

# Radiation Shielding of Extraction Absorbers for a Fermilab Photoinjector\*

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## Abstract

Results of radiation shielding calculations performed for extraction beam absorbers of a Fermilab photoinjector with the MARS14 code are presented. They can be used in other similar projects, particularly early sections of linear colliders.

## 1 Introduction

A Fermilab high-brightness photoinjector (HBPI) was developed to be a key research facility in the NICADD (Northern Illinois Center for Accelerator and Detector Development) collaboration between Fermilab and Northern Illinois University [1]. Radiation safety regulations impose a restriction on prompt dose observed in a controlled area in the vicinity of the photoinjector. Namely, the dose in a control room, which will not be occupied full time, should not exceed  $50 \mu\text{Sv/hr}$  [2]. Present work describes radiation shielding and beam absorbers for the photoinjector, calculated with the MARS14 code [3], which ensures the radiation safety requirement. The investigation was performed for the MP-9 building.

## 2 Geometry Model

The HBPI is a 300-MeV linear electron accelerator composed mainly of a 5-MeV electron gun, two 150-MeV accelerating sections, and two diagnostic sections. Its total length is about 80 m. The injector infrastructure consists of a control room, assembly area and some equipment. It is supposed that the injector hall and control room are separated with a concrete wall 80 cm thick. A calculation model of the area is presented in Fig. 1. The most important contribution to prompt dose in the control room comes from photons and photoneutrons penetrating through the separating wall. Therefore proper taking account of

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particle backscattering prevents from significant underestimation of the dose. Thus, floor, walls, and ceiling (except the ceiling above the control room and next assembly area) have been included in the model. It reflects a typical arrangement of the considered installation.

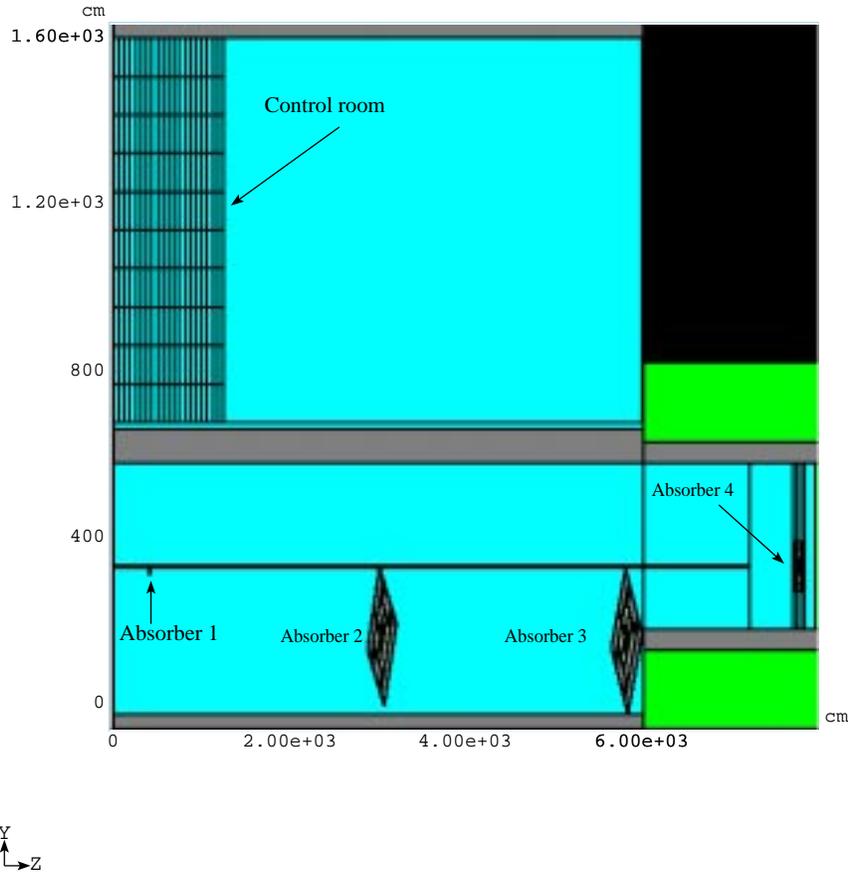


Figure 1: A horizontal cross-section of the MARS model of the control room and injector hall with the beam absorbers.

For gun tuning purpose, a 5-MeV beam absorber is to be installed near the gun. To absorb the electron beam at different stages of the injector commissioning, a movable beam absorber can be used, if possible. Thus, four absorbers altogether have been incorporated in the model (see Fig. 1). Each of the absorbers is supposed to be a solid aluminum cylinder covered with cylindrical layers of shielding. A horizontal cross-section of the beam absorber model and actual layer thicknesses used in the study are presented in Fig. 2 and Table 1, respectively.

### 3 Calculation Results

Calculations of prompt dose in the control room have been performed for each of the absorbers for the electron beam impinged on an aluminum absorber under consideration.

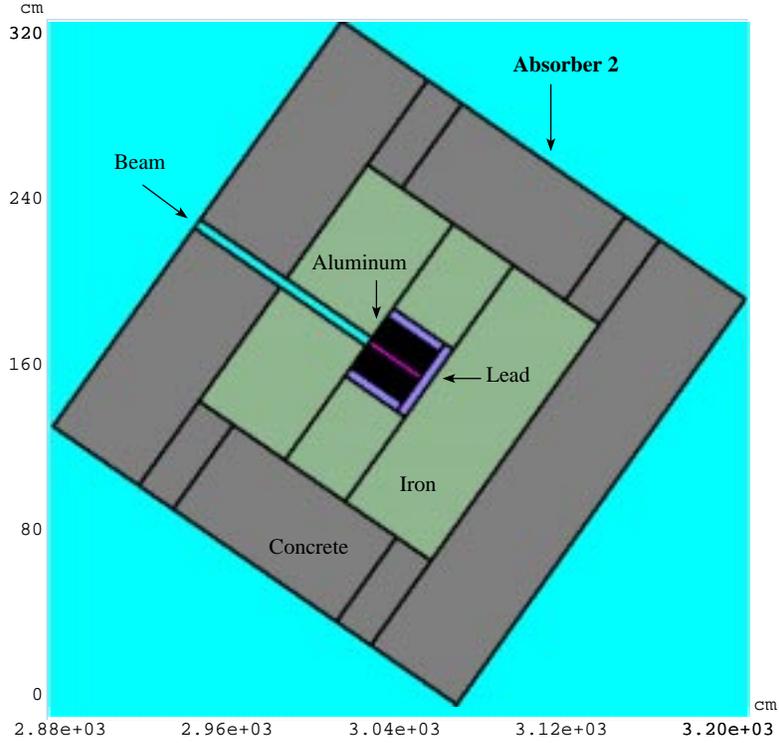


Figure 2: Horizontal cross-section of the beam absorber model.

Table 1: Dimensions (cm) of cylindrical aluminum beam absorbers and thickness,  $\Delta$  (cm), of the shielding layers (lead, iron, and concrete) used in the model.

Dump No.	$R_{Al}$	$H_{Al}$	$\Delta_{Pb}$	$\Delta_{Fe}$	$\Delta_{Conc}$
1	5	5	2	0	0
2	15	30	5	50	50
3	20	40	5	50	50
4	15	40	5	20	20

Beam losses in the beamline were not taken into account. Calculated prompt dose rate distributions in the control room are presented in Fig. 3. One can see that the absorber and shielding described in Table 1 provide reasonable radiation protection to comply with the limit imposed upon an area of restricted access [2]. These results should be considered as a starting point for more detailed radiation shielding considerations when going from the typical arrangement to the final one. In addition, two-dimensional distribution of prompt dose in the injector hall and assembly area due to the 150-MeV beam absorption in the Absorber 2 is presented in Fig. 4. Similar results were obtained for Absorbers 3 and 4. It follows from the data that extra shielding is required if personnel would be present in the assembly area during such a beam extraction.

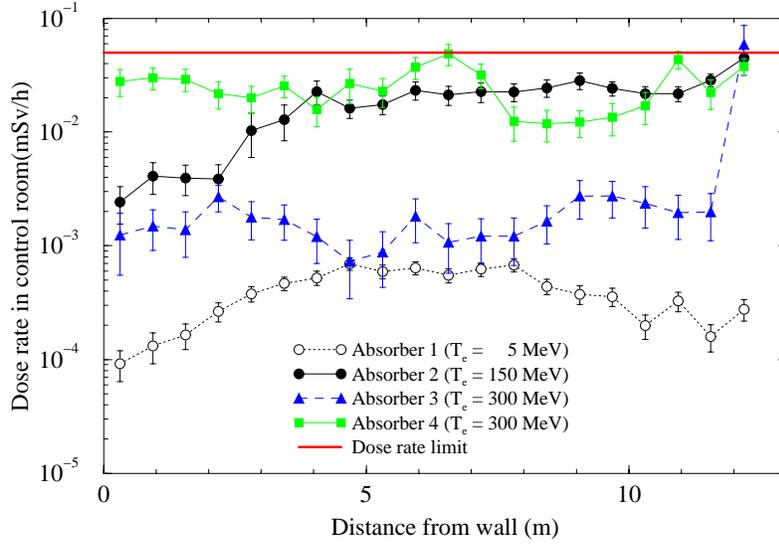


Figure 3: Calculated distribution of average prompt dose rate in the control room due to beam absorption in the absorbers. The average values were calculated over the box-shaped  $400\text{cm} \times 920\text{cm} \times 62\text{cm}$  regions (see Fig. 1). Normalization is per electron beam current of  $45 \mu\text{A}$  which is supposed to be continuous.

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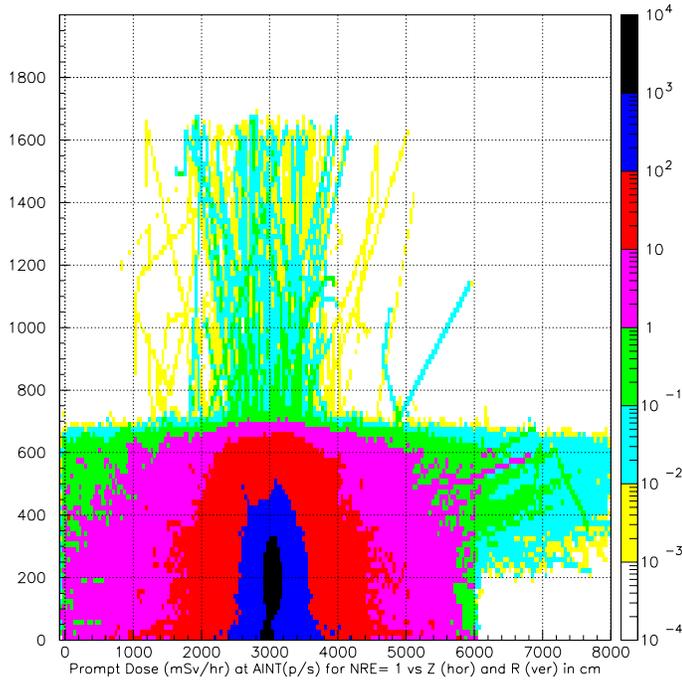


Figure 4: Calculated 2D distribution of prompt dose rate in the injector hall and assembly area behind the shielding wall due to the 150-MeV beam absorption in Absorber 2. Normalization is per electron beam current of  $45 \mu\text{A}$  which is supposed to be continuous.

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## References

- [1] [http://www.fnal.gov/orgs/fermilab\\_users\\_org/min042603.txt](http://www.fnal.gov/orgs/fermilab_users_org/min042603.txt)
- [2] “Fermilab Radiological Control Manual”, Article 236, <http://www-esh.fnal.gov/FRCM/>.
- [3] N.V. Mokhov, “The MARS Code System User’s Guide”, Fermilab-FN-628 (1995); N. V. Mokhov, O. E. Krivosheev, “MARS Code Status”, Proc. of the Monte Carlo 2000 Conference, Lisbon, October 23-26, 2000, Springer, p. 943; Fermilab-Conf-00/181 (2000); <http://www-ap.fnal.gov/MARS/>