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Neutron and Photon Fluxes at SSC Electronics Racks in Niches

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We have run some simple calculations which may help you understand your shielding problem. It is assumed that there are two line sources of neutrons located on the axes of the two magnets. Each has an intensity of one neutron per centimeter and has an initial isotropic distribution. The spectra is the same as used in the previous calculations and is illustrated in Fig. 1. Several cases were run to illustrate various effects.

The first case assumes that the two line sources are located in a huge void. The detector is positioned at a height midway between the two line sources and at a distance from them equal to the distance, in the real case, from the magnets to the center of the shielded volume. For a given distance, this height yields the maximum flux. The solution to this case is analytic but the Monte Carlo Code CDG was employed just to test the problem set-up. The results are indicated in Table 1.

Case two takes the same positions as case one but puts them into a tunnel-niche configuration. The tunnel walls are assumed to be pure absorbers—i.e., any neutron which hits them disappears from the calculation. Figs. 2 through 5 illustrate the assumed tunnel configuration. The various regions illustrated on these figures are assigned different materials to simulate the problem cases being considered. (We may have misunderstood the cross section at points away from the niche. I don't think that this will matter much.) The effect of case two is to illustrate the attenuation caused by the tunnel geometry.

The tunnel walls were next changed from the previous pure absorbing material to the rock dolomite. The dolomite was considered to have a composition of:

Ca	0.728 gm/cc
Mg	0.442 gm/cc
C	0.436 gm/cc
O	1.747 gm/cc

and to this we added 0.0335 gm/cc of water (1% by weight) to represent some dampness. In this problem we also follow the photons made from the neutron reactions since their transport properties are different from the neutrons. This problem is labeled as case number three and illustrates what you would obtain with no shielding around the electronics.

Case four is identical to that just described except that we now calculate the average flux within the lower six feet of the shielded volume instead of that at a single point within this volume. Remember, at this time, the shielded volume is not shielded.

Case five adds half of the shield. This was done by adding the concrete at only half its real density but keeping the shield walls where you specified. The concrete is the same ORNL composition as we used the last time around.

Case six has full density concrete.

Note that we have inset the concrete door rather than have it stand outside of the remaining concrete wall. When you design the shield itself, you will probably have a 'stepped' door so there is no crack through the shield. You will also want to insure that no one drills holes directly through the shield walls without having a bend in them. But that amount of detail will come much later. The composition of the concrete used for the shield is important and can be varied to obtain much better attenuation than indicated here. This will depend upon your electronics' response to neutrons and gammas, the cost of special concrete, radiation that was not considered in this work, and the availability of physical space. Reactor Experiments, Inc., of San Carlos, CA, specializes in shielding materials and probably can give you a lot of valuable advice. I have never done business with them but their literature has been valuable to us and may be to you.

We have included the energy deposition in SiO_2 in Table 2 because it may be a better indication of the damage that your electronics will undergo than the neutron flux. The flux figure can easily be dominated by thermal (room temperature) neutrons. In real practice, these lower energy neutrons can easily be attenuated by simple materials like boron encased in aluminum ("boral"). Very sensitive components can probably best be shielded with local shielding which has a smaller volume and, consequently, a smaller dollar expenditure.

Somewhere down the line you will also want to consider the activation of rock, magnets, support structure, and the concrete. This may not be important but the present trend is to have almost zero doses to workers in radiation areas.

Table 1

Results of calculations (neutron and photon flux).

	Neutrons/cm^2		Photon MeV/cm^2	
Case 1	2.40×10^{-3}	(0.001)*	—	
Case 2	1.94×10^{-3}	(0.002)	—	
Case 3	1.20×10^{-2}	(0.04)	6.19×10^{-4}	(0.17)
Case 4	1.30×10^{-2}	(0.12)	7.79×10^{-5}	(0.26)
Case 5	6.18×10^{-4}	(0.08)	1.11×10^{-4}	(0.11)
Case 6	2.61×10^{-5}	(0.35)	1.40×10^{-5}	(0.35)

Table 2

Results of calculations (neutron and photon energy deposition in SiO_2).

	Neutrons (MeV/gm)		Photons (MeV/gm)		Total (MeV/gm)	
Case 1	6.13×10^{-5}	(0.008)*	—		6.13×10^{-5}	(0.008)
Case 2	5.01×10^{-5}	(0.012)	—		5.01×10^{-5}	(0.012)
Case 3	5.96×10^{-5}	(0.04)	1.39×10^{-5}	(0.16)	7.35×10^{-5}	(0.05)
Case 4	5.99×10^{-5}	(0.04)	1.76×10^{-5}	(0.23)	7.75×10^{-5}	(0.06)
Case 5	3.01×10^{-6}	(0.07)	2.49×10^{-6}	(0.11)	5.50×10^{-6}	(0.06)
Case 6	1.56×10^{-7}	(0.25)	3.36×10^{-7}	(0.34)	4.91×10^{-7}	(0.25)

* Fractional standard deviation: one standard deviation divided by the calculated quantity.

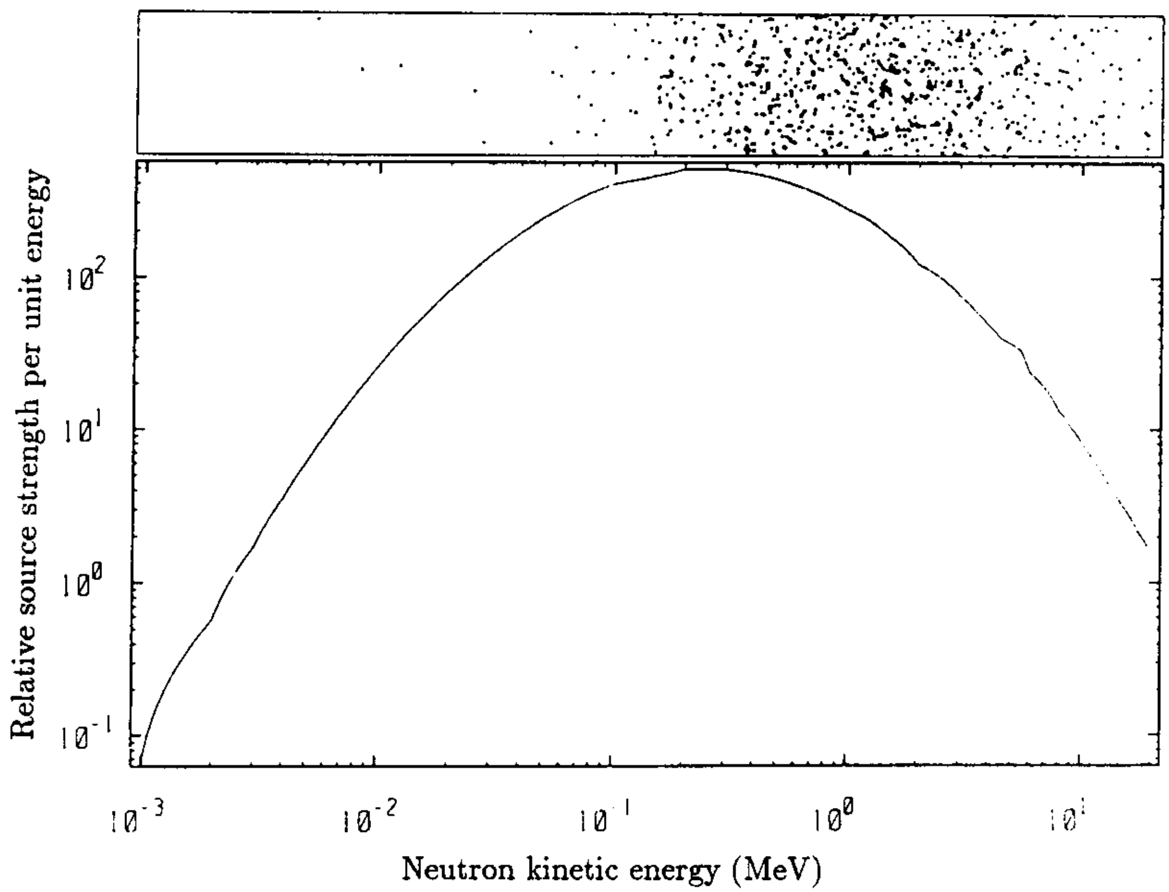

FIG. 1. Source neutron spectra. Note that dN/dE rather than the usual $E\,dN/dE$ is plotted, so that the most probable energy is really about 1 MeV. The box at top shows the points chosen by the Monte Carlo program.

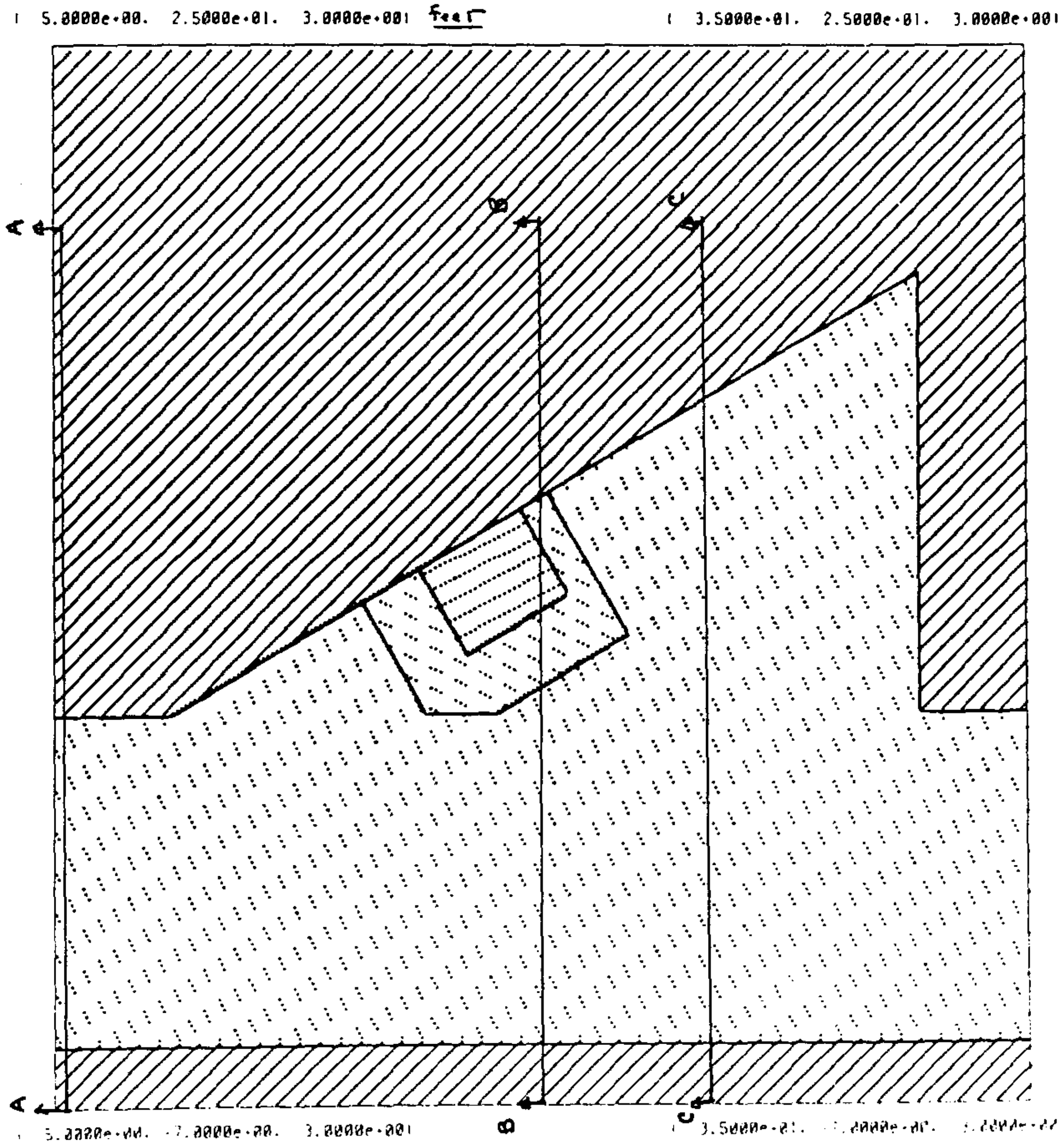

FIG. 2. x-y geometry layout.

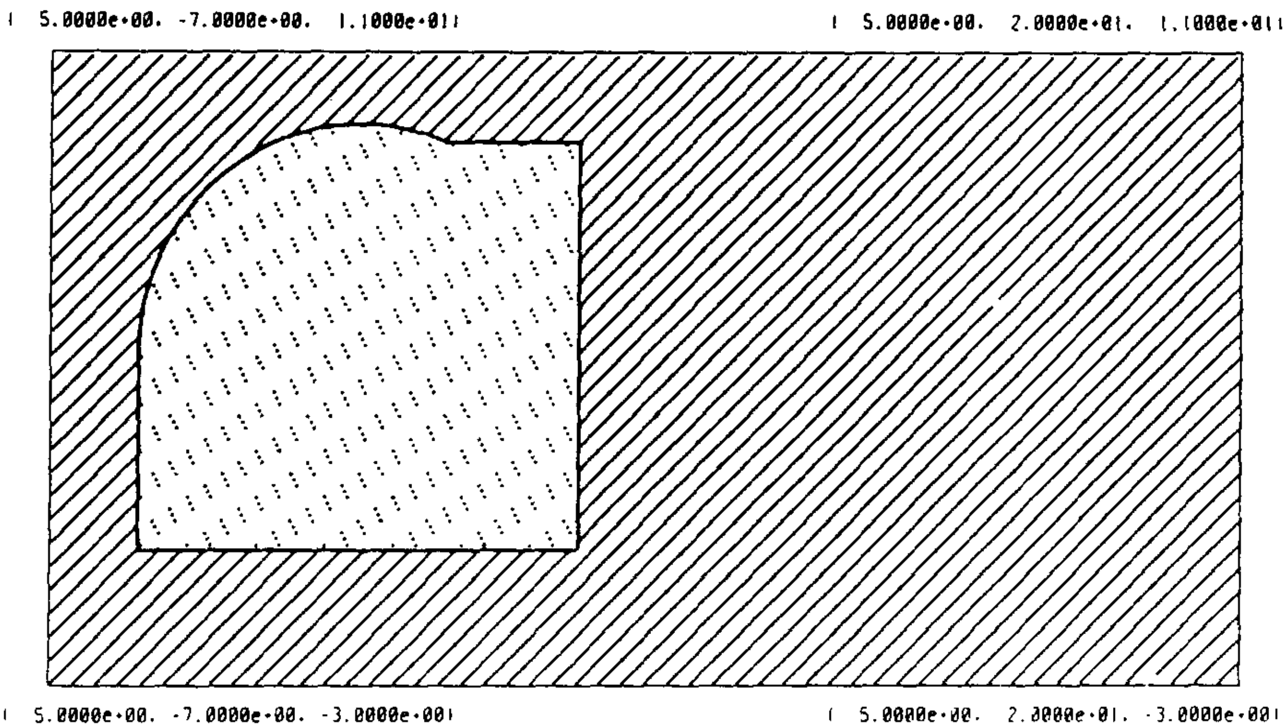

FIG. 3. y-z geometry layout; section A-A.

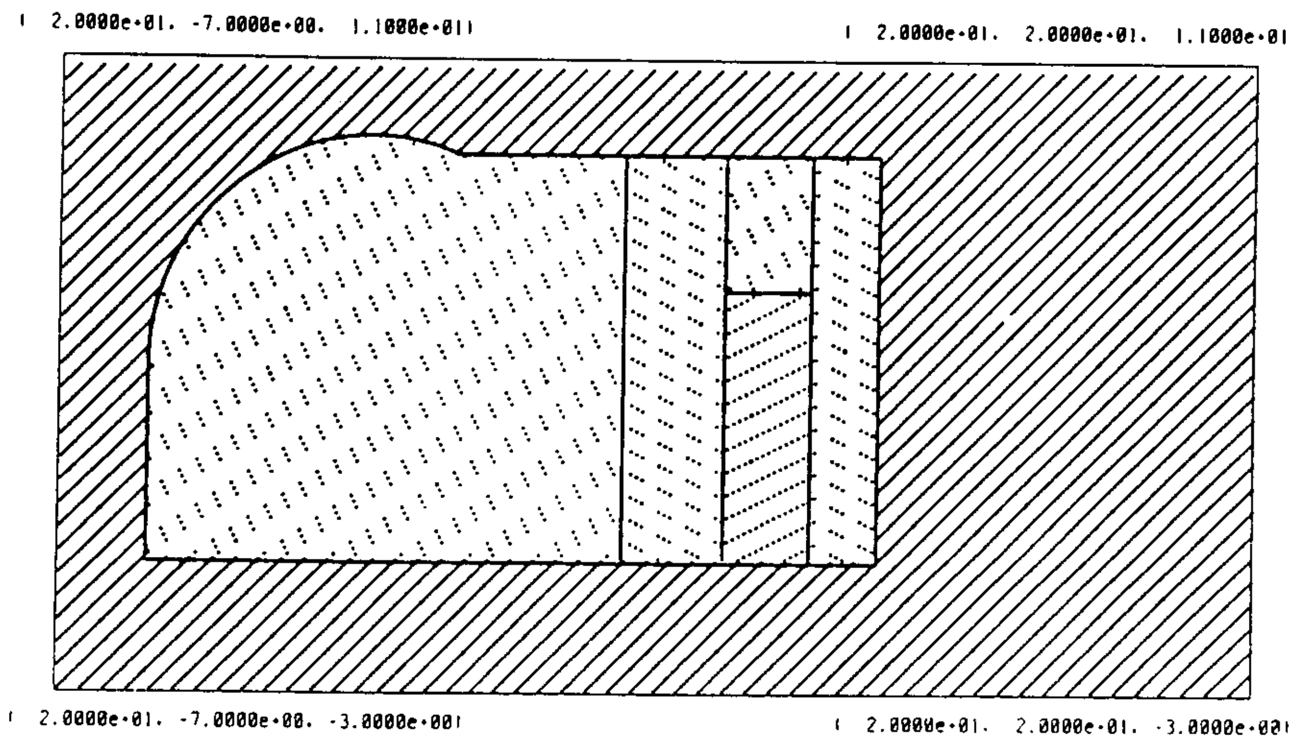

FIG. 4. y-z geometry layout; section B-B.

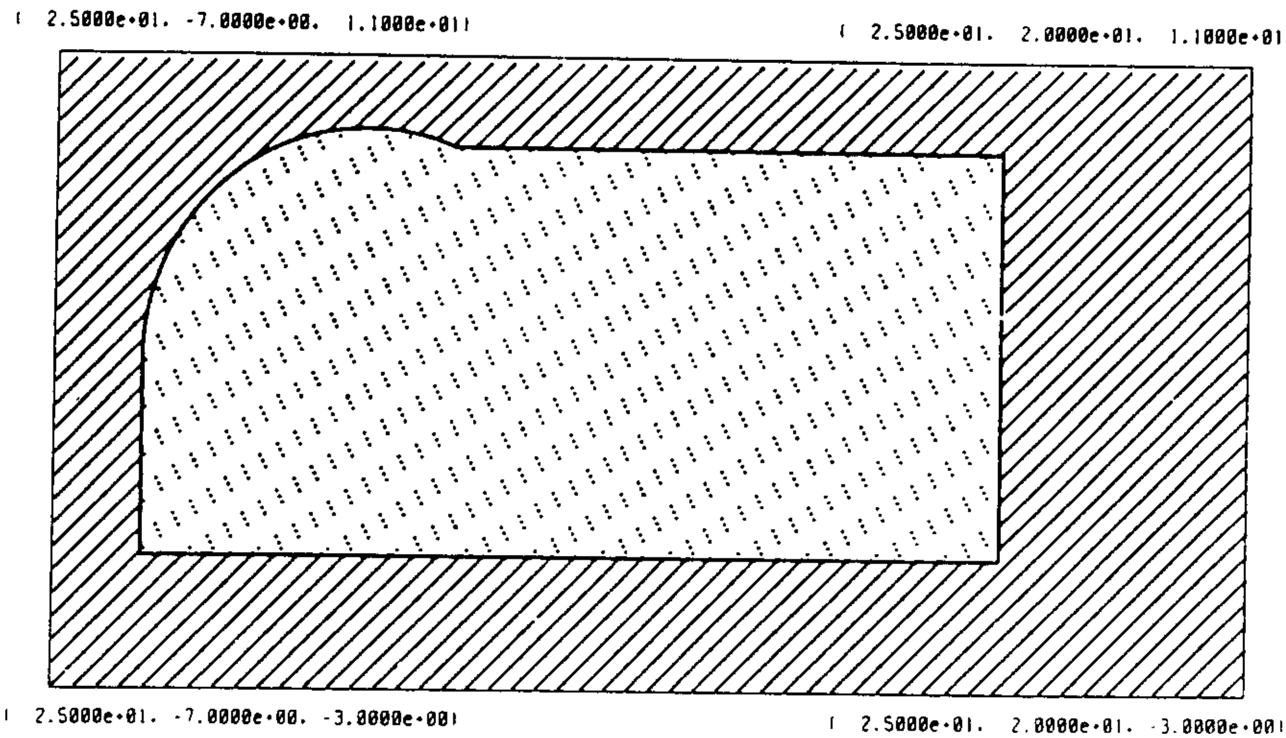

FIG. 5. *y-z* geometry layout; section C-C.