Spectral characterization of the *Roman Space Telescope* Grism and Prism assemblies

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Abstract

The Roman Space Telescope (RST) Wide Field Instrument (WFI) recently completed its thermal vacuum (TVAC) campaign in Boulder, CO. This campaign, which concludes multiple years of preparation, represented the last opportunity for characterization and verification of the Grism and Prism spectral properties before launch; currently scheduled for late-2026.

To this end, a highly-automated series of measurements were performed to acquire images of calibration spectra at many field points. Features that were measured during these efforts include dispersion scale, blue/red bandpass edges, diffraction order radiometry, and ghost images. A summary of the techniques and results for several of these efforts is provided here.

Dispersion Scale (Grism and Prism)

By using a multi-line tunable filter (SuperK SELECT) with the projector telescope, images were acquired with many combinations of 6-8 input lines. An upstream optical spectrum analyzer (OSA) was used to acquire near real-time measurements of the input spectrum, which allowed us to relate each observed PSF to a unique wavelength. This was performed at 19 field points and used to identify small corrections (tenths of a percent) in the final optical models.

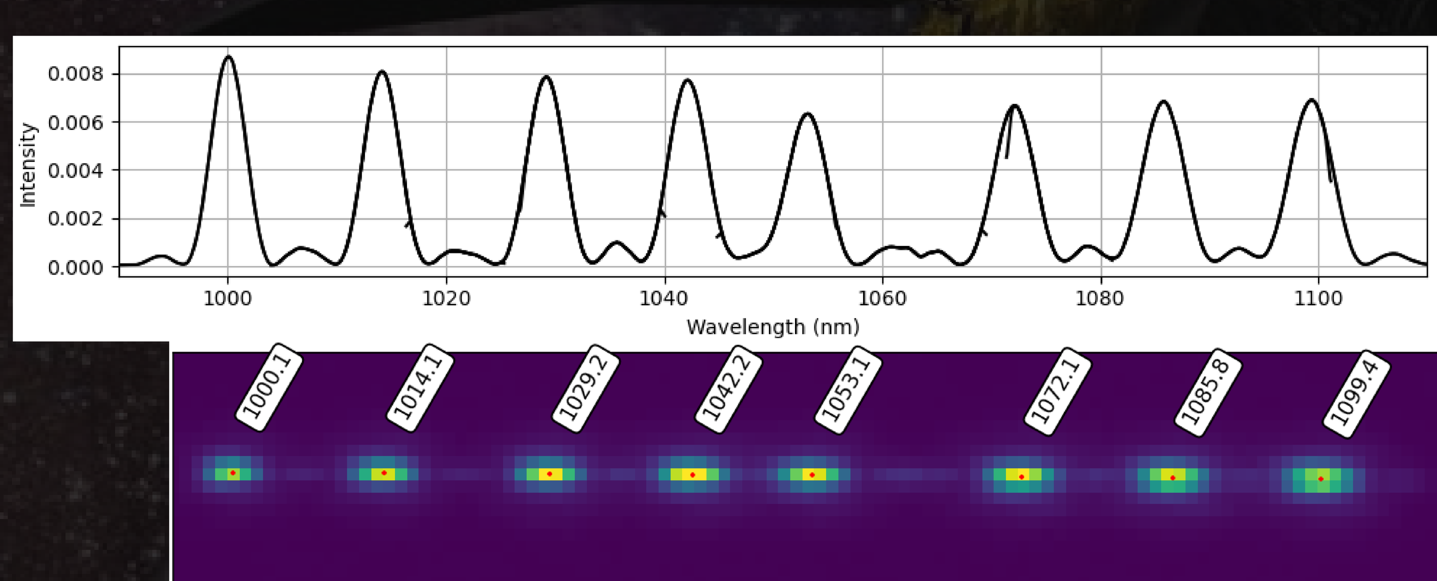

Figure 1: An example input spectrum used for characterizing the Grism dispersion scale and the resulting image observed by the WFI.

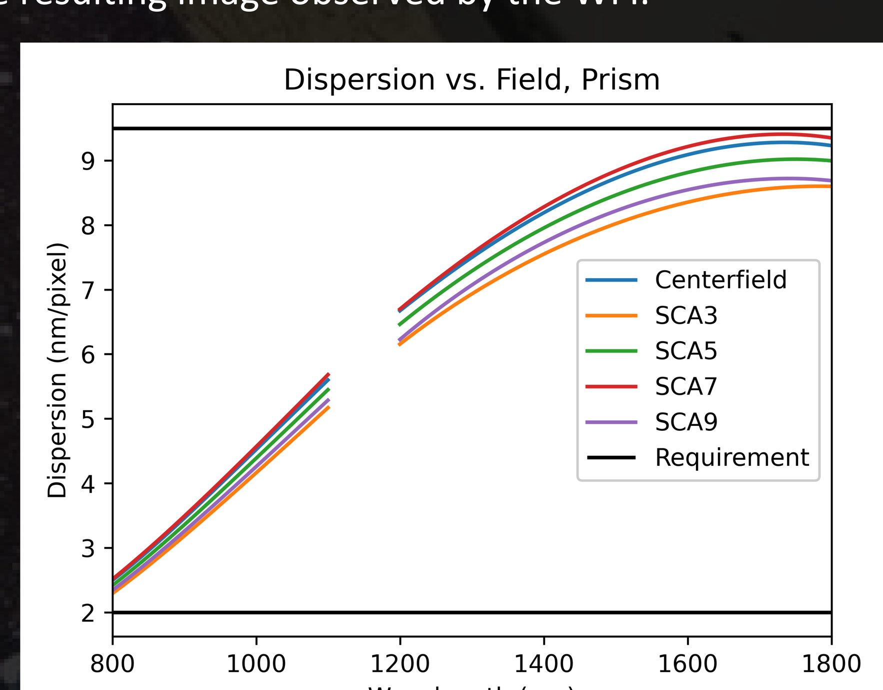

Figure 2: The Prism dispersion scale vs. wavelength, for all measured fields. Prism spectral resolution varies significantly with wavelength, in contrast to the more uniform resolution of the Grism (not shown here).

Bandpass Edges (Grism)

By using a multi-line tunable filter (NKT SELECT), we produce variations of an input spectrum consisting of a "top hat" and two distinct lines. The Grism blue + red edge can then be calculated by comparing the input spectrum, measured by the upstream OSA, and transmitted spectra, observed by the WFI. This process was performed at 17 field points and used to generate a global model of the bandpass coating edge wavelength vs. angle of incidence (AOI).

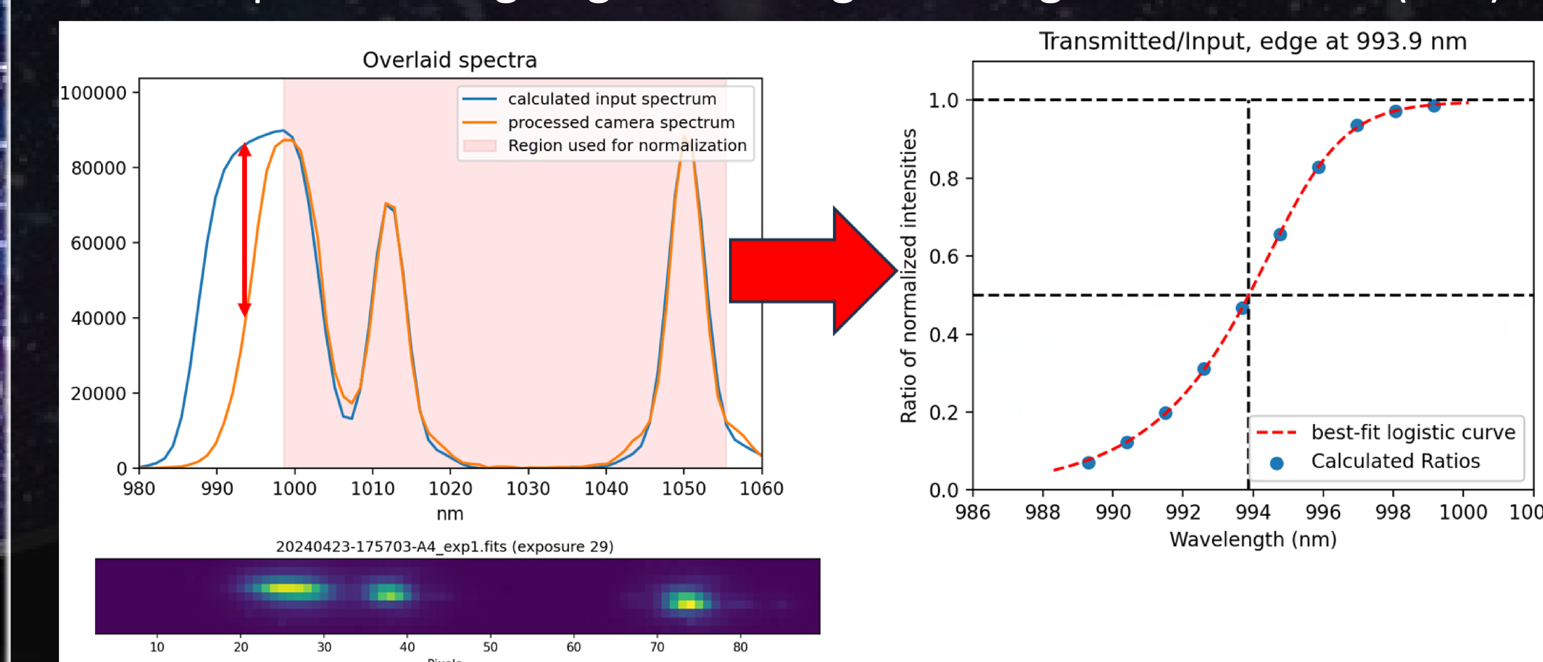

Figure 3: An example of the measurement process for the Grism blue edge. A similar process is repeated for the Grism red edge.

Bandpass Edges (Prism)

Because the Prism has a much lower spectral resolution, the above method can't provide the needed level of accuracy. Instead, the Prism is exposed to a diffuser flatfield, illuminated by a laser line tunable filter (LLTF). By comparing the flatfield flux vs. wavelength, combined with knowledge of the input source intensity, the blue edge can be calculated for the entire field of view.

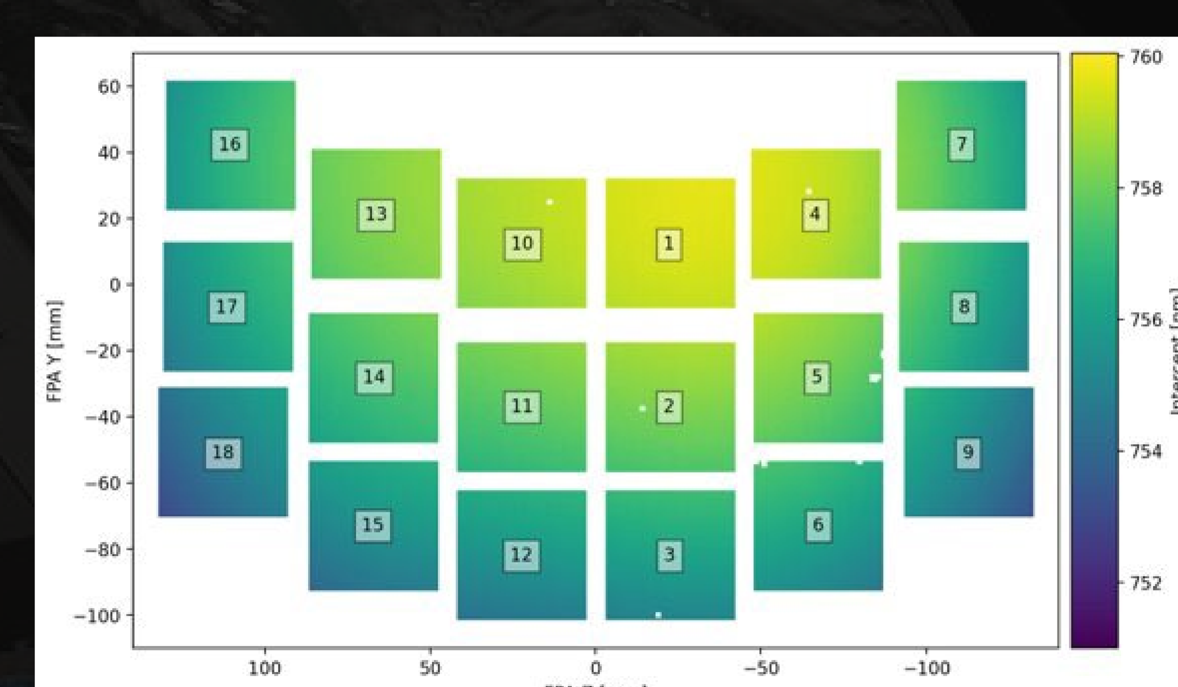

Figure 4: An illustration of how the measured Prism blue edge changes with field. The field-dependence of the Grism edges has a similar form (not shown here)

Diffraction Order Radiometry (Grism)

The Grism background is dominated by the complex spatial structure of the unwanted diffraction orders. Because the Grism contains two gratings, there are many order combinations. By acquiring monochromatic images with the laser line tunable filter at a variety of wavelengths and signal-to-noise levels (both during the latest TVAC campaign and element-level testing), properties of the Grism diffraction grating could be characterized in a much more robust way than what can be performed on-orbit.

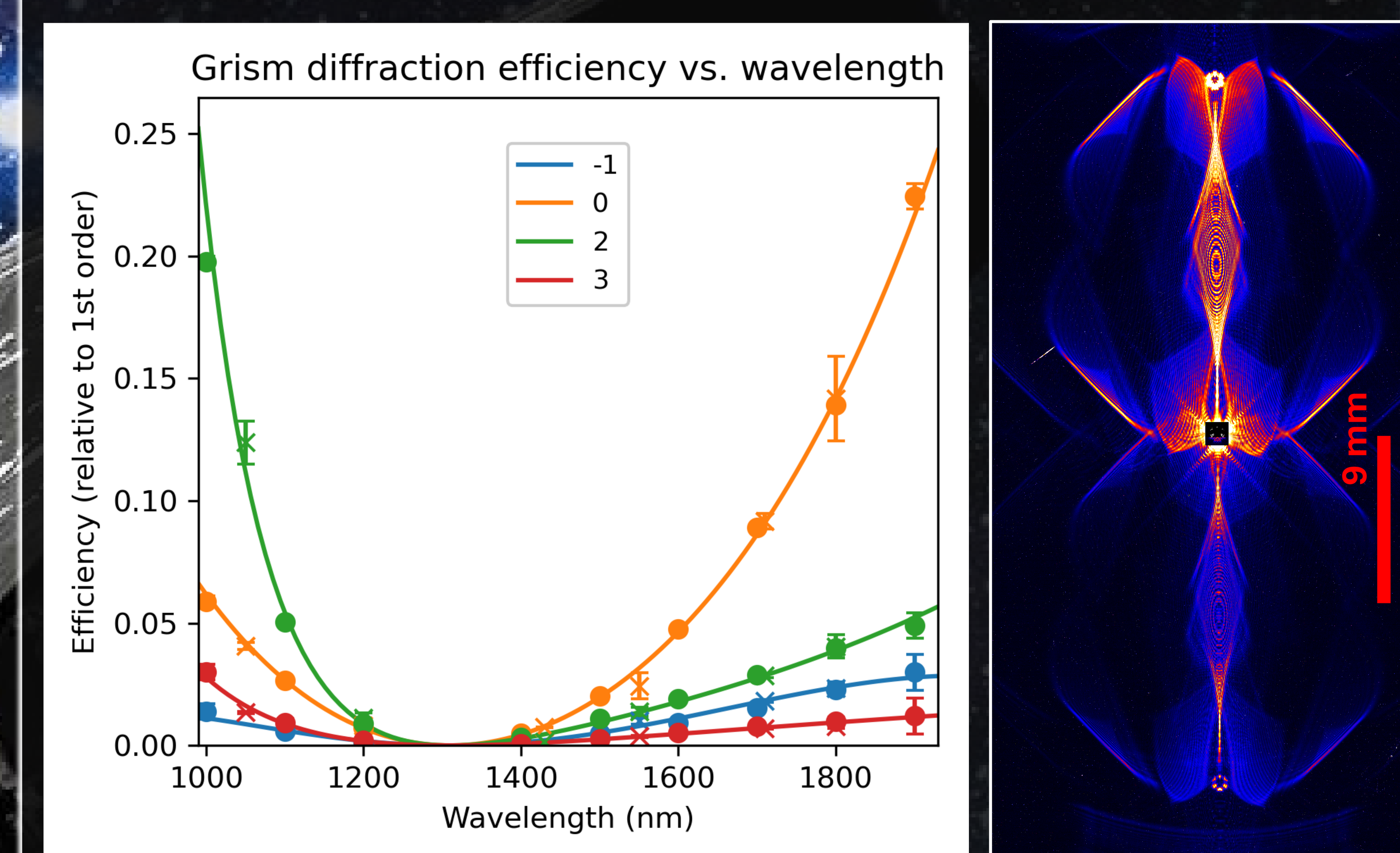

Figure 5: (Left) Relative Grism diffraction efficiency vs. wavelength for several different orders, illustrating how the intensity of the unwanted orders becomes significant near the bandpass edges. (Right) A saturated, log-scaled image of the most prominent Grism diffraction orders for a monochromatic 1710 nm input. The length of a nominal Grism spectral trace is overlaid as a red line, for scale.

Conclusion

The Grism and Prism spectral characterization campaign performed during TVAC testing of the completed RST Wide Field Instrument has met or exceeded expectations in many categories. The data acquired from these efforts is actively being used to update instrument optical models and fine-tune post-launch analysis pipelines. Any observed deviations from existing models are minor and easily explained.

The final, tabulated calibration data is available on both TDMS and NASA's Explore/ADAPT computing cloud or can be acquired by contacting the authors.

References:

- Bray, Evan, et al. *"Spectral characterization of the grism and prism slitless spectrometers for the Nancy Grace Roman space telescope." Journal of Astronomical Telescopes, Instruments, and Systems*, vol. 10, no. 01, 8 Feb. 2024, https://doi.org/10.1117/1.jatis.10.1.014003.
- Switzer, Eric R., 2024 Oct. *"Roman-WFI: characterization of widefield chromatic response."* Accurate Flux Calibration in the Era of Space Astronomy and All-Sky Surveys. Space Telescope Science Institute