A Statistical Look at the Radiation Belt Seed Population

Alexander Boyd, H. Spence, G. Reeves, D. Baker, B. Blake, J. Fennell, S. Claudepierre, Y. Shprits
Contact: a.j.boyd@unh.edu

University of New Hampshire

Exploring the Extremes of Space Weather — Van Allen Probes

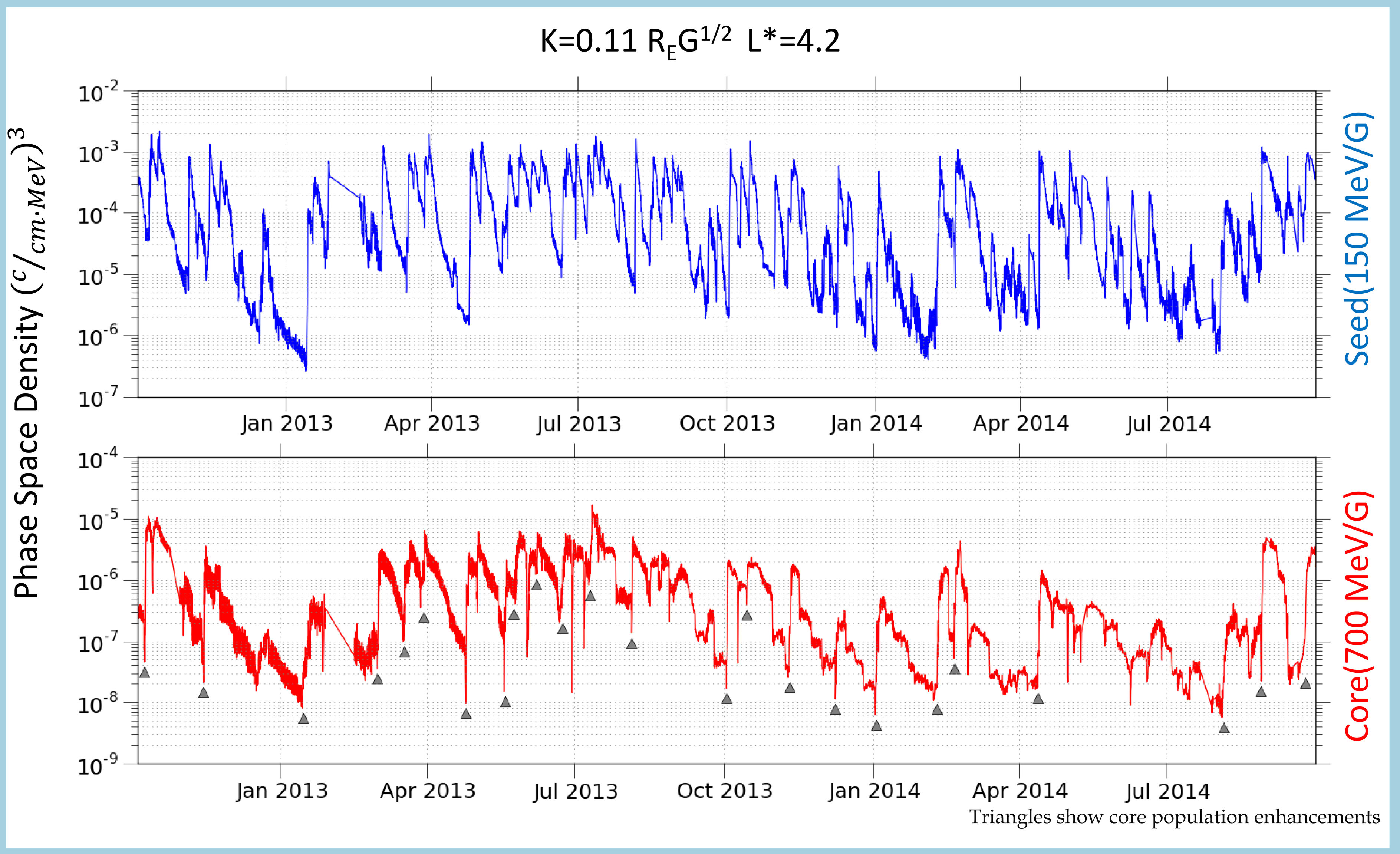
1. Introduction

One of the most important goals of the Van Allen Probes mission is to understand the acceleration of the core radiation belt population (electrons with energy ≥ 1 MeV). One process that can create these core electrons is the acceleration of lower energy (10s-100s keV) seed electrons via wave-particle interactions.

Up to this point, studies of the seed population in the inner magnetosphere have been mostly limited to event case studies. With the availability of detailed measurements from the Van Allen Probes we now have the opportunity to investigate how the seed and core radiation belt populations interact over a long time scale. In this study we look at phase space density (PSD) data from the first two years of the Van Allen Probes mission to investigate the correlations between the seed and core populations and quantify the acceleration timescales.

2. Data

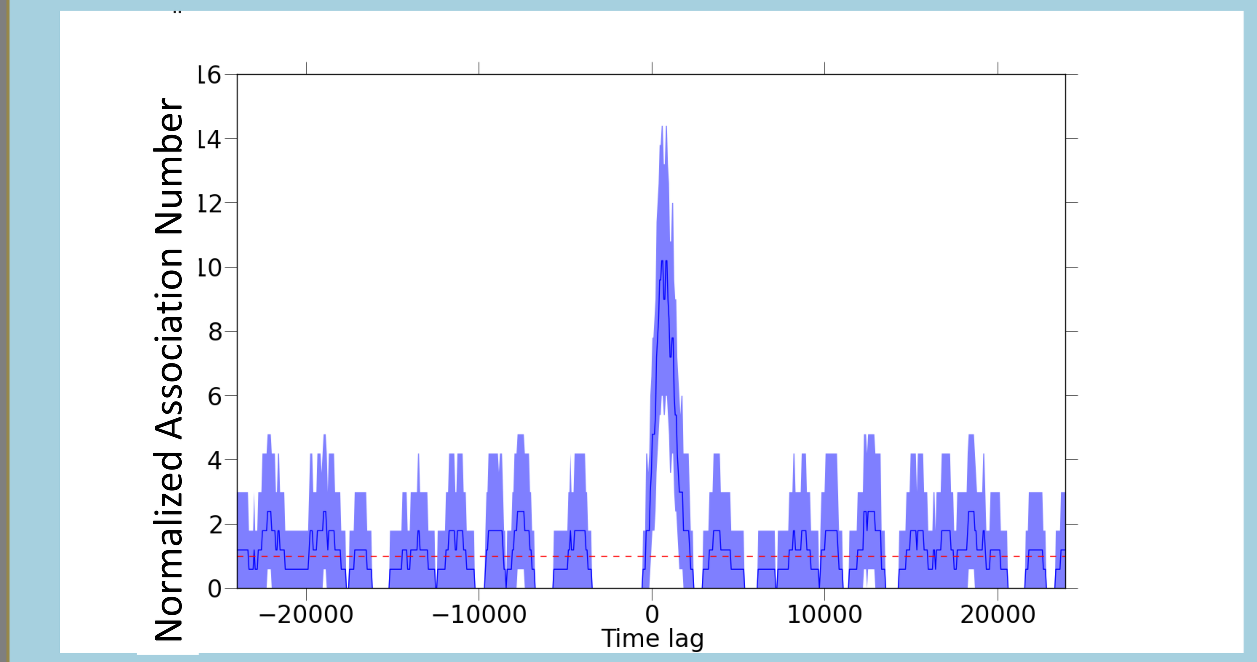
- We've calculated phase space density (PSD) using data from the Magnetic Electron Ion Spectrometer (MagEIS) for the first two years of the mission (Oct 2012 – Sep 2014)
- Looking at fixed 2nd invariant K and 3rd invariant L* we can see how different energy populations evolve over time
- We chose μ = 700 MeV/G (~1.5 MeV at L*=4.5) to represent the core population and μ = 150 MeV/G (~300 keV at L*=4.5) to represent the seed population
- We defined the time for an enhancement events to be when the PSD reaches 10% of the maximum for that event. Only events without large data gaps and with an increase of at least a factor of 2 were considered.
- 24 events for core, 63 events for seed



Triangles show core population enhancements

3. Point Processes

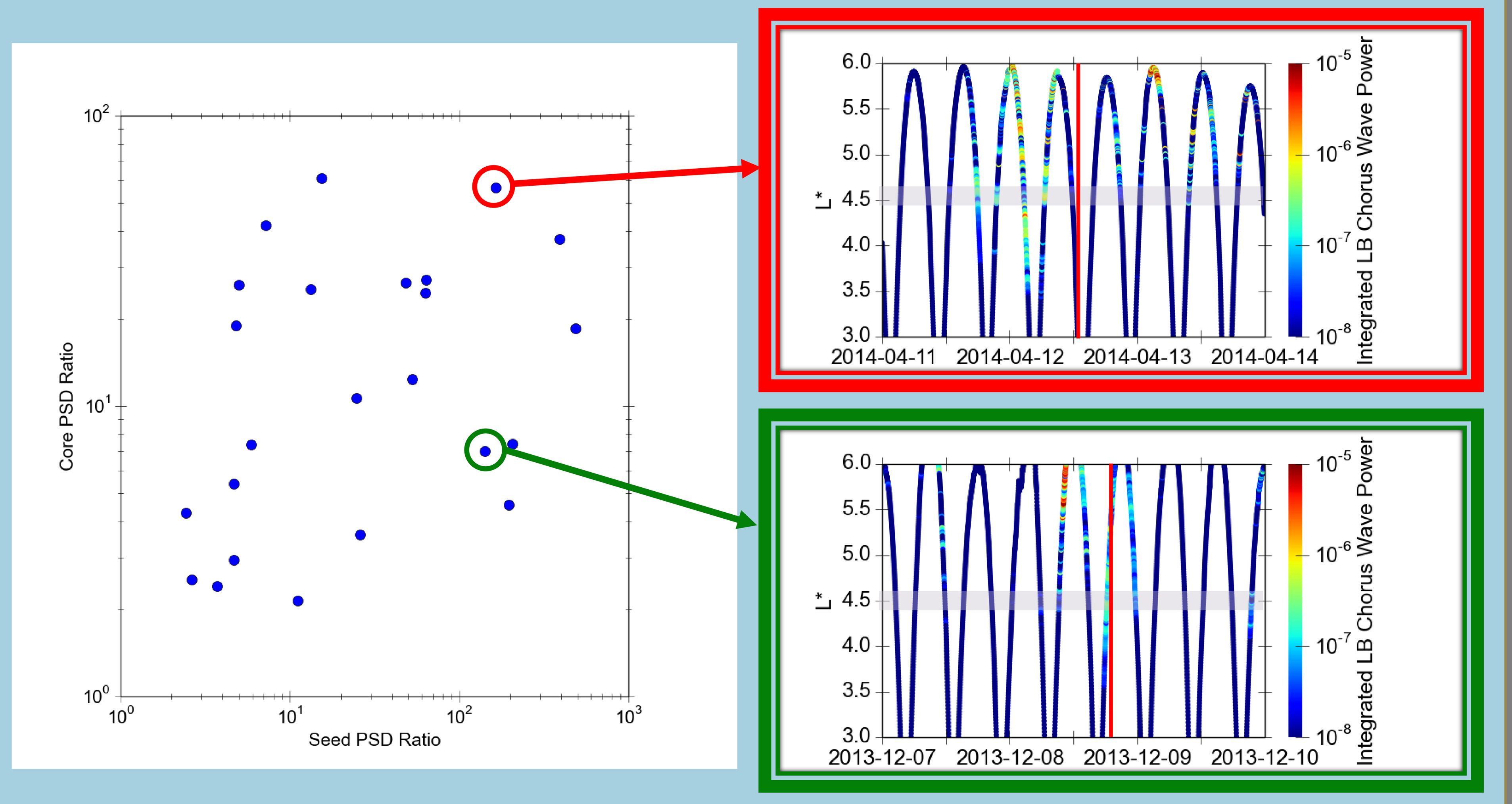
We quantified the correlation between the seed and core population enhancements using the analysis of point process statistics as described in Morley and Freeman [2007]. This analysis quantifies the statistical association between two sets of discrete events through a quantity called the association number. This number is calculated for a large range of time lags.



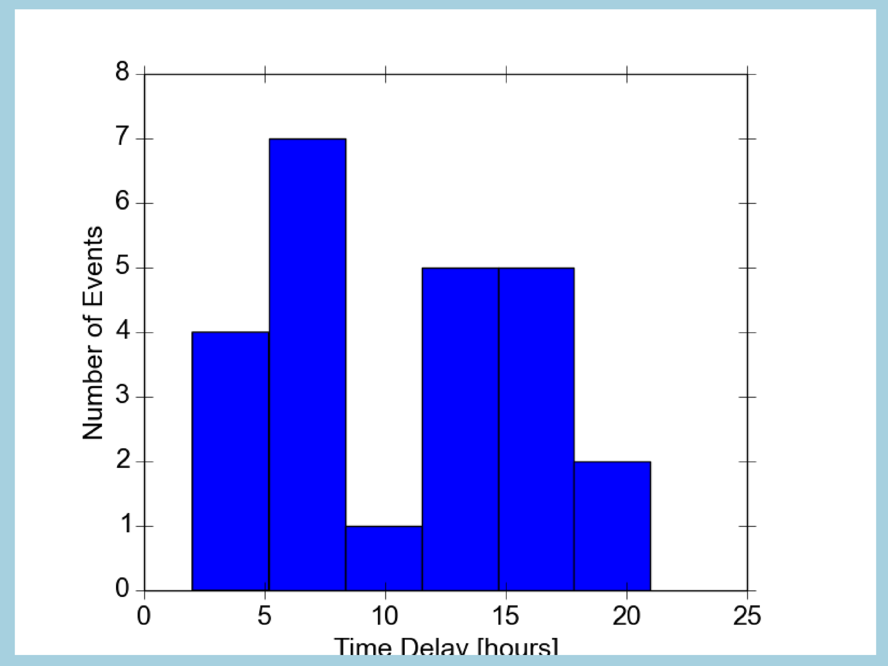
At very large time lag, we expect the events to be independent. Since there is a large increase in association number at a small time lag, this indicates that seed and core population enhancements are correlated.

4. Timing & Correlations

- Correlation between seed and core enhancements
- Weak positive correlation



- Distribution of the time lag between seed and core population enhancements
- In all the events, the seed precedes the core
- The mean time lag is 10.2 hours



- Integrated Lower Band Chorus wave power for two events (2013-12-08 and 2014-04-12) that have similar seed enhancements
- Apr 2014 event has more chorus activity and a larger core increase
- Waves are also needed to produce acceleration

Conclusions

- Clearly shown that enhancements of the seed and core populations are correlated
- In all the events studies, the seed population increases first, on average ~10 hours earlier
- An enhanced seed population is necessary but not sufficient to produce acceleration

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