# Device-Orientation Effects on Single Event Upsets in 65-nm SRAMs

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2. NASA-GSFC
3. Texas Instruments
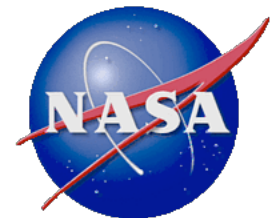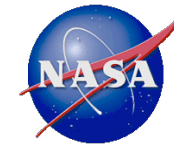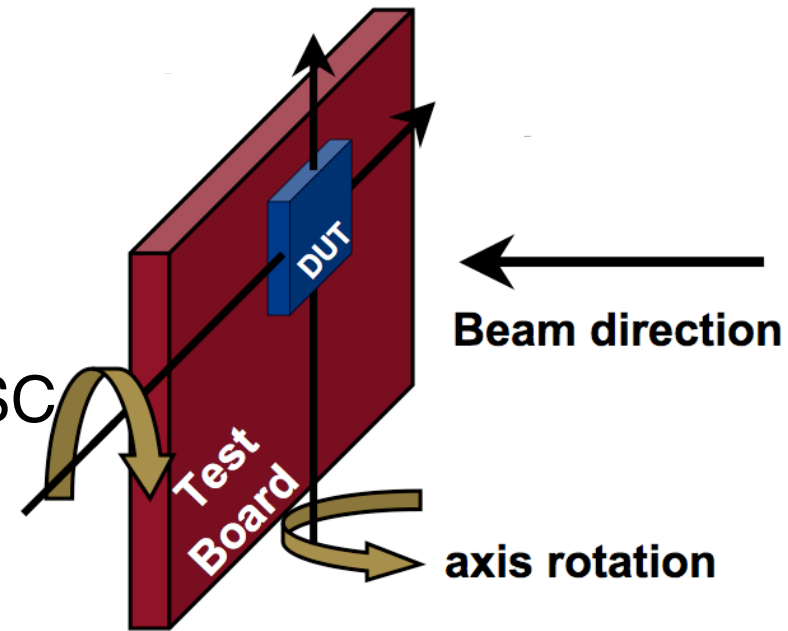
VANDERBILT

School of Engineering

Outline

- Device under test
- Protons
  - Single-event upset (SEU)
  - Multiple-bit upset (MBU)
- Heavy ions
  - SEU
  - Single-bit upset (SBU)
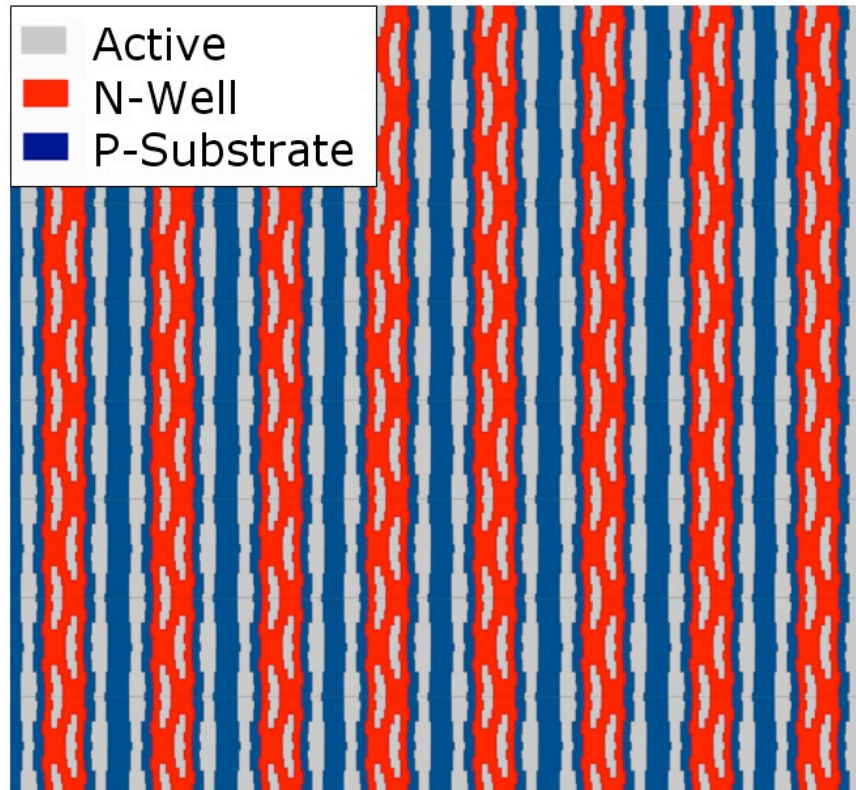 - MBU
- Conclusion

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

- Protons at UC-Davis and IU
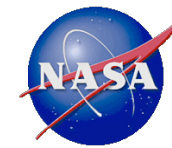
- Low energy protons at NASA-GFSC

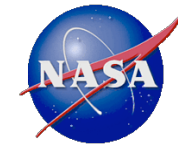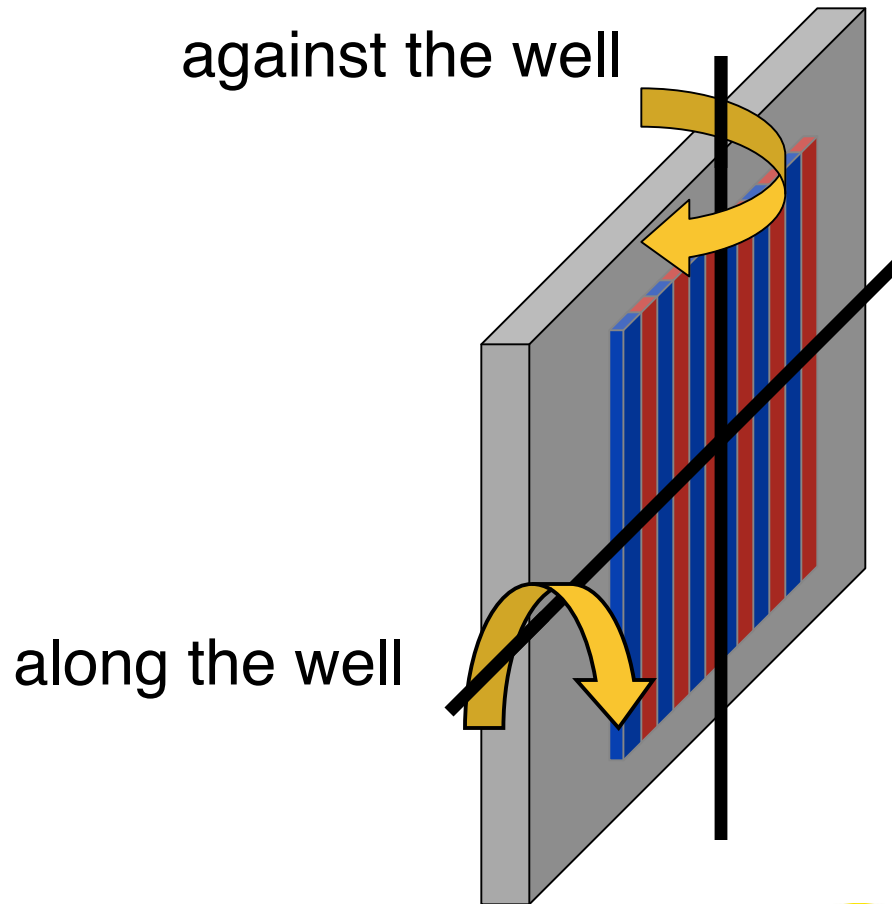# SRAM layout produces alternating columns of wells

Typical High-Density SRAM Layout

Active
N-Well
P-Substrate

from Hutson *et al.*

Define the device orientation by the wells

against the well
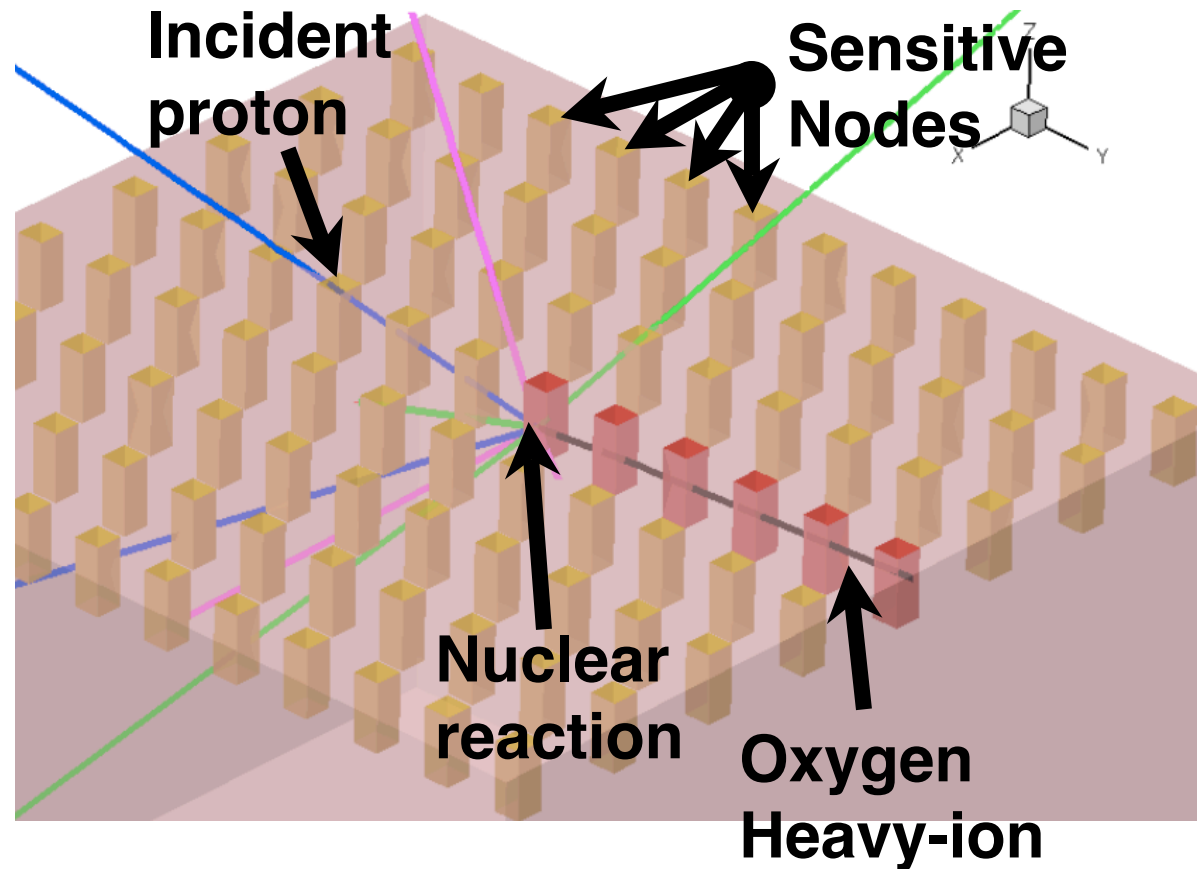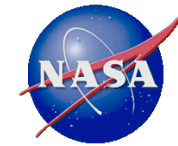
along the well

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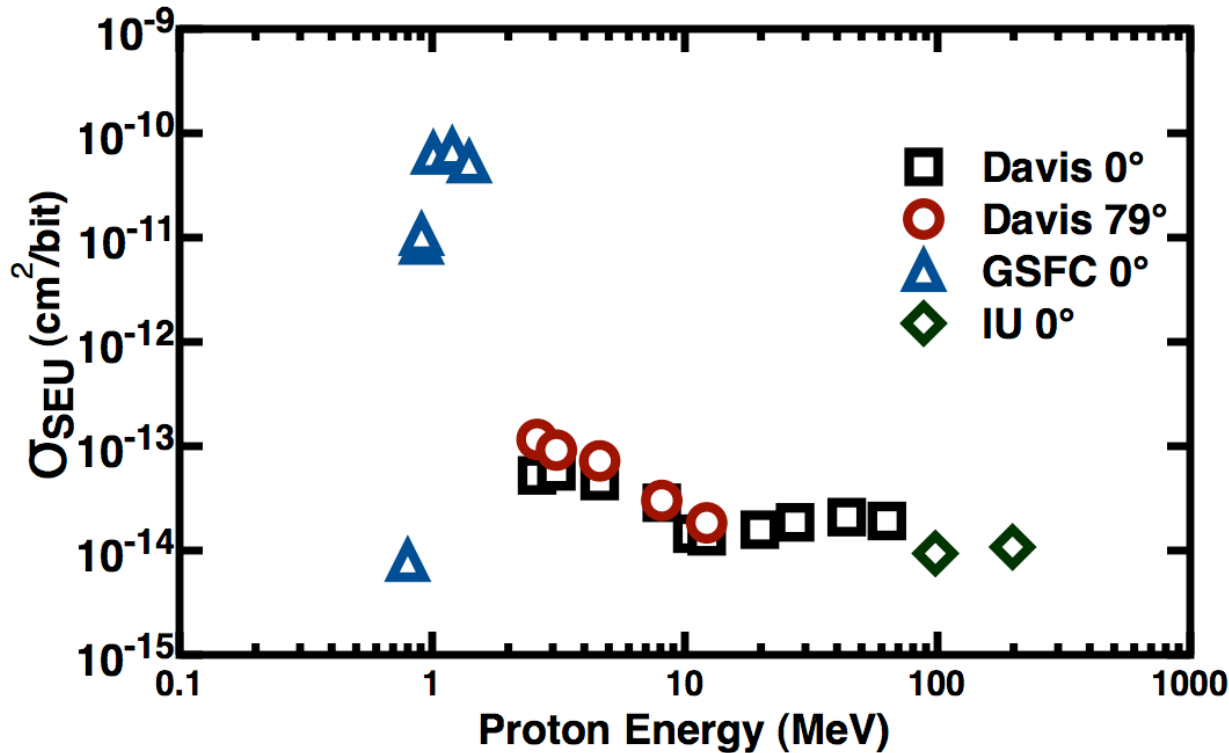 - SEU
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Proton-induced upset differs from heavy-ion

- Protons lightly ionizing

- Proton-induced nuclear reactions

- Secondary products

Incident proton

Sensitive Nodes

Nuclear reaction

Oxygen Heavy-ion
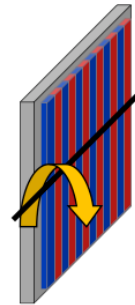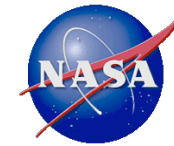
TEXAS INSTRUMENTS

Proton SEU increases at low energies

- Device orientated along the wells
- SEU at grazing angles increases

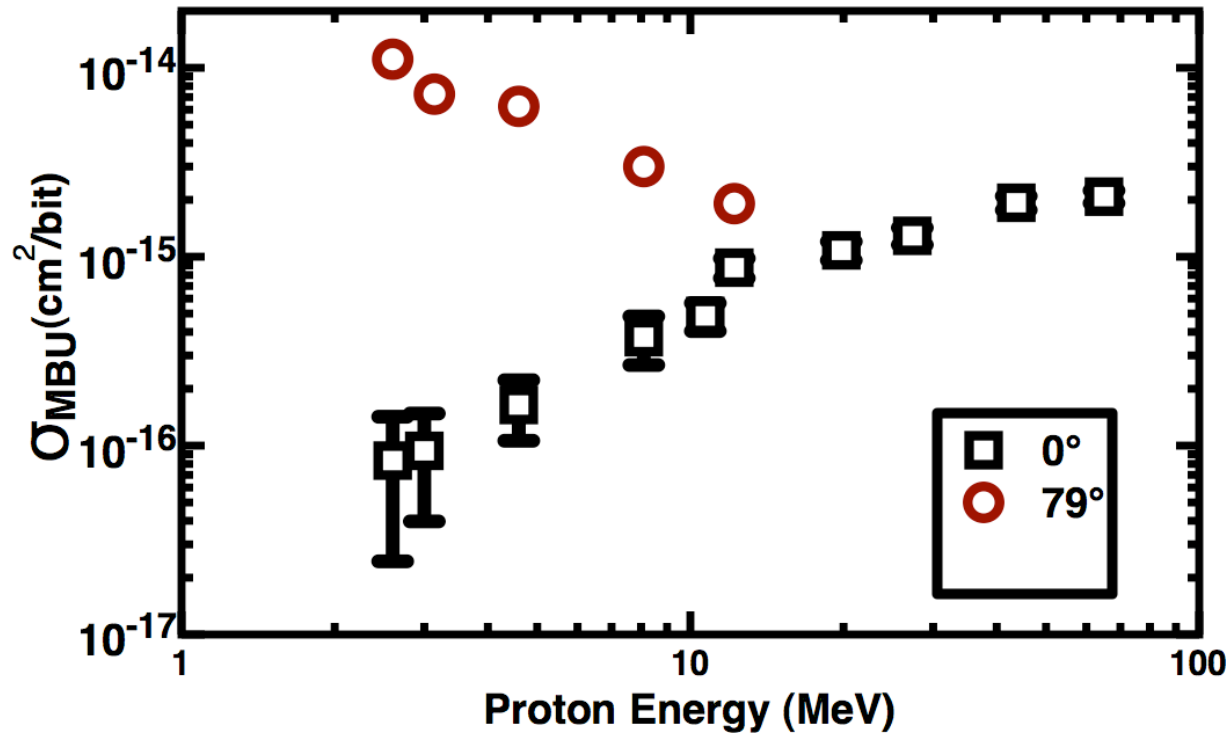$$\sigma_{SEU} = \frac{upsets_{total}}{\phi}$$

along the well

Device under test
Protons
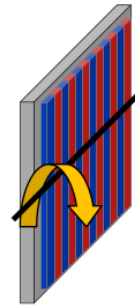Heavy ions
Conclusion

SEU
MBU

Proton MBU cross section larger at grazing angle
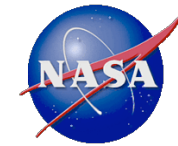
- MBU defined as physically adjacent bit upsets

$$\sigma_{MBU} = \frac{Events_{MBU}}{\phi}$$
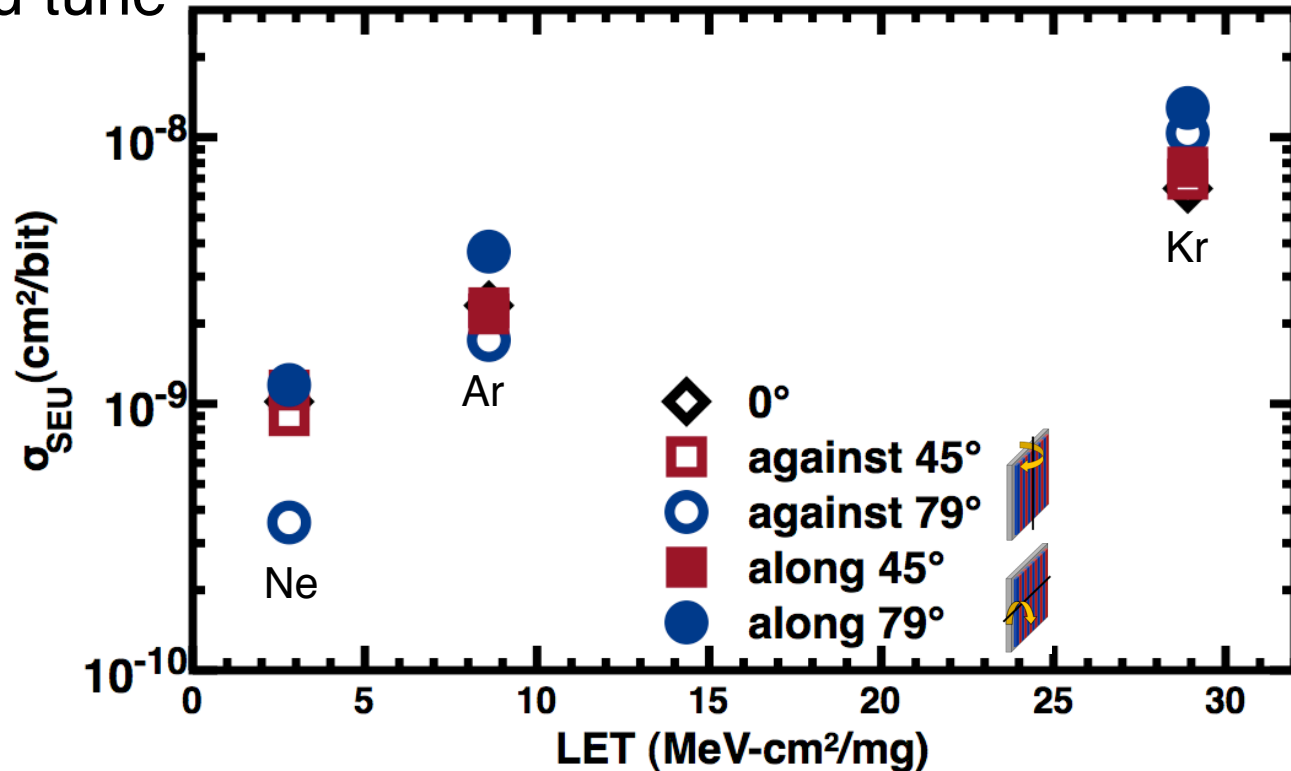

along the well

Outline

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  - SEU
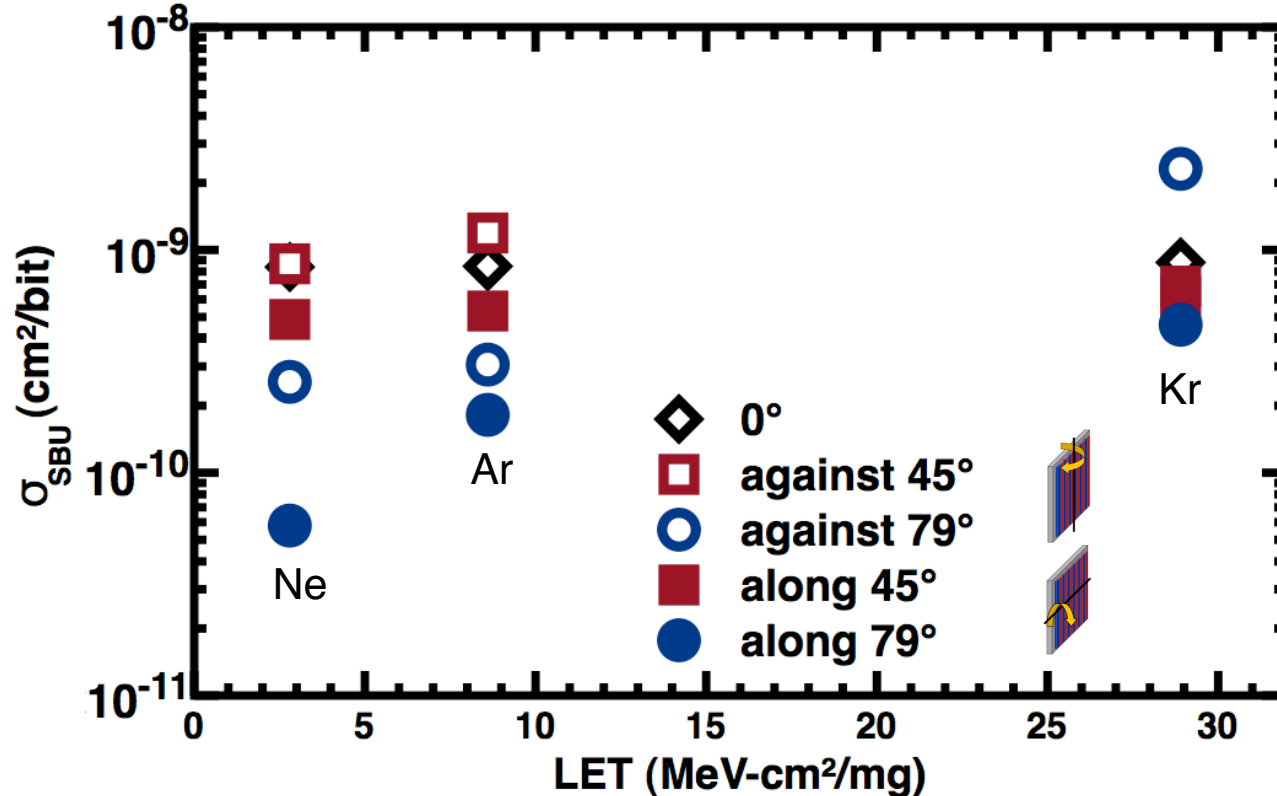 - Single-bit upset (SBU)
  - MBU
- Conclusion

Device under test   SEU
Protons   SBU
Heavy ions   MBU
Conclusion

SEU cross section varies little with orientation

- LET values are at top of DUT

- 15 MeV/u tune

Device under test
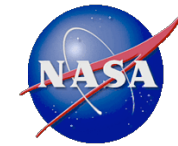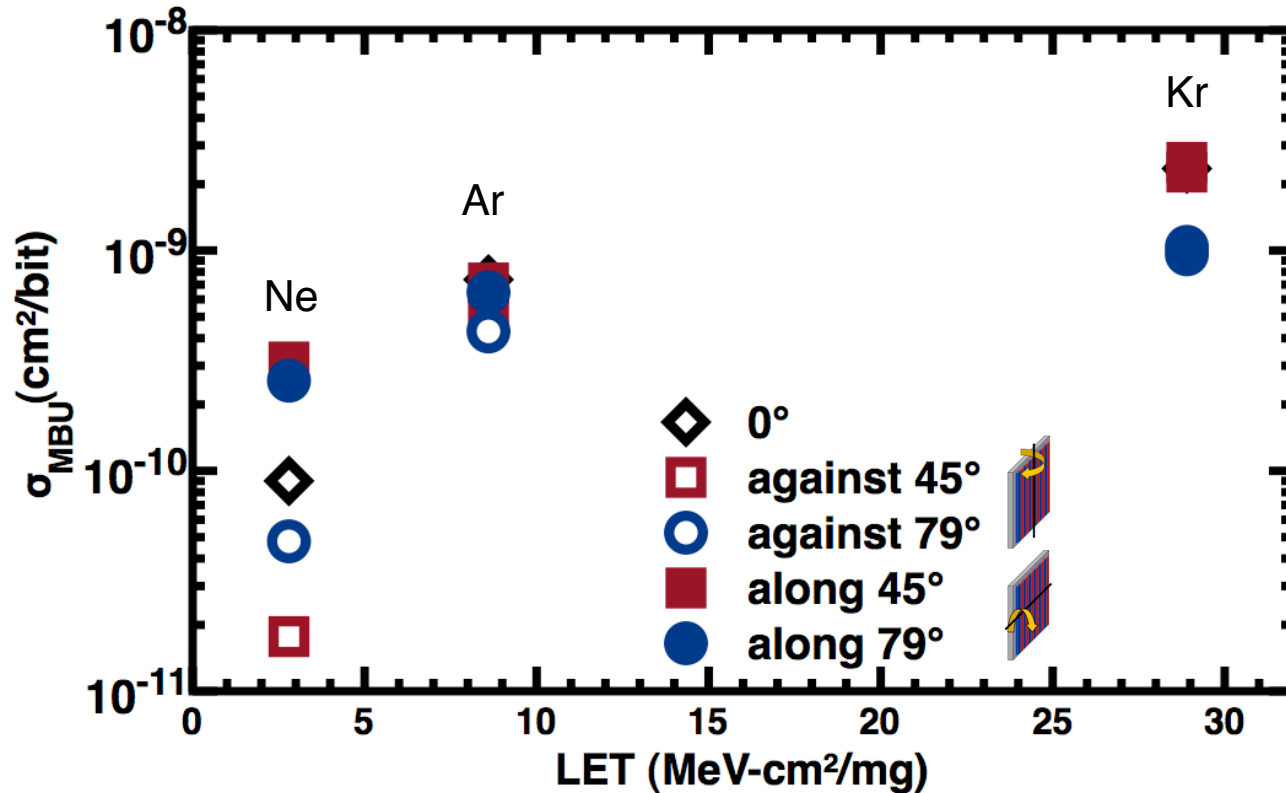Protons
Heavy ions
Conclusion

SEU
SBU
MBU

SBU cross section varies with orientation

- Does not vary across normally incident ions

MBU cross section

- Order of magnitude variation for ^{20}Ne ions
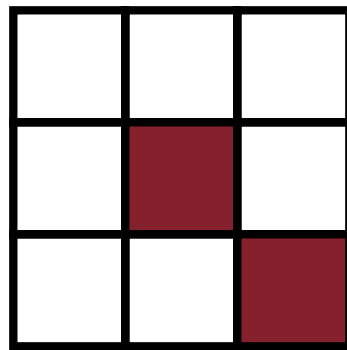
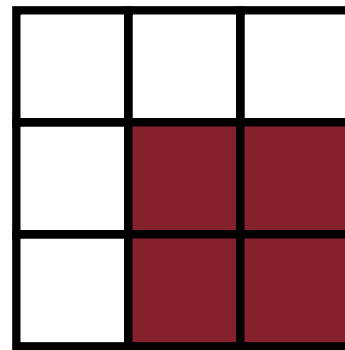Device under test
Protons
Heavy ions
Conclusion

SEU
SBU
MBU

MBU size

- Size is defined as the number of affected rows or columns
- MBU dimension ≡ affected rows x affected columns
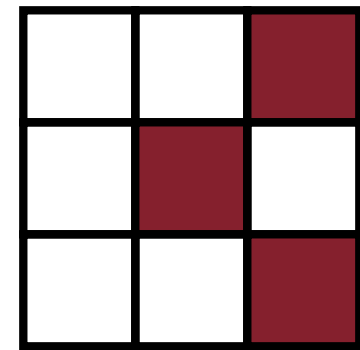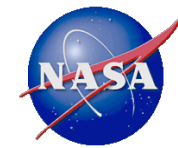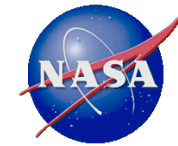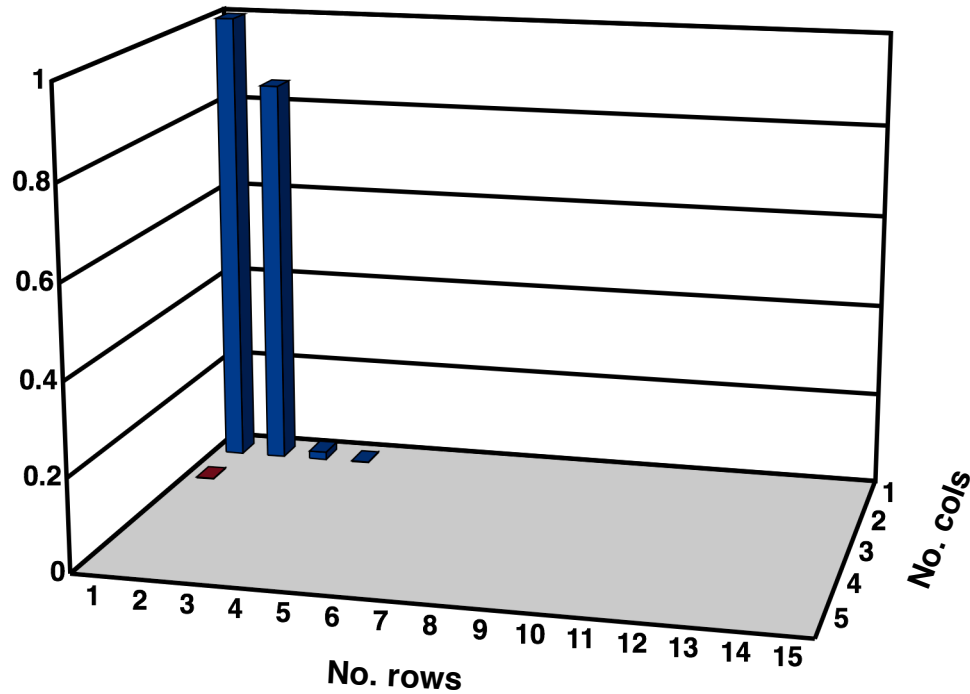- Wells run along the columns
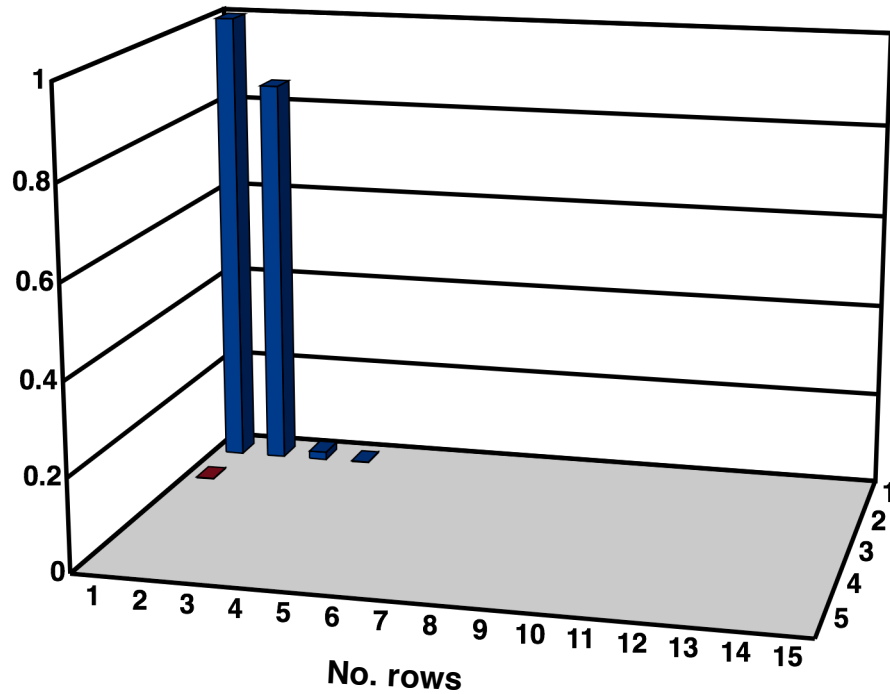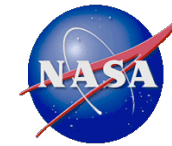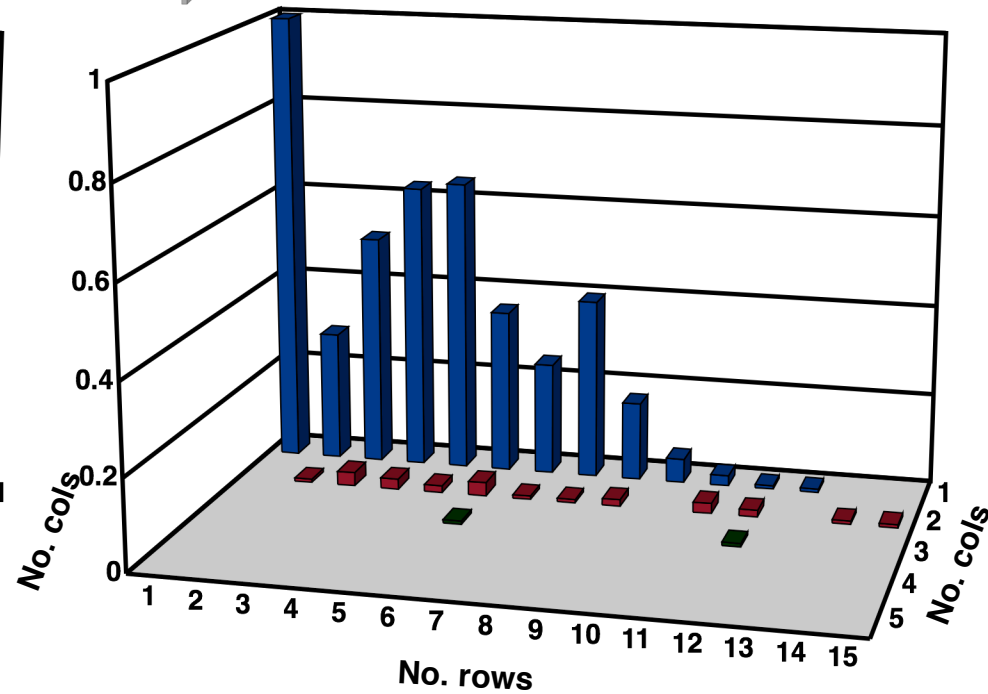- Examples
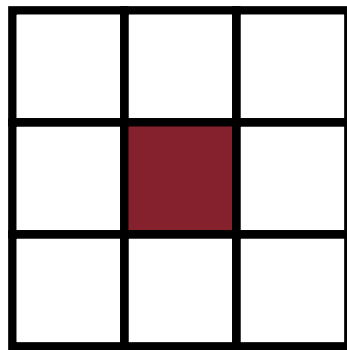
| 1x1 | 2x2 | 2x2 | 3x2 |

MBU size

Ar normal incidence

MBU size

Ar normal incidence

Ar 79° along the well

Device under test   SEU
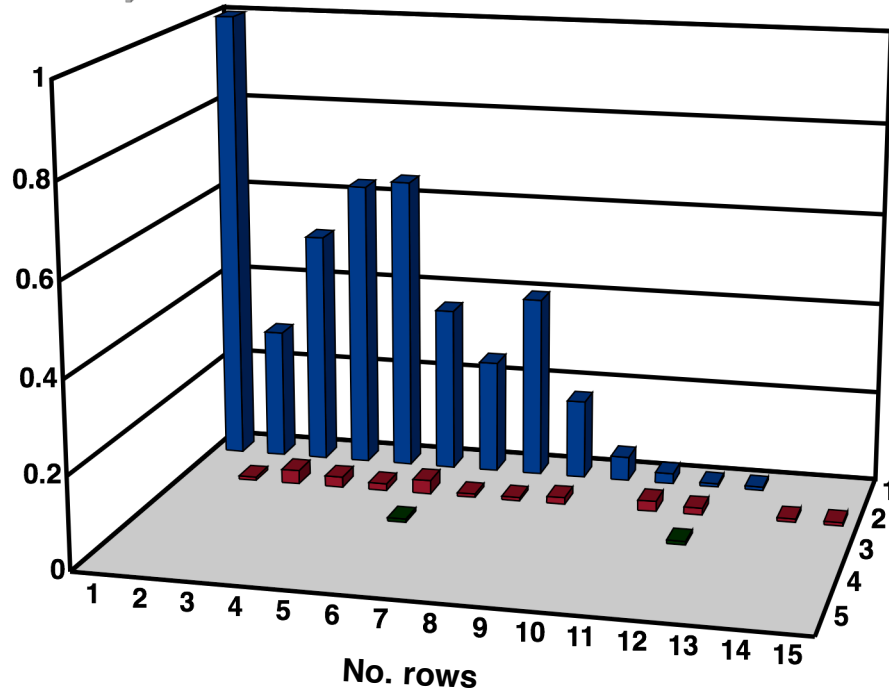Protons   SBU
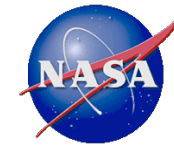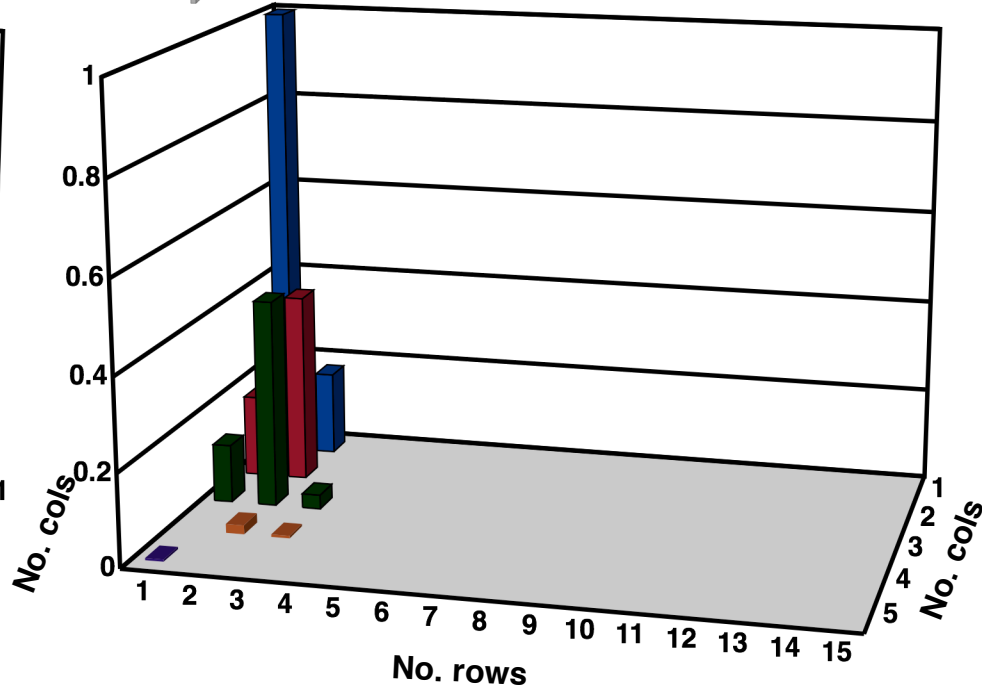Heavy ions   MBU
Conclusion

Shape of MBU events depend on orientation

Ar 79° along the well

Ar 79° against the well

Conclusion

- Proton irradiations have been performed
  - SEU increase for protons < 10 MeV
  - MBU increases for large angles
- Heavy ion irradiations have been performed
  - SEU varies little with angle of ion incidence
  - SBU and MBU depend on the device orientation
- The SEU/SBU/MBU response depends on the well orientation of the device