Van Allen Probes observations of high energy radiation belt electrons and SEP protons: Space weather aspects

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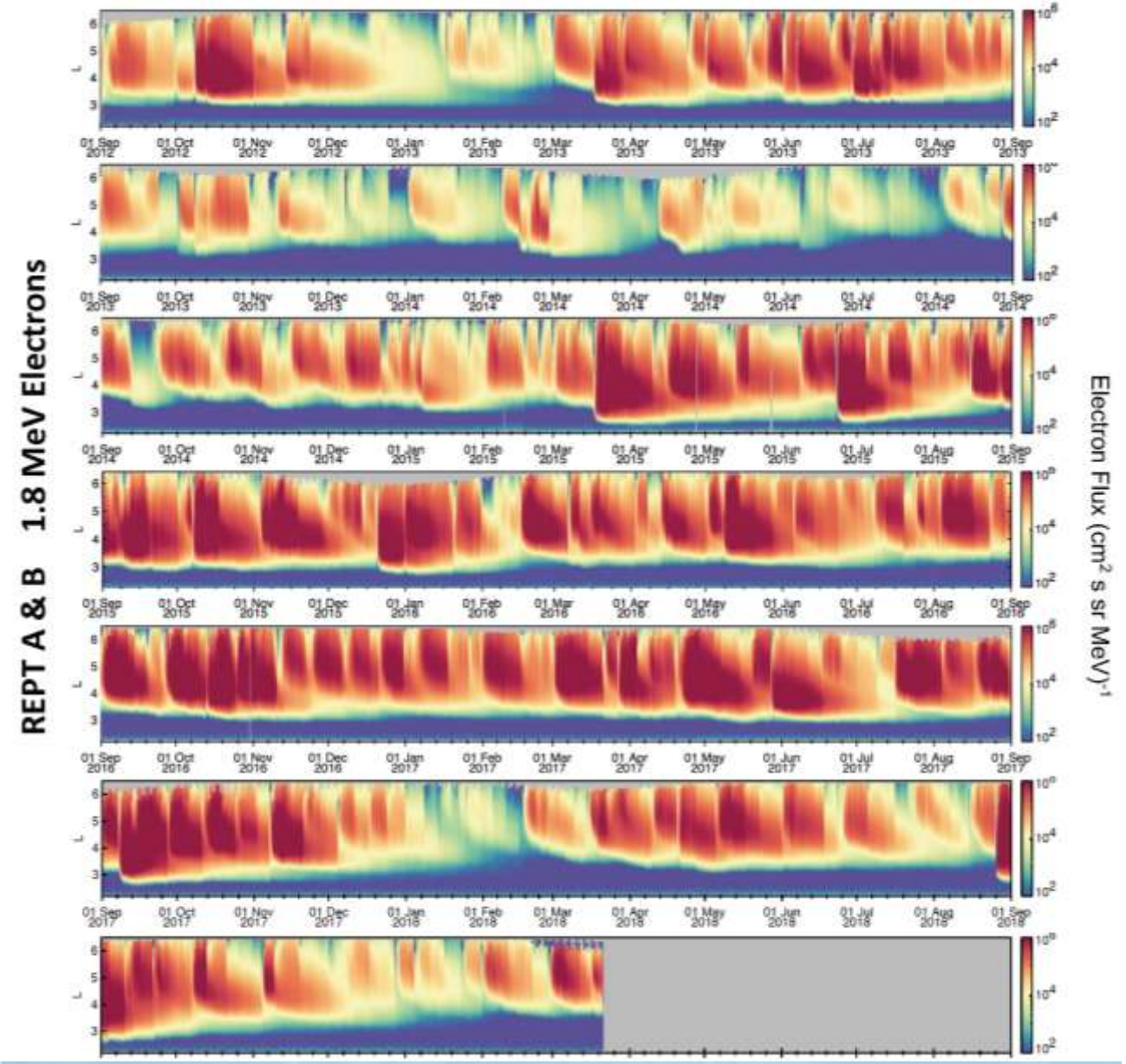
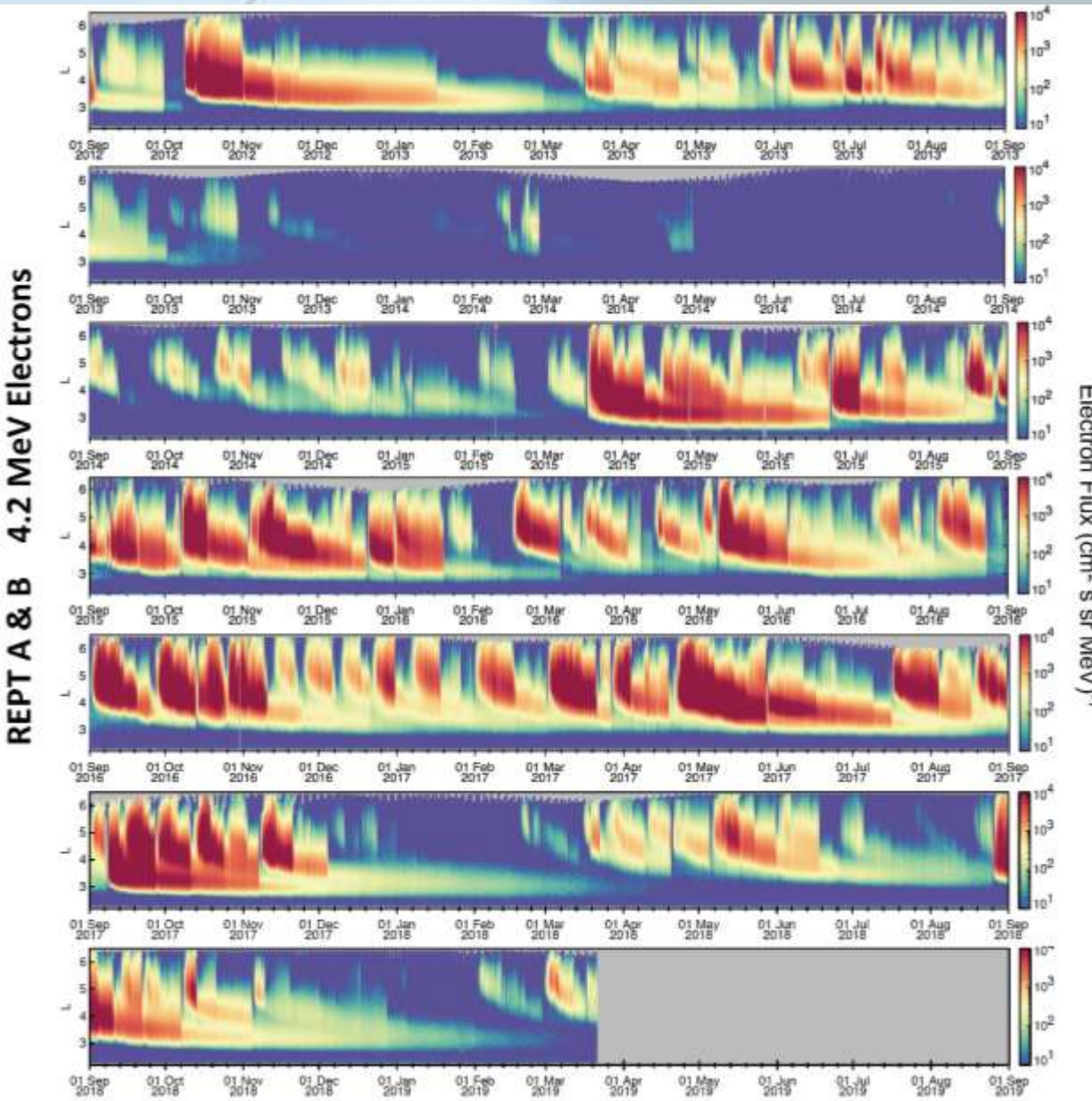
Van Allen Probes: Seven years of Relativistic Electron measurements



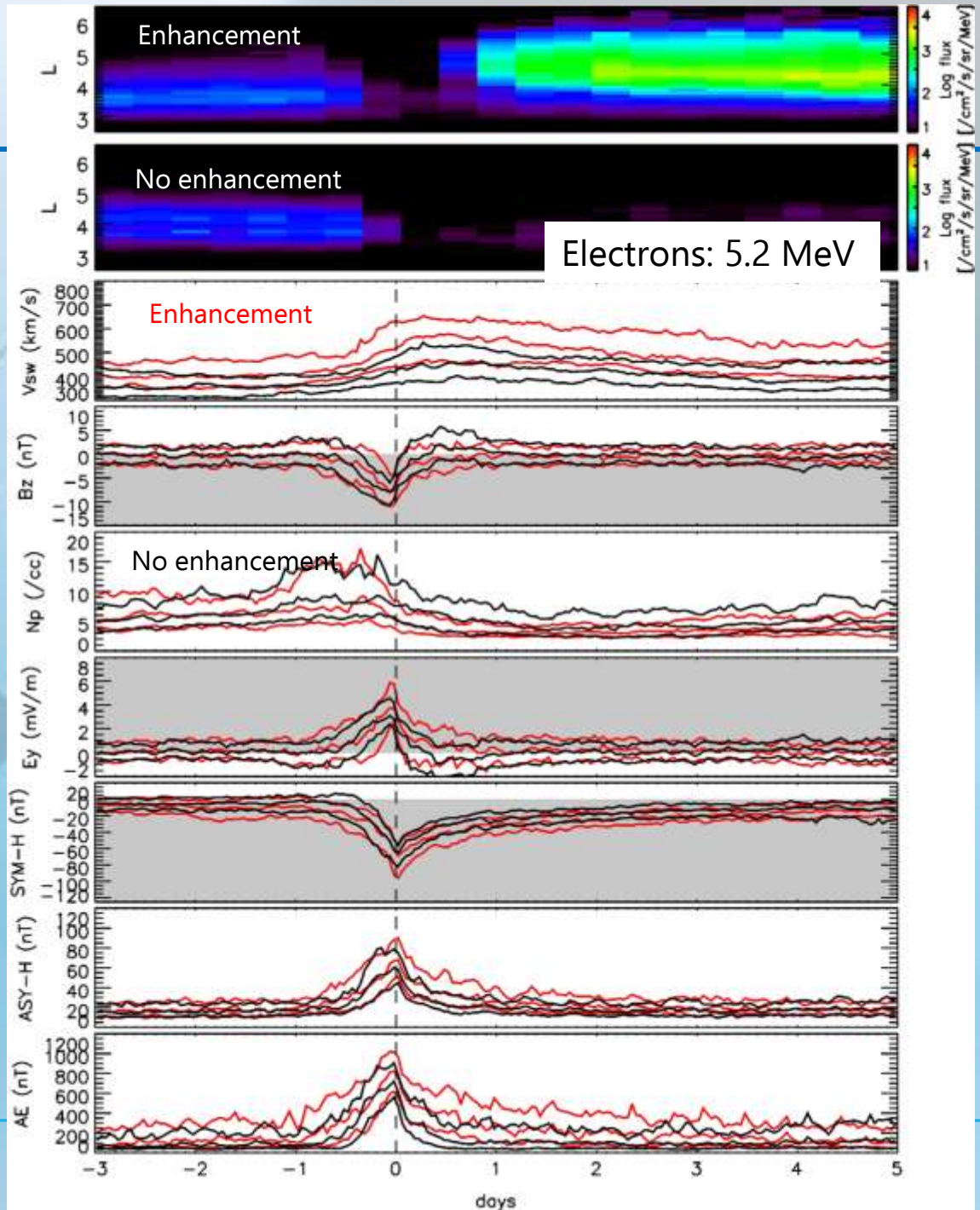


When are ultra-relativistic electrons produced?

Superposed Epoch: Sep. 2012 to Apr. 2018
Storms 49 (38) enhancement (no) of 5.2 MeV e^-

Storms with Enhancement

- Higher solar wind speed
- Longer and sustained IMF Bz
  - energy transfer to the magnetosphere
- Solar wind E_y higher peak value
  - energy transfer to the magnetosphere
- Persistent higher AE
  - seed population from substorms
- Higher ASY-H
  - conducive to wave generation

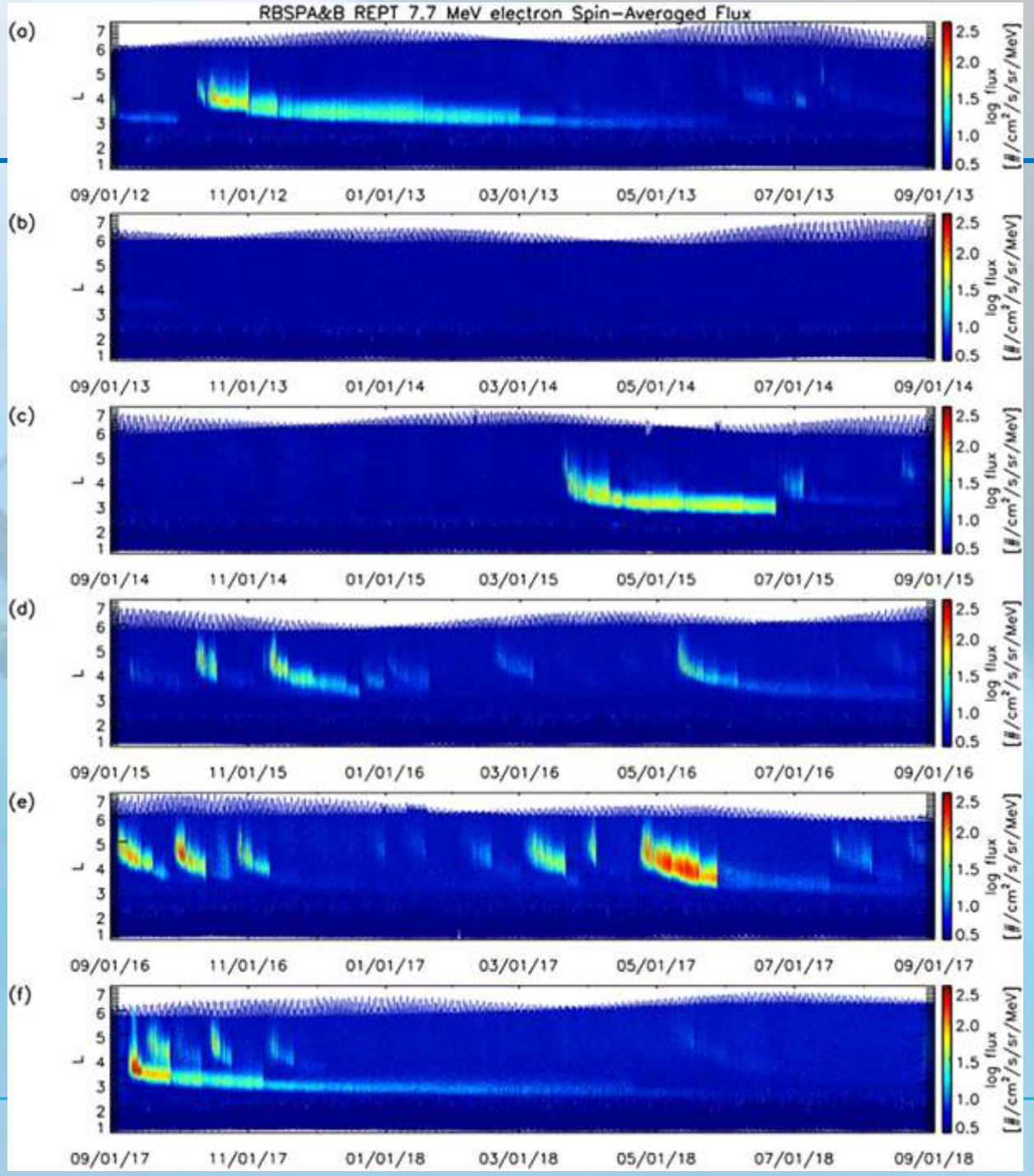


Zhao, H., Baker, D. N., Li, X., Jaynes, A. N., & Kanekal, S. G. (2019). The effects of geo-magnetic storms and solar wind conditions on the ultrarelativistic electron flux enhancements. JGR: Space Physics, 10.1029/2018JA026257

REPT observations of ultra-relativistic electrons

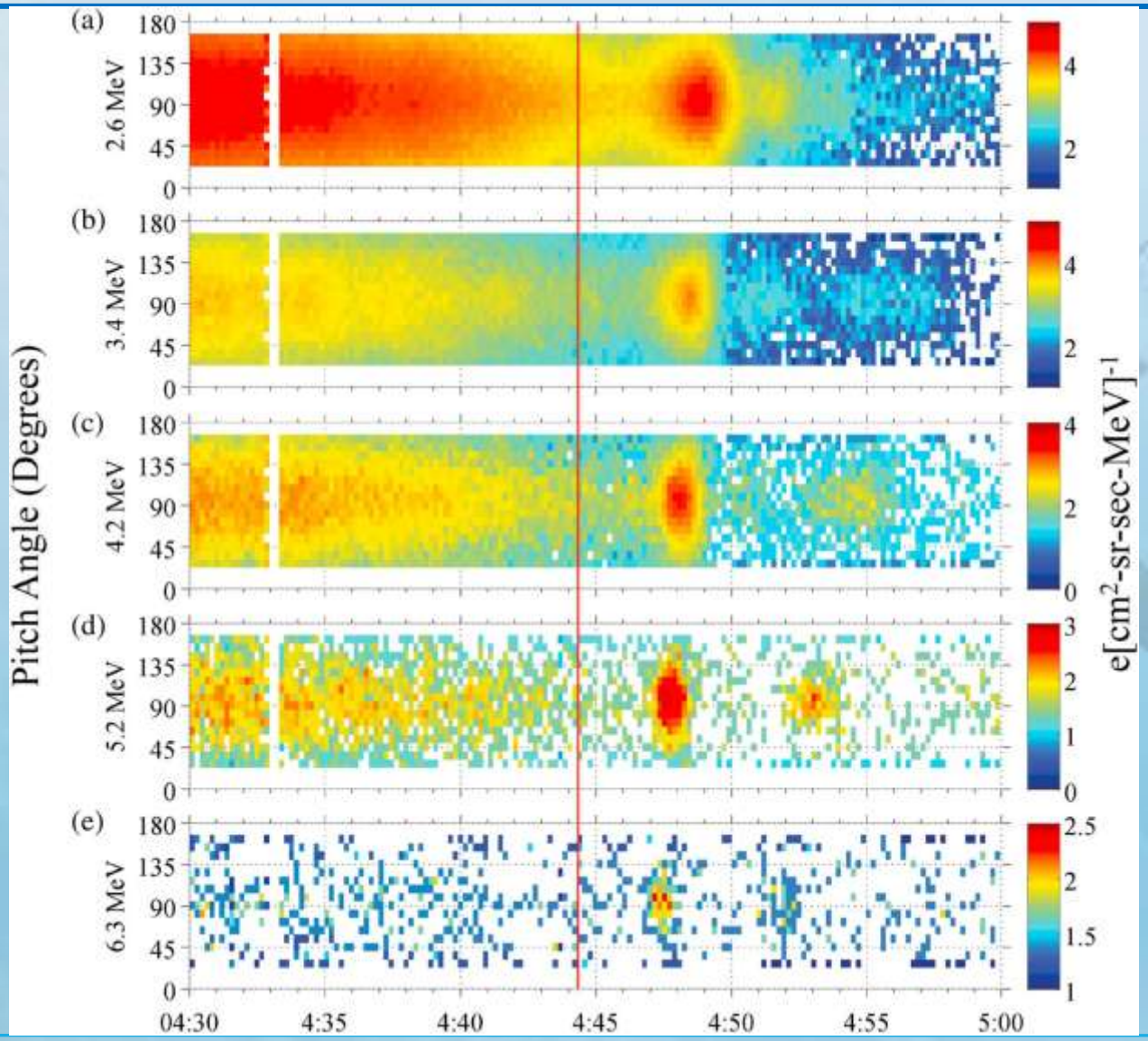
REPT electron Channel ~7-9 MeV

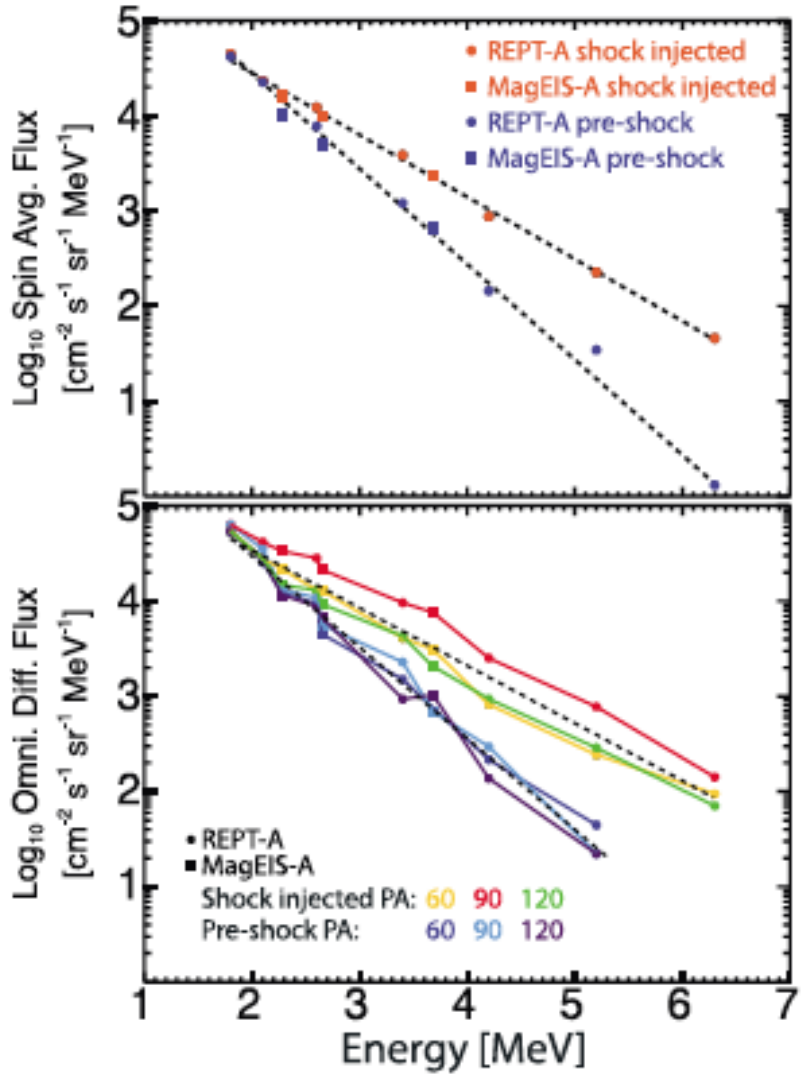
- Six years of observations
- Relatively rare (no events in 2013)
- October 2012 and September 2017 events showed persistent long term enhancements
- Enhancements occur at high L and radially diffuse to lower L
- Both gradual and sudden decay, latter caused by CME/shock interaction



Baker, D. N., et al., (2019). Multiyear measurements of radiation belt electrons: Acceleration, transport, and loss. JGR Space Physics, 10.1029/2018JA026259

Two Space weather events: March 2015 and …





Kanekal, S. G., et al. (2016), Prompt acceleration of magnetospheric electrons to ultrarelativistic energies by the 17 March 2015 interplanetary shock, JGR 121, 7622–7635, doi:10.1002/2016JA022596.

September 2017

Both March 2015 and September 2017 events resulted in rapid energization of electrons to very high energies.

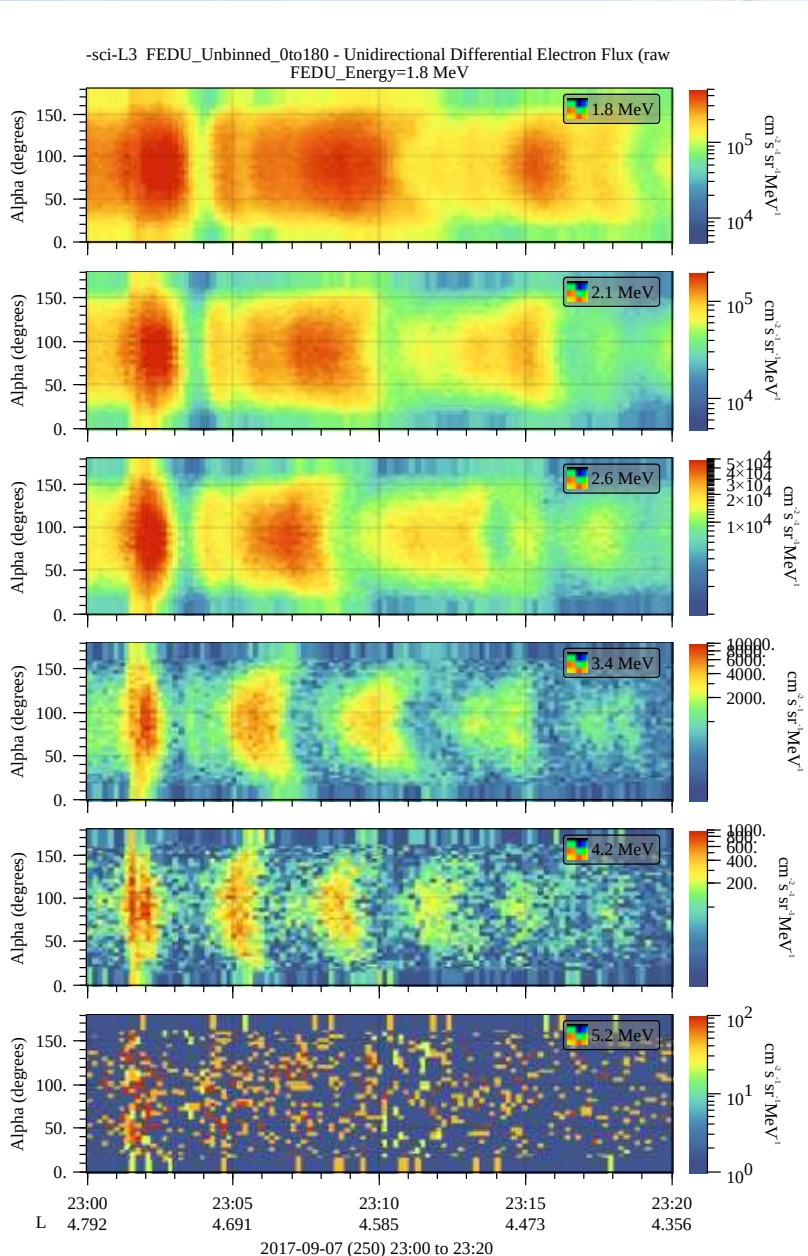
They were however short lived.

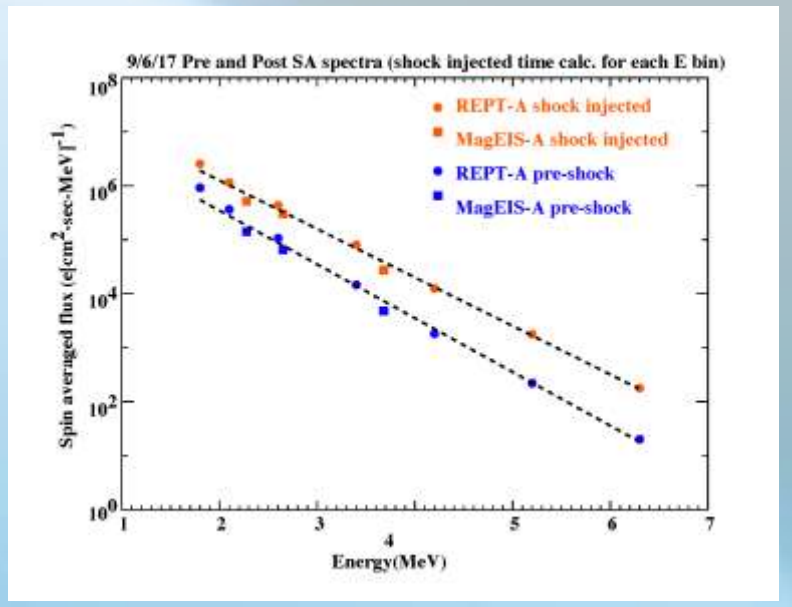
But remember

March 1991 shock

> 15 MeV electrons
With lifetimes of months

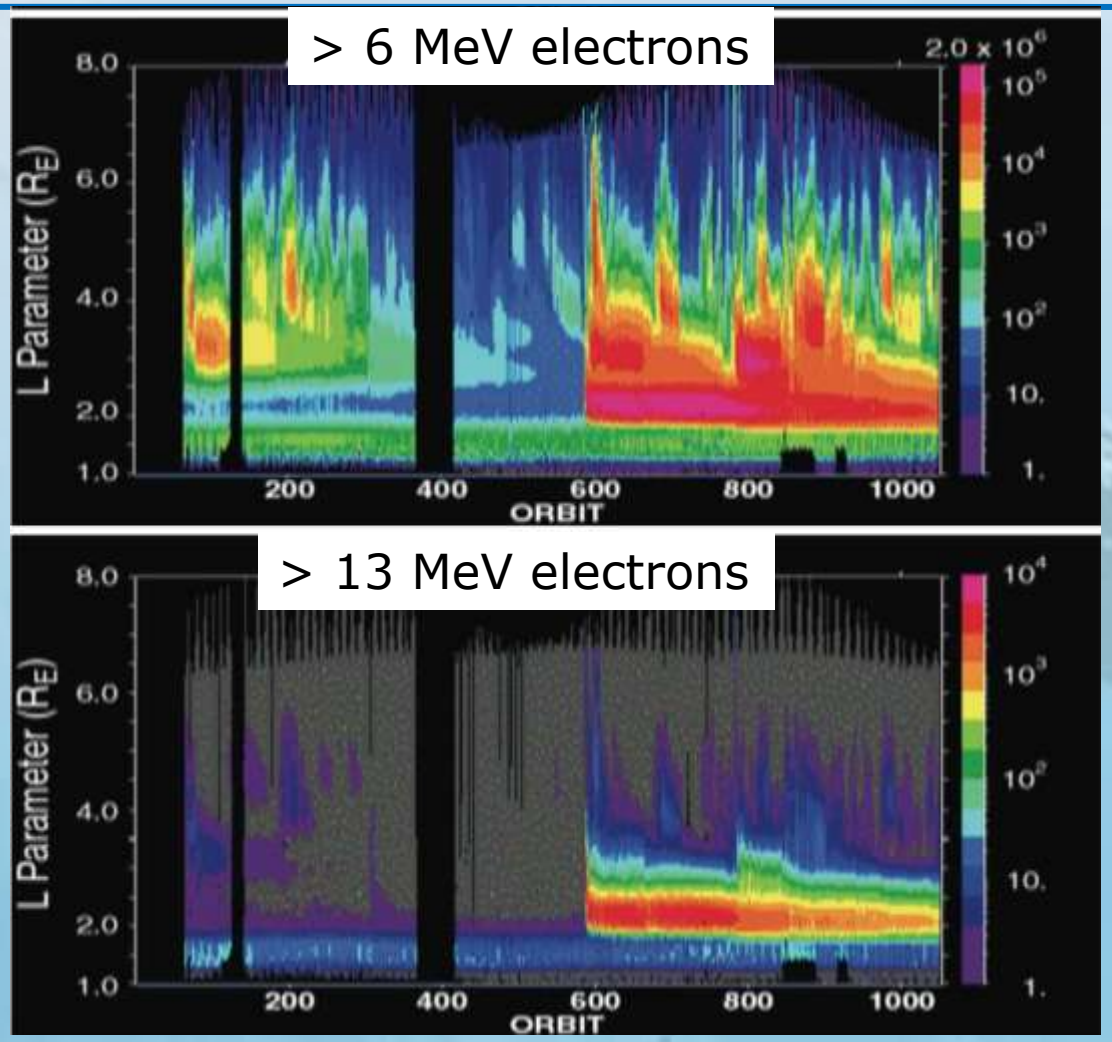
And again in Feb. 1994!

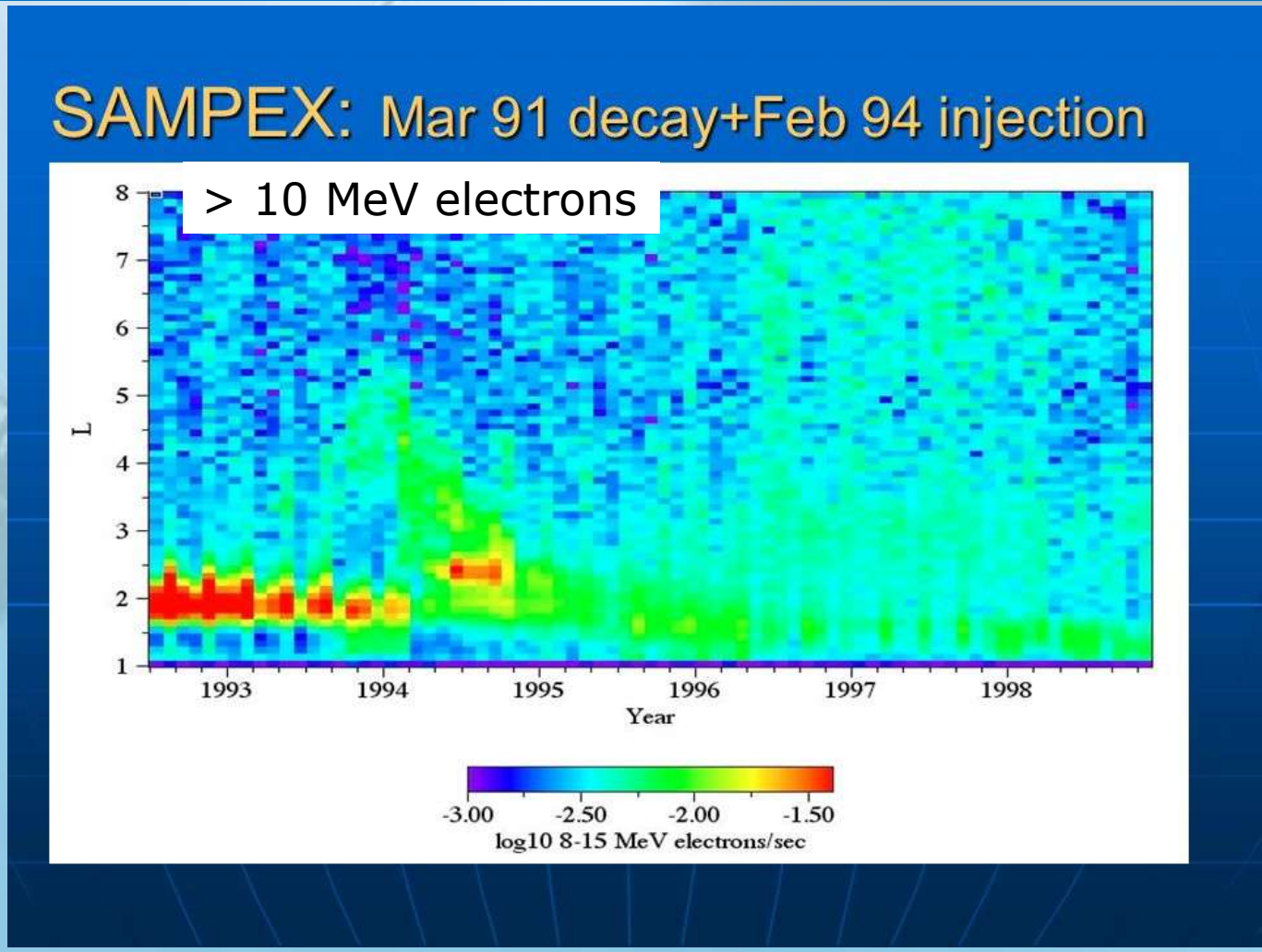




X9.3 class solar flare Sept. 6, 2017.

The March 1991 and February 1994 events



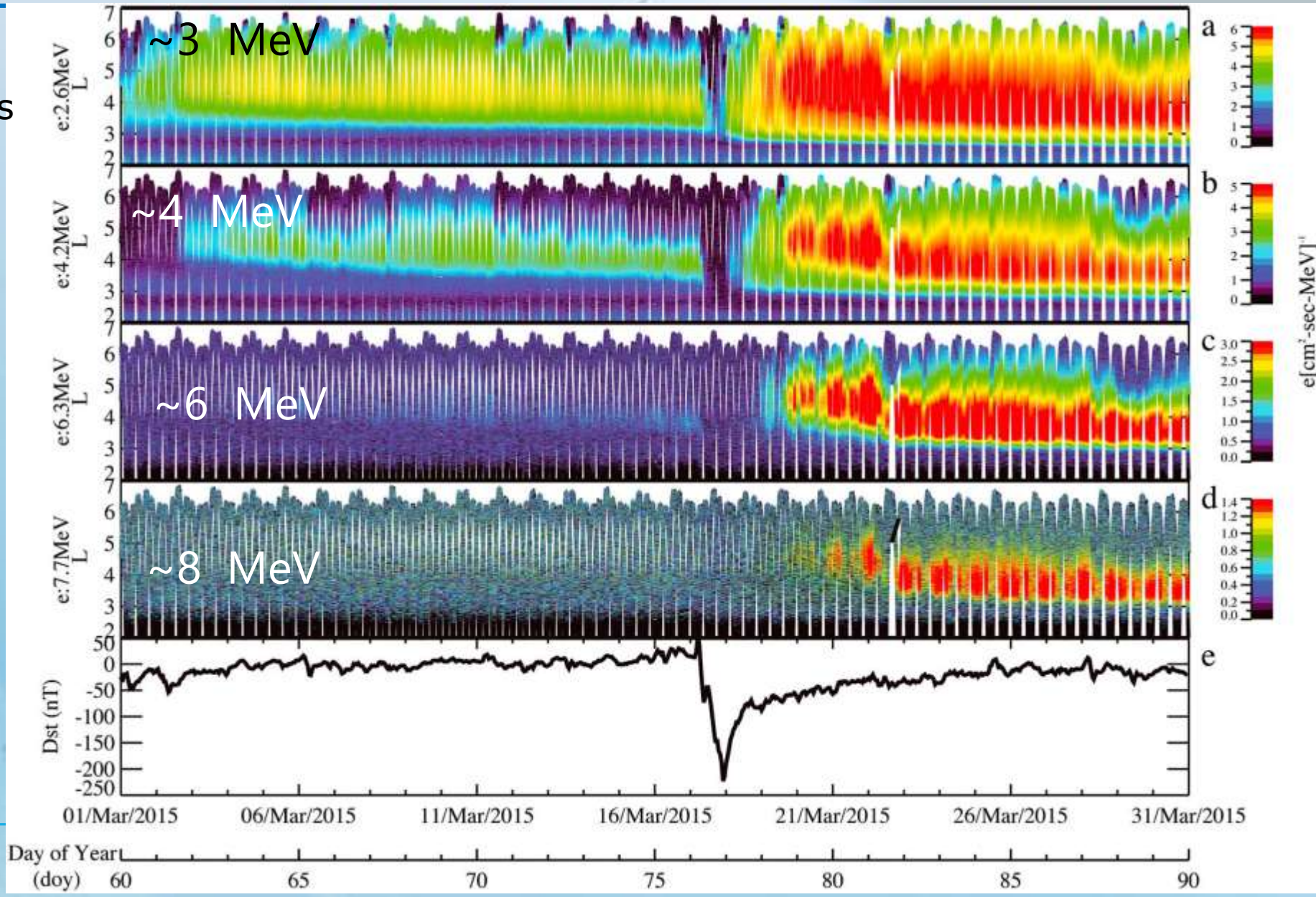


Courtesy Mark Looper, & Mary Hudson

J.B. Blake, W.A. Kolasinski, R.W. Fillius, E.G. Mullen, Injection of electrons and protons with energies of tens of MeV into L < 3 on 24 March 1991. Geophys. Res. Lett. 19(8), 821–824 (1992). doi:10.1029/92GL00624

March 2015

- Sudden flux dropout across all L during main phase
- Energy dependent acceleration
- Gradual radial diffusion to lower L
- Electrons accelerated to ultra-relativistic energies

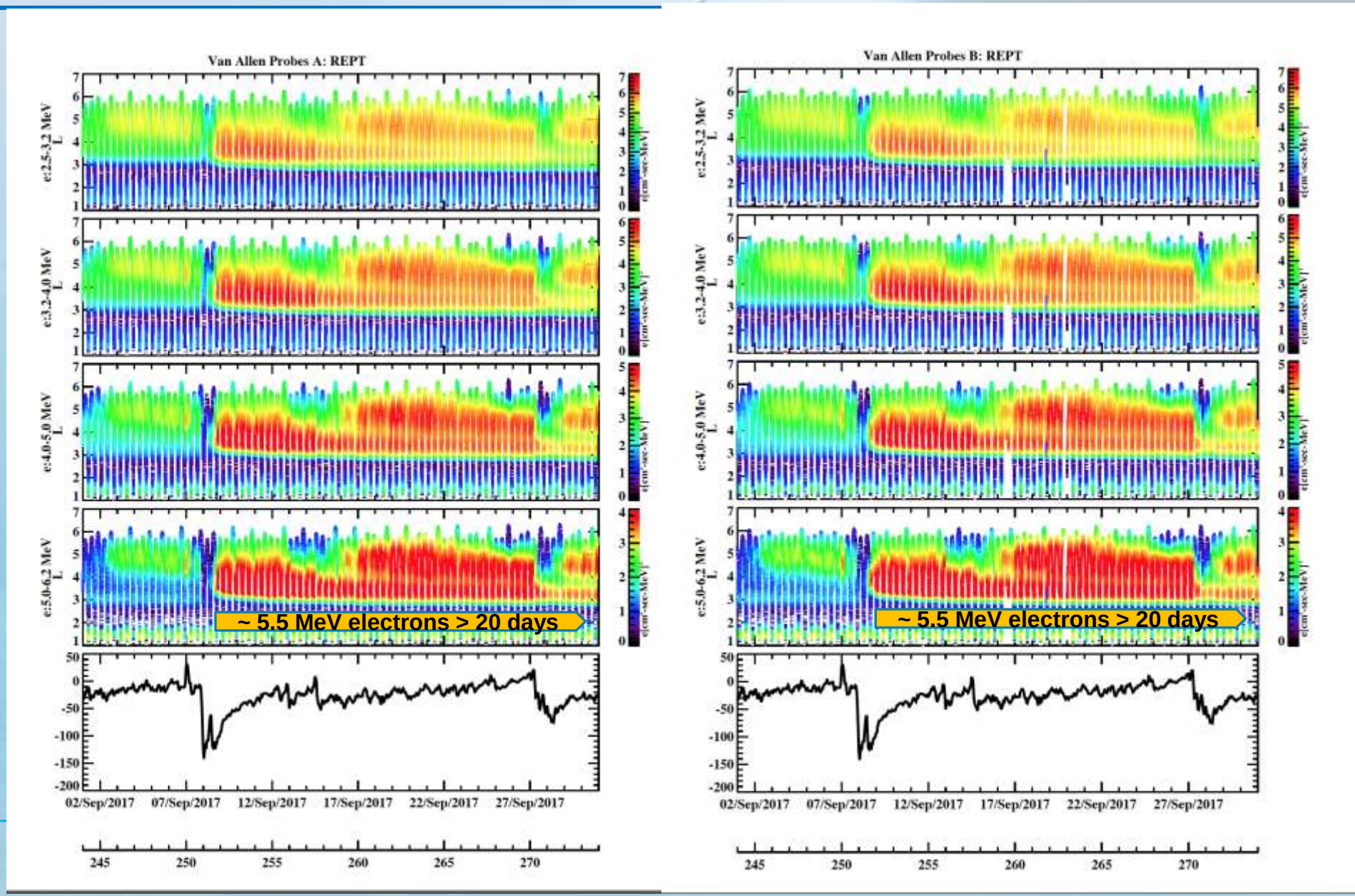


September 2017 events

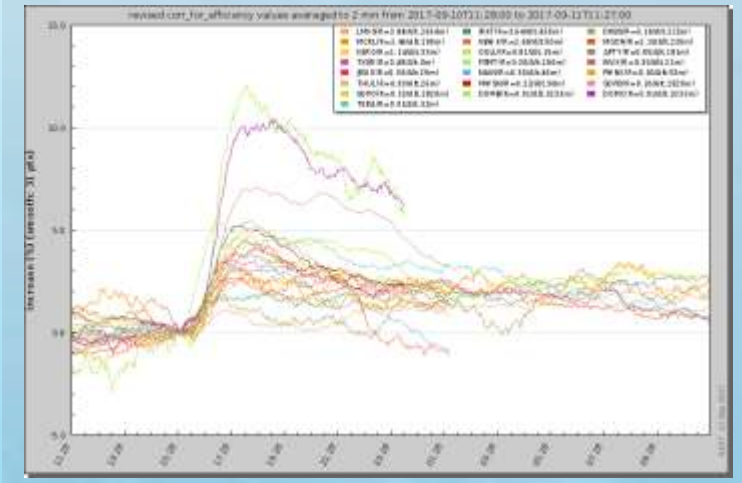
Long duration elevated levels of high energy electrons

- >5 MeV > 20 days

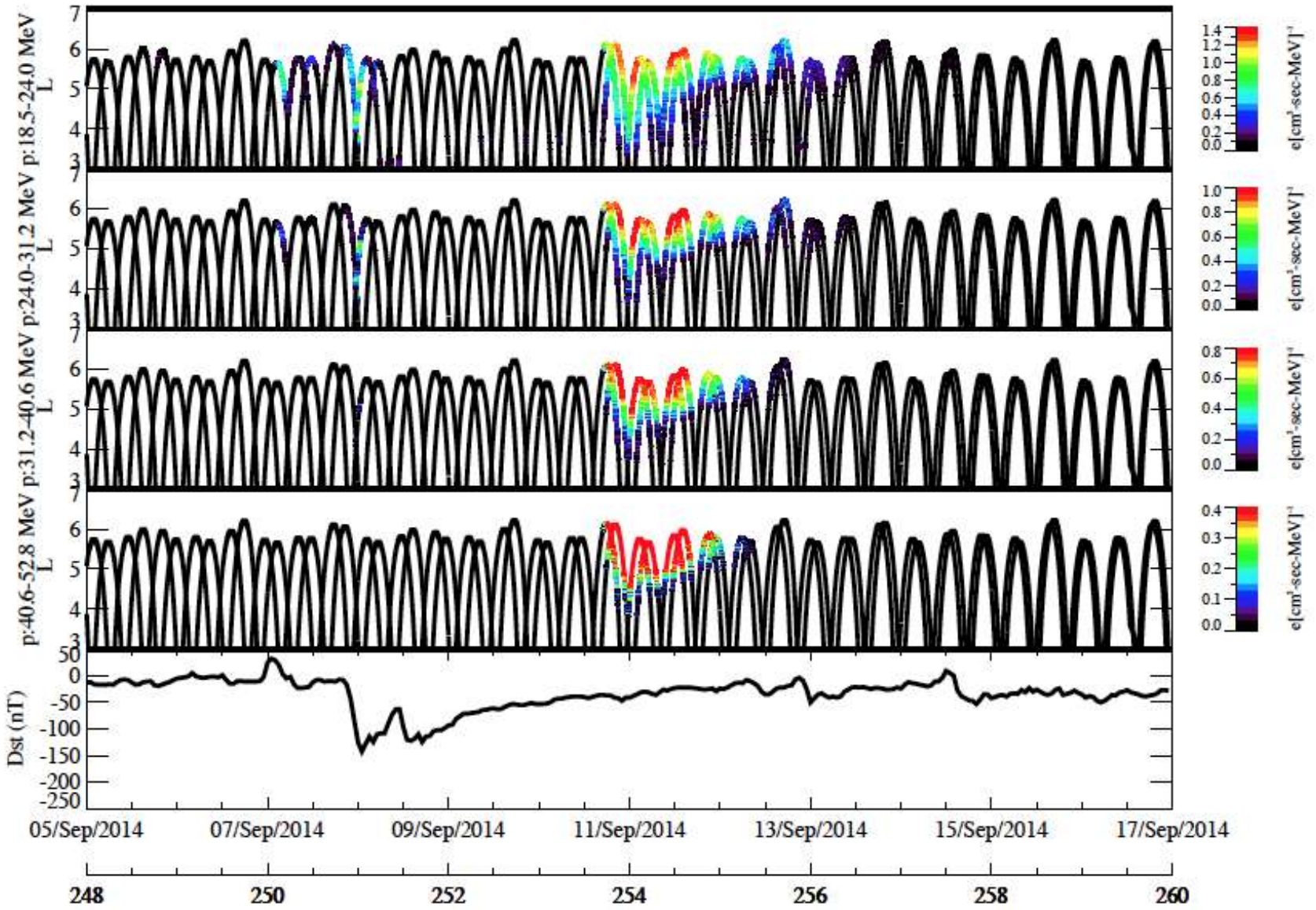
- space weather hazard



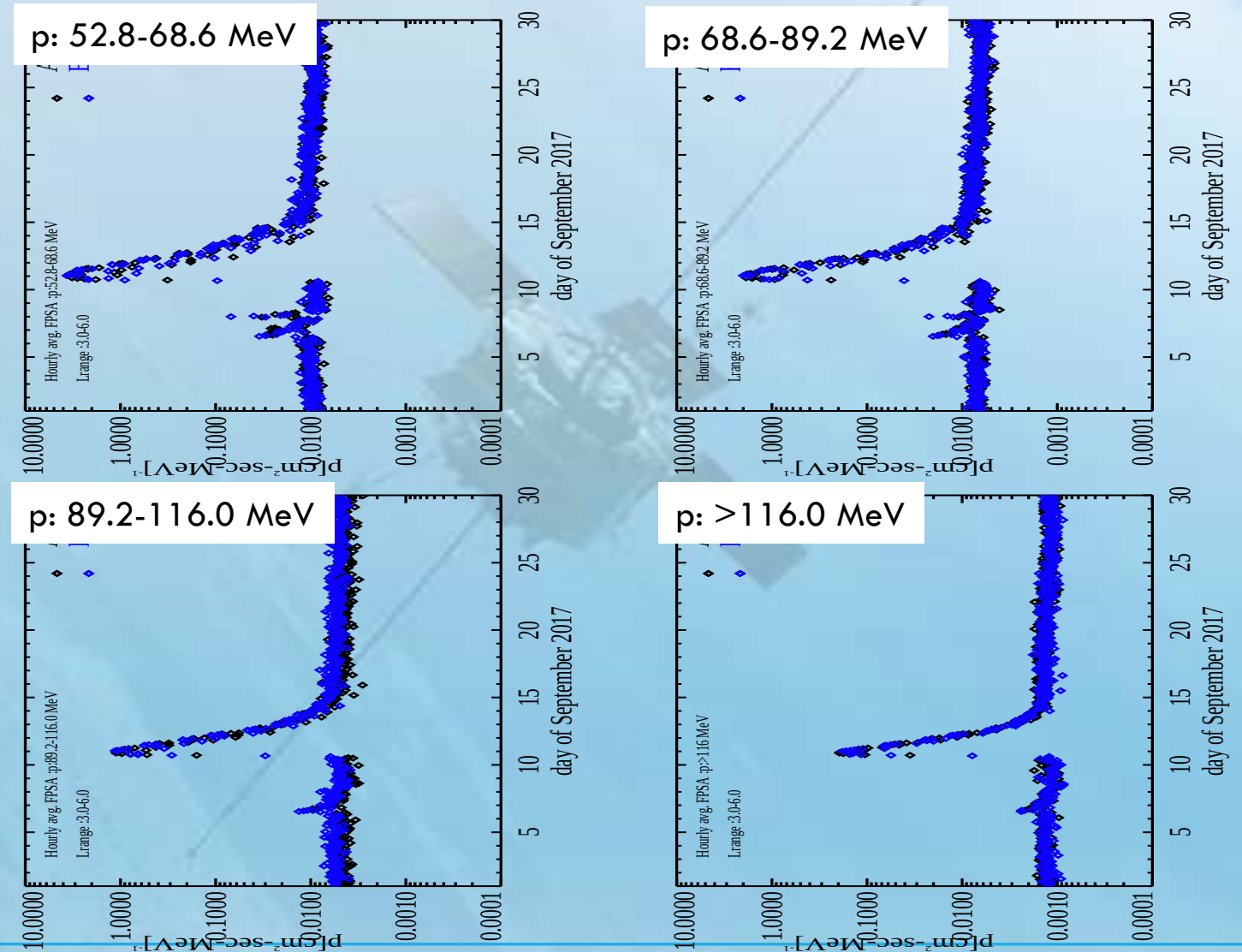
SEP Protons measured by REPT September 11 2017



count rate increases of neutron monitors with nominal cutoff rigidity up to 3.9 GV, corresponding to a proton energy of 3.2 GeV, relative to the count rate between 15h and 16h UT.

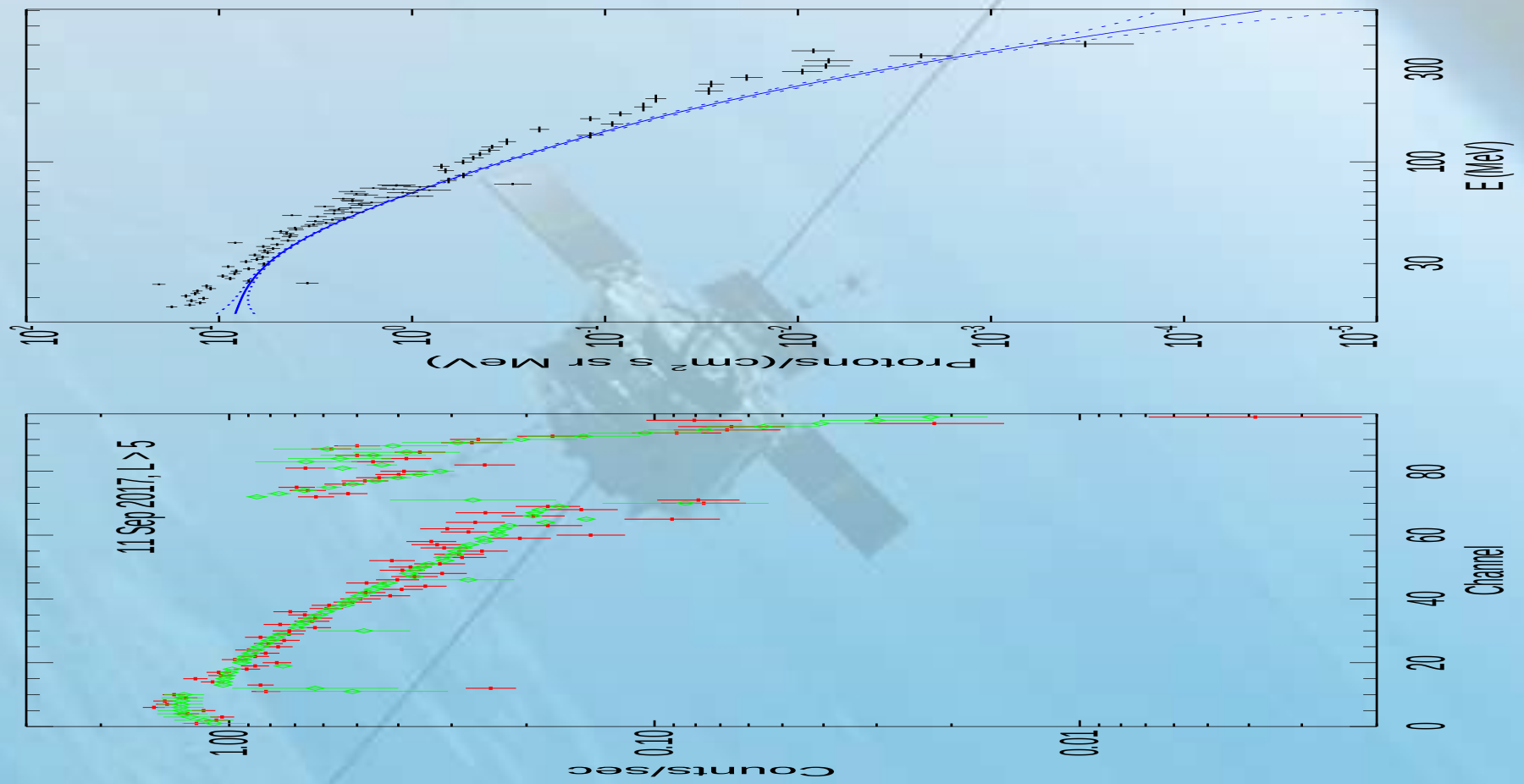


Solar protons(hourly avg.) September 11 2017



L>3

September 11 SEP spectrum: REPT PHA



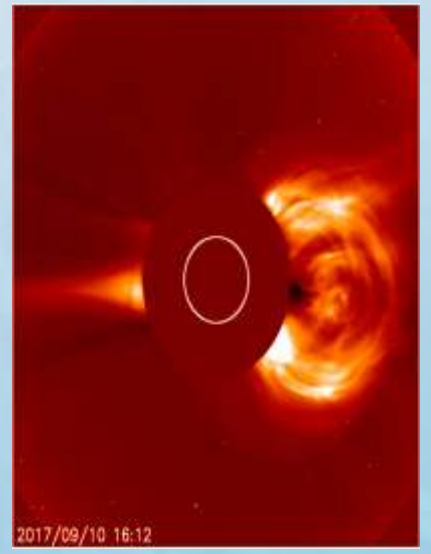
REPT PHA 97 differential channels

REPT PHA Spectrum

Selesnick et al., JGR 2017

Solar Protons up to 1 GeV in the 9/10/17 CME Event

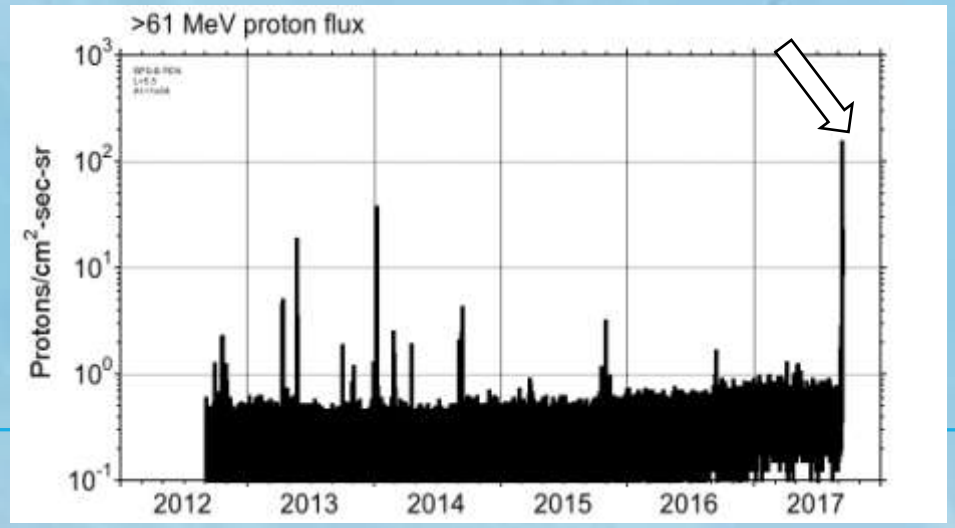
From Joe Mazur, Aerospace Corp



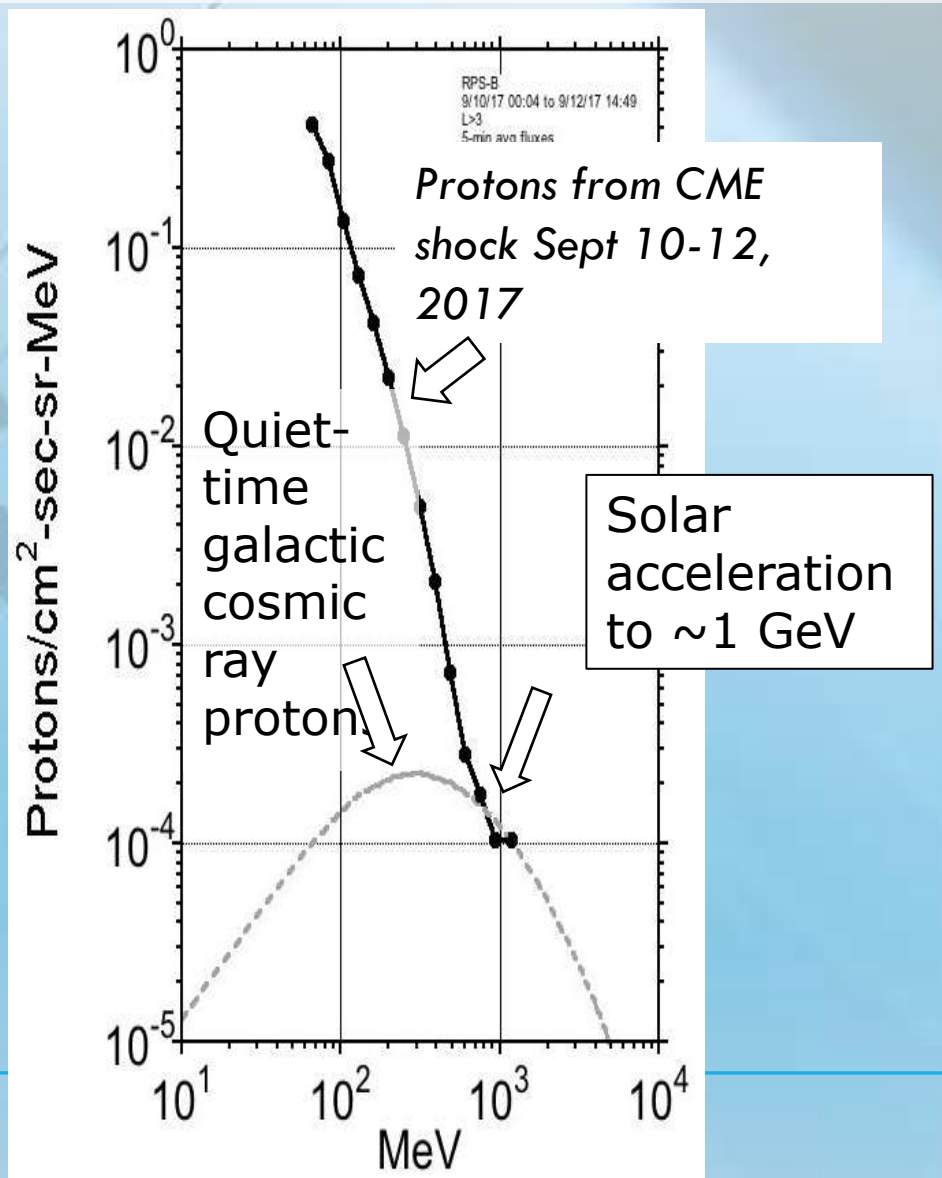
CME liftoff: 9/10/17 1600UT
Estimated speed: 1081 km/sec

www.spaceweather.gmu/edu

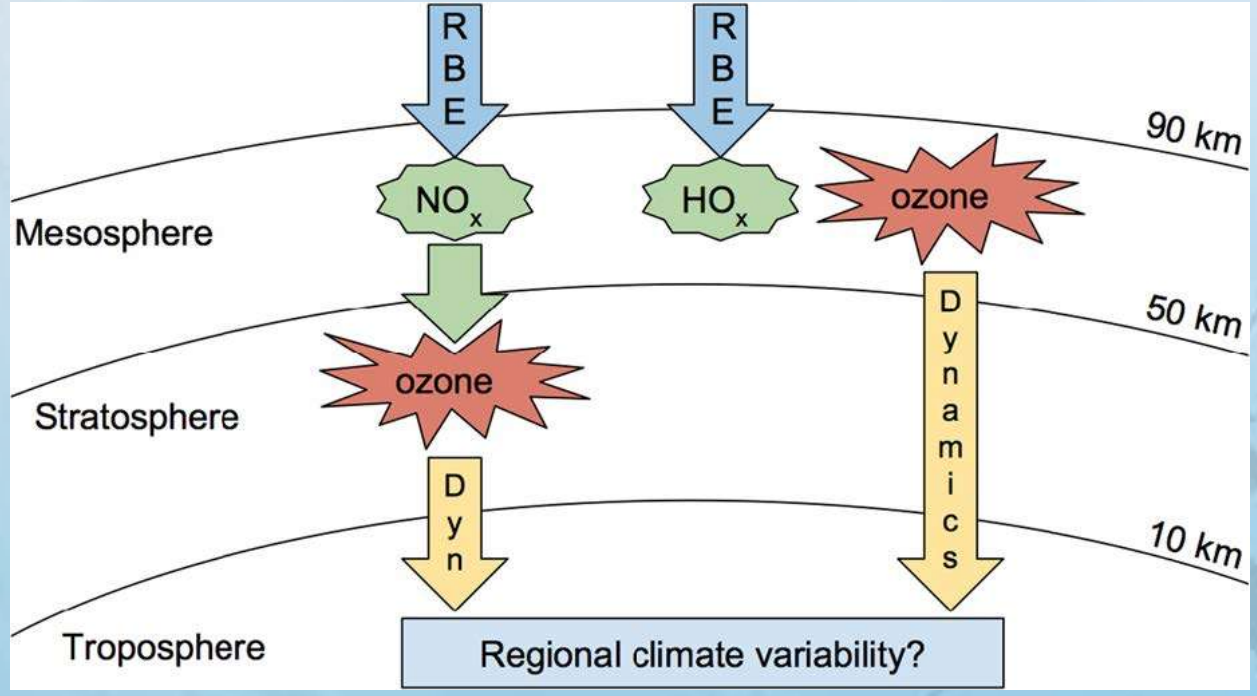
Most intense >60 MeV solar proton event seen during the RBSP mission



Van Allen Probes/RPS-B Proton Energy Spectrum

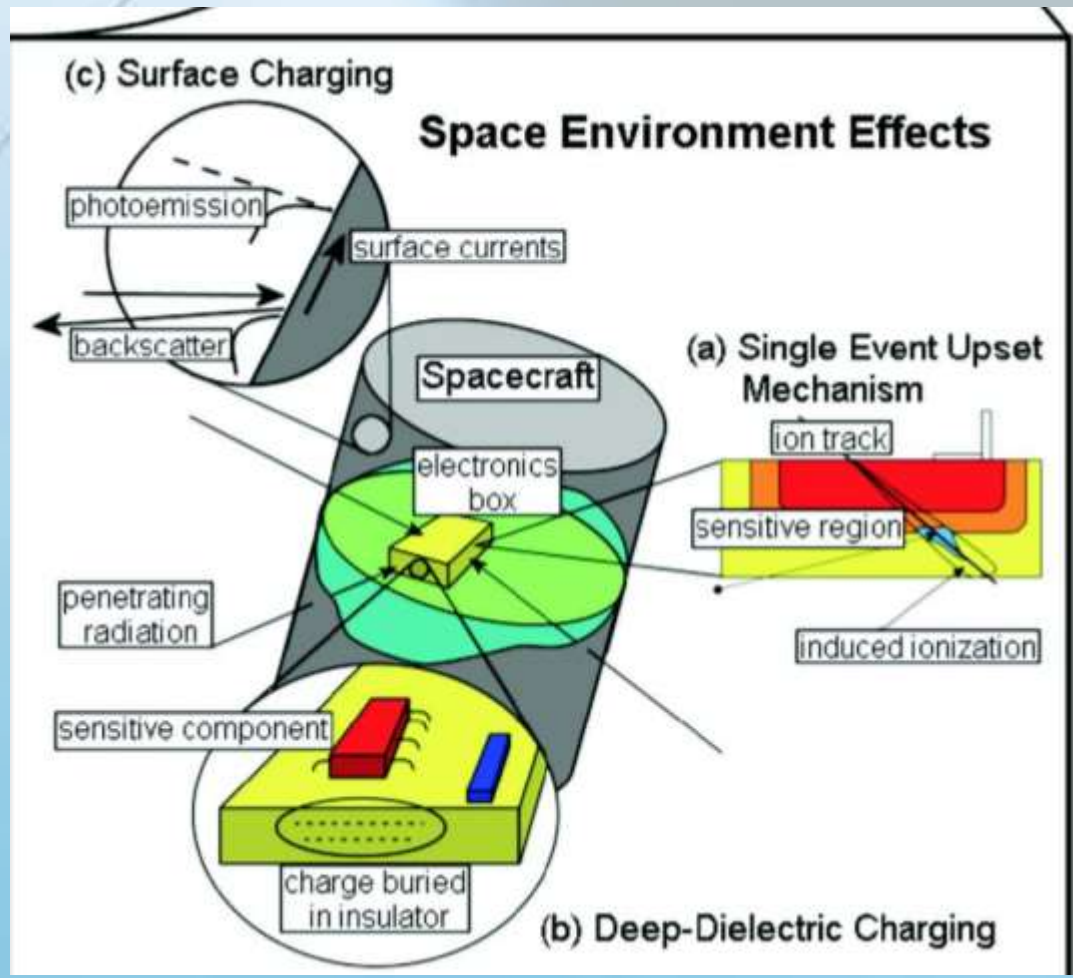


Space Weather effects: energetic electrons and protons



Baker et al., Space Weather Effects in the Earth's Radiation Belts, Space Sci Rev (2018) 214:17, DOI 10.1007/s11214-017-0452-7

- Prolonged elevated fluxes of high energy electrons
  - Satellite anomalies/failure:deep dielectric discharge
- Energetic Protons & SEP ions
  - Satellite anomalies/failure: SEU
- Electrons and Protons
  - Atmospheric Chemistry



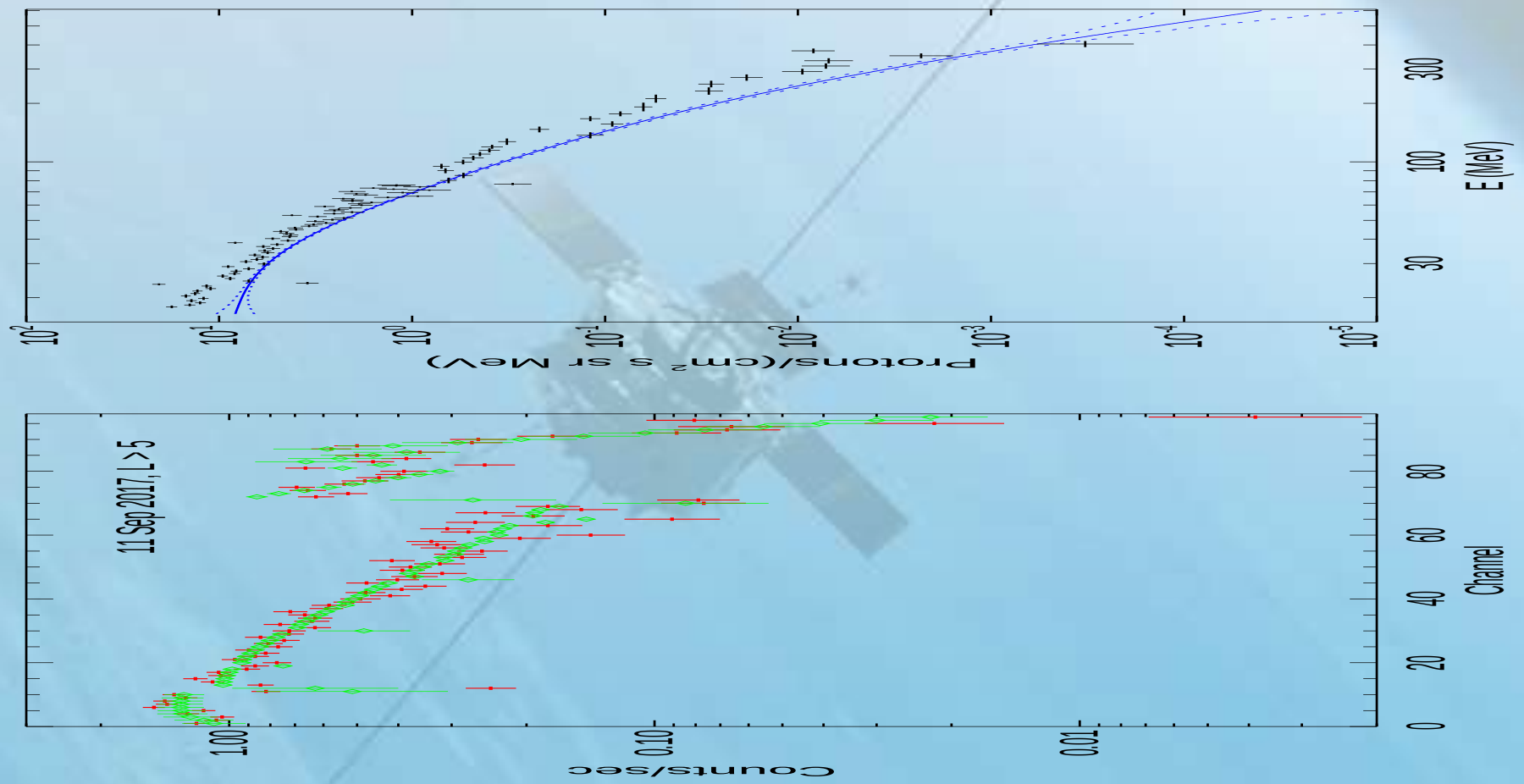
Baker et al., Space Weather Effects in the Earth's Radiation Belts, Space Sci Rev (2018) 214:17, DOI 10.1007/s11214-017-0452-7

Summary and Conclusions

Van Allen Probes measurements of radiation belt electrons have significantly advanced our understanding of radiation belt electron dynamics, and revealed new features of the outer belt. Mission expected to end April 2020.

- Important to monitor and measure radiation belt electrons from a space weather perspective
- Continuous measurement and characterization of SEP
- Role of energetic electrons and protons in affecting atmospheric chemistry
- IP shock driven rapid energization can inject ultra-relativistic electrons that can linger for years

September 11 SEP spectrum: REPT PHA



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