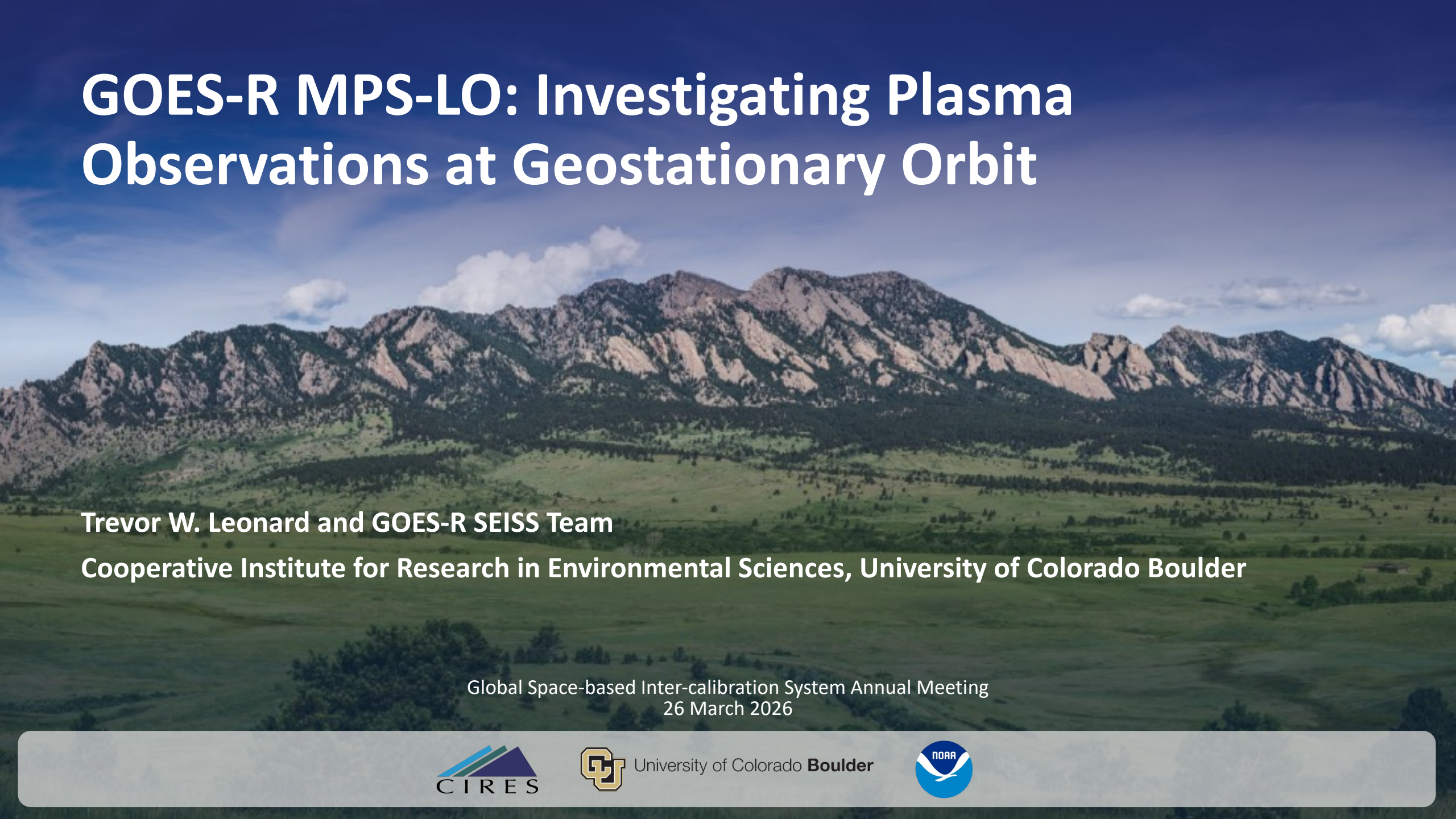
GOES-R MPS-LO: Investigating Plasma Observations at Geostationary Orbit



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Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder

Global Space-based Inter-calibration System Annual Meeting
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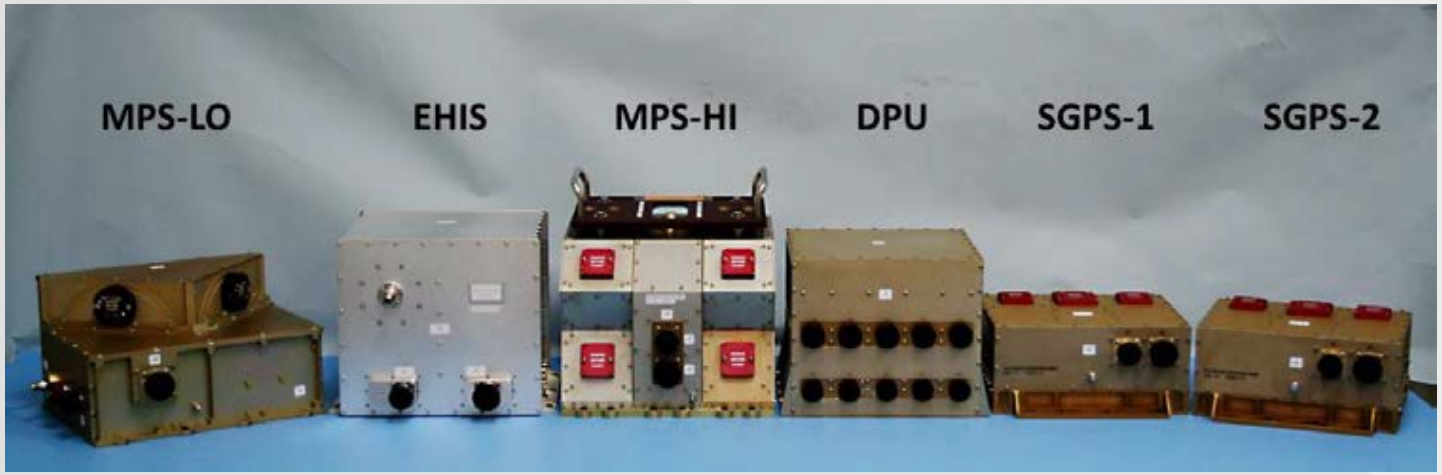
CIRES University of Colorado **Boulder** NOAA

Outline

- MPS-LO Instrument Overview
- MPS-LO L1b Data Processing
- Instrument Effect: MCP Gain Decline
- MPS-LO Zone Intracalibration
- Future Cross Satellite Study
- Comparison with Denton Model (LANL MPA)
- Summary

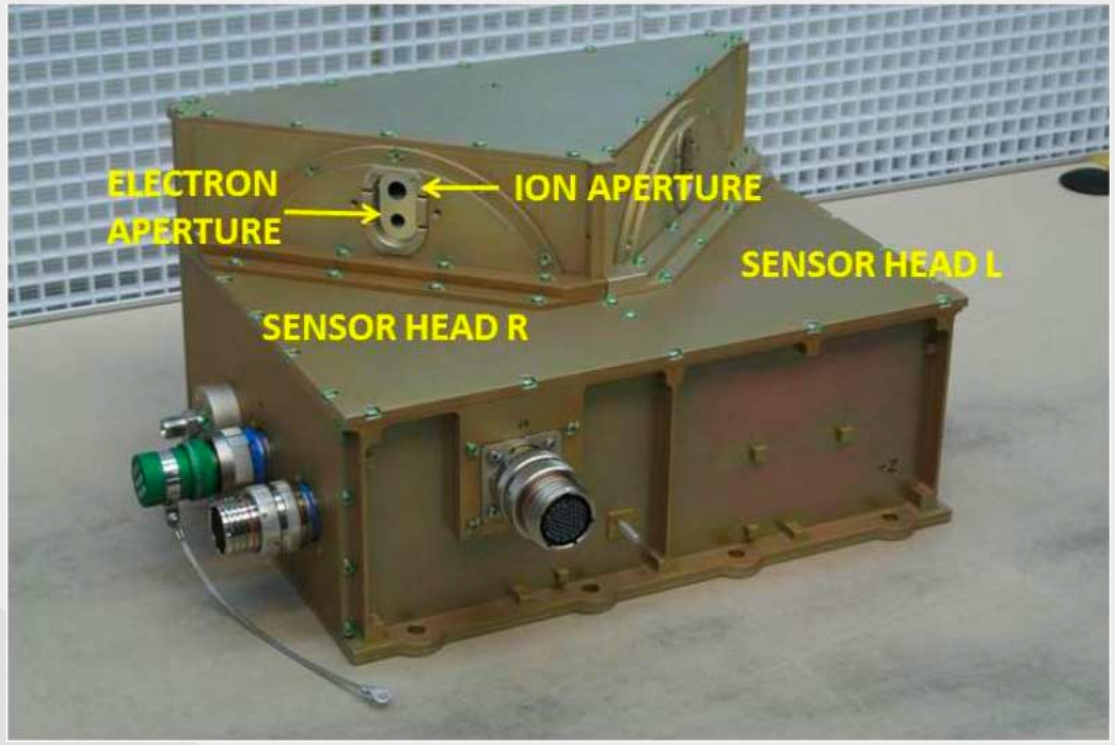
GOES-R+ Space Environment In-Situ Suite (SEISS) Magnetospheric Particle Sensor - Low Energy (MPS-LO)

- SEISS includes 4 particle detecting instruments and MPS-LO is the lowest energy particle sensor on each GOES-R+ satellite
- Primary purpose: measure GOES frame charging and spacecraft charging environment
- Electrostatic analyzers (2 ESAs per species) with Microchannel plates (MCPs) as the detection elements

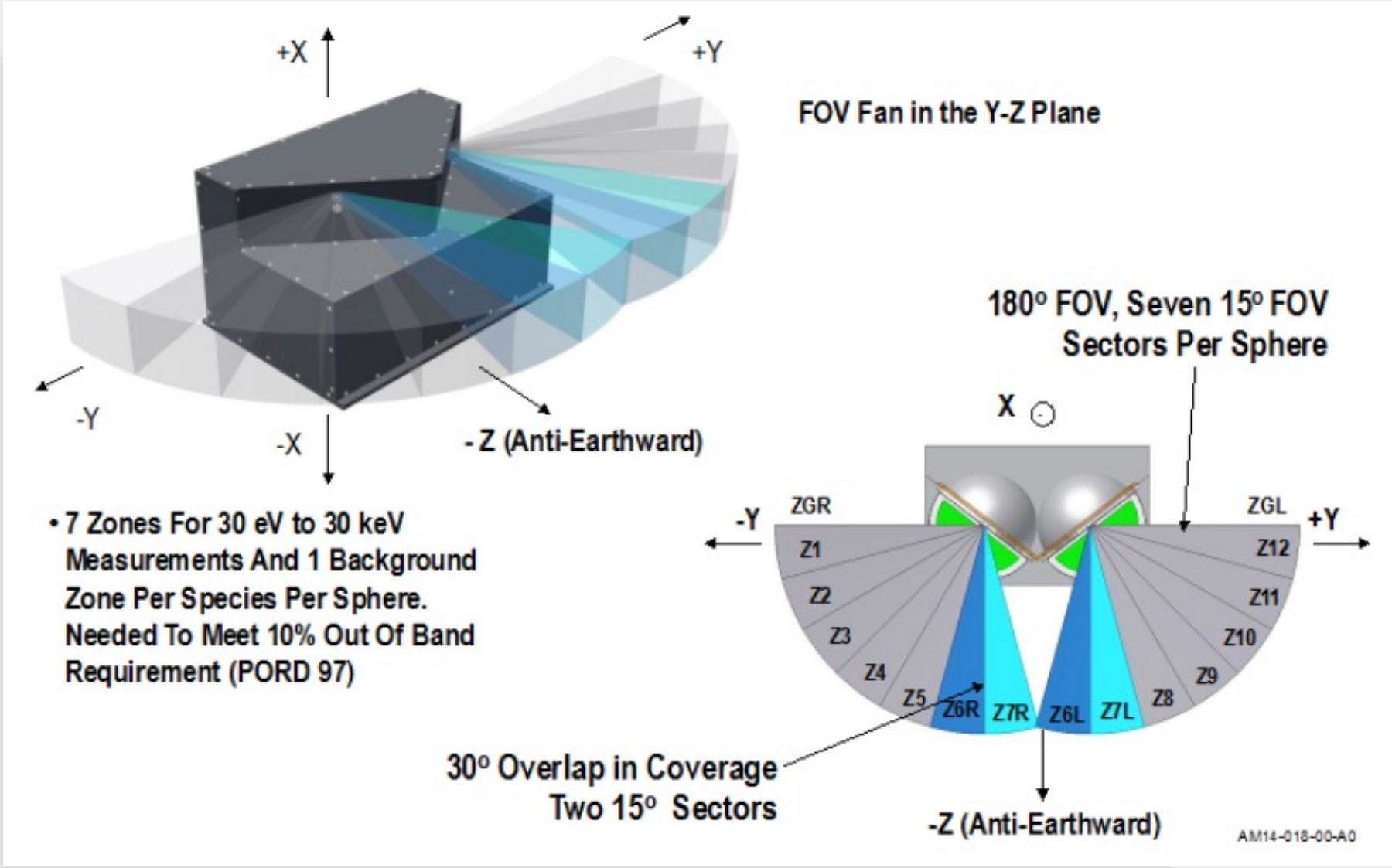


GOES-R+ SEISS MPS-LO Field of View

- 14 angular zones (12 unique) in the north-south plane and 2 background zones
  - Each zone has a 15 degree field of view (FOV) with combined total 180 degree FOV
  - 30 degree overlap in FOV across 4 angular zones should yield similar fluxes



GOES-R+ SEISS MPS-LO Field of View

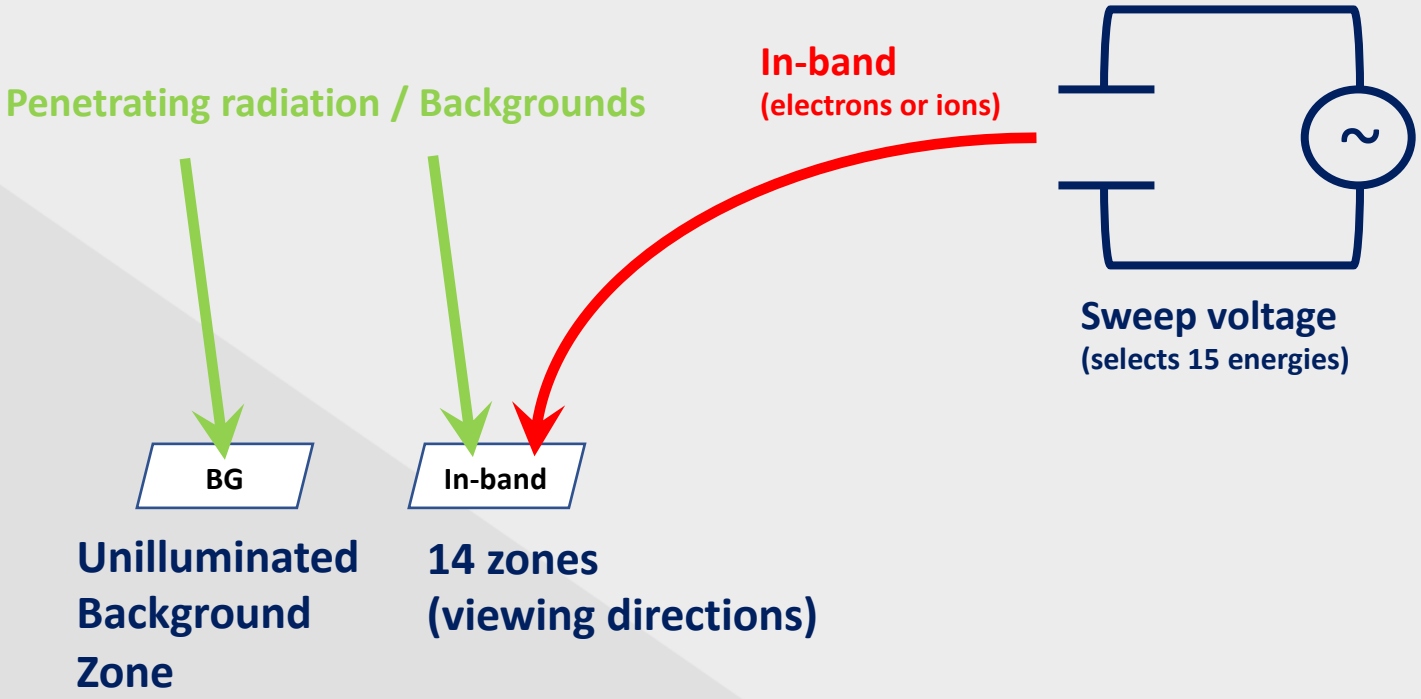


GOES-R+ SEISS MPS-LO Energy Range

- Measures electrons and ions within 30 eV – 30 keV over 15 logarithmically-spaced energy channels
- An individual energy step observation interval is slightly less than 1/16 of a second and all 15 energy steps are observed during a 1 second cycle

- Observation Summary:
  - 2 species x 14 zones x 15 energy steps = 420 flux observations per second

MPS-LO Background Removal



- Simplified background (BG) removal expression:

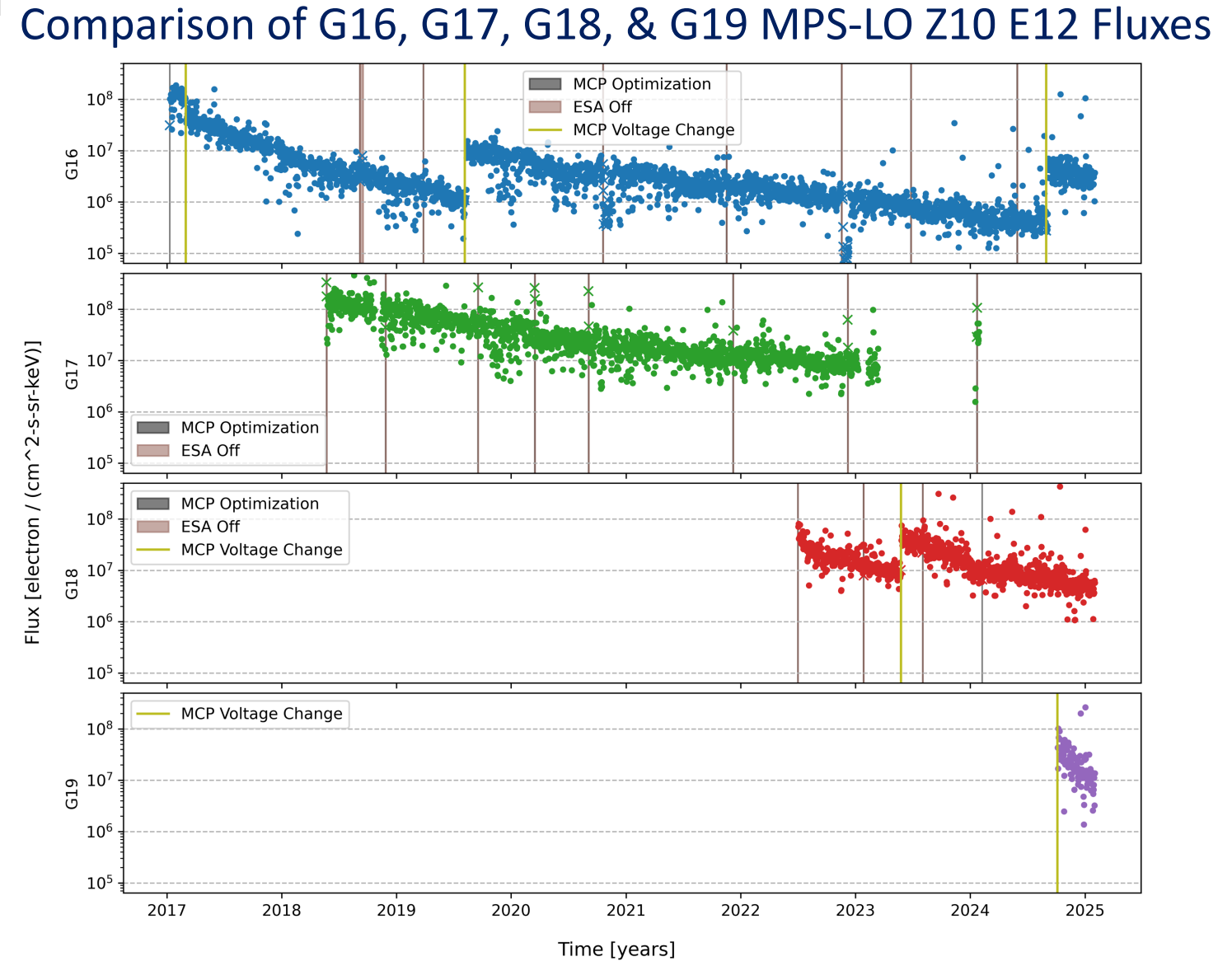
Corrected Counts = Total Counts – BG Removal Coefficient x BG Counts

MPS-LO L1b Data Processing

- A dead-time correction is applied to each observation in accordance to the electronics event processing time
- The background zone observations are used to remove penetrating radiation from the plasma observations
- 1 day (24 hours) of observations are stored in NetCDF files and are accessible by the public here:

https://www.ncei.noaa.gov/products/goes-r-space-environment-in-situ

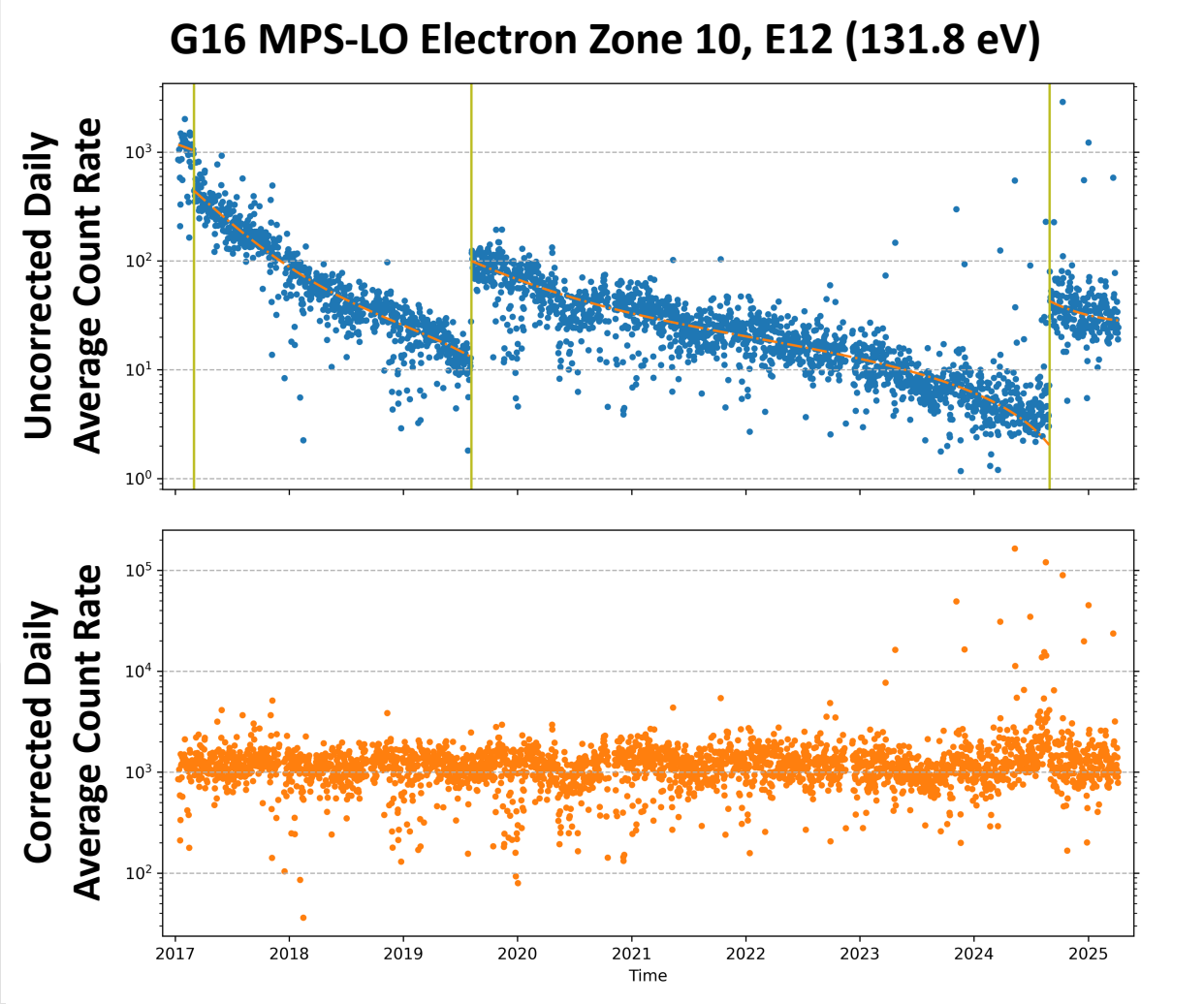
Instrument Effect: MCP Gain Decline



- Long-term trending of day-averaged fluxes show non-geophysical decline
- Similar decline is seen in all electron zones across all 4 GOES-R series spacecraft
- Ion zones show significantly less decline
- MCP performance is tested regularly and has resulted in MCP bias voltage changes, which appear as abrupt flux increases

MCP Gain Decline Correction

- A non-linear fit is made to each zone-energy channel
- Count rate is scaled up to first light observations
- Demand agreement before and after MCP bias voltage change



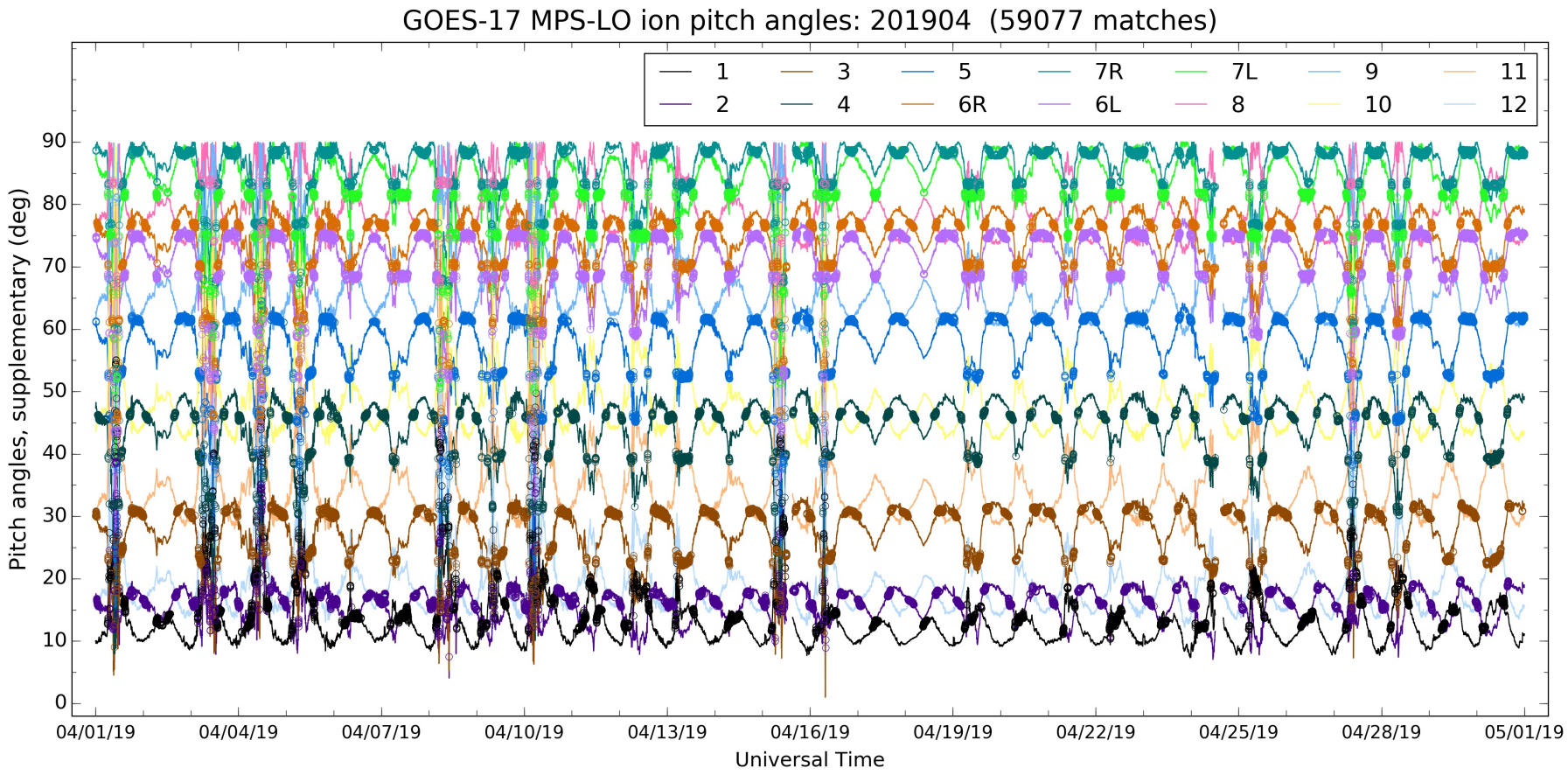
MPS-LO Zone Intracalibration

- Compares fluxes measured by pairs of MPS-LO angular zones when central pitch angles (α) are the same or supplementary.

- Estimate scaling factors based on a large dataset of pitch angle matches with a Nelder-Mead minimization.
- Zone intracalibration method is independently confirmed by comparing zones with overlapping FoV (Z6R/Z6L and Z7R/Z7L)
- Ref: Rowland, W., and R. S. Weigel (2012), Intra-calibration of particle detectors on a three-axis stabilized geostationary platform, Space Weather, 10, S11002, doi:10.1029/2012SW000816.

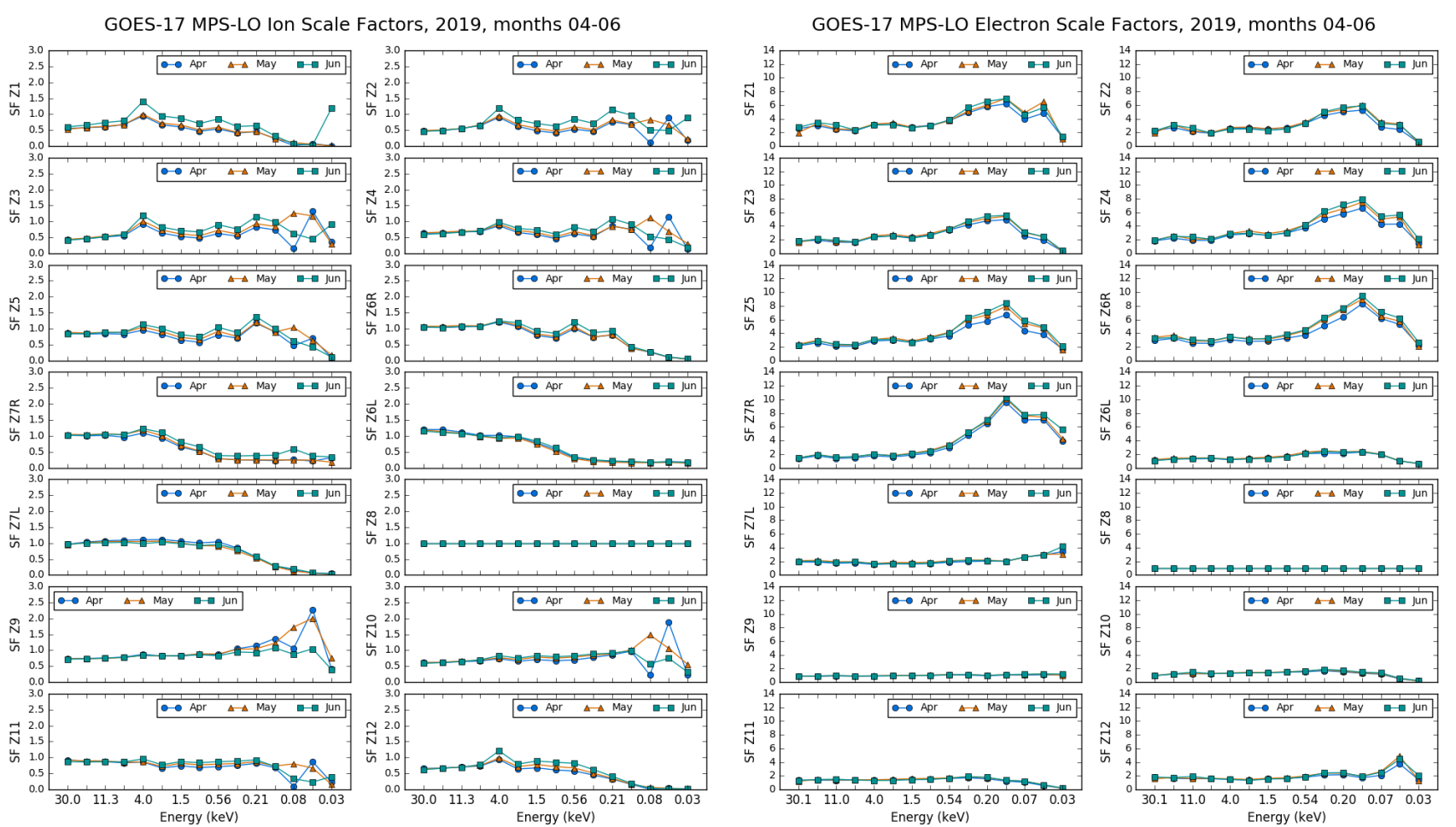
MPS-LO Pitch Angles

Example: Ion Pitch Angles, April 2019 (including supplementary angles)



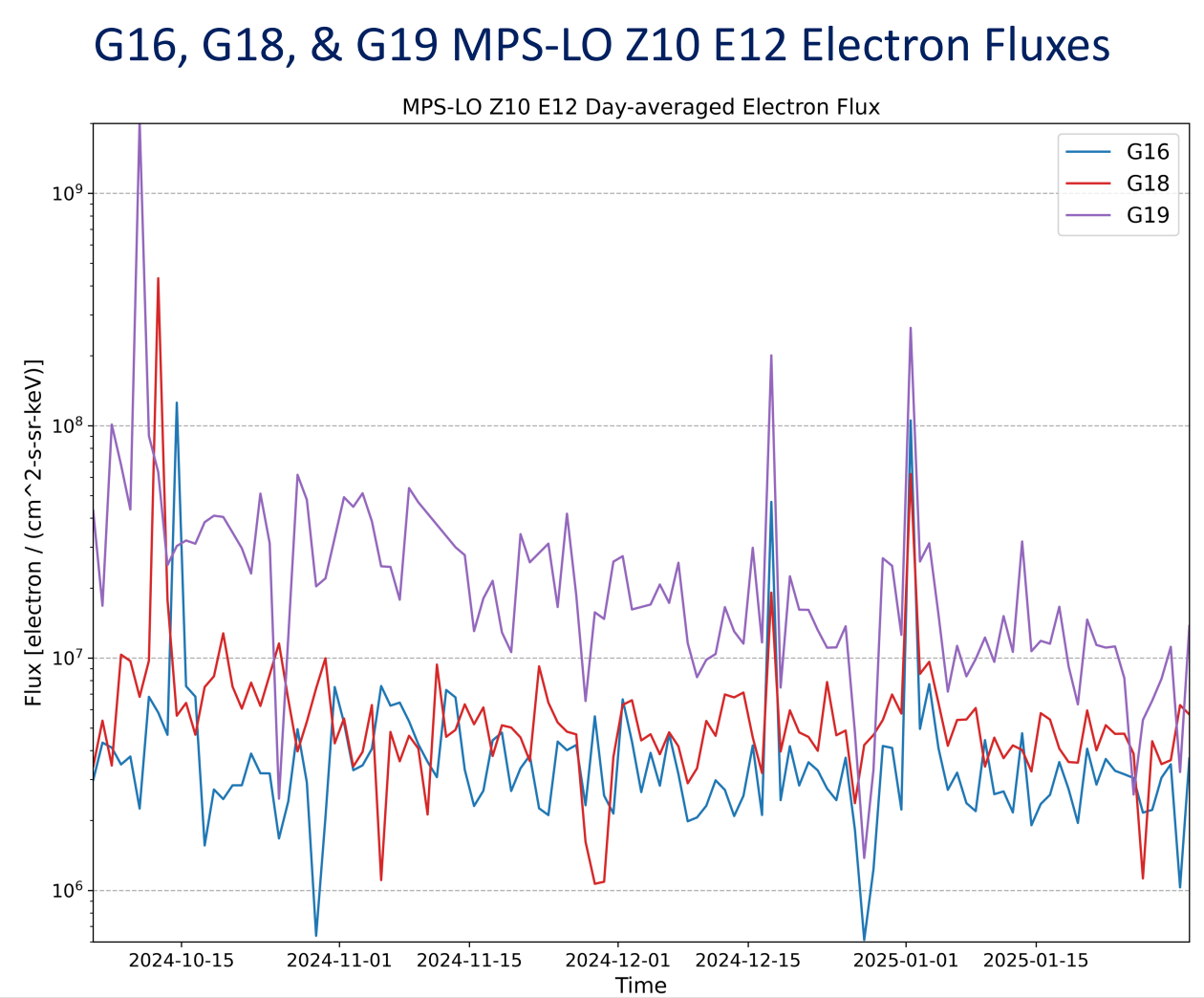
Dots indicate pitch angle matches
1,000-10,000 matches per month per energy-zone pair

MPS-LO Zone Intracalibration Scale Factors



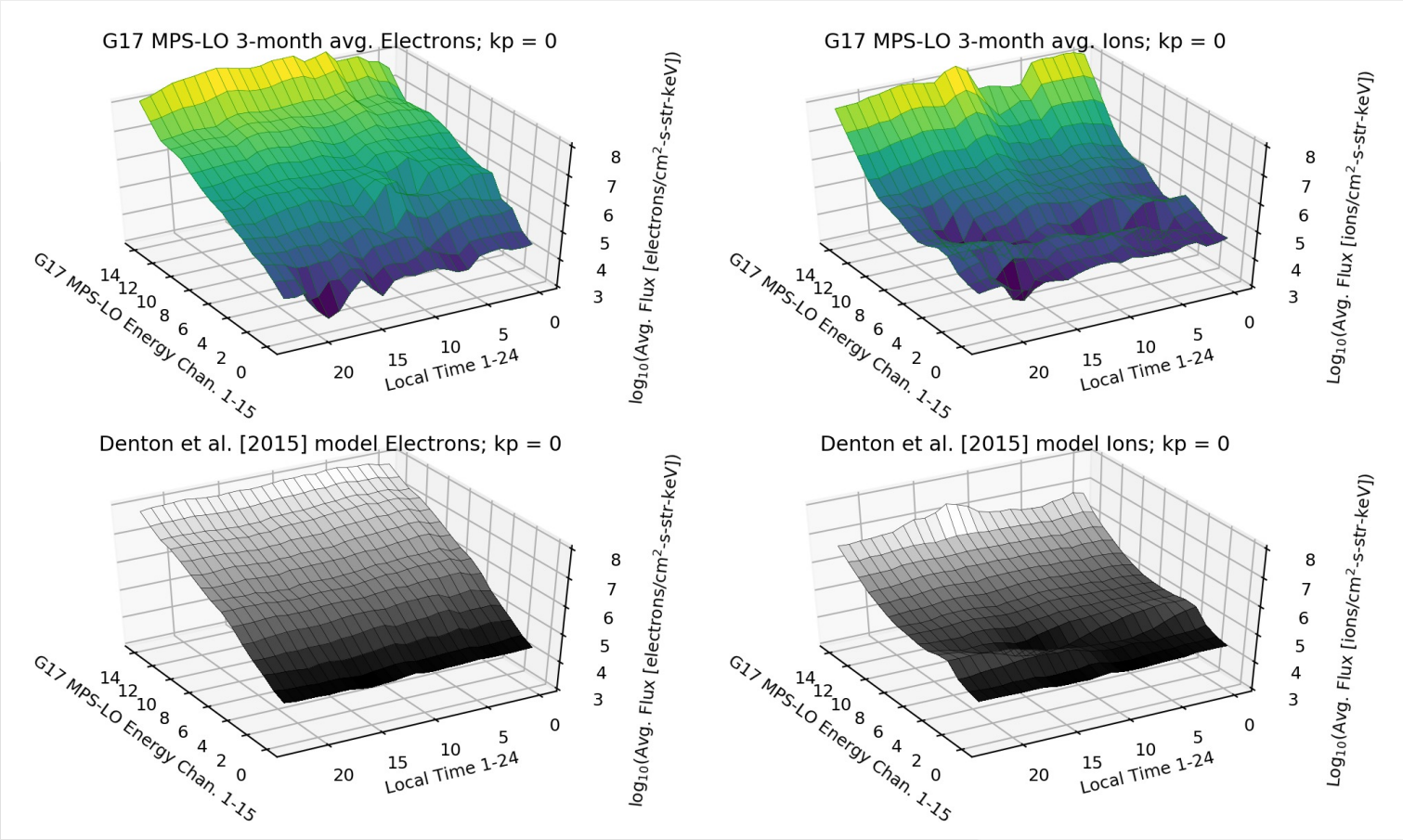
Multiplicative scale factors plotted vs energy step for each zone

Future Cross Satellite Study



- Before G19 became operational as GOES-East, G19 and G16 were in close proximity for multiple months, providing the opportunity for cross satellite comparisons
- As with the past MPS-LO units, the MCP gain decline is greatest at mission start and the G19 MCP gain correction is needed before a cross satellite comparison

Comparison with Denton Model

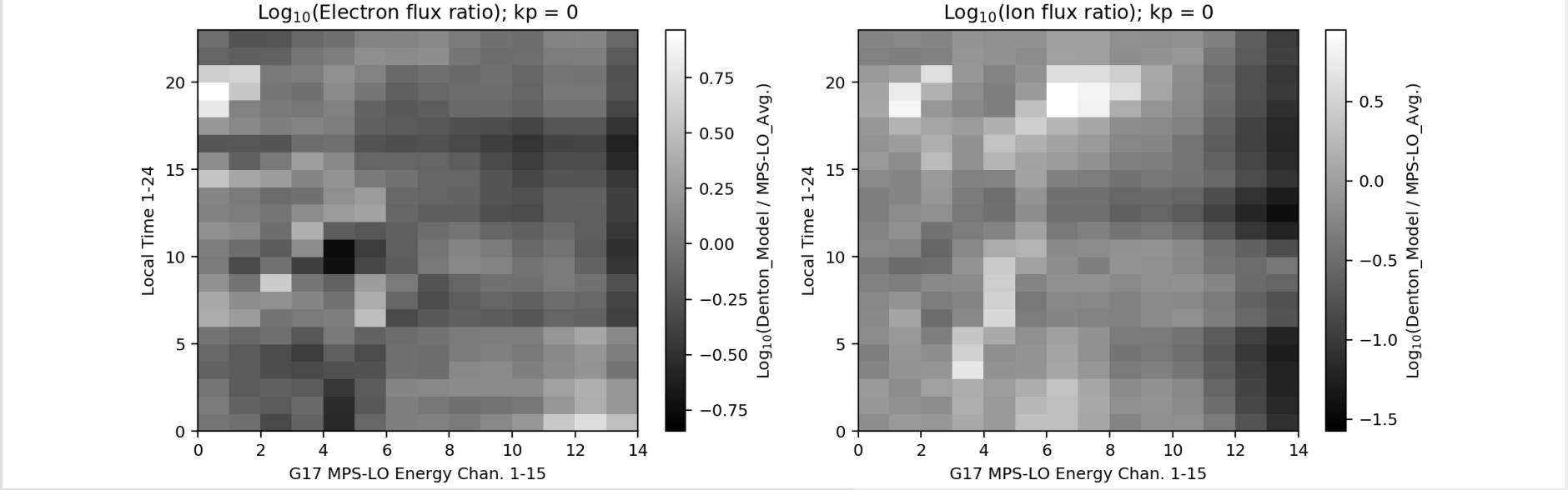


Comparison of G17 MPS-LO April-June 2019 data with Denton et al. [2015; 2016] model, based on 1990-2007 observations from the Magnetospheric Plasma Analyzer (MPA) instruments on seven Los Alamos National Laboratory (LANL) satellites at GEO. MPS-LO fluxes are binned in local-time and Kp geomagnetic activity index, and then 3-month averaged, for comparison with Denton model.

Comparison with Denton Model

G17 MPS-LO and Denton model electron fluxes differ up to an order of magnitude.

G17 MPS-LO ion fluxes up to factor of 30 higher than Denton model.



- The Denton et al. [2015; 2016] model electron fluxes are up to an order of magnitude higher than the LT-Kp binned MPS-LO electron fluxes.
- The MPS-LO ion fluxes are up to a factor of 30 higher than Denton model ion fluxes.
- Not apples to apples comparison (3-months of MPS-LO data during solar min. vs. 1990-2007 MPA)
- General trends in data are similar – Verification that MPS-LO is measuring environmental fluxes.

Summary

- The MPS-LO dataset provides long-term observations of the geostationary plasma environment.
- Nearly a decade of MPS-LO observations allows for in-depth studies of the long-term instrument performance and the dataset continues to improve with instrument corrections, intracalibrations, and future cross satellite comparisons.
- The Sci_L1b day-files of observations are stored in NetCDF files and are accessible by the public here:

https://www.ncei.noaa.gov/products/goes-r-space-environment-in-situ

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