Ultra-relativistic Electron Flux Enhancements in the Van Allen Belts

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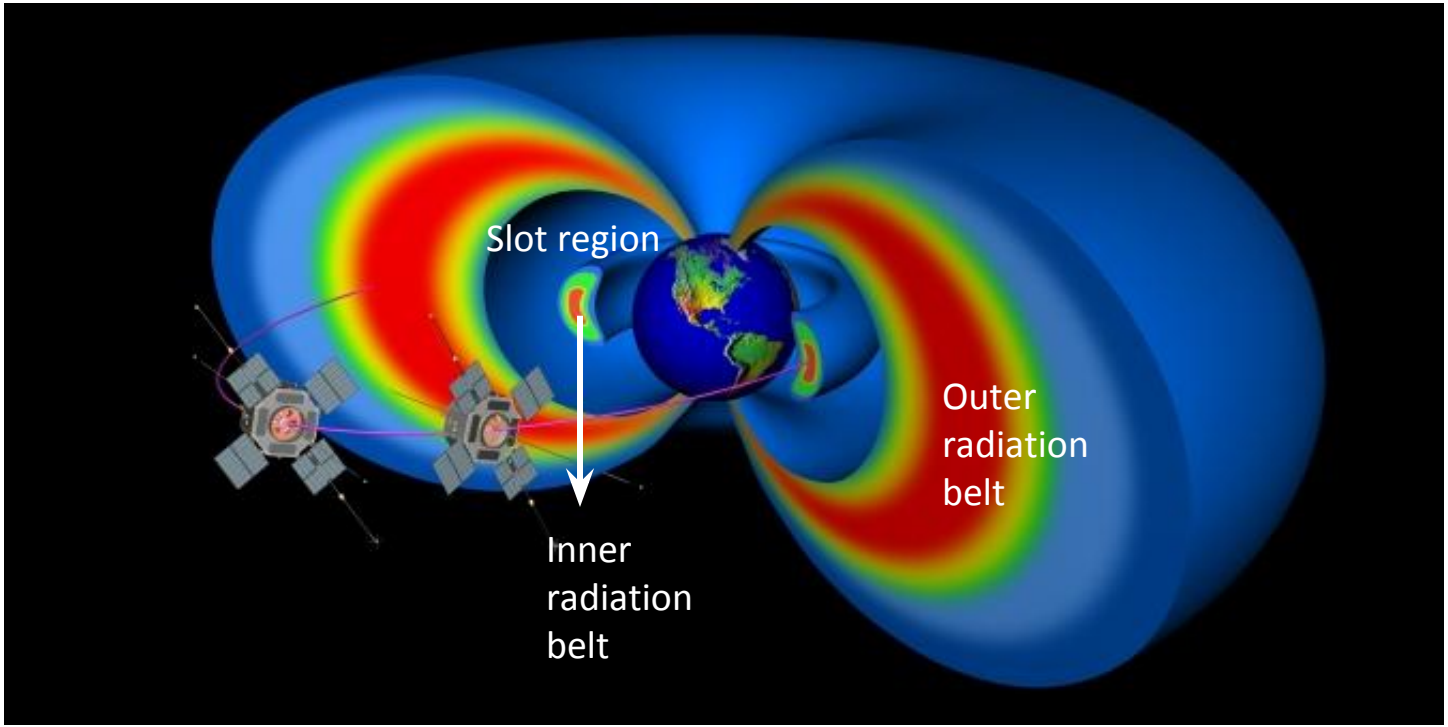
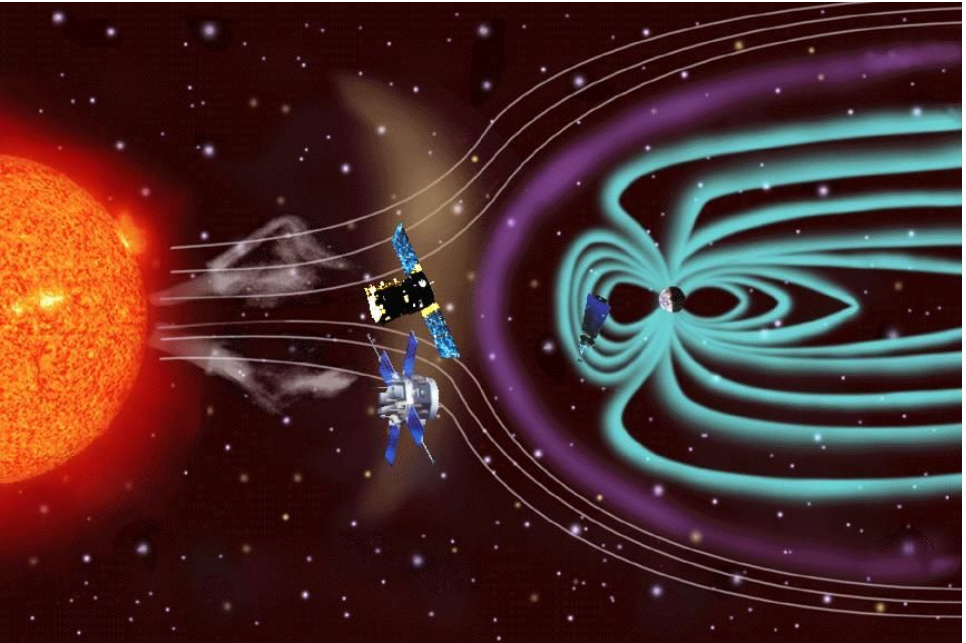
The Earth's Radiation belts



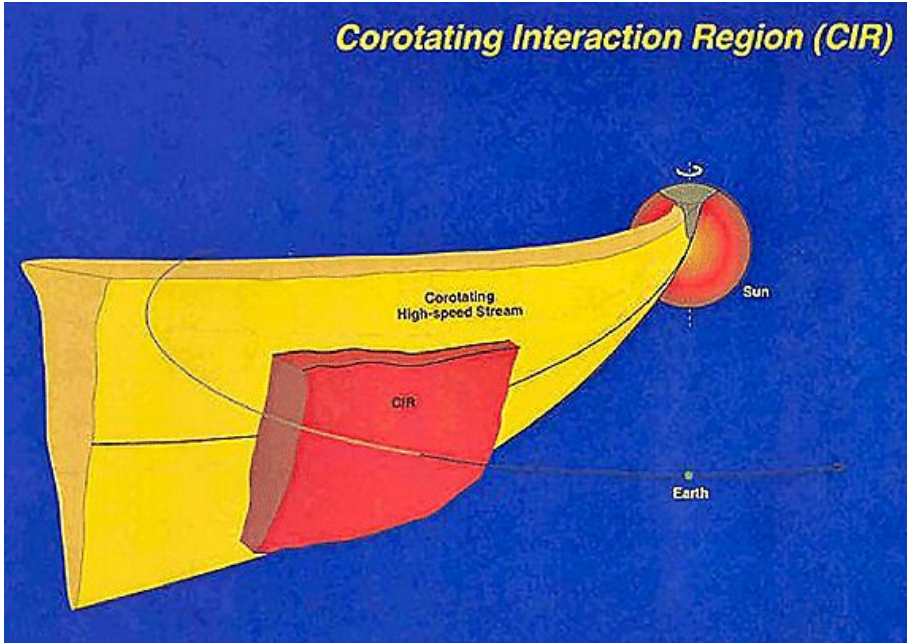
[From nasa.gov]

Solar Wind Drivers for Geomagnetic Storms

The Coronal Mass Ejection is a magnetised jet of plasma.

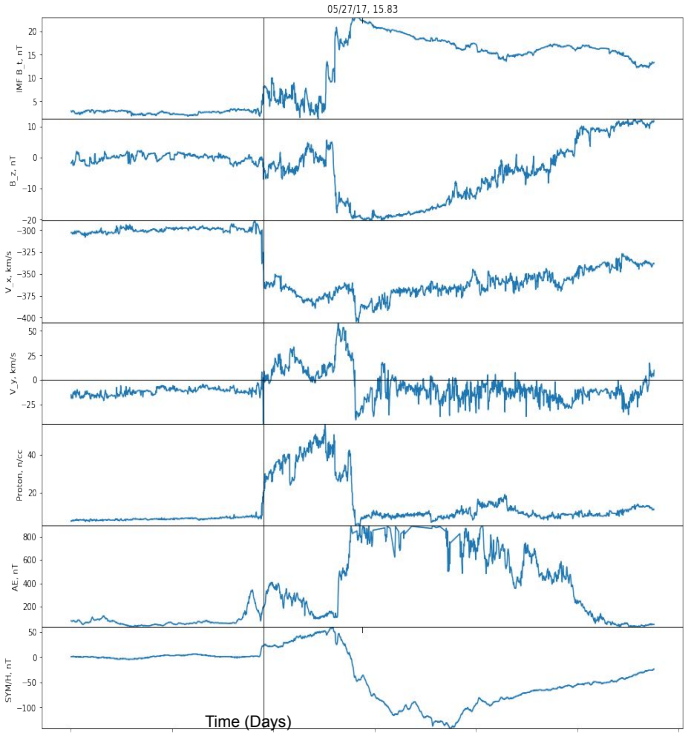


The Corotating Interaction Regions are areas of compressed solar wind that influences the Earth's magnetic field.



Determining when a CME/CIR driven Geomagnetic storm occurs

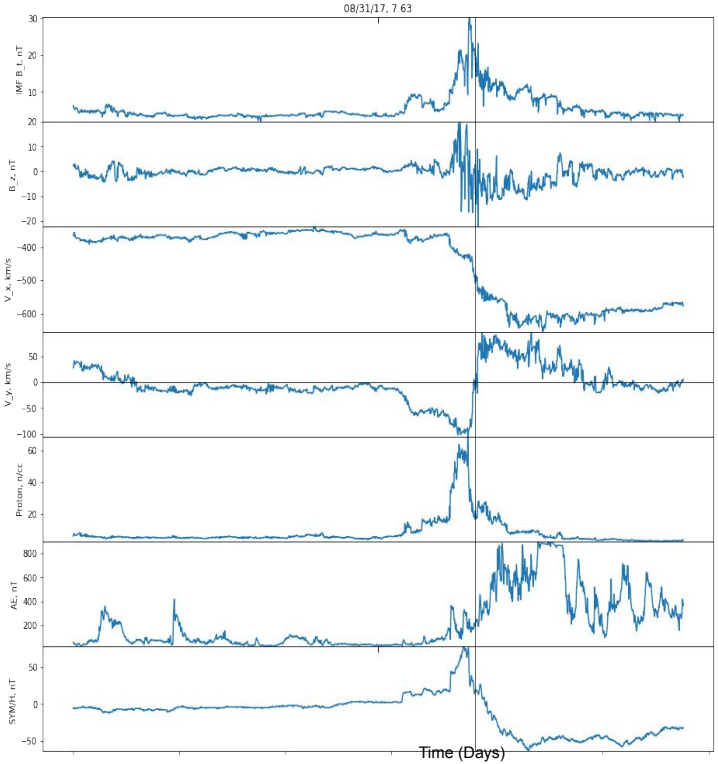
First, when the Dst is lower than -50nT, the geomagnetic storm is flagged and put into a list of dates.



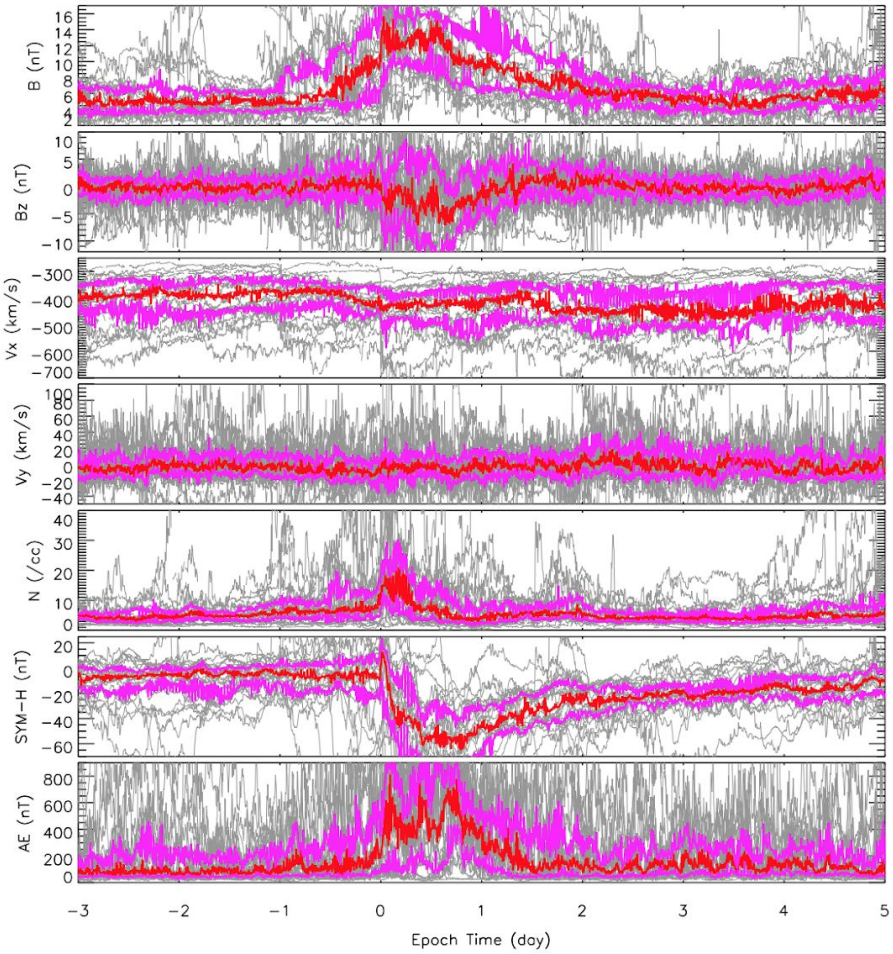
CME:
1. Associated with an ICME on Richardson/Cane ICME list.
2. Use time of proton density increase, rounded to the nearest hour.

CIR:
1. If during the storm solar wind speed was always less than 500 km/s, then it is not a CIR-driven storm
2. Enhanced solar wind speed, bipolar Vy, decreased proton density
3. Use time of Vy crossing 0, rounded to the nearest hour

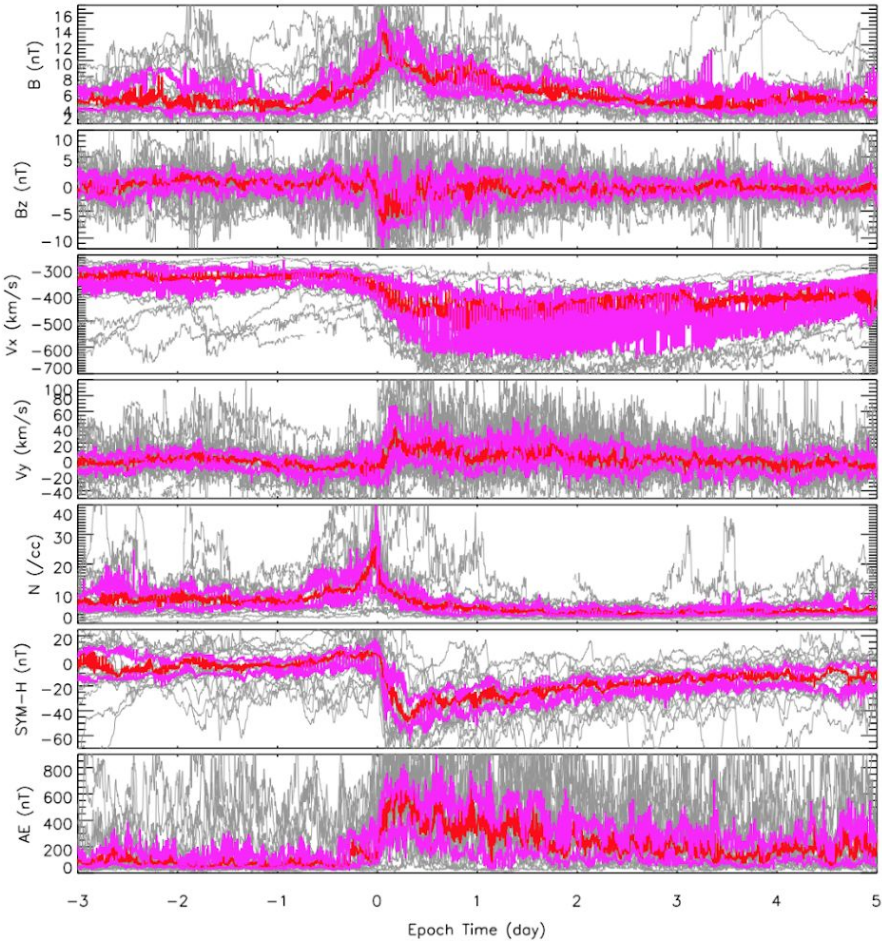
Then each event is looked at individually to see if it matches The signature CME/CIR trends.



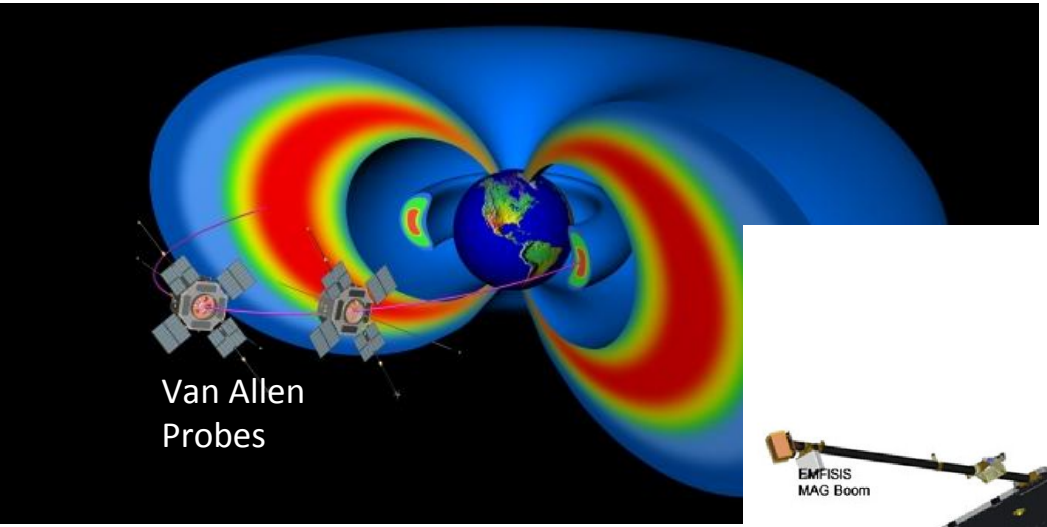
CME (27 storms)



CIR Events (28 storms)

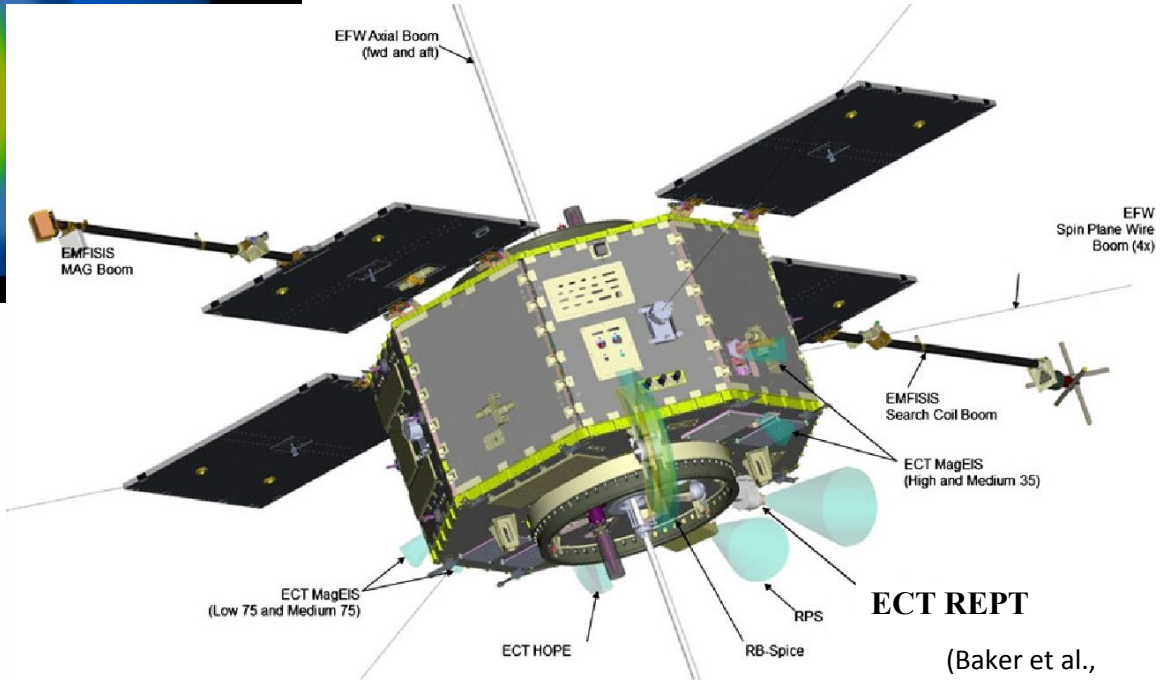


The Van Allen Probes



[From nasa.gov]

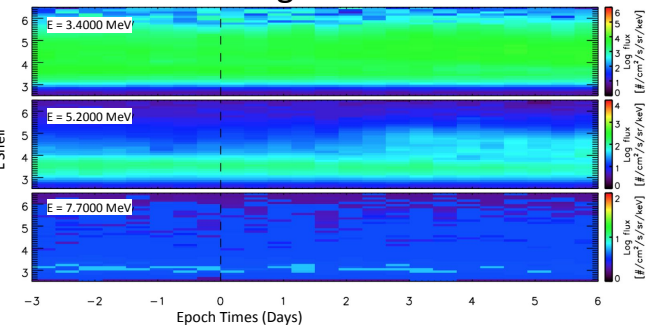
ECT REPT: ~1.8 – 20 MeV e^-
(Baker et al., 2012)



(Baker et al., 2012)

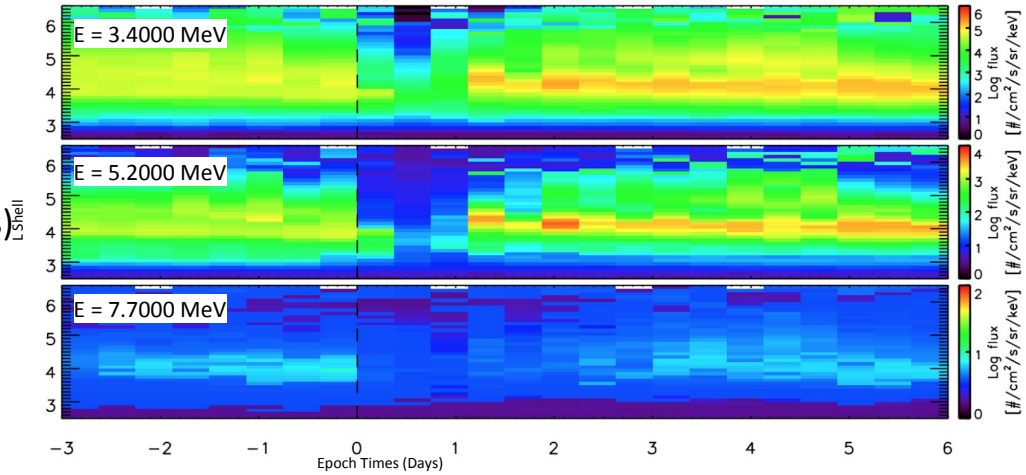
Reading the Enhancement Superposed Epoch Analysis

30 dates picked by random generator

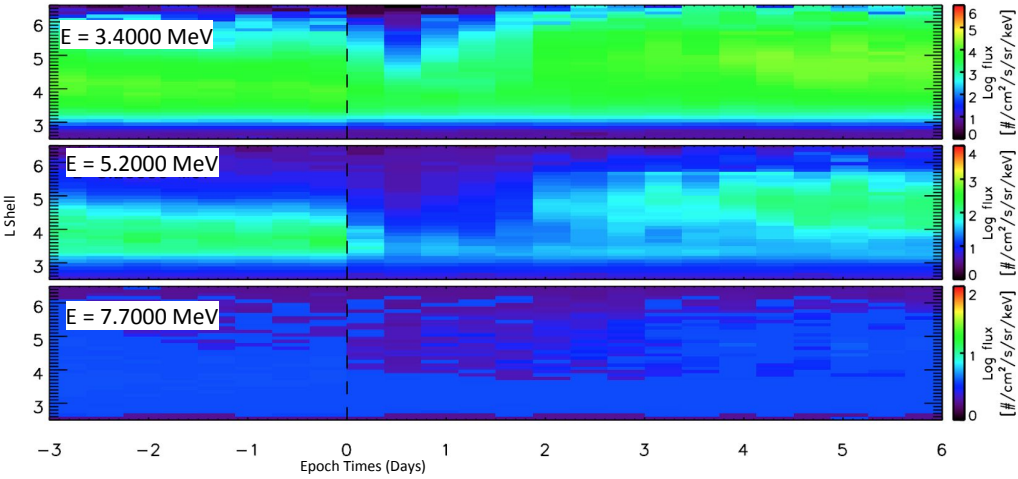


Enhancement is when the density of particle flux at a certain L and energy channel is greater than before the storm.

CME (27 storms)

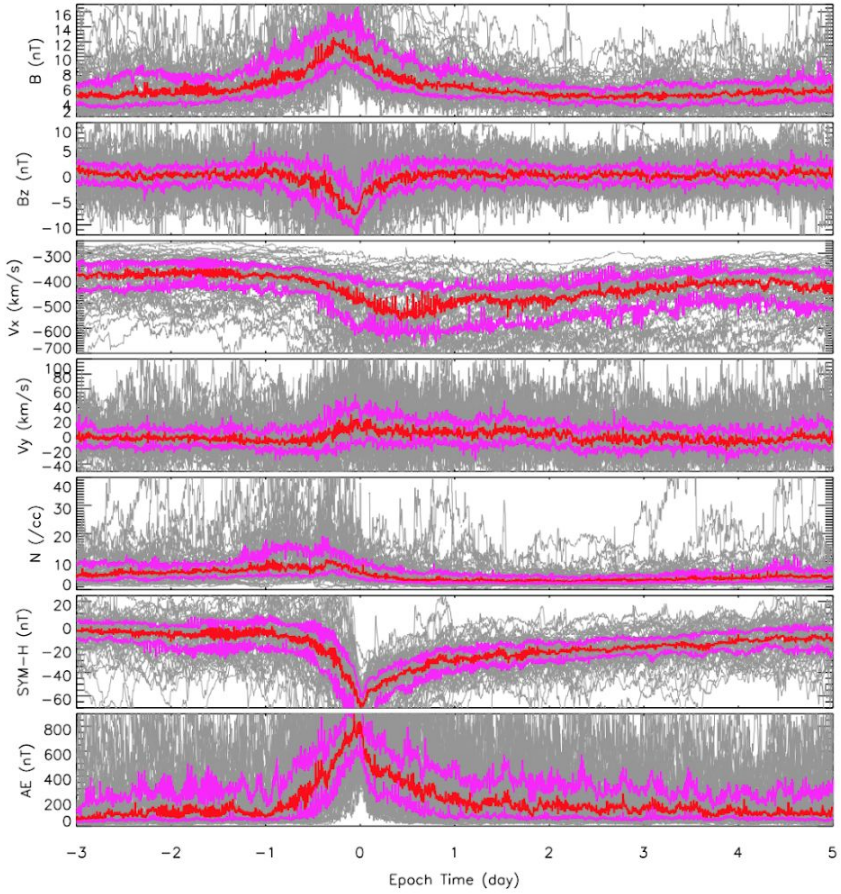


CIR (28 storms)

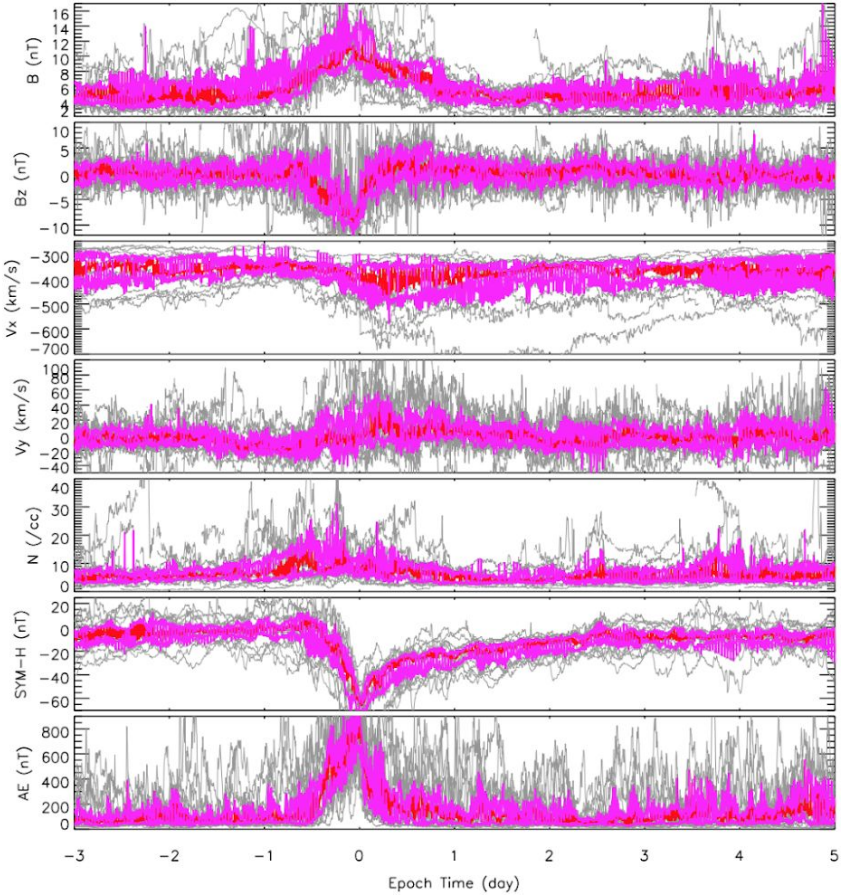


Solar Wind SEA for Enhancement vs Non Enhancement

Enhancement 3.4 MeV (67 events)

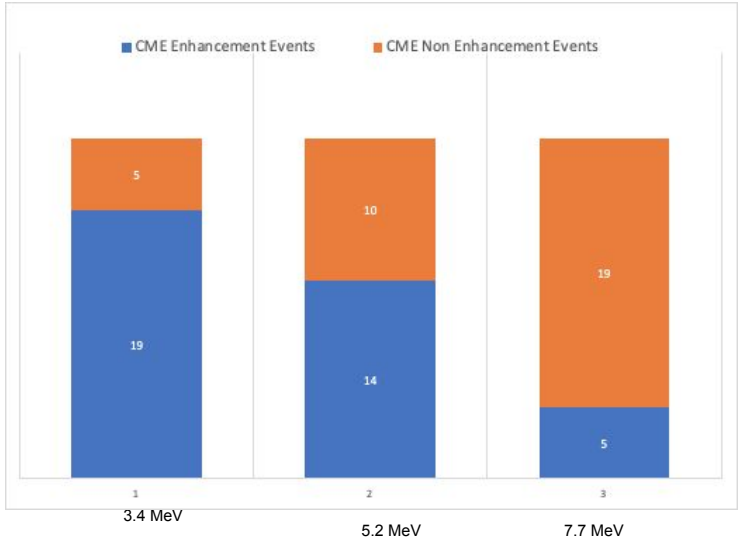


Non Enhancement 3.4 MeV (20 events)

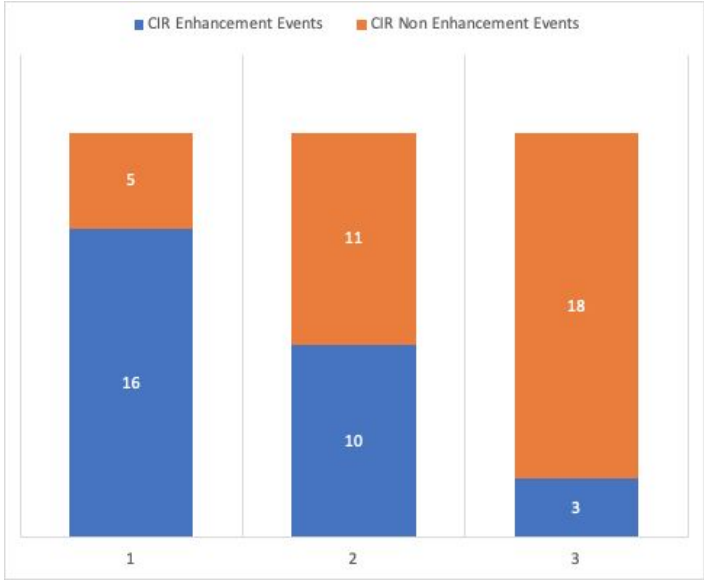


CME/CIR Enhancement Event Numbers

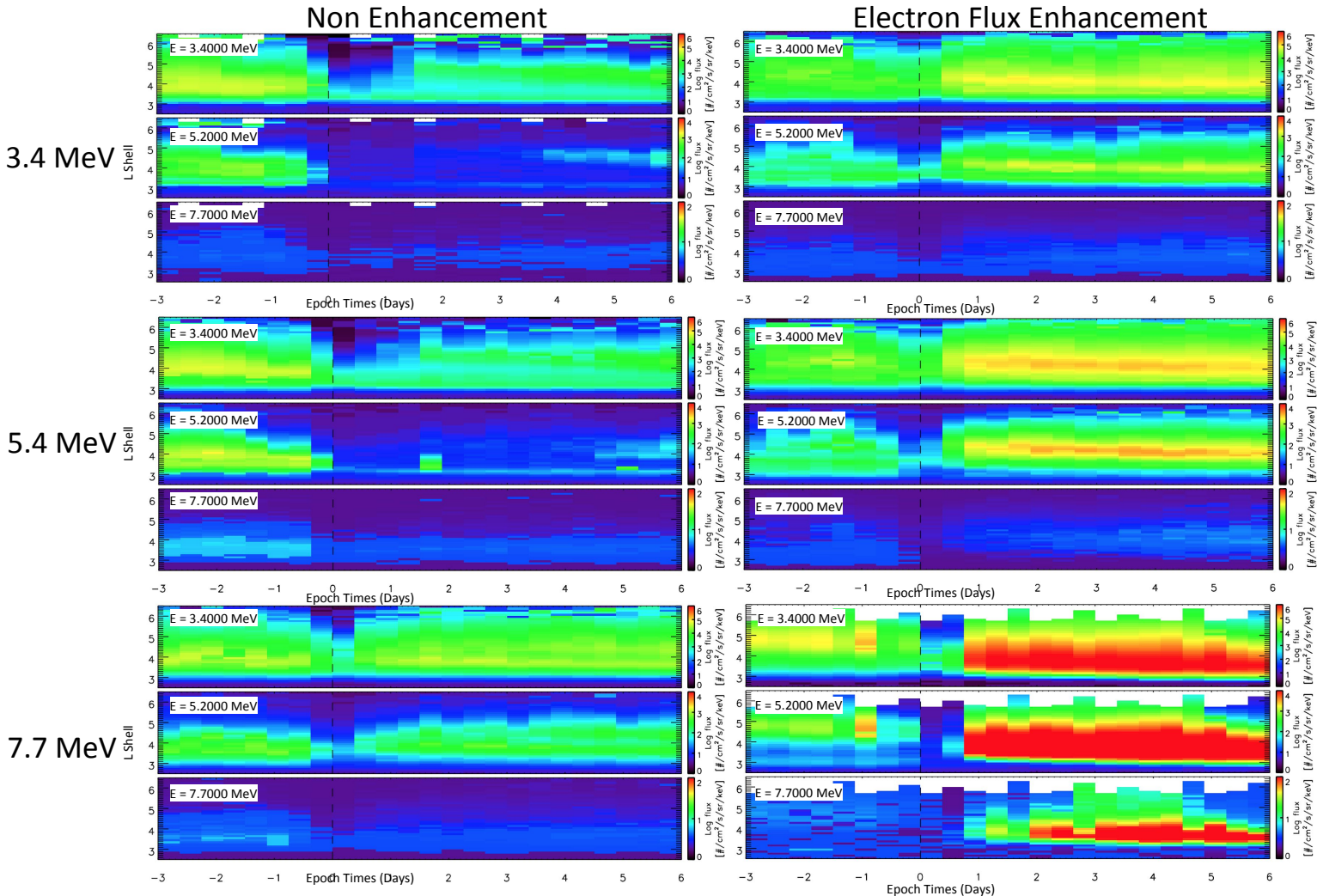
CME



CIR



CME Enhancement Events



CIR Enhancement Events

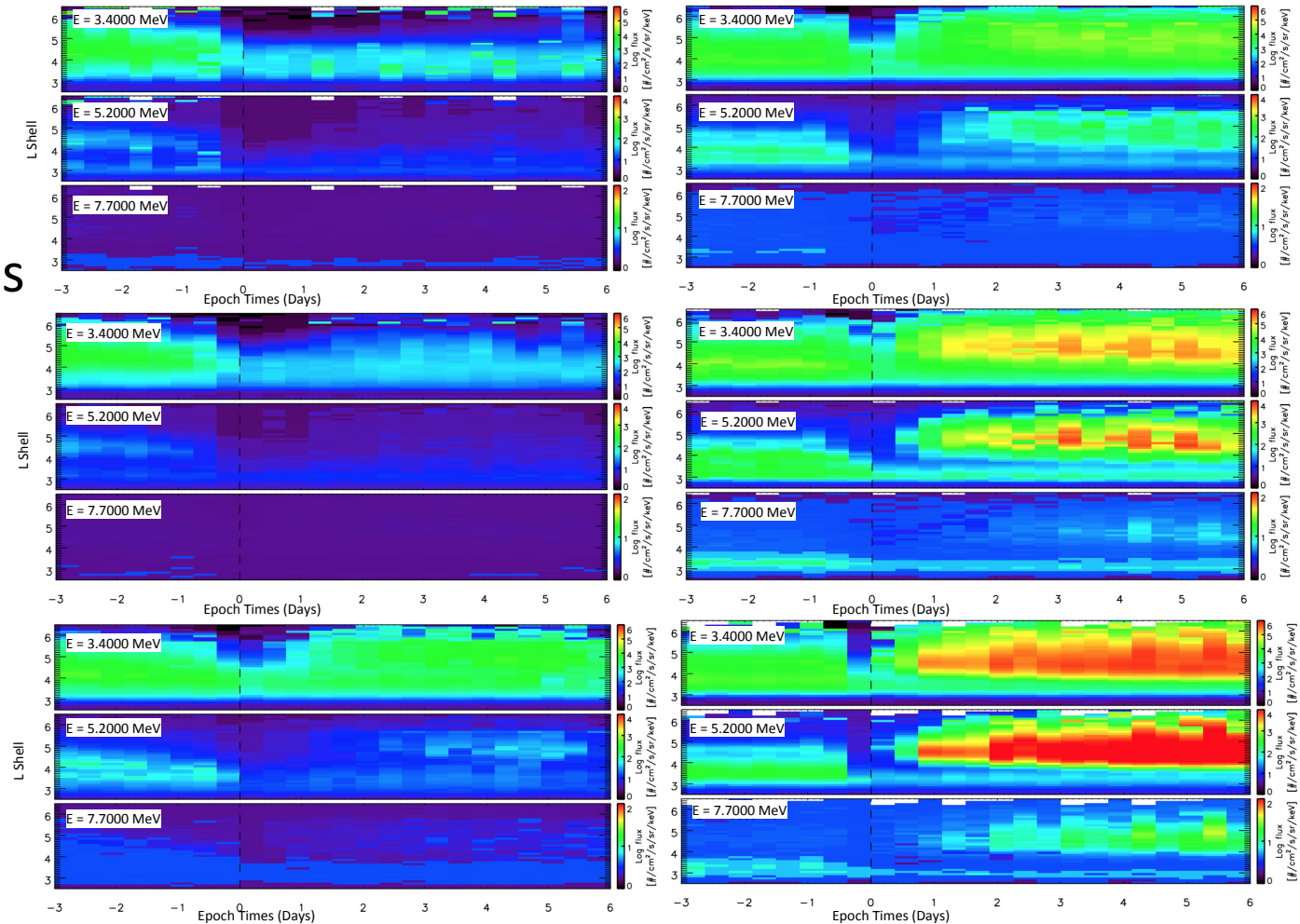
Non Enhancement

Electron Flux Enhancement

3.4 MeV

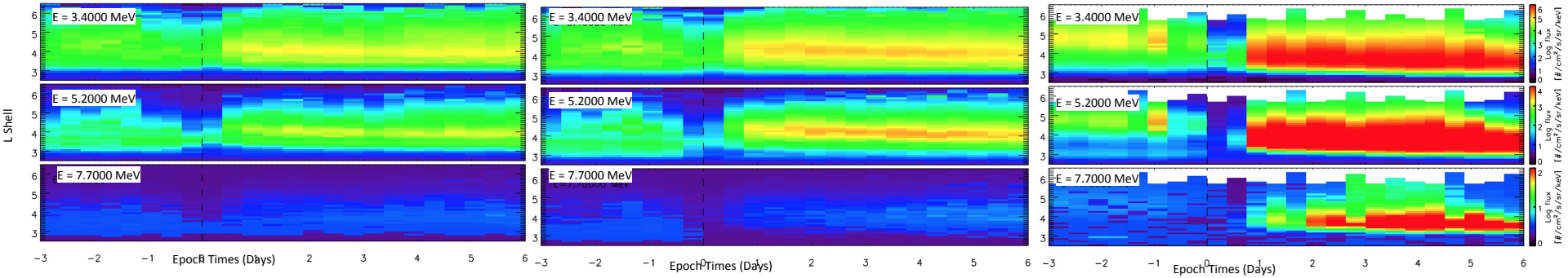
5.4 MeV

7.7 MeV

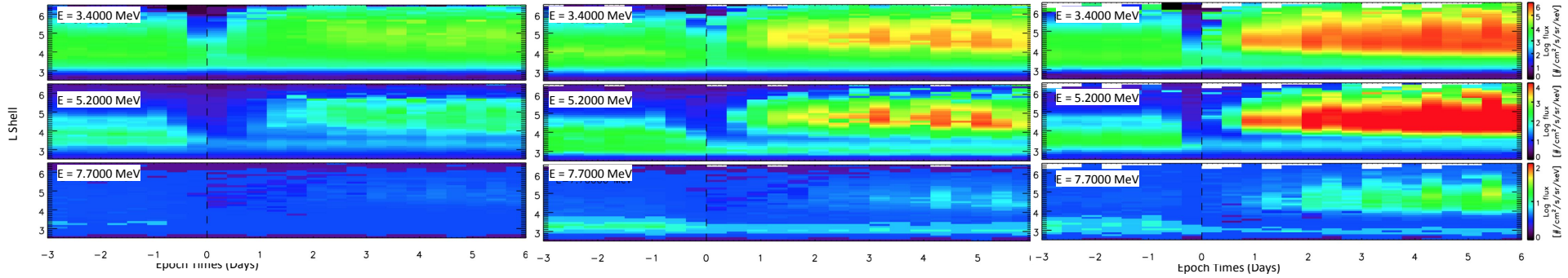


CME and CIR Flux Enhancement

CME Electron Flux Enhancement

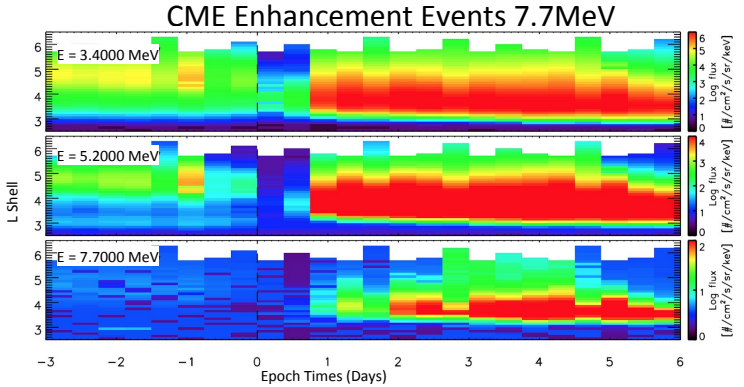


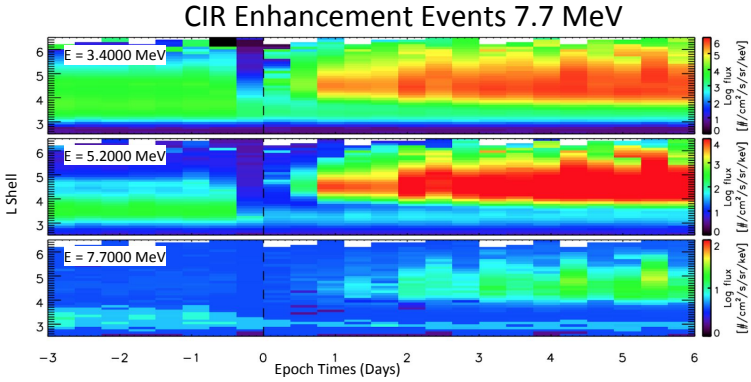
CIR Electron Flux Enhancement



Results

1. Higher solar wind speed results in higher probability for enhancement.
2. Enhancement in higher energies usually means enhancement in lower energies.
3. Enhancement occurs approximately one day after a CME, two days after CIR.
4. CIR flux enhancement occurs at higher L shell values than pre-flux enhancement and CME flux enhancement occurs at lower L shell values than pre-flux enhancement.
5. Confirms Zhao's method for determining enhancement events.





Acknowledgments

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For mentoring me along this research process.
Leng Ying
For being an available mentor.

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Thank you.

References

Shen et al. (2012)

Zhao et al. (2019)

Ask Me a Question?

Important definitions

Dst

Geomagnetic storm

CME

CIR

SEA

Electron Flux Enhancement

Explain range of energies

Discuss different probes used

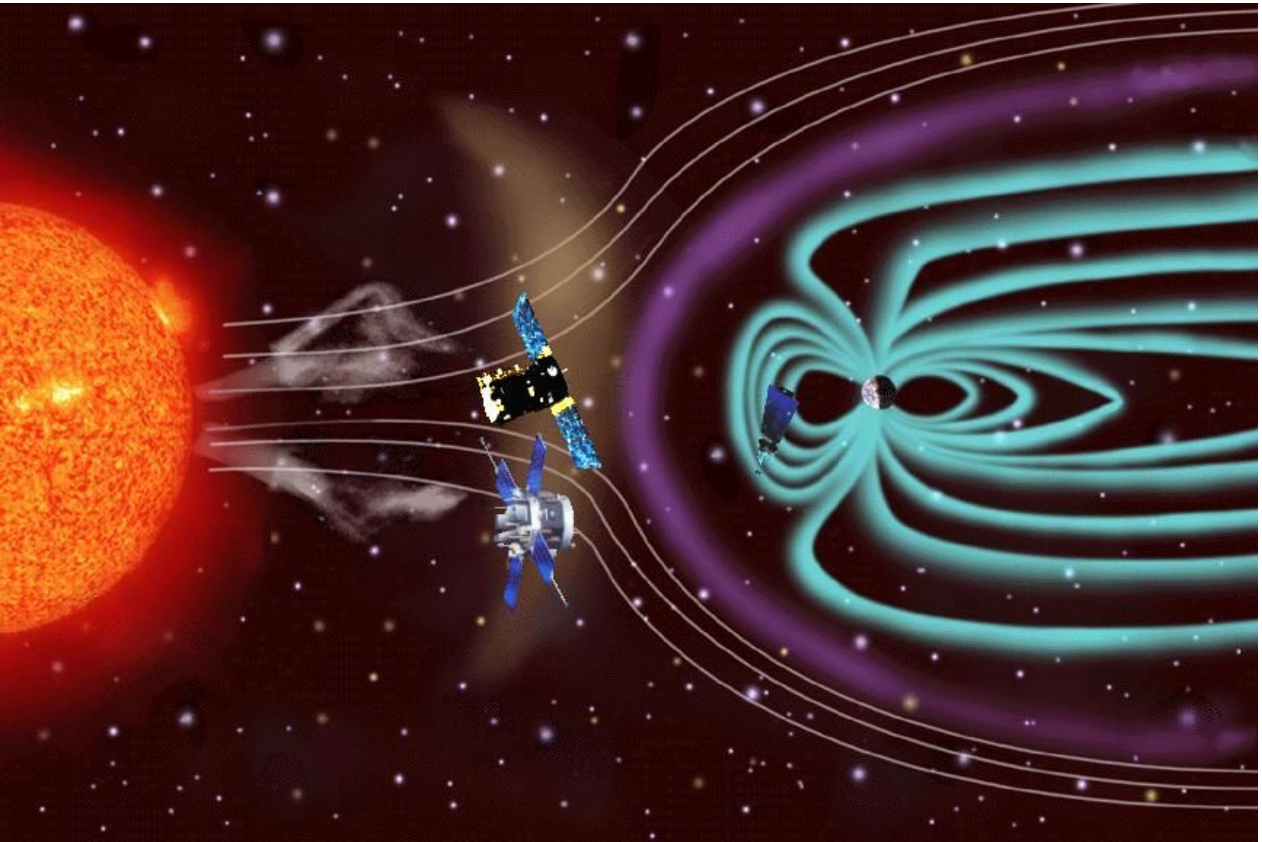
Discuss past studies

Discuss old results

Discuss new results

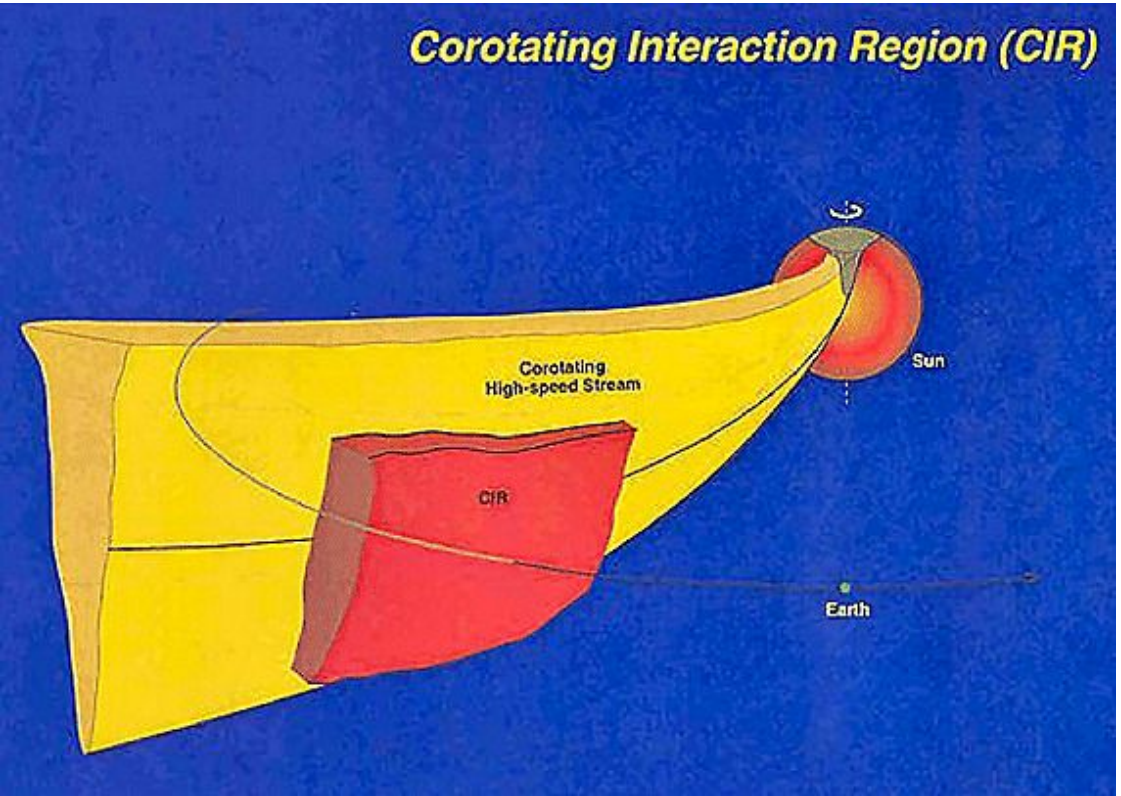
Discuss how they match up

CME



A flow of mass.

CIR

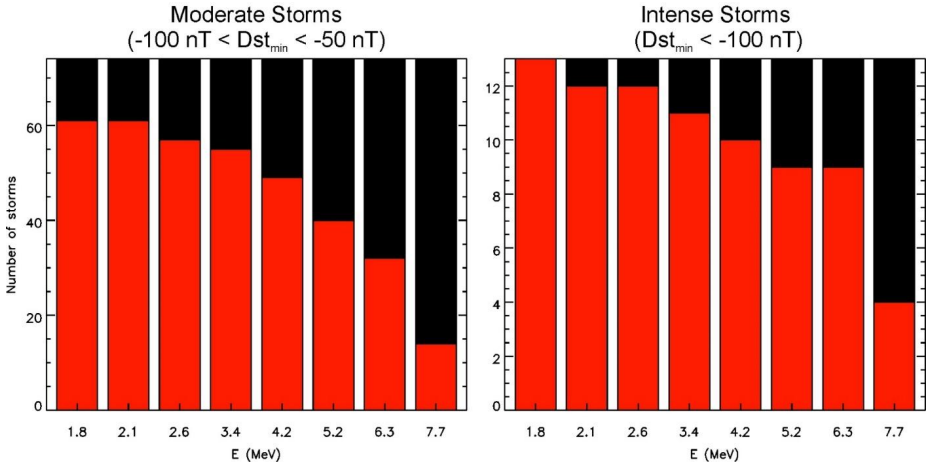


Comes from Coronal Holes.

High solar wind speed.

Solar wind fast streams emanating from solar coronal holes cause recurrent, moderate intensity geomagnetic activity at Earth. Intense magnetic field regions called Corotating Interaction Regions or CIRs are created by the interaction of fast streams with upstream slow streams

The Effect of Geomagnetic Storms on the Ultrarelativistic Electron Flux Enhancements



Storms with flux enhancement

Storms without flux enhancement

(Zhao et al., 2019)

Flux enhancement: post-storm fluxes enhanced by at least a factor of 2 over an L range > 0.5 compared to pre-storm fluxes during moderate or intense storms.

- As the electron energy gets higher, the probability of flux enhancements gets lower;
- Intense geomagnetic storms are indeed more likely to cause flux enhancements;
- No 7.7 MeV electron flux enhancement occurred during small storm or non-storm time;
- A total of 19 storms triggered flux enhancements up to 7.7 MeV electrons in the Van Allen Probes era.

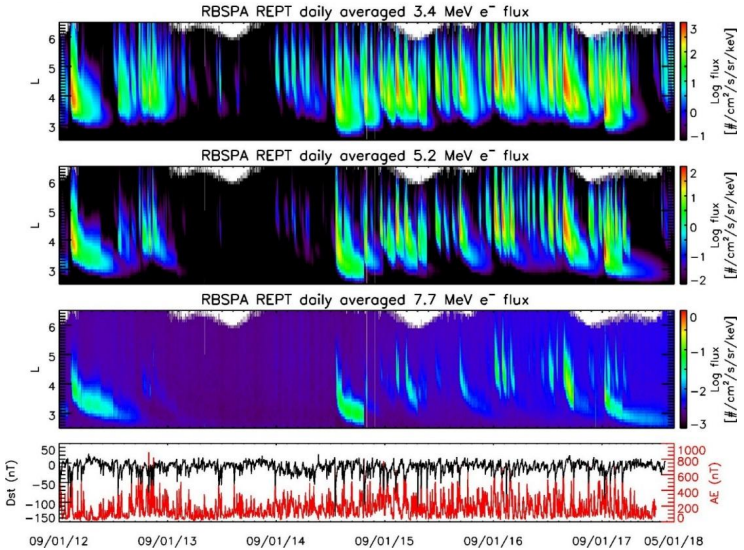
Daily-Averaged Fluxes of Relativistic and Ultrarelativistic Electrons

3.4 MeV

5.2 MeV

7.7 MeV

Dst & AE



- Relativistic and ultrarelativistic electrons are quite dynamic in the outer belt especially during geomagnetic active times;
- Long-term behaviors of relativistic and ultrarelativistic electrons are clearly energy-dependent.

https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2005JA011273