PI Kurt Retherford (SwRI)
• 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.
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
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

Kurt Retherford
Europa-UVS Heritage

A) Rosetta-Alice
B) Pluto-Alice
C) LRO-LAMP
D) Juno-UVS
E) JUICE-UVS
F) Europa-UVS

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/MgF₂ coating

Grating:
- 50 mm × 50 mm
- 1600 gr/mm toroid
- Al/MgF₂ coating

MCP Detector:
- XDL (Cross delay-line)
- CsI photocathode
- ALD & Borosilicate glass plates, as on JUICE-UVS
### Europa-UVS Specs

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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<tbody>
<tr>
<td>Mass (CBE+cont.)</td>
<td>6.43 kg plus 11.1 kg shielding = 17.5 kg</td>
</tr>
<tr>
<td>Power (CBE+cont.)</td>
<td>9.7 W</td>
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<tr>
<td>Dimensions</td>
<td>34.6 cm x 38.2 cm x 14.5 cm</td>
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<tr>
<td>Spectral Range</td>
<td>55-210 nm</td>
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<tr>
<td>Spectral Resolution</td>
<td>&lt;0.6 nm (point source), &lt;1.2 nm (extended source); resolving power λ/Δλ=220</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>0.16° (AP), 0.04° (HP); Nyquist sampled</td>
</tr>
<tr>
<td>Field of View</td>
<td>0.1° x 7.3° + 0.2° x 0.2° (7.5° full length)</td>
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<tr>
<td>Effective Area</td>
<td>0.6 cm² @ 125 nm</td>
</tr>
<tr>
<td>Telescope / Spectrograph</td>
<td>Off-axis Primary / Rowland circle mount</td>
</tr>
<tr>
<td>Detector Type</td>
<td>2D MCP (solar blind), CsI photocathode, cross-delay-line (XDL) readout, 2048 spectral x 512 spatial x 256 PHD</td>
</tr>
<tr>
<td>Radiation Mitigation</td>
<td>Contiguous High-Z shielding (4π sr @ detector and electronics)</td>
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The JUICE-UVS Phase B effort is maturing our baseline Europa-UVS design, with IPDR planned for 2016 Mar./Apr.
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.
Atmosphere & Plume Composition from UV Spectra

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

Plasma Environment from Oxygen Emission

Surface Structure & Composition from scattering of Ly-α
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
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

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 Spectrograph
  - 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
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$_2$O 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 Ly$\alpha$ feature above the limb.
- Likely not proton aurora.
- Brightens in plasma sheet.