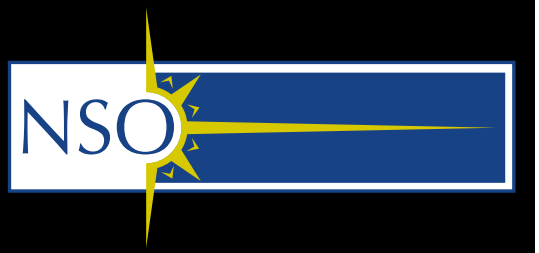
Daniel K. Inouye Solar Telescope: Collaborations and synergies between DKIST and SOLAR-C

V. Martínez Pillet, T. Rimmele & DKIST Team

National Solar Observatory



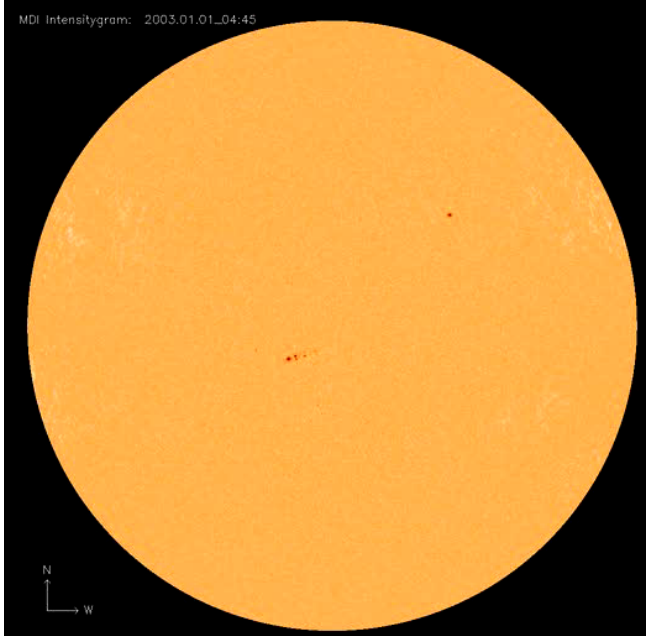
Outline

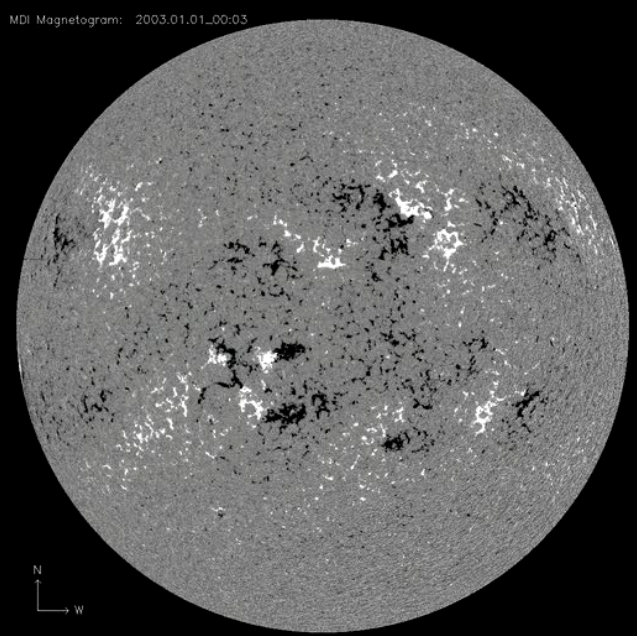
1. Where is Solar Physics Heading?
2. Why 4m?
3. DKIST Status
4. Solar-C & DKIST collaborations

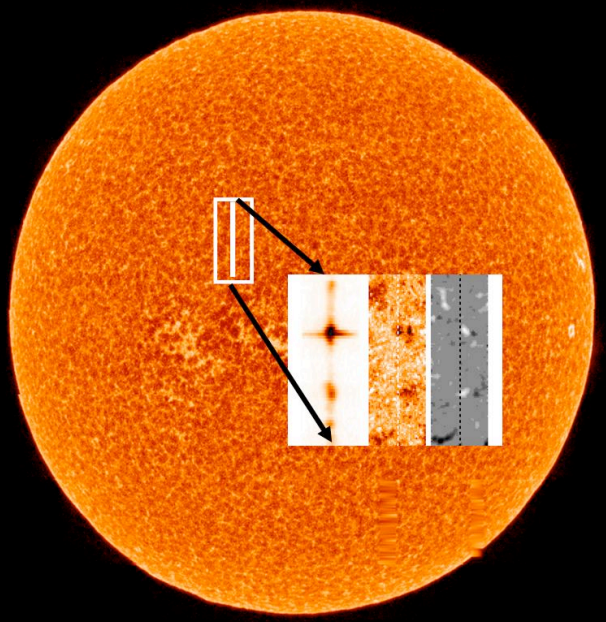
Where is Solar Physics Heading?

Accurate measurements of the Magnetic Field from the interior of the Sun all the way into the Heliosphere

(Interior/Photosphere/Chromosphere/Corona)

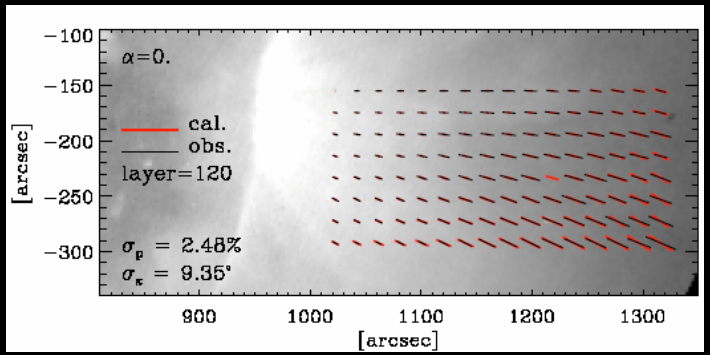




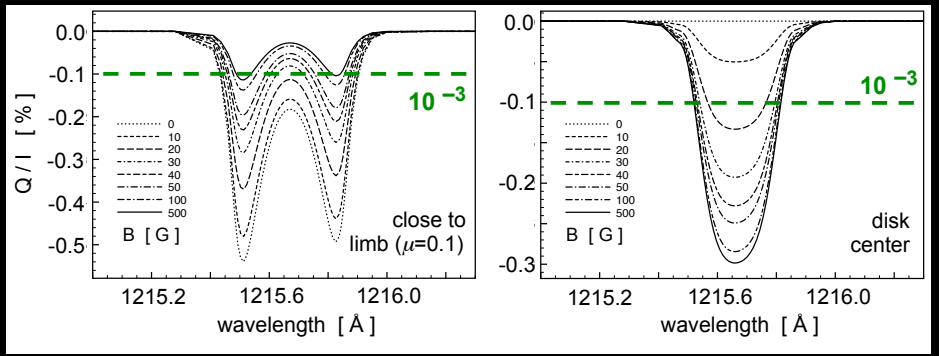


Measuring ***B*** in the TR & Corona

- Forbidden line *FeXIII 10747 Å* **off disk**, Hanle saturated. Stokes V from Zeeman
- 10^{-4} pol. accuracy was needed for observations with arcsecs (t_{exp} minutes !)
- *MgII h & k line (2795 Å)*: upper chromosphere & TR. Stokes V expected large. k line sensitive to Hanle effect: 10-100 G fields.
- *HI Lyα (1215 Å)* off disk will provide full vector in the range 10-100 G for 1 R_{sun}
- *HI Lyα (1215 Å)* on disk transition region: full vector in the range 10-100 G
- Japanese led **CLASP** experiment

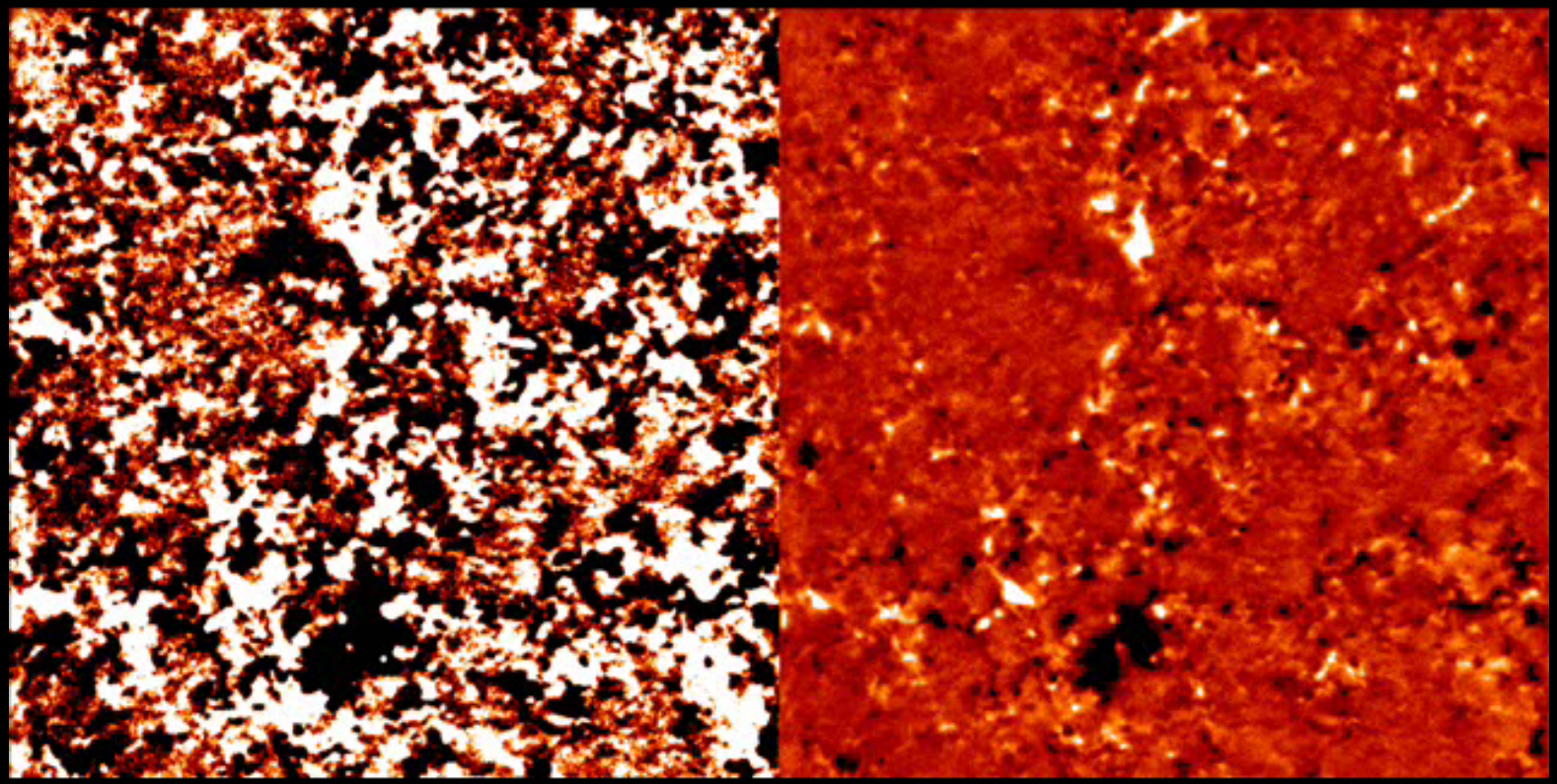


Lin et al,2001



Trujillo Bueno et al.

Explore the 10^{-4} limit

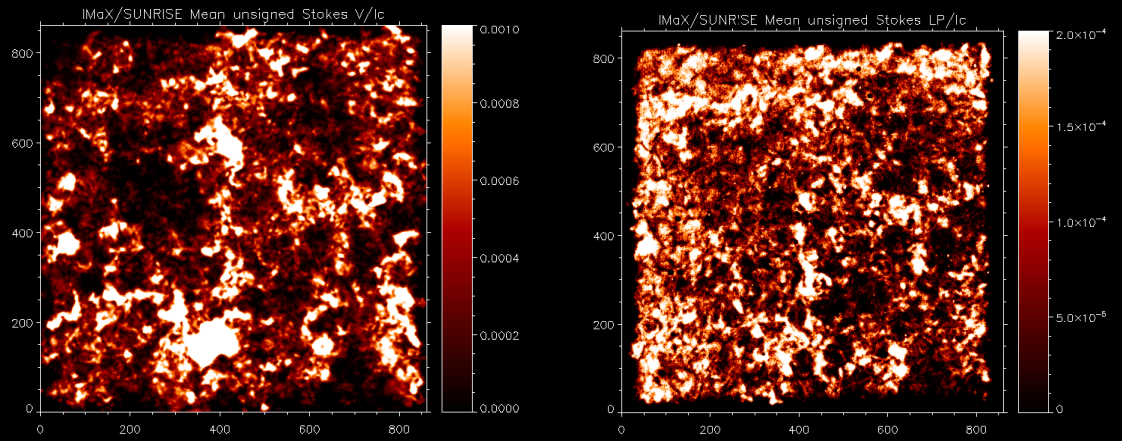


$\pm 5\ 10^{-4}$

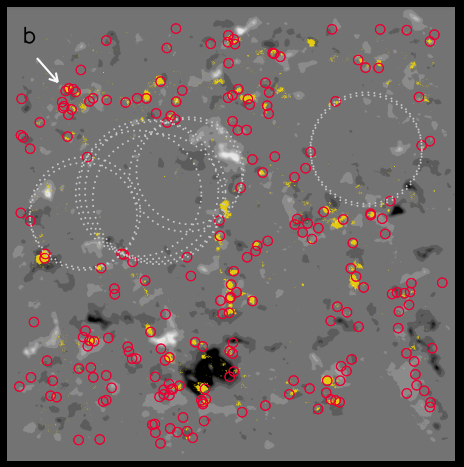
$\pm 5\ 10^{-3}$

The origin of the Quiet Sun fields

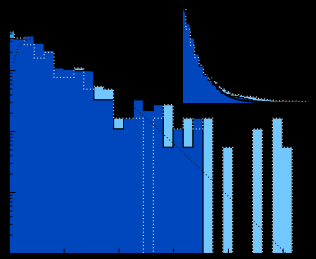
Martínez Pillet 2013



Martínez González et al. 2013



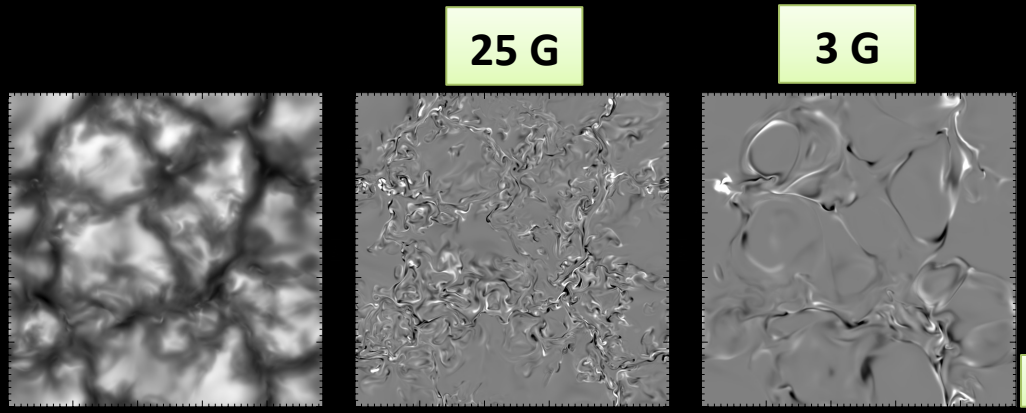
- At 10^{-3} (saturation) large voids are evident in deep magnetograms
- 250 loops in a 45x45 arcsec^2 FOV and in 30 minutes
- Loop emergence is not uniformly distributed
- It seldom occurs within the voids
- These voids are very unlikely (3 10^{-4})



Loop emergence at meso/supergranular sizes?

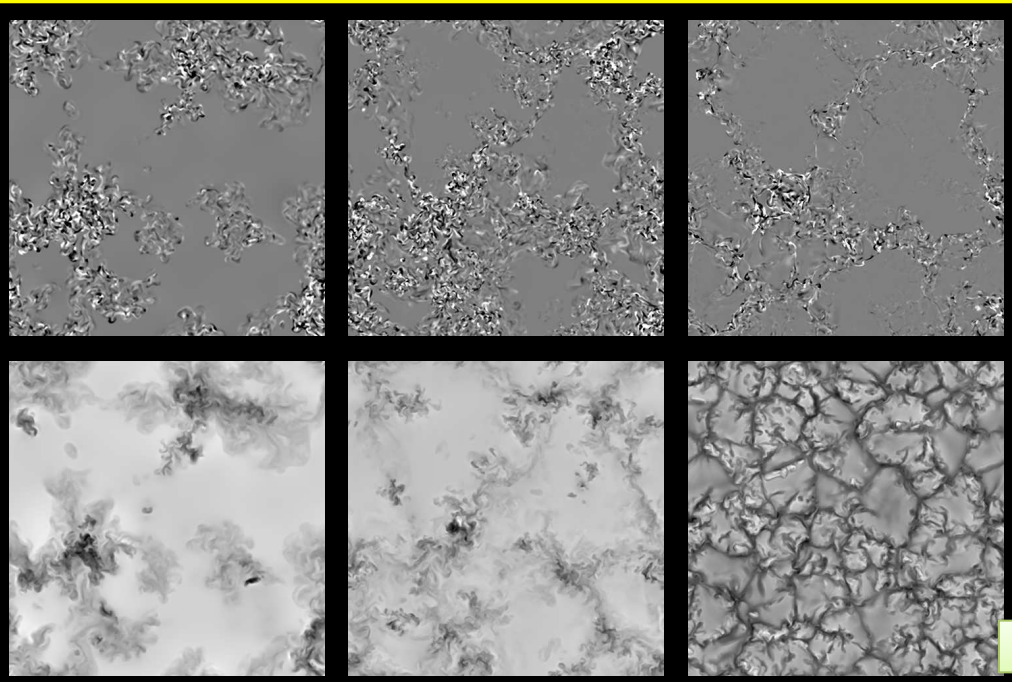
Are the granular fields still hidden (10^{-4}) from our resolution/sensitivity

The origin of the Quiet Sun fields



Intergranular lanes filled with SSD fields

Vogler et al 2007



At some sensitivity level all intergranular lanes must be filled with mixed polarity fields.

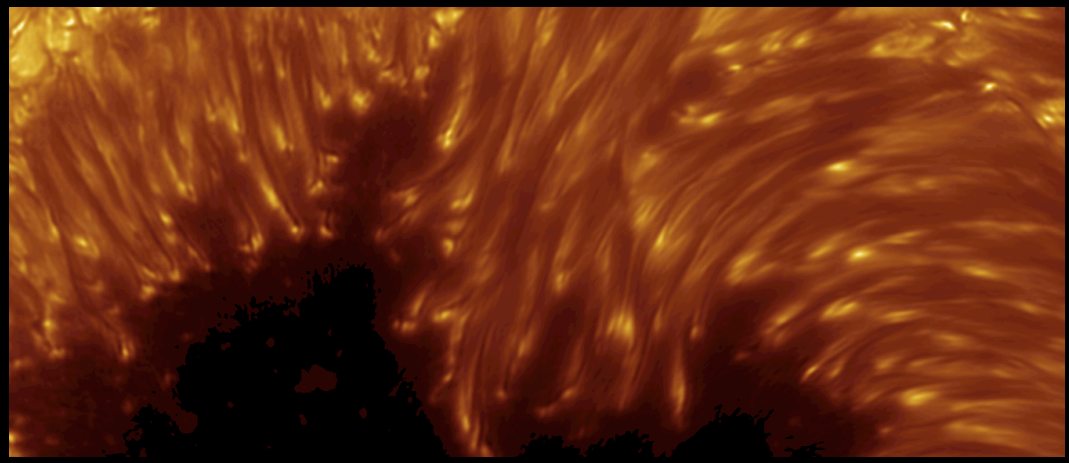
At the 10^{-4} level?

Schussler et al 2013

Why were Hinode & SUNRISE successful?

Resolution & photons

l <100 km is photon mean free path & H_p (scale height)



l=100 km (ϕ ~0.1 arcsec) requires

$$t_{\exp} \propto \frac{\phi / 2}{v_c}$$

→ 25 seconds. Polarimetry forces it to be 25/4 ≈ 6 s

Science requires ***SNR* ≈10⁴** (m_o= -10.7 magnitudes/arcsec², $\phi_{px} = \phi / 2$)

$$D = \frac{SNR}{\sqrt{0.7N10^{-0.4m_\circ}\tau\Delta\lambda Qt_{\exp}\phi_{px}^2}}$$

→ $D \approx$ 4.6m

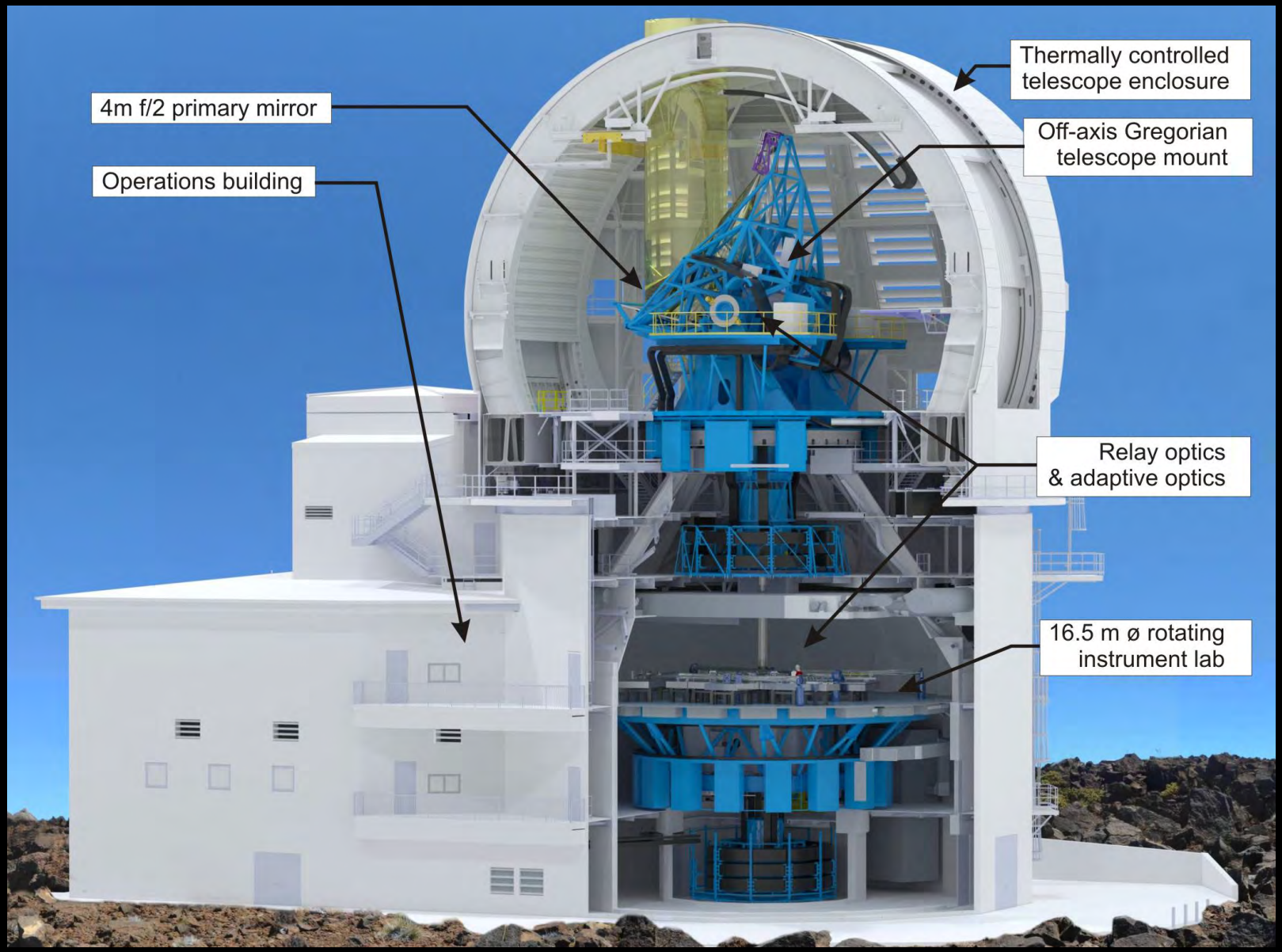
We need the photons !

DKIST: 4m class

Spectropolarimetry is a major driver in the design of our flagship facility and its instrumentation:

Clear aperture coronagraph, imaging, spectroscopy and polarimetry of rapidly evolving features


I&L
WIDE


Thermally controlled telescope enclosure
4m f/2 primary mirror
Off-axis Gregorian telescope mount
Operations building
Relay optics & adaptive optics
16.5 m ø rotating instrument lab

DKIST: 4m class

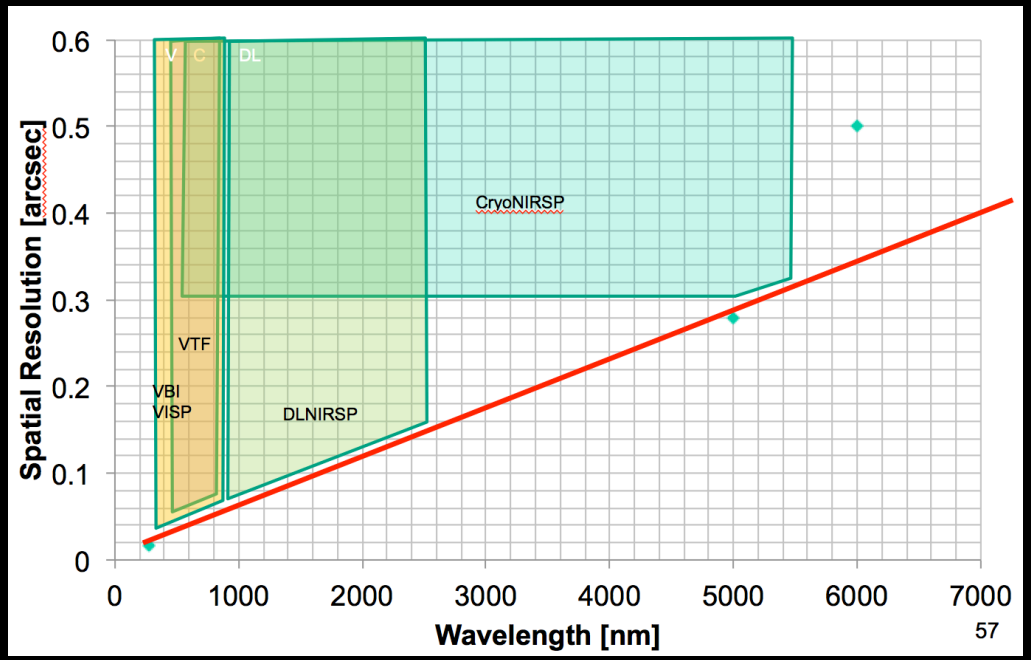
VBI : Visible Broad band imager
- Wavelength range: 380–900 nm
- Spatial resolution: 0.03” @ Hα
- Spatial FOV: 2×2 arcmin^2
- Real-time speckle

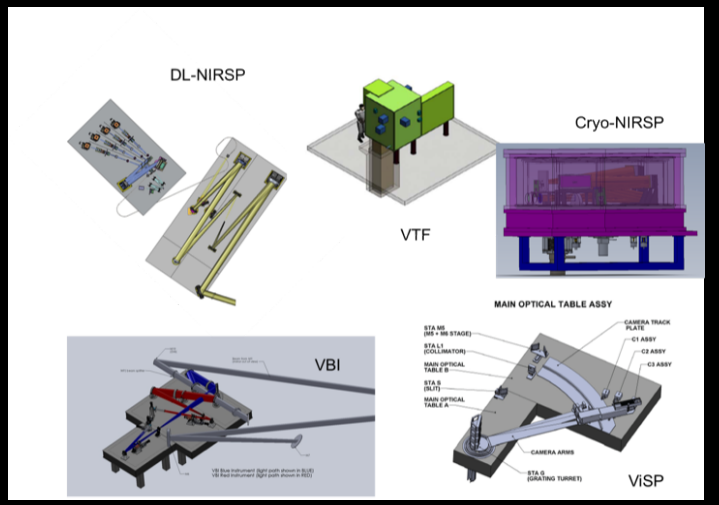
ViSP: Visible Spectropolarimeter
- Wavelength range: 380–900 nm
- Up to three lines simultaneously/fast reconfig (10 mins)
- Spatial resolution: 0.03”/pixel
- Spatial FOV: 2×2 arcmin^2
- Spectral Resolution: R ~ 3.5 pm at 630 nm

VTF: Fabry-Perot tunable Spectropolarimeter
- Wavelength range: 520–860 nm
- Spatial resolution: 0.03”
- Spatial FOV: 1x1 arcmin^2
- Spectral Resolution: R ~ 3.5 pm at 630 nm

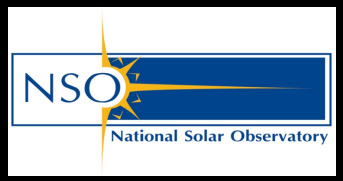
DL-NIRSP: Diffraction Limited NIR Spectropolarimeter
- Wavelength range: 900–2300 nm
- Spatial resolution: 0.03-1”/pixel
- Spatial FOV: 2.4x1.8 arcmin^2

Cryo-NIRSP: Cryogenic NIR Spectropolarimeter
- Wavelength range: 1000–5000 nm
- Spatial resolution: 1” (corona)
- Spatial FOV: 3x4 arcmin^2





DKIST



- Co-Investigators
  - P. Goode (NJIT),
  - M. Knoelker (HAO),
  - J. Kuhn (IfA),
  - B. Rosner (U.of Chicago)

Instrument Partners

- University of Hawaii
  - CRYO-NIRSP, PI: Jeff Kuhn
  - DL-NIRSP, PI: H. Lin
- High Altitude Observatory
  - ViSP, PI: R. Casini
- Kiepenheuer Institute, Germany,
  - Visible Tunable Filter, MCAO Development, PI: O. vd Luhe
- UK (proposal submitted)
  - Visible Detectors, PI: M.Mathioudakis, Belfast
- Spain (MOU in progress)
  - Polarimetric analysis PI: Jose Carlos del Toro Iniesta, Granada

Full operations begin in 2019

NSO Remote Operations Building

Maui, HI

NSO Data Center

Boulder, CO

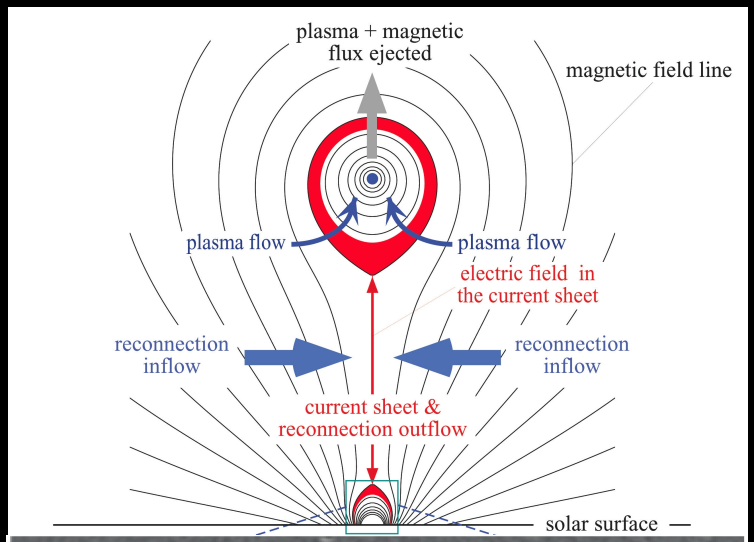
DKIST Operations

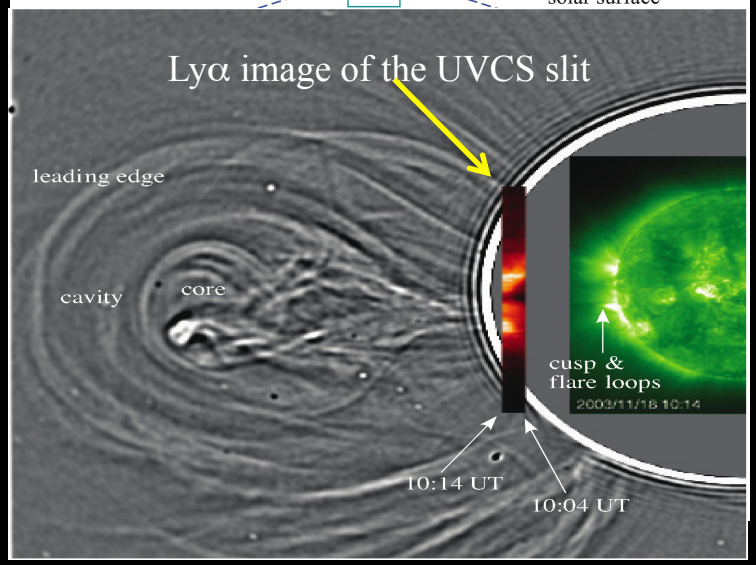
"operate more like a space mission"

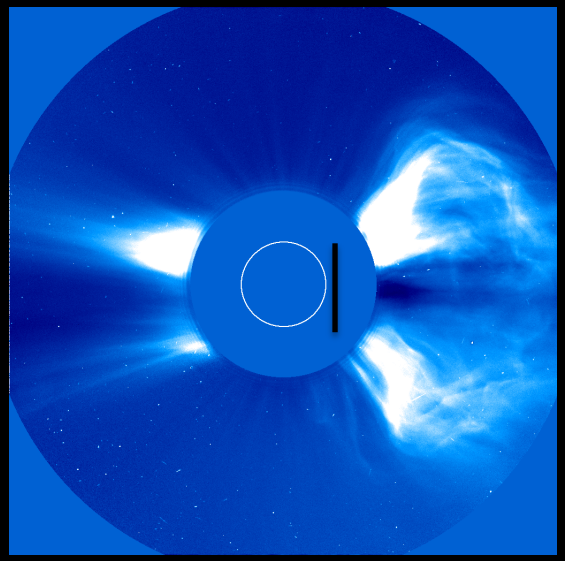
Access Mode	Service Mode	Facility Mode
PI present Dedicated time PI runs facility Proprietary data	PI at remote site Dynamic scheduling RA runs queue Open data policy	No PI Dynamic scheduling RA selects program Open data policy
Install New Instrument Inst. Scientist Training	Nominal Science Mode	Test/Develop new Programs
~ 10%	~ 80%	~10% ??

DKIST operates ~ space missions: DKIST+Solar-C common TAC?

Solar-C & DKIST collaboration



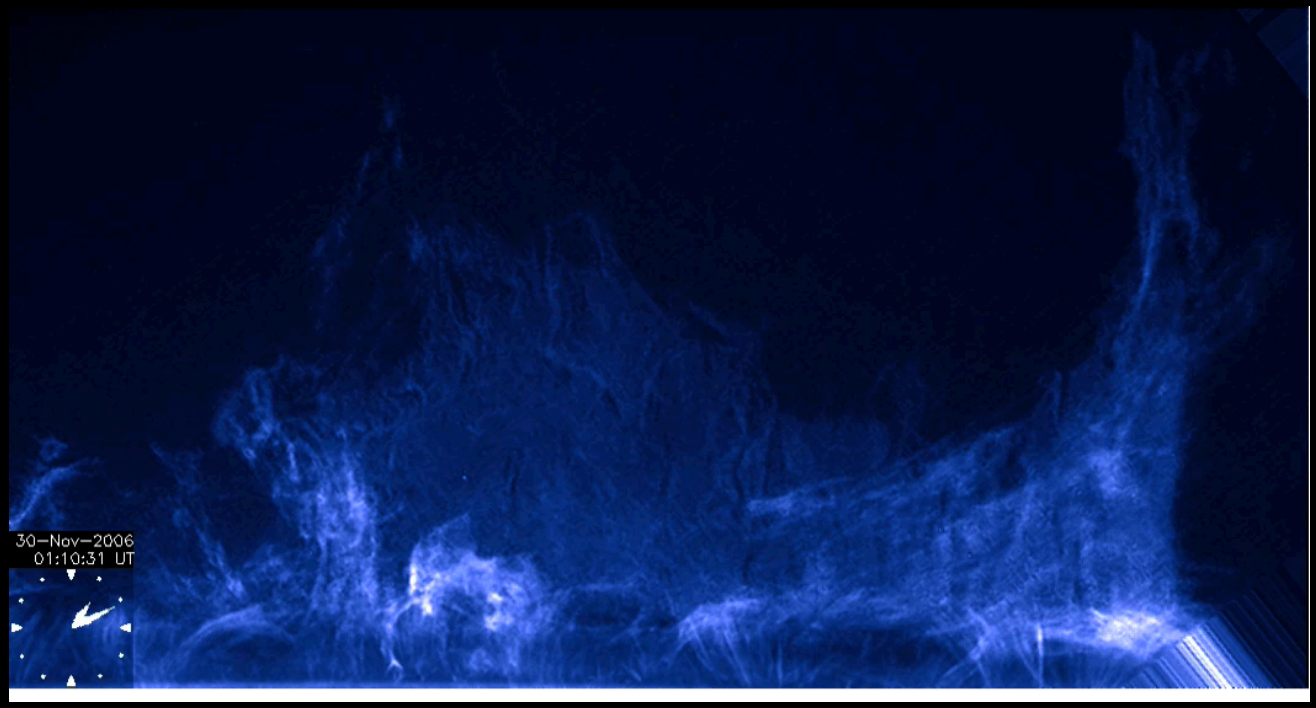




DKIST will measure the Coronal magnetic field in these critical areas.

Perhaps using as yet unknown spectral features

Solar-C & DKIST collaboration

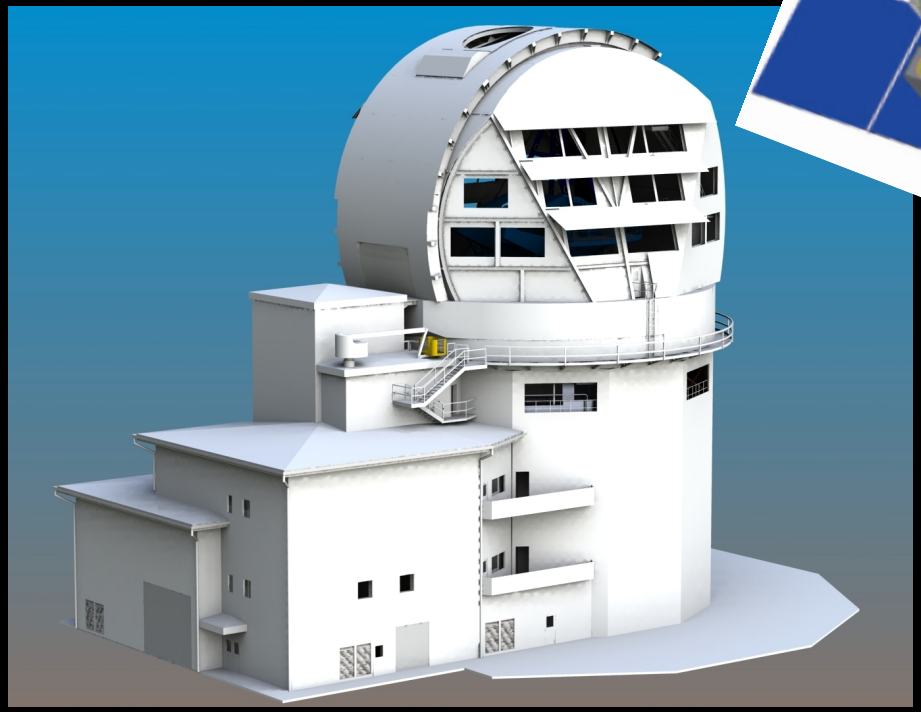


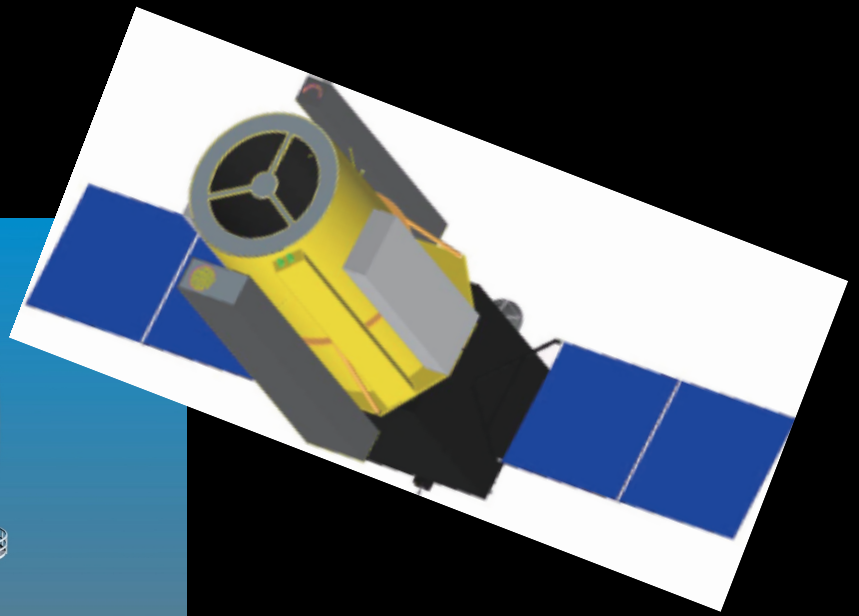
$$r_0 = 0.185\lambda^{6/5}\cos^{3/5}\zeta\left[\int\left(C_n^2(h)dh\right)\right]^{-3/5}$$

Call H imaging: A Hinode success story

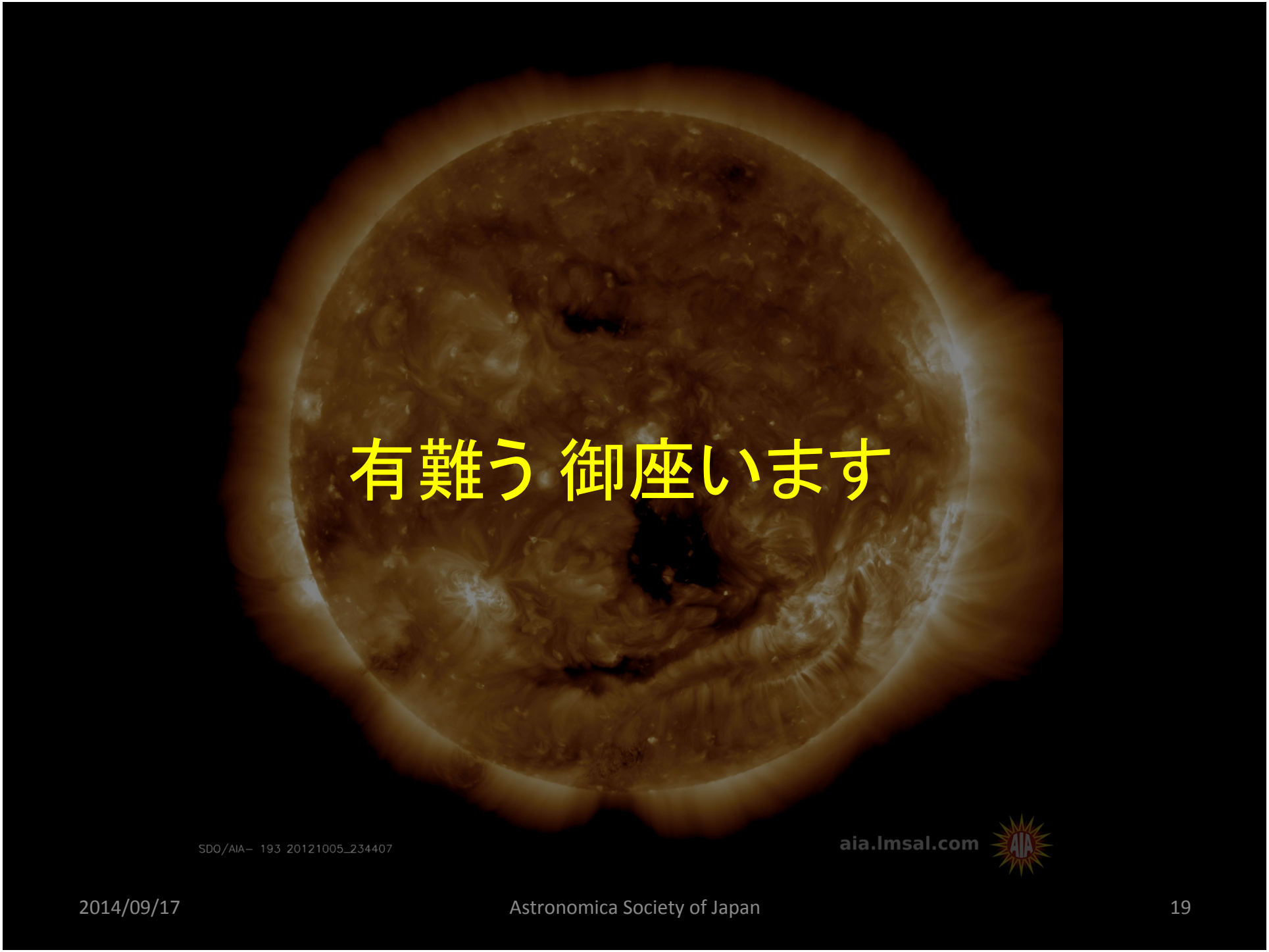
The blue is hard from the from the ground: AO has a much harder job

Solar-C & DKIST collaboration





Solar-C & DKIST collaboration: the next **Golden Age** for Solar Magnetism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