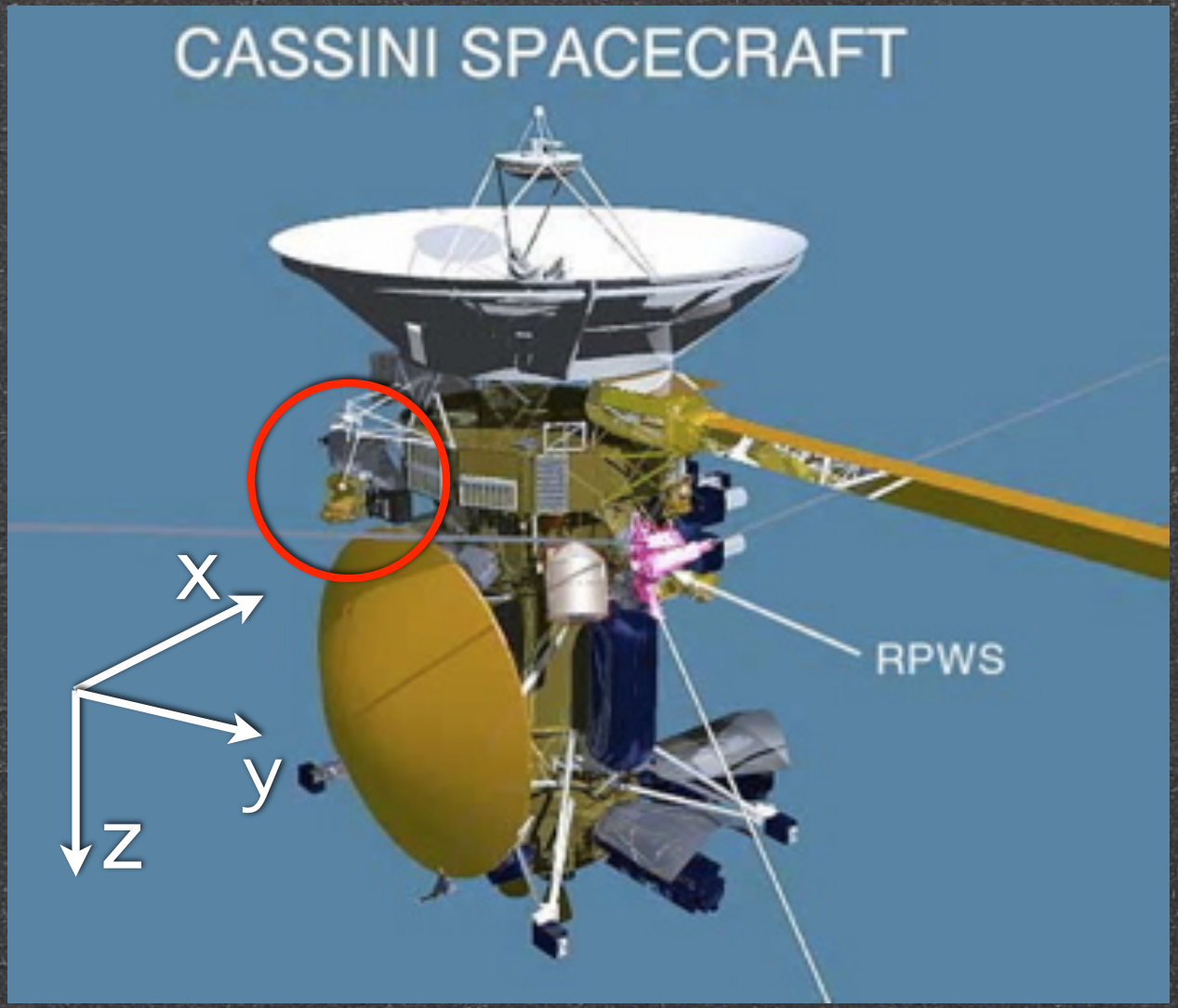
Cassini LP photoelectron calibration and its use

Michiko Morooka,
J.-E. Wahlund, M. Holmberg, and K. Gwosch (IRF Uppsala)

Cassini Langmuir Probe

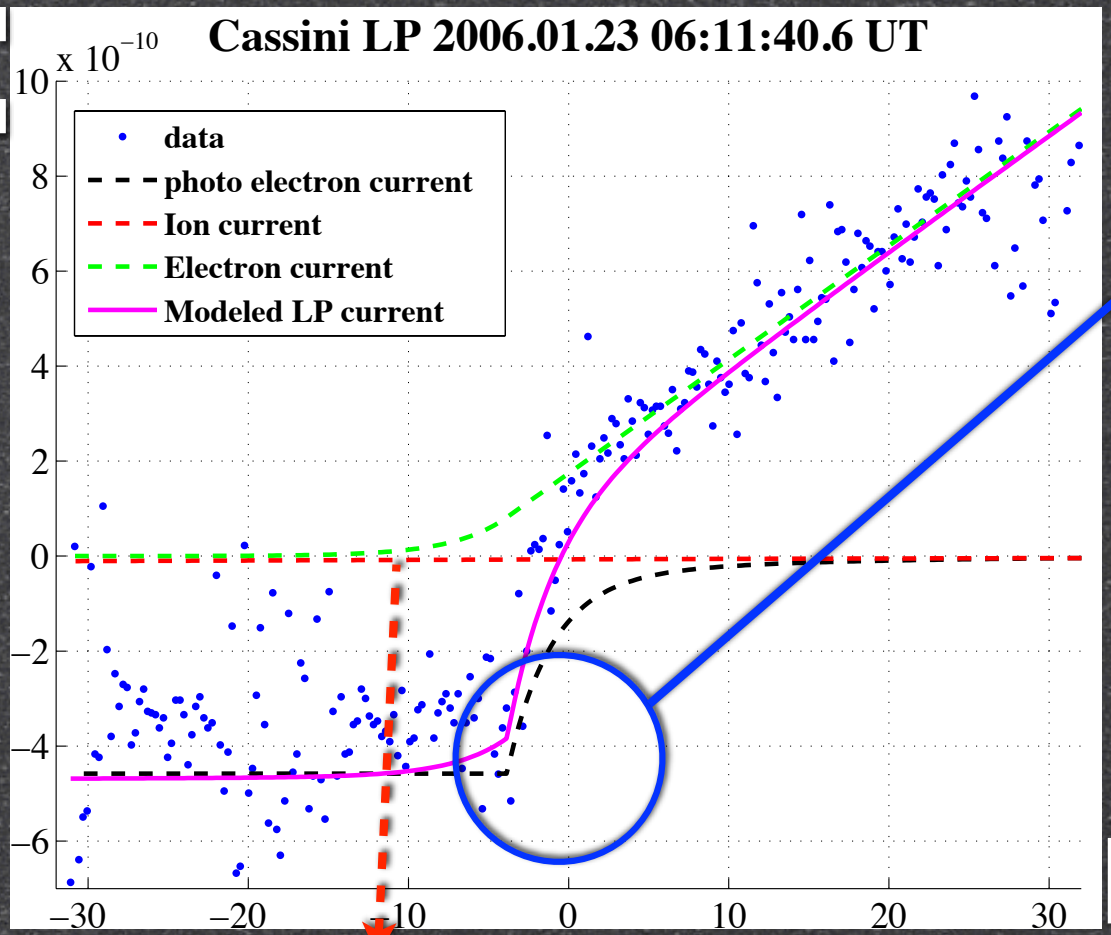
mounted:

- -X direction of SC
- 1.5m away from SC



$I = I_{ion} + I_{electron} + I_{photoelectron}$

- In a magnetospheric thin plasma, photoelectron characteristics is dominant.



$I_{electron} =$

$$I_{e0}\left(1 - \frac{q_e(U_{bias} + U_{float})}{k_B T_e}\right)$$

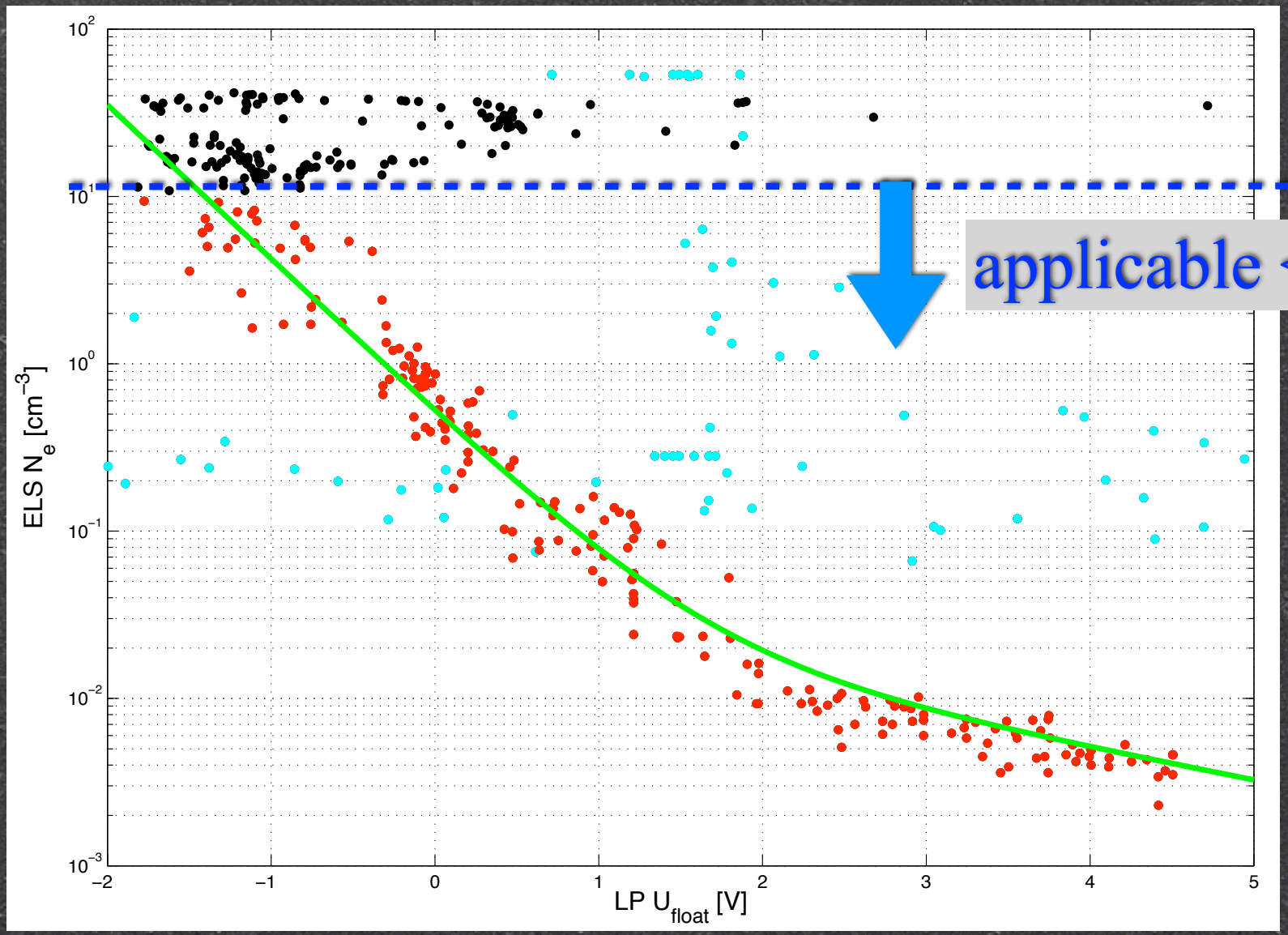
U_{float} is essential for electron-side estimation.
U_{float} can be used to estimate N_e when it is low.

$I_{ion} \sim 1 \cdot 10^{-10}$ [A]

If the ambient plasma becomes hot or dense, I_{ion} significant but still $I_{phototelectron}$ must be calibrated.

Electron density estimation from U_{float}

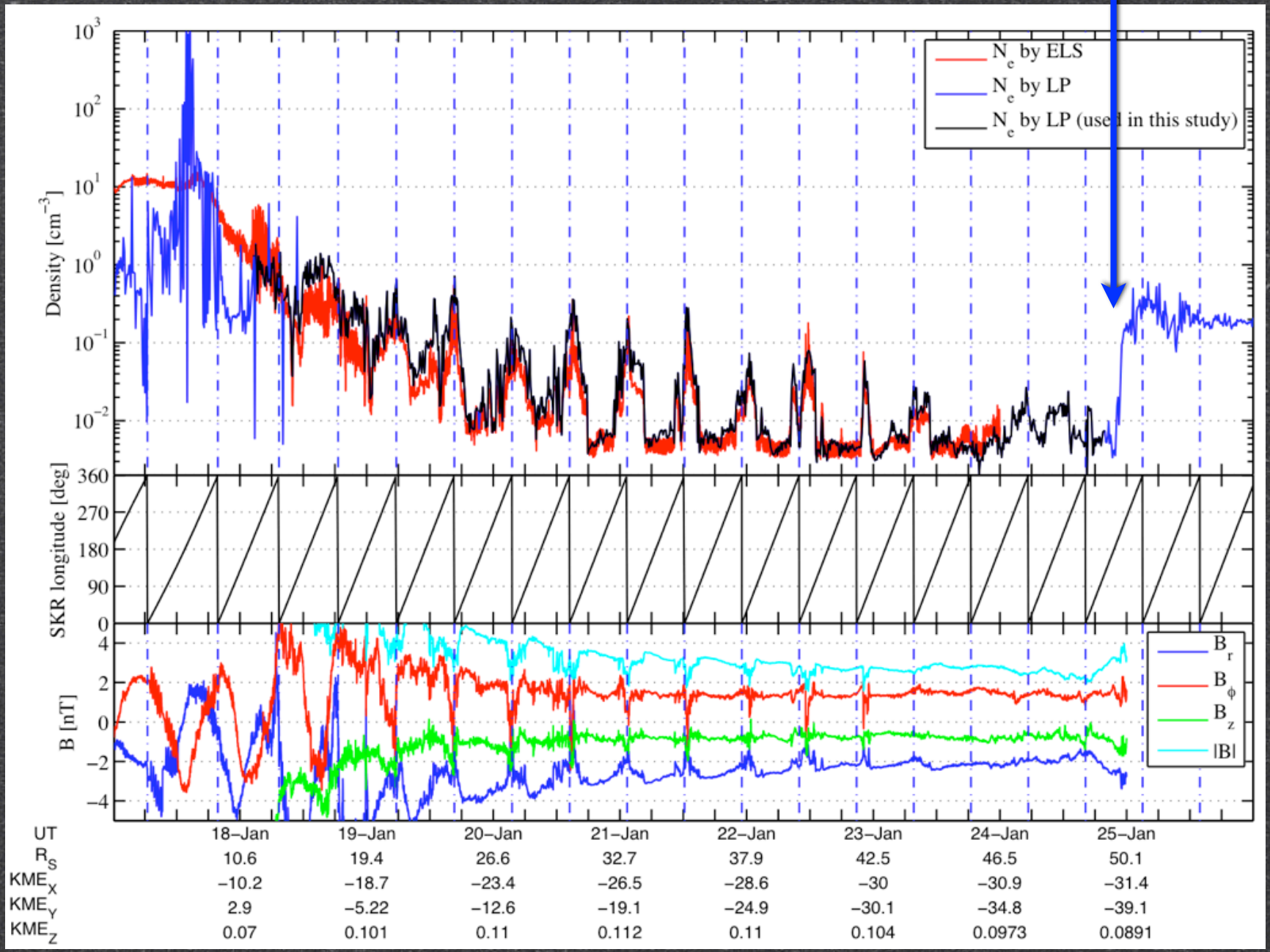
- N_e and U_{float} have linear relationship in thin plasma.



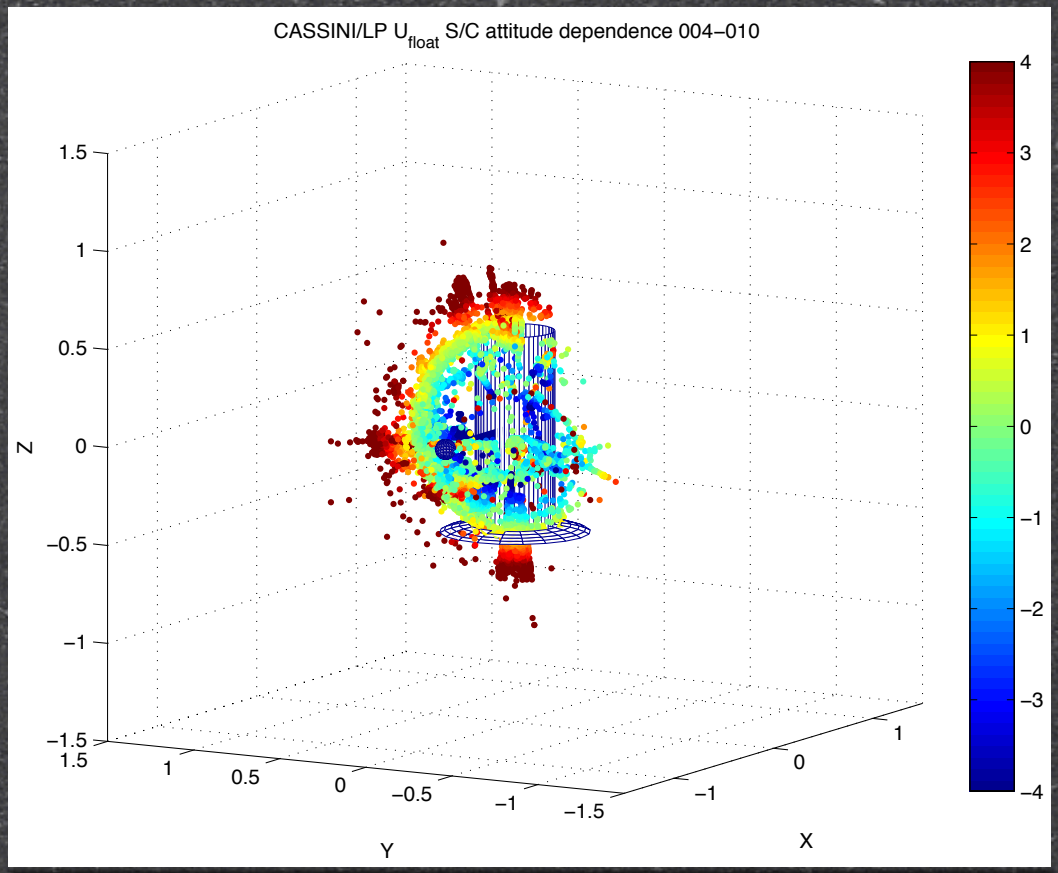
Data from SOI

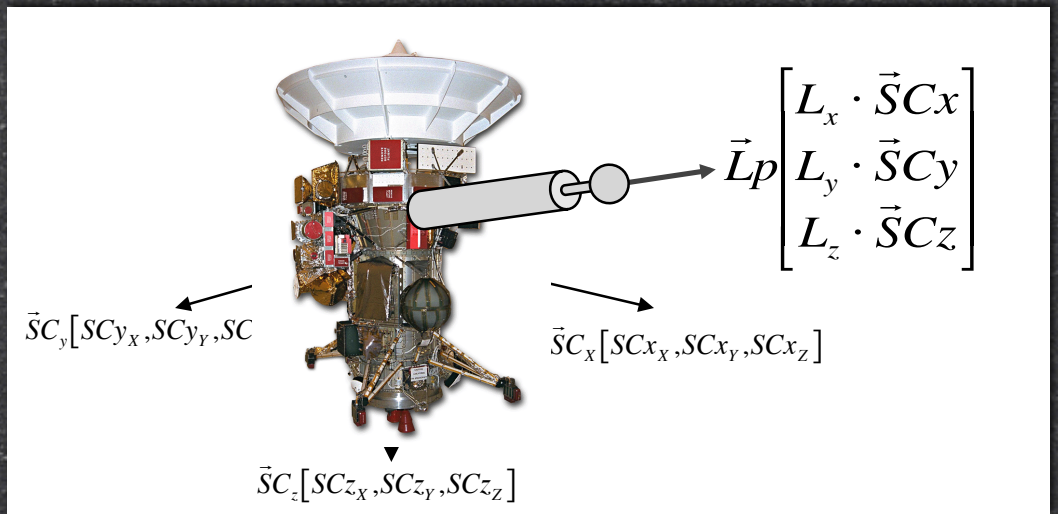
applicable < ~10 cm^{-3}

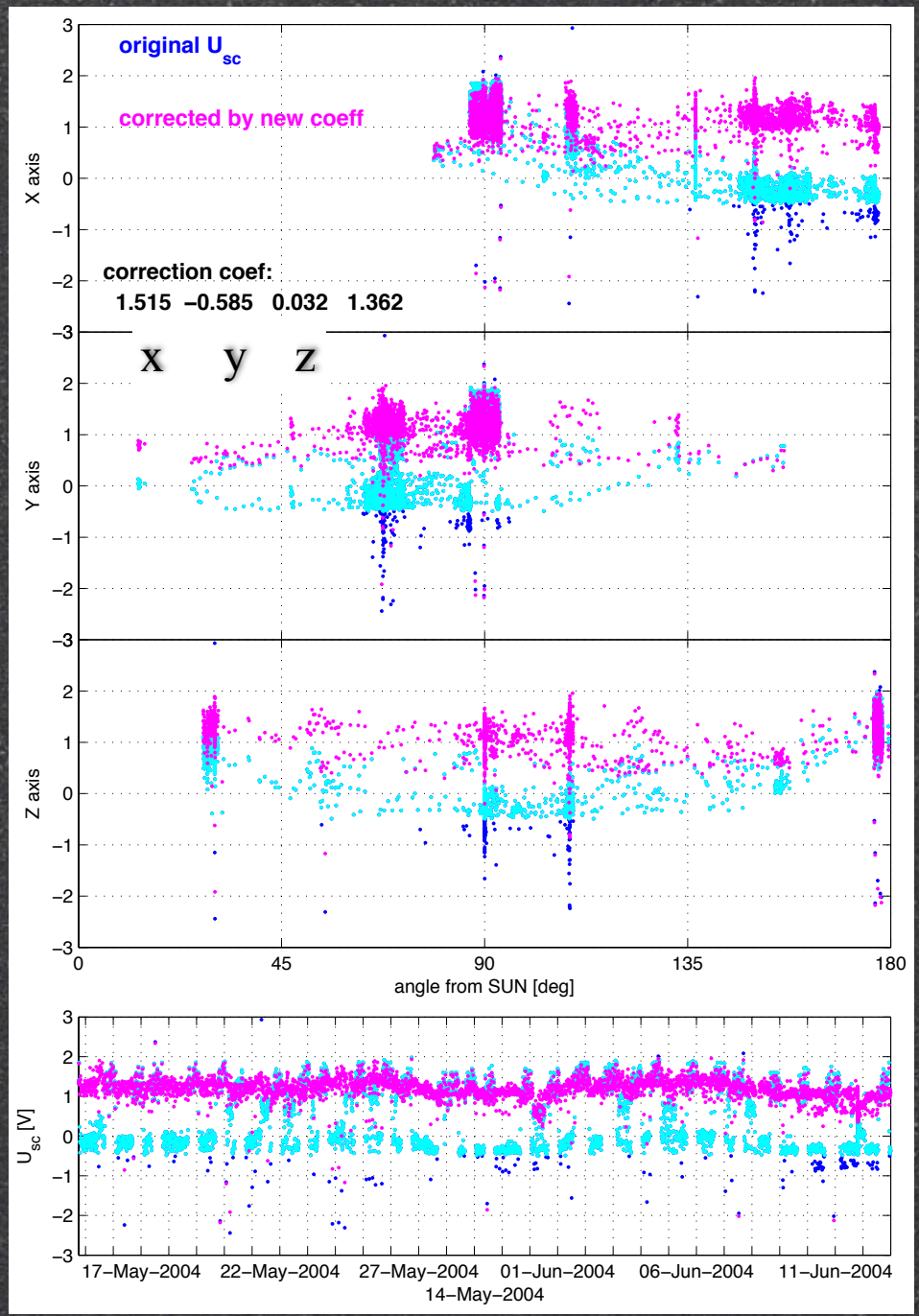
Rev 20 (2006)


MP
Ne by ELS
Ne by LP
Ne by LP (used in this study)
Density [cm−3]
SKR longitude [deg]
B [nT]
Br
Bϕ
Bz
|B|
UT 18–Jan 19–Jan 20–Jan 21–Jan 22–Jan 23–Jan 24–Jan 25–Jan
RS 10.6 19.4 26.6 32.7 37.9 42.5 46.5 50.1
KMEX −10.2 −18.7 −23.4 −26.5 −28.6 −30 −30.9 −31.4
KMEY 2.9 −5.22 −12.6 −19.1 −24.9 −30.1 −34.8 −39.1
KMEZ 0.07 0.101 0.11 0.112 0.11 0.104 0.0973 0.0891

U_{float} S/C attitude correction

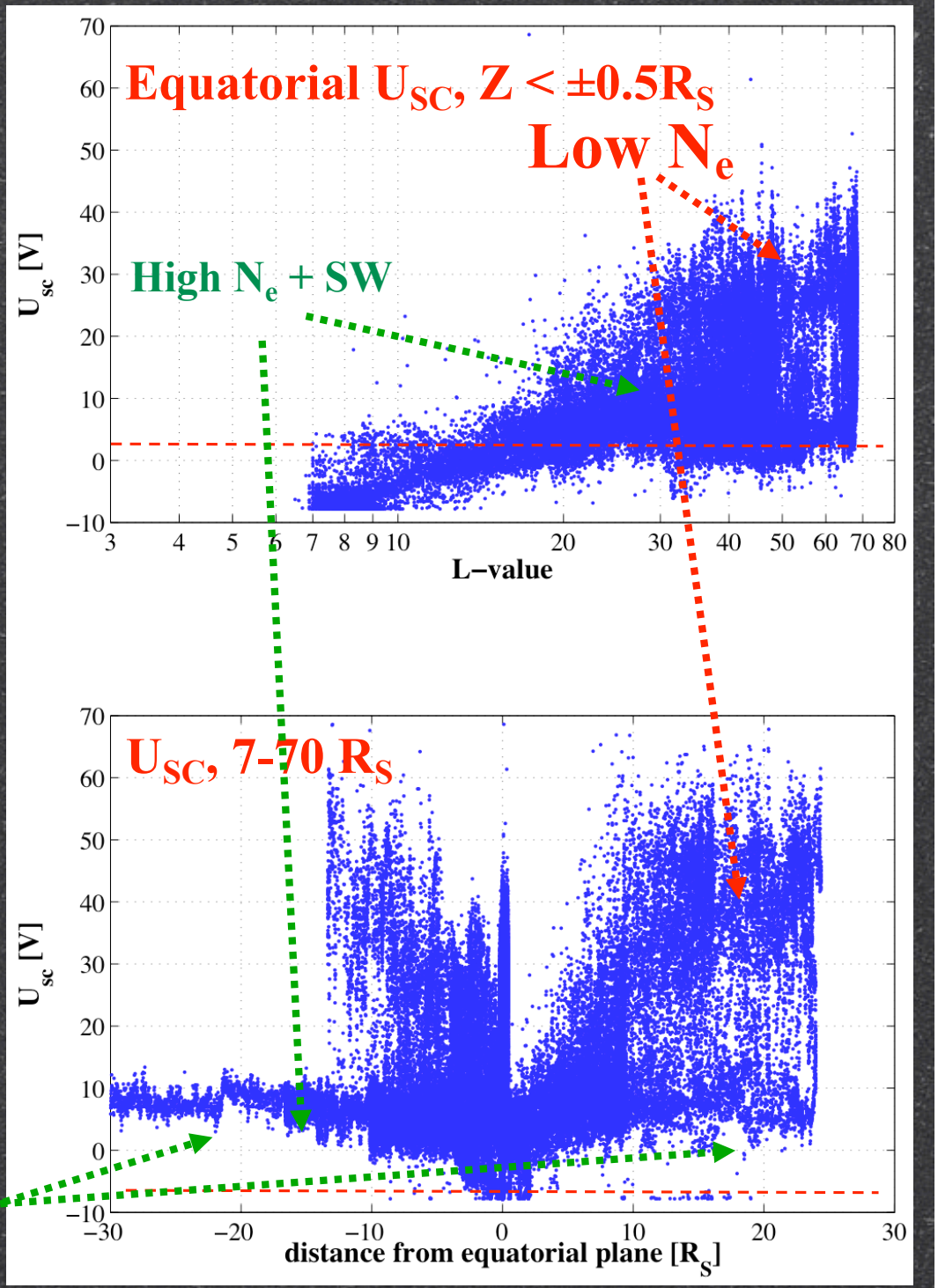




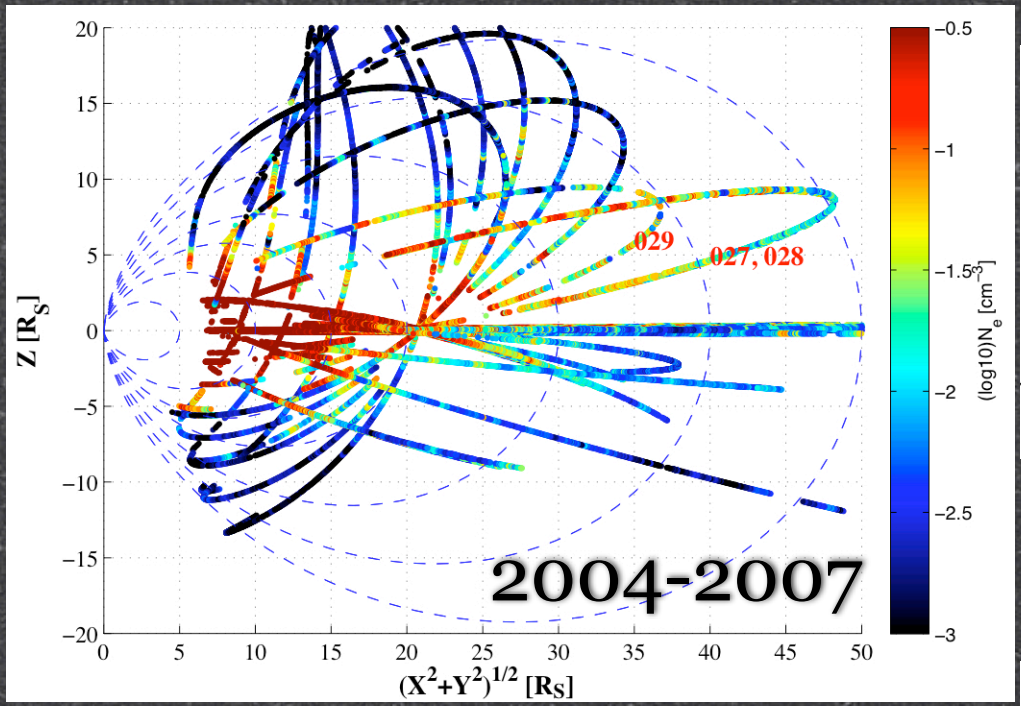


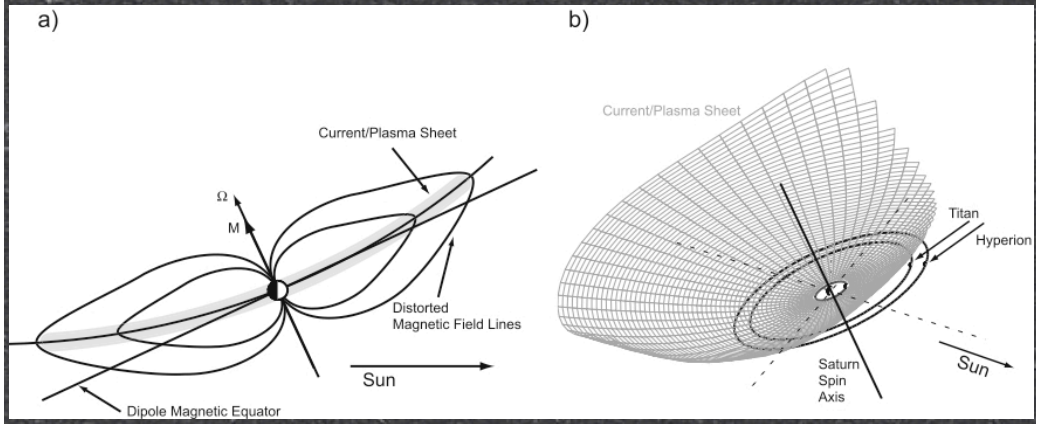
U_{SC} in Saturn's Magnetosphere

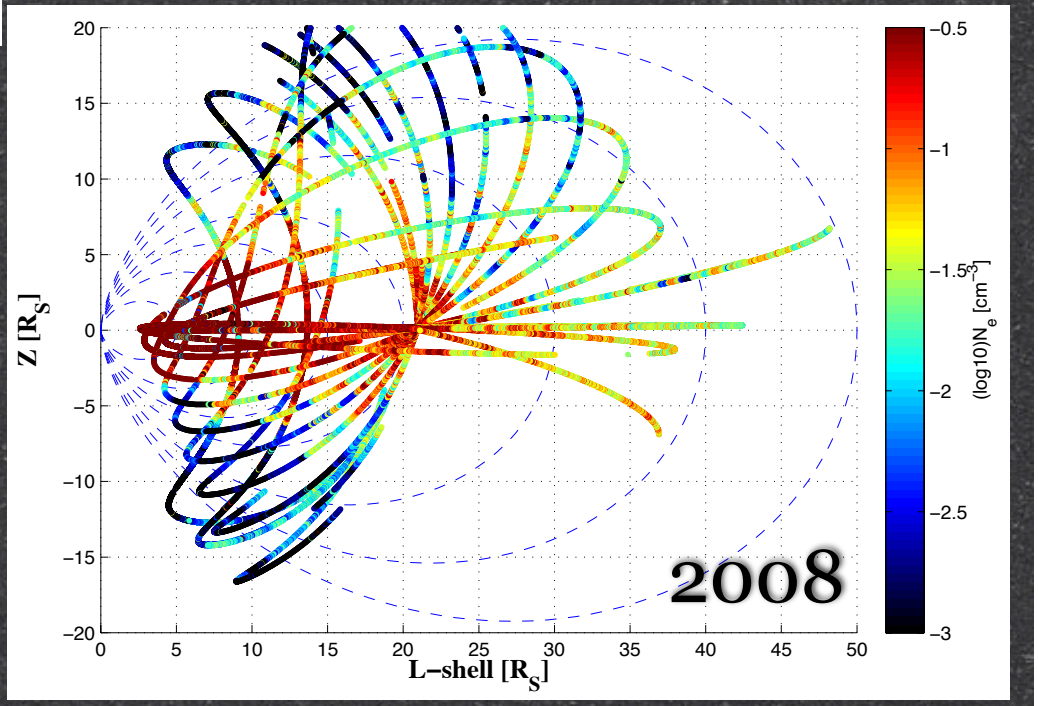
- **Equatorial U_{SC}**
  - **Plasma Disk (<11-14 R_S) : < 0V**
  - **Beyond 11-14 R_S: > 0V**
  - **High N_e: + few V**
  - **Low N_e: +15-40V**
- **Z-dependence:**
  - **Lobe regions: +25V to +60V**
  - **SW: + few V**



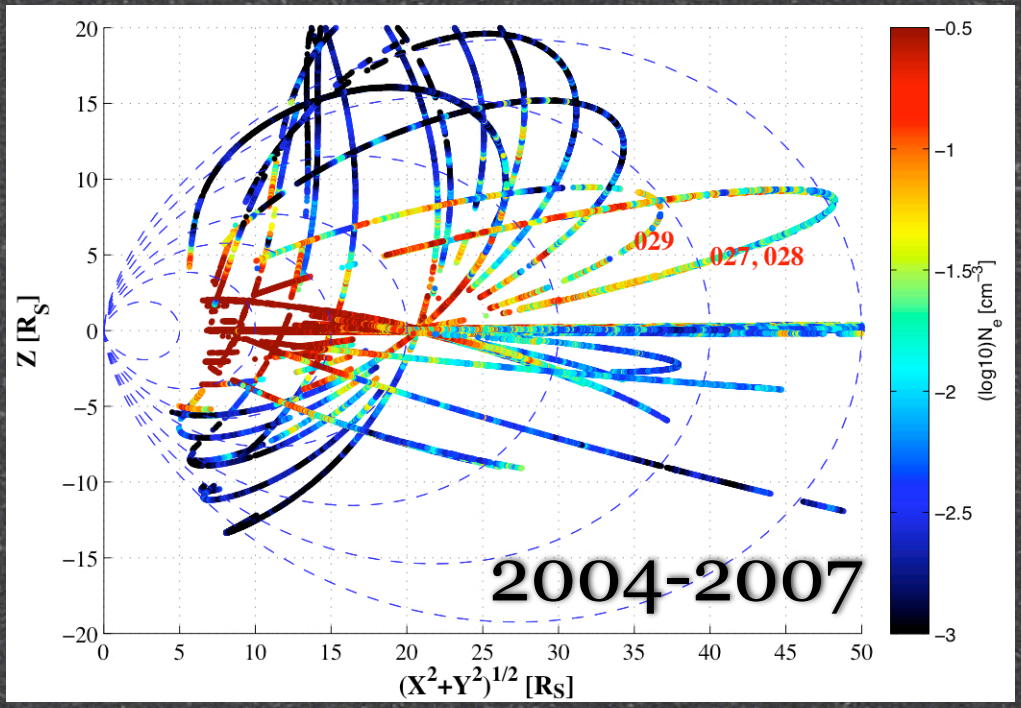
N_e in the Kronian magnetosphere

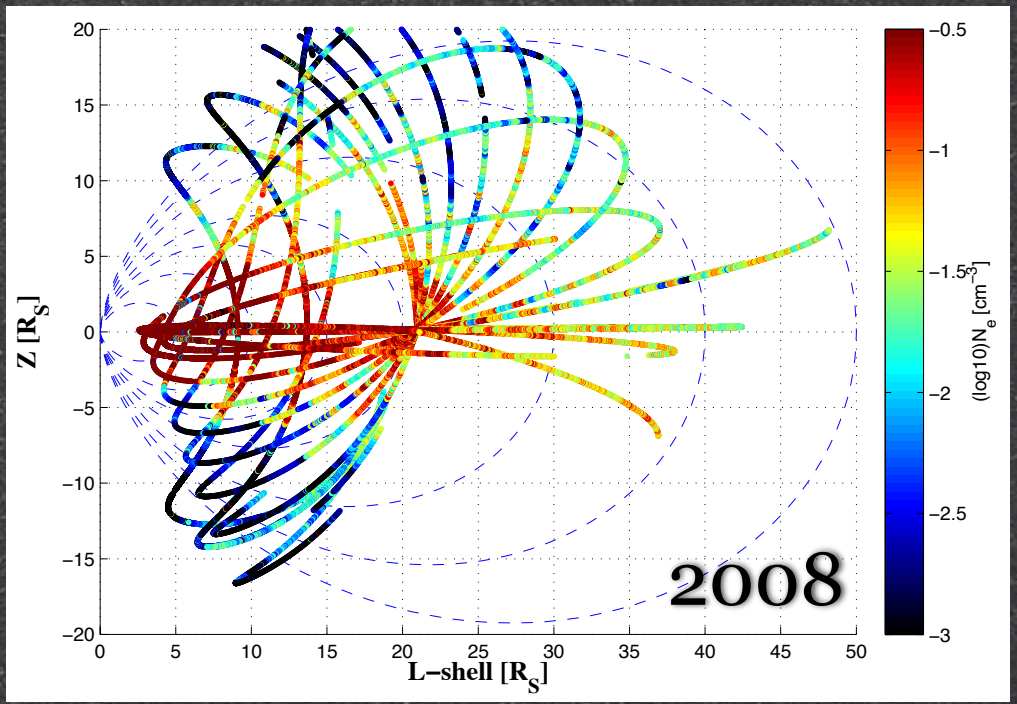


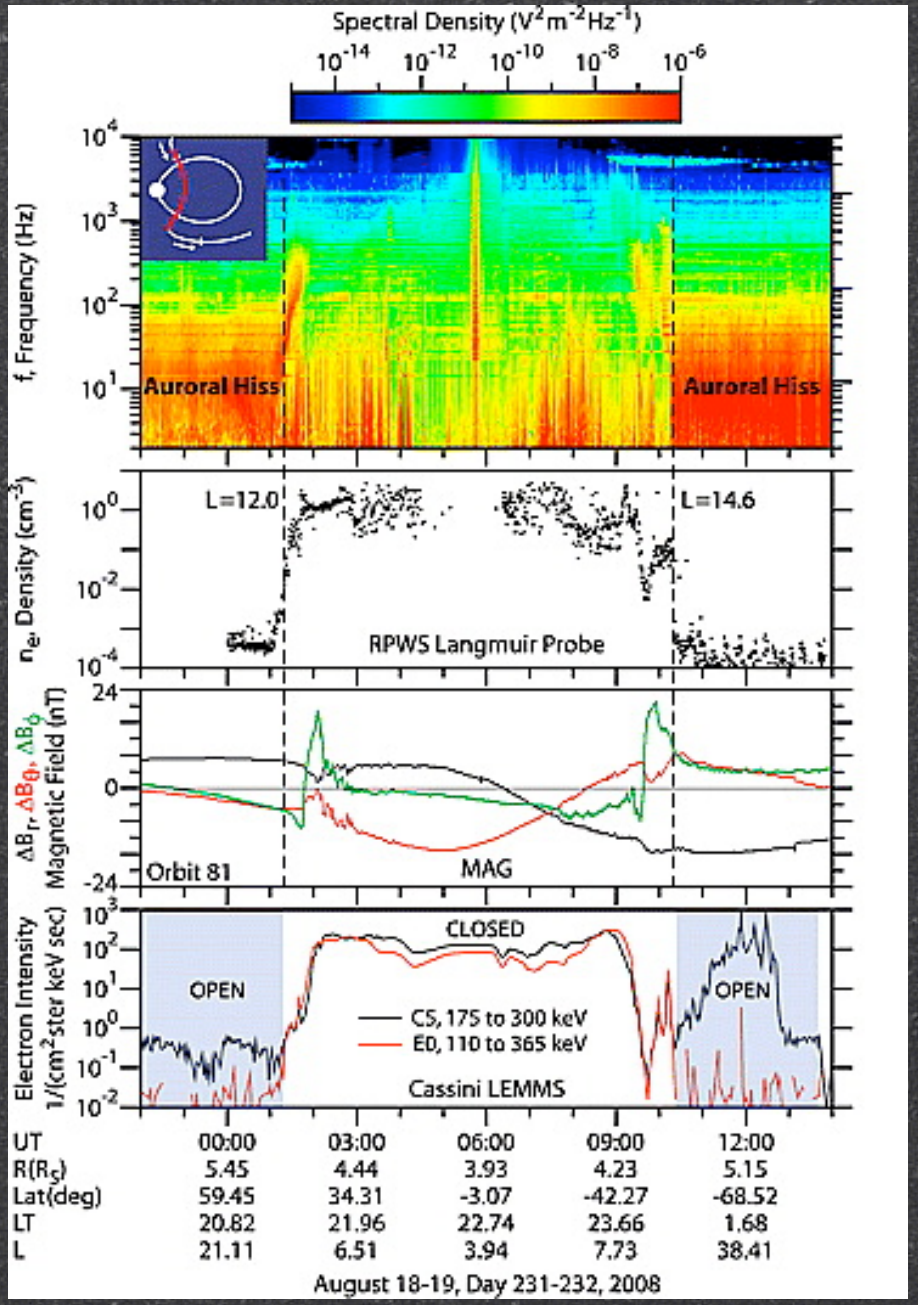




N_e in the Kronian magnetosphere

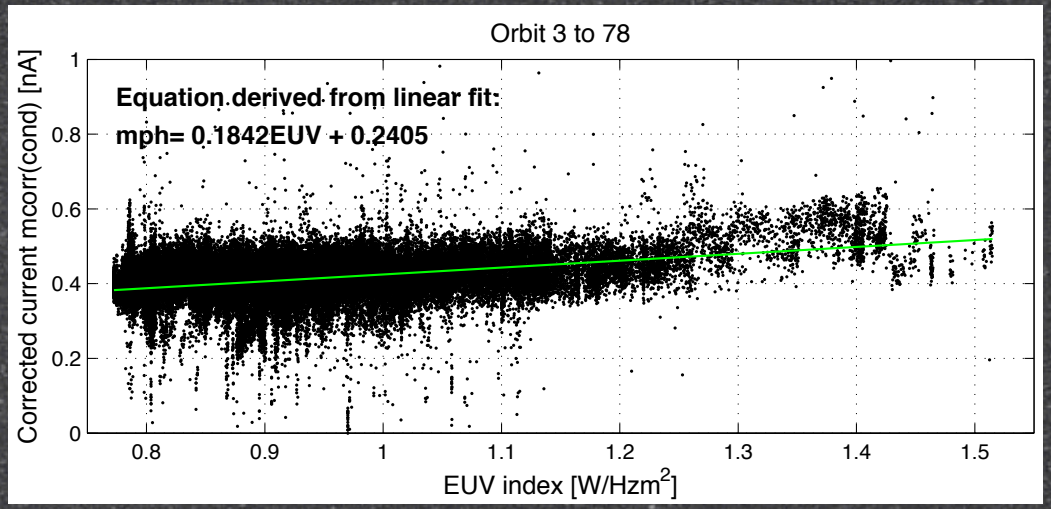


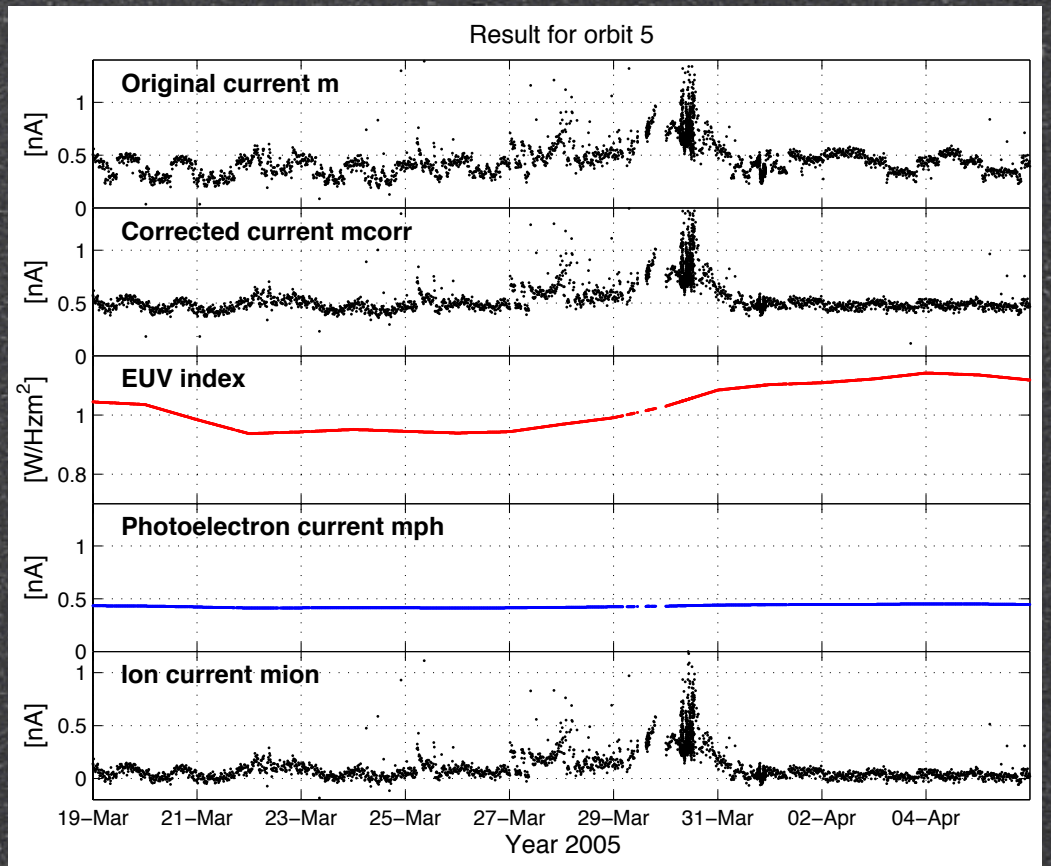




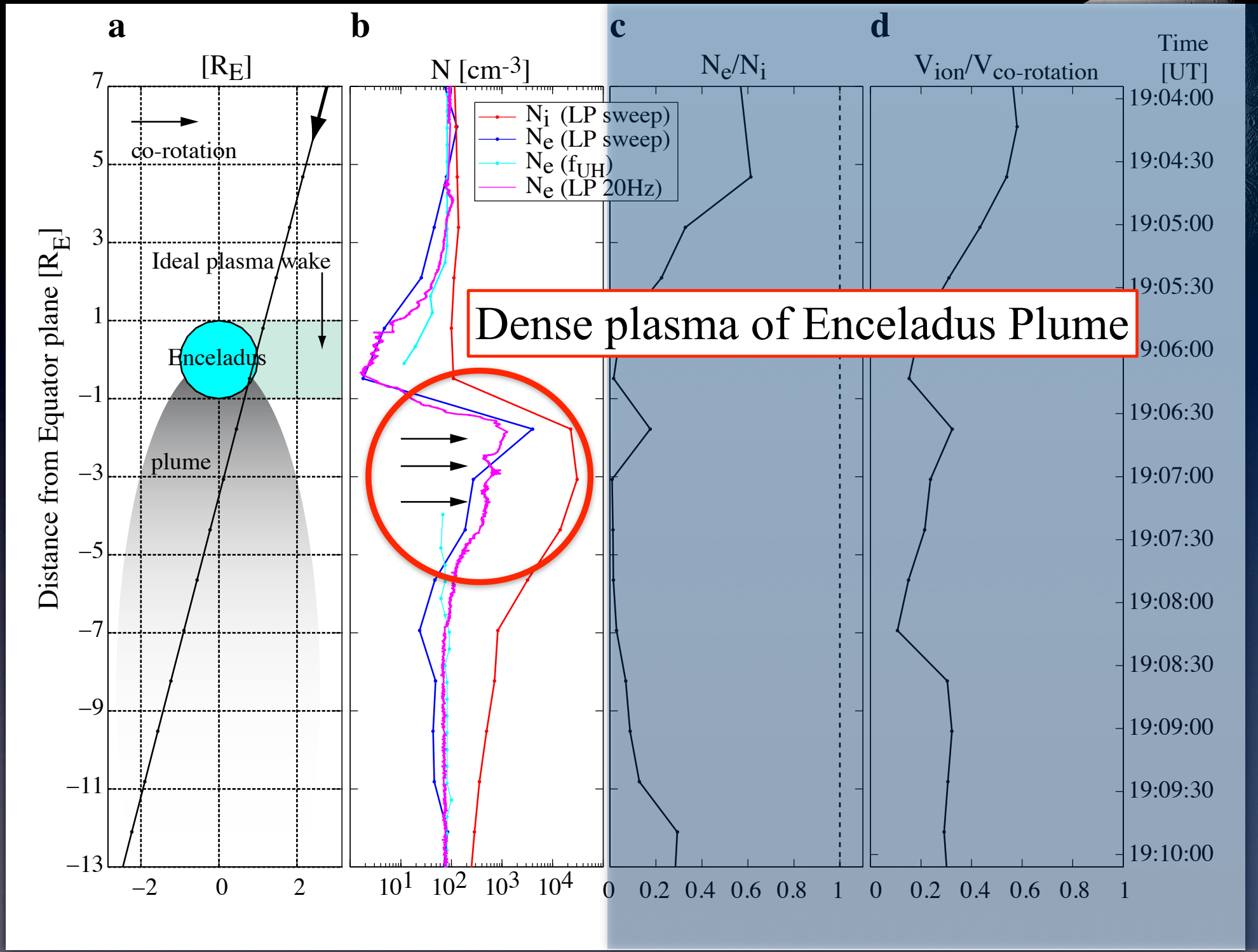
Gurnett et al 2010

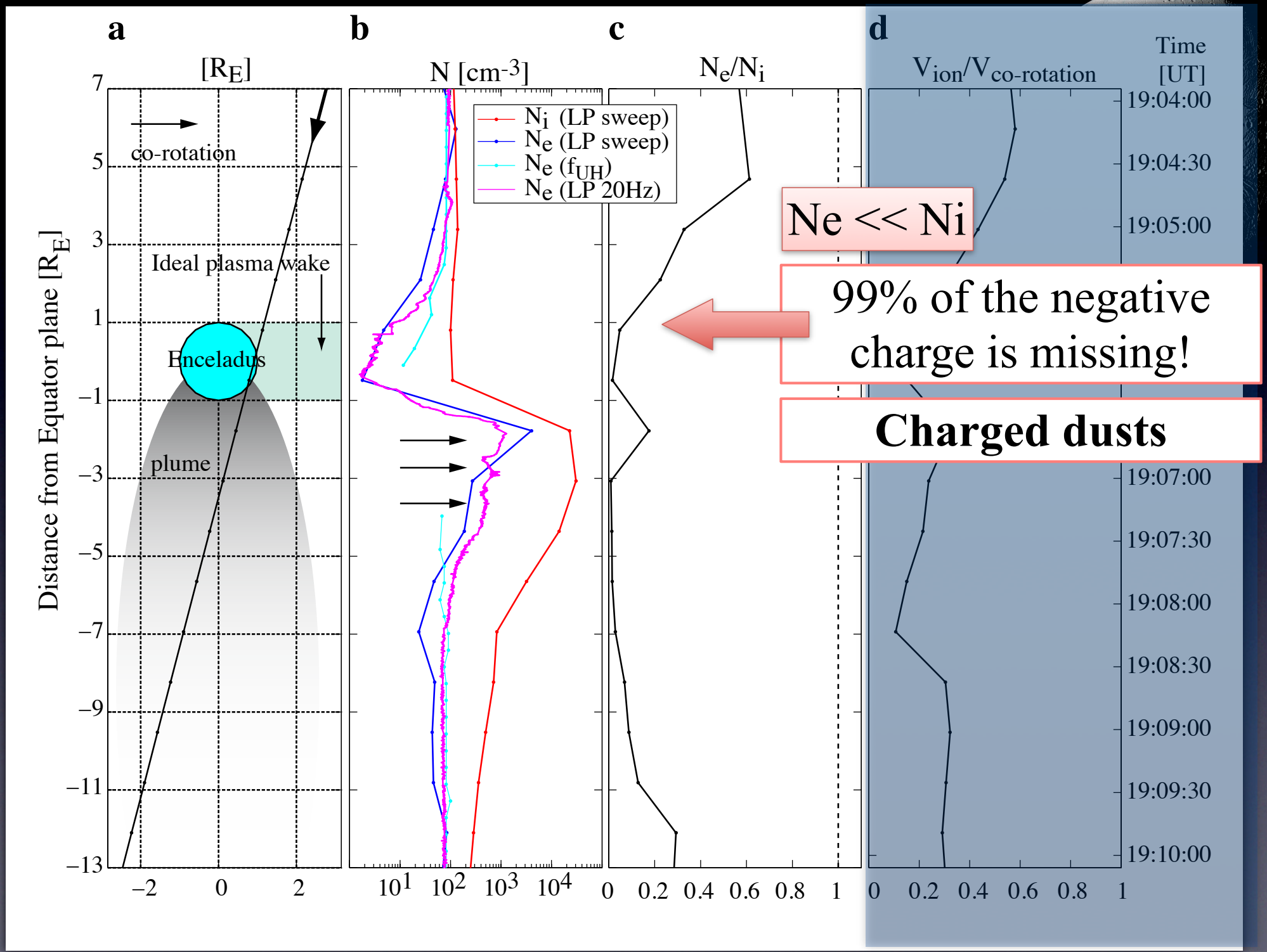
I_{photo} calibration for <V (ion side)



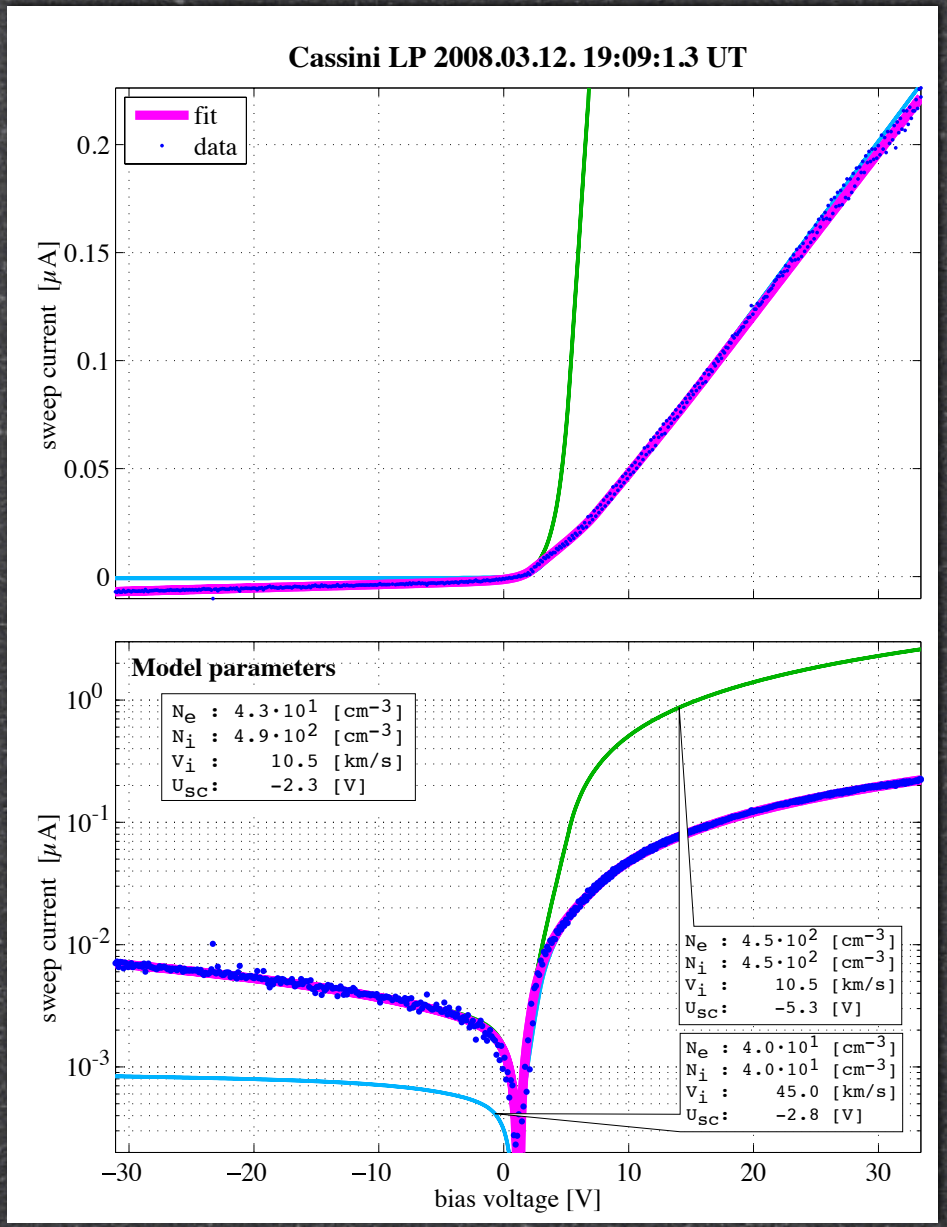


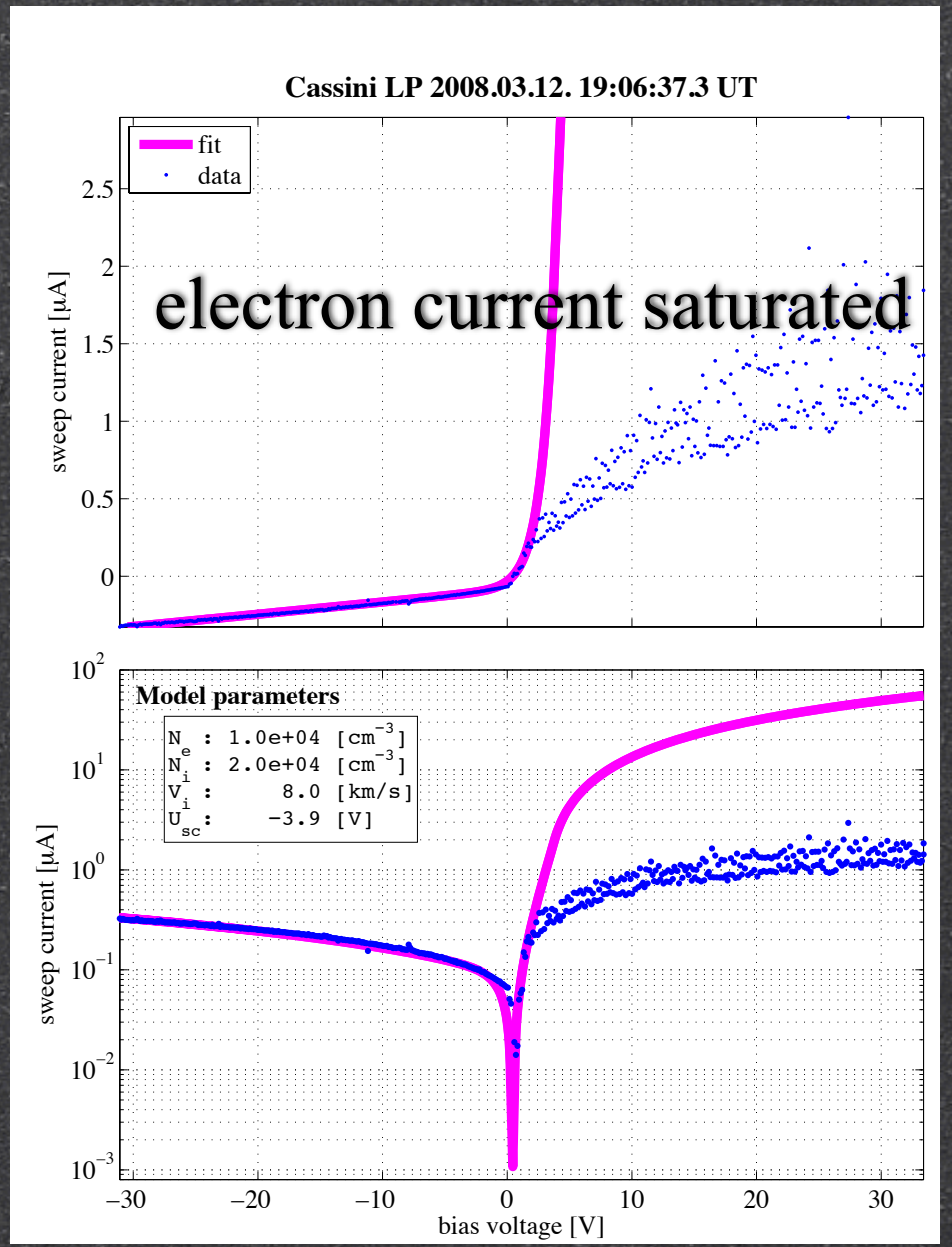
- Linear correlation with solar EUV intensity (F10.7).

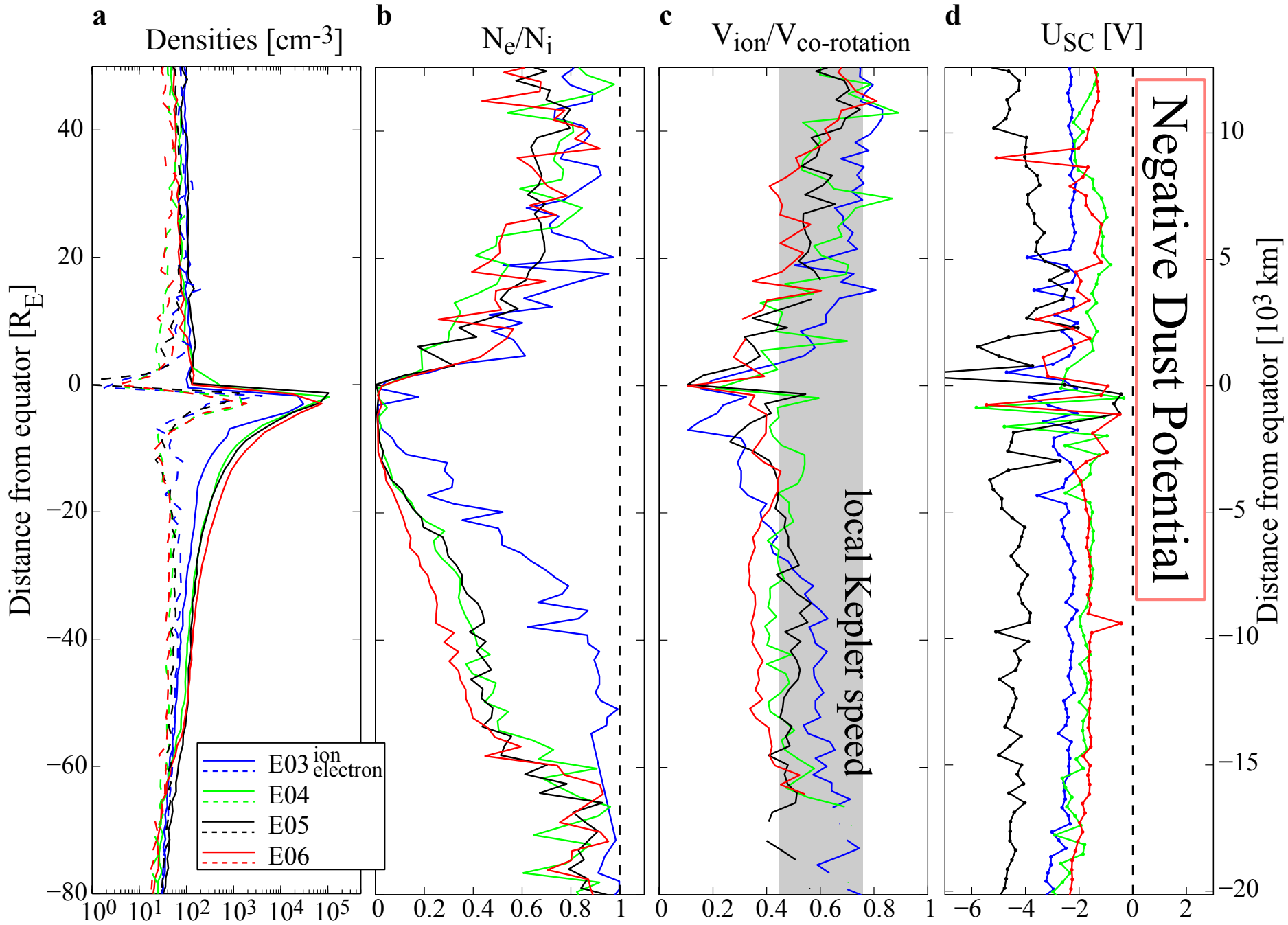

a
b
c
d
[R_E]
N [cm^-3]
N_e/N_i
V_ion/V_co-rotation
Time [UT]
co-rotation
Ideal plasma wake
Enceladus
plume
Distance from Equator plane [R_E]
N_i (LP sweep)
N_e (LP sweep)
N_e (f_UH)
N_e (LP 20Hz)
Dense plasma of Enceladus Plume
7
5
3
1
−1
−3
−5
−7
−9
−11
−13
−2
0
2
10^1
10^2
10^3
10^4
0
0.2
0.4
0.6
0.8
1
19:04:00
19:04:30
19:05:00
19:05:30
19:06:00
19:06:30
19:07:00
19:07:30
19:08:00
19:08:30
19:09:00
19:09:30
19:10:00


a
b
c
d
[R_E]
N [cm^-3]
N_e/N_i
V_ion/V_co-rotation
Time [UT]
co-rotation
Ideal plasma wake
Enceladus
plume
Distance from Equator plane [R_E]
N_i (LP sweep)
N_e (LP sweep)
N_e (f_UH)
N_e (LP 20Hz)
Ne << Ni
99% of the negative charge is missing!
Charged dusts
19:04:00
19:04:30
19:05:00
19:07:00
19:07:30
19:08:00
19:08:30
19:09:00
19:09:30
19:10:00

LP current in dusty plasma






a
Densities [cm-3]
b
Ne/Ni
c
Vion/Vco-rotation
d
USC [V]
Distance from equator [RE]
Distance from equator [10³ km]
ion
electron
E03
E04
E05
E06
local Kepler speed
Negative Dust Potential

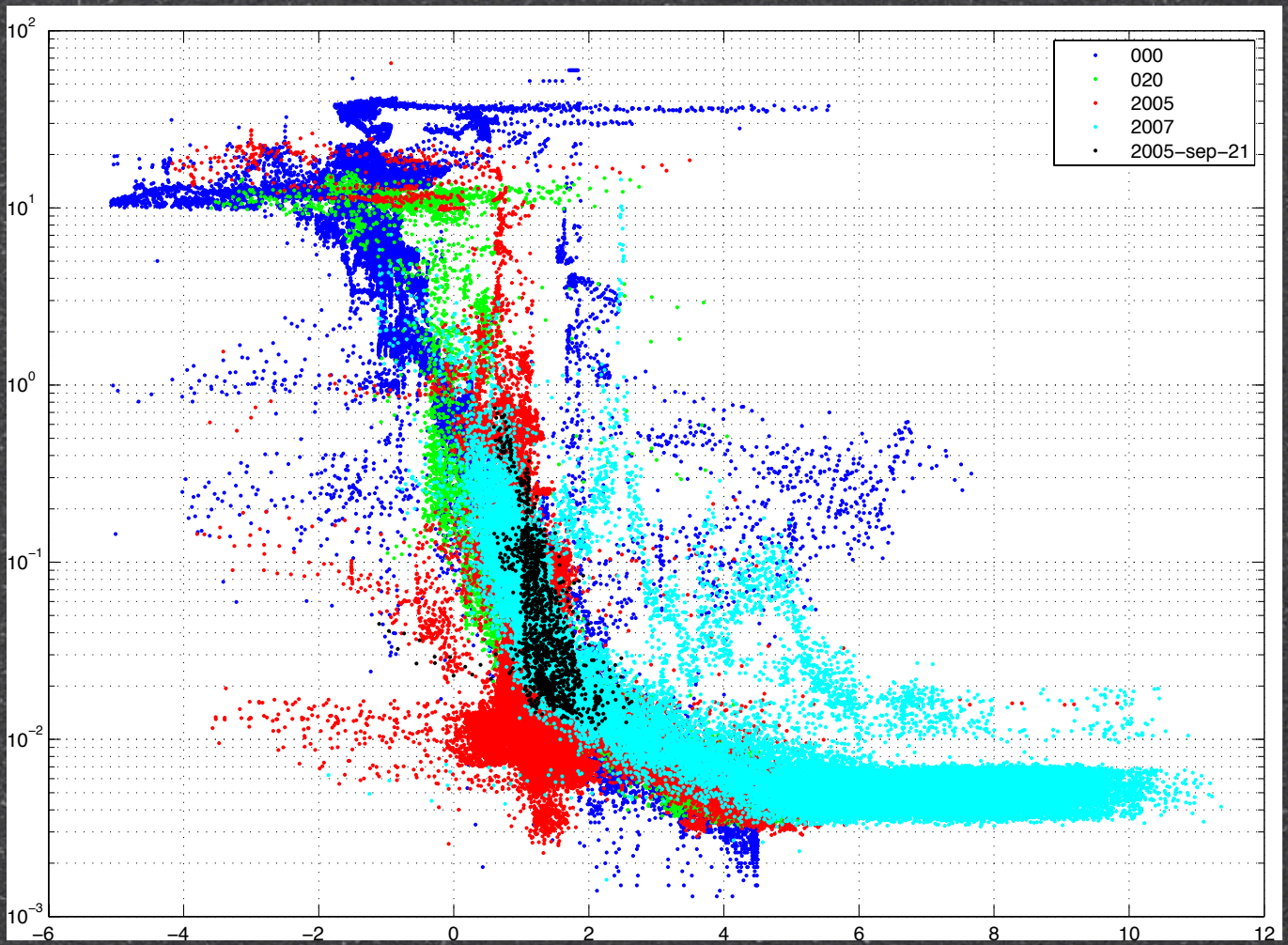
Photoelectron calibration for LP

U_{float} (U_{sc}) calibration

- S/C attitude, and Sun UV, solar wind condition
- Very useful to measure N_e
- U_{sc} can be used as proxy to the charged dust potential
- Additional calibration to understand?
  - High energy particle effect
  - EUV reflected by spacecraft antenna

I_{ion} calibration

- S/C attitude, and Sun UV, solar wind condition


000
020
2005
2007
2005−sep−21
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
−6
−4
−2
0
2
4
6
8
10
12