



**Jet Propulsion Laboratory**  
California Institute of Technology

# WFIRST Coronagraph Polarization Update – 11<sup>th</sup> Stanford Meeting

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- **Re-cap of science requirement on polarization**
- **Changes in optical design**
- **Discussion**



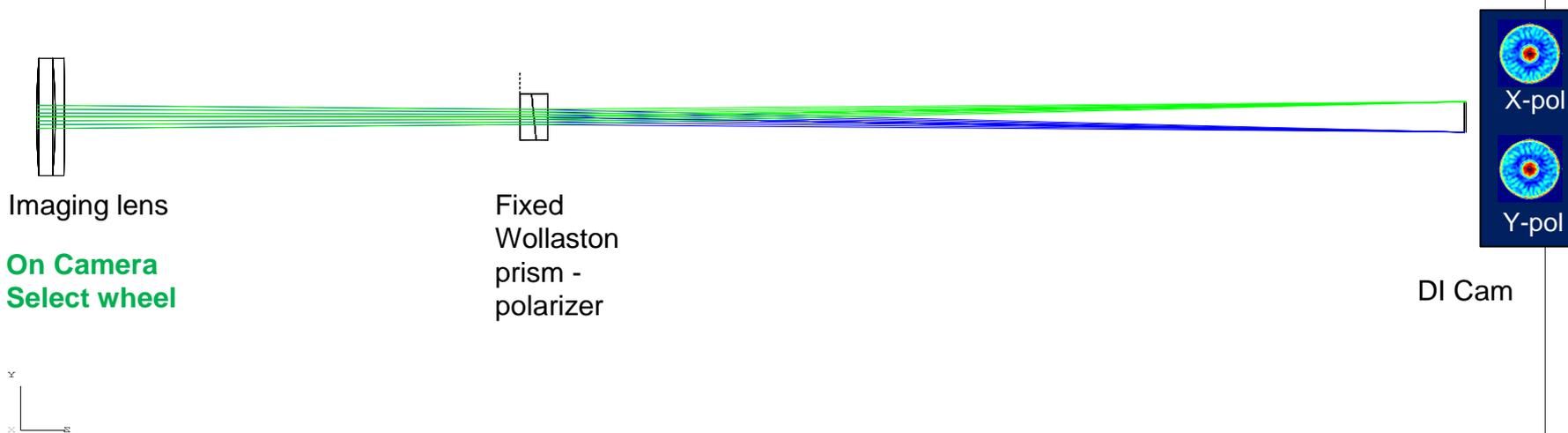
# Science Requirement on Polarization (Draft)



- ID: CGI-2.9
- **Short Name:** Polarization of Disks
- **Requirement:** WFIRST CGI shall be able map the linear-Stokes polarization of circumstellar disks to an accuracy of 5% assuming a photometric SNR per single resolution element of TBD.
- **Comment:** interest exists in determining the linear-Stokes polarization of exoplanets as well, but no requirement currently exists.

# WAS -- CGI Polarization design using Wollaston prism

- Direct Imaging Channel forms two linearly polarized images simultaneously
- No option for un-polarized images

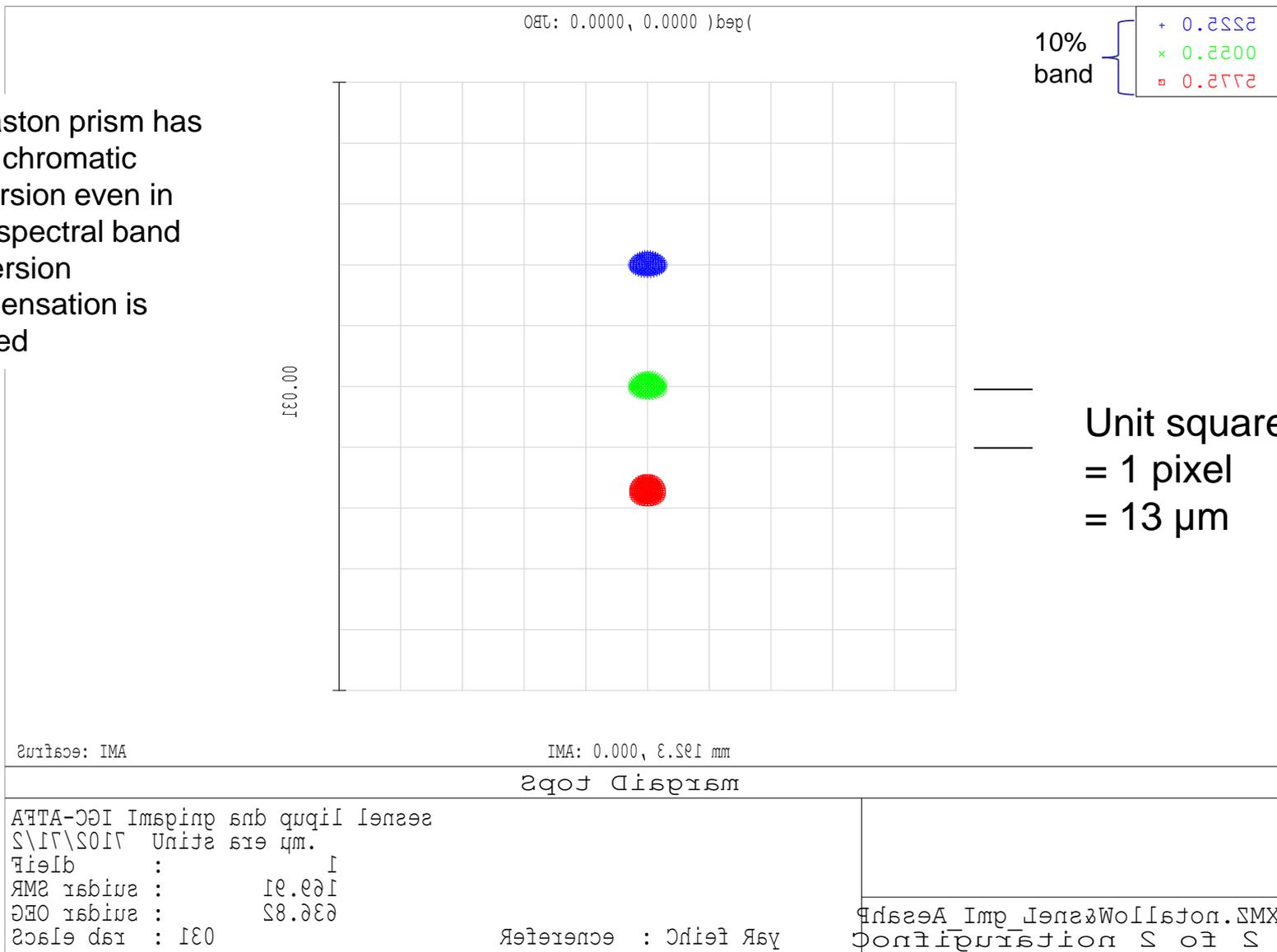


Courtesy of H. Tang

# Issue with Wollaston Prism -- Dispersion



- Wollaston prism has large chromatic dispersion even in 10% spectral band
- Dispersion compensation is needed



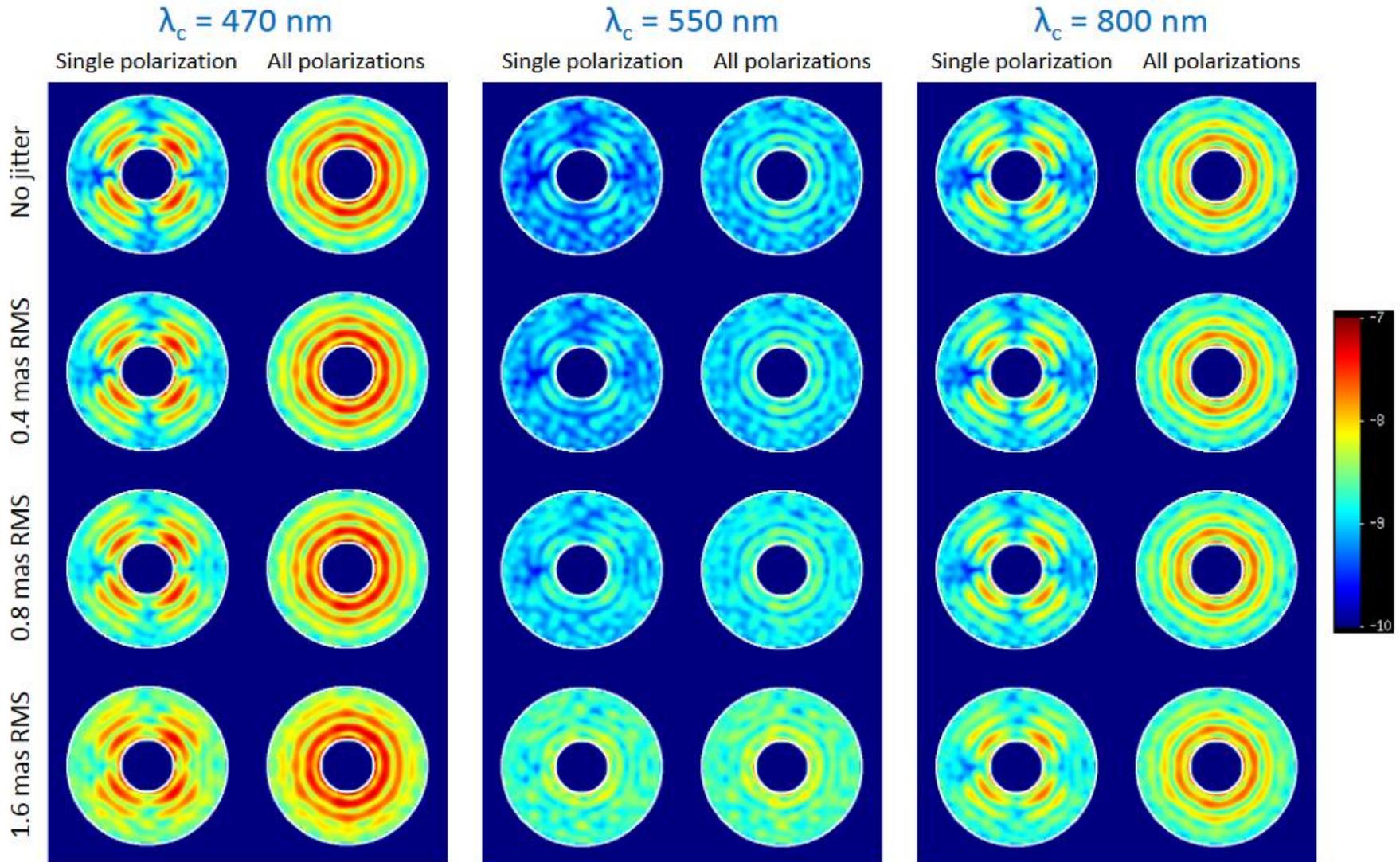
Courtesy of H. Tang

# Polarization: throughput (SNR) considerations



- **A deeper dark hole can be created in one linear polarization than in unpolarized light, particularly for HLC.**
  - Difference varies by mode (HLC vs. SPC) and wavelength band
- **Hence a trade-off of deeper raw contrast vs. 50% lower throughput**
- **Depending on the target and CGI observing mode, it will be advantageous to observe some targets in one linear polarization and others in unpolarized light**
  - This refers to observations not focused on polarization science

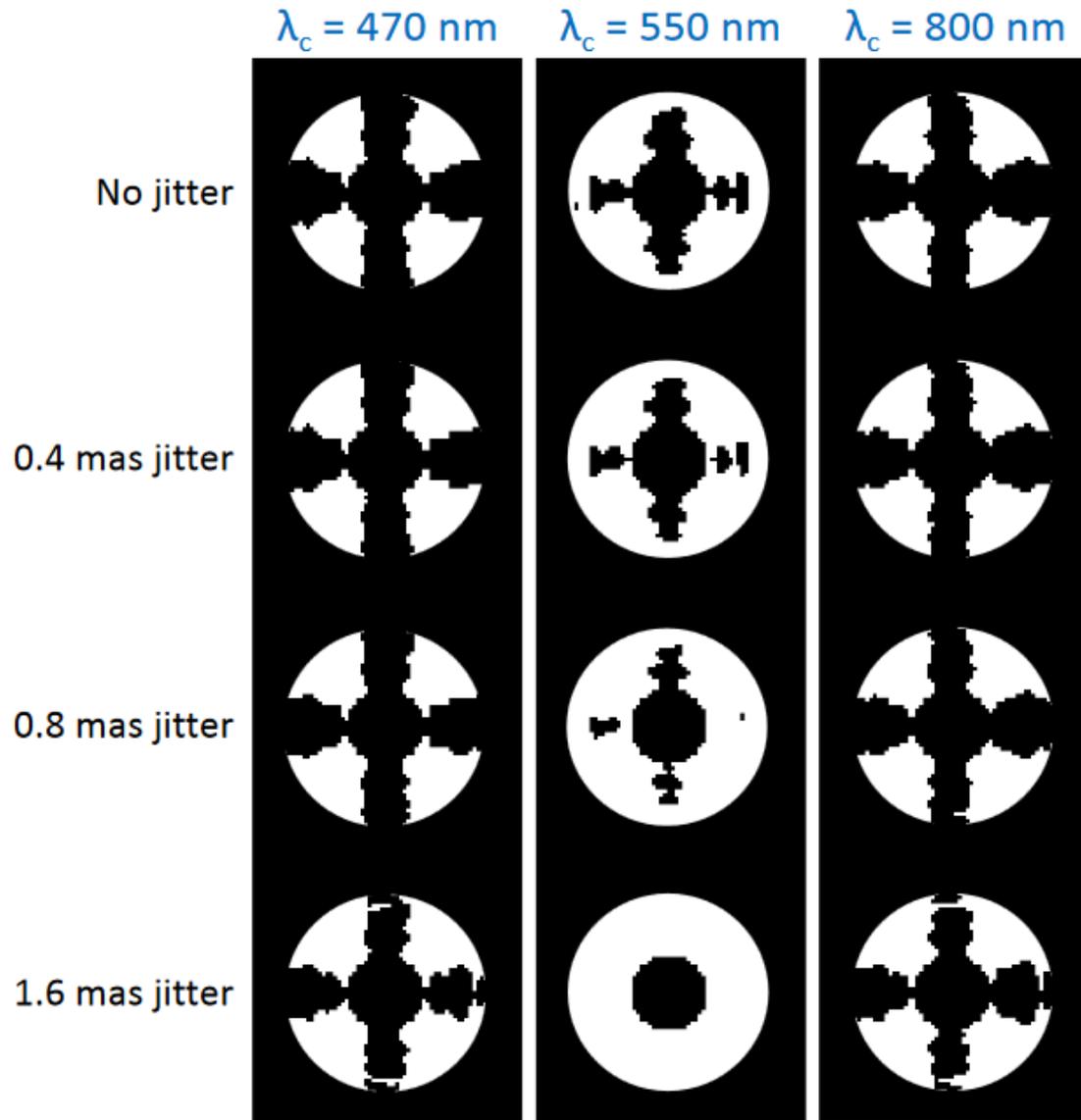
# HLC with Polarization and Jitter



Images with all polarizations (x+y) win in many cases

Courtesy of J. Krist

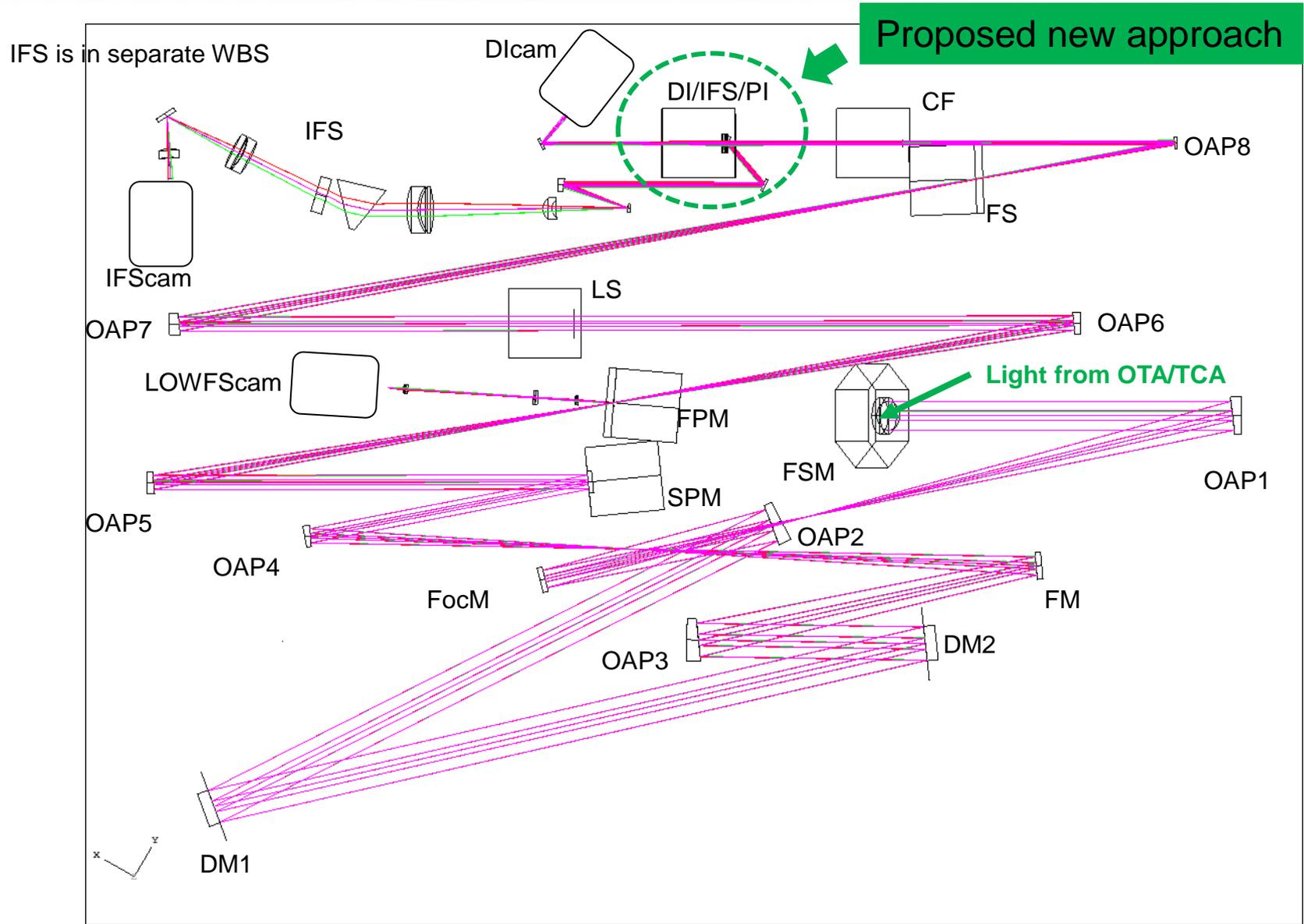
# Where No Polarization Splitting is Equal to or Faster than Splitting to Reach the Same SNR



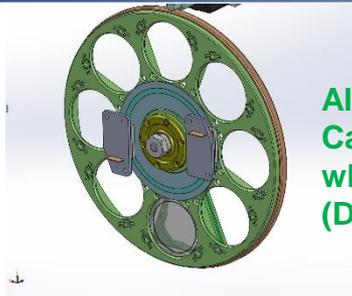
➔ Shall have the option of unpolarized images (i.e. images with all polarizations)

Courtesy of J. Krist

# CGI Optical Layout - Top View

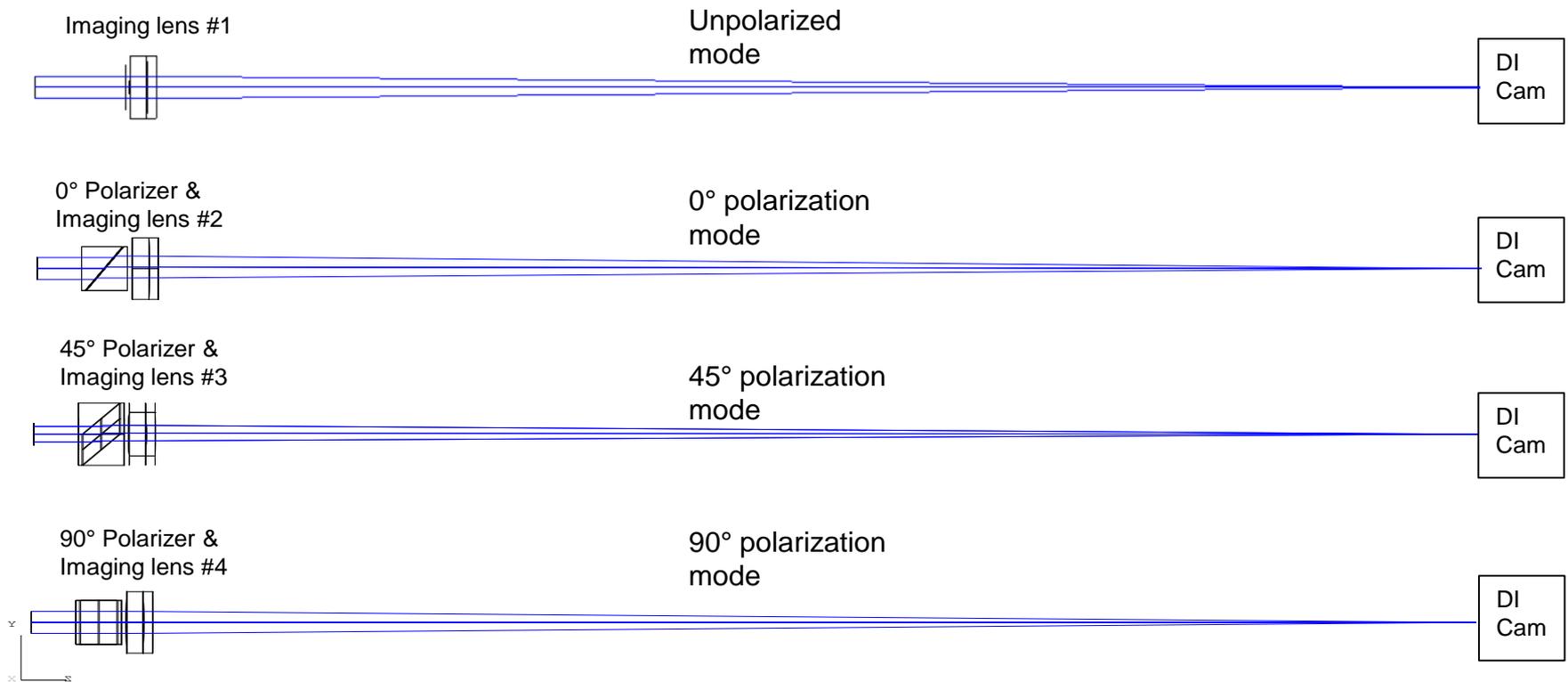


Courtesy of H. Tang

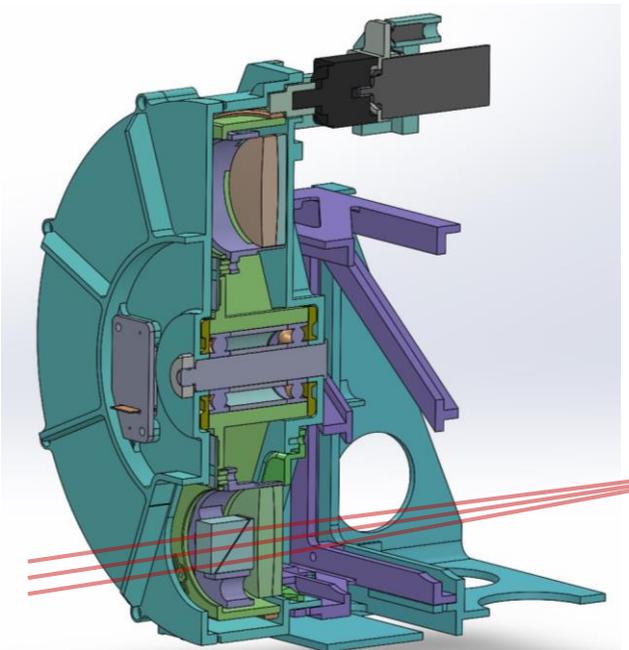
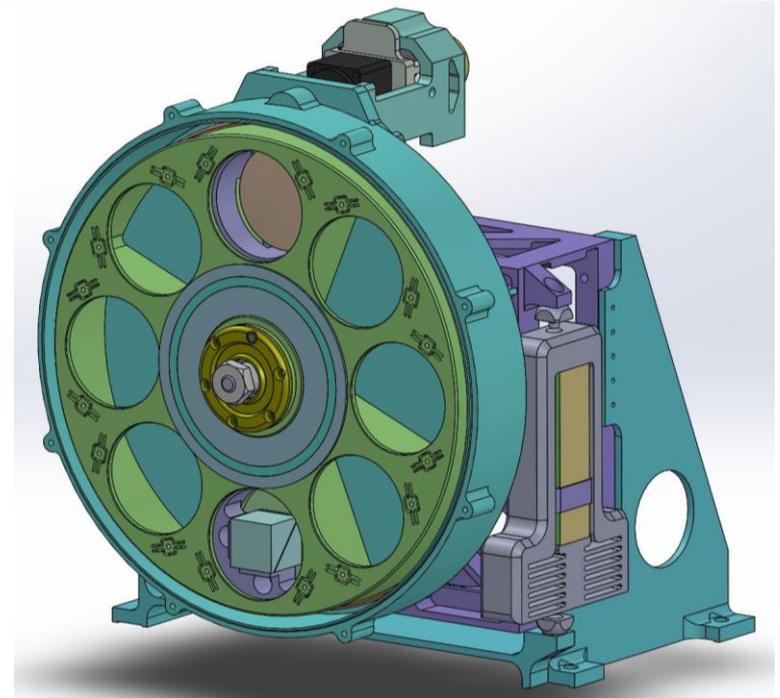
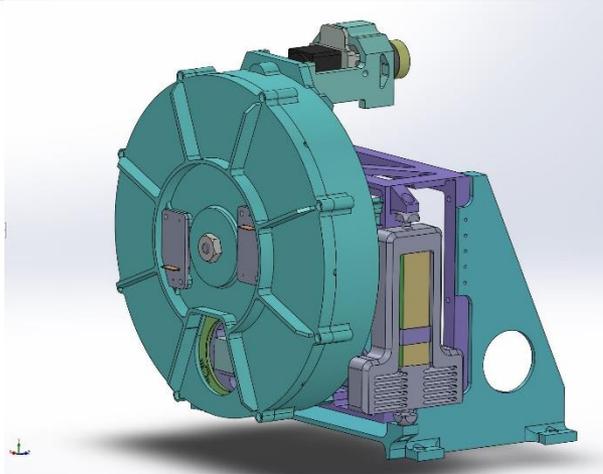


All lenses on  
Camera Select  
wheel  
(DI/IFS/PI)

- Provides a single unpolarized image (Mode #1) with higher throughput
- Meets requirements of polarization imaging (Modes #2, 3 and 4)



# Polarizer and Lens in Wheel

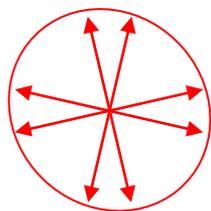


- 12 slots (enough for new baseline)
- Optic diameter 14 mm fits the slot size

- **4 images of exoplanet system**

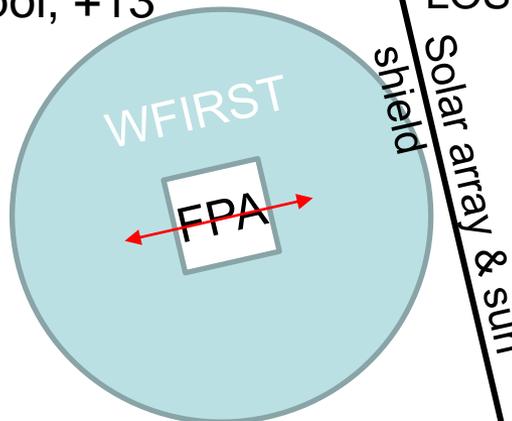
X pol, +13°

- **All sampled polarization axes**

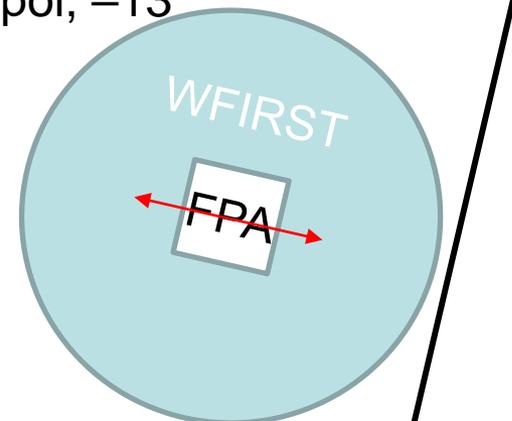


- **4 samples of the linear polarization state at each location in the image**

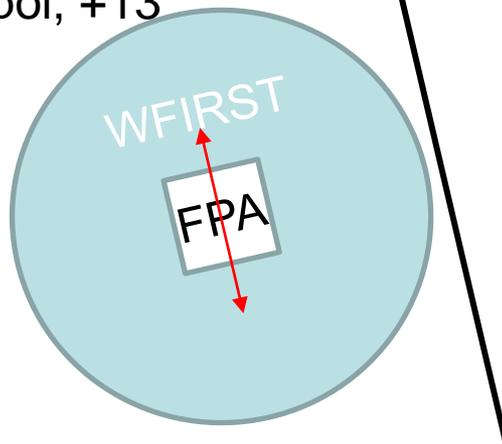
- Stokes params I, Q, U
- Excludes circular



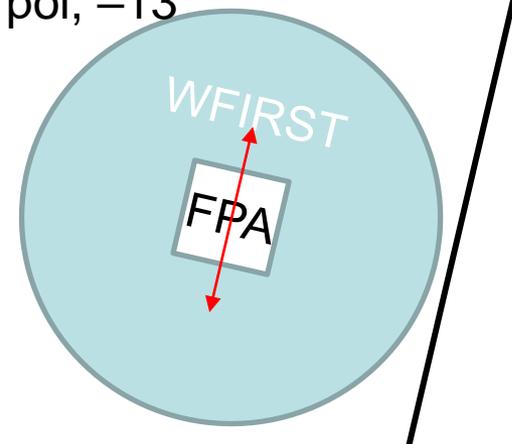
View of observatory, imager, and polarization axis, seen along the LOS X pol, -13°



Y pol, +13°



Y pol, -13°



## Propose:

- **Drop Wollaston prism design**
- **Adopt new polarization design with: (1) un-polarized; (2) 0-deg linear; (3) 45-deg linear; (4) 90-deg linear images**