Tests of Microchannel Plate (MCP) Detector Response to MeV Electrons in Support of Juno, JUICE, and Europa Mission UVS Instrument Investigations. K. D. Retherford[1,] M.W. Davis[1], T. K. Greathouse[1], R. M. Monreal[1], R. C. Blase[1], U. Raut[1], A. J. Steffl[1], C. M. Cooke[2], O. Siegmund[3], and G. R. Gladstone[1], [1]Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78238, [2]Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, MA 02139, [3]Sensor Sciences, 3333 Vincent Road, Ste. 103, Pleasant Hill, CA 94523.

Introduction: Beamline tests were conducted at MIT to determine the responsivity of Microchannel Plate (MCP) detectors, typically used in UV instruments, to the energetic MeV electrons expected in the Jupiter and Europa radiation environments during operations by Juno, JUICE, and Europa UVS instruments.

Approach: The response of Microchannel Plate (MCP) detectors to far-UV photons is excellent. MCPs provide a photon-counting capability that is especially useful for high-quality stellar and solar occultation measurements. However, use of MCPs within the Jovian magnetosphere for UV measurements is hampered by their ~30% detection efficiency to energetic electrons and ~1% efficiency to γ-rays. High-Z shielding stops energetic electrons, but creates numerous secondary particles; γ-rays are the most important of these for MCPs. These detected particles are a noise background to the measured far-UV photon signal, and at particularly intense times their combination can approach detector global count rates of ~500 kHz when operating at nominal HV levels. To address the challenges presented by the intense radiation environment experienced during Europa encounters we performed electron beam radiation testing of the Juno-UVS flight spare cross-delay line (XDL) MCP in June 2012 at MIT's High Voltage Research Laboratory (HVRL), and again in Nov. 2013 adding an atomic-layer deposition (ALD) coated test-MCP, to measure the detection efficiency and pulse height distribution characteristics for energetic electrons and γ-rays.

Experiments: A key result from our initial UVS-dedicated SwRI IR&D project in 2012 is a qualitative characterization of our XDL's response to both particles (electrons and γ-rays) and photons as a function of HV level. These results provided confidence that good science data quality is achievable when operating at Europa closest approach and/or in orbit. Comparisons with in-flight data obtained with New Horizons Pluto-Alice MeV electron response measurements at Jupiter [1], LRO-LAMP electron and proton event data, and Juno-UVS Earth proton-belt flyby data, and recent bench tests with radioactive sources at Sensor Sciences increase this confidence. The effects of fluorescence on the detector housing window in the first round of tests prohibited quantitative analyses, which prompted a second round of tests in 2013.

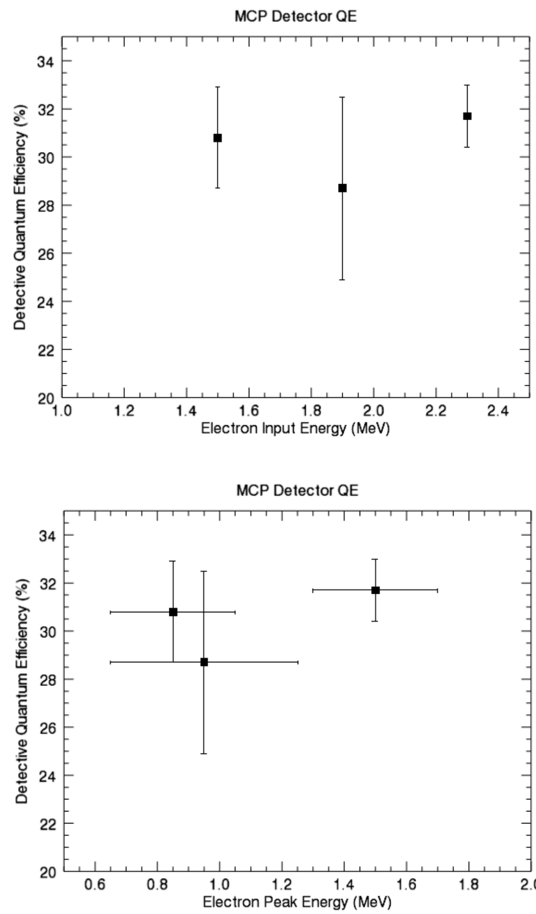

Figure 1. (top) Measured Juno flight spare detector efficiency to electrons as a function of beam input energy. These results agree well with previous measurements of similar MCP detectors. (bottom) MCNP6 modeled response.

Davis et al. [2] report a description of the 2013 test setup and the quantitative results shown in Figure 1-top. The detector response was measured at multiple beam energies ranging from 0.5-2.5 MeV and multiple currents. This response was then checked with MCNP6, a radiation transport simulation tool, to determine the secondary gamma rays produced by the primary electrons striking the detector window (Figure 1-bottom & Figure 2). We report on the measurement approach and the inferred electron and gamma sensitivities.

Results: The measured efficiency of the UVS-style microchannel plate detectors to MeV-level electrons is approximately 31%, consistent with previous measurements with UVS-style detectors, but not consistent with measurements by other microchannel plate detectors with thinner MCP stacks. The measured efficiency of UVS-style detectors to gamma rays is 2.4±0.1% at 0.5 MeV input energy based on the electron-to-gamma conversion of the fused silica window. This measurement is consistent with the 2% QE to gammas reported by Siegmund et al. [3].

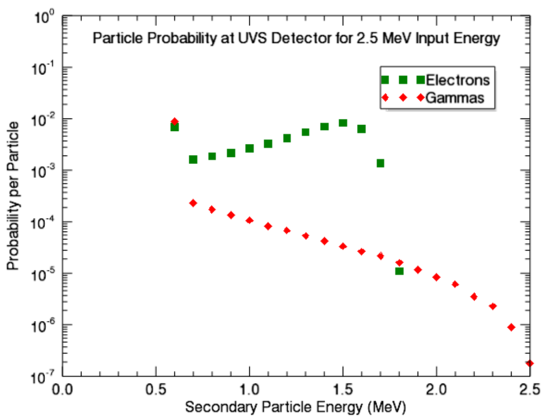

Figure 2. MCNP6 simulation calculation of the probability per particle that a secondary particle reaching the Juno-UVS spare detector within the beamline test setup will have a certain energy for a primary source electron with input energy of 2.5 MeV. Similar calculations were performed for input electron energies of 2.0 MeV, 1.5 MeV, and 0.5 MeV.

Summary: We will discuss several lessons learned to help inform future beamline test experiments dedicated to instrument developments for NASA's next large missions to Europa and ESA's JUICE mission to Ganymede. This information is central to the design of high-Z shielding material for minimizing background count rates for science measurements to be performed by the JUICE-UVS and Europa-UVS instruments.

References:

[1] Steffl, A.J., A.B. Shinn, G.R. Gladstone, J.W. Parker, K.D. Retherford, D.C. Slater, M.H. Versteeg, and S.A. Stern (2012), MeV electrons detected by the Alice UV spectrograph during the *New Horizons* flyby of Jupiter, *J. Geophys. Res., 117*, A10222, doi:10.1029/2012JA017869.

[2] Davis, M.W., T.K. Greathouse, C.M. Cooke, R.C. Blase, G.R. Gladstone, K.D. Retherford (2016) MeV-level electron and gamma ray sensitivities of modern far ultraviolet sensitive microchannel plate detectors, *Proc. of the SPIE*, Proceedings of the SPIE Vol. 9915, doi: 10.1117/12.2232755.

[3] Siegmund, O.H.W., C. Ertley, and J. Vallerga (2015), High Speed Large Format Photon Counting Microchannel Plate Imaging Sensors, *Proceedings of the Advanced Maui Optical and Space Surveillance Technologies Conference*, Maui, Hawaii, id.94.