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 μm.
  - 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

DKIST PI:

NSO/AURA

DKIST Director: T. Rimmele

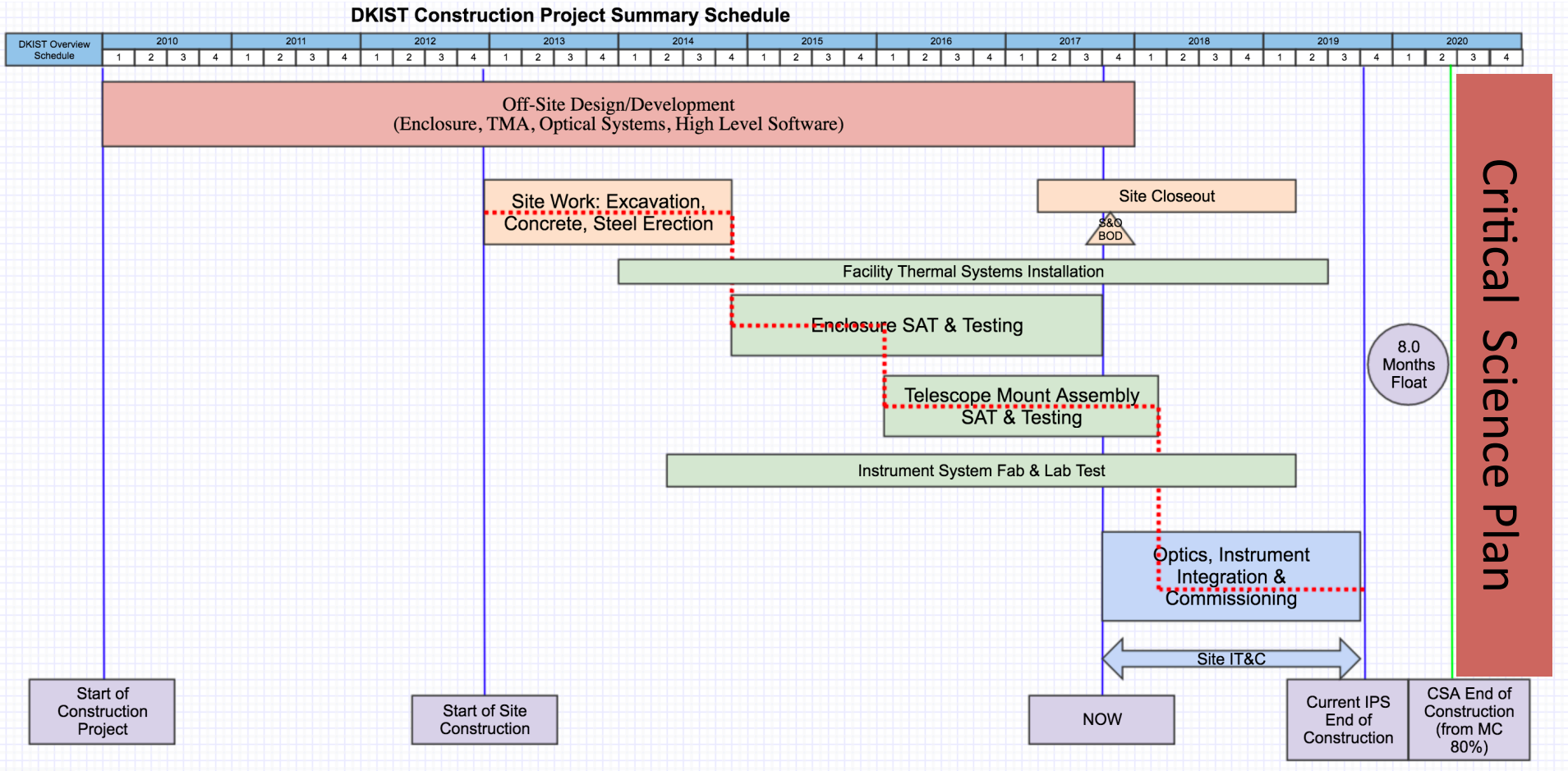
DKIST co-Is:

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

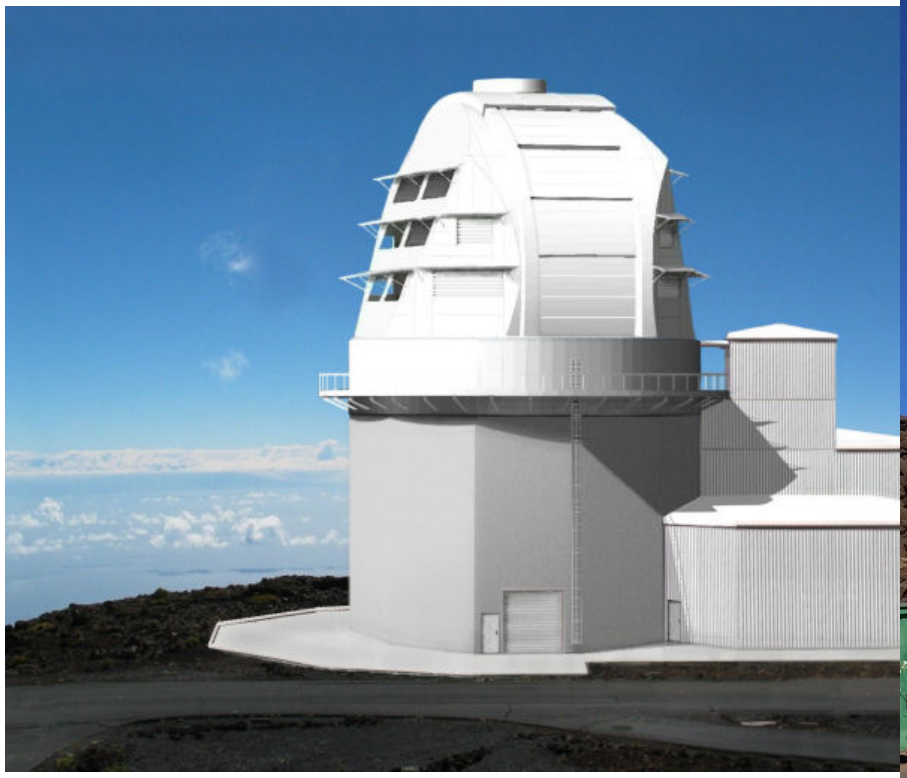
First light instruments

- 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

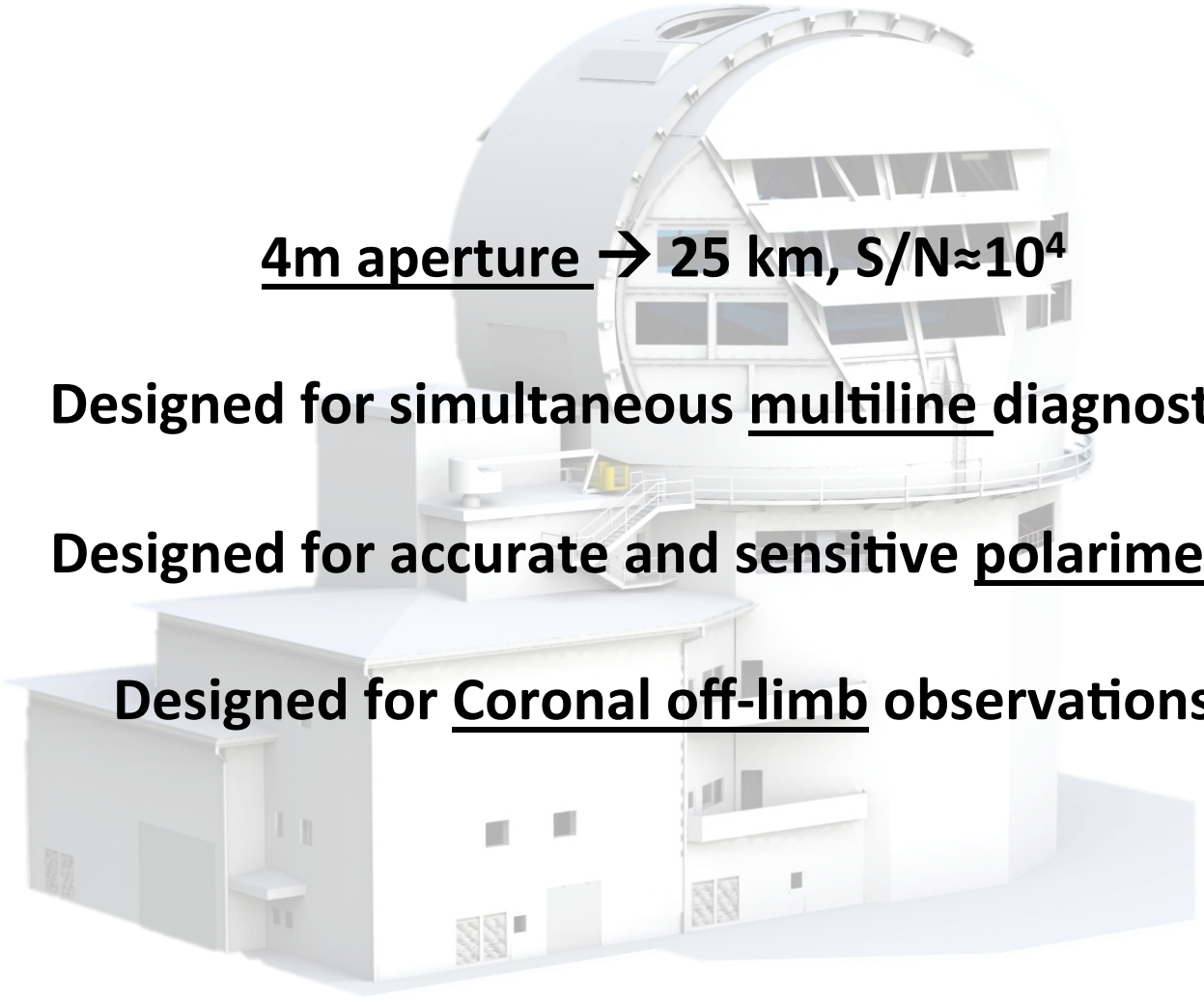
The DKIST: status and timeline



7 years of construction; 75% complete



DKIST: a transformational facility



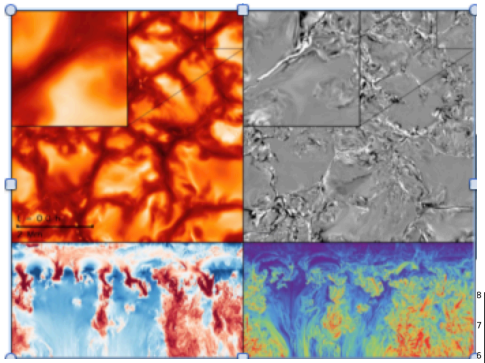
4m aperture → 25 km, S/N≈10^4

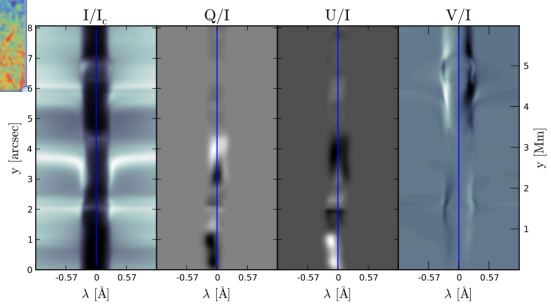
Designed for simultaneous multiline diagnostics

Designed for accurate and sensitive polarimetry

Designed for Coronal off-limb observations

DKIST: a transformational facility





$$SNR \sim 10^4$$

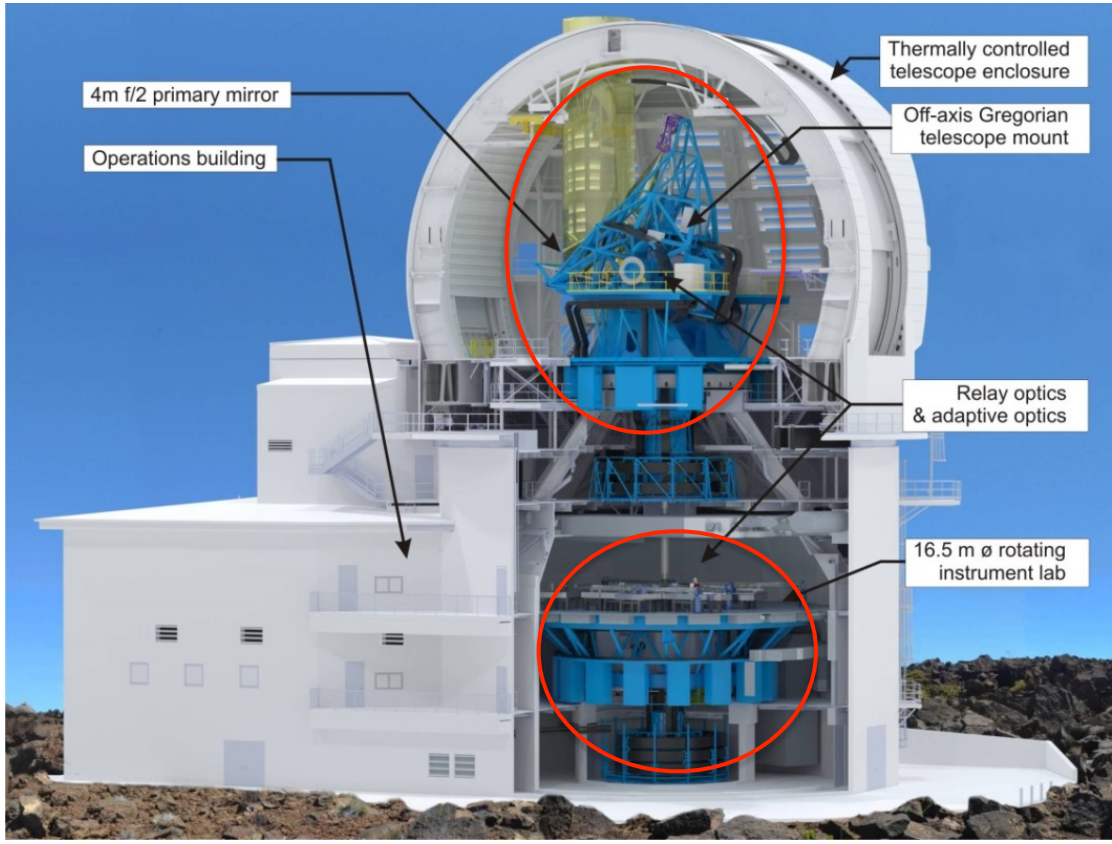
$$\phi_{px} \sim 0.1 \text{arcsec}$$

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

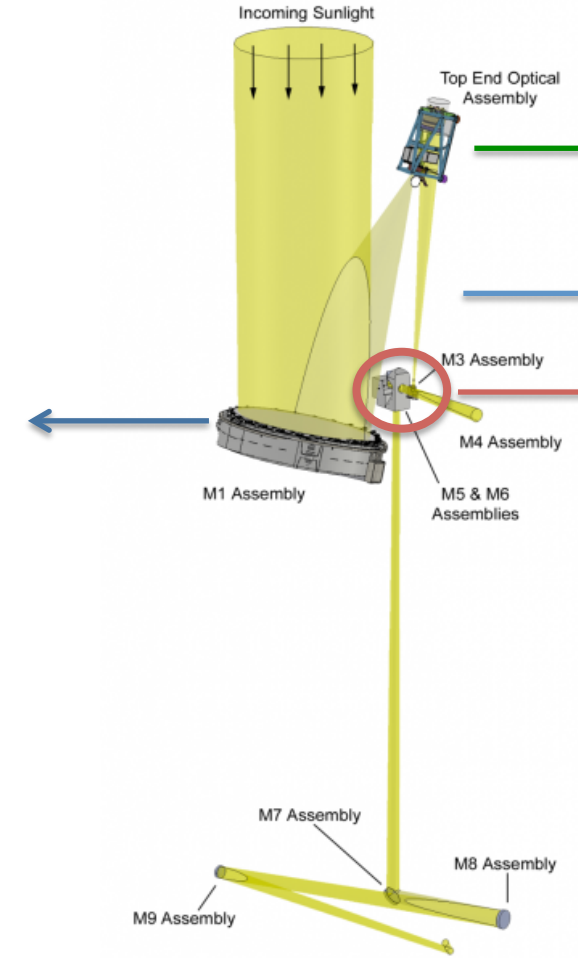
$$D = \frac{SNR}{\sqrt{0.7 N 10^{-0.4 m_\circ} \tau \Delta\lambda Q \phi_{px}^2 t_{\text{exp}}}}$$

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



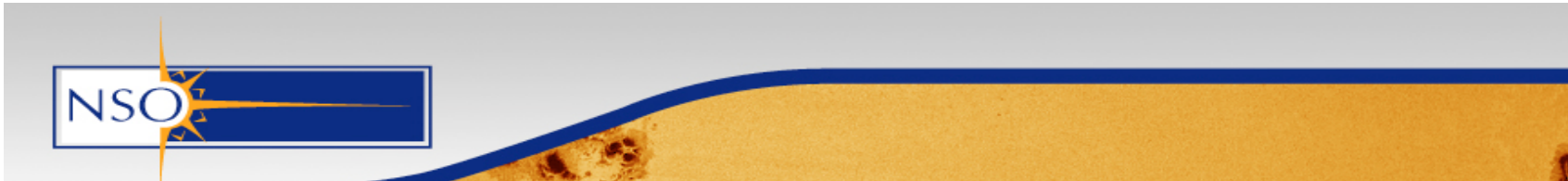
Heat stop and secondary (M2)

Lyot occulter

Gregorian Optical System (GOS)
secondary focus (limb occulters, polarization calibration)

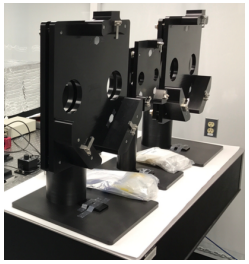
Primary mirror (M1)

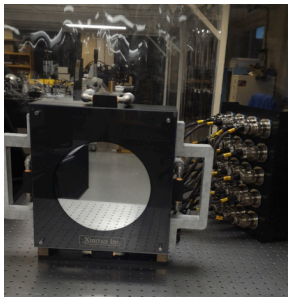
Coude platform

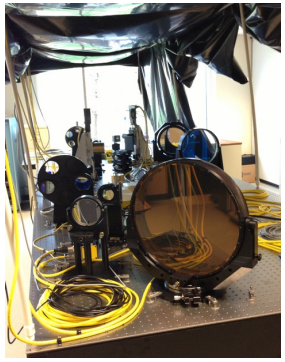


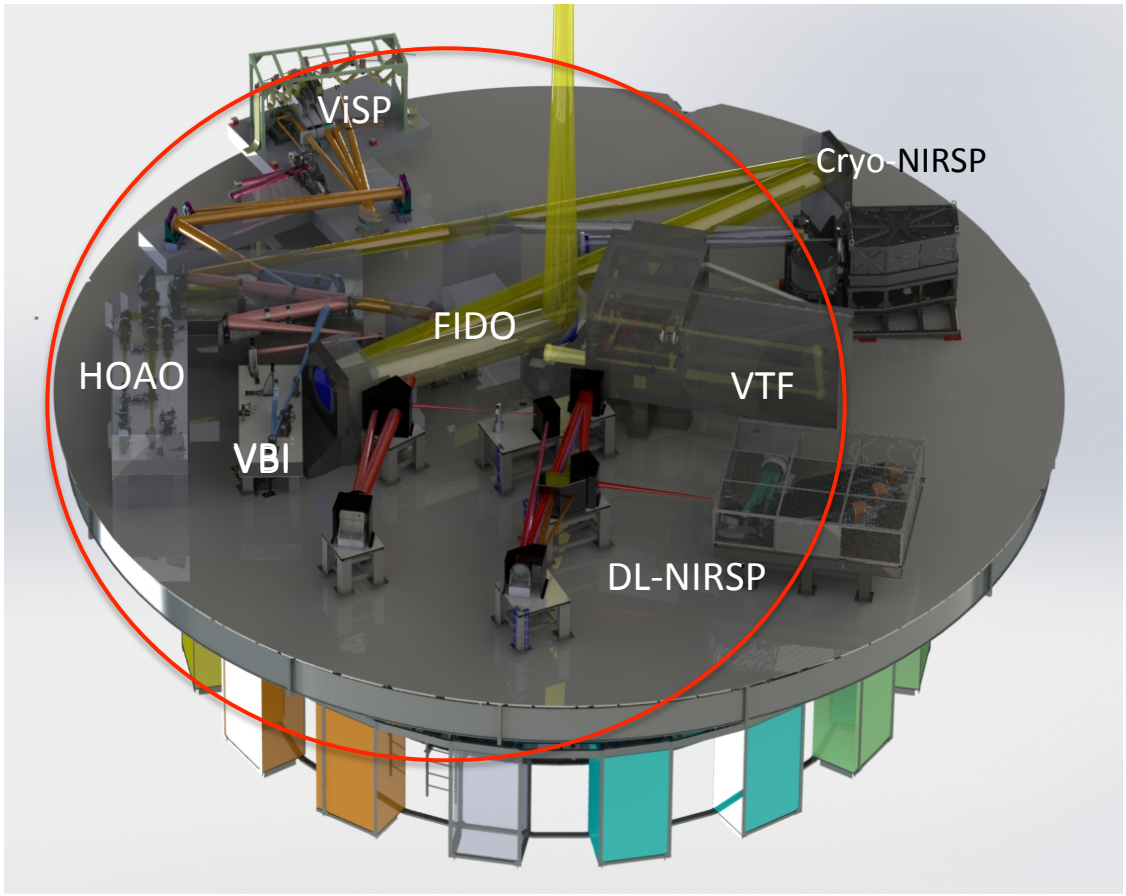
DKIST: a transformational facility

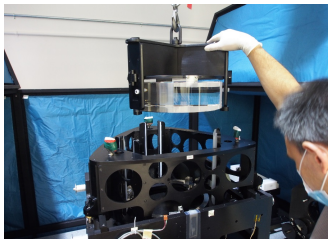
DKIST as a Multiwavelength Observatory

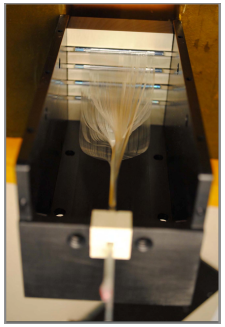






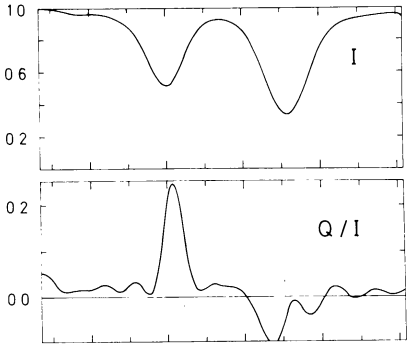


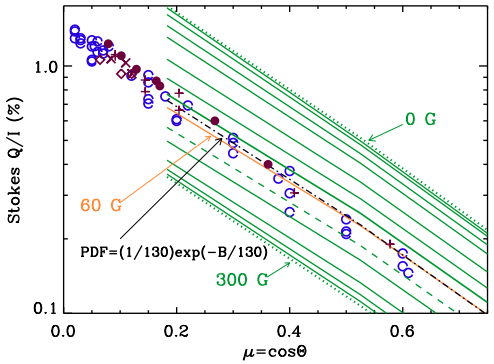


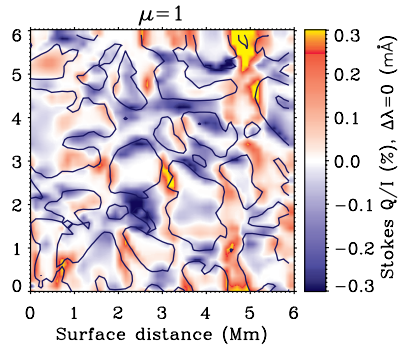


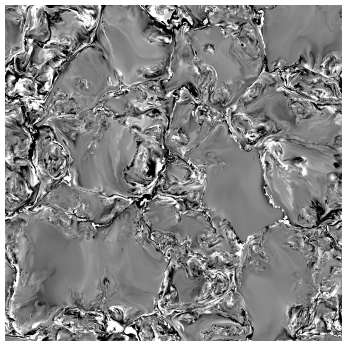
DKIST as a Multiwavelength Observatory

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

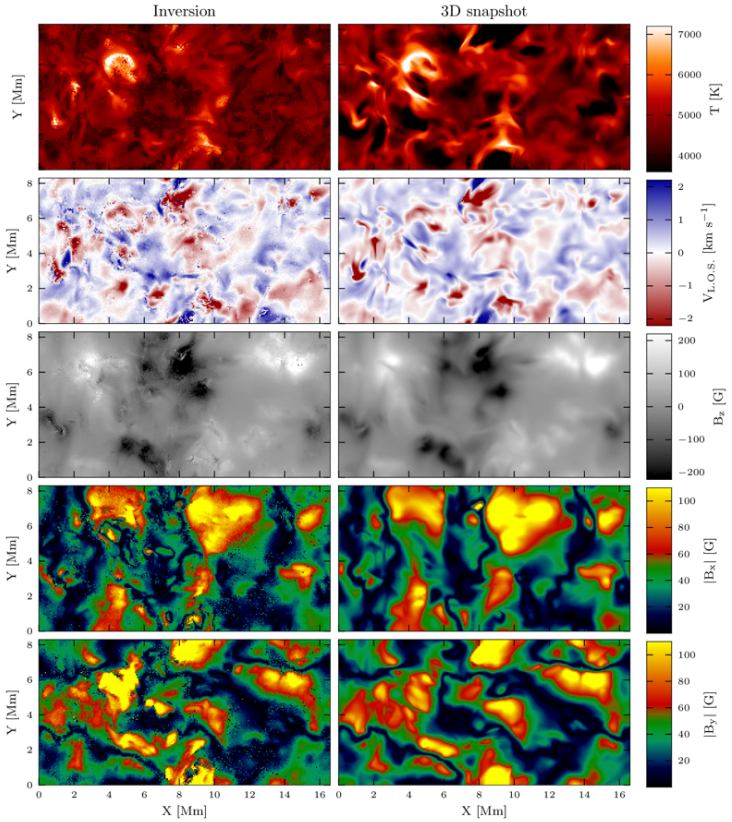




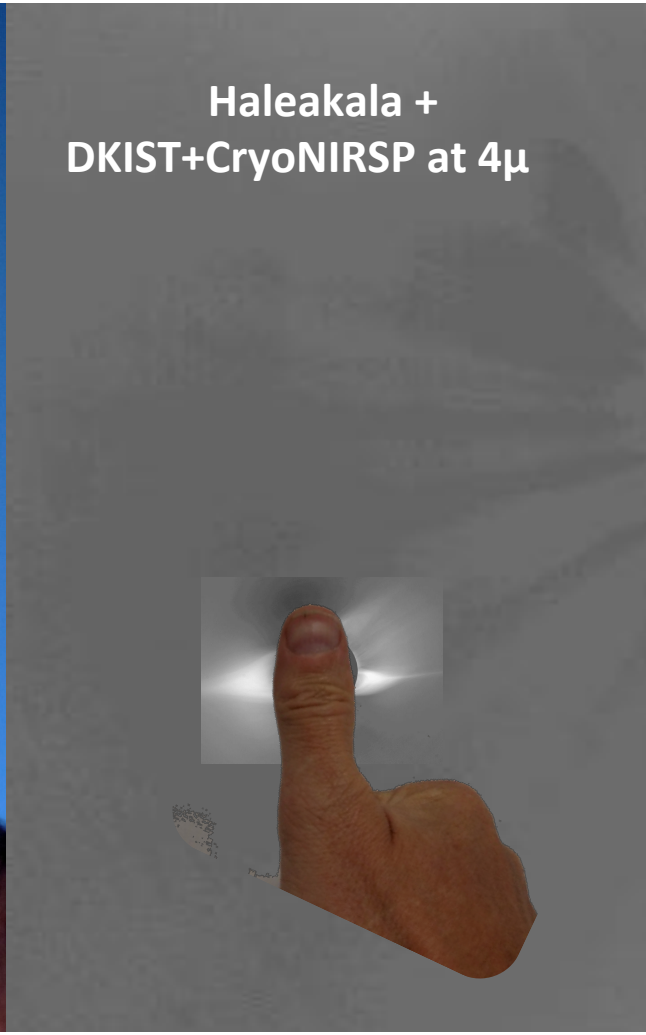




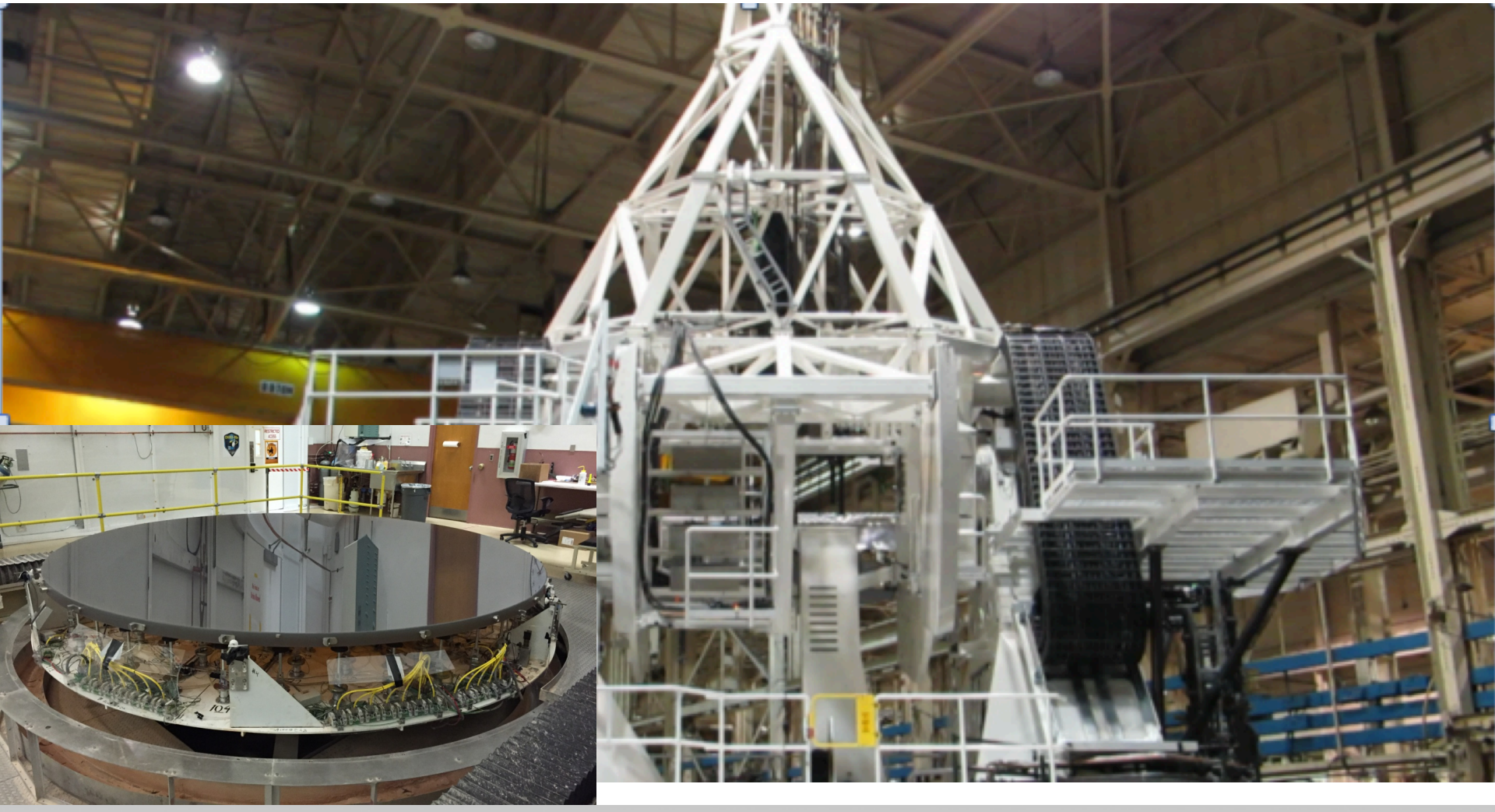
- CaII IR 8542 Å: ViSP, VTF
- SNR 10^{-4} , short cadence, multi-height



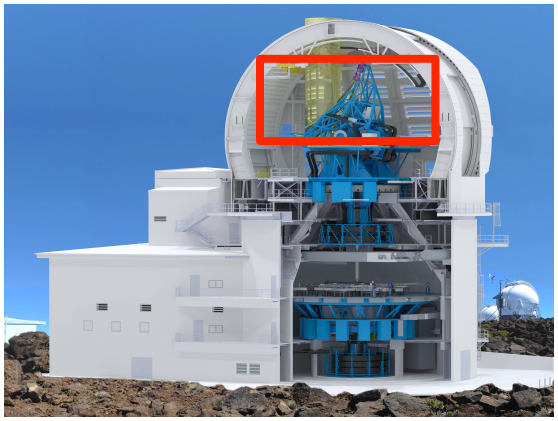
DKIST as a coronagraph

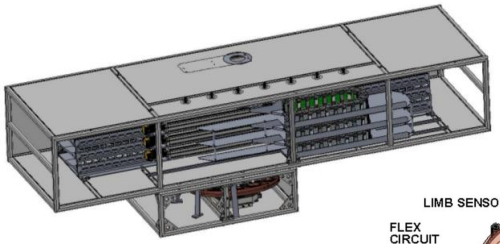


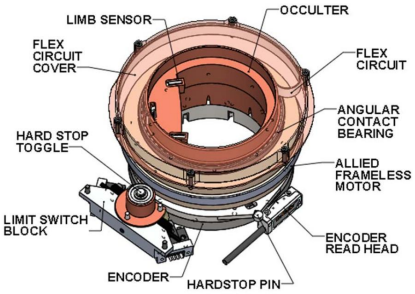
DKIST as a coronagraph

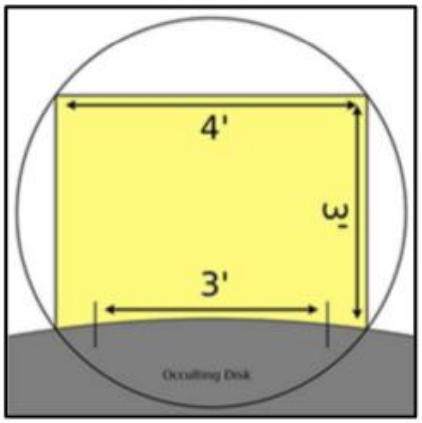


DKIST as a coronagraph







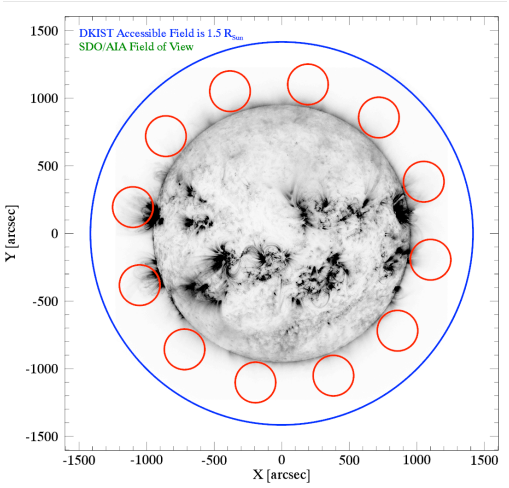


Lyot and limb occulter (3'x4' FOV)

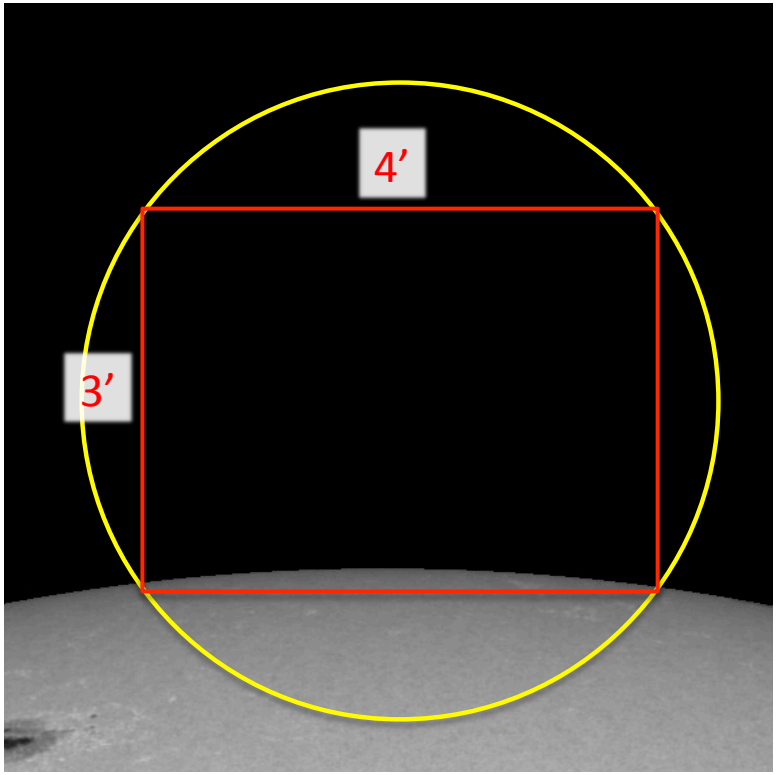
- How close?: 1 arcsec.
- How far from the limb? 0.5 $R_\odot$ max

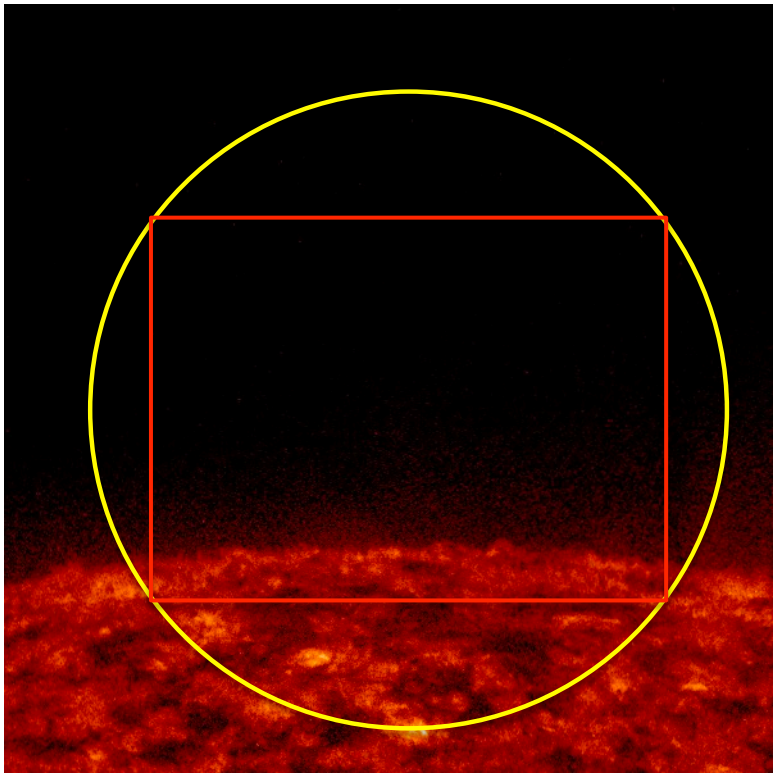
The Gregorian Optical System (GOS)

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



5’ Limb Occulter



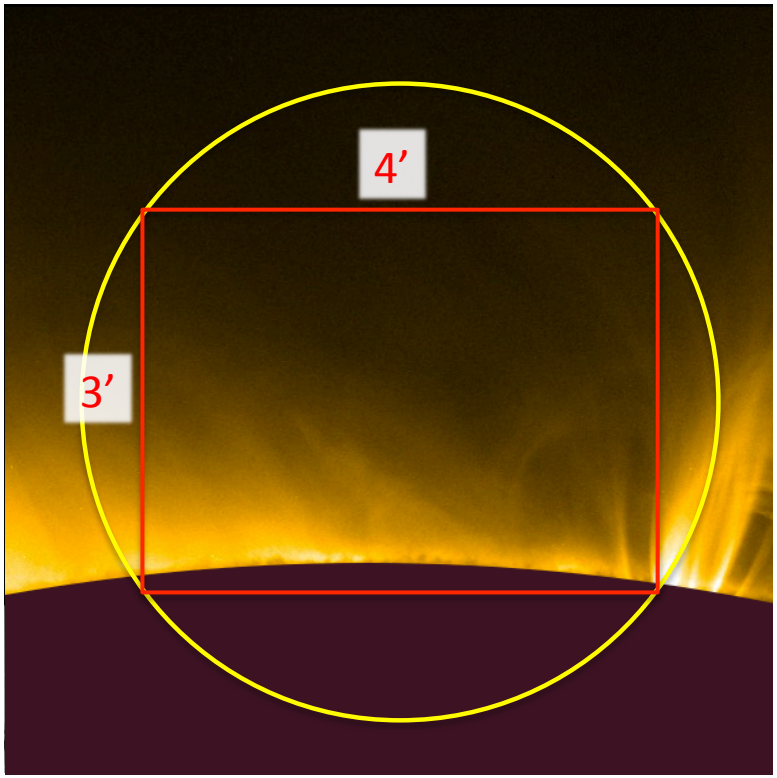


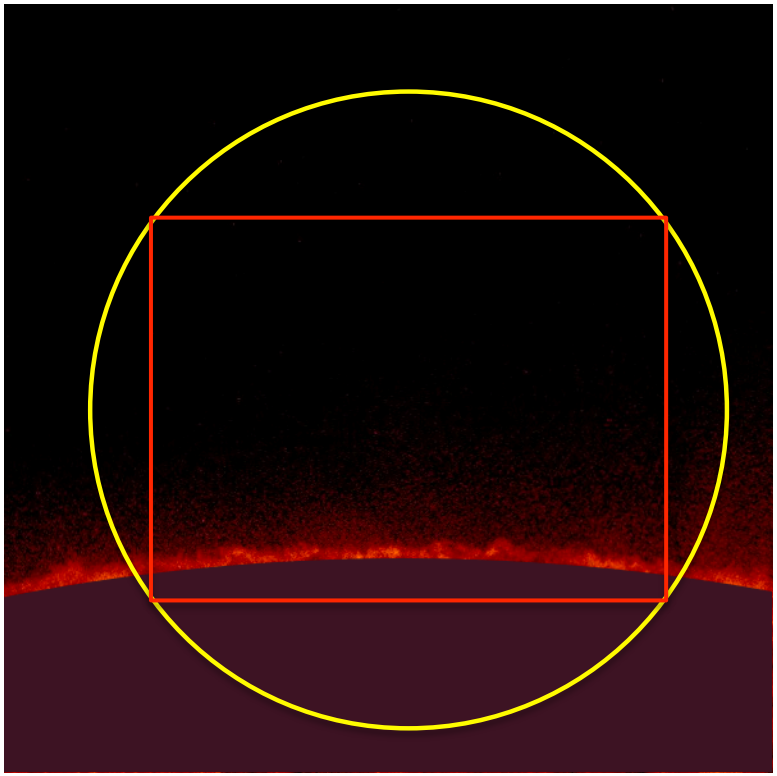
± 5”

over/under occultation

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

5’ Limb Occulter





± 5”

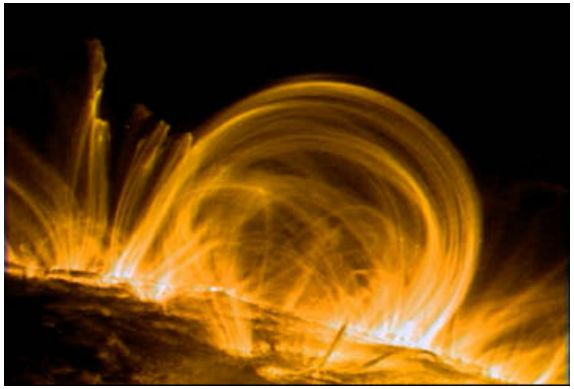
over/under occultation

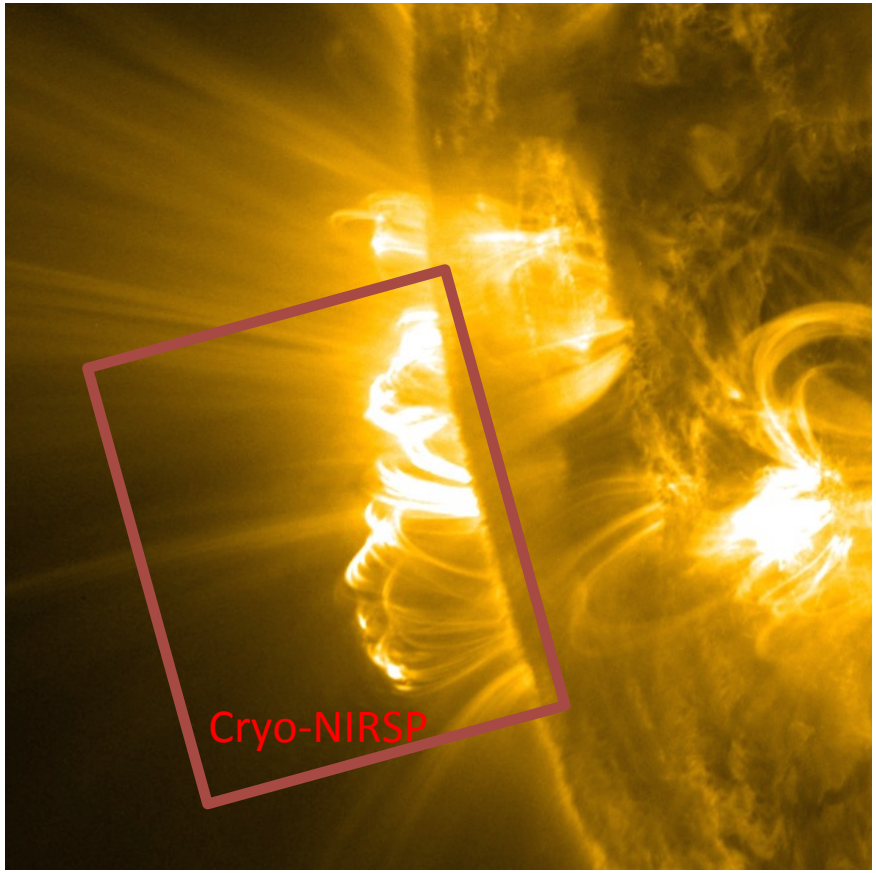
Limb sensor tracks image motion perpendicular to limb (only), corrected by M2 fast tip

DKIST as a coronagraph

Cryo-NIRSP (UH/IfA)

4’ slit x 3’ scan
1-5 µm
Off-point up to 1.5 $R_\odot$
1 arcsec resolution
Full Stokes-Dual Beam
~60 minutes cadence
(faster for smaller FOVs)
(I-only available)



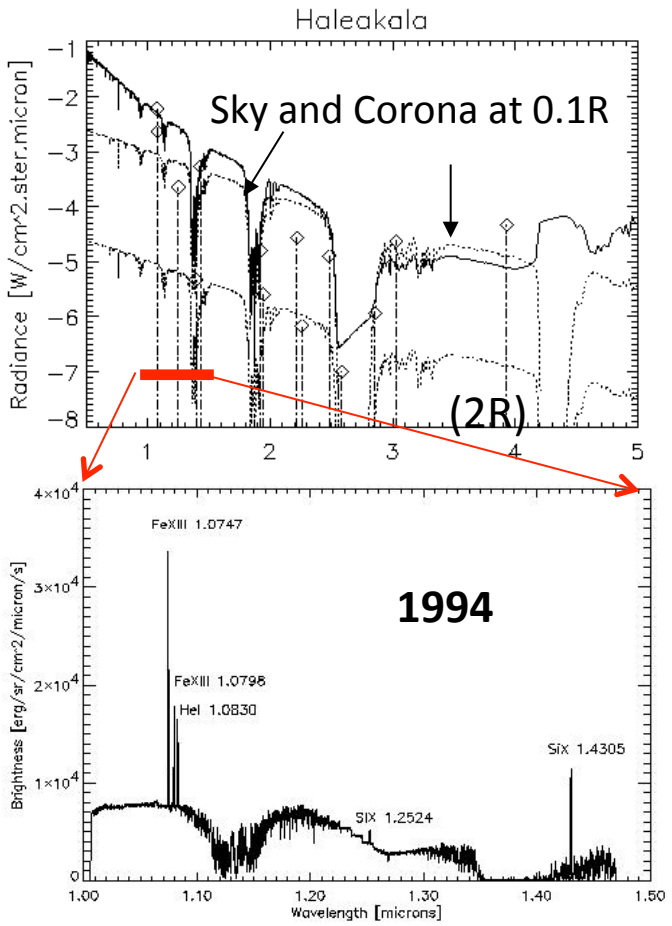


DKIST as a coronagraph

Temperature sensitivity from 3000K to 2MK

Zeeman and saturated Hanle effect in forbidden lines

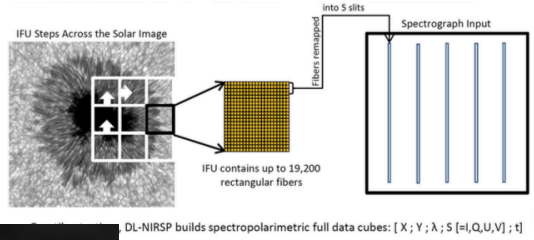
Wavelenght (nm)	Line
1074.7, 1079.7	Fe XIII
1083	He I triplet
1430	Si X
2218	Fe IX
2326	CO
2580	Si IX
3028	Mg VIII
3935	Si IX
4651	CO

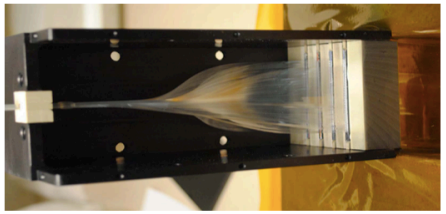


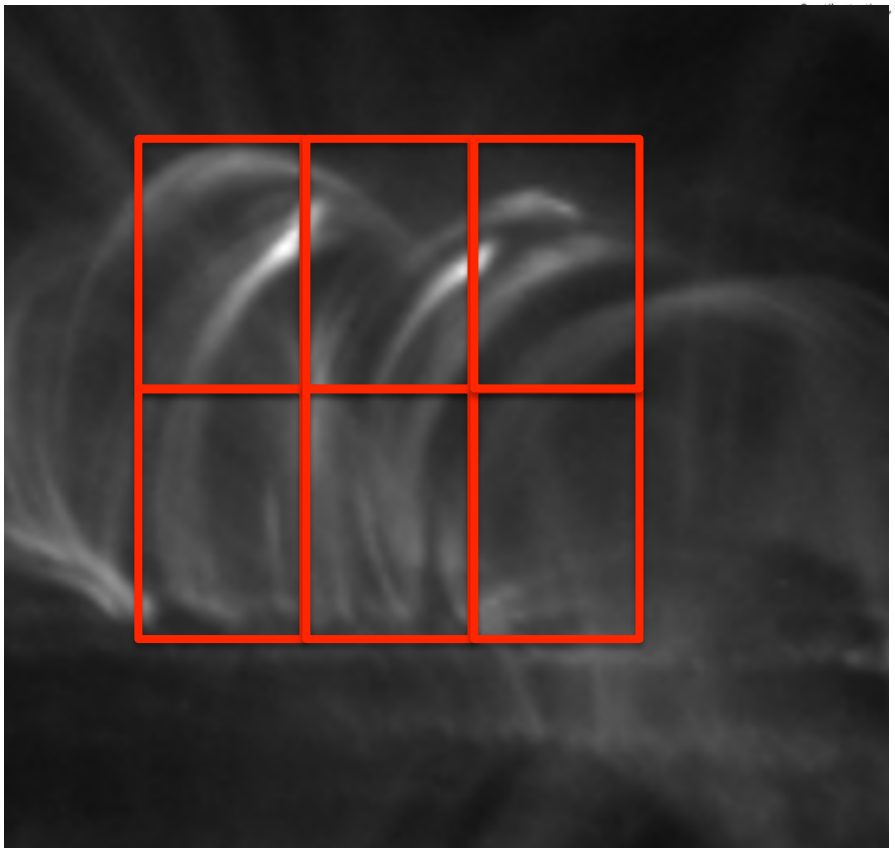
Discovery Space: MHD waves, Coronal Abundances, FIP effect, etc.

DKIST as a coronagraph

But also…
DL-NIRSP







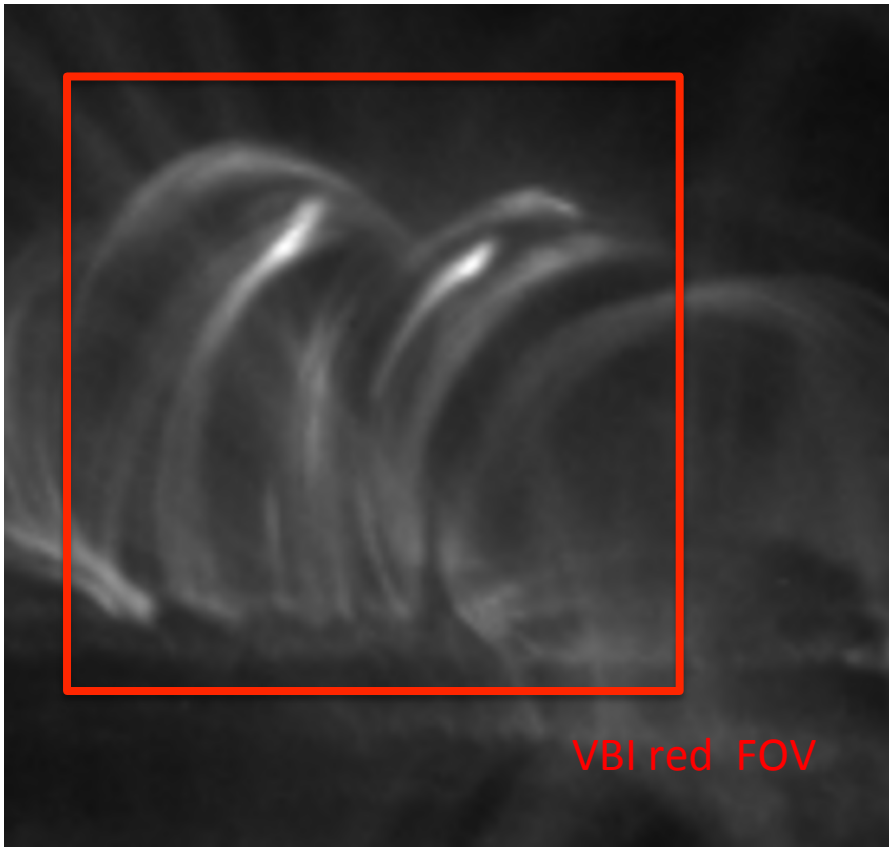
55”x55” (6 tiles)
Near-limb (occulted)
0.464” sampling
15x6 seconds
Full Stokes-Dual Beam
Pol. sensitivity 10^{-3}

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)

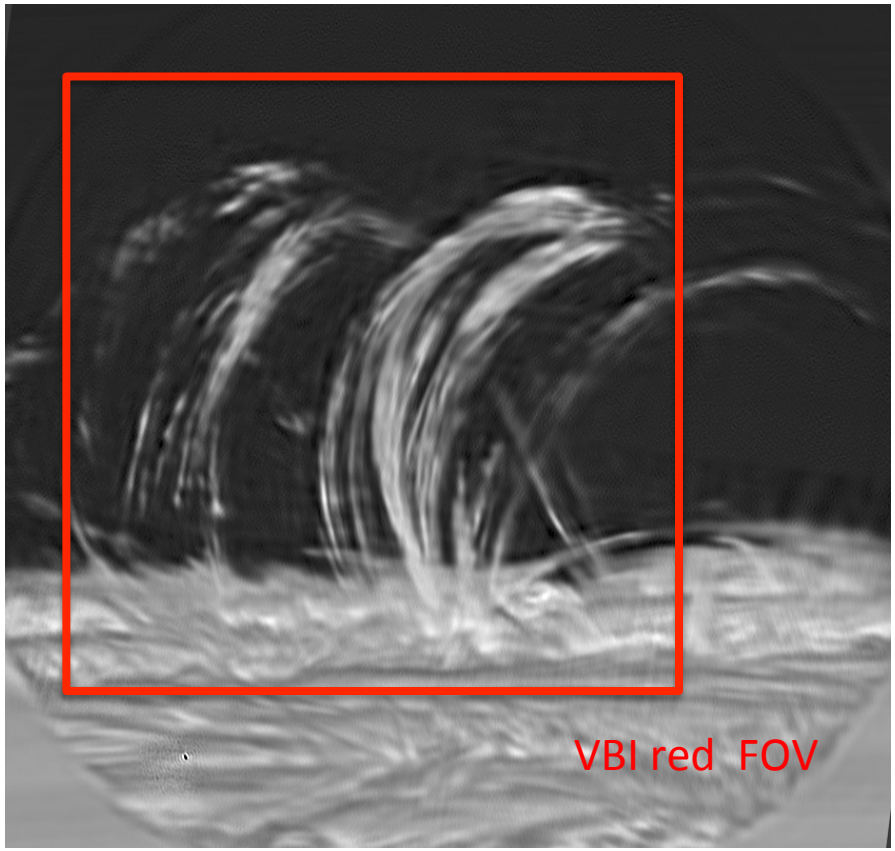


SDO/AIA 171 – 900 km resolution

DKIST as a coronagraph

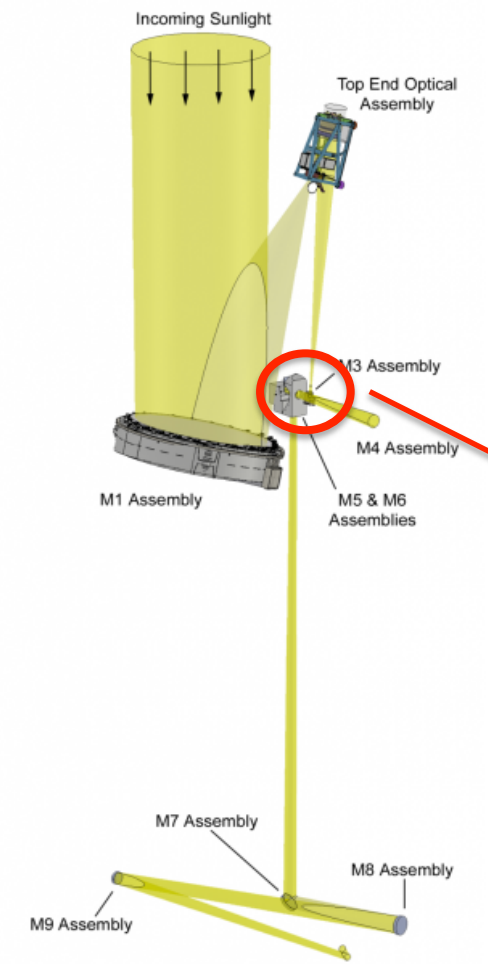
But also…
VBI
(and other instruments)

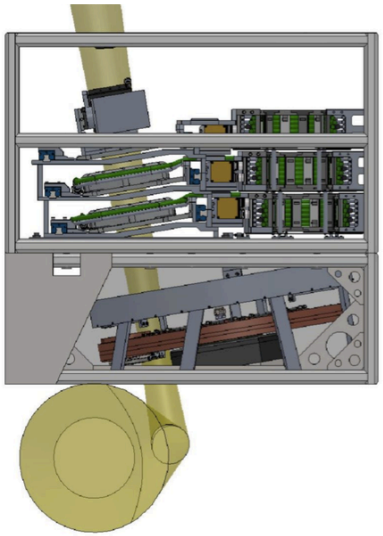
Fe XI 789.2 nm
FOV: 69” x 69”
0.03” resolution (no binning)
Few s cadence (depending on line brightness)



IBIS Hα – 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 10^{-4}
- Cal optics after M_{12}

DKIST as a Polarimeter

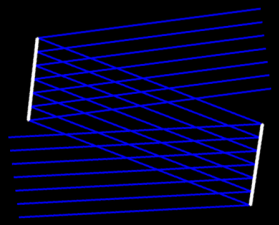
$$\bar{\bar{M}}_{DKIST} = \bar{\bar{M}}_7 \bar{\bar{R}}(Az-Table)\bar{\bar{M}}_{56}\bar{\bar{R}}(El)\bar{\bar{M}}_{34}\bar{\bar{M}}_{12}$$

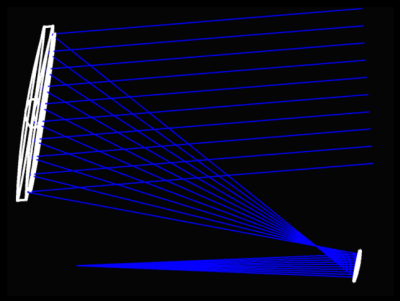
Powered Optics & Aperture Averaging

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

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

0	0.00012	0	0
0.00012	0.00095	0	0
0	0	0.00074	0.00153
0	0	0.00147	0.00169

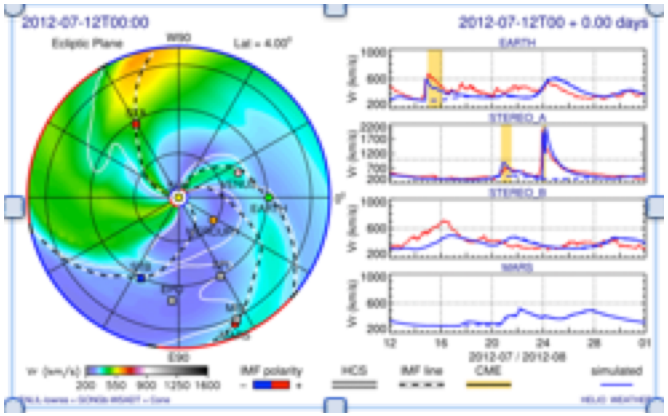


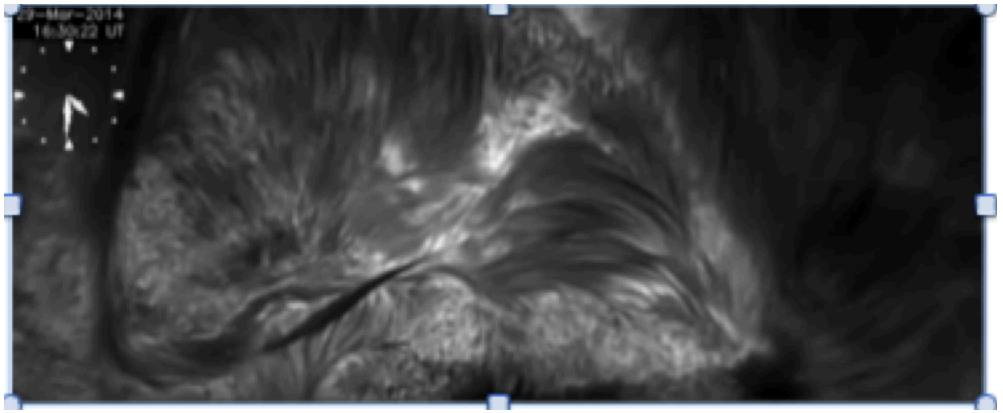


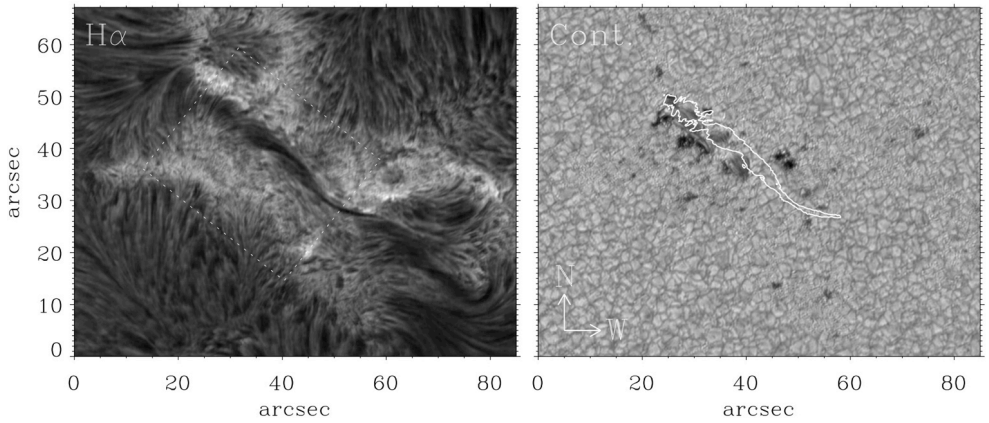
Diattenuation & retardance differ
Diagonal terms lower than expected
400nm, Al+Al2O3 on M1, 3-layer Ag on M2

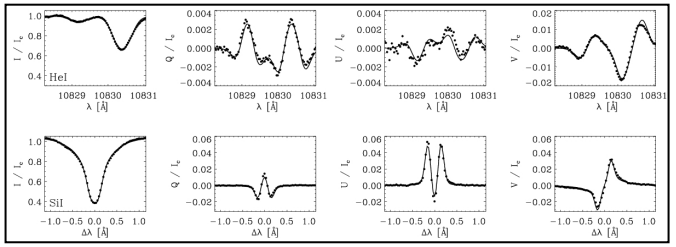
- M_{12} independent of pointing
- Zeemax modeling including coatings
- Expected V→U larger than V→Q
- Sky polarization
- Lines with no Q & U: Sun pointing
- Mirror samples
- **PolCal is a facility task**

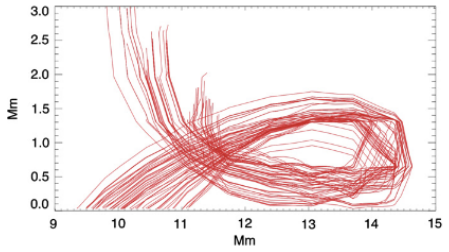
DKIST as a Polarimeter



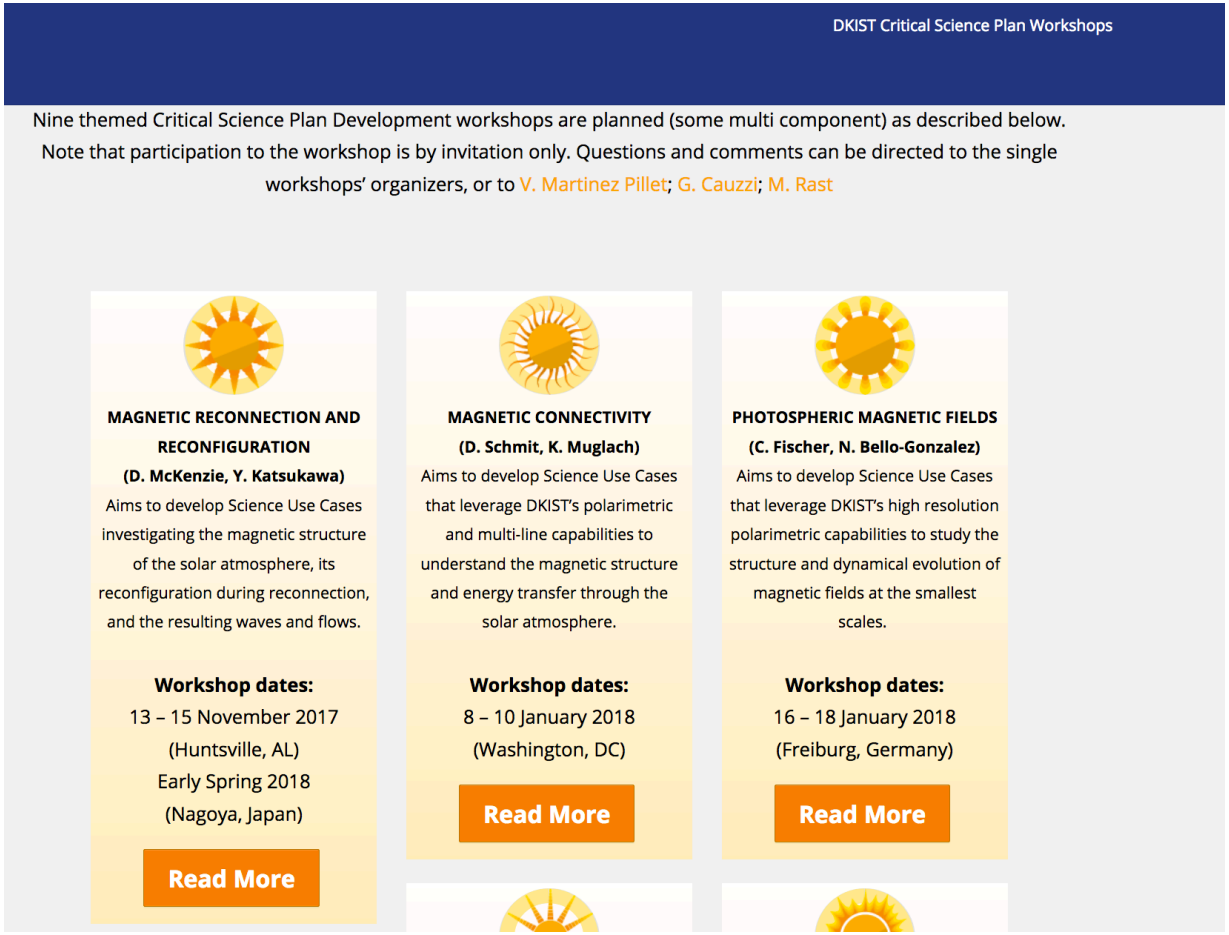








Critical Science Plan Workshops



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Thanks !

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