national accelerator laboratory

TM-146
1101.2

REMANENT EXPOSURE DOSE RATE FROM THE BOOSTER AND MAIN-RING MAGNETS

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January 7, 1969

Introduction

Recently, A. Armstrong and R. G. Alsmiller of O.R.N.L. have performed Monte Carlo extranuclear cascade calculations for the case of a uniform proton-loss rate along the axis of an iron cylinder to get the induced radioactivity and corresponding exposure dose rates.

These calculations were made initially as a first step in a study of the shielding needed around passive beam stops or beam scrapers for the booster (10 GeV) and the M.R. (200 GeV).

Bearing in mind the following limitations,

1) no magnetic field in the iron,

2) uniform loss rate along the axis (vacuum chamber),

the results may be used to estimate the exposure dose rate to personnel working or transiting at 30 cm and 100 cm from the sides of the magnets.

Description

The O.R.N.L. group is capable of making intranuclear cascade calculations up to 3 GeV. Hence, they gave us extranuclear cascade results for 3 GeV protons with some confidence and for 200 GeV protons with great misgivings. For energies greater than 3 GeV, the cross-sections and production spectra for p's, n's and π's at large angles are essentially unknown and hence, the calculations are made with source terms of doubtful validity.

To extrapolate the 3 GeV results to our booster, it was assumed that the number of stars (non-elastic events) is directly proportional to the proton energy. Then, the remanent radioactivity and the exposure dose rates were multiplied by (10/3). The return legs are assumed to be 2 1/2 inch thick. 10^{11} protons per second are assumed lost uniformly in the magnets, giving a proton loss rate $(di/dl) = 3.6\times10^{6}$ p/(sec cm).

For the main ring, a proton loss rate of 1.5×10^{10} p/sec is assumed uniformly distributed in the magnets, giving a proton loss rate of 3.2×10^{4} p/(cm sec). The side shielding consists of 4.67 in. of Cu+5.0 in. of Fe, which is treated as 10 inches of Fe.

Results

The results are given for exposure dose rates at 30 cm and 100 cm from the side of the magnets. Irradiation time = infinite (over one month), cooling-off time = 1 hour.

In the 200 GeV case, the contribution of secondary protons and pions created by the 200 GeV protons on the Fe nuclei was neglected. Hence, I have multiplied Alsmiller's results by two as a zero order correction.

Ep	di/dl	Magnet Thickness	Remanent Exposure Dose Rate	
GeV	$p(\text{sec cm})^{-1}$	g/cm^2	@30 cm mrem/hr	@100 cm mrem/hr
10	$3.6x10^6$	50	24	8.1
200	$3.2x10^4$	198	2.5	1.1

CAUTION: This table assumes uniform proton losses. Variations about these values by factors of ten both up and down should be expected.

Conclusions

It is quite clear that using the presently prognosticated current losses by R. Billinge (booster) and A. Maschke (main ring), we may not have any problems with remanent radioactivity and exposure dose rates in the M.R. However, we definitely have a problem in the booster if we keep in mind that the given exposure dose rates are for a uniform beam loss. One should be prepared to find exposured dose rates of up to ten times the value given namely ~ 0.24 rem/hr. Such exposure dose rates should be avoided. Possible ways to reduce the booster remanent exposure dose rates are,

1) reduce beam losses to .1% (10^{10} p/sec),

2) reduce beam losses to .5% and add 3 inches of steel or lead to the lateral magnet thickness.

One possible way to add lead between the coils would be by stamping lead sheet (~1/16 inch thick) and anodized aluminum. Then, stacking them together with one bolt.

3) A less elegant solution consists in placing local absorbers outside the magnets. If such a solution is chosen, then sodium-free limestone should be considered in addition to steel and lead.

4) The mechanism for beam loss has to be examined carefully. Then, the efficient use of one or more beam scraper with strategically positioned lips may reduce the "general" background sufficiently to make unnecessary the use of absorbers.

Reference

A. Armstrong and R. G. Alsmiller, O.R.N.L. report to be published.