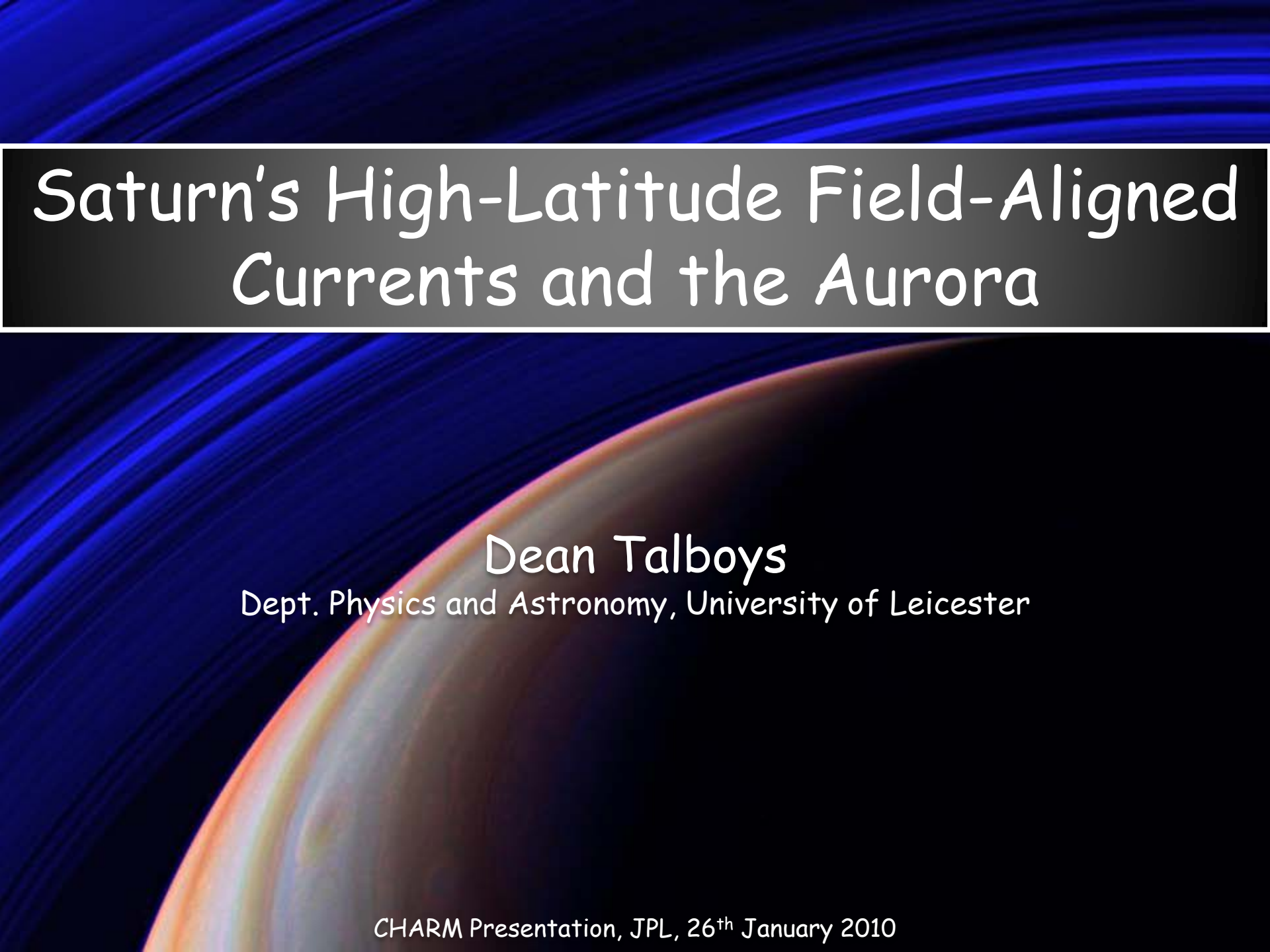
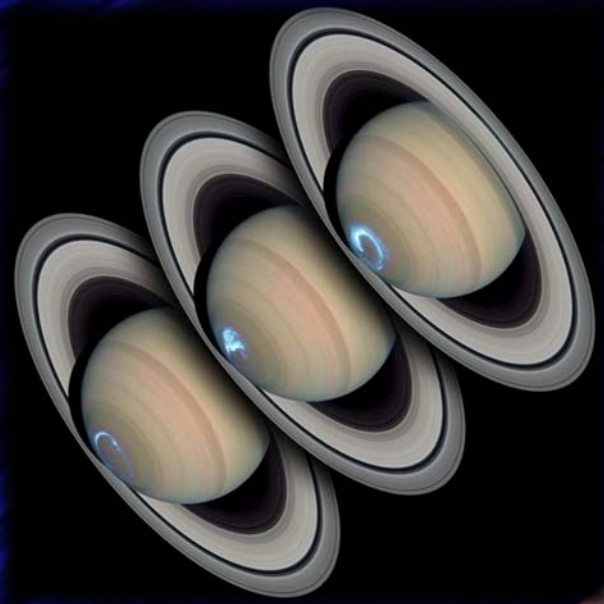
Saturn's High-Latitude Field-Aligned Currents and the Aurora



Dean Talboys
Dept. Physics and Astronomy, University of Leicester

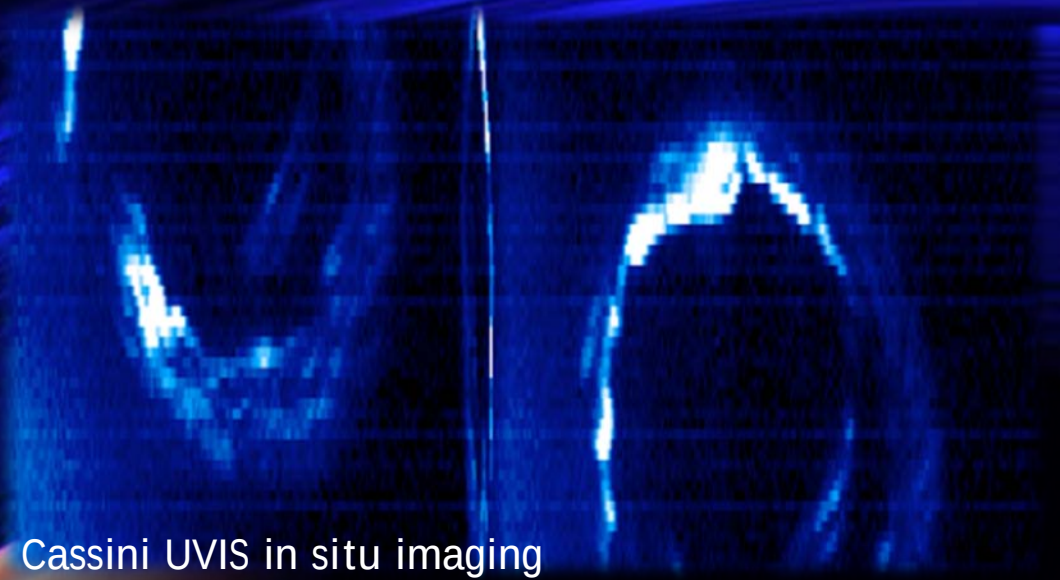
CHARM Presentation, JPL, 26th January 2010

What is the origin of Saturn's auroral emission?



Hubble Space Telescope remote imaging

Taken from Clarke et al, 2005

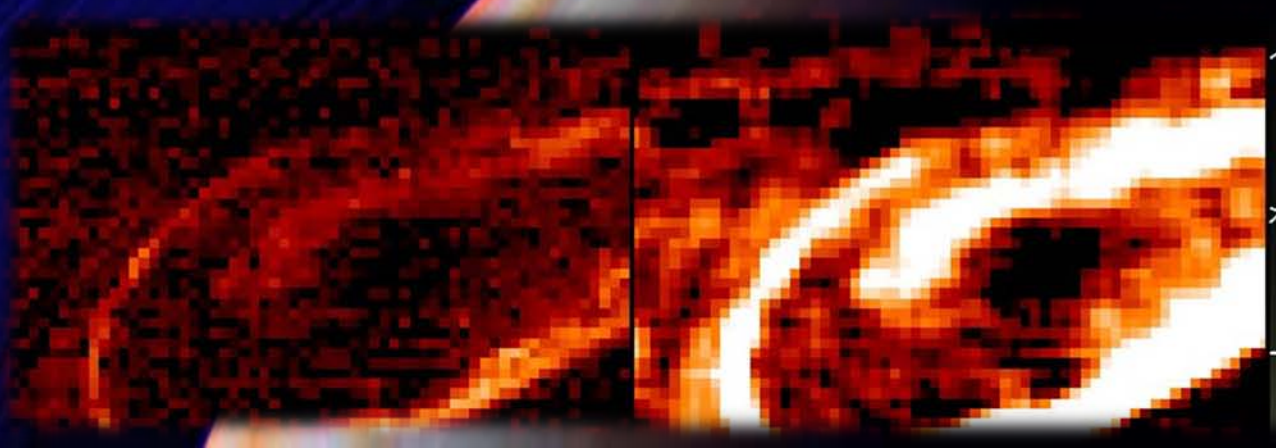


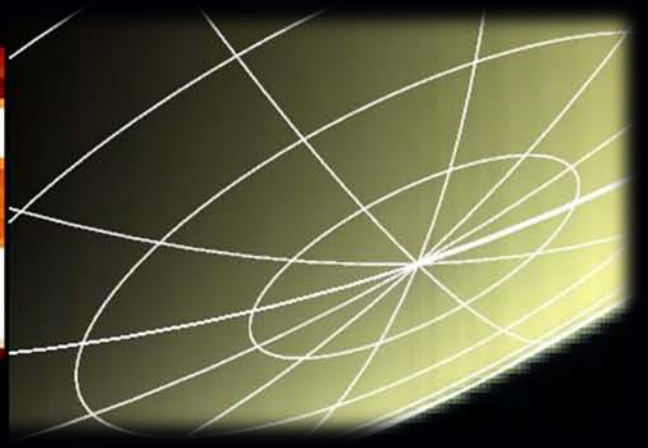
Cassini UVIS in situ imaging

Image Credit: Wayne Pryor (UVIS)

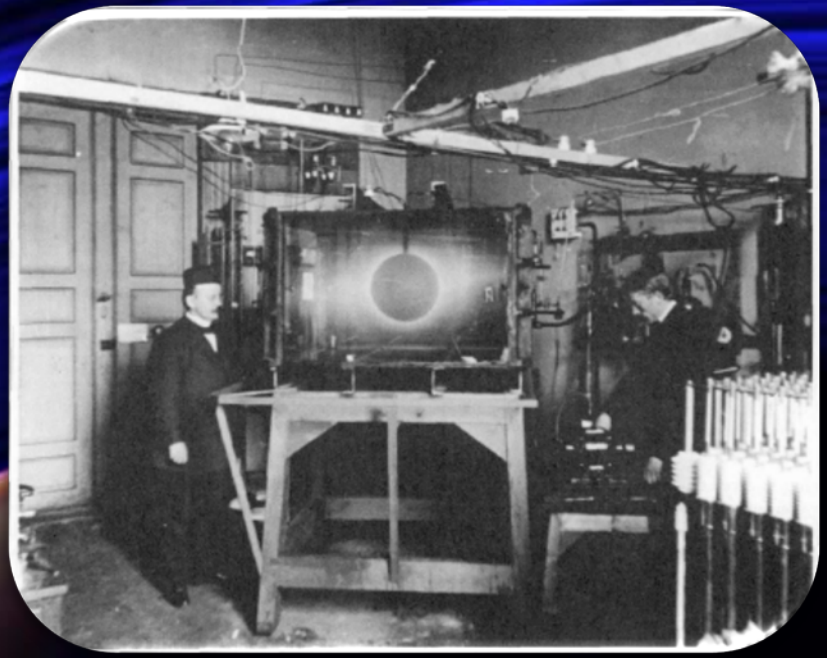
Cassini VIMS in situ imaging

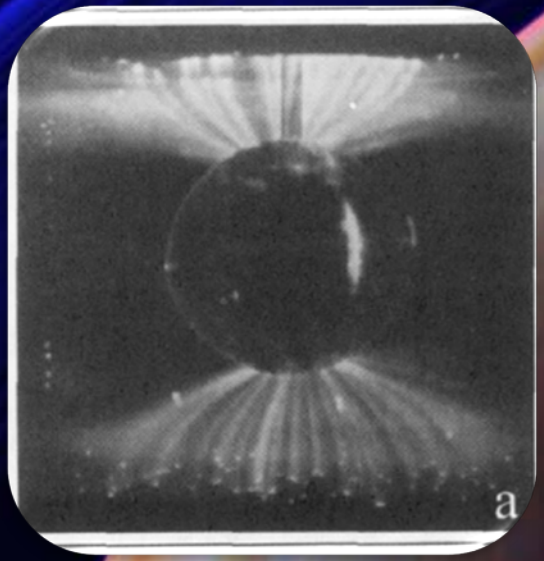
Taken from Stallard et al, 2008

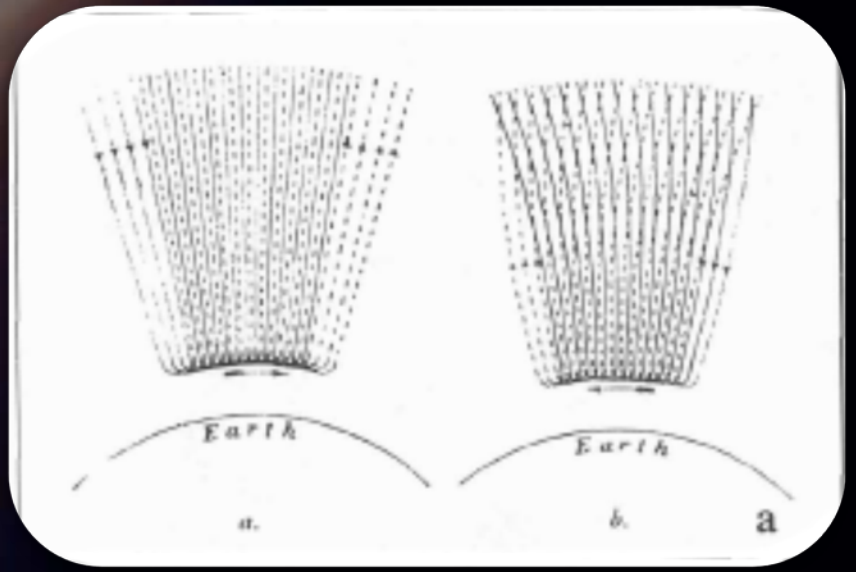




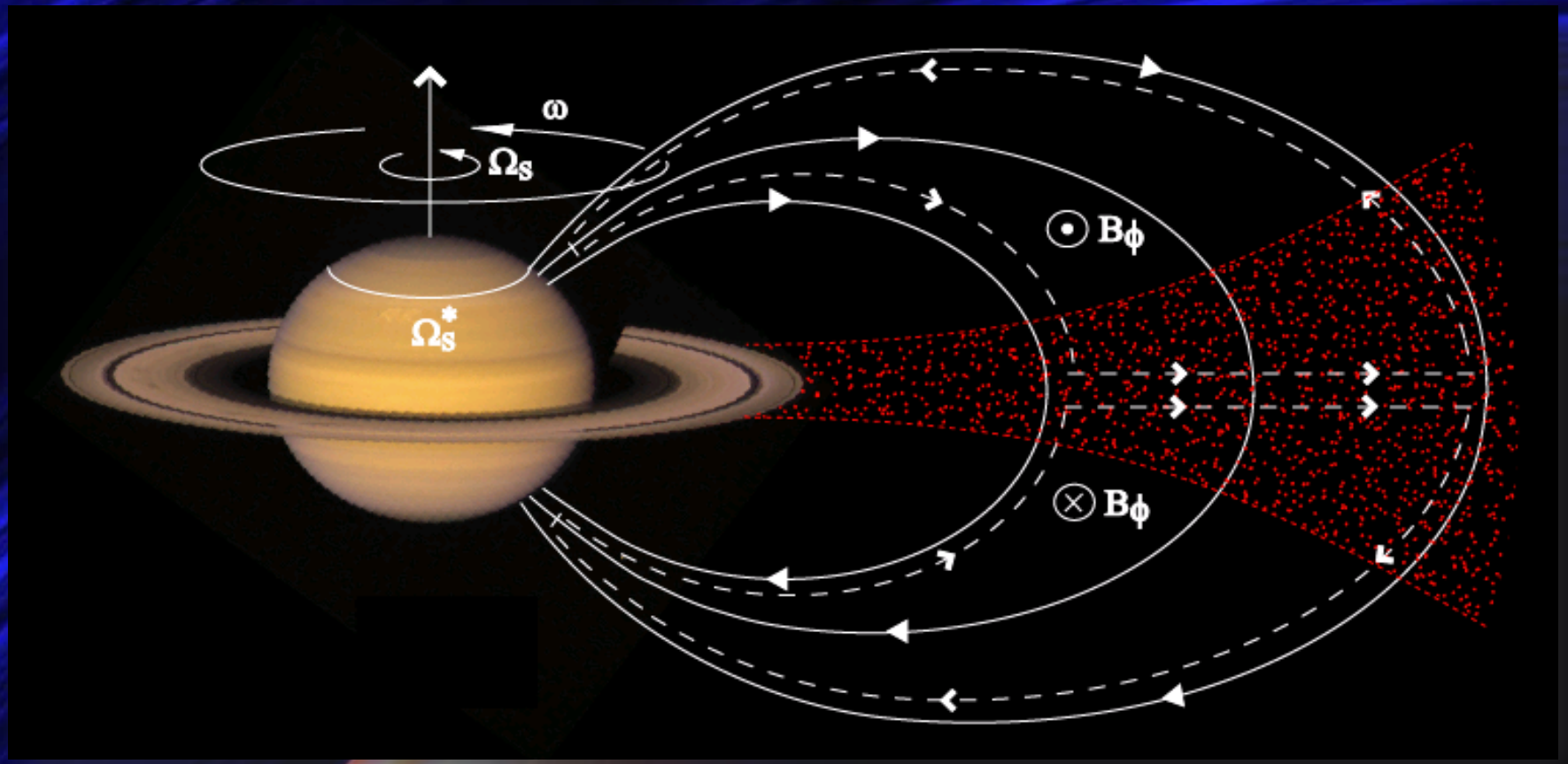
Kristian Birkeland







Magnetosphere-Ionosphere coupling current System



Bunce et al., 2003

HST observations with high-latitude in situ Cassini observations

Image A: January 16th: 05:31 UT

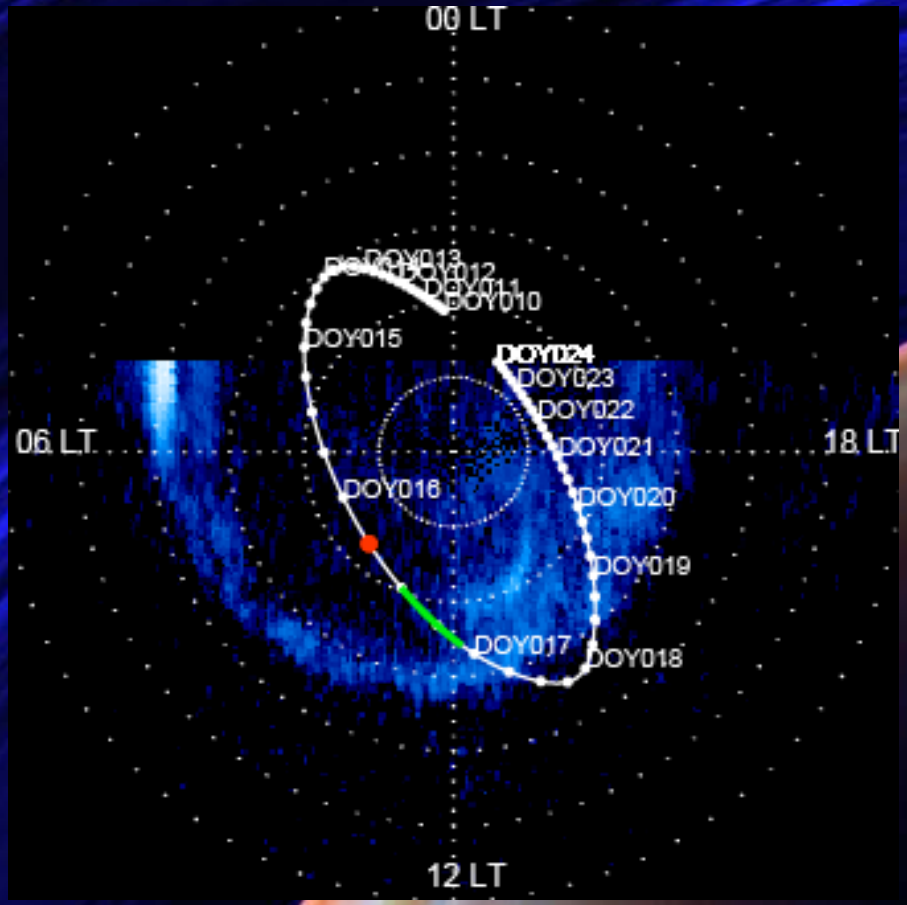
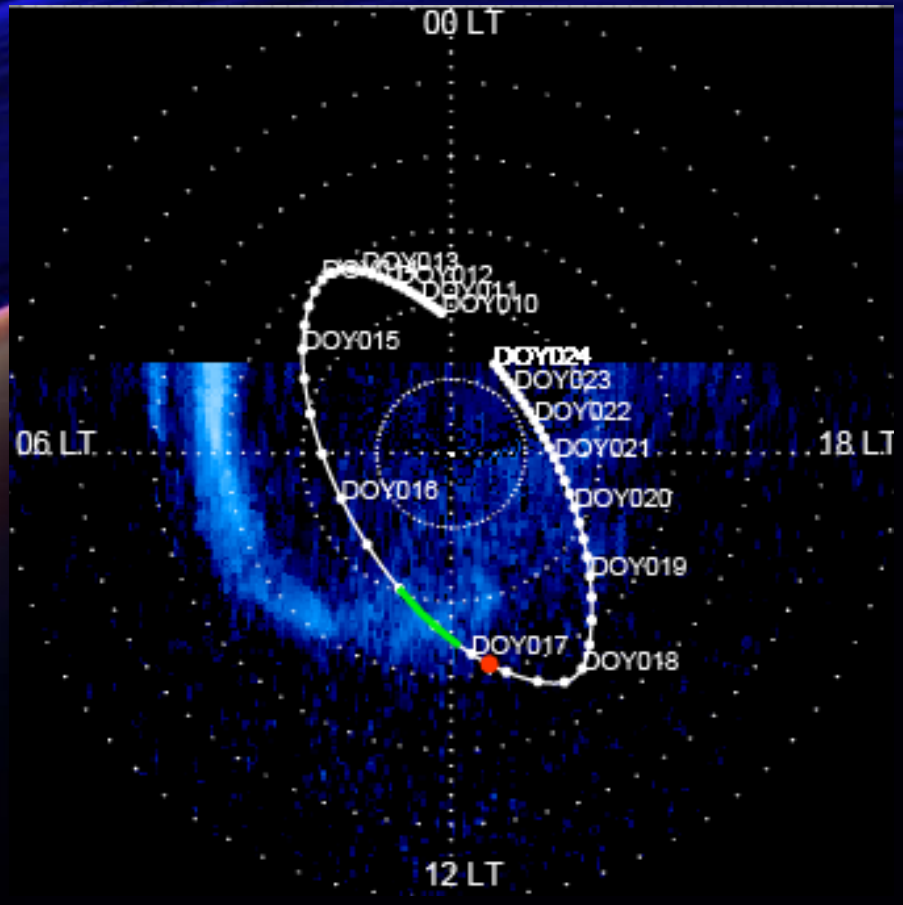
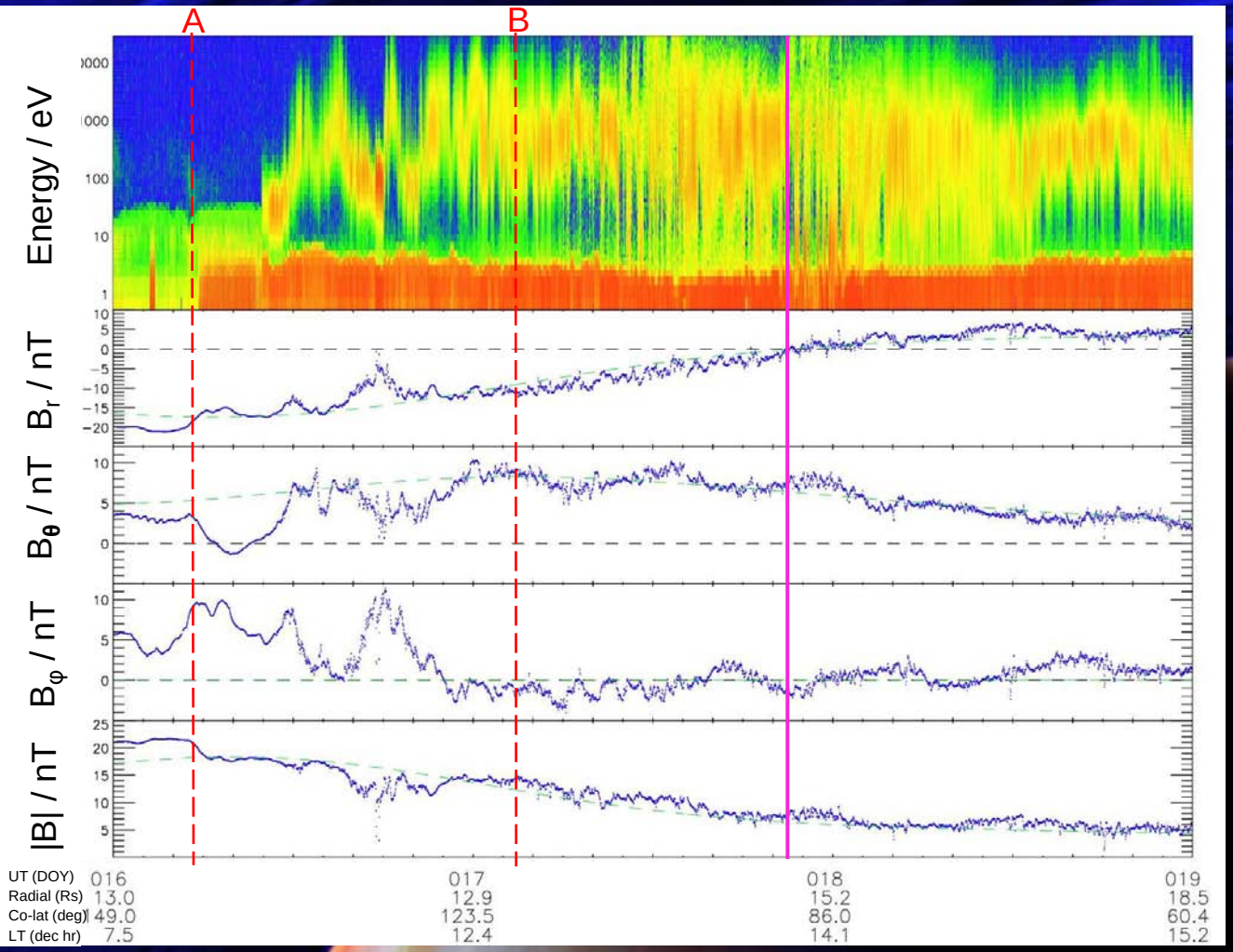


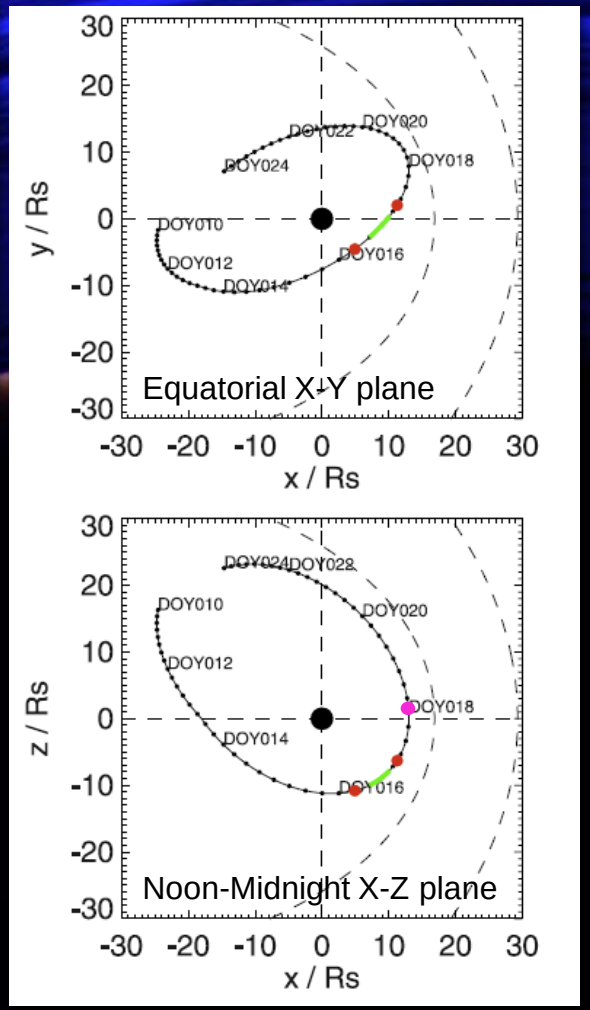
Image B: January 17th: 03:21 UT



Bunce et al., 2008

Rev 37: In situ Cassini observations





Bunce et al., 2008

HST observations with high-latitude in situ Cassini observations

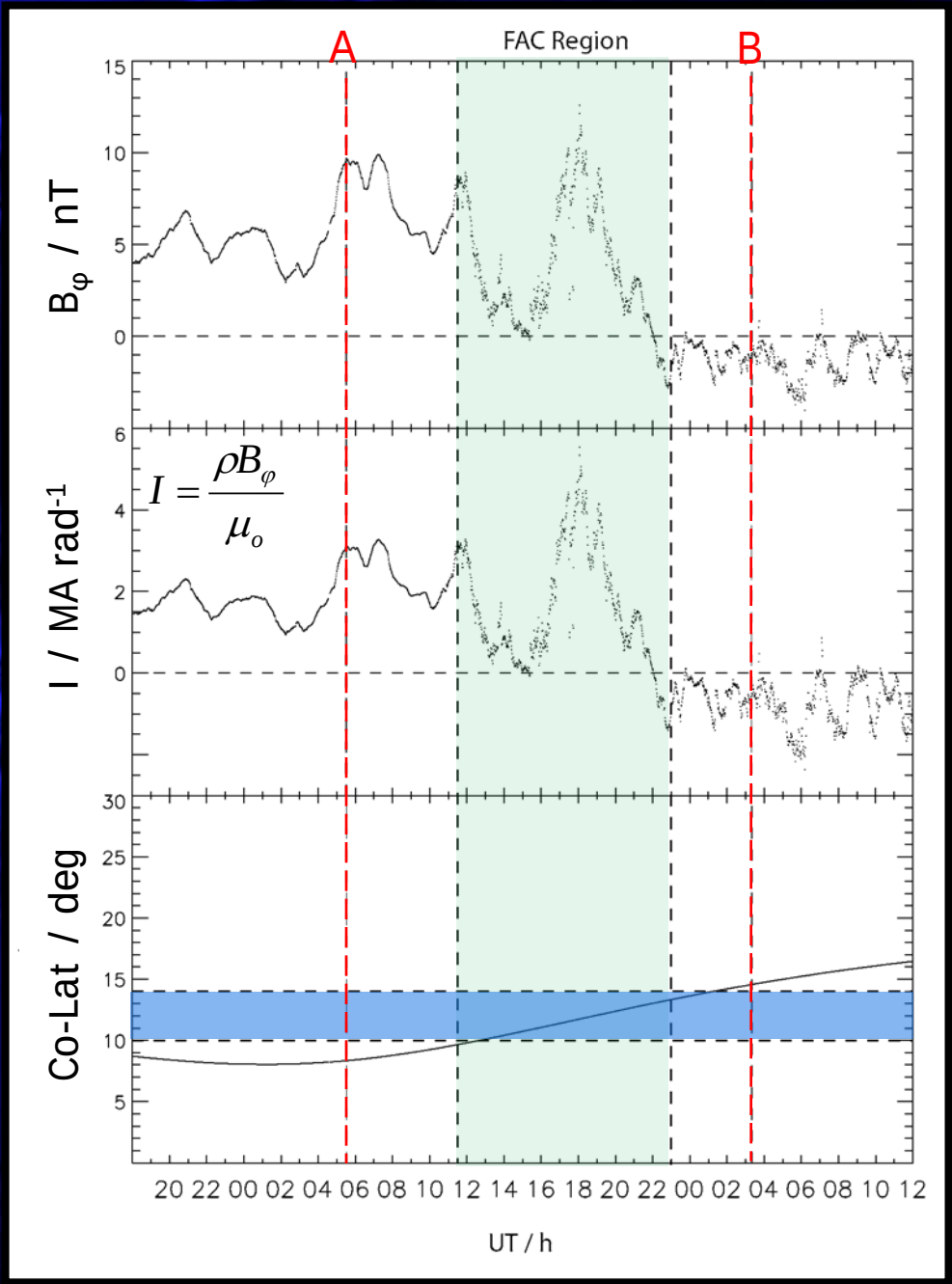
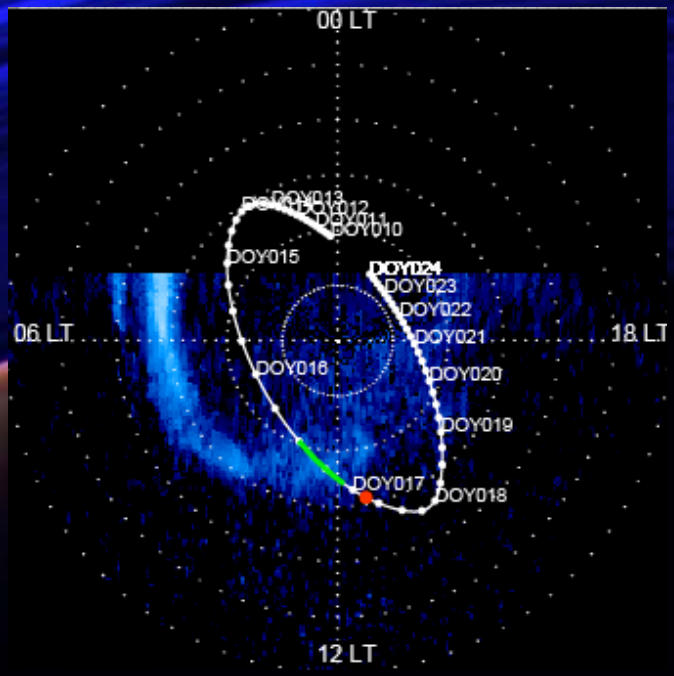


Image B: January 17th: 03:21 UT

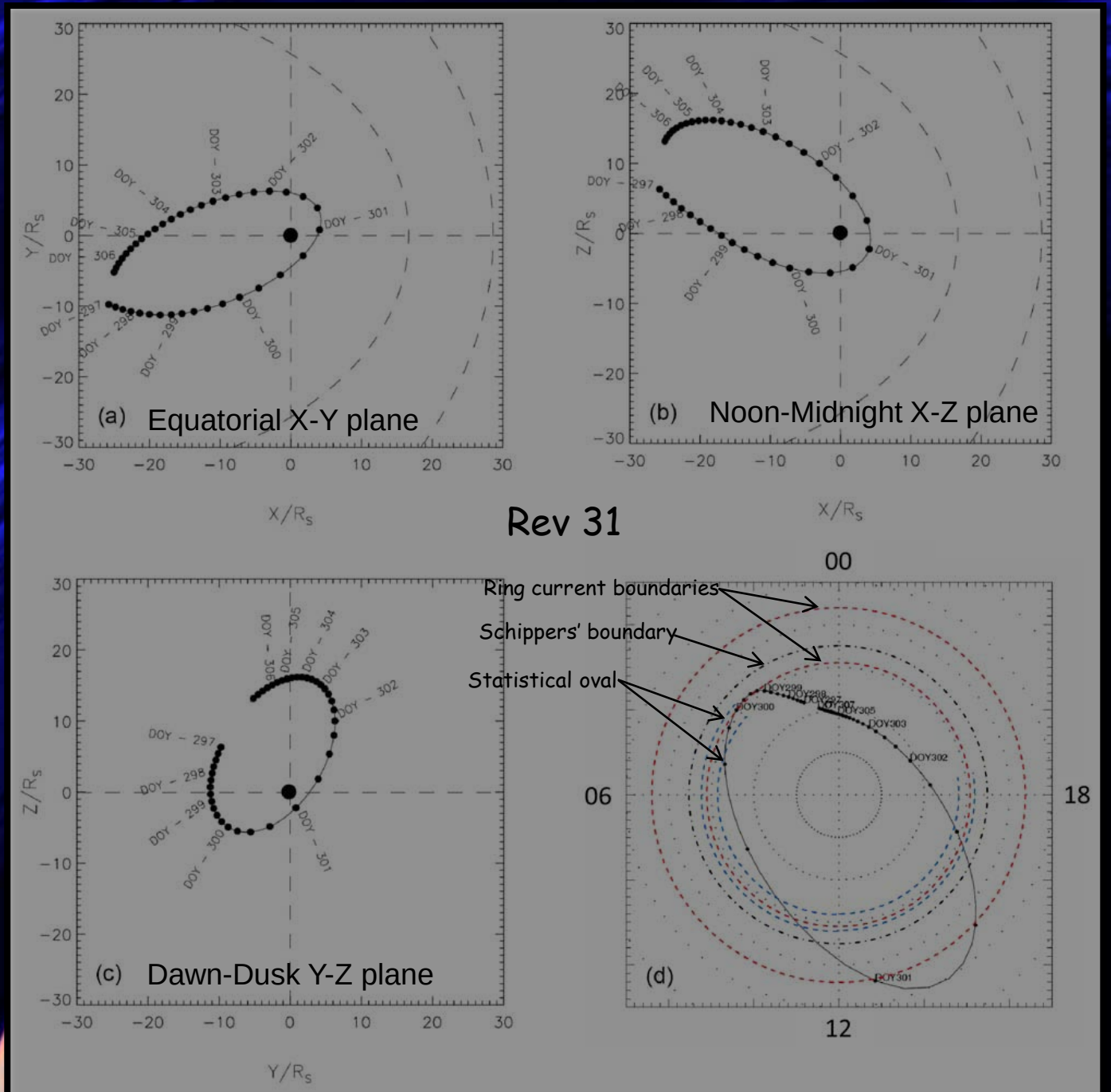


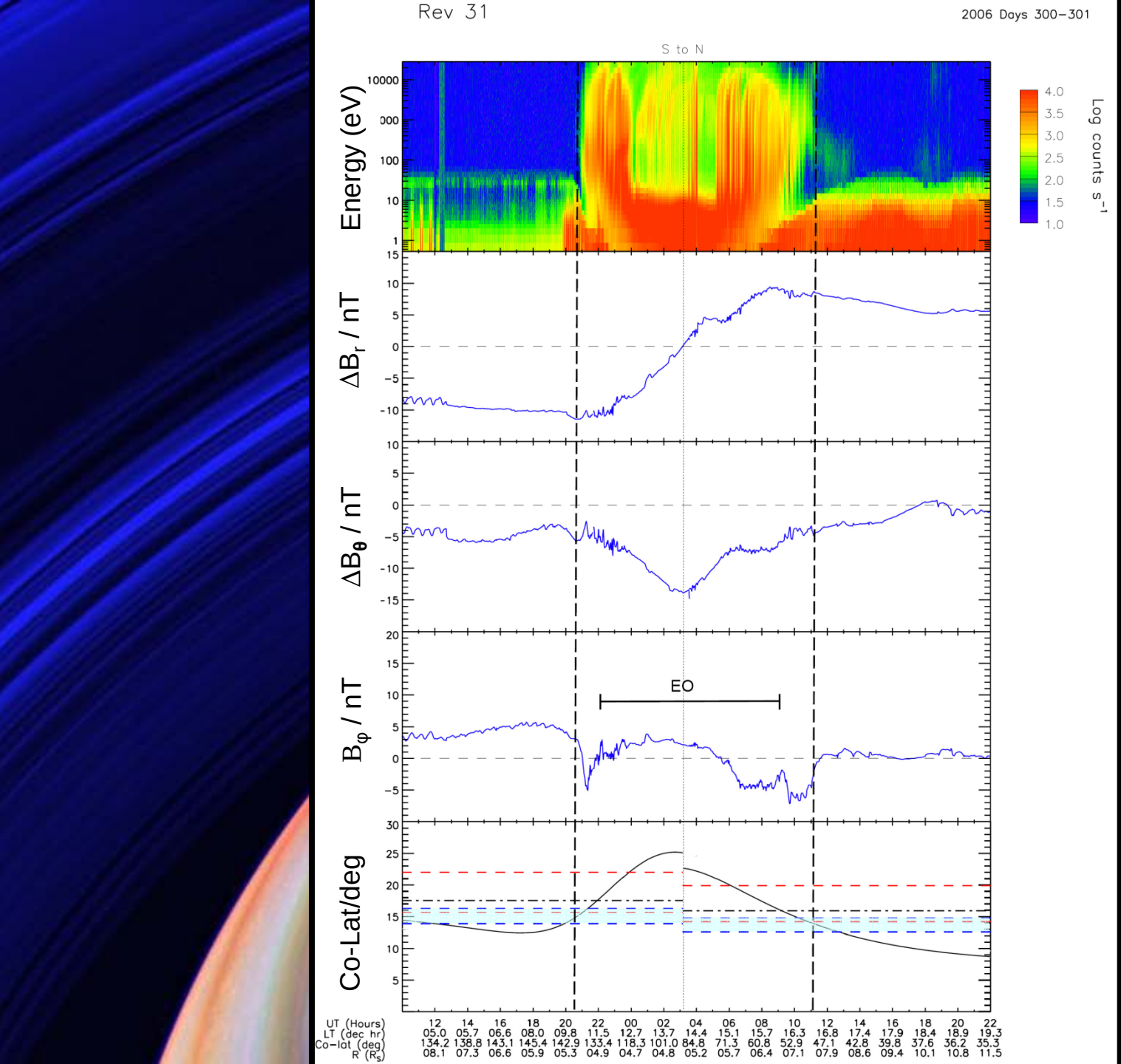
Estimate the FAC density to be:

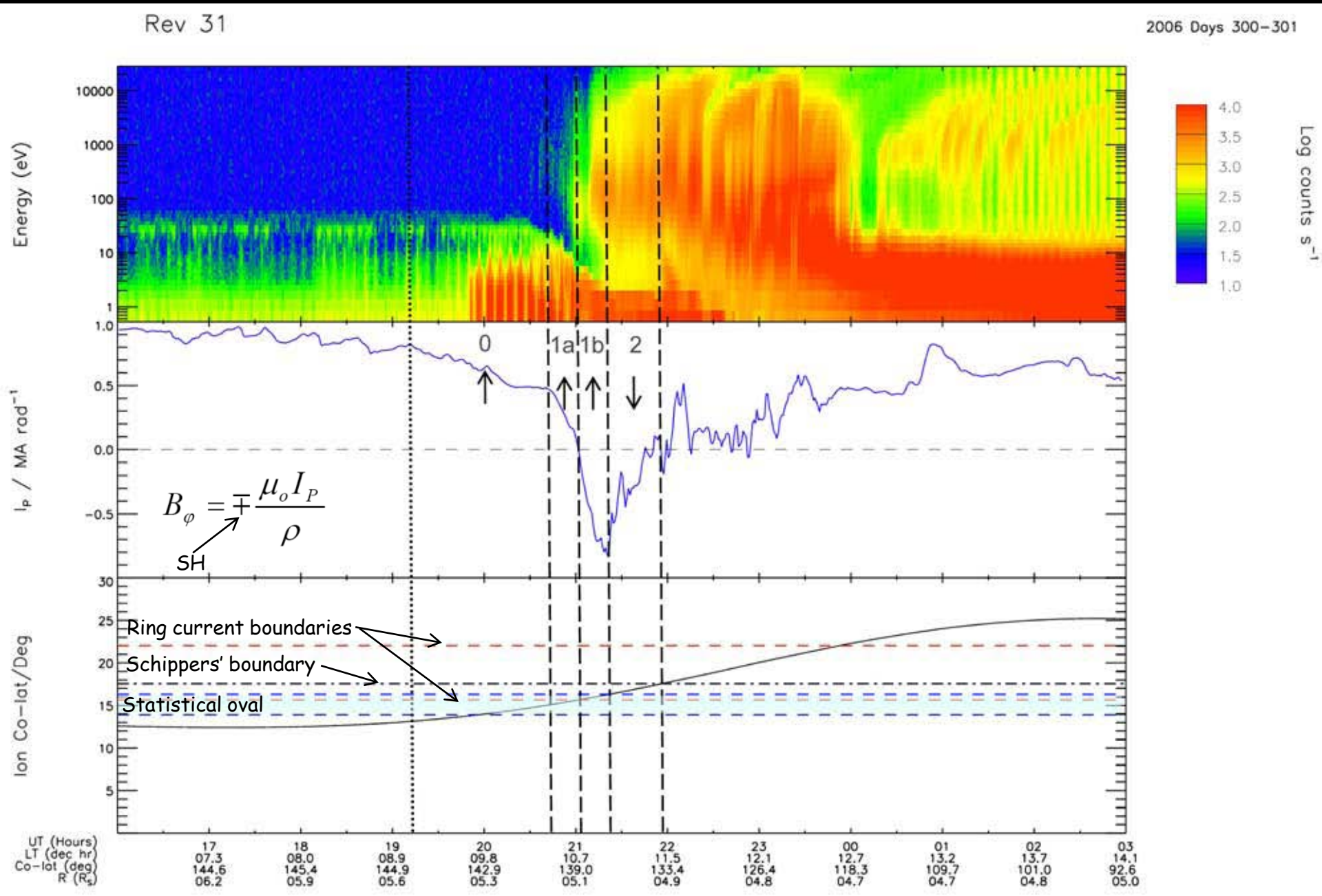
$j_{||} \sim 275$ nA m^{-2}

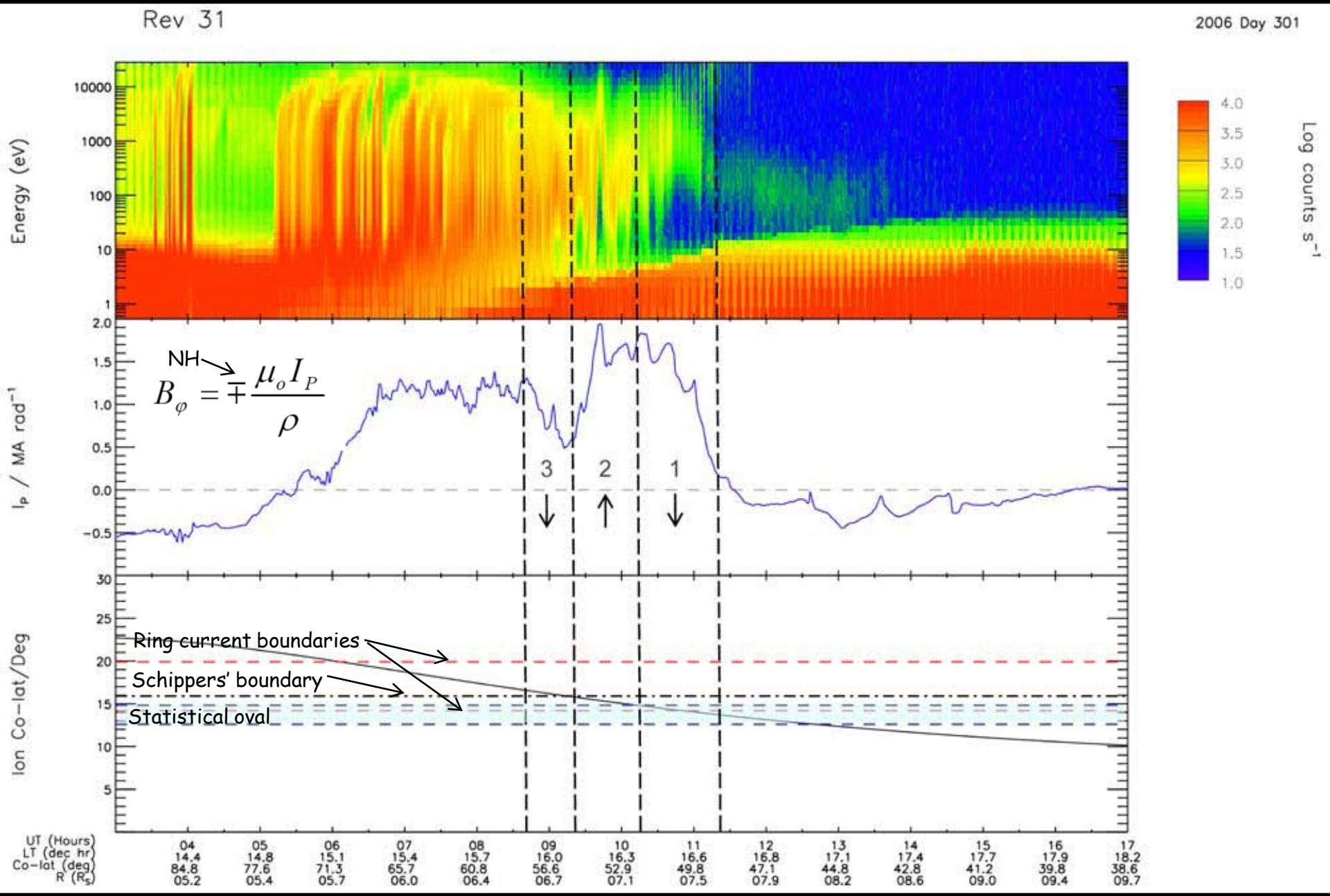
Bunce et al., 2008

Characterization of high-latitude current systems from mid-2006 to mid 2007




Rev 31
2006 Days 300–301
S to N
Energy (eV)
10000
1000
100
10
1
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Log counts s⁻¹
ΔBr / nT
ΔBθ / nT
Bφ / nT
EO
Co-Lat/deg
UT (Hours)
LT (dec hr)
Co-lat (deg)
R (Rs)
12 14 16 18 20 22 00 02 04 06 08 10 12 14 16 18 20 22
05.0 05.7 06.6 08.0 09.8 11.5 12.7 13.7 14.4 15.1 15.7 16.3 16.8 17.4 17.9 18.4 18.9 19.3
134.2 138.8 143.1 145.4 142.9 133.4 118.3 101.0 84.8 71.3 60.8 52.9 47.1 42.8 39.8 37.6 36.2 35.3
08.1 07.3 06.6 05.9 05.3 04.9 04.7 04.8 05.2 05.7 06.4 07.1 07.9 08.6 09.4 10.1 10.8 11.5


Rev 31
2006 Days 300-301
Energy (eV)
10000
1000
100
10
1
Log counts s^{-1}
4.0
3.5
3.0
2.5
2.0
1.5
1.0
I_P / MA rod^{-1}
1.0
0.5
0.0
-0.5
0
1a
1b
2
$B_\varphi = \mp \frac{\mu_o I_P}{\rho}$
SH
Ion Co-lat/Deg
30
25
20
15
10
5
Ring current boundaries
Schippers' boundary
Statistical oval
UT (Hours)
LT (dec hr)
Co-lat (deg)
R (Rs)
17 07.3 144.6 06.2
18 08.0 145.4 05.9
19 08.9 144.9 05.6
20 09.8 142.9 05.3
21 10.7 139.0 05.1
22 11.5 133.4 04.9
23 12.1 126.4 04.8
00 12.7 118.3 04.7
01 13.2 109.7 04.7
02 13.7 101.0 04.8
03 14.1 92.6 05.0


Rev 31
2006 Day 301
Energy (eV)
10000
1000
100
10
1
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Log counts s⁻¹
NH
$B_\varphi = \mp \frac{\mu_o I_P}{\rho}$
I_P / MA rad^{-1}
2.0
1.5
1.0
0.5
0.0
-0.5
3
2
1
Ion Co-lat/Deg
30
25
20
15
10
5
Ring current boundaries
Schippers' boundary
Statistical oval
UT (Hours)
LT (dec hr)
Co-lat (deg)
R (R_s)
04 14.4 84.8 05.2
05 14.8 77.6 05.4
06 15.1 71.3 05.7
07 15.4 65.7 06.0
08 15.7 60.8 06.4
09 16.0 56.6 06.7
10 16.3 52.9 07.1
11 16.6 49.8 07.5
12 16.8 47.1 07.9
13 17.1 44.8 08.2
14 17.4 42.8 08.6
15 17.7 41.2 09.0
16 17.9 39.8 09.4
17 18.2 38.6 09.7

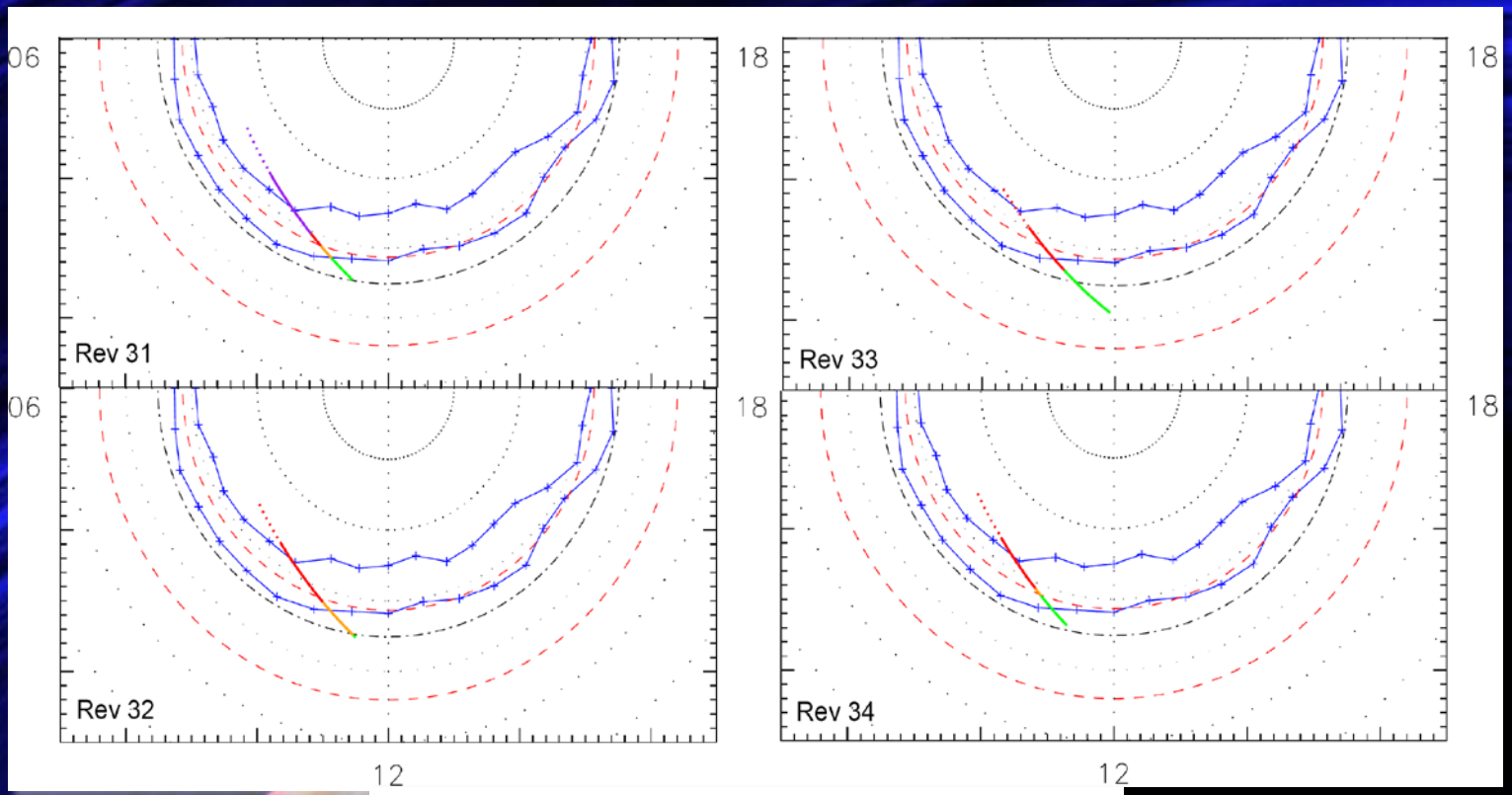
SH Currents for Revs 31-35

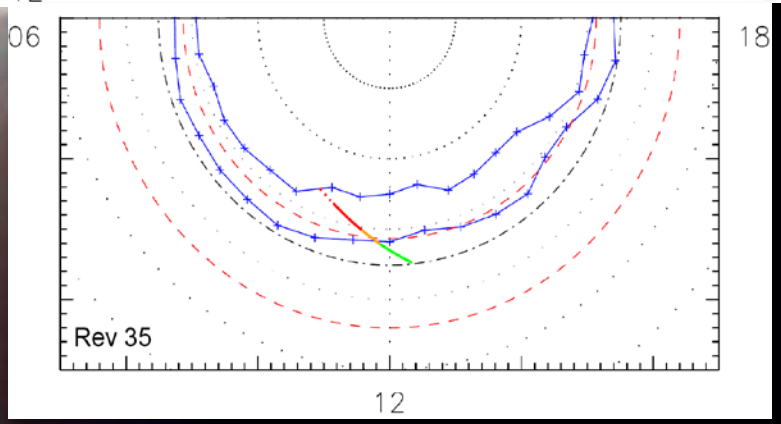
Purple - Upward region 0

Red - Upward region 1a

Orange - Upward region 1b

Green - Downward region 2



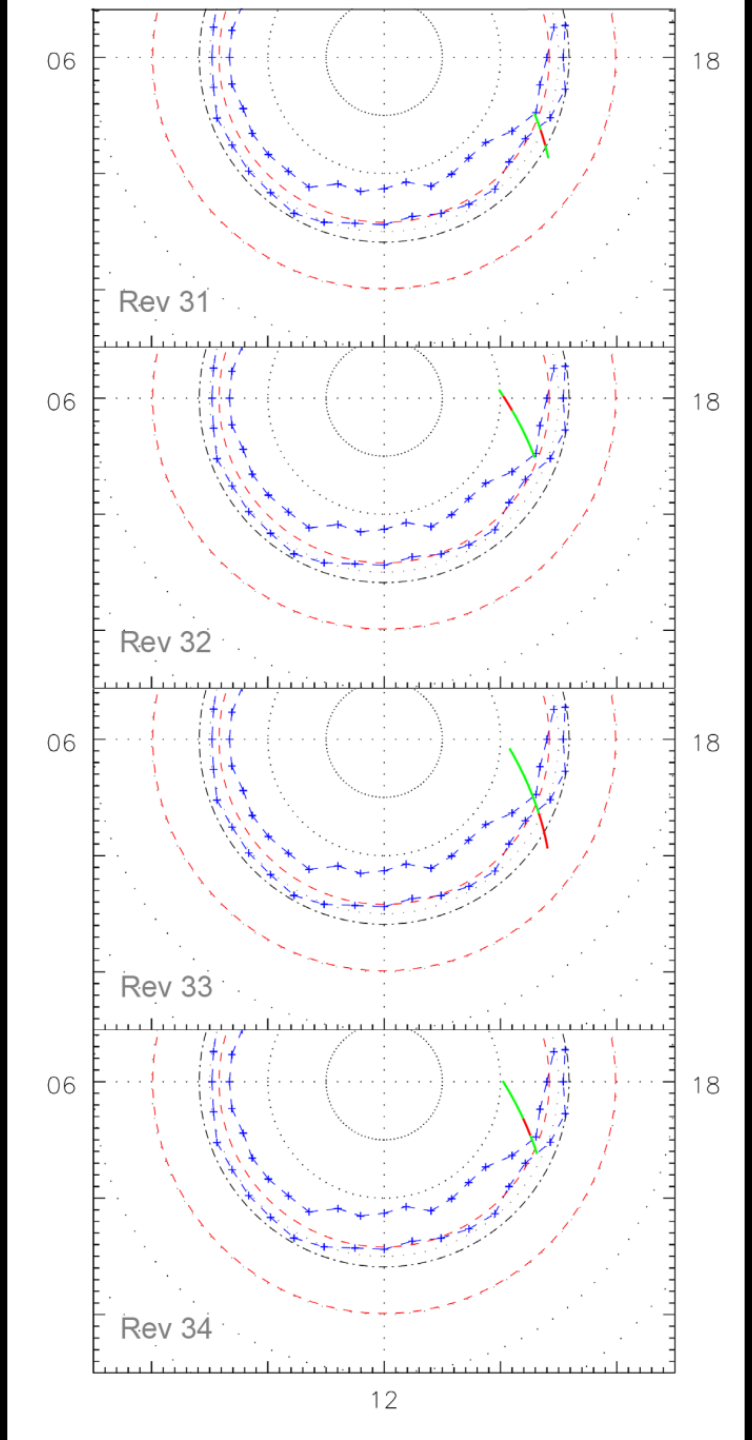


NH Currents for Rev 31-34

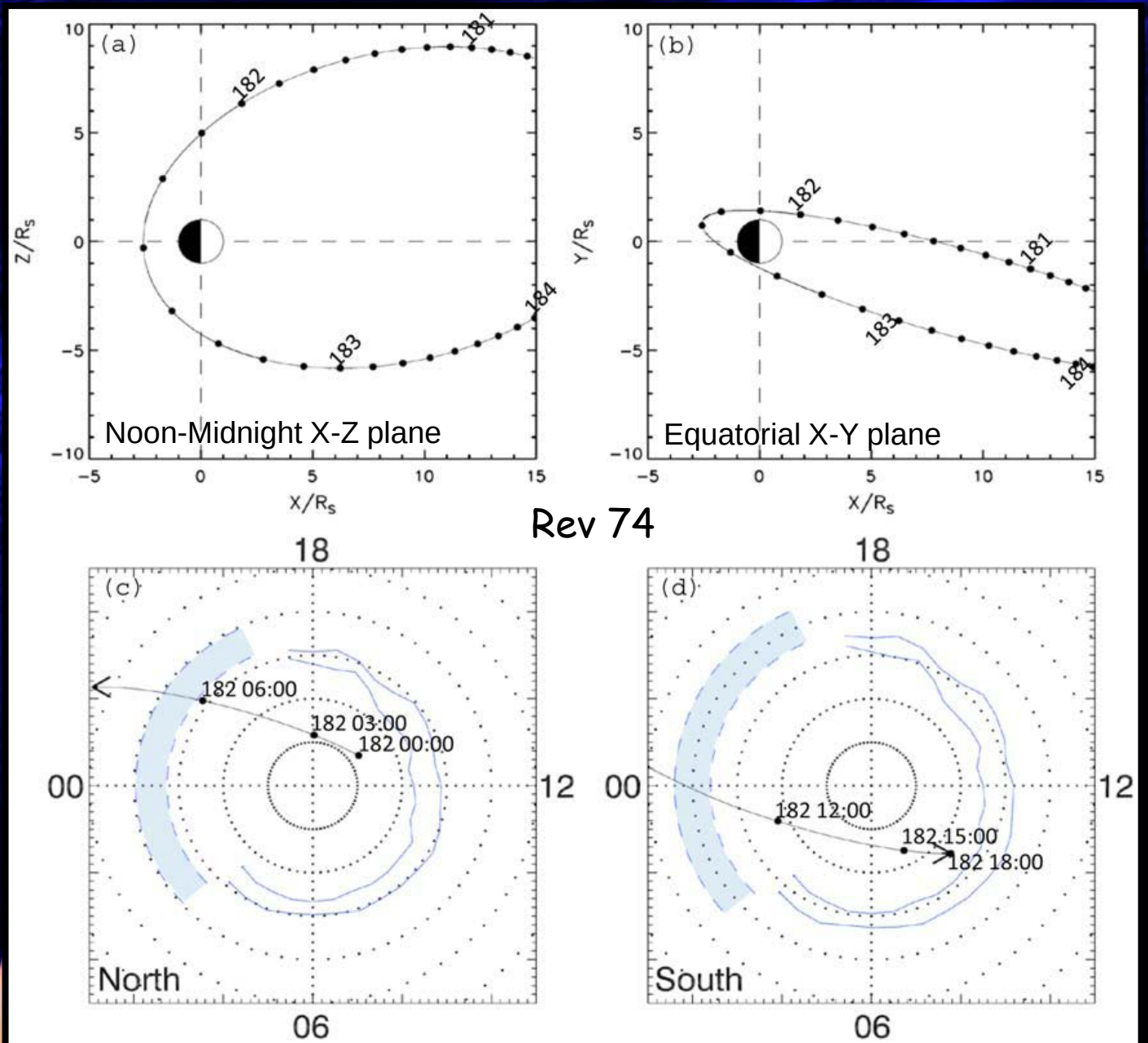
Green - Downward region 1

Red - Upward region 2

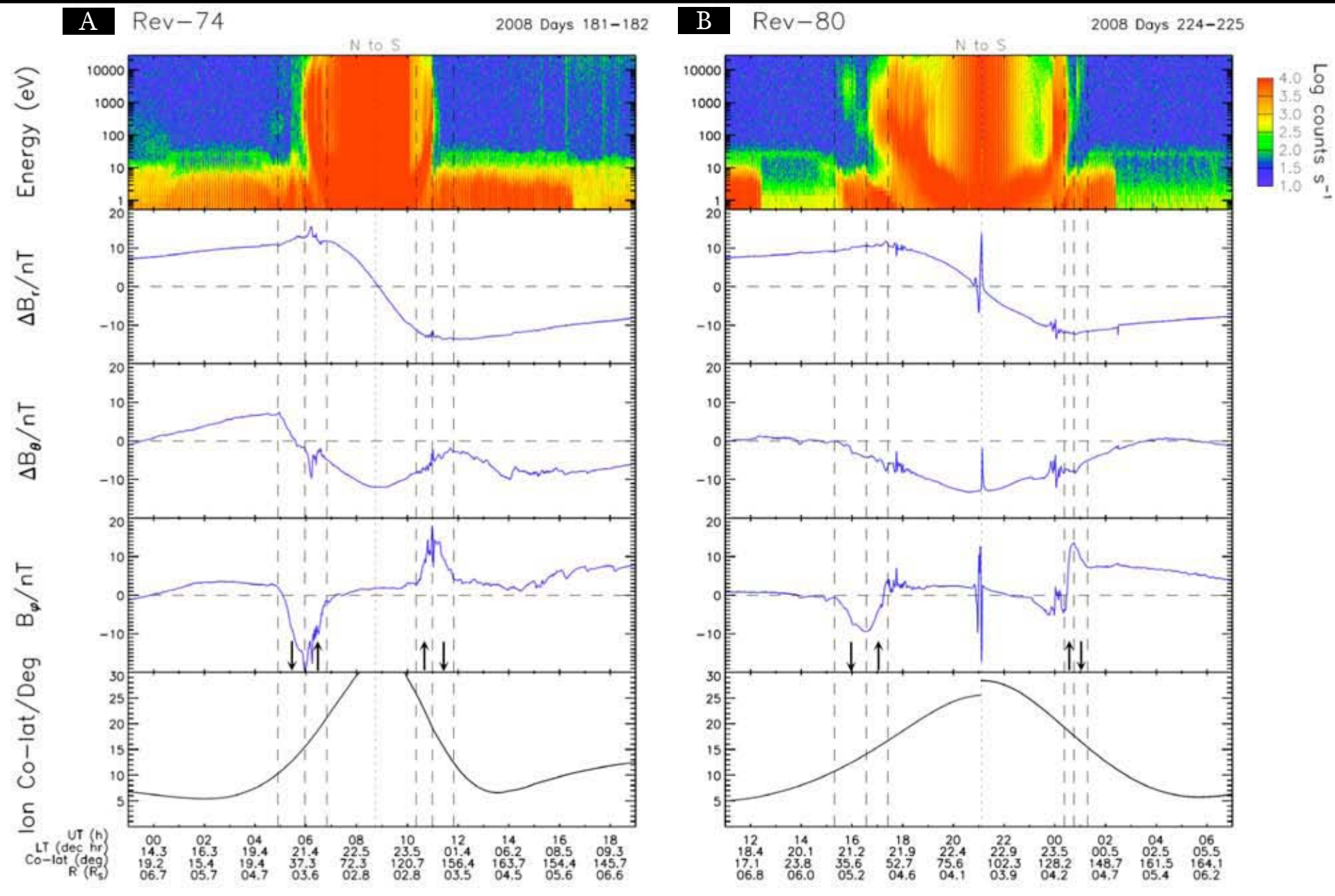
Green - Downward region 3



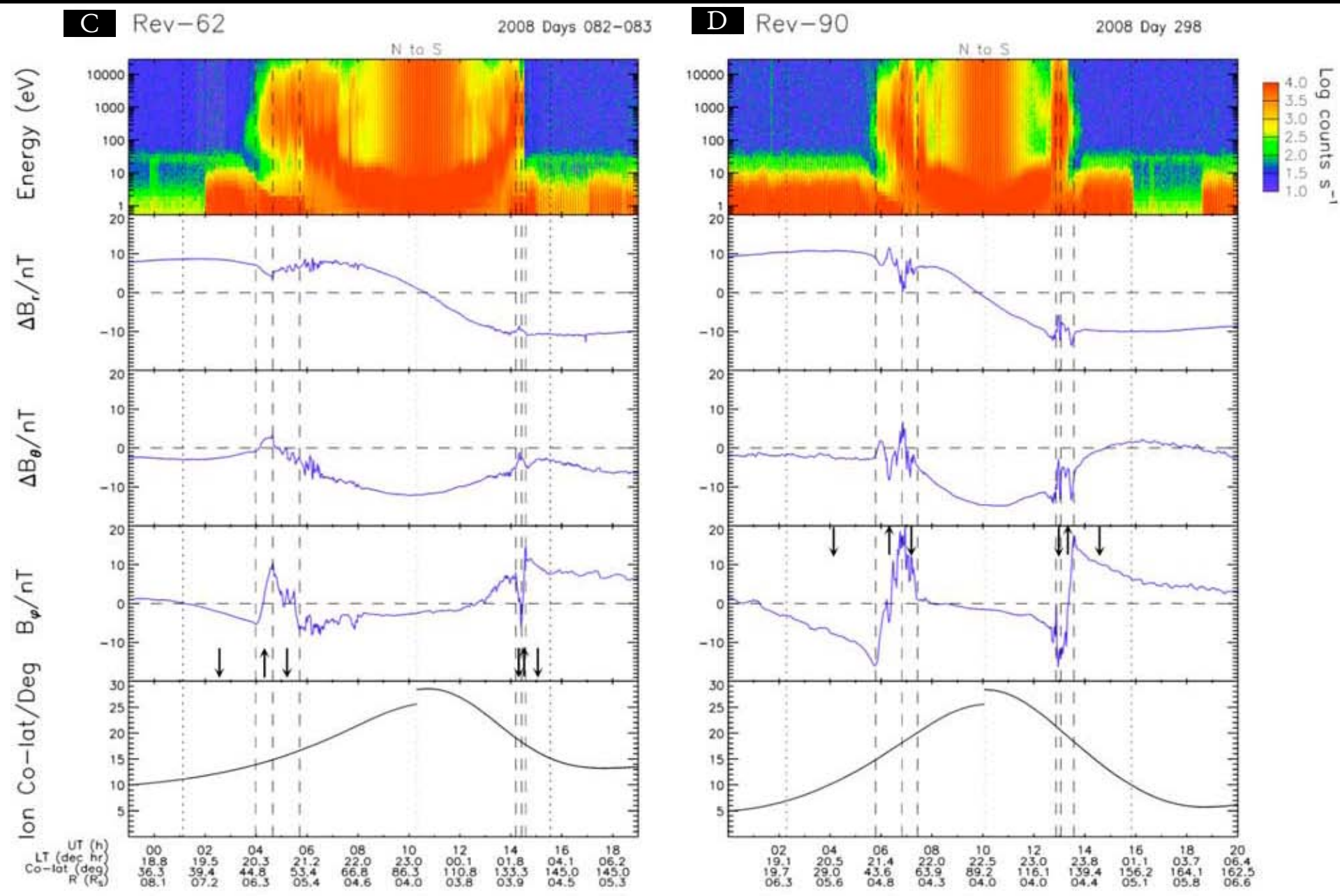
Field-aligned current signatures during 2008



Examples of 'Lagging' Field Signatures



Examples of 'Leading' Field Signatures



Summary and Open Questions

- The joint HST-Cassini campaign associated for the first time the high-latitude field-aligned currents with the aurora.
- Near-simultaneous in situ observations of the field-aligned currents and imaging of the aurora are of primary value.
- How does the main auroral oval (X-ray,UV,IR,Radio) at different local times relate to the field-aligned currents?
    - How do the two different types of upward FAC (those generated by sub-corotating flow shears and those from the unusual super-corotating flow shears) relate to the morphology of the aurora?
    - What dynamical event is occurring to produce the super-corotating flows (with associated 'leading' field signatures) that are unanticipated by various models.
    - How does the sub-structure in the upward FAC relate to the fine structure in the aurora?