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

$5 \times 10^{-8}$ source at $3.9 \lambda/D$
Spectrally dispersed point source

5x10^{-8} source at 3.9 \lambda/D

Dispersed source on ExCAM
Spectrally dispersed point source

$5 \times 10^{-8}$ source at $3.9 \lambda/D$

Dispersed source on ExCAMS

Prism dispersion axis
Slit masks

FSAM field stop array layout with slit masks:
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).
Impact of speckles

Ideal dispersed planet

Noisy dispersed planet
Impact of speckles

- Ideal dispersed planet
- Noisy dispersed planet
- Dispersed speckles (no planet)
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
Spectral resolution (simulated)

- Measured from monochromatic PSF sweep
- Measured dispersion at \( \lambda = 730.0 \) nm: 203.30 nm/mm
- Requirement min/max dispersion

Graphs showing:
- \( \frac{d\lambda}{dx} \) (nm/mm) vs. Wavelength (nm)
- Spectral resolution \( R = \frac{\lambda}{\Delta \lambda} \) vs. Wavelength (nm)

- Measured \( R = 50 \) occurs at \( \lambda = 733.5 \) nm
- Requirement min/max wavelength