Overview of the MagEIS Electron Spectrometers Aboard RBSP

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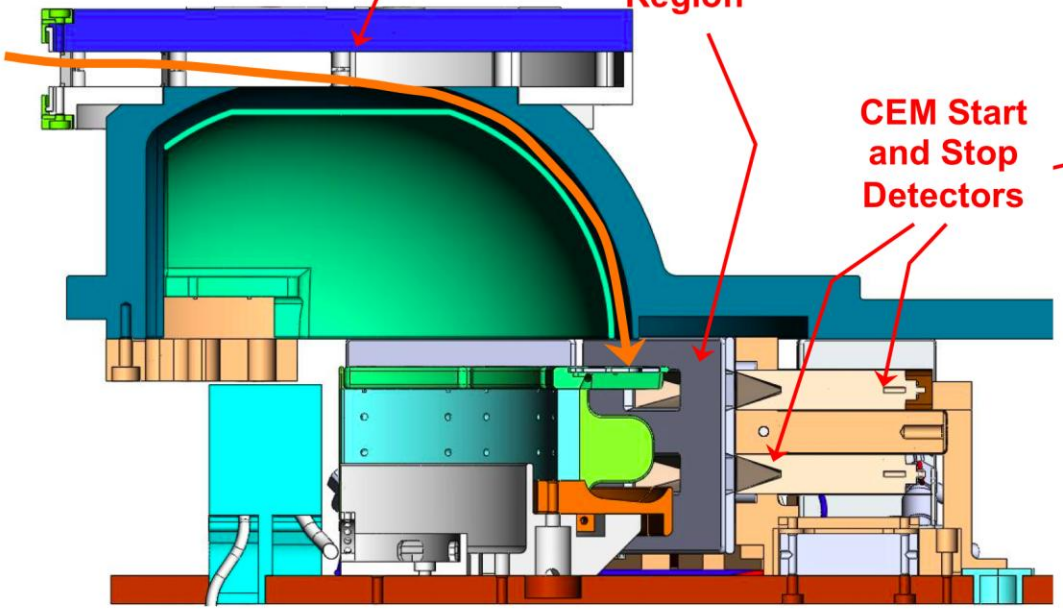
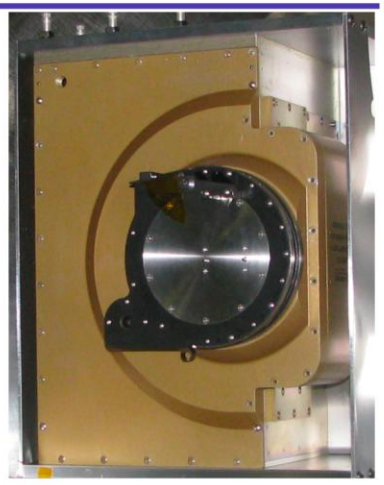
Purpose of Briefing

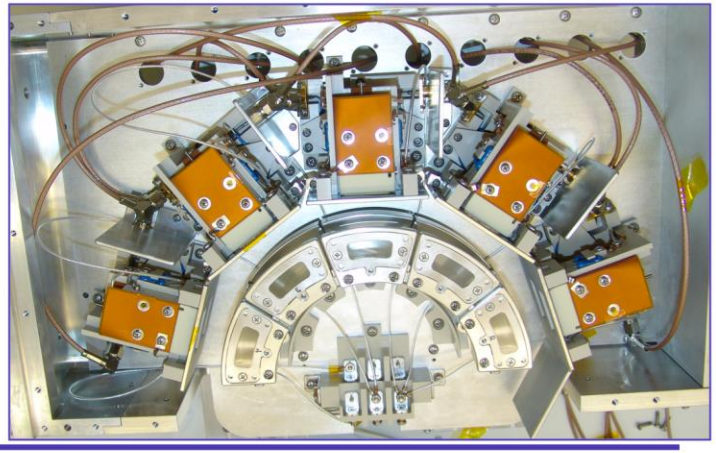
- To describe the data output of the MagEIS suite:
  - For scientific research
  - For space weather applications

The HOPE Measurement Technique

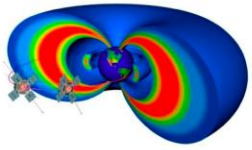


$$m = \frac{2E}{\left(d / t_{TOF}\right)^2}$$

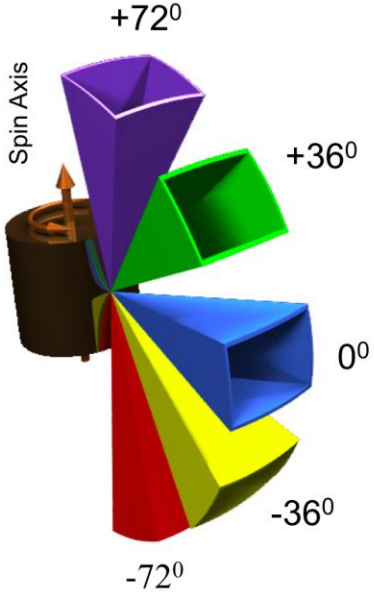


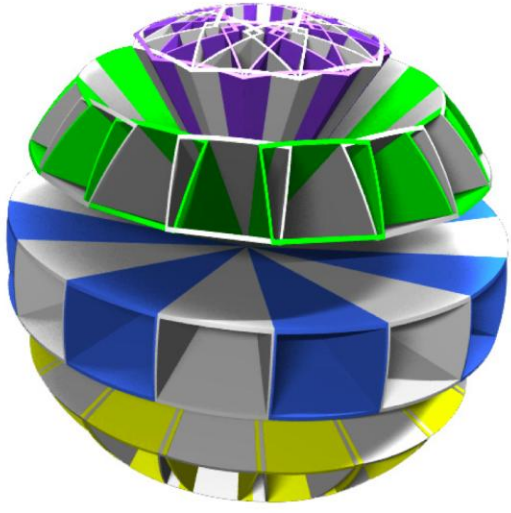


HOPE Measurement Strategy



Requirement	Description	Requirements
RHOPE_1152, RHOPE_1153, RHOPE_1154, RHOPE_1155	Observatory Accommodation	Nominal spin rate 4-6 rpm, 3-15 RPM during commissioning, spin rate stability +/- 0.25 rpm





- Not synchronized to spin pulse
- Electron mode and ion mode during alternate spins (spin assumed to be 5 rpm, 12 sec)
- FOV: 5 pixels, +/-72⁰, +/-36⁰, 0⁰
- Energy sweep: every 0.75 s
- Each spin: 16 azimuthal sectors (based on 5 rpm)
- Azim. sectors combined (4-8-16-8-4)
  - +/-72⁰: 4 azim sectors
  - +/-36⁰: 8 azim sectors
  - 0⁰: 16 azim sectors
- *Measure* 72 (but *Report* 36) energy steps in interleaved, windshield-wiper mode (1,2,5,6,9,10…72, 71, 68, 67, … 8,7, 4,3)

ECT REPT

Ultra relativistic electrons

Spectral information unavailable
from SAMPEX/PET

✧ Clean Spectral measurements
from REPT
- how are these energized ?
- decay and lifetimes ?
- 3 differential channels

>~ 10 MeV

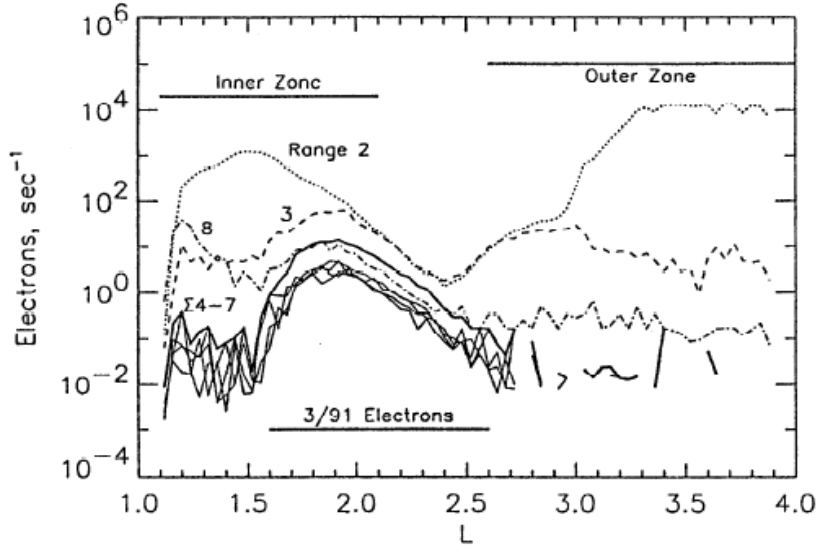
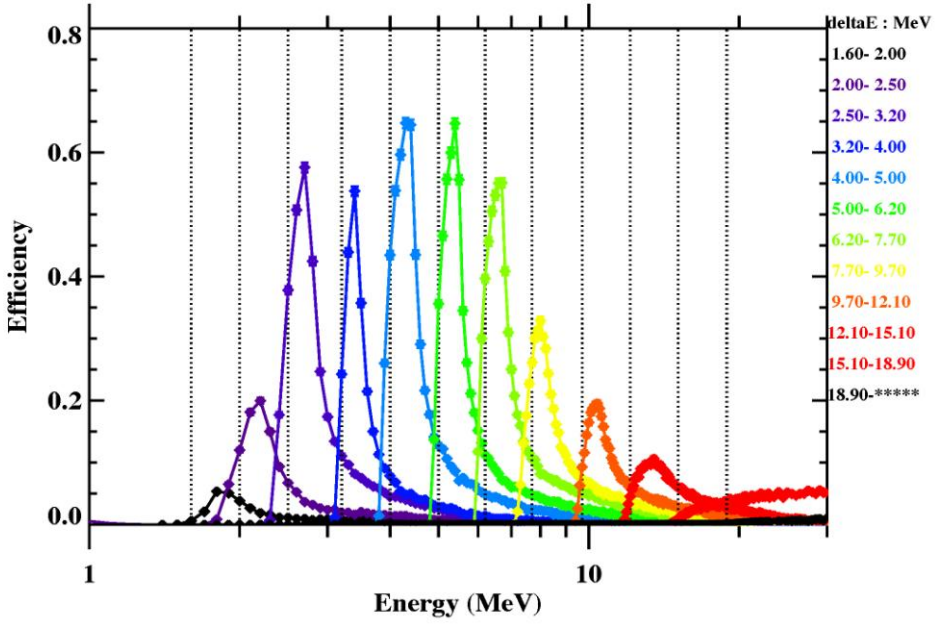


Figure 1. PET electron counting rates during 16–31 August 1992 as a function of L. Dotted line is Range 2, dashed is Range 3, dash-dotted is Range 8, solid lines are Ranges 4 to 7, and heavy solid line is their sum.



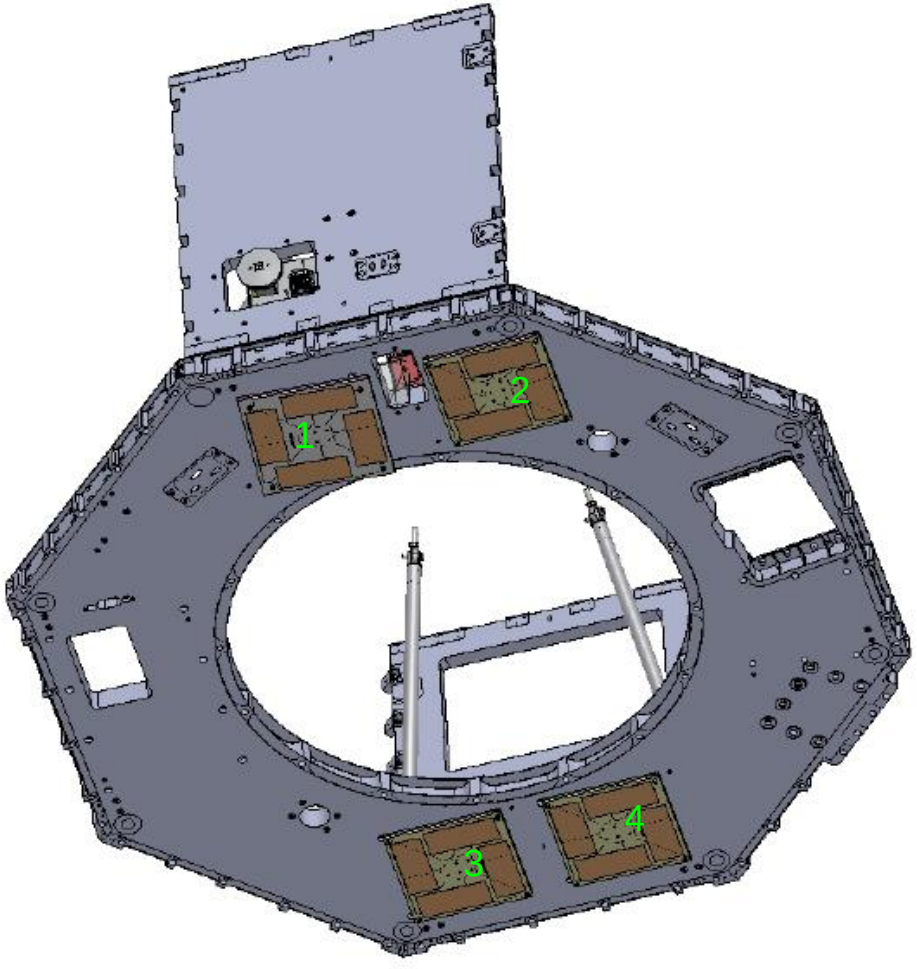
What is MagEIS?

- ON EACH SPACECRAFT

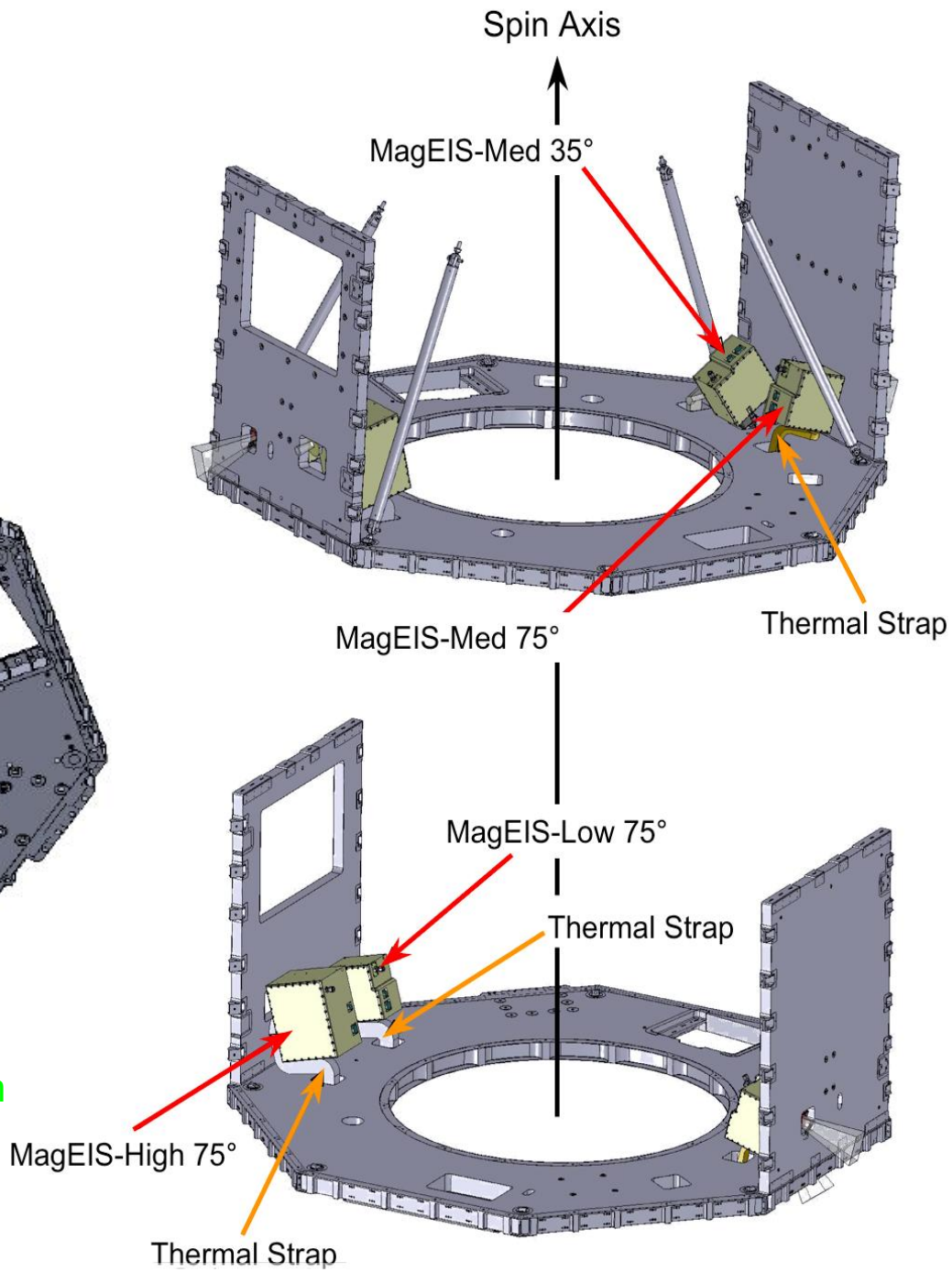
- Four (Independent) Magnetic Electron Spectrometers
  - One low (energy) spectrometer with FOV centered 75 degrees to spin axis
  - Two medium (energy) spectrometers with FOVs centered at 75 and 35 degrees
    - Multiple medium (energy) spectrometers for enhanced pitch-angle coverage

- One high (energy) spectrometer with FOV centered at 75 degrees

- Ion Telescope
  - Inside of high spectrometer box



Four thermal radiators facing down Sun



MagEIS Instrument Design Summary
Low-Medium Spectrometers

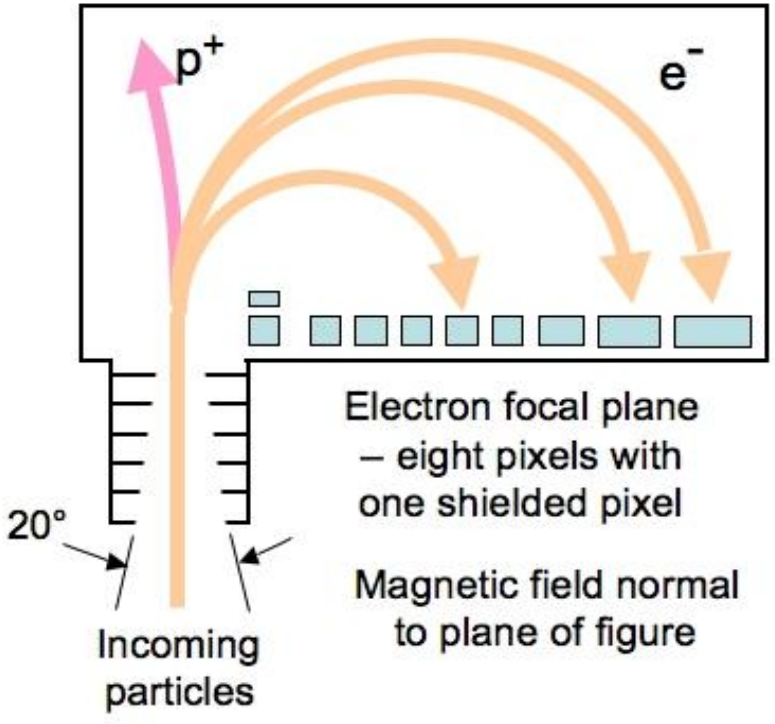
Particles enter magnetic-field chamber through a collimator-defined field-of-view

The magnetic field is uniform and normal to the plane of the drawing

Electrons are focused upon a 9-pixel silicon focal plane whose thickness is matched to the electron energy (500 microns - 3000 microns)

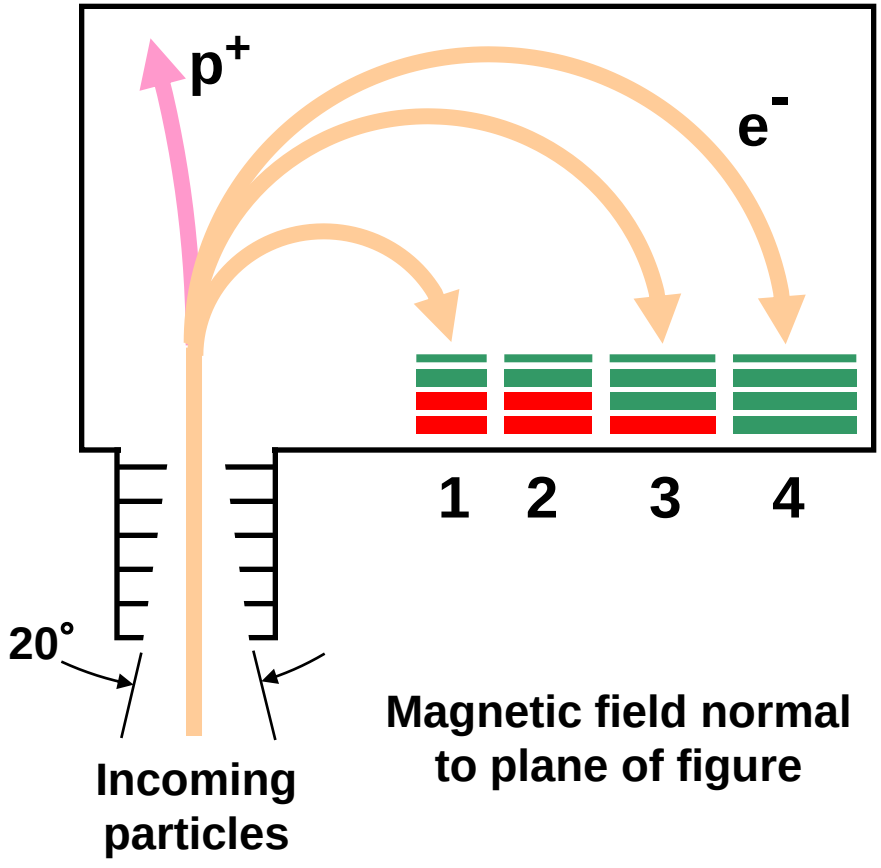
Momentum selection by the magnetic field results in each pixel having a defined, differential energy range; <u>all events outside of this defined energy range must be background</u>

Positive particles are deflected in the opposite direction, away from the electron pixels



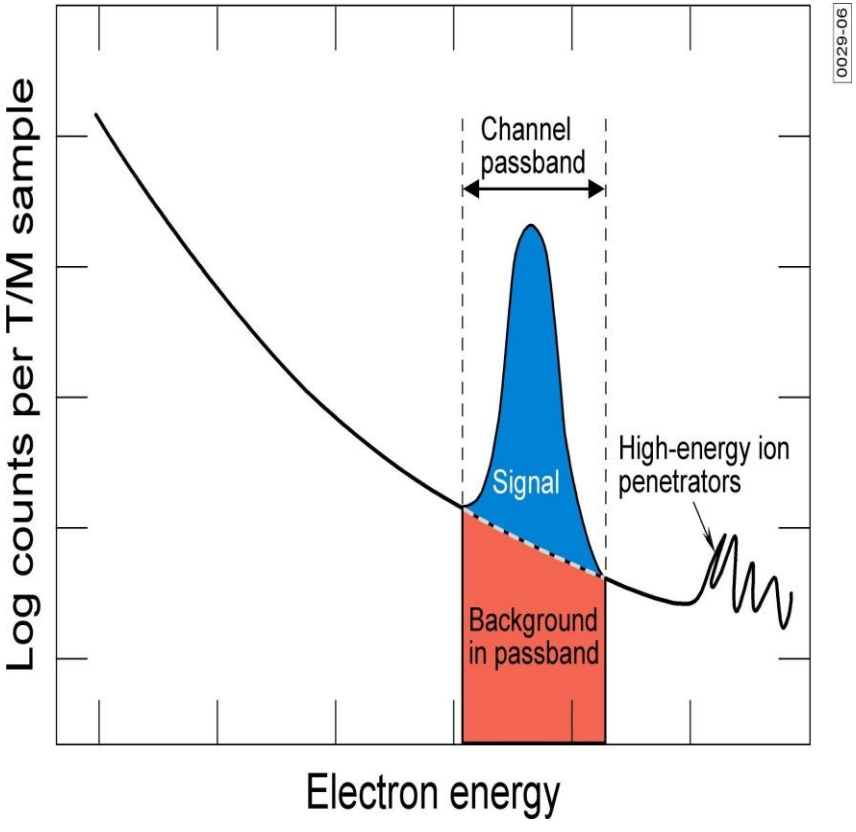
MagEIS Instrument Design Summary
High Spectrometer

- Four pixels in focal plane
- Front detector 300 microns thick
- Three pairs of back-to-back 1500 micron detectors (up to 9 mm) used as rear detector
- Outputs from co-aligned pixels are summed to the silicon thickness needed (green) in a common electronics chain
- Unused detectors support background removal
- Each of the eight pixels (four front and back) is connected to a separate electronic system
- A pulse-height spectrum is generated for each pixel
- Data processing includes coincidences between front and back pixels

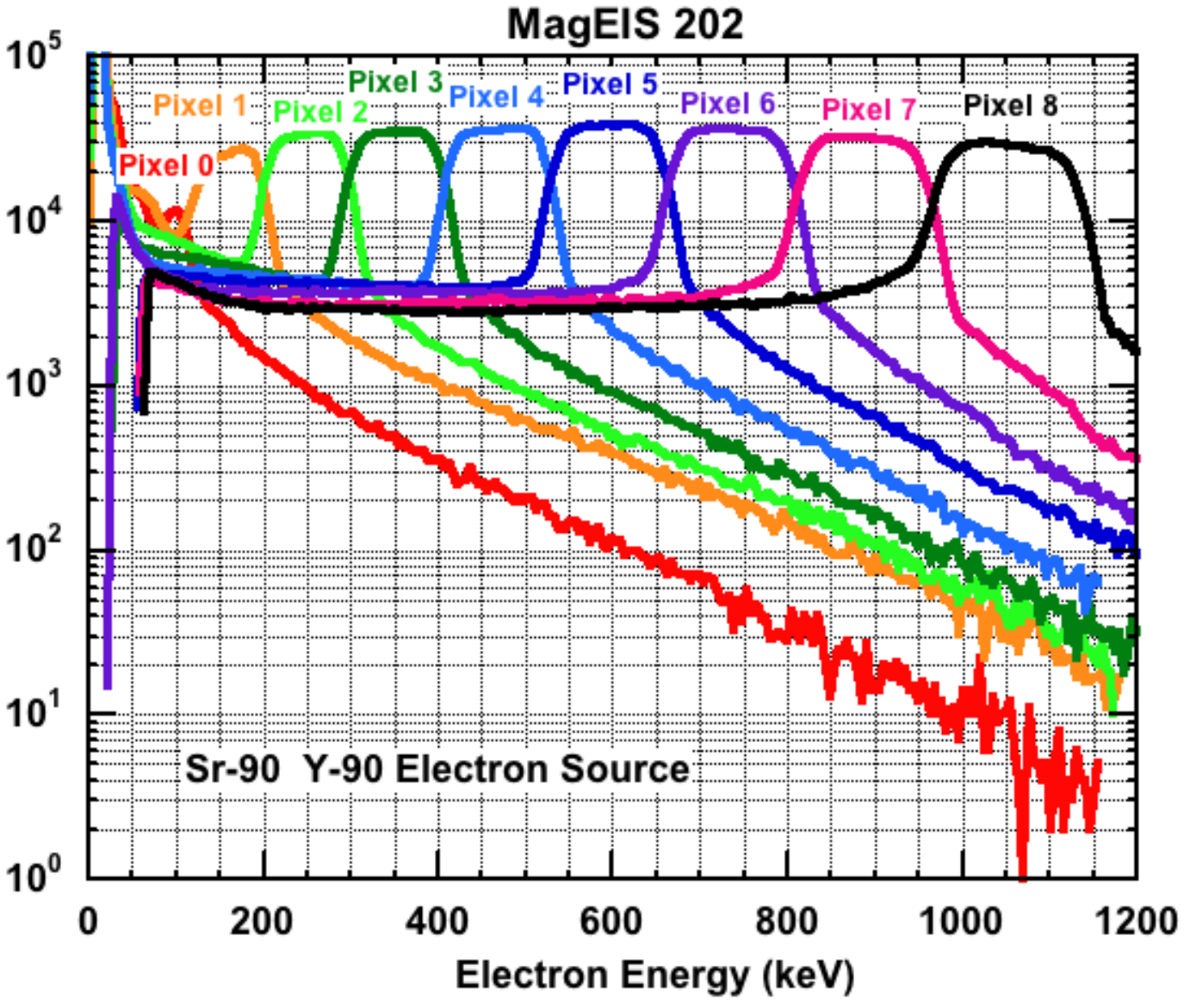


MagEIS Background Determination
The Key to Clean Measurements

- The magnetic field deflects only those electrons within a given momentum range upon a given pixel
  - The channel passband in momentum space corresponds to a defined passband in energy space
  - All energy deposits in a given pixel outside of the channel energy passband cannot be valid events
  - The out-of-passband events define the energy spectrum of the background
  - The background events energy-spectrum thus determined will be used to determine the background within the channel passband.
  - Background in adjacent pixels will be similar, and in fact expected to be so along the entire array, allowing much better definition of the background



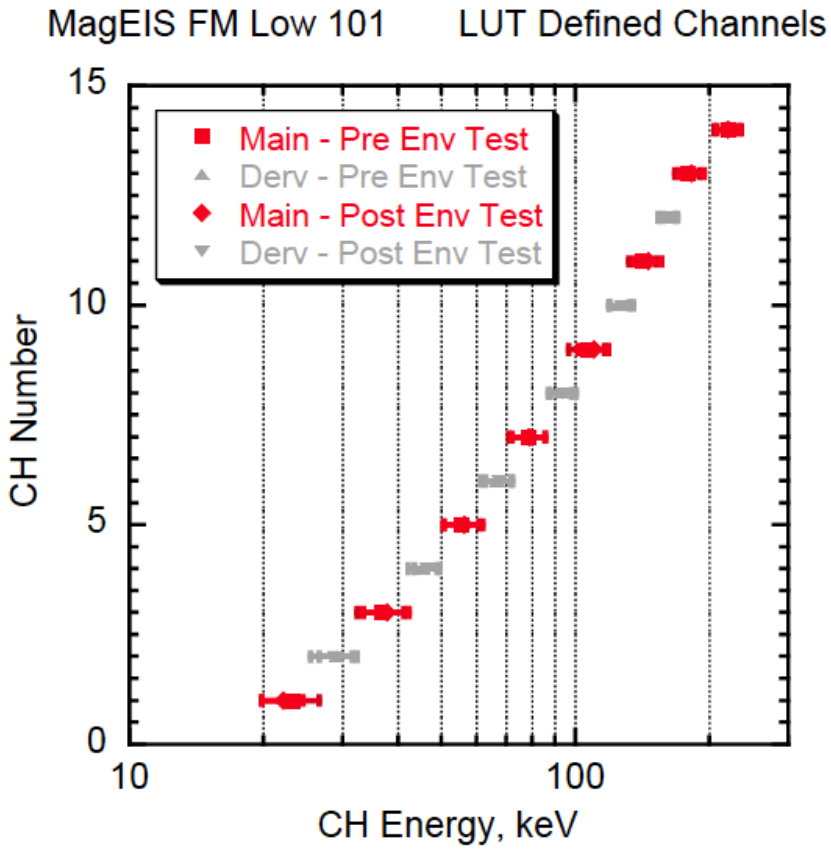
Medium Unit Response to Beta Spectrum

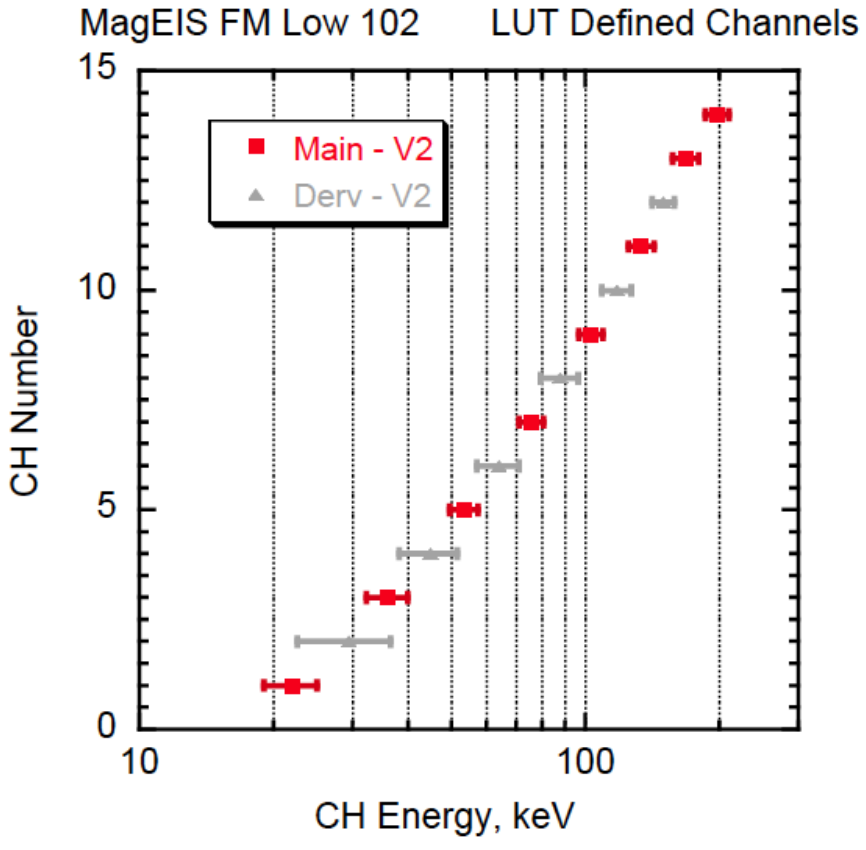


Main and Derived Data

- Main data are counts within passbands delineated by colored pillars
  - Regions where pixel response ~ independent of energy
- Derived data from combining counts in skirts of adjacent pixels
- Data telemetered 20 times per spacecraft rotation

Look Up Tables - Low Units



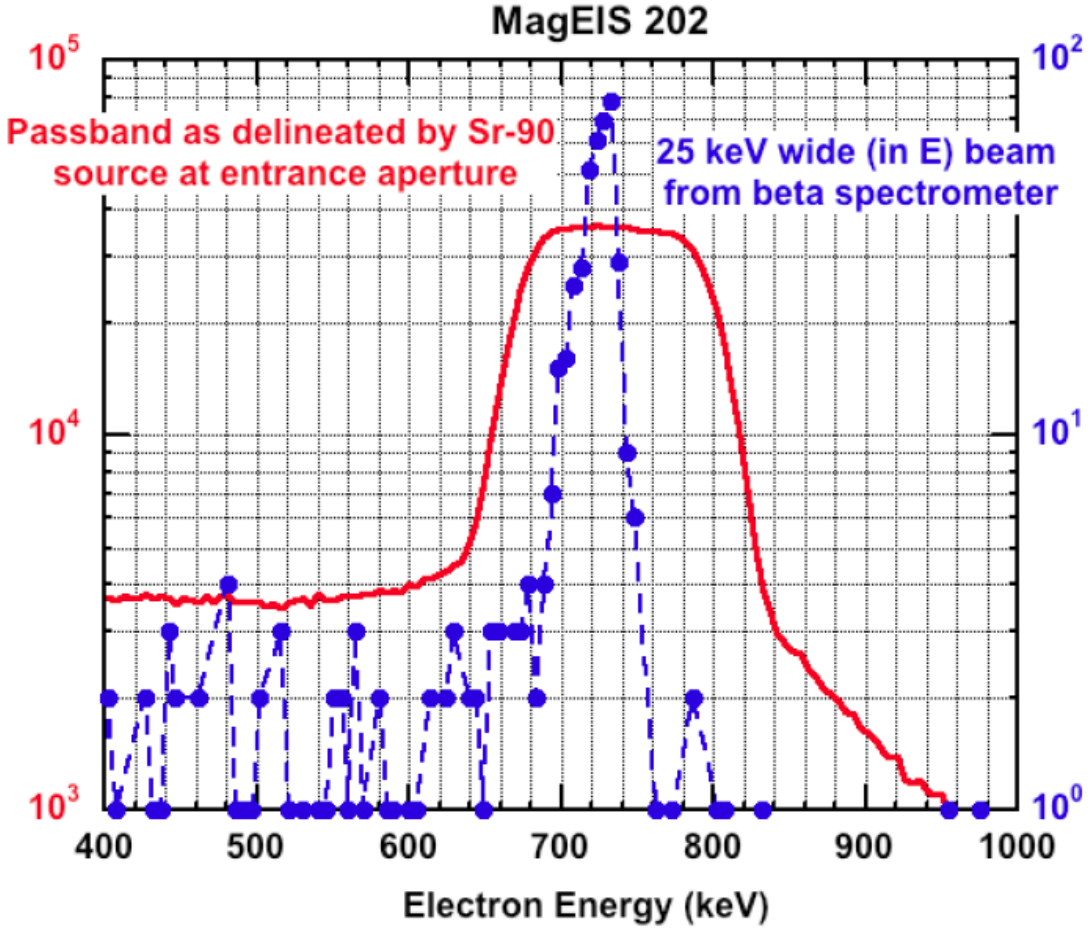


Histogram Data

- Every event pulse-height analyzed into 256 channel histogram
- Of these 256 channels, 64 are saved covering the pixel region in energy space plus outliers
- Data saved at all pitch angles
- Telemetered every 8 s/c rotations
- To be used to analyze and remove background
  - Will be used to observe fine energy structure

Intrinsic Detector/Electronics Resolution

MagEIS response to narrow beam demonstrates 3.5% resolution at 730 keV



MagEIS Histogram Data Can Be Used to Observe Complex Spectral Features

OZ Electron Spectra

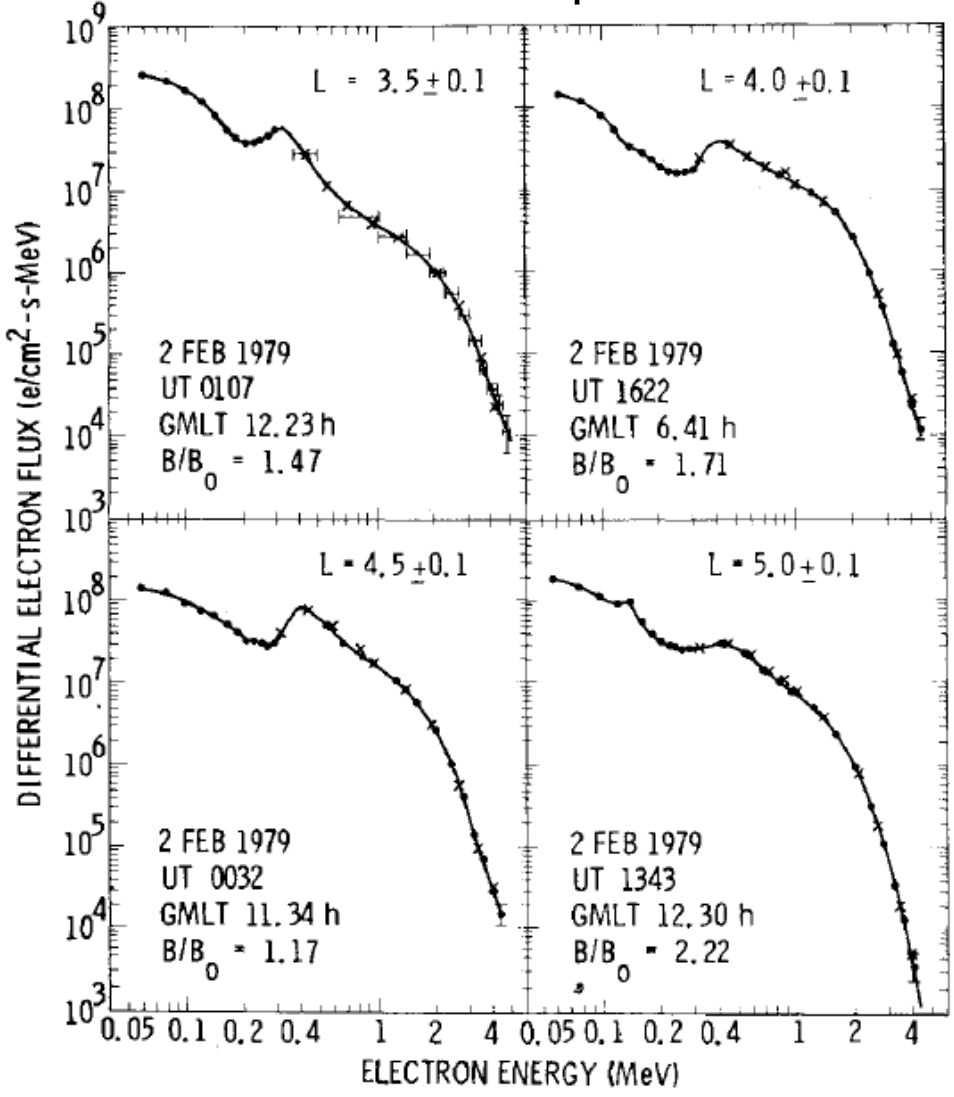


Fig. 2 Measured spin-averaged differential electron spectra for the *L* shells 3.5, 4.0, 4.5 and 5.0.

after Regan et al., 1983

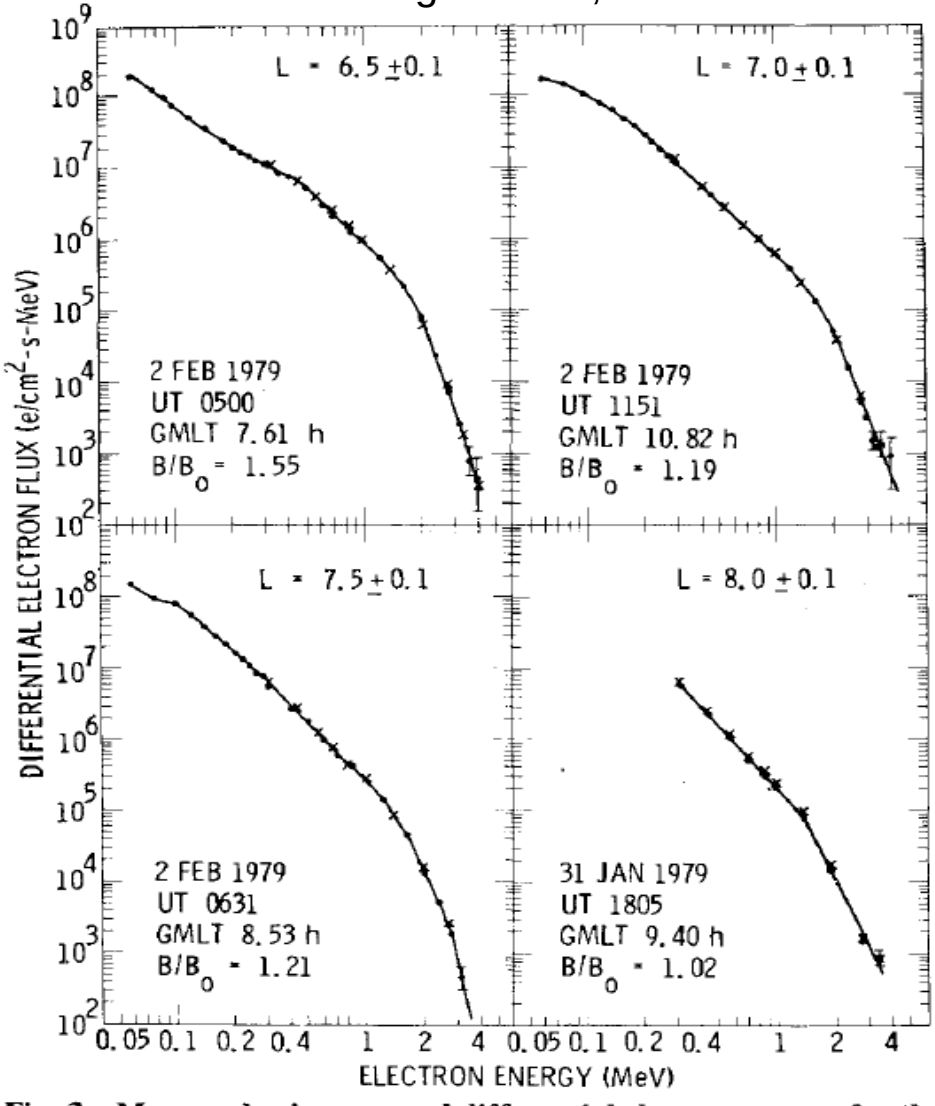


Fig. 3 Measured spin-averaged differential electron spectra for the *L* shells 6.5, 7.0, 7.5 and 8.0.

MagEIS Data Modes

Normal Mode

- The **Main Rate** data are accumulated in 20 sectors/spin over 1 spin period
- The **Derived Rate** data are accumulated in 20 sectors/spin over 1 spin period
- The **Histogram** data are accumulated in 20 sectors/spin over 8 spin periods
- Sectoring can be more complex and will be examined during commissioning
  - For example 29 sectors/spin over 2 spin periods
- Low and medium units individually mode commanded
- High unit Normal Mode Only

Sample Mode

- Selected **High Rate** data channels nominally are sampled few hundred times/spin every spin
  - Bounds are 8 -1200
- These **High Rate** channels are generated by LUTs and can represent multiple pixels combined into a single output channel
- The **Main Rate** data are accumulated in 20 sectors/spin over 1 spin periods same as in Normal Mode
- No **Derived Rate** data taken by Low and Med units
- No **Histogram** data taken by the Low and Med units

Ion Telescope

- Three Si detector stack in heavily shielded housing a upstream 1500 gauss electron sweeping magnet
  - No coincidence requirements

- Front detector in both telescopes (in both s/c) are identical, 50 micron annular detectors

- Second and third detector in one telescope are 2 microns and 9 microns thick respectively

- Second and third detector in second telescope are 10 microns and 2500 microns thick respectively

Space Weather

MagEIS Space Weather Data

Energies, keV	MagEIS Sensor	No. Ch	Bits/ value	No. Sectors	TM rate, bps
45, 75, 100	Low	3	10	8	36
300, 600, 1000	Med 75	3	10	8	36
2000	High Electrons	1	10	8	18
1000	High Protons	1	10	8	18
300, 600, 1000	Med 35*	0	10	8	0
				bps	108

* Med 35 is considered a backup for Med 75

Thank You