Saturn's secondary auroral ring

Denis Grodent
Aikaterini Radioti
Bertrand Bonfond
Jean-Claude Gérard
Jacques Gustin ..... *LPAP, Université de Liège, Belgium*
Wayne Pryor ..... *Central Arizona College, Arizona, USA*

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 115, A08219, doi:10.1029/2009JA014901, 2010

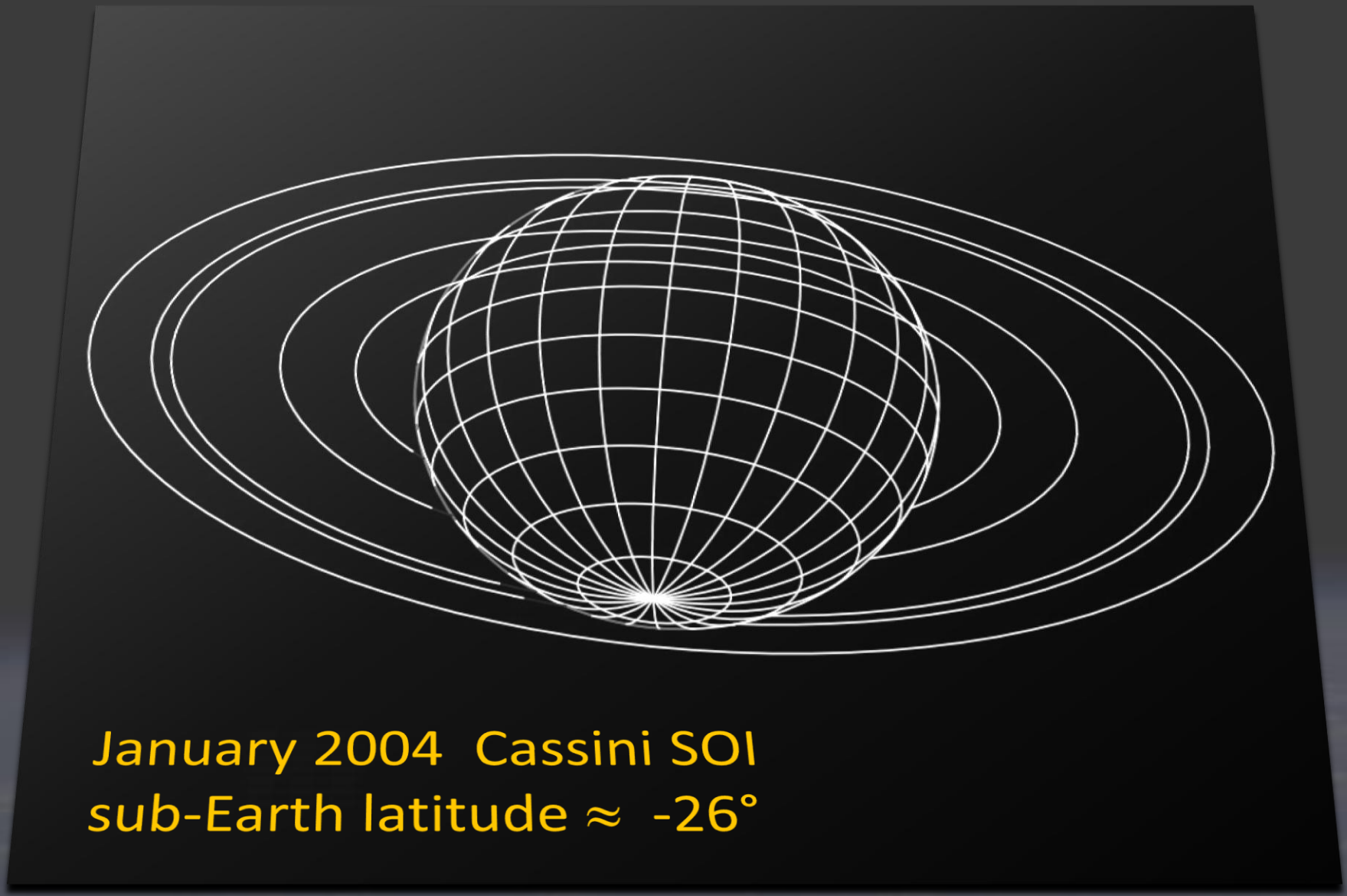
On the origin of Saturn's outer auroral emission

Denis Grodent,[1] Aikaterini Radioti,[1] Bertrand Bonfond,[1] and Jean-Claude Gérard[1]

Received 14 September 2009; revised 5 January 2010; accepted 8 January 2010; published 18 August 2010.

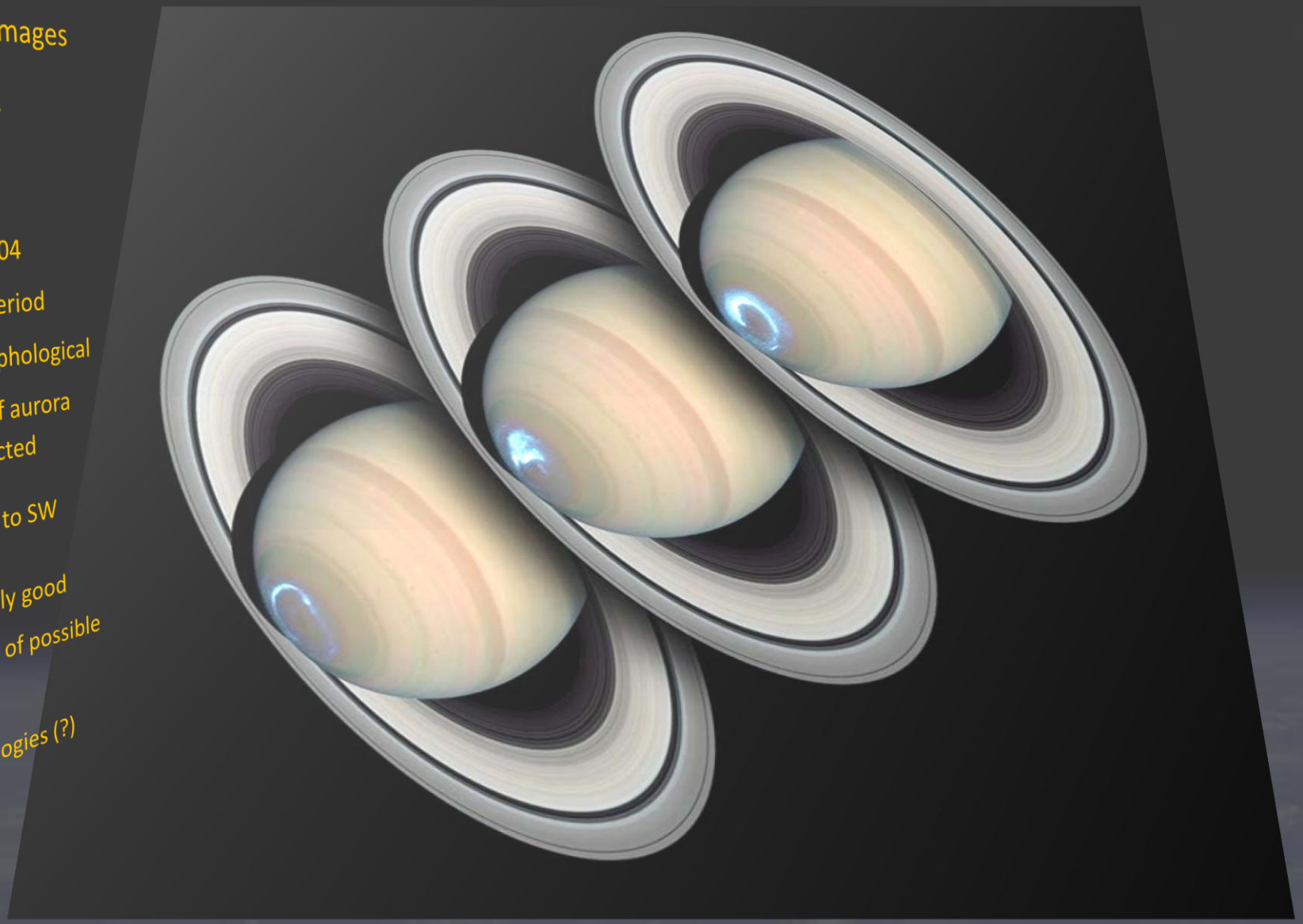
[1] Ultraviolet Hubble Space Telescope images reveal a faint but distinct auroral emission equatorward of the main ring of emission of Saturn's southern polar region. This outer auroral emission is only visible near the nightside limb for the strongly tilted viewing geometry achieved in January 2004. We model the limb-brightening amplification of this emission, and we show that the observations are compatible with an ~7° wide emission ring approximately centered on the 67°S parallel. The 1.7 kR brightness of this emission requires an injected electron energy flux of ~0.3 mW m^{-2}. The outer auroral emission maps to a region of the equatorial plane between 4 and 11 R_S. We suggest that a population of suprathermal electrons observed by Cassini can provide more than the required energy flux without the need for field-aligned acceleration. This auroral UV emission may also be associated with energetic neutral oxygen and hydrogen atoms originating from the energetic protons and O^+ of magnetosphere and/or with a secondary infrared auroral oval.

Citation: Grodent, D., A. Radioti, B. Bonfond, and J.-C. Gérard (2010), On the origin of Saturn's outer auroral emission, *J. Geophys. Res.*, *115*, A08219, doi:10.1029/2009JA014901.

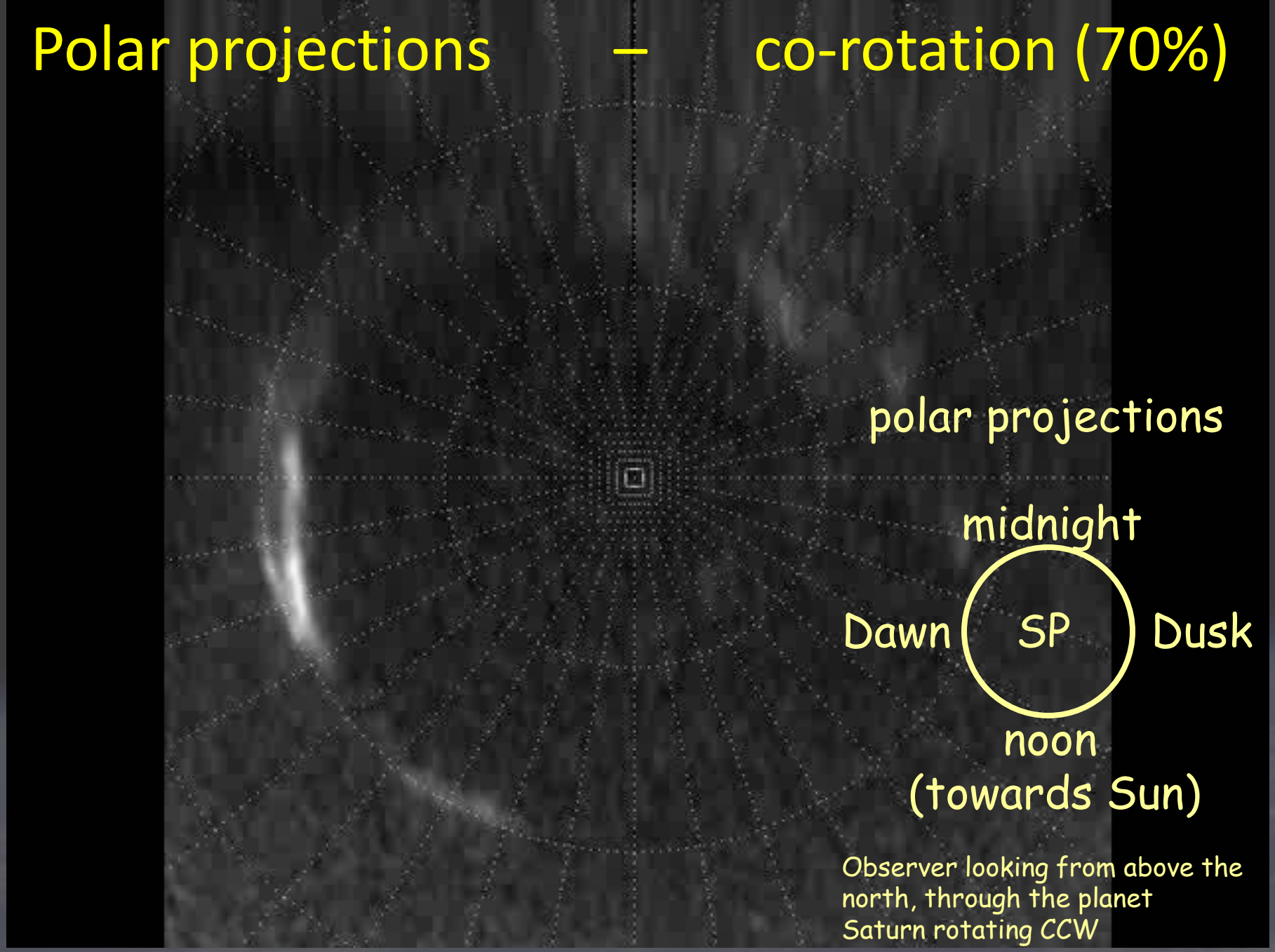

January 2004 Cassini SOI
sub-Earth latitude ≈ -26°

HST (STIS) images of Saturn's southern UV aurora.

- January 2004
- 1 month period
- Large morphological changes of aurora
  - unexpected
  - fast
  - related to SW activity
- Apparently good sampling of possible auroral morphologies (?)



Polar projections – co-rotation (70%)

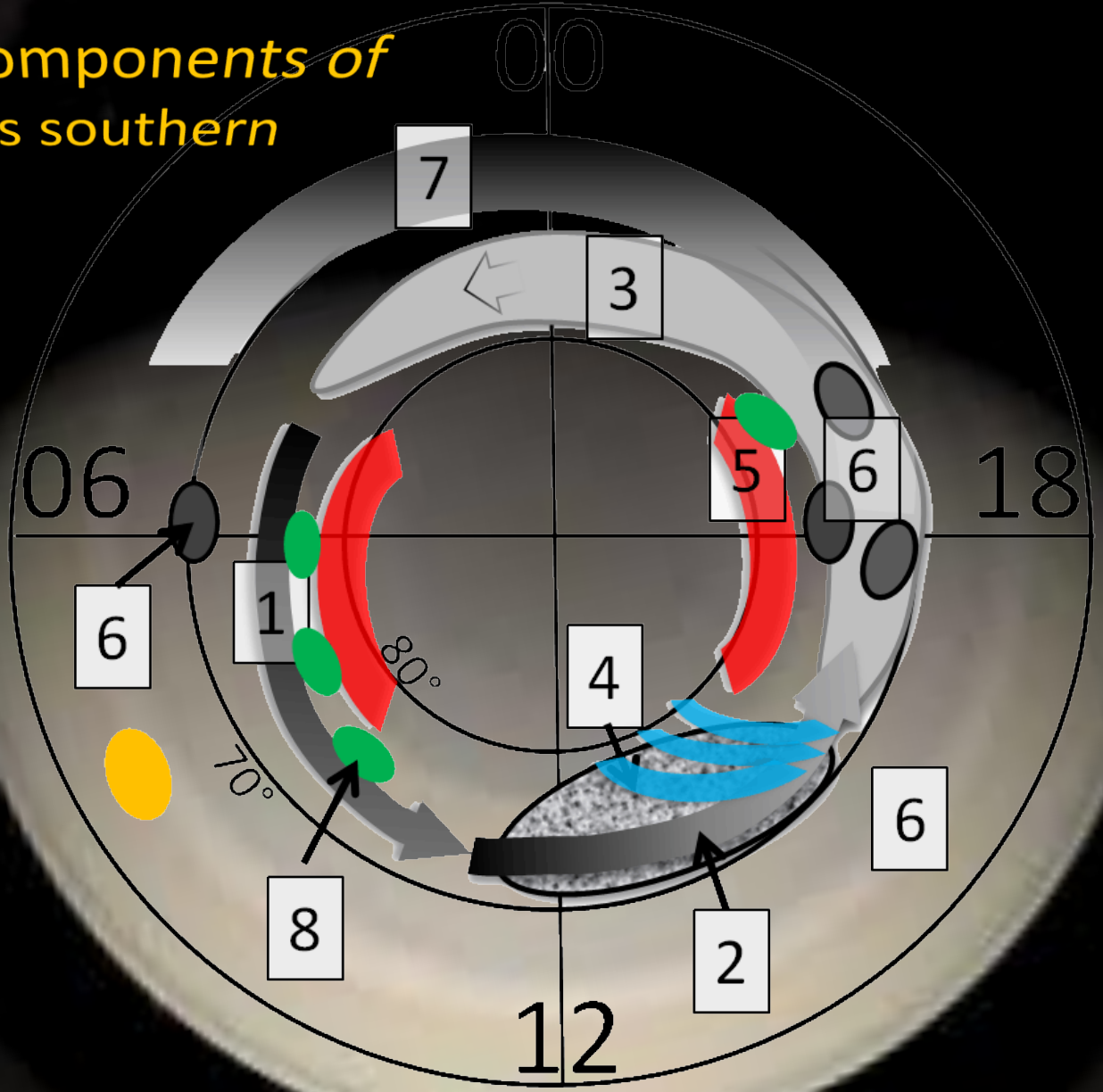


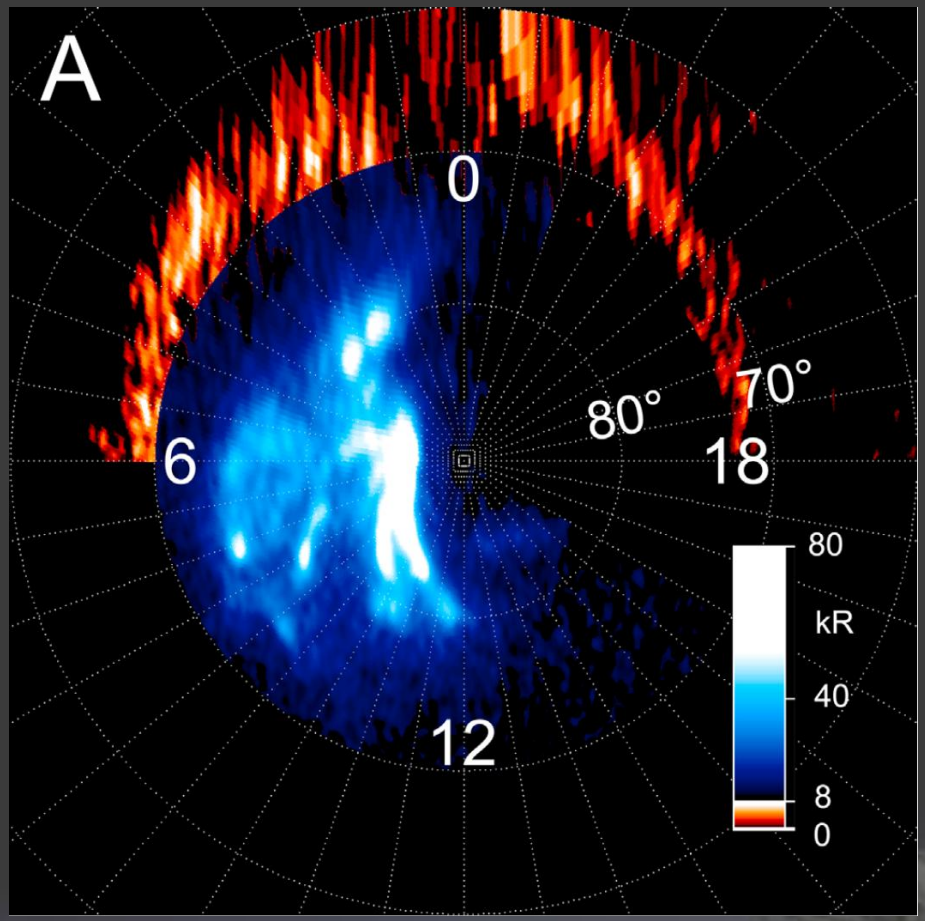
Family portrait of Saturn's UV aurora

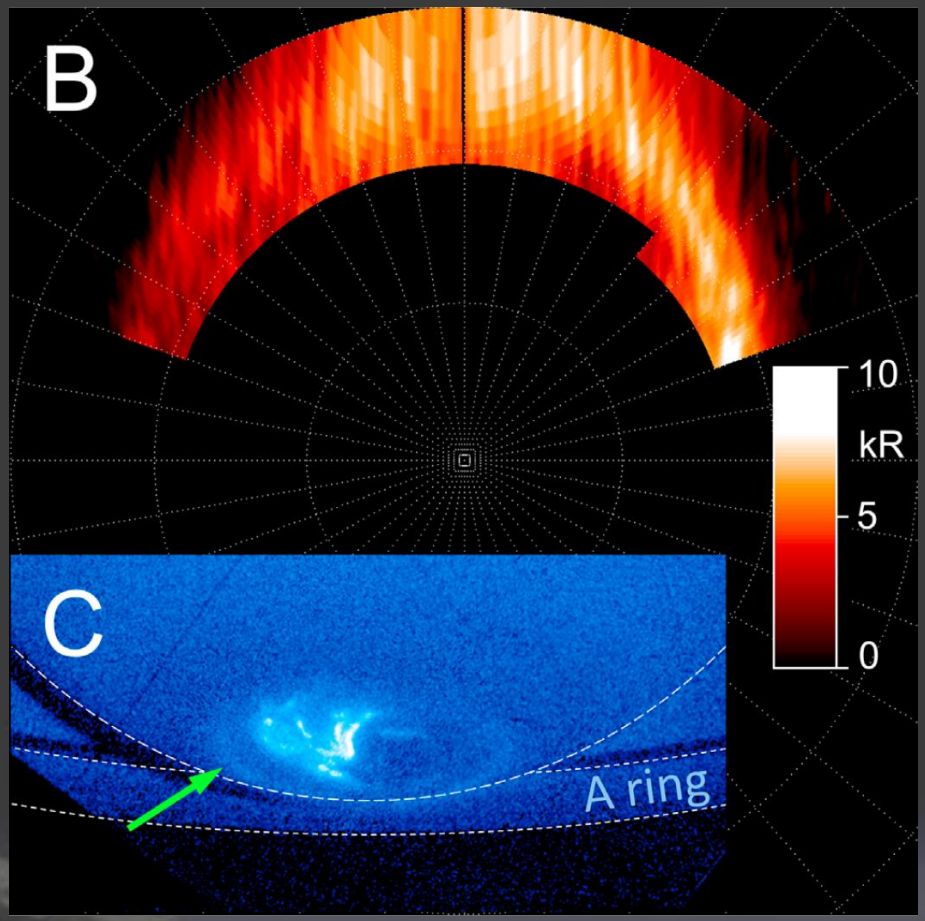
photographed by HST

Define main auroral components

Main components of Saturn's southern aurora





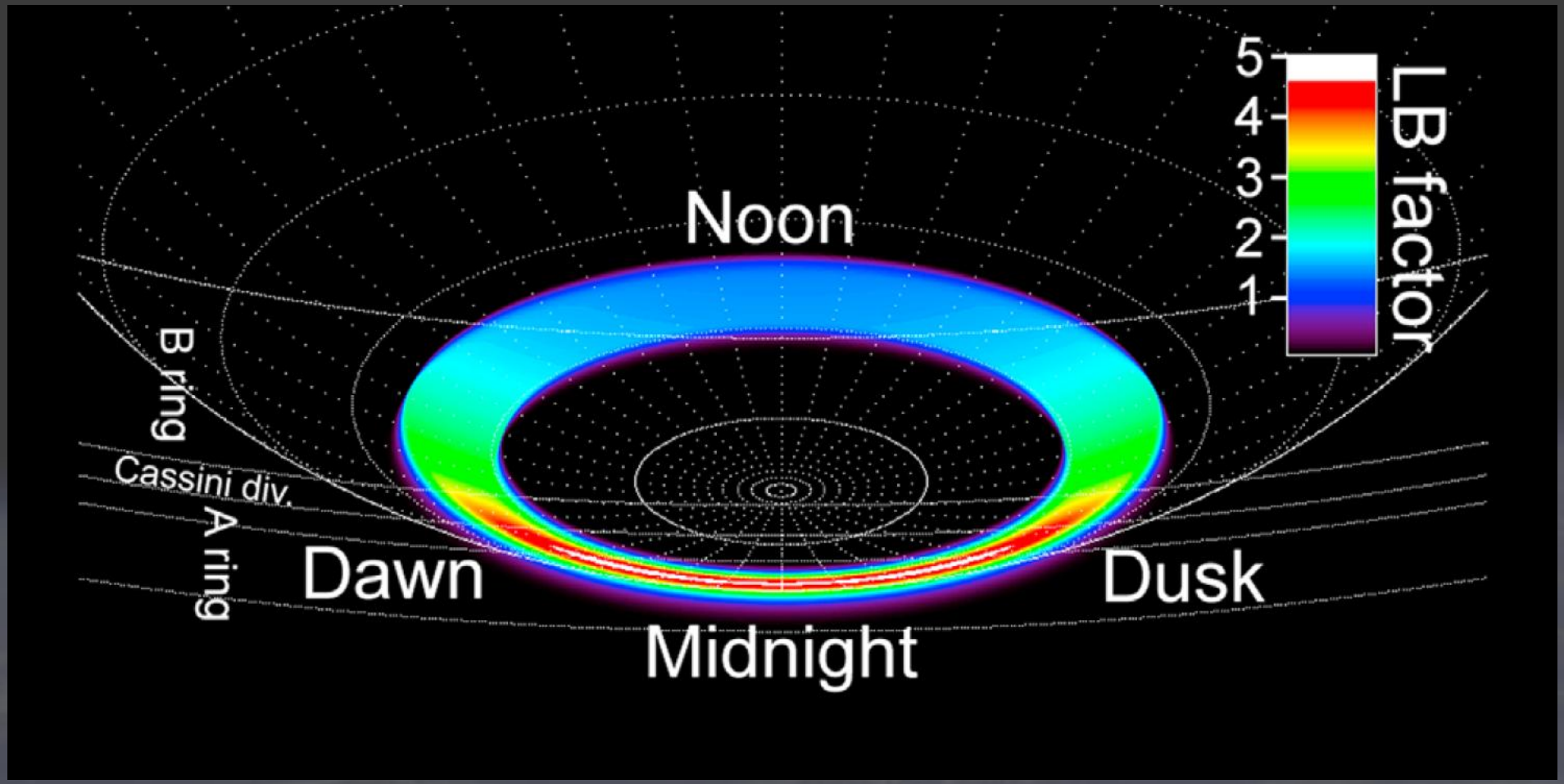


Grodent et al., 2010

Outer emission brought up by limb brightening

Modeling of the viewing geometry and limb brightening effect

Uniform unit emission in a 7° wide ribbon centered on the 67°S parallel.
Assumes Chapman profile peaking at 1000km

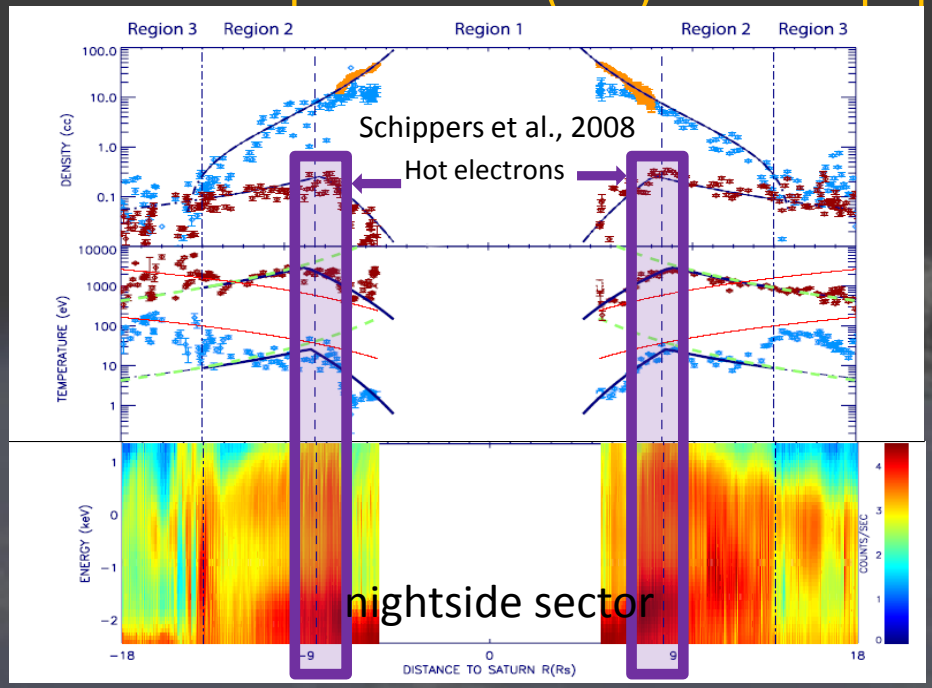


conclusion of modeling :

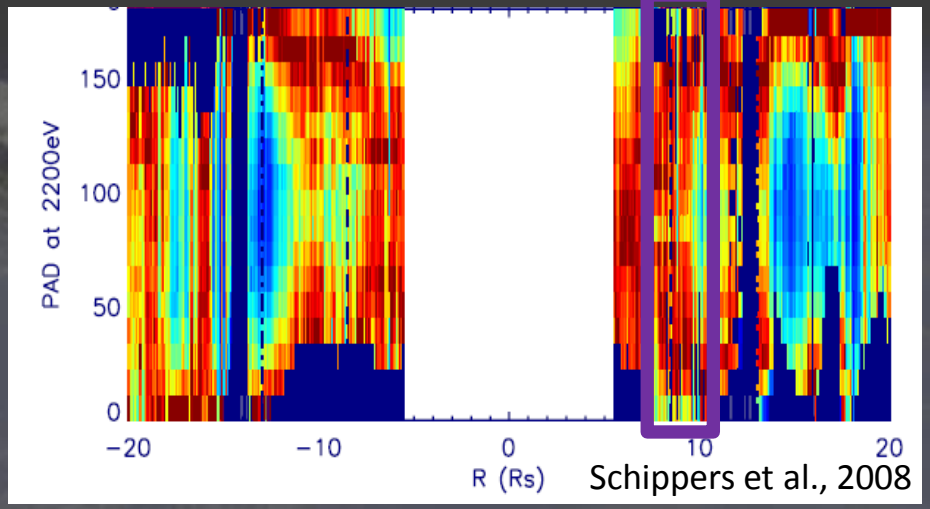
the outer UV emission

- forms a 7° wide ribbon centered on the 67°S parallel
- maps to 4 – 11 Rs (E-ring, inner plasmasphere)
- emits 1.7 kR of H_2 which requires injection of 0.27 mW m^{-2}

Cassini/CAPS : Schippers et al., 2008; Lewis et al., 2008
suprathermal (keV) electron population 7-10 RS (9 RS)



PAD pancake ⇒ bidirectional distribution ⇒ whistler waves



Transform available thermal energy into auroral energy (need to inject 0.27 mW m^{-2})

first method
Cowley and Bunce, 2003
assumes full loss cone distribution
precipitated flux (FAC) ≈ 0.17 mW m^{-2}
(without FA acceleration)

about right

second method
Radioti et al., 2009
assumes full loss cone distribution
pitch angle scattering by whistler waves
accounts for energy distribution
precipitated flux ≈ 0.27 mW m^{-2} ($\bar{e} \in [0.2,3]$ keV)
precipitated flux > 2 mW m^{-2} ($\bar{e}$ >3keV)

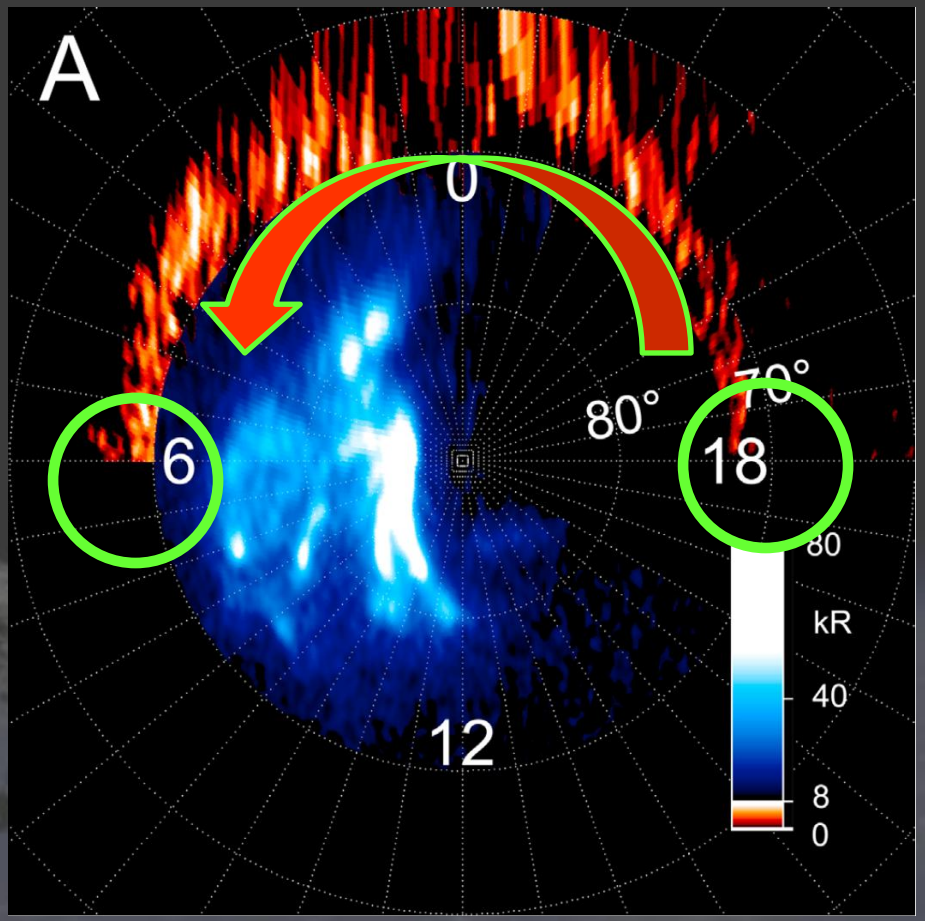
largely enough energy

Suprathermal electron population has enough energy to produce the outer UV emission

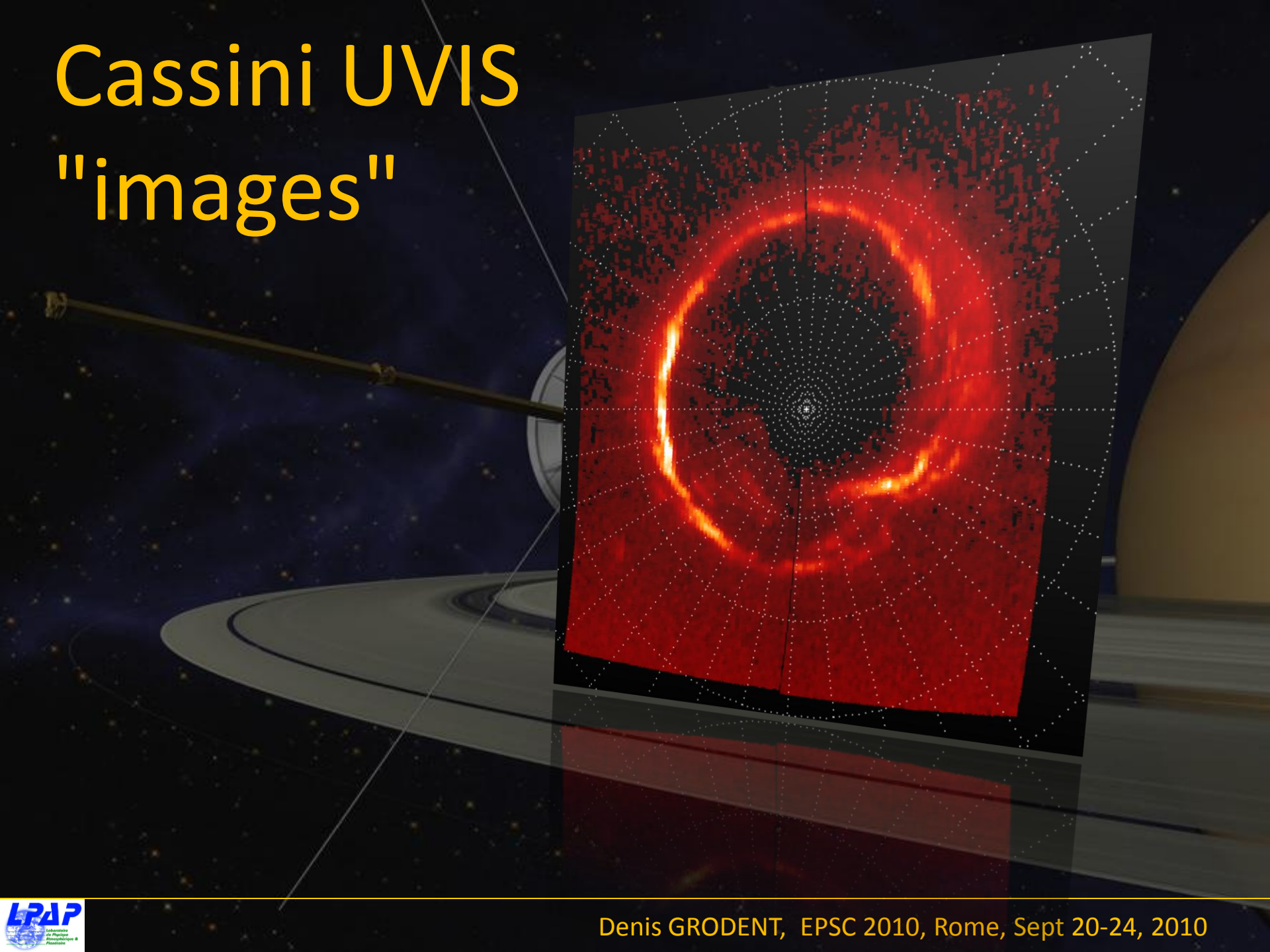
2 pending questions unresolved by HST obs.

Longitudinal extent of the outer emission?

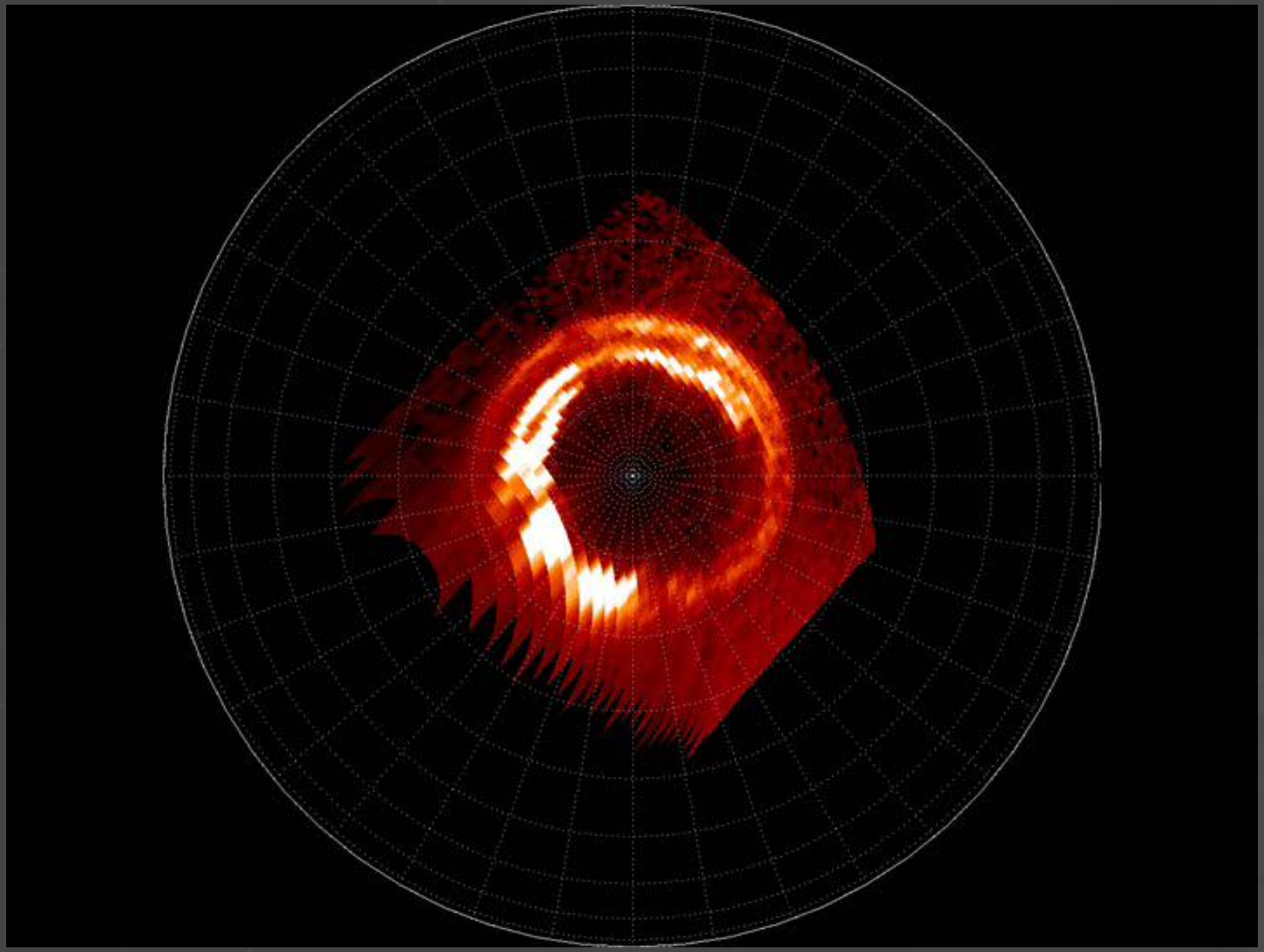
Is it fixed in LT?

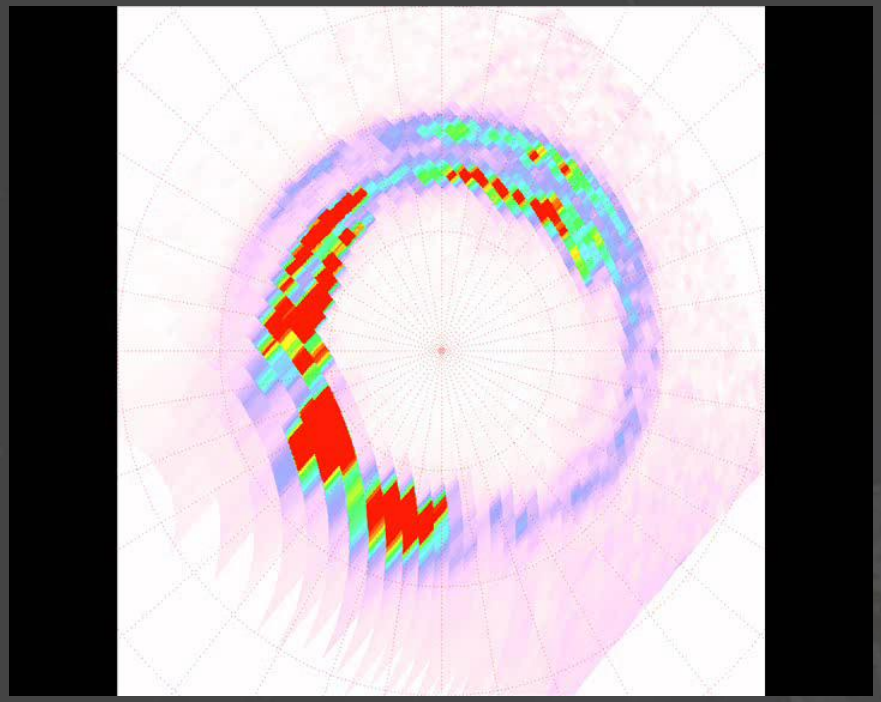


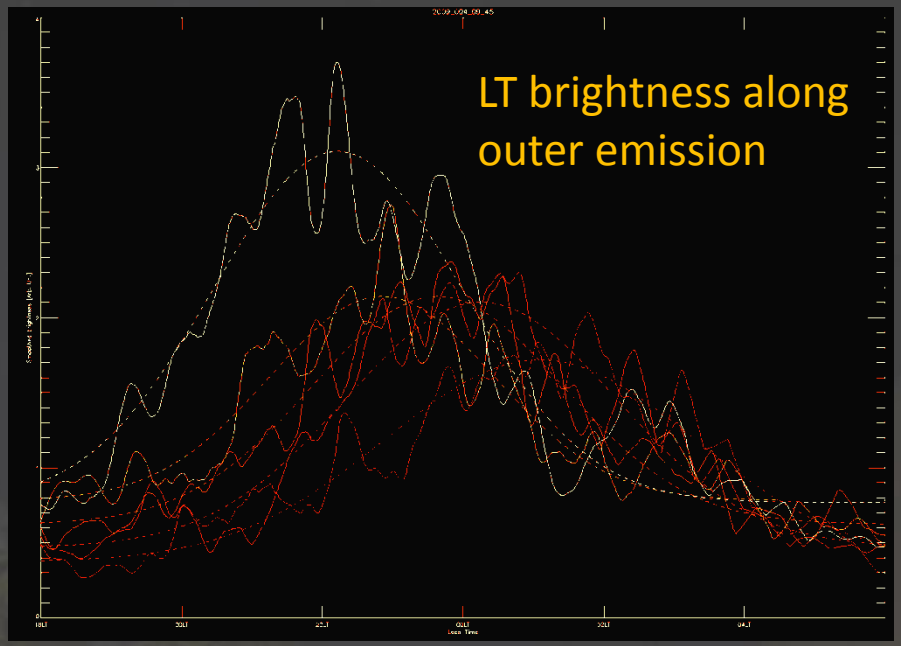
Cassini UVIS "images"

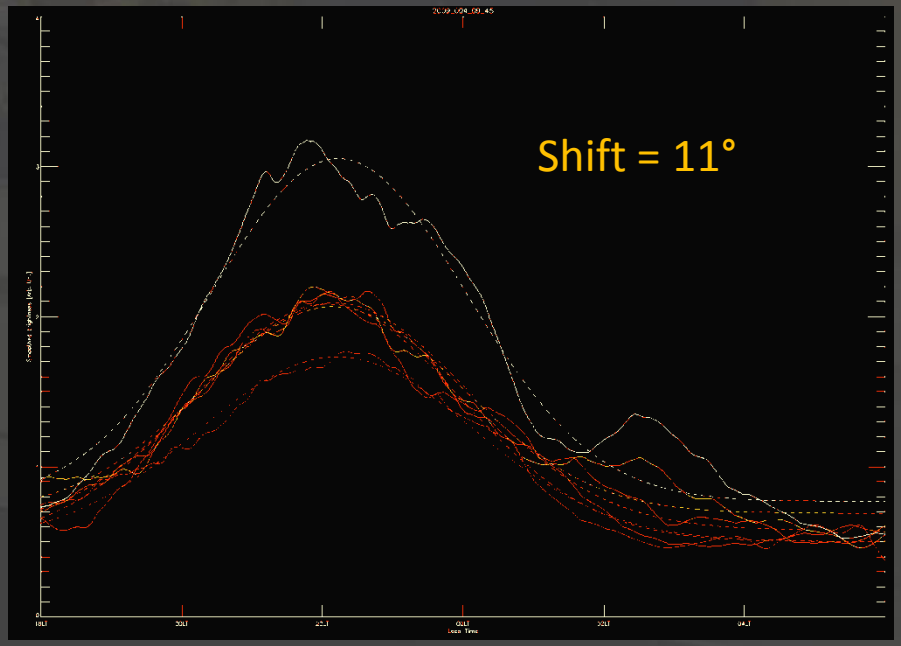


UVIS 2009_004_09_45 North Pole









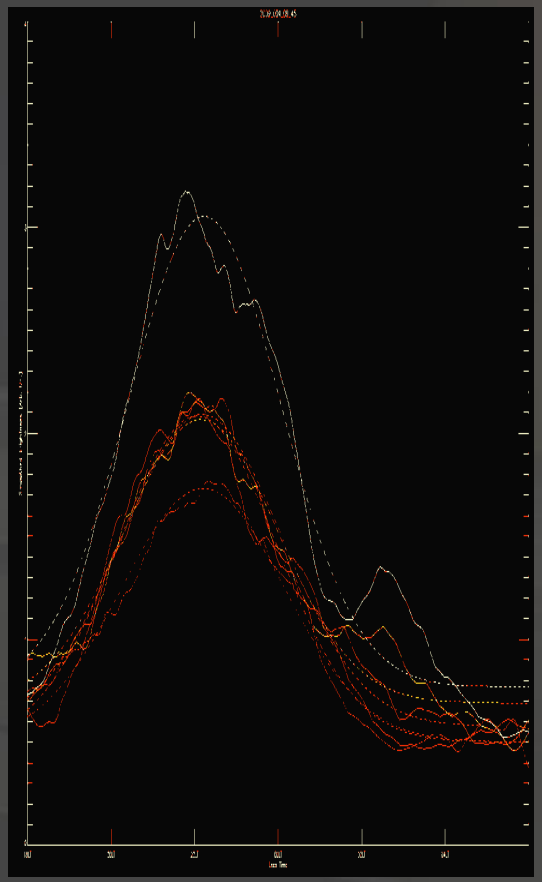
Shift = 11° in 28.8 min

67% rigid-rotation

compatible with 7-10 Rs

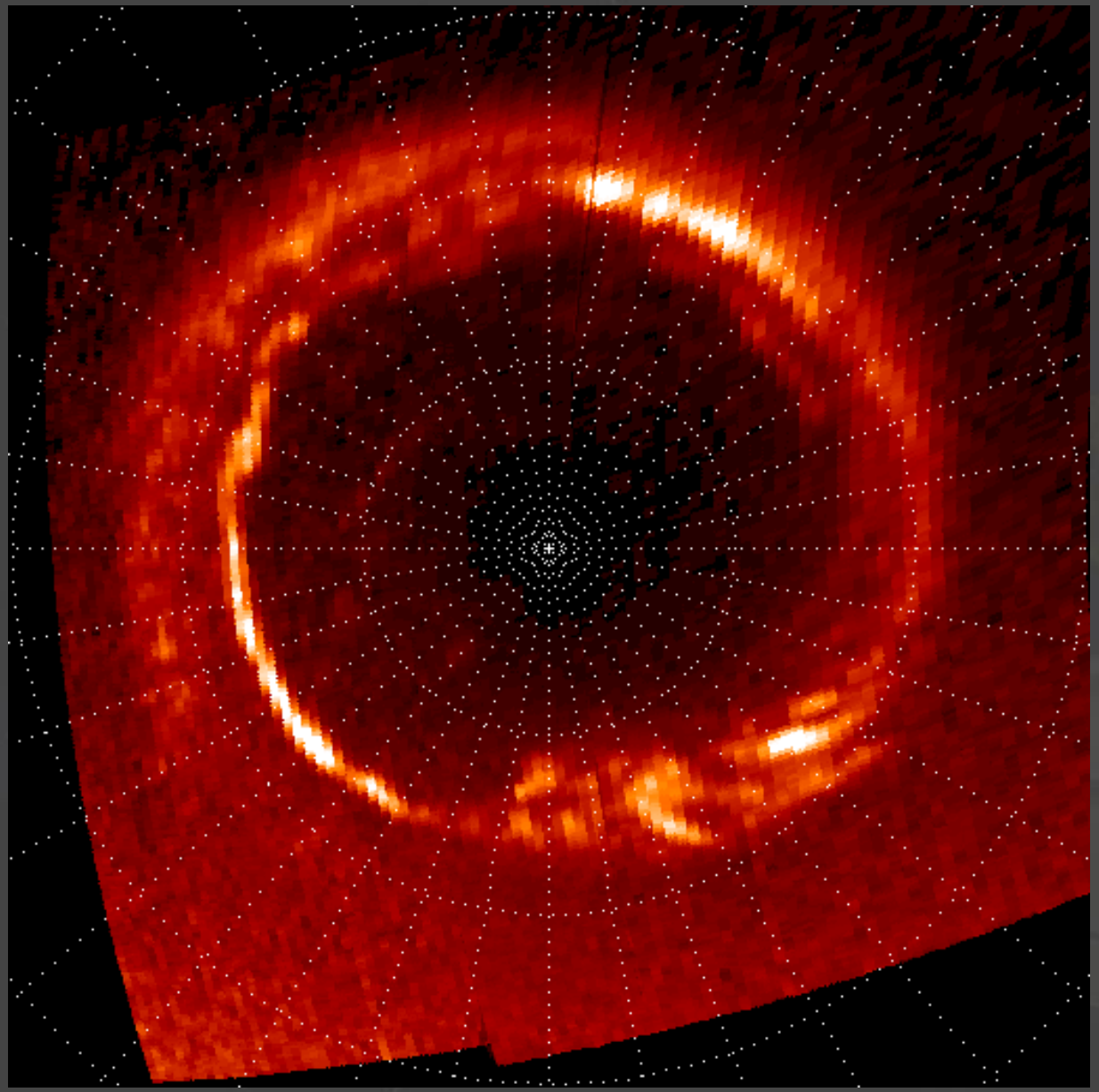
UVIS 2009_004_09_45 North Pole

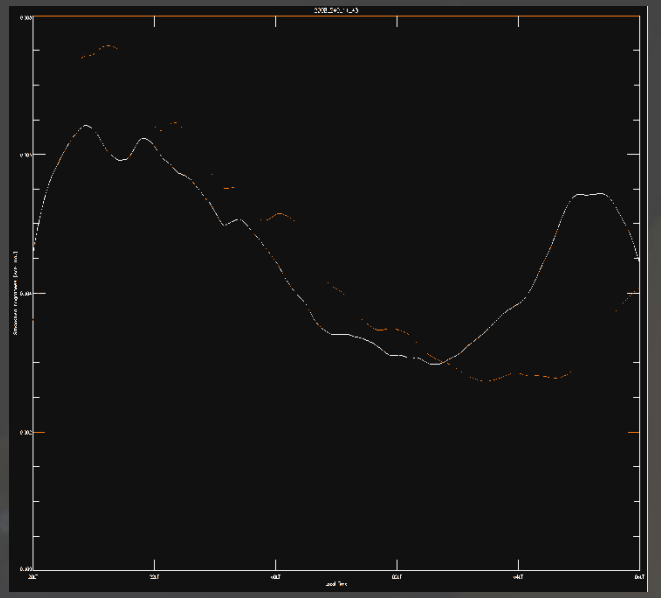
Narrow feature (~2°)
Centered on 71°N
Maps to ~9 RS
Brightness ~3kR
decreasing

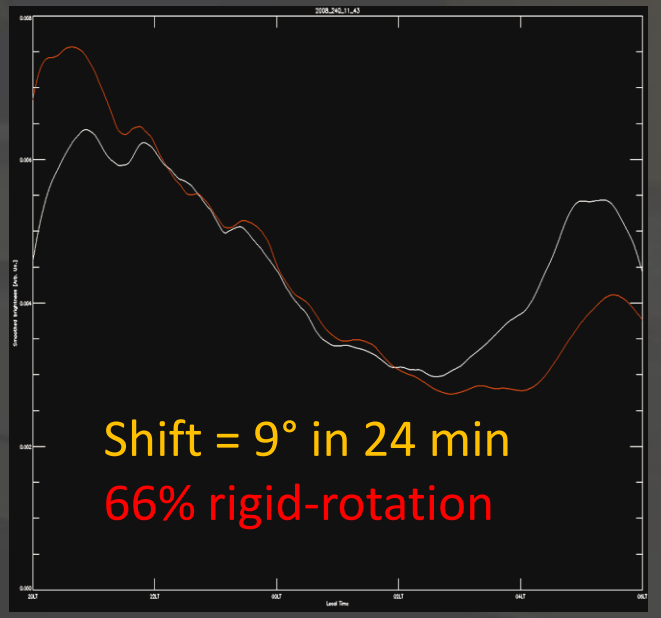


UVIS 2009_004_09_45 North Pole

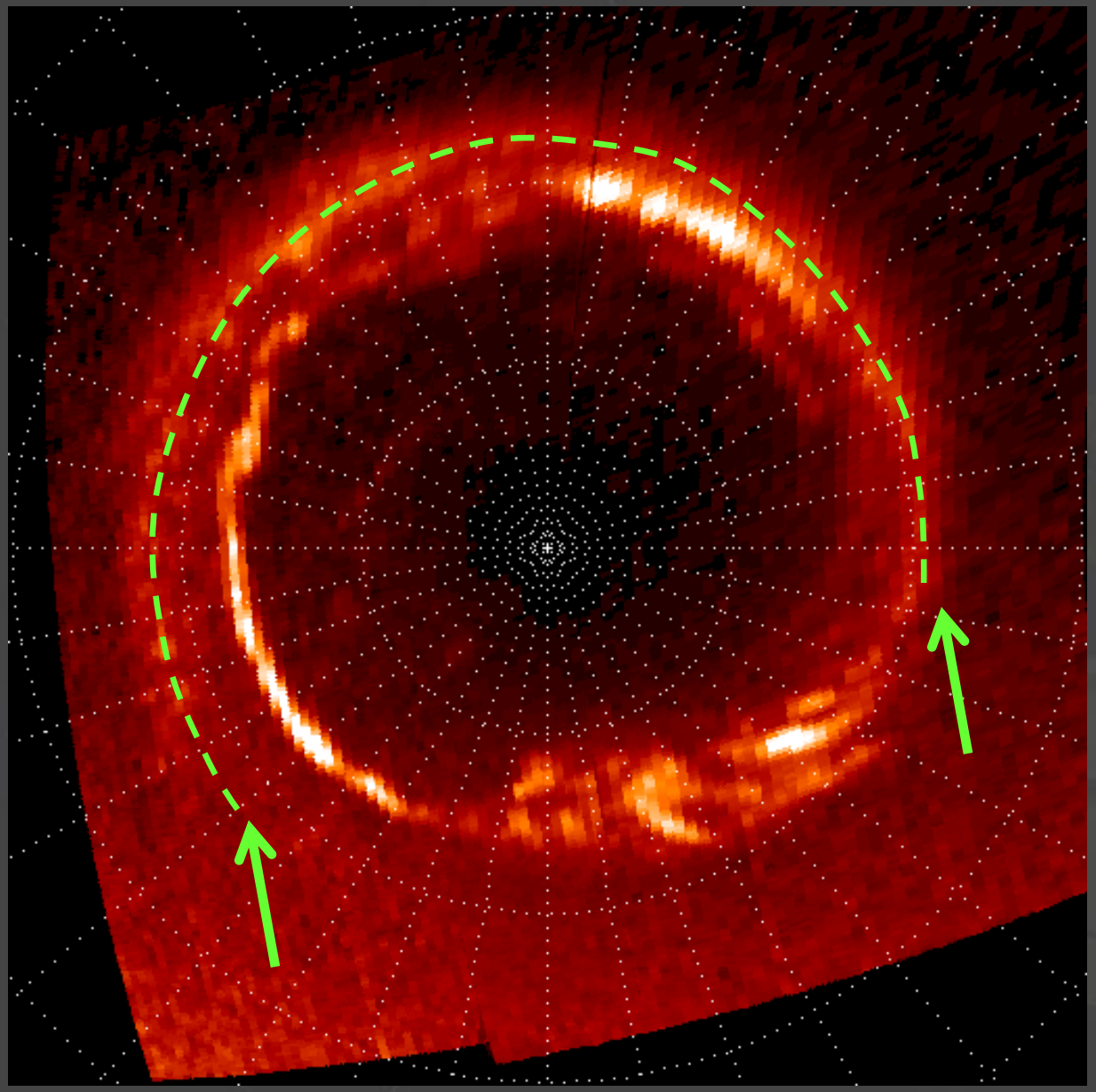
UVIS 2008_240_05_46 South Pole







UVIS 2008_240_05_46 South Pole



Narrow feature (~3°)
Centered on ~67°S *
Maps to ~9 RS

* 69°-70° near Dusk
LT spiral ?

18LT - 00LT – 09LT

Cassini UVIS observations (N-S) more than confirm HST observations (S)

- outer emission always present
- limited to nightside
- corotating at 70% rigid-rotation (7-10Rs)
- a few kR brightness (decr. noon to dawn)
- a few degrees wide (variable)
- centered on 67°S - 71°N (spiral?)
- maps to 9Rs (± 2Rs)