Spectroscopy data simulations

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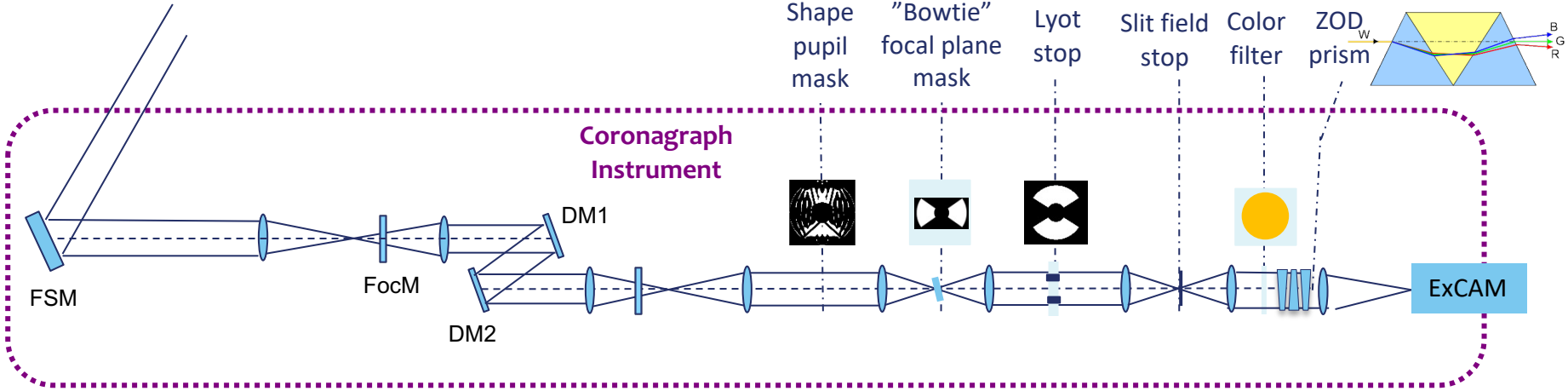
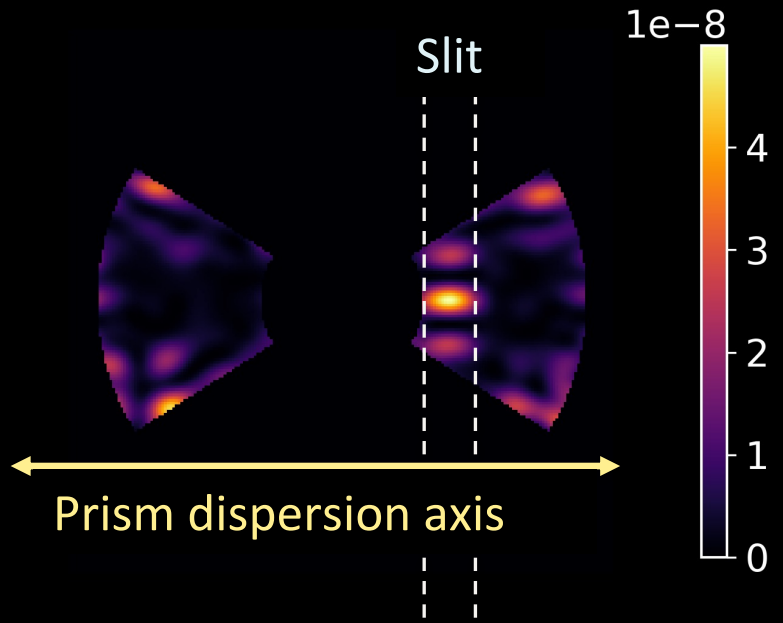
Spectroscopy mode overview

- Zero-deviation (“ZOD”) prism selectable after coronagraph masks
- Design and engineering led by Tyler Groff (GSFC).
- Spectral resolution R~50 over the Band 2 (610-710 nm) and Band 3 (675-785 nm) Shaped Pupil Coronagraph modes.



Spectrally dispersed point source

$5x10^{-8}$ source at 3.9 λ/D



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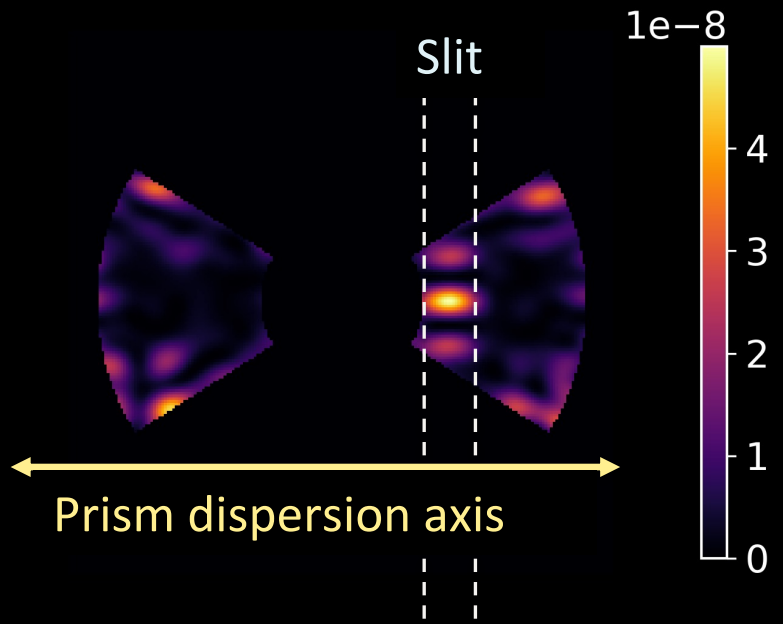
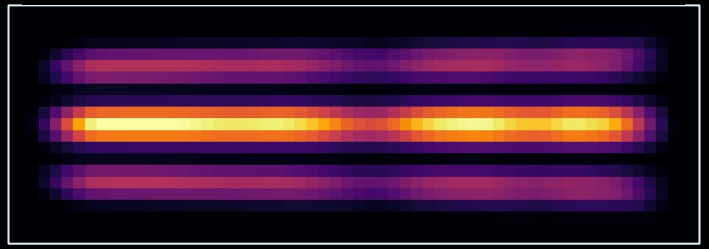
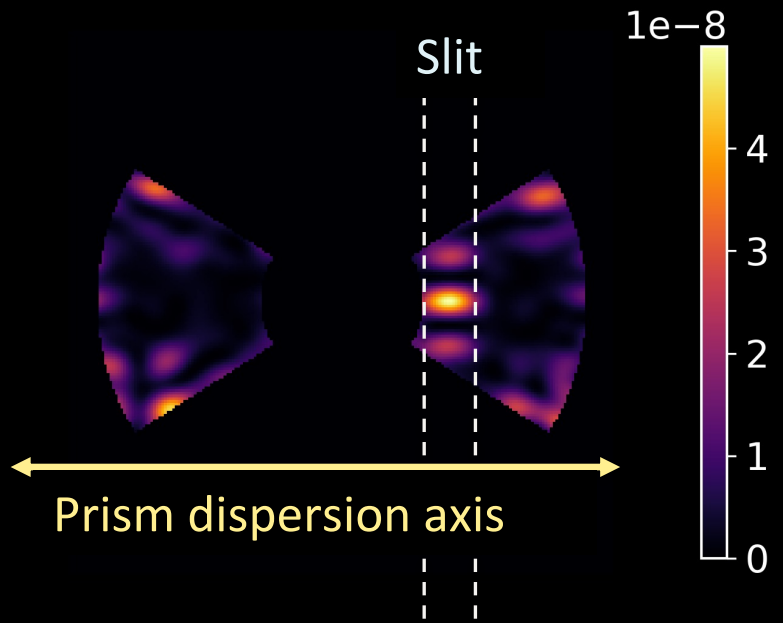


Dispersed source on ExCAM

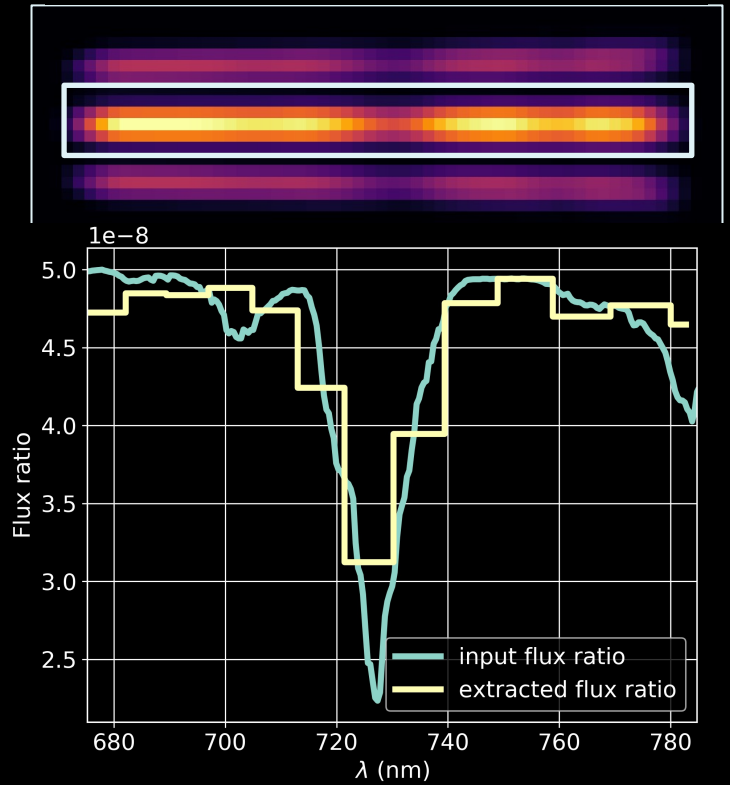


Spectrally dispersed point source

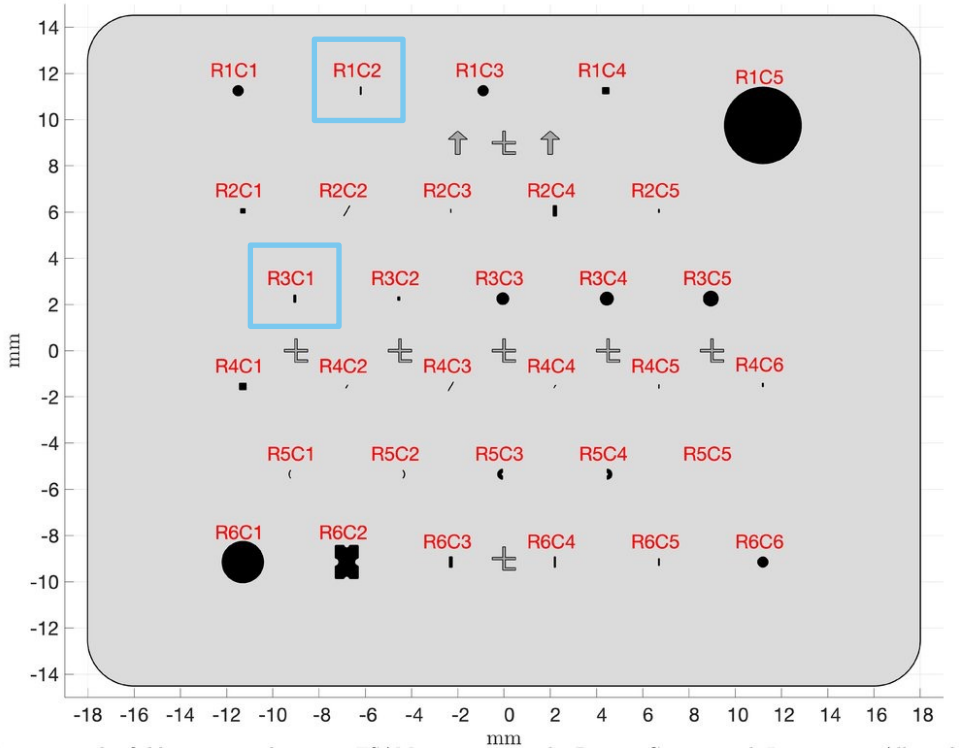
$5x10^{-8}$ source at 3.9 λ/D

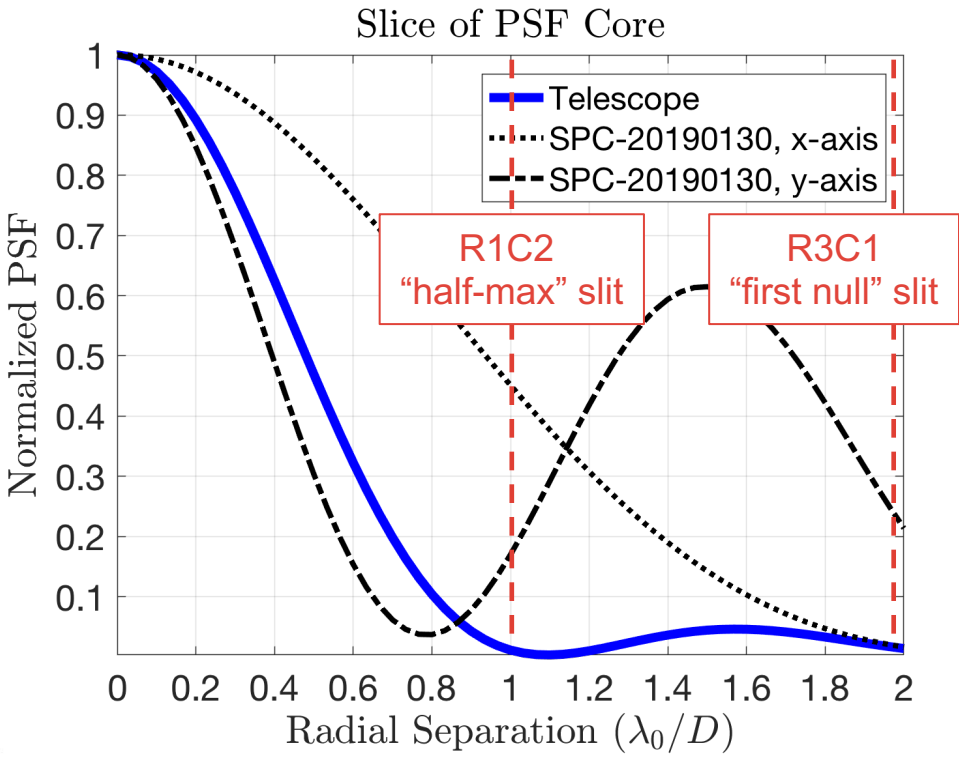


Dispersed source on ExCAM



Slit masks

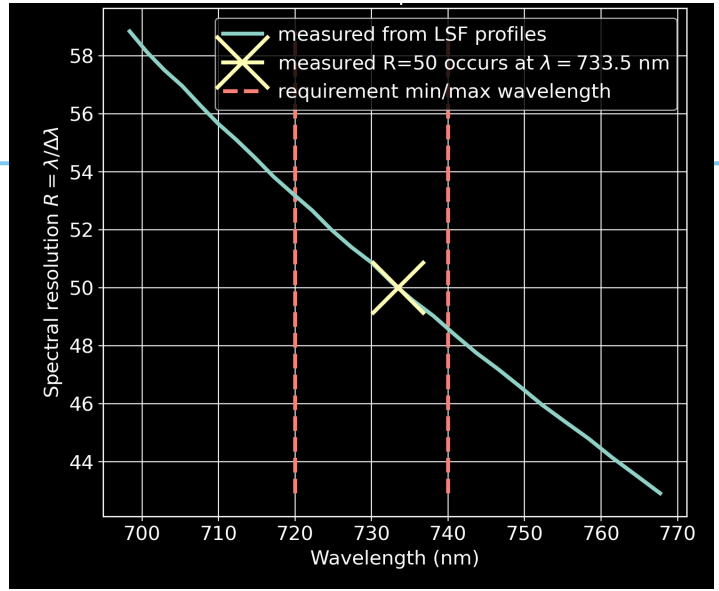




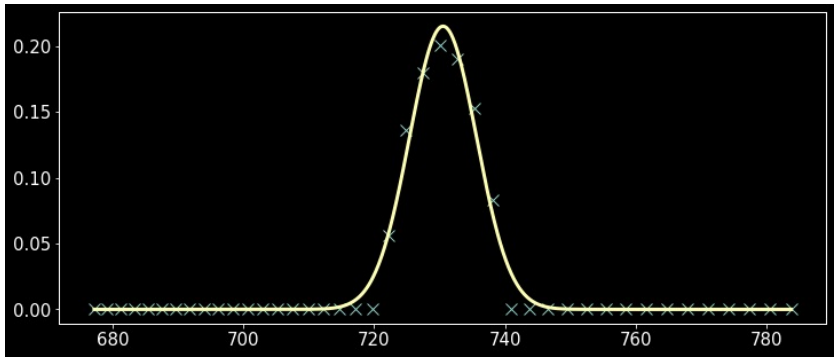
FSAM field stop array layout with slit masks:
A.J. Riggs, V. Bailey, et al., *Proc. SPIE* 11823 (2021)

Spectral resolution

- Designed for R=50 at center wavelength, with wider slit (R3C1).
- Spectral resolution varies across the bandpass: determined by combination of PSF main lobe size, prism dispersion characteristic, choice of slit mask, and data extraction method.
- Good approximation to LSF: Gaussian with FWHM=12.1 nm (R1C2 slit) or FWHM=14.4 nm (R3C1 slit).



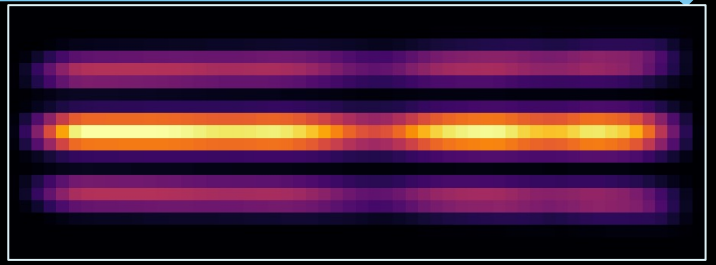
Spectral resolution with R3C1 slit



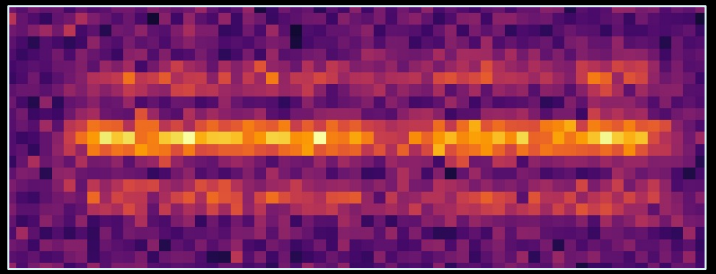
Line spread function (LSF)

Impact of speckles

Ideal dispersed planet



Noisy dispersed planet

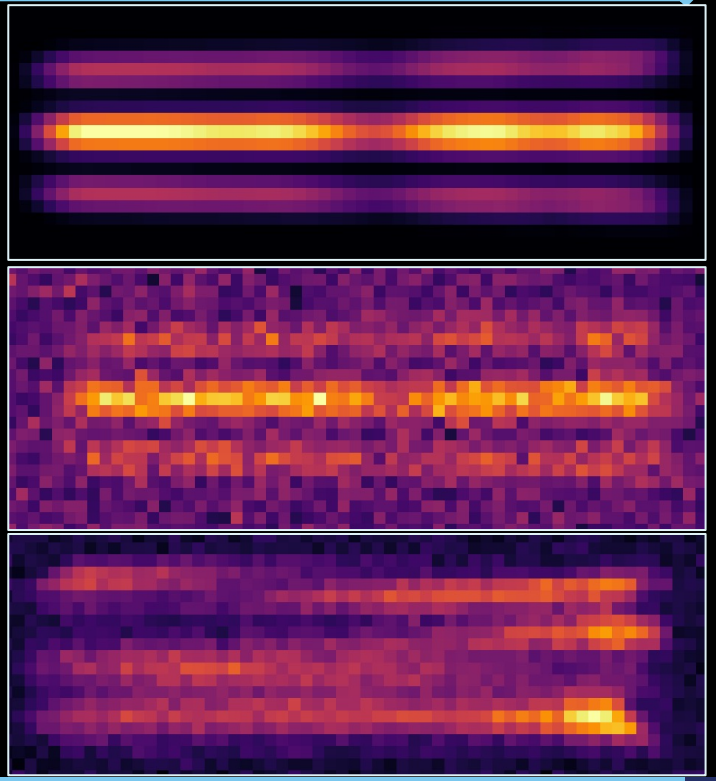


Impact of speckles

Ideal dispersed planet

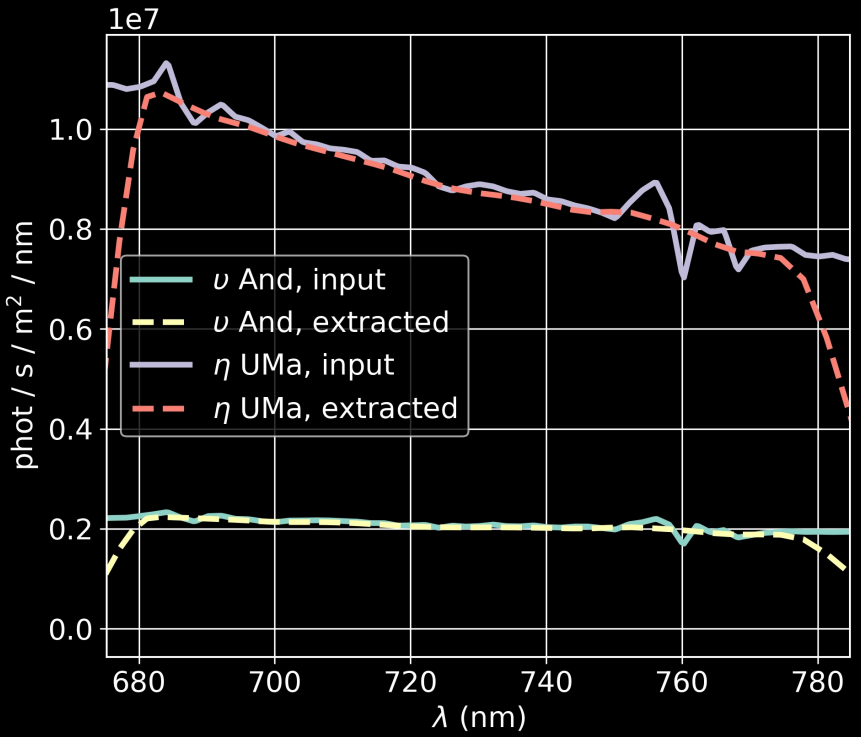
Noisy dispersed planet

Dispersed speckles (no planet)



Reference differential imaging

Expect SED mismatch between reference and target stars. Example: “blue” reference (eta UMa; B3V) and “red” target (ups And; F8V).

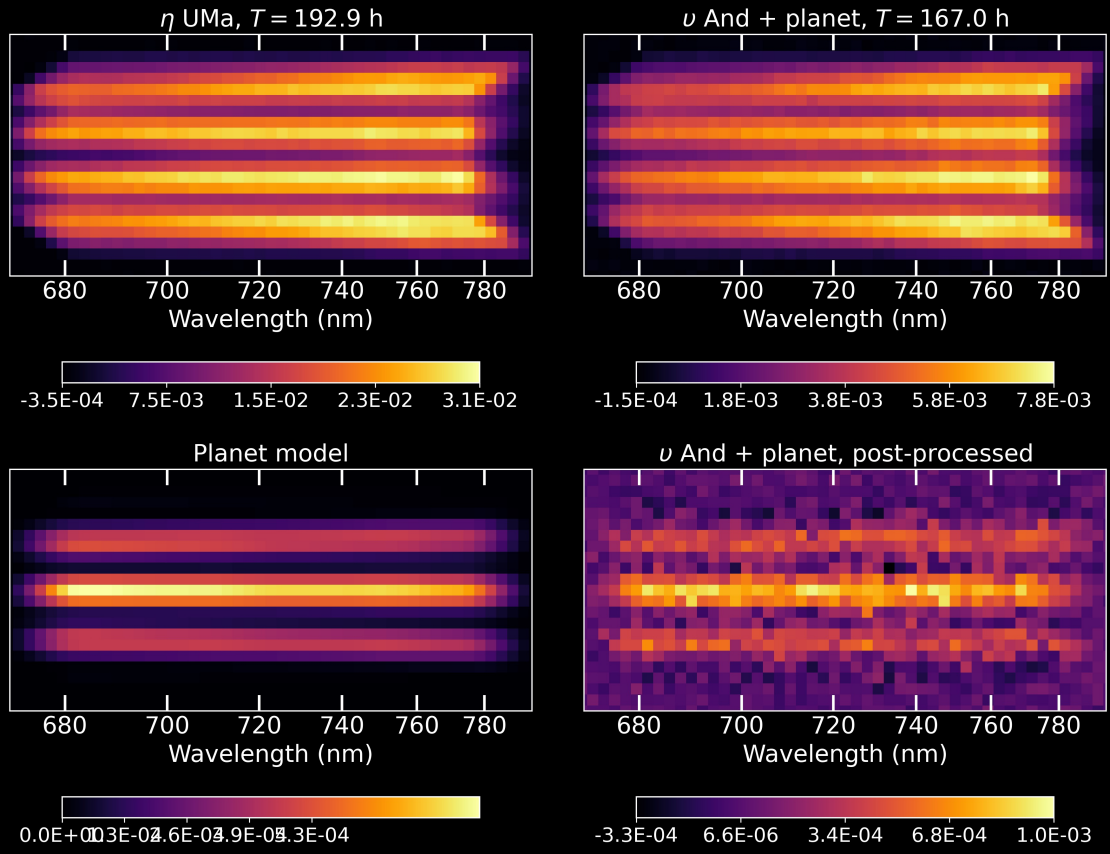


Reference differential imaging

1. Use unocculted star observations to measure their respective count rates as a function of wavelength.
2. Scale the dispersed reference speckle co-add image to compensate for the SED ratio.
3. Subtract the scaled reference speckle co-add from the dispersed planet co-add.

Reference differential imaging

Example of RDI with “blue” reference star (eta UMa; B3V) and “red” target (ups And; F8V)



Work remaining

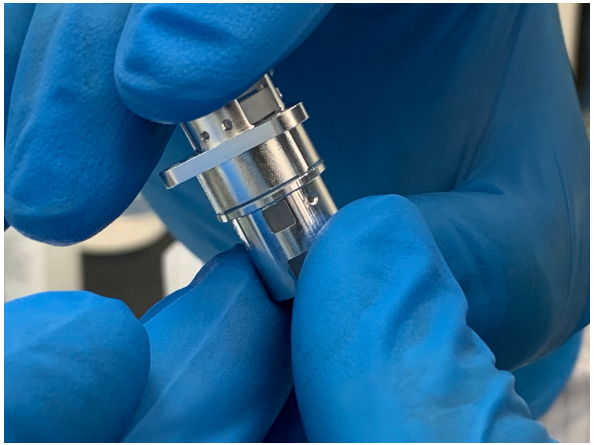
- Incorporate complete ExCAM EMCCD model, with QE variations.
- Continue evaluation of potential tech demo targets and atmosphere models.
- Investigate potential improvements in post-processing algorithms.

Summary

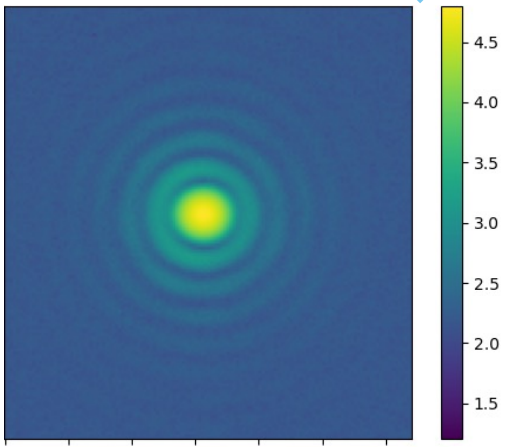
- Project has a framework for pixel-level spectroscopy data simulations based on STOP-model PSF time series (OS6 and OS9); code is not yet public.
- Simulation results have been used to define baseline algorithms for data calibration and post-processing.

ZOD prism assembly and test progress at GSFC

Arrival of flight hardware from JAXA

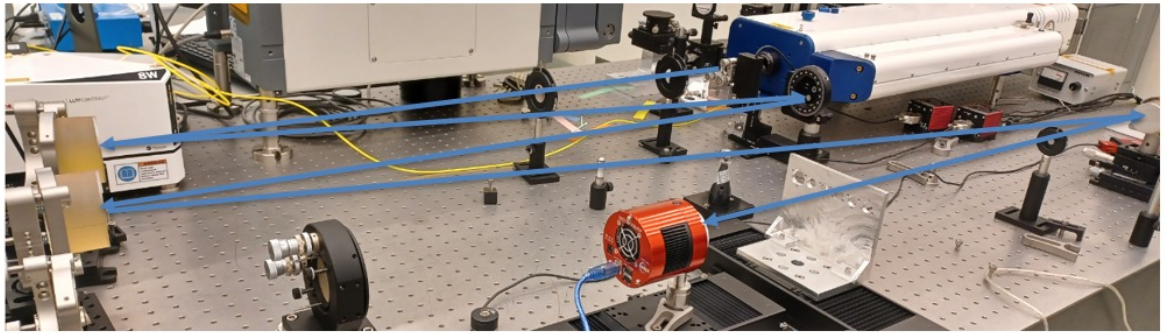


730 assembly EDU



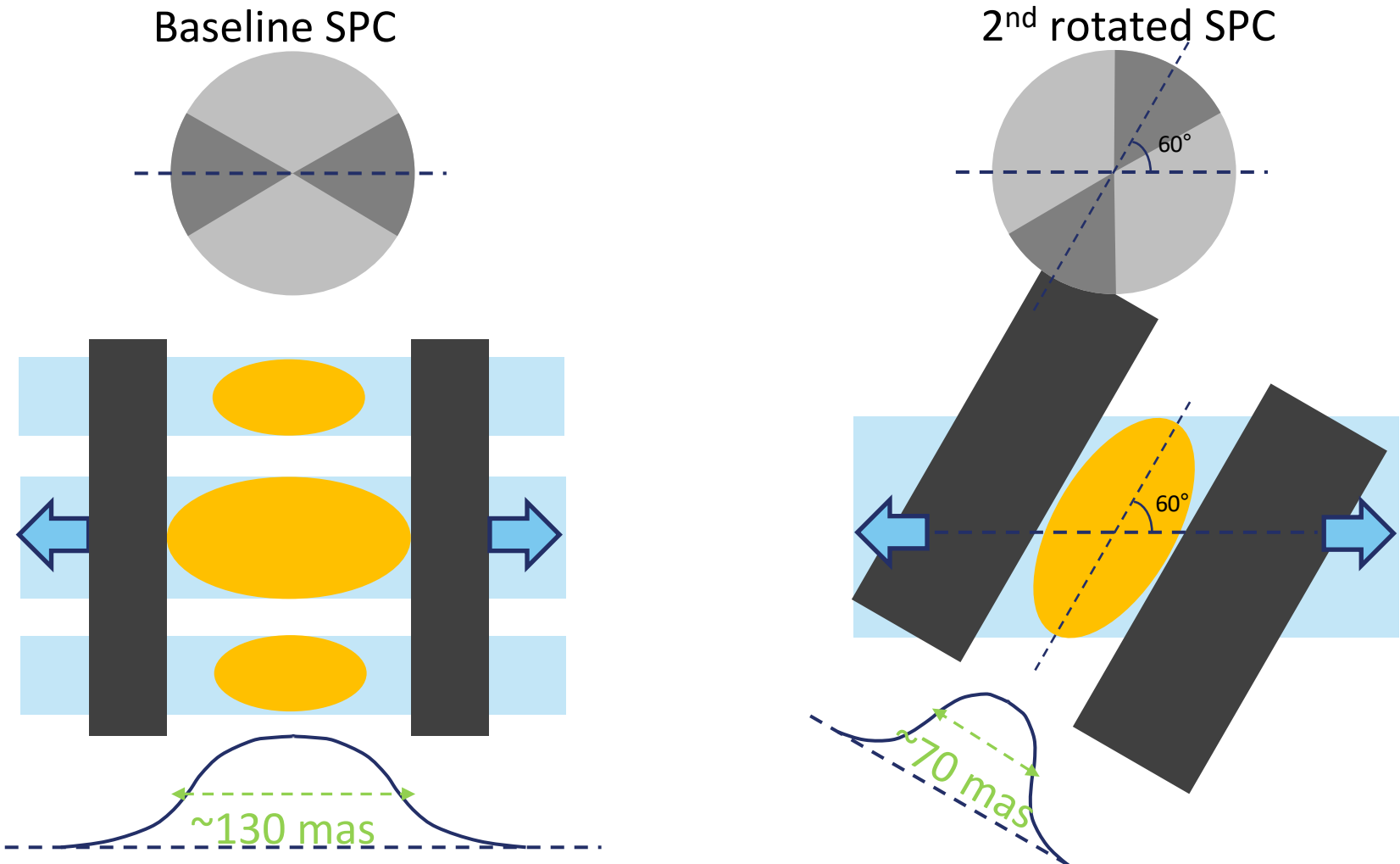
ZOD 730 prism “first light”

Photos by Tyler Groff & Hari Subedi



Optical testbed in Building 34 lab

BACKUP


Baseline SPC
2nd rotated SPC
60°
60°
~130 mas
~70 mas

Spectral resolution (simulated)