GOES-R Energetic Particles: Capabilities Overview

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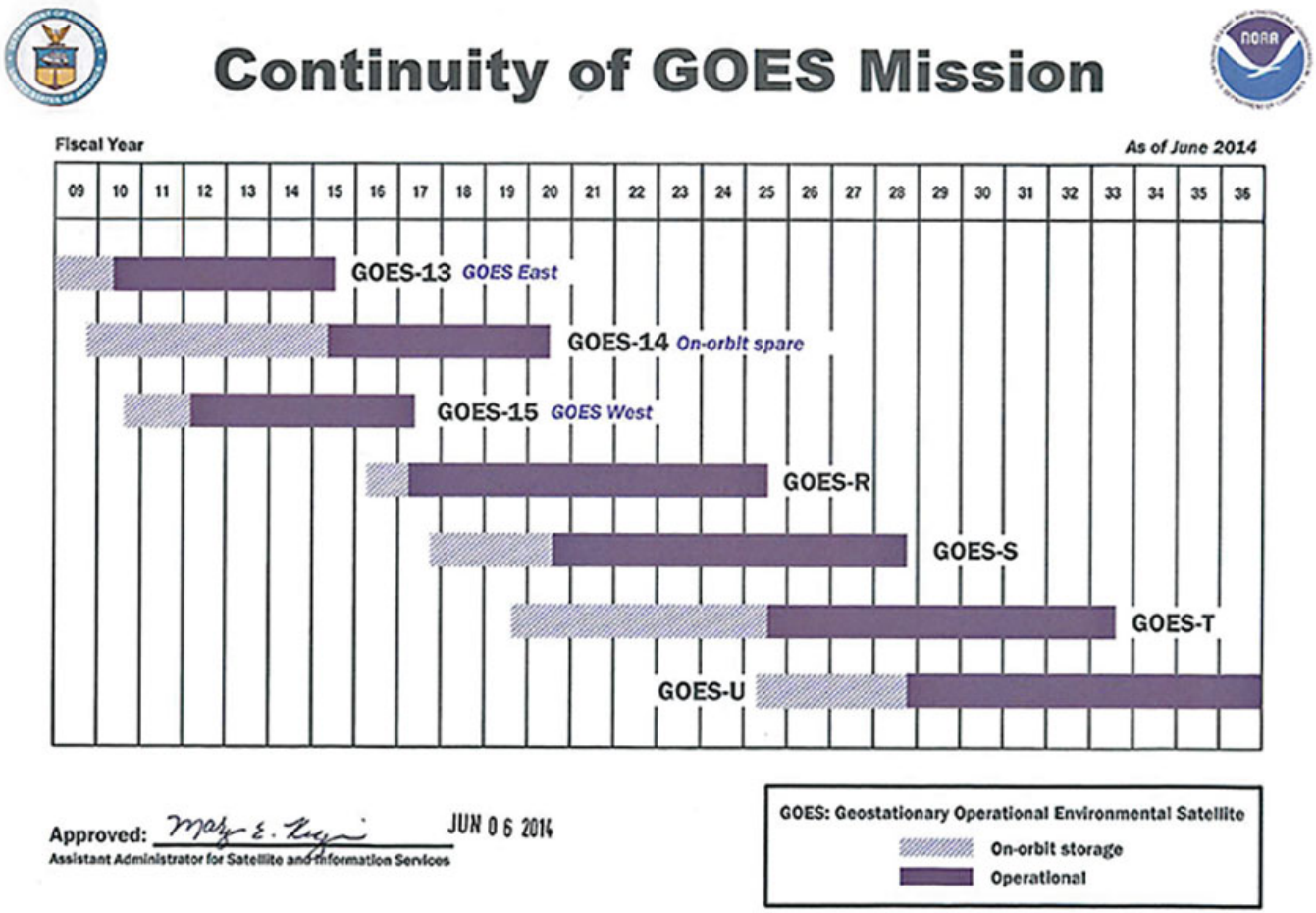
GOES Next Requirements Workshop

April 13, 2015

GOES-R+ Series:
First Launch 15 March 2016

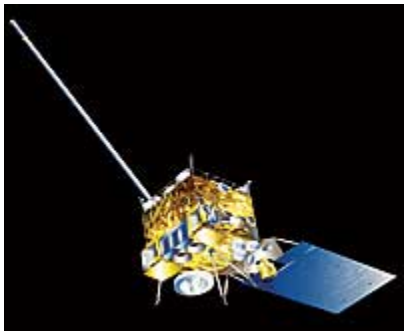


Evolution of GOES Charged Particle Coverage

Satellite Series	Electrons 0.03-30 keV	Electrons 30-600 keV	Electrons >800 keV	Ions 0.03-30 keV	Protons 80-800 keV	Protons >740 keV	Heavy Ions, >10 MeV/n
GOES 8-12			√			√	He
GOES 13-15		√	√		√	√	He
GOES R-U	√	√ (gap 30-50 keV)	√	√	√	√	He, Z=4-29 (Be-Cu)
Space weather application	Frame charging, charging signatures	Frame and interior charging	Interior charging, radiation belt alerts	Frame charging signatures, ring current	Surface damage	SEP event alerts, surface damage	Single event effects

GOES 8-12

GOES 13-15



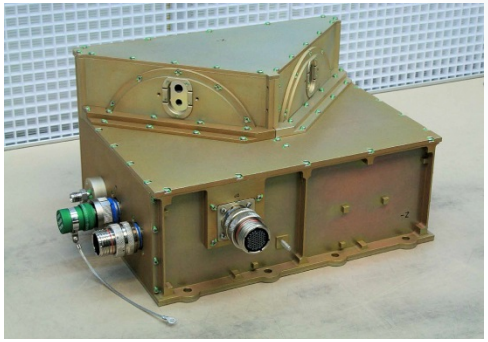
GOES R-U

Space Environment In-Situ Suite (SEISS): Magnetospheric Particles

Magnetospheric Particle Sensor – Low Energy (MPS-LO):

Spacecraft frame charging

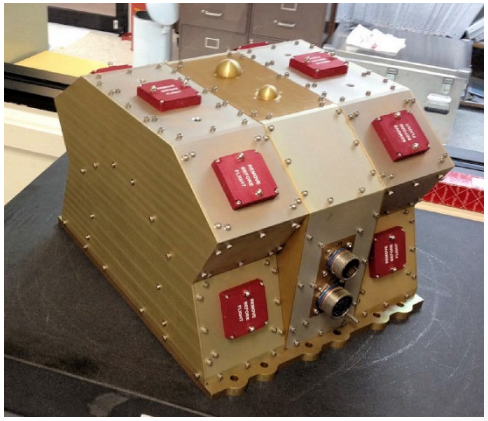
- Electrostatic analyzers
- 14 angular zones (12 unique)
- 30 eV-30 keV electrons: 15 energies
- 30 eV-30 keV ions: 15 energies
- Heritage: DMSP SSJ/5



Magnetospheric Particle Sensor – High Energy (MPS-HI):

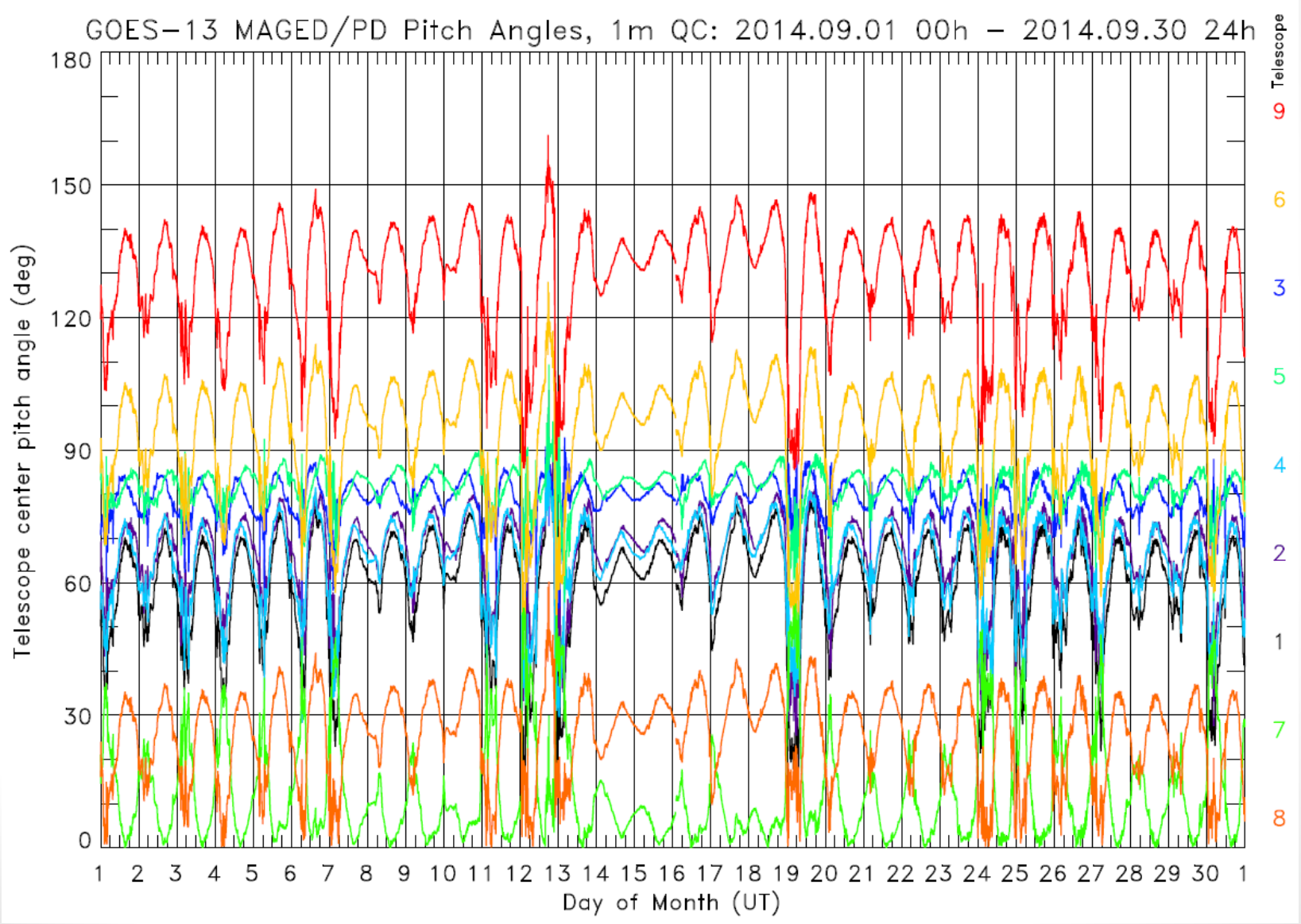
Spacecraft internal charging, >2 MeV electron alerts

- Solid-state telescopes (5 per species)
- 50 keV-4 MeV, >2 MeV electrons: 11 energy bands
- 80 keV-10 MeV protons: 11 energy bands
- Two hemispherical dosimeters:
  - 100 mil Al: >1.2 MeV electrons, >22 MeV protons
  - 200 mil Al: >2.8 MeV electrons, >37 MeV protons



Magnetic field vector from GOES tri-axial fluxgate magnetometer is essential for calculating pitch angle for each telescope / zone

Example: Pitch Angles from GOES-13



Space Environment In-Situ Suite (SEISS): Solar and Galactic Ions

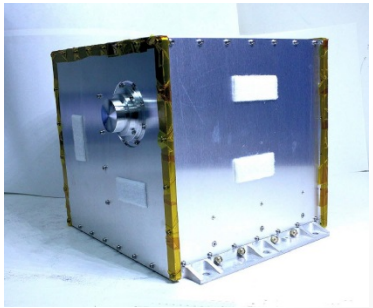
Solar and Galactic Proton Sensor (SGPS):

Solar radiation storm alerts, polar-cap HF communication (airlines), radiation dose, solar array degradation

- Two SGPS on each satellite, one looking W and one looking E
- Three solid-state telescopes per SGPS
- 1 MeV-500 MeV, >500 MeV protons: 14 energy bands
- 4 MeV-500 MeV alphas: 12 energy bands (not processed)
- Two highest-energy proton bands replace the four HEPAD bands

Energetic Heavy Ion Sensor (EHIS):

Satellite single event upsets, radiation dose



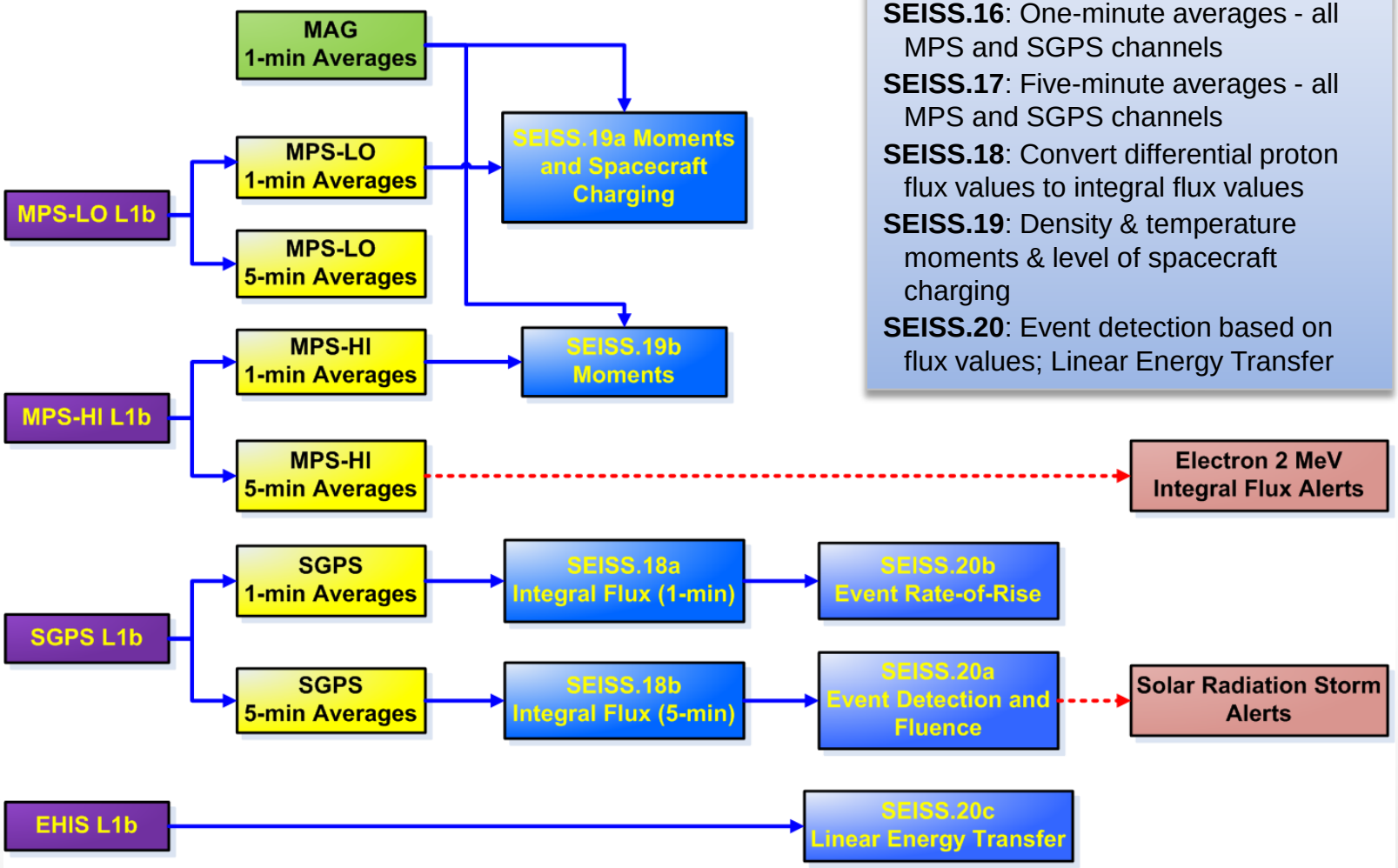
- 10-200 MeV/nucleon
- Distinguishes H, He, Z = 4-29 (Be-Cu, incl. CNO, Ne-S, Fe)
- 5 energy bands, one look direction (radially outward)

See poster by M. Golightly on Thursday

GOES-R Space Weather Data Processing: New Approach

- In the past, NOAA Space Weather Prediction Center (SWPC) has developed and implemented the complete GOES space weather data processing chain
- GOES-R+: all space weather data will be processed from raw telemetry to Level 1b (L1b) by NOAA at Wallops Island, Virginia
  - Corrected and calibrated physical quantities (magnetic fields and particle fluxes) at full time resolution
  - Instrument vendors are responsible for the L1b algorithms
  - NOAA provides technical review and advice
- GOESR+ Level 2 (L2) space weather processing will be performed by NOAA in Boulder, Colorado
  - Time-averages, derived quantities, event detector
  - NOAA National Geophysical Data Center (NGDC) is responsible for developing the L2 algorithms and a demonstration processing system

SEISS L2+ Product Precedence Tree



SEISS Level 2 Algorithms

SEISS.16: One-minute averages - all MPS and SGPS channels

SEISS.17: Five-minute averages - all MPS and SGPS channels

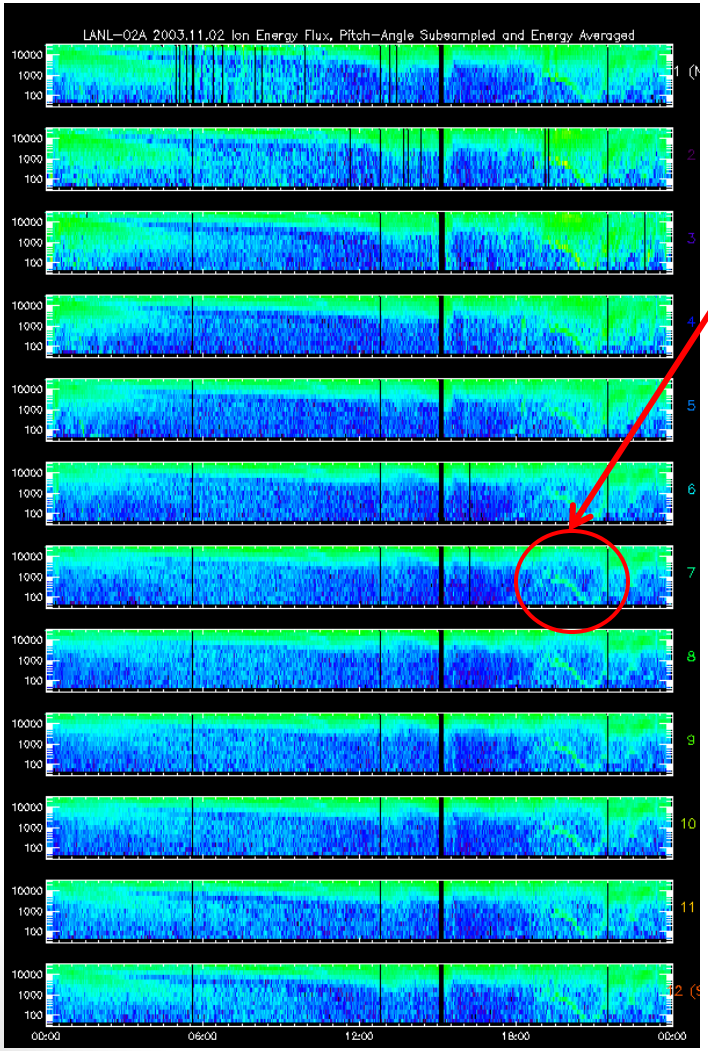
SEISS.18: Convert differential proton flux values to integral flux values

SEISS.19: Density & temperature moments & level of spacecraft charging

SEISS.20: Event detection based on flux values; Linear Energy Transfer

L2+ SEISS.19 Moments and Level of Spacecraft Charging

MPS-LO proxy data derived from LANL-02A MPA fluxes:
30 eV – 30 keV ions in 15 energy channels, 12 angular zones



Product variables:

Pitch angles for MPS-LO and MPS-HI

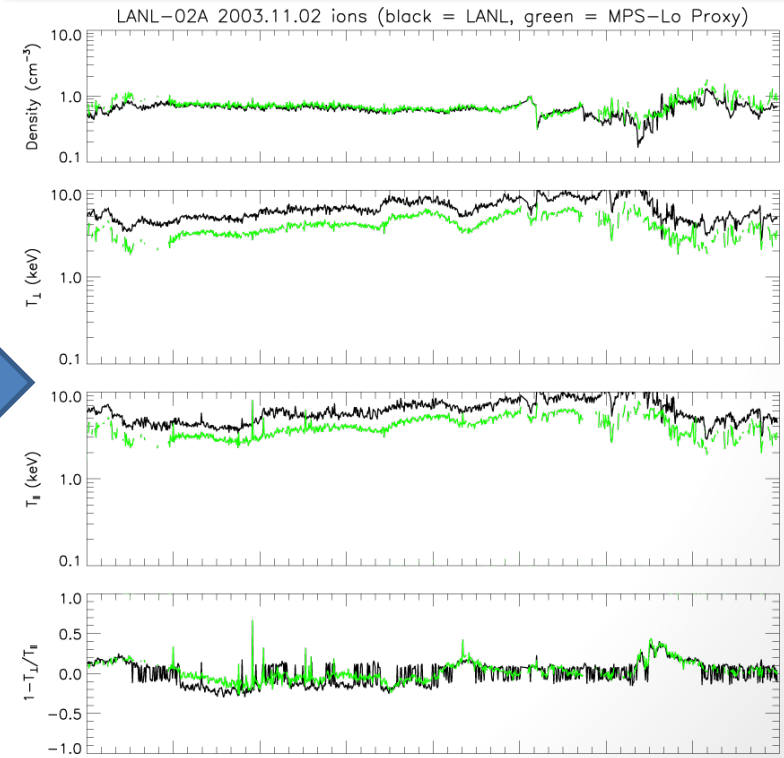
MPS-LO 0.03-30 keV densities and temperatures, electrons and ions

Spacecraft frame potential

Differential barrier potential

MPS-HI 50-300 keV and >300 keV densities and temperatures, electrons and protons

Kennel-Petschek anisotropy measure



L2+ SEISS.18b 5-min Integral Fluxes and SEISS.20a Event Detection

Product variables:

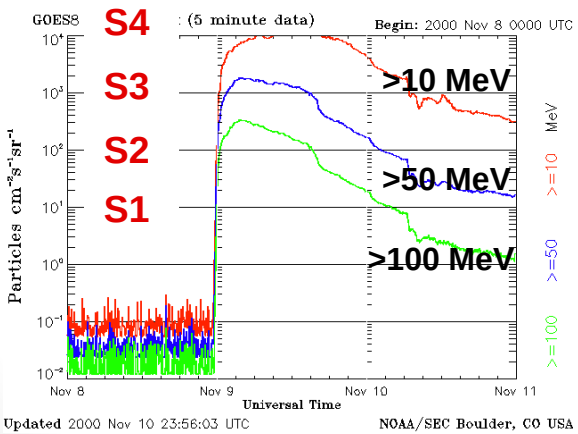
1, 5, 10, 30, 50, 60, & 100 MeV proton integral fluxes

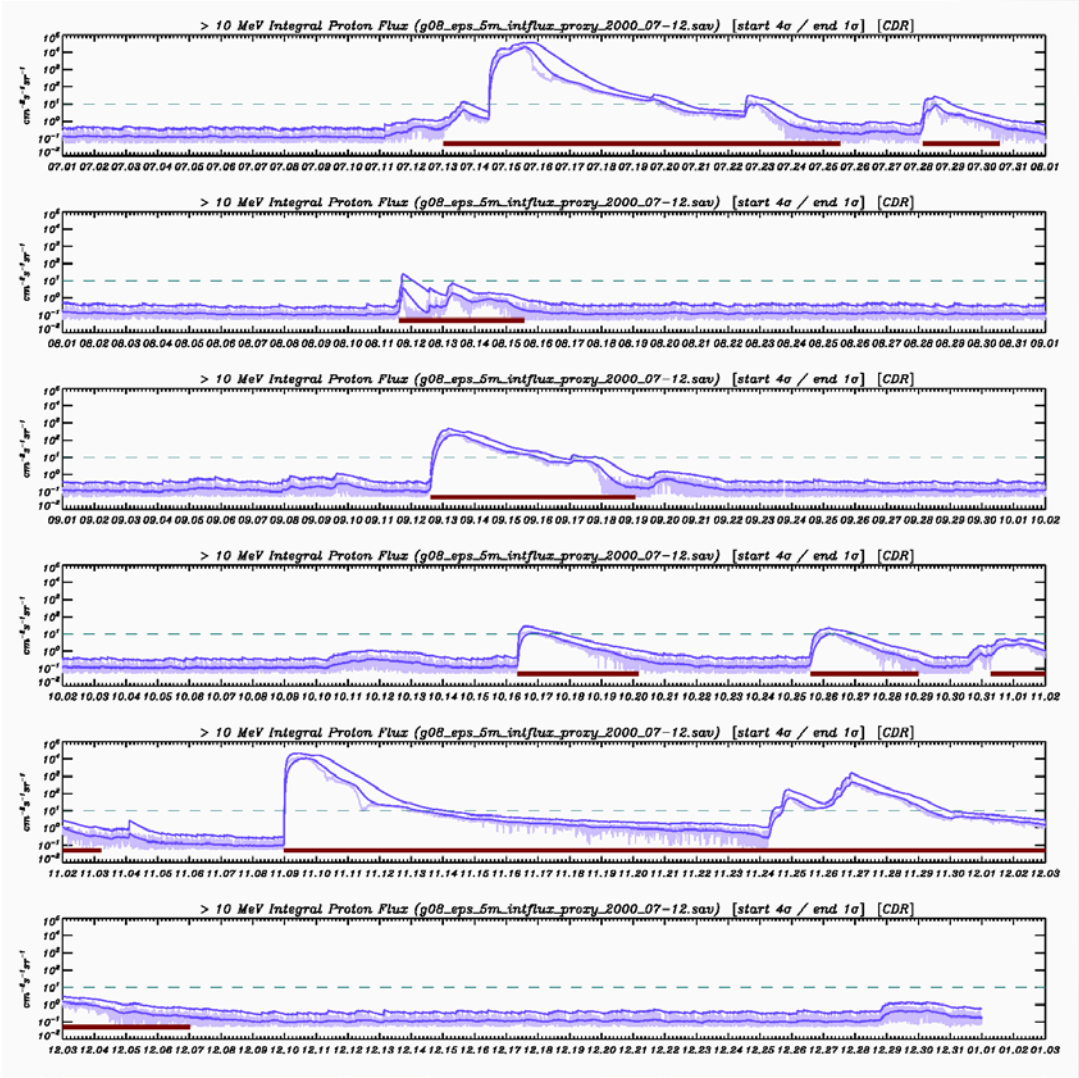
1, 5, 10, 15, 30, 50, 60, & 100 MeV proton differential fluxes

Event onset, peak and end in 10, 30, 60 and 100 MeV integral fluxes

Event fluence from 10, 30, 60, and 100 MeV integral fluxes

Daily fluence from 1, 10, 30, 60 and 100 MeV integral fluxes

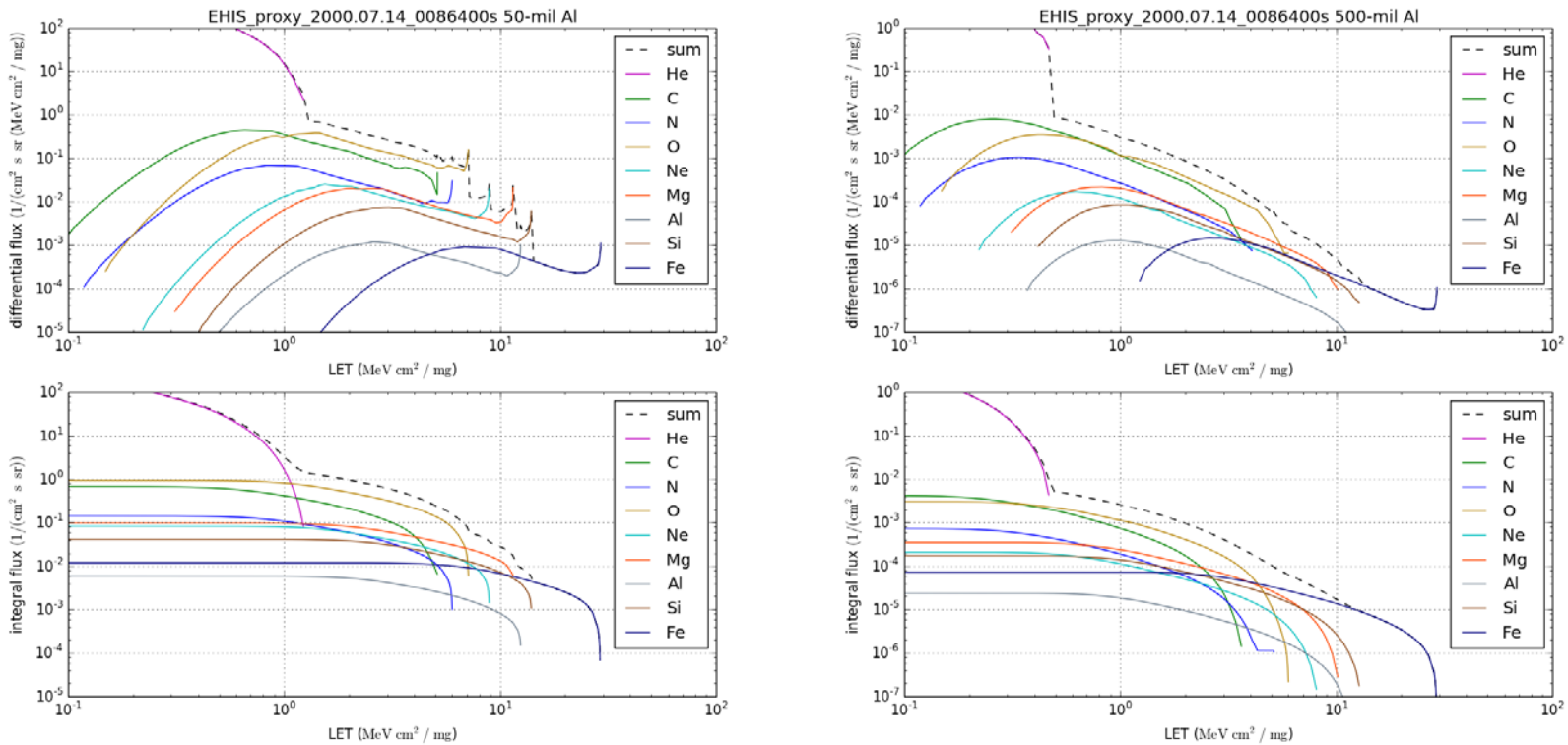




SGPS proxy data derived from GOES EPS differential and integral fluxes

L2+ SEISS.20c: Linear Energy Transfer (LET)

Derived from EHIS spectra (Helium through Iron)



Bastille Day 2000 event, 50-mil Al, one-day average

Bastille Day 2000 event, 500-mil Al, one-day average

EHIS proxy data derived from ACE SIS Level 2 hourly fluxes

Thoughts for this Workshop

- All requirements need to be re-affirmed – *take nothing for granted*
- Which capabilities do we need to maintain?
- Which capabilities do we need to improve?
- If needed in the future, non-required capabilities need to become requirements, for example:
  - Dosimeters
  - Knowledge of relative alignment between magnetic field and SEISS fields-of-view