National Aeronautics and
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Heavy Ion Testing at the Galactic Cosmic Ray Energy Peak

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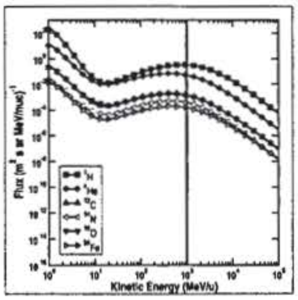
Abstract

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.

Radecs 2009

Space Environment

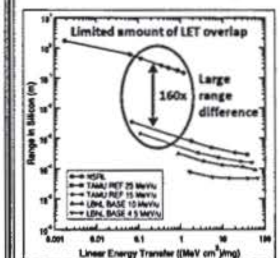
- The galactic cosmic ray (GCR) environment has a flux-energy peak at ≈1 GeV/u
- At this level of kinetic energy, LETs > 1 ((MeV·cm²)/mg) are dominated by iron
- 1 GeV/u ^{56}Fe has an LET of 1.2 ((MeV·cm²)/mg) and a range in silicon of 15 cm



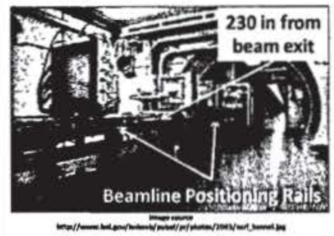
GCR Fluxes for geostationary orbit at solar minimum (CREME96)

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 JYFL REF is similar to LBNL BASE facility

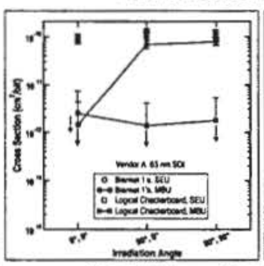


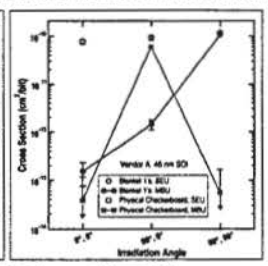
Target Room

- Facility has rotation and translation stages
- Can stack multiple experiments
- Experiments conducted ≈230 in from beam exit

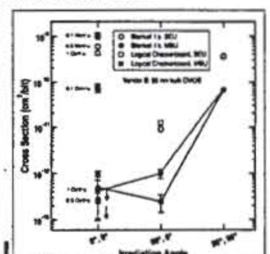
Static Random Access Memories

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





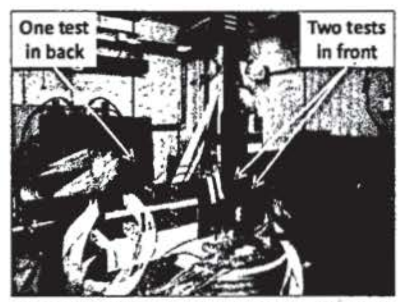
65 nm SOI — Vendor A — 45 nm SOI



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

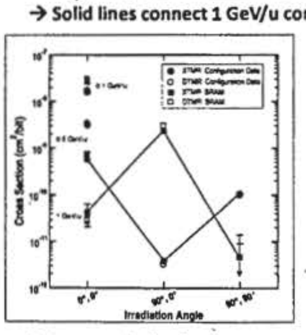


- Test setup for normal incidence irradiations
- Taking advantage of 8 in × 8 in beam spot
  - Two setups in front and one in back
- Roughly ± 2% uniformity over this area

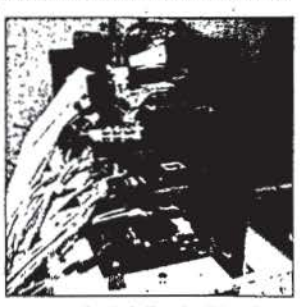
Pattern and orientation sensitivities arise from SOI's inter-device isolation and bit cell layout. These features are muted in bulk CMOS due to charge transport.

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



- Test setup for 90° tilt, 0° roll irradiations
- Taking advantage of 8 in × 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

To be presented by Jonathan A. Pellish at the 2009 RADECS, 14-18 September 2009, Brugge, Belgium