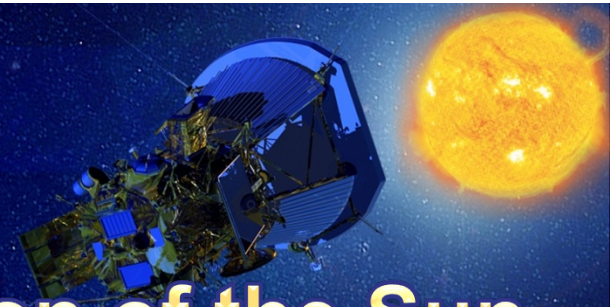
Solar Probe Plus

A NASA Mission to Touch the Sun



Integrated Science Investigation of the Sun
Energetic Particles

Preliminary Design Review
05 – 06 NOV 2013

NASA • GSFC • SwRI • APL • Caltech • U-Az • U-Del • UNH

ISIS

Solar Probe Plus

Energetic Particles

EPI-Lo Sensor

Don Mitchell, Matt Hill, Ralph McNutt

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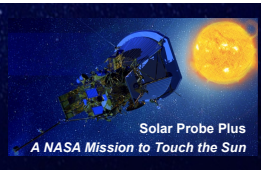
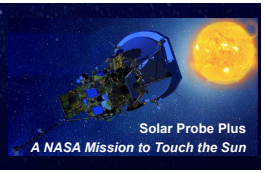
Outline EPI-Lo Sensor Design



- ISIS Science Requirements Relevant for EPI-Lo
- EPI-Lo Instrument
- Block Diagram(s)
- Principles of Operation Overview
- Sensor Voltages
- Electrostatic Optics
- Collimators and Start Foils
- Solid State Detectors & Stop Foils
  - Anti-coincidence System
  - GEANT
- Microchannel Plate (MCP)
- Mass Resolution
- Light & Dust Mitigation
- Follow-up from peer reviews
- Summary

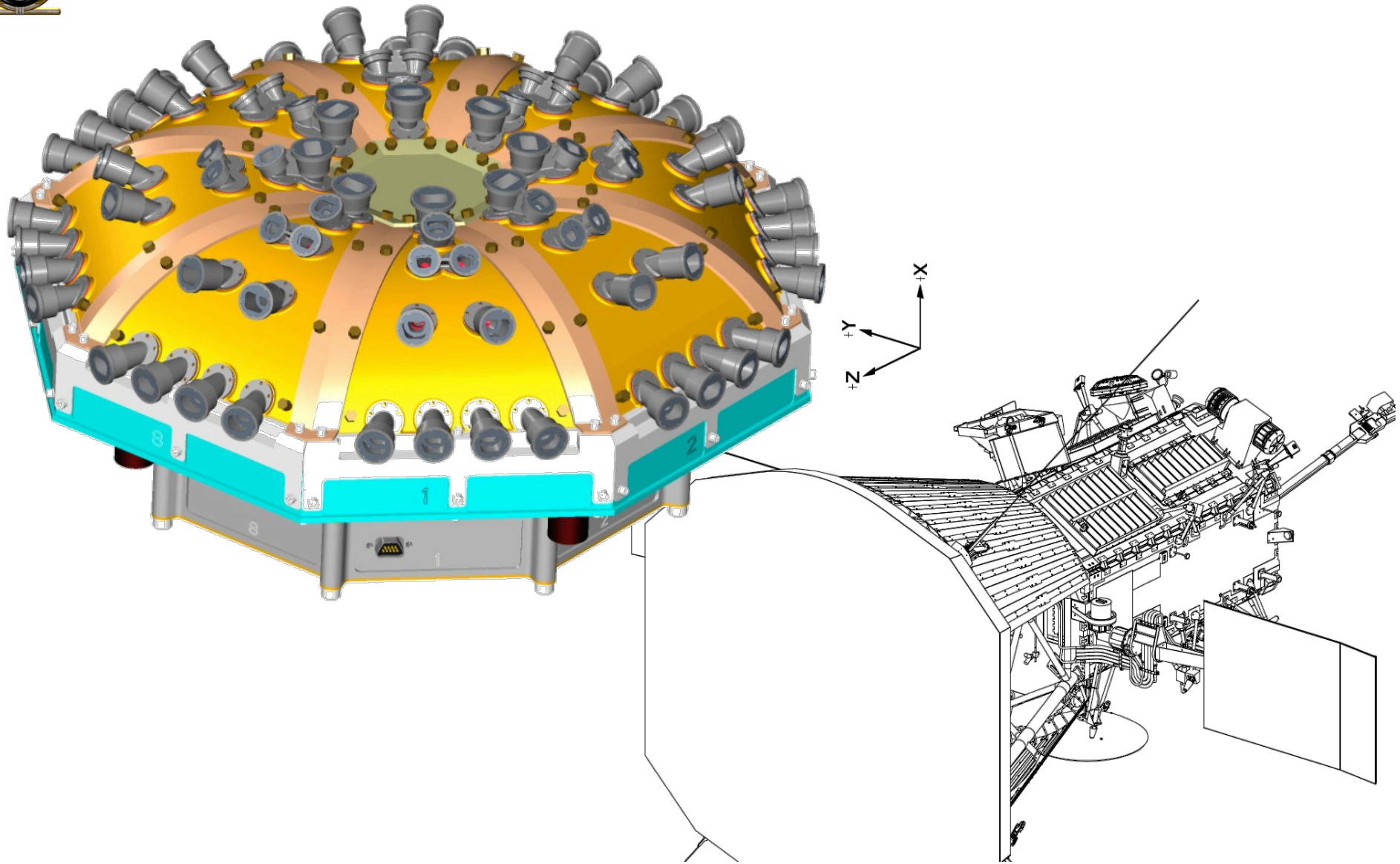
- **THIS IS NOT UP TO DATE...IGNORE THIS PAGE.**

The EPI-Lo Instrument Requirements

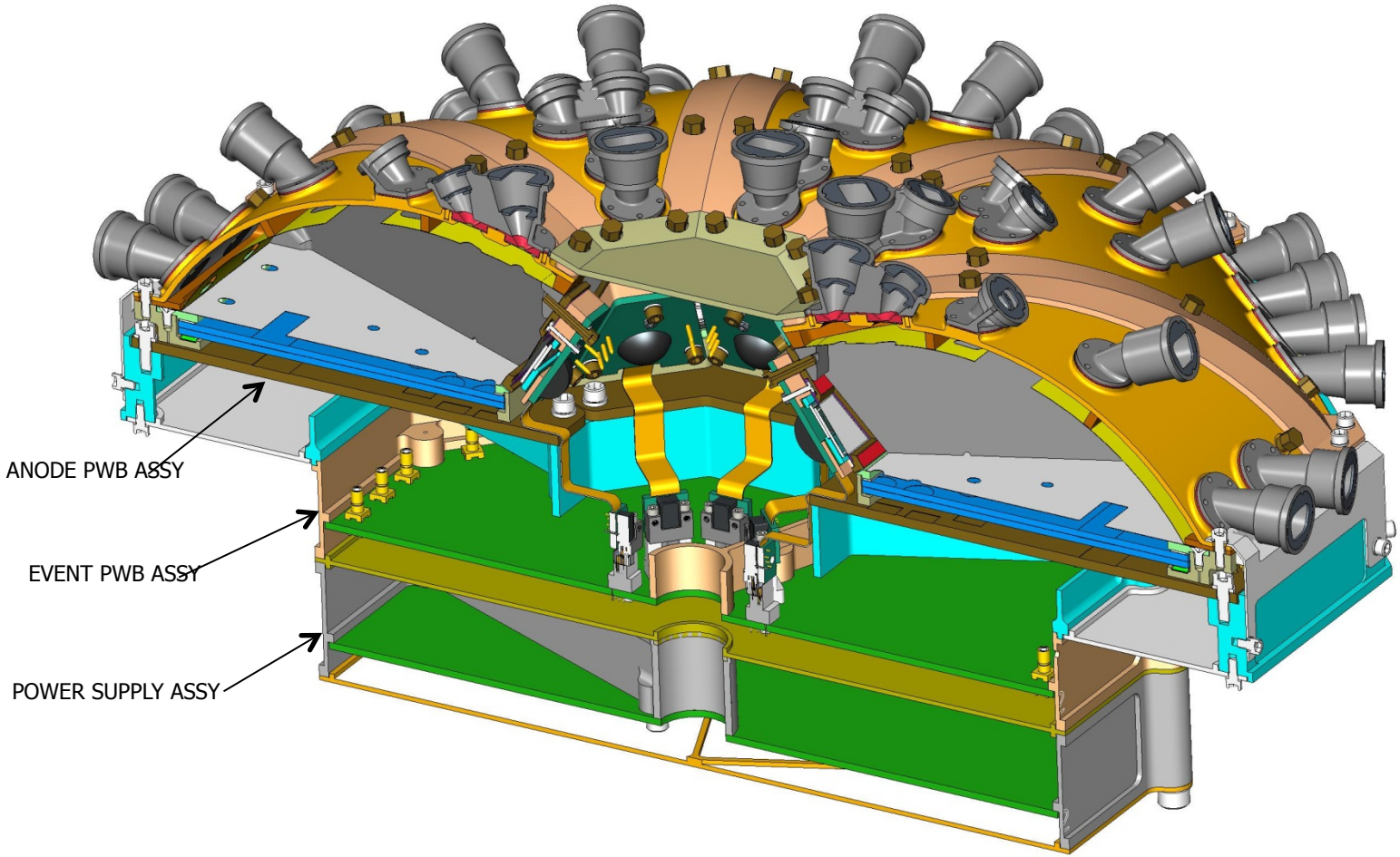


Parameter	Required	Goal (Capability)	Comment/Heritage
Electron Energies	50 - 500keV	25 - 1000 keV	Electron capability from JEDI, RBSPICE
Ion Energies	**50 keV/nucleon – 15000 keV Total E**	**50 keV/nucleon – 15000 keV Total E**	Capability partially based on RBSPICE capabilities. Top energy ~250keV/nuc for Fe
Energy Resolution	45% for required energy range	40% for required energy range	Telemetry limited
Time sampling	5 sec	1 sec	Telemetry and/or statistics limited
Angle resolution	<30° x <30°	Ions, ~15° x 12° to <30° x <30° e-, 45°	Varies with elevation
Pitch Angle (PA) Coverage	0°-90° or 90°-180°, some samples in both hemispheres	0°-90° or 90°-180°, some samples in both hemispheres	
Time for Full PA	1 – 5 sec	1 – 5 sec	Telemetry limited
Ion Composition	H, He3, He4, C, O, Ne, Mg, Si, Fe	H, He3, He4, C, O, Ne, Mg, Si, Fe	He3/He4 ~50 to 1000 keV/ nuc
Electron Sensitivity: j=Intensity	j = 1E1-1E6/cm^2-s-sr	Sensor-G:0.144 (cm^2.sr) Pixel-G: ~0.02 (cm^2.sr) Up to 6E6 1/s counting	j=Intensity (1/cm^2-s-sr) G=Geom. Factor (cm^2-sr) 8 pixels/sensor
Ion Sensitivity	j = 1E1-1E6/cm^2-s-sr	Sensor-G:0.16 (cm^2.sr) Pixel-G: ~0.002 (cm^2.sr) Up to 3.5E6/s rate (TOFxE)	80 pixels/sensor

The EPI-Lo Instrument

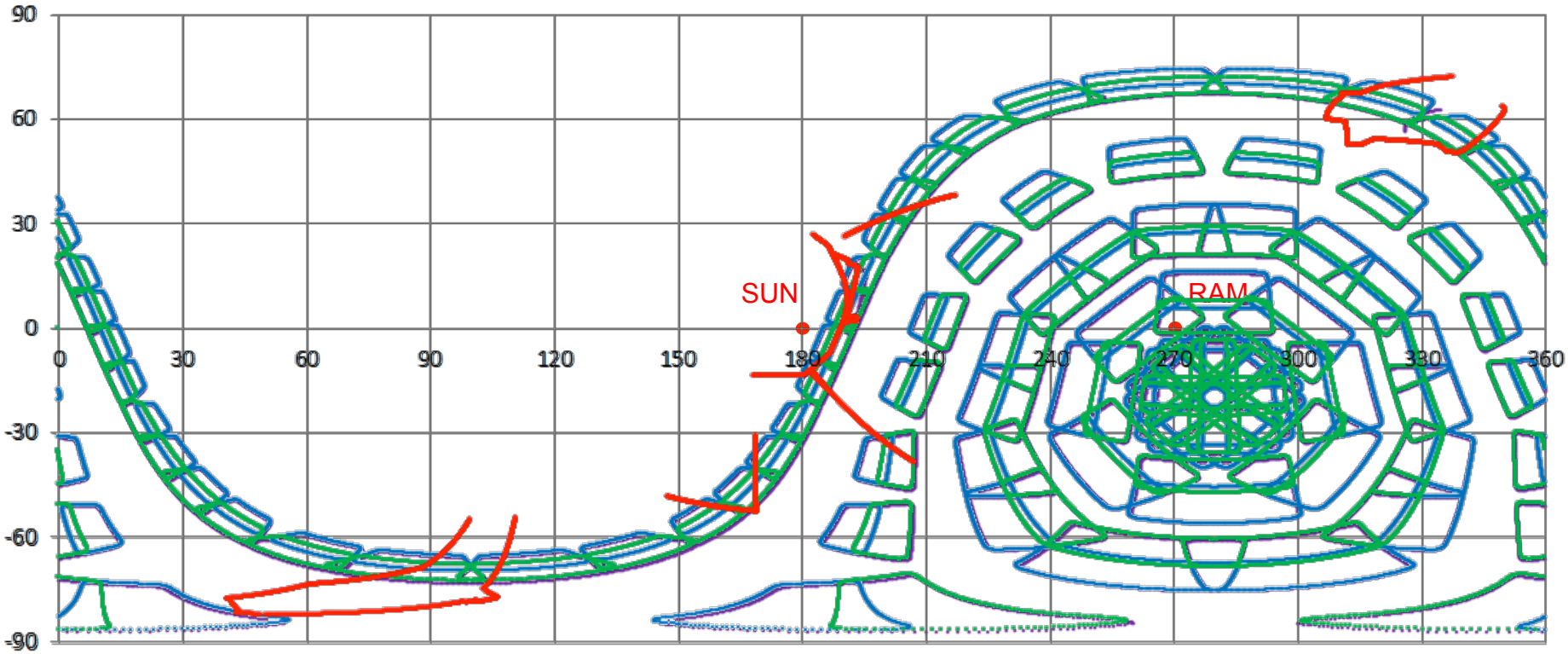


EPI-Lo Instrument, cut-away



EPI-LO CROSS-SECTION VIEW ISOMETRIC

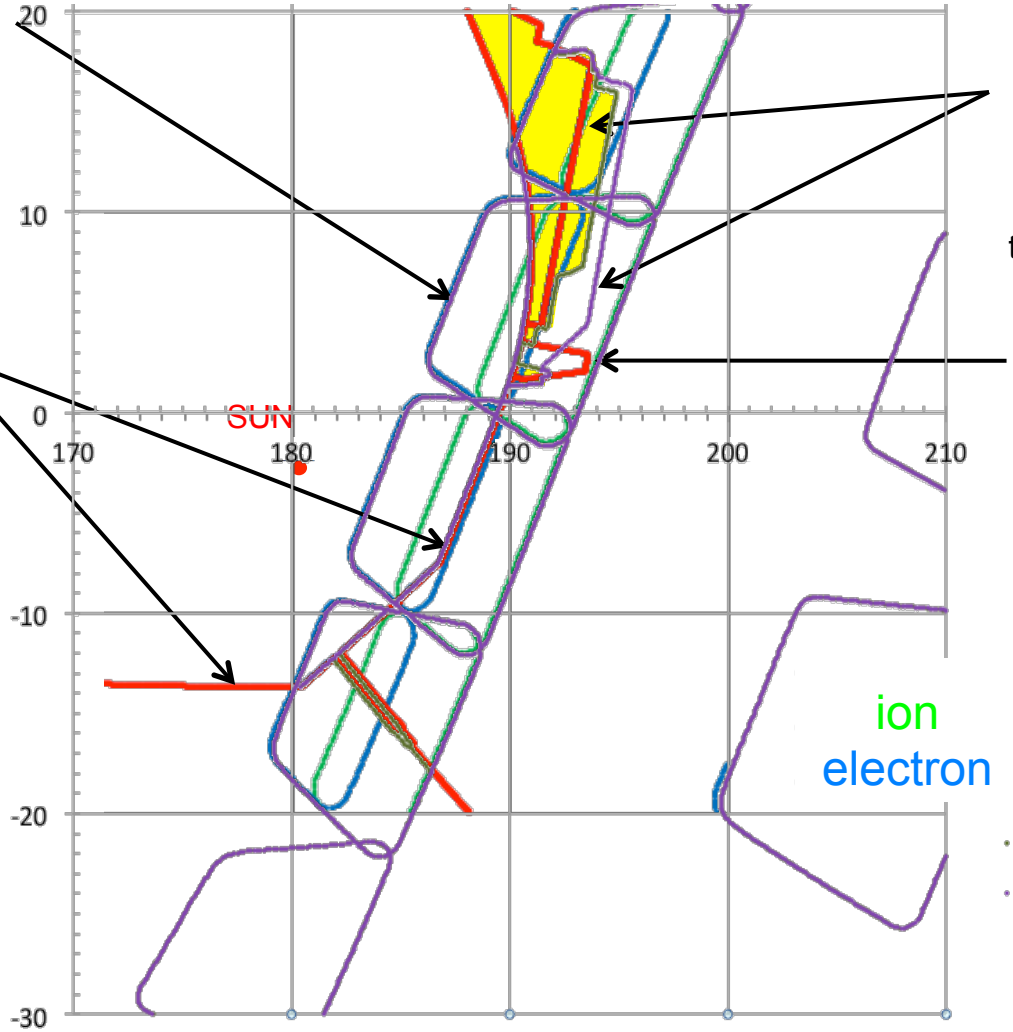
The EPI-Lo Field of View



The EPI-Lo Field of View

These trapezoids, with the rounded corners, represent EPI-Lo unobstructed FOV's

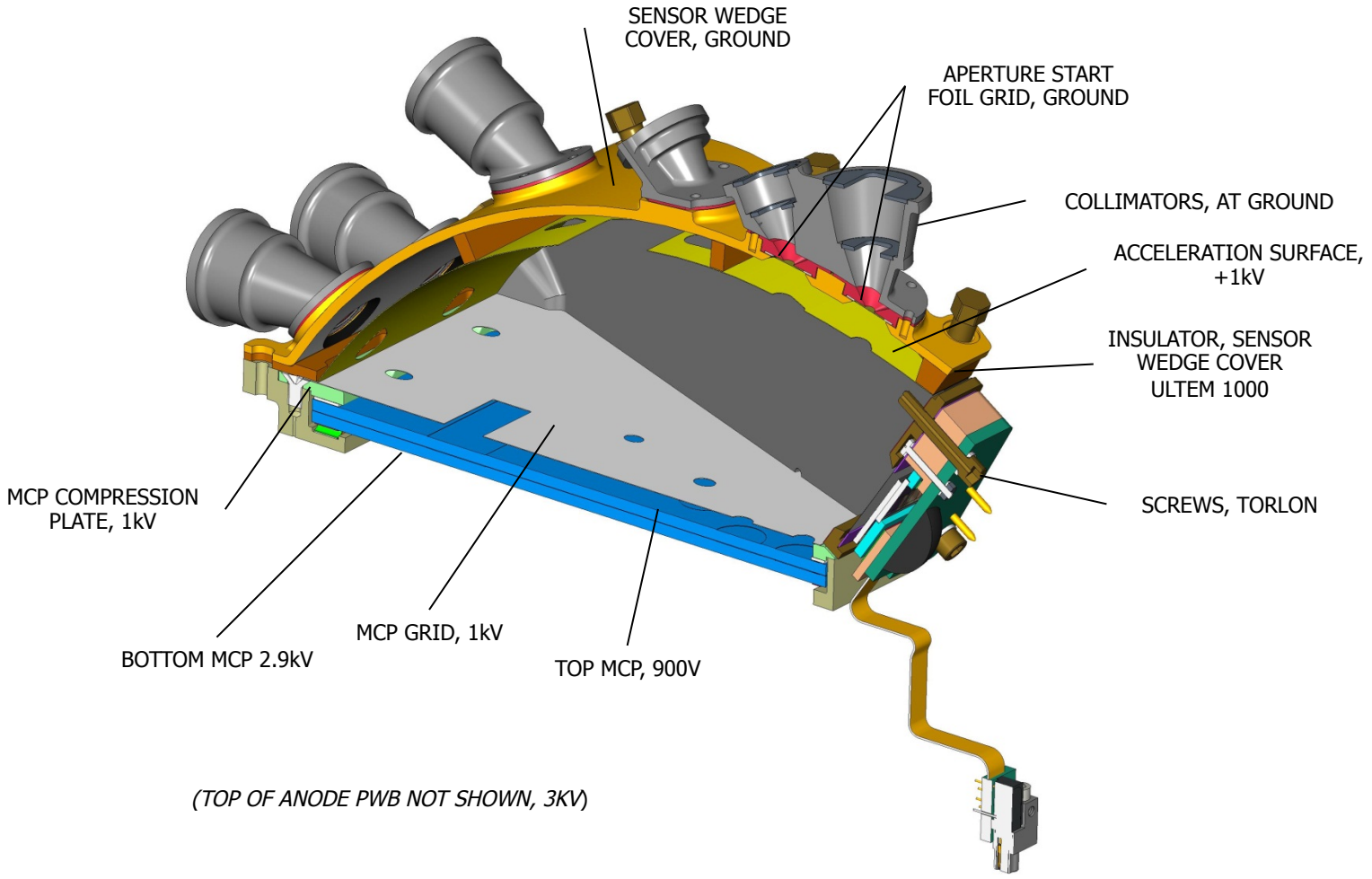
This line(s) represents the obstruction caused by the TPS



This line(s) represent the obstruction caused by WISPR: Red was March 2013 and 2011-ish envelope and yellow is the Sept 2013 one. Outer purple is the closed door (Sept 2013).
Don't think this red obstruction was in 2011 model. Part of WISPR?

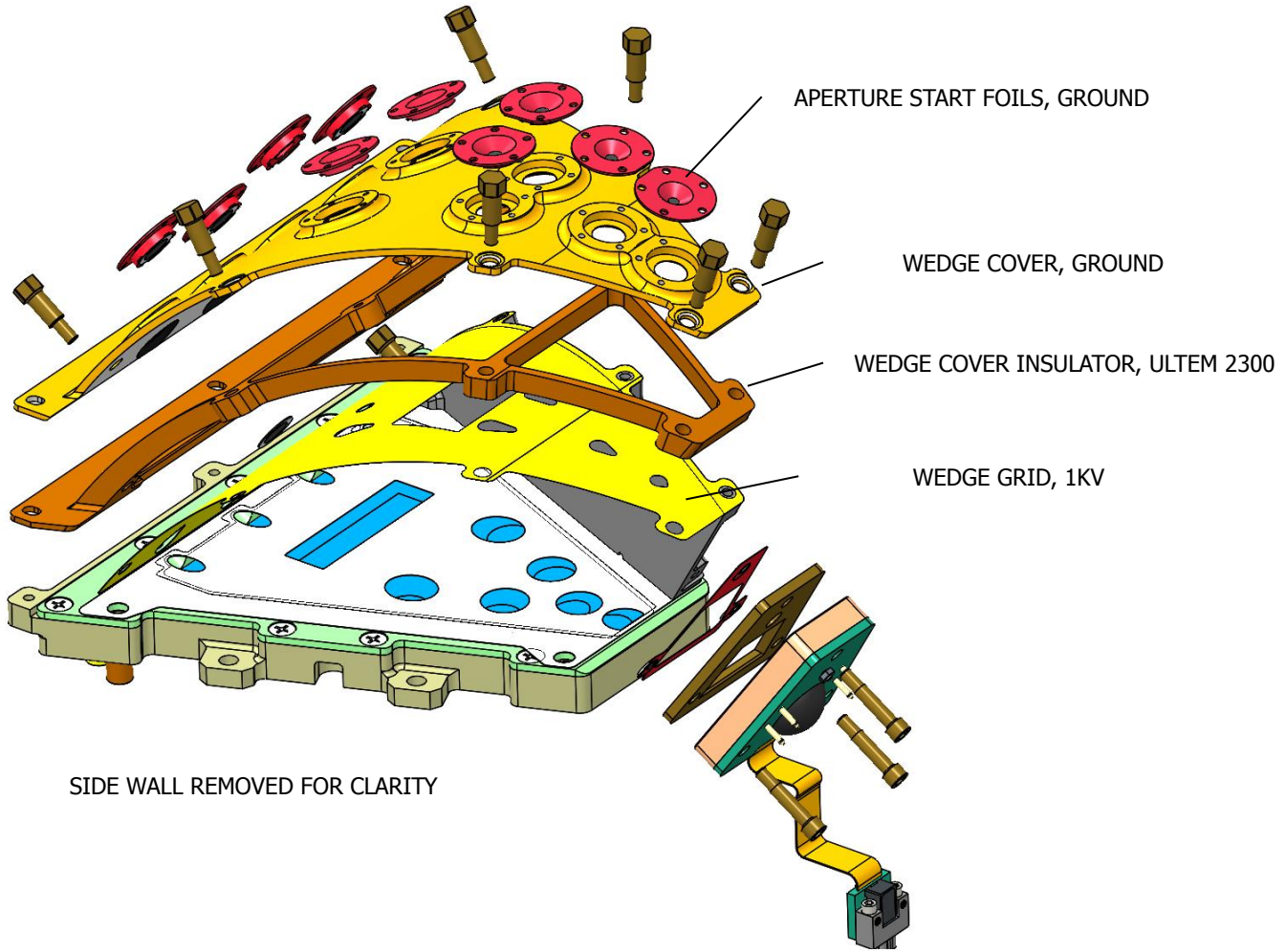
At 0 degrees elevation, the viewing angle is 9.4 degrees off from looking straight at the sun

EPI-Lo Wedge Components



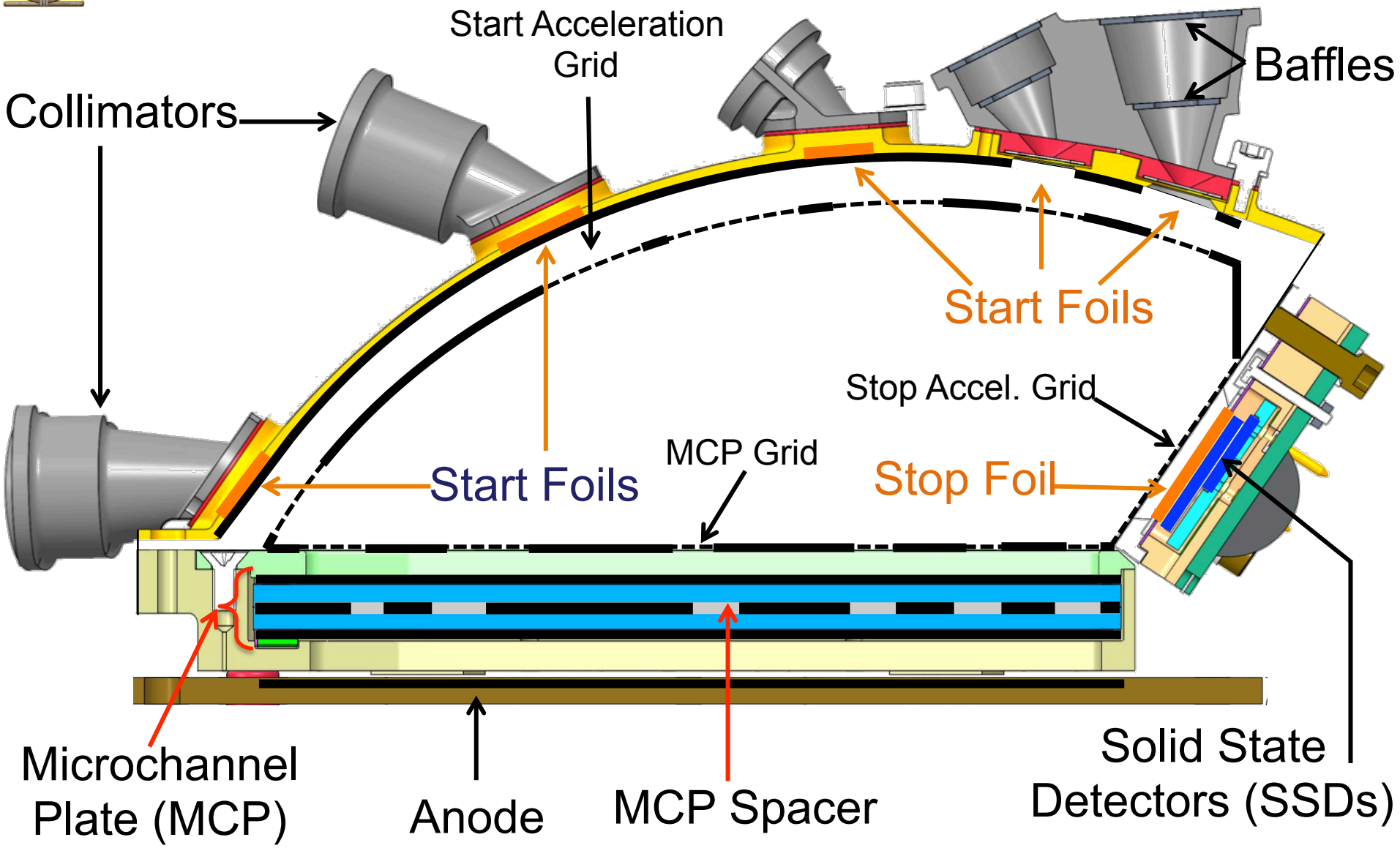
EPI-LO INDIVIDUAL SENSOR WEDGE ASSY CROSS SECTION

EPI-Lo Wedge, Exploded View

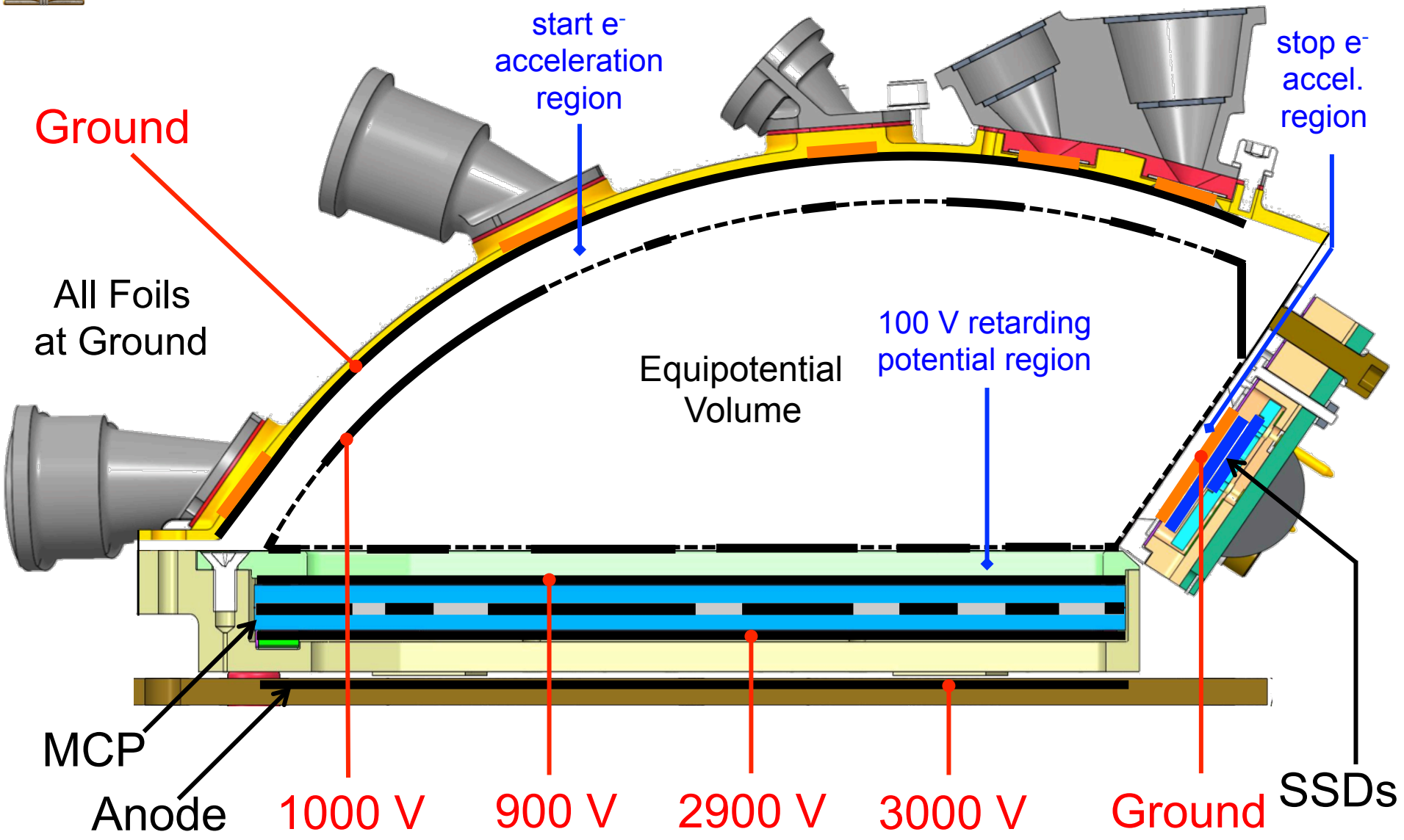


EPI-LO INDIVIDUAL SENSOR WEDGE ASSY CROSS SECTION

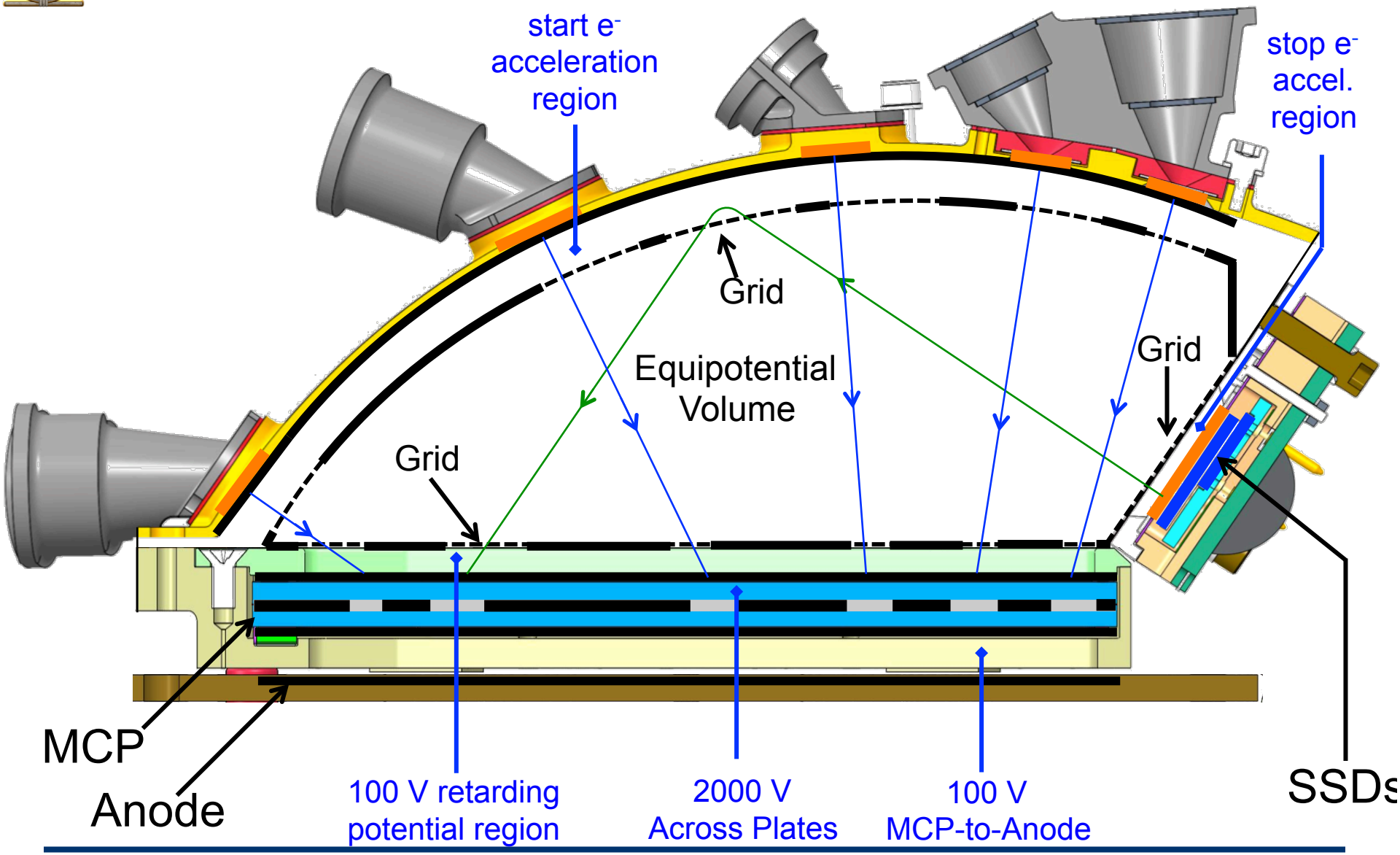
Sensor Functional Schematic



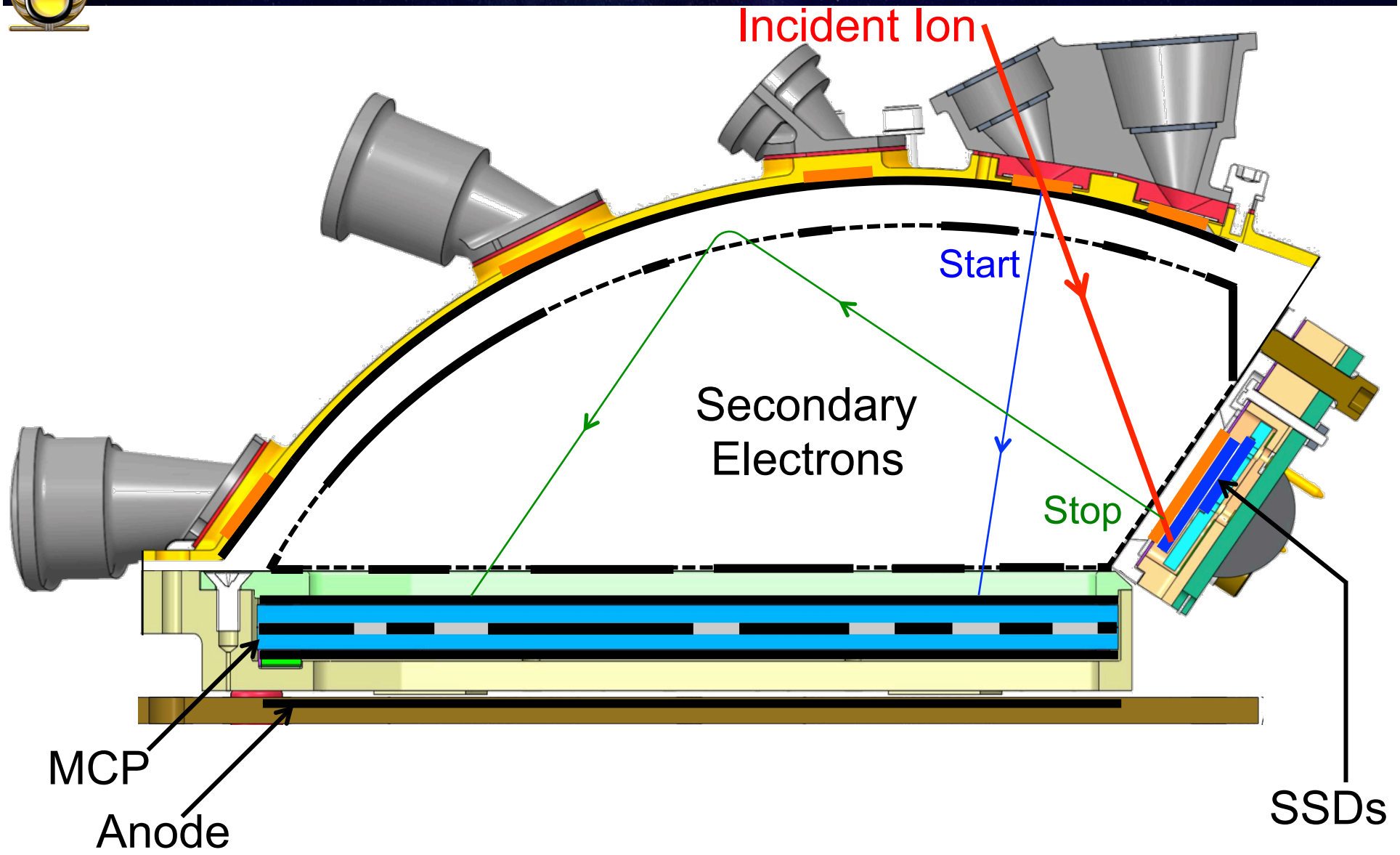
Sensor Voltages



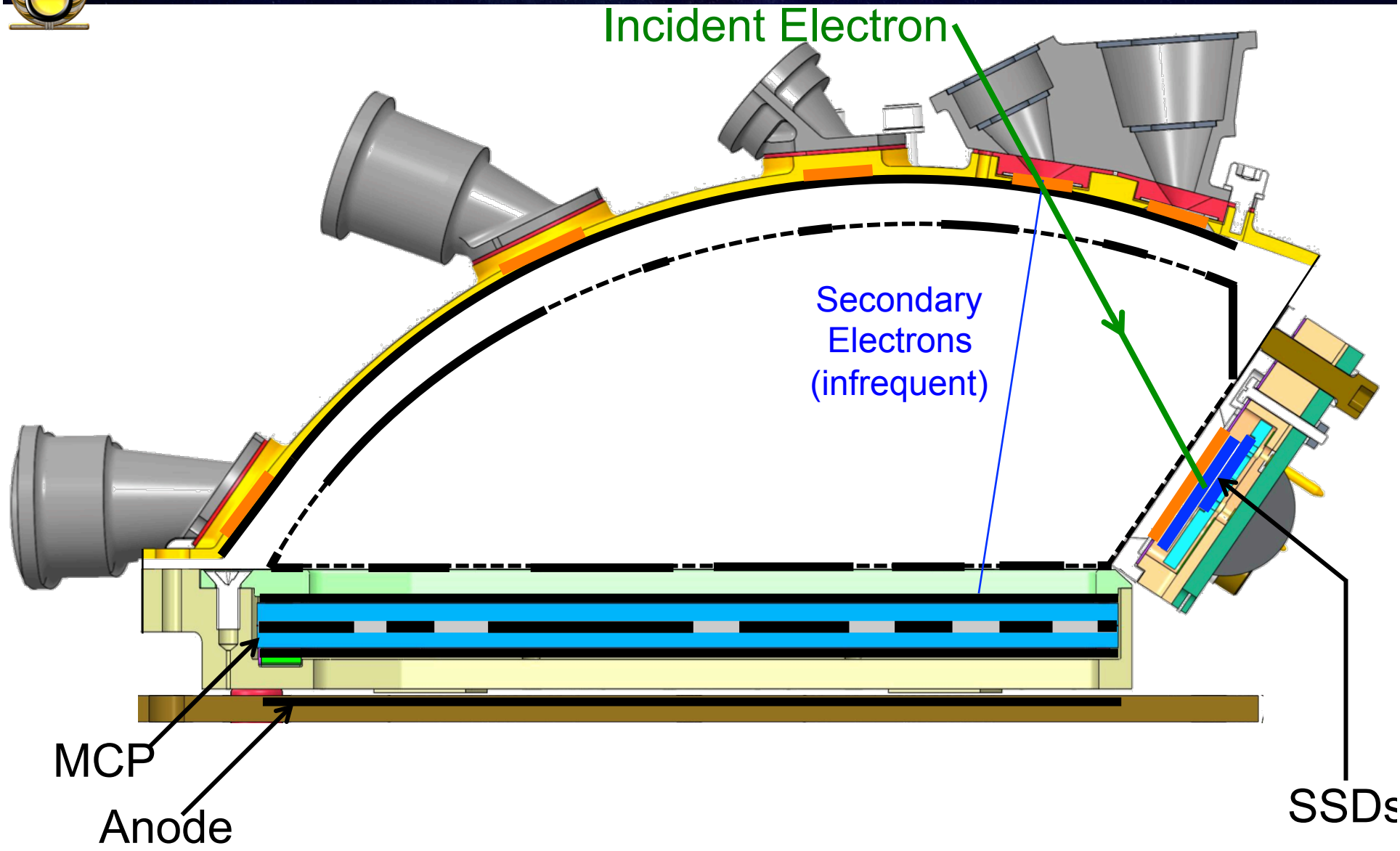
Secondary Electrons & Potentials



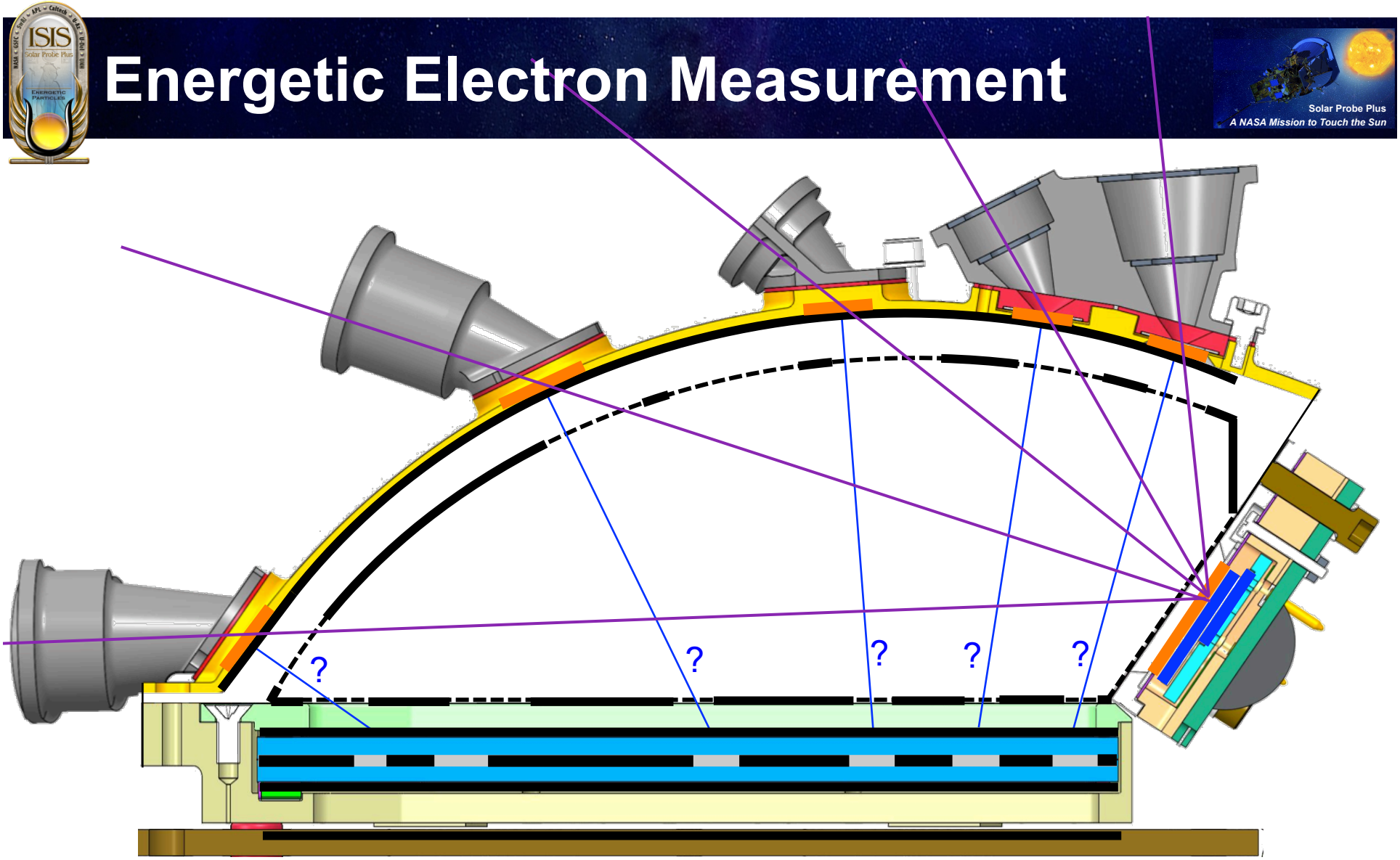
Ions (Energy, TOF, and Position)



Electrons: Energy (& Position)

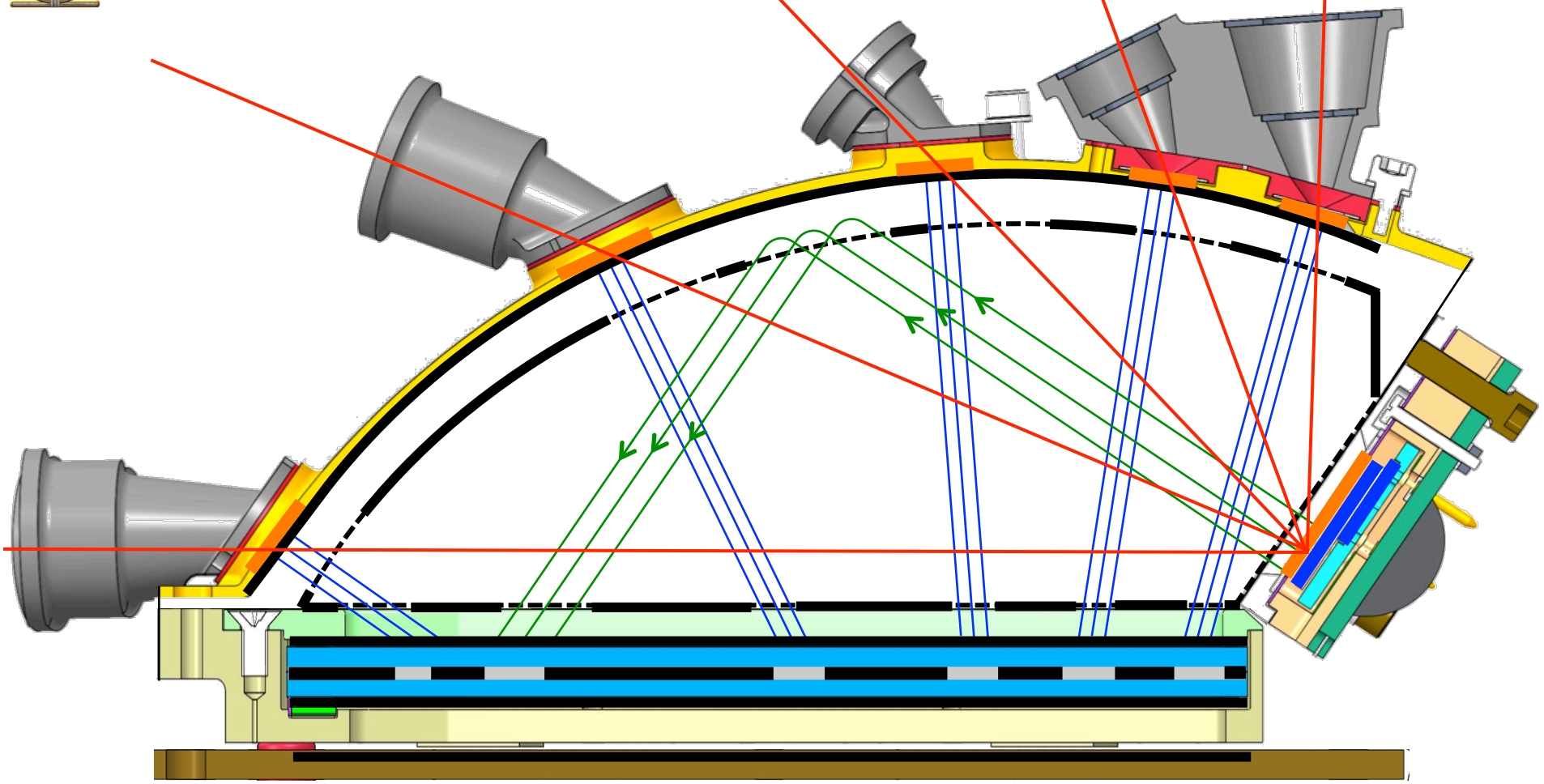


Energetic Electron Measurement



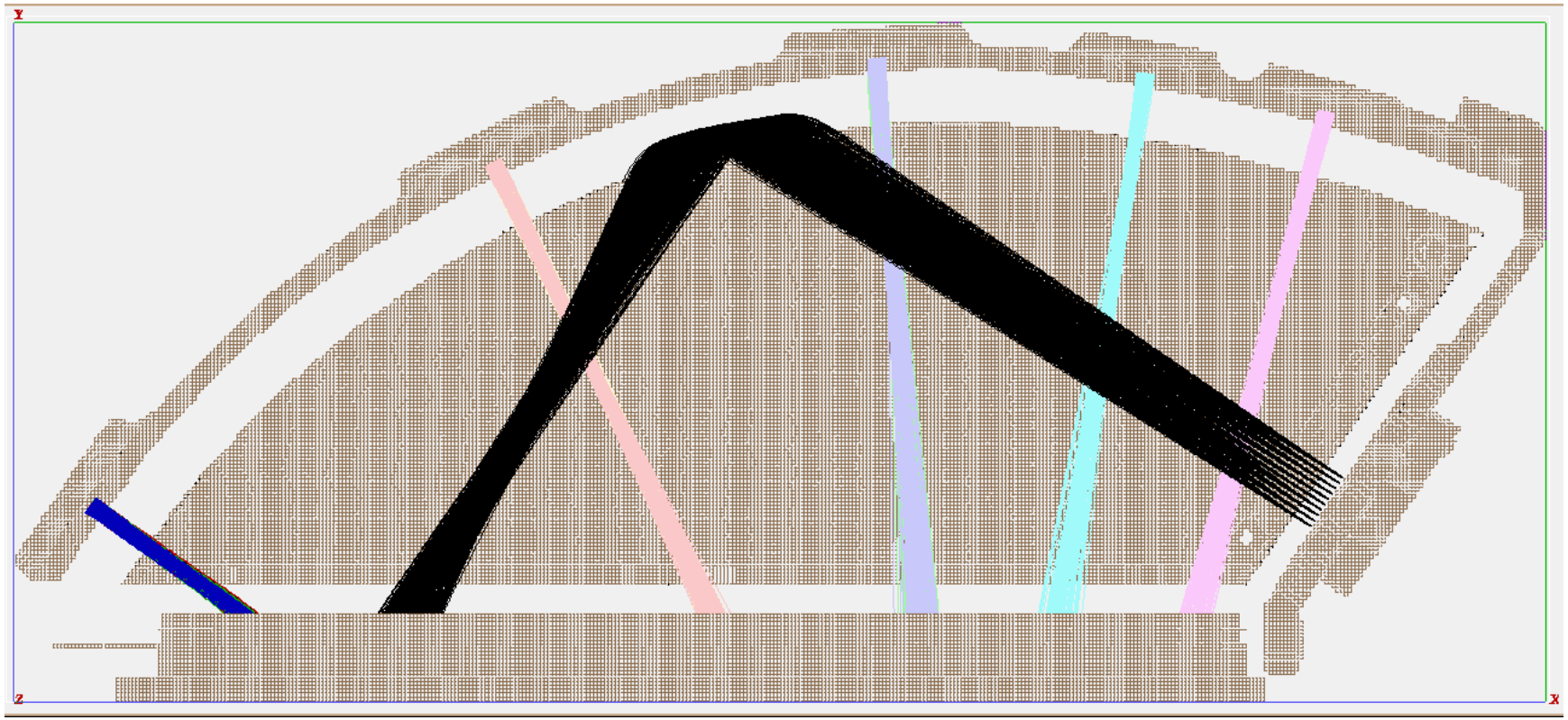
Secondary Electrons from Start Foils possible, but Low Probability;
Start Electron present identifies entrance aperture

Energetic Ion Measurement



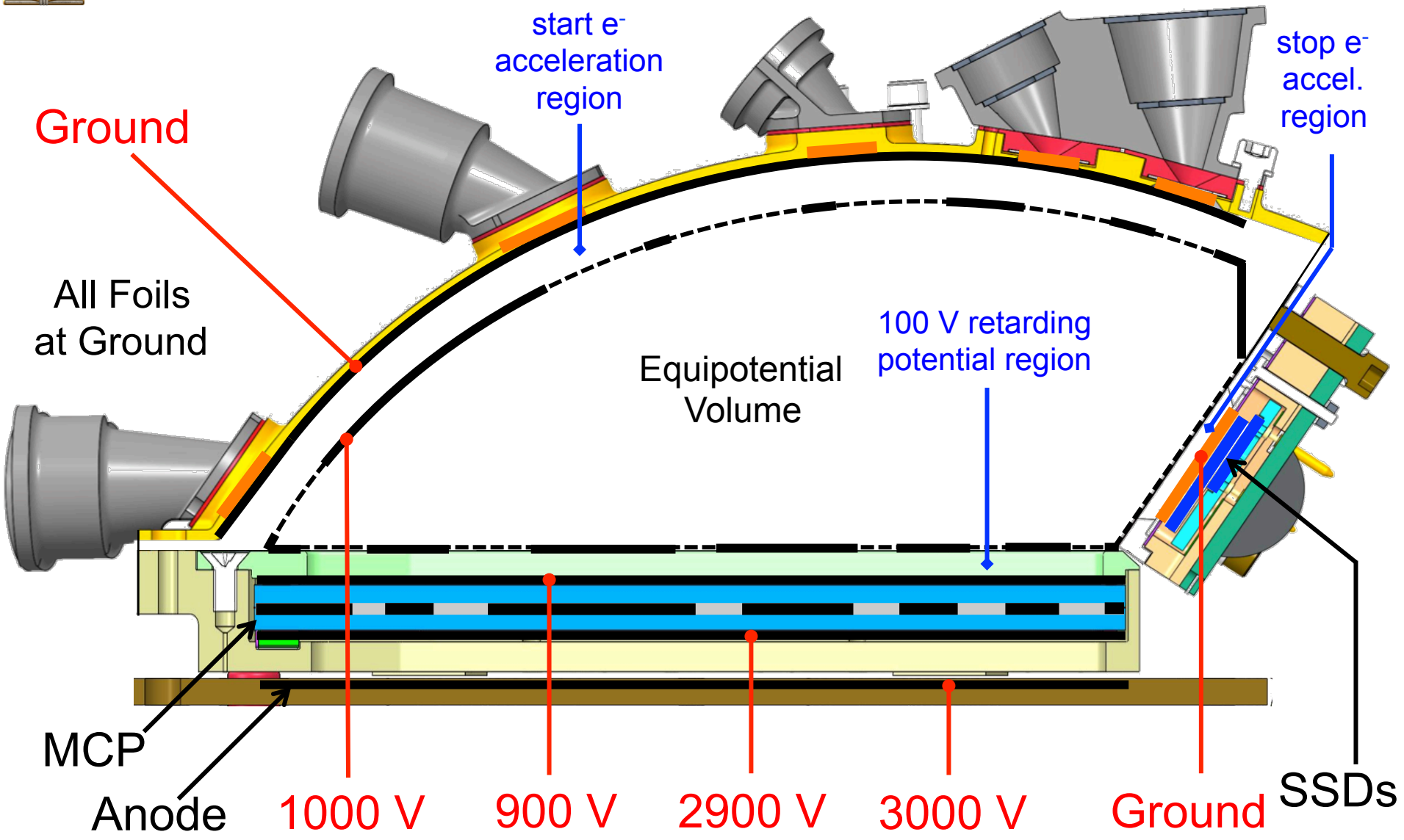
Ion Measurement Logic can require TOF or not, but with not TOF, no species

Electrostatic Optics

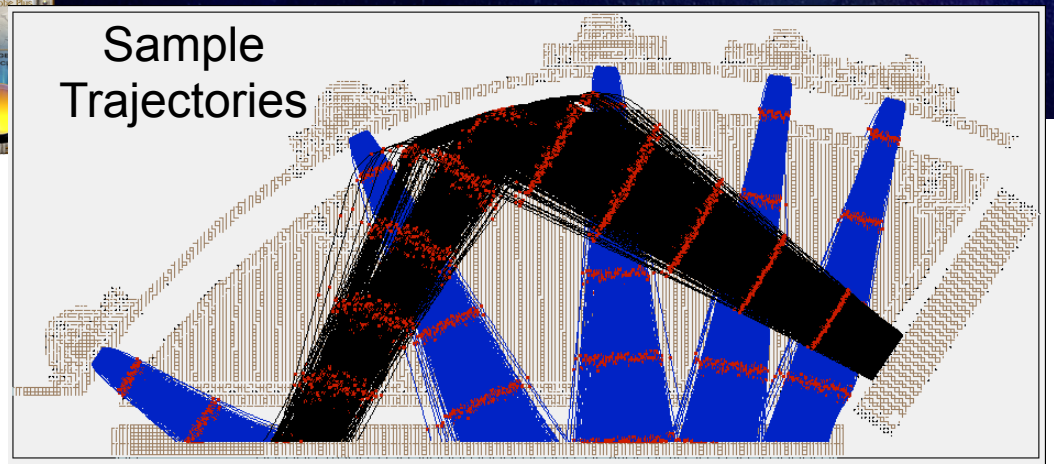


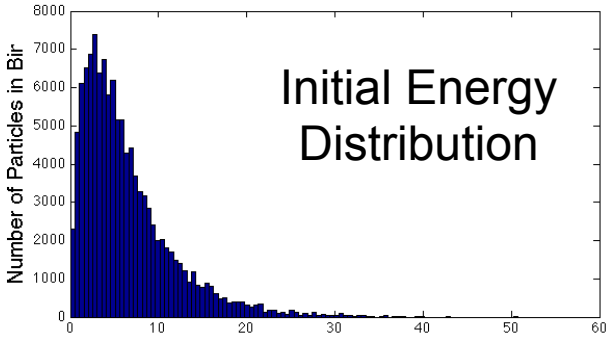
- SIMION simulation of electron optics using ~3eV random initial electron velocities.

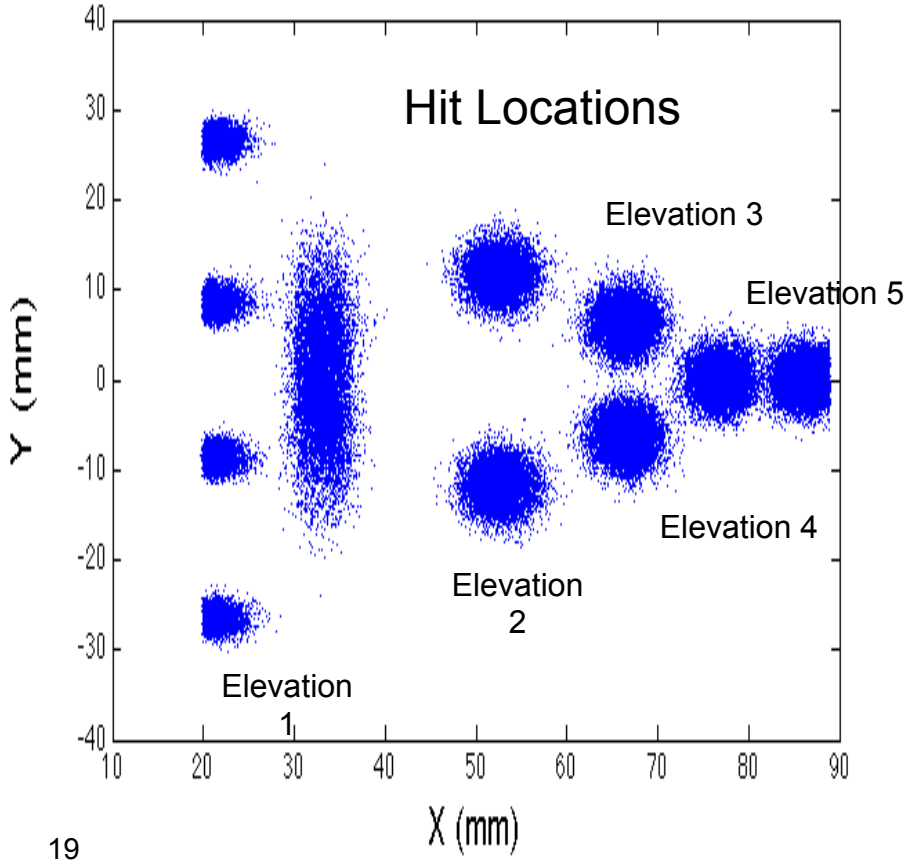
Sensor Voltages

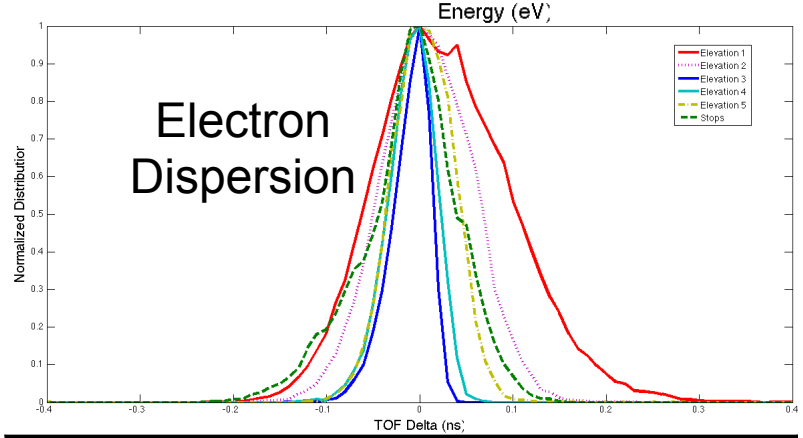


SIMION, Alegrini Energy Distribution



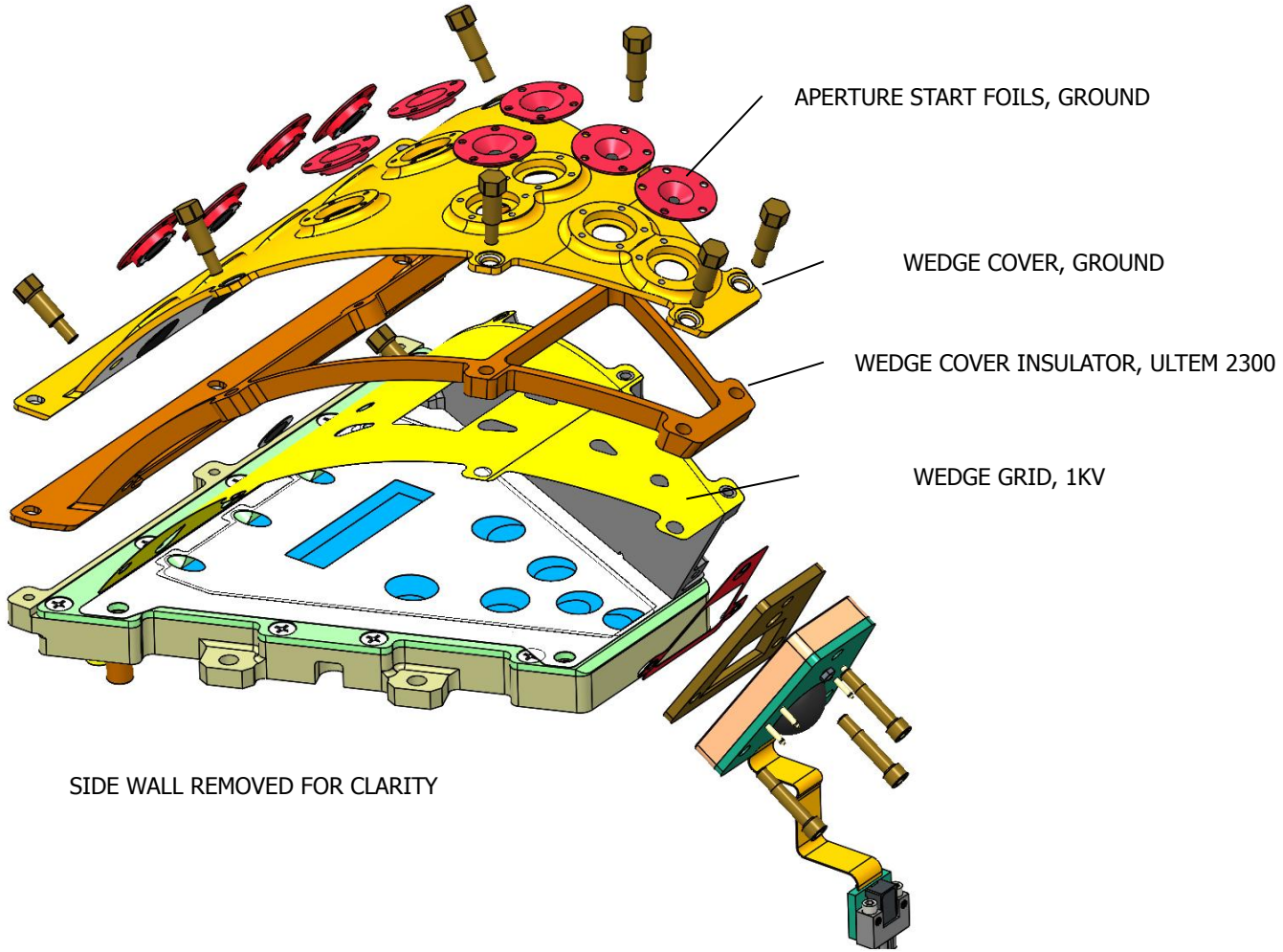






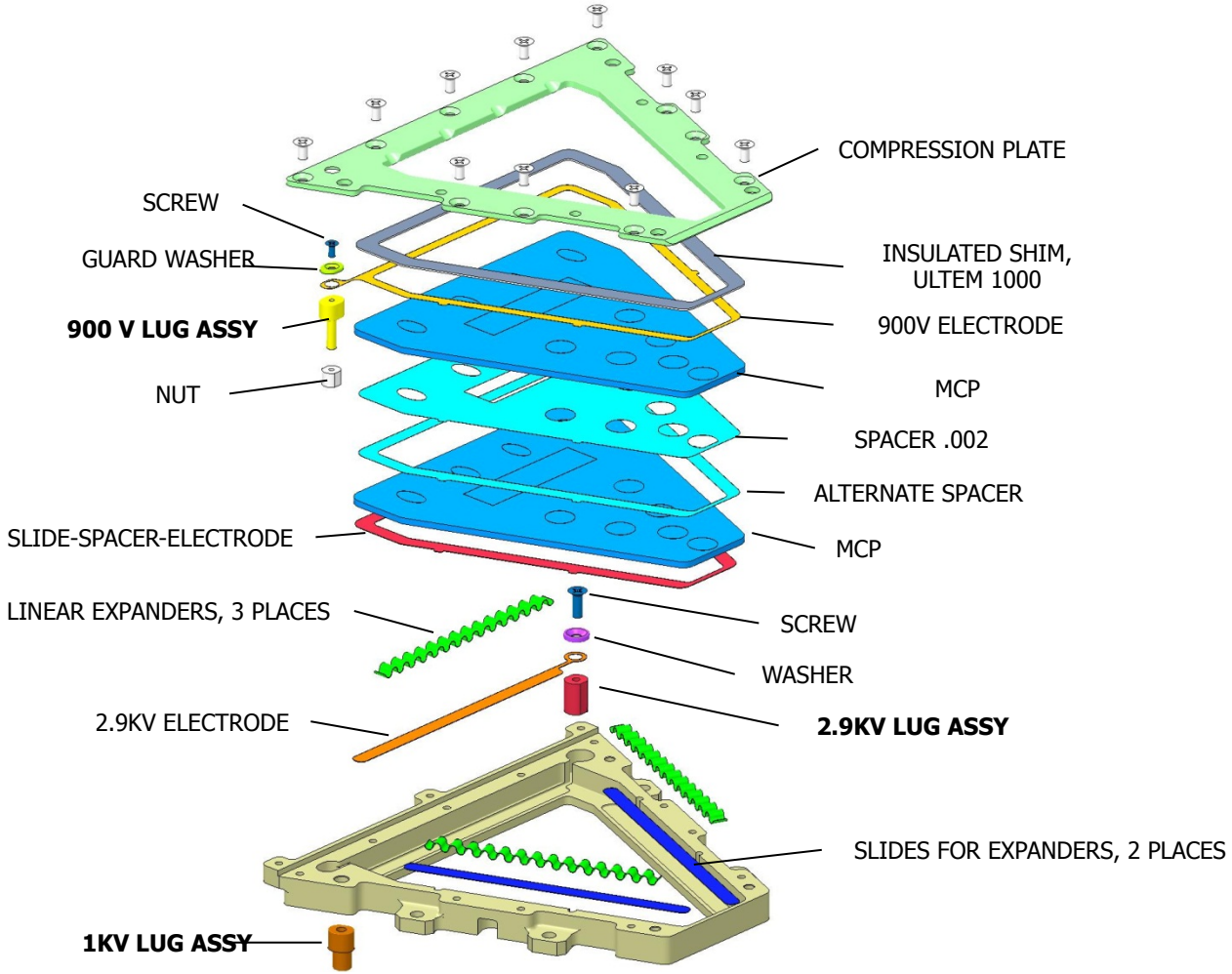
Name	Mean TOF (ns)	TOF Sigma (ns)
Elevation 1	1.06	0.19
Elevation 2	2.17	0.13
Elevation 3	2.35	0.05
Elevation 4	2.33	0.06
Elevation 5	2.32	0.12
Stops	5.23	0.11

EPI-Lo Wedge, Exploded View



EPI-LO INDIVIDUAL SENSOR WEDGE ASSY CROSS SECTION

MCP Inter-Plate Spacer also a mask

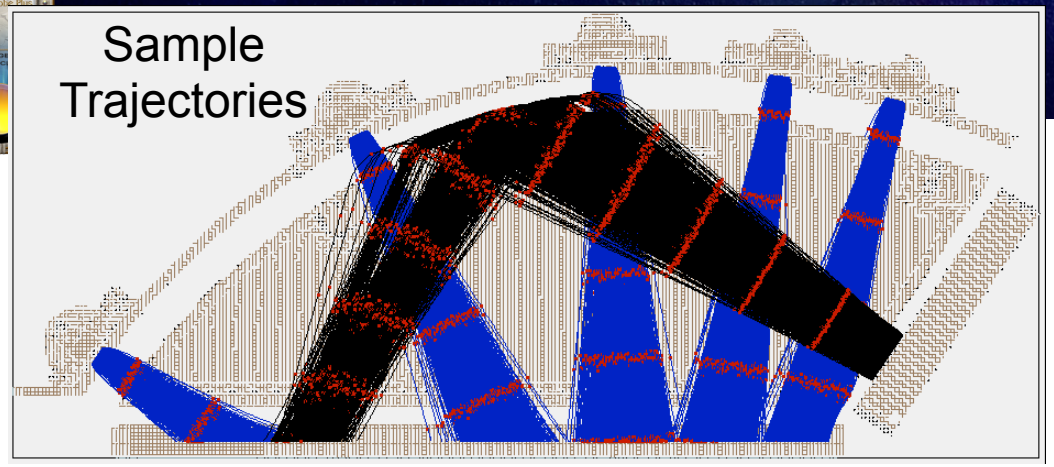


EXPLODED VIEW "NEW" MCP ASSEMBLY

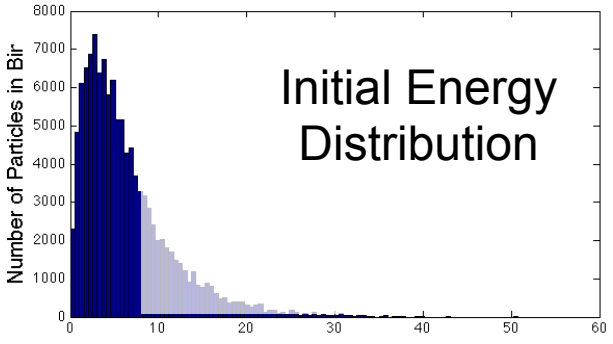
SIMION, Alegrini Energy Distribution

Solar Probe Plus
A NASA Mission to Touch the Sun

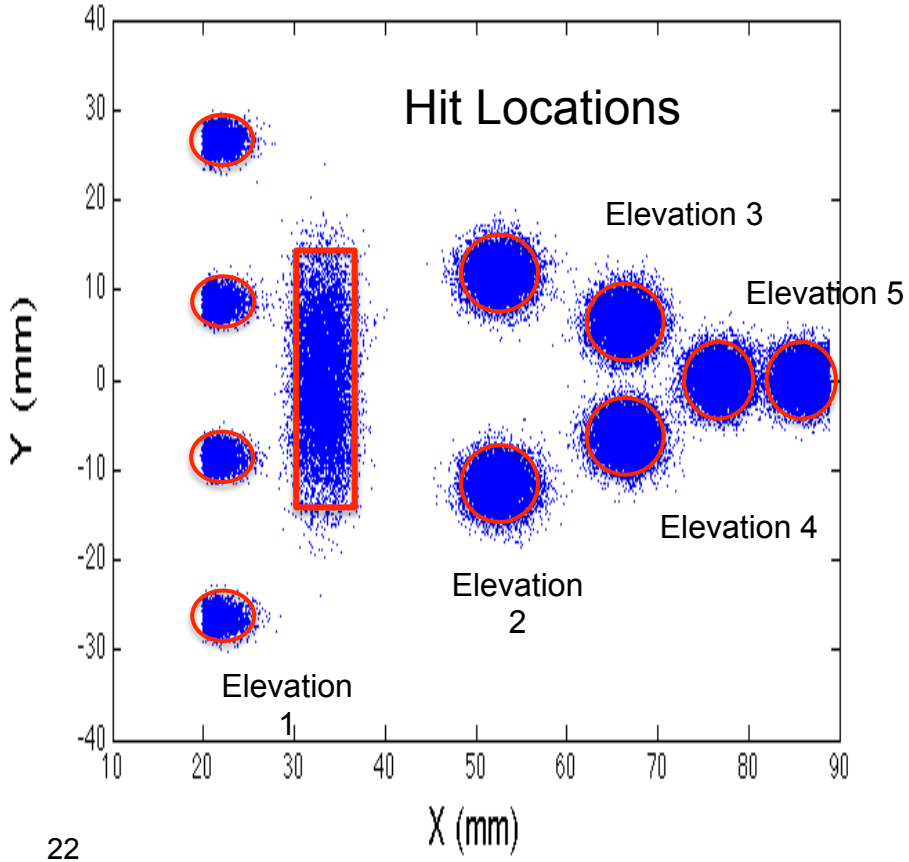
Sample Trajectories



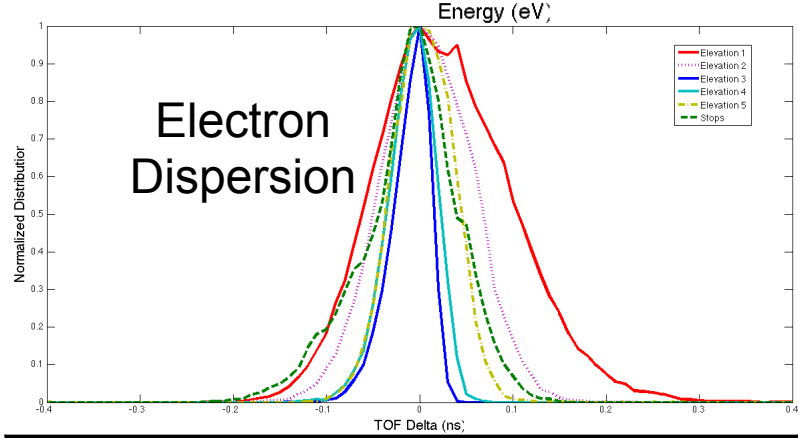
Initial Energy Distribution



Hit Locations



Electron Dispersion



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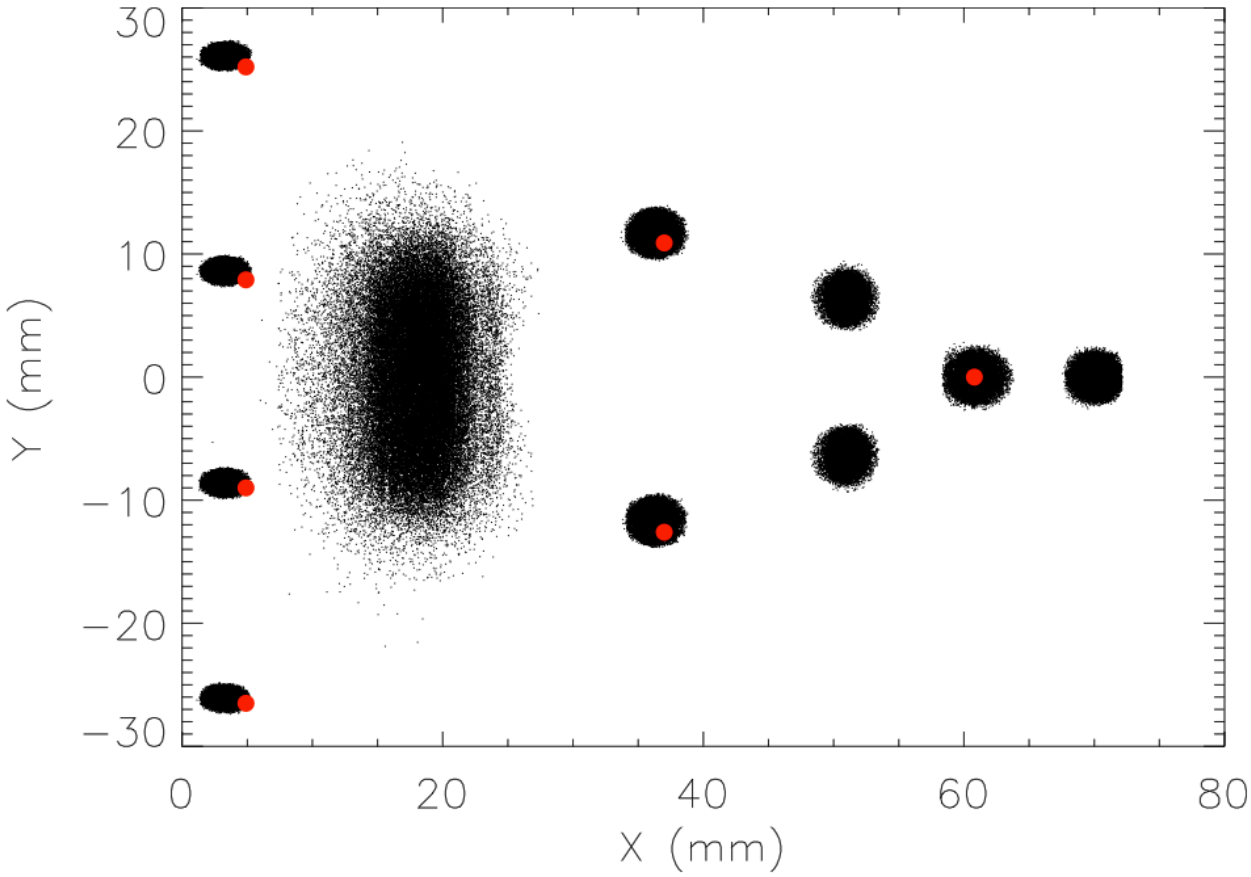
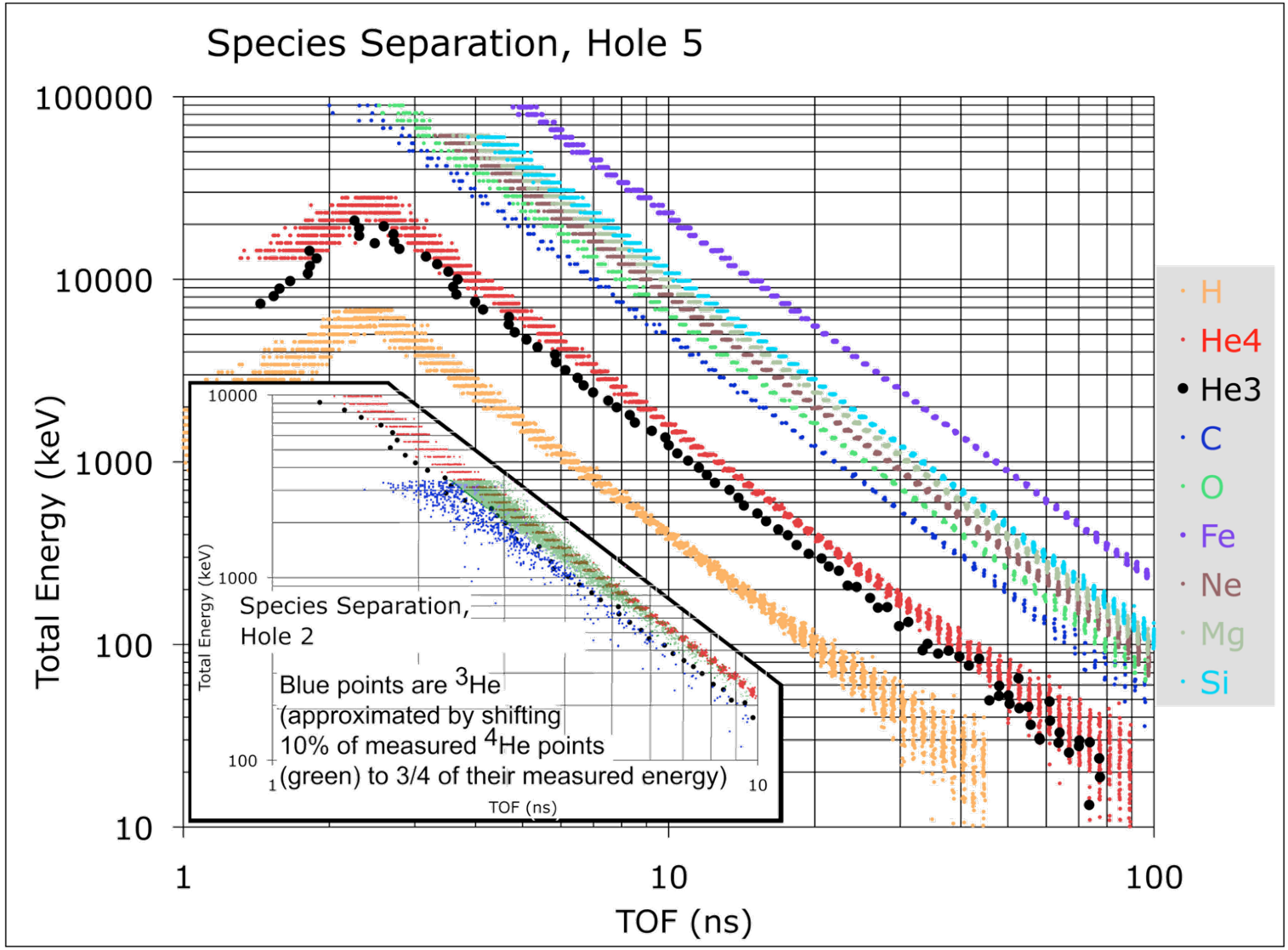
Elevation 5	2.32	0.12
Stops	5.23	0.11

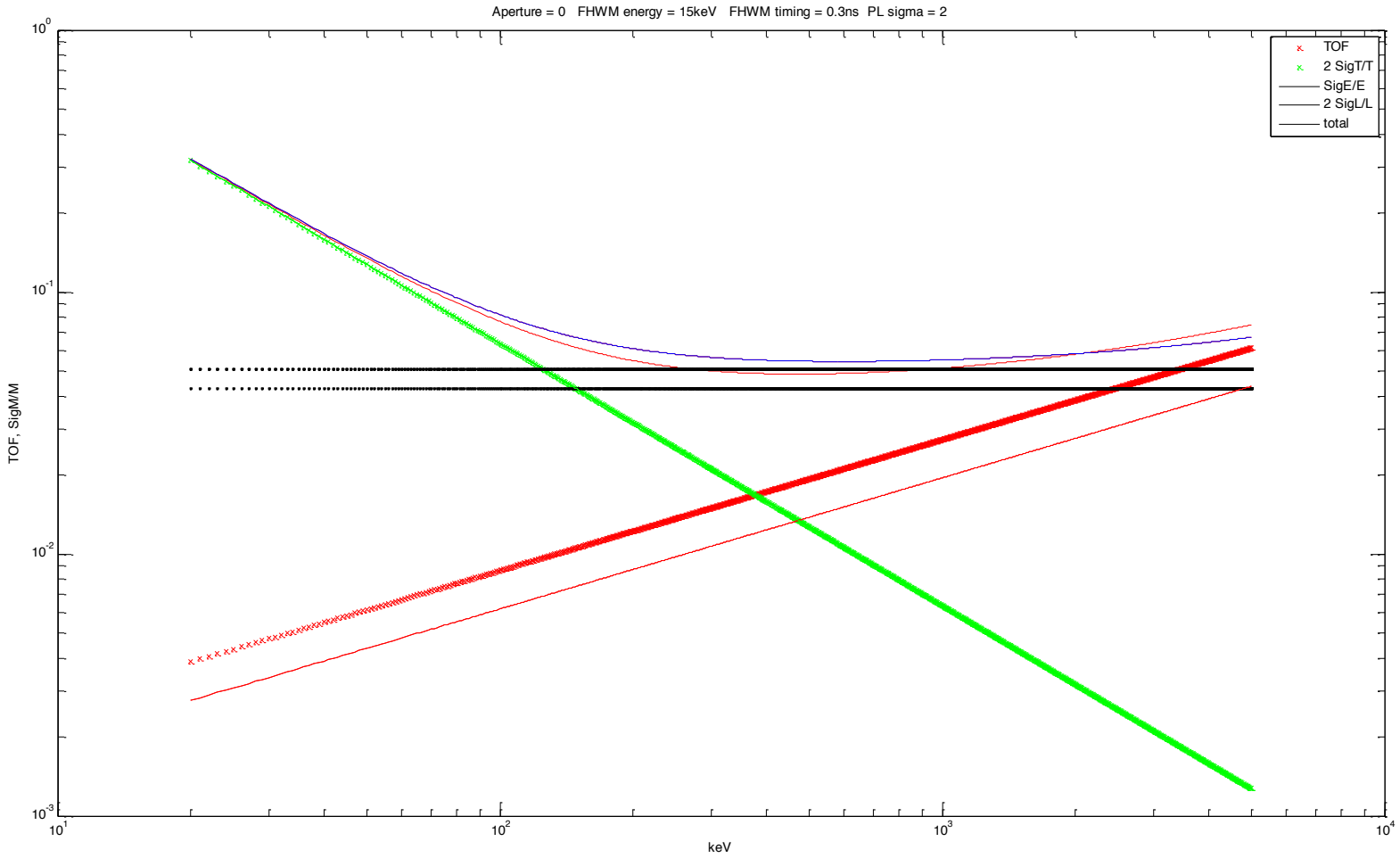
Microchannel Plate (MCP)



Mass Resolution

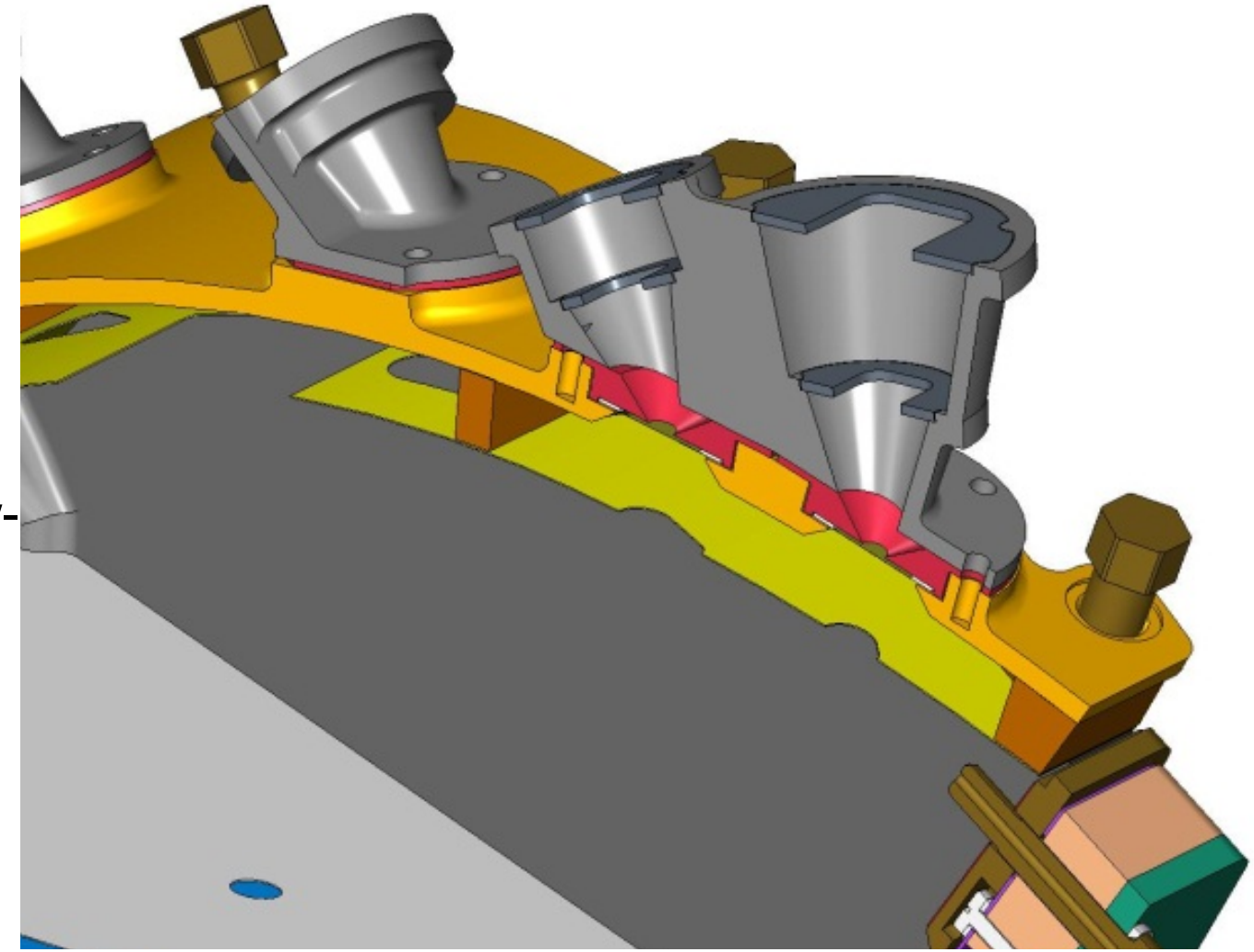


Mass Resolution

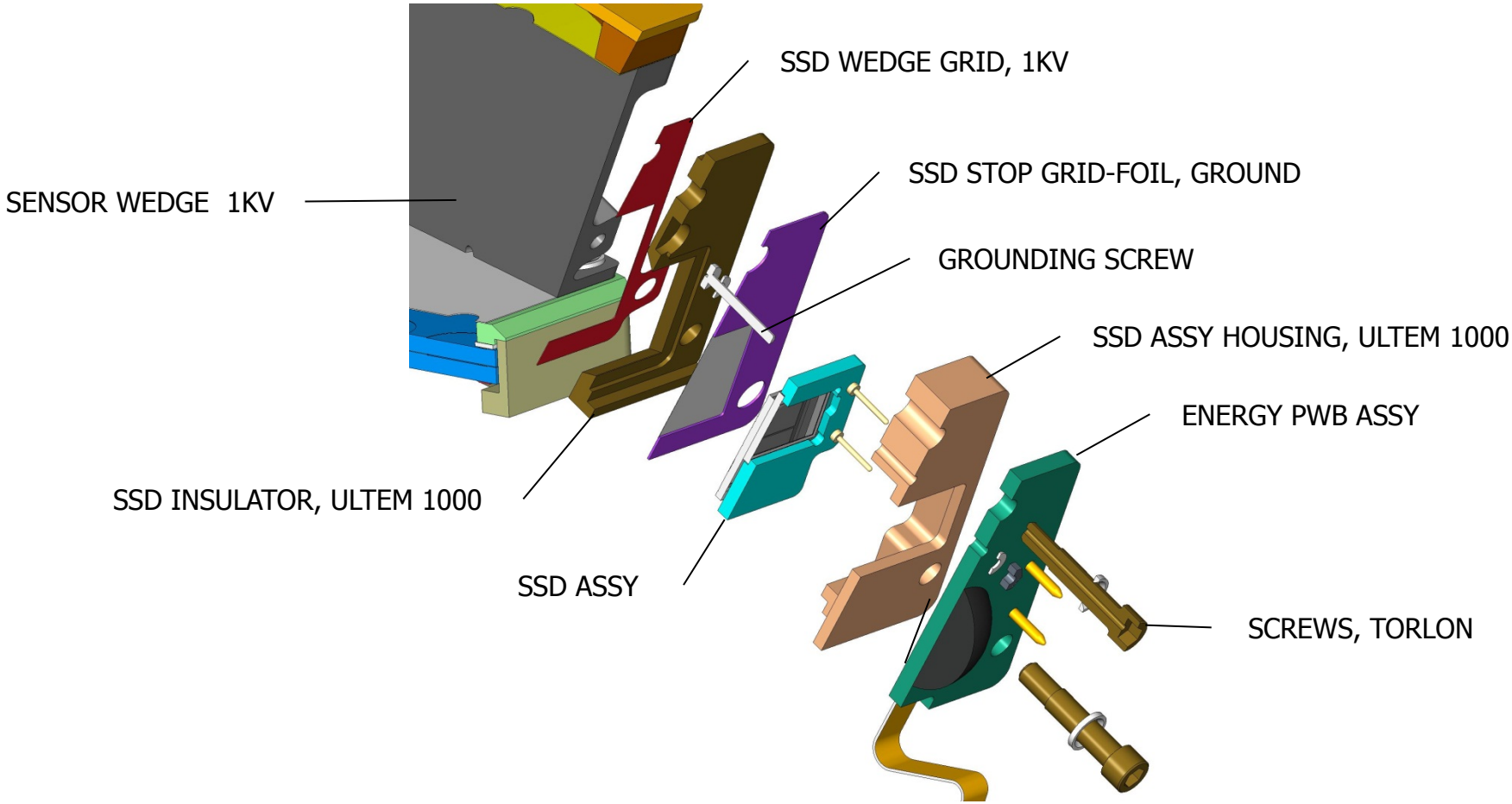


Collimators and Start Foils

- Foils Mount on Apertures (red)
  - Each elevation tailored for equal GF
  - Second foil planned at intermediate baffle
- Collimators screw-mount to outer cover, capture foils
  - Each Elevation and azimuth is unique



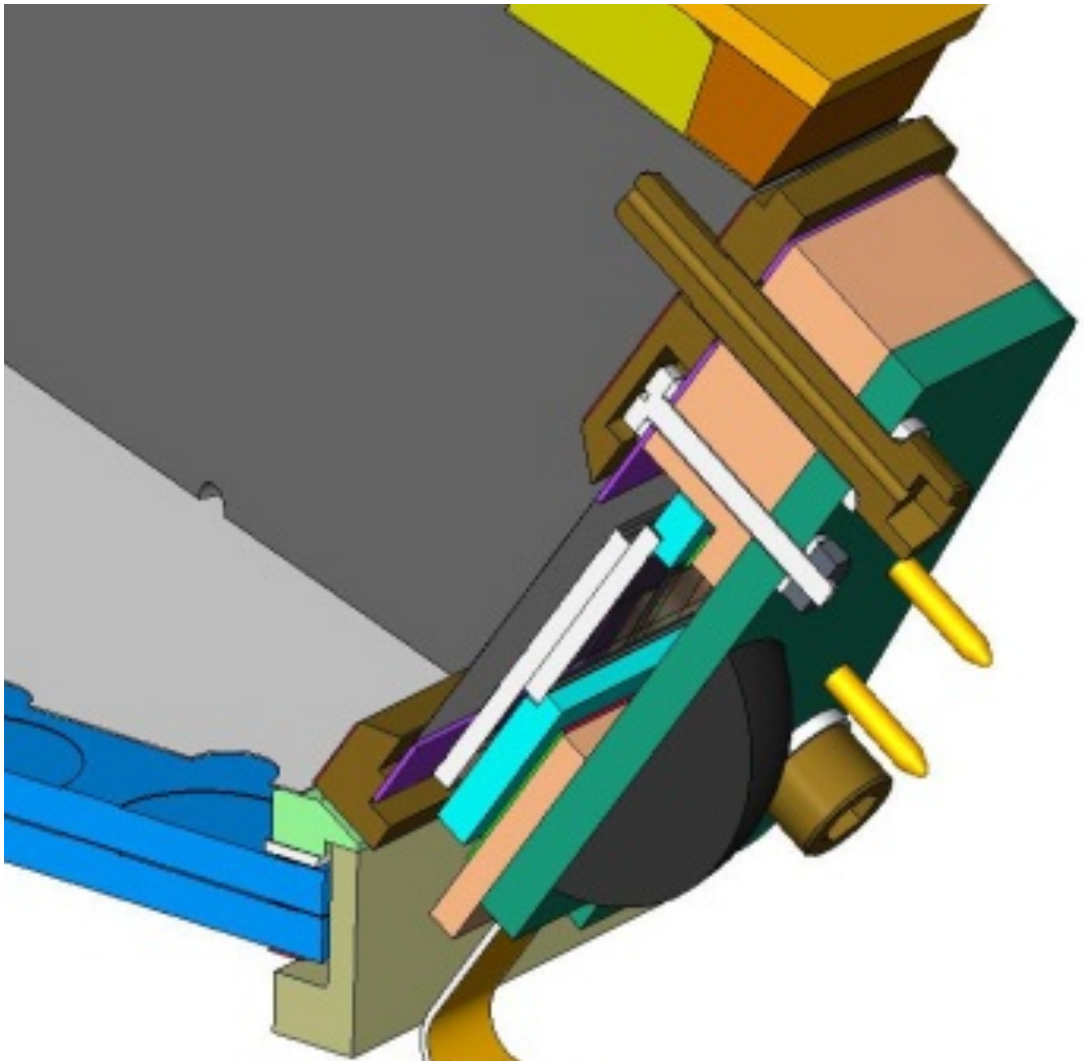
EPI-Lo SSD Assemblies (8)



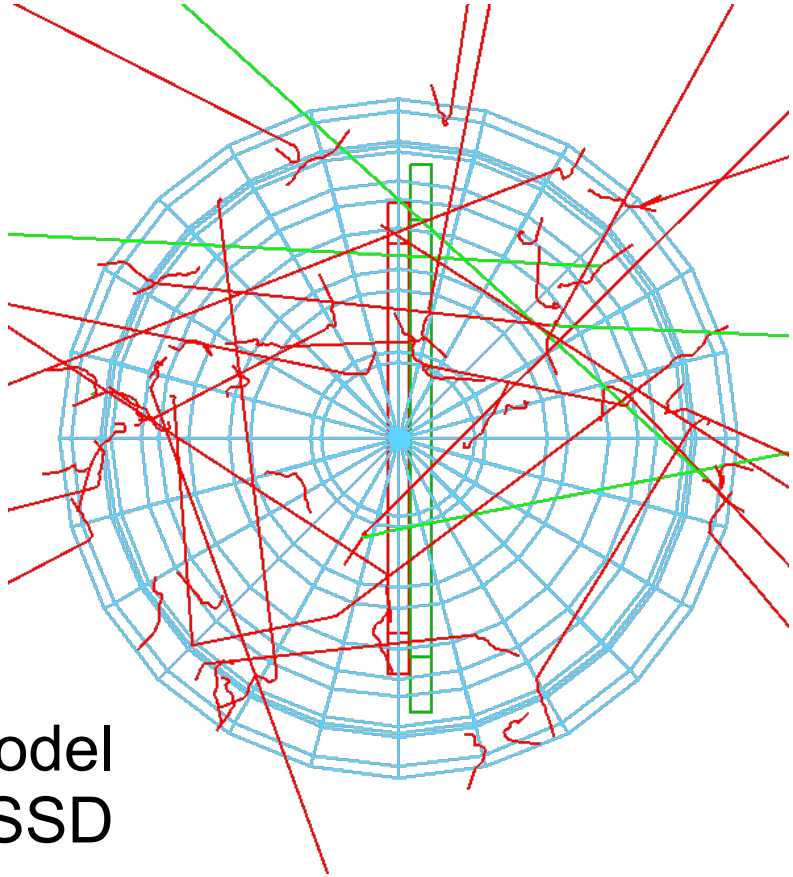
SSD ASSY TO WEDGE EXPLODED CROSS SECTION

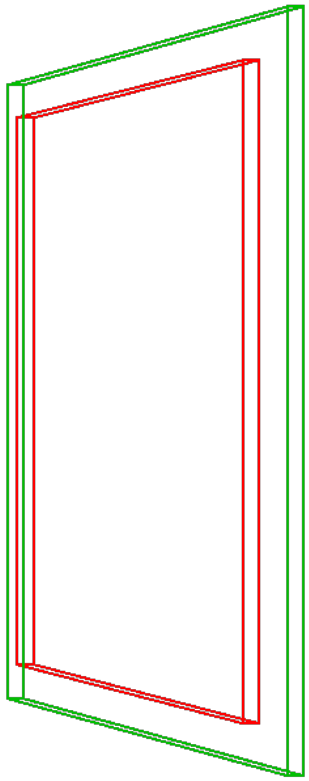
Anti-coincidence System

- Electron SSD is backed by an anti-coincidence SSD



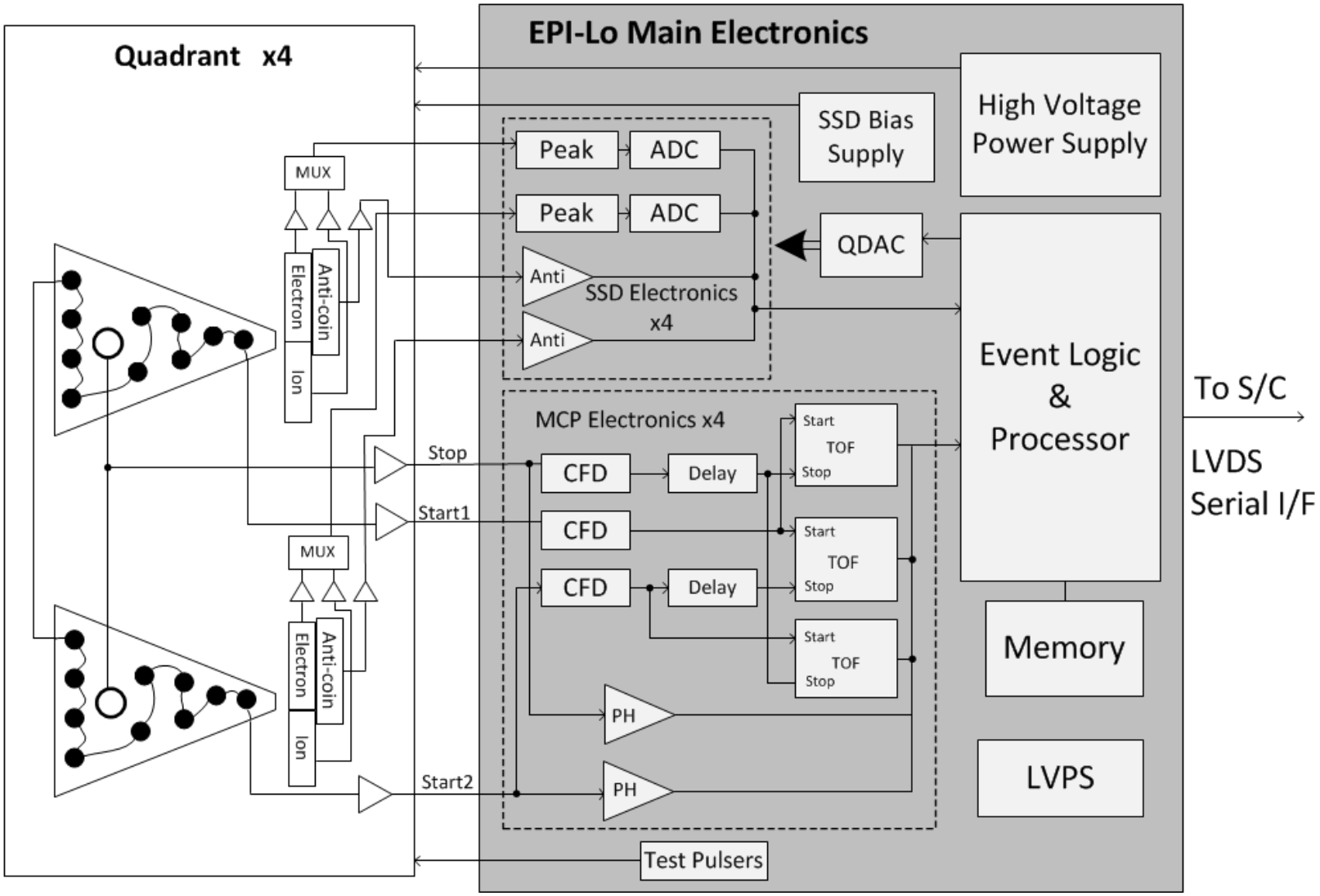
Anti-coincidence System: GEANT



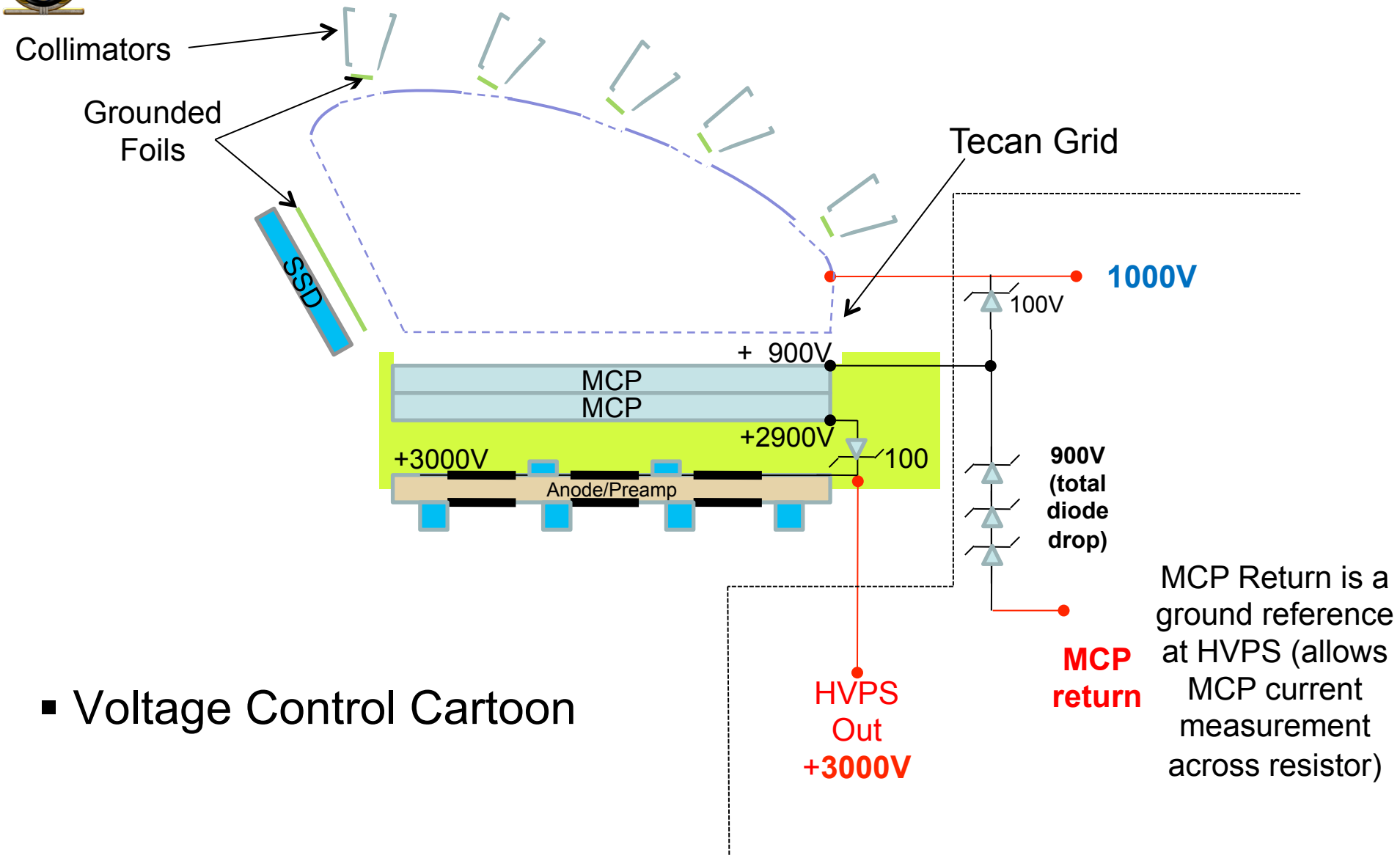


- Setup for GEANT4 model of electron SSD anticoincidence

EPI-Lo Block Diagram



Sensor Voltages

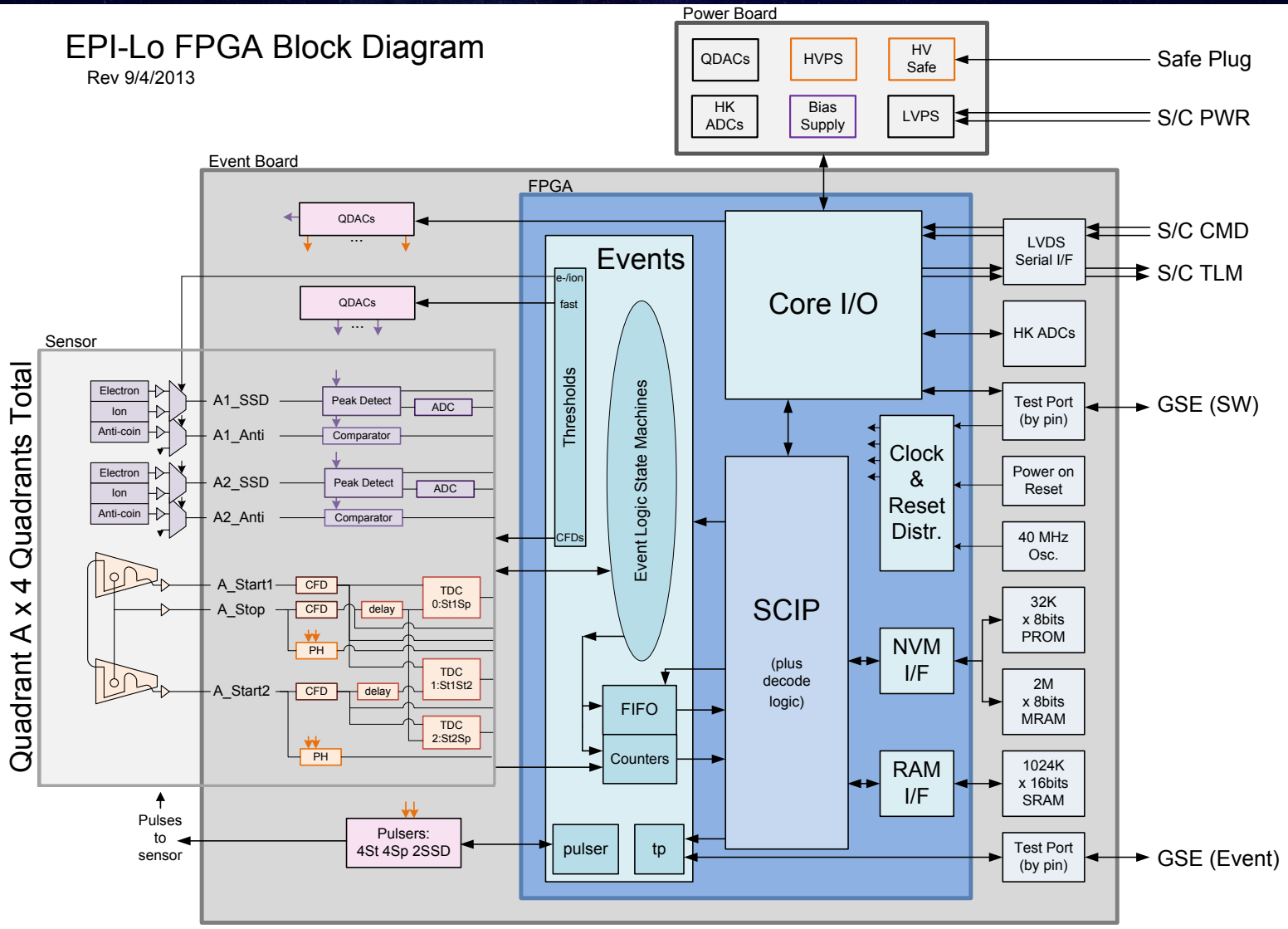


- Voltage Control Cartoon

EPI-Lo Block Diagram

EPI-Lo FPGA Block Diagram

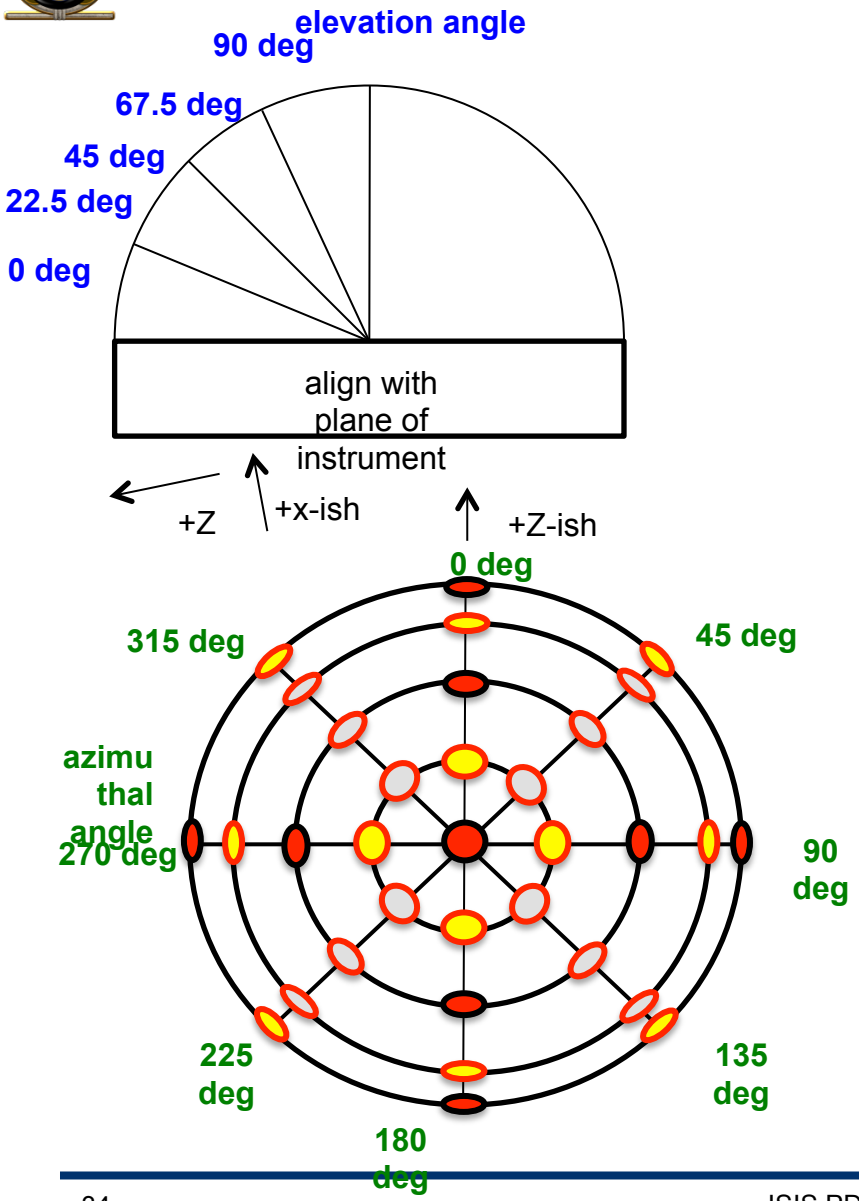
Rev 9/4/2013

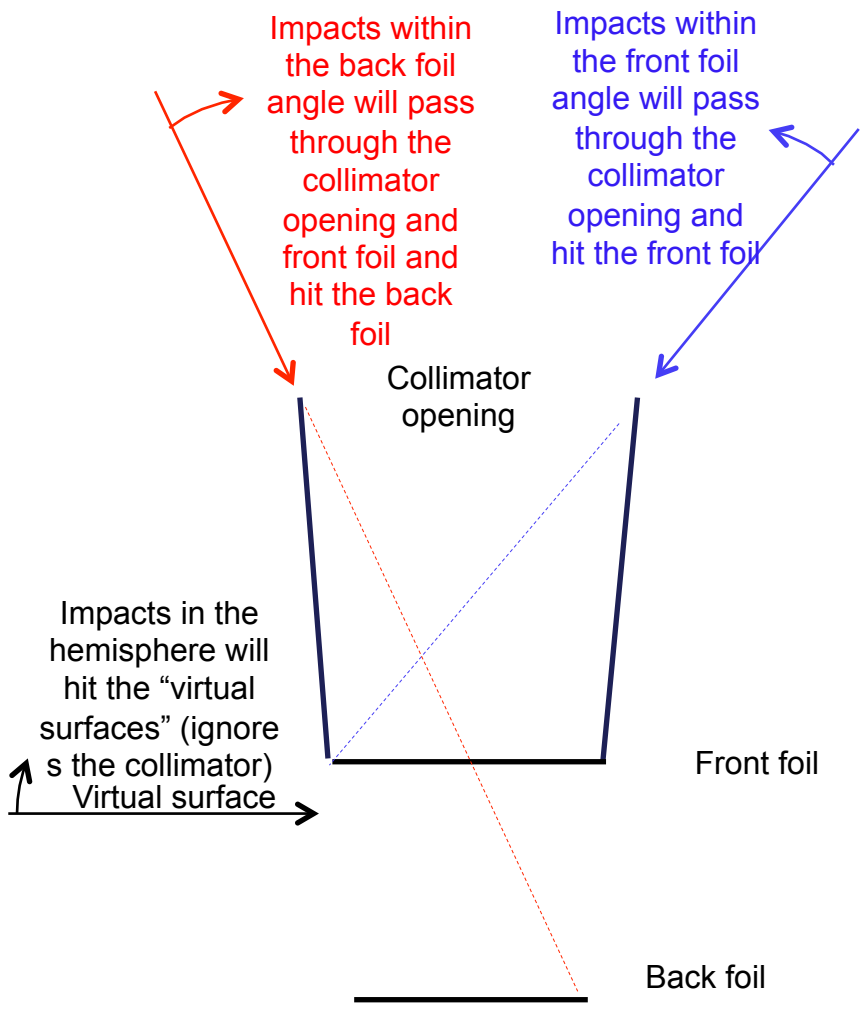


Light & Dust Mitigation

- TBD

Dust: Simulating the Environment

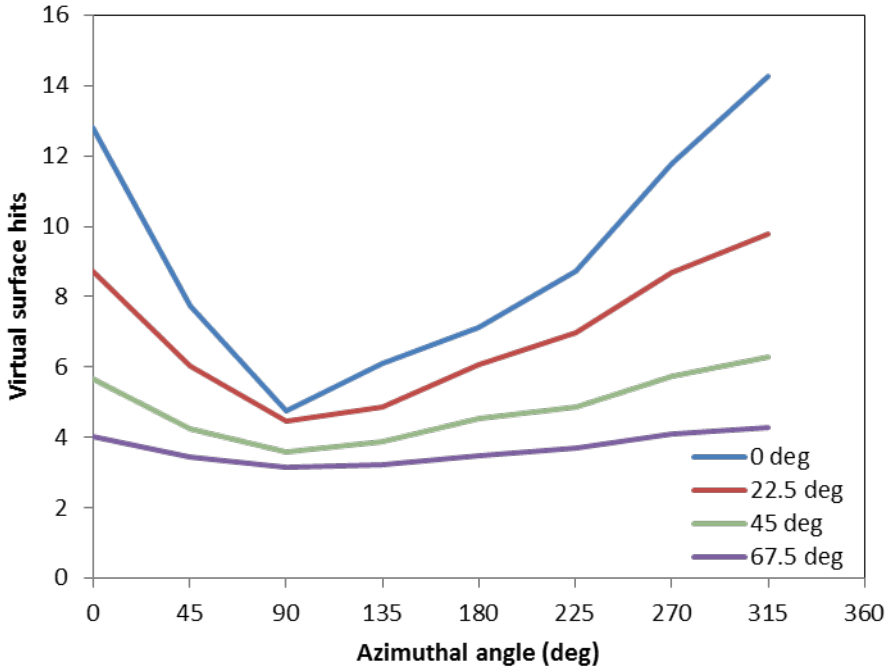


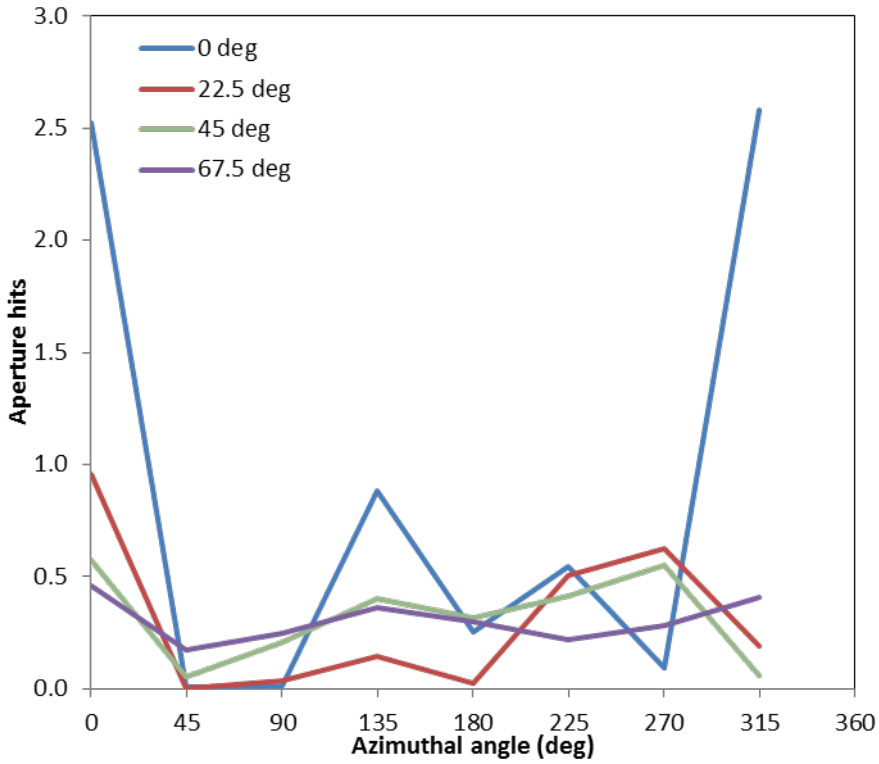


NOTE: actually only polar angle is limited, not position on surface, so foil area was adjusted to account for this and produce actual foil geometry factors,

Dust: Simulating the Environment

- Each unprotected foil would expect ~10 damage-inducing hits per mission. Reduced to ~1 hit per mission with collimator. Order of magnitude decrease.





Dust: Lab tests

- TBD

SLIDE PREPARATION NOTES

Are we handling dust in this presentations? Assuming yes.
Should we discuss photons suppression here? Assuming yes, it's background.

How about details like how the MCPs work (in general)? Or this could be handled when someone discusses the anode boards. Special features like the inter-plate mask (or is that handled in a mechanical section)?
Backup slides: MCPs

We are only supposed to respond to requirements, so I wasn't going to go into any of the rate estimates from the work that I (Matt) and Rob D. did since that is for goals. Is this the right approach?

Follow Up from Peer Reviews

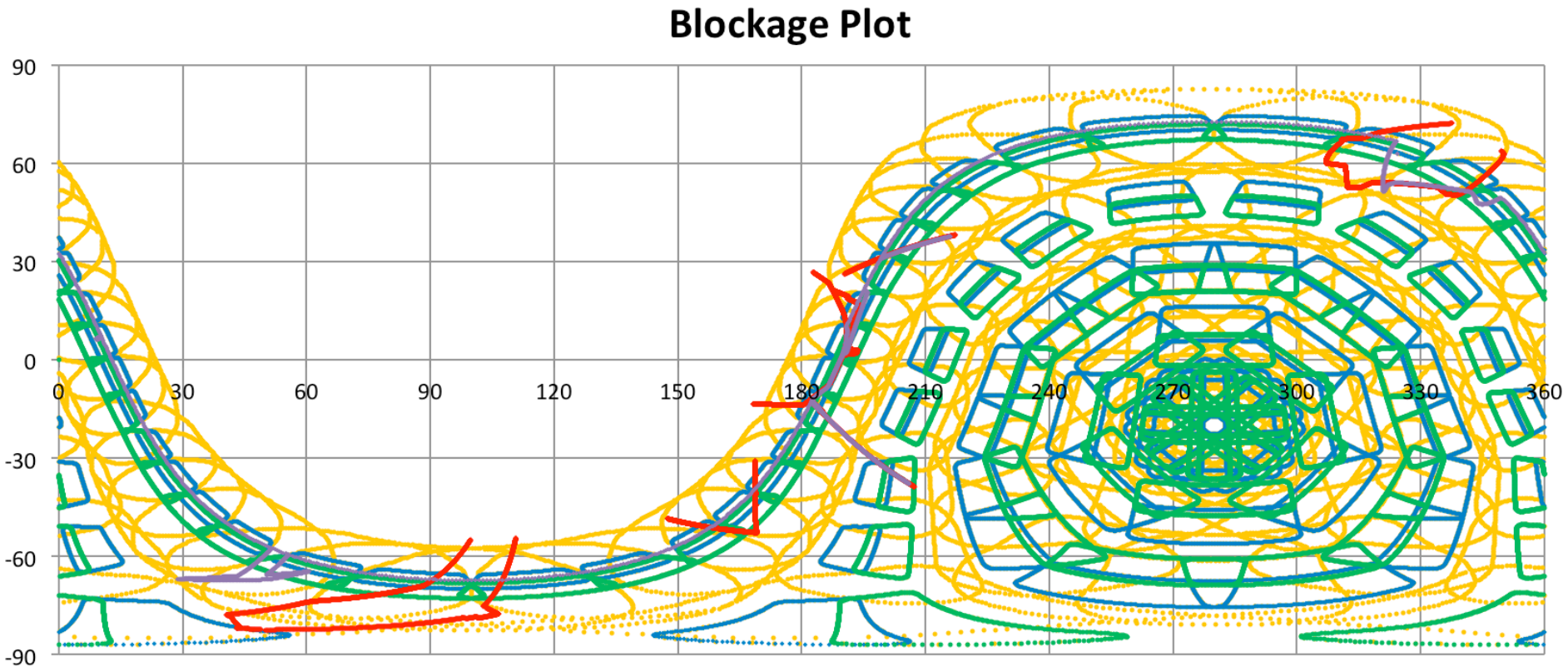
- TBD

Summary

- TBD

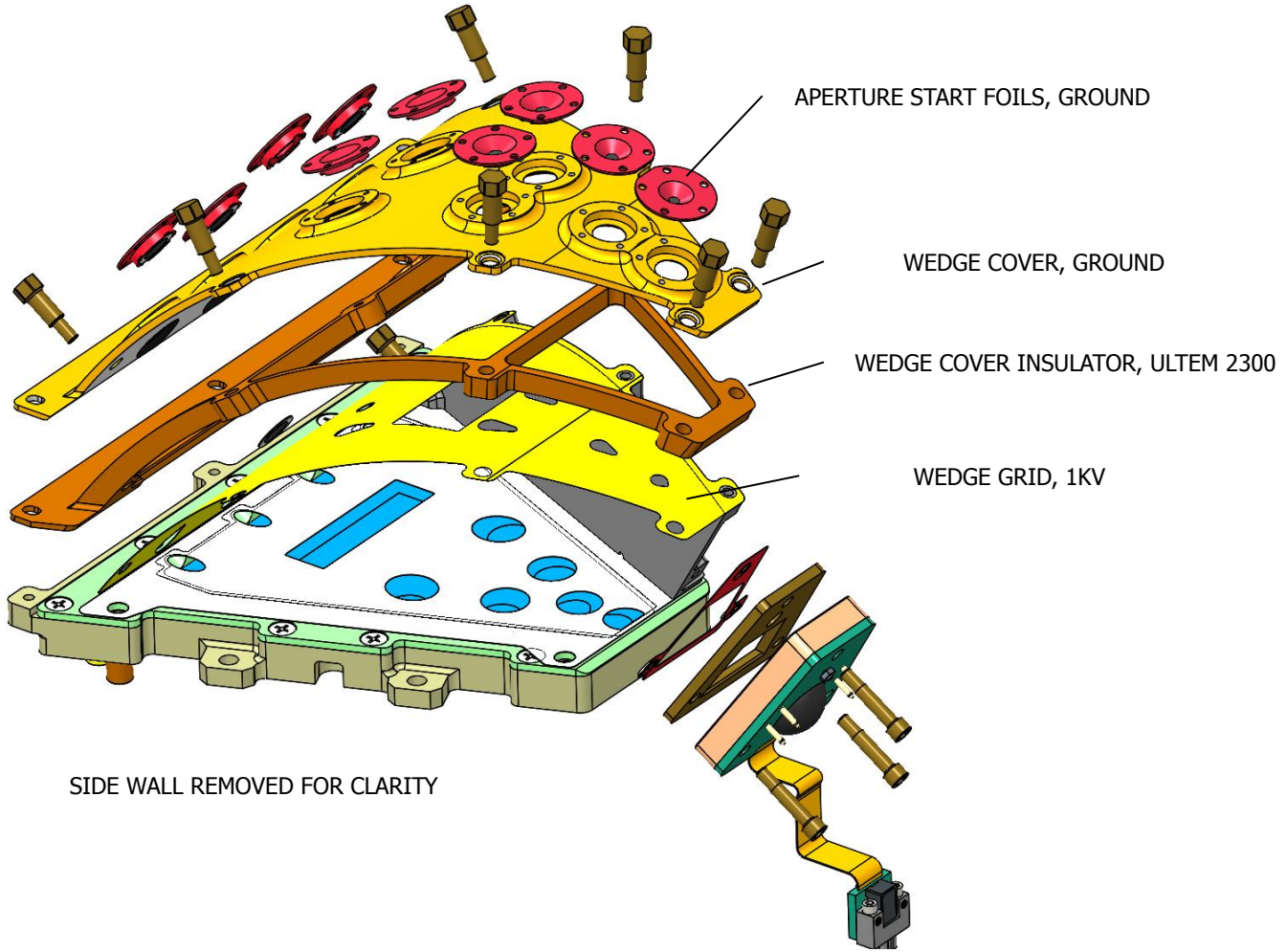
Backup

Collimator Foil FOV



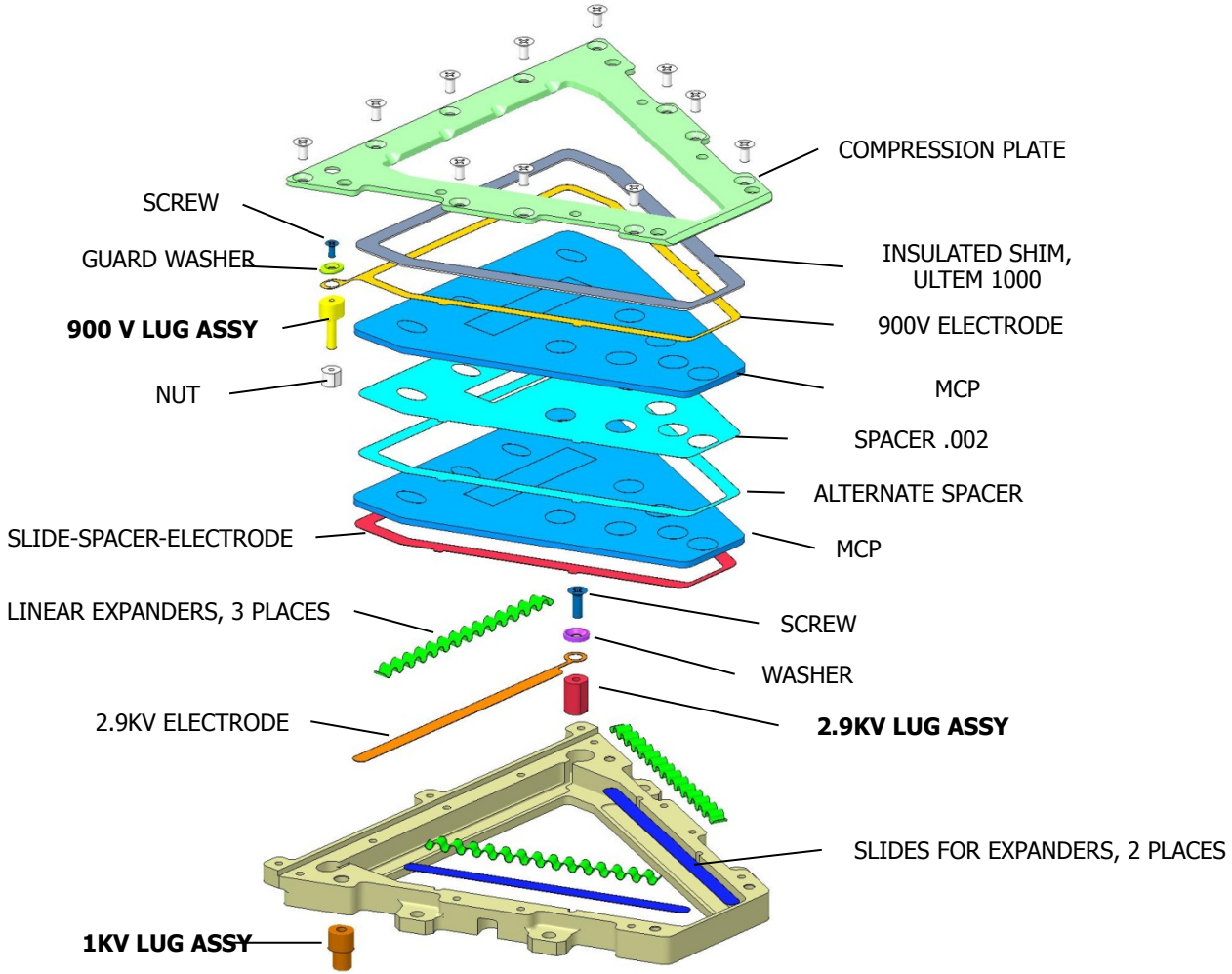
- Foil FOVs shown in yellow (these are not with the latest collimators).

EPI-Lo Instrument Peer Review



EPI-LO INDIVIDUAL SENSOR WEDGE ASSY CROSS SECTION

EPI-Lo Instrument Peer Review



EXPLODED VIEW "NEW" MCP ASSEMBLY

Principles of Operation