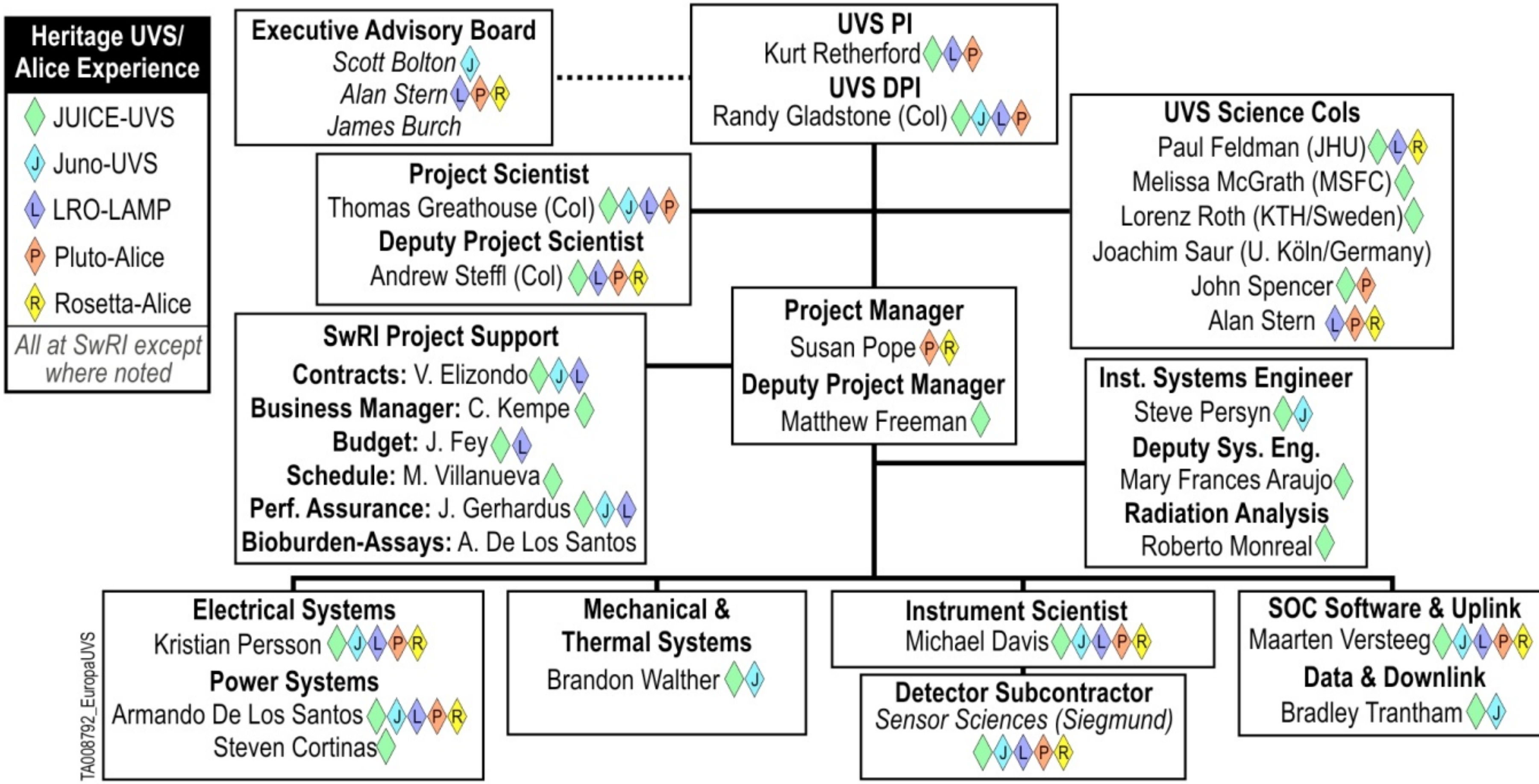
EUROPA-UVS

PI Kurt Retherford (SwRI)

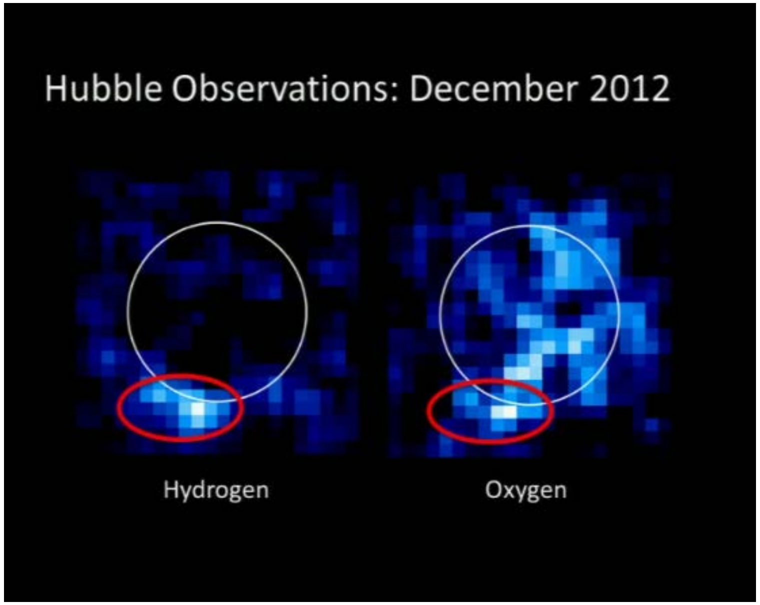
Europa-UVS Team



Instrument Engineer:
Laura Jones (JPL)
Investigation Scientist:
Scott Edgington (JPL)

Europa-UVS: Science Objectives

- **Selected as the mission "Plume Hunter"**
- **Europa-UVS Objectives**
  - **Determine the composition & chemistry, source & sinks, and structure & variability of Europa's atmosphere, from equator to pole.**
  - **Search for and characterize active plumes in terms of global distribution, structure, composition, and variability.**
  - **Explore the surface composition & microphysics and their relation to endogenic & exogenic processes.**
  - **Investigate how energy and mass flow in the Europa atmosphere, neutral cloud & plasma torus, and footprint on Jupiter.**

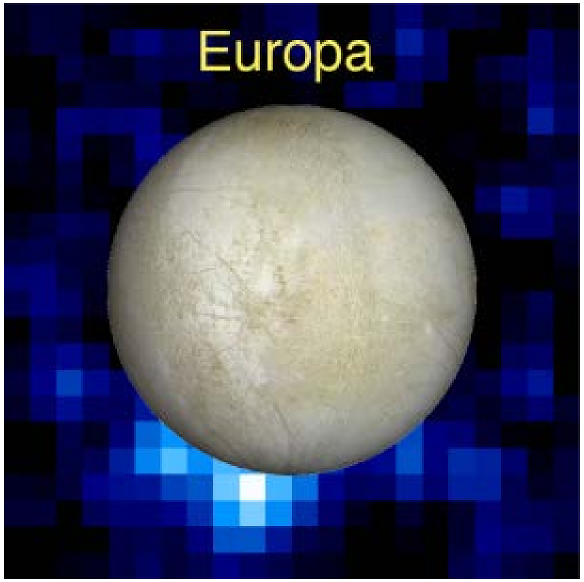


Europa-UVS: Science Goals Trace

1. **Europa Atmosphere:** Understand Europa's atmosphere and its exchanges with the surface/sub-surface (to reveal composition and chemistry)
   - Key: Decadal Survey (DS) #3; Supporting: DS #2 & #5
2. **Europa Plumes:** Determine regions of current activity and the nature of subsurface water reservoirs (future exploration sites)
   - Key: DS #4 & AO PEA+; Supporting: DS #3, #2, #5, & #1
3. **Europa Surface:** Relate surface composition, chemistry, and maturity to geological provenance
   - Supporting DS: #3, #4, and PEA+
4. **Europa Plasma Environment:** Investigate connections which transport mass and energy between Europa, its space environment, and Jupiter's magnetosphere
   - Key: DS #5

Europa-UVS Techniques

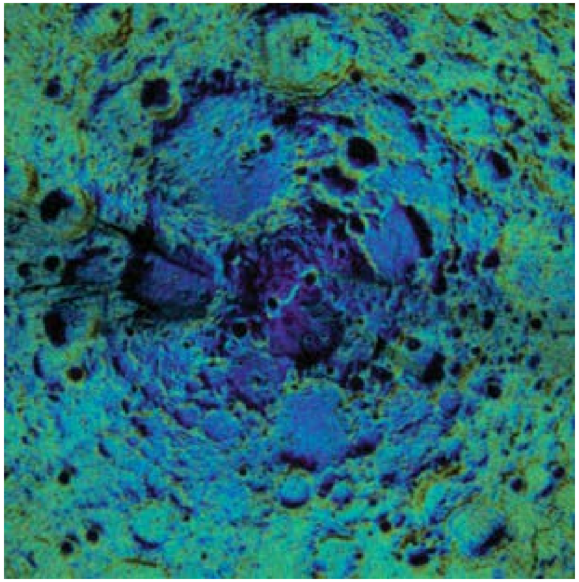
1) UV Emissions



HST-STIS observation of H aurora diagnostic of water vapor plumes

Aurora & Airglow

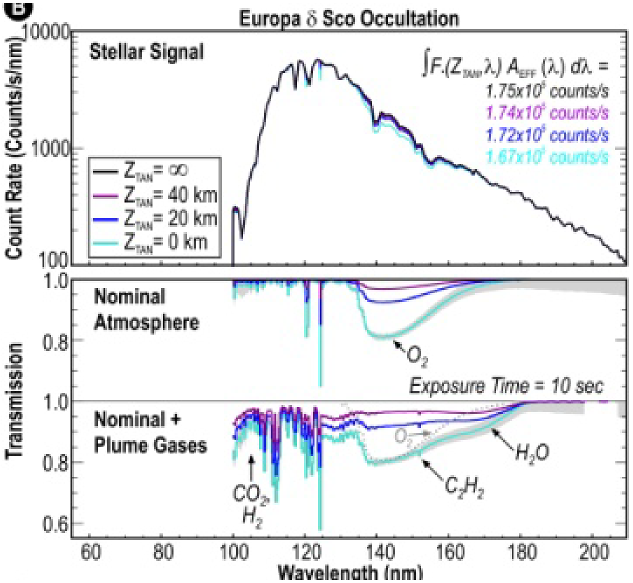
2) UV Reflections



LRO-LAMP observation of reflected solar Lyα from the Moon's north polar region

Surface Albedos

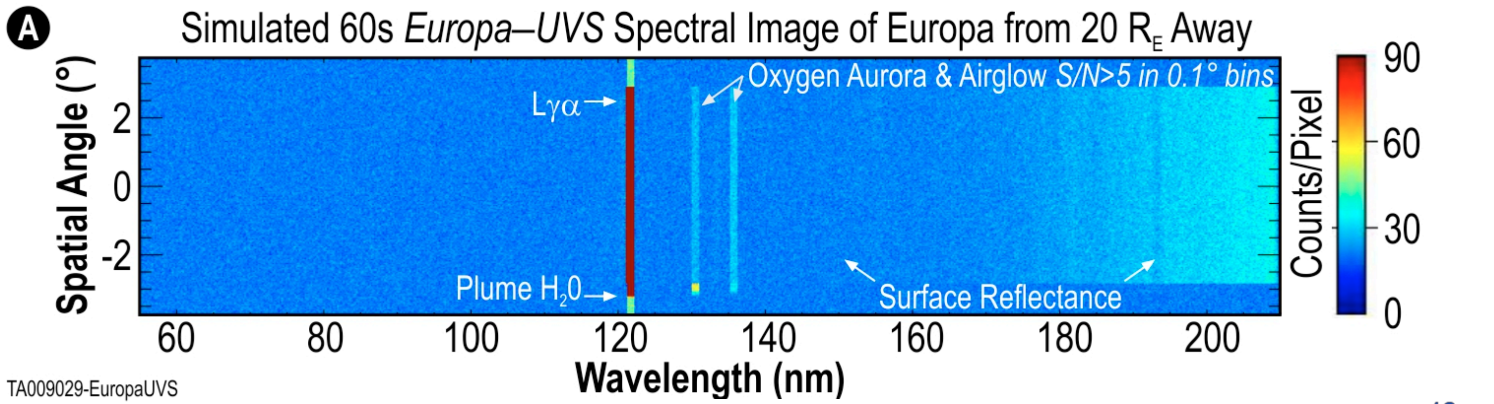
3) UV Transmissions

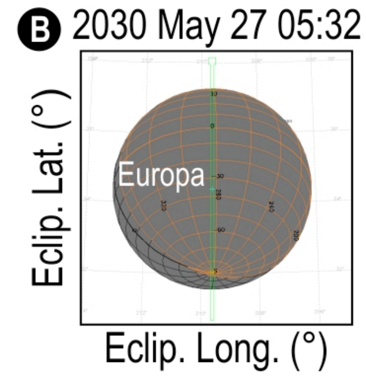


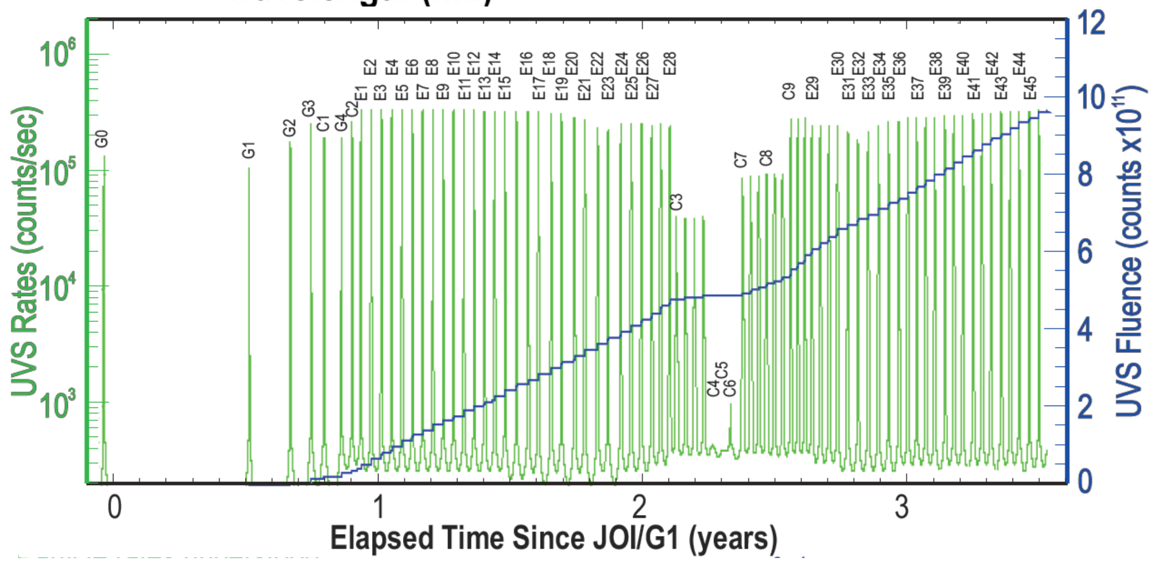
Simulated Europa-UVS observation of a stellar occultation by Europa

Stellar & Solar Occultations

Europa-UVS Estimated Count Rates

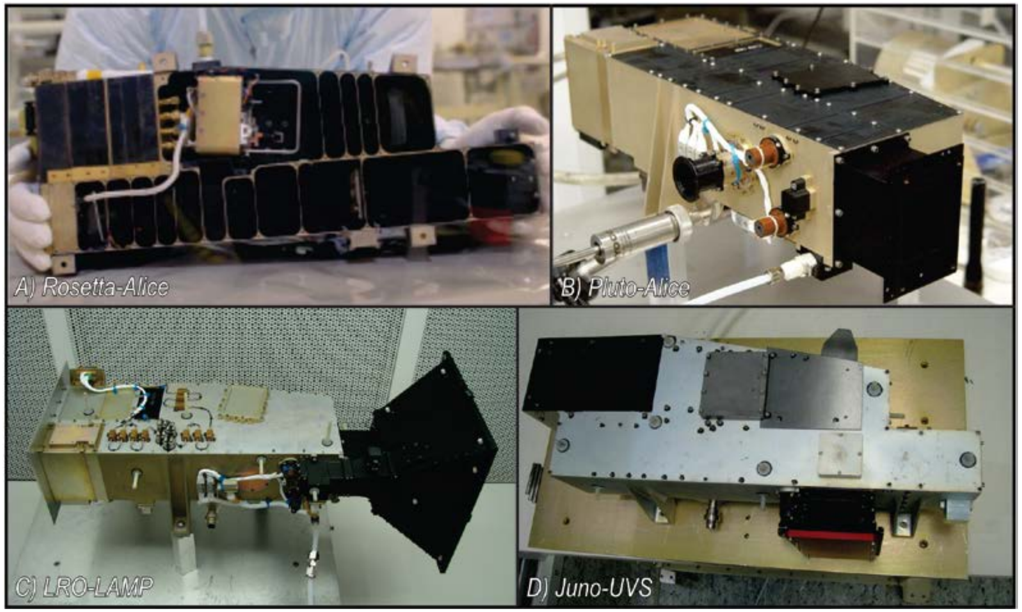


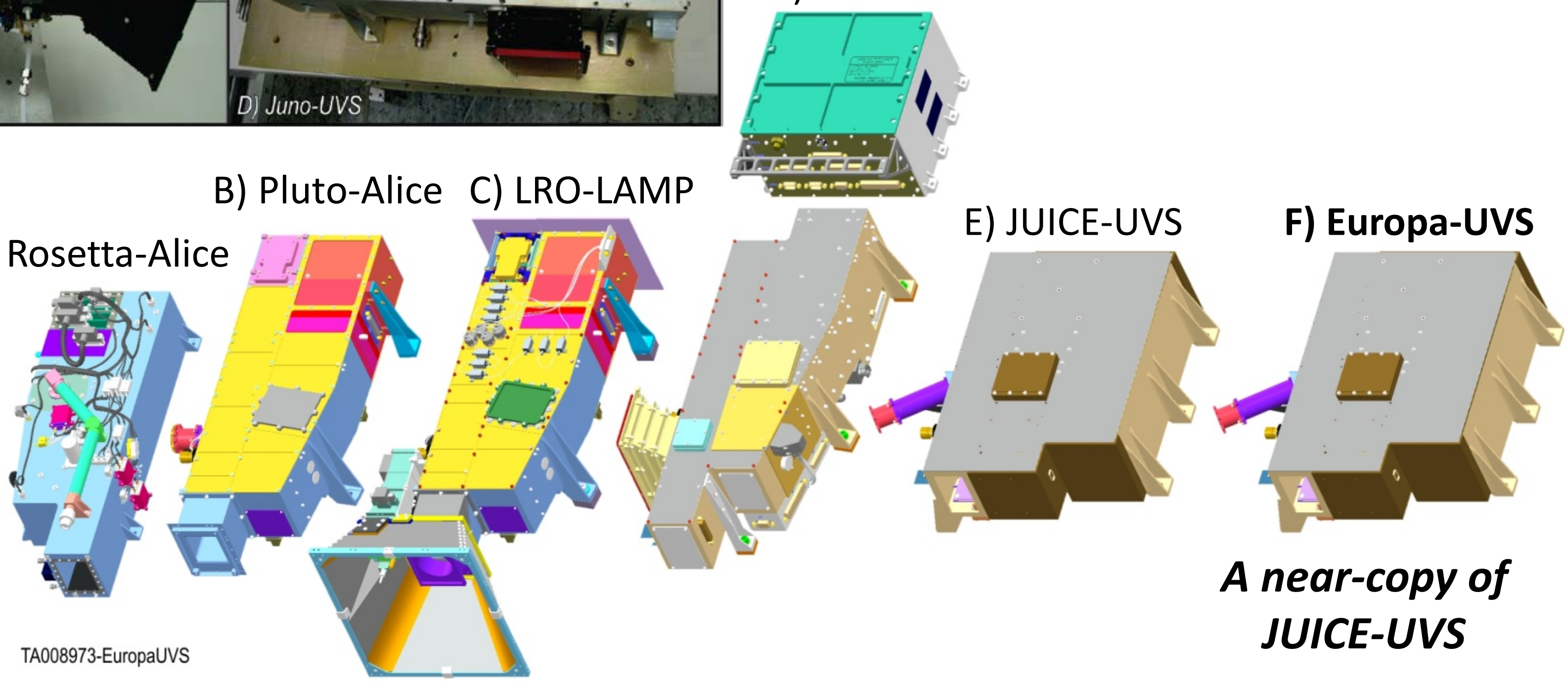




- **Top:** Expected Europa-UVS count rates during a typical Europa flyby, with *excellent signal-to-noise even with high background rates*
- **Bottom:** Expected background count rates and total fluence from penetrating electrons, throughout the mission

Europa-UVS Heritage



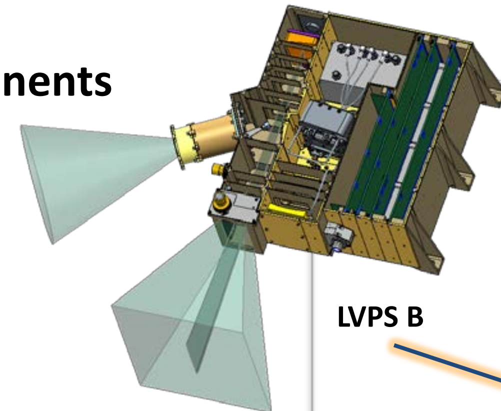


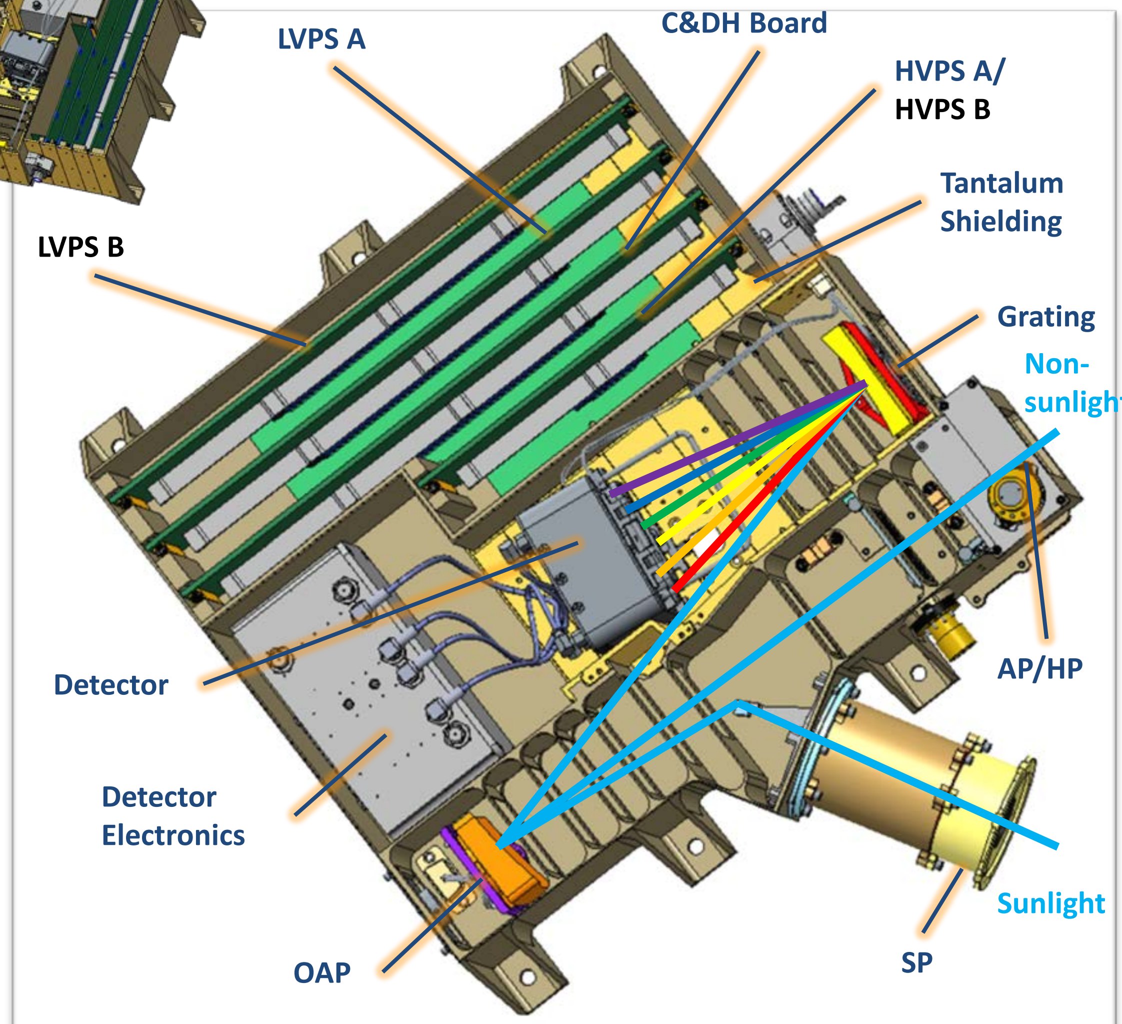
A near-copy of JUICE-UVS

Current Configuration

Instrument Components

- Housing
  - Al Structure
  - Doors
  - TaW Shielding
- Apertures
  - Airglow Port (AP)
  - High-spatial-resolution Port (HP)
  - Solar Port (SP)
- Optics
  - Off-axis Paraboloid (OAP) Mirror
  - Solar pickoff mirror
  - Grating
  - Slit
- MCP XDL Detector Assembly
- Electronics
  - Detector
  - Command & Data Handling (C&DH)
  - Low Voltage Power Supply (LVPS A&B)
  - High Voltage Power Supply (HVPS A&B)

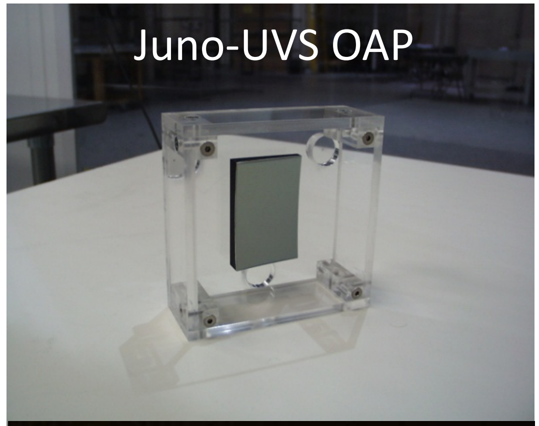




Europa-UVS Key Components

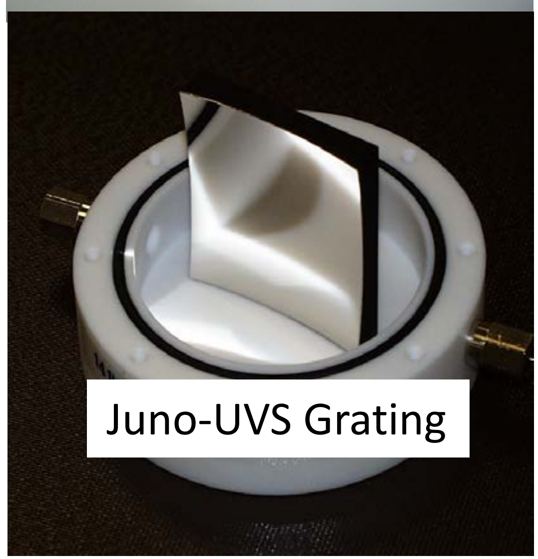
OAP Mirror:

- **41 mm × 65 mm**
- **120 mm focal length**
- **Al/MgF_2 coating**



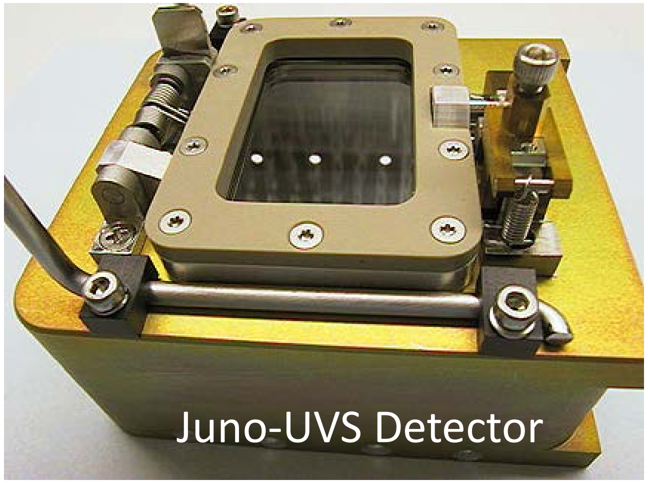
Grating:

- **50 mm × 50 mm**
- **1600 gr/mm toroid**
- **Al/MgF_2 coating**



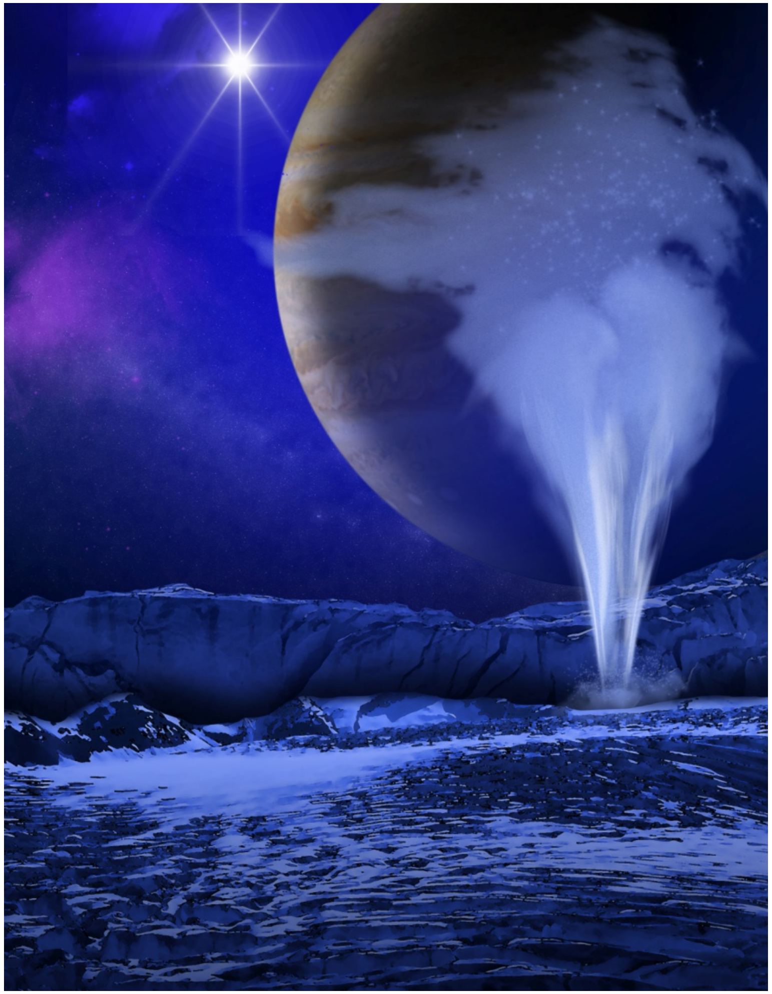
MCP Detector:

- **XDL (Cross delay-line)**
- **CsI photocathode**
- **ALD & Borosilicate glass plates, as on JUICE-UVS**



Europa-UVS Specs

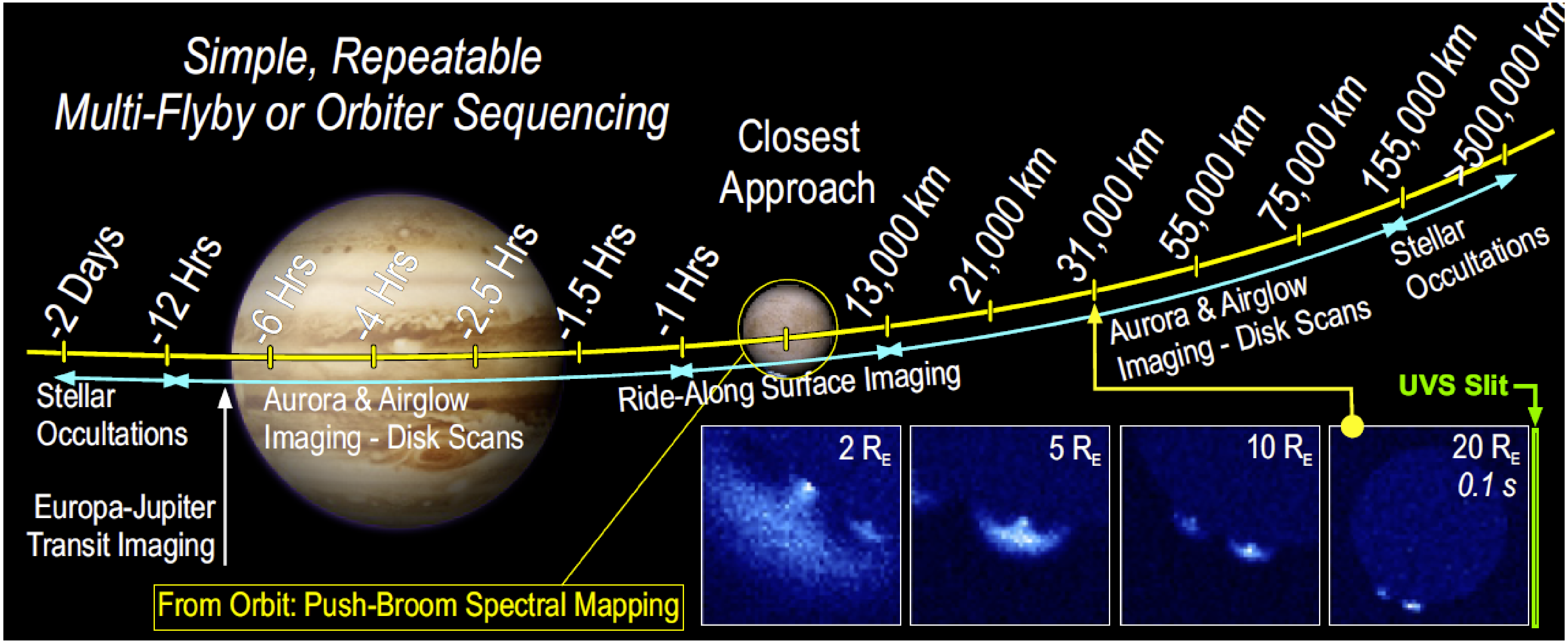
Mass (CBE+cont.):	6.43 kg plus 11.1 kg shielding = 17.5 kg
Power (CBE+cont.):	9.7 W
Dimensions:	34.6 cm x 38.2 cm x 14.5 cm
Spectral Range:	55-210 nm
Spectral Resolution:	<0.6 nm (point source), <1.2 nm (extended source); resolving power $\lambda/\Delta\lambda$=220
Spatial Resolution:	0.16° (AP), 0.04° (HP); Nyquist sampled
Field of View:	0.1° x 7.3° + 0.2° x 0.2° (7.5° full length)
Effective Area:	0.6 cm^2 @ 125 nm
Telescope / Spectrograph:	Off-axis Primary / Rowland circle mount
Detector Type:	2D MCP (solar blind), CsI photocathode, cross-delay-line (XDL) readout, 2048 spectral x 512 spatial x 256 PHD
Radiation Mitigation:	Contiguous High-Z shielding (4π sr @ detector and electronics)



The JUICE-UVS Phase B effort is maturing our baseline Europa-UVS design, with IPDR planned for 2016 Mar./Apr.

Europa-UVS Operations Approach

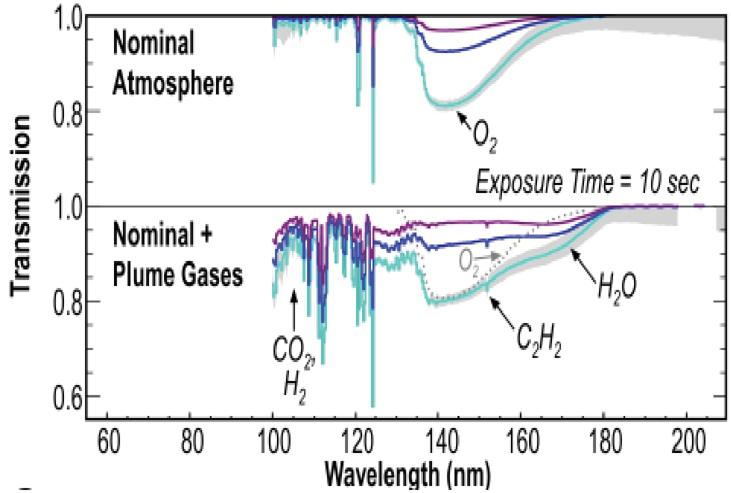
UVS's approach to ops and sequencing is very flexible and we strive to not drive the S/C design



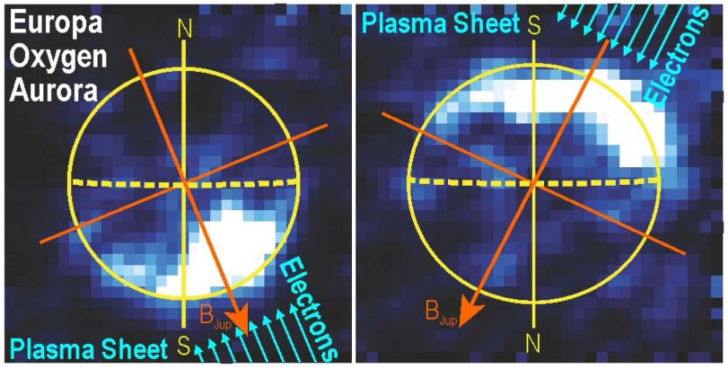
Direct observation of UV emissions from Europa aurora, airglow, surface albedo, and other Jovian system atmospheres, and atmospheric absorption measurements via stellar and attenuated solar occultation

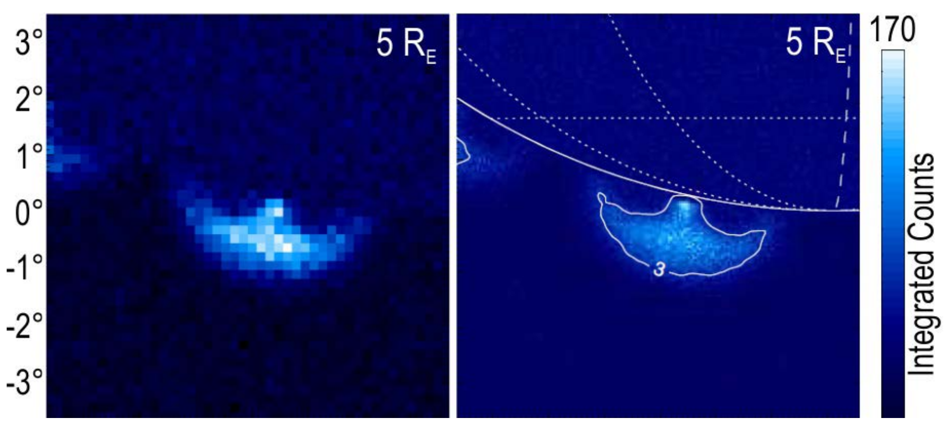
Multi-faceted for spatial and spectral imaging

Atmosphere & Plume Composition from UV Spectra

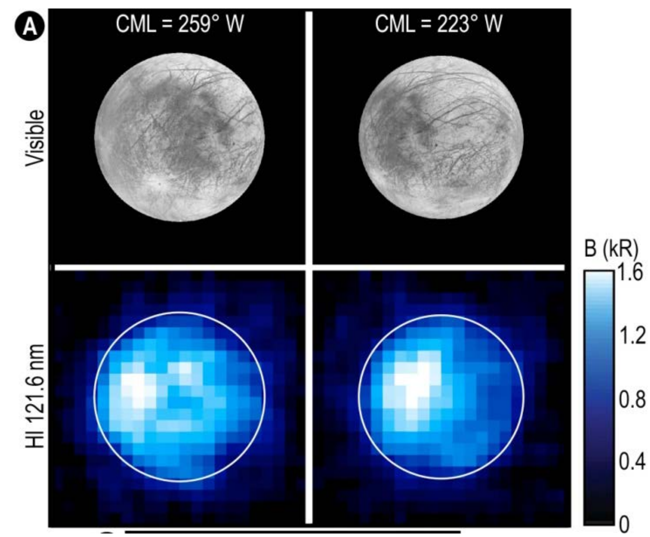


Plasma Environment from Oxygen Emission





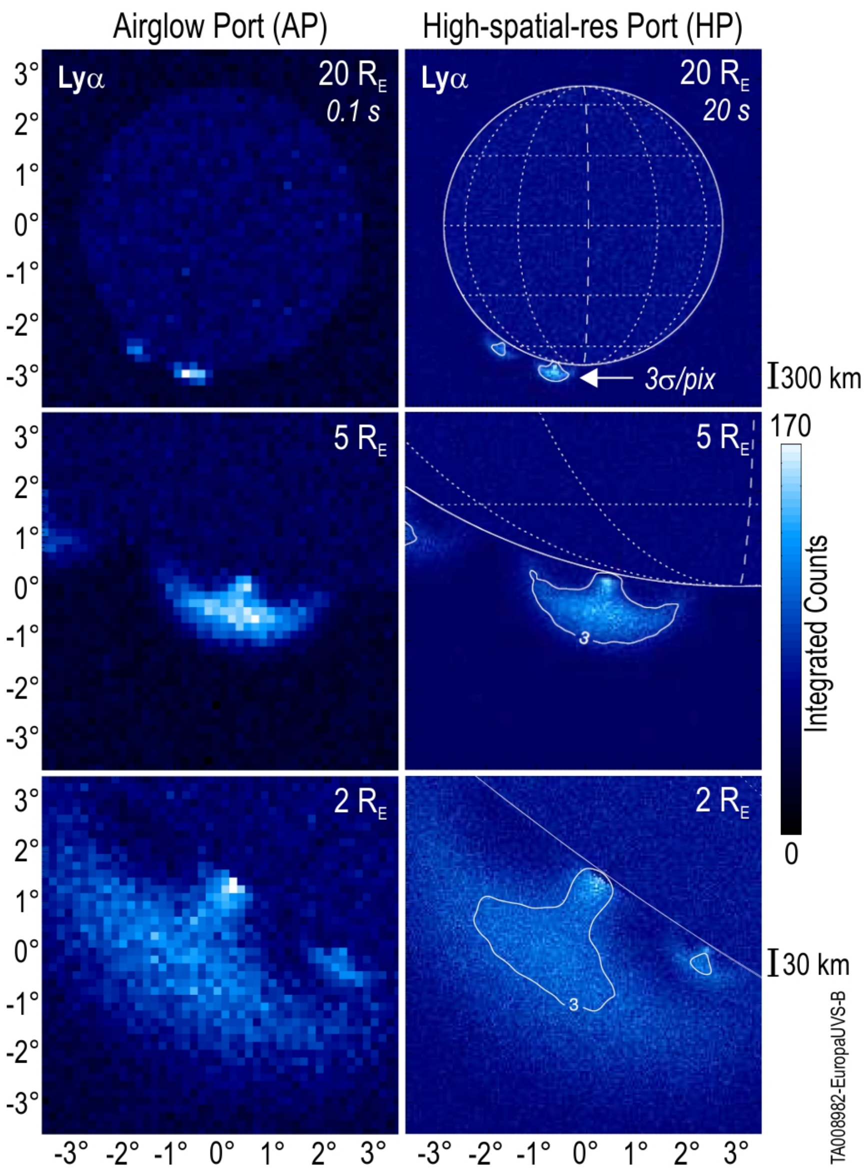
Plume Detection and Density
(low and high resolution modes illustrated)



Surface Structure & Composition
from scattering of Ly-α

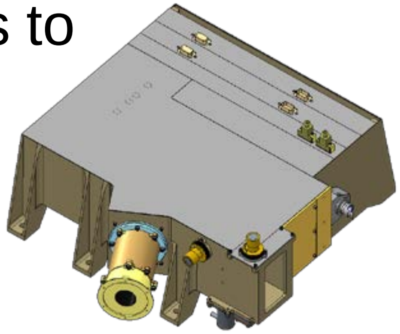
Scans Provide Plume Images, Searches

- When at 20 R_E a 7.5° one-axis scan is all that is needed to provide the global view *at top*
  - Even smaller angular scans when at greater distance
  - Assuming a ~0.05°/s rate (e.g., as for LRO) the whole observation fits within ~5 min.
- Nadir pointed push-broom style observations within ±1 hr from C/A obtains great image quality
  - Won't target limb at C/A, *as shown at middle & bottom*, but not a problem
- Stellar occultations from >66,000 km still target Europa within ~2°
  - No crazy slews are needed for UVS
  - Inertial pointing should be easier than base-body tracking



Europa-UVS Summary

- UVS addresses key science goals regarding Europa's composition and surface chemistry
- UVS contributes unique plume searching capabilities to the Europa mission
  - Same UV technique used by Hubble to discover plumes
  - Stellar & Solar occultations, as for Enceladus plumes



- UVS's simple & repetitive approach to modest non-nadir operations minimizes costs
- UVS's family of heritage Rosetta, New Horizons, Lunar Reconnaissance Orbiter, Juno, and JUICE instruments provides low technical risk
- UVS is ready to go for Jupiter's radiation environment

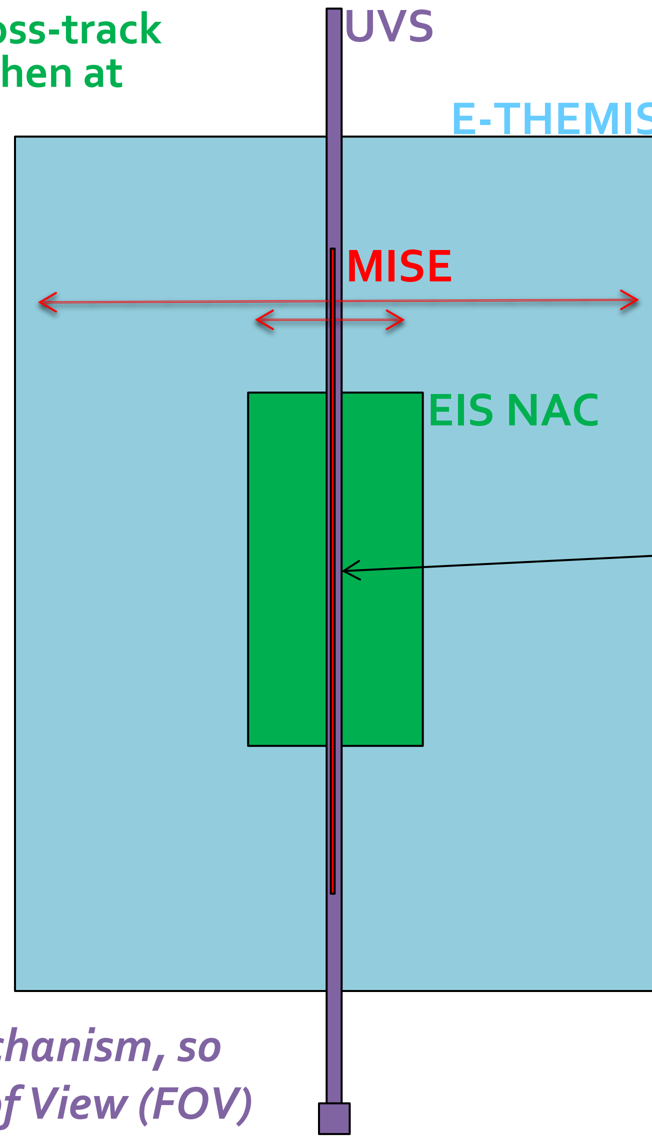
Backup

Remote Sensing FOVs: Co-Alignment

Details under discussion, TBR

- EIS NAC: 2.35° x 1.17°
  - Gimbal FOR: ±30° along- and cross-track (plan to stay within MISE FOR when at close range to Europa)
- EIS WAC: 24° x 48°
  - *Not shown*
- UVS: 7.3° x 0.1° + 0.2° x 0.2°
  - Full length 7.5°
- MISE: 4.3° x 0.007°
  - Scan FOR: ±30° along-track
  - Typically scan x4° or x 1°
- E-THEMIS: 5.7° x 4.3°
- REASON: 60 ° (deep mode)
  - *Not shown*

◆ Pushbroom imaging by EIS, UVS, E-THEMIS, REASON, and (at times) MISE enable arbitrary image lengths along-track, all nadir at C/A



Mapping pixel scales @100 km:
NAC: 1 m
WAC: 22 m
E-THEMIS: 20 m
MISE: 25 m
UVS: 35 m (best case)
(spatial resolution is not equal to pixel scale)

Shown at common nadir boresight location

Along-track

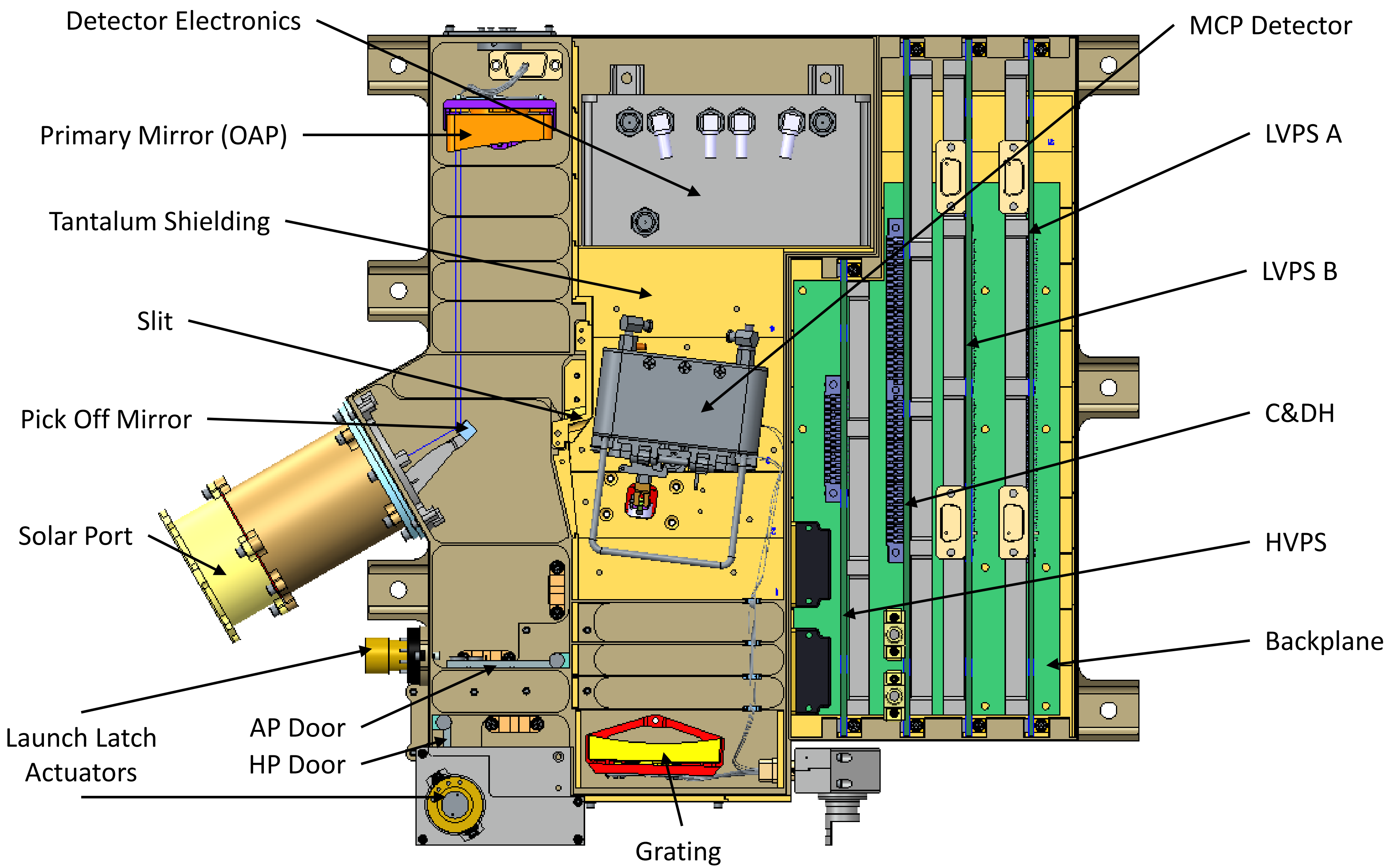
Cross-track

UVS does not have a scan mechanism, so Field of Regard (FOR) = Field of View (FOV)

What's in a Name?

- Europa-UVS, not E-UVS
  - E-UVS can imply "extreme" ultraviolet, 10-124 nm
  - Europa-UVS observes in 55- 210 nm – not just the "extreme" band!
- Europa-UVS = Europa Ultraviolet Spectro**graph**
  - Not spectrometer
  - Not spectroscope
  - In the standard definition a spectrograph obtains information across frequency space all at once and by contrast a spectrometer scans frequency space
- Not just "UVS" unless the context is clear
  - There is also Juno-UVS and JUICE-UVS
  - Many members of the Europa-UVS team have worked/are still working on other UVS instruments, so it is best to avoid confusion

Internal View: Top view, cover off



Hubble December 2012 Plume Detection

- Repeated detection is still needed, despite an extensive Hubble campaign last year
- Detectable signals persist for 5 orbits (~7 hours)
  - With multiple detected occurrences in a row a random noise explanation is unsatisfactory
- Roth et al., Science, 2014 Supplement details three rigorous statistical approaches

- Roth et al., PNAS, 2014 explain why an impact explanation is highly improbable (one in 80 yr)
- Unlike the O_2 aurora, the H_2O aurora features do not rock with Jupiter's magnetic field orientation
  - Several dozen similar Io and Ganymede STIS G140L datasets show no signs of a ~600 R Lyα feature above the limb
  - Likely not proton aurora
  - Brightens in plasma sheet

obzp01010-20 12-30 19:05 obzp01030-40 12-30 20:29 obzp01050-60 12-30 22:05 obzp01070-80 12-30 23:41 obzp010a0-a0 12-31 01:30