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# Single Event Latchup Results for COTS Devices Used on SmallSat Missions

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We present single event latchup (SEL) results for a variety of microelectronic devices frequently designated for SmallSat missions. The data presented is only a small representation of all the SEL tests performed in 2019.

# Devices

1. *TMS320F28027*
   - TI 32-bit Piccolo Microcontroller
2. *TMS320F28335*
   - TI 32-bit Delfino Microcontroller
3. *MCP14700*
   - Dual Input Synchronous MOSFET Driver
4. *CY7C104CV33*
   - 4-Mbit (256K x 16) SRAM, 3.3V VCC
5. *DS1834AU*
   - Dual EconoReset, 5V & 3.3V POR
6. *ADR4525*
   - Voltage Reference, Low Noise & High Accuracy

# Test Facility

Heavy-ion SEL measurements were performed at the Brookhaven National Laboratory's (BNL) twin Tandem Van De Graaff accelerator SEE test facility

Linear Energy Transfer (LET) and range values provided are for ion beams used for our measurements at normal incidence in vacuum

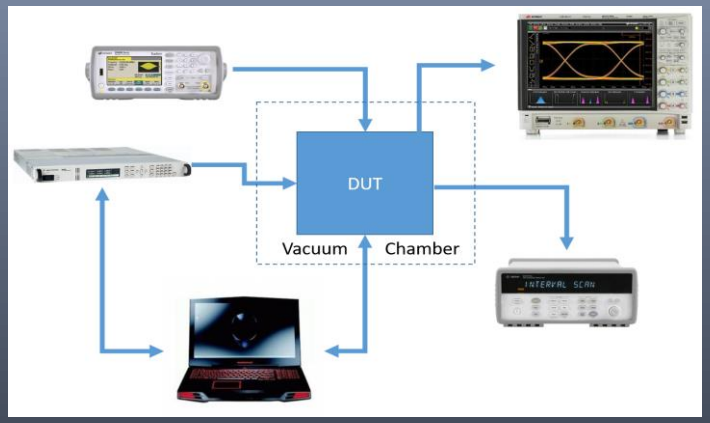
| Ion | LET (MeV-cm$^2$/mg) | Range (μm) |
|---|---|---|
| $^{28}$Si | 8.0 | 74 |
| $^{35}$Cl | 11.7 | 59 |
| $^{48}$Ti | 19.8 | 40 |
| $^{58}$Ni | 26.6 | 42 |
| $^{81}$Br | 37.5 | 36 |
| $^{127}$I | 59.7 | 31 |

# Test Procedure

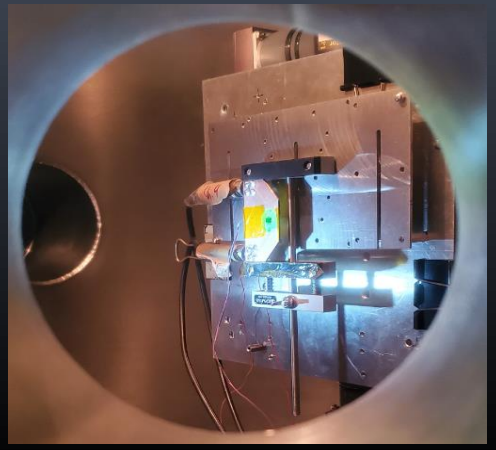
- Test devices were delidded/thinned and evaluated prior to heavy ion testing
- Devices were irradiated at normal incidence in vacuum operating at application voltage(s)
- Devices were tested for functionality before, during, and after running the beam
- Fifty latchup events were accumulated or a beam fluence of $1x10^7$ ions/$cm^2$
- Beam flux ranged from $1x10^2$ to $5x10^4$ ions/$cm^2$/s
- Devices were tested for SEL at both room & elevate/application temperatures
- Induced latchup, turned off the beam, held the device in a latched state for several minutes, repeated several times in an attempt to gain confidence in device survivability
- Followed ASTM F1192 & JEDEC JESD57 standards

# Test Setup

- Used evaluation boards or in-house, application circuit designed boards
- Direct external power supplied to all DUT rails, running custom SEL detection software



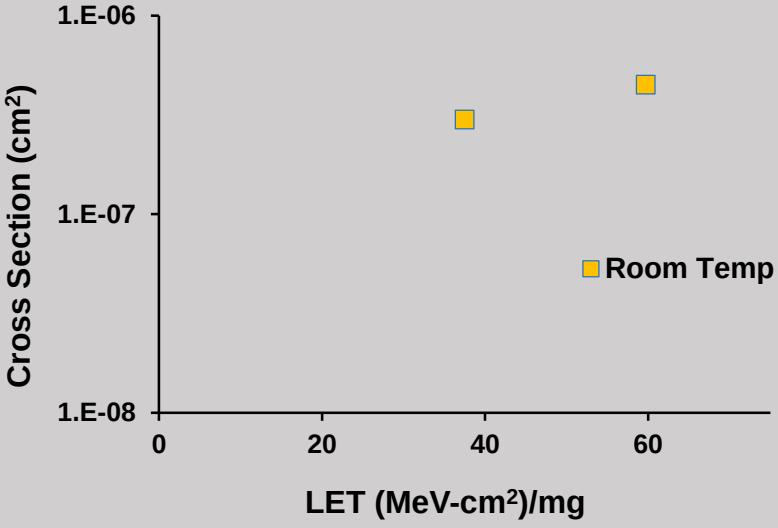

- DUTs mounted to the test plate in the chamber



# Test Results

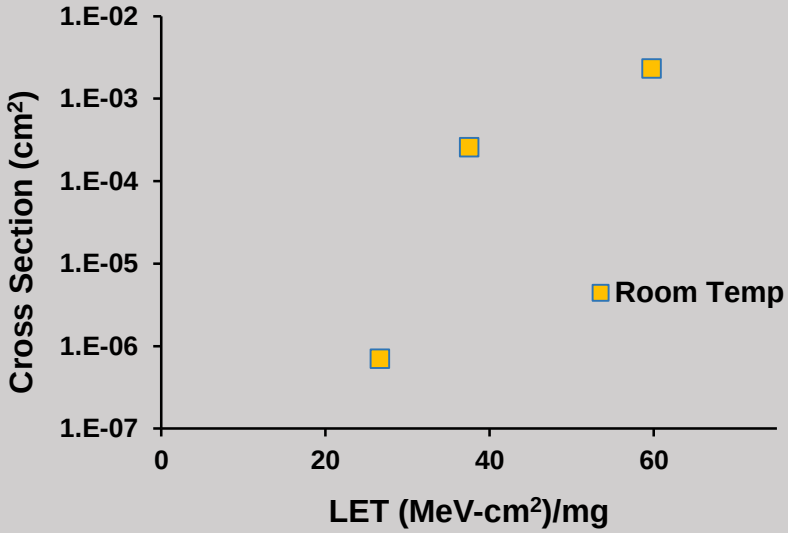
## TMS320F28027

- Two devices tested at ambient temperature
- $V_{DDCORE}$ = 1.8V & $V_{DDIO}$ = 3.3V
- SELs observed at LET of 37.5 MeV-cm$^2$/mg
- No SELs at LET of 26.6 MeV-cm$^2$/mg
- Supply current increased up to 350mA
- Microcontroller recovered after power cycle



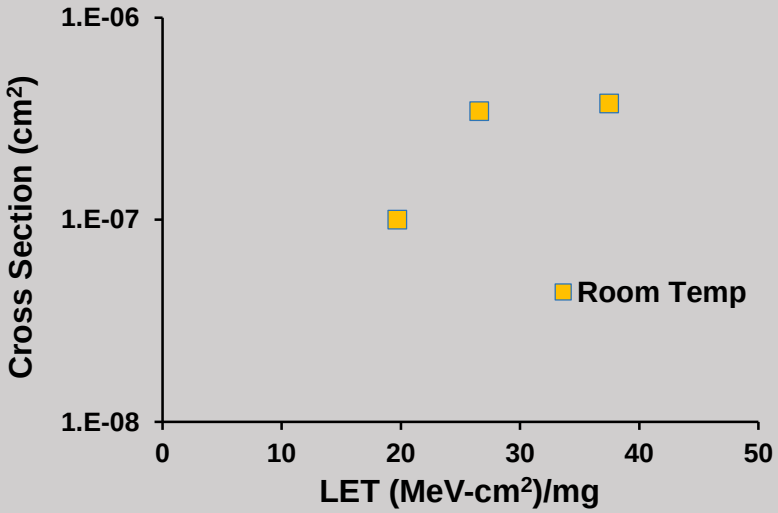

## TMS320F28335

- Three devices tested at ambient temperature
- $V_{DDCORE}$ = 1.8V & $V_{DDIO}$ = 3.3V
- SELs observed at LET of 26.6 MeV-cm$^2$/mg
- No SELs at LET of 19.8 MeV-cm$^2$/mg
- Supply current increased up to 1A
- Microcontroller recovered after power cycle



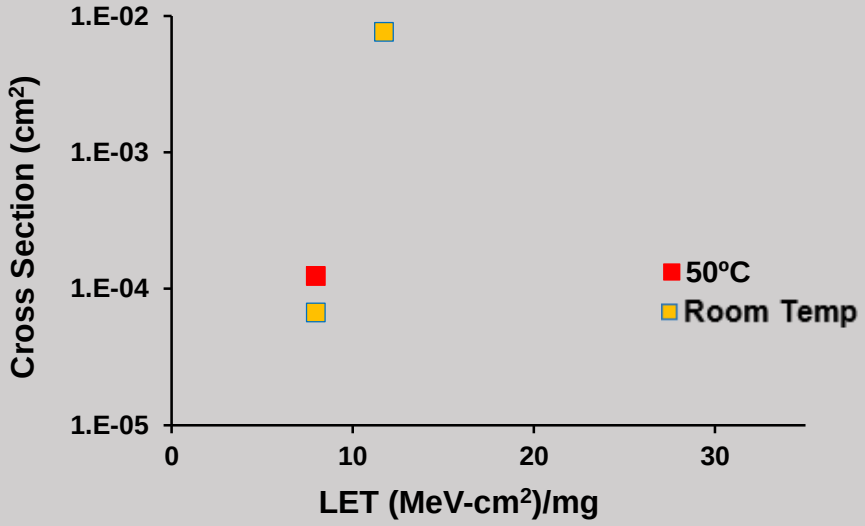
## MCP14700

- Four devices tested at ambient temperature
- $V_{CC}$ = 5V & $V_{BUCK}$ = 12V
- Application circuit with 2 N-Channel FETs
- Destructive effects observed either from SEL or possible shoot-through
- $LET_{TH}$ for destructive effect is between 11.7 and 19.8 MeV-cm$^2$/mg



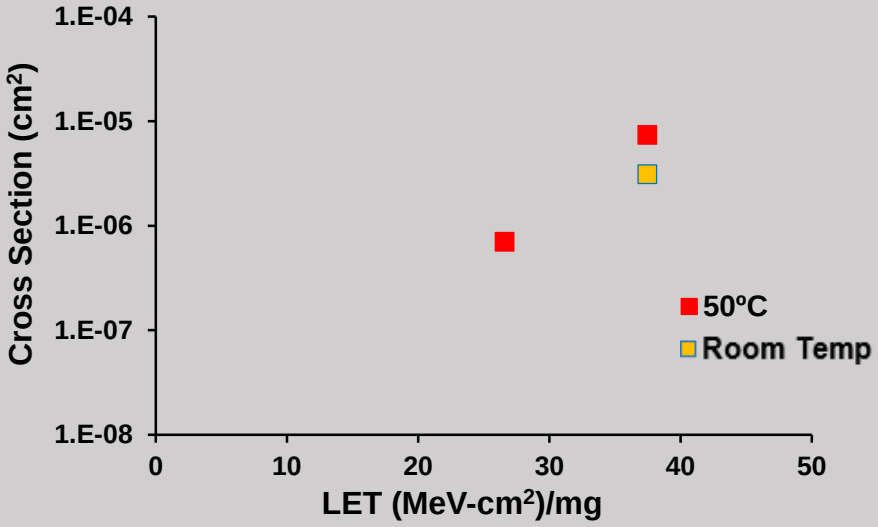

## ADR4525

- Three devices tested at ambient & at 50°C
- $V_{IN}$ = 3.3V
- Observed high transient current events
- Supply current increased by 18mA and almost immediately dropped back to nominal levels
- Beam possibly inducing latchup and activating a sensitive power region on the die that causes power cycles or shutdown mode
- Great candidate for pulsed laser testing



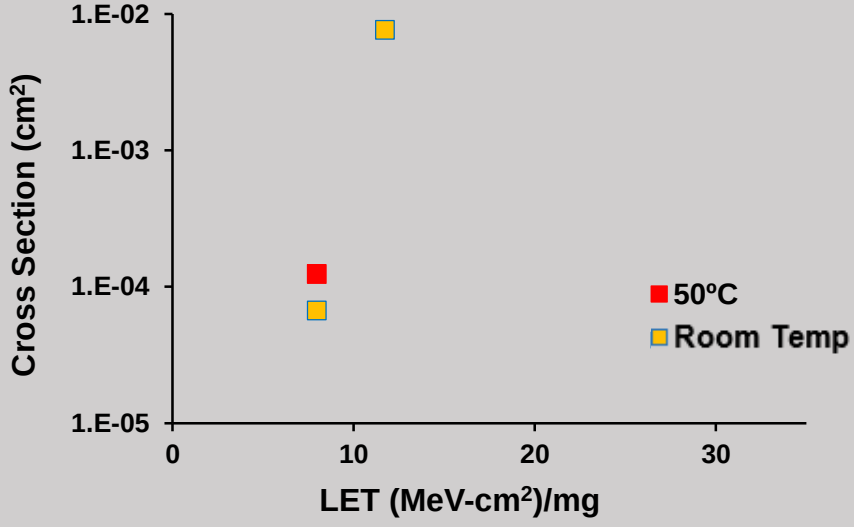
## DS1834AU

- Three devices tested at ambient & 50°C
- $V_1$ = 3.3V & $V_2$ = 3.3V
- SELs observed at LET of 37.5 MeV-cm$^2$/mg
- No SELs at LET of 19.8 MeV-cm$^2$/mg
- Ambient temp SEL $LET_{TH}$ > 26.6 MeV-cm$^2$/mg
- Device recovered after power cycle




## CY7C104CV33

- Two devices tested at ambient & at 50°C
- $V_{CC}$ = 3.3V
- SEL $LET_{TH}$ is below 8.0 MeV-cm$^2$/mg
- Huge cross-section
- Supply current increased up to 400mA
- SRAM recovered after power cycle



# Conclusion

We have presented SEL data for a variety of COTS microelectronic devices often used on SmallSat missions. The SEL measurements were performed at application voltage(s) and temperature to ensure mission reliability and success. The data presented is only a small representation of all the SEL tests performed in 2019.