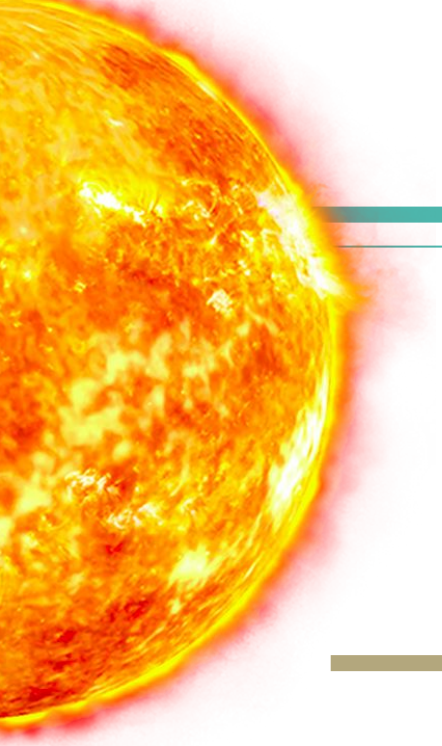
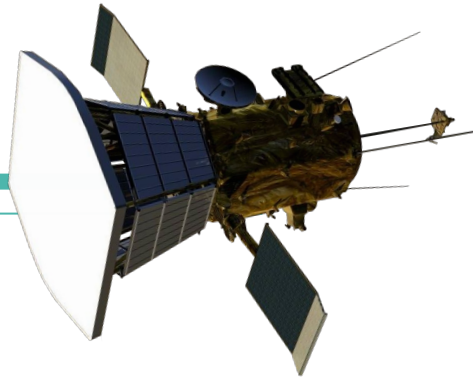




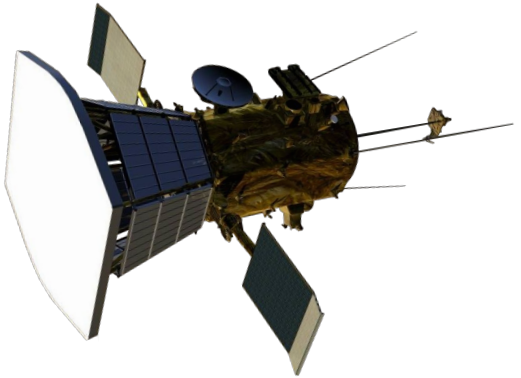
ISOIS

Integrated Science Investigation of the Sun

Contents

- Parker Solar probe
- Instruments
- ISOIS mission objectives
- Requirements
- EPI-Lo
- EPI-Hi

The Parker Solar probe



- Launched on 12 Aug 2018
- 6.16 million km to the Sun (>7x closer)
- Into the corona
- 1377°C to 315°C in 11.43 cm
- Instrument suite:
  - Fields Experiment (FIELDS)
  - **Integrated Science Investigation of the Sun (IS⊙IS)**
  - Wide-field Imager for Solar PRobe (WISPR)
  - Solar Wind Electrons Alphas and Protons (SWEAP) Investigation

Mission Goal

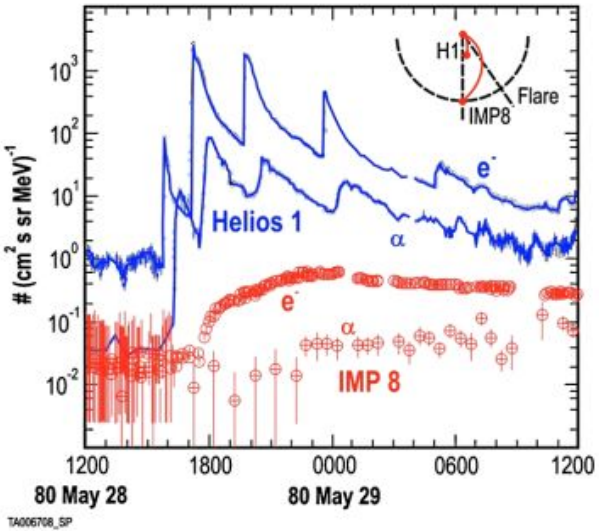
1. What is the seed population of solar energetic particles (SEPs)?
    a. Identify particles and ion composition, ^{3}He / ^{4}He
2. How are these SEPs accelerated?
    a. Detect particle (kinetic) energies
3. What mechanisms are responsible for transporting SEPS into the solar system?
    a. Detect pitch-angle distributions

Why so close?

Different acceleration mechanisms

- Coronal Mass Ejections (CME)
- Solar Flares

At large distances particles are accelerated by multiple mechanisms



Environmental Constraints

Mass

- Only 9.384 kg

Thermal

- Highest temperature at 1AU
- Protection by the heat shield gives a stable environment
- Requires heaters

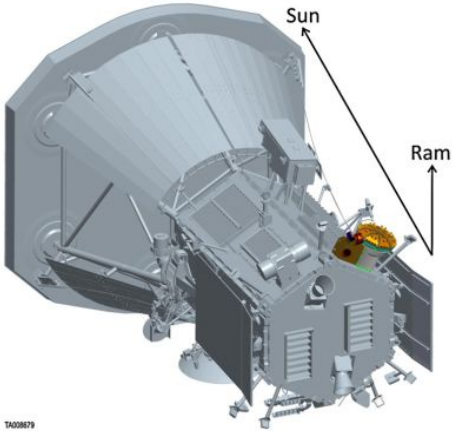
Radiation

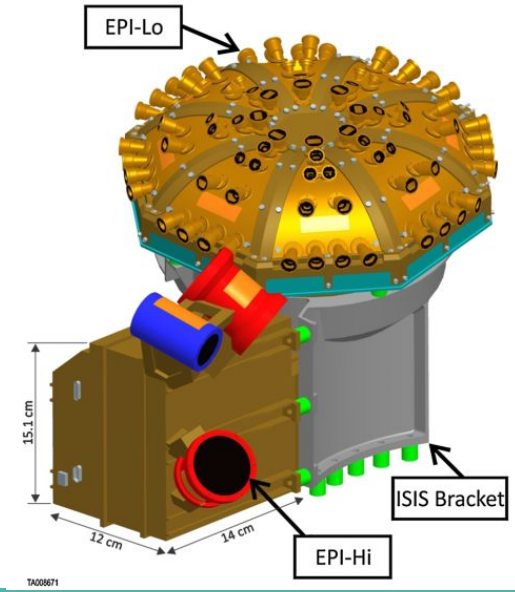
- >100 krad dose
- UV, solar wind, SEP

ISOIS: Integrated Science Investigation of the sun

- 2 Energetic Particle Instruments
- EPI-Lo:
  - Ions 20 keV - 15 MeV
  - Electrons 25 keV - 1 MeV
  - 80 apertures
- EPI-Hi:
  - Ions 1 - 200 MeV
  - Electrons 0.6 - 6 MeV
  - 5 apertures

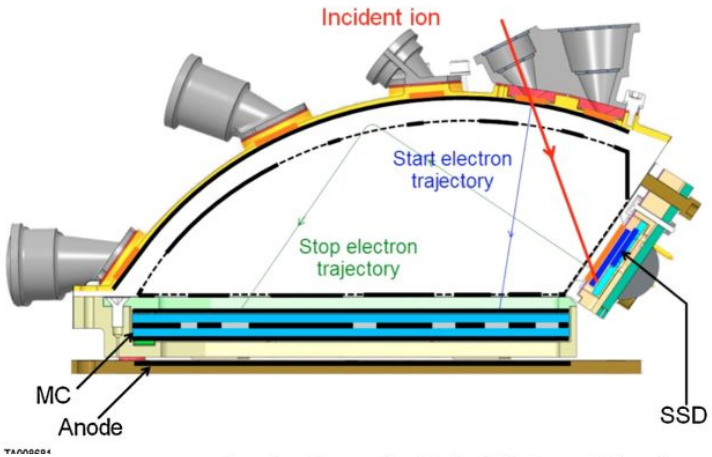
ALICE: 5.36 TeV per particle pair

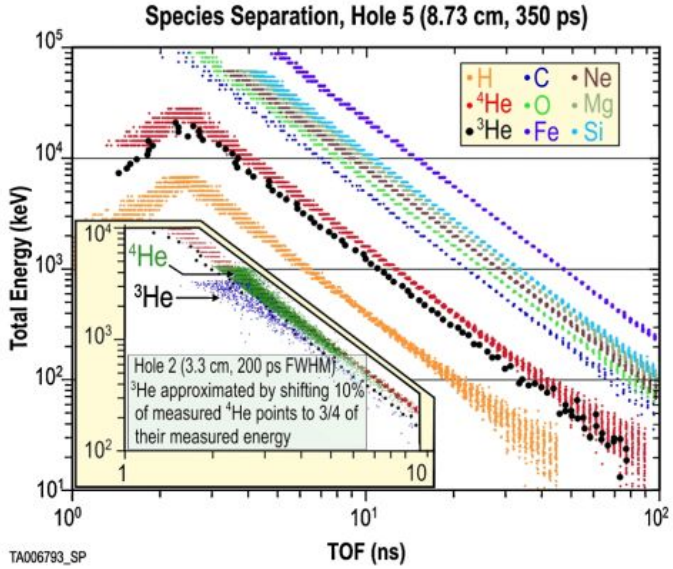




EPI-Lo

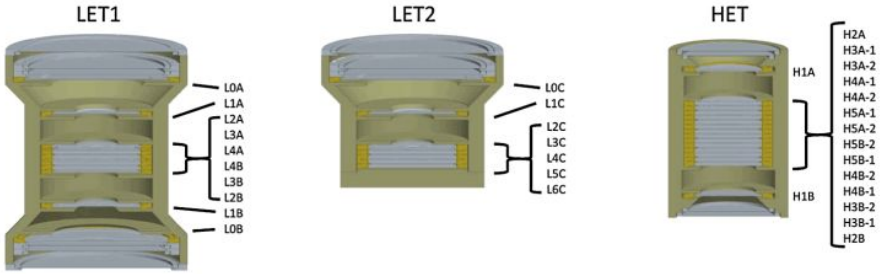
- Time of Flight based Mass spectrometer
- Start & Stop foils
  - Polyamide, Aluminium and Palladium
  - Light filtering
  - Holes
- Silicon Solid State detector (SSD)
  - 250V
  - Electron - Positron hole production
  - Energy from Pulse Height Analysis
  - 2 um Al shielding
- Micro Channel Plate detector (MCP)
  - 900, 100, 2900, 3300V
  - Electron multiplication
  - TOF
  - Aperture angle*
- Particle Identification
  - TOF + Total energy

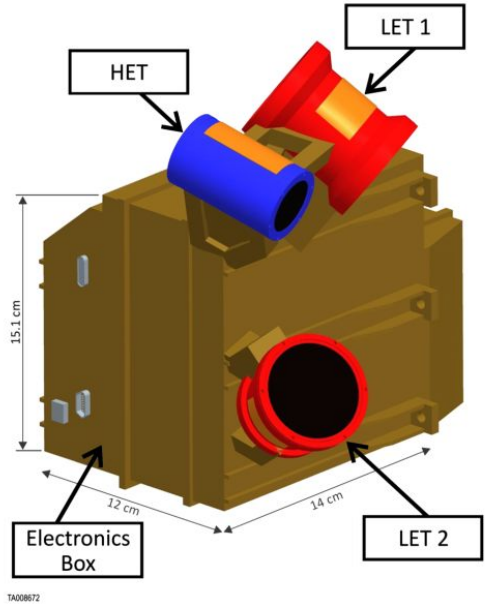




EPI-Hi

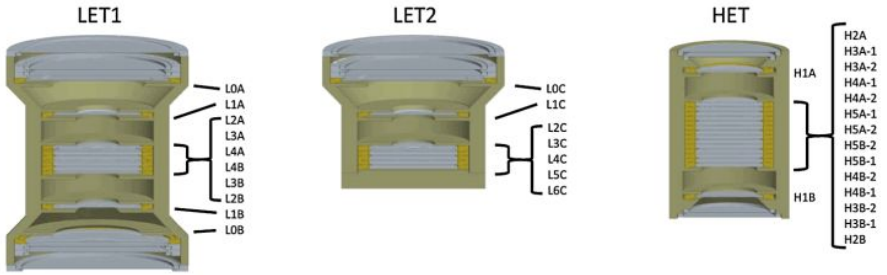
- Silicon detector stacks
- dE/dx vs total energy
- 5x 45° “apertures”
- LET1, 2
  - 1 - 20 MeV ions
  - 0.5 - 2 MeV electrons
- HET
  - up to 100 MeV ions
  - up to 6 MeV electrons

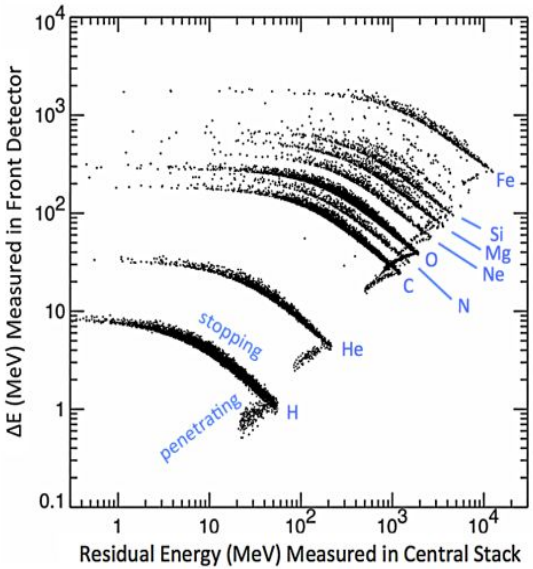


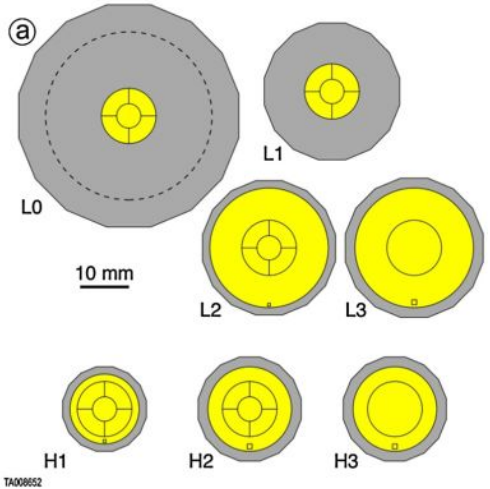


EPI-Hi mechanism

- Plates
  - 500 - 1000 um and double
- 5 Sectors
- Guard rails
- Particle identification
- Penetrating particles
- Dynamical range

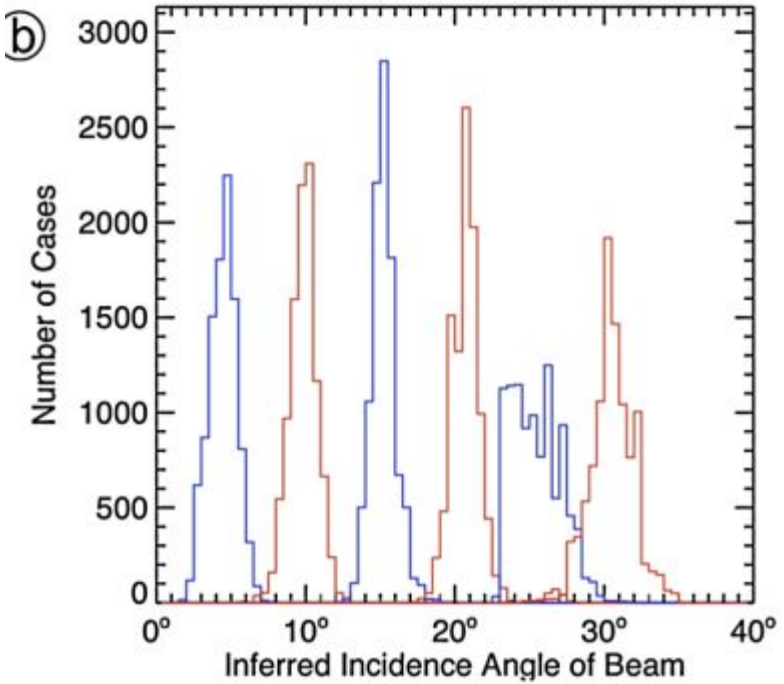






EPI-Hi angular resolution

- Raw angular resolution <25°
- Improvements using overlap between regions



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McComas, D.J., Alexander, N., Angold, N. *et al.* Integrated Science Investigation of the Sun (ISIS): Design of the Energetic Particle Investigation. *Space Sci Rev* **204**, 187–256 (2016). https://doi.org/10.1007/s11214-014-0059-1

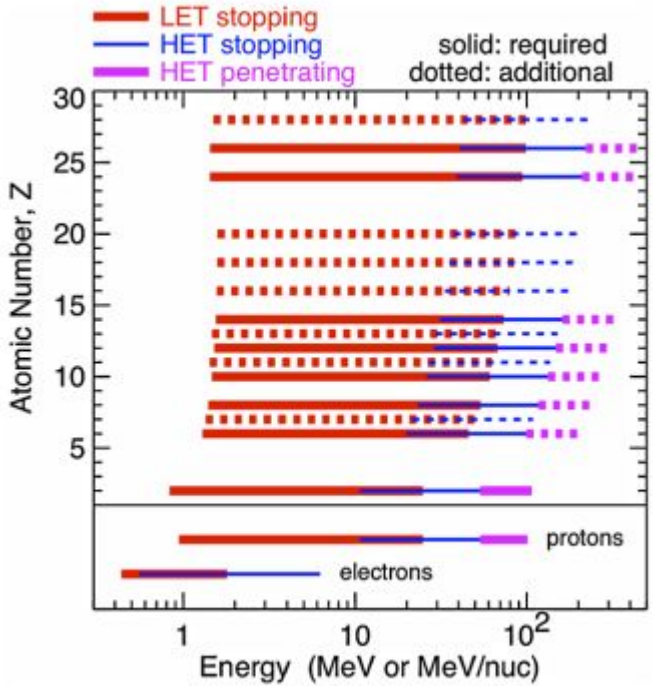
https://www.deviantart.com/prussiaart/art/Sun-on-a-transparent-background-720156039

By National Aeronautics and Space Administration (NASA) - Cropped from an image hosted by nasa.gov, Public Domain, https://commons.wikimedia.org/w/index.php?curid=59476892

https://parkersolarprobe.jhuapl.edu/The-Mission/index.php accessed 26 March 2024

https://parkersolarprobe.jhuapl.edu/Spacecraft/index.php accessed 26 March 2024

Questions?


LET stopping
HET stopping
HET penetrating
solid: required
dotted: additional
Atomic Number, Z
30
25
20
15
10
5
protons
electrons
1
10
10^2
Energy (MeV or MeV/nuc)

EPI-Hi stats

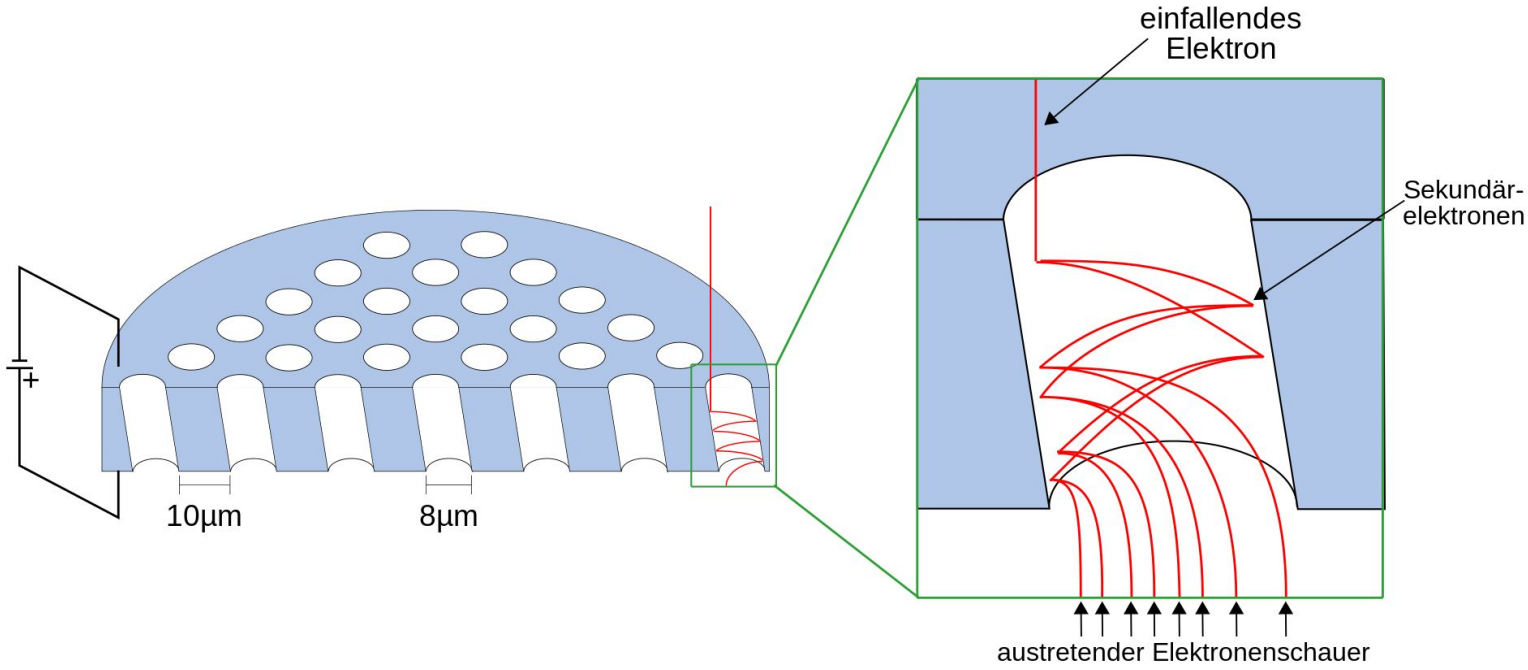
Table 5 EPI-Hi instrument required and expected performance

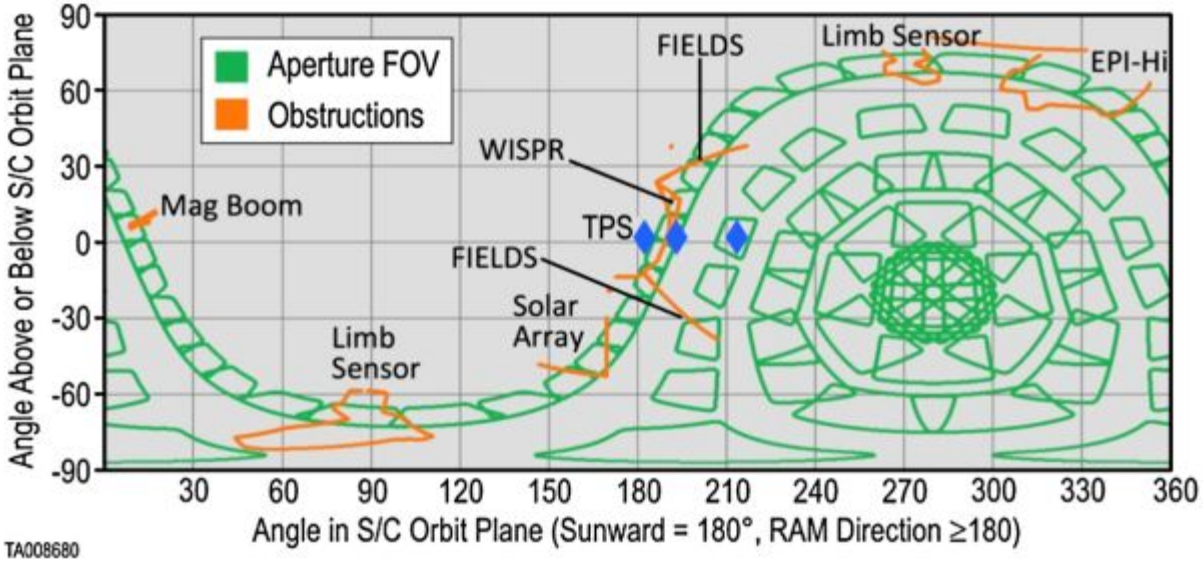
Parameter	Required	Goal (expected)	Comment/Heritage
Electron energies	0.5–3 MeV	0.5–6 MeV	STEREO/HET
Ion energies	~1 to ≥50 MeV/nuc	p, He: 1 to 100 MeV/nuc $Z \geq 6$: 1.5 to >100 MeV/nuc	STEREO/LET & HET
Energy binning	≥6 bins per decade	12 bins/decade	Logarithmic bins
Cadence	Fastest: e 1 s, p 5 s	Fastest: e 1 s, p 1 s most data products: 1 min angular distributions: 5 min	Large energy bins best energy resolution
Fields of view	$\geq \pi/2$ steradians in sunward and anti-sunward hemisphere	Five 45° half-angle view cones covering sunward and anti-sunward hemispheres	View cones overlap to provide full energy coverage near Parker spiral to within 10° of spacecraft-Sun line
Angular sectoring	e: ≤45°; ions: ≤30°	45° half-angle cones subdivided into 25 overlapping sectors	Overlapping sectors provide improved angular resolution for deriving pitch angle distributions
Elemental composition	H, He, C, O, Ne, Mg, Si, Fe	H, He, C, N, O, Ne, Na, Mg, Al, Si, S, Ar, Ca, Cr, Fe, Ni	STEREO/LET
Isotopic composition	^{3}He/^{4}He	^{3}He/^{4}He	In selected viewing directions STEREO/LET
Intensity range	Up to 3×10^6 protons cm^{-2} sr^{-1} s^{-1}	Normal mode: up to ~1×10^6 protons cm^{-2} sr^{-1} s^{-1} Pixel mode: up to ~4×10^7 protons cm^{-2} sr^{-1} s^{-1}	>10 MeV protons
Geometrical factor	N/A	5 view cones, each with $A\Omega \approx 0.5$ cm^2 sr	Value at energy with maximum $A\Omega$

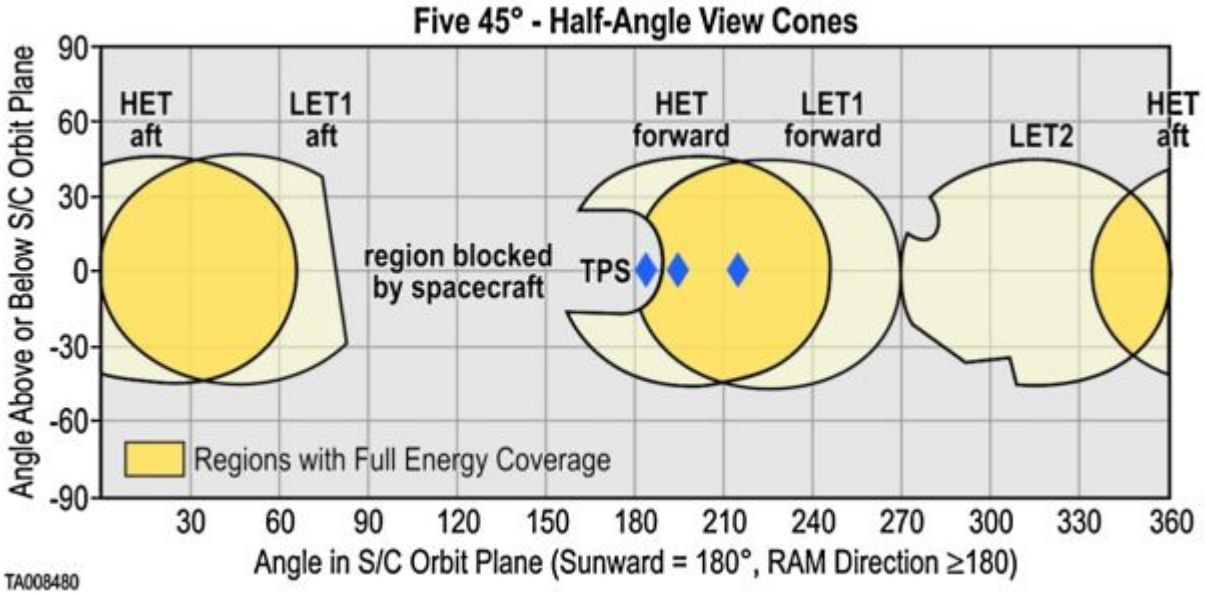
EPI-Lo stats

Table 4 EPI-Lo instrument required and projected performance

Parameter	Required	Goal (expected)	Comment/Heritage
Electron energies	50–500 keV	25–1000 keV	Electron capability from JEDI, RBSPICE
Ion energies	50 keV/nuc–15 MeV Total E	~20 keV/nuc–15 MeV Total E ~85 MeV Total E for Fe	Capability based on that of RBSPICE. Maximum energy ~1.5 MeV/nuc for Fe
Energy resolution	45 % for required energy range	11 % for required energy range	Telemetry limited
Time sampling	5 sec	1 sec	Telemetry and/or statistics limited
Angle resolution	$<30° \times <30°$	Ions, $\sim 15° \times 12°$ to $<30° \times <30°$ $e-$, 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, ^{3}He, ^{4}He, C, O, Ne, Mg, Si, Fe	H, ^{3}He, ^{4}He, C, O, Ne, Mg, Si, Fe	^{3}He/^{4}He ~50 to 1000 keV/nuc
Electron sensitivity, geometric factor, counting rate, and background drivers	$<10^6$ cm^{-2} s^{-1} sr^{-1} ($G \sim 0.05$ cm^2 sr; measure event rates to >50 kHz)	10^2–10^7 cm^{-2} s^{-1} sr^{-1} ($G > 0.05$ cm^2 sr; measure event rates to >700 kHz; background rate <1 Hz)	G = Geometric factor (cm^2 sr) 8 pixels/sensor; background rate is spectral-slope dependent
Ion sensitivity, geometric factor, counting rate, and background drivers	10^1–10^6/cm^{-2} s^{-1} sr^{-1} ($G \sim 0.05$ cm^2 sr; measure event rates to >50 kHz; at minimum intensity require accidental rate <~50 kHz)	10^0–10^7/cm^{-2} s^{-1} sr^{-1} ($G > 0.07$ cm^2 sr; measure event rates to >700 kHz; at minimum intensity require accidental rate <~5 kHz)	80 pixels/sensor


einfallendes
Elektron
Sekundär-
elektronen
+
10µm
8µm
austretender Elektronenschauer


Aperture FOV
Obstructions
FIELDS
Limb Sensor
EPI-Hi
WISPR
Mag Boom
TPS
FIELDS
Solar Array
Limb Sensor
Angle Above or Below S/C Orbit Plane
90
60
30
0
-30
-60
-90
30
60
90
120
150
180
210
240
270
300
330
360
Angle in S/C Orbit Plane (Sunward = 180°, RAM Direction ≥180)
TA008680


Five 45° - Half-Angle View Cones
HET aft
LET1 aft
region blocked by spacecraft
TPS
HET forward
LET1 forward
LET2
HET aft
Regions with Full Energy Coverage
Angle Above or Below S/C Orbit Plane
90
60
30
0
-30
-60
-90
30
60
90
120
150
180
210
240
270
300
330
360
Angle in S/C Orbit Plane (Sunward = 180°, RAM Direction ≥180)
TA008480