

A GOES-R satellite is shown in orbit above the Earth. The satellite has a large rectangular solar panel array and a long boom extending to the left. The Earth is visible in the lower right, showing clouds and landmasses. The background is a dark blue space filled with stars.

# **New Charged Particle Measurements and Products from GOES-R**

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**European Space Weather Week 11**

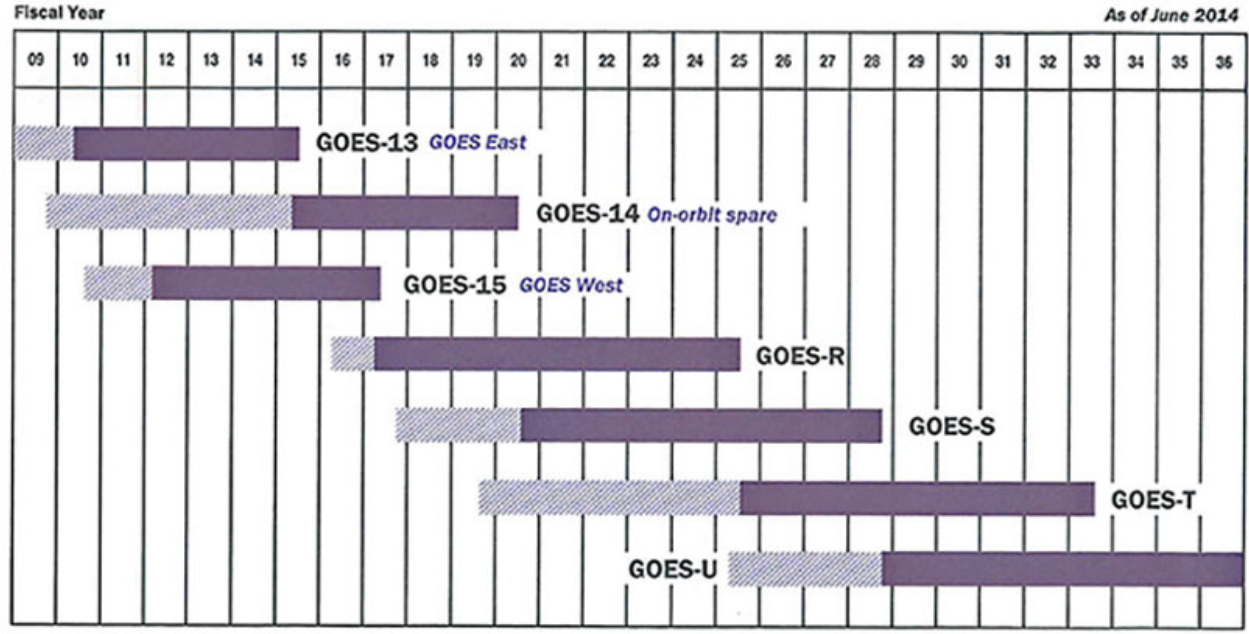
**20 November 2014**



# New GOES-R+ Series: First Launch 15 March 2016



## Continuity of GOES Mission



Approved: Mary E. Kagan JUN 06 2014  
Assistant Administrator for Satellite and Information Services

GOES: Geostationary Operational Environmental Satellite

On-orbit storage  
 Operational



# GOES-R+ Space Weather Instruments: All New Designs



- GOES-R+ series will carry a set of newly-designed space weather instruments:
  - Solar Ultraviolet Imager (SUVI)
  - EUV and X-Ray Irradiance Sensors (EXIS)
    - Extreme Ultraviolet Sensor (EUVS)
    - X-Ray Sensor (XRS)
  - Fluxgate Magnetometers (MAG)
  - **Space Environment In-Situ Suite (SEISS)**
    - **Magnetospheric Particle Sensor – Low Energy (MPS-LO)**
    - **Magnetospheric Particle Sensor – High Energy (MPS-HI)**
    - **Solar and Galactic Proton Sensor (SGPS)**
    - **Energetic Heavy Ion Sensor (EHIS)**



# 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 processing prototype



# Evolution of GOES Charged Particle Coverage



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

**GOES 8-12**



**GOES 13-15**



**GOES R-U**





# SEISS: Four Instruments Measuring Electrons, Protons and Heavier Ions



**MPS-LO: Spacecraft frame charging, geomagnetically-induced currents (electric power grid)**

**NEW**

- 30 eV-30 keV electrons
- 30 eV-30 keV ions
- 15 energies at 14 angles

**MPS-HI: Spacecraft frame and interior charging, >2 MeV electron alerts**

- 50 keV-4 MeV electrons
- 80 keV-10 MeV protons
- 11 energy bands at 5 angles

**SGPS: Solar radiation storm alerts, HF communication (airlines), astronaut radiation dose, solar array degradation**

- 1 MeV-500 MeV, >500 MeV protons
- 4 MeV-500 MeV alphas
- 11 energy bands, 2 look directions

**EHIS: Satellite single event upsets, astronaut radiation dose**

**NEW**

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

## SEISS Level 2 Algorithms

**SEISS.16:** One-minute averages - all MPS 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



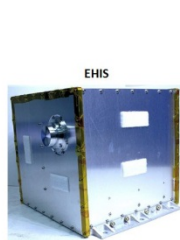
MPS-LO



MPS-HI



SGPS



EHIS



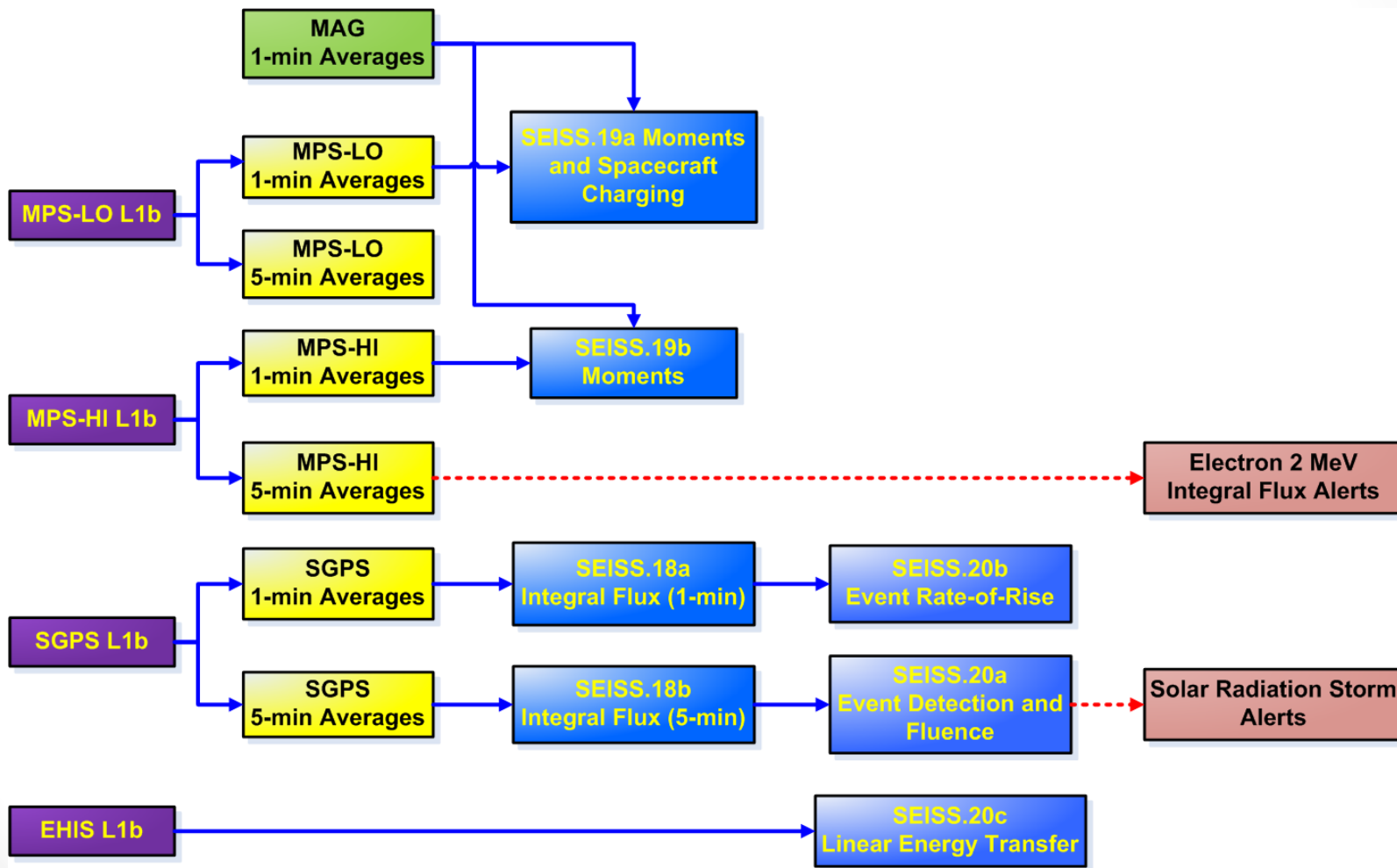
DPU



SGPS



# SEISS L2+ Product Precedence Tree



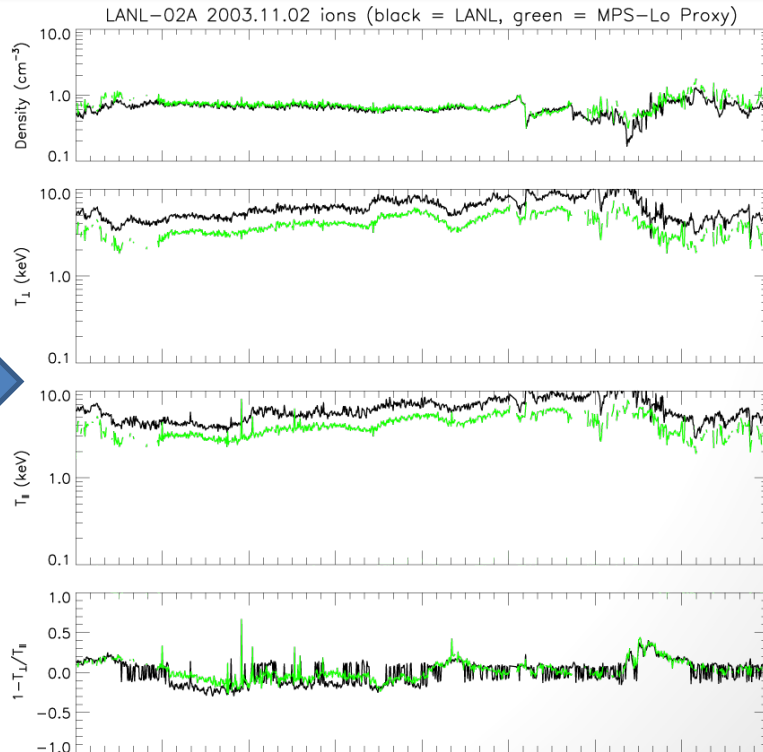
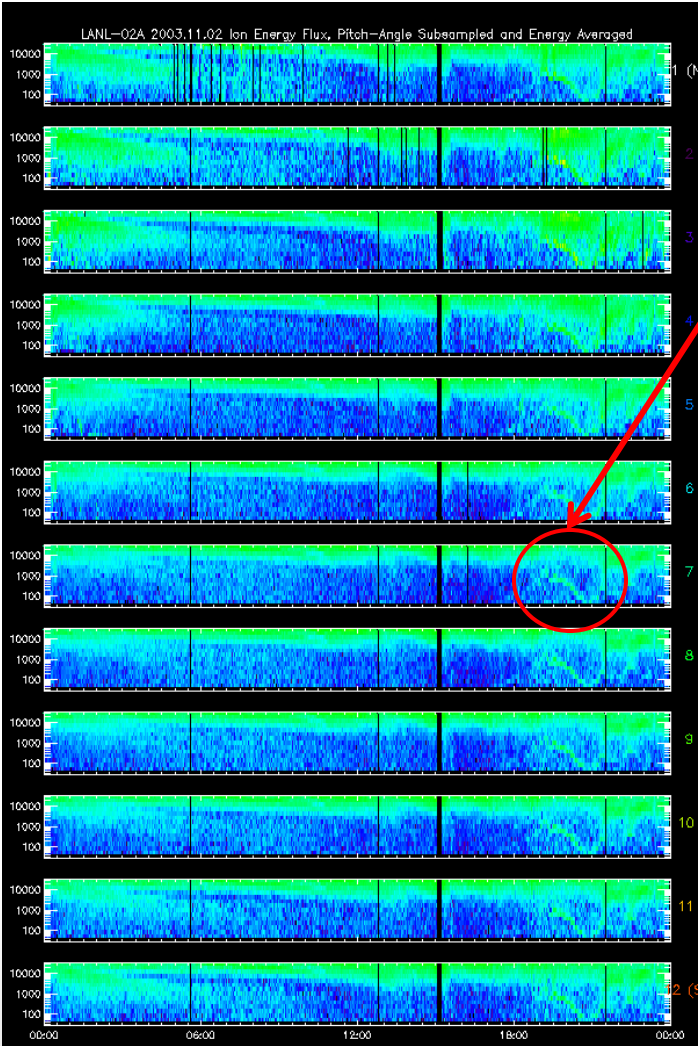


# L2+ SEISS.19 Moments and Level of Spacecraft Charging



*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





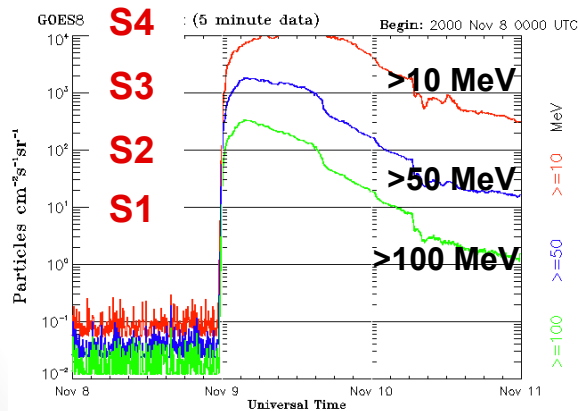
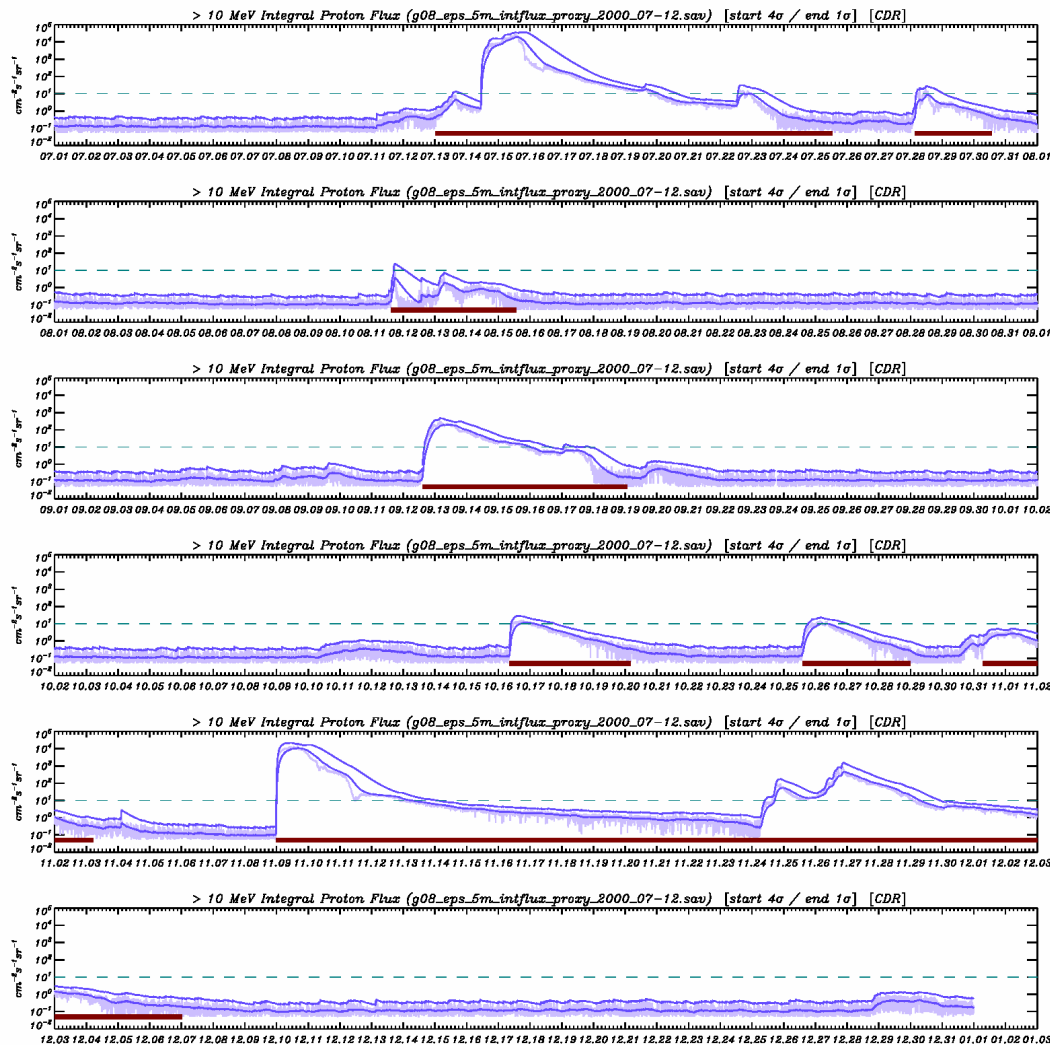


# L2+ SEISS.18b 5-min Integral Fluxes and SEISS.20a Event Detection



## 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



Updated 2000 Nov 10 23:56:03 UTC NOAA/SEC Boulder, CO USA

SGPS proxy data derived from GOES EPS differential and integral fluxes

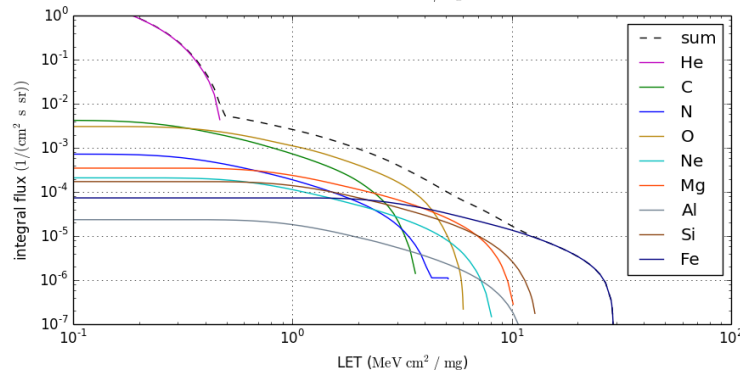
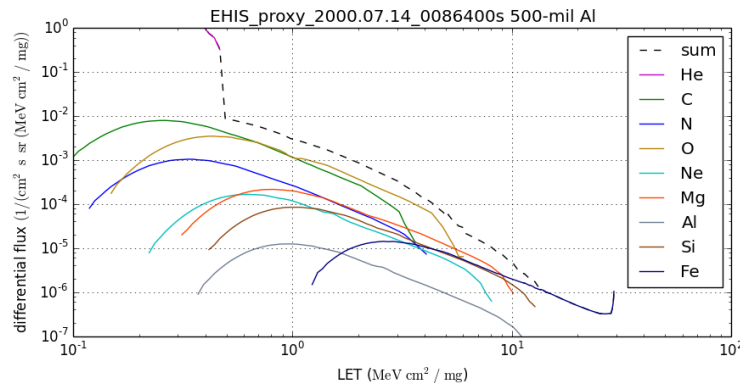
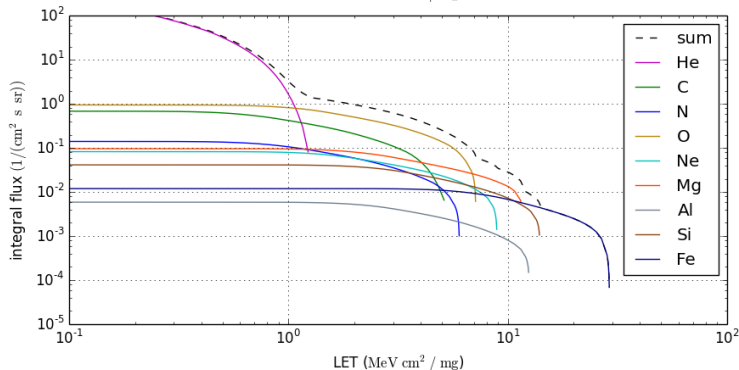
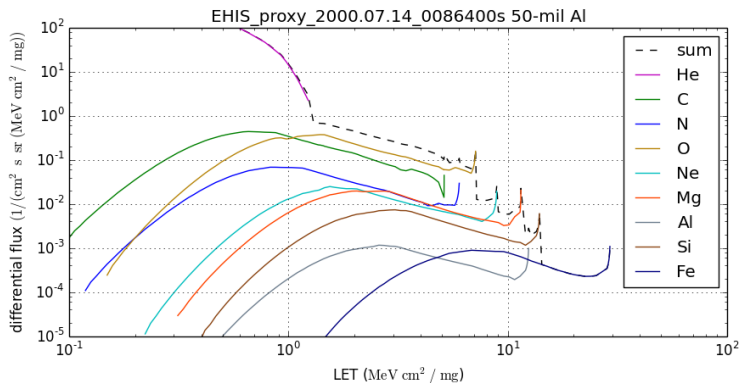


# L2+ SEISS.20c:

# Linear Energy Transfer (LET)



*Derived from EHS spectra (Helium through Iron)*



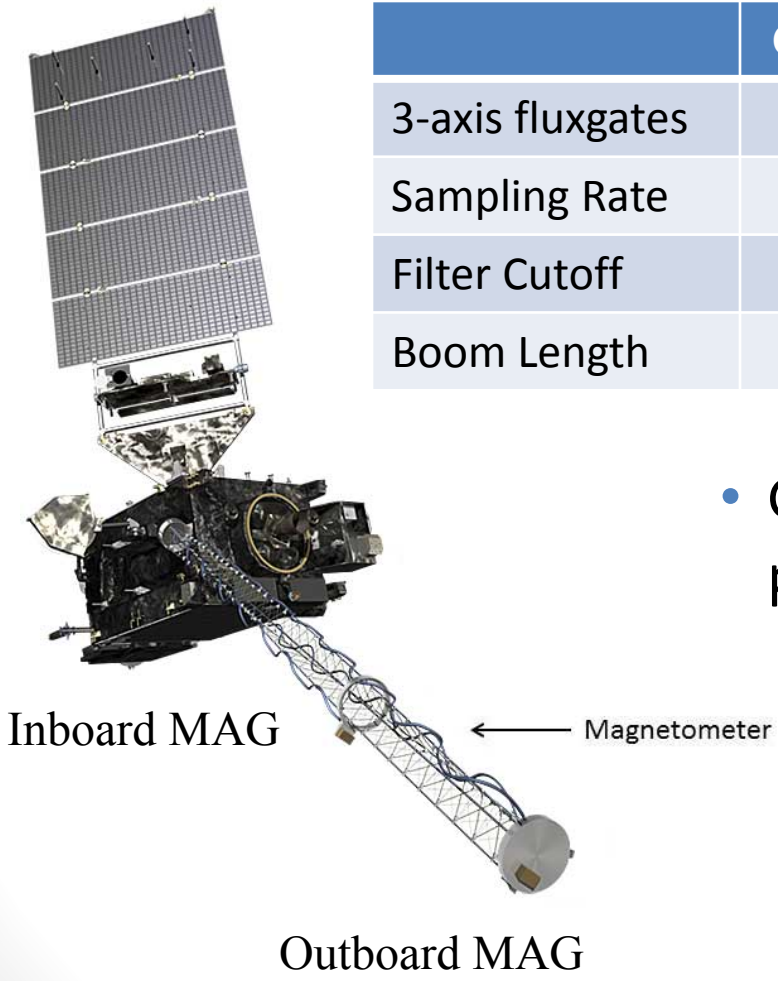
**Bastille Day 2000 event, 50-mil Al,  
one-day average**

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

EHIS proxy data derived from ACE SIS Level 2 hourly fluxes



# GOES-R Magnetometer: Essential for Interpretation of Particle Data



	GOES 8-12	GOES 13-15	GOES R-U
3-axis fluxgates	1	2	2
Sampling Rate	2 Hz	2 Hz	10 Hz
Filter Cutoff	0.5 Hz	0.5 Hz	2.5 Hz
Boom Length	3 m	3 m	8.5 m

- GOES R-U magnetometer products
  - Field vector in 7 coordinate frames: instrument, spacecraft, EPN, ECI, GSE, GSM, VDH
  - Magnetopause crossing identification
  - Pitch angles for SEISS



# Summary: New Charged Particle Measurements from GOES-R



- GOES particle measurements form the basis for real-time alerts, retrospective anomaly investigations and long-term data sets of the geosynchronous radiation environment
- GOES-R will have substantially improved and new capabilities in charged particle measurements:
  - NEW: electron and ion measurements below 30 keV
  - NEW: solar heavy ion measurements above 10 MeV/nucleon
  - IMPROVED: energy and pitch angle resolution above 800 keV
- New Level 2 products include:
  - Densities and temperatures and level of spacecraft frame charging
  - Automatic solar proton event detection
  - Linear energy transfer