A Statistical Look at the Radiation Belt Seed Population

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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 26 months of the Van Allen Probes mission to answer the following questions:

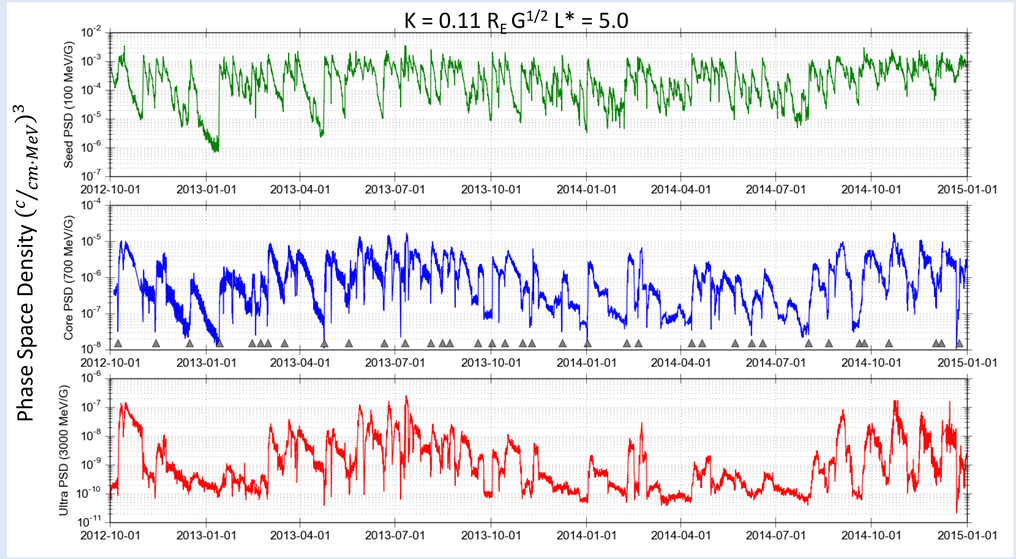
1) What correlations exist between the seed and core populations?

2) What are the acceleration timescales?

3) What are the seed population conditions that lead to core population enhancements?

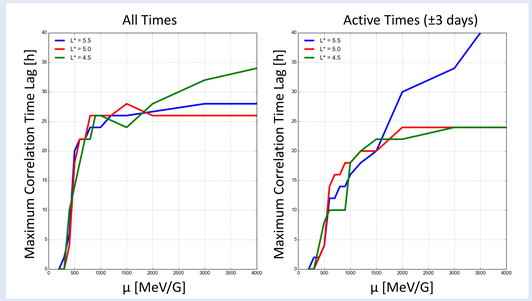
2. Data

- Phase Space Density at fixed 2nd and 3rd invariant from October 2012 through December 2014
- 3 different particle populations:
  - Seed (100 MeV/G; ~300 keV)
  - Core (700 MeV/G; ~1.5 MeV)
  - Ultra (3000 MeV/G; ~3.5 MeV)
- Core enhancement events marked by gray triangles. Enhancement events meet the following criteria:
  - Increase of at least 2x
  - Enhancement occurs in less than 48 hours
  - No significant data gaps

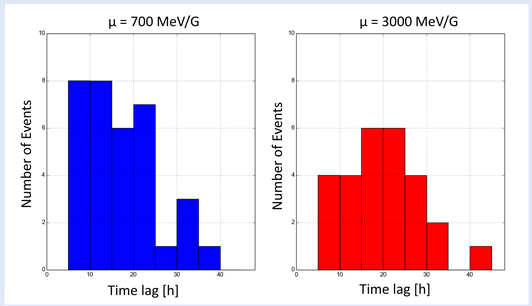


3. Correlations & Timing

- Time-lag linear correlation analysis with respect to 100 MeV/G seed population
- For all times:
  - Core: 20-24 hour lag; Coefficient: 0.7
  - Ultra: 25-30 hour lag; Coefficient: 0.6
- For active times:
  - Core: 10-15 hour lag; Coefficient: 0.7
  - Ultra: >20 hour lag; Coefficient <0.5

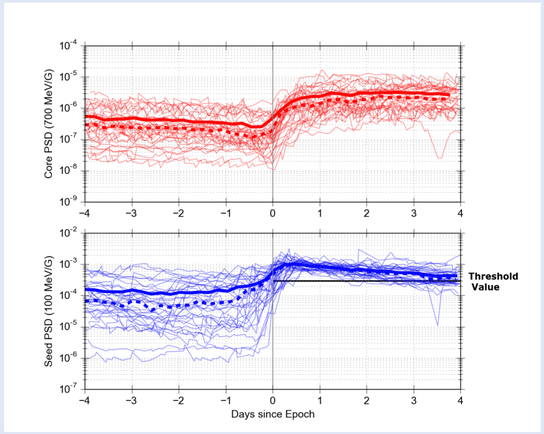


- Individual event timing
- Each individual event can vary greatly
- Core: Average 10-20 hour lag
- Ultra: Average 15-25 hour lag



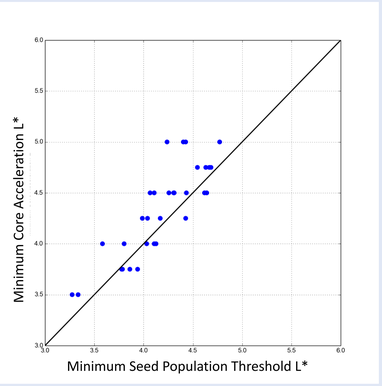
4. Threshold

- Superposed epoch analysis for core enhancement events
- T=0 epoch at the start of the core increase, use L* with the largest enhancement
- Mean (solid line), Median (dashed line), individual traces shown
- Despite large difference in initial conditions, all events end with nearly same number of seed electrons
- Seed population threshold?



- Relation between minimum L* where seed above threshold and minimum L* where core increases by at least 2x
- Penetration of seed population forms inner boundary for acceleration process
- Not all events above threshold produce enhancements – Seed alone is not enough!

L*	Fraction of Total Time above threshold	Total Events	Enhancement Events (%)	Acceleration, but no Enhancement Events (%)	No Acceleration Events (%)
4	0.075	25	14 (56%)	2 (8%)	9 (36%)
4.5	0.301	52	31 (59%)	14 (26%)	7 (13.5%)
5	0.532	55	33 (60%)	9 (16%)	13 (24 %)



5. Conclusions

- **First statistical study of the radiation belt seed population**
- **Correlation between the seed and the core populations maximized at 10-20 hour time lag**
- **Evidence for a seed population threshold**
- **Seed population forms an inner boundary for the acceleration of higher energy populations**
- **Seed population is a necessary but not sufficient condition for radiation belt acceleration**

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