

*71-3*

*A-91-011*  
*71-3*  
*MP-DO*



LOS ALAMOS SCIENTIFIC LABORATORY  
UNIVERSITY OF CALIFORNIA  
LOS ALAMOS, NEW MEXICO 87545  
Telephone Ext:

**OFFICE MEMORANDUM**

DATE October 16, 1980

TO Distribution

FROM P. Berardo *pp*

SUBJECT PIPLAN

SYMBOL MP-3

MAIL STOP 844

712983

Attached is a PIPLAN plan.

1s/

Distribution:

- S. Bush
- A. Smith
- J. Bradbury
- M. Paciotti
- S. Zink
- P. Berardo

**COPIED FOR  
HSPT**

FILE BARCODE



00133413

00133413.001

1087889

## PIPLAN, Prospects, Procedures, and Plans

By 15 November we believe that PIPLAN will provide more efficient and more accurate dose distributions and templates for bolus and collimator fabrication. We expect by then that CT data will be inserted into the case file in a much more efficient manner, with regions of interest (ROI's) entered at the CT consoles, preliminary hardcopy images and digitizing be eliminated, and disk space reduced. In addition to the full range of planning capabilities available with our current production, single slice, planning system, there are many additional features in PIPLAN. Increased accuracy in PIPLAN results from fewer manual operations, a full three-dimensional calculation, multiple scattering used throughout the volume, inclusion of off-axis collimator dose effects, and from increased lateral resolution in bolus design.

Detailed below are more complete specifications of capabilities regarding clinical appliances, expected procedures, and longer range plans for upgrades.

### A. Steps in Treatment Planning:

1. Scan patient
2. Mark target volume and surface on CT console (replaces CTVIEW/AUTOPLOT and transcription of target volume to hardcopy)
3. Export scan tape as per SOP described below
4. On PDP-11/70 or PDP-11/45 mount scan tape and run PILIST to create tape directory (replaces CTLIST)
5. Edit Directory for files to be entered into case file (same as is done for CTVIEW/AUTOPLOT and CTLINK)
6. Run PILINK to stage tape files directly to case file (replaces

**COPIED FOR  
HSPT**

CTBILD and CTLINK with one automated step)

7. Run PIPLAN-RSX to edit effective-target volume (replaces marking of hardcopy for CTVIEW/BOLUS design)
8. Optionally verify 3-D consistency of data
9. Export case file to tape and deliver to CCF
10. Run PIPLAN-CCF from Biomed terminal or dial-up  
(replaces CTVIEW, CTPOST, XYZGEN, OVLAP, TRTRM)
11. Distribute output and view results at Biomed terminal (replaces PLTPLN)  
Includes bolus and collimator templates and dose distributions

**B. Recalibration Procedures of CT Data**

Our current CT programs and PIPLAN have the capability to linearly correct for miscalibration of the CT data. The required inputs are the CT values for air and water as measured and converted to our standard scale with CT numbers of zero and 1000 for air and water, respectively. These values can be determined in two ways. The easiest is at the CT console using ROI's. The second is our present method where a file is copied to disk with CTBILD and analyzed with CTEXAM. A standard phantom scan is recommended.

The recalibration values can be inserted in the case file with PILINK, PIPLAN-RSX, or PIPLAN-CCF.

**C. Interface of Treatment Planning to CT Scanner**

With the implementation of two new programs, PILIST and PILINK, irregular regions of interest (IROI's) can be entered at the CT console and incorporated into the PIPLAN case file automatically. Because of inherent

**COPIED FOR  
HSPT**

limitations in the EMI software, a standard procedure is required to achieve this capability.

1. Starting with a diagnostic image or an image marked with an IROI tumor volume, the therapist adds the target-volume IROI. If the tumor volume is present, the target volume must be external to it. The EMI software will inhibit any pixel from being in both IROI's. Circular or rectangular ROI's are not allowed. The resulting image is saved as, what we here call, image A.
2. Image A is recovered and the surface IROI is added and the result saved as image B.
3. If any landmark IROI's are to be added, Image B is recovered, the IROI's are added inside the surface IROI and the result saved as the new Image B.
4. For each slice of a study, Image A followed by the final Image B must be exported to the scan type. Staging of the original diagnostic image is optional. For efficiency, if the original diagnostic images and/or raw data are staged to tape, they preferably are staged after all A and B images.

D. Nomenclature:

PIPLAN provides for six types of contours:

- 0 - general contour
- 1 - effective target volume
- 2 - surface
- 3 - target volume
- 4 - tumor volume
- 5 - collimator

COPIED FOR  
HSPT

The target volume is the prescribed volume to receive a minimum percentage of maximum dose. The effective target volume is the planner's contour for controlling the results of the calculation. PIPLAN designs its beams and appliances based on the surface and effective volume. The effective volume is automatically duplicated whenever the target volume is entered and may later be modified to the planner's purpose. The treatment volume is not required explicitly but is always the isodose surface that matches the therapist's prescription.

#### E. Appliances

The three appliances handled by PIPLAN are the collimator, bolus, and range shifter. This section describes briefly the required input with options, the design criteria, and the output available.

##### Appliance Input

Collimator (Default is no collimator)

Density code (default is cerrobend)

mm thickness

mm offset (default is zero)

offset positive implies above patient surface

offset negative implies above bolus top

x mm margin (default is 15 mm)

y mm margin (default is 15 mm)

Margins are amount of expansion of  
collimator opening beyond effective  
target volume boundary.

As an upgrade, PIPLAN will design the collimator based on  
beam trajectories.

COPIED FOR  
HSPT

Range shifter (Default is no range shifter)

Nominal function in Biomed standard notation

Bolus (Default is no bolus)

Density code (default is paraffin)

Shape code

conform to surface (default)

Flat top, bottom touching surface

Flat bottom, bottom touching surface

Pion stopping code (matches point in modulated peak with point in effective target volume):

<u>RS</u>	<u>ETV</u>	<u>How</u>	<u>Why</u>
DISTAL	DISTAL	each x,y	avoid critical postpeak tissue
DISTAL	MIDDLE	each x,y	abutting opposed ports
PROXIMAL	PROXIMAL	each x,y	avoids critical prepeak tissue
MIDDLE	MIDDLE	each x,y (default)	centered everywhere
MIDDLE	MIDDLE	average over (x,y)	symmetric about midline

Appliance Design, Present Criteria, and Method

Collimator

The grid of density cells overlying the effective target volume (ETV) is expanded in X and Y by the number of cells required to assure the input collimator margins. All remaining cells in X and Y are defined as collimator. The collimator thickness is adjusted to the number of cells required to satisfy the input thickness. The collimator parameters are adjusted to give an effective thickness equal to the input thickness. The offset of the bottom of the collimator is adjusted to the nearest cell.

COPIED FOR  
HSPT

Bolus:

Bolus thickness at each X,Y is adjusted to the nearest integral number of cells by integrating from the surface down the necessary number of steps to the stopping point. Note that by the expansion method used for the collimator, the bolus is extended laterally from the outer edge and has a thickness such that the stopping point is also extended laterally. The bolus is then extended farther from the edge without changing the thickness by the number of cells required to satisfy the collimator margins. Thus the total extension of the bolus is two collimator margins. If a conflict occurs between bolus and collimator, collimator dominates.

Range Shifter:

While designing the bolus, the maximum effective thickness of the effective target volume is obtained. The range shifter function given in the input may be redefined if not sufficiently large. Only the thickness will change, not the series or tune specifications. If no suitable function is available, that plan calculation is aborted.

Appliance Output

Collimator:

Three printed life-size templates with resolution determined by mapping density matrix to printer matrix - Printout can be immediately directed to LOB for pickup. Adjusted collimator parameters and collimator opening area provided. Area determined from density matrix and from printer matrix to evaluate resolution.

COPIED FOR  
HSPT

Bolus:

Templates designed in same plane and with same interplane spacing as CT data - Output is on plot file. Scale of output adjusted so that life-size template is produced with hardcopy of Tektronix 4010 "PSCAN" image on large Versatec copier.

Range Shifter:

Listing on standard output file of function used. Reduced function is used and listed if library function is symmetric.

F. General Output Capabilities

Hardcopy printout with record of input and calculation, appliance parameters, statistics, dose rate, dose distributions in the beam system and the reference system.

Plot file for local terminal inspections and hardcopy.

Microfiche copy of plot file

Updated case file for iteration or import at Biomed

G. Program, Plans, and Proposals

To achieve the above capabilities, there is still a significant amount to be done in the next month. The primary tasks are:

- Finish bolus and collimator upgrades
- Finish plans and beam module upgrades so that all specifications can be preserved and recalled at any time

**COPIED FOR  
HSPT**

-Write PILIST and PILINK programs

-Plan several cases with existing bolus and collimator and with

-PIPLAN designed appliances

Within the next two to three months we plan the following upgrades

(priority unassigned at present)

-Autoplot in PIPLAN

-Dose file preserved in case file

-Dose distribution optimization

-Beam dependent bolus and collimator

-Biological model

-Bolus and collimator contours

-CT data averaged at Biomed

-Collimator output on plot file

-Bolus output on print file

Within the next three to five months we propose the following upgrades

(priorities unassigned):

Fan Tune Calculations

Upgraded Physics

Enhanced Graphics

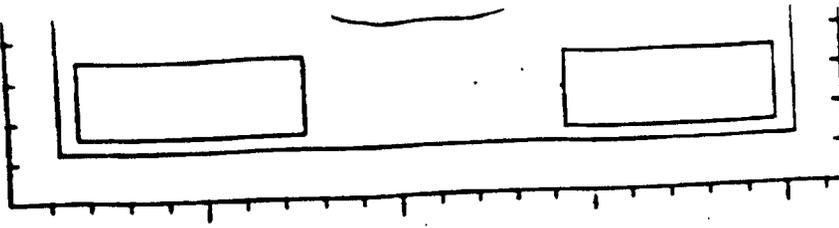
CCF → VAX conversion

Electron Dose Model

**COPIED FOR  
HSPT**



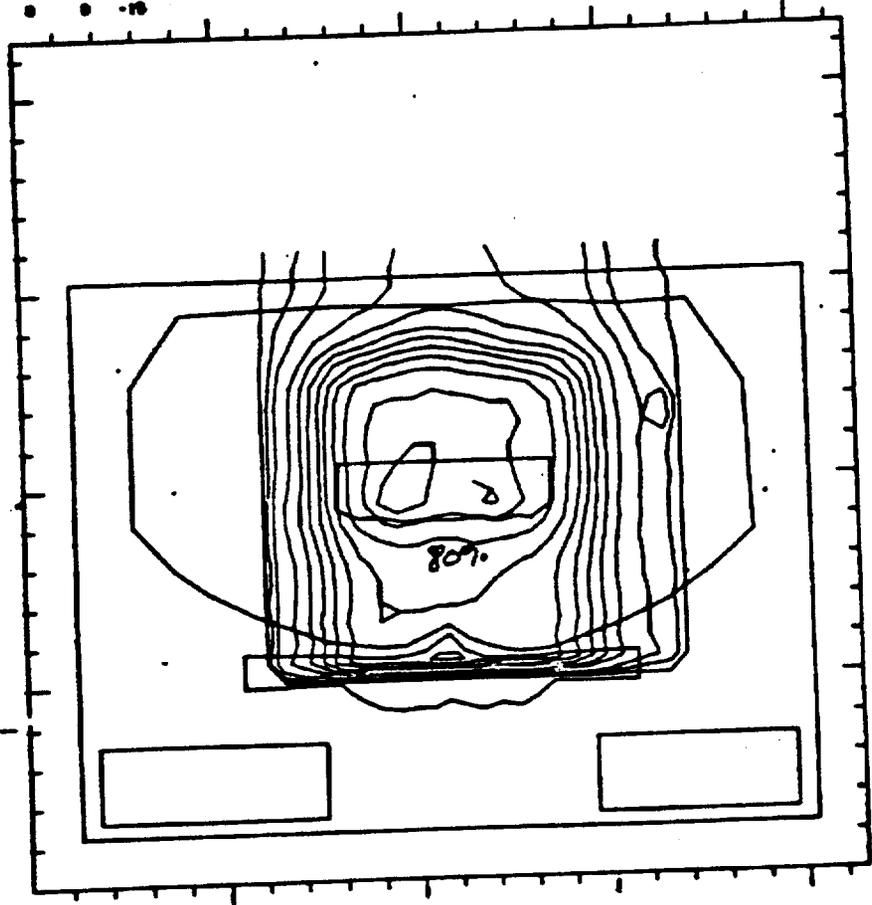
PLAN -10



Plan 2-PA.

PLAN 10001 00/10/31. 10:40:25.

LEVEL	DATA	PSI	SCAN
1	0	0	-10
2	0	0	
3	10	0	
4	20	0	
5	30	0	
6	40	0	
7	50	0	
8	60	0	
9	70	0	
10	80	0	
11	90	0	
12	0	0	
13	0	0	



PLAN

COPIED FOR HSPT

PLAN 10001 00/10/31. 10:40:27.

00133413 011

1087899

# Plan 2-PA

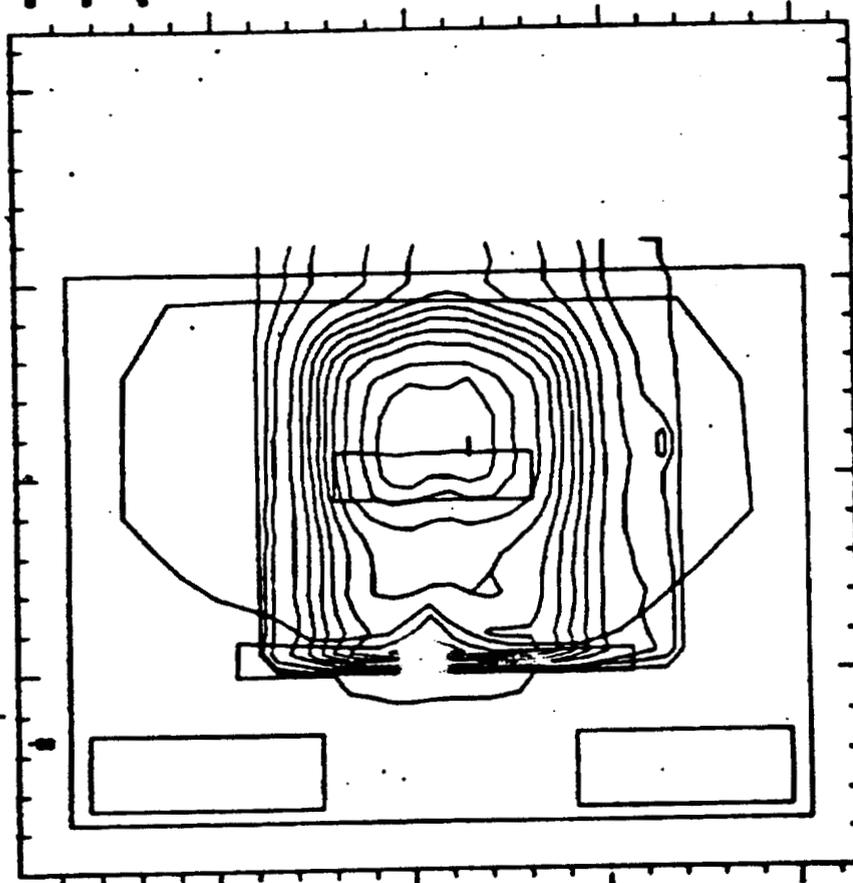
PLANES

00/00/01. 00/00/00.

X Y Z PHI THETA PSI SCAN

NUMBER LEVEL

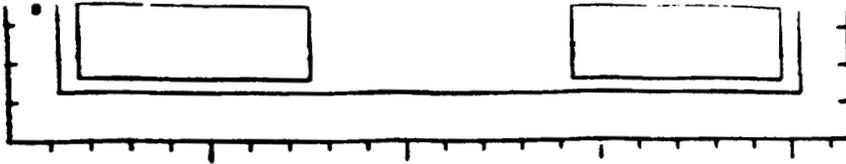
- 1 1
- 2 2
- 3 10
- 4 20
- 5 30
- 6 40
- 7 50
- 8 60
- 9 70
- 10 80
- 11 90
- 12 100
- 13 110



NOTES-

COPIED FOR  
HSPT

00133413.012

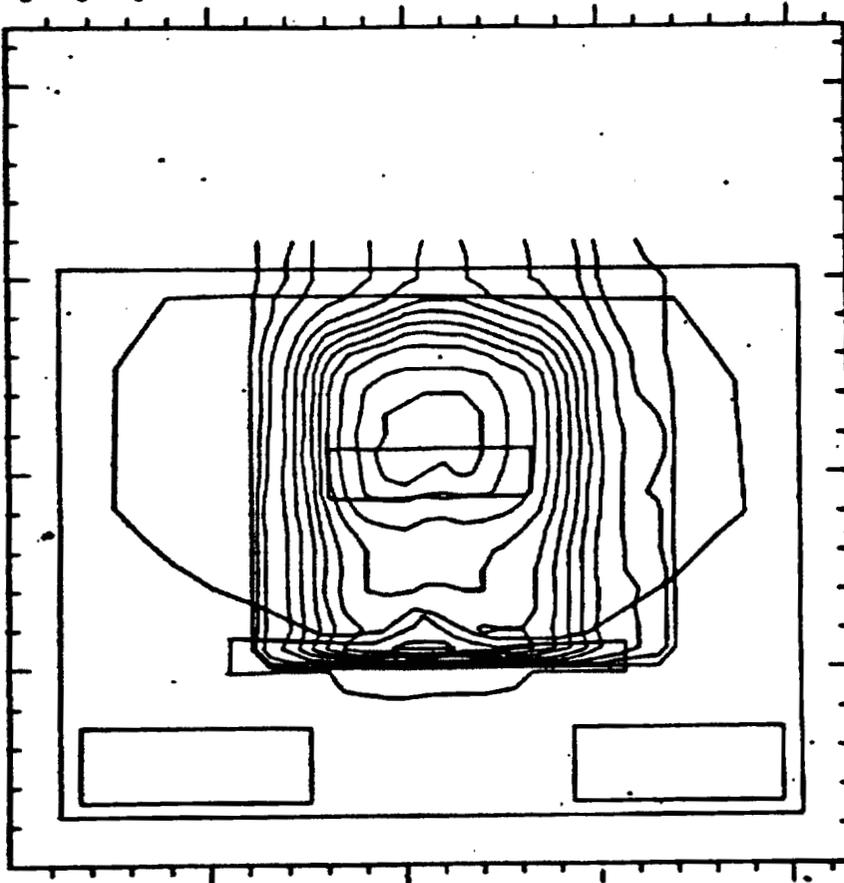


P/PLANNED 00/10/21. 10/10/21.

X Y Z PHI WETA PSI SCAM

CLIPPER LEVEL

- 1 1
- 2 1
- 3 10
- 4 10
- 5 10
- 6 10
- 7 10
- 8 10
- 9 10
- 10 10
- 11 10
- 12 10
- 13 10



SCAM -75

COPIED FOR  
HSPT

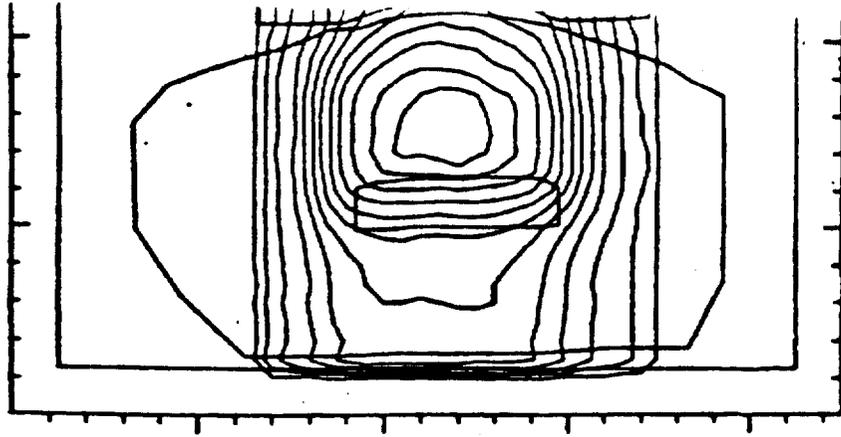
P/PLANNED 00/10/21. 10/10/21.

X Y Z PHI WETA PSI SCAM

00133413.013

1087901

SCAN -18



Plan 3-AP/PA

OPERATION

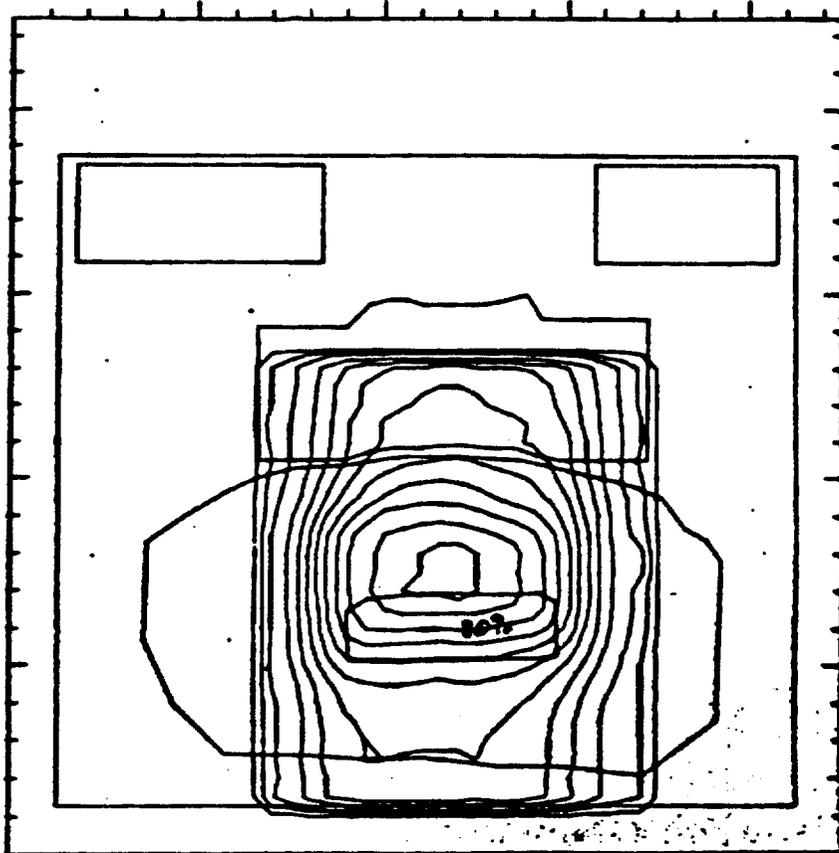
00/11/01. 00:20:40.

X Y Z PHI THETA PSI SCAN  
 ● ● ● ● ● ● ● -18

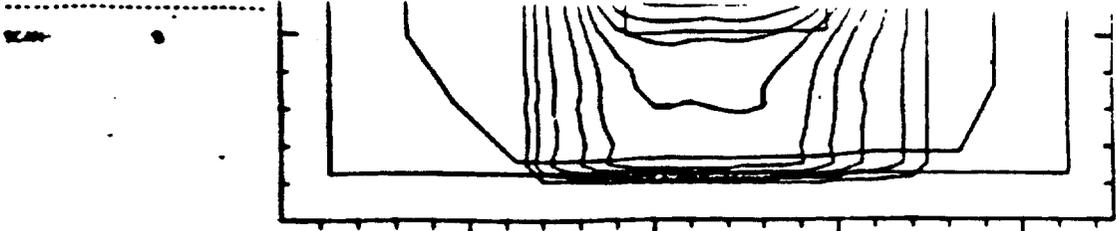
NUMBER LEVEL

- 1 1
- 2 5
- 3 10
- 4 20
- 5 30
- 6 40
- 7 50
- 8 60
- 9 70
- 10 80
- 11 90
- 12 95
- 13 98

SCAN ●



COPIED FOR  
HSPT

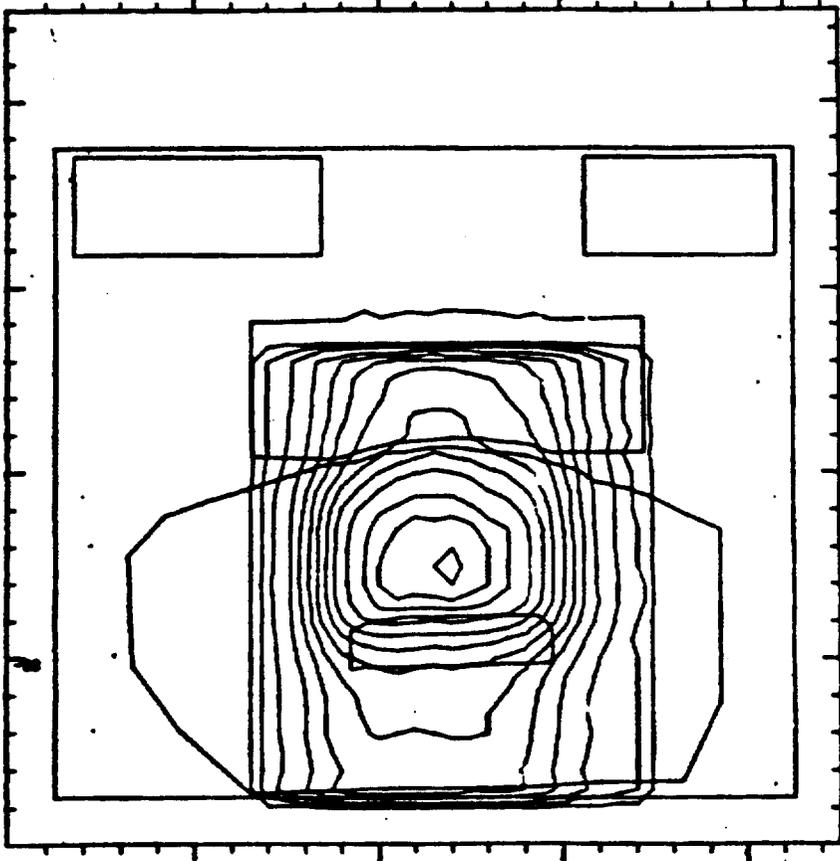


PLANES 00/11/01. 00/05/01.

0 1 2 3 4 5 6 7 8 9 10 11 12

BASED LEVEL

- 1 1
- 2 2
- 3 3
- 4 4
- 5 5
- 6 6
- 7 7
- 8 8
- 9 9
- 10 10
- 11 11
- 12 12



NOTE- 00 00 00

COPIED FOR  
HSPT

PLANIMETER

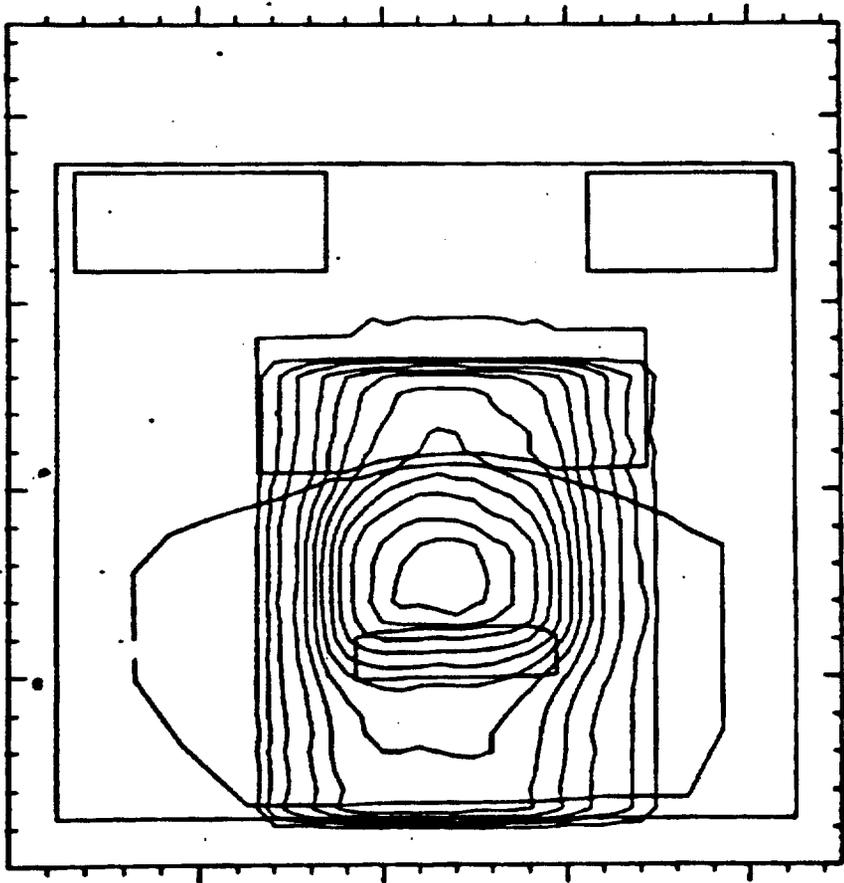
00/11/01. 00.25.10L.

X Y Z PHI BETA PSI SCAN

• • • • • • • •

NUMBER LEVEL

- 1 1
- 2 5
- 3 10
- 4 20
- 5 30
- 6 40
- 7 50
- 8 60
- 9 70
- 10 80
- 11 90
- 12 100
- 13 110



ROTATE

• • •

COPIED FOR  
HSPT

PLANIMETER

00/11/01. 00.25.10L.

X Y Z PHI BETA PSI SCAN

• • • • • • • •

00133413.016

1087904