Design and Results of a Radiation Test System for SEE and TID Assessment of the VLAST-P CsI(Tl) Calorimeter Readout Electronics

中国科学技术大学
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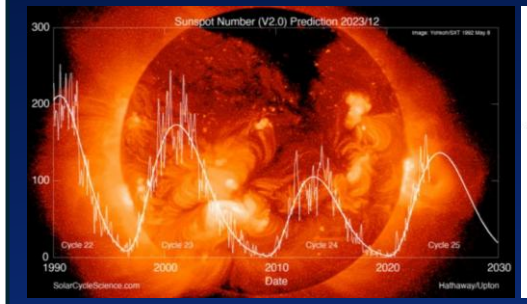
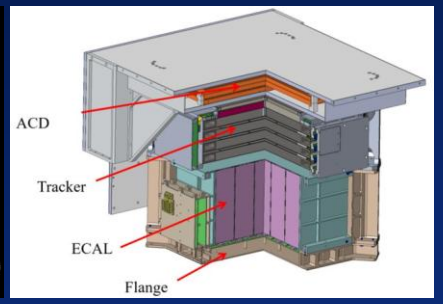
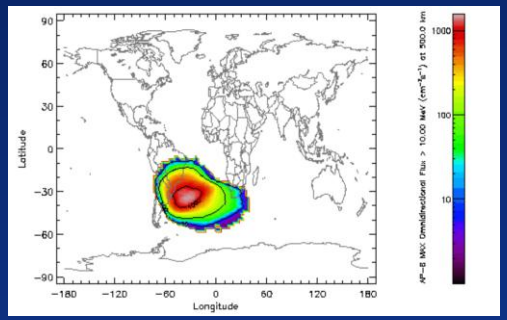
VLAST-P(Very Large Area gamma-ray Space Telescope-Pathfinder)





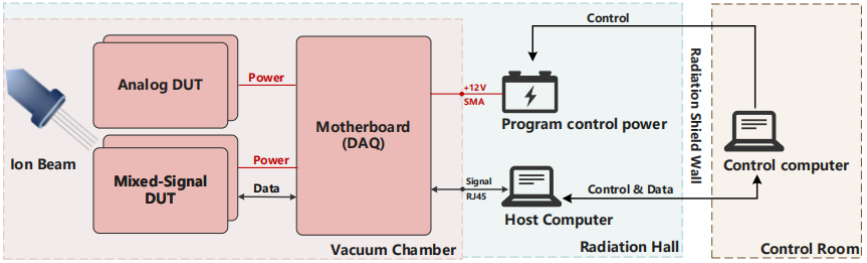
- VLAST-P: Observe high-energy solar gamma rays and protons
- CsI(Tl) Calorimeter: Measure particle energy and select events
- Orbit: Operates in low-Earth Sun-synchronous orbit (~500 km)
- Radiation Environment: Low-Earth orbit exposure, enhanced proton flux in South Atlantic Anomaly, background cosmic rays



Radiation Effects in Electronics

- Single-Event Effects (SEE): radiation effects from single particles
  - · Single-Event Upset (SEU): particle-induced register upset, restored by refresh
  - · Single-Event Latch-up (SEL): abnormal high-current state, cleared by power shutdown
- Total Ionizing Dose (TID): cumulative dose degradation, seen as noise/current drift

- ≥ 50 krad(Si) : LEO TID Margin
- ~10 μs : SEL Mitigation Target



Ground-based Heavy-ion Irradiation Test System

- Evaluate radiation reliability
- Characterize SEE and TID effects
- Assess recovery capability

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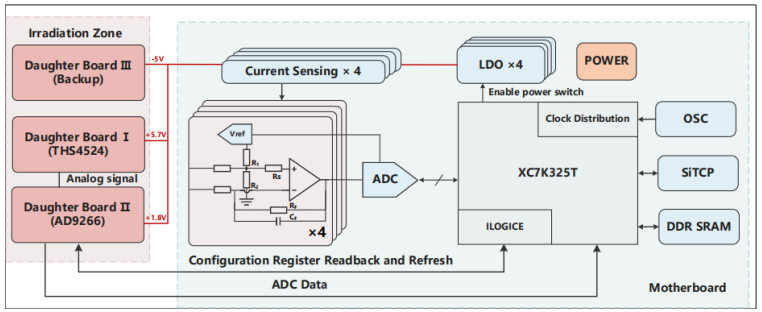
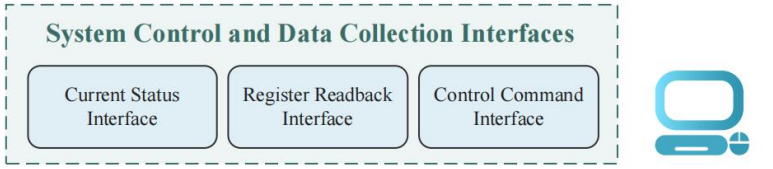
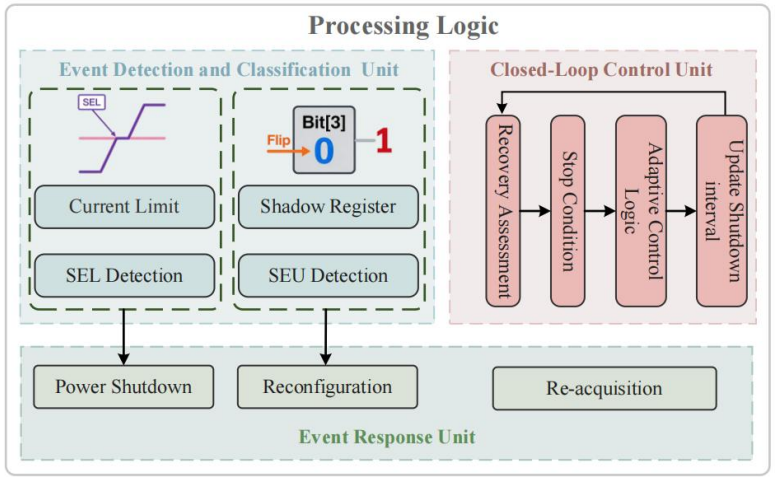






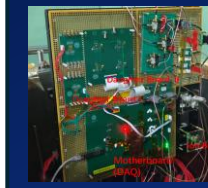
Hardware Design

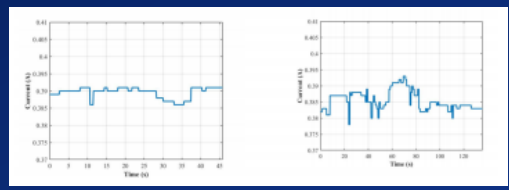
- Radiation-decoupled modular DAQ architecture
- Fast and redundant power protection
- Flexible analog / mixed-signal DUT support

Logic Design

- Real-time SEE monitoring
- Autonomous SEU recovery
- Adaptive SEL recovery characterization
  - · Adaptive shutdown interval optimization
  - · Quantitative recovery time evaluation
- Timestamped event reconstruction

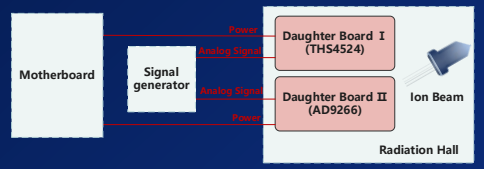
- Heavy-ion irradiation test
- Ion range: 30.3 μm
- LET 15: Cl, 109 MeV, fluence 1.70 × 10^6 ions/cm²
- LET 37: Ge, 205 MeV, fluence 1 × 10^7 ions/cm²





45 SEUs detected and automatically recovered in AD9266.

- ^{60}Co gamma-ray irradiation
- Initial dose: 10 krad
- Over-irradiation: 30 krad after annealing
- Dose rate: 5 krad/h, non-uniformity < 10%



Parameter	Pre-rad	Post-rad	Over-rad
AD9266TCPZ-65EP			
I_{CC}	4.17 mA	5.83 mA	4.5 mA
Noise	75.6 mV	94.7 mV	94.4 mV
THS4524MDBTREP			
I_{CC}	52.62 mA	52.75 mA	50.50 mA
DNL	0.25 LSB	0.27 LSB	0.29 LSB