IMPROVING PERFORMANCE IN PLANETARY ULTRAVIOLET SPECTROGRAPHS. M. W. Davis[1], G. R. Gladstone[1] and K. D. Retherford[1], [1]Space Science and Engineering Division, Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78238 (mdavis@swri.edu).

Introduction: Four compact planetary ultraviolet spectrographs have been built by Southwest Research Institute and successfully operated on different planetary missions: Rosetta-Alice [1], New Horizons-Alice [2], LRO-LAMP [3], and Juno-UVS [4]. Two more are in the works to observe Jupiter and its moons aboard the JUICE and Europa missions. Both of these spectrographs feature advancements that improve spatial resolution, maximum instantaneous count rates, and radiation background rejection when compared to previous spectrographs. The new designs also allow solar occultations at Jovian distances.

UVS Instrument Summary: Light enters the instrument through the main airglow port (AP; a 40-mm square aperture), the high-resolution port (HP; a 10-mm diameter aperture co-aligned with a door at the AP), or the solar port (SP; a 0.25-mm pinhole that feeds a small, gold-coated pickoff mirror). The light is then focused by the off-axis paraboloid (OAP) mirror onto a slit plane. The slit passes the solid angle of interest (7.5° by 0.1°) to a toroidal grating co-aligned with the location of the pupil image. The grating then focuses the spectral image onto a cylindrical MCP detector over the 55-210 nm range. The detector is read out by cross-delay-line (XDL) electronics. The detector and its accompanying electronics are inside the local tantalum shields, which act to both reduce the total MeV electron dose on the electronics as well as reduce the background noise on the detector (Figure 1). The shielding design is derived from the Juno-UVS instrument that arrived at Jupiter in July 2016.

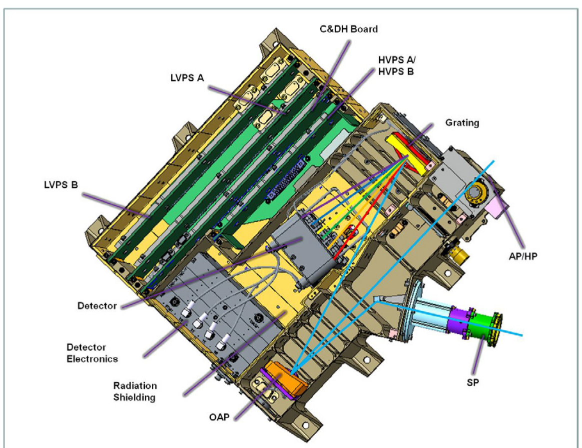

Figure 1. JUICE-UVS instrument design.

JUICE features dual low-voltage and high-voltage power supplies. Both HVPSs fit on one board. The LVPSs, however take up one board each. Europa-UVS features single-string power supplies, so it only has one LVPS board. As such, the Europa-UVS width is slightly smaller than JUICE-UVS by 1.125 inches, with a corresponding mass reduction of approximately 2 kg. Europa-UVS also features the solar port at 40° incidence to the airglow port, instead of 60° for JUICE-UVS. Otherwise, the designs are currently identical.

Design Improvements: The following changes maximize performance in the Jovian environment:

Spatial Resolution. The HP is designed to improve the spatial resolution of the base UVS design by a factor of approximately 4 at a cost of 20 times worse signal-to-noise. In practice, there are variations in optical aberrations that do not always scale with aperture size, so the HP spatial resolution varies as a function of wavelength. Furthermore, the optical resolution must be convolved with the native resolution of the detector to determine the final PSF as a function of wavelength. As shown in Figure 2, the resulting HP resolution is best at 90 nm (0.04°), and varies between 0.05° and 0.11° across the 55-210 nm bandpass.

Solar Port. The Solar Port is derived from the SOCC that flew on P-Alice past Pluto. This heritage assembly has been reworked for use at Jupiter in a few ways. First, the actuator is updated from a one-shot to a reusable actuator, similar to the scan mirror launch lock on Juno-UVS. Second, the pinhole has been resized from 1-mm to 0.25 mm to reduce solar flux. Finally, the pickoff mirror will be coated with gold to further reduce incoming solar flux to a safe level.

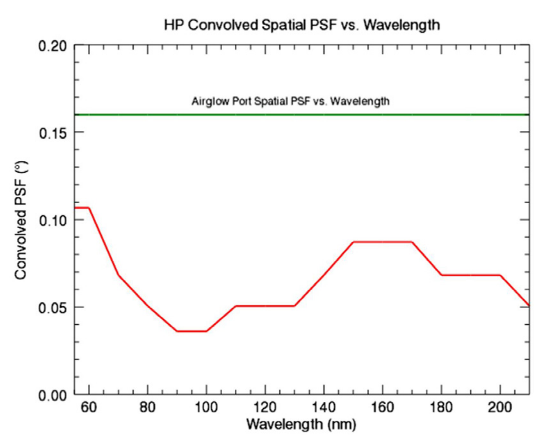

Figure 2. HP resolution as a function of wavelength.

Faster Detector Count Rates. The Juno-UVS cross-delay line (XDL) detector was limited to a maximum count rate of 85 kHz. While this rate exceeds the maximum rate seen by P-Alice by approximately a factor of three, it is still too low to ensure good science during the 300 kHz background rates expected at Europa closest approach. The JUICE and Europa-UVS XDL detectors are specified to have no worse than 30% deadtime loss at 300 kHz rates. The detectors achieve this rate by reducing the native resistance of the microchannel plates as well as optimizing the readout speed of the XDL electronics. Furthermore, the data connection to the spacecraft will be fast enough to handle sustained data rates over 300 kHz.

Improved Radiation Background Rejection. The pulse height distribution of detected UV photons differs from both electrons and gamma rays. The JUICE- and Europa-UVS detector electronics will feature a couple of improvements to the pulse height recording that will enhance rejection of background radiation. First, the number of recorded pulse height bins is increasing from 32 on Juno-UVS to 256. This improved resolution allows finer rejection of background events with large pulse height, potentially reducing background rates by 30%. As shown in Figure 3, potentially half of the detected electrons have pulse heights higher than any of the photons, so they may be rejected outright [5]. Second, an additional analog-to-digital converter has been added to the detector electronics to allow accurate reporting of the pulse heights even at high count rates. Previous electronics would report "sag" in the pulse height as count rate increased, which is inadequate for a high radiation background environment.

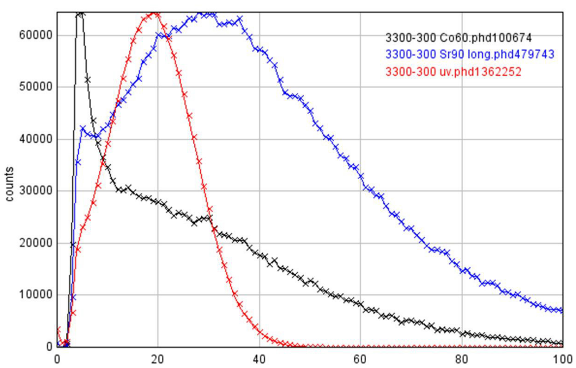

Figure 3. Pulse height distributions for UV photons (red), MeV electrons (blue), and MeV gamma rays (black) [5].

References:

[1] Stern S. A. et al. (2007) *SSR, 128,* 1, 507–527. [2] Stern S. A. et al. (2008) *SSR, 140,* 155-187. [3] Gladstone G. R. et al. (2010) *SSR, 150,* 161-181. [4] Gladstone G. R. (2014) *SSR,* doi:10.1007/s11214-014-0040-z. [5] Siegmund O. H. W. et al. (2015) *Proc of SPIE, 9601*, 96010S