Abstract
A 1 GeV/u $^{56}$Fe ion beam allows for true 90° tilt irradiations of various microelectronic components and reveals relevant upset trends for an abundant element at the galactic cosmic ray (GCR) flux-energy peak.

Space Environment

- The galactic cosmic ray (GCR) environment has a flux-energy peak at 1 GeV/u.
- At this level of kinetic energy, LETs > 1 (MeV·cm$^2$/mg) are dominated by iron.
- 1 GeV/u $^{56}$Fe has an LET of 1.2 (MeV·cm$^2$/mg) and a range in silicon of 15 cm.

GCR Fluxes for geostationary orbit at solar minimum [CREME96]

Facility

The NASA Space Radiation Effects Laboratory
Brookhaven National Laboratory, Long Island, NY USA

- The NSRL compared to other heavy ion facilities
- Note that the FYIL REF is similar to LBNL BASE facility
- 230 in from beam exit
- Beamline Positioning Rails
- Target Room
  - Facility has rotation and translation stages
  - Can stack multiple experiments
  - Experiments conducted in 230 in from beam exit

Static Random Access Memories

Note: Different scales for Vendor A’s SOI and Vendor B’s bulk CMOS.

Vendor A: 65 nm SOI
Vendor B: 65 nm bulk CMOS

- Solid lines connect 1 GeV/u MBU cross sections
- Vendor A’s SOI devices have both a data pattern and orientation dependence
- Vendor B’s bulk CMOS device only has an orientation dependence

Pattern and orientation sensitivities arise from SOI’s inter-device isolation and bit cell layout.
These features are muted in bulk CMOS due to charge transport.

Field Programmable Gate Array

- Solid lines connect 1 GeV/u configuration and BRAM cross sections
- Extreme variation between configuration and BRAM cross section based on orientation
- Suspect physical layout is responsible

- Extreme variation across configuration and BRAM cross section based on orientation
- Test setup for 90° tilt, O° roll irradiations
- Taking advantage of 8 in x 8 in beam spot
- All four DUTs are stacked (FPGA on bottom)
- Roughly 2% uniformity over this area

Conclusions

- First time the NSRL facility has been used to characterize highly-scaled commercial technologies
- 1 GeV/u $^{56}$Fe beam allowed for true 90° tilt irradiations
- Extreme upset cross section variation observed as a function of roll angle, data pattern, and storage elements
- Data provides impetus to study these limiting irradiation conditions with radiation transport modeling since studies like these are not feasible on a regular basis

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