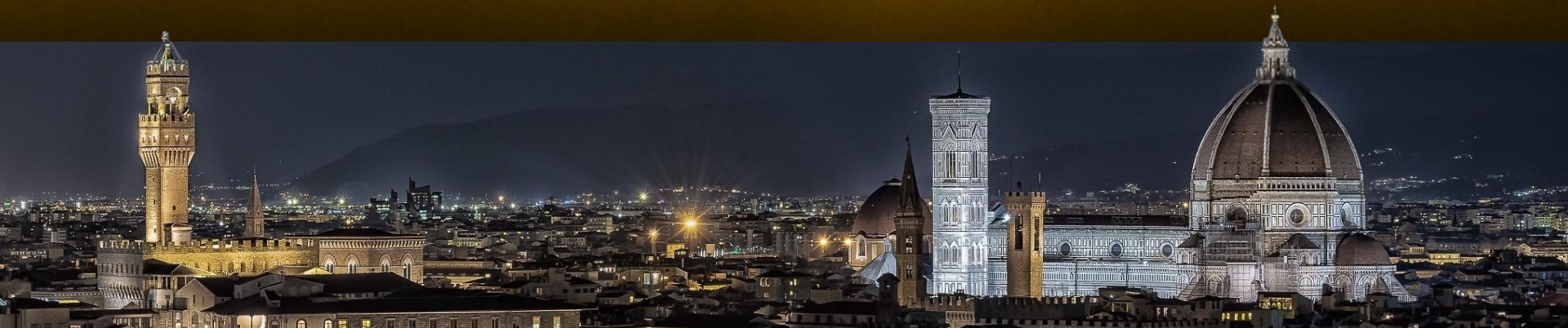
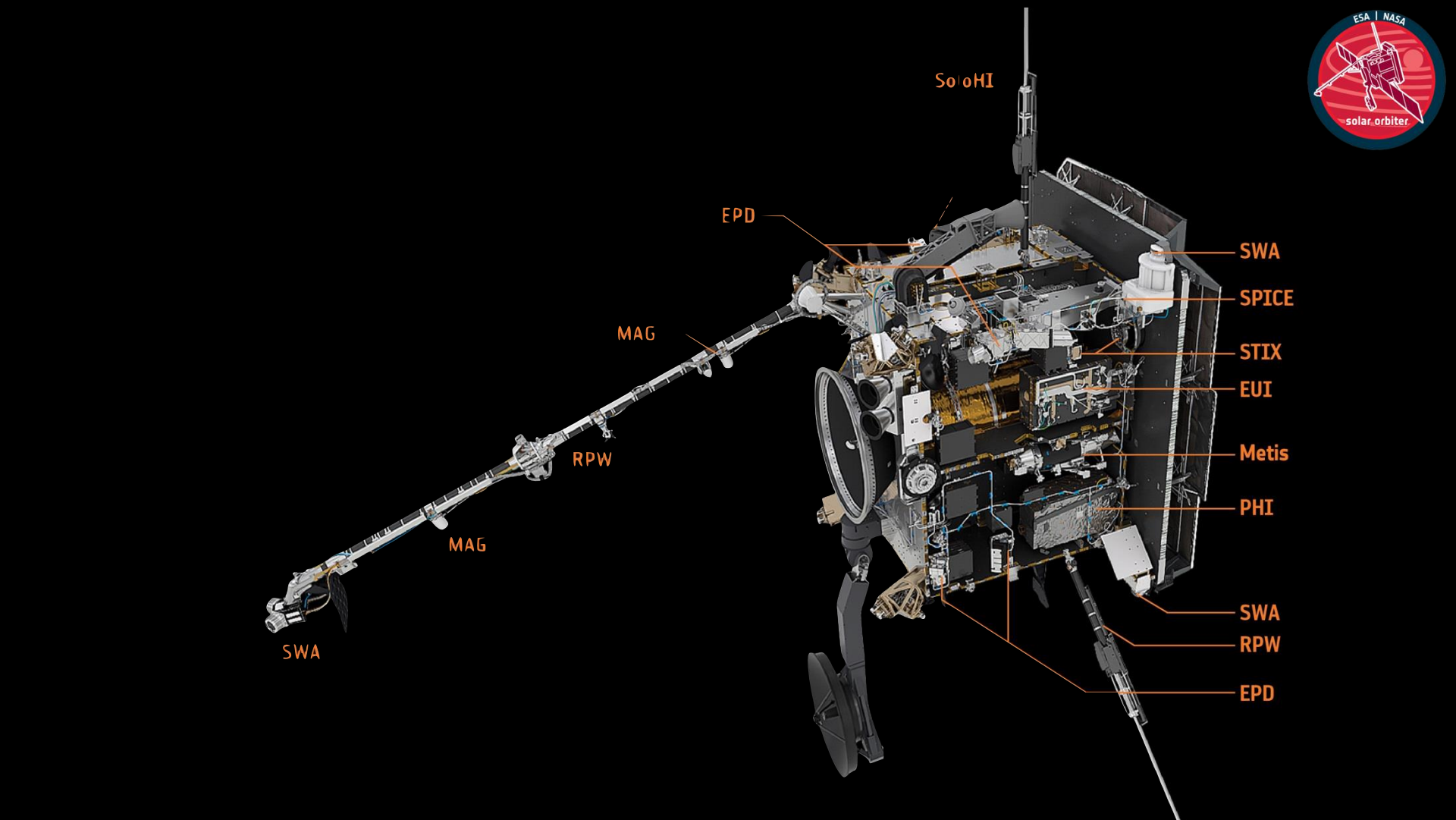
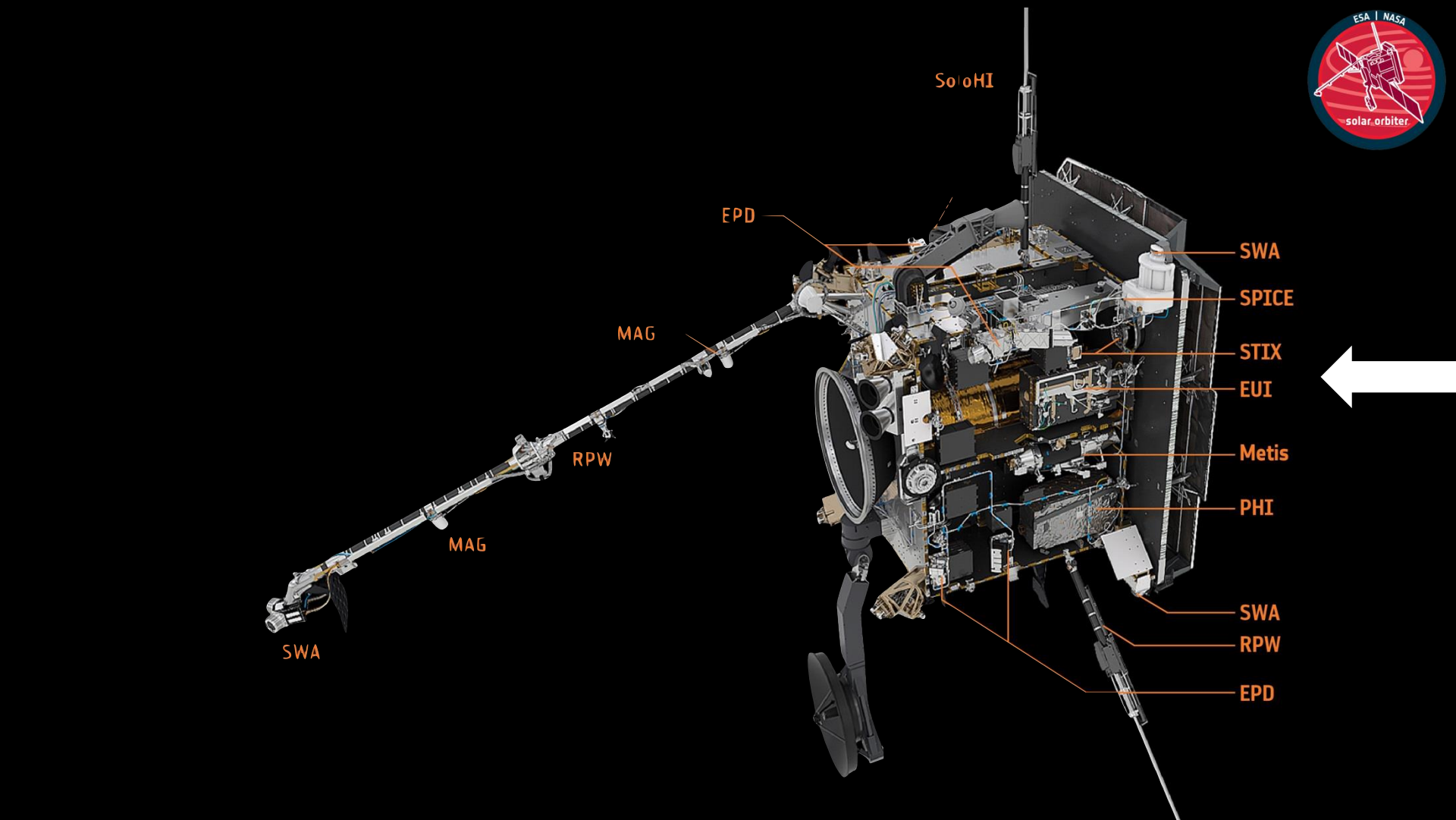
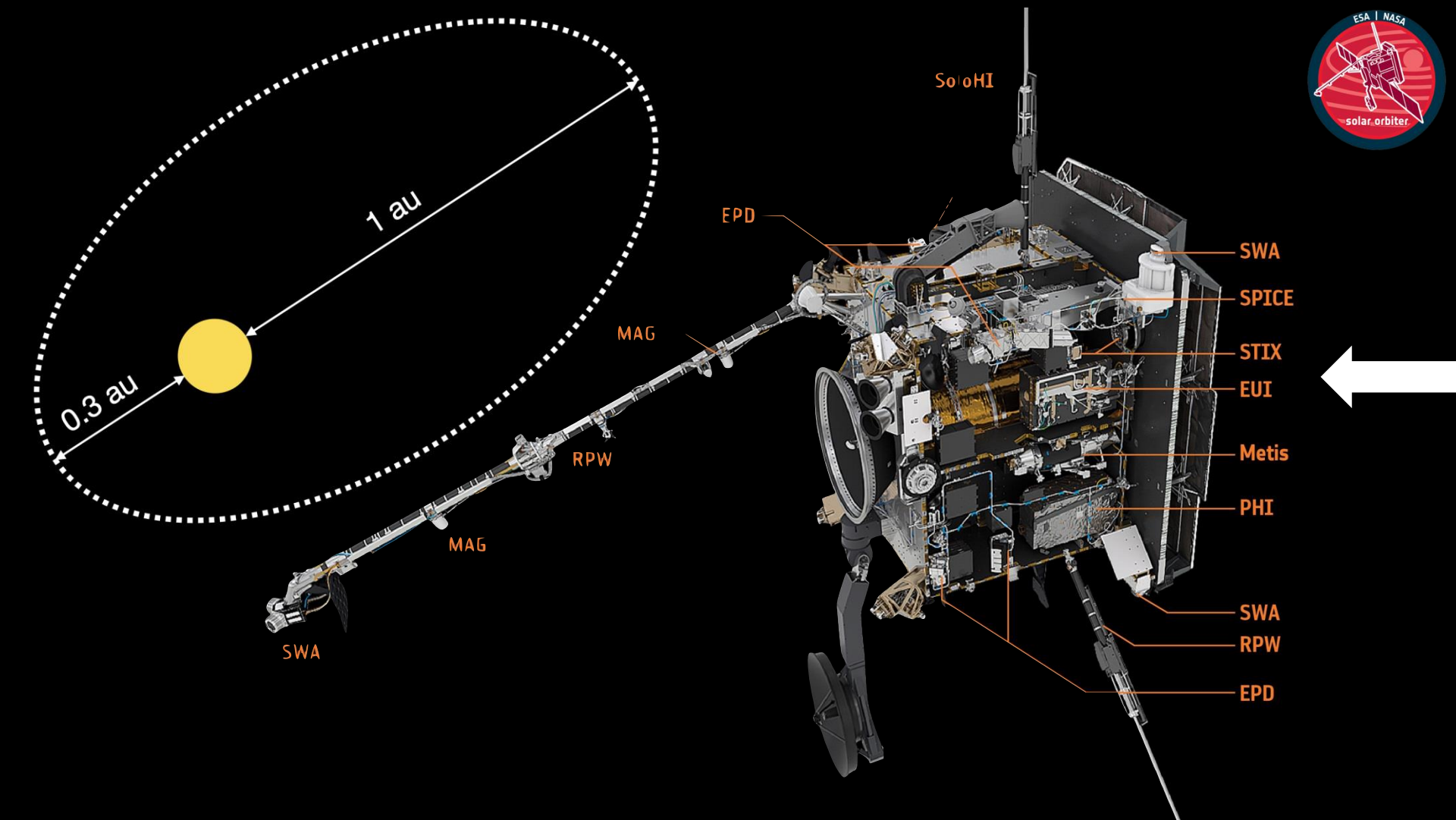
CROSS-SCALE OBSERVATIONS OF SOLAR FLARES BY EUI AND STIX ON SOLAR ORBITER

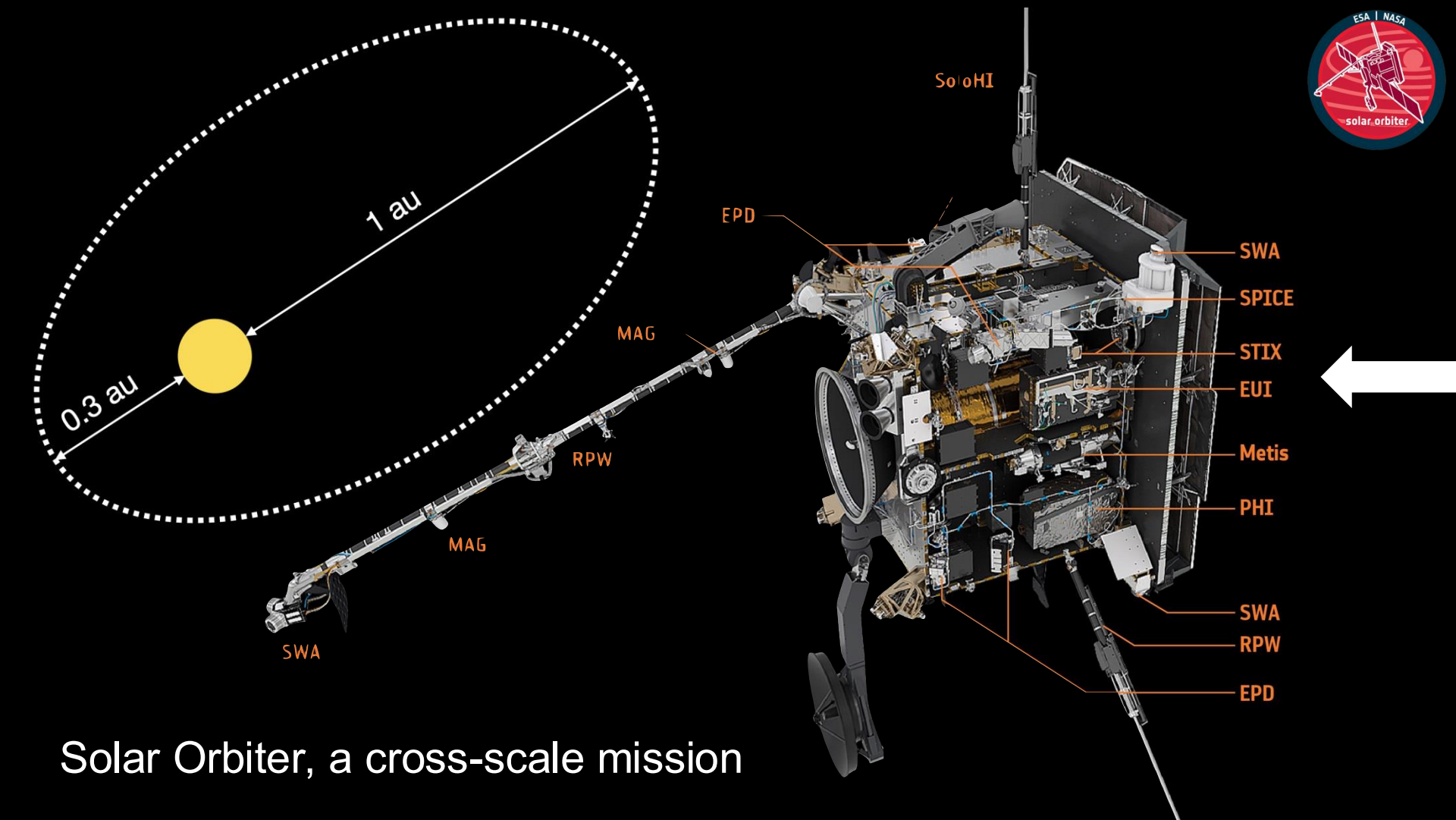
D. Berghmans, L.P. Chitta, H. Collier, M. Dominique, L. Hayes,
J. Kasporova, E. Kraaikamp , J. Lorincik, L. Rodriguez, C. Verbeeck




SoloHI
EPD
MAG
RPW
MAG
SWA
SWA
SPICE
STIX
EUI
Metis
PHI
SWA
RPW
EPD
ESA | NASA
solar orbiter

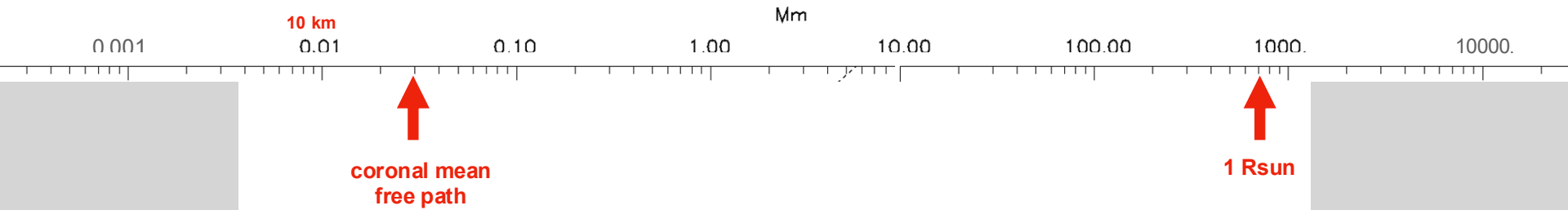

SoloHI
EPD
MAG
RPW
MAG
SWA
SWA
SPICE
STIX
EUI
Metis
PHI
SWA
RPW
EPD


1 au
0.3 au
SoloHI
EPD
SWA
SPICE
STIX
EUI
Metis
PHI
SWA
RPW
EPD
MAG
RPW
MAG
SWA
ESA | NASA
solar orbiter



Solar Orbiter, a cross-scale mission

Cross-scales observations of solar flares

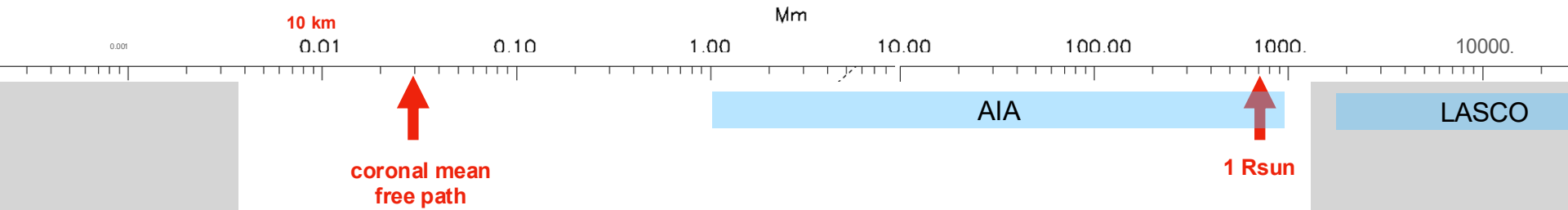


Kinetic Plasma physics

Solar Terrestrial Physics

Space Weather

Cross-scales observations of solar flares



Kinetic Plasma physics

Solar Terrestrial Physics

Space Weather

Cross-scales observations of solar flares

Mm

10 km

0.001 0.01 0.10 1.00 10.00 100.00 1000. 10000.

coronal mean free path

AIA

LASCO

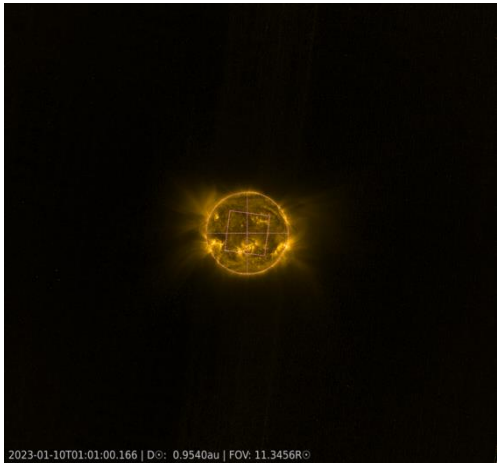
1 Rsun

2 pix=6.5 Mm FSI at 1 au FOV=14 Rsun

Kinetic Plasma physics

Solar Terrestrial Physics

Space Weather



Cross-scales observations of solar flares

Mm

10 km

0.001 0.01 0.10 1.00 10.00 100.00 1000. 10000.

coronal mean free path

AIA

LASCO

1 Rsun

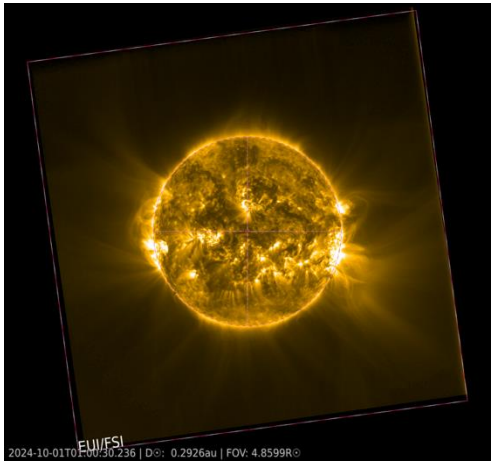
2 pix=6.5 Mm FSI at 1 au FOV=14 Rsun

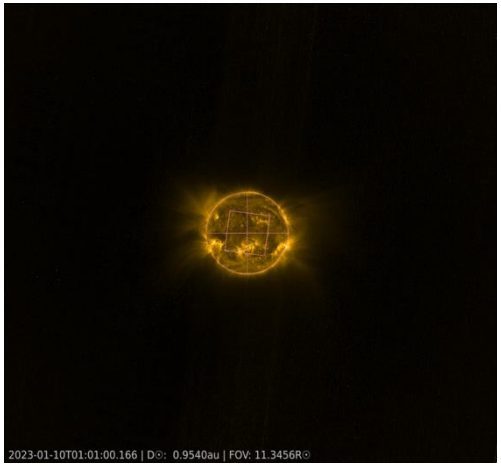
2 pix=1.8 Mm FSI at 0.28 au FOV= 4 Rsun

Kinetic Plasma physics

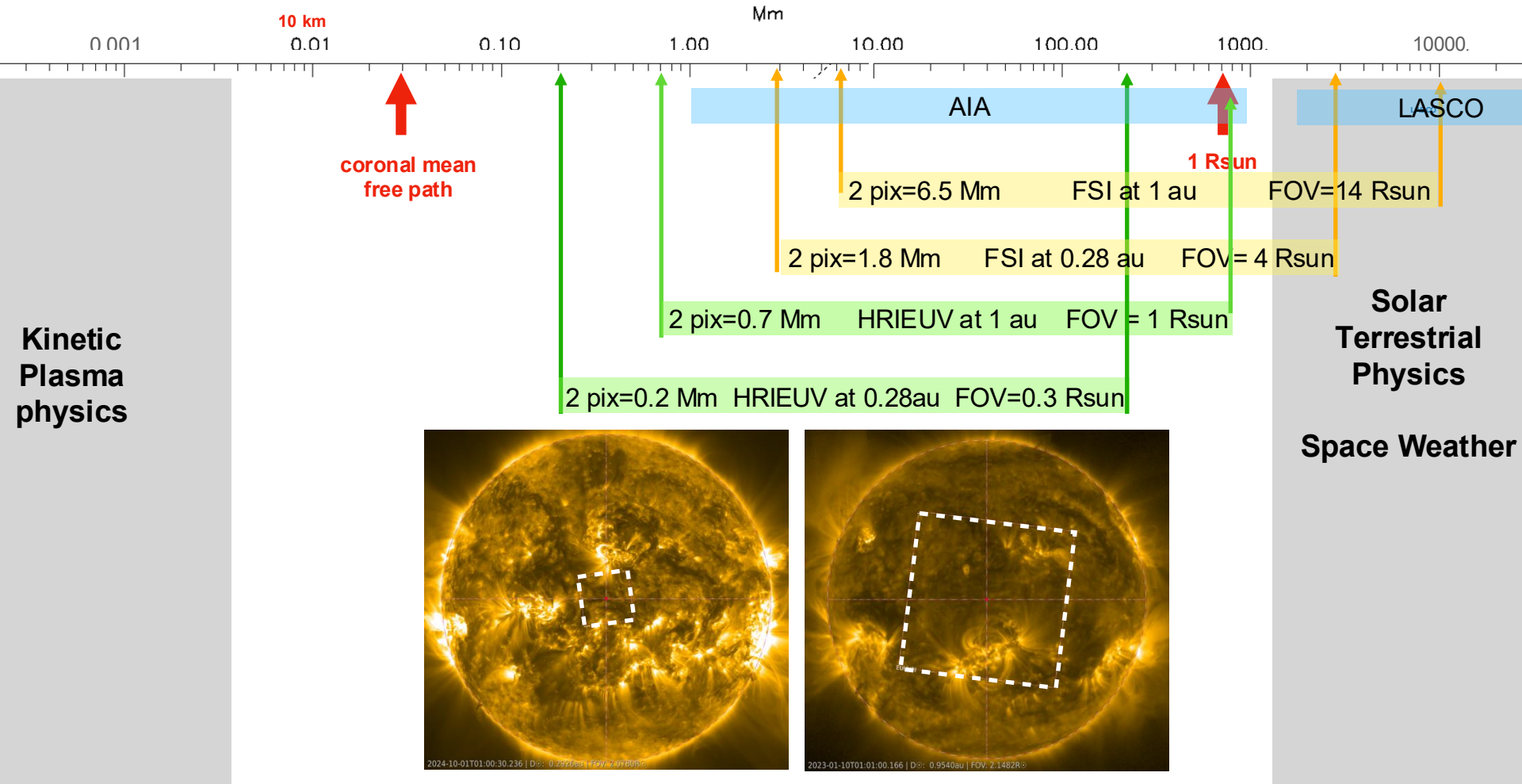
Solar Terrestrial Physics

Space Weather

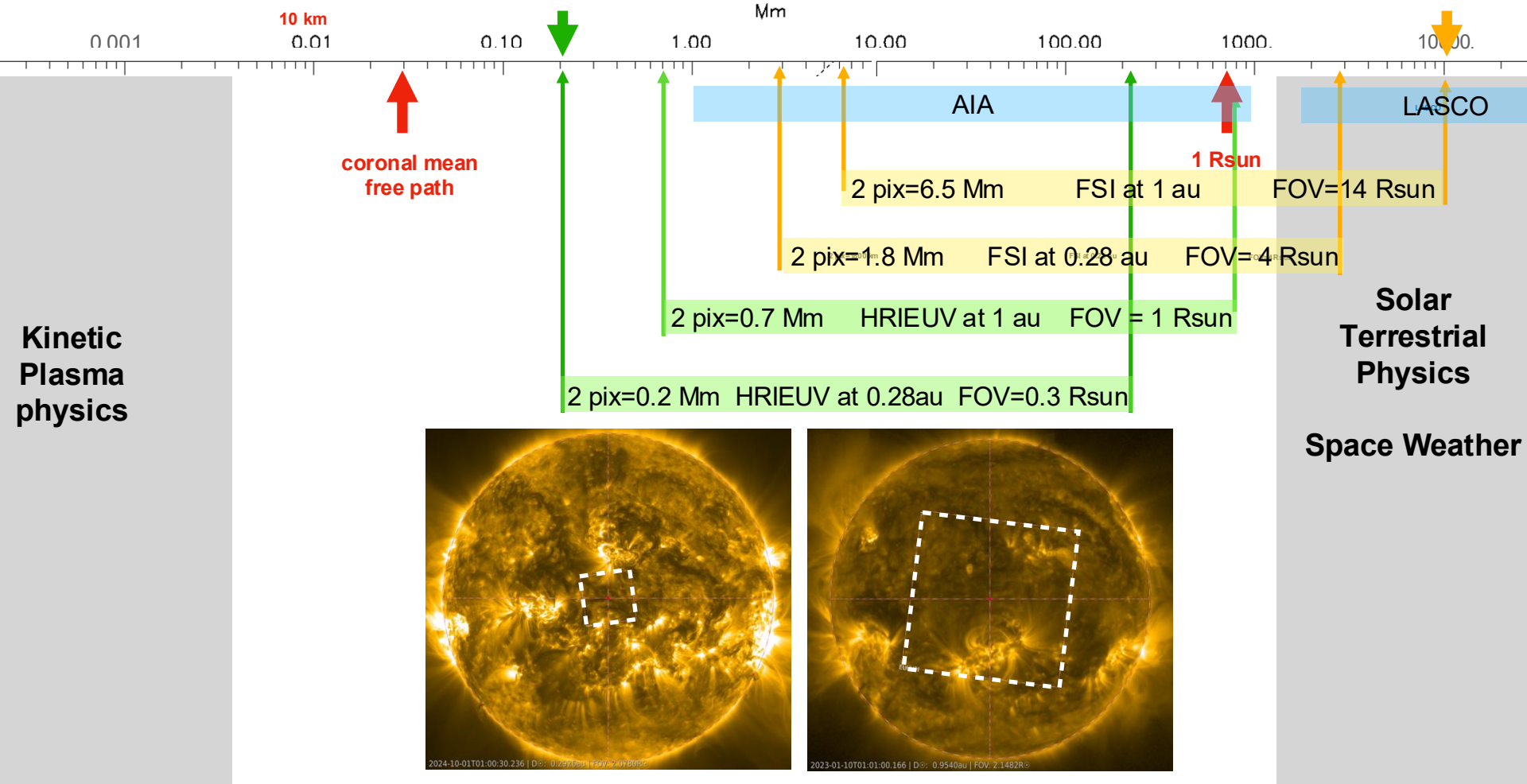




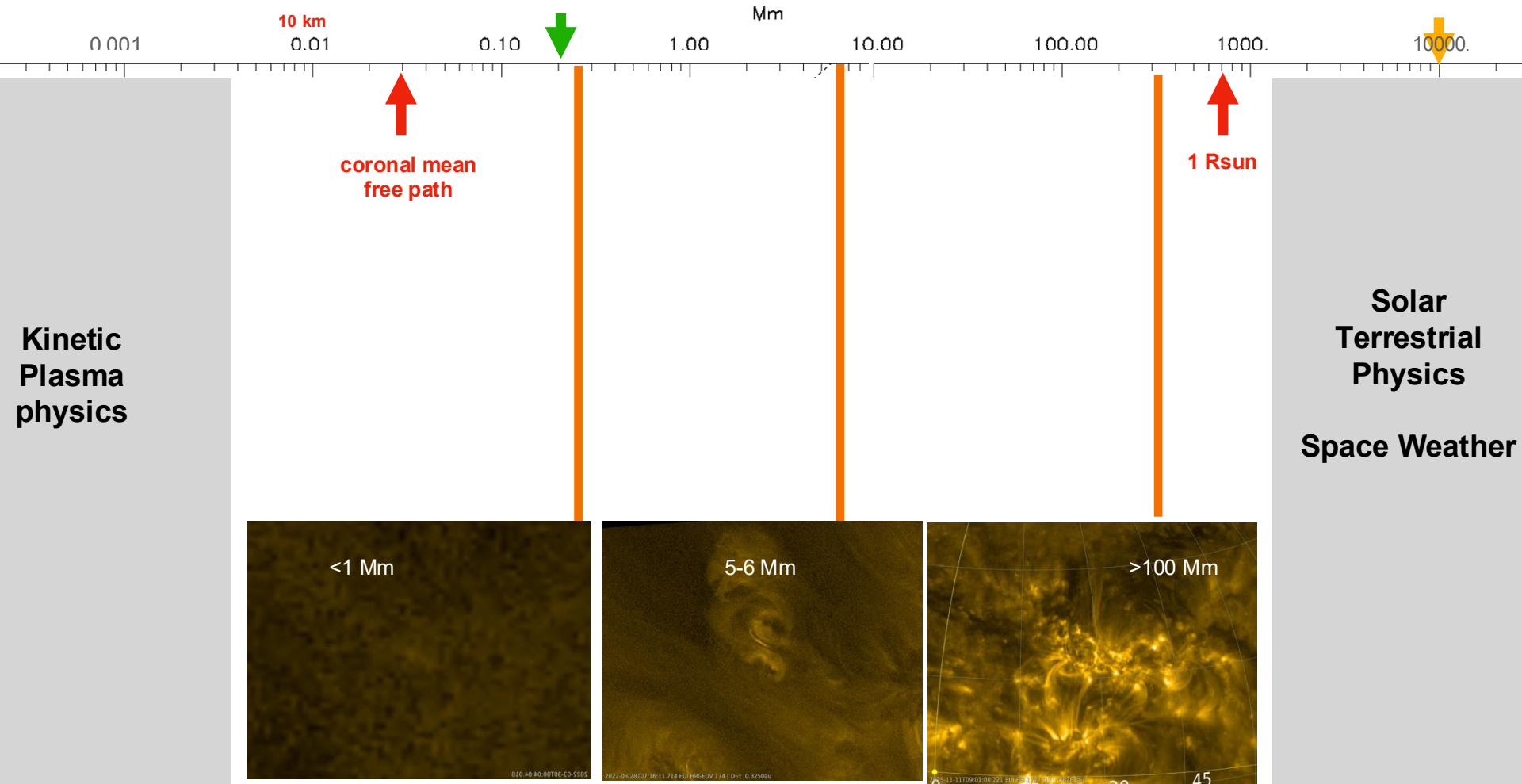
Cross-scales observations of solar flares



Cross-scales observations of solar flares



Cross-scales observations of solar flares



Cross-scales observations of solar flares

Mm

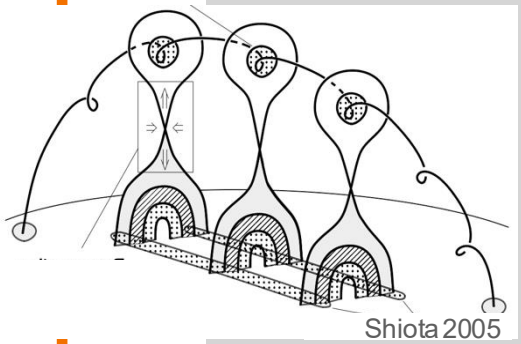
10 km

0.001 0.01 0.10 1.00 10.00 100.00 1000. 10000.

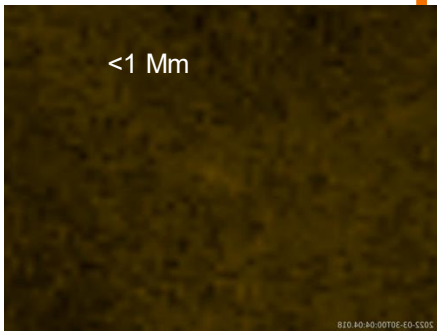
coronal mean free path

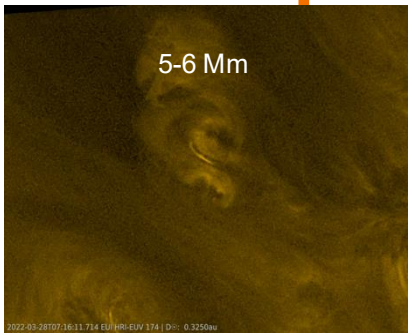
1 Rsun

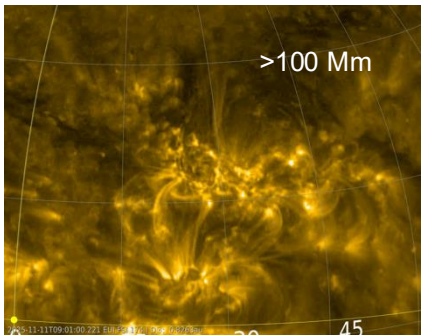
Kinetic Plasma physics



Shiota 2005







Cross-scales observations of solar flares

10 km

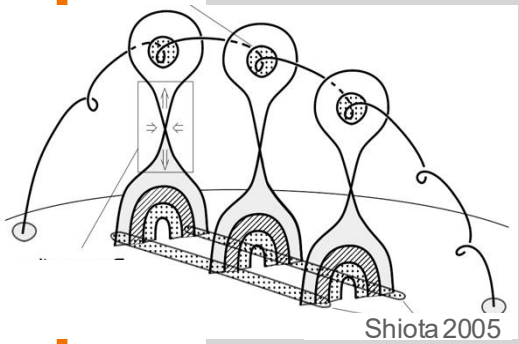
Mm

0.001 0.01 0.10 1.00 10.00 100.00 1000. 10000.

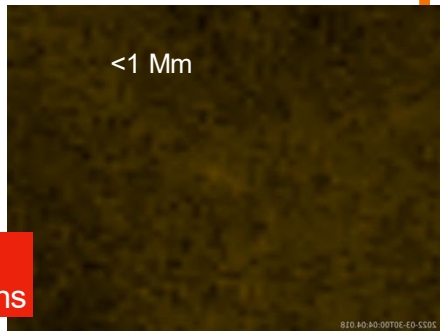
coronal mean free path

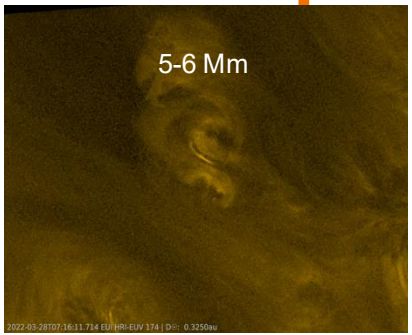
1 Rsun

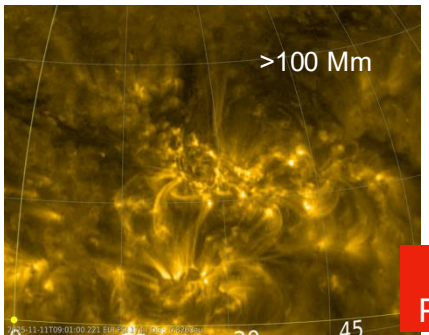
Kinetic Plasma physics



Shiota 2005







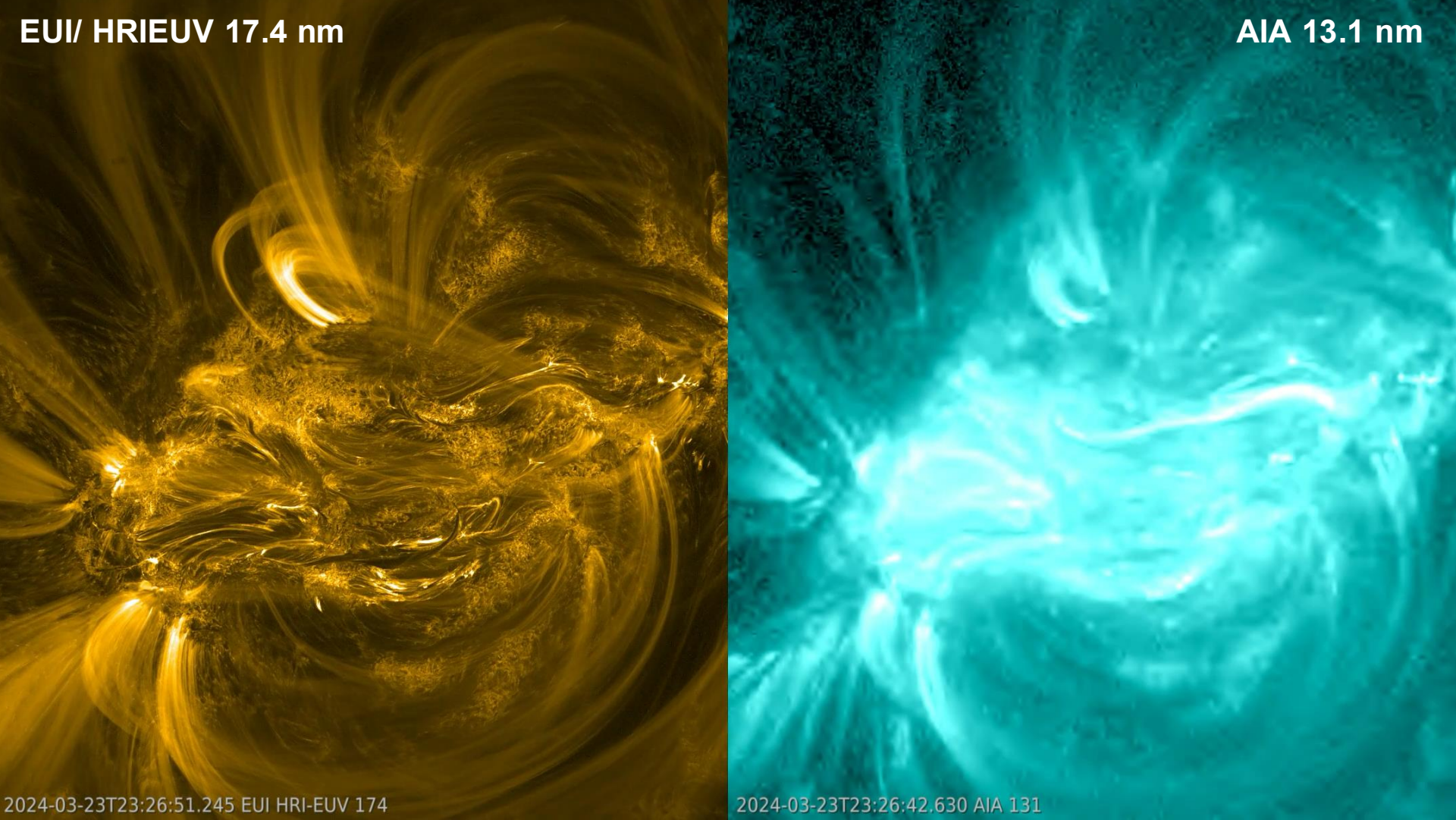
EUV Brightenings P1SOL207 Hermans

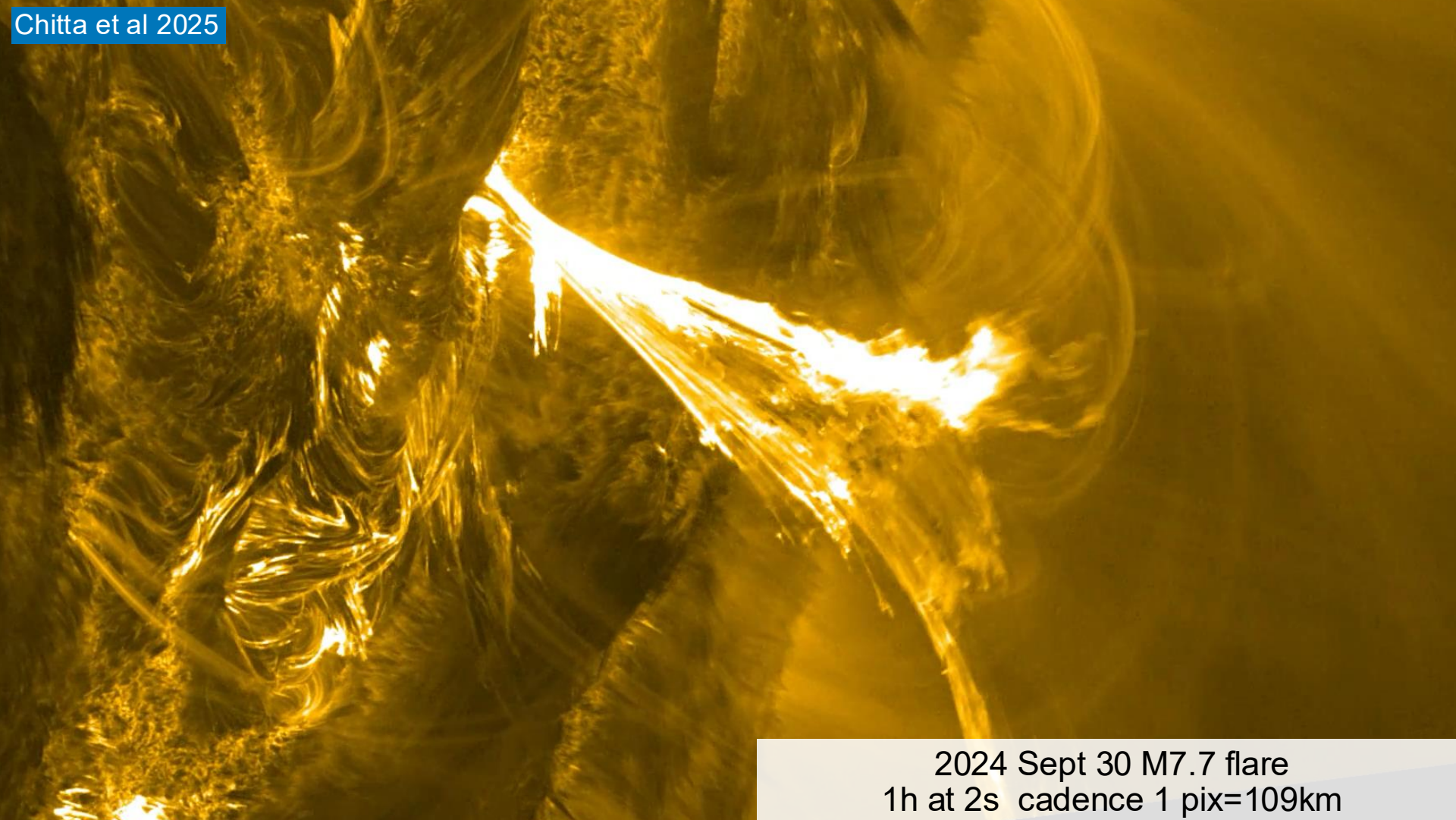
Big FSI Flares: P1SOL208 Kraaikamp

Study details of big flares to understand the small flares.

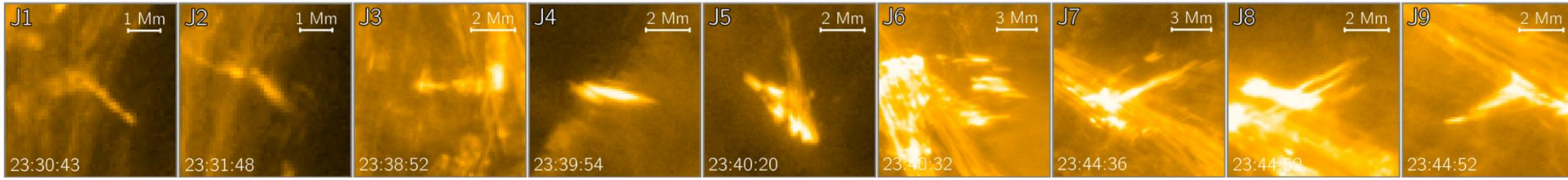
Study details of big flares to understand the small flares.

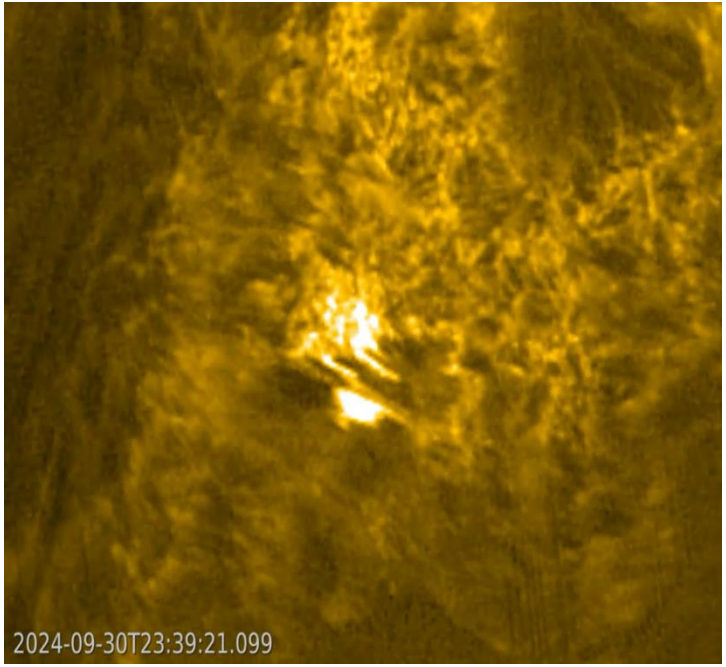
Are big flares single events or are they compounds of many small events?


EUI/ HRIEUV 17.4 nm
AIA 13.1 nm
2024-03-23T23:26:51.245 EUI HRI-EUV 174
2024-03-23T23:26:42.630 AIA 131

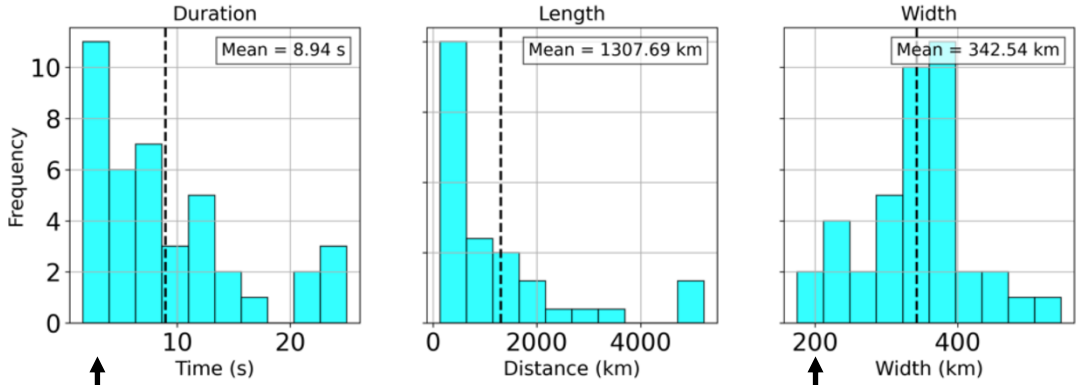

Chitta et al 2025
2024 Sept 30 M7.7 flare
1h at 2s cadence 1 pix=109km

Tan et al 2025





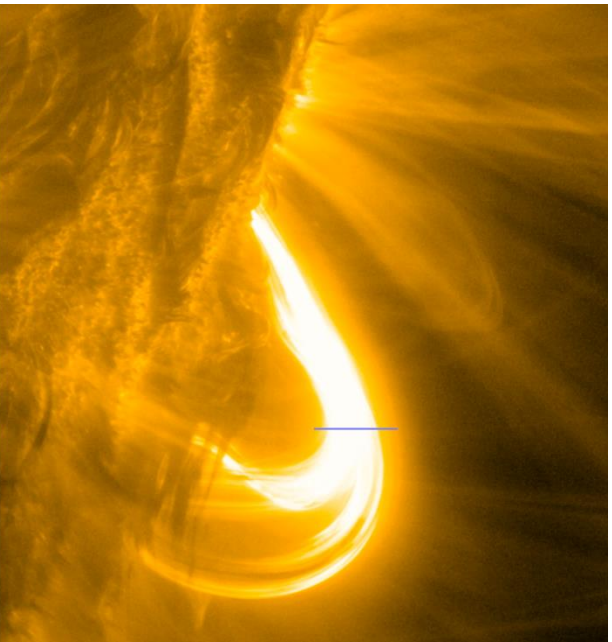
Wallace & Antolin, 2025



Temporal resolution

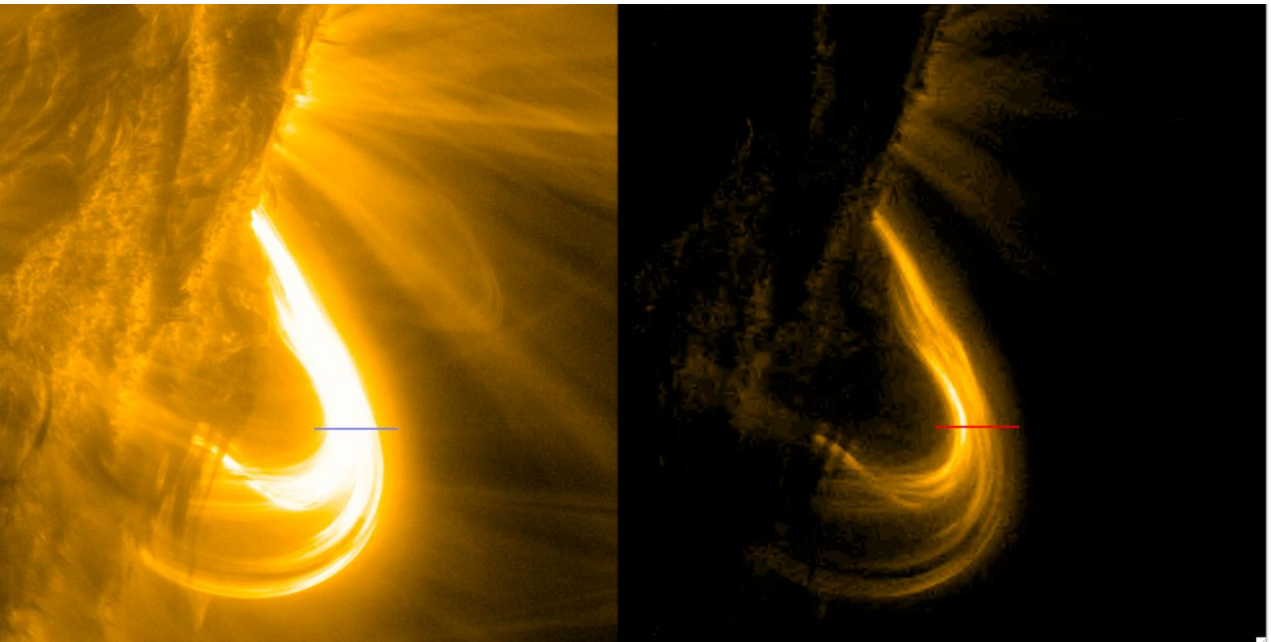
Spatial resolution

- **Exposure: 2s**
- **Compression x7**



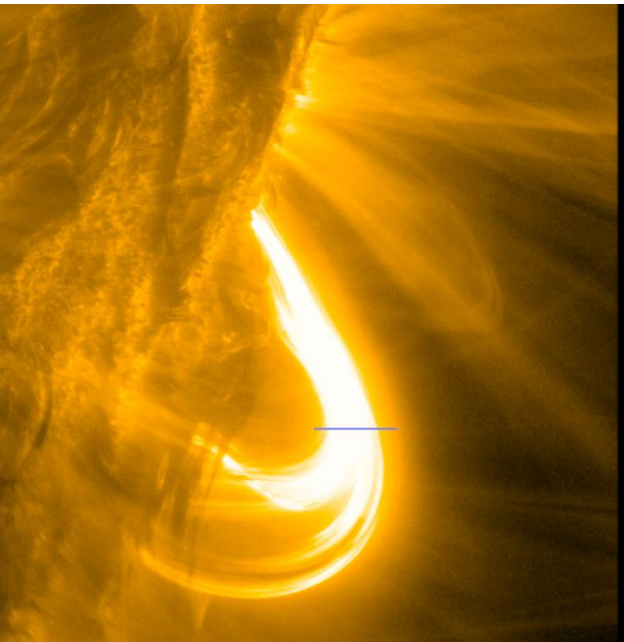
- **Exposure: 2s**
- **Compression x7**

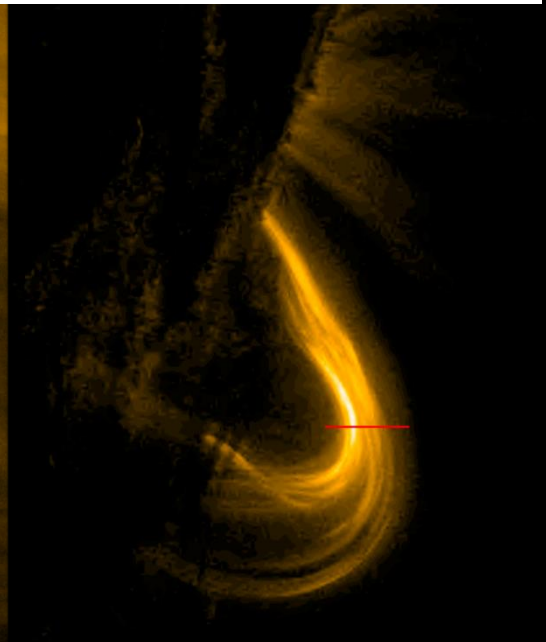
- **Exposure: 0.04s**
- **Compression x120**

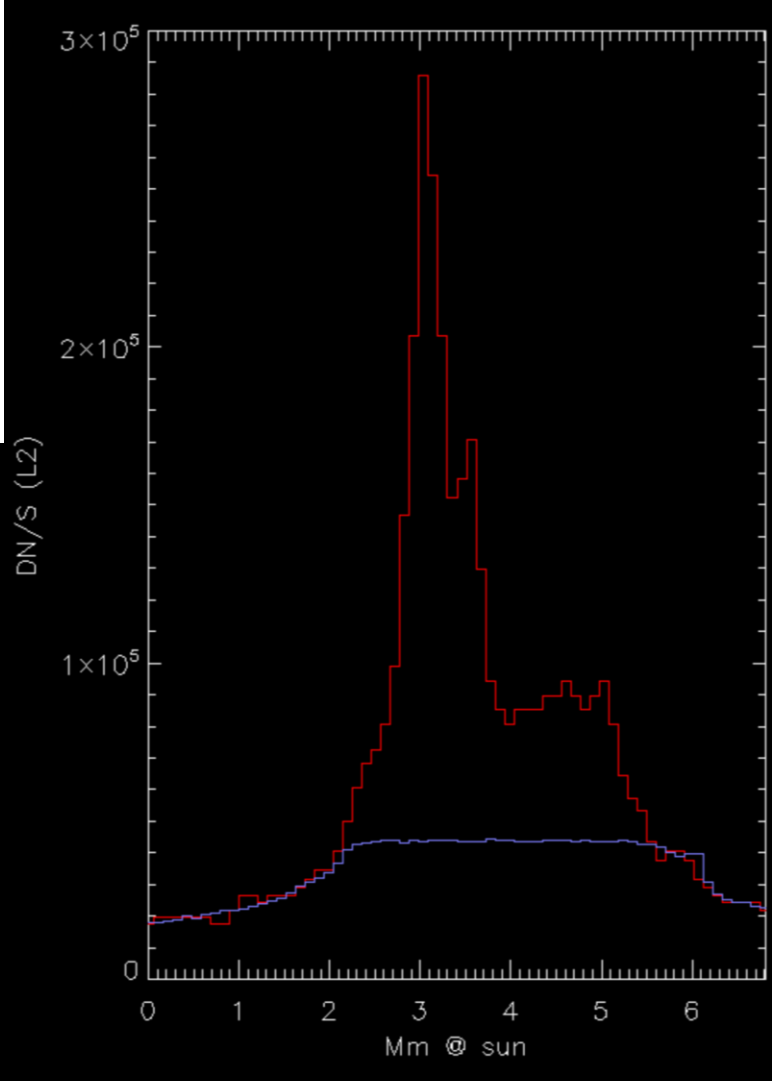


- Exposure: 2s
- Compression x7

- Exposure: 0.04s
- Compression x120

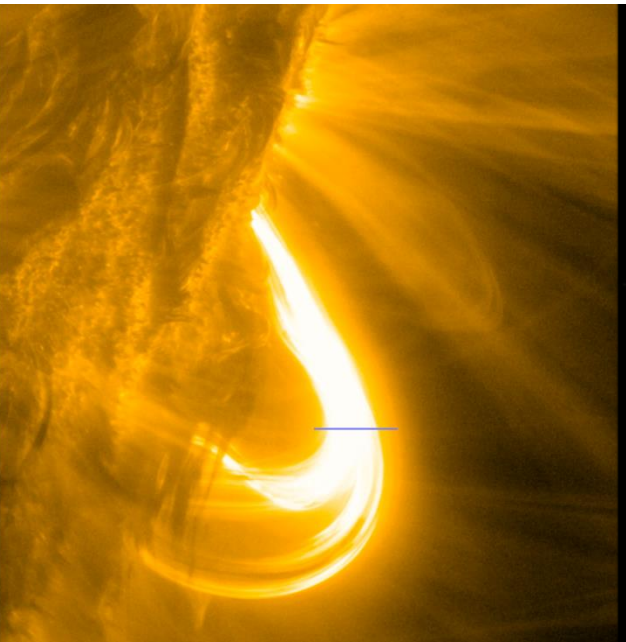


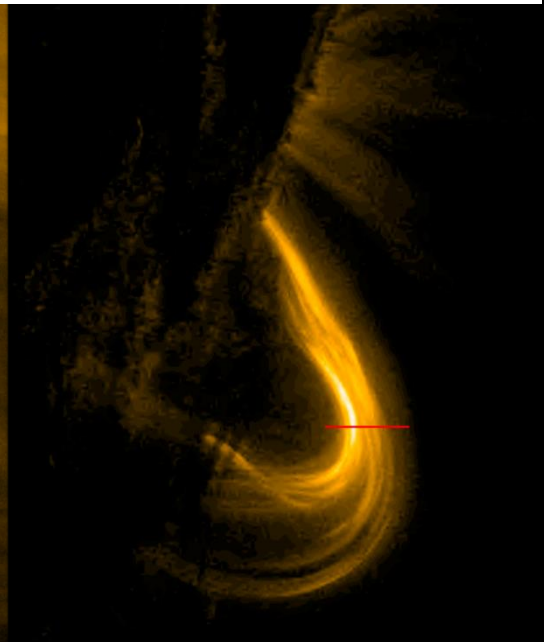


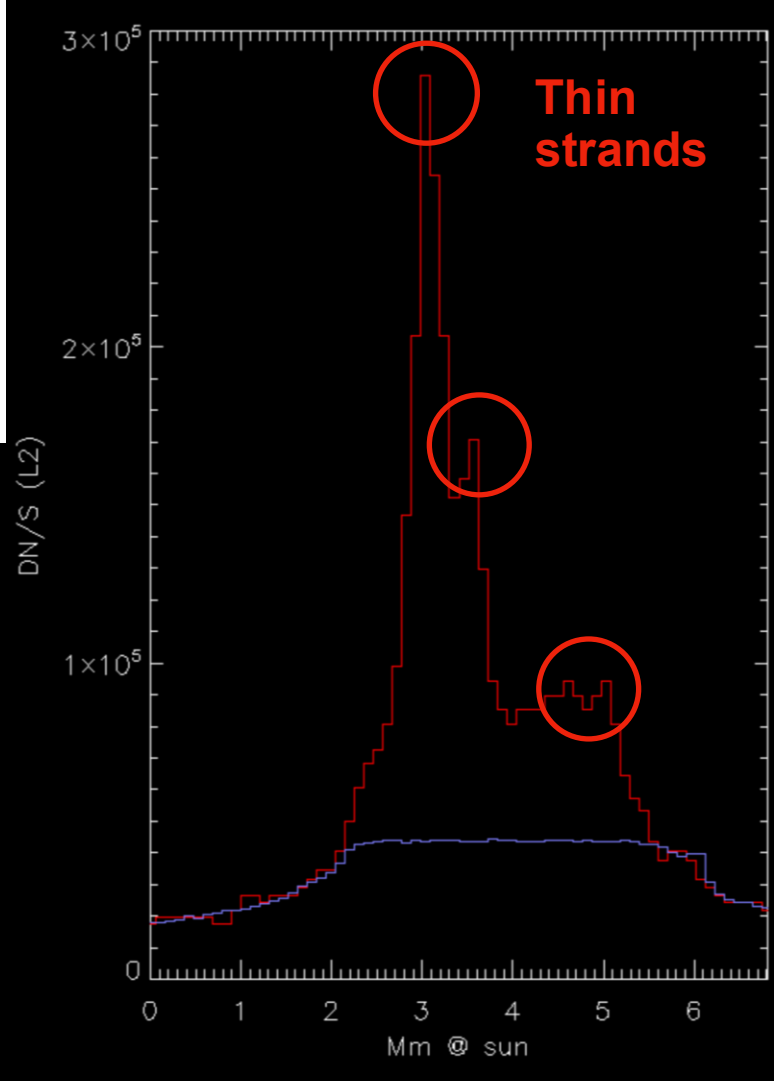


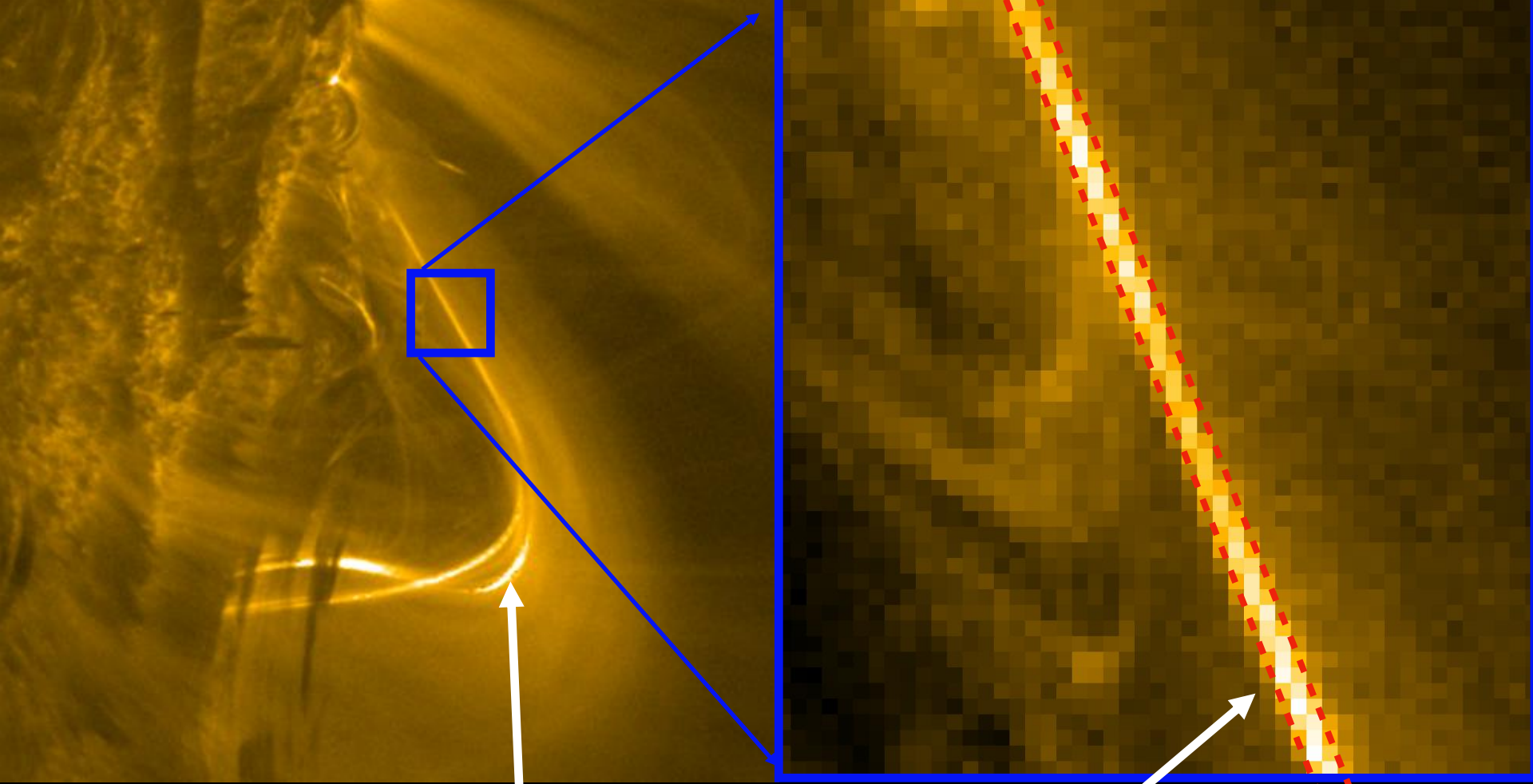
- Exposure: 2s
- Compression x7

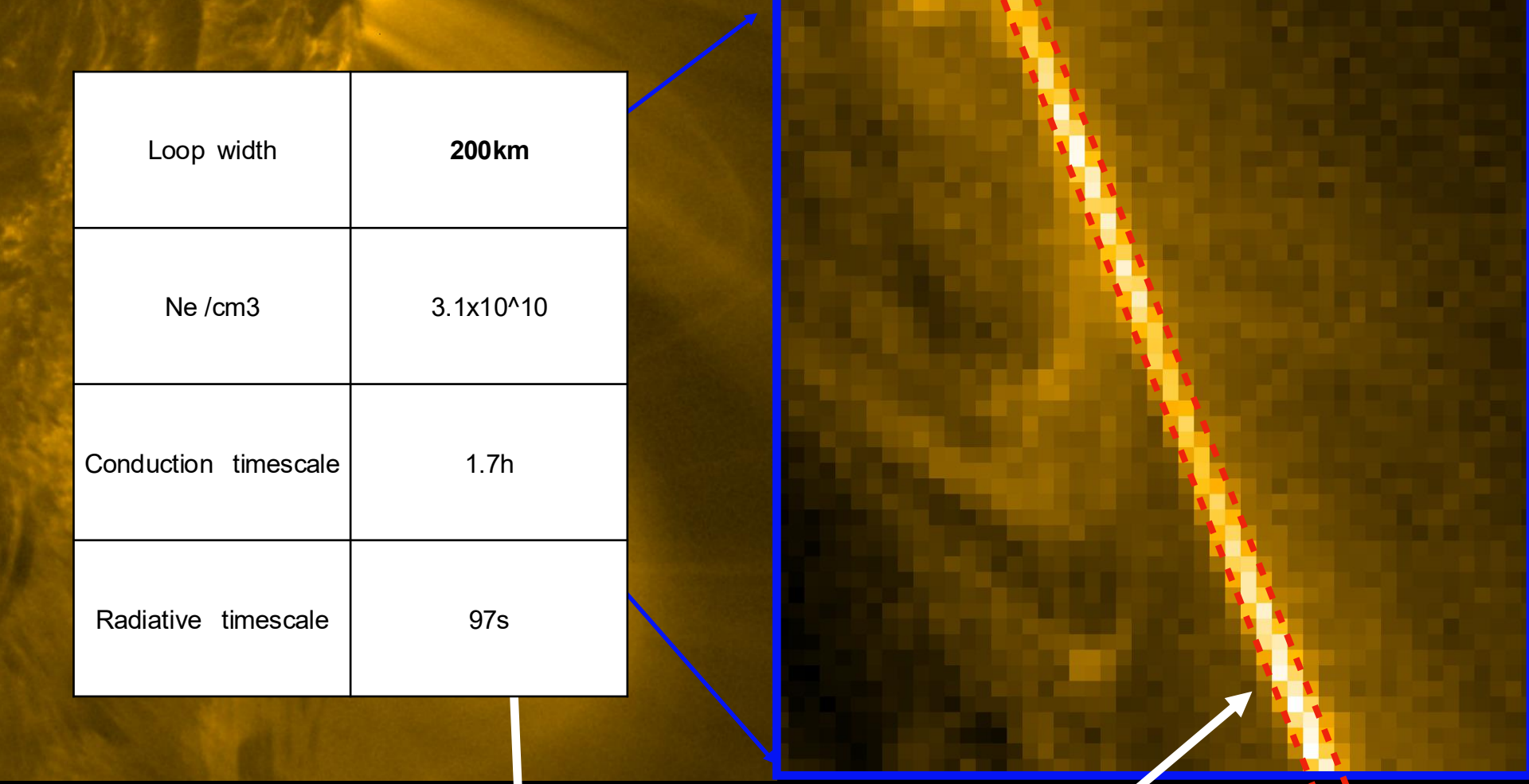
- Exposure: 0.04s
- Compression x120

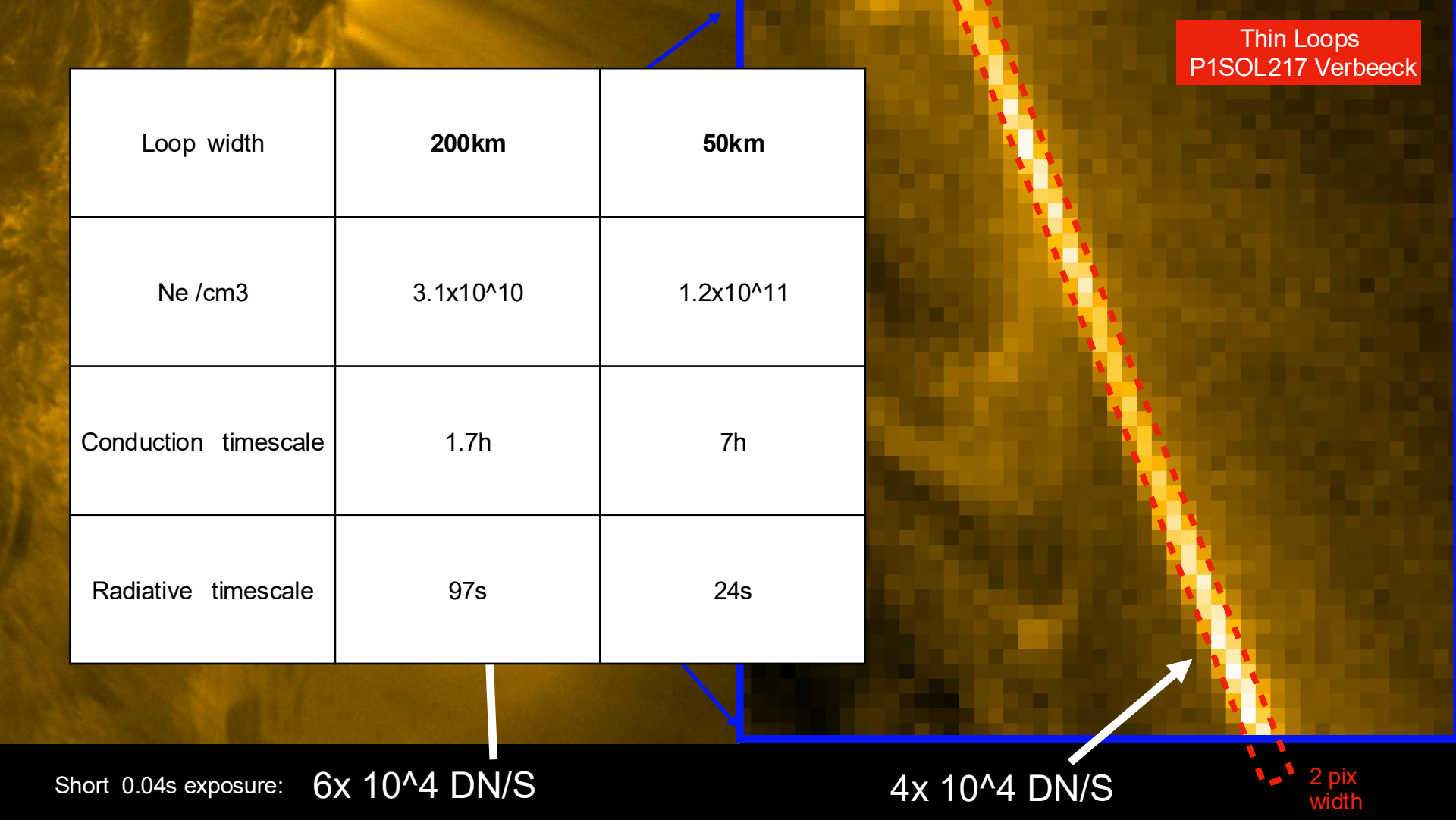






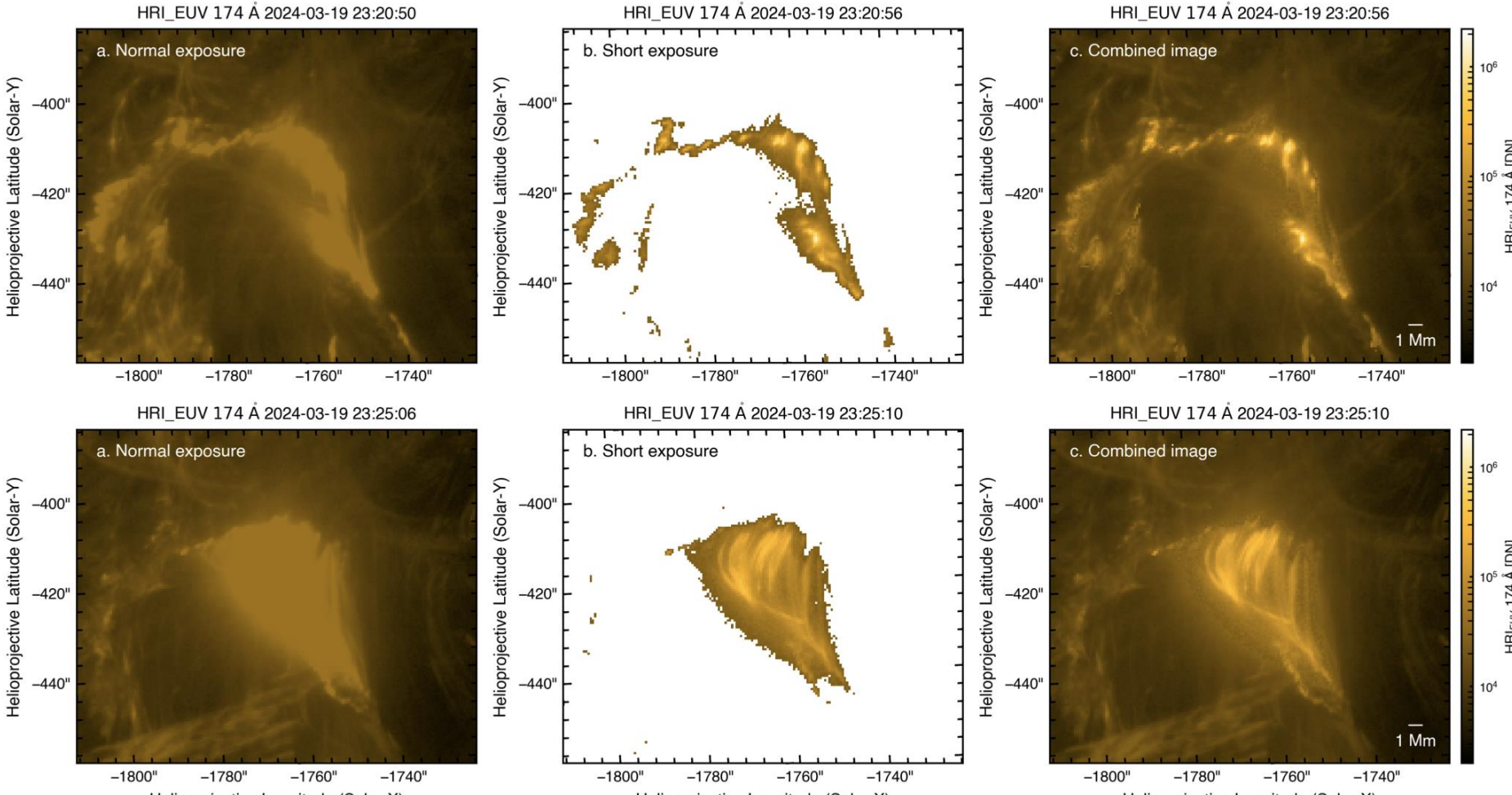

Short 0.04s exposure:
6x 10^4 DN/S
4x 10^4 DN/S
2 pix
width

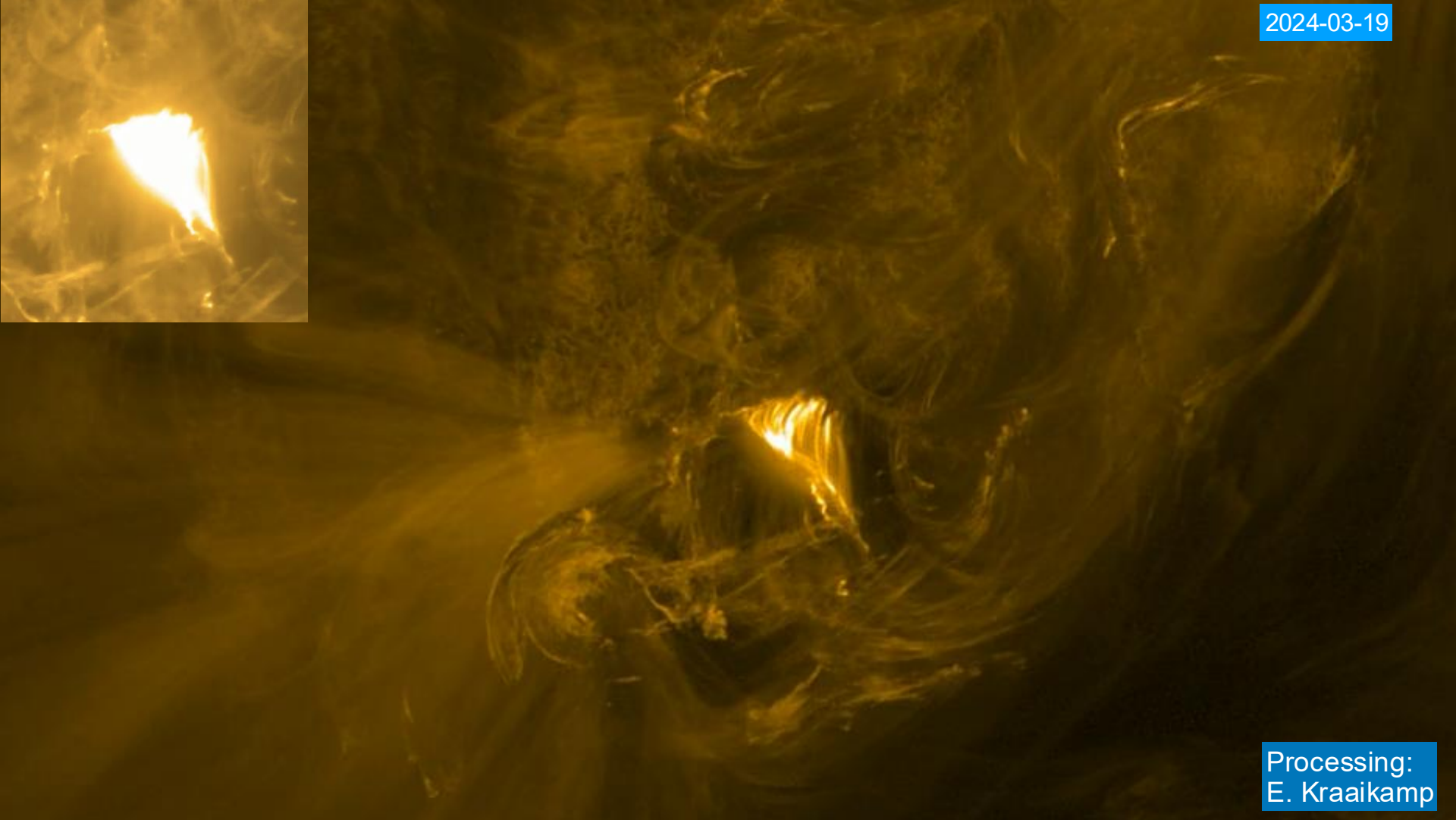

Loop width
200km
Ne /cm3
3.1x10^10
Conduction timescale
1.7h
Radiative timescale
97s
Short 0.04s exposure:
6x 10^4 DN/S
4x 10^4 DN/S
2 pix width



Loop width	**200km**	**50km**
Ne /cm3	3.1x10^10	1.2x10^11
Conduction timescale	1.7h	7h
Radiative timescale	97s	24s

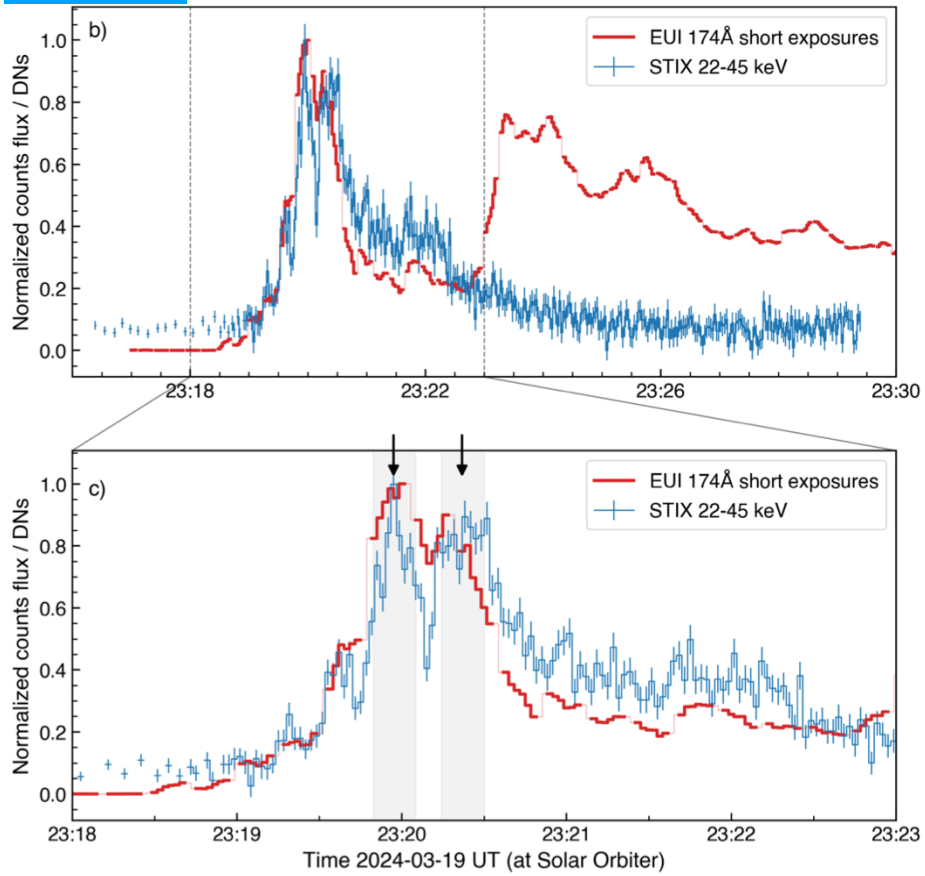
Hayes et al 2026

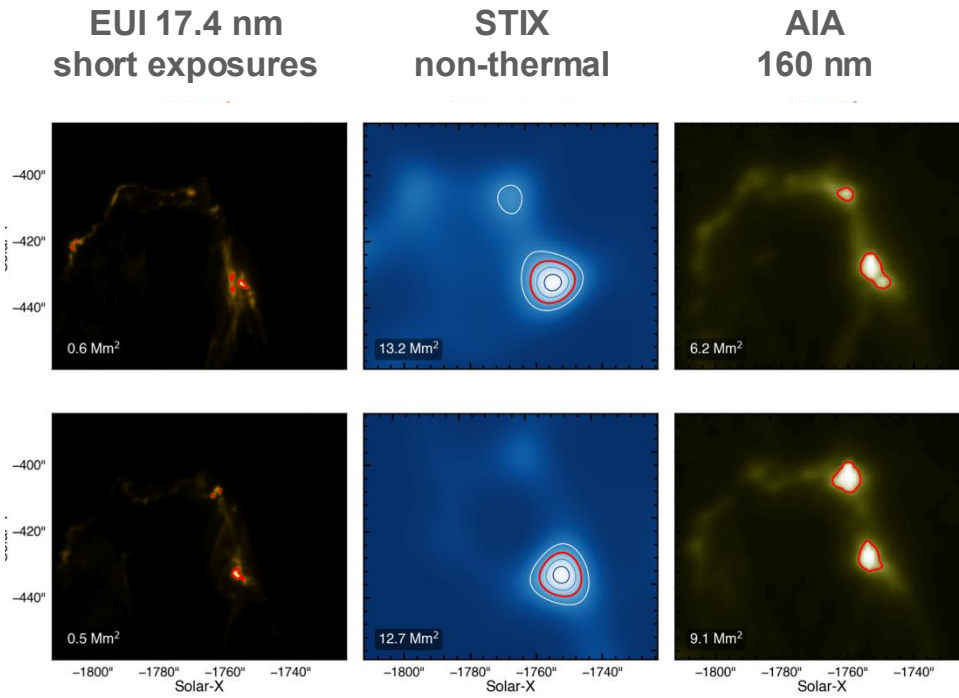



2024-03-19
Processing:
E. Kraaikamp

Hayes 2026

2024-03-19



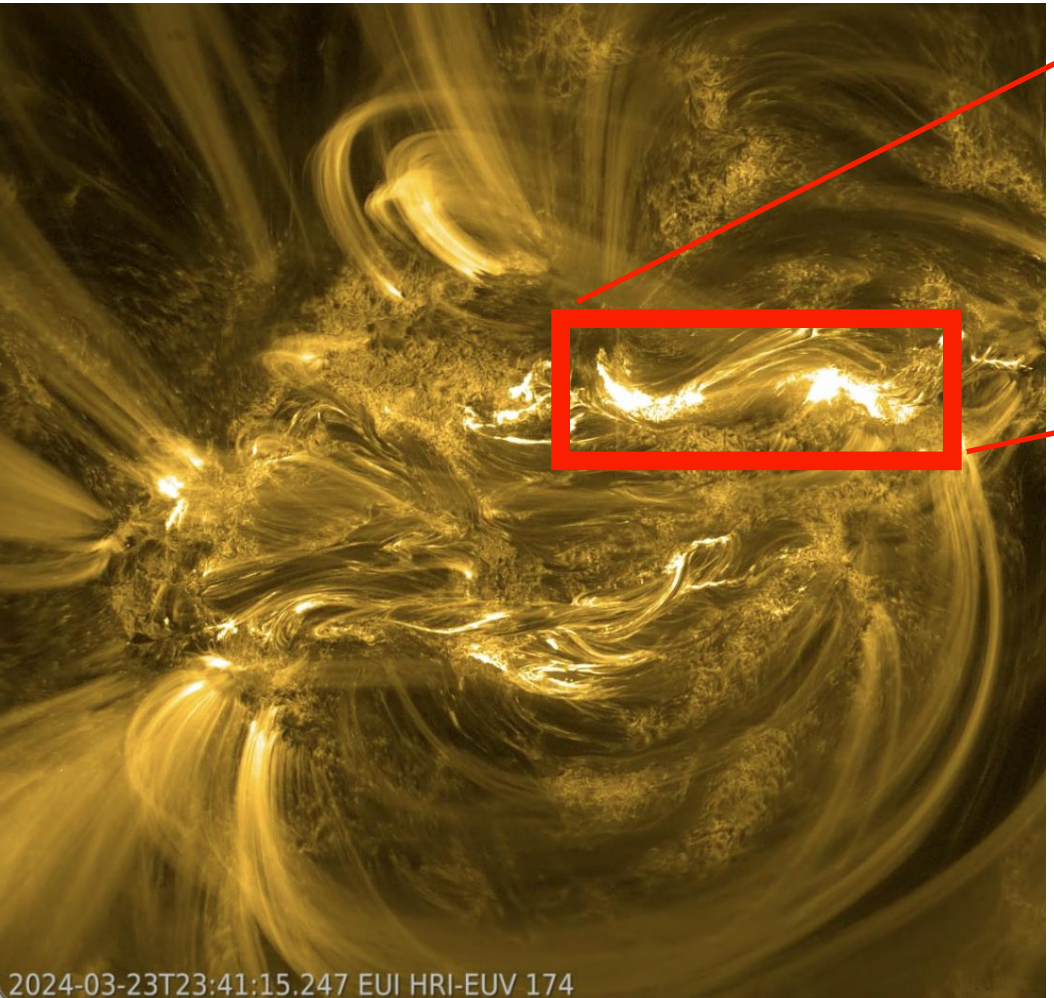


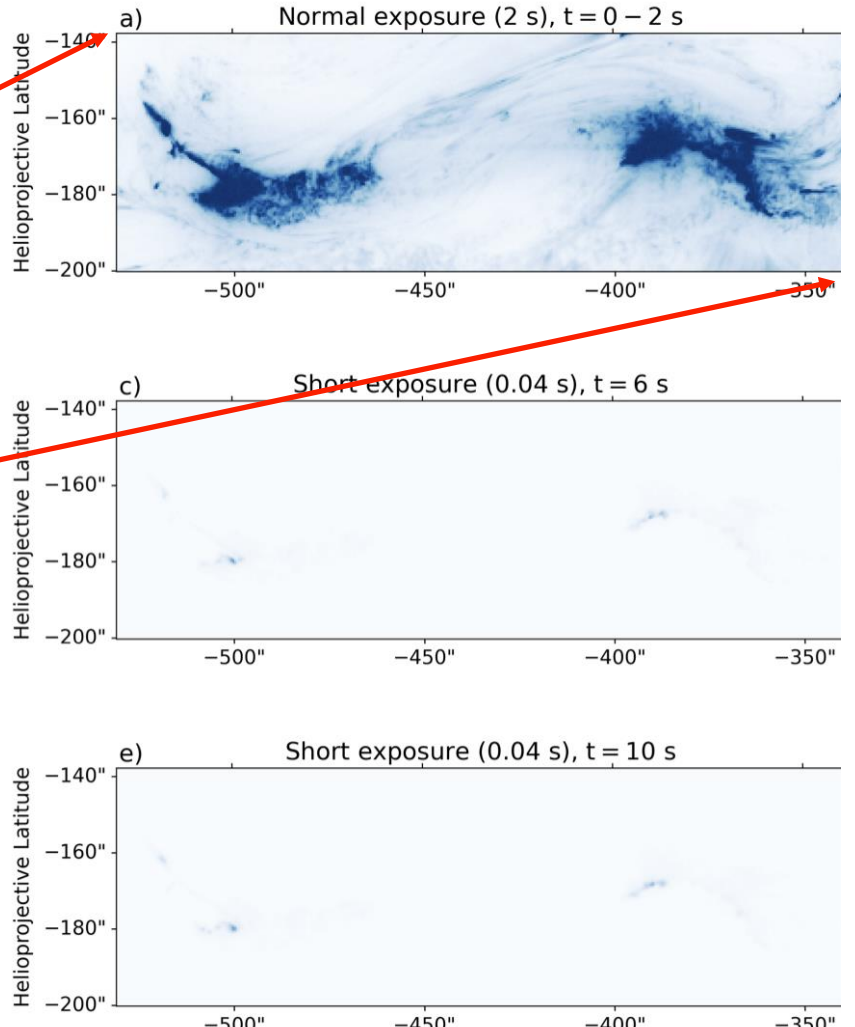
EUI short exposures follow hard X-rays

HRIEUV short exposures show that flare footpoints are way more compact than what we believed so far

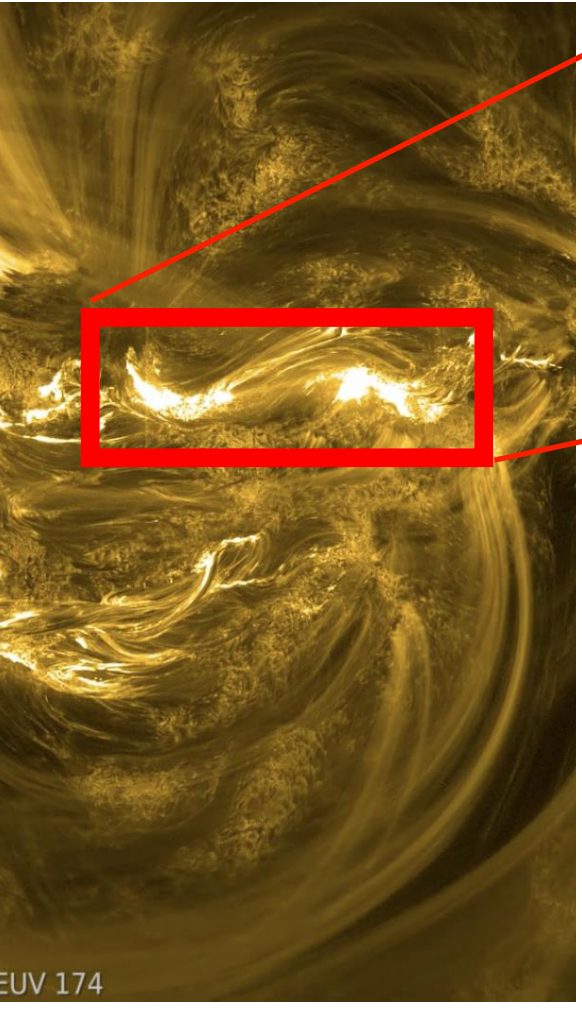
Collier et al 2026

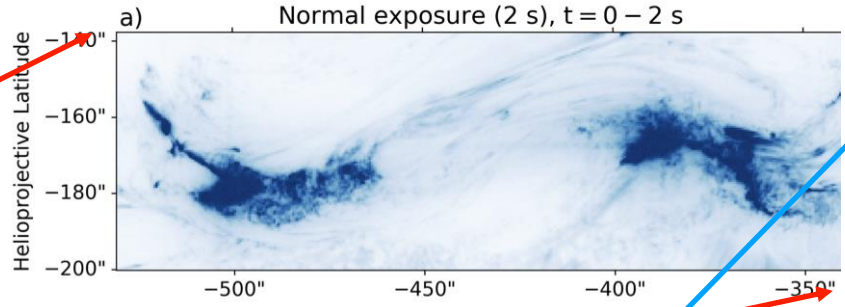
2024-03-23 M2.5

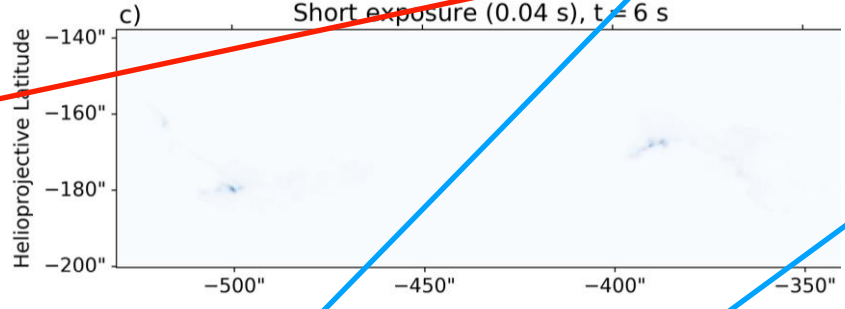


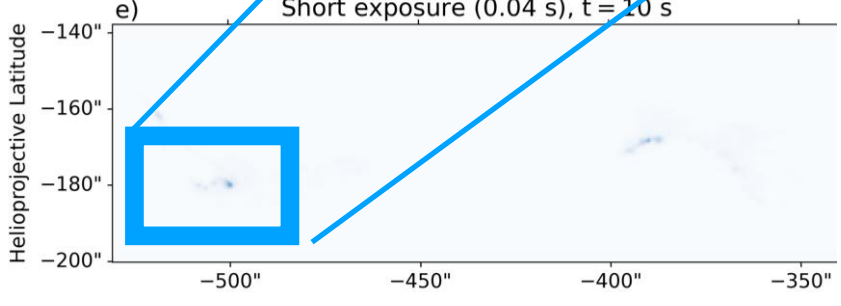


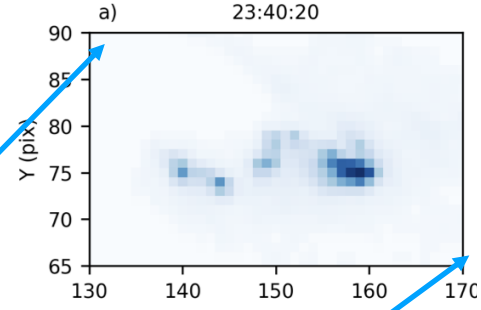
Collier et al 2026

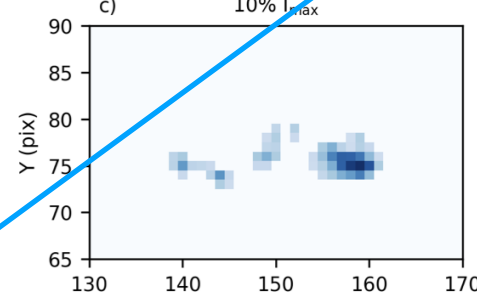


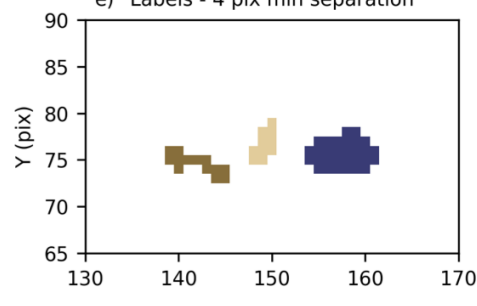




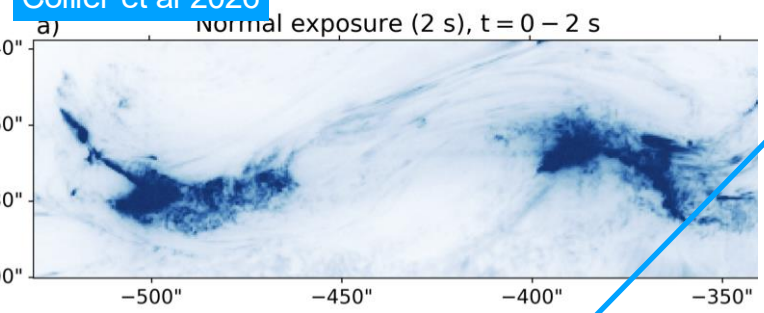


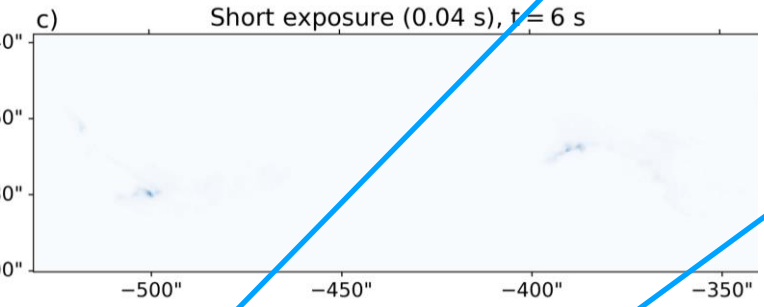


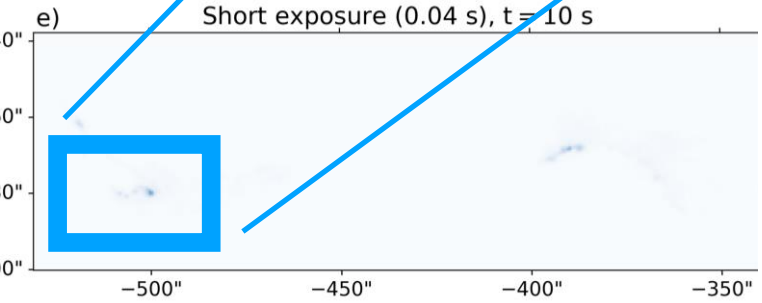


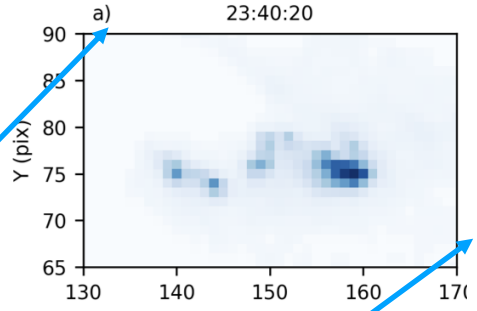


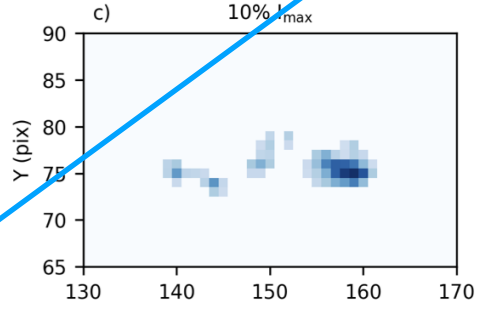
Collier et al 2026

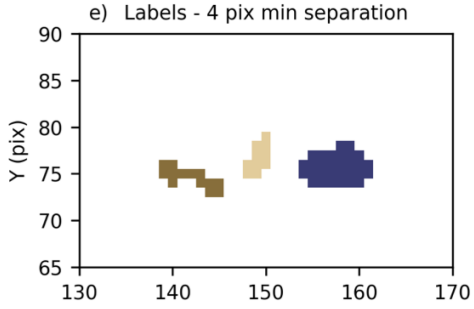


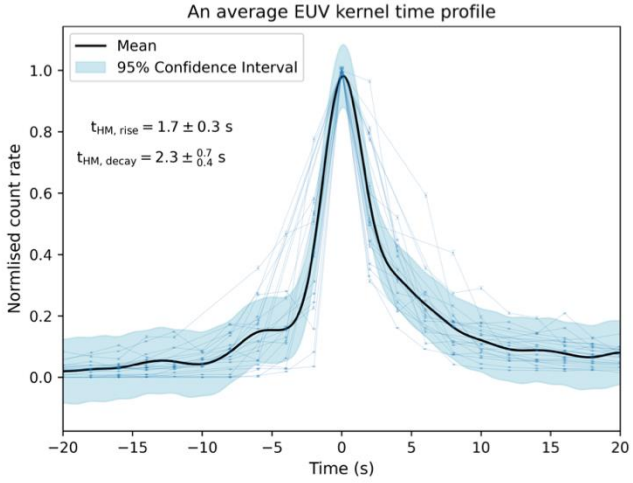








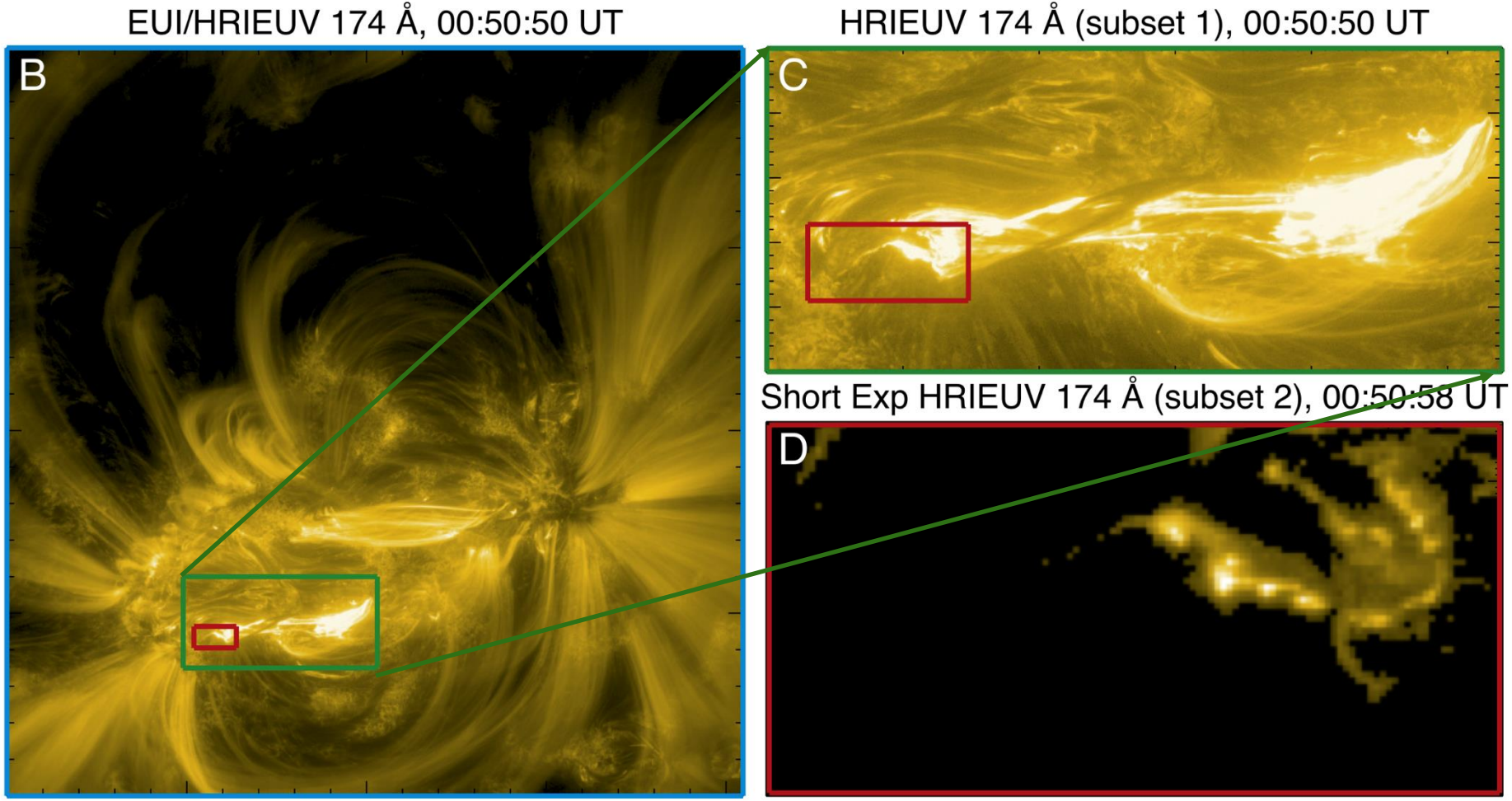




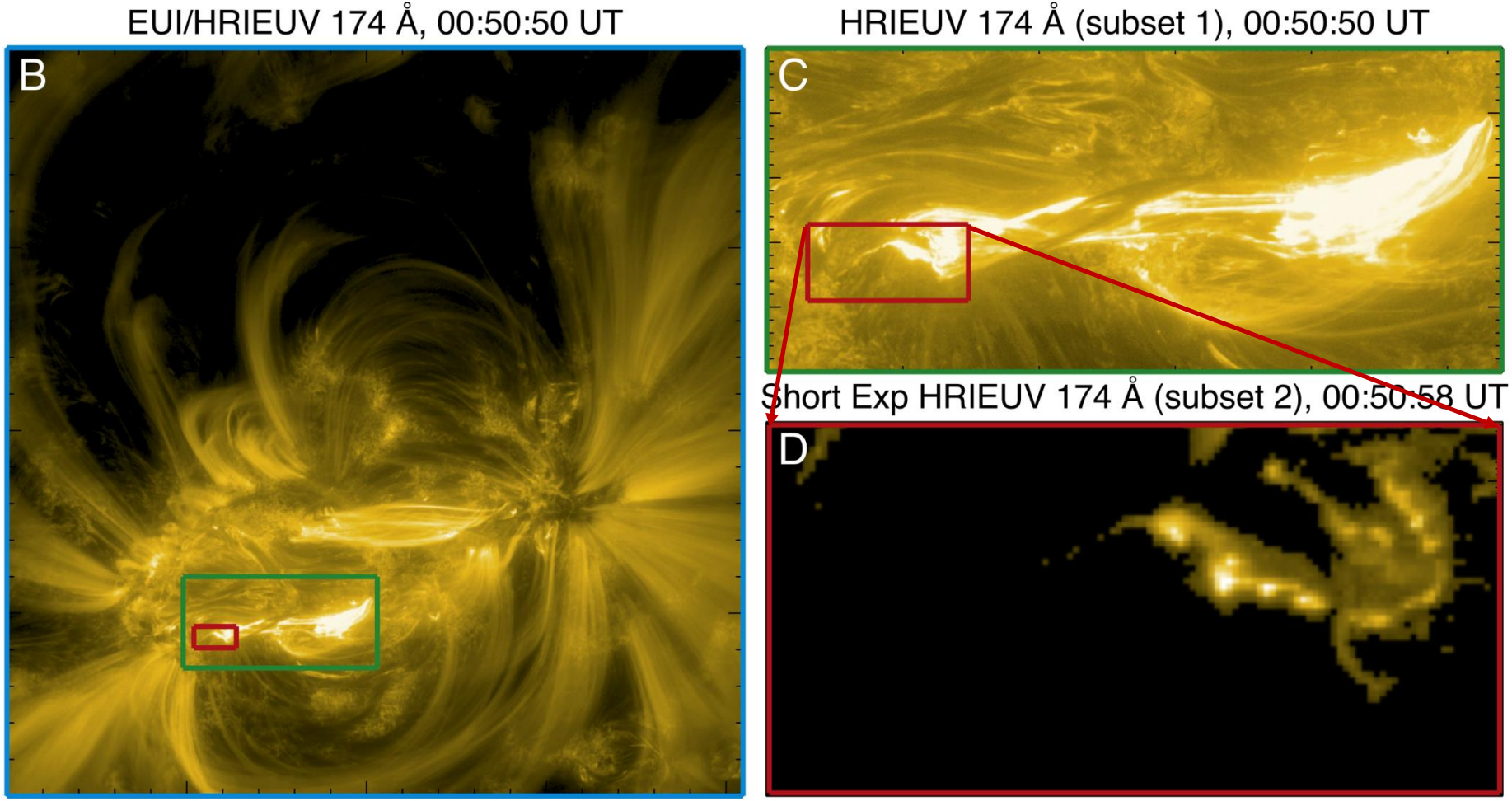
Rise time ~ 1.7s
Decay time ~ 2.3s

Unresolved?

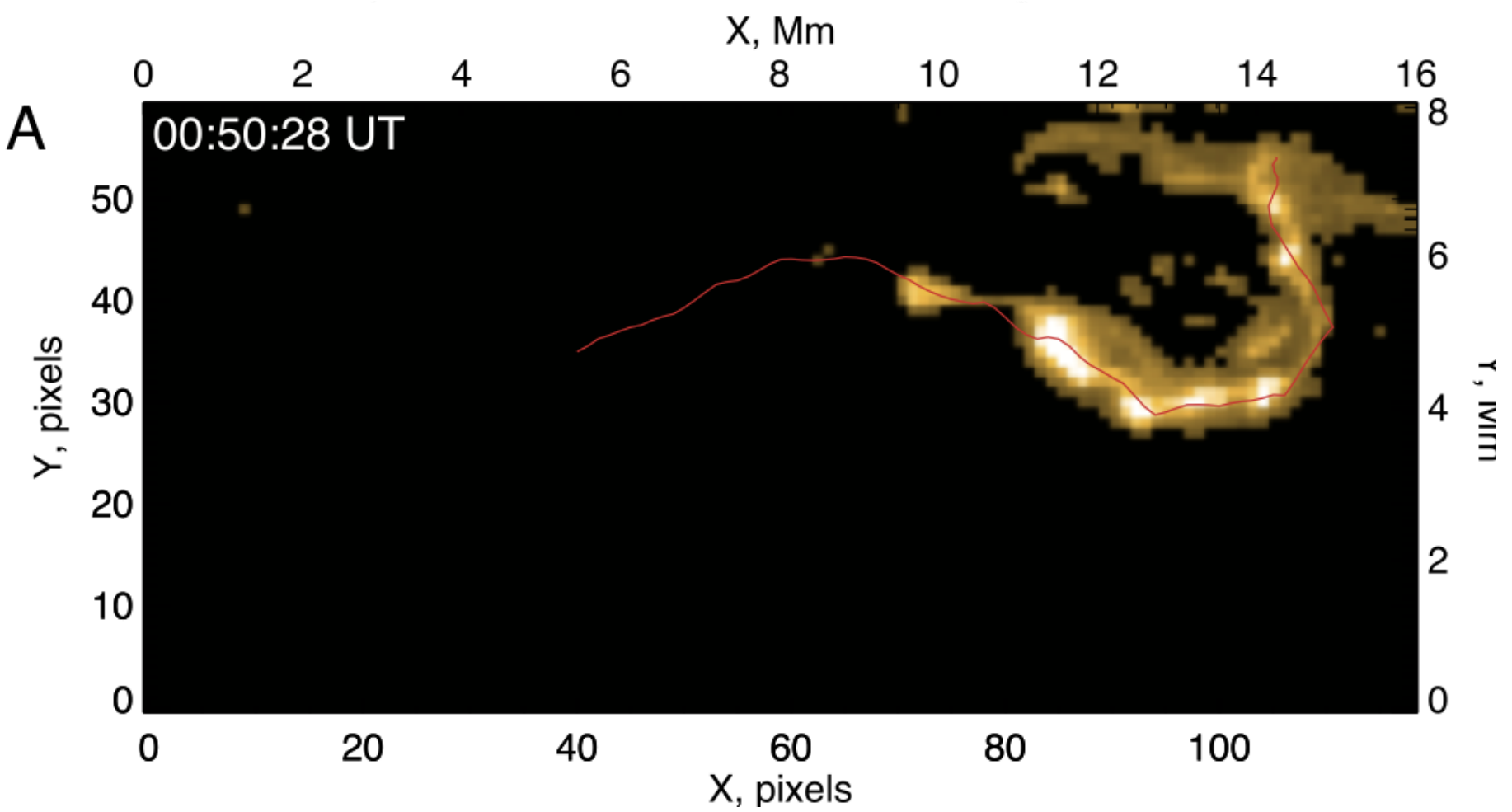
French 2025


EUI/HRIEUV 174 Å, 00:50:50 UT
B
HRIEUV 174 Å (subset 1), 00:50:50 UT
C
Short Exp HRIEUV 174 Å (subset 2), 00:50:58 UT
D

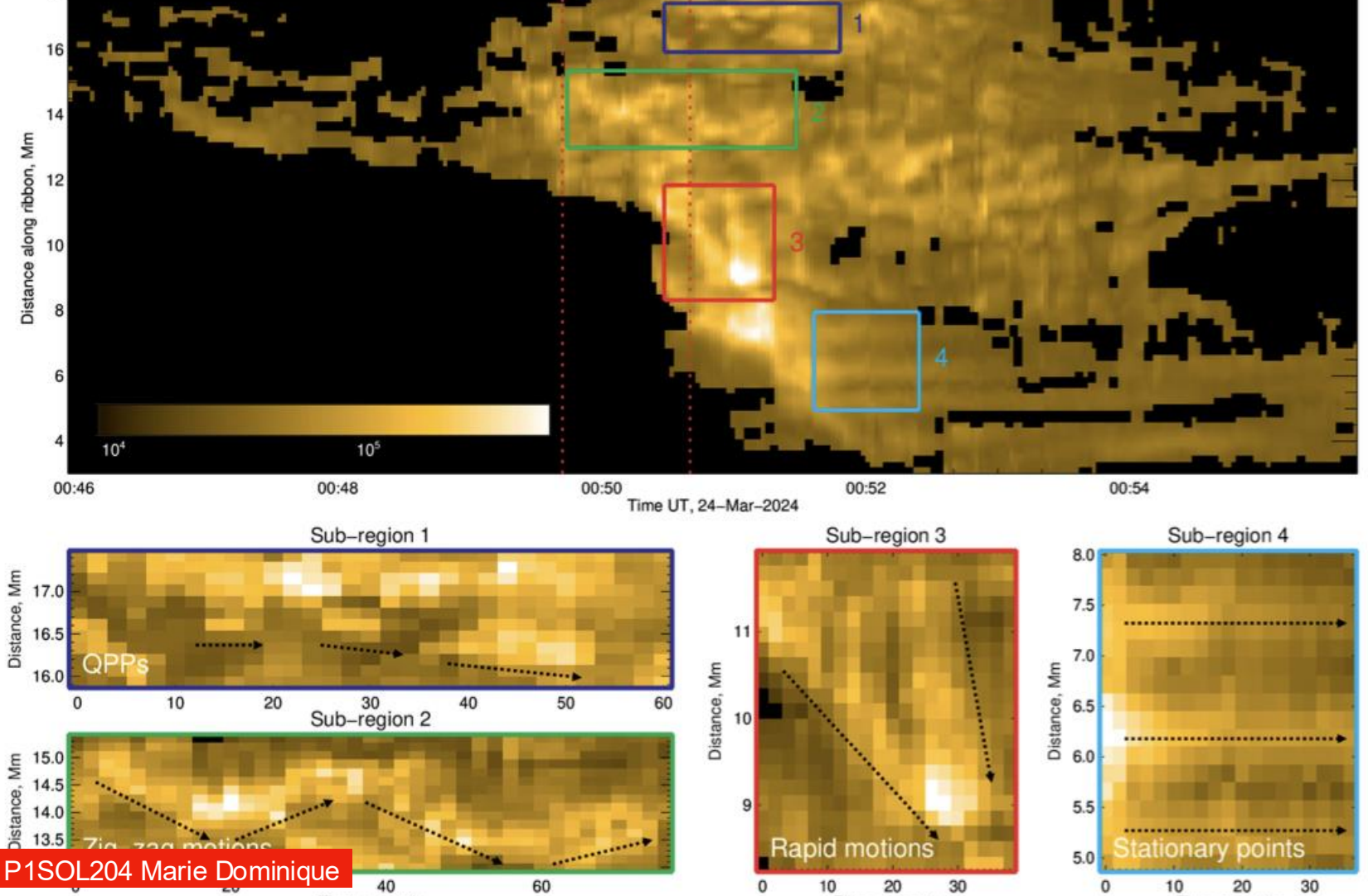
French 2025


EUI/HRIEUV 174 Å, 00:50:50 UT
B
HRIEUV 174 Å (subset 1), 00:50:50 UT
C
Short Exp HRIEUV 174 Å (subset 2), 00:50:58 UT
D

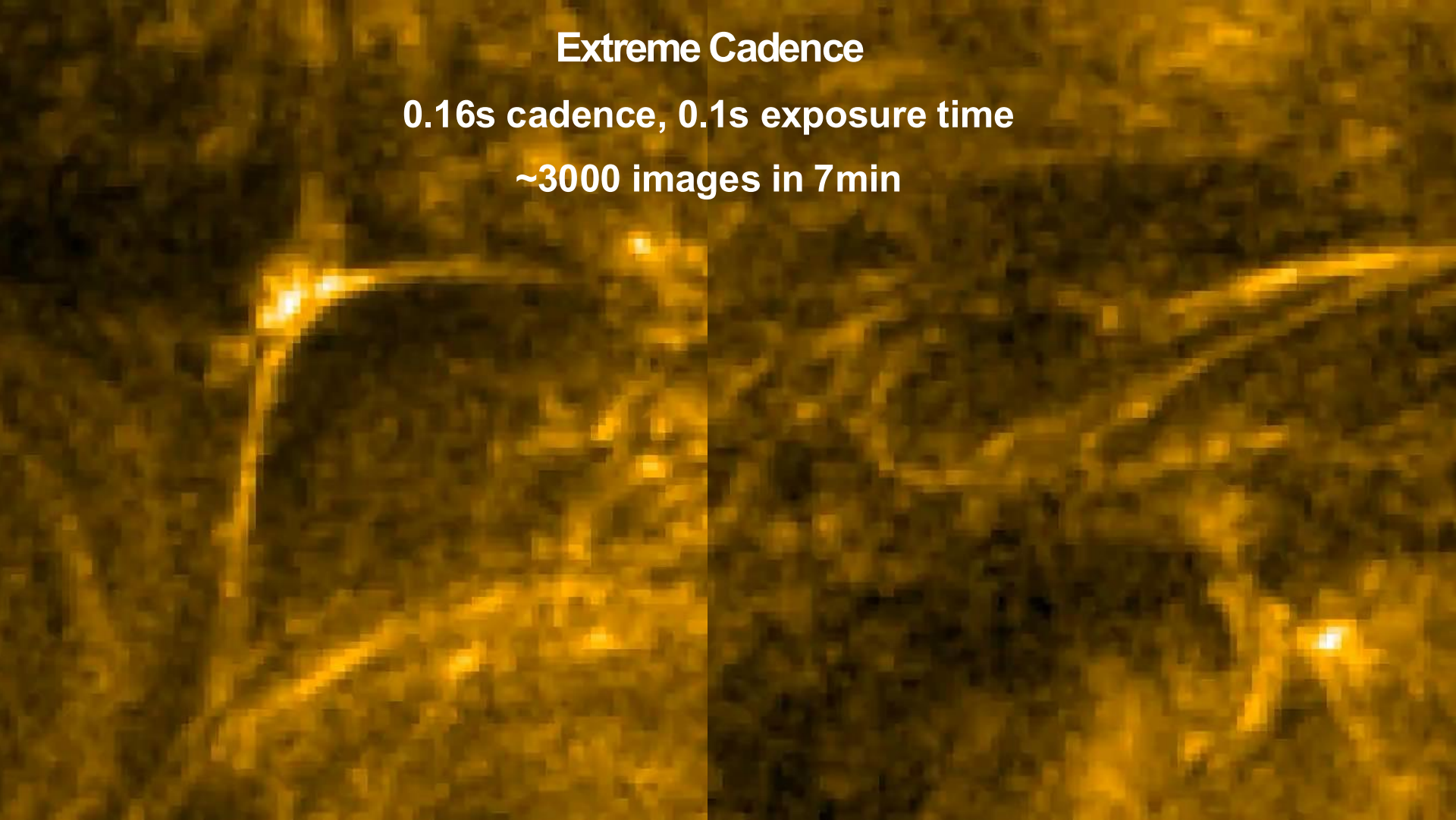
French 2025


X, Mm
0
2
4
6
8
10
12
14
16
A
00:50:28 UT
50
40
30
20
10
0
Y, pixels
8
6
4
2
0
Y, Mm
0
20
40
60
80
100
X, pixels

French 2025



QPP: Poster P1SOL204 Marie Dominique


Extreme Cadence
0.16s cadence, 0.1s exposure time
~3000 images in 7min

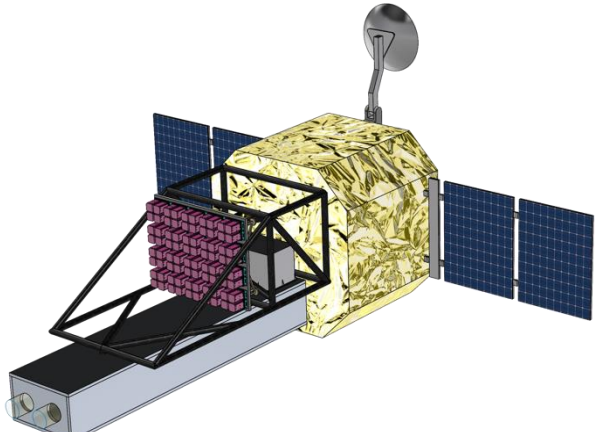
SPARK

Solar Particle Acceleration Radiation and Kinetics



Submitted in response to the ESA's call for an M-class mission opportunity 2025
Lead Proposer - Dr. Hamish Reid, UCL Mullard Space Science Laboratory, RH5 6NT, UK
Email: hamish.reid@ucl.ac.uk; Phone +44 1483 204 107

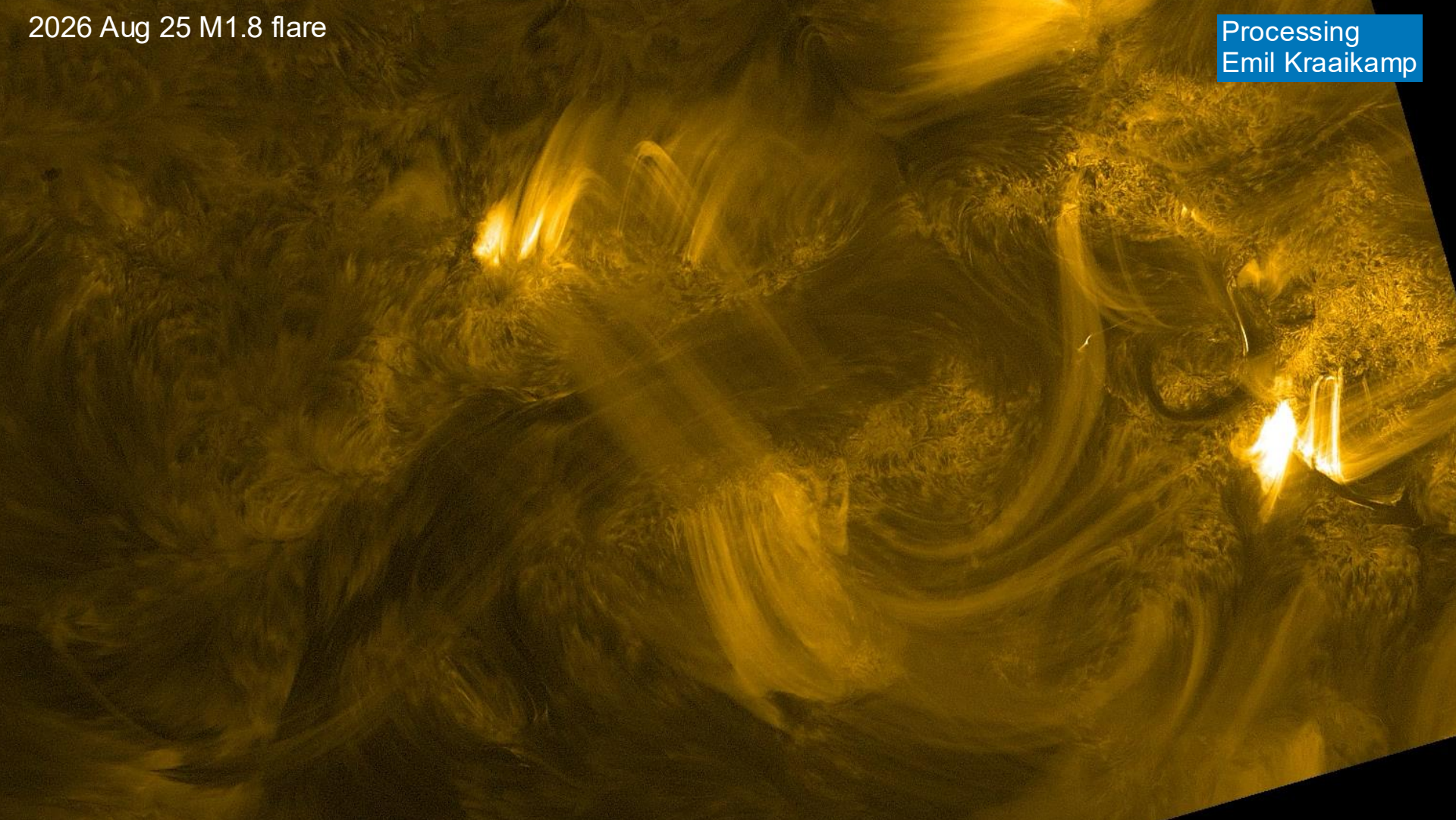
mission proposed for the ESA M8 mission call.



Channel	$\Delta\lambda$	Main spectral lines	log T_{max}	Telescope
94 Å	10 Å	Fe XVIII - 93.93 Å	6.9	T1
132 Å	10 Å	Fe XX - 132.84 Å, Fe XXIII - 132.91 Å, Fe XXII - 135.81 Å	7.2	T1
171 Å	10 Å	Fe IX - 171.53 Å, Fe X - 174.53 Å	5.8	T2
304 Å	10 Å	He II - 303.78 Å	4.9	T2

Summary

- The same standard flare model applies from the biggest flares to the smallest observable flares
- Critical areas of big flares are poorly observed in EUV because of saturation
- Short exposures by EUI/HRIEUV show unsaturated cores of flares
- Ribbon kernels and post-flare loops can be as small as 200km and evolve faster than a few seconds.
- Estimates of densities & energy fluxes in flare cores might be off by orders of magnitude
- The ESA M8 mission proposal “SPARK” is designed to observe the smallest scales in flares and to understand particle acceleration


2026 Aug 25 M1.8 flare
Processing
Emil Kraaikamp

Abstract

Major solar flares are at the origin of many space weather phenomena. Besides the flash across the entire spectrum, flares are associated with shock waves, particle acceleration, radio bursts, prominence eruptions and CMEs. Since 2024, Solar Orbiter has embarked on a series of campaigns to observe Major Solar Flares. In this presentation we discuss the results so far of a series of unique data sets collected mainly by the STIX instrument and the HRIEUV telescope of the EUI instrument.
As an X-ray imaging spectrometer, STIX has continuously observed on the order of 10^5 flares from solar minimum in 2020 till now. For the high resolution HRIEUV imager it is much harder to catch a flare, because it can operate only occasionally and with subfield as small as 1/30th of the solar disk at perihelion. Thanks to the so-called short exposures at 2s cadence, HRIEUV can however for the first time observe flare dynamics at small length & time-scales that have remained veiled for earlier EUV imagers due to pixel saturation & blooming.
These Solar Orbiter Major Flare observations indicate that flares are not always the monolithic, catastrophic collapse of an entire magnetic structure but rather a build-up or an avalanche of magnetic threads reconnecting. The footpoint kernels in the flare ribbons have time and length-scales that are barely resolved with the 2s cadence /100 km pixel size characteristics of HRIEUV datasets. Also the width of some post-flare loops are at the 2-pixel scale suggesting the actual width is smaller than 200km. These small scales pose new questions on the required energy and plasma densities.

Whereas the impact of solar flares can be felt at heliospheric scales, the data from Solar Orbiter are thus telling us that the physics driving major flares, operates at remarkably small spatial and temporal scales.

Using this insight for timely flare reporting suggests that modest resolution requirements for monitoring instruments might be suboptimal.