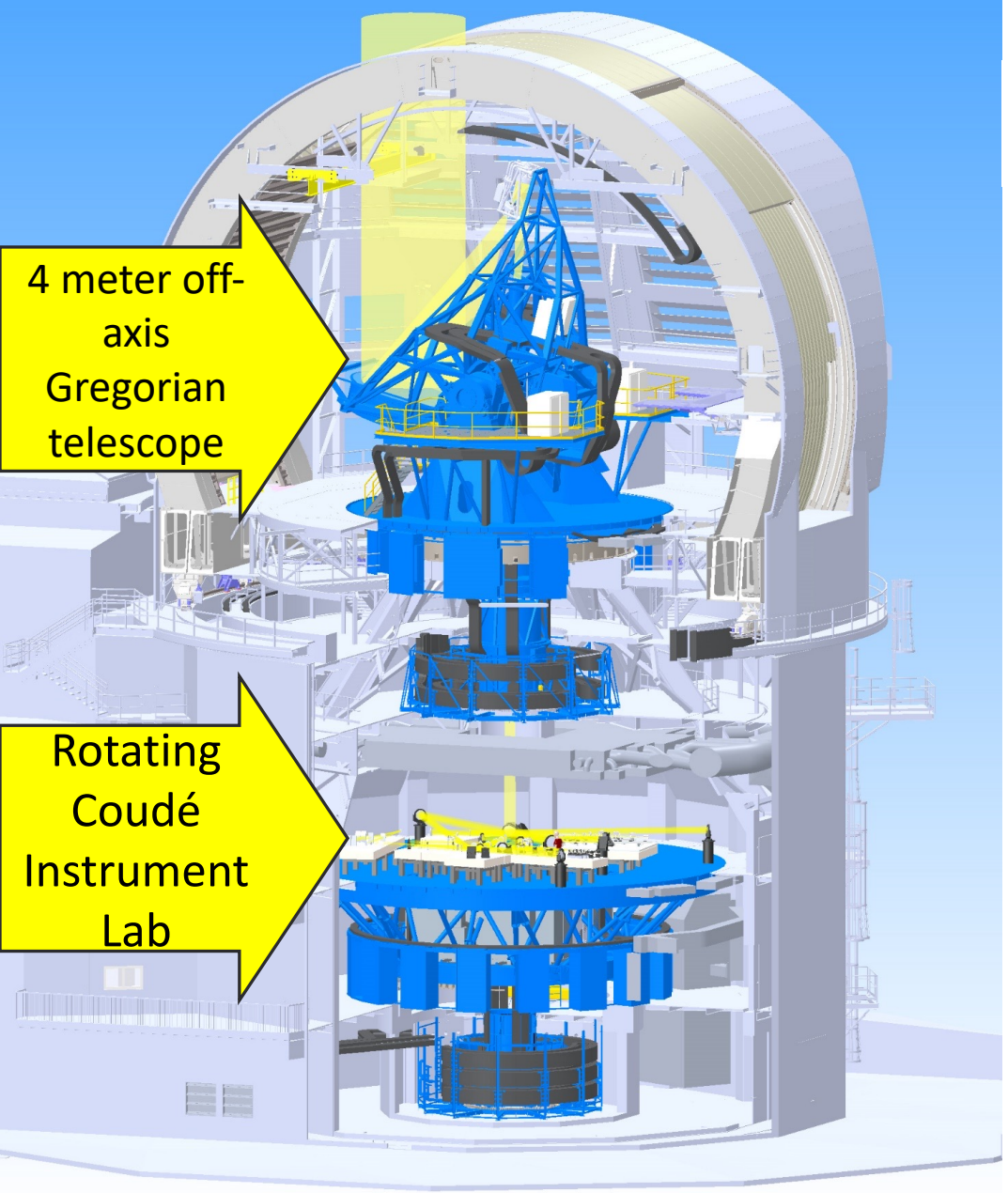
National Solar Observatory

DKIST
DANIEL K. INOUYE SOLAR TELESCOPE

AURA

Operations Update and Science Highlights from the Daniel K. Inouye Solar Telescope

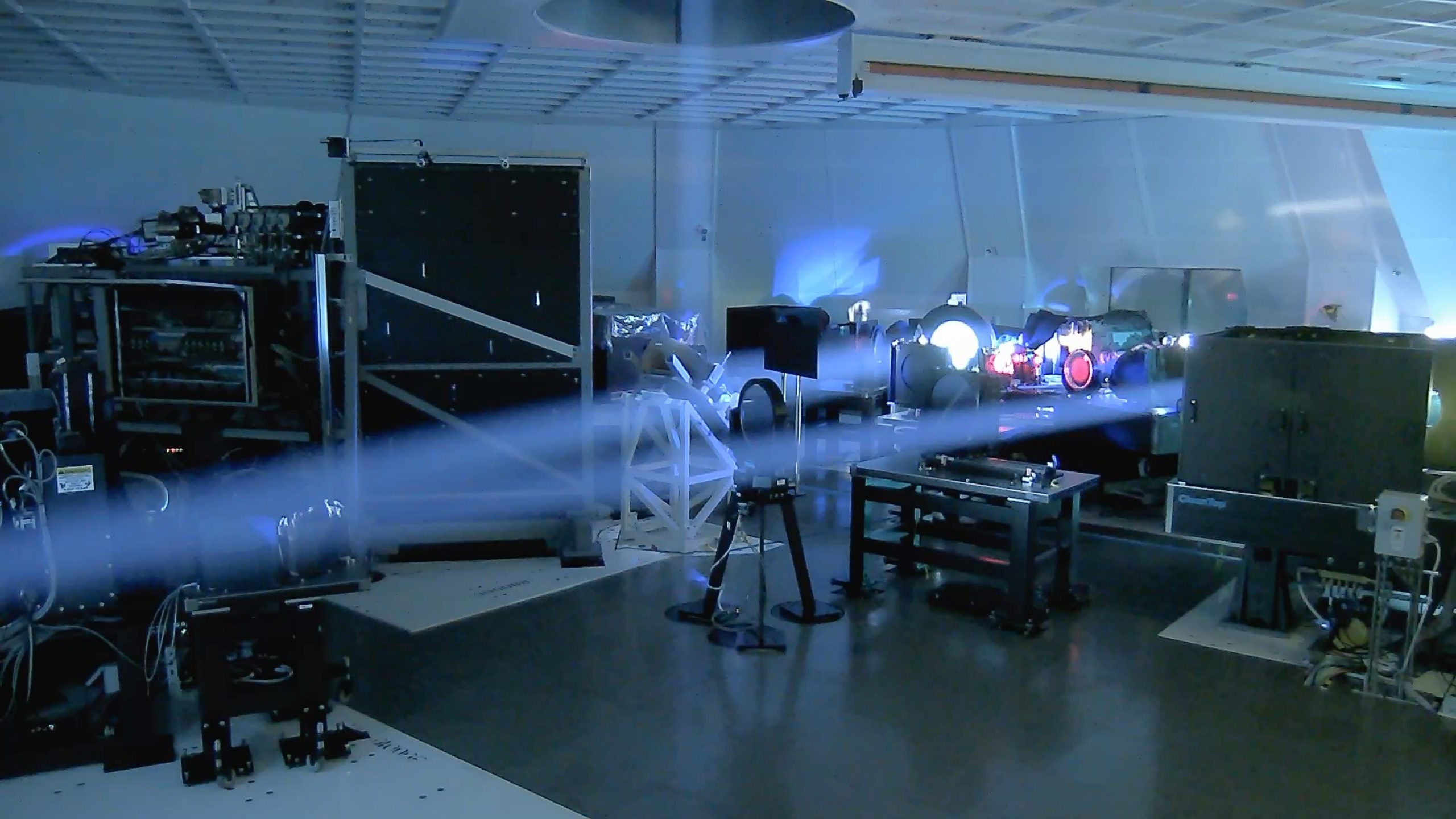
Christoph U. Keller for the
NSO/DKIST team



World's Largest Optical Solar Telescope

- Haleakalā, Maui, Hawaii at 10,023 ft
- 4-m off-axis Gregorian with facility Adaptive Optics (AO): **diffraction-limited, visible-light** observations down to 20-30 km resolution
- Unique off-axis design and excellent sky quality enables measurements of corona
- Rotating coudé lab with 5 instruments: imaging and spectro-polarimetry in the visible/IR of the photosphere, chromosphere, and corona


30,000 LBS
Yale



Why a 4-meter Solar Telescope?

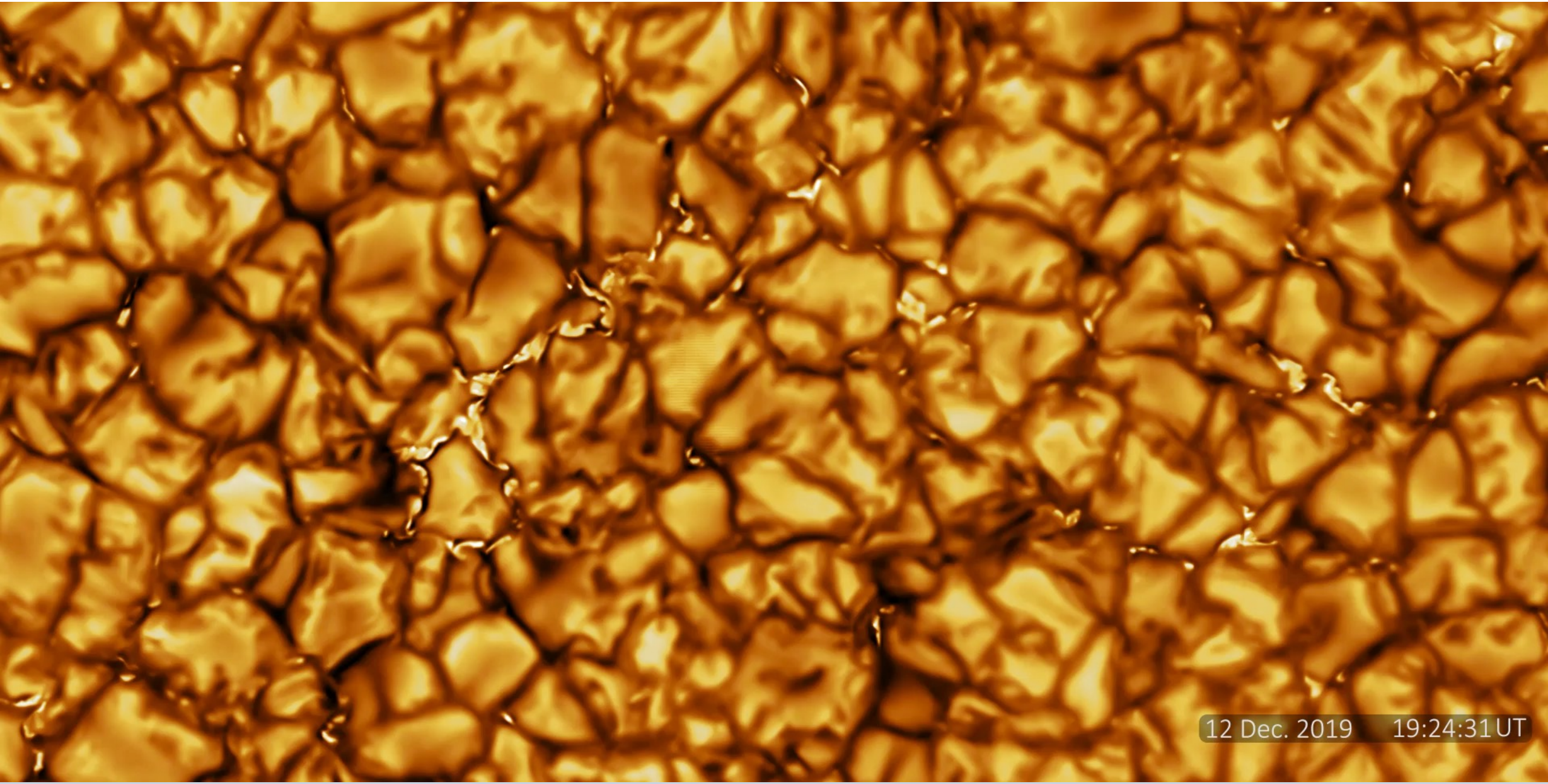
Number of photons per diffraction-limited resolution element from extended source is:

- Independent of telescope size
- Independent of distance of star
- Only depends on surface temperature

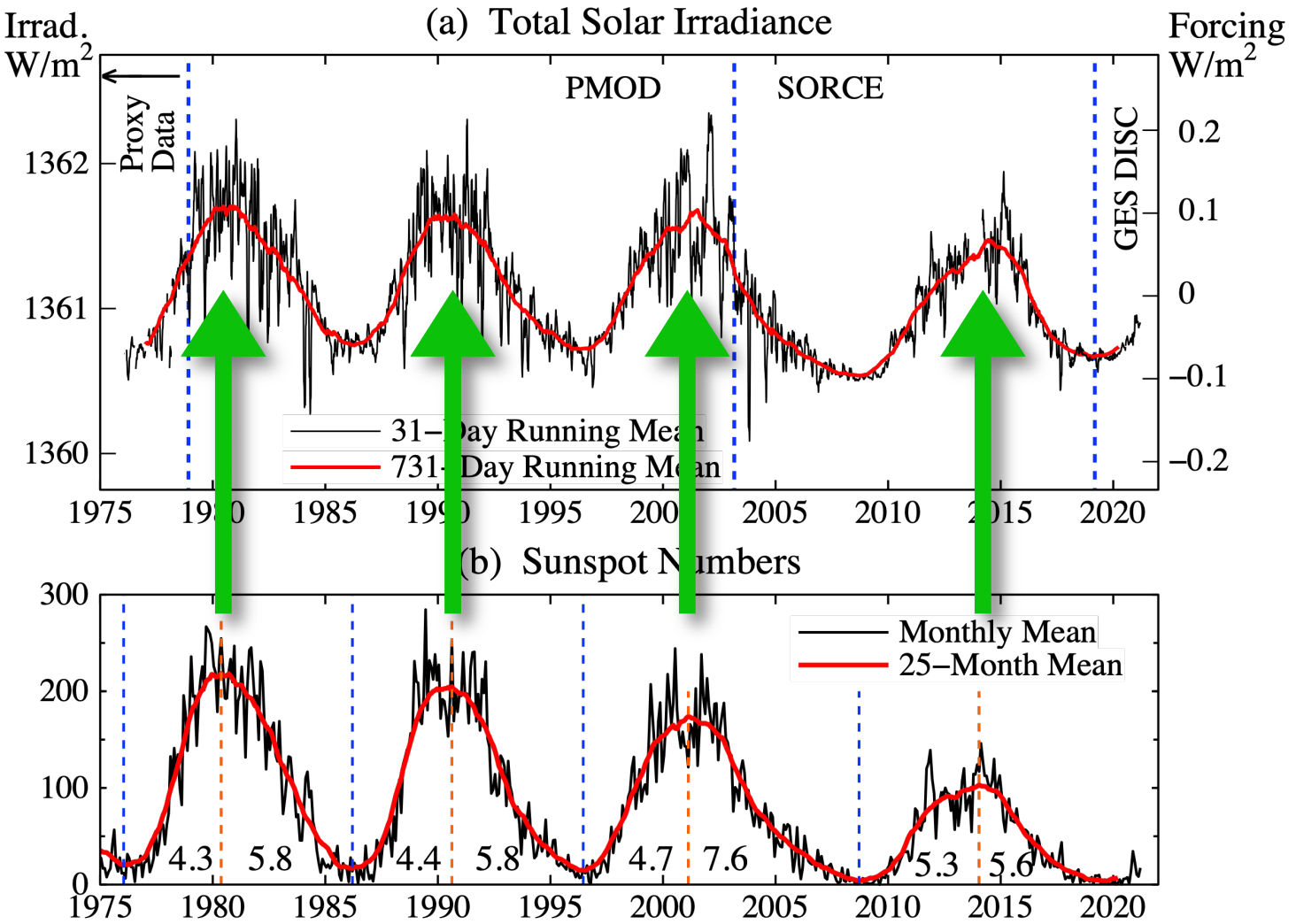
Maximum integration time is reduced with increasing angular resolution

Solar telescope size needed to collect photons

Why 4 meter? Need enough photons while resolving about 50km (photon mean-free path, pressure scale height in lowest visible layers)

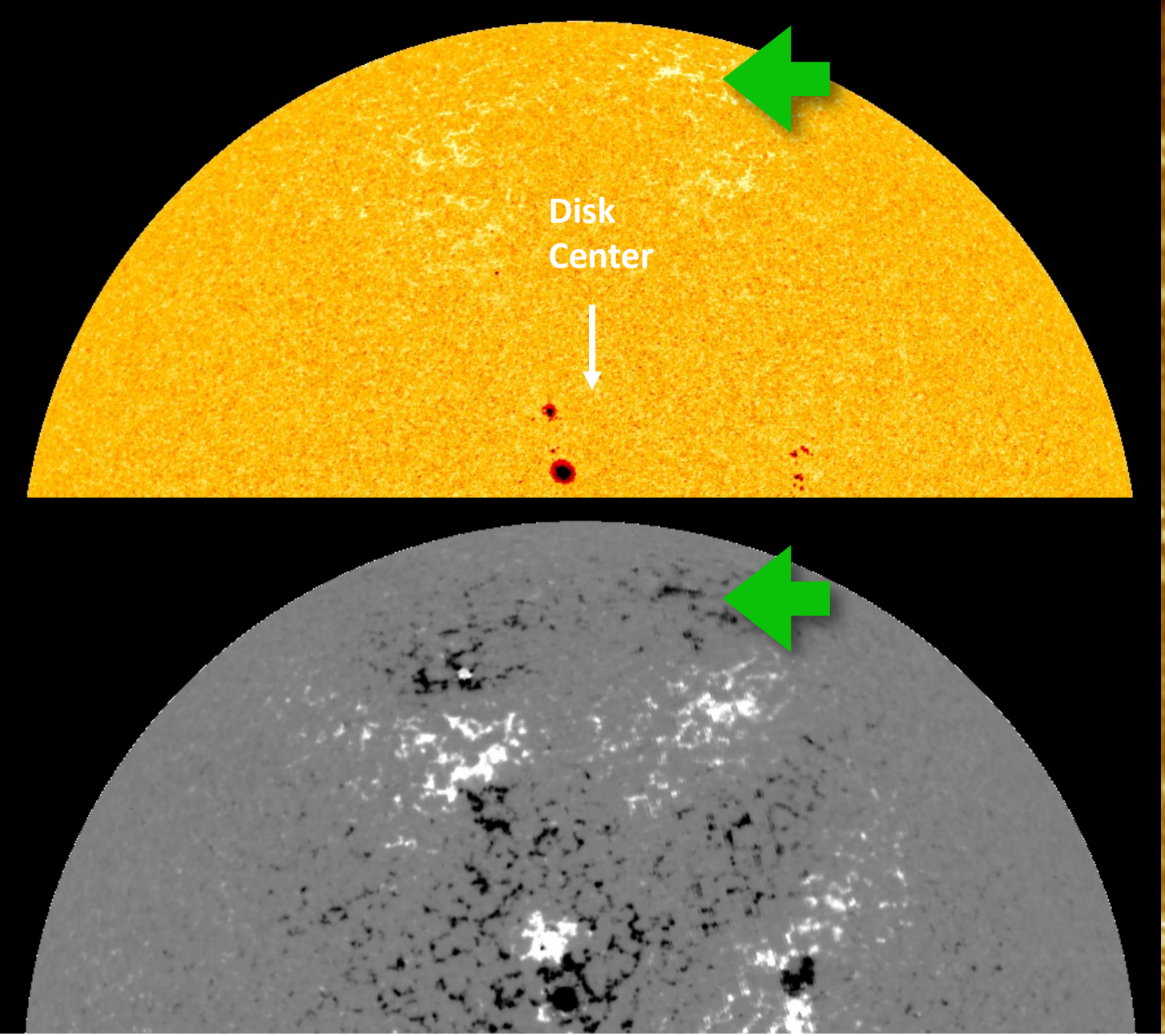

12 Dec. 2019 19:24:31UT

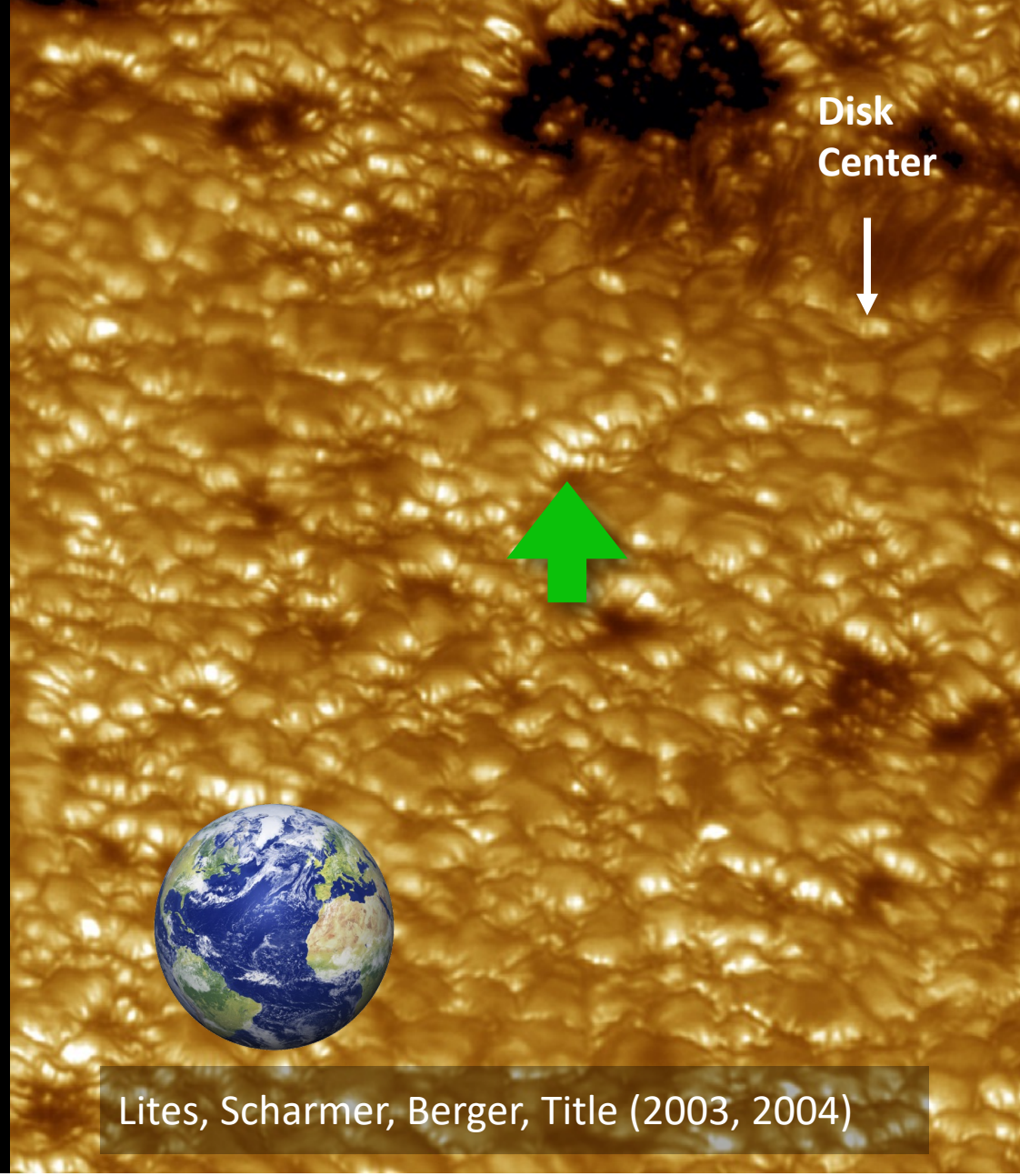
Variable Solar Constant



Hansen J, Kharecha P, Sato M, Masson-Delmotte V, Ackerman F, et al. (2013) Assessing ''Dangerous Climate Change'': Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature. PLoS ONE 8(12): e81648. doi:10.1371/journal.pone.0081648

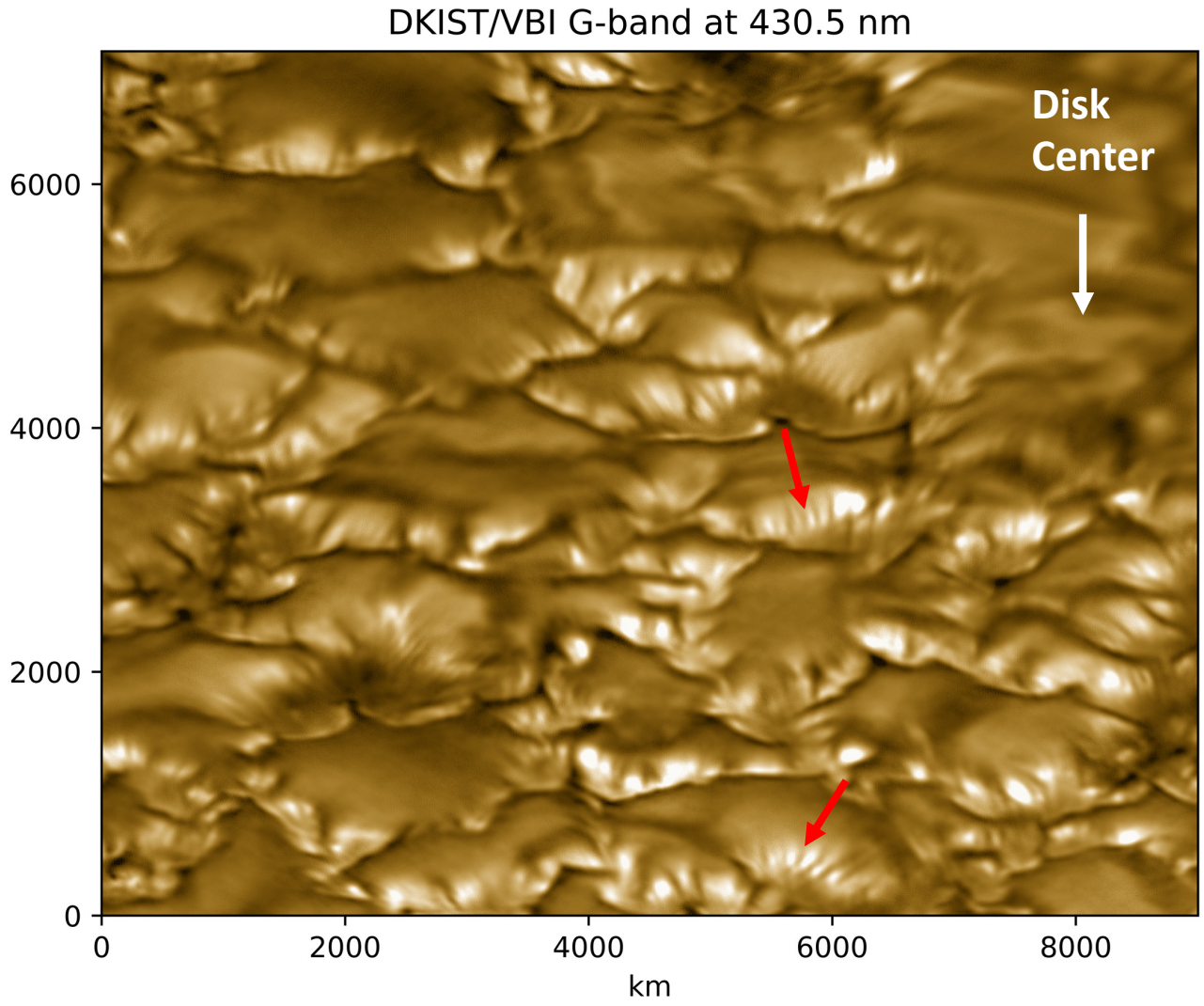
Updated figure from: www.columbia.edu/~mhs119/Solar

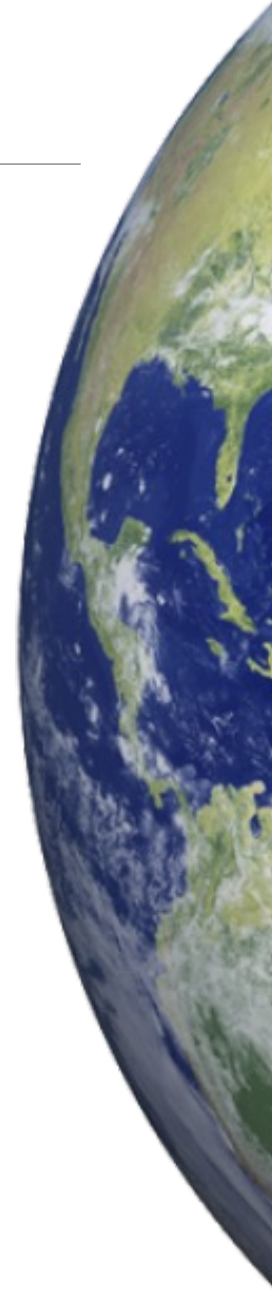

Disk
Center


Disk
Center
Lites, Scharmer, Berger, Title (2003, 2004)

D. Kuridze et al. (2025)

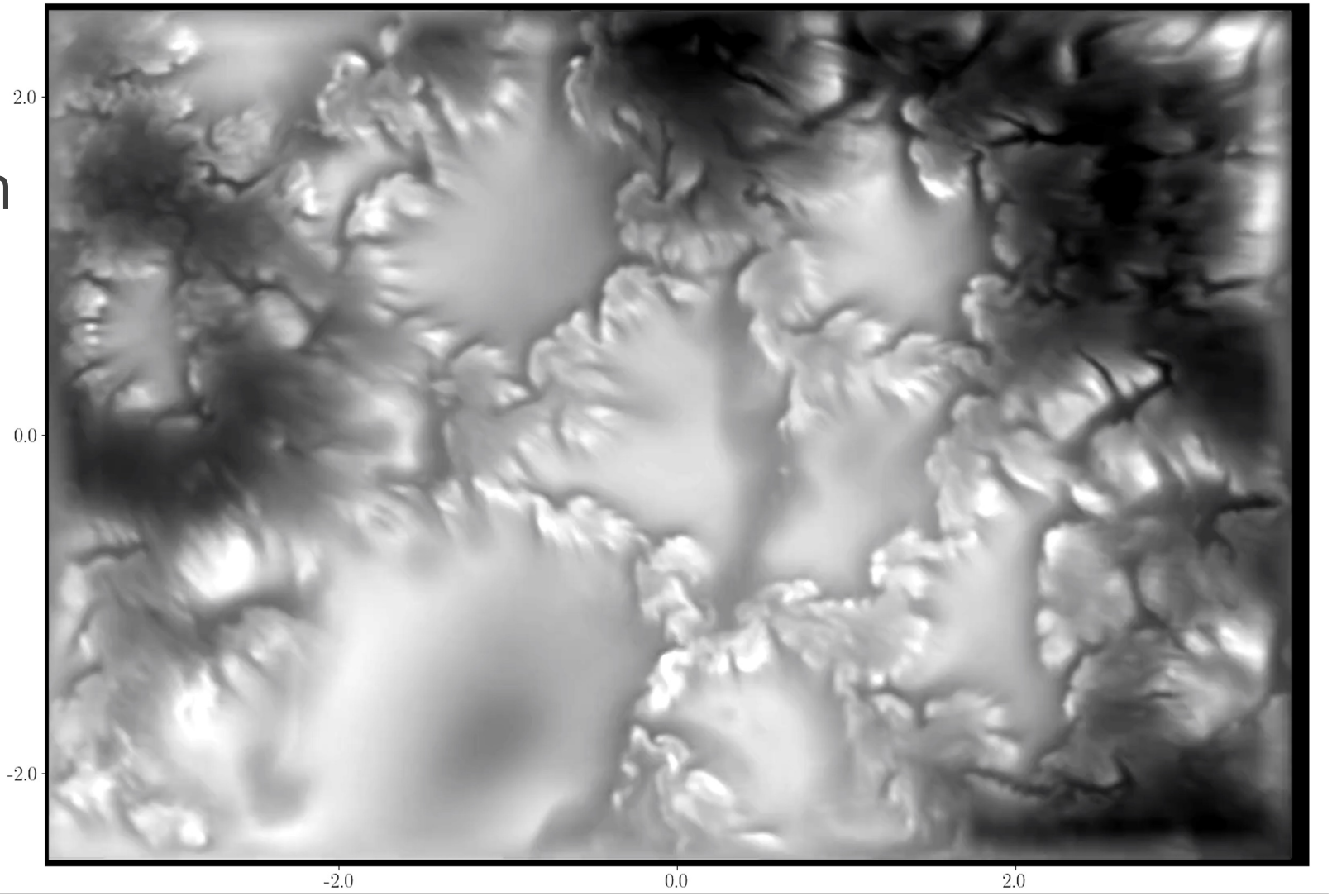
- G-band (430.5 nm)
- Fine striation pattern observed at DKIST diffraction limit (~ 20 km)
- Numerical simulations confirm that striations are linked to spatial variations in magnetic field





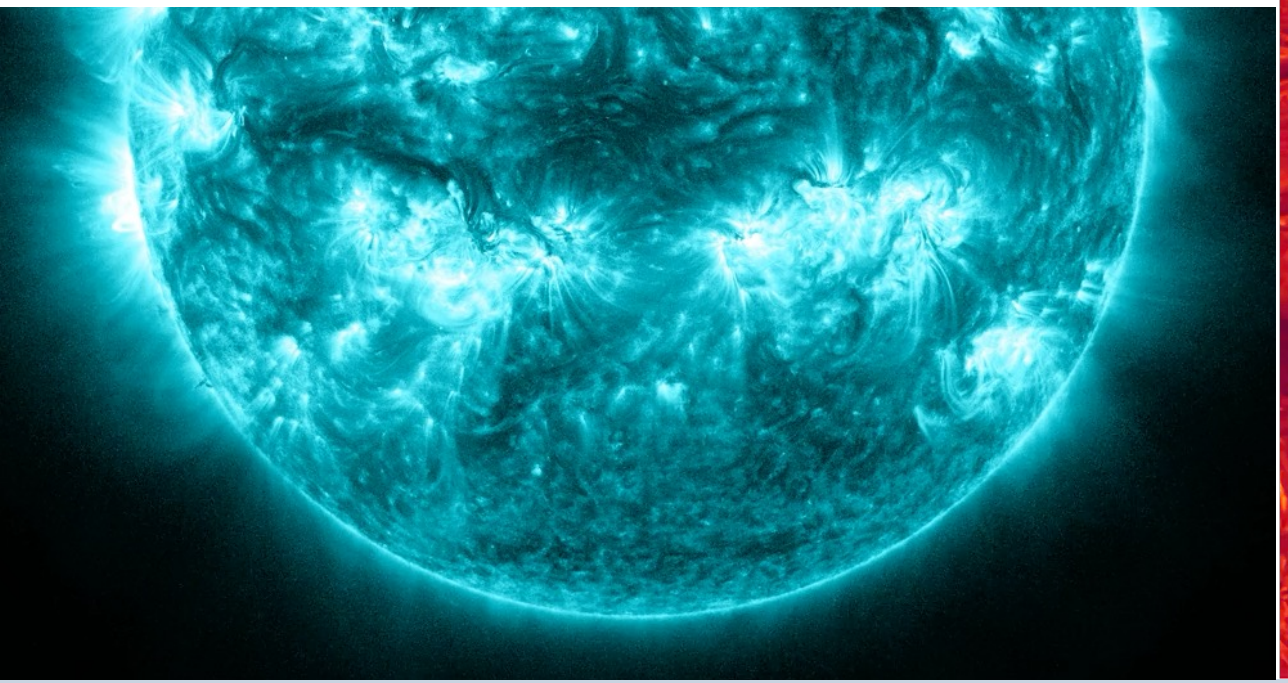
Wöger (NSO), van Noort (MPS) et al. 2025

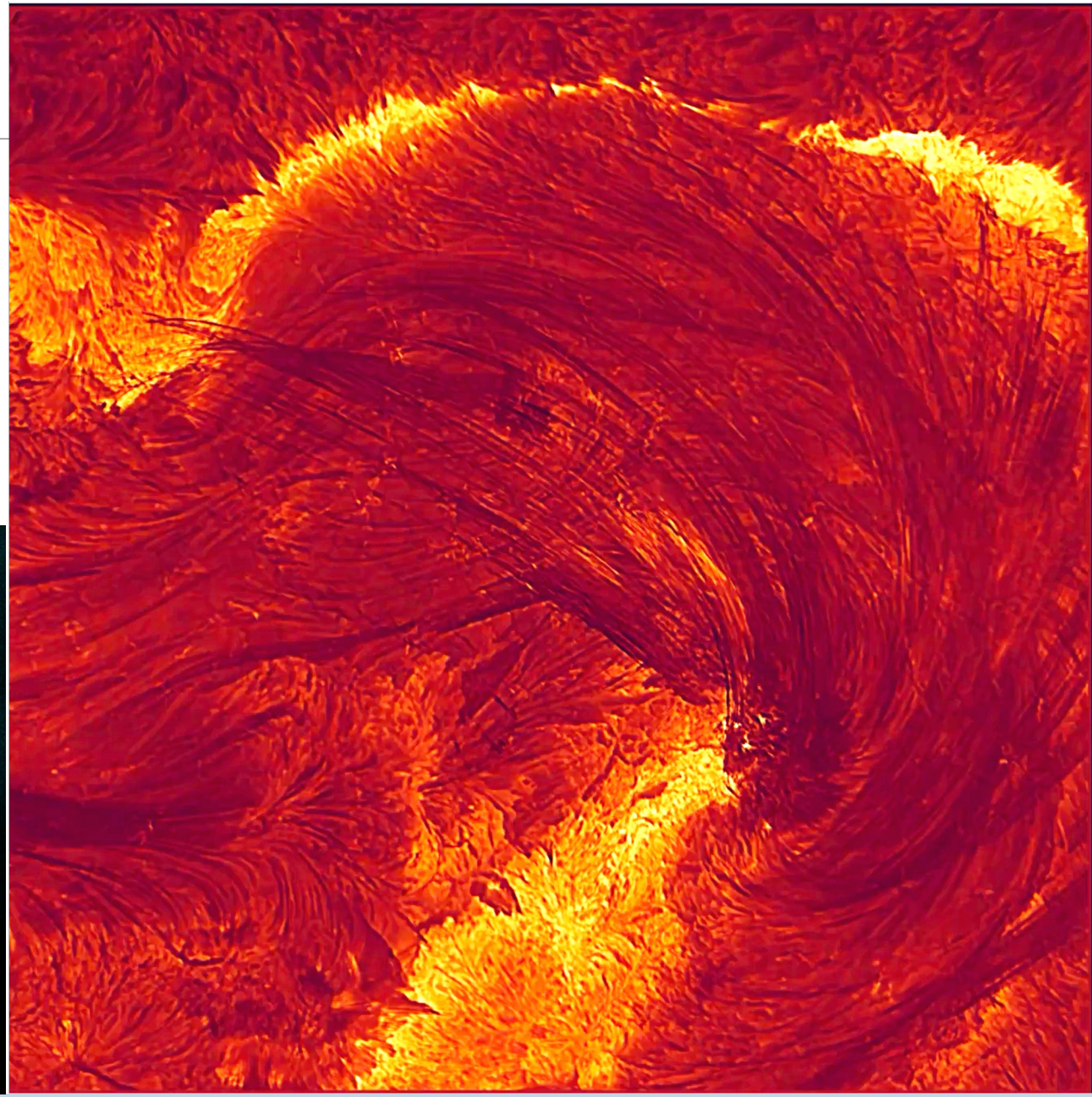
- 8.25 milli-arcsec pixels
- 3 minutes total duration
- Kelvin-Helmholtz instabilities?
- Affects Sun-as-a-Star Doppler signal
- Data available via Virtual Solar Observatory



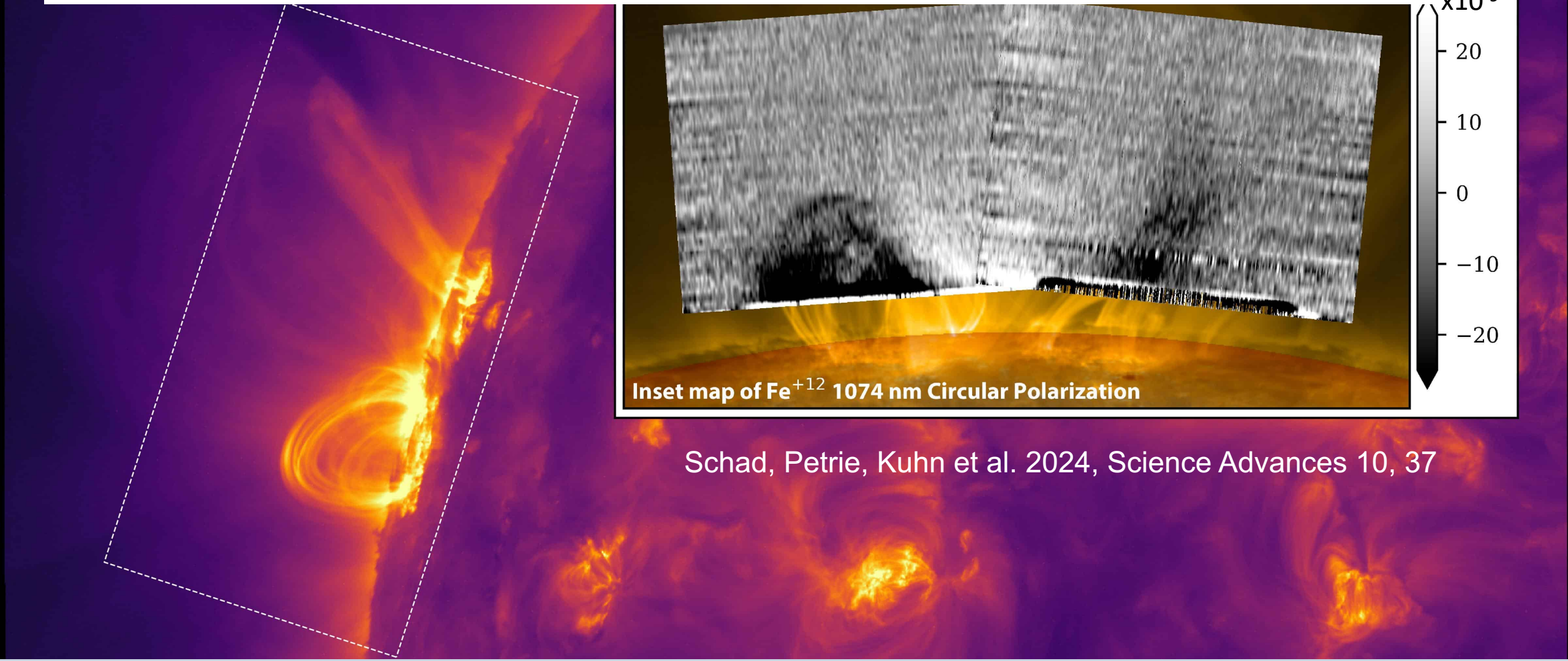
X1.3 Flare Decay

- Observed highly-structured flare ribbons in Hα
- Smallest coronal loops ever imaged: ~20km width
- Cole Tamburri et al. (2025) is a CU, Boulder grad student and DKIST Ambassador





DKIST achieves 10^{-8} Contrast to Measure Coronal Magnetic Field



Schad, Petrie, Kuhn et al. 2024, Science Advances 10, 37

Telescope Size and Mass

	DKIST	RUBIN	GEMINI	VLT UT	SOAR
Telescope diameter (m)	**4.2**	8.4	8.1	8.2	4.1
Telescope size (m, WDH)	**5,13,10**	9,9,12	9,9,15	9,9,13	5,5,6
Telescope moving mass (kg)	**510,000**	220,000	380,000	430,000	41,000
Dome height (m)	**41**	44	46	29	30
Dome diameter (m)	**27**	30	26	29	20
Dome moving mass (kg)	**750,000**	600,000	780,000	270,000	79,000
Incident Energy (W)	**13,000**	~0	~0	~0	~0

DKIST is comparable to an 8-m class telescope in every way!

Instruments and Data Rates

	DKIST	RUBIN	GEMINI	VLT UT
Instruments per telescope	**5**	1	4	3
Simultaneous instrument use	✓	X	X	X
Facility Adaptive Optics	✓	X	✓	✓
Data Rate (TB / 24 hours)	**10**	**20**	**~0.03**	**~0.1**

DKIST instrumentation and Adaptive Optics are more complex than any 8-m class telescope!

DKIST data rates are >100 times that of a classical 8-m class telescope and 50% of Rubin!

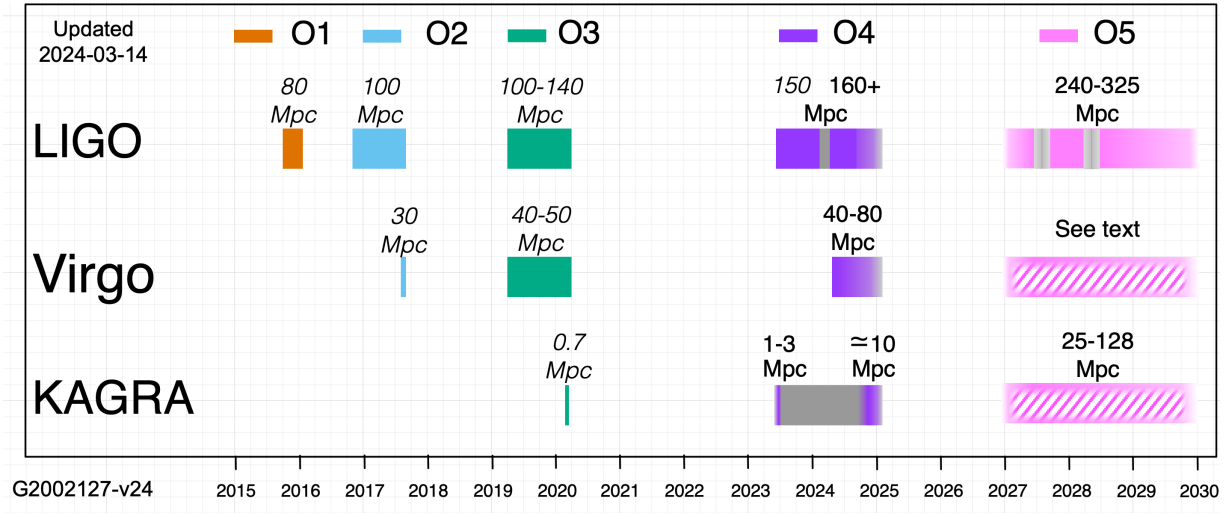
Construction and Operations Costs in 2025 $M

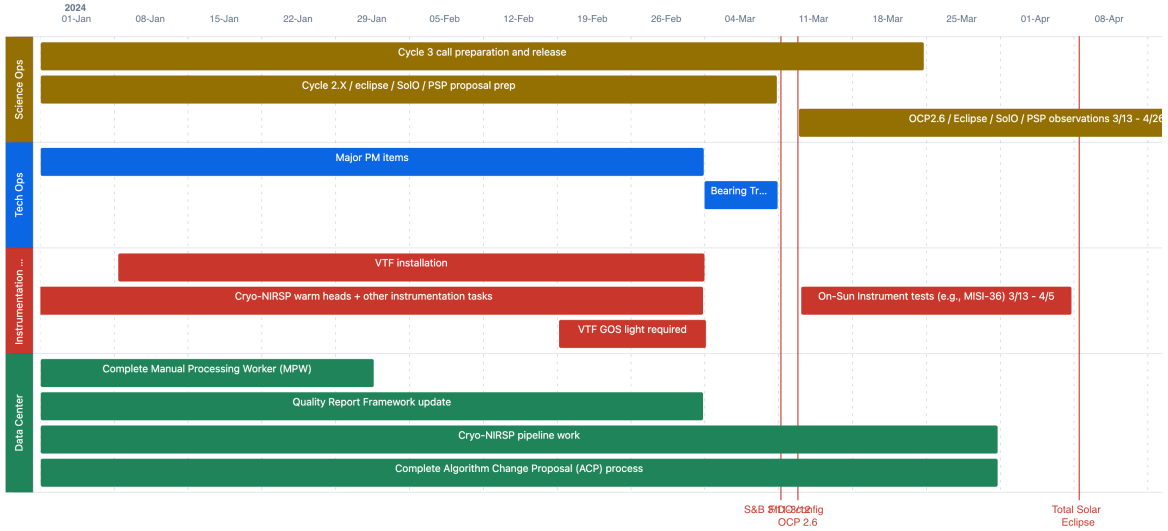
	DKIST	RUBIN	GEMINI	VLT
Number of Telescopes	1	1	2	4
Construction Year	2021	2025	2000	1998
Construction costs per telescope	450	840	172	142
Operations costs	35	74	46	82
Operations costs per telescope	35	74	23	20
Operations costs / Construction costs	**8%**	**9%**	**12%**	**14%**
Instrumentation development included	✓	X	some	X

DKIST operations costs compared to construction costs are comparable or less than 8-m class telescopes!

DKIST Ops is Different from Nighttime Telescopes

- Science Observing, Instrument Commissioning, and Facility Engineering all occur during the daytime
- DKIST Ops model more like LIGO or CERN
- Block schedule
  - 7 weeks on-Sun, 2 weeks Engineering
- Extended Winter Engineering
  - non-Concurrent Infrastructure
  - Instrumentation Upgrades
  - Preventive Maintenance





Targeted and Synoptic Observations

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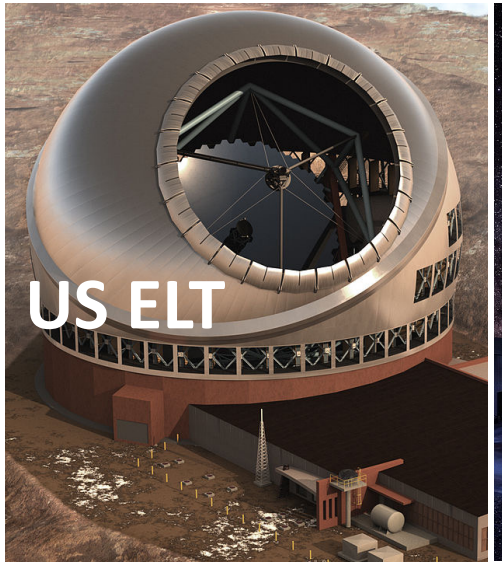

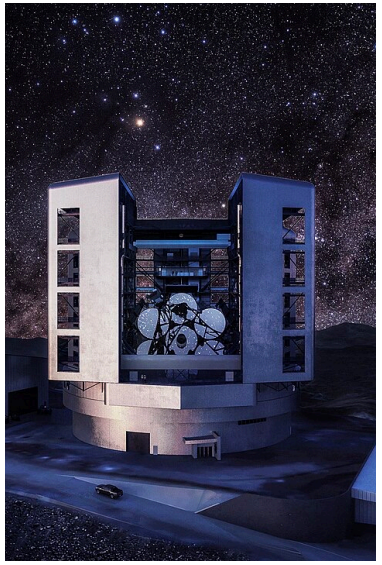

ngGONG design funded

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Much More to Come…

- 2450 DKIST data sets now available at the DKIST Data Center
- Second etalon to be installed on VTF - Nov. 2025
- New DKIST instrumentation under development
  - MCAO (4km DM completed, 11km DM under develop.)
  - new IR cameras (collaboration w/ Raytheon),
  - new Visible cameras (collaboration w/ Teledyne)
- Cycle 4 Observations to begin March 2026
  - Will include a dedicated community flare program

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Ka Lā | The Sun, the Earth and Us

YouTube · National Science Foundation News · Sep 12, 2025