Device-Orientation Effects on Multiple-Bit Upset in 65-nm SRAMs

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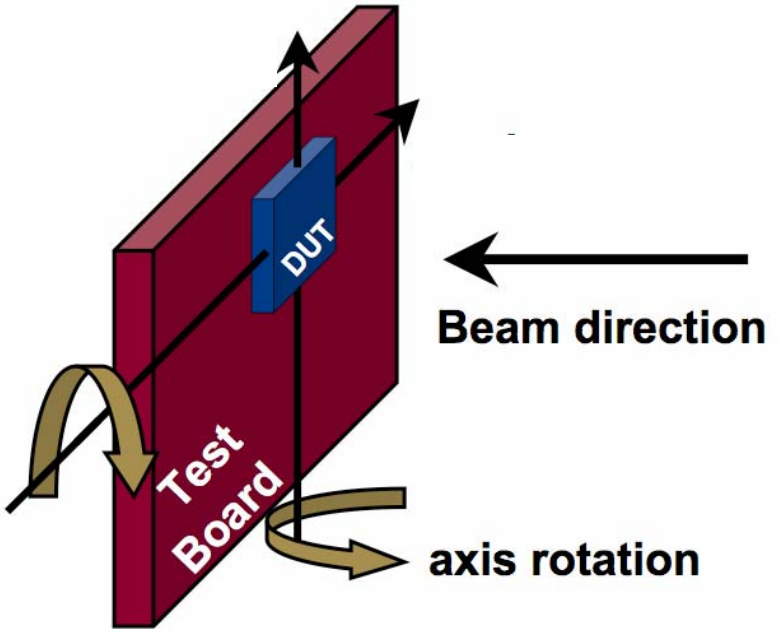
2. Texas Instruments
3. NASA-GSFC
4. MEI Technology

Outline

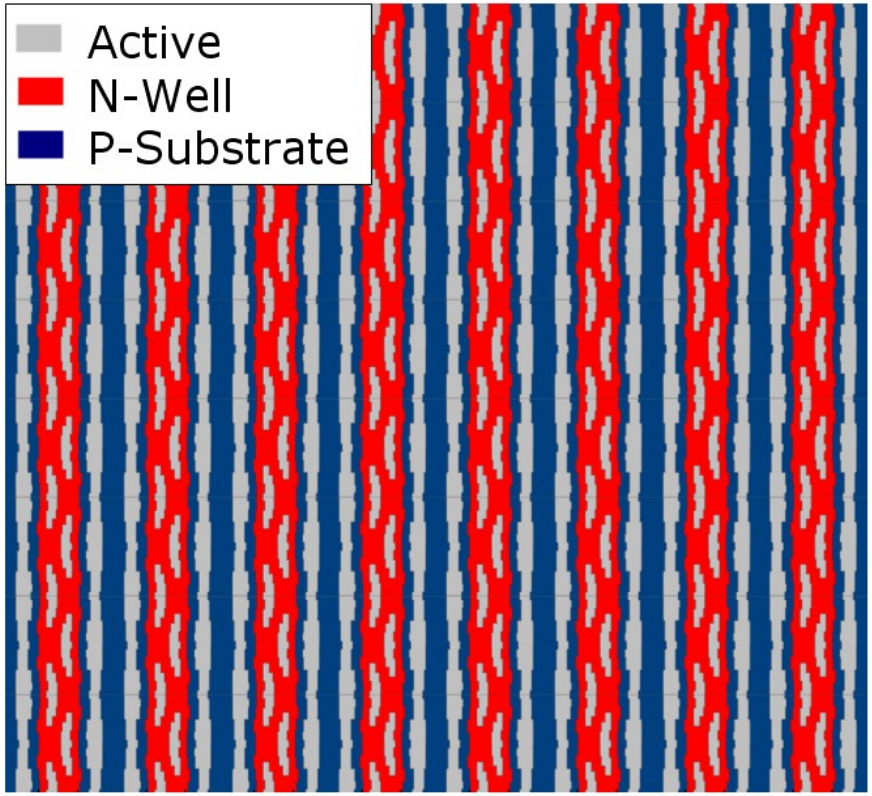
- Device under test
- Heavy ion irradiations
  - Single event upset (SEU)
  - Multiple-bit upset (MBU)
- Monte-Carlo simulation (MRED)
  - Physical model
  - Environment
  - MBU response
- Conclusion

Device under test

- Texas Instruments 65 nm CMOS SRAM
- 4 Mbit memory
- 1.2 V operating voltage
- Irradiations about two axes
- Heavy ions at TAMU



SRAM layout produces alternating columns of wells

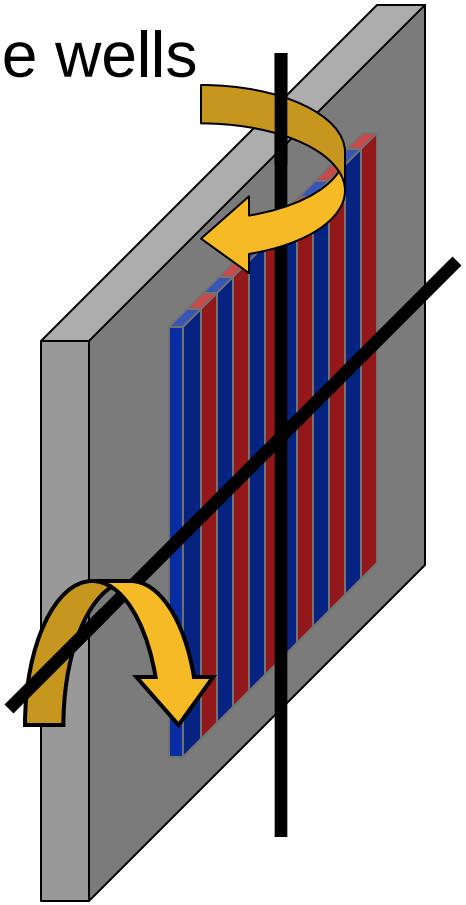


from Hutson *et al.*

Define the device orientation by the wells

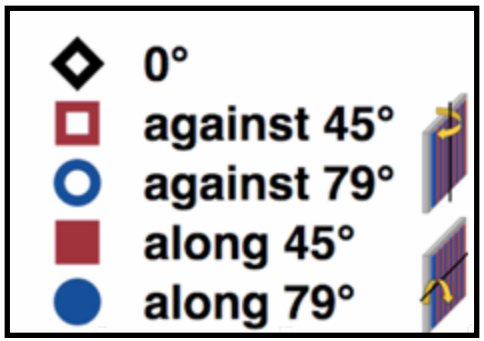
against the wells

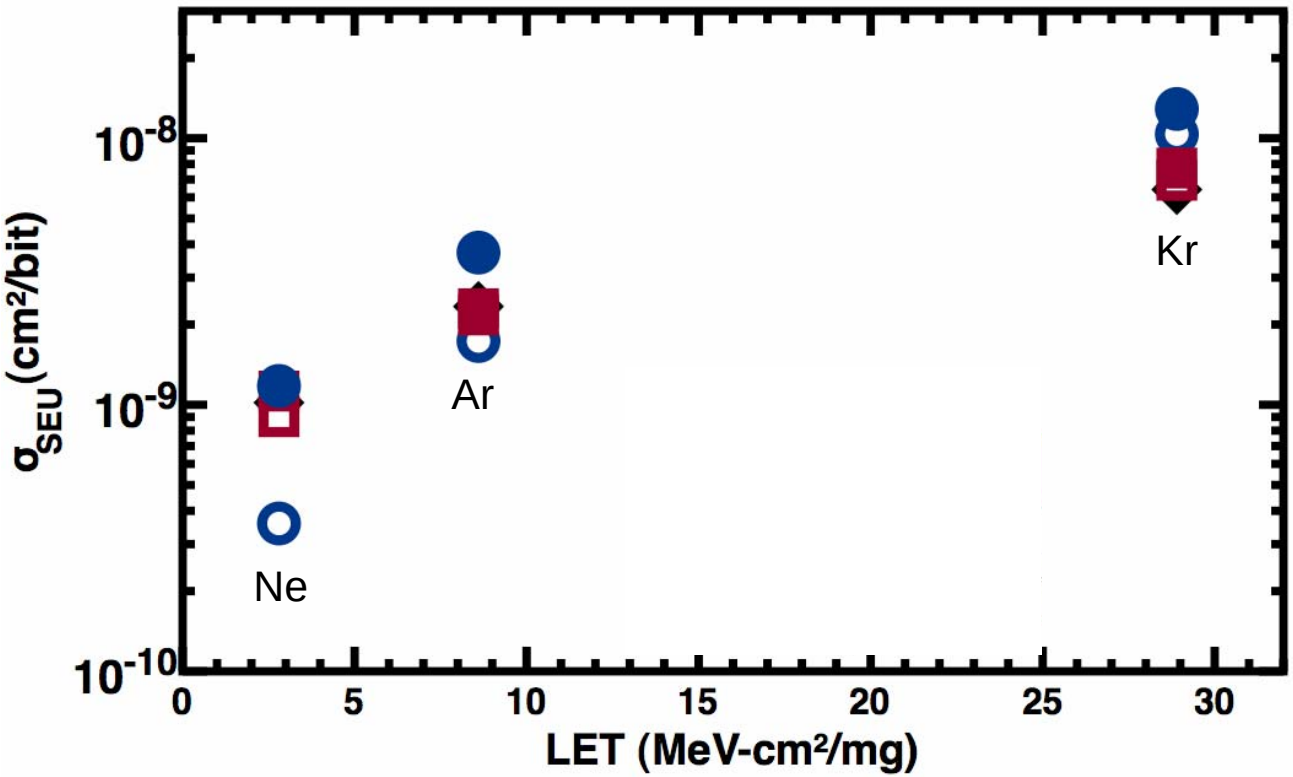
along the wells



SEU cross section varies little with orientation

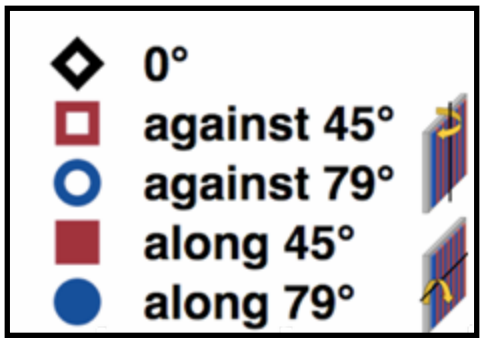
- SEU cross section for all bit upsets
- LET values are at top of DUT
- 15 MeV/u tune

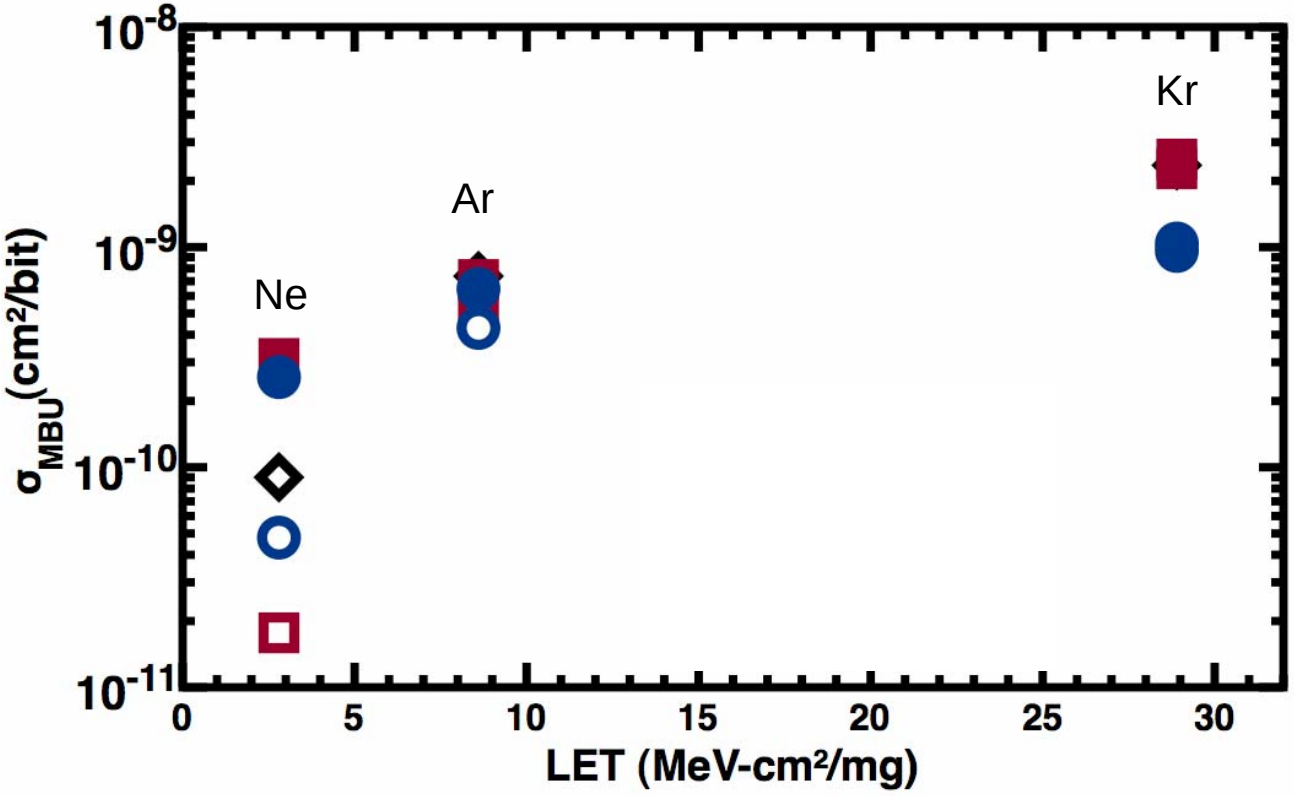




MBU cross section changes with orientation

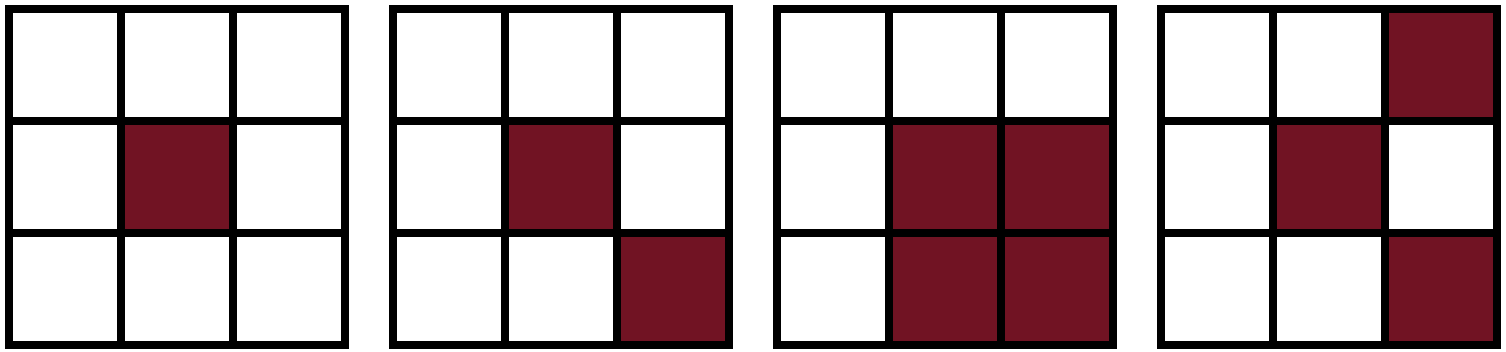
- MBU events are physically adjacent upsets



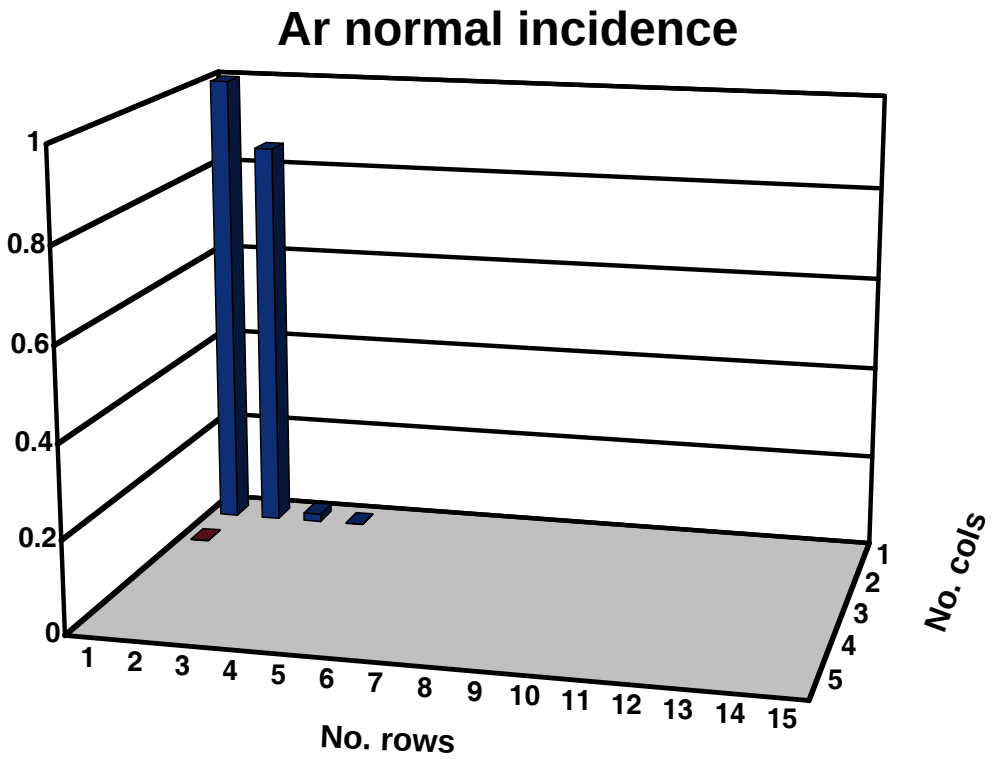


MBU size

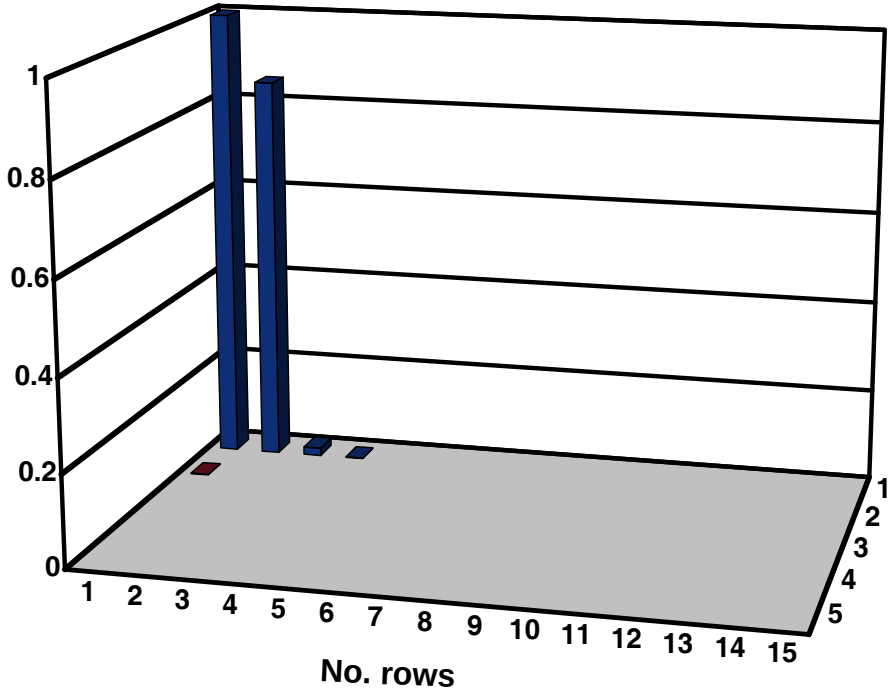
- Size is defined as the number of affected rows or columns
- MBU dimension ≡ affected rows x affected columns
- Wells run along the columns
- Examples

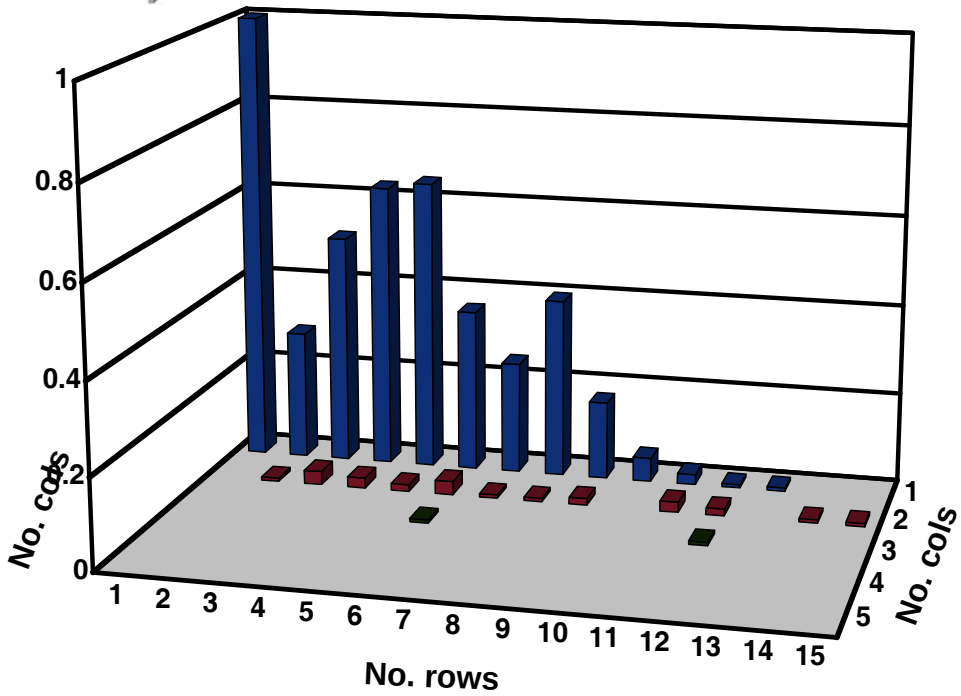


MBU dimension

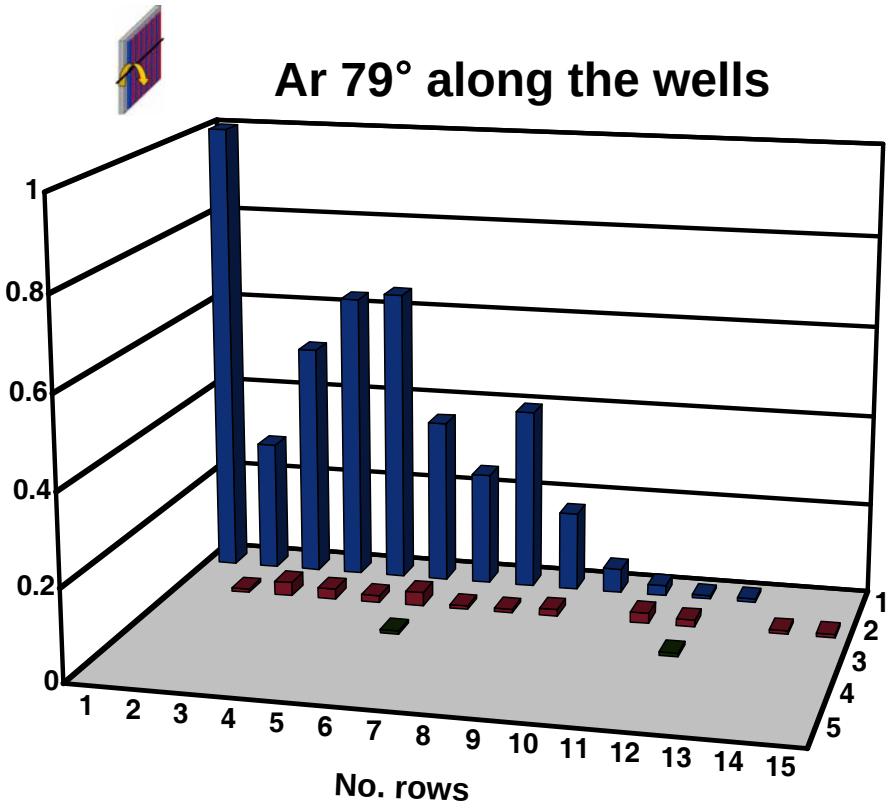


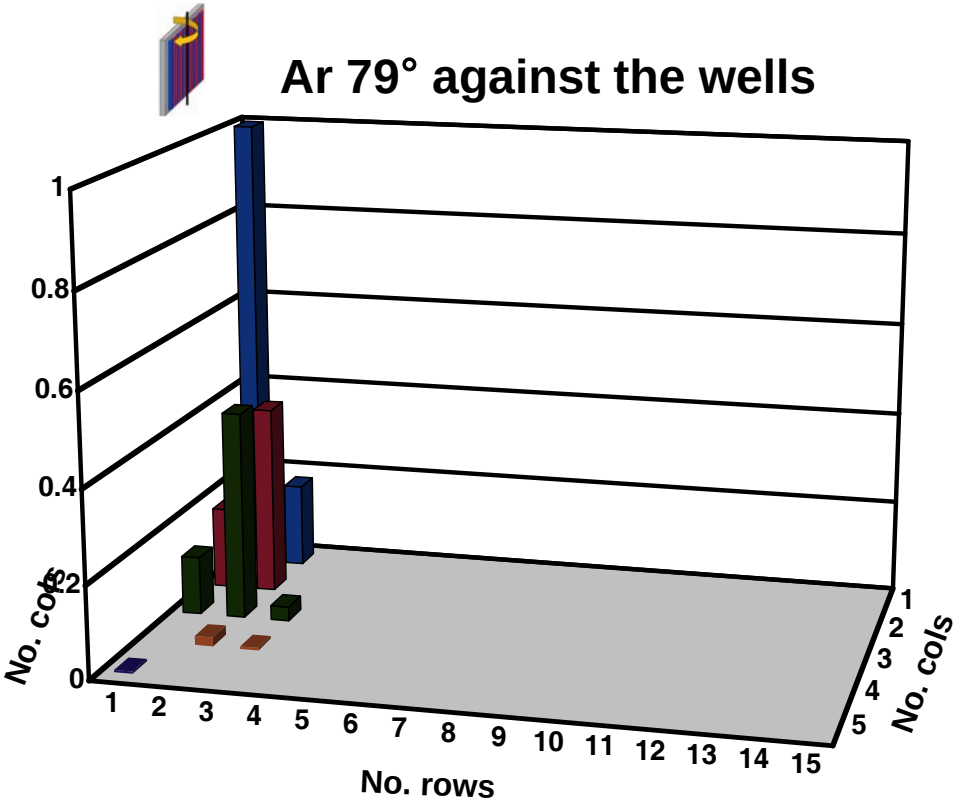
MBU dimension





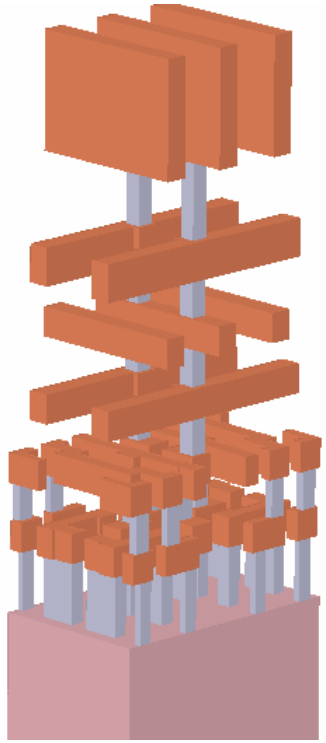
The shape of MBU events depends on orientation





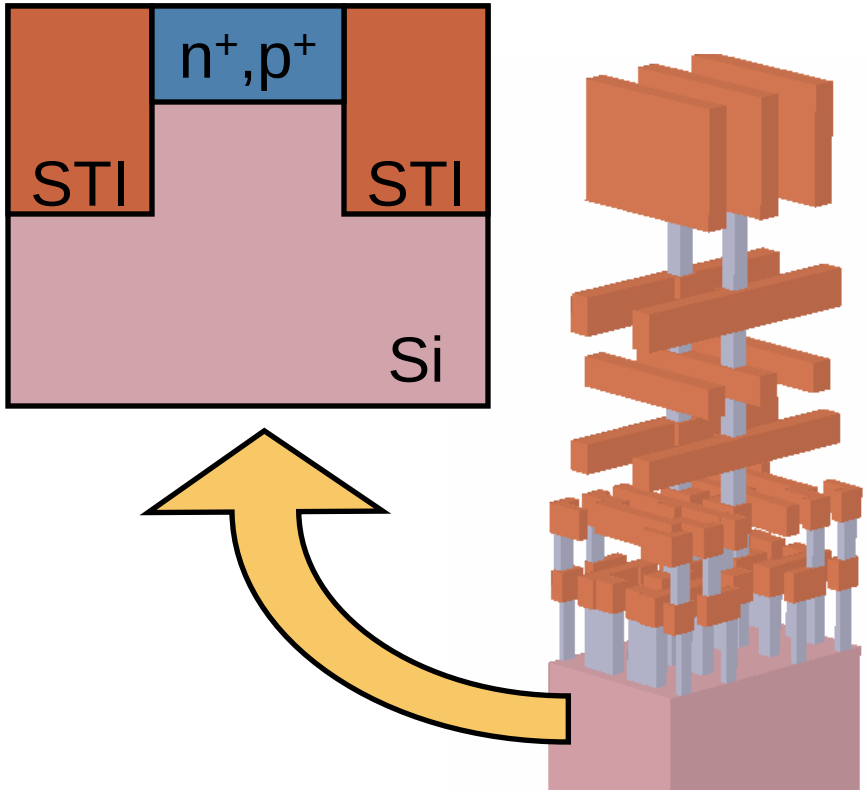
The device was modeled in MRED

- TCAD structure
  - Layout information
  - Metallization



The device was modeled in MRED

- TCAD structure
  - Layout information
  - Metallization
- Sensitive volume
  - Layout and process boundaries
  - Calibrated using TCAD



The device was modeled in MRED

- TCAD structure
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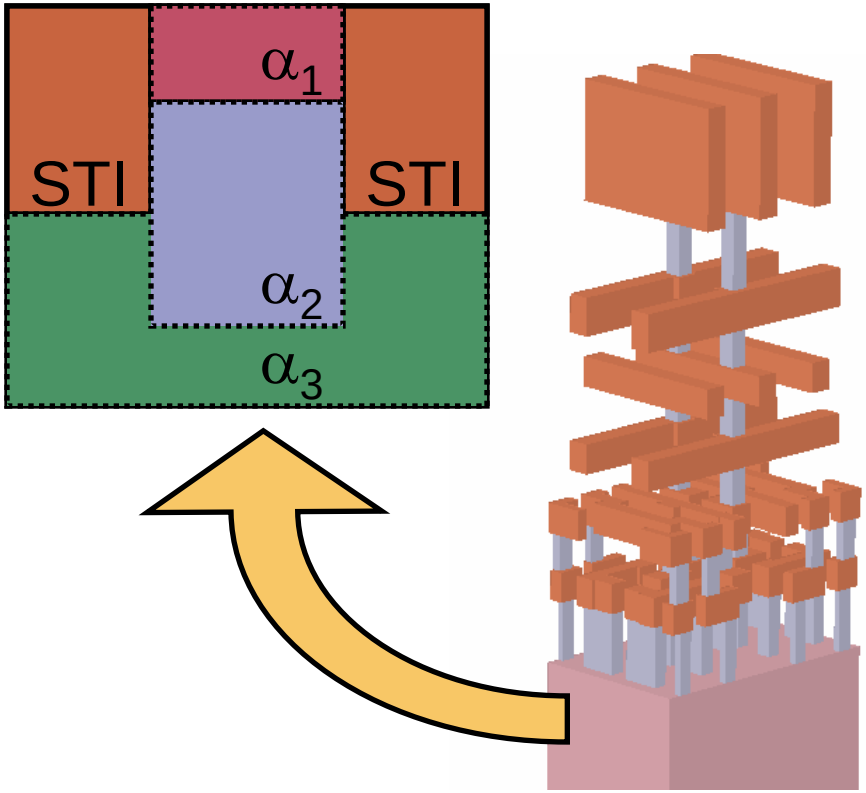
  - Metallization
- Sensitive volume
  - Layout and process boundaries
  - Calibrated using TCAD
  - Nested approach
    - Charge collection efficiency, α



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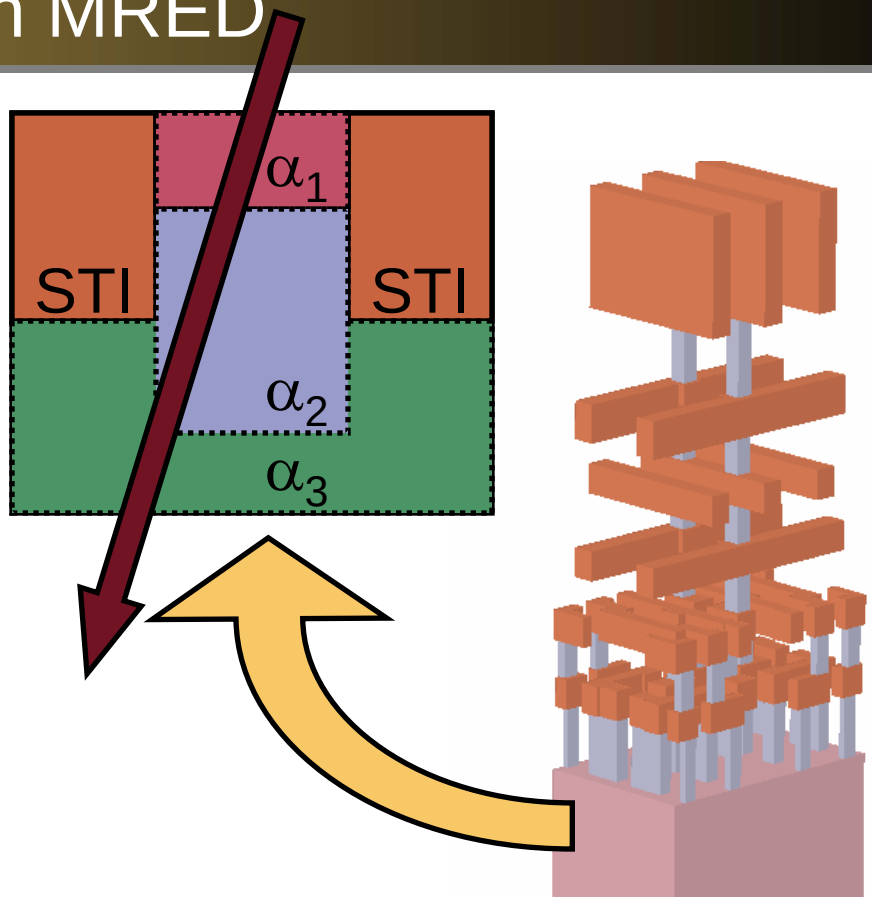
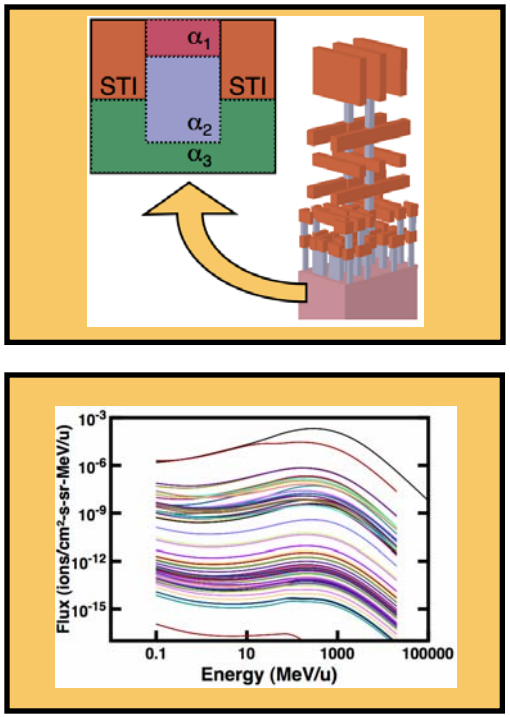
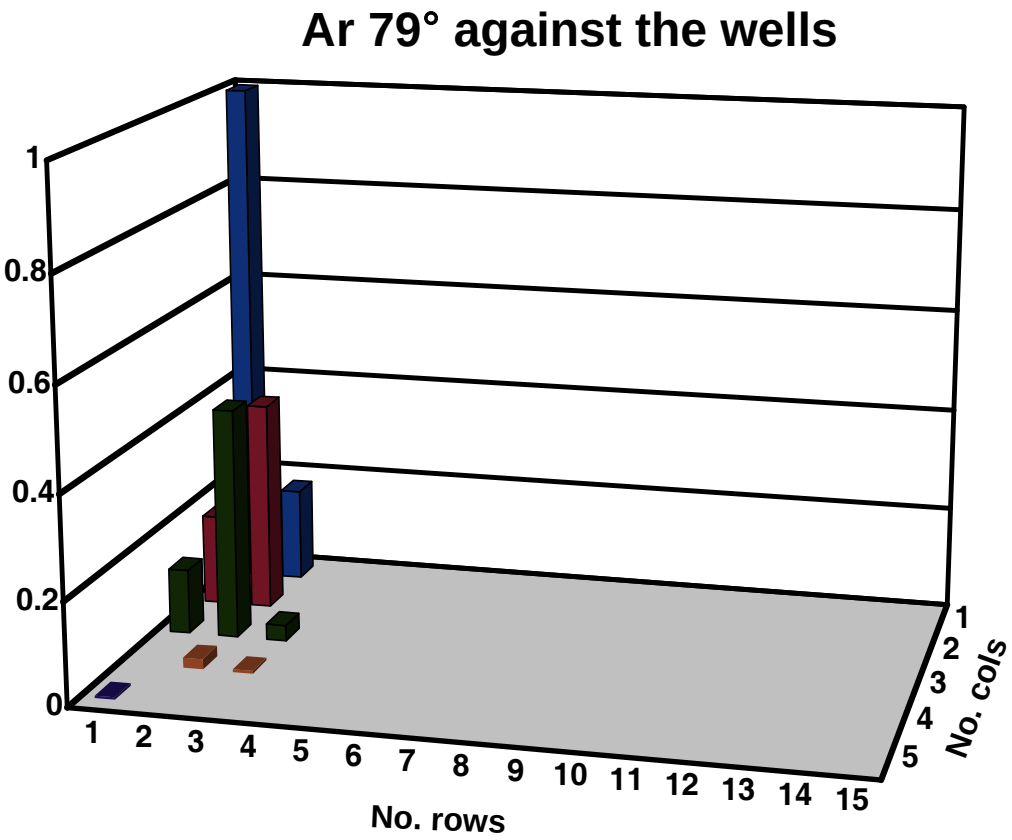


$$Q_{total} = (Q_1 \times \alpha_1) + (Q_2 \times \alpha_2) + (Q_3 \times \alpha_3)$$

MRED simulated a GEO environment



Omni-directional simulation results



Conclusion

- Heavy ion irradiations have been performed
  - SEU varies little with angle of ion incidence
  - MBU depend on the device orientation
- The MBU response depends on the well orientation of the device
- MRED simulation of an omni-directional GEO environment shows the MBU response to be a combination of response from different orientations
- Testing and simulation must account for multiple orientations