Automotive Failures from Space?

Neutron and alpha particle single event upset (SEU) failures in SRAM technologies

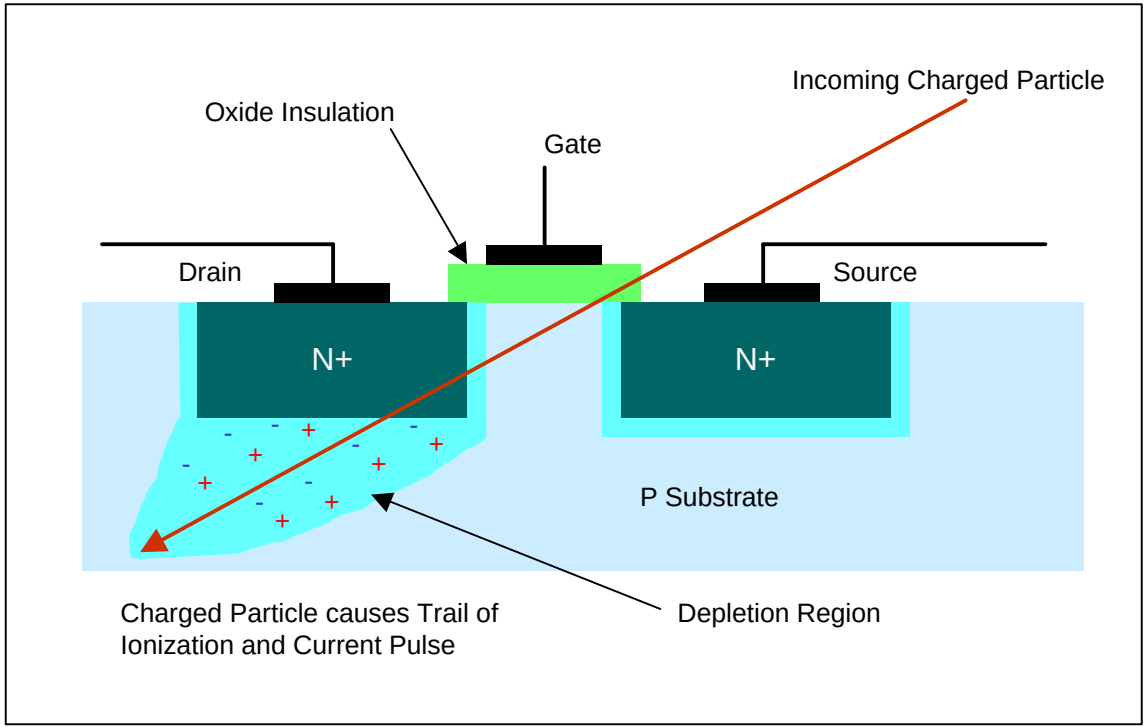
Martin Mason
Director, Automotive Products

Radiation Sources – Neutrons

Radiation Effects in Semiconductors

-
-
  -
  -

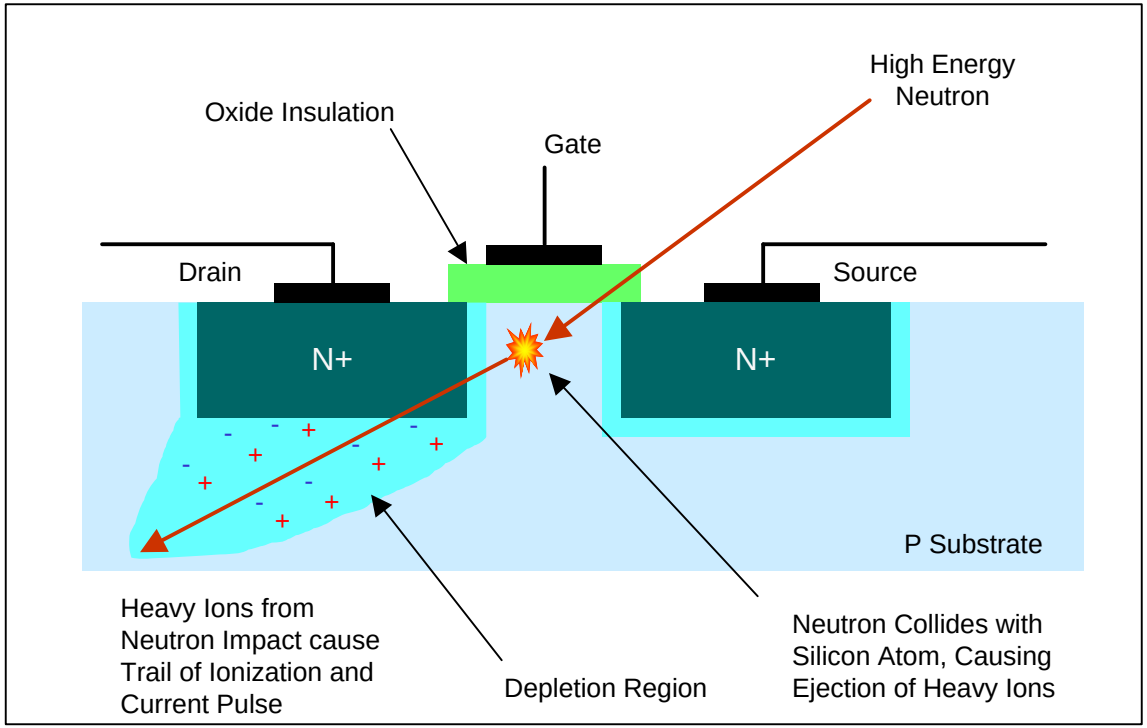
soft errors



Neutron Effects on ICs

-
-
-

Neutron-induced upsets are <u>secondary</u> effects



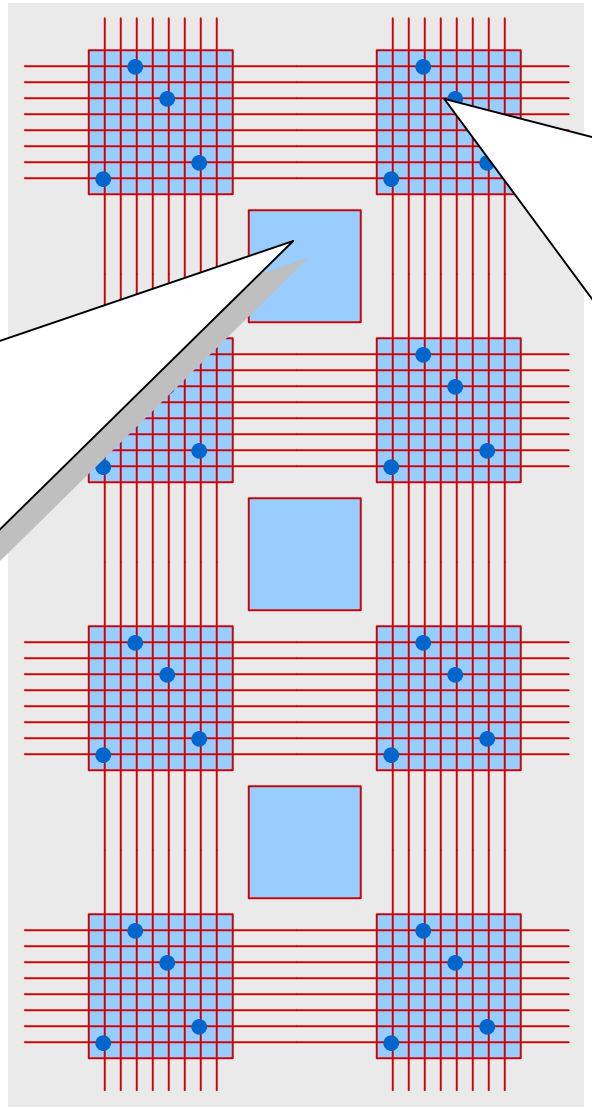
Soft Errors – Industry-Wide Issue

- *Paper - “Soft Memory Errors and Their Effect on Sun-Fire Systems”*
- *Internal procurement specs requiring soft error characterization*
- *Papers discussing soft errors versus hard errors*
- *2003 Military & Aerospace Electronics paper*
- *2004 Automotive conference paper*
- *Soft error Webinar*
- *Soft error resistant SRAM*
- *Soft error white papers*
- *JESD-89 spec covering soft error measurement*
- *June 2002 report lists soft errors as a growing concern*

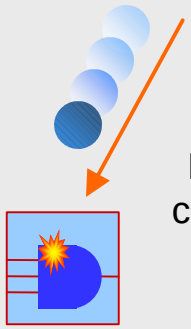
Definitions...
Soft and Firm Errors

-
  -
  -
-
  -
  -
-

Examples of Firm Errors in SRAM FPGAs

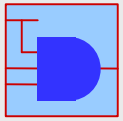


Logic Module



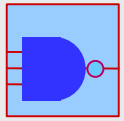
Incoming neutron causes firm error in Logic Module

Firm error leads to . . .



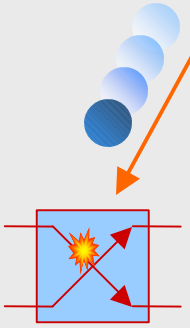
misconnected signal

or



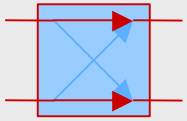
function change

Routing Matrix



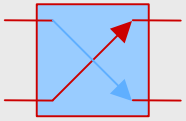
Incoming neutron causes firm error in Routing Matrix

Firm error leads to . . .



misrouted signal

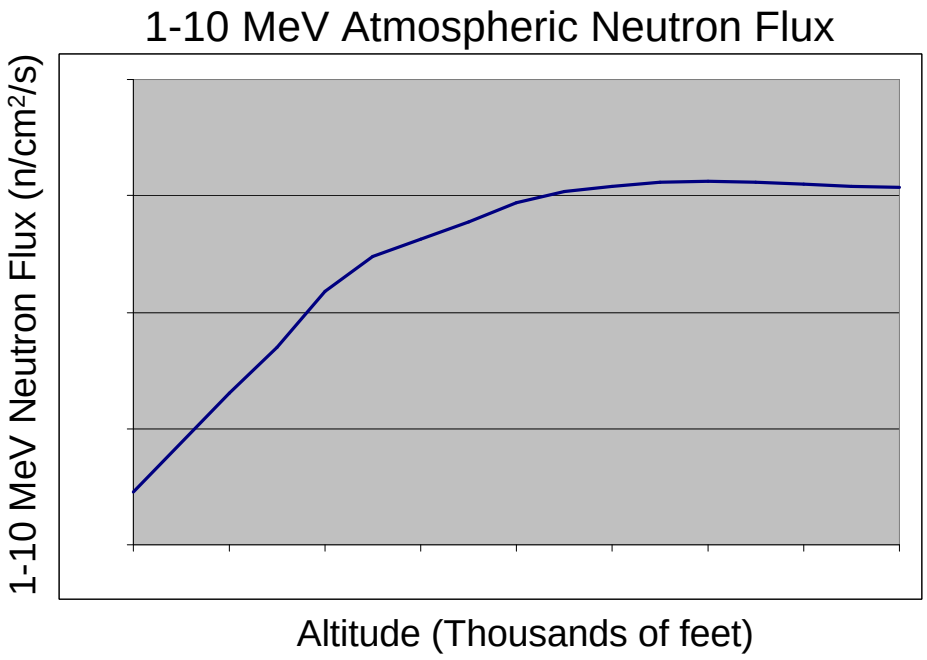
or

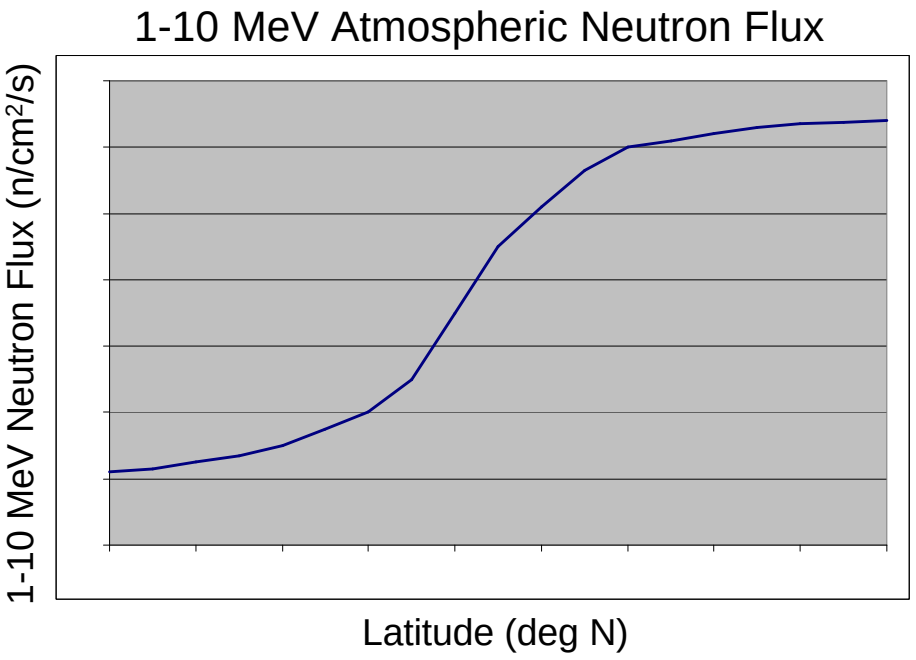


missing signal

Where to find Neutrons

- ***Still a significant Issue at sea-level***
- ***Denver, Colorado is @ 6,000ft***





Neutron Testing

- Comprehensive Programmable Logic testing has been performed
  -
  -
  -
  -
  -
- Real-World testing or Accelerated testing?
  -
    -
    -
  -
    -
    -
- iRoC Technologies – 3rd party testing
  -
    -
    -
      - ***LANSCE matches energy spectrum of naturally-occurring ground-level neutrons***

iRoC Technologies Neutron Testing

- Test Method in compliance with JEDEC JESD-89
  -
  -
    -
    -
    -
      - ***Eliminates flip-flop data upsets which could mask configuration firm errors***
    -
  -
  -
  -
    -
- FIT rates calculated using JEDEC JESD-89 method

$$\text{FIT Rate} = \frac{\text{Number of Failures during Test} \times \text{Flux of Natural Environment} \times 10^9 \text{ Hours}}{\text{Number of Devices Tested} \times \text{Test Fluence}}$$

  -
- Report published on Actel web site
  -

Neutron Test Results Summary – Configuration Failures

Neutron Failure Rate Examples

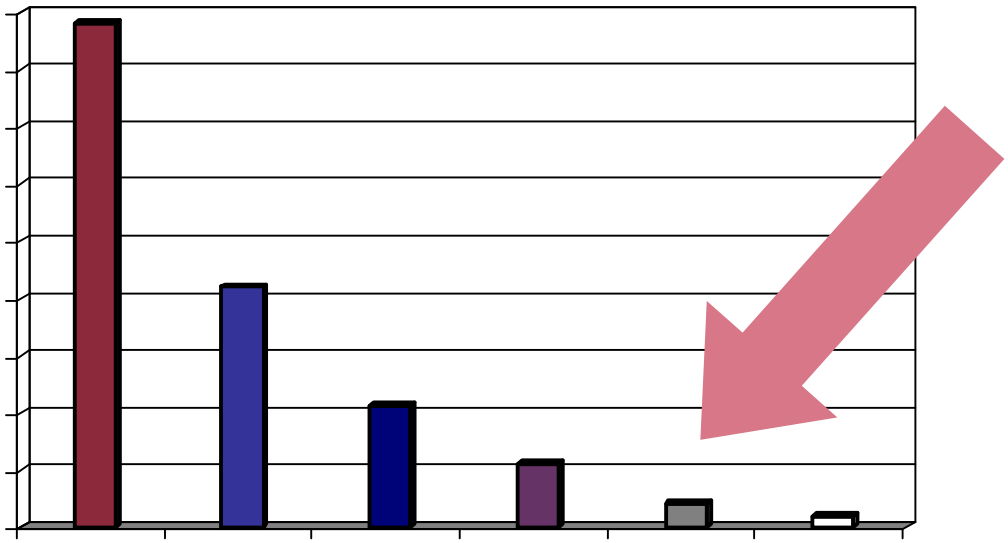
-
-

Where do Alphas Come From?

- Alphas are emitted by naturally-occurring radioactive isotopes
  -
  -
  -
- Alphas are absorbed by very thin layers of material
  -
  -
- Low-Alpha mold compounds are being increasingly used
  -

	a

Deep Sub-Micron Processes Increase Probability of Firm Errors

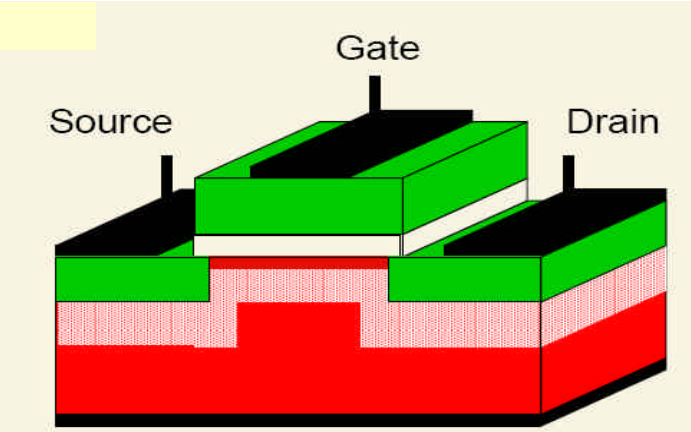


Alpha Test Results Summary

		a	a
		140 FITs	5,600 FITs
		260 FITs	10,400 FITs
		100 FITs	4,000 FITs

Effect of Deep Sub-Micron Processes on Soft Errors

- CMOS technologies continue to shrink and will have a substantial impact on firm errors
  -
    -
  -
    -
  -



Conclusion

- SRAM-based programmable logic is susceptible to firm errors even at ground level
  -
- Non-volatile (anti-fuse and flash) based FPGAs are immune to firm errors
- Advancing process technology predicted to make the problem worse
- Data confirmed by independent, third party research