

# DKIST Critical Science Plan (CSP)

- DKIST CSP outlines *specific* science topics that the telescope will address in the first 2 years of operations (2020/21).
- Unique science enabled by DKIST.
  - 4m aperture: resolution (advanced AO), photon collector
  - Polarimetry: 4 instrument 0.4-5  $\mu\text{m}$ .
  - Off-axis: Coronal observations, low stray-light
- Consists of PI-led Science Use Cases (observing proposals).
  - facilitate early science
  - clarify operations and pipeline data processing needs
  - CSP helps to focus data center effort (calibrations)
- DKIST CSP: Community driven with discussion led by the DKIST Science Working Group Chair (Mark Rast)
  - Uses JIRA tool

# A new window to the Sun: The Daniel K Inouye Solar Telescope

The DKIST team



# Outline

1. The team & timeline
2. DKIST: a transformational facility
3. DKIST as a multiwavelength observatory
4. DKIST as a coronagraph
5. DKIST as a polarimeter
6. The CSP Workshops



# Daniel K Inouye Solar Telescope: The Team

## First light instruments

### DKIST PI:

NSO/AURA

DKIST Director: T. Rimmele

### DKIST co-Is:

P. Goode, M. Knoelker, J.  
Kuhn, R. Roesner

– NSO

• VBI

PI: F. Woeger

– University of Hawaii, IfA

• CRYO-NIRSP

PI: J. Kuhn

• DL-NIRSP

PI: H. Lin

– High Altitude Observatory

• ViSP

PI: R. Casini

– KIS, Germany,

• VTF

PI: O. vd Luehe

– UK DKIST Consortium

• Visible Detectors,

PI: M. Mathioudakis, QUB

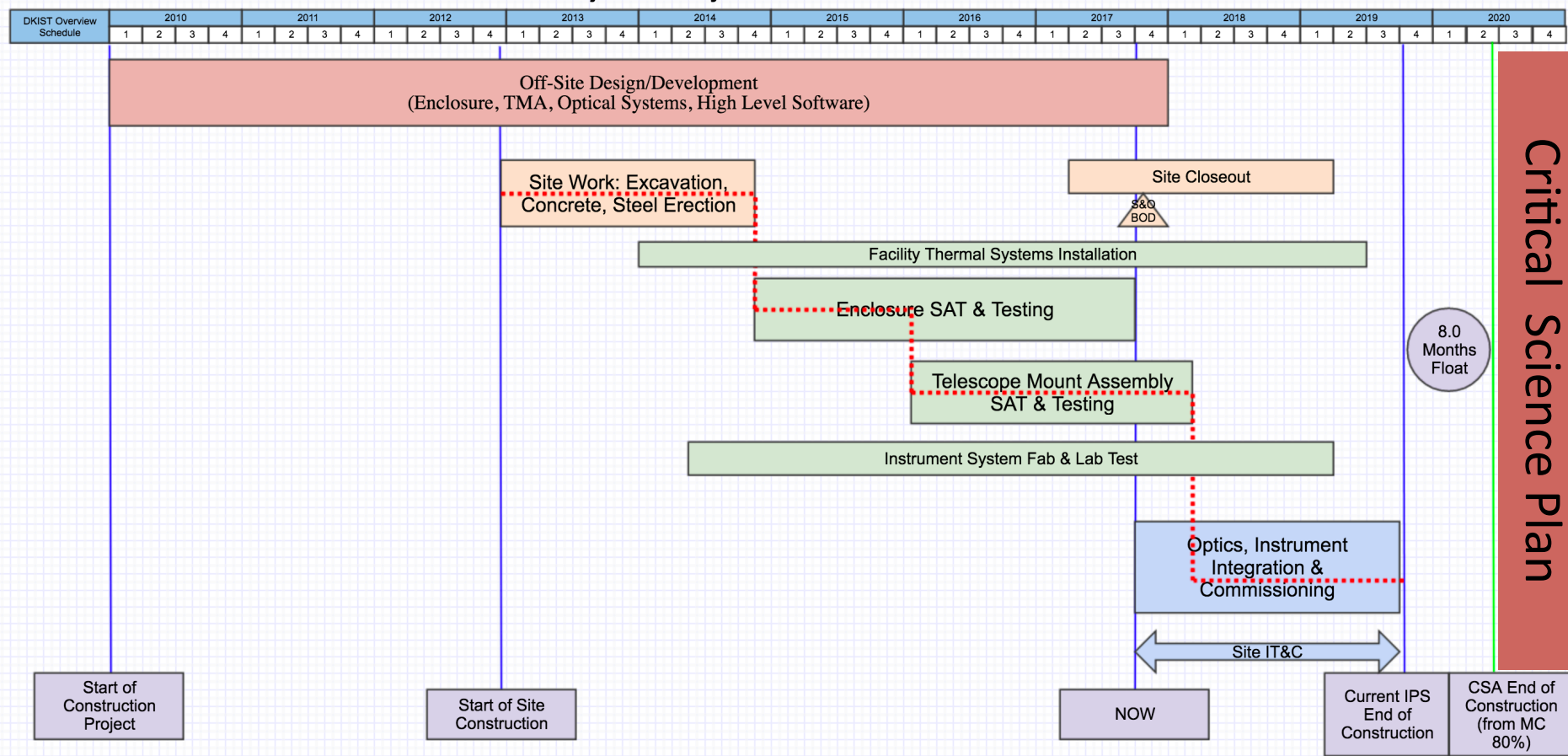


Institute for Astronomy  
University of Hawaii

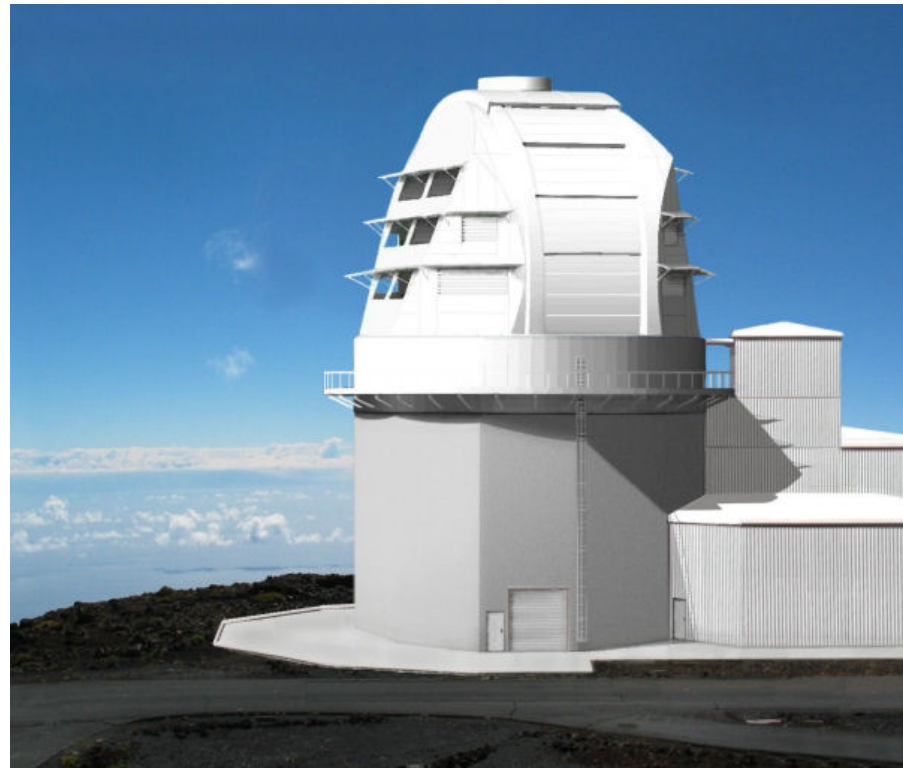


# The DKIST: status and timeline

DKIST Construction Project Summary Schedule



7 years of construction; 75% complete



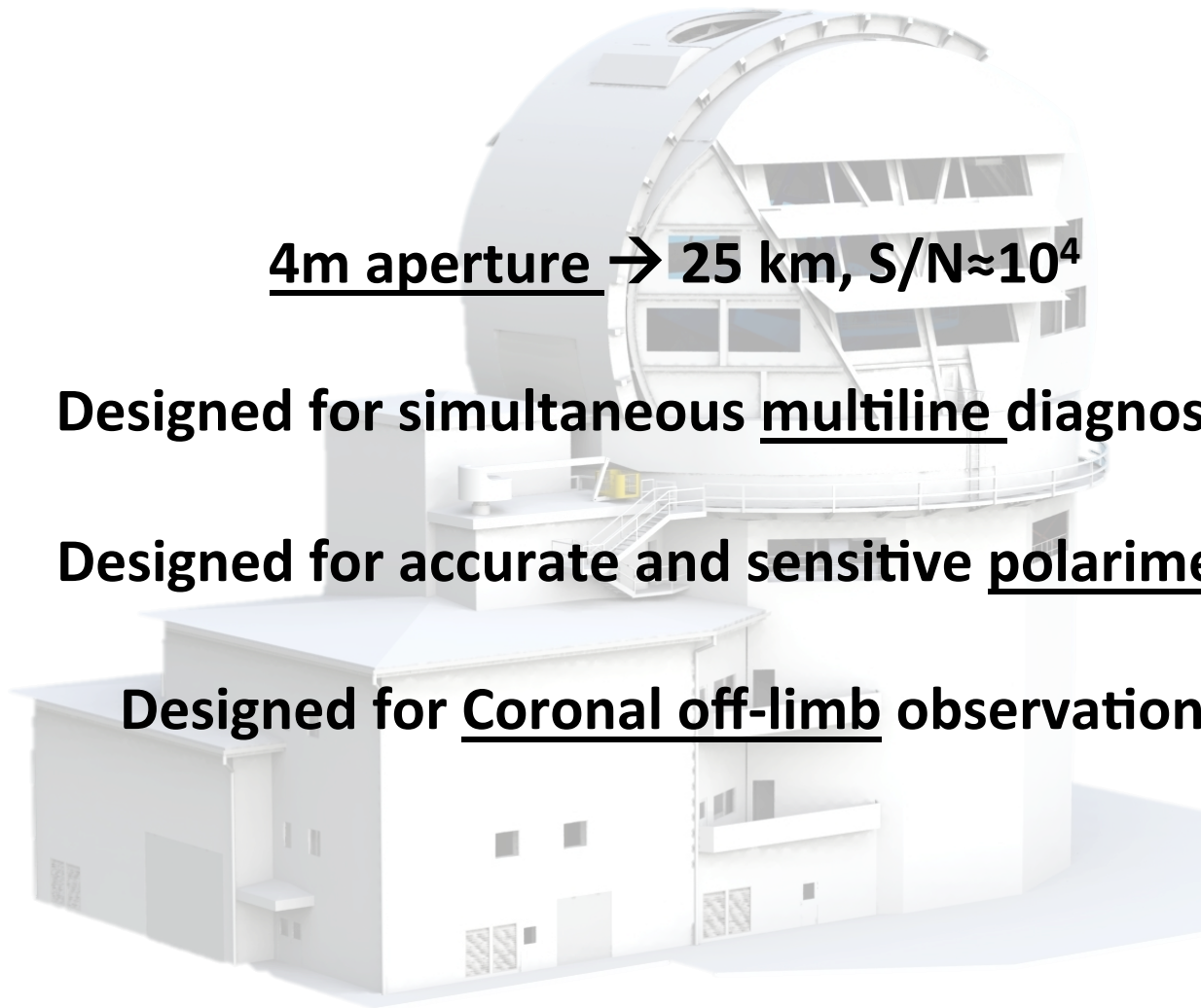
# DKIST: a transformational facility

4m aperture → 25 km,  $S/N \approx 10^4$

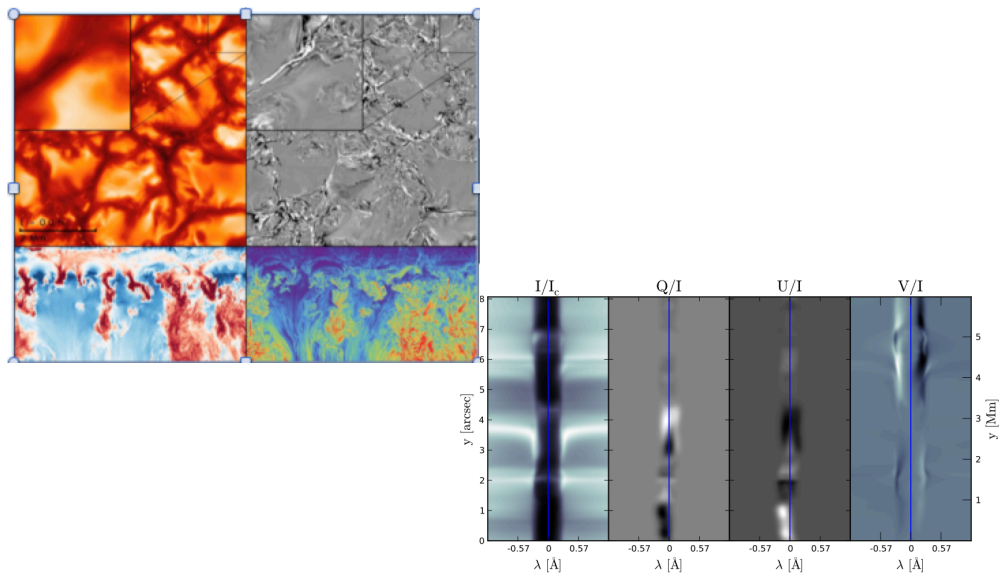
Designed for simultaneous multiline diagnostics

Designed for accurate and sensitive polarimetry

Designed for Coronal off-limb observations



# DKIST: a transformational facility



$$SNR \sim 10^4$$

$$\phi_{px} \sim 0.1 \text{ arcsec}$$

$$t_{\text{exp}} \sim 10 \text{ s}$$



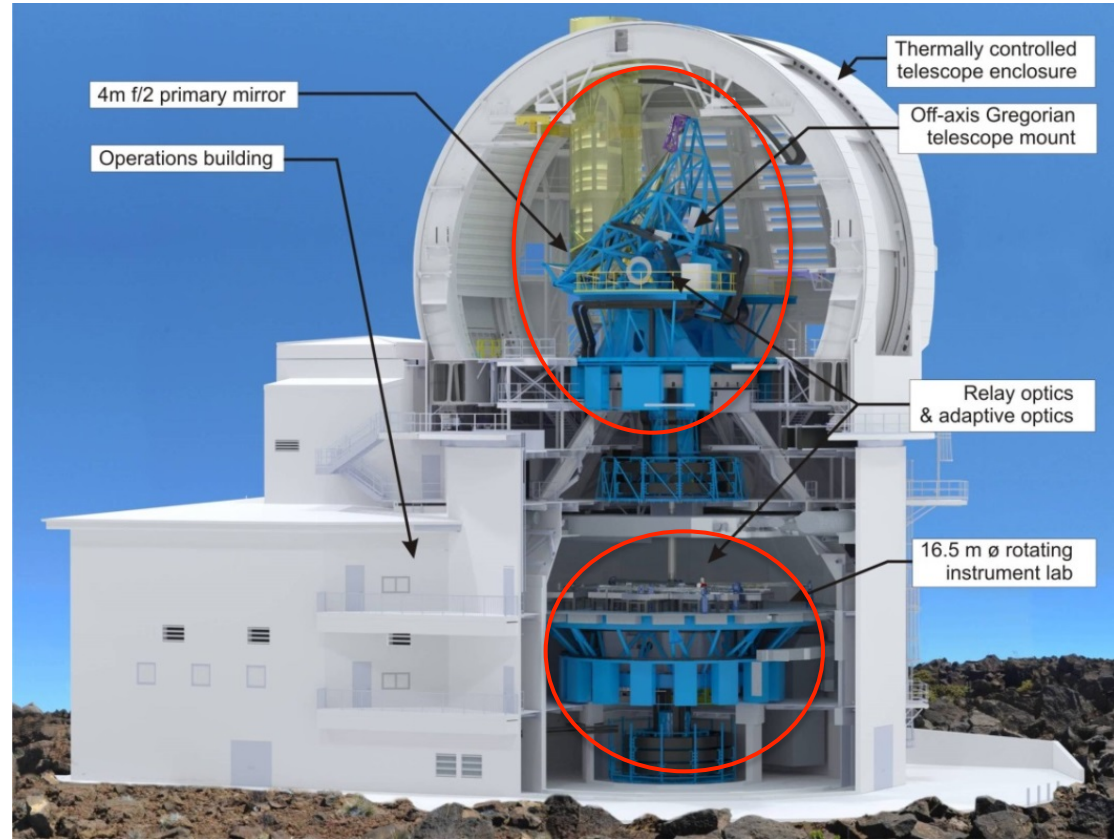
$$D = \frac{SNR}{\sqrt{0.7 N 10^{-0.4 m_o} \tau \Delta \lambda Q \phi_{px}^2 t_{\text{exp}}}}$$



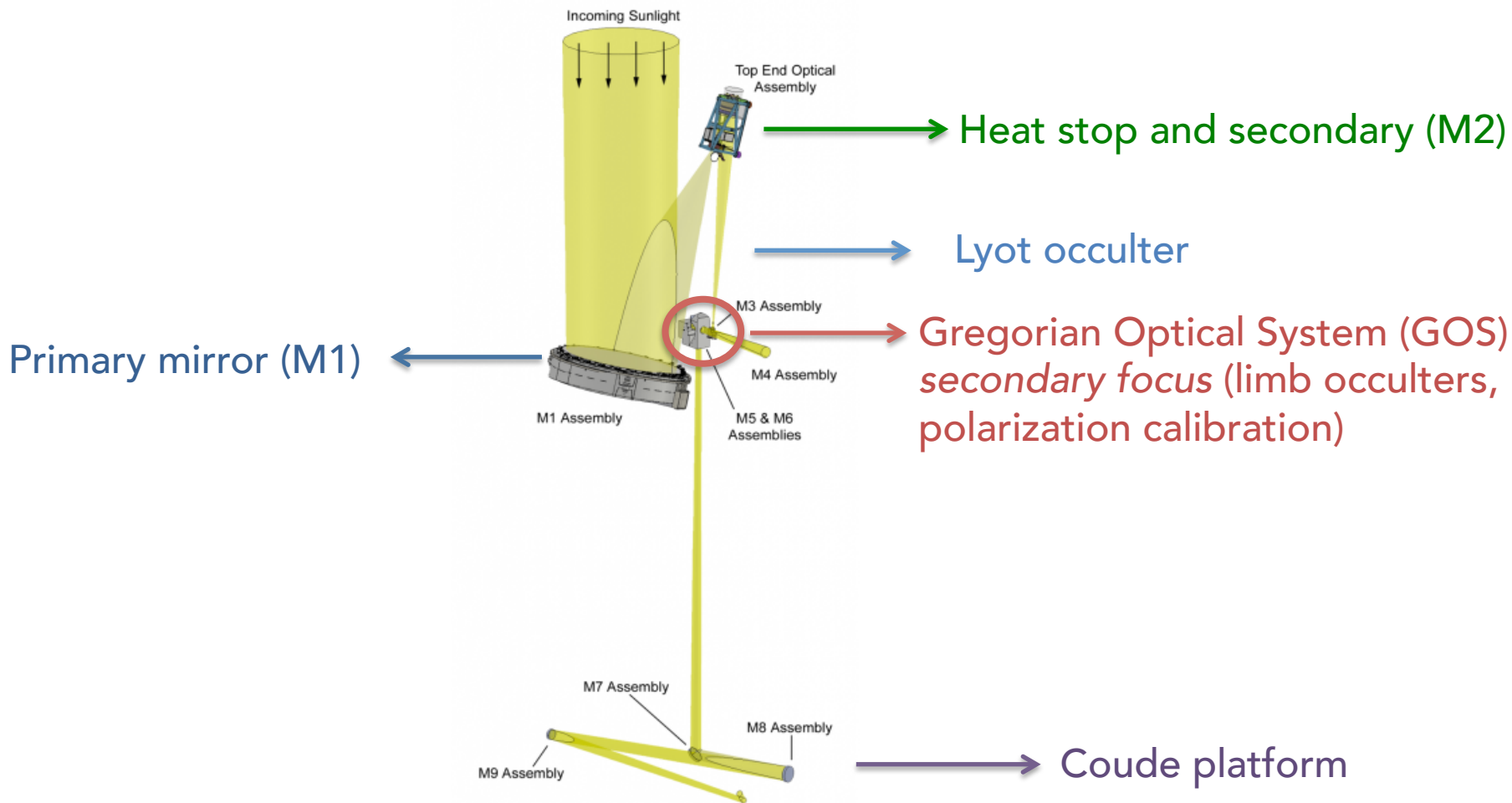


# DKIST: a transformational facility

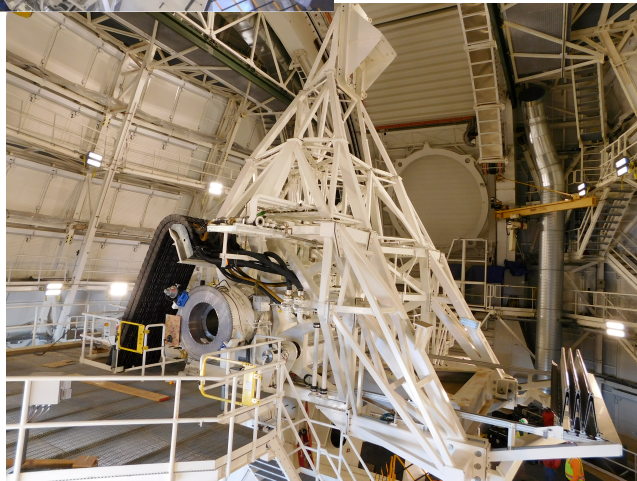
- Four-meter aperture,  $f/2$
- Alt/azimuth mount
- All reflecting optics
- Off-axis design (no spider, no central obscuration)
- Heat stop at prime focus: hard limit of 5' FOV
- Low-scattered light
  - Coronagraph
  - Lyot stop & limb occulter
  - In situ clean & wash of M1
- Integrated adaptive optics (on-disk)
- High-precision polarimetry
- Clean room conditions
- Service Mode: PI not present.
- Data available on-line: Boulder DC



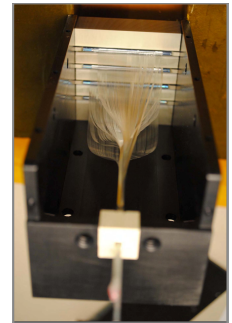
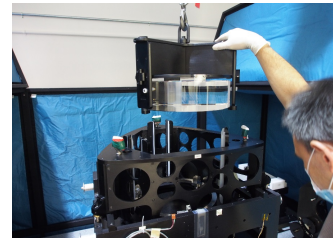
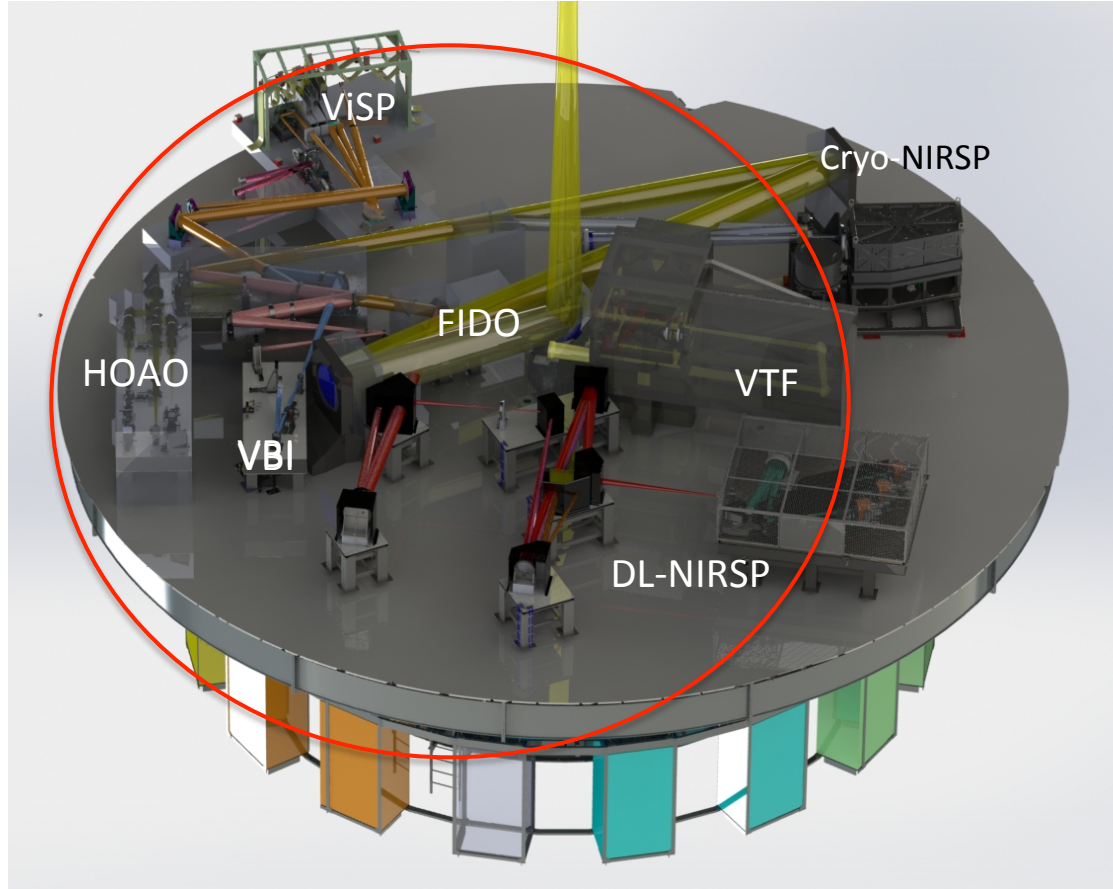
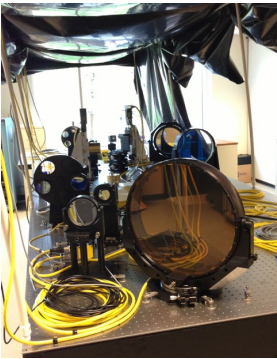
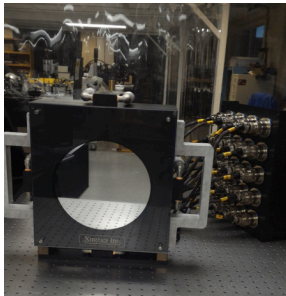
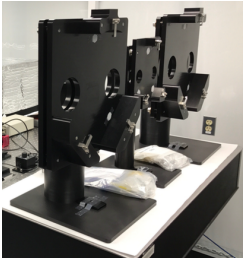
# Light Feed



# DKIST: a transformational facility



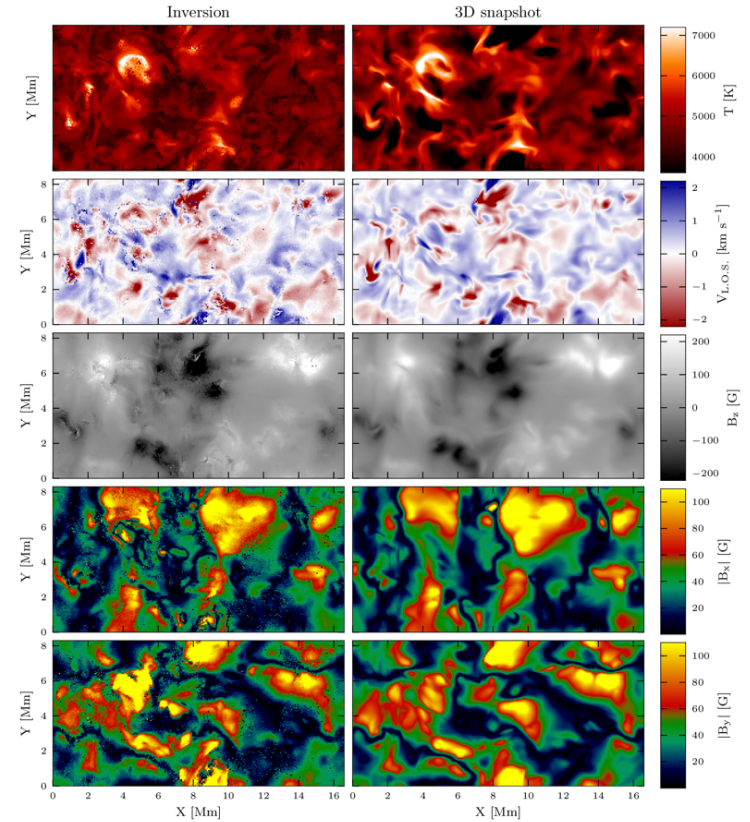
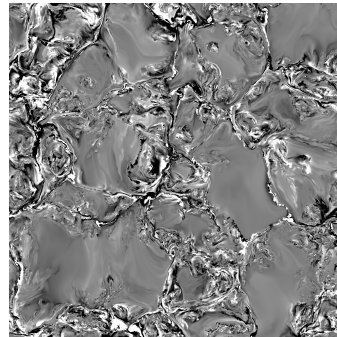
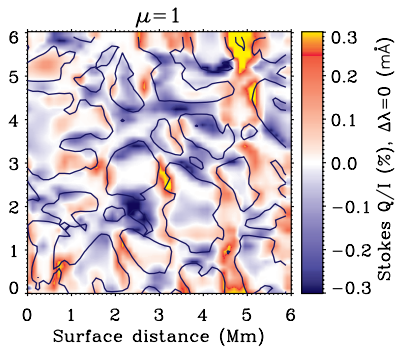
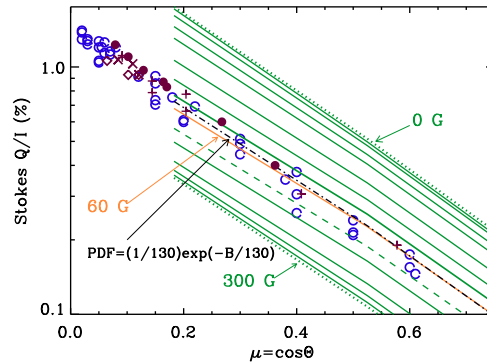
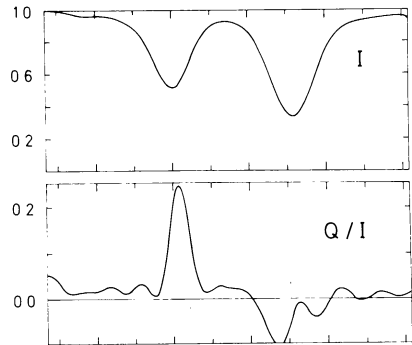
# DKIST as a Multiwavelength Observatory



# DKIST as a Multiwavelength Observatory

- Sr I 4607 Å: ViSP
- S/N  $10^{-4}$ , short cadence, Zeeman lines

- Ca II IR 8542 Å: ViSP, VTF
- SNR  $10^{-4}$ , short cadence, multi-height



# DKIST as a coronagraph

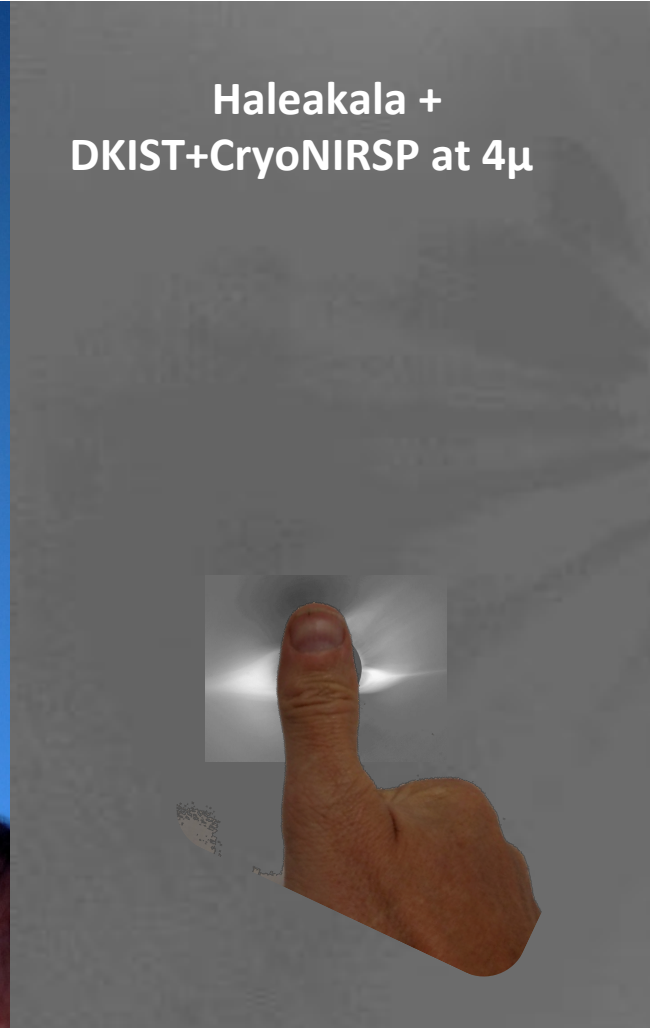
Wailea



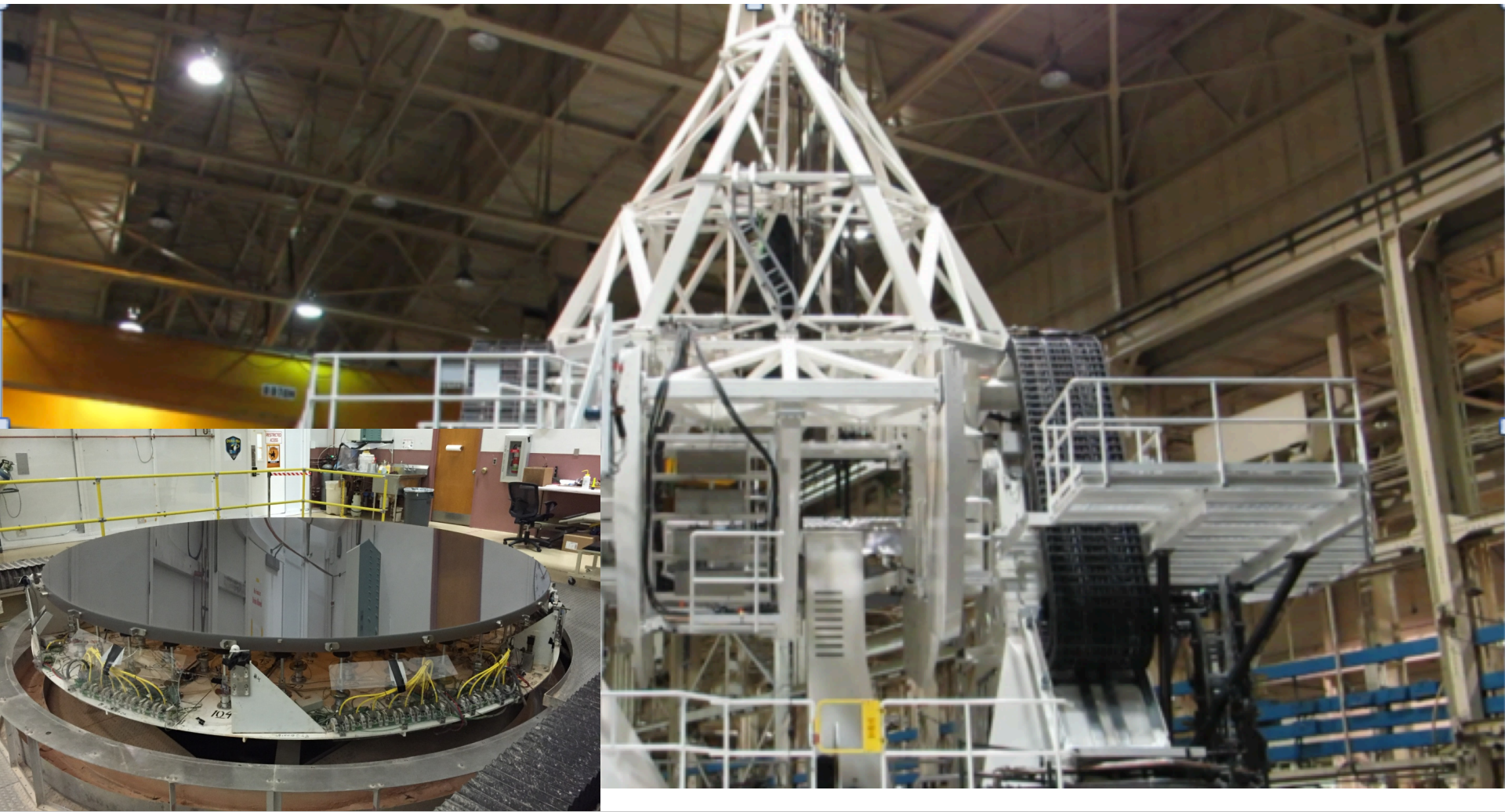
Haleakala



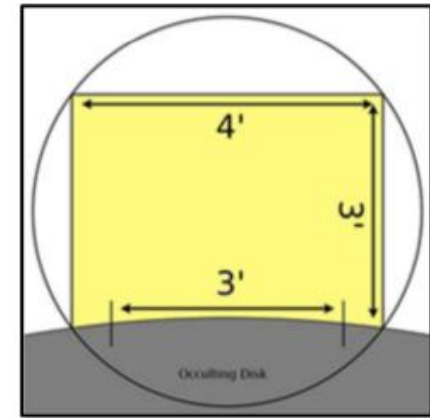
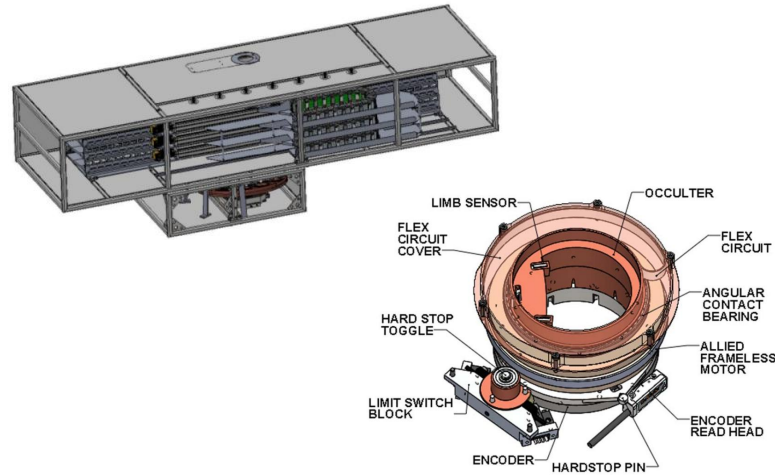
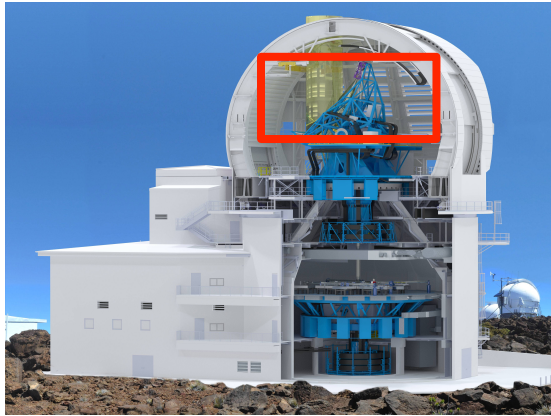
Haleakala +  
DKIST+CryoNIRSP at 4μ



# DKIST as a coronagraph



# DKIST as a coronagraph

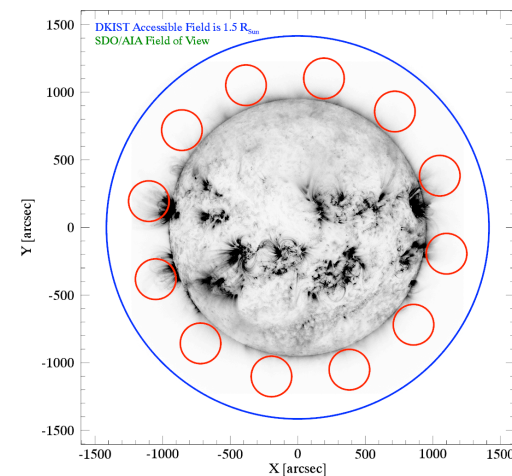


## Lyot and limb occulter (3'x4' FOV)

- How close?: 1 arcsec.
- How far from the limb?  $0.5 R_{\odot}$  max

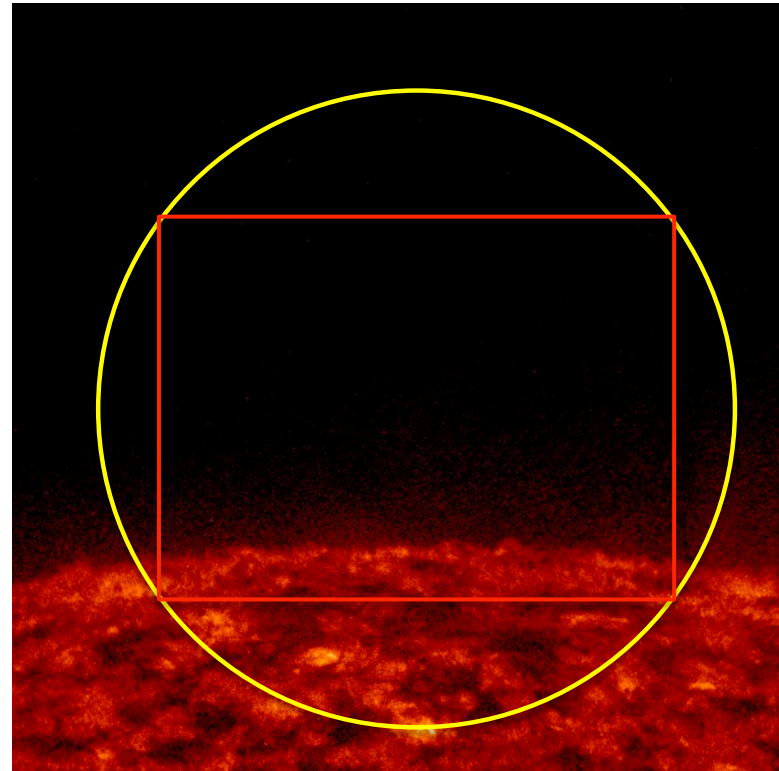
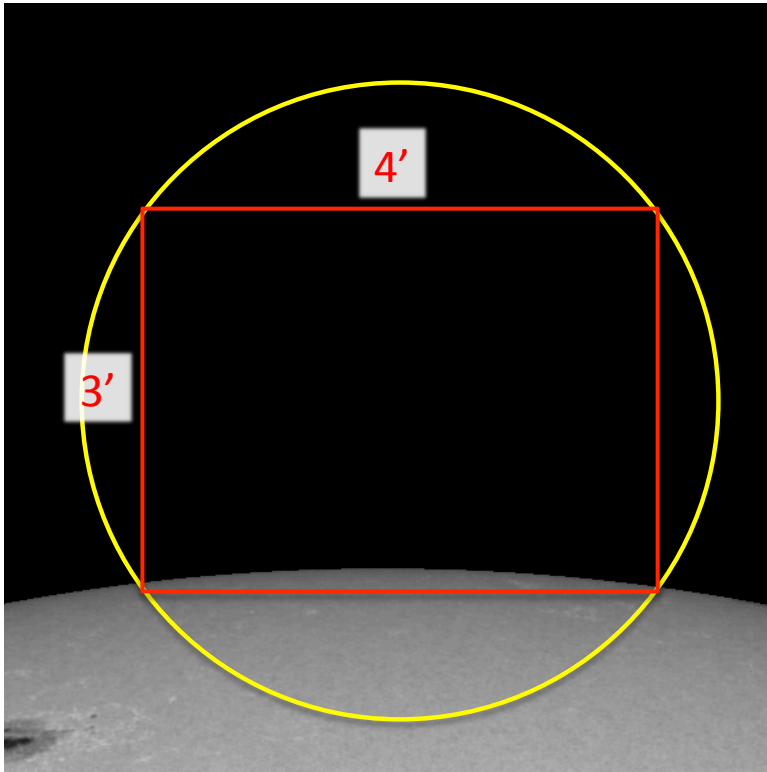
## The Gregorian Optical System (GOS)

- Limb occulter: Disc to block the solar disc near the limb
- Limb over/under-occulting of  $\pm 5$  arcsec possible
- Comes with a “limb sensor” that measure limb motions
- Drives M2 for image stabilization





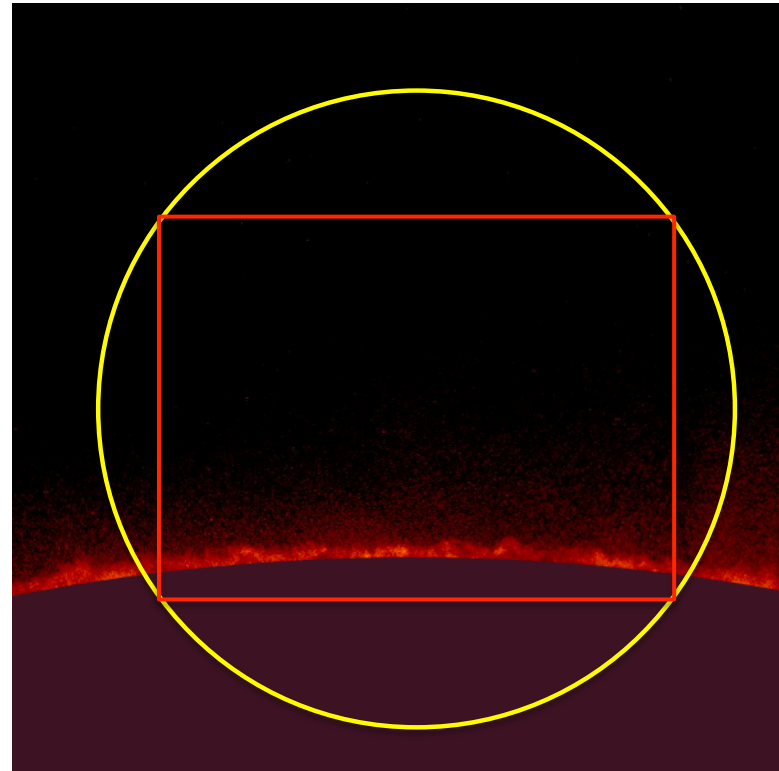
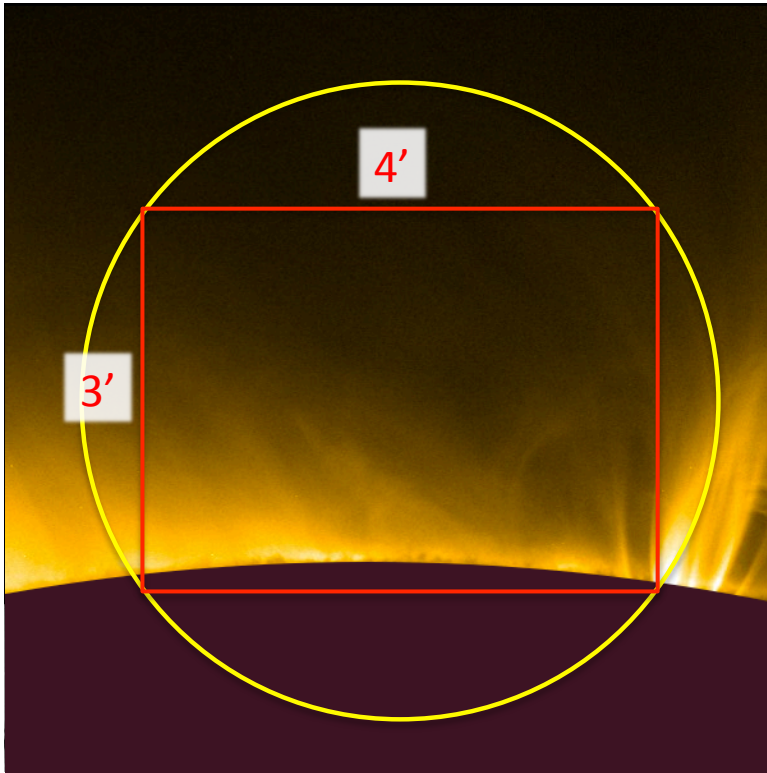
# 5' Limb Occulter



$\pm 5''$   
over/under  
occultation

Limb sensor tracks image motion perpendicular to limb (only), corrected by M2 fast tip

# 5' Limb Occulter



Limb sensor tracks image motion perpendicular to limb (only), corrected by M2 fast tip

# DKIST as a coronagraph

## Cryo-NIRSP (UH/IfA)

4' slit x 3' scan

1-5  $\mu\text{m}$

Off-point up to  $1.5 R_{\odot}$

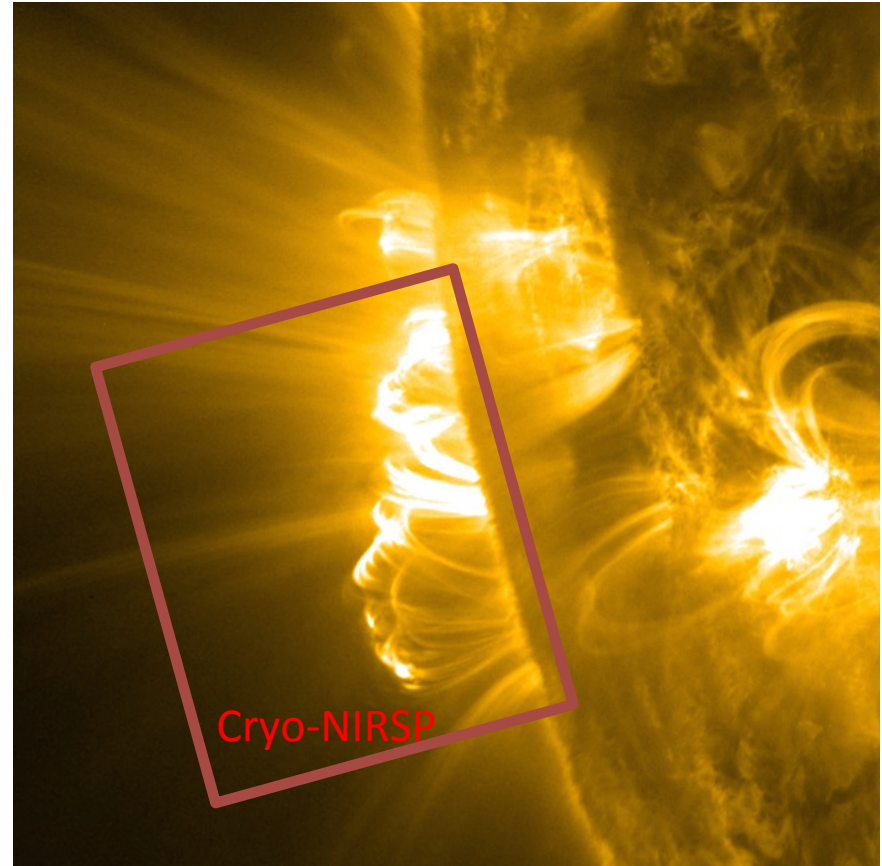
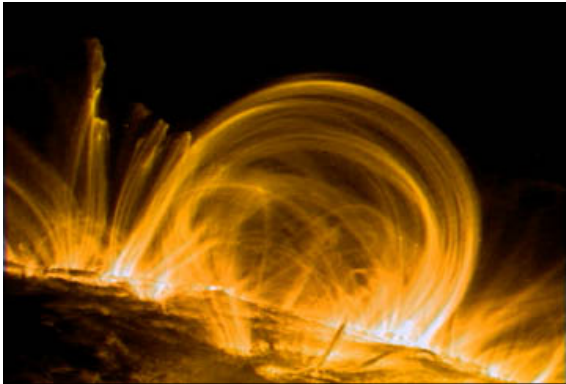
1 arcsec resolution

Full Stokes-Dual Beam

$\sim 60$  minutes cadence

(faster for smaller FOVs)

(I-only available)

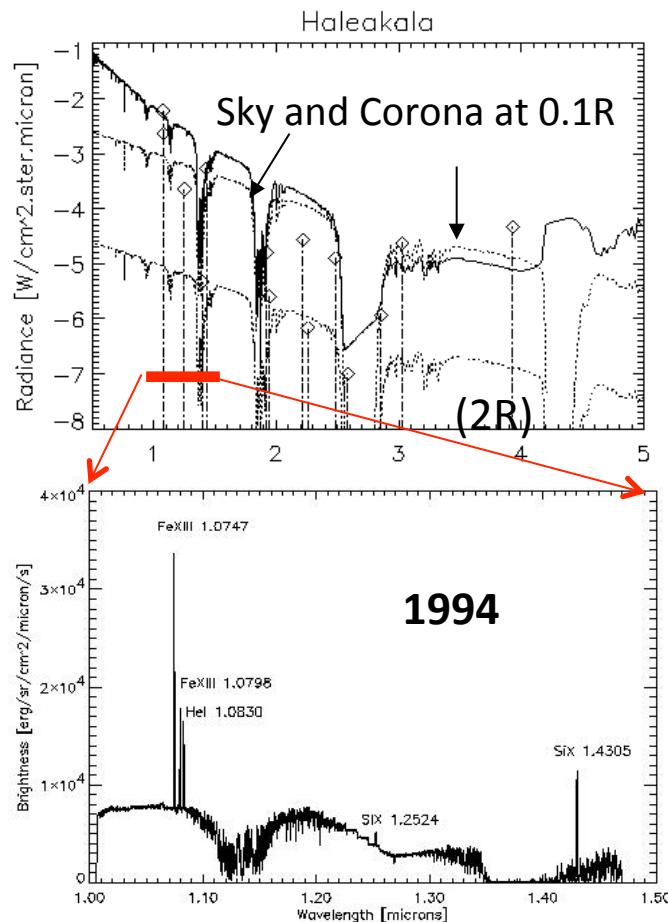


# DKIST as a coronagraph

Temperature sensitivity from 3000K to 2MK

Zeeman and saturated Hanle effect in forbidden lines

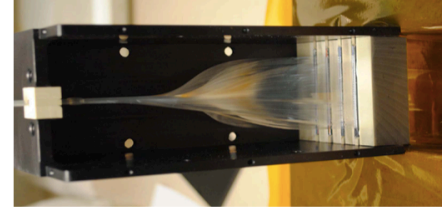
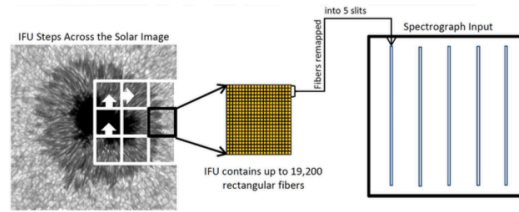
Wavelength (nm)	Line
1074.7, 1079.7	Fe XIII
1083	He I triplet
1430	Si X
2218	Fe IX
2326	CO
2580	Si IX
3028	Mg VIII
3935	Si IX
4651	CO



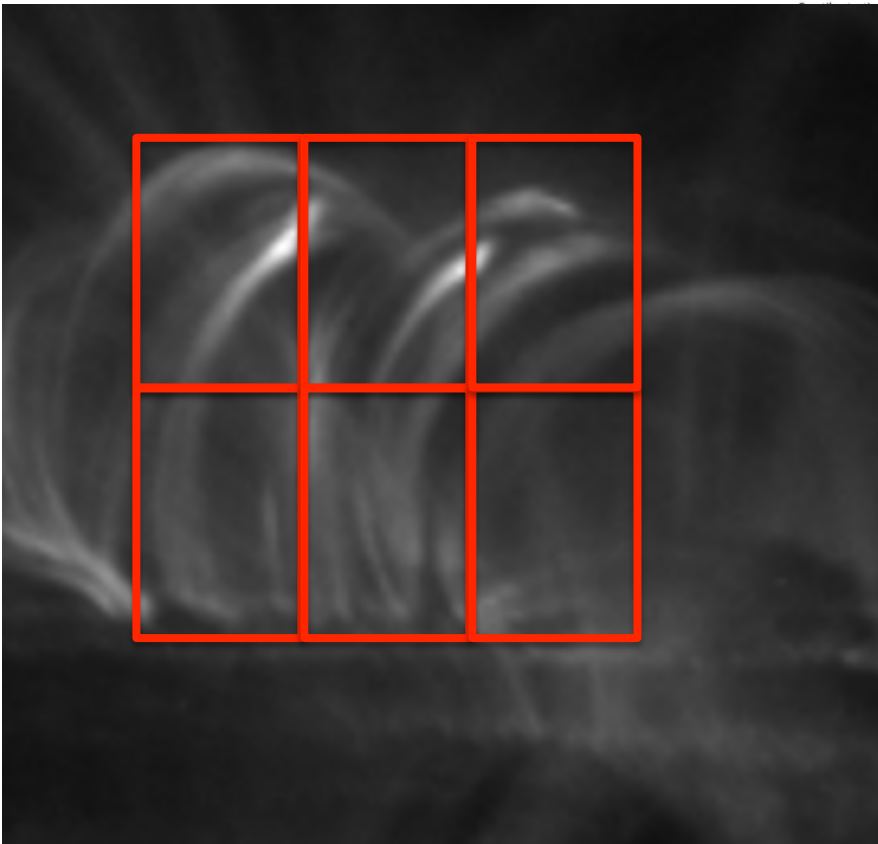
Discovery Space: MHD waves, Coronal Abundances, FIP effect, etc.

# DKIST as a coronagraph

But also...  
DL-NIRSP



DL-NIRSP builds spectropolarimetric full data cubes: [ X ; Y ;  $\lambda$  ; S [=L,Q,U,V] ; t]



55" x 55" (6 tiles)  
Near-limb (occulted)  
0.464" sampling  
15x6 seconds  
Full Stokes-Dual Beam  
Pol. sensitivity  $10^{-3}$

*FeXI 789.2, FeXIII 1074.7, SiX 1430*  
**at once**

# DKIST as a coronagraph

**But also...**

**VBI**

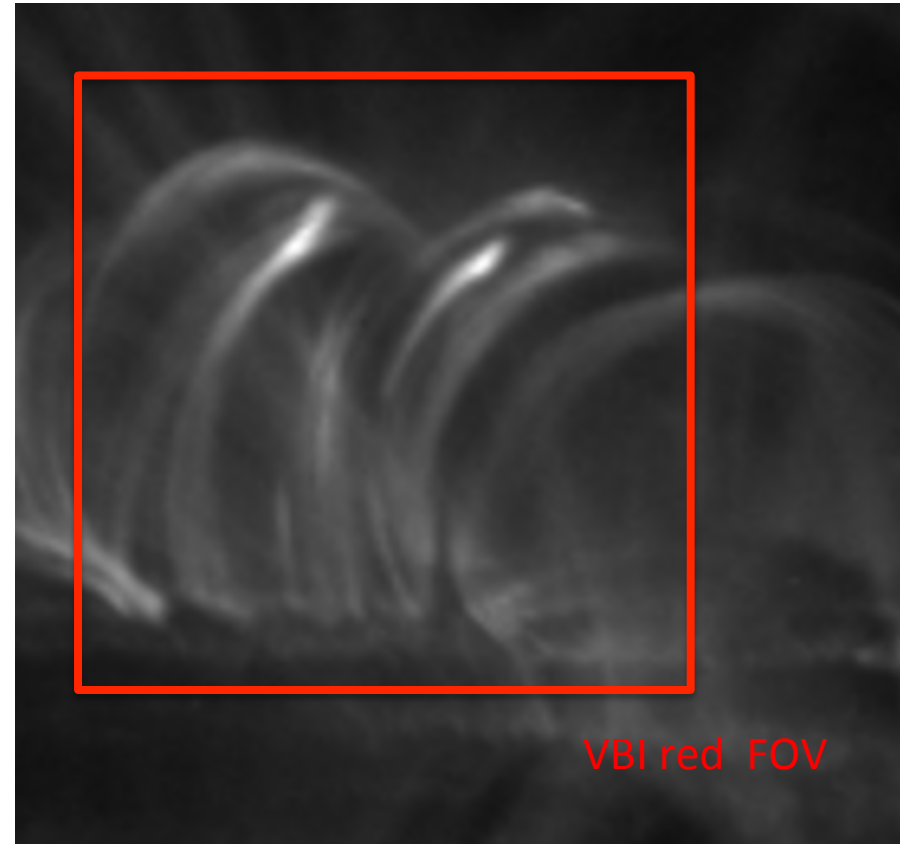
**(and other instruments)**

Fe XI 789.2 nm

FOV: 69" x 69"

0.03" resolution (no binning)

Few s cadence (depending on line  
brightness)



SDO/AIA 171 – 900 km resolution

# DKIST as a coronagraph

**But also...**

**VBI**

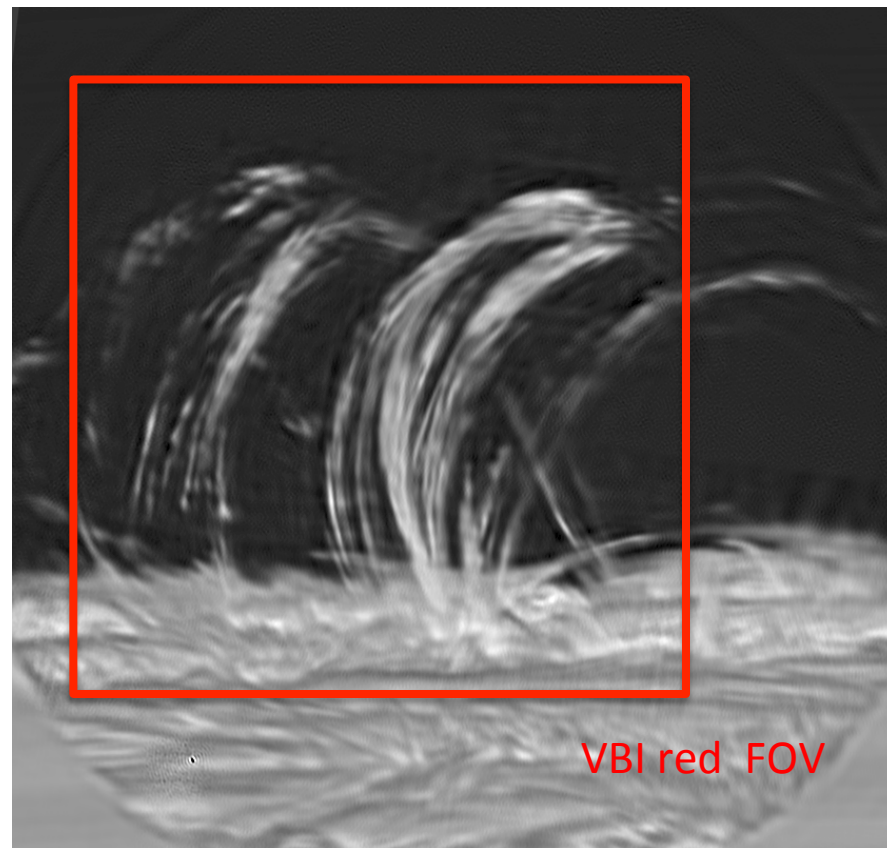
**(and other instruments)**

Fe XI 789.2 nm

FOV: 69" x 69"

0.03" resolution (no binning)

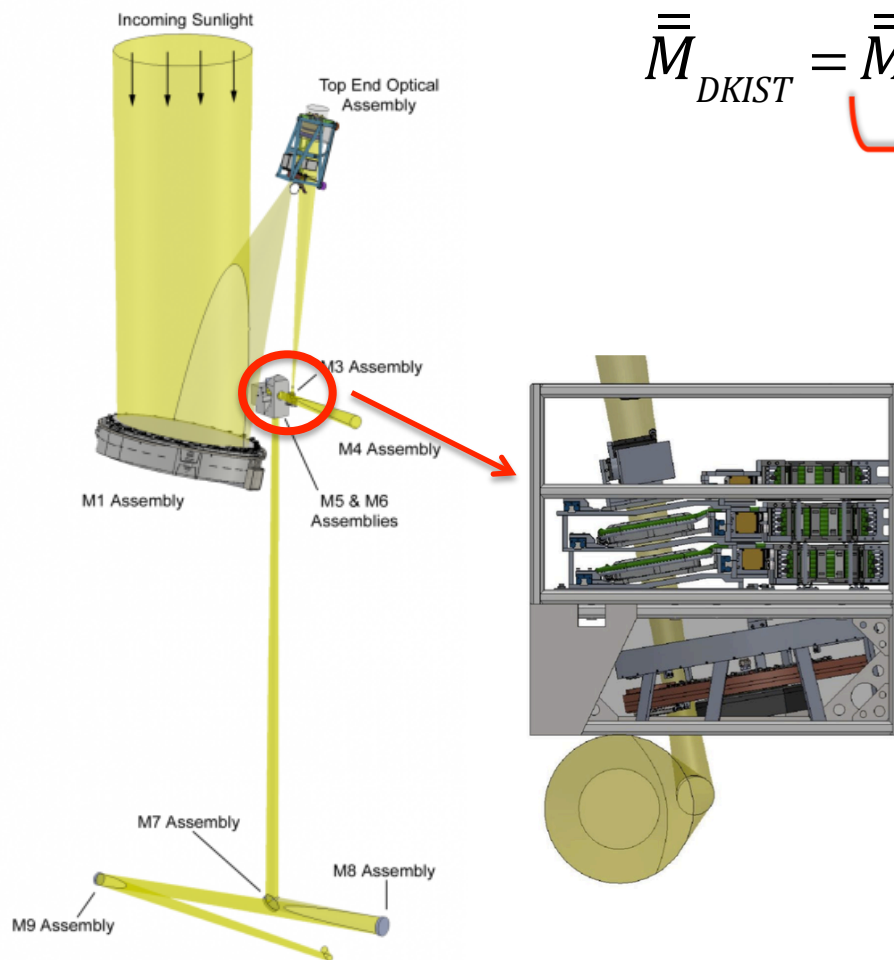
Few s cadence (depending on line  
brightness)



IBIS H $\alpha$  – 130 km resolution

# DKIST as a Polarimeter

$$\bar{\bar{M}}_{DKIST} = \bar{\bar{M}}_7 \bar{\bar{R}}(Az - Table) \bar{\bar{M}}_{56} \bar{\bar{R}}(El) \bar{\bar{M}}_{34} \bar{\bar{M}}_{12}$$



- PA&C unit at Gregorian Focus
- Calibrates all optics downstream
- Similar to Gregor
- Polarization sensitivity  $10^{-5}$
- Exposure time dependent
- Polarization accuracy  $5 \cdot 10^{-4}$
- Cal optics after  $M_{12}$



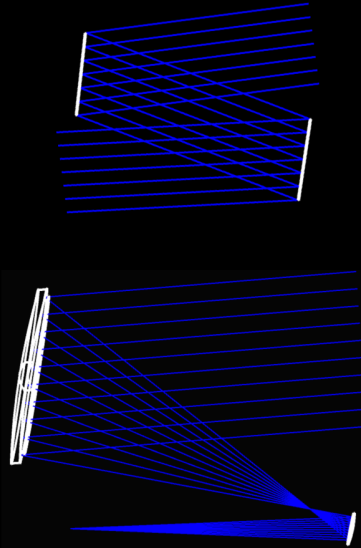
# DKIST as a Polarimeter

$$\bar{\bar{M}}_{DKIST} = \bar{\bar{M}}_7 \bar{\bar{R}}(Az - Table) \bar{\bar{M}}_{56} \bar{\bar{R}}(El) \bar{\bar{M}}_{34} \underbrace{\bar{\bar{M}}_{12}}$$

## Powered Optics & Aperture Averaging

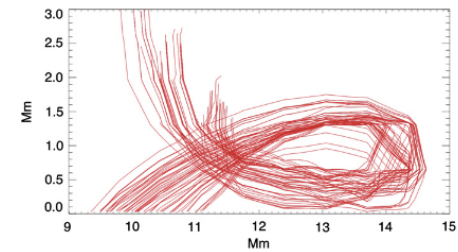
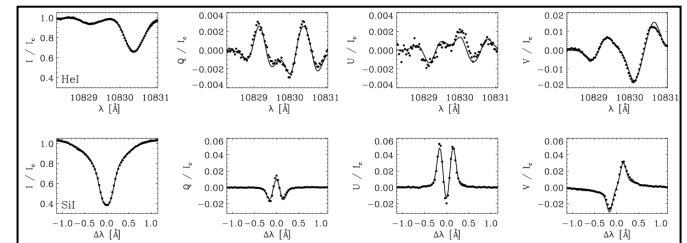
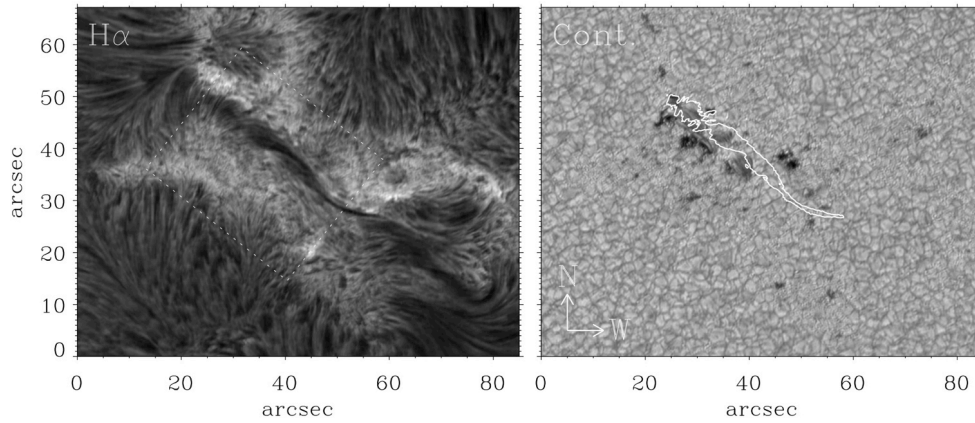
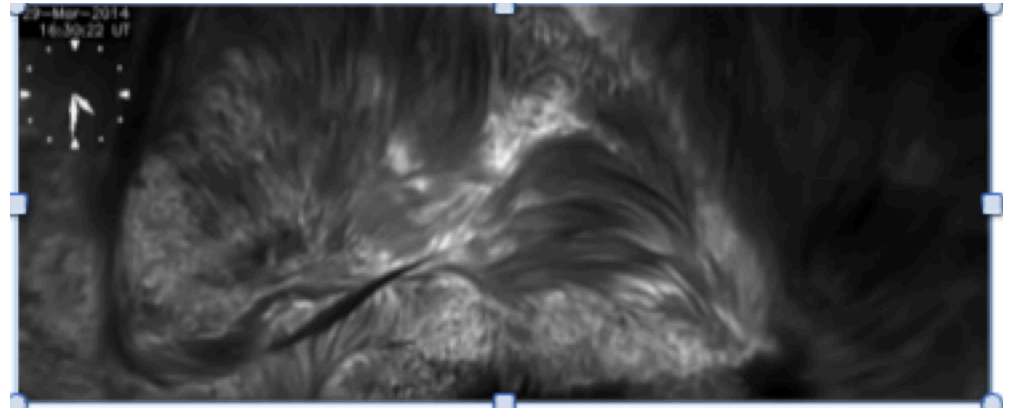
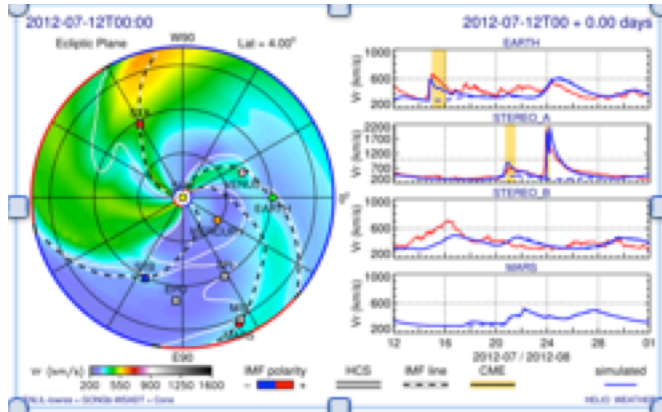
1.00000	0.00461	0.00000	0.00000
0.00461	1.00000	0.00000	0.00000
0.00000	0.00000	0.99626	-0.08624
0.00000	0.00000	0.08624	0.99626
<hr/>			
1.00000	0.00449	0.00000	0.00000
0.00449	0.99905	0.00000	0.00000
0.00000	0.00000	0.99552	-0.08471
0.00000	0.00000	0.08477	0.99457
<hr/>			
0	0.00012	0	0
0.00012	0.00095	0	0
0	0	0.00074	0.00153
0	0	0.00147	0.00169

Diattenuation & retardance differ  
Diagonal terms lower than expected  
400nm, Al+Al<sub>2</sub>O<sub>3</sub> on M1, 3-layer Ag on M2



- $M_{12}$  independent of pointing
- Zeemax modeling including coatings
- Expected  $V \rightarrow U$  larger than  $V \rightarrow Q$
- Sky polarization
- Lines with no Q & U: Sun pointing
- Mirror samples
- **PolCal is a facility task**

# DKIST as a Polarimeter



# Critical Science Plan Workshops

DKIST Critical Science Plan Workshops

Nine themed Critical Science Plan Development workshops are planned (some multi component) as described below. Note that participation to the workshop is by invitation only. Questions and comments can be directed to the single workshops' organizers, or to [V. Martinez Pillet](#); [G. Cauzzi](#); [M. Rast](#)



## MAGNETIC RECONNECTION AND RECONFIGURATION

(D. McKenzie, Y. Katsukawa)

Aims to develop Science Use Cases investigating the magnetic structure of the solar atmosphere, its reconfiguration during reconnection, and the resulting waves and flows.

### Workshop dates:

13 - 15 November 2017  
(Huntsville, AL)  
Early Spring 2018  
(Nagoya, Japan)

[Read More](#)



## MAGNETIC CONNECTIVITY (D. Schmit, K. Muglach)

Aims to develop Science Use Cases that leverage DKIST's polarimetric and multi-line capabilities to understand the magnetic structure and energy transfer through the solar atmosphere.

### Workshop dates:

8 - 10 January 2018  
(Washington, DC)

[Read More](#)



## PHOTOSPHERIC MAGNETIC FIELDS (C. Fischer, N. Bello-Gonzalez)

Aims to develop Science Use Cases that leverage DKIST's high resolution polarimetric capabilities to study the structure and dynamical evolution of magnetic fields at the smallest scales.

### Workshop dates:

16 - 18 January 2018  
(Freiburg, Germany)

[Read More](#)



<http://nso.edu/cspw.php>

# Thanks !



<http://dkist.nso.edu/>

