

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

Reid Gurnee

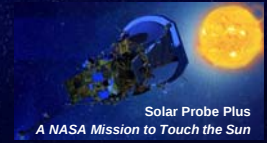
EPI-Lo SE (JHU/APL)



This document contains technical data that may be controlled by the International Traffic in Arms Regulations (22 CFR 120-130) and may not be provided, disclosed or transferred in any manner to any person, whether in the U.S. or abroad, who is not 1) a citizen of the United States, 2) a lawful permanent resident of the United States, or 3) a protected individual as defined by 8 USC 1324b(a)(3), without the written permission of the United States Department of State.



Outline



- 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



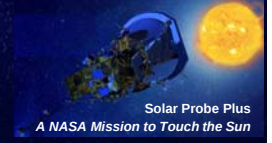
EPI-Lo Technology Developments to TRL6



- Species composition driven by two systems: energy system and timing system
- Energy and TOF performance to meet $3\text{He} / 4\text{He}$ separation
 - 3He , 4He : 0.5 FWHM AMU
for incoming energies between $\leq 0.2 \text{ MeV}$ and $\geq 2.0 \text{ MeV}$
 - 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



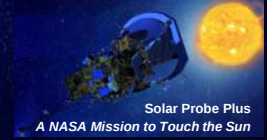
EPI-Lo Performance Modeling



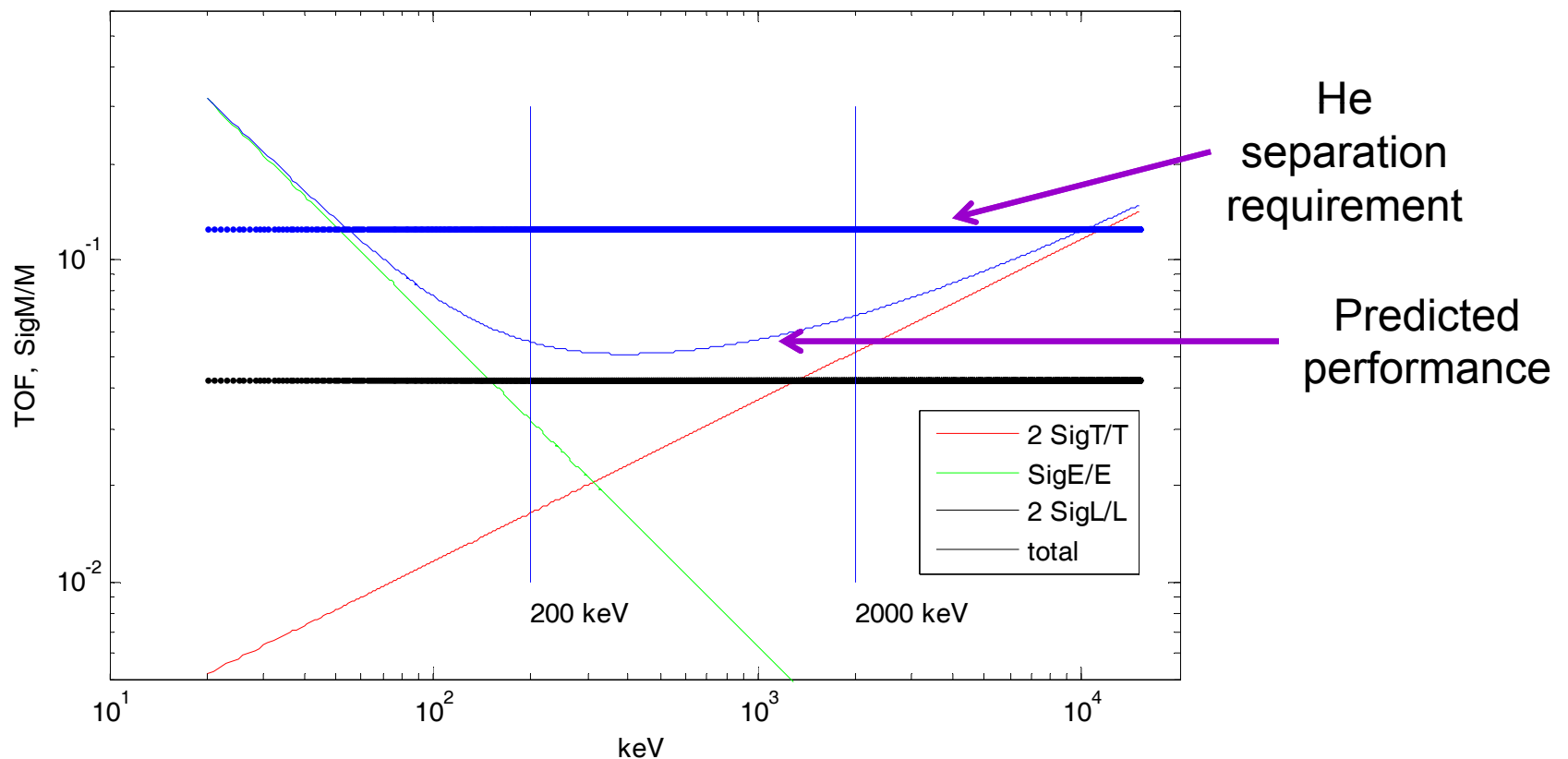
- Two independent models used
 - Monte-Carlo
 - Inputs are timing noise, SSD noise, and path length variation
 - Inputs can be any distribution (not limited to Gaussian)
 - Analytical
 - Inputs are timing noise, SSD noise, and path length variation
 - All inputs are Gaussian
- The two models have been 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

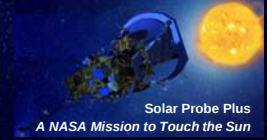


- At low energies the energy resolution dominates performance
- At high energies the timing resolution dominates performance
- Predicted performance has ample margin from requirement

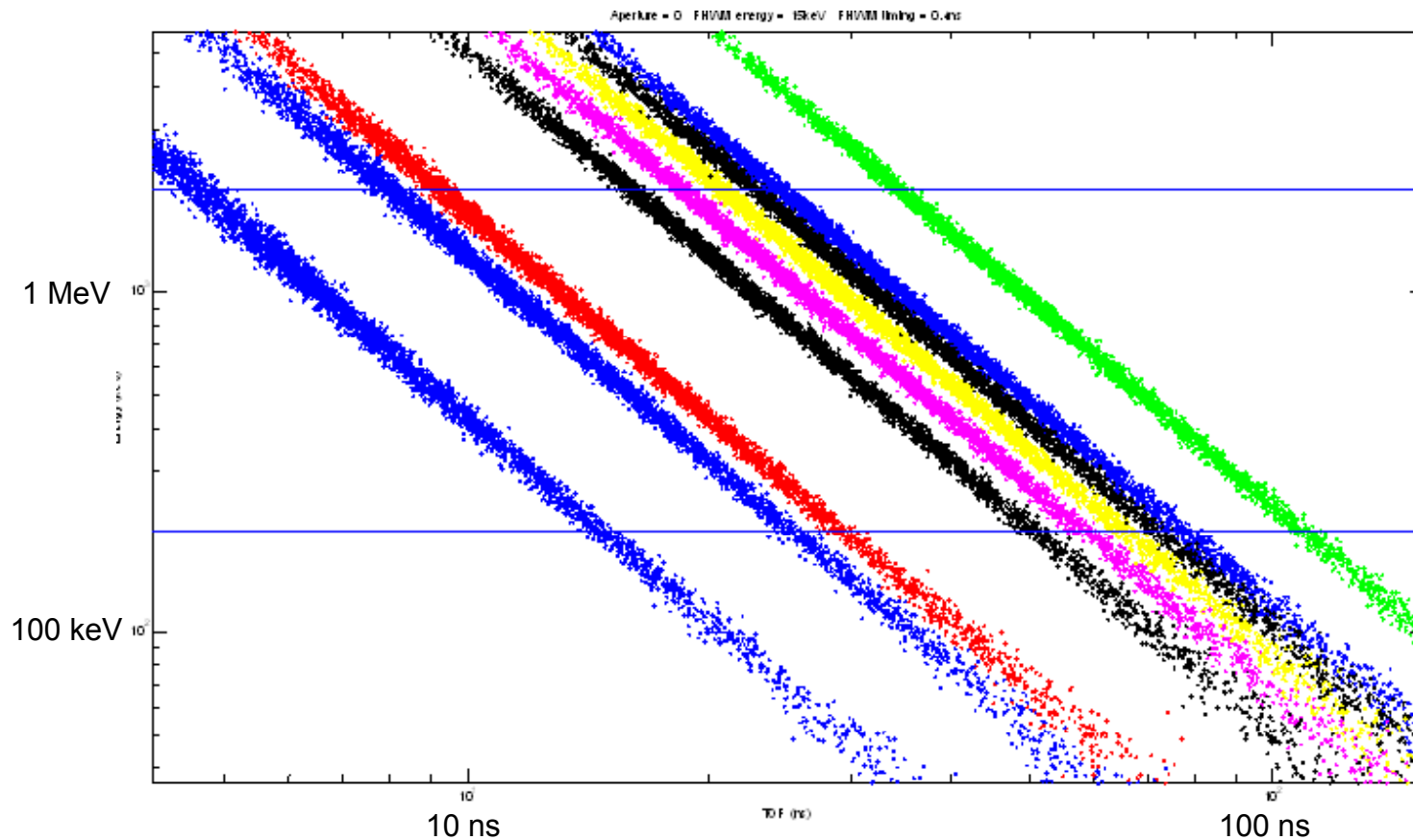




Track Simulations

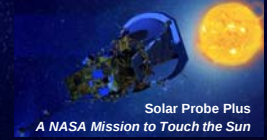


- Monte-Carlo model for all species with 400 ps FWHM timing and 15 keV FWHM energy resolutions

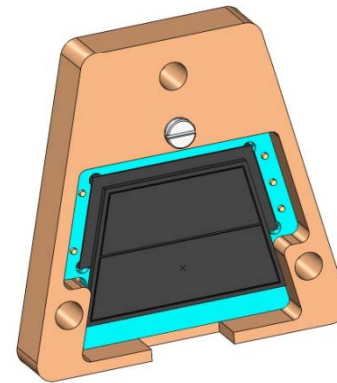
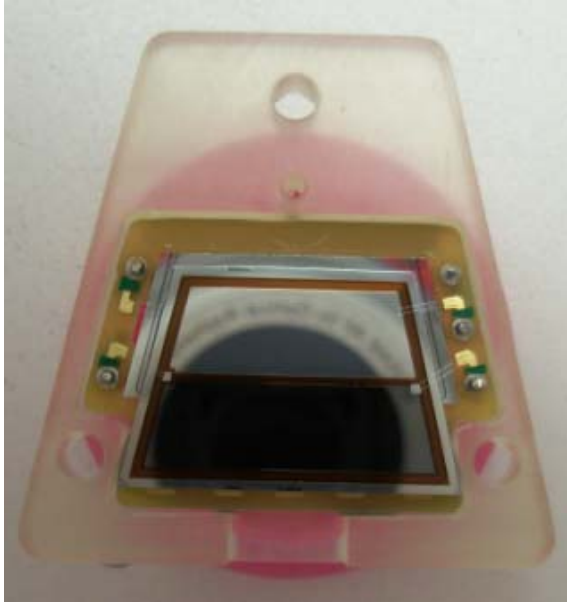




Energy System Development



- 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

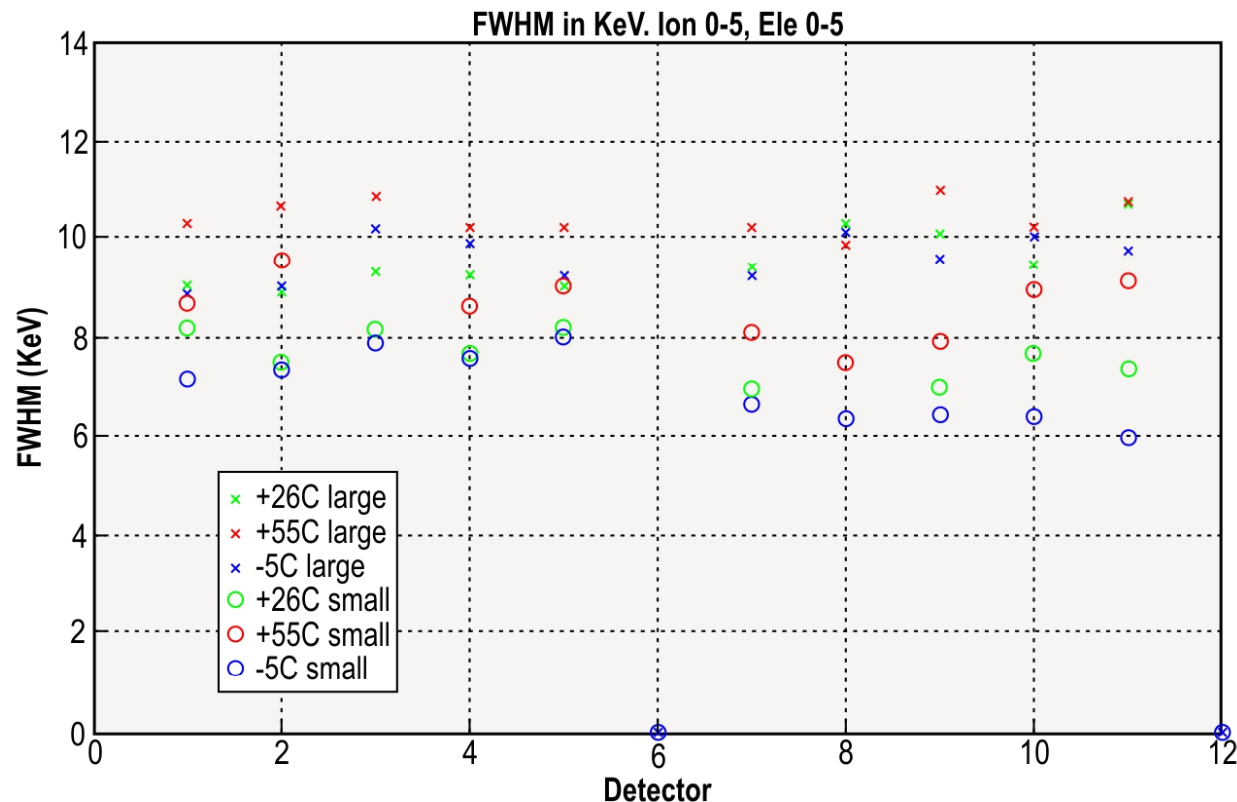




RBSPICE DATA with 60keV X-ray Source



- 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



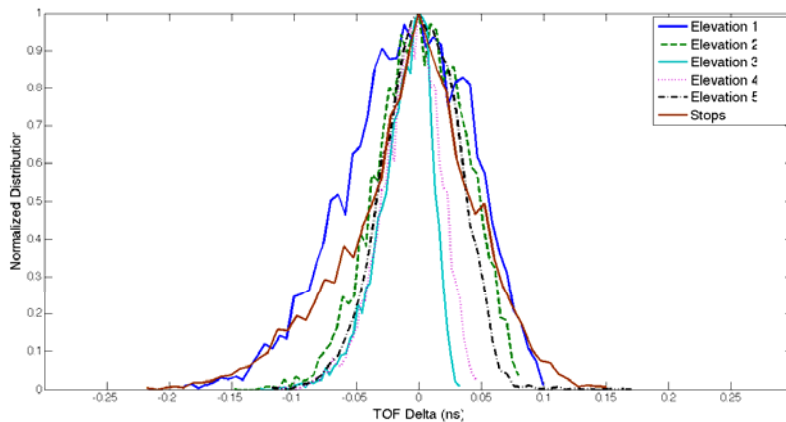
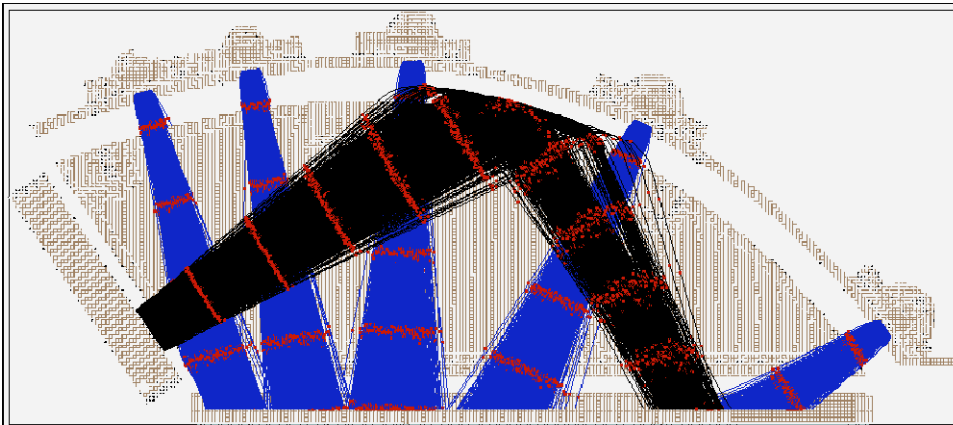
- Electron Dispersion: 200 ps
- TOF-D ASIC: 200 ps
- CFD-D ASIC: 200 ps
- Total: 350 ps (requirement is 400 ps)



Timing budget – Secondary Electron Dispersion Simulations



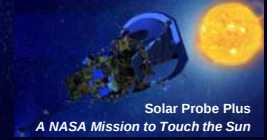
- 250 ps Time Markers
- Electron dispersion (start and stop combined) for worse case elevation 1 is 150 ps



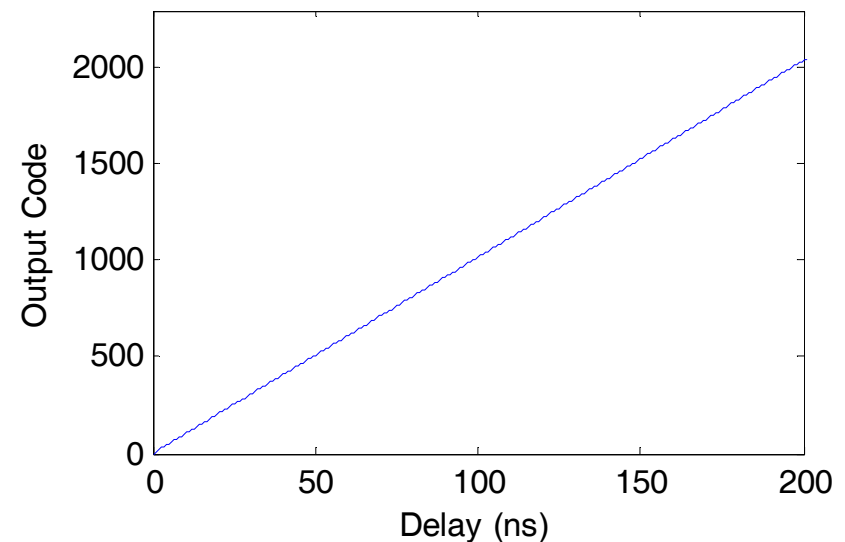
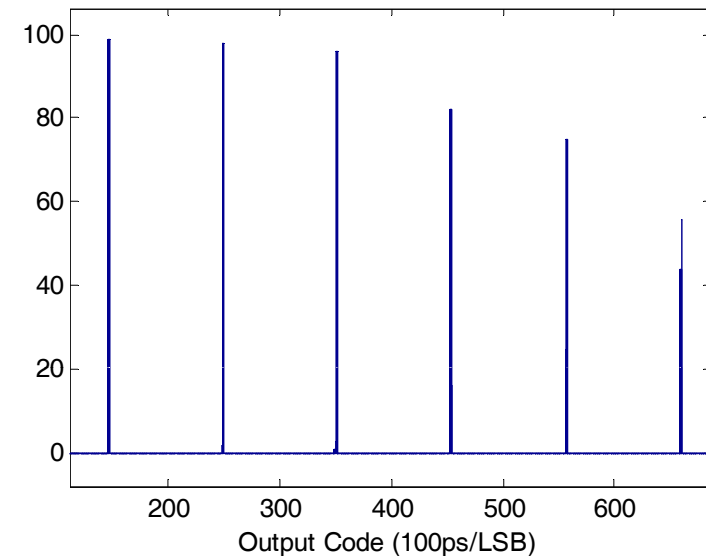
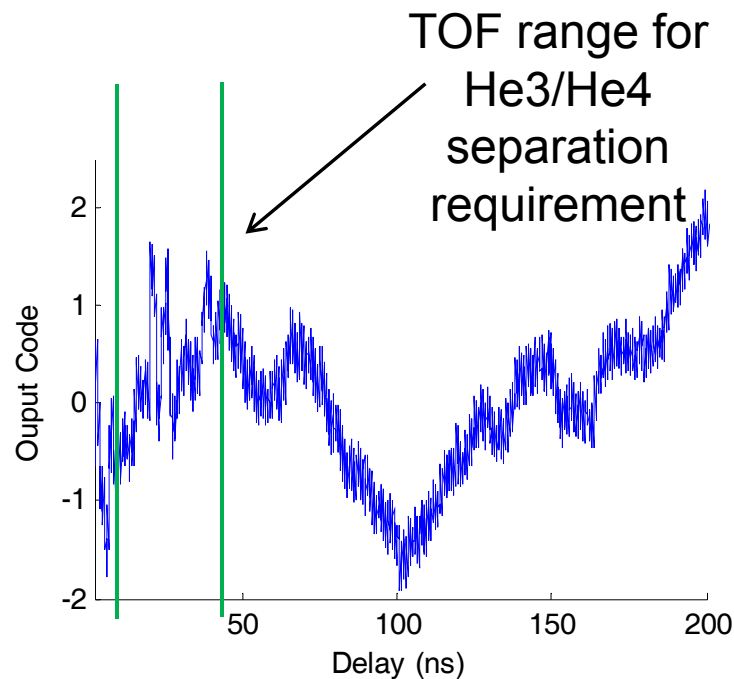
Name	Mean TOF (ns)	FWHM (ns)
Elevation 1	0.93	0.12
Elevation 2	2.12	0.08
Elevation 3	2.35	0.04
Elevation 4	2.32	0.05
Elevation 5	2.26	0.08
Stops	5.23	0.09



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

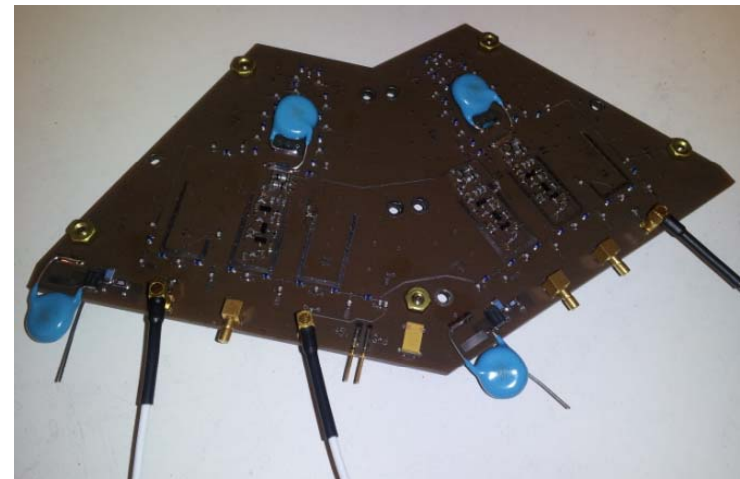
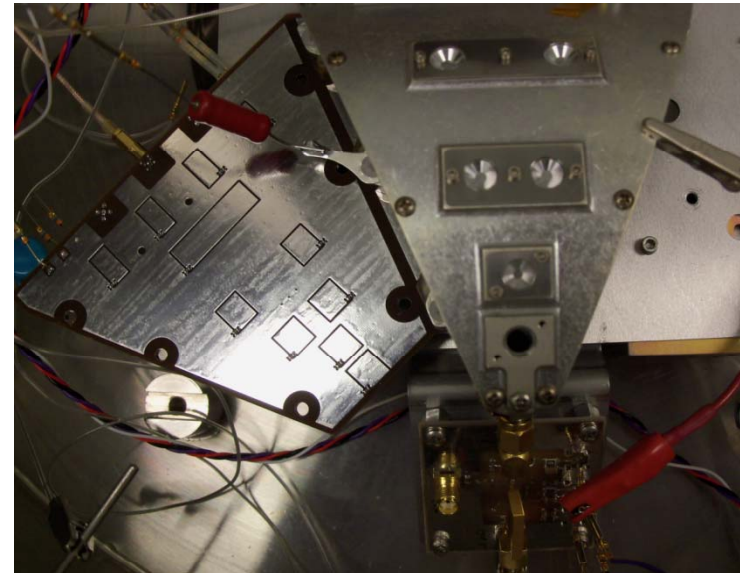




Prototype Quadrant Sensor Testing (1/2)



- 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

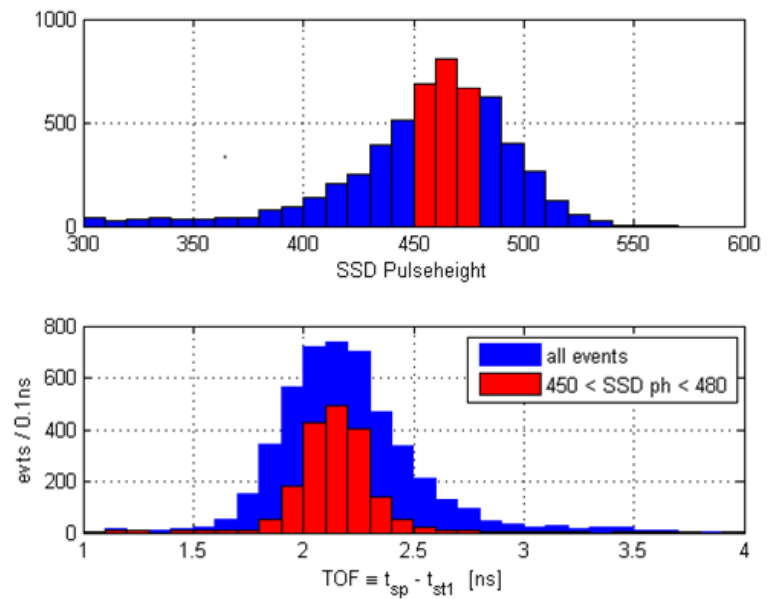
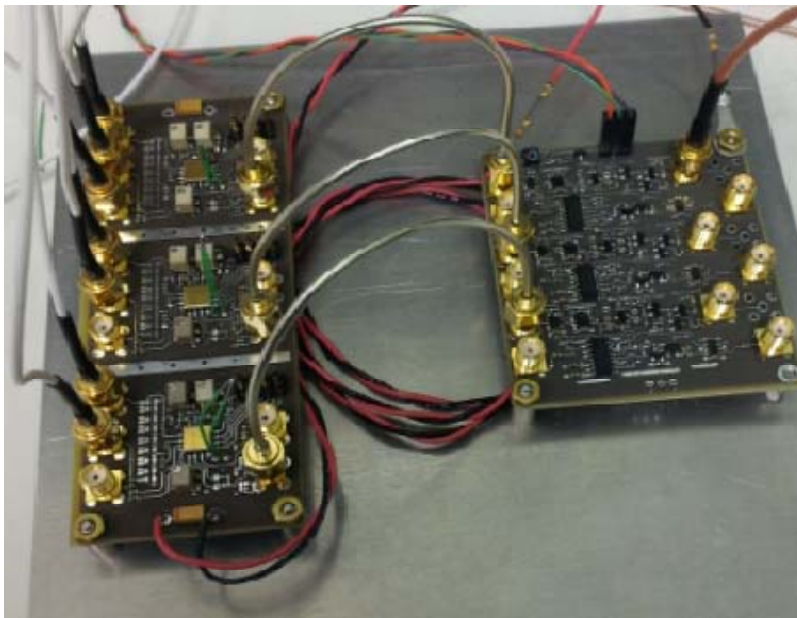




Prototype Quadrant Sensor Testing (2/2)

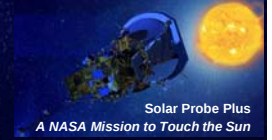


- Initial results show about 300 ps FWHM timing performance (CFD-D and electron optics contributions), which meets our requirements
- The final version of the CFD-D has lower jitter at low thresholds and reduced walk, which we expect will improve performance

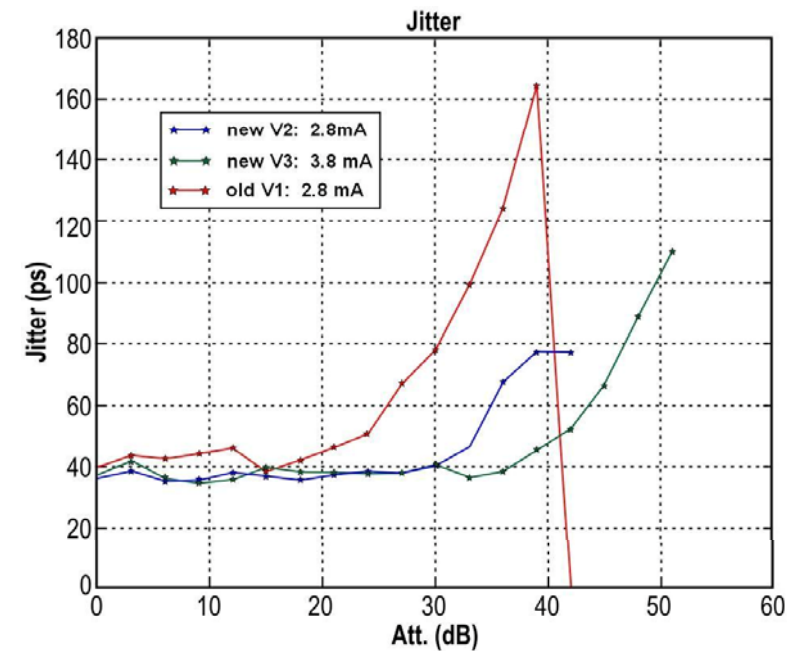
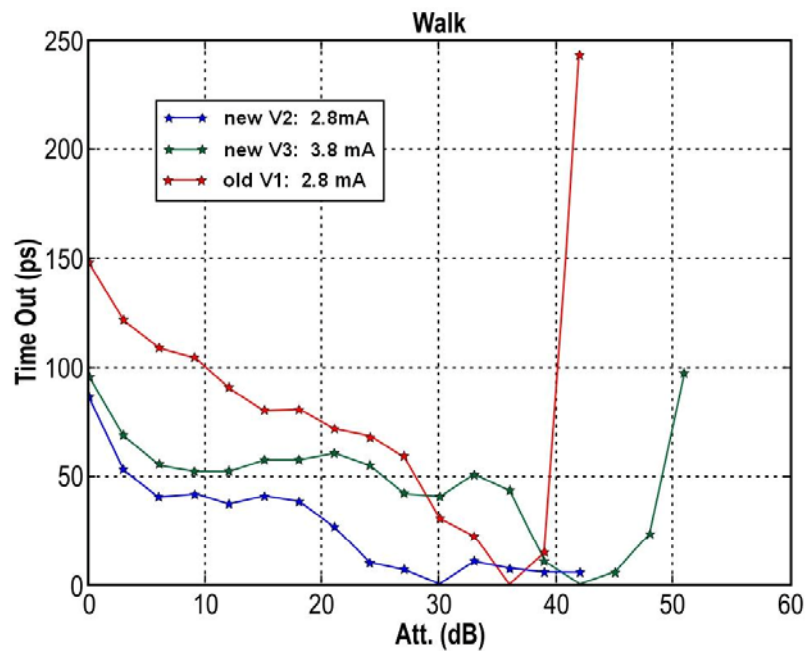
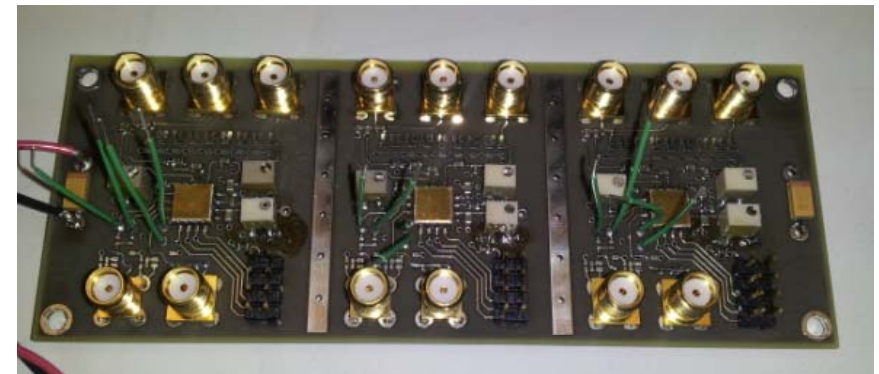




CFD-D Test Results

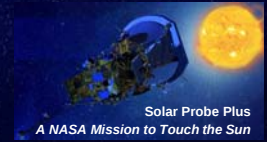


- CFD-D extensively tested using the CFD-D test board
- CFD-D V3 has improved performance

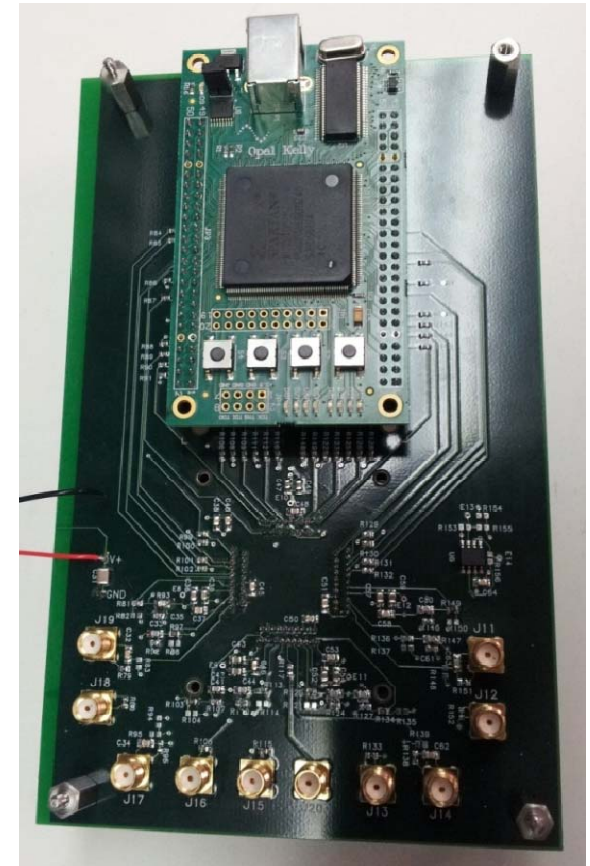




Technical Development: ASIC Progress

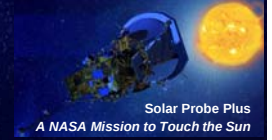


- First version of TOF-D chip fabricated and tested
 - Temperature testing from -40°C to 70°C
 - Supply tested from 3.0 V to 3.6 V
 - Functionality verified over 10 ps to 2 ns LSB
 - Successfully completed SEE testing at Texas A&M
 - Completed total dose testing
- Second version of TOF-D chip and first 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**