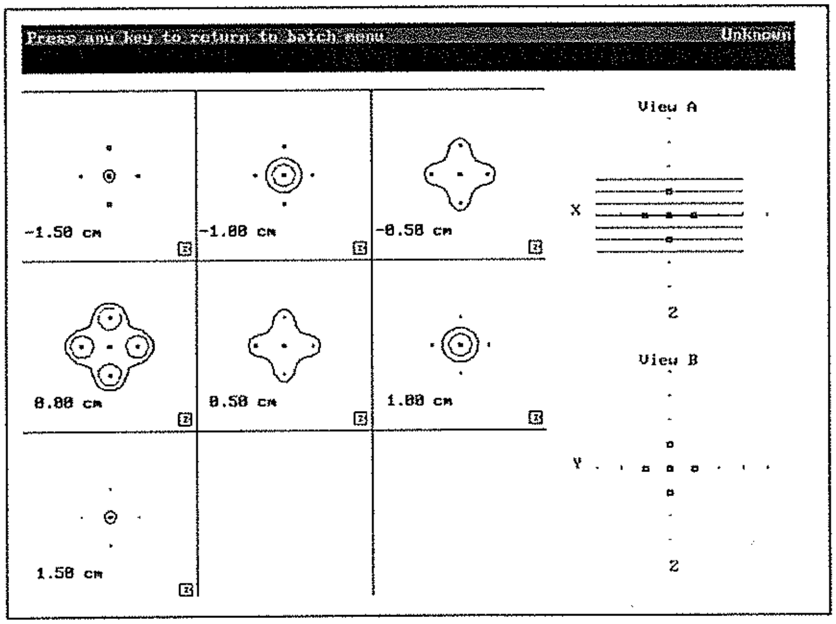
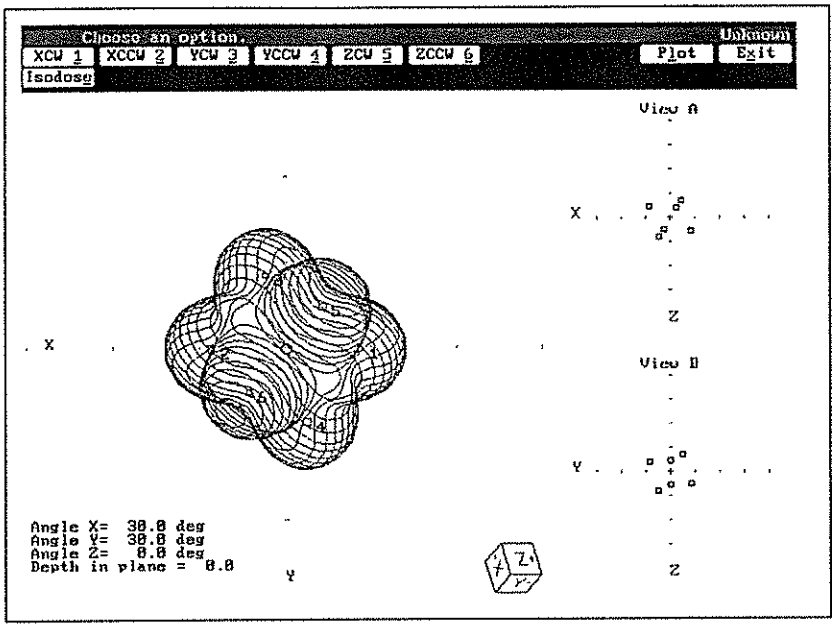

Press any key to return to batch menu

Figure 8.22 - Slides Display Window

B. Rings Display

Choose Rings to display the 3D dose distribution in a stacked wire frame projection. The projection may be rotated using the usual menu selections. Choose Plot to produce a plot of the display shown on the screen.



Choose an option.

```
Angle X=  30.0 deg
Angle Y=  30.0 deg
Angle Z=   0.0 deg
Depth in plane =  0.0
```

Figure 8.23 - Rings Display Window

IV. VOLUMETRIC ANALYSIS

After source entry, select Volume from the Brachytherapy Planning Window to perform a volumetric analysis.

The 16,384 volume element matrix is calculated when you select this option. The actual volume is automatically selected by forming a volume that is 2 cm larger than the maximum coordinate of the sources. The dose is calculated to each element.

A. Dose-Volume Histogram

Once this calculation is complete, a dose-volume histogram is presented on the screen as shown in Figure 8.24.

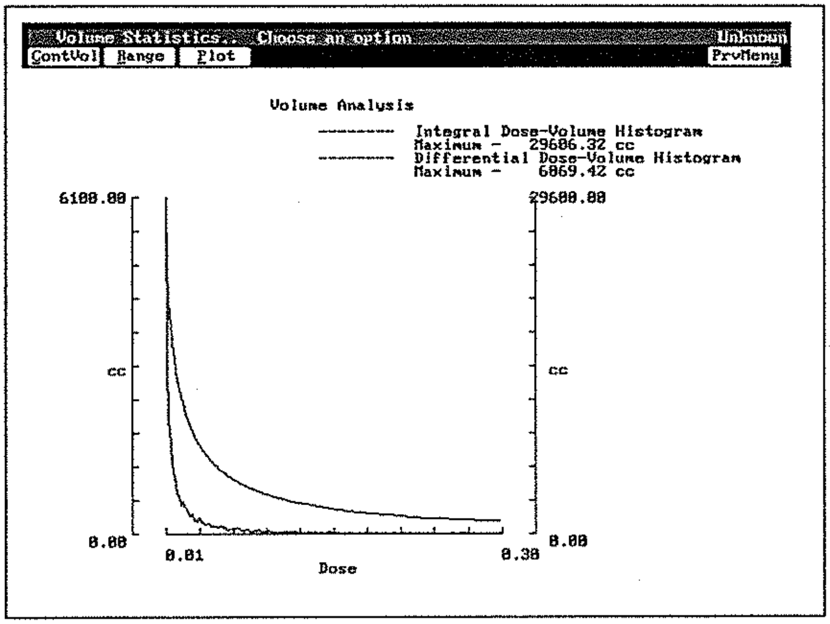
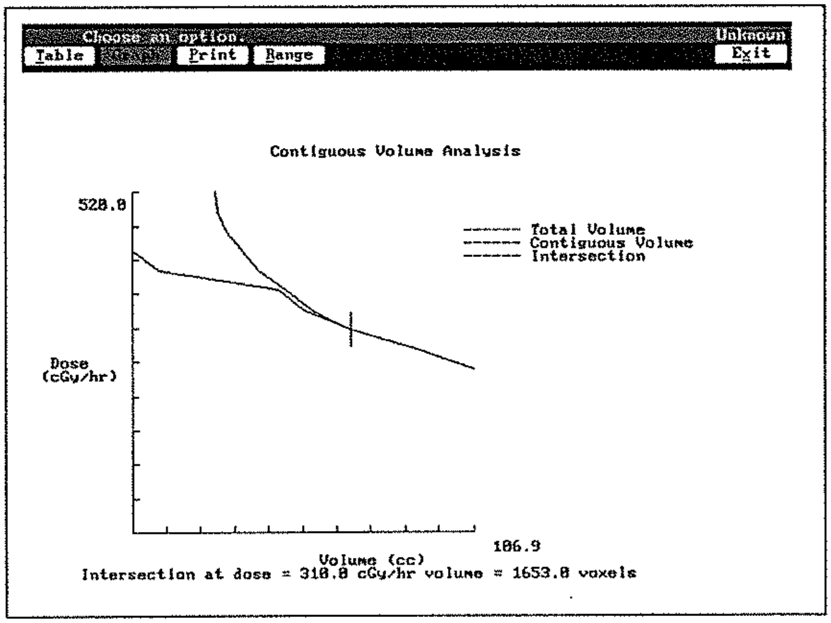


Figure 8.24 - Dose volume Histogram Display Window

B. Contiguous Volume Analysis

After calculating the dose volume histogram, you may perform a contiguous volume analysis by selecting Contig. Once the analysis is finished, a plot appears on the screen as shown in Figure 8.25.

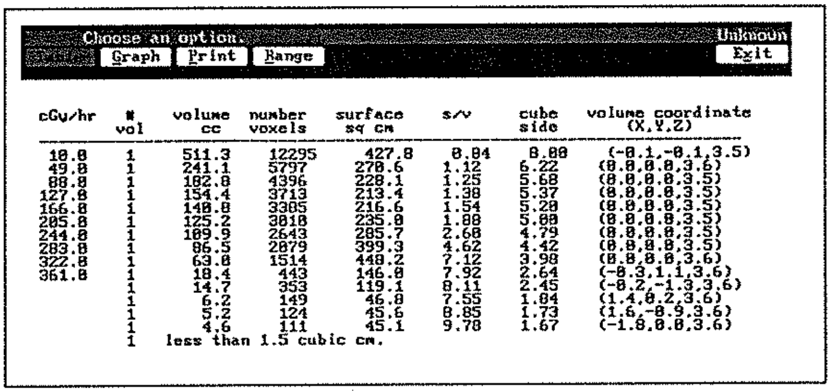


```
Intersection at dose = 310.0 cGy/hr volume = 1653.0 voxels
```

Figure 8.25 - Contiguous Volume Analysis Display Window

The plot shows total volume and contiguous volume. The critical dose rate is chosen from this curve by finding the point where the total volume and contiguous volumes are equal.

Choose Table to view the results as shown in Figure 8.26.



cGy/hr	# vol	volume cc	number voxels	surface sq cm	s/v	cube side	volume coordinate (X,Y,Z)
10.0	1	511.3	12295	427.8	0.84	8.00	(-0.1,-0.1,3.5)
49.0	1	241.1	5797	270.6	1.12	6.22	(0.0,0.0,3.6)
88.0	1	182.8	4396	228.1	1.25	5.68	(0.0,0.0,3.5)
127.0	1	154.4	3713	213.4	1.38	5.37	(0.0,0.0,3.5)
166.0	1	140.8	3385	216.6	1.54	5.20	(0.0,0.0,3.5)
205.0	1	125.2	3010	235.0	1.88	5.00	(0.0,0.0,3.5)
244.0	1	109.9	2643	285.7	2.60	4.79	(0.0,0.0,3.5)
283.0	1	86.5	2079	399.3	4.62	4.42	(0.0,0.0,3.5)
322.0	1	63.0	1514	448.2	7.12	3.98	(0.0,0.0,3.6)
361.0	1	18.4	443	146.0	7.92	2.64	(-0.3,1.1,3.6)
	1	14.7	353	119.1	8.11	2.45	(-0.2,-1.3,3.6)
	1	6.2	149	46.8	7.55	1.84	(1.4,0.2,3.6)
	1	5.2	124	45.6	8.85	1.73	(1.6,-0.9,3.6)
	1	4.6	111	45.1	9.78	1.67	(-1.0,0.0,3.6)
	1	less than 1.5 cubic cm.					

Figure 8.26 - Contiguous Volume Analysis Table Display Window

The table summarizes each contiguous volume, its size, surface area, and location. Choose Print to print the table.

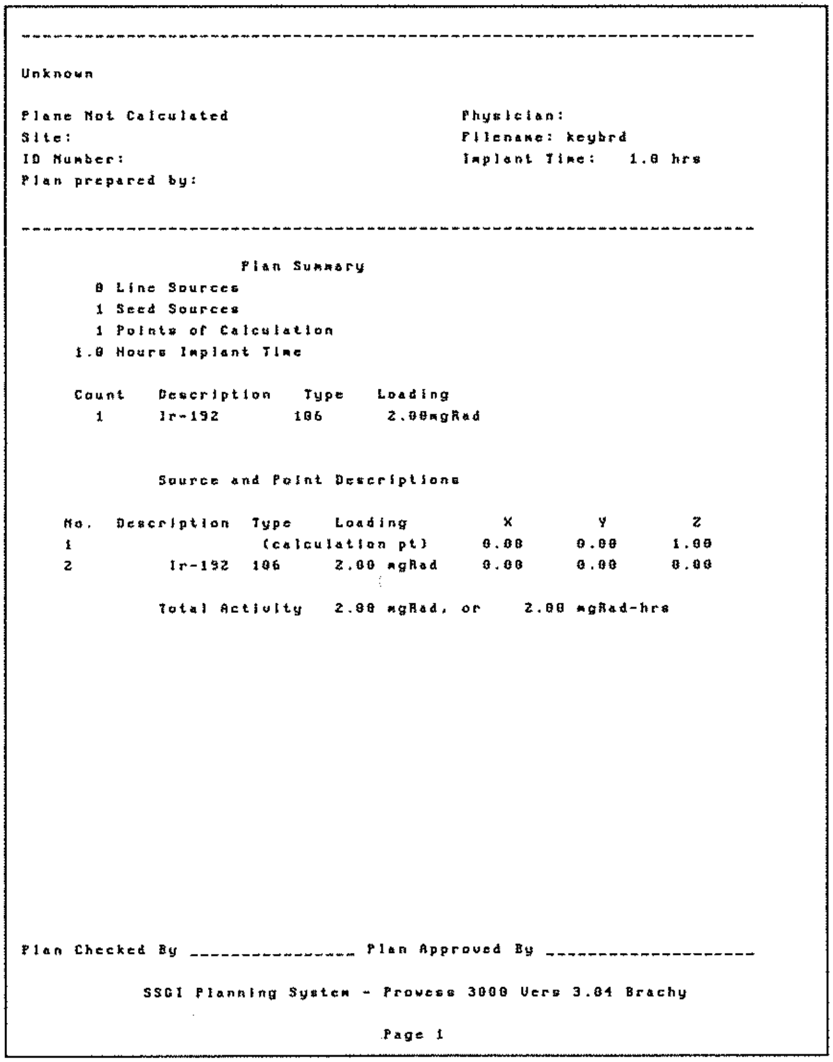
The calculation of the surface area depends upon a sum of the surface area of the contiguous voxels. This has a built-in uncertainty that increases as the volume approaches a sphere. The calculation should only be used as an approximation and for relative comparisons.

To change the range of dose rates analyzed, select Range and enter a new range of dose rates. This entry effects both the table and the graphics. If no intersection is displayed, it is outside the dose range selected.

V. HARDCOPY RESULTS

A. Keyboard

From the Keyboard Entry Window, select Print to print a source summary for the current implant configuration.

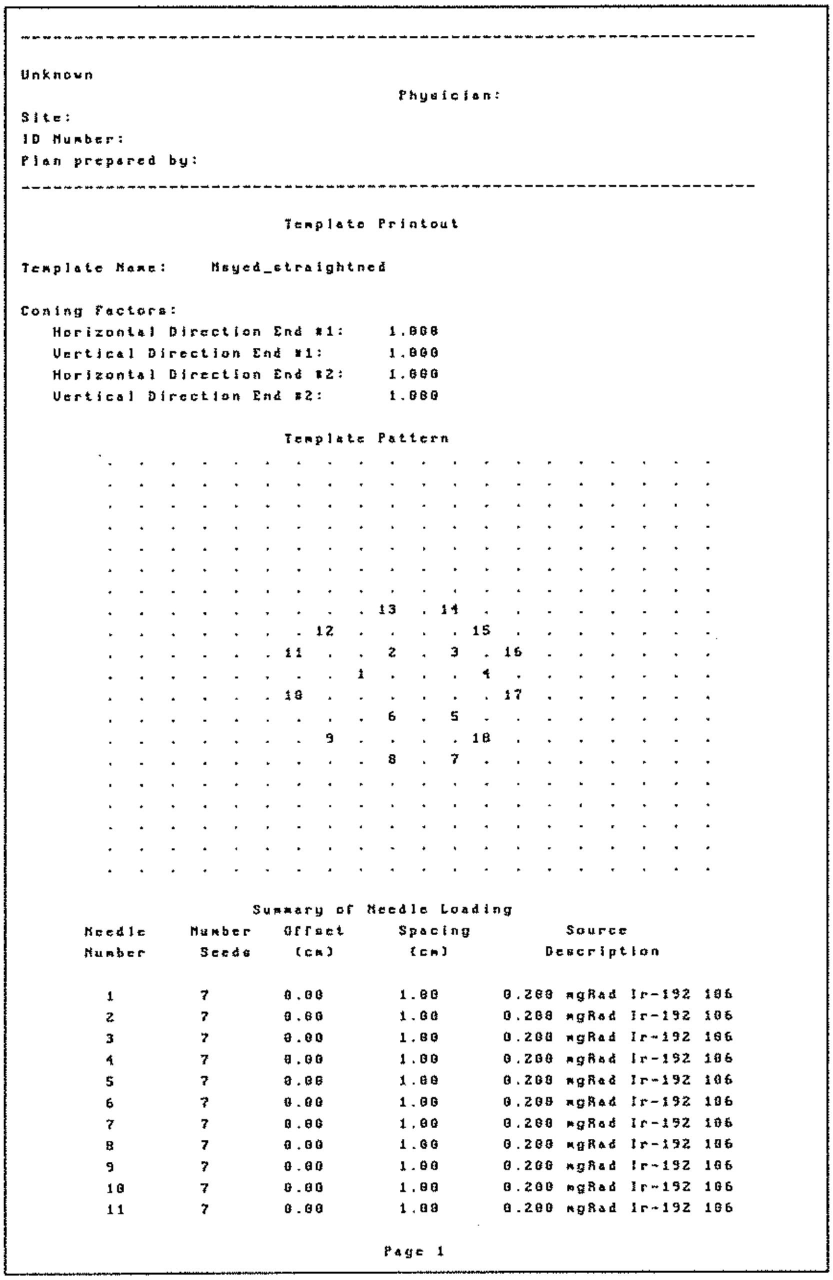


```
---------------------------------------------------------------------

Unknown

Plane Not Calculated                       Physician:
Site:                                      Filename: keybrd
ID Number:                                 Implant Time:   1.0 hrs
Plan prepared by:

---------------------------------------------------------------------

                     Plan Summary
       0 Line Sources
       1 Seed Sources
       1 Points of Calculation
     1.0 Hours Implant Time

     Count   Description   Type   Loading
       1     Ir-192        106     2.00mgRad


             Source and Point Descriptions

    No.  Description  Type    Loading         X         Y         Z
    1                  (calculation pt)      0.00      0.00      1.00
    2          Ir-192  106     2.00 mgRad    0.00      0.00      0.00

             Total Activity   2.00 mgRad, or    2.00 mgRad-hrs











Plan Checked By ________________ Plan Approved By ____________________

           SSGI Planning System - Prowess 3000 Vers 3.04 Brachy

                               Page 1
```

Figure 8.27 - Keyboard Entry Data Print

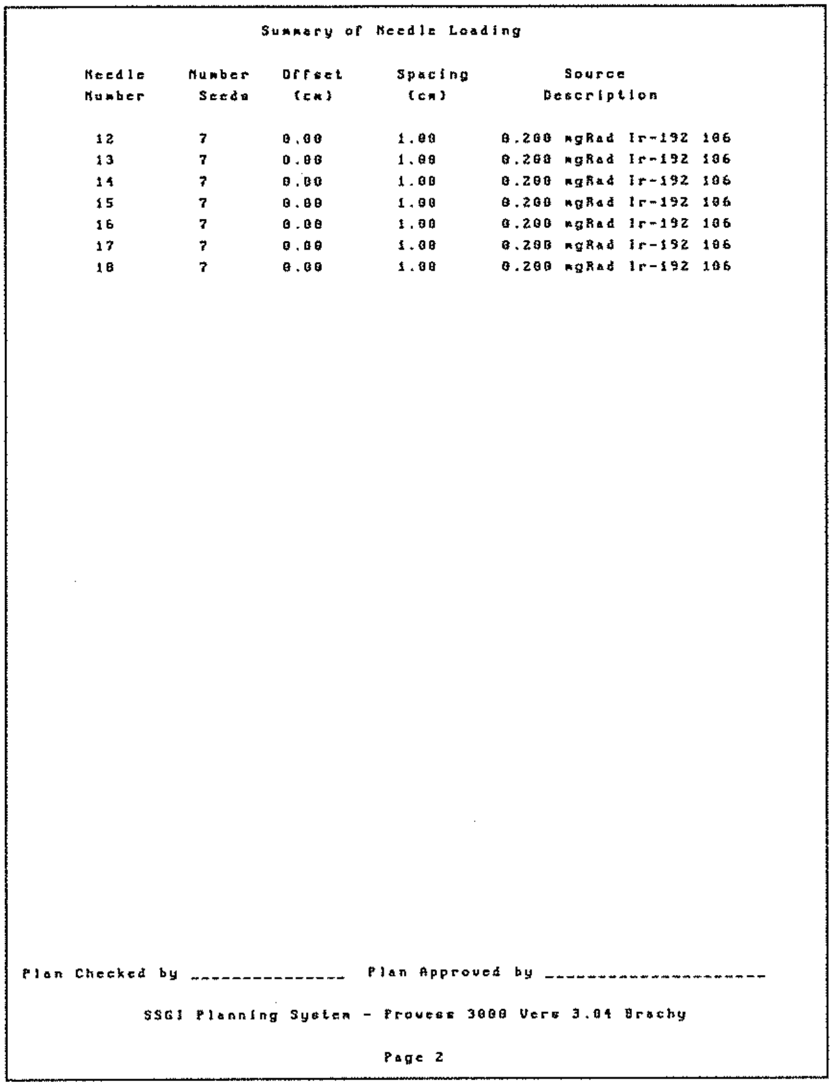
B. Template

From the Template Loaded Window, select Print to print a needle loading diagram.



```
------------------------------------------------------------------------

Unknown
                                     Physician:
Site:
ID Number:
Plan prepared by:
------------------------------------------------------------------------

                         Template Printout

Template Name:     Msyed_straightned

Coning Factors:
   Horizontal Direction End #1:     1.000
   Vertical Direction End #1:       1.000
   Horizontal Direction End #2:     1.000
   Vertical Direction End #2:       1.000

                         Template Pattern
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  . 13  . 14  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  . 12  .  .  .  . 15  .  .  .  .  .  .  .
        .  .  .  .  .  . 11  .  .  2  .  3  . 16  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  1  .  .  .  4  .  .  .  .  .  .  .
        .  .  .  .  .  . 10  .  .  .  .  .  . 17  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  6  .  5  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  9  .  .  .  . 18  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  8  .  7  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
        .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .

                      Summary of Needle Loading
     Needle     Number   Offset     Spacing        Source
     Number     Seeds     (cm)       (cm)        Description

       1          7       0.00       1.00      0.200 mgRad Ir-192 106
       2          7       0.00       1.00      0.200 mgRad Ir-192 106
       3          7       0.00       1.00      0.200 mgRad Ir-192 106
       4          7       0.00       1.00      0.200 mgRad Ir-192 106
       5          7       0.00       1.00      0.200 mgRad Ir-192 106
       6          7       0.00       1.00      0.200 mgRad Ir-192 106
       7          7       0.00       1.00      0.200 mgRad Ir-192 106
       8          7       0.00       1.00      0.200 mgRad Ir-192 106
       9          7       0.00       1.00      0.200 mgRad Ir-192 106
       10         7       0.00       1.00      0.200 mgRad Ir-192 106
       11         7       0.00       1.00      0.200 mgRad Ir-192 106

                              Page 1
```

Figure 8.28 - Template Entry Data Print



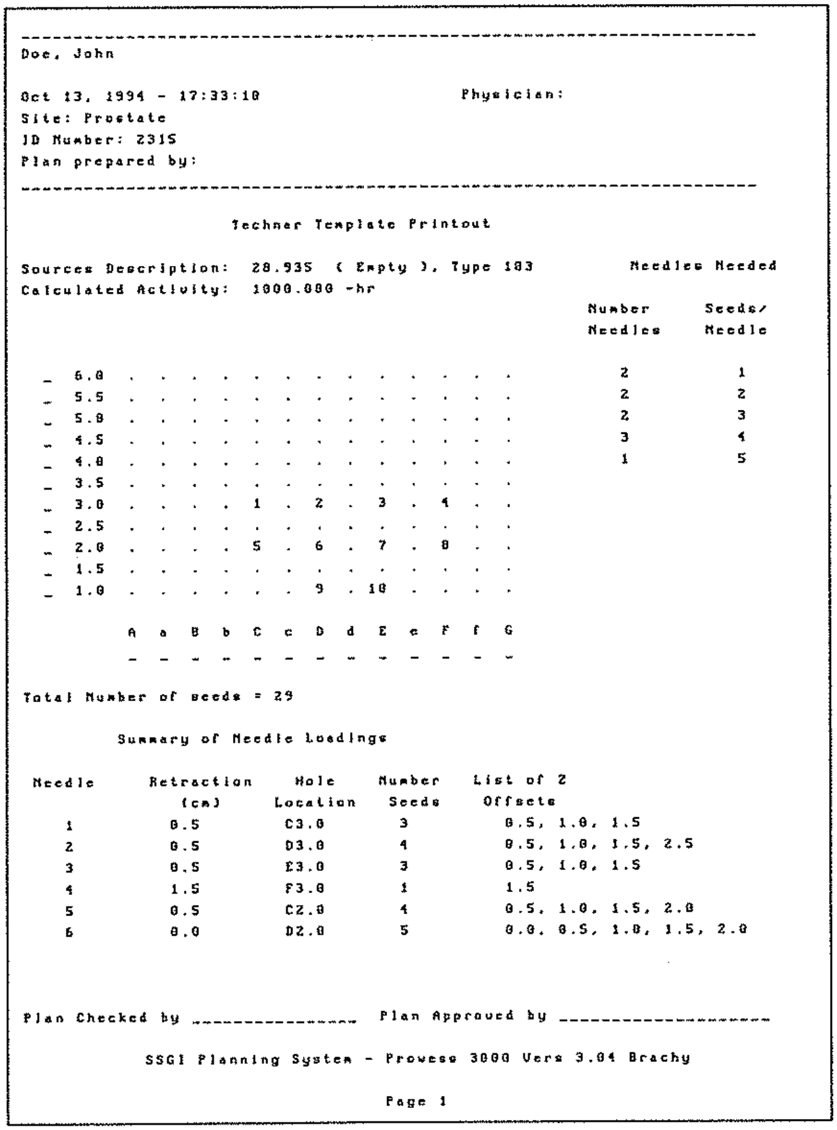
```
                        Summary of Needle Loading

     Needle      Number   Offset      Spacing          Source
     Number       Seeds    (cm)        (cm)          Description

       12          7       0.00        1.00       0.200 mgRad Ir-192 106
       13          7       0.00        1.00       0.200 mgRad Ir-192 106
       14          7       0.00        1.00       0.200 mgRad Ir-192 106
       15          7       0.00        1.00       0.200 mgRad Ir-192 106
       16          7       0.00        1.00       0.200 mgRad Ir-192 106
       17          7       0.00        1.00       0.200 mgRad Ir-192 106
       18          7       0.00        1.00       0.200 mgRad Ir-192 106









Plan Checked by _______________  Plan Approved by _____________________

              SSGI Planning System - Prowess 3000 Vers 3.04 Brachy

                                    Page 2
```

Figure 8.29 - Template Entry Data Print (cont.)

C. Axial Contours

1. Print

From the IProst Planning Window, select Print to print the needle loading diagram.

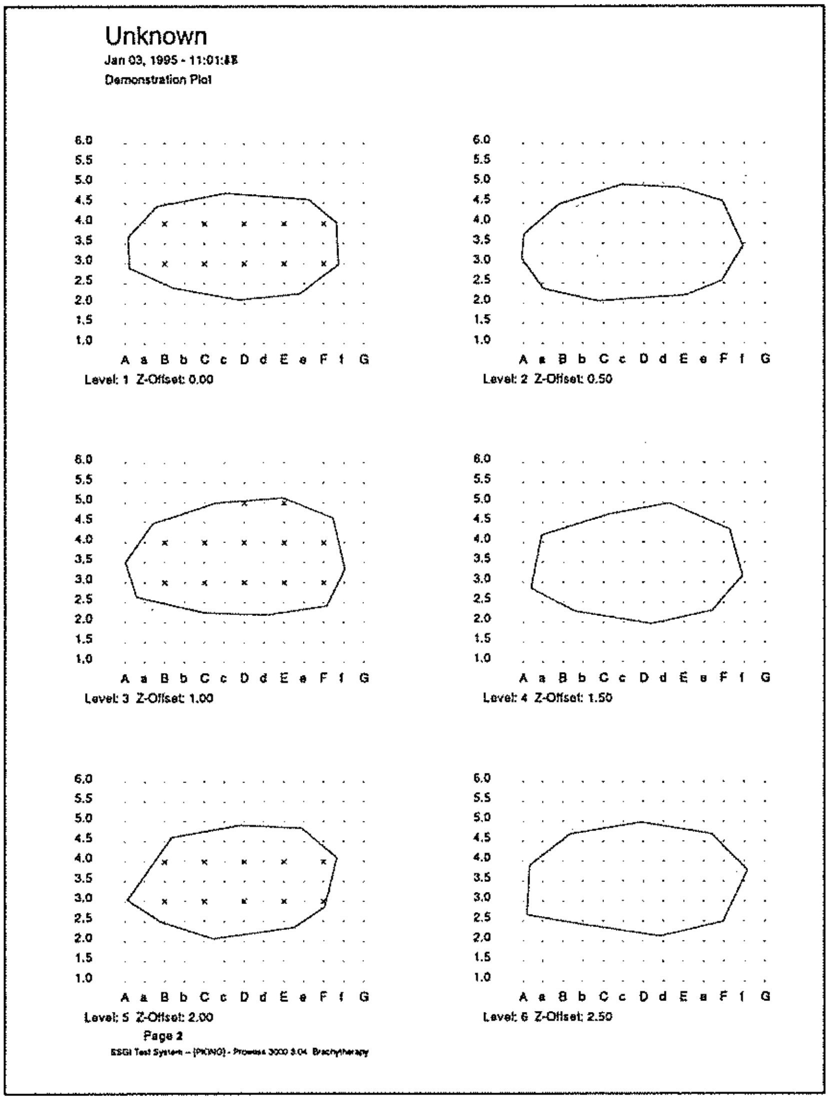


```
---------------------------------------------------------------------
Doe, John

Oct 13, 1994 - 17:33:10                    Physician:
Site: Prostate
ID Number: 2315
Plan prepared by:
---------------------------------------------------------------------

                   Techner Template Printout

Sources Description:  28.935  ( Empty ), Type 103        Needles Needed
Calculated Activity:  1000.000 -hr
                                                       Number     Seeds/
                                                       Needles    Needle

  _  6.0  .  .  .  .  .  .  .  .  .  .  .  .  .            2          1
  _  5.5  .  .  .  .  .  .  .  .  .  .  .  .  .            2          2
  _  5.0  .  .  .  .  .  .  .  .  .  .  .  .  .            2          3
  _  4.5  .  .  .  .  .  .  .  .  .  .  .  .  .            3          4
  _  4.0  .  .  .  .  .  .  .  .  .  .  .  .  .            1          5
  _  3.5  .  .  .  .  .  .  .  .  .  .  .  .  .
  _  3.0  .  .  .  .  1  .  2  .  3  .  4  .  .
  _  2.5  .  .  .  .  .  .  .  .  .  .  .  .  .
  _  2.0  .  .  .  .  5  .  6  .  7  .  8  .  .
  _  1.5  .  .  .  .  .  .  .  .  .  .  .  .  .
  _  1.0  .  .  .  .  .  .  9  . 10  .  .  .  .

          A  a  B  b  C  c  D  d  E  e  F  f  G
          _  _  _  _  _  _  _  _  _  _  _  _  _

Total Number of seeds = 29

         Summary of Needle Loadings

 Needle     Retraction     Hole     Number    List of Z
               (cm)      Location    Seeds     Offsets
   1           0.5         C3.0        3         0.5, 1.0, 1.5
   2           0.5         D3.0        4         0.5, 1.0, 1.5, 2.5
   3           0.5         E3.0        3         0.5, 1.0, 1.5
   4           1.5         F3.0        1         1.5
   5           0.5         C2.0        4         0.5, 1.0, 1.5, 2.0
   6           0.0         D2.0        5         0.0, 0.5, 1.0, 1.5, 2.0


Plan Checked by _______________  Plan Approved by ___________________

          SSGI Planning System - Prowess 3000 Vers 3.04 Brachy

                              Page 1
```

Figure 8.30 - IProst Enter Data Print

2. Plot

From the IProst Planning Window, select PlotAll to plot all axial contours with the seed loadings overlaid as shown in Figure 8.31.



Unknown
Jan 03, 1995 - 11:01:48
Demonstration Plot

Level: 1 Z-Offset: 0.00

Level: 2 Z-Offset: 0.50

Level: 3 Z-Offset: 1.00

Level: 4 Z-Offset: 1.50

Level: 5 Z-Offset: 2.00

Level: 6 Z-Offset: 2.50

Page 2

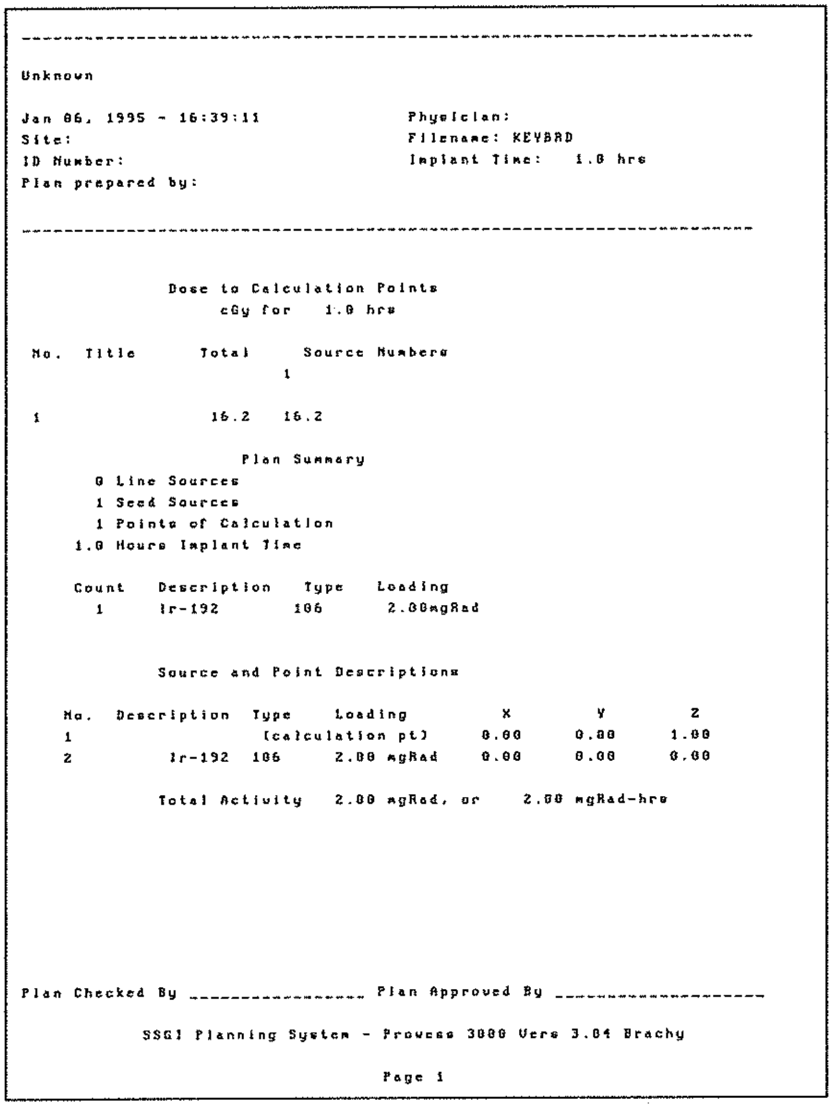
ESGI Test System -- [PKING] - Prowess 3000 3.04 Brachytherapy

Figure 8.31 - Axial Contours Plot

D. 2D Planar Planning

1. Print

Select Print to get a printed copy of the sources in this calculation and the dose to the specific calculation points. Patient name, calculation data, and time are duplicated on the printed copy for identification. These should be included in the patient file.



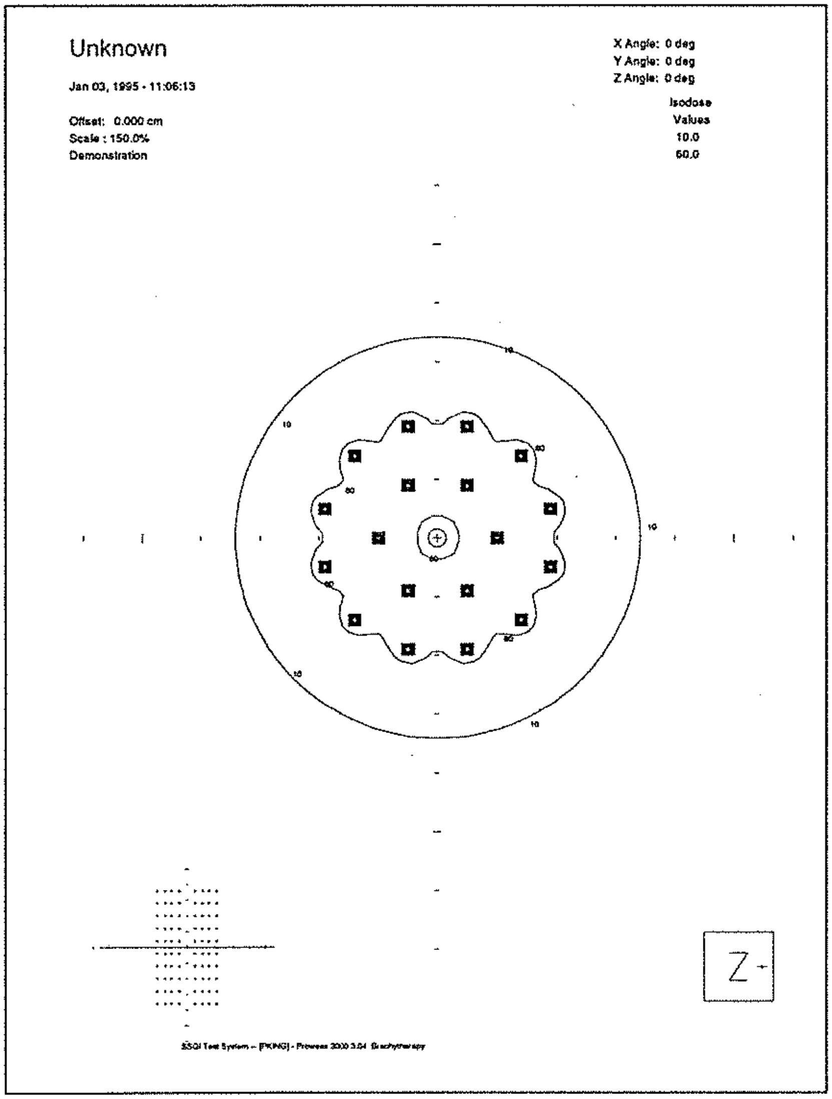
```
----------------------------------------------------------------------

Unknown

Jan 06, 1995 - 16:39:11                Physician:
Site:                                  Filename: KEYBRD
ID Number:                             Implant Time:    1.0 hrs
Plan prepared by:

----------------------------------------------------------------------


              Dose to Calculation Points
                   cGy for    1.0 hrs

 No.  Title       Total      Source Numbers
                          1

 1                 16.2   16.2

                     Plan Summary
      0 Line Sources
      1 Seed Sources
      1 Points of Calculation
    1.0 Hours Implant Time

    Count   Description   Type   Loading
      1     Ir-192        106      2.00mgRad


             Source and Point Descriptions

    No.  Description  Type    Loading        X        Y        Z
    1                  (calculation pt)     0.00     0.00     1.00
    2          Ir-192  106      2.00 mgRad  0.00     0.00     0.00

             Total Activity    2.00 mgRad, or     2.00 mgRad-hrs





Plan Checked By ________________ Plan Approved By ___________________

           SSGI Planning System - Prowess 3000 Vers 3.04 Brachy

                                Page 1
```

Figure 8.32 - Planar Calculation Results Print

2. Plot

Plot selects the plot option. The isodose values selected for screen display will reappear. The screen will display the maximum scale factor allowed by the plotter and ask you for the desired scale factor. The program proceeds to ask you whether the paper is 8½"x11", 11"x17", or European sized paper.

After selecting the paper size for the plot, the plotter begins operation. If you wish to stop the plotting before it is complete, press **ESC**ape.



Unknown

Jan 03, 1995 - 11:06:13

Offset: 0.000 cm
Scale : 150.0%
Demonstration

X Angle: 0 deg
Y Angle: 0 deg
Z Angle: 0 deg

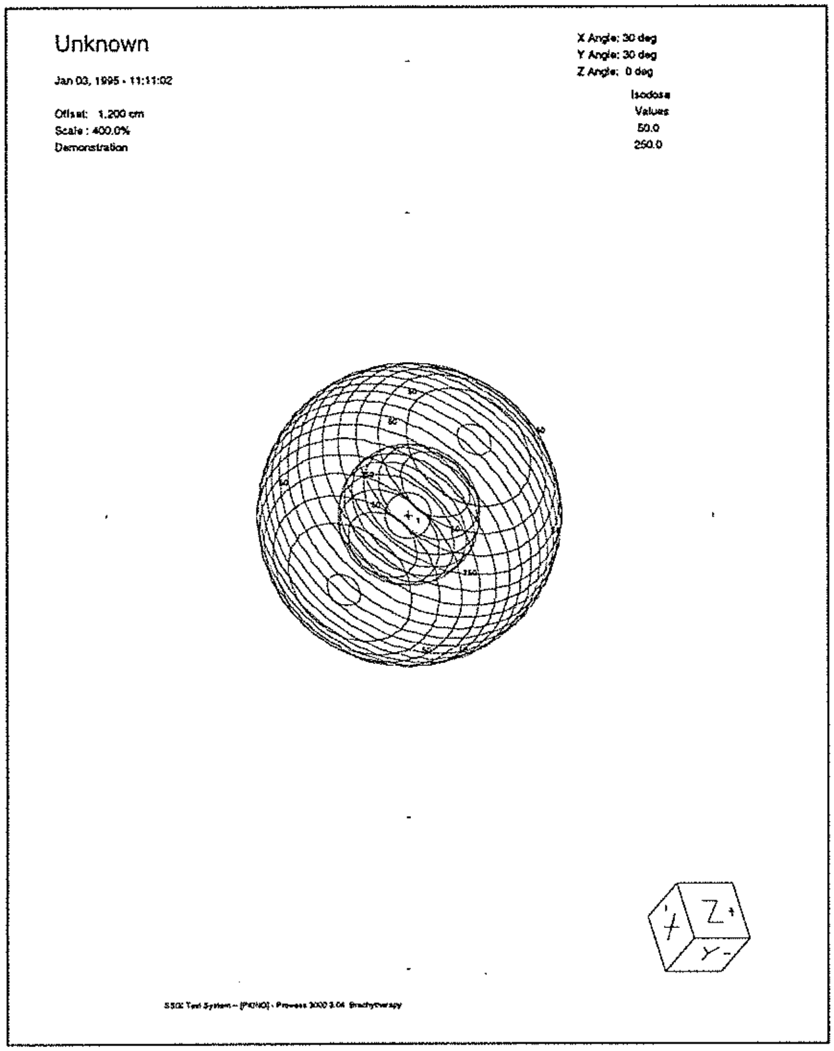
Isodose
Values
10.0
60.0

SSGI Test System -- [PKING] - Prowess 2000 3.04 Brachytherapy

Figure 8.33 - Planar Isodose Plot

E. 2D Multislice Planning

Select Plot from the rings display window to get a rings plot.



Unknown

Jan 03, 1995 - 11:11:02

Offset: 1.200 cm
Scale : 400.0%
Demonstration

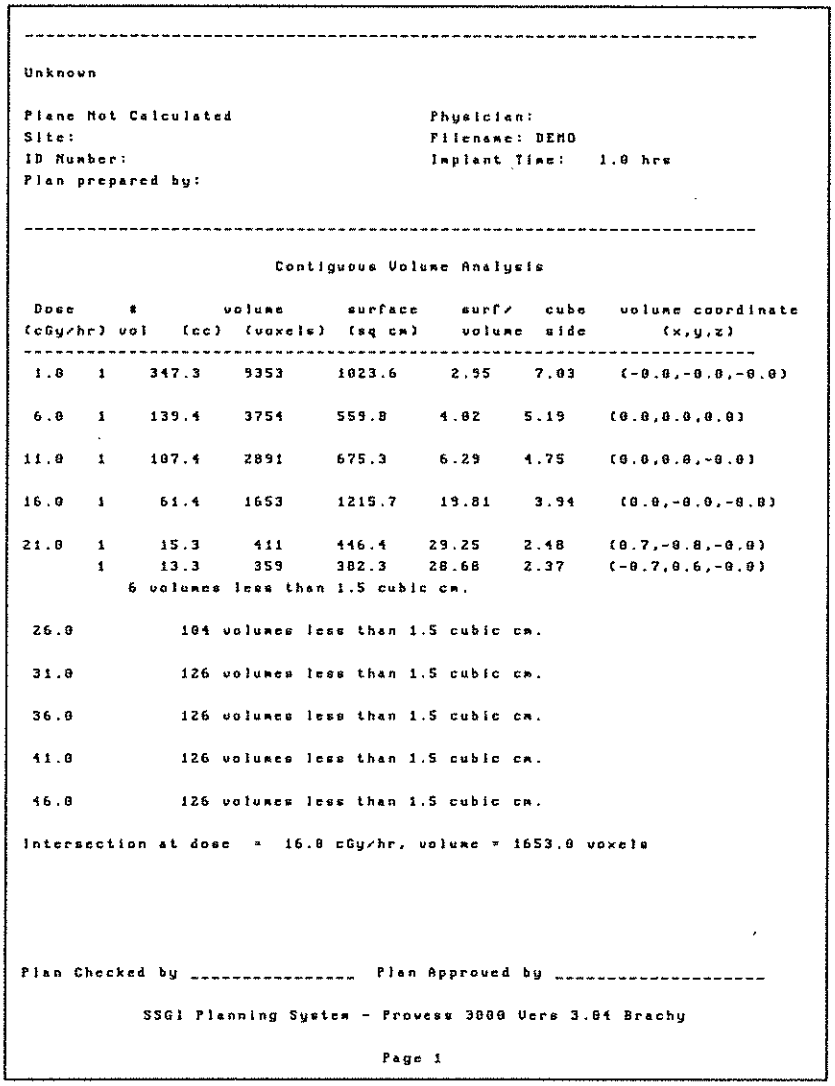
X Angle: 30 deg
Y Angle: 30 deg
Z Angle: 0 deg

Isodose
Values
50.0
250.0

Figure 8.34 - Batch Isodose Plot

1. Volumetric Analysis

From the Contiguous Volume Analysis Table Display Window, select Print to print the contiguous volume analysis table.



```
------------------------------------------------------------------

Unknown

Plane Not Calculated                    Physician:
Site:                                   Filename: DEMO
ID Number:                              Implant Time:   1.0 hrs
Plan prepared by:


------------------------------------------------------------------

                      Contiguous Volume Analysis

 Dose      #        volume      surface    surf/   cube   volume coordinate
(cGy/hr) vol   (cc)  (voxels)  (sq cm)    volume  side       (x,y,z)
------------------------------------------------------------------
 1.0    1    347.3    9353     1023.6     2.95    7.03    (-0.0,-0.0,-0.0)

 6.0    1    139.4    3754      559.8     4.02    5.19    (0.0,0.0,0.0)

11.0    1    107.4    2891      675.3     6.29    4.75    (0.0,0.0,-0.0)

16.0    1     61.4    1653     1215.7    19.81    3.94    (0.0,-0.0,-0.0)

21.0    1     15.3     411      446.4    29.25    2.48    (0.7,-0.0,-0.0)
        1     13.3     359      382.3    28.68    2.37    (-0.7,0.6,-0.0)
          6 volumes less than 1.5 cubic cm.

 26.0           104 volumes less than 1.5 cubic cm.

 31.0           126 volumes less than 1.5 cubic cm.

 36.0           126 volumes less than 1.5 cubic cm.

 41.0           126 volumes less than 1.5 cubic cm.

 46.0           126 volumes less than 1.5 cubic cm.

Intersection at dose  =  16.0 cGy/hr, volume = 1653.0 voxels




Plan Checked by ________________  Plan Approved by ____________________

             SSGI Planning System - Prowess 3000 Vers 3.04 Brachy

                                  Page 1
```

Figure 8.35 - Contiguous Volume Analysis Print

REFERENCES:

1. NEBLETT, D., et al, *Interstitial-Intracavitary (Syed-Neblett Applicator) Dose Rate Distribution Plots*, Los Angeles: University of Southern California Medical Center.

2. NEBLETT, David L., *Clinical Techniques and Applicators Available for Interstitial Implantation*, Modern Clinical Brachytherapy Physics, 1994, AAPM Summer School, July 19, 1994.

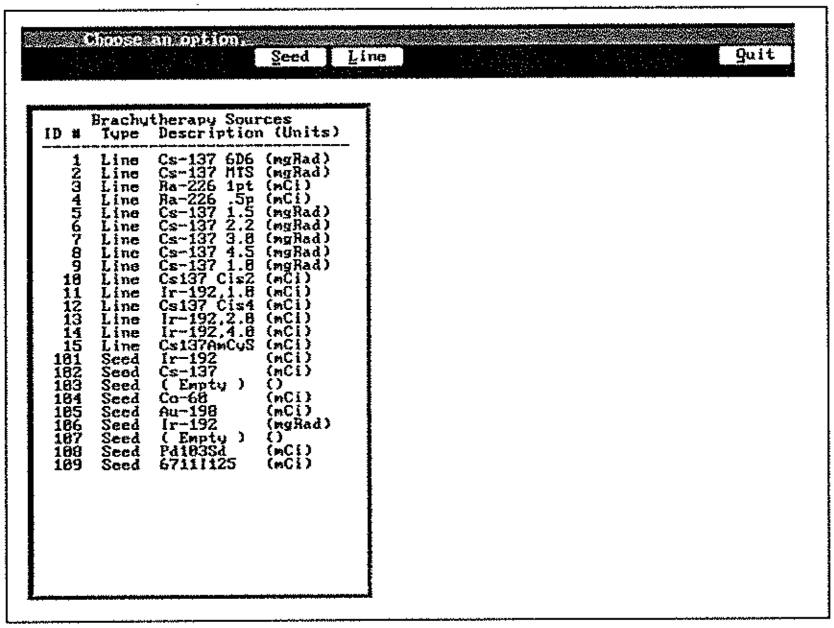
3. PITTS, Jon, *Automatic Location of Points from Stereo Radiographs*, August 24, 1965.

4. DUTREIX, A., et al, Dosimetrie en Curietherapie, 1982.

BRACHYTHERAPY SOURCE AND TEMPLATE EDITING

I. SOURCE ENTRY

The Brachytherapy Source Edit Program is used for entering and editing the physical properties of brachytherapy sources. To reach this option from the main menu, select Configuration, then Source Edit Program. The source selection window is shown in Figure 9.1.



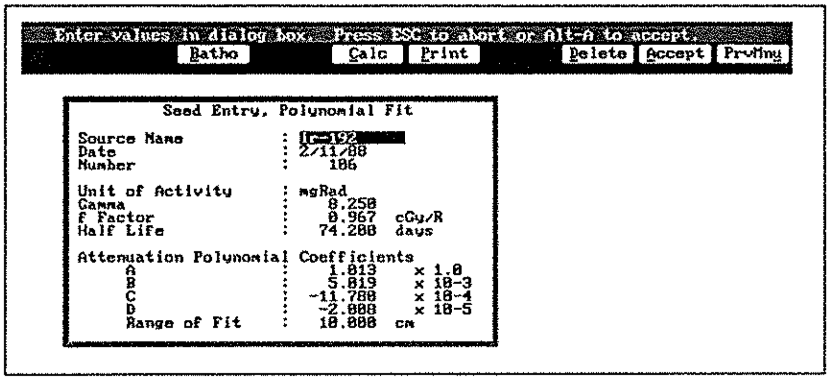
```
      Brachytherapy Sources
ID #  Type  Description (Units)
---------------------------------
  1   Line  Cs-137 6D6  (mgRad)
  2   Line  Cs-137 MTS  (mgRad)
  3   Line  Ra-226 1pt  (mCi)
  4   Line  Ra-226 .5p  (mCi)
  5   Line  Cs-137 1.5  (mgRad)
  6   Line  Cs-137 2.2  (mgRad)
  7   Line  Cs-137 3.0  (mgRad)
  8   Line  Cs-137 4.5  (mgRad)
  9   Line  Cs-137 1.0  (mgRad)
 10   Line  Cs137 Cis2  (mCi)
 11   Line  Ir-192,1.0  (mCi)
 12   Line  Cs137 Cis4  (mCi)
 13   Line  Ir-192,2.0  (mCi)
 14   Line  Ir-192,4.0  (mCi)
 15   Line  Cs137AmCyS  (mCi)
101   Seed  Ir-192      (mCi)
102   Seed  Cs-137      (mCi)
103   Seed  ( Empty )   ()
104   Seed  Co-60       (mCi)
105   Seed  Au-198      (mCi)
106   Seed  Ir-192      (mgRad)
107   Seed  ( Empty )   ()
108   Seed  Pd103Sd     (mCi)
109   Seed  6711I125    (mCi)
```

Figure 9.1 - Source Selection Window

From the Source Edit window, you can enter data for a Seed source or a Line source.

A. Seed Entry

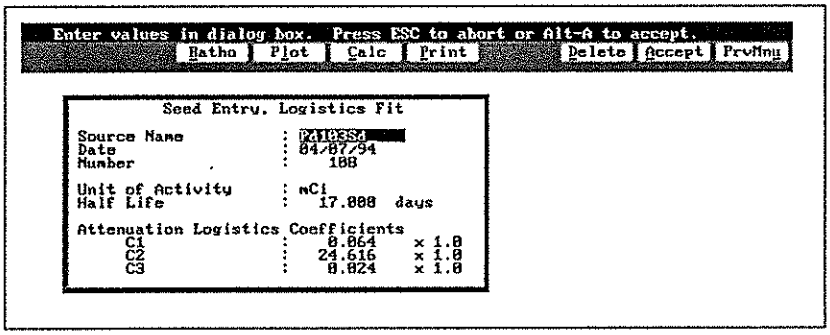
From the Seed Source Edit window, select Seed to enter the description of a brachytherapy seed source. Specify a source number between 101 and 199. Indicate whether the seed source is to be described using a polynomial fit or a logistics function fit. The seed polynomial edit window is presented as shown in Figure 9.2.



```
Enter values in dialog box.  Press ESC to abort or Alt-A to accept.

              Seed Entry, Polynomial Fit

Source Name             : Ir-192
Date                    : 2/11/88
Number                  :   106

Unit of Activity        : mgRad
Gamma                   :    8.250
f Factor                :    0.967  cGy/R
Half Life               :   74.200  days

Attenuation Polynomial Coefficients
      A                 :    1.013    x 1.0
      B                 :    5.019    x 10-3
      C                 :  -11.780    x 10-4
      D                 :   -2.000    x 10-5
      Range of Fit      :   10.000  cm
```

Figure 9.2 - Seed Polynomial Edit Window

The seed logistic function edit window is presented as shown in Figure 9.3.



```
Enter values in dialog box.  Press ESC to abort or Alt-A to accept.

              Seed Entry, Logistics Fit

Source Name             : Pd103Sd
Date                    : 04/07/94
Number                  :   100

Unit of Activity        : mCi
Half Life               :   17.000  days

Attenuation Logistics Coefficients
      C1                :    0.064    x 1.0
      C2                :   24.616    x 1.0
      C3                :    0.024    x 1.0
```

Figure 9.3 - Seed Logistic Function Edit Window

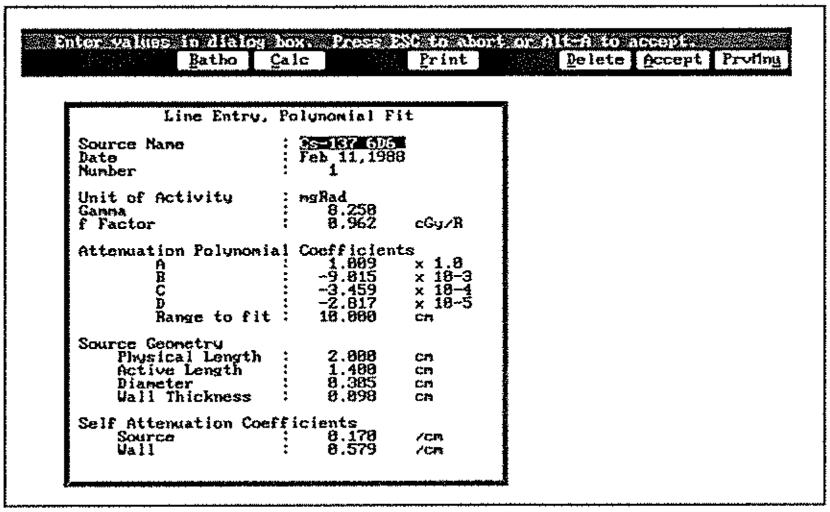
Using the keyboard, enter the source parameters shown. Verify that all source parameters are entered using consistent units. An exponential extrapolation will be used to calculate doses beyond the maximum range for a polynomial fit. The logistic function parameters are assumed to describe the dose disposition at all distances.

Warning: The entered parameters for each source type must be verified by the user before clinical use. Verify the parameters by comparing the dose distribution (calculated by Prowess using these parameters) with measured or published dose distributions. The source parameters used are solely the responsibility of the clinical site.

Select Print to print all the parameters and a Batho "along and away" table. Select Delete to delete the current source. After the parameters are entered, select Calc and Accept or Exit.

B. Line Entry

Select Line from the source edit window to enter the description of a line source. Specify a source number between 1 and 90. The line edit window will be presented as shown in Figure 9.4.



```
              Line Entry, Polynomial Fit

Source Name           : Cs-137 6D6
Date                  : Feb 11,1988
Number                :    1

Unit of Activity      : mgRad
Gamma                 :    0.250
f Factor              :    0.962      cGy/R

Attenuation Polynomial Coefficients
        A             :    1.009      x 1.0
        B             :   -9.015      x 10-3
        C             :   -3.459      x 10-4
        D             :   -2.817      x 10-5
        Range to fit  :   10.000      cm

Source Geometry
    Physical Length   :    2.000      cm
    Active Length     :    1.400      cm
    Diameter          :    0.305      cm
    Wall Thickness    :    0.098      cm

Self Attenuation Coefficients
    Source            :    0.170      /cm
    Wall              :    0.579      /cm
```

Figure 9.4 - Line Edit Window

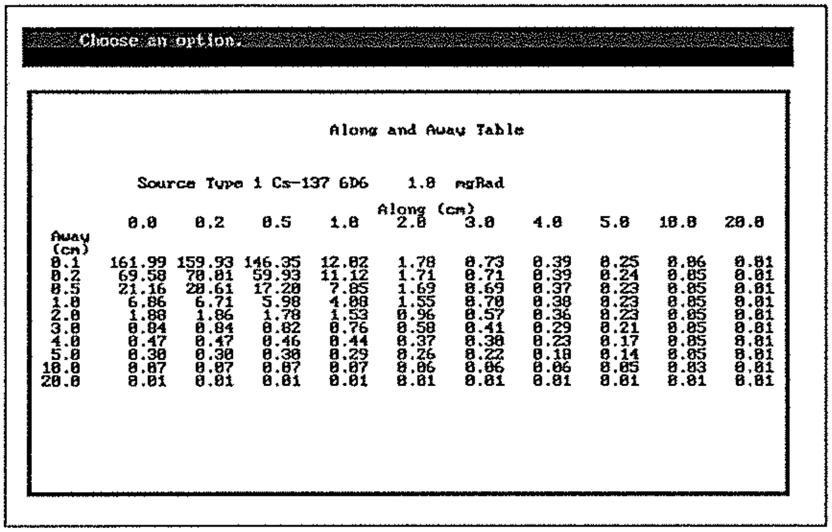
All of the seed parameters are required in addition to source geometry and self attenuation properties.

Warning: The entered parameters for each source type must be verified before clinical use. Verify the parameters by comparing the dose distribution (calculated by Prowess using these parameters) with measured or published dose distributions.

Select Print to print out all the parameters and a Batho "along and away" table. Select Delete to delete the current source. After the parameters are entered, select Calc and Accept or Exit.

C. Table Calculation

After entering a seed or line source, a Batho "along and away" table can be calculated by selecting Batho from the seed or line source edit window as shown in Figure 9.5.



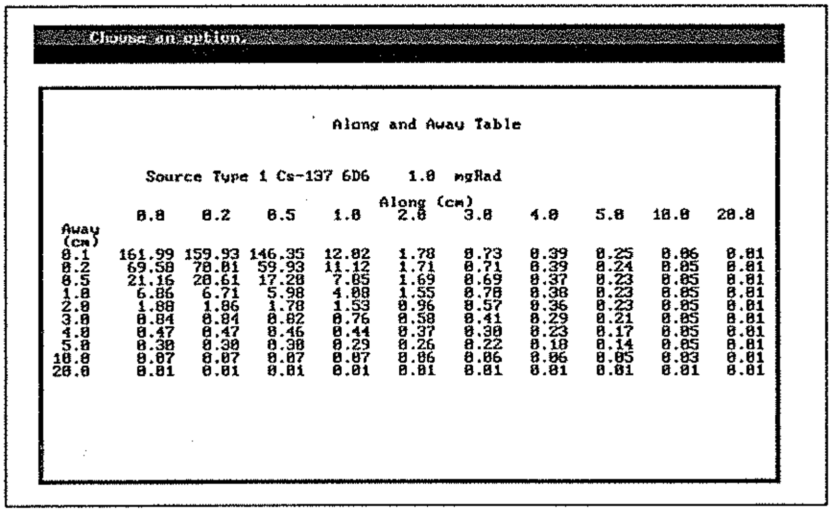
```
                              Along and Away Table

             Source Type 1 Cs-137 6D6     1.0  mgRad
                                      Along (cm)
          0.0     0.2     0.5     1.0     2.0     3.0     4.0     5.0    10.0    20.0
 Away
 (cm)
 0.1    161.99  159.93  146.35   12.02    1.78    0.73    0.39    0.25    0.06    0.01
 0.2     69.58   70.01   59.93   11.12    1.71    0.71    0.39    0.24    0.05    0.01
 0.5     21.16   20.61   17.20    7.05    1.69    0.69    0.37    0.23    0.05    0.01
 1.0      6.86    6.71    5.98    4.08    1.55    0.70    0.38    0.23    0.05    0.01
 2.0      1.88    1.86    1.78    1.53    0.96    0.57    0.36    0.23    0.05    0.01
 3.0      0.84    0.84    0.82    0.76    0.58    0.41    0.29    0.21    0.05    0.01
 4.0      0.47    0.47    0.46    0.44    0.37    0.30    0.23    0.17    0.05    0.01
 5.0      0.30    0.30    0.30    0.29    0.26    0.22    0.18    0.14    0.05    0.01
10.0      0.07    0.07    0.07    0.07    0.06    0.06    0.06    0.05    0.03    0.01
20.0      0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01
```

Figure 9.5 - Batho Table Window

Warning: The entered parameters for each source type must be verified by the user before clinical use. Verify the parameters by comparing the dose distribution (calculated by Prowess using these parameters) with measured or published dose distributions. The source parameters used are solely the responsibility of the clinical site.

II. TEMPLATE ENTRY

The Brachytherapy Template edit program is used for entering and editing the geometry or a brachytherapy template as well as default values for use of the template. To reach this option from the main menu, select Configuration, then Template Edit Program. The template entry window is shown in Figure 9.6.



```
                              Along and Away Table

             Source Type 1 Cs-137 6D6     1.0  mgRad
                                      Along (cm)
          0.0     0.2     0.5     1.0     2.0     3.0     4.0     5.0    10.0    20.0
 Away
 (cm)
 0.1    161.99  159.93  146.35   12.02    1.78    0.73    0.39    0.25    0.06    0.01
 0.2     69.58   70.01   59.93   11.12    1.71    0.71    0.39    0.24    0.05    0.01
 0.5     21.16   20.61   17.20    7.05    1.69    0.69    0.37    0.23    0.05    0.01
 1.0      6.86    6.71    5.98    4.08    1.55    0.70    0.38    0.23    0.05    0.01
 2.0      1.88    1.86    1.78    1.53    0.96    0.57    0.36    0.23    0.05    0.01
 3.0      0.84    0.84    0.82    0.76    0.58    0.41    0.29    0.21    0.05    0.01
 4.0      0.47    0.47    0.46    0.44    0.37    0.30    0.23    0.17    0.05    0.01
 5.0      0.30    0.30    0.30    0.29    0.26    0.22    0.18    0.14    0.05    0.01
10.0      0.07    0.07    0.07    0.07    0.06    0.06    0.06    0.05    0.03    0.01
20.0      0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01    0.01
```

Figure 9.6 - Template Entry Window

To create a template, enter a file name, description, and seed type. Next, indicate the number of ribbons available and the (x, y) location of each ribbon. Select Accept or Quit after entry. All template files are located in the machine directory and have a .BTX extension.

TREATMENT MACHINE DATA ENTRY

I. OVERVIEW

The External Beam, Irregular Field, and Daily Dose Calculation modules must have the characteristics of a treatment machine available for calculations to be made. The Prowess machine data entry module accommodates the needs of these programs by creating machine characteristic files. These files are stored on the hard disk in the C:\PROWESS\MACHINE directory and are identified by an .MCH extension.

A separate machine data file is created for each modality and energy available on each treatment unit. Keyboard, digitizer, and direct file transfers are available for machine data entry.

The properties of a megavoltage photon or electron beam are stored in the form of a set of data tables. Much of the process of calculating a dose is simply retrieving values from these tables. These tables can be one-dimensional such as peak scatter factor vs. field size. They can be two-dimensional such as scatter-maximum ratio vs. field size and depth. They can also be three-dimensional such as off-center ratio vs. field size, depth, and distance. In practice, a three-dimensional data set is treated as a group of two-dimensional data tables.

Only linear interpolation is used during table lookup. The calculation modules do not form fit or extrapolate from these data tables. The data entered is what will be later retrieved. Thus, it is crucial that the data in these tables be correct, complete, and accurate. The purpose of this section of the manual is to explain how to access, fill, and manipulate these data tables.

II. MACHINE DATA NEEDED

This section describes the basic machine data needed for the External Beam, Irregular Field, and Daily Dose Calculation modules. Some of this data is measured directly and some is derived from measured data. In some cases, alternatives as to how to determine this data are available, therefore, this section should be read completely before making measurements.

A. General Information

The general machine data consists of the following: name of treatment unit, SAD or nominal SSD of treatment unit, depth of dose maximum (d_{max}), typical blocking tray transmission factor, gantry angle when the gantry is pointed at the floor, direction of gantry rotation which is taken to positive.

B. Central Axis Data

Tissue Maximum Ratio (TMR) and Scatter Maximum Ratio (SMR) data is generally calculated from measured and entered Percent Depth Dose (%DD) data. Depth dose data is typically measured for 3, 4, 5, 6, 8, 10, 12, 15, 20, 25, 30, and 40 cm square fields. This data is entered and used to calculate TMRs.

If plotted curves are to be entered with a digitizer, the location of the phantom surface, zero level, and depth scale must be known. The best way to enter this data is using direct file transfer from a beam scanning system. TMR data must extend to zero field size and this zero area data can be extrapolated from finite field size data. TMRs can also be extrapolated to depths deeper than those for which measurements are available.

C. Off-Axis External Beam Data

Off-Center Ratios (OCRs) must be measured from smallest to largest field widths for which plans are to be calculated. Up to 20 field widths may be entered. Suggested field widths are 3, 4, 5, 6, 8, 10, 12, 15, 20, 30, and 40 cm. For x-ray fields, profiles are required at d_{max} and at four or more other depths. For electron fields, profile depths should be evenly distributed throughout the useful range of the electron beam. One profile should be measured in the bremsstrahlung tail of the beam.

OCR profiles are needed for each wedge. Half beam blocks, split wedges, and other specially blocked fields are considered to be separate wedge types. The open field is designated wedge type zero.

Different wedges need not be scanned at the same set of depths, however, all field sizes must be scanned at the same depths. Though not recommended, it is possible to calculate wedge OCR data from wedge shapes, open field OCR data, and the attenuation properties of the wedge. The central axis wedge factor for each wedge is required at each field width for which OCRs are entered.

D. Machine Output

The calibrated dose rate is required at nominal SSD and d_{max} for the reference field size. For Cobalt machines, the calibration date and timer error are also needed. Output factor is measured as a function of field size at d_{max}. Output factors are normalized to 1.0 for the reference field size.

E. Radial Dependence of Beam Intensity

A diagonal scan is measured from the central axis to a field corner at the depth of dose maximum.

F. Radial Dependence of Beam Energy

The off-axis half value layer can be measured using good geometry attenuation in water. It can also be calculated from beam profile and OCR data.

G. Peak Scatter Factor vs. Field Size

The Peak Scatter Factor (PSF) is measured as the ratio of the relative output measured in water at the depth of d_{max} and in air with a build up cap at the same location.

H. Virtual SSD

The virtual SSD is measured as a function of field size based on a best fit to inverse square measurements. This data is entered for electron beams only.

I. Block Edge Transmission

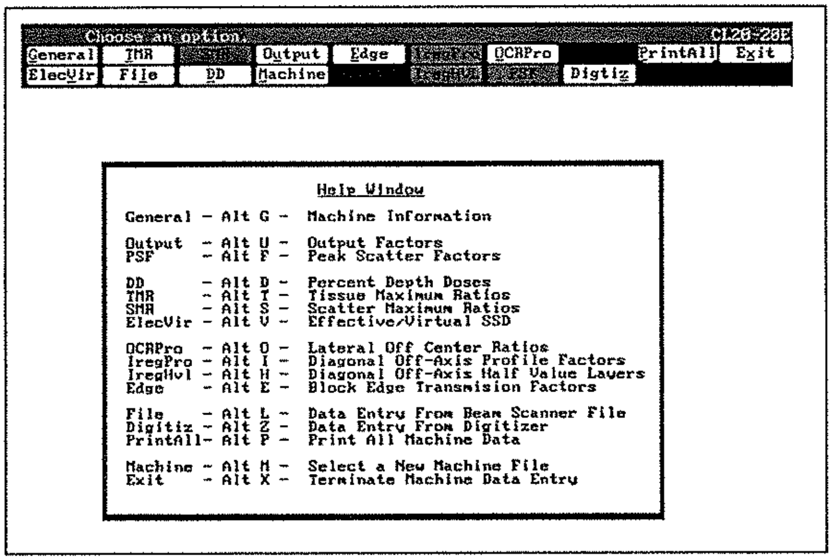
The block edge profile must be measured for all blocking types used. Profiles are measured at d_{max} for an open field and a blocked field and ratioed on a point-by-point basis.

III. MACHINE FILE INITIALIZATION

From the main treatment planning menu, select **Configuration** and then **Machine Data Entry**. To create a new machine file, enter the machine file name using a minimum of six and a maximum of eight characters (the name is not case sensitive). The file name entered will be displayed when selecting a machine from within the calculation modules. After it is created, the file will be available to all calculation modules. Press **Enter**.

When a new machine data file is created, all of the appropriate structures are created and access to these structures is provided through the functions shown on the screen. With few restrictions, editing the data can be done in almost any order.

The main machine data entry window is presented in Figure 10.1.



```
                    Help Window

General - Alt G -  Machine Information

Output  - Alt U -  Output Factors
PSF     - Alt F -  Peak Scatter Factors

DD      - Alt D -  Percent Depth Doses
TMR     - Alt T -  Tissue Maximum Ratios
SMR     - Alt S -  Scatter Maximum Ratios
ElecVir - Alt V -  Effective/Virtual SSD

OCRPro  - Alt O -  Lateral Off Center Ratios
IregPro - Alt I -  Diagonal Off-Axis Profile Factors
IregHvl - Alt H -  Diagonal Off-Axis Half Value Layers
Edge    - Alt E -  Block Edge Transmision Factors

File    - Alt L -  Data Entry From Beam Scanner File
Digitiz - Alt Z -  Data Entry From Digitizer
PrintAll- Alt P -  Print All Machine Data

Machine - Alt M -  Select a New Machine File
Exit    - Alt X -  Terminate Machine Data Entry
```

Figure 10.1 - Main Machine Data Entry Window

You are then prompted for the general machine information (see the next section).

The next pop-up prompts for parameters that are needed to initialize all data tables. Enter the maximum depth of your depth dose data in centimeters. This value is not generally important because most of the machine file entry options override it, however, if the data is going to be manually entered or digitized, an accurate value is needed.

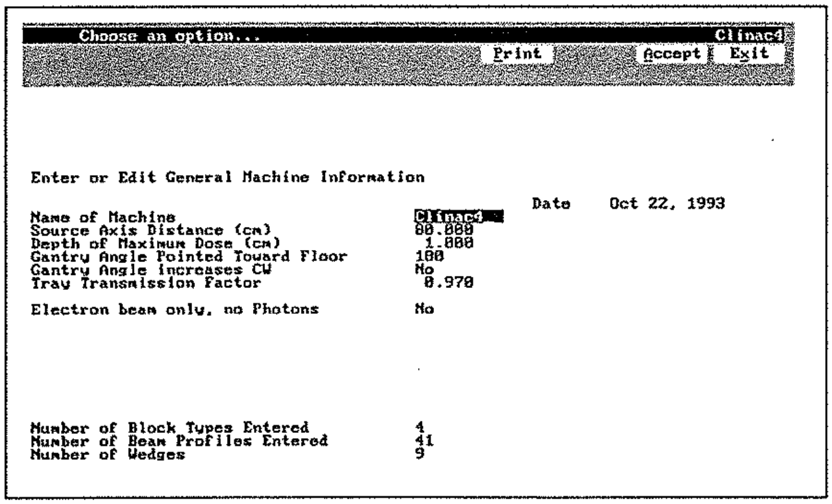
Next, enter the maximum 2X/W OCR profile width. The units of 2X/W are dimensionless where X is the off-axis distance and W is the width of the beam at depth. Thus, 2X/W distance is the proportion of the distance from the central axis to the geometric beam edge at depth. Using this dimensionless quantity, the geometric edge of the beam is always at a distance of 1.0. A large maximum value provides for many data points outside the beam at the expense of high resolution. The default value of 1.5 is generally a good compromise.

Third, enter the number of profile depths that will be used for wedge zero (i.e., the open beam). There must be at least four depths, however, five to seven are recommended. The profiles start at either the surface or at d_{max} and generally proceed to approximately 30 cm deep. Finally, enter the profile depths in centimeters. d_{max} must be included for x-ray fields.

The bottom of the screen displays the number of blocks, beam profiles, and the number of wedges entered. The date the file created is also shown on the screen. To save this data, select Accept.

IV. GENERAL DATA

Choose General to edit general information. The general data edit window is shown in Figure 10.2.



```
Enter or Edit General Machine Information

                                                    Date     Oct 22, 1993
Name of Machine                          Clinac4
Source Axis Distance (cm)                80.000
Depth of Maximum Dose (cm)                1.000
Gantry Angle Pointed Toward Floor        100
Gantry Angle increases CW                No
Tray Transmission Factor                  0.970

Electron beam only, no Photons           No



Number of Block Types Entered            4
Number of Beam Profiles Entered          41
Number of Wedges                         9
```

Figure 10.2 - General Data Edit Window

Enter the name of the machine. It will appear on all printouts and may be the same as the file name.

Enter the Source to Axis Distance (SAD) or nominal Source to Skin Distance (SSD). This is typically 80 or 100 cm.

Enter the depth of dose maximum in centimeters along the central axis for a 10 x 10 cm field.

Enter the gantry angle indicated when the beam is pointed at the floor. Enter "Yes" or "No" to indicate whether the gantry angle increases when the beam rotates in the clockwise direction.

Enter the most common blocking tray transmission factor.

Answer "Yes" or "No" as to whether this is an electron beam. When the entries are satisfactory, choose Accept.

V. CENTRAL AXIS DATA

From the machine data entry menu, central axis data (see Figure 10.3) may be examined by selecting TMR, SMR or DD. Prowess uses the TMR and SMR tables for all teletherapy calculations. These tables are generally calculated from measured %DD data.

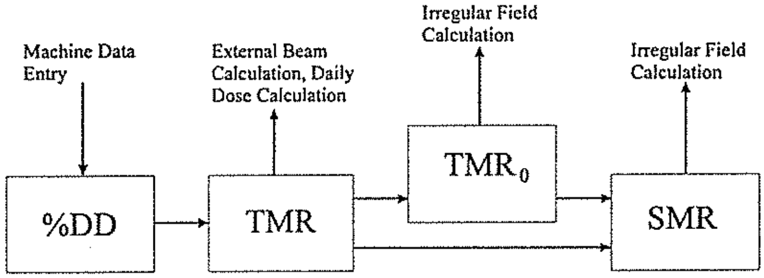
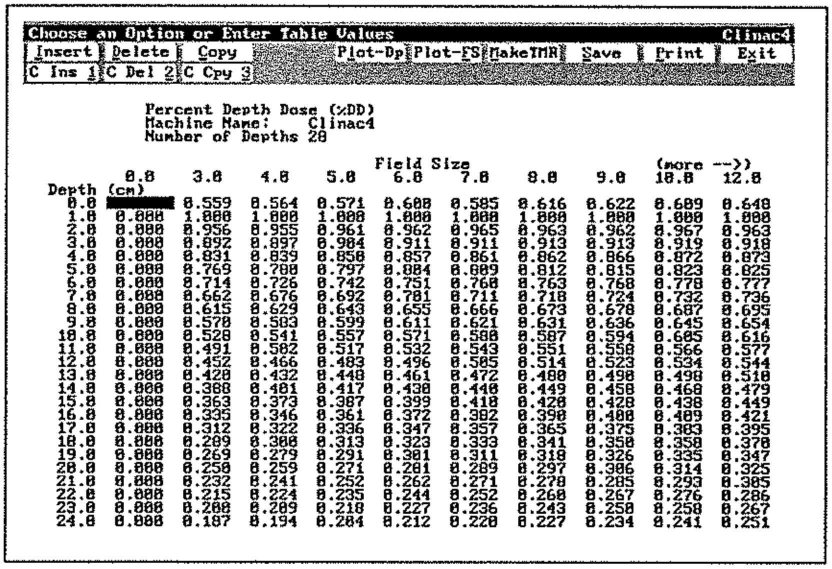


Figure 10.3 - Central Axis Data

A. Depth Dose

Choose DD to access the %DD data edit window as shown in Figure 10.4. Initially, you will find an empty matrix with no field sizes and depths from 0 cm to the maximum depth specified during initialization. Type in the %DD if desired. Ensure that as a field size is entered, a column (C Ins 1) is inserted into your data set. Also, ensure that a valid field size label is entered at the top of each column.



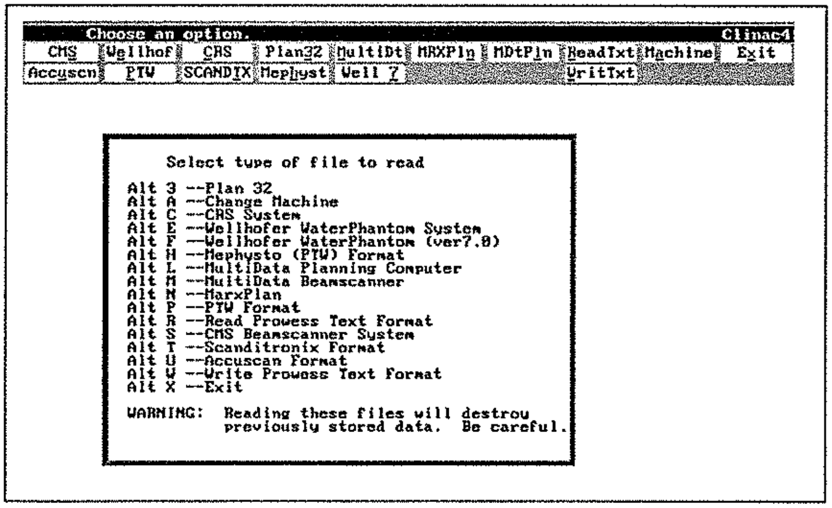
```
           Percent Depth Dose (%DD)
           Machine Name:     Clinac4
           Number of Depths 20

                                        Field Size                         (more -->)
         0.0     3.0     4.0     5.0     6.0     7.0     8.0     9.0    10.0    12.0
Depth (cm)
  0.0          0.559   0.564   0.571   0.600   0.585   0.616   0.622   0.609   0.640
  1.0   0.000  1.000   1.000   1.000   1.000   1.000   1.000   1.000   1.000   1.000
  2.0   0.000  0.956   0.955   0.961   0.962   0.965   0.963   0.962   0.967   0.963
  3.0   0.000  0.892   0.897   0.904   0.911   0.911   0.913   0.913   0.919   0.918
  4.0   0.000  0.831   0.839   0.850   0.857   0.861   0.862   0.866   0.872   0.873
  5.0   0.000  0.769   0.780   0.797   0.804   0.809   0.812   0.815   0.823   0.825
  6.0   0.000  0.714   0.726   0.742   0.751   0.760   0.763   0.768   0.778   0.777
  7.0   0.000  0.662   0.676   0.692   0.701   0.711   0.718   0.724   0.732   0.736
  8.0   0.000  0.615   0.629   0.643   0.655   0.666   0.673   0.678   0.687   0.695
  9.0   0.000  0.570   0.583   0.599   0.611   0.621   0.631   0.636   0.645   0.654
 10.0   0.000  0.528   0.541   0.557   0.571   0.580   0.587   0.594   0.605   0.616
 11.0   0.000  0.491   0.502   0.517   0.532   0.543   0.551   0.558   0.566   0.577
 12.0   0.000  0.452   0.466   0.483   0.496   0.505   0.514   0.523   0.534   0.544
 13.0   0.000  0.420   0.432   0.448   0.461   0.472   0.480   0.490   0.498   0.510
 14.0   0.000  0.388   0.401   0.417   0.430   0.440   0.449   0.458   0.468   0.479
 15.0   0.000  0.363   0.373   0.387   0.399   0.410   0.420   0.428   0.438   0.449
 16.0   0.000  0.335   0.346   0.361   0.372   0.382   0.390   0.400   0.409   0.421
 17.0   0.000  0.312   0.322   0.336   0.347   0.357   0.365   0.375   0.383   0.395
 18.0   0.000  0.289   0.300   0.313   0.323   0.333   0.341   0.350   0.358   0.370
 19.0   0.000  0.269   0.279   0.291   0.301   0.311   0.318   0.326   0.335   0.347
 20.0   0.000  0.250   0.259   0.271   0.281   0.289   0.297   0.306   0.314   0.325
 21.0   0.000  0.232   0.241   0.252   0.262   0.271   0.278   0.285   0.293   0.305
 22.0   0.000  0.215   0.224   0.235   0.244   0.252   0.260   0.267   0.276   0.286
 23.0   0.000  0.200   0.209   0.218   0.227   0.236   0.243   0.250   0.258   0.267
 24.0   0.000  0.187   0.194   0.204   0.212   0.220   0.227   0.234   0.241   0.251
```

Figure 10.4 - %DD Data Edit Window

It is generally preferable to enter depth dose data using files created by a beam data acquisition system.

1. %DD File Entry

Choose File from the main machine data entry menu. Choose the file type from the button bar shown in Figure 10.5.



```
Select type of file to read

Alt 3 --Plan 32
Alt A --Change Machine
Alt C --CRS System
Alt E --Wellhofer WaterPhantom System
Alt F --Wellhofer WaterPhantom (ver7.0)
Alt H --Mephysto (PTW) Format
Alt L --MultiData Planning Computer
Alt M --MultiData Beamscanner
Alt N --MarxPlan
Alt P --PTW Format
Alt R --Read Prowess Text Format
Alt S --CMS Beamscanner System
Alt T --Scanditronix Format
Alt U --Accuscan Format
Alt W --Write Prowess Text Format
Alt X --Exit

WARNING:  Reading these files will destroy
          previously stored data.  Be careful.
```

Figure 10.5 - File Source Selection Window

Select %DD entry from the curve type selection window as shown in Figure 10.6.

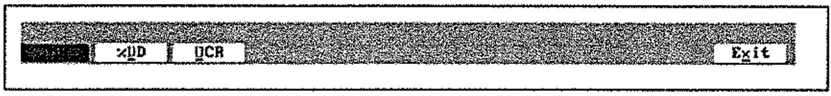
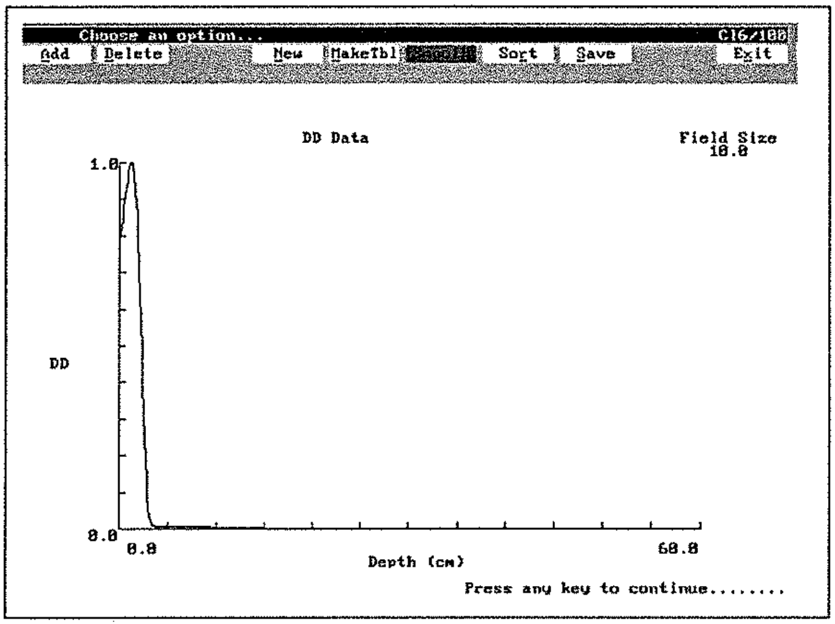


Figure 10.6 - Curve Type Selection Window

The TMR format should not be used because better results are obtained if the TMR table is calculated from a %DD table.

Enter the complete path and file name of the beam scanner file to be converted, e.g., C:\PROWESS\ACCUSCAN\410.DAT.

Multiple files can be entered from the file entry window as shown in Figure 10.7.



Choose an option...

Press any key to continue........

Figure 10.7 - File Entry Window

Prowess only reads beam data files which are stored in an ASCII format. The CRS and ACCUSCAN beam data acquisition systems store their data in ASCII format, therefore, no manipulation is necessary. If using the Scanditronix, MultiData, PTW, or Welhöfer water tank, refer to the manufacturer's manual to determine how to store an ASCII text file. From the MultiData file format options, choose the comma delimited ASCII option, instead of the printer text file option. If you encounter problems, contact the beam scanner manufacturer.

2. Discrete Scanner Files

One %DD data entry procedure is used for all beam scanners except MultiData, Welhöfer, and CMS. To begin, choose File, Accuscan (or some other name), and %DD options. An empty depth dose graph will appear on the screen. Add the depth dose data files for each field size. To enter the first field size, choose Add and then type in the exact drive path and name of the data file to be used (e.g., A:\DIRECTORY\filename.dat). Enter the field size of the data set. If the field size you enter does not match that specified in the data file, an error will occur. To override the field size in the data file, type **Enter**. Select **ESC**ape to abort the entry.

If the file is read and the format is correct, a %DD scan will appear on the screen. The field size is shown on the right in the same color as the %DD displayed. Continue entering the remaining data files until all field sizes have been entered.

Each time Add is chosen, the last path and file name will be displayed. The program will add the default extension for the scanner. When a scan is entered at an existing field size, the previous scan is overwritten.

After all of the field sizes have been entered, save the data by choosing Save. If the field sizes were not entered in ascending order, choose Sort, then Save. Choose MakeTbl to move this data into the depth dose matrix. All existing data will be overwritten. The %DD of each depth in the %DD table will be interpolated from the beam scanner file and stored in the %DD table.

Return to the main data entry menu to review the data set. Choose %**D**D to view the entered data. Notice that the zero field size is blank.

3. Combined Scanner Files

MultiData, Welhöfer, and CMS files are entered using a different procedure. For MultiData and CMS, ensure that the depth dose data has been combined into one file and saved in comma delimited or ASCII format. For Welhöfer, the ASCII files must be stored in a single directory on the C: drive. To enter the depth dose, choose the type of scanner and the depth dose option. Then, give it either the name of the directory or the name of the composite data file where the data is stored. The program reads the data file and puts it directly into the depth dose matrix. Individual depths cannot be entered easily from the MultiData scanner. With CMS and Welhöfer, they may be entered one at a time and appended to the %DD file.

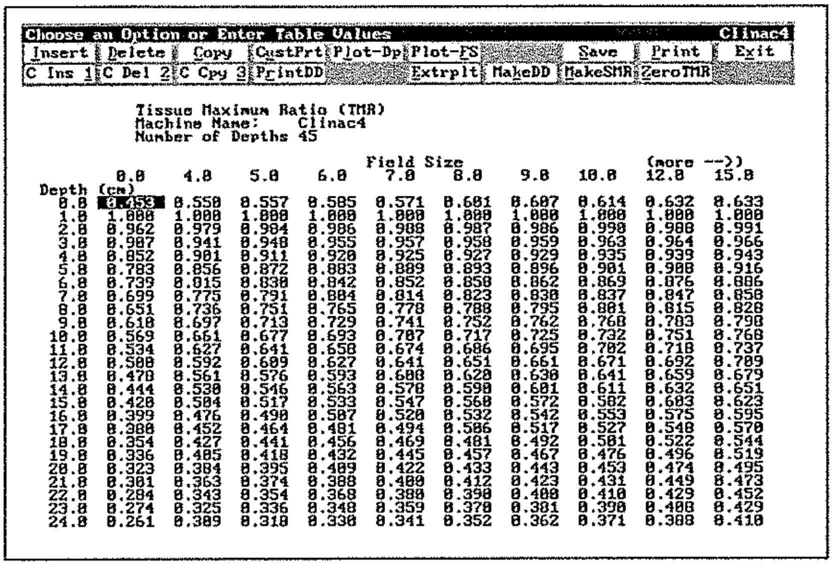
VI. TMR

After the %DD values have been entered, the TMR table can be calculated from the %DD table. If this is an electron machine, ensure that the virtual SSDs for all field sizes and energies have been entered. Note that PSFs are not used in calculating TMRs from %DD.

There is a limitation on the field size conversion from depth dose to TMR. When a TMR table is generated from the depth dose data, the smallest field size entered will be deleted. If this field size is needed, create a new column of field sizes 1 cm smaller than the smallest available field size. Manually extrapolate %DD values for this new field size from existing values.

Before making the TMR table, choose Save to save the %DD table. To make the TMR table, choose MakeTbl. Note that existing TMR data will be overwritten.

Examine the new TMR table by exiting the %DD table and choosing TMR. The TMR data edit window appears as shown in Figure 10.8.

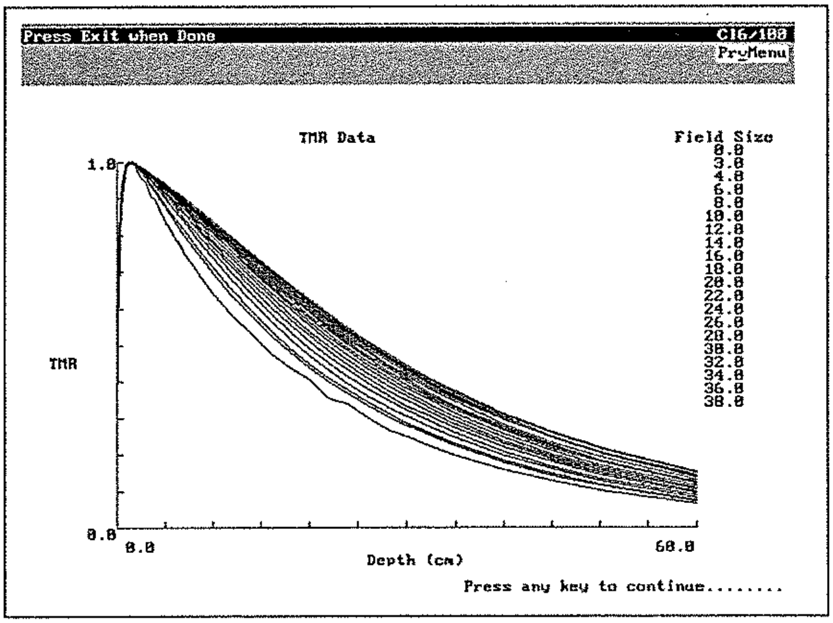


Tissue Maximum Ratio (TMR)
Machine Name: Clinac4
Number of Depths 45

Depth (cm)	Field Size 0.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	(more -->) 12.0	15.0
0.0	0.453	0.550	0.557	0.585	0.571	0.601	0.607	0.614	0.632	0.633
1.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2.0	0.962	0.979	0.984	0.986	0.988	0.987	0.986	0.990	0.988	0.991
3.0	0.907	0.941	0.948	0.955	0.957	0.958	0.959	0.963	0.964	0.966
4.0	0.852	0.901	0.911	0.920	0.925	0.927	0.929	0.935	0.939	0.943
5.0	0.783	0.856	0.872	0.883	0.889	0.893	0.896	0.901	0.908	0.916
6.0	0.739	0.815	0.830	0.842	0.852	0.858	0.862	0.869	0.876	0.886
7.0	0.699	0.775	0.791	0.804	0.814	0.823	0.830	0.837	0.847	0.858
8.0	0.651	0.736	0.751	0.765	0.778	0.788	0.795	0.801	0.815	0.828
9.0	0.610	0.697	0.713	0.729	0.741	0.752	0.762	0.768	0.783	0.798
10.0	0.569	0.661	0.677	0.693	0.707	0.717	0.725	0.732	0.751	0.768
11.0	0.534	0.627	0.641	0.658	0.674	0.686	0.695	0.702	0.718	0.737
12.0	0.500	0.592	0.609	0.627	0.641	0.651	0.661	0.671	0.692	0.709
13.0	0.470	0.561	0.576	0.593	0.608	0.620	0.630	0.641	0.659	0.679
14.0	0.444	0.530	0.546	0.563	0.578	0.590	0.601	0.611	0.632	0.651
15.0	0.420	0.504	0.517	0.533	0.547	0.560	0.572	0.582	0.603	0.623
16.0	0.399	0.476	0.490	0.507	0.520	0.532	0.542	0.553	0.575	0.595
17.0	0.380	0.452	0.464	0.481	0.494	0.506	0.517	0.527	0.548	0.570
18.0	0.354	0.427	0.441	0.456	0.469	0.481	0.492	0.501	0.522	0.544
19.0	0.336	0.405	0.418	0.432	0.445	0.457	0.467	0.476	0.496	0.519
20.0	0.323	0.384	0.395	0.409	0.422	0.433	0.443	0.453	0.474	0.495
21.0	0.301	0.363	0.374	0.388	0.400	0.412	0.423	0.431	0.449	0.473
22.0	0.284	0.343	0.354	0.368	0.380	0.390	0.400	0.410	0.429	0.452
23.0	0.274	0.325	0.336	0.348	0.359	0.370	0.381	0.390	0.408	0.429
24.0	0.261	0.309	0.318	0.330	0.341	0.352	0.362	0.371	0.388	0.410

Figure 10.8 - TMR Data Edit Window

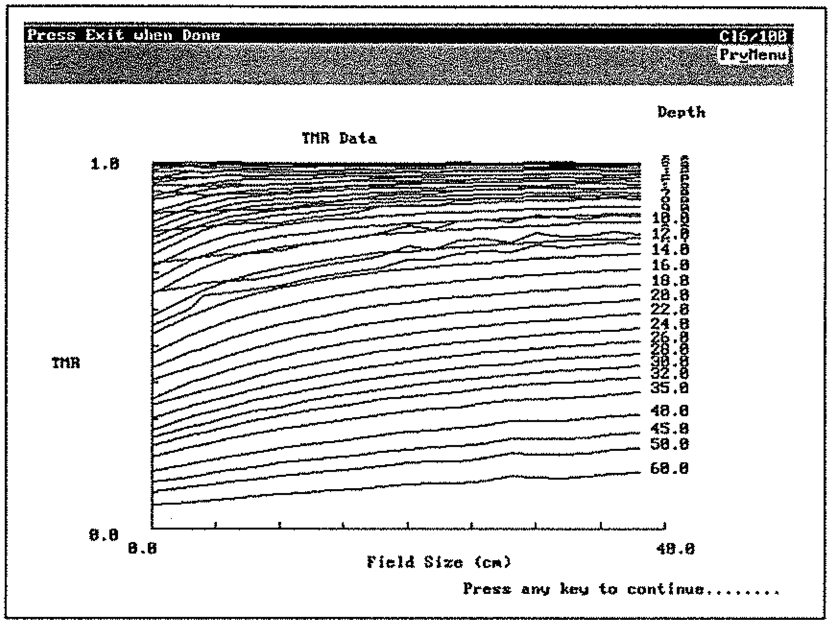
Select Plot-Dp to plot on the screen in a depth dependent format as shown in Figure 10.9.



Press any key to continue........

Figure 10.9 - Plot vs. Depth Window

Select Plot-FS to plot on the screen in a field size dependent format as shown in Figure 10.10.


Press Exit when Done

Press any key to continue........

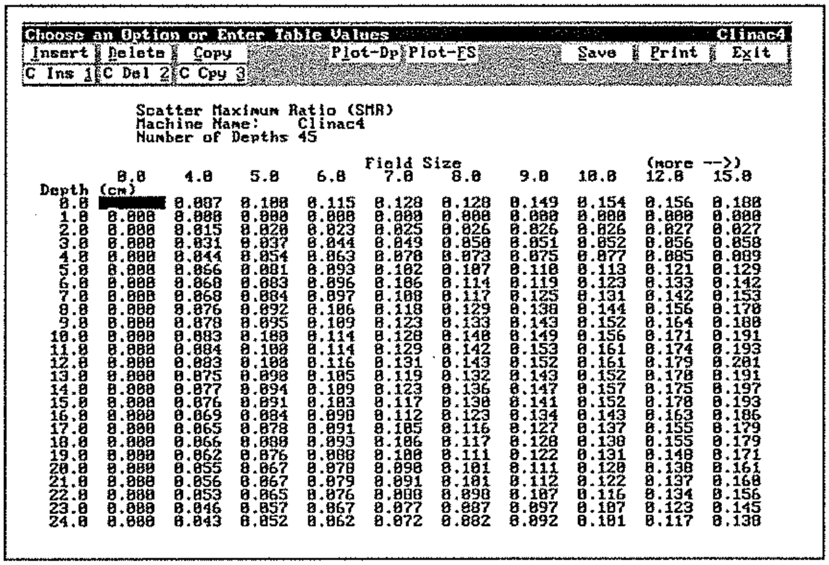
Figure 10.10 - Plot vs. Field Size Window

The TMR data must be extrapolated to depths as great as the thickest patient to be treated. Choose Extraplt to extrapolate the data. This procedure fits the last 15 cm of the measured data to an exponential function and extrapolates the TMR to fill the matrix (50 depths). If the last depth is not large enough, hand extrapolate the data and enter this data into the last depth position. For electrons, simply append a depth of approximately 50 cm to the end of the TMR table with values of zero. Spacing of depths does not have to be equal, so depths may be concentrated in the build-up region and expanded near the end of the table.

For photon machines, zero area TMR data must be entered. To calculate zero area TMRs from finite area TMRs, choose ZeroTMR. Ensure that there are zero depth entries for all field sizes. Plot the data on the screen by choosing Plot-FS or Plot-Dp and ensure that the data is acceptable. When plotting as a function of depth, a new blue line (the zero field size) should be below all other curves and follow the general shape of the curves. Sometimes, noise in measured data can lead to errors in the extrapolated TMR values. It may be necessary to hand extrapolate some of the data until the results are acceptable. Of course, the zero TMR may be entered by hand from manually measured or generated data. Once the TMR table is satisfactory, save and print the table.

VII. SMR

The SMR table is calculated from within the TMR data edit window. To calculate the SMR table, choose MakSMR. This procedure will overwrite any existing SMR data and confirmation of the overwrite is necessary. To view the SMRs, exit the TMR table by selecting Exit. Then, choose SMR. The table of SMRs will be shown on the screen as in Figure 10.11.



Scatter Maximum Ratio (SMR)
Machine Name: Clinac4
Number of Depths 45

Field Size (more -->)

Depth (cm)	0.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	12.0	15.0
0.0		0.087	0.100	0.115	0.128	0.128	0.149	0.154	0.156	0.180
1.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.0	0.000	0.015	0.020	0.023	0.025	0.026	0.026	0.026	0.027	0.027
3.0	0.000	0.031	0.037	0.044	0.049	0.050	0.051	0.052	0.056	0.058
4.0	0.000	0.044	0.054	0.063	0.070	0.073	0.075	0.077	0.085	0.089
5.0	0.000	0.066	0.081	0.093	0.102	0.107	0.110	0.113	0.121	0.129
6.0	0.000	0.060	0.083	0.096	0.106	0.114	0.119	0.123	0.133	0.142
7.0	0.000	0.068	0.084	0.097	0.108	0.117	0.125	0.131	0.142	0.153
8.0	0.000	0.076	0.092	0.106	0.118	0.129	0.138	0.144	0.156	0.170
9.0	0.000	0.078	0.095	0.109	0.123	0.133	0.143	0.152	0.164	0.180
10.0	0.000	0.083	0.100	0.114	0.128	0.140	0.149	0.156	0.171	0.191
11.0	0.000	0.084	0.100	0.114	0.129	0.142	0.153	0.161	0.174	0.193
12.0	0.000	0.083	0.100	0.116	0.131	0.143	0.152	0.161	0.179	0.201
13.0	0.000	0.075	0.098	0.105	0.119	0.132	0.143	0.152	0.178	0.191
14.0	0.000	0.077	0.094	0.109	0.123	0.136	0.147	0.157	0.175	0.197
15.0	0.000	0.076	0.091	0.103	0.117	0.130	0.141	0.152	0.170	0.193
16.0	0.000	0.069	0.084	0.090	0.112	0.123	0.134	0.143	0.163	0.186
17.0	0.000	0.065	0.078	0.091	0.105	0.116	0.127	0.137	0.155	0.179
18.0	0.000	0.066	0.080	0.093	0.106	0.117	0.128	0.138	0.155	0.179
19.0	0.000	0.062	0.076	0.088	0.100	0.111	0.122	0.131	0.148	0.171
20.0	0.000	0.055	0.067	0.078	0.090	0.101	0.111	0.120	0.138	0.161
21.0	0.000	0.056	0.067	0.079	0.091	0.101	0.112	0.122	0.137	0.160
22.0	0.000	0.053	0.065	0.076	0.088	0.098	0.107	0.116	0.134	0.156
23.0	0.000	0.046	0.057	0.067	0.077	0.087	0.097	0.107	0.123	0.145
24.0	0.000	0.043	0.052	0.062	0.072	0.082	0.092	0.101	0.117	0.130

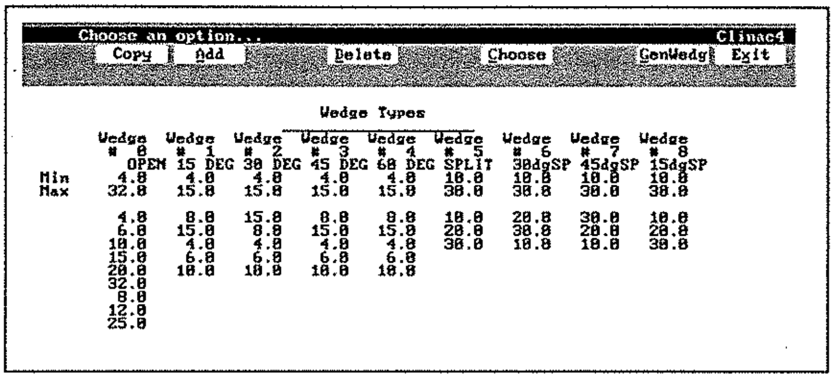
Figure 10.11 - SMR Data Edit Window

This table contains the SMR values for circular fields and the field size shown indicates the diameter in centimeters. View this data by choosing Plot-FS or Plot-Dp to ensure that it is acceptable. If SMR is plotted as a function of field size, the curves may not be completely smooth. If they are very jagged, go back and recheck the TMR data. If all the SMR values for certain field sizes are jagged, this is a result of the zero TMR data not being smooth. If all SMR curves are unsmooth, this probably indicates a problem in the extrapolation of zero area TMR. Edit these zero area TMR values and then recalculate the SMR table. Notice that the largest field size in the SMR table is the largest field size in the depth dose table. If field sizes greater than this diameter are needed, (e.g., for extended SSD treatments), a larger field size may need to be calculated. Do this by hand extrapolating the table to a 50 x 50 cm field size.

VIII. OFF-AXIS EXTERNAL BEAM DATA

Select OCRPro to enter, edit, and display open beam profile data. The data entered is a series of lateral profiles at five or more depths over the range of available field sizes. For x-rays, the first profile is measured at d_{max} and the remaining depths are spaced at intervals of 5-8 cm below d_{max} (suggested depths of d_{max}: 5, 10, 15, 20, and 25 cm deep). For electron beams, the profiles are measured at equal depth increments throughout the useful range of the beam. At least one profile should be measured in the Bremsstrahlung Tail. The data is stored in the dimensionless 2X/W distances and conversion to 2X/W coordinates is made automatically.

Entry begins with display of the wedges, names, field sizes, and field size minima and maxima. A new wedge can be added or an existing wedge can be deleted from the wedge selection window as shown in Figure 10.12.

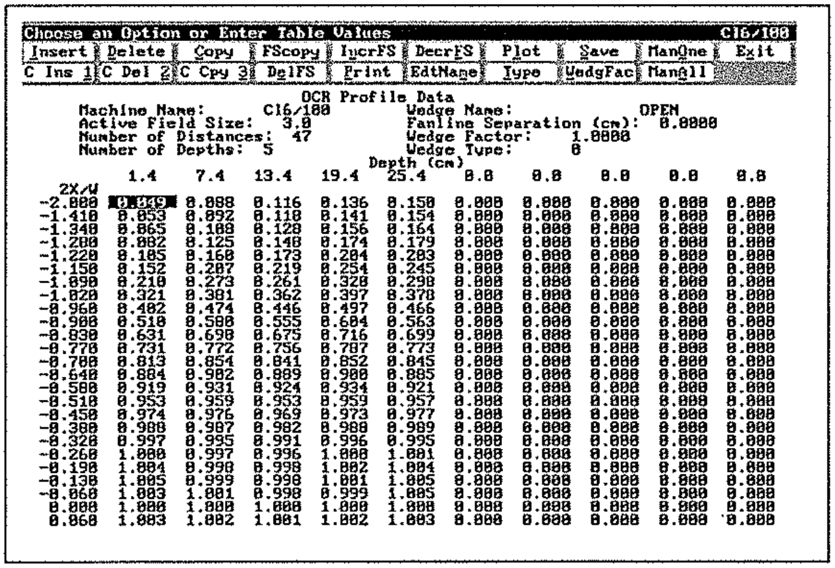


```
                          Wedge Types

       Wedge  Wedge  Wedge  Wedge  Wedge  Wedge  Wedge  Wedge  Wedge
       #  0   #  1   #  2   #  3   #  4   #  5   #  6   #  7   #  8
        OPEN 15 DEG 30 DEG 45 DEG 60 DEG SPLIT  30dgSP 45dgSP 15dgSP
Min     4.0    4.0    4.0    4.0    4.0   10.0   10.0   10.0   10.0
Max    32.0   15.0   15.0   15.0   15.0   30.0   30.0   30.0   30.0

        4.0    8.0   15.0    8.0    8.0   10.0   20.0   30.0   10.0
        6.0   15.0    8.0   15.0   15.0   20.0   30.0   20.0   20.0
       10.0    4.0    4.0    4.0    4.0   30.0   10.0   10.0   30.0
       15.0    6.0    6.0    6.0    6.0
       20.0   10.0   10.0   10.0   10.0
       32.0
        8.0
       12.0
       25.0
```

Figure 10.12 - Wedge Selection Window

After a wedge is selected, the OCR edit window is presented and the OCR values shown as in Figure 10.13.

The OCR data is stored from negative 2X/W to positive 2X/W values. The positive 2X/W data is shown on the screen on the right side as illustrated on the screen in Figure 10.12. Using this data for external beam calculation, the positive OCR data appears on the right side of a beam if the beams is pointing downward in a plane.



```
                          OCR Profile Data
   Machine Name:        C16/100        Wedge Name:                  OPEN
   Active Field Size:    3.0           Fanline Separation (cm):  0.0000
   Number of Distances:  47            Wedge Factor:      1.0000
   Number of Depths:  5                Wedge Type:        0
                                     Depth (cm)
           1.4    7.4    13.4   19.4   25.4    0.0    0.0    0.0    0.0    0.0
   2X/W
 -2.000  0.049  0.088  0.116  0.136  0.150  0.000  0.000  0.000  0.000  0.000
 -1.410  0.053  0.092  0.118  0.141  0.154  0.000  0.000  0.000  0.000  0.000
 -1.340  0.065  0.100  0.128  0.156  0.164  0.000  0.000  0.000  0.000  0.000
 -1.280  0.082  0.125  0.140  0.174  0.179  0.000  0.000  0.000  0.000  0.000
 -1.220  0.105  0.160  0.173  0.204  0.203  0.000  0.000  0.000  0.000  0.000
 -1.150  0.152  0.207  0.219  0.254  0.245  0.000  0.000  0.000  0.000  0.000
 -1.090  0.210  0.273  0.261  0.320  0.290  0.000  0.000  0.000  0.000  0.000
 -1.020  0.321  0.381  0.362  0.397  0.370  0.000  0.000  0.000  0.000  0.000
 -0.960  0.402  0.474  0.446  0.497  0.466  0.000  0.000  0.000  0.000  0.000
 -0.900  0.510  0.580  0.555  0.604  0.563  0.000  0.000  0.000  0.000  0.000
 -0.830  0.631  0.690  0.675  0.716  0.699  0.000  0.000  0.000  0.000  0.000
 -0.770  0.731  0.772  0.756  0.787  0.773  0.000  0.000  0.000  0.000  0.000
 -0.700  0.813  0.854  0.841  0.852  0.845  0.000  0.000  0.000  0.000  0.000
 -0.640  0.884  0.902  0.889  0.900  0.885  0.000  0.000  0.000  0.000  0.000
 -0.580  0.919  0.931  0.924  0.934  0.921  0.000  0.000  0.000  0.000  0.000
 -0.510  0.953  0.959  0.953  0.959  0.957  0.000  0.000  0.000  0.000  0.000
 -0.450  0.974  0.976  0.969  0.973  0.977  0.000  0.000  0.000  0.000  0.000
 -0.380  0.980  0.987  0.982  0.988  0.989  0.000  0.000  0.000  0.000  0.000
 -0.320  0.997  0.995  0.991  0.996  0.995  0.000  0.000  0.000  0.000  0.000
 -0.260  1.000  0.997  0.996  1.000  1.001  0.000  0.000  0.000  0.000  0.000
 -0.190  1.004  0.990  0.998  1.002  1.004  0.000  0.000  0.000  0.000  0.000
 -0.130  1.005  0.999  0.998  1.001  1.005  0.000  0.000  0.000  0.000  0.000
 -0.060  1.003  1.001  0.998  0.999  1.005  0.000  0.000  0.000  0.000  0.000
  0.000  1.000  1.000  1.000  1.000  1.000  0.000  0.000  0.000  0.000  0.000
  0.060  1.003  1.002  1.001  1.002  1.003  0.000  0.000  0.000  0.000  0.000
```

Figure 10.13 - OCR Edit Window

Select Plot from the OCR Plotting window to view the OCR curves on the screen as shown in Figure 10.14.

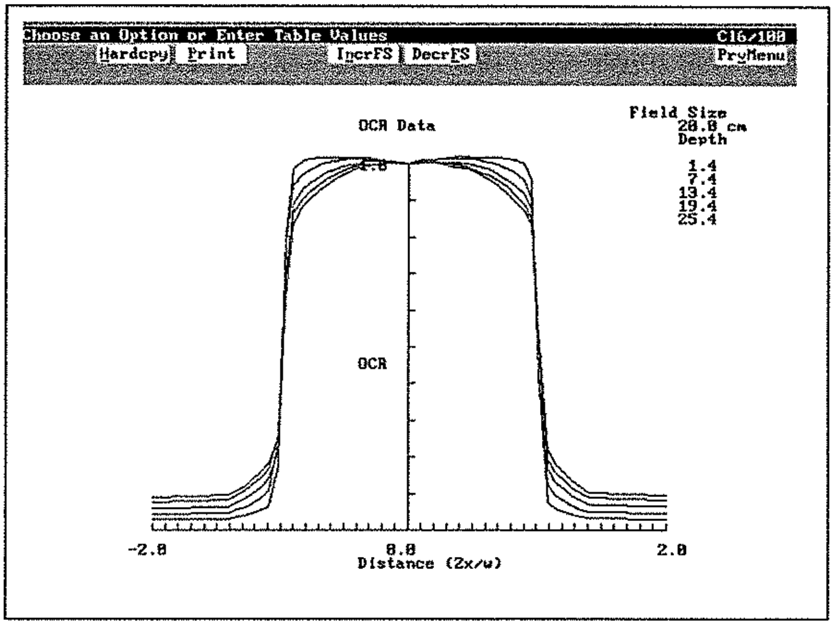
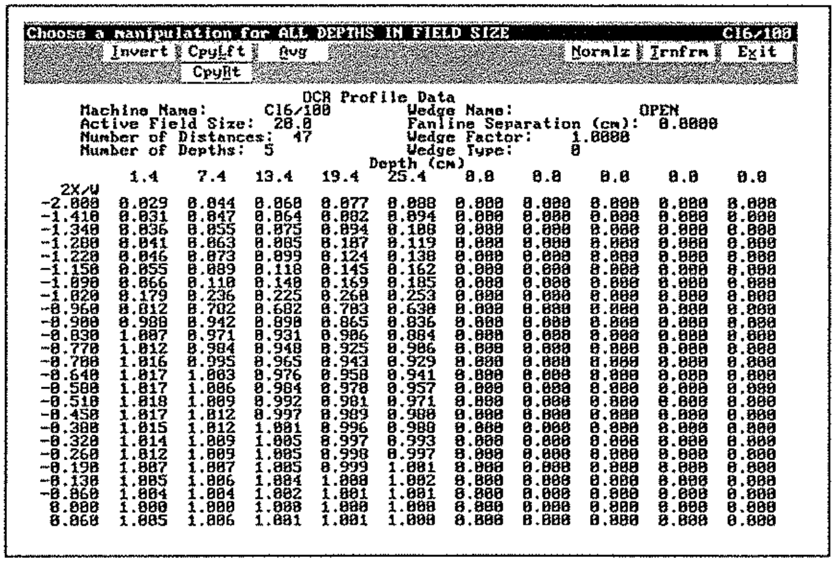


Figure 10.14 - OCR Plotting Window

Individual OCR values can be edited. Single OCR curves can be manipulated or the entire field sizes OCR table can be manipulated. Choose ManOne to change only the current depth or ManAll to change all depths. Choosing either will take you to the OCR manipulation window shown in Figure 10.15.

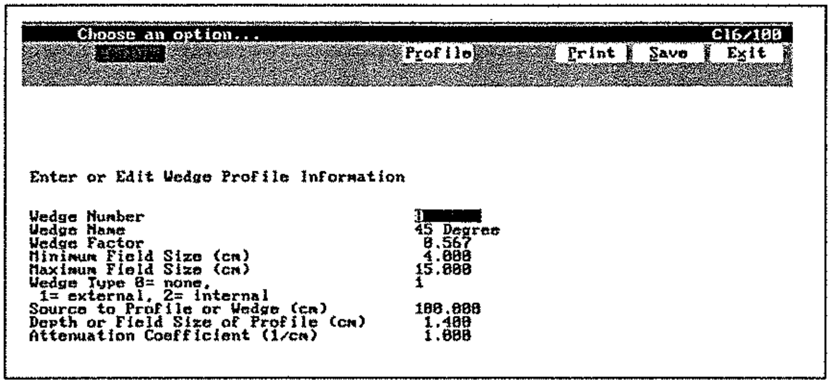


```
                              OCR Profile Data
       Machine Name:       C16/100           Wedge Name:              OPEN
       Active Field Size:  20.0              Fanline Separation (cm):  0.0000
       Number of Distances:  47              Wedge Factor:     1.0000
       Number of Depths:  5                  Wedge Type:       0
                                        Depth (cm)
           1.4     7.4    13.4    19.4    25.4    0.0     0.0     0.0     0.0     0.0
   2X/W
 -2.000   0.029   0.044   0.060   0.077   0.088   0.000   0.000   0.000   0.000   0.000
 -1.410   0.031   0.047   0.064   0.082   0.094   0.000   0.000   0.000   0.000   0.000
 -1.340   0.036   0.055   0.075   0.094   0.100   0.000   0.000   0.000   0.000   0.000
 -1.280   0.041   0.063   0.085   0.107   0.119   0.000   0.000   0.000   0.000   0.000
 -1.220   0.046   0.073   0.099   0.124   0.138   0.000   0.000   0.000   0.000   0.000
 -1.150   0.055   0.089   0.118   0.145   0.162   0.000   0.000   0.000   0.000   0.000
 -1.090   0.066   0.110   0.140   0.169   0.185   0.000   0.000   0.000   0.000   0.000
 -1.020   0.179   0.236   0.225   0.260   0.253   0.000   0.000   0.000   0.000   0.000
 -0.960   0.812   0.702   0.682   0.703   0.638   0.000   0.000   0.000   0.000   0.000
 -0.900   0.980   0.942   0.890   0.865   0.836   0.000   0.000   0.000   0.000   0.000
 -0.830   1.007   0.971   0.931   0.906   0.884   0.000   0.000   0.000   0.000   0.000
 -0.770   1.012   0.984   0.948   0.925   0.906   0.000   0.000   0.000   0.000   0.000
 -0.700   1.016   0.995   0.965   0.943   0.929   0.000   0.000   0.000   0.000   0.000
 -0.640   1.017   1.003   0.976   0.958   0.941   0.000   0.000   0.000   0.000   0.000
 -0.580   1.017   1.006   0.984   0.978   0.957   0.000   0.000   0.000   0.000   0.000
 -0.510   1.018   1.009   0.992   0.981   0.971   0.000   0.000   0.000   0.000   0.000
 -0.450   1.017   1.012   0.997   0.989   0.980   0.000   0.000   0.000   0.000   0.000
 -0.380   1.015   1.012   1.001   0.996   0.988   0.000   0.000   0.000   0.000   0.000
 -0.320   1.014   1.009   1.005   0.997   0.993   0.000   0.000   0.000   0.000   0.000
 -0.260   1.012   1.009   1.005   0.998   0.997   0.000   0.000   0.000   0.000   0.000
 -0.190   1.007   1.007   1.005   0.999   1.001   0.000   0.000   0.000   0.000   0.000
 -0.130   1.005   1.006   1.004   1.000   1.002   0.000   0.000   0.000   0.000   0.000
 -0.060   1.004   1.004   1.002   1.001   1.001   0.000   0.000   0.000   0.000   0.000
  0.000   1.000   1.000   1.000   1.000   1.000   0.000   0.000   0.000   0.000   0.000
  0.060   1.005   1.006   1.001   1.001   1.000   0.000   0.000   0.000   0.000   0.000
```

Figure 10.15 - OCR Manipulation Window

A. OCR Calculation

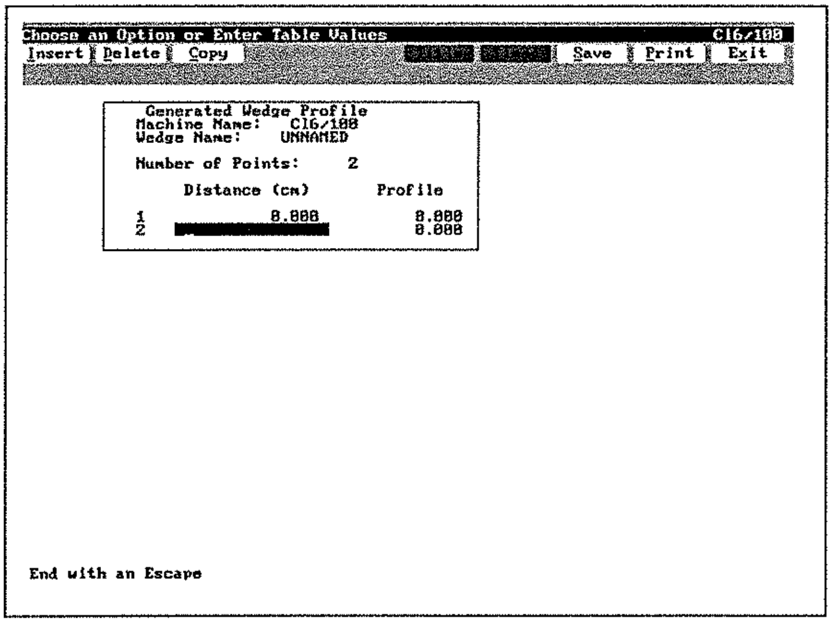
This procedure multiplies a wedge transmission profile by the open field size OCRs for each depth and field size. This is an approximate entry procedure replacing measured data. This technique is not recommended because the results are not as good as measured data. Adjust the shape of the wedge profile as necessary to achieve the appropriate shape. Choose GenWedg to access the wedge generation window as shown in Figure 10.16.



```
Enter or Edit Wedge Profile Information

Wedge Number                              1
Wedge Name                                45 Degree
Wedge Factor                               0.567
Minimum Field Size (cm)                    4.000
Maximum Field Size (cm)                   15.000
Wedge Type 0= none,                       1
  1= external, 2= internal
Source to Profile or Wedge (cm)           100.000
Depth or Field Size of Profile (cm)         1.400
Attenuation Coefficient (1/cm)              1.000
```

Figure 10.16 - Wedge Generation Window

Select Profile to enter the wedge shape as shown in Figure 10.17.



```
 Generated Wedge Profile
Machine Name:    C16/100
Wedge Name:      UNNAMED

Number of Points:      2

     Distance (cm)       Profile

1            0.000         0.000
2                          0.000

End with an Escape
```

Figure 10.17 - Wedge Profile Entry Window

Specify the attenuation coefficient for the wedge material. Two new options are now shown: MakWedg and Profile. Enter the shape of the profile at the source to the wedge distance specified. Once the profile is entered, the wedge may be created and saved. Choose wedge profile, plot, and verify it. This wedge profile data is saved.

B. OCR Measurement

OCRs are measured across each field width at a series of depths. They are generally normalized to 1.000 on the central axis. See Figure 10.18.

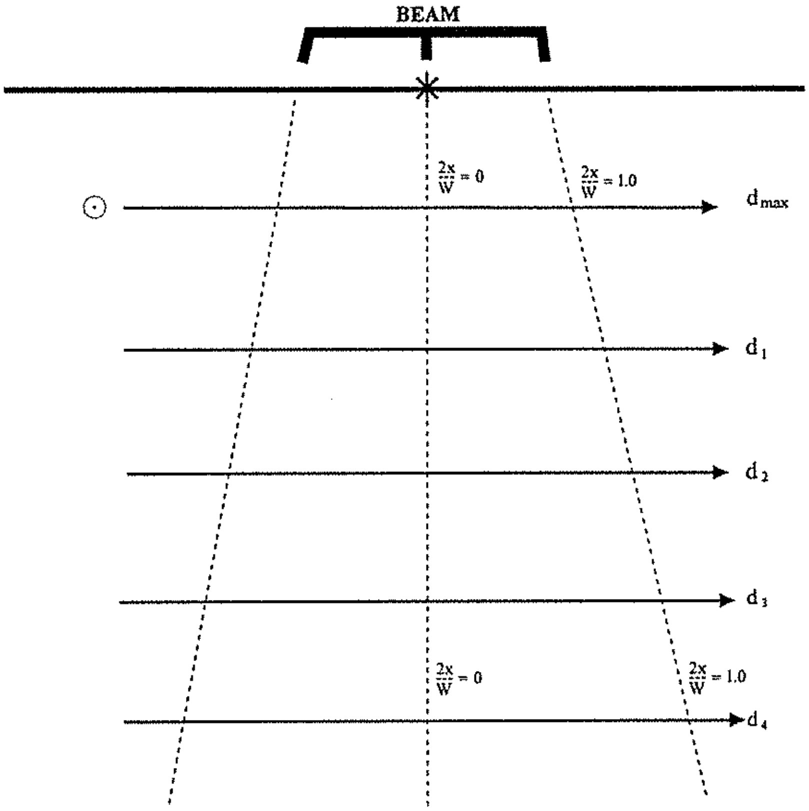


Figure 10.18 - OCR Measurement

Verify that the profile depths for each of the wedges are consistent. It will not be possible to enter wedge data unless the profile depths match for all field sizes. The depths for each wedge may be different, but all the measured depths for a single wedge must be the same.

C. OCR Entry

Create the number of wedges that are to be entered into this data set. Typically, this is four additional wedges (15°, 30°, 45°, and 60°). If there is an asymmetric collimator or a beam splitter, treat this as a wedge and add a fifth wedge type. If beam split wedges are used, create a new wedge for each of these configurations. A maximum of 10 wedges including the open field can be entered into each machine file. Create these additional wedges by selecting Add. A blank wedge will appear on the screen. Choose Save and Quit. Repeat this process until all empty wedge profiles have been created.

Choose a wedge for editing. The wedge OCR table is presented.

All of the data in this table may be edited. Use the arrow keys to move through the table. Remember, changing the depths and distances effects all field sizes within this wedge set. Depths and distances must be specified before profiles may be digitized or data can be entered from a file. After making changes to data files, press Save to save the changes. To edit depth or off-axis distance, use the arrow keys to move to the desired position. Type in the new value. Changes to these values effect all field sizes for that wedge. Save makes these changes permanent.

Wedge profiles must be entered such that the maximum value (e.g., the toe of the wedge) is displayed on the right side of the screen (i.e., positive distances). If it is reversed, finish entering all of the data and press ManAll, then Invert. This will reverse the orientation of the wedge.

If the profile measured depths within a wedge are not the same, compensate by changing the depths, saving them, entering the data for that particular field size, saving it, going back and editing the depths, saving them, entering the profiles for the next field size, and so on. The profiles are frequently slow, varying with field size and depth. Though this technique is not recommended, misregistration of depth will generally cause only minimal effect on the profile shape as all the data is normalized to a dimensionless distance parameter 2X/W.

1. OCR File Entry

Choose File from the Machine Entry menu.

Choose the beam scanner file type by name. Then choose OCR to signify profile data entry. Identify the wedge number to be entered. If this is the open wedge, enter zero. The screen displays an X-Y axis with OCR on the vertical axis and the distance on the horizontal axis extending from -30 cm to +30 cm. Select Add to enter a profile and enter the name of the file desired (e.g., C:\ACCUSCAN\347.DAT). Verify the field size. The profile or profiles will be normalized to 1.0 on the central axis and displayed on the screen.

If using a CRS or Accuscan scanner and there is one profile depth per file, enter all of the file names to build the complete profile set for that field size by selecting Add each time. When all of the profiles for that field size are entered, choose MakeTbl and verify. The profile set will be added to the OCR profile for the wedge number and field size specified. The order of field size entry is unimportant as sorting is handled internally by Prowess. To enter another field size, choose New to clear the screen. Repeat the procedure described above for each field size until all field sizes are entered. Be sure to choose MakeTbl, for each field size, and to save it before entering a new field size.

After entering the first profile, verify the data. To do this, select Quit until reaching the Main Machine entry menu. Choose OCRPro. Select the wedge and field size to view. Plot the profile with Plot. Ensure that the data is acceptable before proceeding to the next field size or wedge. Enter the remaining wedges following the same procedure choosing the appropriate wedge number and appropriate files to enter.

After entering all of the wedge profiles, add the remaining wedge data. To do this, choose OCRPro. Displayed on the screen is a listing of all of the profiles which have been added to the wedges. The minimum and maximum field sizes are still 10, which means that this data has not been processed or saved. Therefore, the minimum and maximum field sizes have not been registered in the data set. Each of the wedges must be processed.

Choose wedge zero and "0" for wedge number. A 10 x 10 field size will be displayed on the screen. View the profile by choosing Plot. Ensure that the data is acceptable and press **ES**Cape. Edit the remaining data for the wedges. Enter the name of the wedge by pressing EditNam and type "OPEN". This entry titles all field sizes for this wedge. Next, enter the wedge factor (WedgFac). For the open wedge, the wedge factor is 1.0 for all field sizes. Plot the profile on the screen and increment (IncrFS) and decrement (DecrFS) through all field sizes verifying the shape of the curves. If data points are found which are in error, manually edit them. To edit, select PrvMenu to exit from the plot. Using the arrow keys, move to the location of the error and correct it. Replot the data to verify your entry, then Save. Reviewing all the field sizes again and save the final version. All field sizes are saved and the maximum and minimum field sizes are registered. Press **ES**Cape to see the registered minimum and maximum field sizes and a name that has been entered for this wedge. Proceed to edit each of the wedge data sets entered.

More editing is required for the other wedges. Choose wedge one and plot it on the screen. The data may have been entered with the peak of the wedge data (thin end of wedge) on the left side of the screen. Prowess requires that the peak be on the right side of the screen. Increment through all of the field sizes to make sure that they are consistent, one might be reversed from the others.

Select ManAll to reverse or renormalize all the profiles in a field size. Choose Invert to reverse the wedge orientation. Confirm the result by plotting the data. Increment through all of the field sizes and perform the same procedure. ManAll applies to all depths for this single field size, it does not apply to all field sizes within this wedge. The function ManOne modifies only the active depth.

Enter the name of the wedge and the wedge type. The type specifies the screen display. An open field size is type zero, a normal wedge is type one, a beam splitter is type two, and a beam split wedge is type three. The type and the name apply to all field sizes in this wedge and must only be entered once.

Increment through each field width and enter the appropriate wedge factor for that field width. Even if wedge factor does not vary with field width, it must still be entered for all field widths.

2. Digitizing OCR Data

OCR data may be entered by using the digitizer. The depth increment is dependent upon the initial data entered when the machine was first created. All OCR data for a wedge must be at the same depth for all field sizes. However, they may be different for each wedge. The lateral increment spacing for each field size must be consistent. Prowess automatically modifies data to coincide with these principles.

Prepare the data by having all the OCR curves in the same format. The central axis zero radiation level must be marked along with a point to the right on the zero level. Mark the maximum of the curve on the central axis.

When the data is ready for entry, select Digitiz from the main machine entry menu and OCR from the sub-menu. Choose the wedge number and field size for the entry. The program will display the depths of the profile to be entered. Press any key to continue. See Figure 10.19.

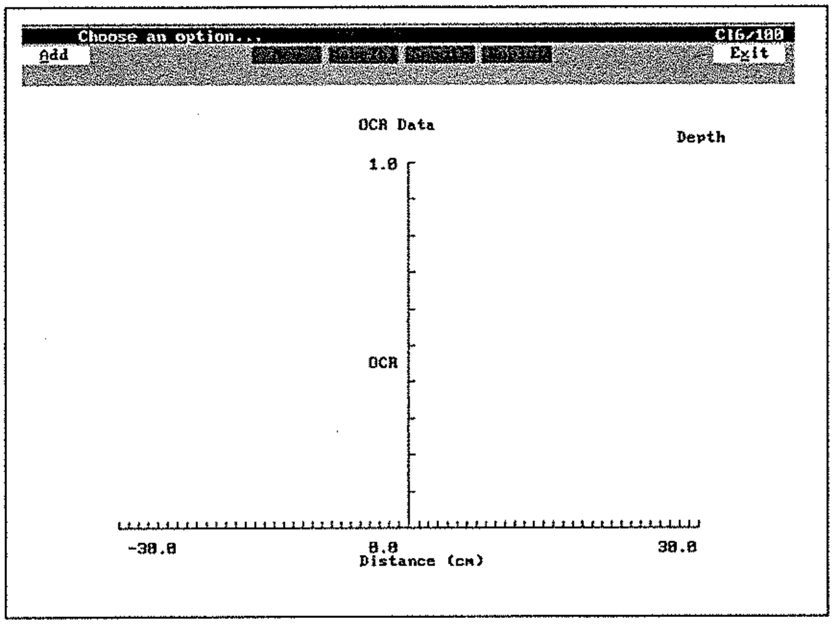


Figure 10.19 - Digitizer Entry Window

Start the procedure by selecting Add. Enter the magnification and calibrate the digitizer by entering points "U" and "L". Touch the stylus to the origin on the central axis profile and on a point to the right of the origin on the zero radiation level. This orients the graph to the digitizer. Touch the stylus to the maximum of the curve on the central axis. This normalizes the curve to 1.0 on the central axis. Then trace the profile from left to right. The program will continuously enter data until the stylus is lifted from the graph. Touch **End** to complete the profile. Enter all of the profiles in succession until all of the depths have been entered.

Touch Restart on the digitizer to restart entry. If, during entry of a curve, correction of misentered data is necessary, touch **Delete** until the misentered data is erased. Continue entering data from that point until the curve is completed. To change the curve number, touch **Change** and enter the new curve number.

Choose MakeTbl to store the data in a tabular format. When all the curves have been entered, the menu will reappear. Select New to erase and restart the curves.

To enter the next profile, select New and Add. Enter the data and store the results. Exit the function by selecting Quit or **ESC**ape.

Check the data entry by selecting OCR from the main machine entry menu. Select the wedge number and profiles just entered. Plot the data. The data may be edited, renormalized, or flipped. Examine its shape as necessary from this function. Save the data after editing is complete.

D. Split Wedges

When a beam split wedge is entered into a field, the three effects on the dose to a point under the wedge are: (1) The beam is attenuated by the wedge, (2) the beam is hardened by the wedge, and (3) there is a loss of scatter.

For an unsplit wedge, transmission is separated into two components: OCR and wedge factor. The OCR gives the relative dose normalized to the central axis, and wedge factor relates the central axis to the open field. Due to large dose gradients, an absolute measurement at the central axis of a beam split field is of little value and should not be used for normalization.

Loss of scatter from the split beam is considered by specifying the appropriate effective field sizes when looking up TMR values. However, this technique becomes more uncertain as blocking is increased and would not yield the best answers near the block edge in the beam split wedge case.

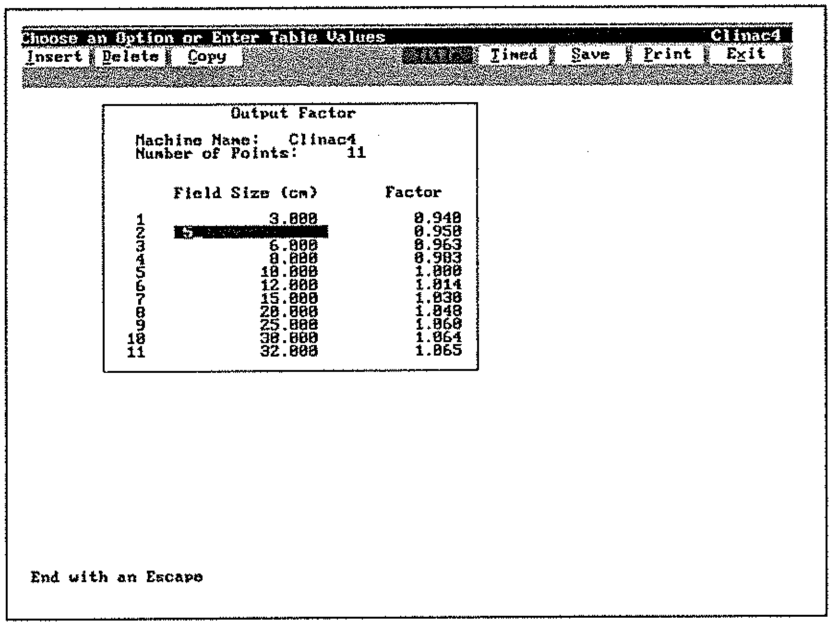
Prowess can handle beam hardening wedges by renormalizing OCR profiles in such a way that these factors are considered. The first step is to choose a measurement point inside the wedged part of the beam at d_{max} (which is away from the split edge). 2 cm should work well, although, 1 cm for small field sizes may be necessary. Measure the output at this point with and without the split wedge and find the ratio (value between zero and one). This ratio includes the effect of loss of scatter and wedge transmission and it is the desired OCR at that point. Measuring this factor at all scan depths will include the effect of differential hardening. Ratios are measured at all field sizes for which profile scans exist.

To normalize an OCR profile for a given field size and depth, select the normalization option under ManOne. If differential wedge hardening is neglected, ManAll can be used to normalize the whole field size. First, determine the OCR at the calculation point from the 2X/W table. Interpolation may be required. Geometric projection into the tabulated coordinate system is necessary. Divide the OCR by the desired OCR (the measured ratio) and the result (generally between one and four) is the normalization constant. The use of a spreadsheet program, if available, can be helpful.

It is possible to do this type of renormalization for unsplit wedge data if you want to integrate wedge factors and beam hardening into the OCR data.

IX. MACHINE OUTPUT

Output factors may be entered for up to 25 field sizes. These factors are specified at d_{max} and machine's nominal SSD. Select Output and the program will display a table of the equivalent square output factors as shown in Figure 10.20.



```
Choose an Option or Enter Table Values

                  Output Factor

     Machine Name:    Clinac4
     Number of Points:      11

          Field Size (cm)         Factor

     1              3.000          0.940
     2    5                        0.950
     3              6.000          0.963
     4              8.000          0.983
     5             10.000          1.000
     6             12.000          1.014
     7             15.000          1.030
     8             20.000          1.048
     9             25.000          1.060
    10             30.000          1.064
    11             32.000          1.065

End with an Escape
```

Figure 10.20 - Output Factor Edit Window

Fill in the table with the equivalent square field sizes (cm) and the relative output factor for each field size. It is customary to normalize the output factor data such that it is 1.000 for a 10 x 10 cm field.

Choose Insert to add the number of field sizes to be entered up to a maximum of 25 field sizes. Start from the smallest field size and proceed to the largest field size in ascending order.

Select Timed to specify a cobalt unit, enter a shutter factor, and enter a calibration date. Most modern linear accelerators are not timed with a calibrated dose rate of 1.000 cGy/mm and no shutter factor.

Calculations made by Prowess expect the calibrated dose rate to be specified at d_{max} and the nominal SSD as shown in Figure 10.21. Additional corrections may be required for a unit that is not calibrated this way.

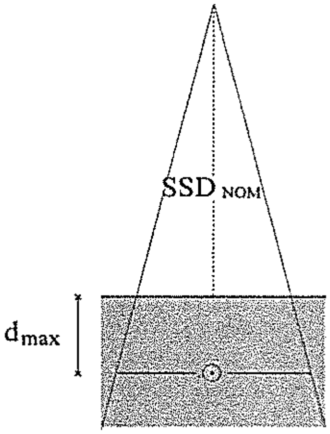
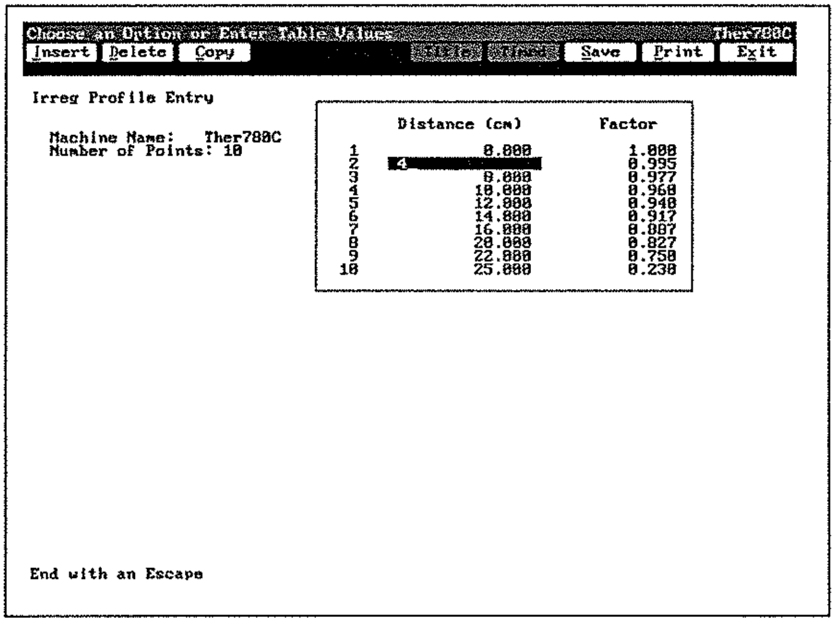


Figure 10.21 - Calibration Set Up

X. RADIAL DEPENDENCE OF INTENSITY

Off-axis factors characterize the non-uniformity of the field. They are measured at d_{max} from the central axis along the diagonal of the largest field. Enter this data by selecting IregPro. Selecting this option takes you to the off-axis intensity edit window shown in Figure 10.22.



```
Irreg Profile Entry

  Machine Name:   Ther780C
  Number of Points: 10

              Distance (cm)        Factor

        1            0.000          1.000
        2     4                     0.995
        3            8.000          0.977
        4           10.000          0.960
        5           12.000          0.940
        6           14.000          0.917
        7           16.000          0.887
        8           20.000          0.827
        9           22.000          0.750
       10           25.000          0.230

End with an Escape
```

Figure 10.22 - Off-Axis Intensity Edit Window

Up to 25 points may be entered. For most linear accelerators, the off-axis factor will increase when the distances increase away from the central axis and then decrease dramatically into the corner of the largest field. The off-axis data is normalized to 1.000 on the central axis.

XI. RADIAL DEPENDENCE OF ENERGY

The irregular field calculation program includes a correction for off-axis spectral changes (softening) caused primarily by the varying thickness of an accelerator's flattening filter. This requires tabulated values of the beam's first-scatter half value layer (HVL) in water measured under good geometry. The units of the HVL are cm $H_2 0$.

Good geometry HVL can be determined by measuring the transmission of a beam through a slender column of water that is placed along a ray line using an ionization chamber with an appropriate buildup cap as shown in Figure 10.23.

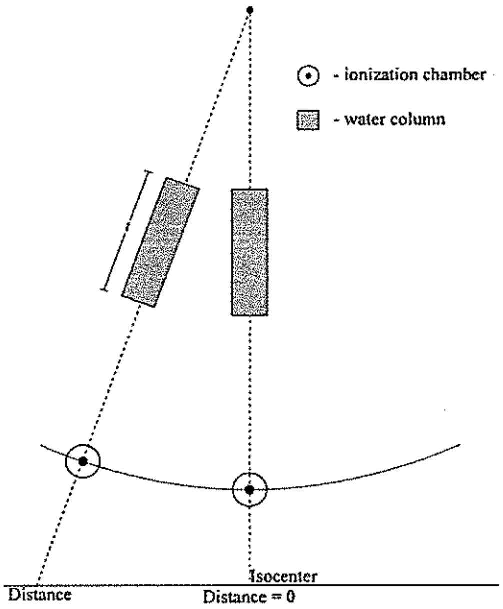


Figure 10.23 - Off-Axis Energy Measurement

The thickness (t) is varied until a 50% signal reduction is seen. Published values of off-axis HVLs have been measured in this way and reported in the literature for several accelerators. Note that for a cobalt unit, no appreciable variation in spectrum is expected across a field.

Though a description of the measurement is useful for understanding the data, it is a somewhat difficult measurement to make. Thus, it is generally more practical to infer the values from more customary measurements.

Collect and load all beam data necessary to do an external beam calculation. Include a set of scans which go across the diagonal of the largest square field size in the OCR data. Temporarily, include this set of profiles in the machine data and label it as 1.414 (i.e., $\sqrt{2}$) and multiply it by the largest field size. Delete the data before clinical use so that the field size will not be available for patient planning.

Enter a rectangular water phantom as shown in Figure 10.24. Place an SSD beam whose collimator field size is that of the diagonal scans and whose effective field size is zero (or very nearly zero). The effect of this is to approximate a beam without any phantom scatter such that the isodose distribution is impacted only by absorption and inverse square losses.

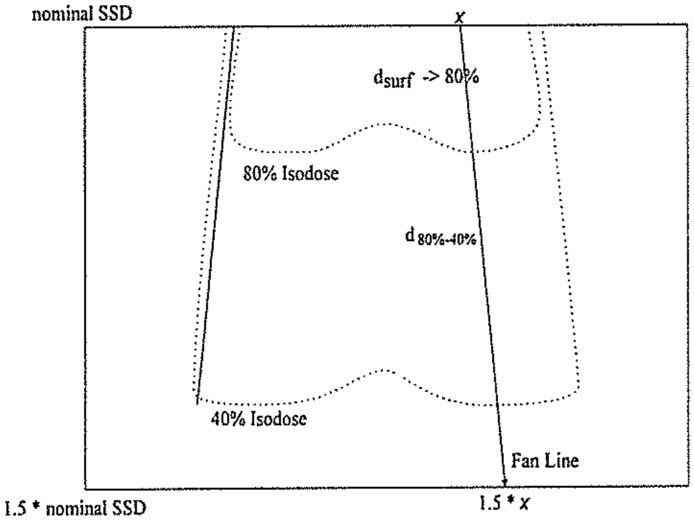


Figure 10.24 - Off-Axis HVL Determination

Calculate the dose distribution and generate two isodose lines whose values differ by a factor of two (80% and 40% work well). Construct a set of ray lines using geometric divergence from the front of the phantom to the back. Take note of where each ray line intersects each isodose line. The distance between these two intersections is required to reduce the beam by 50% and, when corrected for inverse square along the fan line, it will be the HVL. Use the following formula for calculation:

$$\mathrm{HVL} = d_{80\%-40\%}\left\{\frac{\ln(2)}{-\ln\left[\frac{1}{2}\left(\frac{\sqrt{x^2+(\mathrm{SSD}_{NOM})^2}+d_{\mathrm{surf}-80\%}+d_{80\%-40\%}}{\sqrt{x^2+(\mathrm{SSD}_{\mathrm{NOM}})^2}+d_{\mathrm{surf}-80\%}}\right)^2\right]}\right\}$$

After calculation, the off-axis HVLs are required from the central axis to the corner of the largest square field size. If OCRs are available only up to the largest lateral field width, some extrapolation will be required.

After entering the off-axis HVLs, they will be used by the irregular field program to try to predict measured OCRs. Figure 10.25 shows the geometry of the calculation as well as calculated profiles which could indicate a need to adjust the off-axis HVL values.

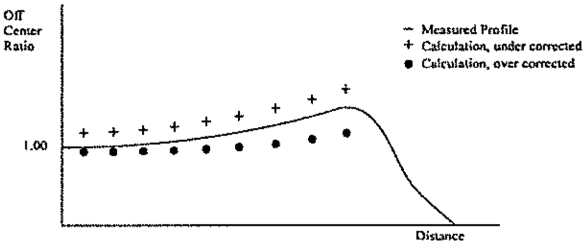
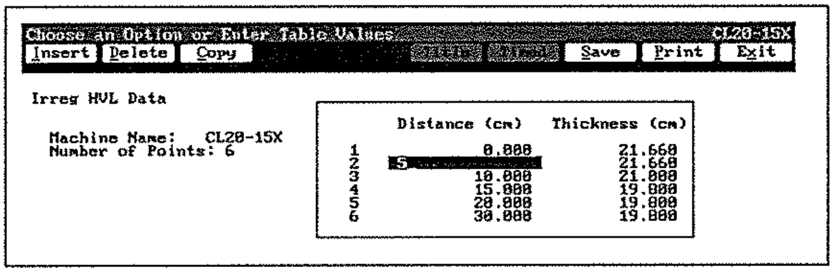


Figure 10.25 - Off-Axis Energy Verification

At least two HVL entries are needed. The distance must start at the central axis (zero distance) and proceed in increasing distance along the diagonal to the corner of the field. It may be necessary to extrapolate from calculated values to ensure converge along the diagonal of the largest possible field.



```
Irreg HVL Data

  Machine Name:    CL20-15X
  Number of Points: 6

        Distance (cm)   Thickness (cm)
  1              0.000           21.660
  2     5                        21.660
  3             10.000           21.000
  4             15.000           19.000
  5             20.000           19.000
  6             30.000           19.000
```

Figure 10.26 - Off-Axis Energy Edit Window

To enter the data, press Insert to create the number of entries you are going to enter, then the distance and the HVL in each entry. After completing entry, select Save and Print.

XII. PEAK SCATTER FACTOR ENTRY

A clinical x-ray beam's peak scatter factor (PSF) or back scatter factor (BSF) is the proportion by which the beam's apparent output is increased by back scatter from a phantom. PSF is measured as a function of square field size using the measurement setup depicted in Figure 10.27.

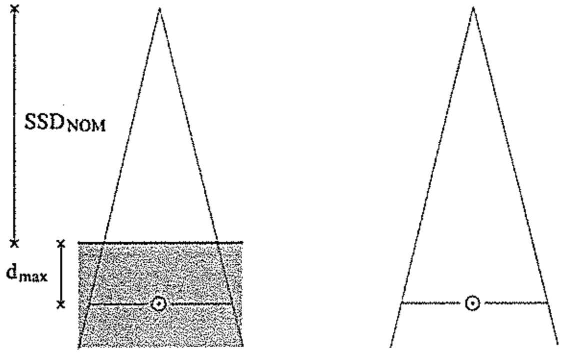
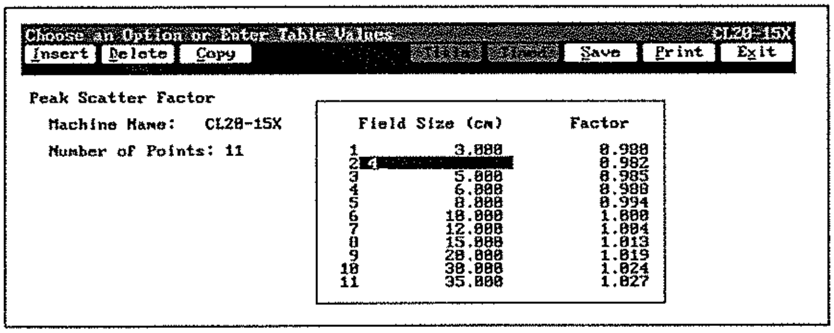


Figure 10.27 - PSF Measurement

An ionization chamber is setup in the phantom at d_{max} and the machine's nominal SSD. Relative ionization is measured as a function of square field size. Then the process is repeated with the ionization chamber at the same location without a back scattering phantom, but with an appropriate build-up cap. The ionization values are ratioed to yield PSF as a function of field size on the surface.

PSF always takes on values which are no less than one and should monotonically increase with field size.

Enter the values by selecting PSF which then takes you to the menu shown in Figure 10.28.



Peak Scatter Factor

Machine Name: CL20-15X

Number of Points: 11

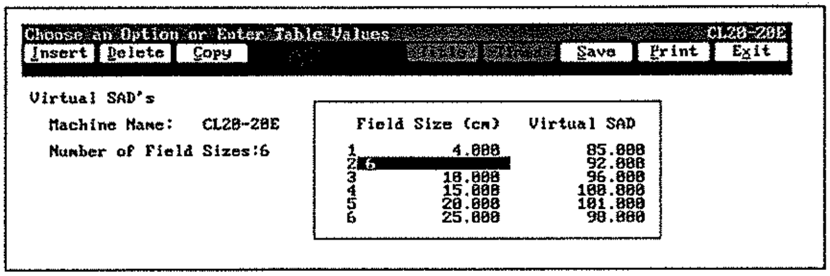
	Field Size (cm)	Factor
1	3.000	0.980
2	4	0.982
3	5.000	0.985
4	6.000	0.988
5	8.000	0.994
6	10.000	1.000
7	12.000	1.004
8	15.000	1.013
9	20.000	1.019
10	30.000	1.024
11	35.000	1.027

Figure 10.28 - PSF Edit Window

Enter the values for at least 3 and not more than 20 field sizes. The values must be entered in order of increasing field size. PSF data must be entered for field sizes from the minimum to the maximum collimator setting. Some extrapolation from measured data may be necessary.

XIII. EFFECTIVE SSD

A clinical electron beam does not undergo simple geometric divergence and, thus, does not strictly conform to an inverse square law relationship. However, if the beam is treated as if it originates at an effective source location, an inverse square relationship is followed over a limited range of distances.



Virtual SAD's

Machine Name: CL20-20E

Number of Field Sizes:6

	Field Size (cm)	Virtual SAD
1	4.000	85.000
2	6	92.000
3	10.000	96.000
4	15.000	100.000
5	20.000	101.000
6	25.000	98.000

Figure 10.29 - VSSD Edit Window

Prowess calculations do consider this virtual source effect and the virtual source positions must be measured for each electron beam. Since the virtual source position can change with field size, it should be measured for all available electron cones or over the field sizes available.

Khan recommends and describes the following technique to measure the virtual electron source. Make a series of relative dose measurements (Ig) along the central axis of the beam with differing gaps (g) between the cone end and phantom surface. Make measurements which cover the range from zero gap (I_0) up to a 10-15 cm gap.

Plot $\sqrt{\frac{I_o}{I_g}}$ against g and fit a line to the transformed data as shown in Figure 10.30.

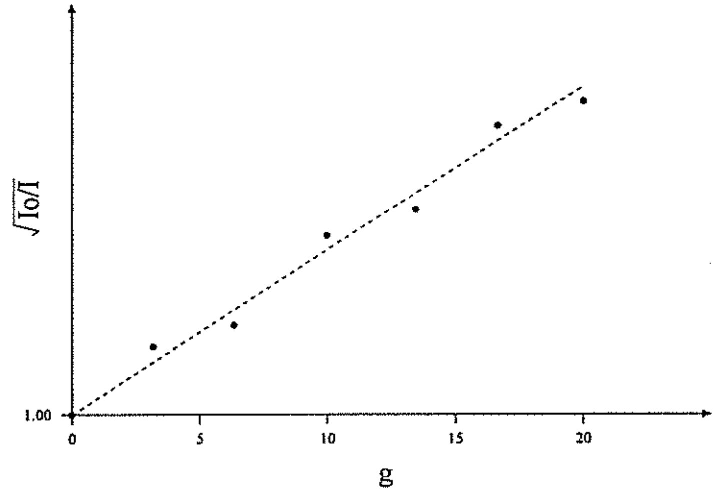


Figure 10.30 - Effective SSD Data Analysis

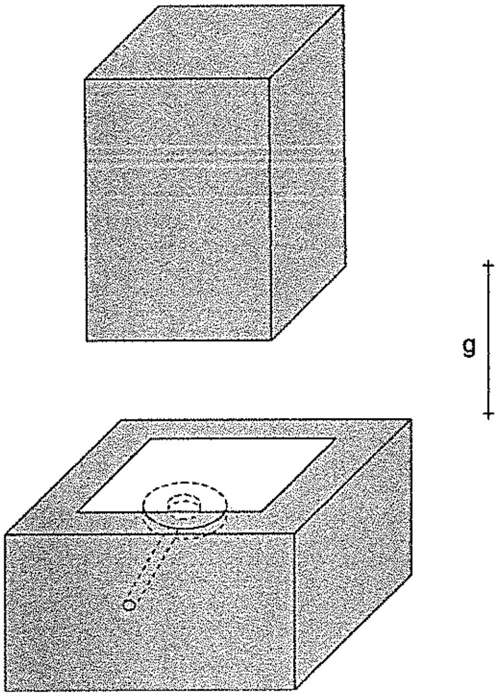


Figure 10.31 - Effective SSD Measurement

Measure the slope of the line and calculate the effective SSD as:

$$\text{vSSD} = \frac{1}{\text{slope}} - d_{\text{max}}$$

To enter the vSSD values, select ElecVir from the main machine data entry window. The vSSD edit window is shown in Figure 10.29. Use Insert, Delete, and Copy to create a vSSD table. Use the keyboard to enter the values. Select Print to print the table and Save and Exit when table entry is complete.

Note that vSSD values must be entered before converting %DD data to TMRs.

XIV. BLOCK EDGE TRANSMISSION

Block edge transmission data is stored by the type of block or edge. Type zero is reserved for the collimator. Numbers greater than zero can be used for any other block type such as non-diverging lead, diverging cerrobend, and patient edge. Partial transmission blocks may be entered, but should be used with care. Enter a descriptive title for each block type.

The data is stored as an array of transmission factors which depend on the distance from the block edge. The distance (in centimeters) into the beam is positive and negative under the block. Be sure the first and last points are far from the edge (±60 cm). Transmission is defined as the blocked beam/open beam. It has a value of 1.00 when there is no edge effect and 0.00 when there is no transmission through the block. Distance is specified at isocenter and has a value of zero at the geometric edge of the beam. The first distance is outside the beam, (negative distance) with the increasing distances following.

Block edge transmission factors are measured by making two lateral scans: One with a block in place and one with no block in place as shown in Figure 10.32. The results of these two scans are divided on a point-by-point basis.

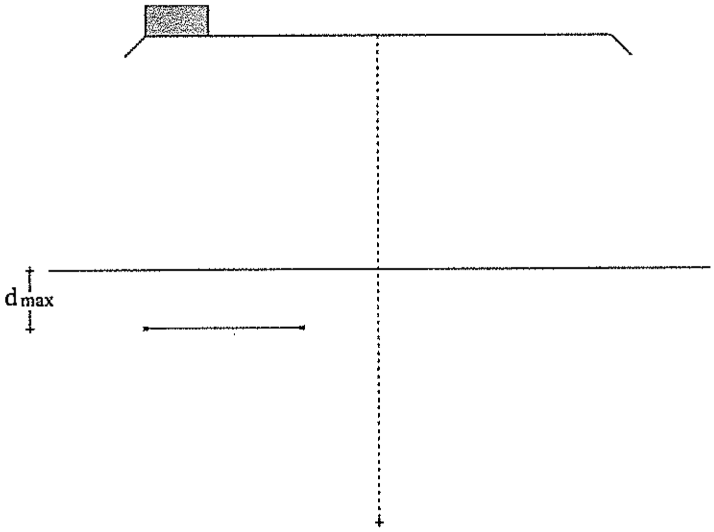


Figure 10.32 - Double Scan Geometry for Block Profile Determination

The raw values may need to be adjusted manually. The features of the edge factor profiles are shown in Figure 10.33.

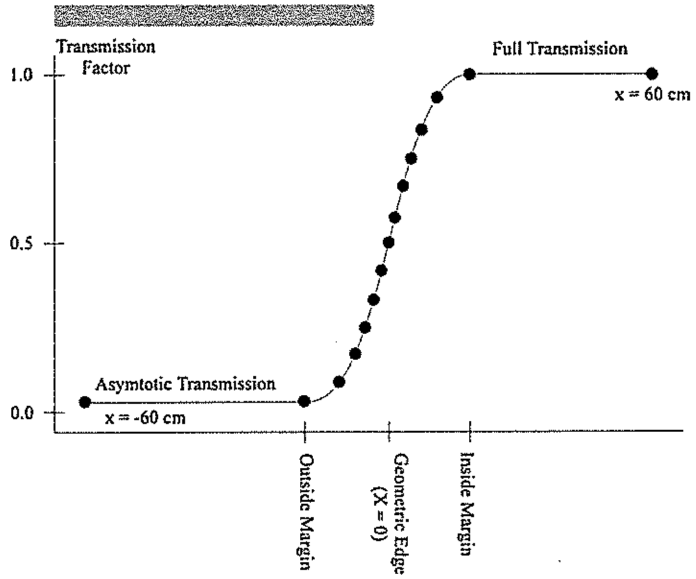


Figure 10.33 - Block Edge Profile and Features

Diverging blocks are expected to have a sharper step than non-diverging blocks. The patient surface in Figure 10.34 is entered as an ideal step function.

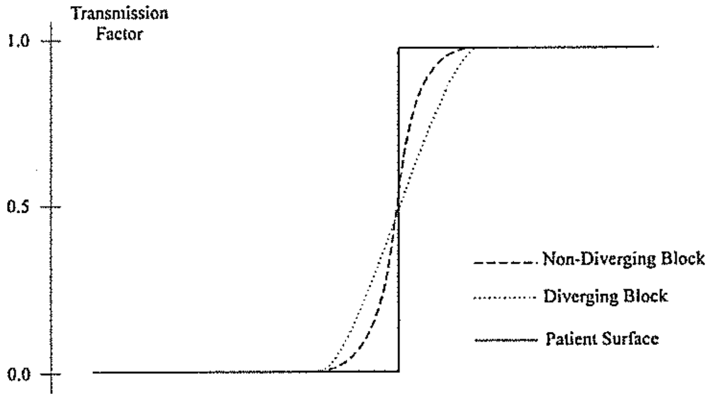


Figure 10.34 - Effect of Blocking Type on Profile Shape

Transmission blocks may be specified by causing the asymptotic tail of the transmission curve to be equal to the block transmission as shown in Figure 10.35.

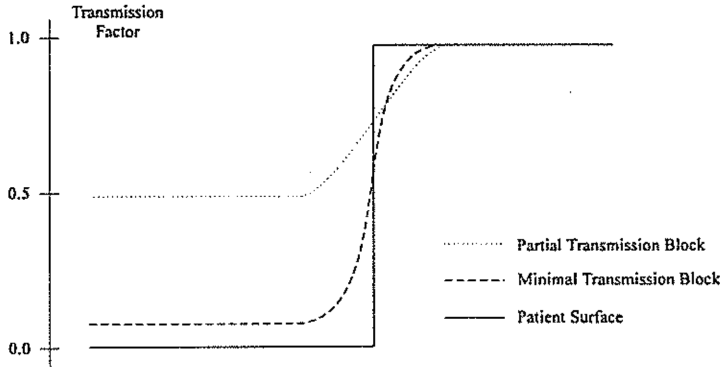
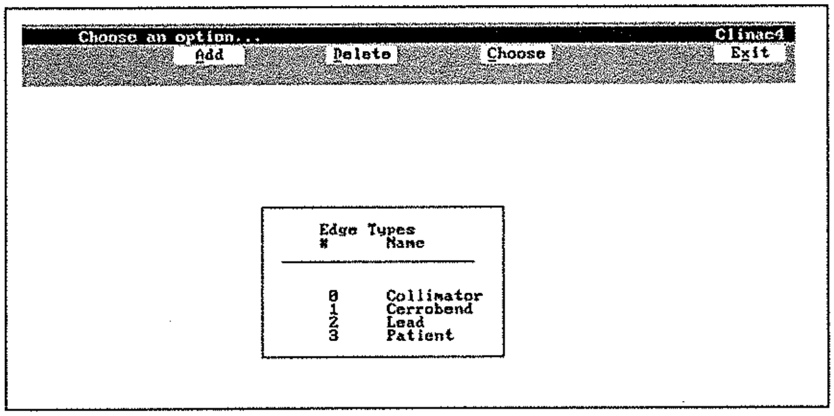


Figure 10.35 - Effect of Block Thickness on Profile Shape

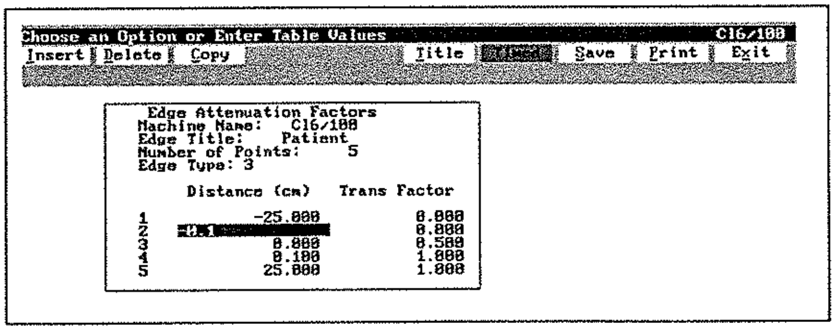
To enter edge characteristics select Edge and a list of edge types will appear as shown in Figure 10.36.



```
Edge Types
#      Name
------------------
0      Collimator
1      Cerrobend
2      Lead
3      Patient
```

Figure 10.36 - Edge Selection Window

Add, Delete, or Choose one of the edge types. If one of the types is chosen or a new one is added, the edge edit menu will appear with the distances and transmission factors. See Figure 10.37.



```
 Edge Attenuation Factors
Machine Name:   C16/100
Edge Title:    Patient
Number of Points:     5
Edge Type: 3

      Distance (cm)   Trans Factor

1          -25.000          0.000
2   -0.1                    0.000
3            0.000          0.500
4            0.100          1.000
5           25.000          1.000
```

Figure 10.37 - Edge Edit Window

Select Title to enter the title. When complete, choose Save to save the values and ESCape to exit without change.

Before entering the edge types, decide what block types will be entered. If there is more than one machine file entered, you should enter them in the same order for all the machines so that if the machines are changed, the block types will remain consistent from one machine to the next.

To enter the first edge type, select Edge and then Add. Choose Insert to insert the number of entries for the block edge shape. Up to 25 entries for each edge type may be used (they do not have to be equally spaced). Start with the negative distances in the blocked edge of the field and proceed into the open beam. Typically, the block transmission factor will be a value near 0.0 under the block proceeding to 1.0 in the open beam. Enter the title. Save and print the data. Enter remaining block edge types in a similar manner.

The last edge entry should be the patient edge type. It is used in the irregular field program when the beam flashes over the edge of the patient. There is no degradation in the primary beam shape due to blocks. However, because a patient is not present, there is a loss of scatter. This edge type should be a step function.

CALCULATION ALGORITHMS

I. EXTERNAL BEAM

The external beam calculation module is used to calculate the two-dimensional dose distributions across multiple slices of a teletherapy patient. As many as 40 beams may be included in a single plan. Each of these beams can be fixed SSD, fixed SAD, or rotating from any machine for which data has been entered. Doses are calculated at grid points which are equally spaced across the calculation area. The matrix size can vary from 100 to 16,384 points with a default of 1,024. After calculation, the dose matrix is stored for rapid display of the isodose pattern and easy renormalization without recalculation.

Wedges, blocks, compensators, and bolus can be added to any photon beam. Blocks and bolus can be added to any electron field. A wedge is added by selecting one of the wedge types stored in the data file. Blocks can be entered by specifying their shape and type from BEV. The block type is chosen from one of those listed in the machine file. Enter a compensator by specifying the compensator thickness along the central axis. To specify no compensator, enter a thickness of 0.00 cm. To specify a compensator present with infinitesimal central axis thickness, enter a thickness of 0.01 cm. Bolus is entered by specifying the bolus thickness.

To simplify treatment planning, defaults are provided for all required parameters. These values are located in the program control file and can be changed by editing this file.

Contours may be entered manually by using a digitizer or mouse or they may be entered automatically by using CT autocontour. The crucial element of a patient slice is the external contour which is assumed to enclose unit density tissue. This contour must be entered before any external beam calculation can be made. The density of structures defined by internal contours can be specified.

Contours are entered as a sequence of three or more end points. Each pair of end points is linked by a straight line segment. These points may be spaced no less than 0.5 cm apart. In addition to the external contour, Prowess contour types include reference points, calculation points, structures, heterogeneities, and tumors. A reference point is a single point entered only to indicate its location. A calculation point differs from a reference point in that its dose is calculated and reported. A structure is a sequence of connected reference points which need not be closed. A heterogeneity differs from a structure in that it must be a closed structure and the density of the enclosed region may be specified. A tumor differs from a heterogeneity in that dose statistics (minimum, maximum, and mean) are calculated for the region enclosed.

A. Photon Beam Model

The photon beam model used to calculate the dose distribution inside a patient is an expanded and improved version of the two-dimensional model developed at Memorial Hospital[1]. Two different heterogeneity models are available. They are the effective path length[1&2] and the batho power law[10]. Figure 11.1 describes the calculation geometry.

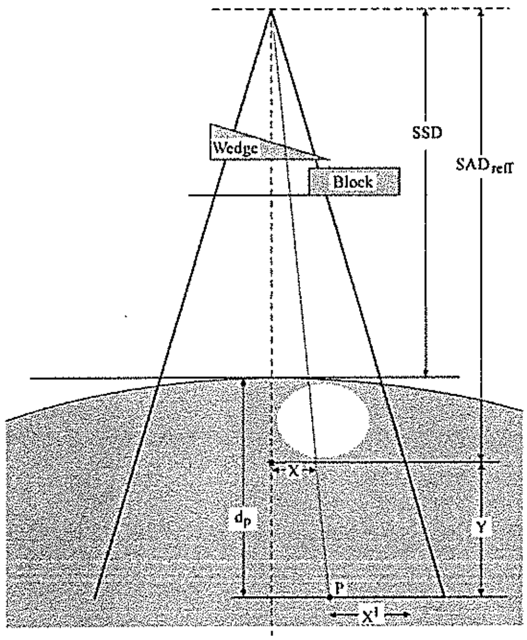


Figure 11.1 - External Beam Calculation Geometry

This is an example of an isocentric beam which passes through an off-axis heterogeneity. The beam has a collimator field size of FS and a blocked field size of FS'. Both of these field sizes are referenced to the machine isocenter. Point P is the point to which the dose is calculated. Point P is located at depth d_p and a distance X_d from the central axis. The dose to point P, D(P) is calculated as described:

D(P) = Beam Weight * Machine Output * Collimator Output Factor * Peak Scatter Factor Correction * Inverse Square Calculation * Tissue Maximum Ratio * Off-Center Ratio * Heterogeneity Correction * Block Edge Factor * Modifier Transmission Factor

Where:
Beam Weight = Machine setting, monitor units, or treatment time
Machine Output = Calibrated dose rate * Cobalt decay factor
Collimator Output Factor = 0(FS)
FS = Collimator field size as projected to isocenter
Peak Scatter Factor Correction = PSF(FS') / PSF (FS)
FS' = Blocked effective field size as projected to isocenter

Inverse Square Correction = $\left(\frac{\text{Nominal SSD + dmax}}{\text{Nominal SSD}}\right)^2$
SAD_{reff} = Nominal source to axis distance
d_{max} = depth of dose maximum
Y = Distance from isocenter to point P along the central axis
Tissue Maximum Ratio = TMR(FS'_d, d_p)
FS'_d = Blocked field size as projected to d_p
d_p = Calculation point depth projected to the central axis
Off-Center Ratio = $OCR_{LATERAL} * OCR_{VERTICAL}$
2X/W = Relative distance of point P from the CAX to the beam edge
FS = Collimator field size as projected to isocenter
d_p = Calculation point depth projected to the central axis
Wdg = Wedge
Heterogeneity = Correction factor determined using heterogeneity model
Block Edge Factor = Bf(x')
X' = Distance from point P to block edge projected to d_p
d_p = Calculation point depth projected to the central axis
Modifier Transmission Factor = Wf * Tf * Cf
Wf = Wedge transmission factor
Tf = Tray transmission factor
Cf= Compensator transmission factor

The following sections explain the components of the calculation.

1. Field Size (FS)

The field size is specified at SAD_{reff} by two sets of parameters: collimator settings and effective field size. The collimator field size (FS) is based on the collimator setting. The effective field size (FS') is the blocked field size as seen by the patient. Both collimator and effective field dimensions are converted to an equivalent square before they are used in calculations.

$$\text{Equivalent Square} = \frac{2xy}{x+y}$$

2. Depth of Dose Maximum (d_{max})

The depth of dose maximum is specified along the central axis of a 10 x 10 cm field at nominal SSD.

3. Tissue Maximum Ratio (TMR)

The Tissue Maximum Ratio is defined as the ratio of the dose at a point when that point lies under a depth (d) of tissue to the dose when that point lies under a depth (d_{max}) of tissue as shown in Figure 11.2.

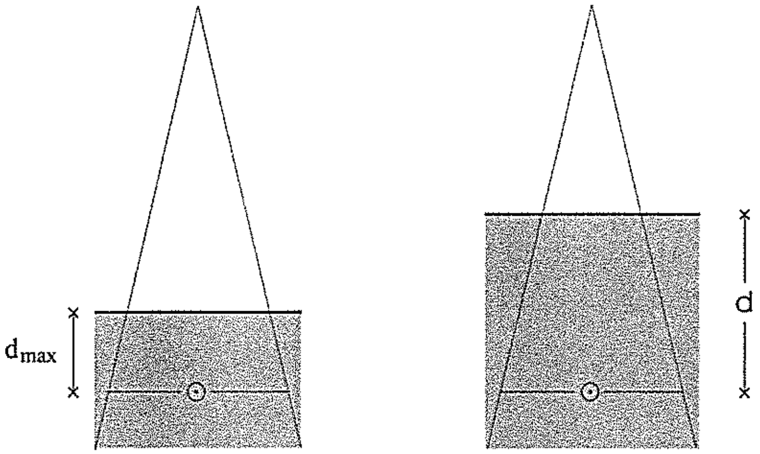


Figure 11.2 - Tissue Maximum Ratio Geometry

TMR is related to the central axis depth dose at nominal SSD by the following equation:

$$\mathrm{TMR}\,(d, \mathrm{FS}') = \left(\frac{1}{100}\right)\%\mathrm{DD}\left[d, \left(\mathrm{FS} * \left\{\frac{\mathrm{SSD} + d_{\max}}{\mathrm{SSD} + d}\right\}\right)\right] * \left[\left(\frac{\mathrm{SSD} + d}{\mathrm{SSD} + d_{\max}}\right)^2\right]$$

During machine data entry, the peak scatter ratio correction is neglected. The error introduced is small. The TMR table looks up the %DD value for the field size defined at depth. This presents a problem for small field sizes because a 3 cm %DD curve does not give adequate data for a 3 cm TMR table. TMR data for a 3 x 3 cm field can be measured directly or calculated from 2 x 2 cm data.

4. Off-Center Ratio (OCR)

An OCR is the quotient of the dose at a point in a rectangular field to the dose at the same depth along the central axis[4].

$$\mathrm{OCR} = \frac{D\,(x, y, d)}{D\,(o, o, d)}$$

Thus, OCR values characterize the shape (i.e., the flatness and symmetry) of a beam. The value of OCR depends on position in the field, field width, field length, and depth.

$$\mathrm{OCR} = \mathrm{OCR}\,(x, w, y, L, d)$$

For a field defined by independent jaws, OCR depends on the position of each jaw.

$$\mathrm{OCR} = \mathrm{OCR}\,(x, X1, X2, y, Y1, Y2, d)$$

5. Single Slice

The simplest case to consider is that of a symmetric, unrotated field on a single central slice.

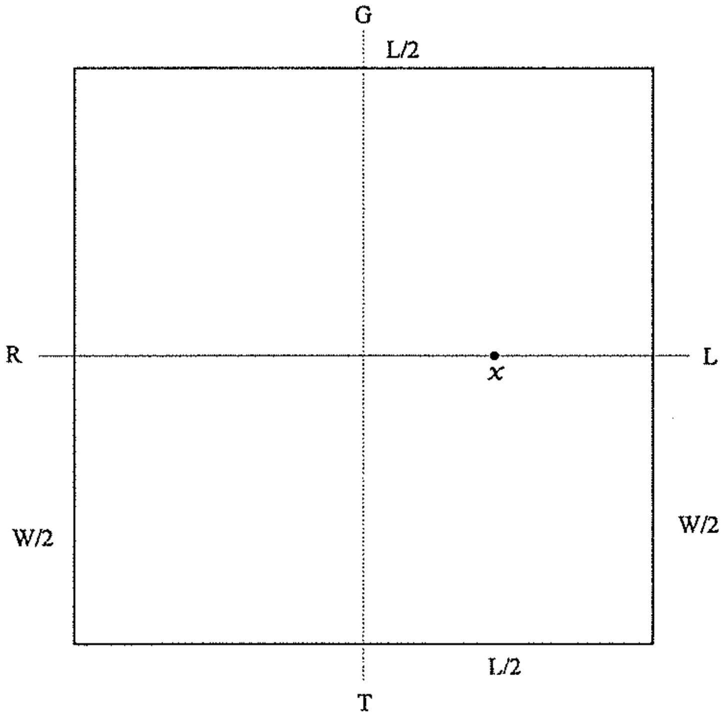


Figure 11.3 - Single Central Slice

In this case, OCR is assumed independent of field length and values are simply looked up from a table.

$$\text{OCR} = \text{OCR}\left(\frac{2x}{W}, W, d\right)$$

As indicated, OCR values are stored as a function of the unit-less coordinate 2X/W. The distance (X) and width (W) are both defined as projected to the reference point of the beam. Thus, a distance expressed in terms of 2X/W coordinates indicates the relative position of the point between the central axis (CAX) and the edge of the beam. A point located on the CAX will have a 2X/W distance of 0.0 and a point on a beam edge will have a 2X/W distance of ±1.0.

6. Off-Axis Slice, Rotated Collimator, and Asymmetric Fields

In this case, Cartesian symmetry is assumed to hold5 and the OCR at a point is taken to be the product of an x and y component. The field length is taken to influence only the y component and field width is taken to influence only the x component.

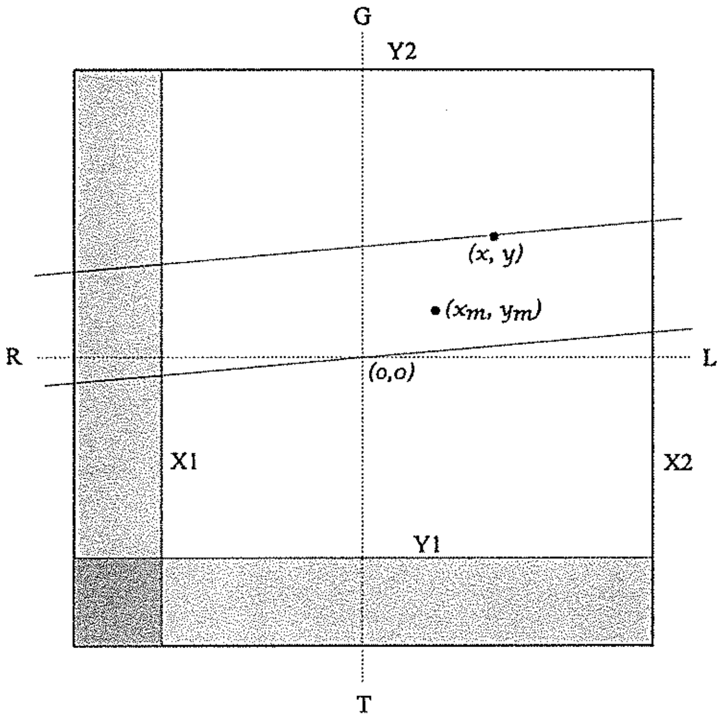


Figure 11.4 - Off-Axis Slice, Rotated Collimator, and Asymmetric Fields

$$\mathrm{OCR}\,(x, X_1, X_2, y, Y_1, Y_2) = [\mathrm{OCR}_A\,(x, X_1, X_2)]\,[\mathrm{OCR}_B\,(y, Y_1, Y_2)]$$

The point (x_M, y_M) is the center of the open point of the field.

$$x_M = \frac{X2 - X1}{2} - X_1$$

$$y_M = \frac{Y2 - Y1}{2} - Y1$$

$$r = \sqrt{x^2 + y^2}$$

$$\mathrm{OCR}_A\,(x, X_1, X_2) = \mathrm{OCR}\,[\,(x - x_M),\ (X_2 - X_1)\,]\left[\frac{\mathrm{OAF}\,(R)}{\mathrm{OAF}\,(x - x_M)}\right]^{\frac{x}{x+y}}$$

$$\mathrm{OCR}_B\,(y, Y_1, Y_2) = \mathrm{OCR}\,(y - y_M),\ (Y_2 - Y_1)\left[\frac{\mathrm{OAF}\,(r)}{\mathrm{OAF}\,(y - y_M)}\right]^{\frac{y}{x+y}}$$

In calculating a wedge field (excluding asymmetric fields), the wedge is to be oriented along the x direction and the open field table is used to look up OCRs in the y direction.

7. Wedged Asymmetric Fields

Not supported at this time.

8. Weight (Wt)

A beam's weight can be specified in one of two ways, either the machine setting or the dose to a weight point (isocenter, d_{max}, or a calculation point). If the machine setting is specified, then the treatment duration is already known and Prowess returns the resulting doses. Typically, the dose (or percent dose) is specified and Prowess returns the required monitor units. It is important to be very careful to what point the dose is specified. If the weight point has a dose which is small in relation to the plan (e.g., on the central axis of a split field), then unacceptably large monitor units can be calculated resulting in unacceptably large doses elsewhere in the slice.

Calculating a dose point weighted beam requires a three-part process. First the weight dose and weight point are used to calculate the machine setting. The relative dose $\left(\frac{\text{dose}}{\text{monitor unit}}\right)$ is then calculated to all points in the patient. Third, the monitor units and relative dose are multiplied to yield the absolute dose at every point. For beams weighted to machine setting, the weight dose and weight point are not necessary.

9. Block Edge Correction

The block edge transmission correction modifies the shape of a beam near a block edge. Its value depends on the distance of a point from the block edge. The block edge transmission factor and TMR of the blocked field size are the two correction techniques used to reflect the effect of secondary blocking (or asymmetric collimation) on a beam. The block edge transmission correction diverges with the beam and partial transmission blocks are permitted.

10. Bolus Correction

Bolus may be added to any beam including beams with compensators. If bolus is added to a beam, the contour is enlarged by the thickness of the bolus for that beam.

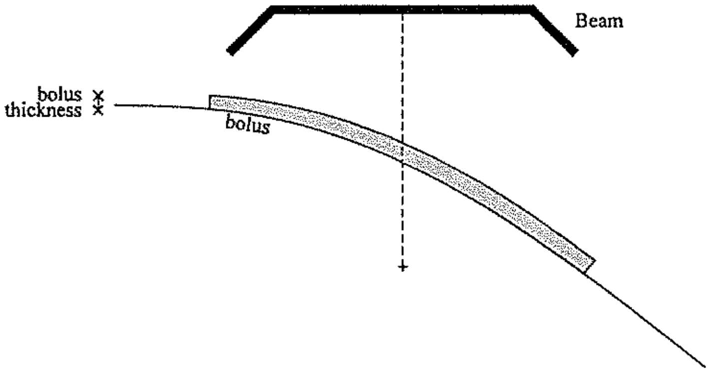


Figure 11.5 - Bolus Geometry

SSDs are specified to the patient surface ignoring bolus. Aside from increasing patient thicknesses, there is no difference in calculating the dose to the patient. When weighting a beam with bolus, the depth to weight point is measured from the surface of the skin and does not include the bolus. When plotting isodose curves for beams with bolus, the curves will go outside the patient surface reflecting dose build up in the bolus. Partial bolus can be added to the patient surface using an external heterogeneity.

11. Compensator Correction

A compensator may be added to any beam even if bolus has been added. Adding a compensator to a beam fills the patient entrance surface for that beam so that it is flat, perpendicular to the central axis of the beam. The surface is filled to the thickness specified on the central axis. If part of the patient surface protrudes beyond the compensator, then the actual patient contour is used for calculation. For example, a sloping chest wall where the compensator only extends to the central axis of an anterior field is an example of compensator or correction. The compensator would fill the cephalad part of the field but use the patient's contour caudad of the central axis. To add a compensator with no thickness on the central axis, choose a thickness of 0.01 cm. A value of 0.00 means there is no compensator present. When plotting isodose curves for beams with compensators, the curves do not extend outside the patient surface. This reflects the dose build up at the actual surface of the patient.

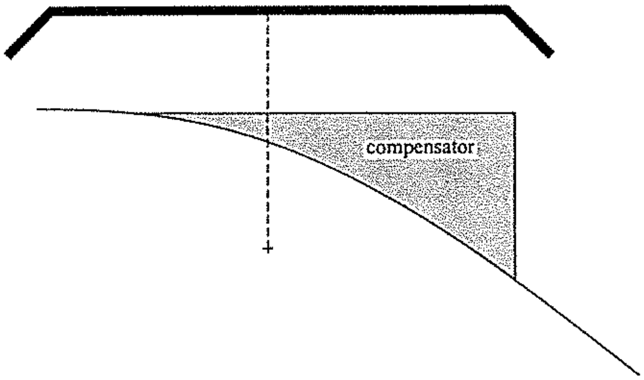


Figure 11.6 - Compensator Geometry

The preceding technique is used to determine how much tissue equivalent compensation lies over a calculation point. An effective transmission factor is decided for this thickness and can be surmised by determining the extent that additional material reduces the TMR at a distance of 8 cm below the calculation point. An 8 cm shift is introduced to ensure that all table loop-ups are made in the exponential part of the TMR curve.

A compensator can be added to the patient surface by entering an external inhomogeneity. Clearly, skin sparing is not reflected when this technique is used. When a bolus and a compensator are both specified, the bolus is included first such that compensation is to the surface of the bolus.

12. Heterogeneity Correction

Two options are available for correcting patient surface curvature and inhomogeneities: Effective Path Length model and Batho Power Law model. Optionally, you can choose not to make any corrections. The program defaults to correct for inhomogeneities, if present. All of these corrections are bulk (not pixel-by-pixel) corrections. One must assign a density to a closed contour inside or outside the patient to make an inhomogeneity correction. Corrections for missing tissue are always made. Only one inhomogeneity model may be used at a time. The calculation model is selected by the physicist from the control file.

Hounsfield numbers are not used for heterogeneity corrections by Prowess. CT data read from tape or film scanner is used only for visualization of anatomy with dose distribution. Heterogeneity corrections are based solely on bulk density values associated by the user with each contour.

All heterogeneity correction models generate a correction factor, I. The techniques for calculating I are shown in the next sections:

13. Effective Path Length Model

The traditional correction for heterogeneities use the density weighted effective path length. In this model, the correction becomes:

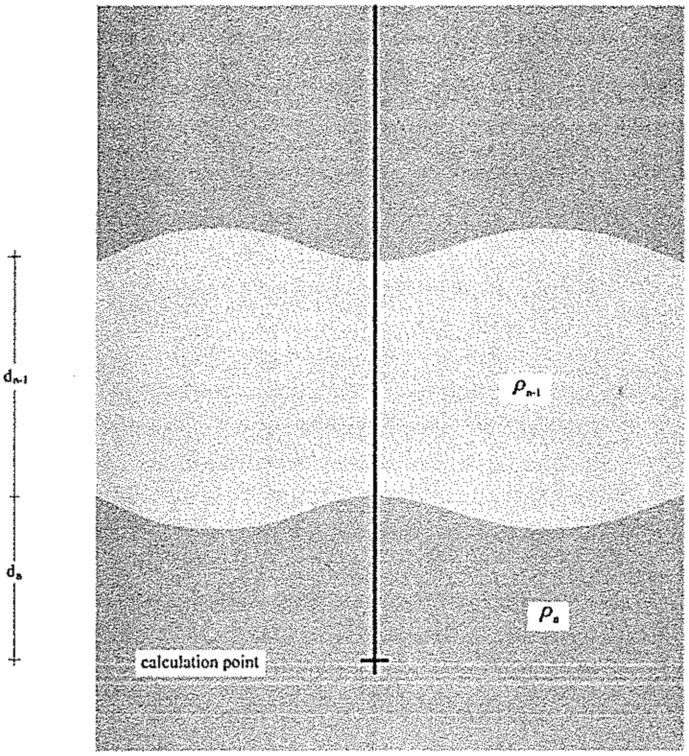


Figure 11.7 - Effective Path Length Geometry

$$I = \frac{\mathrm{TMR}\left(\mathrm{FS'}_{d}, \sum_{i=1}^{n} \rho_i d_i\right)}{\mathrm{TMR}\left(\mathrm{FS'}_{d}, \sum_{i=1}^{n} d_i\right)}$$

14. Batho Power Law Model

The Batho Power Law model was originally presented by H.F. Batho in 1964[3]. Since then, numerous authors have improved the original derivation. The form that we implemented is described by El-Khabb & Batista[8]. This correction is not valid in the build-up region of the inhomogeneity. As such, it is ignored in this implementation of the algorithm. The inhomogeneity correction becomes:

$$I = \frac{\mathrm{TMR}\,(\mathrm{FS'}, Z_1)^{\rho_1 - \rho_2}}{\mathrm{TMR}\,(\mathrm{FS'}, Z_2)^{1 - \rho_2}}$$

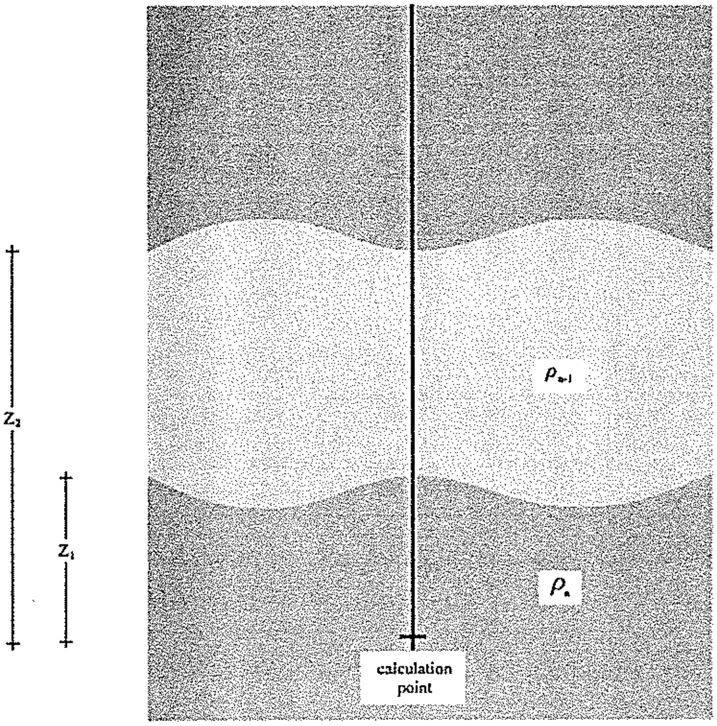


Figure 11.8 - Batho Power Law Geometry

15. Correction for Patient Curvature

Figure 11.1 shows the geometry used to calculate the dose to point P. Since the patient surface is not flat, the ray from the source to point P traverses an area of missing tissue. To correct this, the TMR ratio is necessary. The correction function is:

$$I = \frac{\mathrm{TMR}\,(\mathrm{FS}'_d, m)}{\mathrm{TMR}\,(\mathrm{FS}'_d, s)}$$

Where:
s = slant depth from source to point P for a flat surface
m = slant depth from source to point P for the curved surface

An SSD beam uses the same calculation technique as TMR. An SSD beam is considered to be an isocentric beam with an isocenter located on the surface.

16. Arc Rotations

Arc rotation calculations are treated by summing multiple fixed beams spaced uniformly along the arc. Each beam is weighted equally and a minimum of six beams are used for the summation. The default angle increment is 10 degrees which can be reset. No beam is added at the exact ends of the rotation because the beam does not spend any time at these angles. The beam is only able to rotate counter-clockwise.

17. Data Format & Look Up

Data is stored in vector or matrix format and interpolated when necessary. TMR tables contain as many as 20 field sizes and 50 depths. The OCRs for each wedge are stored in an array of up to 50 distances and 10 depths, one of which must include d_{max}.

Calculations that require greater depth than those measured for the TMR table, assume an exponential fit to the data beyond the last depth. If the last measured depth is 40 cm, an extrapolation will seldom be necessary. The dose error associated with this assumption should not exceed 2%. This extrapolation must be done at the time the machine data is entered. Extrapolation is not done in the external beam calculation.

TMR is assumed to vary linearly between stored values. To obtain reasonable accuracy, several TMR values should be included in the build up region. Like most treatment planning systems, the accuracy of dose calculations in this region is not very good and should be used with care.

For table lookup in OCRs which exceed the table's width, the profile is assumed to vary linearly with distance from the last value to zero at two times the width of the field size. Errors should be no greater than 3% in areas outside the primary beam. If the depth exceeds the table depth, the profile of the largest depth is assumed. No significant error is expected from the assumption as the profile shape varies slowly with depth.

18. Accuracy

The expected accuracy of the model is generally well within 5% inside the beam for homogeneous media. Errors in calculation can occur near the corners of the field where cartesian symmetry does not adequately describe the beam shape. When inhomogeneities are entered, the error will increase. Careful choice of the density of the inhomogeneity will minimize this error. There are no models which accurately depict the dose within the buildup region of an inhomogeneity. Errors as large as ±10% in this region can be expected.

Off-axis plane calculations assume radial symmetry. Therefore, the OCR is chosen by 2X/W that is the diagonal distance from the central axis to the calculation point. This assumption should create errors no greater than ±5% except near the edge of the beam. Errors in this region may exceed ±10% and such calculations should not be performed. In extreme cases (near the corner of rotated fields), the error can exceed ±20%. Therefore, use of off-axis calculations in these regions is not advised.

B. Electron Beam

Prowess uses the Memorial Hospital[1] electron model.

$$D(P) = \frac{\mathrm{VSSD}_{\mathrm{reff}}}{\mathrm{VSSD}_{\mathrm{reff}} + y} * \mathrm{TMR}\,(\mathrm{FS}'_{d}, d_p) * \mathrm{OCR}\left(\frac{2x}{\mathrm{FS}'}, d_p\right) * \mathrm{Wt} * O\,(\mathrm{FS})$$

Where:

VSSD = effective source to skin distance for each electron cone and energy
d_p = depth of point P
FS' = field size at point P
x = perpendicular distance from central axis to P
TMR(FS'_d, d_p) = pseudo tissue maximum ratio for electrons for field size FS'_d and depth d_p
$OCR\left(\frac{2x}{FS'}, d_p\right)$ = Off Center Ratio at distance $\frac{2x}{FS'}$ from central axis and depth d_p
Wt = The desired weight at d_{max} from the beam
0(FS) = output factor for cone size specified at nominal SSD and a depth of dose maximum
y = depth on central axis to point P

II. MONITOR UNIT CALCULATION PROGRAM

The monitor unit calculation program is intended for use when doses along the central axis are of interest and secondary blocking can be represented by known effective field dimensions.

To calculate the machine setting required to deliver a dose to a point, the prescribed dose is divided by the current calibrated dose rate at the collimated field size; the TMR at the effective field size and depth; total transmission factor of trays, wedge, and compensator; and an inverse square correction from the calibration point to the calculation point. A shutter correction is added if applicable. The model is as follows:

$$\text{Machine Setting} = \frac{\text{Dose}}{CDR * INVSQ * Tf * Cf * Wf * OF(FS) * \frac{PSF(FS')}{PSF(FS)} * TMR(FS', D)} + SF$$

Where:

Machine Setting = monitor units or timer setting
Dose = prescribed dose in cGy at depth d_p and SSD
CDR = calibrated dose rate * cobalt decay
Tf = block tray transmission factor
Cf = compensator transmission factor
Wf = wedge transmission factor
SAD_{reff} = source axis distance for specific machine (i.e., 80 or 100 cm)

$FS = \frac{2\,(\mathrm{Col\ x} * \mathrm{Col\ y})}{\mathrm{Col\ x} + \mathrm{Col\ y}}$ equivalent square of collimator field size

$FS' = \left[\frac{2\,(Eff_x * Eff_y)}{Eff_x + Eff_y}\right]\left[\frac{SAD_{reff} + d_p}{SAD_{reff}}\right]$ equivalent square for effective field size at depth

OF(FS) = relative output factor for collimator setting FS

d_{max} = depth of dose maximum

d = depth of point P

SF = shutter factor or timer error

PSF(FS) = Peak Scatter Factor for field size FS

TMR(FS', d) = Tissue Maximum Ratio for field size FS' at depth d_p

SSD = Source to Skin Distance at point P

III. IRREGULAR FIELD CALCULATION

The Irregular Field Calculation program is used to calculate machine settings and doses for fields which have significant secondary blocking. Doses are calculated at any point, either in an open area or under a block. As many block edge types as necessary can be stored in the machine data file.

The shape of the field is entered by using the digitizer. Each edge segment that is entered can have a different edge type. Points of calculation are also entered by using the digitizer. Once the contour and point entry are complete; the SSD, depth, and name for each calculation point are entered. Finally, the machine collimator setting, tray transmission factor, point of dose specification and dose are entered. These entries can be edited later from the keyboard.

From this data, the dose to each calculation point is calculated and displayed on the screen. If the results are satisfactory, then they may be printed and plotted for permanent record.

The model used to find the dose at the calculation points is an extension of the model developed by Cunningham[1]. The primary dose is calculated from the zero area TMRs corrected for off-axis beam softening[2&4], beam profile, and block edge effects. Appropriate transmission factors are applied to points under blocks. The scatter dose component is calculated using the Clarkson[3] integration technique from the table of circular scatter maximum ratios.

With accurate data, the dose to any calculation point in the field can be calculated to within ±3%. The present model does not assume that scatter originates from under blocks, therefore, doses within 1 cm of a block or under a block may be in error by as much as 5-6%.

The dose to point P is calculated from the following equation:

$$\frac{D(P)}{mu} = \mathrm{CDR} * \mathrm{INVSQ} * \mathrm{O(FS)} * \mathrm{Tf} * \mathrm{TMR} * \mathrm{PSF}_R$$

Where: $$\text{INVSQ} = \left(\frac{\text{Nominal SSD} + \text{dmax}}{\text{SSD} + \text{depth}}\right)^2$$

$$\text{TMR} = \left[\text{TMR}\,(0, d_p)^{\frac{\text{HVL(0)}}{\text{HVL(R)}}} * E_i * P\,(R_i)\right] + \left[\overline{\text{SMR}}\,(d_p)\right]$$

The first term of the TMR is due to primary photons. The zero area TMR and, thus, the primary irradiation is modified for off-axis softening, edge attenuation, and off-axis intensity changes. The second term is due to scattered photons and is calculated using the Clarkson integration technique.

$$\overline{\text{SMR}\,(d_p)} = \frac{1}{360}\sum_{i=1}^{360} \text{SMR}\,(r_i, d_p)$$

When the total TMR is reported on a printed hardcopy, its value is calculated to be the sum of the zero over TMR (without modifying factors) and the SMR. This value cannot be used independent of the previous equation for hand calculations.

$$\text{PSF}_R = \frac{PSF\,(FS_{EFF})}{PSF\,(FS_{COLL})}$$

$$FS_{EFF} = \frac{4A_{EFF}}{P_{EFF}}$$

$$FS_{COLL} = \frac{2\,[\,(X_{COLL})\,(Y_{COLL})\,]}{X_{COLL} + Y_{COLL}}$$

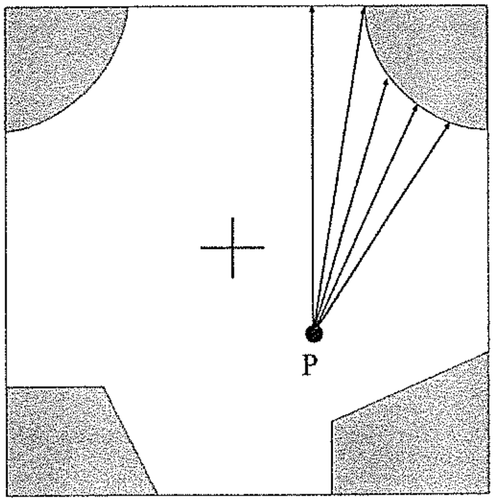


Figure 11.9 - Scatter Integration

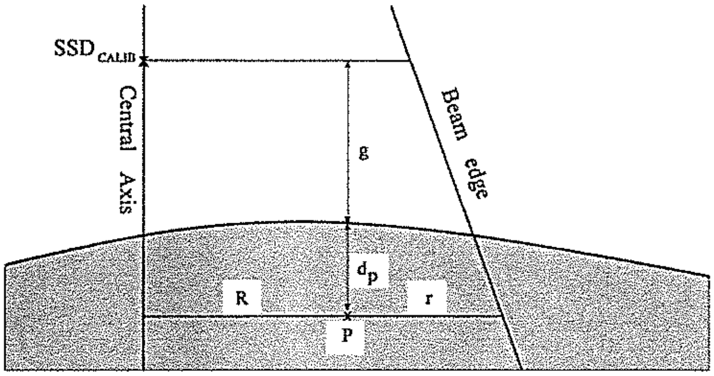


Figure 11.10 - Axial Geometry

Variable Names:

D(P) = dose to point P
Mu = treatment machine setting
CDR = calibrated dose rate under reference conditions
INVSQ = inverse square correction factor
SSD_{calib} = source to surface distance of calibration
d_{max} = depth of dose maximum along central axis under calibration conditions.
g = vertical gap between SSD_{calib} and skin surface at calculation point
d_p = vertical distance between skin and calculation point
0(FS) = output factor of collimator equivalent square
Tf = tray transmission factor
TMR = Tissue Maximum Ratio at calculation point
TMR(0, d_p) = zero area TMR at depth of calculation point
HVL(0) = good geometry half value layer in water of beam along the central axis
E(r_i) = edge transmission factor of nearest collimation device to the calculation point
P(R_i) = beam profile factor for point P
$\overline{SMR}(d_p)$ = average Scatter Maximum Ratio at point P
n = number of angles for scatter integration
r_i = distance at depth from calculation point to field edge at anglei
SMR(r_i, d_p) = Scatter Maximum Ratio of a circular field of radiusr_i and depth d_p
PSF(FS) = Peak Scatter Factor for field size FS
EQS = Equivalent Square of beam as calculated by the Clarkson integration
$FS = \frac{2\,(Col_x * Col_y)}{Col_x + Col_y}$ equivalent square of collimator field size

It is possible to specify edge factor data as a partial transmission block which can be entered as part of a field perimeter. However, since no scatter is assumed to originate under the field edge, this is not recommended.

IV. BRACHYTHERAPY CALCULATION

The Brachytherapy Calculation Program calculates the dose rate to any point for seed and line sources. To calculate the dose distribution in a plane from an array of sources, the dose rate from each source is summed for an evenly spaced array. Size and spacing of the spacial array are determined by you before calculating. The array size can be set between 100 and 4096 calculation points. The window of calculation can be changed from 2 x 2 cm into as large an area as necessary. After calculation, isodose lines are plotted by interpolating on the calculated matrix. Therefore, the larger the number of matrix points the more accurate the isodose curves. 1024 (32 x 32) is the default matrix size and this is accurate enough for most implants.

A. Orthogonal Film Entry

The coordinates from the orthogonal film entry procedure are derived by triangulation. No correction for changes in off-axis divergence is made. For a line source, the error is minimized by error analysis and by choosing the common y coordinate that most closely approximates the true physical source size.

To correct for off-axis changes in magnification, you must 1) know the target to film distance or the target to implant distance and 2) know the exact orientation of the films. In most cases, this information is not available. Incorrectly entering these items can double the length errors.

Assuming that the source to mid-implant plane is 80-100 cm and the maximum source distance from the magnification plane of a typical implant is 5 cm, the maximum positive error generated is 2-3 mm. Typically, this error will not be greater than 1-2 mm. The precision of the entry is better than ±1 mm and the accuracy is ±1-2 mm. The inaccuracies due to changes in magnification above and below are on the order of the accuracy. Therefore, the total accuracy can be expected to be ±2 mm.

After digitizing each film, a summary of the entry results is provided. If the difference in y coordinates is greater than ±2 mm between the two films, the sources are flagged after analyzing the error and you may re-enter the sources or accept them.

The y or common axis coordinate of the two films are fit using a least square to a straight line. If the two sets of y data are plotted on linear graph paper, you will see a line at 45 degrees through the origin. A line which does not pass through the origin is indicative of an unsatisfactory origin. The origin error must be removed before any subsequent change in magnification. When the line is not at 45 degrees, one or both films have magnification factors entered incorrectly. The ratio of these errors is shown at the bottom of the screen. A perfect fit between the two films would give a ratio of 1.000 with a variance of 0.000. If the magnification differs by less than 5%, (the ratio is between

0.95 and 1.05), you may wish to proceed without further change. A variance of greater than 0.05 is indicative of bad data entry. If this occurs, re-enter all sources.

The effect of a 2-3 mm maximum source displacement at the edges will change the dose rate by no more than 2%, primarily at the edges of the implant.

To help you improve the entry of line sources, the summary screen also shows the difference in calculated versus expected source length. If this differs by more than ±10%, the source is flagged.

B. General Model

The dose from a linear source is determined by a four point interpolation from a reduced polar coordinate dose table. The dose tables are generated for a specific source using physical parameters that are descriptive of the source or measured data. An inverse square law calculation which corrects for scatter and absorption is used for seeds. Measured or Polynomial coefficients are used for absorption and scatter correction. To enhance the calculation speed, a precalculated table of dose values is generated before performing the implant calculation. The following sections describe the calculational models.

C. Seed Polynomial Model

The dose rate at a distance r from a seed source is calculated assuming the seed is an idealized point source.

$$D(r) = \frac{S}{r^2}\mathrm{SRM}(r)$$

Where:
S = Source strength
r = distance from the source

SRM(r) is precalculated at the time of source description and includes the contribution of all effects except source strength and geometric attenuation. It includes the gamma ray exposure constant, the f factor, and a correction for absorption and scatter in tissue. The Meisberger polynomial method of data reduction represents this attenuation and scatter as follows:

$$\frac{\mathrm{SRM}(r)}{\Gamma * f} = \begin{cases} M(r) & \text{for } (r \le r_L) \\ M(0.75r_L) * e^{-\left(4.0 * \ln\left[\frac{M(r_L)}{M(75r_L)}\right]\left[\frac{r-(0.75r_L)}{r_L}\right]\right)} & \text{for } (r > r_L) \end{cases}$$

Where:
G = Gamma Ray exposure constant
f = exposure to dose conversion factor
A, B, C, D = Polynomial coefficients

For $r > r_L$, the SRM values are exponentially extrapolated based on the polynomial value at r_L and 0.75 r_L.

D. Line Model

The dose rate D(P) to any point P is calculated by assuming a line source is cylindrically symmetric. The dose to point P is found integrating over the activity along the line source. Attenuation and scatter through the source itself, clad material, and media are accounted for.

Figure 11.11 describes the geometry for the calculation. The source is assumed to be symmetric about the middle of the cladding area. Published data[12] shows this assumption to produce errors no greater than 3%.

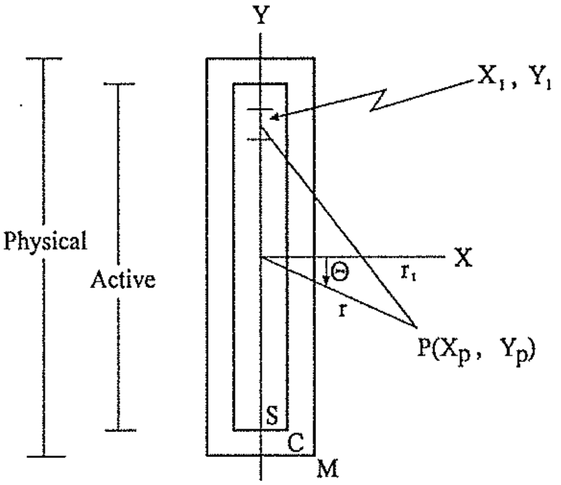


Figure 11.11 - Line Source Calculation Geometry

Area S contains the source material, Area C is the cladding, and area M is the medium or patient. r is the distance from the center of the source to point P at an angle of from the perpendicular.

As in the seed model, the scatter and attenuation through the medium or the correction factor K(r) is described by a polynomial from 0 to r_L cm. Beyond r_L the correction is an exponential extrapolation to the tail of K(r). The attenuation through the source and cladding is assumed to be exponential.

The equation describing D(P) is as follows:

for $r \leq r_L$

$$D(P) = \left(\sum_{i=1}^{N} \frac{A * \Gamma * C}{N * r^2} \right) e^{\mu s (r_s - s)} * e^{\mu c (r_c - c)} * K(r_M)$$

for $r \geq r_L$

Where:

N = number of discrete increments into which source is divided Typically 15 from $-\frac{Active}{2}$ to $+\frac{Active}{2}$

S = source strength

G = gamma ray exposure constant

r = distance from center of source to point P (cm)

θ = angle from perpendicular to r

r_L = maximum range of the polynomial fit (cm)

$K(r) = K_1 + K_2 + K_3r^2 + K_4r^3$ = equation used to account for scatter and attenuation of the media for $r \leq r_L$

$$l(r) = 4.0 * \ln\left[\frac{K(r_L)}{K(0.75r_L)}\right]\left[\frac{r_c - 0.75r_L}{r_L}\right]$$

$r_t = r_s + r_C + r_M$ = distance from point of integration or segment to point P

μ_s = attenuation coefficient through clad material (cm^{-1})

r_s = thickness along integration radius through source (cm)

s = thickness of source on central axis (cm)

μ_C = attenuation coefficient through clad material (cm^{-1})

r_c = thickness along integration radius through clad (cm)

c = thickness of clad material (cm)

Active = active length of source (cm)

Physical = physical length of source (cm)

To increase the speed of computation, a table of precalculated factors is generated. The table is a two dimensional array in radius and angle. The dose rate to point P becomes:

$$D(P) = \frac{A}{r^2}L(r, \Theta) = \frac{A}{r^2}L(dt)$$

EXTERNAL BEAM REFERENCES

1. Memorial Hospital Treatment Planning Users Guide (1982).
2. W.L. Tang, F.M. Khan, B.J. Gerbi, "Validity of Lung Correction Algorithms", *Medical Physics,* Vol. 13, No. 5, 1986.
3. H.F. Batho, J. *Can Associates, Radiol* 15, 79, (1964).
4. J. Milan, R. Bentley, "The Storage and Manipulation of Radiation Dose Data in a Small Digital Computer", *British Journal of Radiology*, 47, 115-121, (1974).
5. J. Purdy, "Advances in Radiation Oncology Physics", 1992.
6. C. Chui, R. Mohan, D. Fontenla, "Dose Computations for Asymmetric Fields Defined by Independent Jaws", *Medical Physics*, 15(1), 92-95, 1988.

7. D. Loshek, K. Keller, "Beam Profile Generator for Asymmetric Fields", *Medical Physics*, 15(4), 604-610, 1988.

8. E. El-Khalib, J.J. Batista, *Improved Lung Correction Using Tissue-Maximum Ratios in the Batho Correction*, Medical Physics, 11(3), 279-280. 1984

9. ICRU Report 24, *Determination of Absorbed Dose in a Patient Irradiated with Beams of X and Gamma Rays in Radiotherapy Procedures*, ICRU, Washington D.C., 1976.

10. R. Mohan, J. Bading, R.J. Caley, A. Reed, J. Ding, and T.S. Laughlin, "Computerized Electron Beam Dosimetry", F.C.H. Chu and J.S. Laughlin (Editors), *Proceedings of the Symposium on Electron Beam Therapy*, 75-81, September 25-27, 1987.

11. International Commission on Radiation Units and Measurements: *Radiation Dosimetry: Electron Beams With Energies Between 1 and 50 MeV.*, Report 35, pp 1-132, 1984.

12. F.M. Kahn, *The Physics of Radiation Therapy*, Williams & Wilkins Publishers, 1984.

13. J.W. Wong, J.A. Purdy, *On Methods of Inhomogeneity Corrections for Photon Transport*, Medical Physics, 17(5), 1990

14. M.R. Sontag, J.R. Cunningham, "The Equivalent Tissue: Air Ratio Method For Making Absorbed Dose Calculations In A Heterogenous Media", *Radiology* 129, 1978

15. *British Journal of Radiology*, Supplement No. 17, "Central Axis Depth Dose Data for Use in Radiotherapy", London, 1983.

IRREGULAR FIELD REFERENCES

1. J.R. Cunningham, D.N. Shrivanstava, J.M. Wilkinson, "Program Irregular-Calculation of the Dose from Irregular Shaped Beams", *Computer Programs in Biomedicine* 2:192-199, 1972.

2. W.F. Hanson, L.W. Berkley, M. Pertson, "Off-axis Beam Quality Change In Linear Acceleration X-Ray Beams". *Medical Physics*, 7(2) 145, 1980.

3. J.R. Clarkson, "A Note On Depth Doses In Fields Of Irregular Shapes", *British Journal of Radiology*, 14:265, 1941.

4. *British Journal of Radiology*, Supplement No. 17, "Central Axis Depth Dose Data for Use in Radiotherapy", 1983.

5. F.M. Kahn, *The Physics of Radiation Therapy*, Williams and Wilkins Publishers, 1984.

6. H.E. Johns, *The Physics of Radiology*, Charles C. Thomas Publisher, 1969.

7. J.A. Purdy, *Advances in Radiation Oncology Physics*, American Institute of Physics, 1992.

BRACHYTHERAPY REFERENCES

1. K. Breitman, "Dose-Rate Tables for Clinical ^{137}Cs Sources Sheathed in Platinum", *British Journal of Radiology* 47:657-664, 1974.

2. H.E. Johns, J. Cunningham, *The Physics of Radiology*, 3rd Edition, 1969, pp.471-531.

3. V. Krishnaswamy, "Dose Distribution About ^{137}CS Sources in Tissue", *Radiology* 105:181-184, 1972.

4. L. L. Meisberger, et.al., "The Effective Attenuation in Water of the Gamma Rays of ^{198}Au, ^{192}Ir, ^{137}Cs, ^{226}Ra, and ^{60}Co", *Radiology* 90:953-957, 1968.

5. *NCRP Report 41*, Specification of Gamma-Ray Brachytherapy Sources, 1974.

6. R.J. Shalek, M. Stovall, "Dosimetry in Implant Therapy", *Radiation Dosimetry Volume III*, F.H. Attix and E. Tochlin, Editors, 1969, pp. 743-807.

7. M.E.J. Young, H.F. Batho, "Dose Rate Tables for Linear Radium Sources Calculated by an Electronic Computer", *British Journal of Radiology* 37:38-44, 1964.

8. V. Krishnaswamy, "Dose distribution around an ^{125}I seed source in tissue", *Radiology*, 126:489-491, 1978.

9. R.G. Dale, "A Monte Carlo Derivation Of Parameters For Use In The Tissue Dosimetry Of Medium And Low Energy Nuclides", *British Journal of Radiology*, 55:748-757, 1982.

10. R.G. Dale, "Some Theoretical Derivations Relating To The Tissue Dosimetry Of Brachytherapy Nuclides, With Particular Reference To ^{125}I", *Medical Physics*, 10(2) 176-183, 1983, (revisions: MP 13(6) 963-964, 1986).

11. G.P. Glasgow, "Exposure Rate Constants for Filtered ^{192}Ir Sources", *Medical Physics*, 8(4) 502-503, 1981.

12. R. Waggner, J. Langer, J. Feldmeier, P. Eagan, S. Martin; "^{137}Cs Dosimetry Table for Asymmetric Source", *Medical Physics*, 16(2) 305-308, 1989.

13. J. Purdy, "Advances in Radiation Oncology Physics, Dosimetry, Treatment Planning, and Brachytherapy", 632, 1992.

14. F. Khan, "The Physics of Radiation Therapy", 125-355, 1984.

15. C. Thomason, "Radial dose distribution of ^{192}Ir and ^{137}Cs Seed Sources", *Medical Physics*, 16(2), 1989.

SAMPLE CALCULATIONS

I. EXTERNAL BEAM

This section describes entry of an external beam treatment plan by using a four field box, bilateral arcs, and a wedged pair CT plan. Use the plotted results at the end of this chapter as a template to duplicate the contour.

A. Four Field Box

1. Place the contour under the plastic sheet on the digitizer table. Before entry, be sure that all tumor volumes, points of calculations, reference points, etc. are marked on the contour.
2. Select External Beam Calculation from the main menu.
3. Enter the patient demographics.
4. Choose Outline. Respond to the prompt: "Enter magnification from the digitizer Y or N?" - In this case, choose "N" since it is scaled 2:1. Enter the magnification by selecting the value 0.50.
5. Using the digitizer pen, digitize point "U" in the upper left corner and point "L" in the lower right corner. Digitize the origin and a point to the right on the X axis.
6. Enter the outside patient contour by tracing the pen around the contour. Quit by touching the digitizer box labeled **End**.
7. Enter the tumor volume by touching the digitizer box labeled **Tumor**. Enter tumor volume. Quit entry by touching the digitizer box labeled **End**.
8. Enter three triangulation points by touching the digitizer box labeled **Reference Pts** and enter the points to the anterior, left, and right. Quit by touching the digitizer box **End**.
9. Enter the calculation points by touching the digitizer box **Calculation Pts**, enter the isocenter as a calculation point.
10. Exit the digitizer by touching **Exit**.
11. Input the densities and names of any areas you entered. Press **Enter**.
12. Enter the name of the calculation points.
13. Enter the name of the contour.
14. Add the beams to the contour by selecting Plan.
    a. Add a new beam by selecting Beam.
15. Select a treatment machine from the list.

a. Enter the following new beam data:

Machine:	Linac 15X
Beam Type:	Isocenter
Wedge No.:	0
Beam Name:	Anterior
Col Width cm:	11.000
Col Length cm:	12.000
Eff Width cm:	10.000
Eff Length cm:	10.000
Weight Value:	30.000
Fraction:	25
Tray Factor:	0.98

16. Select Accept. The beam appears on the screen. Select BmDisp to display the beam description on the bottom of the screen. Select BmRot and CngAngl. Enter 180. You have now entered the anterior field.
17. Enter Beam Number 2 by selecting Beam. Choose a new beam by selecting New. Select CopyInv and choose beam 1. Edit the name of the beam, "posterior." Accept the beam.
18. Enter beams 3 and 4 by using the same technique as beams 1 and 2. Enter the angles at 90° and 270° and edit names to RT lateral and LT lateral, respectively.
19. Following entry of the four beams, select Calcul to calculate the dose distribution. After the calculation is complete, the dose distribution is presented.
20. Select the isodose 100, 95, 90, 80, 60, and 40%. Select **ES**Cape to end.
21. Enter the prescription by selecting Prescri. Enter a total dose of 5000 cGy to the 95% isodose line.
22. Select Prt/Plt to print and plot. Enter plot title, paper size, and plot orientation.
23. Save the plan by selecting File, then Save. Enter a new plan name.
24. Select Quit.

The results of this calculation are shown in Figures 12.1, 12.2, 12.3, 12.4, and 12.5

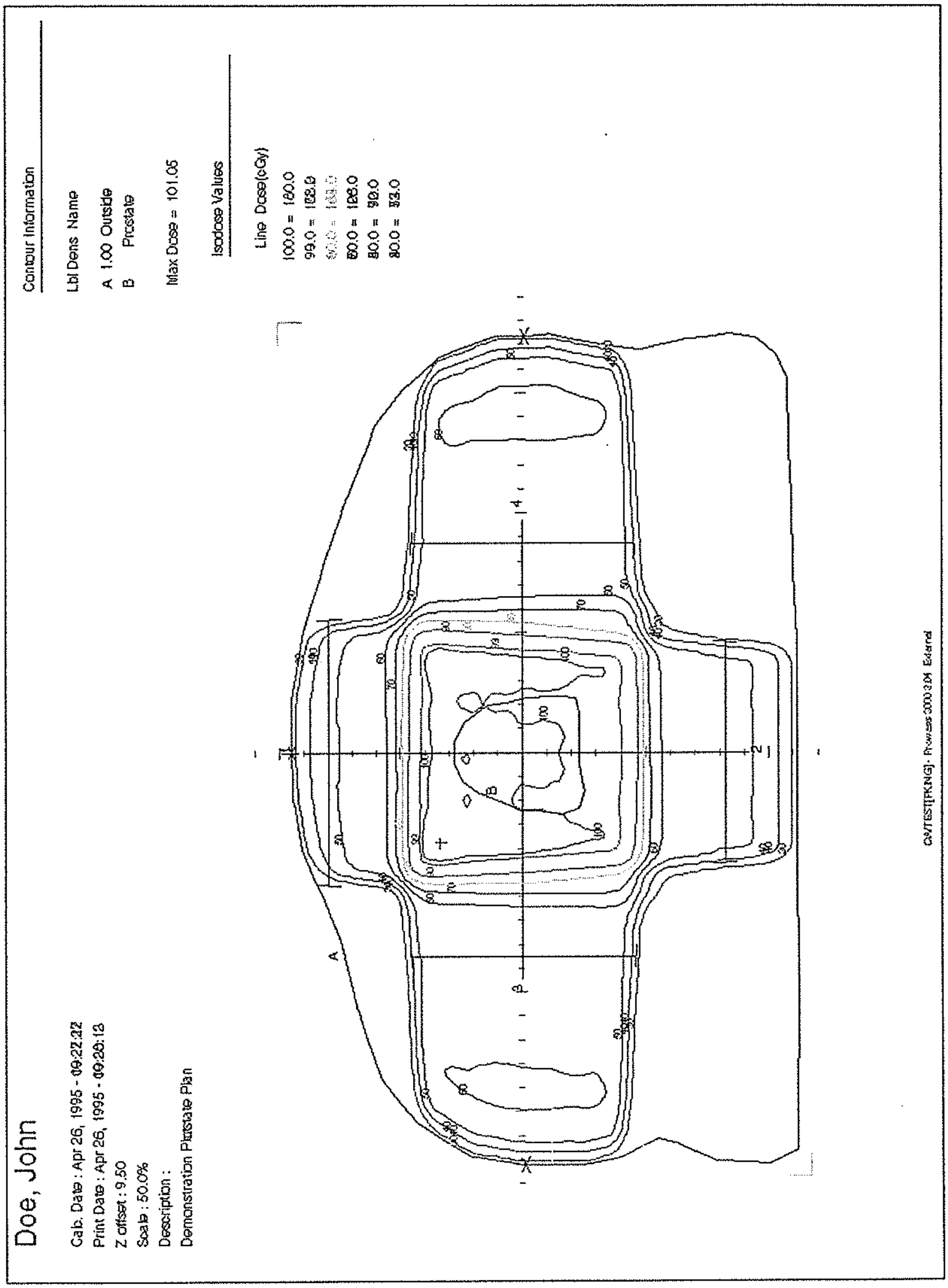
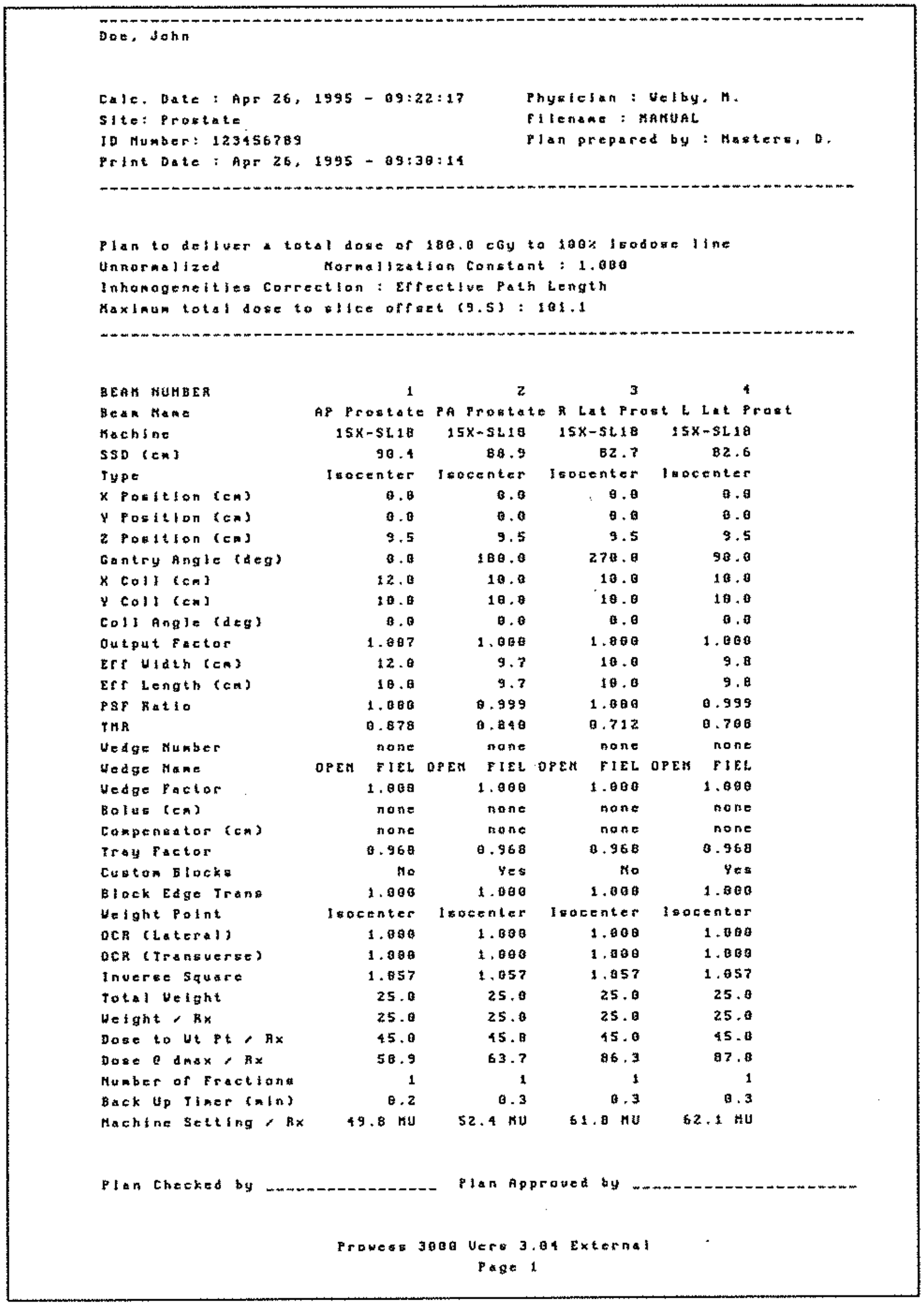
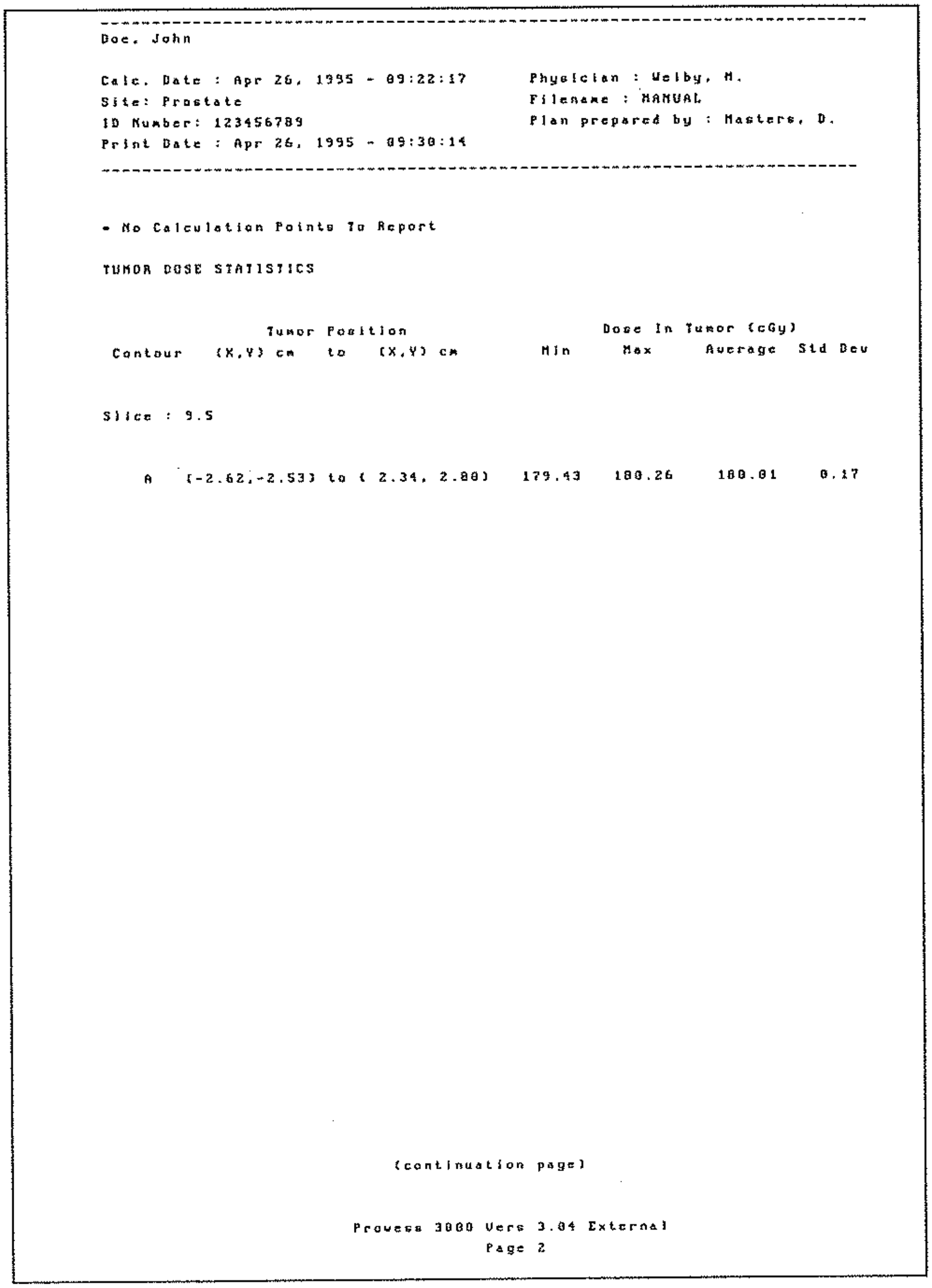


Figure 12.1 - Four Field Box Isodose Plot



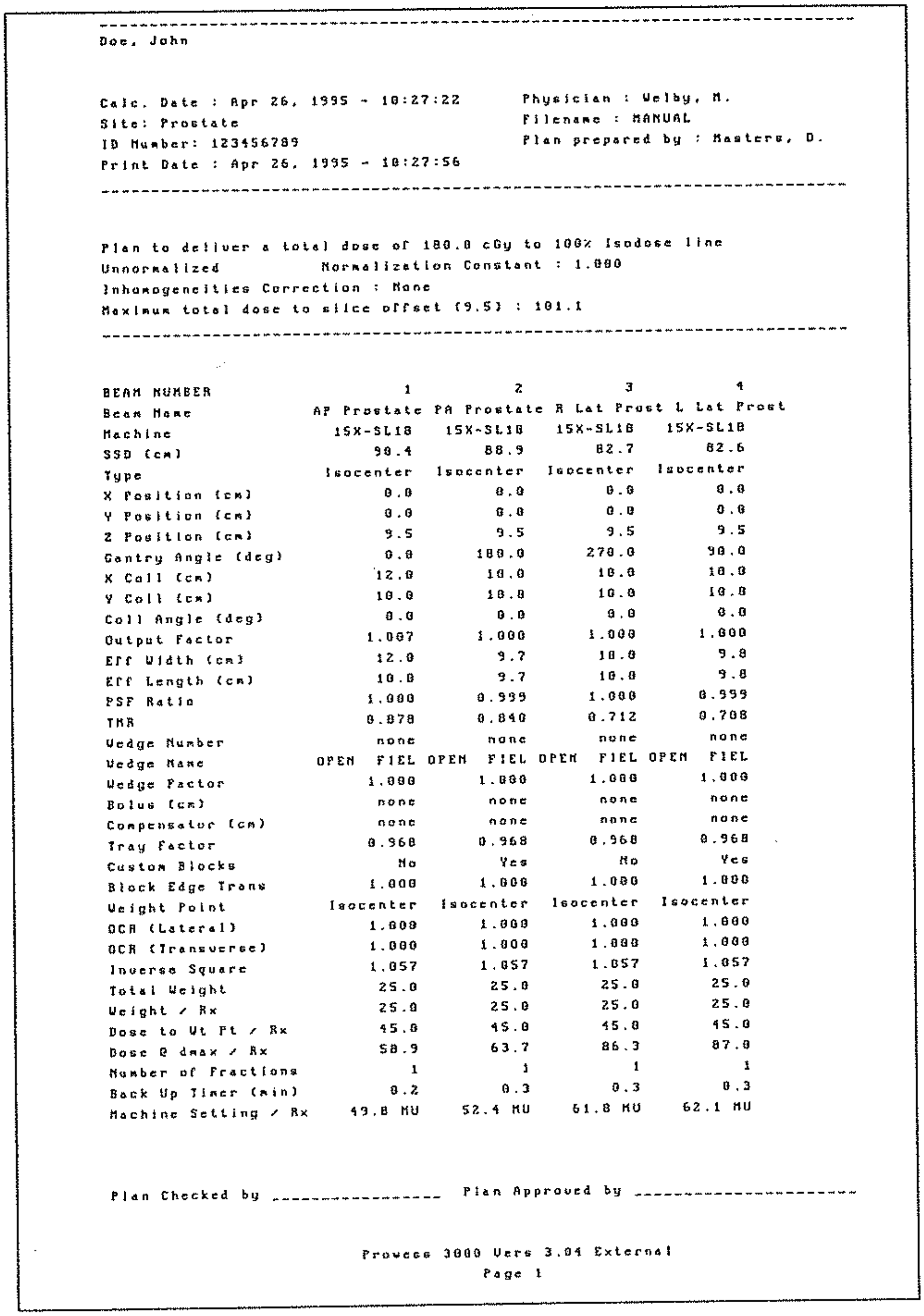
```
--------------------------------------------------------------------------
Doe, John


Calc. Date : Apr 26, 1995 - 09:22:17         Physician : Welby, M.
Site: Prostate                               Filename : MANUAL
ID Number: 123456789                         Plan prepared by : Masters, D.
Print Date : Apr 26, 1995 - 09:30:14
--------------------------------------------------------------------------


Plan to deliver a total dose of 180.0 cGy to 100% isodose line
Unnormalized           Normalization Constant : 1.000
Inhomogeneities Correction : Effective Path Length
Maximum total dose to slice offset (9.5) : 101.1
--------------------------------------------------------------------------


BEAM NUMBER                      1          2          3          4
Beam Name              AP Prostate PA Prostate R Lat Prost L Lat Prost
Machine                   15X-SL18   15X-SL18   15X-SL18   15X-SL18
SSD (cm)                      90.4       88.9       82.7       82.6
Type                     Isocenter  Isocenter  Isocenter  Isocenter
X Position (cm)                0.0        0.0        0.0        0.0
Y Position (cm)                0.0        0.0        0.0        0.0
Z Position (cm)                9.5        9.5        9.5        9.5
Gantry Angle (deg)             0.0      180.0      270.0       90.0
X Coll (cm)                   12.0       10.0       10.0       10.0
Y Coll (cm)                   10.0       10.0       10.0       10.0
Coll Angle (deg)               0.0        0.0        0.0        0.0
Output Factor                1.007      1.000      1.000      1.000
Eff Width (cm)                12.0        9.7       10.0        9.8
Eff Length (cm)               10.0        9.7       10.0        9.8
PSF Ratio                    1.000      0.999      1.000      0.999
TMR                          0.878      0.840      0.712      0.708
Wedge Number                  none       none       none       none
Wedge Name             OPEN   FIEL OPEN   FIEL OPEN   FIEL OPEN   FIEL
Wedge Factor                 1.000      1.000      1.000      1.000
Bolus (cm)                    none       none       none       none
Compensator (cm)              none       none       none       none
Tray Factor                  0.968      0.968      0.968      0.968
Custom Blocks                   No        Yes         No        Yes
Block Edge Trans             1.000      1.000      1.000      1.000
Weight Point             Isocenter  Isocenter  Isocenter  Isocenter
OCR (Lateral)                1.000      1.000      1.000      1.000
OCR (Transverse)             1.000      1.000      1.000      1.000
Inverse Square               1.057      1.057      1.057      1.057
Total Weight                  25.0       25.0       25.0       25.0
Weight / Rx                   25.0       25.0       25.0       25.0
Dose to Wt Pt / Rx            45.0       45.0       45.0       45.0
Dose @ dmax / Rx              58.9       63.7       86.3       87.8
Number of Fractions              1          1          1          1
Back Up Timer (min)            0.2        0.3        0.3        0.3
Machine Setting / Rx       49.8 MU    52.4 MU    61.8 MU    62.1 MU


Plan Checked by _________________ Plan Approved by ______________________


                    Prowess 3000 Vers 3.04 External
                                Page 1
```

Figure 12.2 - Four Field Box Calculation Results



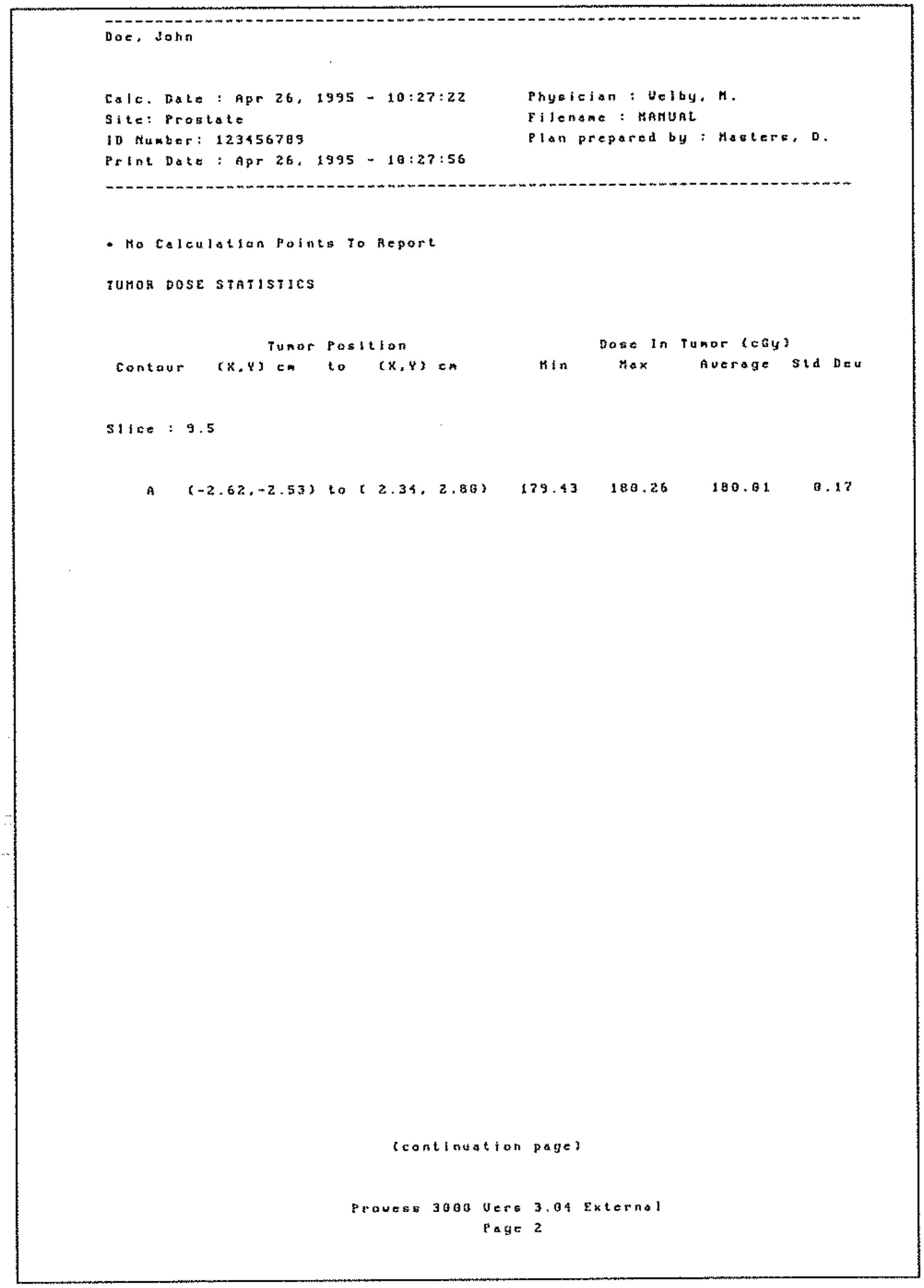
```
--------------------------------------------------------------------------
Doe, John

Calc. Date : Apr 26, 1995 - 09:22:17      Physician : Welby, M.
Site: Prostate                            Filename : MANUAL
ID Number: 123456789                      Plan prepared by : Masters, D.
Print Date : Apr 26, 1995 - 09:30:14
--------------------------------------------------------------------------


- No Calculation Points To Report

TUMOR DOSE STATISTICS


                Tumor Position                   Dose In Tumor (cGy)
 Contour    (X,Y) cm    to    (X,Y) cm        Min      Max      Average  Std Dev


Slice : 9.5


     A   (-2.62,-2.53) to ( 2.34, 2.80)   179.43   180.26    180.01     0.17




                            (continuation page)


                        Prowess 3000 Vers 3.04 External
                                    Page 2
```

Figure 12.3 - Four Field Box Calculation Results (cont.)



```
-----------------------------------------------------------------------
Doe, John

Calc. Date : Apr 26, 1995 - 10:27:22        Physician : Welby, M.
Site: Prostate                              Filename : MANUAL
ID Number: 123456789                        Plan prepared by : Masters, D.
Print Date : Apr 26, 1995 - 10:27:56
-----------------------------------------------------------------------

Plan to deliver a total dose of 180.0 cGy to 100% Isodose line
Unnormalized          Normalization Constant : 1.000
Inhomogeneities Correction : None
Maximum total dose to slice offset (9.5) : 101.1
-----------------------------------------------------------------------

BEAM NUMBER                   1           2           3           4
Beam Name             AP Prostate PA Prostate R Lat Prost L Lat Prost
Machine                  15X-SL18    15X-SL18    15X-SL18    15X-SL18
SSD (cm)                     90.4        88.9        82.7        82.6
Type                    Isocenter   Isocenter   Isocenter   Isocenter
X Position (cm)               0.0         0.0         0.0         0.0
Y Position (cm)               0.0         0.0         0.0         0.0
Z Position (cm)               9.5         9.5         9.5         9.5
Gantry Angle (deg)            0.0       180.0       270.0        90.0
X Coll (cm)                  12.0        10.0        10.0        10.0
Y Coll (cm)                  10.0        10.0        10.0        10.0
Coll Angle (deg)              0.0         0.0         0.0         0.0
Output Factor               1.007       1.000       1.000       1.000
Eff Width (cm)               12.0         9.7        10.0         9.8
Eff Length (cm)              10.0         9.7        10.0         9.8
PSF Ratio                   1.000       0.999       1.000       0.999
TMR                         0.878       0.840       0.712       0.708
Wedge Number                 none        none        none        none
Wedge Name              OPEN FIEL   OPEN FIEL   OPEN FIEL   OPEN FIEL
Wedge Factor                1.000       1.000       1.000       1.000
Bolus (cm)                   none        none        none        none
Compensator (cm)             none        none        none        none
Tray Factor                 0.968       0.968       0.968       0.968
Custom Blocks                  No         Yes          No         Yes
Block Edge Trans            1.000       1.000       1.000       1.000
Weight Point            Isocenter   Isocenter   Isocenter   Isocenter
OCR (Lateral)               1.000       1.000       1.000       1.000
OCR (Transverse)            1.000       1.000       1.000       1.000
Inverse Square              1.057       1.057       1.057       1.057
Total Weight                 25.0        25.0        25.0        25.0
Weight / Rx                  25.0        25.0        25.0        25.0
Dose to Wt Pt / Rx           45.0        45.0        45.0        45.0
Dose @ dmax / Rx             58.9        63.7        86.3        87.0
Number of Fractions             1           1           1           1
Back Up Timer (min)           0.2         0.3         0.3         0.3
Machine Setting / Rx      49.8 MU     52.4 MU     61.8 MU     62.1 MU


Plan Checked by _______________  Plan Approved by ____________________

                  Prowess 3000 Vers 3.04 External
                              Page 1
```

Figure 12.4 - Four Field Box Dose Summary



```
---------------------------------------------------------------------------
Doe, John


Calc. Date : Apr 26, 1995 - 10:27:22       Physician : Velby, M.
Site: Prostate                             Filename : MANUAL
ID Number: 123456789                       Plan prepared by : Masters, D.
Print Date : Apr 26, 1995 - 10:27:56
---------------------------------------------------------------------------


• No Calculation Points To Report

TUMOR DOSE STATISTICS


                Tumor Position                      Dose In Tumor (cGy)
 Contour   (X,Y) cm   to   (X,Y) cm         Min      Max      Average  Std Dev


Slice : 9.5


    A   (-2.62,-2.53) to ( 2.34, 2.80)  179.43   180.26    180.01    0.17




                            (continuation page)


                      Prowess 3000 Vers 3.04 External
                                  Page 2
```

Figure 12.5 - Four Field Box Dose Summary (cont.)

B. Bilateral Arcs

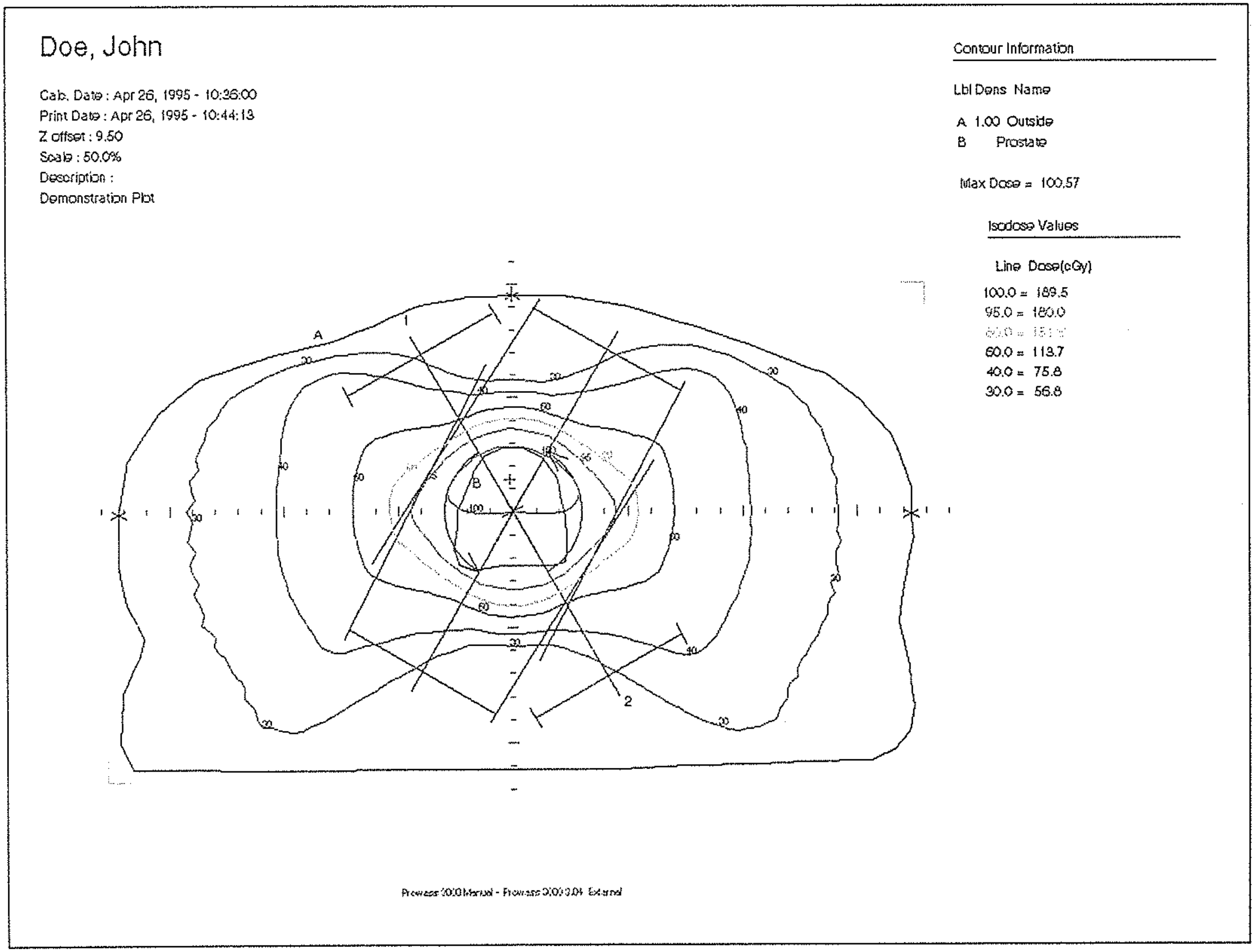
A pelvis contour has already been entered. To plan a pair of bilateral arcs:

1. Select **External Beam Calculation** from the main menu.
2. Press the down arrow to display the patient files available. Select the patient named GRADY. Choose Plan.
3. Select Beam and select a treatment machine. Enter beam number 1 by filling in the new beam window.
4. Change the beam type by selecting BmType then Rotate. Enter the following new data and select Accept.

Machine:	Linac 6X
Beam Type:	Rotate
Wedge No.:	0
Beam Name:	Rt Lat
Col Width cm:	8.000
Col Length cm:	8.000
Eff Width cm:	8.000
Eff Length cm:	8.000
Weight Value:	50.000
Fraction:	25
Tray Factor:	0.95

5. The beam will appear on the screen. Choose BmRot to change the start and stop angles.
6. Choose StrtAgl and enter 30. Select EndAngl to enter stop angle. Enter 150 to produce a 120° arc. Select **ESCape** to return to the Beam menu.
7. Enter Beam Number 2 by selecting Beam and choose CopyInv. Change title to Left Lateral and select Accept. Check the angles to be sure they are appropriate.
8. Calculate by choosing Calcul and wait for the calculation to complete.
9. Select isodose values of 100, 95, 90, 80, 60, 40, and 30.
10. Select **ESCape**.
11. Enter the prescription by selecting Prescri. Enter a total dose of 4500 cGy to the 95% isodose line.
12. Print and plot this by selecting Prt/Plt. Enter plot title, paper size, and orientation.
13. Save the plan by choosing File. Press **ESCape** to return to the planning menu.
14. Select Quit to exit the program and return to the main menu.

The results of this calculation are shown in Figure 12.6, 12.7, and 12.8.



Doe, John

Calc. Date : Apr 26, 1995 - 10:36:00
Print Date : Apr 26, 1995 - 10:44:13
Z offset : 9.50
Scale : 50.0%
Description :
Demonstration Plot

Contour Information

Lbl	Dens	Name
A	1.00	Outside
B		Prostate

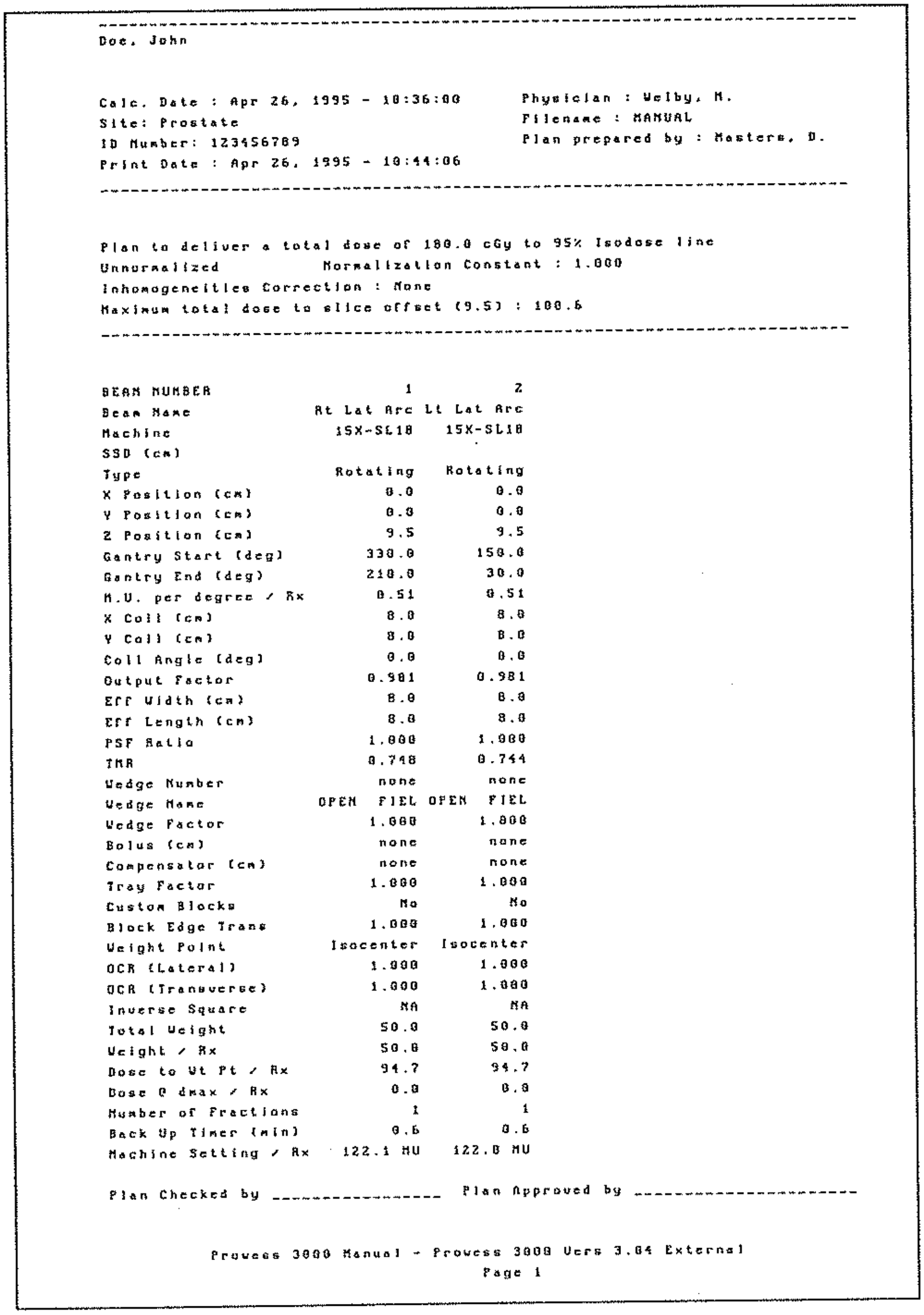
Max Dose = 100.57

Isodose Values

Line	Dose(cGy)
100.0 =	189.5
95.0 =	180.0
80.0 =	15[illegible]
60.0 =	113.7
40.0 =	75.8
30.0 =	56.8

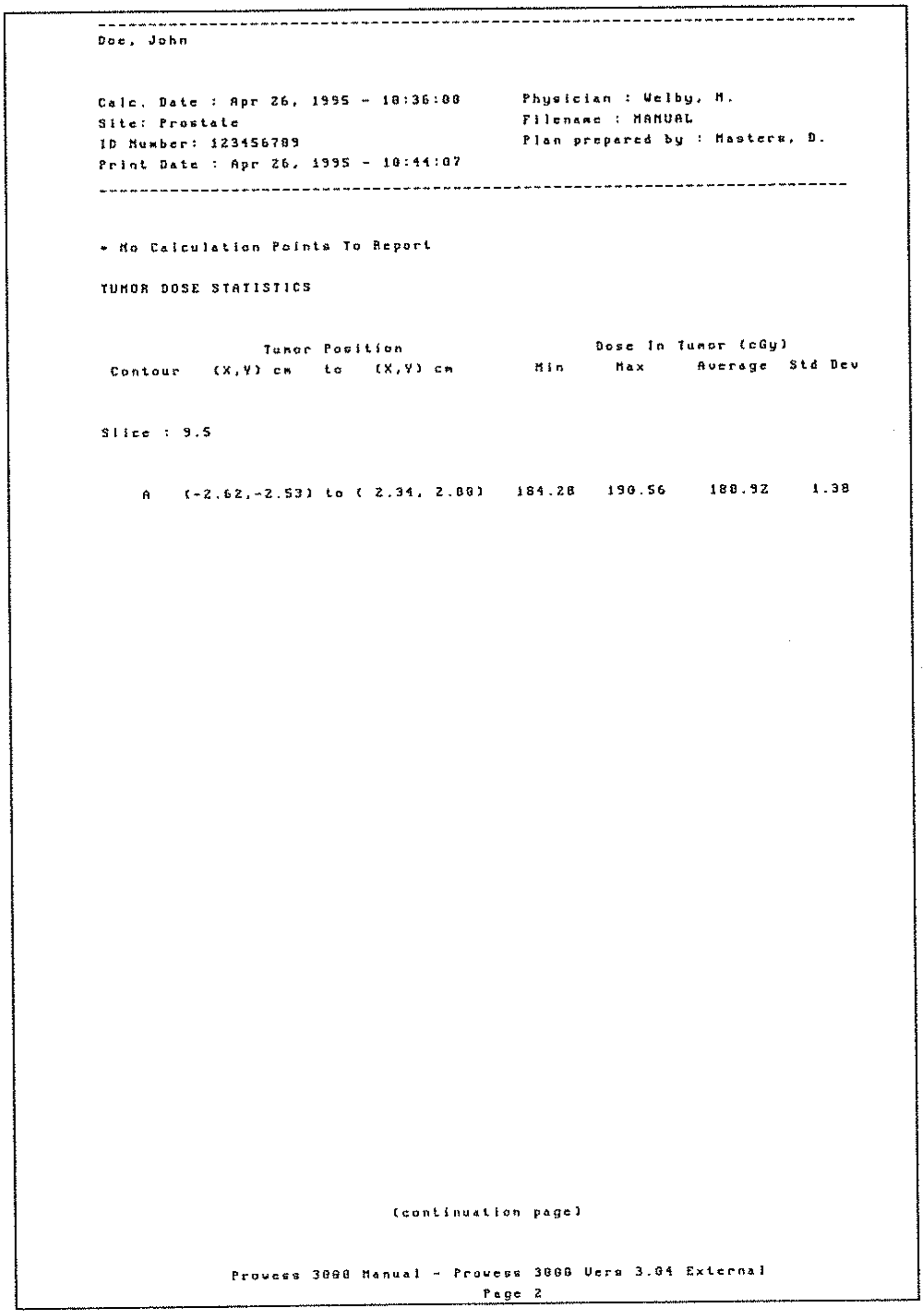
Prowess 3000 Manual - Prowess 3000 3.04 External

Figure 12.6 - Bilateral Arcs: Isodose Plot



```
---------------------------------------------------------------------------
Doe, John


Calc. Date : Apr 26, 1995 - 10:36:00        Physician : Welby, M.
Site: Prostate                              Filename : MANUAL
ID Number: 123456789                        Plan prepared by : Masters, D.
Print Date : Apr 26, 1995 - 10:44:06
---------------------------------------------------------------------------


Plan to deliver a total dose of 180.0 cGy to 95% Isodose line
Unnormalized            Normalization Constant : 1.000
Inhomogeneities Correction : None
Maximum total dose to slice offset (9.5) : 100.6
---------------------------------------------------------------------------


BEAM NUMBER                        1          2
Beam Name                 Rt Lat Arc Lt Lat Arc
Machine                     15X-SL18   15X-SL18
SSD (cm)
Type                        Rotating   Rotating
X Position (cm)                  0.0        0.0
Y Position (cm)                  0.0        0.0
Z Position (cm)                  9.5        9.5
Gantry Start (deg)             330.0      150.0
Gantry End (deg)               210.0       30.0
M.U. per degree / Rx            0.51       0.51
X Coll (cm)                      8.0        8.0
Y Coll (cm)                      8.0        8.0
Coll Angle (deg)                 0.0        0.0
Output Factor                  0.981      0.981
Eff Width (cm)                   8.0        8.0
Eff Length (cm)                  8.0        8.0
PSF Ratio                      1.000      1.000
TMR                            0.748      0.744
Wedge Number                    none       none
Wedge Name                OPEN  FIEL OPEN  FIEL
Wedge Factor                   1.000      1.000
Bolus (cm)                      none       none
Compensator (cm)                none       none
Tray Factor                    1.000      1.000
Custom Blocks                     No         No
Block Edge Trans               1.000      1.000
Weight Point               Isocenter  Isocenter
OCR (Lateral)                  1.000      1.000
OCR (Transverse)               1.000      1.000
Inverse Square                    NA         NA
Total Weight                    50.0       50.0
Weight / Rx                     50.0       50.0
Dose to Wt Pt / Rx              94.7       94.7
Dose @ dmax / Rx                 0.0        0.0
Number of Fractions                1          1
Back Up Timer (min)              0.6        0.6
Machine Setting / Rx        122.1 MU   122.0 MU

Plan Checked by ________________  Plan Approved by ______________________


          Prowess 3000 Manual - Prowess 3000 Vers 3.04 External
                                 Page 1
```

Figure 12.7 - Bilateral Arcs: Calculation Results



```
--------------------------------------------------------------------------
Doe, John

Calc. Date : Apr 26, 1995 - 10:36:00          Physician : Welby, M.
Site: Prostate                                Filename : MANUAL
ID Number: 123456789                          Plan prepared by : Masters, D.
Print Date : Apr 26, 1995 - 10:44:07
--------------------------------------------------------------------------


* No Calculation Points To Report

TUMOR DOSE STATISTICS


                 Tumor Position                     Dose In Tumor (cGy)
 Contour    (X,Y) cm    to    (X,Y) cm        Min      Max      Average  Std Dev


Slice : 9.5


    A    (-2.62,-2.53) to ( 2.34, 2.80)   184.28   190.56    188.92    1.38


                             (continuation page)

             Prowess 3000 Manual - Prowess 3000 Vers 3.04 External
                                    Page 2
```

Figure 12.8 - Bilateral Arcs: Calculation Results (cont.)

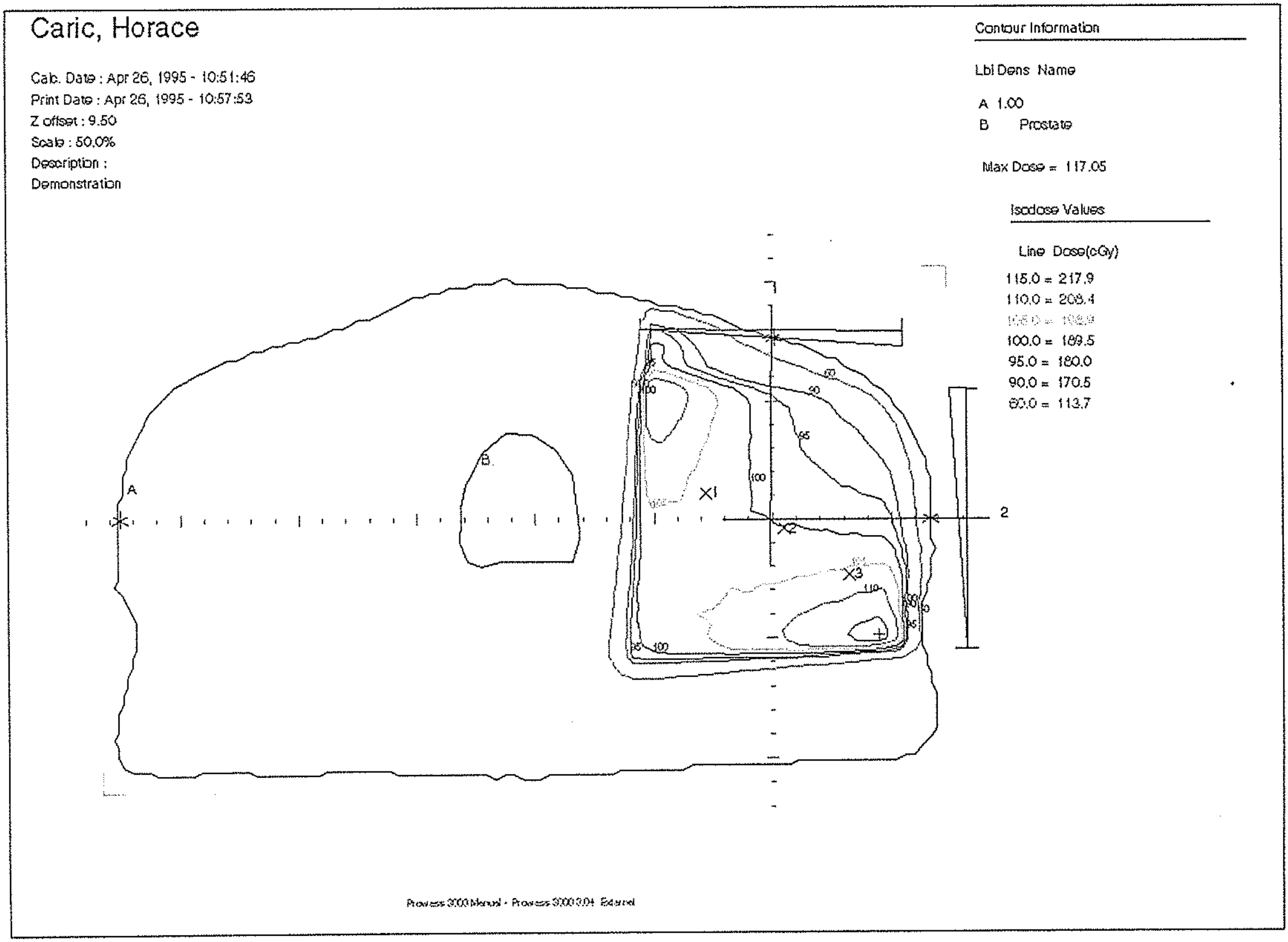
C. Wedged Pair

1. Enter the three isocenter points by choosing the menu item labeled RefPt. Enter the points to the anterior, left, and right. End by clicking the right mouse button or the End key.
2. Enter the calculation points by selecting the menu item CalcPt. Enter the center of the tumor as a calculation point.
3. Input the densities and titles of any areas you entered by choosing ChgDens.
4. Complete the contour entry by choosing PrvMenu. Add beams by selecting Plan.
5. Add a new beam by selecting Beam. Select a treatment machine from the list. Enter the following new beam data:

Machine:	Linac 4
Beam Type:	Isocenter
Wedge No.:	0
Beam Name:	Lt Ant Ob
Col Width cm:	7.000
Col Length cm:	7.000
Eff Width cm:	7.000
Eff Length cm:	7.000
Weight Value:	1250.000
Fraction:	25
Tray Factor:	1.00

6. Select Accept and the beam will appear on the screen.
7. Select BmDisp to display the beam description on the bottom of the screen. Using the mouse, rotate the beam to 191°.
8. Add a wedge by selecting Wedge. Using the mouse, select the 45° wedge, clockwise.
9. Move the isocenter with the mouse to the center of the tumor (maxillary antrum).
10. Select Beam to enter Beam Number 2. To choose a new beam, select New. Select CopyInv and choose beam 1. Edit the name of the beam "Lt Ant Ob." Rotate the beam to 97°.
11. After entering the beams, select Calcul to calculate the dose distribution. Normalize to the maximum.
12. Select the isodose curve values of 95, 90, 80, 60, and 40. Press ESCape to end.
13. Enter the prescription by selecting Prescri. Enter the total dose of 4500 cGy to the 95% isodose line.
14. Select HardCpy and Print to print. Chose ImagPrt to print a hardcopy of the CT image.
15. Save the plan by choosing File. Press ESCape to exit the current plan.
16. Select Quit to exit from the program.

The results of this calculation are shown in Figures 12.9, 12.10, and 12.11.



Caric, Horace

Cab. Date : Apr 26, 1995 - 10:51:46
Print Date : Apr 26, 1995 - 10:57:53
Z offset : 9.50
Scale : 50.0%
Description :
Demonstration

Contour Information

Lbl	Dens	Name
A	1.00	
B		Prostate

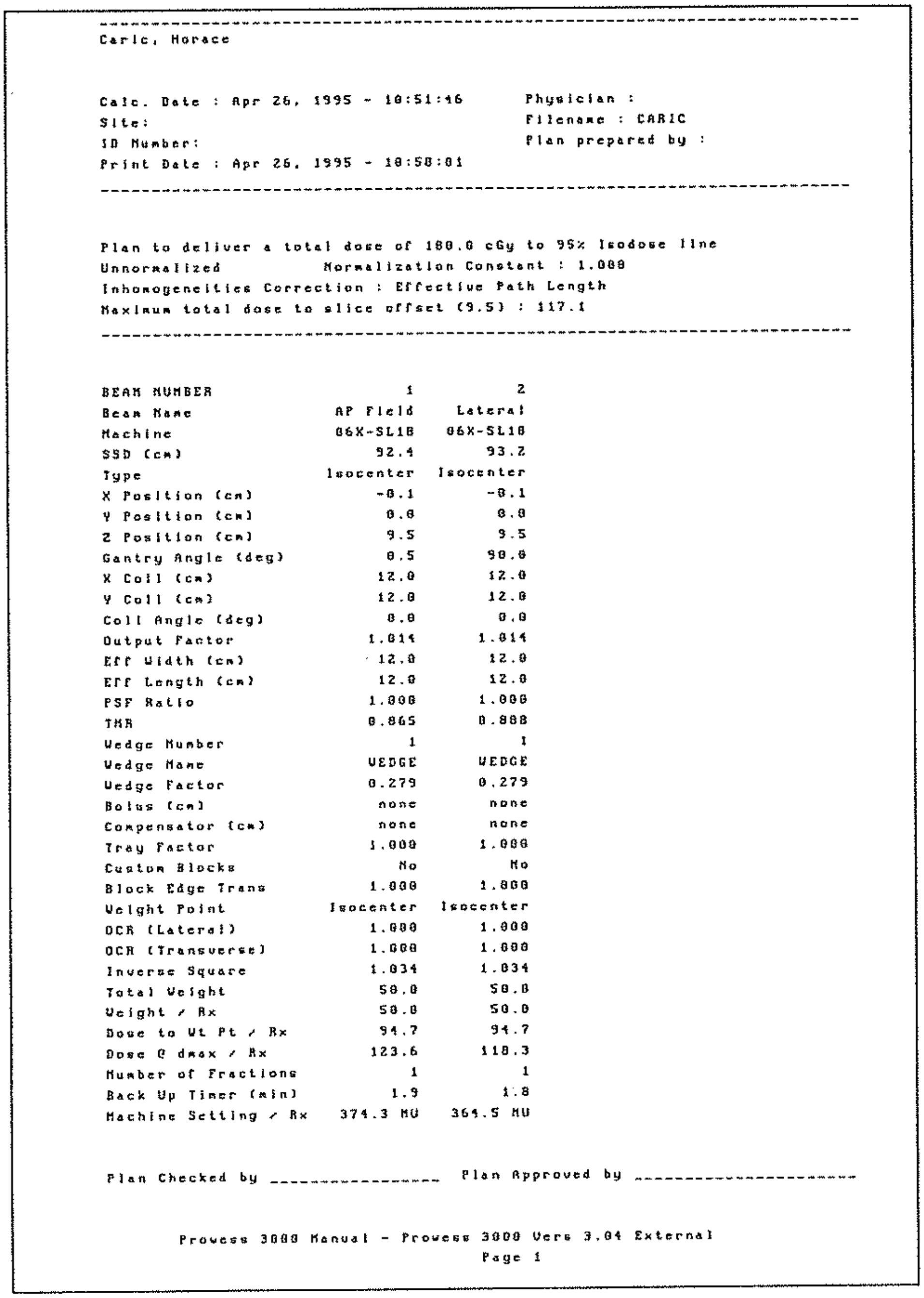
Max Dose = 117.05

Isodose Values

Line Dose(cGy)
115.0 = 217.9
110.0 = 208.4
105.0 = 198.9
100.0 = 189.5
95.0 = 180.0
90.0 = 170.5
60.0 = 113.7

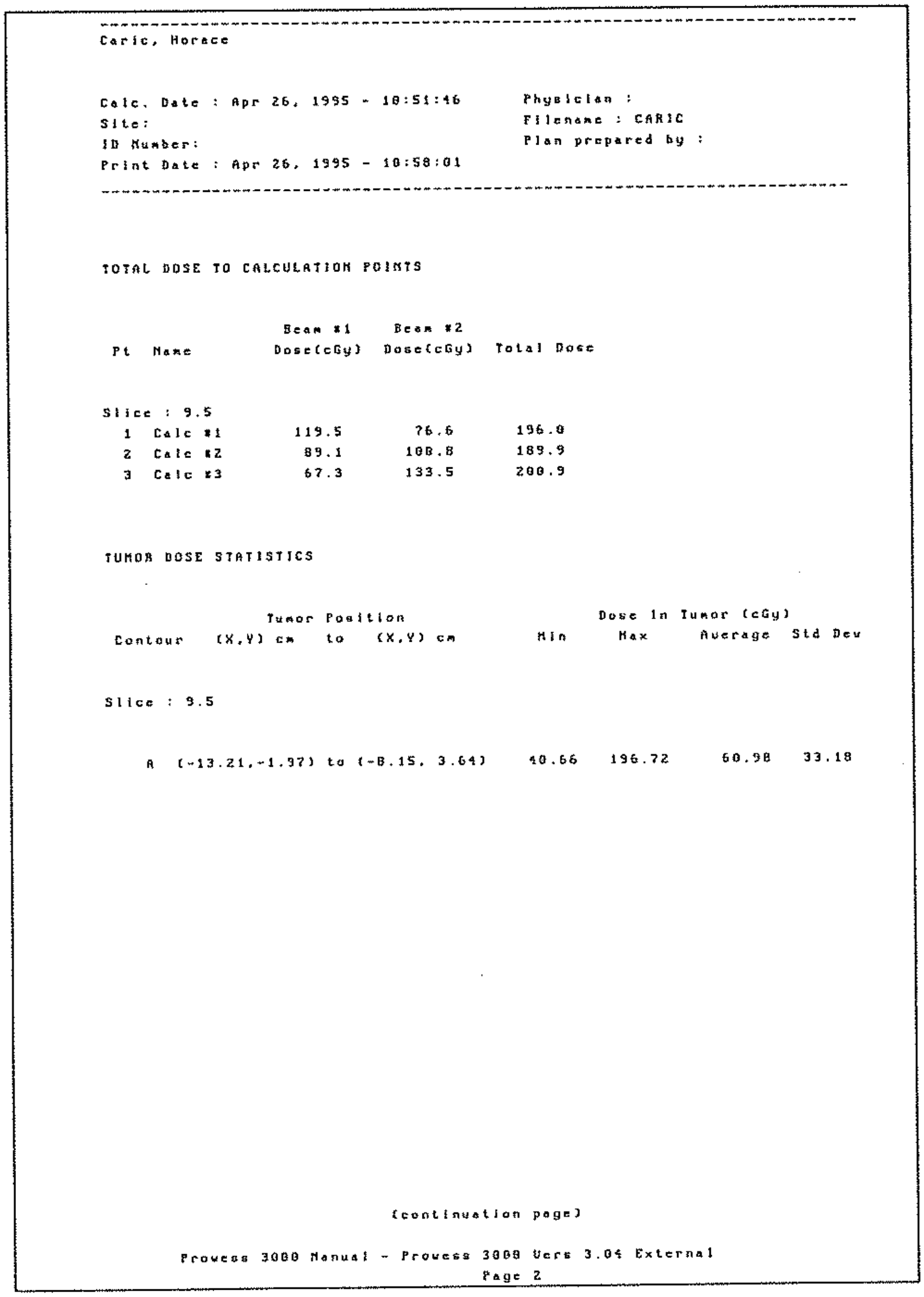
Prowess 3000 Manual - Prowess 3000 3.04 External

Figure 12.9 - Bilateral Arcs: Isodose Plot



```
-------------------------------------------------------------------------
Caric, Horace


Calc. Date : Apr 26, 1995 - 10:51:46         Physician :
Site:                                        Filename : CARIC
ID Number:                                   Plan prepared by :
Print Date : Apr 26, 1995 - 10:50:01
------------------------------------------------------------------------


Plan to deliver a total dose of 180.0 cGy to 95% Isodose line
Unnormalized           Normalization Constant : 1.000
Inhomogeneities Correction : Effective Path Length
Maximum total dose to slice offset (9.5) : 117.1
------------------------------------------------------------------------


BEAM NUMBER                    1           2
Beam Name               AP Field     Lateral
Machine                 06X-SL18    06X-SL18
SSD (cm)                    92.4        93.2
Type                   Isocenter   Isocenter
X Position (cm)             -0.1        -0.1
Y Position (cm)              0.0         0.0
Z Position (cm)              9.5         9.5
Gantry Angle (deg)           0.5        90.0
X Coll (cm)                 12.0        12.0
Y Coll (cm)                 12.0        12.0
Coll Angle (deg)             0.0         0.0
Output Factor              1.014       1.014
Eff Width (cm)              12.0        12.0
Eff Length (cm)             12.0        12.0
PSF Ratio                  1.000       1.000
TMR                        0.865       0.888
Wedge Number                   1           1
Wedge Name                 WEDGE       WEDGE
Wedge Factor               0.279       0.279
Bolus (cm)                  none        none
Compensator (cm)            none        none
Tray Factor                1.000       1.000
Custom Blocks                 No          No
Block Edge Trans           1.000       1.000
Weight Point           Isocenter   Isocenter
OCR (Lateral)              1.000       1.000
OCR (Transverse)           1.000       1.000
Inverse Square             1.034       1.034
Total Weight                50.0        50.0
Weight / Rx                 50.0        50.0
Dose to Wt Pt / Rx          94.7        94.7
Dose @ dmax / Rx           123.6       118.3
Number of Fractions            1           1
Back Up Timer (min)          1.9         1.8
Machine Setting / Rx    374.3 MU    364.5 MU


Plan Checked by ________________ Plan Approved by _____________________


        Prowess 3000 Manual - Prowess 3000 Vers 3.04 External
                                Page 1
```

Figure 12.10 - Wedged Pair: Calculation Results



```
--------------------------------------------------------------------------------
Caric, Horace


Calc. Date : Apr 26, 1995 - 10:51:46         Physician :
Site:                                        Filename : CARIC
ID Number:                                   Plan prepared by :
Print Date : Apr 26, 1995 - 10:58:01
--------------------------------------------------------------------------------



TOTAL DOSE TO CALCULATION POINTS


                    Beam #1    Beam #2
 Pt  Name          Dose(cGy)  Dose(cGy)  Total Dose


Slice : 9.5
  1  Calc #1         119.5       76.6       196.0
  2  Calc #2          89.1      100.8       189.9
  3  Calc #3          67.3      133.5       200.9



TUMOR DOSE STATISTICS


                  Tumor Position                     Dose in Tumor (cGy)
 Contour   (X,Y) cm   to   (X,Y) cm         Min      Max       Average  Std Dev


Slice : 9.5


    A  (-13.21,-1.97) to (-8.15, 3.64)    40.66   196.72      60.98    33.18
















                              (continuation page)

          Prowess 3000 Manual - Prowess 3000 Vers 3.04 External
                                    Page 2
```

Figure 12.11 - Wedged Pair: Calculation Results (cont.)

II. IRREGULAR FIELD

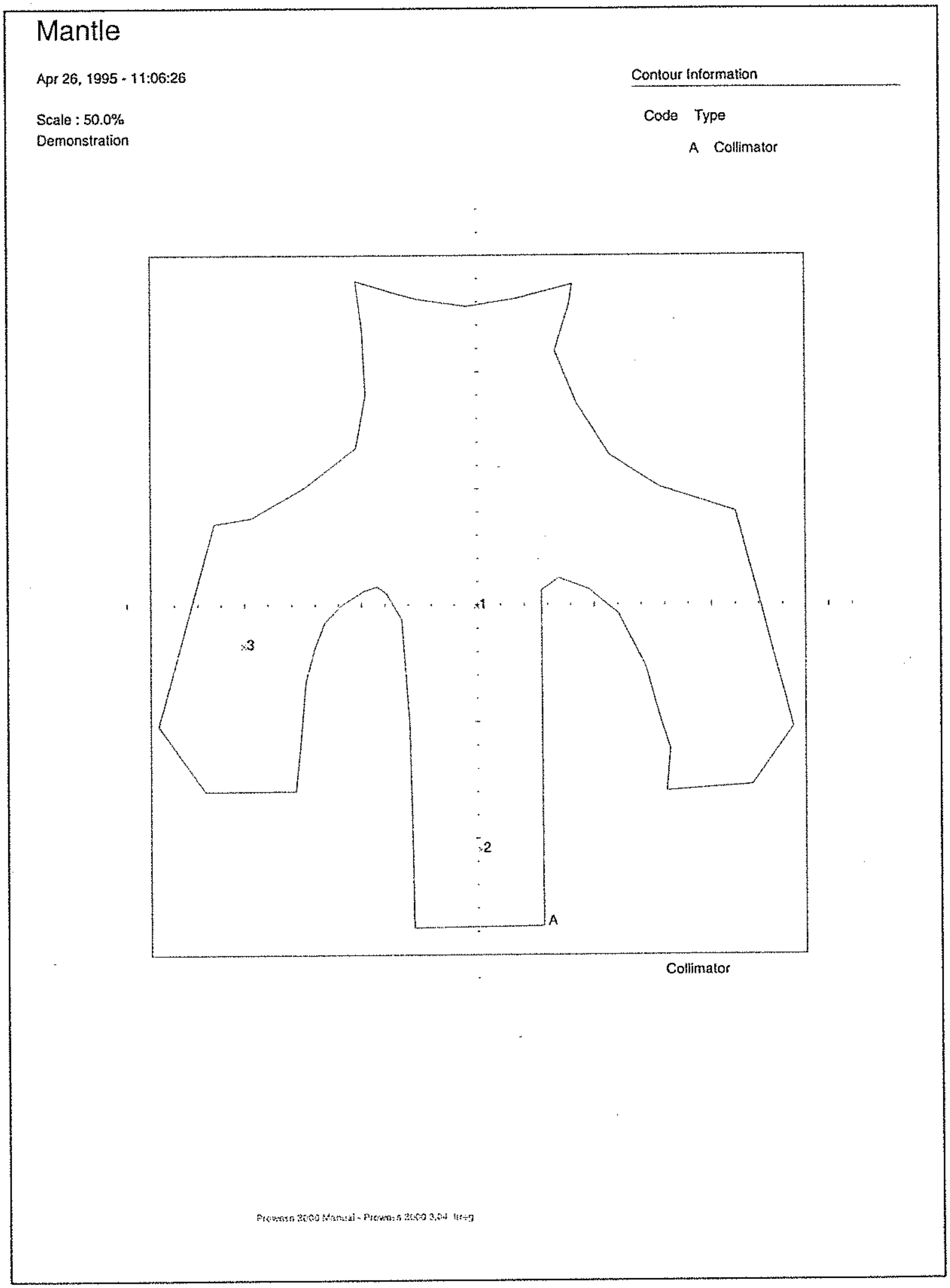
This section describes the calculation of an irregular field by using the irregular field program. The field is a mantle used to treat Hodgkin's disease. Use the field shape in Figure 12.11 as the beam outline for a sample case. To calculate an irregular field:

1. Place the contour under the plastic film on the digitizer.
2. Measure or enter the magnification of the field from the scale markings.
3. Mark the points of calculation on the film and record the SSD and depth of calculation for each point.
4. Mark the type of beam blocking at each edge of the field.
5. Start the program by selecting **Irregular Field Calculation** from the main treatment planning menu.
6. Enter the patient demographics:
7. Press Outlin.
8. Select a machine from the list of those available.
9. Enter the magnification.
10. Proceed through the calibration by touching points "U" and "L" with the stylus on the digitizer.
11. Digitize the origin at the central axis of the beam and at a point on the major axis to the right of the origin (on the axis of the beam).
12. The default value for the edge type is set to collimator. To change the collimator type, touch the digitizer box labeled **Collimator Type**. Select the type of beam edge from the screen.
13. Enter the shape of the field point by point. You may enter it in either direction.
14. When you are finished, touch the digitizer box labeled **End**.
15. Enter the calculation points. Once they are completed, touch the digitizer box labeled **End**.
16. The digitizer entry has been completed. Touch the digitizer box labeled **Exit**.
17. Enter the SSD, depth, and description of each calculation point.
    Point 1, SSD: 100.0 cm, Depth 10.0 cm, Description: CA
    Point 2, SSD: 105.0 cm, Depth 5.0 cm, Description: Neck
    Point 3, SSD: 101.0 cm, Depth 9.0 cm, Description: Axilla
    Point 4, SSD: 94.0 cm, Depth 14.0 cm, Description: Lower
18. Edit field parameters.

X Collimator size:	28.000 cm
Y Collimator size:	30.000 cm
Calculation Point:	1
Dose (cGy):	90.000
Tray Factor:	0.970

19. Press Calcul to calculate the irregular field. The calculation summary for each point will appear at the bottom of the screen. Press any key to continue.
20. Select Print to print the calculation. Select Plot to plot the results. Enter "Anterior Mantle" as the title, enter the scale factor as 0.5, and type "Y" to enter an 8½"x11" paper size.
21. Select Quit to exit the Irregular Field program and return to the main treatment planning menu.

The results of this calculation are shown in Figures 12.12 and 12.13.



Mantle

Apr 26, 1995 - 11:06:26

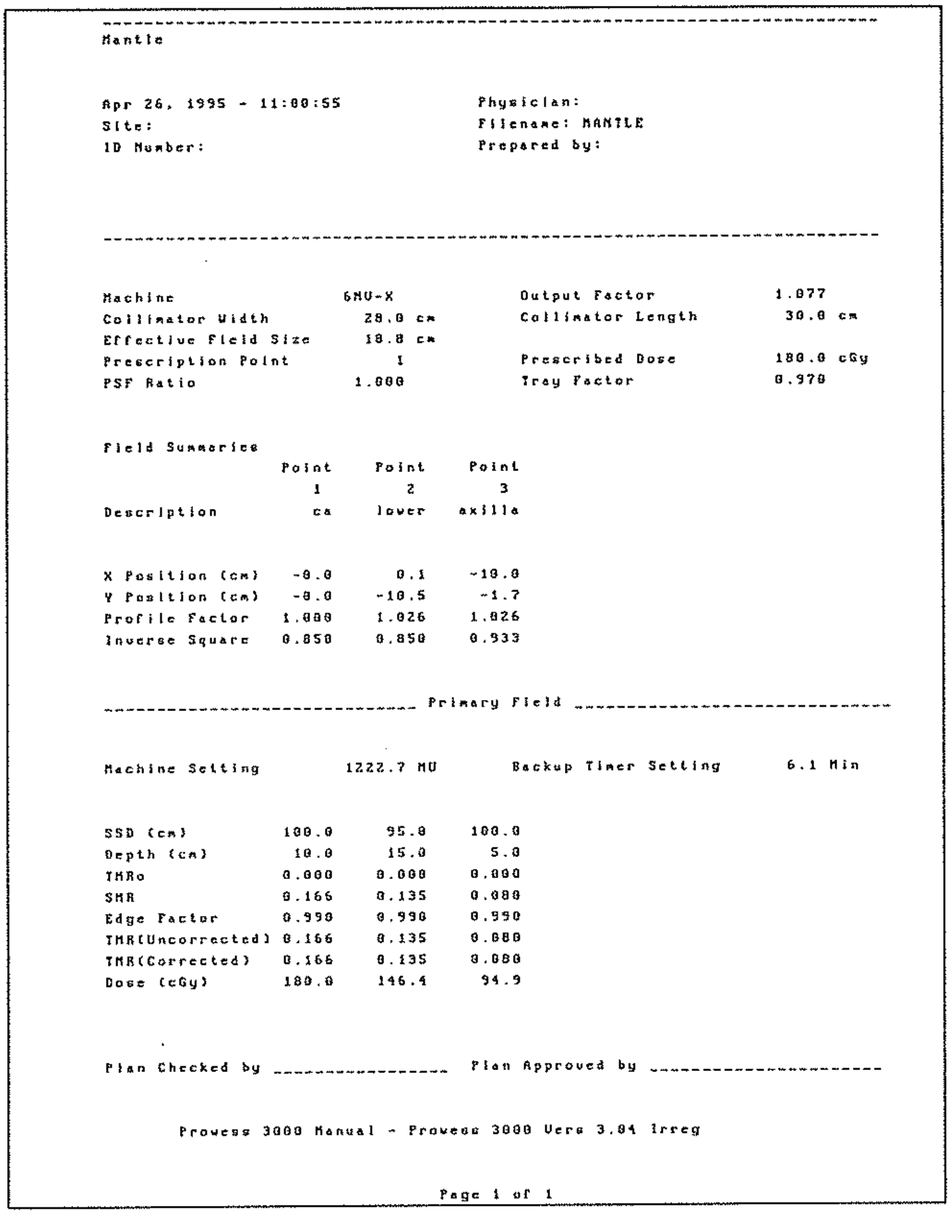
Scale : 50.0%
Demonstration

Contour Information

Code	Type
A	Collimator

Prowess 3000 Manual - Prowess 3000 3.04 Ireg

Figure 12.12 - Mantle Field: Beam Outline



```
--------------------------------------------------------------------------
Mantle


Apr 26, 1995 - 11:00:55                Physician:
Site:                                  Filename: MANTLE
ID Number:                             Prepared by:



--------------------------------------------------------------------------


Machine                    6MU-X           Output Factor              1.077
Collimator Width             20.0 cm       Collimator Length           30.0 cm
Effective Field Size         10.0 cm
Prescription Point            1            Prescribed Dose            100.0 cGy
PSF Ratio                   1.000          Tray Factor                0.970


Field Summaries
                   Point     Point     Point
                     1         2         3
Description         ca     lower    axilla


X Position (cm)    -0.0       0.1     -10.0
Y Position (cm)    -0.0     -10.5      -1.7
Profile Factor    1.000     1.026     1.026
Inverse Square    0.850     0.850     0.933

------------------------------ Primary Field ------------------------------


Machine Setting          1222.7 MU        Backup Timer Setting        6.1 Min


SSD (cm)          100.0      95.0     100.0
Depth (cm)         10.0      15.0       5.0
TMRo              0.000     0.000     0.000
SMR               0.166     0.135     0.080
Edge Factor       0.990     0.990     0.990
TMR(Uncorrected)  0.166     0.135     0.080
TMR(Corrected)    0.166     0.135     0.080
Dose (cGy)        100.0     146.4      94.9


Plan Checked by ________________  Plan Approved by ______________________

        Prowess 3000 Manual - Prowess 3000 Vers 3.04 Irreg

                              Page 1 of 1
```

Figure 12.13 - Mantle Field: Calculation Results and Dose Summary

III. BRACHYTHERAPY

The calculation of two types of implants is included in this section. The first type is a typical gynecological cervix implant that uses five ^{137}Cesium sources. The second type is a two plane, 32 seed, ^{192}Iridium used for a breast boost.

A. Cesium Cervix

For the cesium implant, use a standard Fletcher Suite applicator with a loading of 20, 15, and 10 mg sources in the tandem and two 15 mg sources in the ovoids.

Use two orthogonal films, one AP and one lateral, in order to input the source coordinates (or use the templates provided in Figure 12.13 and 12.14). Set the two films side-by-side (common axis vertical) under the plastic cover of the digitizer. Be sure that the ends of the sources are visible and numbered. Match the AP, lateral sources, and points of calculation such as A_{Rt}, A_{Lt}, B_{Rt}, B_{Lt}, Bladder, and Rectum.

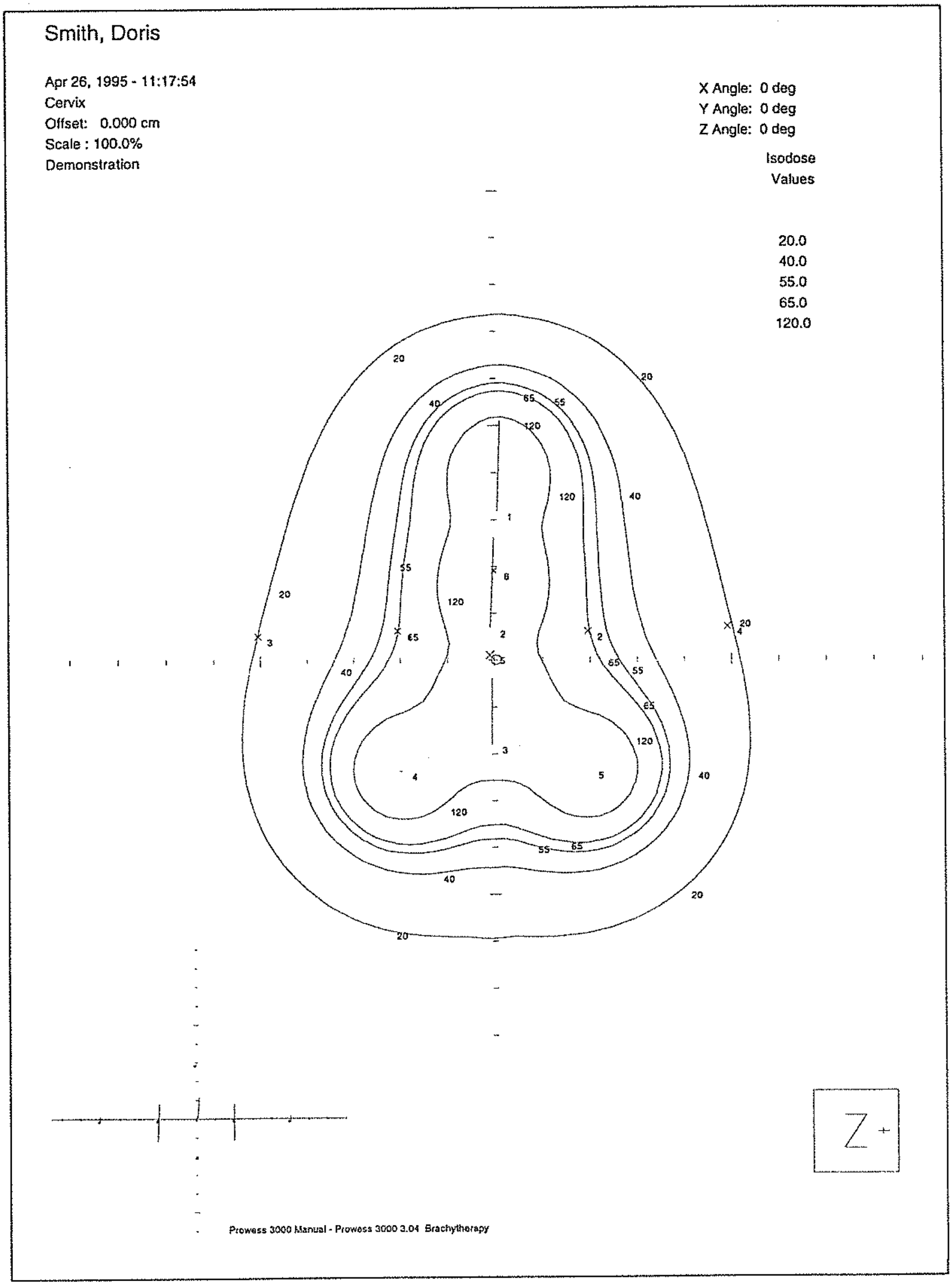
1. Choose **Brachytherapy Calculation** from the main menu to start the program.
2. Enter the patient demographics and select Accept when complete.
3. Select Orthog to enter the coordinates from film. Enter the source code. Chose ^{137}Ce 3M 6D6C (type 1). Enter the source strengths in mgRaeq which, for source 1, is 20.
4. Enter "N" to the question "Enter magnification from the digitizer? Y or N?". Enter the magnification factor of the localization films by entering 1.0 for both films.
5. Go through the calibration procedure for the digitizer by sparking points "U" and "L." Digitize the origin of film one and a point to the right on the film axis.
6. View the split screen. The coordinates for the first film will be on the right. The coordinates for the second film will be on the left. Digitize the coordinates of source 1.
7. To change the strength of source number 2, touch the digitizer box labeled **Change**. Enter the source type 1 and source strength 15 mgRaeq from the keyboard. Digitize source 2.
8. To change the strength of source 3, touch digitizer box labeled **Change.** Enter the source type 1 and source strength 10 mg Ra eq on the keyboard. Digitize source 3.
9. To change the source for the last time, touch digitizer box **Change**. Enter the source type 1 and source strength 15 mg Ra eq. Since both ovoids are the same strength, digitize the two ovoids. If there are points of calculation, touch digitizer box **Calculation Pts** and enter them in order. Touch the digitizer box **End** to complete film one.

10. Digitize the origin and a point to the right of film number two. There is no need to change and re-enter the source strengths because they were entered from film 1. Enter the names of the calculation points.
11. A summary of the sources and the Y-axis error summary are displayed on the screen. The magnification difference and the variance shown in the system window shows that the magnification difference is near 1.0 and the variance is near 0. Press Enter to proceed. Enter Y to the question "Save Info?".
12. Select the first view to calculate by pressing Plane. Three views appear on the screen. The largest view shows the AP projection. This is the plane of calculation. View A shows the transverse projection. View B shows the lateral projection.
13. If this calculation plane is satisfactory, select Calcul. The point numbers will appear on the screen while the program calculates the dose from each source.
14. After calculating all five sources, the default isodose curves appear in the upper left window. To plot these curves on the screen, accept the default values by pressing **Enter** after each number. After completing the display, press **ES**Cape.
15. Select Print to Print the results. Select Plot to plot the results. Accept the displayed isodose values by pressing **ES**Cape. Enter the plot scale factor of 1.0 and plot on the left side of an 8½"x11" sheet of paper.
16. Select SwapB to move the lateral plane in the calculation window. Repeat steps 13 through 15 to calculate and display. Plot the plane on the right side.
17. Following the print/plot process, press **ES**Cape and then select Quit to exit the program and return to the main menu.

The results of this calculation are shown in Figures 12.14, 12.15, 12.16, and 12.17.

The results are presented on two separate pages: A written description and a graphical description. The written results describe the radiation source in the implant including the location, type, and activity. The name and location of each calculation point is also given. A table of dose or dose rate is included for each calculation point. The table includes total dose to each point and the contribution to each point when there are no more than 10 sources.

The graphical page shows the dose distribution for the calculational planes specified. One plane per page is shown. Each page gives the angle and the offset of the plane. It shows the projection of the sources and a perpendicular view to illustrate offset. The isodose lines are shown in a unique color for each value.



Smith, Doris

Apr 26, 1995 - 11:17:54
Cervix
Offset: 0.000 cm
Scale : 100.0%
Demonstration

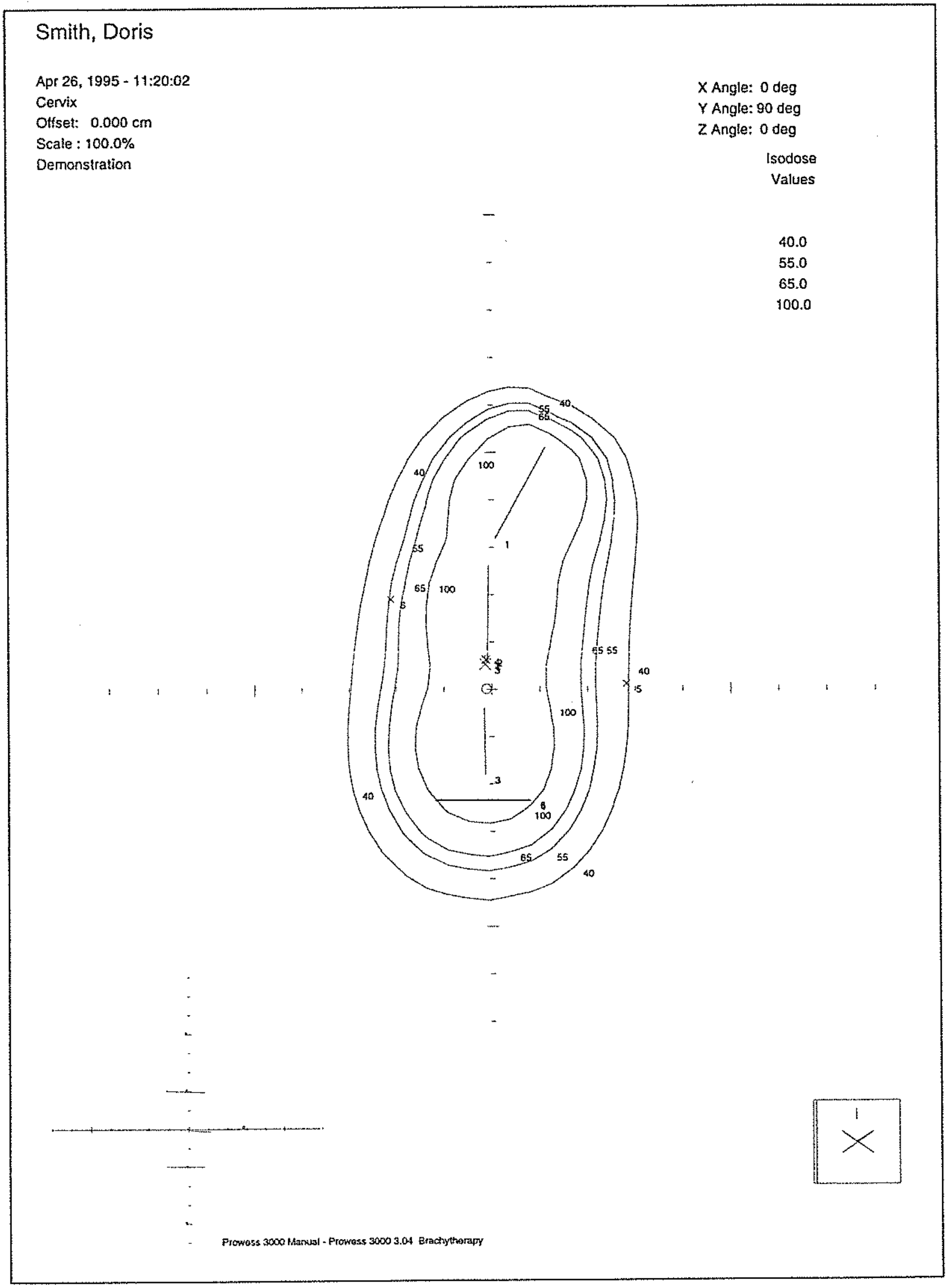
X Angle: 0 deg
Y Angle: 0 deg
Z Angle: 0 deg

Isodose
Values

20.0
40.0
55.0
65.0
120.0

Prowess 3000 Manual - Prowess 3000 3.04 Brachytherapy

Figure 12.14 - Fletcher Suite Isodose Plot: AP View



Smith, Doris

Apr 26, 1995 - 11:20:02
Cervix
Offset: 0.000 cm
Scale : 100.0%
Demonstration

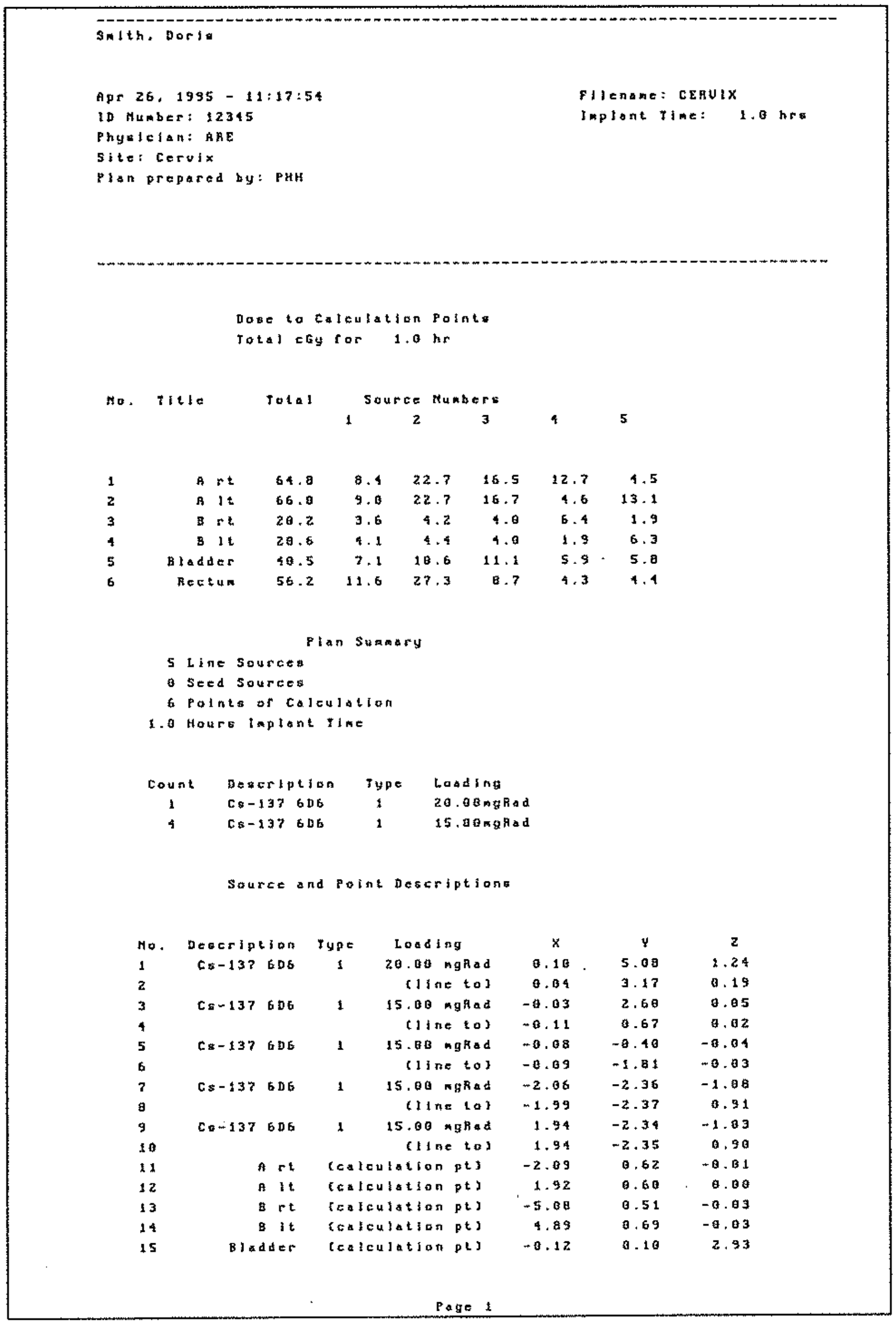
X Angle: 0 deg
Y Angle: 90 deg
Z Angle: 0 deg

Isodose
Values

40.0
55.0
65.0
100.0

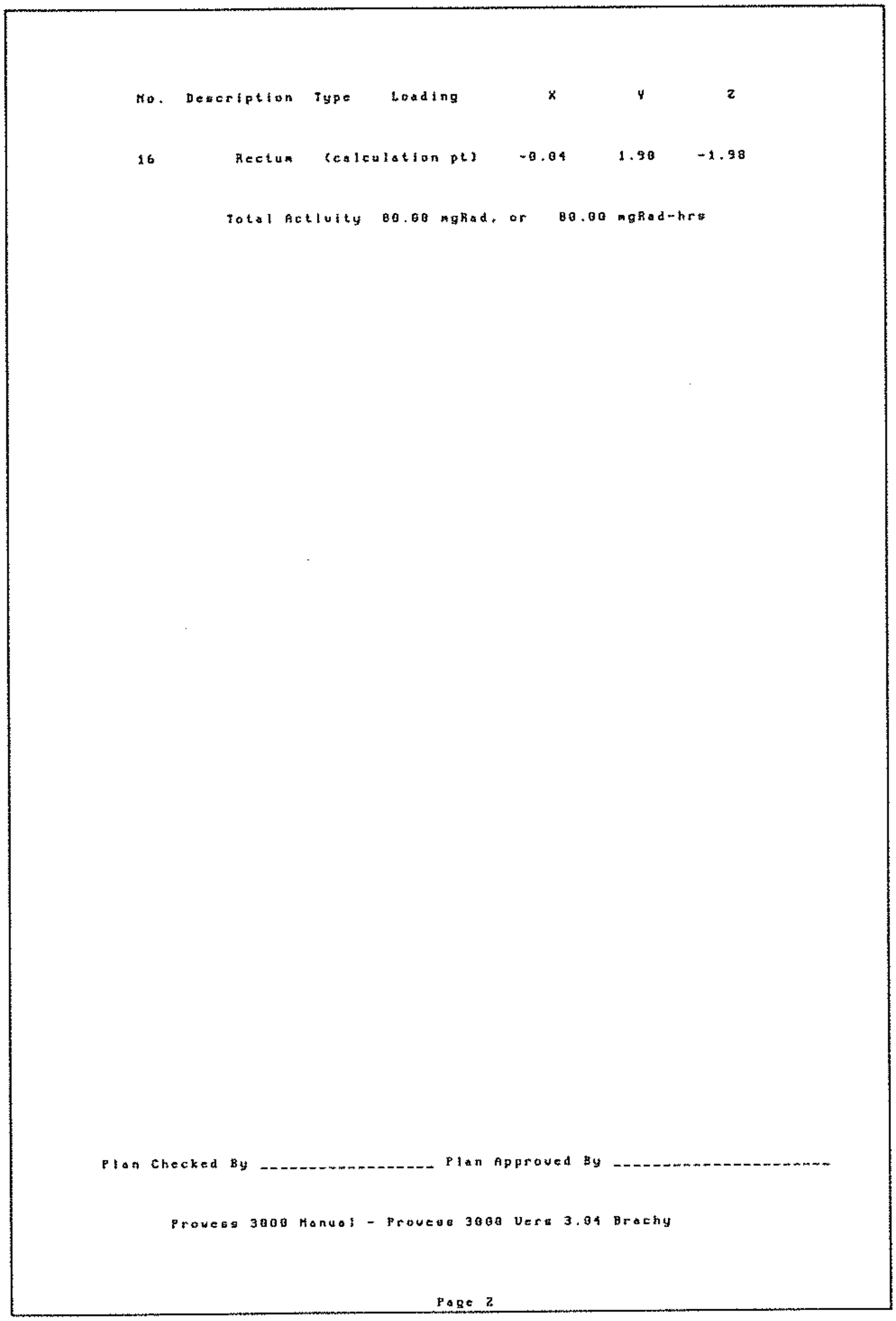
Prowess 3000 Manual - Prowess 3000 3.04 Brachytherapy

Figure 12.15 - Fletcher Suite Isodose Plot: Lateral View



```
--------------------------------------------------------------------------
Smith, Doris

Apr 26, 1995 - 11:17:54                          Filename: CERVIX
ID Number: 12345                                 Implant Time:   1.0 hrs
Physician: ABE
Site: Cervix
Plan prepared by: PHH



--------------------------------------------------------------------------


              Dose to Calculation Points
              Total cGy for   1.0 hr


 No.  Title       Total     Source Numbers
                                 1      2      3      4      5


 1       A rt      64.0     8.4   22.7   16.5   12.7    4.5
 2       A lt      66.0     9.0   22.7   16.7    4.6   13.1
 3       B rt      20.2     3.6    4.2    4.0    6.4    1.9
 4       B lt      20.6     4.1    4.4    4.0    1.9    6.3
 5    Bladder      40.5     7.1   10.6   11.1    5.9    5.0
 6     Rectum      56.2    11.6   27.3    8.7    4.3    4.4


                     Plan Summary
      5 Line Sources
      0 Seed Sources
      6 Points of Calculation
    1.0 Hours Implant Time


    Count   Description   Type   Loading
      1     Cs-137 6D6     1     20.00mgRad
      4     Cs-137 6D6     1     15.00mgRad


             Source and Point Descriptions


   No.  Description  Type   Loading         X        Y        Z
   1     Cs-137 6D6   1    20.00 mgRad    0.10     5.00     1.24
   2                         (line to)    0.04     3.17     0.19
   3     Cs-137 6D6   1    15.00 mgRad   -0.03     2.60     0.05
   4                         (line to)   -0.11     0.67     0.02
   5     Cs-137 6D6   1    15.00 mgRad   -0.08    -0.40    -0.04
   6                         (line to)   -0.09    -1.81    -0.03
   7     Cs-137 6D6   1    15.00 mgRad   -2.06    -2.36    -1.08
   8                         (line to)   -1.99    -2.37     0.91
   9     Cs-137 6D6   1    15.00 mgRad    1.94    -2.34    -1.03
   10                        (line to)    1.94    -2.35     0.90
   11          A rt   (calculation pt)   -2.09     0.62    -0.01
   12          A lt   (calculation pt)    1.92     0.60     0.00
   13          B rt   (calculation pt)   -5.08     0.51    -0.03
   14          B lt   (calculation pt)    4.89     0.69    -0.03
   15       Bladder   (calculation pt)   -0.12     0.10     2.93

                                Page 1
```

Figure 12.16 - Fletcher Suite: Calculation Results



```
No.  Description  Type    Loading         X        Y        Z

16         Rectum  (calculation pt)   -0.04     1.98    -1.98

           Total Activity  80.00 mgRad, or   80.00 mgRad-hrs




Plan Checked By ________________ Plan Approved By ______________________

        Prowess 3000 Manual - Prowess 3000 Vers 3.04 Brachy

                              Page 2
```

Figure 12.17 - Fletcher Suite: Calculation Results (cont.)

B. Iridium Interstitial

This section describes a two-plane ^{192}Ir seed implant with 16 seeds per plane. Source strength is 0.40 mg Ra eq.

Use two orthogonal films, one AP and one lateral, or use the enclosed templates in Figures 12.17 and 12.18.

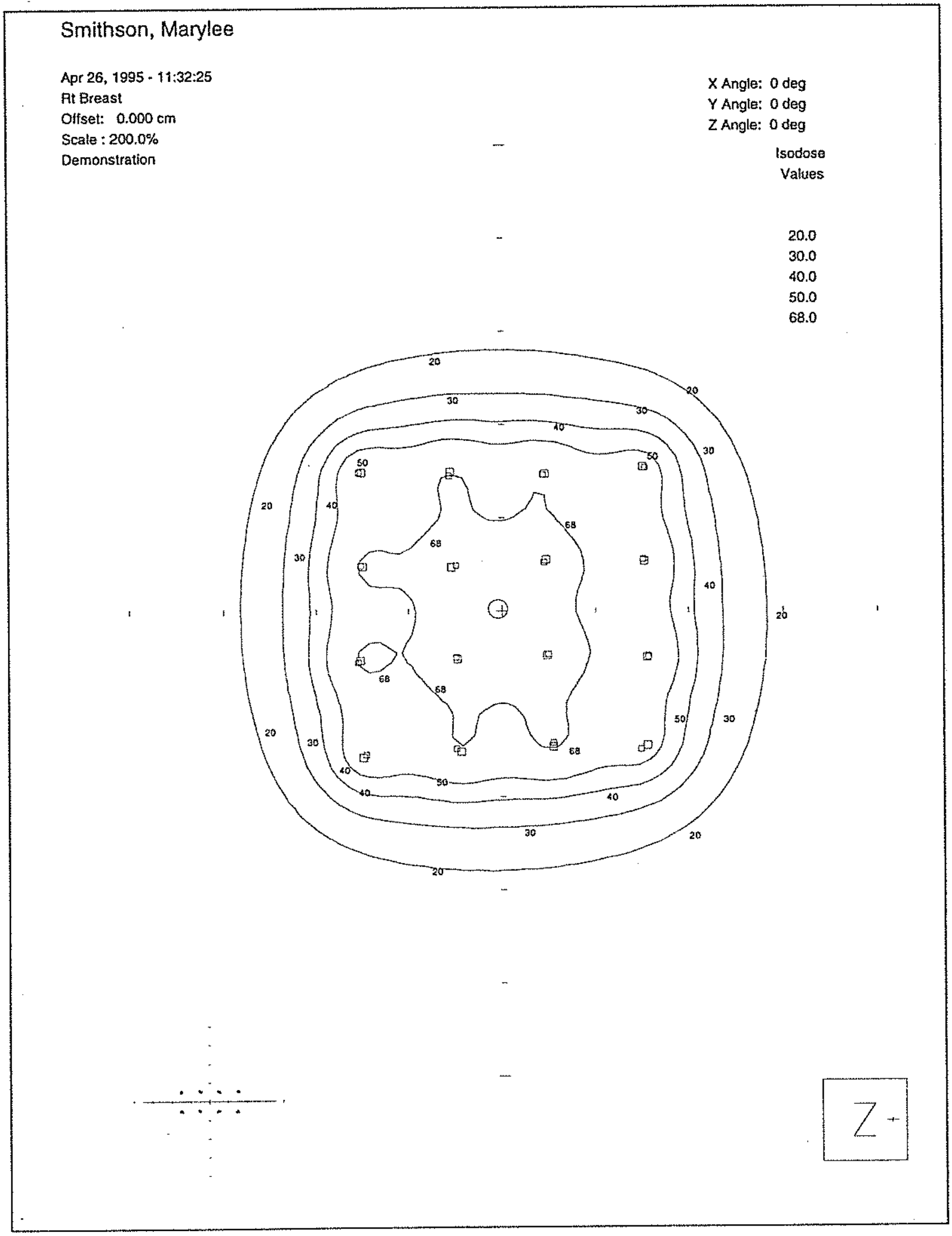
1. Set the two films side-by-side (common axis vertical) under the plastic cover on the digitizer light box. Be sure the sources are visible and numbered. Match the AP and lateral sources.
2. Choose **Brachytherapy Calculation** from the main menu to start the program.
3. Enter the following patient demographics and select Accept.

Patient File Name:	Smith
Patient Name:	Smith, Mary
Patient Number:	12345
Site:	Lt Breast
Physician:	CJ
Plan Prepared by:	Your Name
Comment:	Any Comment

4. Select Orthog to enter one film at a time. Enter the source types. Choose ^{192}Ir seeds (type 106). Enter the source strength as 0.40 mg Ra eq.
5. Answer N to the question: "Enter magnification from the digitizer Y or N?". Enter the magnification factor of the localization film by entering 1.0 for both films.
6. Calibrate the digitizer by sparking points "U" and "L." Digitize the origin of film one (on right) and a point to the right on the film axis.
7. View the split screen. The coordinates for the first film will be on the left, the coordinates for the second, on the right. Digitize the coordinates of all 32 sources. Touch digitizer box labeled **End**.
8. Digitize the origin, a point to the right, and the sources for film two. Touch digitizer box labeled **Exit** to end the digitizer entry. There is no need to change and re-enter the source strengths.
9. After digitizing, the sources and the Y-axis error summary are displayed on the screen. The magnification difference and the variance shown in the system window shows the magnification difference is near 1.0 and the variance is near 0. Press Enter to continue.
10. Answer Y to the question, "Save these coordinates, Y or N?". Select Plane to select the first view for calculation. Three views appear on the screen. The largest view shows the AP projection. This is the plane of calculation. View A shows one perpendicular projection, View B, another perpendicular projection.
11. If this calculation plane is satisfactory, select Calcul. The source number will appear on the screen as the program calculates the dose from each source.

12. After calculating all 32 sources, the default isodose curves will appear in the upper left window. Plot the curves by selecting 10, 20, 30, 40, 50, and 60 cGy/hour. After completing the plot, press **ES**Cape.
13. Select Print to print the results and select Plot to plot the results. Accept the displayed isodose values with an **ES**Cape. Enter the title "mid-plane" and the plot scale factor of 2.0.
14. Select SwapA to display the lateral plane. Recalculate and display the plane as described above. Enter the title "Transverse" and plot with a scale of 2.0.
15. After printing and plotting, press **ES**Cape to reach the main menu. Select Quit to exit the program and return to the main menu.

The results of this calculation are shown in Figures 12.18, 12.19, 12.20, and 12.21.

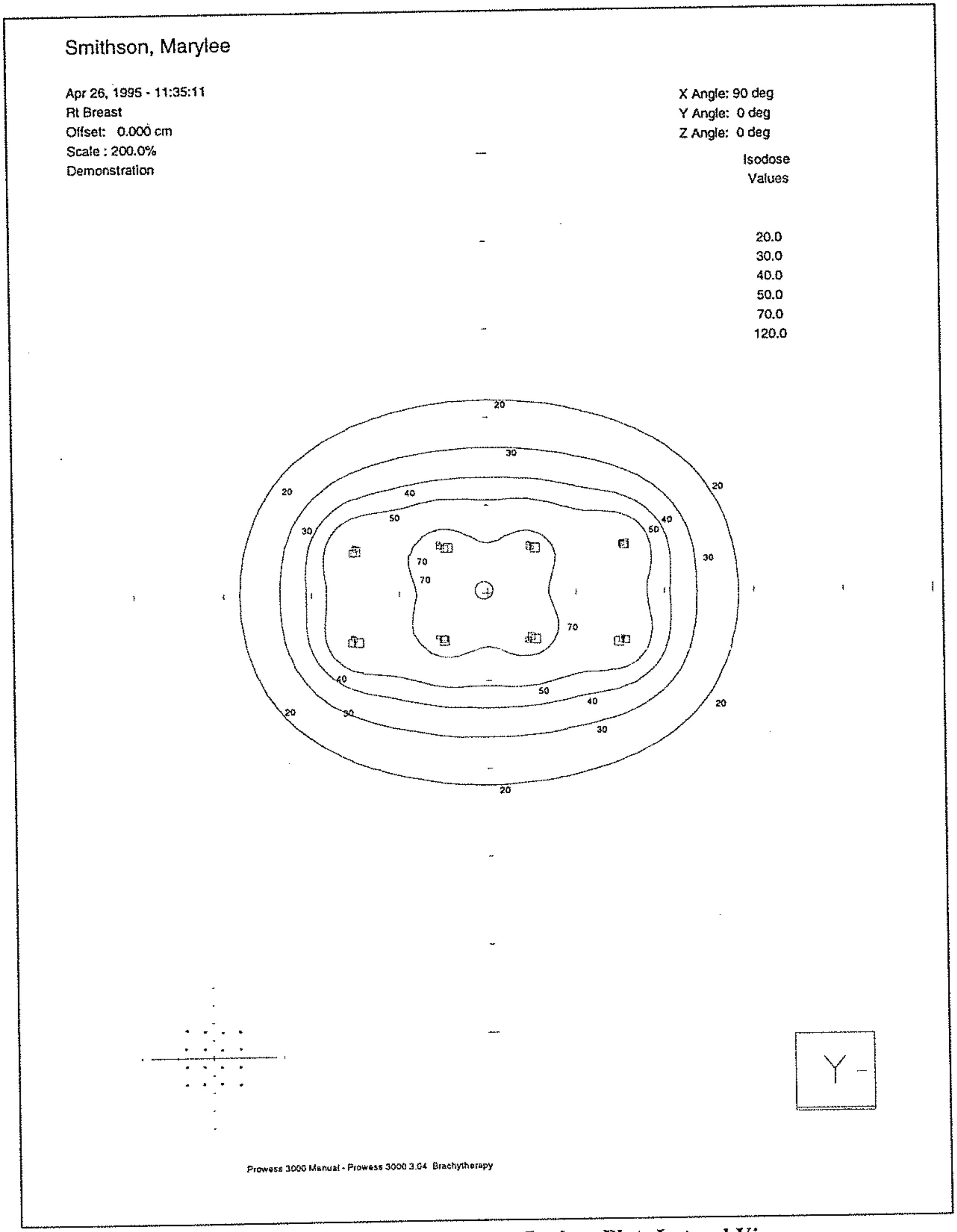


Smithson, Marylee

Apr 26, 1995 - 11:32:25
Rt Breast
Offset: 0.000 cm
Scale : 200.0%
Demonstration

X Angle: 0 deg
Y Angle: 0 deg
Z Angle: 0 deg

Figure 12.18 - Two Plane Implant Isodose Plot: AP View



Smithson, Marylee

Apr 26, 1995 - 11:35:11
Rt Breast
Offset: 0.000 cm
Scale : 200.0%
Demonstration

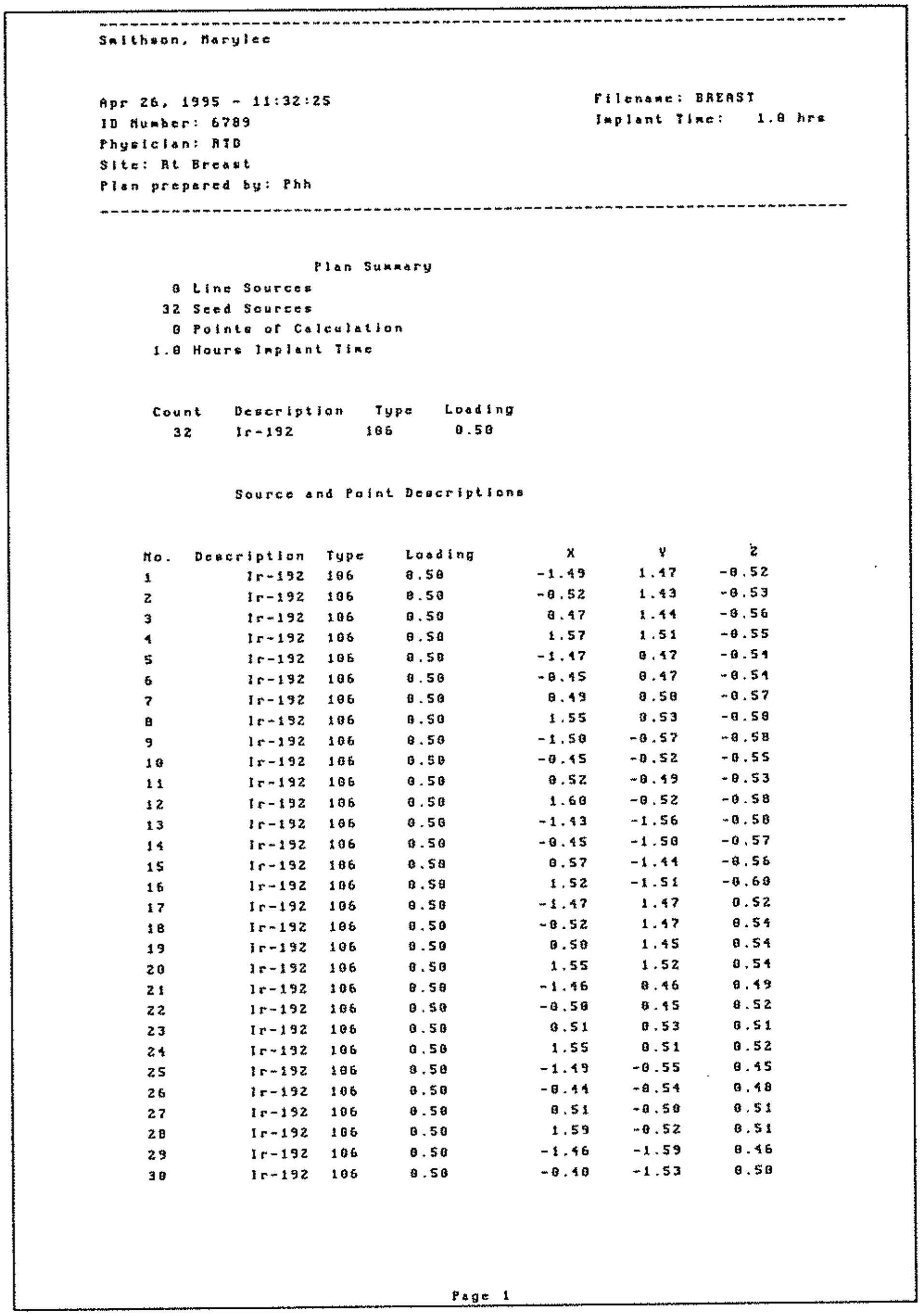
X Angle: 90 deg
Y Angle: 0 deg
Z Angle: 0 deg

Isodose
Values

20.0
30.0
40.0
50.0
70.0
120.0

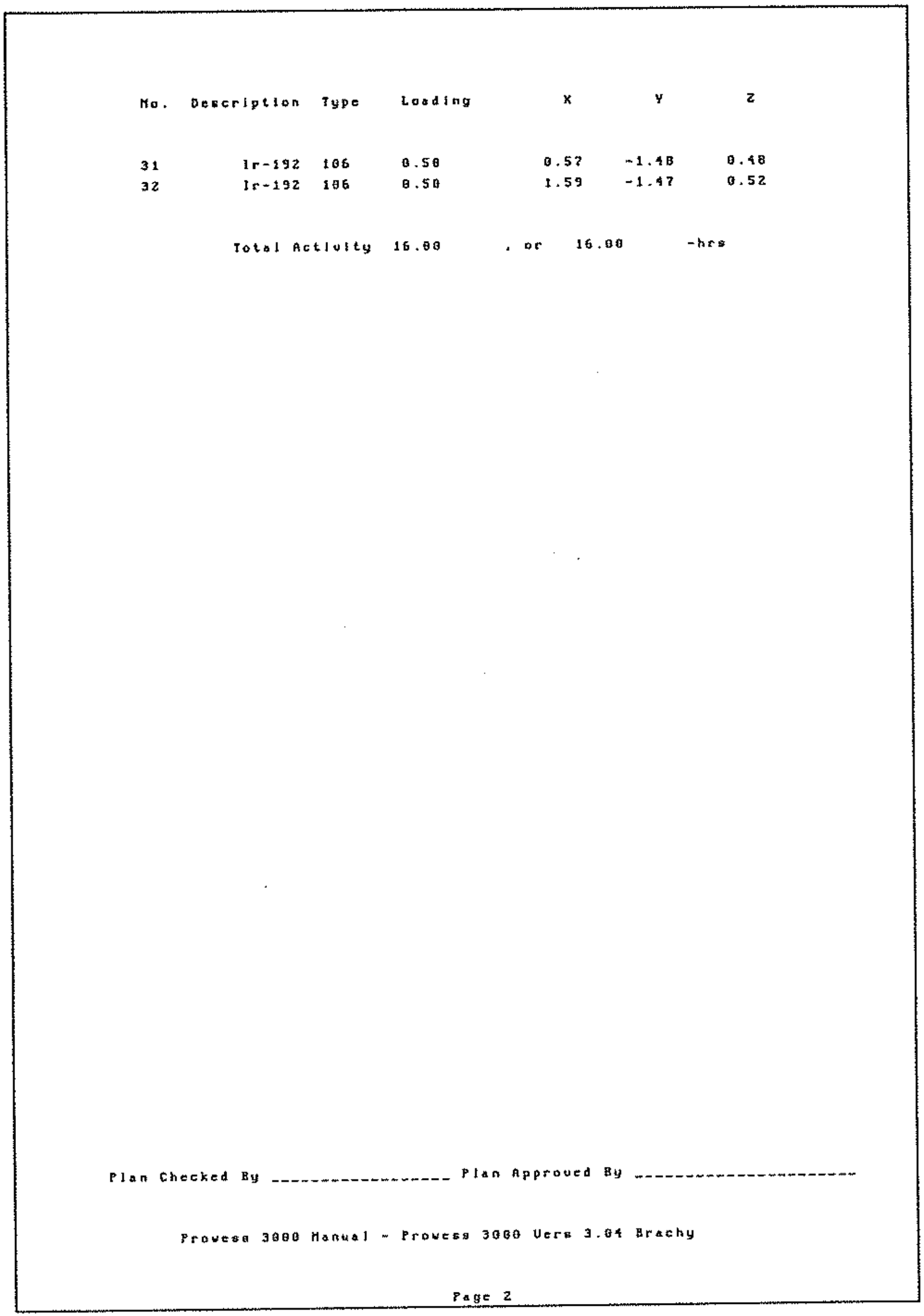
Prowess 3000 Manual - Prowess 3000 3.04 Brachytherapy

Figure 12.19 - Two Plane Implant Isodose Plot: Lateral View



```
------------------------------------------------------------------------
Smithson, Marylee


Apr 26, 1995 - 11:32:25                              Filename: BREAST
ID Number: 6789                                      Implant Time:   1.0 hrs
Physician: RTD
Site: Rt Breast
Plan prepared by: Phh
------------------------------------------------------------------------


                    Plan Summary
    0 Line Sources
   32 Seed Sources
    0 Points of Calculation
  1.0 Hours Implant Time


  Count   Description   Type   Loading
    32    Ir-192        106     0.50


          Source and Point Descriptions


No.  Description  Type    Loading          X          Y         Z
1         Ir-192  106     0.50          -1.49       1.47     -0.52
2         Ir-192  106     0.50          -0.52       1.43     -0.53
3         Ir-192  106     0.50           0.47       1.44     -0.56
4         Ir-192  106     0.50           1.57       1.51     -0.55
5         Ir-192  106     0.50          -1.47       0.47     -0.54
6         Ir-192  106     0.50          -0.45       0.47     -0.54
7         Ir-192  106     0.50           0.49       0.50     -0.57
8         Ir-192  106     0.50           1.55       0.53     -0.50
9         Ir-192  106     0.50          -1.50      -0.57     -0.58
10        Ir-192  106     0.50          -0.45      -0.52     -0.55
11        Ir-192  106     0.50           0.52      -0.49     -0.53
12        Ir-192  106     0.50           1.60      -0.52     -0.58
13        Ir-192  106     0.50          -1.43      -1.56     -0.50
14        Ir-192  106     0.50          -0.45      -1.50     -0.57
15        Ir-192  106     0.50           0.57      -1.44     -0.56
16        Ir-192  106     0.50           1.52      -1.51     -0.60
17        Ir-192  106     0.50          -1.47       1.47      0.52
18        Ir-192  106     0.50          -0.52       1.47      0.54
19        Ir-192  106     0.50           0.50       1.45      0.54
20        Ir-192  106     0.50           1.55       1.52      0.54
21        Ir-192  106     0.50          -1.46       0.46      0.49
22        Ir-192  106     0.50          -0.50       0.45      0.52
23        Ir-192  106     0.50           0.51       0.53      0.51
24        Ir-192  106     0.50           1.55       0.51      0.52
25        Ir-192  106     0.50          -1.49      -0.55      0.45
26        Ir-192  106     0.50          -0.44      -0.54      0.40
27        Ir-192  106     0.50           0.51      -0.50      0.51
28        Ir-192  106     0.50           1.59      -0.52      0.51
29        Ir-192  106     0.50          -1.46      -1.59      0.46
30        Ir-192  106     0.50          -0.40      -1.53      0.50



                                 Page 1
```

Figure 12.20 - Two Plane Implant: Calculation Results



```
No.  Description  Type    Loading          X          Y          Z

31         Ir-192  106     0.50           0.57     -1.48       0.48
32         Ir-192  106     0.50           1.59     -1.47       0.52

           Total Activity  16.00        , or    16.00        -hrs










Plan Checked By __________________ Plan Approved By ______________________

      Prowess 3000 Manual - Prowess 3000 Vers 3.04 Brachy

                              Page 2
```

Figure 12.21 - Two Plane Implant: Calculation Results (cont.)

TEST 1 - HARDWARE VERIFICATION
Test Procedure

Select **Configuration,** then **Device Testing** from the main treatment planning menu. Carry out each of the hardware tests listed below and record the results

Bitpad:	Pass	Fail	Not Connected
Mouse:	Pass	Fail	Not Connected
Scanner:	Pass	Fail	Not Connected
Printer:	Pass	Fail	Not Connected

Measured Box Length: ____________ inches Should be 3 in x 3 in.

Measured Box Width: ____________ inches

Plotter:	Pass	Fail	Not Connected

Measured Box Length: ______________ cm Should be 10 cm x 10 cm.

Measured Box Width: ______________ cm

Actual Plotter Name: ____________________ Printed Name: ________________________

Actual Port: ___________________________ Printed Port: ________________________

Image Printer:	Pass	Fail	Not Connected

Measured Box Length: ______________ cm Should be 10 cm x 10 cm.

Measured Box Width: ______________ cm

Actual Image Printer Name: ______________ Printed Name: ________________________

Actual Port: ___________________________ Printed Port: ________________________

Please list below any error messages or problems you encountered while executing this test:

____

____

____

TEST 2 - DAILY CALCULATION VERIFICATION
Test Procedure

1. Print out the following machine data tables and attach them and the printed calculation results to the evaluation sheet:
    - General Machine Data
    - TMRs
    - Output Factors
    - PSFs
    - OCR Table (for wedge used)

2. Enter a single treatment field's parameters into the machine setting calculation program, then calculate and print the results. All field parameters are chosen at your discretion.

3. Verify the results manually using the Daily Calculation Evaluation Work Sheet. Save as a department record.

TEST 2 - DAILY CALCULATION VERIFICATION
Worksheet

Date: ______________

	Clinical Site		Testing Physicist
Name:		Name:	
Address:		Address:	
City, State:		City, State:	
Phone:		Phone:	
Fax:		Fax:	

	User Entered or Calculated	Prowess Result	Error
Machine Name:			
Beam Type:			
Prescribed Dose:			
Nominal SSD:			
SSD:			
dmax:			
Depth:			

$$\text{Inverse Square} = \left(\frac{\text{Nominal SSD} + dmax}{\text{SSD} + depth}\right)^2$$

	User Entered or Calculated	Prowess Result	Error
Inverse Square:			
Calibrated Dose Rate:			
Decay Factor			
Collimator Width:			
Collimator Length:			

$$\text{Eq Sq} = \frac{2(width * length)}{width + length}$$

	User Entered or Calculated	Prowess Result	Error
Collimator Eq Sq:			
Output Factor:			
Effective Width:			
Effective Length:			

$$\text{Effective Eq Sq} = \left(\frac{2(width * length)}{width + length}\right)\left(\frac{\text{SSD} + depth}{\text{Nominal SSD}}\right)$$

	User Entered or Calculated	Prowess Result	Error
Effective Eq Sq:			
TMR:			
PSF (effective):			
PSF (collimator):			
PSF Ratio:			

$$\text{Corrected Ouptut Factor} = \textit{Output Factor} * \textit{Calibrated Dose Rate} * \textit{Decay Factor} * \textit{PSF Ratio}$$

	User Entered or Calculated	Prowess Result	Error
Corrected Output Factor:			

TEST 2 - DAILY CALCULATION VERIFICATION
Worksheet

	User Entered or Calculated:	Prowess Result	Error
Compensator Factor:			
Tray Factor:			
Wedge Factor:			
Effective Transmission:			

$$\text{Machine Setting} = \frac{\textit{Prescribed Dose}}{\textit{Corrected Output Factor} * \textit{TMR} * \textit{INVSQ} * \textit{Effective Transmission}}$$

	User Entered or Calculated:	Prowess Result	Error
Machine Setting:			

$$\text{Backup Timer} = \frac{\textit{Machine Setting}}{\textit{200 MU per min}}$$

	User Entered or Calculated:	Prowess Result	Error
Backup Timer:			

$$\text{Inverse square @ dmax} = \left(\frac{SSD + dmax}{SSD + depth} \right)^2$$

$$\text{Dose @ dmax} = \frac{\textit{Prescribed Dose}}{\textit{inverse square @ dmax} * \textit{TMR}}$$

	User Entered or Calculated:	Prowess Result	Error
Dose @ dmax:			

Please list below any error messages or flow problems you encountered while executing this test.

Signature: ____________________

Date: ____________

TEST 3 - IRREGULAR FIELD VERIFICATION
Test Procedure

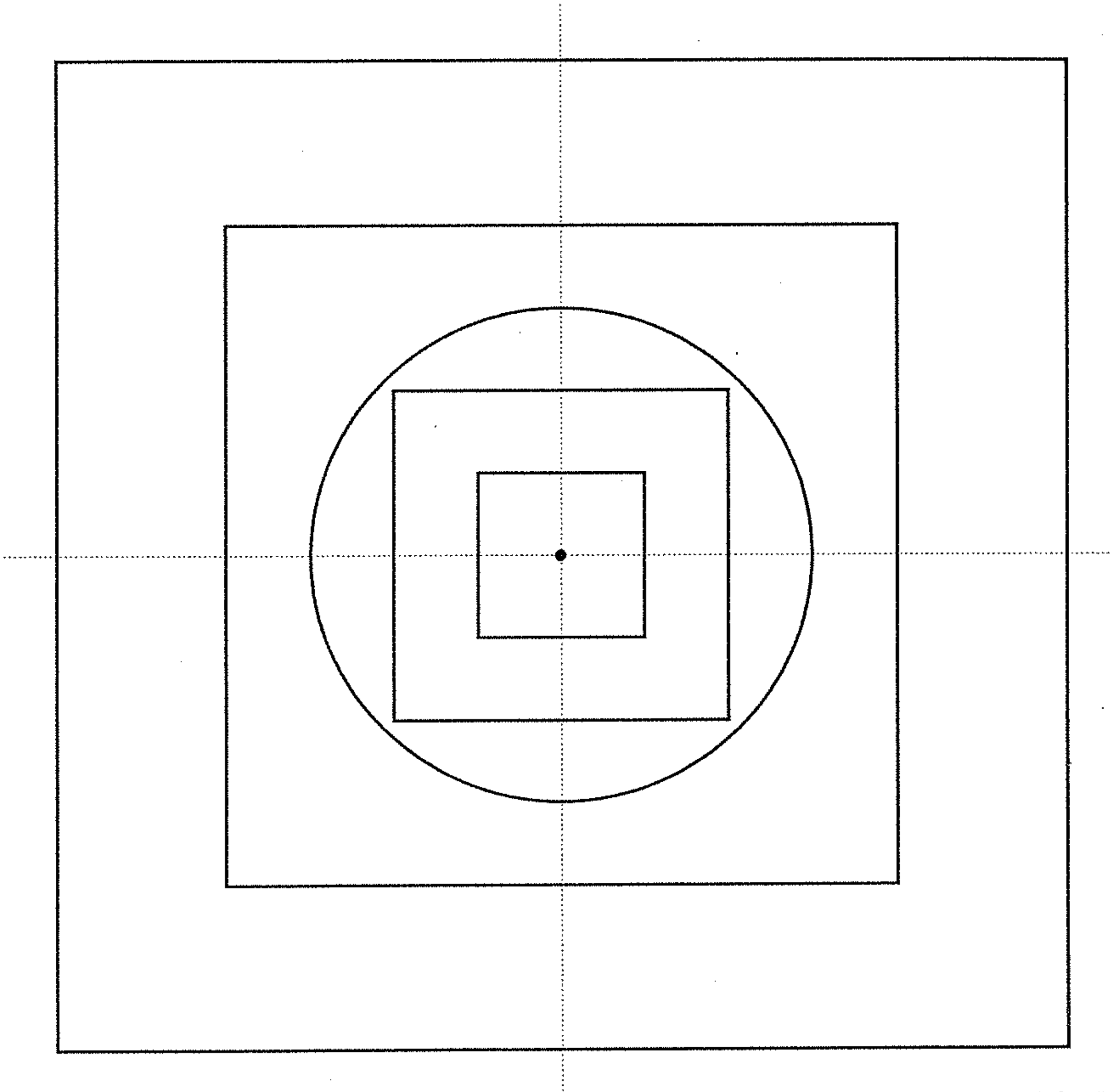
1.Print the following machine data tables and attach to this document:
  - General Machine Data
  - SMR
  - TMR
  - Profile Factors
  - Off-Axis HVLs
  - Edge Factors
  - Output Factors
  - PSFs

2. Enter the 30 cm diameter circle shown in the figure as the field shape. Enter a single calculation point on the central axis at a 10 cm depth. Set the SSD to be 10 less than the nominal SSD or isocenter. Set the collimator to 30 x 30 cm. Prescribe 100 cGy to the point and calculate the results. Print and plot the results and confirm by manual calculation using the attached form.

3. Enter the four square fields shown in the figure. For each field, enter calculation points along the CAX at d_{max}, 5 cm, 10 cm, 20 cm, and 30 cm. For each field, prescribe 100 cGy to d_{max} and determine the %DD calculated for the other points. Compare this to the measured %DD data using the provided table. Make copies of the table and repeat this for every x-ray beam. Save as a department record.

TEST 3 - IRREGULAR FIELD VERIFICATION

Beam Outlines



30 cm square
20 cm square
10 cm square
5 cm square

15 cm circle

50% Scale

TEST 3 - IRREGULAR FIELD VERIFICATION
Machine Data Verification Table

Depth

Field Size	5	10	20	30
5	Calc %DD =	Calc %DD =	Calc %DD =	Calc %DD =
	Meas %DD =	Meas %DD =	Meas %DD =	Meas %DD =
	%Error =	%Error =	%Error =	%Error =
10	Calc %DD =	Calc %DD =	Calc %DD =	Calc %DD =
	Meas %DD =	Meas %DD =	Meas %DD =	Meas %DD =
	%Error =	%Error =	%Error =	%Error =
20	Calc %DD =	Calc %DD =	Calc %DD =	Calc %DD =
	Meas %DD =	Meas %DD =	Meas %DD =	Meas %DD =
	%Error =	%Error =	%Error =	%Error =
30	Calc %DD =	Calc %DD =	Calc %DD =	Calc %DD =
	Meas %DD =	Meas %DD =	Meas %DD =	Meas %DD =
	%Error =	%Error =	%Error =	%Error =

TEST 4 - EXTERNAL BEAM VERIFICATION
Test Procedure

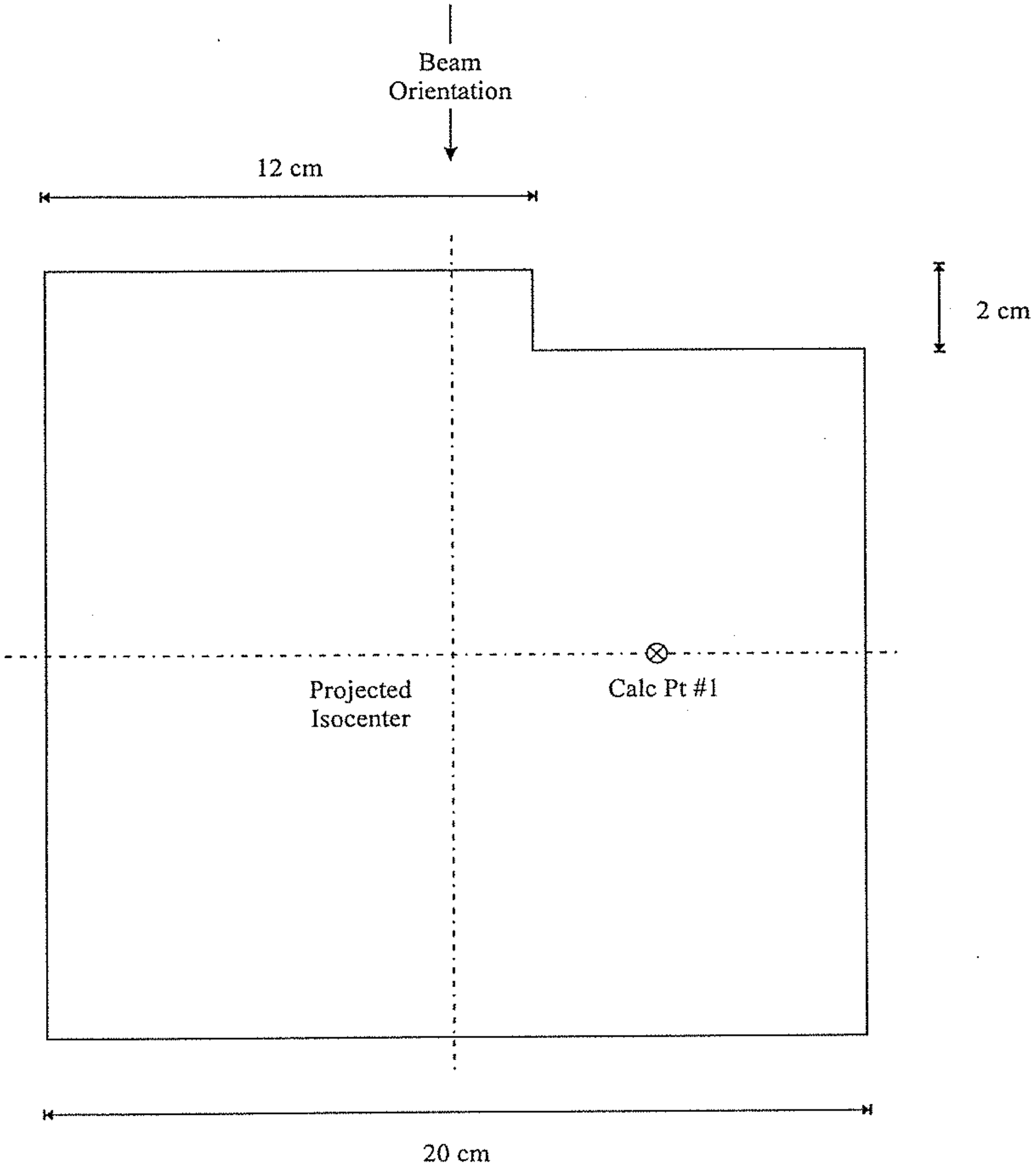
1.Attach a copy of the following machine tables:
- General Machine Data
- TMRs
- Output Factors
- PSFs
- OCR Table for Open Field
- Block Edge Factor Tables

2. Enter the attached contour twice into a single plan. The first slice should have a Z-offset of 0 cm and the second should have a Z-offset of +5 cm. The Z=0 slice will be used solely for fixing a beam. All weighting and calculation will be done on the Z=+5 slice.

3. Create and calculate a plan with a single isocentric beam whose isocenter is located at the indicated contour origin on the Z=0 slice . The beam parameters will be as follows:
   Orientation: Pointing straight down (0° or 180°)
   Collimator Field Size: 20 x 20
   Beam's Eye View: (See attached diagram)
   Wedge: None
   Weight: 100% to Calculation Point #1 on slice Z=+5
   Fractions: 1
   Normalization: Unnormalized
   Prescription: 200 cGy to the 100% line

4. Use the verification form to check the calculated results. Print and plot the calculation results and attach to the verification form.

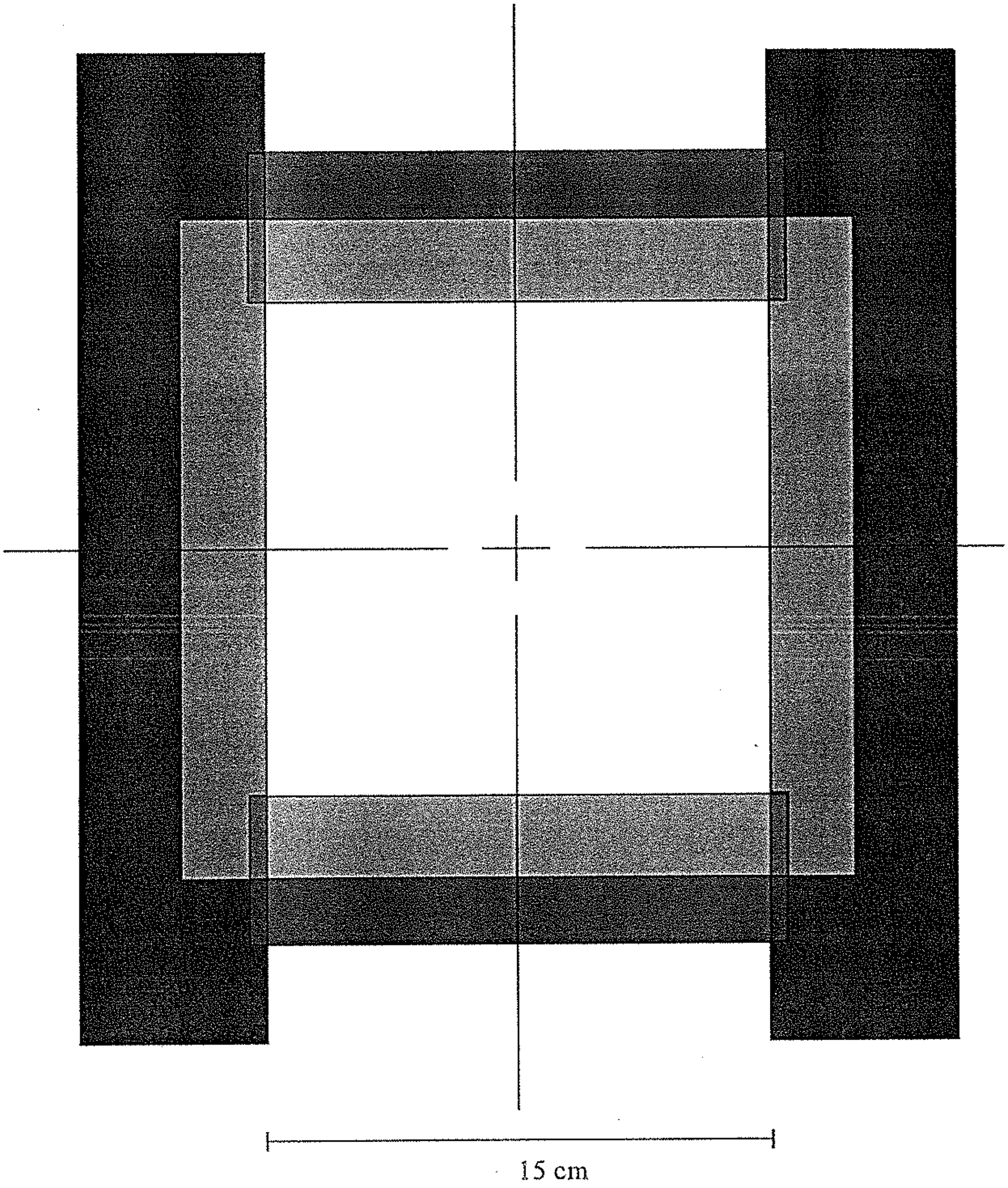
TEST 4 - EXTERNAL BEAM VERIFICATION
Patient Contour



Z = 0 cm and Z = +5 cm

TEST 4 - EXTERNAL BEAM VERIFICATION

Beam's Eye View



TEST 4 - EXTERNAL BEAM VERIFICATION

Worksheet

Date: ______

Clinical Site
Name: ______
Address: ______
City, State: ______
Phone: ______
Fax: ______

Testing Physicist
Name: ______
Address: ______
City, State: ______
Phone: ______
Fax: ______

	User Entered or Calculated	Prowess Result	Error
Depth:	8.0		
Nominal SSD:			
Machine dmax:			

$$\text{Inverse Square} = \left(\frac{Nominal\ SSD + dmax}{Nominal\ SSD}\right)^2$$

Inverse Square:			

$$SSD = Nominal\ SSD - Depth$$

SSD:			
Collimator Width:	20.0		
Collimator Length:	20.0		
Output Factor:			
Effective Width:	15.0		
Effective Length:	15.0		
TMR:			
PSF (20 x 20):			
PSF (15 x 15):			
PSF Ratio:			
Wedge Number:	None		
Wedge Name:	Open		
Wedge Factor:	1.000		
Bolus:	None		
Compensator:	None		
Tray Factor:			
Custom Block:	Yes		
Block Edge Trans:	1.000		
Weight Point:	Pt 1 (5.0)		
2X/W Distance:	0.500		
Lateral 2X/W Distance:	0.500		
Lateral OCR:			

TEST 4 - EXTERNAL BEAM VERIFICATION
Worksheet

	User Entered or Calculated	Prowess Result	Error
Transverse 2X/W Dist:	0.500		
Transverse OCR			
Does Lateral OCR equal Transverse OCR for this case?			
Total Weight:	100		
Weight/Rx:	100		

$$\text{Dose to Wt Pt/Rx} = \left(\frac{\textit{Prescription Dose}}{\textit{Prescription Line}}\right)\left(\frac{\textit{Total Weight}}{\textit{Number of Fractions}}\right)$$

	User Entered or Calculated	Prowess Result	Error
Dose to Wt Pt/Rx:	200		

$$\text{Dose @ dmax/Rx} = \textit{Machine Setting} * \textit{Output Factor} * \textit{PSF Ratio}\left(\frac{\textit{Nominal SSD + dmax}}{\textit{SSD + dmax}}\right)^2$$

	User Entered or Calculated	Prowess Result	Error
Dose @ dmax/Rx:			
Number of Fractions:	1		

$$\text{Machine Setting/Rx} = \frac{\textit{200 cGy}}{\textit{Output Factor * TMR * PSF Ratio * Tray Factor * Lateral OCR * Transverse OCR * INVSQ * Block Edge}}$$

	User Entered or Calculated	Prowess Result	Error
Machine Setting:			

$$\text{Backup Timer} = \frac{\textit{Machine Setting}}{\textit{200 MU/min}}$$

	User Entered or Calculated	Prowess Result	Error
Backup Timer:			
Normalization:	Unnormalized		
Normalization Constant:	1.000		
Maximum Total Dose to slice offset (0.0):		______	______
Does this value agree with the plot?			

Please list below any error messages or problems you encountered while executing this test.

____

____

____

____

____

____

____

Signature: ______________________ Date: ____________

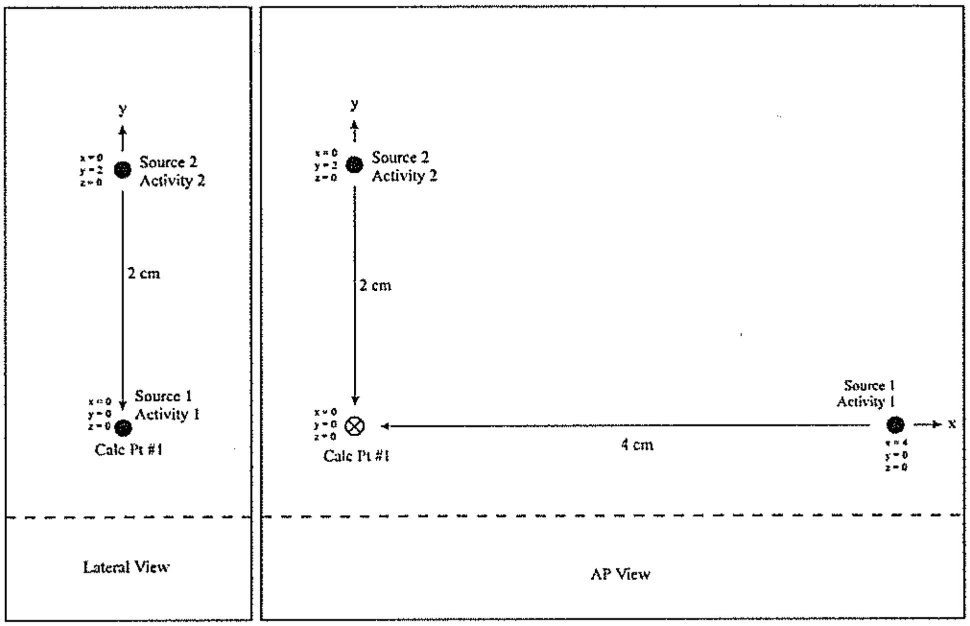
TEST 5 - BRACHYTHERAPY VERIFICATION

Test Procedure

1. Select a brachytherapy seed which you commonly use.

2. From the source edit program, print out the parameters of the selected source.

3. Enter the following plan using the keyboard mode. Use an appropriate activity.



4. Calculate and print the results. Plot an isodose distribution.

5. Use the verification form to check the dose calculations. Attach the printed and plotted results as well as the source parameters. Save as a department record.

TEST 5 - BRACHYTHERAPY VERIFICATION
Worksheet

Date: ____________

Clinical Site

Name: ____________
Address: ____________
City, State: ____________
Phone: ____________
Fax: ____________

Name: ____________
Address: ____________
City, State: ____________
Phone: ____________
Fax: ____________

Source 1

	User Entered or Calculated	Prowess Result	Error
Strength:			
r:			
r^2:			
r^3:			
Γ:			
f factor:			
A :			
B:			
C:			
D:			

Mei burg

Meisburger Attenuation Factor = $A + Br + Cr^2 + Dr^3$

Meisburger Attenuation Factor: ____________

$$\text{Dose Rate} = \frac{\text{Strength} * \text{ffactor} * \text{Meisburger Factor} * \Gamma}{r^2}$$

	User Entered or Calculated	Prowess Result	Error
Dose Rate:			

Source 2

	User Entered or Calculated
Strength:	
r:	
r^2:	
r^3:	
Γ:	
f factor:	
A :	
B:	
C:	
D:	

Meis

Meisburger Attenuation Factor = $A + Br + Cr^2 + Dr^3$

Meisburger Attenuation Factor: ____________

TEST 5 - BRACHYTHERAPY VERIFICATION

Worksheet

$$\text{Dose Rate} = \frac{\text{Strength} * \text{f factor} * \text{Meisburger Factor} * \Gamma}{r^2}$$

	User Entered or Calculated	Prowess Result	Error
Dose Rate:			
Summaries			
Total Activity:			
Total Seed Sources:			
Total Line Sources:			
Total Calculation Points:			
Total Dose Rate:			

Error messages or problems: ______________________

Signature: ______________________

Date: ______________

Photon Beam
Machine Data Review Report

File Name: ______________________________ Energy: ______________________________
Institution: ____________________ Manufacturer: ____________________ Model: __________
Evaluation Done By: ____ Date: ___/___/___

Pass	Fail	Mode	Evaluation Parameters	No	Yes
Pass	Fail	General	Block tray factor reasonable	___	___
			Name satisfactory	___	___
			Dmax reasonable	___	___
			Comment:______________________________		
Pass	Fail	Depth Dose	Smooth	___	___
			Includes zero depth	___	___
			Comment:______________________________		
Pass	Fail	TMR	Extrapolated to at least 50 cm deep	___	___
			Extrapolated to at least 50 cm field size	___	___
			Extrapolated to zero field size	___	___
			Smooth TMR data	___	___
			Comment:______________________________		
Pass	Fail	SMR	Smooth	___	___
			All 0.00 at d_{max}	___	___
			Enough depths	___	___
			Comment:______________________________		
Pass	Fail	Output Factor	< = 25 values	___	___
			Increasing field size	___	___
			Increasing order of magnitude with field size	___	___
			Normalized to 10 x 10	___	___
			Comment:______________________________		
Pass	Fail	Edge Factors	____ # Edge Types	___	___
			Increasing distances	___	___
			0.5 at 0 cm	___	___
			Starts at near zero transmission	___	___
			Ends at 1.0 transmission	___	___
			Comment:______________________________		
Pass	Fail	Irreg Profiles	Increasing distances	___	___
			Smooth	___	___
			< = 25 Values	___	___
			Comment:______________________________		
Pass	Fail	Irreg HVL	CAX value Reasonable	___	___
			Decreasing HVL with increasing distance	___	___
			< = 25 Values	___	___
			Comment:______________________________		
Pass	Fail	PSF	Values Reasonable	___	___
			Increasing magnitude with increasing field size	___	___
			< = 25 Values	___	___
			Comment:______________________________		

OCR DATA	Open	Wedge ____	Wedge ____
Orientation Correct (peak on rt)		Yes No	Yes No
Wedge factor for each field size	Yes No	Yes No	Yes No
Wedge type correct	Yes No	Yes No	Yes No
Wedge name present	Yes No	Yes No	Yes No
Shape of curve smooth and reasonable	Yes No	Yes No	Yes No
Curve centered	Yes No	Yes No	Yes No
Symmetric/Normalized Correctly	Pass Fail	Pass NA Fail	Pass NA Fail

	Wedge ____	Wedge ____	Wedge ____
Orientation Correct (peak on rt)	Yes No	Yes No	Yes No
Wedge factor for each field size	Yes No	Yes No	Yes No
Wedge type correct	Yes No	Yes No	Yes No
Wedge name present	Yes No	Yes No	Yes No
Shape of curve smooth and reasonable	Yes No	Yes No	Yes No
Curve centered	Yes No	Yes No	Yes No
Symmetric/Normalized Correctly	Pass NA Fail	Pass NA Fail	Pass NA Fail

	Wedge ____	Wedge ____	Wedge ____
Orientation Correct (peak on rt)	Yes No	Yes No	Yes No
Wedge factor for each field size	Yes No	Yes No	Yes No
Wedge type correct	Yes No	Yes No	Yes No
Wedge name present	Yes No	Yes No	Yes No
Shape of curve smooth and reasonable	Yes No	Yes No	Yes No
Curve centered	Yes No	Yes No	Yes No
Symmetric/Normalized Correctly	Pass NA Fail	Pass NA Fail	Pass NA Fail

Comments:

Electron Beam
Machine Data Review Report

File Name: ______________________ Energy: ______________________
Institution: ______________ Manufacturer: ______________ Model: ________
Evaluation Done By: ________________________________ Date: ___/___/___

Pass	Fail	Mode	Evaluation Parameters	No	Yes
Pass	Fail	General	Default block tray factor = 1.000	___	___
			Name satisfactory	___	___
			Dmax reasonable	___	___
			Comment:______________________		
Pass	Fail	Depth Dose	Smooth	___	___
			Includes zero depth	___	___
			Comment:______________________		
Pass	Fail	TMR	Extrapolated to 50+ cm deep	___	___
			Extrapolated to 50+ cm field size	___	___
			Smooth TMR data	___	___
			Comment:______________________		
Pass	Fail	Output Factor	< = 25 values	___	___
			Increasing field size	___	___
			Increasing order of magnitude with field size	___	___
			Normalized to 10 x 10	___	___
			Comment:______________________		
Pass	Fail	Edge Factors	_____ # Edge Types	___	___
			Increasing distances	___	___
			0.5 at 0 cm	___	___
			Starts at near zero transmission	___	___
			Ends at 1.0 transmission	___	___
			Comment:______________________		
Pass	Fail	Effective SSD	Varies in Uniform Manner	___	___
			One value for each cone size	___	___
			Comment: ______________________		

OCR DATA	Open	
Wedge factor for each field size = 1.000	Yes	No
Wedge type = 0	Yes	No
Wedge name present	Yes	No
Shape of curve smooth and reasonable	Yes	No
Curve centered	Yes	No
Symmetric/Normalized Correctly	Pass	Fail

Comments:

____

____

____

____

PROWESS HARDWARE SETUP CHECKLIST

(Check off boxes as you complete each item)

Unbox all units:	☐ CPU	☐ Digitizer
	☐ Monitor	☐ Scanner
	☐ Printer	☐ Plotter

- ☐ Make sure all items are removed from boxes (especially HP printers and plotters).

CHECK PACKING LIST

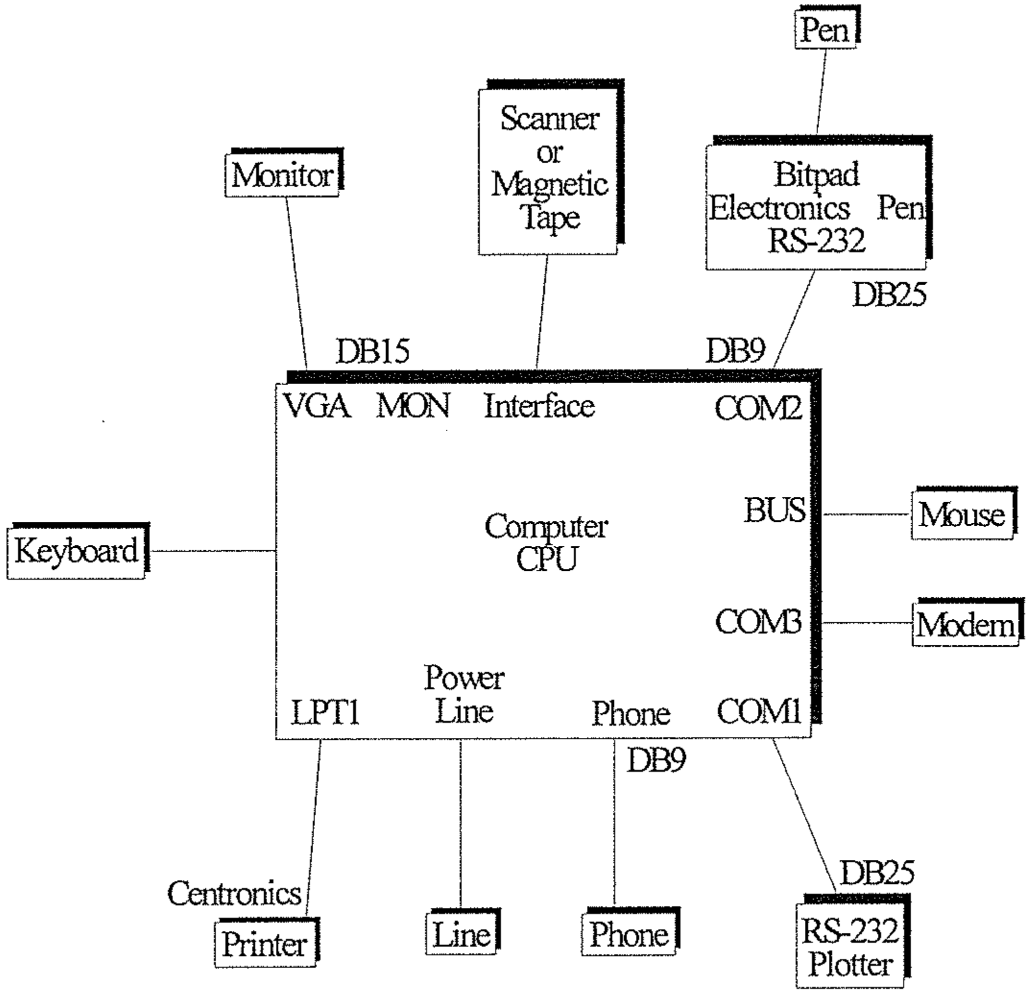
- ☐ Follow instructions with each unit for unpacking and assembly.
- ☐ Remove cardboard 5¼" floppy drive protector from CPU.
- ☐ Lock scanner bulb in place above scanner surface.
- ☐ Unlock scanner carriage. It is critical that this be done before operating the scanner. See the user's manual.
- ☐ Plug in surge protector and turn it off.
- ☐ Attach all power cords to units. Plug into surge protector.
- ☐ Attach cable from monitor to CPU.
- ☐ Plug mouse and keyboard into CPU ports.
- ☐ Attach scanner cable from scanner to interface port on CPU.
- ☐ Attach Prowess security block (about 2" x 2" x ½") on LPT1 of CPU.
- ☐ Attach printer cable from printer to CPU.
- ☐ (LPT2 if you have a PaintJet plotter; LPT1 if using other plotter)
- ☐ Attach cable from Plotter to CPU.
- ☐ (LPT1 if PaintJet; COM1 or 2 for other plotter)

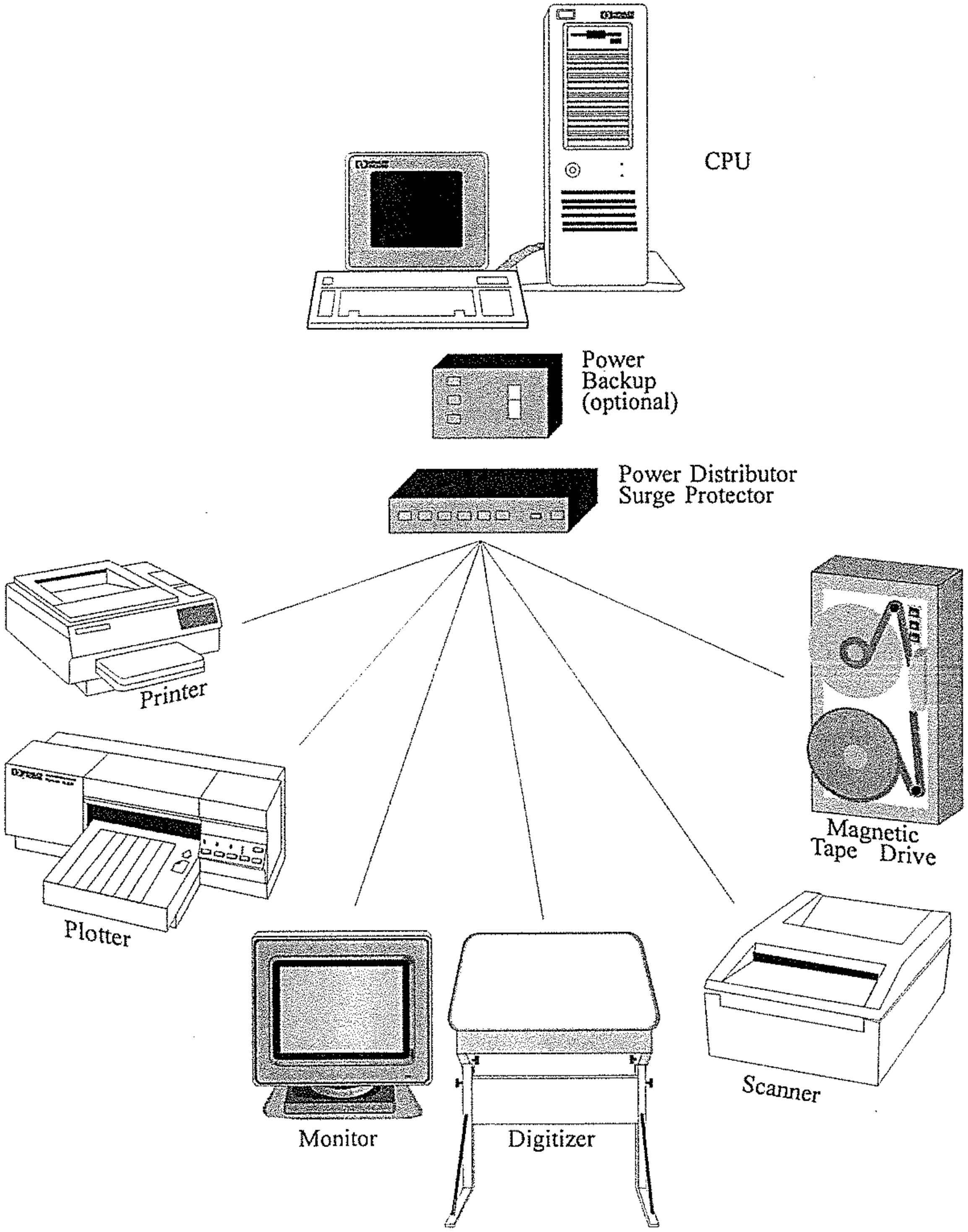
DIGITIZER

- ☐ Assemble light stand according to enclosed diagram.
- ☐ Place digitizer on stand.
- ☐ Attach pen to electronics box and place pen on Velcro patch on digitizer tablet.
- ☐ Attach cable from digitizer to CPU port (COM1 or COM2).
- ☐ If using external modem, plug unit into surge protector, telephone line, and CPU (usually COM3).
- ☐ Turn surge protector on. All units should power on properly.

HARDWARE CONNECTIONS

The Prowess Systems computer hardware is connected as shown in Figure B.1 and B.2.




CPU
Power
Backup
(optional)
Power Distributor
Surge Protector
Printer
Plotter
Monitor
Digitizer
Scanner
Magnetic
Tape Drive

Cable descriptions are as follows:

SCIENCE ACCESSORIES GRAF PEN OR NUMONICS TO DIGITIZER CPU

GrafPen (DB25 Male)	CPU (DB9 Female)	CPU (DB25 Female)
2	3	2
3	2	3
7	ground 5	7
6&10 jumpered	4,6,7,8 jumpered	4,5,6,20 jumpered

HP PLOTTER TO CPU

7475A HP Plotter (DB25 Male)	CPU (DB9 Female)	CPU (DB25 Female)
7550A HP Plotter (DB25 Female)	CPU (DB9 Female)	CPU (DB25 Female)
2	2	3
3	3	2
5 & 6	4	20
7 ground	5	7
20	6&8	6&5

PRINTER TO CPU (LPT1)

Printer	CPU
Standard Centronics Parallel Connector	Standard DB25 Male Connector

MONITOR TO CPU (VGA)

Special 15 pin monitor cable to CPU

HARDWARE SETTINGS

NUMONICS ACCUGRID 20"X24" TRANSLUCENT DIGITZER

(2400 baud, 8 bit, no parity, 1 stop bit)

Set up with menu:
Numonics ASCII
Point Mode
40 lines/mm resolution
CR, LF, Sep, Flag Options
Beep enabled
Save as Application 1

NUMONICS MODEL 2200 20"X24" TRANSLUCENT TABLET

(2400 baud, 7 bit, no parity, 1 stop bit)
Baud rate 2400 mode switch ON, OFF, ON, OFF

Switch A(DS1)

1	Off	Point mode - enabled
2	On	Stream mode - disabled
3	On	Increment Stream Mode - disabled
4	On	Switch stream mode - disabled
5	On	Metric mode
6	On	Absolute mode - OFF
7	On	Standard ASCII mode
8	On	Polled mode - disabled

Switch B (DS2)

1	Off	Carriage return
2	On	No line feed
3	On	No parity
4	On	-----
5	On	1 stop bit
6	On	Audible - disabled
7	On	XON/XOFF - disabled
8	On	Self diagnostic - disabled

SCIENCE ACCESSORIES GP7 MODEL II GRAFBAR

(2400 baud, 7 bit, even parity, 2 stop bits, menu off)
Must install pin 10 jumper
Use ROM with default start up of metric, menu off, extended range toward digitizer enabled

Switch Settings

1	Up	Stylus
2	Up	2400 Baud
3	Down	2400 Baud
4	Down	2400 Baud
5	Down	Parity even
6	Up	Parity yes
7	Up	Stylus

SCIENCE ACCESSORIES GP8 SONIC DIGITIZER

(2400 baud, 7 bit, odd parity, 2 stop bits, menu off)
Must install pin 10 jumper
Use ROM with default start-up of metric

Switch Settings

1	Down (ON)	2400 Baud
2	Down	2400 Baud
3	Up (OFF)	2400 Baud
4	Up	Parity yes
5	Up	Odd parity
6	Up	Carriage return only
7	Up	Stylus
8	Up	Standard frame
9	Up	-----
10	Down	Menu Off

NUMONICS GRIDMASTER DIGITIZER

(2400 Baud, 8 bit, no parity, 1 stop bit, XON XOFF disables, Polled mode, 200 lpi (English, S-BPI ASCII)
Set up with set up program using menu. Press ASCII mode first and touch all other boxes. Exit with Save Configuration

Important If using metric paper on any printer or plotter, be sure the correct paper setting is chosen in the configuration (i.e., A4).

HEWLETT PACKARD DESKJET 1200 C/PS

Parallel only. Switch settings

language	down	PCL5
language	down	PCL5
context	down	
centrone	down	
Roman 8	down	
12 cpi	down	
Letter/A4	down (up if using metric paper)	
----	down	

HEWLETT PACKARD PAINTJET XL300 WITH POSTSCRIPT

Parallel only. RS422-1, Baud0-0, Baud 1-0, Xon-Xoff-0, PCL5-0, PCL5-0, Roman8-0, 10 cpi-0, English-0.

HEWLETT PACKARD PAINTJET XL WITH HPGL CARTRIDGE

Parallel only. Switch settings (BAUD0-0, BAUD1-0, PAR0-0, PAR1-0, XON/XOFF-0, MET-1, ROM8-0).

HEWLETT PACKARD 7475A PLOTTER	(9600 baud, 8 bit, no parity, 1 stop bit) Baud B1-0, B2-1, B3-0, B4-1, Size A3-1, Met US-1, Y-0, Parity S1-0, S2-0. Pens: 1 - Black (.7 mm) 2 - Red (.3 mm) 3 - Green (.3 mm) 4 - Orange (.3 mm) 5 - Blue (.3 mm) 6 - Purple (.3 mm)
HEWLETT PACKARD 7550A PLOTTER SETUP	Serial 9600, 8 bit, no parity, 1 stop bit, hardware handshake HP-IB-Standard, bypass off, mode direct, remote, stand alone, half duplex, monitor mode off. Pens: 1 - Black (.7 mm) 2 - Red (.3 mm) 3 - Green (.3 mm) 4 - Orange (.3 mm) 5 - Blue (.3 mm) 6 - Brown (.3 mm) 7 - Purple (.3 mm) 8 - Yellow (.3 mm)
HEWLETT PACKARD LASERJET SERIES 4 PRINTERS	Set default font to PC-8 of 10 cpi, page protection to LTR
HEWLETT PACKARD LASERJET SERIES III PRINTERS SETUP	Set default font to **PC-8** of 10 cpi (Internal 32) Page Protection to LTR

LEXMARK IBM PS 4079 PRINTER

Main Menu Parallel only. Print quality - draft. Screening - enhanced. Color balance - plain or coded paper (indicate which). Emulation mode - Automatic. Start page - off. Auto scaling - off. Auto eject - on. Paper size - A (letter). Copies - 1. Load method - 1.

PS Menu Start page - off. Wait time-out - 300 seconds. Job time-out - disabled.

Plotter GL Menu Autoscaling - off. Time-out - 1 minute. Autoeject - off. Pen - 1-8. Width - 0.3 mm.

Pen 1 color = black
Pen 2 color = red
Pen 3 color = green
Pen 4 color = yellow
Pen 5 color = blue
Pen 6 color = red - violet
Pen 7 color = aqua
Pen 8 color = orange

Interface Menu Parallel Prot. - fastbytes. Honor Init - off.

PROWESS 6FS COLOR FILM SCANNER

Interface card switch settings: 1 & 5 down, all the rest are up. (Address is 220.) Be sure that the system driver **MSCAN.SYS** is installed in the **CONFIG.SYS** file.

COMPUTER COMPONENTS

SERIAL COM PORT ADDRESSES

COM	Address Interrupt Level
COM 3	3E8IRQ 2 (Vector Address 34)
Bus Mouse	IRQ 5
COM 2	IRQ 3
COM 1	IRQ 4

EVEREX MAGIC I\O SERIAL BOARD MODEL 170B

COM 3 SW1		Interrupt 2 Jumpers
1	Off	o o o o o o
2	Off	o o o o o o
3	On	o o o o o o
4	Off	Serchint
		Lptsel
LPT	Jumper Off	

NUMONICS ACCUGRID SETUP INSTRUCTIONS

1. Place the tip of the digitizer pen on the MENU softkey near the right edge of the tablet. The tablet will emit a rapid sequence of beeps.
2. Press down and hold the digitizer pen to the tablet. The tablet will emit a steady beep. Continue to hold the pen until the tone terminates (approximately two seconds) signifying activation of menu selection. At this point, the digitizer emits a slow sequence of beeps. This is to remind you to digitize the menu origin crosshairs (step 3).
3. Place the digitizer Setup Menu in the lower left corner of the active area (parallel with the vertical and horizontal axes)
4. Place the digitizer pen directly over the menu origin crosshairs along the bottom of the menu (next to Numonics phone number) and press down and hold the digitizer pen. This will stop the slow beeping.
5. The tablet emits three short beeps to confirm menu mode. You can now move the cursor around the menu.
6. Place the digitizer pen over the box beside each of the parameters listed below. Press down and hold the digitizer pen until a rapid sequence of beeps is heard. This will activate the selection you have made.

OUTPUT FORMAT:	ASCII	
ASCII OPTIONS:	CR	
	LF	
	Sep	
	Flag	
INTERFACE:	Baud Rate:	2400
	Data Bits:	8
	Parity:	None
	Stop Bits:	1
MODES:	Point	
	Increment Size:	0 = OFF
	Stream Rate:	Max
RESOLUTION:	Lines/mm:	40
TRANSMIT OUT OF PROX:	Disable	
BEEPER:	Disable	

7. After all parameters are set, press down and hold the digitizer pen on the box marked APPLICATION 1 under SAVE CONFIGURATION. Then, press down and hold the pen on CONFIRM CHANGES under EXIT. The tablet will beep once to confirm the end of menu input.
8. Remove the menu. Configuration of the digitizer is now complete.

CONTROL FILE EDITING

There are two master configuration files reconfigure the entire Prowess system. They are text files that can be changed, however, any change can have a significant effect on the operation of the program.

The files (**TPS3.CTL** and **TPS.INI**) are located in the C:\PROWESS directory. Each time the TPS3.CTL file is updated, the treatment planning programs recompile the file into a usable format. Make sure the security plug is in place before changing the control file.

If the security plug is not present, "Demo Version" will appear in the upper left corner. Thus, many Prowess functions will be inaccessible. If the control file is compiled without the security plug, all input/output functions will be disabled until the program is recompiled with the plug in place.

TPS3.CTL FILE

Choose **Configuration** from the main Prowess menu to edit the control file. Choose **Edit Configuration** from the second menu. The Prowess system uses the DOS Editor to edit the file. The control file will appear as a text file. Use the arrow keys and page up and down to move through the file. The insert, backspace, and delete keys are useful as well. Press Exit to end the session. Press Enter to save. The control file will be compiled for use with the treatment planning programs when control returns from the editor.

The control file is a text file written in pseudo-English terms. An active line or command starts with a ">" symbol in column one followed by a command. The command is usually one or more words in all capital letters. For example:
>PRINTER is LASERJET3 at LPT1
means that text will be printed on an HP LaserJet or equivalent.

All other lines are treated as comments and should start with a blank space or a semicolon (;).

The file has been organized by category which include:

- File location paths
- Menu and submenu items
- Display colors
- Peripheral Device list, location, and settings
- Serial port parameters
- Bitpad calibration data
- Default program settings such as isodose curves

The exact format of each command line is important. **Before changing any line, be sure you understand its format and usage.** If you have any questions concerning this file, please contact Technical Support (see Appendix F).

TPS.INI FILE

The TPS.INI file contains initialization information that is read when Prowess is executed. The sections are designated by brackets (e.g., [Graphics]). It contains categories which control:

- Video adapters
- Scanning parameters for Prowess 14FS scanner
- Iodine prostate grid template
- Video graphic resolutions
- Independent jaw capability

To edit this file, exit Prowess. From the C:\> prompt, type:

```
CD PROWESS
EDIT TPS.INI
```

Active lines are not preceded by a semicolon ";" (comments) or a greater than ">" symbol as in the TPS3.CTL file. Changes will take effect the next time Prowess is used.

SYSTEM FILE MANAGEMENT

INVOKING POP-UP DOS[1]

1. Select **Patient File Management** from the Configuration Menu.
2. Select **File Management** from the Main Menu.
3. Pop-Up DOS can be started from the C:\> prompt by typing "POPDOS".

TRAVERSING DIRECTORIES

DOS has a tree-like directory structure. To go into a directory, select the directory name (i.e. [PROWESS]) with the mouse or cursor keys and press the **Enter** key.

To move to the parent directory, select the [..] directory.

PATIENT FILE MANAGEMENT

Prowess patient files are in two places:

1. \PROWESS\PATIENT
   Digitized contours for external beam, irregular field data, and brachytherapy source locations are all stored in this directory.
2. \PROWESS\CATIMAGE
   Scanned and tape images are stored in this directory.

MODIFYING FILE DISPLAY

To change the way files are displayed: Select Options/Directory Display to sort files by date, file name, or type of file (file extension).

SELECTING FILES

Select files by using the mouse or the keyboard. Tapping the space bar will highlight the file name. Clicking on the file under the mouse will also highlight the file.

Once a file or group of files are selected, copy, delete, or remove them. Choose File to perform the desired function to these files. Be sure the files are copied to the backup media before deleting them.

FORMATTING A FLOPPY DISK

Insert the diskette into the drive. Select Disk/Format from the Pop-Up DOS menu. A screen will come up asking for volume name (usually leave blank), diskette format (either 1.2 MB 5.25" or 1.44 MB 3.5"), and diskette drive (**A: or B:**). Choose the correct sizes and select OK.

---

[1] Pop-Up DOS is distributed by SSGI under license from Logitech Software.

COPYING FILES

Once the files are selected, they can be copied to another directory or a floppy disk. Select File/Copy. If copying the file to a floppy drive, type **A:** or **B:**. If copying the file to another directory, type the path of the directory (i.e., C:\PROWESS\OLDPAT\).

DELETING FILES

Selected files can be deleted by choosing File/Delete. Delete must be selected with the mouse as Pop-Up DOS does not allow the keyboard command to work.

CHECKING HARD DISK

Pop-Up DOS has the ability to check the hard disk for lost clusters or chains. Select Disk/Check Disk to activate.

ADDING NEW PROWESS VERSION TO THE PROGRAM MANAGER MENU

Bring up the Program Manager Main Menu. Press F7 to edit menu.

Select **MENU.**
Select **ALTER.**
Select **INSERT.**

Press the **ES**Cape key to go to the previous Program Manager Menu.

Select **Command** to edit menu item.

Change menu item name to: A. Prowess Version 3.04
Option: C (Clear)
Comment to Execute:
C:\COMMAND.COM /E:1024 /C C:\PROWESS\PROWESS.BAT
Change to Directory: C:\PROWESS

Press **ES**Cape key twice followed by <Enter> key.

To switch back and forth between Prowess Version 3.04 and Version 3.02, you will need to change the Program Manager entry for Version 3.02 to be the same form as above. Contact SSGI Technical Support if you have questions or problems.

PRODUCT SUPPORT

SSGI can be contacted by telephone at (916) 898-0660 between the hours of 8:00 a.m. and 5:30 p.m. Pacific Time or by fax at (916) 342-8966 at any time.

BULLETIN BOARD INSTRUCTIONS

In order to use SSGI's bulletin board service, please follow the instructions as outlined below:

1. **Turn your Modem on. Select Procomm or Procomm Plus from the Main Menu.**

2. **Setting up Communication Parameters:**
   From the Procomm "Ready" screen, type Alt-P. This brings up the port selection menu. Make settings:

Baud Rate:	2400 (or 9600)
Parity:	None
Data Bits:	8
Stop Bits:	1
Port:	COM1, COM2, or COM3 depending on which port the modem is plugged into on your computer

   Save changes

3. **Setting up Dialing Directory:**
   Type Alt-D from the Procomm "Ready" screen. This brings up the dialing directory menu. If the phone number you want to call is shown, go to Step 4.
   To revise an entry, Type "R".

Name:	SSGI Bulletin Board
Number:	1-916-898-0675 (add a 9 if your facility requires it)
Baud:	2400 (or 9600)
Parity:	None
Data Bits:	8
Stop Bits:	1
Other Parameters:	Accept Default Values

4. **Dialing the Number:**
   Select the number in the Dialing Directory you wish to call. The modem will dial the number and connect you with the remote computer.

5. SSGI Bulletin Board:

Accounts have been set up for each Prowess facility under the name of our principal contact. If you desire other accounts, call us.

If you cannot access your account:
Enter full name: TPS User
Password: Prowess

6. Sending a file:

Type: “F” to select File Menu
“U” to Upload a file
“X” for XModem protocol
File to Upload: Type in file name
Press Page Up key
(Tells Procomm to upload file)
Type File Name: (need exact location of file: e.g., \PROWESS\BIN\CLINAC6.MCH)

7. Downloading a file from BBS:

Type: “F” to select File Menu
“A” to select a new file area
“L” to list files in the area
“D” to download a file
Files to Download: FILE.EXT (type file name)
“X” for XModem protocol
Press Page Down key
(Tells Procomm to download file)

8. Leaving a Message:

You can leave a message for Glen Orcutt (Product Support) to let him know you have left a file:
Type: “M” from main menu to get message menu
“P” to post a message
To: “Glen Orcutt” (follow directions)
Type: “S” to save and send message

9. Exiting BBS:

Type: “G” for Good-bye
“G” for Good-bye, Really!

PROWESS TECHNICAL SUPPORT FAX TRANSMITTAL SHEET

To: SSGI Customer Support
Fax No.: (916) 342-8966
Date: ______________________________
From: ______________________________
Center: ______________________________
Tel No.: ______________________________
Fax No.: ______________________________
No. of Page(s): ______________ (including face sheet)

SSGI
1370 Ridgewood Dr., Ste. 20
Chico, California 95926 USA
Tel: 916-898-0660
Fax: 916-342-8966

Prowess Customer Support:

I have...

☐ a problem with... ☐ Prowess *2000* Ver_____ ☐ Release Date: ___/___/___
☐ a suggestion for... ☐ Prowess *3000* Ver _____ ☐ Release Date: ___/___/___

- ☐ External Beam Program
- ☐ MRI/CT Film Scanning Program
- ☐ Brachytherapy Program
- ☐ Irregular Field Program
- ☐ Daily Calculation Program
- ☐ Machine Data Entry Program
- ☐ Source/Template Entry Program
- ☐ Film Densitometry Program

regarding...

- ☐ Calculation
- ☐ Hardcopy
- ☐ Contour Entry
- ☐ Beam Entry
- ☐ Image Entry
- ☐ File Save/Retrieve

☐ Other: ____

Description: ____

INTERNET TECHNICAL SUPPORT

SSGI is now on the Internet. To send our technical support staff an e-mail message, send the message to the following address:

support@ssgi.prowess.com

Internet e-mail sent to this address gets routed directly to the desktops of the technical support staff. Using this mechanism for support allows the technical support staff to direct your queries to the appropriate personnel, if necessary, without the possibility of interpretation error. Essentially, this gives our Internet-connected customers direct communication with the SSGI staff without the cost of placing a long distance phone call.

GLOSSARY

BEV	Beam's Eye View
blocks	beam shaping device
bolus	tissue equivalent material
BSF	Back Scatter Factor
cGy	centiGray
cm	centimeter
cm^3	cubic centimeter
collimator	rectangular beam limiting device
compensator material	material used to compensate for missing or irregular patient surface
contours	outline of patient or feature
CT	Computed Tomography
%DD	Percent Depth Dose
d_{max}	depth of maximum dose
FS	collimator Field Size
gap	distance between adjacent fields specified at surface of patient
hot region	location(s) within beam icon where icon can be manipulated
HVL	Half-Value Layer
%ISO	percent isodose
isocenter	alignment point for treatment unit
mCi	millicurie
MeV	Mega electron Volt
MV	Mega Volt
mg Ra eq	milligram Radium equivalent
mm	millimeter
MRI	Magnetic Resonance Imaging
MU	Monitor Unit
NSD	Nominal Standard Dose
OCR	Off-Center Ratio
open beam	accelerator collimator with no beam modifiers
phantom	simulated patient
PSF	Peak Scatter Factor
SAD	Source to Axis Distance
SMR	Scatter Maximum Ratio
split field	accelerator collimator 50% blocked by wedge
split wedge	accelerator collimator 50% blocked and modified by wedges
SSD	Source to Skin Distance
TMR	Tissue Maximum Ratio
wedge	beam modifying device
Wt	beam weight

INDEX

INDEX

INDEX

INDEX

SSGI
1370 Ridgewood Dr., Ste. 20
Chico, CA 95926 USA

Corporate Offices & Technical Support:
Tel: 916-898-0660
Fax: 916-342-8966
E-Mail: support@prowess.com
BBS: 916-898-0675

Sales & Marketing:
Tel: 714-374-0833
Fax: 714-374-0835
E-Mail: sales@prowess.com