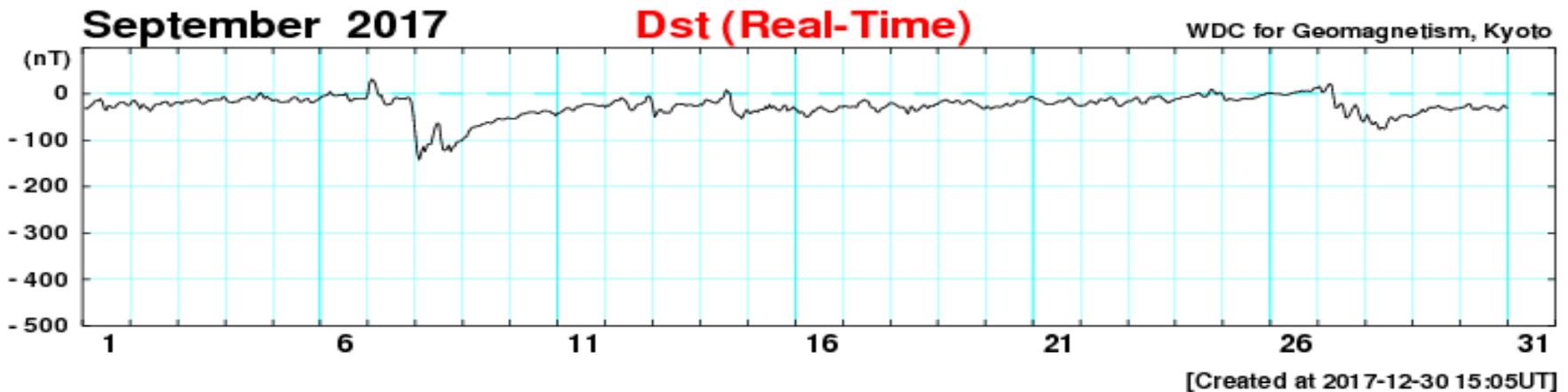
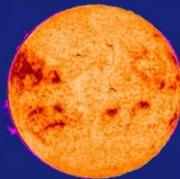
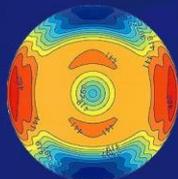




Simulated prompt acceleration of multi-MeV electrons by the 6-7 September 2017 interplanetary shock



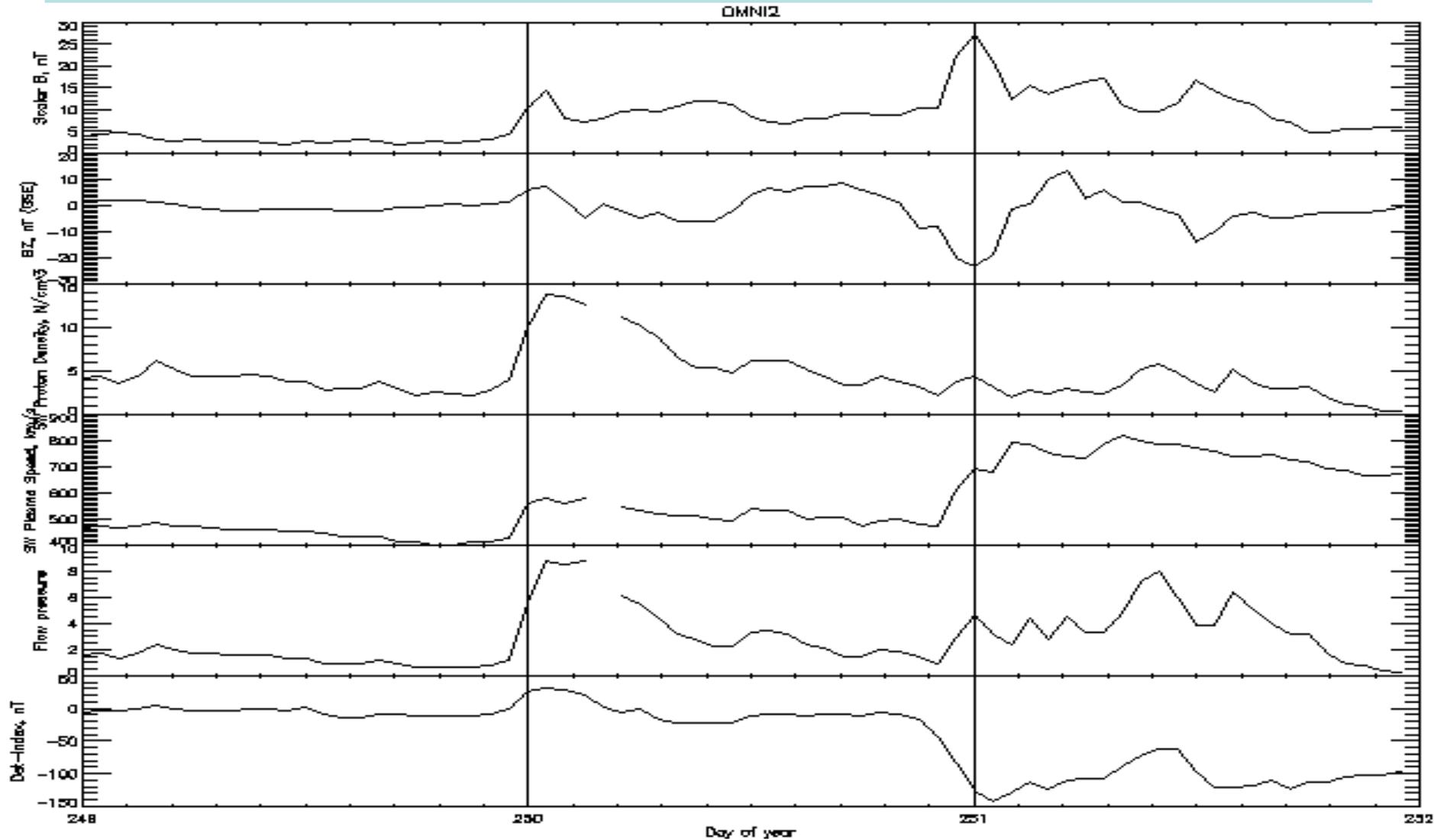
Mary K. Hudson, Shri Kanekal, Zhao Li, Maulik Patel, John Wygant
Dartmouth, NCAR/HAO, NASA GSFC, UMN



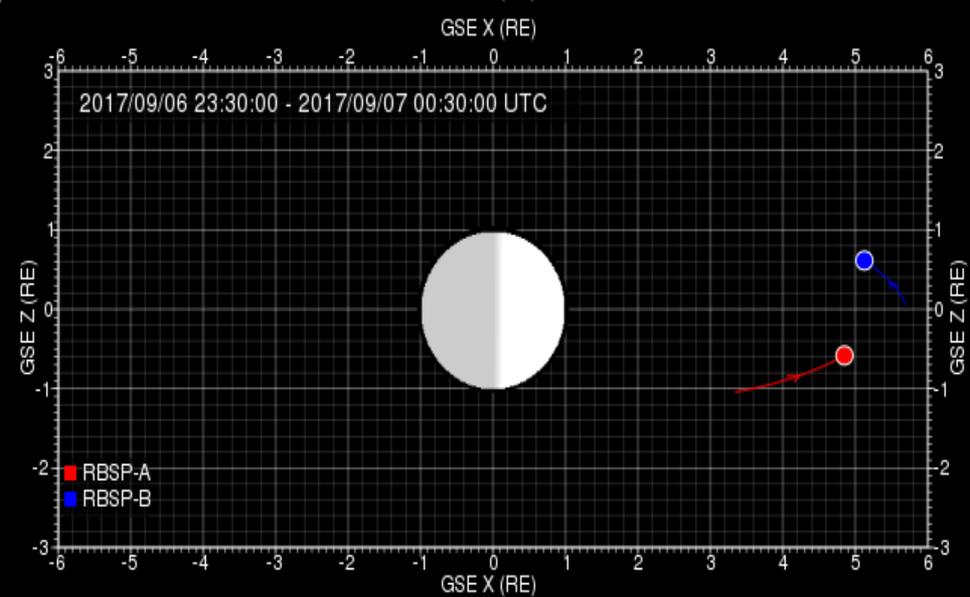
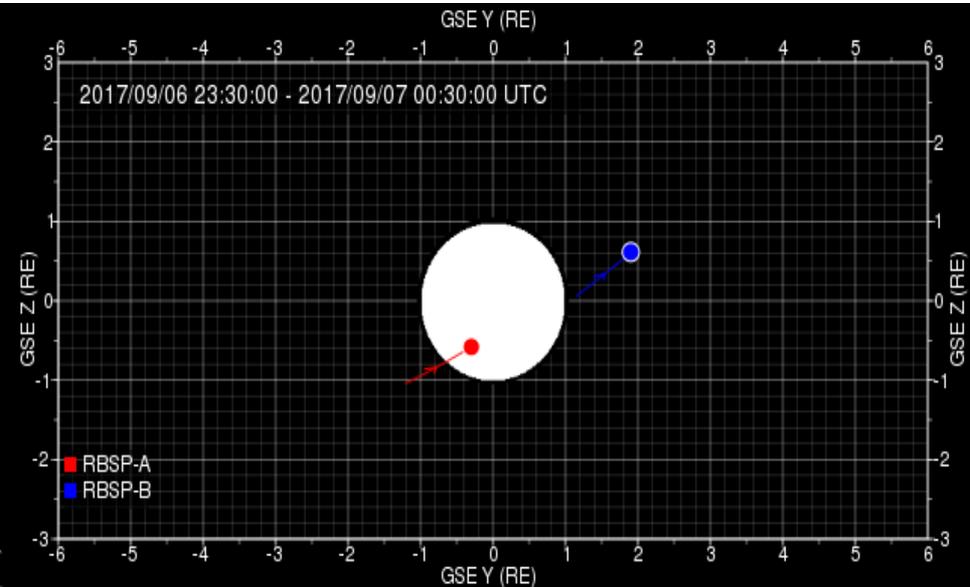
Outline

- IP-shock compressions of dayside m'sphere launch fast mode impulse
- Accelerates electrons azimuthally & transports radially inward conserving μ
- Strong events rare, RBSP measurements see weaker events, pitch angle dispersed drift echoes
- 17 March 2015; 8 Oct 2013; 16 July 2017;
6 Sept 2017;

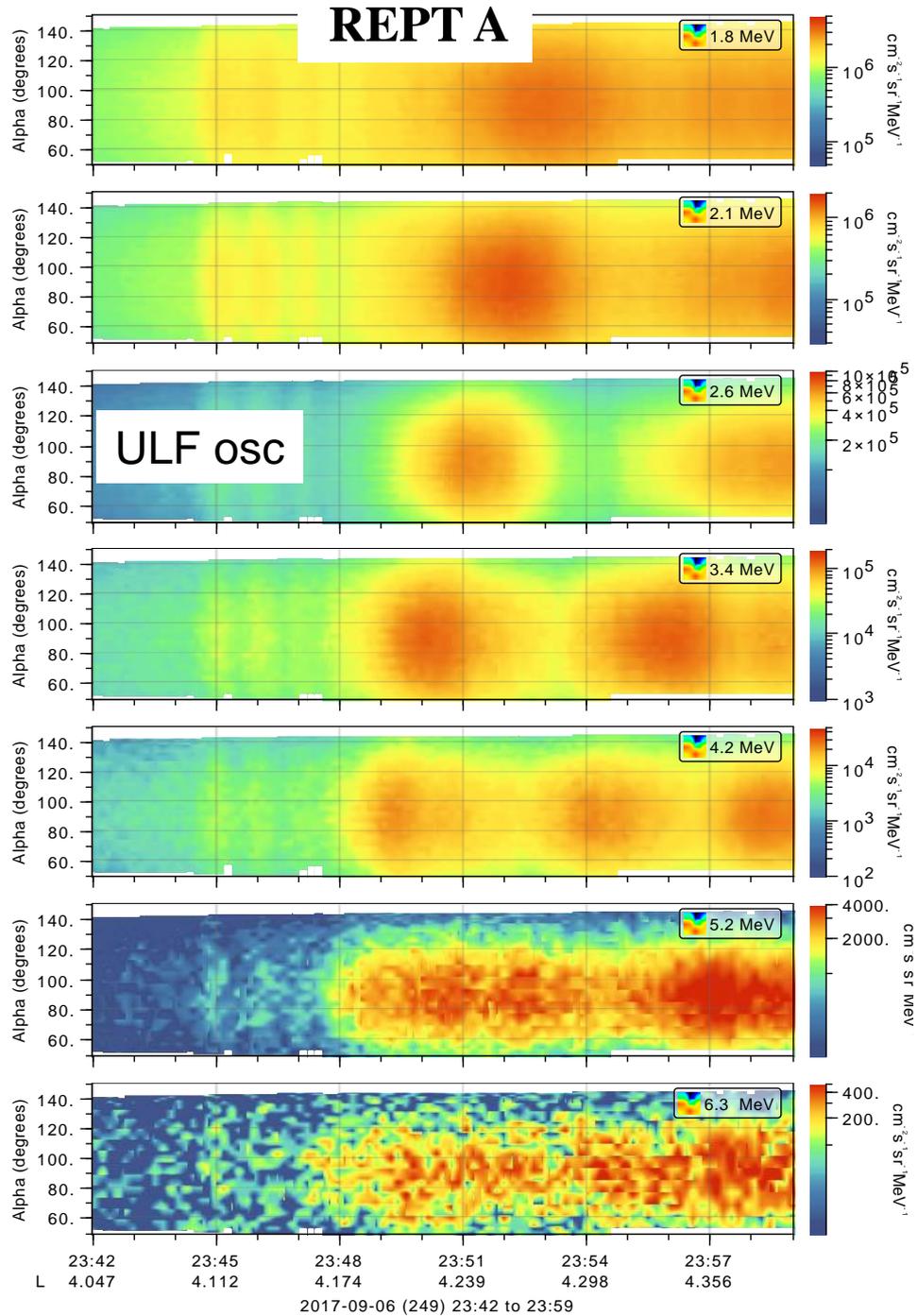
Solar Wind Shock Pair 9/6-9/8



Van Allen Probes 6 September 2017

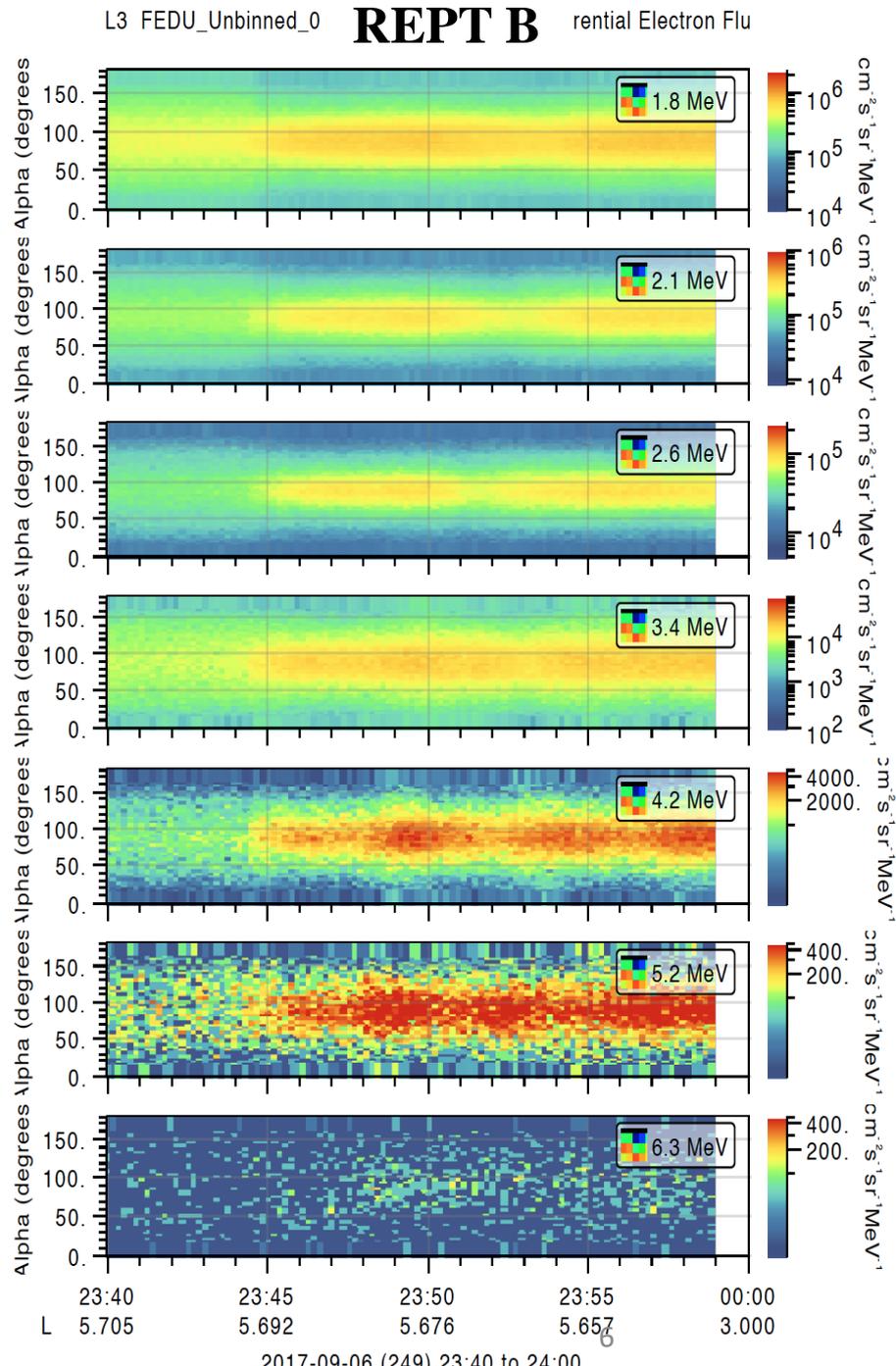


REPT A



2017-09-06 (249) 23:42 to 23:59

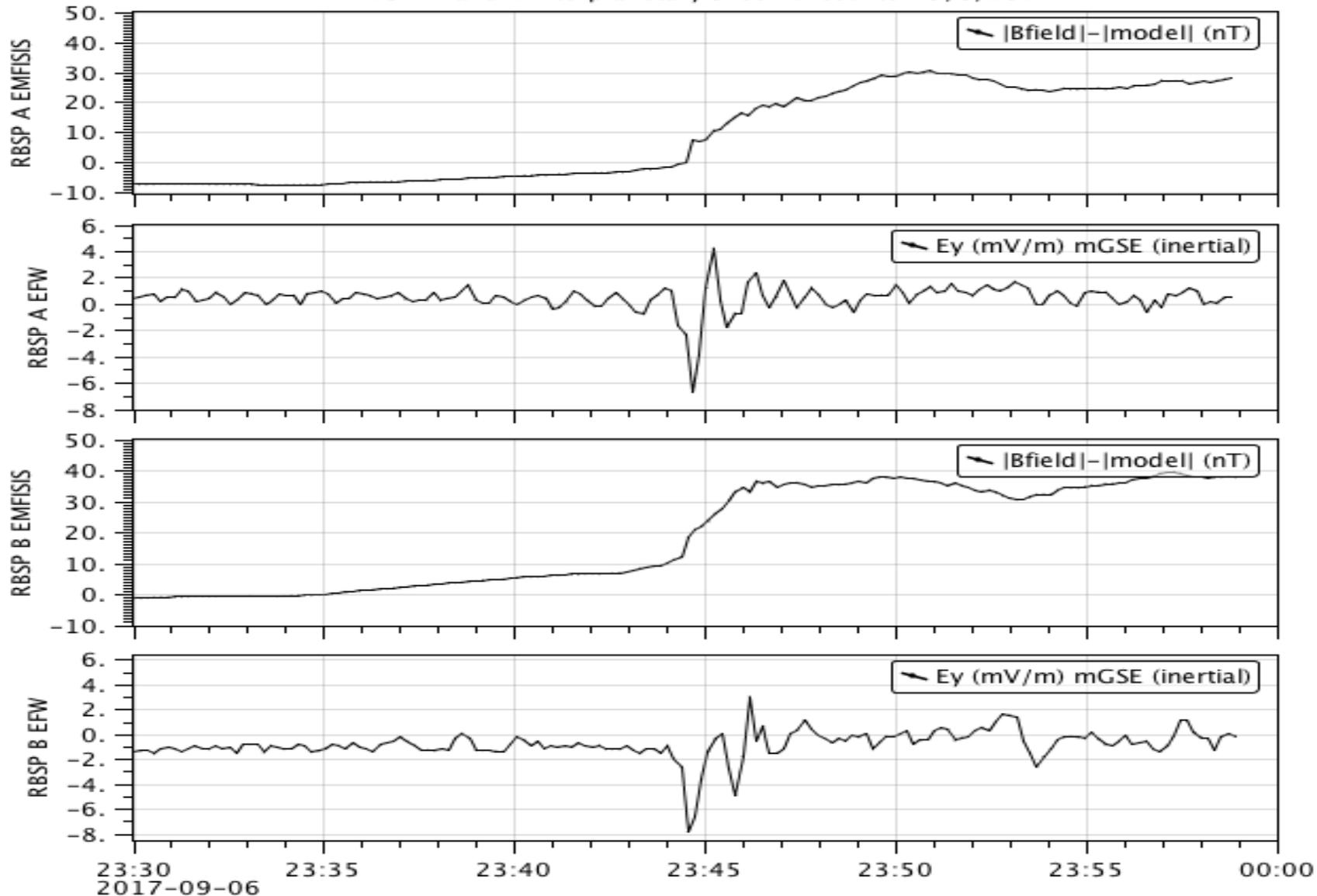
L3 FEDU_Unbinned_0 REPT B



2017-09-06 (249) 23:40 to 24:00

EFW E-field Measurements

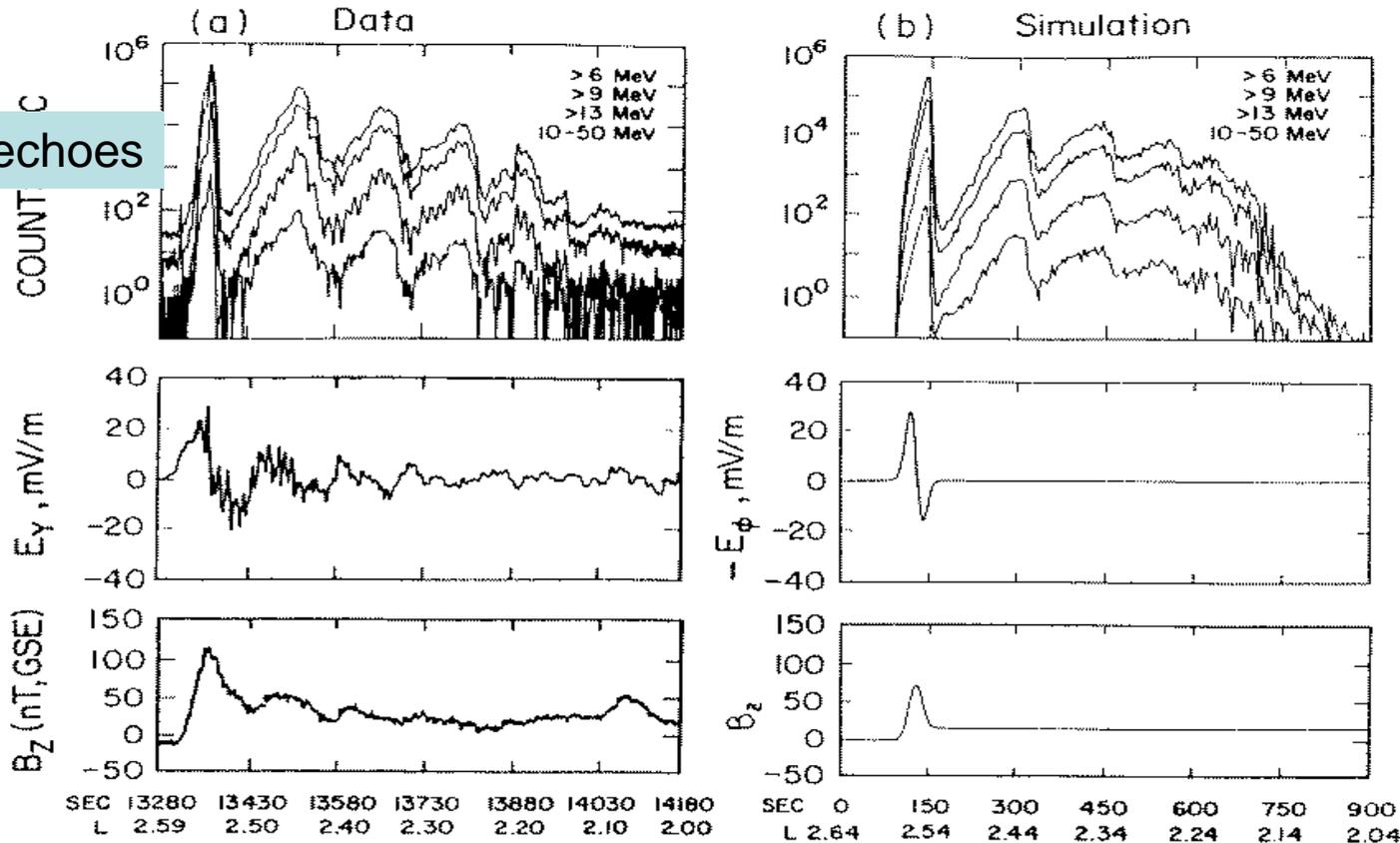
RBSP-A and B Interplanetary Shock Encounter 9/6/2017



CRRES Data from ~2200 MLT

Energetic Electron, Electric and Magnetic Fields
24 March 1991

Drift echoes

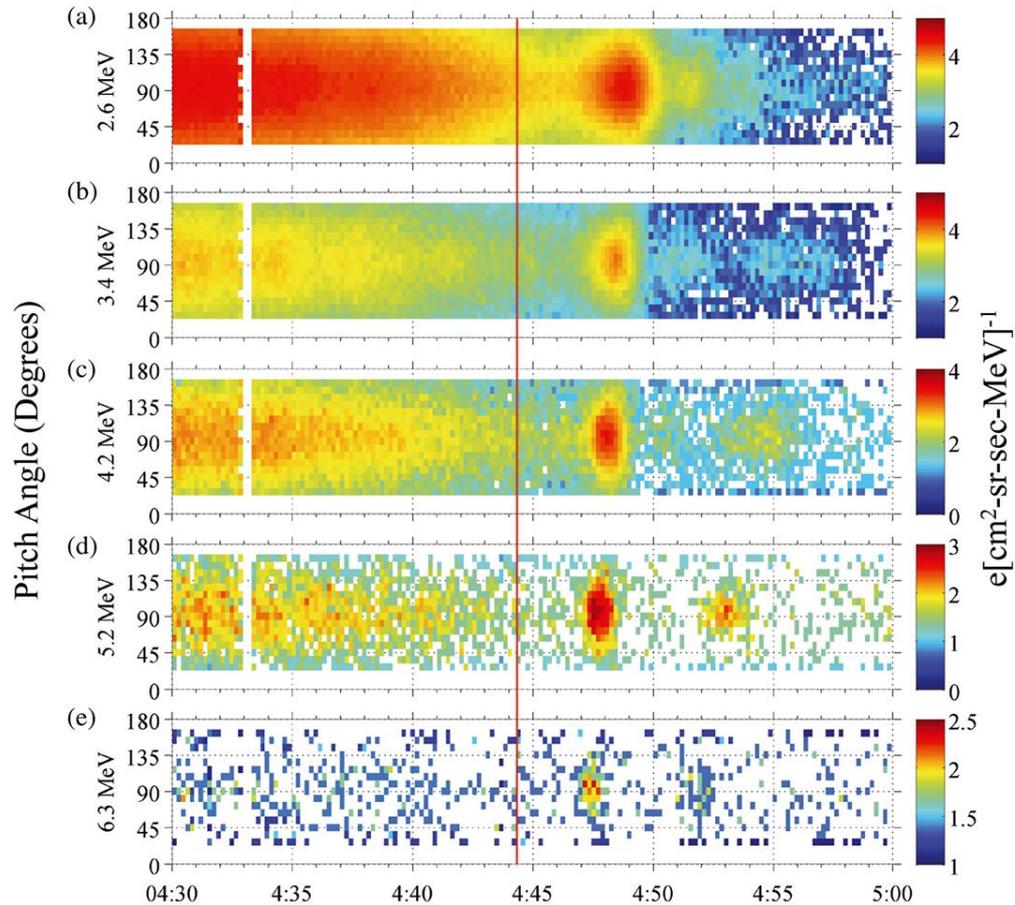


Li et al., GRL, 1993

Prompt acceleration of magnetospheric electrons to ultrarelativistic energies by the 17 March 2015 interplanetary shock

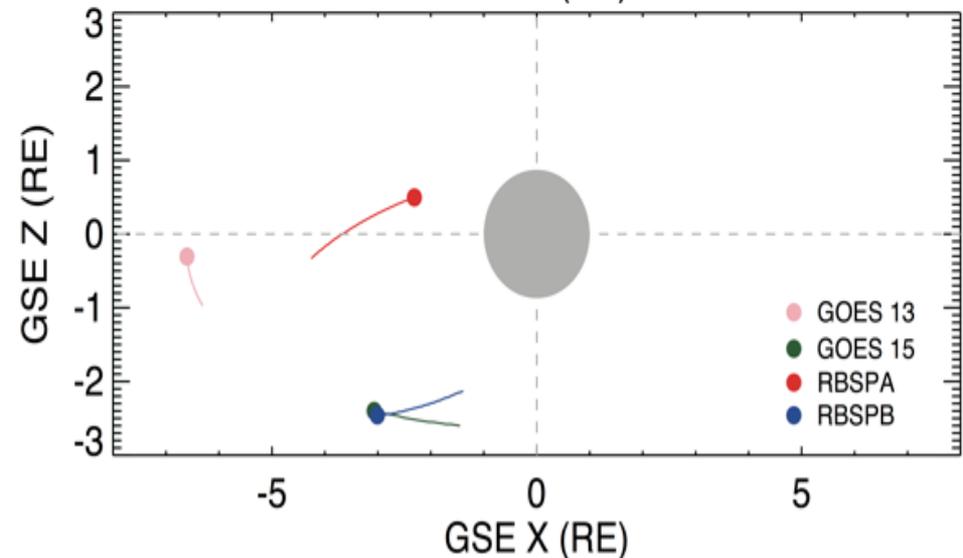
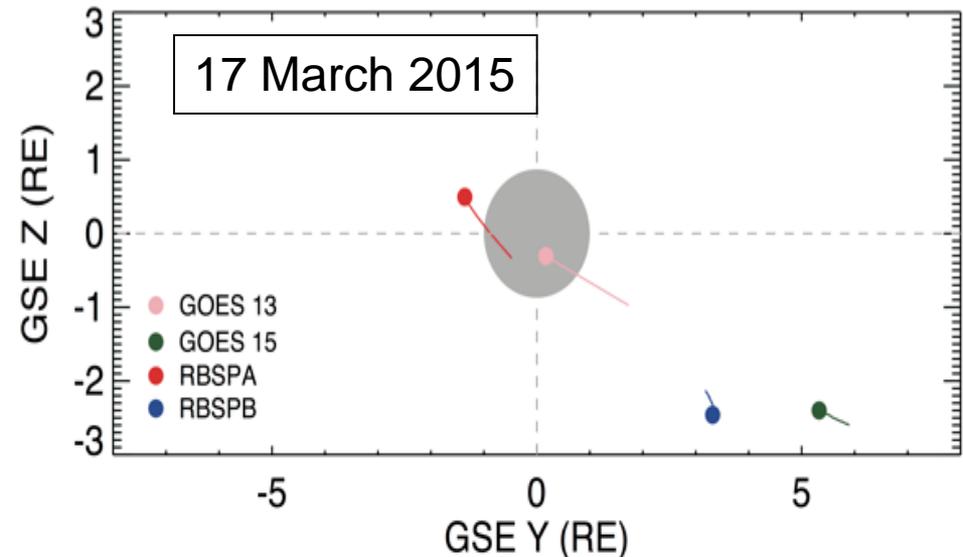
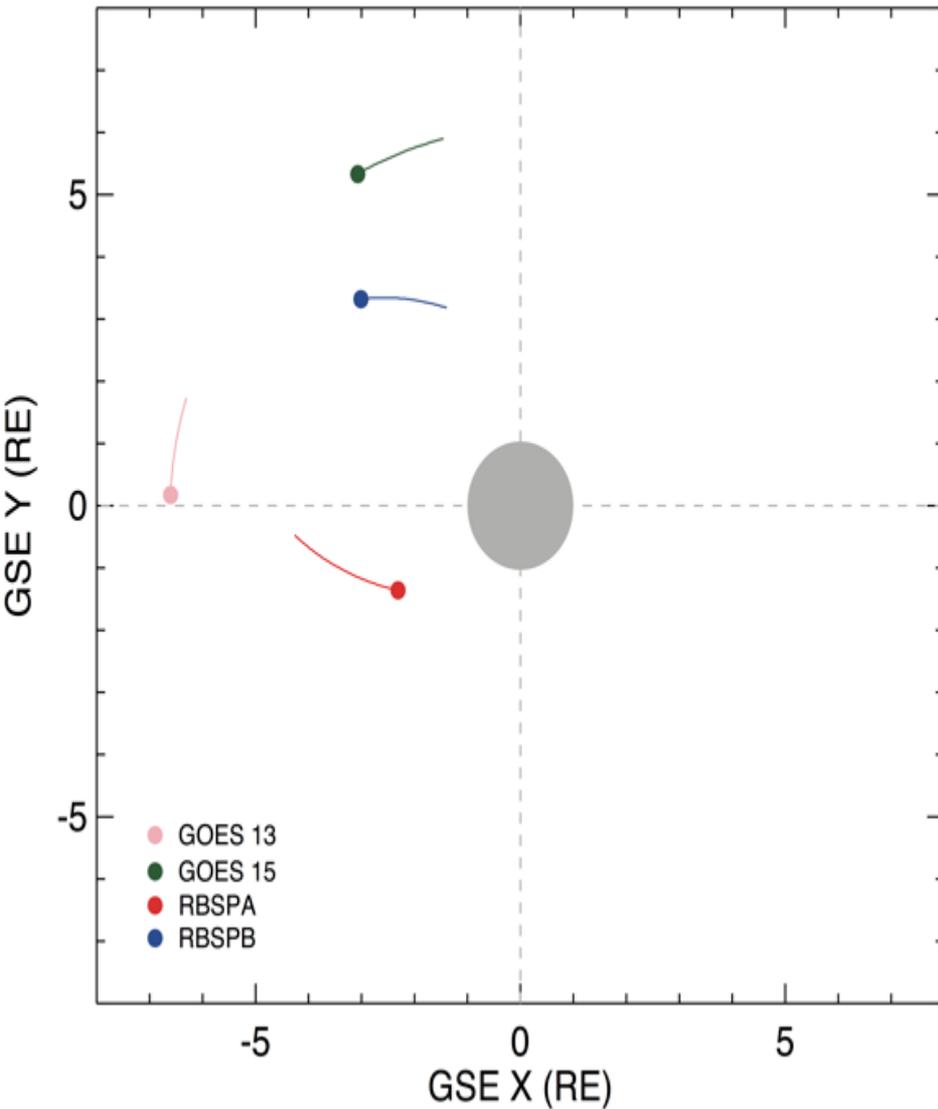
VAP-A at L ~ 3

Kanekal et al.,
JGR, 2016



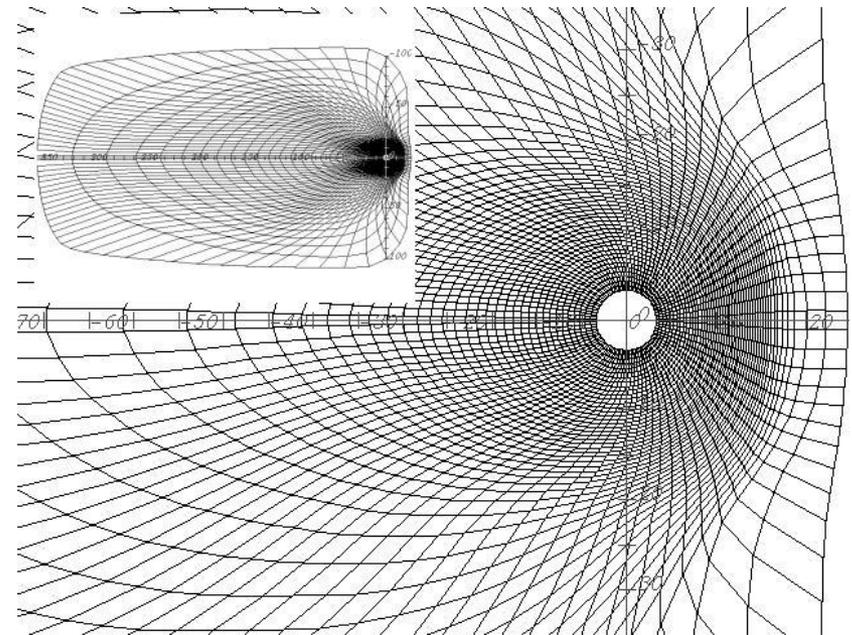
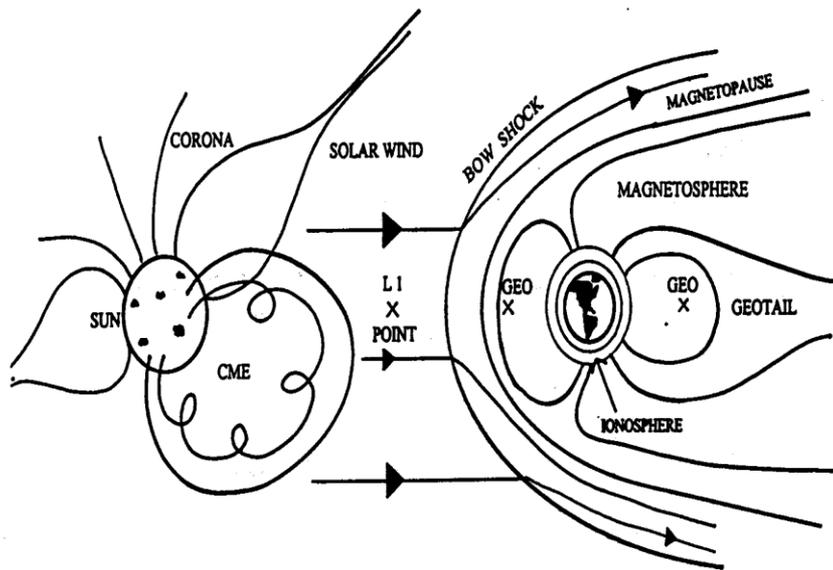
S/C Location at IP Shock Arrival

2015-03-17/04:00:00 - 2015-03-17/05:00:00 UTC



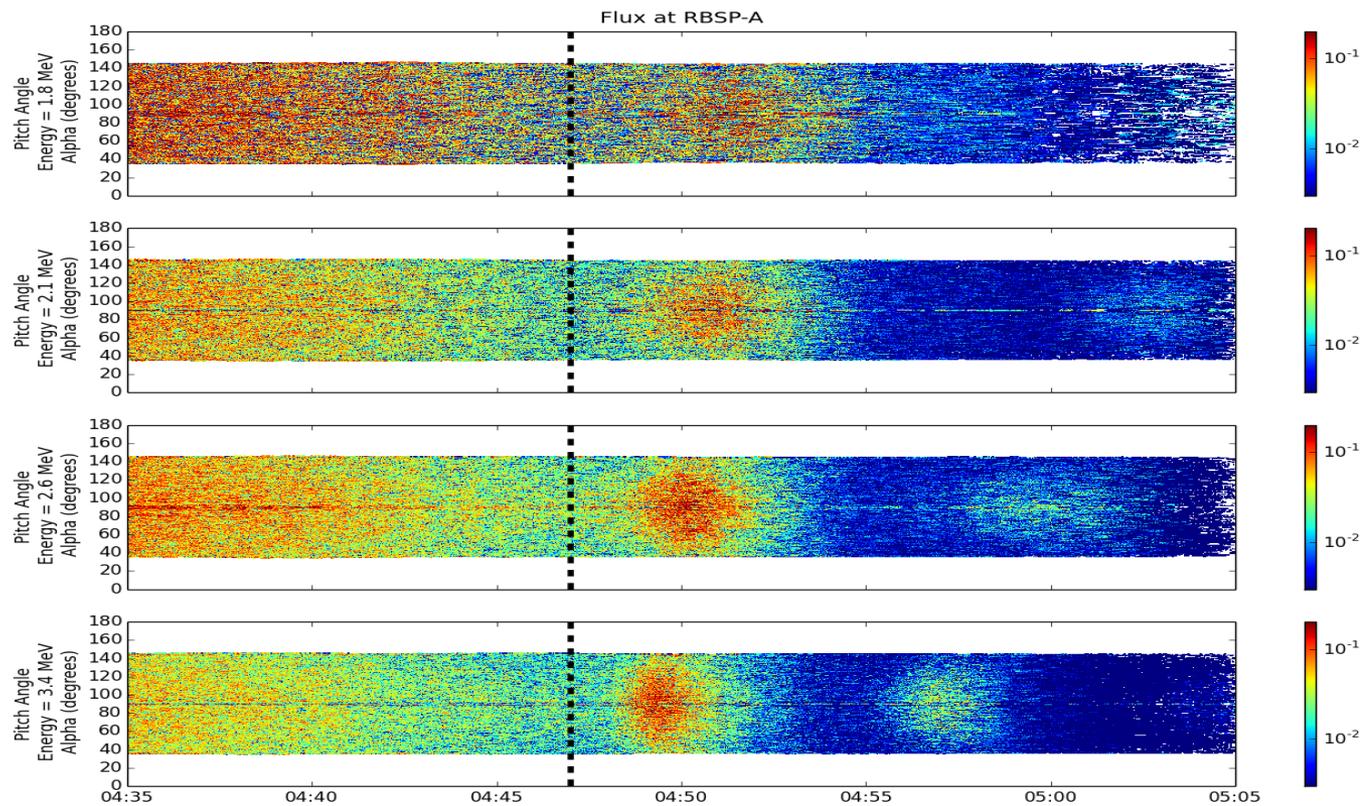
Global MHD Simulations of Magnetosphere + Test Particles

- Observations of the solar wind parameters made by satellites, operating at the L1 point (**OMNI data**)



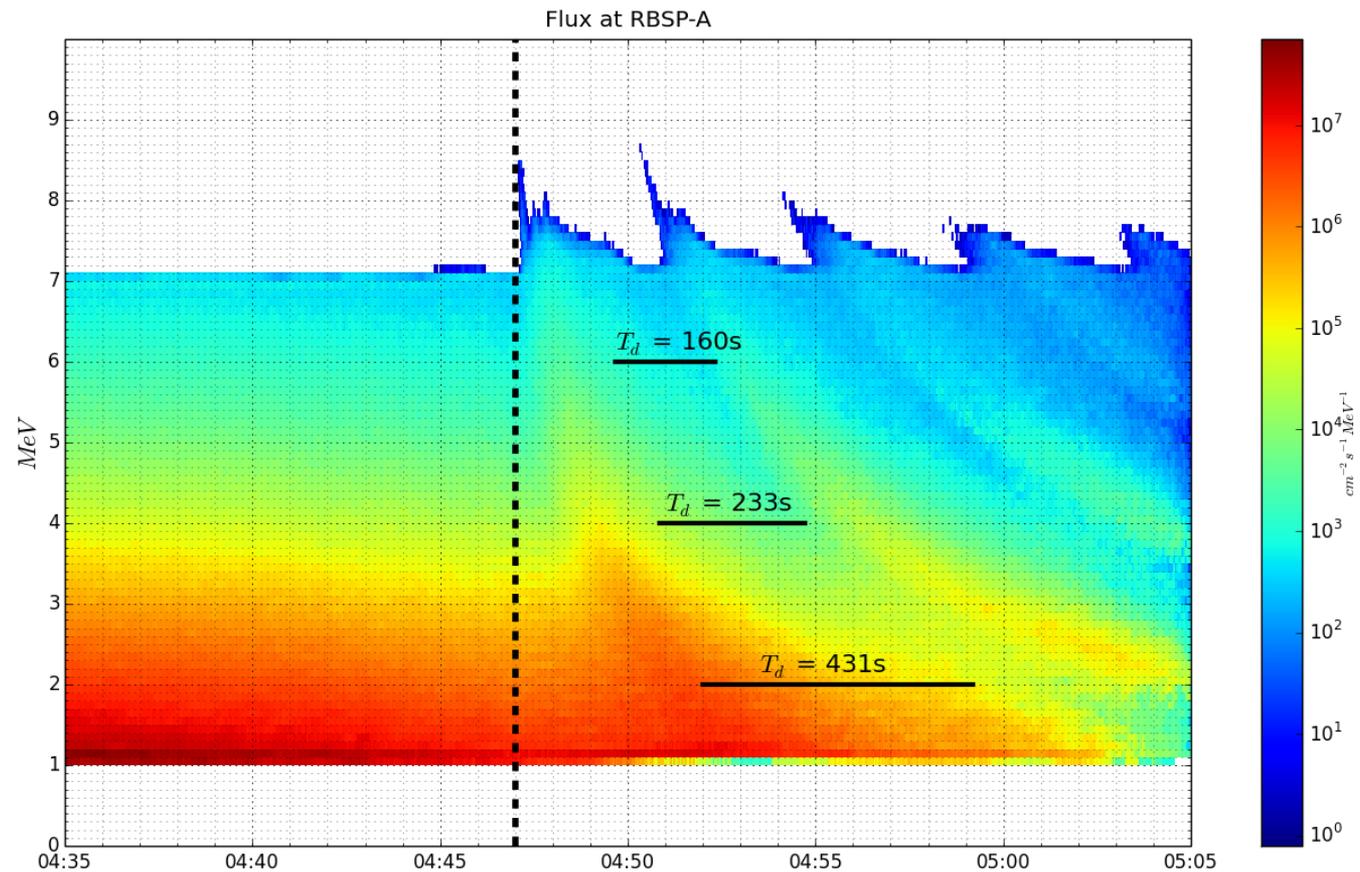
- The ideal MHD equations are solved on a grid to simulate the response of the magnetosphere to the dynamic solar wind –
- Lyon-Fedder-Mobarry model coupled to ionospheric BC & RC

Simulated Pitch Angles at RBSP-A 17 March 2015 Shock



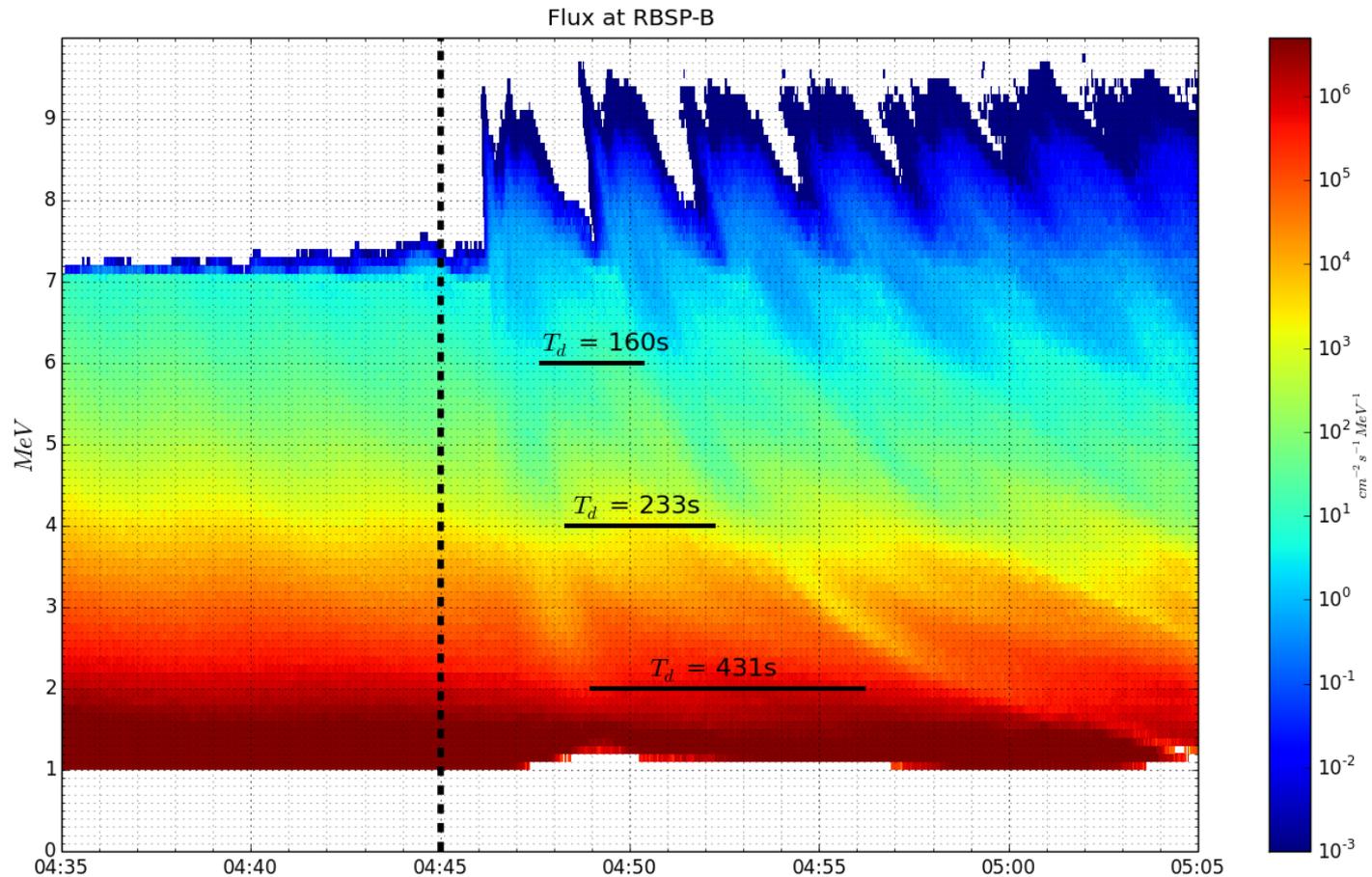
Hudson et al., JGR, 2017

Simulated RB-A Weighted Flux



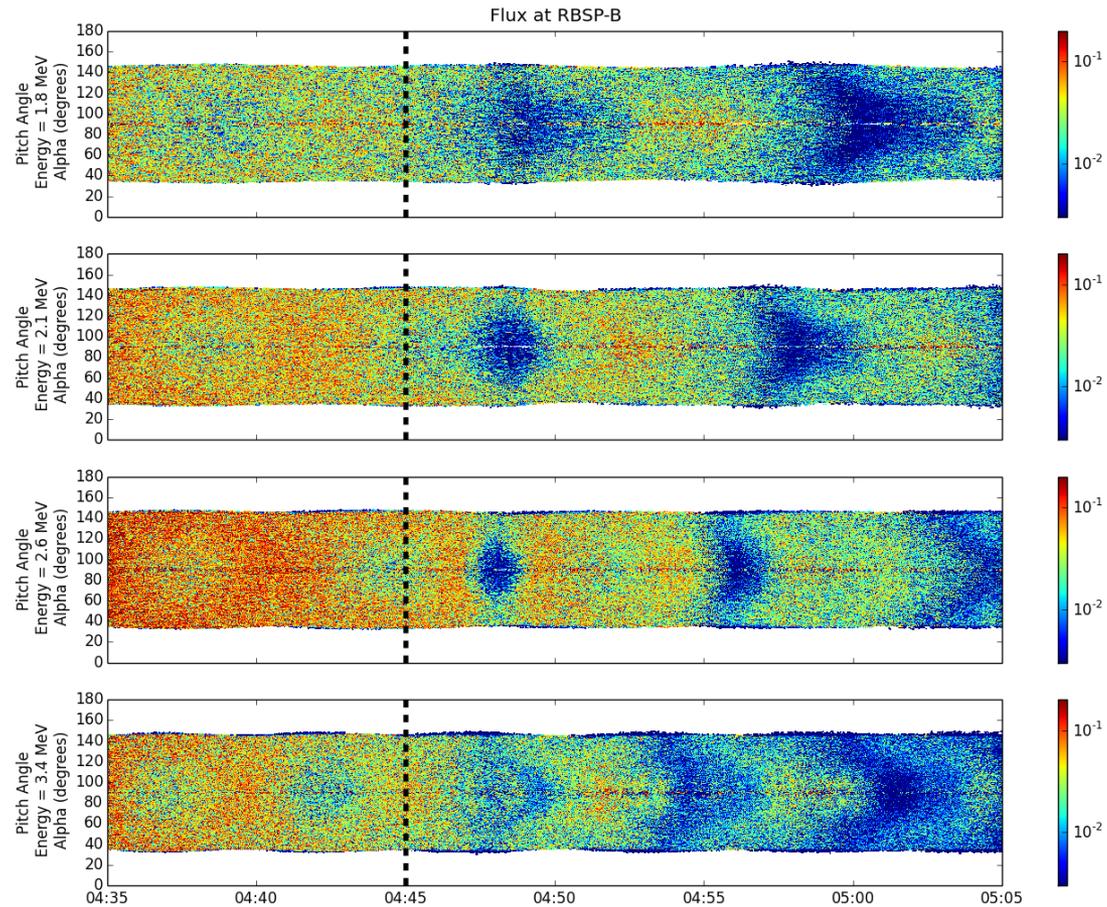
L ~ 3

Simulated RB-B Weighted Flux

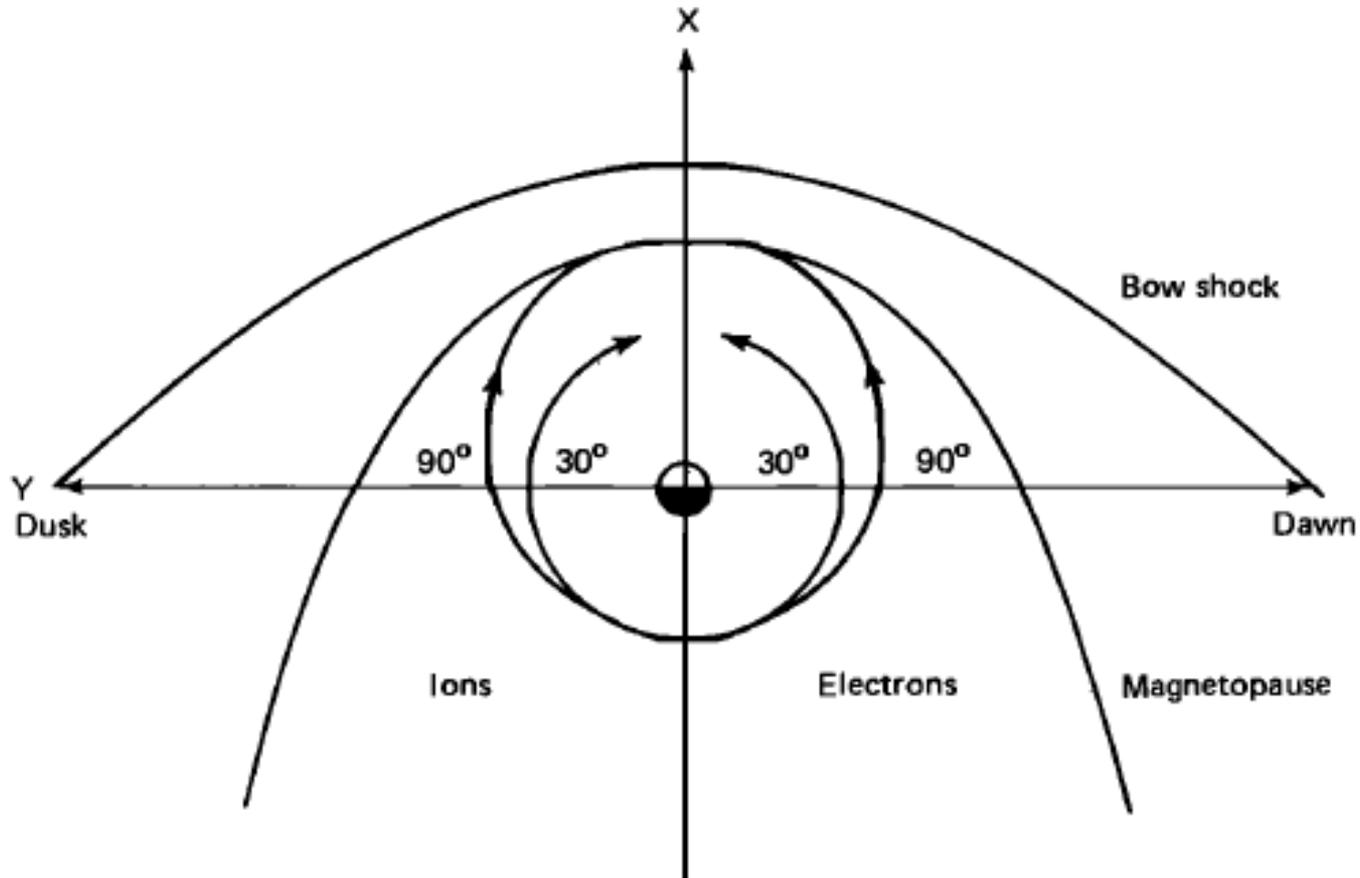


L ~ 5

Simulated Pitch Angles at RBSP-B



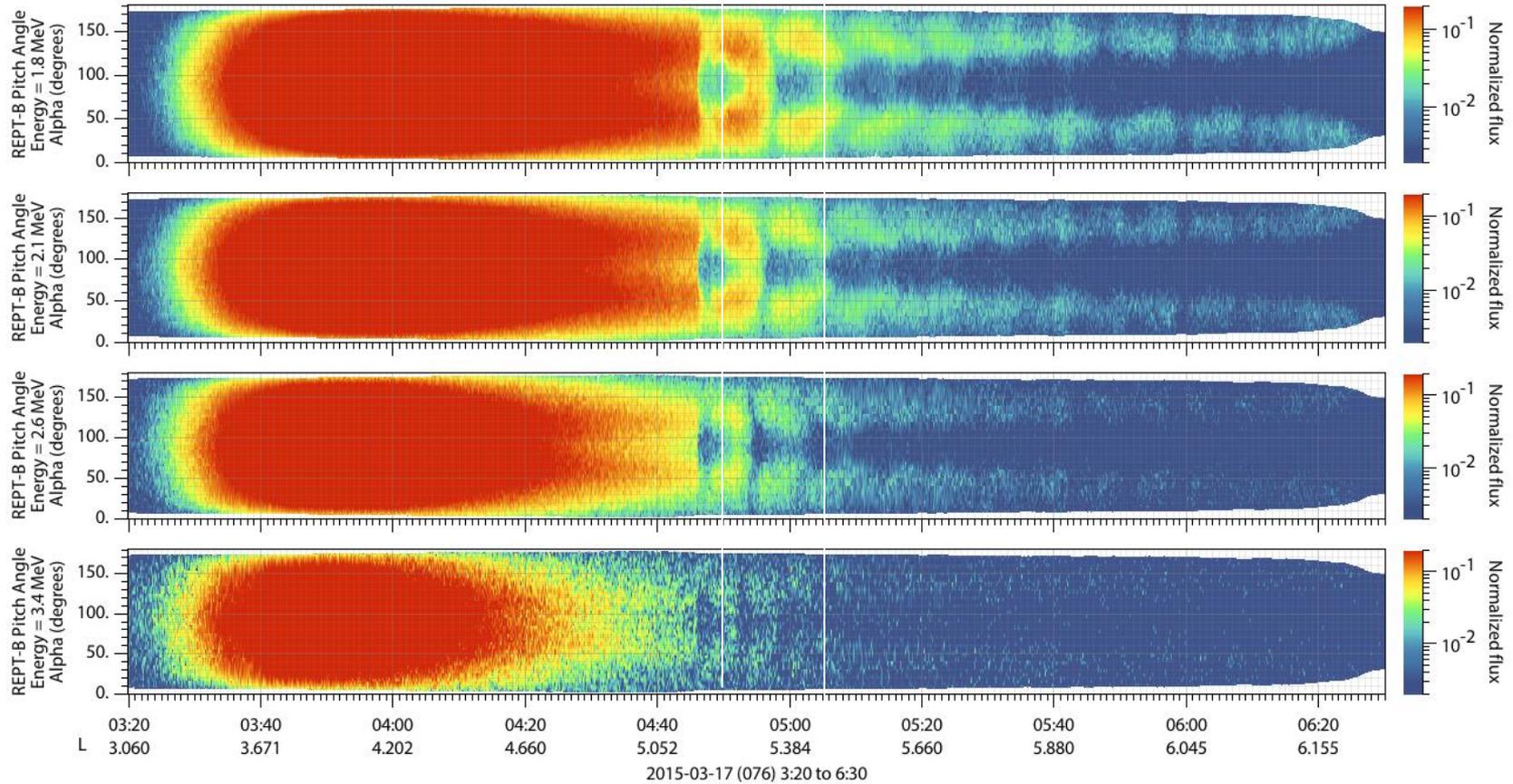
Drift Shell Splitting Effect on PAD Depends on Radial Gradient



Sibeck et al., JGR, 1987

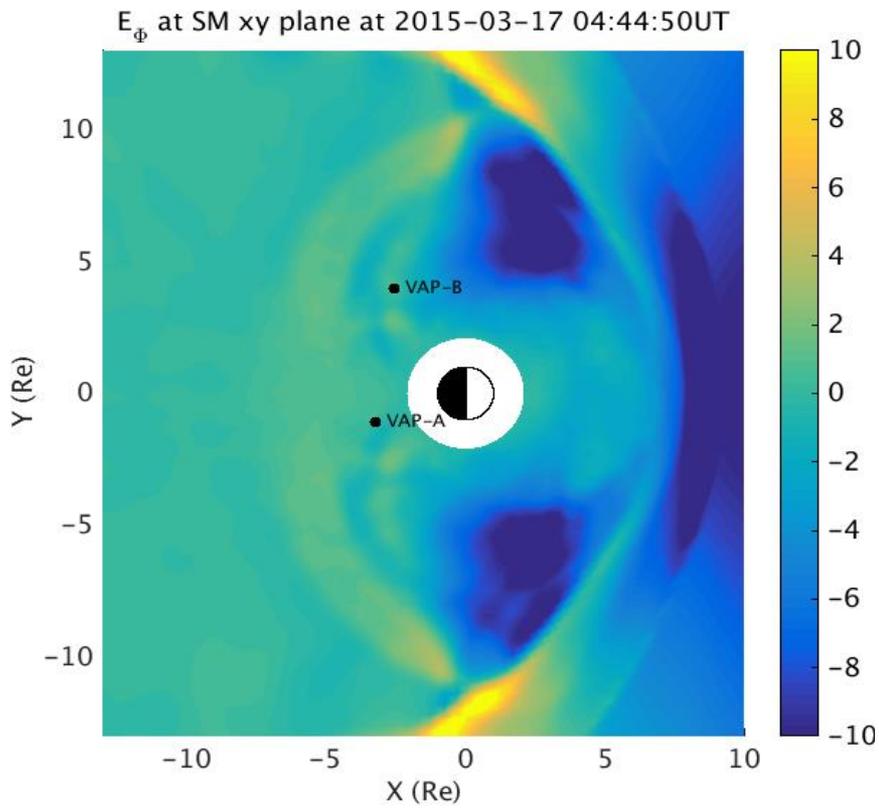
Normalized REPT Flux at RB-B

Van Allen Probe – B at L~5



Baker et al, 2016
extended

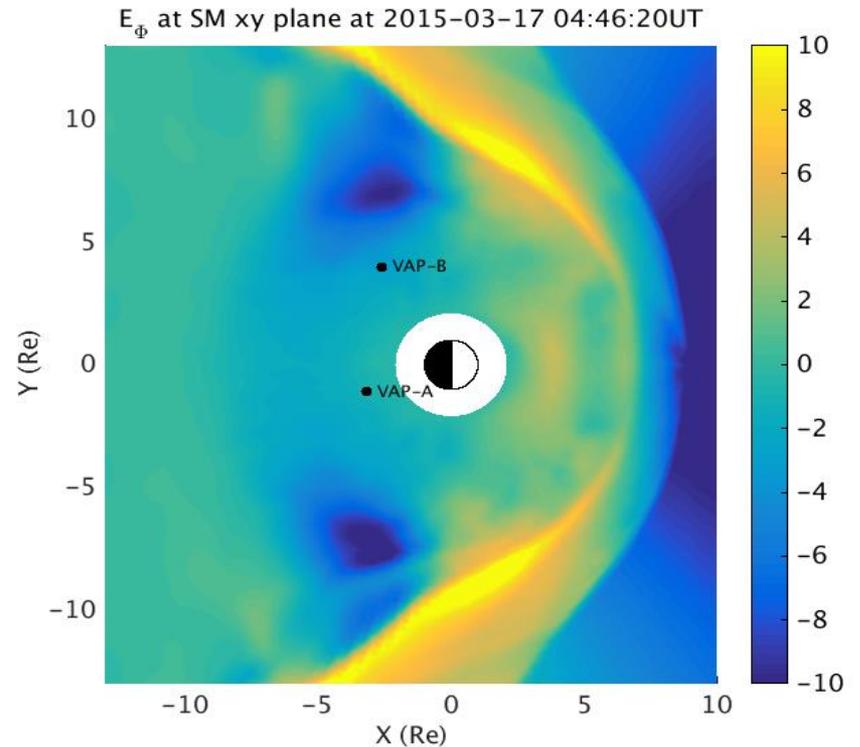
17 March 2015 IP Shock Injection Event



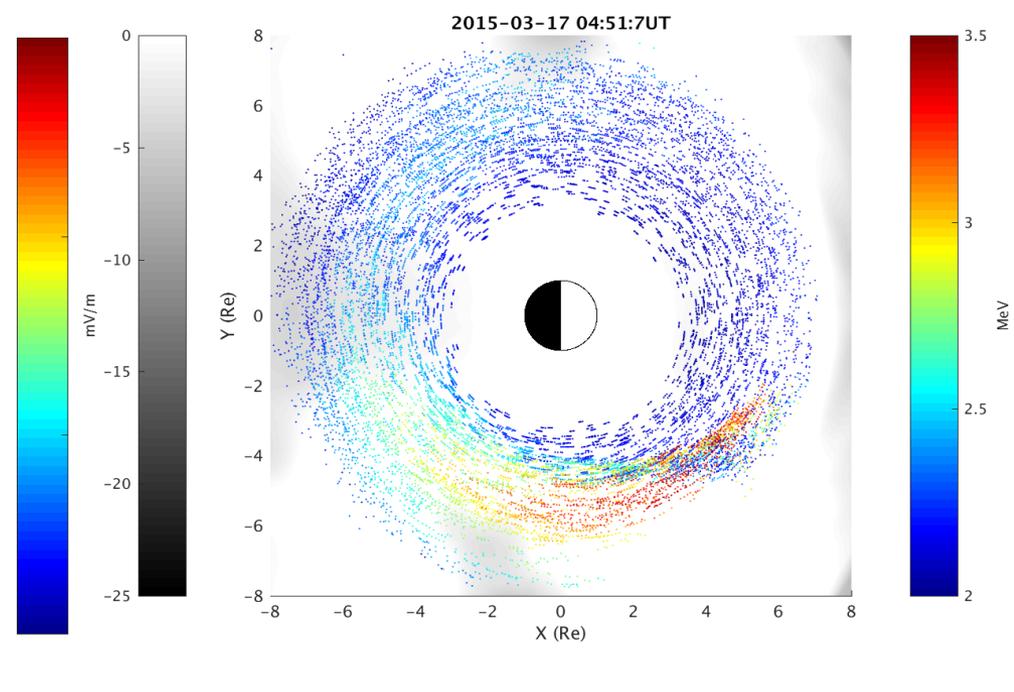
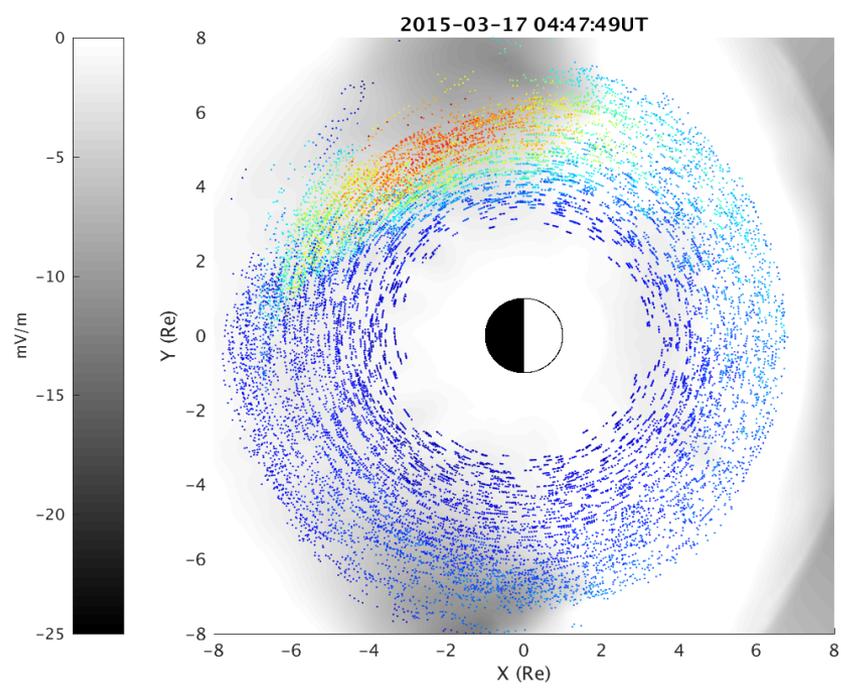
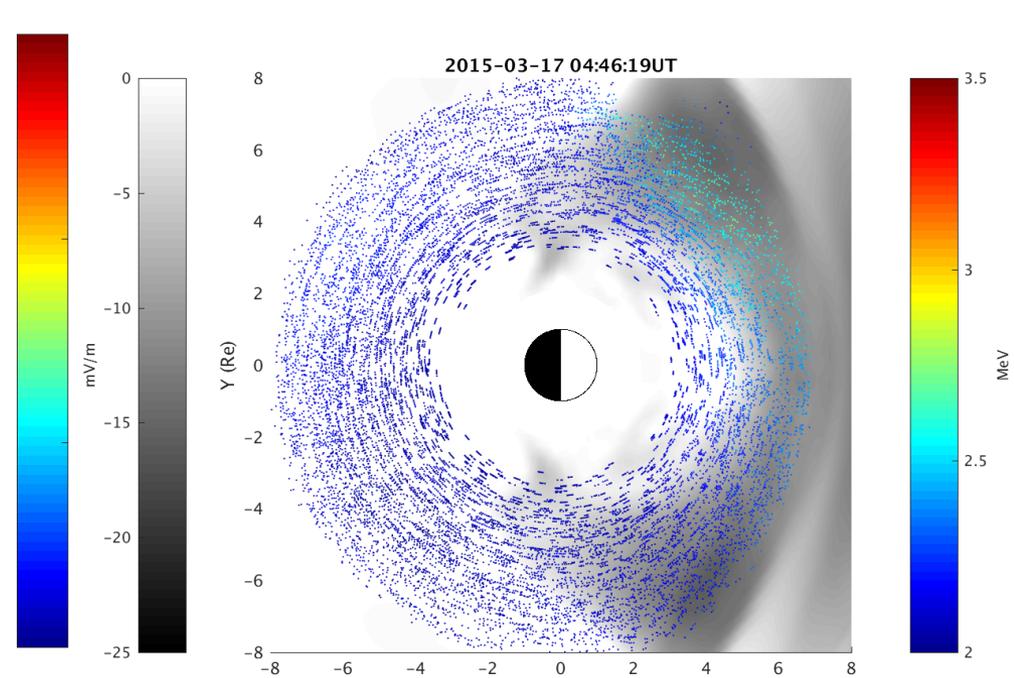
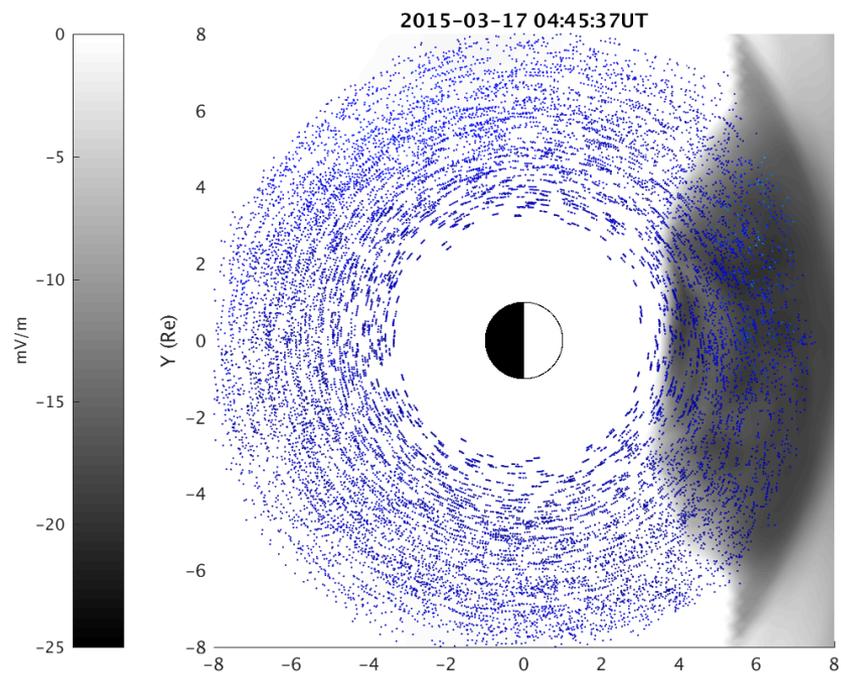
LFM Ephi Snapshots

17 March 2015 IP Shock

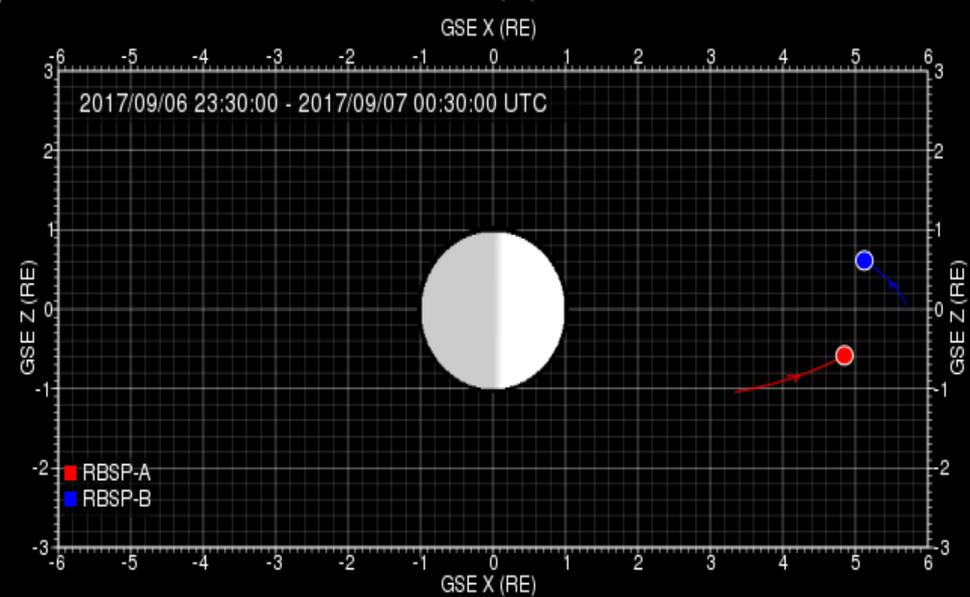
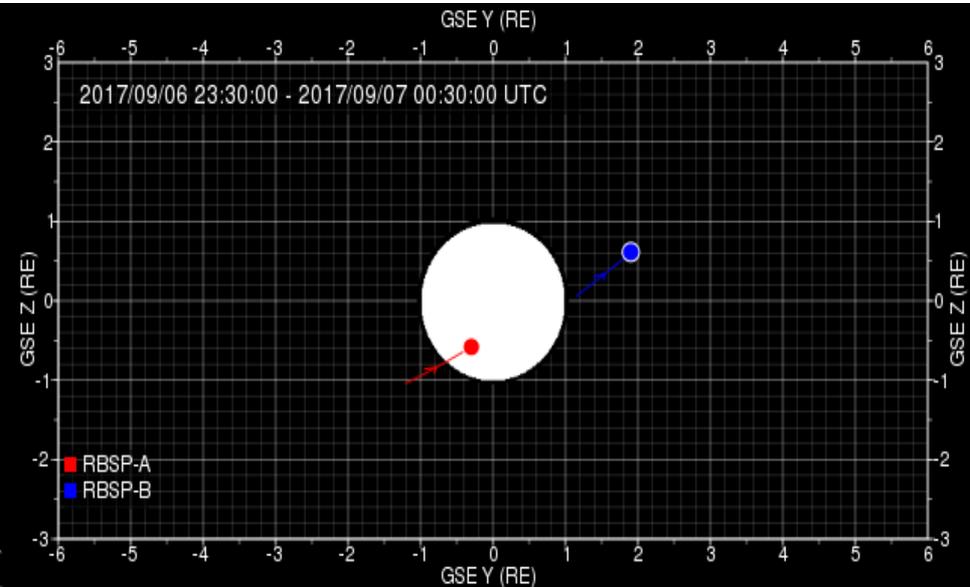
Faraday's Law:
 $\partial B_z / \partial t = -\nabla \times E_{\phi}$



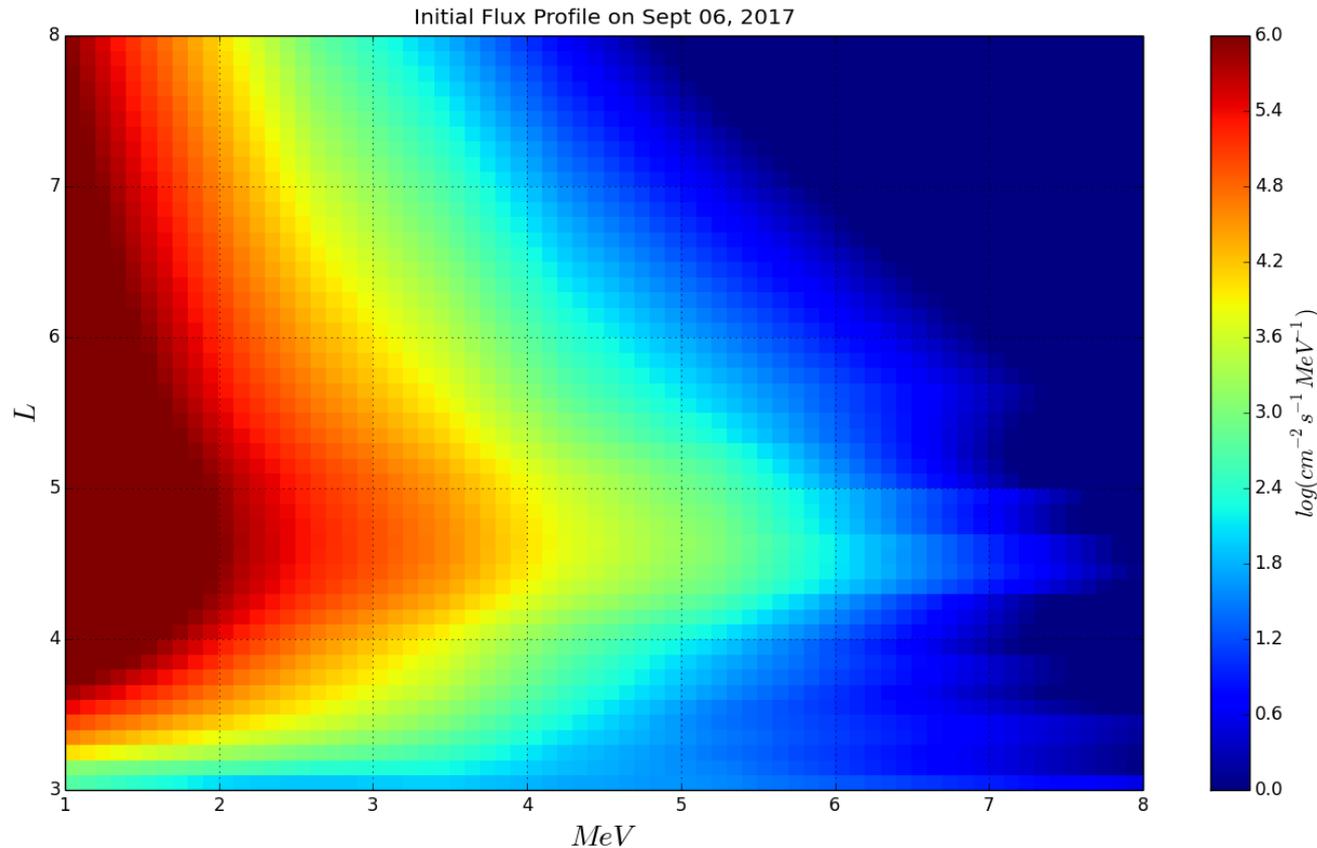
2 MeV electrons – 3D Pitch Angles –
Eq Plane Crossing in LFM-RCM Fields
17 March 2015 IP Shock Event



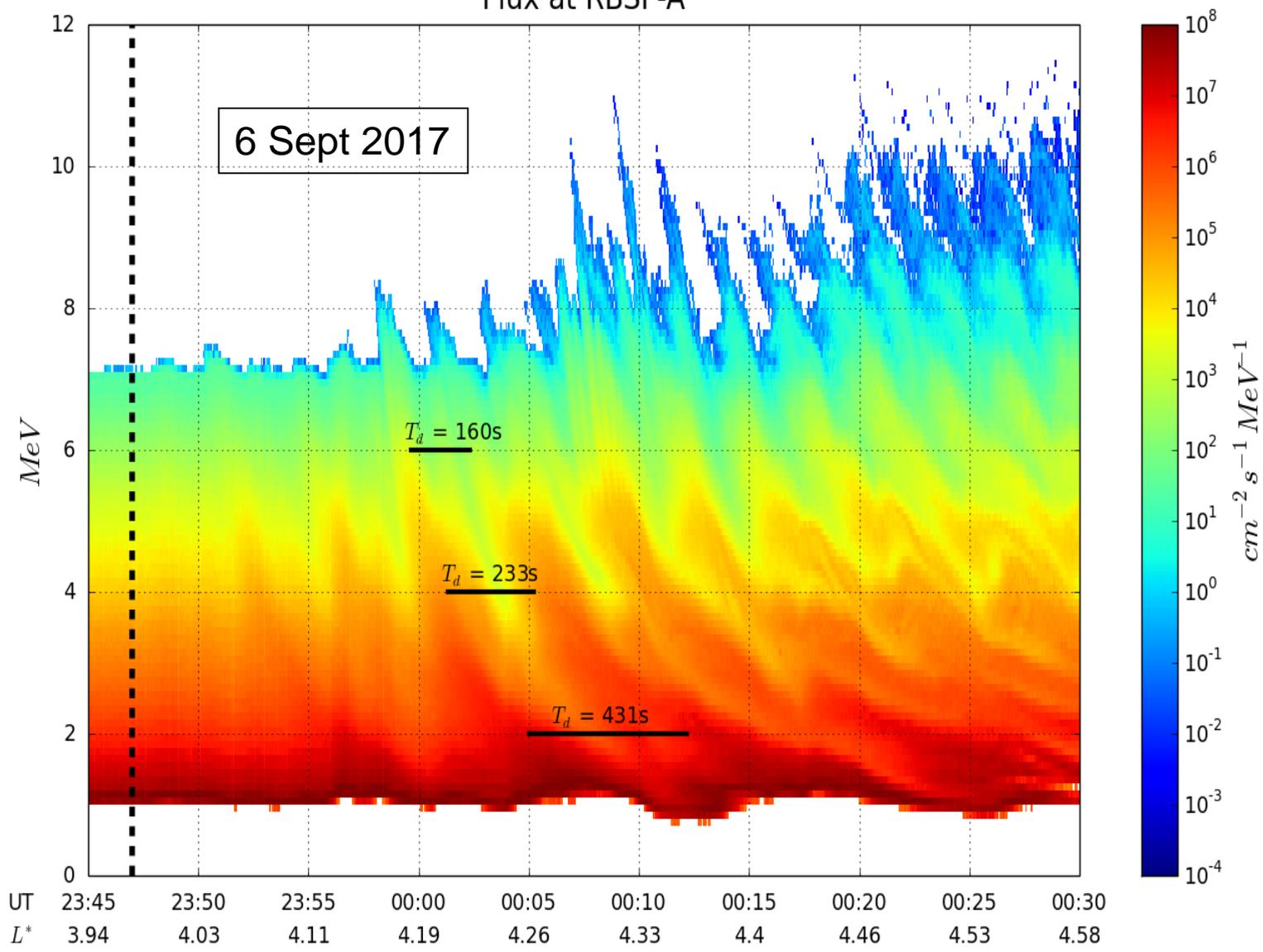
Van Allen Probes 6 September 2017



ECT Flux Distribution Prior to Shock for 6 Sept 2017 Storm



Flux at RBSP-A

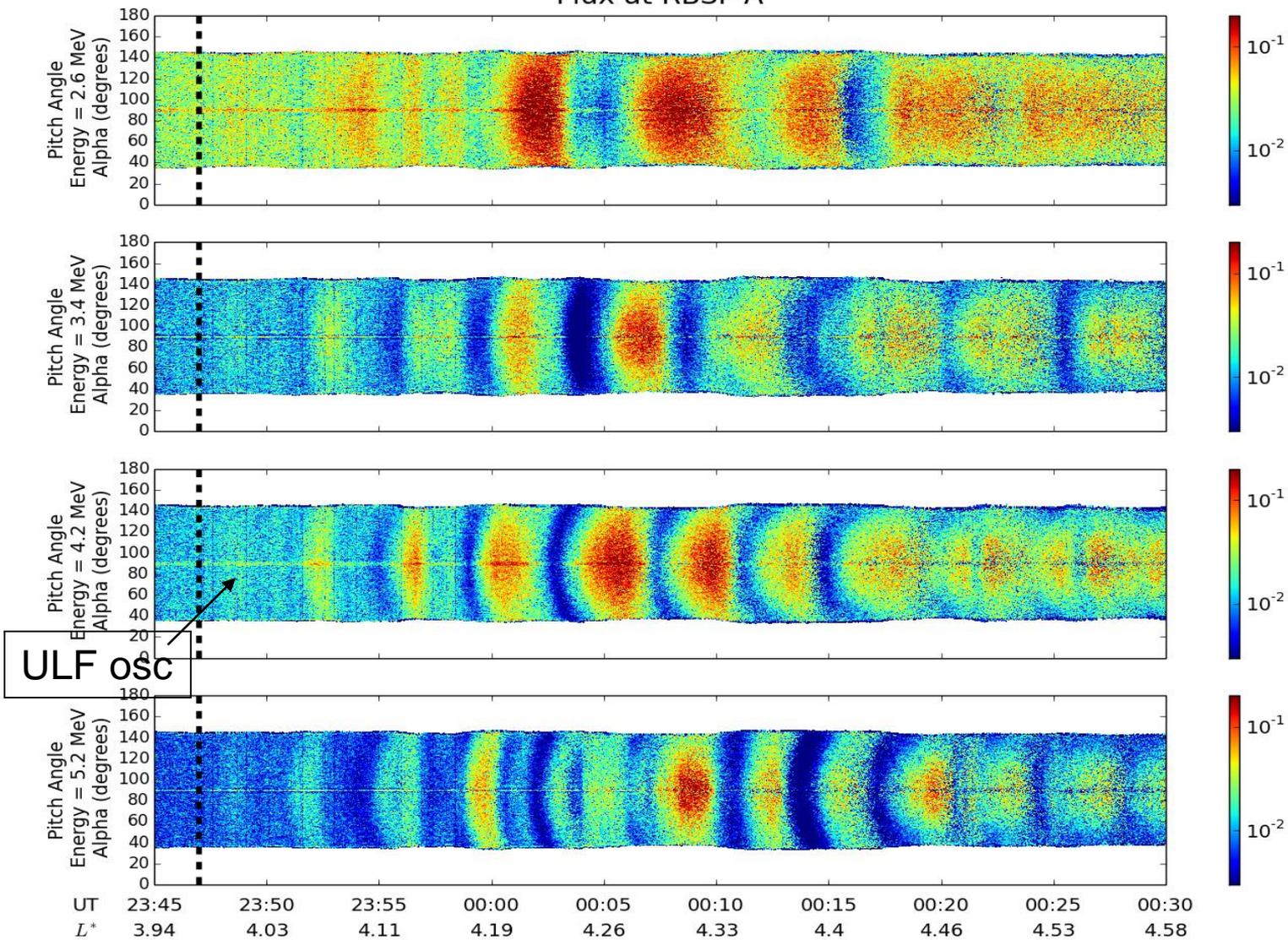


$L^* = 3.9 - 4.6$

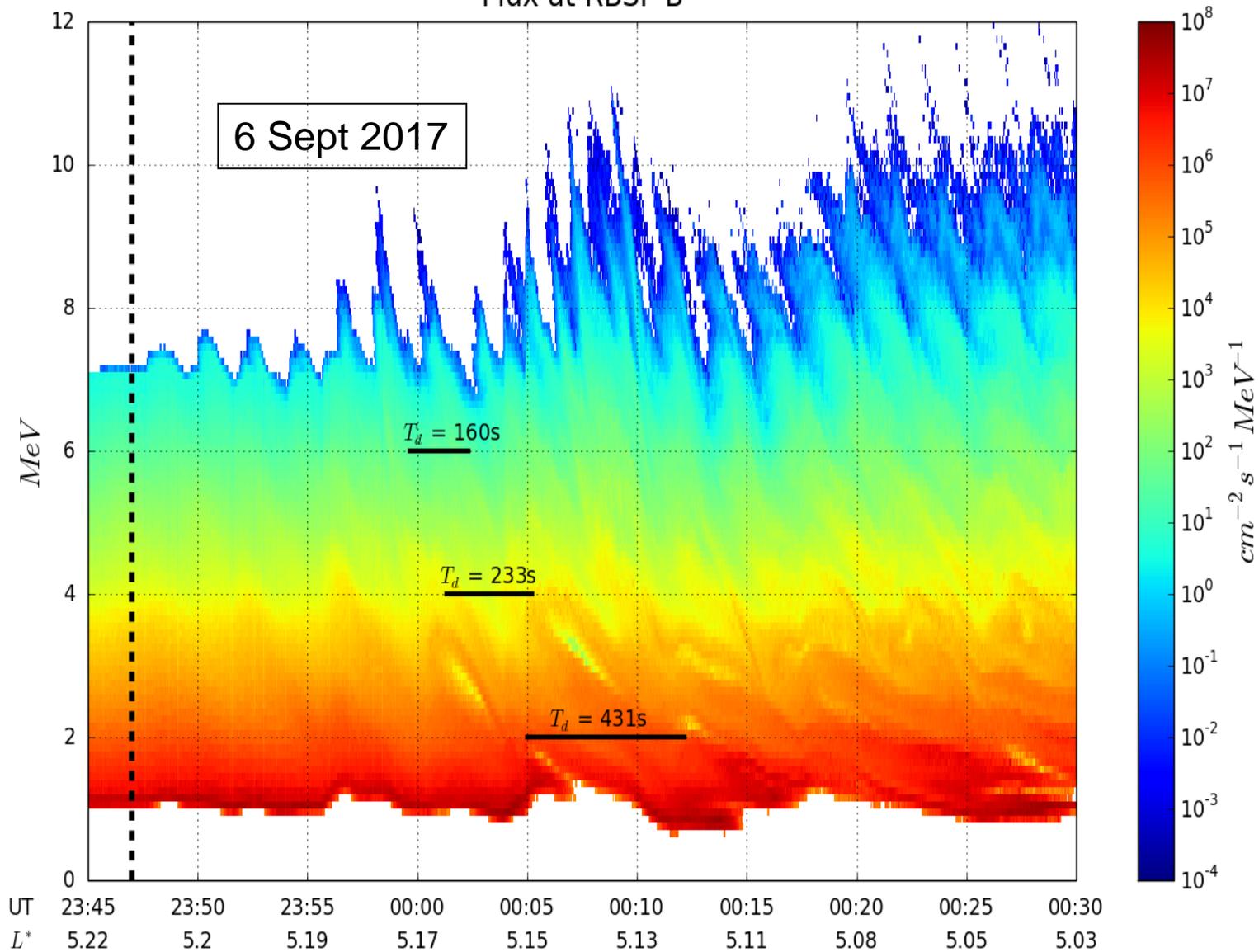
Pitch Angle Distributions at Probe A

6 Sept 2017

Flux at RBSP-A



Flux at RBSP-B

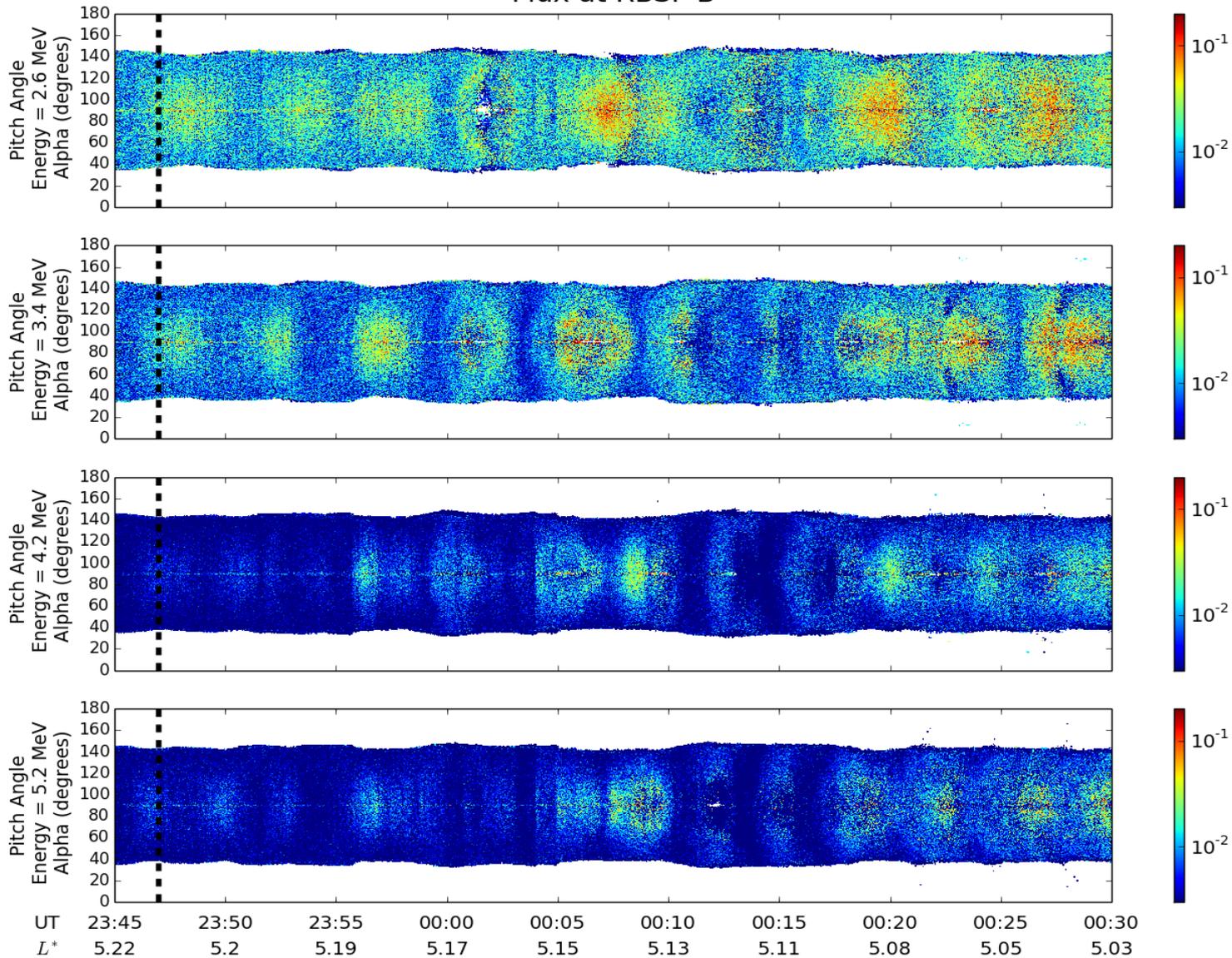


$L^* = 5.22 - 5.11$

Pitch Angle Distributions at Probe B

6 Sept 2017

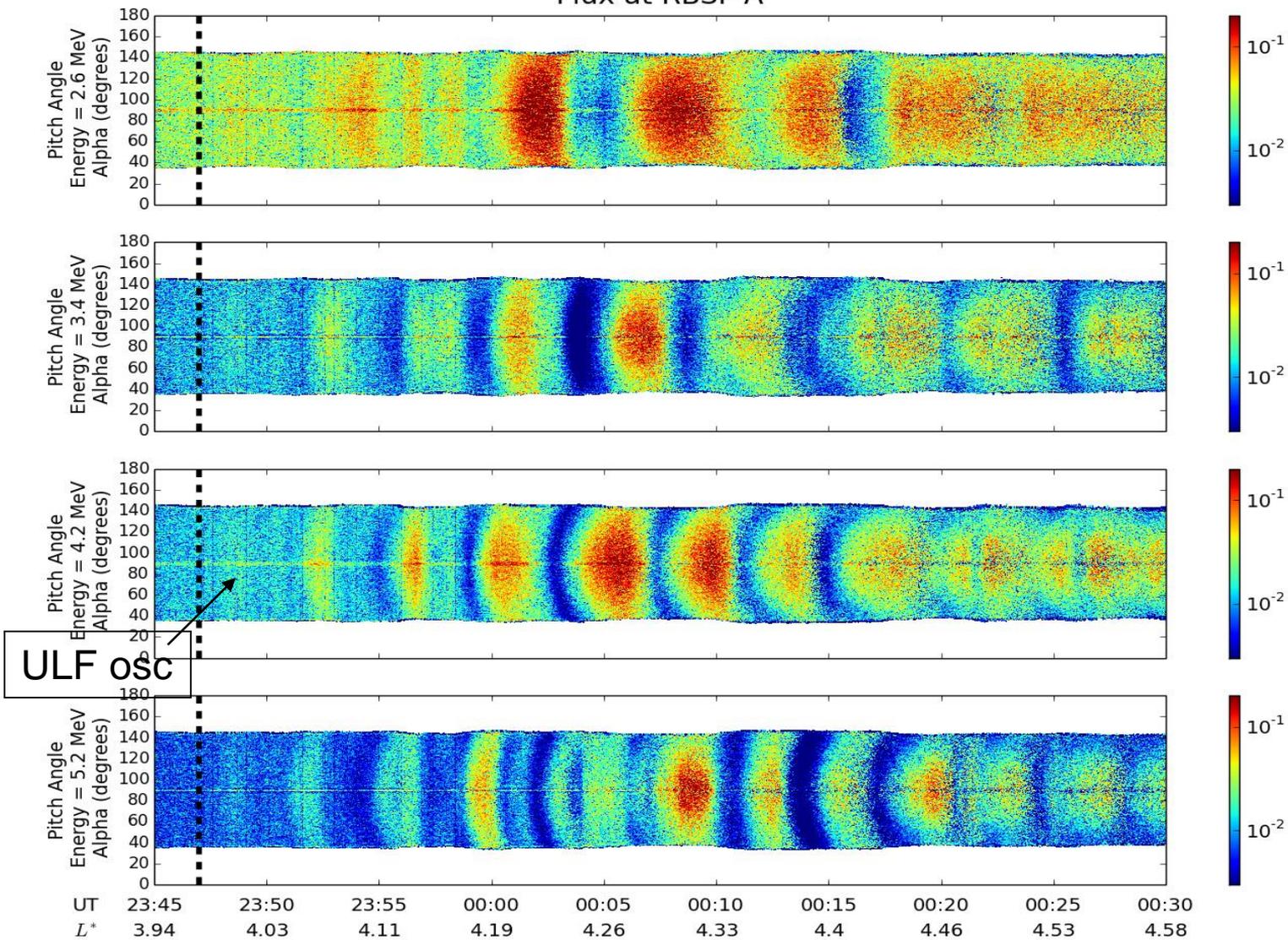
Flux at RBSP-B



Pitch Angle Distributions at Probe A

6 Sept 2017

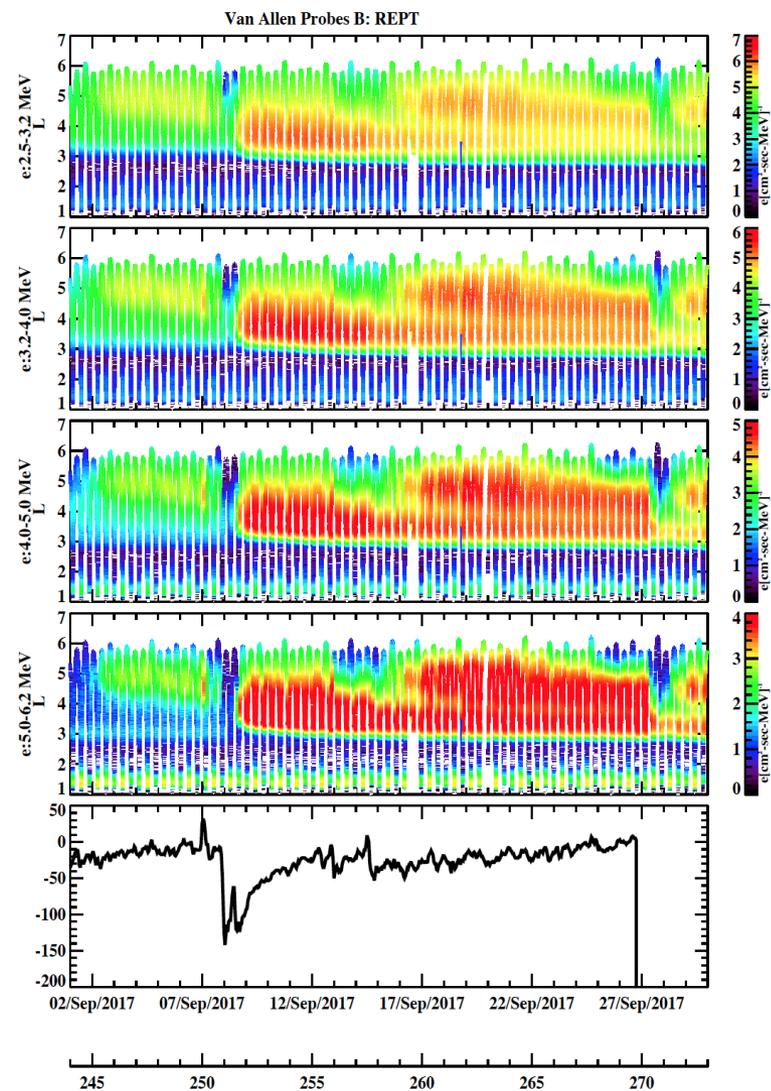
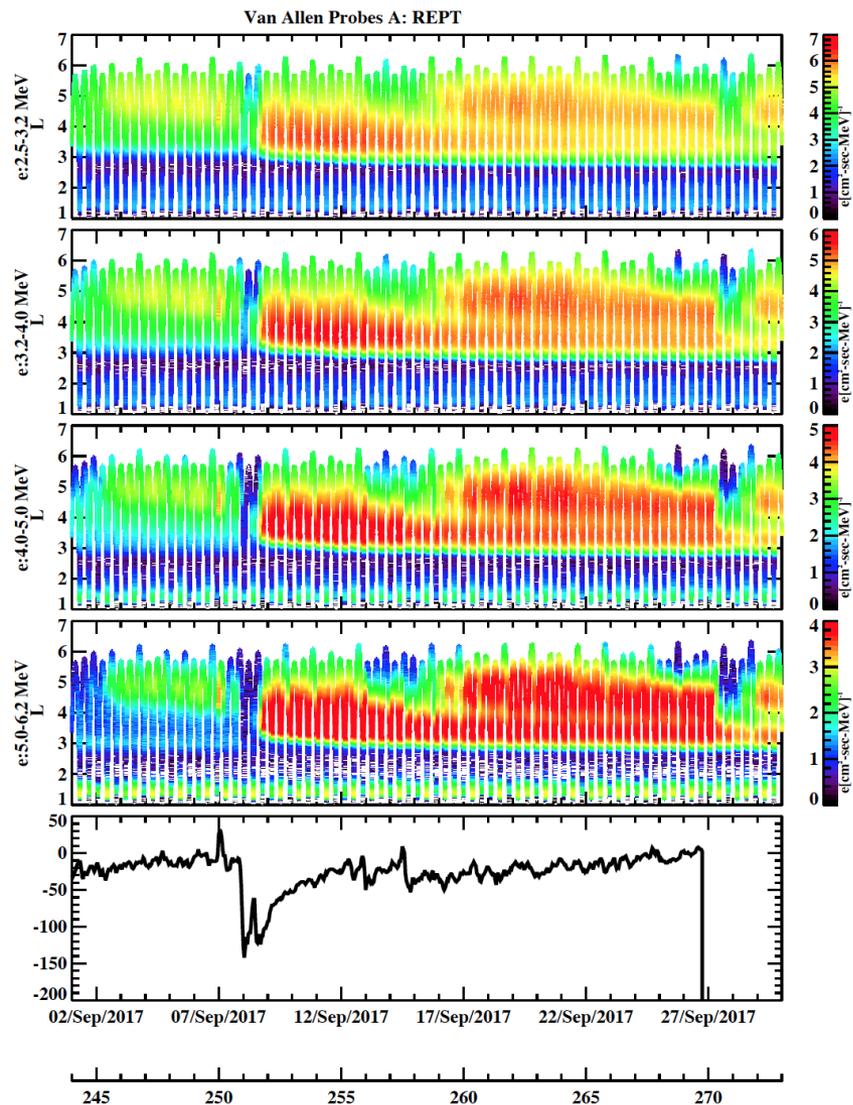
Flux at RBSP-A



Conclusions

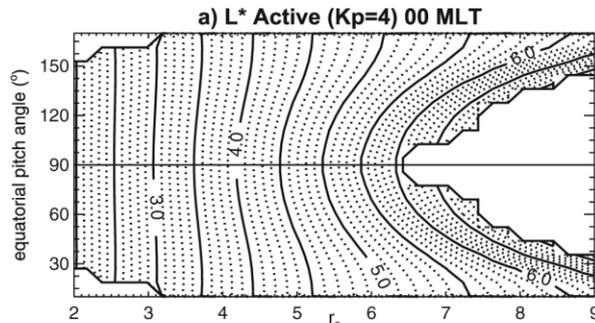
- Prompt increase of MeV el flux $L = 3-5$ on electron drift time scale due to IP shock launched MHD fast mode
- Observed for weaker events by VAP than 24 March 1991:
8 Oct 2013; 17 March 2015; 6 Sept 2017; 16 July 2017
- MHD-test particle simulations reproduce energy, drift echo & pitch angle distributions & ULF- local flux oscillations
- Observed commonly for weaker IP shocks
- Strong events with $E_{phi} \sim 100$ mV/m inject el to low $L \sim 2.5$ and high energy
- Weaker events with $E_{phi} \sim 10$ mV/m transport into $L = 3-5$, lost promptly with inward magnetopause motion, drift shell splitting, m'pause shadowing

September 2017 events - REPT



Backup Slides

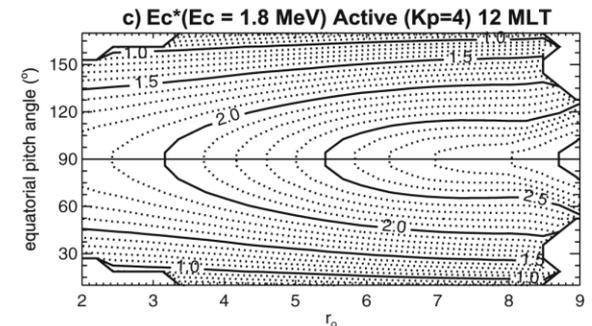
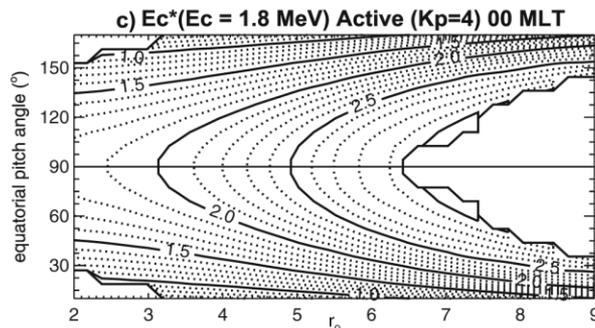
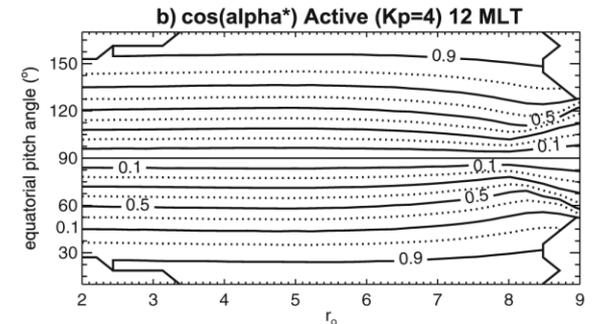
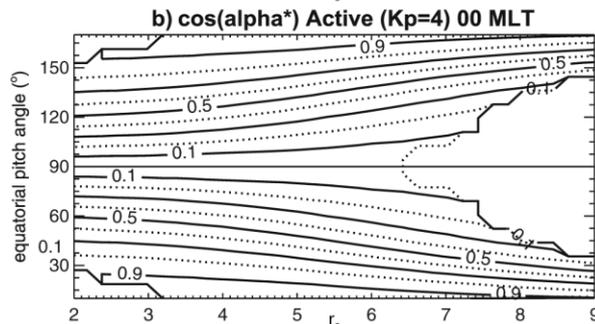
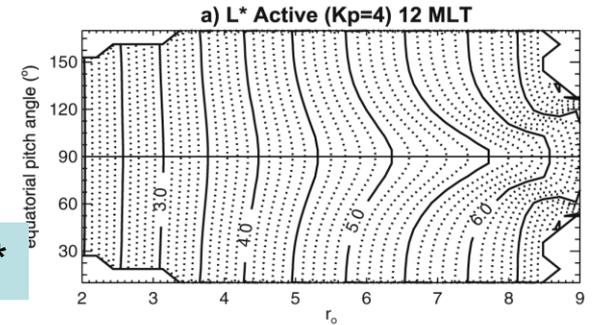
Adiabatic trajectories launched from midnight and noon in TS89



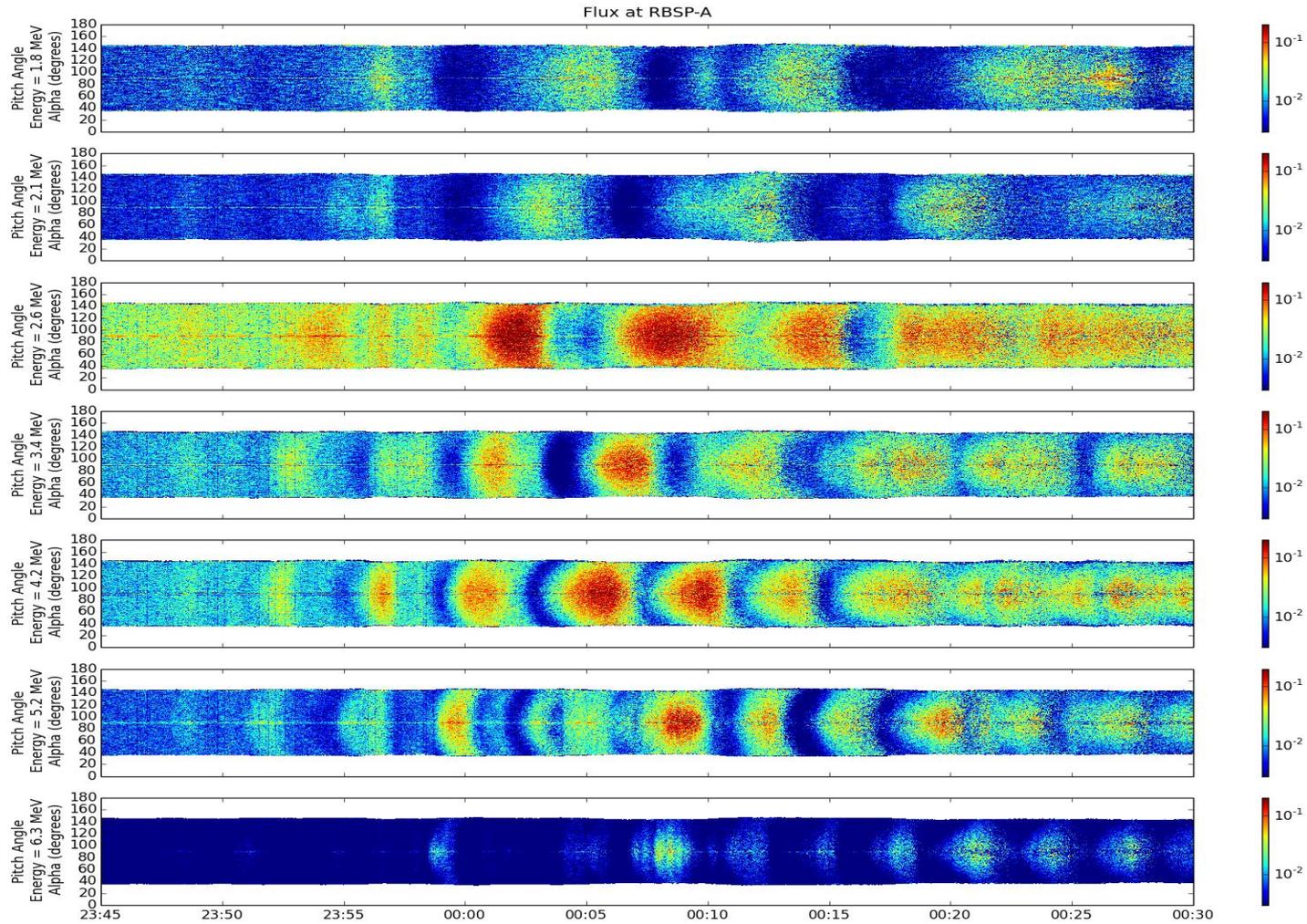
Butterfly

Pancake

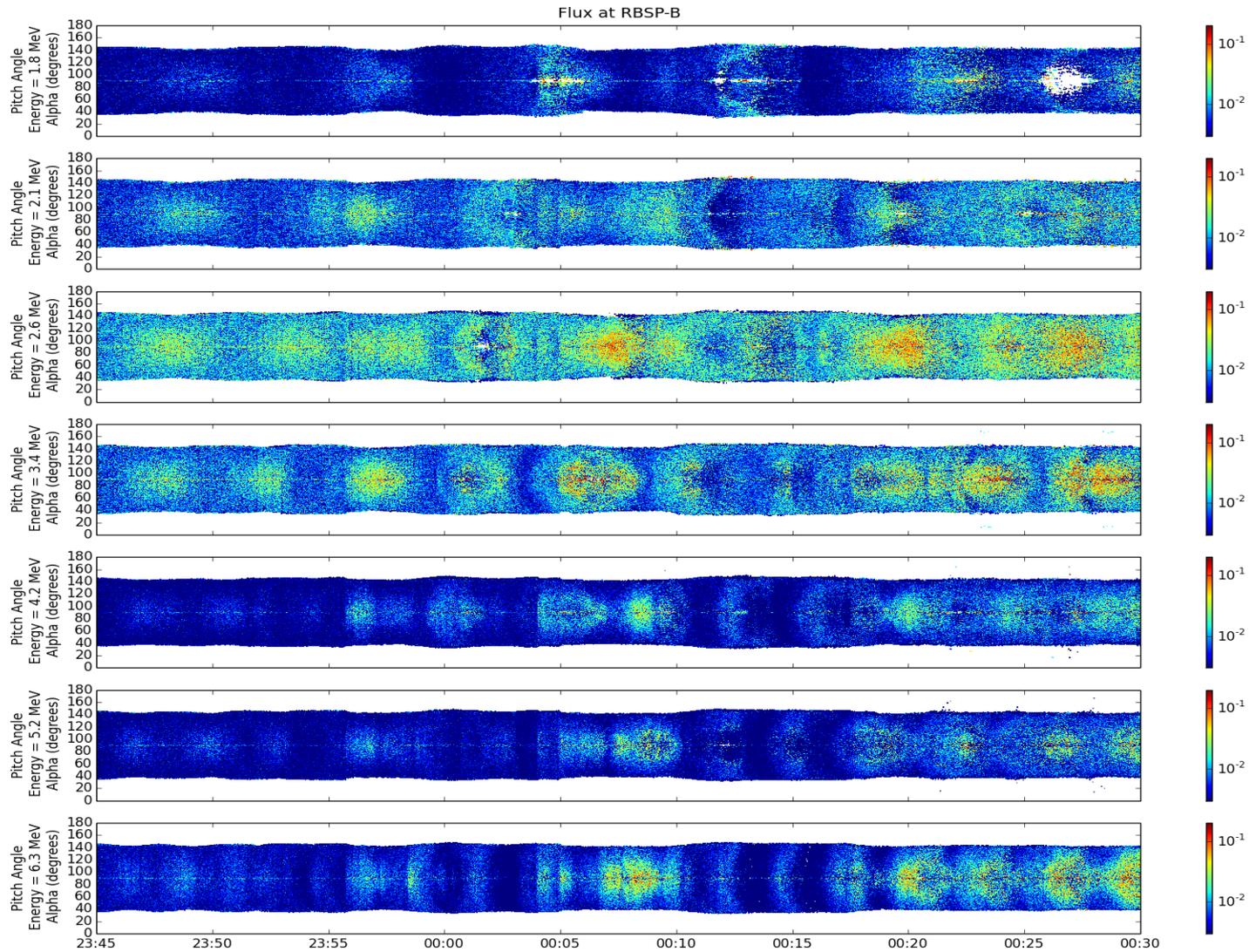
Contours of constant L^*



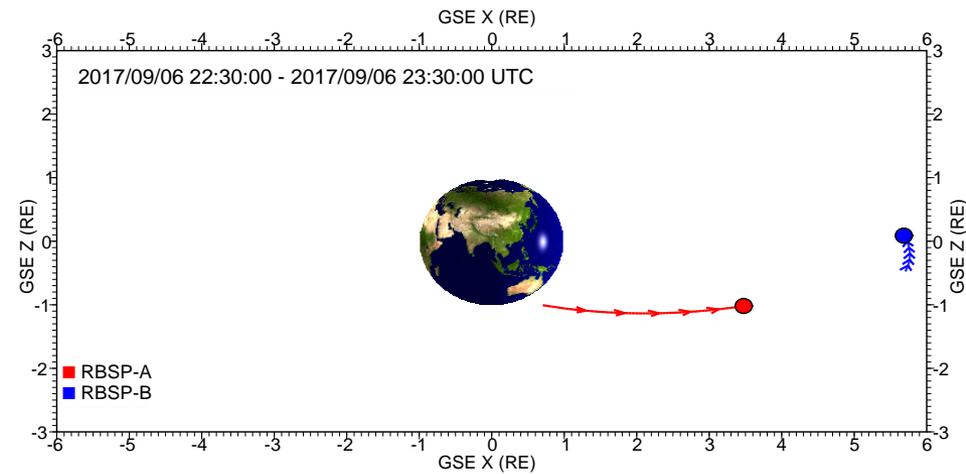
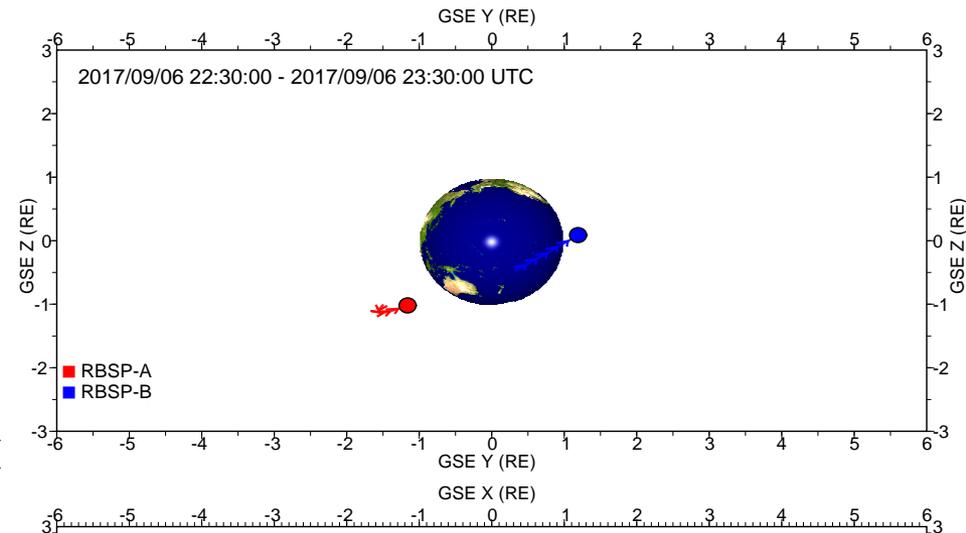
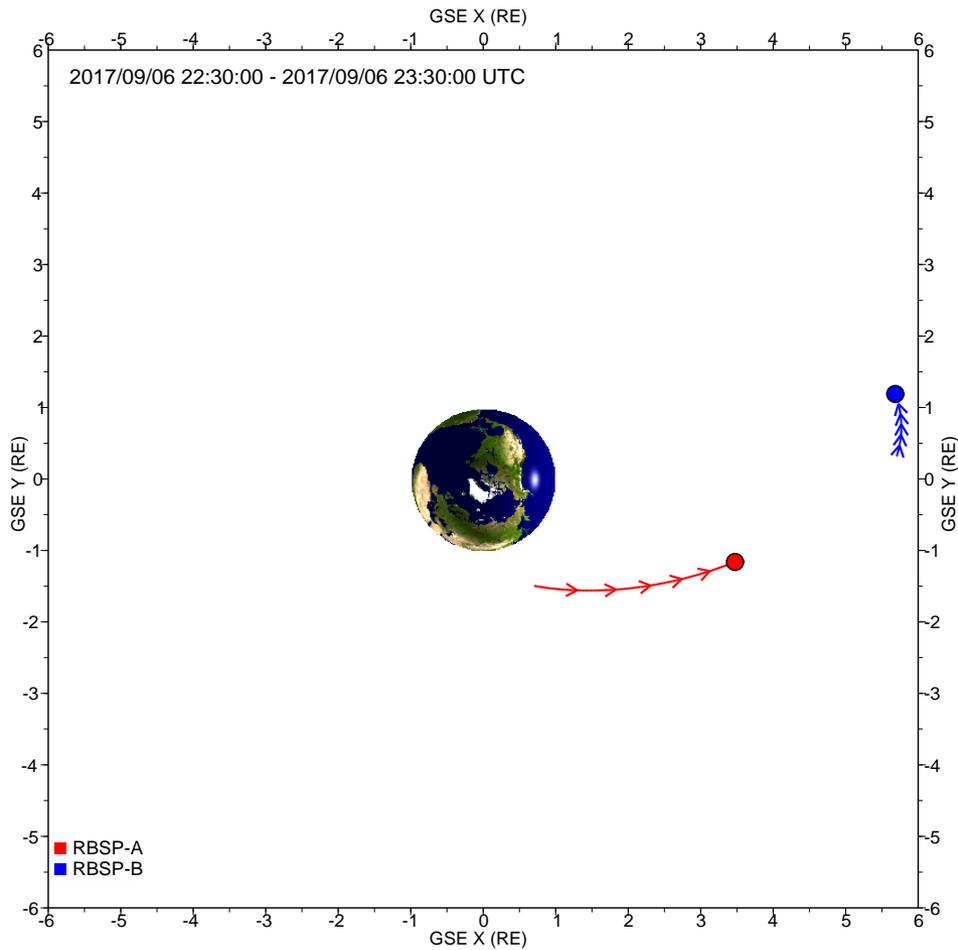
Backup Add'l REPT Channels 6 Sept 2017 VAP-A



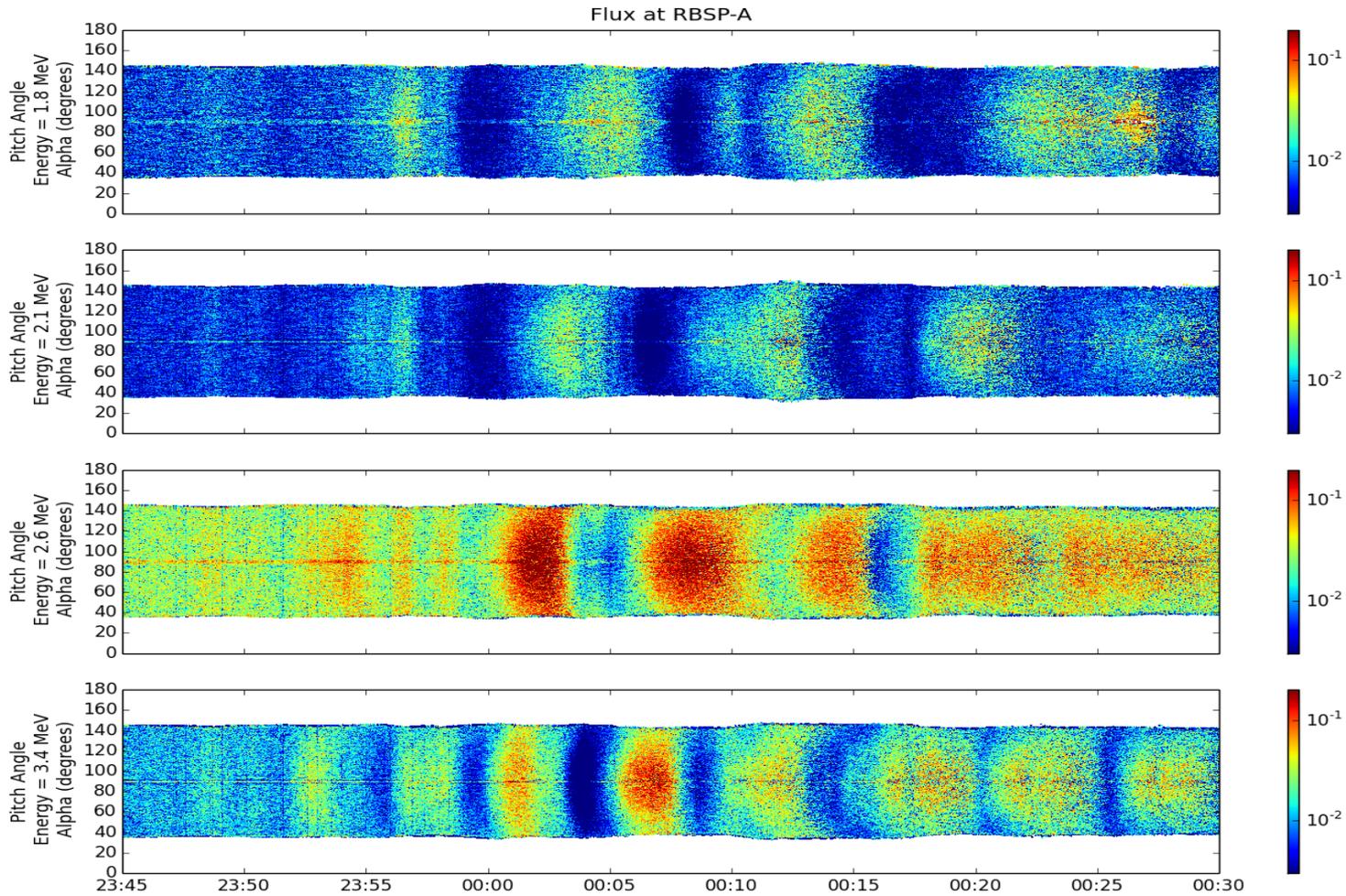
Backup Add'l REPT Channels 6 Sept 2017 VAP-B



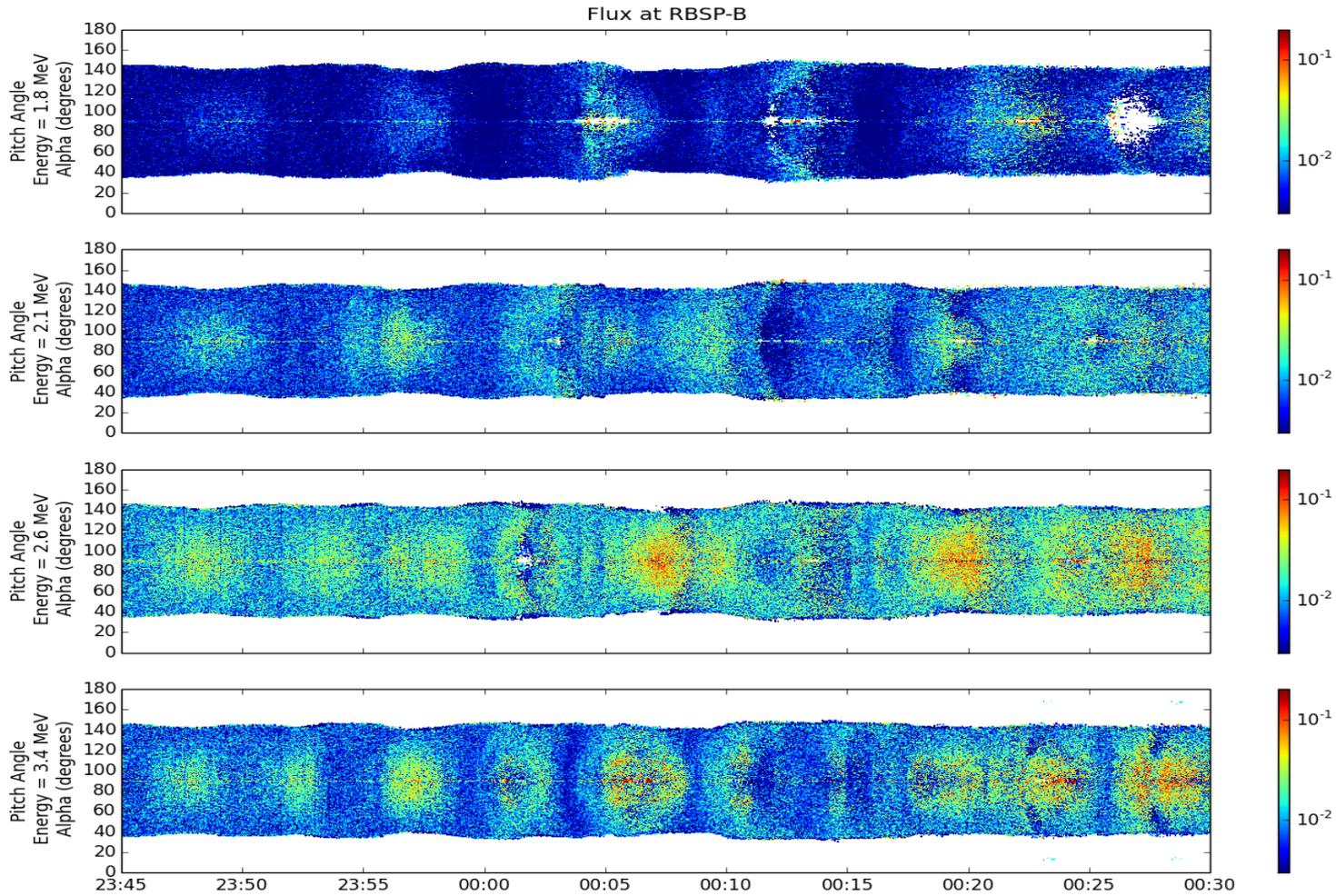
Van Allen Probes 6 September 2017- Including Pre-Shock



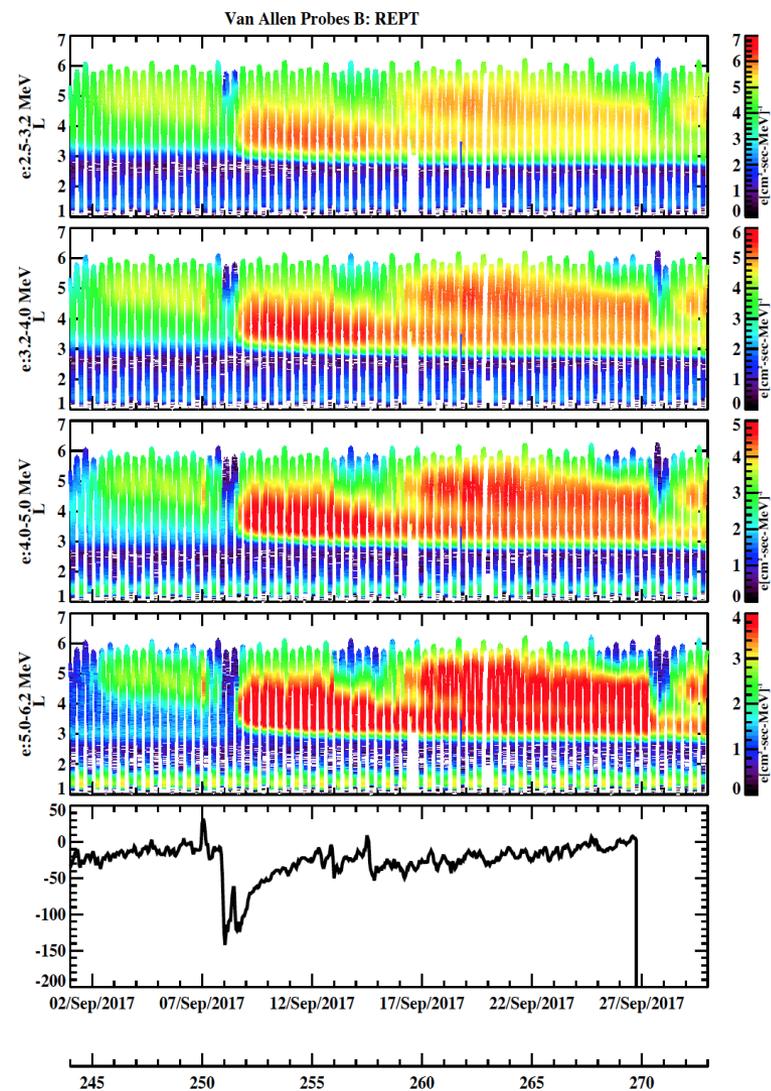
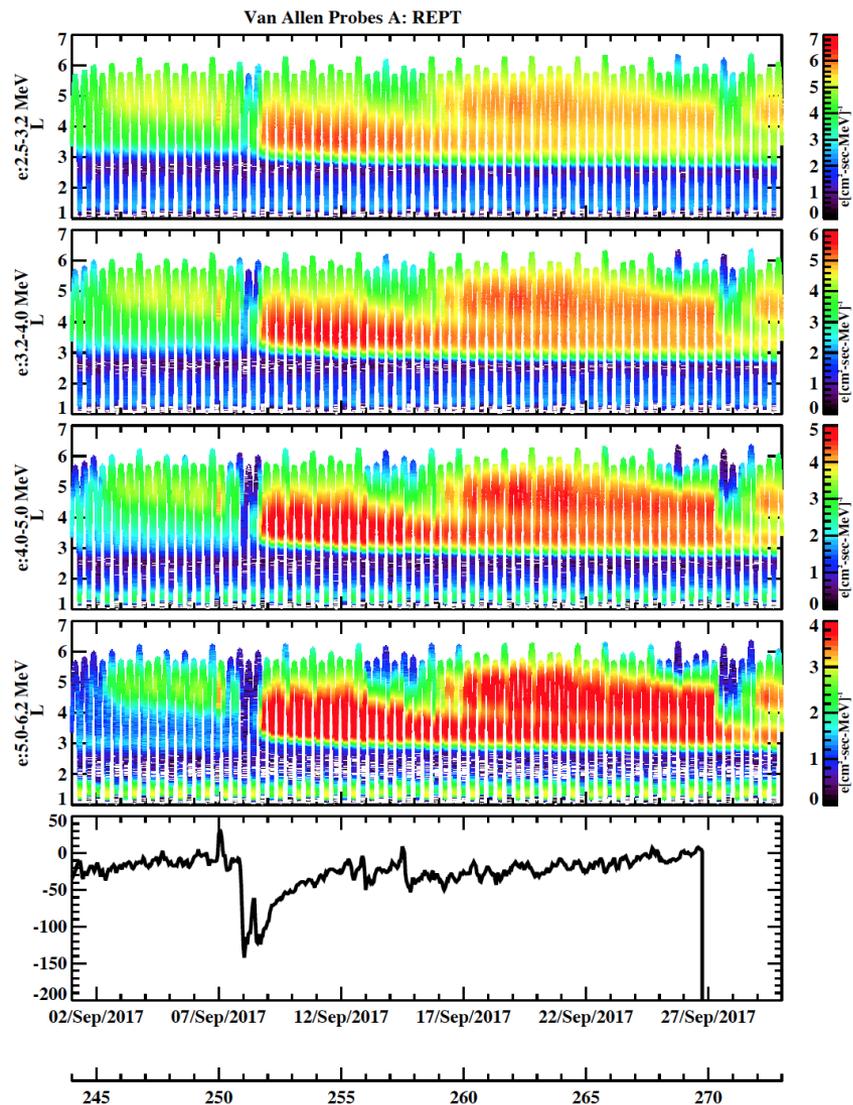
REPT-A Lower Energies 6 Sept 2017



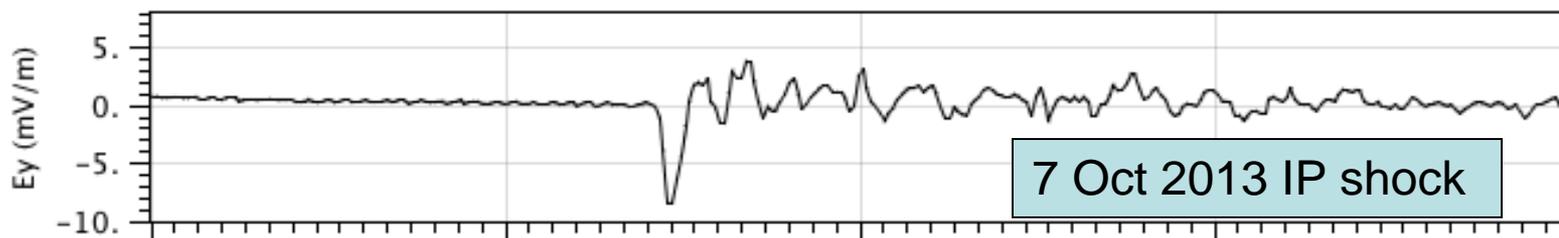
REPT-B Lower Energies 6 Sept 2017



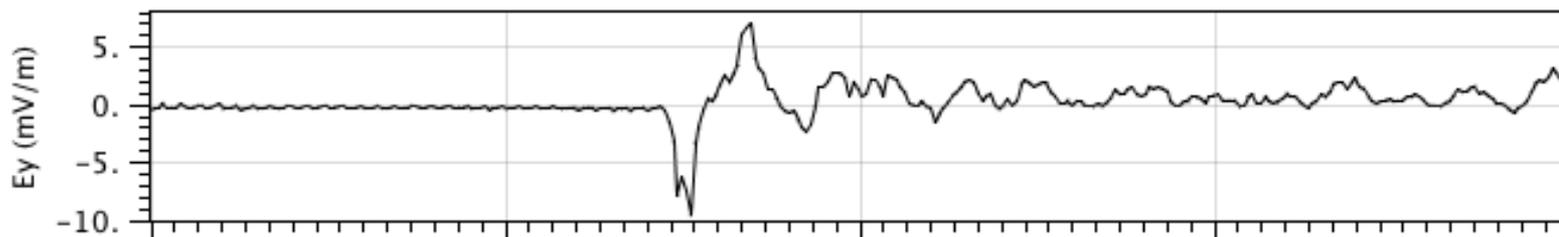
September 2017 events - REPT



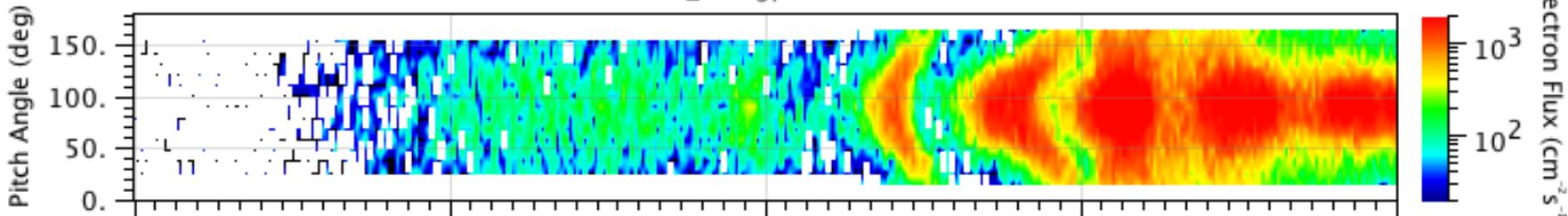
RBSPA/EFW-L2 Ey (Spinfit E-field VxB subtracted)



RBSPB/EFW-L2 Ey (Spinfit E-field VxB subtracted)



rbspa/ect-rept-sci-L3 FEDU - Unidirectional Differential Electron Flux
FEDU_Energy=3.6 MeV



rbspb/ect-rept-sci-L3 FEDU - Unidirectional Differential Electron Flux
FEDU_Energy=3.6 MeV

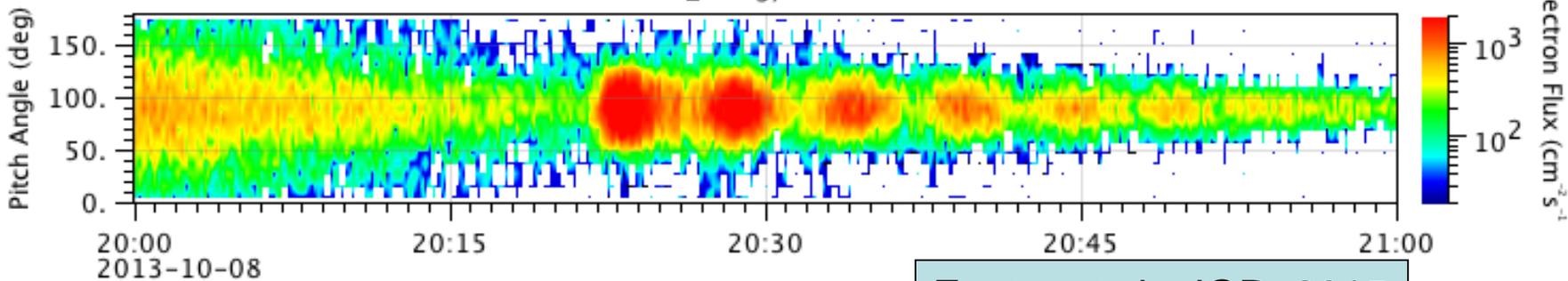


Figure 4

Foster et al., JGR, 2015

VAP Locations for Second Shock

