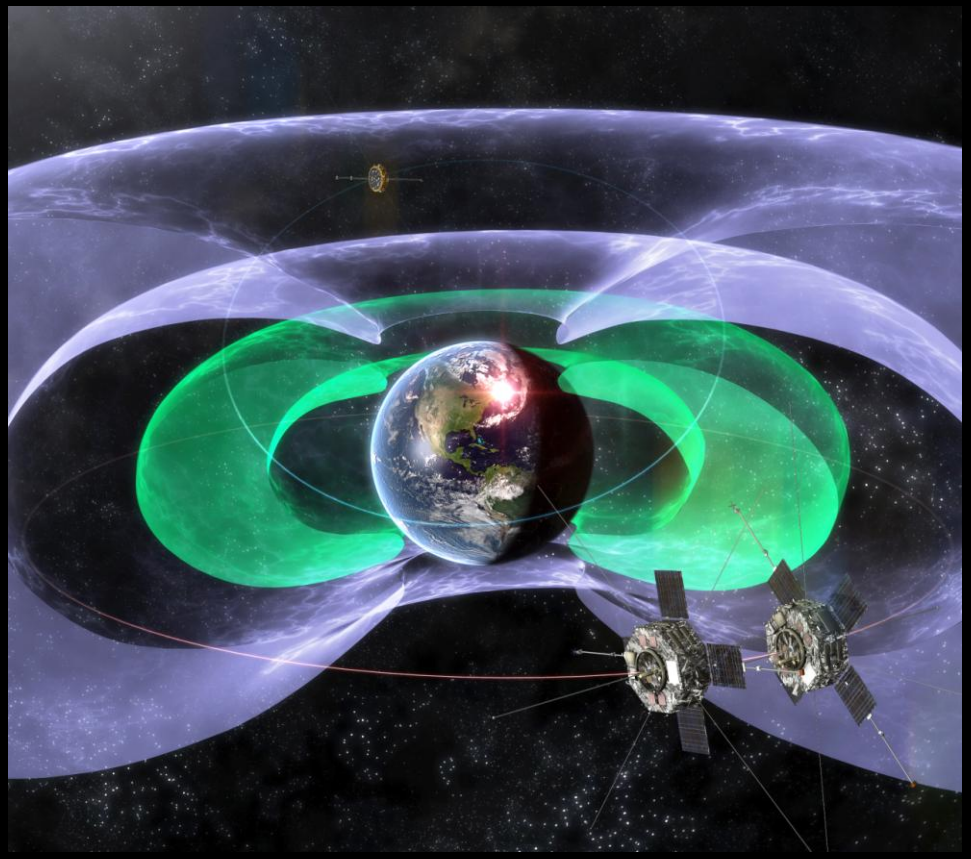

Van Allen Probes: Storms, Substorms, and Radiation Belt Structure

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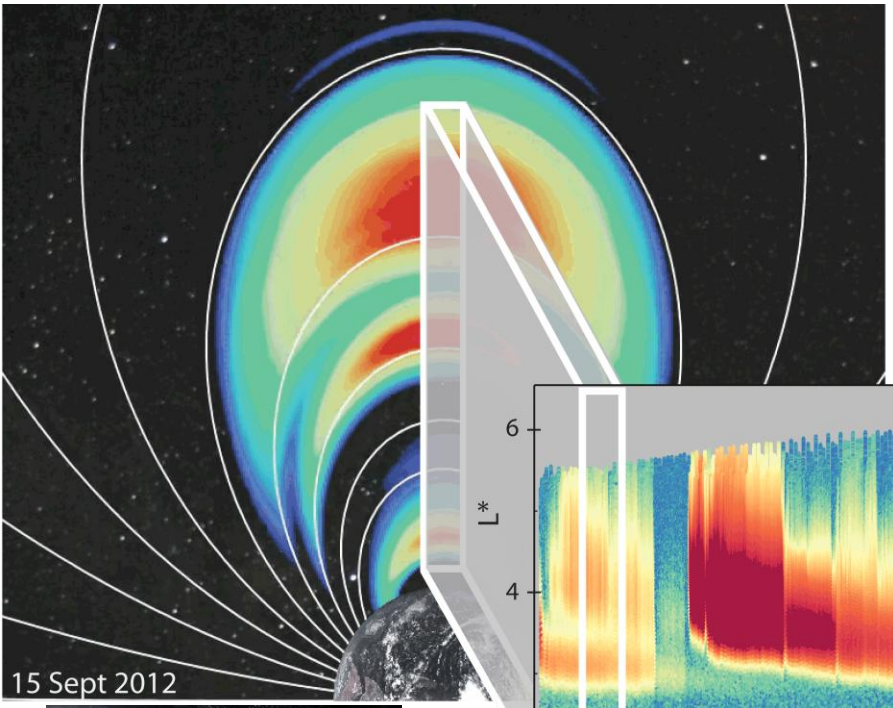
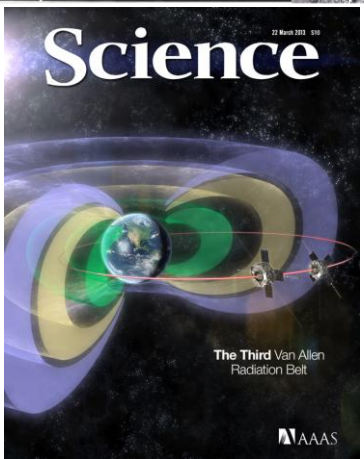
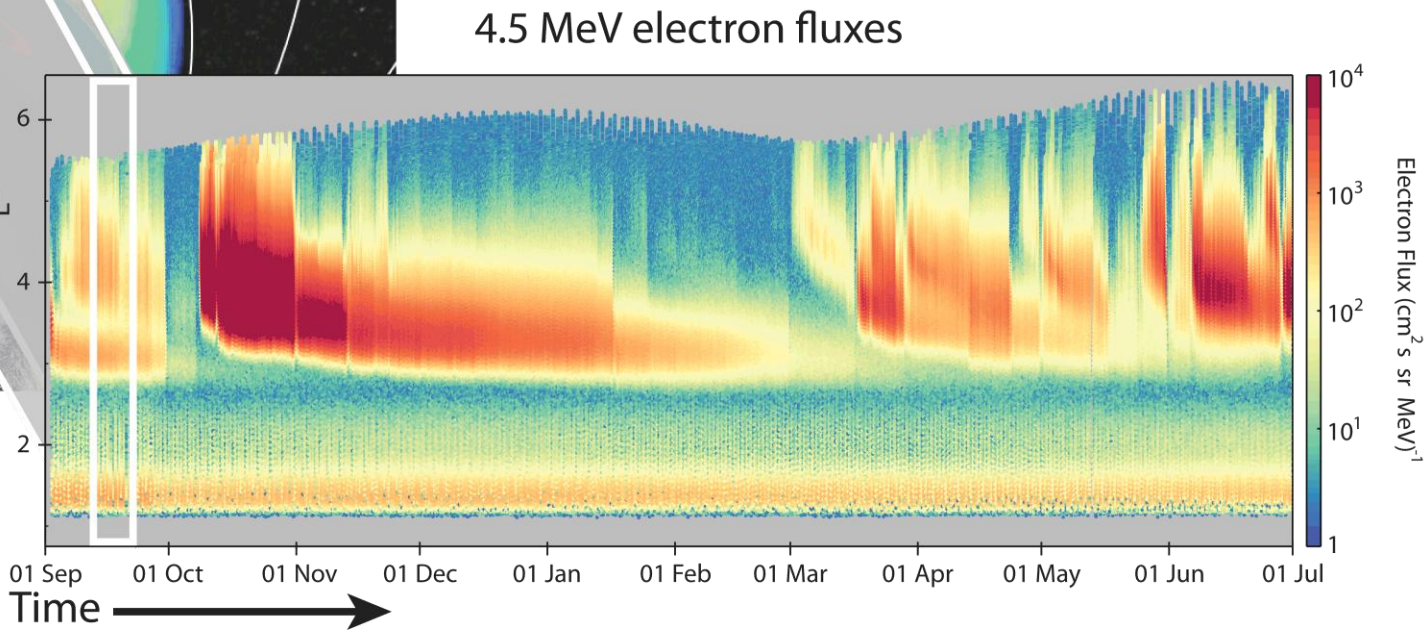
REPT Observations:

Acceleration, Remanence, and Sudden Loss

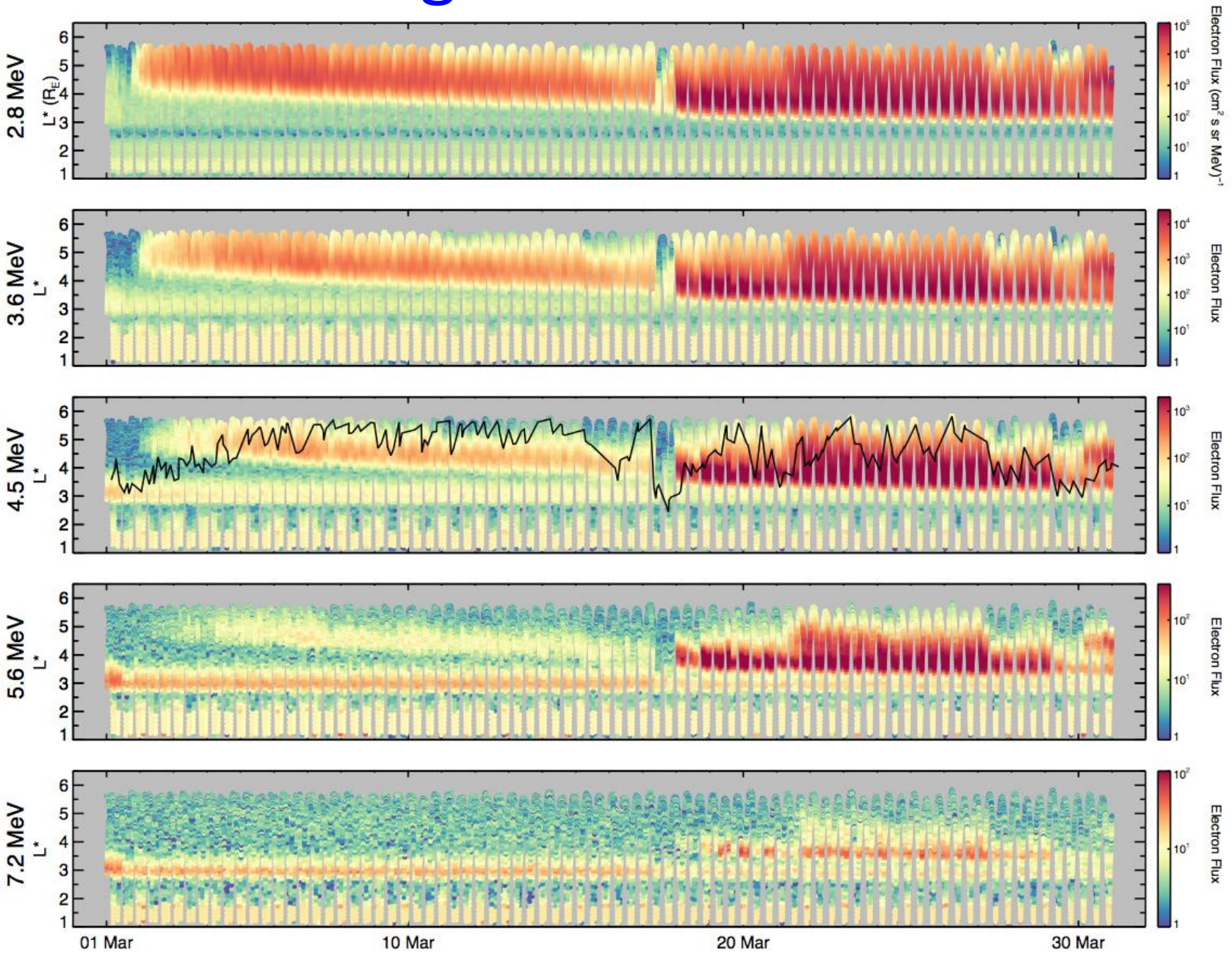




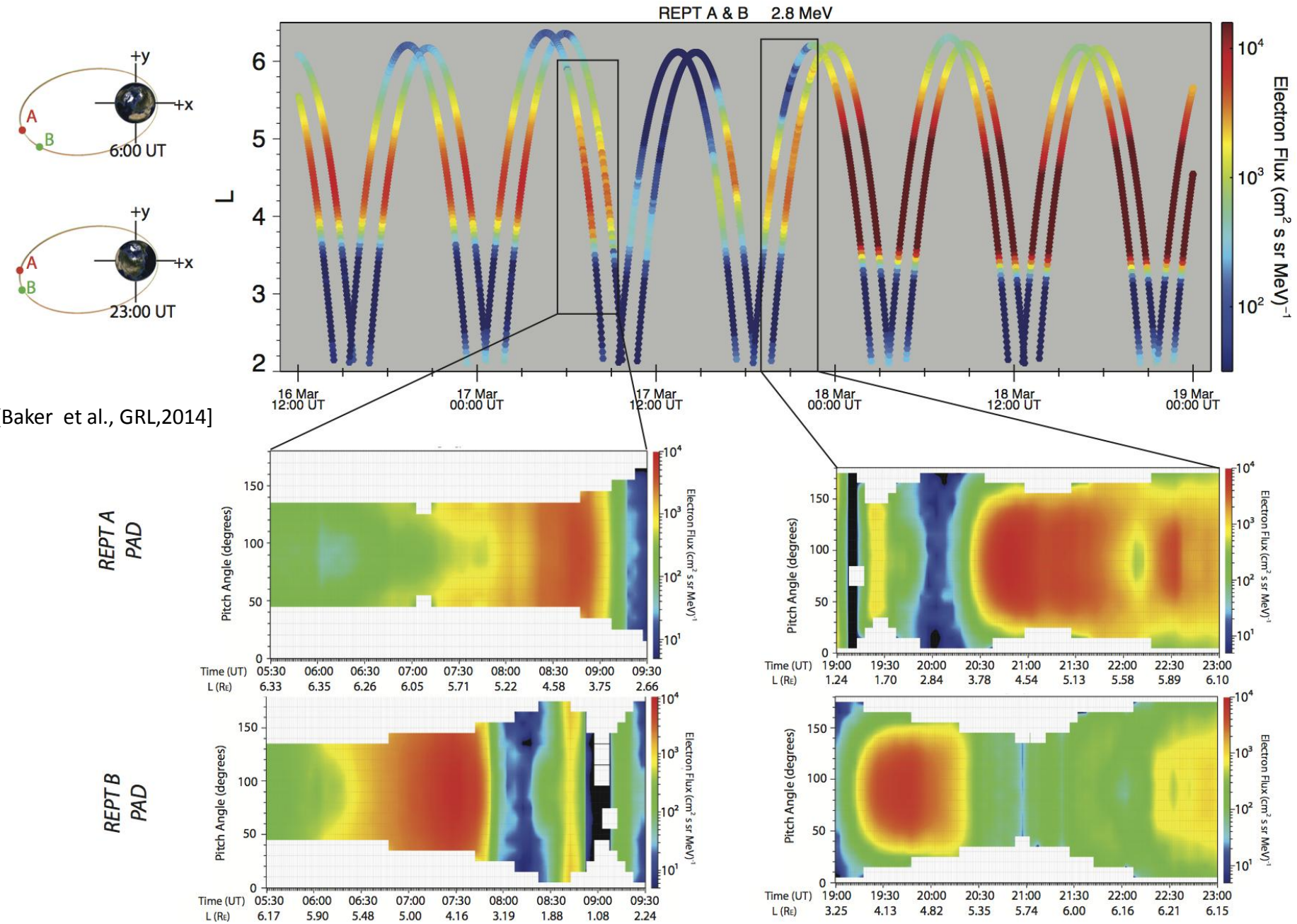


Baker et al., 2013

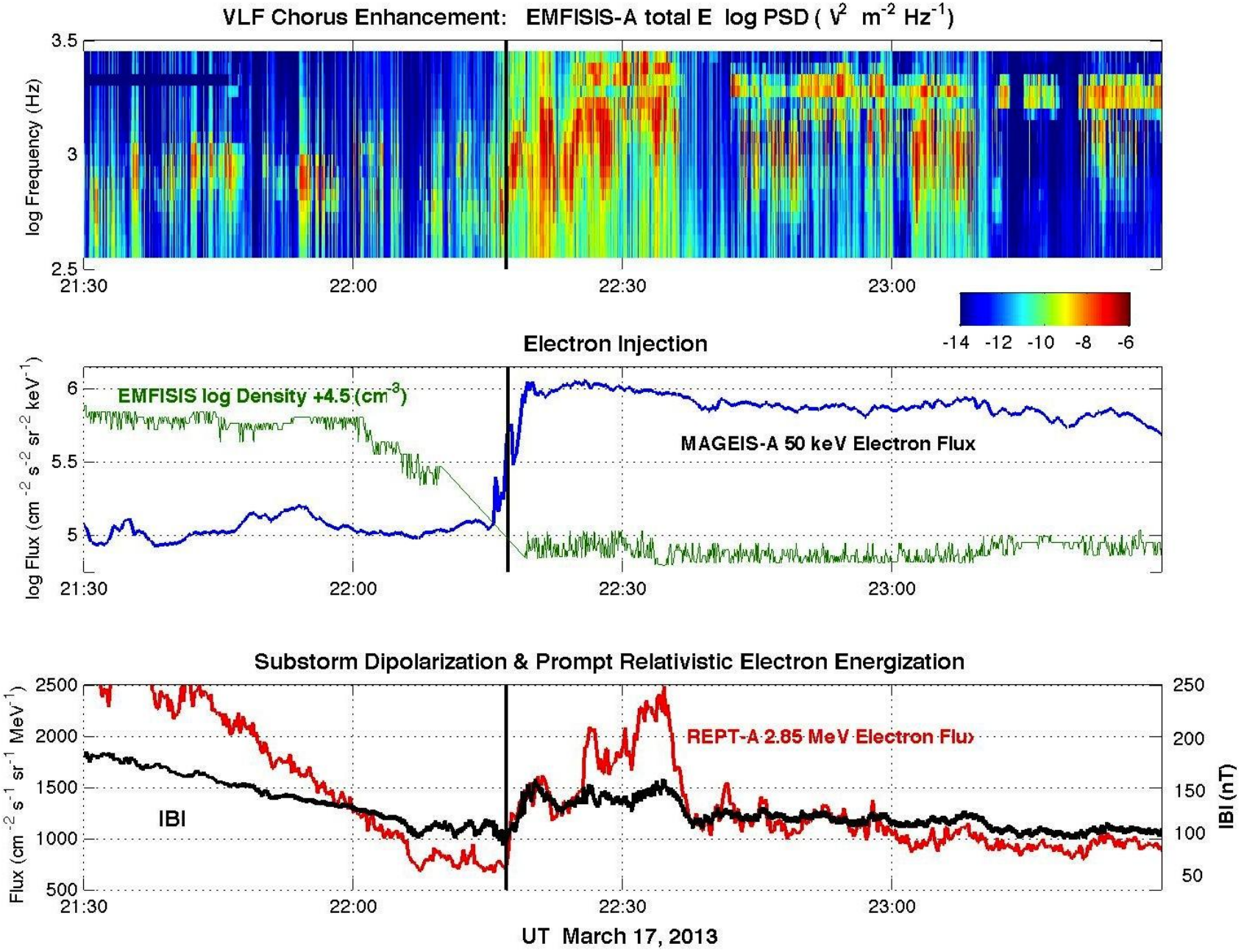
Fascinating Period: March 2013



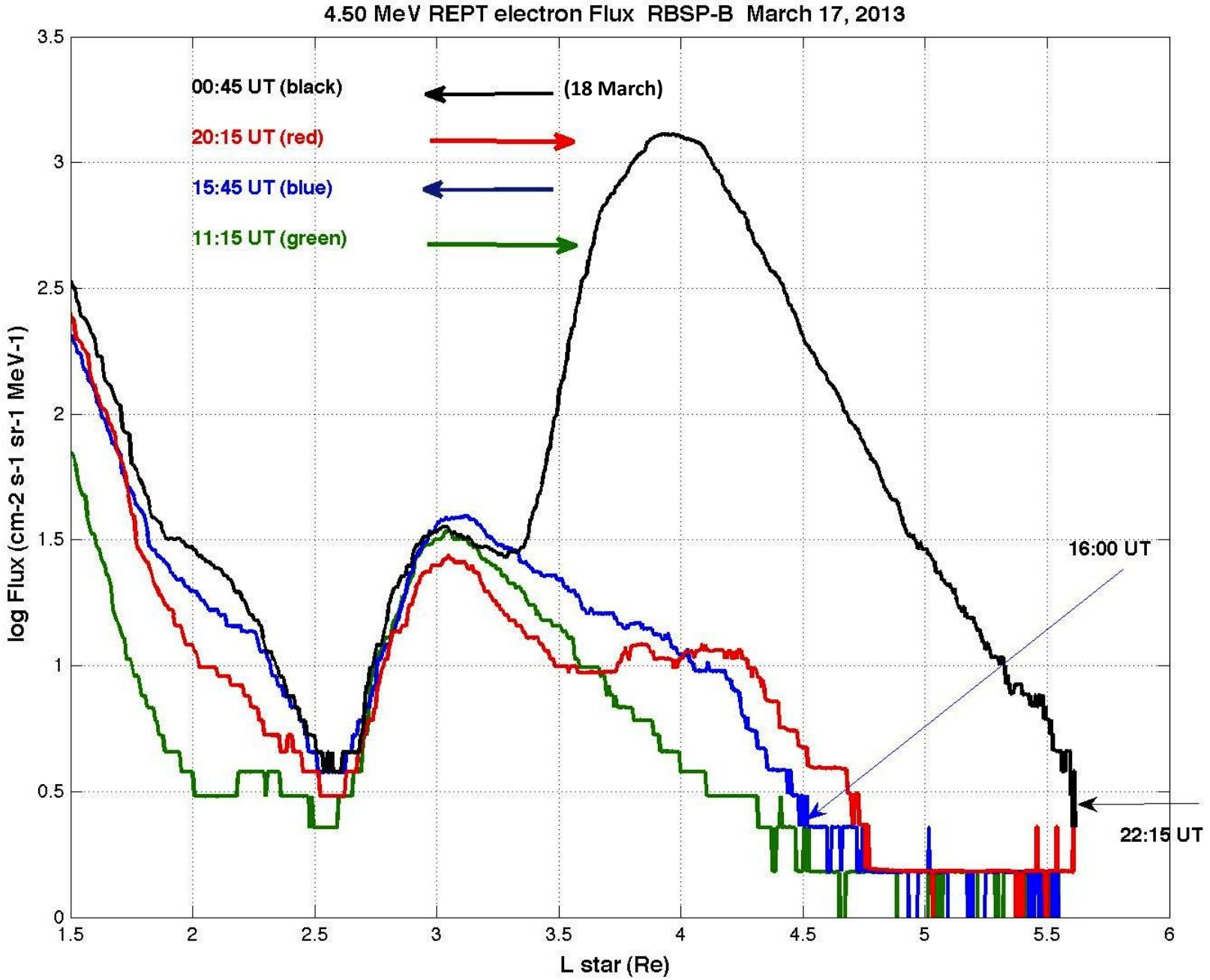
Exquisite View of Flux Dropout and Recovery

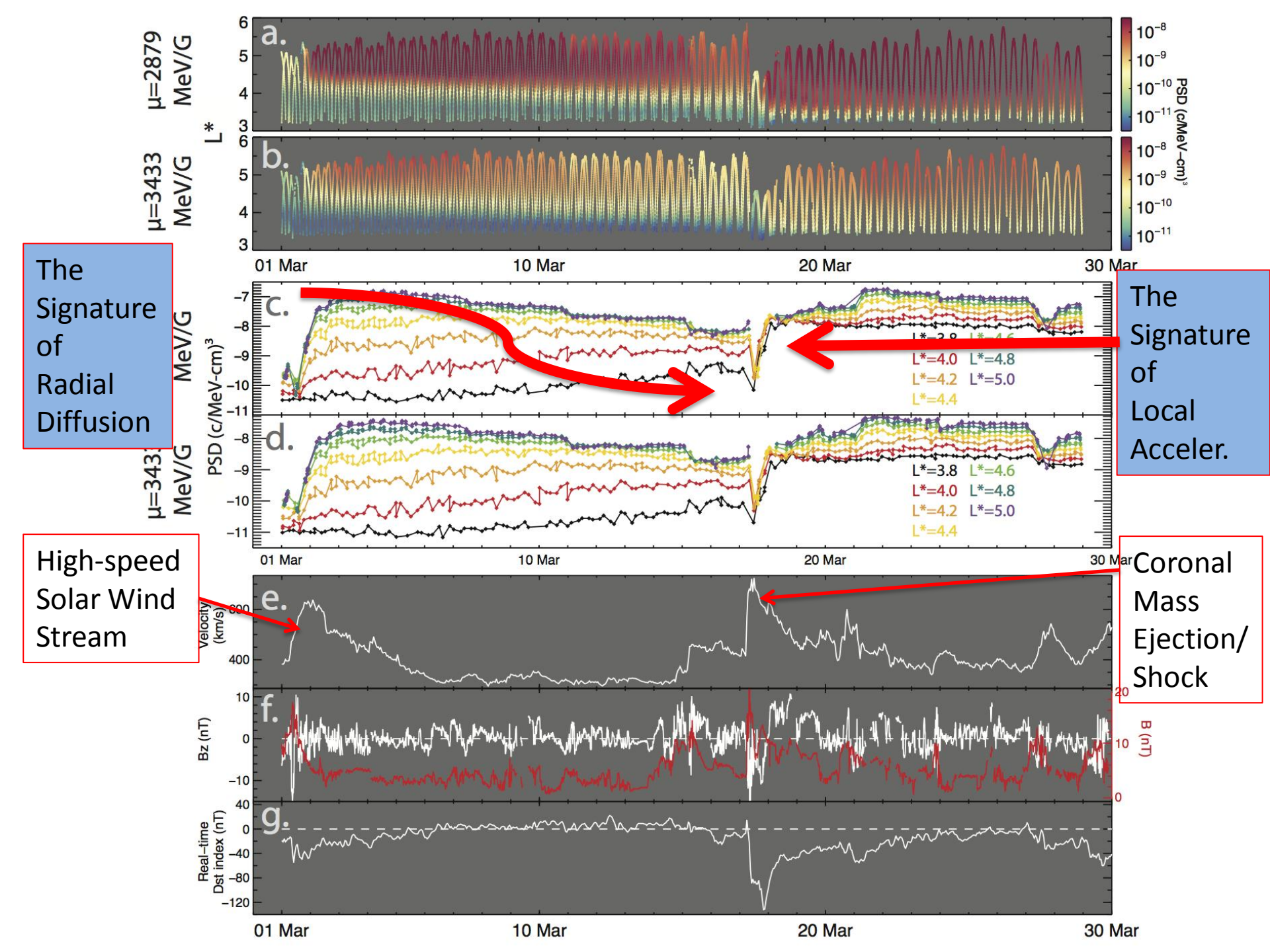


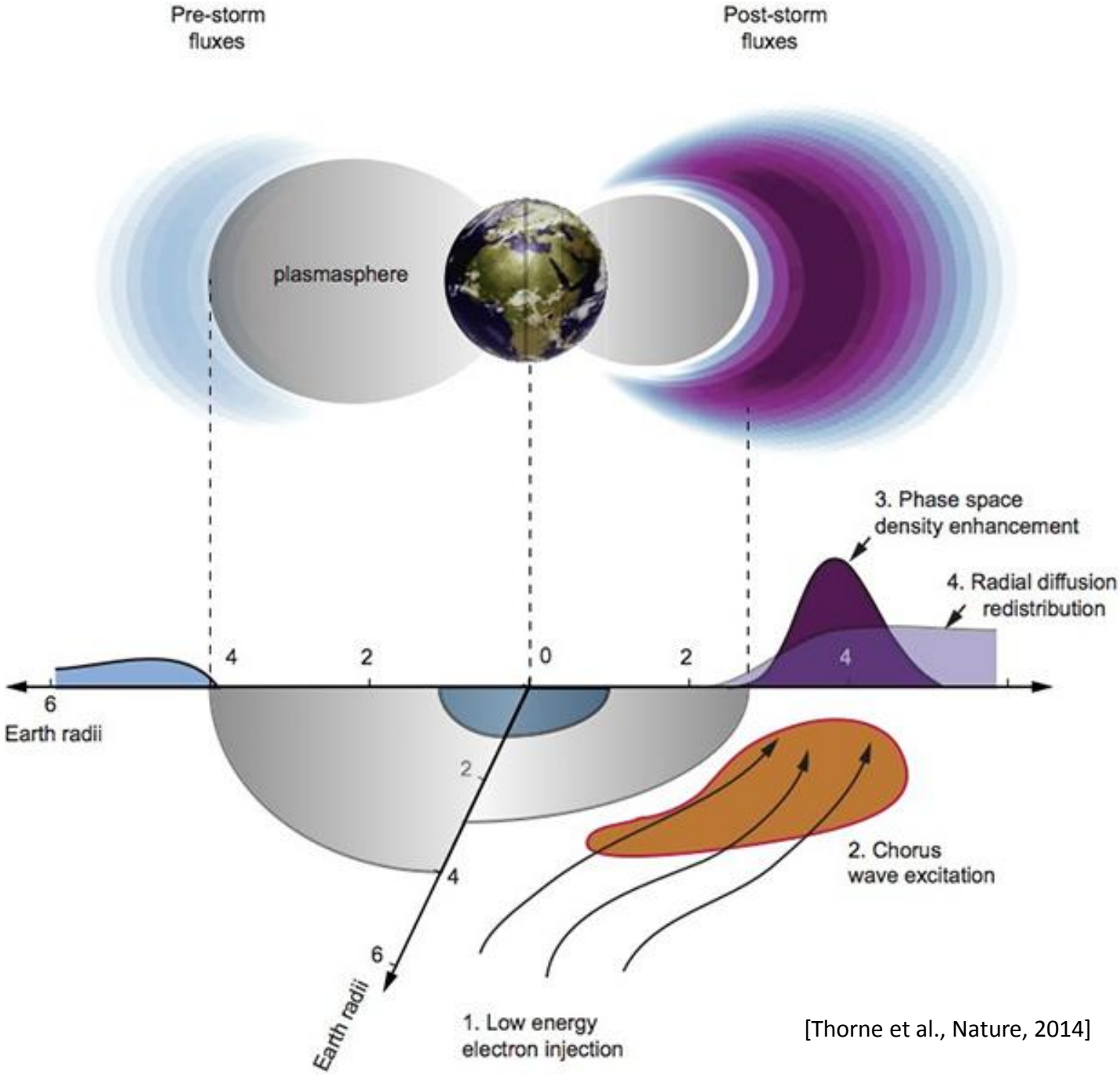
[Baker et al., GRL,2014]



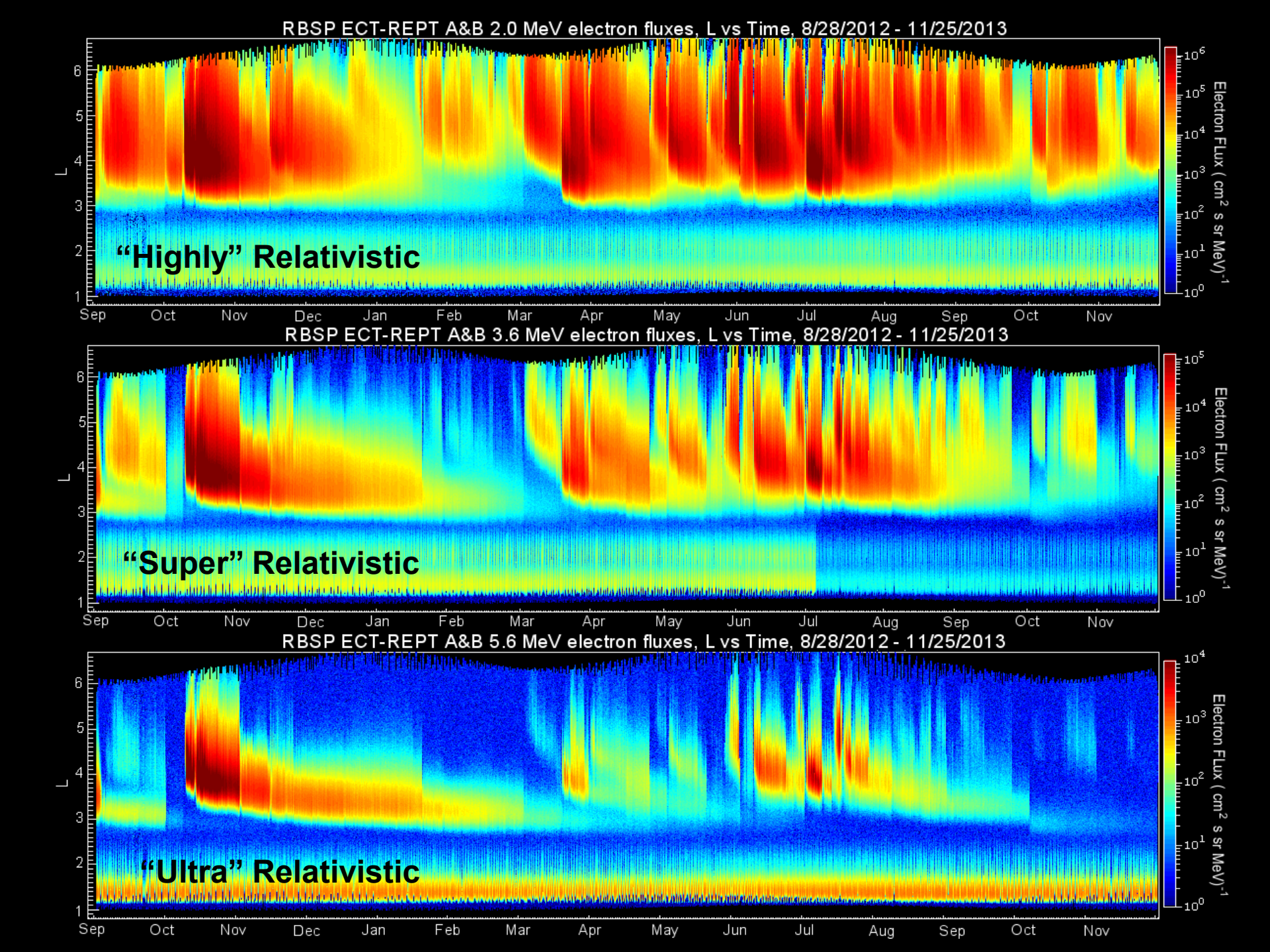
[Foster et al., GRL, 2014]


4.50 MeV REPT electron Flux RBSP-B March 17, 2013
00:45 UT (black)
(18 March)
20:15 UT (red)
15:45 UT (blue)
11:15 UT (green)
16:00 UT
22:15 UT
log Flux (cm-2 s-1 sr-1 MeV-1)
L star (Re)
3.5
3
2.5
2
1.5
1
0.5
0
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6


The Signature of Radial Diffusion
The Signature of Local Acceler.
High-speed Solar Wind Stream
Coronal Mass Ejection/ Shock
a.
b.
c.
d.
e.
f.
g.
μ=2879 MeV/G
μ=3433 MeV/G
L*
PSD (c/MeV-cm)³
L*=3.8
L*=4.0
L*=4.2
L*=4.4
L*=4.6
L*=4.8
L*=5.0
Velocity (km/s)
Bz (nT)
B (nT)
Real-time Dst index (nT)
01 Mar
10 Mar
20 Mar
30 Mar



[Thorne et al., Nature, 2014]


RBSP ECT-REPT A&B 2.0 MeV electron fluxes, L vs Time, 8/28/2012 - 11/25/2013
"Highly" Relativistic
RBSP ECT-REPT A&B 3.6 MeV electron fluxes, L vs Time, 8/28/2012 - 11/25/2013
"Super" Relativistic
RBSP ECT-REPT A&B 5.6 MeV electron fluxes, L vs Time, 8/28/2012 - 11/25/2013
"Ultra" Relativistic
L
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov
Electron Flux (cm^2 s sr MeV)$^{-1}$

Using full PHA data from REPT

Pulse-height analysis (PHA) packets are recorded onboard at a rate of 83 per second. Much more detail can be determined from this than from the binned flux values calculated onboard.

Method for PHA data analysis (Selesnick, Baker, Jaynes, Li, Kanekal, Hudson & Kress, JGR, 2014):

Valid electron and proton PHA events, that enter through the collimator and stop in detector N, are identified by combined theoretical Landau-Vavilov probability distributions $L(\Delta, E)$ for energy loss Δ given incident energy E:

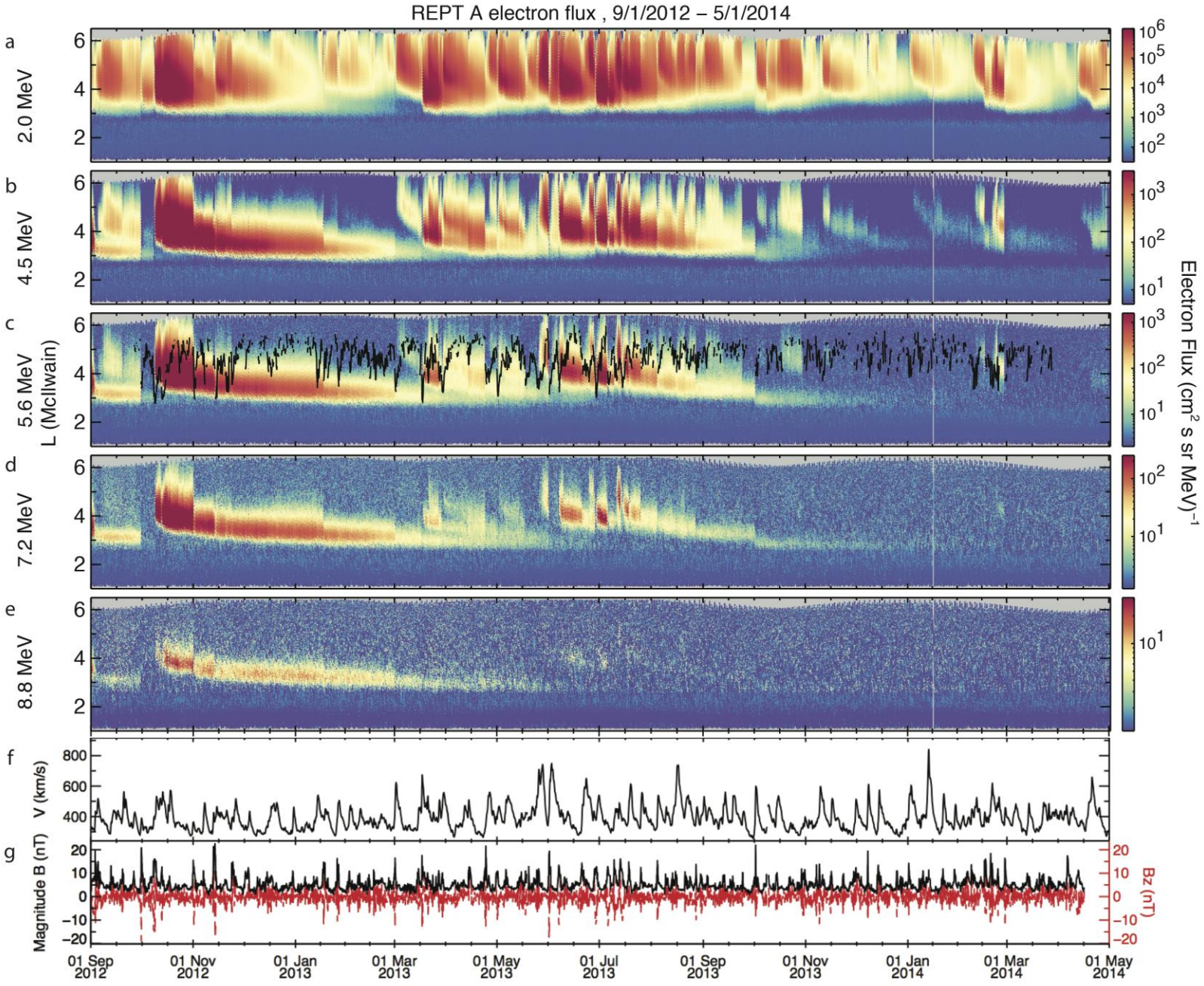
$$P = \prod_{i=1}^{N} L(\Delta_i, E_N - E_{i-1})$$

where Δ_i are the measured energy losses in each detector and

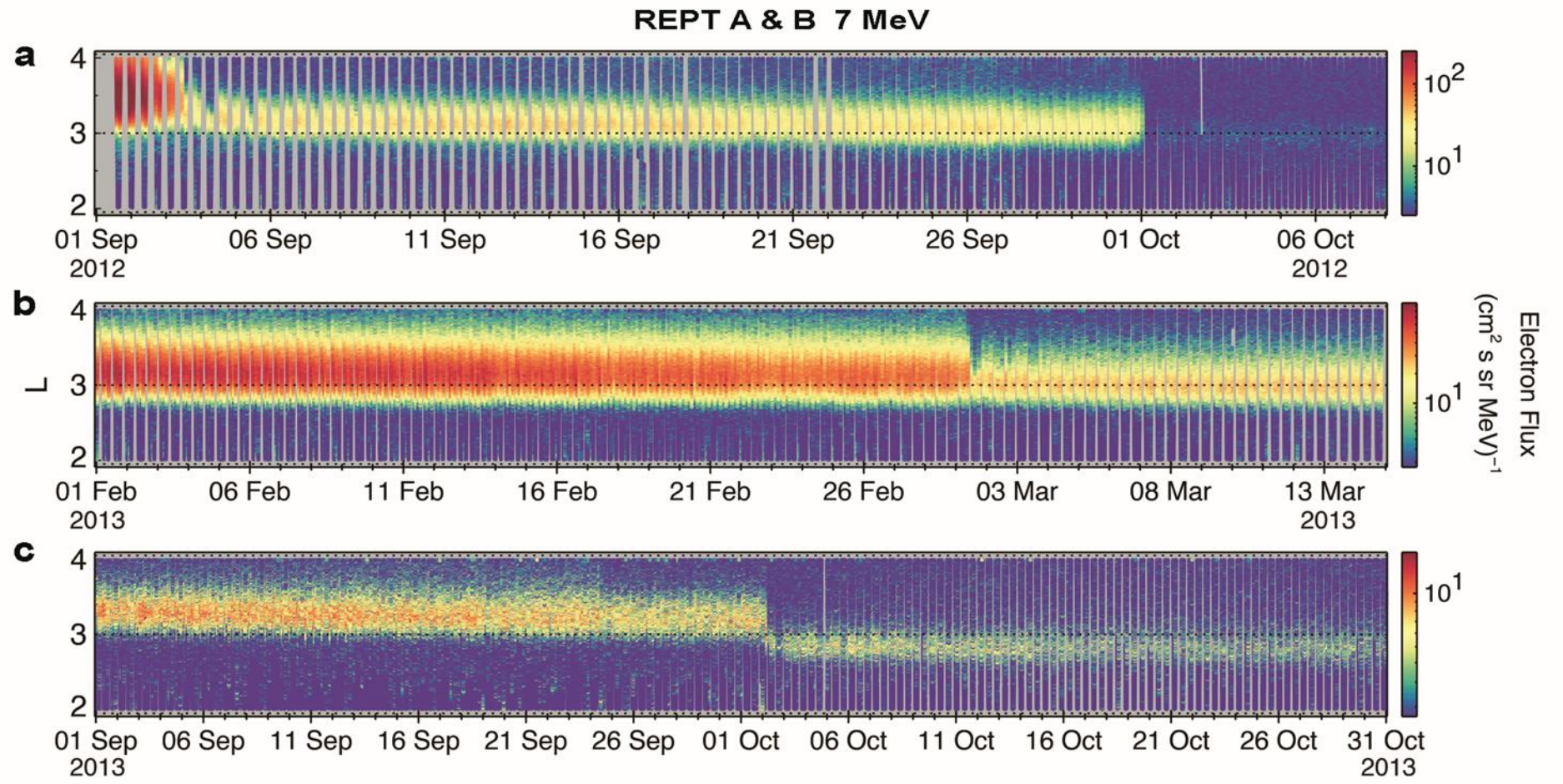
$$E_i = \sum_{j=1}^{i} \Delta_j$$

is the total energy loss up to detector i.

Solar Wind Drivers

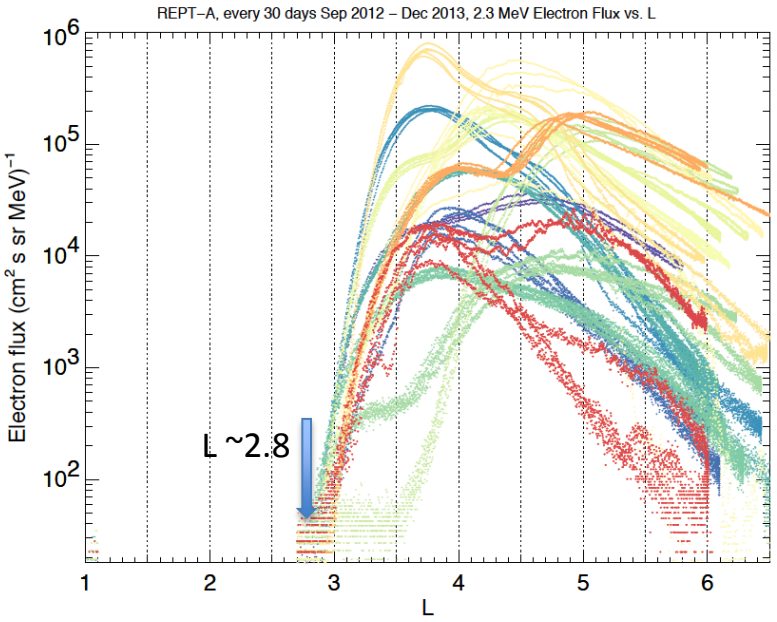


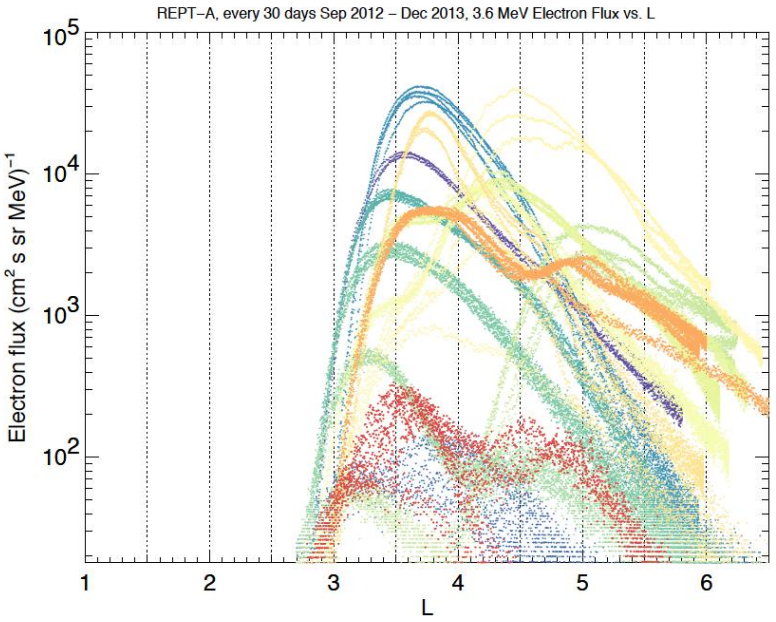
Ultra-Relativistic Electrons: Inner Edge

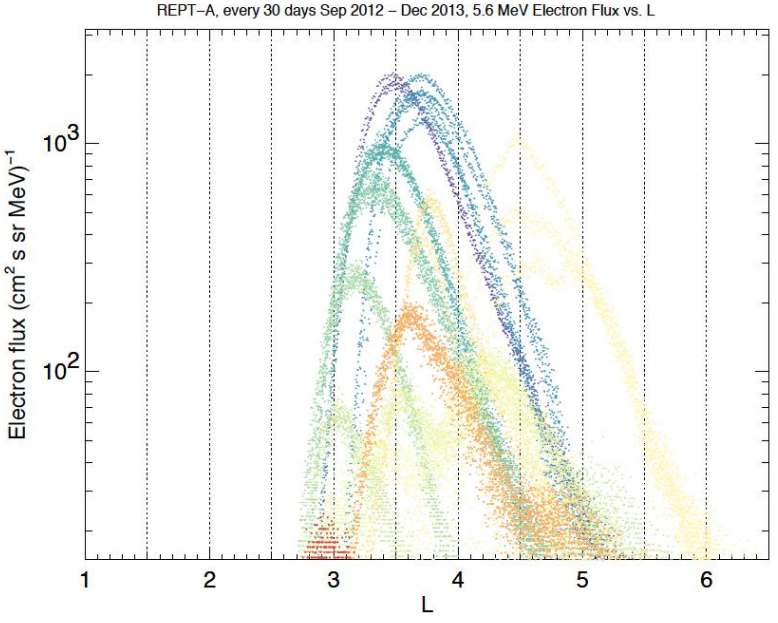


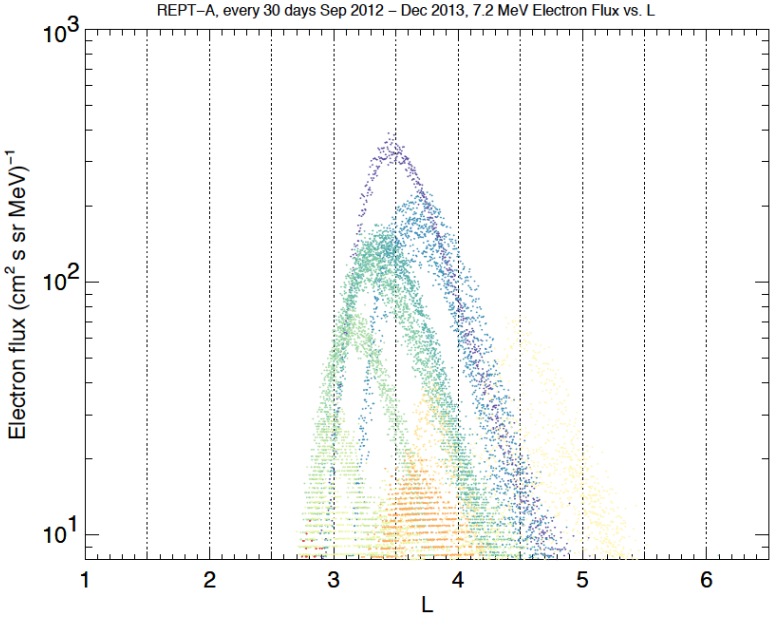
[Baker et al., Nature, 2014]

Radial profiles of electron flux 2012-2013





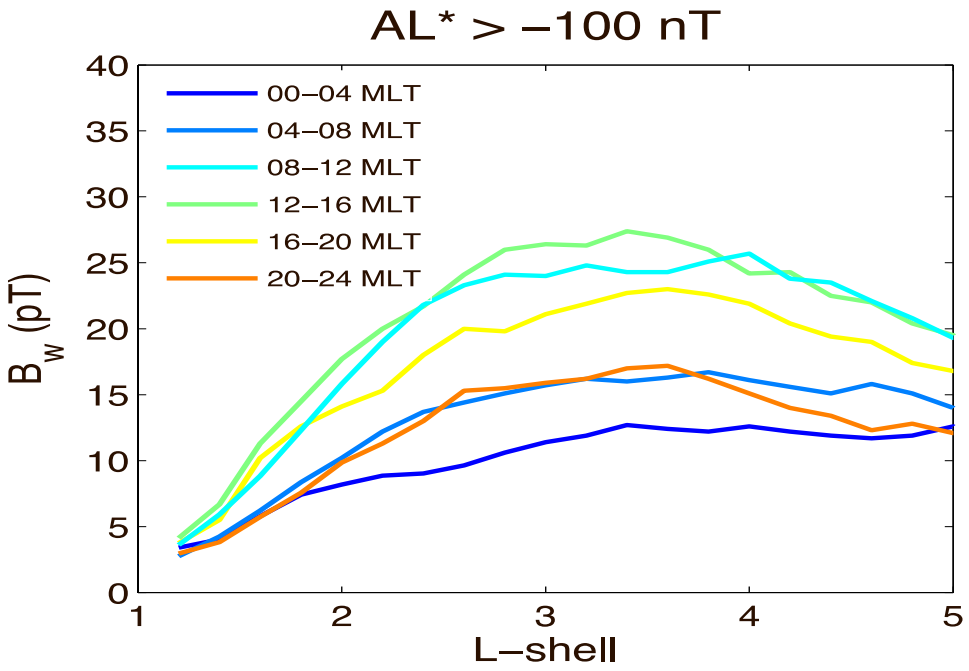




02 Oct 2012 … color indicates 30 days … 10 Dec 2013

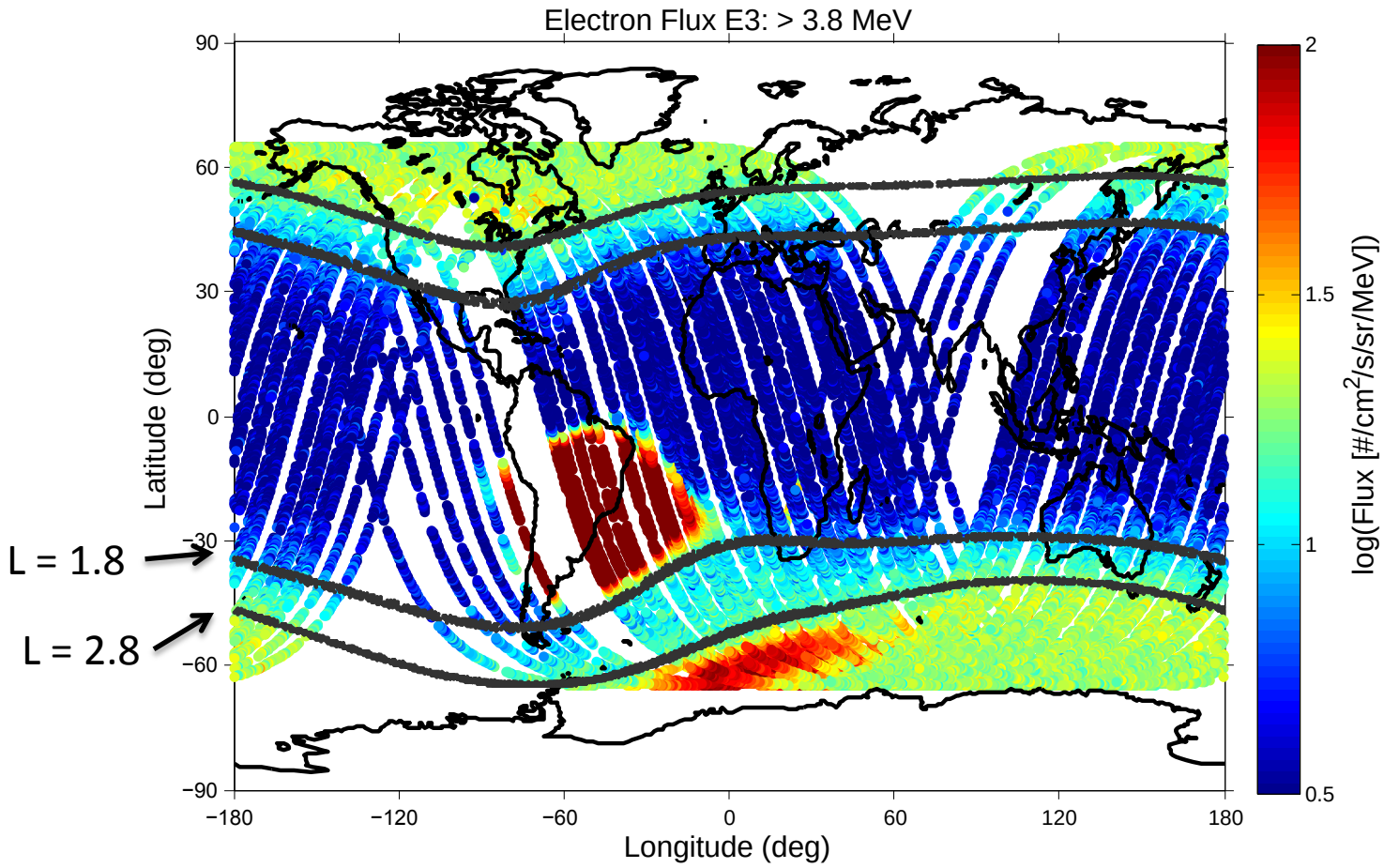
Survey of Plasmaspheric Hiss

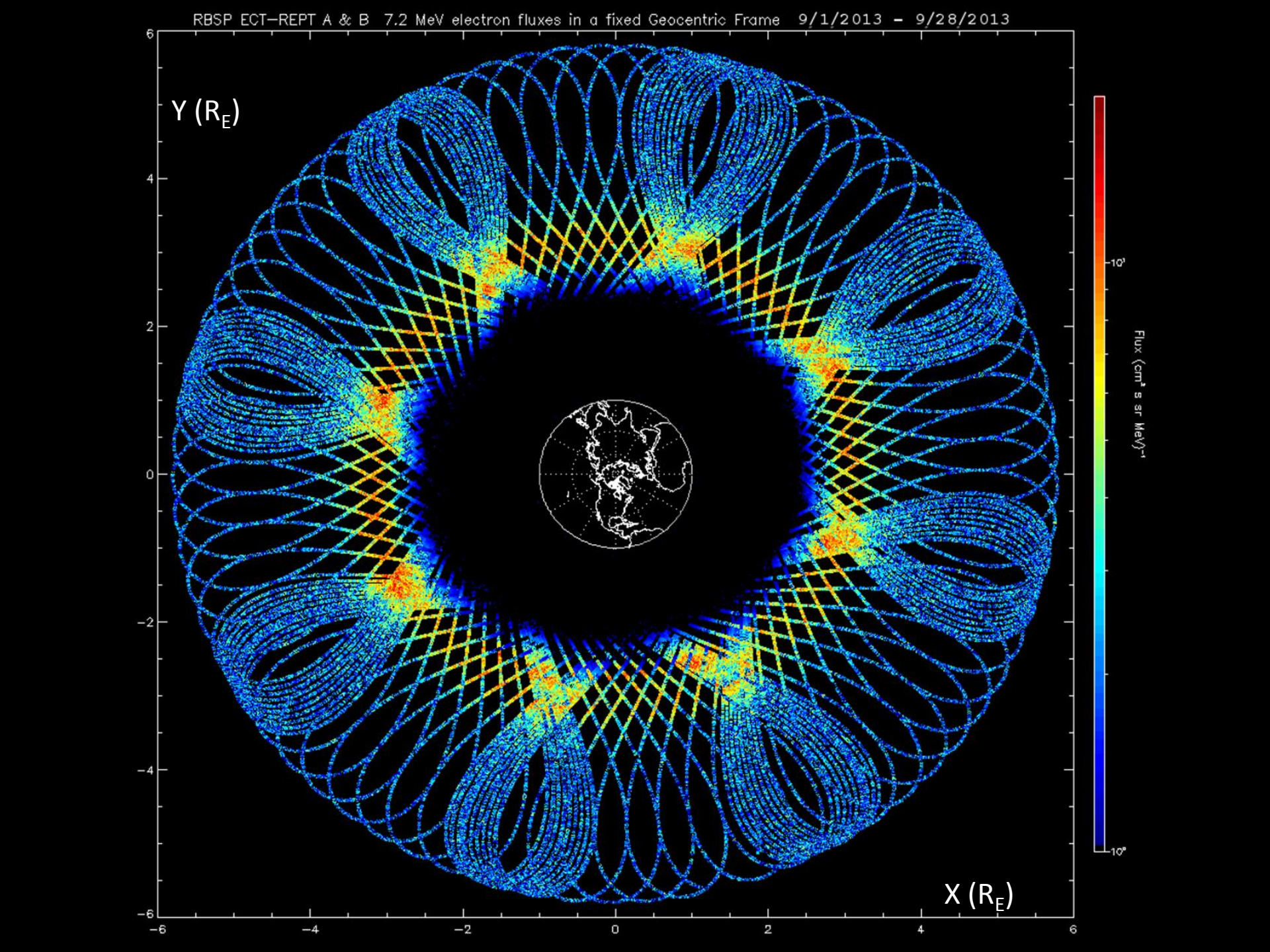
(EMFISIS Data-Wen Li Analysis)

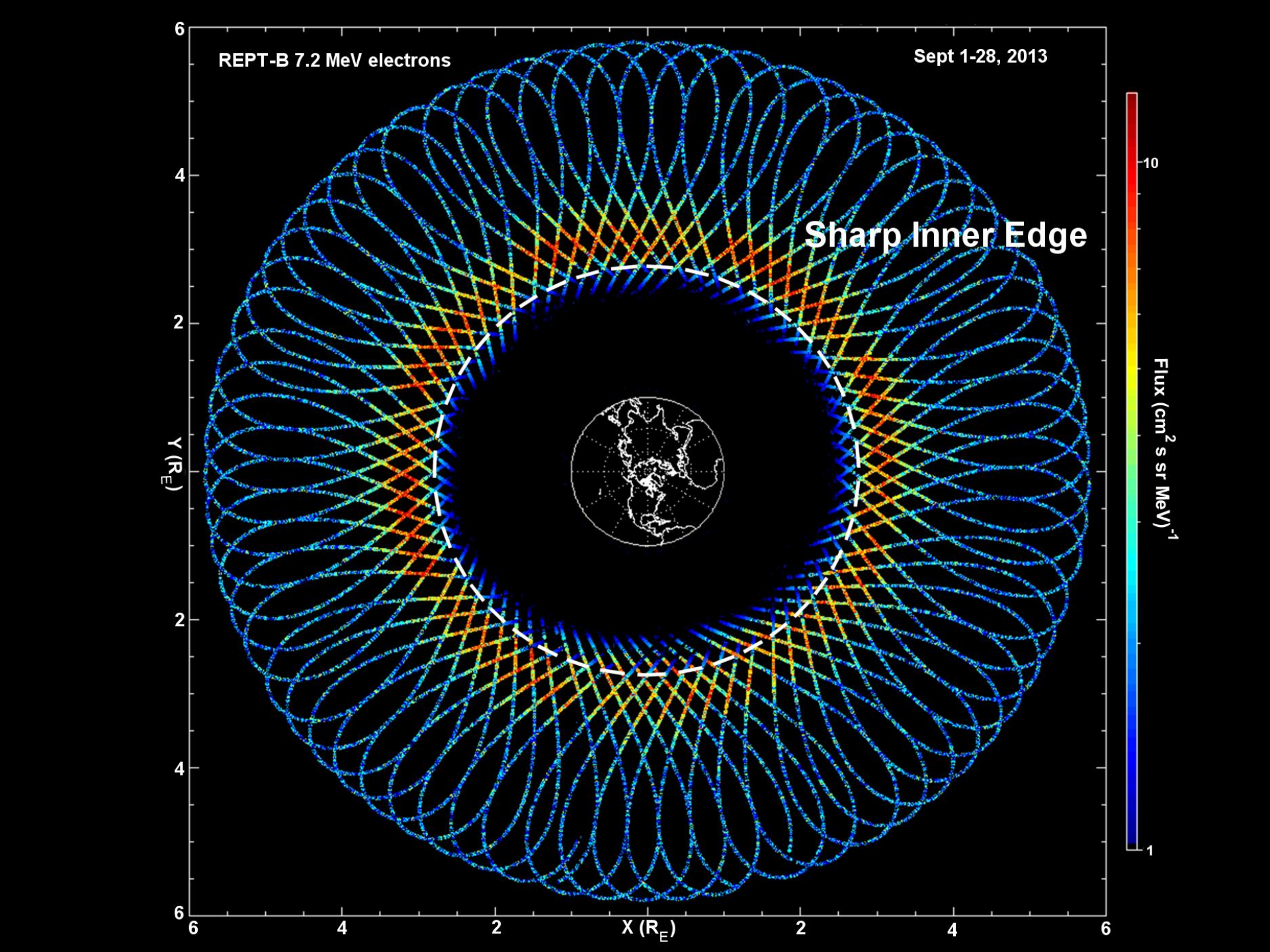


Colorado Student Space Weather Experiment

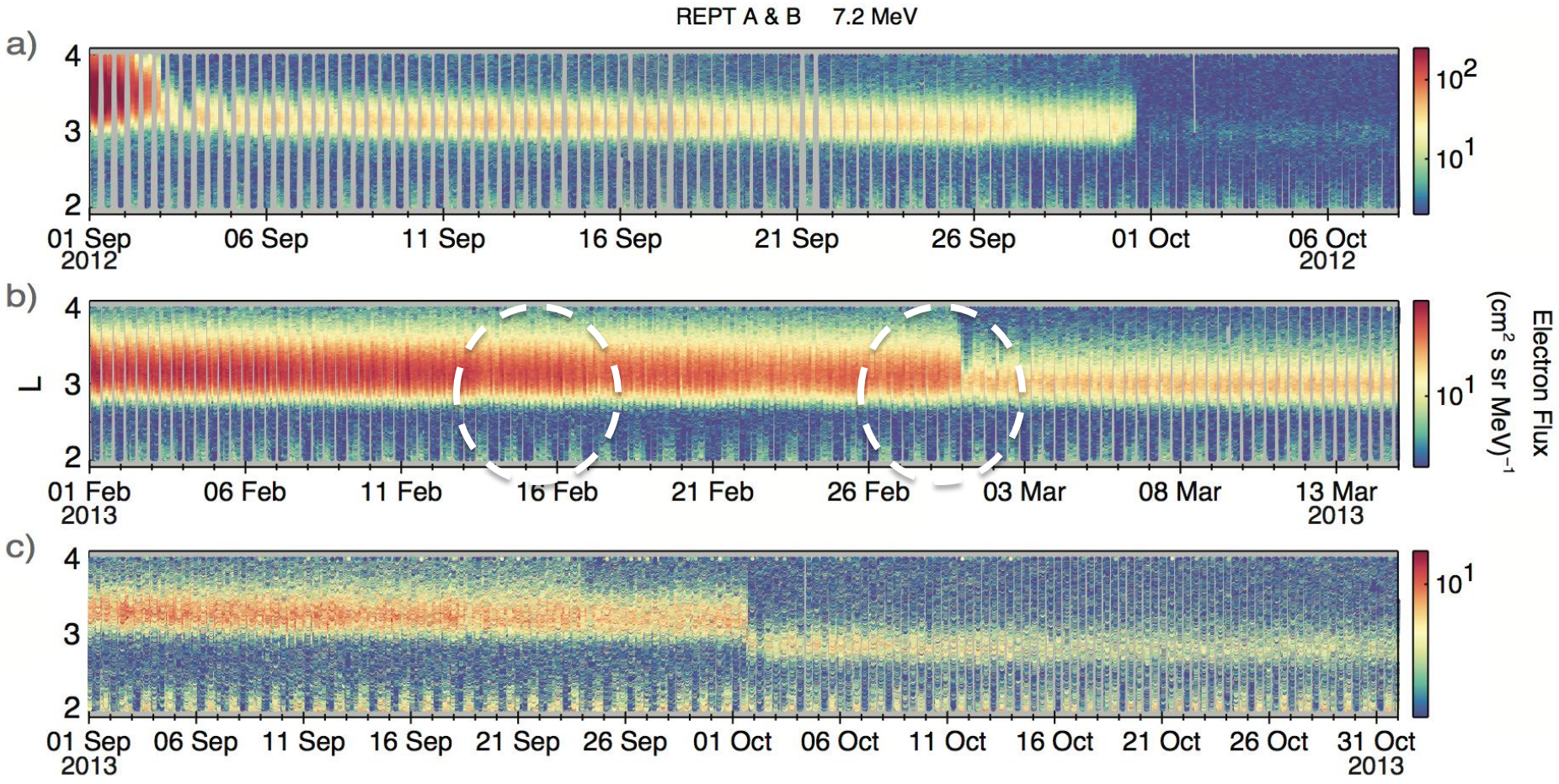
REPTile Data – September 2013

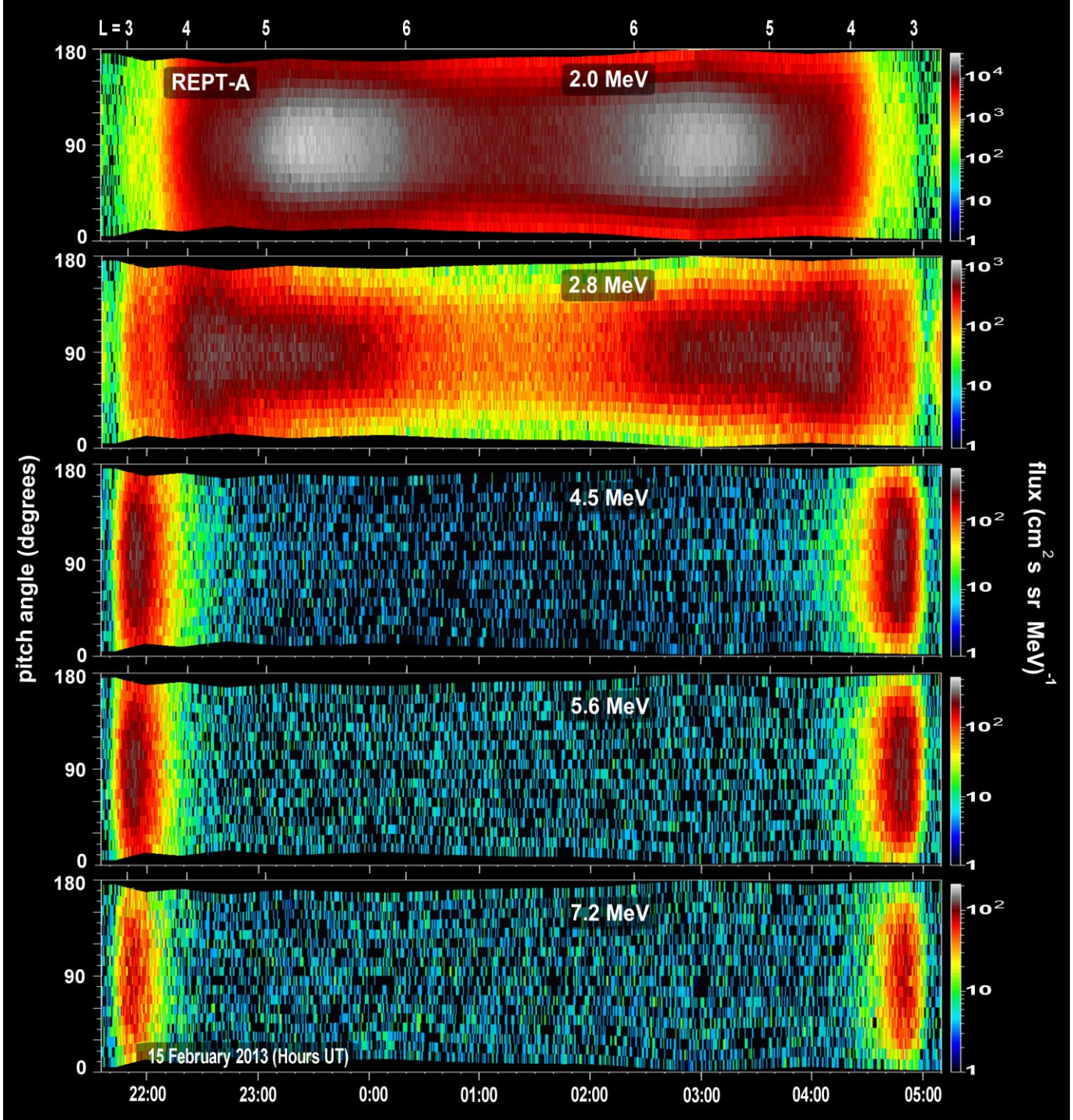


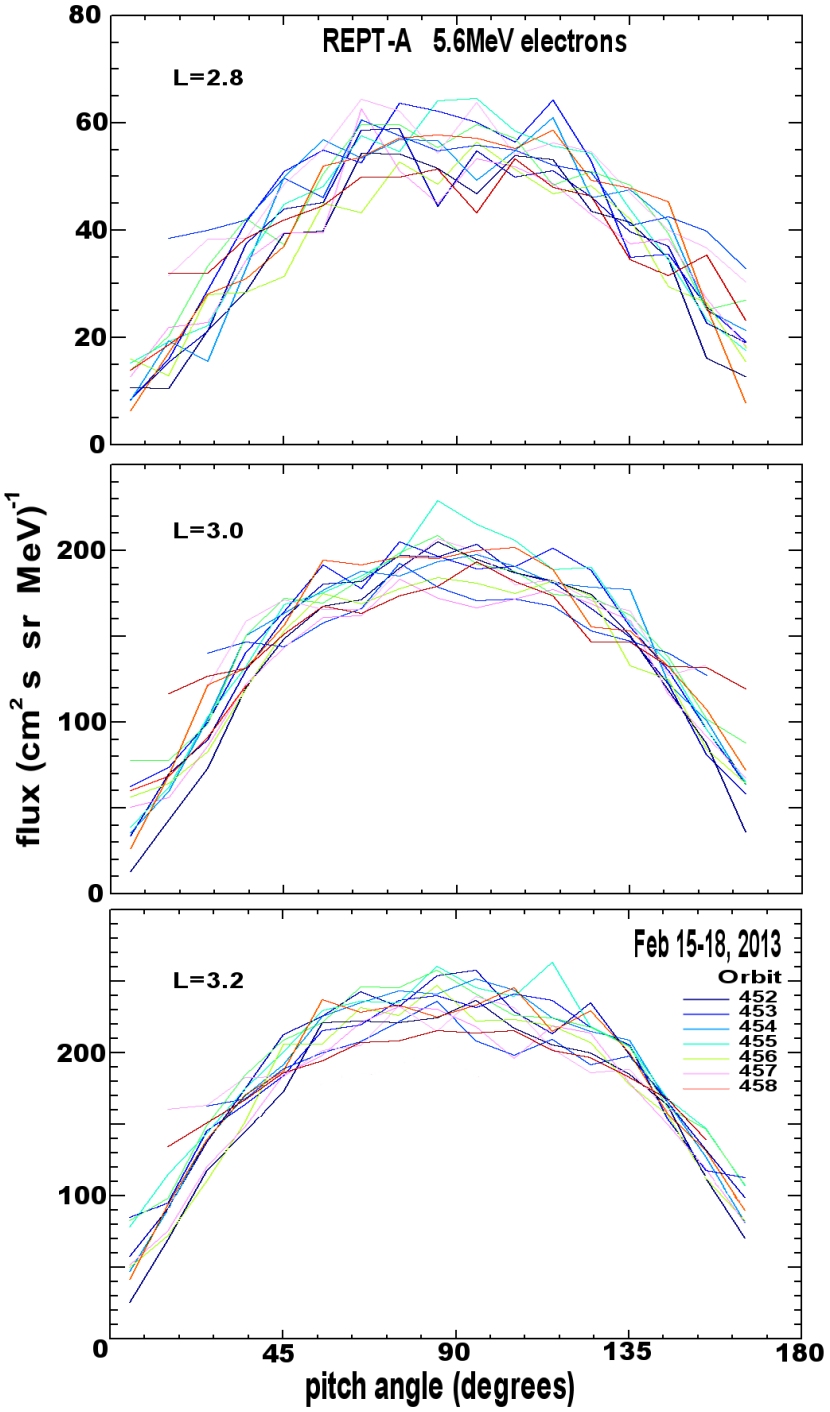

RBSP ECT–REPT A & B 7.2 MeV electron fluxes in a fixed Geocentric Frame 9/1/2013 – 9/28/2013
Y (R_E)
X (R_E)
6
4
2
0
−2
−4
−6
−6
−4
−2
0
2
4
6
10^1
10^0
Flux (cm^2 s sr MeV)^-1


REPT-B 7.2 MeV electrons
Sept 1-28, 2013
Sharp Inner Edge
Flux (cm^2 s sr MeV)$^{-1}$
10
1
X (R_E)
Y (R_E)
6
4
2
2
4
6

Ultra-Relativistic Electrons: Inner Edge

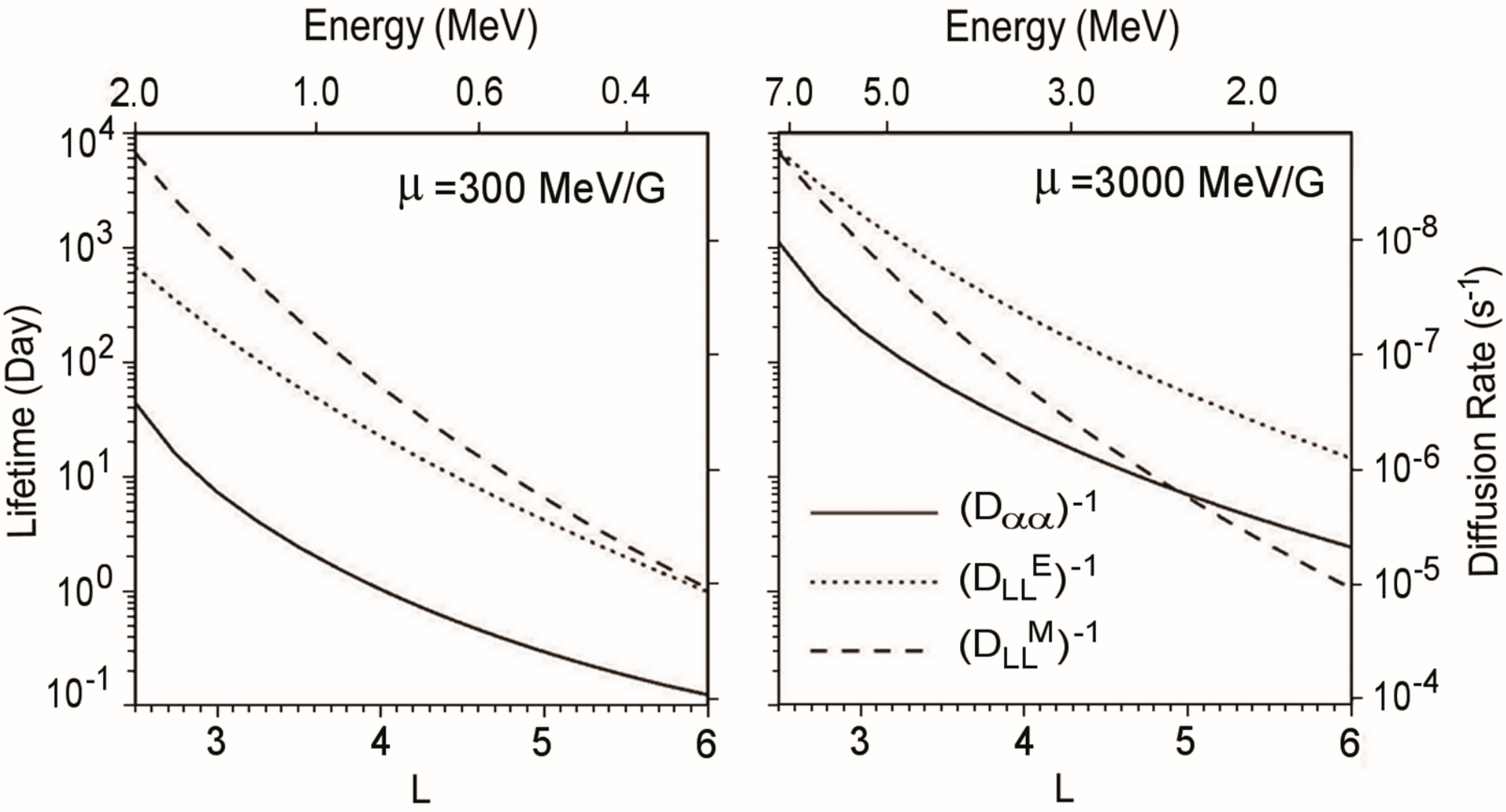



L = 3
4
5
6
6
5
4
3
REPT-A
2.0 MeV
2.8 MeV
4.5 MeV
5.6 MeV
7.2 MeV
pitch angle (degrees)
180
90
0
flux (cm^{2} s sr MeV)$^{-1}$
10^{4}
10^{3}
10^{2}
10
1
15 February 2013 (Hours UT)
22:00
23:00
0:00
01:00
02:00
03:00
04:00
05:00


REPT-A 5.6MeV electrons
L=2.8
L=3.0
L=3.2
Feb 15-18, 2013
Orbit
452
453
454
455
456
457
458
flux (cm^2 s sr MeV)$^{-1}$
pitch angle (degrees)
0
20
40
60
80
100
200
45
90
135
180

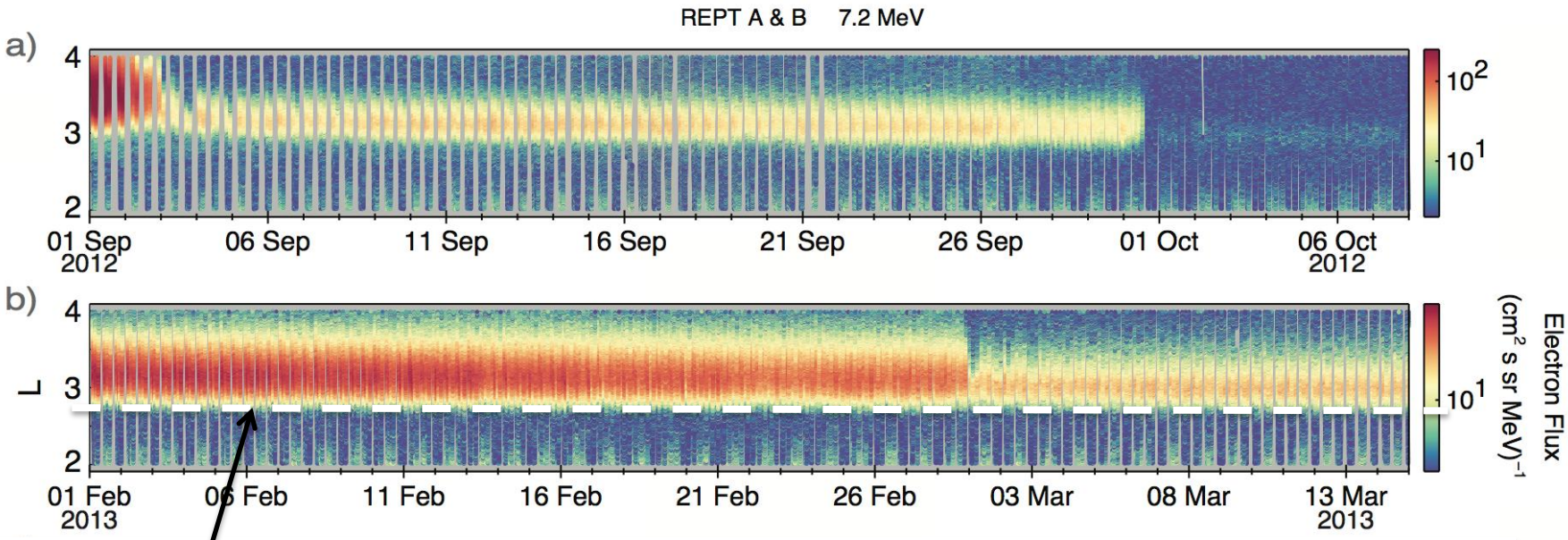
Electron Lifetime Estimates

(Qianli Ma Modeling Results)



[Baker et al., Nature, 2014]

An Impenetrable Barrier?



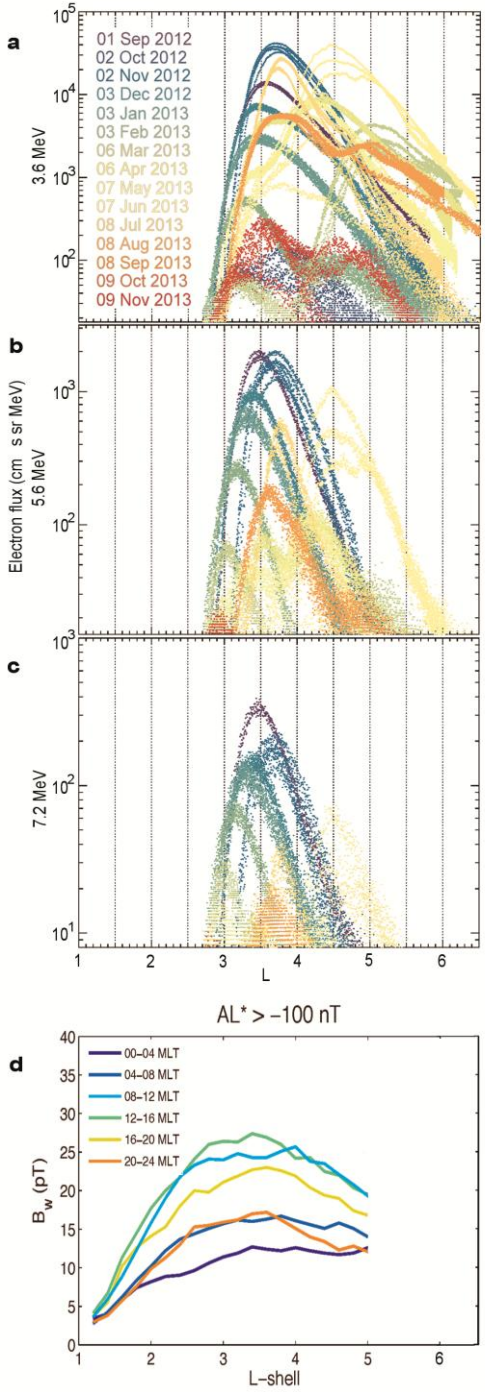
Ultrarelativistic electrons seem never to penetrate inward of L~2.8

Conclusions

- Results from the Van Allen Probes mission have been rewriting the textbooks about radiation belt structure, acceleration, transport, and loss.
- Excellent energy and pitch angle data reveal distinctive behavior in several electron energy regimes: Highly; Super; and Ultra (> 5 MeV) relativistic.
- REPT data clearly show there is an impenetrable barrier to inward penetration of ultra-relativistic electrons at L ~2.8 [Baker et al., Nature, 2014].
- The barrier is extremely sharp and is caused neither by geomagnetic field features nor by manmade radio transmissions.
- **A new window has been opened on understanding strong plasma physical gradients in Earth's magnetosphere and this has important significance for remote cosmic systems.**

Thank you.

Questions?


a
b
c
d
01 Sep 2012
02 Oct 2012
02 Nov 2012
03 Dec 2012
03 Jan 2013
03 Feb 2013
06 Mar 2013
06 Apr 2013
07 May 2013
07 Jun 2013
08 Jul 2013
08 Aug 2013
08 Sep 2013
09 Oct 2013
09 Nov 2013
3.6 MeV
5.6 MeV
7.2 MeV
Electron flux (cm s sr MeV)
L
AL* > −100 nT
00–04 MLT
04–08 MLT
08–12 MLT
12–16 MLT
16–20 MLT
20–24 MLT
B_w (pT)
L–shell

REPT: The First 19 Months