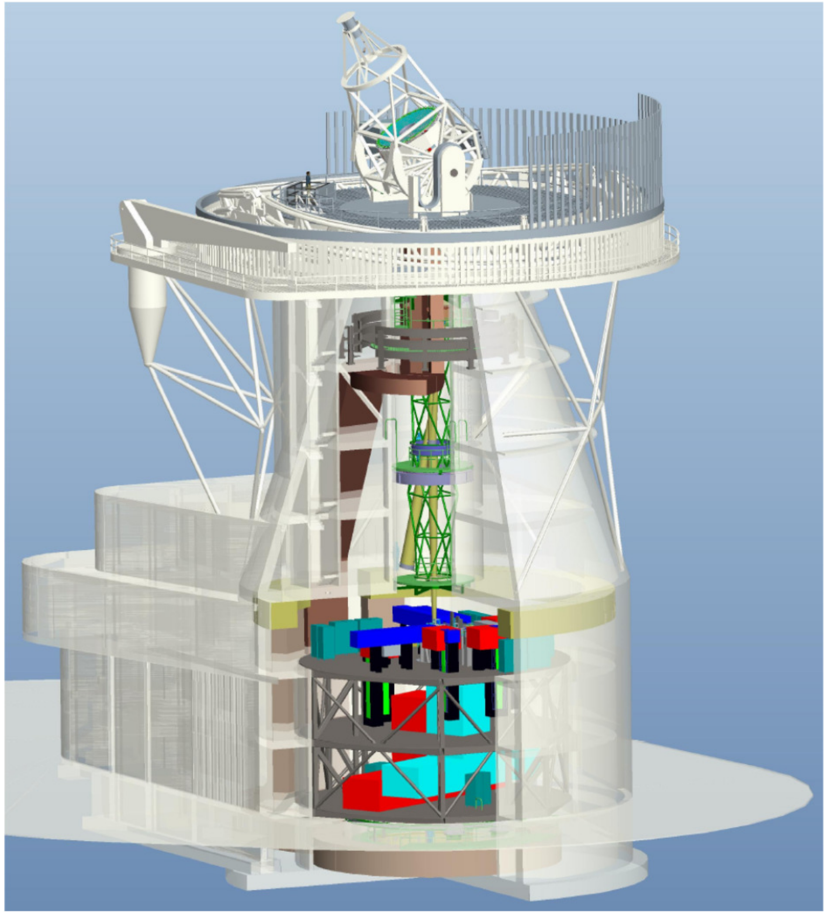
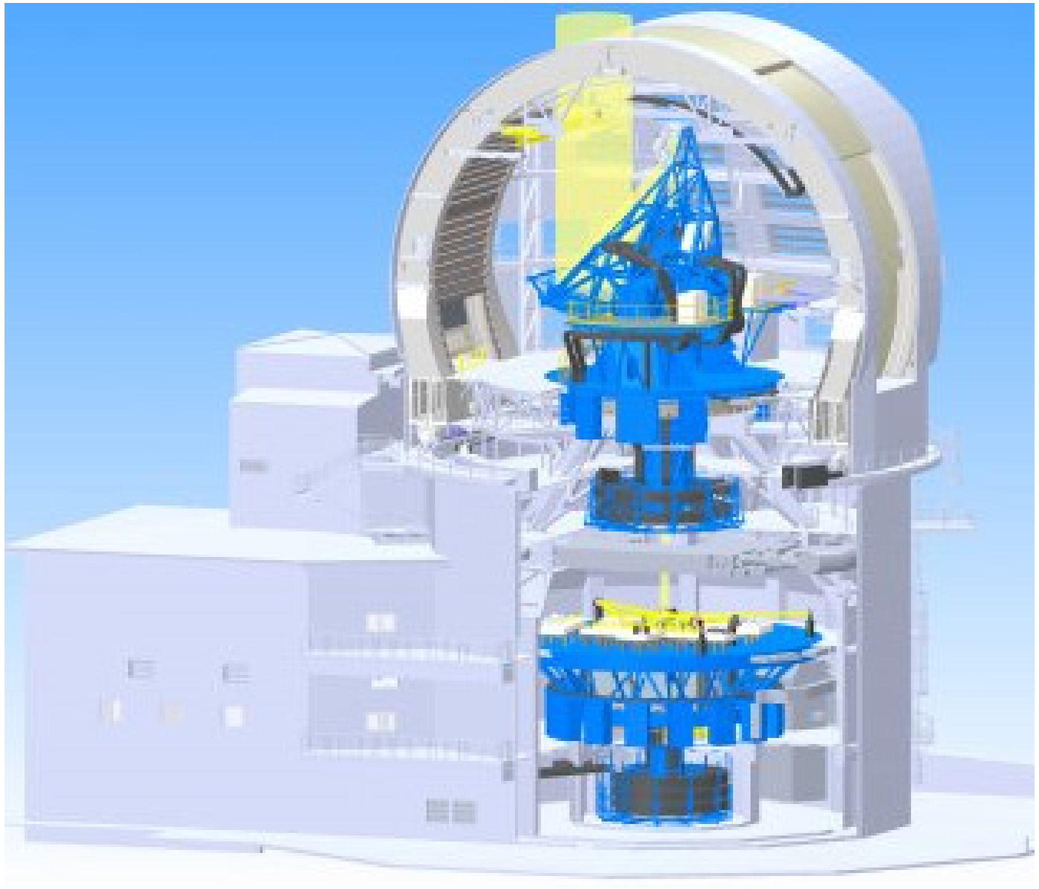
POLARIMETRY with EST and DKIST

M. Collados

Instituto de Astrofísica de Canarias





EST – 2026
Canary Islands

DKIST – 2019
Hawaii

Advantages of ground-based observations:

1. Large telescopes: increased spatial resolution
   or larger photon flux
1. Flexibility for wavelength selection
   (and simultaneous observations)
3. Photospheric, chomospheric measurements
4. Coronal measurements
5. Instruments upgrade and new technical
   developments

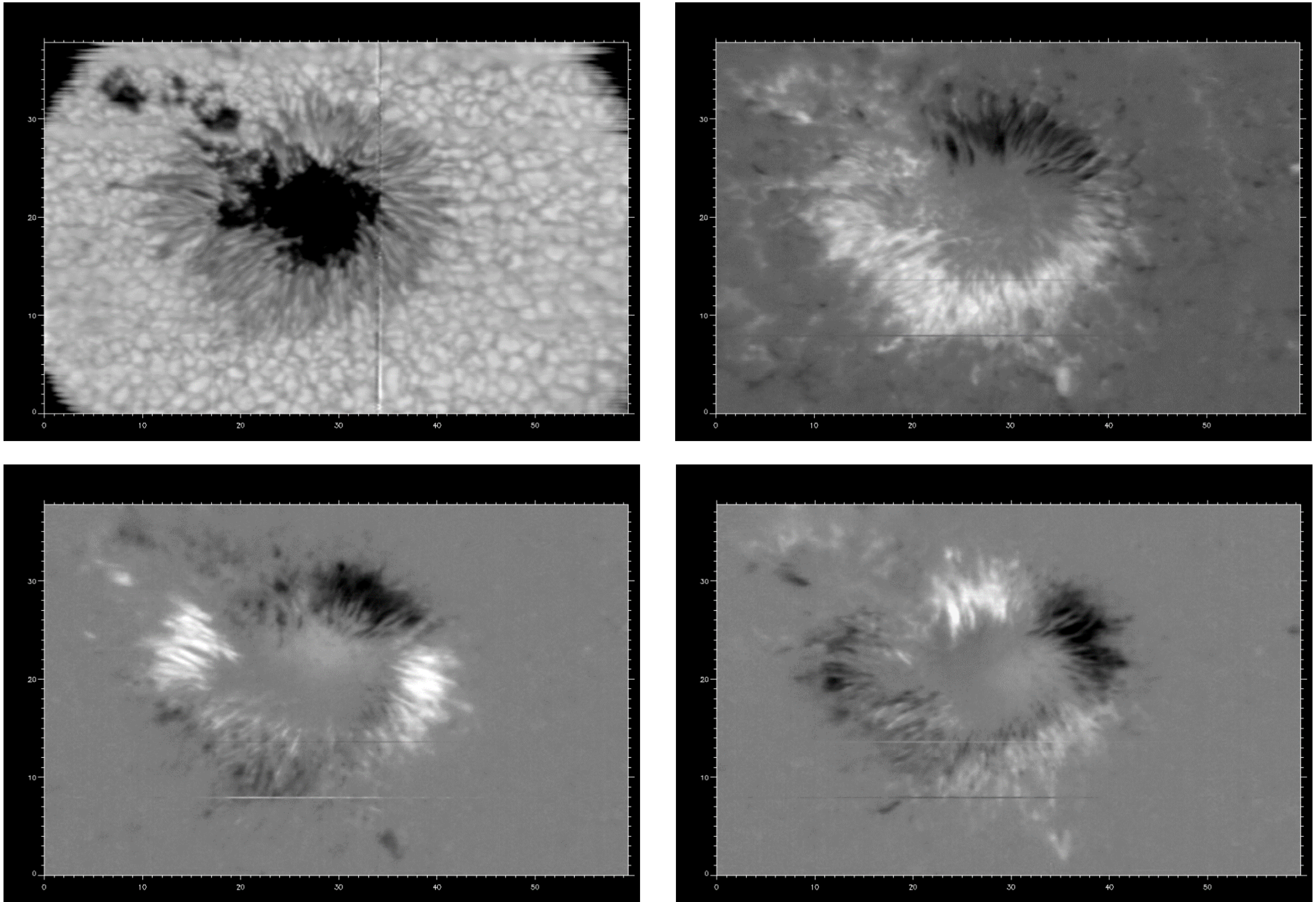
Observable Targets

- Photosphere
  - ❖Sunspots and active regions (KG)
  - ❖Quiet sun (hG)
  - ❖ …
- Chromosphere
  - ❖Prominences/filaments (tens of Gauss)
  - ❖Spicules (tens of Gauss)
  - ❖ …
- Corona (Gauss)

Science Goals

- Magnetic field topology
- Magnetic field instabilities
- MHD wave generation and propagation
- MHD wave transformation
- Shock waves
- Reconnection
- Partial ionization effects
- …

Photosphere - Sunspots



I

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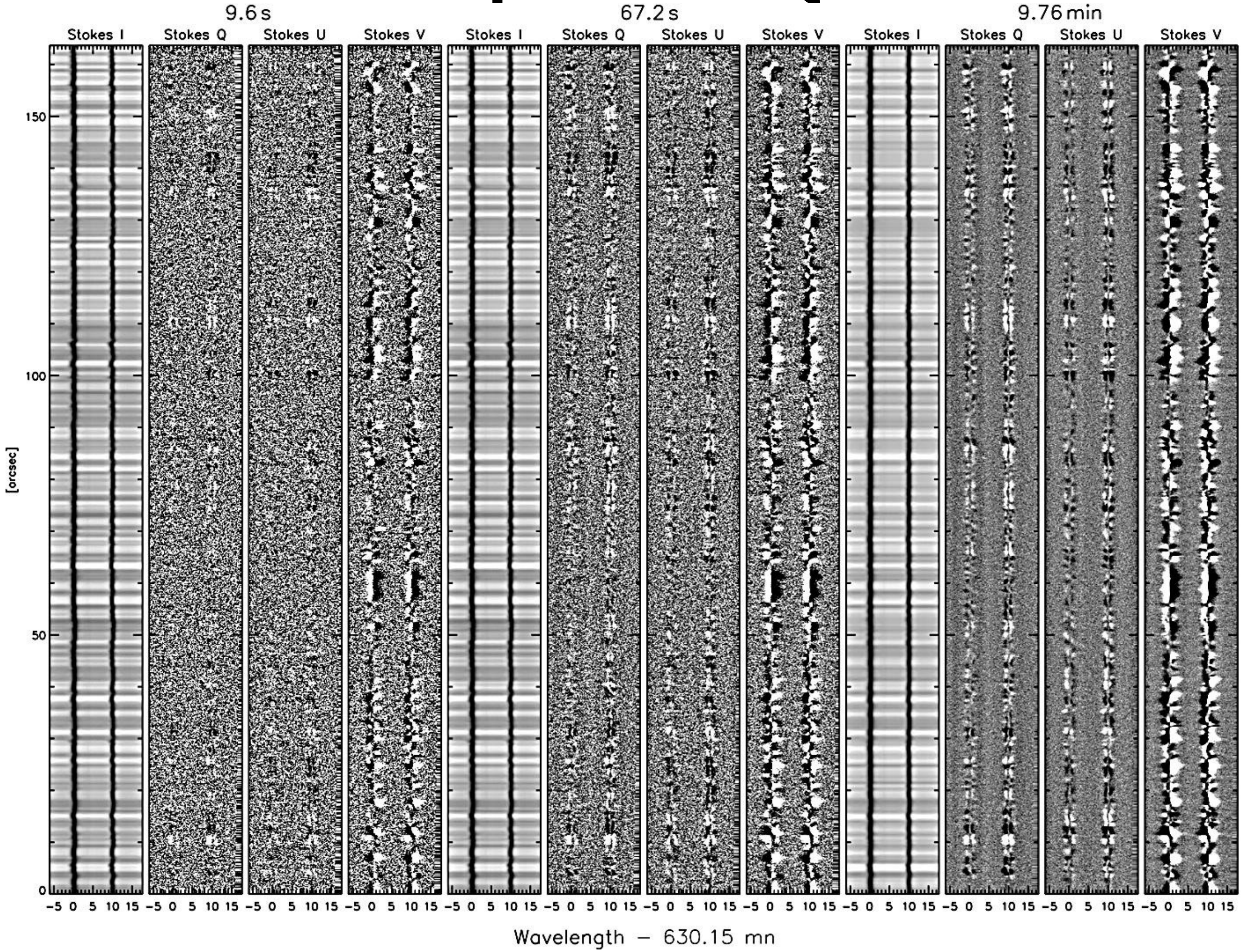
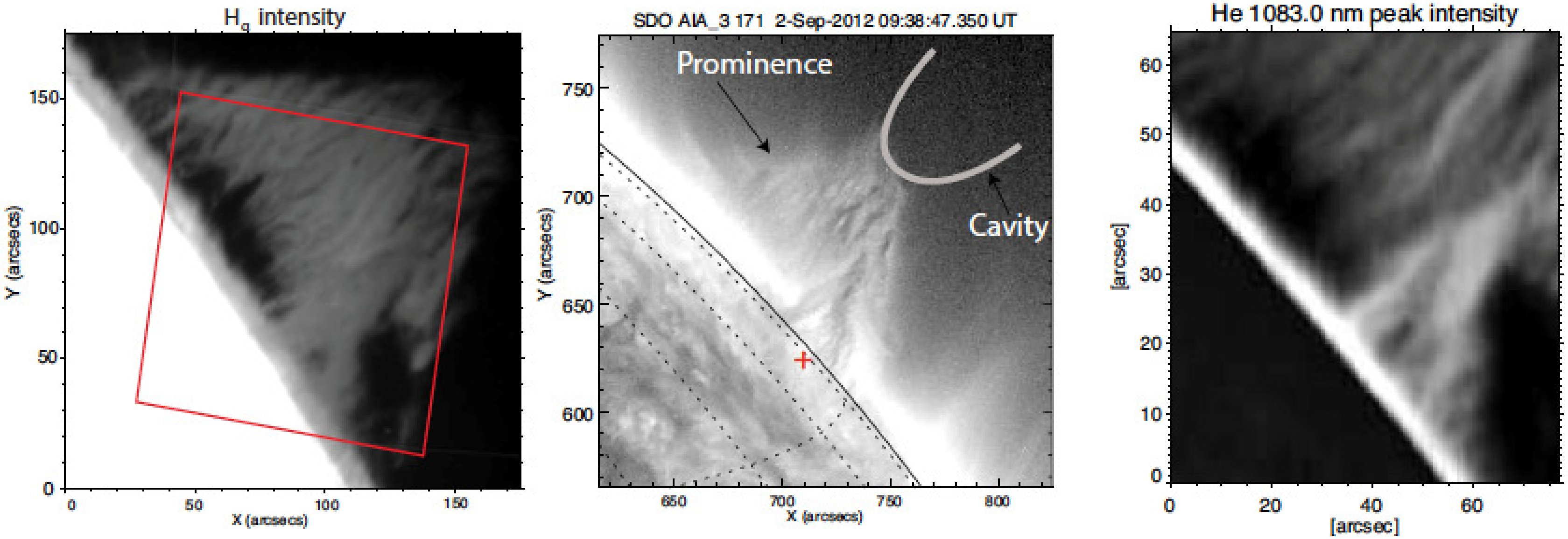
Photosphere – Quiet Sun



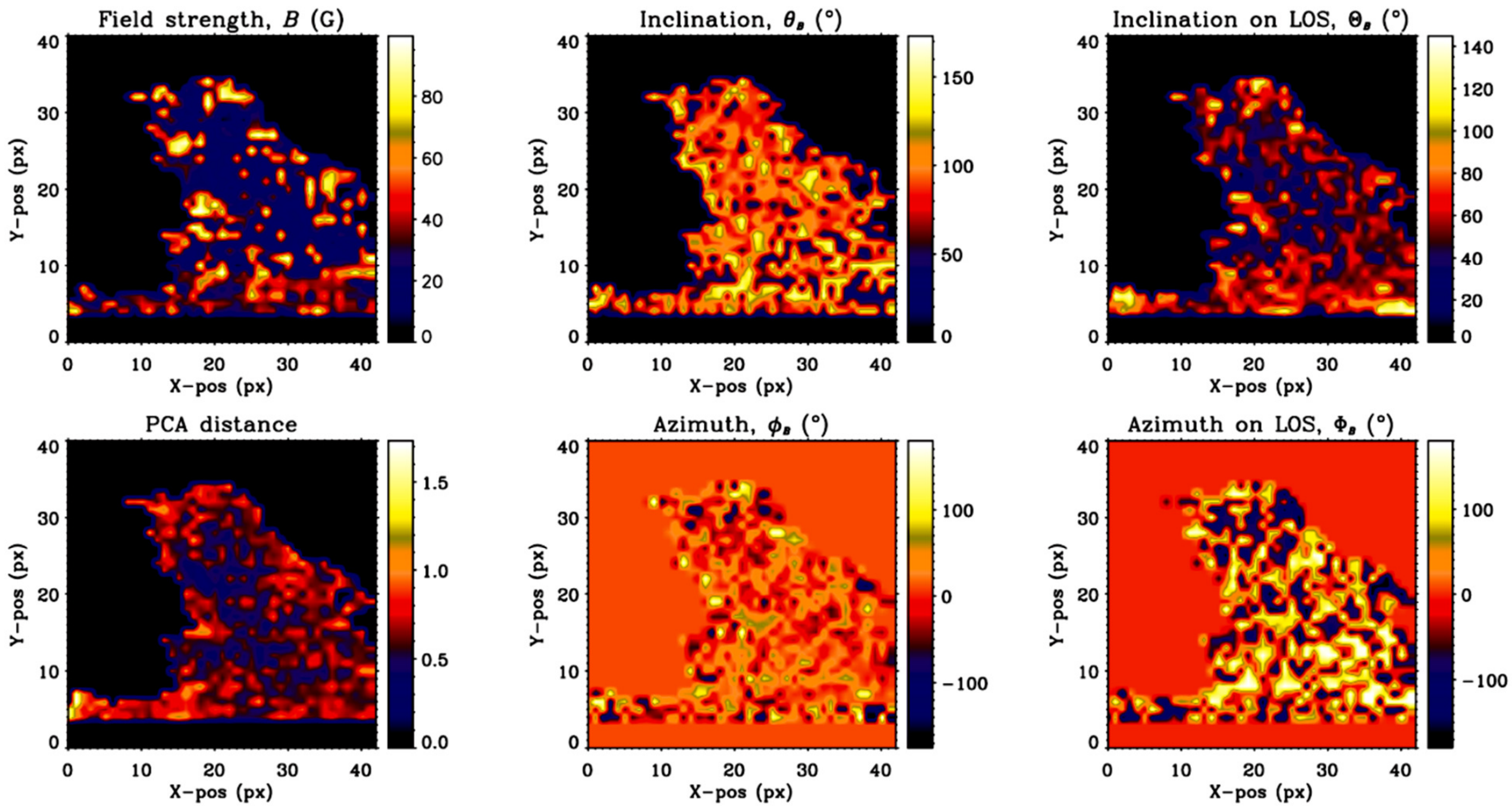
Bellot Rubio and Orozco Suárez (2012)

Chromosphere – Prominences



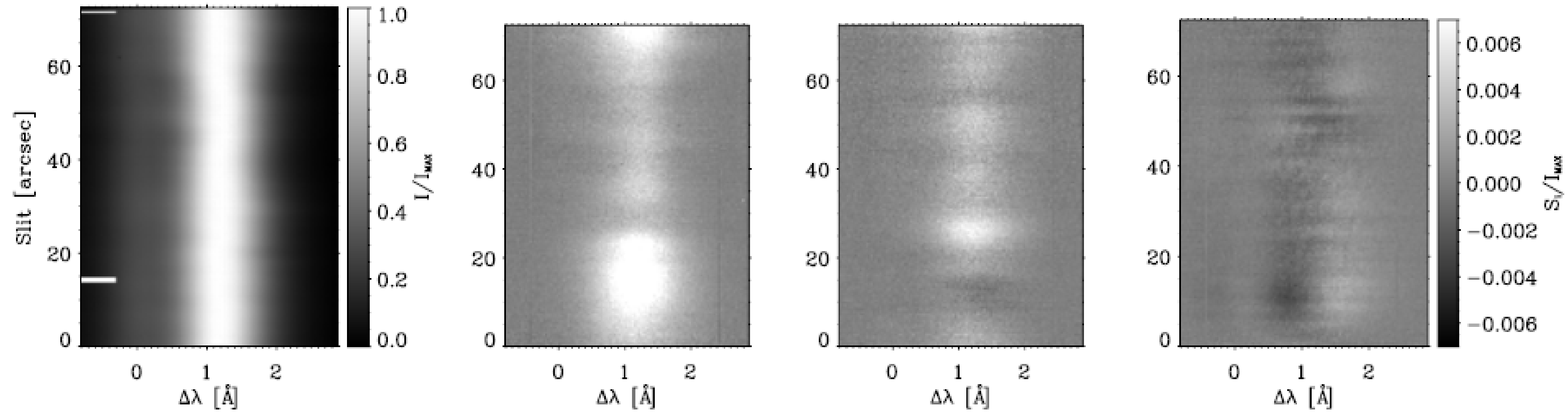
Courtesy of David Orozco Suárez

Chromosphere – Prominences

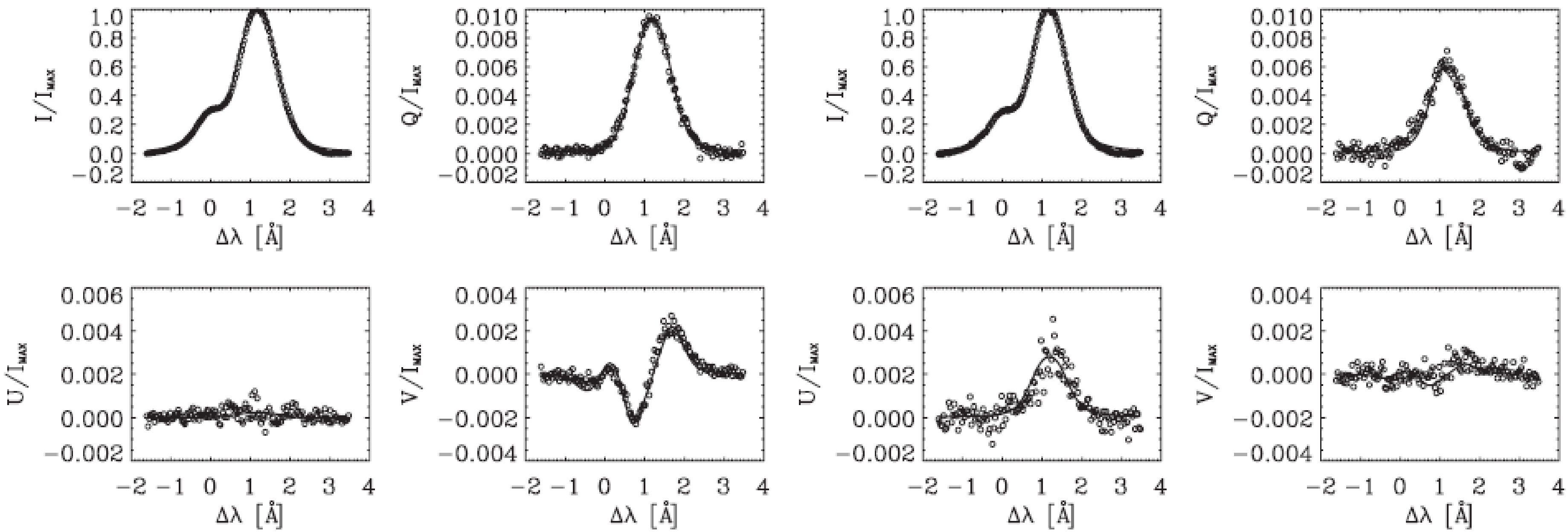


Casini et al (2003)

Chromosphere – Spicules



Centeno et al (2010)



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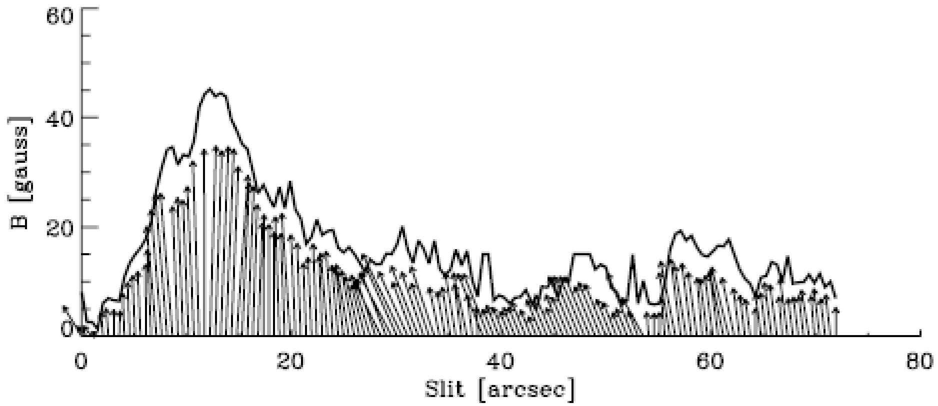
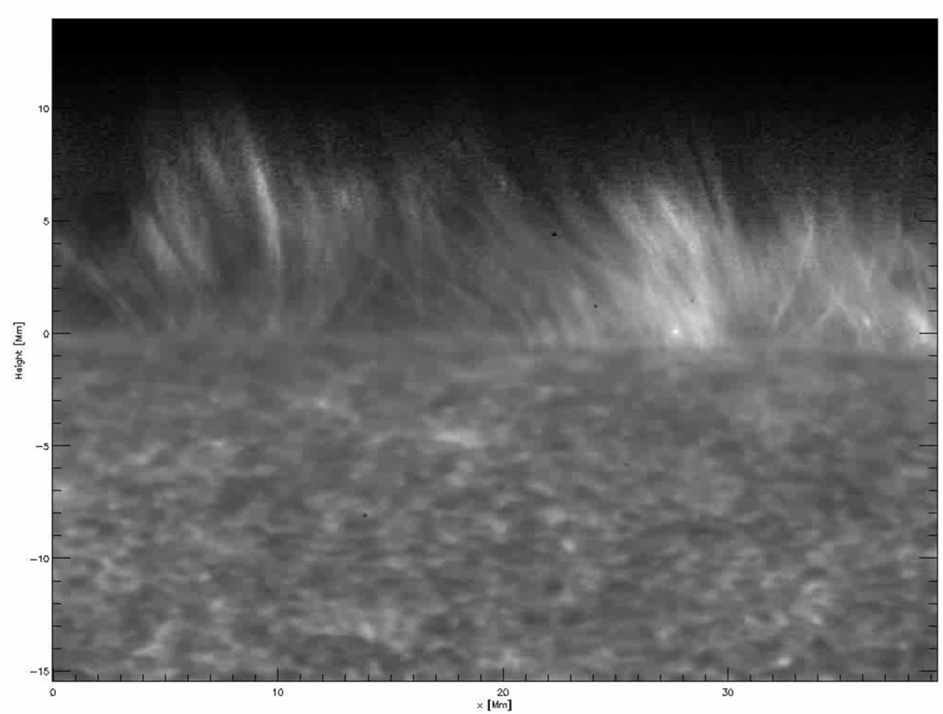
Chromosphere – Spicules

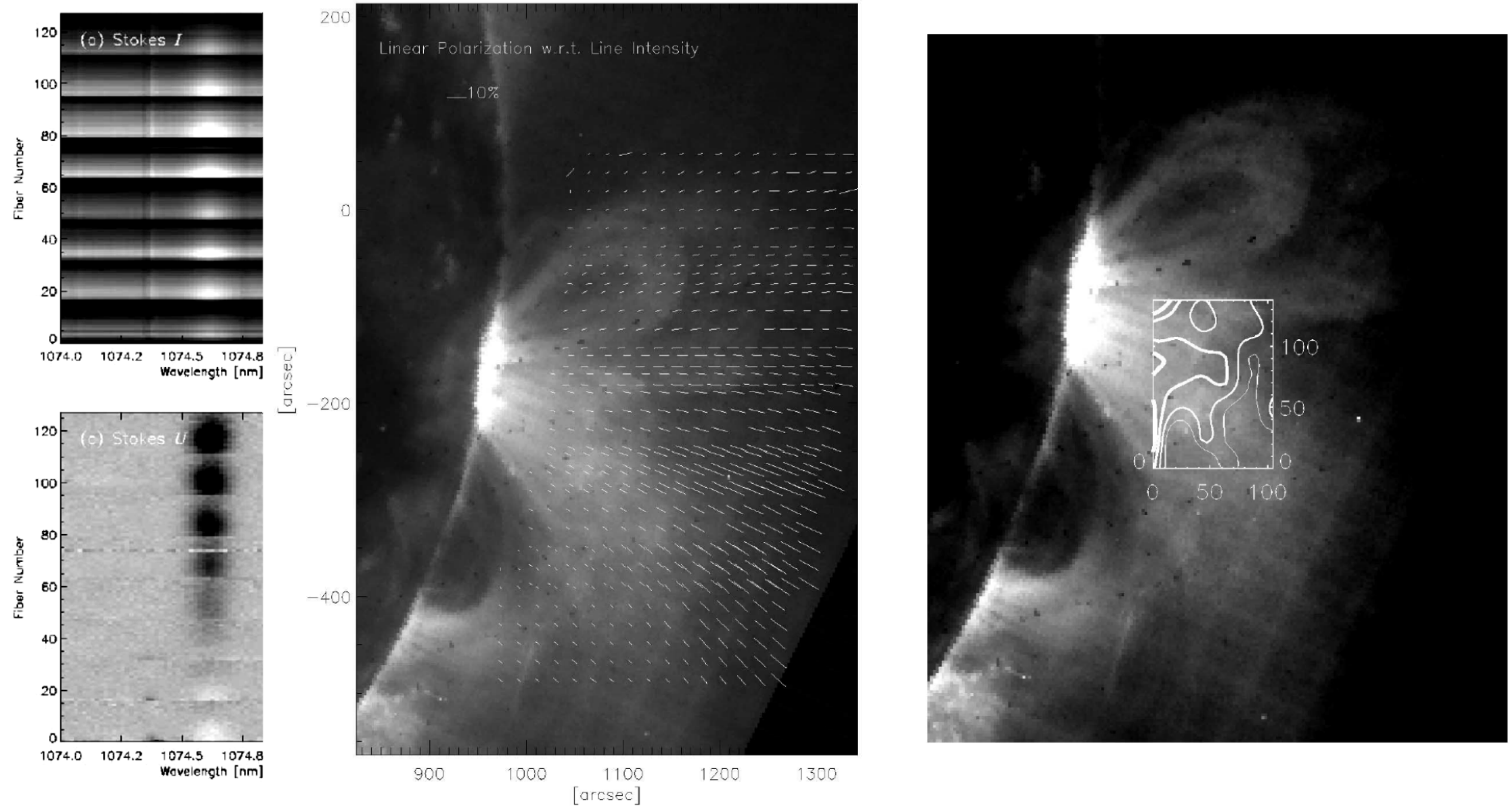


Centeno et al (2010)

De Pontieu et al (2007)

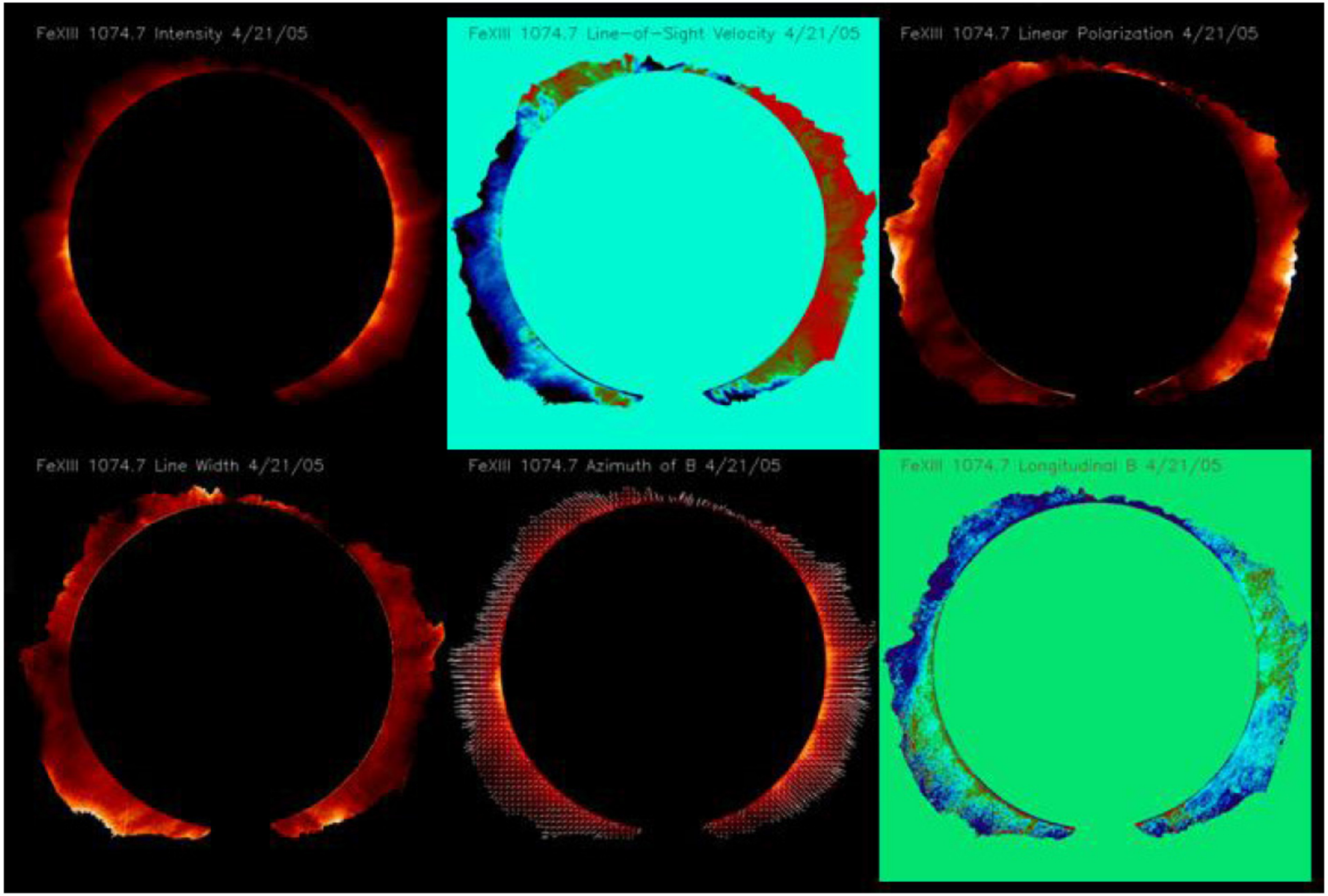


Coronal measurements



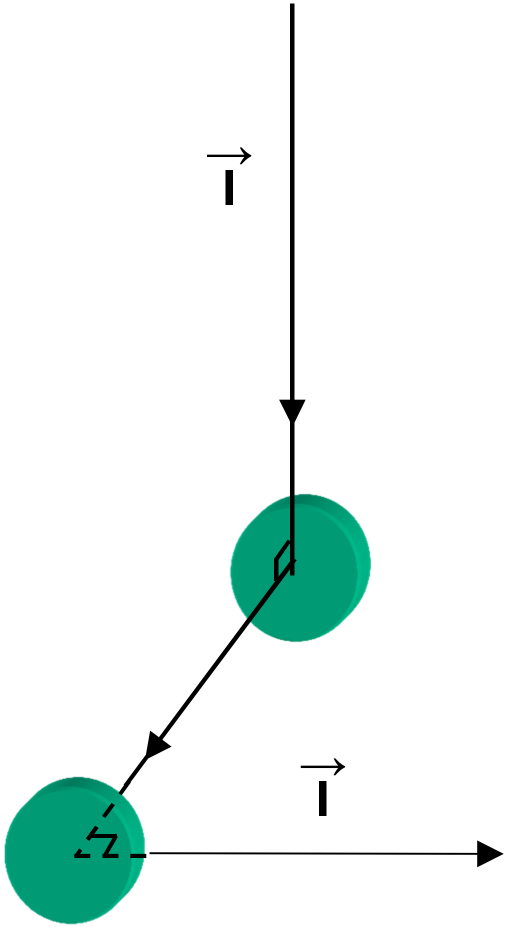
Lin et al. (2004)

Coronal measurements



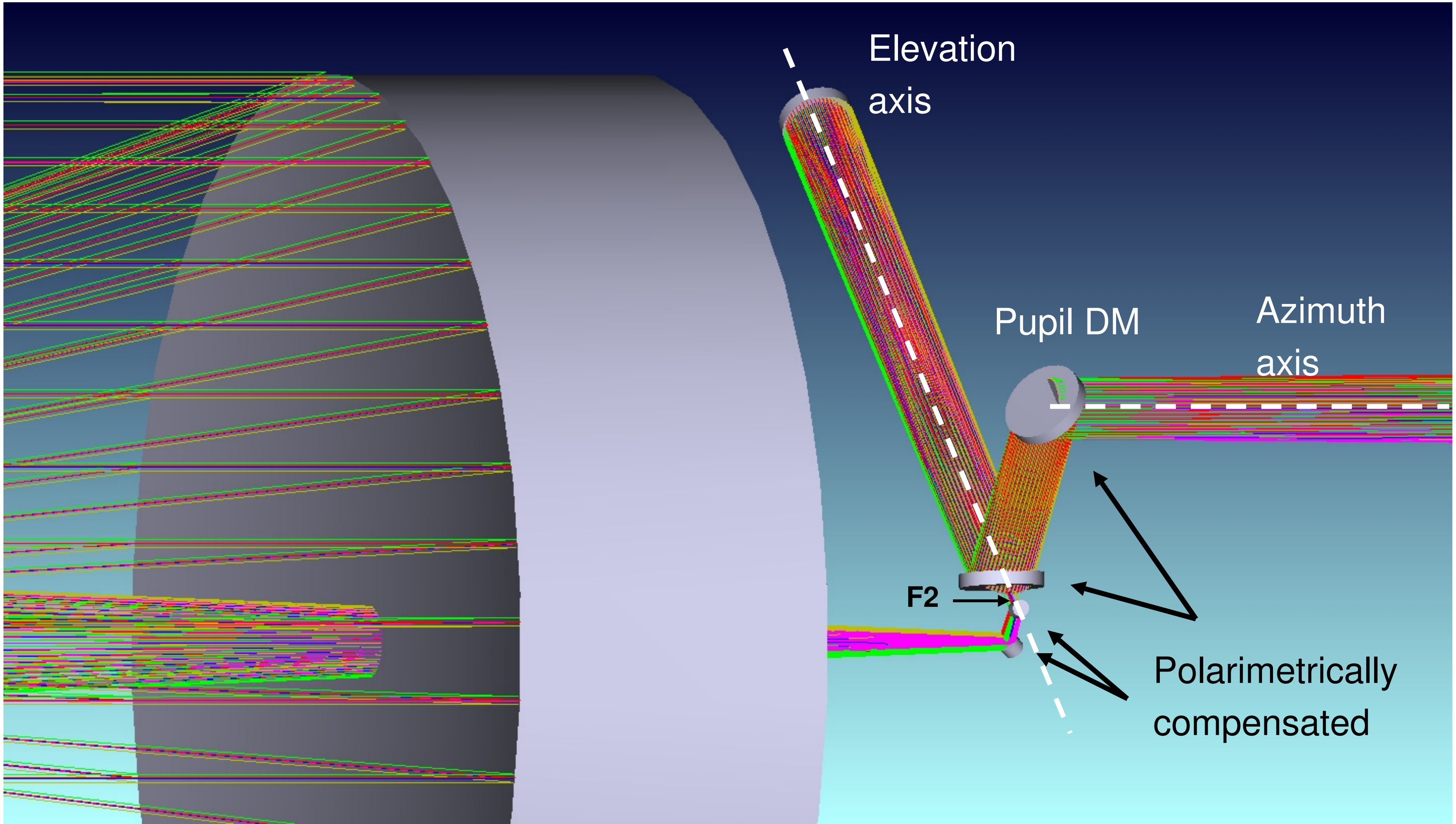
COMP - Tomczyk et al (2007)
CorMag – Fineschi et al (2014)

Two perpendicular mirrors compensate their instrumental polarization



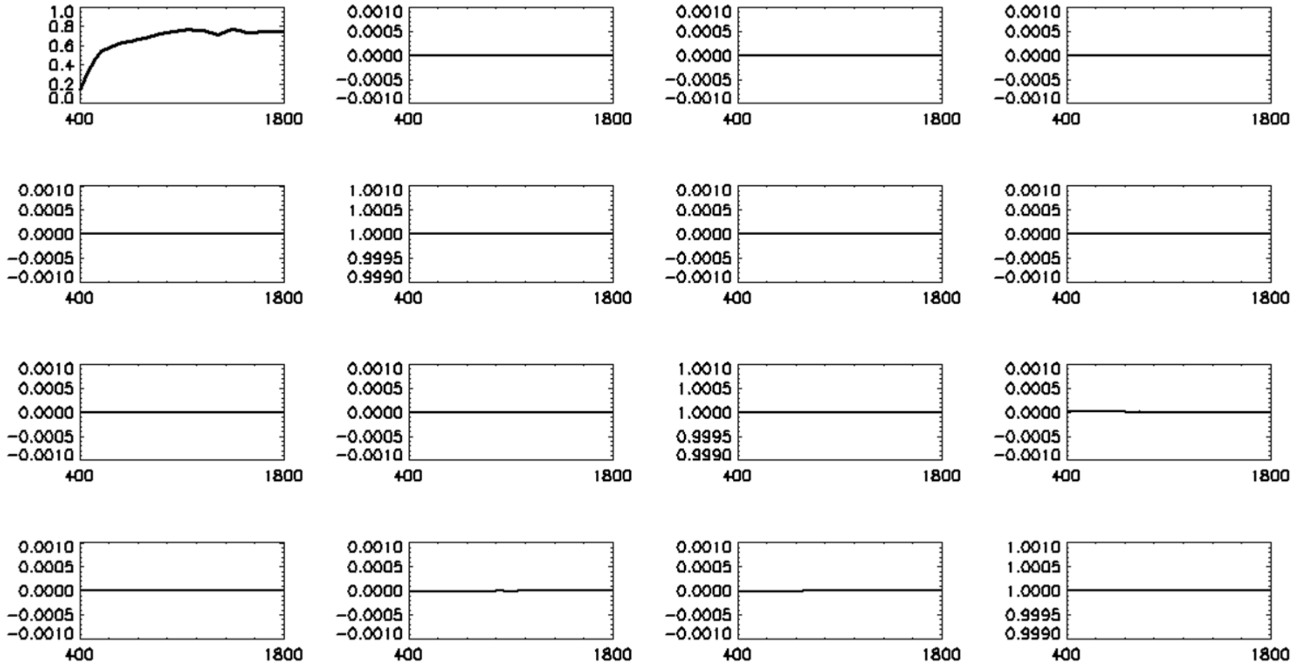
EST

EST: POLARIMETRICALLY COMPENSATED DESIGN

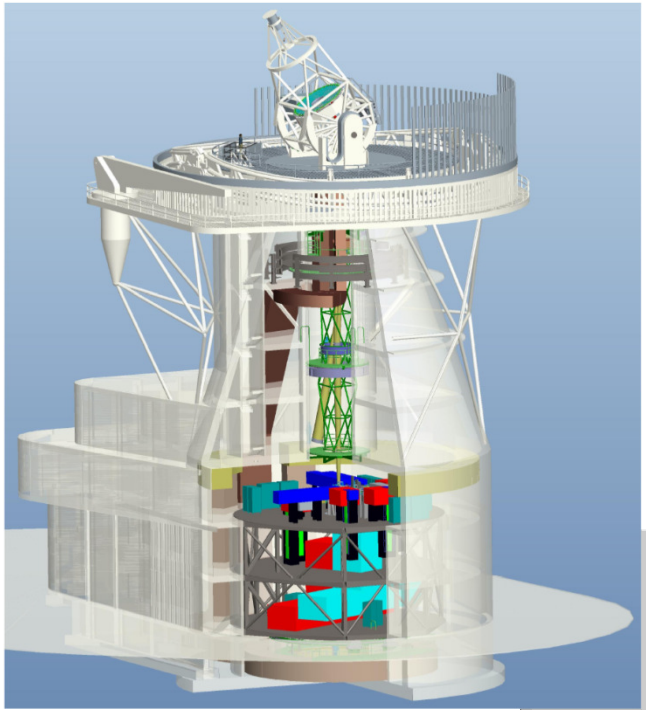


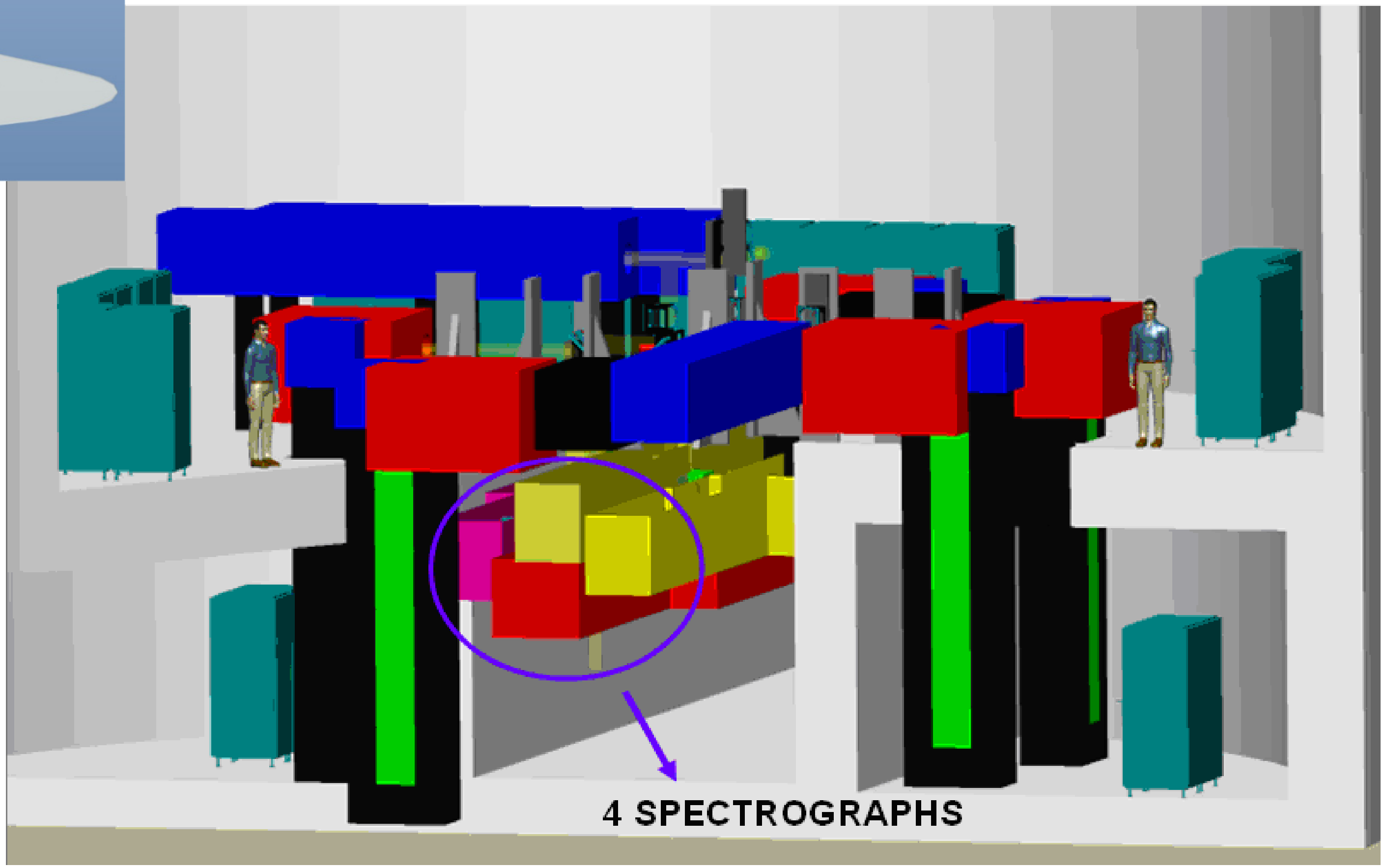
EST

- Telescope Mueller Matrix is Unity for all wavelengths and independent of:
  - Elevation
  - Azimuth



EST





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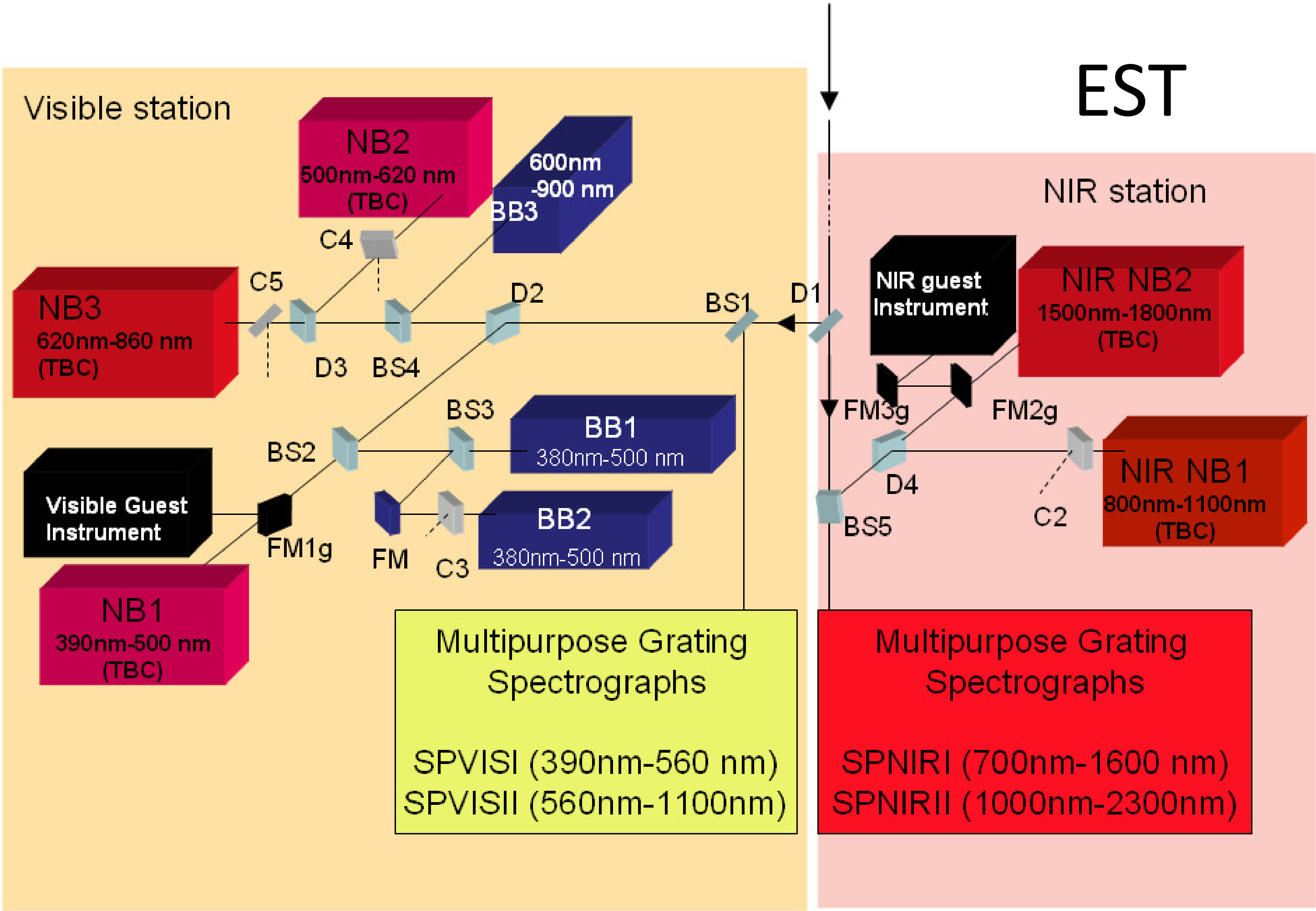
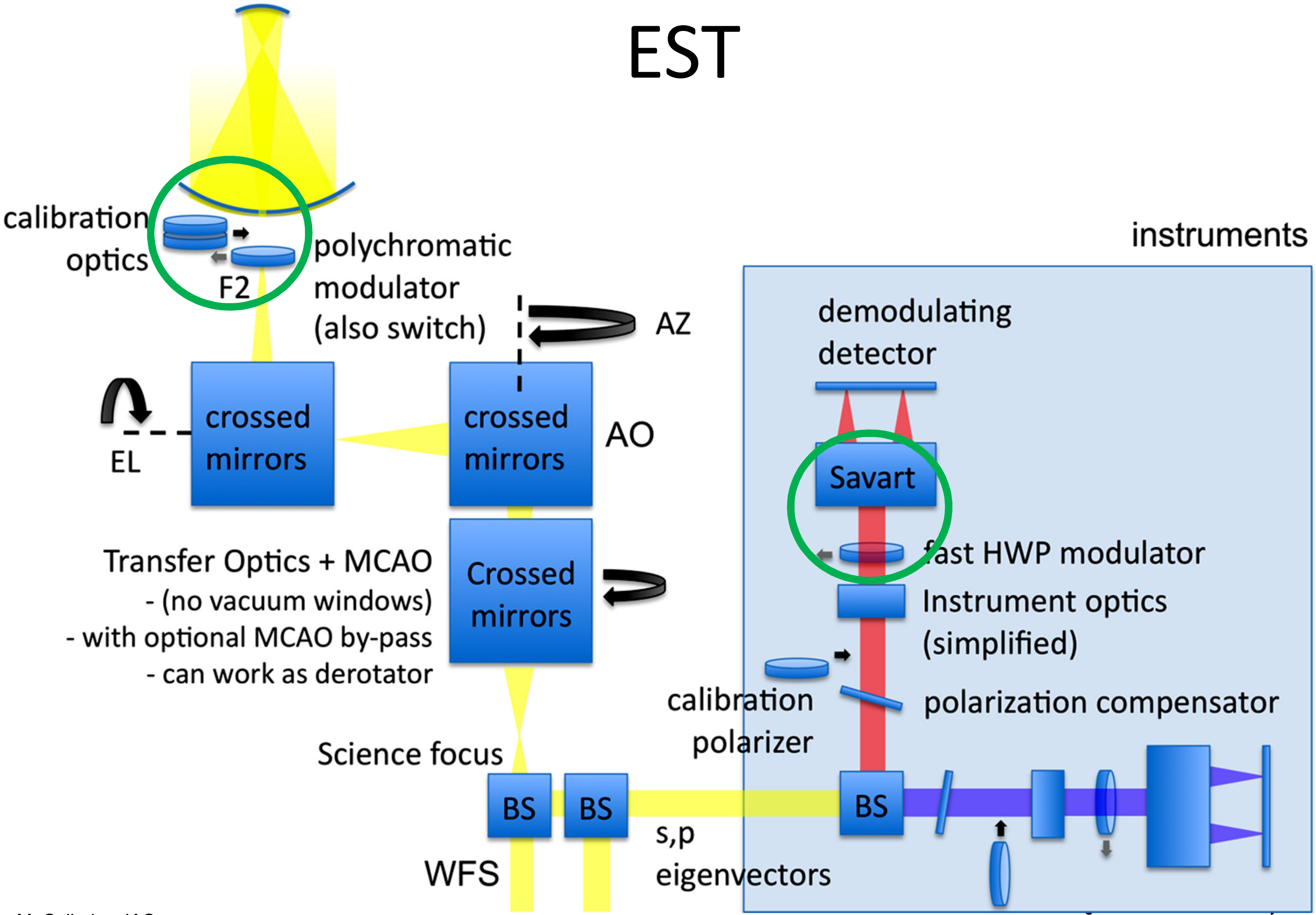
LIGHT DISTRIBUTION



EST



calibration optics
F2
polychromatic modulator (also switch)
AZ
crossed mirrors
EL
crossed mirrors
AO
Transfer Optics + MCAO
- (no vacuum windows)
- with optional MCAO by-pass
- can work as derotator
Crossed mirrors
Science focus
BS
BS
WFS
s,p eigenvectors
instruments
demodulating detector
Savart
fast HWP modulator
Instrument optics (simplified)
calibration polarizer
polarization compensator
BS

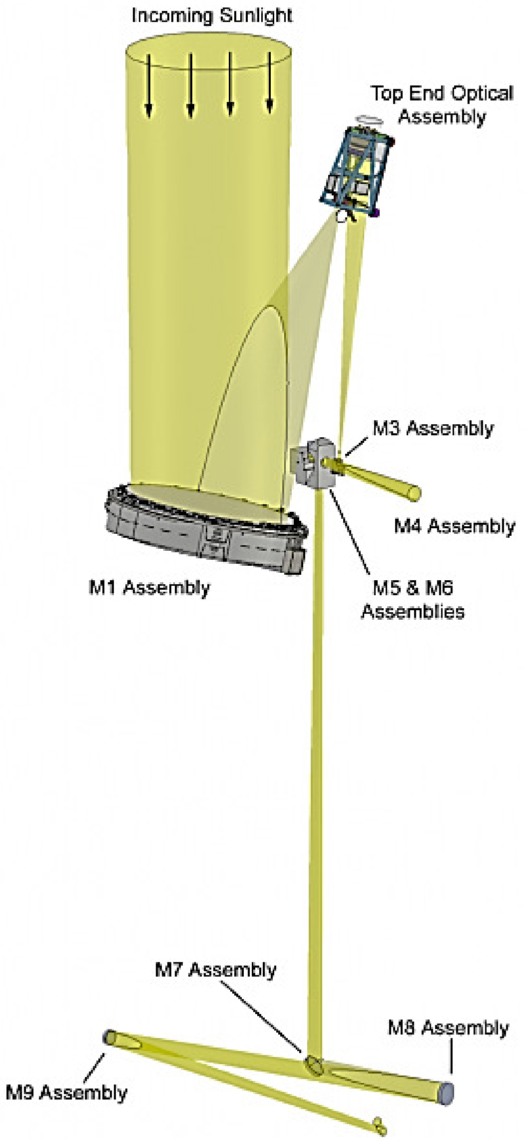
Polarimeters

DUAL BEAM

- 1 rotating waveplate (ASP, POLIS, SPINOR)
- 2 retarders with discrete orientations (THEMIS)
- 2 nematic liquid crystals (ViSP, IMaX, SST)
- 2 ferroelectric liquid crystals (TIP, LPSP)

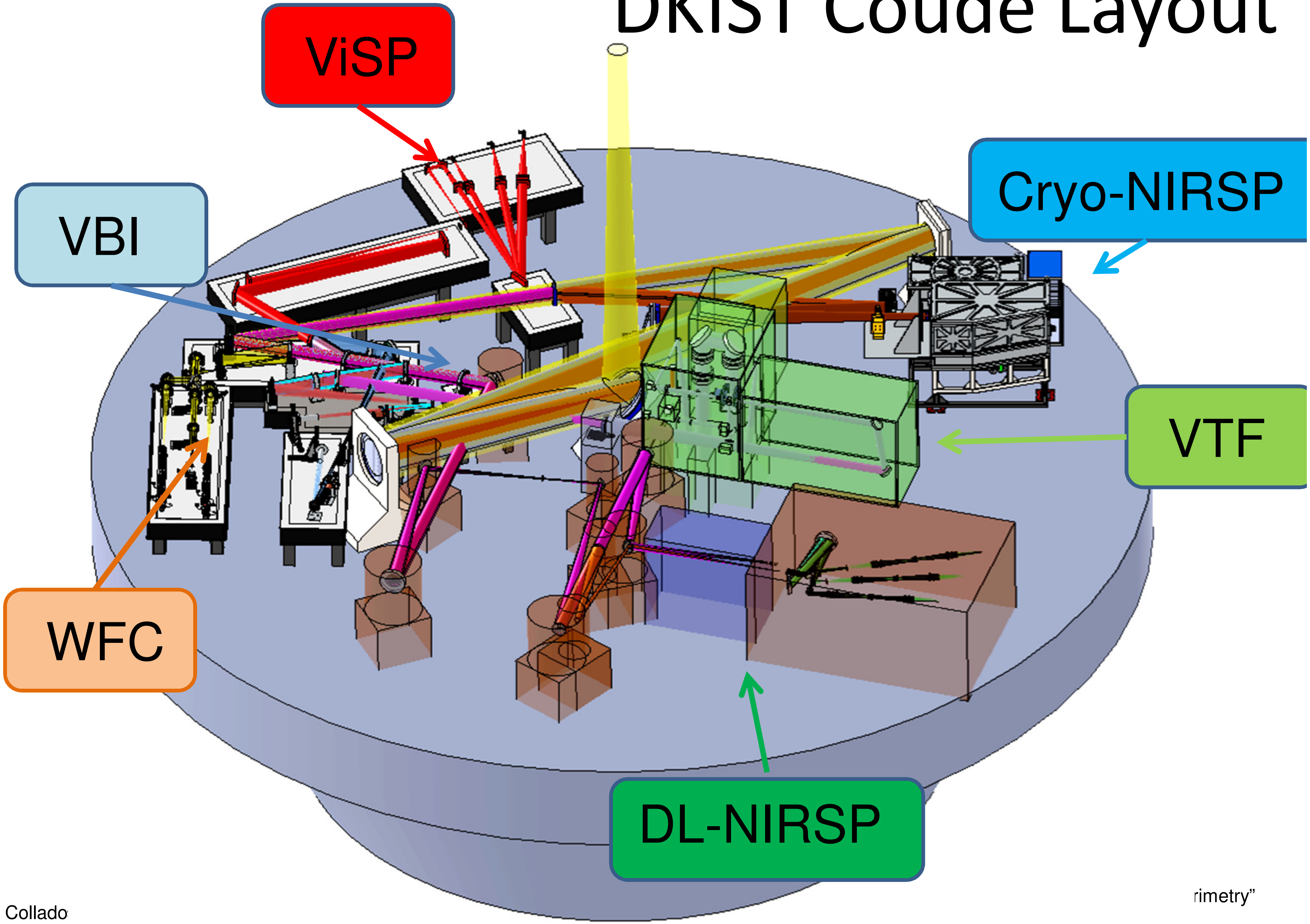
SINGLE BEAM

- 2 piezoelastic modulators (ZIMPOL)


Incoming Sunlight
Top End Optical Assembly
M3 Assembly
M4 Assembly
M1 Assembly
M5 & M6 Assemblies
M7 Assembly
M8 Assembly
M9 Assembly

DKIST

DKIST Coudé Layout



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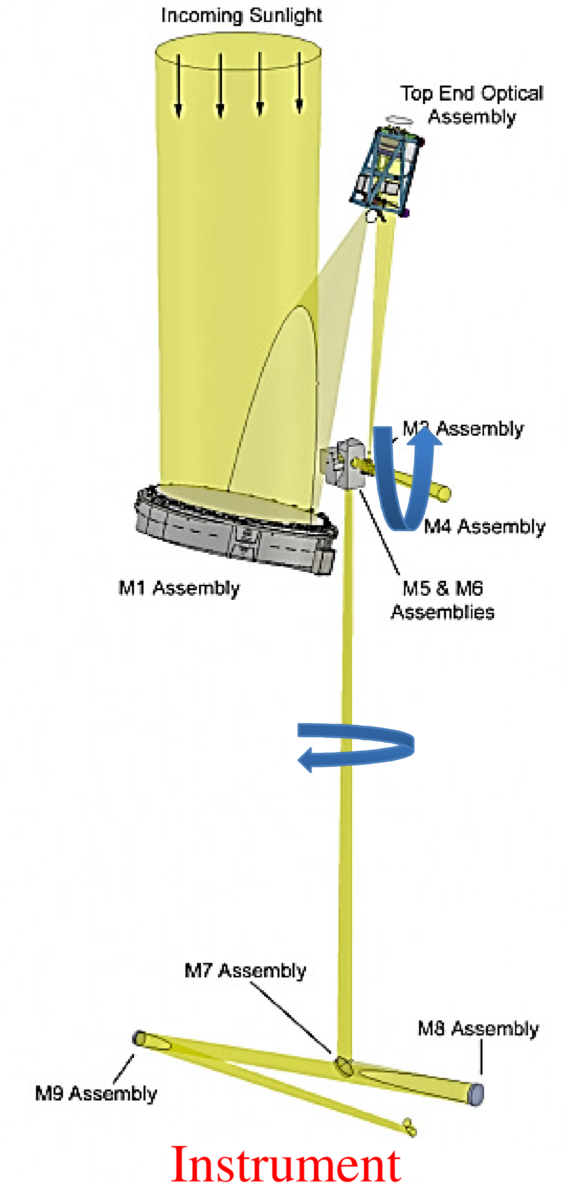
rimetry”

$$\vec{N}_{meas} = \mathbf{I}\ \mathbf{M_9}\ \mathbf{M_8}\ \mathbf{M_7}\ \mathbf{R_{coude}}(t)\ \mathbf{M_6}\ \mathbf{M_5}\ \mathbf{R_{el}}(t)\ \mathbf{M_4}\ \mathbf{M_3}\ \mathbf{M_2}\ \mathbf{M_1}\ \vec{S}_{in}$$



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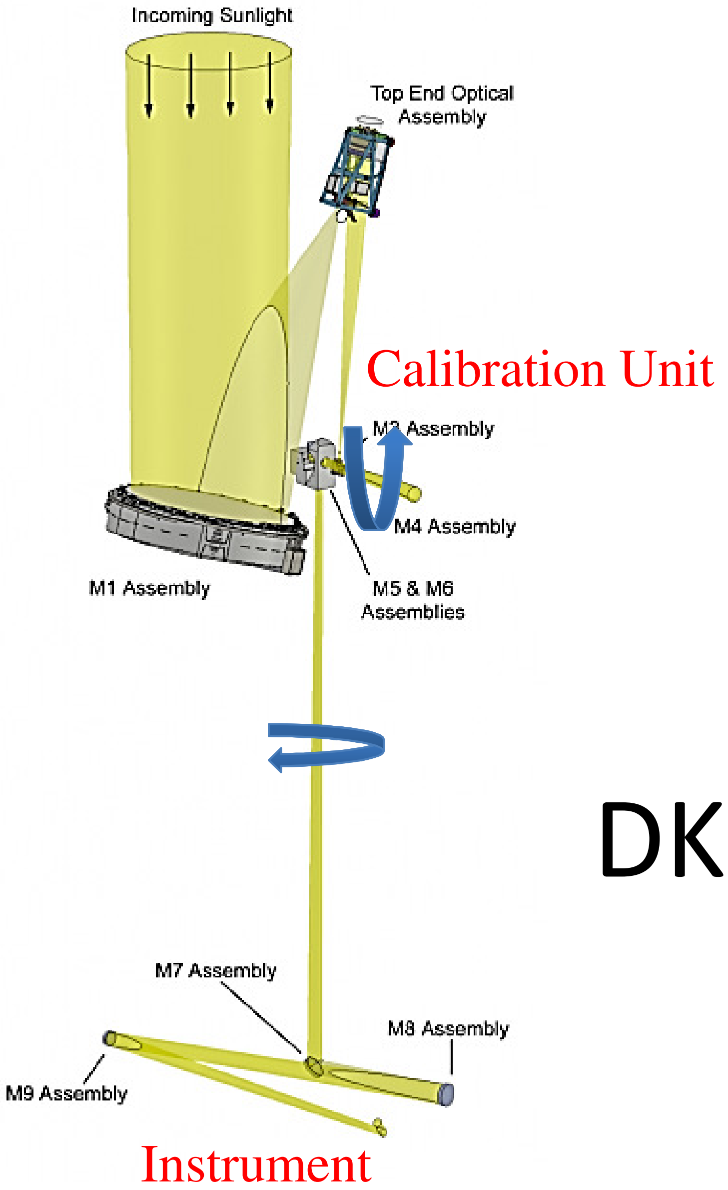
$$\vec{N}_{meas} = \mathbf{I}\ \mathbf{M_9}\ \mathbf{M_8}\ \mathbf{M_7}\ \mathbf{R_{coude}}(t)\ \mathbf{M_6}\ \mathbf{M_5}\ \mathbf{R_{el}}(t)\ \mathbf{M_4}\ \mathbf{M_3}\ \vec{S}_{in}$$



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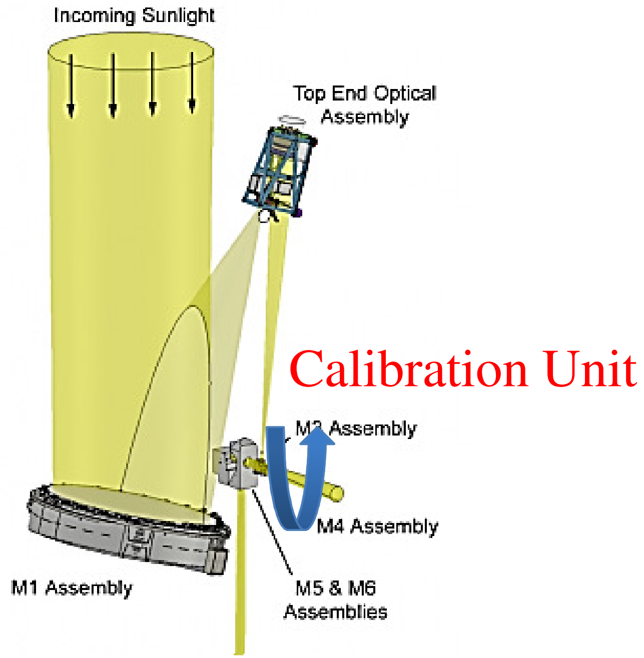
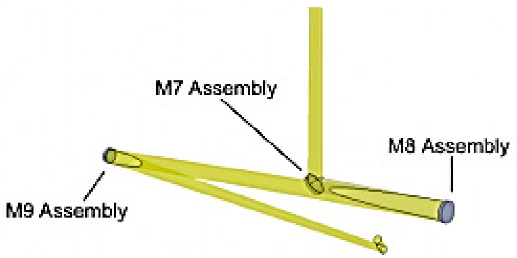
$$\vec{N}_{meas} = \mathbf{I}\ \mathbf{M_9}\ \mathbf{M_8}\ \mathbf{M_7}\ \mathbf{R_{coude}}(t)\ \mathbf{M_6}\ \mathbf{M_5}\ \mathbf{R_{el}}(t)\ \mathbf{M_4}\ \mathbf{M_3}\ \vec{S}_{in}$$



$$\mathbf{M_2}\ \mathbf{M_1} = \begin{pmatrix} 1 & 0.004472 & 0 & 0 \\ 0.004472 & 0.999998 & 0 & 0 \\ 0 & 0 & 0.998424 & 0.049914 \\ 0 & 0 & -0.049914 & -0.998422 \end{pmatrix}.$$

DKIST

Keller (2003)



Instrument

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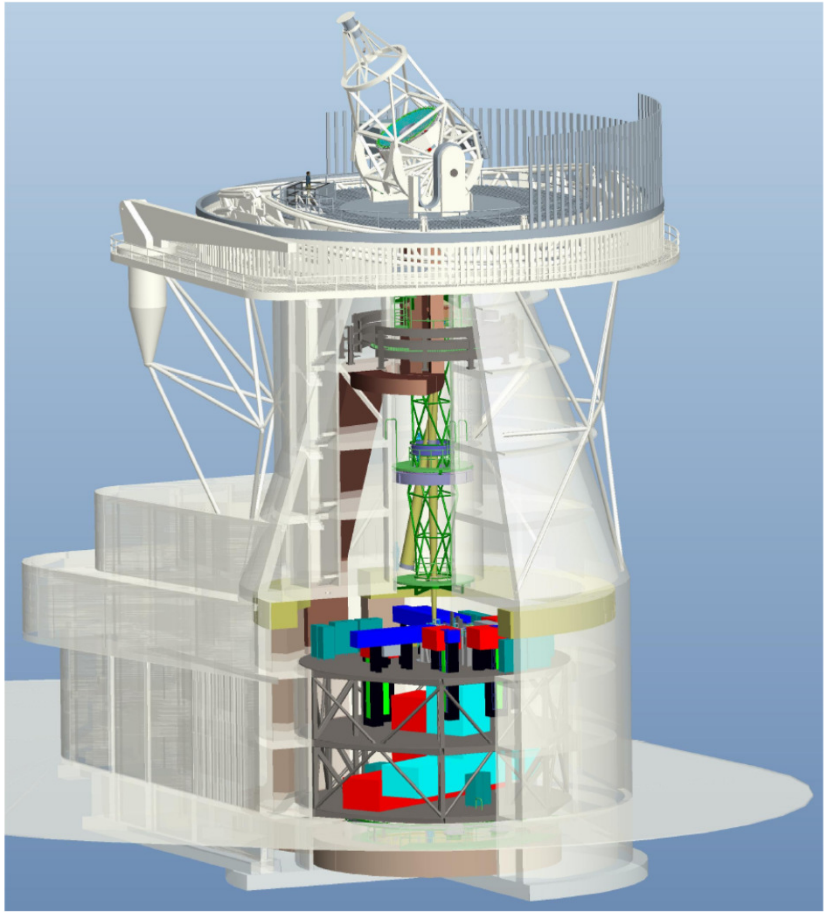

EST – 2026
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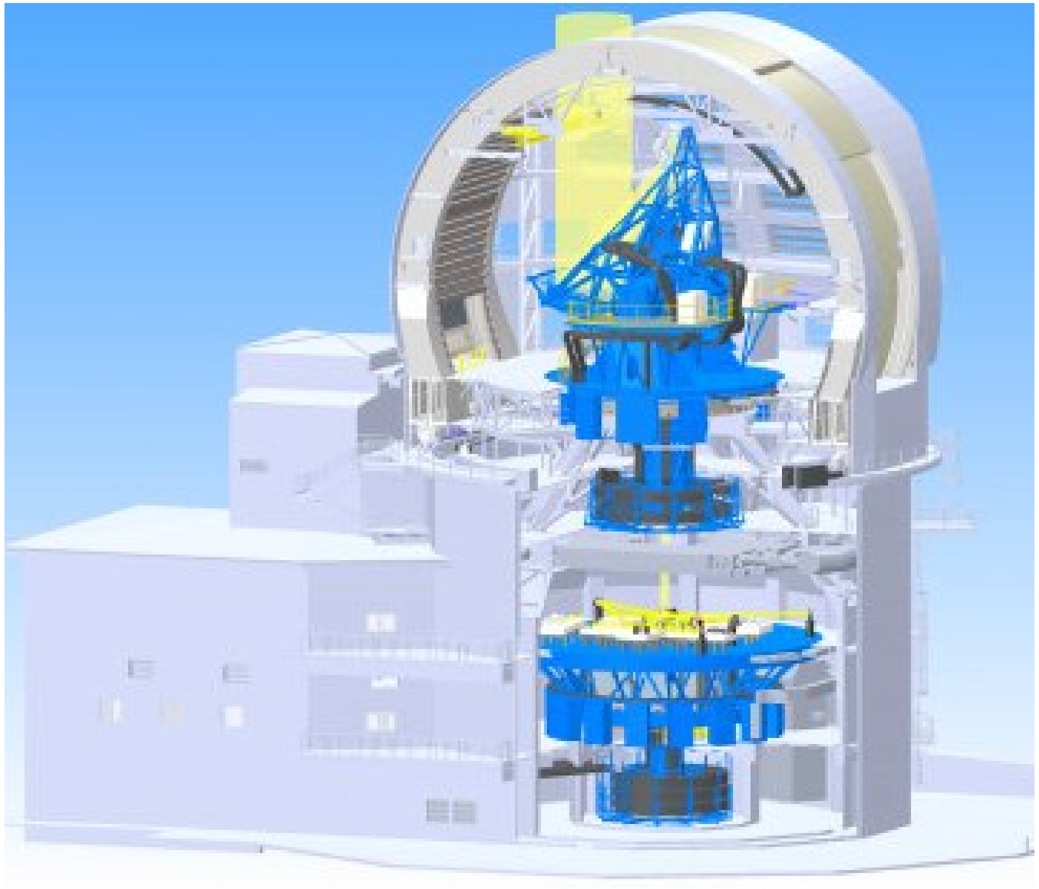

DKIST – 2019
Hawaii