Non-Nuclear Science Programs at the 88-Inch Cyclotron: Part A. Space Applications*

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The 88-Inch Cyclotron runs about 20% of the time for non-nuclear science fields, including high-energy physics, radiobiology, materials, and space applications. The largest part, space applications, consists of two parts: radiation-induced effects in microelectronics and calibration of detectors for NASA missions.

Radiation Induced Effects

Recent demands by both the Defense Department and the communications industry for cost, flexibility, and speed of getting new satellites into space, have led to an increased use of commercial off-the-shelf (COTS) parts. These parts must be ground tested before committing them to an expensive space mission. Ground-based testing is done at accelerators and with radioactive sources. Accelerators in the USA, Europe, and Japan now provide radiation effects test facilities for heavy ions, protons, or electrons. At the 88-Inch Cyclotron, the bulk of non-nuclear science time (≈15%) goes to space effects studies for a wide variety of companies and laboratories, on a cost-recovery basis.

Several types of "single event effects (SEEs)" have been identified, ranging from a simple flip of a bit, as in an upset, to more catastrophic effects such as latch-ups or burn-outs, which destroy the part.

Models of these effects begin with an initial charge distribution or current source positioned along the track of an energetic ion. The sensitivity of a device to a particular type of SEE is expressed in terms of the cross section as a function of LET, which gives a characteristic curve with two key parameters: the threshold, L_{th}, for onset of the SEE, and the cross section at saturation, σ_{sat}. The saturation cross-section is related to the total area of the sensitive regions of the component, and the threshold LET is a measure of the critical, or minimum, charge required to trigger the event.

The 88-Inch Cyclotron has features which make it ideal for SEE studies. The Cyclotron runs both heavy-ions and protons, enabling both kinds of measurements to be done at the same facility. Also, the combination of ECR (Electron Cyclotron Resonance) source and cyclotron makes possible the development of "cocktail" beams‡, which allow the ion species, and thus LET, to be changed very quickly. In addition, with bismuth beams, LETs as high as 100 MeV/mg/cm^2 can be reached.

These studies require accurate measurements of energy, fluence, and spatial uniformity. Energy measurements are performed with silicon detectors, and dose and uniformity obtained with various types of scintillators or ion chambers.

Detector Calibrations

Another use of the 88" Cyclotron is for ground-based calibrations and tests of detector packages being prepared for future space launches. NASA's Advanced Composition Explorer (ACE) satellite, scheduled for launch in 1997, will investigate a wide range of fundamental problems in i) the elemental and isotopic composition of matter, ii) origin of the elements and subsequent evolutionary processing, iii) formation of the solar corona and acceleration of the solar wind, and iv) particle acceleration and transport in nature. Two of the nine instruments being designed for this mission have been tested and calibrated at the 88-Inch Cyclotron.

Footnotes and References

*Condensed from Proceedings of the International Symposium on Large-Scale Collective Motion of Atomic Nuclei, Brolo, IT, October 1996, to be published.

‡ M.A. McMahan, et al., Nucl. Instr. Meth. **A253**, 1 (1986).