Prism Assembly for Roman Space Telescope Wide Field Instrument Slit-less Spectroscopy

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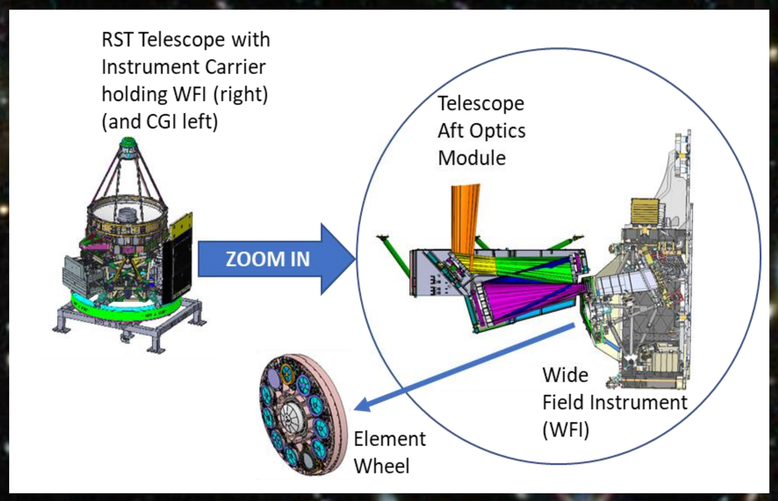
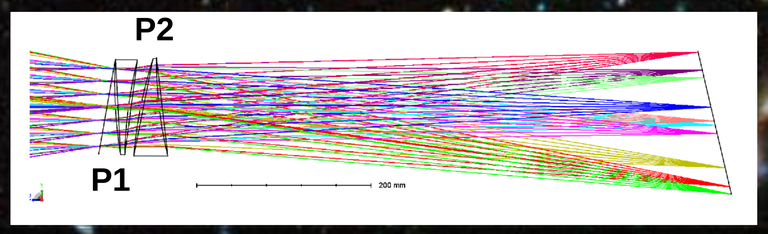
INTRODUCTION

The Prism Assembly is a small add-on instrument to the Roman Space Telescope Wide Field Instrument (RST WFI), installed in a slot in WFI's element wheel.

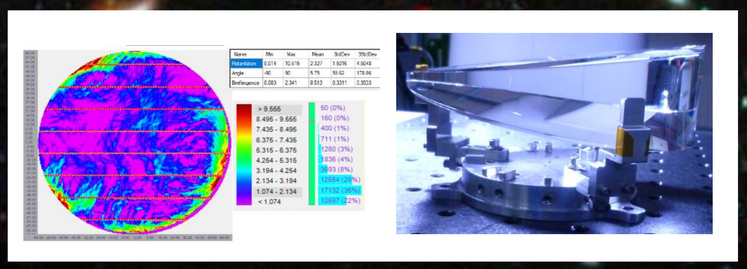


The Prism passband from 0.75 µm to 1.8 µm, enables survey of redshifts in the range from 0.2 to 1.7, enough to cover the faint afterglow of supernovae. The Prism Assembly provides low resolution slit-less spectroscopy with a spectral resolution R>70 for all wavelengths, and R< 170 for wavelengths > 0.8 µm across the full field.

METHODOLOGY



The Prism design is a trade-off between wave front error and resolving power. A 2-element design achieved with all four surfaces spherical was favored, and although challenging, considered the least complicated to manufacture, test, align and integrate. P1, the dispersive element, is S-TIH-1 (Ohara) glass with a high refractive index of > 1.7 and a CaF2 is the low index material selected for P2. (Ohara, Hellma, USA).



It was imperative to source large (120 mm) CaF2 blanks of high homogeneity material, free of grain boundaries and slip planes. Low stress-birefringence (<10 nm/cm P-V) was required and verified via quantitative mapping (Hinds Instruments). Both P1 and P2 have challenging geometries featuring a highly wedged shape between the 2 spherical surfaces. Optimax Systems manufactured the P1 and P2 optical elements. QED Optics supplied extra P2 spare. It was essential that P1 and P2 had flawless bevels and impeccable edges (necessary for bond strength). Each element was characterized (using interferometry with Computer Generated Hologram, and optical Coordinate Measurement Machine to determine Radius of Curvature), before final selection for Flight and Spare elements.

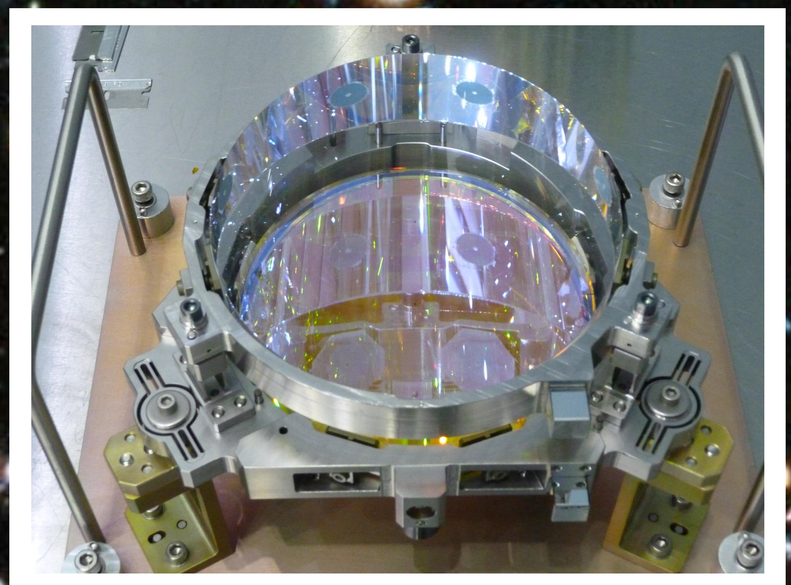
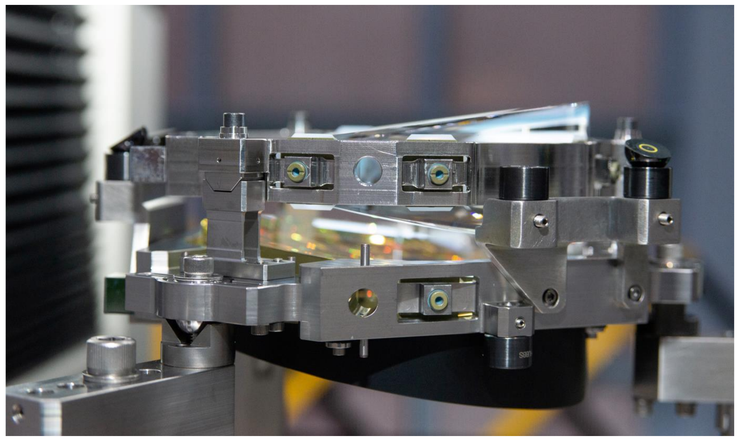
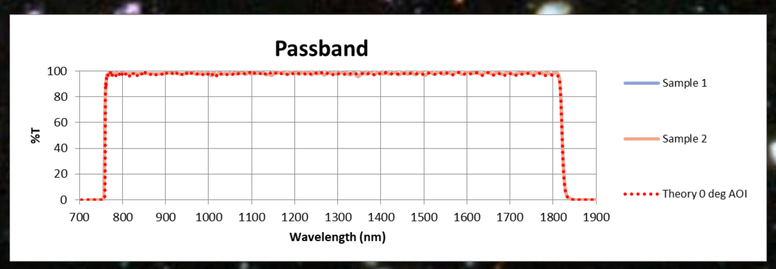


Photo of the Prism Assembly. The P2 element in view is radially bonded to the A286 stainless steel cell with 6 bond pads, the P1 element is bonded to the Titanium cell with 4 bond pads. The Prism mount will connect to a flexured Titanium interface pad on the Be Element Wheel.

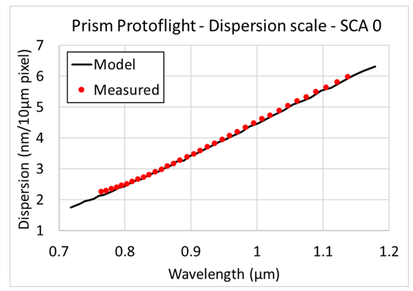


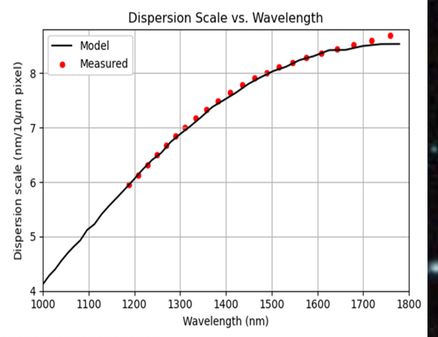
Prism Assembly with optical axis vertical. P2 visible at the top; pupil mask at the bottom. Simple fiducials in the center of each optic. Metrology targets, and alignment cubes on the mounts are used during nominal alignment of the parts. The Prism Assembly thickness is ~80 mm. The CaF2 element; 119.25 mm ø. P1 includes a multi-layer bandpass coating (Alluxa).

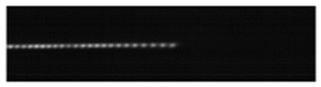


RESULTS

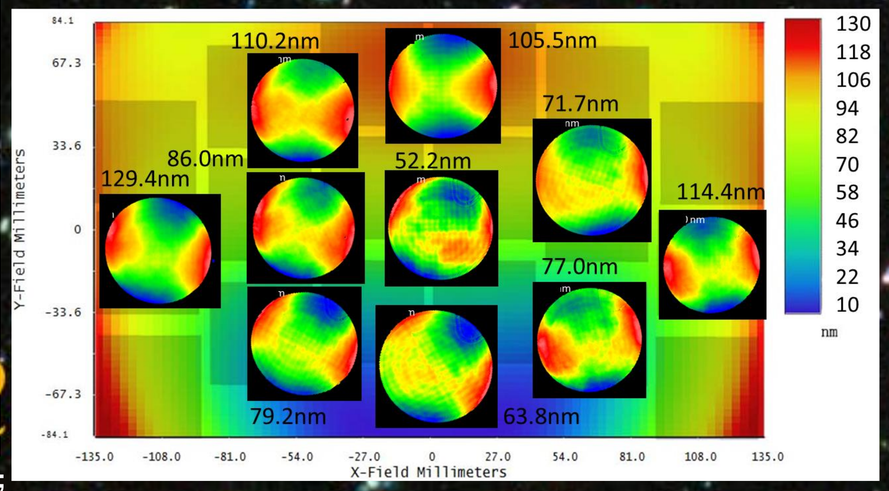
Prism Dispersion Scale







The required resolving power, R = λ / D λ , is achieved for all wavelengths, for all fields. R is directly verified by measurement of the dispersion profile and by showing that the Prism Assembly has a spectral dispersion > 2 nm/10 µm pixel and < 9.5 nm/10 µm pixel for all wavelengths λ > 0.8 µm, across the full field of view. The dispersion clocking is within 5 mrad as required.



Prism Assembly wavefront error (WFE) performance in the telescope at 1200 nm wavelength shows the variation over the WFI field of view. The WFE is measured interferometrically in a cryo chamber at 175K at 1053 nm, and performance transferred to the telescope model and shown for 1200 nm. The wavefront error and parfocality (11.4 µm) at all field points at all field points across the Sensor Chip Array are within specification.

CONCLUSION

The Prism Assembly was a late add-on to the RST project. Despite the challenging task, the Prism Assembly is now complete and tested. It will undergo final calibration and bakeout before being delivered for integration into the RST Wide Field Instrument.

REFERENCES

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2. Dominguez, M., Marx, C., Gong, Q., Hagopian, J., Griesmann, U., Burge, J., Kim, D. "Infrared computer-generated holograms: design and application for the WFIRST grism using wavelength-tuning interferometry", Opt. Eng. 57*7), 074105 (2018).

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