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Radial Evolution of Multi-MeV Relativistic Electrons during Enhancement Events at Geostationary Orbit

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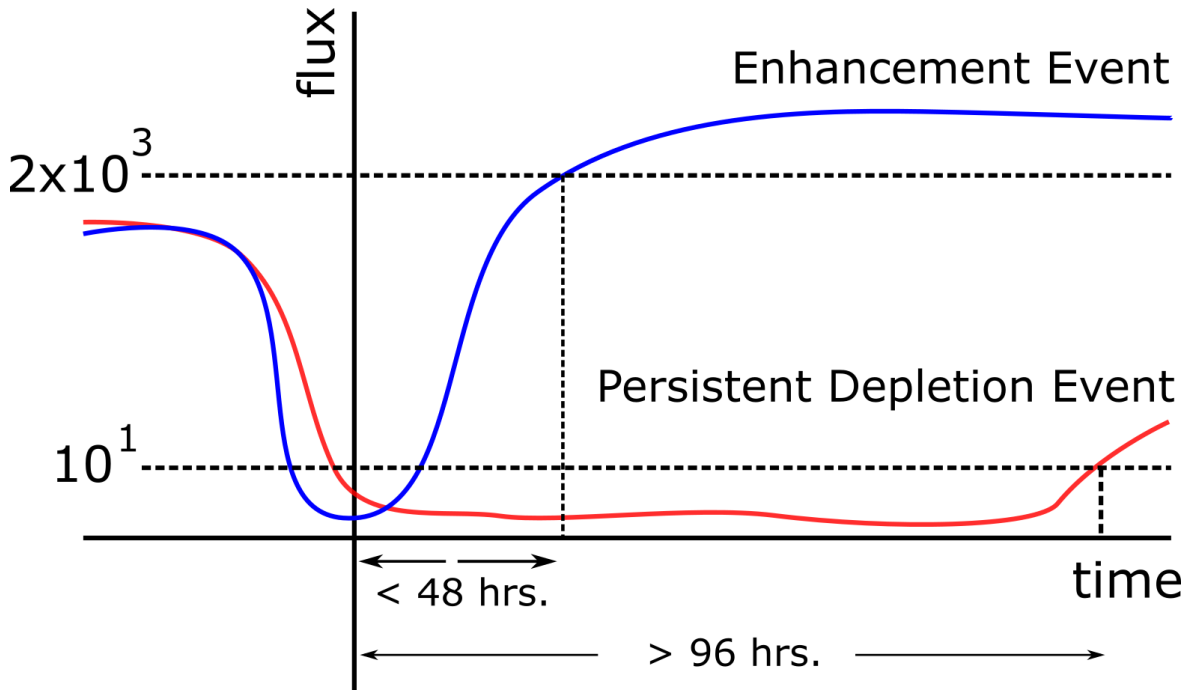
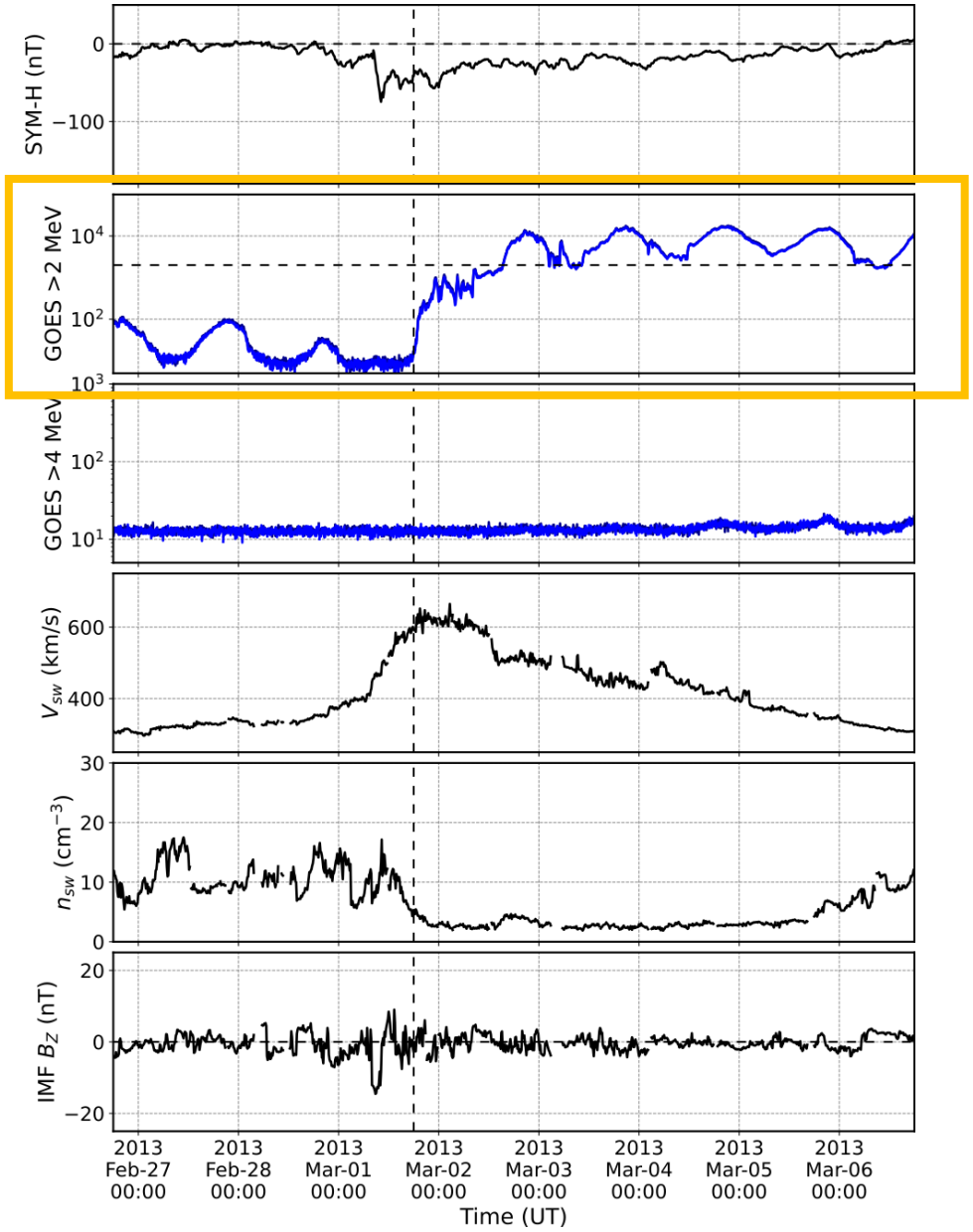
Finding all Enhancement Events From Data



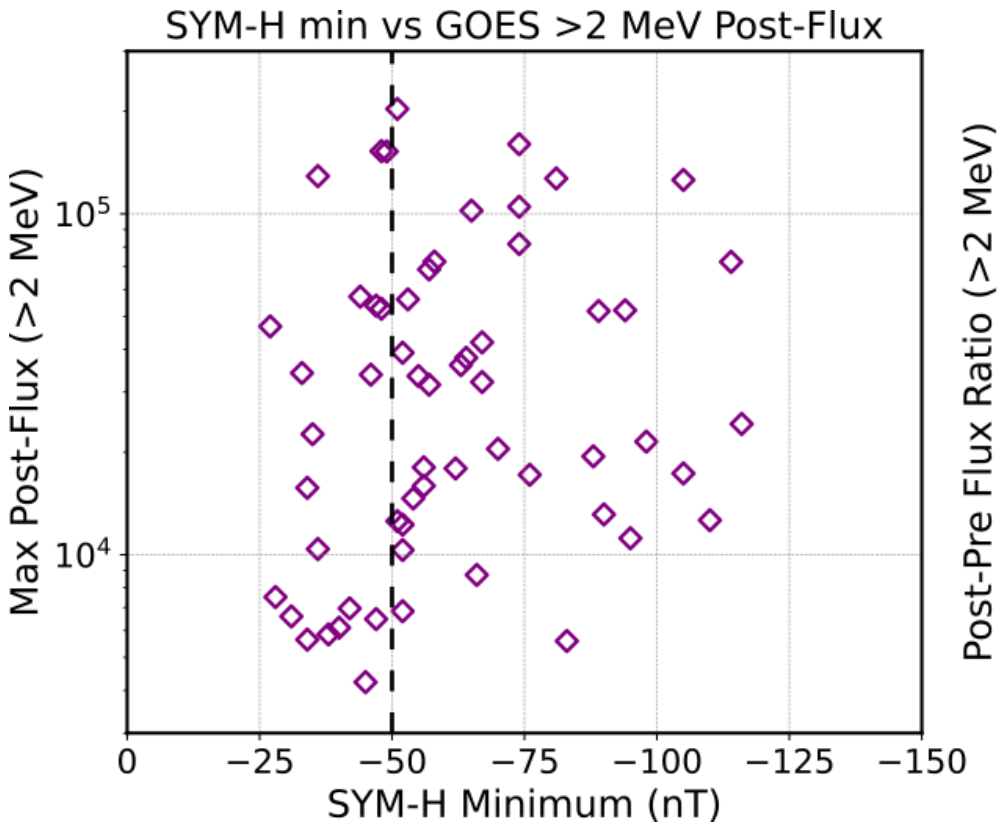
Relativistic electron enhancement event: an increase in the >2 MeV electron flux from less than 100 cm^{-2} s^{-1} sr^{-1} up to at least $2x10^3$ cm^{-2} s^{-1} sr^{-1} in a period of time of less than 2 days.

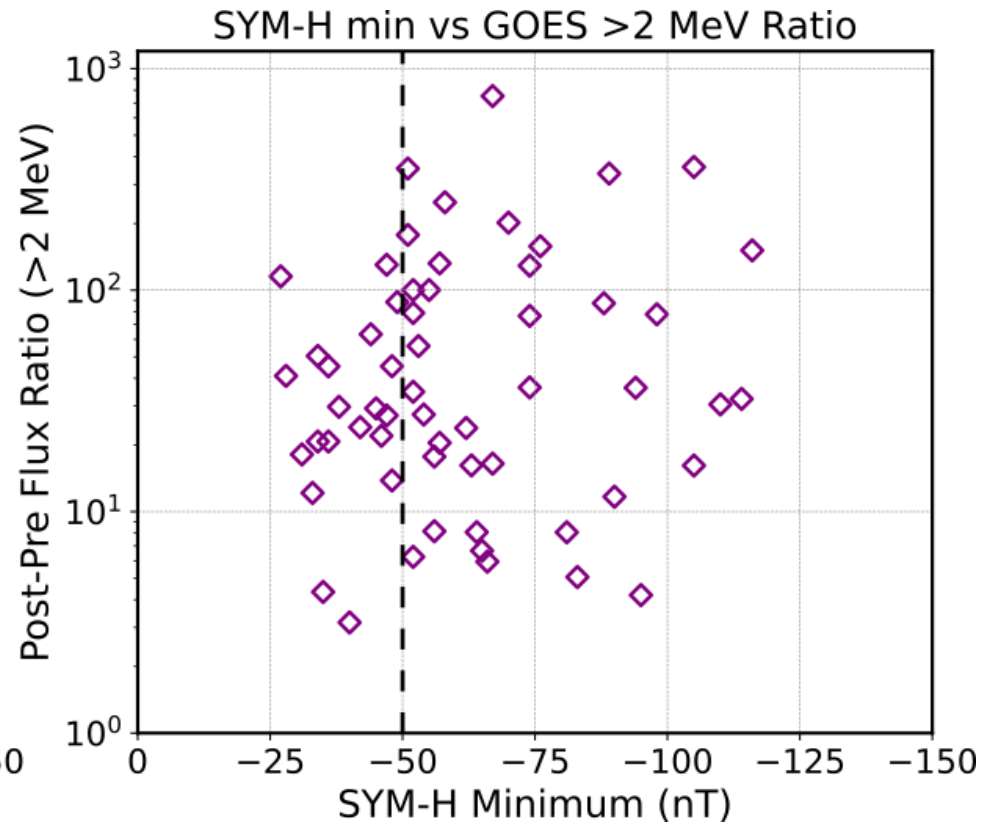
Period of study: 2012 to 2019
Enhancement events: 60



Pinto et al., (2018) JGR, *"Interplanetary Parameters Leading to Relativistic Electron Enhancement and Persistent Depletion …"*

Mínimum SYM-H Associated With Enhancements

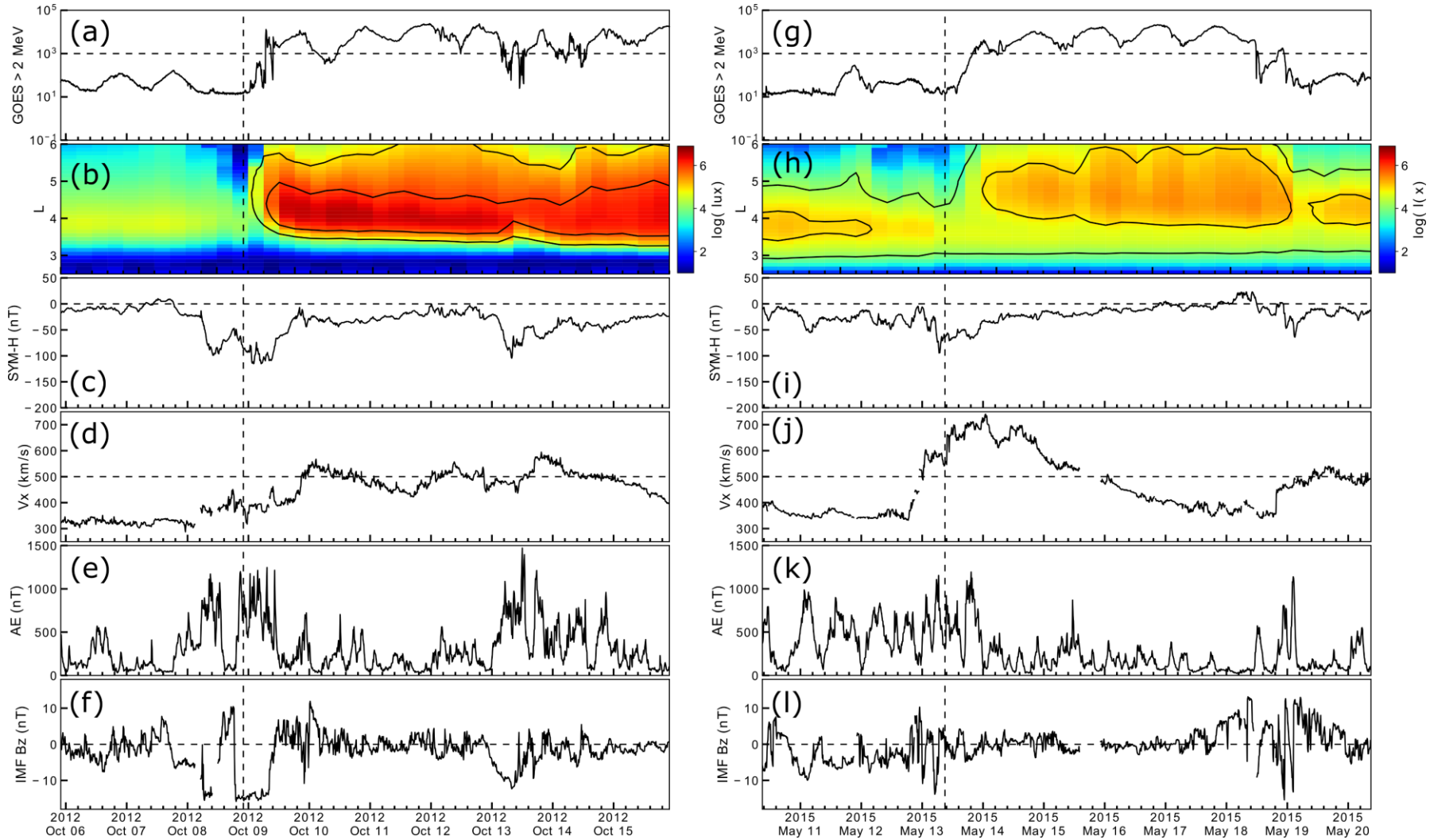




20 of 60 events (33%) occur with SYM-H min > -50, the most common definition for storm time

This indicates that a significant portion of events occur under “no storm condition” and thus are generally ignored in the statistical studies

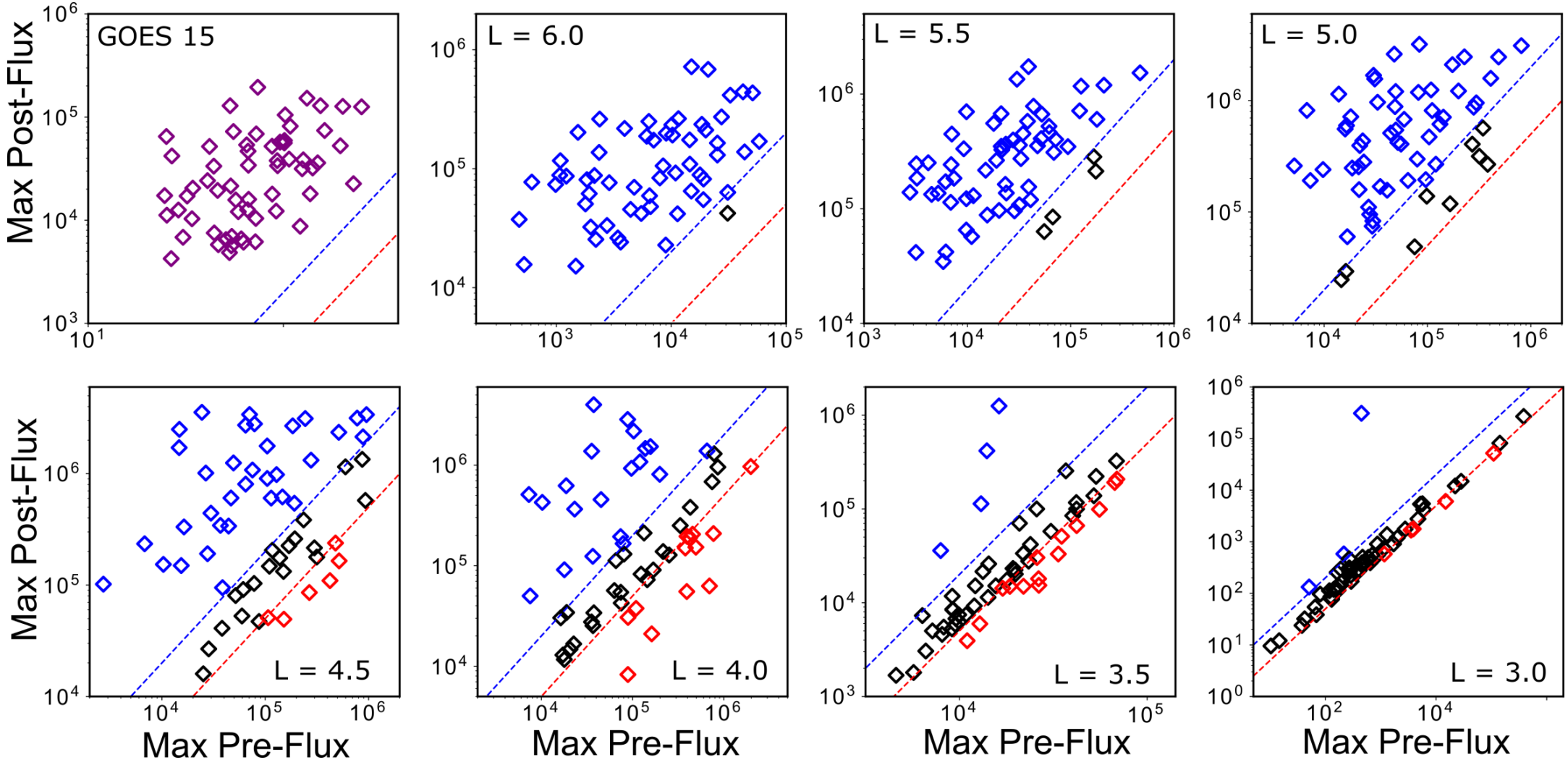
Extending GEO Results Across the Outer Radiation Belt



- MeV electron enhancement events in geostationary orbit (GOES), may present a different response in different L-shells (Van Allen Probes)
- 2 enhancements on 8 October 2012 and 13 May 2015 show very similar behavior at GEO but different behavior at different L-shells

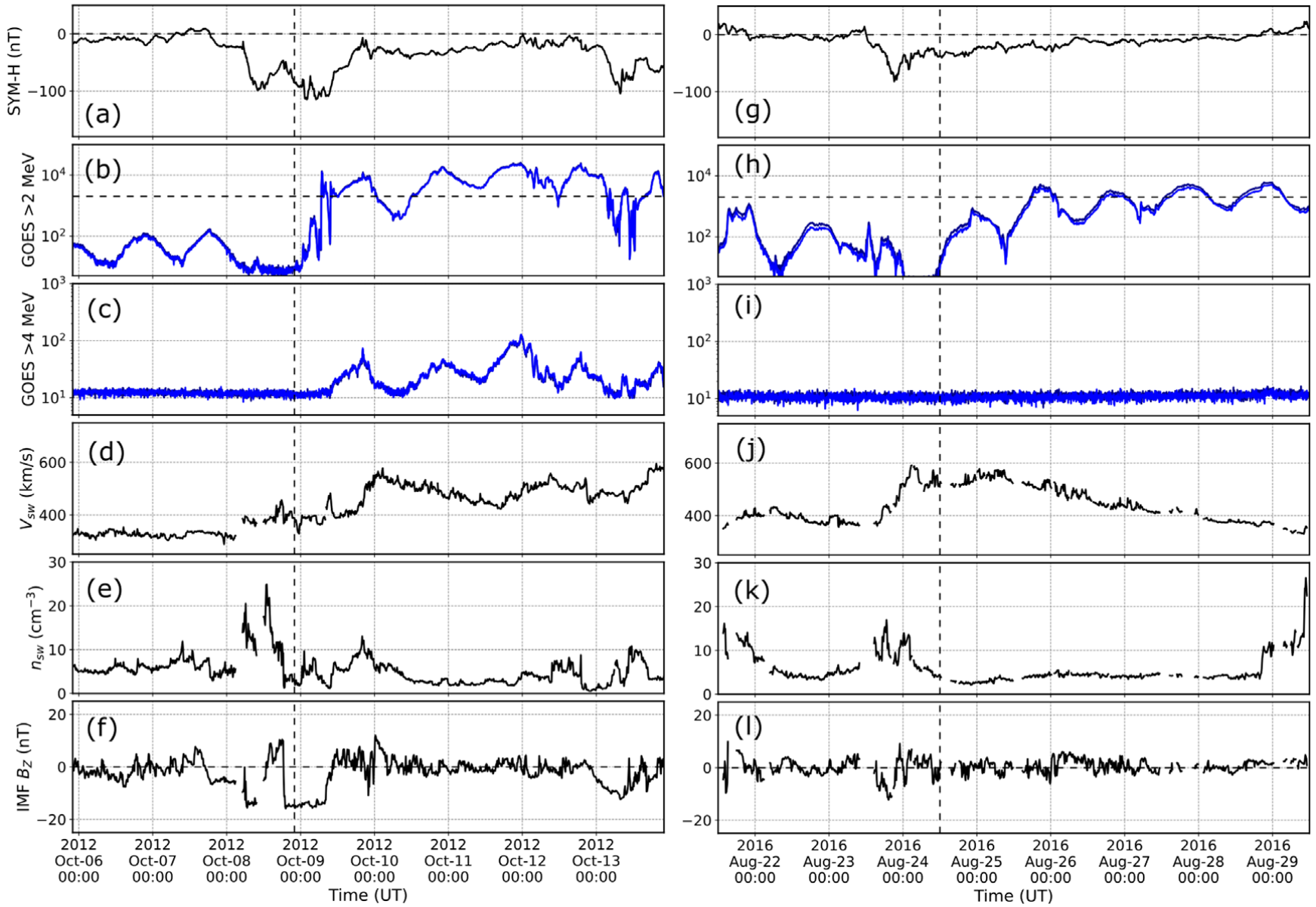
Pinto et al., (2020) JGR, *"Radial Response of Outer Radiation Belt Relativistic Electrons During Enhancement Events …"*

Occurrence of Enhancement Events as function of L



- Pre-flux to post-flux maximum values for all 60 events different L-shells.

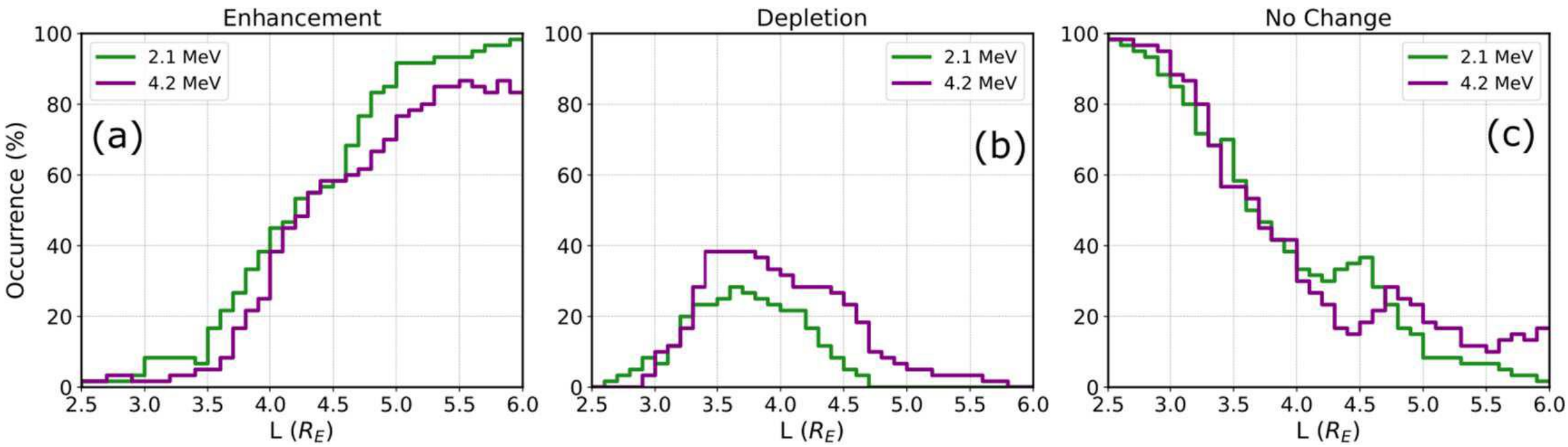
What happens if we include >4 MeV fluxes from GOES



- MeV electron enhancement events in geostationary orbit (GOES), may present a different response even in the >2 MeV and >4 MeV channels
- 2 enhancements on 8 October 2012 and 23 August 2016 show very different responses at the >4 MeV channels

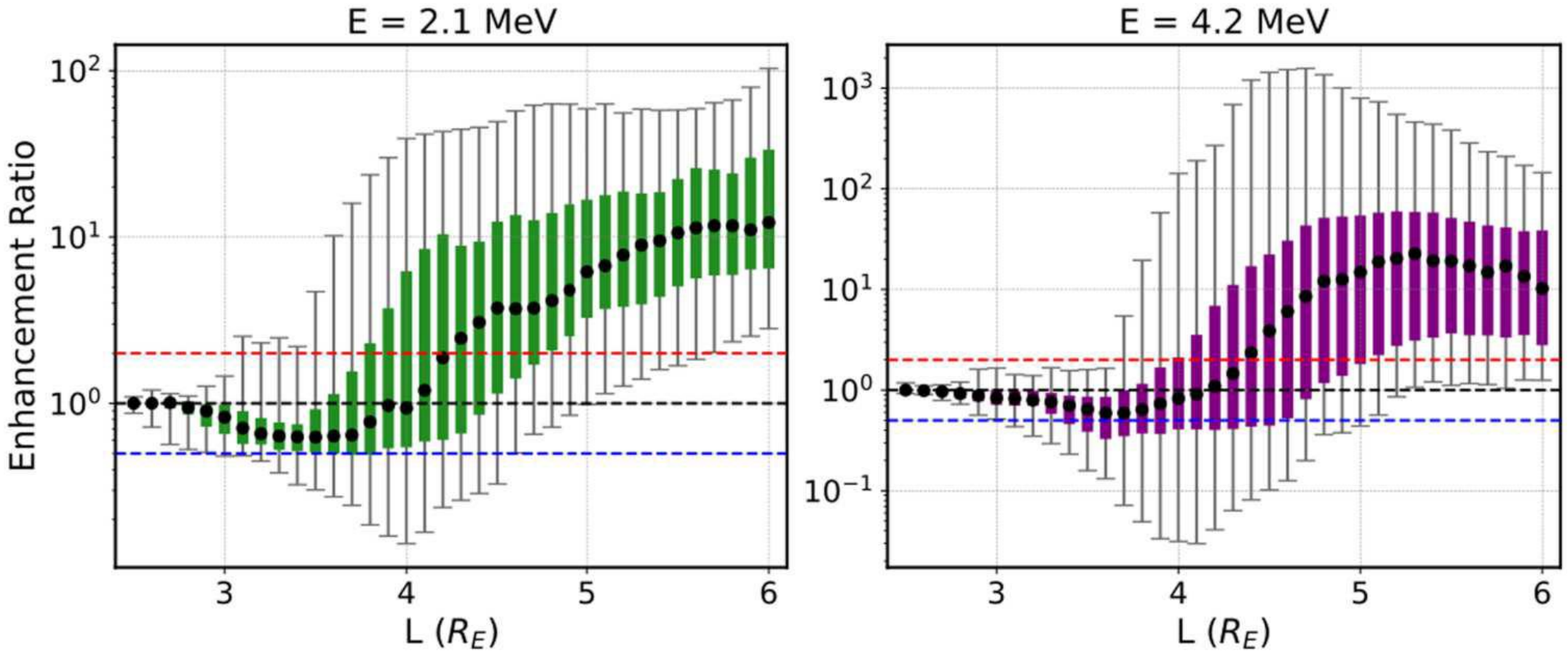
Pinto et al., (2025) Phys. Scri., *"Radial evolution of ultrarelativistic electrons during enhancement events"*

Characterizing Radial Response of Events



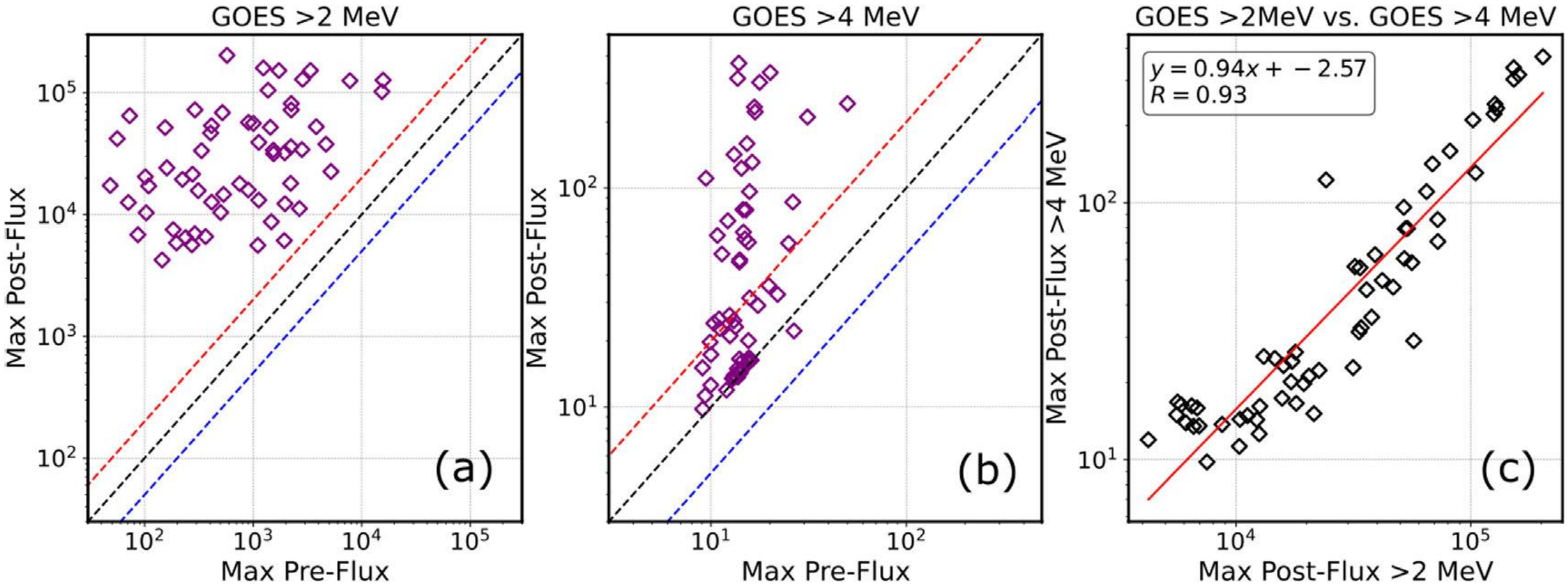
- Ocurrence of flux enhancement at different L-Shell for 2.1 MeV and 4.2 MeV energy measured by ECT-REPT
- While results are similar, there is an increase in depletion instances for 4.2 electrons

Pinto et al., (2025) Phys. Scri., *"Radial evolution of ultrarelativistic electrons during enhancement events"*



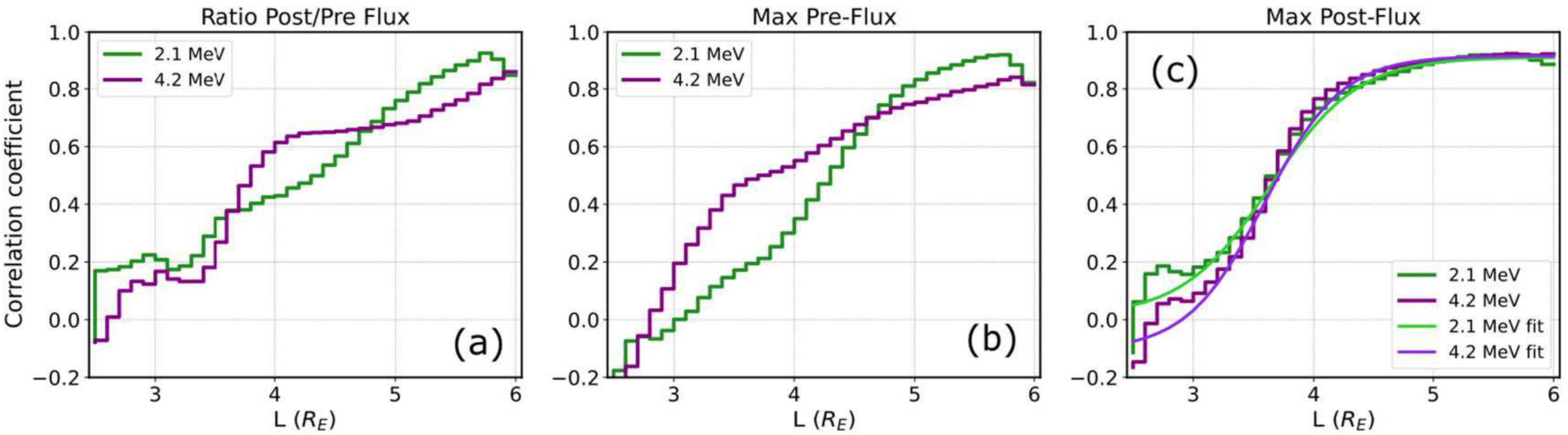
- Up to 25% of events result in depletion of fluxes with the most common occurrence at L=4.0

Correlation of GOES >2 MeV and >4 MeV Fluxes



- > 2 MeV and > 4 MeV electron flux ratio at geostationary orbit (GOES 15) for each of 60 events.
- Good correlation between >2 MeV and >4 MeV fluxes

Correlation of GEO fluxes with lower L-shell fluxes



- Correlation of maximum fluxes between GEO and lower L-shells decreases as the distance to Earth decreases.
- For both 2.1 MeV and 4.2 MeV electrons, the correlation can be described by a logistic function functional form

$$R(L) = C + \frac{A}{1 + \exp[-k\,(L - L_0)]}.$$

Summary

- Relativistic electrons (~2 MeV) and ultrarelativistic electrons (~4 MeV) measured at GEO orbit present a very high correlation (~0.93) during relativistic electron enhancement events
- Both >2 MeV and >4 MeV fluxes at GEO also correlate well with fluxes in the outer radiation belt, with a correlation that can be described by a logistic function. The correlation decreases as L decreases
- There is a clear coupling in the flux response for L>4 (high correlation) that quickly decreases for L< 4 (low correlation)
- Models that rely on in-situ data to describe or predict the state of the outer radiation belt can benefit from including GOES >2 MeV and >4 MeV data since it contains relevant information of lower L-shells

Thanks