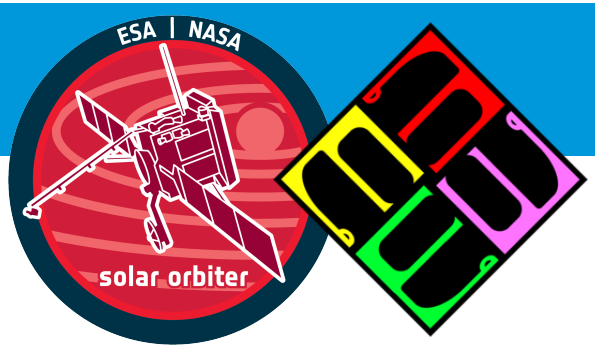
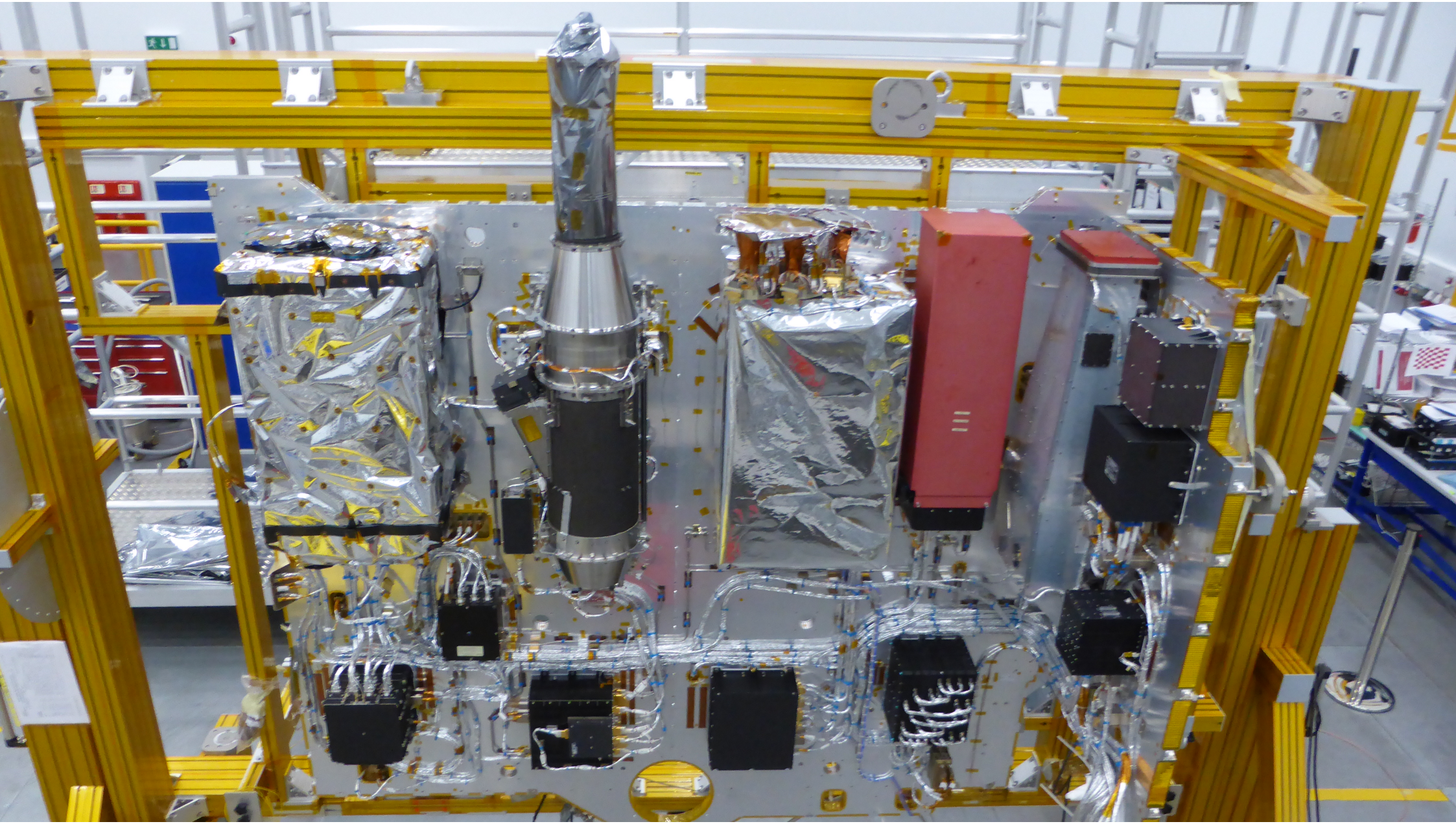


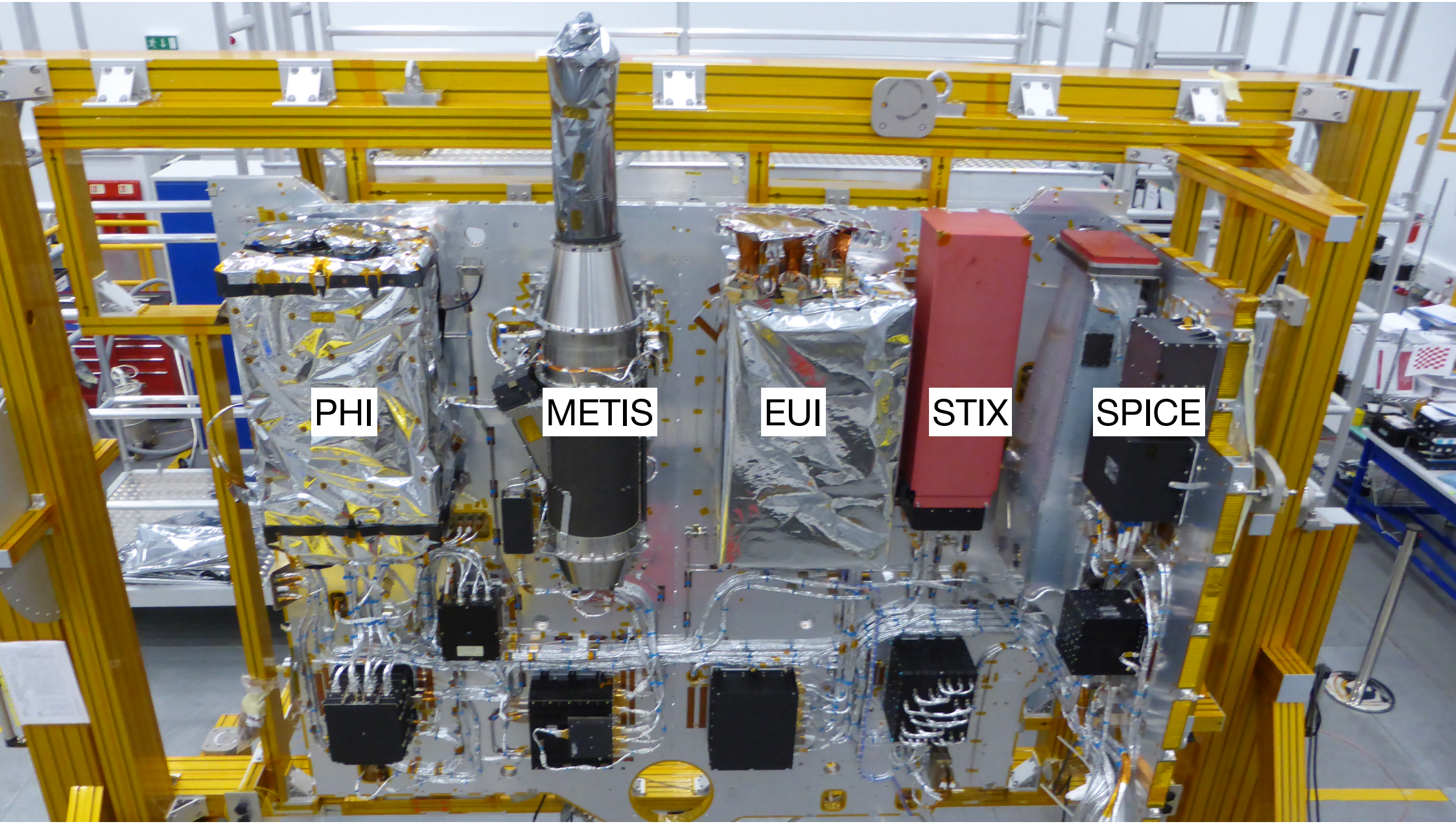
Observing flares with EUI

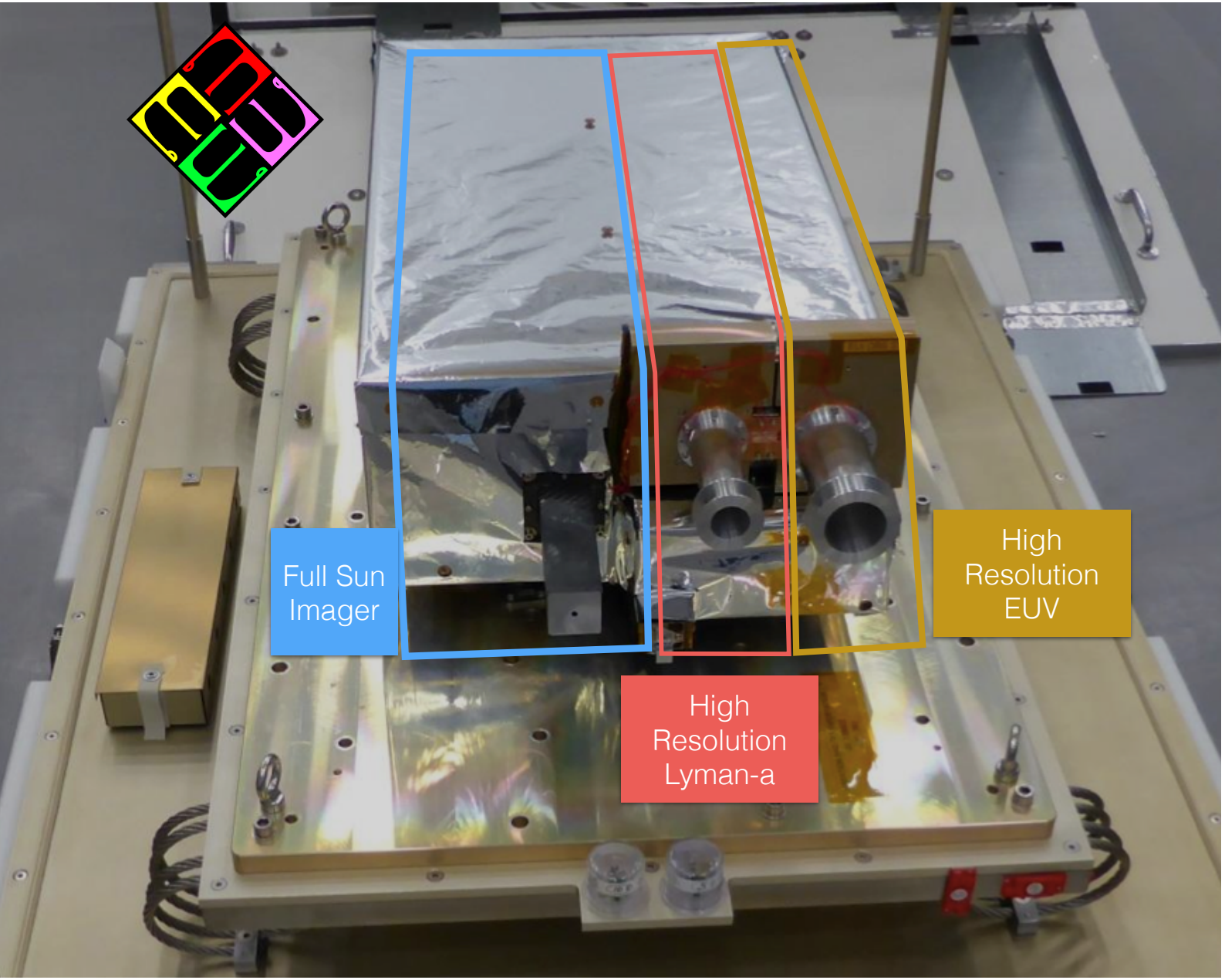
D. Berghmans, E. Kraaikamp for the EUI consortium

STIX meeting 2024-06-05

Contact: david.berghmans@sidc.be (PI)




PHI
METIS
EUI
STIX
SPICE



The "Extreme Ultraviolet Imager" (EUI) consortium

Centre Spatial de Liège

Institut d'Astrophysique Spatiale

Laboratoire Charles Fabry, Institut d'Optique

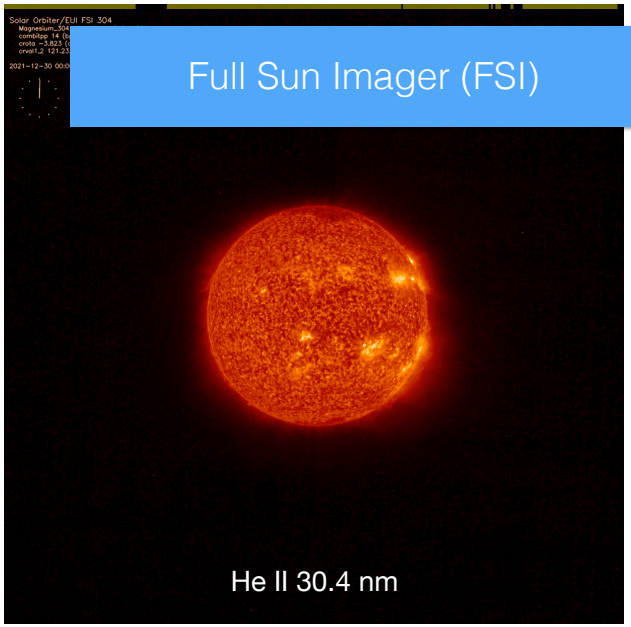
Max Planck Institute for Solar System Research

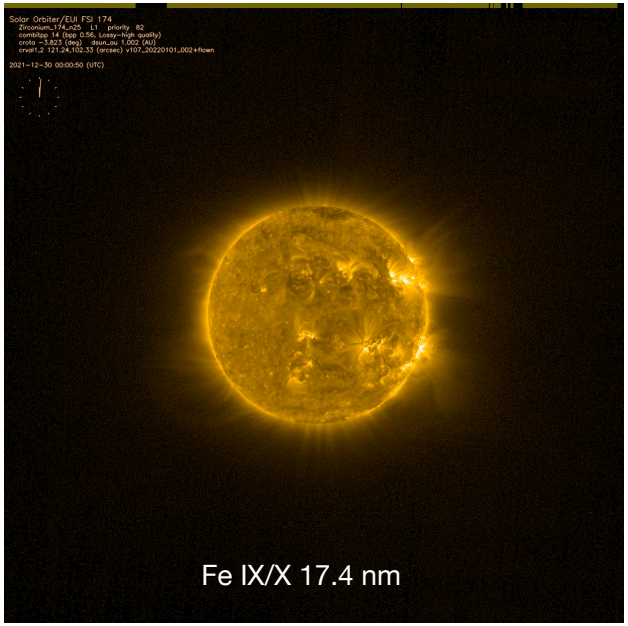
Physikalisch-Meteorologisches Observatorium Davos

UCL-Mullard Space Science Laboratory

Koninklijke Sterrenwacht van Belgie

Full Sun Imager (FSI)

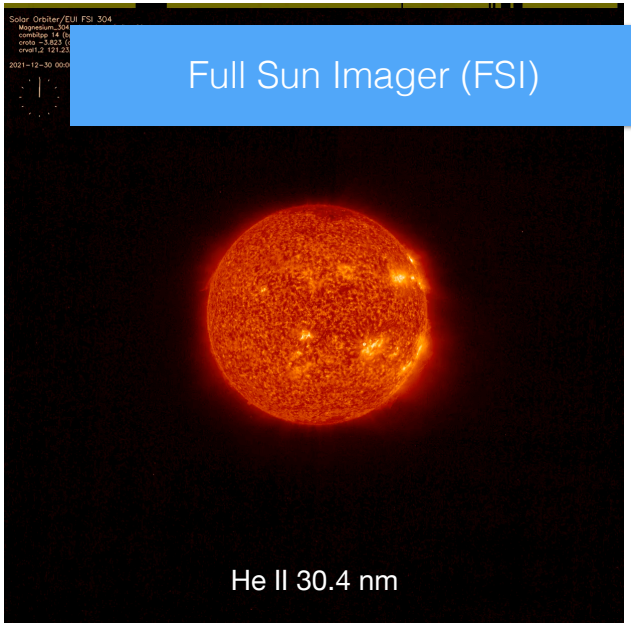


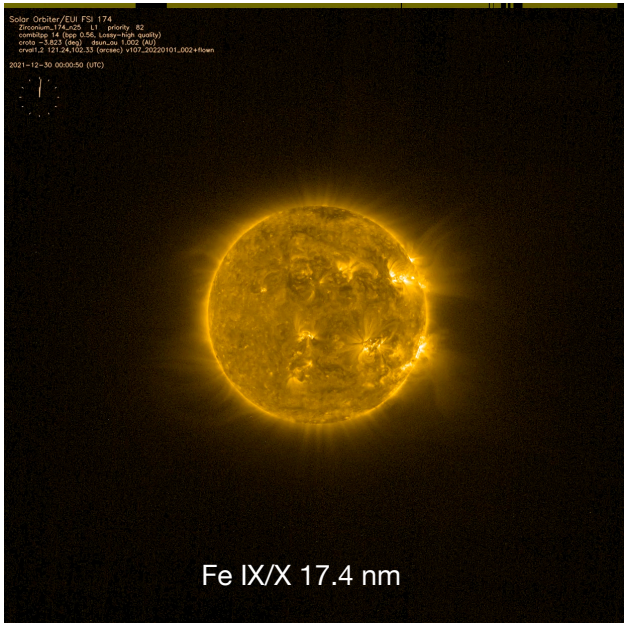


	FSI
FOV	3.8 deg ~ 4 Rs
plate scale	~4.5 arcsec ~920km
cadence	min

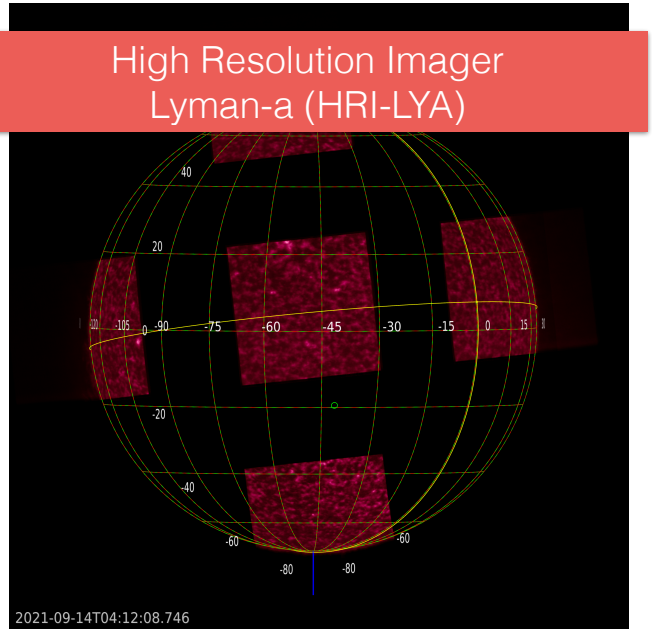
red = perihelion

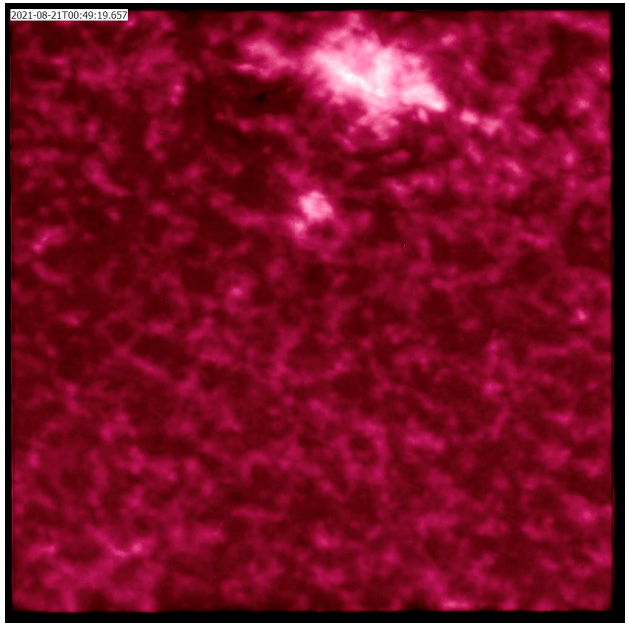
Full Sun Imager (FSI)





High Resolution Imager
Lyman-a (HRI-LYA)

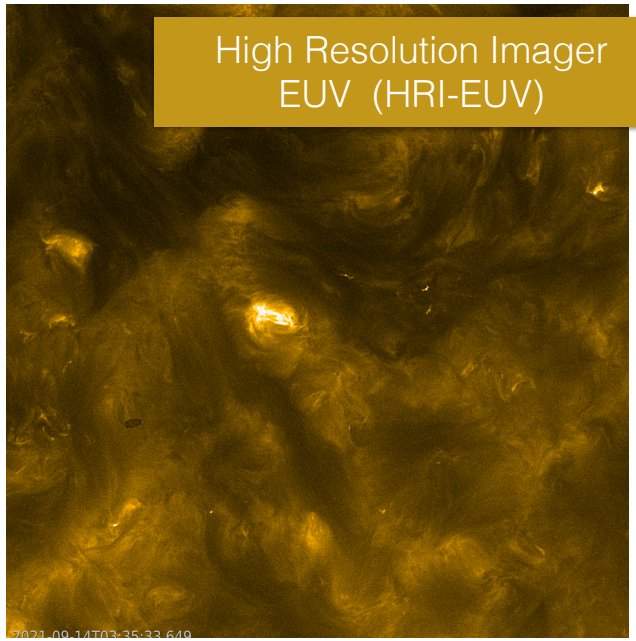




	FSI	HRIs
FOV	3.8 deg ~ 4 Rs	17 arcmin ~ 0.3 Rs
plate scale	~4.5 arcsec ~920km	~0.5 arcsec ~100km
cadence	min	sec

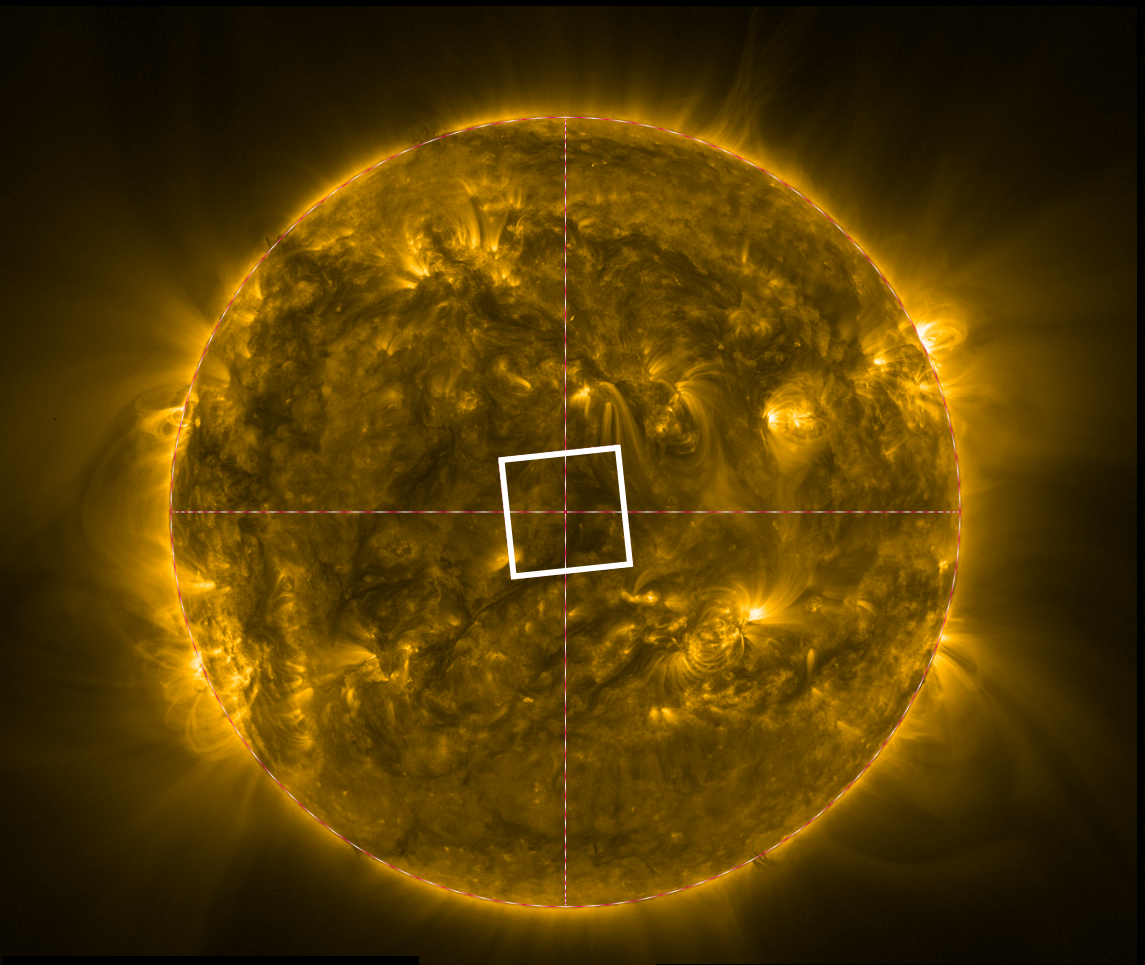
red = perihelion

High Resolution Imager
EUV (HRI-EUV)

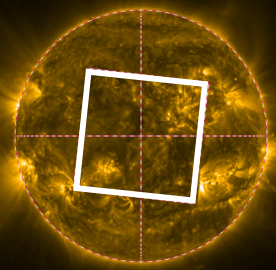


Why is it hard to observe flares with HRIs?

Spatial coverage is low:
HRIEUV covers < 1/30th of the disk during perihelion



D☉: 0.2971au



D☉: 0.9360au

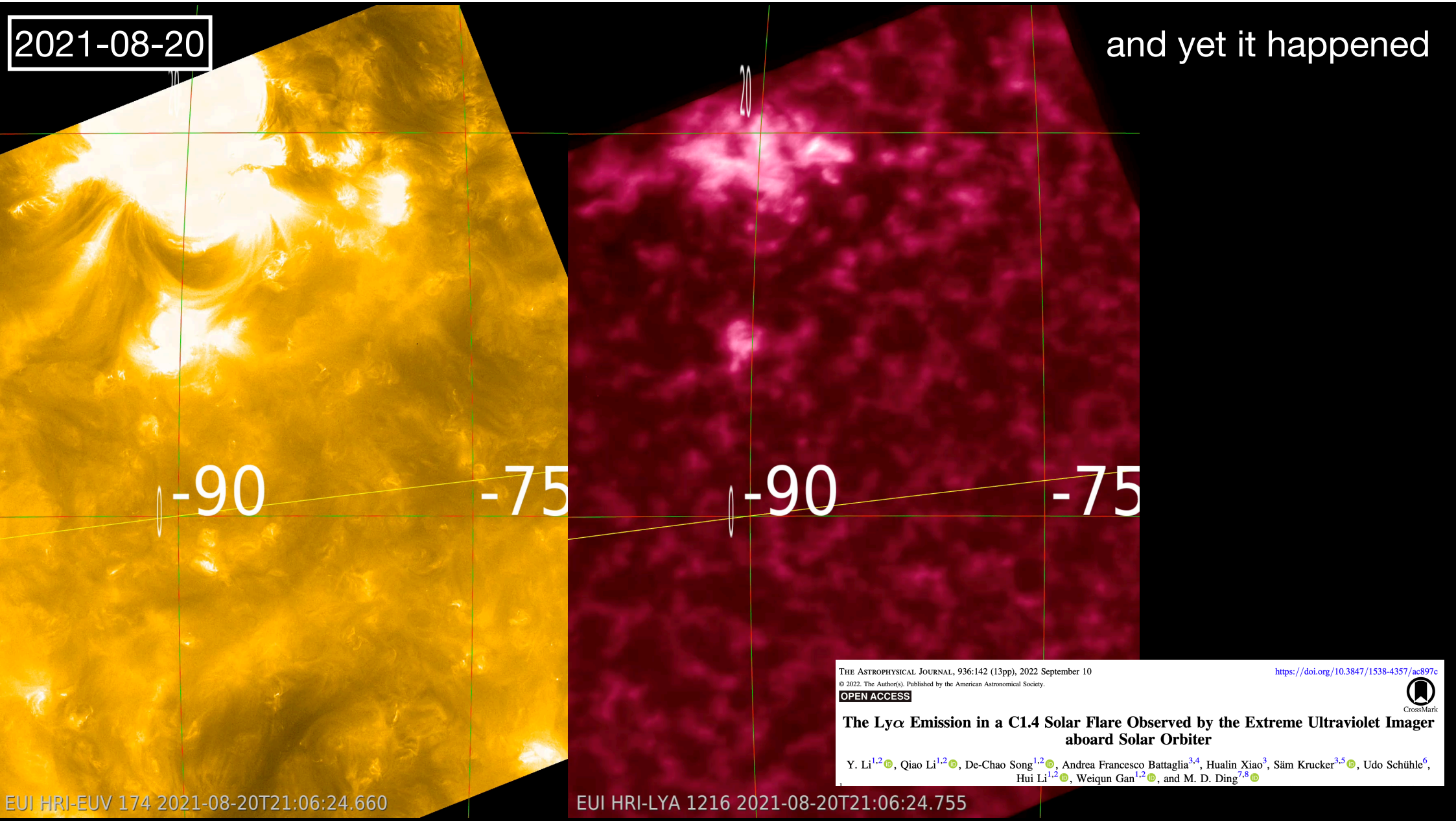
Spatial coverage is low:
HRIEUV covers < 1/30th of the disk during perihelion

Duty cycle is low:
Telemetry corresponds to 20min HRIEUV imaging at 2s cadence: 20 min/day = 1/72 duty cycle

Spatial coverage is low:
HRIEUV covers < 1/30th of the disk during perihelion

Duty cycle is low:
Telemetry corresponds to 20min HRIEUV imaging at 2s cadence: 20 min/day = 1/72 duty cycle

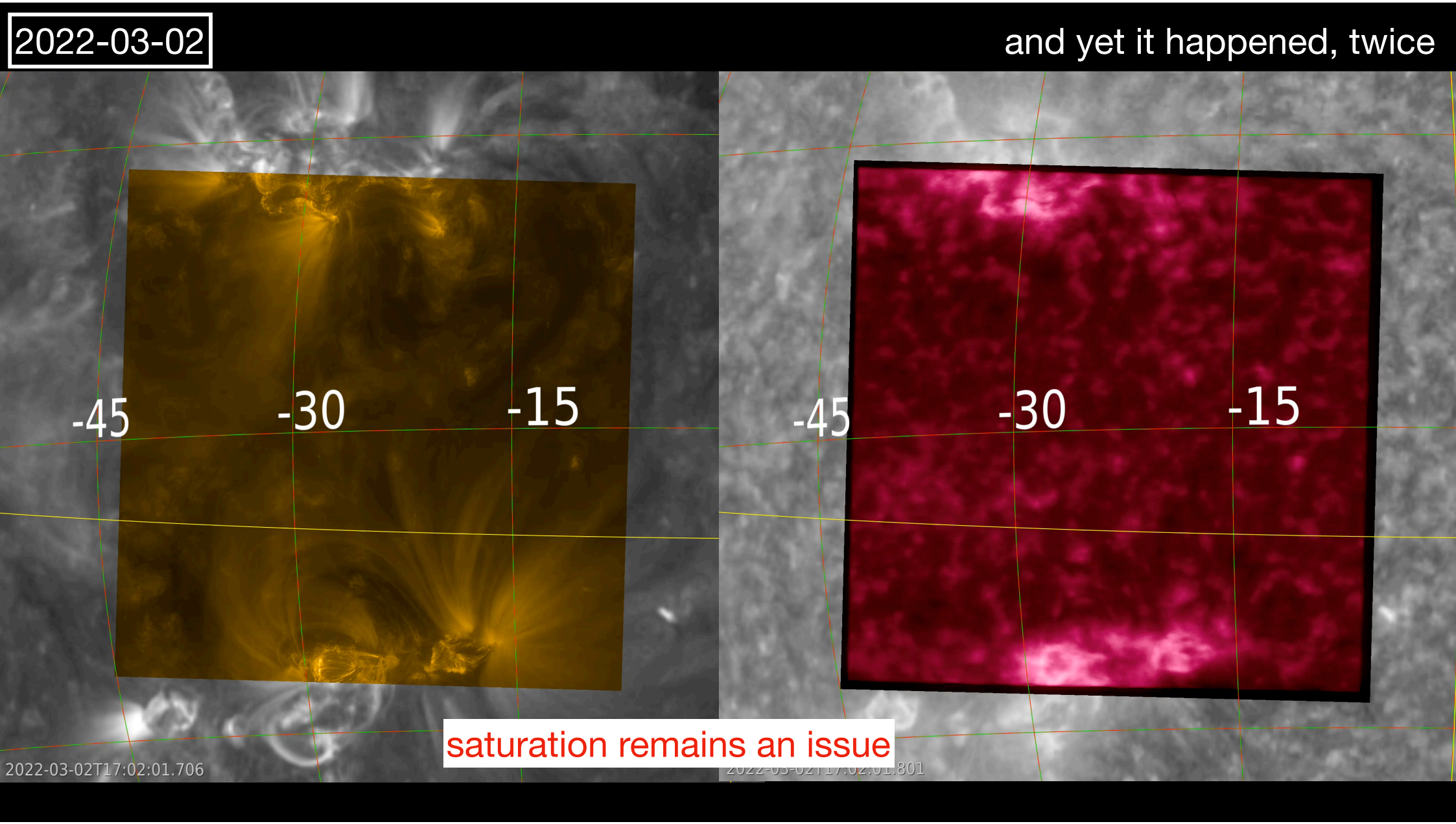
Spatio-temporal coverage is (1/30)*(1/72) < 1/2000.



The Astrophysical Journal, 936:142 (13pp), 2022 September 10 https://doi.org/10.3847/1538-4357/ac897c

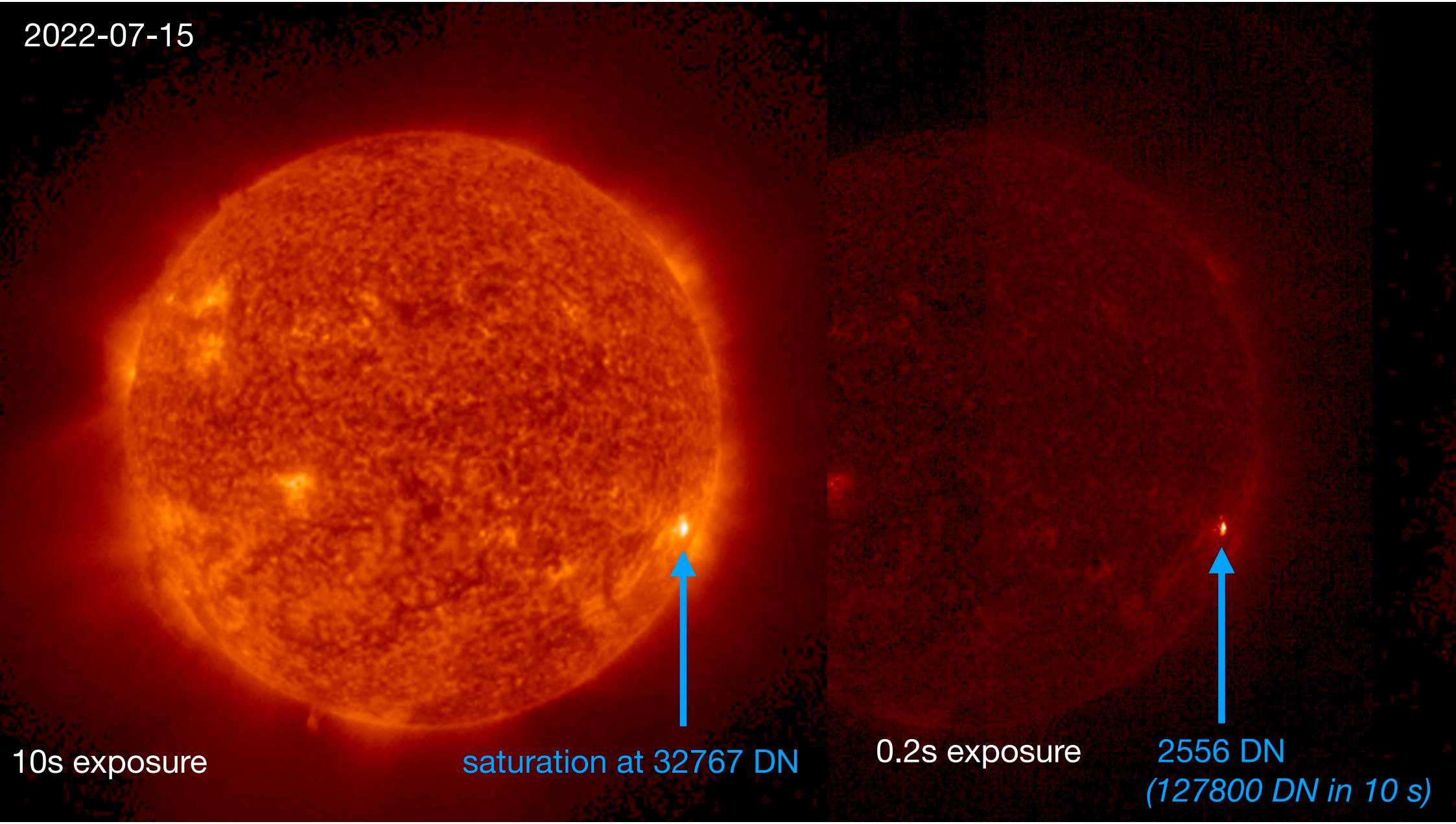
The Lyα Emission in a C1.4 Solar Flare Observed by the Extreme Ultraviolet Imager aboard Solar Orbiter

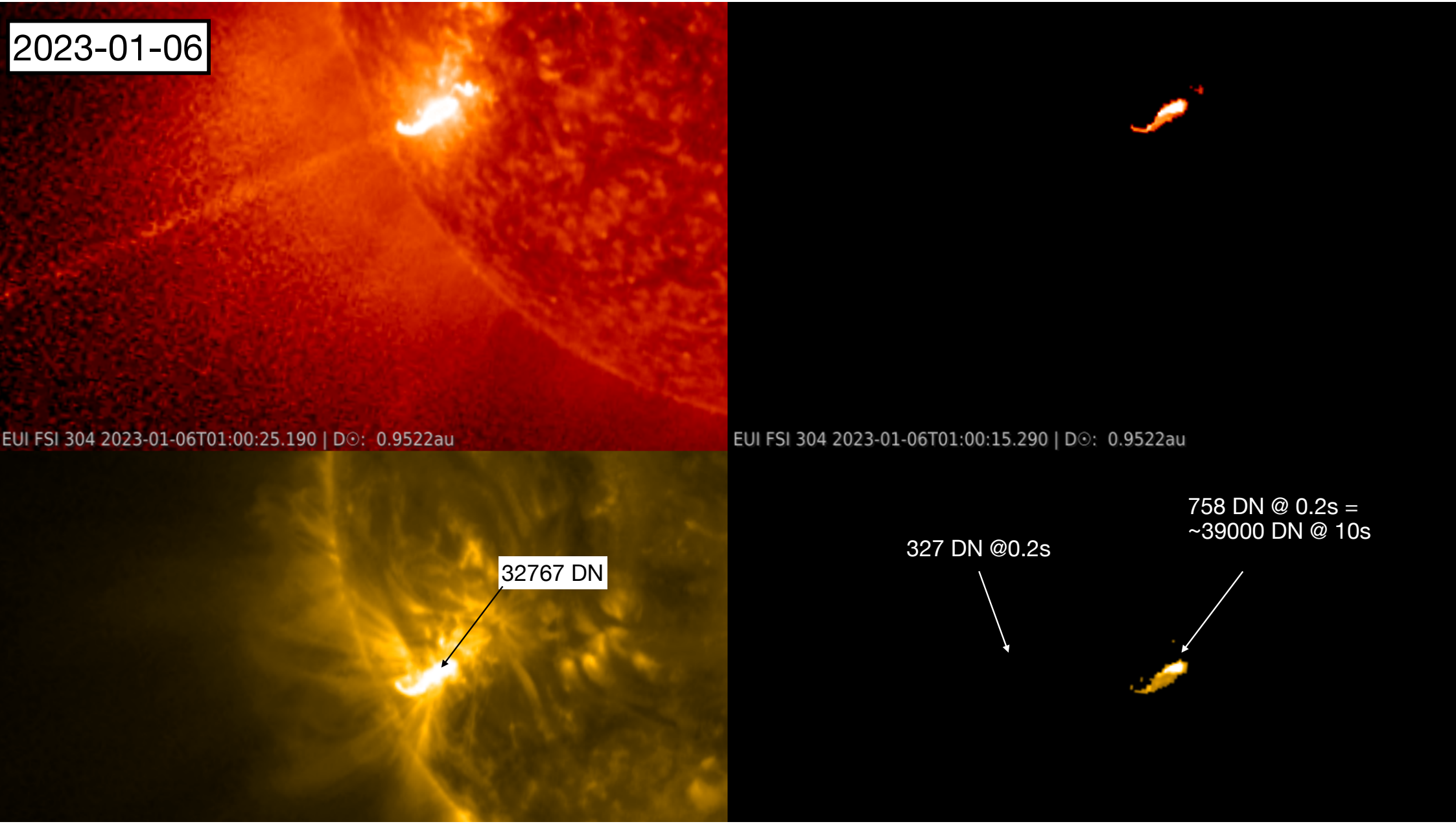
Y. Li[1,2], Qiao Li[1,2], De-Chao Song[1,2], Andrea Francesco Battaglia[3,4], Hualin Xiao[3], Säm Krucker[3,5], Udo Schühle[6], Hui Li[1,2], Weiqun Gan[1,2], and M. D. Ding[7,8]


2022-03-02
and yet it happened, twice
-45
-30
-15
-45
-30
-15
saturation remains an issue
2022-03-02T17:02:01.706

Solving saturation in flares

- the 15bit dynamic range of EUI sensors is not sufficient for the EUV flare signal
- Real time adaptive exposure times not foreseen in EUI
- Adding extra short exposure images is load on limited TM
- for FSI systematically from 2022-11-09


2022-07-15
10s exposure
saturation at 32767 DN
0.2s exposure
2556 DN
(127800 DN in 10 s)


2023-01-06
EUI FSI 304 2023-01-06T01:00:25.190 | D☉: 0.9522au
EUI FSI 304 2023-01-06T01:00:15.290 | D☉: 0.9522au
32767 DN
327 DN @0.2s
758 DN @ 0.2s =
~39000 DN @ 10s

Short exposures

- for FSI systematically from 2022-11-09

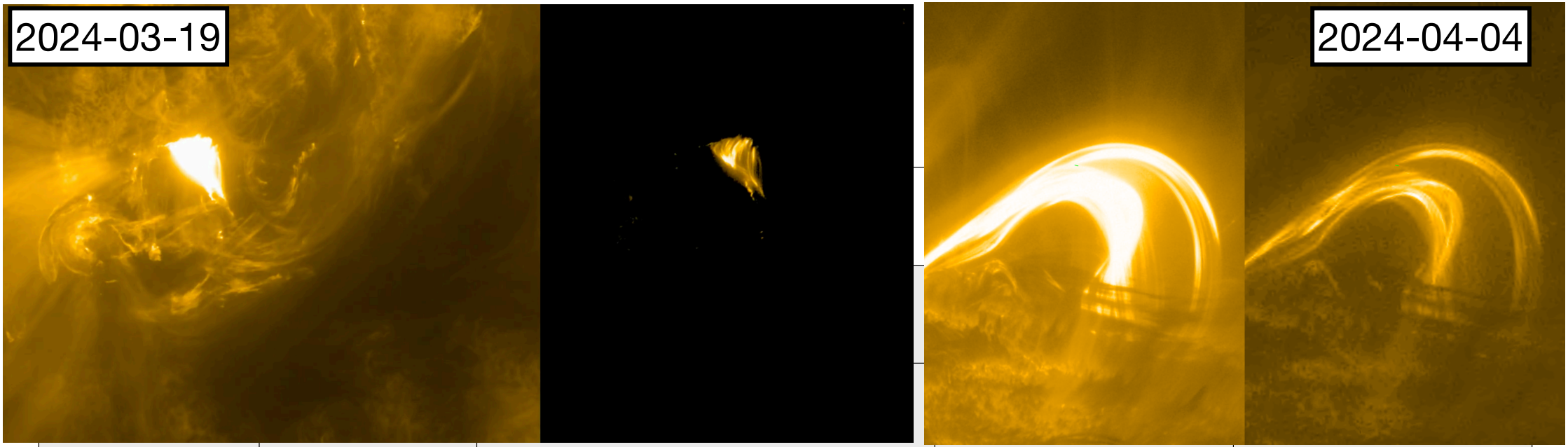
	exposure time	**dynamic range**	**compression**	**filesize**
FSI regular image	10s	0-32767 DN	lossy (factor 27)	0.63 MiB
FSI short exposure	0.2s	327-32767 DN	lossless	0.1 MiB

Short exposures

	exposure time	dynamic range	compression	filesize
FSI regular image	10s	0-32767 DN	lossy (factor 27)	0.63 MiB
FSI short exposure	0.2s	327-32767 DN	lossless	0.1 MiB
HRIEUV regular image	1.65s	0-25600 DN	lossy (factor 8)	1 MiB
HRIEUV short exposure	0.033s	256-25600 DN	lossless	0.04 MiB

Short exposures

	exposure time	dynamic range	compression	filesize
FSI regular image	10s	0-32767 DN	lossy (factor 27)	0.63 MiB
FSI short exposure	0.2s	327-32767 DN	lossless	0.1 MiB
HRIEUV regular image	1.65s	0-25600 DN	lossy (factor 8)	1 MiB
HRIEUV short exposure	0.033s	256-25600 DN	lossless	0.04 MiB
HRIEUV 2022 Apr 4 shorts	0.04	0-32767 DN	lossy (factor 125)	0.06 MiB



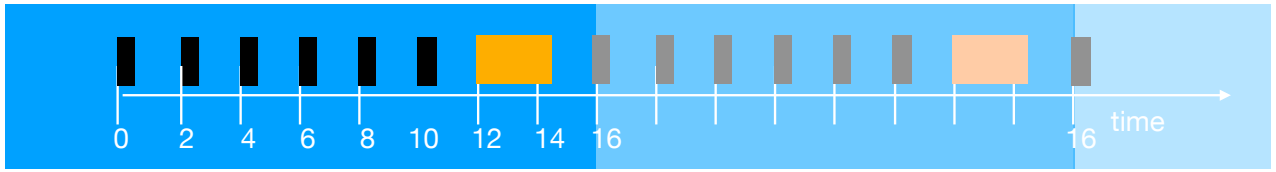
HRIEUV regular image	1.65s	0-25600 DN	lossy (factor 8)	1 MiB
HRIEUV short exposure	0.033s	256-25600 DN	lossless	0.04 MiB
HRIEUV Apr 4 shorts	0.04	0-32767 DN	lossy (factor 125)	0.06 MiB

Major Flare Watch

- long (4h) periods of pointing to the most active region
- 4h @ 2s cadence is not compatible with TM budget

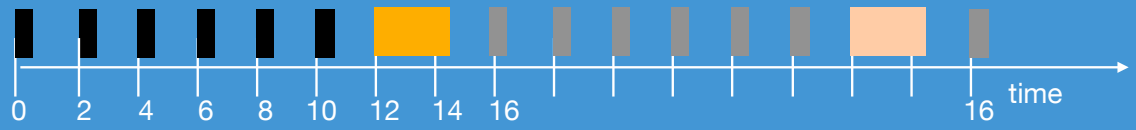
Major Flare Watch

- long (4h) periods of pointing to the most active region
- 4h @ 2s cadence is not compatible with TM budget
- high cadence is the most important in flares where signal is high
- solution: low cadence for regular images, high cadence for short exposures
- 16s cycles of 6 shorts + 1 regular image.
- 4h= 960 cycles =1190 MiB=5600 images

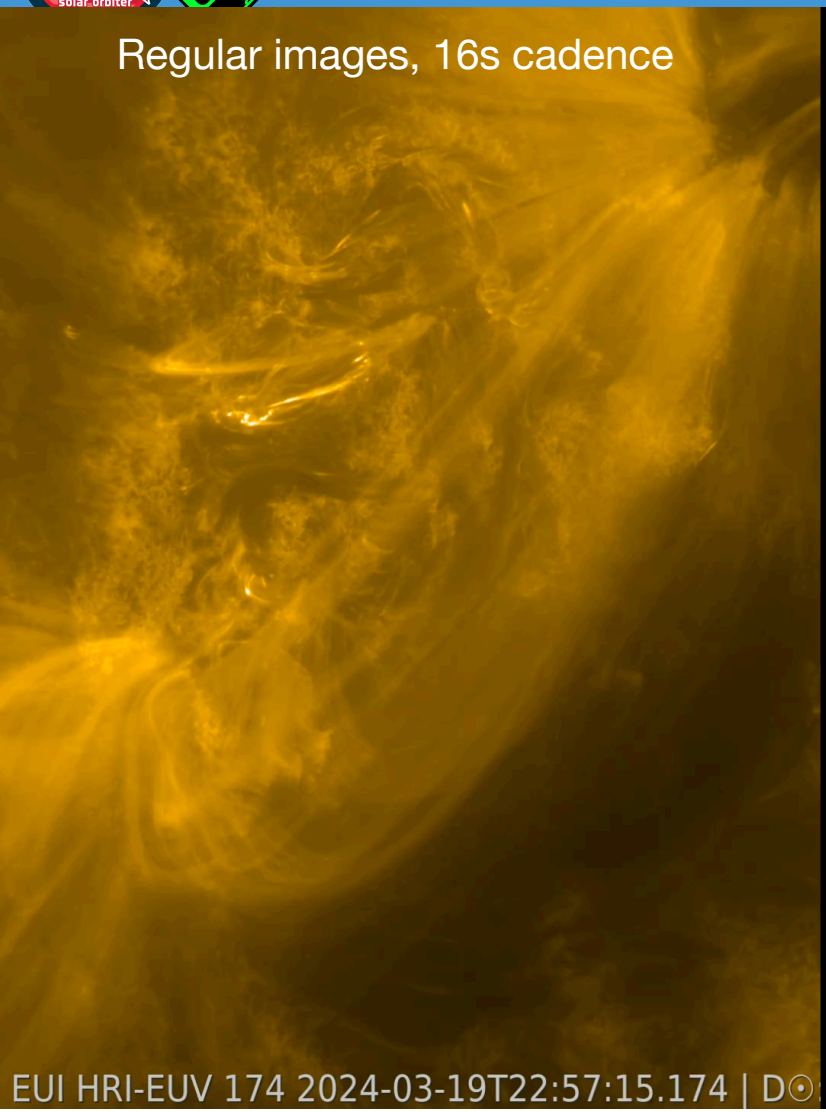


6*0.04+1 MiB = 1.24 MiB per cycle

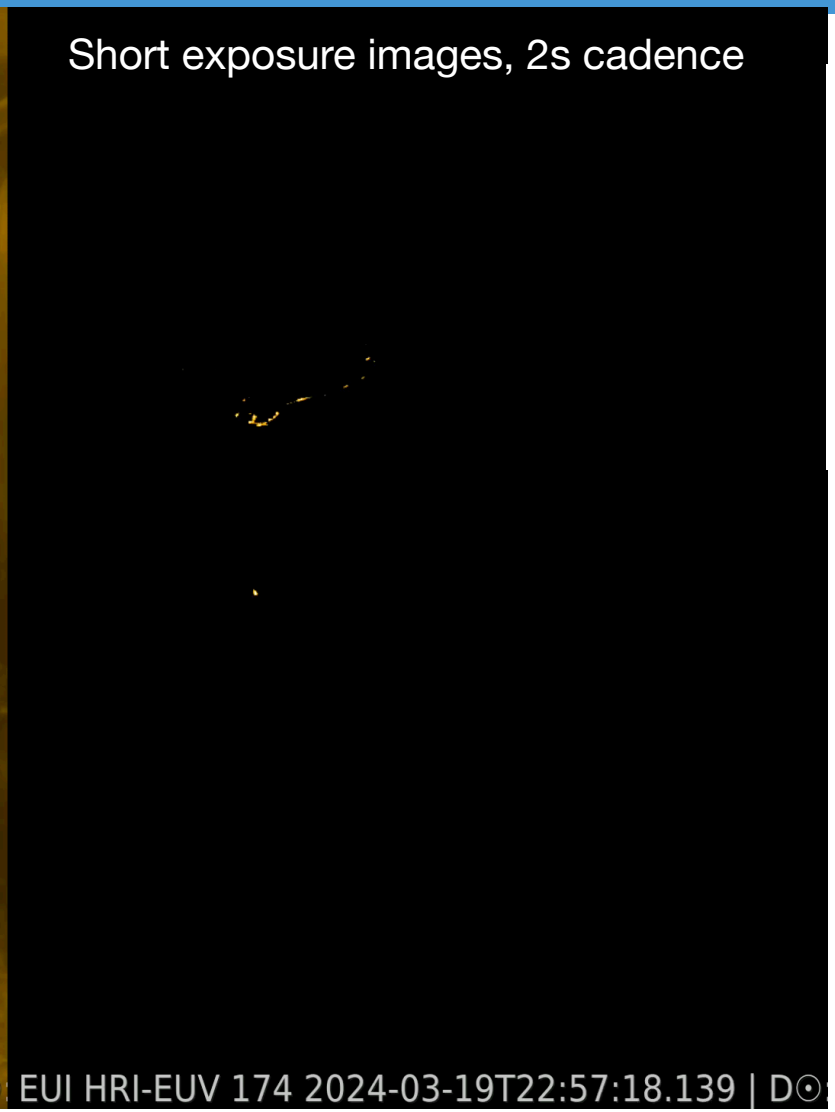
Major flare watch

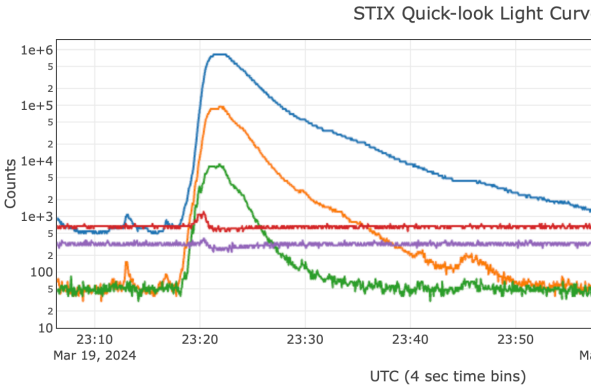


Regular images, 16s cadence

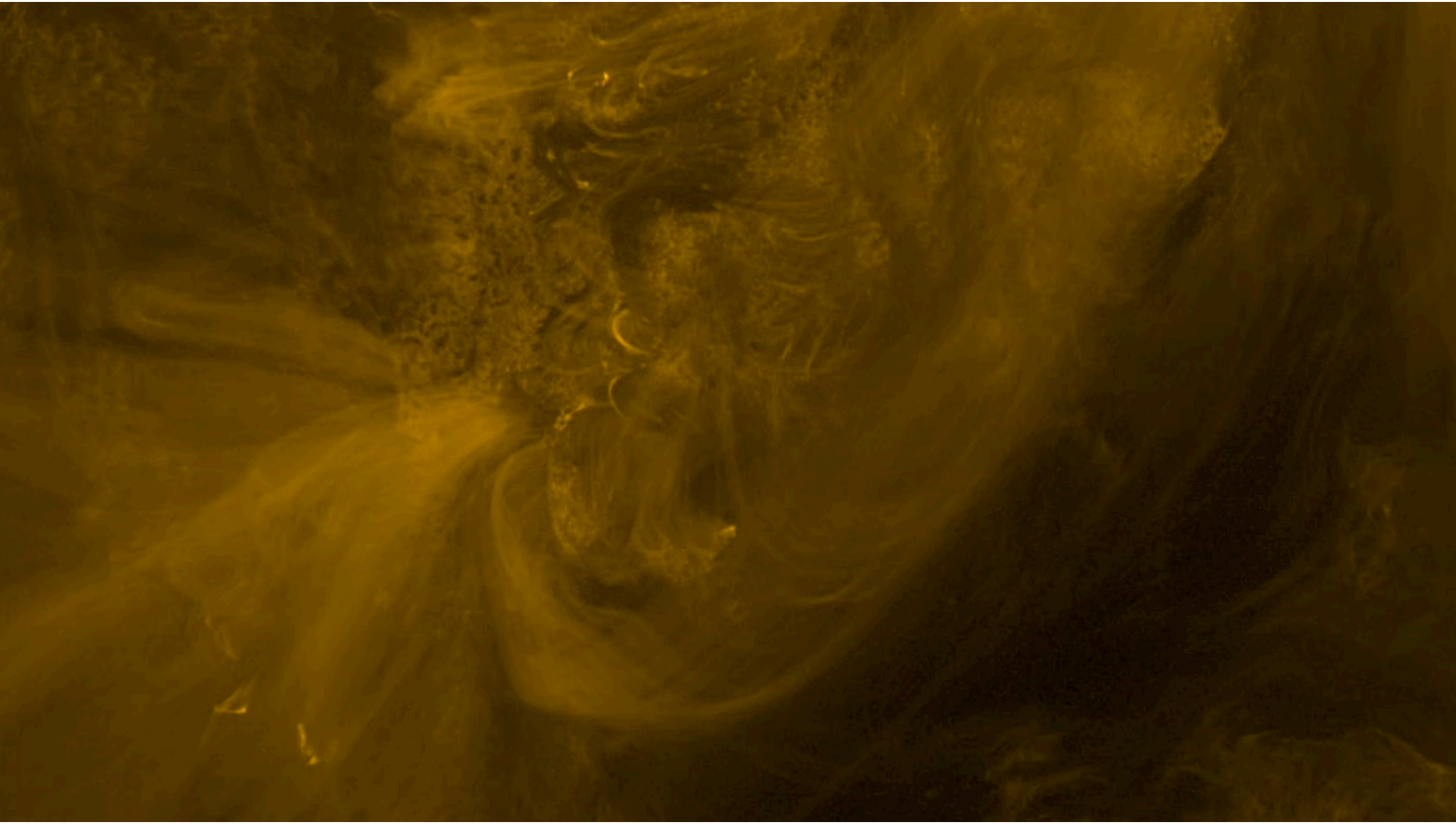


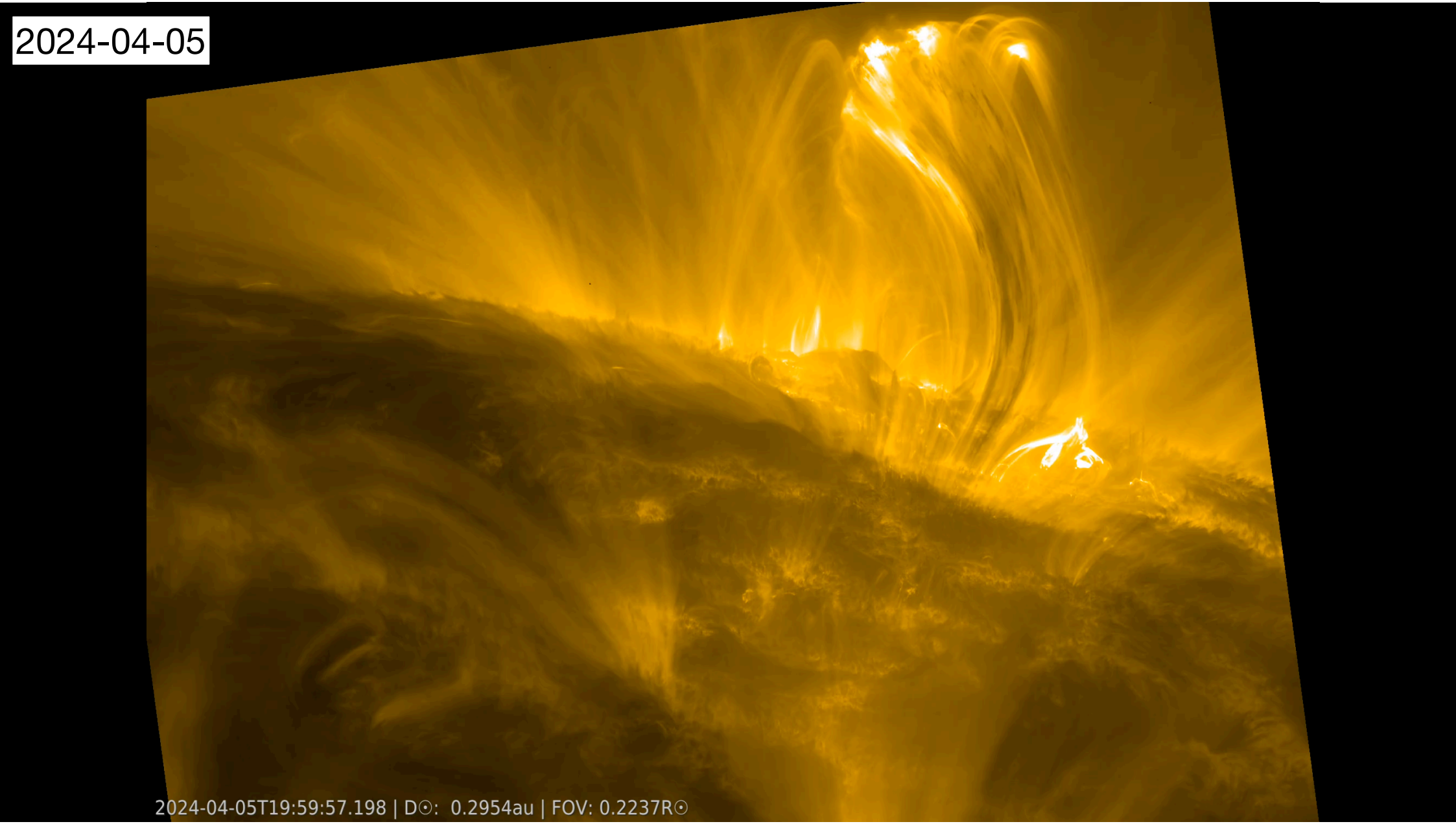
Short exposure images, 2s cadence

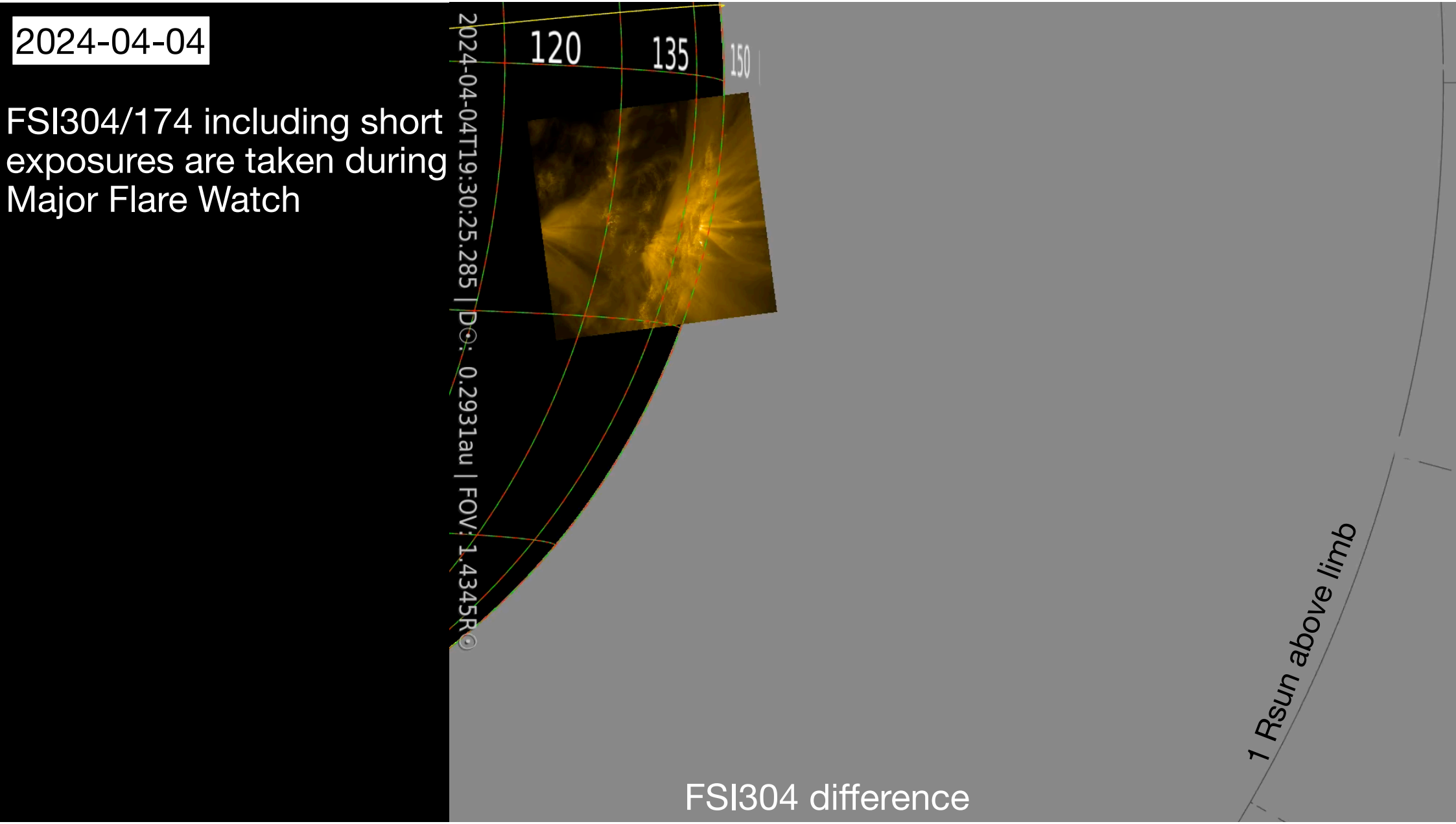




Talk Hannah Collier



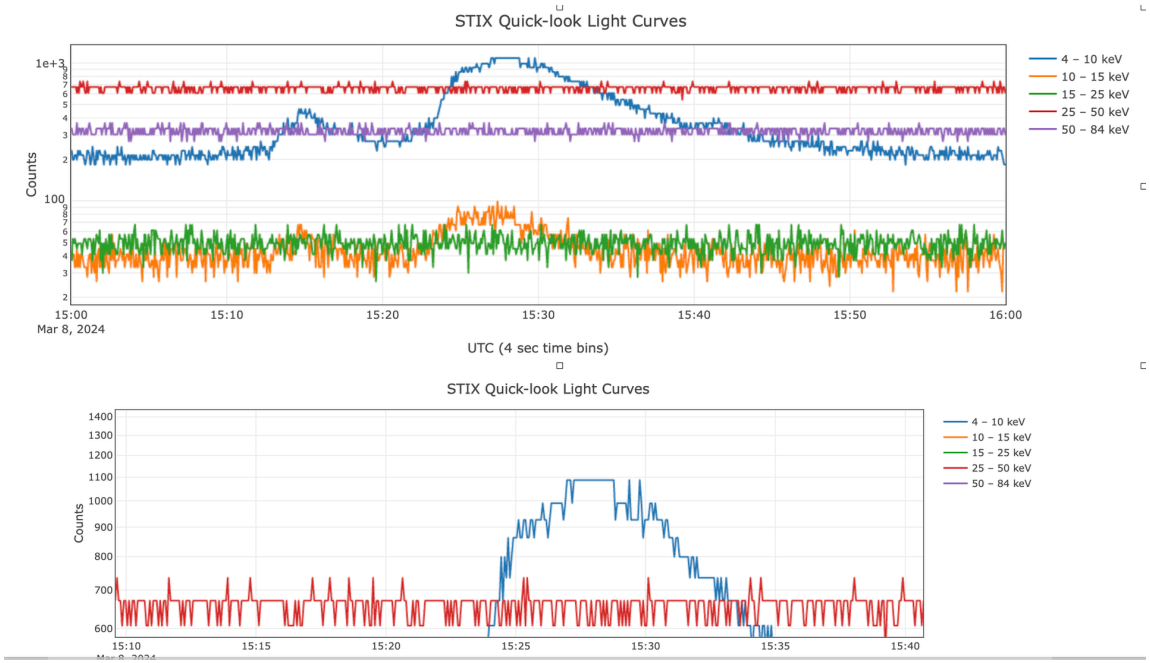

2024-04-05
2024-04-05T19:59:57.198 | D⊙: 0.2954au | FOV: 0.2237R⊙

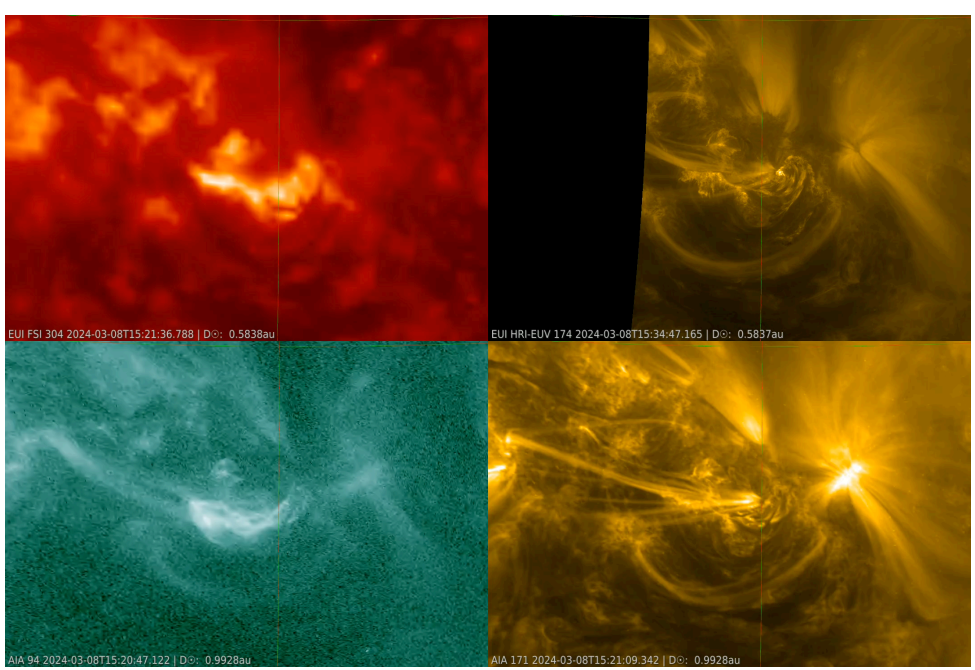

2024-04-04
FSI304/174 including short exposures are taken during Major Flare Watch
120
135
150
2024-04-04T19:30:25.285 | D☉: 0.2931au | FOV: 1.4345R☉
1 Rsun above limb
FSI304 difference

Other cards we can play

1. instead of flushing everything into the SSMM, we can keep some data in the EUI memory and bring it down after confirmation from the ground
2. we can use the STIX flare trigger
3. we can use the EUI flare trigger
4. we could add Lyman-alpha again (at the expense of HRIEUV cadence)
5. continuous mode (=regular images at 2s cadence or semi-short at 1s cadence)

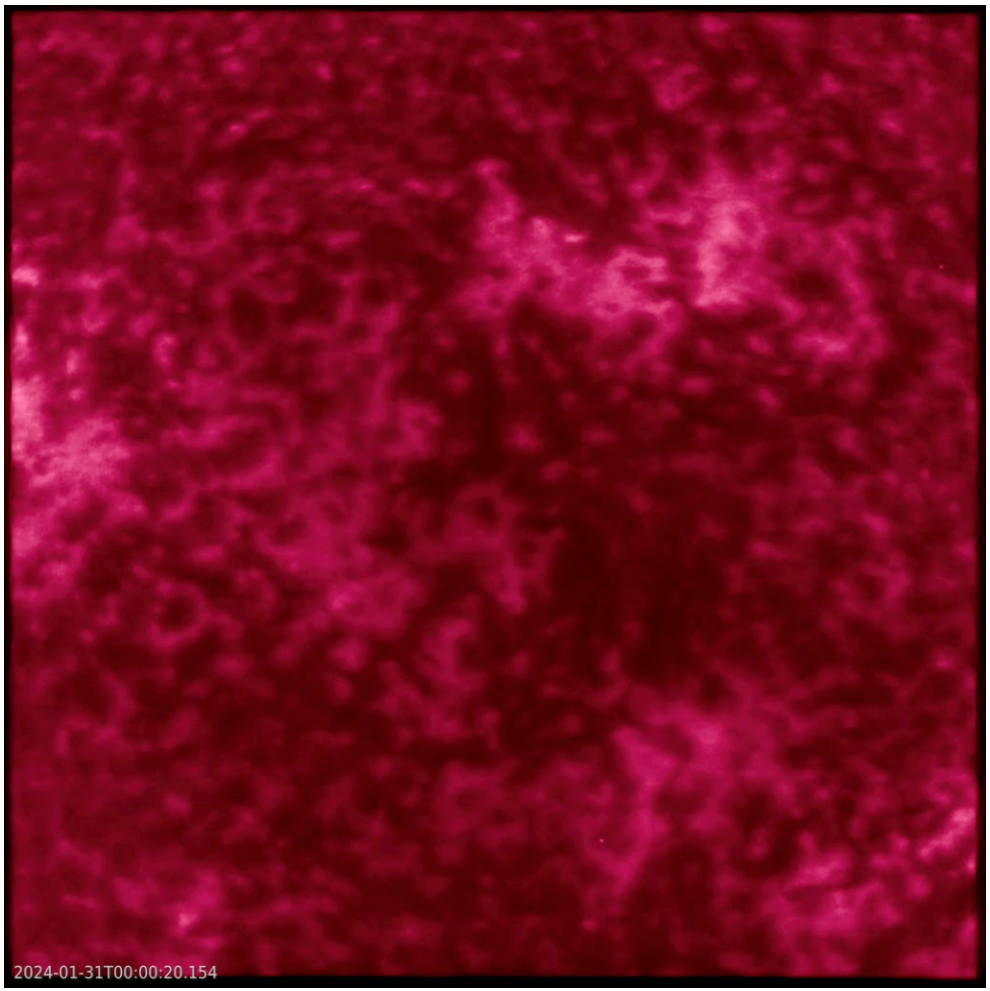
March 8 EUI-STIX Flare trigger test: success!





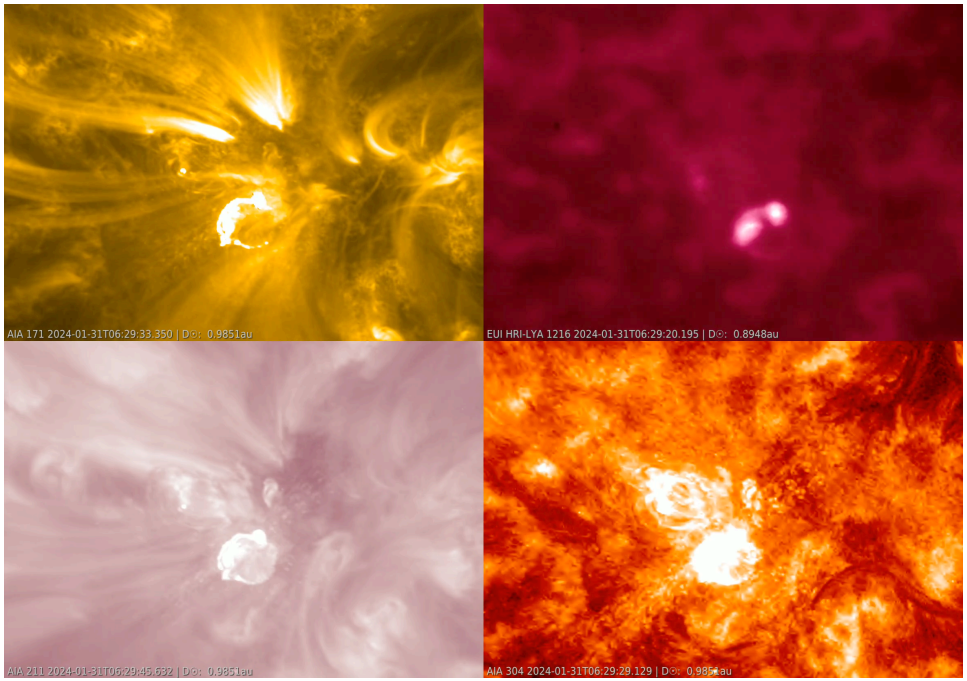
EUI send HRIEUV images to SSMM in response to an incoming STIX S20 flare trigger.
Secondary bugs found in EUI onboard software, to be fixed

2024 Jan 31: HRILYA aphelion experiment (24h@1 min cadence)

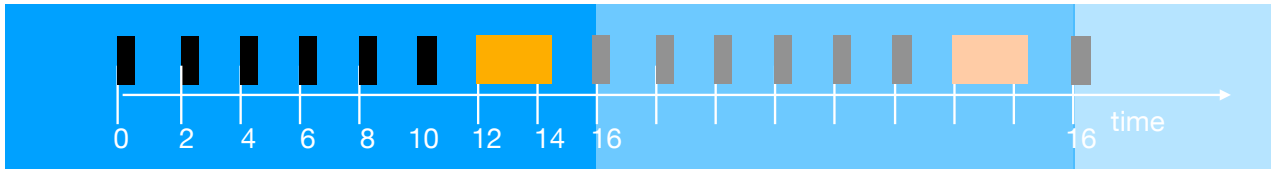


HRILYA is more performant outside the RSW when far away from the Sun.

This implies no last-minute off-pointing and moderate spatial resolution.

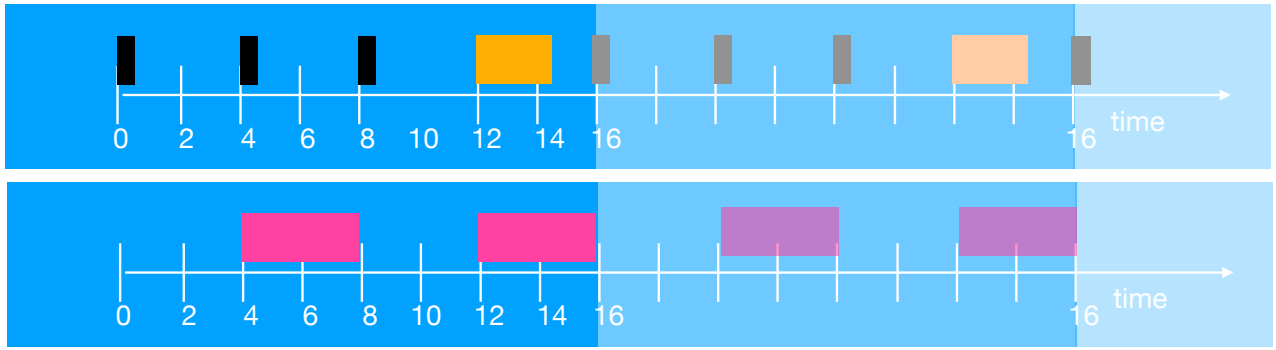


Major Flare Watch, adding HRIYLA



HRIEUV only

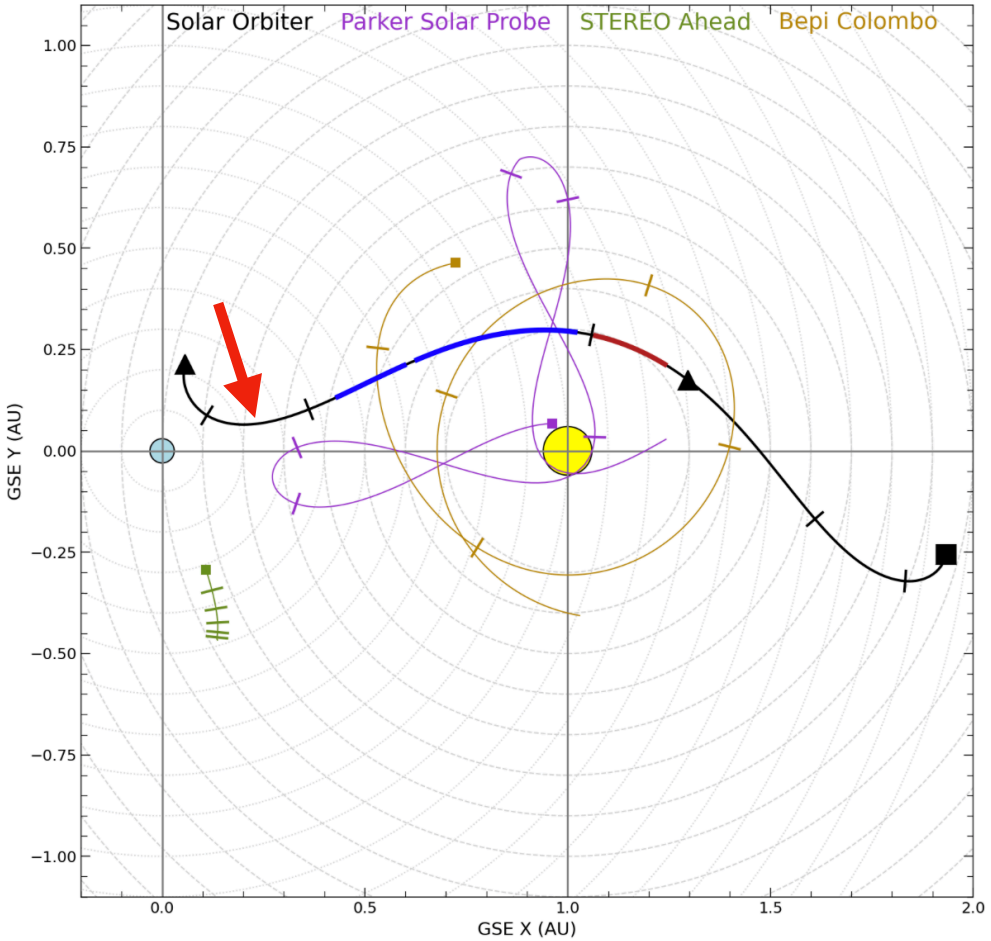
6*0.04+1 MiB = 1.24 MiB per cycle
900 cycles = 1116 MiB = 5600 images

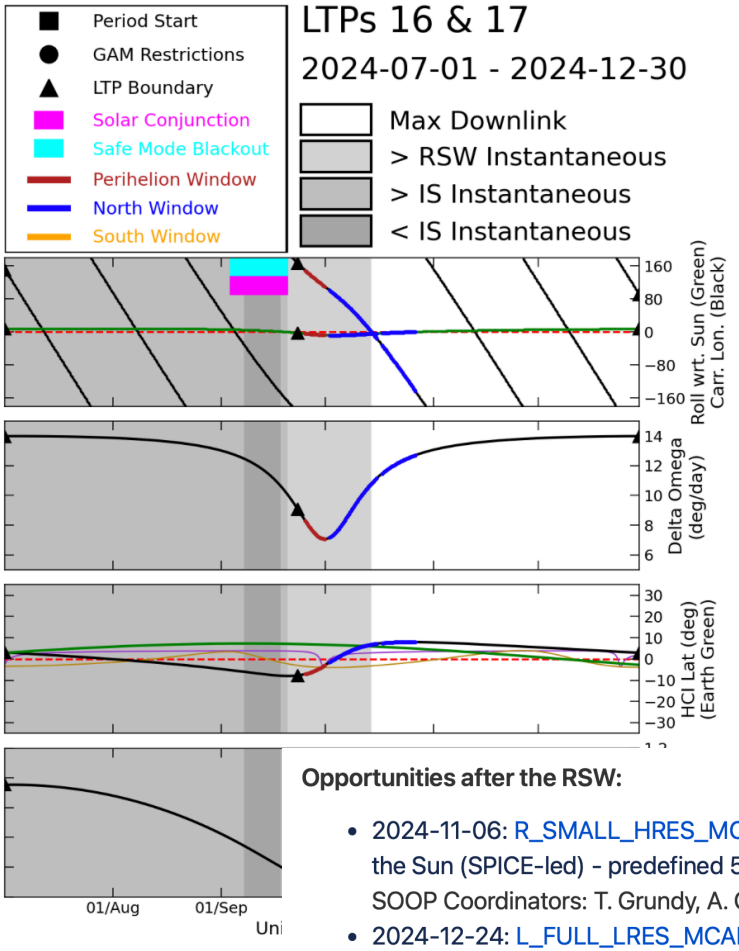


HRIEUV

HRILYA

3*0.04+1 +2*0.25 MiB = 1.62 MiB per cycle
900 cycles = 1458 MiB = 5600 images





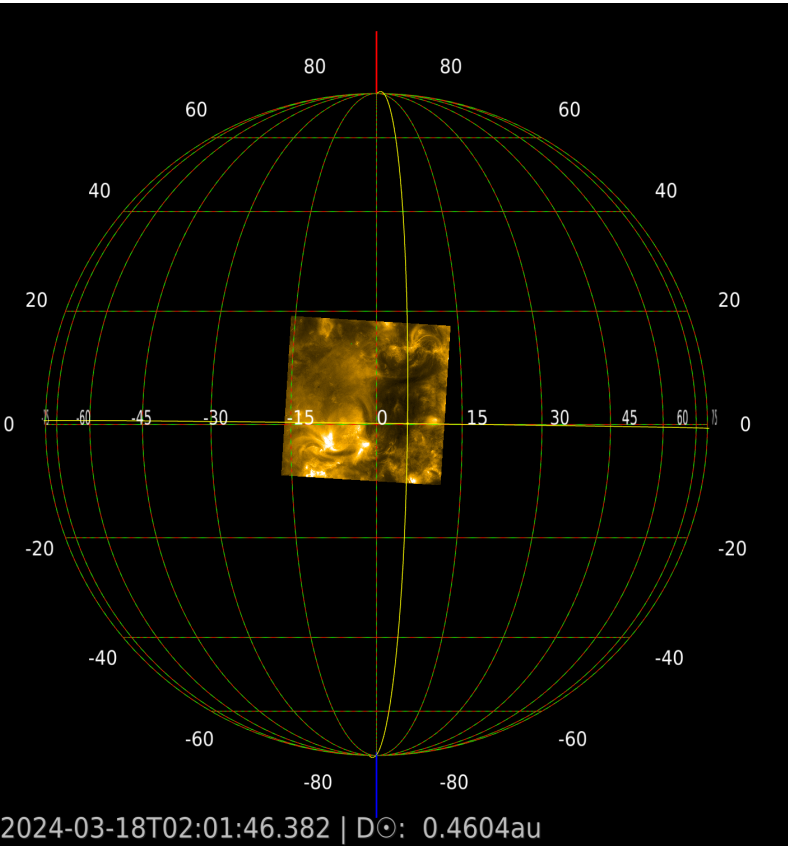
Opportunities after the RSW:

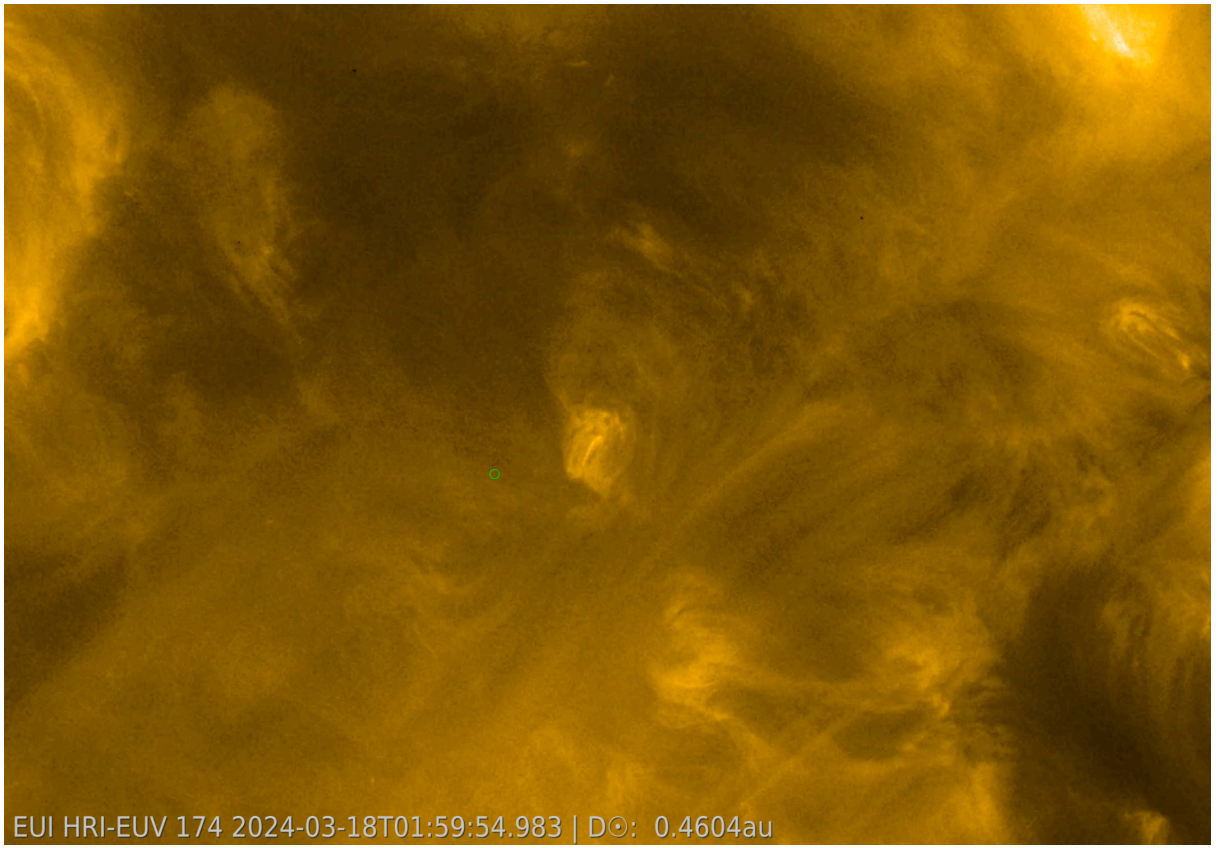
- 2024-11-06: R_SMALL_HRES_MCAD_Full-Disk-Mosaic at 0.7 au from the Sun (SPICE-led) - predefined 5x5 pointing pattern
  SOOP Coordinators: T. Grundy, A. Giunta
- 2024-12-24: L_FULL_LRES_MCAD_Probe-Quadrature PSP Perihelion and Quadrature: off-pointing to the limb and additional roll to catch PSP in Metis' FOV
  SOOP coordinator: D. Telloni, A. Zhukov
- EUI LYA observations when far from the Sun. Not time critical, likely in December

Continuous mode refurbished following software update

March 18: HRIEUV at 2s cadence during 56 min, while taking FSI synoptics.

=> **Continuous mode available for 2024 autumn RSWs**

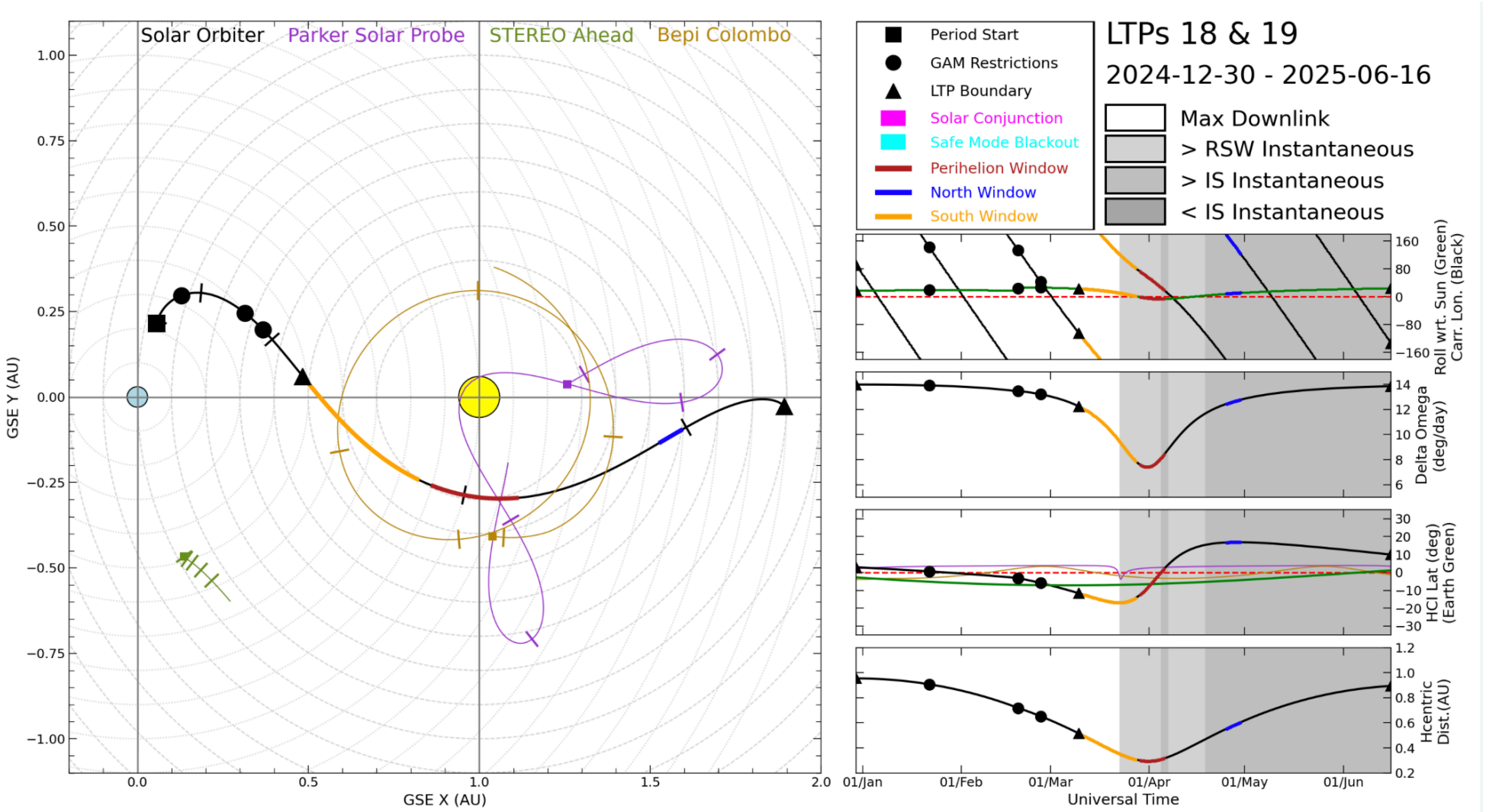


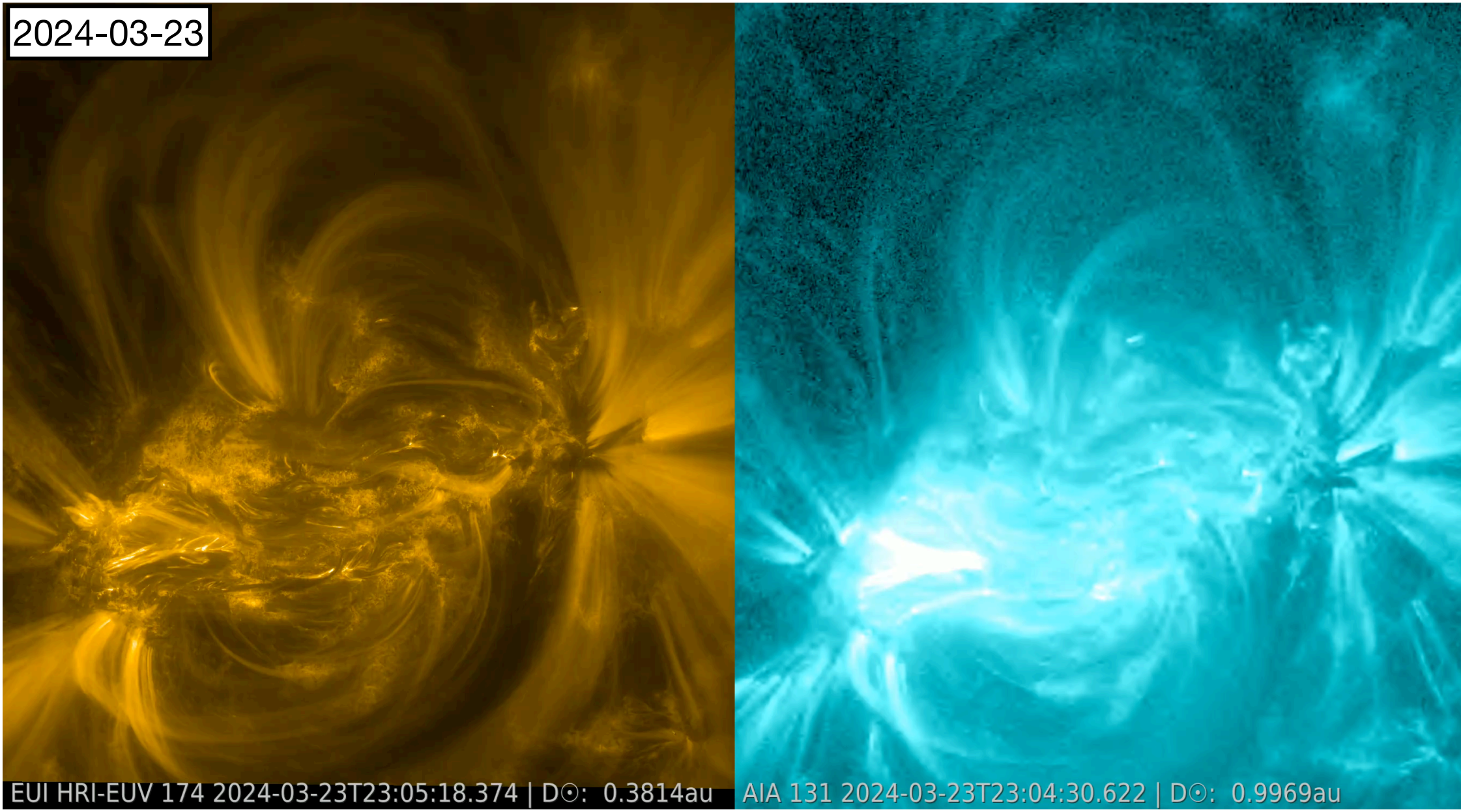


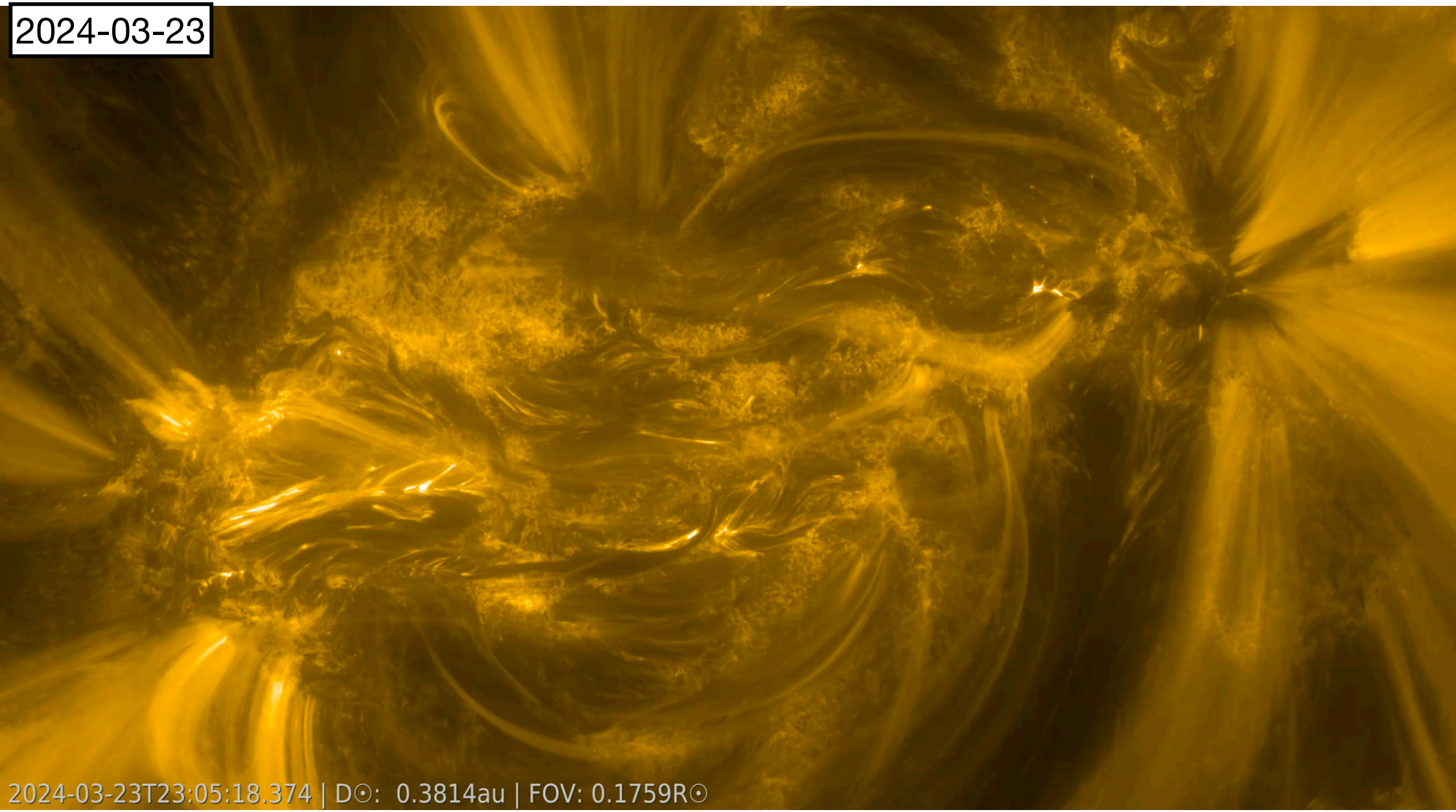
Conclusions

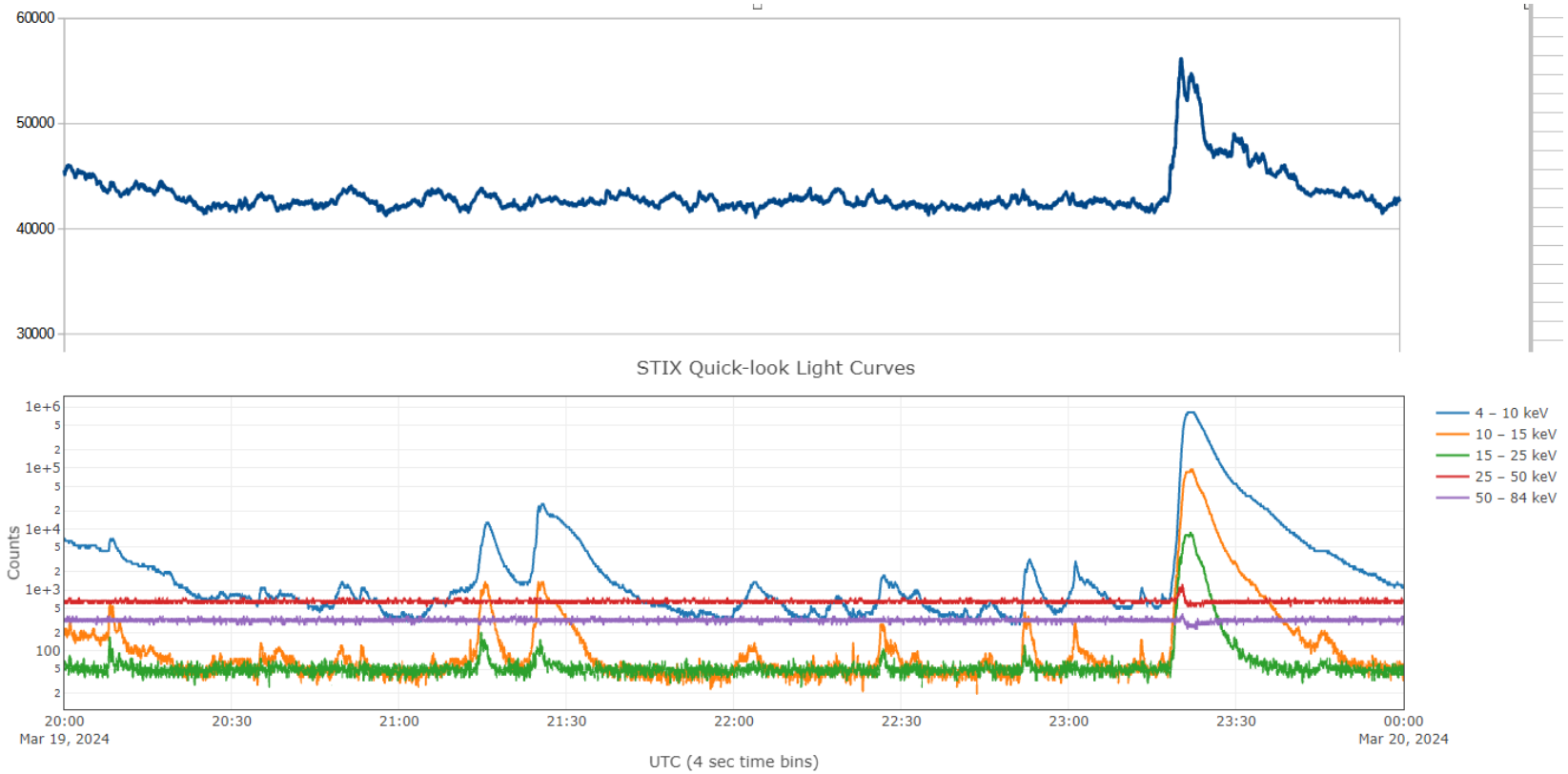
- STIX-EUI Major Flare Watch has had fabulous pointings. Thanks Dan Ryan!
- The 16s cycle of 6 shorts + 1 regular HRIEUV image works great
- With HRIEUV we can observe length/timescales in flare cores that were not observable before.
- Further experiments possible with flare triggers, HRILYA, continuous mode
- If sensor degradation is under control (TBC), we really want to do this again.

reserve slides


Solar Orbiter
Parker Solar Probe
STEREO Ahead
Bepi Colombo
GSE Y (AU)
GSE X (AU)
Period Start
GAM Restrictions
LTP Boundary
Solar Conjunction
Safe Mode Blackout
Perihelion Window
North Window
South Window
LTPs 18 & 19
2024-12-30 - 2025-06-16
Max Downlink
> RSW Instantaneous
> IS Instantaneous
< IS Instantaneous
Roll wrt. Sun (Green)
Carr. Lon. (Black)
Delta Omega
(deg/day)
HCI Lat (deg)
(Earth Green)
Hcentric
Dist.(AU)
01/Jan
01/Feb
01/Mar
01/Apr
01/May
01/Jun
Universal Time


2024-03-23
EUI HRI-EUV 174 2024-03-23T23:05:18.374 | D☉: 0.3814au
AIA 131 2024-03-23T23:04:30.622 | D☉: 0.9969au


2024-03-23
2024-03-23T23:05:18.374 | D☉: 0.3814au | FOV: 0.1759R☉


60000
50000
40000
30000
STIX Quick-look Light Curves
1e+6
1e+5
1e+4
1e+3
100
Counts
4 – 10 keV
10 – 15 keV
15 – 25 keV
25 – 50 keV
50 – 84 keV
20:00
Mar 19, 2024
20:30
21:00
21:30
22:00
22:30
23:00
23:30
00:00
Mar 20, 2024
UTC (4 sec time bins)