# NSREC conference

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**CERN, Geneva,  Switzerland**

**The Nuclear and Space Radiation Effects Conference**
**July 16-20, 2012, Miami, FL**

# Conference information

**NSREC 2012:** 10 sessions, short course and data workshop:

- Session A – Single Event Effects: Mechanisms and Modeling
- Session B – Single Event Effects: Transient Characterization
- Session C – Single Event Effects: Devices and Integrated Circuits
- Session D – Hardening by Design
- Session E – Photonic Devices and Integrated Circuits
- Session F – Radiation Hardness Assurance
- Session G – Radiation Effects in Devices and Integrated Circuits
- Session H – Basic Mechanisms of Radiation Effects
- Radiation Effects Data Workshop
- Session I – Dosimetry
- Session J – Space and Terrestrial Environments

# Short Course

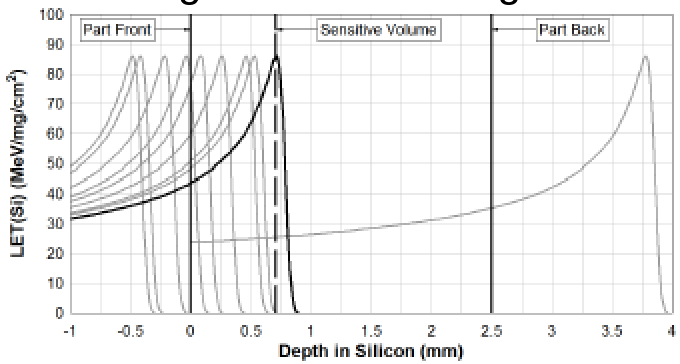
**NSREC 2012:** Short course: **TESTING AND SIMULATION METHODS FOR CHARACTERIZING RADIATION EFFECTSIN ADVANCED ELECTRONICS**

- **SINGLE-EVENT AND TOTAL DOSE TESTING FOR ADVANCED ELECTRONICS** Jonathan A. Pellish *NASA Goddard Space Flight Center*
- **RADIATION EFFECTS IN EMERGING TECHNOLOGIES** Steven J. Koester *University of Minnesota*
- **MONTE CARLO BASED SINGLE-EVENT EFFECT AND SOFT-ERROR RATE PREDICTION METHODS** Kevin M. Warren *Vanderbilt University*
- **SYSTEM-LEVEL SINGLE-EVENT EFFECTS** Subhasish Mitra *Stanford University*

- Variable Depth Bragg Peak Method (VDBP)
  - Described by Buchner at NSREC 2011 and applied to SEE tests (here extention to SEL)
  - Use of long-range high-energy ions (Au) with polyethylene degraders (0.3mm equivalent to 2.5mm Si) for change LET in Si and plot SEL XS=f(LET).

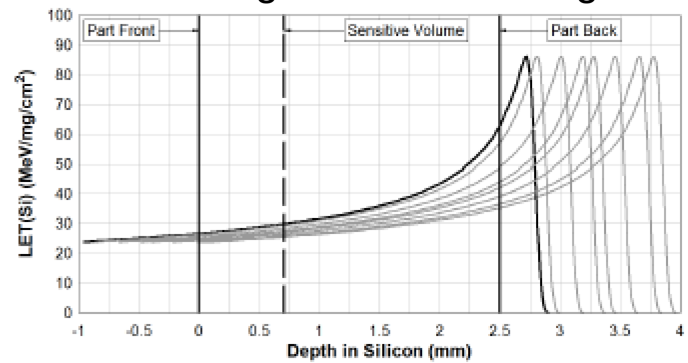
1st sensitive volume depth

Decreasing thickness of degrader

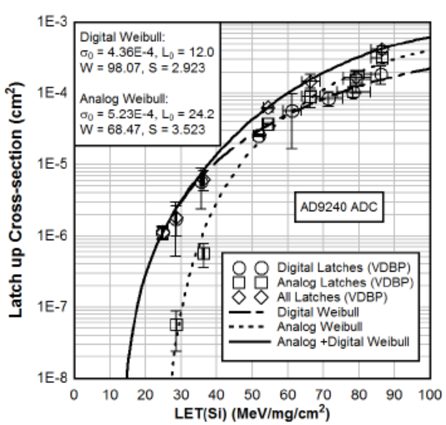


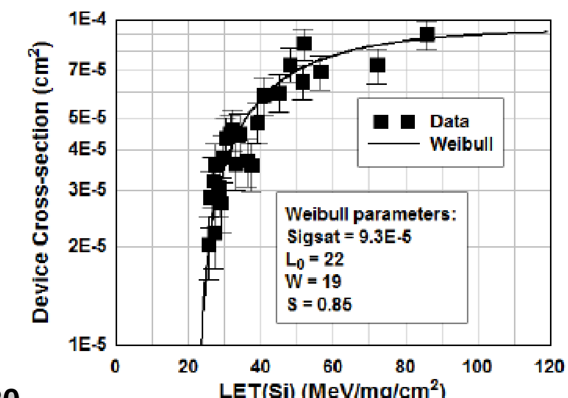

2nd LETth determination

Increasing thickness of degrader




  - Demonstrated on ADC AD9240 & Power Monitor/Reset ISL705ARH

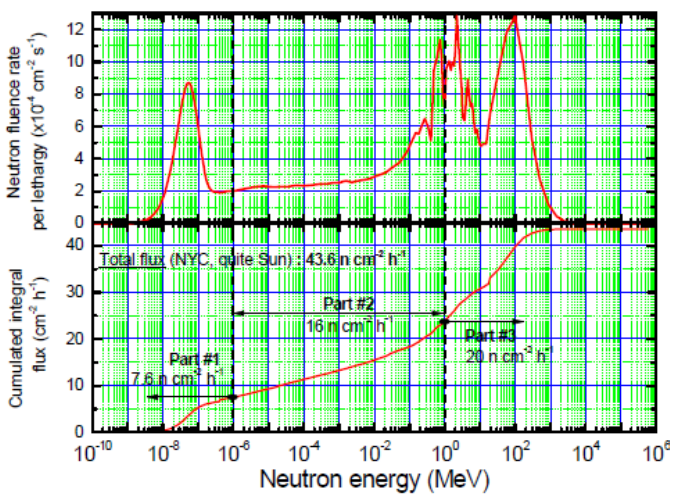


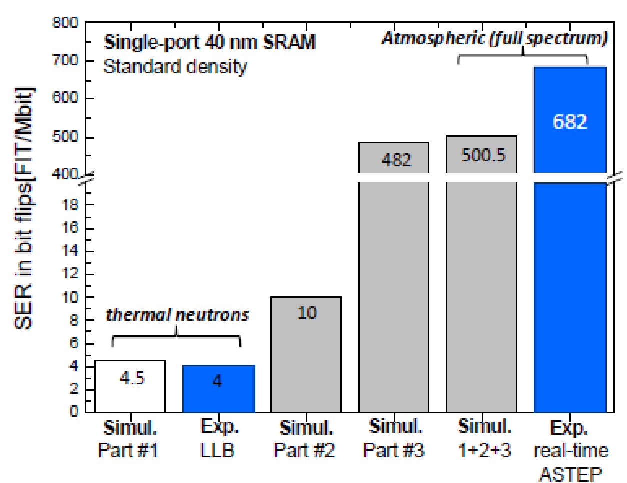



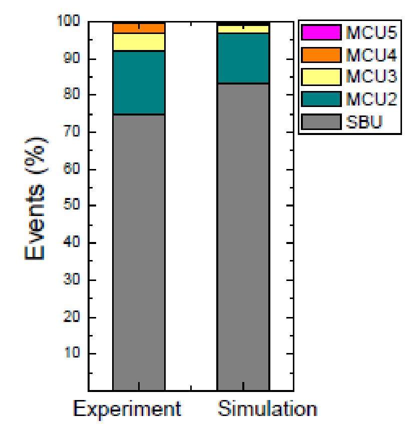
# Soft-Error Rate Induced by Thermal and Low Energy Neutrons in 40nm SRAMs

- Thermal & low energy neutron interactions with natural boron-doped silicon
  - GEANT4+TIARA simulations developed and compared with experimental tests
  - Bulk SP-REG 40nm SRAM from STMicroeletronics, experiments performed at LLB (CEA Saclay)

| Neutron source | Target [1 cm$^2$ x 20 µm] | Number of incoming neutrons | Total number of nuclear reactions in the database[1] | Total number of generated products[2] | Comments |
|---|---|---|---|---|---|
| Part #1 <1 eV | Natural Si | $1.9\times10^8$ (17.4%) | 2,212 | 2,212 | 93% of $^{28}$Si(n,γ)$^{29}$Si |
| | p-type Si [B] =$10^{16}$ cm$^{-3}$ | | 2,276 | 2,276 | |
| | p-type Si [B] = $10^{20}$ cm$^{-3}$ | | 23,619 | 44,771 | ~90% of $^{10}$B(n,α)$^7$Li |
| Part #2 [ 1 eV, 1 MeV] | Natural Si | $4\times10^8$ (36.7%) | 10,018 | 10,018 | 98.5% of elastic reaction (Si recoil nuclei) |
| | p-type Si [B] =$10^{16}$ cm$^{-3}$ | | 10,072 | 10,072 | |
| | p-type Si [B] = $10^{20}$ cm$^{-3}$ | | 11,401 | 12,292 | ~8% of $^{10}$B(n,α)$^7$Li ~91% of elastic events |
| Part #3 > 1 MeV | Natural Si | $5\times10^8$ (45.9%) | 66,364 | 93,716 | 41% of inelastic events 59% of elastic events |
| | p-type Si [B] =$10^{16}$ cm$^{-3}$ | | 66,770 | 95,068 | |
| | p-type Si [B] = $10^{20}$ cm$^{-3}$ | | 66,216 | 94,470 | |

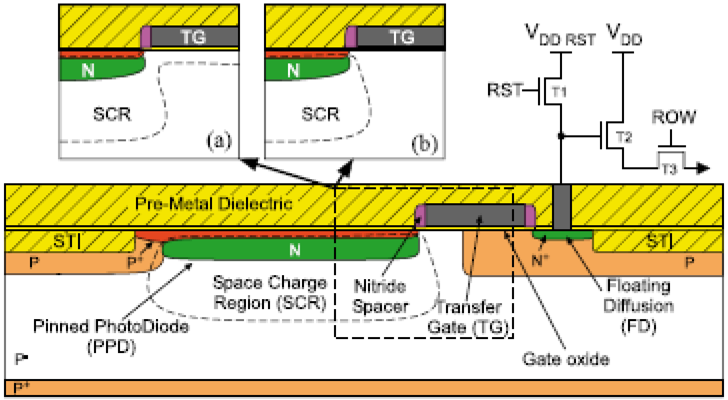


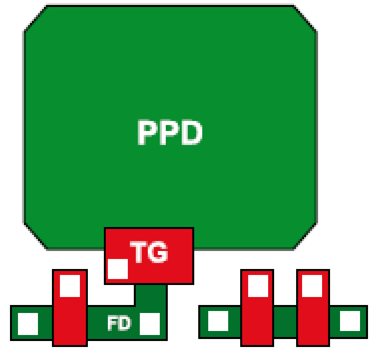



# Radiation Effects in Pinned Photodiode CMOS Image Sensors: Pixel Performance Degradation Due to Total Ionizing Dose

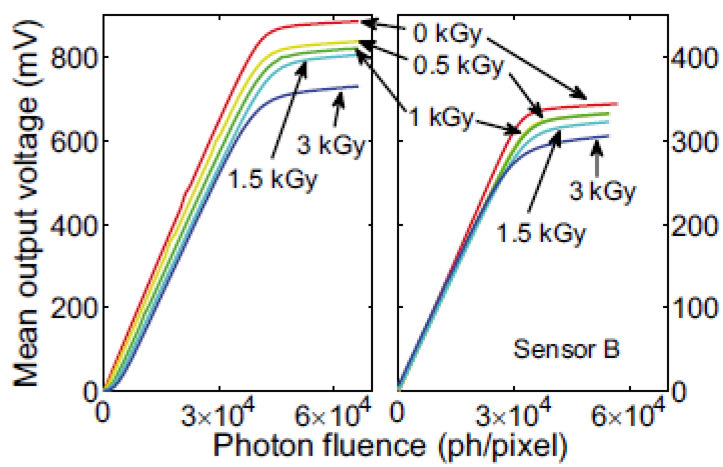
- Several pinned photodiode CMOS sensors designed and characterized up to 10kGy

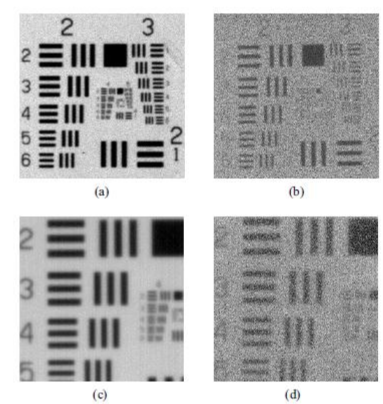



| Features | Sensor A | Sensor B |
|---|---|---|
| Array size | 256 × 256 | 256 × 256 |
| Pitch (μm) | 7 | 4.5 |
| PPD area ($\mu m^2$) | 6.25 | 2.2 |
| PPD perimeter (μm) | 10 | 7.7 |
| CVF ($\mu V/e^-$) | 57 | 38 |
| $V_{LOTG}$ (V) | −0.65 | −0.5 |
| MOVS (mV) | 885 | 345 |
| Full Well ($ke^-$) | 15.5 | 9.1 |
| Technology | CIS PPD 0.18 μm | CIS PPD 0.18 μm |
| Foundry | Foundry A | Foundry B |

- Results
  - Both pixels still functional after irradiation
  - Increase of pinning voltage, decrease of buried photodiode capacity, large charge transfer efficiency change, loss control of the transfer gate (TG)
  - Dark current increase
  - Bias conditions independent



# Process Variability Effect on Soft Error Rate by Characterization of Large Number of Samples

- STMicroelectronics Dual-Well 90nm SRAM (M10 technology: flash gate compatible)
  - Alpha (Am source placed directly on BEOL) and neutron (TRIUMF) measurements of big number of testchips from one silicon lot, die-2-die variations assessment
  - Wafer 46 sites, 30 packeged, 20 tested x 3 instances in each = 60 memories (44% of the die)

- Alpha measurement results:
  - SER variations ±20% for 100% of tested chips

- Neutron measurements:
  - SER variations ±20% for 90% of tested chips

- SER variation as a position on the die:
  - Maximum SER values on the edges, minimum in the center
  - Mean values of SER show however that least sensitive components come from the center and the most from the middle, components from edges on average are less sensitive than from the moddle

# Compendia of SEE and TID Test Results

- GODDARD Space Flight Center
  - SEE test results between Feb 2011 and Feb 2012
  - TID and DD test results between Feb 2011 and Feb 2012

- Jet Propulsion Laboratory
  - SEE recent test results
  - SEL and TID on the commercial ADCs
  - SEE Results for Newly Available MOSFETs (JPL & CALTECH)

- Compendium of radiation test results from Ball Aerospace and Technologies Corp.

- Reports single-event latchup and total ionizing dose results for a variety of analog to digital converters targeted for possible use in NASA spacecraft. The compendium covers devices tested over the last 15 years.
- From 8-bit to 24-bit components
- Tested devices:
  - MAXIM: MAX195,
  - Texas Instruments: ADS5483, ADC14155, ADC1175,
  - Linear technology: LTC1605, LTC1864, LTC1608, LTC1609, LTC1604, LTC1419, LTC1417, , LTC2297, LTC1407, LTC1272, LTC1409
  - Cirrus logic: CS5016,
  - Analog devices: AD7664, AD977 , AD976, AD7621, AD7714, AD7760, , AD9259, AD9240, AD9240, AD1671, AD9223, AD7476, AD7472, AD7888, AD7858, AD7854, AD6640, AD1674, AD1672 AD9042, AD574, AD9200, AD571, AD7821, AD670
  - Burr Brown: ADS7809,
  - Intersil: HI1276
  - Fairchild: SPT7725,

# Compendium of Single Event Effects for Candidate Spacecraft Electronics for NASA

- Reports single-event effect tests conducted between Feb 2011 and Feb 2012 for possible use in NASA spacecraft.
- Tests are performed at LBNL and TAMU with Heavy-ions, at IUCF for protons, at NRL with laser
- Tested devices:
  - Power MOSFETs
  - Linear and analog devices
  - Power devices
  - ADCs/DACs
  - Memories
  - ASICs
  - DC/DC converters
  - Miscellenaous
  - FPGAs

| Principal Investigator (PI) | Abbreviation |
|---|---|
| Melanie Berg | MB |
| Megan Casey | MC |
| Dakai Chen | DC |
| Hak Kim | HK |
| Jean-Marie Lauenstein | JML |
| Robert Gigliuto | RG |
| Timothy Oldham | TO |
| Jonathan Pellish | JP |
| Anthony Sanders | AS |

- http://radhome.gsfc.nasa.gov/radhome/papers/nsrec2012_W22_SEE.pdf