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ISABELLE PROJECT

BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York

ACCELERATOR DEPARTMENT
Informal Report

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ANTICIPATED AVERAGE DOSE IN ISABELLE

G.W. Bennett and G.S. Levine

December 7, 1972

ABSTRACT

An order of magnitude calculation is used to obtain the average radiation exposure of ISABELLE components.

N O T I C E

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INTERSECTING STORAGE ACCELERATOR NOTES

ANTICIPATED AVERAGE DOSE IN ISABELLE*

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Introduction

The question of radiation levels is especially important in the proposed intersecting storage accelerator because of the high beam energy and innovative technological features. In this work the Isabelle dose is calculated in first approximation. The same method is used to approximate the dose in the ISR, and this is seen to agree with recent measurements performed at CERN.

Discussion

Assume 6×10^{14} protons are accelerated in Isabelle and ultimately interact in a vacuum chamber with 10 cm ∅ and total circumferential length of 2×10^5 cm.(1) Using William Moore's result(2) of ~ 20 energetic secondaries per interacting proton, and the measurement of 3×10^{-8} Rad/secondary/cm^2,(3) the average dose deposited in each ring per charging cycle will be

$$6 \times 10^{14} \text{ Proton} \times 20 \frac{\text{secondaries}}{\text{Protons}} \times \frac{1}{6\text{x}10^6 \text{cm}^2 \text{ area}} \times \frac{3 \times 10^{-8} \text{ Rad}}{\text{secondaries/cm}^2}$$

$= 60$ Rad/cycle.

There are some weaknesses in this, e.g. if the protons escape to larger radius before interacting the flux decreases as r^{-2}. The beam will, however, generally intersect the vacuum chamber at grazing incidence and >90% will

*Work performed under the auspices of the U.S. Atomic Energy Commission.

interact in 50 cm of steel. Also, the flux to dose conversion varies (but slowly), and energy dependence is ignored temporarily.

To test this approach let's consider recent CERN measurements on the ISR after some months of operation.[4] In ring 1 there was an average of 10 A during running in for 710 hours and 5 A for 744 hours of colliding beam time. Assume that the beam was recharged at 2 hour intervals during testing and 24 hours during colliding beam time, and that the vacuum chamber has the same diameter. The length was 10^5 cm. The dose deposited per cycle during running in should have been

$$\frac{10\ \text{A}}{1.6 \times 10^{-19}\ \text{A sec/p}} \cdot \frac{\text{circumference}}{\text{vel. of light}} \cdot \frac{710\ \text{hrs.}}{2\ \text{hrs/cycle}} \cdot \frac{20\ \text{secondaries}}{\text{Proton}}$$

$$\cdot \frac{1}{\text{surf. area}} \cdot \frac{3 \times 10^{-8}\ \text{Rad}}{\text{secondary/cm}^2} \simeq 10^4\ \text{Rad}$$

Similarly, for the operational beam time the dose per cycle should have been

$$\sim 4 \times 10^2\ \text{Rad}$$

then the average dose per cycle deposited near the vacuum chamber should be $\sim 10^4$ Rad. Lambert and Van de Voorde[4] have measured the total dose to the ISR under the above conditions and the average to ring 1 is of the order of 10^4 Rad which lends credence to the Isabelle dose calculated above. Note that the dose was not uniform, the peak absorbed dose was 7×10^5 Rad, but this is determined by structure and targets. The anticipated peak dose per year at 20 A circulating is $\sim 7 \times 10^7$ Rad. Samples of the pole face windings were tested and found to be satisfactory up to doses of 2×10^9 Rad.

In extrapolating from 30 GeV to 200 GeV the effect of energy must be included. The relative multiplicity of secondaries may be expressed as E^n where E is the kinetic energy of the proton beam, and n is a parameter ranging in value from 1/4 to 1, depending on the theoretical model chosen. Measurements at CERN and RHEL of secondary fluence vs production angle for 8 and 24 GeV/c proton beams show $n = 0.3 \pm .05$ at angles larger that 30^o.[5]

Conclusion

A reasonable value for the increase in multiplicity is then $(200/300)^{0.3} \approx 1.8$. Hence the dose from secondaries will be about twice as large at 200 GeV as that calculated for the 30 GeV case. Approximately 100 Rads will be the average dose in each ring per filling cycle. Assuming the ISA is charged every day the total average dose per ring per year will be $\sim 4 \times 10^4$ Rad and peak values will be about 2 orders of magnitude higher.

References

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