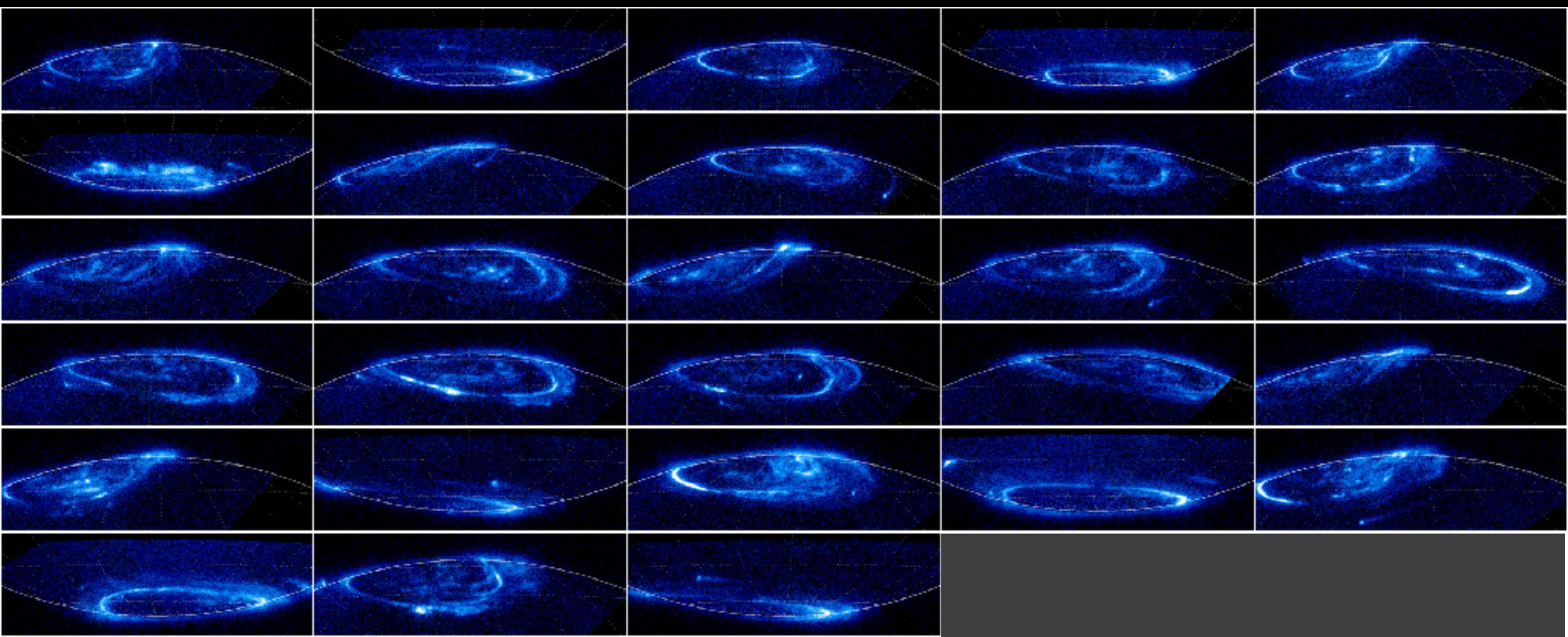


# Jupiter is alive!

HST observations of Jupiter's aurora during Juno orbits 18, 19 and 20



**Denis Grodent**  
 Zhonghua Yao  
 Bertrand Bonfond  
 Benjamin Palmaerts  
 Jean-Claude Gérard  
 Aikaterini Radioti

Sarah V. Badman  
 Emma J. Bunce  
 Jonathan D. Nichols  
 Lorenz Roth  
 Joachim Saur  
 William Dunn

Carl Schmidt  
 John T. Clarke  
 Jack E. Connerney  
 G. Randall Gladstone  
 Tomoki Kimura  
 William S. Kurth

Barry Mauk  
 David J. McComas  
 Alessandro Mura  
 Glenn S. Orton

New HST campaign  
near solar minimum

GO 15638

50 HST orbits during

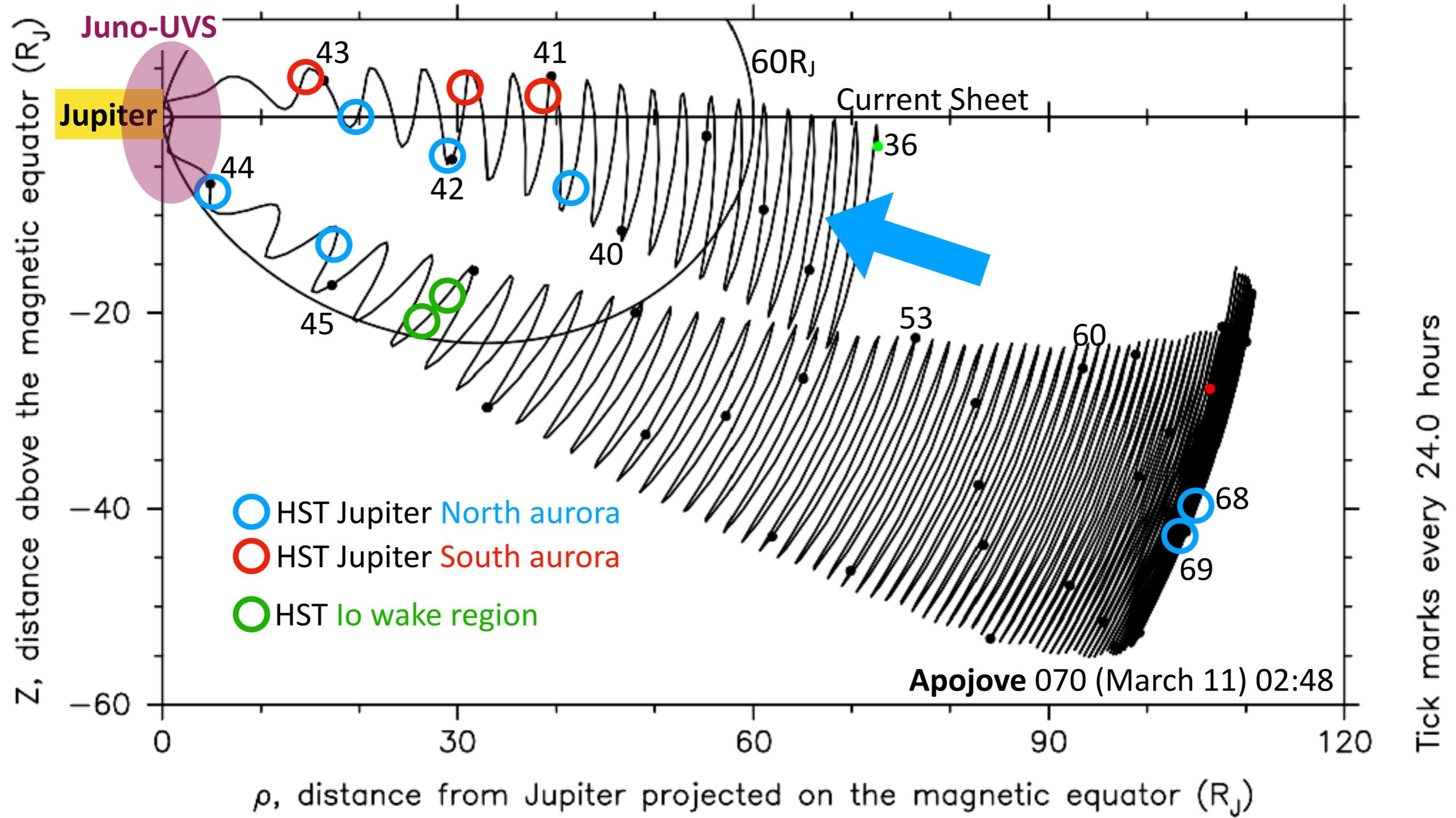
Juno orbits 18-22

HST observations (STIS FUV)  
of Jupiter's aurora  
during  
Juno orbit 18

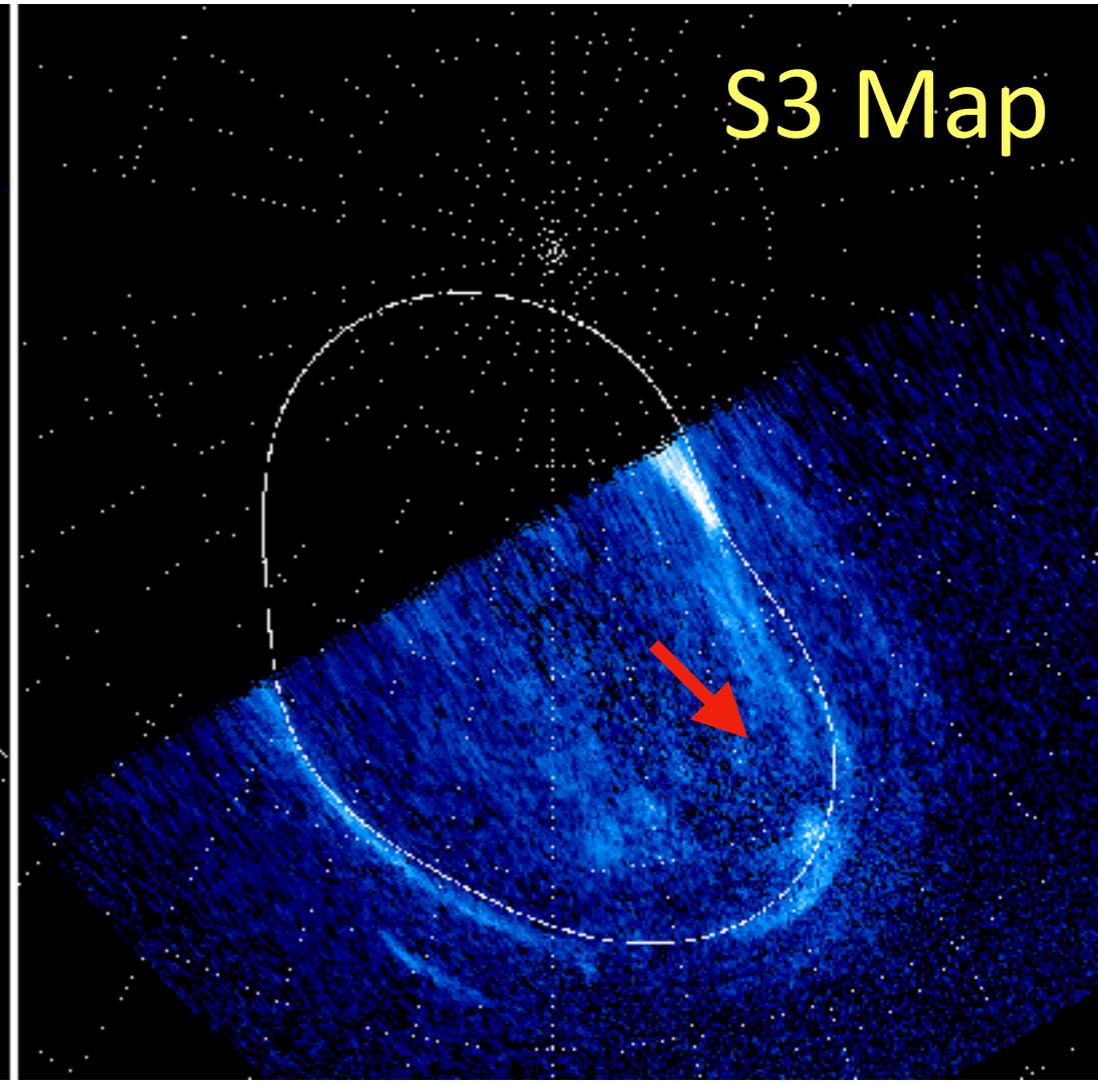
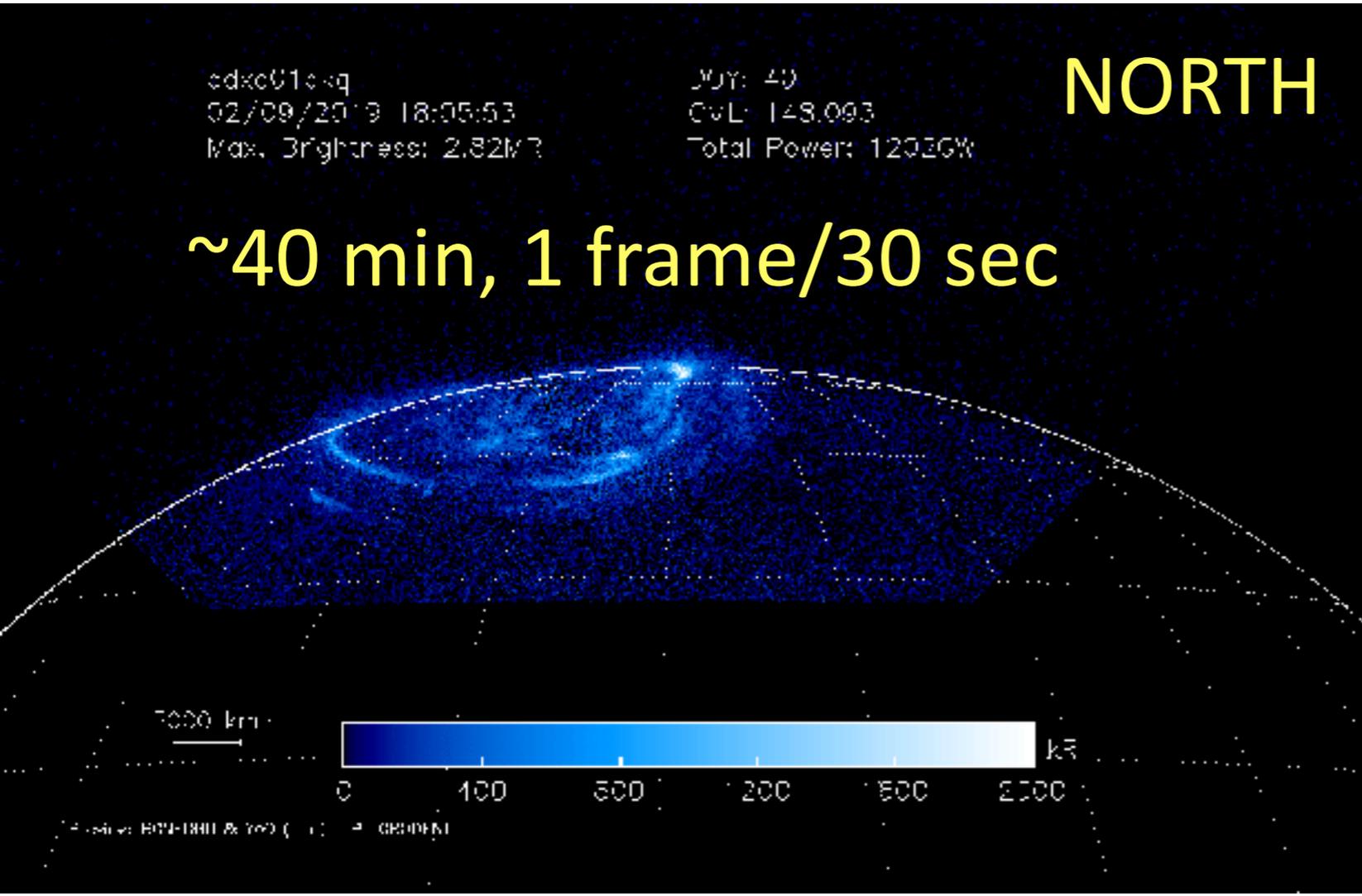
# Juno trajectory in magnetic coordinates

HST during Juno Orbit #18

2019 036 (February 5) 00:00:00 – 2019 075 (March 16) 00:00:00

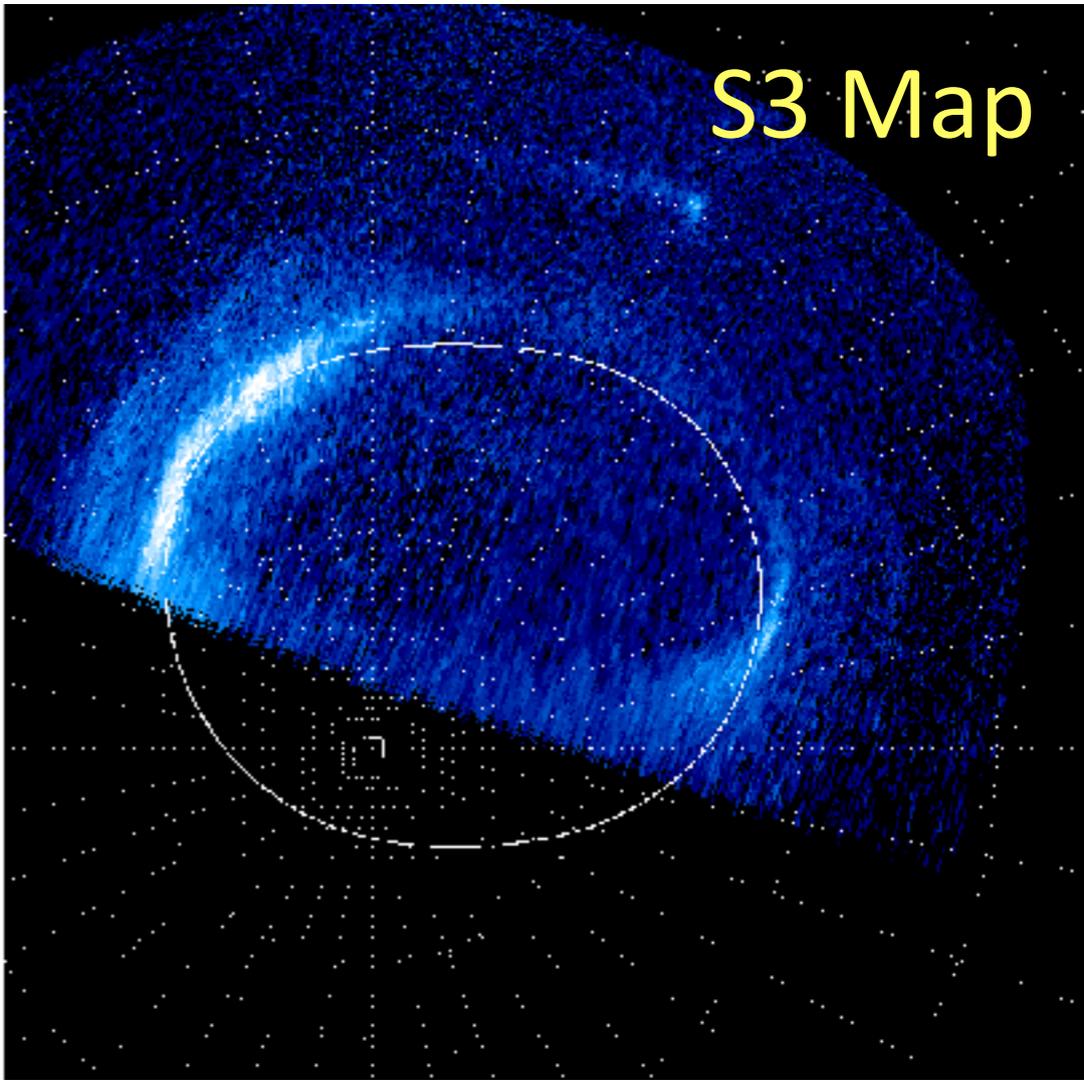
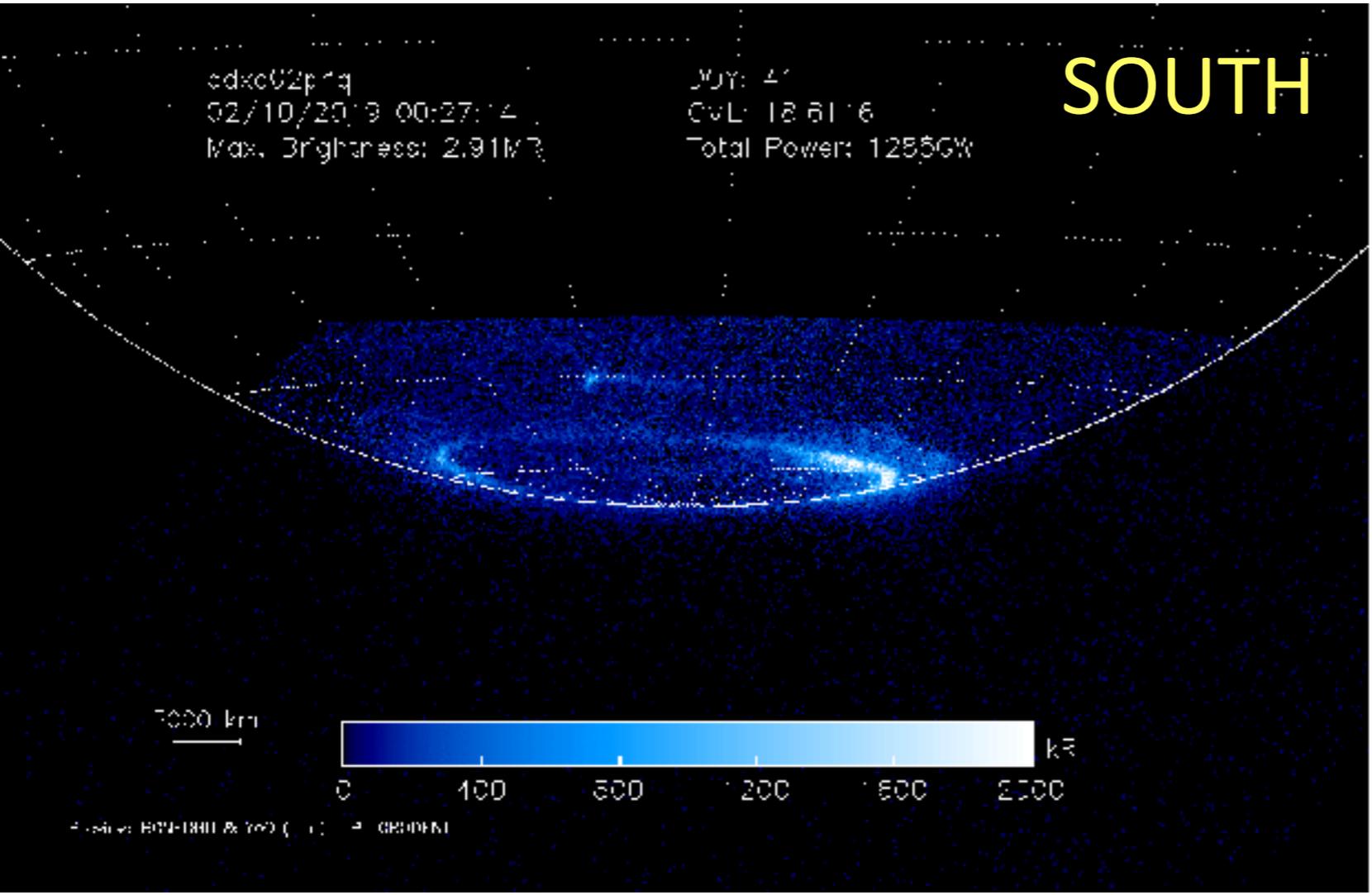


# PJ18 - 3d

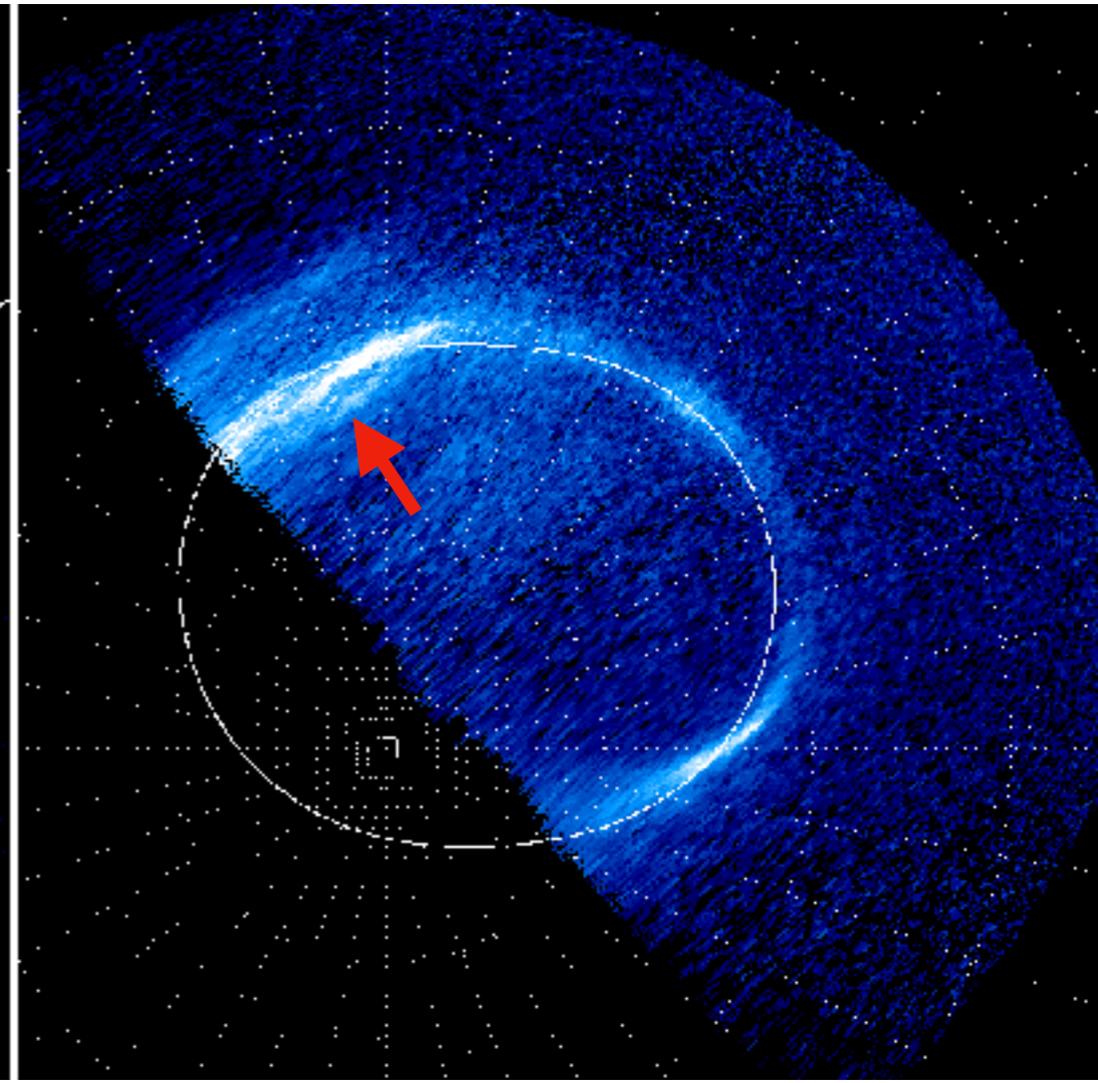
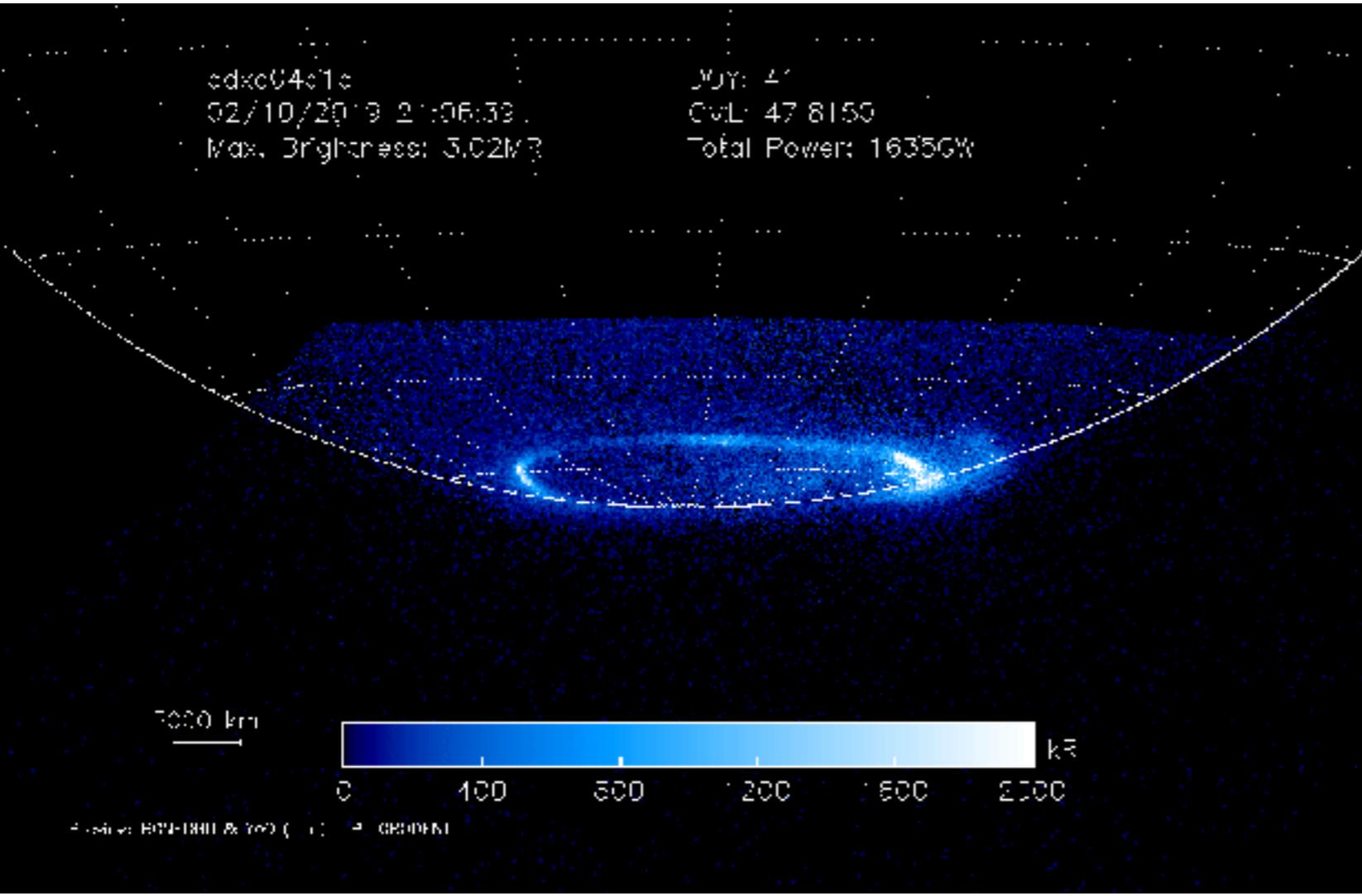


## Multiple Pulsating Bridges

+ ~6 hr

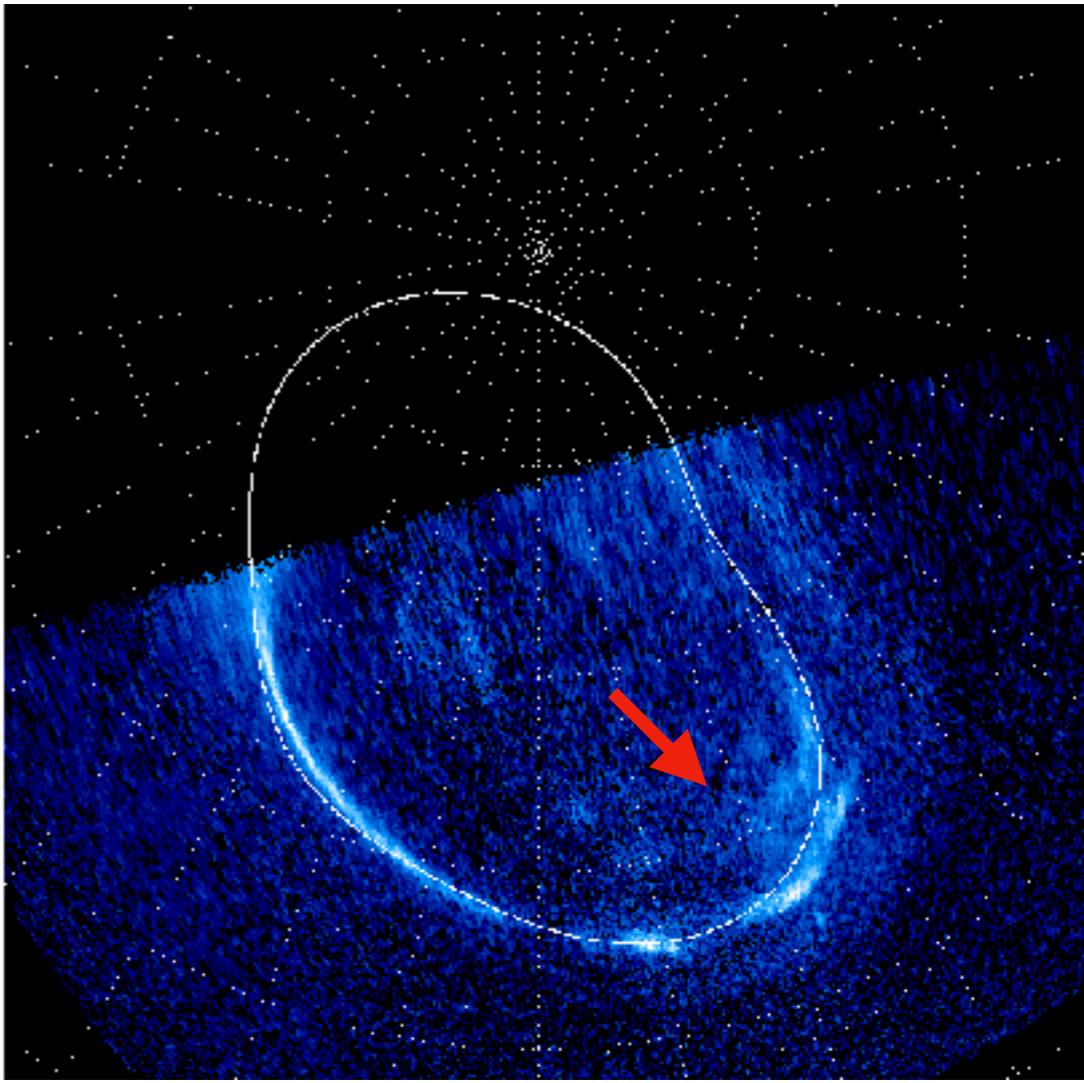
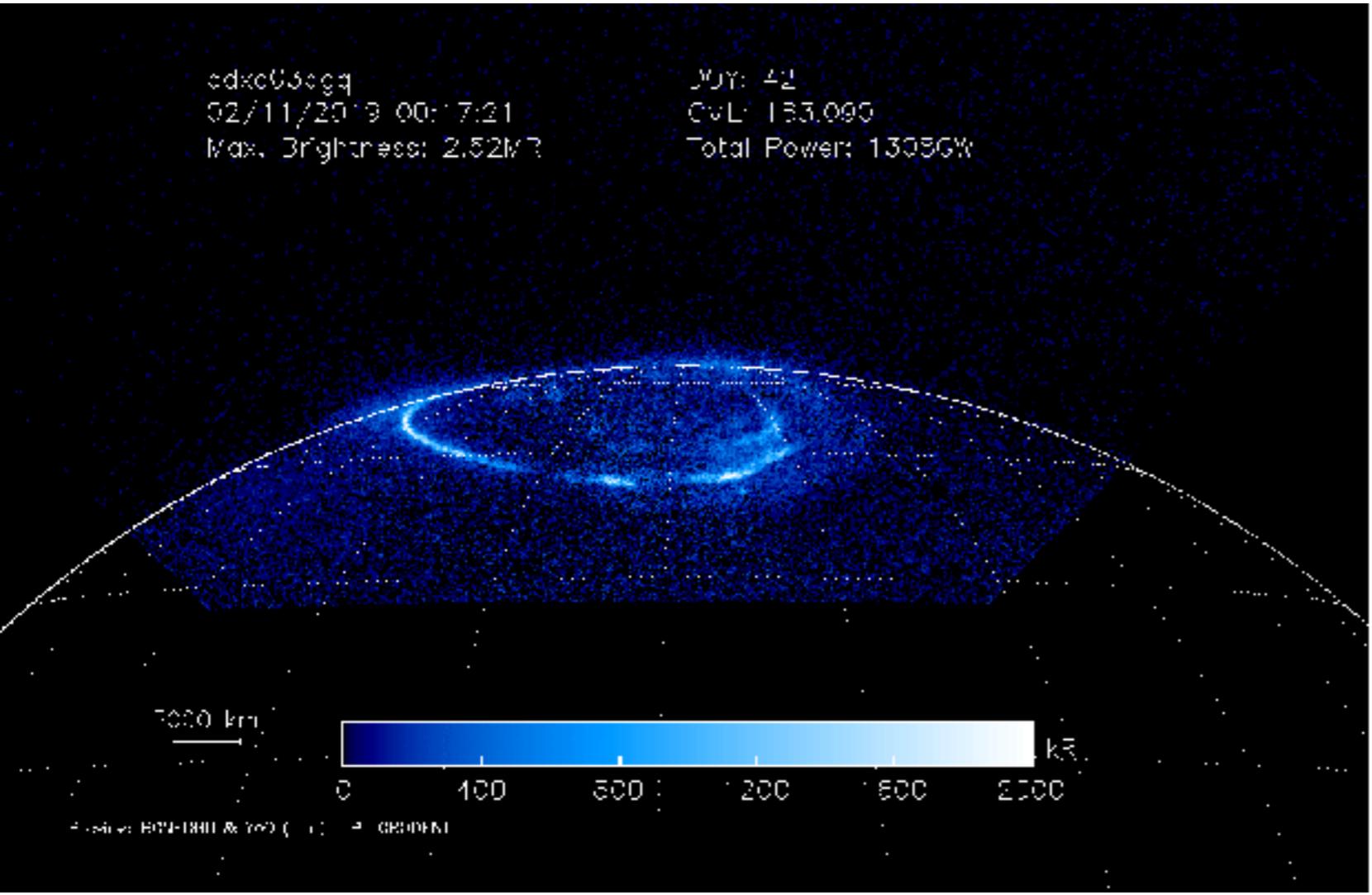


+ ~21 hr



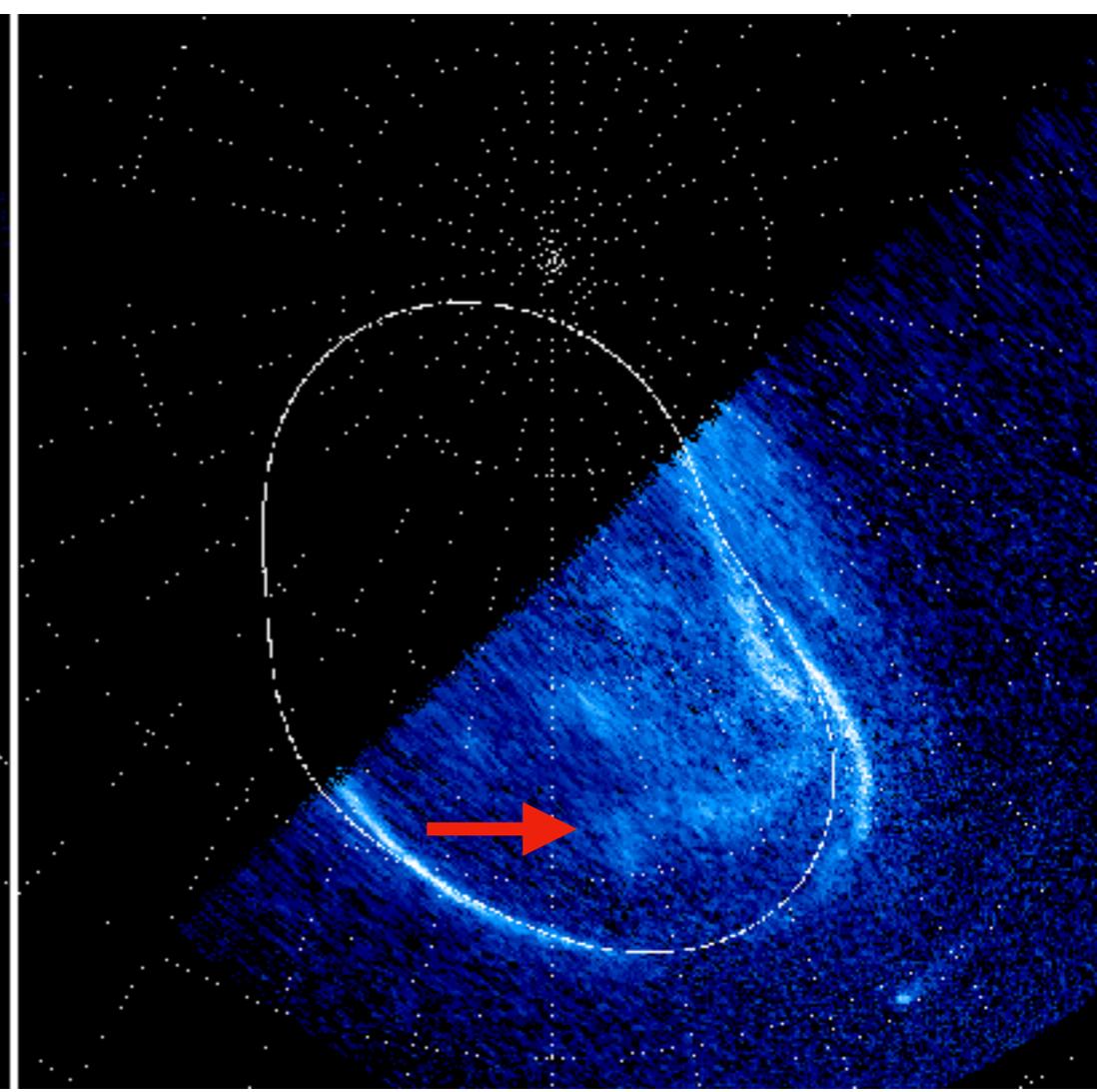
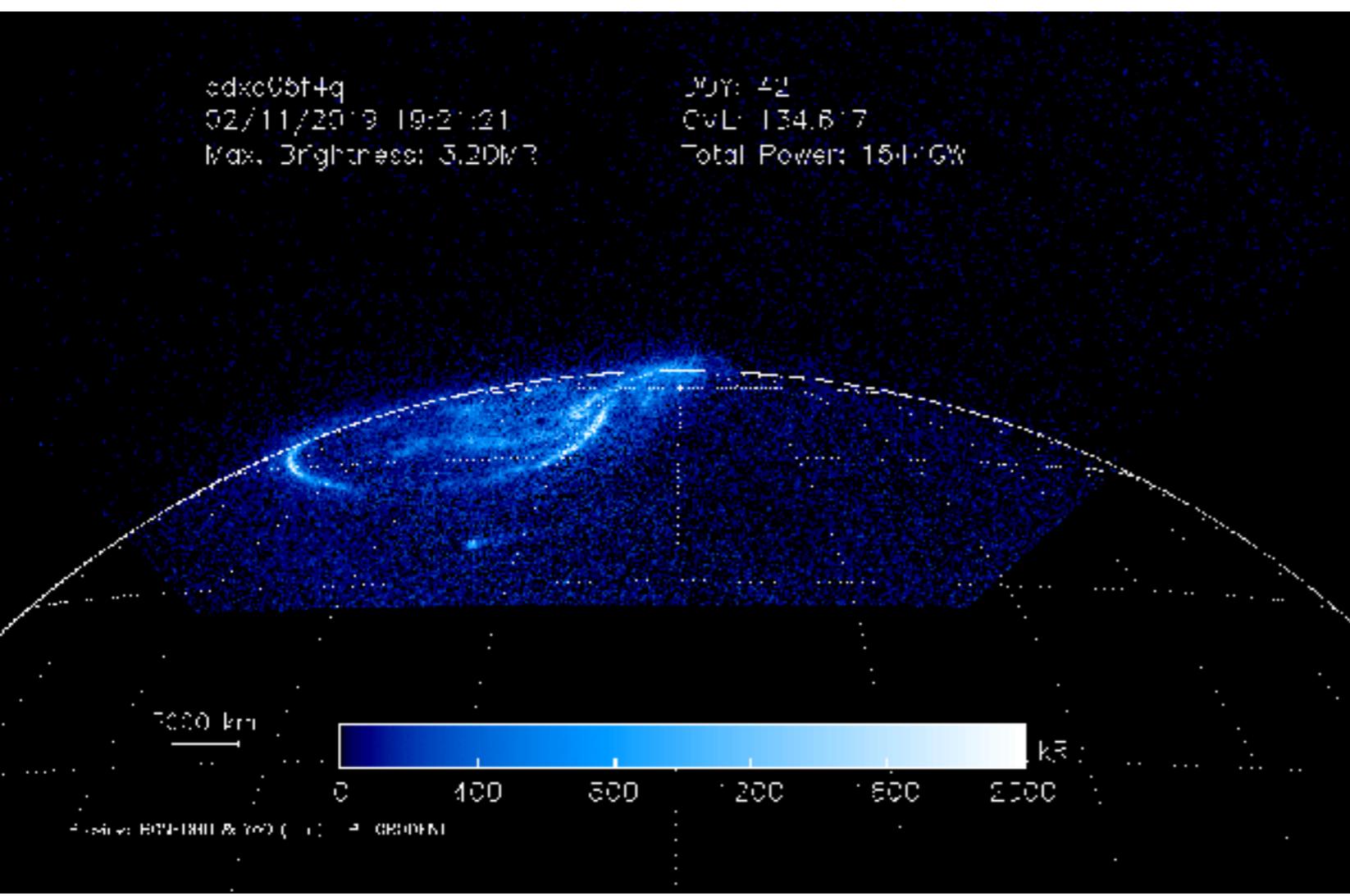
Dusk Brightening of ME

+ ~3 hr



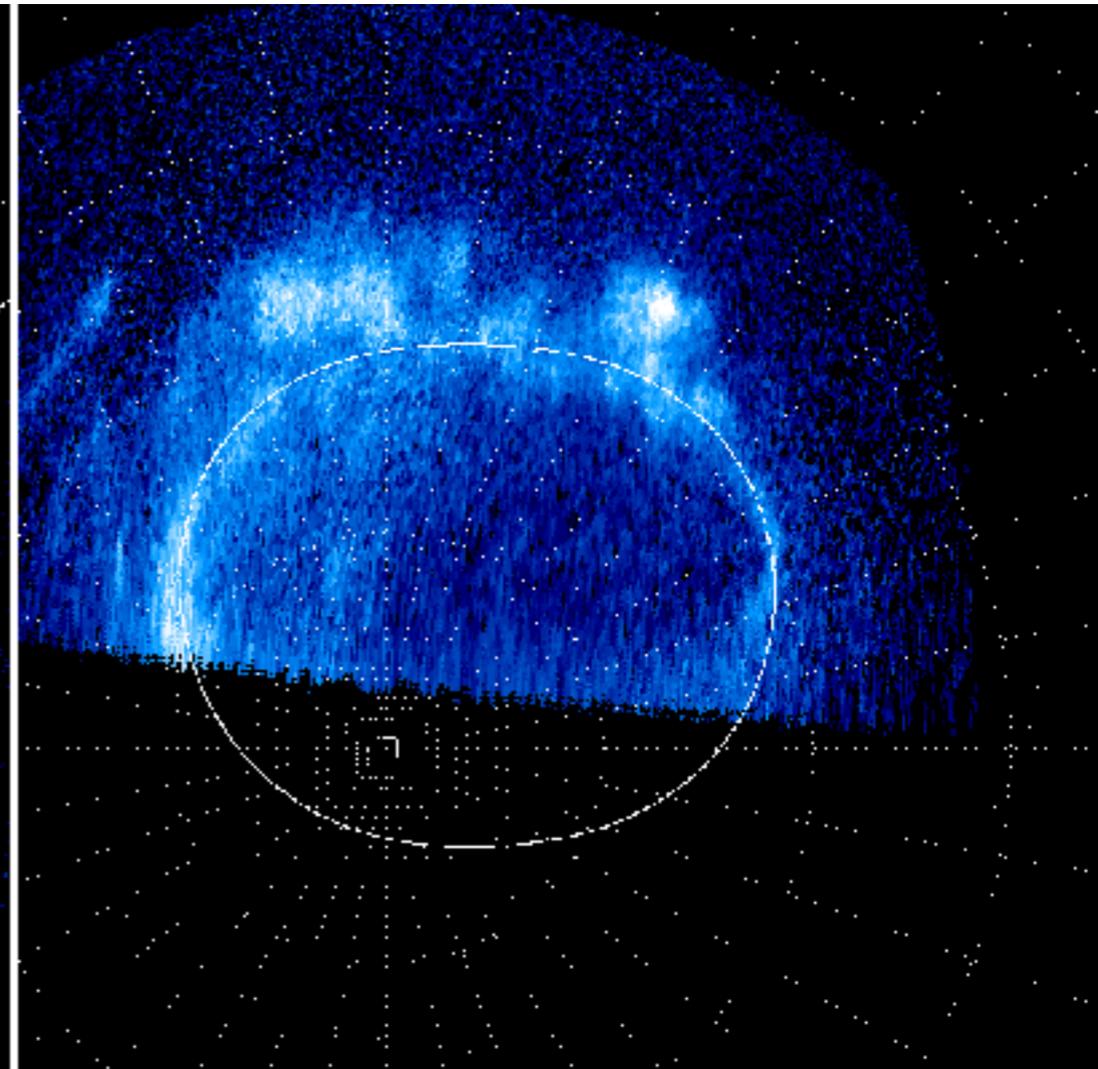
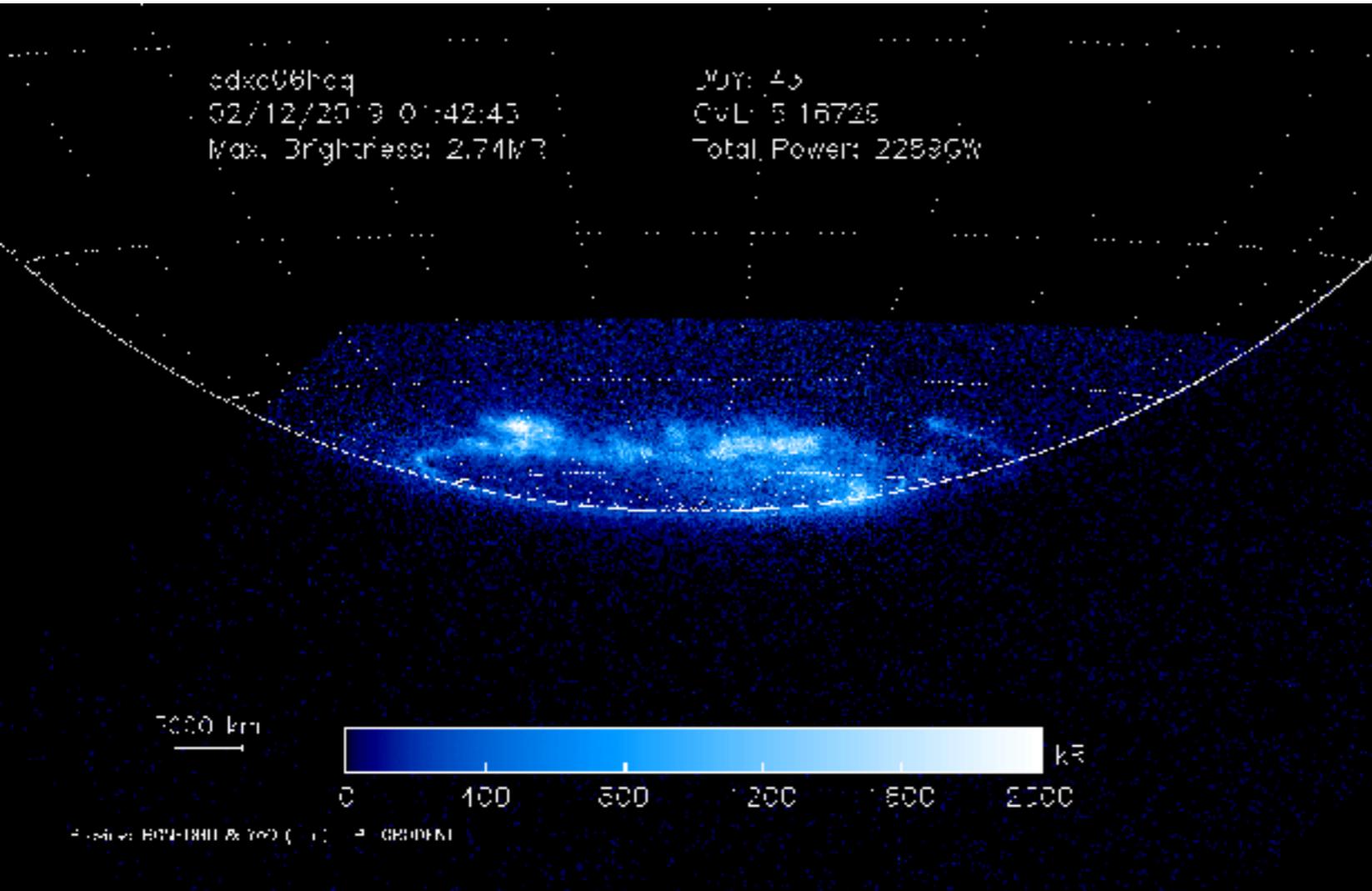
Bridge drifting equatorward (LT effect)

+ ~19 hr PJ18 - 1d



Pulsating Bridge drifting equatorward

+ ~6 hr PJ18 - 16h



**INJECTIONS INJECTIONS INJECTIONS**

Injection "auroral blobs": corotating, moving equatorward

+ ~16 hr Juno/UVS

SOUTH

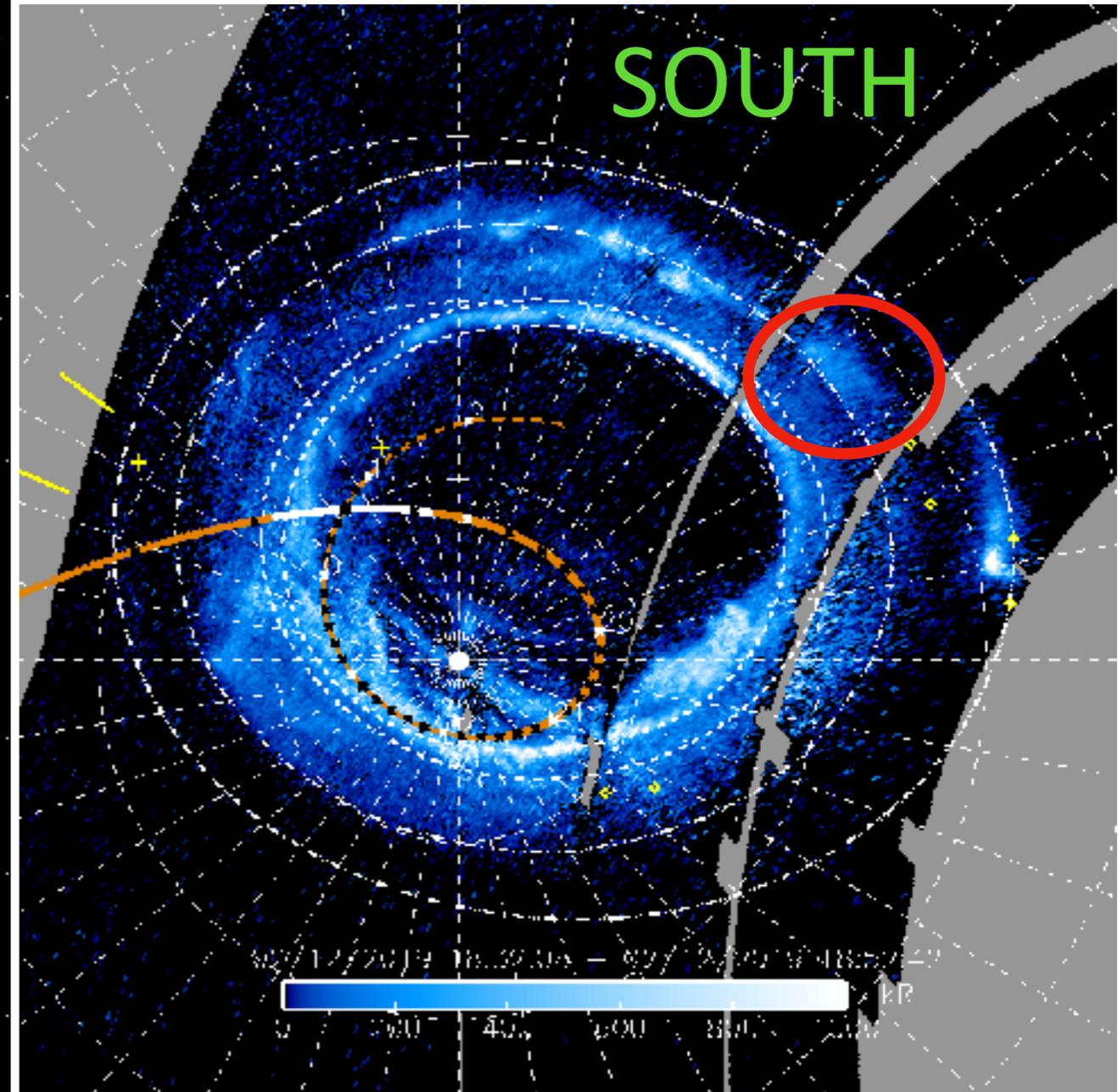
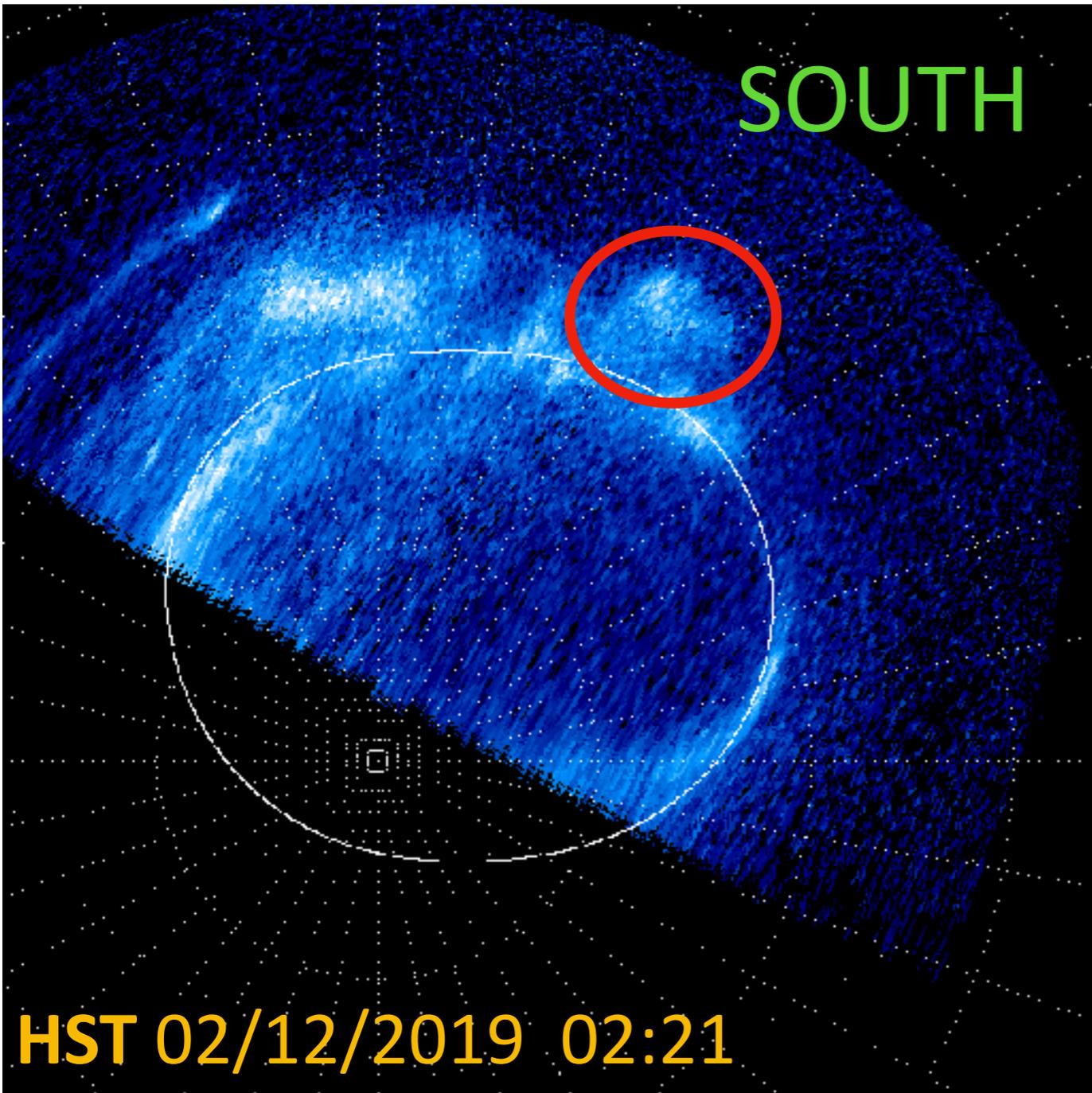
NORTH

HST 02/12/2019 02:21



B. Bonfond and the Juno/UVS Team

+ ~17 hr Juno/UVS

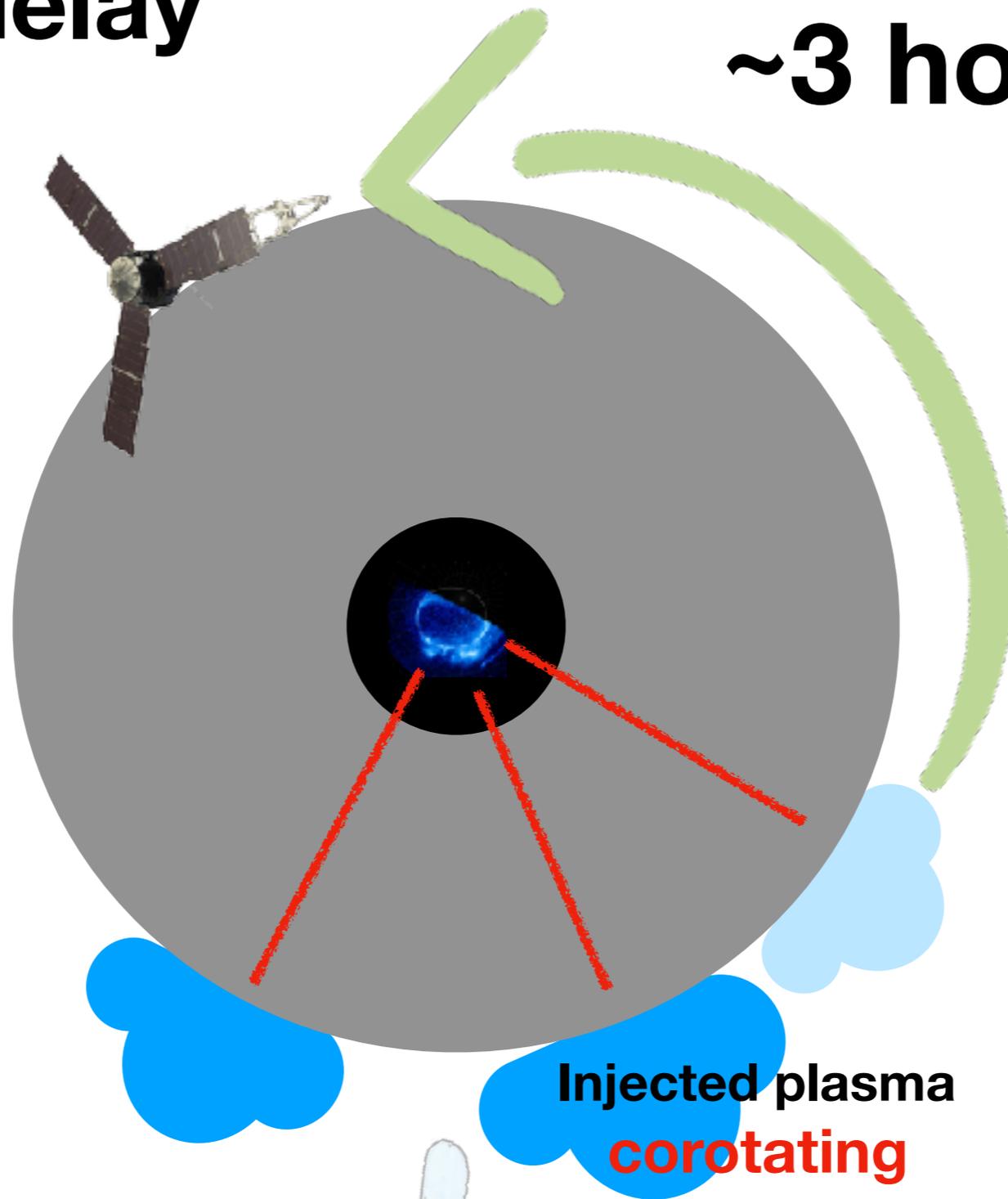


B. Bonfond and the Juno/UVS Team

sub-corotation (drift) =  $\sim 10^\circ / 10\text{hr}$

# HST - JEDI delay

**~3 hours**

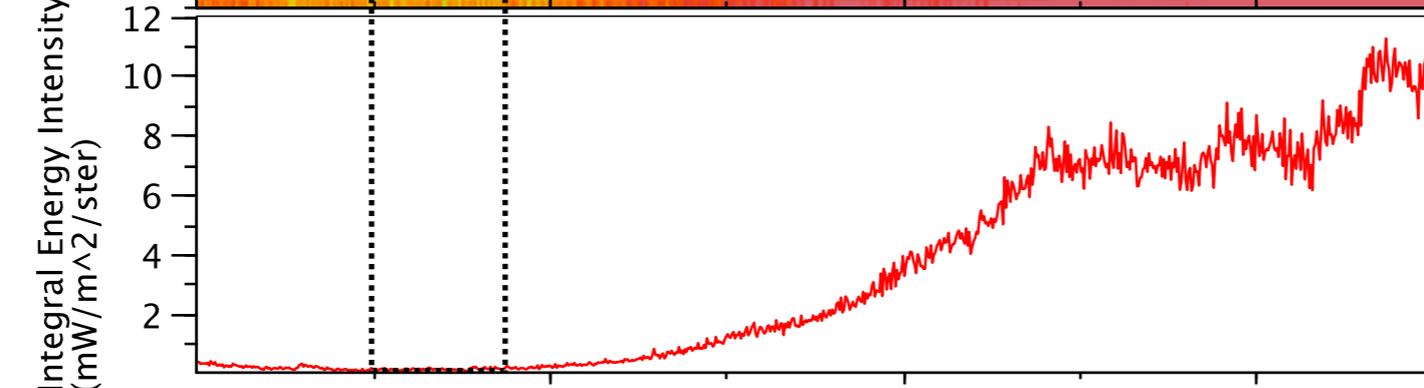
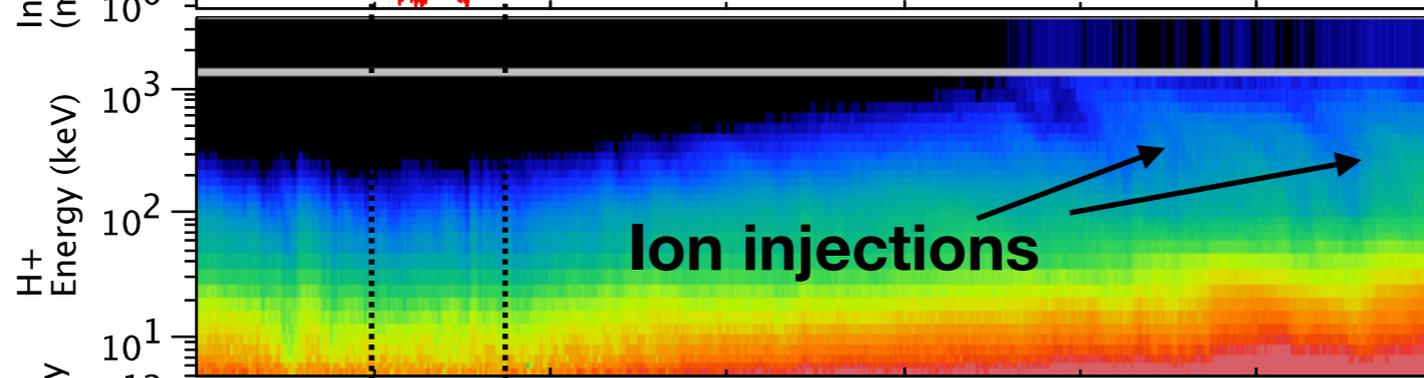
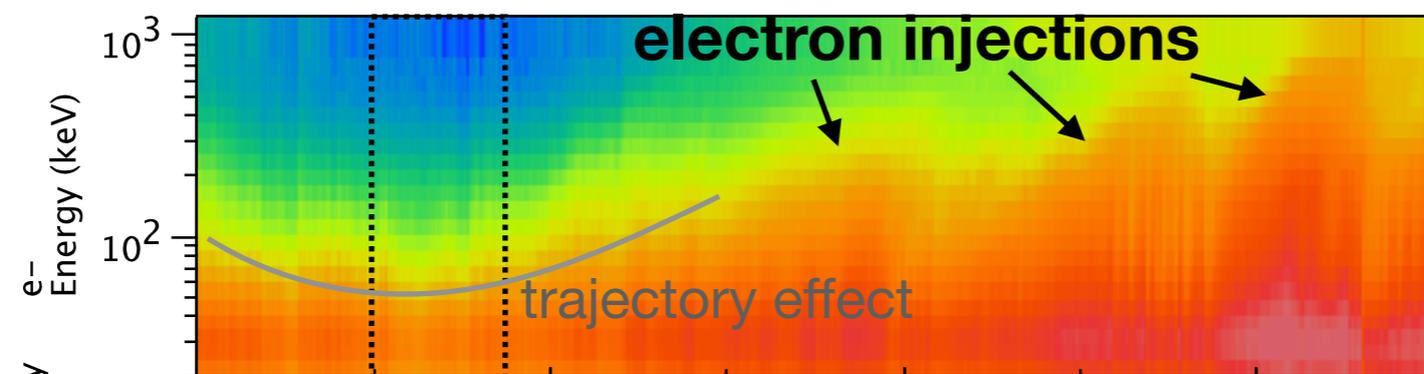


**Injected plasma  
corotating**



**HST**

JED900EXFL03 e- (22.5900,25.6500) keV ...  
 Energy Spectrogram configuration  
 Calendar Time (2019-043T00:00:00.000 to 2019-043T07:00:00.000)

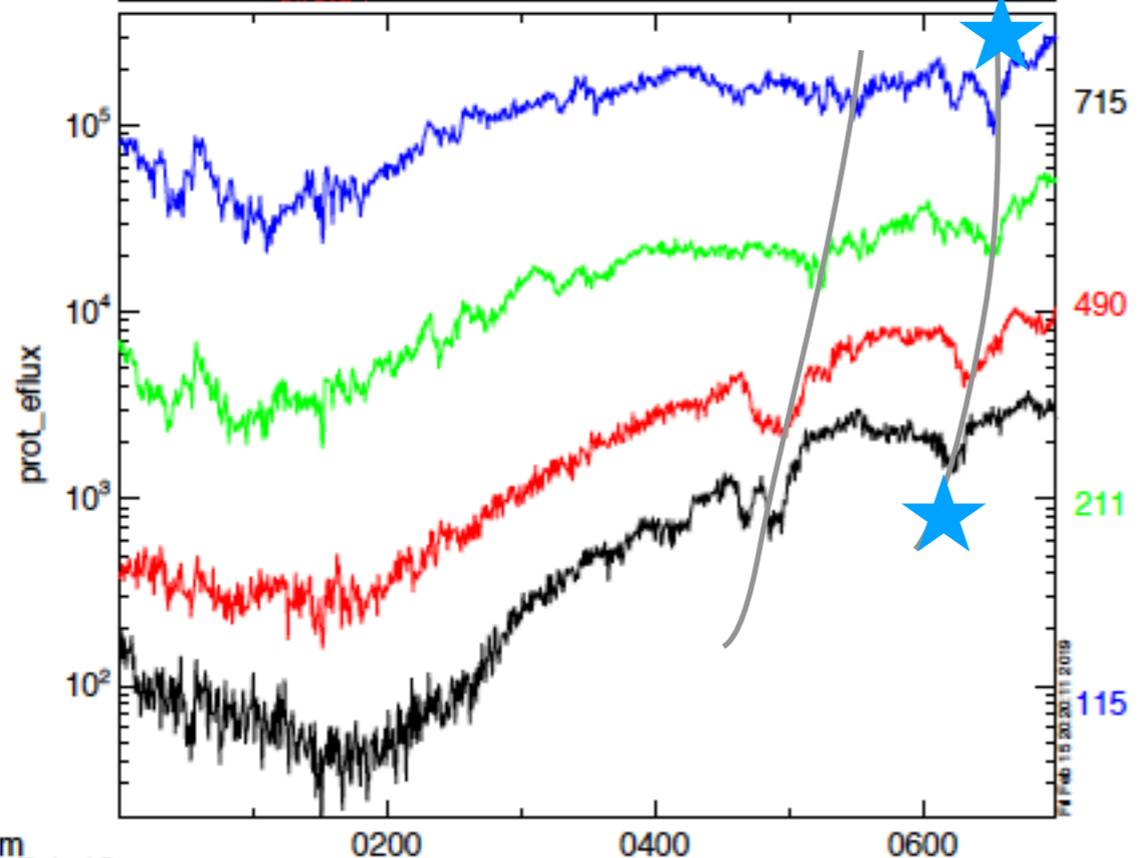
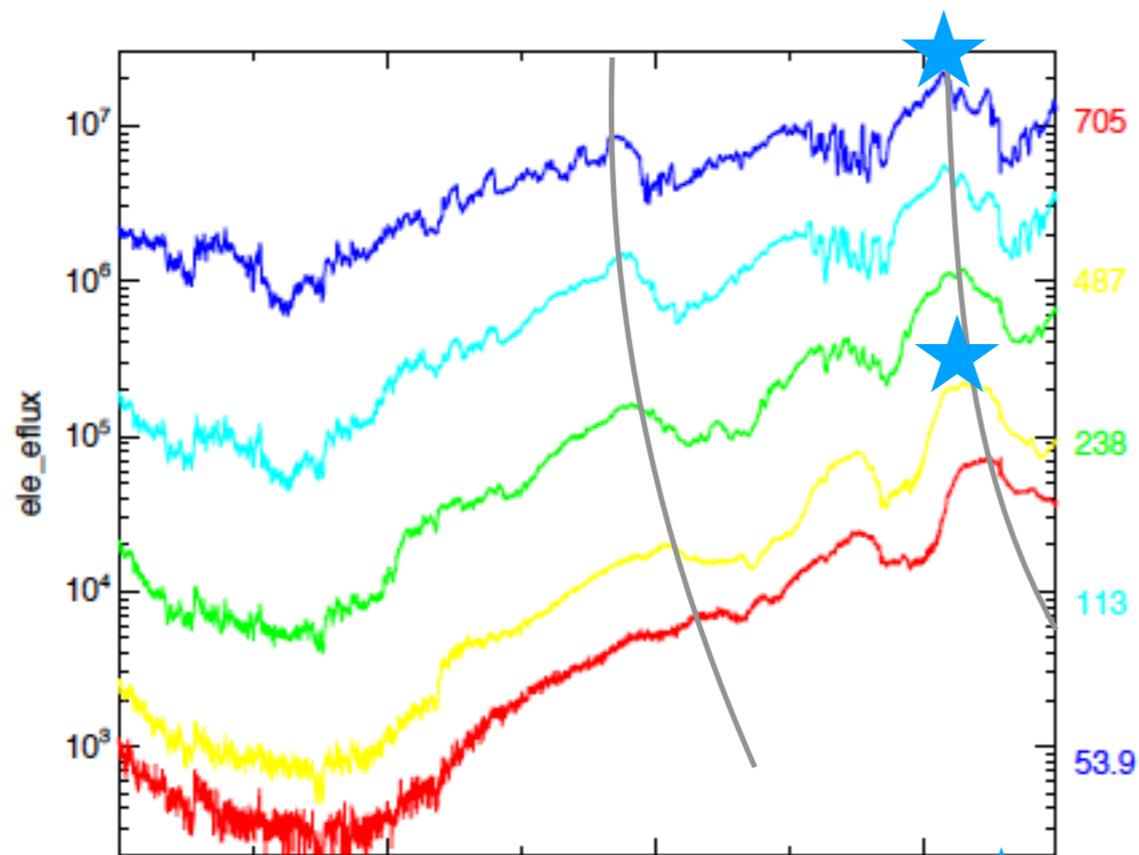


density (c/s/ster/cm<sup>2</sup>/keV)  
 JED900EXFL03 e- (22.5900,25.6500) keV ...

density (c/s/ster/cm<sup>2</sup>/keV)  
 JED900TPFL04 H+ (59.6700,65.3000) keV ...

	02:00	04:00	06:00
Jupiter-Mag-Latitude (degrees)	18.41	11.00	3.74
Jupiter-Dipole-L (Rj)	17.22	14.64	12.69
Jupiter-R (Rj)	15.50	14.11	12.63

**JEDI in current sheet near Ganymede's orbit**



hhmm  
2019 Feb 12

## Tracing back the source region (following Mauk et al., 1997)

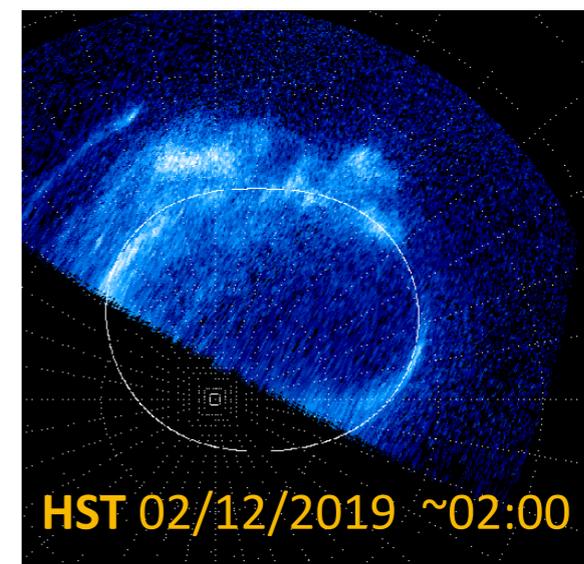
$$\Phi_1 = \Delta T \cdot [(\Omega_o + \Omega_{gl}) / (\Omega_{gl} - \Omega_{gh})] \cdot [\Omega_o + \Omega_{gh} - \Omega_{gl/c}]$$

(in radians), (1)

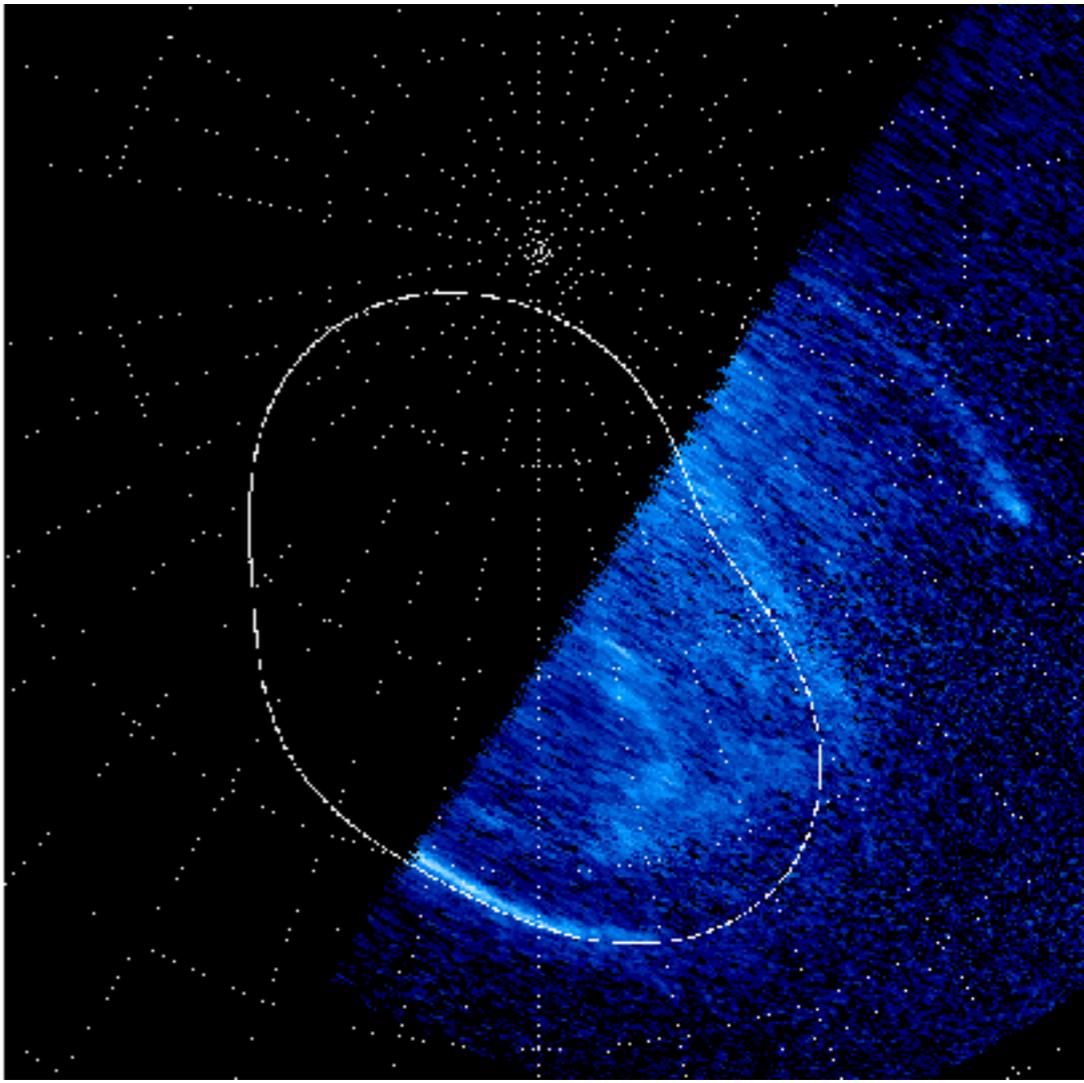
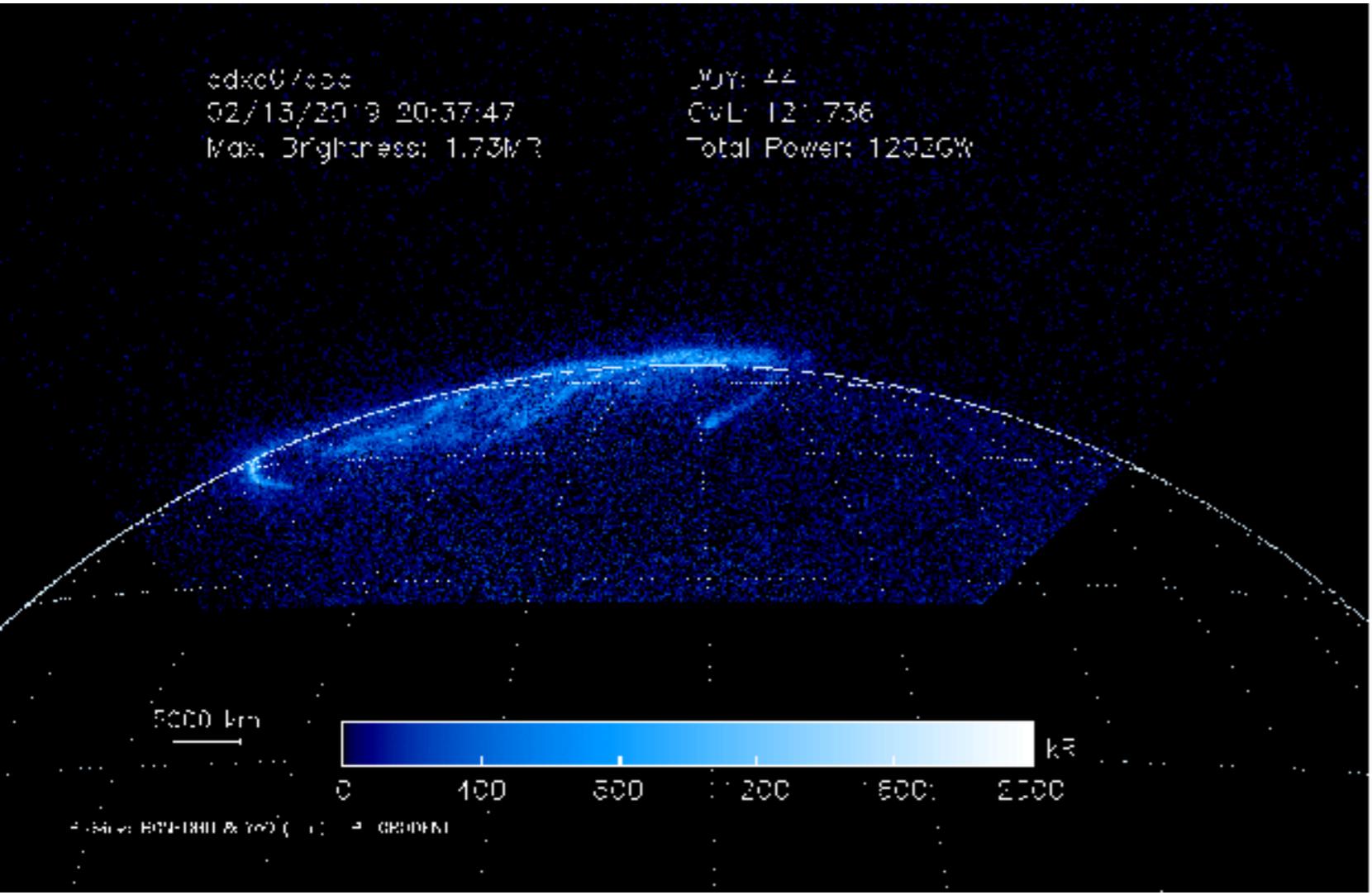
From electrons: **injection time is 5.7h ago**

From protons: **injection time is 5.3h ago**

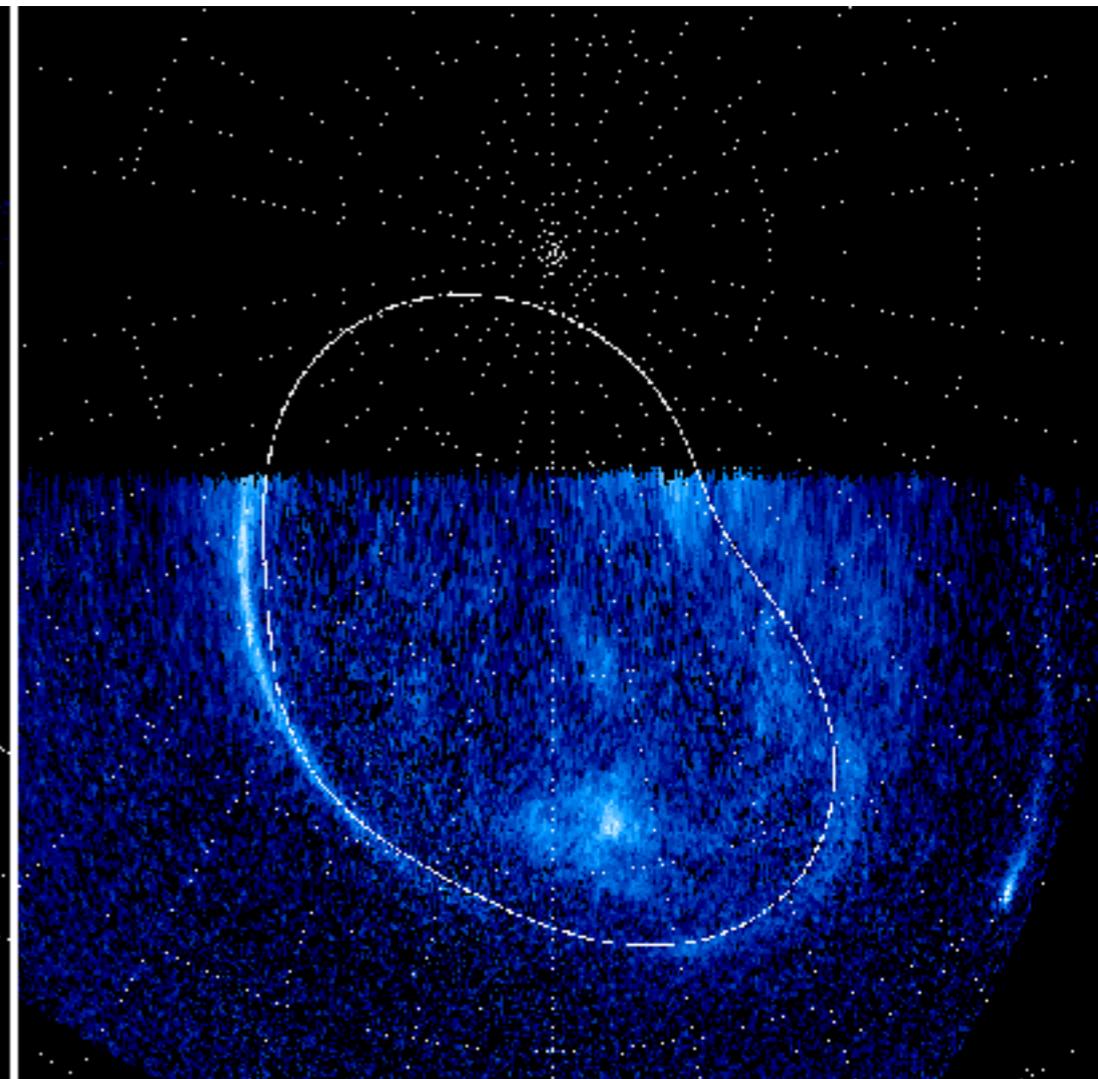
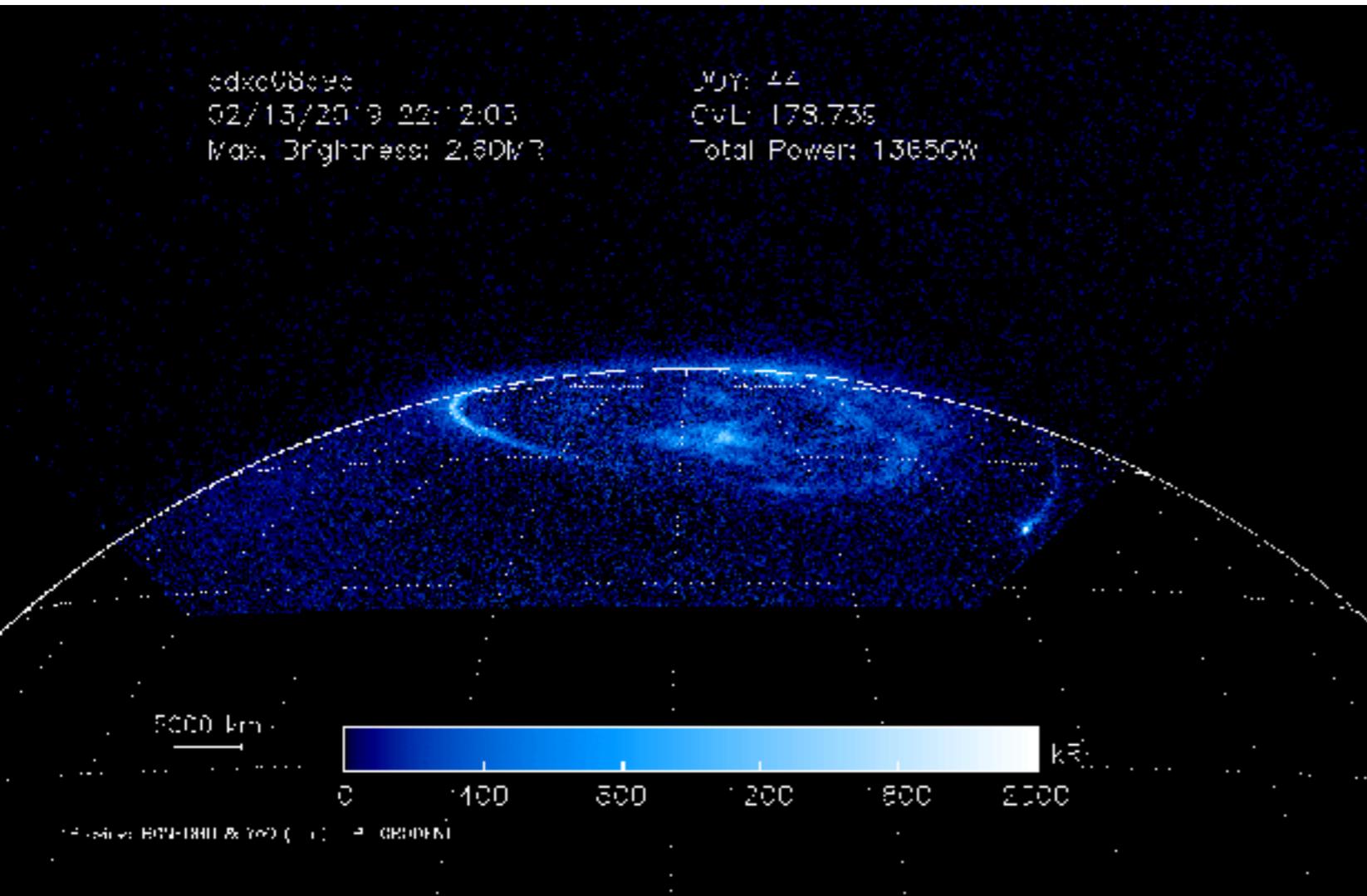
**near 02/12/2019 01:00 HST time**



# PJ18 + 1d



+ ~1.5 hr

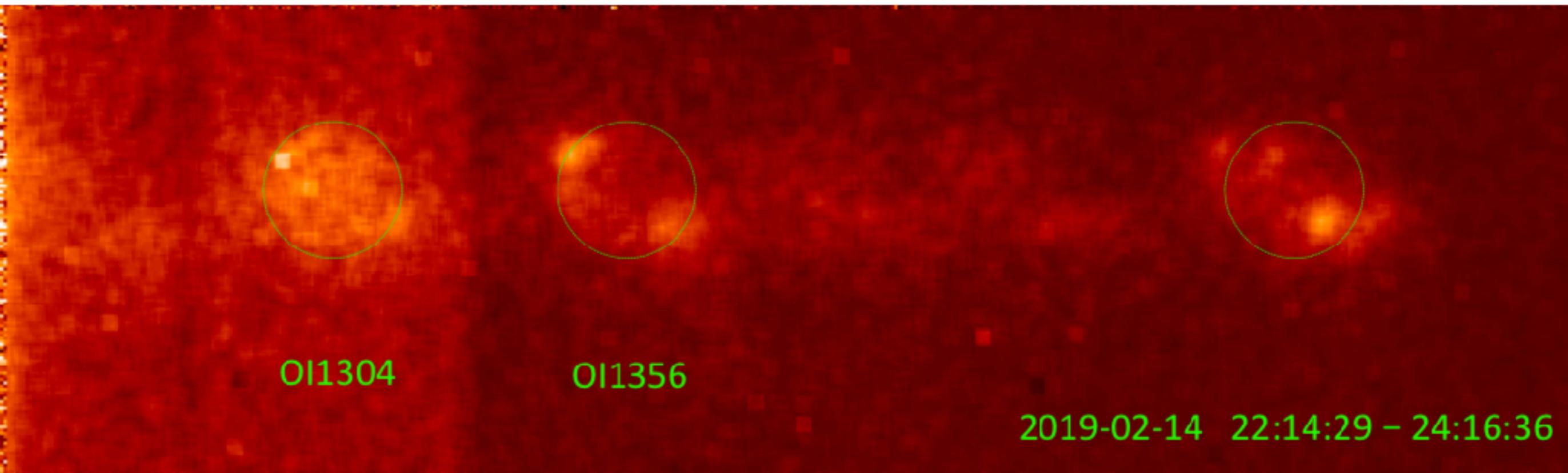


Flares (>10 MR)  
Expansion of main emission (?)

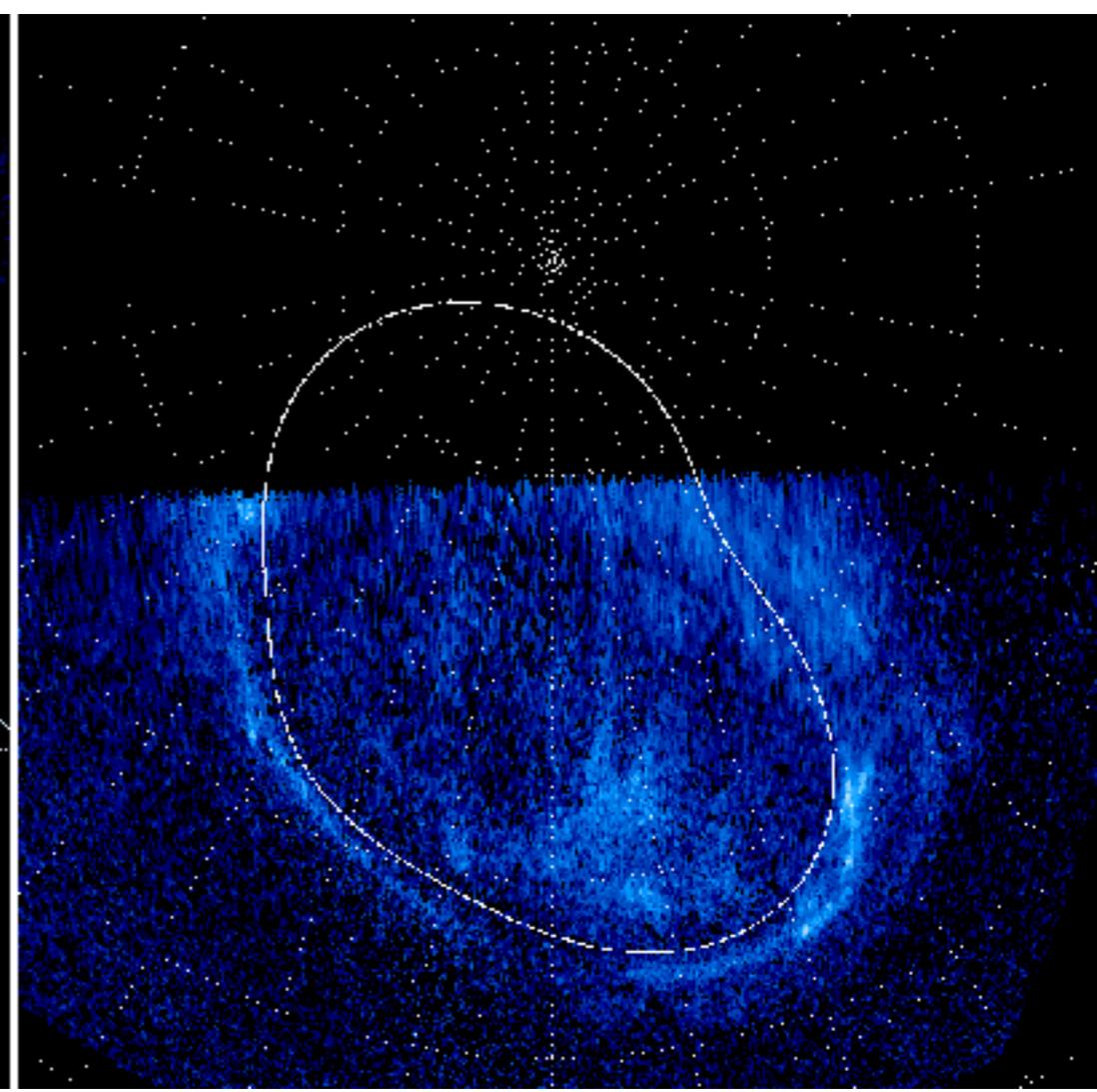
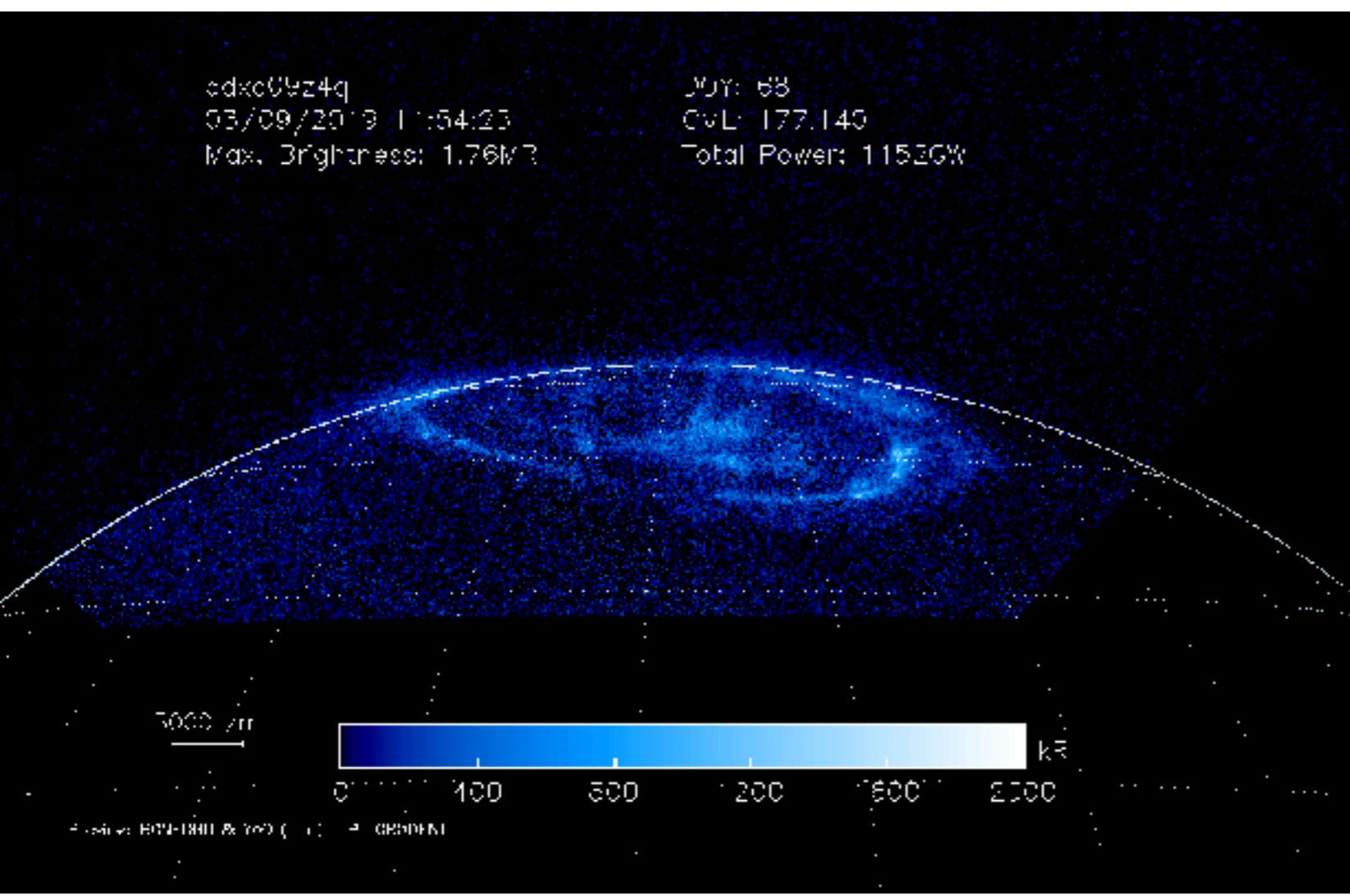
# Io UV aurora

Roth et al. O53, Moon interactions

STIS G140L 52x2 Io Wake (Sum)

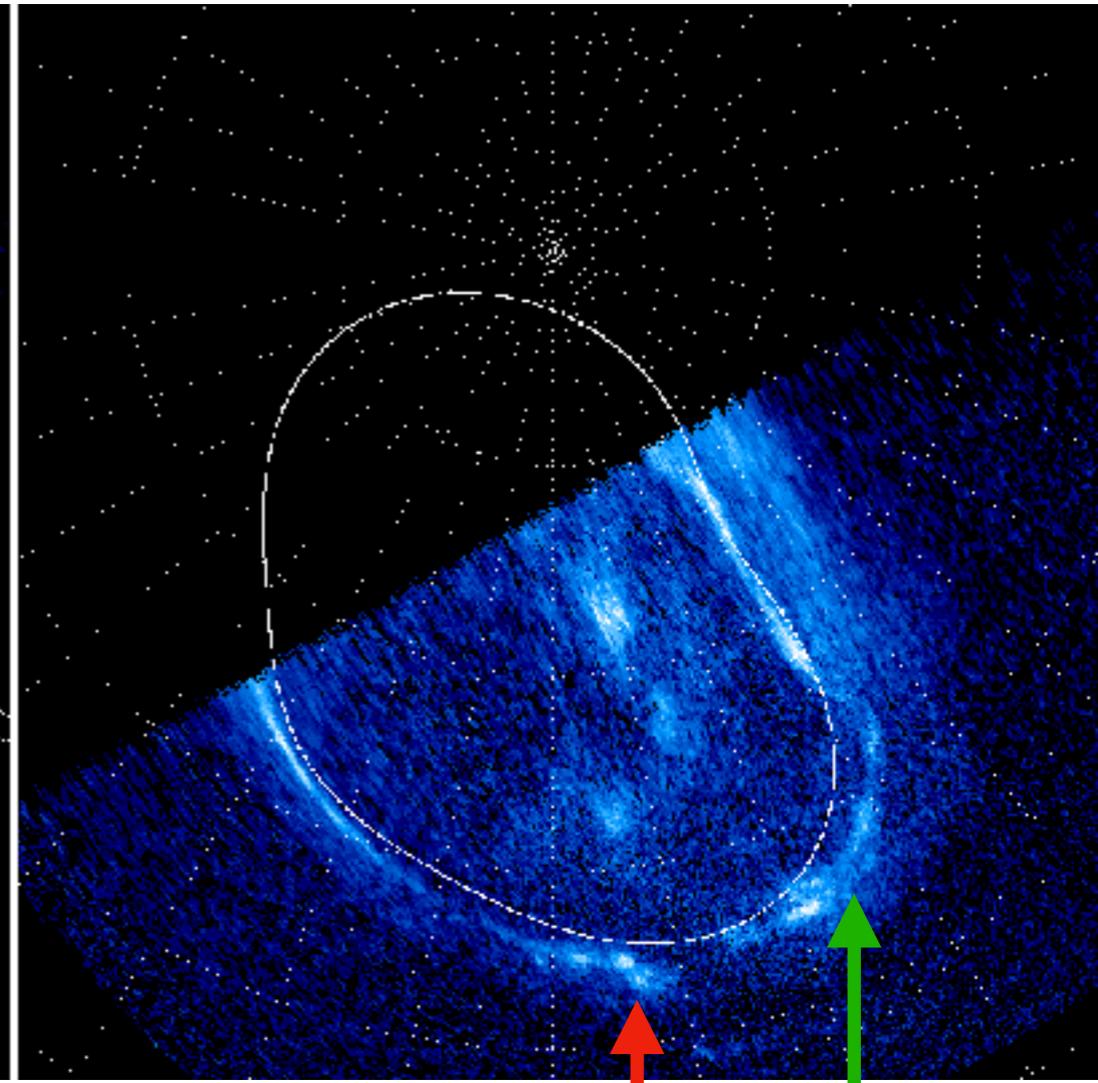
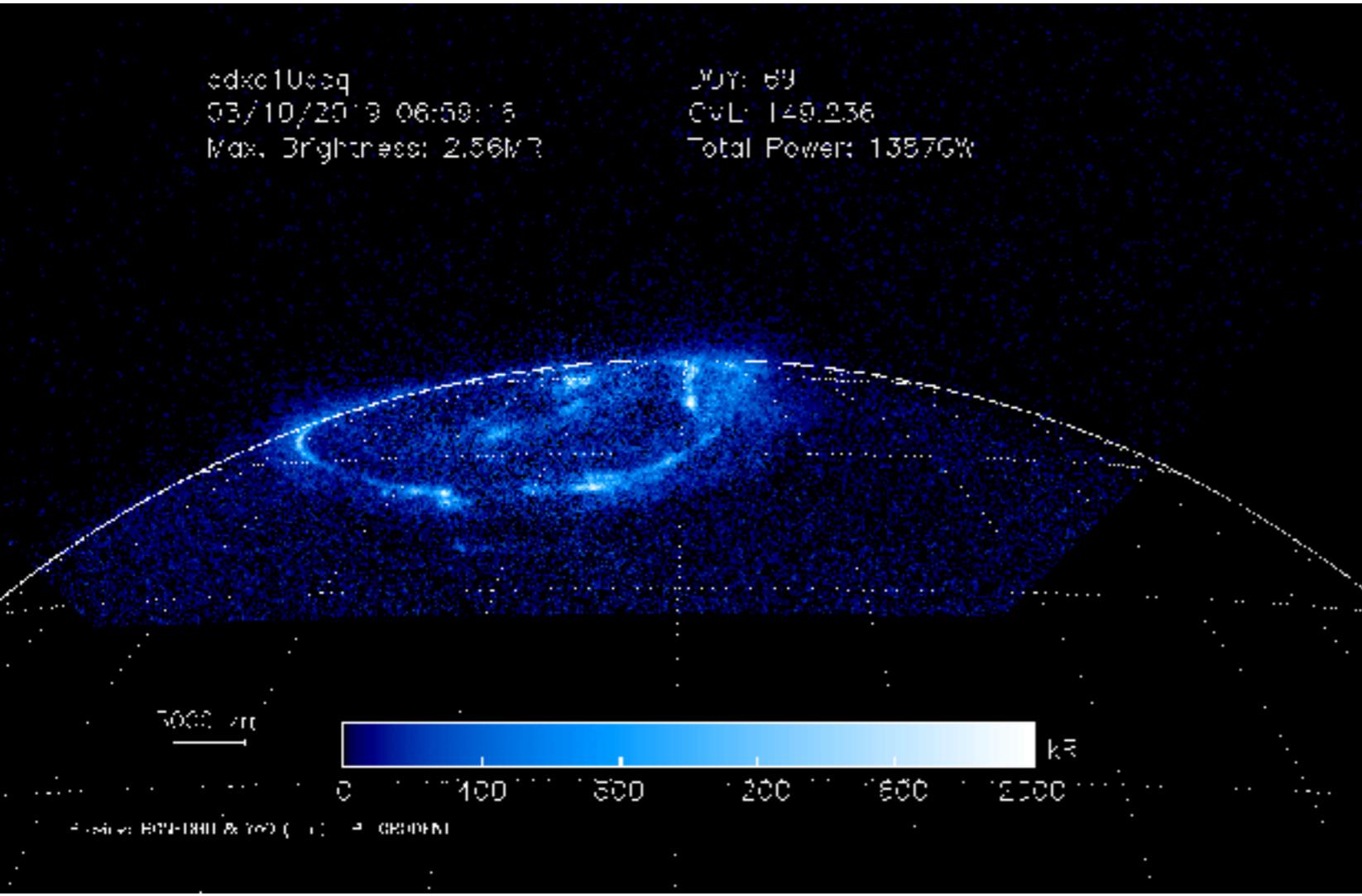


+3 wk AJ18 - 2d



Expanded, faint main emission + Dusk beads

+ ~19 hr



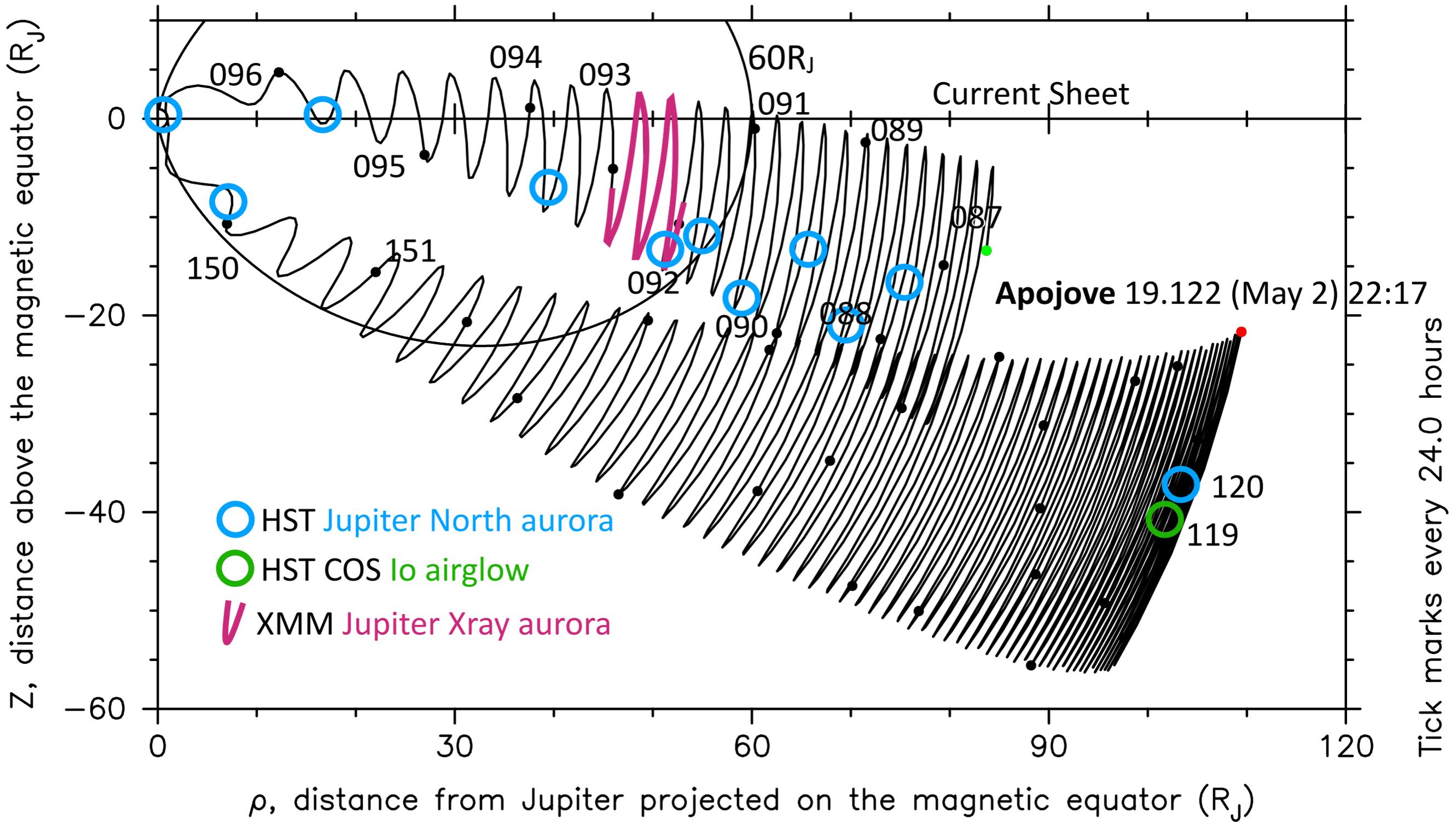
Small injection (from faint Dawn Storm)

broken main emission

Bonfond et al. poster P16

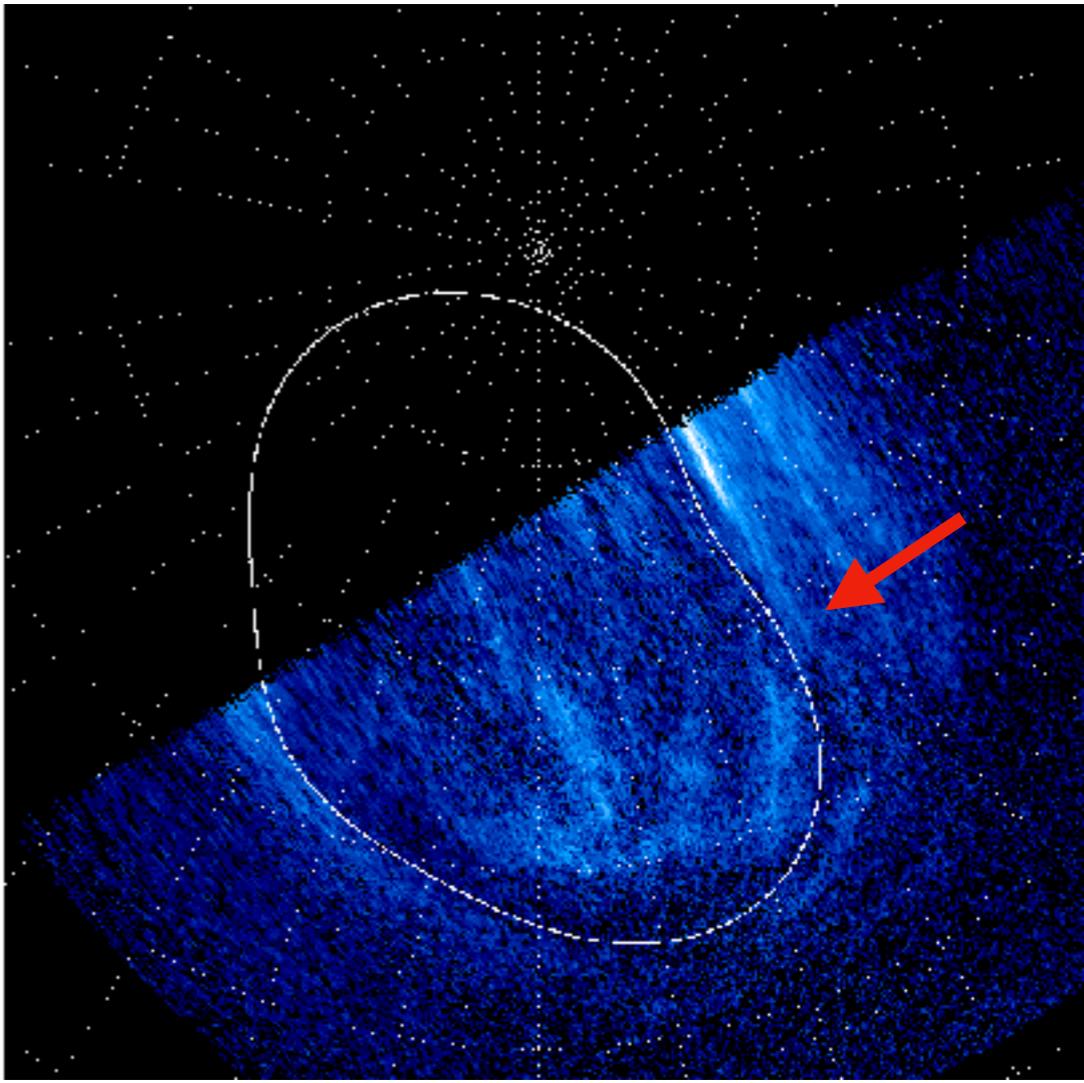
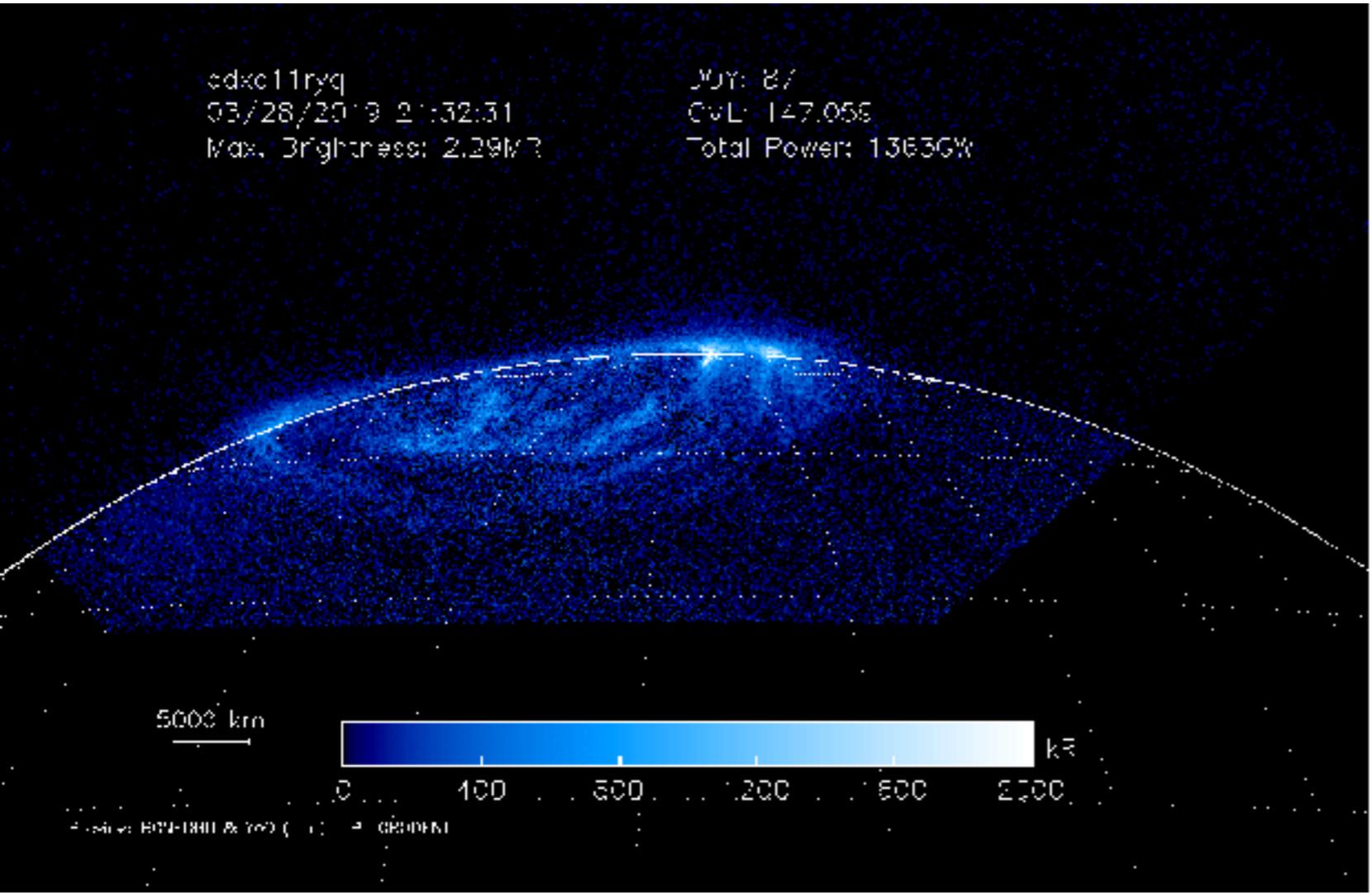
HST observations (STIS FUV)  
of Jupiter's aurora  
during  
Juno orbit 19

2019 086 (March 27) 00:00:00 – 2019 120 (April 30) 00:00:00



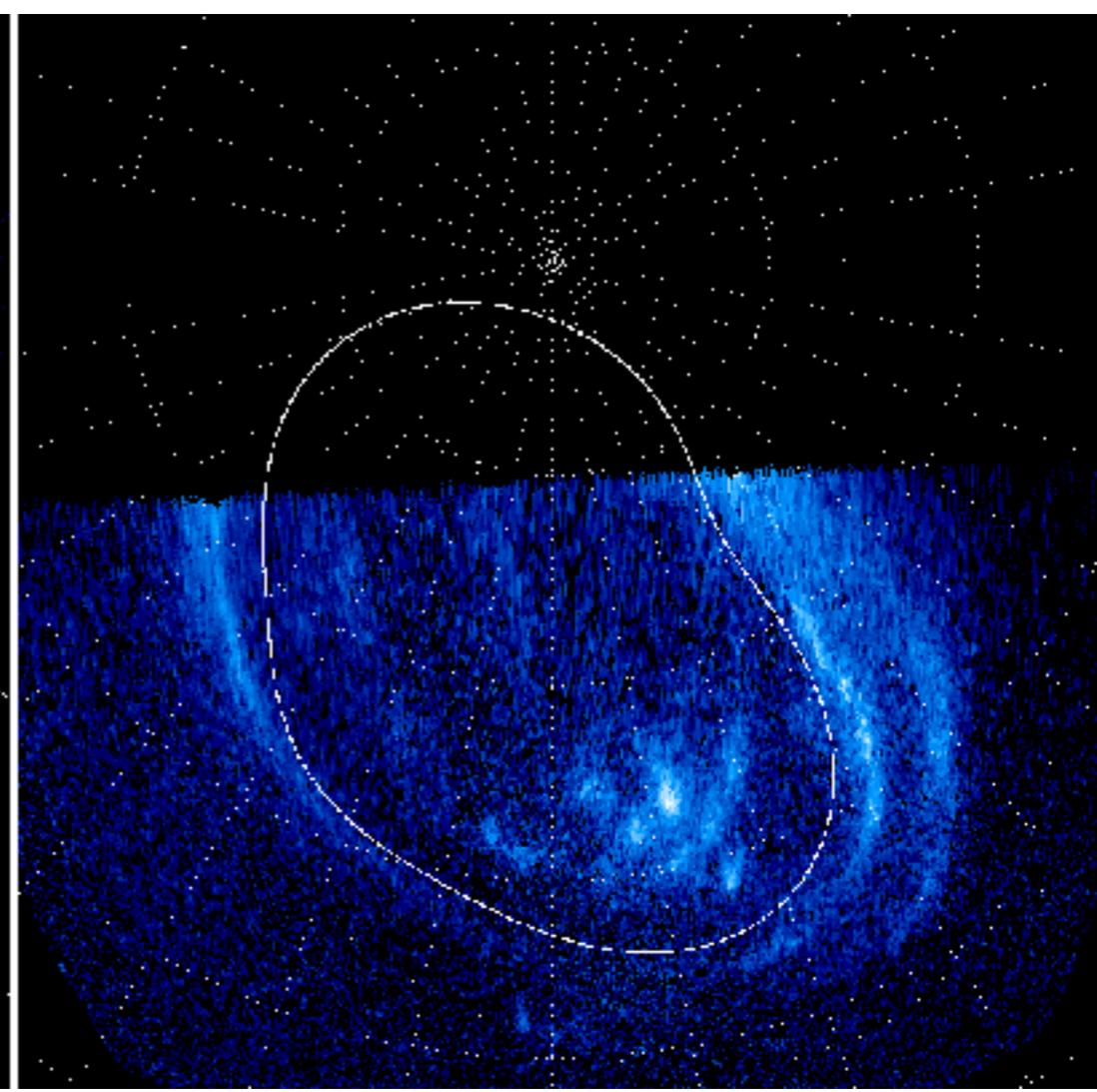
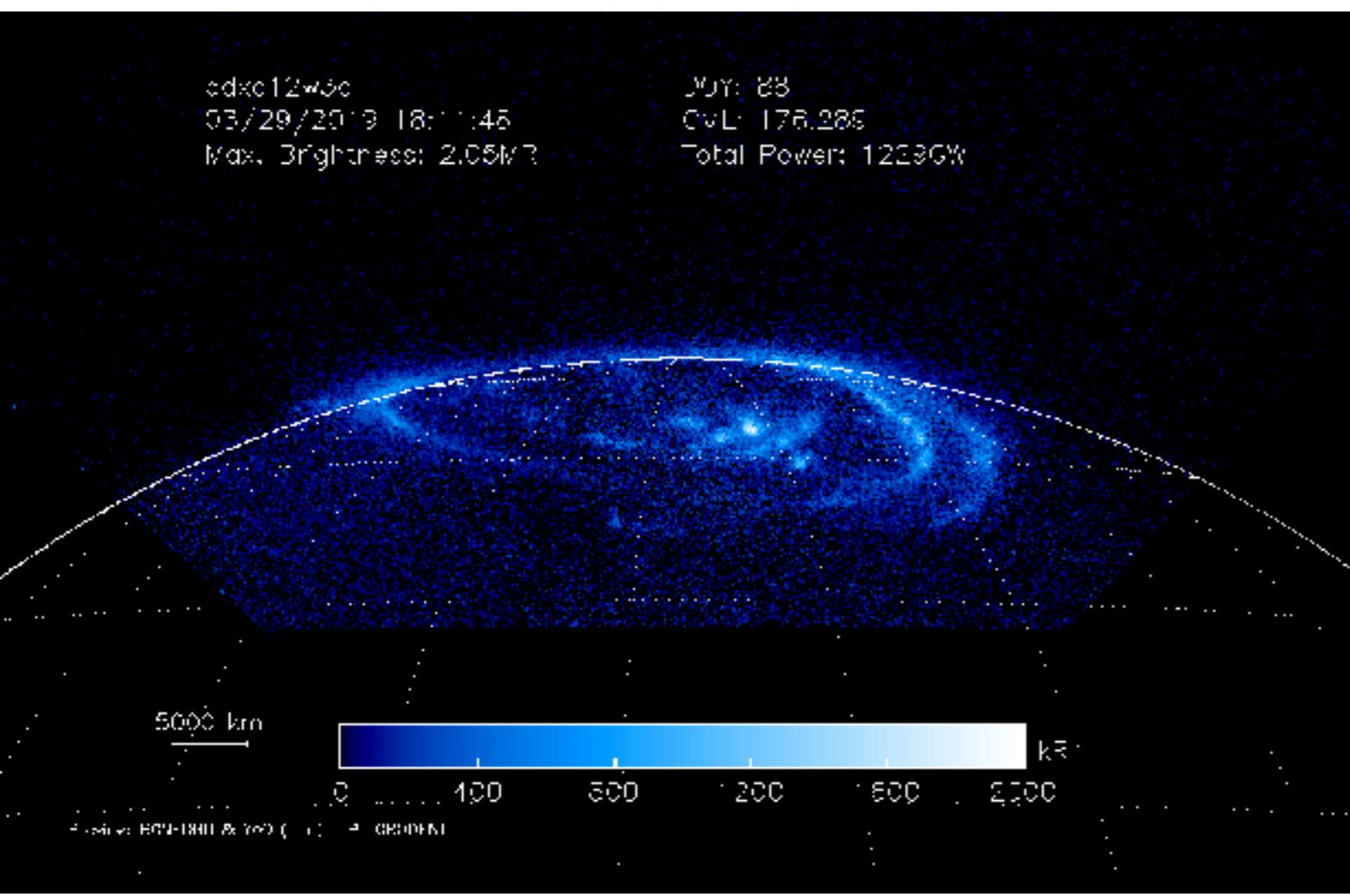


# PJ19 - 9 days



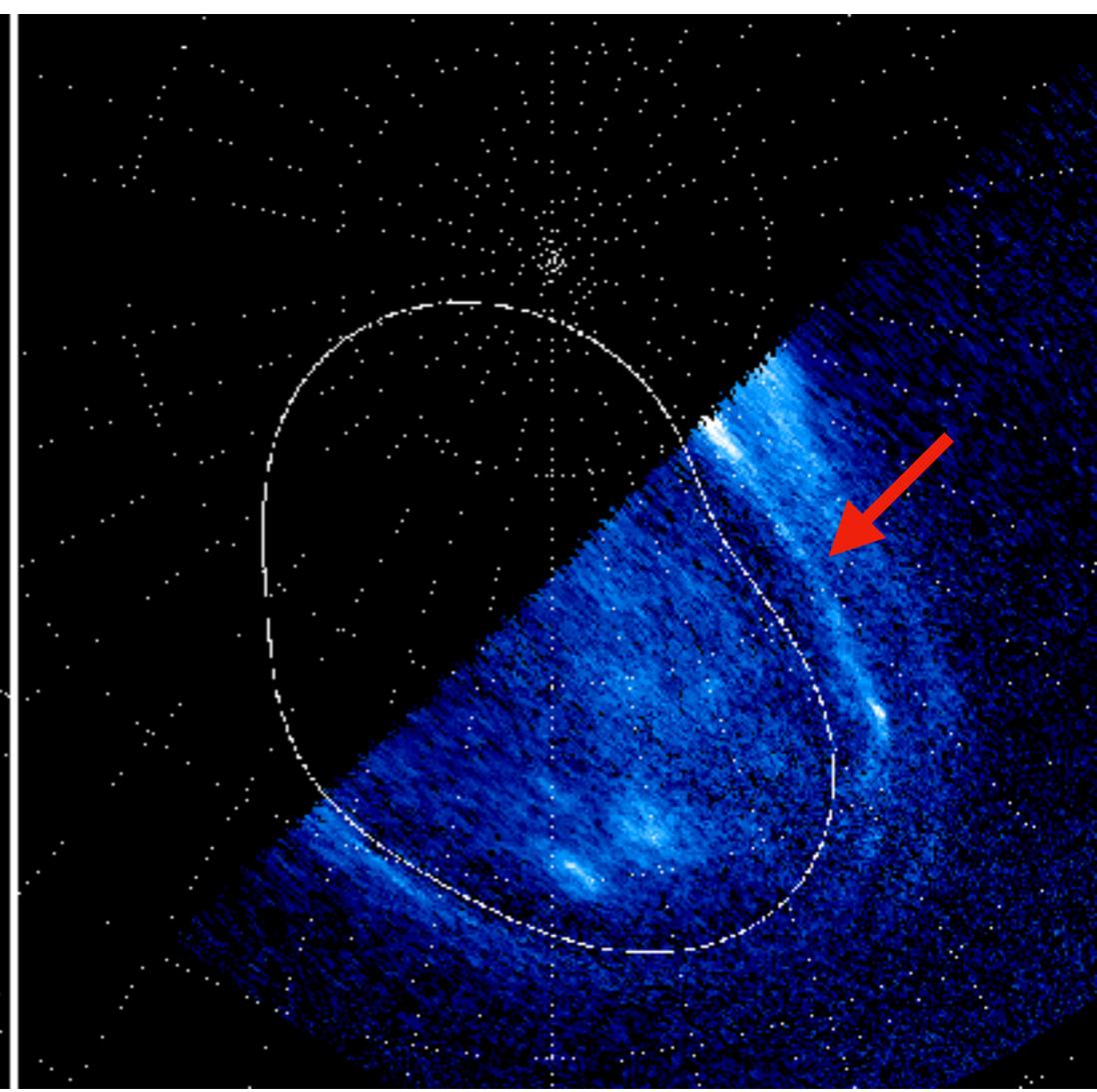
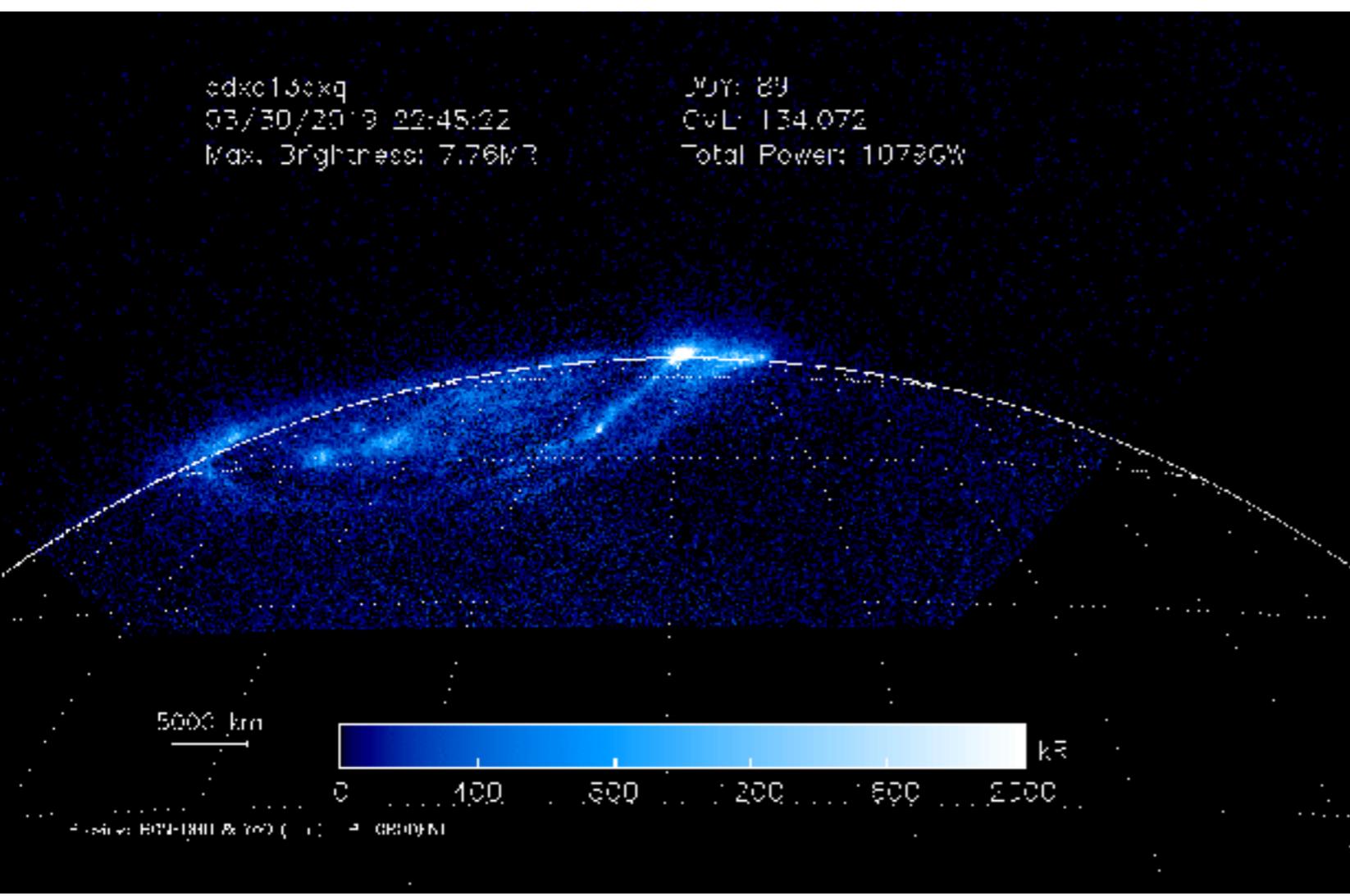
Weak expanded ME  
Brightening near Dusk  
Pulsating Bridge

# 1 day later



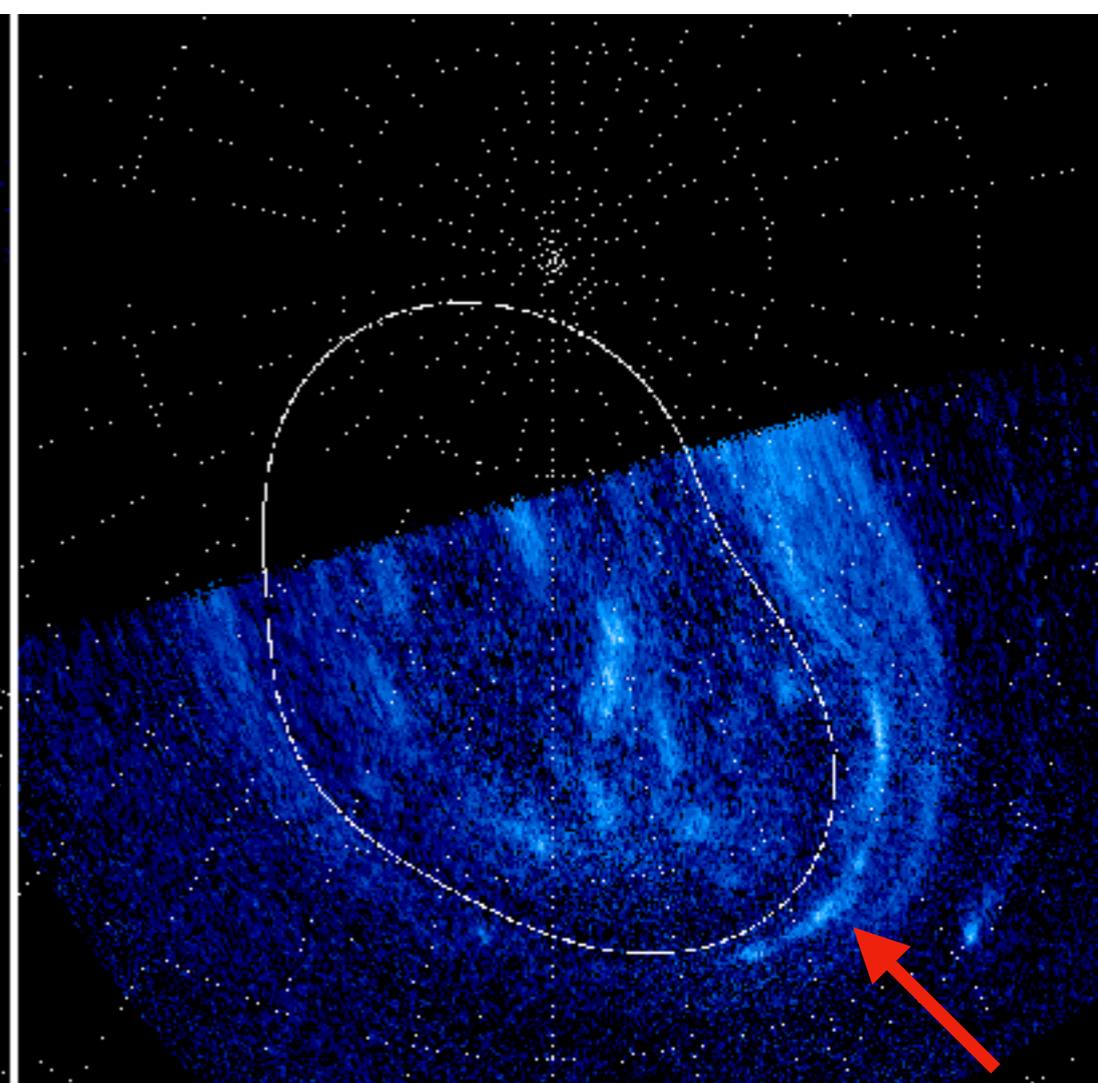
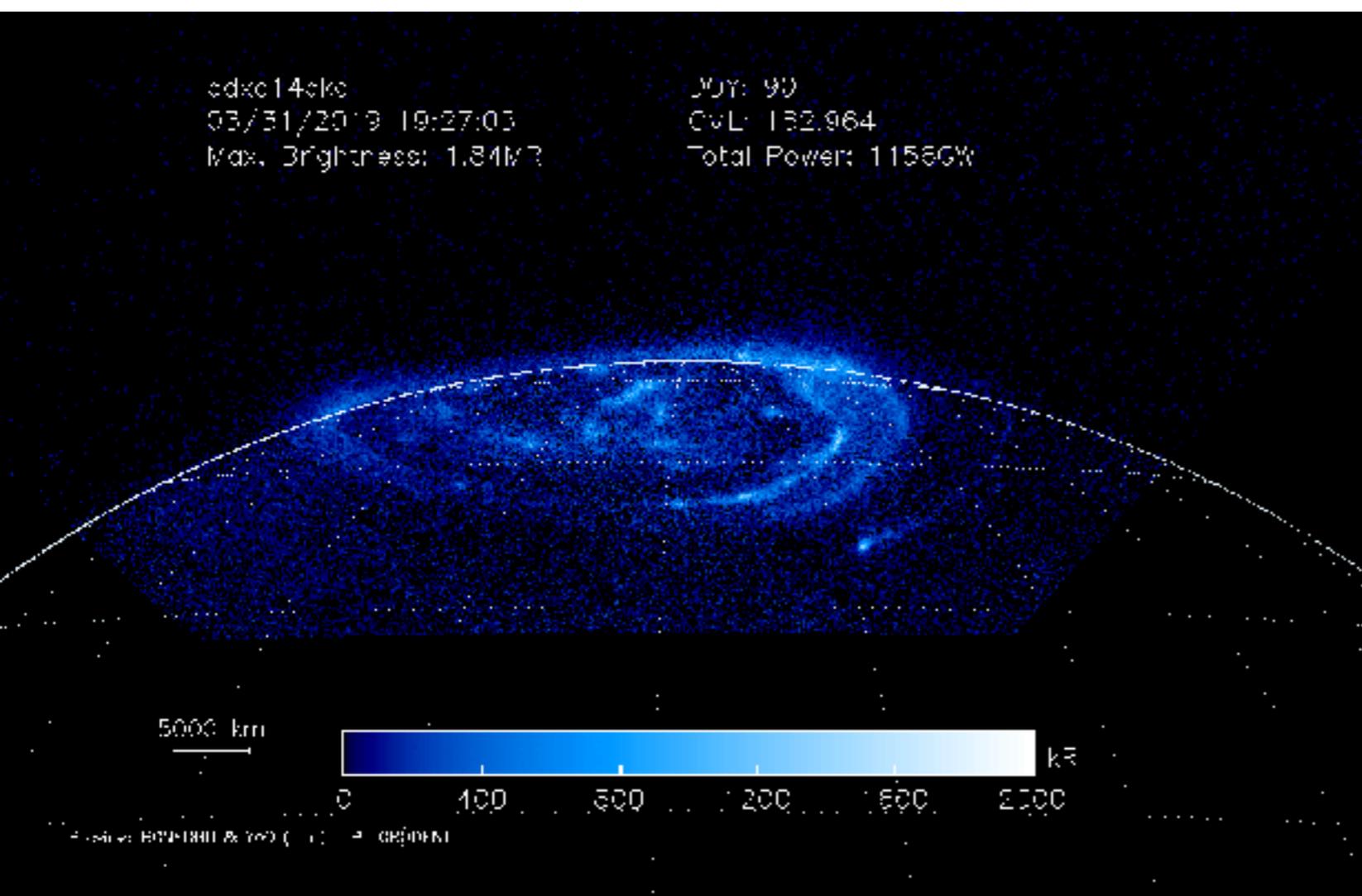


1 day later



Weak expanded ME  
Dawn Storm  
Breaking Dusk arc

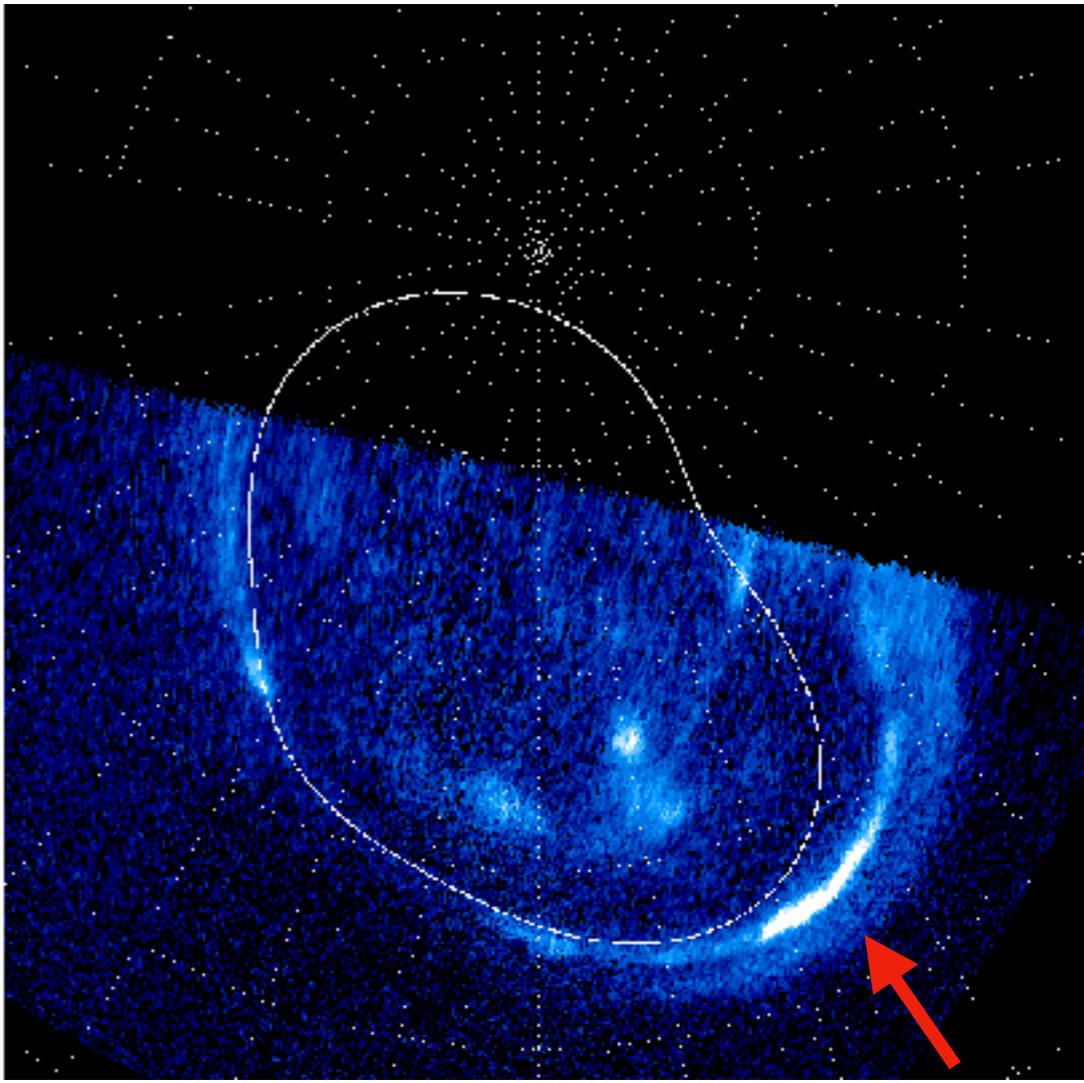
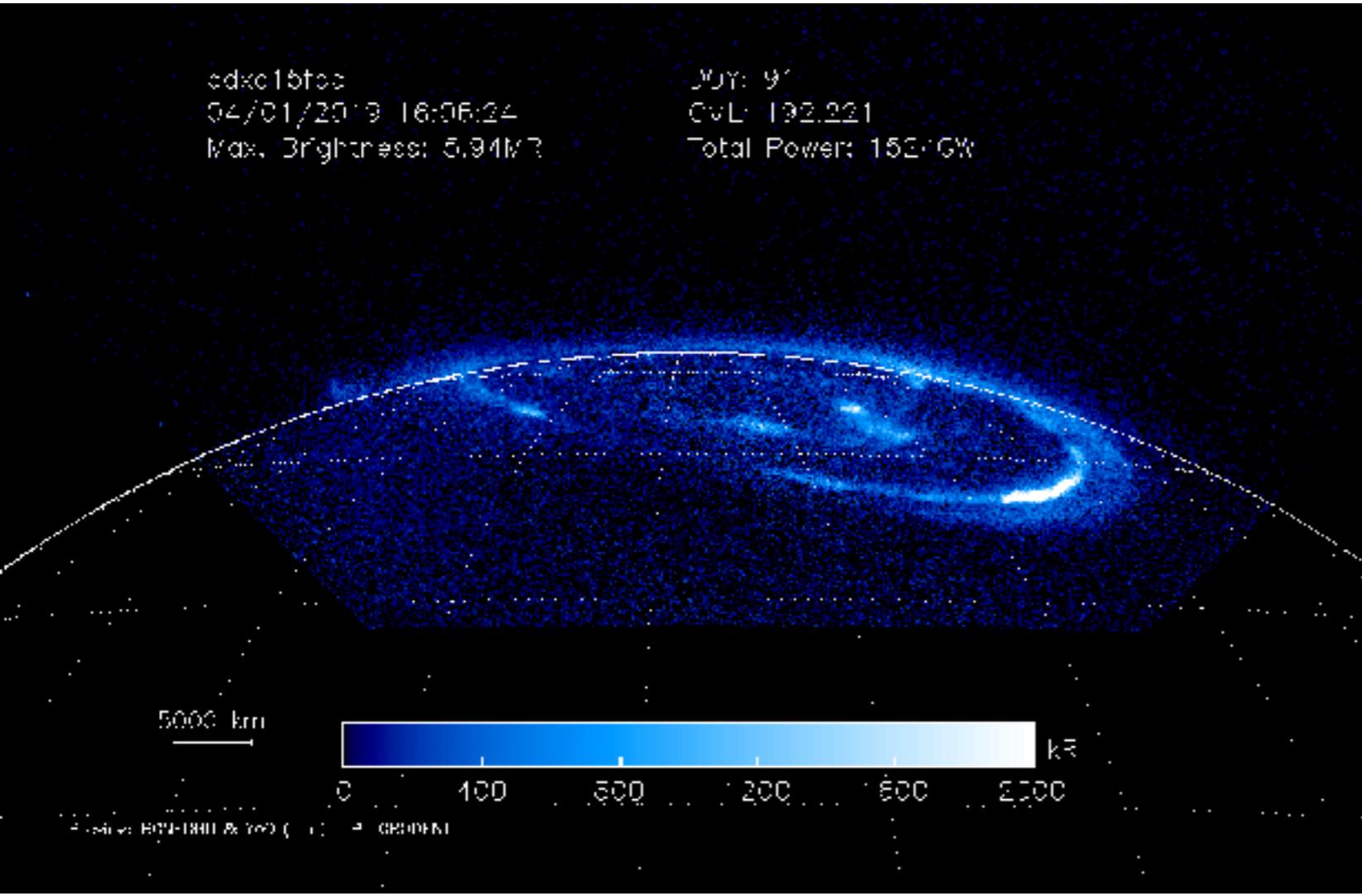
# 1 day later



Weak ME  
Dusk spots



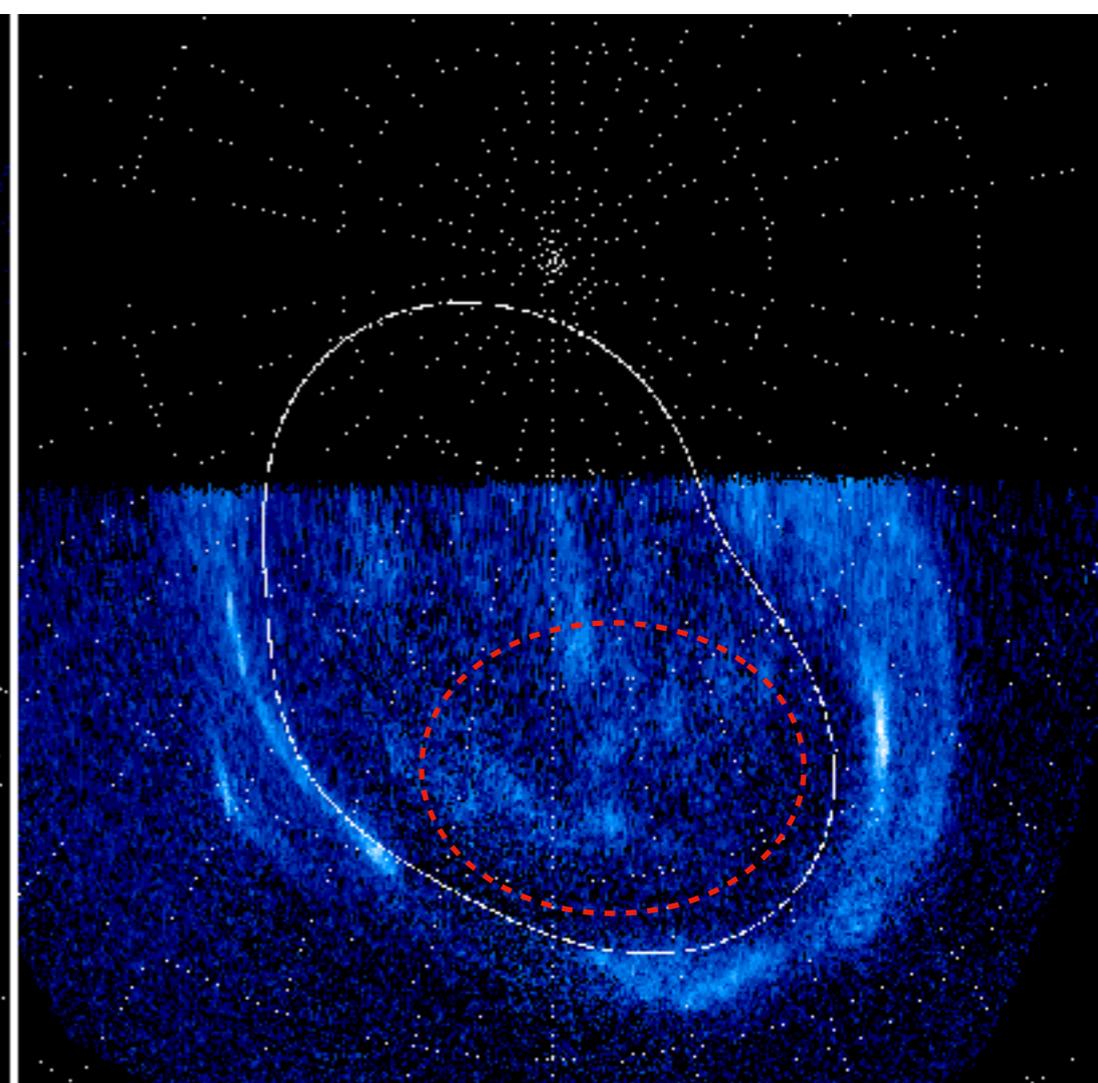
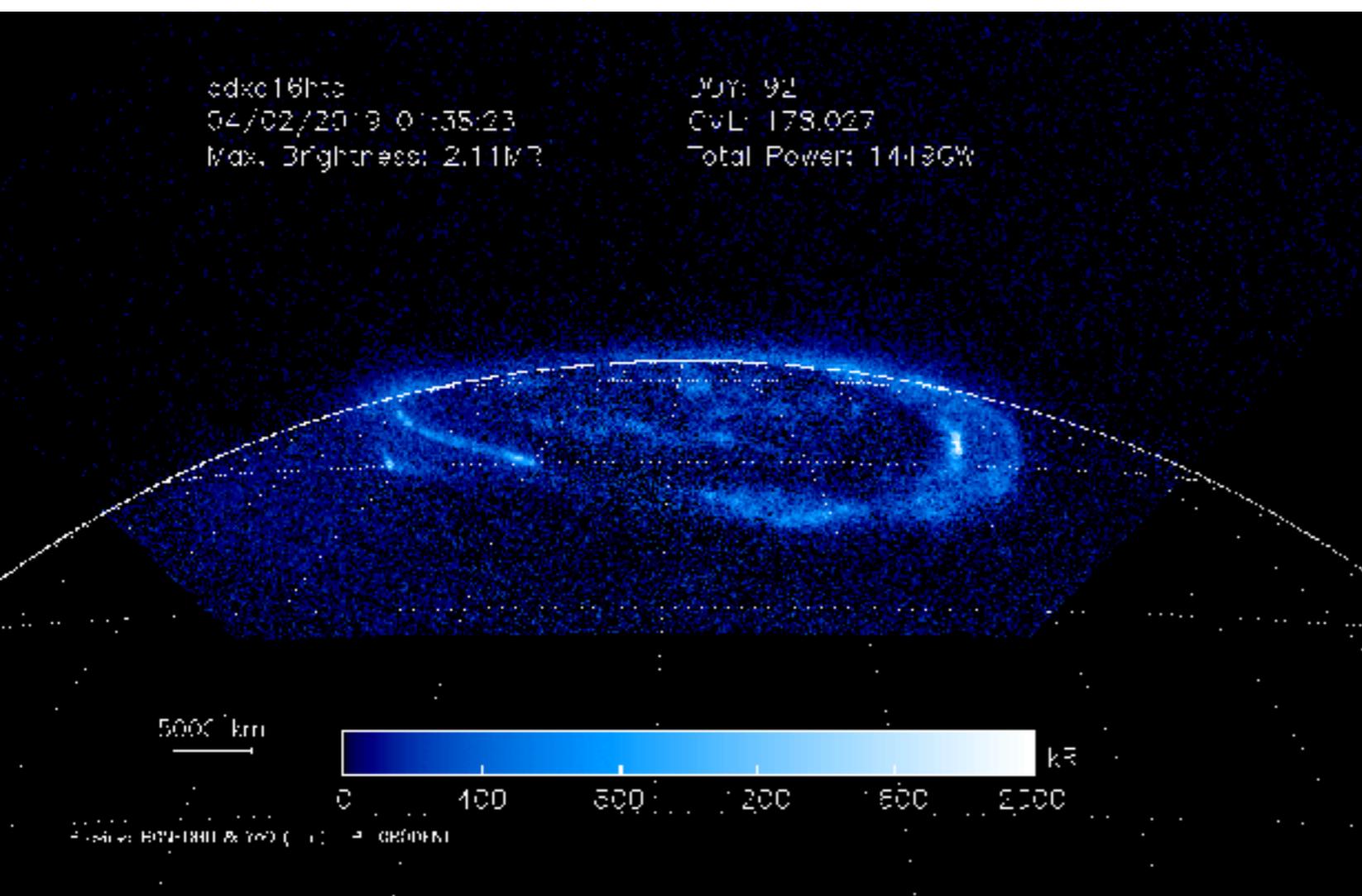
1 day later



Strong dusk ME arc  
Narrow SE

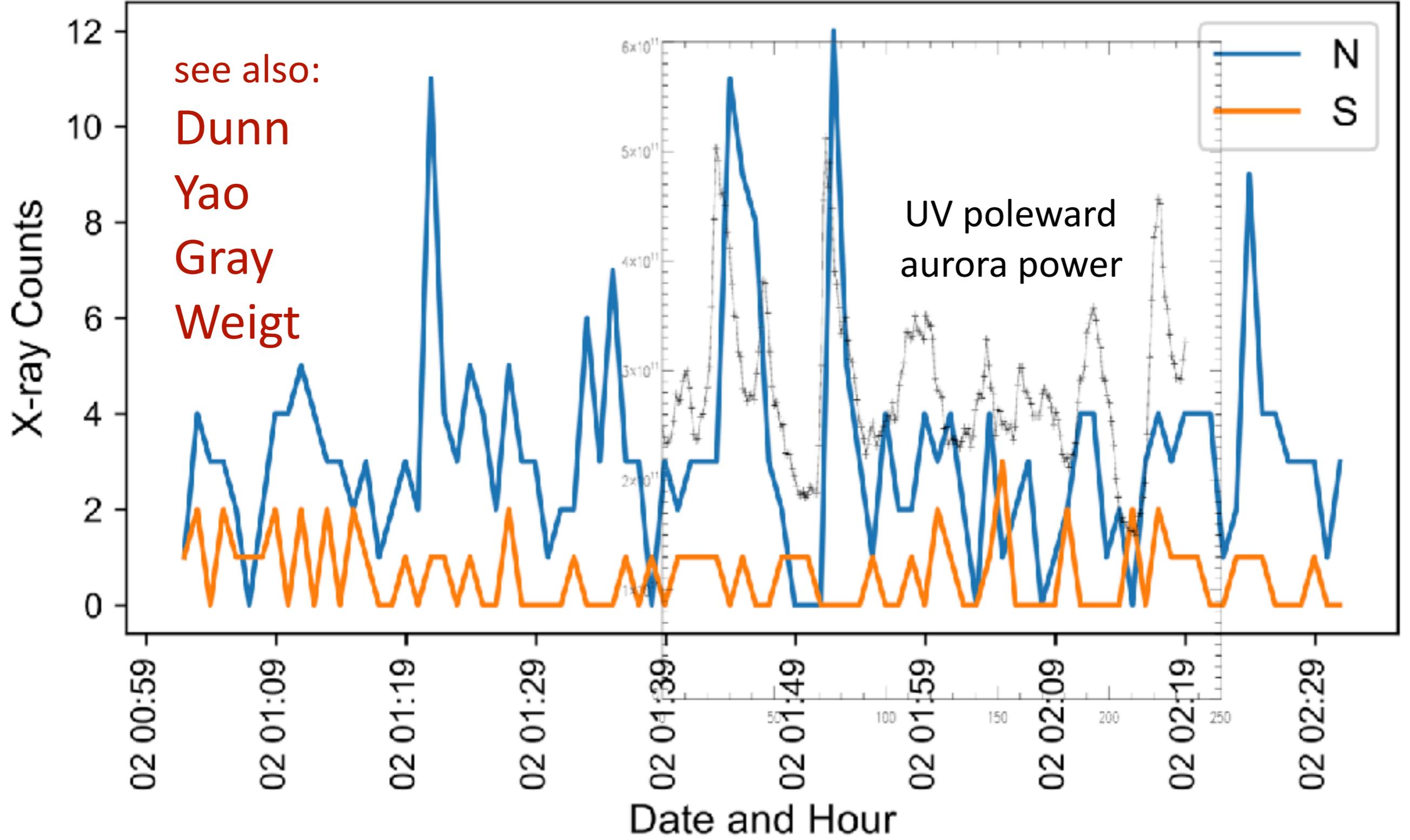


# 1 day later PJ19 - 4 days



Xray Xray Xray

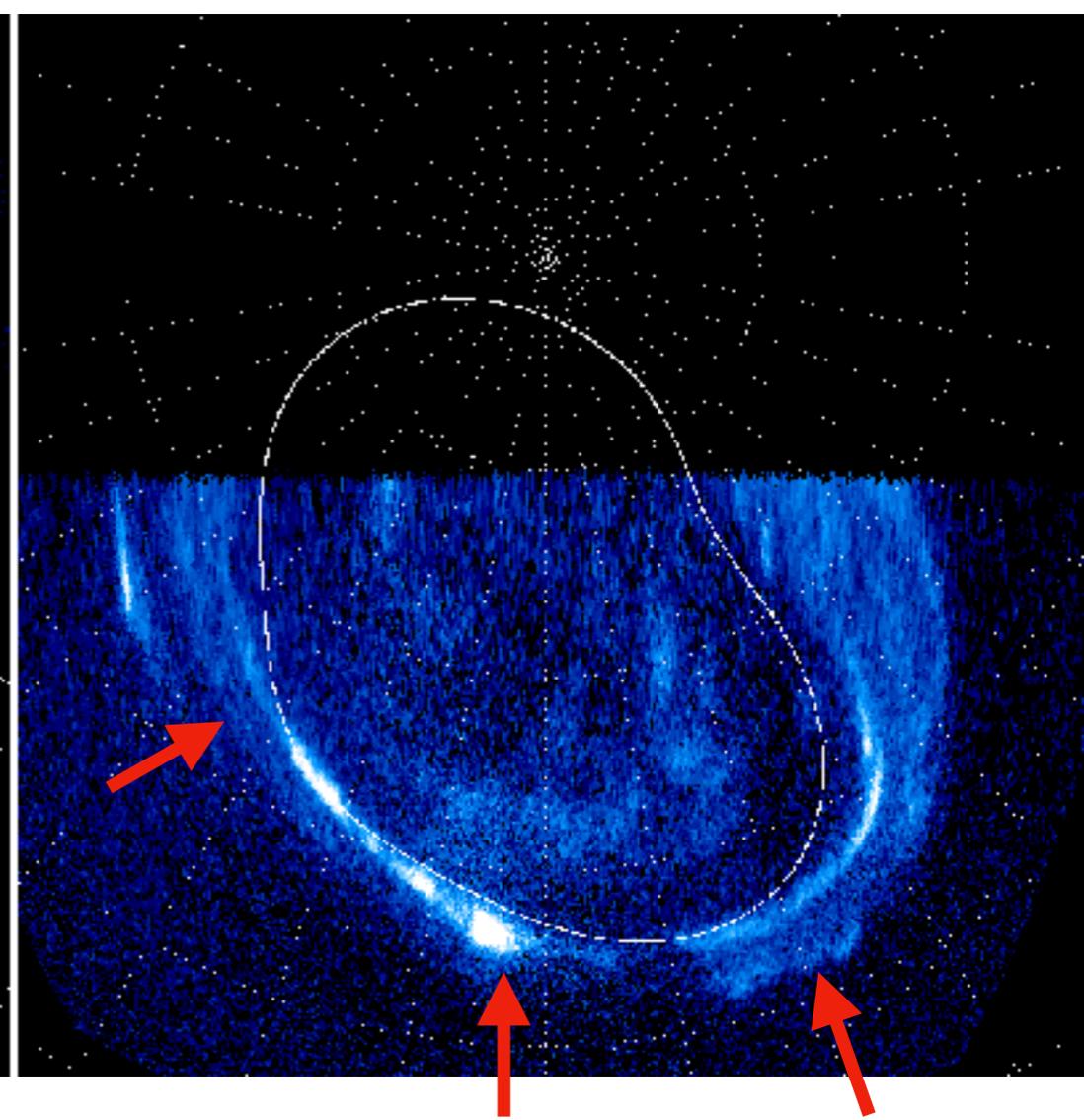
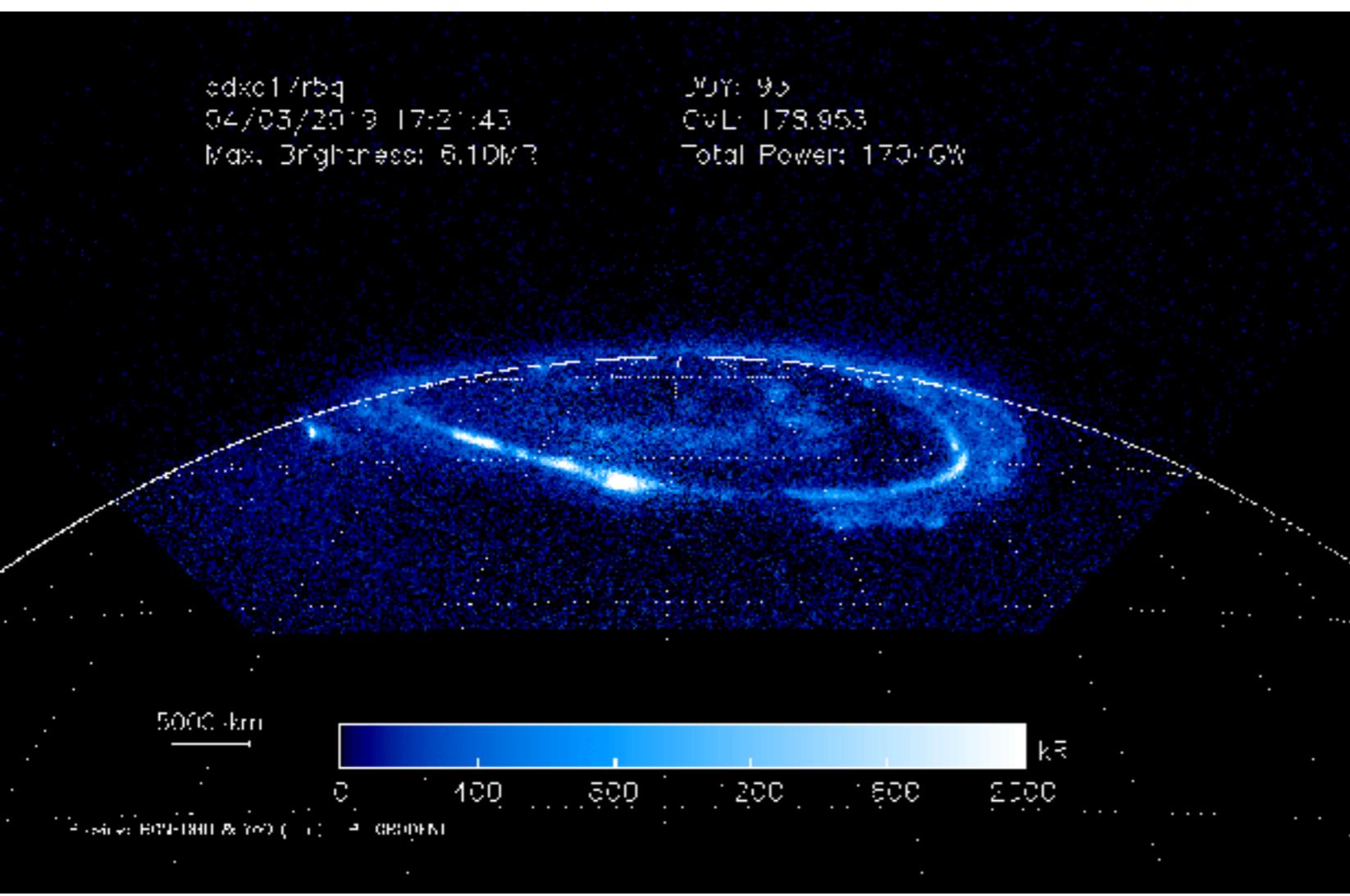
2019-04-02T01:00:00 - 2019-04-02T02:30:00



Xr plot, courtesy W. Dunn

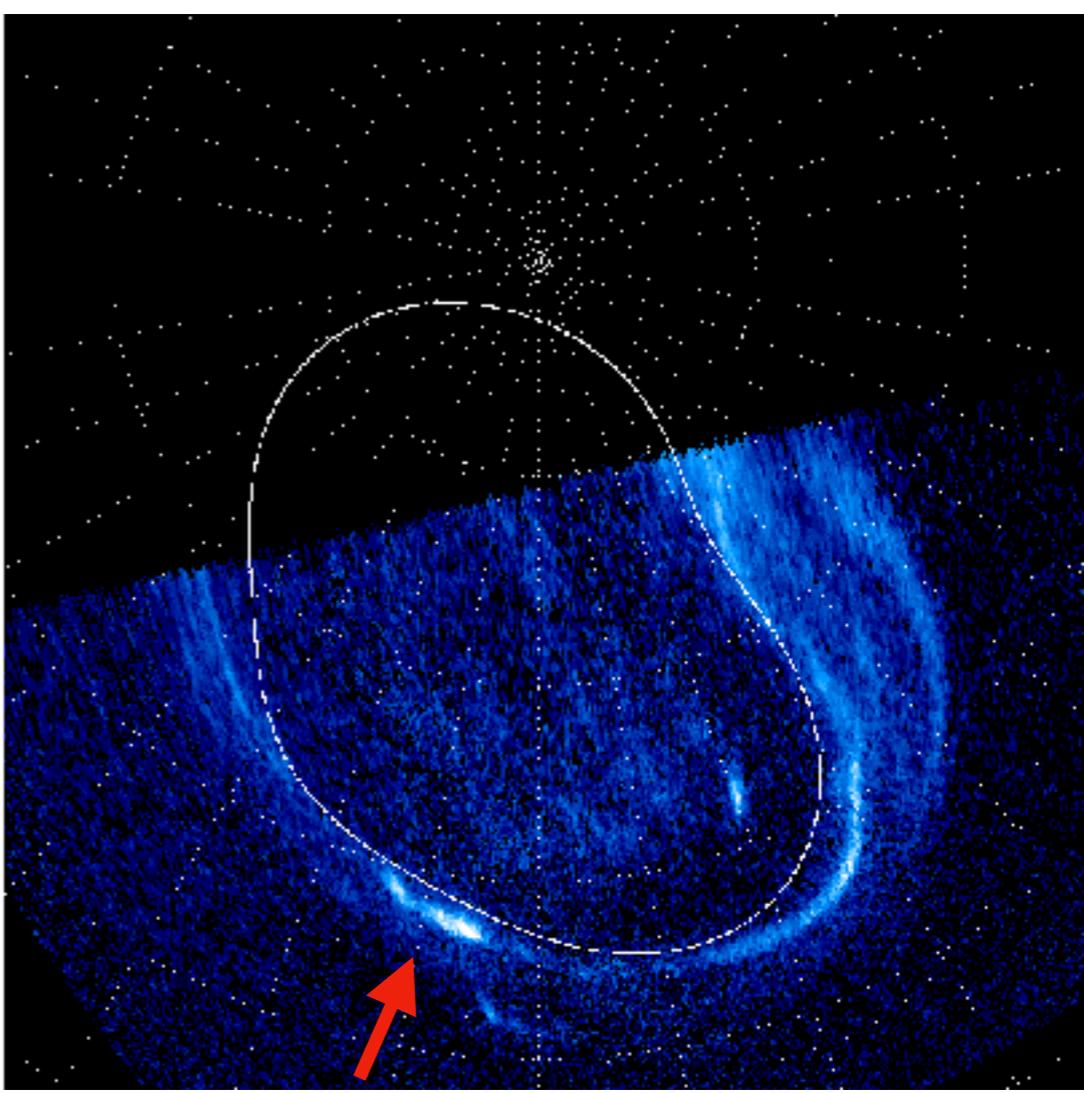
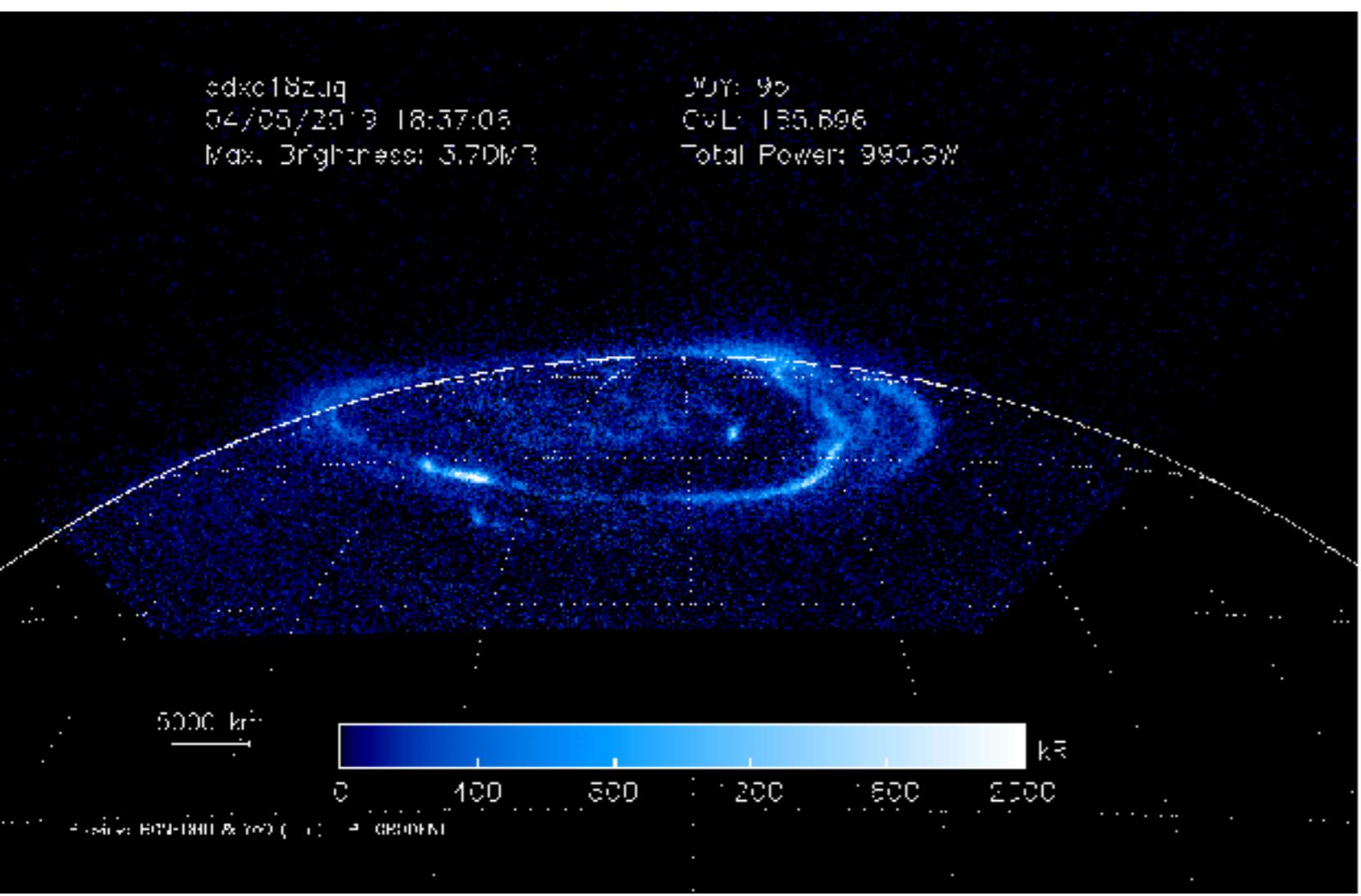


1 day later

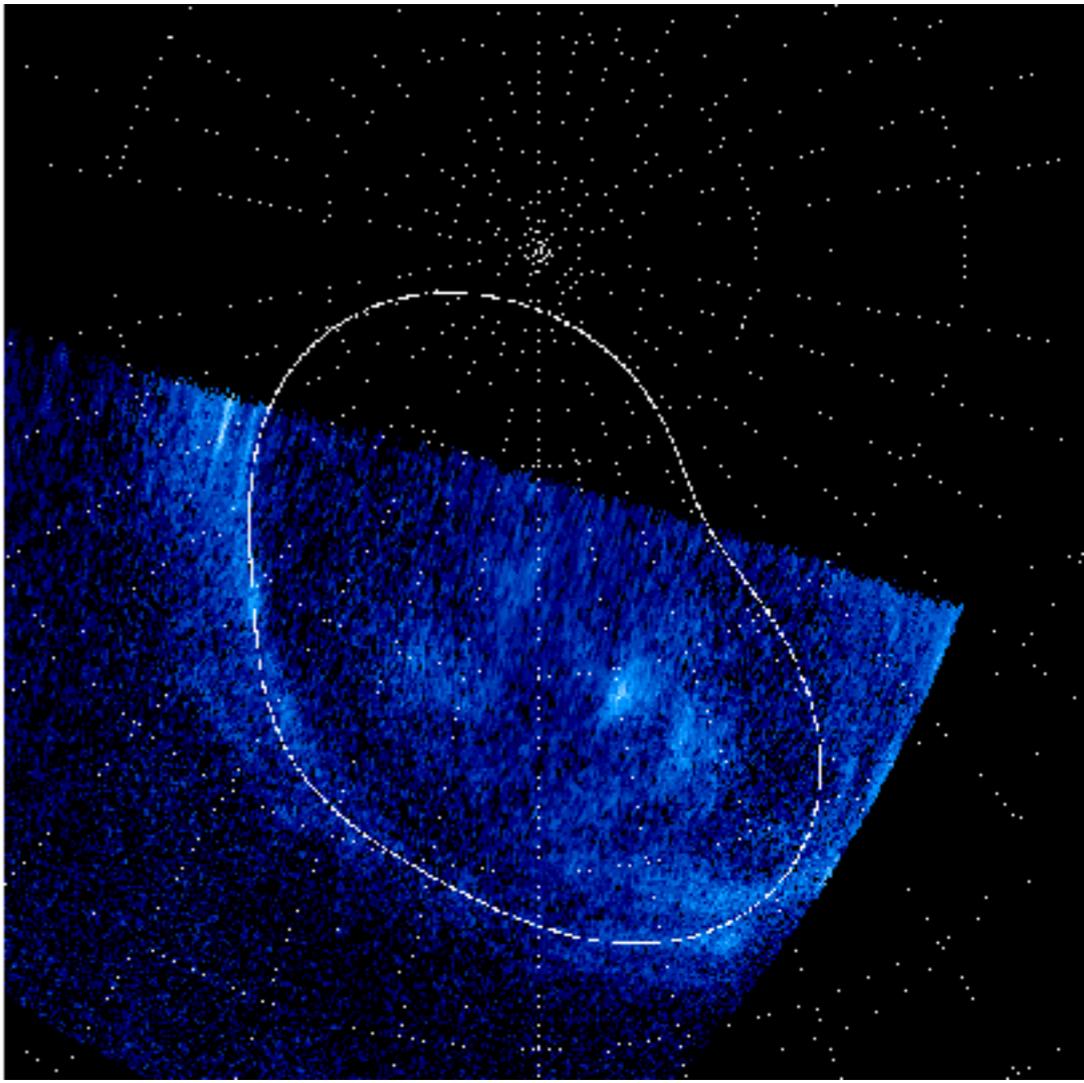
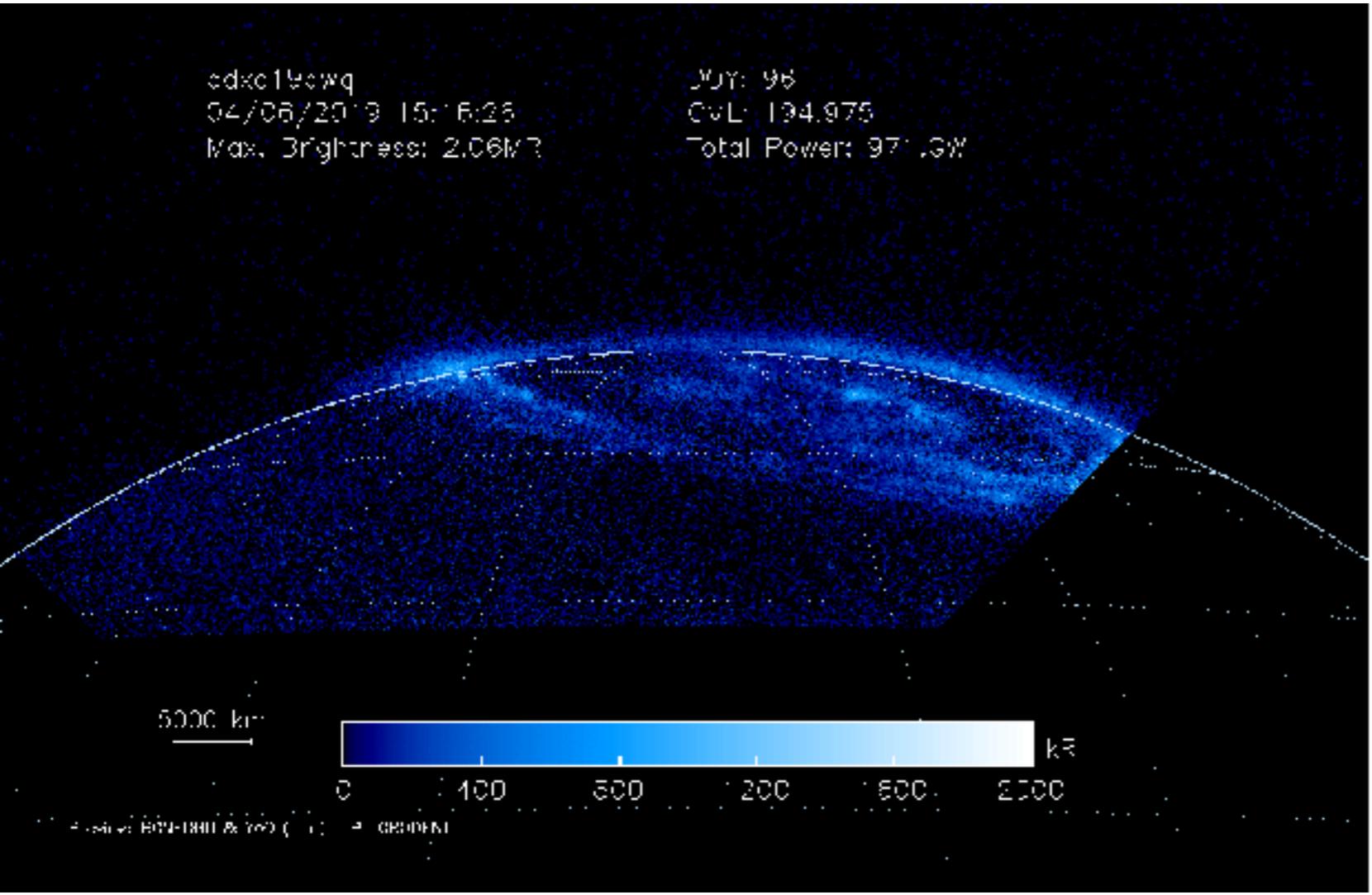


Dawn Storms Creation => Injections

# 2 days later

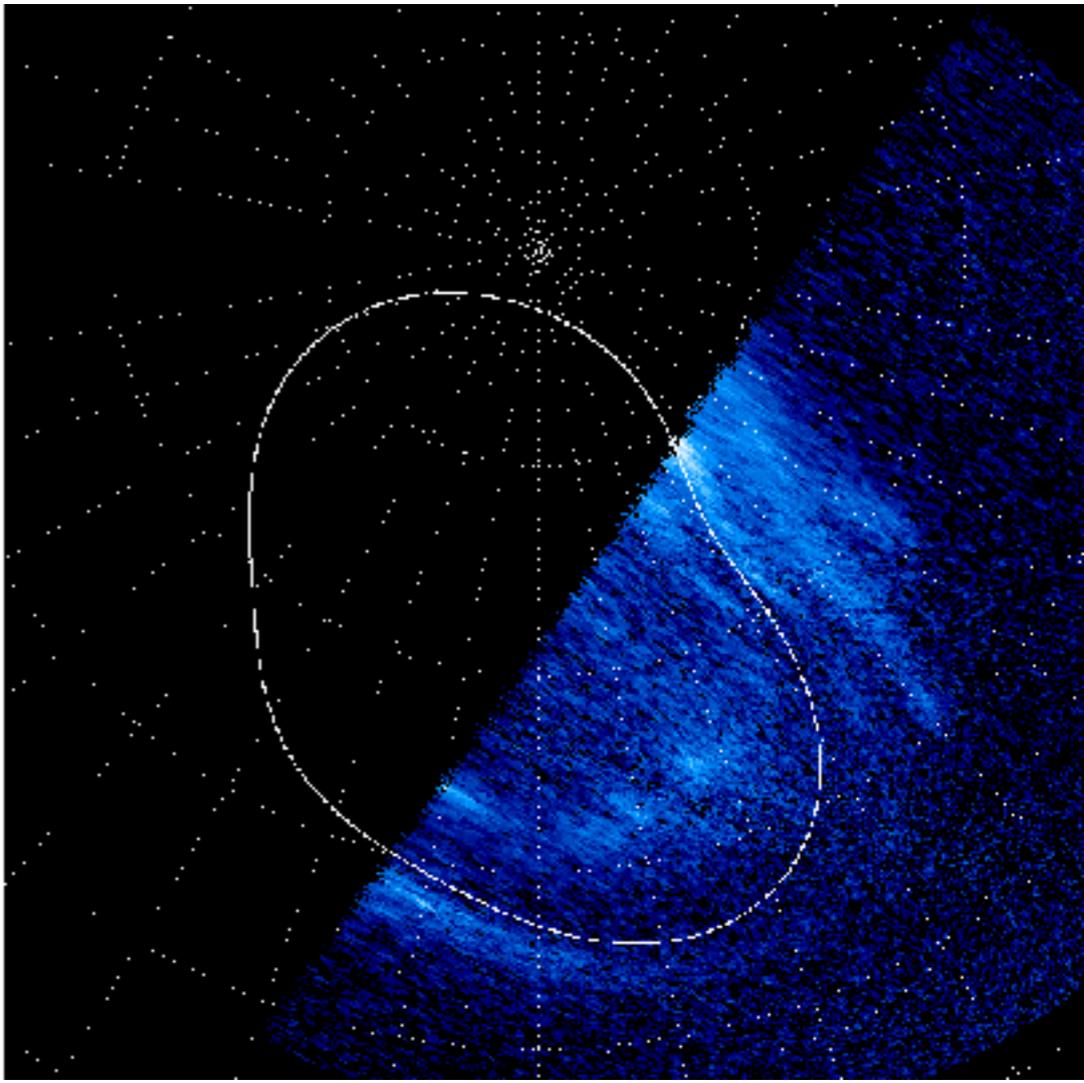
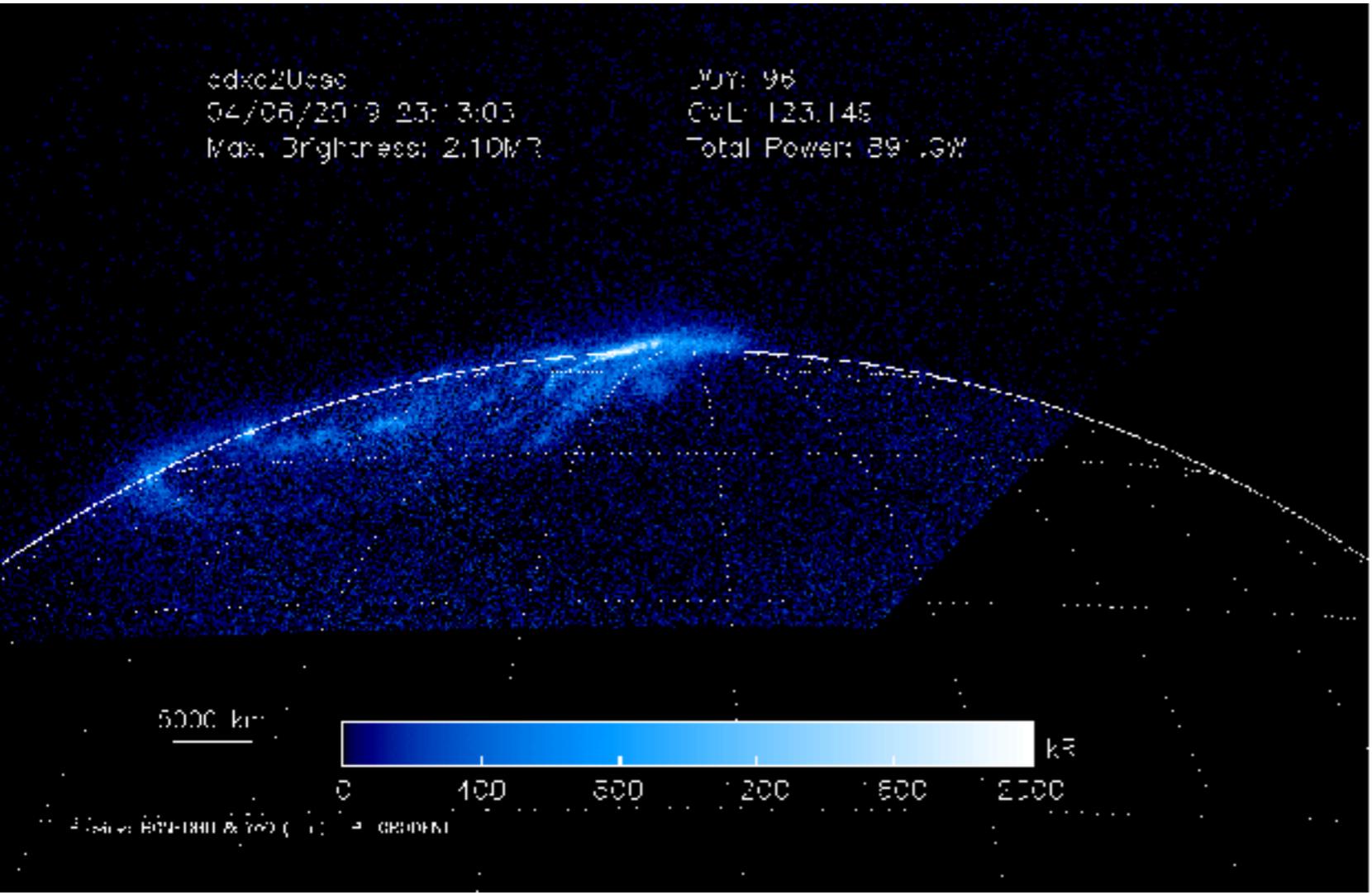


# PJ19 + 2 hr



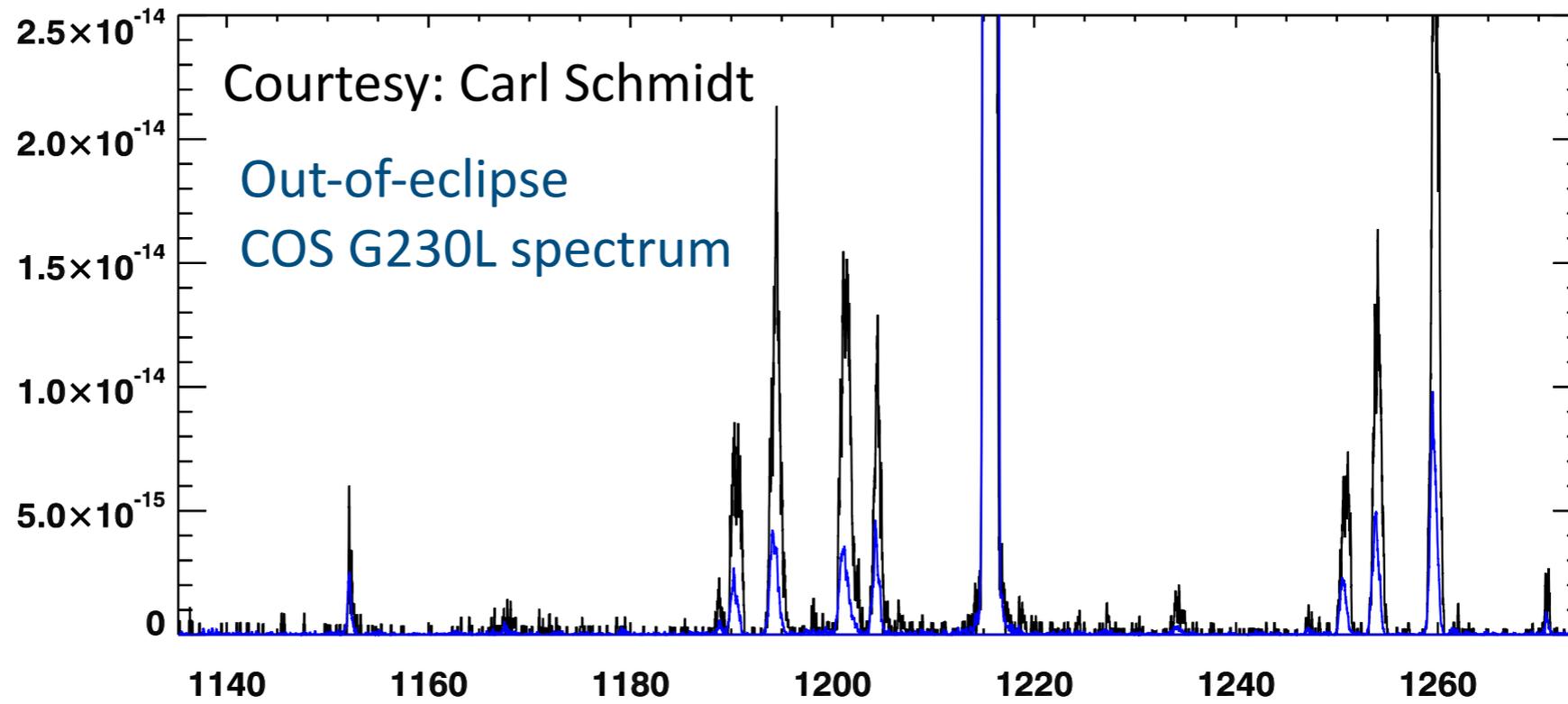
Weak expanded ME  
Brightening near Dusk  
Pulsating Bridge

# PJ19 + 10 hr



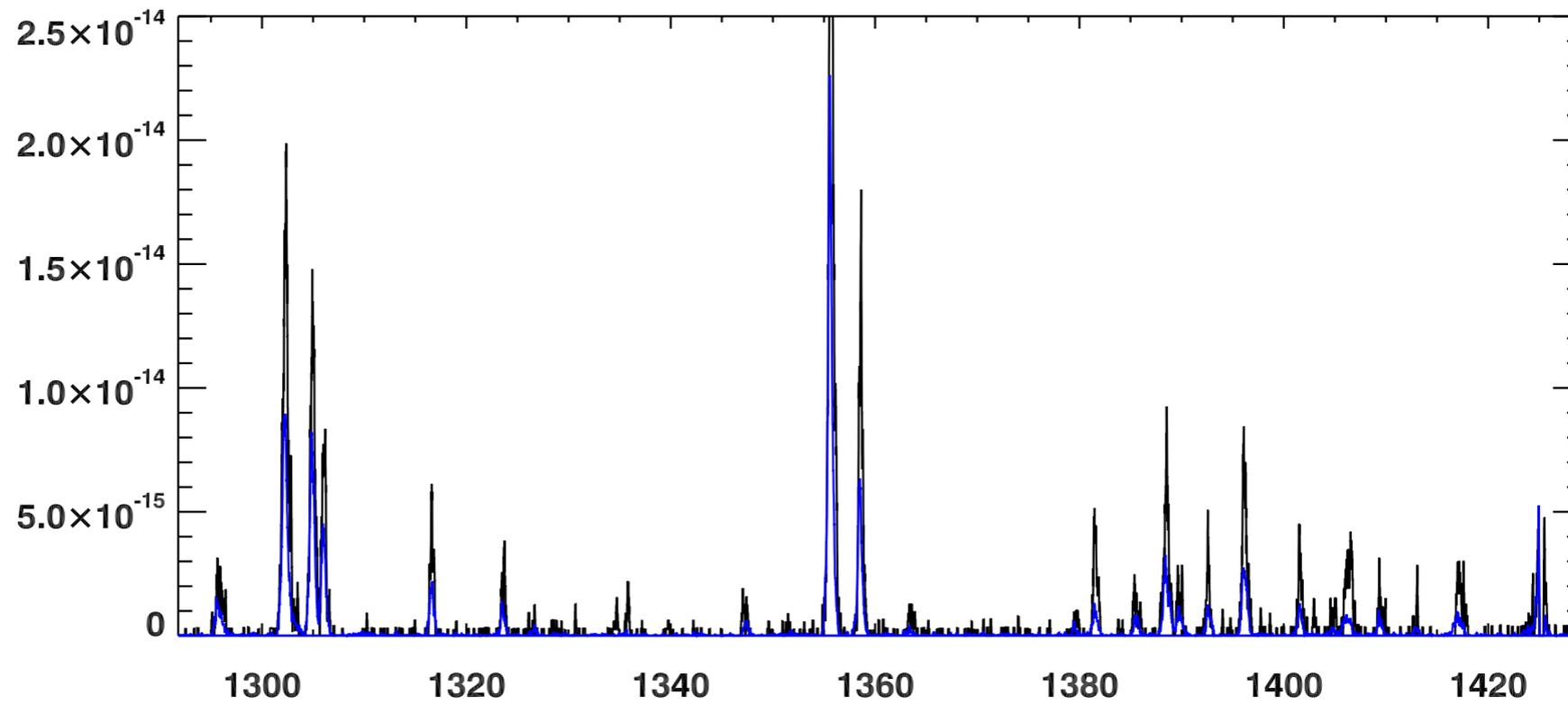
Weak expanded ME

FUV A Channel



2019-04-29 16:04-16:12

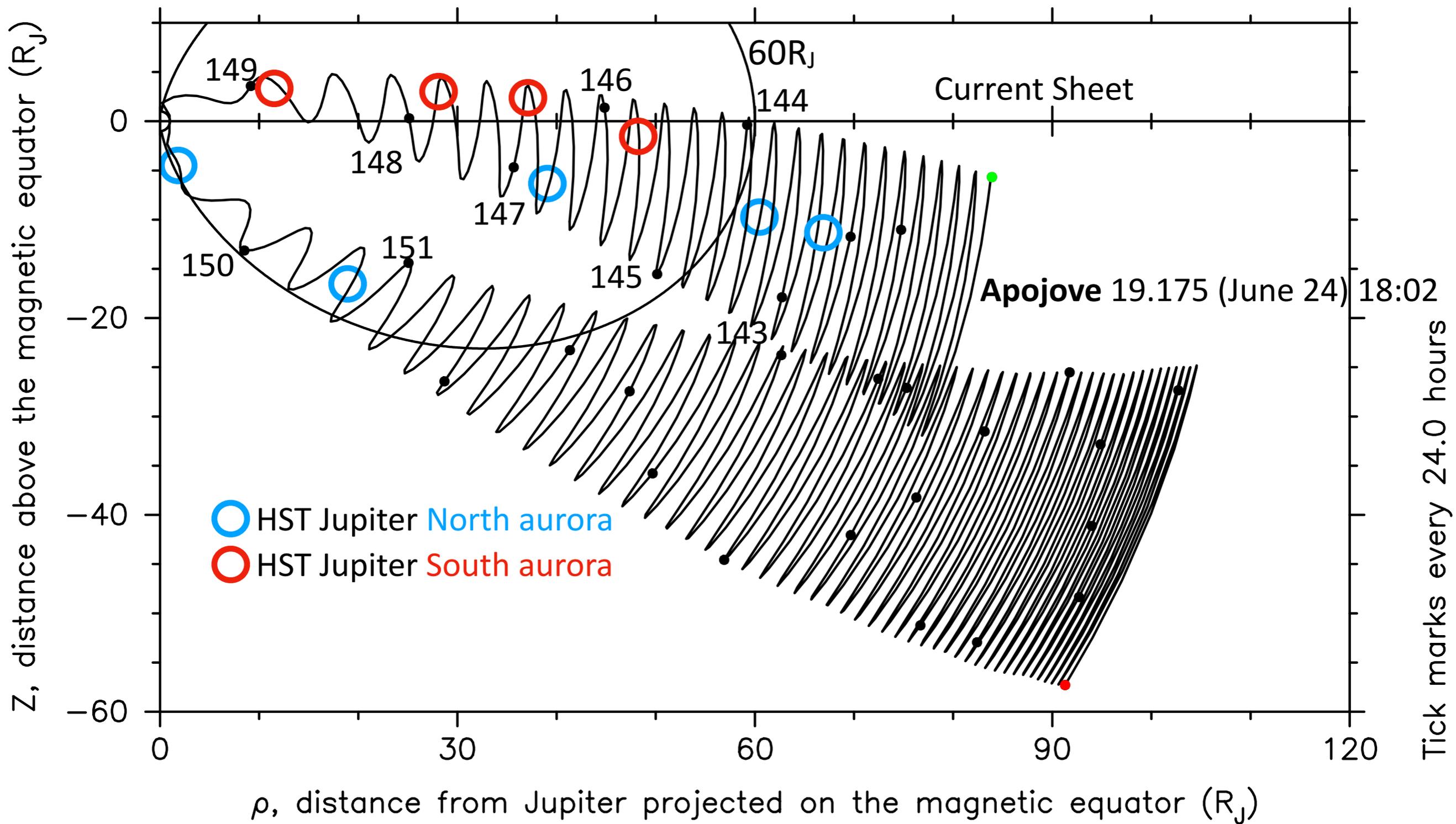
FUV B Channel



HST observations (STIS FUV)  
of Jupiter's aurora  
during  
Juno orbit 20

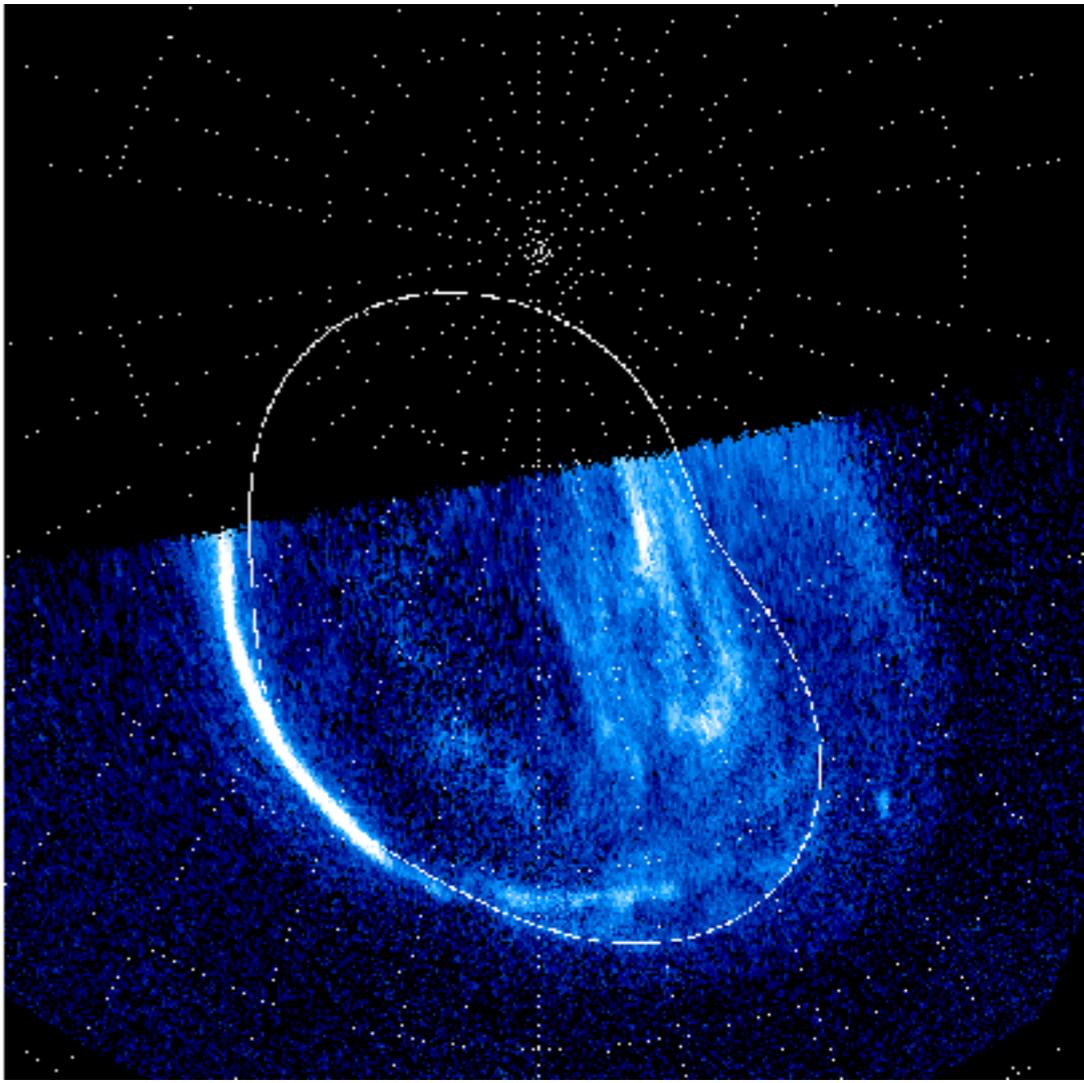
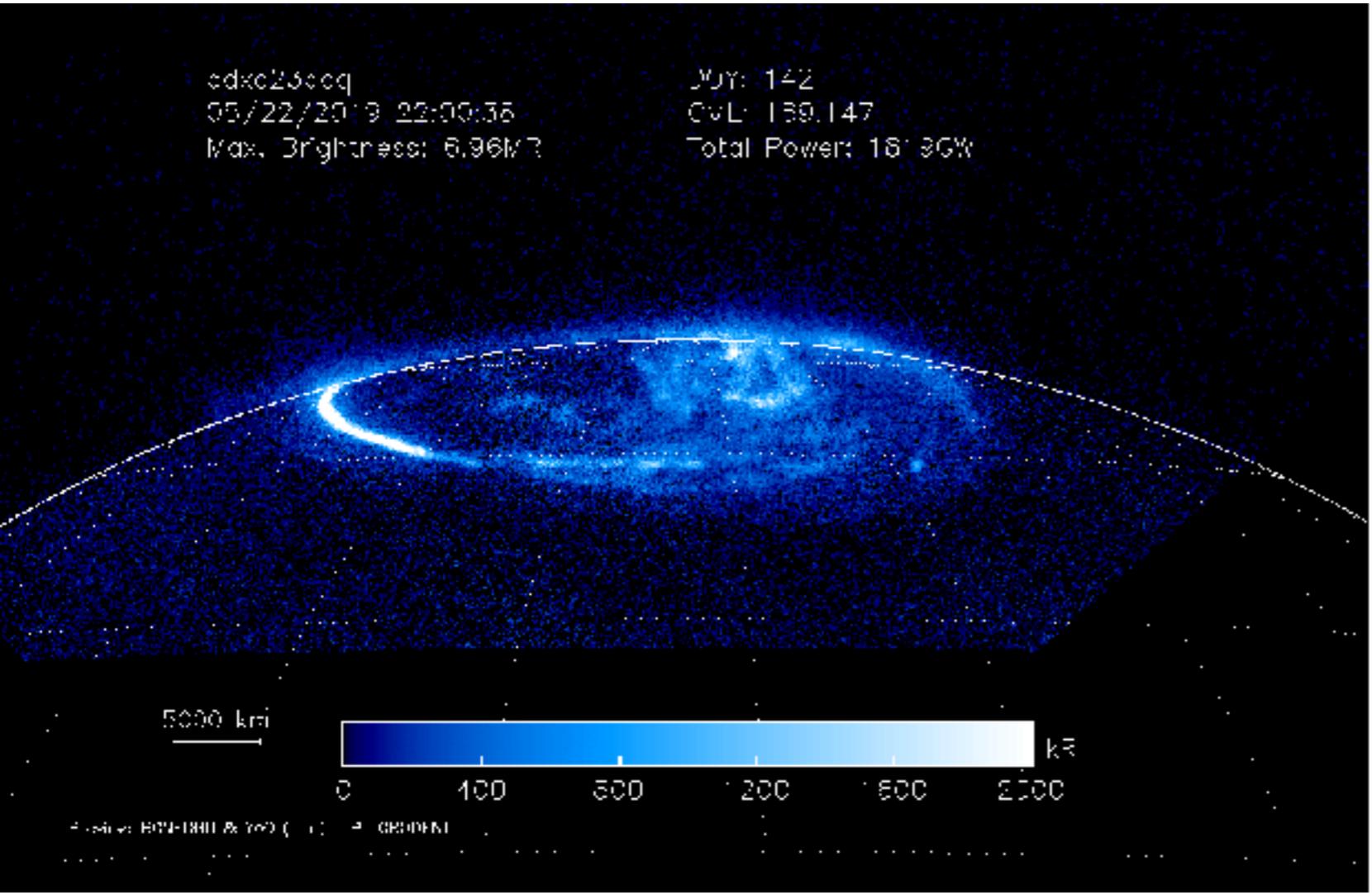
PJ20 60RJ

2019 139 (May 19) 00:00:00 – 2019 169 (June 18) 00:00:00





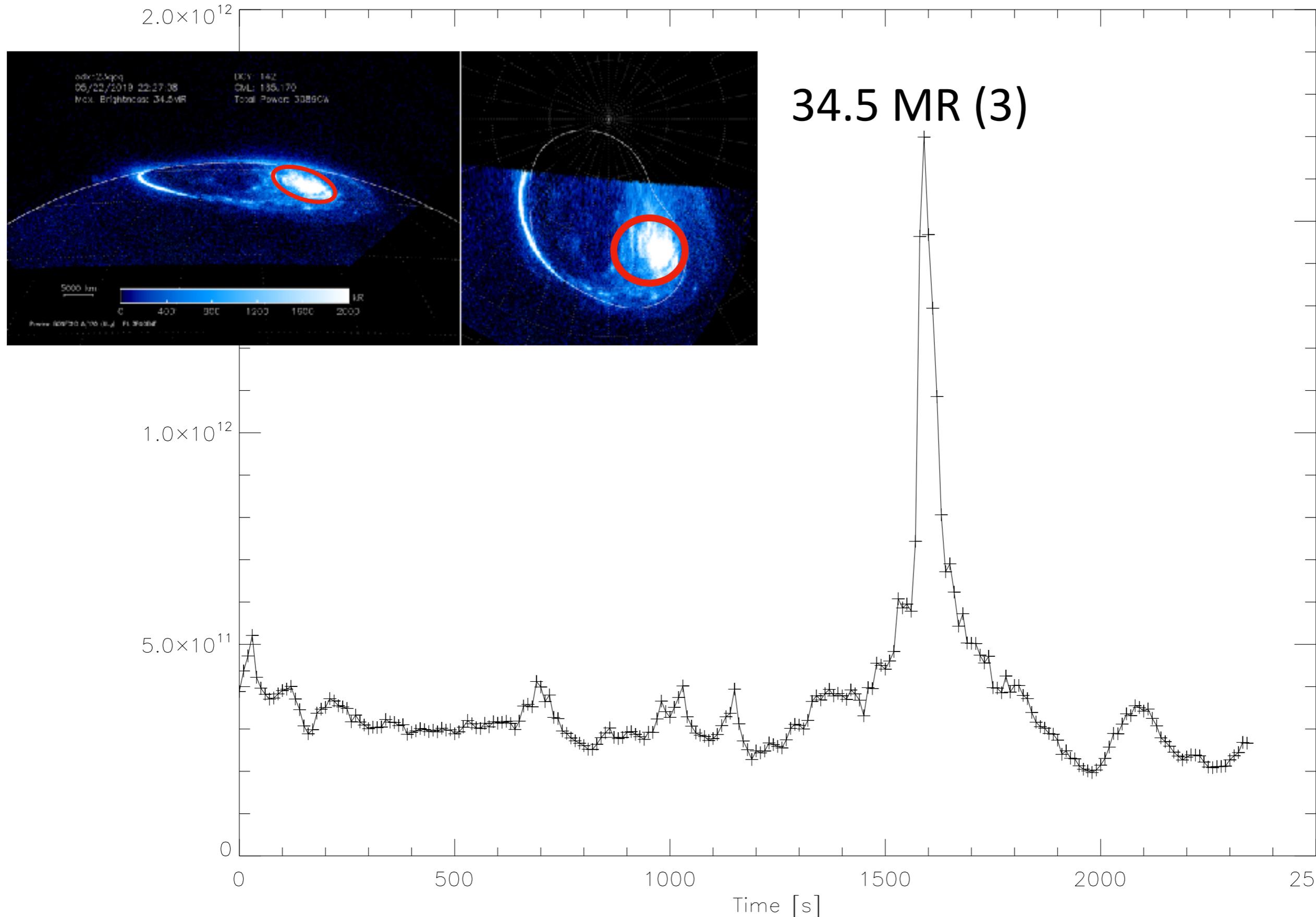
# PJ20 - 1 week



Polar Explosion 35 MR  
Bright dawn ME

# Total auroral power ~3 TW (2)

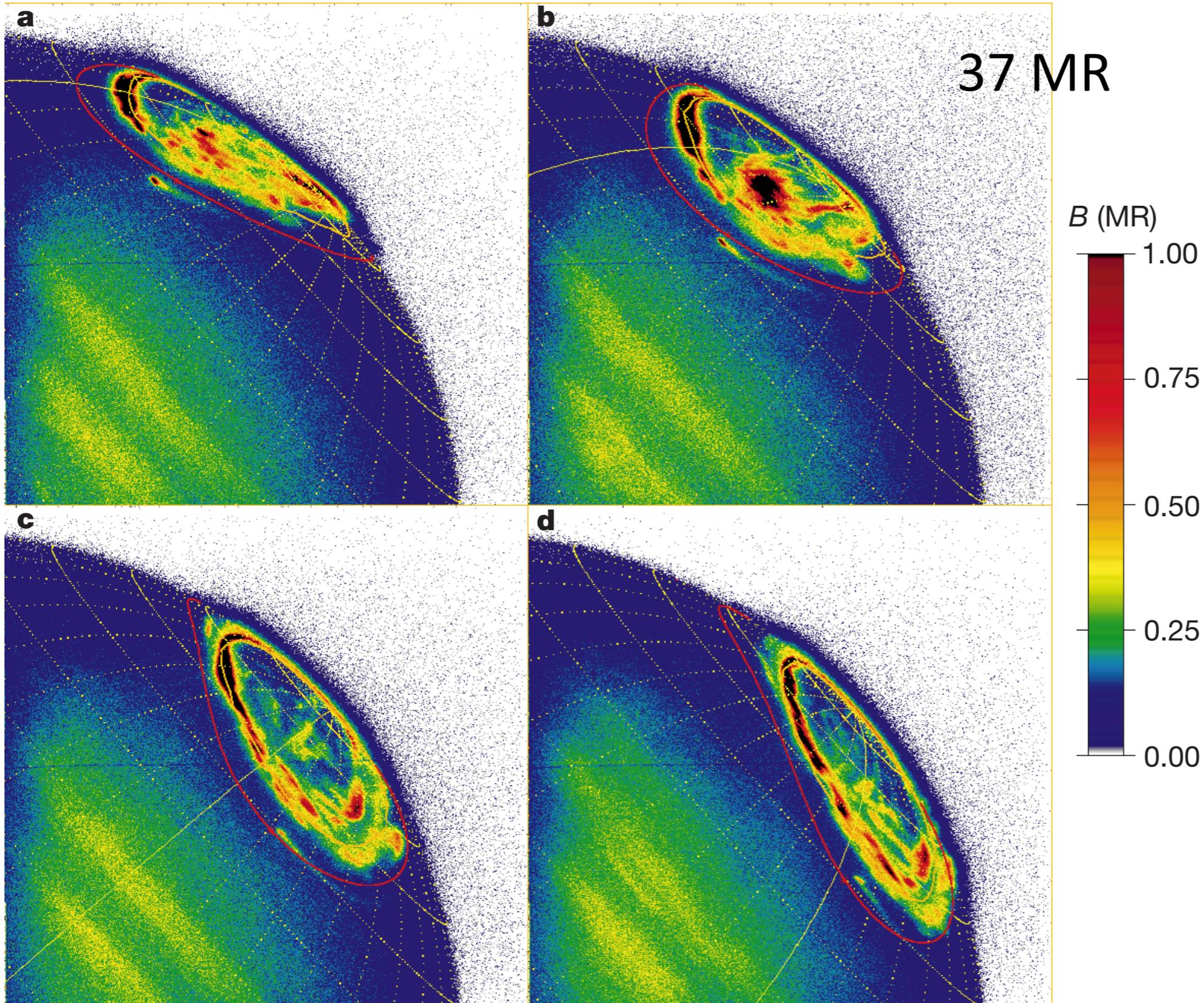
~6TW both hemispheres ~10x power produced by all nuclear plants on Earth



# An auroral flare at Jupiter

J. H. Waite Jr<sup>\*</sup>, G. R. Gladstone<sup>†</sup>, W. S. Lewis<sup>†</sup>, R. Goldstein<sup>†</sup>,  
 D. J. McComas<sup>†</sup>, P. Riley<sup>‡</sup>, R. J. Walker<sup>§</sup>, P. Robertson<sup>†</sup>, S. Desai<sup>||</sup>,  
 J. T. Clarke<sup>\*</sup> & D. T. Young<sup>\*</sup>

NATURE | VOL 410 | 12 APRIL 2001 | www.nature.com



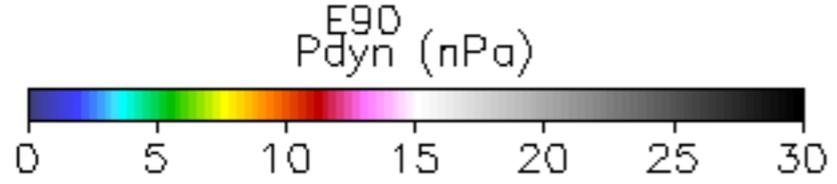
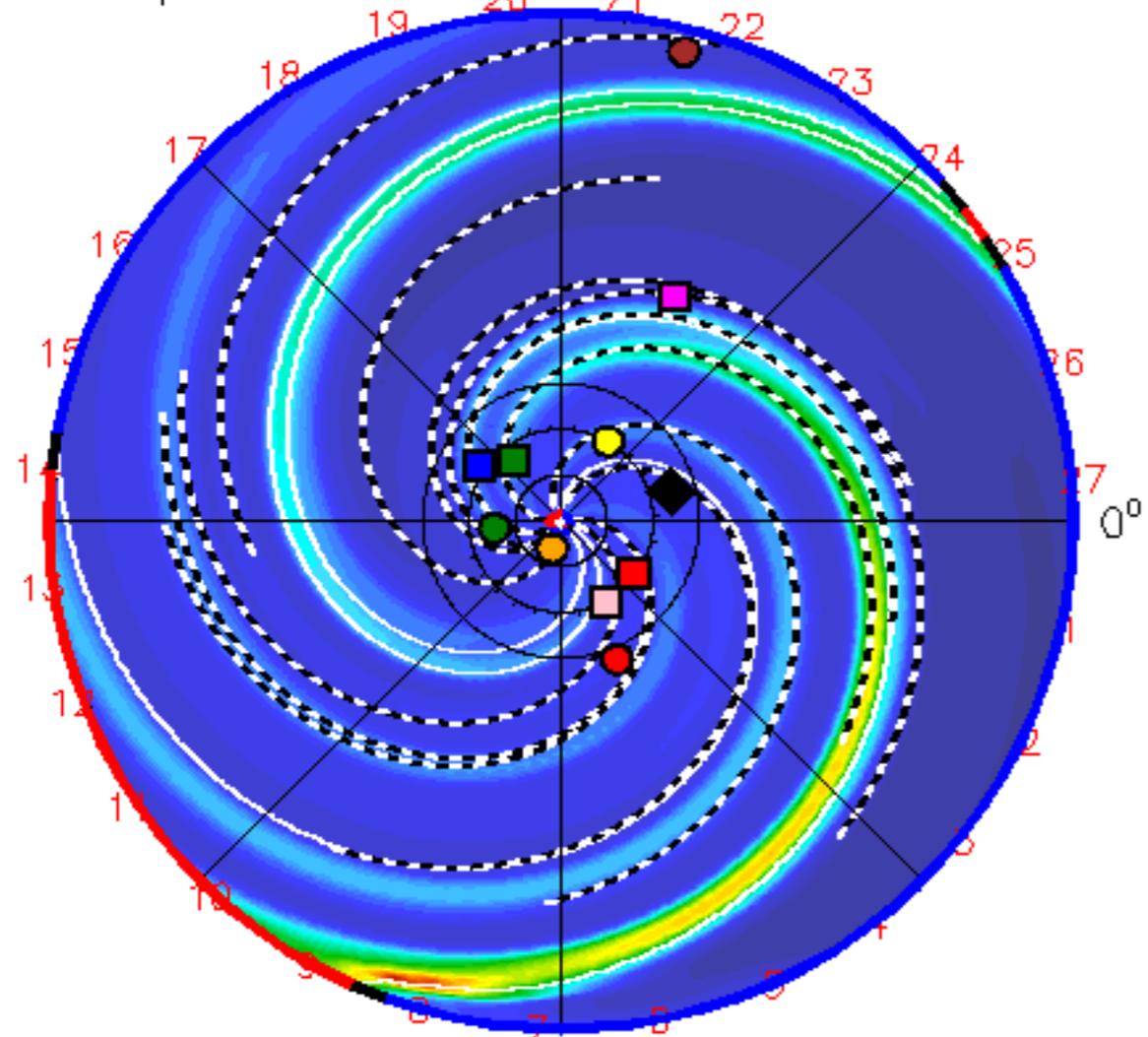
"This type of flaring emission has not previously been reported for Jupiter .../..., and it may be related directly to changes in the solar wind."

Jupiter

2019-05-22T19:00

- Earth
- Jupiter
- Mars
- Mercury
- Spitzer
- Stereo\_A
- Stereo\_B

Ecliptic Plane W90 LAT = 1.40°

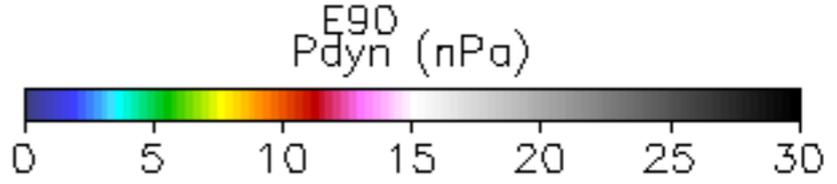
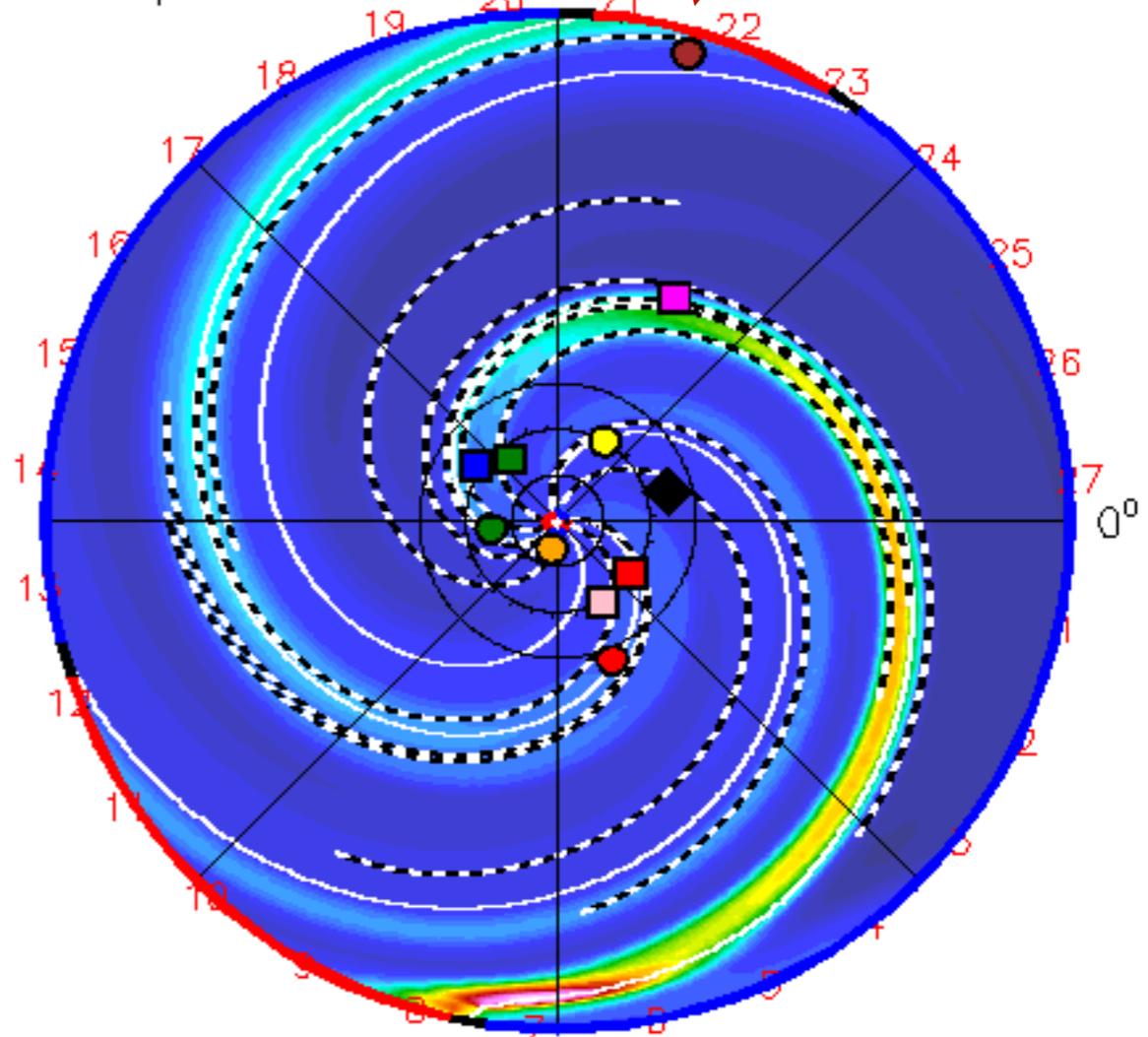


Jupiter

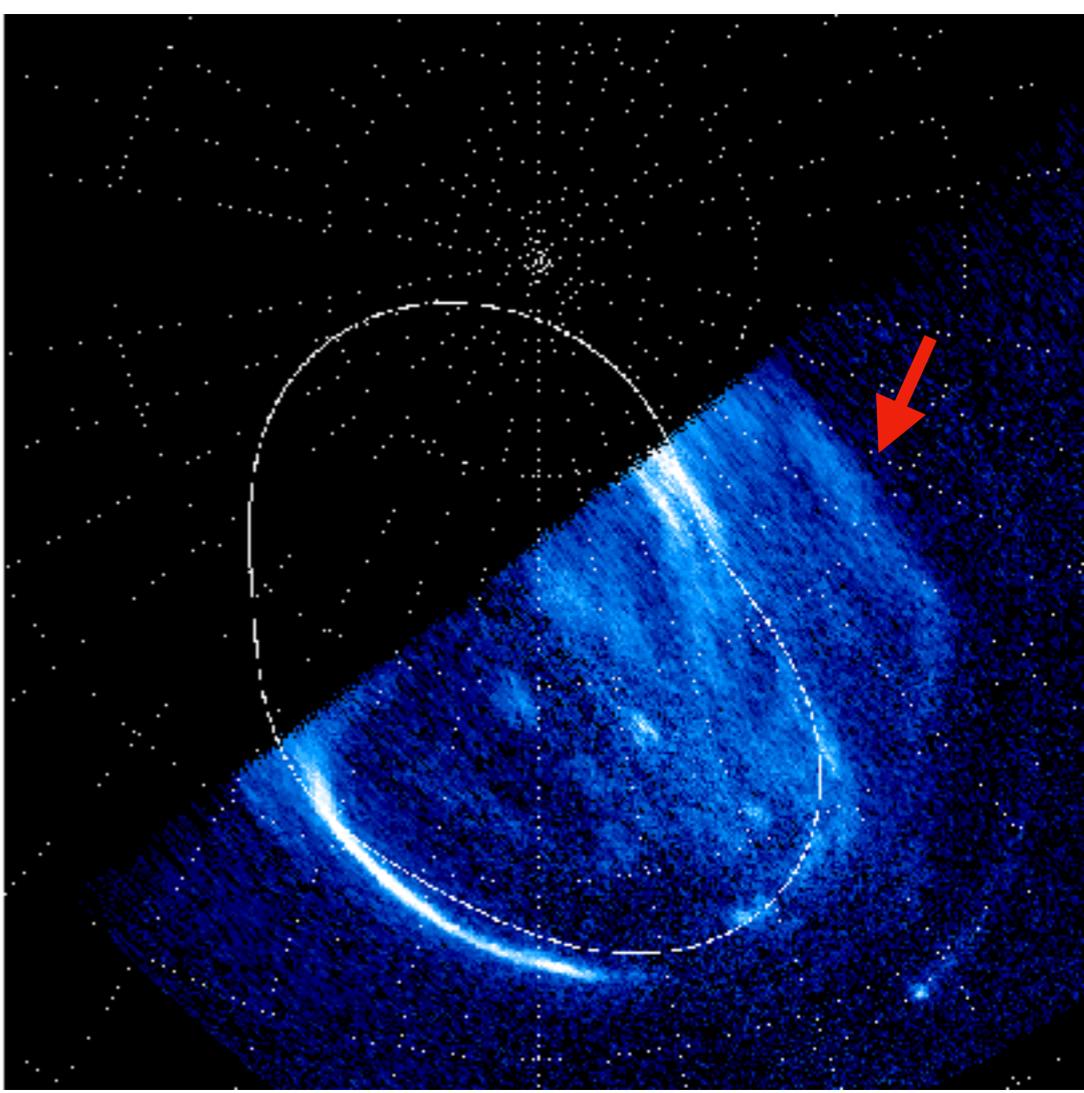
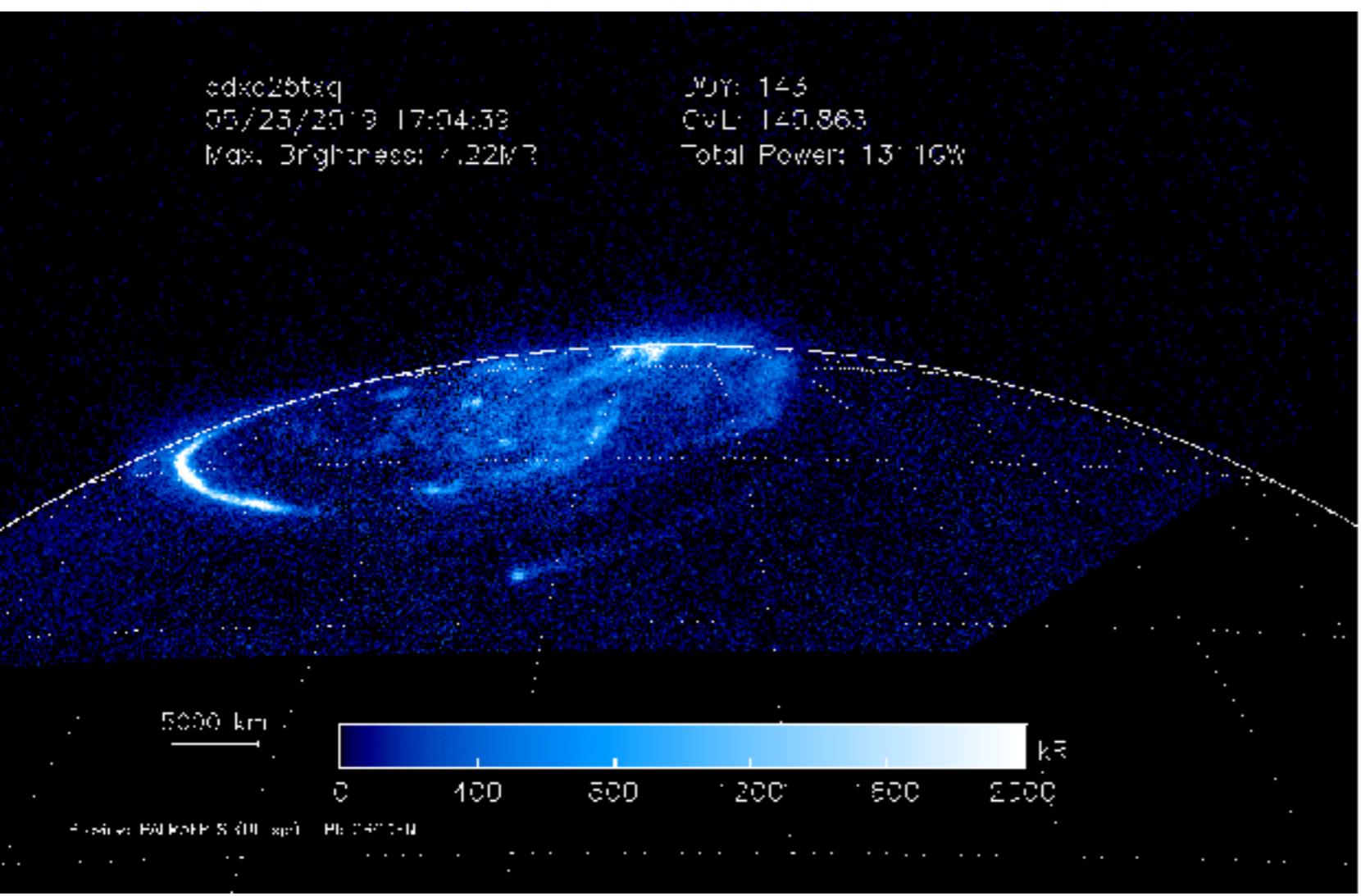
2019-05-23T18:00

- Earth
- Jupiter
- Mars
- Mercury
- Spitzer
- Stereo\_A
- Stereo\_B

Ecliptic Plane W90 LAT = 1.40°

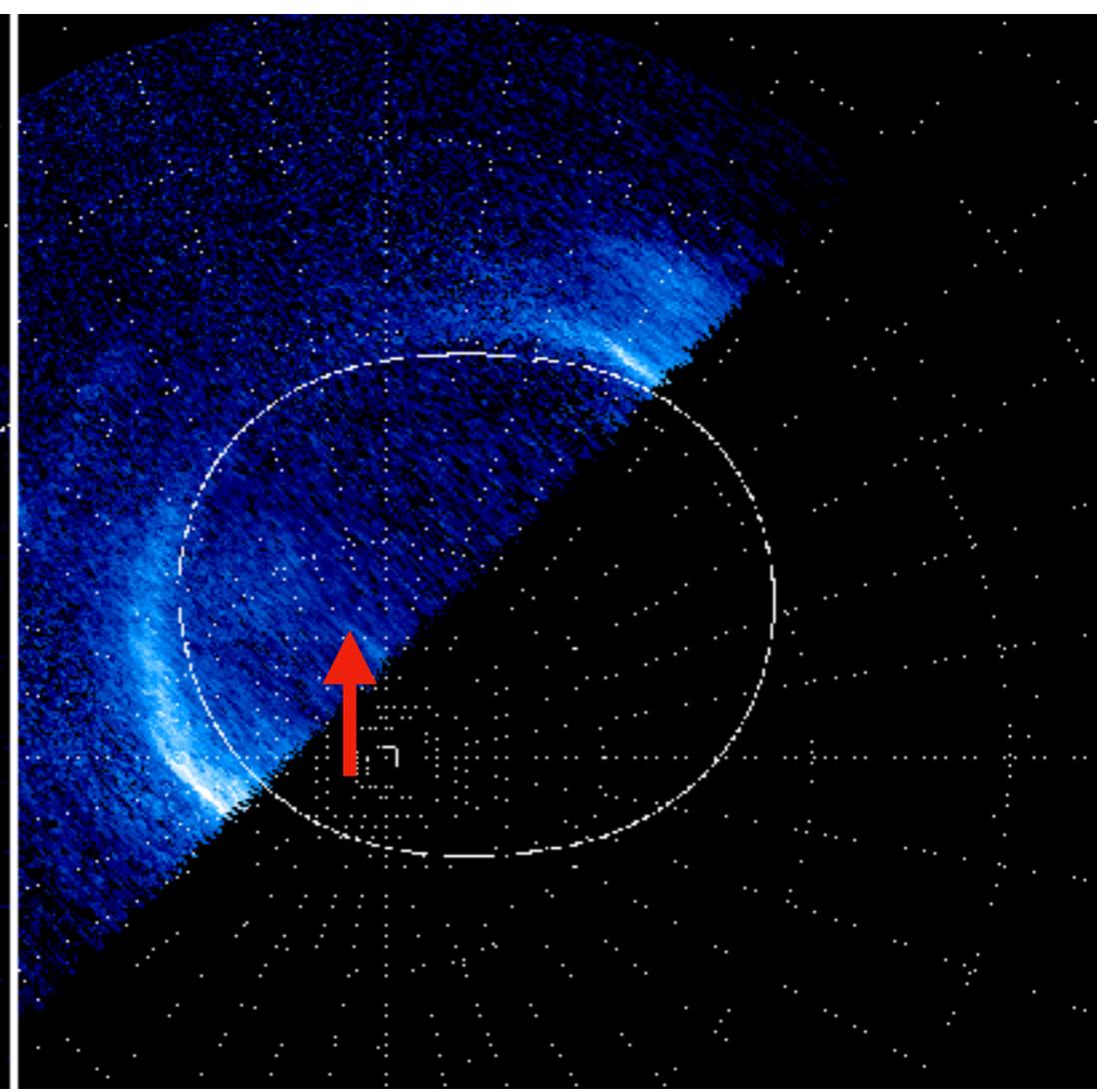
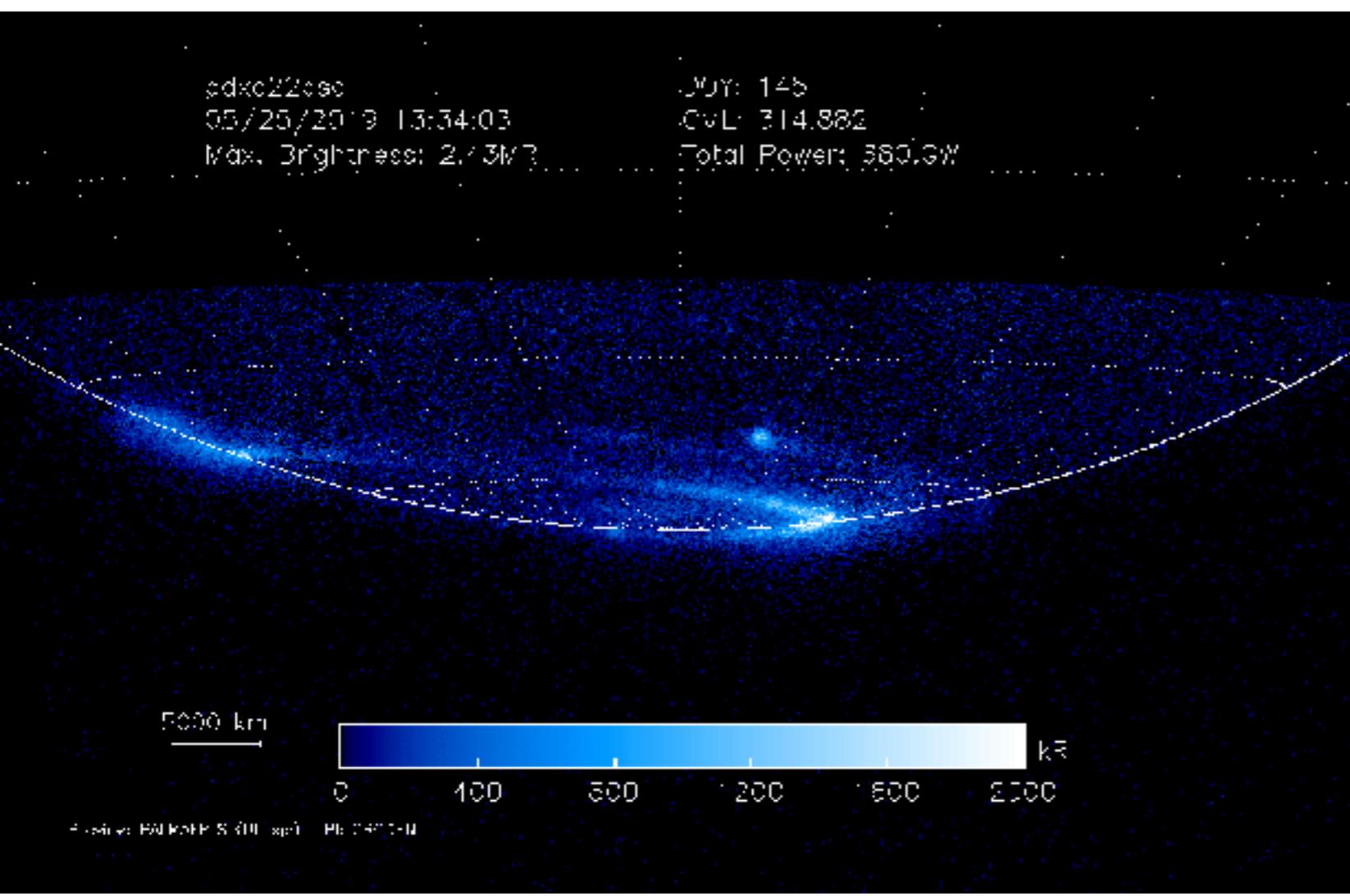


1 day later



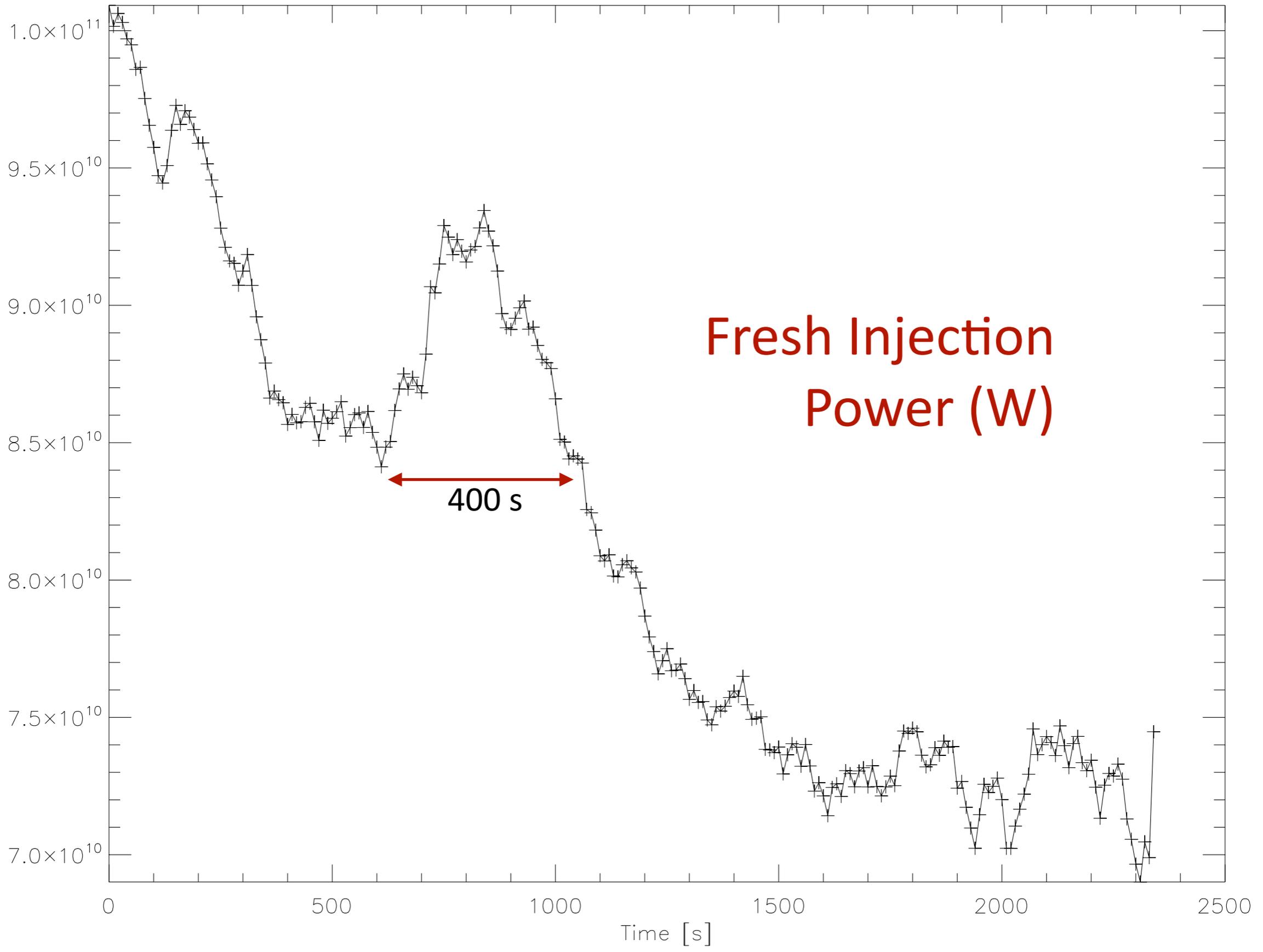
Polar Explosion 15 MR Injections

# 2 days later



Polar Explosion >4 MR  
Pulsating IFP

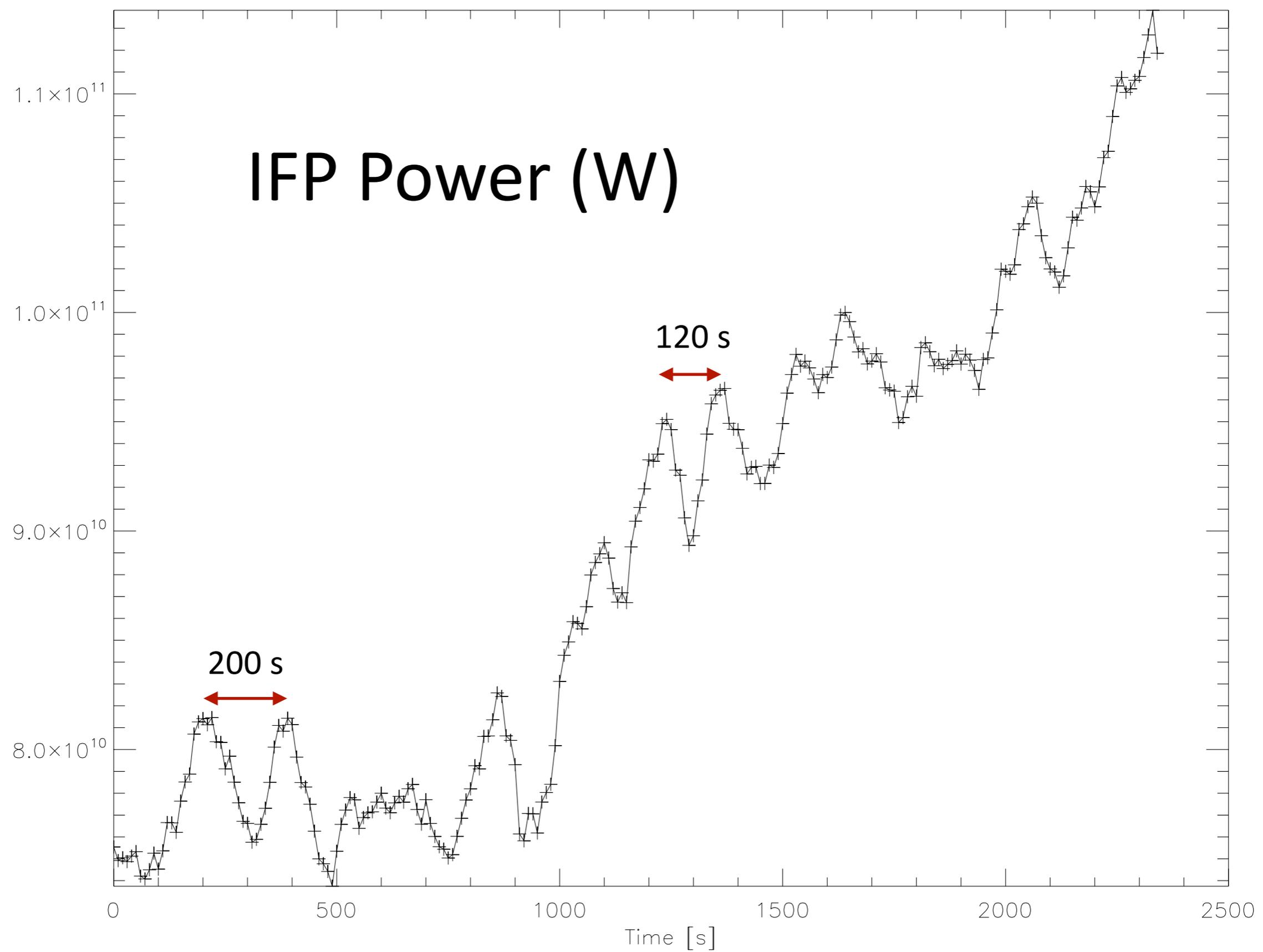




**Fresh Injection  
Power (W)**

**400 s**



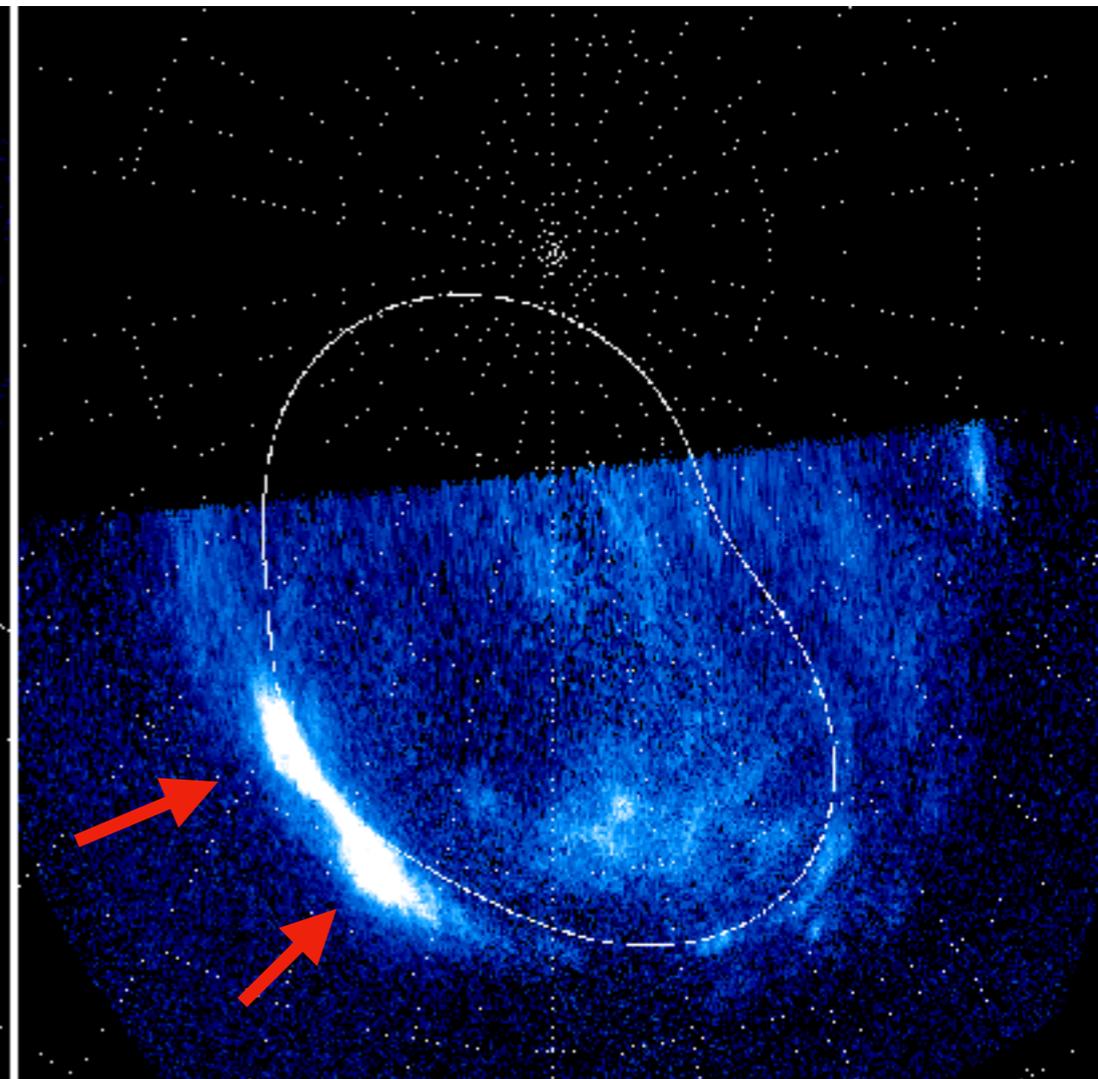
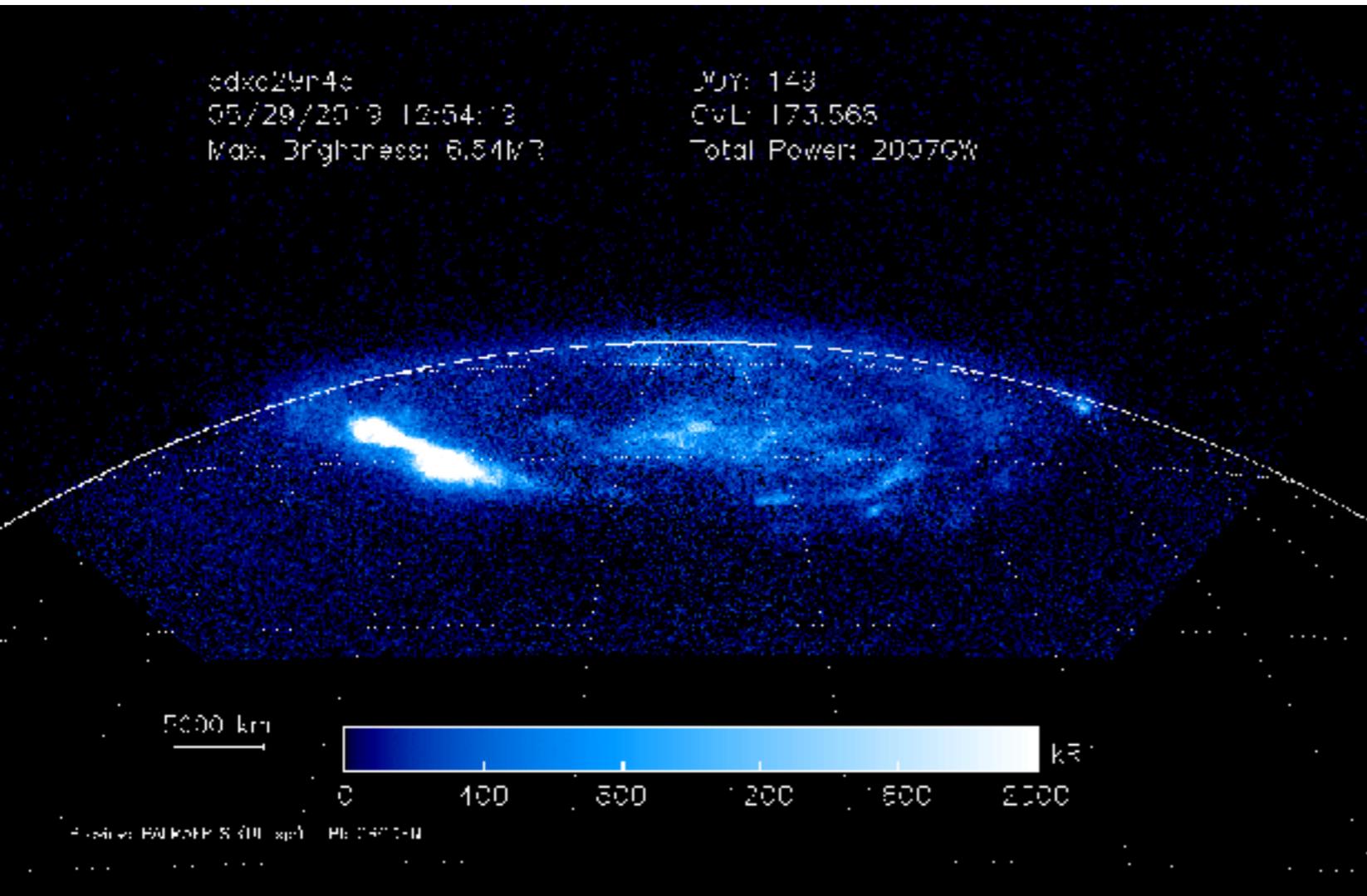






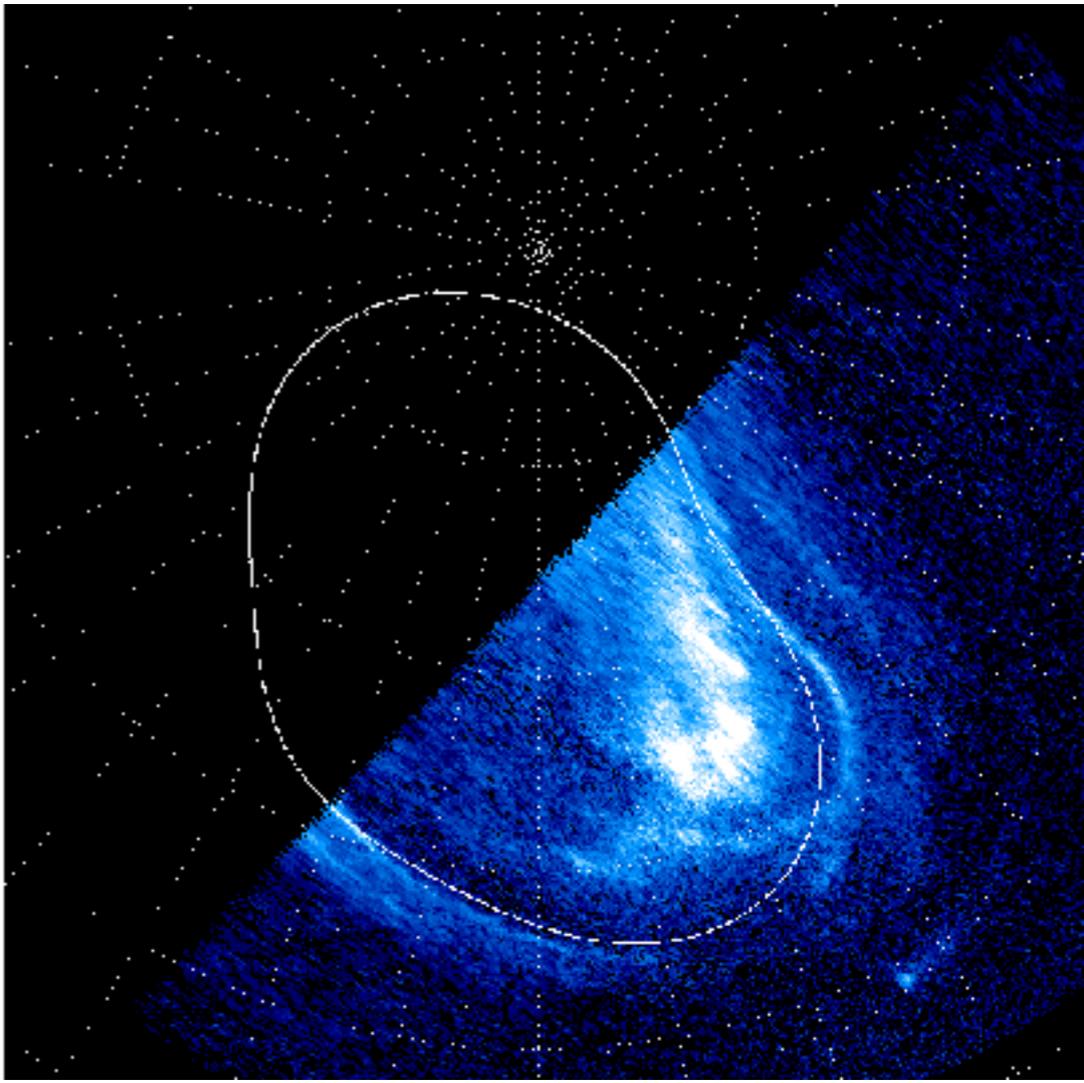
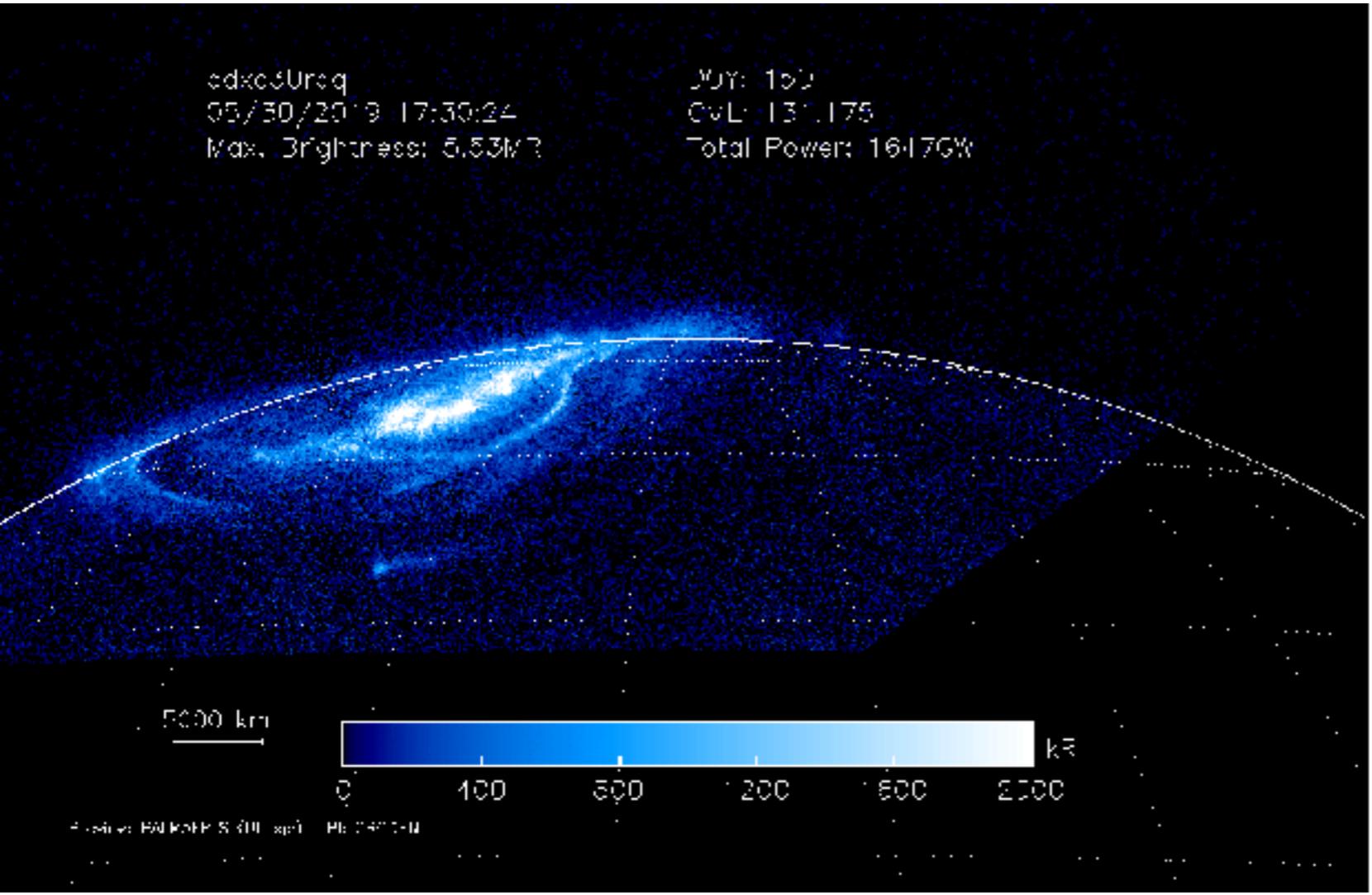


# PJ20 + 4 hr



Weak ME, Dawn Storms -> Injections, Polar Flashes  
(Quiet Solar Wind)

# Thu 30 1 day later



Weak ME, Old Injections, Polar Flashes



Movies (soon) available at:

<https://www.lpap.uliege.be/>

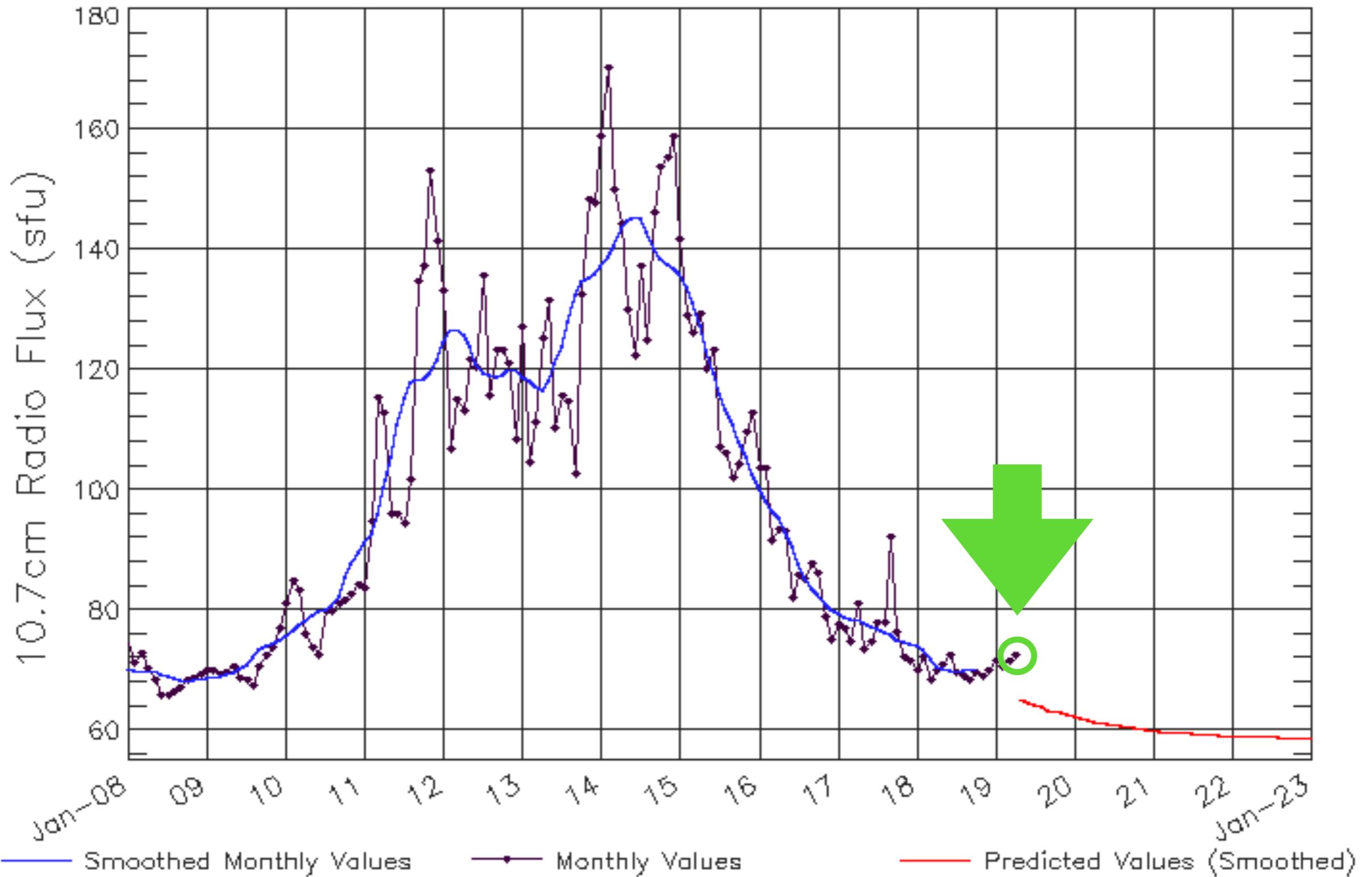
**Google** keywords: **lpap, jupiter, hst**

Back up

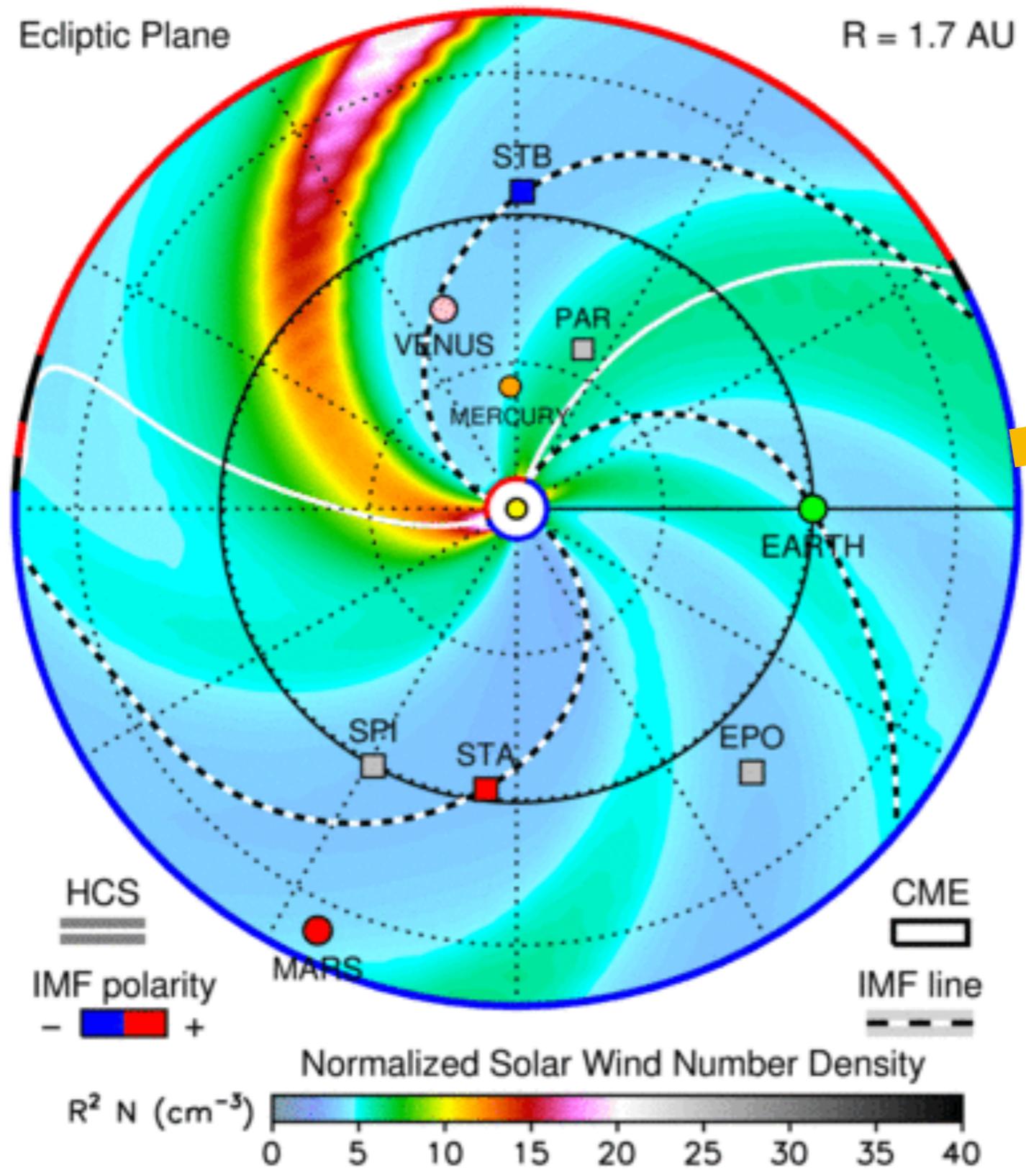


# ISES Solar Cycle F10.7cm Radio Flux Progression

Observed data through Apr 2019



2019-04-28T06



To Jupiter ...

HST observation times  
during orbit #18

## JUPITER

*- North Aurora:*

19.040 (Feb 9) 18:01-18:50

19.042 (Feb 11) 00:13-01:01

19.042 (Feb 11) 19:18-20:05

19.044 (Feb 13) 01:29-02:19

19.044 (Feb 13) 20:35-21:20

*- South Aurora:*

19.041 (Feb 10) 00:24-01:11

19.041 (Feb 10) 21:03-21:50

**19.043 (Feb 12) 01:40-02:26**

*- Apojove, North Aurora:*

19.068 (Mar 9) 11:43-12:42

19.069 (Mar 10) 06:48-07:47

## IO

*- Io wake region (visit 51)*

19.045 (Feb 14) 20:27-21:10

19.045 (Feb 14) 21:58-22:45

Perijove: 02/12/2019 17:34

Apojove : 03/11/2019 02:48

## JUPITER

- *North Aurora:*

19.087 (03/28/2019) 21:30:00

19.088 (03/29/2019) 18:09:00

19.089 (03/30/2019) 22:45:00

19.090 (03/31/2019) 19:25:00

19.091 (04/01/2019) 16:04:00

19.092 (04/02/2019) 01:36:00

XMM 04/01/2019 23:42

- 04/02/2019 23:02

19.093 (04/03/2019) 17:19:00

19.095 (04/05/2019) 18:34:00

**19.096 (04/06/2019) 13:38:00**

19.096 (04/06/2019) 23:11:00

- *Apojove, Io airglow and North Aurora:*

19.119 (04/29/2019) 17:00:00 COS spectra (1/2 success)

19.120 (04/30/2019) 03:17:00

HST observation times  
during orbit #19

## JUPITER

Perijove: 19.149 (05/29/2019) 08:08

Apojove : 19.175 (06/27/2019) 18:02

20

*- North Aurora:*

19.142 (May 22) 22:00-22:40

19.143 (May 23) 17:03-17:47

19.146 (May 26) 14:57-15:42

19.149 (May 29) 12:52-13:36 PJ20+4h

19.150 (May 30) 17:28-18:13

*- South Aurora:*

19.145 (May 25) 13:32-14:16

19.146 (May 26) 21:18-22:03

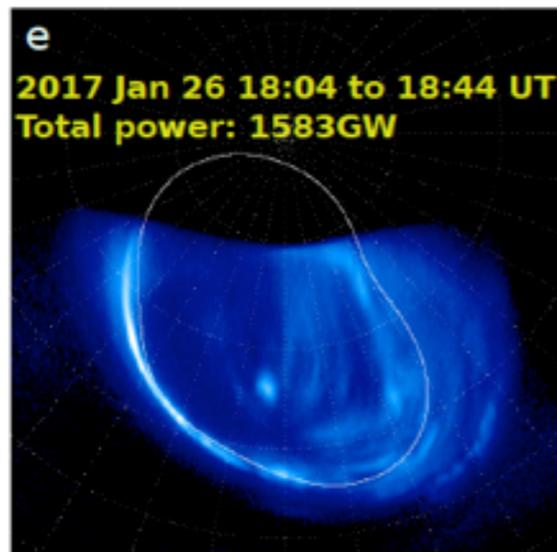
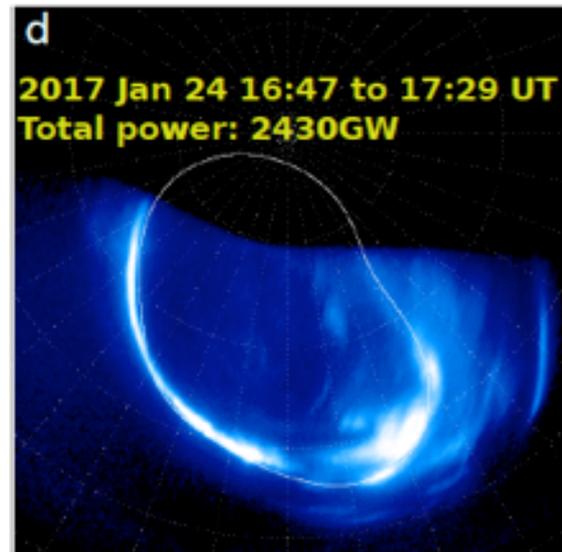
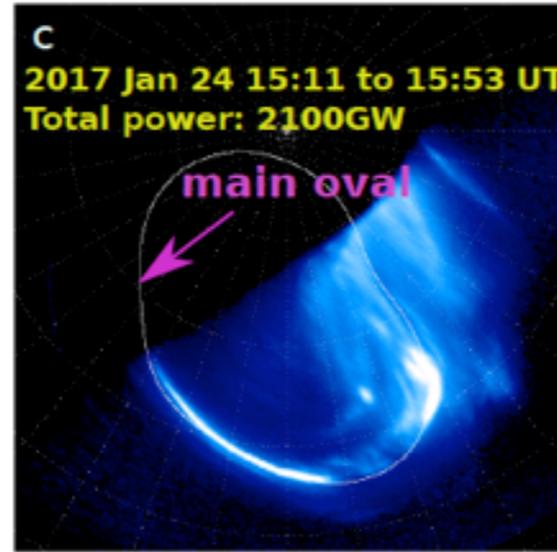
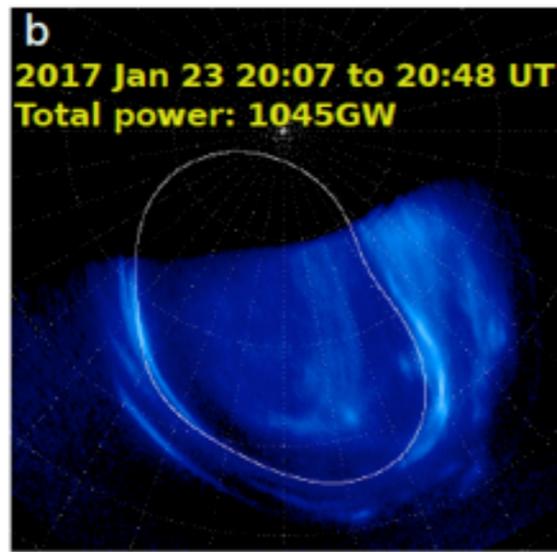
19.147 (May 27) 17:58-18:42

19.148 (May 28) 20:59-21:43

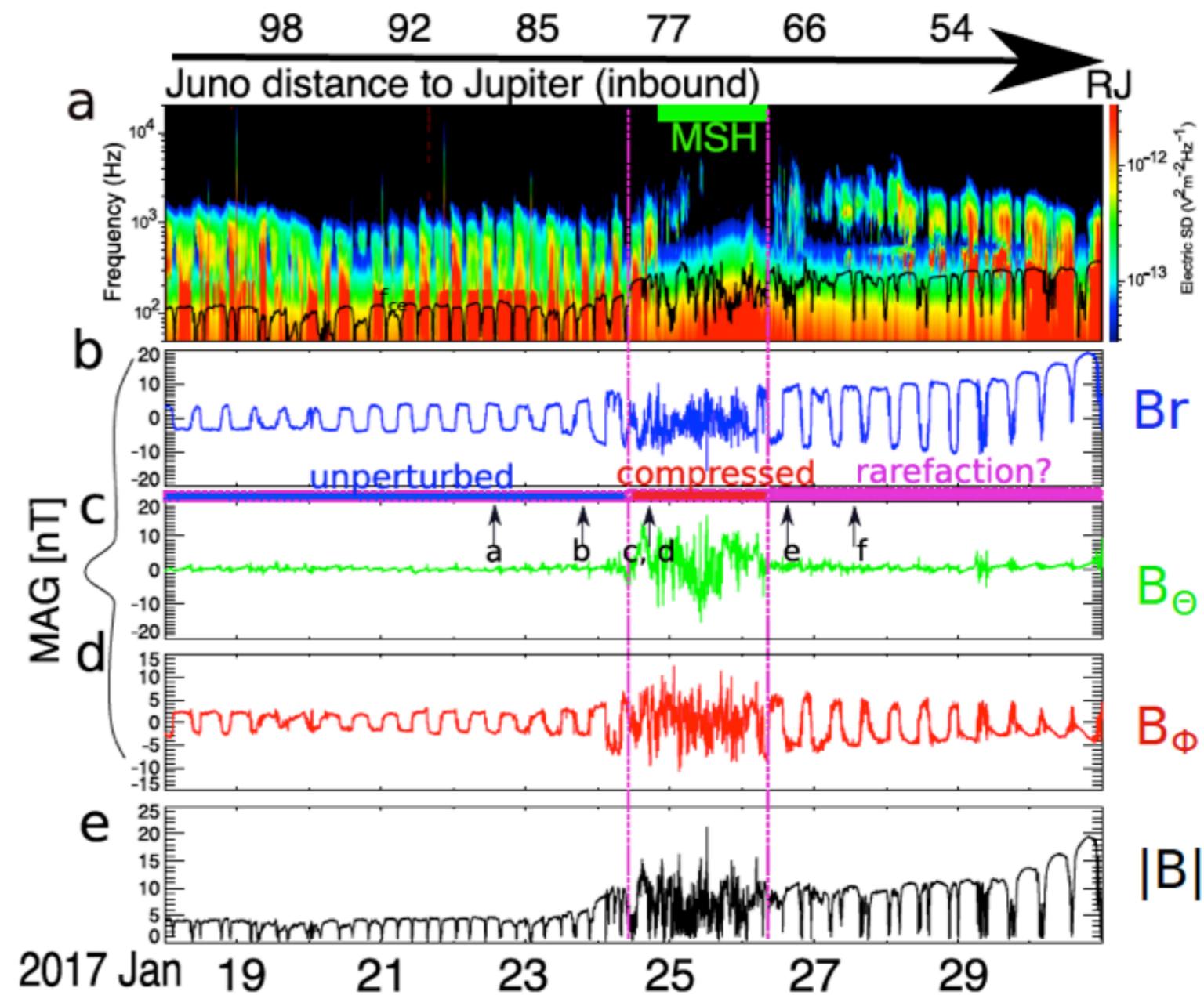
*- Apojove, North Aurora:*

HST observation times  
during orbit #20

Polar projection of HST ultraviolet auroral images (northern pole)



Yao et al., submitted  
**Yao et al. poster P13**

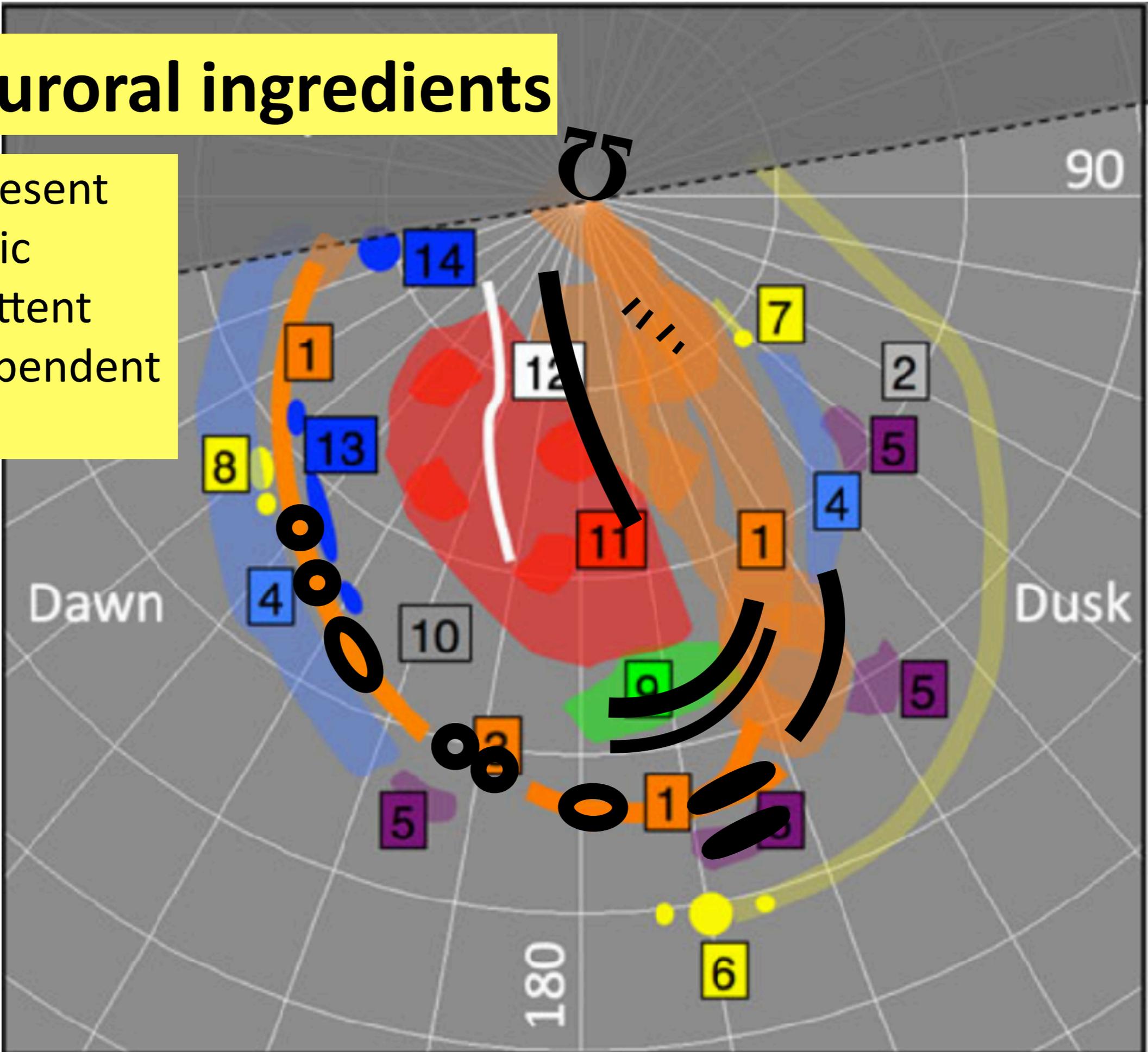


Take away message



# Possible auroral ingredients

- \*Not always present
- \*Highly dynamic
- \*Some intermittent
- \*Local time dependent
- \*...



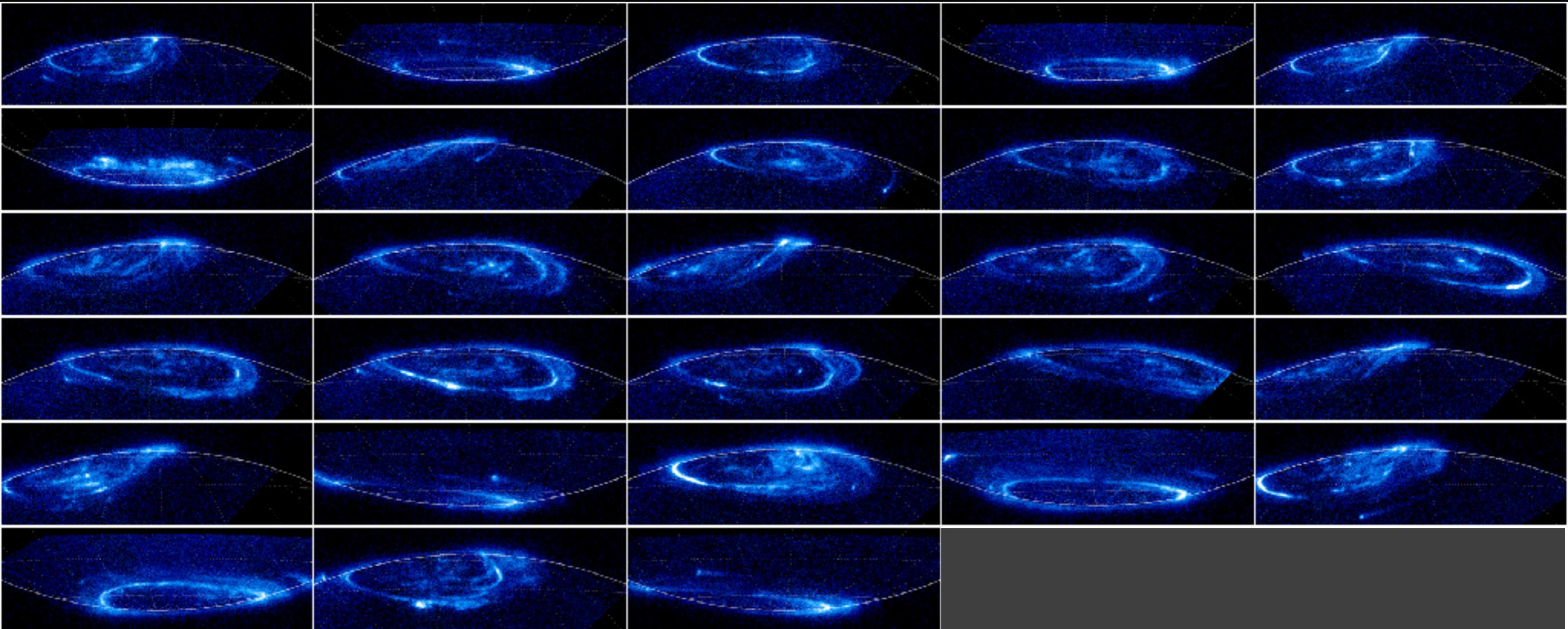
# Jupiter is alive!

HST observations of Jupiter's aurora  
during Juno orbits 18, 19 and 20

Denis Grodent  
Zhonghua Yao  
Bertrand Bonfond  
Benjamin Palmaerts  
Jean-Claude Gérard  
Aikaterini Radioti  
Sarah V. Badman  
Emma J. Bunce  
Jonathan D. Nichols  
Lorenz Roth  
Joachim Saur  
William Dunn  
Carl Schmidt  
John T. Clarke  
Jack E. Connerney  
G. Randall Gladstone  
Tomoki Kimura  
William S. Kurth  
Barry Mauk  
David J. McComas  
Alessandro Mura  
Glenn S. Orton

WILTED-SCENES

# HST Movie Wall PJ18 - PJ19 - PJ20



<https://www.lpap.uliege.be/>  
google keywords: **lpap, jupiter, hst**

# Zoom 04:00 - 07:00

JED900EXFL03 e- (22.5900,25.6500) keV ...  
Energy Spectrogram configuration  
Calendar Time (2019-043T00:00:00.000 to 2019-043T07:00:00.000)

