NOAA/NCEI

Selected Results From GOES-16 Solar and Galactic Cosmic Ray Sensor (SGPS) Calibration and Anomaly Resolution

HARMONISATION OF SEP DATA CALIBRATIONS
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Introduction/Outline

- SGPS GOES-16 Level 1b data publically available (Level 2 forthcoming): https://www.ngdc.noaa.gov/stp/satellite/goes-r.html
- Selected results from GOES-16 SGPS calibration activities presented herein (mainly Sept. 2017 SEP events, but also including analysis of GCR backgrounds)
  - Overview (Sept. 2017 SEP events)
  - Temperature Dependence and Correction Scheme
  - Source of backgrounds (GCRs)
  - Geomagnetic Cutoffs During Sept. 2017 SEP events

GOES-R Series Space Environment In-Situ Suite (SEISS)
Solar and Galactic Cosmic Ray Sensor (SGPS)

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)


P/N SEISS-MA-8000 S/N 101 8/23/12

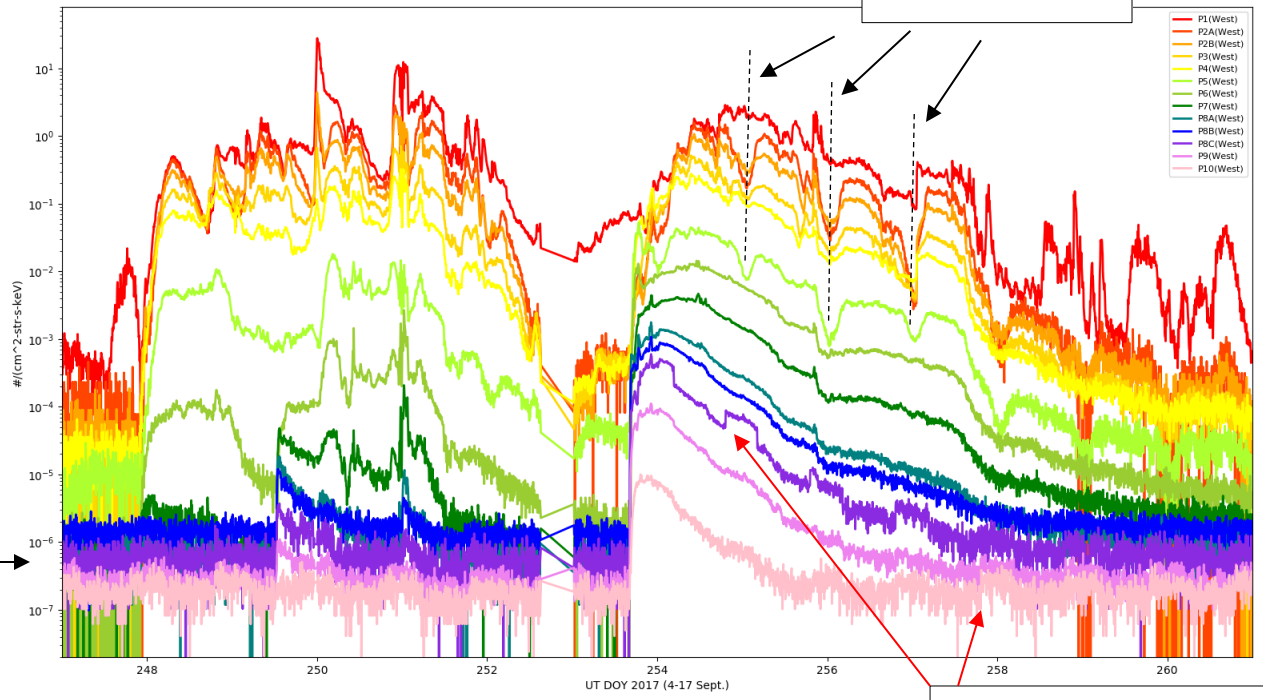
SEISS designed, built, tested and calibrated by Assurance Technology Corporation

Proton energy channels by telescope (13 differential and 1 integral)		
Telescope 1	**Telescope 2**	**Telescope 3**
P1 (1.0-1.9 MeV)	P6 (25-40 MeV)	P8A (83-99 MeV)
P2A. (1.9-2.3 MeV)	P7 (40-80 MeV)	P8B (99-118 MeV)
P2B (2.3-3.4 MeV)		P8C (118-150 MeV)
P3 (3.4-6.5 MeV)		P9 (150-275 MeV)
P4 (6.5-12 MeV)		P10 (275-500 MeV)
P5 (12-25 MeV)		P11 (>500 MeV)

September 2017 SEP Events

SGPS-X (West) L1b 5m averages During Sep. 2017 Solar Proton Event

Temperature dependent Drops in SGPS-X T1 fluxes



P1 (1-1.9 MeV)
P2A (1.9-2.3 MeV)
P2B (2.3-3.4 MeV)
P3 (3.4-6.5 MeV)
P4 (6.5-12 MeV)
P5 (12-25 MeV)
P6 (25-40 MeV)
P7 (40-80 MeV)
P8AF (83-99 MeV)
P8BF (99-118 MeV)
P8CF (118-150 MeV)
P9F (150-275 MeV)
P10 (275-500 MeV)

GCR fluxes too high

SGPS-X T3 temperature dependence

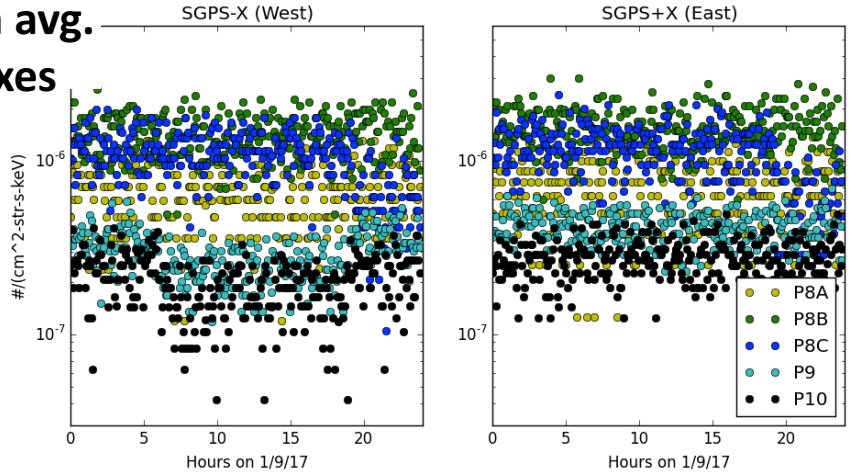
- Temperature Dependence in SGPS-X T1 and T3 - Addressed with correction algorithm downstream of Level 1b processing.
- Reported GCR fluxes too high

Selected Results From GOES-16 SGPS Calibration Activities

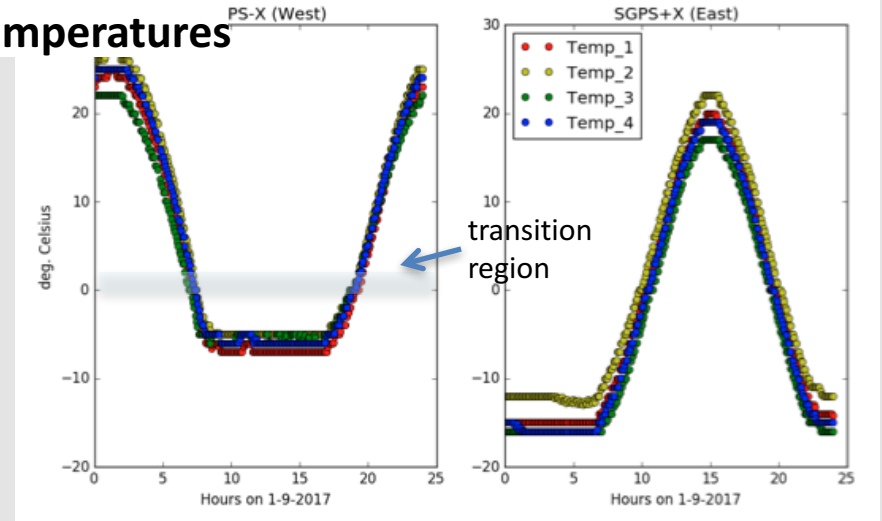
TEMPERATURE DEPENDENCE AND CORRECTION SCHEME

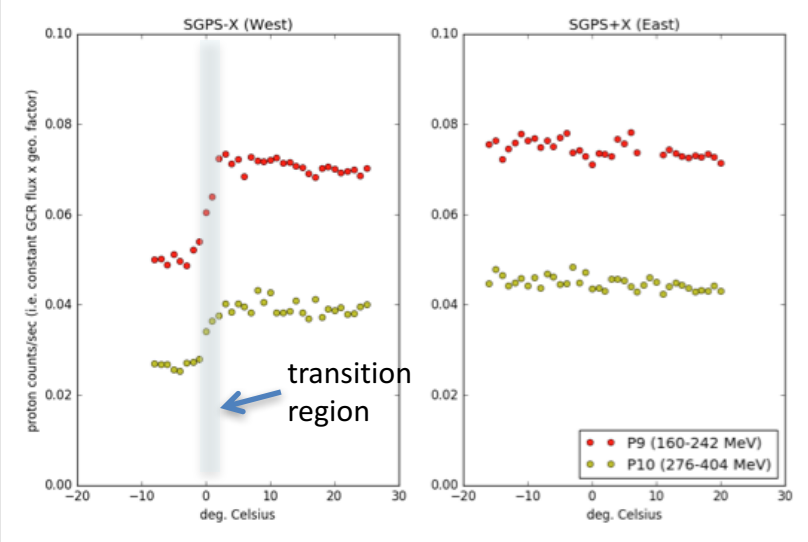
SGPS-X (West) Temperature Dependence

5m avg. fluxes



Temperatures



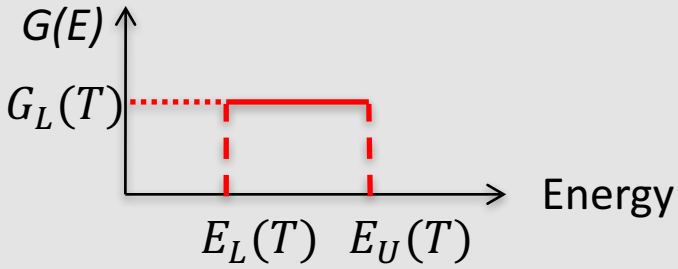


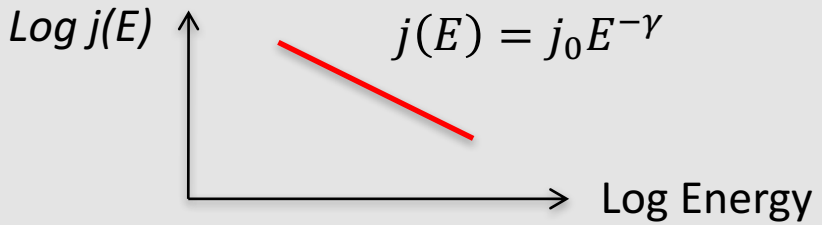
22 day averages of counts/sec in 1 deg. temperature bins between -20° and +30° C.

Here, P9 and P10 are shown as examples. There is also significant temperature dependence in response of P11, P1-P3, and P5 channels.

Temperature Correction Scheme

A rectangular function with temperature dependent boundaries is used to model the energy channel response function, and a power law is used to model the ambient spectrum





The total counts/sec. in the channel is the convolution of the channel response function and the ambient spectrum

$$C = \int_{E_L}^{E_U} G_0 \, j_0 E^{-\gamma} dE \; = G_0 j_0 \frac{(E_U^{1-\gamma} - E_L^{1-\gamma})}{1-\gamma}$$

A temperature and spectrum dependent correction is used to determine the counts expected in the fixed/calibrated channel (at 25°C), given counts from temp. dep. chan.

$$C_{corrected} = X(\gamma, T) * C_{measured} \, ,$$

$$\text{where } X(\gamma, T) = \frac{G_0(T{=}25^oC)[E_U^{1-\gamma}(T{=}25^oC) - E_L^{1-\gamma}(T{=}25^oC)]}{G_0(T)[E(T)_U^{1-\gamma} - E(T)_L^{1-\gamma}]}$$

To Get Low Temp. E_L, E_U and G_0

- Obtain spectral index γ_i from fit to SGPS+X T3 channels (P8A-P10) (SGPS+X does not exhibit temperature dependence.) This is done for many *(i=1-N)* 5m averaged intervals from the Sept. 2017 SEP events.

- Minimize the function

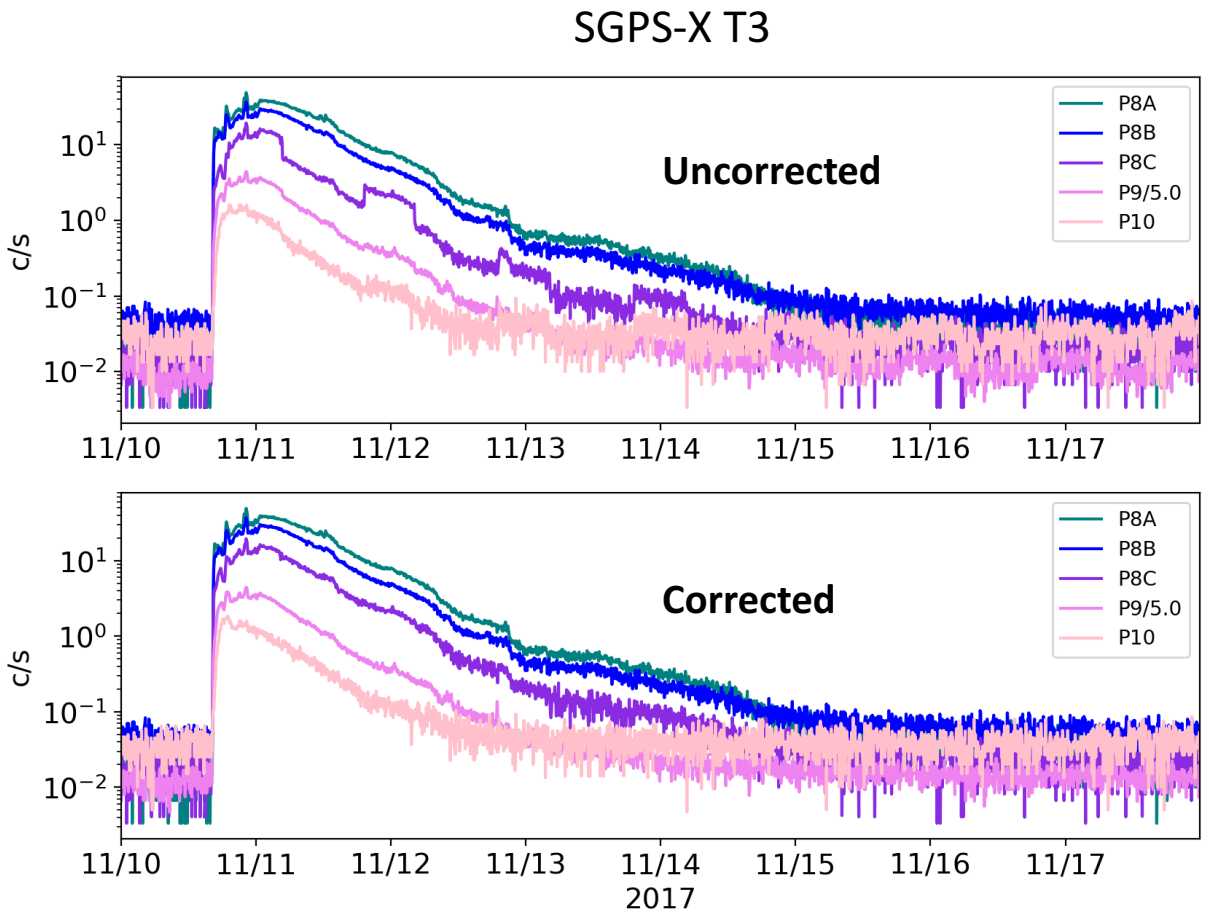
Model channel counts

Measured counts In channel

$$f(E_L, E_U, G_0) = \sum_{i=1}^{N} \left\{ \log\left(G_0 j_{0,i} \frac{(E_U^{1-\gamma_i} - E_L^{1-\gamma_i})}{1-\gamma_i} \right) - \log C_i \right\}^2$$

with respect to E_L, E_U and G_0 using many spectra.

SGPS Temperature Correction

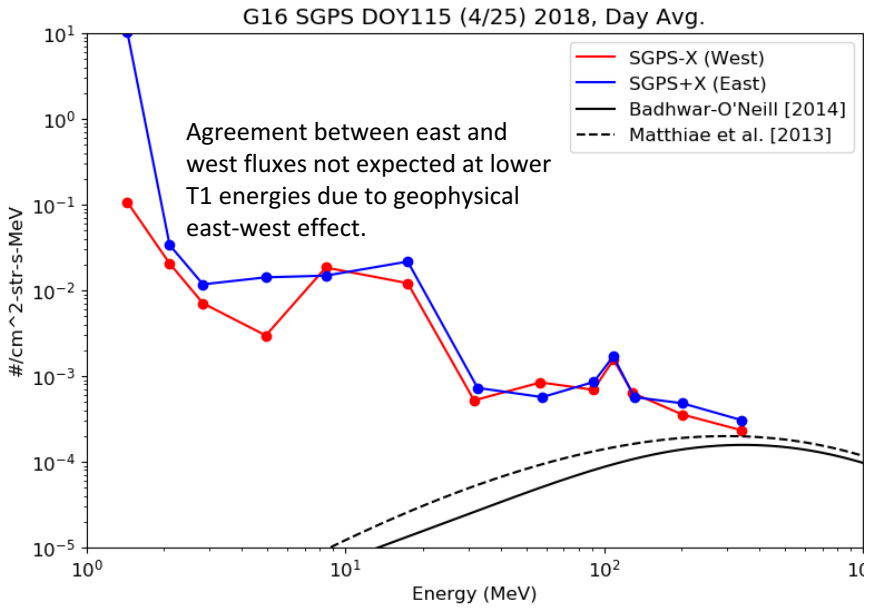


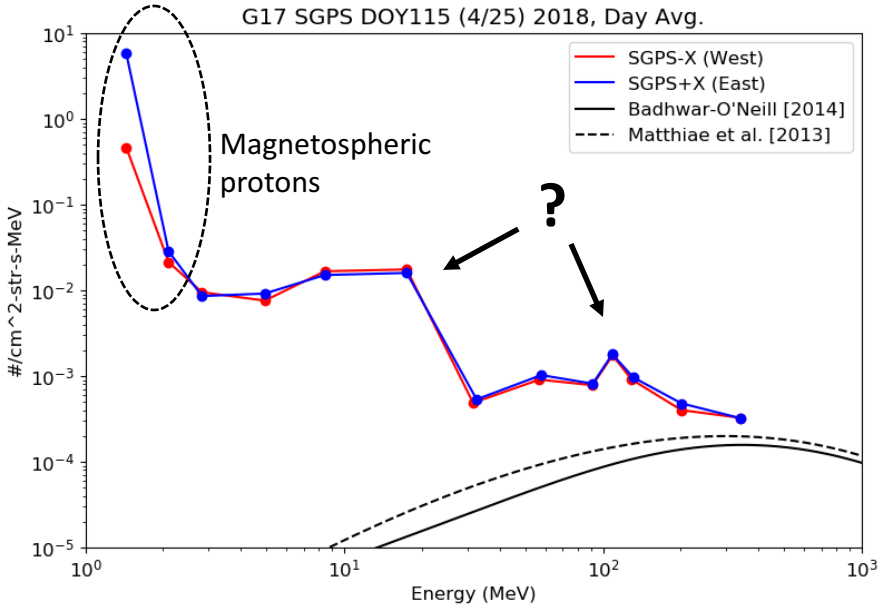
SGPS-X T3 5 minute averaged counts per second during Sept. 2017 SEP event, showing uncorrected c/s in top panel and temperature corrected c/s in bottom panel.

Selected Results From GOES-16 SGPS Calibration Activities

SGPS BACKGROUNDS

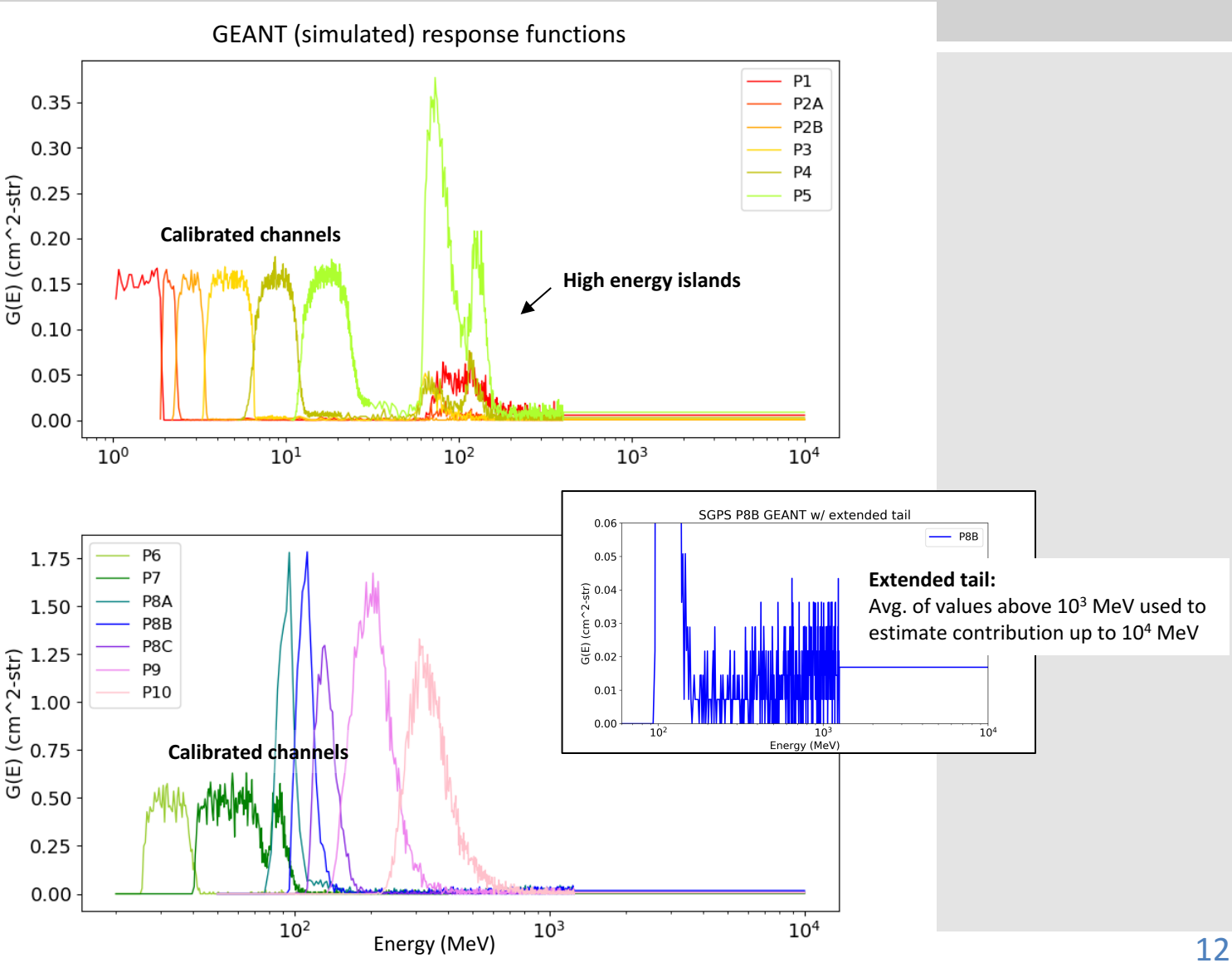
High GCR/background Rates





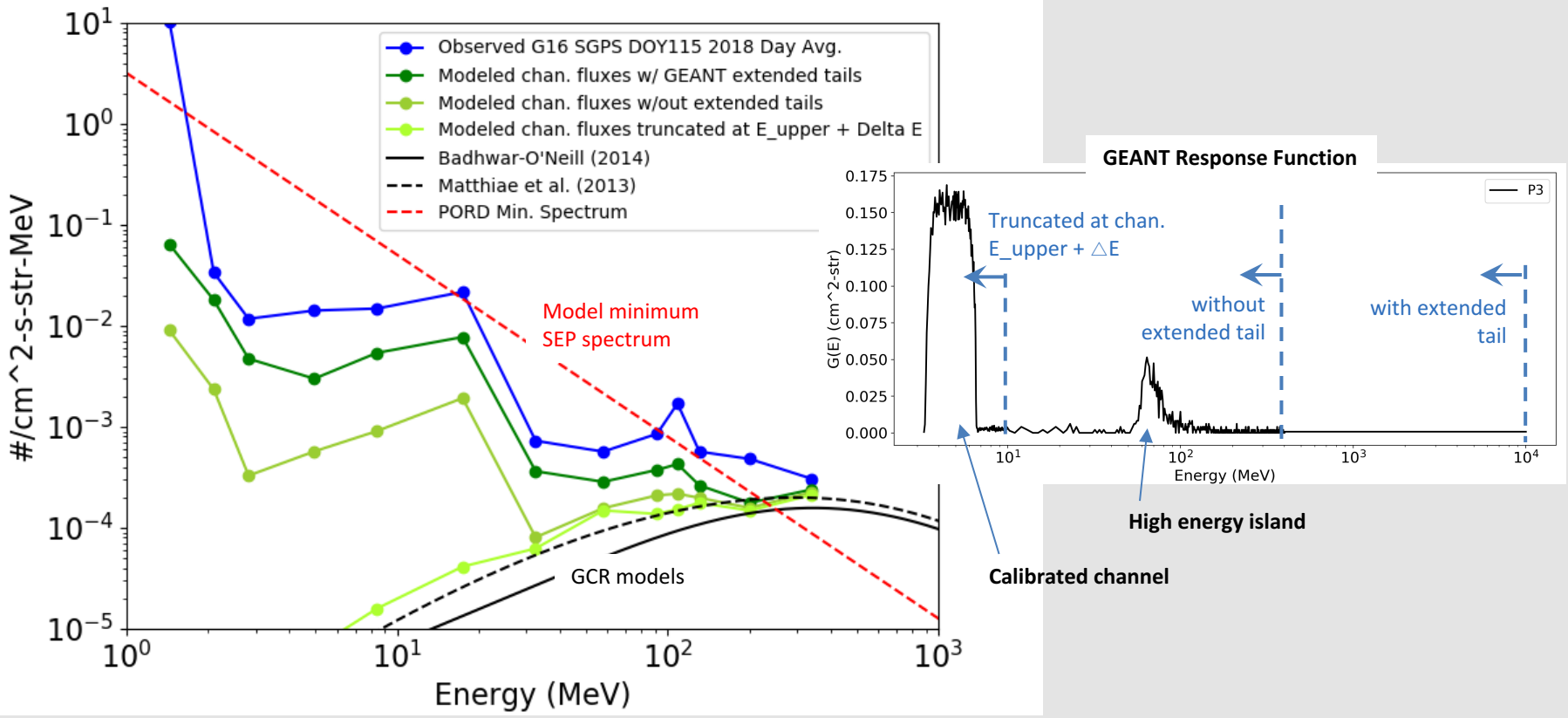
GOES-16 and -17 SGPS 1-day averaged quiet-time background/GCR measurments and standard GCR models. Observed fluxes are well above GCR models and have negative spectral exponent, while GCR models have a positive spectral exponent in the SGPS energy range.

SGPS GEANT Simulated Response Functions



GOES-16 SGPS Backgrounds

Observed vs. Modeled GCR Backgrounds

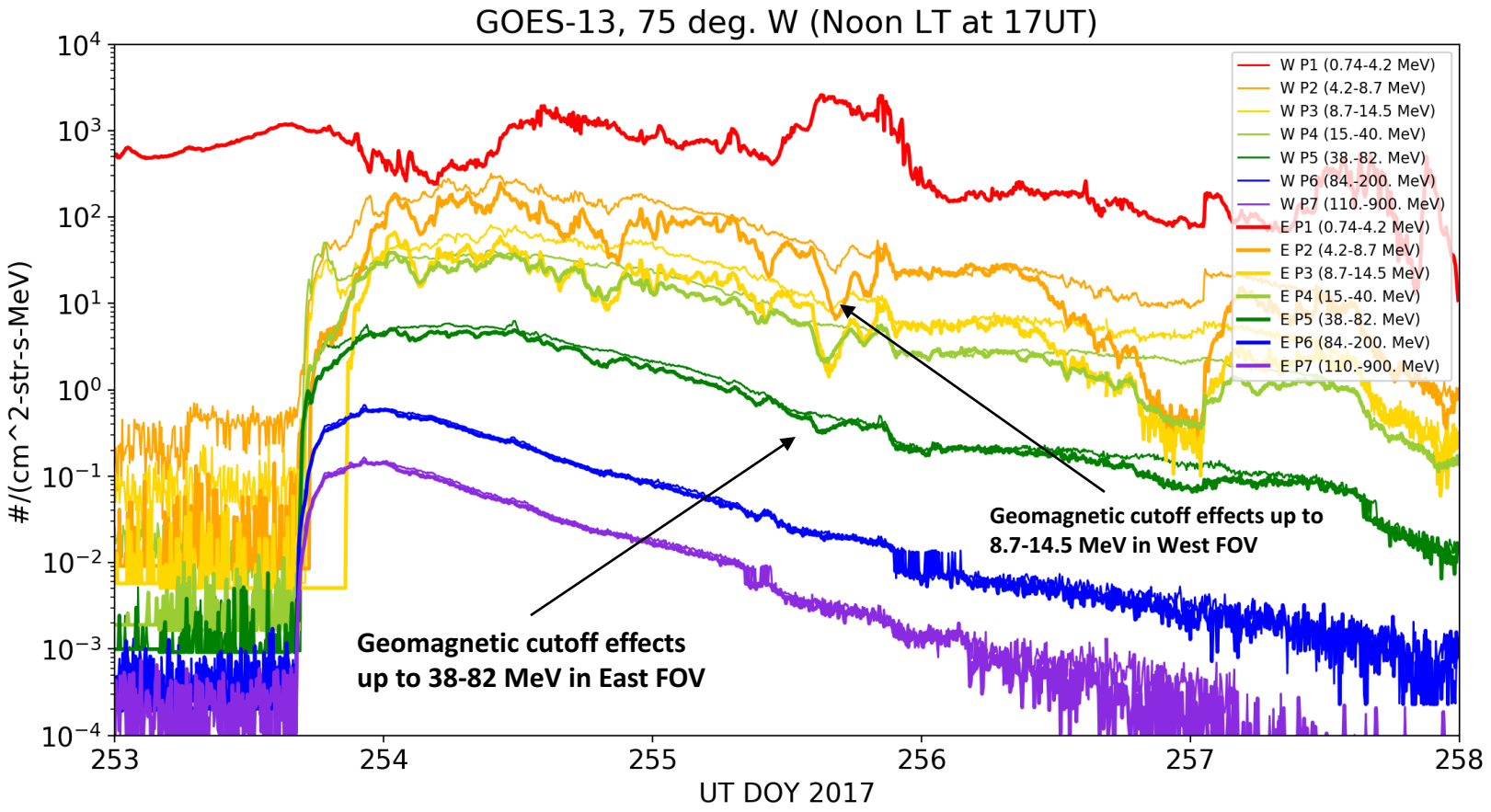


- Source of SGPS backgrounds is GCR counts.
- Reported GCR fluxes are significantly higher than accepted empirical models.
- High GCR fluxes are due to high energy tail portion of response function, not part of calibrated channel.
- Differential channels calibrated for observing SEP events; P11 (>500 MeV integral chan.) measures GCRs.

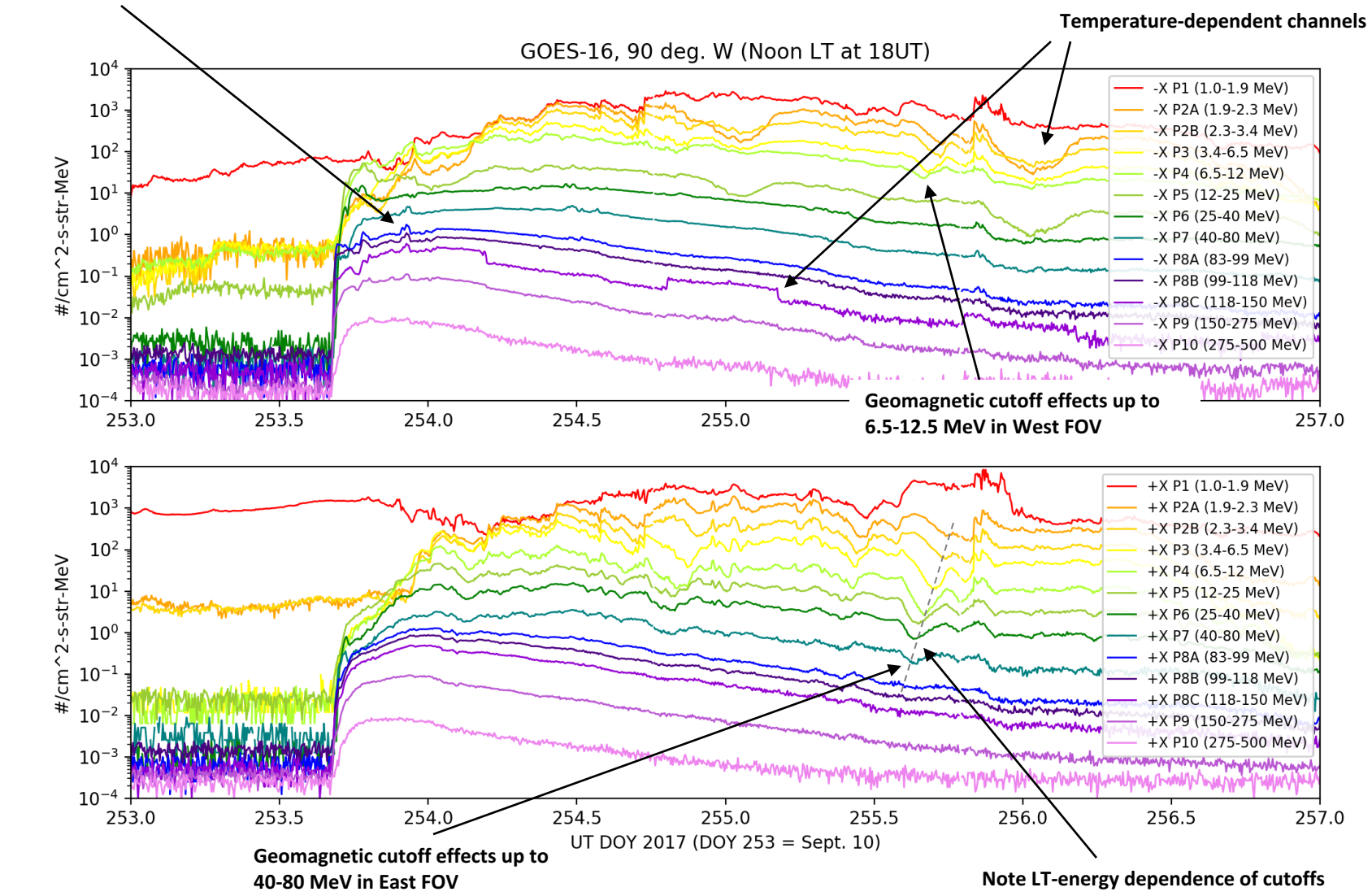
Selected Results From GOES-16 SGPS Calibration Activities

GEOMAGNETIC CUTOFFS DURING SEPTEMBER 2017 SEP EVENT

GOES-13 EPS


GOES-13, 75 deg. W (Noon LT at 17UT)
#/(cm^2-str-s-MeV)
UT DOY 2017
W P1 (0.74-4.2 MeV)
W P2 (4.2-8.7 MeV)
W P3 (8.7-14.5 MeV)
W P4 (15.-40. MeV)
W P5 (38.-82. MeV)
W P6 (84.-200. MeV)
W P7 (110.-900. MeV)
E P1 (0.74-4.2 MeV)
E P2 (4.2-8.7 MeV)
E P3 (8.7-14.5 MeV)
E P4 (15.-40. MeV)
E P5 (38.-82. MeV)
E P6 (84.-200. MeV)
E P7 (110.-900. MeV)
Geomagnetic cutoff effects up to 8.7-14.5 MeV in West FOV
Geomagnetic cutoff effects up to 38-82 MeV in East FOV

GOES-16 SGPS


Time-dependent structures (spikes)
up to >100 MeV not seen in East FOV
Temperature-dependent channels
GOES-16, 90 deg. W (Noon LT at 18UT)
#/cm^2-s-str-MeV
-X P1 (1.0-1.9 MeV)
-X P2A (1.9-2.3 MeV)
-X P2B (2.3-3.4 MeV)
-X P3 (3.4-6.5 MeV)
-X P4 (6.5-12 MeV)
-X P5 (12-25 MeV)
-X P6 (25-40 MeV)
-X P7 (40-80 MeV)
-X P8A (83-99 MeV)
-X P8B (99-118 MeV)
-X P8C (118-150 MeV)
-X P9 (150-275 MeV)
-X P10 (275-500 MeV)
Geomagnetic cutoff effects up to
6.5-12.5 MeV in West FOV
+X P1 (1.0-1.9 MeV)
+X P2A (1.9-2.3 MeV)
+X P2B (2.3-3.4 MeV)
+X P3 (3.4-6.5 MeV)
+X P4 (6.5-12 MeV)
+X P5 (12-25 MeV)
+X P6 (25-40 MeV)
+X P7 (40-80 MeV)
+X P8A (83-99 MeV)
+X P8B (99-118 MeV)
+X P8C (118-150 MeV)
+X P9 (150-275 MeV)
+X P10 (275-500 MeV)
UT DOY 2017 (DOY 253 = Sept. 10)
Geomagnetic cutoff effects up to
40-80 MeV in East FOV
Note LT-energy dependence of cutoffs

Summary

- Two SGPS sensor units mounted on each GOES-R series spacecraft
- GOES-16 SEISS SGPS Level 1b (1 sec.) provisional quality data released on July 11, 2018.
- Instrument and Level 1b processing anomalies are being worked – Corrected Level 2 data (1- and 5-minute averages) are forthcoming.