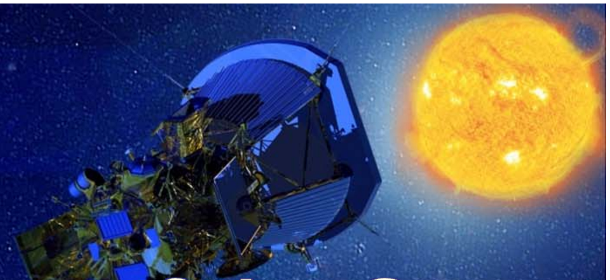
Solar Probe Plus

A NASA Mission to Touch the Sun



Integrated Science Investigation of the Sun Energetic Particles

Preliminary Design Review

05 – 06 NOV 2013

EPI-Lo Technology Development

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Outline

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- EPI-Lo Technology Developments to TRL6
- Performance Requirements and Derivation
- Energy System Development
  - Fidelity of Test Article
  - Test and Analysis Results
- Sensor / Timing System Development
  - Fidelity of Test Article
  - Test and Analysis Results
- TOF-D/CFD-D ASIC Development
  - Fidelity of Test Article
  - Test and Analysis Results
- Transition to Flight

EPI-Lo Technology Developments to TRL6

- Species composition driven by two systems: energy system and timing system
- Energy and TOF performance to meet 3He / 4He separation
  - 3He, 4He: 0.5 FWHM AMU
    for incoming energies between ≤0.2 MeV and ≥2.0MeV
  - Validate that one anode covering two sensors has adequate timing performance – quadrant anode design uses significantly less readout electronics than an octant design
  - Validate that SSD has adequate energy performance
- TOF-D and CFD-D ASIC development

EPI-Lo Performance Modeling

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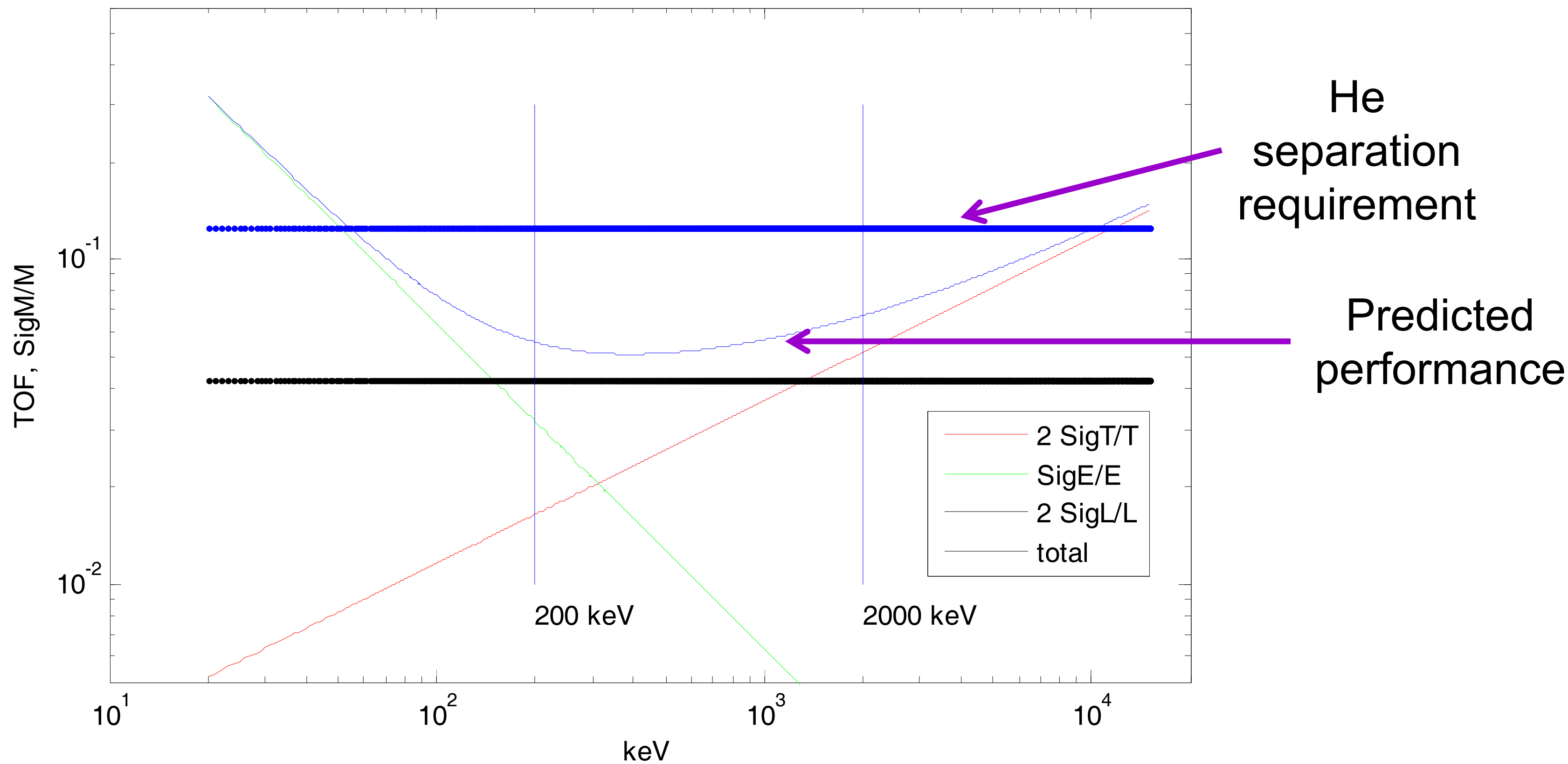
- Two independent models used
  - Monte-Carlo
    - Inputs are timing noise, SSD noise, and path length variation
    - Inputs can by any distribution (not limited to Gaussian)
  - Analytical
    - Inputs are timing noise, SSD noise, and path length variation
    - All inputs are Gaussian
  - The two models have been compared and shown to give identical results
  - Does not include foil losses (not significant for >200 keV He)
- **Modeling shows 400 ps FWHM, 15 keV FWHM performance comfortably meets requirements**

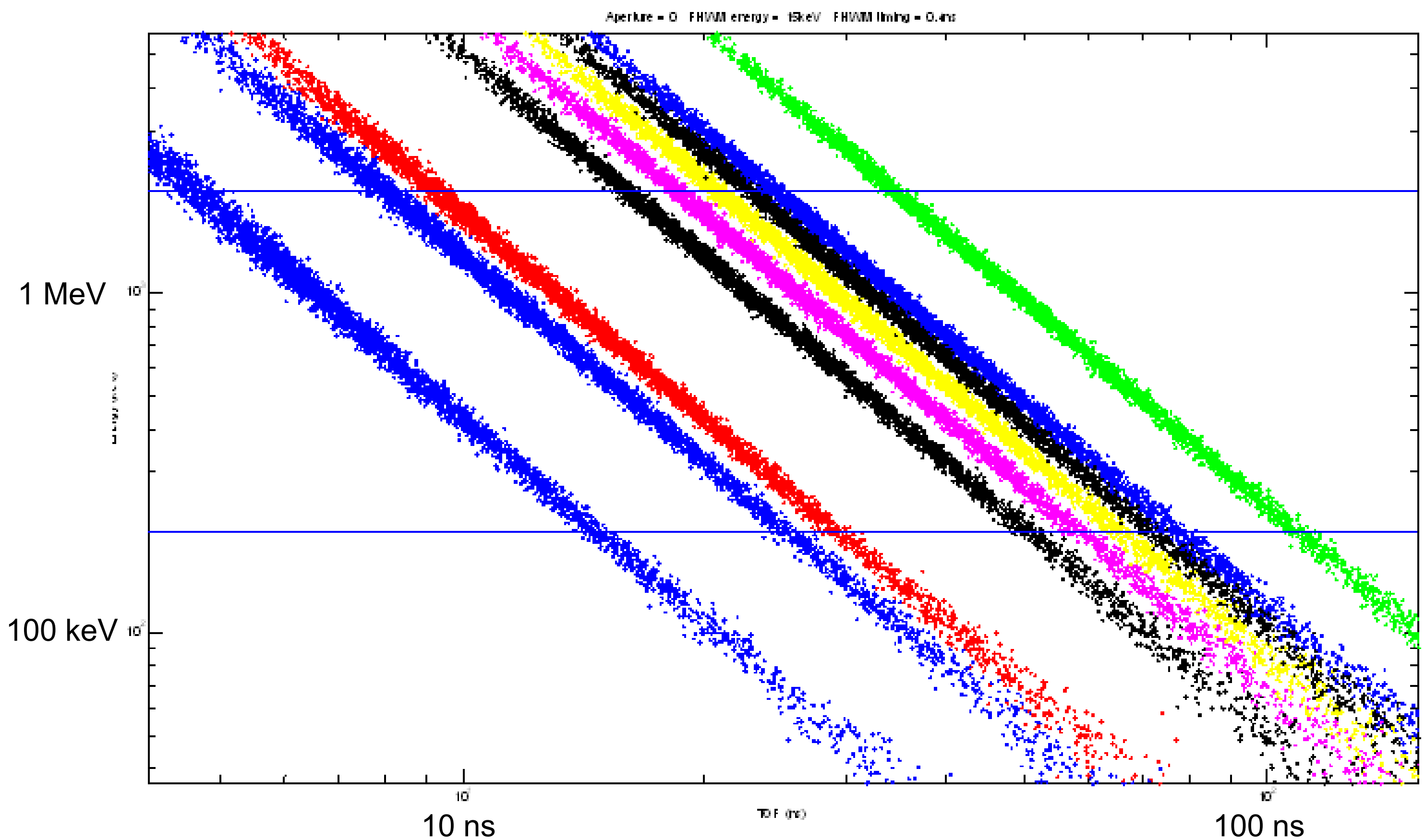
He Separation Requirements

- At low energies the energy resolution dominates performance
- At high energies the timing resolution dominates performance
- Predicted performance has ample margin from requirement



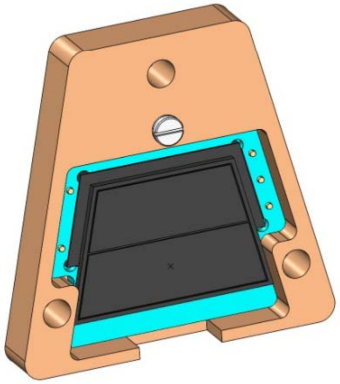
Track Simulations

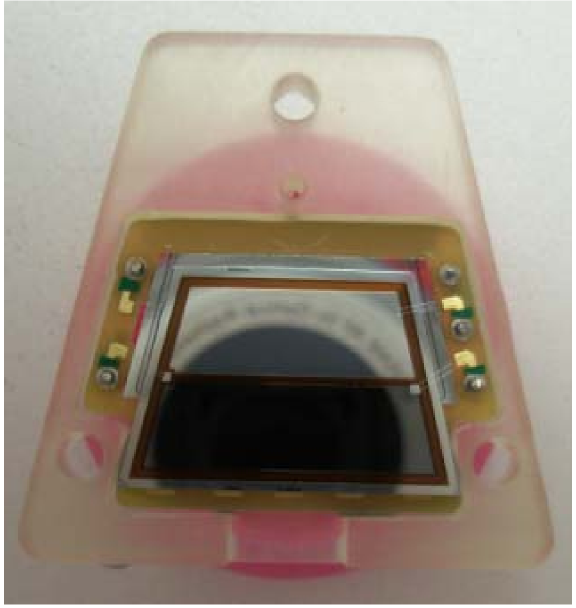
- Monte-Carlo model for all species with 400 ps FWHM timing and 15 keV FWHM energy resolutions

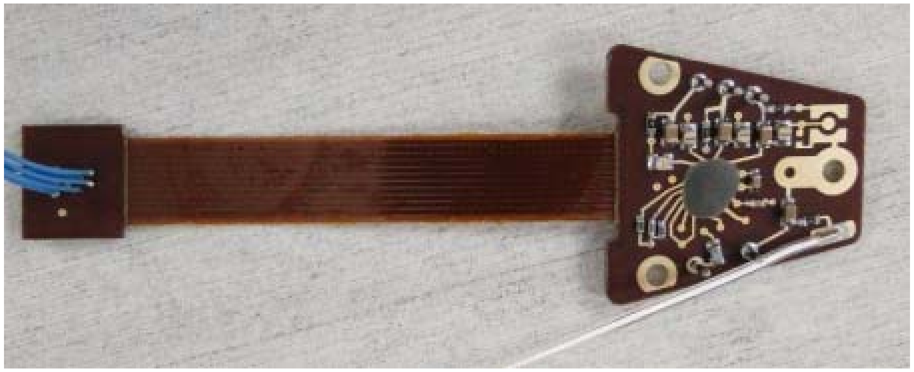


Energy System Development

- Solid-State Detector is fabricated and mounted to carrier board
- Energy board is fabricated and populated
- All components nearly identical to flight – no design changes expected

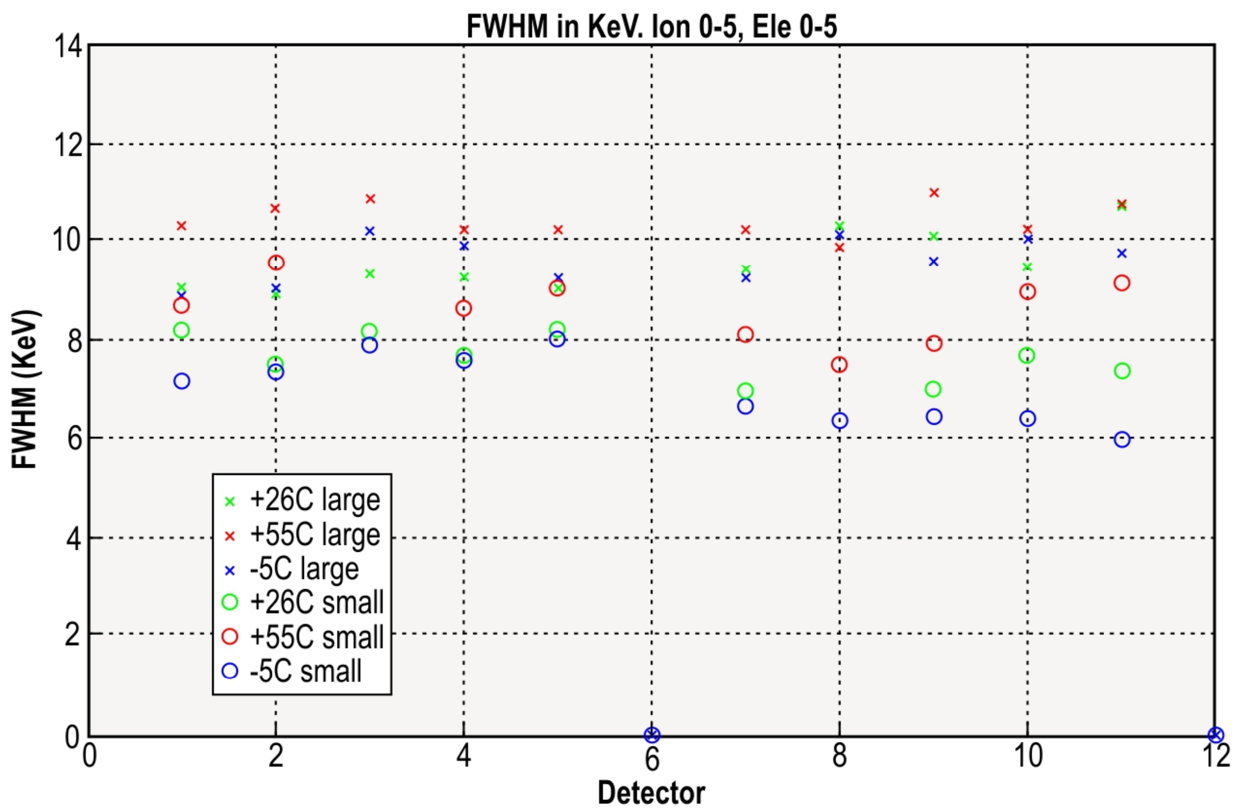






RBSPICE DATA with 60keV X-ray Source

- SSD performance base-lined on RBSPICE instrument tested with 60 keV X-ray
- Performance is ~11 keV FWHM over a wide temperature range
- EPI-Lo SSD in testing now – preliminary results show <15 keV FWHM at 60 keV

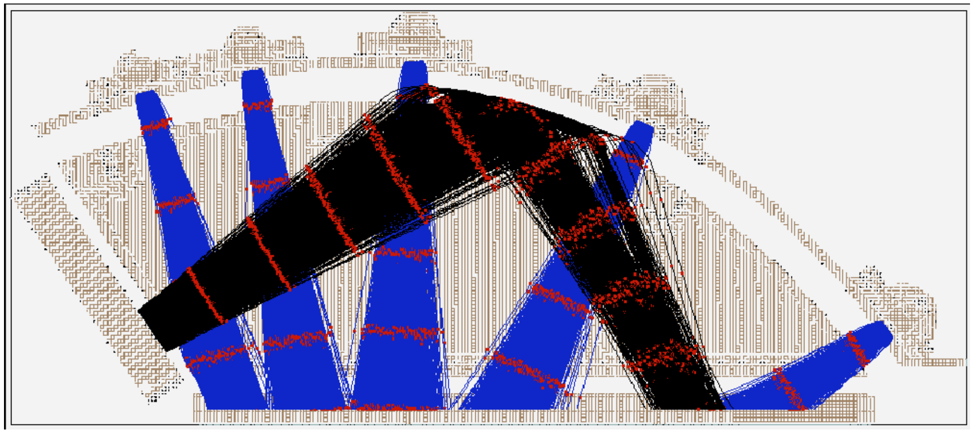


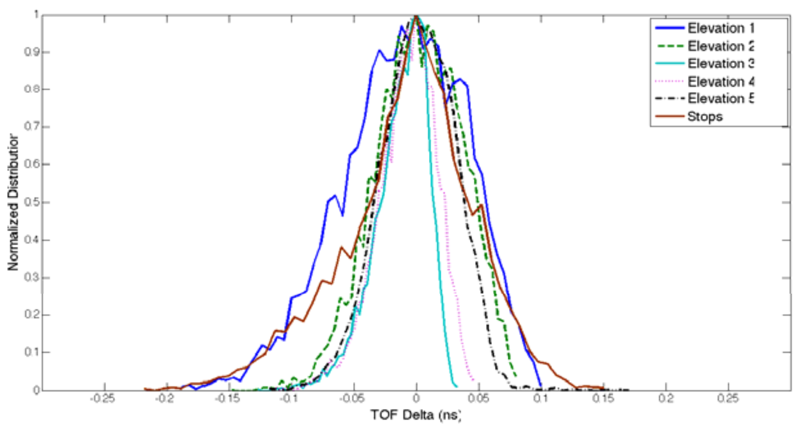
Timing Performance: Timing Budget

- Electron Dispersion: 200 ps
- TOF-D ASIC: 200 ps
- CFD-D ASIC: 200 ps
- Total: 350 ps (requirement is 400 ps)

Timing budget – Secondary Electron Dispersion Simulations

- 250 ps Time Markers
- Electron dispersion (start and stop combined) for worse case elevation 1 is 150 ps

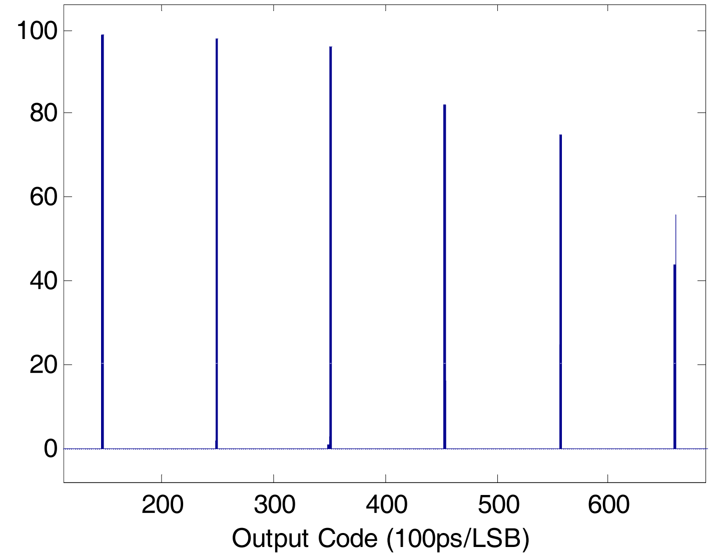


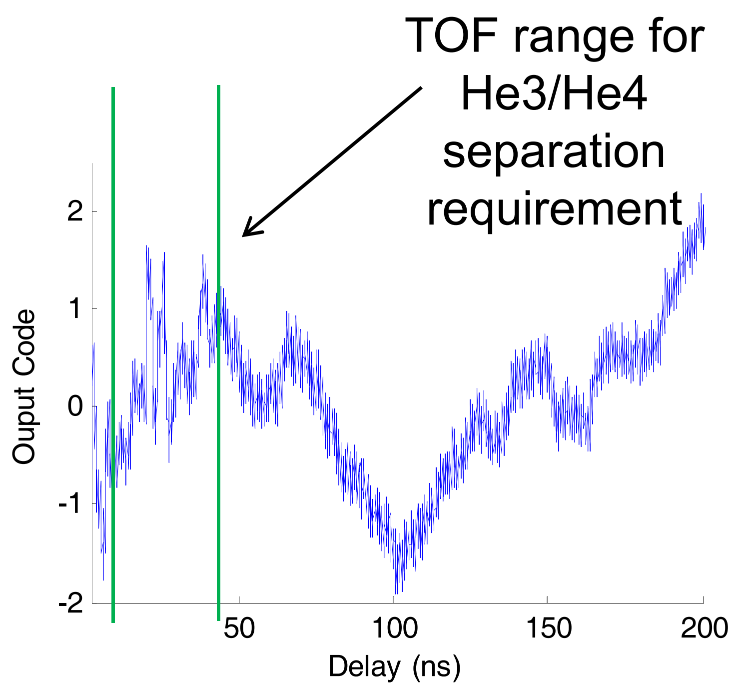


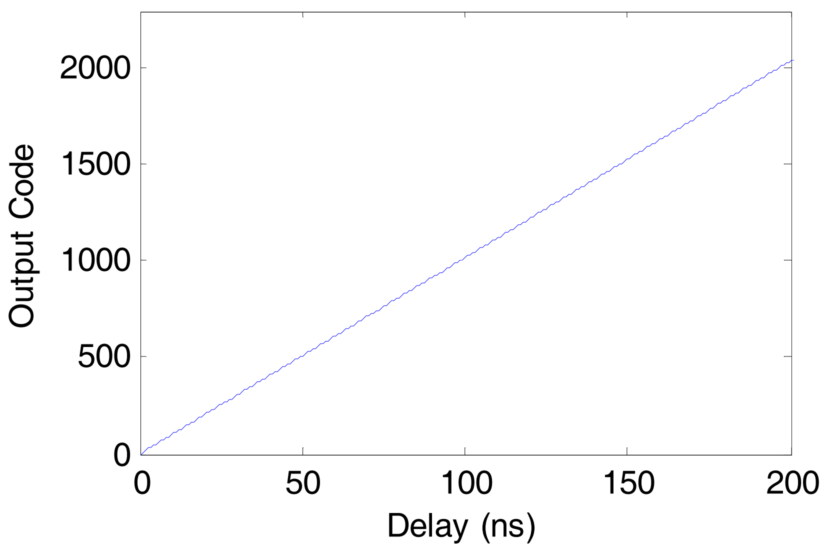
Name	Mean TOF (ns)	FWHM (ns)
Elevation 1	0.93	0.12
Elevation 2	2.12	0.08
Elevation 3	2.35	0.04
Elevation 4	2.32	0.05
Elevation 5	2.26	0.08
Stops	5.23	0.09

TOF-D Test Results

- TOF-D performance meets requirement
- INL variations compensated for with look-up tables
  - Same LUTs used to normalize path length for different apertures
- Jitter is less than 1 LSB FWHM







Prototype Quadrant Sensor Testing (1/2)

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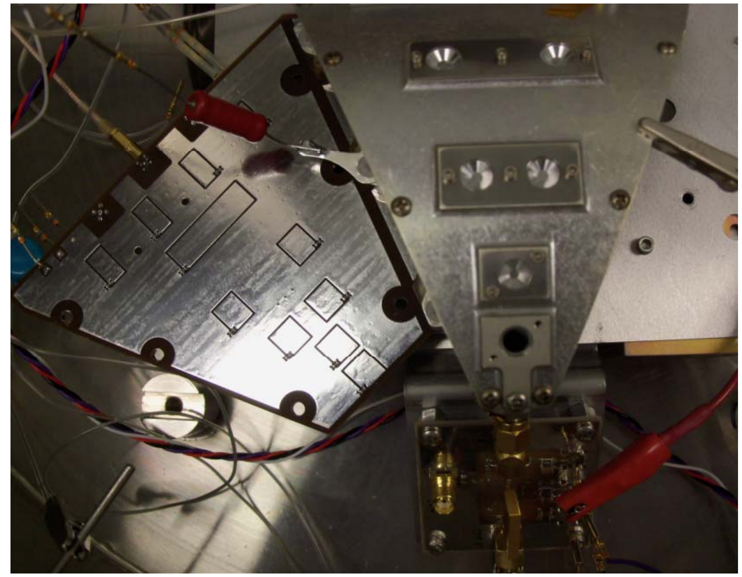
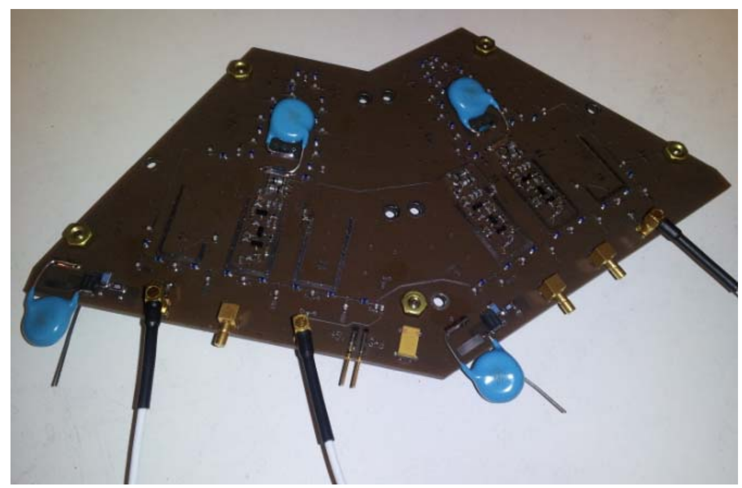
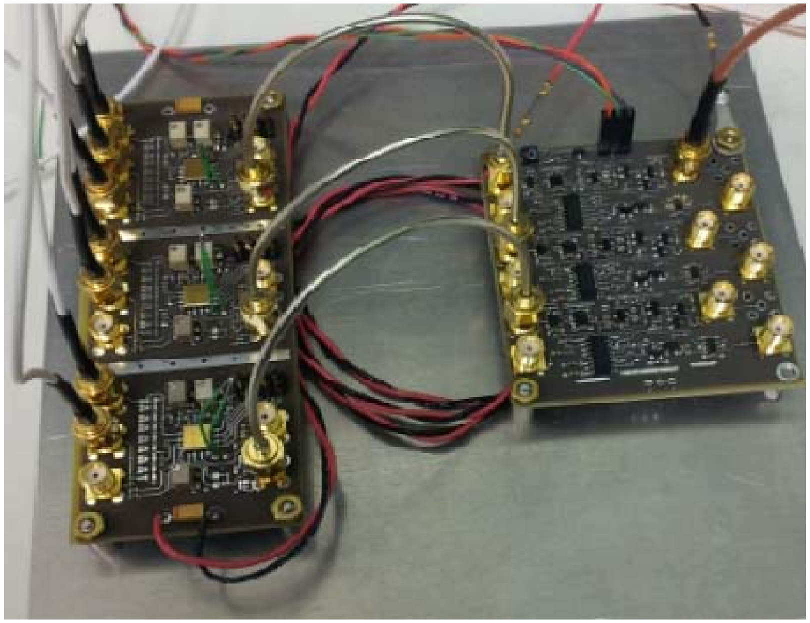
- Timing performance testing completed on prototype sensor
- End-to-end test includes variations due to electron dispersion, anode board performance, and CFD-D V0 performance
  - Does not include TOF-D ASIC
- Prototype anode board is close to flight configuration
  - HV isolation in imbedded capacitance
  - Start delay line covers two sensors
  - Does not mechanically fit flight design
- Prototype sensor is similar to flight sensor – key sensor geometries are the same

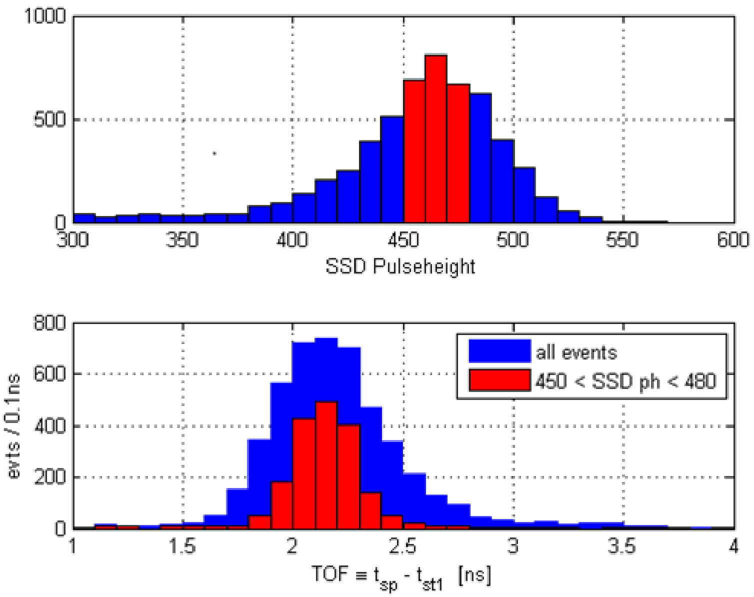




Prototype Quadrant Sensor Testing (2/2)

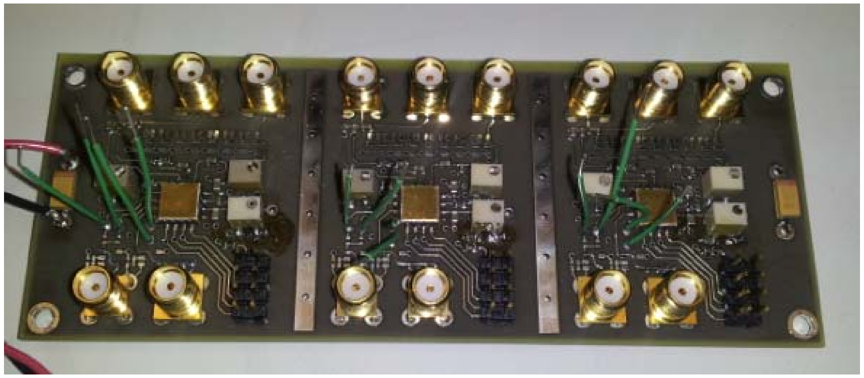
- Initial results show about 300 ps FWHM timing performance (CFD-D and electron optics contributions), which meets our requirements
- The final version of the CFD-D has lower jitter at low thresholds and reduced walk, which we expect will improve performance

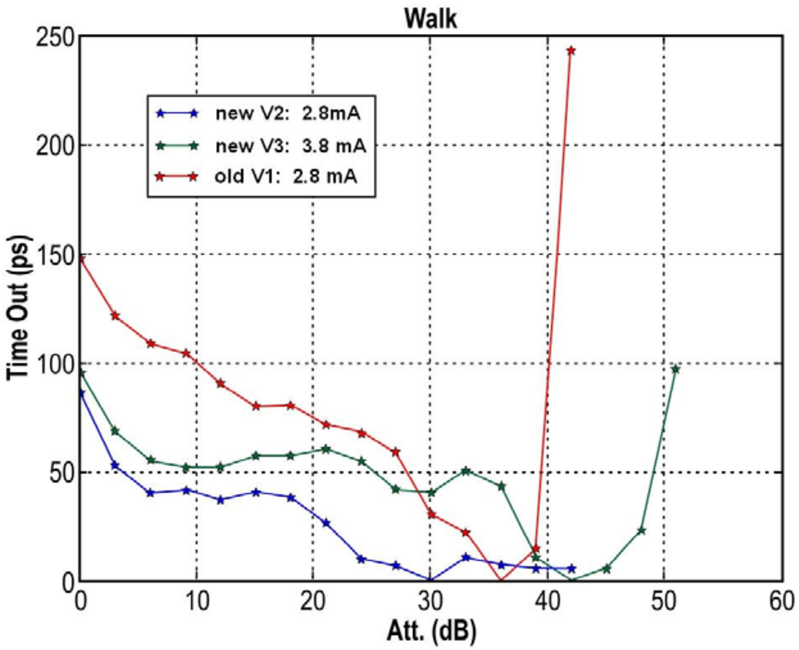


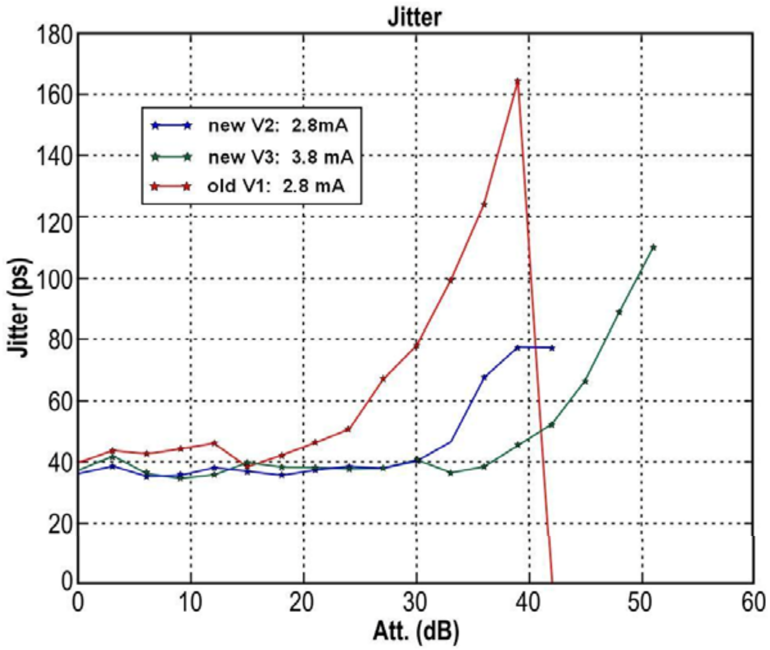


CFD-D Test Results

- CFD-D extensively tested using the CFD-D test board
- CFD-D V3 has improved performance

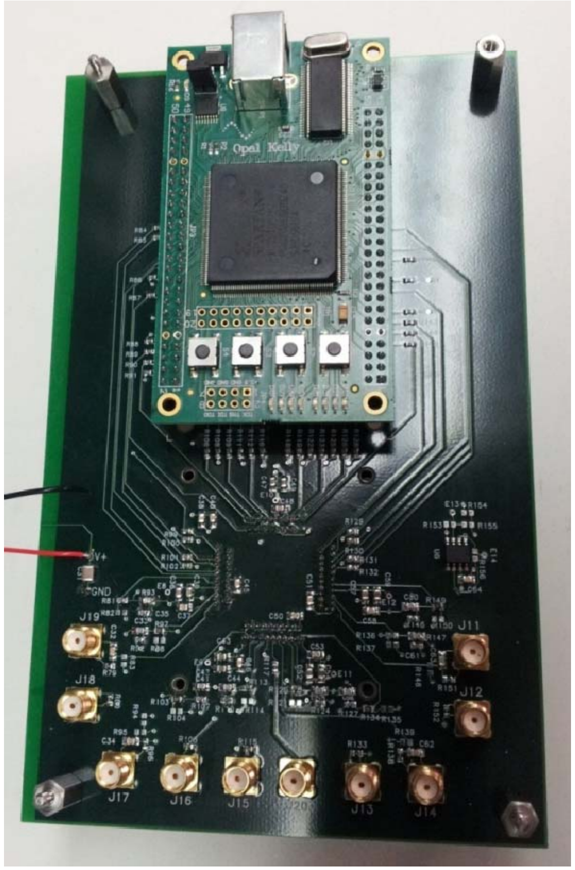






Technical Development: ASIC Progress

- First version of TOF-D chip fabricated and tested
  - Temperature testing from -40°C to 70°C
  - Supply tested from 3.0 V to 3.6 V
  - Functionality verified over 10 ps to 2 ns LSB
  - Successfully completed SEE testing at Texas A&M
  - Completed total dose testing
- Second version of TOF-D chip and first version of CFD-D chip fabricated and tested
- Flight Fabrication - third version of TOF-D chip and second version of CFD-D chip fabricated and tested
  - Temperature testing from -40°C to 70°C
  - Supply tested from 3.0 V to 3.6 V
  - TOF-D functionality verified over 10 ps to 2 ns LSB
  - Working with vendor for final qualification of both ASICs



Transition to Flight

- TOF-D, CFD-D ASICs
  - Complete qualification with external test house
  - Parts are needed in early 2014 for SIS instrument – EPI-Lo not the driver
  - Complete radiation testing on flight parts (prototype parts passed all radiation testing)
- Sensor Development
  - Build and test EM sensor
  - Integrate sensor with SSD
- SSD
  - EM design complete
  - Finish testing EM SSD
  - Flight design will be identical

- **All critical performance metrics for quadrant anode design have been verified with prototype testing**