APPENDIX IV. RADIATION-DAMAGE CONSIDERATIONS

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The effects of radiation on the superconducting magnets may be an important factor in both the operation and the long-term reliability of the Energy Doubler. Studies of these effects have been concentrated in two main areas, effects of beam heating on magnet performance and long-term degradation of materials such as insulations and conductors.

A problem in the understanding of radiation-heating effects is the lack of detailed theoretical and experimental investigations in this area. It can, however, be concluded that the response of a system to radiation heating is strongly dependent on the details of construction, notably the enthalpy of the magnet-coil materials and the heat-transfer capabilities of the conductor.[1] The approach adopted for the Energy Doubler has been to correlate experimentally the quench current of our magnets under simulated loss conditions to a simple calorimeter under the same loss conditions. This correlation then allows us to evaluate the performance of our magnets at other locations without the complications of installing a cryogenic magnet at that location. Preliminary data indicate that radiation heating will probably not be a serious limitation to the normal operation of the Energy Doubler. Nevertheless, tuning will have to be accomplished at the lowest possible intensity. The use of superconducting elements in the extraction, injection, and abort systems is questionable and has been avoided. (See Appendix II.)

The sensitivity of polymeric materials to ionizing radiation varies greatly depending on their composition. Usable limits range from 10^5 rads (Teflon) to 10^{11} rads (mineral-filled epoxy). Energy-Doubler magnets will utilize epoxies as structural adhesives and as part of the conductor insulation, various polymers as high-voltage electrical insulation for instrumentation leads, and Mylar in the thermal insulation. Reasonable choices for each application can be made based on typical dose rates in the present accelerator. Measurements are in progress to determine dose levels at locations comparable to those planned for the superconducting magnets. Dose rates of the order of 10^8 rads/yr are expected.[2,3]

Radiation effects on the metallic components of the magnets are also being investigated. The resistivity of the stablizing copper matrix of the conductor is the most sensitive to radiation.[4] Sizable resistivity increases have been measured and are being studied. It has been found that the effect of these changes can be minimized by periodic room-temperature anneals.

References

[1]G. T. Danby, Radiation Heating: Experience and Projections, Proc. 1975 Isabelle Summer Study, BNL-20550, Vol. 2, p. 631

[2]M. Awschalom et al., Radiation Measurement Around the Fermilab 300 GeV Main Accelerator, TM-516, September 1974.

[3]J. H. McCrary et al., Radiation Levels in the Fermilab Main Ring Enclosure During Accelerator Operation, TM-623, November 1975.

[4]P. Sanger, Displacement Damage for 300 GeV Protons, Proc. 1975 Isabelle Summer Study, BNL-20550, Vol. 2, p. 626.