An introduction to the new GOES 13-15 magnetospheric electron and proton data (Tutorial)

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Outline

- Overview of GOES 13-15 MAGED/MAGPD instruments and flux data products
- Examples:
  - 5 April 2010
  - 4 August 2010
  - 7 January 2011
  - 15 March 2008
- Ideas for future work

Overview of GOES 13-15 MAGED/MAGPD instruments and flux data products

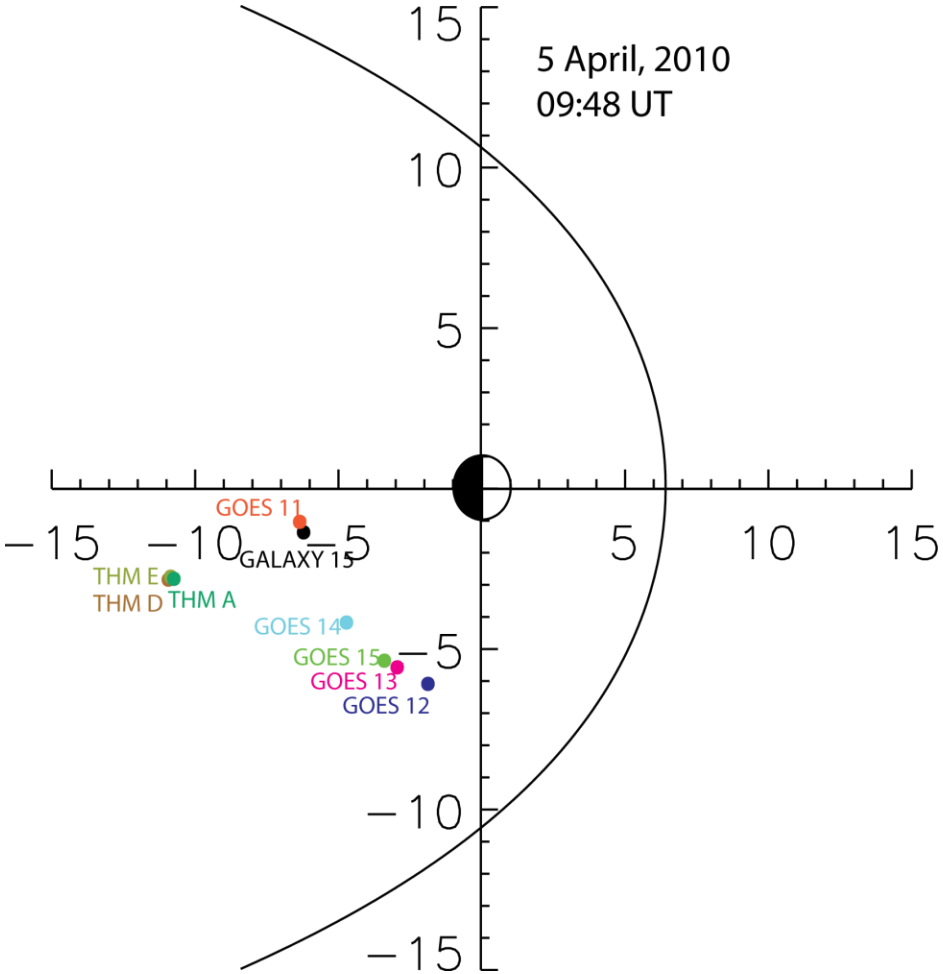
GOES 13-15 Particle and Field Data Coverage

- GOES N (13) launched 24 May 2006
  - Particle and field data recorded by SWPC sporadically through 16 April 2009, then continuously since late on 5 April 2010
  - Replaced GOES 12 as GOES-East in April 2010
  - Currently the SWPC Primary GOES particle and magnetometer satellite
- GOES O (14) launched 27 June 2009
  - Particle and field data recorded by SWPC 13 July 2009 through 4 Nov 2010
  - One MAGPD proton telescope (#5) was noisy in PLT but has recovered
  - Currently in storage (no data available)
- GOES P (15) launched 4 March 2010
  - Particle and field data recorded by SWPC since launch
  - Replaced GOES 11 as SWPC Secondary GOES particle and magnetometer satellite on 28 February 2011
  - One MAGED electron telescope (#7) experienced temperature-correlated diurnal noise increase that could overwhelm the counts (lower energy channels affected the most) – seems to have recovered by mid-December 2010 (M. Garhart, NSOF)

Operational processing of GOES 13 MAGED and MAGPD fluxes started 28 Dec 2010.
Operationally processed data are available through NGDC.
Earlier data available upon request to the authors.

GOES Locations During GOES 15 Post-Launch Test (2010)

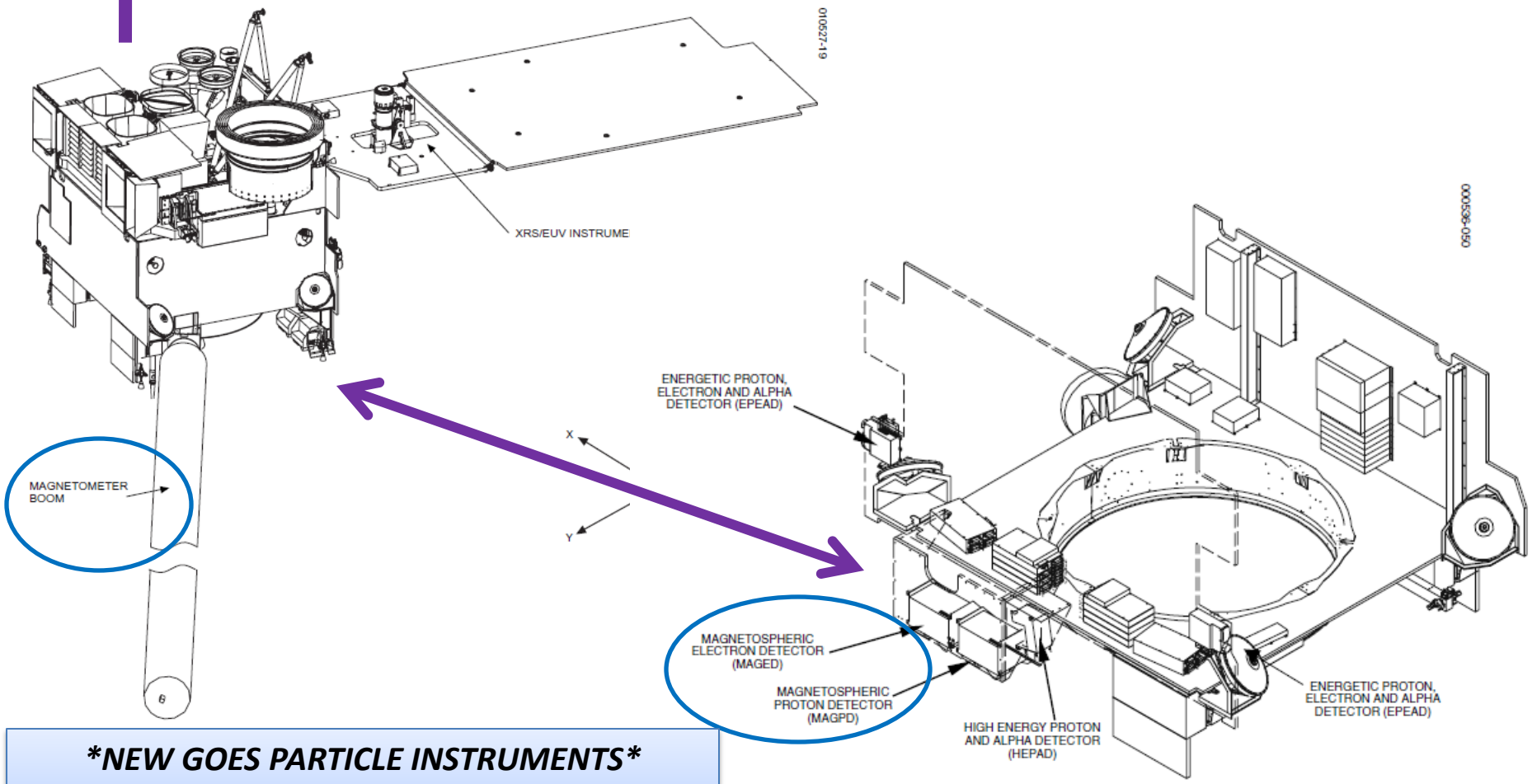
- Operational, West: 135 W
  - GOES 11
- Storage: 105 W
  - GOES 13 until Feb 19
  - GOES 14
- Post-launch test: 90 W
  - GOES 15
- Operational, East: 75 W
  - GOES 12 until May
  - GOES 13 after late April
- South America: 60 W
  - GOES 12 starting June



GOES 13, 14 and 15 MAGED and MAGPD were all operating during GOES 15 post-launch test in 2010 – spaced 1 hour apart in local time for several months

Location of SEM Instruments on GOES 13-15 Spacecraft

Earth



NEW GOES PARTICLE INSTRUMENTS
MAGED = Magnetospheric Electron Detector
MAGPD = Magnetospheric Proton Detector

Anti-Earth Deck

GOES Magnetospheric Electron and Proton Detectors (MAGED/PD)

- MAGED
  - Based on POES SEM-2 MEPED electron telescope
  - Single solid-state detector
  - Foil light shield
  - Algorithm provided by contractor to correct for proton contamination
  - 9 telescopes, 5 energy channels per telescope

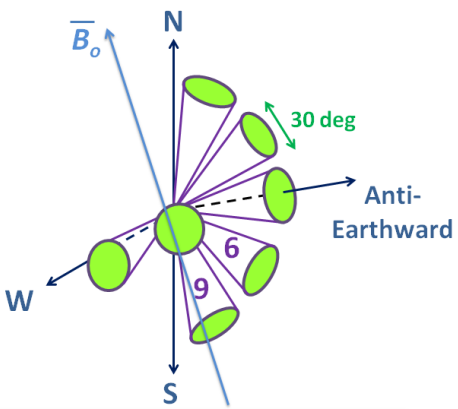
- MAGPD
  - Based on POES SEM-2 MEPED proton telescope
  - Two solid-state detectors in anticoincidence
  - Magnet to sweep 100's of keV electrons
  - Algorithm provided by contractor to correct for electron contamination
  - 9 telescopes, 5 energy channels per telescope

Since GOES 8, GOES satellites are three-axis-stabilized.

Center pitch angles for the MAGED and MAGPD telescopes are derived from GOES Magnetometer data

MAGED and MAGPD Energy Channels

MAGED		MAGPD	
Nominal Energy Range	Accumulation Time	Nominal Energy Range	Accumulation Time
30-50 keV	2.0 s	80-110 keV	16.4 s
50-100 keV	2.0 s	110-170 keV	16.4 s
100-200 keV	4.1 s	170-250 keV	16.4 s
200-350 keV	16.4 s	250-350 keV	32.8 s
350-600 keV	32.8 s	350-800 keV	32.8 s



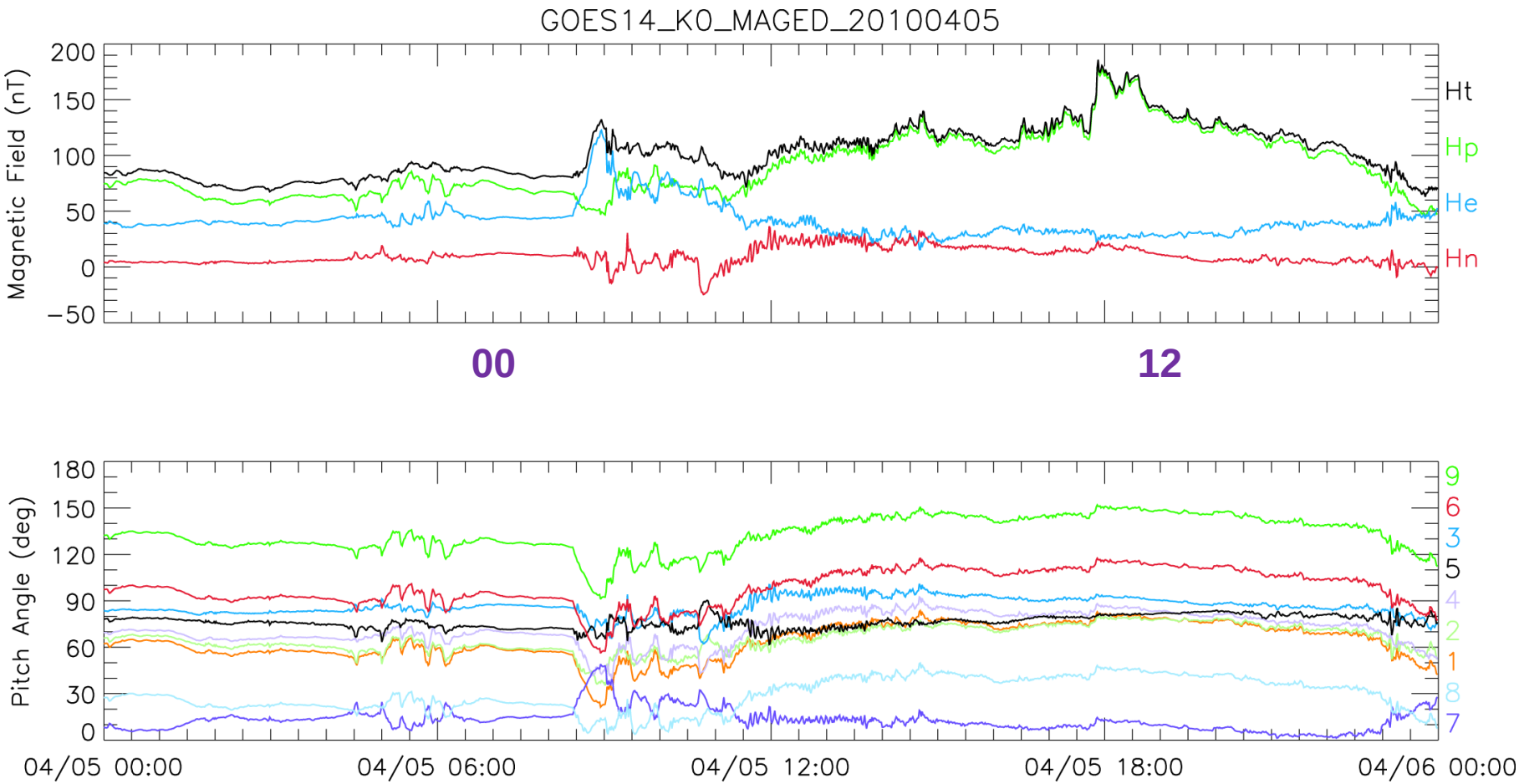
Upright: T7 is usually closest to $\alpha = 0$
Inverted: T9 is usually closest to $\alpha = 0$

Nine telescopes: each has 30 deg full cone angle

Central telescope directed radially anti-Earthward
North-South fan: ±35 deg and ±70 deg telescopes
East-West fan: ±35 deg and ±70 deg telescopes

Pseudo-log data compression reduces amplitude resolution
8 bits -- 4 bits mantissa, 4 bits exponent: $100/2^4$ ~ 6% resolution

Pitch Angles Calculated from GOES Magnetometer Data: GOES 14, 5 April 2010



MAGED and MAGPD Flux Products

- Granular (unaveraged in time)
  - Uncorrected count rates
  - Dead-time-corrected count rates
  - Dead-time-corrected fluxes
- 1-min averages
  - Dead-time-corrected fluxes
  - Dead-time and contamination-corrected fluxes
- 5-min averages
  - Dead-time and contamination-corrected fluxes
- Quality flags are set if dead time or contamination correction could not be applied or if a channel saturates

Product Files

- Separate data files (CSV or netCDF) for granular, 1-min and 5-min averages
- g13_maged_19me5_32s_20110130_20110130.csv (or .nc)
  - GOES 13, MAGED, Telescopes 1-9, Channel 5, 32 s accumulation time, 30 January 2011
- The following mnemonics are used within each file to identify each channel from each telescope and the level of processing:
  - Examples:
    - M_1ME2_UDTC_UNCOR_CR (count rates, neither dead-time nor contamination-corrected)
    - M_1ME2_DTC_UNCOR_CR (dead-time-corrected count rates, not contamination-corrected)
    - M_1ME2_DTC_UNCOR_FLUX (dead-time-corrected fluxes, not contamination-corrected)
    - M_1ME2_DTC_COR_FLUX (dead-time and contamination-corrected fluxes)
  - 1ME2 = telescope 1, channel 2
- To read netCDF files:
  - IDL 'read_ncdf_doc.pro'
    - Returns structure that includes data and metadata
    - Type *.EDIT read_ncdf_doc.pro* at command line
  - ncBrowse (http://www.epic.noaa.gov/java/ncBrowse/)

MAGED and MAGPD Products at NGDC

www.ngdc.noaa.gov/stp/satellite/goes/dataaccess.html

GOES Space Environment Monitor-Data Access - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.ngdc.noaa.gov/stp/satellite/goes/dataaccess.html

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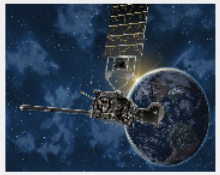


STP Home
GOES Home
Online Publications

GOES Data & Information

Data Access
Documentation
NGDC Technical Data Services
What's New?
Important Notices

Mailing Address:
National Geophysical Data Center
Solar and Terrestrial Physics Division
325 Broadway

Data Access to GOES SEM data

Data describing the environment at geosynchronous orbit

Interactive Data Access — Primary access to GOES SEM data is through the interactive tool -- **SPIDR.**

Real-Time Data — You can view GOES SEM data in real time by visiting the Space Weather Prediction Center.

Direct Access to GOES NOP Data & Plots

NOP Satellite	Launch Date	Began Operations	Ended Operations
GOES-13 SXI	May 24, 2006	April 14, 2010: not XRS, EUV or SXI	
GOES-14 SXI	June 27 , 2009	December 1, 2009: XRS only	
GOES-15-SXI	March 4, 2010	September 1, 2010: XRS only	

New users should familiarize themselves with the GOES NOP satellite series by reading the entire Data Book.
Busy users can make do by just reading the section on the Space Environment Monitor.

View a PDF summary plot of the latest three days of full resolution data from GOES-13, or the latest fourteen days of time averages.

./new_plots					Browse plots in PDF format.
	./yyyy (i.e., ./2010)	./goesxx (i.e., ./goes13)	./qc		Monthly quality control plots.
			./summary		Monthly summary plots
	./latest	./goesxx (i.e., ./goes13)			QC and summary plots of latest 3-days and 14-days.
./new_full	./yyyy (i.e., ./2010)	./mm (i.e., ./04)	./goesxx (goes13)	./csv	Full resolution data in CSV format, daily files.
				./netcdf	Full resolution data in NetCDF format, daily files.
./new_avg	./yyyy (i.e., ./2010)	./mm (i.e., ./04)	./goesxx (i.e., ./goes13)	./csv	Time averaged data in CSV format, monthly files.
				./netcdf	Time averaged data in NetCDF format, monthly files.

Files in NetCDF and CSV (Comma Separated Variable) format are internally documented.
CSV files can be opened with MicroSoft Excel or similar software. Any text editor will also work.
NetCDF files can be read with any and all programming languages, get details from UniData. Text editors will not work.

Data Notes:

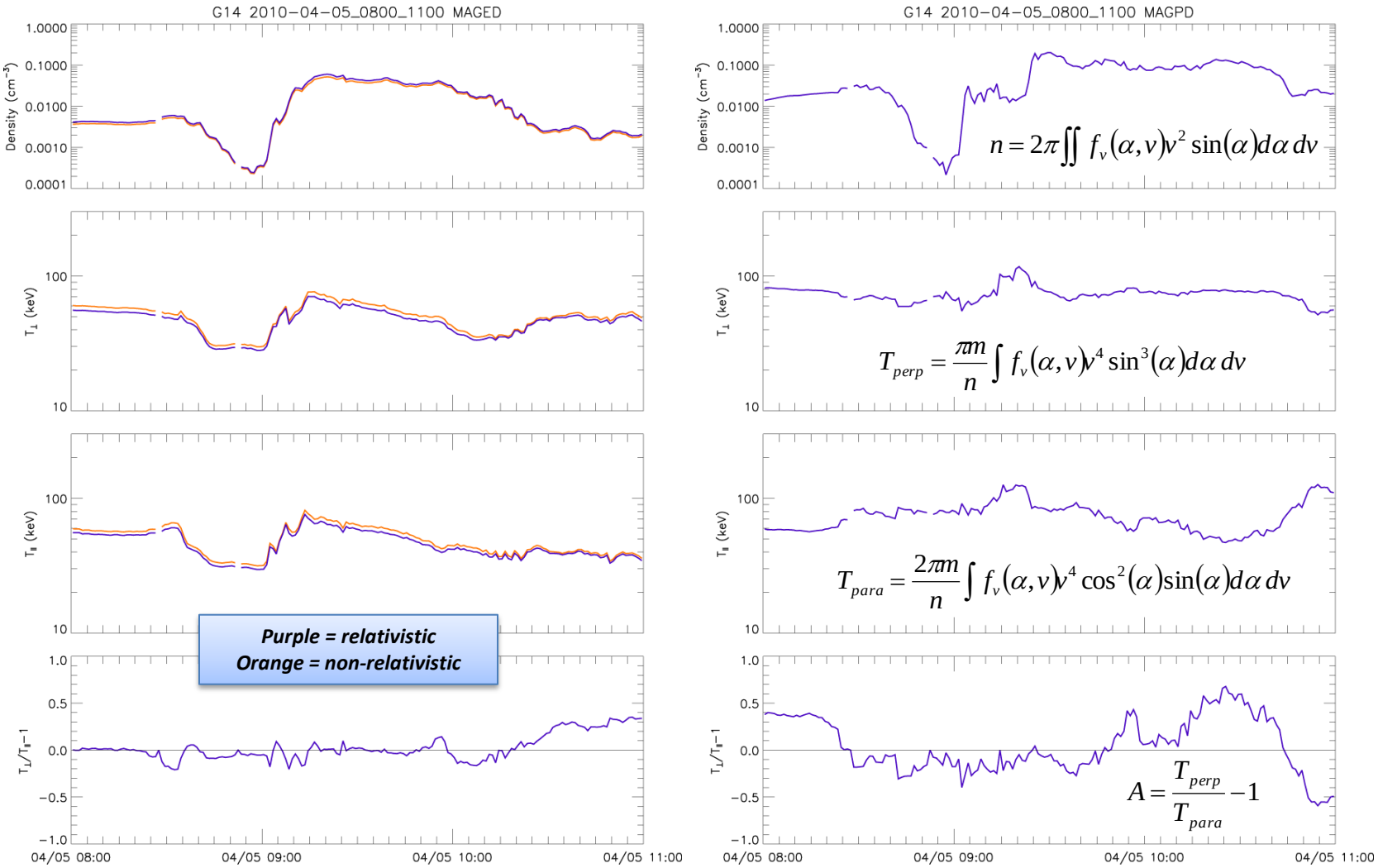
Done

GOES 13 MAGED/PD data available since 28 Dec 2010, when operational processing of fluxes started.

Examples

Density and Temperature Partial Moments, GOES 14, 5 Apr 2010, 8-11 UT

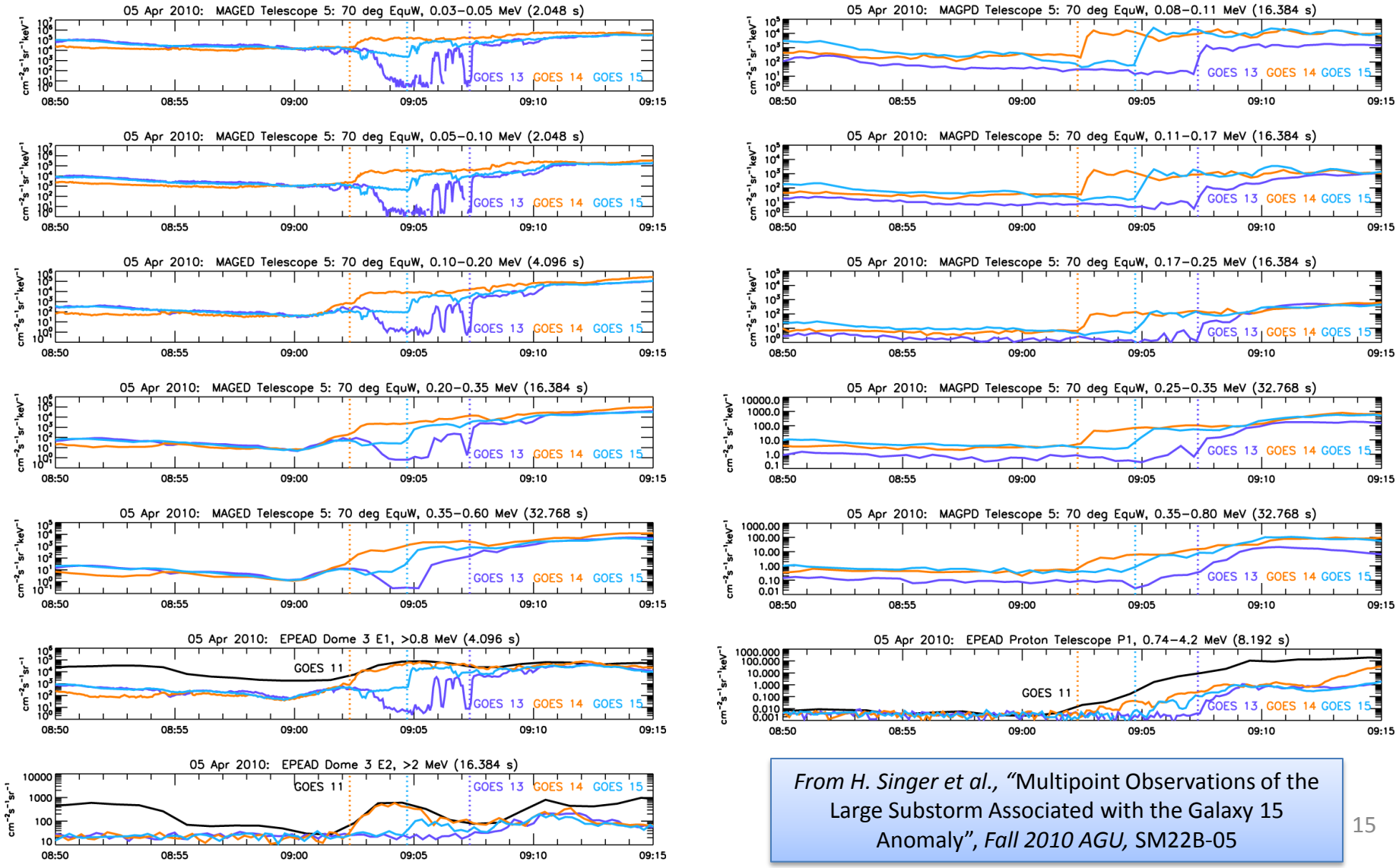
Local midnight 7 UT



Purple = relativistic
Orange = non-relativistic

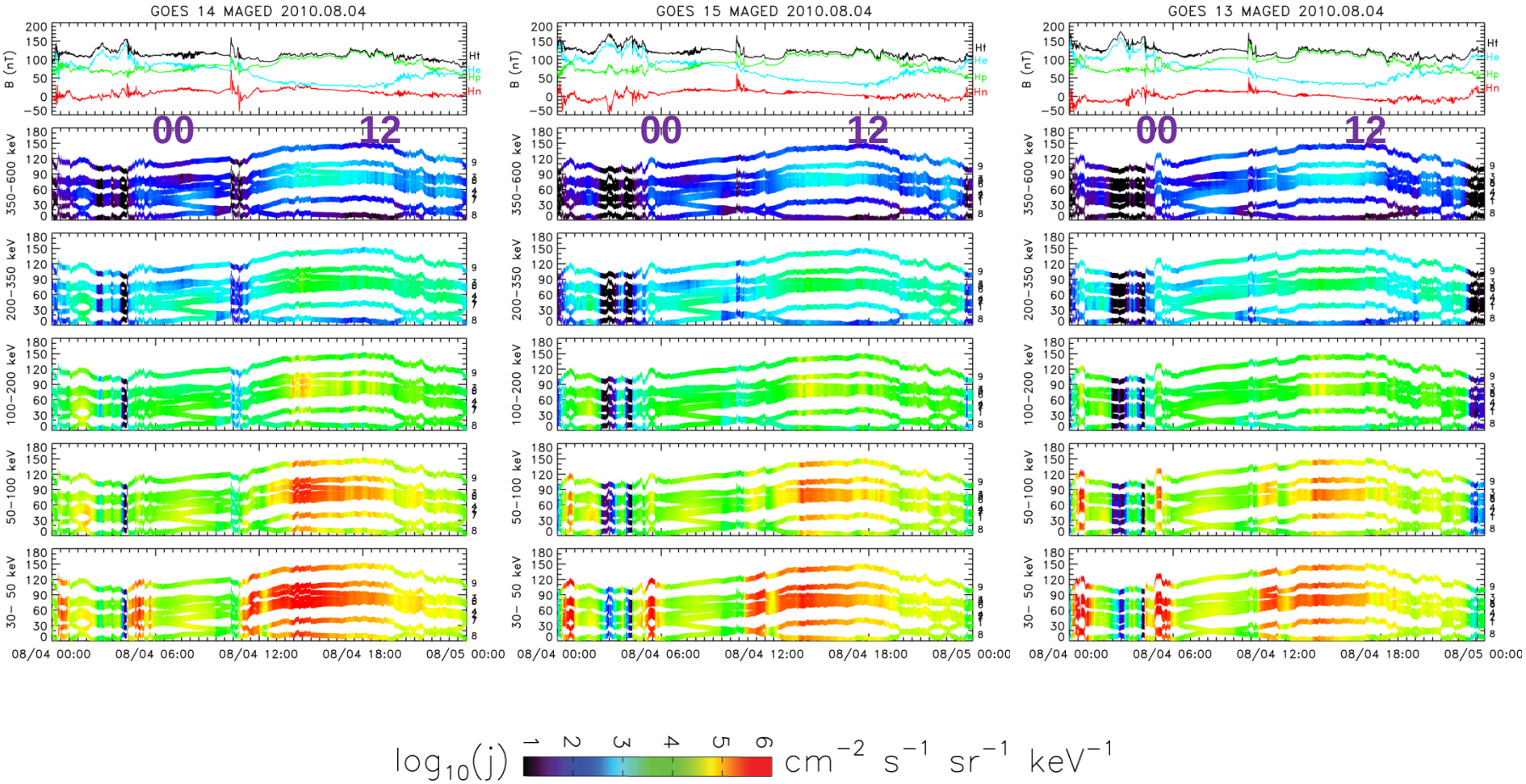
Related presentation: H. Singer et al., "Multipoint Observations of the Large Substorm Associated with the Galaxy 15 Anomaly", *Fall 2010 AGU,* SM22B-05, and this workshop

GOES 11, 13-15 Particles, 5 April 2010, 0850-0915 UT



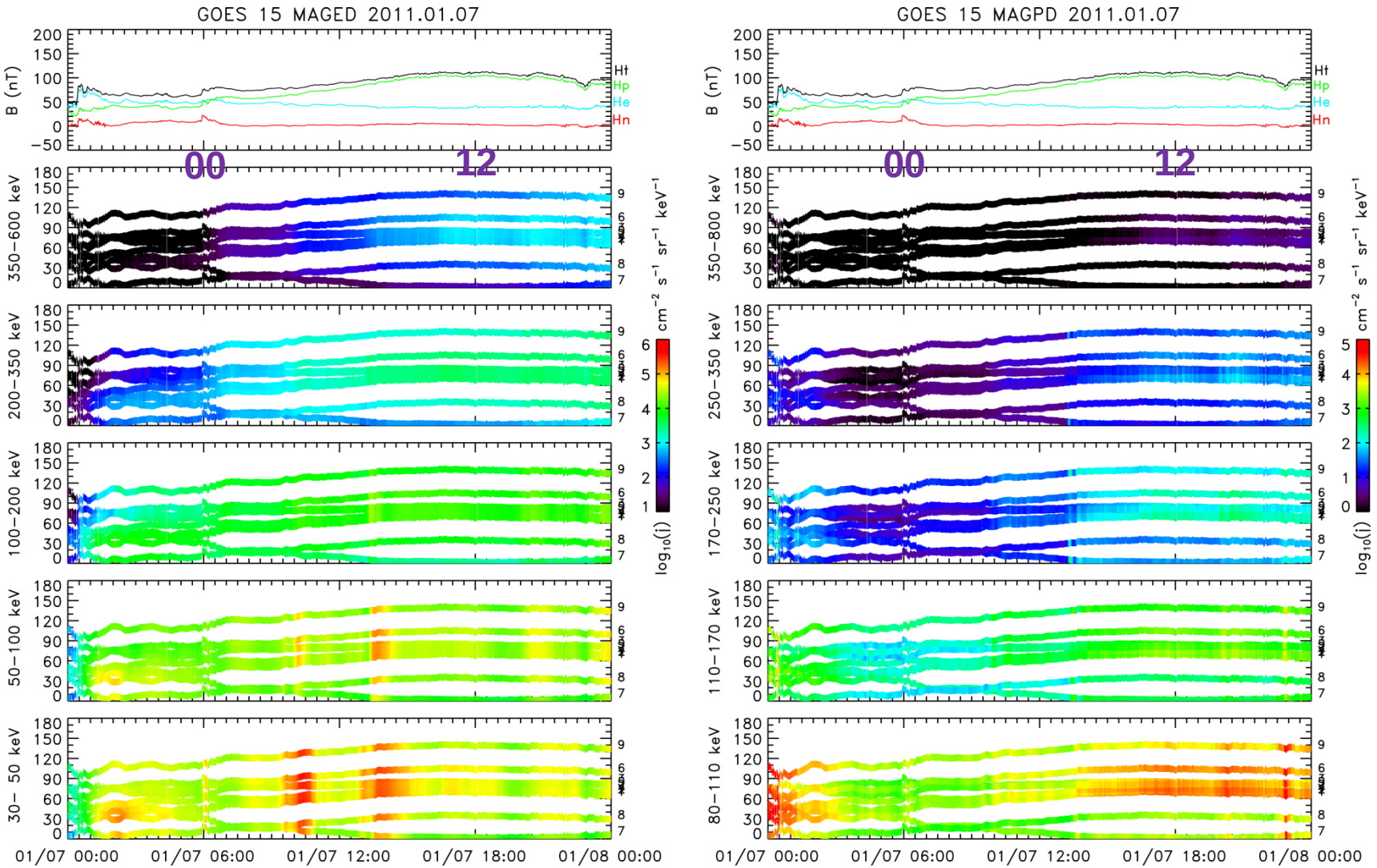
From H. Singer et al., "Multipoint Observations of the Large Substorm Associated with the Galaxy 15 Anomaly", *Fall 2010 AGU,* SM22B-05

4 August 2010: MAGED and MAG, GOES 14 (L), GOES 15 (C), GOES 13 (R)



GOES 13, 15 and 14 are spaced at 1 hr LT intervals during this event

7 January 2011: GOES 15 MAG, MAGED (left) and MAGPD (right)



GOES 13 data also available (1 hr LT later)

15 Mar 2008: GOES 13 electron fluxes and pulsating aurora in THEMIS all-sky images

Fluctuations in T9 30-100 keV electron fluxes correspond to pulsations found in The Pas (TPAS) all-sky images, 1100-1140 UT (0400-0440 LT)

- Count rate R_{ik} in channel i and telescope k is related to differential flux j via integral equation:

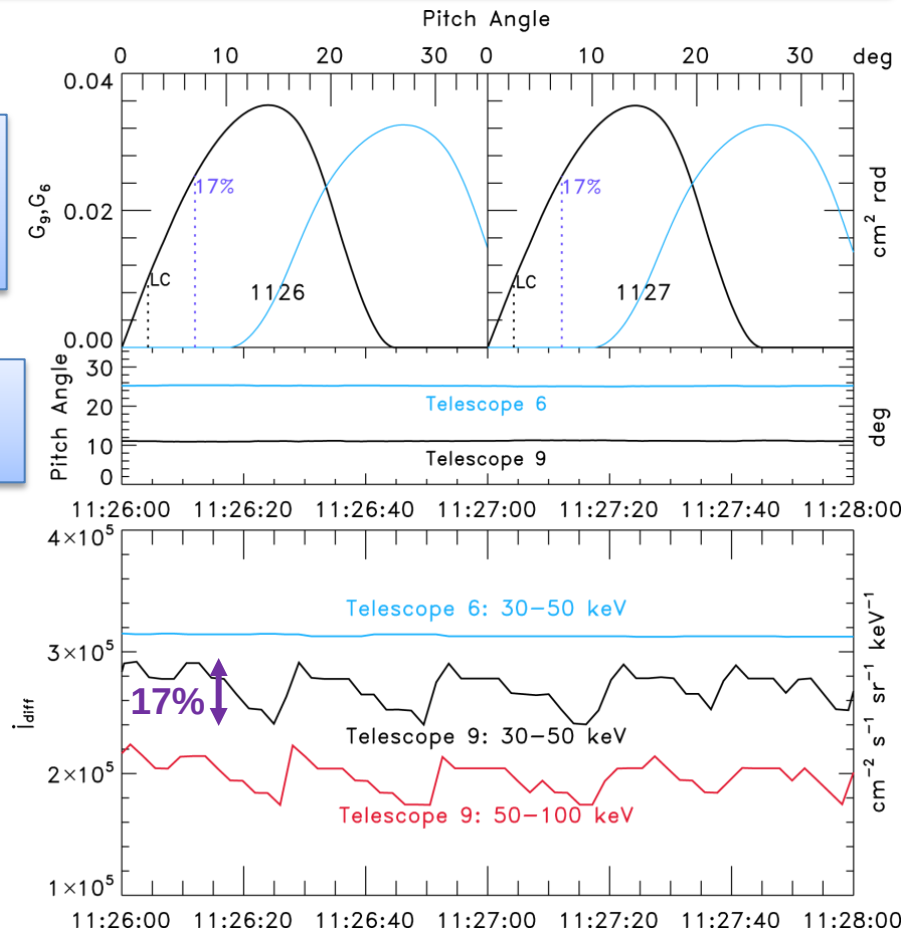
$$R_{ik} = \delta E_i \int j(\overline{E}_i, \alpha) G_k(\alpha) d\alpha$$

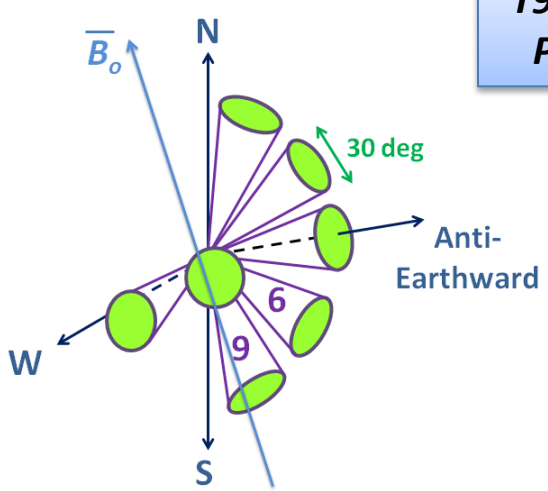
$$G_k(\overline{E}_i, \alpha) = \sin\alpha \int_0^{2\pi} A_k[\overline{E}_i, \theta_t(\alpha, \beta)] d\beta$$

T9 & T6 Response Functions

T9 & T6 Center Pitch Angles

T9 &T6 Fluxes





On 15 Mar 2008, GOES 13 was inverted so Telescope 9 was usually closest to $\alpha = 0$

Related presentation: M. Lessard et al., 'Recent advances in pulsating aurora,' Chapman Conference, Fairbanks, 28 Feb 2011

Ideas for Future Work

- Intercalibrate telescopes on individual satellites
  - W. Rowland, R. Weigel and C. Cao, 'Results from a prototype for the GOES particle intersensor analysis toolkit,' American Meteorological Society annual meeting, Seattle, 2011
- Intercalibrate GOES 13, 14 and 15 telescopes, taking advantage of 1-hr local time separation during much of 2010
- Intercalibrate with other satellites
- Improve MAGPD electron contamination correction
- Calculate density and temperature moments from GOES 13-15 MAGED/PD and MAG data in real time (including pitch angles)
- Collaborative studies