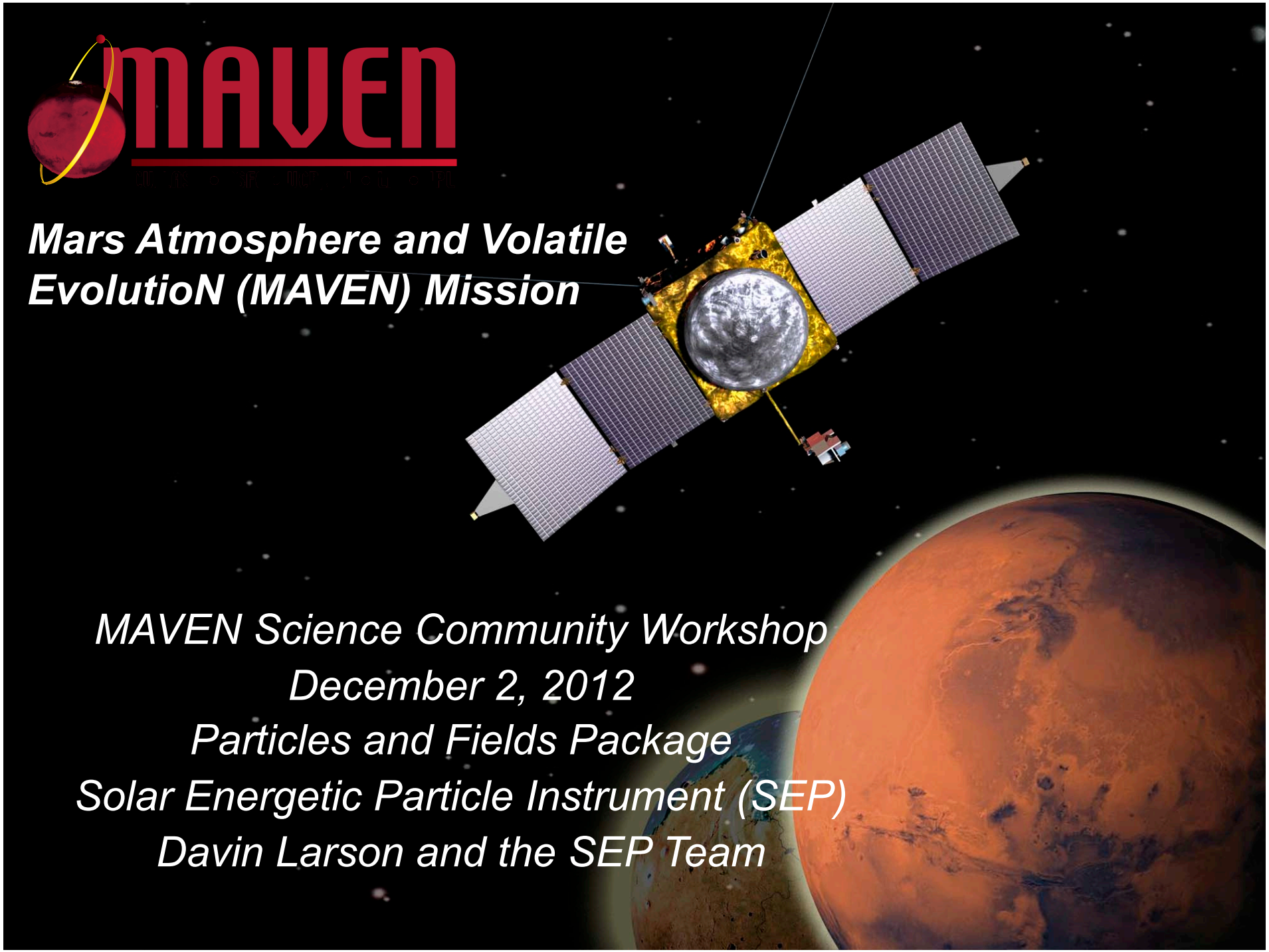
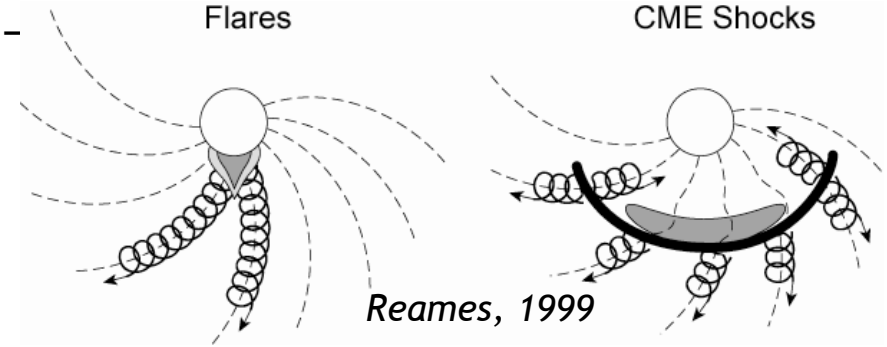
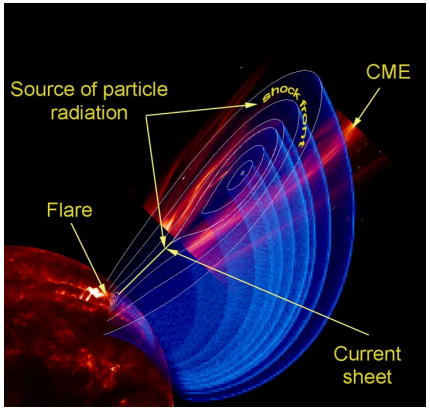

MAVEN
Mars Atmosphere and Volatile
EvolutioN (MAVEN) Mission
MAVEN Science Community Workshop
December 2, 2012
Particles and Fields Package
Solar Energetic Particle Instrument (SEP)
Davin Larson and the SEP Team

Overview of SEP events

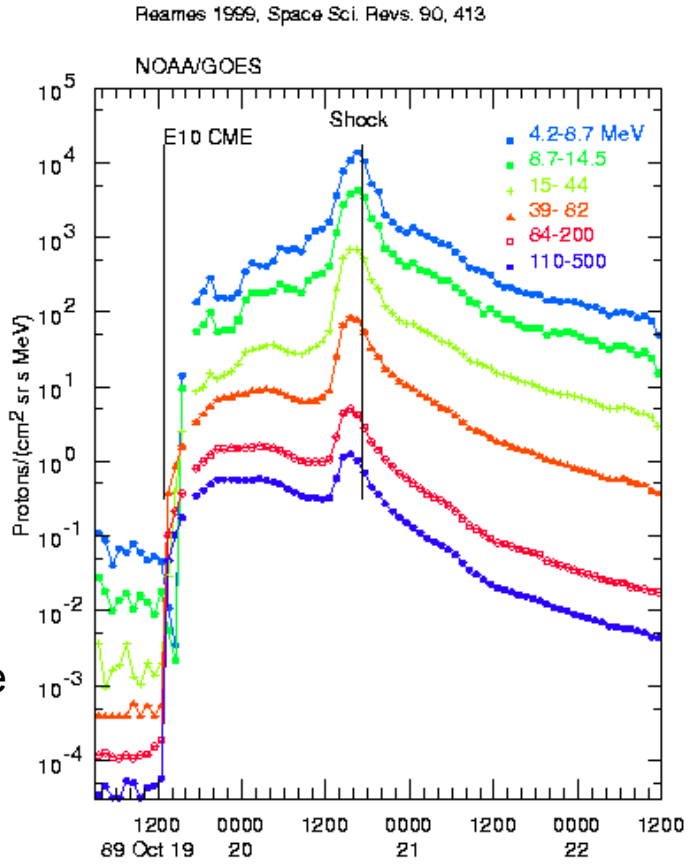
- **SEPs**: Solar Energetic Particles are ions or electrons of solar or interplanetary origin from ~10 keV to ~1000 MeV (i.e. suprathermal solar wind tail up to GCRs).
- Primary acceleration mechanisms to produce SEPs:
  - Solar flares, causing impulsive events (hours)
  - CME shocks, CIRs, causing gradual events gradual events (days)
  -



ESA

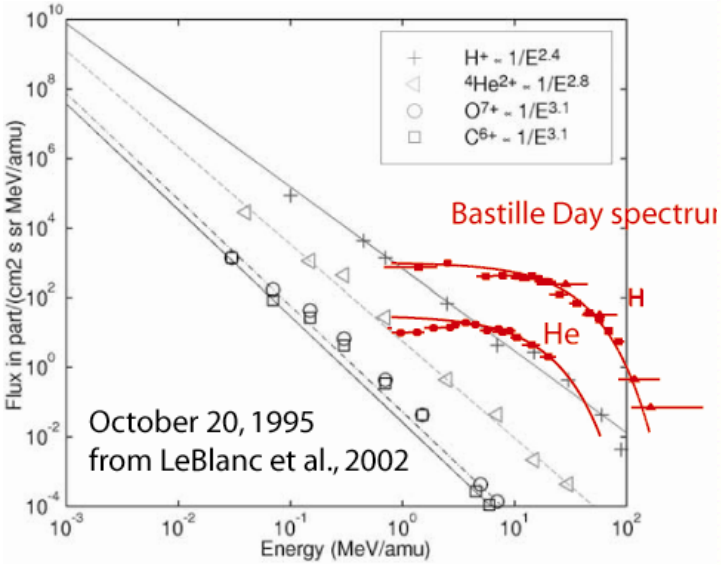


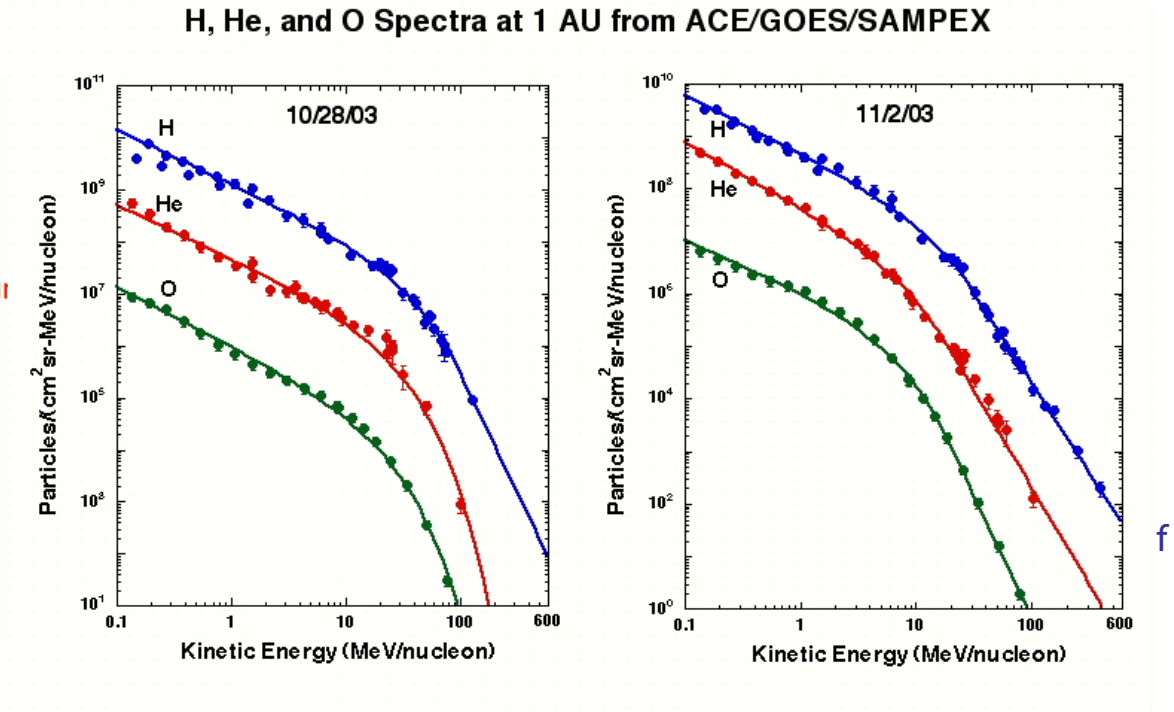
The largest SEP Events often include a prompt increase in MeV proton fluxes 10s of minutes after the related solar activity, and a second increase arriving with the associated interplanetary shock.

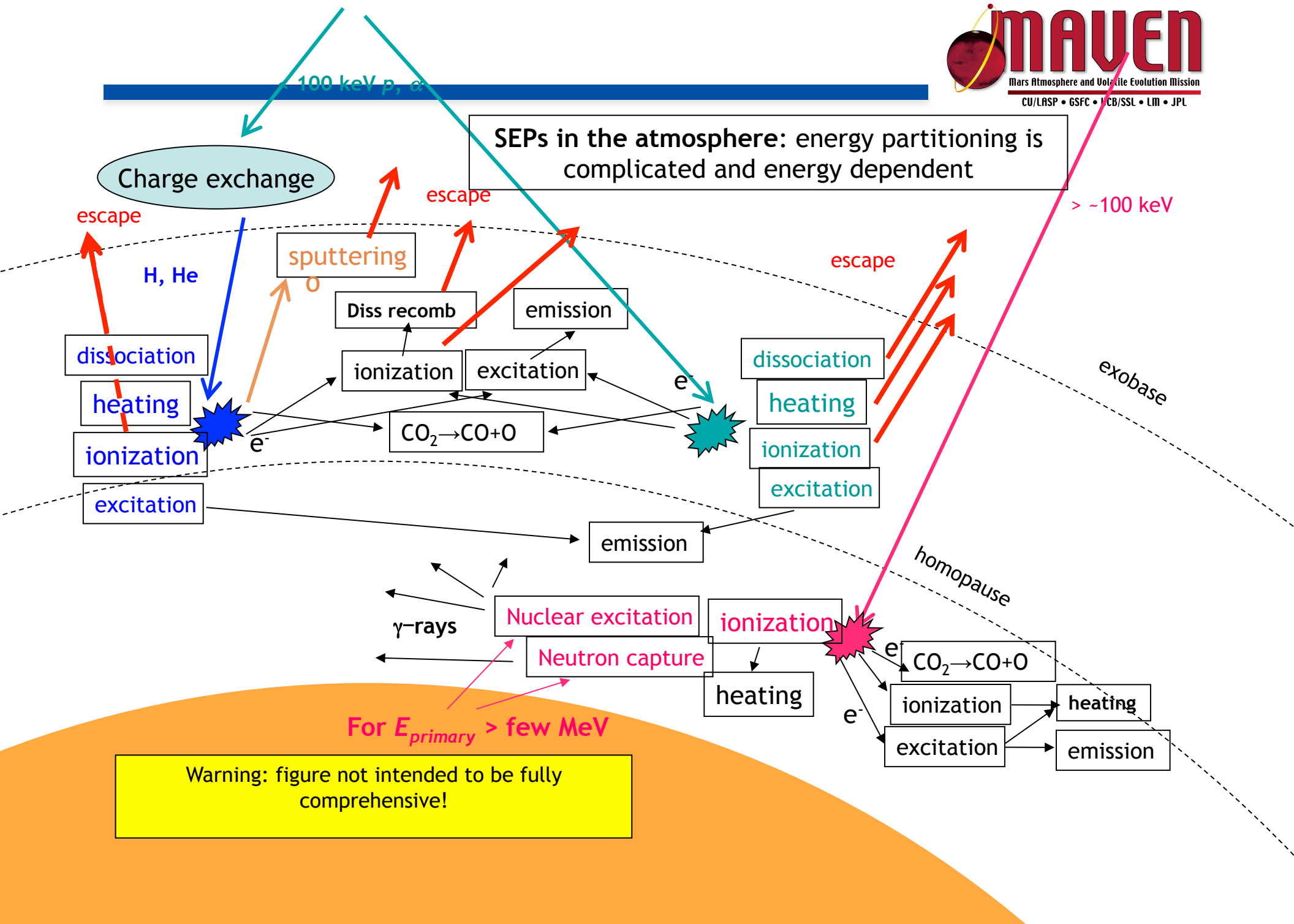


SEP Energy Spectra

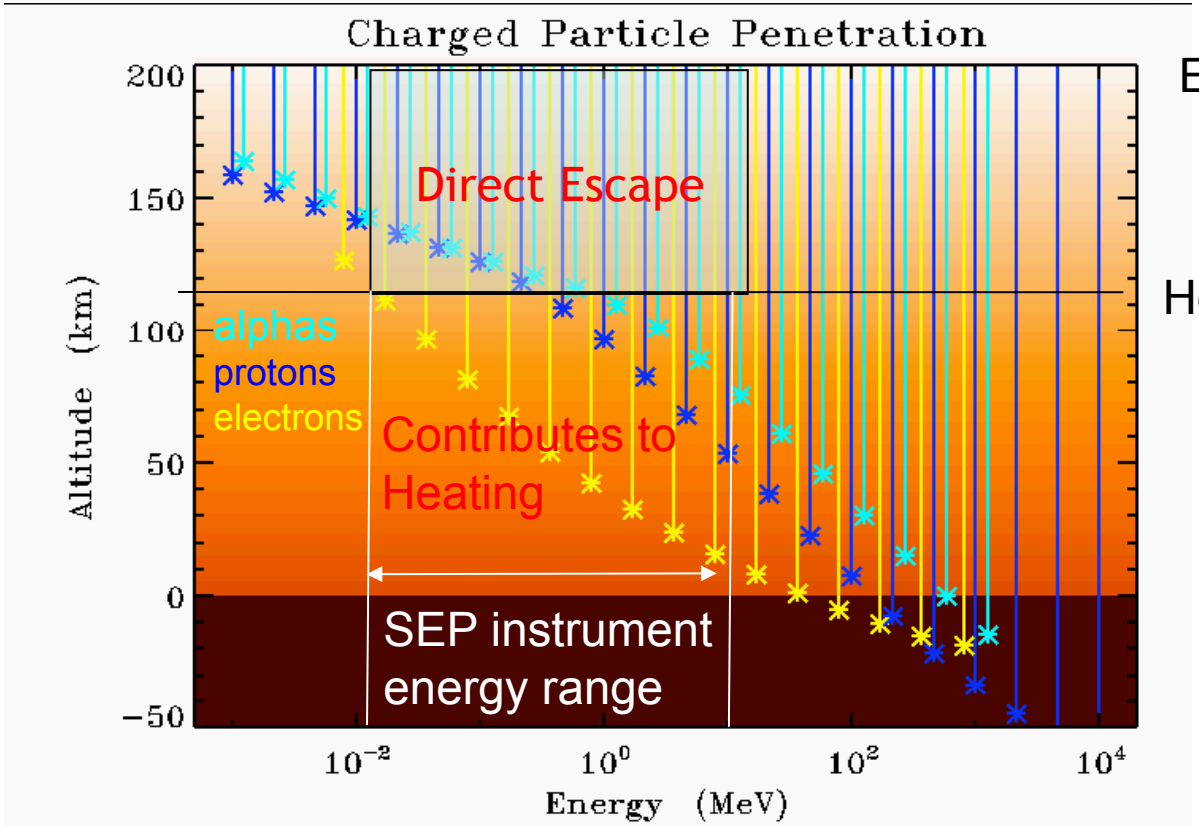
- Smaller SEP event spectra can be fitted with power laws of 2-3 for each ion species (e.g. Reames et al., 1997).
- Large gradual events have much harder spectra with exponential rollover at high energies (Tylka et al., 2000).






MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL
~100 keV p, α
SEPs in the atmosphere: energy partitioning is complicated and energy dependent
Charge exchange
escape
escape
escape
> ~100 keV
H, He
sputtering
O
Diss recomb
emission
dissociation
heating
ionization
excitation
ionization
excitation
e-
e-
CO2→CO+O
dissociation
heating
ionization
excitation
exobase
emission
homopause
γ−rays
Nuclear excitation
Neutron capture
ionization
heating
e-
CO2→CO+O
ionization
heating
e-
excitation
emission
For Eprimary > few MeV
Warning: figure not intended to be fully comprehensive!

SEP instrument will measure particles that penetrate to altitudes important for escape processes.



Analytic calculation by D. Brain

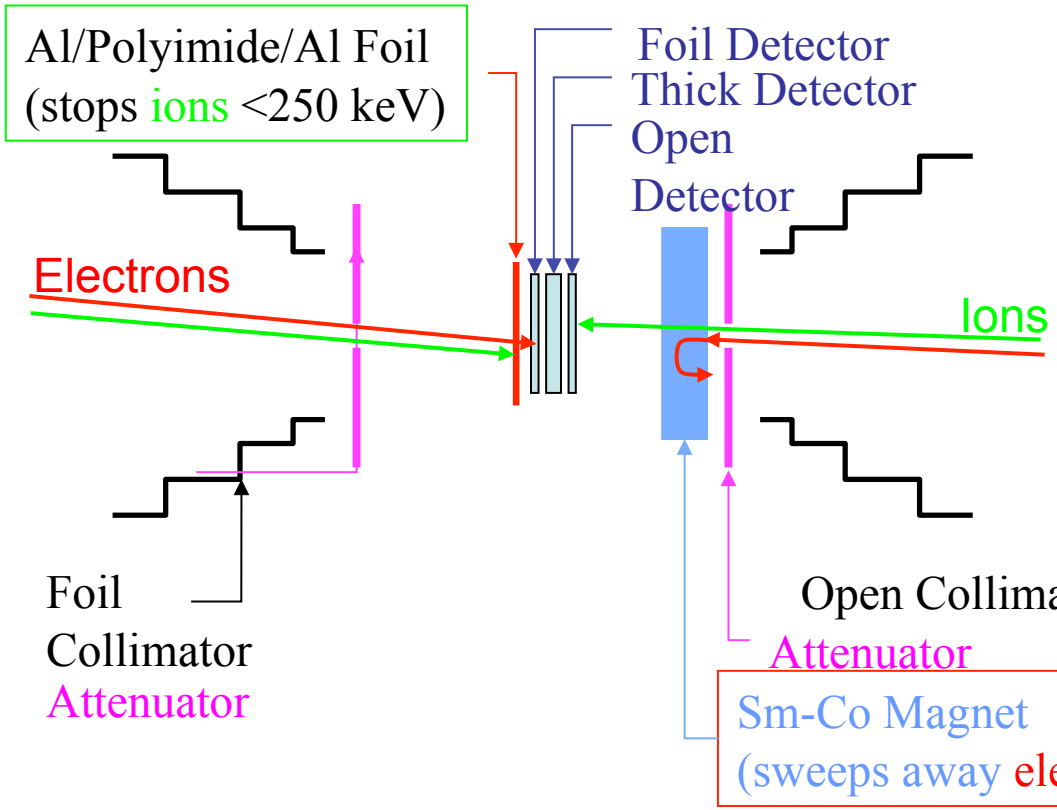
- The bulk of SEP event total energy is generally below 50 keV, deposited mostly between 100 km and 130 km [LeBlanc et al., 2002], though events widely vary.
- We will measure particles that penetrate to 50 km-150 km, providing important constraints on modeling of atmosphere/ionosphere dynamics.
- Energy is partitioned into heating, sputtering, molecular dissociation, ionization, electronic excitation, nuclear excitation and neutron capture.

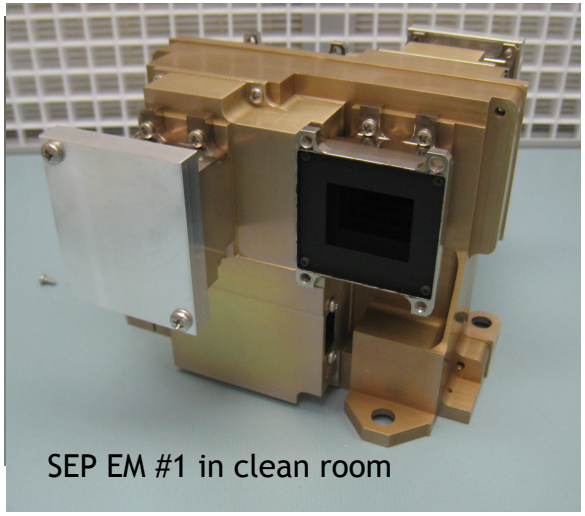
MAVEN's goals w.r.t. SEP events

1) Build up statistics of total escape rates for different sizes of SEP events with different energy spectra, field-line anisotropies and IMF orientations (i.e. blackbox input versus output).
2) Validate models with measurements in all regions, inside and outside of the atmosphere.
3) Extrapolate backwards in time using validated models applied to ancient atmosphere composition and best-guess SEP event strength and frequency over time **to put firm constraints on Mars' total integrated atmospheric loss to such events.**

SEP instrument overview

- **The Solar Energetic Particle (SEP) instrument** measures the energy spectrum and angular distribution of solar energetic electrons (25 keV–1 MeV) and ions (25 keV-12 MeV).

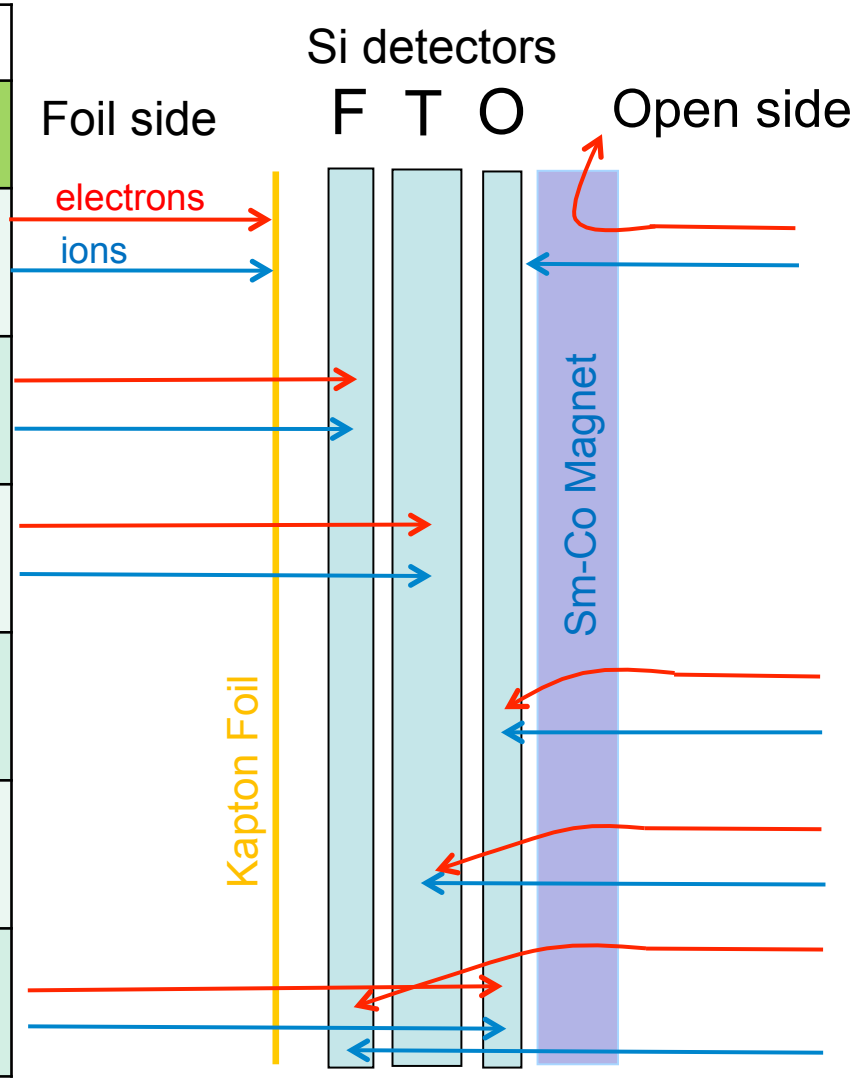



SEP EM #1 in clean room

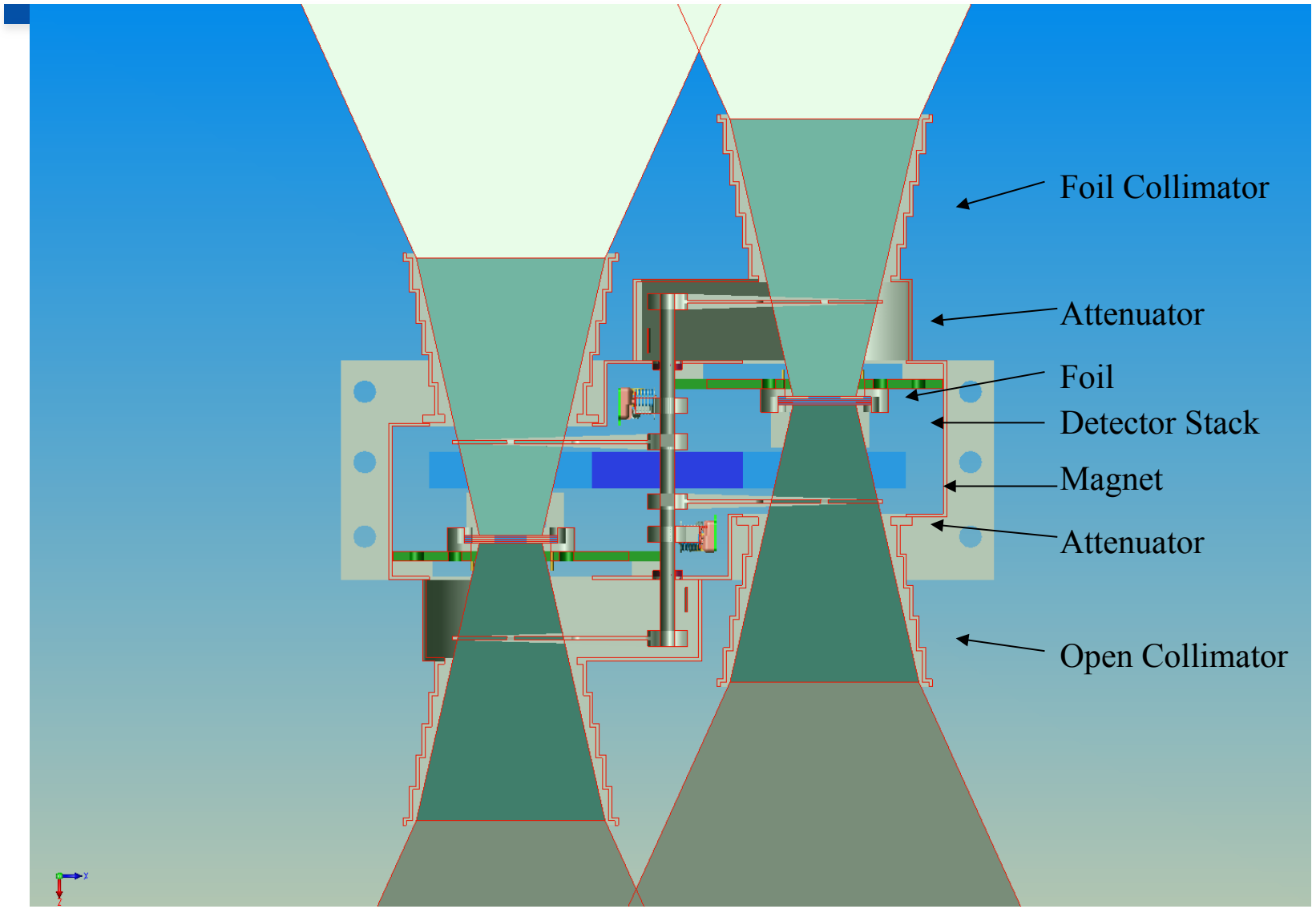
Basic separation strategy: 3 detectors, 2 filters

Energy ranges for counted events

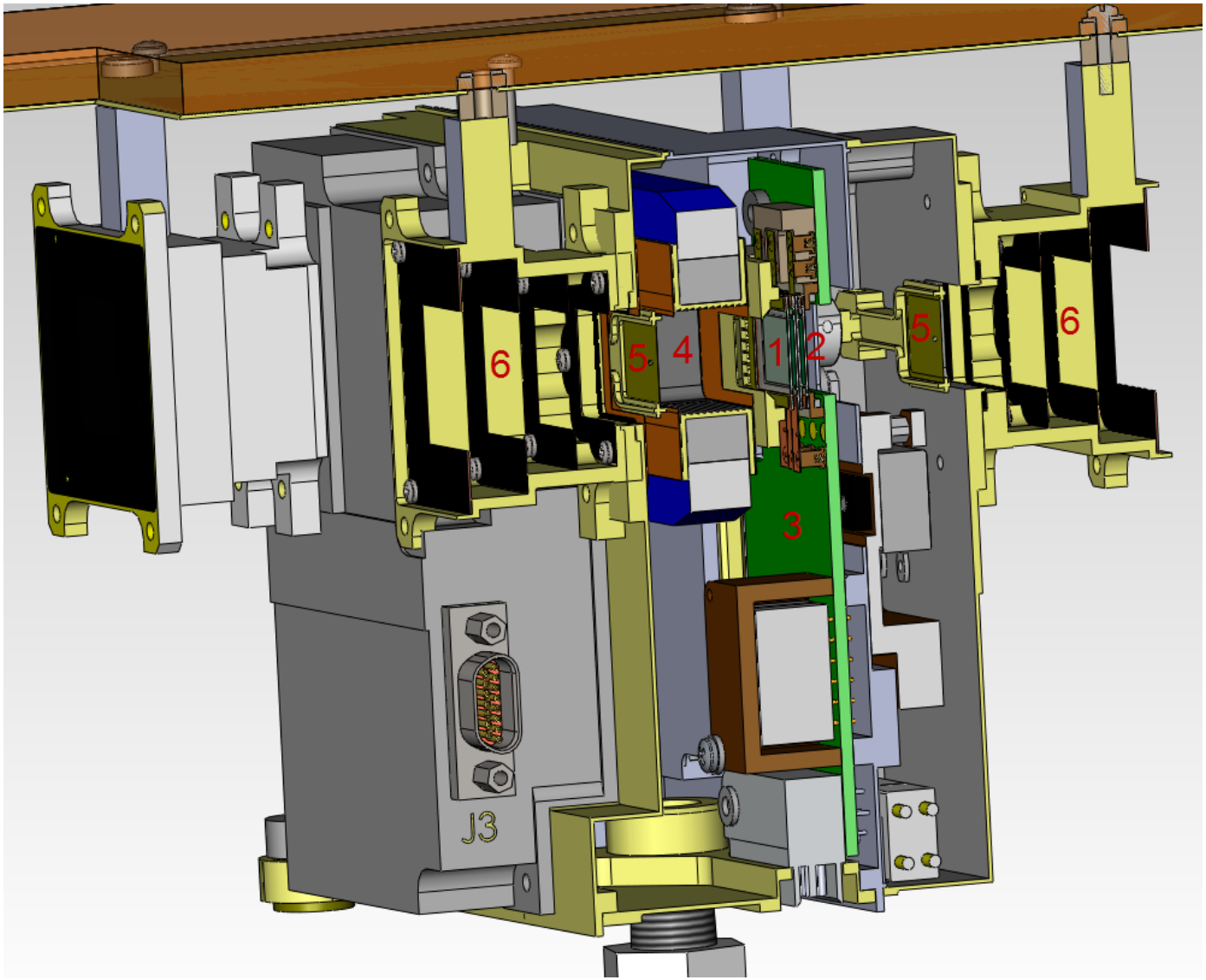
	Electrons		Ions	
keV	Foil side	Open side	Foil side	Open side
No count	<20	<350	<250	<25
F	20-700	X	250-6000	X
FT	350-1300	X	6000-11,000	X
O	X	350-700	X	25-6000
OT	X	350-1300	X	6000-11,000
FTO	>600		>11,000	



Cross-sectional diagram



Mechanical Overview of SEP

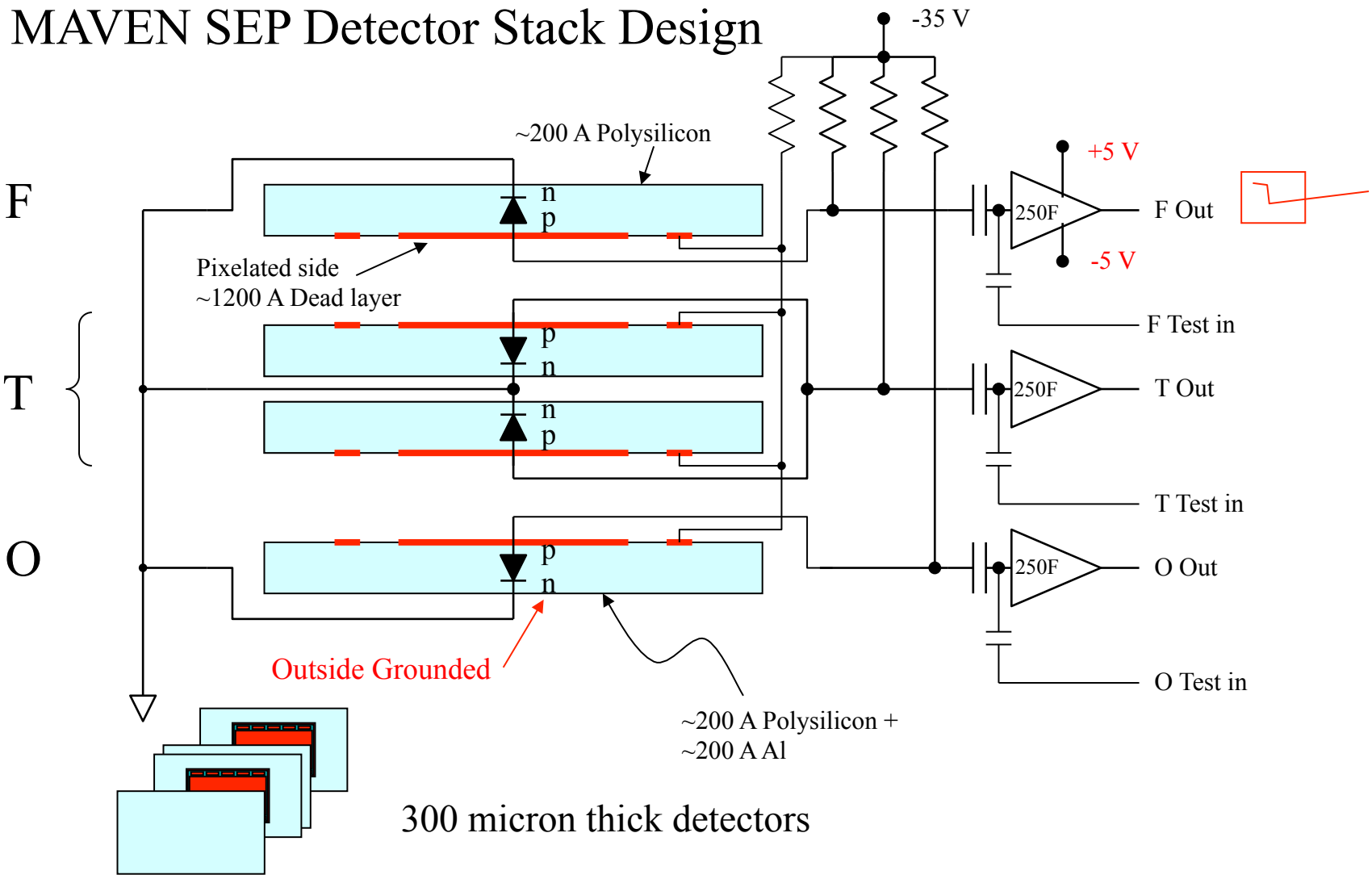


1. Detector Stack
2. Foil Location
3. DFE Board
4. Magnet Assembly
5. Attenuator
6. Collimator

Sensor Units – Summary of last few slides

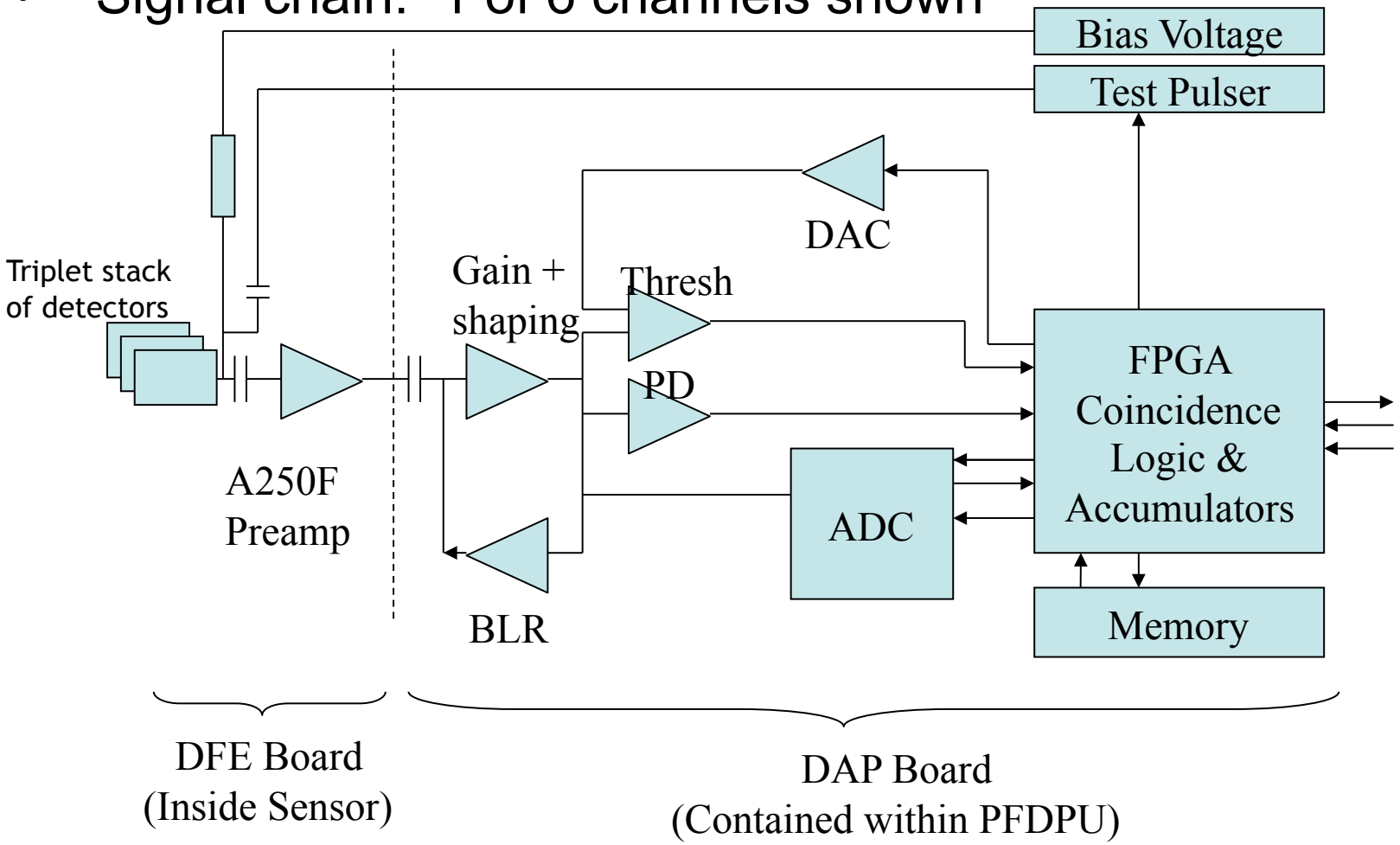
- Each sensor unit is a:
  - Dual double-ended solid state telescope
  - Each double-ended telescope (1/2 sensor) has:
    - Triplet stack of silicon solid state detectors
    - Foil (on one side)
      - Filters out ions <~350 keV
      - Leaves electron flux > ~20 keV nearly unchanged
    - Magnet / Open side
      - Filters out electrons <350 keV
      - Leaves ion flux nearly unchanged
    - Mechanical Pinhole attenuator
      - Protects against against overheating when Sun is in FOV.
      - Reduces count rate during periods of high flux
      - Reduces radiation damage (caused by low energy ions) during periods of high flux
    - Collimators
    - Preamplifier / shaping electronics

SEP Detector Front End

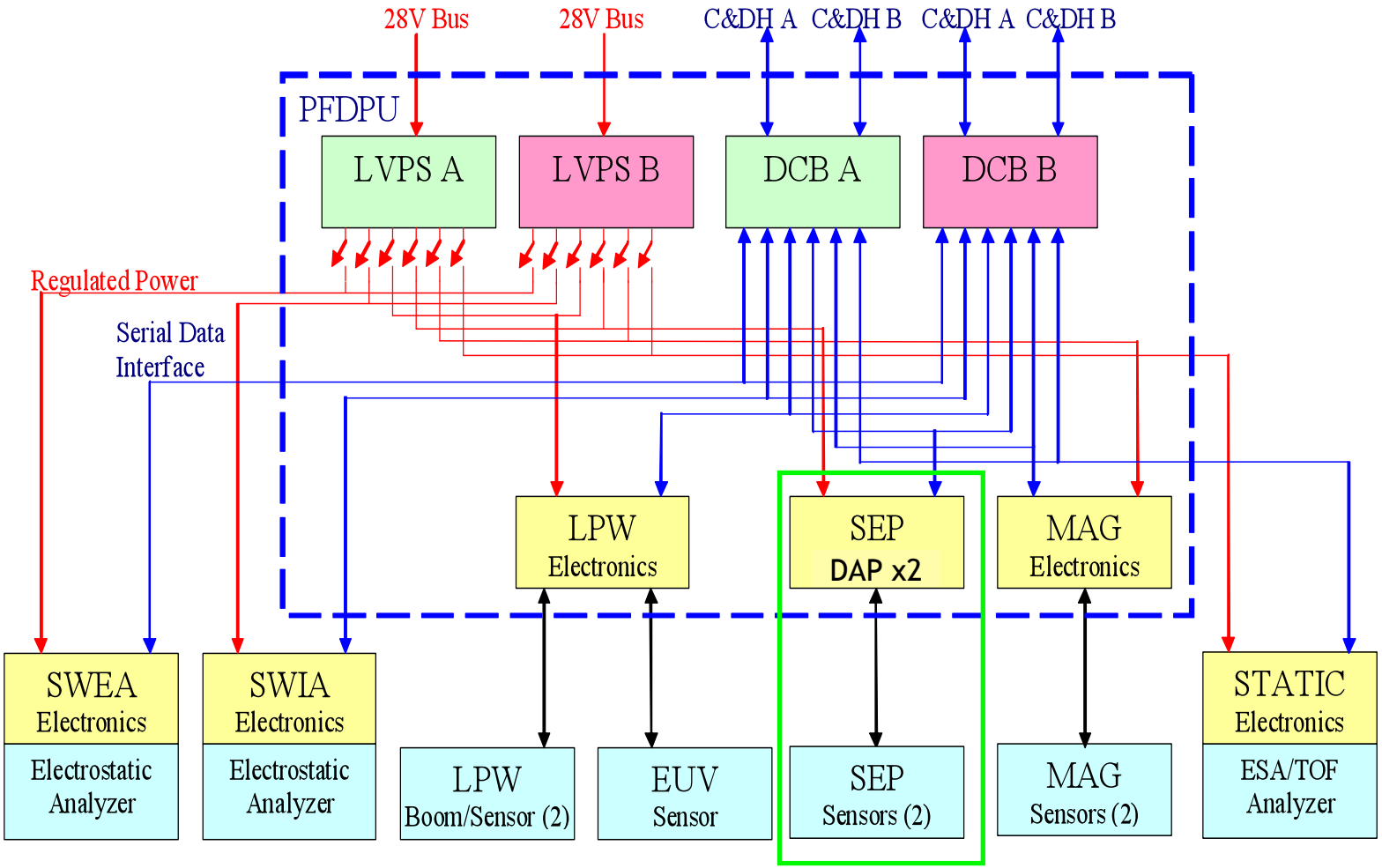


Electronics Block Diagram

- Signal chain: 1 of 6 channels shown

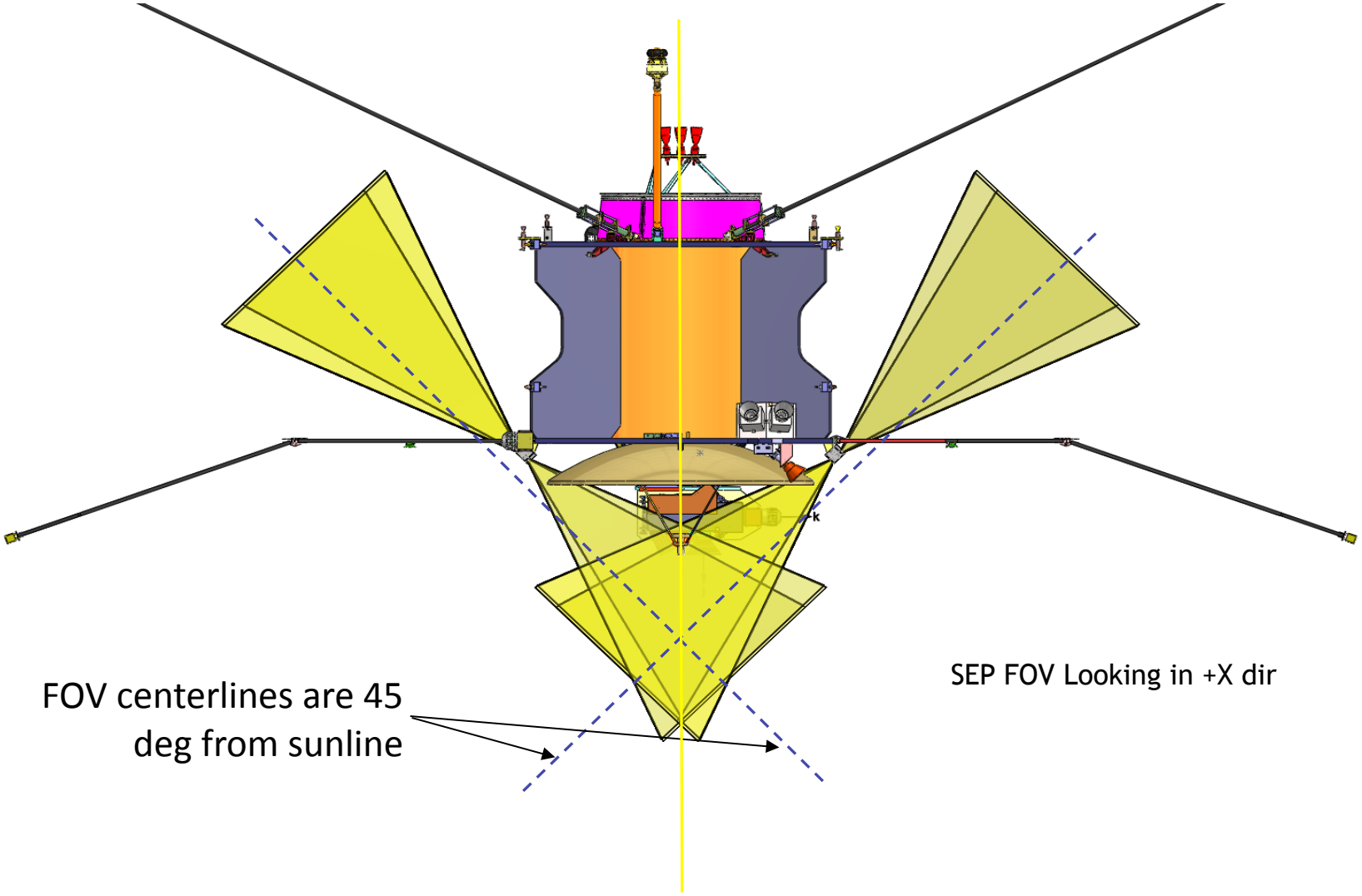


SEP & PFP Block Diagram

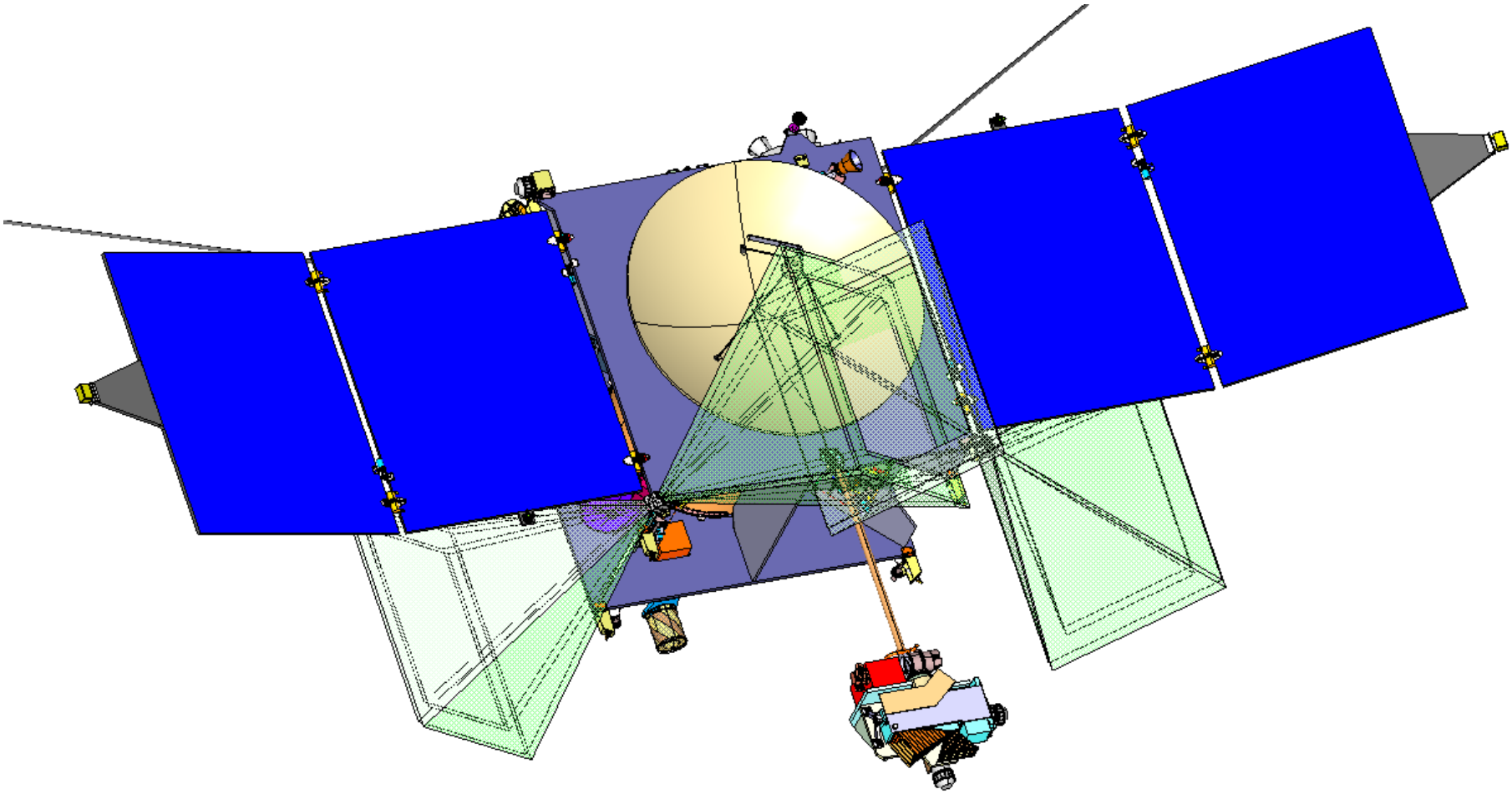


SEP has 2 sensors and 2 DAP boards (inside the PFDPU)

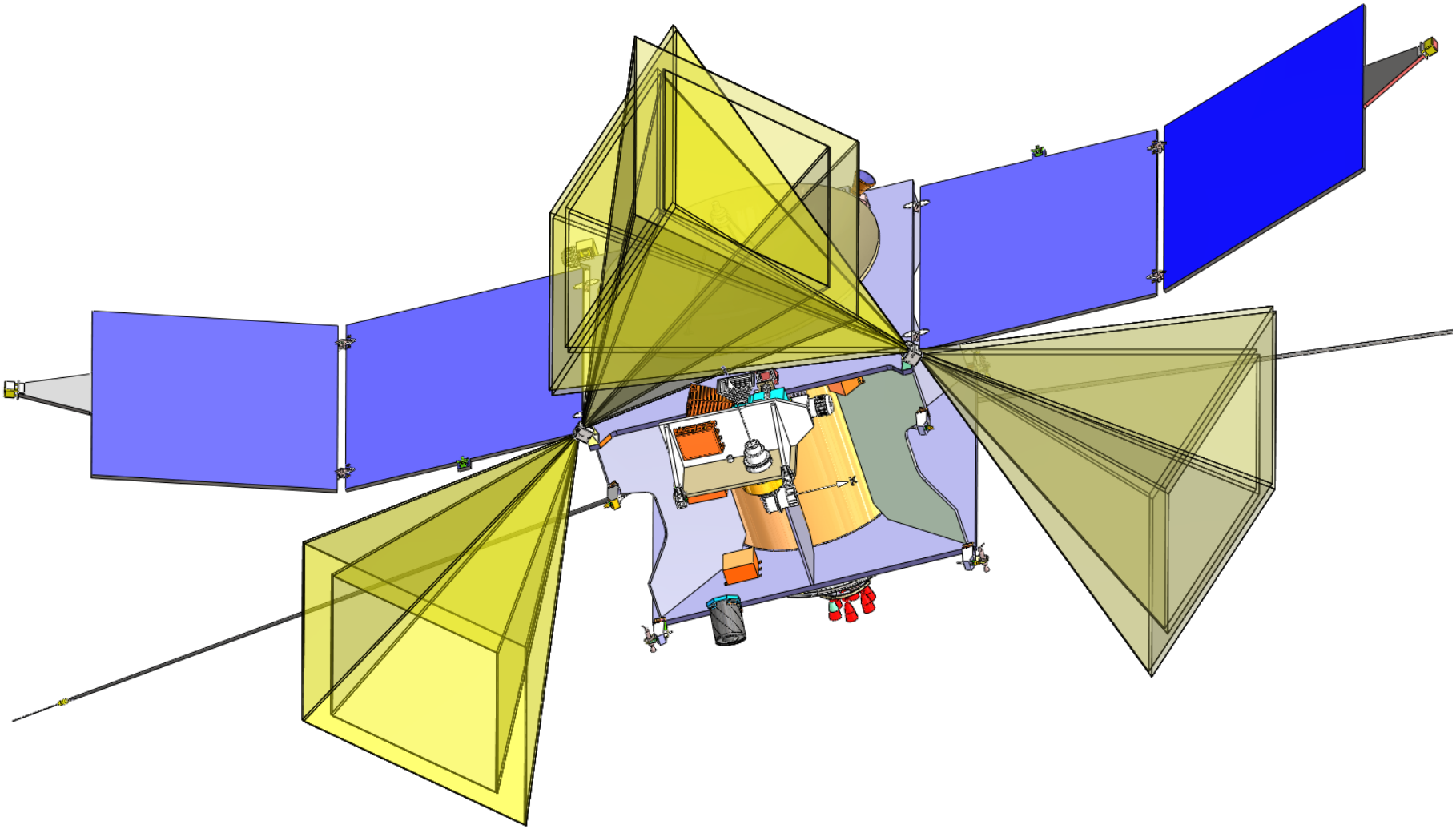
Spacecraft Accommodations



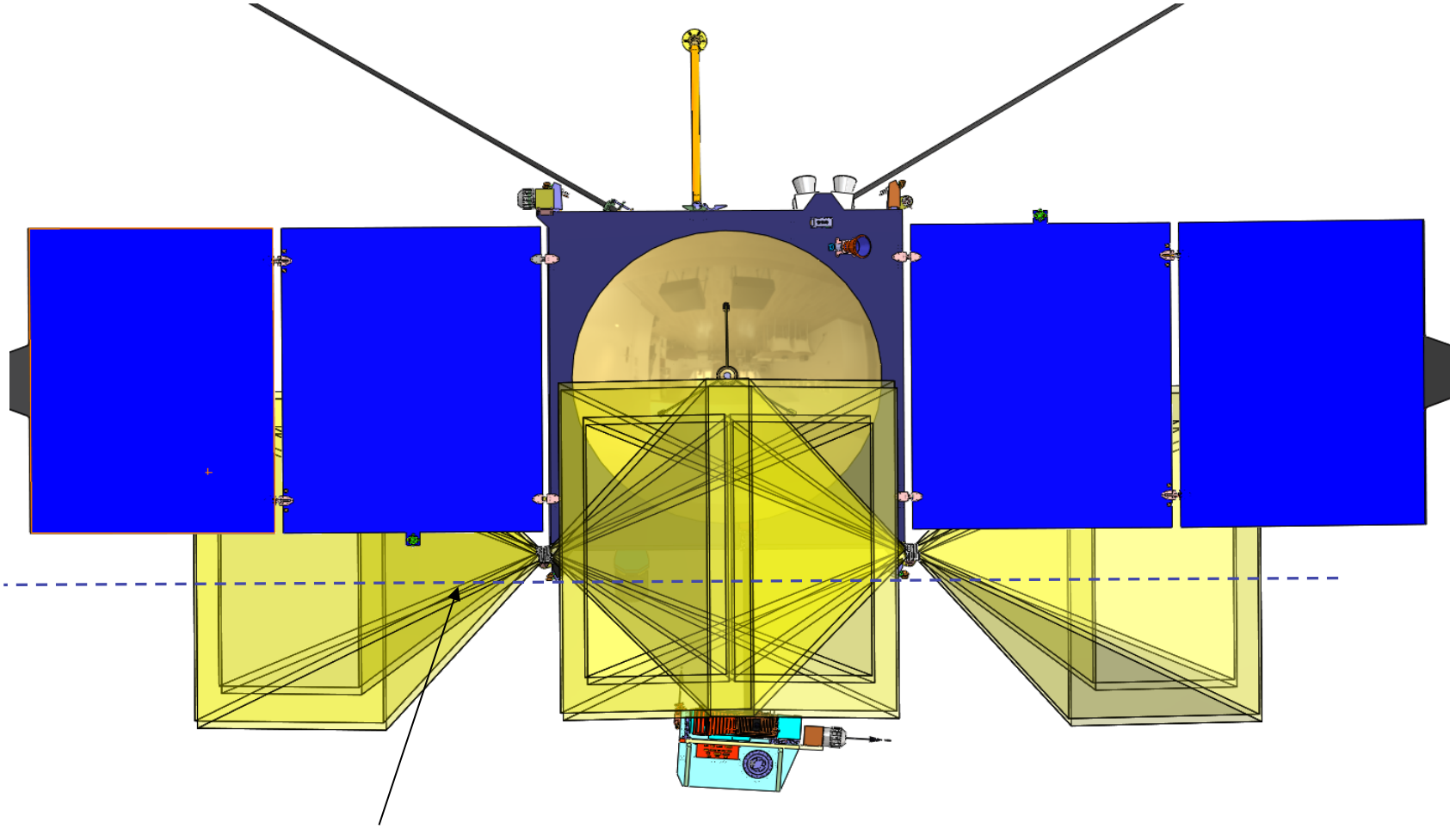
Spacecraft Accommodations



Spacecraft Accommodations



Spacecraft Accommodations



FOV centerlines are in YZ plane

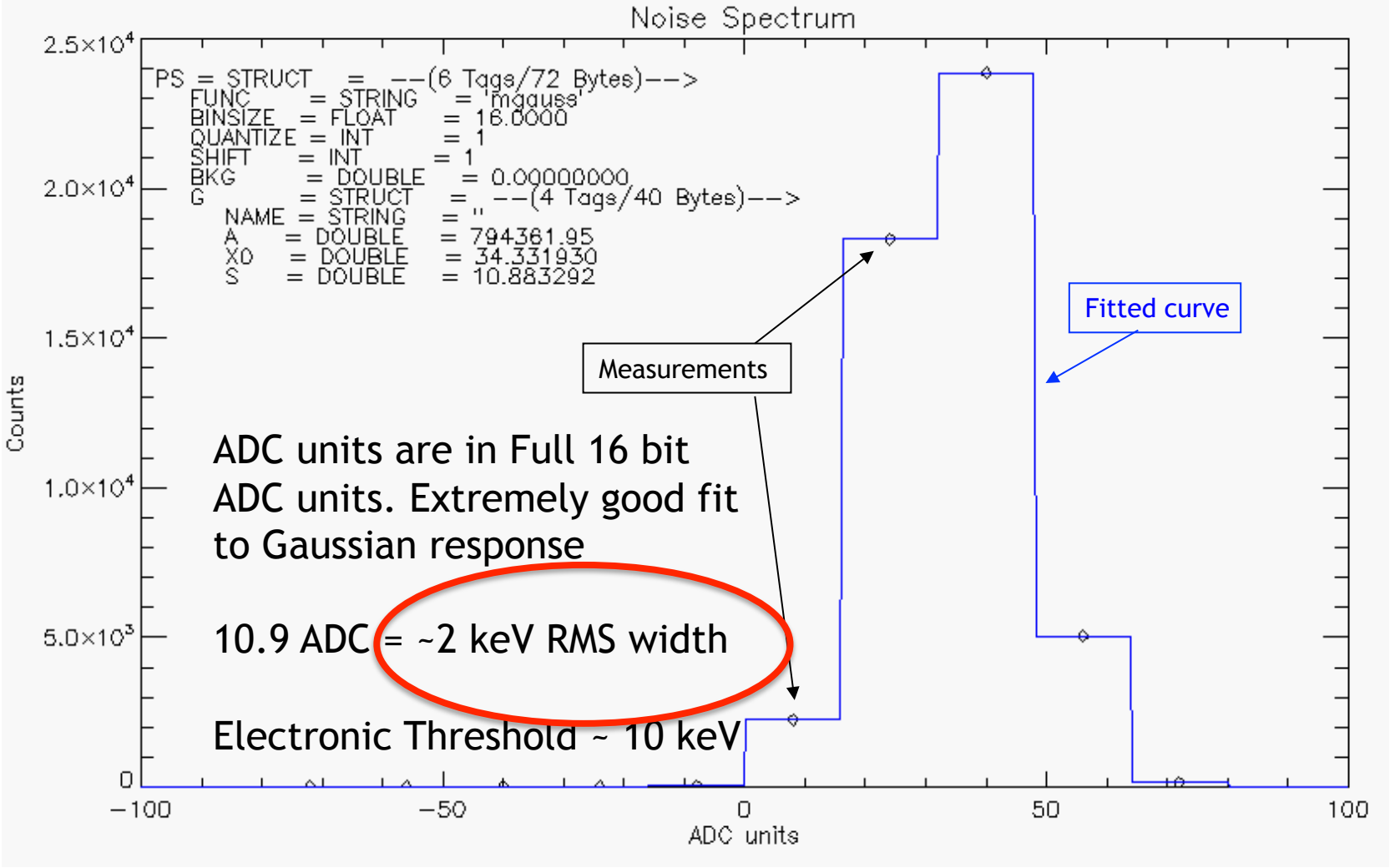
SEP FOV Looking in –Z dir

MAVEN SEP Status – near future schedule

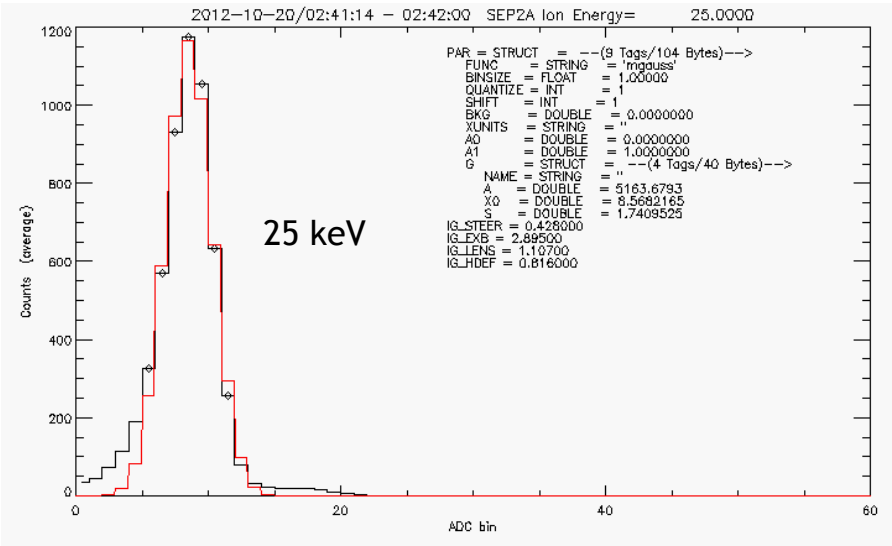
- Environments and Calibration Complete
- Instrument Delivered to Lockheed-Martin

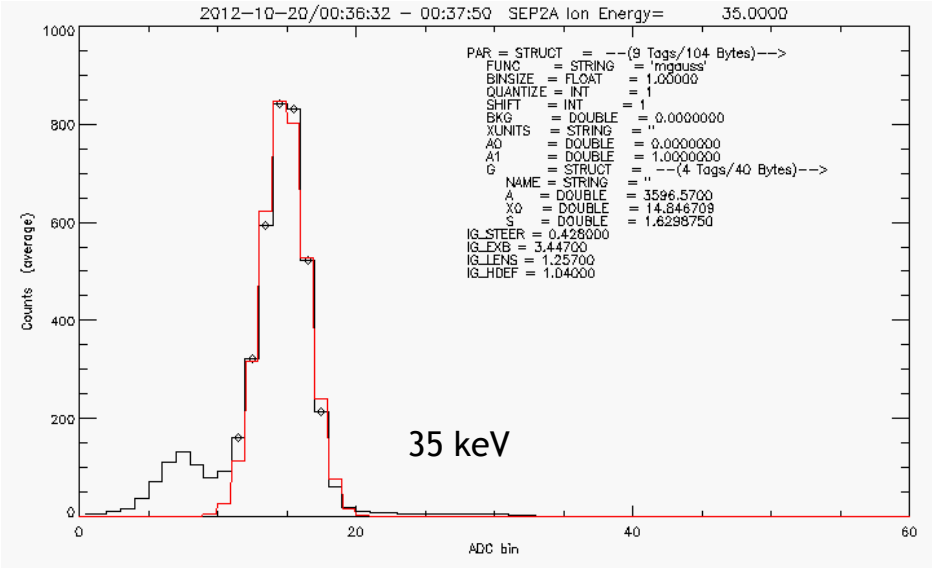
- Initial (post transport) bench test functional was successful
- Integration begins 12/3/2012
- First spacecraft electrical tests scheduled for 12/8/2012

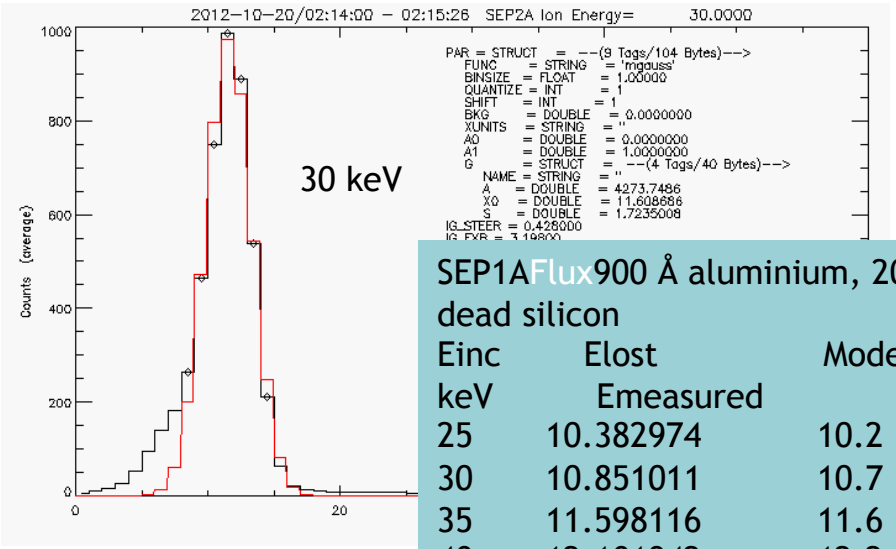
Instrument Capabilities
Fit to Noise Spectrum

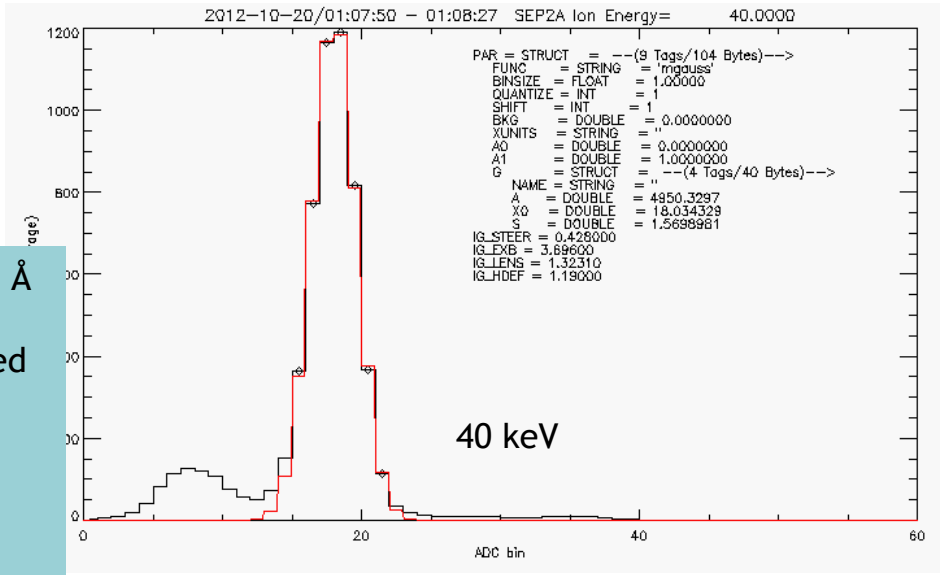


SEP Ion Response







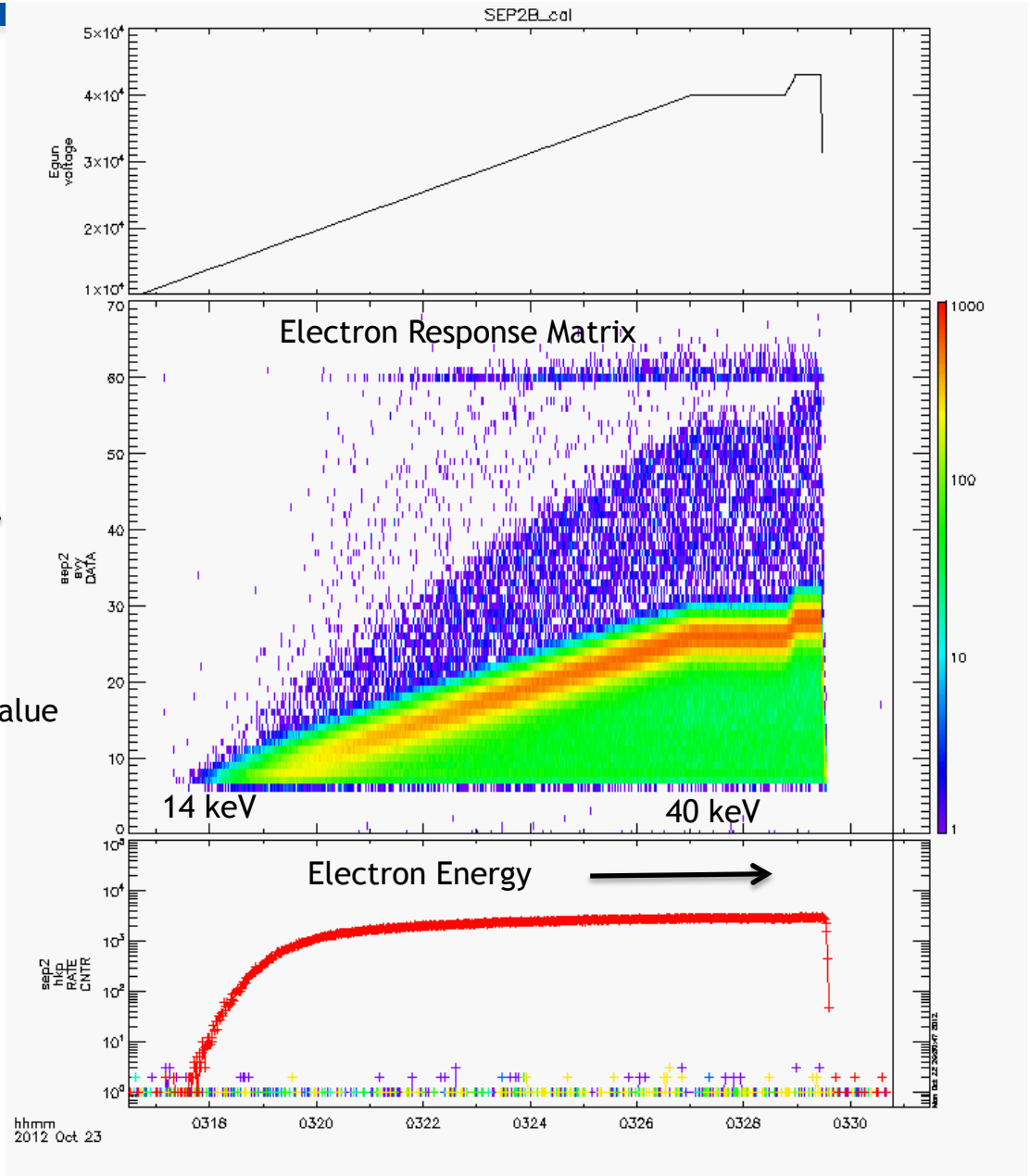


SEP1AFlux900 Å aluminium, 200 Å dead silicon

Einc keV	Elost Emeasured	Modeled
25	10.382974	10.2
30	10.851011	10.7
35	11.598116	11.6
40	12.101942	12.2
45	12.402292	No Calc

SEP Electron Response

- Response to Electrons
- Ramping electron gun from 0 to 40 keV
- Electron detection threshold is 14 keV
- Efficiency exceeds 50% for energy > 20 keV electrons



SEP Instrument Data Products

- SEP has one mode-
  - Differential Energy Flux Spectra for
    - Electrons
      - 20 keV – 1 MeV
    - Ions (no mass discrimination)
      - 20 keV – 10 MeV
    - Each species has 4 look directions - approximately:
      - Parker spiral
      - Anti - parker spiral
      - ~90deg to parker spiral
      - ~90deg to parker spiral
- Three different time resolutions based on altitude:
  - 32 sec
  - 8 sec
  - 2 sec (several measurements per scale height)
- Energy Bins are configurable (still subject to change)
  - 1.5 keV width
  - 256 bins/sensor shared between all channels

- End of presentation