μ-Dose Level in the Vicinity of the Intersection of the 8 GeV and the AP2- Beamlines

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June 28, 1995

There is some concern about the μ shower emanating from the pbar beam dump causing high μ- dose level at one of the EXIT STAIRS of the 8 GeV beamline near the intersection of the AP2 beamline and the 8 GeV beamline. Here we have estimated the μ-dose levels at this EXIT STAIRS and at various locations downstream of the pbar beam-dump.

In the pbar production target station (A0 building) a 120 GeV proton beam from the Main Ring is bombarded on a 7 cm thick metal target to produce the pbars. The average number of protons I, on the target is about,

$$I = 2.5 \times 10^{12} \times \frac{3600}{2.5} = 3.6 \times 10^{15}/hr$$

Then the pbars are focused by using a 15 cm long Li-lens. At about 60 cm downstream of the Li-lens the 8 GeV pbars are selected by using a dipole magnet which gives a 3 deg bend with respect to the 120 proton GeV beam. The pbars will be transported to the debuncher via the AP2 beamline. The unused protons will be dumped on to the pbar beam-dump. A schematic view of the pbar targetting area is shown in Fig. 1. The pions produced in the pbar target have upto about 3.5 m path length before they interacts with the beam-dump or surrounding shielding materials. The high energy pions produced in the pbar target will be having fairly high longitudinal momentum. These pions will decay to produce high energy μs which can penetrate through several feet of soil and are the main contributors for the μ-dose level far away from the beam-dump.

The incident beam on the target is at an elevation of 223.266 m (732.5 ft) and the nominal ground elevation around this region is 226.7712 m (744 ft). This gives about 3.5052 m (11.5 ft) thick soil from the beam elevation to the surface. The 8 GeV beam line tunnel (floor level is at an elevation of 217.4748 m (713.5 ft)) intersects AP2 beam line at about 150 m downstream of the pbar target station. At about 176 m down-stream of the pbar target and at 50 miliradian to the right of the AP2 beamline we expect to have the above mentioned EXIT STAIRS. Some part of this EXIT STAIRS will be at the elevation of the pbar target. To estimate the μ-dose level we have carried out Monte Carlo calculations using Van Ginneken's computer Code MUSIM within the cylindrical geometry. To take into account the effect of magnetic field in LI-lens and the pbar selection dipole magnet, we have made four quadrants viz., left, right, up and down with respect to the beam direction. The calculated isodose contours for μ-dose levels are shown in Fig. 2a and 2b for up and right respectively.

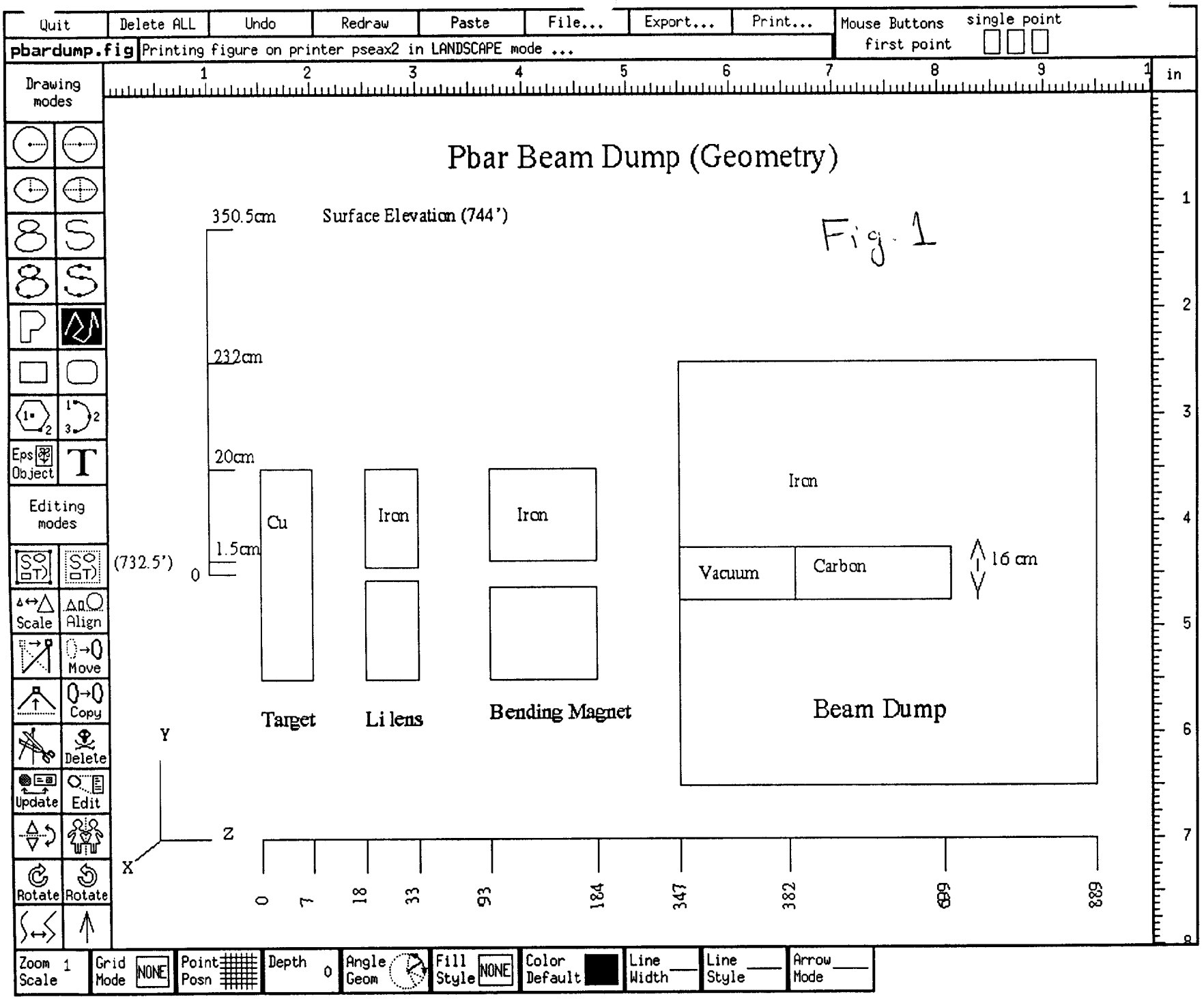
The Table I gives the estimated μ-dose levels at various locations marked in Figs. 3a and 3b. From the Fig. 2a we find that the maximum μ-dose at a distance of 175 m down stream of the pbar target and in the direction of the 120 GeV proton beam is about 0.16 mrem/hr. As shown in Fig. 3b (location F) the EXIT STAIRS is at about 8.76 m displaced horizontally with respect to the 120 GeV proton beam. Hence, the μ-dose near the EXIT STAIRS is four orders of magnitudes less than that along the beam axis as shown in Fig. 2b.

Table I. The calculated μ-dose near the intersection of the 8 GeV and the AP2 beamlines. The calculations have been carried out using the Monte Carlo code MUSIM and the geometry shown in Fig. 1. The coordinates of the target, (X,Y,Z) = (0,0,1.0 m). (X = transverse displacement Y= elevation relative to the 120 GeV beam and Z = coordinate along the beam).

Location	Distance (Along the Beam)(Z) (m)	Elevation (Y) (m)	Transverse Displ. (X) (m)	Radiation (Rad/p)	Dose/hr (mr/hr)
A	76	3.5	0.0	0.5E-19	.18
B	99	3.5	-4.74	1.0E-22	3.6E-4
C	117	3.5	0.0	0.5E-21	0.018
D	121	3.5	4.74	1.0E-22	3.6E-4
E	137	3.5	0.0	1.0E-21	3.6E-3
F (location of the EXIT STAIRS	176	0.0	8.5	$\leq$ 1.0E-22	$\leq$ 3.6E-4

Conclusion:

We find that the radiation due to the μ-dose near the EXIT STAIRS is much smaller than the allowed limit of 0.025 mr/hr for the normal operational conditions.


Quit
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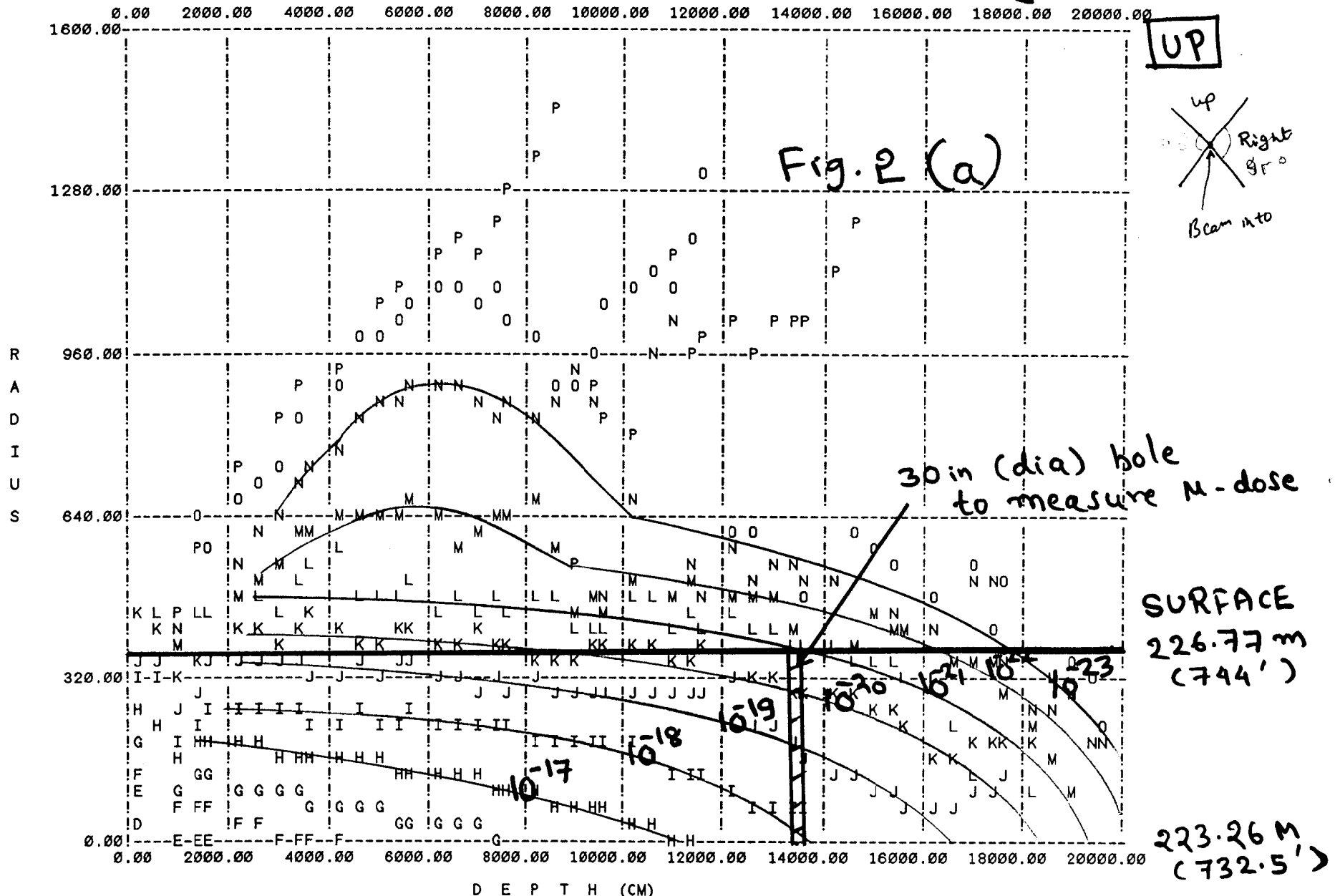
Editing modes
Eps Object
Scale
Align
Move
Copy
Delete
Update
Edit
Rotate
Rotate
in
Pbar Beam Dump (Geometry)
Fig. 1
350.5cm
Surface Elevation (744')
232cm
20cm
1.5cm
(732.5')
0
Cu
Iron
Iron
Target
Li lens
Bending Magnet
Iron
Vacuum
Carbon
16 cm
Beam Dump
Y
Z
X
0
7
18
33
93
184
347
382
689
888
Zoom Scale 1
Grid Mode NONE
Point Posn
Depth 0
Angle Geom
Fill Style NONE
Color Default
Line Width
Line Style
Arrow Mode

Pbc Beam Dump
MUSIM (with magnetic field)

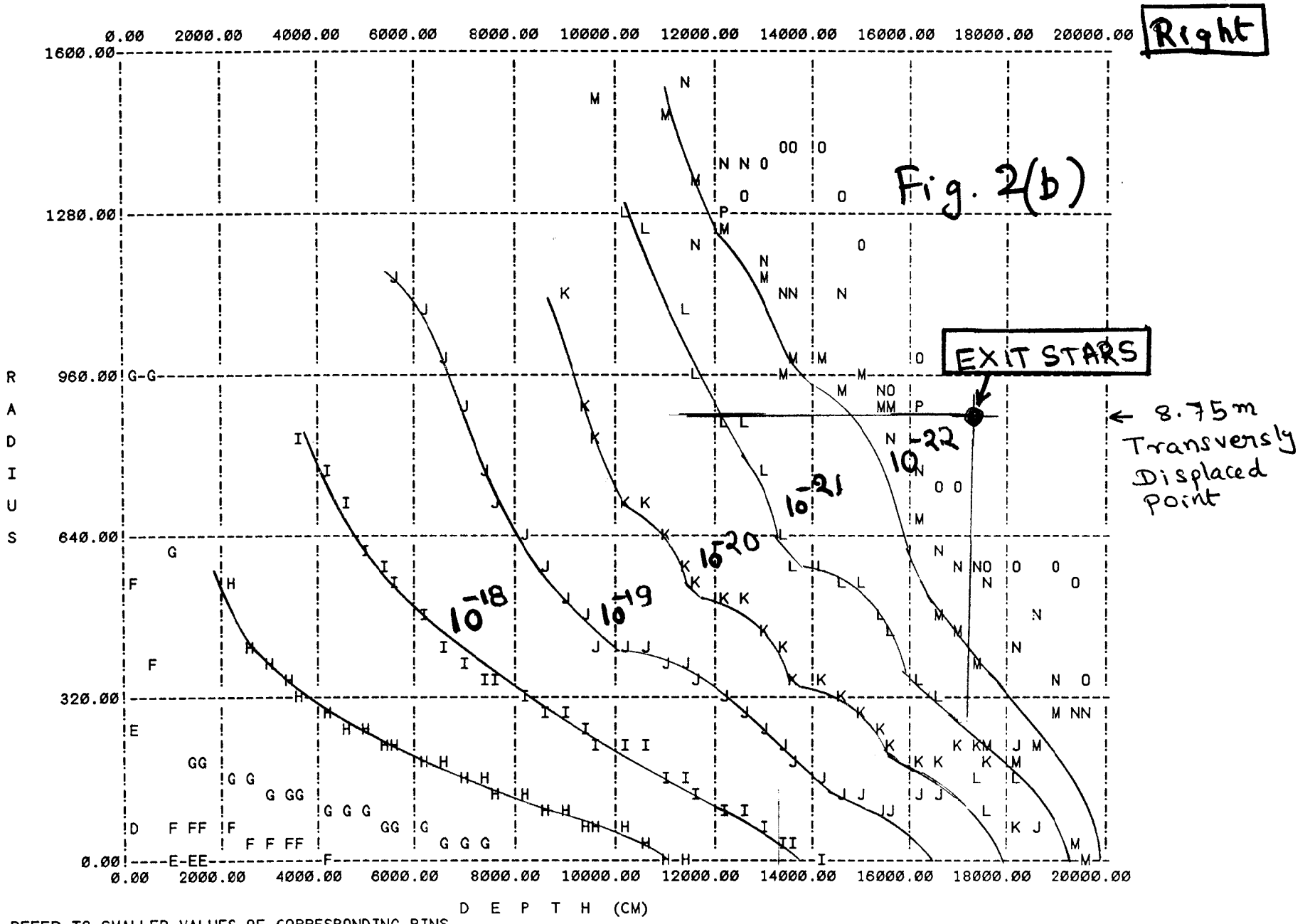


R-LABELS REFER TO SMALLER VALUES OF CORRESPONDING BINS
LEGEND : NUMERICAL SYMBOLS REFER TO THE NEGATIVE POWER OF 10 OF THE STAR(ENERGY) DENSITY E.G., 5 REFERS TO THE 10**-5 CONTOUR
OTHER POWERS OF 10(SYMBOLS) :-10(A),-11(B),-12(C),-13(D),-14(E),-15(F),-16(G),-17(H),-18(I),-19(J),-20(K),-21(L),-22(M)
-23(N),-24(O),-25(P) 1(Z),2(Y),3(X),4(W),5(V),6(U),7(T),8(S),9(R),10(Q)
1CONTOURS OF EQUAL ABSORBED DOSE (RAD/INC.PTCLE) FOR REGION No. = 4
CONTOURS ARE SHOWN FOR INTEGRAL POWERS OF 10

0.00 2000.00 4000.00 6000.00 8000.00 10000.00 12000.00 14000.00 16000.00 18000.00 20000.00

P bar Beam Dump
with Magnetic fields

1CONTOURS OF EQUAL ABSORBED DOSE (RAD/INC.PTCLE) FOR REGION No. = 1
CONTOURS ARE SHOWN FOR INTEGRAL POWERS OF 10



R-LABELS REFER TO SMALLER VALUES OF CORRESPONDING BINS
LEGEND : NUMERICAL SYMBOLS REFER TO THE NEGATIVE POWER OF 10 OF THE STAR(ENERGY) DENSITY E.G., 5 REFERS TO THE 10**-5 CONTOUR
OTHER POWERS OF 10(SYMBOLS) :-10(A),-11(B),-12(C),-13(D),-14(E),-15(F),-16(G),-17(H),-18(I),-19(J),-20(K),-21(L),-22(M)
-23(N),-24(O),-25(P) 1(Z),2(Y),3(X),4(W),5(V),6(U),7(T),8(S),9(R),10(Q)

1CONTOURS OF EQUAL ABSORBED DOSE (RAD/INC.PTCLE) FOR REGION No. = 2
CONTOURS ARE SHOWN FOR INTEGRAL POWERS OF 10

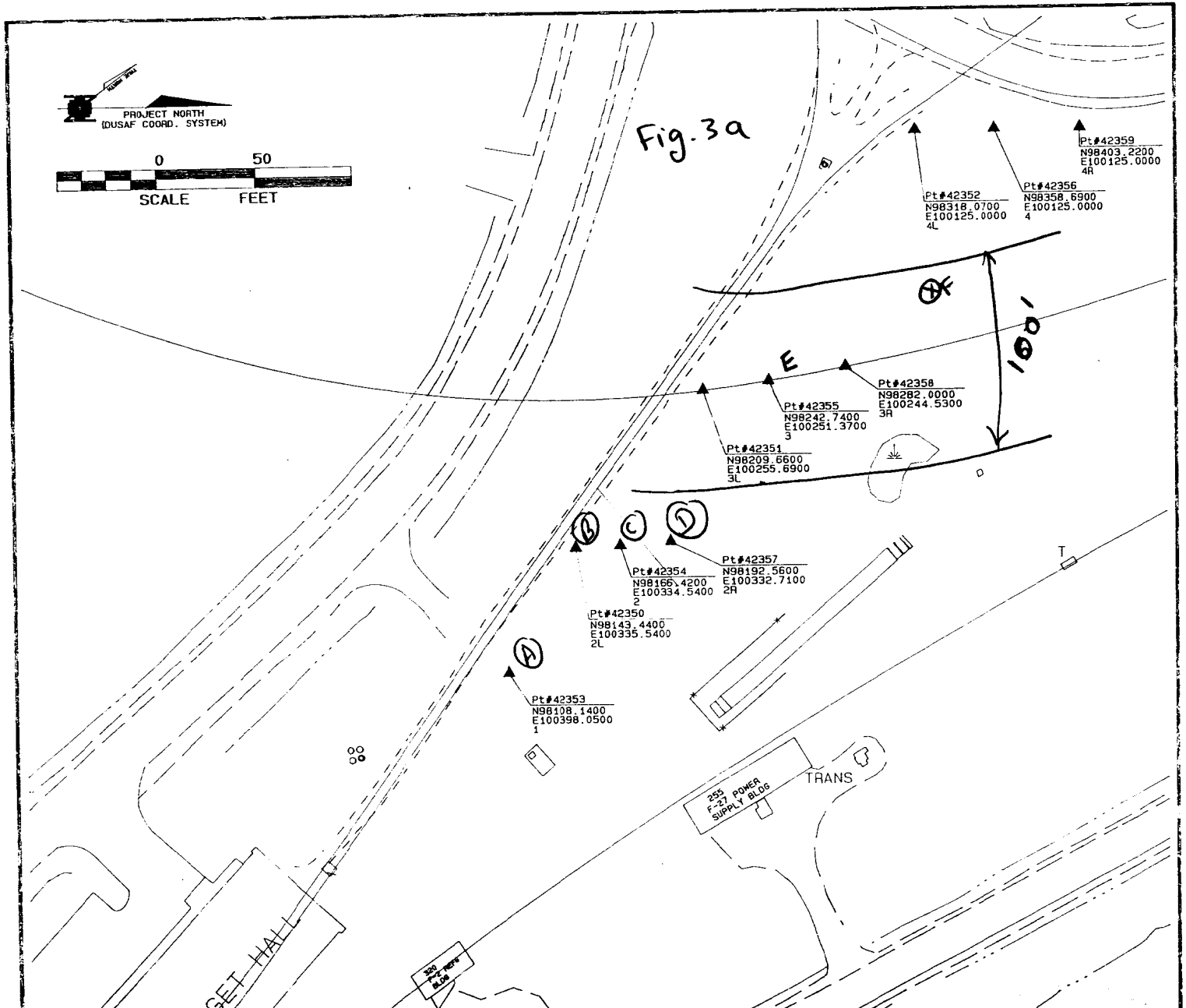
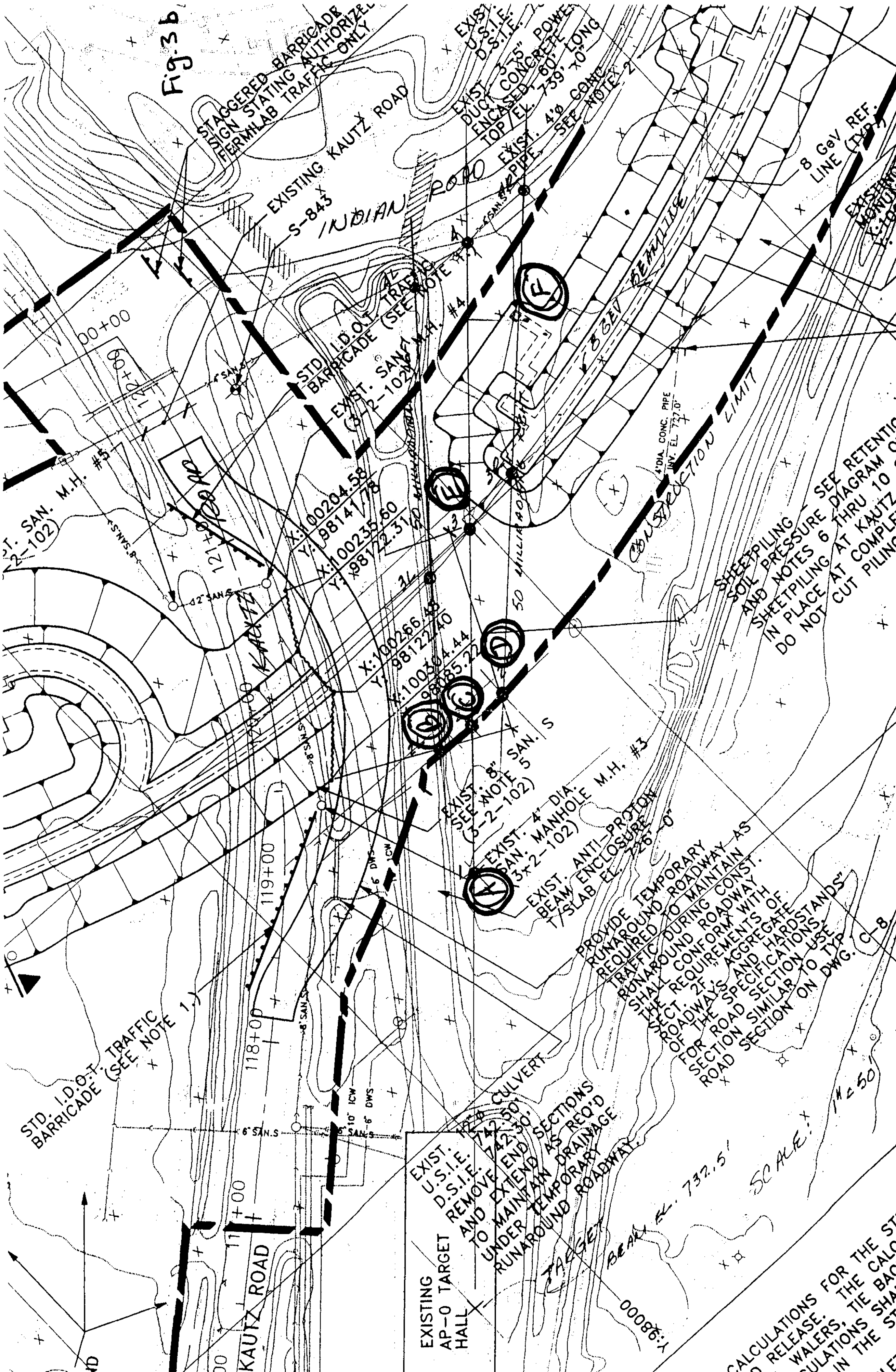


Fig. 3a
PROJECT NORTH
(USAF COORD. SYSTEM)
0
50
SCALE
FEET
Pt#42359
N98403.2200
E100125.0000
4R
Pt#42352
N98318.0700
E100125.0000
4L
Pt#42356
N98358.6900
E100125.0000
4
E
Pt#42358
N98282.0000
E100244.5300
3R
Pt#42355
N98242.7400
E100251.3700
3
Pt#42351
N98209.6600
E100255.6900
3L
100'
Pt#42357
N98192.5600
E100332.7100
2R
Pt#42354
N98166.4200
E100334.5400
2
Pt#42350
N98143.4400
E100335.5400
2L
Pt#42353
N98108.1400
E100398.0500
1
T
TRANS
255
F-27 POWER
SUPPLY BLDG
GET HALL

Fig. 3b


STAGGERED BARRICADE SIGN STATING AUTHORIZED FERMILAB TRAFFIC ONLY
EXISTING KAUTZ ROAD
S-843
INDIAN ROAD
EXIST. U.S.I.E. D.S.I.E.
EXIST. 3-5" POWER DUCT CONCRETE ENCASED, 60' LONG TOP EL. 739' ±0"
EXIST. 4'Ø CONC. PIPE. SEE NOTE 2
8 GeV REF. LINE (TYP.)
8 GEV BEAMLINE
STD. I.D.O.T. TRAFFIC BARRICADE (SEE NOTE 1.)
EXIST. SAN. M.H. #4 (3-2-102)
00+00
122+00
121+00
120+00
119+00
118+00
117+00
EXIST. SAN. M.H. #5 (3-2-102)
KAUTZ
X: 100204.58 Y: 98141.78
X: 100235.60 Y: 98122.31
X: 100266.46 Y: 98122.40
X: 100304.44 Y: 98085.22
F
E
D
C
B
A
50 MILLIAMOS
4'DIA. CONC. PIPE INV. EL. 727.0'
CONSTRUCTION LIMIT
SHEETPILING SEE RETENTION SOIL PRESSURE DIAGRAM AND NOTES 6 THRU 10 SHEETPILING AT KAUTZ IN PLACE AT COMPLETION DO NOT CUT PILING
EXIST. 8" SAN. S SEE NOTE 5 (3-2-102)
EXIST. 4' DIA. SAN. MANHOLE M.H. #3 (3-2-102)
EXIST. ANTI-PROTON BEAM ENCLOSURE T/SLAB EL. 726'-0"
PROVIDE TEMPORARY RUNAROUND ROADWAY AS REQUIRED TO MAINTAIN TRAFFIC DURING CONST. RUNAROUND ROADWAY SHALL CONFORM WITH THE REQUIREMENTS OF SECT. 2F AGGREGATE ROADWAYS AND HARDSTANDS OF THE SPECIFICATIONS. FOR ROAD SECTION USE SECTION SIMILAR TO TYP. ROAD SECTION ON DWG. C-8
STD. I.D.O.T. TRAFFIC BARRICADE (SEE NOTE 1.)
EXIST. 42"Ø CULVERT U.S.I.E. 742.50 D.S.I.E. 742.30 REMOVE END SECTIONS AND EXTEND AS REQ'D TO MAINTAIN DRAINAGE UNDER TEMPORARY RUNAROUND ROADWAY.
6" SAN.S
8" SAN.S
12" SAN.S
6" DWS
10" ICW
EXISTING AP-0 TARGET HALL
KAUTZ ROAD
TARGET
BEAM EL. 732.51
SCALE: 1" = 50'
Y: 98000
CALCULATIONS FOR THE ST... RELEASE. THE CALC... WALERS, TIE BAC... CULATIONS SHA... IN THE ST...

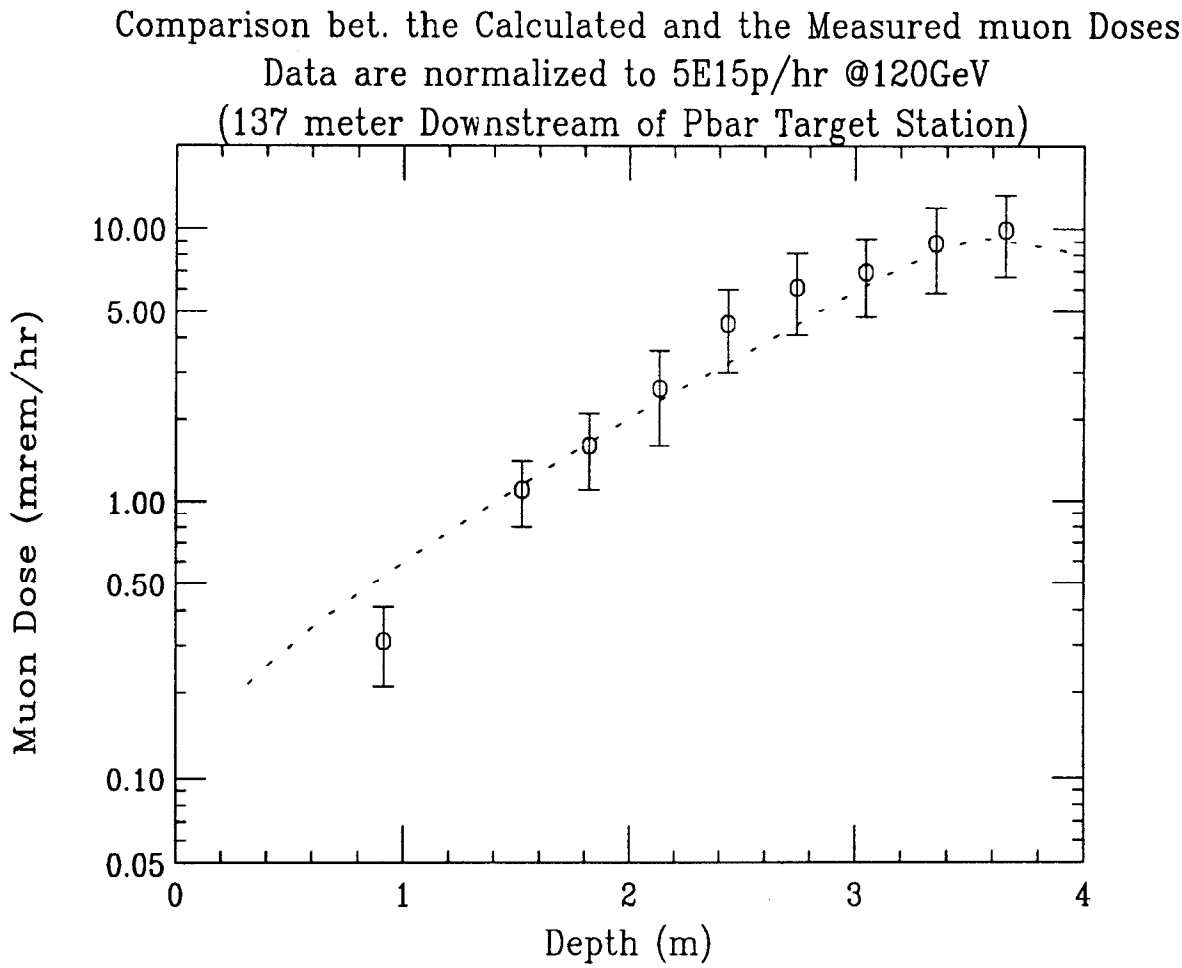


Figure 4: The dashed curve is obtained from a Monte Carlo calculations using MUSIM. The data are from A. Leveling. The error bars are drawn by assuming about 30 % systematic error. The statistical error are negligible.

Appendix:

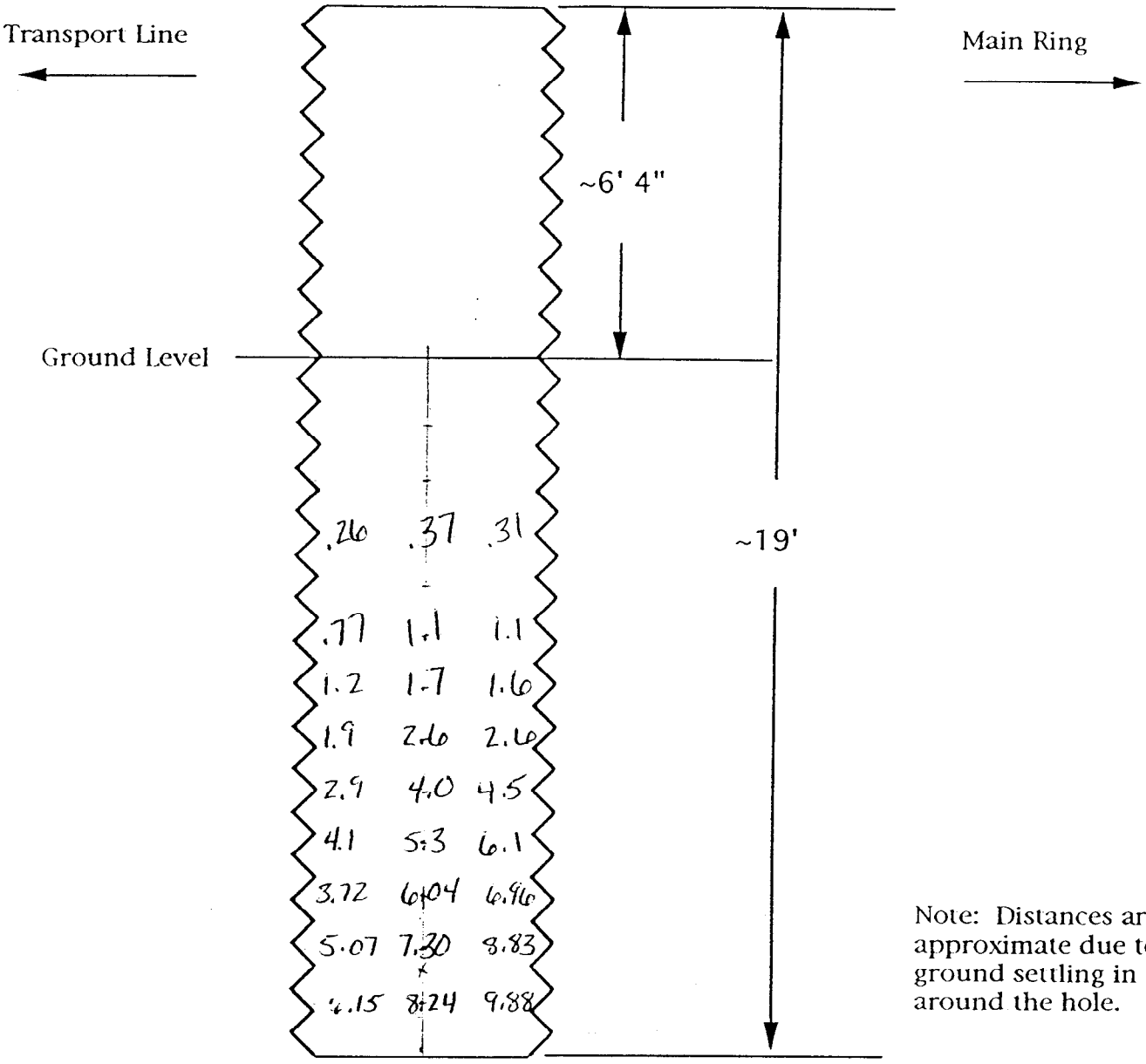
Recently Tony Leveling has measured the μ-dose level (a memo dated 6/23/95 "AP0 muon Survey") during the pbar stacking at location "E" which is about 137 m down stream of the pbar target (see Fig. 3). A 30 in dia 12 ft deep hole is digged in the ground. Using a muon detector the dose rate is measured for five minute duration at different elevations from 3 ft to 12 ft depth. The experiment is repeated several times. The average dose is determined after normalizing the data to 5E15p/hr on the target. The Fig. 4 gives a comparison between the measured data with the calculated results presented here. There is an excellant agreement between the predictions and the measured data. The error on the muon data is assumed to be about 30%. (note that the number of 120 GeV protons per pulse on the pbar target here are different from the one used in Table I)

Fermilab
ACCELERATOR DIVISION

From: T. Leveling

PURPOSE: Transport Line Muon Hole Summary
DATE/TIME: 6/1, 6/7, 6/14/95

Transport Line Muon Hole



Note: Distances are approximate due to ground settling in and around the hole.

SURVEYOR: Ferguson, Busch, White, Leuten
INSTRUMENT/SERIAL NUMBER: chipmunk #157 & #165
BATTERY CHECK(SAT/UNSAT): N/A
SOURCE CHECK(SAT/UNSAT): N/A
DATE CALIBRATED: 11/9/94 8/24/94

LEGEND
[#] - Chamber Center

HIGHEST DOSERATE FOUND: 9.88 mr/hr

REVIEWED BY: J Leuten 6/16/95
SIGNATURE/DATE

CREATED 6/1/95