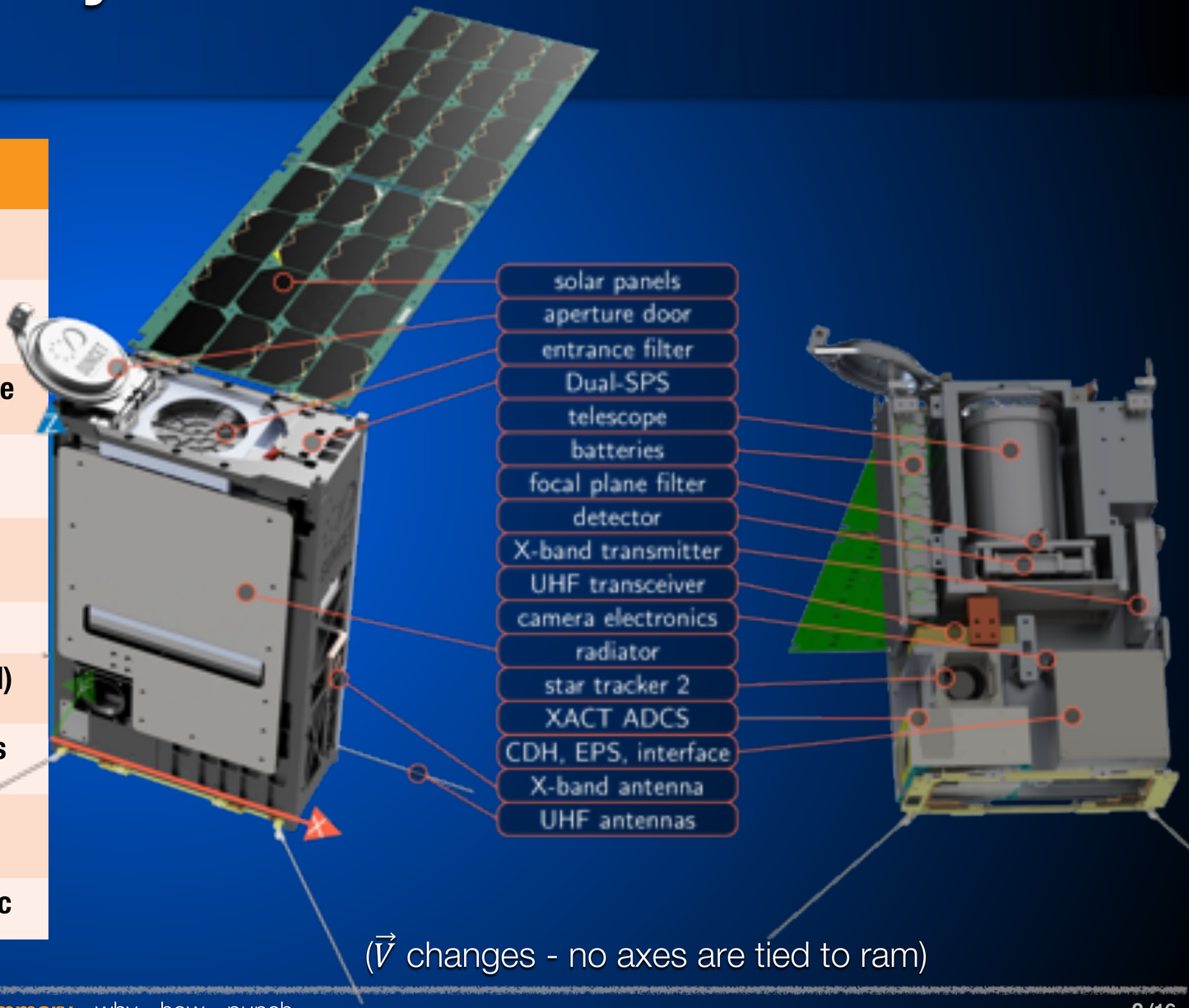
SUNCET

SUN CORONAL EJECTION TRACKER

Concise summary

NASA mission tech specs

Parameter	Value	Note
Form factor	6U CubeSat	~Shoebox size
Launch date	June/July 2025	Space X Falcon 9 Transporter-14
Prime mission	8 months	To extend as long as able
Orbit	Altitude ≤ ~550 km inclination 98º	sun-sync
FOV	±5.34 $R_\odot$ x ±4 $R_\odot$	That's wide! ±1.5 is typical
Bandpass	170-200 Å	Wider than typical
Dynamic range	$2x10^6$	SDO/AIA's is 10^4 (typical)
Spatial resolution	20 arcsec	Similar to coronagraphs
Exposure times	0.035 sec (on disk) 15 seconds (off disk)	Configurable on orbit
Cadence	1 minute	Nominally; can do 15 sec



($\vec{V}$ changes - no axes are tied to ram)

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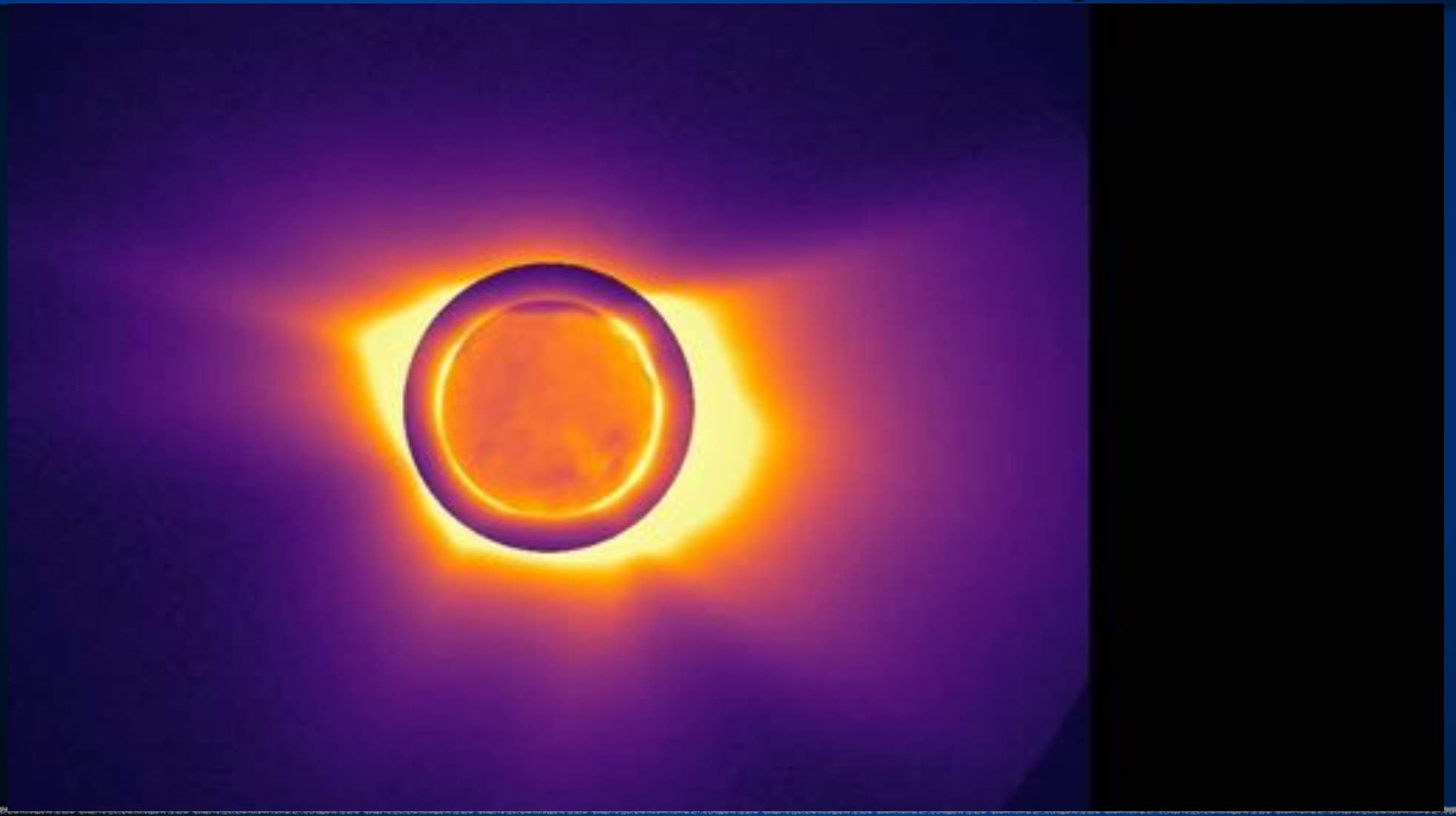
Why SunCET?

Science motivation

Why SunCET is needed

Bulk of CME acceleration occurs in the “middle” corona (e.g., Bein et al., 2011; D’Huys et al., 2014)

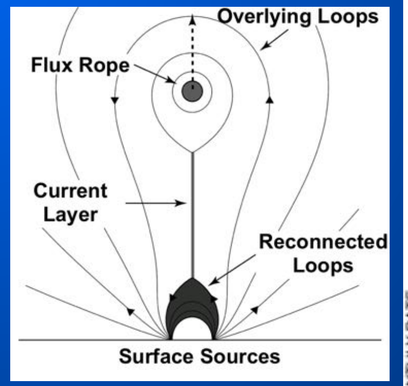


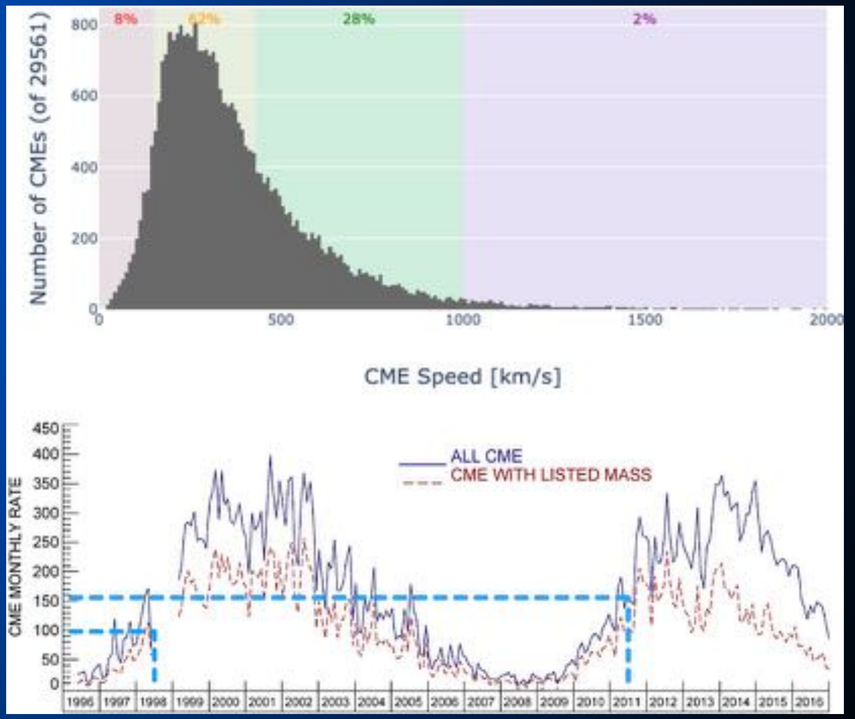
Mason+, ApJ, 924, 63 (2022)

Coronal Mass Ejections (CMEs) 101

Better understanding → better forecasts → more time to prepare for space weather storms

- Result of solar system's most energetic process, up to 10^{25} J (asteroid that killed the dinosaurs ≃ 10^{23} J)
- How are they triggered and accelerated?
  - ≥26 ***review*** papers on this topic in last 2 decades, ≥75 deep dive papers
  - We have lots of competing models (e.g., torus instability, helical kink, breakout, slip-running, …) but lack the observations to discriminate between them
    - Each model can produce predicted kinematic profiles for CMEs



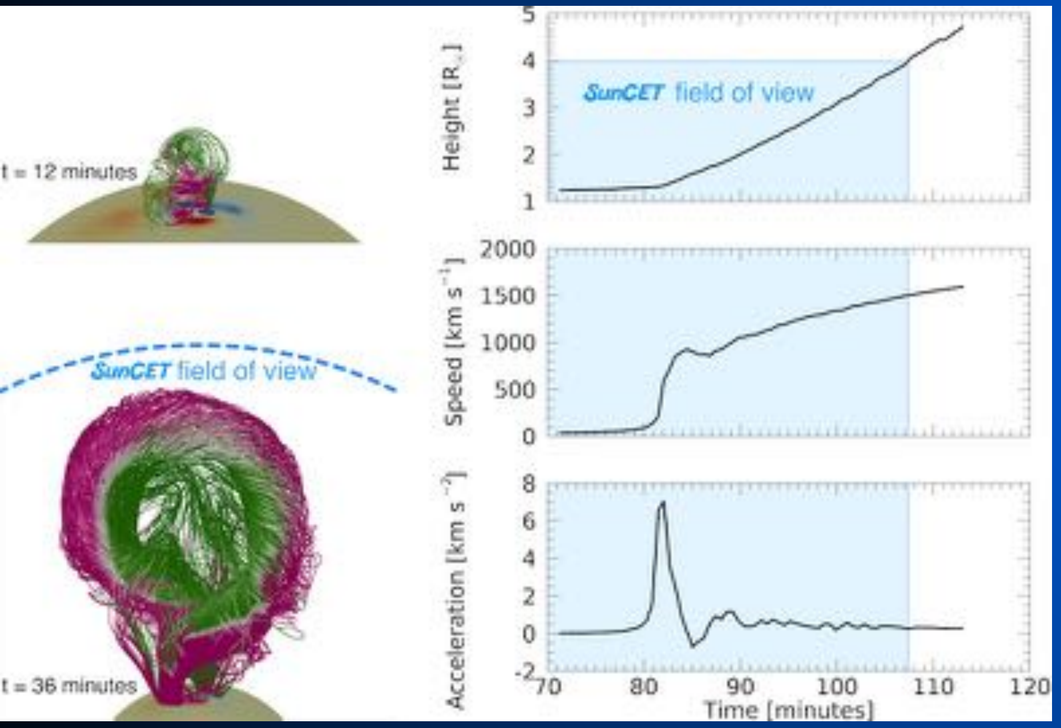


Mason+, JSWSC, 11, 20 (2021)

Some examples of predicted kinematic profiles

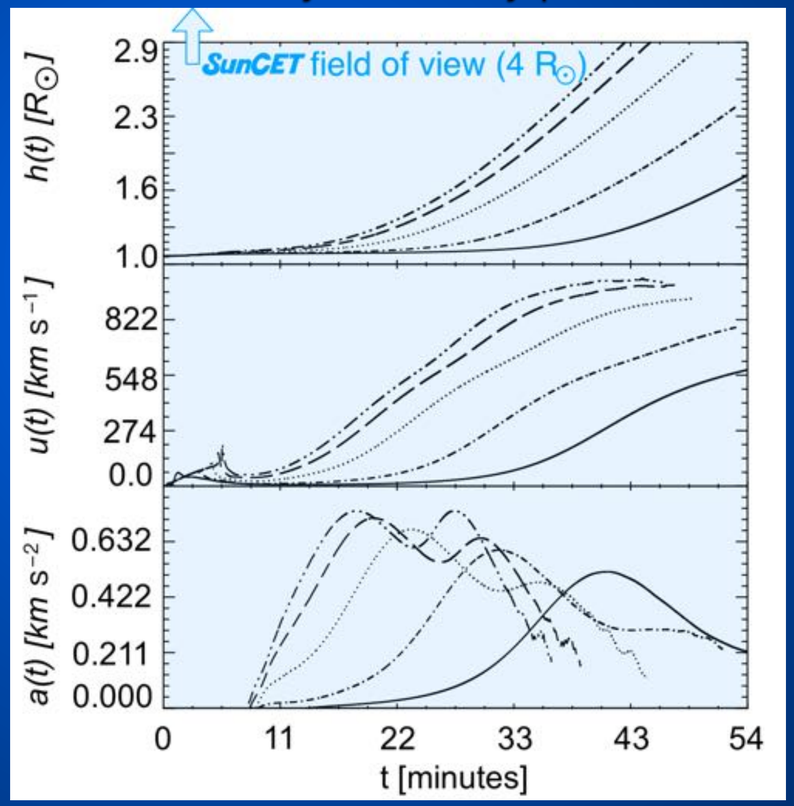
from different models

Helical kink



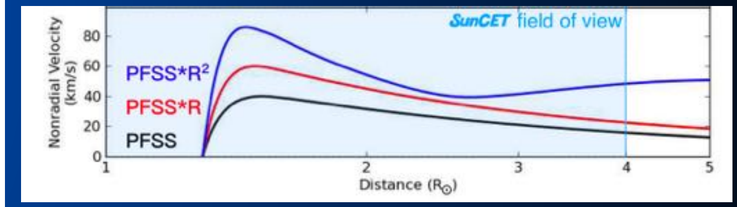
Fan, ApJ, 824, 12 (2016)

Torus instability + velocity perturbation



Schrijver+, ApJ, 674, 586 (2008)

Deflection



Kay, PhD Dissertation, 2016, Boston University

Mason+, JSWSC, 11, 20 (2021)

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How SunCET?

Technical challenge and solution

Lab demo

CubeSat

How SunCET handles 10^4:1 disk:off-disk photons

A novel, simultaneous high dynamic range (SHDR) detector + algorithm

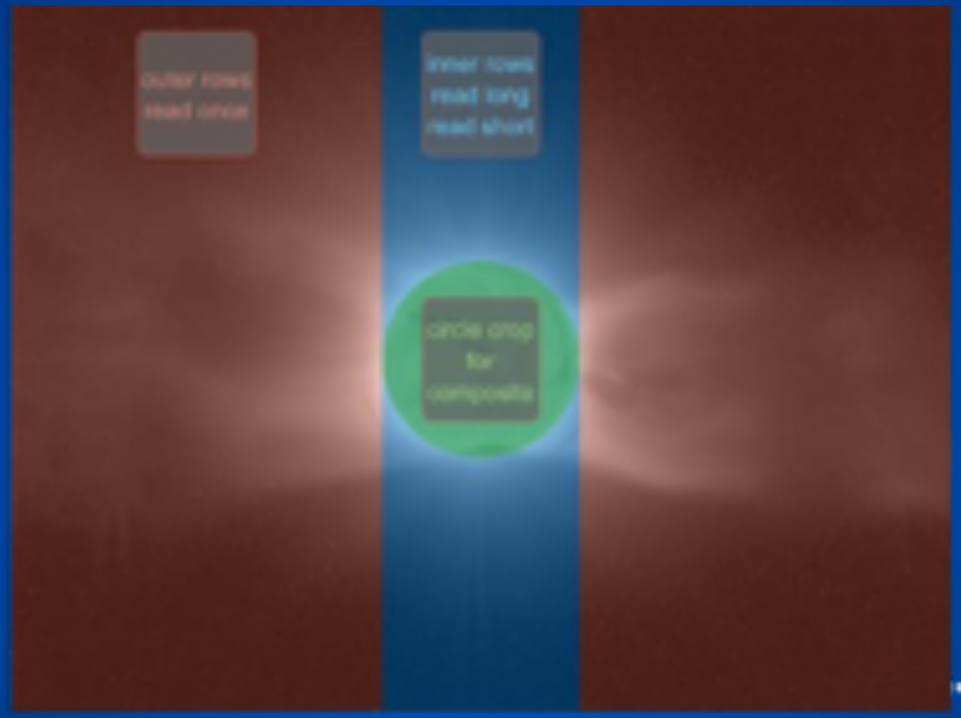


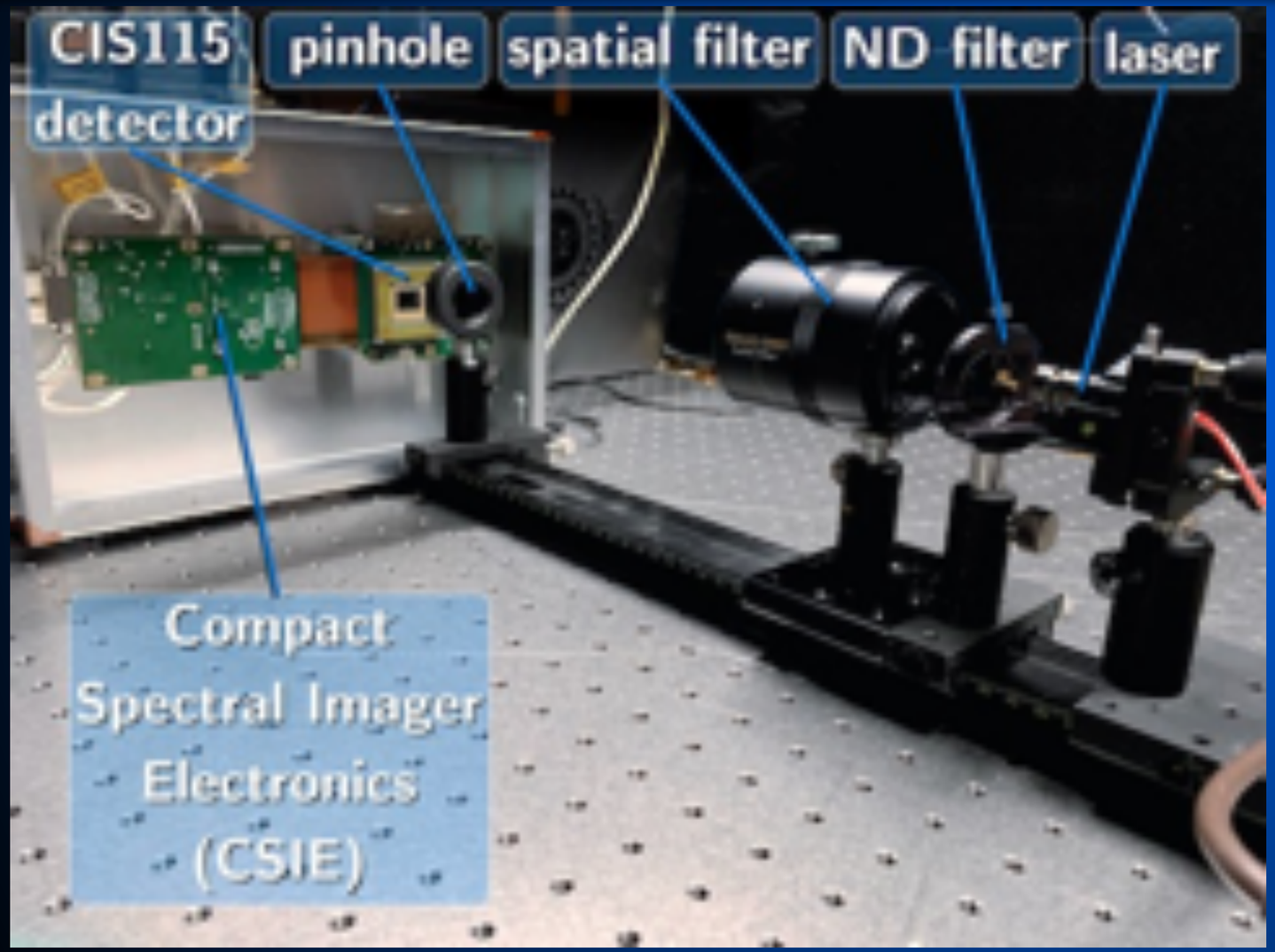
*image dimensions and colored regions to scale

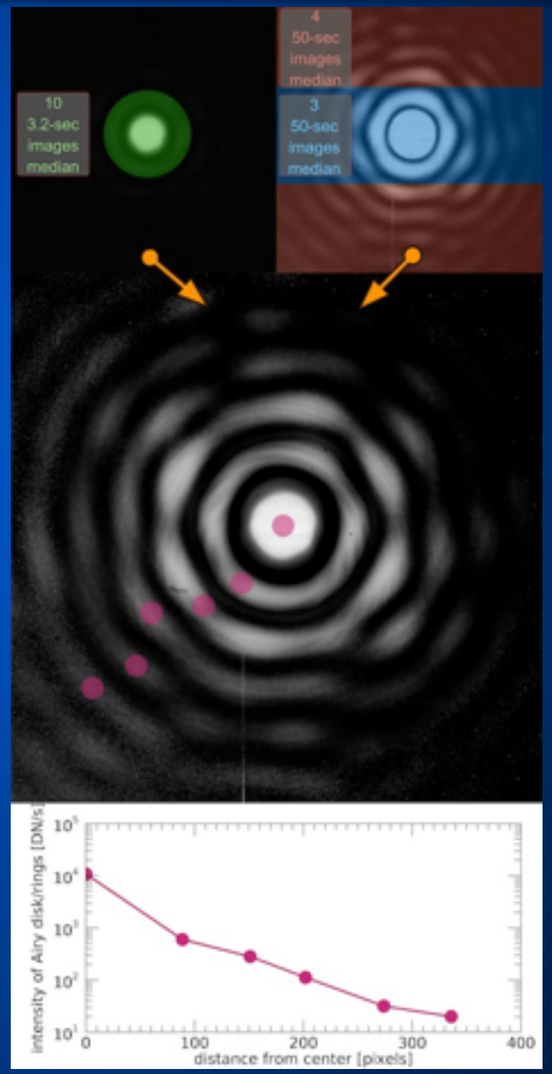
Sun image is MHD simulation run on NASA's Pleiades supercomputer of solar CME (dimmest of the set we ran = worst case),
then passed through our SunCET instrument simulator to create realistic synthetic SunCET image composites (right FOV, spatial/temporal/spectral resolution, QE, QY, reflections, etc)

Mason+, ApJ, 924, 63 (2022)

Lab demo of the SHDR algorithm

It works!



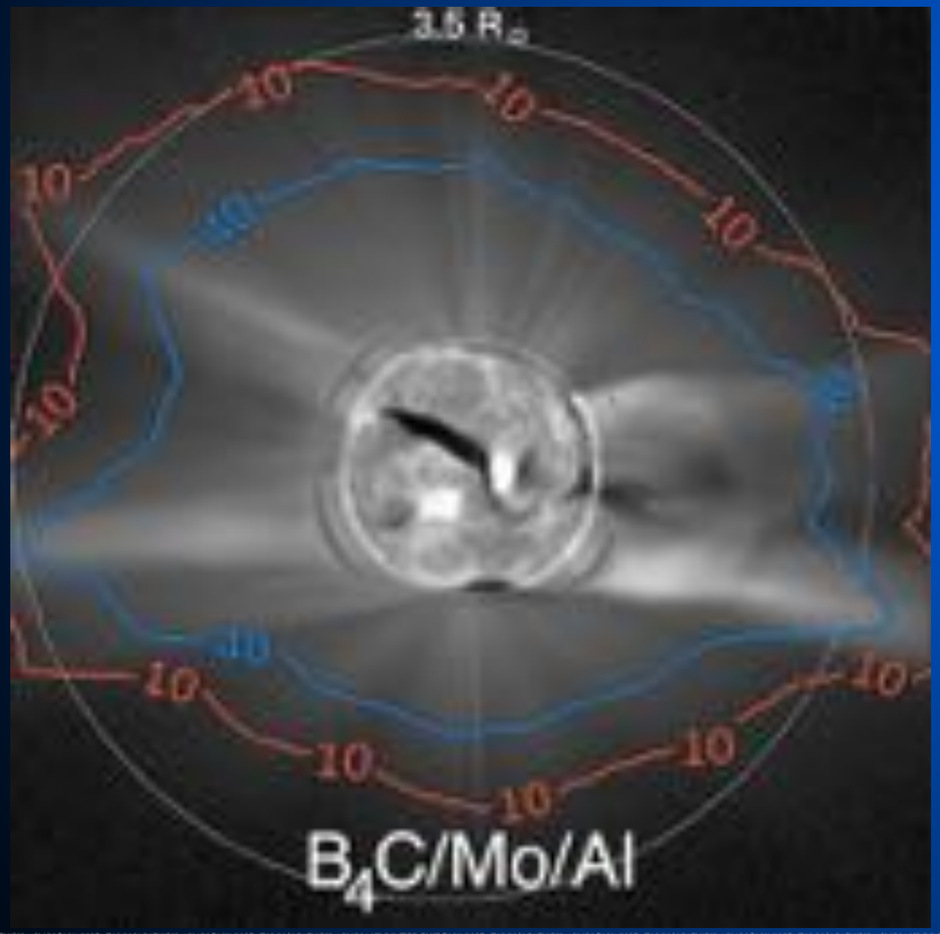


Mason+, ApJ, 924, 63 (2022)

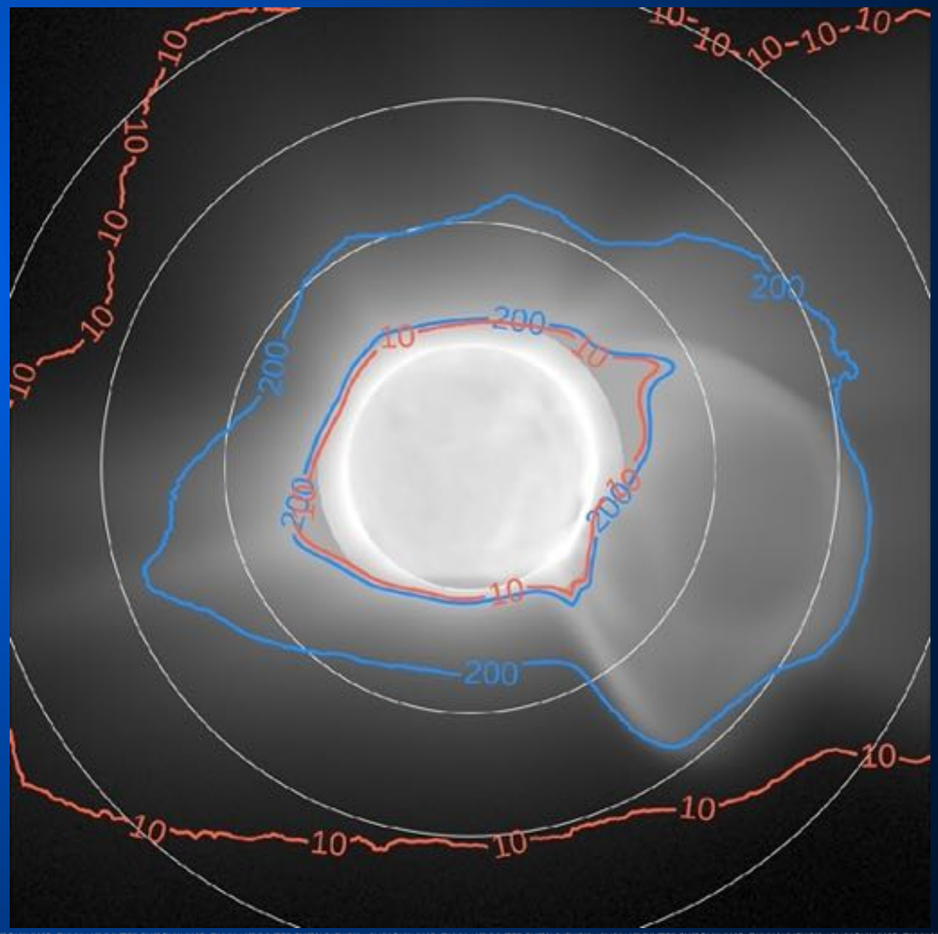
Great signal to noise ratios

Requirement: SNR of CME @ 3.5 $R_\odot$ ≥ 10

Faint CME (worst case)

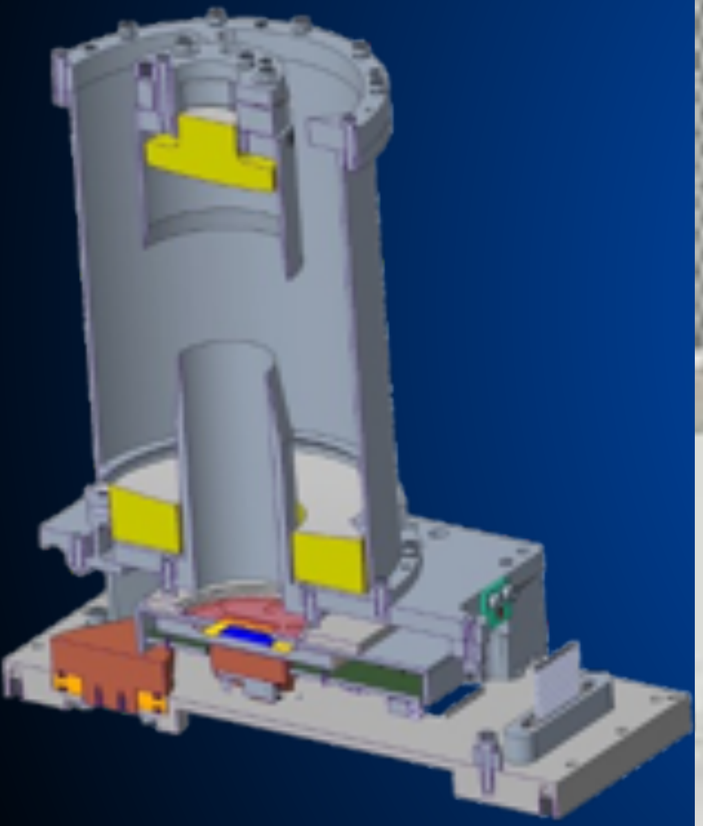


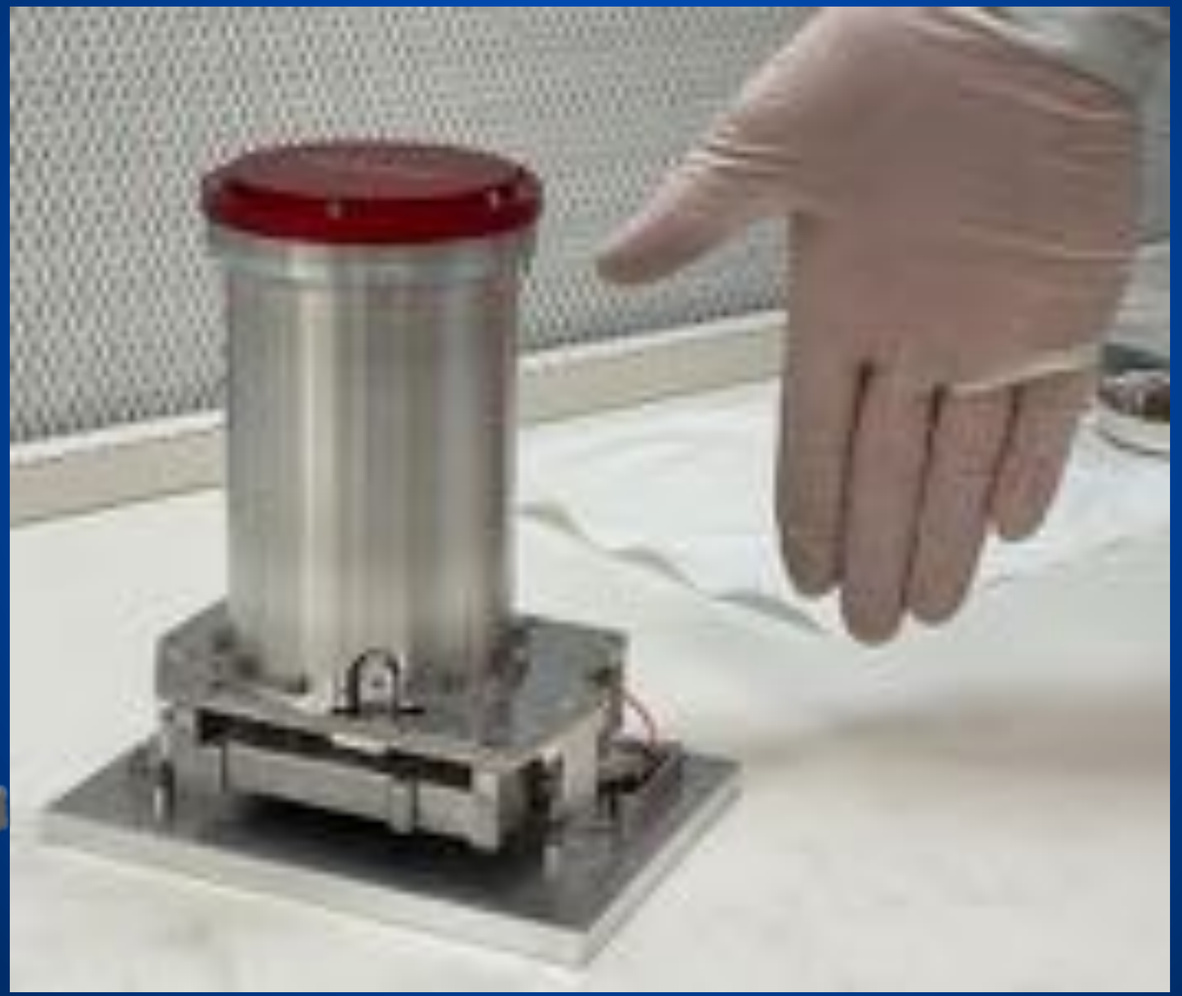
Bright CME (good case)

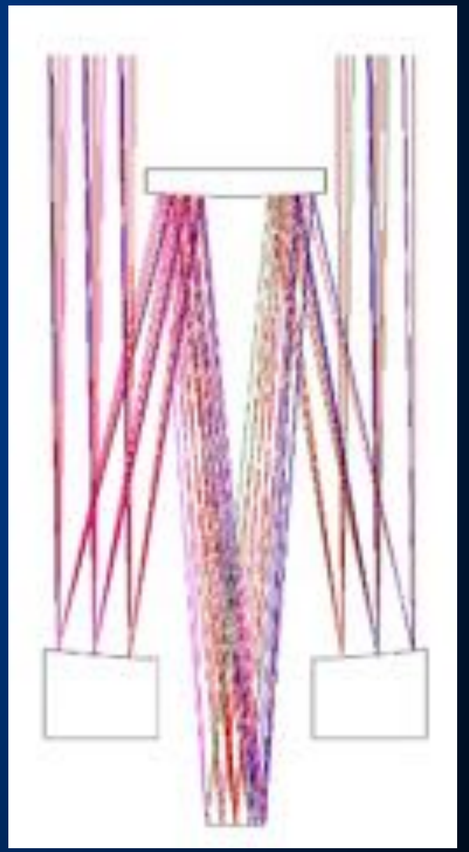


Standard Ritchey-Chrétien Telescope

Provides wide field of view, and can be made *tiny*







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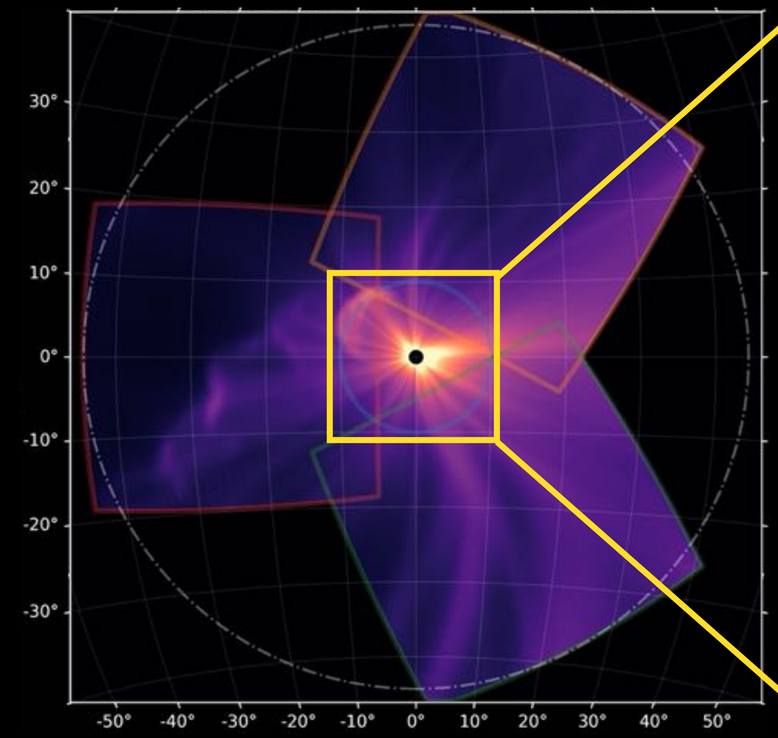
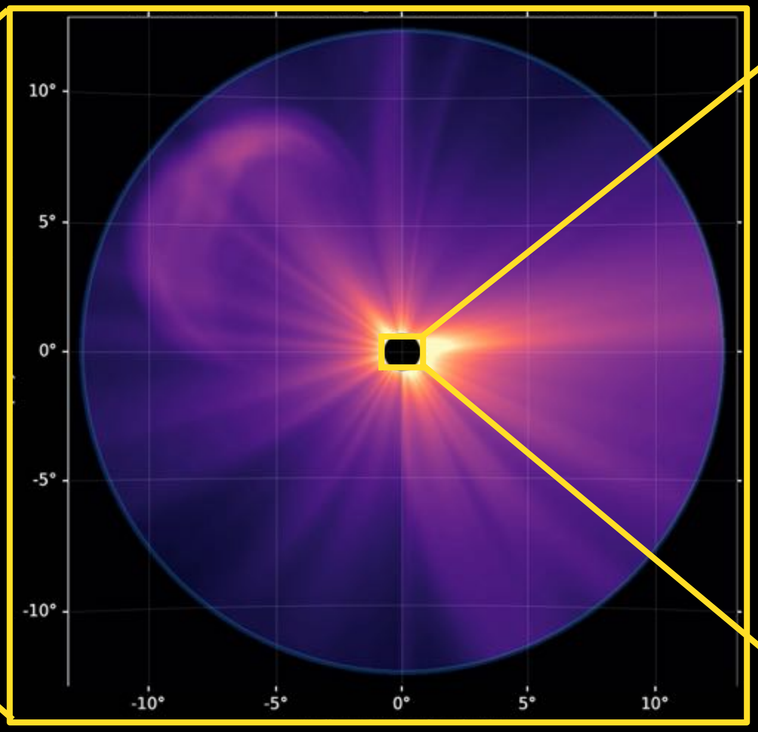
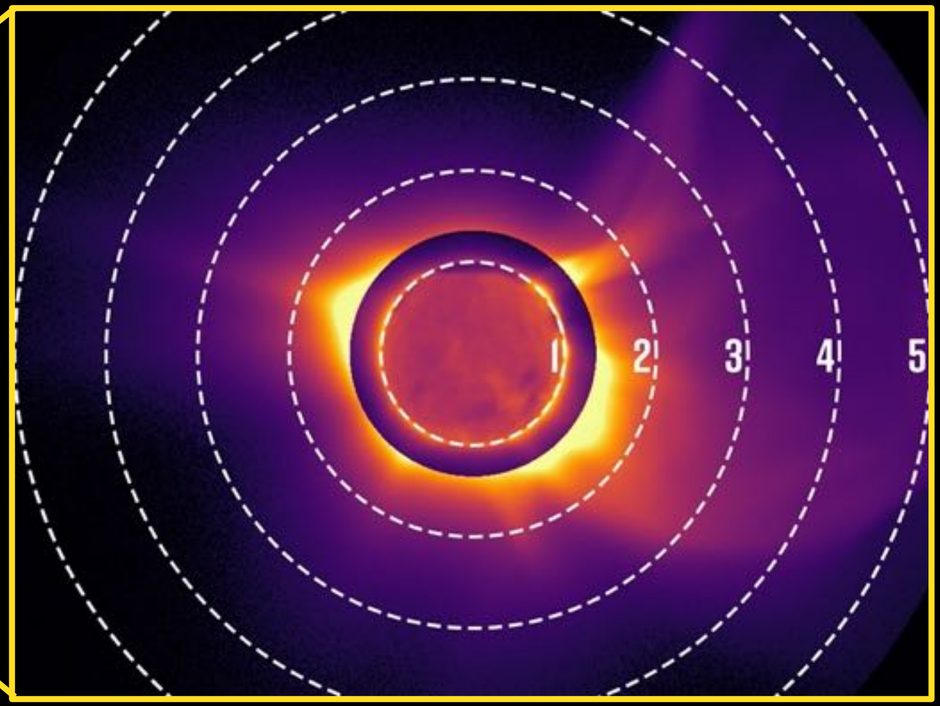
A natural pairing…

The SunCET PUNCH synergies.

SunCET – PUNCH Overlap

Fields of view

WFI	NFI	SunCET
		
17.4 $R_\odot$ – 180 $R_\odot$	**5.4 – 32 $R_\odot$**	**±5.34 $R_\odot$ × ±4 $R_\odot$**

SunCET – PUNCH Overlap

Cadence of Observations

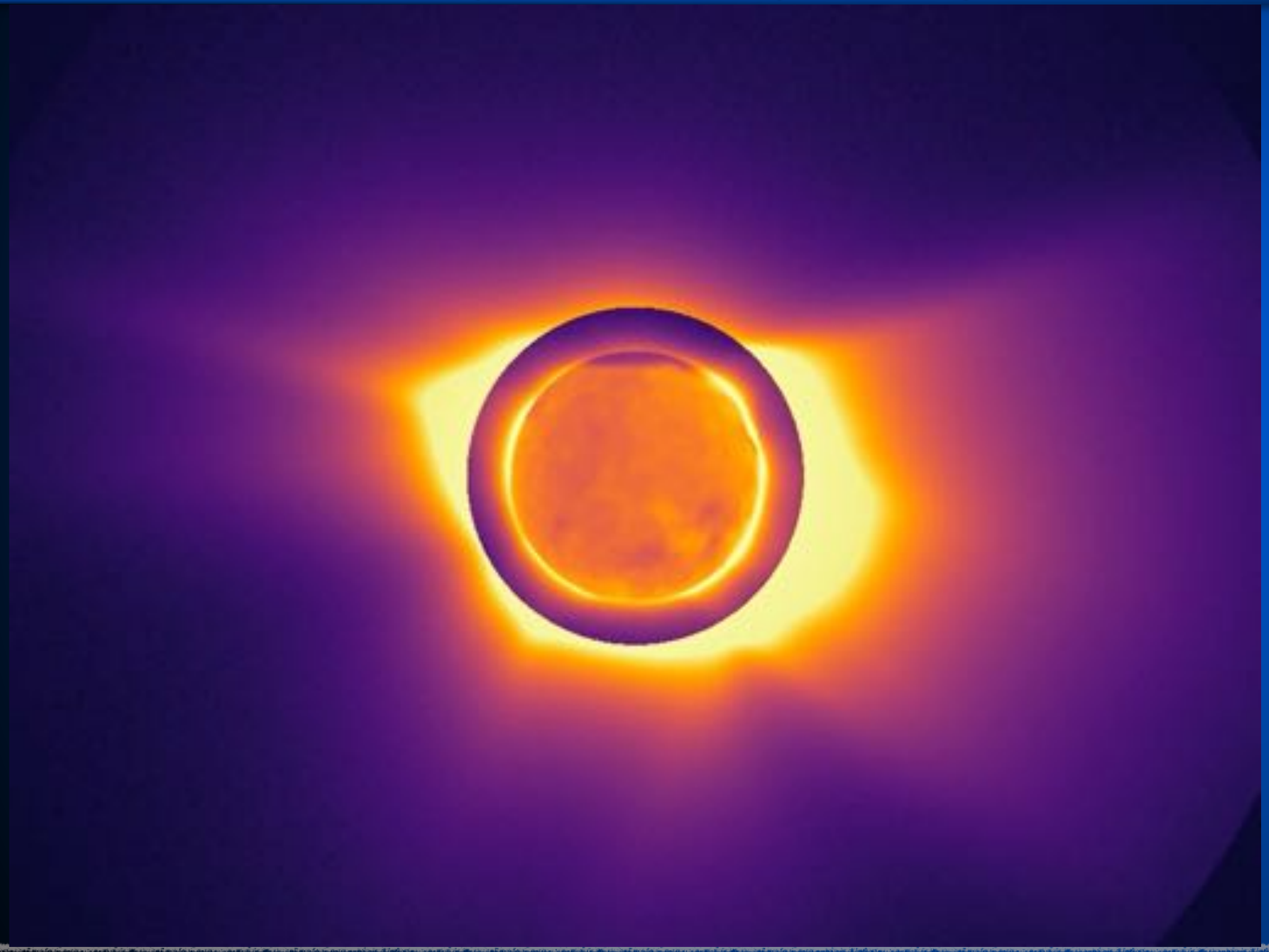
	SunCET	NFI	WFI
Exposure Time	0.035 seconds (solar disk) 15 seconds (off disk)	3x 13 seconds	45 seconds
Cadence	1 minute (nominal) 15 seconds (max)	8 minutes (nominal) 4 minutes (max)	32 minutes (full coverage) 4 minutes (per 30° roll)

Prime mission lasts for 8 months, likely July 2025 – March 2026.

(we will extend as much as possible)

SunCET mission

SunCET can help PUNCH complete the picture of the corona.



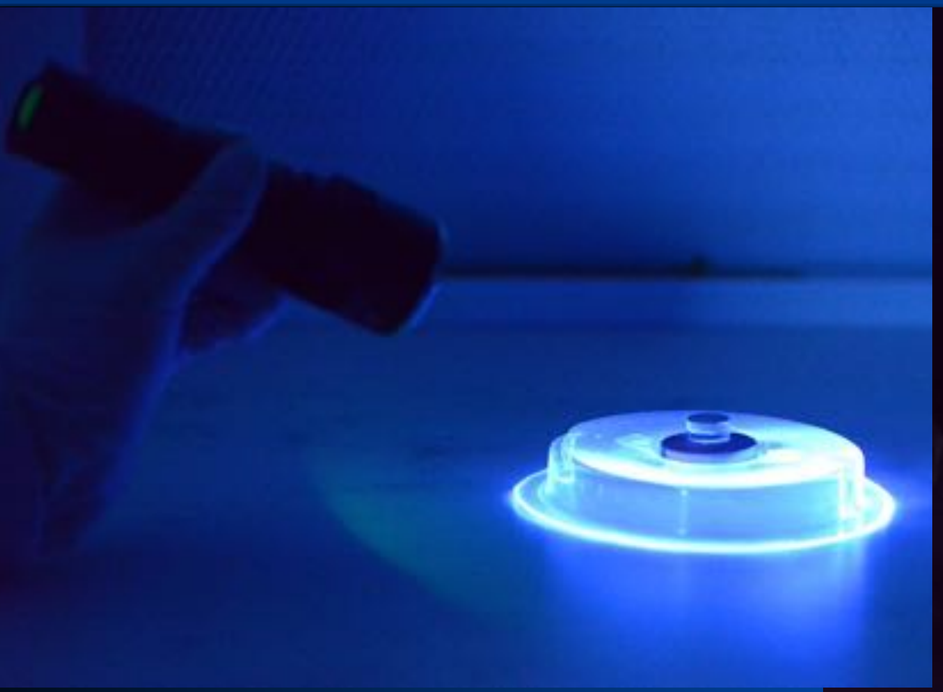
We will release data on the SunCET website in levels 1 and 3 as FITS, NetCDF, and Zarr.

What data products do you want to see?

Thank you!

Great new mirror coatings

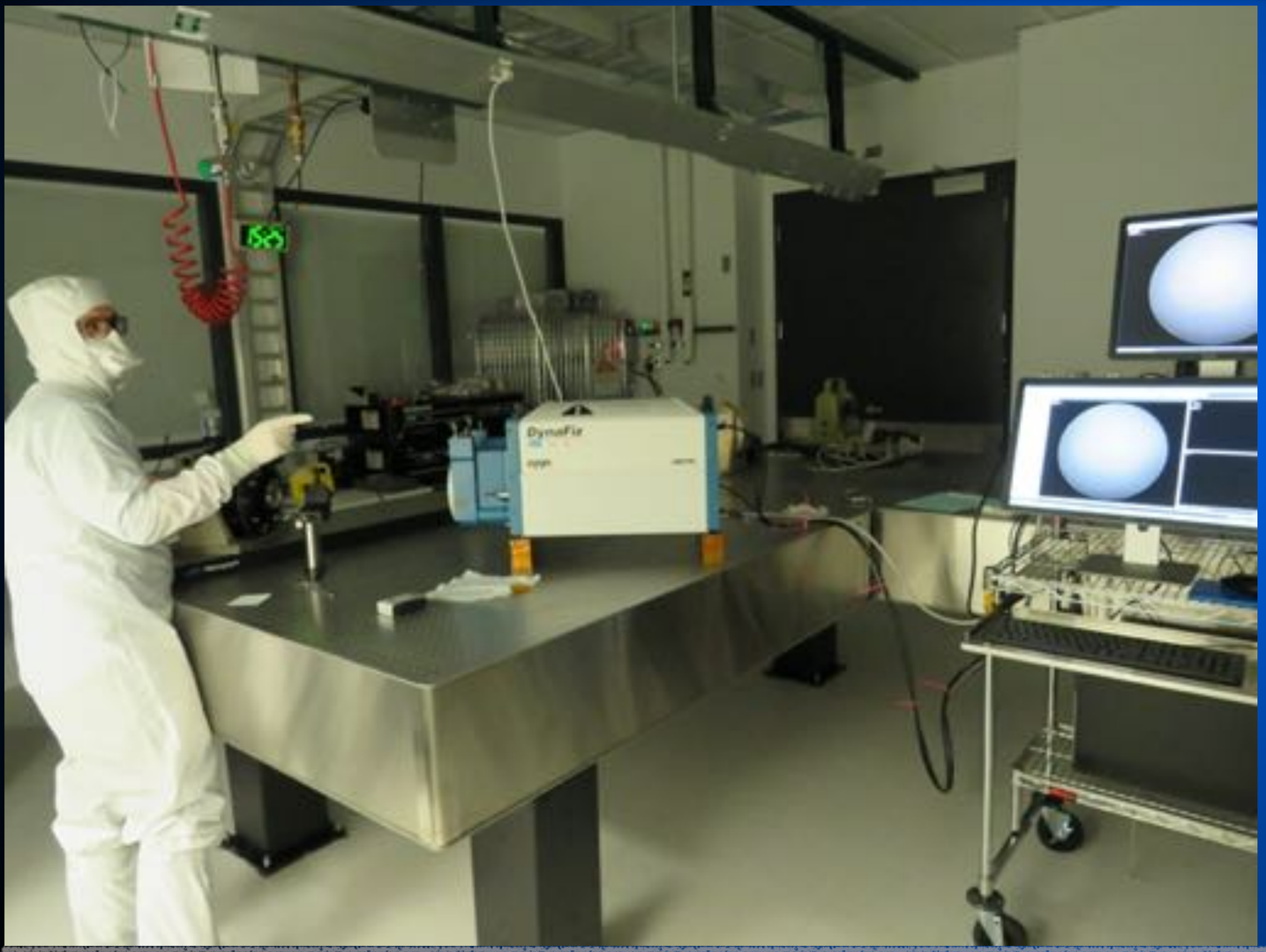
Low scatter, 170-200 Å



Attribution

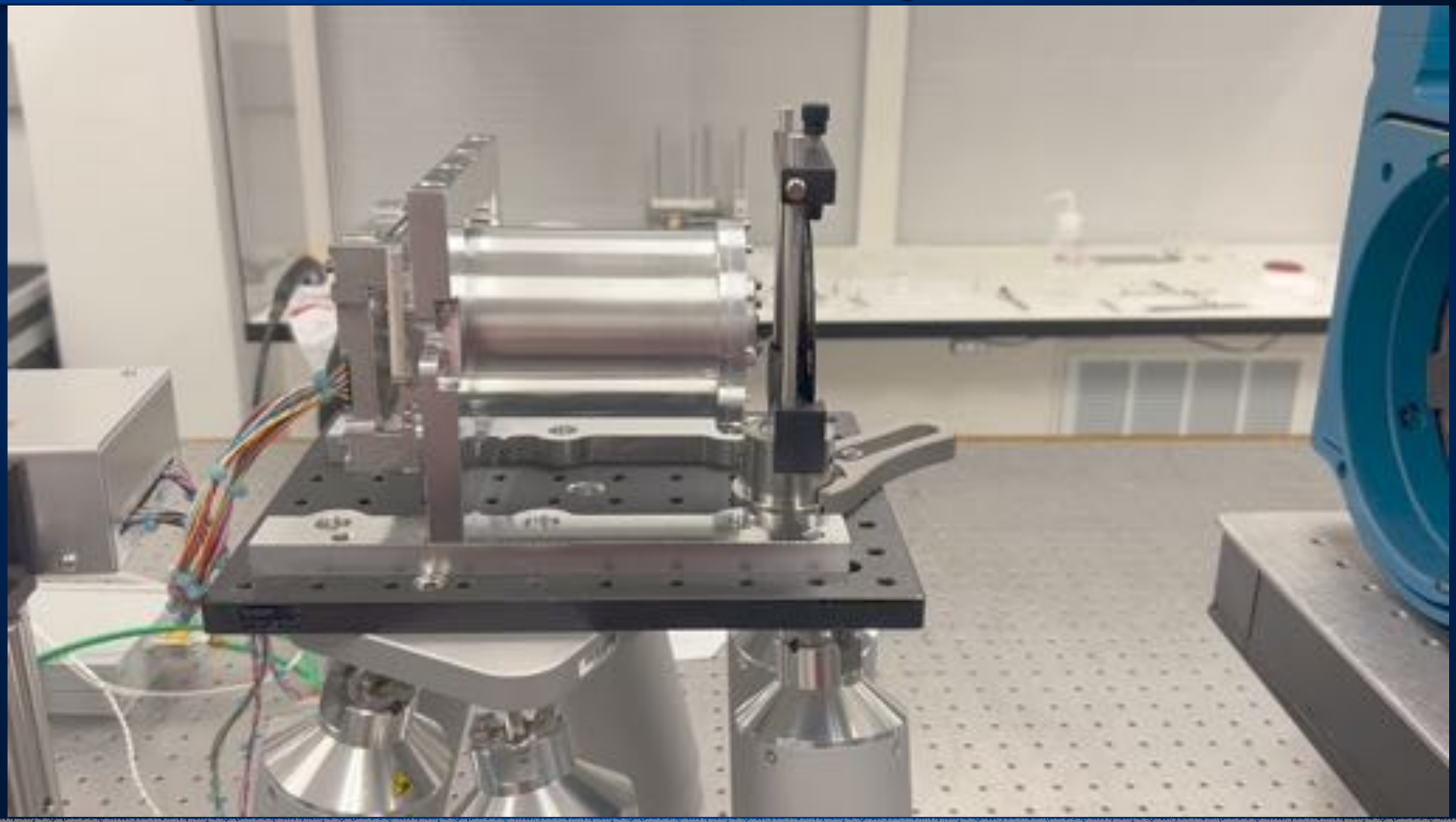
Aligning the telescope

In the same clean room as Europa Clipper telescopes



Characterizing point spread function

i.e., the limiting factor for our spatial resolution (results: right in line with expected performance)



Attribution

SunCET mission

Summary recap

- 6U CubeSat
- 4 kg, 20x10x15 cm instrument
- Simple, RC Telescope
- 2025 launch
- Also looking to fly instrument in constellations off Sun-Earth line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SUN CORONAL EJECTION TRACKER


SUNRISE
SUN RADIO INTERFEROMETER SPACE EXPERIMENT