

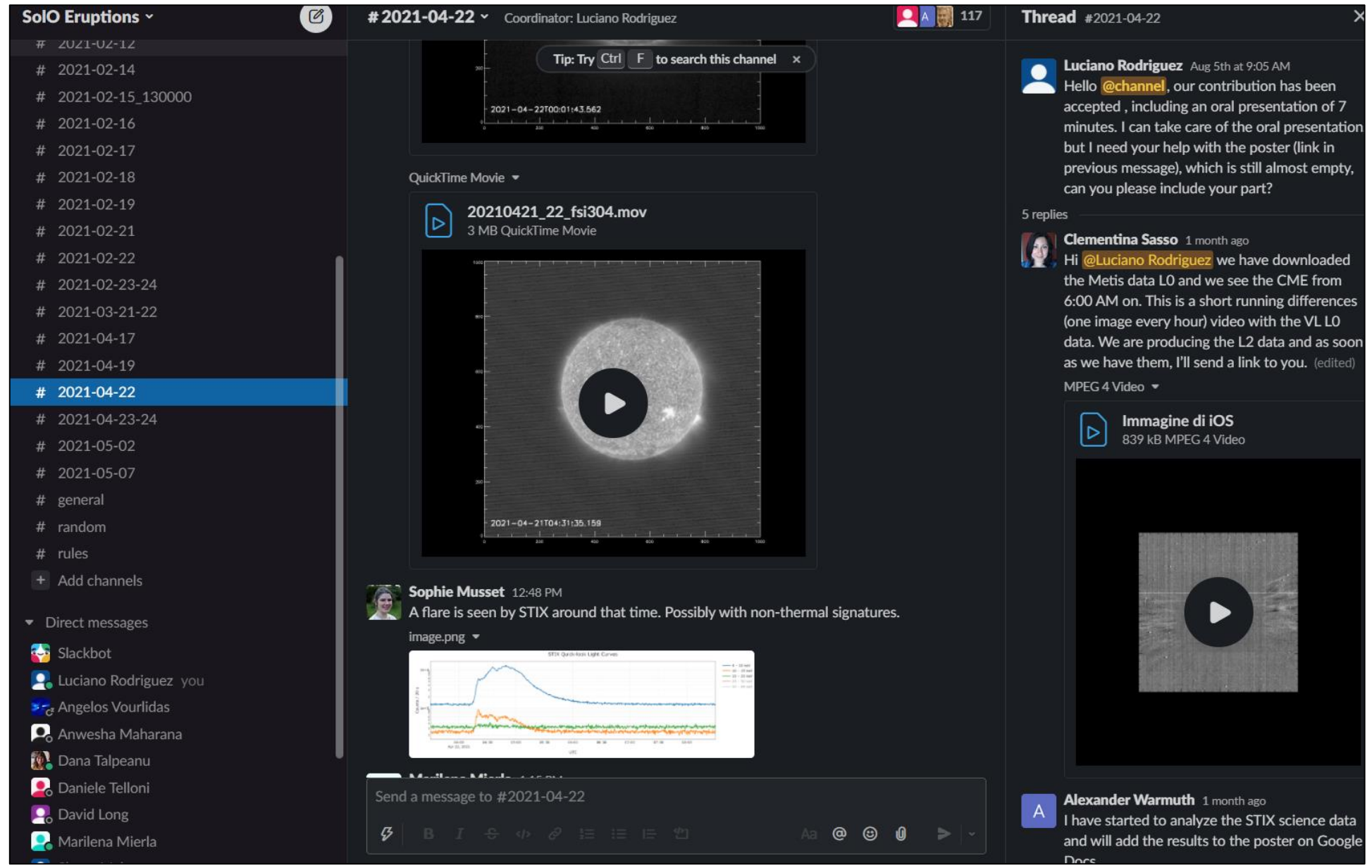
# The eruption of 22 April 2021 as observed by Solar Orbiter, STEREO and Earth bound instruments

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# Ongoing work, started on Slack

- Solar Orbiter Eruptive Events Remote Sensing Science Working Group
- Thanks to the admins: Stephanie Yardley and Kévin Dalmasse.



**Solo Eruptions** #2021-04-22 Coordinator: Luciano Rodriguez

Tip: Try Ctrl F to search this channel

2021-04-22T00:01:43.562

QuickTime Movie

20210421\_22\_fsi304.mov  
3 MB QuickTime Movie

2021-04-22T04:31:35.158

**Sophie Musset** 12:48 PM  
A flare is seen by STIX around that time. Possibly with non-thermal signatures.  
image.png

STIX Quasi-Static Light Curve

Send a message to #2021-04-22

**Thread** #2021-04-22

**Luciano Rodriguez** Aug 5th at 9:05 AM  
Hello @channel, our contribution has been accepted, including an oral presentation of 7 minutes. I can take care of the oral presentation but I need your help with the poster (link in previous message), which is still almost empty, can you please include your part?

5 replies

**Clementina Sasso** 1 month ago  
Hi @Luciano Rodriguez we have downloaded the Metis data L0 and we see the CME from 6:00 AM on. This is a short running differences (one image every hour) video with the VL L0 data. We are producing the L2 data and as soon as we have them, I'll send a link to you. (edited)  
MPEG 4 Video

Immagine di iOS  
839 kB MPEG 4 Video

**Alexander Warmuth** 1 month ago  
I have started to analyze the STIX science data and will add the results to the poster on Google Docs

The Extreme Ultraviolet Imager (EUI) onboard Solar Orbiter (SolO) observed an eruption with its Full Sun Imager (FSI) in both of its channels (17.4/30.4 nm), on 2021-April-22. At the time, the spacecraft was at 0.87 au from the Sun. The eruption was seen at the SW limb, starting at 04:24 UT, with the source slightly backside as seen from SolO (S20W103).

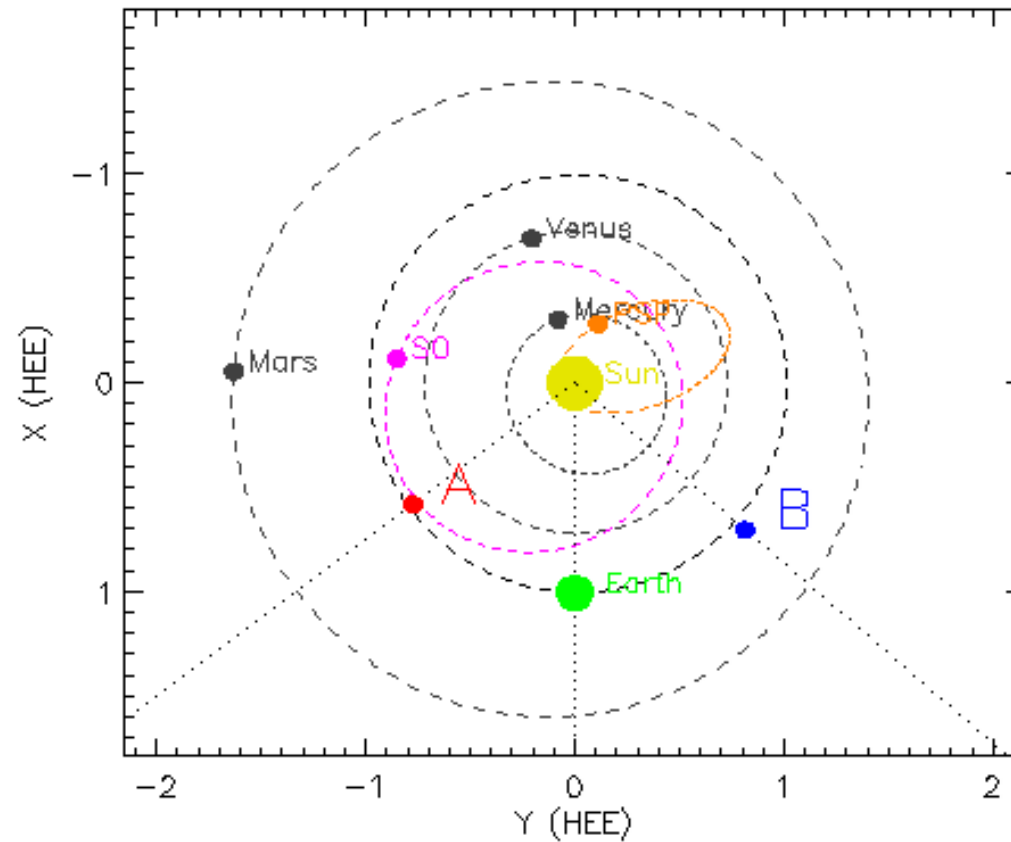
From the Earth's perspective, SDO/AIA and PROBA2/SWAP observed a wave and dimmings starting around 04:07 UT, on-disk at ~S20W05.

STEREO-A/EUVI saw similar signatures of an eruption starting around 04:17 UT, on-disk at ~S20W50. The corresponding CME was visible shortly after in several coronagraphs. SOHO/LASCO-C2 observed a full halo CME starting around 06:00 UT. STEREO-A/COR2 recorded a clear structured CME seen from around 05:23 UT. SolO Metis data will be analysed as it becomes available.

Solo/STIX observed the associated long-duration X-ray flare, which was partially occulted. This allows the characterization of both the thermal plasma and any potential contribution of nonthermal electrons in the tenuous coronal source. The full-Sun radiometer PROBA2/LYRA also observed the event with the two SXR channels.

The corresponding ICME arrived at the Earth on 2021-April-24-25 (probably also at STEREO-A), it was driving a shock and created minor geomagnetic storm conditions. STEREO-A/SEPT and ACE/EPAM observed a weak particle event most likely related to this eruption. We will analyse in depth these CME-ICME connections.

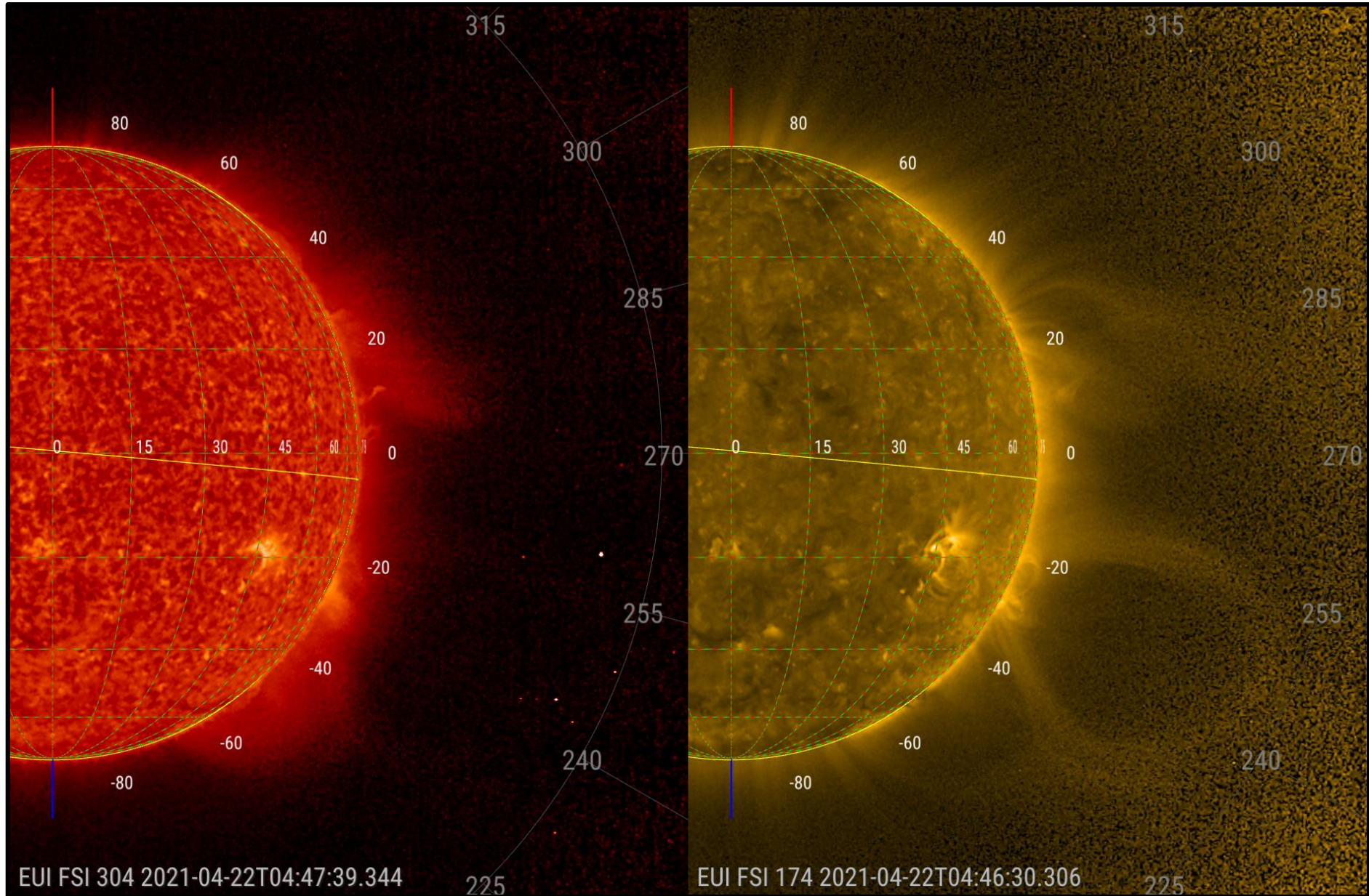
# Spacecraft positions



Date [yyyy-mm-dd]	Sep. angle SOLO - Earth [deg]	Sep. angle SOLO - STA [deg]	lon SOLO HEEQ [deg]	lat SOLO HEEQ [deg]	dist SOLO Sun [AU]
2021-04-22	97.96	45.05	-97.97	0.32	0.86



# The CME in SoLO EUI observations



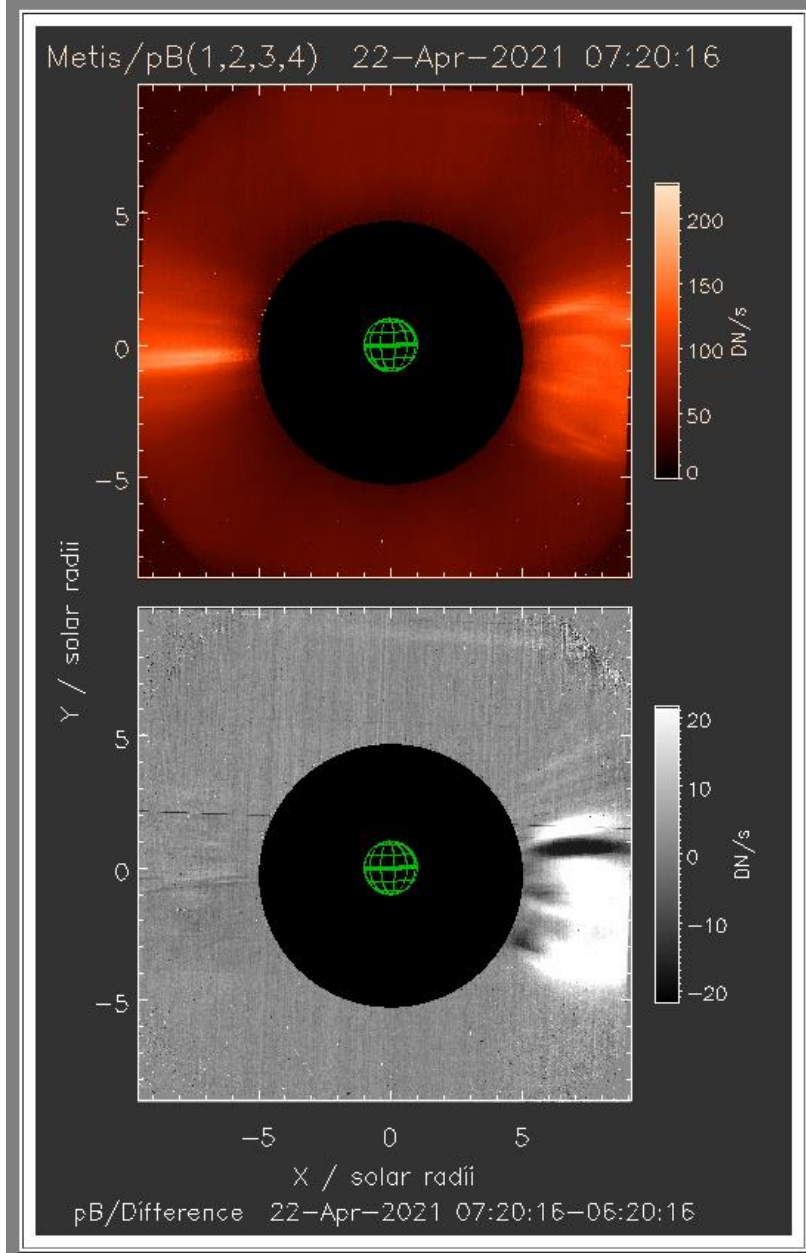


2021-04-22T00:01:30.278

2021-04-22T00:01:30.278

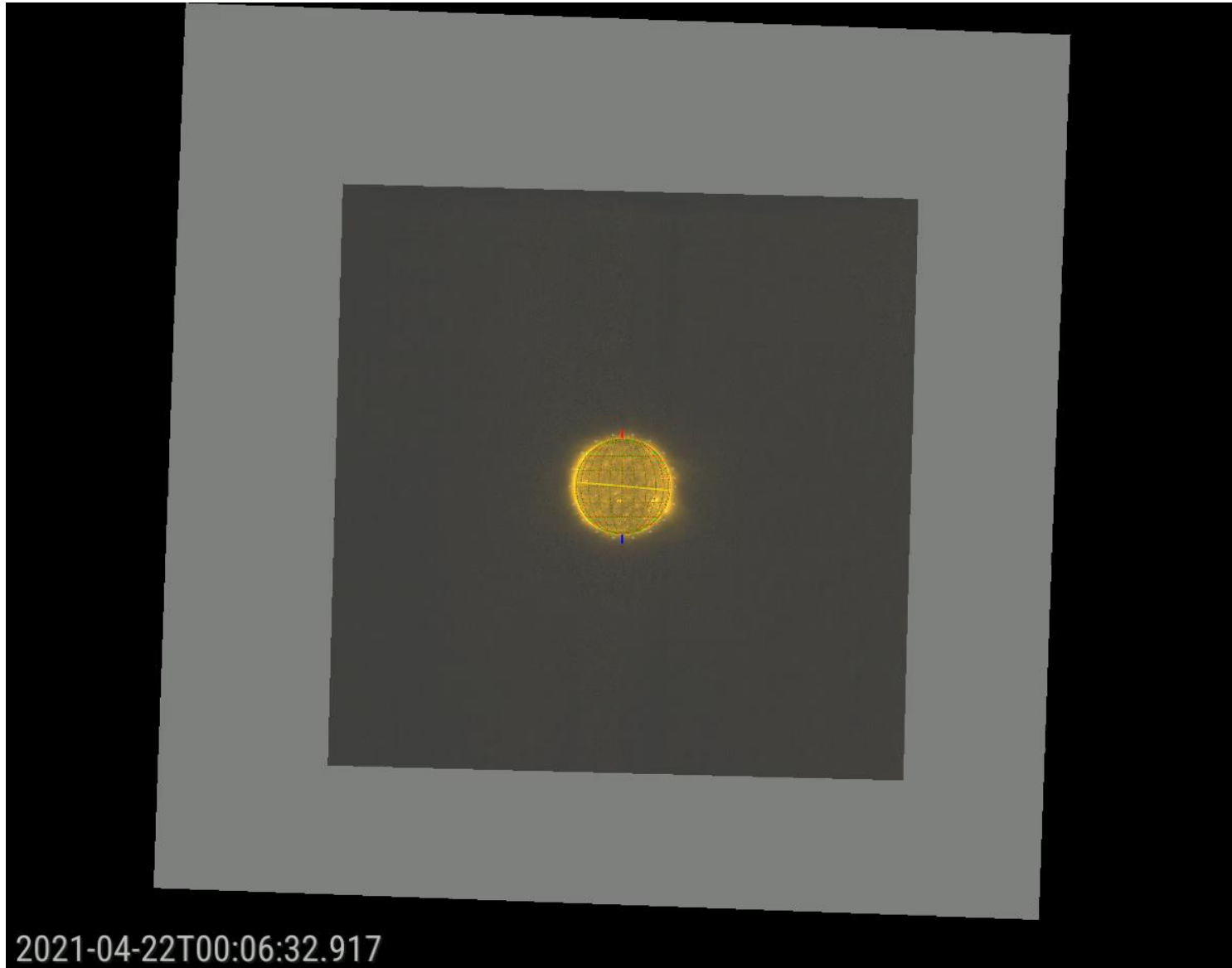
- FSI synoptic program
- ~5 minute cadence





- On April 22, Metis was running a low-frequency synoptic program.
- Cadence of 1 hour
- 4 VL images to form a single pB image

[Movie](#)





ESA JHelioviewer

File View Movie Tools Help

Zoom In Zoom Out Zoom-Fit Actual Size Reset Camera Pan Rotate Axis Track Differential Corona Multiview Projection Annotation SDO Cut-out SAMP

Image Layers

22/128

Options ▾

Play 20 Frames/sec and Loop

Record  One loop  Screenshot  Unlimited

Size On screen

2021-04-22T00:00:00

2021-04-22T12:00:00

New Layer ▾ Sync

<input checked="" type="checkbox"/>		2021-04-22T06:06:32.792	✓ ×
<input checked="" type="checkbox"/>	<b>EUI FSI 174</b>	2021-04-22T06:16:43.23	✓ ×
<input type="checkbox"/>	EUI FSI 304	2021-04-22T10:55:09.385	✓ ×
<input type="checkbox"/>	SWAP 174	2021-04-22T10:50:44.863	×
<input type="checkbox"/>	STEREO-A COR2	2021-04-22T06:23:30.008	×
<input type="checkbox"/>	Viewpoint	2021-04-22T06:16:43.23	
<input type="checkbox"/>	Grid		
<input type="checkbox"/>	FOV		

Difference  None  Running  Base

Opacity 100%

Blend 53%

Slit 0%

Sharpen 100%

Levels 6%

Color SDO-AIA 171 Å

Channels  Red  Green  Blue

Timeline Layers

New Layer Custom interval

Callisto Radiogram

SWEK Events

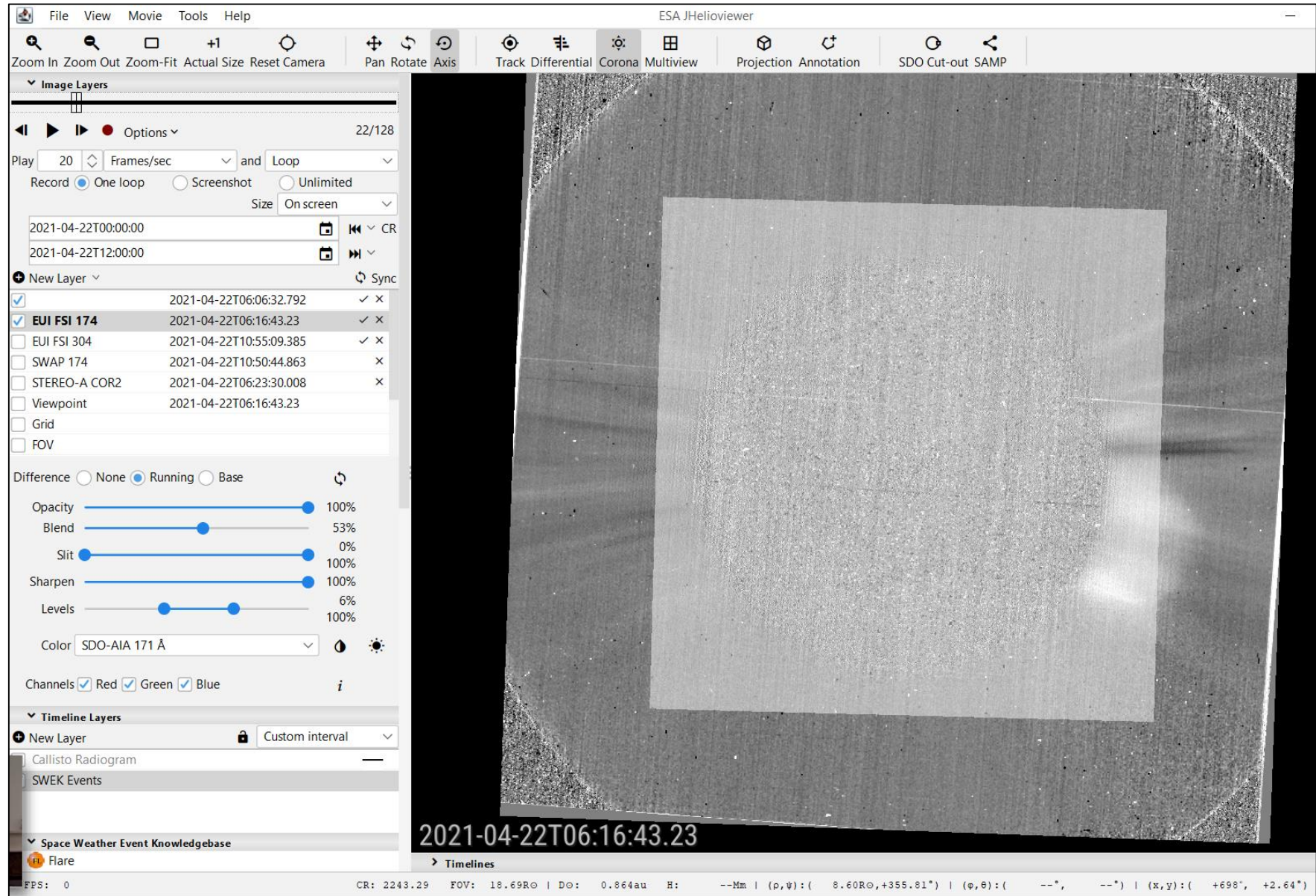
Space Weather Event Knowledgebase

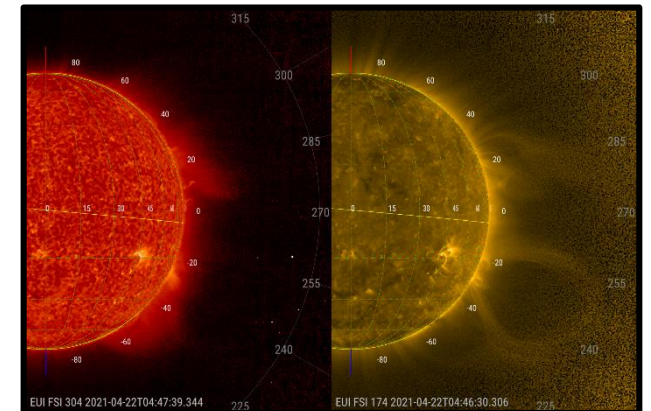
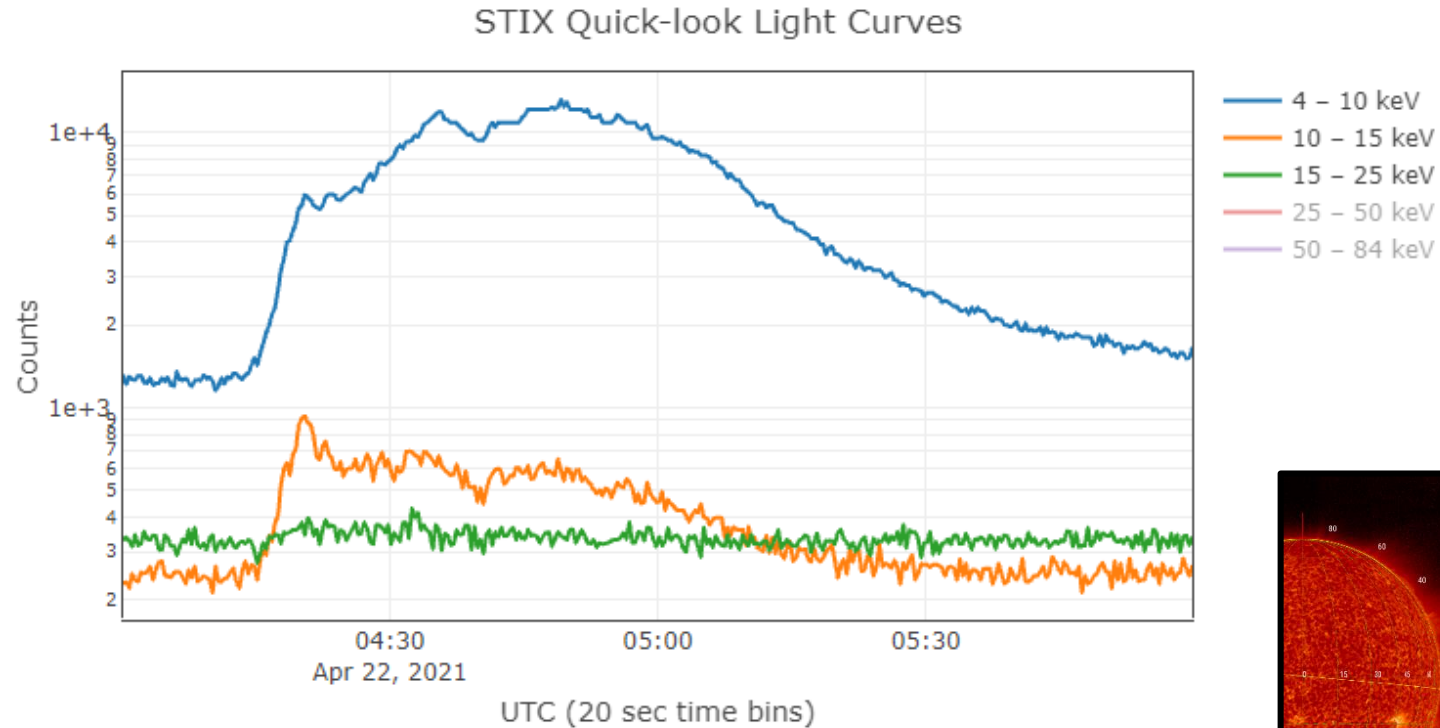
Flare

2021-04-22T06:16:43.23

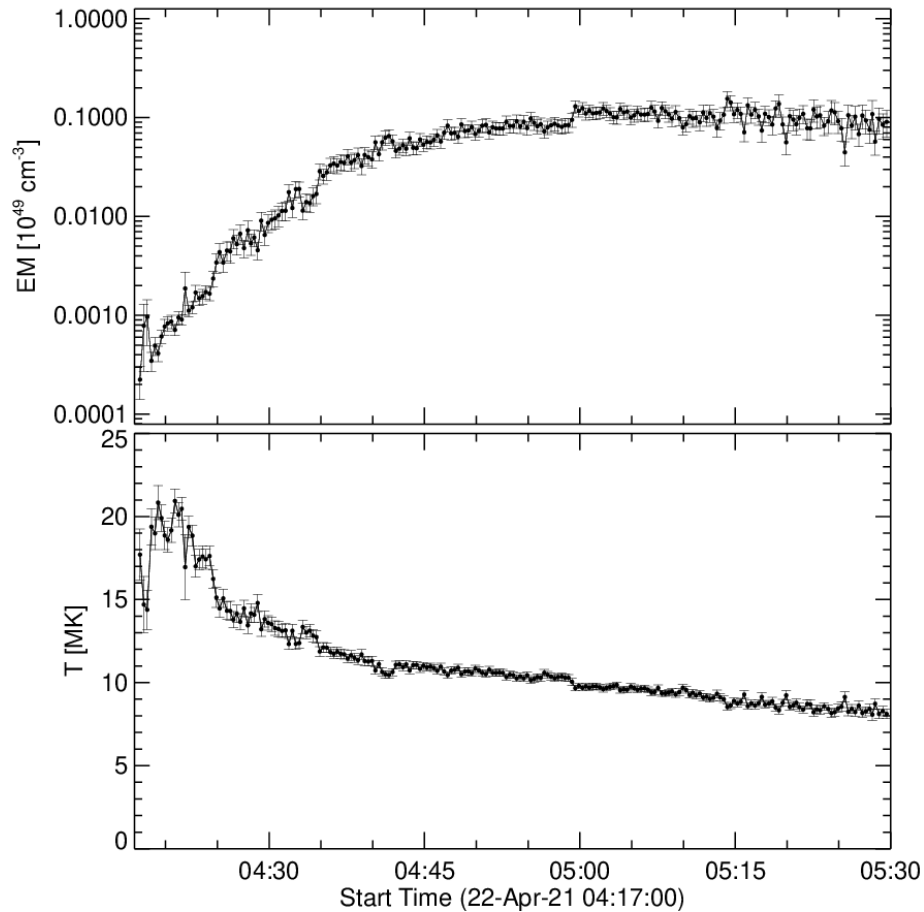
Timelines

FPS: 0 CR: 2243.29 FOV: 18.69R° | DO: 0.864au H: --Mm | (p,ψ):( 8.60R°,+355.81°) | (φ,θ):( --°, --°) | (x,y):( +698°, +2.64°)





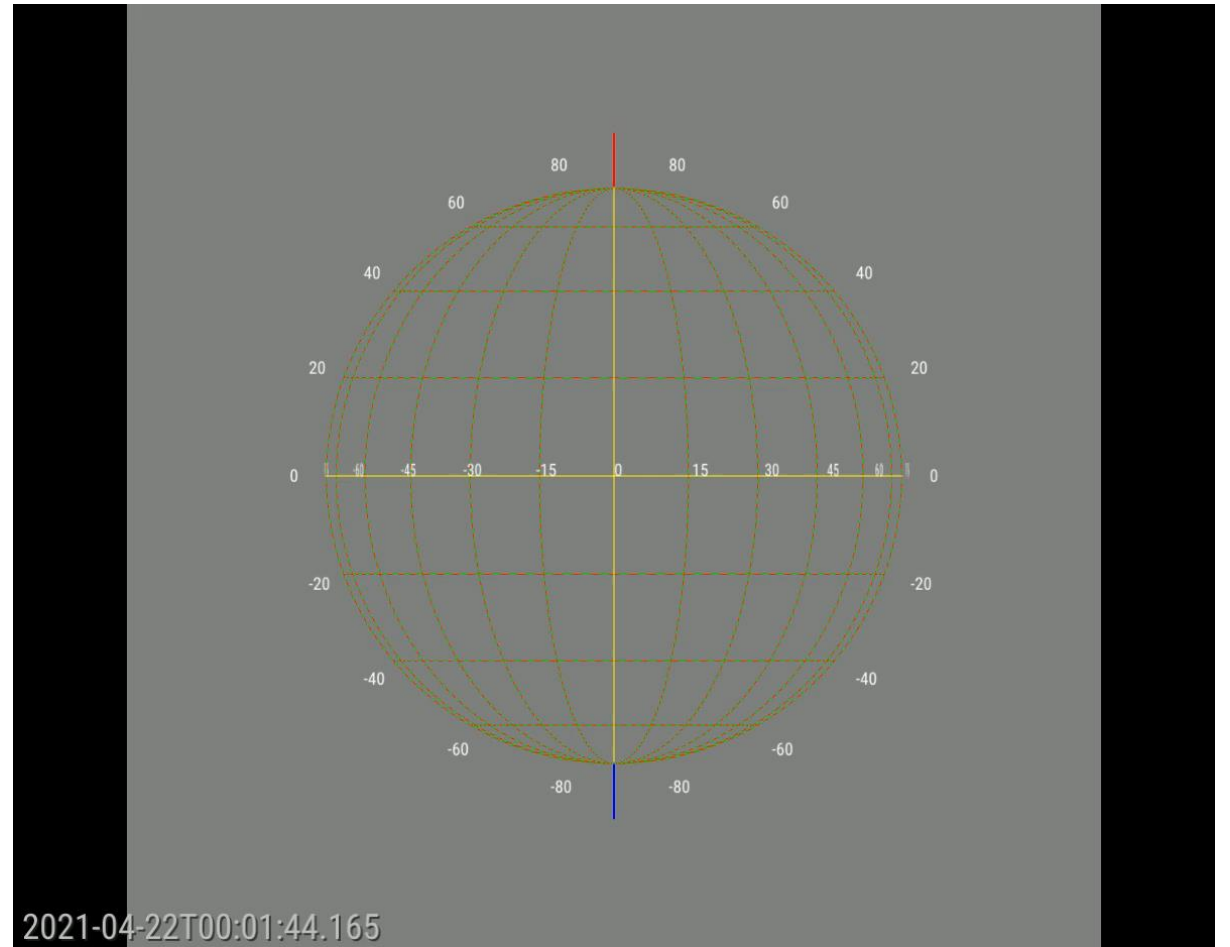
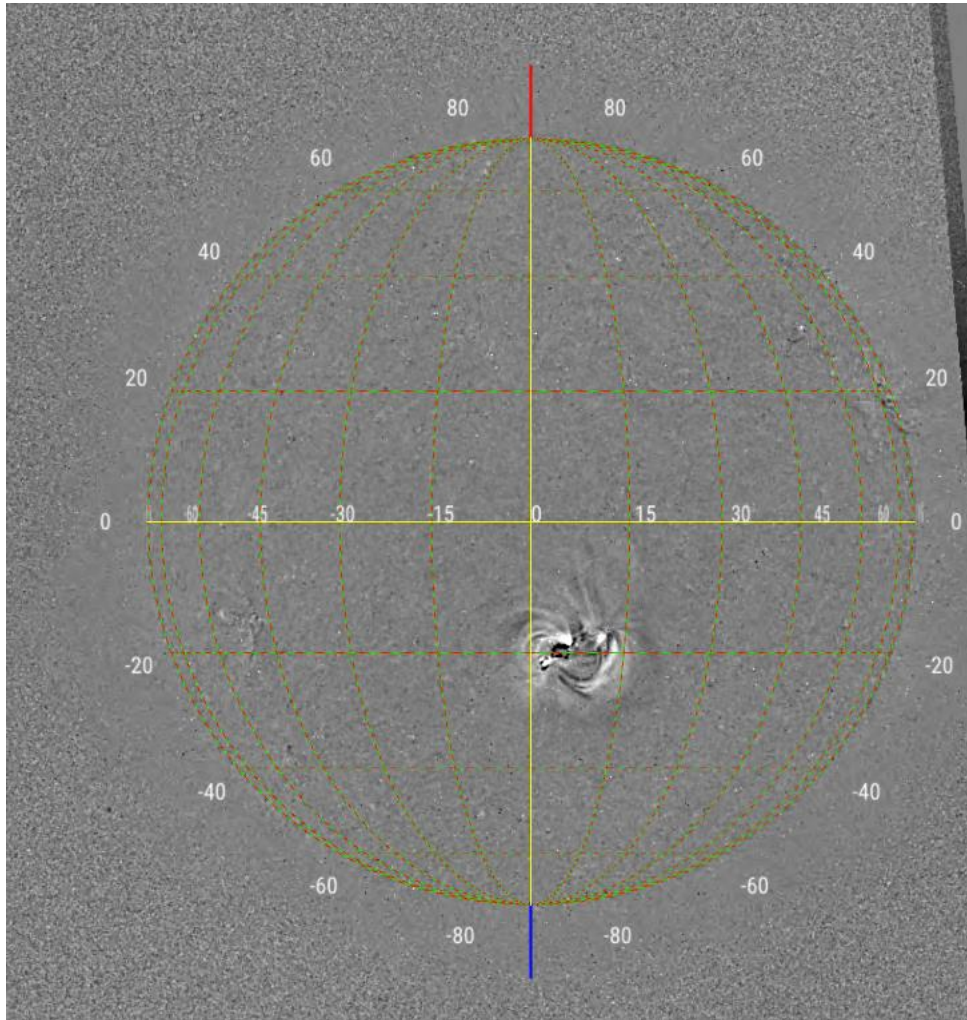
- STIX X-ray light curves of the associated flare (GOES class C3.8)
- Long-duration event with an extended decay phase.
- No pronounced emission above 20 keV, indicative of a weak nonthermal component.
- The flare is partially occulted: chromospheric footpoints which usually dominate the emission are behind the solar limb.



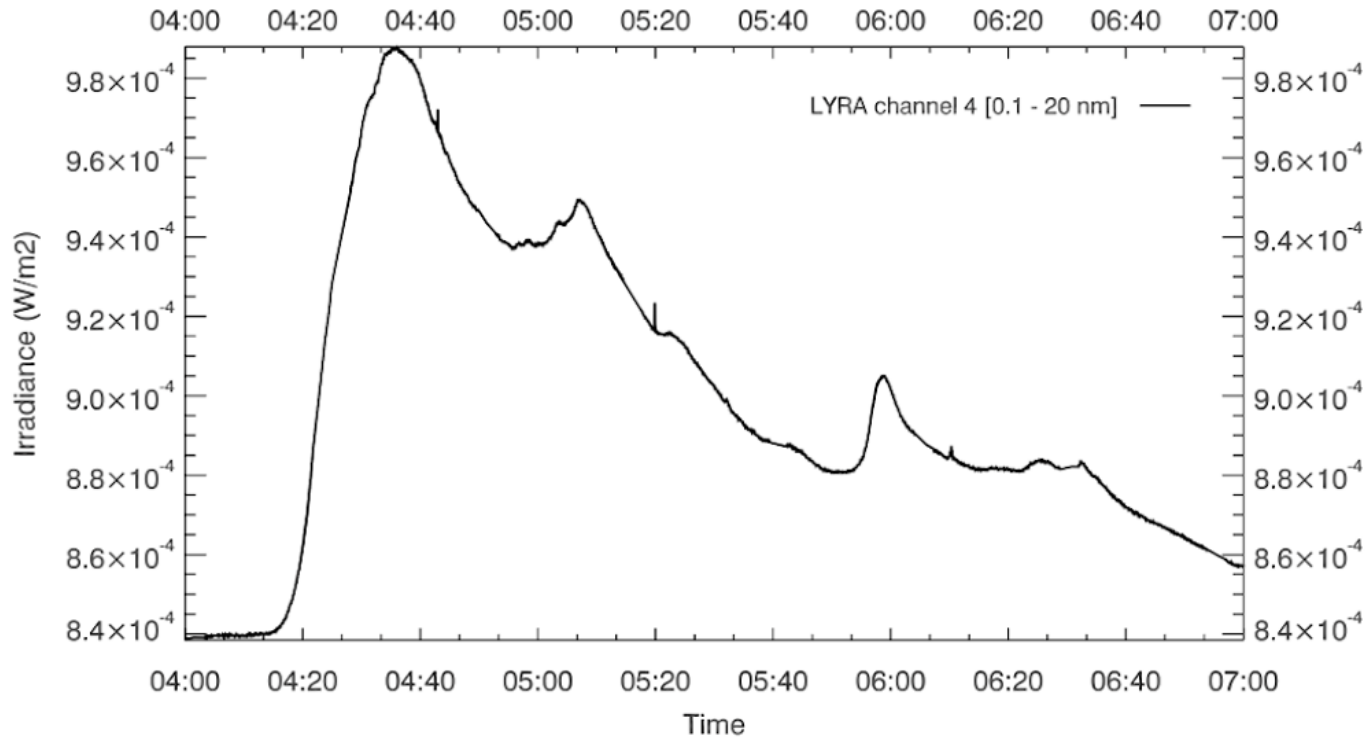
- Evolution of emission measure and temperature of the hot plasma (from X-ray spectra).
- The impulsive phase shows rapid heating to 20 MK, followed by gradual cooling. Peak thermal energy of  $2.4 \pm 0.3 \times 10^{29}$  erg.



# PROBA2-SWAP

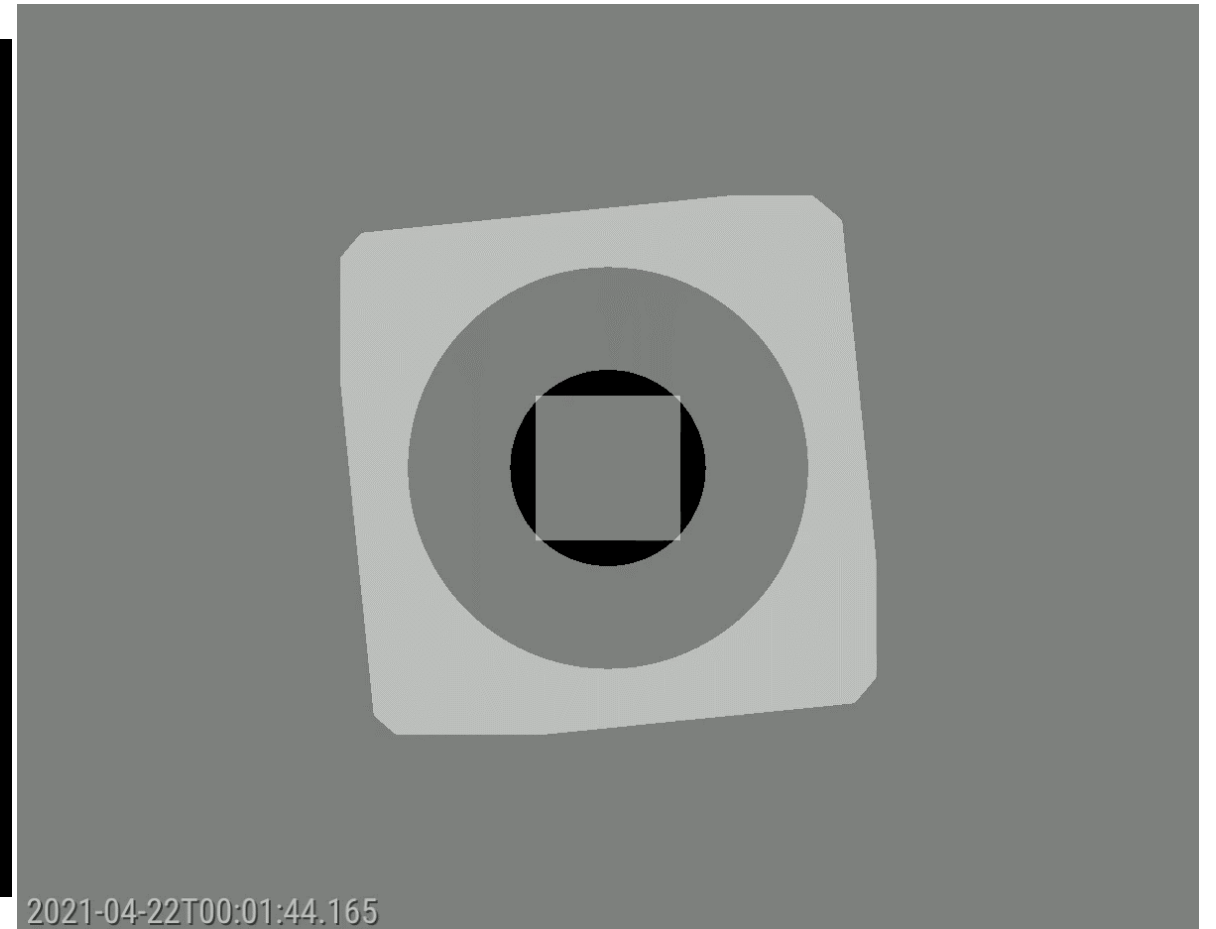
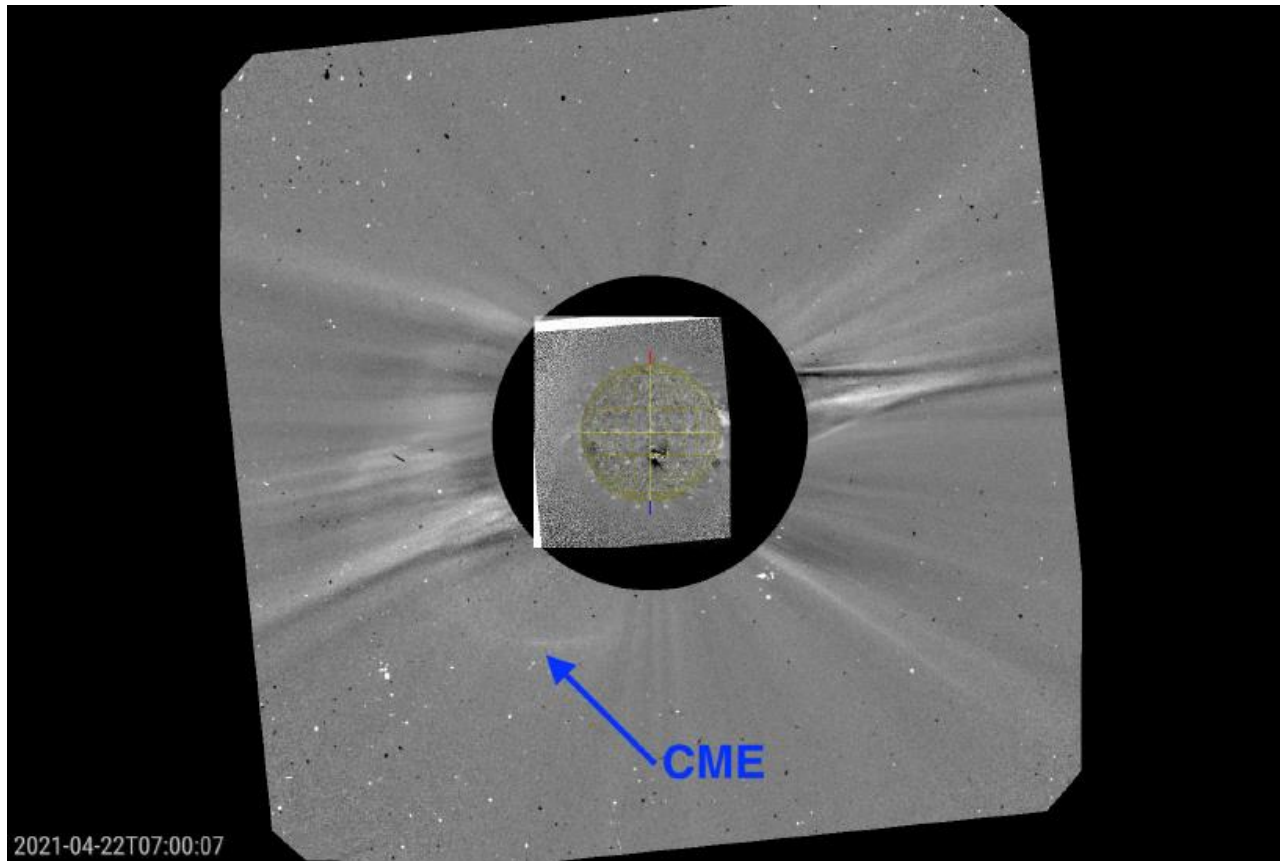






- The C3.8 flare associated to the CME, as seen by PROBA2/LYRA channel 4 (0.1-20 nm).
- The active region was close to the Sun-center. No occultation here, contrarily to Solar Orbiter.
- Long duration event, associated multiple episodes of plasma heating, following a brief main impulsive phase.
- Not all of these secondary heating episodes were produced by the same active regions. Another active region located close to the west limb was, produced the two peaks after 06:00 AM.

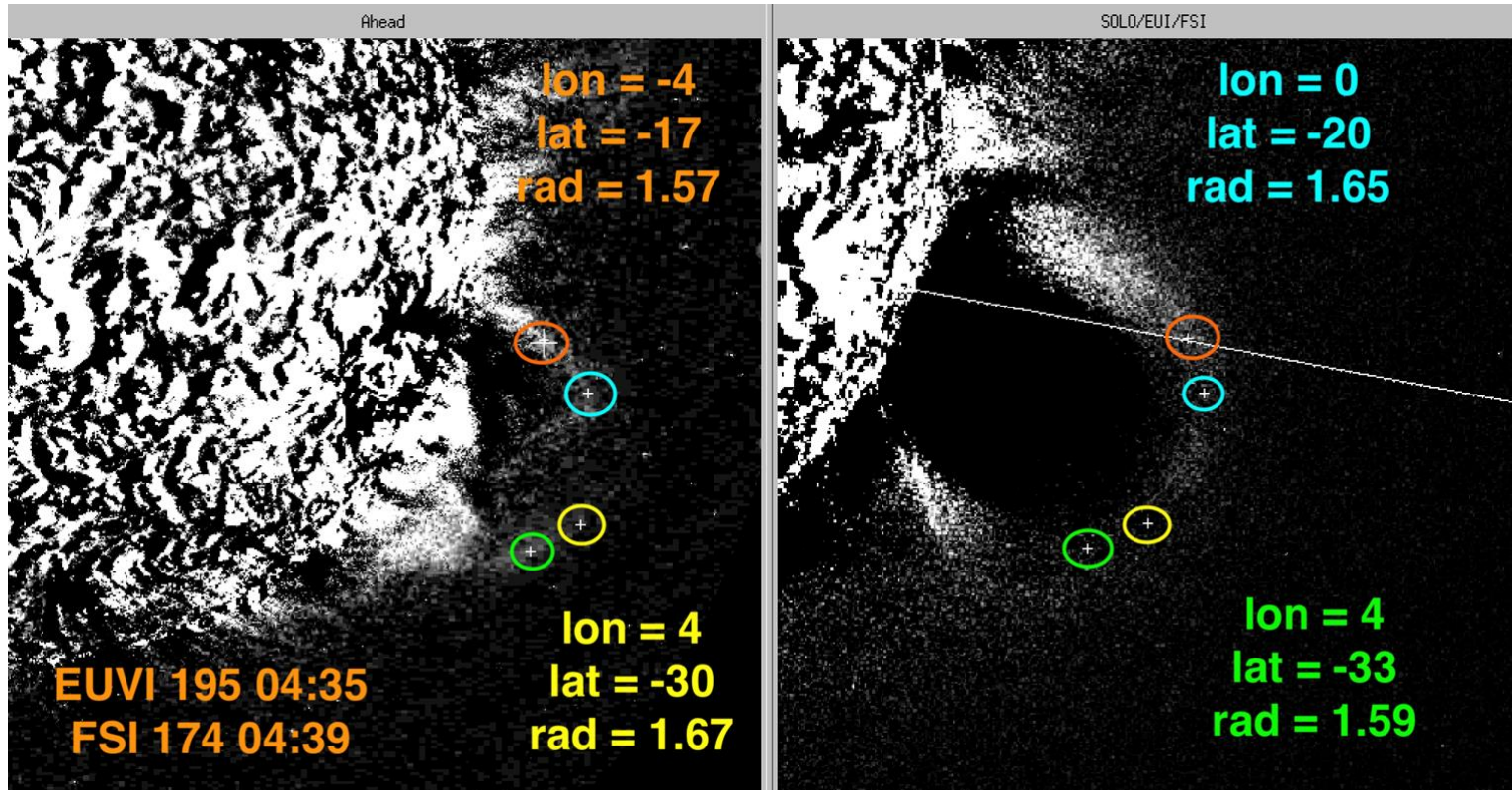
- Weak partial halo
- $V = \sim 350$  km/s







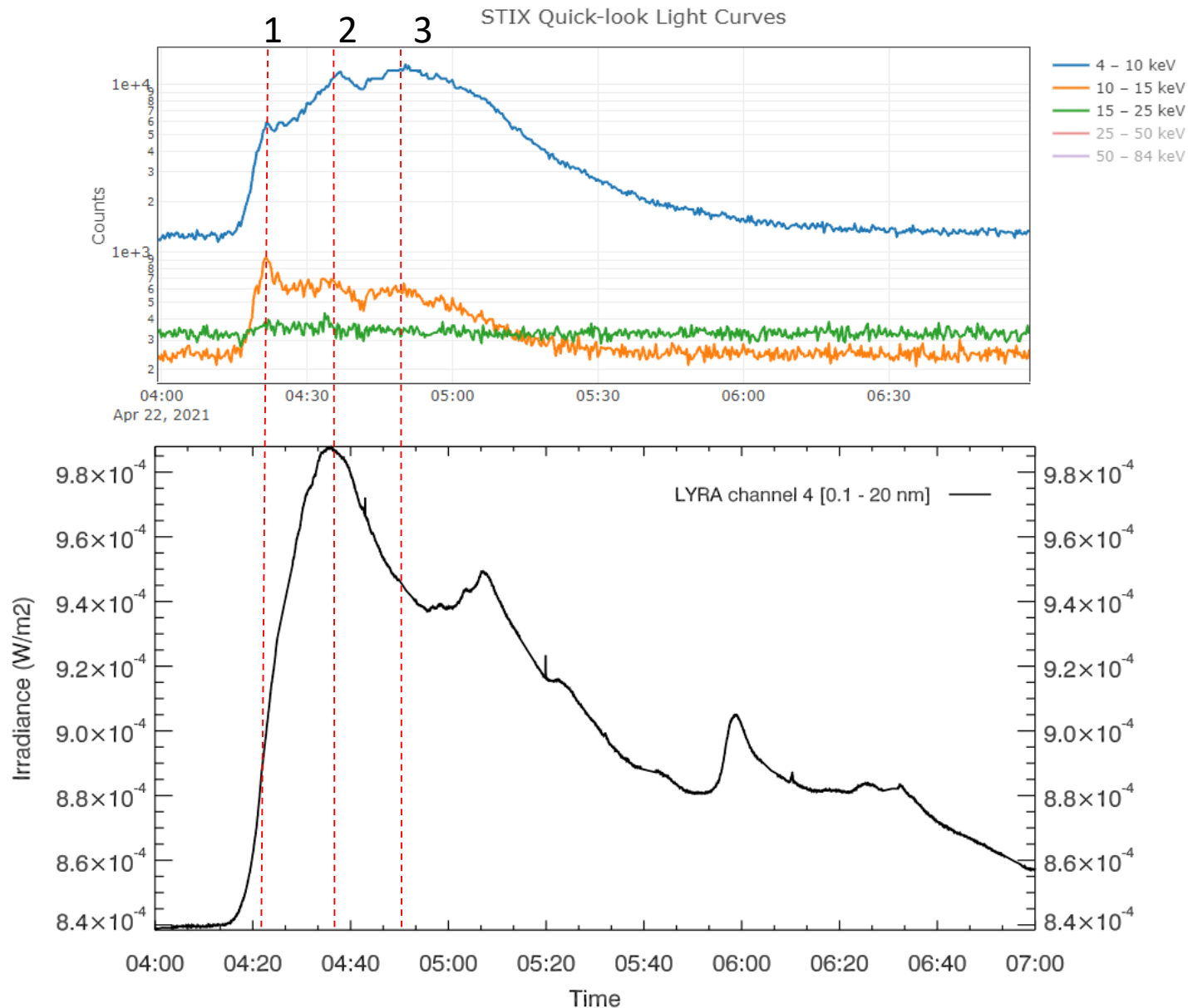
# Triangulation, FSI174 + EUVI-A 195



- Longitudinal values of the triangulation are consistent with an event occurring close to disk center as seen from the Earth, and at the limb as seen from SoLO
- Coronagraph triangulation was not accurate



# Comparison *Solo* STIX – *PROBA2* Lyra



Each peak in the STIX thermal X-ray emission reflects a heating event.

Correlation with UV emission:

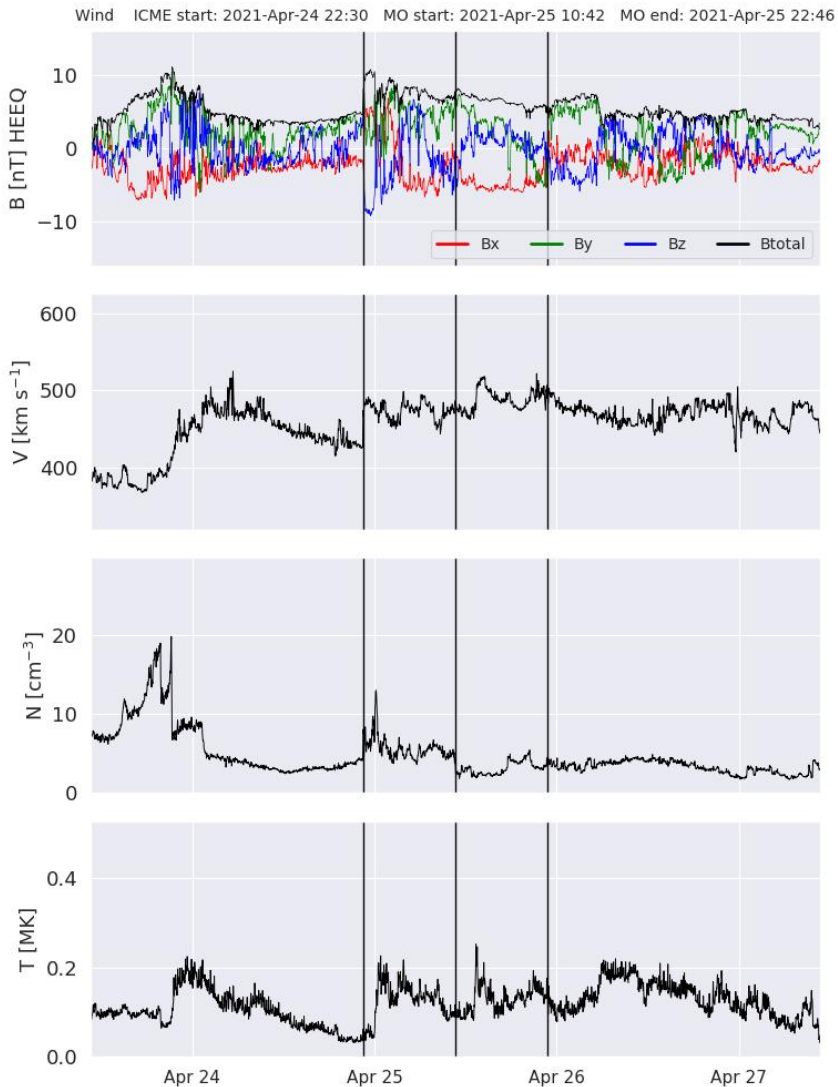
1. in steeply rising phase of UV
2. around peak of UV
3. after peak of UV (small bump)

Later UV peaks are not seen in X-rays – from different locations fully occulted for STIX

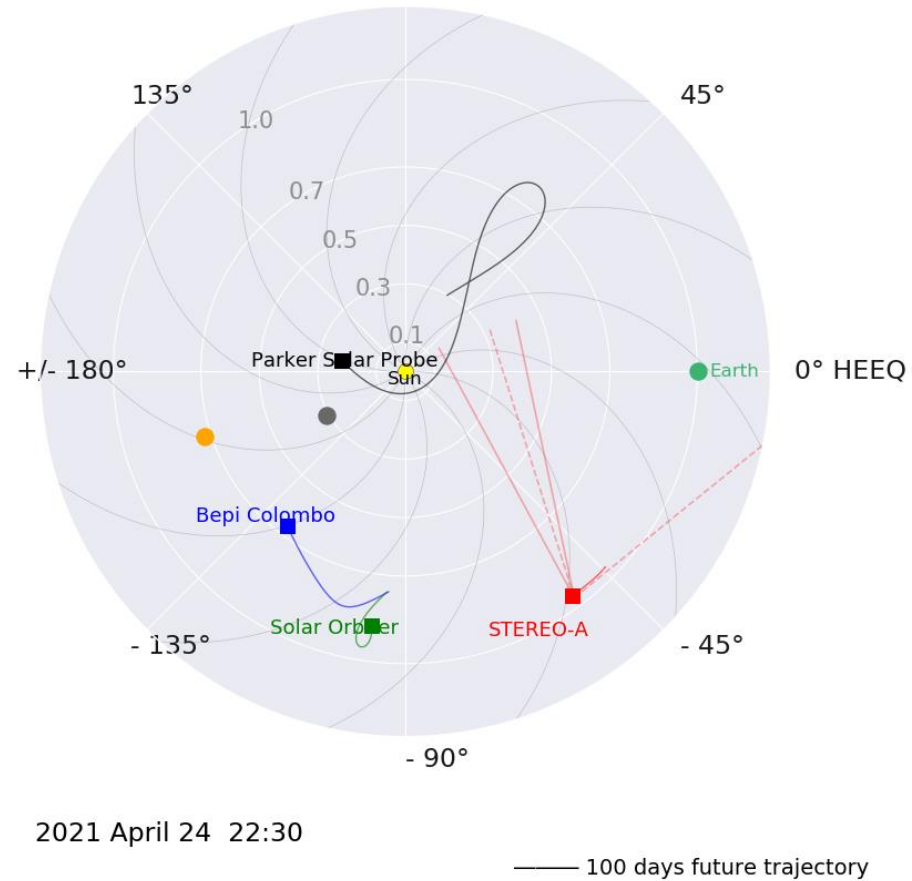
Main peak (2):

X-rays are delayed by ~100 s with respect to UV – typical timescale for chromospheric evaporation

# ICME in situ



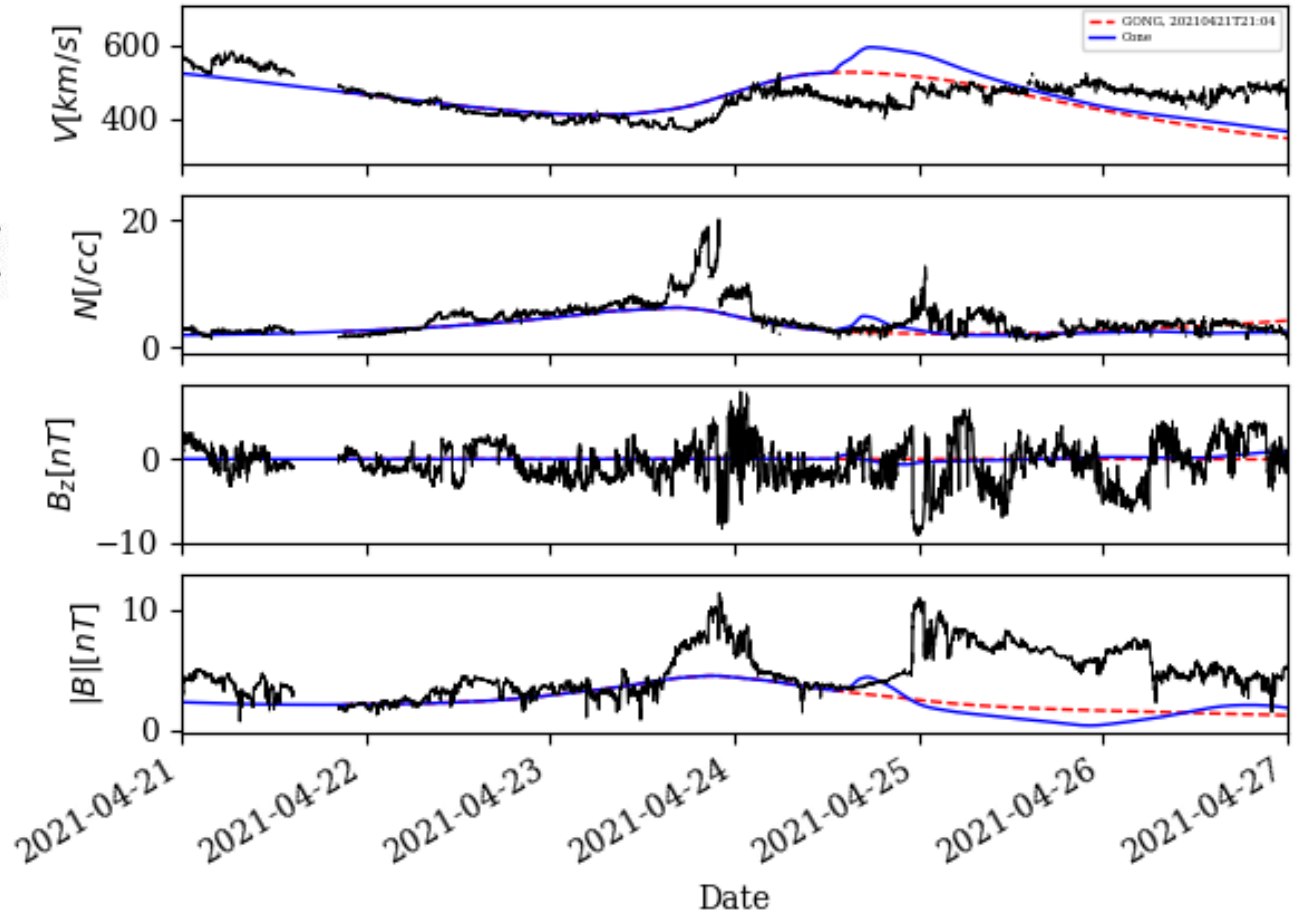
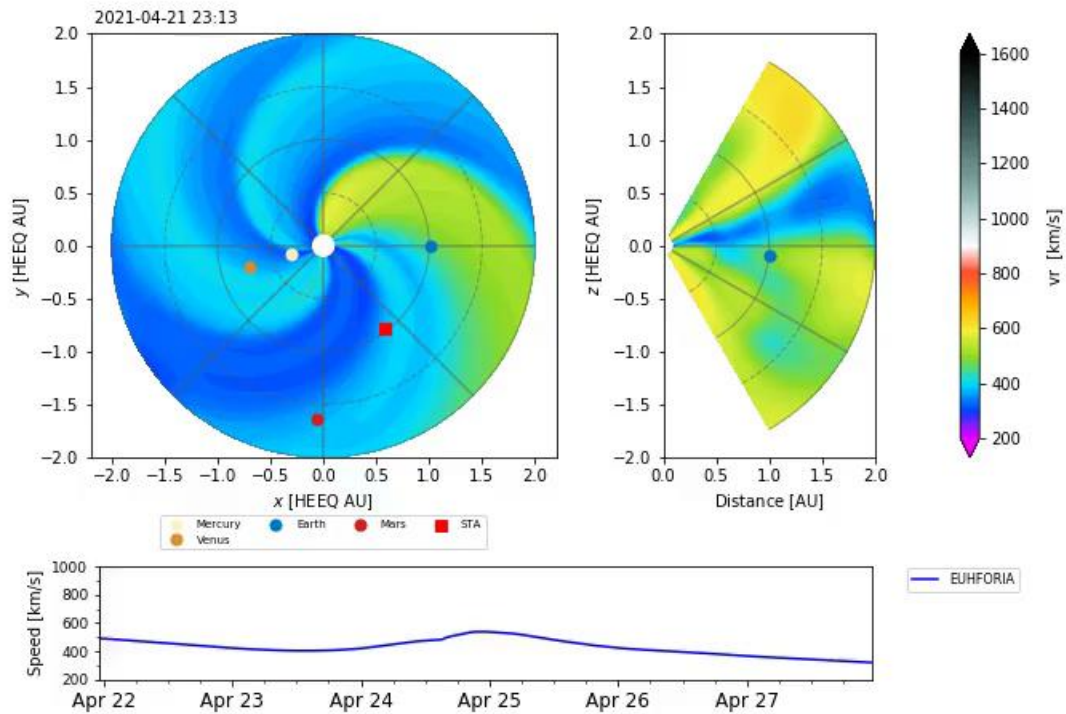
	R	lon	lat		R	lon	lat	
Earth:	1.01	0.0	-4.8		PSP:	0.22	170.3	2.9
Mars:	1.64	-93.7	-3.4		Bepi:	0.67	-127.4	-0.8
STA:	0.97	-53.2	-7.3	90°	Solo:	0.88	-97.5	-0.3



Data source: Wind (MFI, SWE, NASA/Goddard)

C. Möstl / Helio4Cast

# ICME in situ - EUHFORIA



- CME from 22 April 2021, seen by SolO, SOHO, STEREO-A, PROBA2
- The flare was observed as a partially occulted event by STIX and fully visible by Lyra
- Triangulation between EUVI and EUI could be done, but not for the coronagraphs
- The ICME arrived to the Earth late on 24 April
- The ICME can be simulated with EUHFORIA relatively well



# EXTRA

