

The Spatial Distribution of Upstream Ion Events Measured by ACE, Wind, and STEREO-A Near The Earth's Bow Shock

STEREO SWG#17, Nov 13-14 2007

M. I. Desai¹, G. M. Mason², & R. Müller-Mellin³

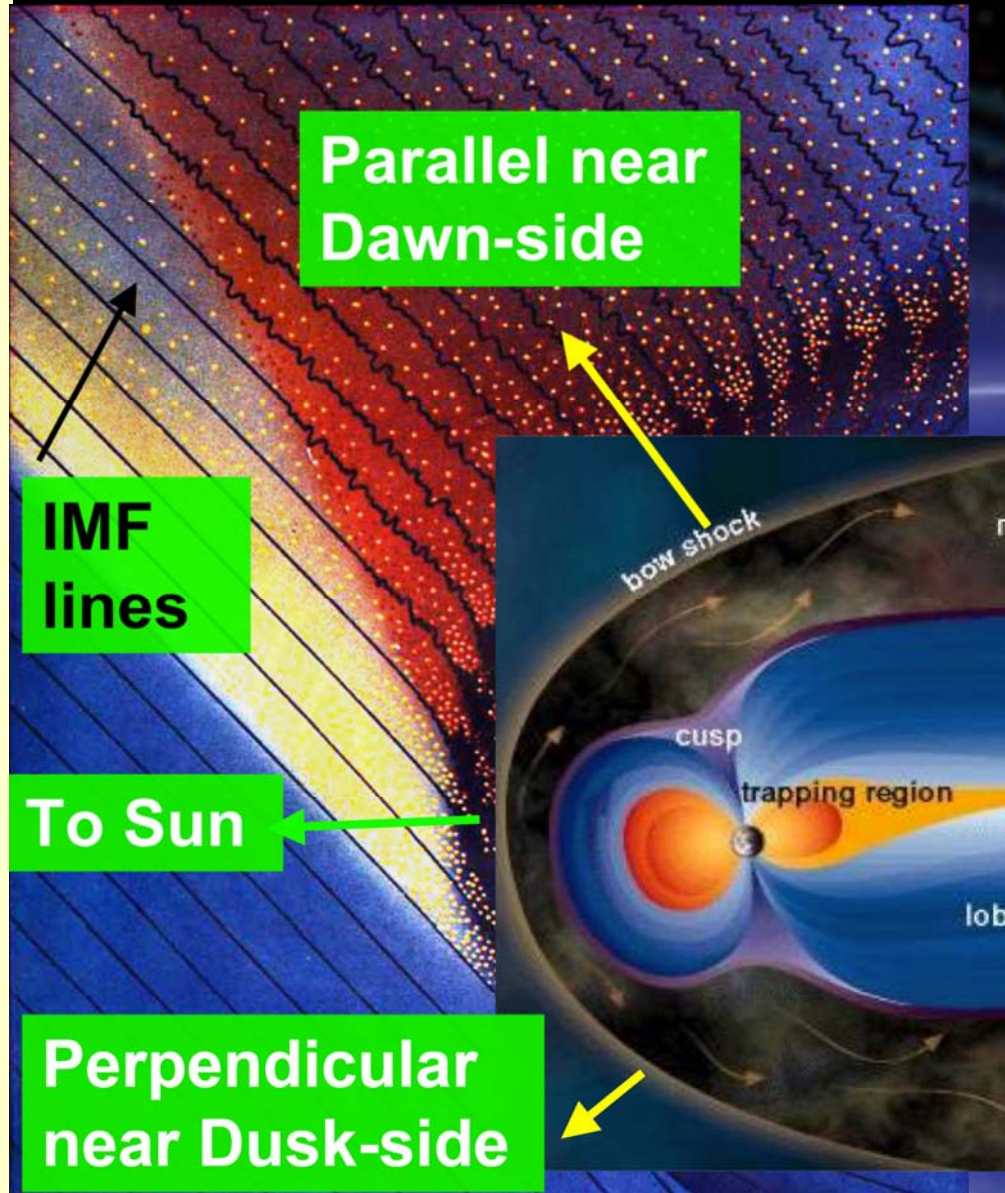
¹Southwest Research Institute, San Antonio, TX, USA

²Johns Hopkins University/Applied Physics Laboratory, Laurel, MD, USA

³University of Kiel, Kiel, Germany

Big Issues: Upstream Ion Events

- **Where accelerated?**
 - Ring current, cusp, magnetotail, bow shock
- **What material?**
 - Ionospheric ions, solar wind, or other
- **How accelerated?**
 - Reconnection-driven, ULF-waves, parallel E fields, or bow-shock acceleration
- **Transport**
 - Leakage, streaming

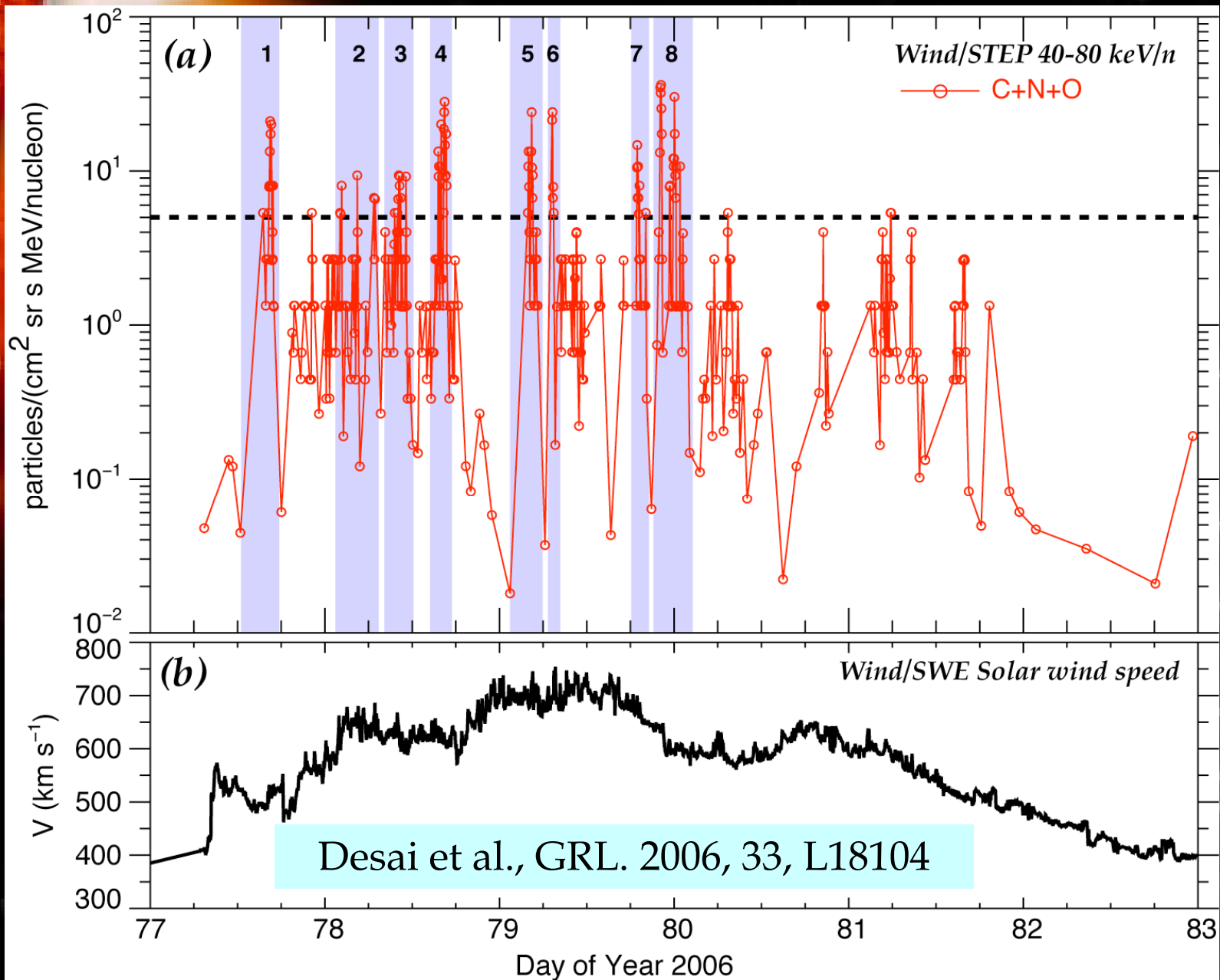


Upstream Events outside Foreshock

- Short duration (~minutes to hours) bursts
- Highly controversial origin and acceleration:

Property	Acceleration at Bow Shock	Acceleration inside magnetosphere + leakage
Composition	Solar wind-like: C, Ne-S, Fe	Ionospheric Ions, O ⁺ , N ⁺ & solar-wind-like
Spectra	Exponential in E/Q; cut-off ~150 keV/q - Diffuse ions Reflected ions, ion Beams	Power-laws, extending up to ~2 MeV
Electrons	Only at quasi-perpendicular portions via shock drift process	Up to ~300 keV
Anisotropy	Isotropic, gyrating, beam-like	Free streaming

Upstream Events outside foreshock



UPSTREAM EVENTS

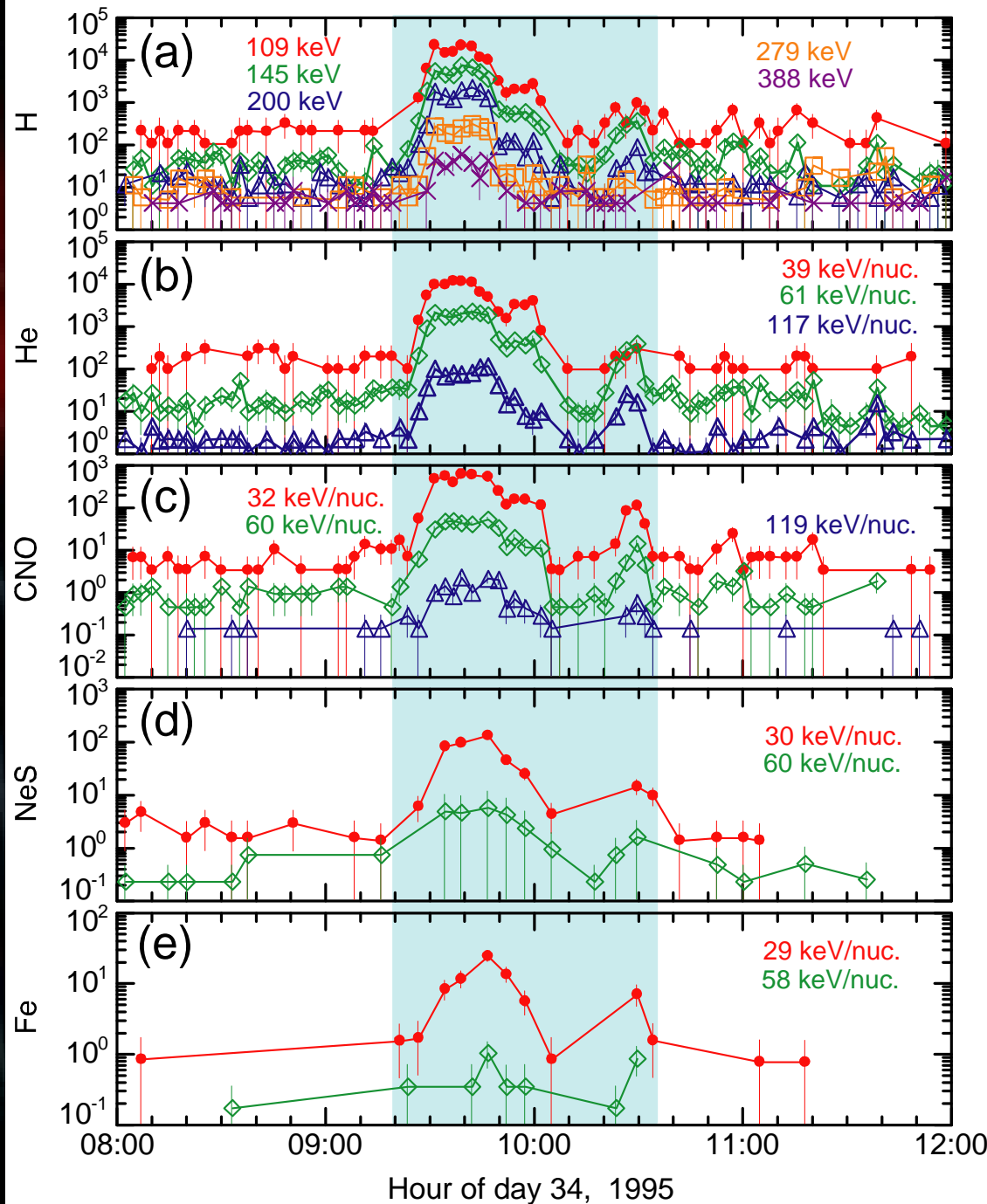
>30 Re

Wind/STEP Time-intensity profiles for 1 event

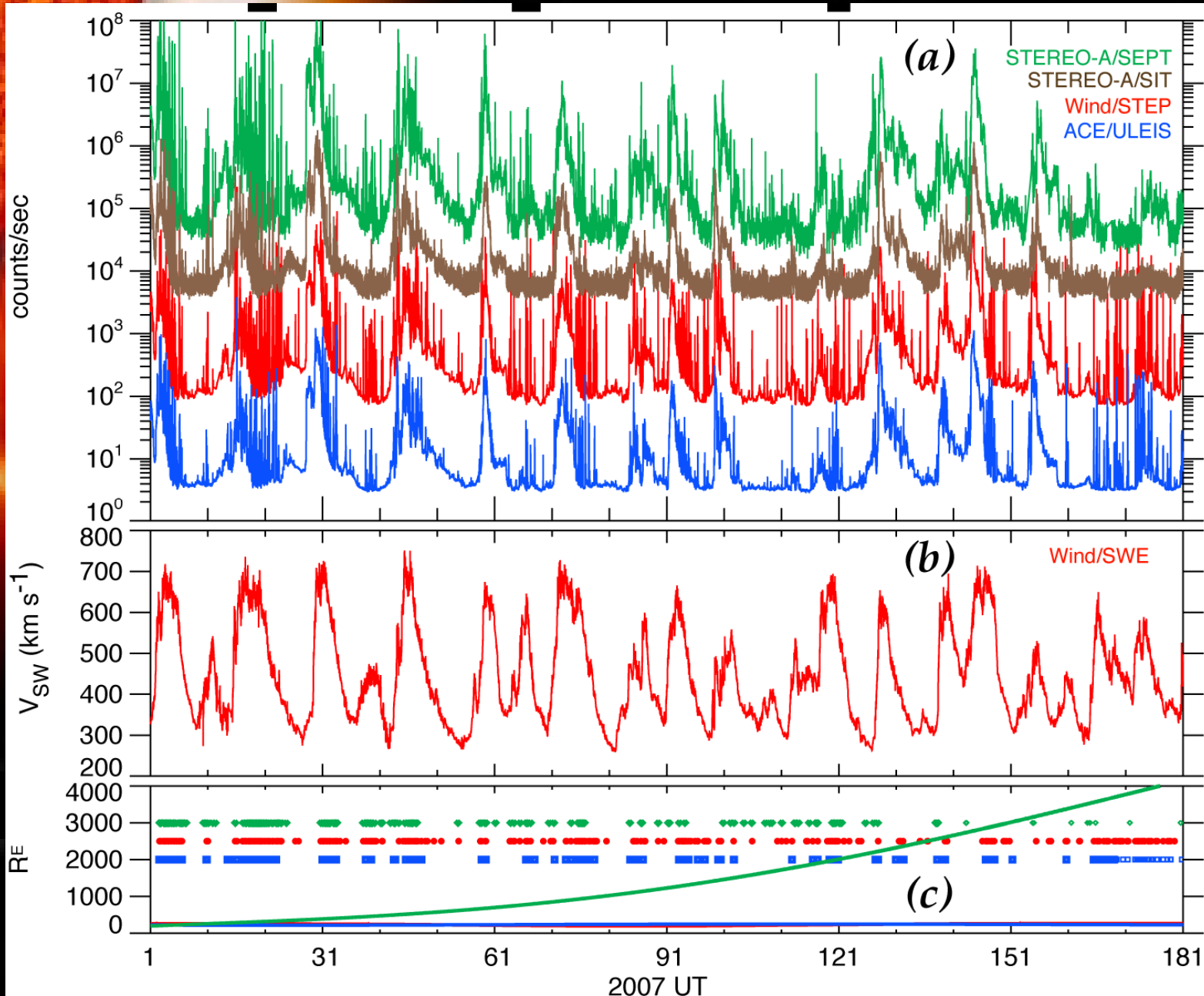
Abrupt intensity increases lasting an hour

Solar-wind species like Ne-S and Fe are present

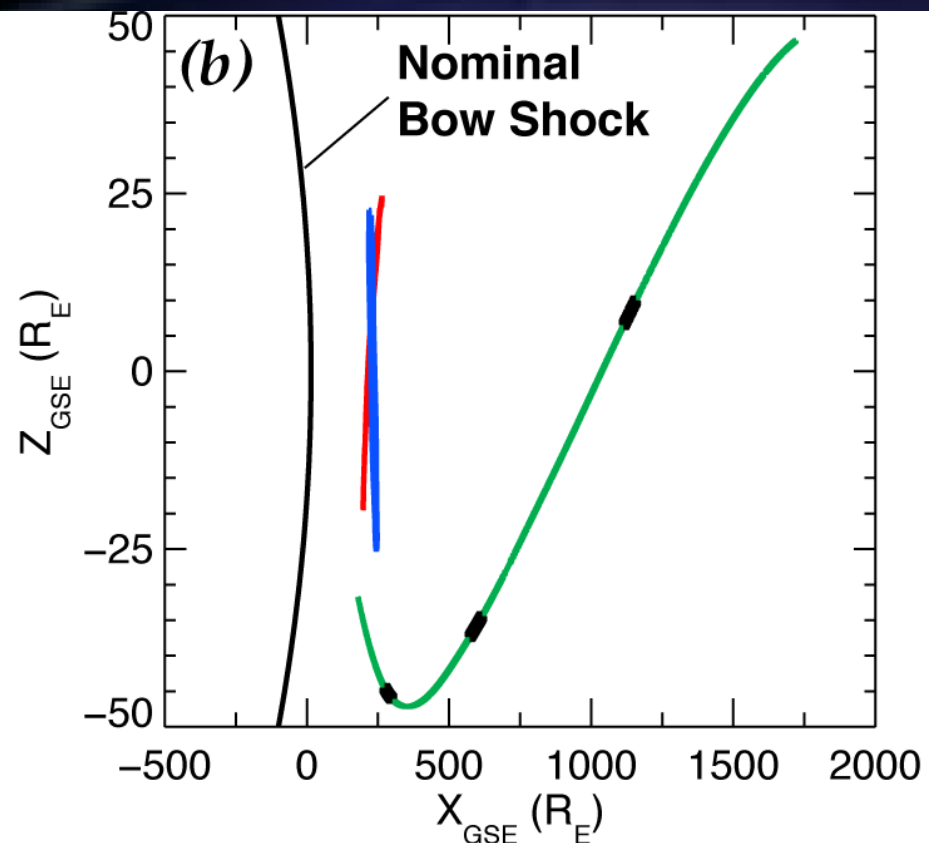
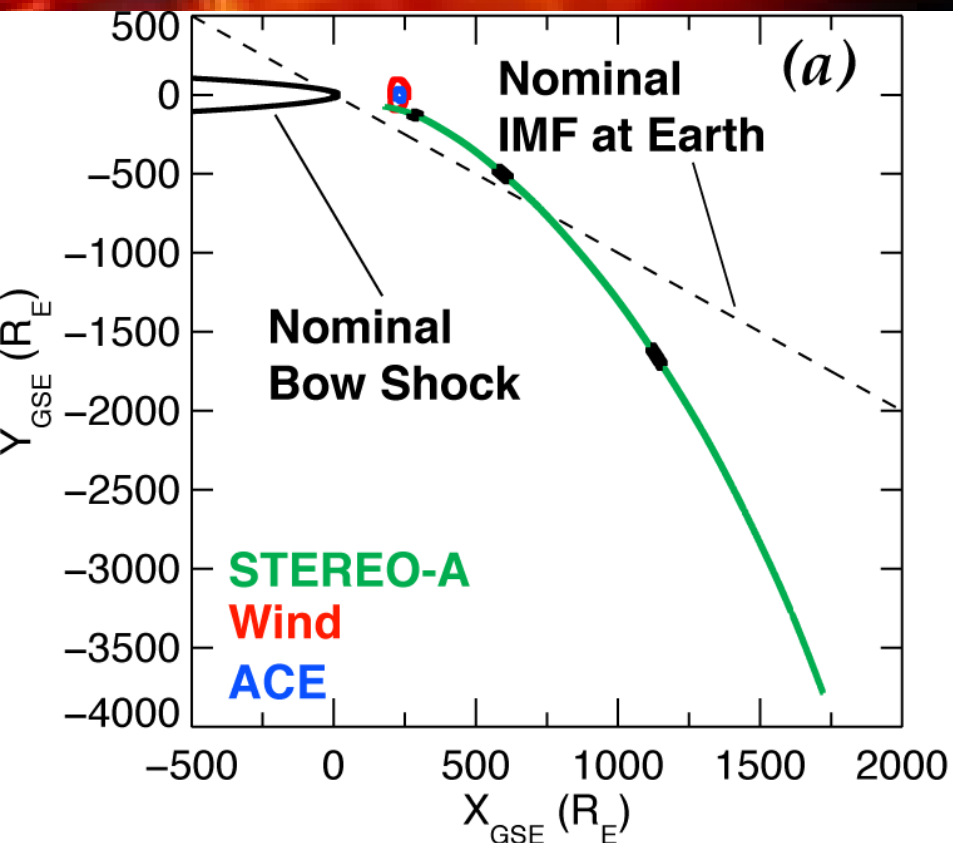
Desai et al., 2000, JGR,
vol. 105, pp. 61-78



Overview



ACE, Wind, and STEREO-A during 2007, 1 - 2007, 181



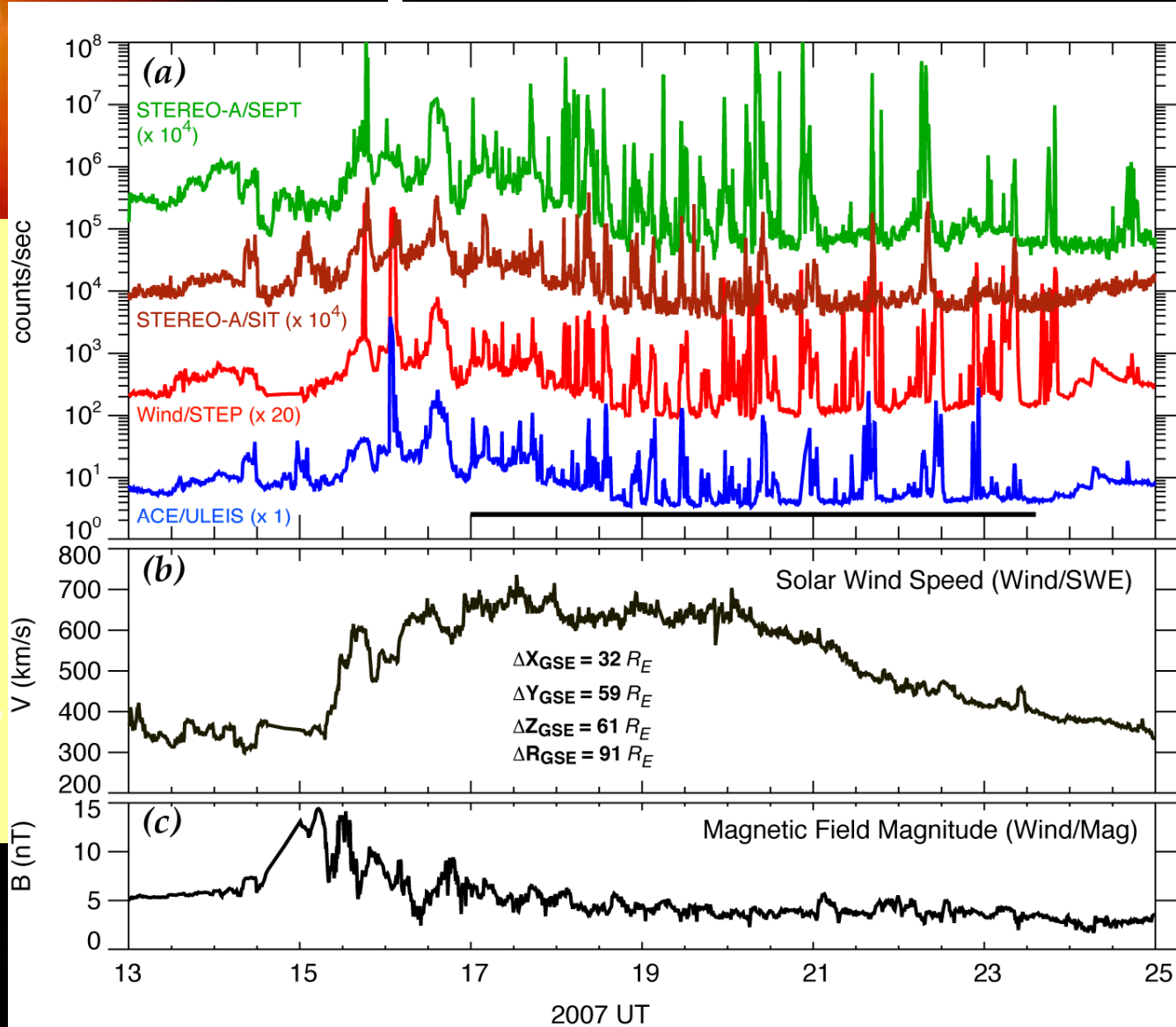


Event Selection and Data Analysis

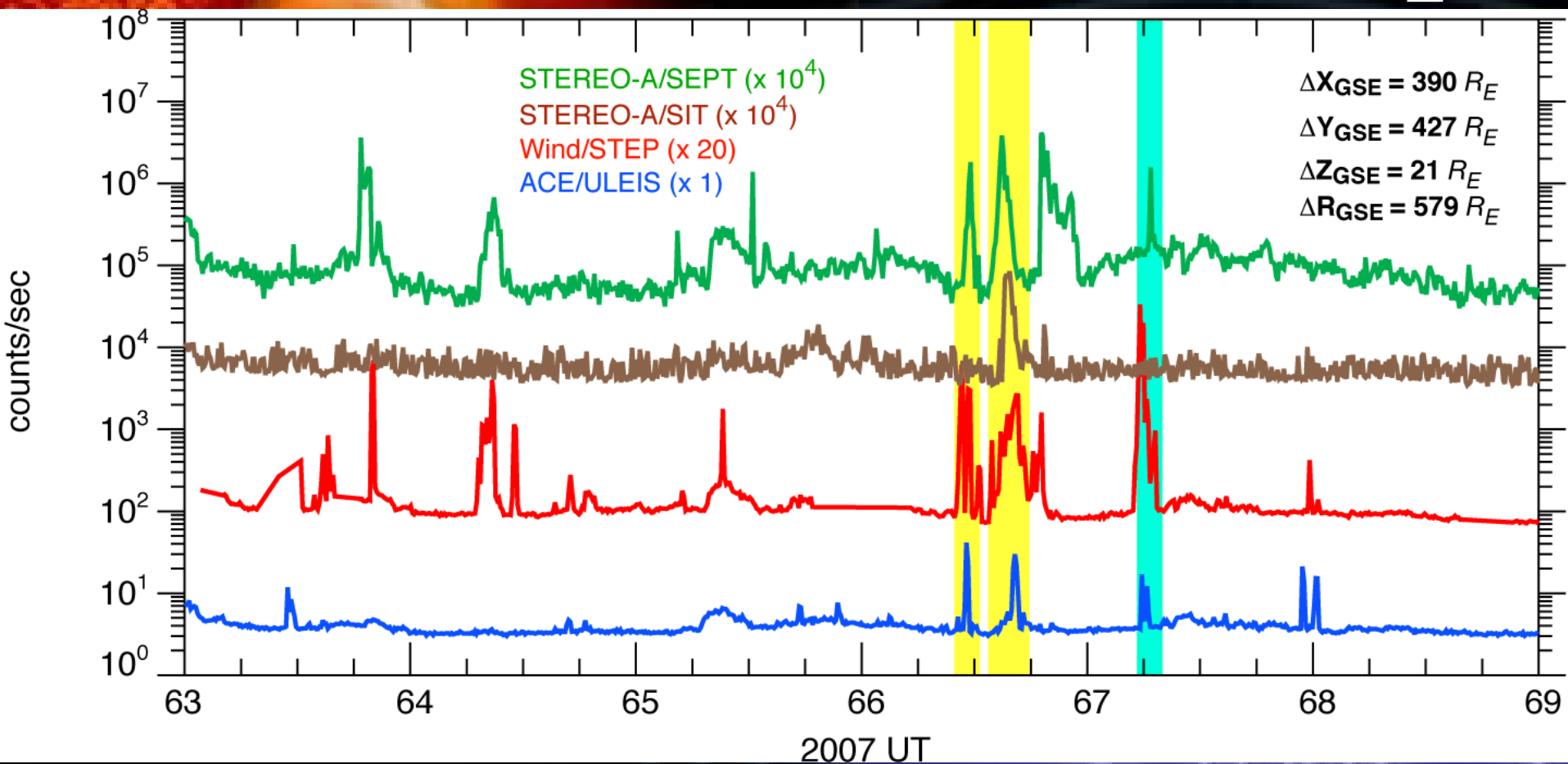
- **Use ACE/ULEIS, Wind/STEP, STEREO-A/SEPT and STEREO-A/SIT measurements from 2007, day 1 - day 181.**
- **Identified upstream events independently at each spacecraft**
 - 300 at Wind, 201 at ACE, and 181 at STEREO-A
- **Identified simultaneous events: Events that occurred within 2-hour intervals of ongoing events at Wind**
 - 90 simultaneous events at WIND/STEREO-A

12-day period, showing a sequence of upstream events

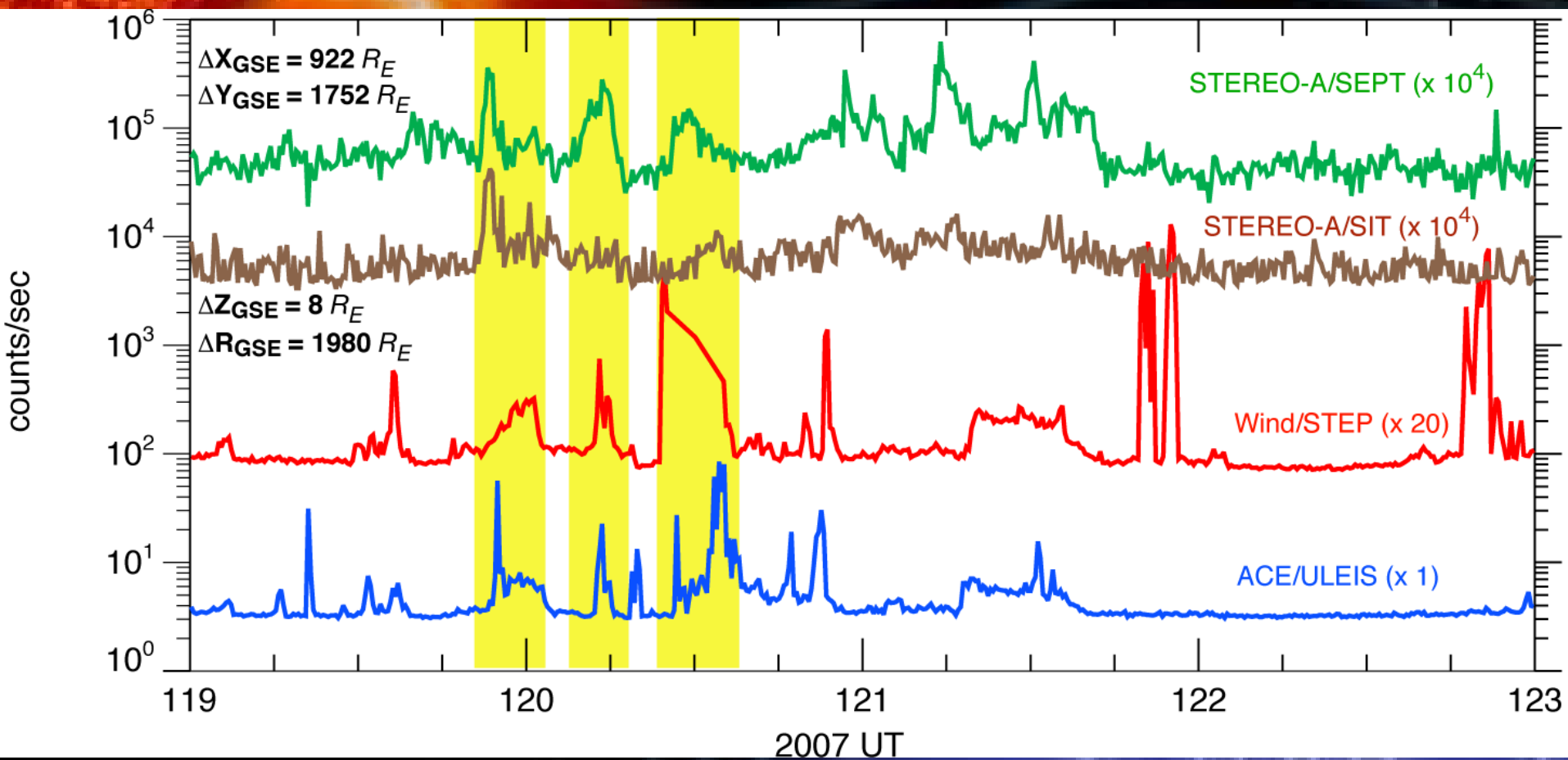
Events occur when the S/C are immersed in the high speed solar wind flow after the compression region has passed Earth



Simultaneous Upstream Events at separation distance of $\sim 580 R_E$

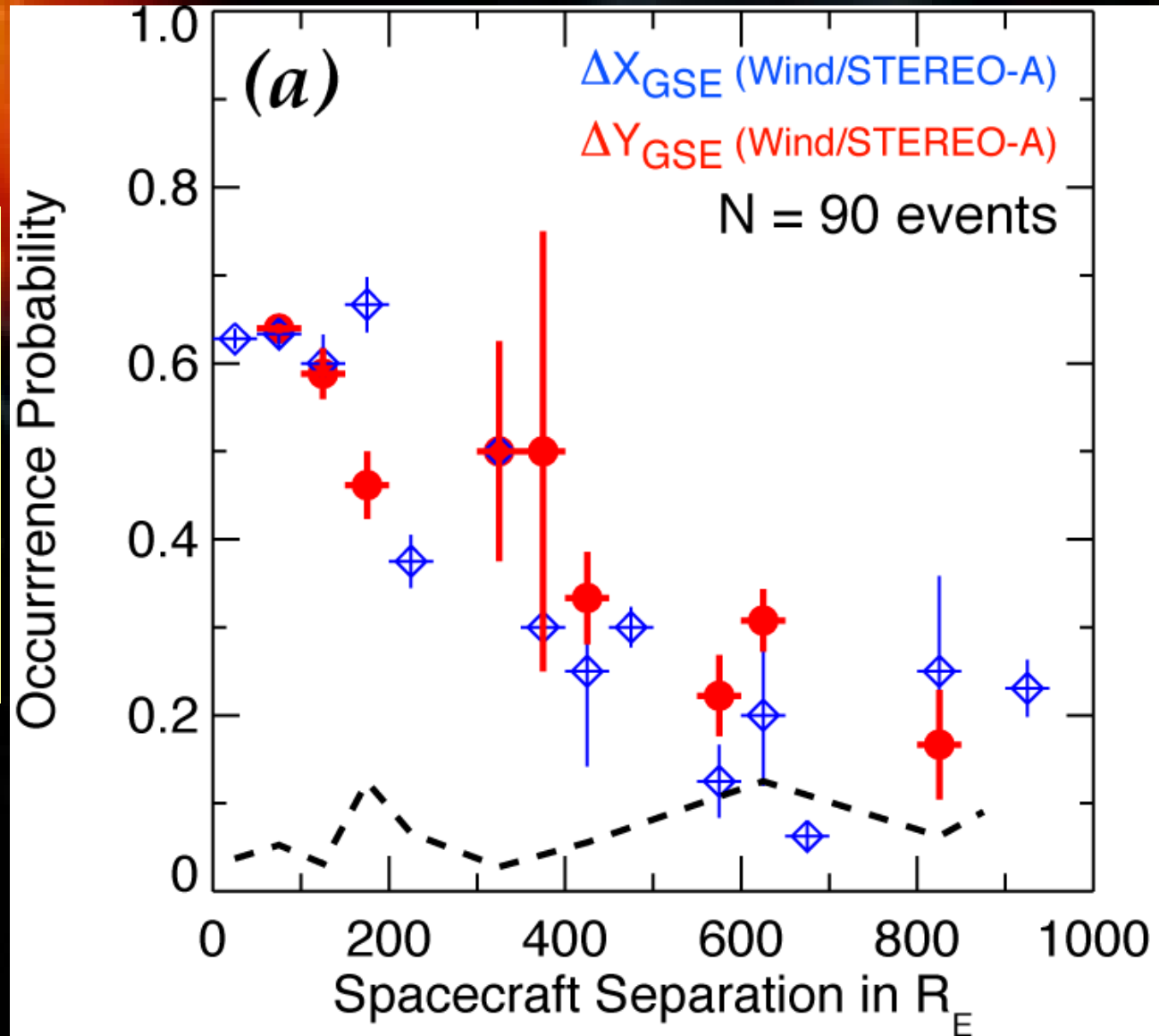


Simultaneous Upstream Events at separation distance of $\sim 2000 R_E$



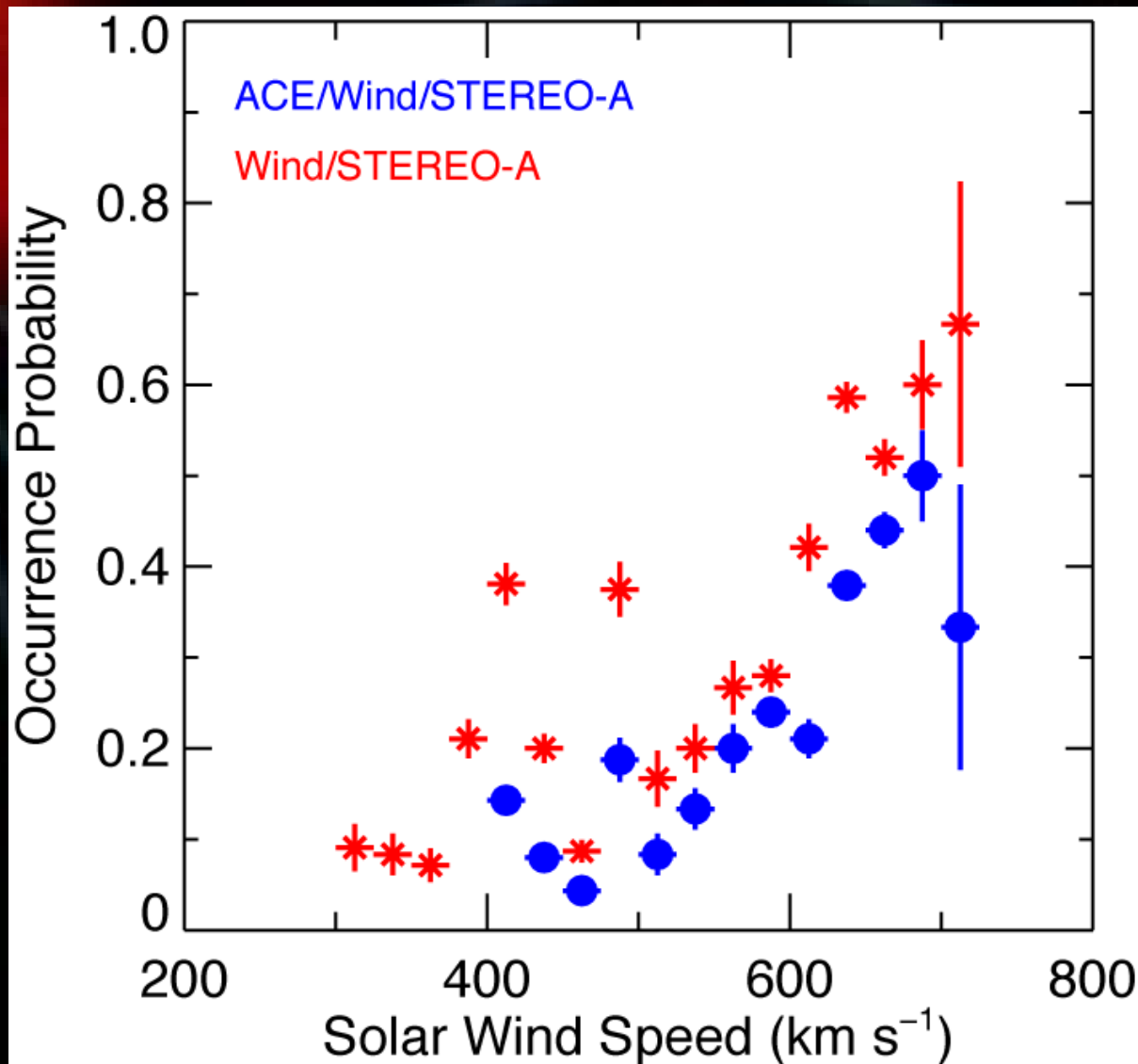
Occurrence Probability of simultaneous upstream events

Upstream events are observed simultaneously at Wind and STEREO-A when the separation distance $>800 R_E$

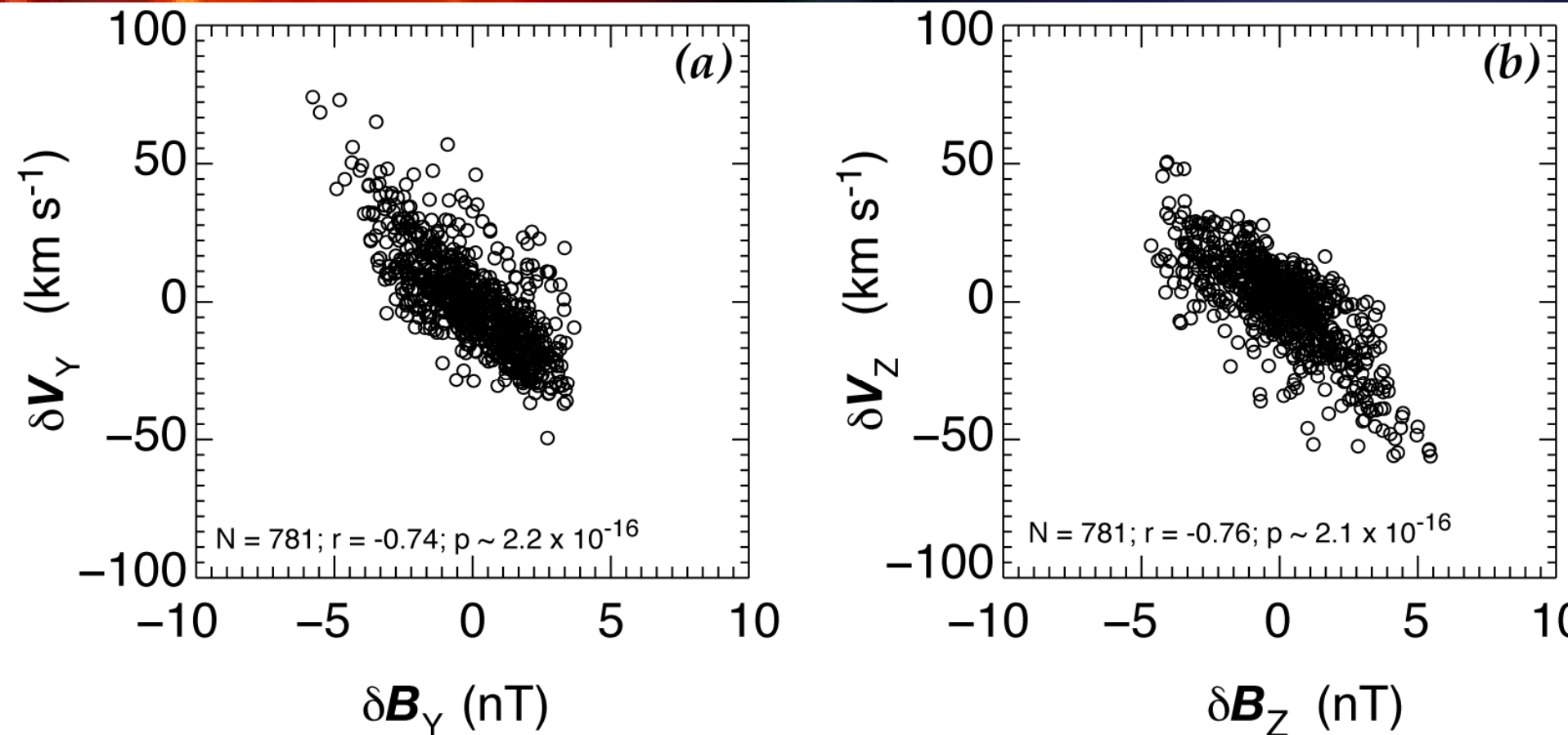


Occurrence Probability of simultaneous vs. V_{SW}

Occurrence probability of simultaneous upstream events increases dramatically when solar wind speed increases above ~600 km/s

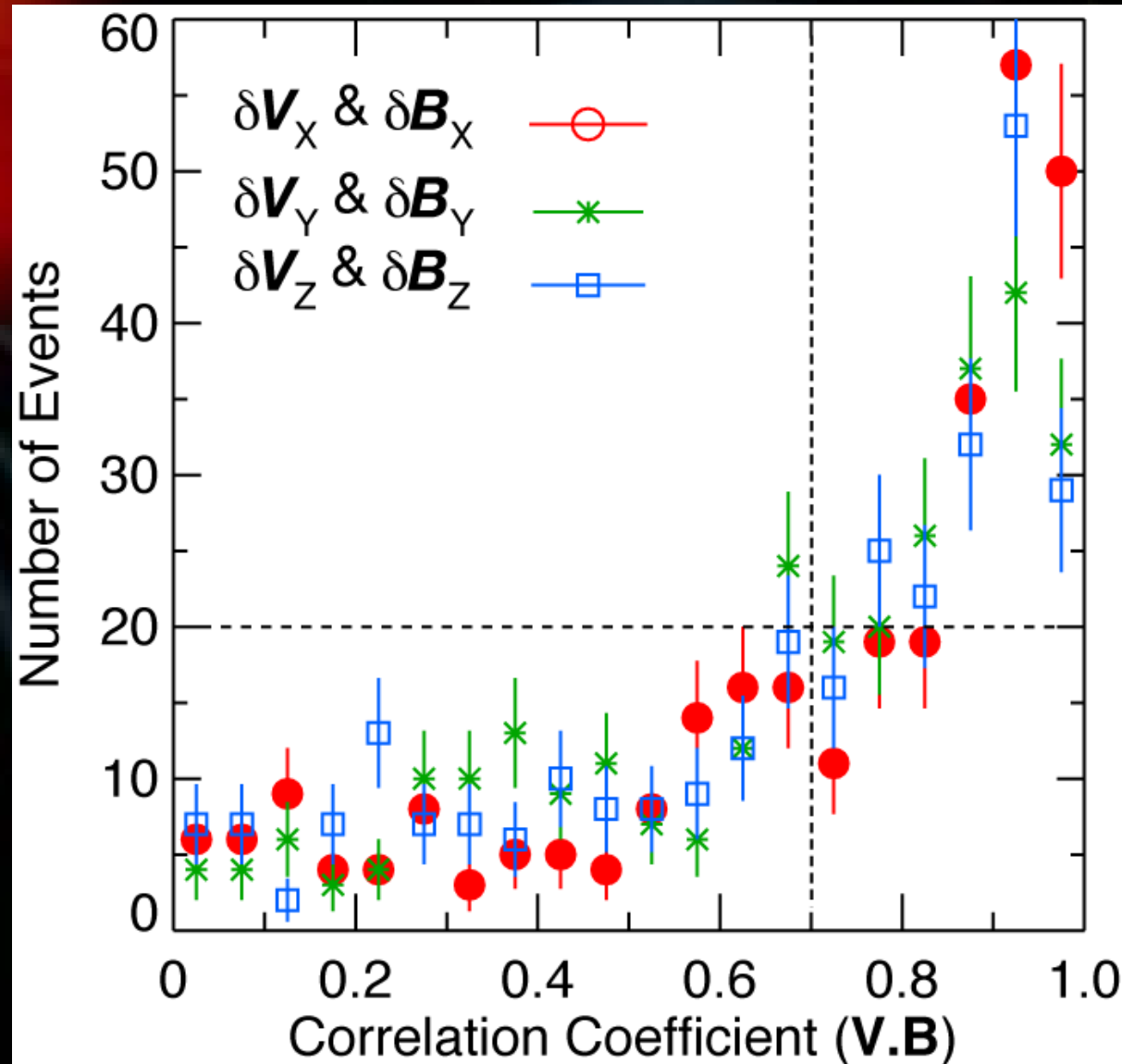


Simultaneous upstream events are accompanied by large amplitude anti-Sunward Alfvén Waves



Number of Upstream events vs V.B correlation Alfvén Waves

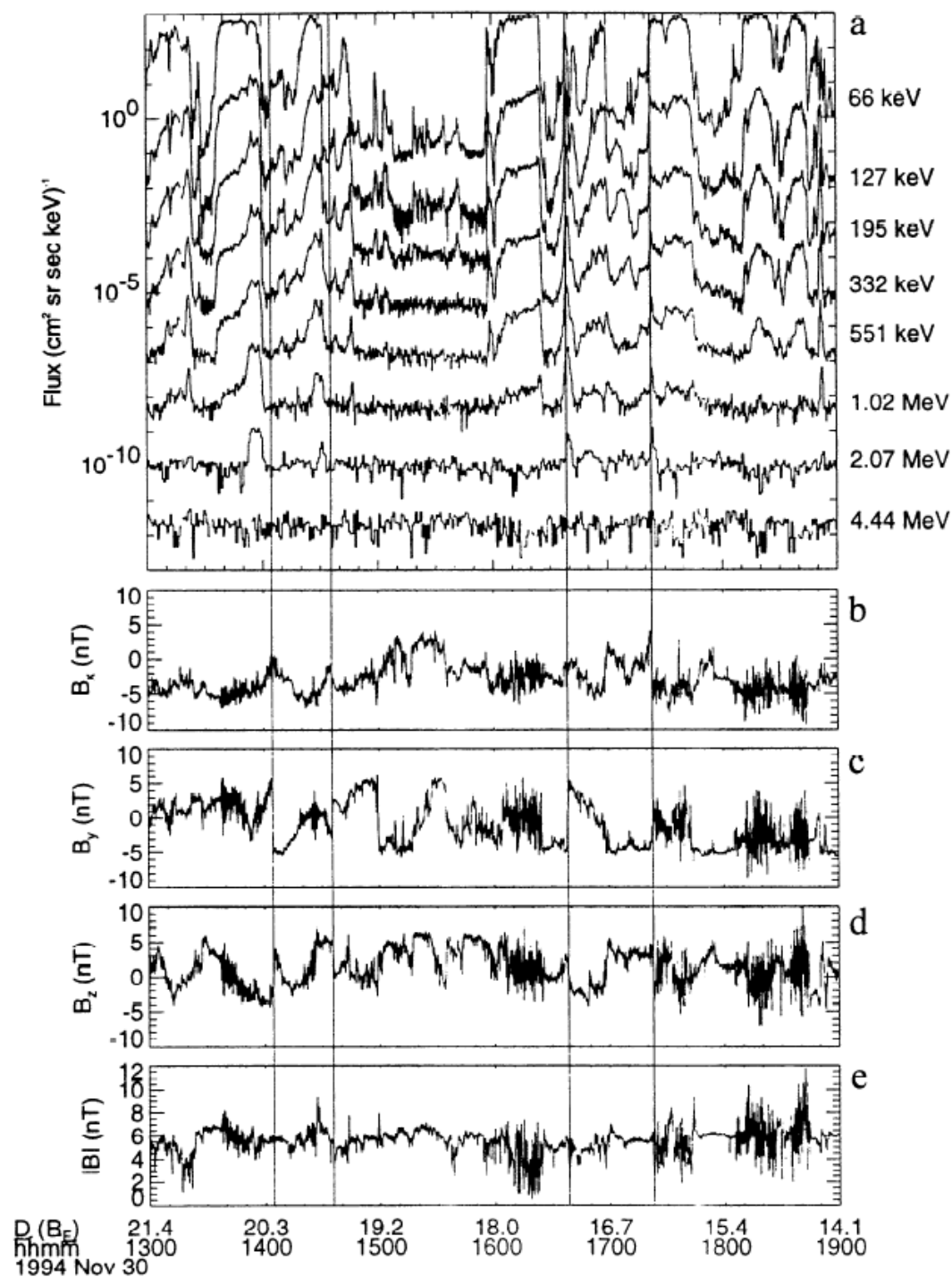
Majority (~92%) of upstream events occur in association with outward propagating Alfvén waves



Freeman & Parks (2000)

Upstream ions are accelerated by reflection between two converging magnetic mirrors: (1) large IMF rotations and (2) the Earth's bow shock

Our Results show that these "IMF rotations" are large amplitude Alfvén waves that are embedded in high-speed solar wind streams



Summary

- **STEREO-A observed upstream events even when it was separated from Earth by $\sim 1750 R_E$ in the radial and $\sim 3800 R_E$ in the lateral directions**
- **Occurrence probability for measuring simultaneous upstream events at L1 and STEREO-A remained high ($\sim 20\text{-}30\%$) even at large radial and lateral separations ($\sim 800 R_E$)**
- **Occurrence probability of simultaneous upstream events at L1 and STEREO-A increases with solar wind speed and in association with anti-sunward propagating large amplitude Alfvén waves.**

Conclusions

- **Upstream ion events originate from a global source region that is comparable to the size of the Earth's bow shock**
- **The presence of large amplitude Alfvén waves embedded in high-speed solar wind streams facilitates the scatter-free propagation of upstream ions in the regions traversed by STEREO-A**
- **The Alfvén waves could also play a critical role in accelerating solar wind and suprathermal ions**
 - **Following the passage of the compression region past the Earth, the expanding bow shock could act as converging magnetic mirrors and accelerate by reflection and first-order Fermi processes (e.g., Freeman & Parks 2000).**