Ionospheric Drivers of ISS Charging

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Introduction

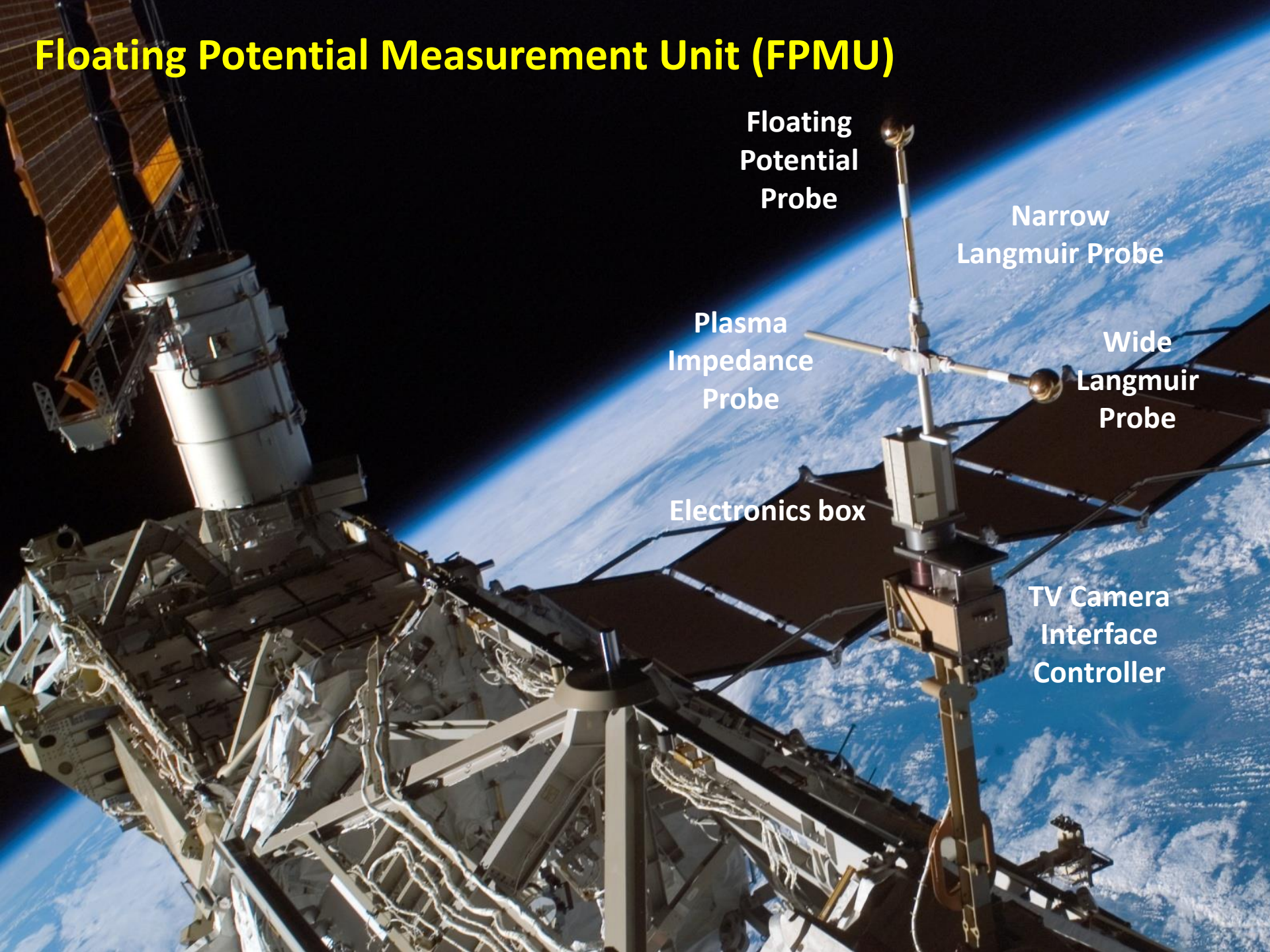
- Severe spacecraft surface charging (100's to 1000's volts) typically results from exposure to electrons with energies of 10's keV:
  - Accelerated auroral electrons at high latitudes in low Earth orbit
  - Hot thermal electrons in the outer magnetosphere during geomagnetic storms

  Predicting surface charging in these environments depends on our ability to specify and forecast auroral acceleration events and geomagnetic storms

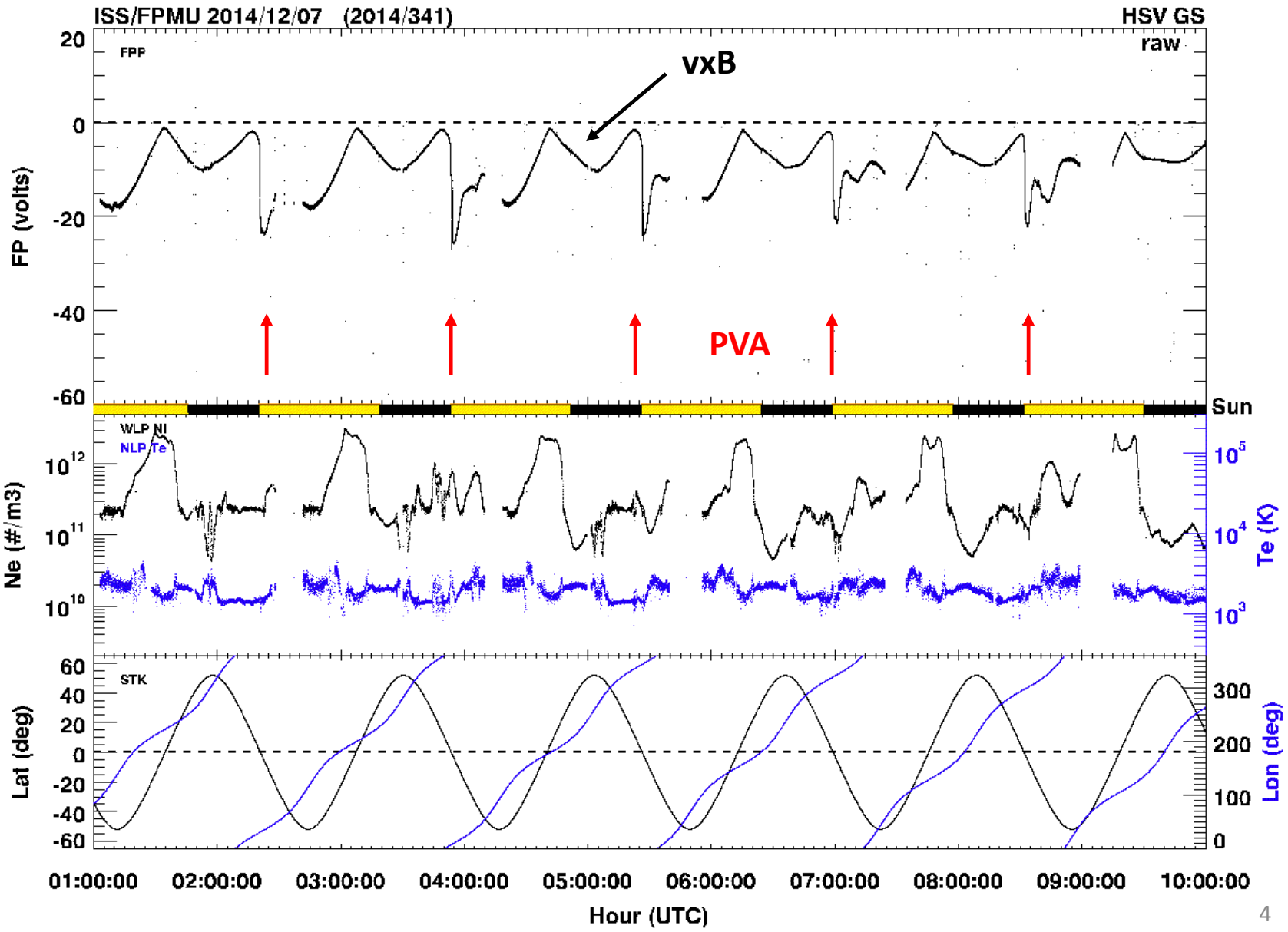
- In contrast, the strongest ISS frame charging to date is dominated by interactions of the US 160 V solar arrays with the ionospheric plasma environment
  - Predicting the dominant ISS charging requires forecasting components of ionospheric variability of importance to high voltage solar array interactions with the plasma environment.

- Today's presentation will describe the ionospheric conditions responsible for some of the more interesting ISS solar array charging events…

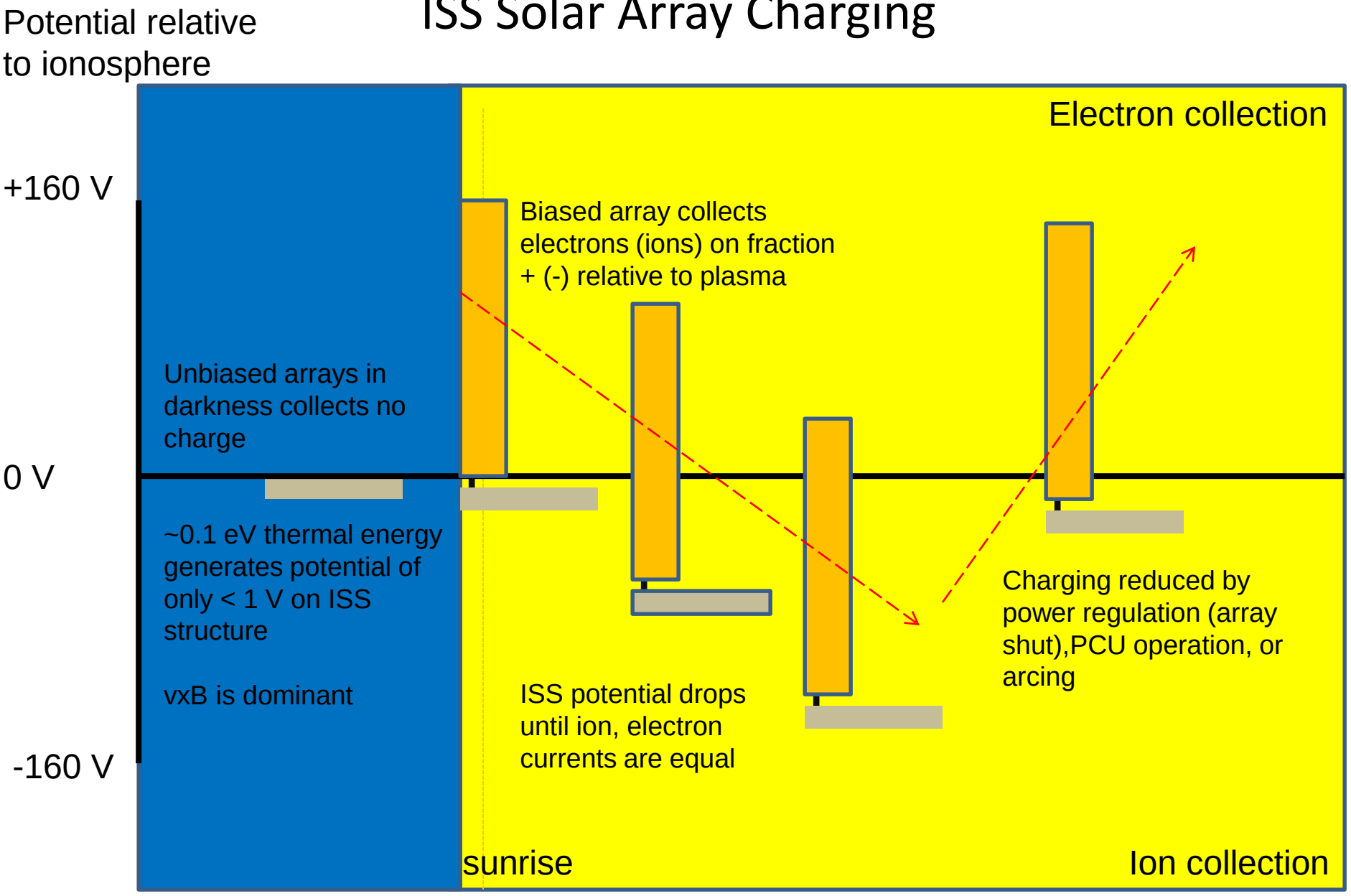
Floating Potential Measurement Unit (FPMU)



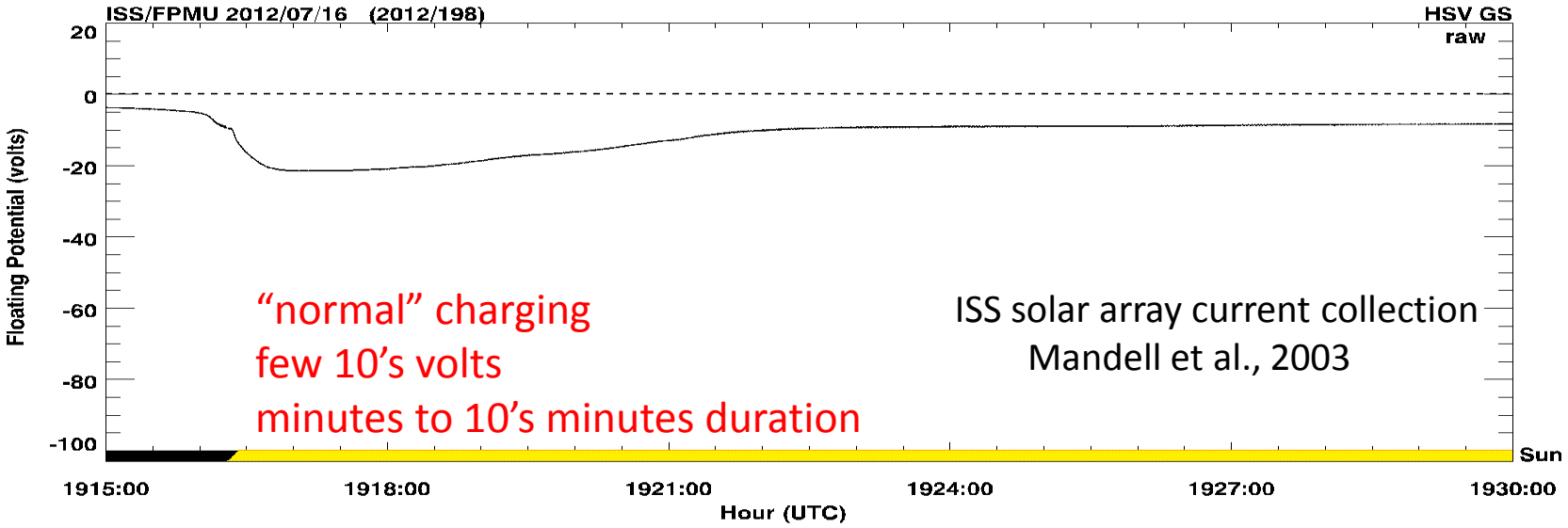
ISS Frame Charging



ISS Solar Array Charging

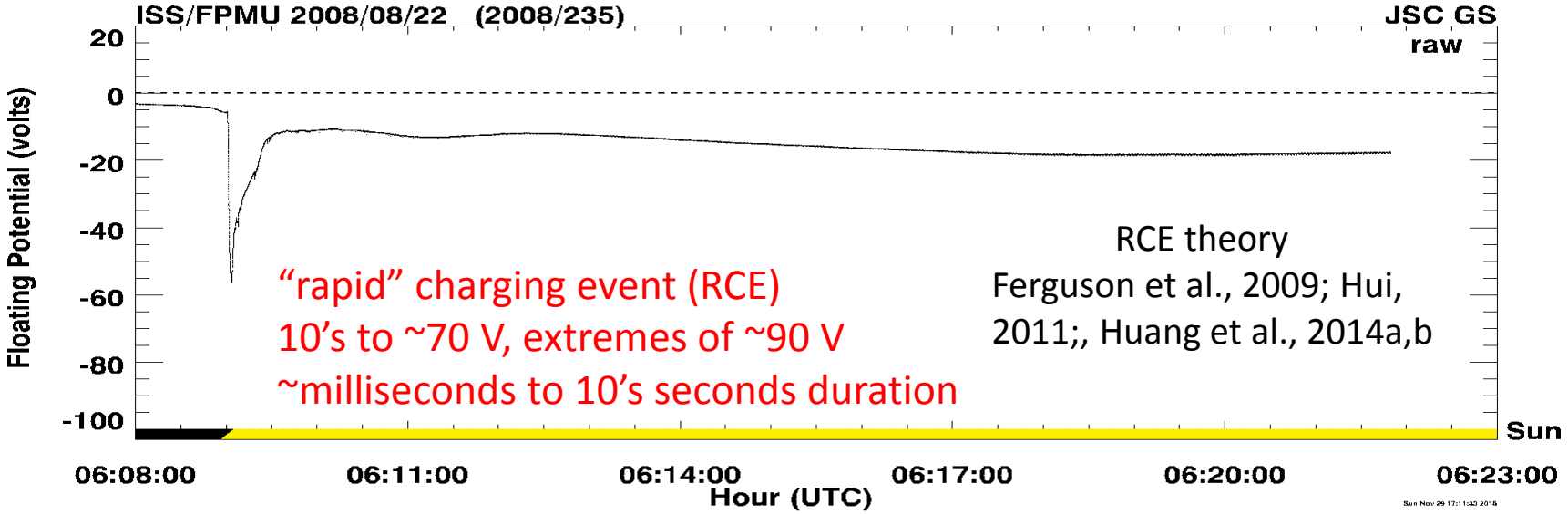


ISS Normal and Rapid Charging Events



"normal" charging
few 10's volts
minutes to 10's minutes duration

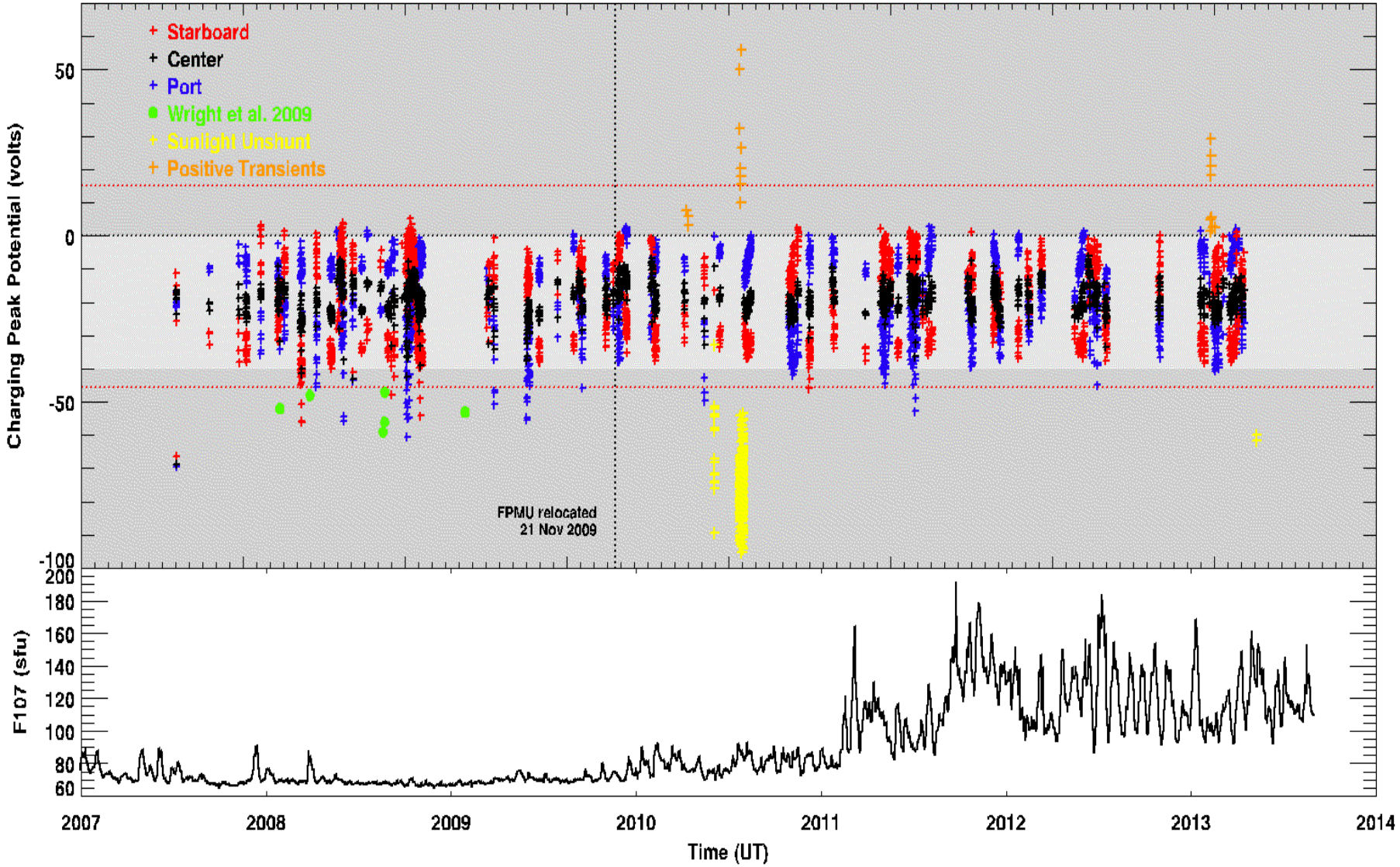
ISS solar array current collection
Mandell et al., 2003



"rapid" charging event (RCE)
10's to ~70 V, extremes of ~90 V
~milliseconds to 10's seconds duration

RCE theory
Ferguson et al., 2009; Hui, 2011;, Huang et al., 2014a,b

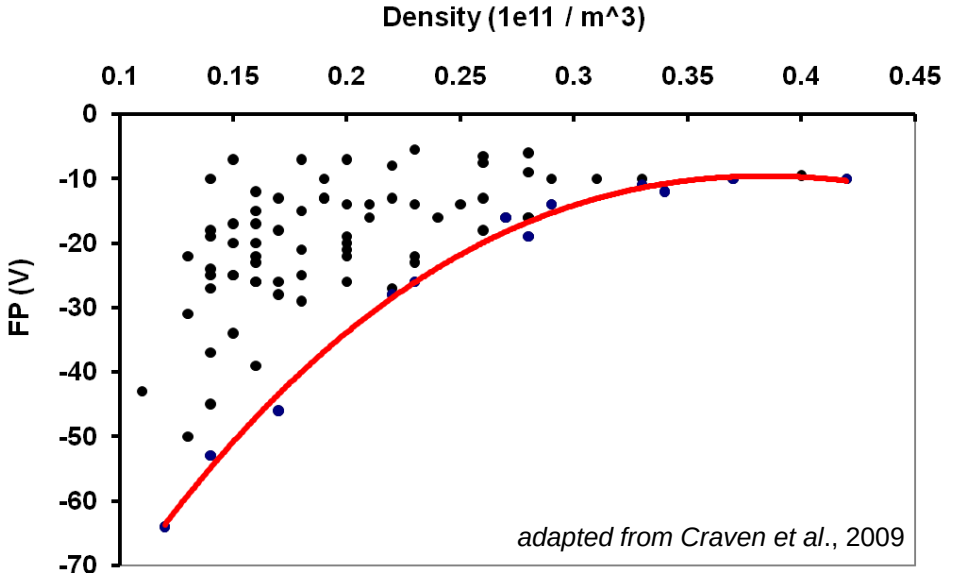
FPMU Charging Events



[*Iannello et al.*, 2014]

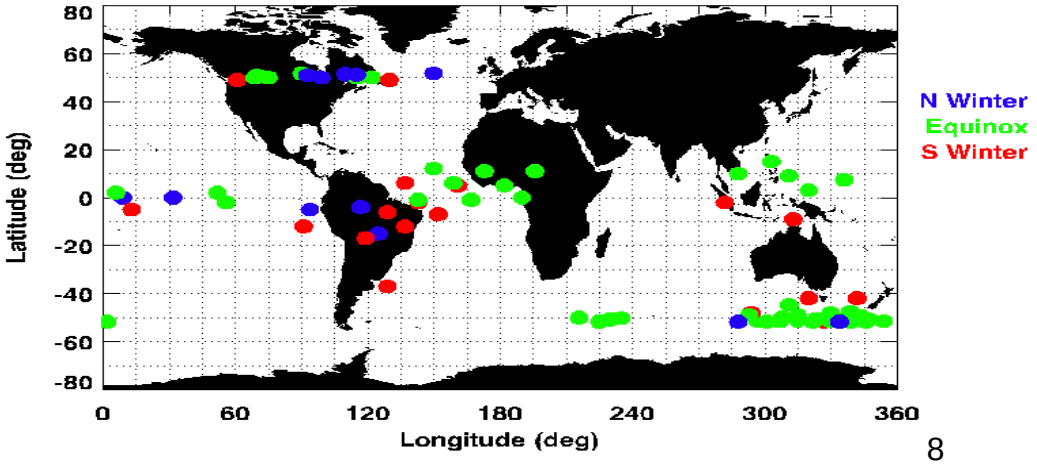
Conditions for RCE Formation

- The magnitude of the potential minimum is inversely related to density
- Scatter is due to umbra duration, solar array attitude, and other variables



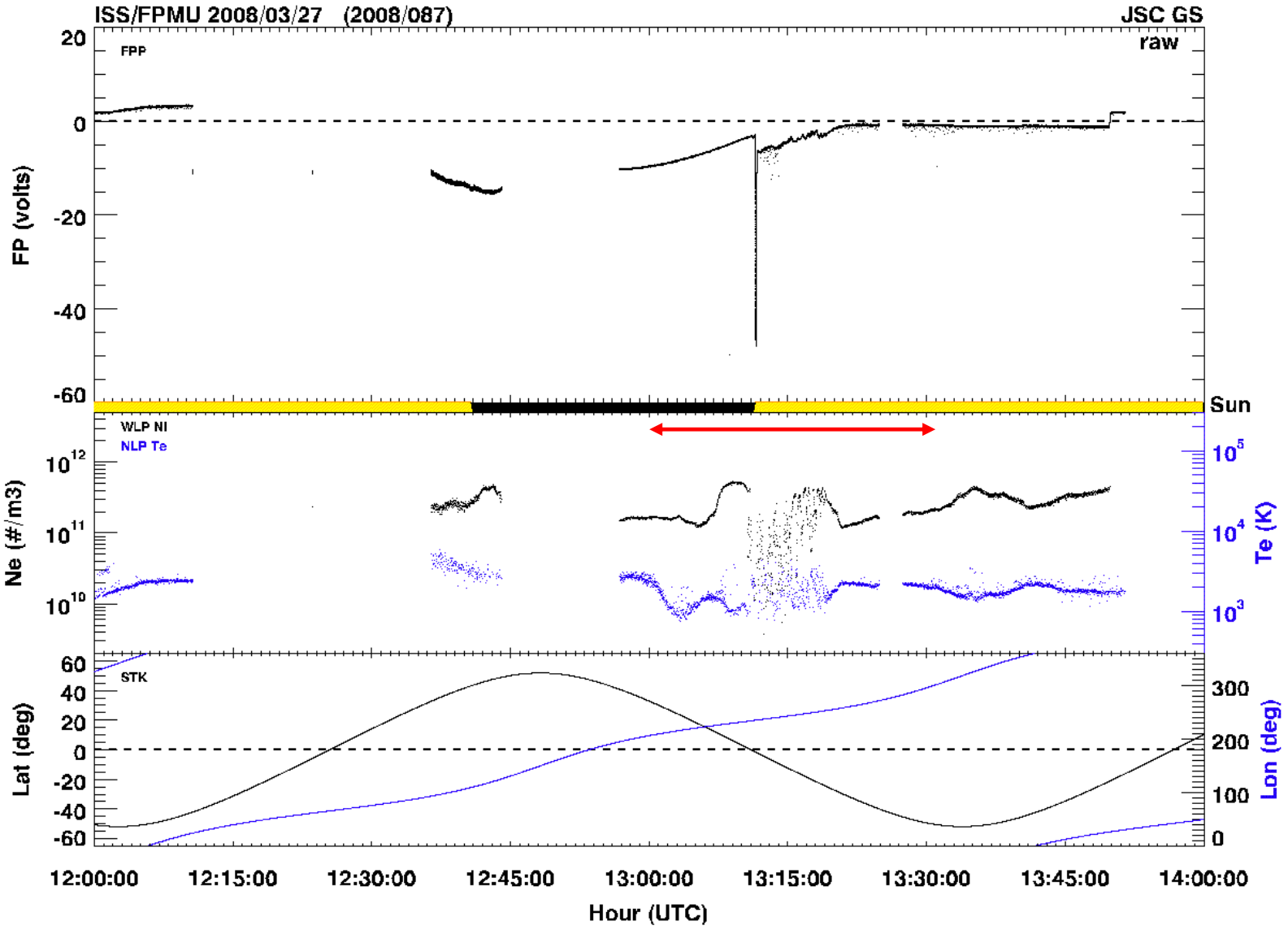
- RCE's are observed in relatively low density plasma environments
- The low density environments occur in two distinct geographic regions
  - plasma troughs at high latitude
  - dawn plasma density depletion in the dawn equatorial ionosphere*

RCE Events Jan 2007 – Feb 2009

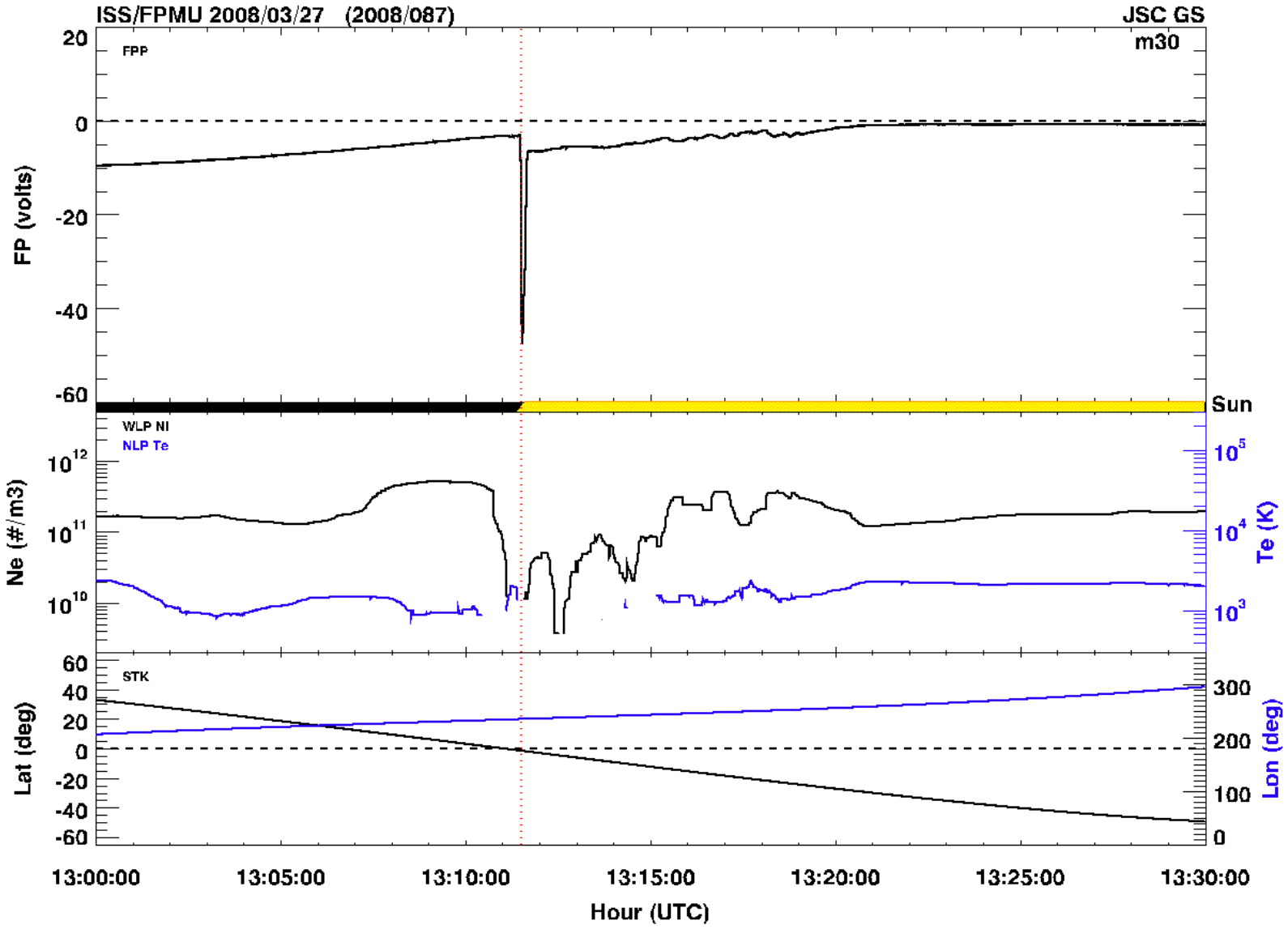


* *Burke et al.*, 1979; *Aggson et al.*, 1995; *de la Beaujardiere et al.*, 2009; Burke et al., 2009; Huang et al., 2009; Su et al., 2009; Gentile et al., 2011

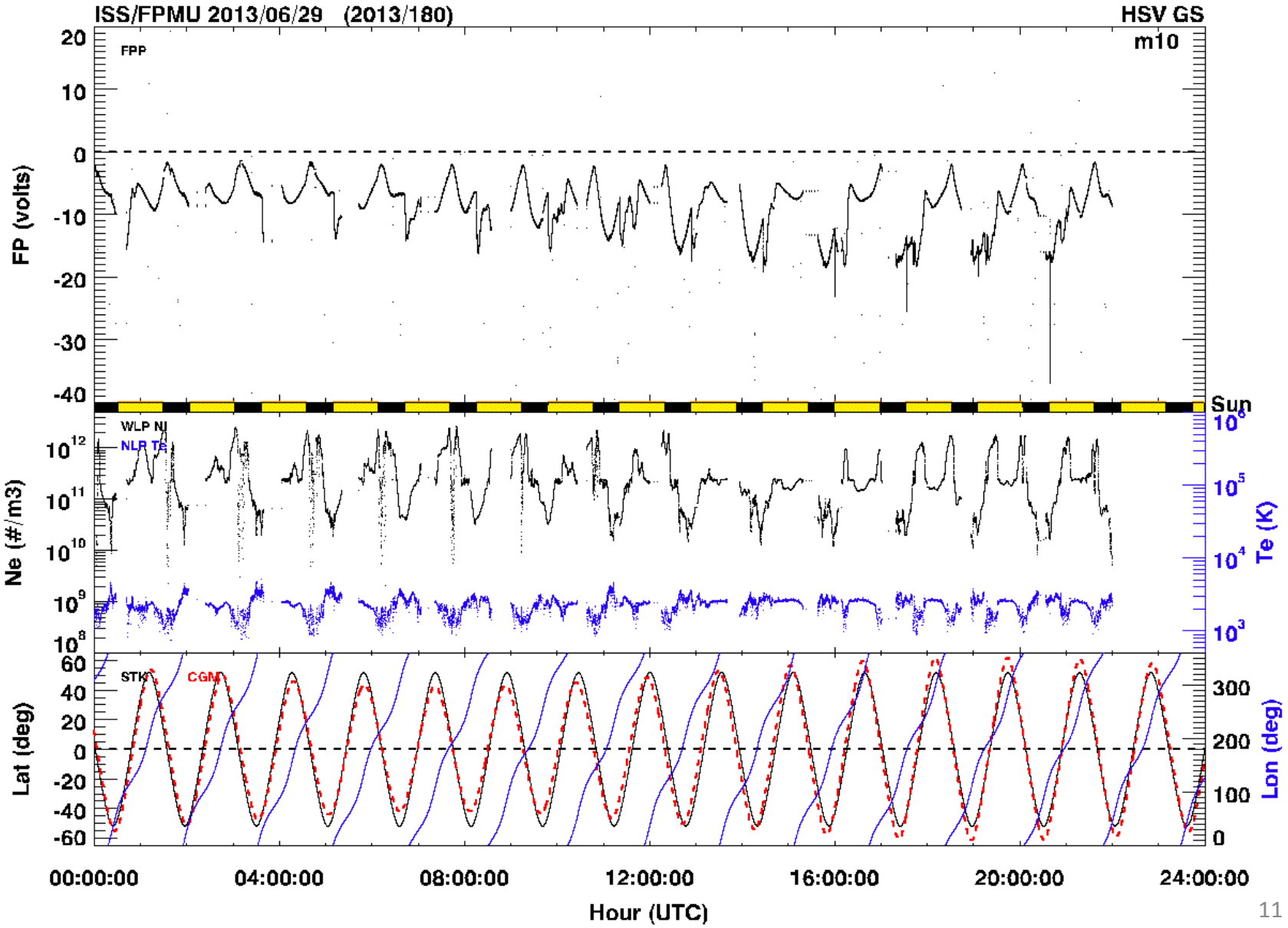
Dawn Plasma Density Depletions



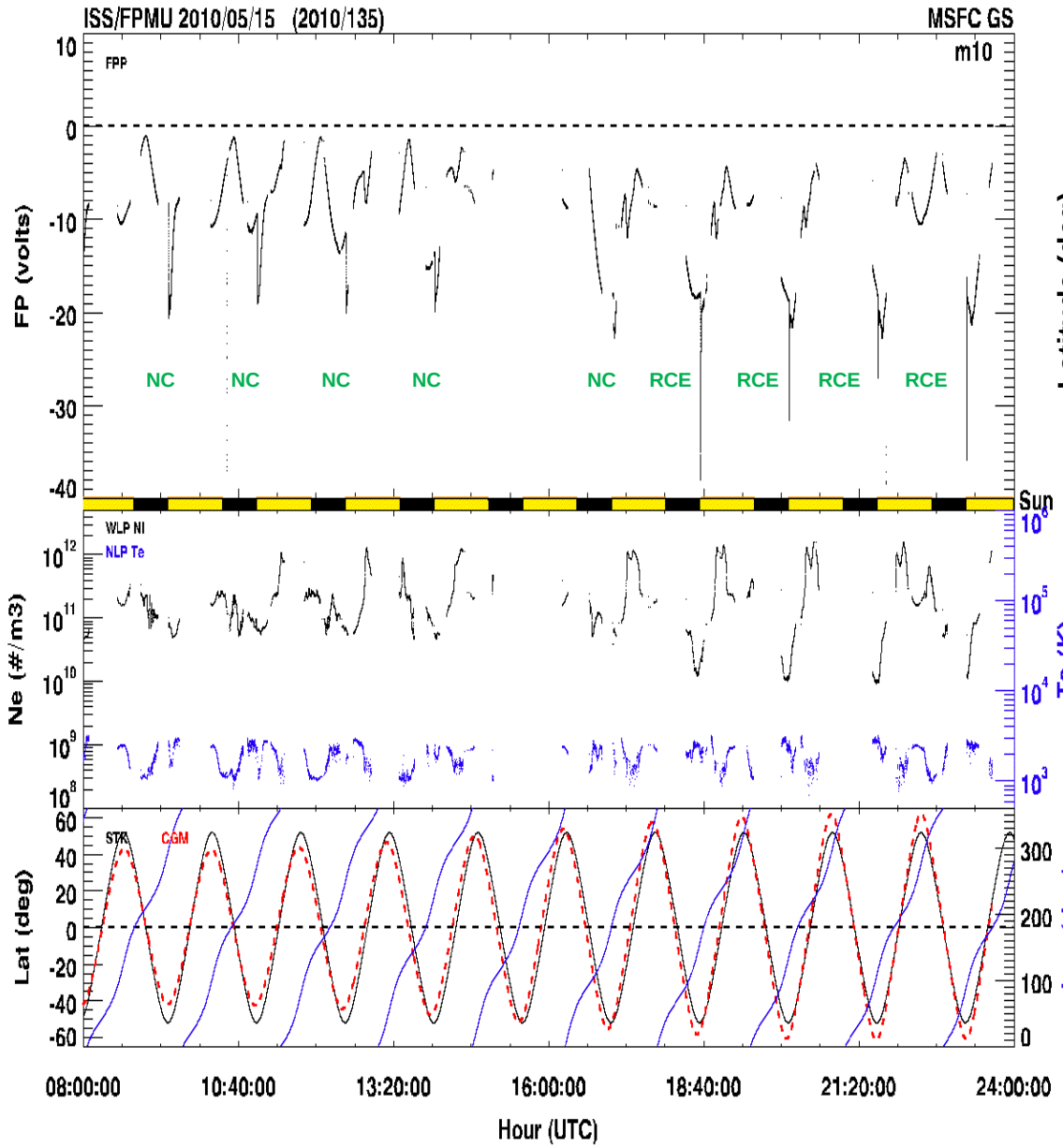
Dawn Plasma Density Depletions

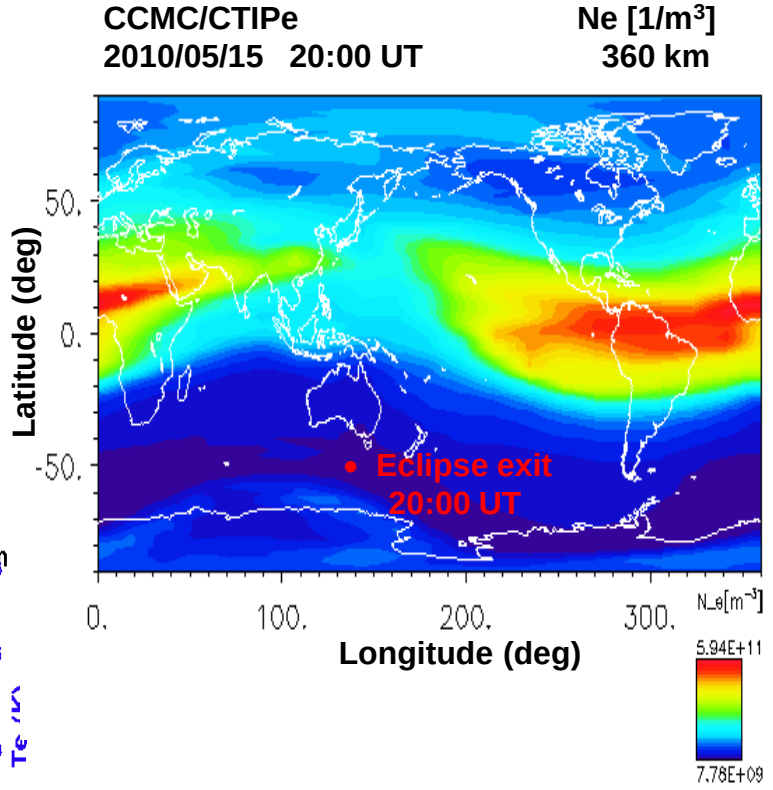


High Latitude, Ion Trough



RCE in High Latitude Ion Trough

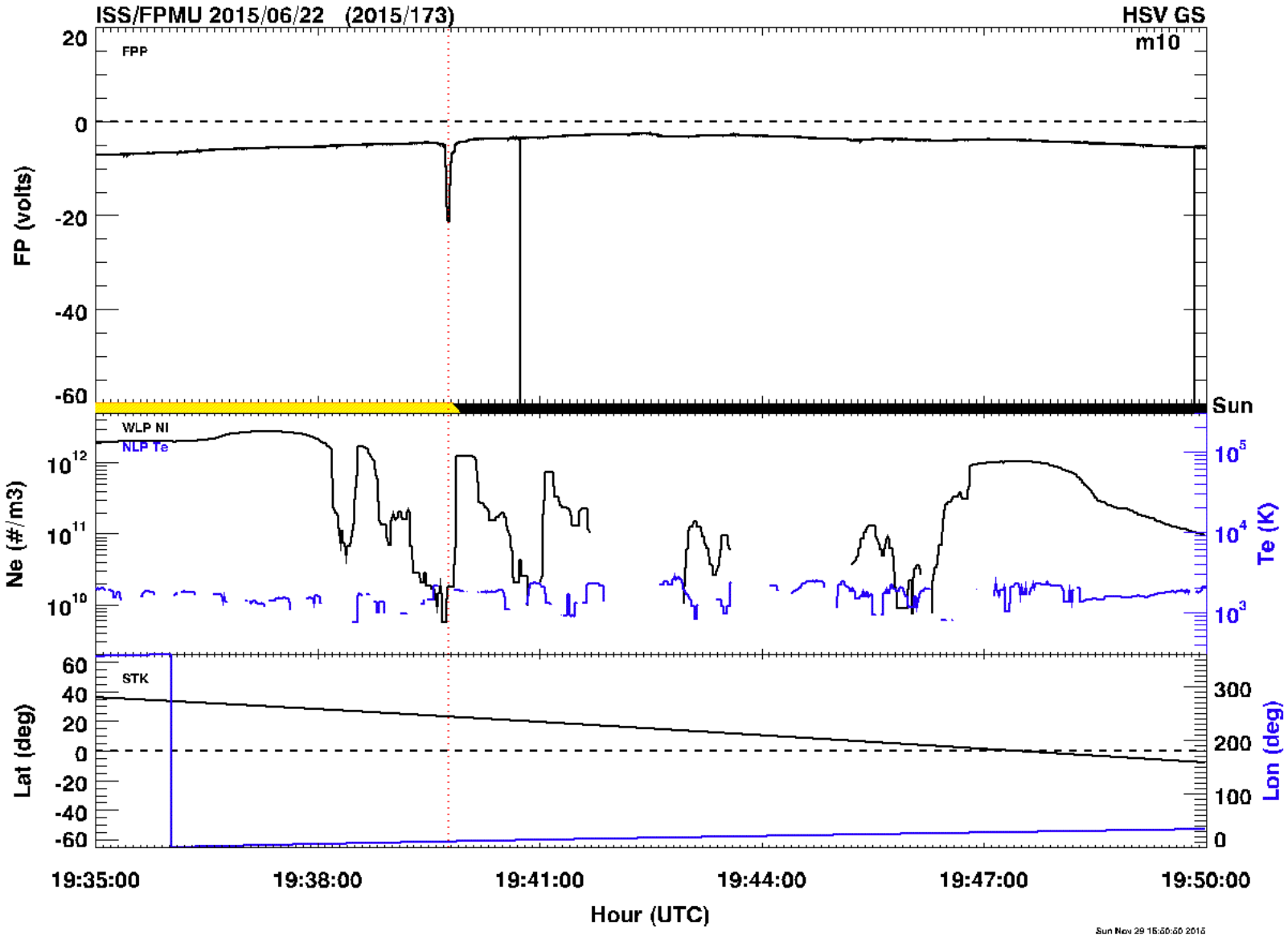




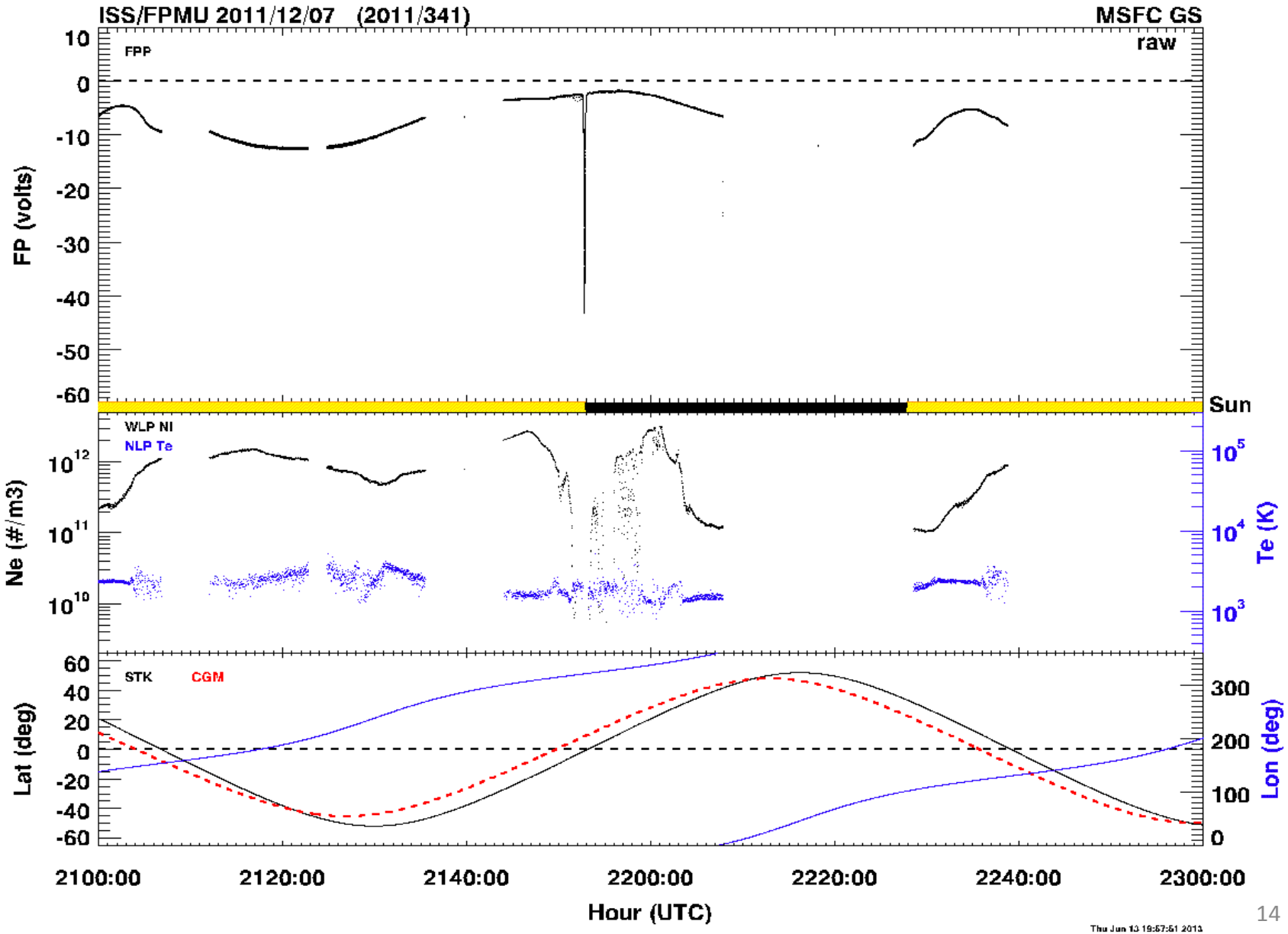
Eclipse exits occur in southern hemisphere, winter conditions for this example

Normal charging events until ISS encounters Ne depletions in high latitude plasma trough

Eclipse Entry Charging, Plasma Depletions



Eclipse Entry Charging, Plasma Depletion



Conclusions

- Large ISS transient charging events typically occur in regions of plasma density depletions

- Forecasting strong ISS charging requires predicting
  - High latitude plasma troughs
  - Dawn density depletions
  - Equatorial spread-f