

HRBE Data Analysis

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Outline

- Review/Background
- Magnetic Activity in the Data
- Comparing HRBE Flux and NOAA POES Flux
- Future Work

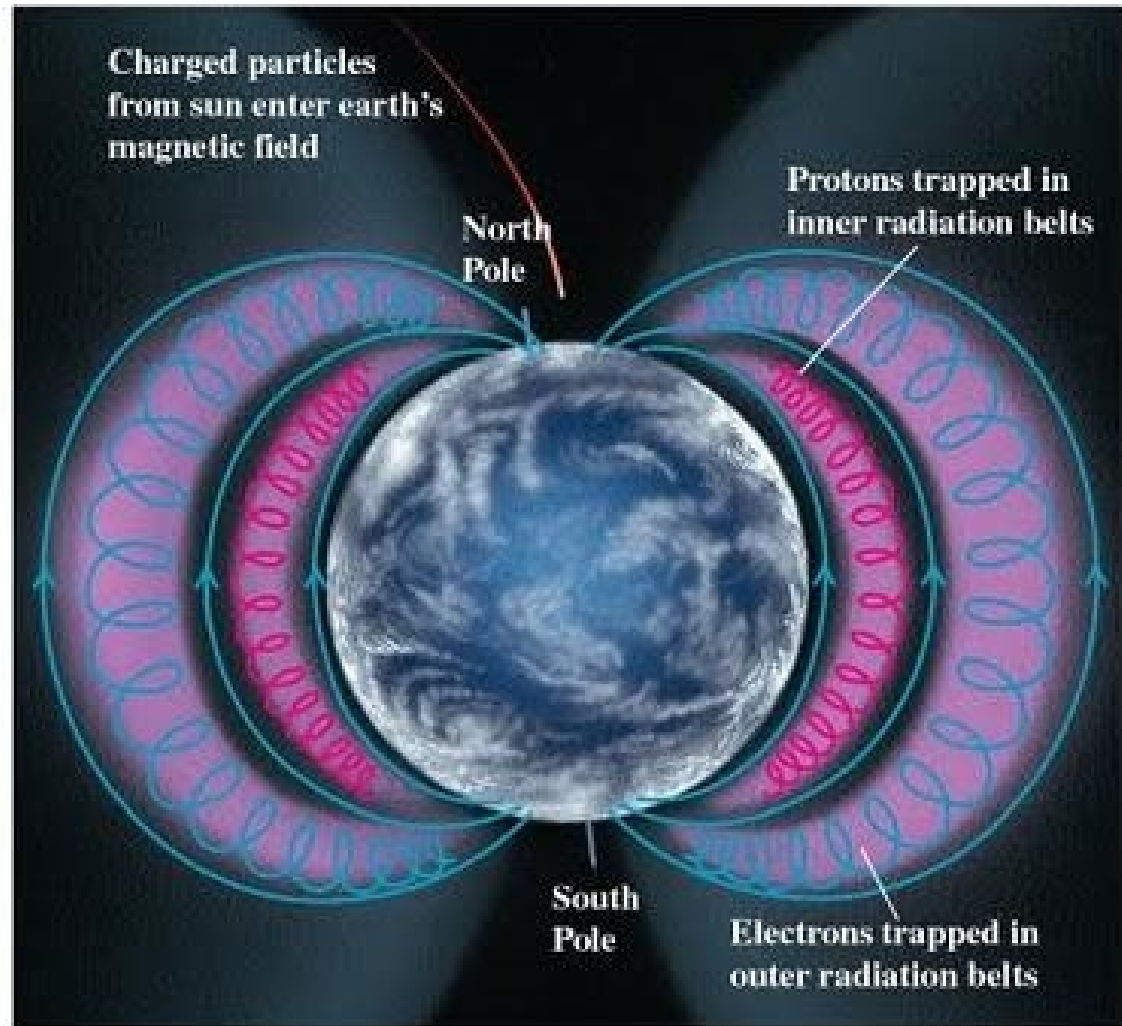
HRBE (aka Explorer -1 [Prime])



- Designed to monitor the intensity and location of the radiation belts
 - Flies a Geiger tube donated by Dr. James Van Allen
 - Counts charged particles, mainly electrons > 50 keV

Van Allen Radiation Belts

- 2 regions of trapped charged particles
- Located at $\sim 1.5 R_E$ and $\sim 4-5 R_E^1$
- Dynamic and highly variable depending on solar activity
- Filled with electrons and protons
 - Protons significant only in inner belt
- Slot region (for Dana):
 - Inward radial diffusion and pitch angle scattering during quiet time
 - Whistler Mode Waves cause pitch angle scattering of trapped particles after storms
 - Particles lost to atmosphere



(a)

Motion of Charged Particles ²

- $F = q(\mathbf{v} \times \mathbf{B} + \mathbf{E})$
 - Gyro Motion:

$$\rho = \frac{p_{\perp}}{Bq}$$

- Gradient Drift

$$v_G = \frac{mv_{\perp}^2}{2qb^3} (\mathbf{B} \times \nabla \mathbf{B})$$

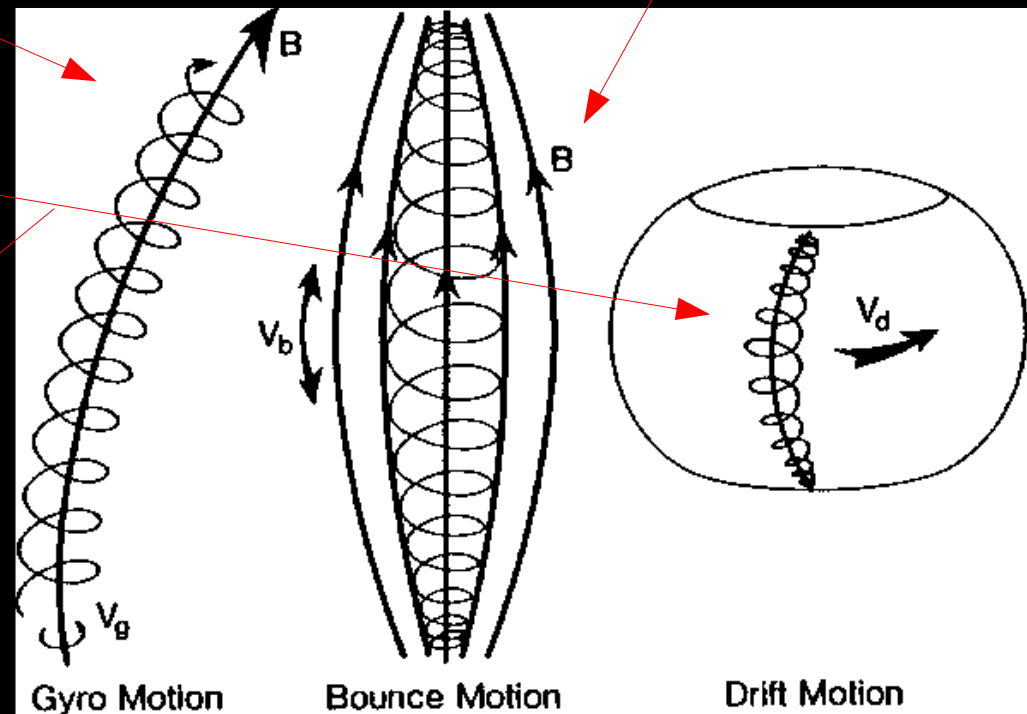
- Curvature Drift

$$v_C = \frac{mv_{\parallel}^2}{qB^3} (\mathbf{B} \times \nabla \mathbf{B})$$

- Bounce Motion:

- The Magnetic Mirror Effect

$$\mathbf{F}_m = \frac{-mv_{\perp}^2}{2B} \nabla \mathbf{B}$$



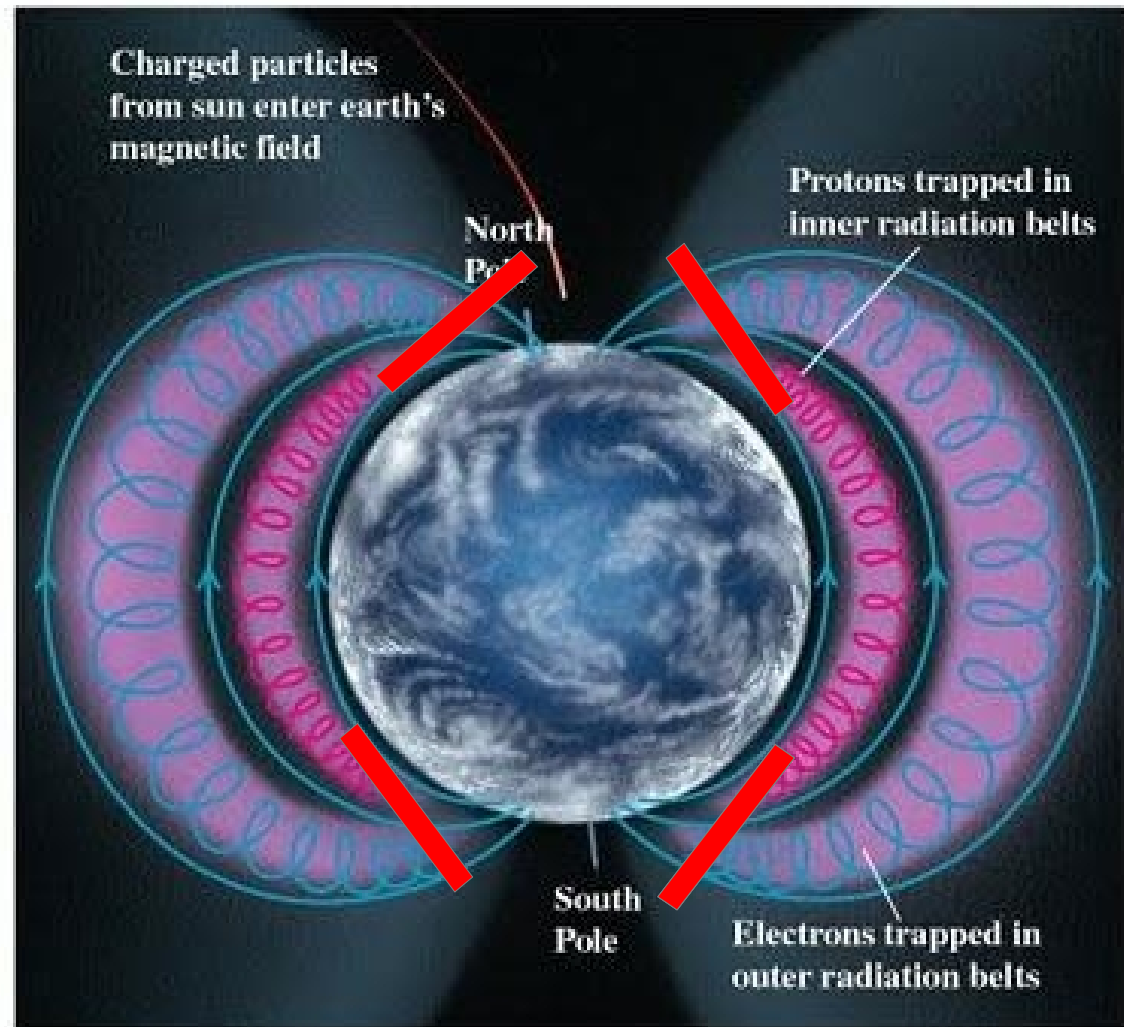
L-Shells

- L-Shell Coordinate system²
 - Eliminates longitudinal coordinate
 - Particle drifting and bouncing around earth has nearly $L = \text{constant}$

$$r = L \cos^2 \lambda$$

$$B = \frac{B_0}{r^3} \left(4 - \frac{3r}{L} \right)^{\frac{1}{2}}$$

- r is in Earth radii, λ is geomagnetic latitude
- $L R_E \sim$ distance from dipole center to a field line at the equator

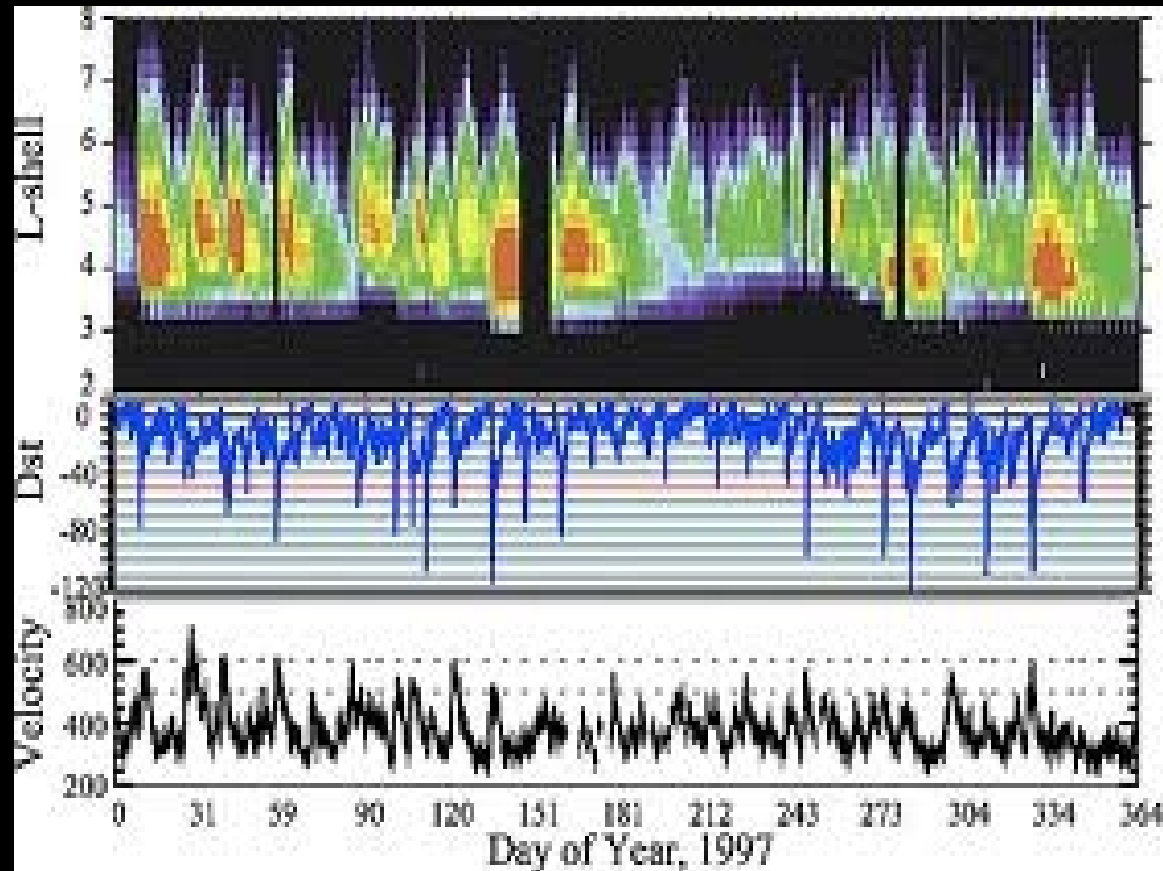


(a)

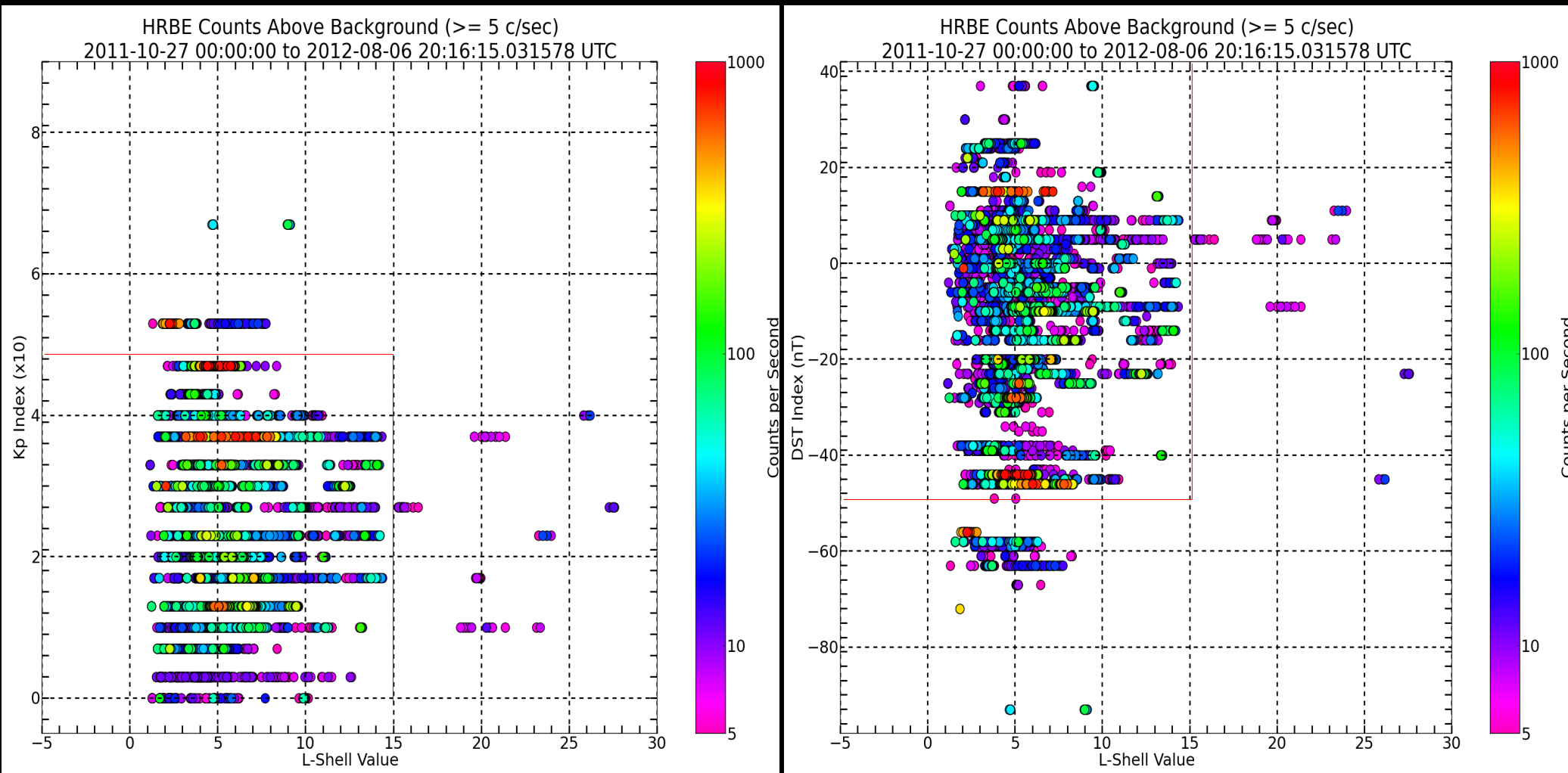
Kp and Dst Indexes

- Measures of the horizontal component of the earth's magnetic field
- Magnetic field varies with solar activity
- KP Index ³
 - Measured from higher latitudes
 - KP of 0-4 is below storm level
 - Kp of 5-9 indicates increasingly powerful storms

- DST Index ⁴
 - Measured close to the equator
 - $DST < -50$ nT indicates a magnetic storm
 - Measure of magnetospheric current (ring current)



Geomagnetic Activity in HRBE Data



18 June: M-Class Flare

GOES-15 SXI Level-1
NOAA/SWPC Boulder, CO

DN/sec

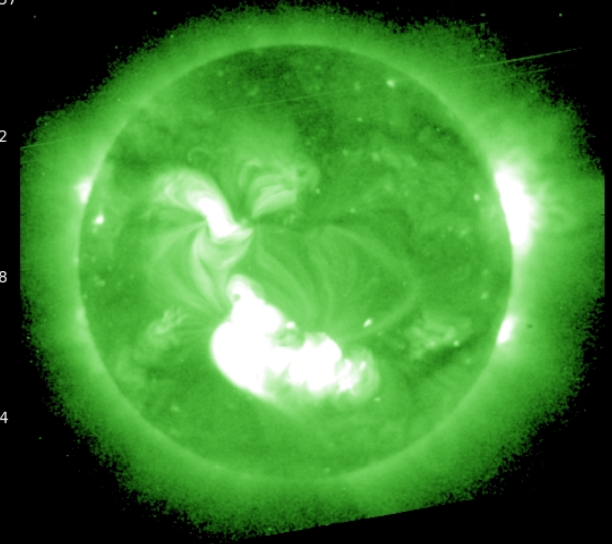
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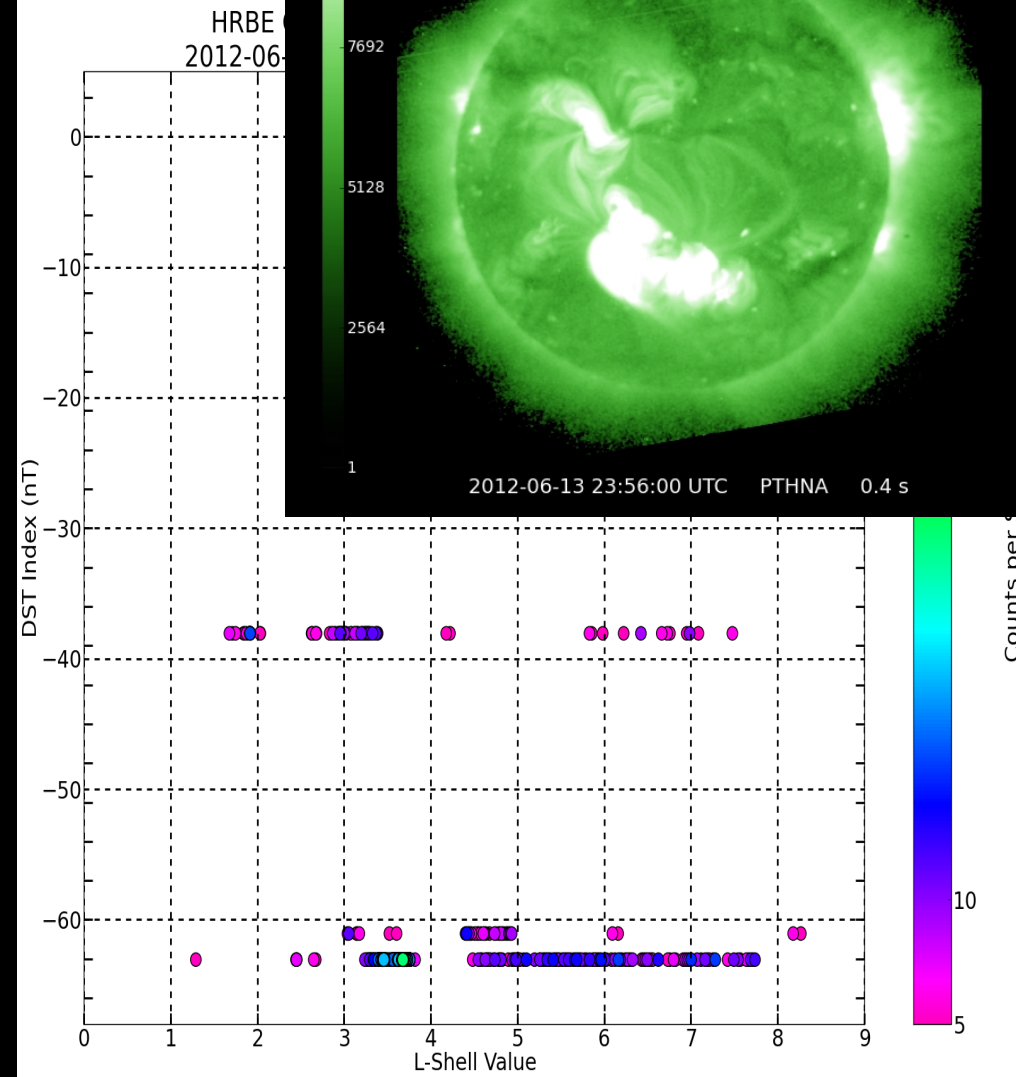
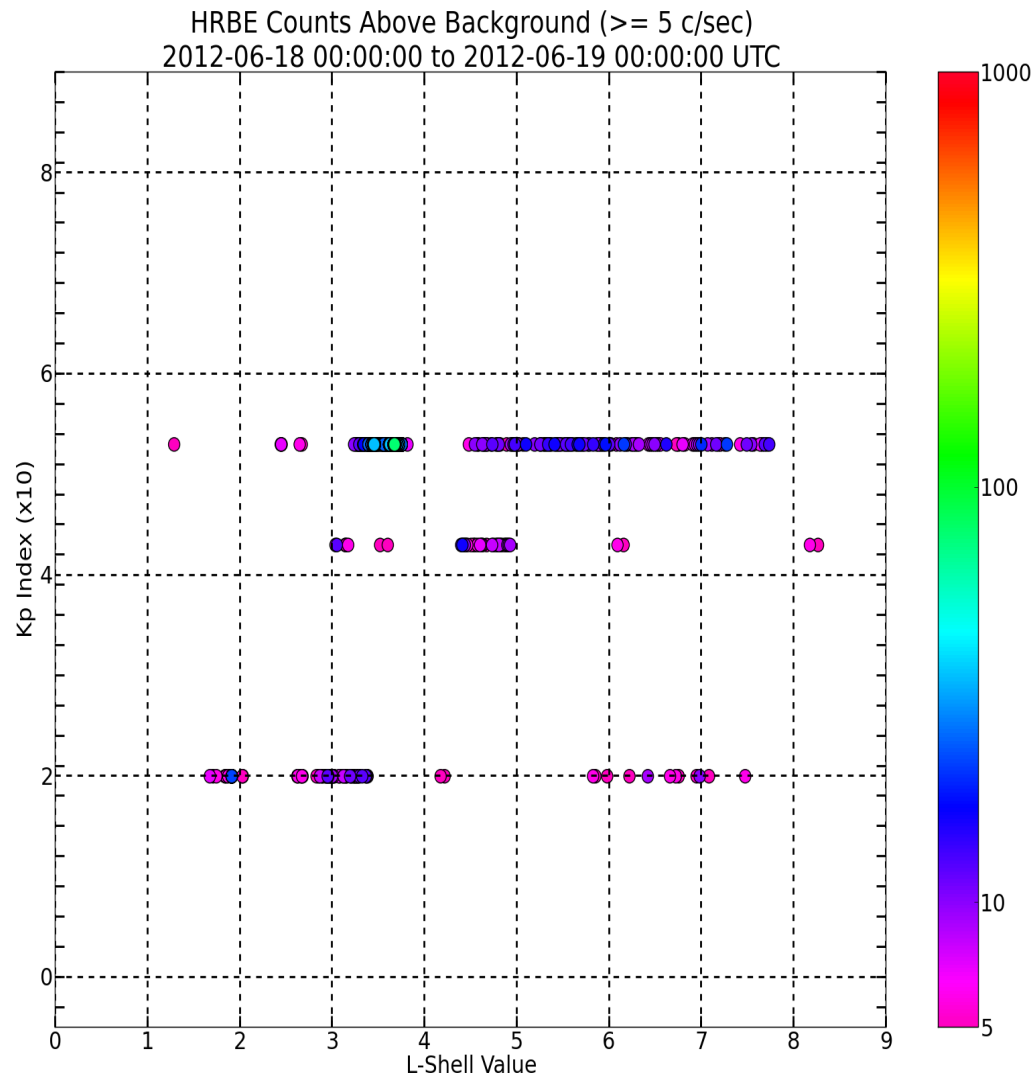
5128

2564

1

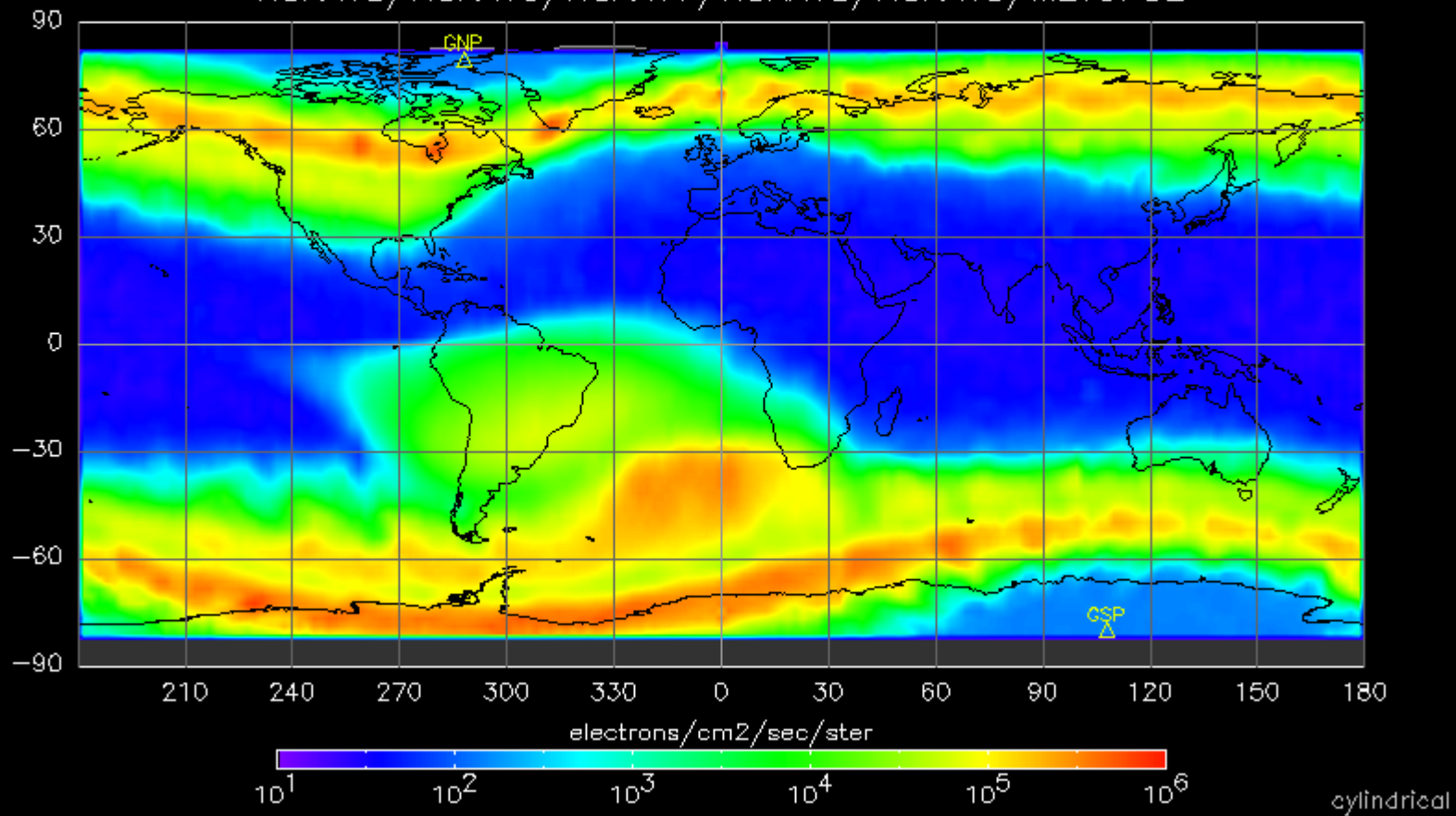


2012-06-13 23:56:00 UTC PTHNA 0.4 s



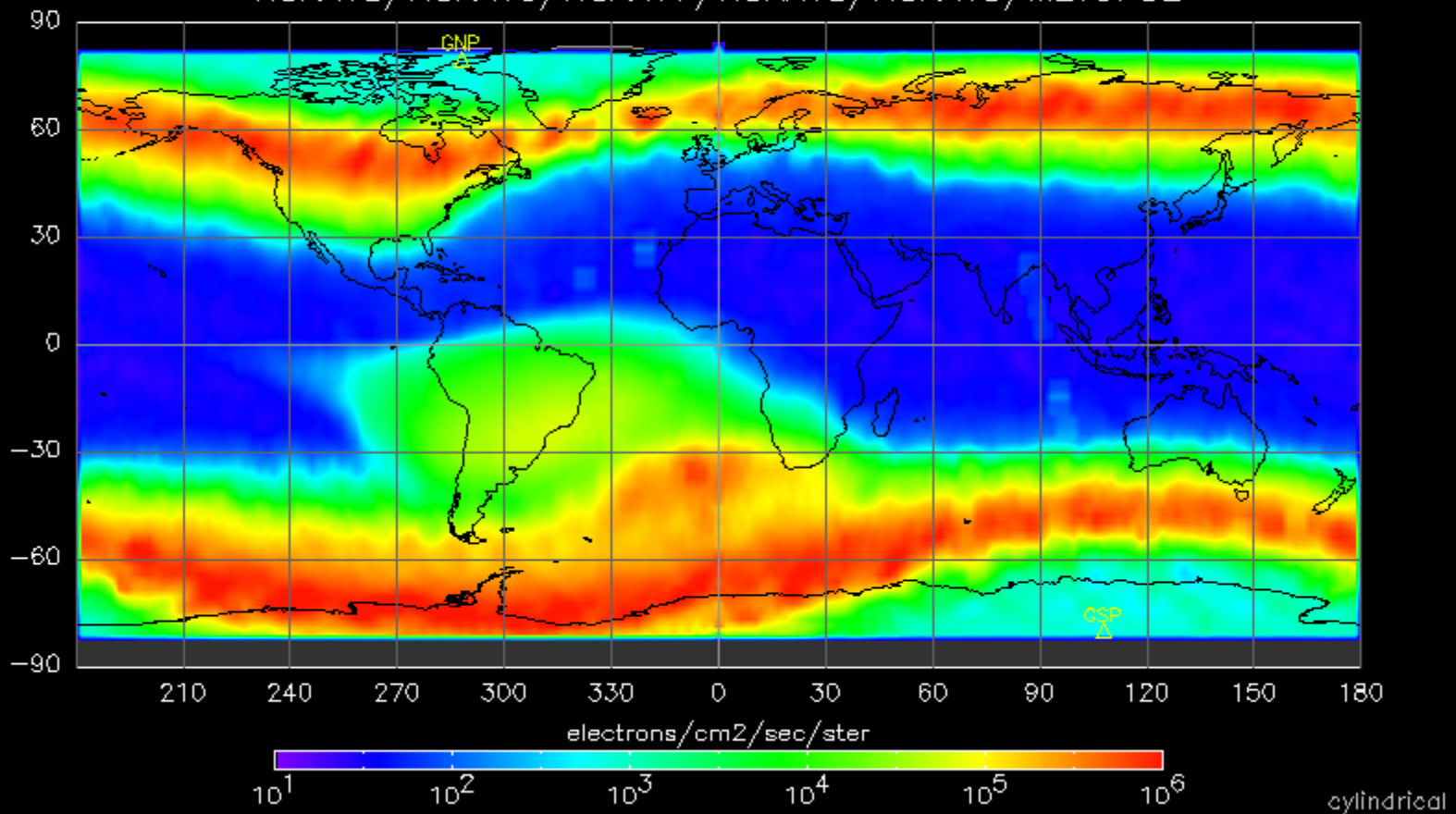
9 June: A Quiet Day

> 30 keV Electrons (E1 90° Horizon)
2012-06-08 to 2012-06-10
NOAA15/NOAA16/NOAA17/NOAA18/NOAA19/METOP02

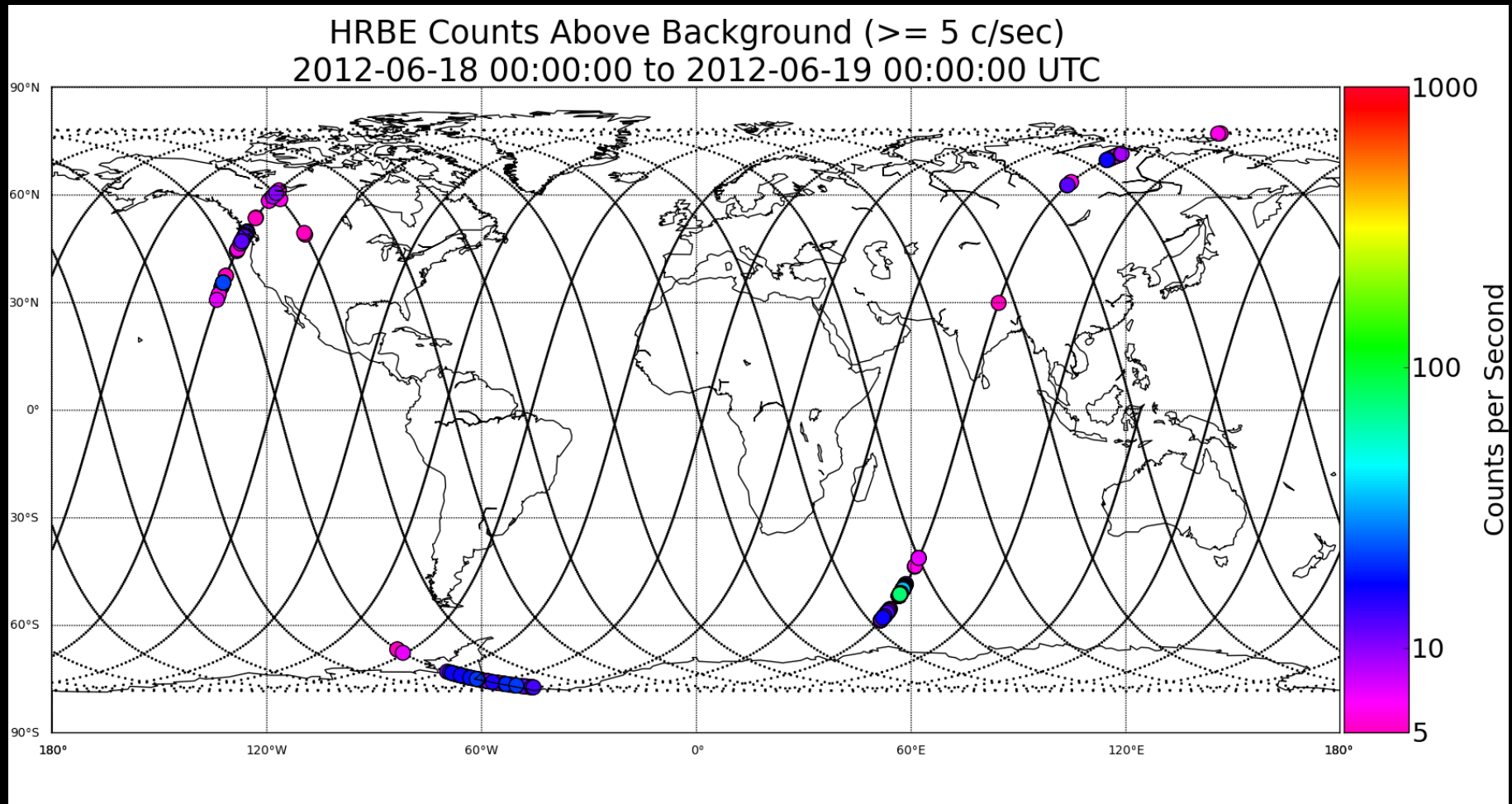


18 June: M-Class Flare

> 30 keV Electrons (E1 90° Horizon)
2012-06-17 to 2012-06-19
NOAA15/NOAA16/NOAA17/NOAA18/NOAA19/METOP02



18 June: M-Class Flare



HRBE Flux

- HRBE software stores a count rate: 'Counts per second'
- Flux can be calculated:

$$\Phi = \frac{\text{Counts}}{s} \frac{1}{GF \times \text{Efficiency}}$$

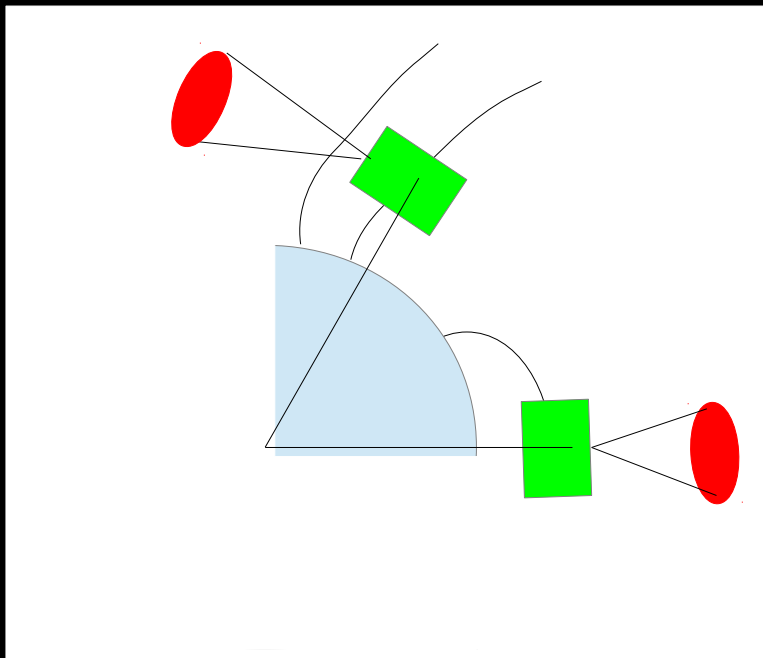
- GF is Geometric Factor:

$$GF = \text{Area} \times \Omega$$

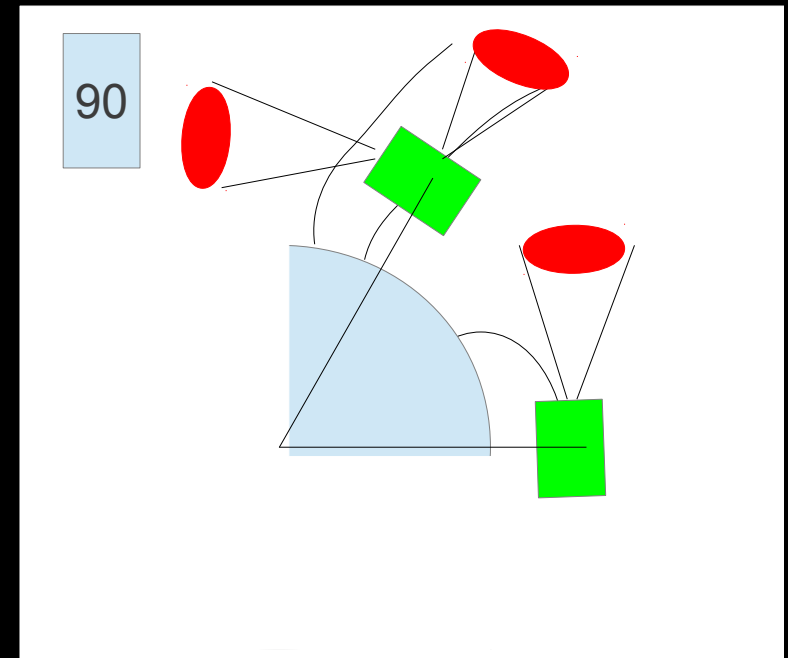
$$\Omega = \text{Solid Angle}$$

Why should HRBE be coincident with the 90-degree detector?

HRBE

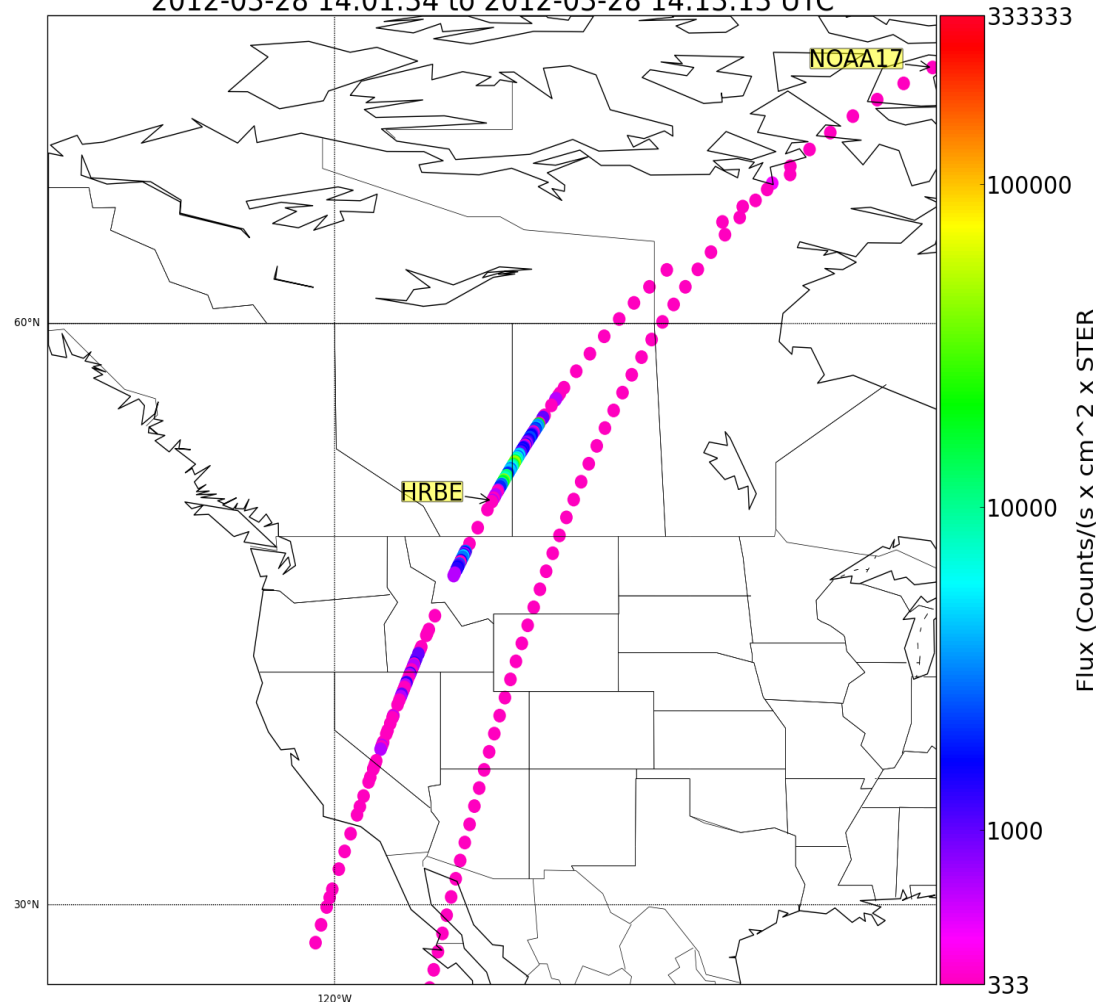


NOAA



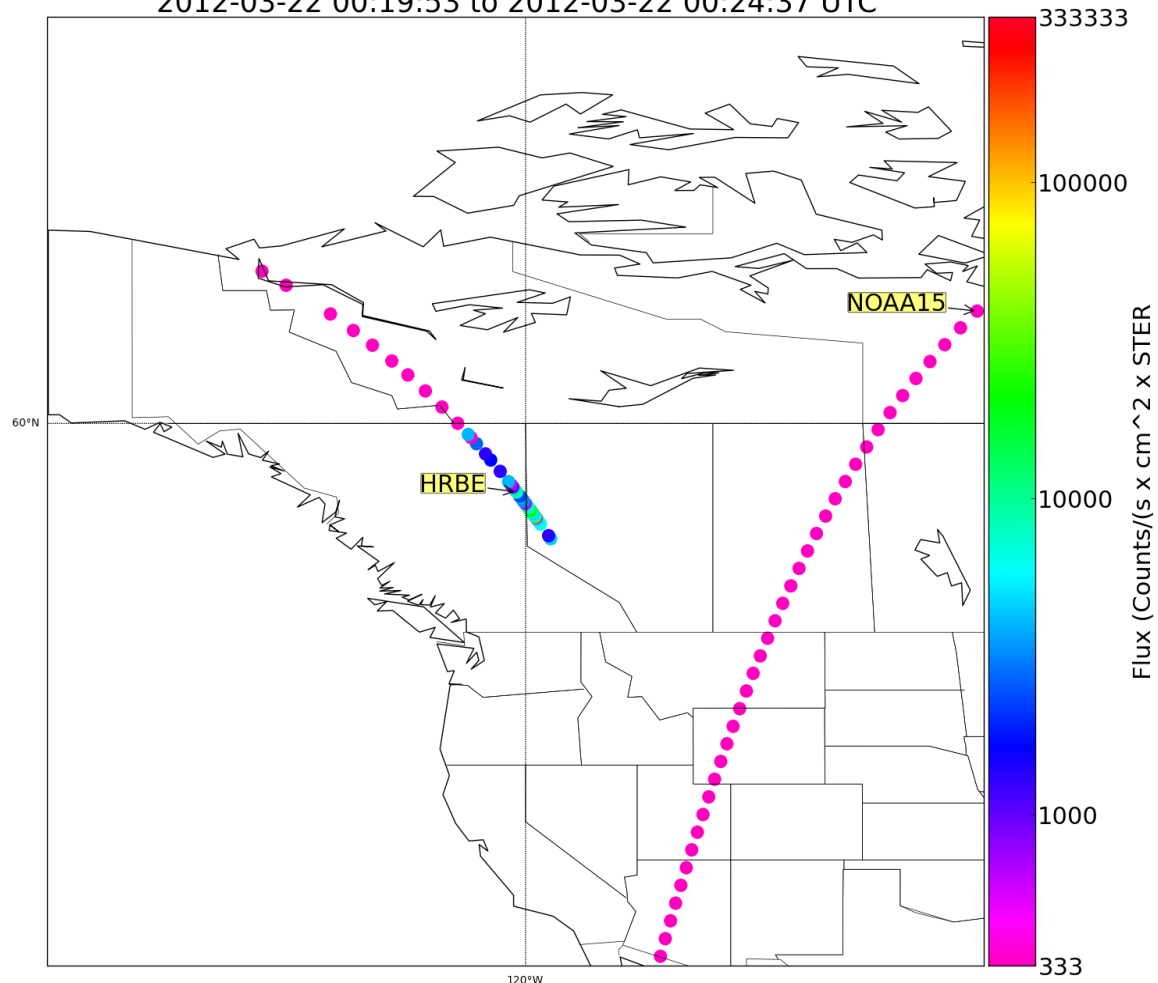
Direct Flux Comparisons: HRBE with NOAA POES Satellites

HRBE Counts Above Background (≥ 333 c/sec) and NOAA POES Flux in 90-degree Direction
2012-03-28 14:01:34 to 2012-03-28 14:13:13 UTC



Direct Flux Comparisons: HRBE with NOAA POES Satellites

HRBE Counts Above Background (≥ 333 c/sec) and NOAA POES Flux in 90-degree Direction
2012-03-22 00:19:53 to 2012-03-22 00:24:37 UTC



Further Work

- Compare our count data to SAPS events
- Continue comparing our flux with NOAA flux
 - Gain a better understanding of how the satellite is working
 - Attempt to normalize our flux with NOAA POES flux
 - Explain differences in our flux and NOAA flux
- Look for solar proton events appearing in our data
 - Data taken at high L-values (over open field lines)
- Write a paper

Citations

- 1. Li, X, and M.A. Temerin, The Electron Radiation Belt, *Space Science Reviews*, 95(1/2), 569, 2001.
- 2. Walt, Martin, Introduction to Geomagnetically Charged Particles, Cambridge University Press, 2005.
- 3. <http://www.swpc.noaa.gov/info/Kindex.html>
- 4. Temerin, M.A., and X. Li, A New Model for the Prediction of Dst on the Basis of the Solar Wind, *Journal of Geophysical Research*, Vol 107 (A12), 1472, 2002.

Acknowledgements

- Special thanks to Dave for all his help and guidance
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