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Brookhaven National Laboratory

MEMORANDUM

DETECTOR RHIC GROUP

Date: 06/06/95

To: A. Etkin, S. Musolino

From: A.J. Stevens AJS

Subj.: Cable Penetrations in the 6 O'clock Backwall

The STAR detector is required to have 6 12" diameter penetrations through the backwall of the hall through which cables will pass. This memorandum makes rough estimates of the dose equivalent at the exits of these penetrations as a function of their elevation location.

A recent CASIM calculation[1] showed that the side walls of the main shield wall act to shield the backwall. The accompanying Figs. 1 and 2 are from Ref. [1]. The maximum star density at the exit of the 3 ft. thick backwall in Fig. 2 is 5×10^{-10} (in units of stars/cc-p. which will not be repeated), significantly lower than the 1.85×10^{-9} at the rear of the (thicker) main shield wall. This is because the side walls of the shielding "protect" the backwall which can be seen from the geometry shown in Fig. 1. However, the geometry in Fig. 1 only extends to an elevation of about 9m. An elevation view is shown in Fig. 3. Two illustrative locations for the penetrations are shown in this figure. The first location examined is the lower "protected" location shown in this figure.

At the low position shown, the star density at the front of the backwall (from the calculations performed related to Ref. [1]) is conservatively[2] taken to be 3.4×10^{-9}. This gives a dose equivalent of 700 mrem at 4 times design intensity.[3]

The excess dose equivalent caused by the holes is the sum of two parts, dose coming directly through the holes and punch-through. A recent MCNP calculation[4] for two 10 inch radius holes in a 4 ft. long wall gave an attenuation for the direct component of .082. In the *absence* of MCNP calculations we have (recently at least) used the first leg labyrinth attenuation of Goebel:

$$H=\frac{1}{1+2.5\sqrt{d}+0.17d^{1.7}+0.79d^{3}}$$

where d is the length in units of the square root of the area. Plugging the MCNP result into this formula gives a (single) hole radius of 13 inches. I view this result as sufficient justification to multiply the single STAR penetration radius (6") by $\sqrt{6}$ and use the formula above. The attenuation turns out to be 0.16. Following the procedure of Gollon, who assumes 80% of the entrance dose as a source term for penetration calculations, we arrive at an excess direct dose of 560 mrem $\times$ 0.16 = 90 mrem.

To obtain the punch through contribution the DOSEXIT program[5] was used with the result that 80 mrem is obtained.

Now the total excess of 170 mrem assumes empty holes. Clearly the holes will be packed to eliminate open space as much as possible. Assuming a factor of 2 reduction should be conservative. The total estimated excess of 85 mrem must be added to the no-hole dose. From the first paragraph above this is obtained from the star density of 5×10^{-10} which translates to 103 mrem. The total of about 200 mrem is well below the high occupancy 500 mrem requirement.

In the higher position shown in Fig. 3, the correct entrance dose is not entirely clear. The highest penetrations in the figure have line of sight to the DX magnet which is the beam loss location. For these, the original formula which served as the basis for design of the shield wall can be used. At 4 times the design intensity this formula is:

$$rem / fault = 1640 \times \frac{e^{-d/.502}}{R^2}$$

where R is the transverse radius and d the (light concrete) wall thickness, both in meters. In the spirit of being conservative, this formula can be used for all the holes. At the front of the backwall, the value of R to the center of the array shown in the upper location of Fig. 3 is about 19.3m. The entrance dose (d = 0 in the above) becomes 4.4 rem instead of the 0.7 rem in the protected geometry. The remainder of the algebra will not be repeated. The components turn out to be (1) no hole - 440 mrem, (2) direct - 280 mrem, punch through - 140 mrem, for a total of 860 mrem. As in the protected geometry version, the calculated excess dose has been divided by 2 to take credit for plugging the holes.

These estimates could be improved by explicit MCNP calculations, but the dominant uncertainty of the source term would remain. Placement of the penetrations at an elevation close to the protected one would clearly be desirable.

References/Footnotes

1. Memorandum from A.J. Stevens to W. Christie dated 05/05/95.

2. From Fig. 2 the dose is changing rapidly as a function of the Z (beam direction) coordinate. The maximum entrance star density rather than the estimate at the location shown in Fig. 3 is taken to be conservative.

3. The usual assumptions are made that the star density to dose equivalent conversion is multiplied by 2 and that the design basis fault is half the beam interacting on the DX magnet in a scraping geometry.

4. Memorandum from A.J. Stevens and J.R. Preisig to S. Musolino dated 02/08/95.

5. J.R. Preisig and A.J. Stevens, "Estimation of Neutron Punch-Through in Circular Shielding Penetrations," AD/RHIC/RD-81, 1994.

cc:

Ralph Brown
Bill Christie
Jim Mills

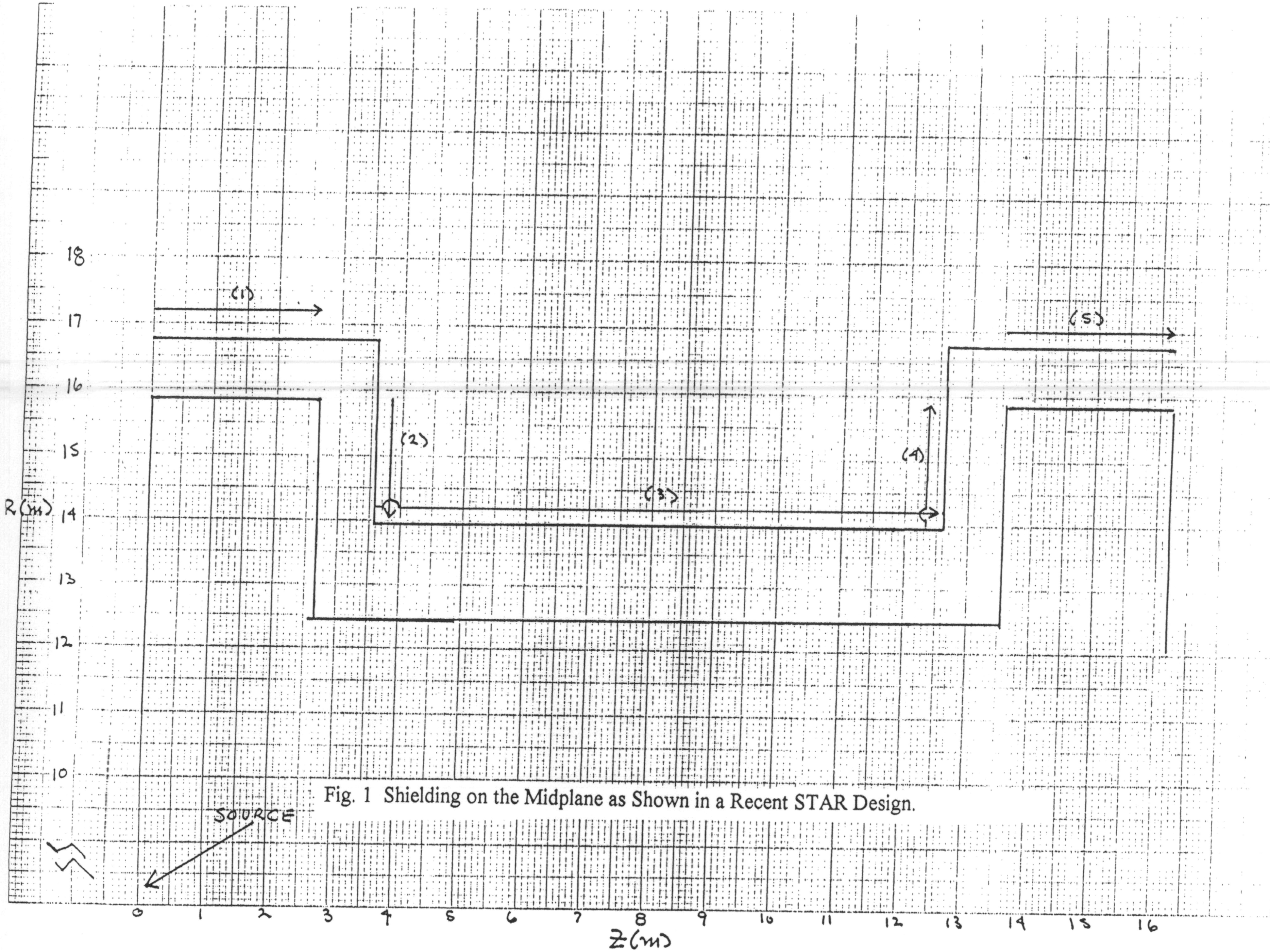

Fig. 1 Shielding on the Midplane as Shown in a Recent STAR Design.

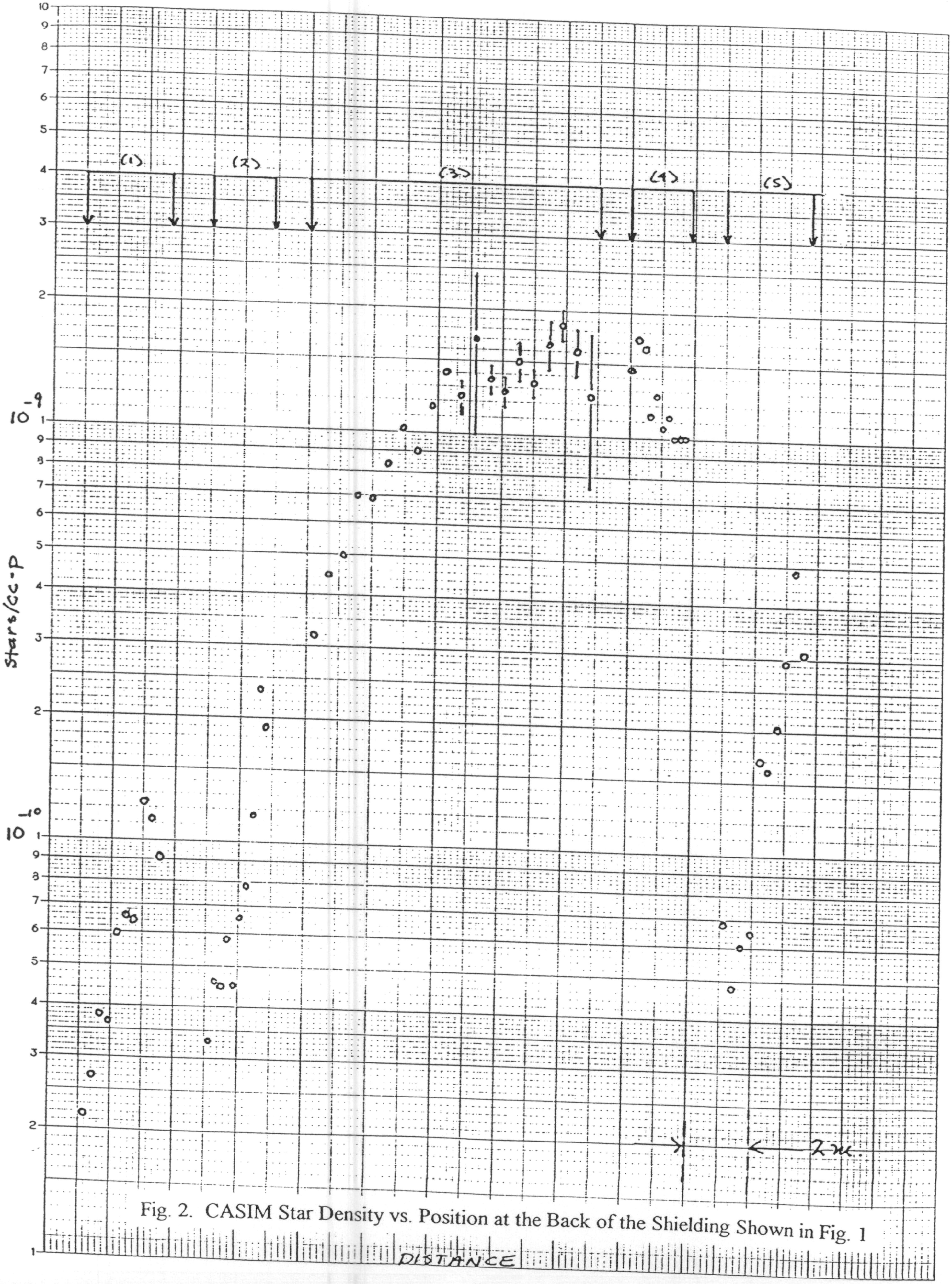

Fig. 2. CASIM Star Density vs. Position at the Back of the Shielding Shown in Fig. 1

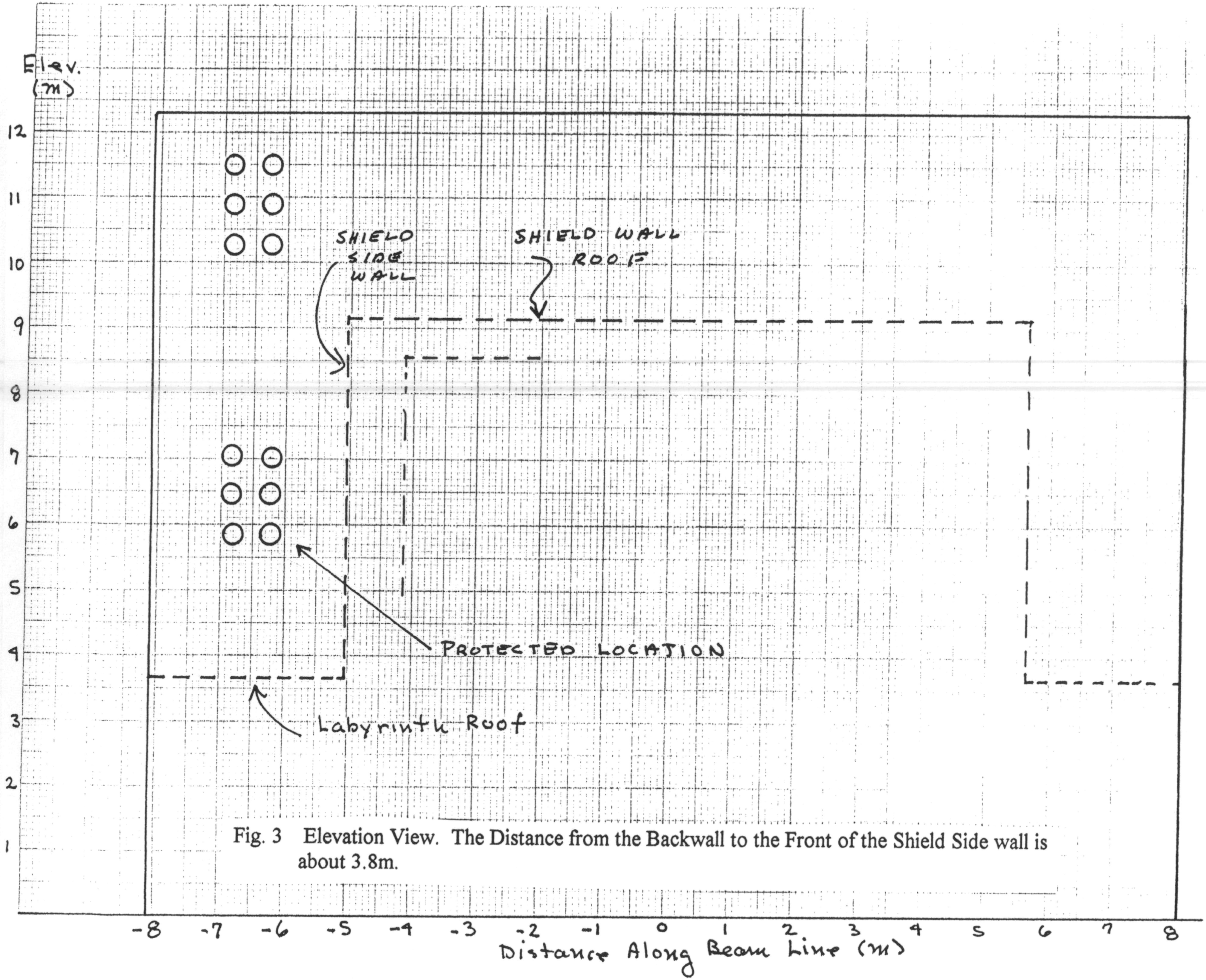

Fig. 3 Elevation View. The Distance from the Backwall to the Front of the Shield Side wall is about 3.8m.