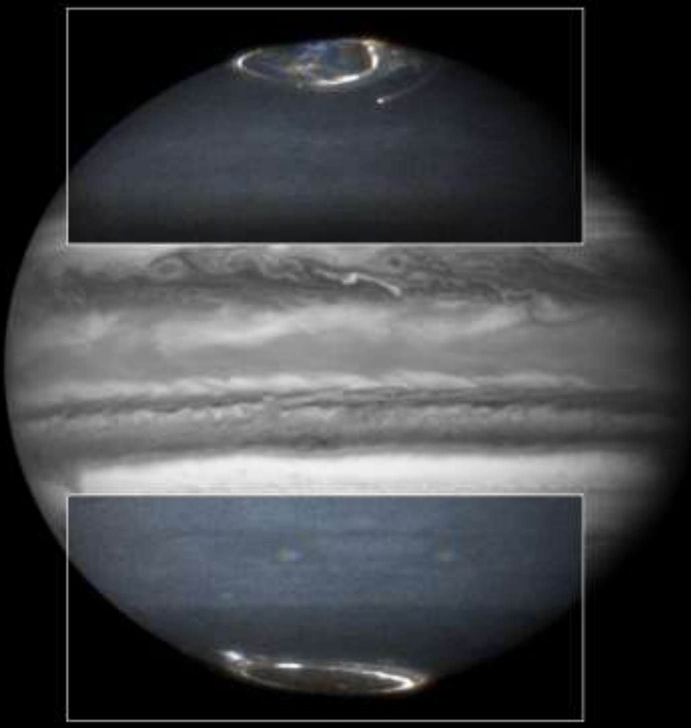
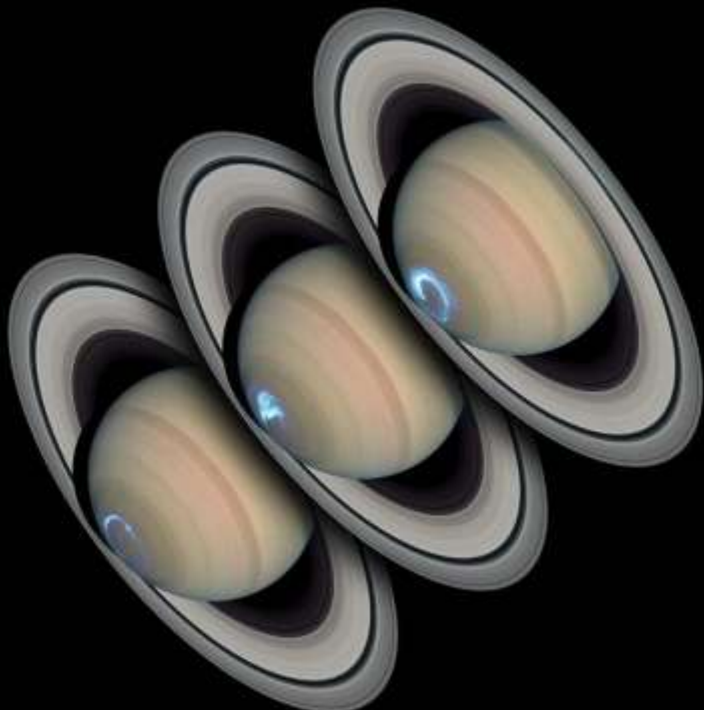
The Variability of Auroral Emissions on Jupiter and Saturn

Magnetospheres
of the Outer Planets
14 July 2011 - Boston





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HST Auroral Campaign(s):

Jupiter:	Feb/March 2007	May/June 2007
Saturn:	Jan 2007	Feb 2008

~3000 images obtained, essentially daily imaging over a month during each of the 4 campaigns

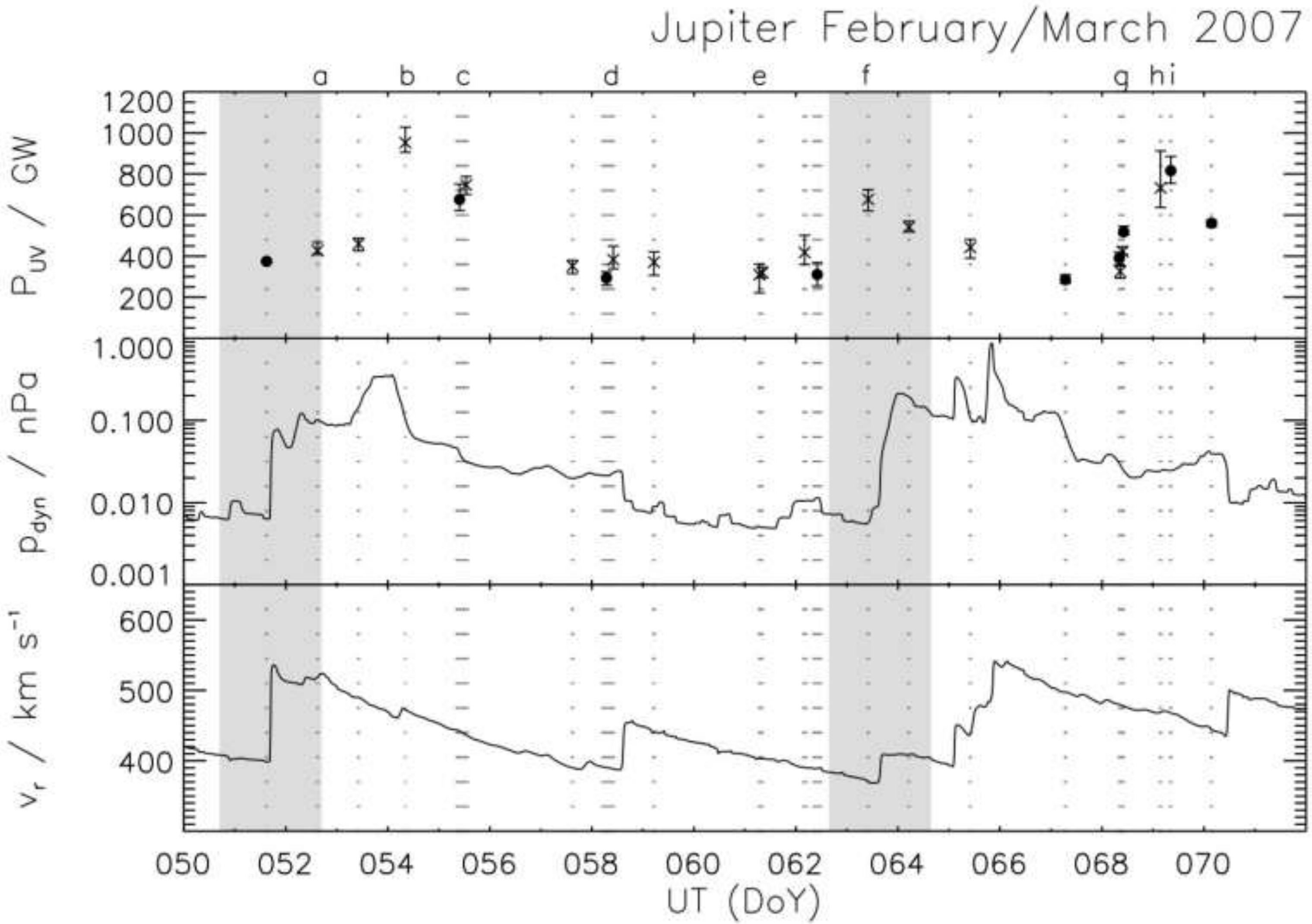
This extensive data set makes possible many quantitative assessments of correlations and comparisons with other measurements (radio emissions, plasma properties, etc.)

All imaging data are available on our web site at BU:

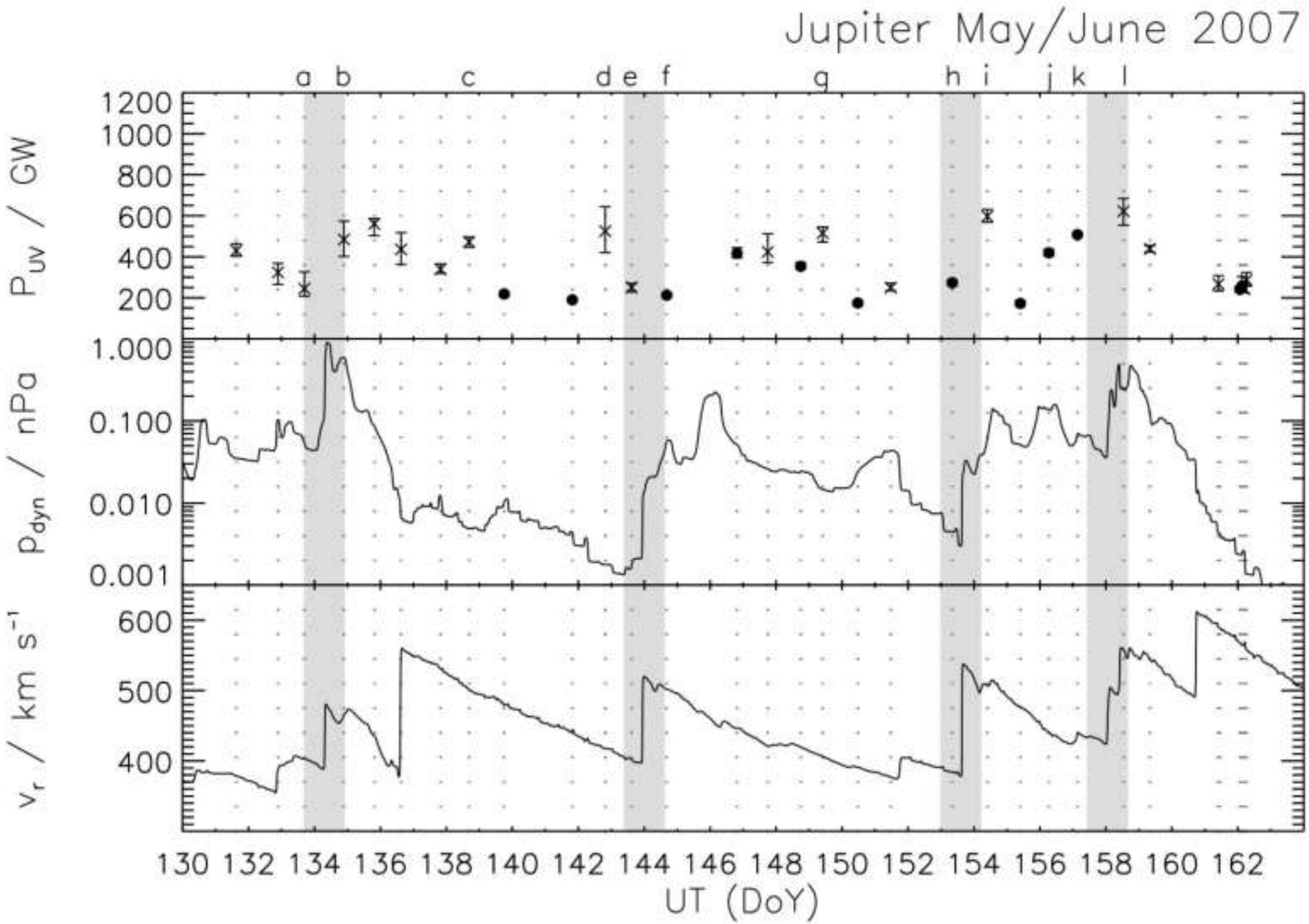
http://www.bu.edu/csp/PASS/main.html

We recommend that you first download the movies…

Comparison of Jupiter Aurora with Solar Wind during New Horizons flyby in 2007:



Comparison of Jupiter's Aurora with Solar Wind in second campaign, near opposition in 2007:



Summary of Jupiter's Auroral Correlations with Solar Wind

Jupiter's overall auroral power is driven mainly by the main oval brightness, with increases seen from specific regions.

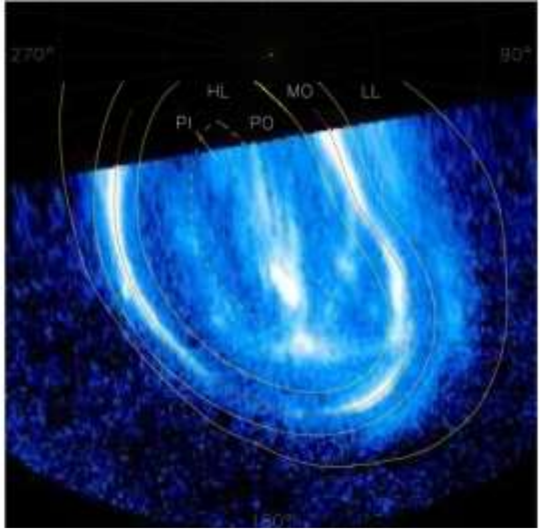
Based on two historical events and 6 events from this campaign, the arrival of a solar wind shock is consistent with a brightening of the main oval (subject to some uncertainty in arrival times).

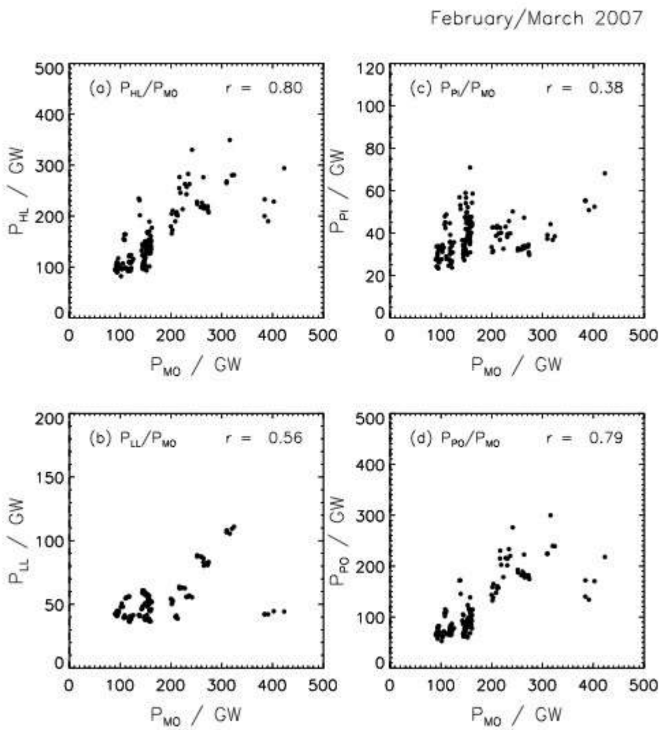
Solar wind velocity increases with a pressure *decrease* have *not* been seen to correlate with auroral brightening (based on 3 events from this campaign).

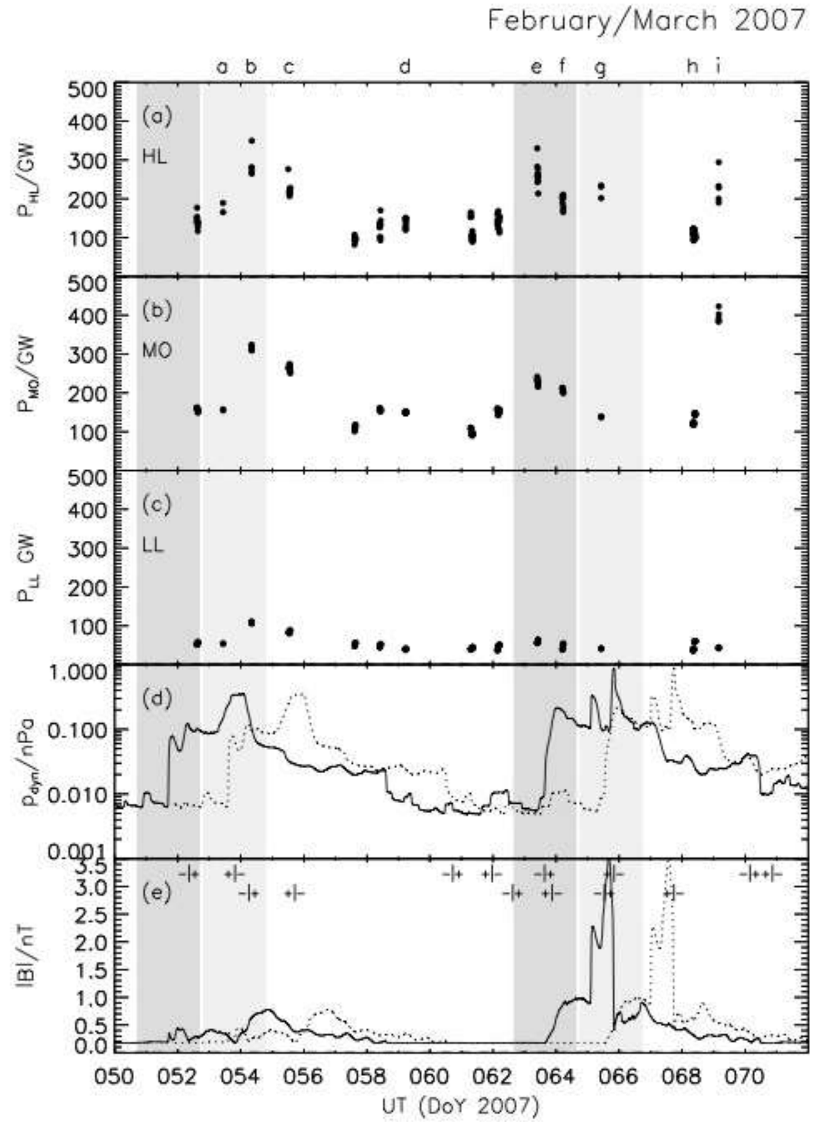
Dawn storms can occur at times of quiet solar wind conditions (based on 2 events from this campaign, with some uncertainty in arrival times).

[J.T. Clarke *et al.*, *JGR,* doi:10.1029/2008JA013694, 2009]

Variations of the Components of Jupiter's Aurora:





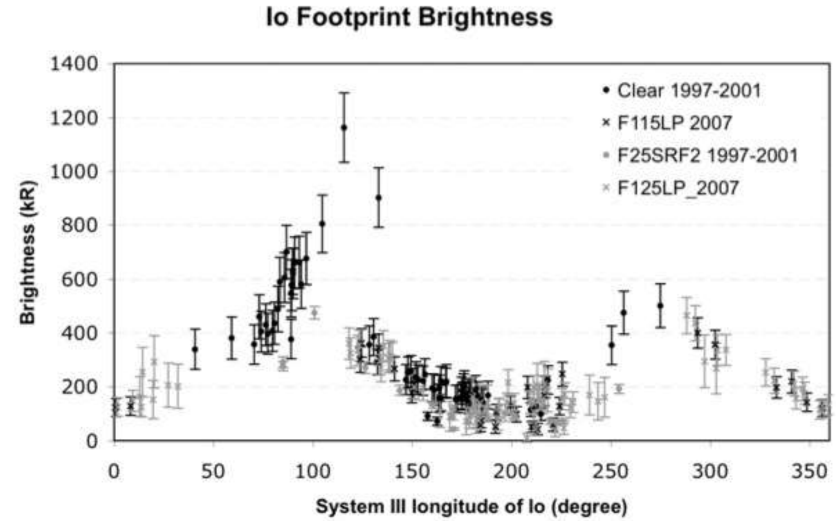


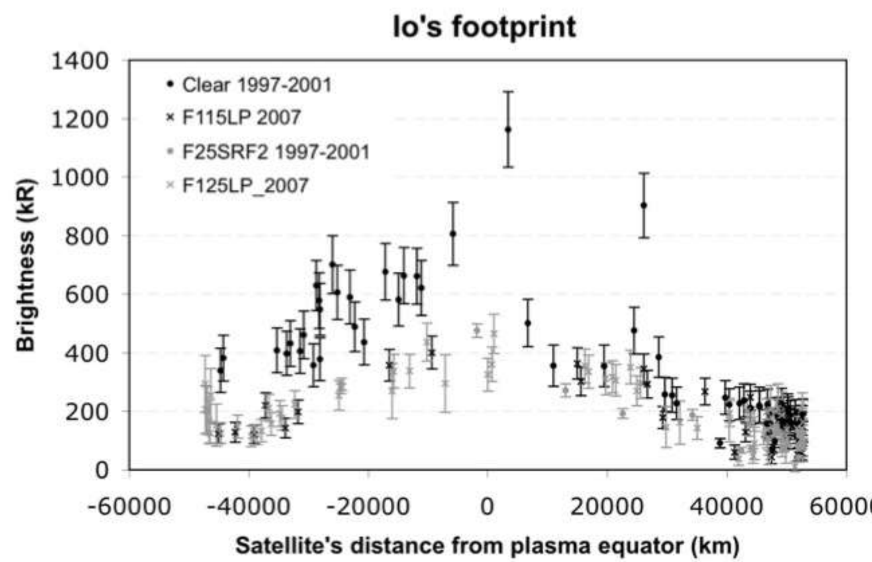
[J. Nichols *et al.*, *JGR*, doi:10.1029/2009JA014051, 2009]

Io Footprints and Interaction Results:

Over 10 years, Io's auroral footprint is consistently brightest when Io is centered in the plasma torus ->

This implies that mass pickup is the dominant process in the near-Io interaction, but a more detailed analysis shows it is more complicated…



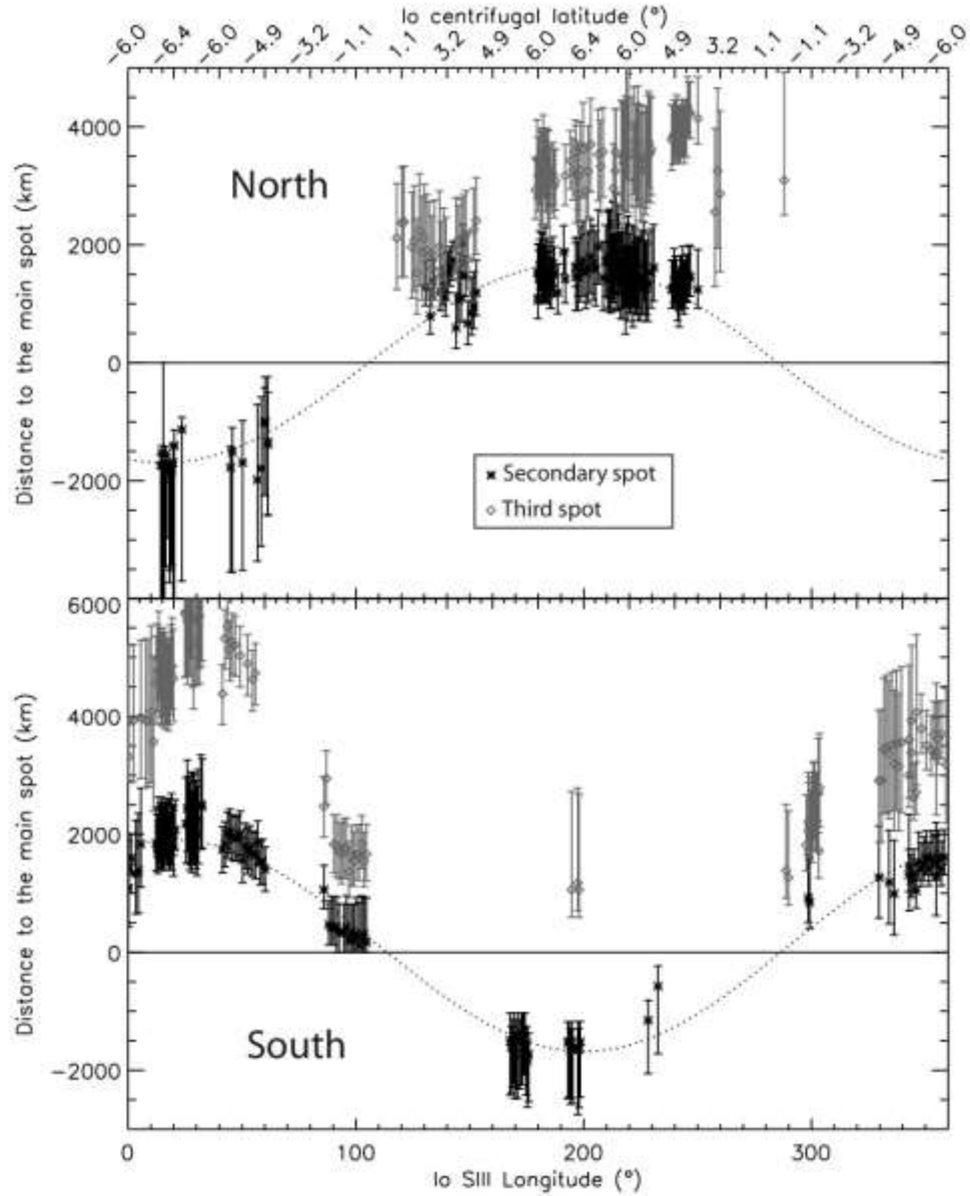


[S. Wannawichian *et al.*, *JGR*, 2009]

Io Footprint Auroral "Tail" Results:

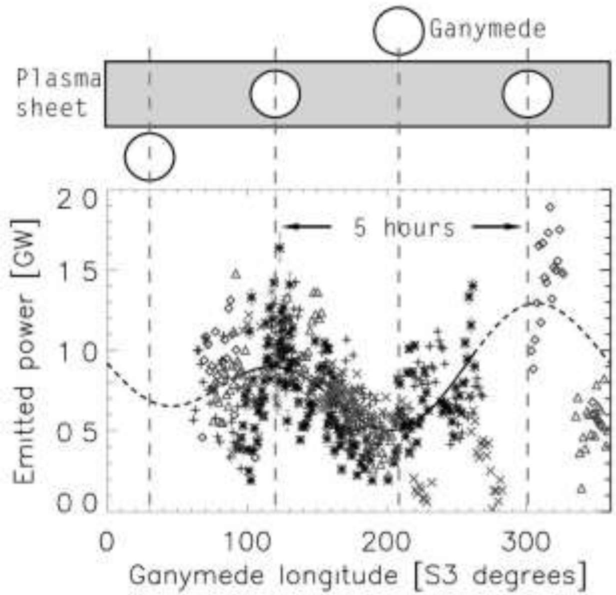
Spacing of downstream "tail" UV emission features varies with system III longitude ->

Auroral curtain from tail emissions seen at higher altitudes than other UV emissions, implies softer incident electrons ~70 eV for auroral processes downstream of Io



[B. Bonfond *et al.*, *JGR*, 2009]

Ganymede Auroral Footprint



Brightness of auroral emission from Ganymede footprint varies on several different time scales, indicating importance of different interaction processes.

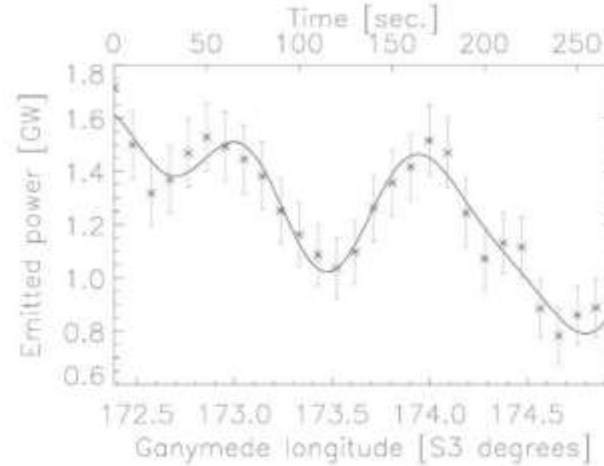


Figure 4a

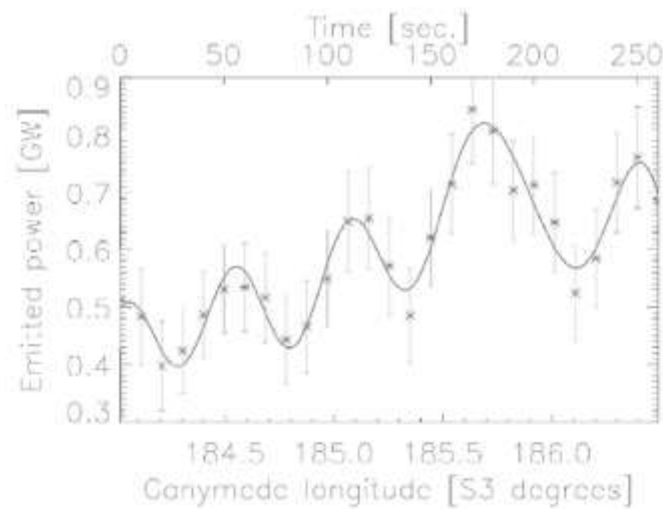


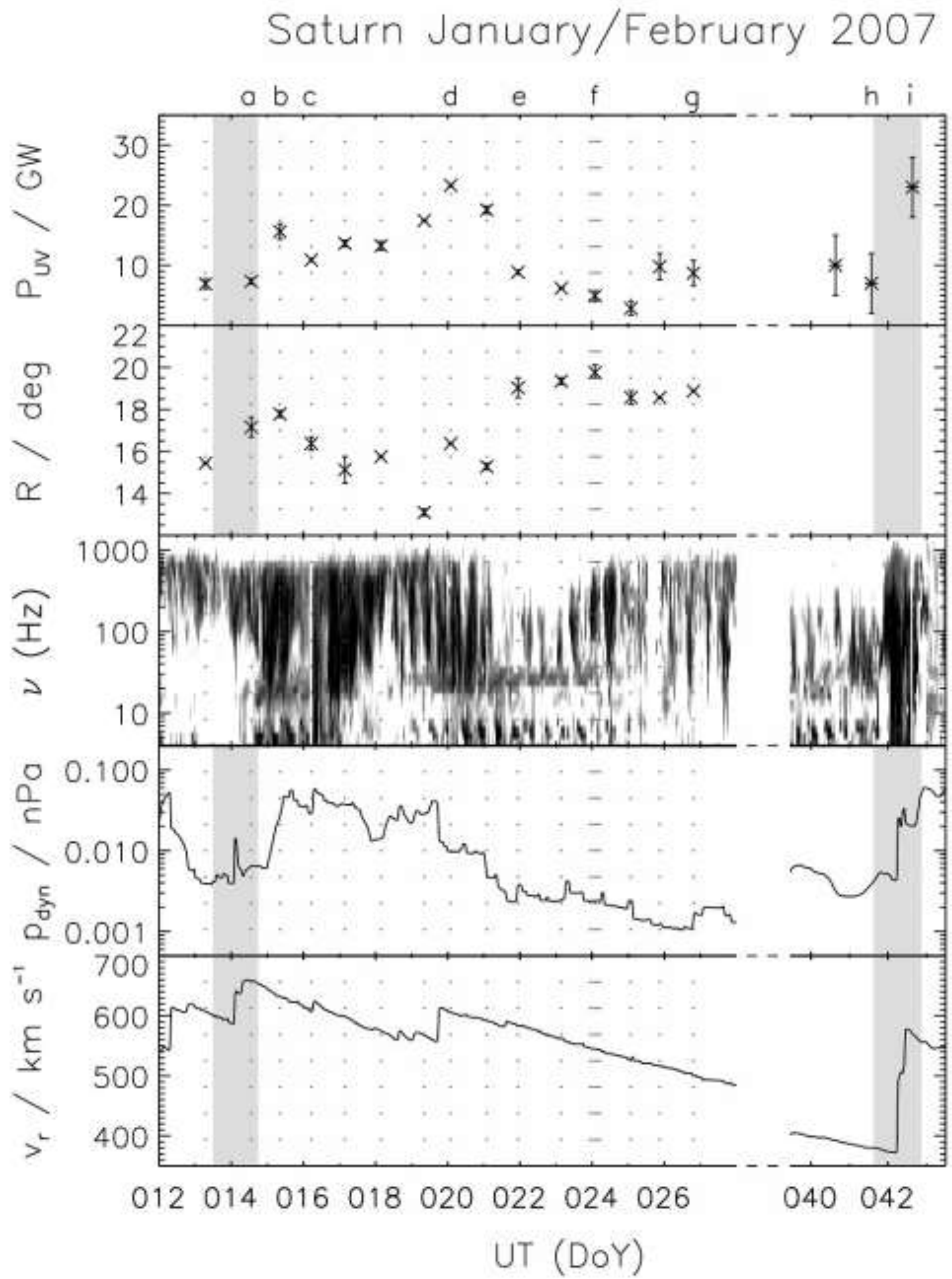
Figure 4b

[D. Grodent *et al.*, *JGR*, doi:10.1029/2009JA014289, 2009]

Saturn Auroral Activity vs Solar Wind - 2007

As see in Jan 2004, bright aurora appears correlated with smaller oval radius and with SKR emission

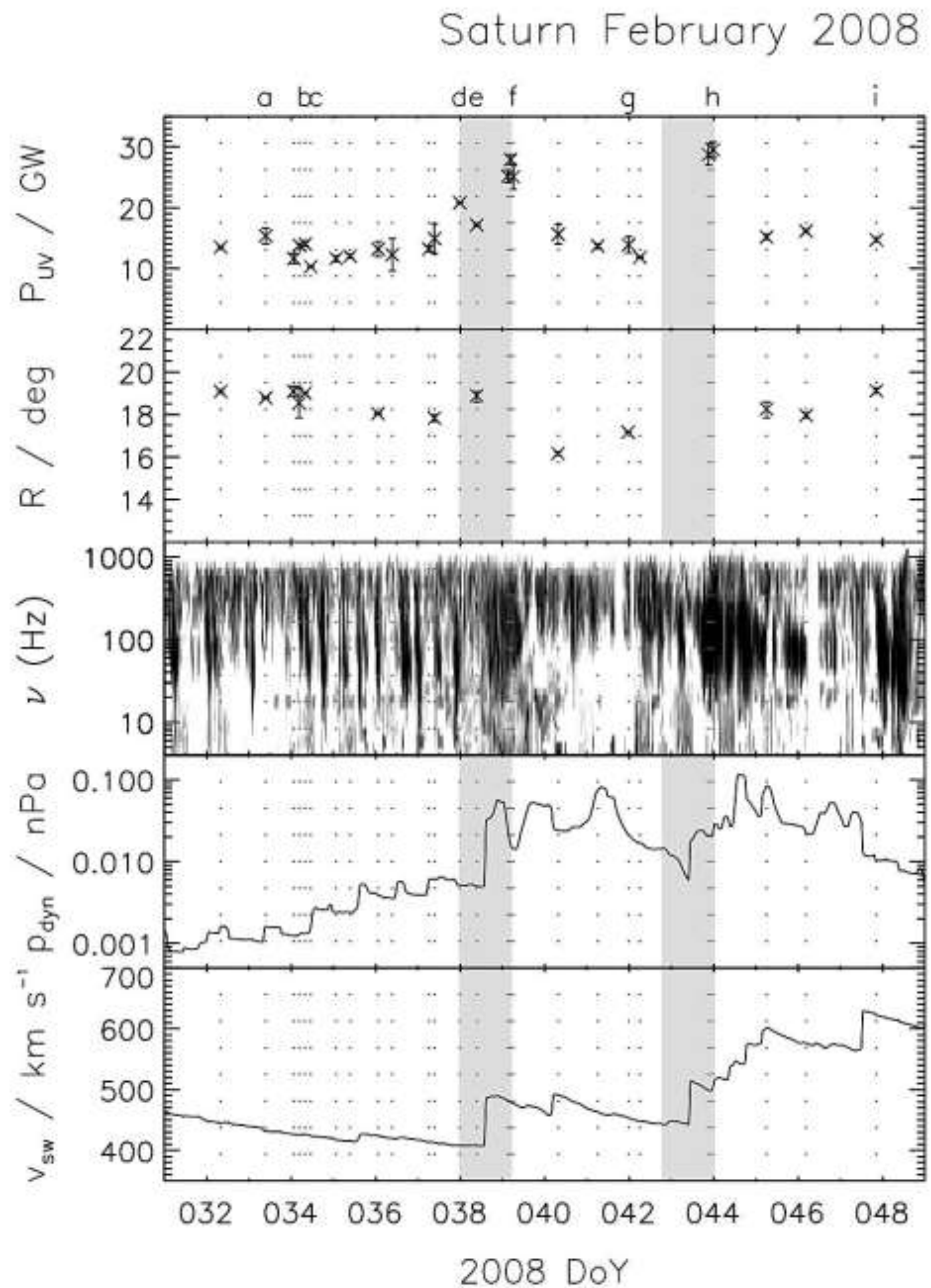
Auroral power & solar wind pressure increased over DOY 15-21, while auroral increase over DOY 26-27 not matched by solar wind pressure, correlated event on DOY 42



Saturn Auroral Activity vs Solar Wind - 2008

As before, bright aurora appears correlated with smaller oval radius and with SKR emission

Two more solar wind events on DOY 38 and 43 both matched by increases in auroral power and likely in SKR emission



Summary of Saturn's Auroral Correlations with Solar Wind

There is a one to one correlation between auroral activity, SKR emission, and size of the oval.

From combined observations now covering almost 3 months duration, all of the above are correlated with solar wind pressure, and auroral brightenings begin at times of solar wind shocks.

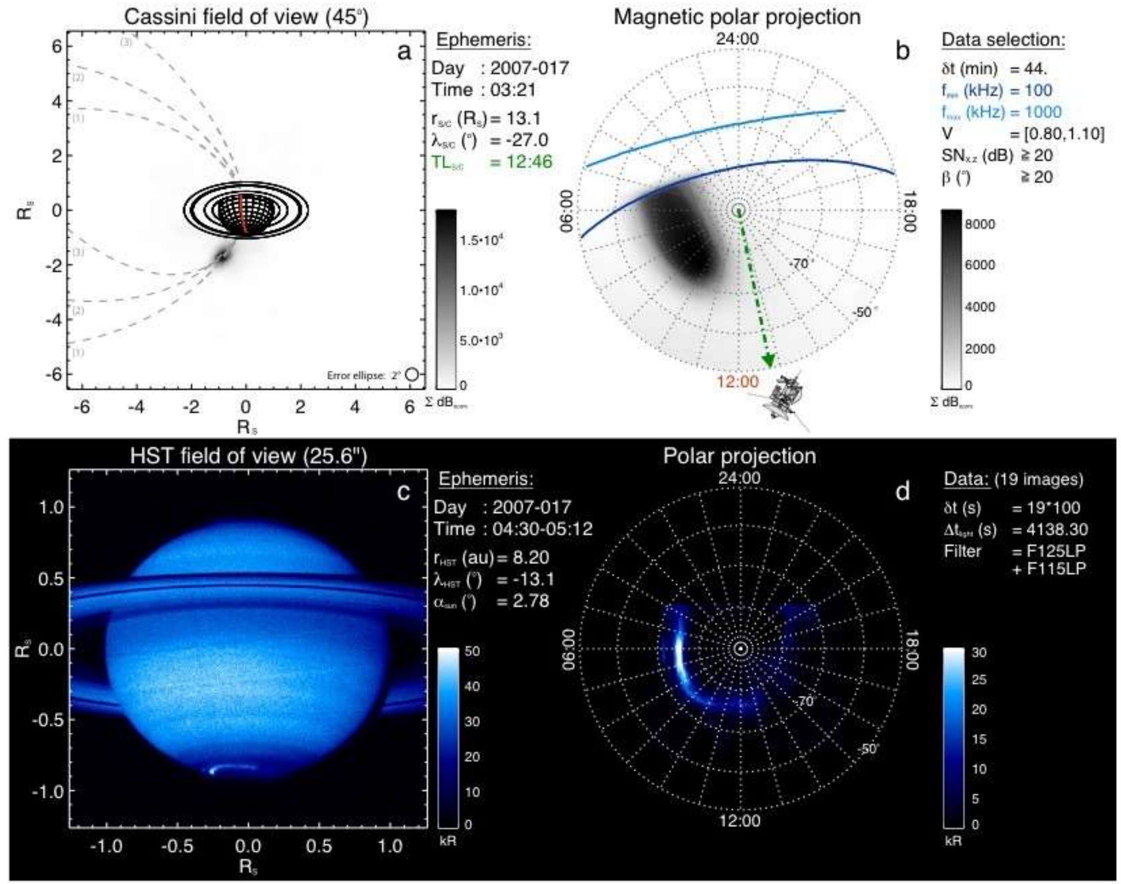
Strong connection to solar wind pressure is consistent with source region in outer magnetosphere, unlike case at Jupiter.

More recent events also observed with Cassini support the one to one correlation.

[J.T. Clarke *et al.*, *JGR,* doi:10.1029/2008JA013694, 2009]

Saturn SKR and Aurora Results:

Goniopolarimetric mapping of SKR emission compared with imaged location of UV auroral emissions confirms the connection between the emissions.

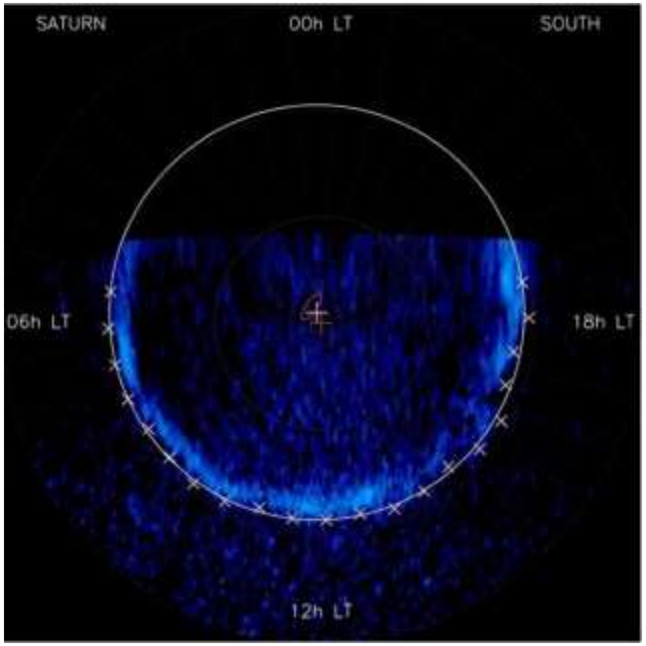


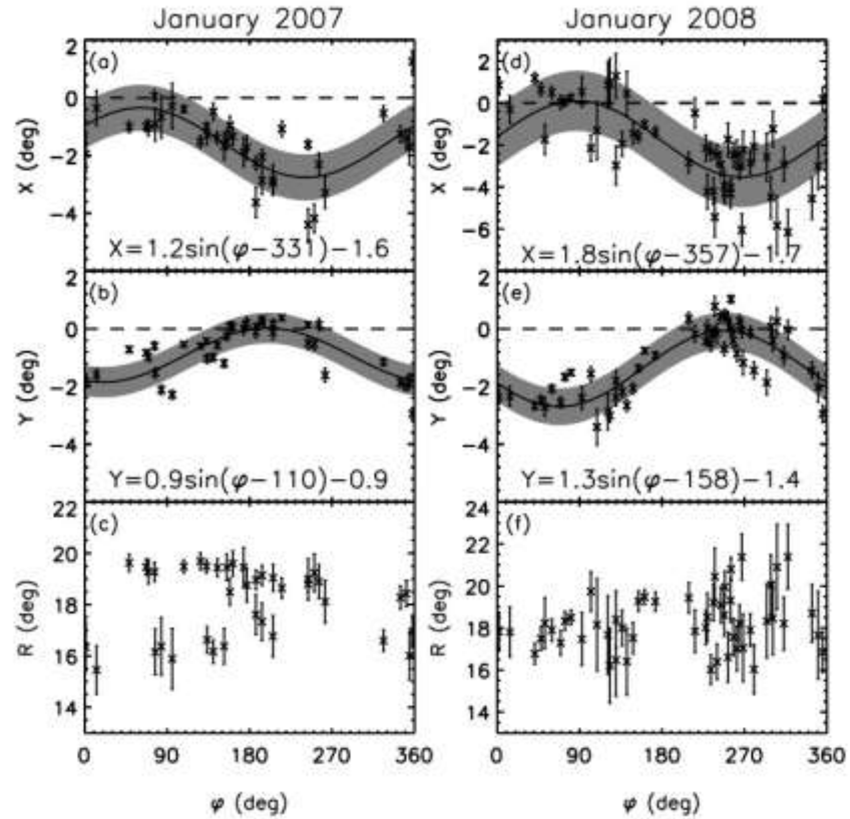
SKR emission are found to be organized along high latitude auroral oval, similar to UV aurora, with brightening near local dawn

Suggests the SKR and UV emissions may be produced by the same energetic electron population

[L. Lamy *et al.*, *JGR*, 2009]

Saturn Rotation and B Field Results:



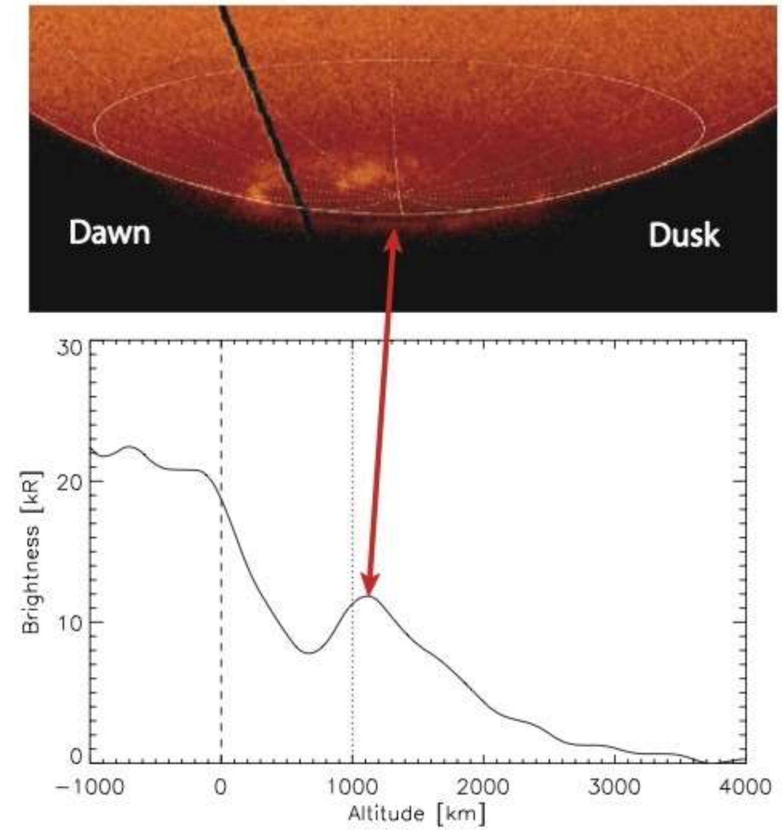


Fitting the equatorward boundary gives center location of the UV auroral oval, seen to rotate close to the SKR period

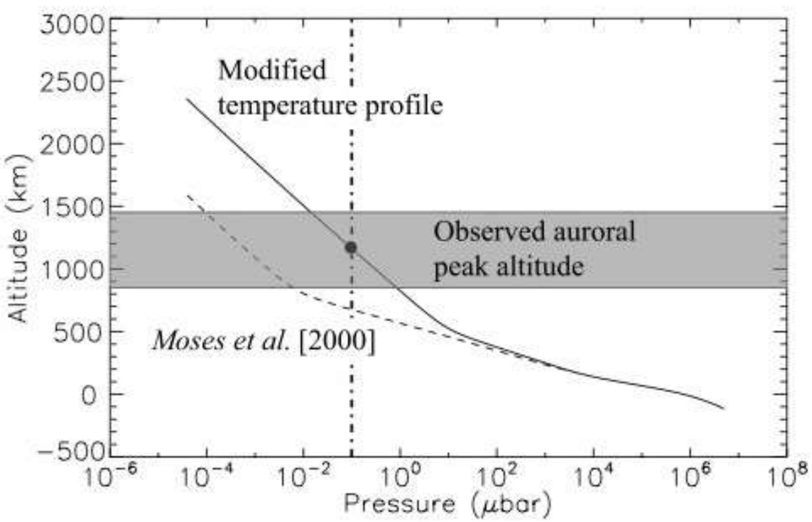
Center offset toward midnight (solar wind pressure?) and toward dawn - consistent with external current system changing period.

[J. Nichols *et al.*, *JGR*, doi:10.1029/2008JA013444, 2008]

Saturn Auroral Curtain and Atmospheric Temperature Results:



Altitude profiles of auroral curtain indicate peak emission is at higher altitudes than expected ->



<- High atmospheric temperature T ~ 400 K could extend the altitude of the curtain

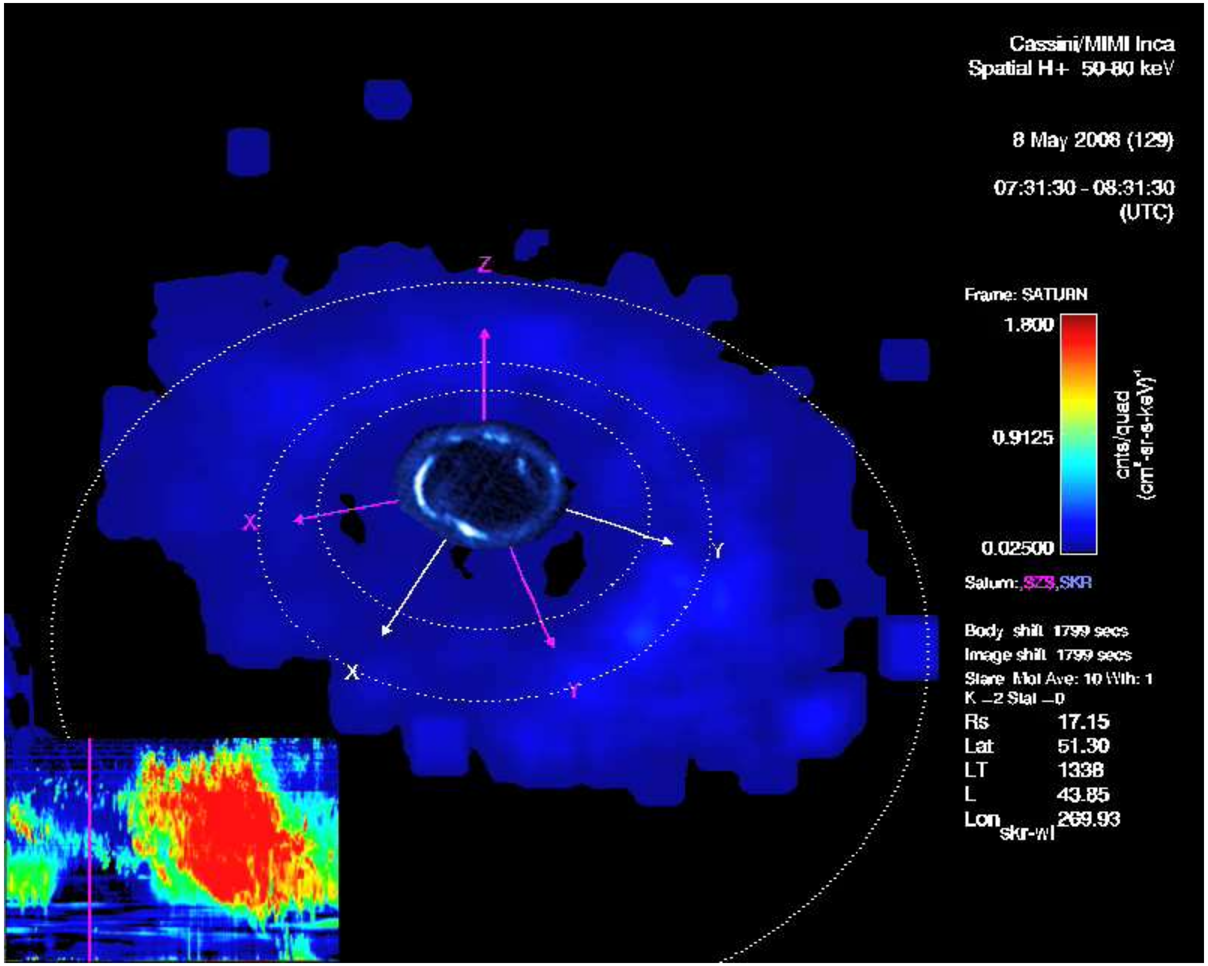
[J.-C. Gérard *et al.*, *GRL*, doi:10.1029/2008GL036554, 2009]

Saturn Auroral Emissions and Energetic Neutral Atoms Results:

Cassini ENA images show acceleration region between midnight and dawn

Suggested that these result from current sheet acceleration between 15-20 R_S

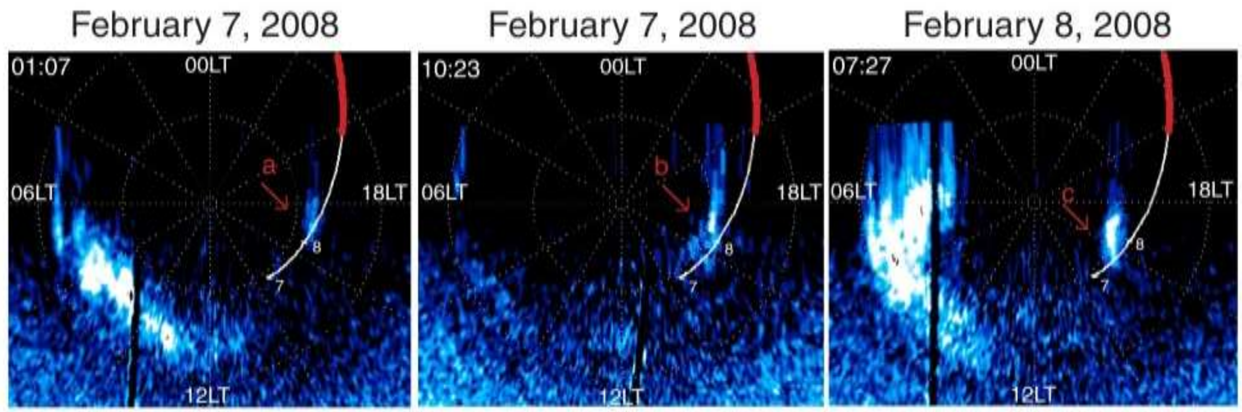
Also may be related to dawn side auroral brightenings seen in HST UV images and SKR emissions



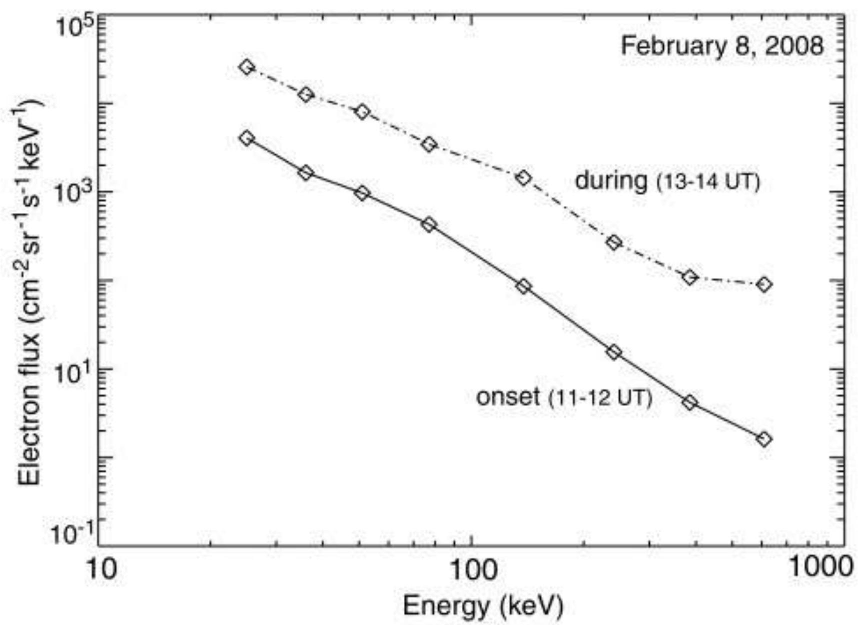
[D. Mitchell *et al.*, *JGR*, 2009]

Saturn Aurora from Electron Injections Results:

Transient (~ 10-30 min.) auroral emissions seen at the footprint of Cassini ->



Associated electron injection events seen in Cassini CHEMS / LEMMS data ->



[A. Radioti *et al., JGR*, doi:10.1029/2008JA013632, 2009]

Challenges for Physical Understanding I:

Why would both Jupiter and Saturn aurora brighten in response to solar wind pressure increases?

Jupiter's main oval maps to middle magnetosphere, while Saturn's maps in theory to the outer magnetosphere, yet both respond with brightenings when solar wind pressure increases

Jupiter - main oval gets brighter, and at times wider in latitude - often exhibits patchy clumps of emission - sometimes starts with a dawn storm which may begin with brightening poleward of the oval - observed time scale for auroral event is 1-2 days

Saturn - main oval gets brighter, brightest emission is poleward of the quiet oval latitude, and dawn side initially fills in with bright emissions - observed time scale for auroral event is 2-4 days - weaker event accompanies smaller increase in solar wind pressure

Challenges for Physical Understanding II:

What is the principal driving physics of the main ovals?

Jupiter - Jupiter is the prototype of a magnetosphere controlled by internal plasma and planetary rotation, yet the aurora are affected by the solar wind. How does the solar wind exert any effect on the main oval, deep within the magnetosphere?

If main oval is driven by corotation breakdown currents, it has been predicted that the outward drifting plasma content would decrease with increased solar wind pressure, giving weaker currents and fainter auroral emissions. The opposite is observed…

Saturn – Initially proposed that the main oval maps to boundary with solar wind - mapping distance is not established by observations, no satellite footprints observed. The Mitchell et al. Cassini ENA/UV movie gives strong evidence for a correlation between plasma 10-20 R_S with bright auroral emission, at least for this one event.