GOES-R XRS Electron Contamination Corrections

and other GOES XRS topics

Janet Machol[1, 2]

Stefan Codrescu[1, 2], Andrew Jones[3], Frank Eparvier[3], Don Woodraska[3], Juan Rodriguez[4], Athanasios Boudouridis[1,2], Courtney Peck[1, 2], Erika Zetterlund[1, 2], Tom Eden[3], Rodney Viereck[1, 2]

[1]CIRES, University of Colorado, Boulder, CO, USA
[2]National Oceanic and Atmospheric Administration (NOAA), Boulder, CO, USA
[3]LASP, University of Colorado, Boulder, CO, USA
[4]Ball Aerospace, Boulder, CO, USA

STCE SXR-EUV Degradation and Intercalibration Workshop, 14-18 October 2019

Topics

GOES-R XRS

Electron Contamination

No More XRS Scaling Factors

GOES 1-15 XRS Reprocessed Science Data

GOES-R XRS Measurements and Data Release

GOES-R Series

GOES: Geostationary Operational Environmental Satellite

- since 1974
- GOES-16, -17 launched in 2016, 2018

EXIS EUV and X-Ray Irradiance Sensors
X-Ray Sensor (XRS)
Extreme Ultraviolet Sensor (EUVS)
Designed and built by LASP

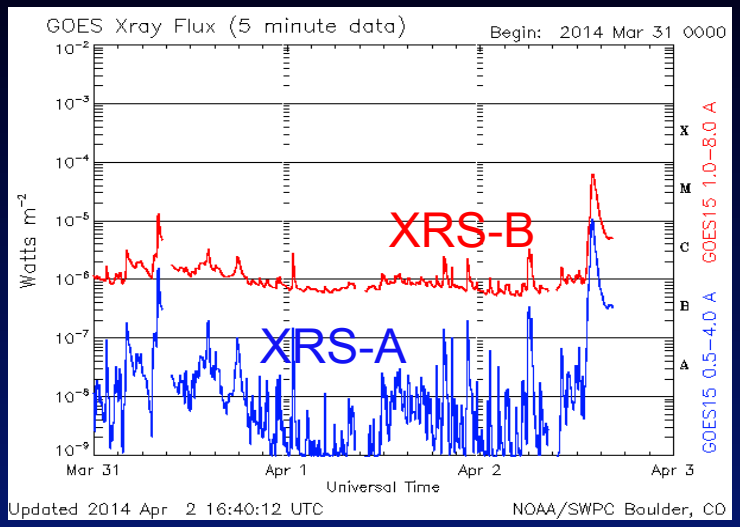
SEISS proton, electron, heavy ion fluxes
Magnetospheric Particle Sensors (MPS-HI)

SUVI Solar Ultraviolet Imager

MAG Magnetometer

GOES-R XRS

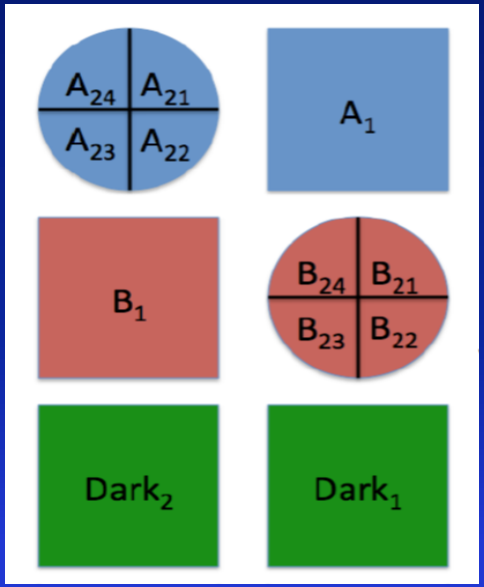
XRS-A ~0.5 - 4 Å
XRS-B ~1 - 8 Å



Cadence: 1 s (was 2 or 3 s)

2 detectors/band (was 1)

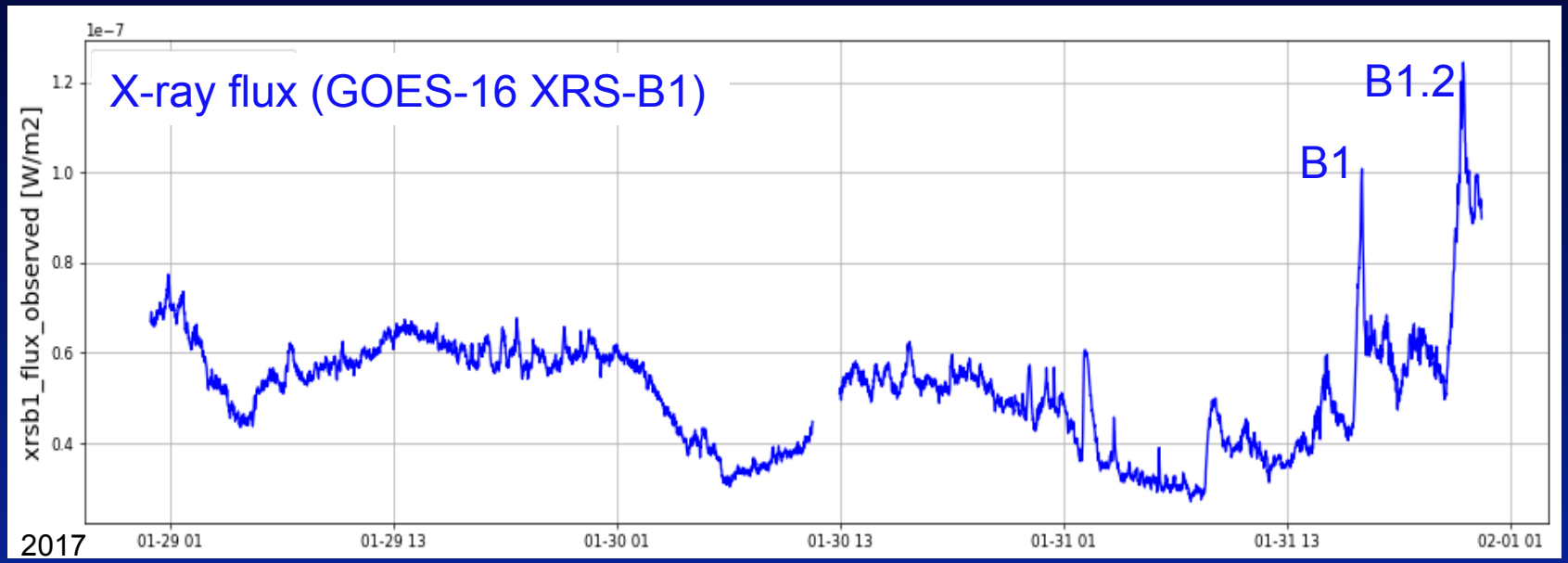
- A1, B1: large detectors for small fluxes
- A2, B2: small quad diodes for large fluxes and flare location
- Better dynamic range, no saturation



Better data quality

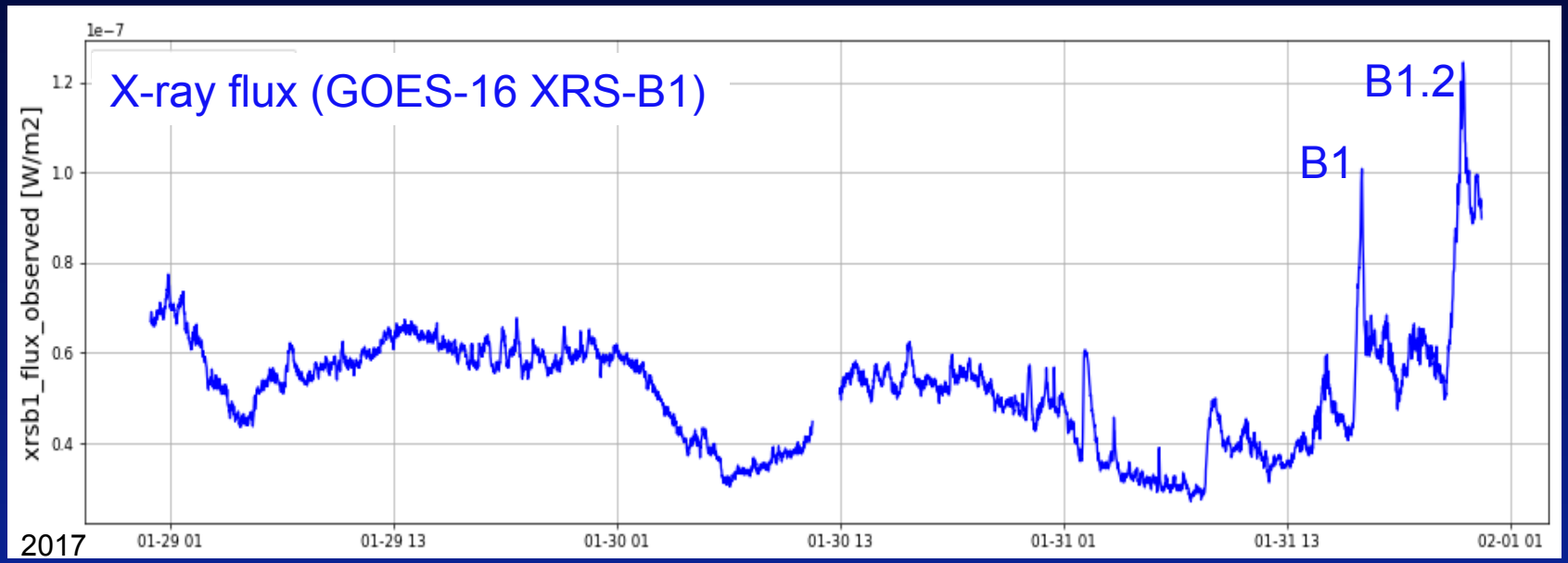
- NIST calibrated
- No scaling factors

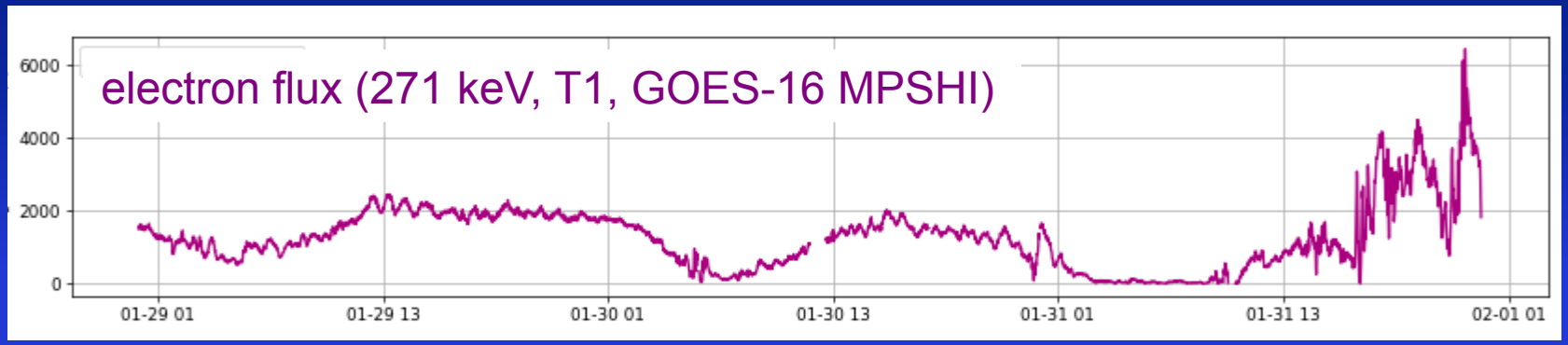
Three Days of Low X-ray Fluxes



A Suspicious Correlation

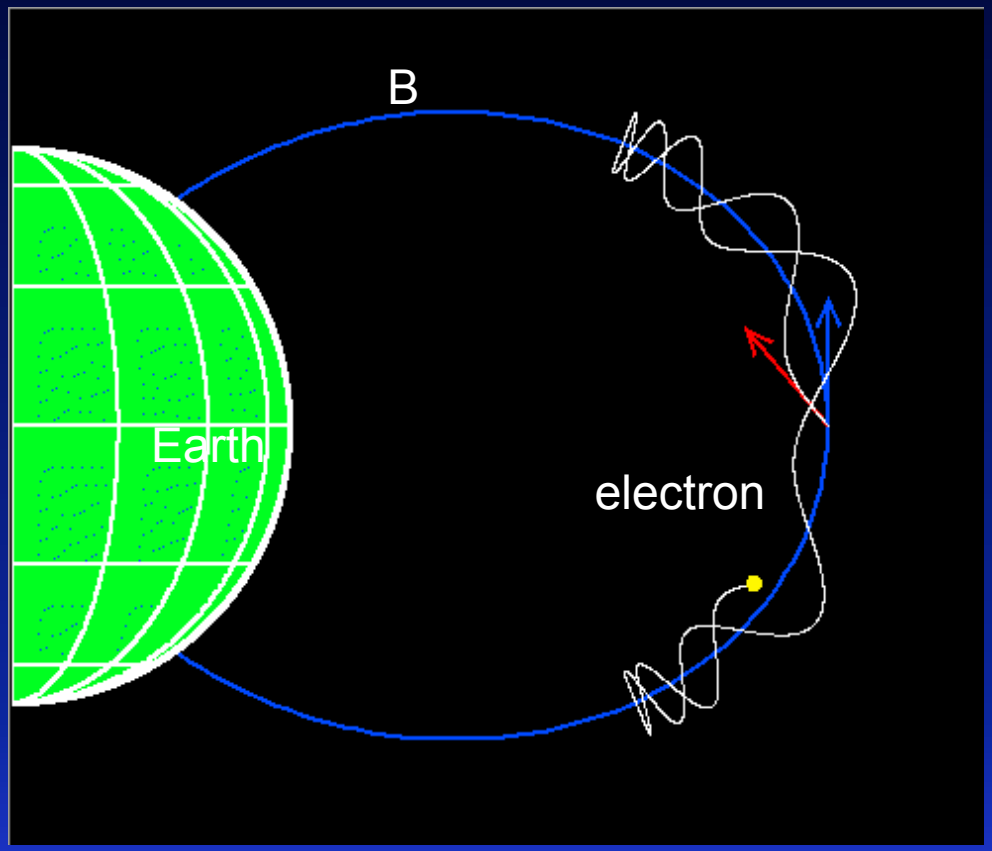
Low X-ray fluxes are correlated with high e- fluxes
→ X-ray signal 'contaminated'





Electron Distributions

1. Electrons bounce back and forth between the N and S magnetic poles. Spiral along the magnetic field lines.



2. Pitch angle steeper near poles.

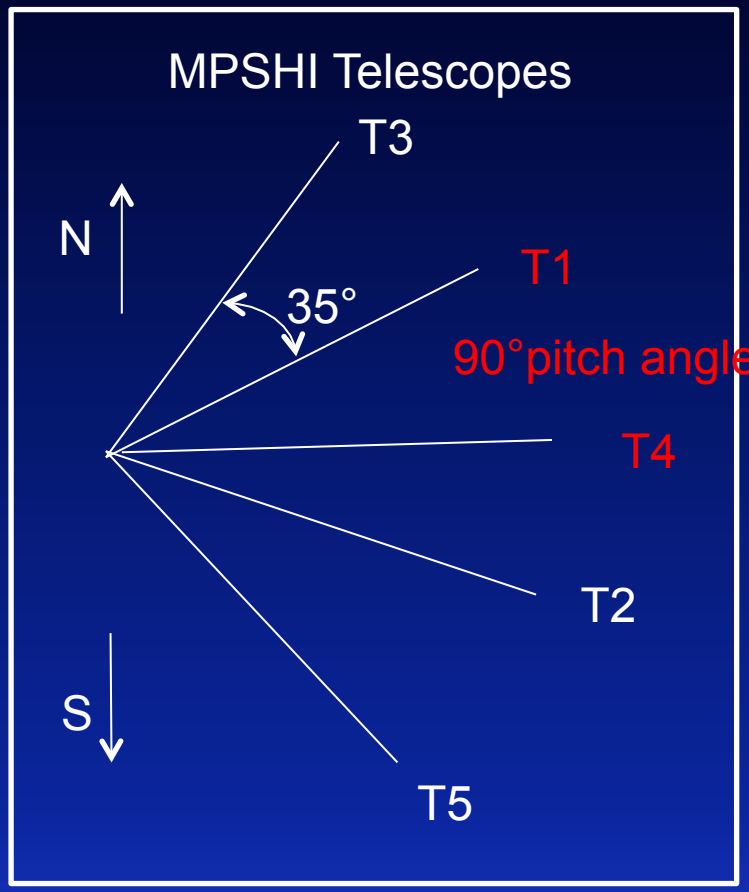
3. Loss cone about 0°.

4. Pitch angle distribution peaks near 90° to B.
   - Particles have been energized as transported inwards within the radiation belts.

Comparisons of XRS with MPS-HI electrons

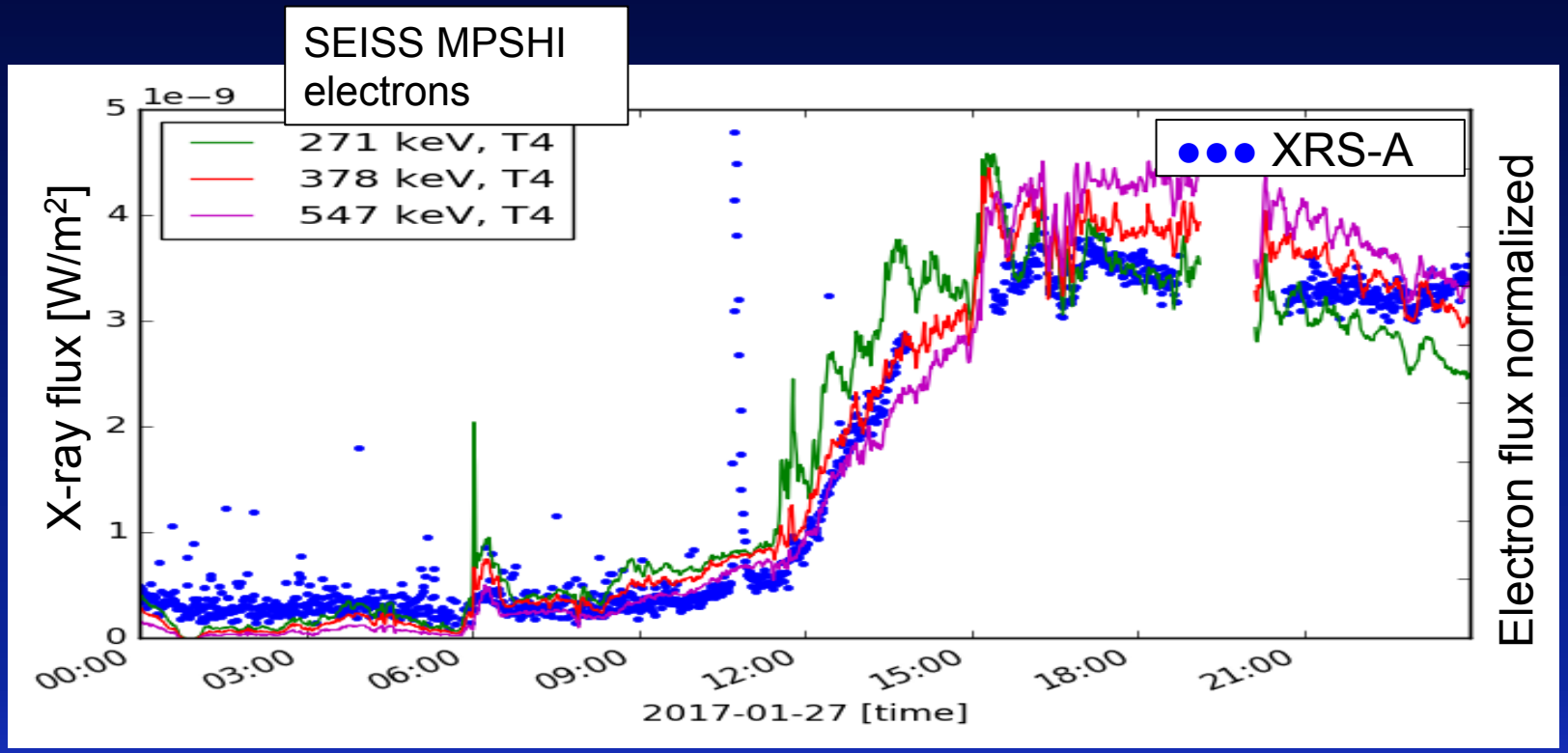
SEISS MPS-HI
- 5 telescopes
- Differential electron energies:
  59, 118, 181, 271, 378, 548, 855 keV
- Integral measurements at 1 s cadence
- 1 minute averages

XRS
- 1 minute averages of L1b data



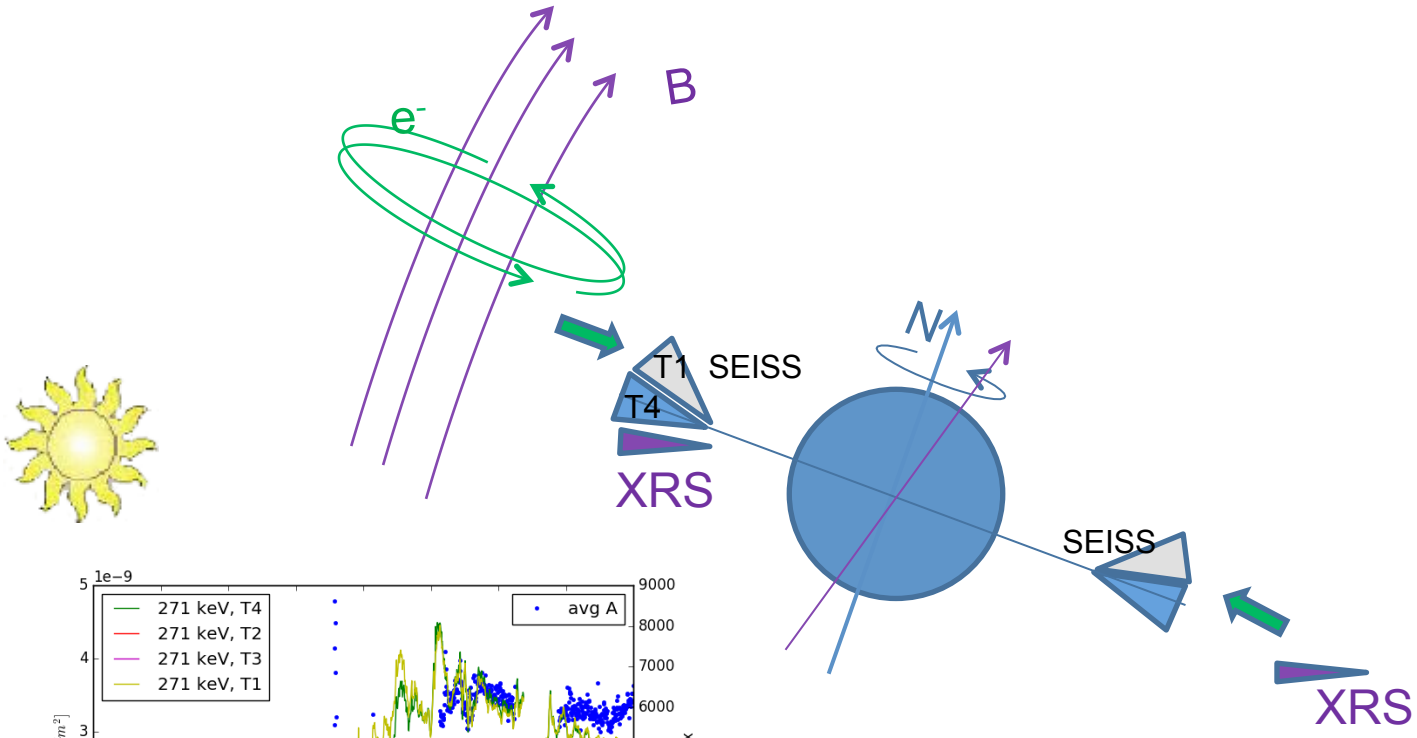
Electron Contamination

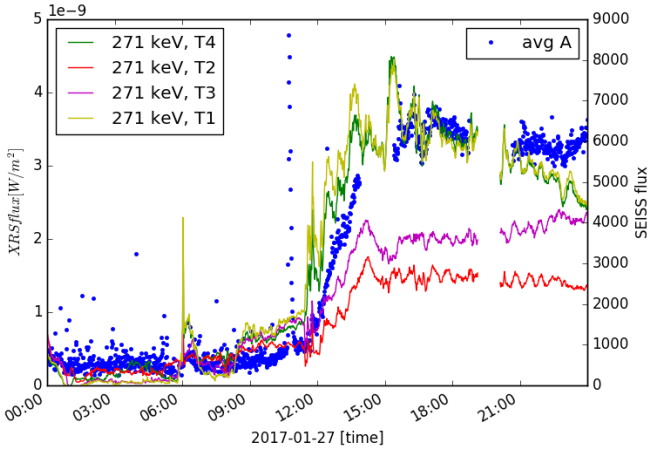
- What is correlation with electron energies and directions?
- Electron fluxes vary in pitch angle and energy.



Typical Electron Distribution

(minimal geomagnetic activity)

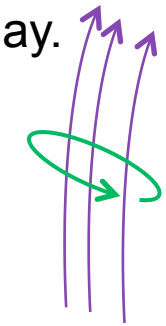


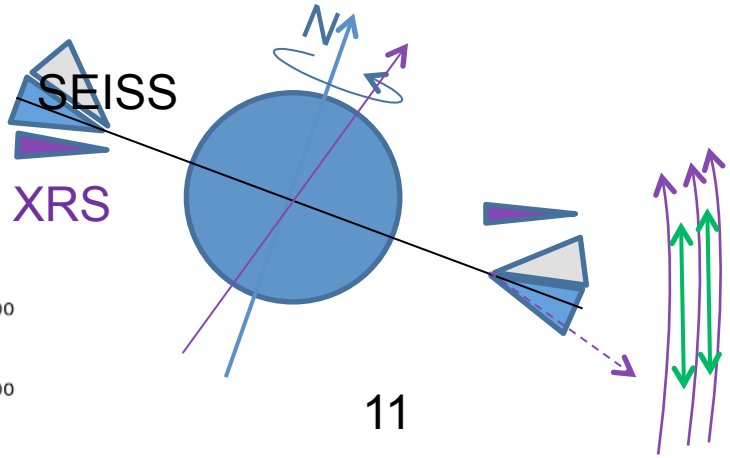


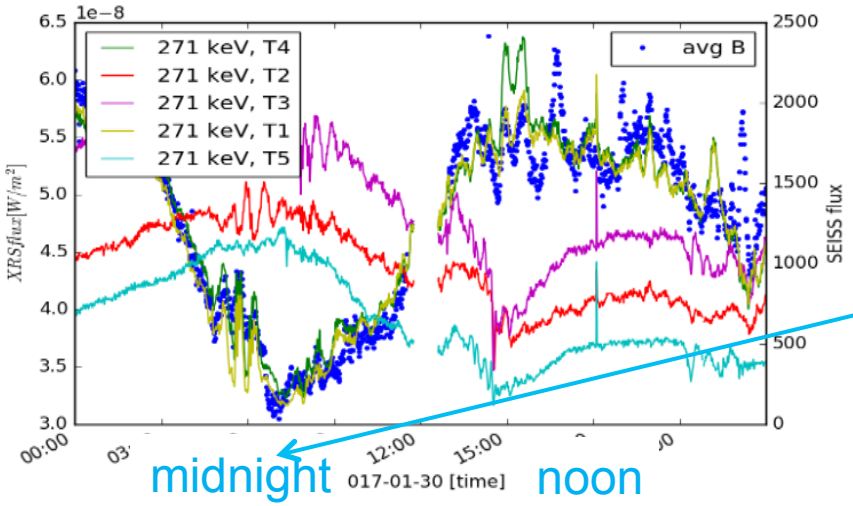
T1 and T4 strongest signal and are correlated with XRS.

‘Unusual Case' Electron Distribution

On January 30, a magnetic field reconfiguration results in an unusual particle distribution for first half of day.







T1 and T4 correlated with XRS suggests electrons coming down boresight.

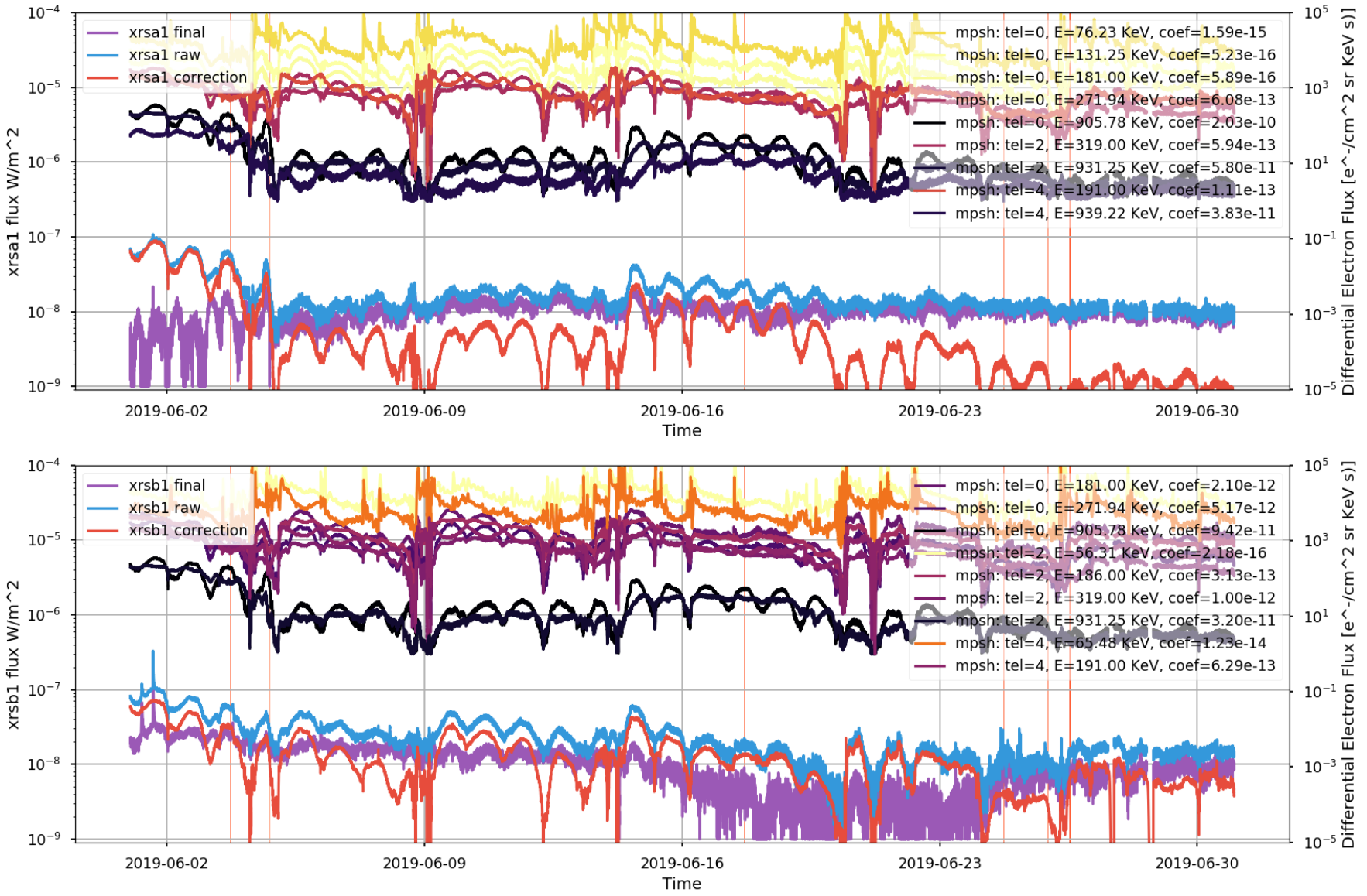
Linear Regression

Goal: Remove electron contamination

Linear regression of SEISS MPSHI data to XRS data.

- Used one year of data (2018).
- Found dominant angles and energies which impact XRS data.
- A1 and B1 channels impacted differently
- Contamination low for small detectors A2, B2.
- The known seasonal impact was not included in analysis. (Also did fit for just dominant T4 telescope.)

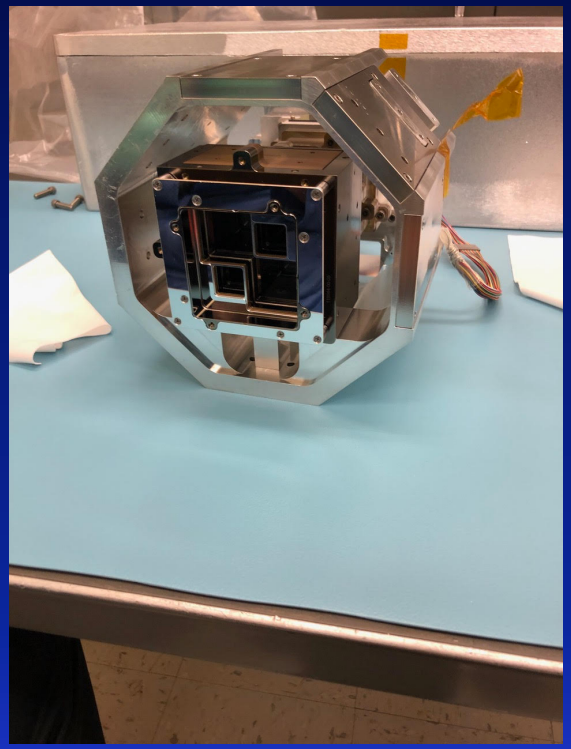
Regression to Correct Electron Impact



Electron Beam Tests

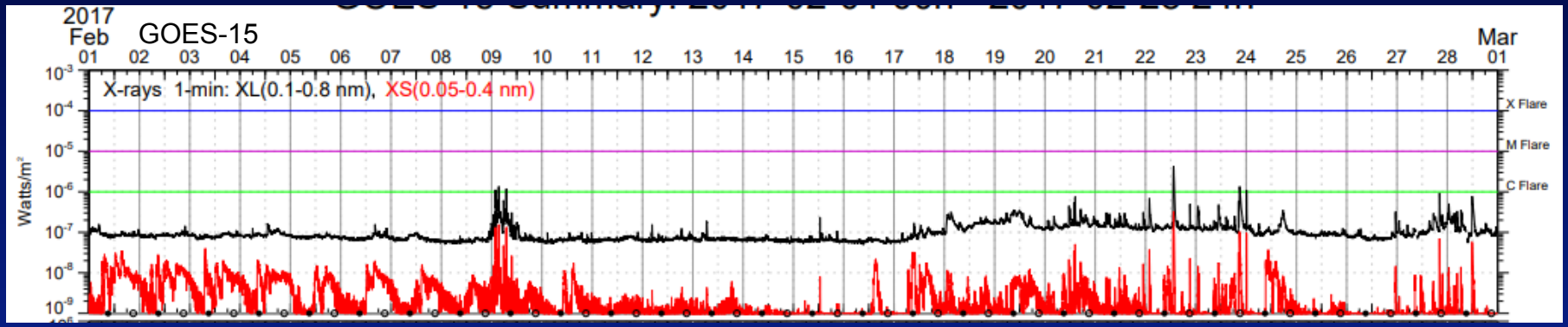
LASP did electron beam tests with MIT Van de Graaff generator

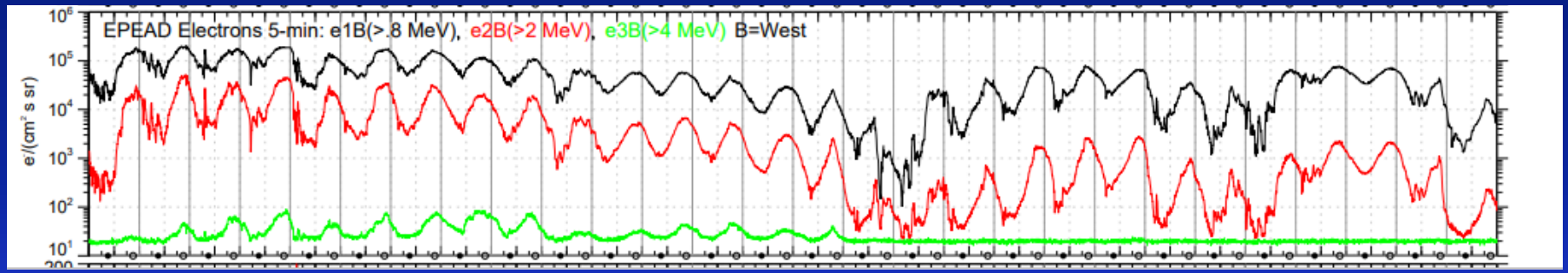
- Cross-talk between channels suggests glowing baffles.



GOES-15 XRS

- Electron impacts also seen on GOES-15.
- Less information in earlier GOES particle data.





Electron Contamination Summary

Current status…

- X-ray signal contaminated when low X-ray fluxes and high e- fluxes.
- Contamination from e- down the boresight with cross-talk.
- Correction is a function of MPSHI angle and energy.

Future improvements…

- Seasonal impacts.
- Compare statistical results with beam tests.
- Correct earlier GOES XRS data.

No more scaling factors for GOES XRS

History
- GOES 1-7 spinning satellites, data consistent
- GOES 8-15 3-axis stabilized, data consistent
- 1994: GOES 7 and 8 XRS data disagreed
- GOES 8-15 XRS data “adjusted” for continuity with GOES 1-7
- Scaling: 85% XRS-A, 70% XRS-B

Newer measurements suggest GOES-8 was correct
- well-calibrated: GOES-16 and -17, rocket tests (MinXSS)

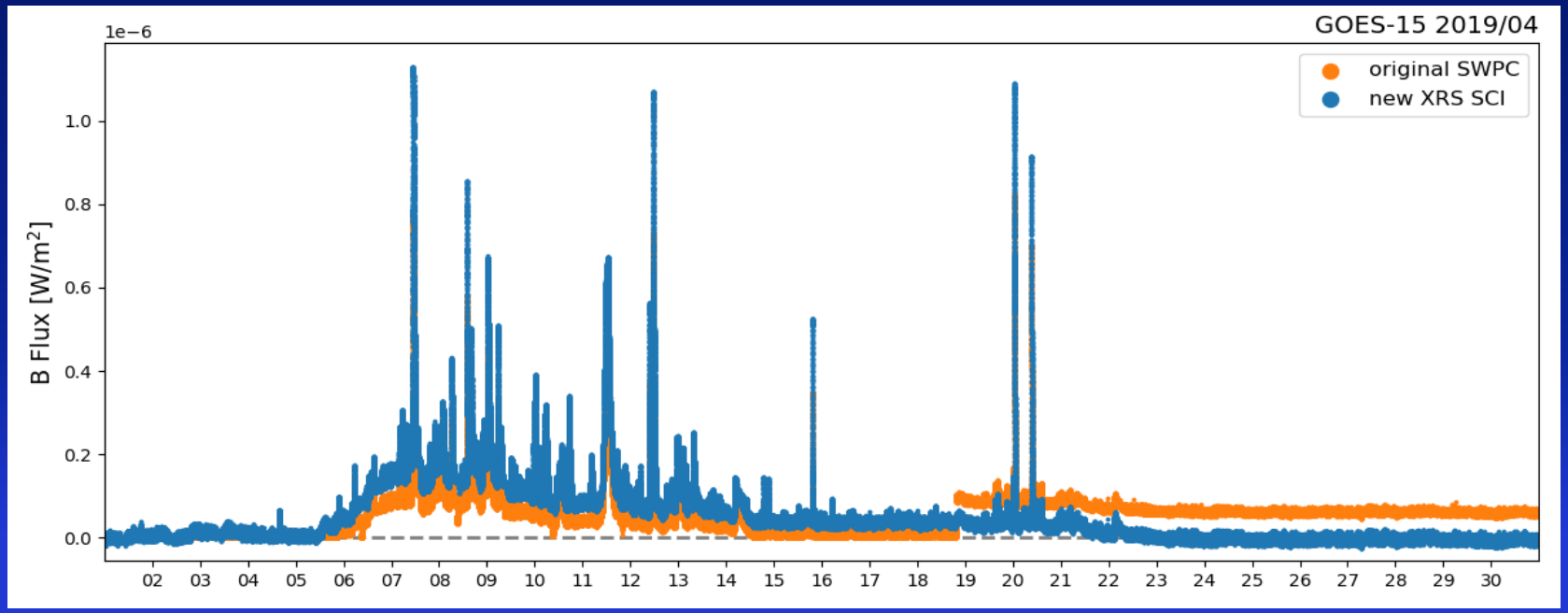
NOAA SWPC: No XRS scaling factors for GOES-R
- *New* science GOES 1-15 data will be corrected.
- Operationally, unimportant at solar minimum
- Impacts to statistical papers and thresholds for alerts

GOES Science Data from NOAA/NCEI

Reprocessing GOES 1-15 data

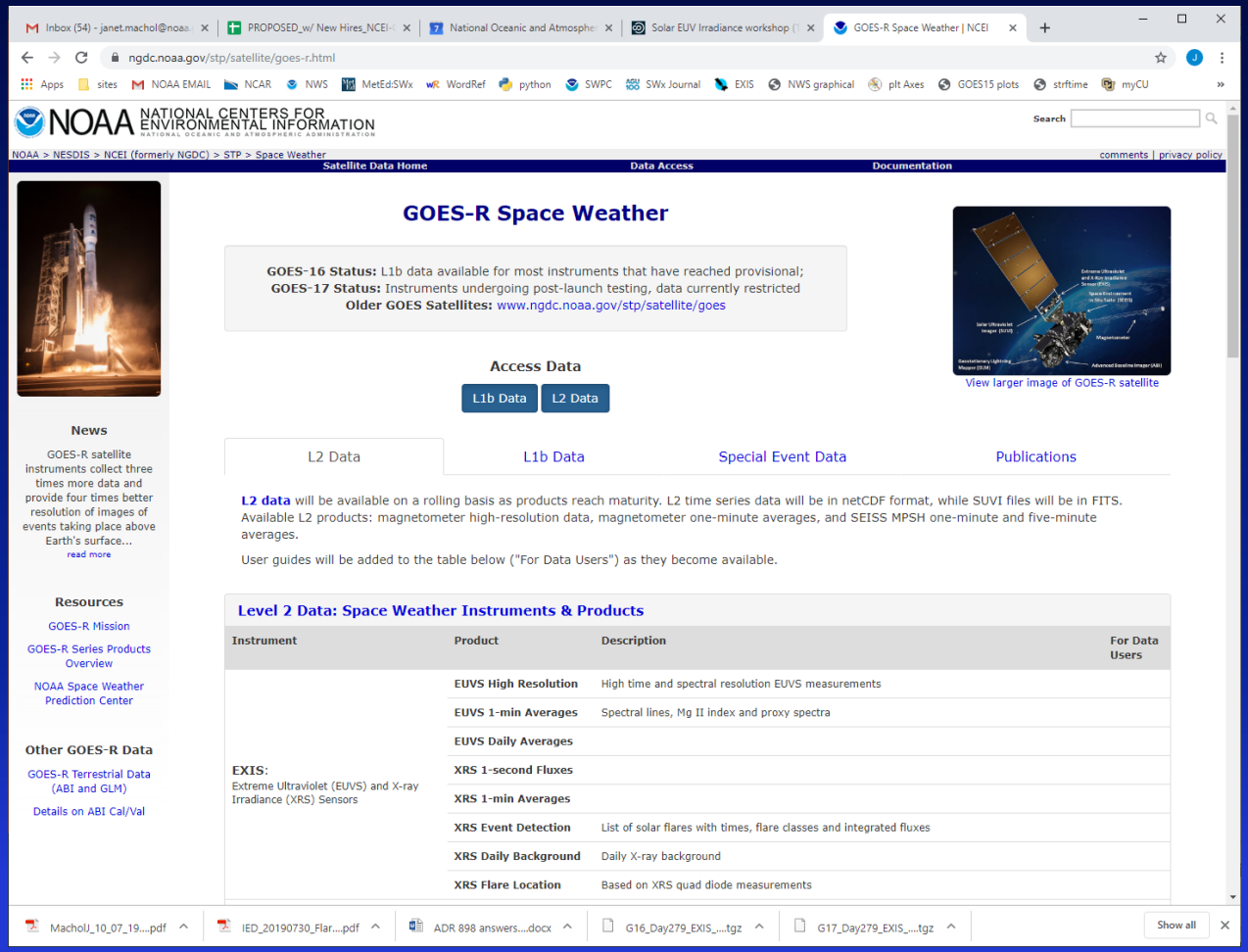
EXIS designed and built at LASP

- Redo calibrations.
- Create flags for offpoints, spikes, eclipses, etc.
- Remove scaling factors.
- Remove electron contamination?
- NetCDF files in same format at GOES-R data.
  - L2 files of averages and flare events.
  - GOES 13-15 available in November. GOES 1-12 next year.



GOES-R science data from NOAA/NCEI

Reprocessed for science quality. Available this year.
https://www.ngdc.noaa.gov/stp/satellite/goes-r.html



Backups

GOES-R Instrument Summary

EXIS

XRS characteristic	value(s)
bandpasses	0.05 - 0.4, 0.1 - 0.8 nm
cadence	1 s

EUVS characteristic	value(s)
wavelengths: corona	28.4 (Fe XV) nm
transition region	25.6 (He II) , 30.4 (He II), 121.6 (H I), 140.5 (Si IV/ O IV) nm
chromosphere	117.5 (C III), 133.6 (C II), Mg II (~280 nm)
cadences	1 - 3 s; primary outputs are 30-s averages

SUVI

Wavelength Log (Te)	94 Å 6.8	131 Å 7.0,7.2	171 Å 5.8	195 Å 6.1,7.3	284 Å 6.3	304 Å 4.7
Filaments						■
Coronal Holes					■	
Active Region Complexity		■	■	■		
CMEs (e.g. dimming)			■	■		
Flare Location and Morphology	■	■				
Quiet Regions		■	■	■		■

Characteristic	GOES 16-19
field of view	53 arcmin
resolution (1280 x 1280 CCD)	2.5 arcsec/ pixel
cadence	10 s

GOES-R Instrument Summary

SEISS

Magnetospheric Particle Sensor - Low (MPS-LO)

- Electrostatic analyzers
- 30 eV-30 keV ions and electrons
- 15 energy channels
- 14 angular zones (12 unique)

Magnetospheric Particle Sensor - High (MPS-HI)

- 5 ion and 5 electron solid state telescopes
- 50 keV-4 MeV electrons in 11 differential channels, plus >2 MeV integral channel
- 80 keV-10 MeV protons in 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

Solar and Galactic Proton Sensor (SGPS)

- 2 Units, one looking East and one West
- 3 solid state telescopes on each unit
- 1 MeV-500 MeV protons in 13 differential channels, plus >500 MeV integral channel
- 4 MeV-500 MeV alphas in 12 energy bands (not processed)

Energetic Heavy Ion Sensor (EHIS)

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

MAG

Characteristic	GOES 16-19	GOES 13-15
3-axis fluxgates	2	
resolution	< 0.16 nT	
sampling rate	10 Hz	
low pass filter cutoff	2.5 Hz	0.5 Hz
boom length	8.5 m	