

Analysis of Suprathermal Events Observed by STEREO/PLASTIC with a Focus on Upstream Events

STEREO SWG - 20 Meredith, NH
October 27-29, 2009

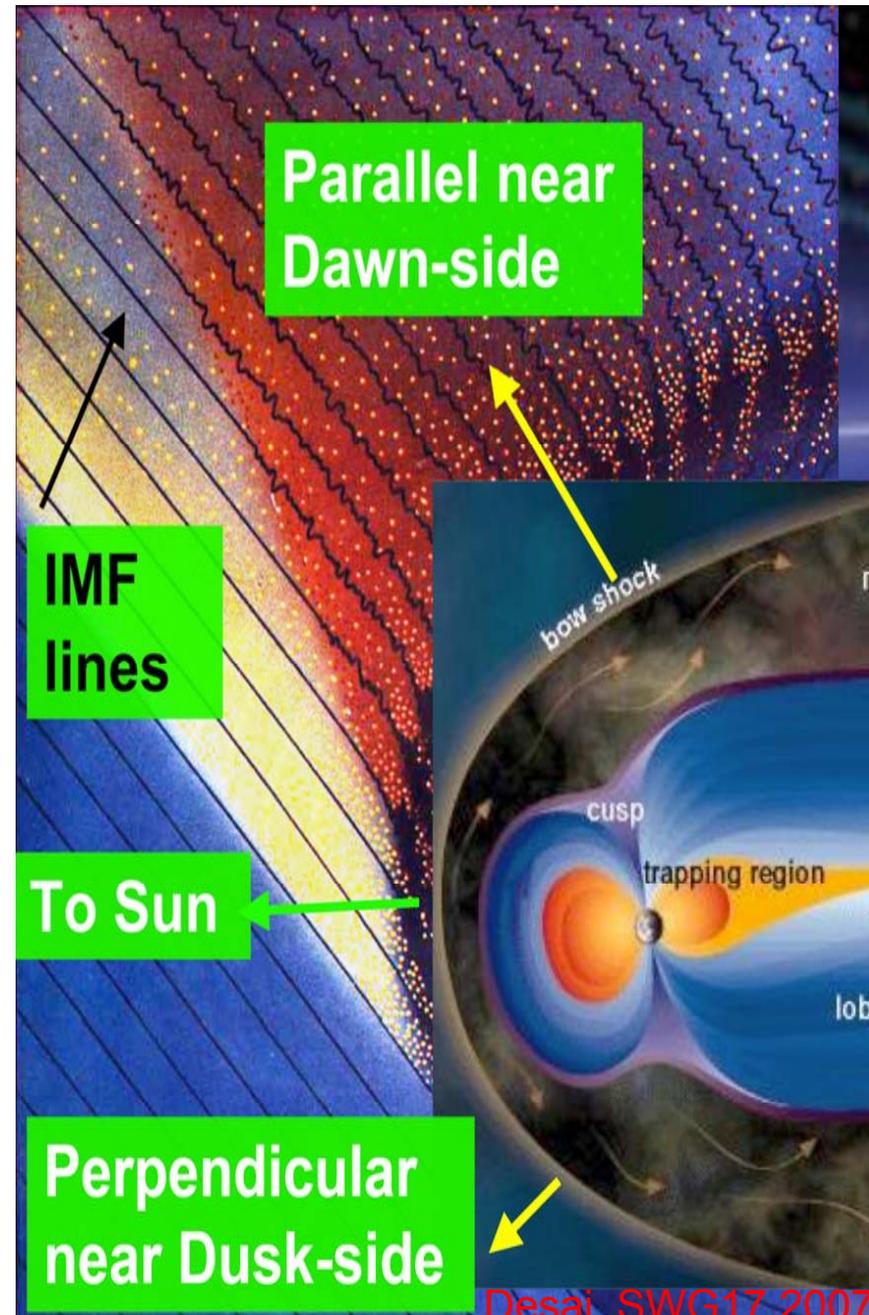
Josh Barry, Antoinette Galvin, Mark Popecki, Lorna Ellis & Kristin Simunac
University of New Hampshire

Overview

- Background on upstream / magnetospheric events.
- Automated process to select suprathermal proton events.
- Criteria for field aligned anisotropic suprathermal proton events (upstream / magnetospheric events).
- Decrease and flattening of the occurrence of events with increasing STA-Earth separation.
- Estimate of the cutoff of upstream /magnetospheric events seen with STEREO.

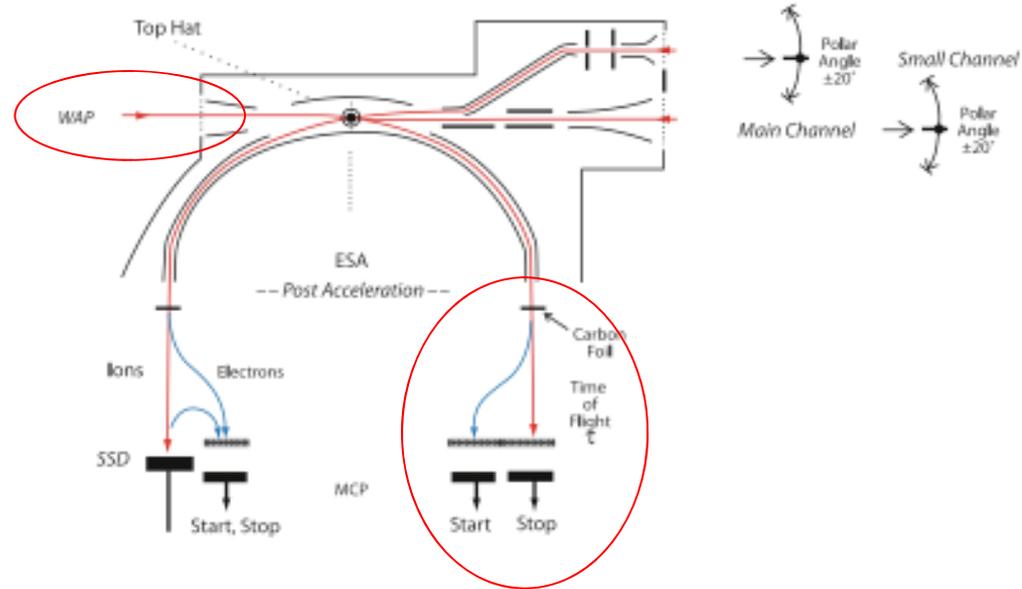
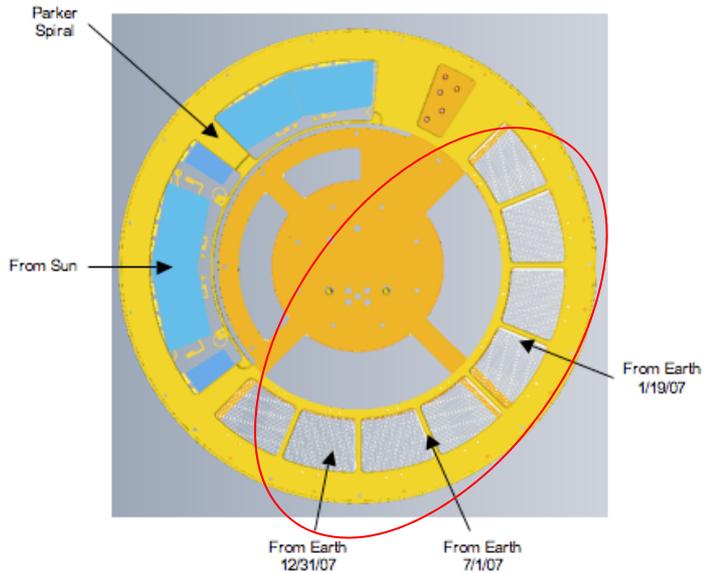
Background on Upstream Ion Events

- Sources of Upstream Ion Events
 - Upstream Events
 - Solar Wind ions accelerated at the Earth's bow shock
 - Field Aligned Beams (FAB's)
 - » Accelerated at the quasi-perpendicular bow shock
 - » Field aligned (Anisotropic)
 - » Proton energy spectrum [$E_{\text{Solar Wind H}^+}$, 15keV]
 - Diffuse Ions
 - » Accelerated at the quasi-parallel bow shock
 - » Isotropic
 - » Ion energy spectrum extends above 150keV/q
 - Magnetospheric Ion Events
 - Accelerated by cusp, magnetotail, or magnetosheath of the magnetosphere
 - Leaked through the bow shock
 - Highly anisotropic
 - Ion energy spectrum extends up to ~ 2MeV

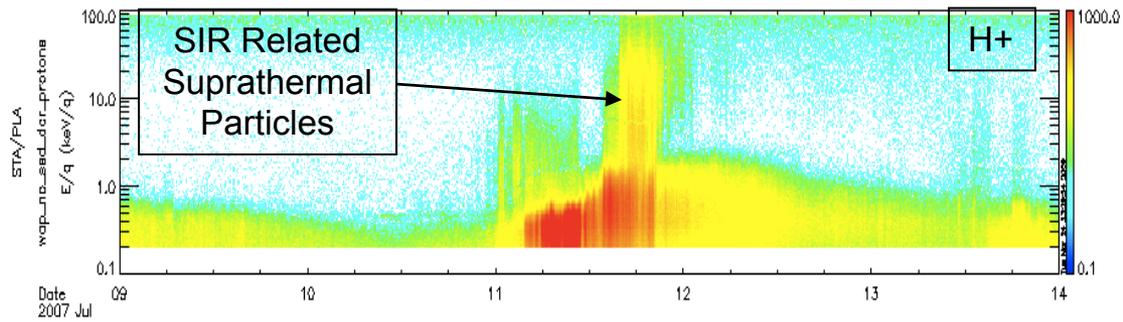
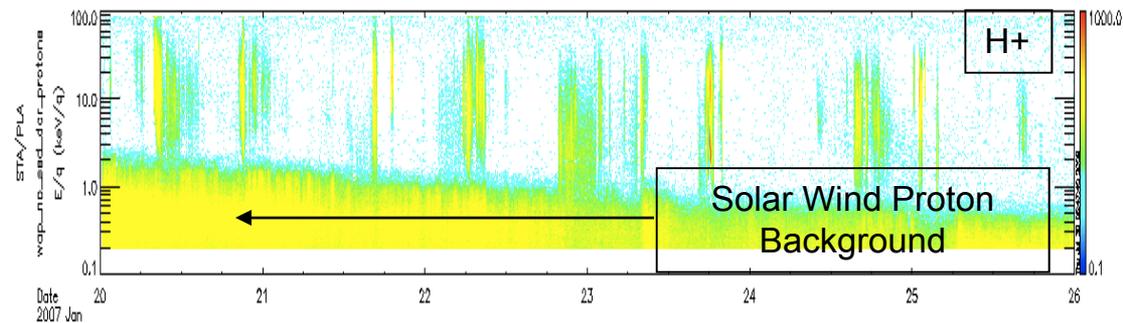


Review of STEREO/PLASTIC

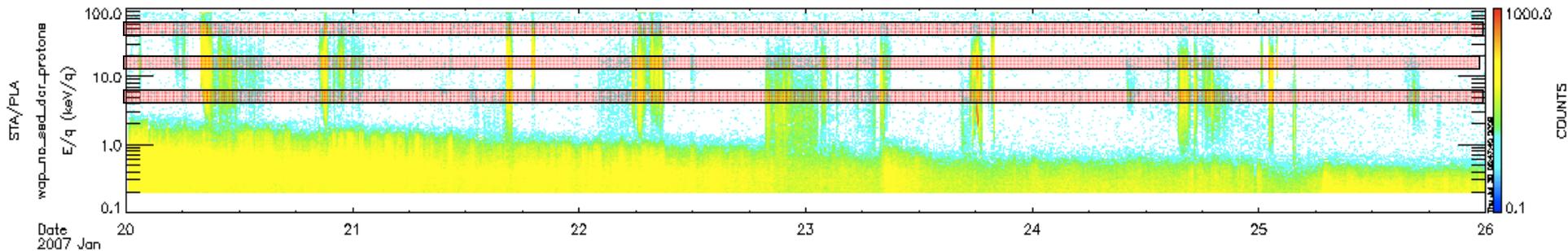
Cutaway of STA/PLASTIC



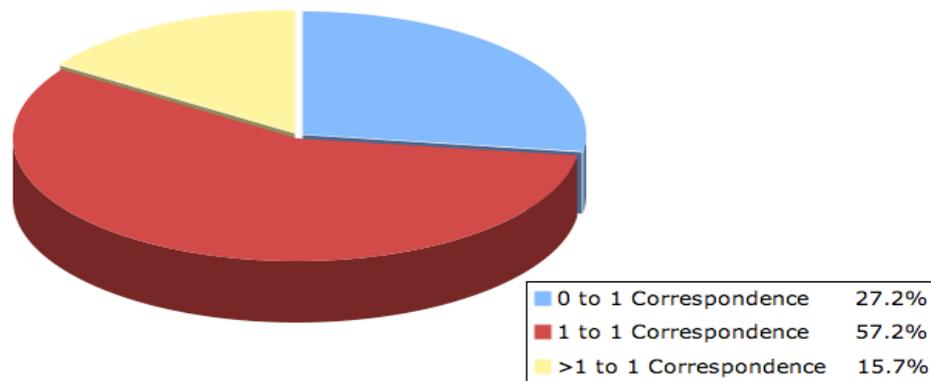
- Analysis utilizes WAP non-SSD portion of STA from 1/19/07-1/01/08.
- Energy spectrograms of protons are used in the search for suprathermal events.
- Solar wind proton background can be seen at lower e/q values (y-axis).
- Possible upstream / magnetospheric suprathermal events can be identified in this energy spectrogram spanning 6 days in Jan-07 (Top Plot).
 - Short duration bursty events.
- SIR related suprathermal protons seen in the lower energy spectrogram of 5 days in Jul-07 (Lower Plot).



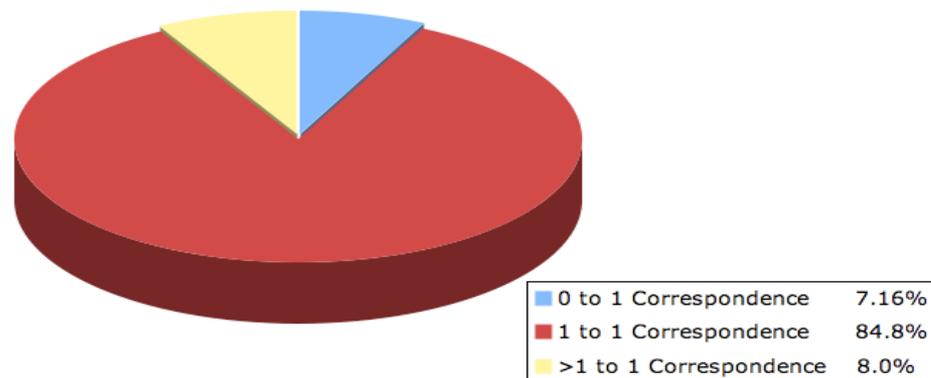
Automated Suprathermal Event Definition



Manually Defined Suprathermal Event Overlapped by Automatically Defined Suprathermal Events



Automatically Defined Suprathermal Event Overlapped by Manually Defined Suprathermal Events

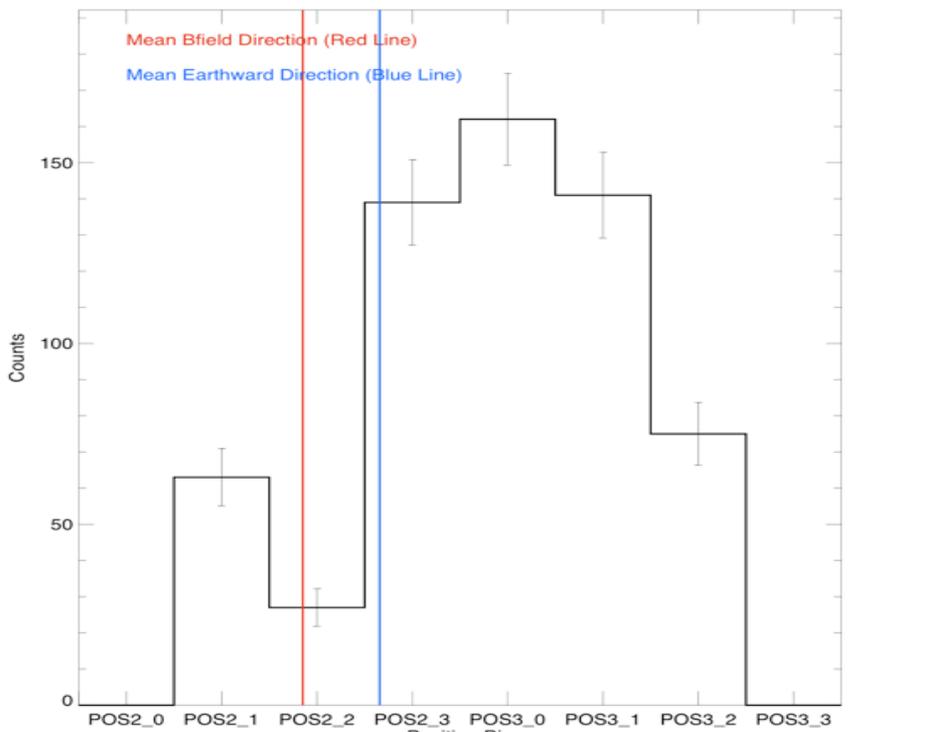


- Each E/Q band (red bands in the energy spectrogram) covers the same number of ESA steps.
- E/Q bands exclude instrument solar wind background.
- An automated suprathermal event is defined if the 10min sum of events in an E/Q band exceeds the daily background of an E/Q band times a scaling factor.
- The scaling factor was optimized to increase the percentage of 1 to 1 correspondences and decrease the percentage of 0 to 1 correspondences.
- Manual inspection lead to the definition of 383 suprathermal events while the Automated selection yielded 363 events.

Selection of Field Aligned Anisotropic Automated Events

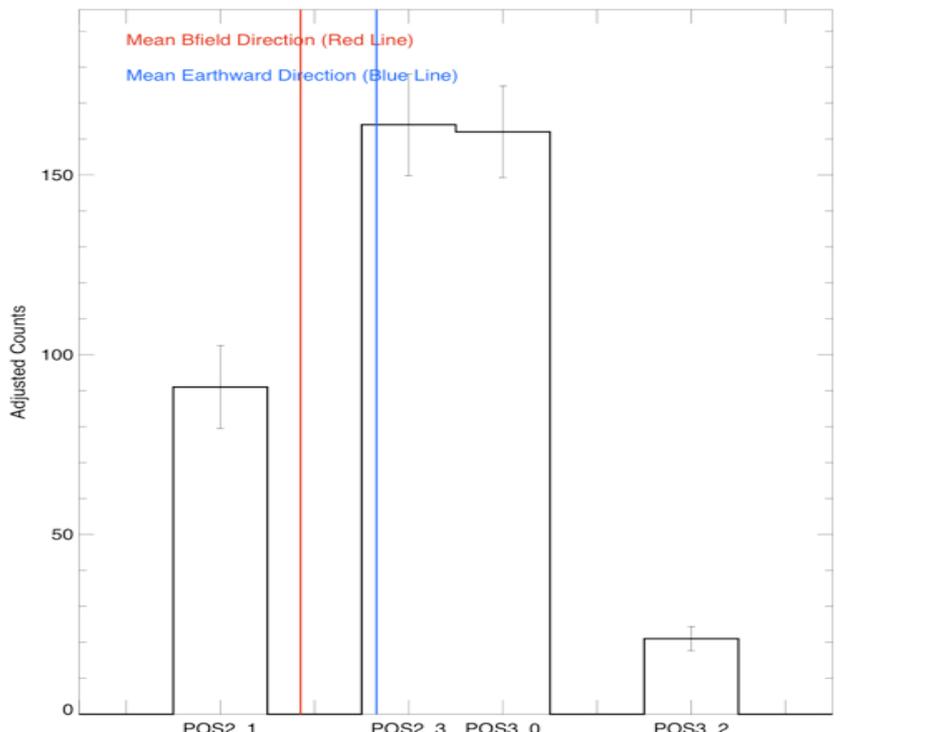
- To obtain the raw position histogram (bottom left) for an automatically defined event, PHA events from the WAP non-SSD side within an event time period are filtered to exclude the following:
 - Events falling outside a proton band in E/q vs TOF
 - Events with unknown position (POS2_0)
 - Solar wind instrument background ($E_{\text{PHA H}^+} \leq \langle E_{\text{Solar Wind H}^+} \rangle + 2\sigma$)
- A set of multiplicative factors are then applied to the raw position bins to normalize them.
 - 4 of the position bins are excluded in the analysis due to a low count rate.
- A bin is classified as anisotropic if the ratio of Max bin / Min bin - $\sigma > 2$.
- A bin is classified as field aligned if the mean magnetic field direction is less than 1 position bin away from the maximum bin.
- Of the 363 events defined automatically 159 are both anisotropic and field aligned.

STA WAP NONSSD PHA Quadrants 2 & 3 Raw Position Bin Response
From 2007-01-22/05:28:00 to 2007-01-22/05:58:00



The Histogram Excludes POS2_0, TOF < 1 ch, ESA Steps Outside the Range [0, 87.000000], and the Second Guess M/Q Outside the Range [0.500000, 1.50000]

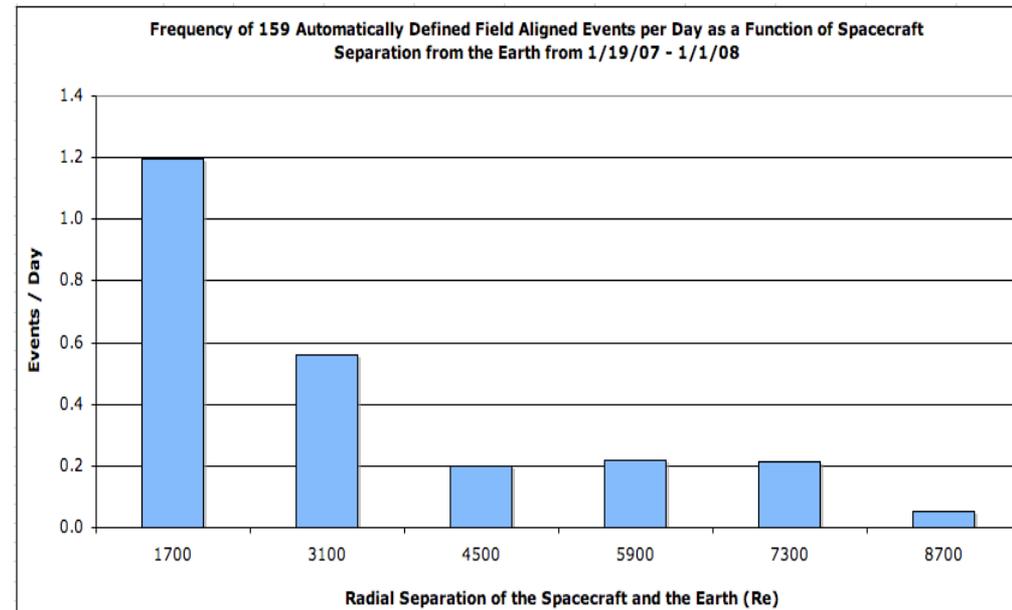
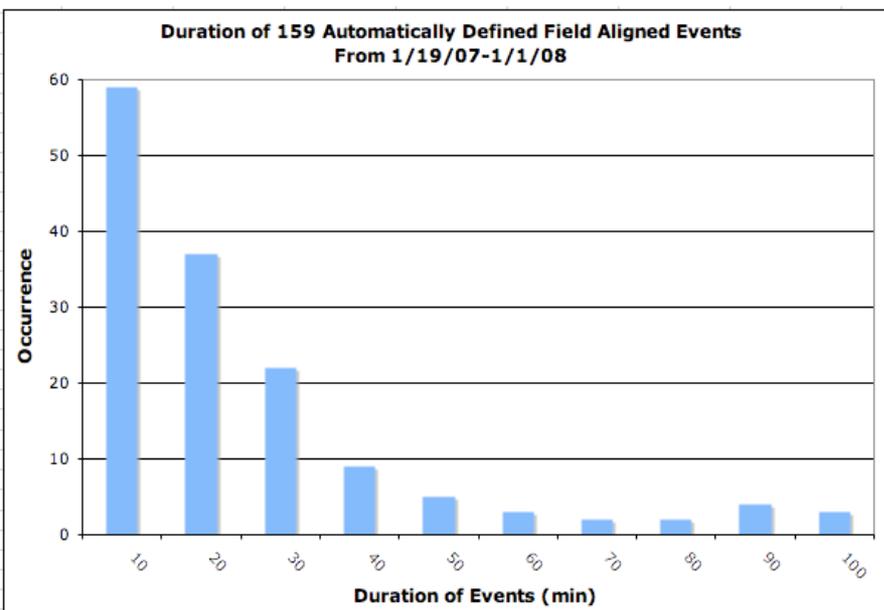
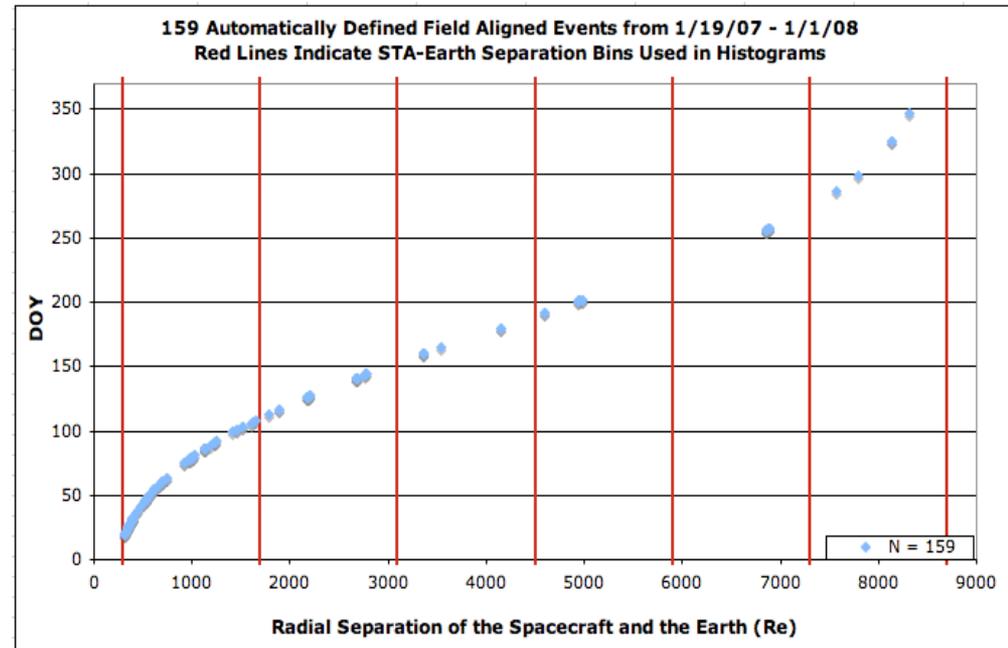
STA WAP NONSSD PHA Quadrants 2 & 3 Adjusted Position Bin Response
From 2007-01-22/05:28:00 to 2007-01-22/05:58:00



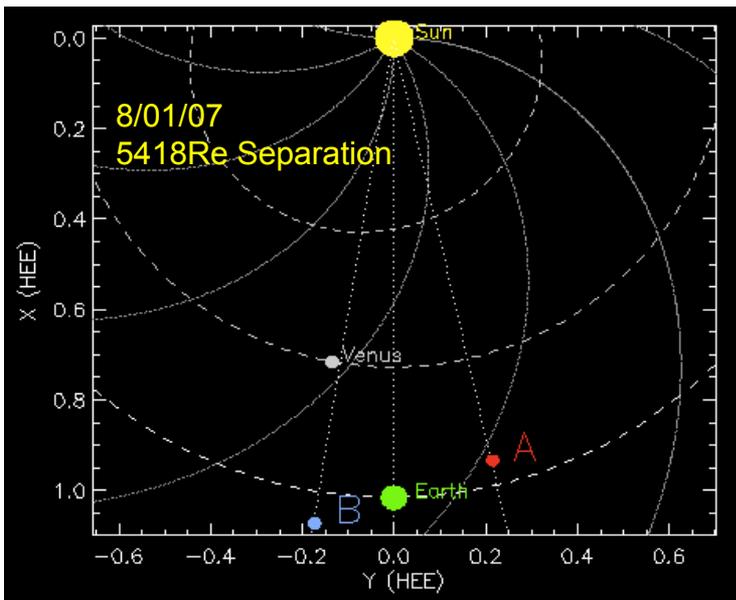
Excludes POS2_(0,2), POS3_(1,3), TOF < 1 ch, ESA Steps Outside the Range [0, 87.000000], and the Second Guess M/Q Outside the Range [0.500000, 1.50000]

Analysis of Filed Aligned Automated Suprathermal Events

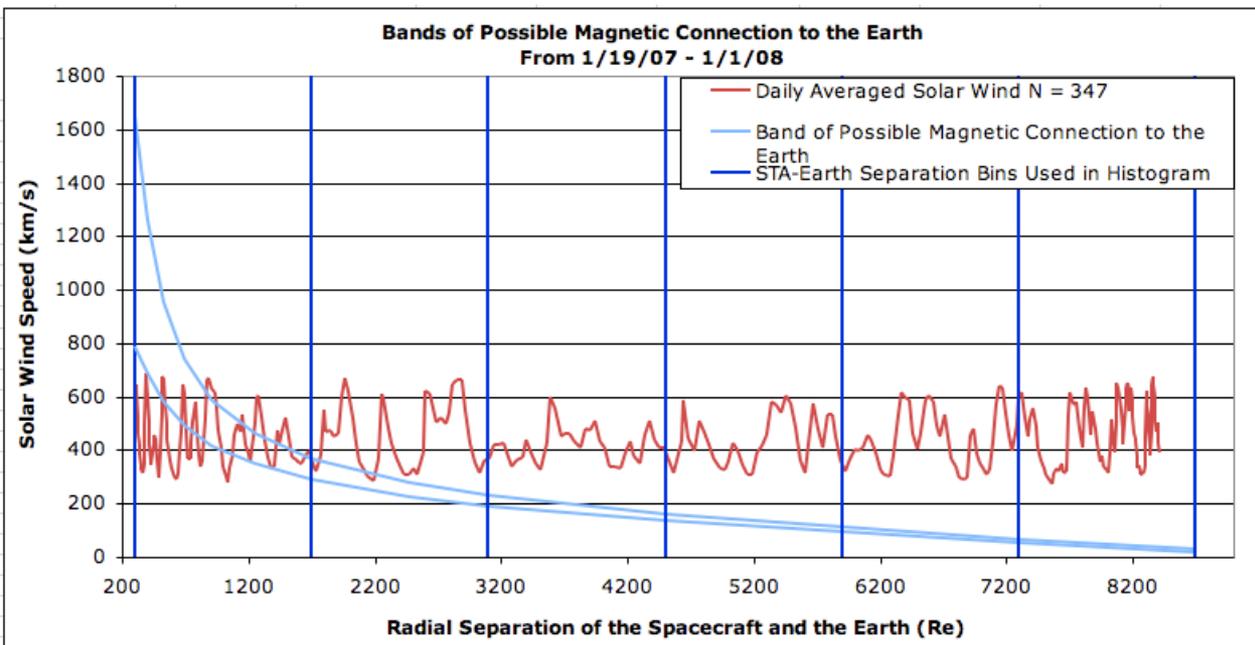
- With increasing spacecraft separation from the Earth the frequency of field aligned events decreases.
- A trend like this is expected if the majority of the suprathermal events in the analysis are upstream or magnetospheric events.
 - Large STA-Earth separation means there is a smaller probability that the spacecraft is magnetically connected to the Earth.
- The histogram of events / day over distance indicates a leveling off after about 3000Re.
- Distribution of event durations is similar to the Desai et. al., 2000 results.



Rough Estimate of the Cutoff for Upstream / Magnetospheric Events



- What Spacecraft-Earth separation is it unlikely that STA is magnetically connected to the Earth?
- A band (area between the light blue lines) representing a rough estimate of the possible magnetic connection of STA to the Earth is produced as follows:
 - X,Y,Z coordinates of STA and the Earth are found for the dates corresponding to the dark blue lines.
 - A solar wind velocity is found so that the Parker spiral will connect STA to positions 40Re upstream and 200 Re downstream of the Earth.



- This simple estimate ignores fluctuations in the magnetic field, distortion in the field due to SIR's, the true size of the bow shock, and the convection of the magnetic field; however, it does shed light on why the histogram bins on the previous page level of after about 3000Re.

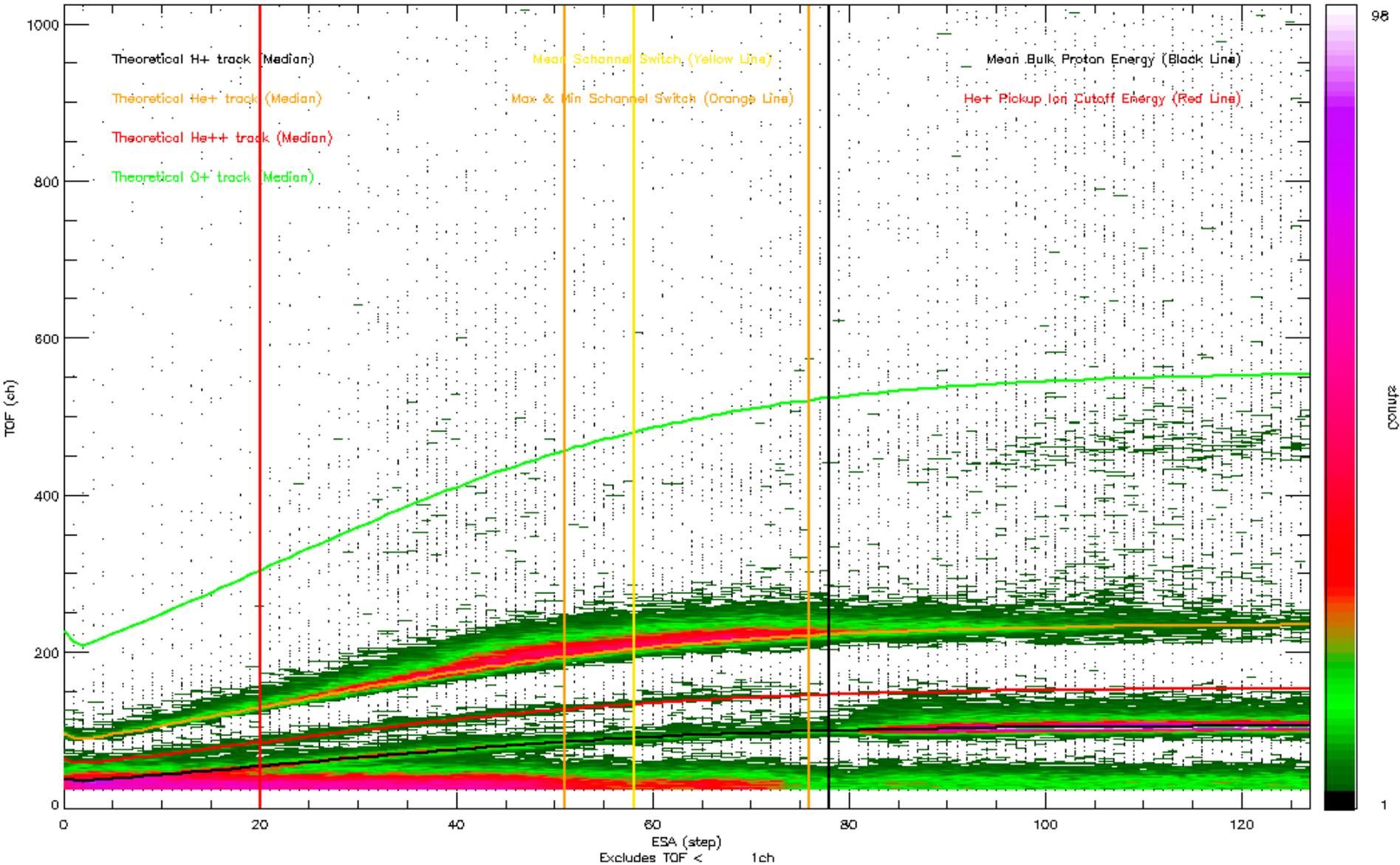
Summary

- Suprathermal proton events can be easily identified using energy spectrograms of STA WAP non-SSD data.
- In early 2007 short duration bursty suprathermal proton events, thought to be upstream or magnetospheric events, can be observed. Later in the mission these events cease to exist.
- An automated technique was created to detect suprathermal events as well as determine if those events have field aligned anisotropies.
- Events defined automatically have a sharp cutoff in occurrence when compared to Spacecraft-Earth separation.
- It is shown through a crude approximation of the magnetic field via the Parker spiral that after about 3000 R_E STA-Earth separation, it is unlikely that the Earth and spacecraft will be magnetically connected. This corresponds well with the observed cutoff in suprathermal activity.

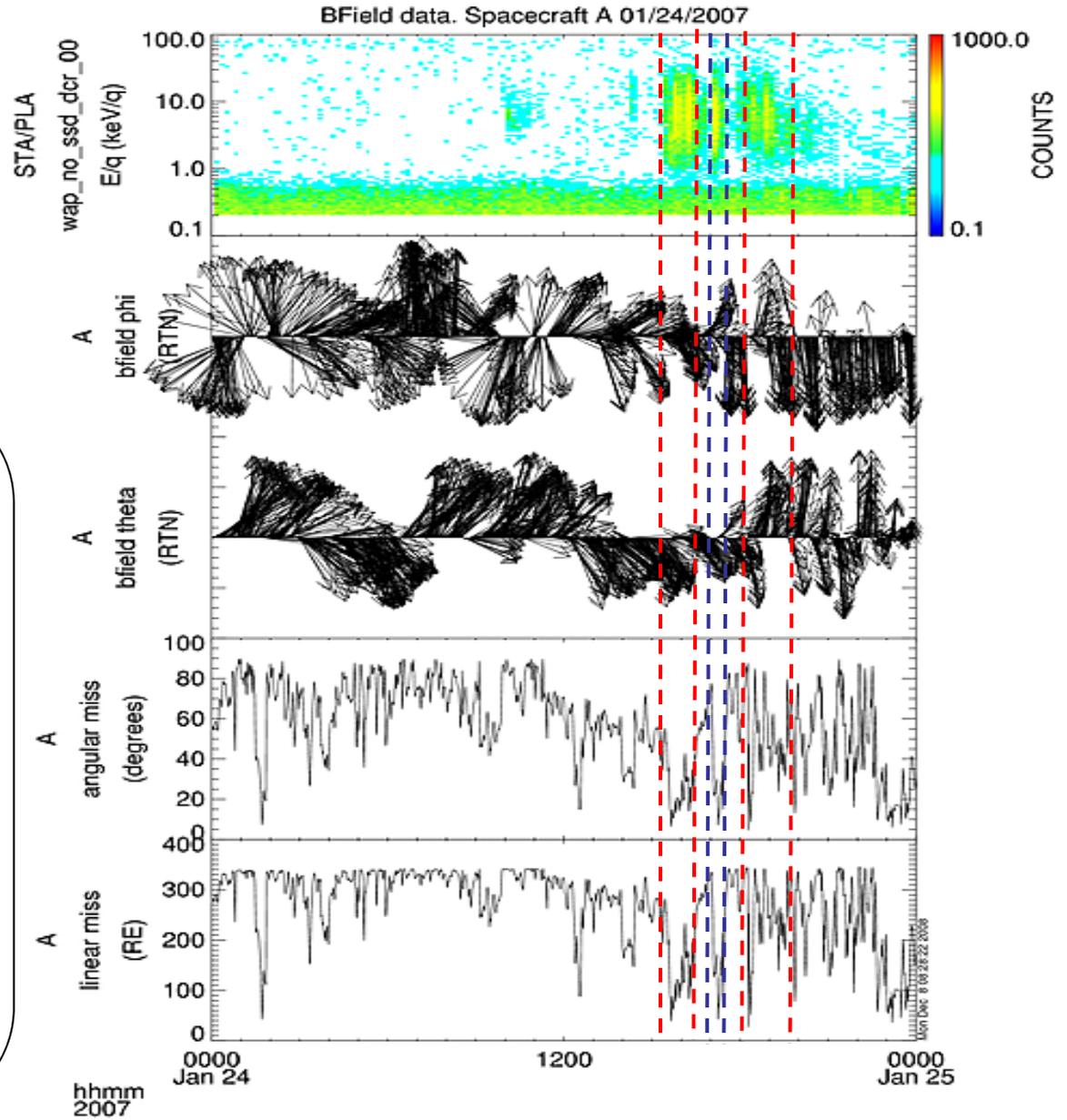
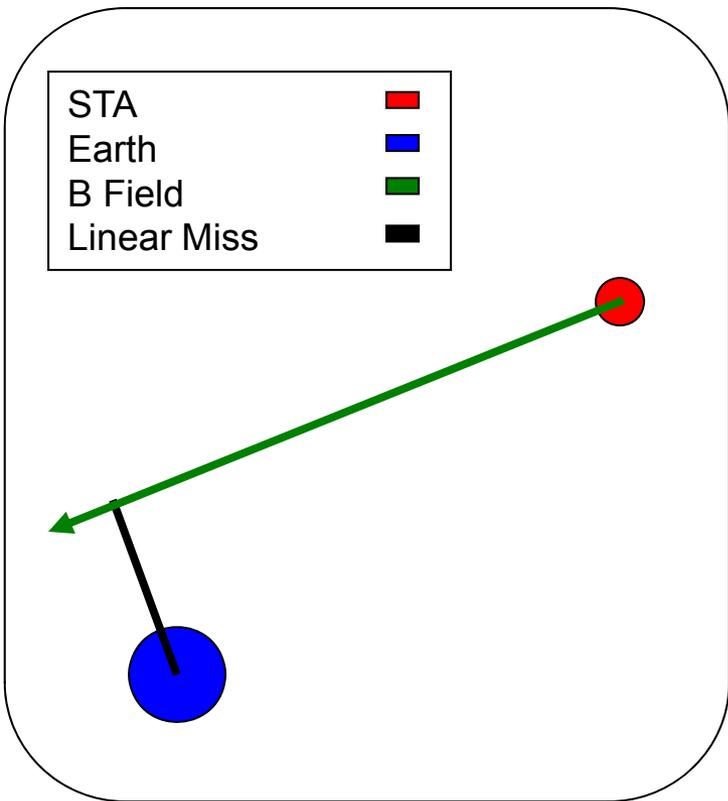
Extra 1

STA WAP NDN-SSD APID Events

From 2007-11-21/00:00:00 to 2007-11-23/00:00:00

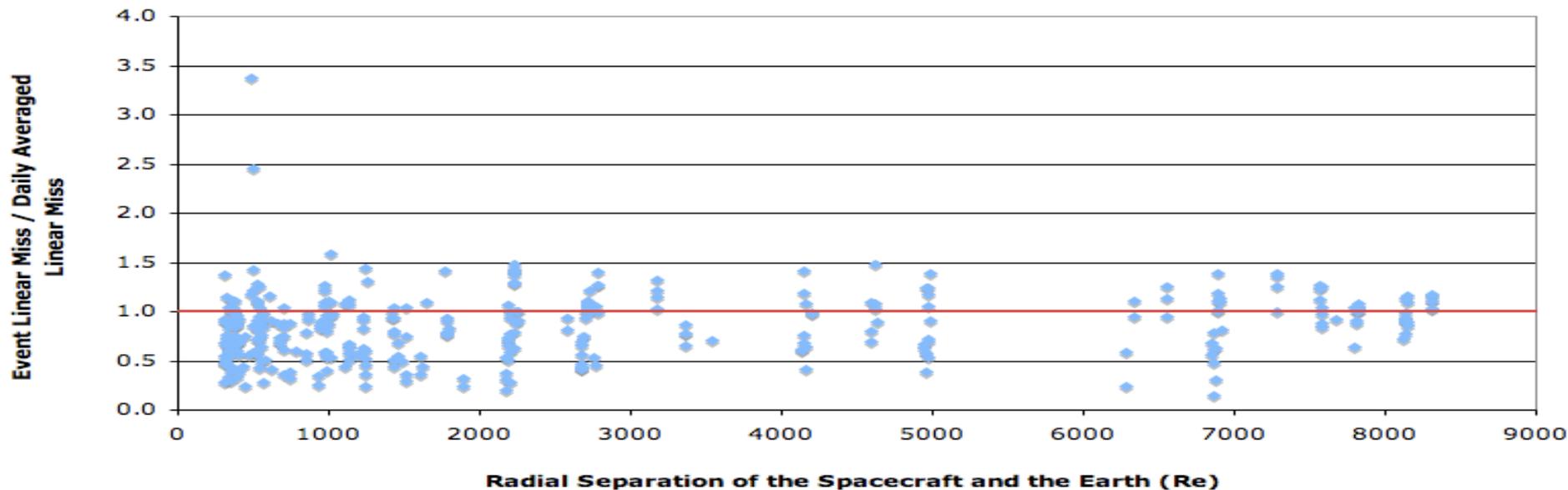


Extra 2

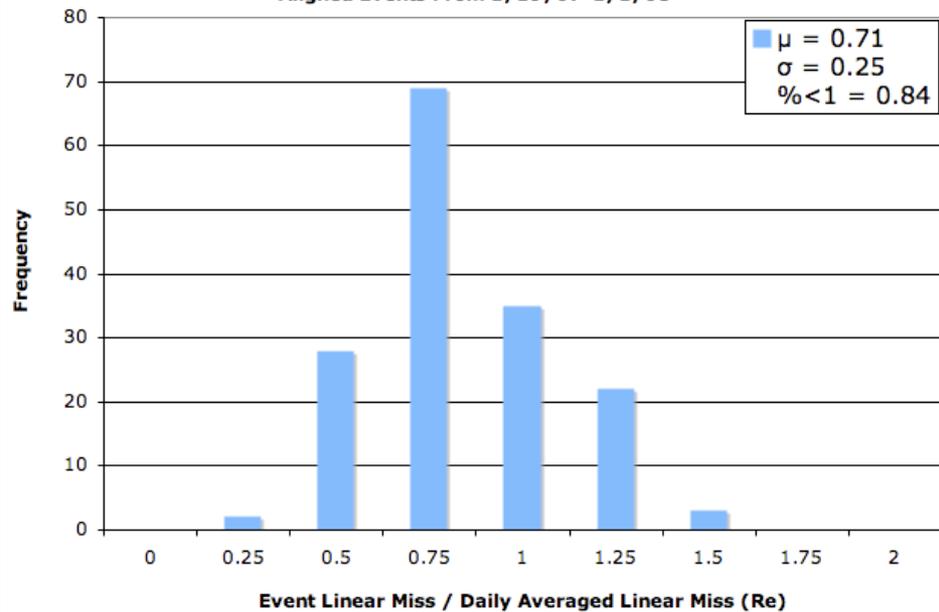


Extra 3

Effects of Distance on Normalized Linear Miss of 362 Automatically Defined Events
From 1/19/07-1/1/08



Histogram of Normalized Linear Miss of 159 Automatically Defined Field Aligned Events From 1/19/07-1/1/08



Dependence of 159 Automatically Defined Field Aligned Events on Solar Wind Speed from 1/19/07 - 1/1/08

