OPTICAL CHARACTERIZATION OF SUPERCAM BELOW 900 nm. C. Legett IV[1], R. T. Newell[1], A. L. Reyes-Newell[1], P. Bernardi[2], O. Forni[3], P. Pilleri[3], A. E. Nelson[1], V. Sridhar[4], S. C. Bender[5], S. M. Clegg[1], D. M. Delapp[1], A. Essunfeld[1,6], R. C. Wiens[1] and S. Maurice[3], [1]Los Alamos National Laboratory (PO Box 1663, MS C331, Los Alamos, NM, 87545, clegett@lanl.gov). [2]Laboratoire d'Etudes Spatiales et d'Instrumentation en Astrophysique (Observatoire de Paris, CNRS, Sorbonne Univ., Univ. Paris-Diderot), Meudon, France. [3]L'Institut de Recherche en Astrophysique et Planétologie, Toulouse, France. [4]NASA JPL. [5]Planetary Science Institute. [6]Yale University.

Introduction: The SuperCam instrument on the Mars 2020 rover is capable of performing imaging (remote micro-imager or RMI), active spectroscopy (laser induced breakdown spectroscopy or LIBS, Raman, & time resolved luminescence or TRLS), & passive reflectance spectroscopy in two wavelength ranges, visible (VIS) & infrared (IR) [1, 2].

The Body Unit (BU) contains two Czerny-Turner spectrometers covering the UV (~244-341 nm) & VIOlet (~379-465 nm) regions & a transmission spectrometer (TS) using an intensified CCD in the green (~533-620 nm), orange (~620-714 nm), & red (~714-853 nm) regions. These spectrometers are used for LIBS, Raman, TRLS, & VIS reflectance measurements.

Here, we present the results of the optical characterization of SuperCam including wavelength calibration, instrument response function, & spectral resolution.

SuperCam uses a number of parameters to control the amount of light collected: 1) the number of rows of the CCDs that are integrated for the UV & VIO CCDs & for the red region of the TS CCD (the rows in the green & orange regions are fixed); 2) the UV & VIO spectrometers do not have a shutter, we can control the integration time of their CCDs while for the TS, the intensifier acts as a shutter, & the "intensifier open time" or "gate" controls how long light is permitted to pass; 3) we can control the intensifier gain. Each of these settings required separate characterization.

Methods: Optical characterization of the instrument was conducted in the cleanroom at JPL's Spacecraft Assembly Facility in August & December 2019 after SuperCam had been integrated into the rover. The characterization was performed by collecting measurements of two calibrated light sources: a Hamamatsu EQ-99 laser-driven light source (EQ-99) & a Labsphere USS-1200 integrating sphere light source (LS).

August 2019: We collected 60 observations over a range of settings. Only the EQ-99 was used – 30 observations were of that light source, & 30 were observations of a black anodized aluminum plate placed in front of the light source with lowered room lights. The EQ-99 was placed at a distance of 10.02 m. Observations were collected in sets of 10. First, 5 observations of the light source (the "lights") with the integration time increasing each time, then 5 observations of the black plate (the "darks") with the same settings as the preceding lights. The 6 sets of 10 observations were grouped by UV/VIO row & TS gain settings. Data were collected for 16 & 200 row integrations in the UV & VIO, 70 & 200 row integrations for the red region of the TS, & intensifier gains of 2300, 2500, 2900, 3200, & 3500 (arbitrary units). UV/VIO integration times ranged from 0.512 to 10 ms & TS gate times from 0.5 to 20 μs.

December 2019: In similar fashion, we collected 86 observations. These consisted of 43 pairs of lights & darks, with 10 pairs observing the LS, & 33 pairs observing the EQ-99. Both lamps were placed at a distance of 5.01 m. The LS produces insufficient light in the UV region to be useful. Observations of the LS were collected with 200 rows integrated in the VIO & 70 rows in the red region of the TS. VIO integration times ranged from 5.02 to 200 ms, & TS gate times ranged from 5-500 μs. Two intensifier gains were used: 2500 & 3200. For the EQ-99 observations, 16, 40, & 200 rows were integrated for the UV/VIO, & 70 & 200 rows were integrated for the red region in the TS. Integration times for the UV/VIO were 5.12-10 ms, & the TS intensifier gate ranged from 0.1-200 μs & gains of 2300, 2500, 2900, & 3200 were used.

Difference of Differences Technique: Since the UV & VIO spectrometers lack shutters, they collect signal during CCD readout. To remove the portion of the signal collected after the end of integration, we employ a technique we refer to as the "difference of differences." We take two light/dark pairs with identical settings except for the integration time. The darks are subtracted from the lights to remove the portion of the signal from the dark current. Next we subtract the dark-corrected observation with a shorter integration time from the longer. This results in the remaining signal consisting only of the signal accumulated during the difference in integration times.

Wavelength Calibration: The pixel to wavelength mapping for each CCD was determined using a LIBS observation of the SCCT titanium reference [3] collected during the System Thermal Test in October 2019. Observed peaks were matched with known Ti emission lines & a wavelength calibration derived from their distribution. The spectral bin width was determined from this wavelength calibration by assuming that each pixel had a wavelength bin width equal to half the distance to the center of each neighboring pixel.

Instrument Response Function: The instrument response function (IRF) maps the signal collected on the

CCDs to the number of photons incident on the telescope. We predict the number of photons from the light source that should be incident on the telescope based on the calibration data, observation geometry, & integration/gate time. Dividing the number of photons by the difference of differences corrected signal (DN) yields the expected instrument sensitivity in Photons/DN at each wavelength.

Results: The UV IRFs are presented in Figure 1. The VIO IRFs are presented in Figure 2. The TS IRFs are presented in Figure 3. The UV & VIO spectral bin widths are presented in Figure 4. The TS spectral bin width is presented in Figure 5.

The wavelength ranges with sufficient signal & resolution to be used during surface operations are 243.75-341.23 nm for the UV, 379.20-464.53 nm for the VIO, 533.34-619.93 nm for the green, 620.20-713.68 nm for the orange, & 713.69-852.76 nm for the red.

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References: [1] S. Maurice et al. (2020) *SSR*, 217, SPAC-D-20-00069R1. [2] R. Wiens et al. (2020) *SSR*, 217, 10.1007/s11214-020-00777-5. [3] J. A. Manrique et al. (2020) *SSR*, 216, 138, doi:10.1007/s11214-020-00764-w.

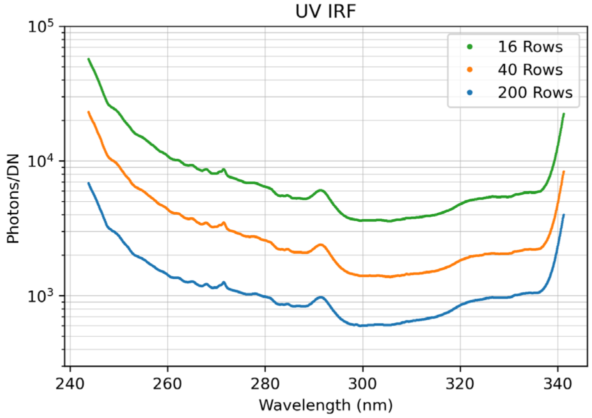

Figure 1. UV IRF for 16, 40, & 200 Rows.

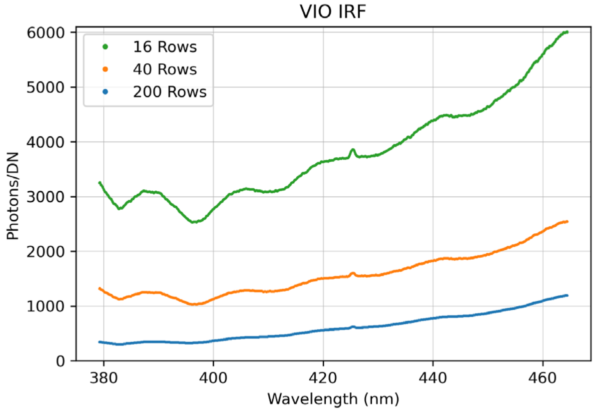

Figure 2. VIO IRF for 16, 40, & 200 Rows.

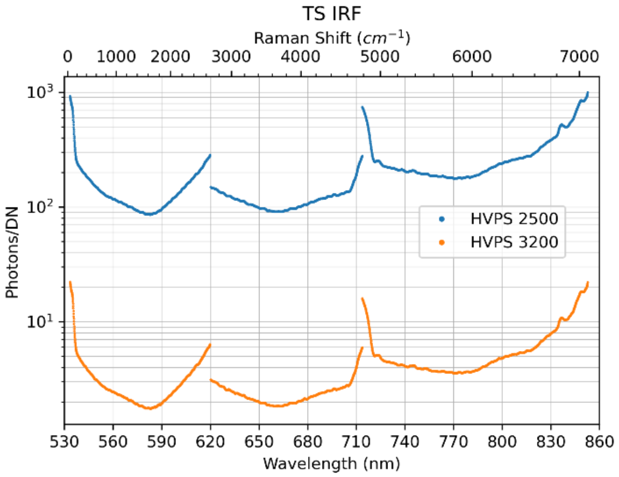

Figure 3. TS IRFs for 2500 & 3200 gains planned for LIBS & Raman, with 70 rows in the red region.

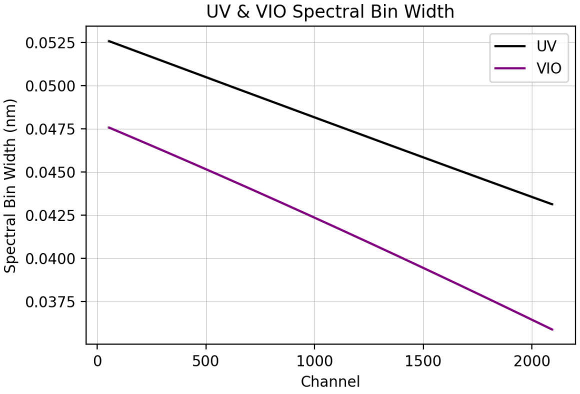

Figure 4. UV & VIO spectral bin widths.

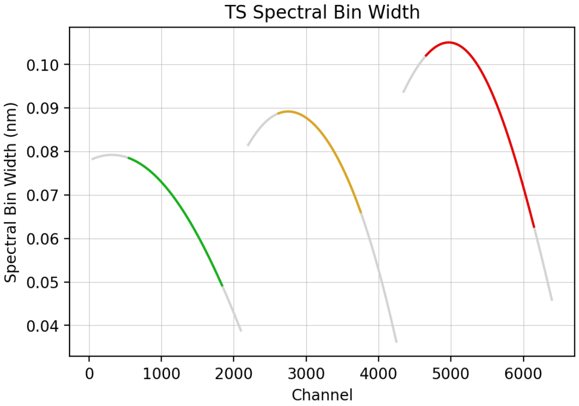

Figure 5. TS spectral bin widths. Gray areas show full range of data from CCD, colored areas show regions expected for use in surface ops.