LA-UR- 96-3453

CONF-970134--10

Title:

AN 800 MEV PROTON BEAM SPILL CALCULATION

Author(s):

Hsiao-Hua Hsu, ESH-4
M. A. Duran, ESH-1
L. S. Walker, ESH-1

RECEIVED

OCT 30 1996

OSTI

MASTER

Submitted to:

Health Physics of Radiation Generating Machines
30th Midyear Topical Meeting of the Health Physics
Society, San Jose, CA, January 5-8, 1997

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the U.S. Department of Energy under contract W-7405-ENG-36. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. The Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy.

Form No. 836 R5
ST 2629 10/91

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

um

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

**Portions of this document may be illegible
in electronic image products. Images are
produced from the best available original
document.**

An 800-MeV Proton Beam Spill Calculation

Hsiao-Hua Hsu, Michael A. Duran, and L. Scott Walker

Los Alamos National Laboratory

Los Alamos, NM 87545

RECEIVED

OCT 30 1996

OSTI

Abstract

Using LAHET, the Los Alamos High-Energy Transport code, we calculated the radiation hazard from an 800-MeV proton beam spill at the bending magnet. Neutron doses were calculated at an area above the 84.0-cm-thick concrete roof, where there existed a gap with only 30.48-cm concrete shielding. We also studied the effect of the gap and proposed a corrective action.

Introduction

In the fall of 1997, the Los Alamos National Laboratory Manuel Lujan Neutron Scattering Center (MLNSCE) is planning an intensity upgrade (800-MeV, 150- μ A proton beam on target). The 800-MeV proton beam at MLNSCE travels diagonally across and about 1.0 m below a corner section of the extraction opening. During a recent on-site evaluation of the 84.0-cm-thick concrete roof, we found a gap to the roof opening 7.62-cm wide with only 30.48-cm of concrete shielding above the proton beam. This raised a question concerning the adequacy, in case of an accidental beam spill, of the present shielding for the upgrade.

The radiation protection team at MLNSCE was given the following tasks:

- Calculate the neutron spectrum, flux, and dose rate above the roof top;
- Study the effect of the gap; and
- Provide any corrective action if needed.

Monte Carlo Calculation and Results

We performed calculations in two steps, using the Monte Carlo transport code, Los Alamos High Energy Transport (LAHET) (Prael; Lichtenstein 1989). First, we calculated the neutron spectrum produced by 800-MeV proton beam incident on a 20.32-cm-thick iron block. The spectrum, tallied at 1.0-m radius spherical surface, is shown in Fig. 1.

The energy cut off for LAHET neutron transport is 0.1 MeV. In the second step, we used a point neutron source, with the spectrum calculated as in step 1 but placed at 1.0 m from the bottom surface of a cylindrical concrete block. To simulate the room's roof, we used a concrete block with a 75.0-cm radius and 213.36-cm thickness. Neutrons were transported through the block and the neutron spectrum was tallied over the top surface. Calculations were performed with three block configurations:

- Case 1— a solid concrete block;
- Case 2—a 7.62-cm-wide air gap in the middle of the block, with the bottom 30.48-cm gap filled by concrete; and
- Case 3—the same air gap described in case 2 filled with soil.

In these calculations, we used concrete and soil that complied with American National Standards Institute standards.

Neutron spectra over the rooftop surface for these three cases are shown in Fig. 2. All three spectra have a similar shape. We calculated neutron doses by folding these spectra with the fluence-to-dose conversion function (Fig. 3 [Stevenson 1986; Siebert, Schuhmacher 1995]). The results are:

- Case 1— (solid concrete) 60 Sv/sec/150 μ A of proton beam.
- Case 2—(with air gap) 120 Sv/sec/150 μ A of proton beam.
- Case 3— (gap filled with soil) 63 Sv/sec/150 μ A of proton beam.

The gap in the concrete increases neutron dose by a factor of 2. We can reduce the dose by filling the gap with soil, as demonstrated in case 3.

Discussion

In this study, we greatly simplified real case conditions, using the following assumptions and effects to the dose calculations:

- **Replace the bending magnet with a 20.32-cm iron block.** The thickness of the iron block has a small effect upon the neutron spectra but changes the neutron flux. In a separate study, we found that the flux difference between a 30.48-cm and 60.96-cm-iron block was about 3%, mostly in the lower energy range.
- **Neglect the scattering of neutrons from the surrounding materials by using a concrete block only in neutron transport.** The scattered neutrons are mostly of lower energy and make a smaller contribution to neutron dose.

- **Use a concrete block much smaller than the roof itself.** Our calculations show that many neutrons escaped from the side surface. A larger block will increase number of lower energy neutrons over our tally surface (top cylinder surface). However, the calculated doses were average values over the surface; a larger block with more lower energy neutron may not significantly change the dose values.
- **Place the point source right below the gap.** If we move the source away from the gap, the neutron incident occurs at an oblique angle and the effect of the air gap will decrease.
- **Test the real case (the proton beam travels parallel to the roof).** The neutron produced in the direction toward the roof has a softer spectrum than the one we used in dose calculations. The softer spectrum will produce lower doses.

The simple cases we present in this paper show how the effects of neutron flux and spectrum may compensate each other to yield the reasonable results presented here.

Conclusion

From this simple study, we conclude that under some conditions, the gap in shielding material may increase neutron dose at points outside the shielding by up to a factor of 2. This problem can easily be fixed by filling the gap with a simple material such as soil.

References

- Prael, R. E.; Lichtenstein, H. The LAHET code system. Los Alamos National Laboratory; LA-UR-89-3014; 1989.
- Siebert, B. R. L; Schuhmacher, H. Quality factors, ambient and personal dose equivalent for neutrons, based on the new ICRU-stopping power data for protons and alpha particles. Rad. Prot. Dosi. 58:177-183; 1995.
- Stevenson, G. R. Dose equivalent per star in Hadron Cascade Calculations. CERN report TIS-RP/173; 1986.

Fig.1. Neutron produced by 800-MeV proton 8-inch-thick Fe

Fig. 2. Neutron spectra at rooftop

Fig. 3. Neutron fluence-to-dose equivalent conversion