Jet Propulsion Laboratory
California Institute of Technology

Juno UV, Optical, & IR Remote Sensing

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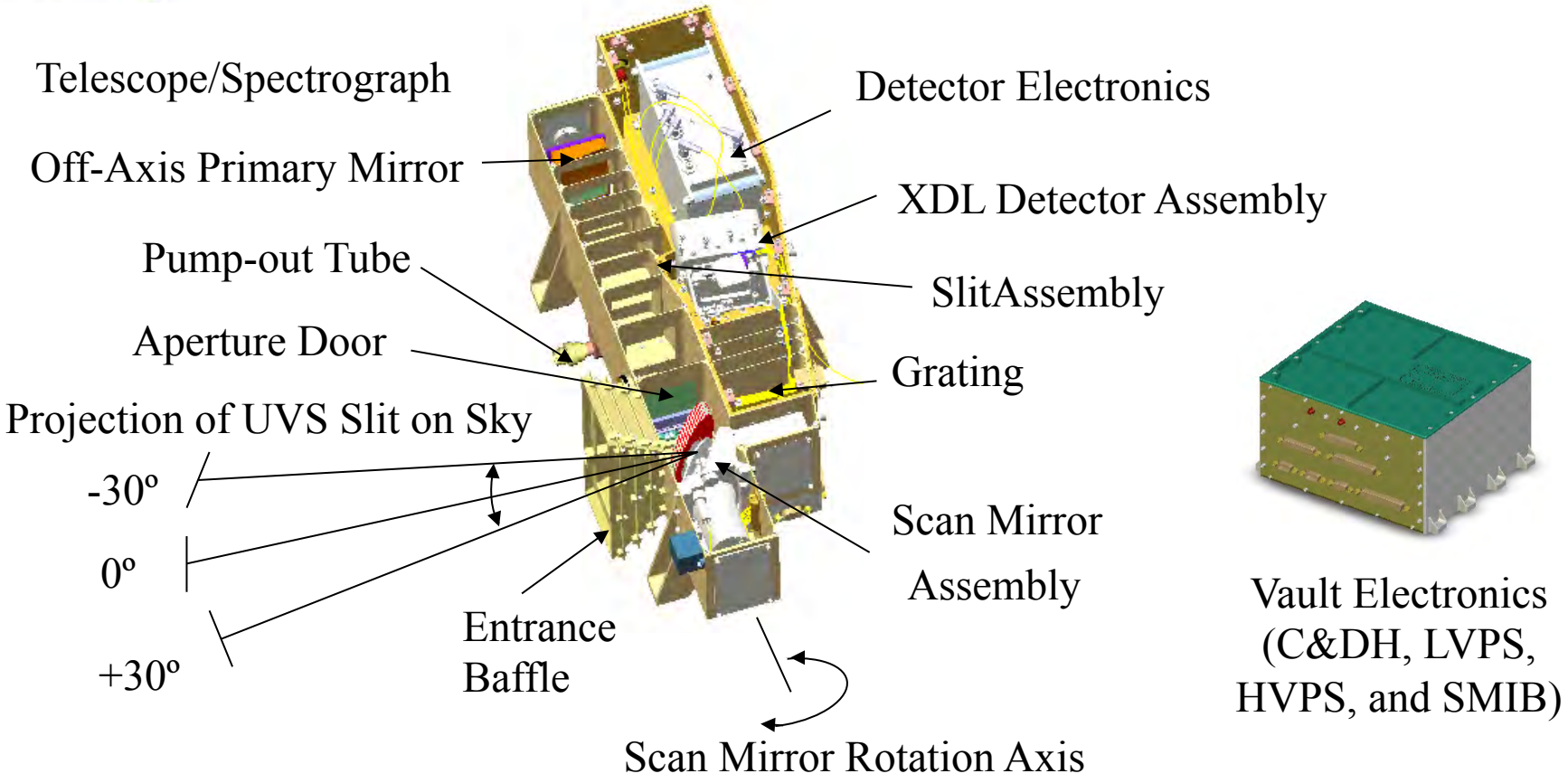
UVS Lead

Workshop on Jupiter's Aurora
Anticipating Juno's Arrival 4th July 2016
CU-LASP
Boulder, CO

UVS Concept Drawing



Changes from heritage instruments (LRO-LAMP, NH-Alice, & R-Alice):

- Scan mirror added for aurora viewing during GRAV science orbits
- Detector upgraded to XDL for higher count rates
- Everything possible moved into the S/C vault for protection from radiation
- Ta shielding surrounds detector and detector electronics

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UVS Characteristics & Performance

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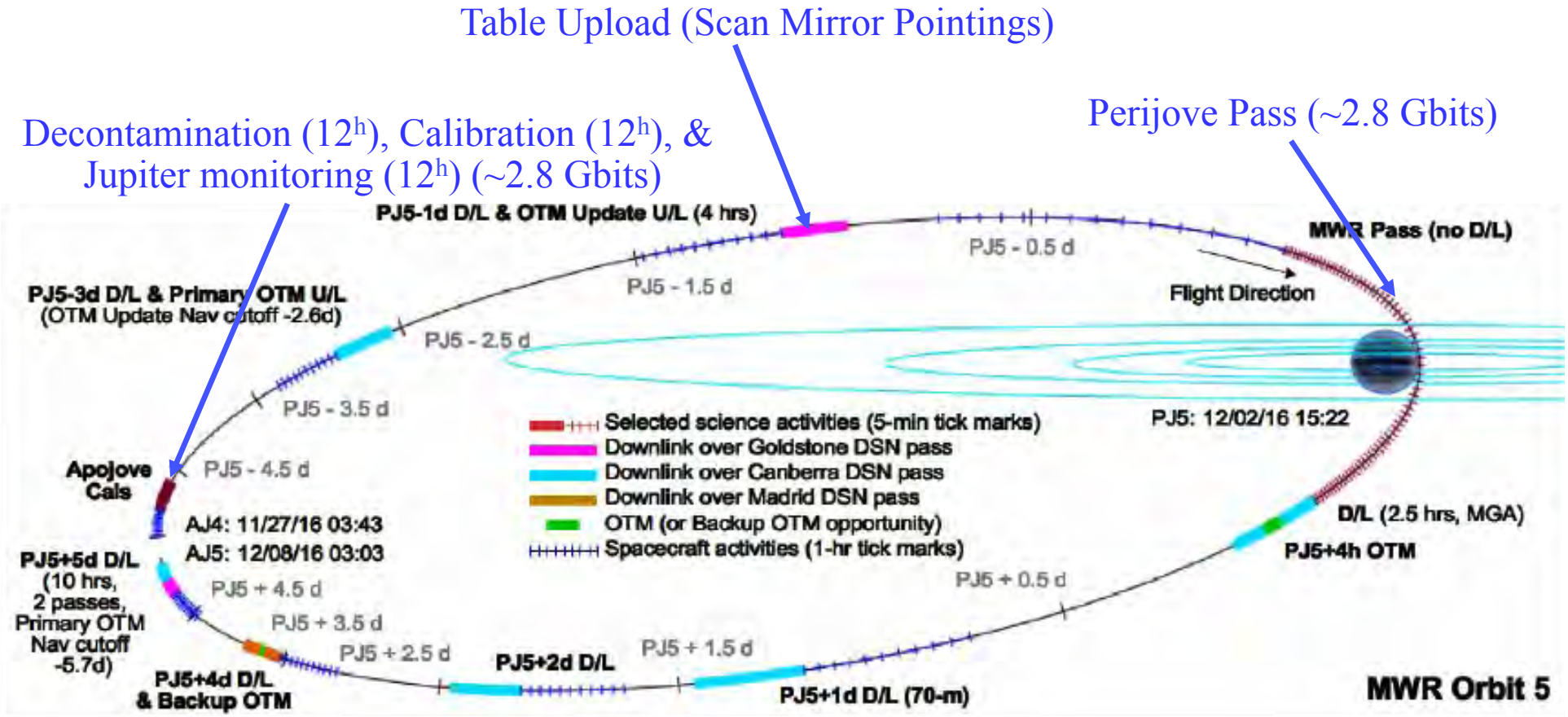
Feature	Characteristic or Performance	Driving Requirement
Spectral Range:	70-205 nm	78-172 nm; L3-PLS-280
Spectral Res.:	~0.4-0.6 nm (point source) ~1.0-2.6 nm (extended source)	<3 nm filled slit; L3-PLS-303
Spatial Res.:	0.15° (180 km from 1 R_J above the aurora)	<500 km; L3-PLS-304
Effective Area:	0.002 cm^2 @ 105 nm, 0.02 cm^2 @ 170 nm	>100 kR; L3-PLS-305
Feature	**Characteristic or Performance**	
IFOV:	0.2° x 2.5° + 0.025° x 2° + 0.2° x 2.5° → "dog-bone" shape	
Field of Regard:	360° x 60° (2 RPM & ±30° from spin plane → half the sky is accessible)	
Design:	Off-Axis Primary telescope / Rowland circle mount spectrograph	
Detector Type:	Curved 2-D MCP (solar blind), CsI photocathode, cross delay-line (XDL) readout, 24 bits/event; 2048 spectral (perpendicular to slit) x 256 spatial (parallel to slit) x 32 (PHD)	
Radiation Mitigation:	Shielding (contiguous 100 mils Ta, ~4π at the detector, rejects energetic electrons <3 MeV); Pulse Height Distribution (PHD) thresholding	

UVS Operations During Science Orbits



- 3 blocks are used to group UVS commands during operations at Jupiter:
  - Perijove, Table Uploads, & Decontamination/Calibration/Jupiter monitoring
- Scan mirror pointing and parameter table uploads allows "last minute" updates in target selection and instrument settings

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UVS Auroral Targets

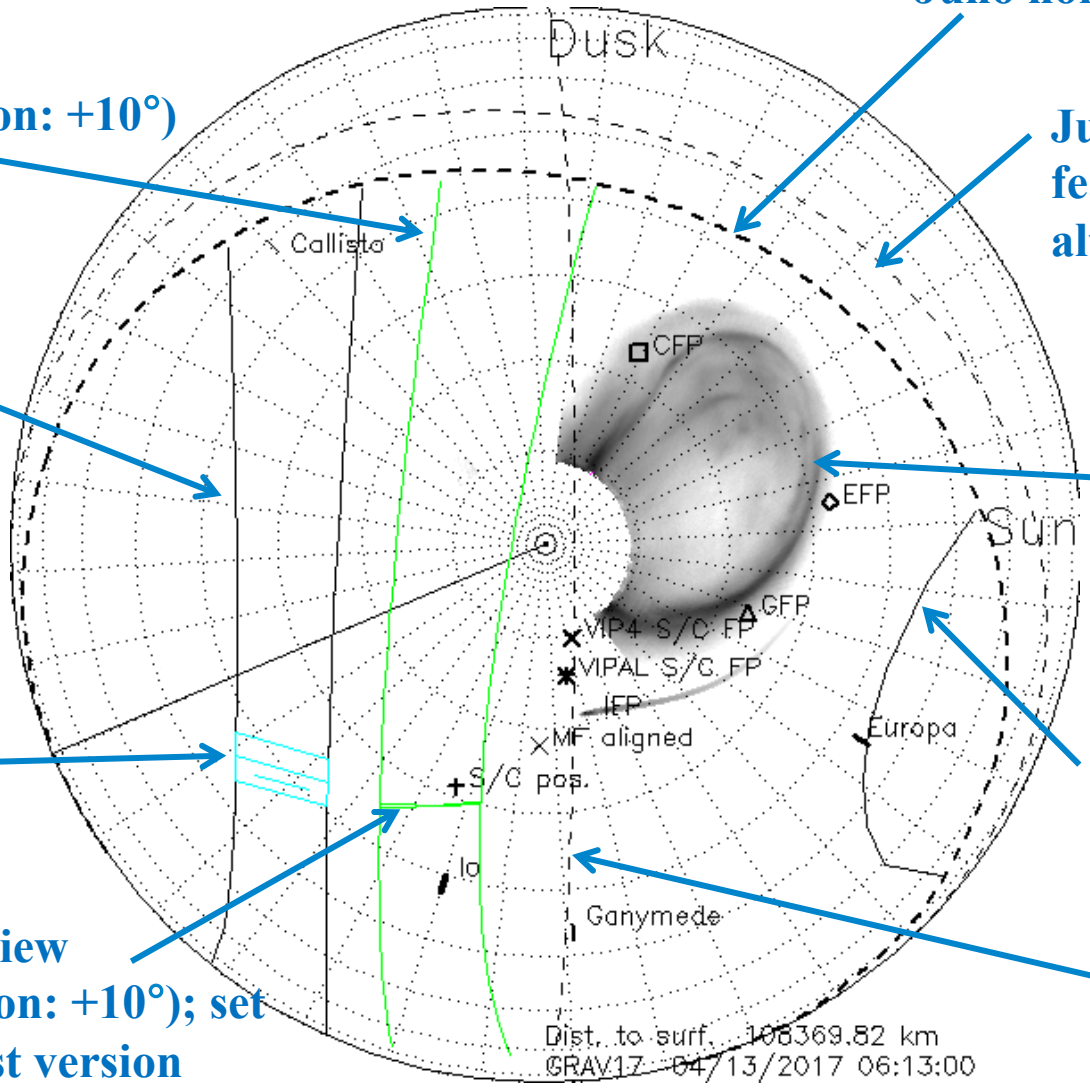
Orbit #	Type	PJ Epoch	Rank	Main Oval Crossings	Io Flux Tube Footprint				Europa Flux Tube Footprint				Ganymede Flux Tube Footprint				Callisto Flux Tube Footprint				IFT Tail			
					FN	NN	NS	FS	FN	NN	NS	FS	FN	NN	NS	FS	FN	NN	NS	FS	FN	NN	NS	FS
0	JOI	07/05/2016 02:47:38.0	0		4	4	4	4	1	1	4	4-1	4-1	1	4	4	1	1	4	4-1	4	4	4	4
1	Capture	08/27/2016 12:51:20.0	0		4-1	1	4	4-1	1	1	1	1	2	2	1	1-2	1-2	2	1	1	4-1	1	4	4-1
2	PRM2	10/19/2016 18:11:07.0	0		4-1	1	1	1	4-1	1	4	4-1	4	4	3	3-4	4-1	1	2	2	4-1	1	1	1
3	PRM3	11/02/2016 17:52:29.0	0		4	4	4	4	4	4	4	4	3-4	4	3	3	3-4-1	1	2	2-1	4	4	4	4
4	MWR4	11/16/2016 16:54:46.0	2	Good	3-4	4	4	4	3-4	4	1-4	4	3	3	3	3	2-3-4	4	1	1	3-4	4	4	4
5	GRAV5	11/30/2016 15:52:21.0	4	Good	3	3	4	4	4-3	3	4	4	2-3	3	4	4-3-2	1-2	2-3	4	4	3	3	4	4
6	MWR6	12/14/2016 14:49:58.0	5		3	3-2	3	3	4	4	3-4	4	4-3-4-1	2	3	3	4	4-1	3	3-4	3	3-2	3	3
7	MWR7	12/28/2016 13:47:35.0	5	Very Good	3	3	2-3	3	3-4	4	3	3	3	3	2	3	3	3	3	3	3	3	2-3	3
8	MWR8 T	01/11/2017 13:59:37.0	2		2	2	2	2	3	3-4	3	3	3	3	2	2-3	3	3	2	2	2	2	2	2
9	MWR9	01/25/2017 12:57:12.0	2	Good	2	2	2	2	2-3	3	2	2-3-2	2-3	3	2	2	2	2	1	1-2	2	2	2	2
10	GRAV10	02/08/2017 11:54:47.0	0		1	1-2	1	1	1-2	2	3	3-2	1-2	2	2	2-1-2	1	1	1	1	1	1-2	1	1
11	GRAV11	02/22/2017 10:52:21.0	1		4-1	1	1	1	2-1	1	2	3-2	4-1	1	2	2	4	4-1	4	4	4-1	1	1	1
12	GRAV12	03/08/2017 09:12:44.0	1		3-4	4	1	1	2	2	2	2	2	2-3	1-2	2	3	3-4	3	3	3-4	4	1	1
13	GRAV13	03/22/2017 08:10:19.0	4	Good	4-3	3	4	4	2	2	1	1-2	2	2	1	1	2-3	3	3	3-2	4-3	3	4	4
14	MWR14 T	04/05/2017 07:07:53.0	2		3-4	4	3	3-4	1	1	1	1	1	1	1	1	1-2	2	2	2	3-4	4	3	3-4
15	GRAV15	04/19/2017 06:05:27.0	2		3	3	3	3	4-1	1	1	1	4-1	1	2-1	1-4	3-4-1	1	2	2-1	3	3	3	3
16	GRAV16	05/03/2017 06:17:26.0	2		3	3	3	3	4	4	1	1-4	4	4	1	1-4	3-4	4	1	1-4	3	3	3	3
17	GRAV17	05/17/2017 05:14:57.0	1	Good	2	2	2	2	1-4-3	3-4	1	1	1-2-3	3	1	1	1-2-3	3	4	4	2	2	2	2
18	GRAV18	05/31/2017 04:12:29.0	1	Good	1-2	2	2	2	4	4-1	4	4-1	1	1	4	4-1	4-1-2	2	4	4	1-2	2	2	2
19	GRAV19	06/14/2017 03:10:03.0	1		4-1	1	1	1	4	4	4	4	4-1	1	4	4	3-4	4-1	3	3	4-1	1	1	1
20	GRAV20	06/28/2017 03:40:40.0	2		4-1	1	1	1	4	4	3	3-4	4	4	3-4	4	3-4-1	1	2	2-3-2	4-1	1	1	1
21	GRAV21	07/12/2017 02:38:12.0	3		4	4	1	1	3	3	3	3	3-4	4	4	3	2	2-3	1-2	2	4	4	1	1
22	GRAV22	07/26/2017 01:35:46.0	2	Good	4-3	3	4	4-1	2-3	3	3	3	1-2-3	3	4	4	1	1-2	1	1	4-3	3	4	4-1
23	GRAV23	08/09/2017 00:33:19.0	1		4	4	4	4	3-2	2	3	3	4	4-1-2	3-4	4	4-1	1	4	4	4	4	4	4
24	GRAV24	08/23/2017 00:08:07.0	2		3	3	3	3	3-2	2	3	3	4	4	3	3	4	4	3	3-4	3	3	3	3
25	GRAV25	09/05/2017 23:05:44.0	3		3	3	3	3	2-3	3	2	2	3	3	3	3	3	3	3	3	3	3	3	3
26	GRAV26	09/19/2017 22:03:21.0	2	Good	2	2	2	2	2	2	2	2	2-3	3	2	2	2	2	2	2	2	2	2	2
27	GRAV27	10/03/2017 21:00:55.0	2	Good	1-2	2	2	2	1-2	2	1	1	1-2	2	3	3-2	1-2	2	1	1	1-2	2	2	2
28	GRAV28	10/17/2017 20:35:43.0	2		1	1	2	2-1	4-1	1	1	1	3-4-1	1	3	3	4-1	1	4	4-1	1	1	2	2-1
29	GRAV29	10/31/2017 19:33:14.0	1		4	4	1	1	1-4	4	1	1-2-1	3	3	2	2	3-4	4	4	4	4	4	1	1
30	GRAV30	11/14/2017 18:30:45.0	1		4-1-4	4	1	1	1	1-4	1	1	2	2-3	2	2	2-3	3	4	4-3	4-1-4	4	1	1
31	GRAV31	11/28/2017 17:28:16.0	1	Good	4	4	4	4	1	1	4	4-1	1-2	2	1	1	1-2	2	3	3	4	4	4	4
32	GRAV32	12/12/2017 17:02:53.0	0		4	4	4	4	4-1	1	4	4	1	1	2	2-1	4-1	1-2	2	2-3-2	4	4	4	4
33	GRAV33	12/26/2017 16:00:20.0	2		3	3-4	3	3	3-4	4	4	4	2-3-4	4-1	2	2	2-3-4	4-1	2	2	3	3-4	3	3
34	GRAV34	01/09/2018 14:57:50.0	3		2-3	3	3	3	3	3	4	4-3	2	2	1	1	1-2-3	3-4	1	1	2-3	3	3	3
35	GRAV35	01/23/2018 13:55:18.0	1		2	2	2	2	4-3-2	2-3	4	4-3	1	2	1	1	1	1	4	4	2	2	3	2
36	Extra 36	02/06/2018 12:52:47.0	0		1	1	2	2	3	3	3	3-4	4-1	1	4	4-1	4	4	3	3-4	1	1	2	2

FN=Far North; NN=Near North; NS=Near South; FS=Far South

Local Time Quadrants: 1=12am-6am; 2=6am-12pm; 3=12pm-6pm; 4=6pm-12am

On "Good" auroral crossings, the S/C footprint runs along the auroral oval for a long time

UVS Targeting



Juno horizon

UVS swath (mirror position: +10°)

Juno visibility limit for features at 1000 km altitude

JIRAM swath

"Mean" aurora from Hubble Space Telescope FUV images

JIRAM field of view

Extremity of the UVS field of regard

UVS field of view (mirror position: +10°); set at -10° in latest version

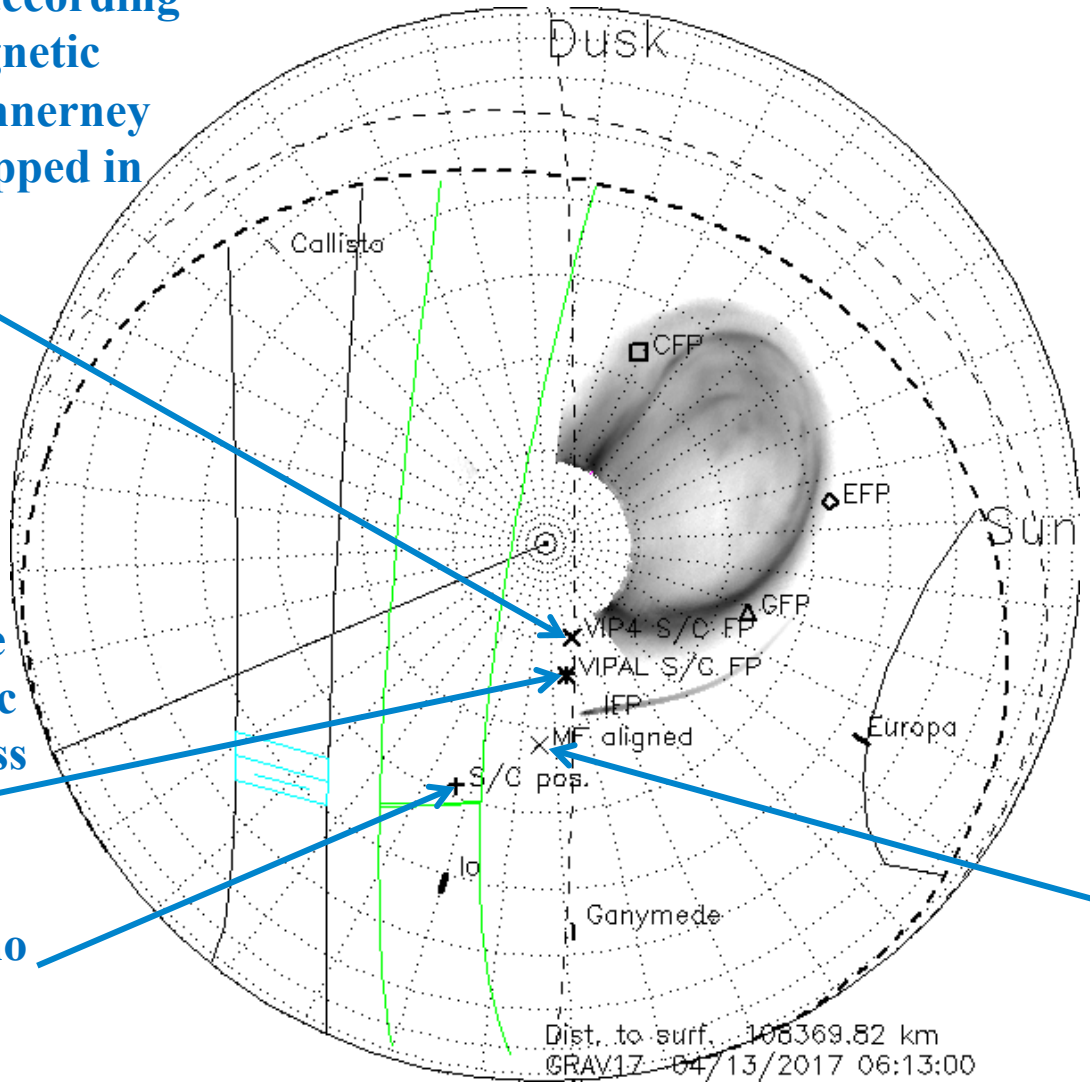
Terminator

UVS Targeting

Juno footprint according to the VIP4 magnetic field model (Connerney et al, 1998); dropped in latest version

Juno footprint according to the VIPAL magnetic field model (Hess et al, 2011)

Sub-Juno position



Point where the surface magnetic field and the Juno direction are co-aligned

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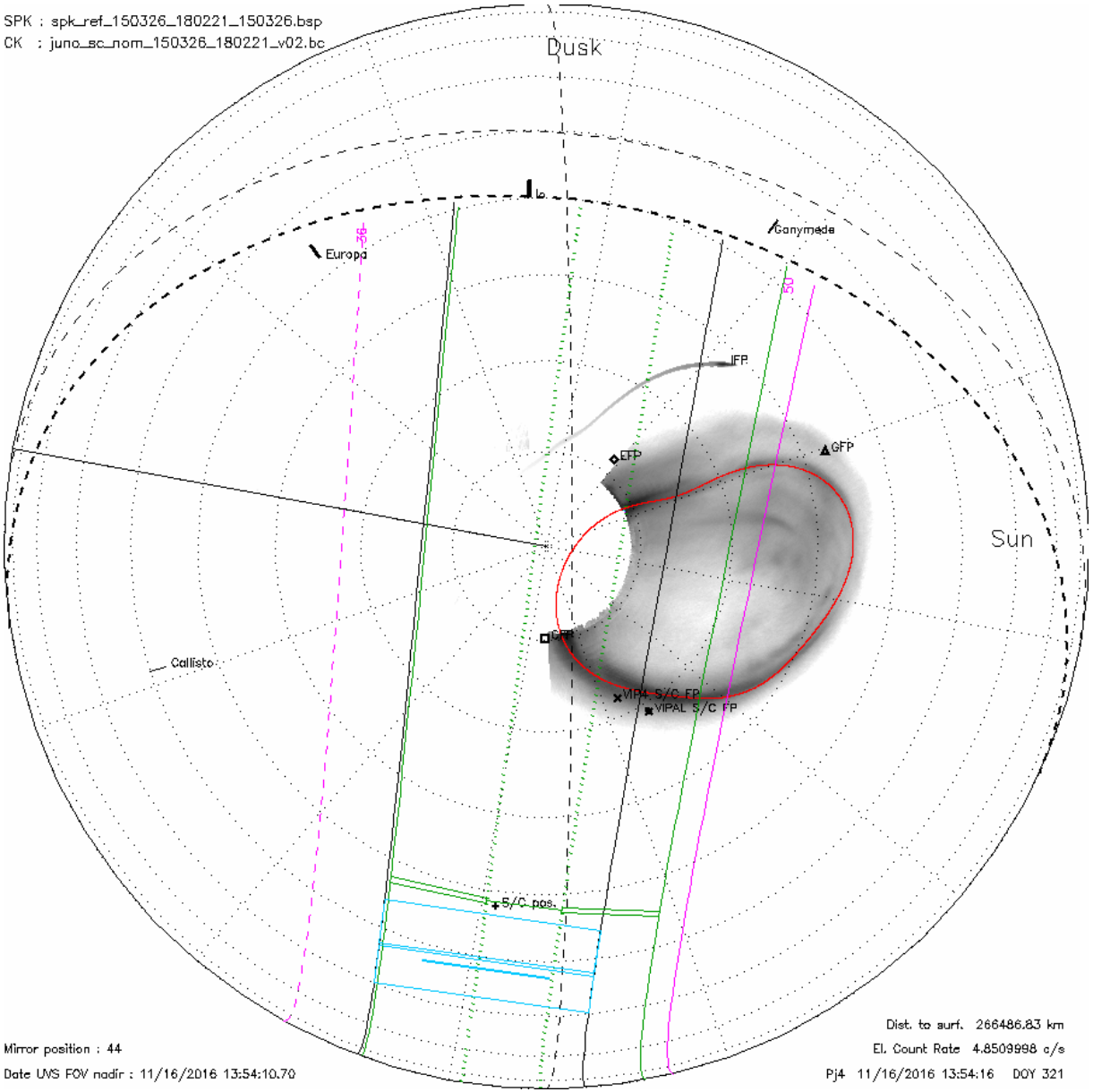
UVS Targeting – PJ4



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JIRAM:
Jovian InfraRed Auroral Mapper

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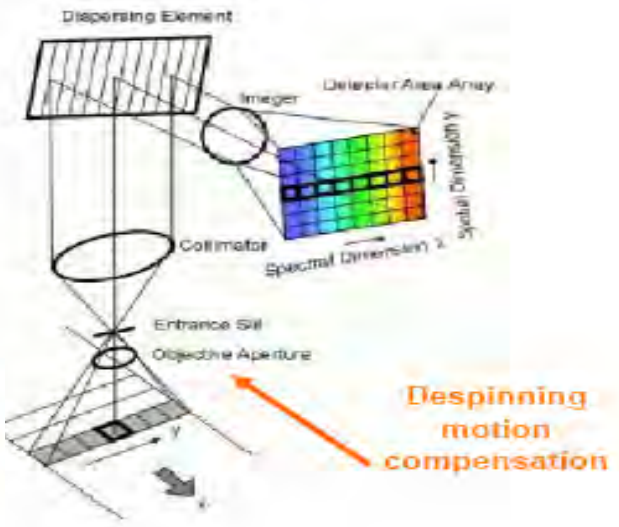
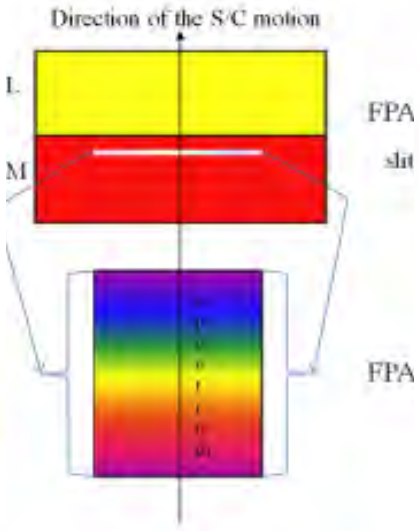
- JIRAM is an imager and spectrograph at the same time. Its heritage comes from similar instruments on other planetary space missions: Cassini, Venus Express, Dawn and Rosetta
- The spectrograph operates in the 2-5 μm spectral range with a resolution of 9 nm
- The imager has two contiguous channels: 3.3-3.6 μm for auroras and 4.5-5.0 μm for Jupiter's thermal emission

Scanning Concept



Focal Plane Assembly



Optical Head

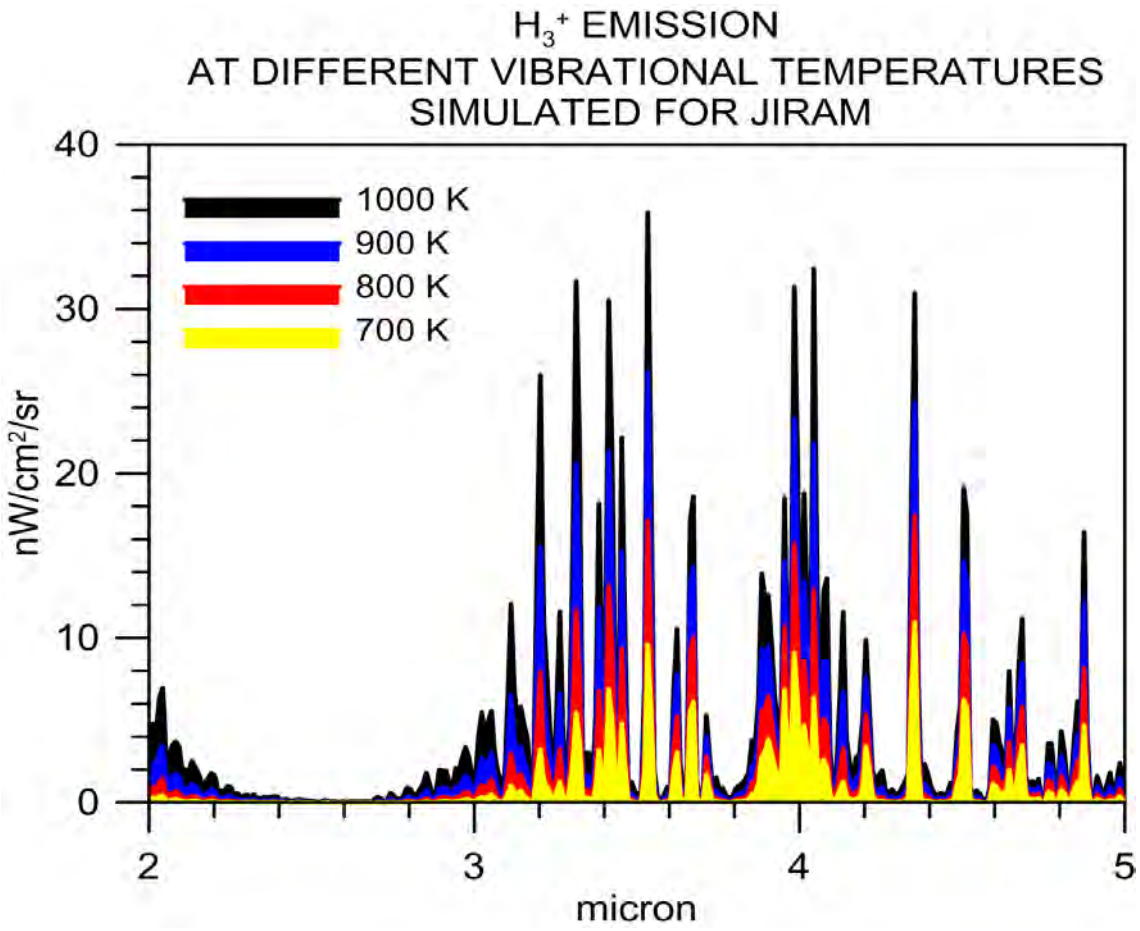
Juno – JIRAM

JIRAM:
Jovian InfraRed Auroral Mapper

JIRAM will map the Northern and Southern auroras at the infrared wavelengths emitted by H_3^+, which has strong emissions in different bands over all the JIRAM spectral range. This ion is formed at the base of the exosphere through the reaction $H_2^+ + H_2 \rightarrow H_3^+ + H$.

JIRAM will investigate auroral links between Jupiter and the Galilean satellites. Infrared auroral emissions will be observed in conjunction with ultraviolet auroral emissions measured by UVS

Both nadir and limb observations will be performed with the JIRAM spectrograph to measure the temperature and concentration of emitting H_3^+ ions



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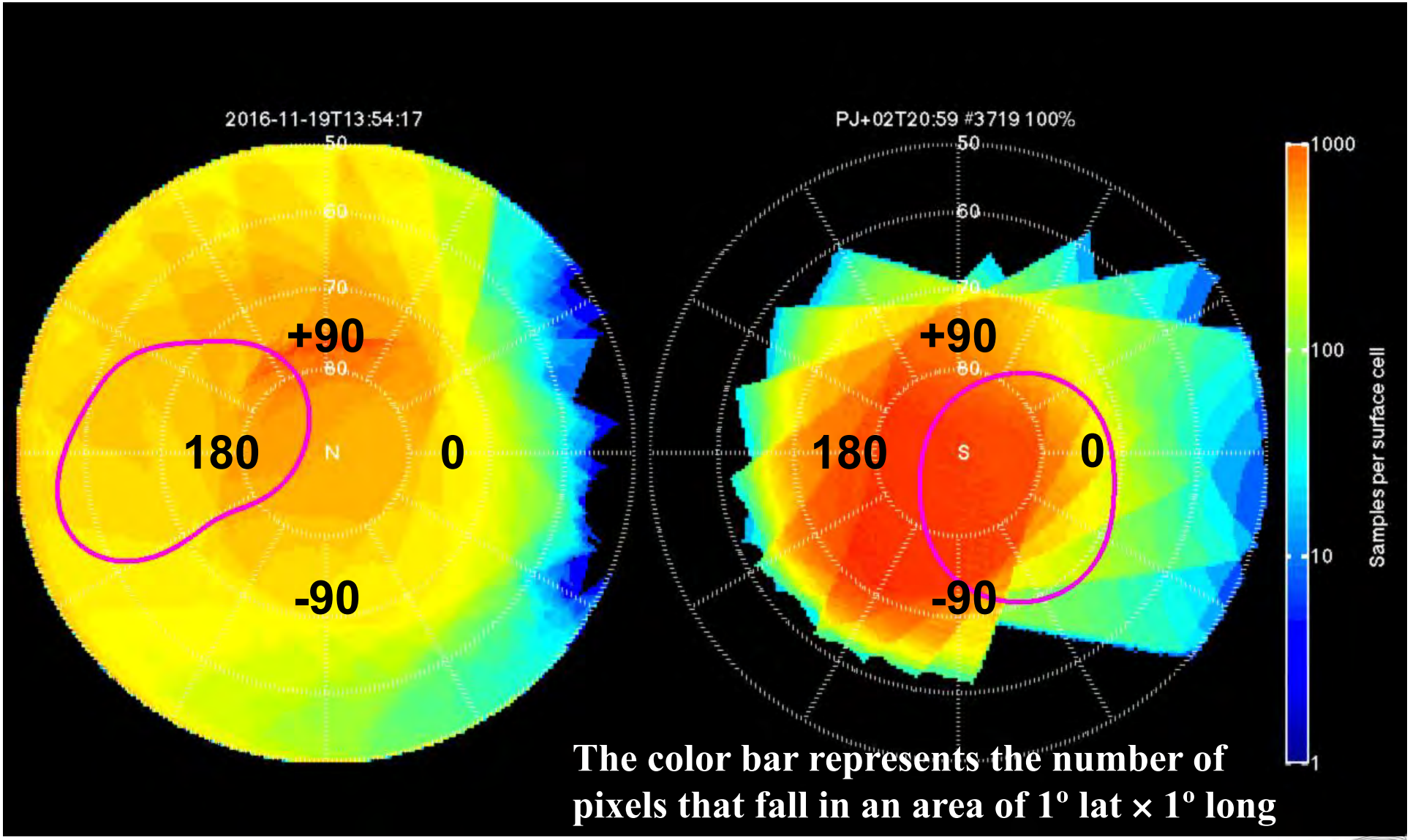
Auroral Mapping During Orbit 4: Imaging Coverage



The color bar represents the number of pixels that fall in an area of 1° lat × 1° long

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Auroral Mapping During Orbit 4: Spectral Coverage

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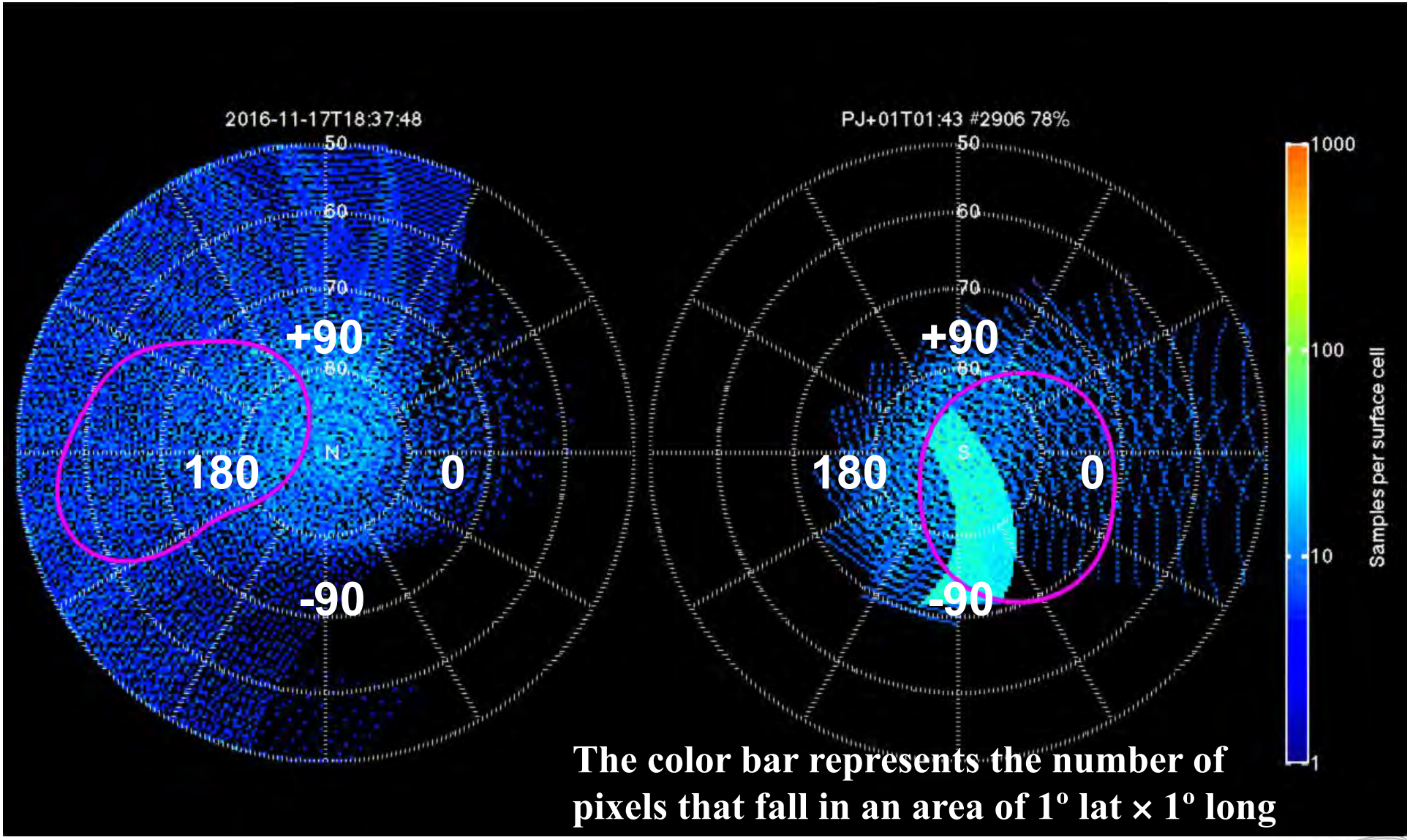
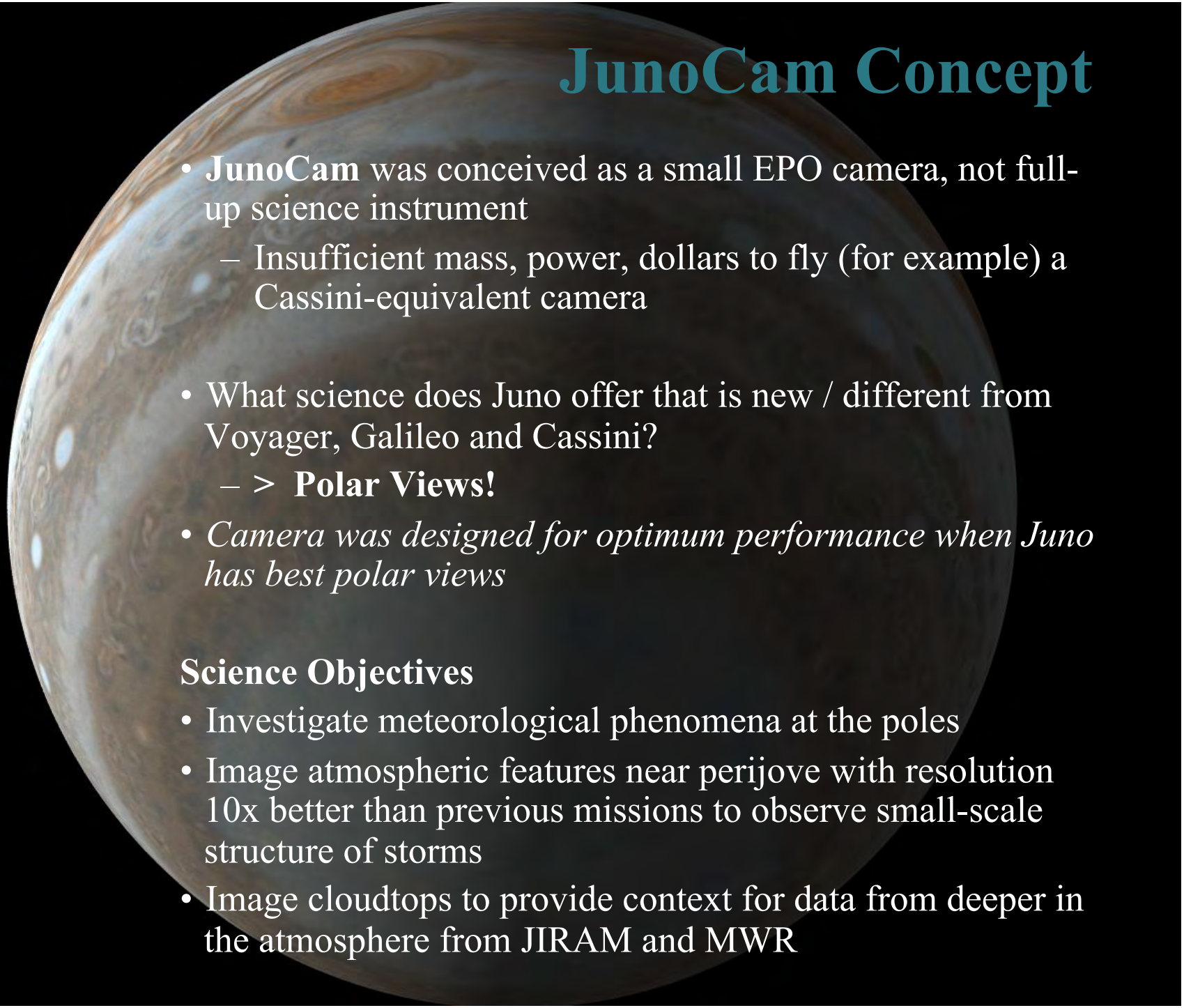


The color bar represents the number of pixels that fall in an area of 1° lat × 1° long



JunoCam Concept

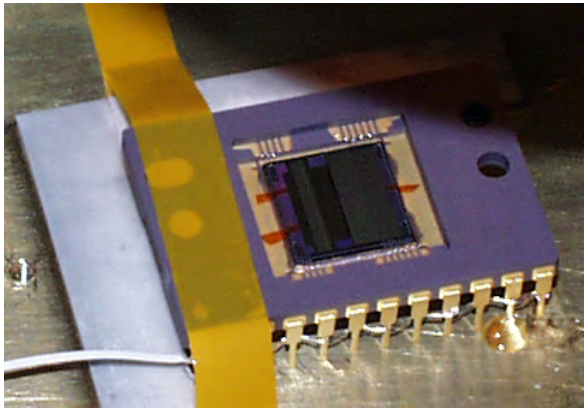
- **JunoCam** was conceived as a small EPO camera, not full-up science instrument
  - Insufficient mass, power, dollars to fly (for example) a Cassini-equivalent camera

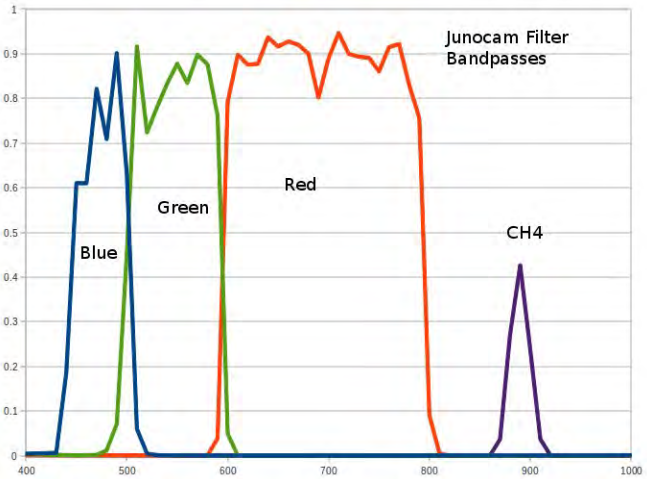
- What science does Juno offer that is new / different from Voyager, Galileo and Cassini?
  - > **Polar Views!**
- *Camera was designed for optimum performance when Juno has best polar views*

Science Objectives

- Investigate meteorological phenomena at the poles
- Image atmospheric features near perijove with resolution 10x better than previous missions to observe small-scale structure of storms
- Image cloudtops to provide context for data from deeper in the atmosphere from JIRAM and MWR

JunoCam Overview





- JunoCam is a fixed-mounted, fixed field of view push-frame visible camera that images in four color bands
  - Blue, green and red
  - Methane band
- Time-delayed integration is used to increase SNR to required levels (actually takes advantage of s/c spin, unlike a framing camera)
- *A JunoCam image is acquired as S/C rotation sweeps the 1600 pixel, 58° wide FOV across Jupiter.* Nominal swath length is 4800 pixels, but depends on actual size of Jupiter.
- JunoCam is a heritage design of the Mars Science Laboratory (MSL) rover Mars Descent Imager (MARDI) with limited modifications, built by Malin Space Science Systems

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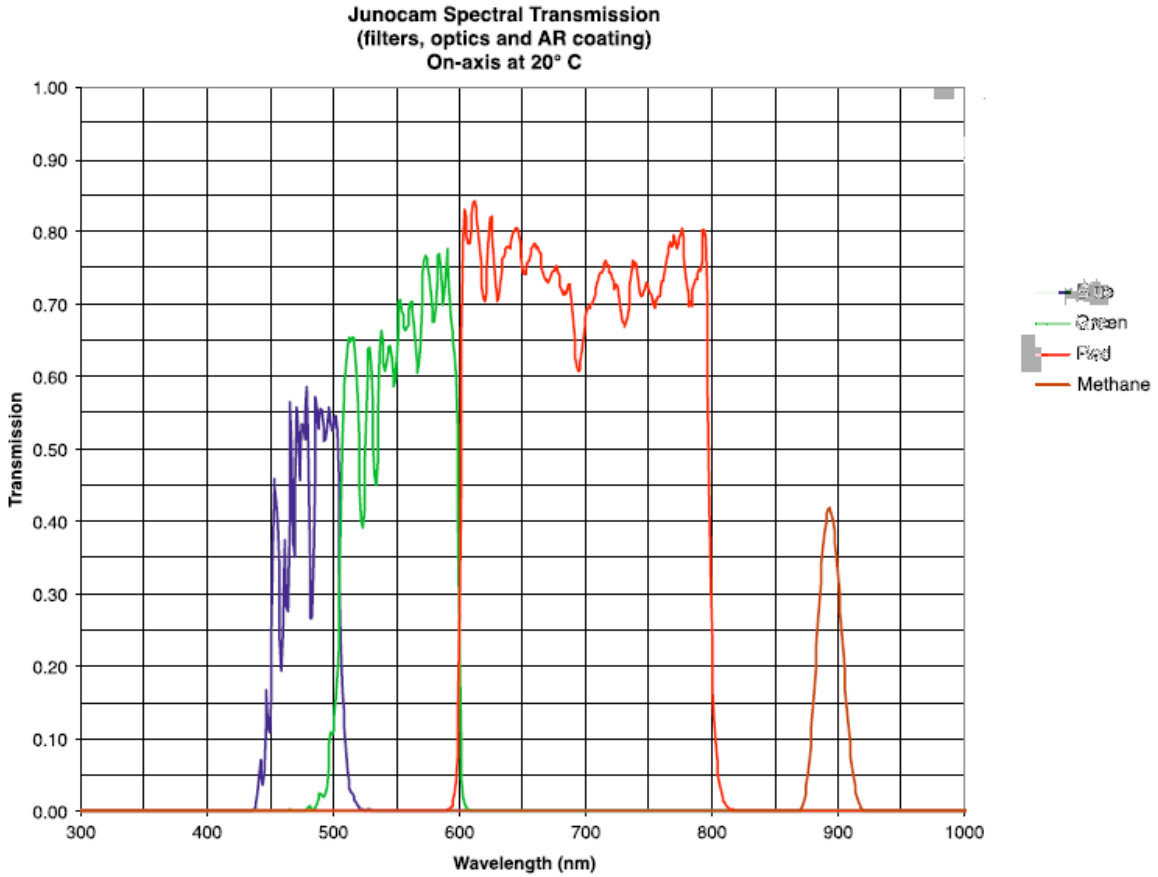
JunoCam Specs

Mass: 2.64 kg (Camera Head)
1.05 kg (Electronics)
Power: 4.7 W Idle
5.9 W Imaging
Size: 97×99×190 mm^3 (Camera Head)
140×224×33 mm^3 (Electronics)

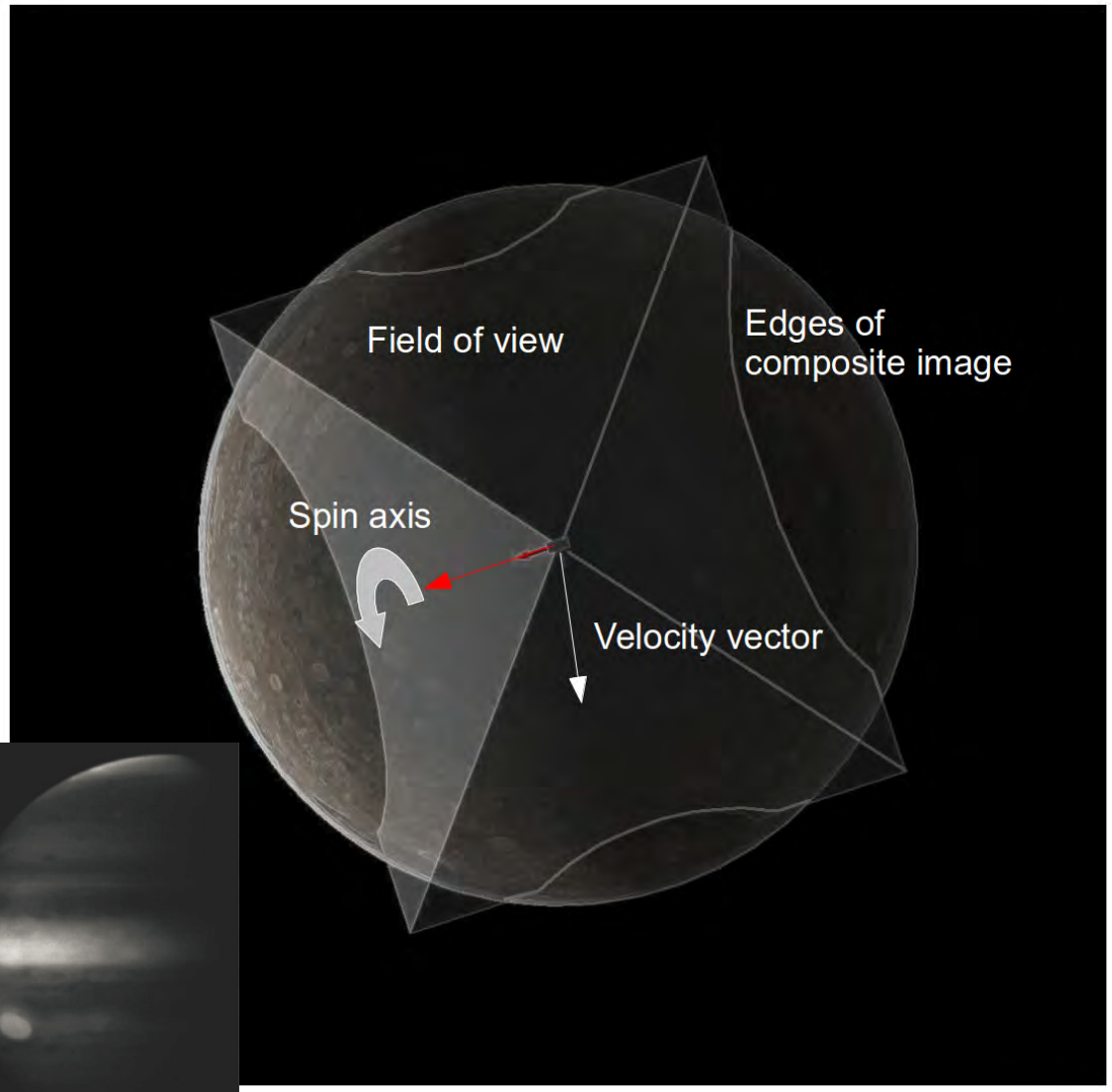
Focal Length: 11 mm
FOV: 58º
Pixel Size: 7.4 µm
IFOV 673 µrad



Filter:	Center Wavelength:	FWHM:
Blue	480.1 nm	45.5 nm
Green	553.5 nm	79.3 nm
Red	698.9 nm	175.4 nm
Methane	893.3 nm	22.7 nm

Jupiter's Aurora

- Every pass we will have the opportunity to image each pole, and the phase angle and orientation of the image is such that we will capture the auroral zone
- Unfortunately the calculated SNR is marginal
- We will acquire images on PJ1 to test our ability to detect the aurora
- Methane band images may indicate areas of auroral soot deposition



Cassini flyby ISS 889 nm image