

Explorer-1 [Prime]: Analyzing the Data

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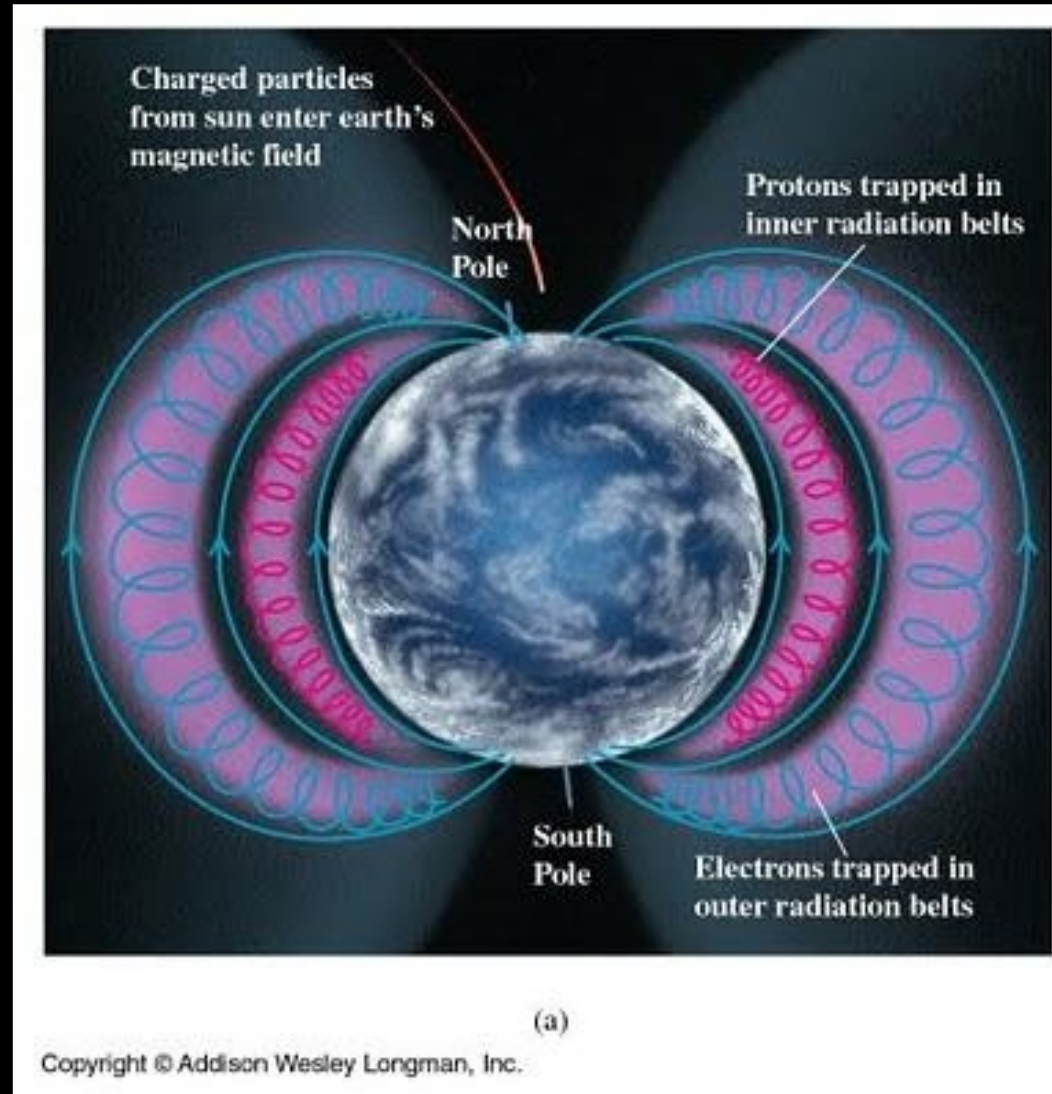
Explorer-1 [Prime] (aka HRBE)



- - United States' first satellite
 - Discovered the Van Allen Radiation Belts
 - E1P uses Geiger Tubes donated by Dr. Van Allen
- Designed to monitor the intensity and location of the radiation belts
 - Counts charged particles, mainly electrons > 50 keV
- Proof of concept of the viability of Small Satellites to monitor space weather and contribute important science

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
- Belts populated from 3 sources
 - Electrons (inner and outer belt)
 - Ionosphere¹
 - Solar wind¹
 - Energetic protons (inner belt)
 - Neutrons produced by cosmic rays¹
 - Neutrons decay¹



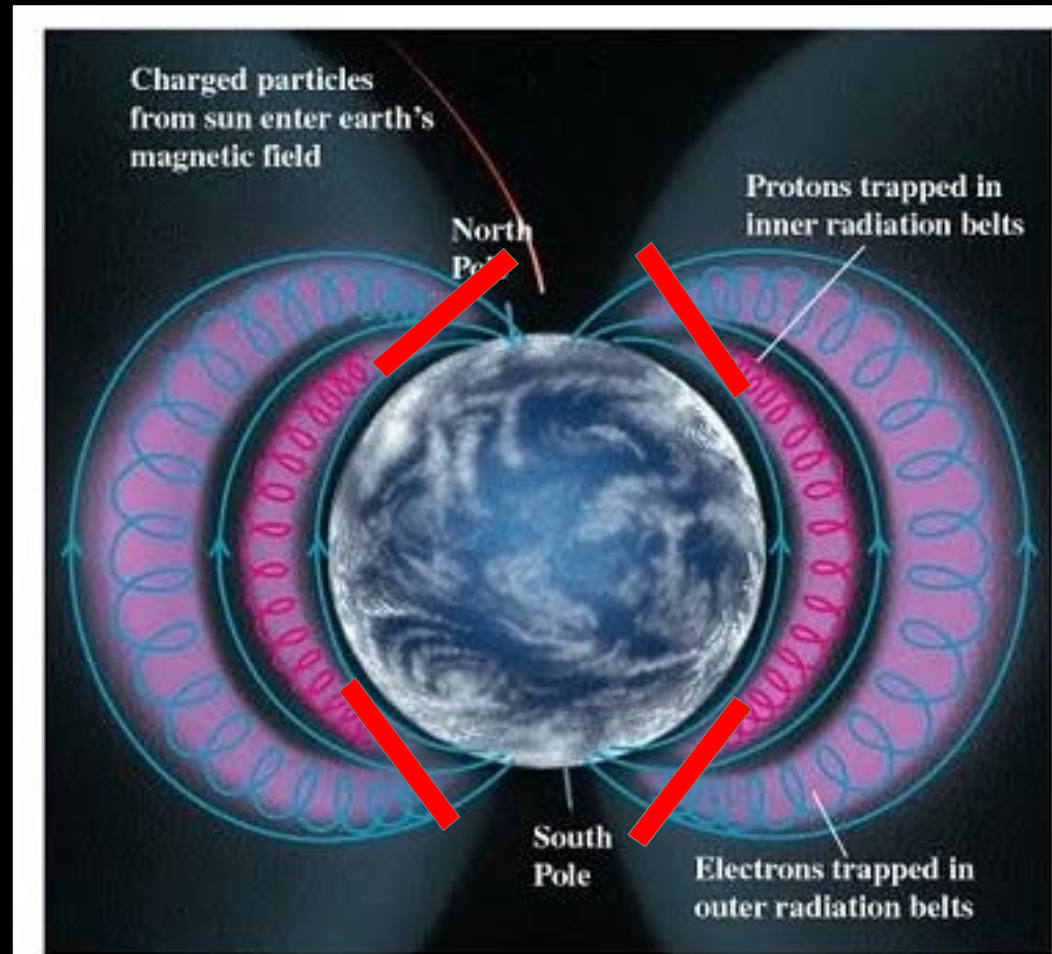
L-Shells

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

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

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

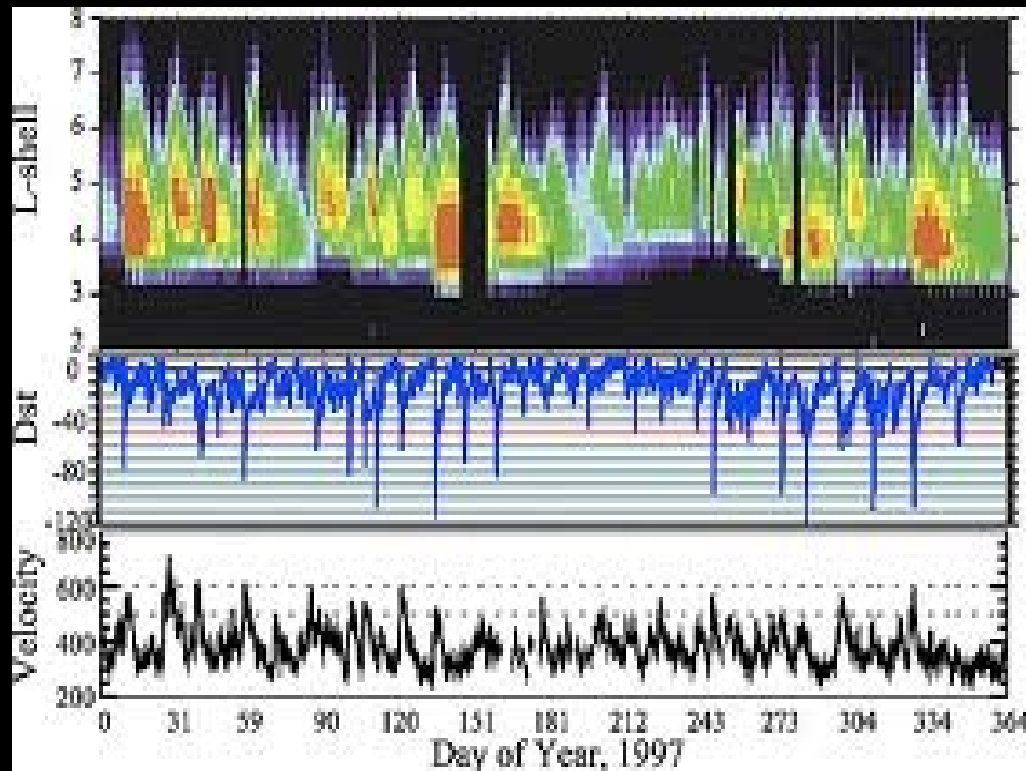
- r is in Earth radii, λ is geomagnetic latitude
- $L R_E \sim$ distance from dipole center to a field line at the equator



Electron Acceleration

- Typical source temperatures ¹
 - Ionosphere: ~ 1 eV
 - Solar Wind: ~ 10 eV
- But the Radiation Belts:
 - ~ 100 keV – 15 MeV**
 - Through heating and acceleration by electric and magnetic forces
- Not well understood:
 - Predictions of radial diffusion theory have withstood some tests ¹
 - Correlations between MeV electron flux and solar wind velocity ¹

- Natural radio waves (whistler waves) generated by geomagnetic storms could be involved ¹



Reeves et al. (2003)

Motion of Charged Particles ²

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

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

- Bounce Motion:

- The Magnetic Mirror Effect

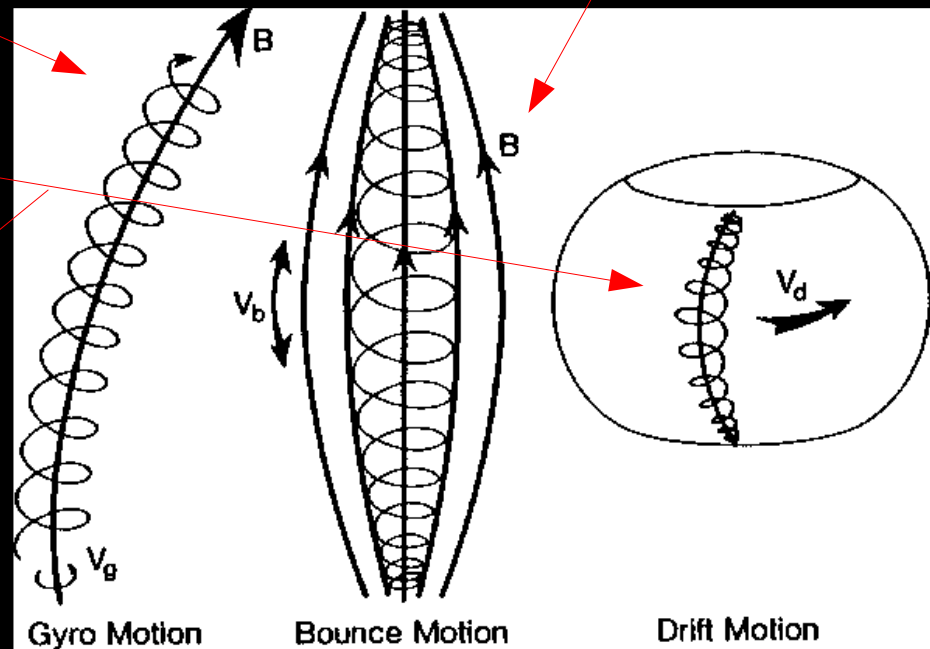
$$\mathbf{F}_m = \frac{-mv_{\perp}^2}{2B} \nabla B$$

- Gradient Drift

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

- Curvature Drift

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

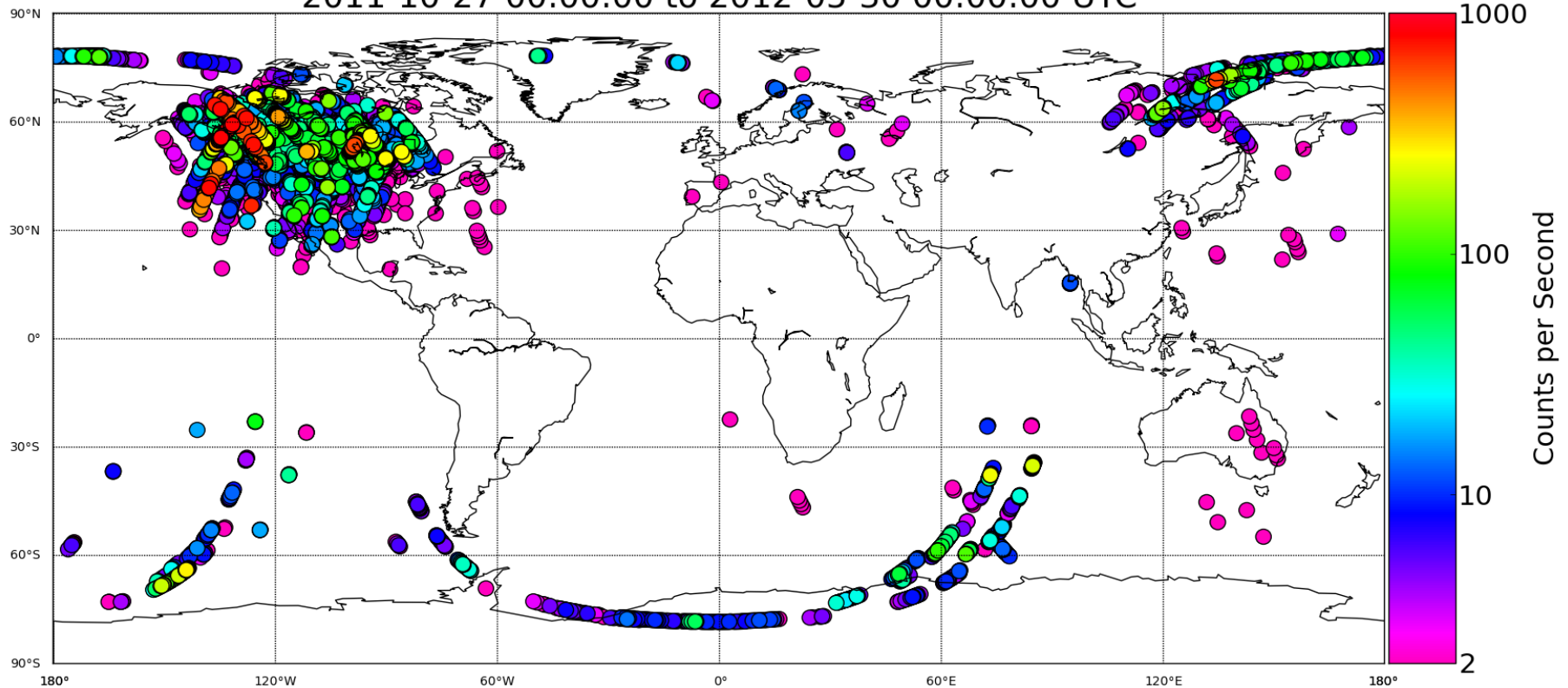


KP and DST Indexes

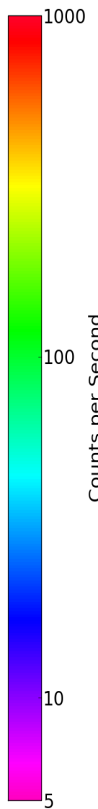
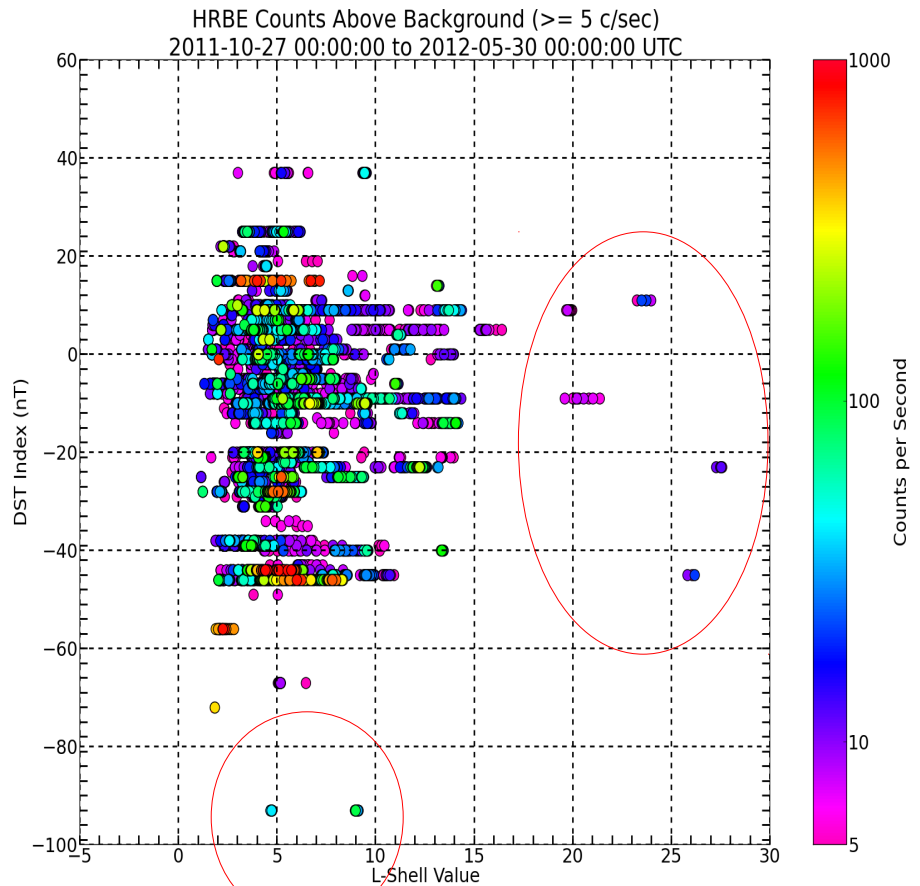
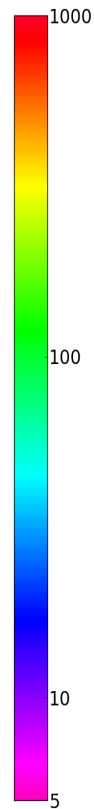
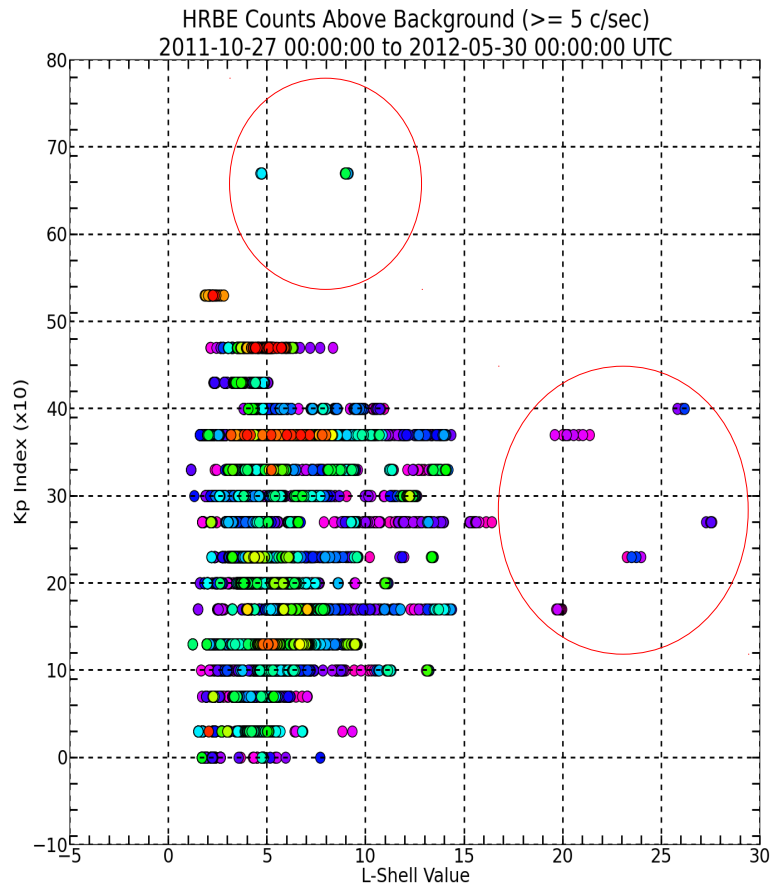
- Measures of the horizontal component of the earth's magnetic field
- Magnetic field varies with solar activity
- KP Index ³
 - Measured from higher latitudes
 - KP of 0-4 is below storm level
 - Kp of 5-9 indicates increasingly powerful storms
- DST Index ⁴
 - Measured close to the equator
 - $DST < -50$ nT indicates a magnetic storm
 - Measure of magnetospheric current (ring current)

Counting particles since 10-28-2011

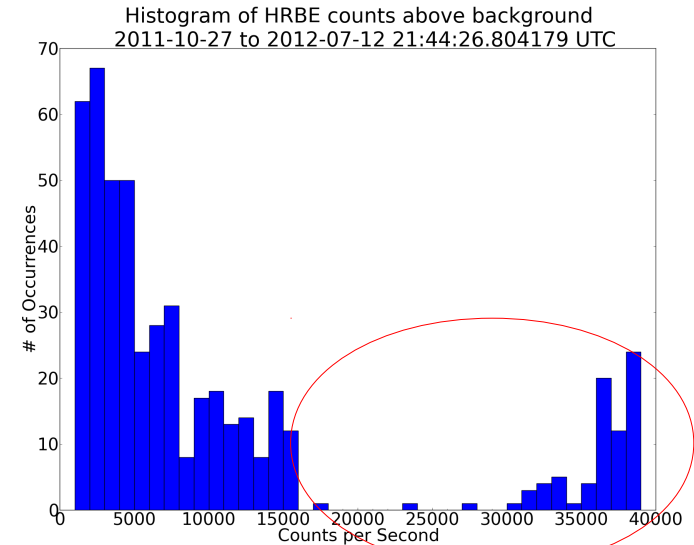
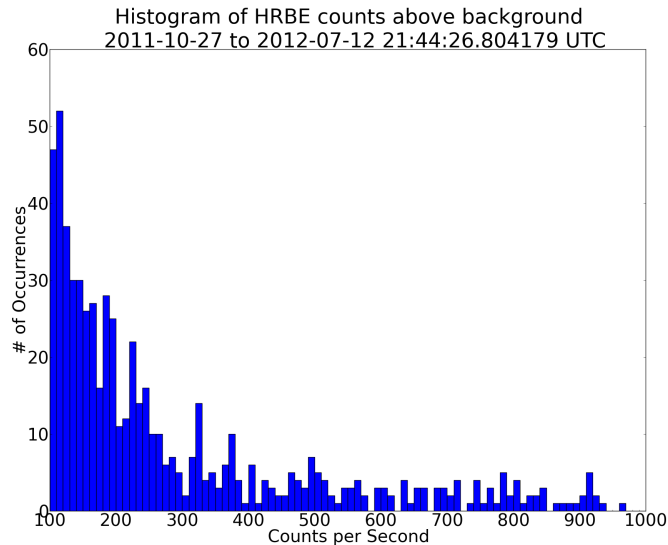
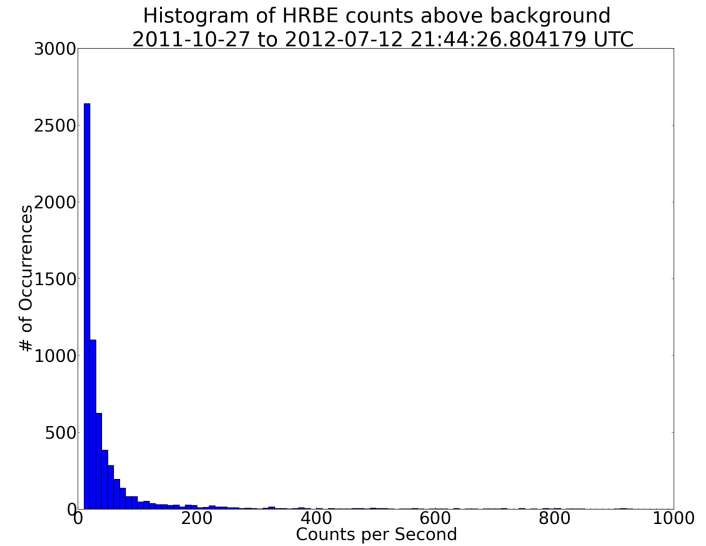
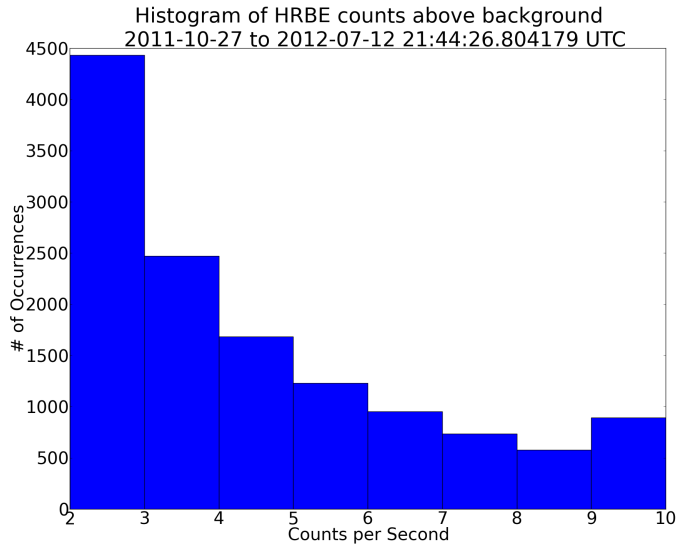
HRBE Counts Above Background (≥ 2 c/sec)
2011-10-27 00:00:00 to 2012-05-30 00:00:00 UTC



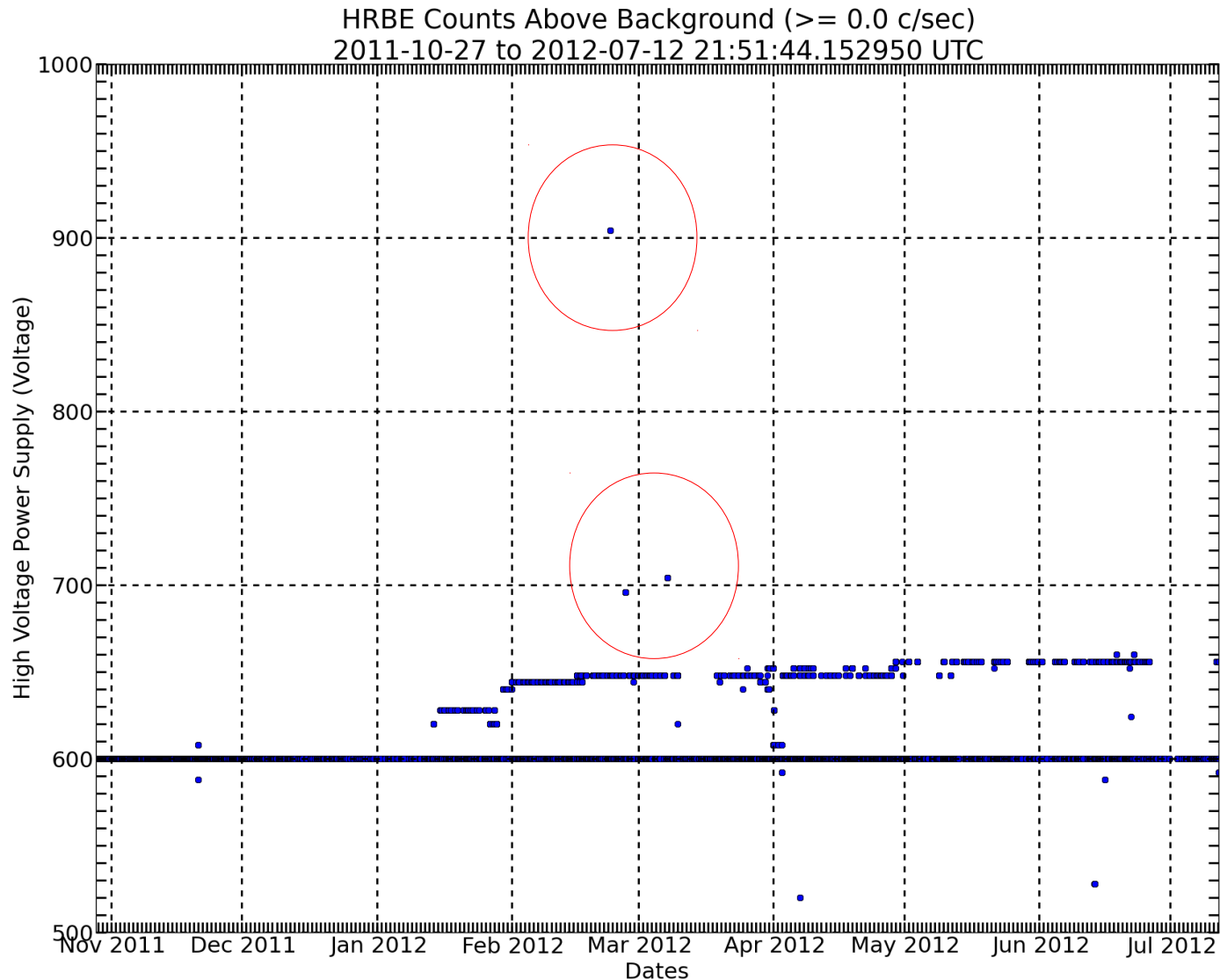
Comparing E1P to KP and DST



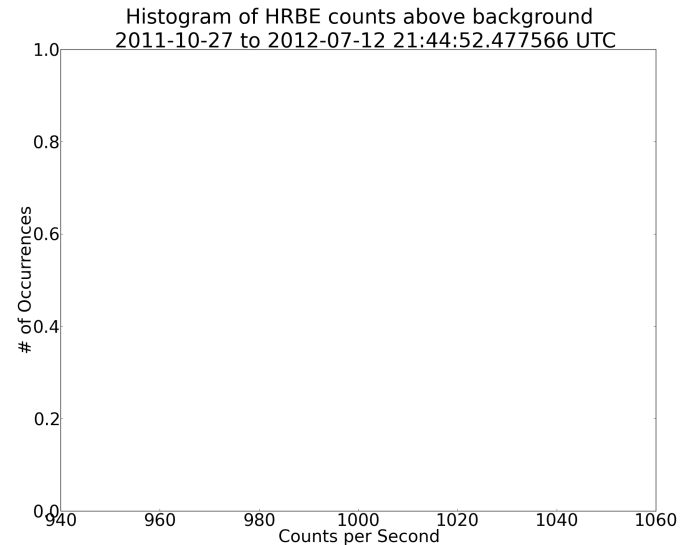
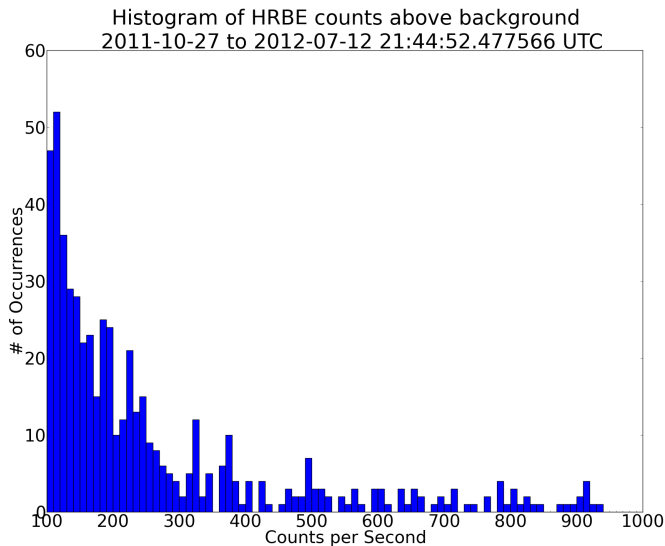
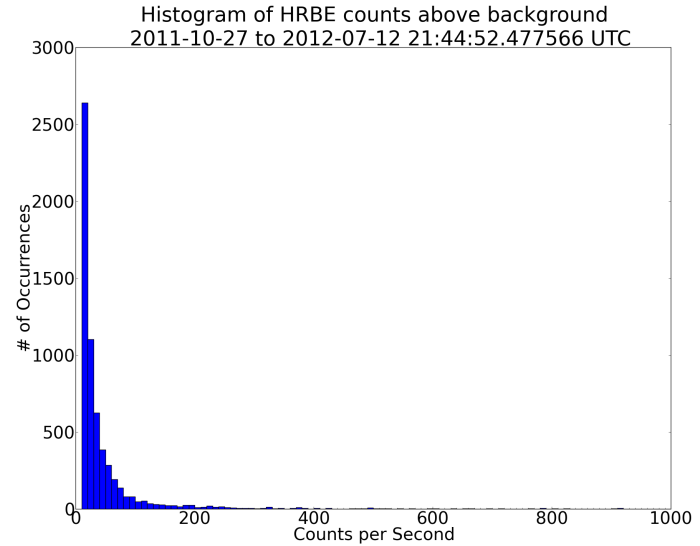
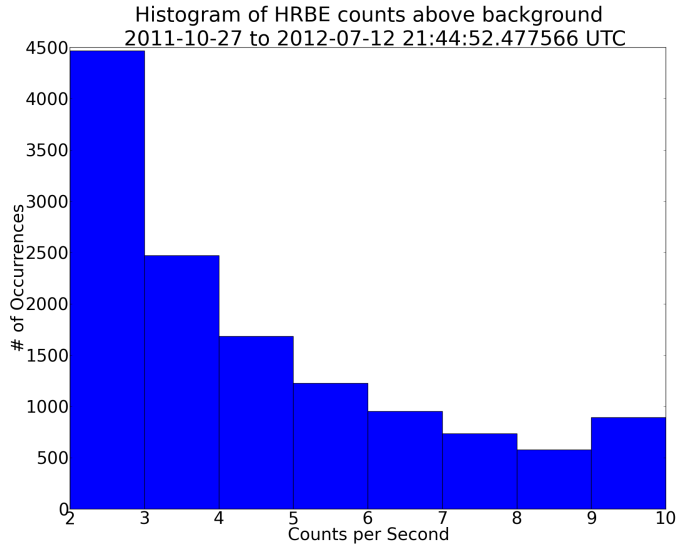
Finding science in E1P's Data



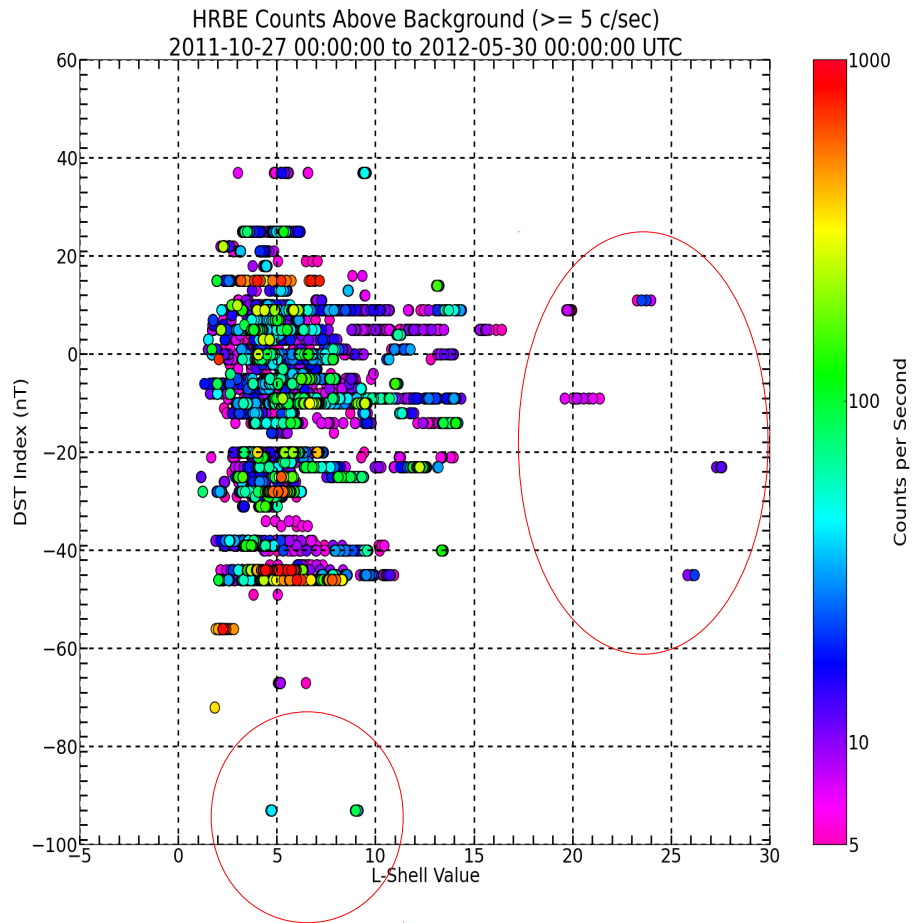
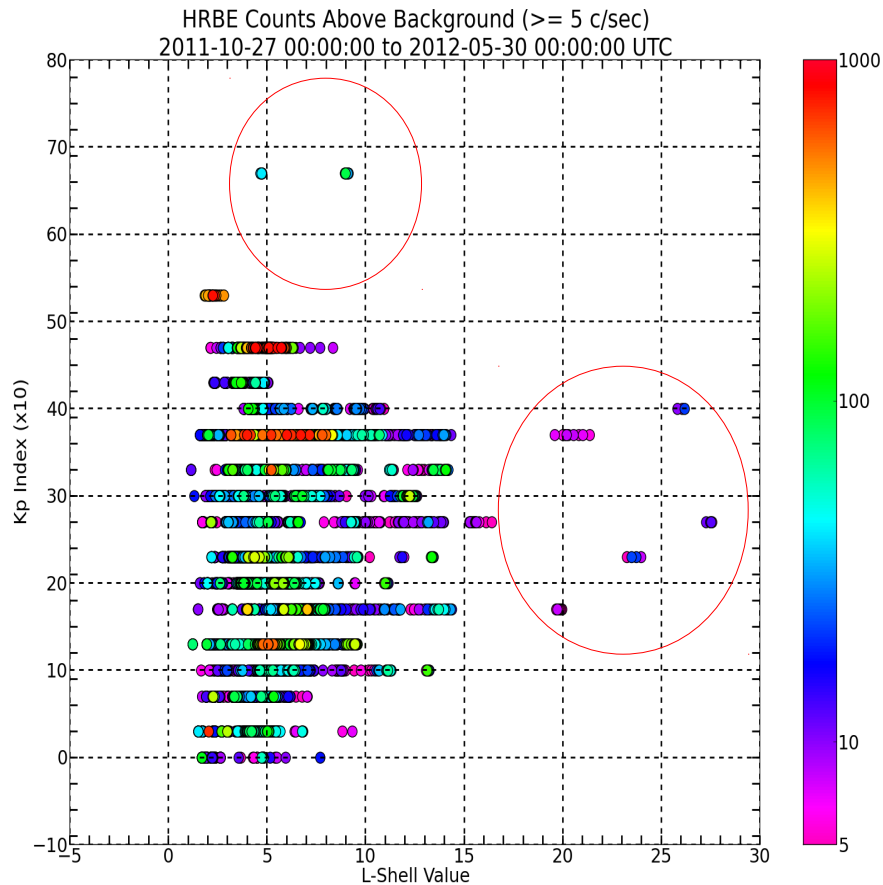
Problems with Over-Voltage



After removing Over-Voltage Data



After removing Over-Voltage Data



Preliminary Conclusions

- Using the telemetry data we were able to remove spurious counts
- We still see large counts after removing bad data
- Possible large geomagnetic events remain apparent after removing bad data

Coming soon...

- Use magnetic activity plots to focus in on possible interesting events (solar activity, etc.)
- Compare E1P flux data (calculated from our counts per second) to flux data from NOAA POES satellites
 - Specifically when E1P's orbit was in conjunction with NOAA satellites' orbit

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.

TO BE CONTINUED...