

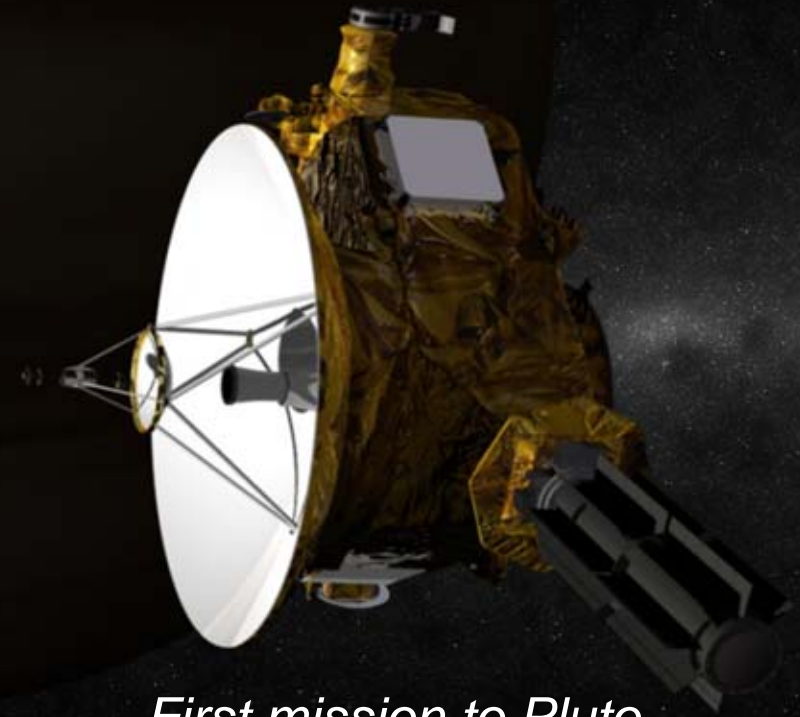


International Workshop on Instrumentation for Planetary Missions



LORRI on the *New Horizons* Mission

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*First mission to Pluto
and the Kuiper Belt*



Presentation Outline



- LORRI design and features
- LORRI at Jupiter
- LORRI in-flight tests
 - Instrument is 100% nominal
 - Added capability
- Some lessons

Cheng AF et al. Space Science Reviews, 140:189-215 (2008)
Conard SJ et al. SPIE 5906, 5906 1D (2005)



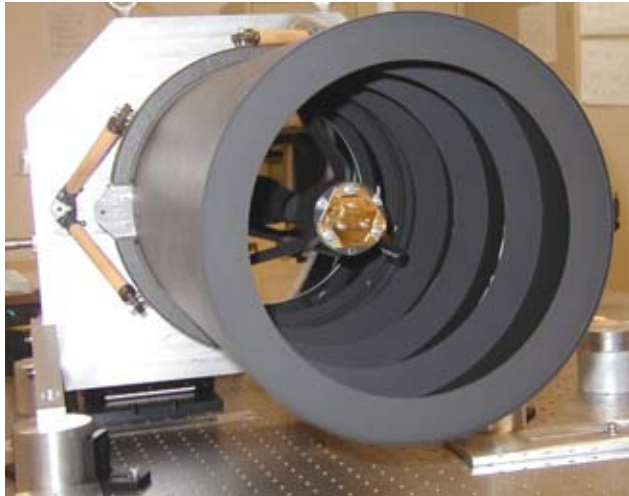
New Horizons launch 2006 January 19



- Nearly perfect trajectory
- Fastest Earth departure ever
(36,000 miles per hour)
- Passed Moon's orbit in 9 hours
- Pass orbits of:
 - Mars on 4/7/2006
 - Jupiter on 2/28/2007
 - Saturn on 6/8/2008
 - Uranus on 3/18/2011
 - Neptune on 8/24/2014
- Pluto system encounter on 7/14/2015



LORRI on *New Horizons*



On the Lab Bench



On the Spacecraft

LVPS



EPU



IM I/O



Three
LORRI
electronics
boards
(center) and
focal plane
unit (above)



LORRI Vital Statistics and Features



Visible Panchromatic Imager

SiC, Ritchey-Chretien Telescope

Aperture 208 mm

Focal Length 2630 mm

Field-of-view $0.29^\circ \times 0.29^\circ$

Instantaneous field-of-view $4.95 \mu\text{rad}$

Passband $0.35 - 0.85 \mu\text{m}$

Back-thinned, frame transfer CCD

Image format 1024×1028 (4 dark)

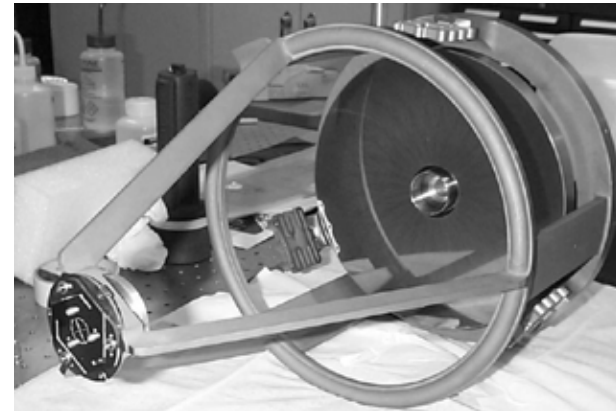
On-chip 4×4 pixel binning available

Exposure times 1 ms to 30 sec

CCD $< -70^\circ\text{C}$, passively cooled

ADC 12 bit

Data interfaces LVDS and RS-422



Optical telescope mass 5.6 kg

Electrical Power 5 W

Heater Power 10 W

Focal plane **calibration lamps** (two)

Embedded **image header** (first 34 px)

32-bin **image histogram**

Autoexposure

Trigger mode

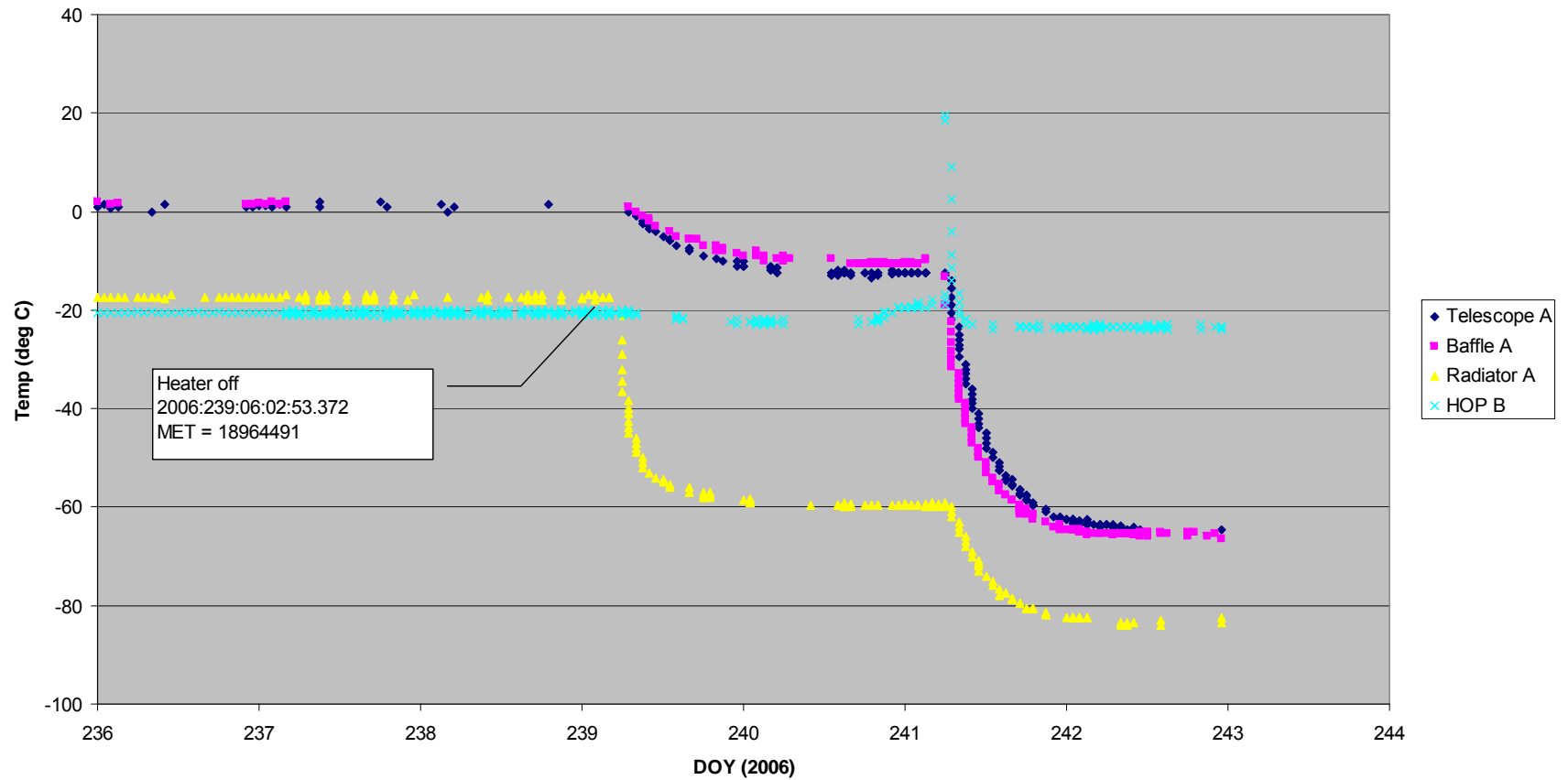


Engineering Performance Trending



Example: Temperatures at Door Opening

LORRI Temperatures (60min Averages)





An Early Oops



- **PFR 186 LORRI Constraint Violation**

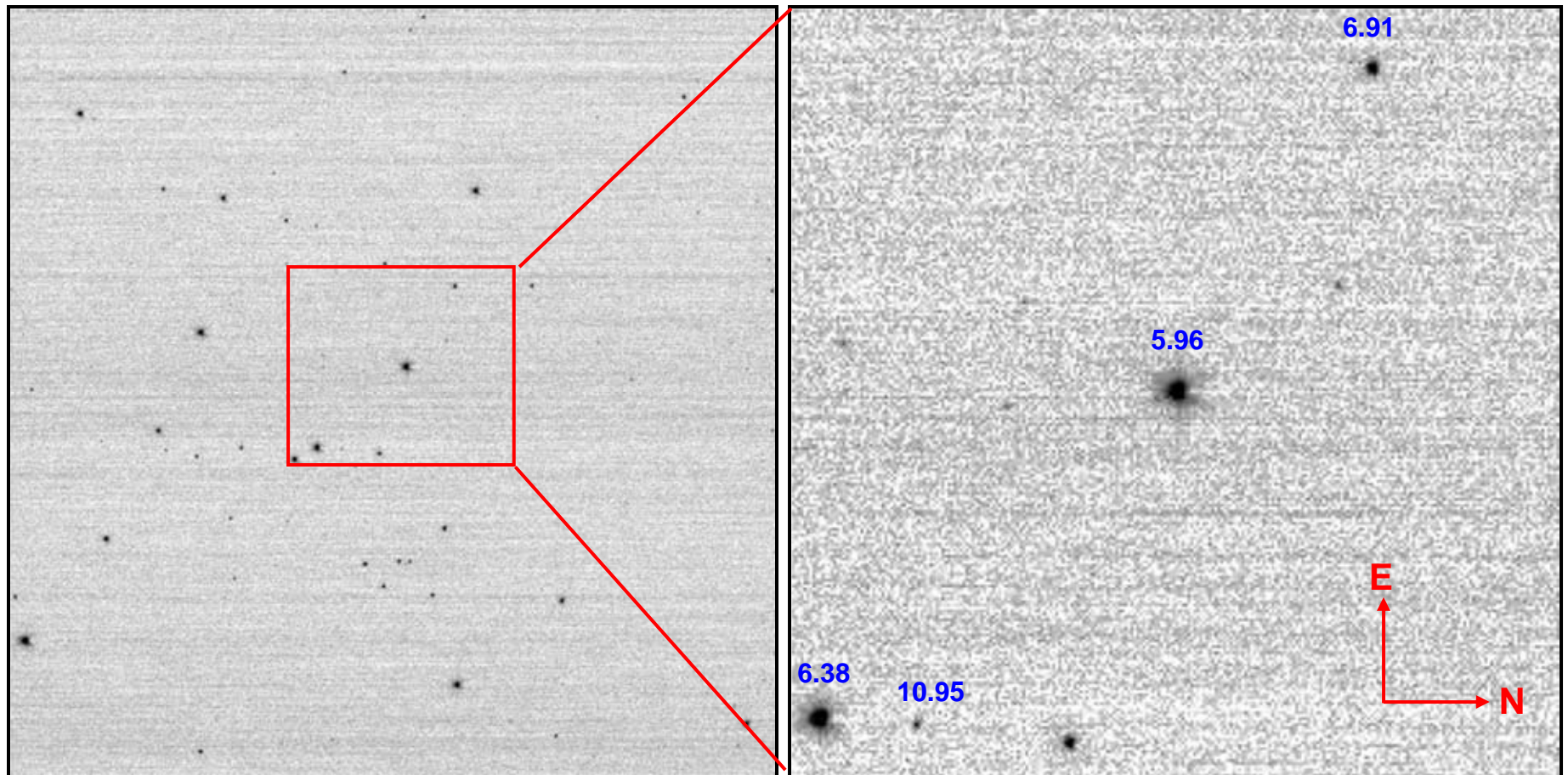
- Upgraded from AR 257 on earlier page
- Description: On 9/4/2006, the LORRI boresight was slewed across the sun, which was focused on the CCD for ~5 seconds at a distance of 3.45 AU.
- Root Cause: Insufficient constraint checking in sequence load
- Disposition:
 - Ground testing suggested there should be no CCD damage, but there was still concern because the conditions in flight are different than during ground testing, and there is also the possibility of contamination movement.
 - Subsequent in-flight testing verified no detectable damage or loss of efficiency to the CCD.
 - NH has now implemented an automated constraint checking method, in addition to the previous manual checking; this should prevent future LORRI constraint violations
- Status: Closed



LORRI First Light : 2006 Aug 29



Messier 7 = NGC 6475, Open Star Cluster, 100ms exp



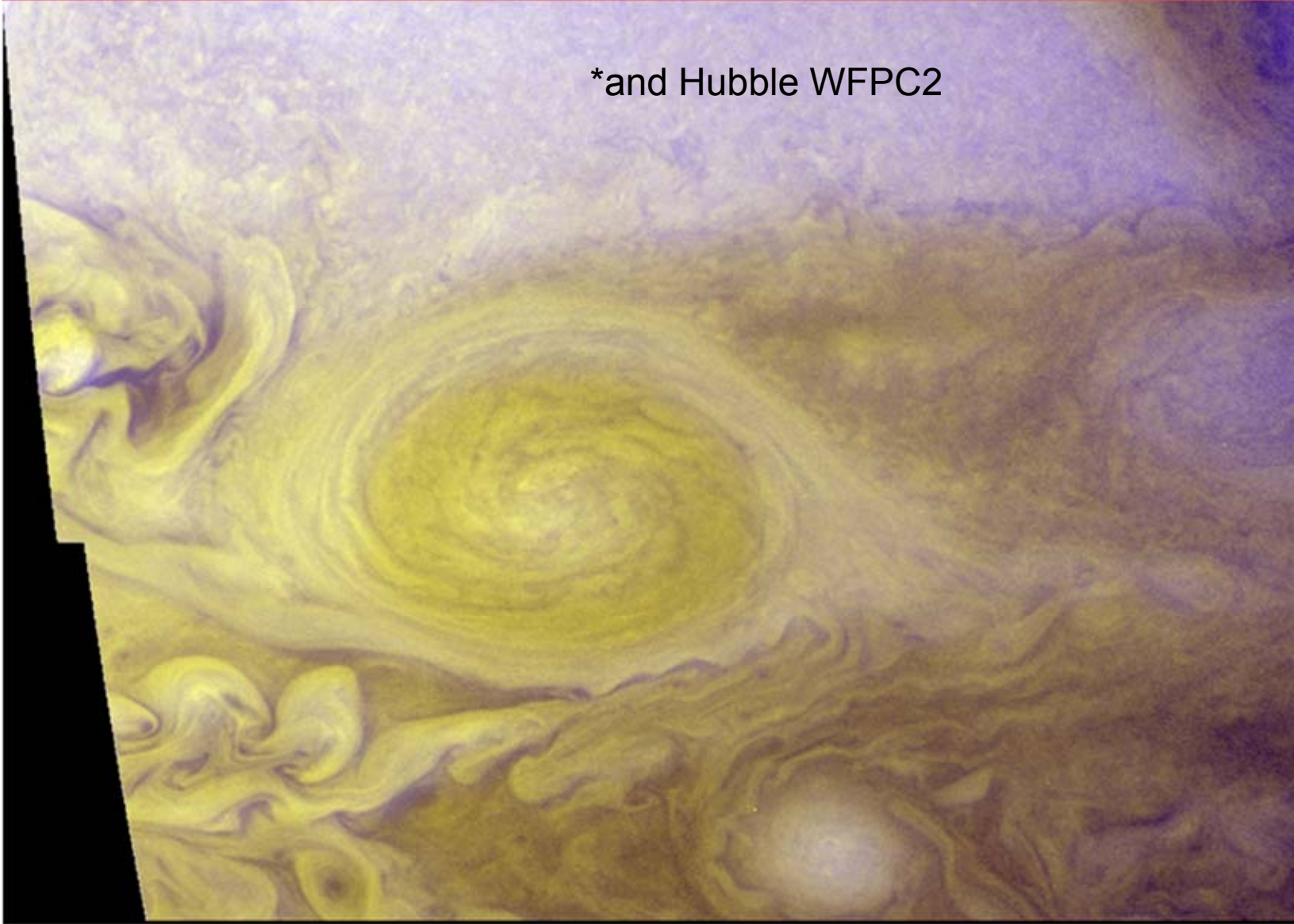
$FOV=5.074 \text{ mrad}=0.2907^\circ$, $IFOV=4.955 \mu\text{rad}=1.022''$, $V = -2.5 \log S + 18.94$



LORRI* at Jupiter: Little Red Spot



*and Hubble WFPC2

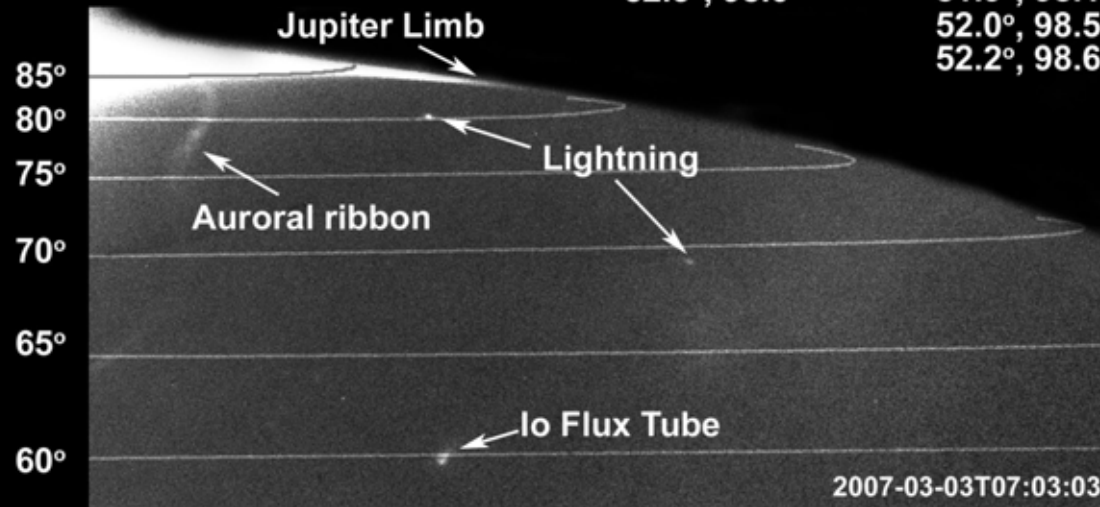




LORRI at Jupiter: Lightning



Cleaned Image



Lightning Strike Sequence

7:06:03



52.3°, 98.0°

7:06:08



51.9°, 98.1°
52.0°, 98.5°
52.2°, 98.6°



80.4°, 123.5°



79.6°, 208.5°



69.7°, 121.4°



-66.0°, 190.0°



-68.9°, 222.6°

Examples of Polar Lightning Strikes



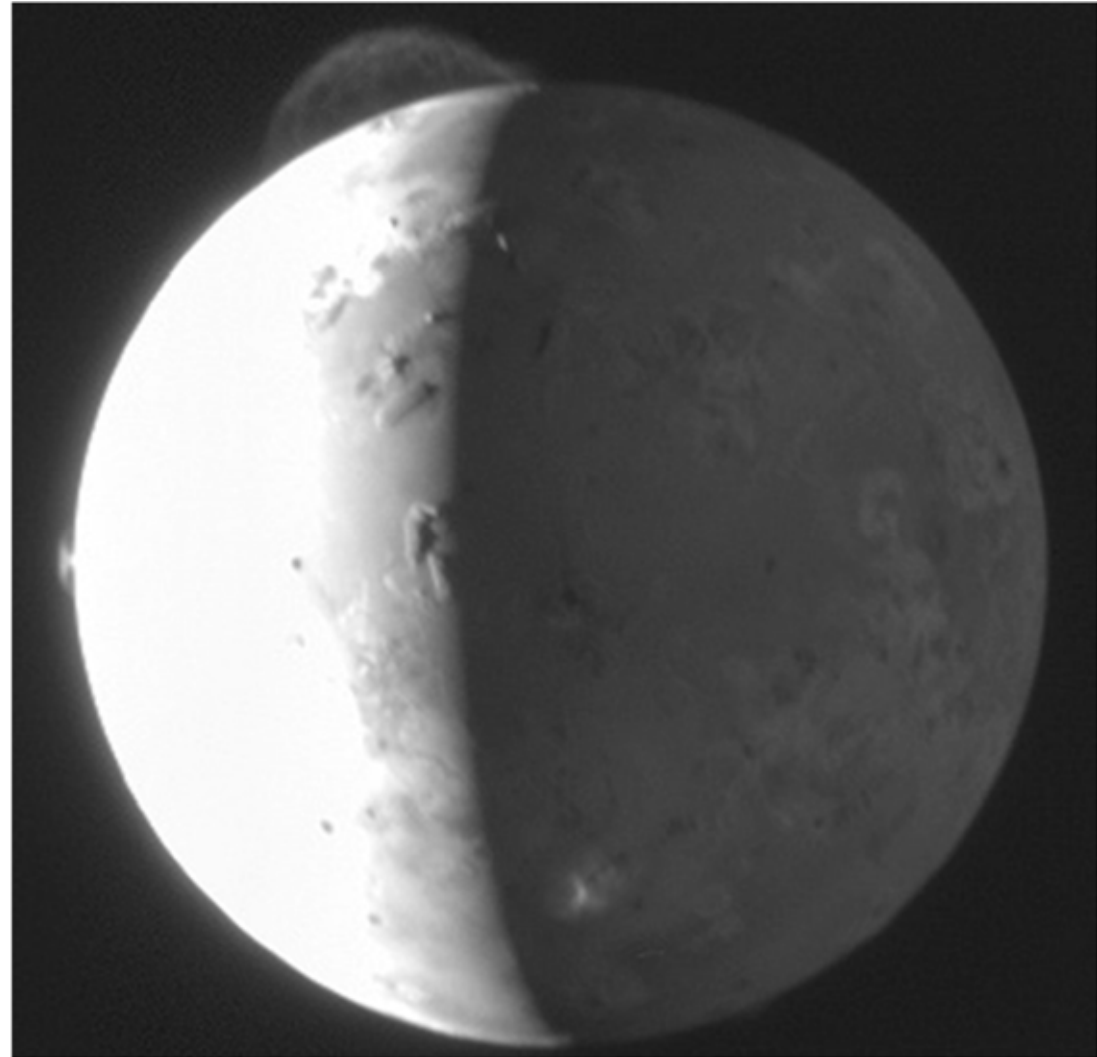
LORRI at Jupiter: Io volcanos



Best ever view of
non-terrestrial
volcano (Tvashtar)

320-360 km high
plume

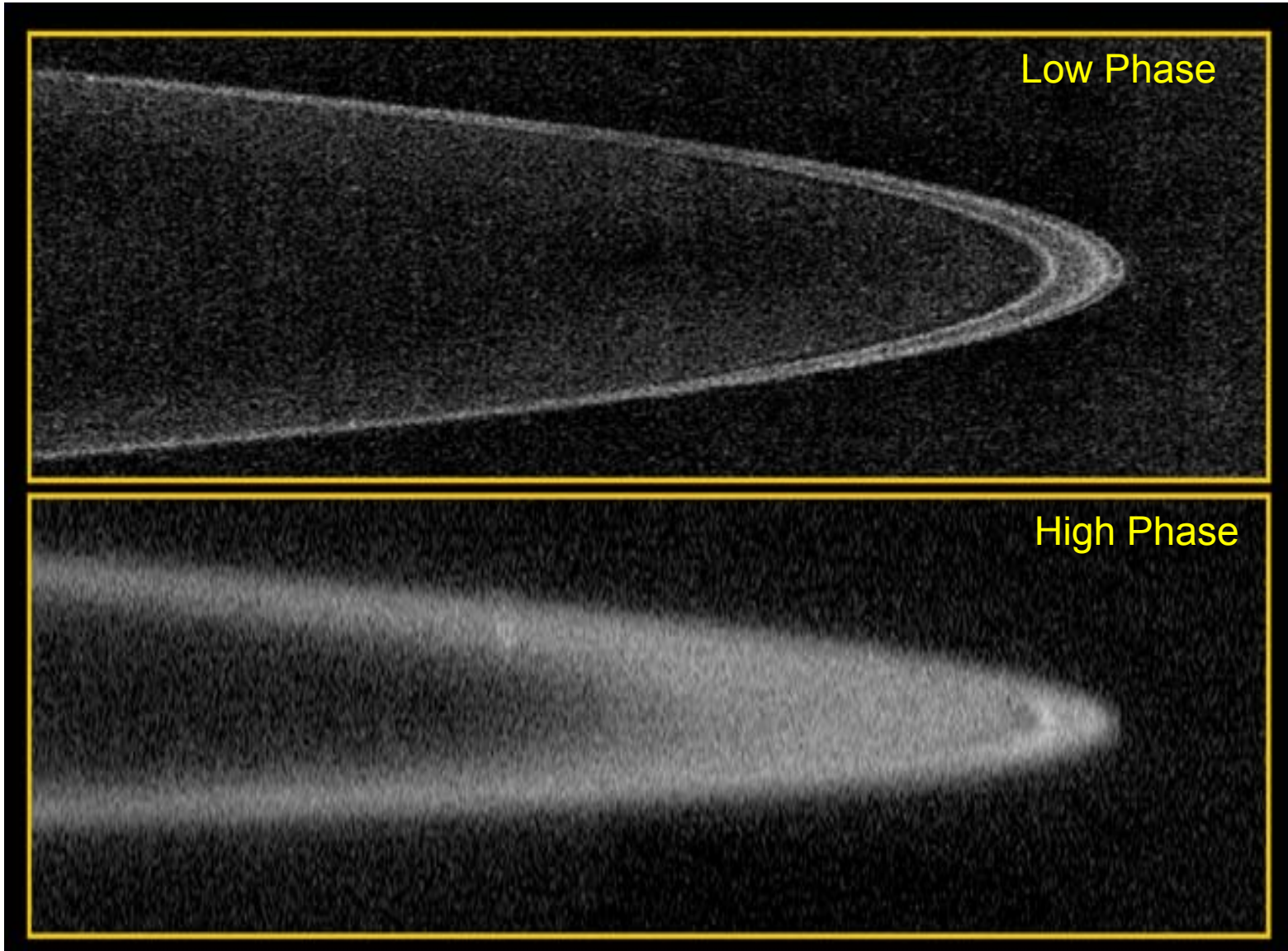
Io plume movie

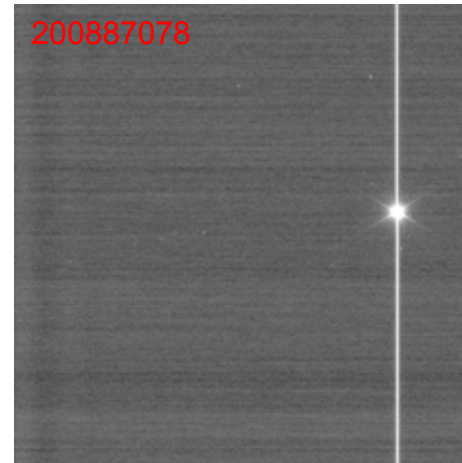
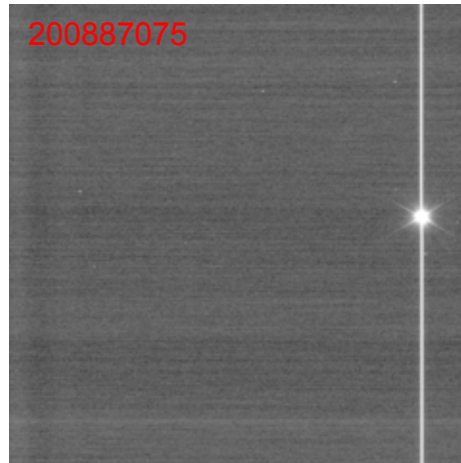
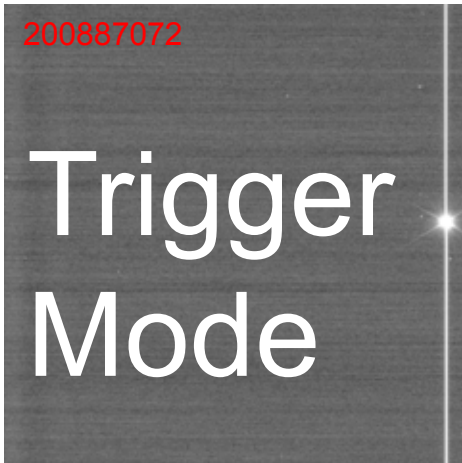


A single exposure – not a composite

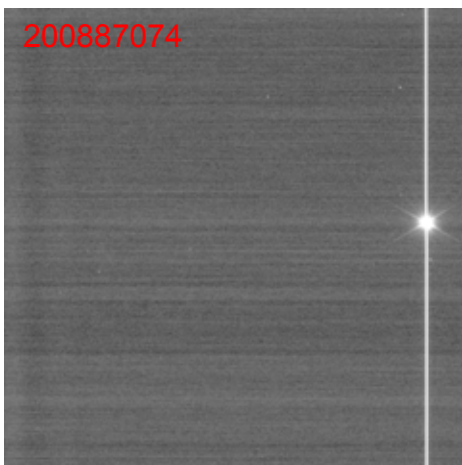
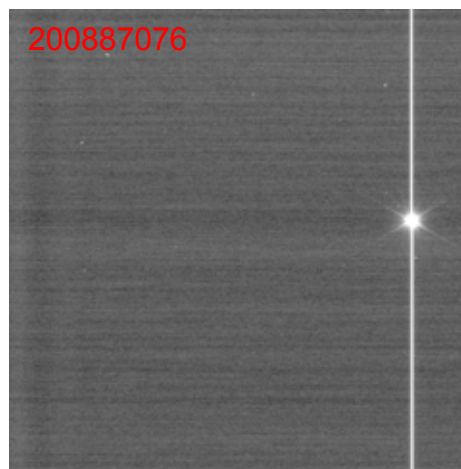
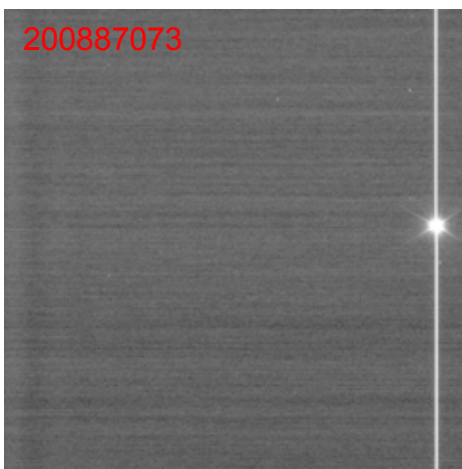


Jupiter's Tenuous Rings

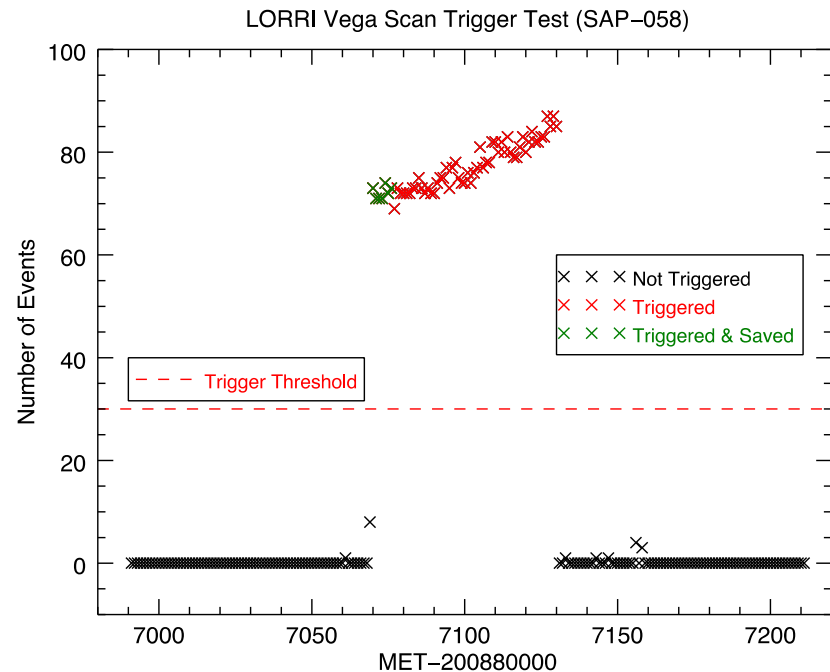




Images taken during a scan across the bright star Vega are displayed using an asinh intensity stretch from 530–600 DN. Images are in time order, top to bottom, left to right (i.e., first image is upper left). Vega enters from the right and moves to the left.



LORRI was in trigger mode, 1x1 format, $t_{exp}=50\text{ms}$. Image taking was set to trigger when ≥ 30 pixels had $\text{DN} \geq 1664$ (sum of bins 14–32 in image histogram). The #pixels in bins 14–32 as a function of time is plotted below; trigger occurred at MET=200887071.





Sensitivity



- Star field containing Pluto
- Pluto circled in red
- Composite of 5 images with 10 sec exposure each
- Limiting magnitude here $V \sim 18$



Lessons



- SiC telescope late but within budget
- Schedule conflict with optical calibration facility at APL
 - Used GSFC DGEF
- Importance of communication
- How to enforce realism of personnel scheduling?
- How can we avoid working key people too hard?