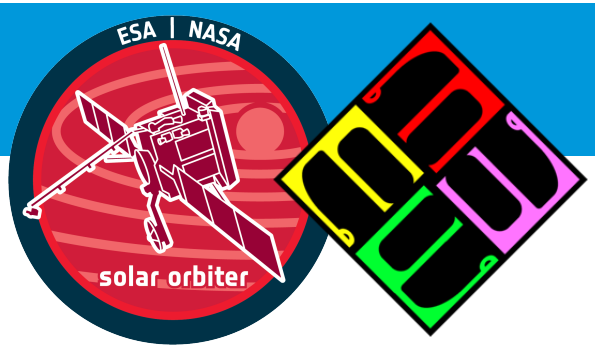


Introduction to EUV brightenings and summary EUI data availability

david.berghmans@oma.be

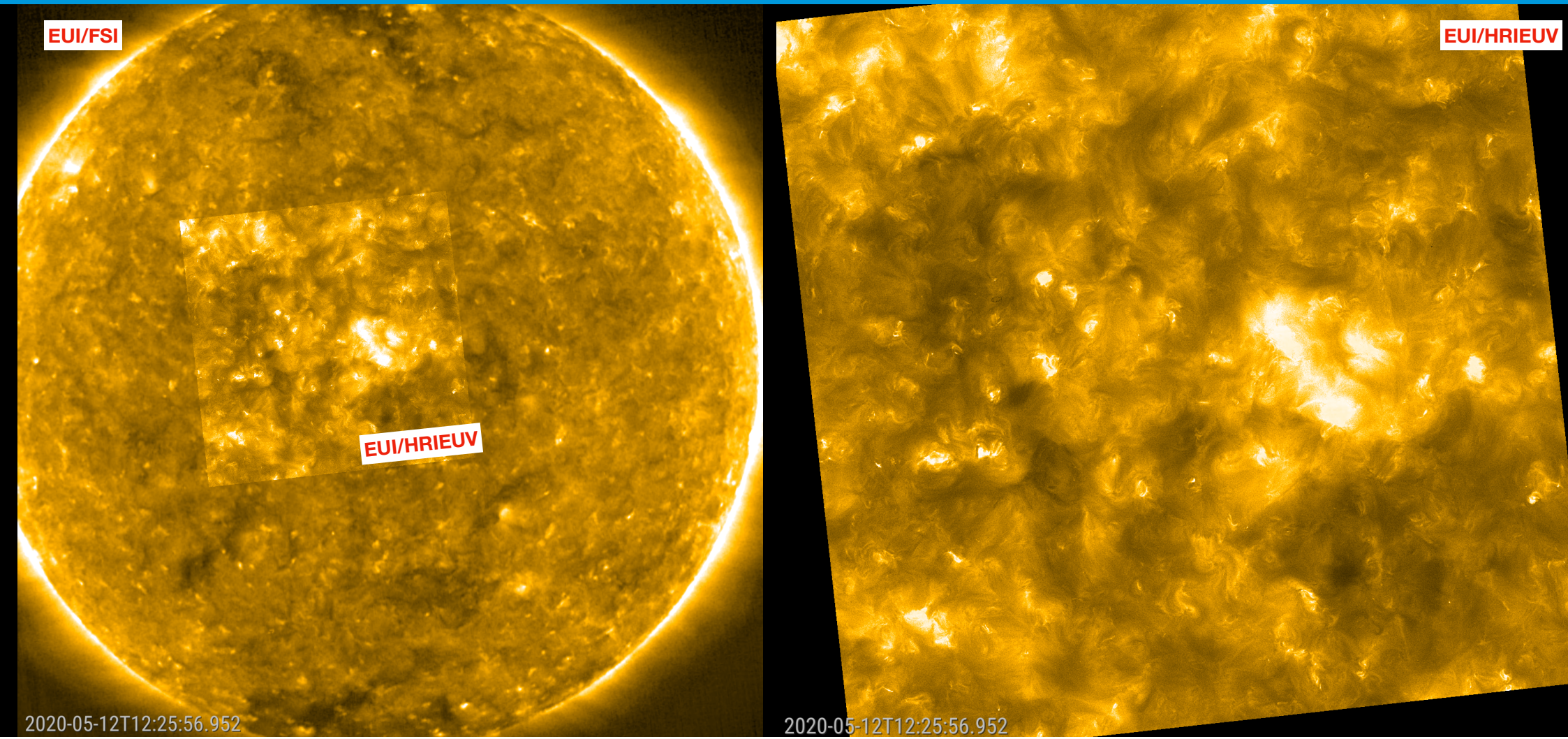
ISSI Team led by Nelson C. & Chitta P. “Novel Insights Into Bursts, Bombs, and Brightenings in the Solar Atmosphere from Solar Orbiter”

Overview

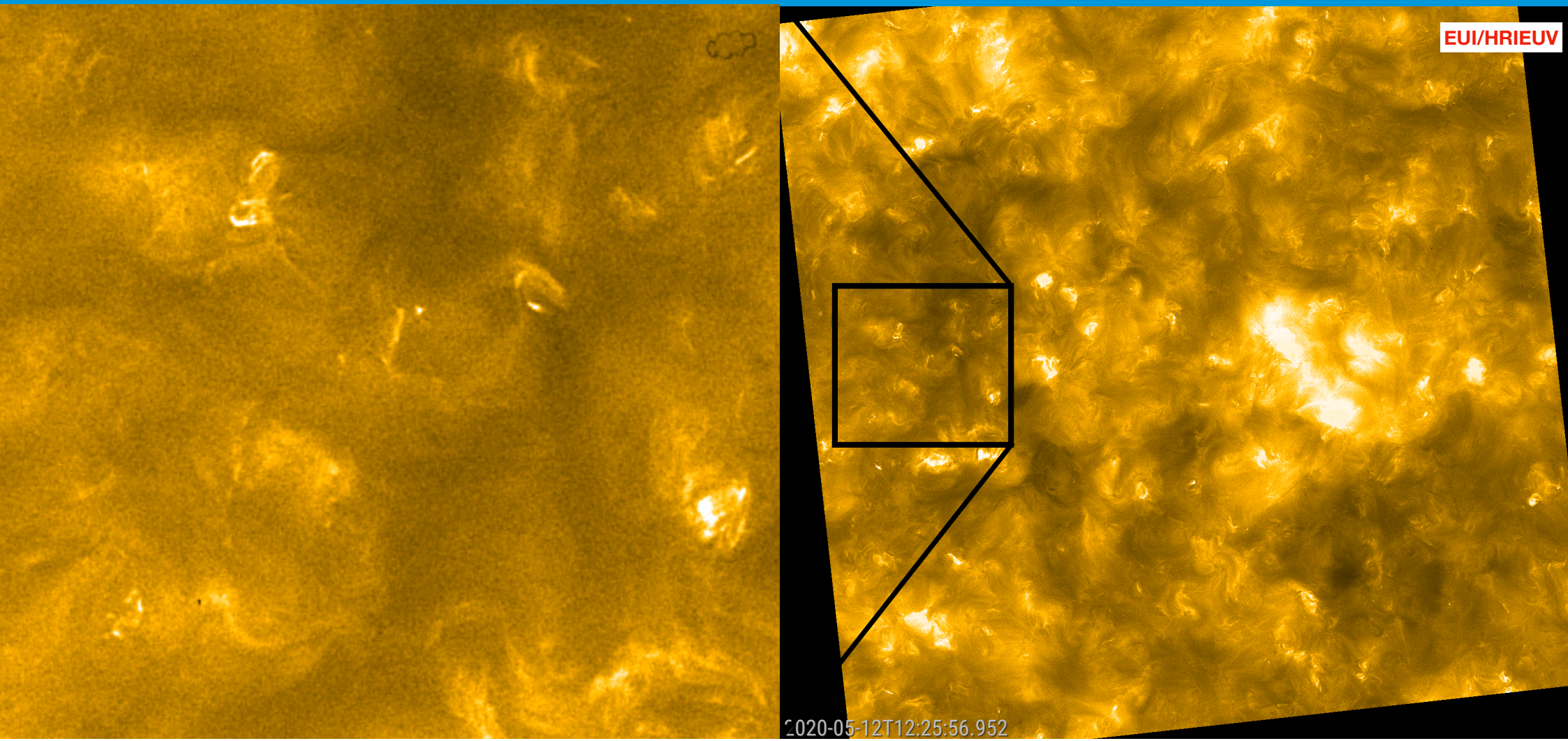
1. Campfires
2. Link with other coronal EUV brightenings
3. Data availability

EUI first light 2020 May 12, @ 0.663 AU

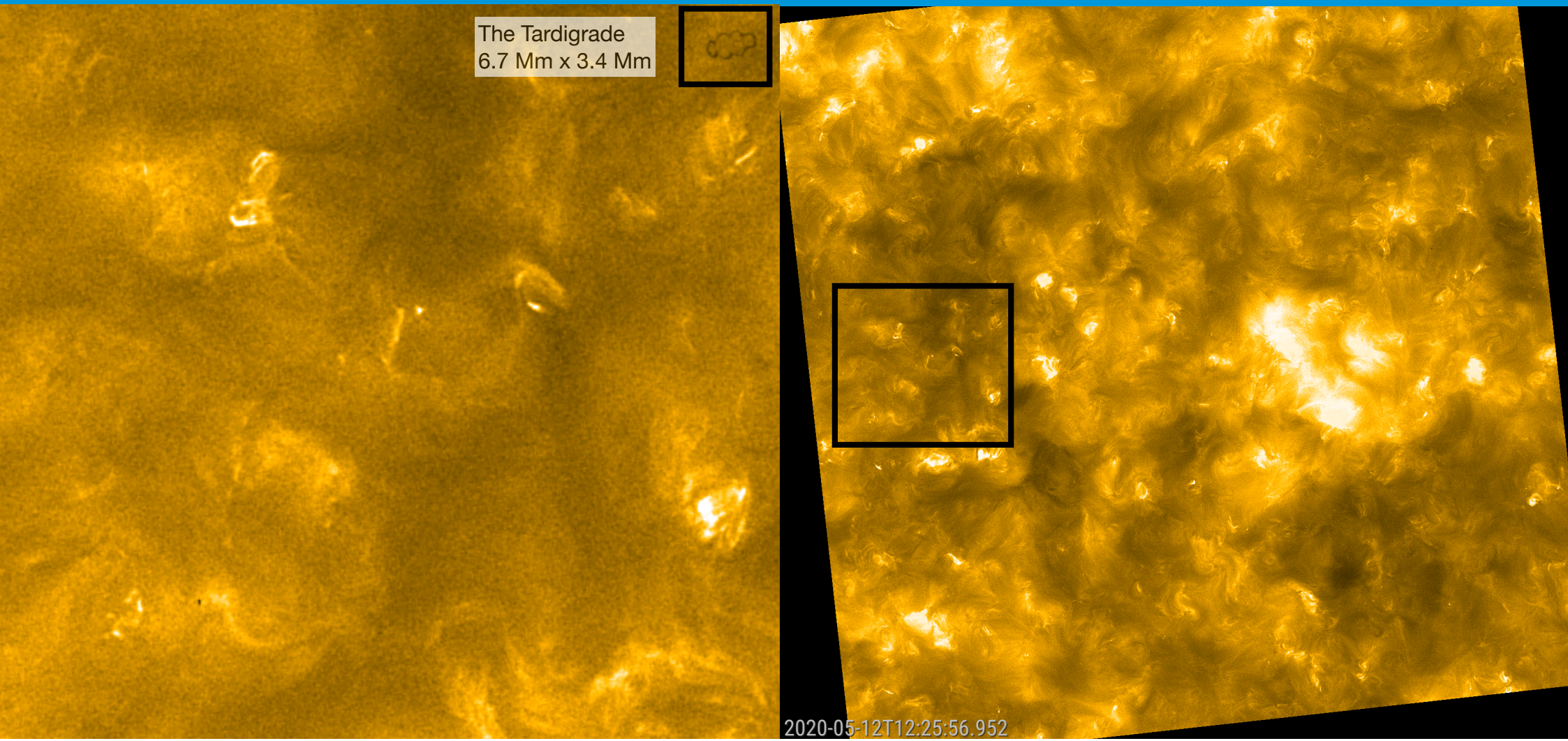
K. Stegen, P. Smith
EUI operator team



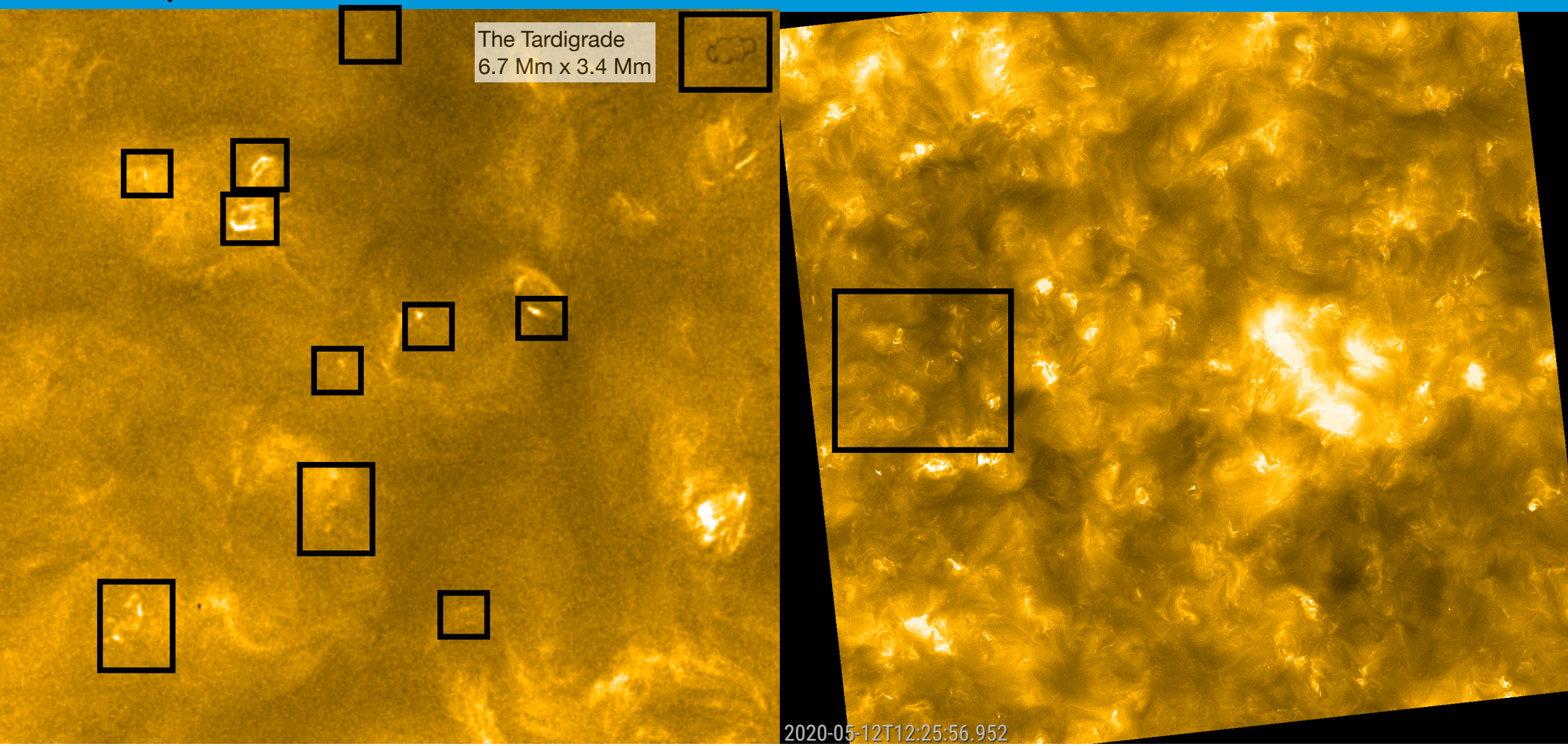
EUI first light 2020 May 12, @ 0.663 AU

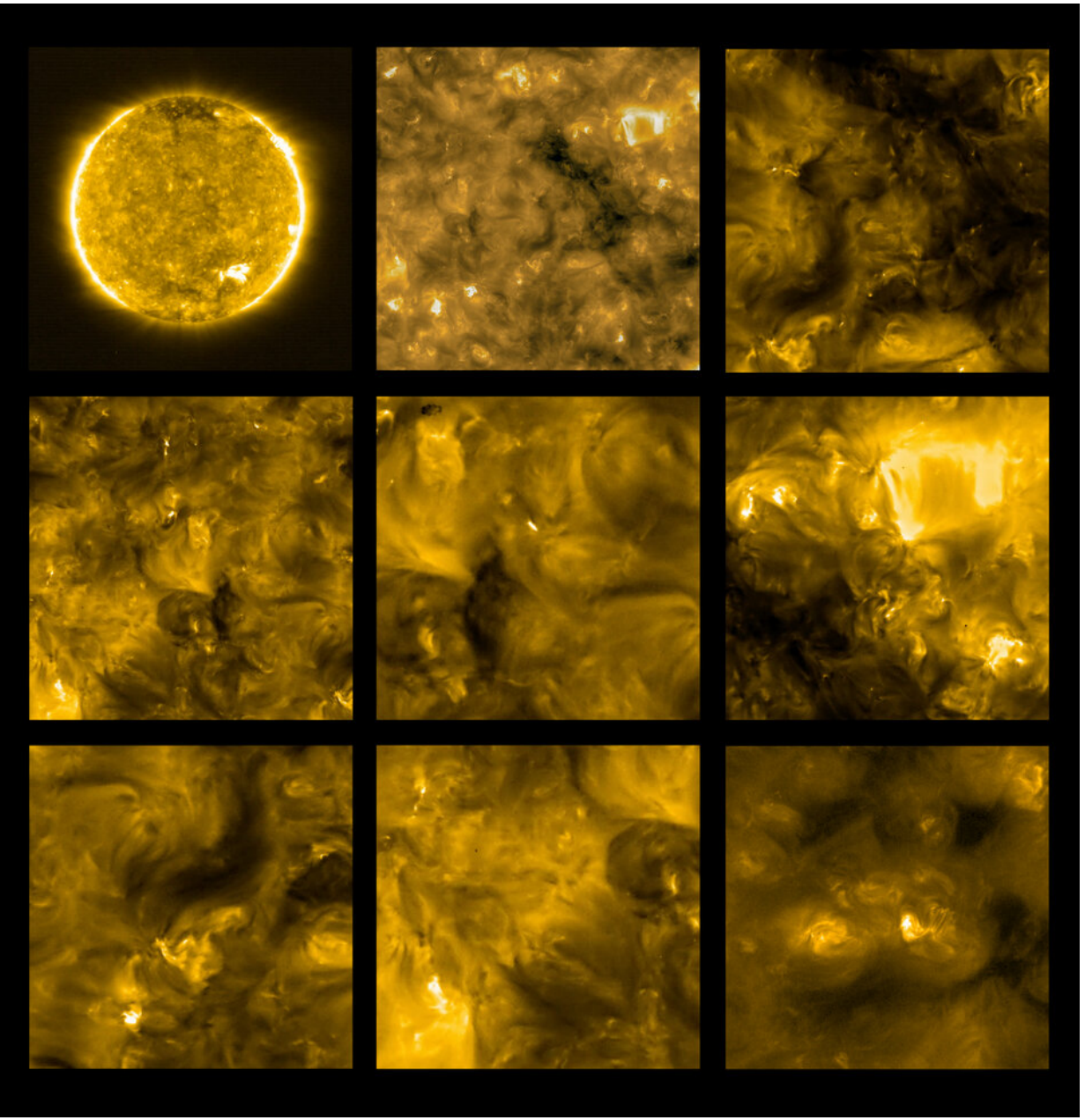


EUI first light 2020 May 12, @ 0.663 AU



EUI first light 2020 May 12, @ 0.663 AU





SCIENCE & EXPLORATION

Solar Orbiter's first images reveal 'campfires' on the Sun

16/07/2020 98446 VIEWS 192 LIKES

ESA / Science & Exploration / Space Science / Solar Orbiter

The first images from Solar Orbiter, a new Sun-observing mission by ESA and NASA, have revealed omnipresent miniature solar flares, dubbed 'campfires', near the surface of our closest star.

According to the scientists behind the mission, seeing phenomena that were not observable in detail before hints at the enormous potential of Solar Orbiter, which has only just finished its early phase of technical verification known as commissioning.

"Solar Orbiter First Results", Special Issue Astronomy and Astrophysics

Extreme-UV quiet Sun brightenings observed by the Solar Orbiter/EUI

D. Berghmans[1,⋆], F. Auchère[2], D. M. Long[3], E. Soubrié[2,8], M. Mierla[1,13], A. N. Zhukov[1,9], U. Schühle[4], P. Antolin[10], L. Harra[5,6], S. Parenti[2], O. Podladchikova[5], R. Aznar Cuadrado[4], É. Buchlin[2], L. Dolla[1], C. Verbeeck[1], S. Gissot[1], L. Teriaca[4], M. Haberreiter[5], A. C. Katsiyannis[1], L. Rodriguez[1], E. Kraaikamp[1], P.J. Smith[3], K. Stegen[1], P. Rochus[11], J. P. Halain[11,12], L. Jacques[11], W.T. Thompson[7], and B. Inhester[4]

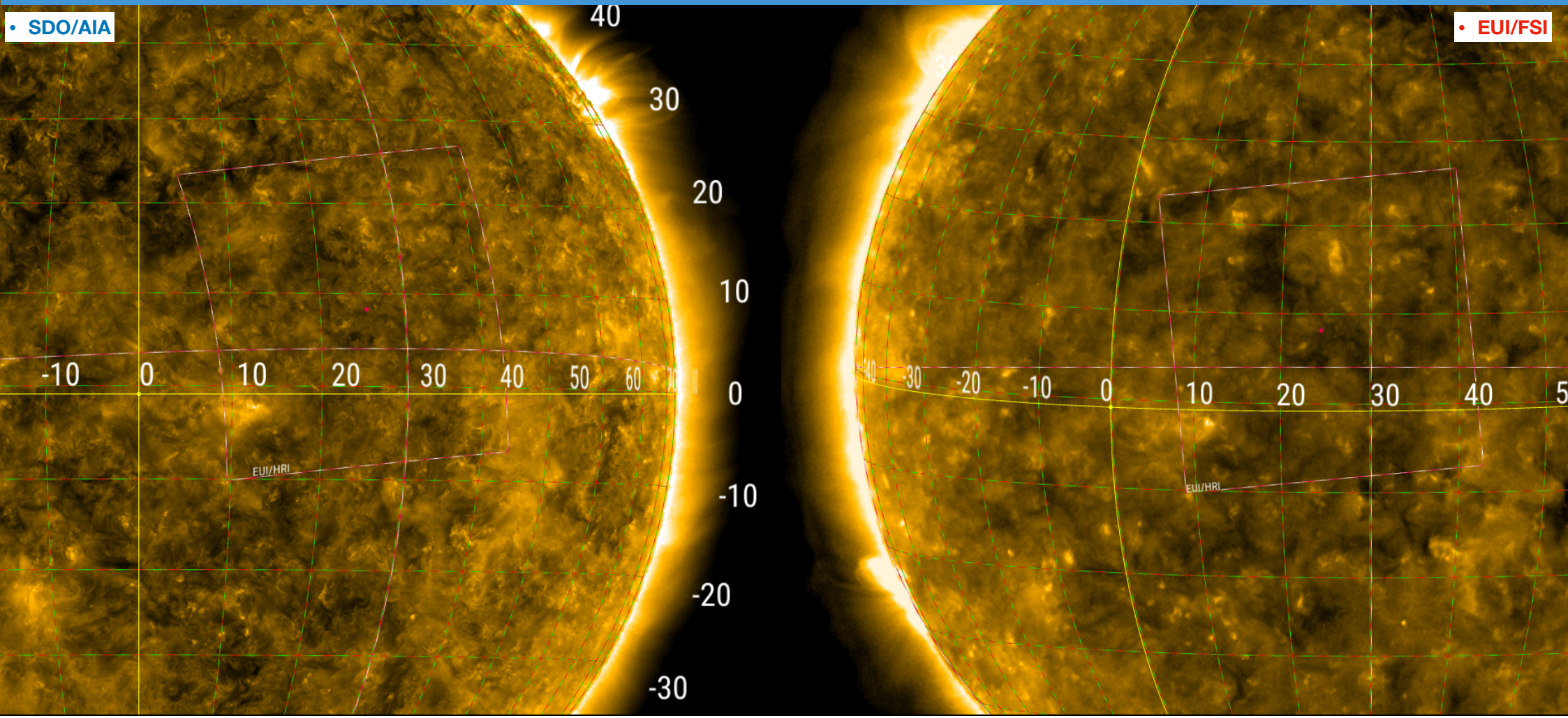
Stereoscopy of extreme UV quiet Sun brightenings observed by Solar Orbiter/EUI

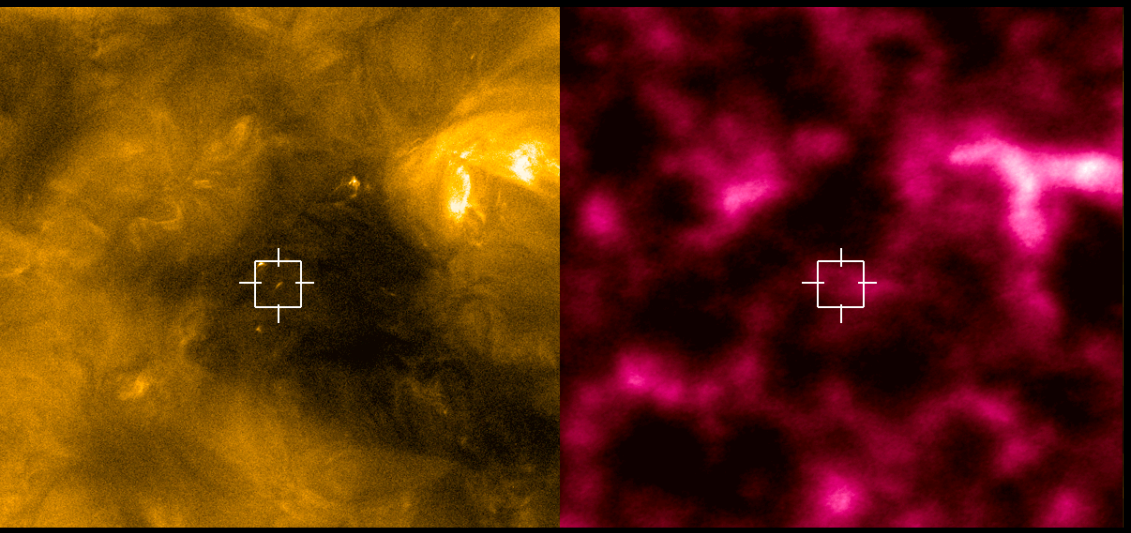
A. N. Zhukov[1,2,⋆], M. Mierla[1,3], F. Auchère[4], S. Gissot[1], L. Rodriguez[1], E. Soubrié[4,5], W. T. Thompson[6], B. Inhester[7], B. Nicula[1], P. Antolin[8], S. Parenti[4], É. Buchlin[4], K. Barczynski[10,11], C. Verbeeck[1], E. Kraaikamp[1], P. J. Smith[9], K. Stegen[1], L. Dolla[1], L. Harra[10,11], D. M. Long[9], U. Schühle[7], O. Podladchikova[10], R. Aznar Cuadrado[7], L. Teriaca[7], M. Haberreiter[10], A. C. Katsiyannis[1], P. Rochus[12], J. P. Halain[12,13], L. Jacques[12], and D. Berghmans[1]

2020 May 30 sequence:
HRIEUV & HRILYA 50 images at 5 sec cadence
30 degrees west of Earth, at 0.56AU

F. Auchère

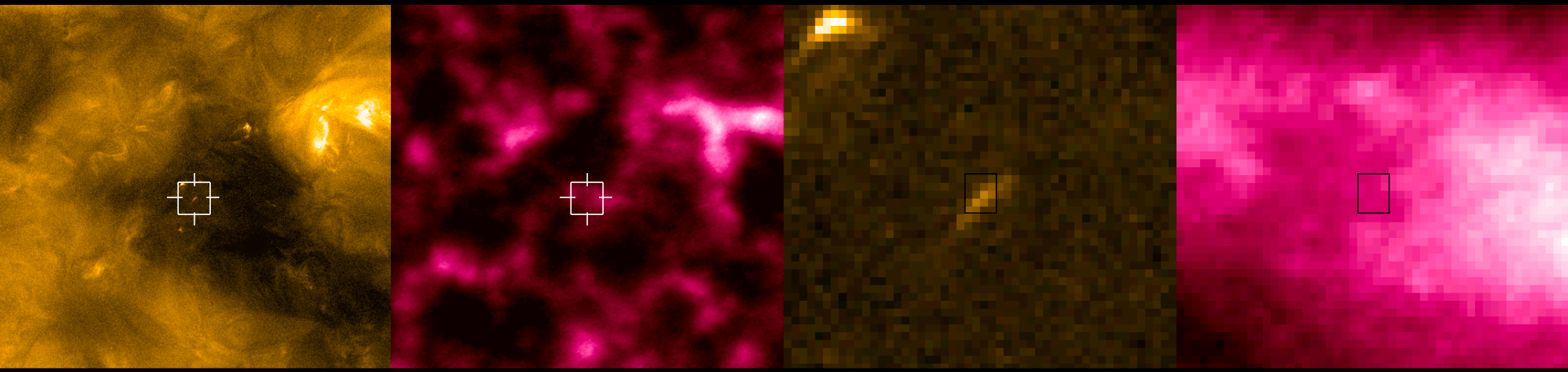
Data reprojected to Carrington coordinates on a sphere of 1.004 Rsun, 2.8 Mm above photosphere





HRIEUV 60x60 Mm2

HRILYA 60x60 Mm2 (+0s)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HRILYA 60x60 Mm2 (+0s)
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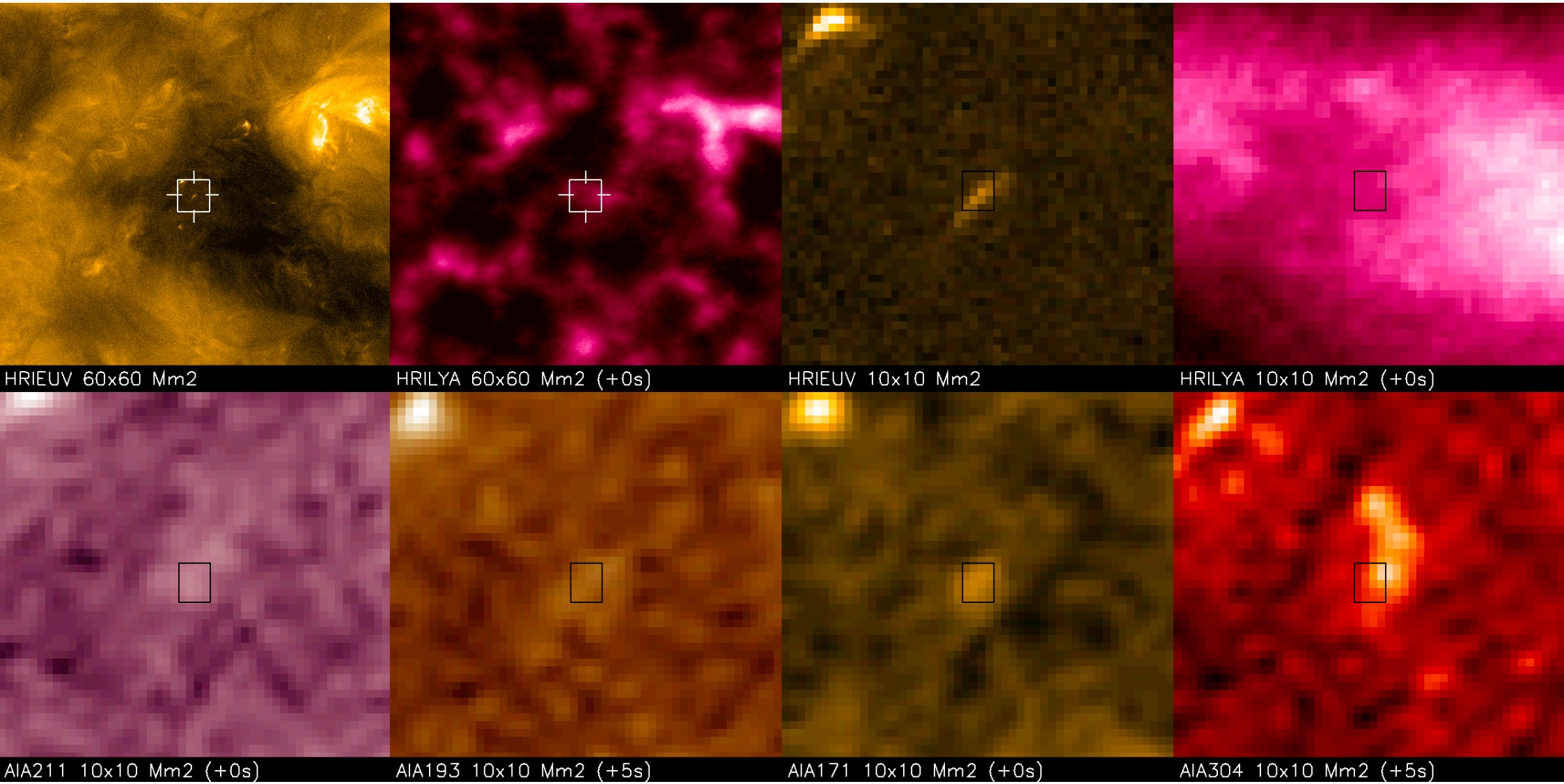
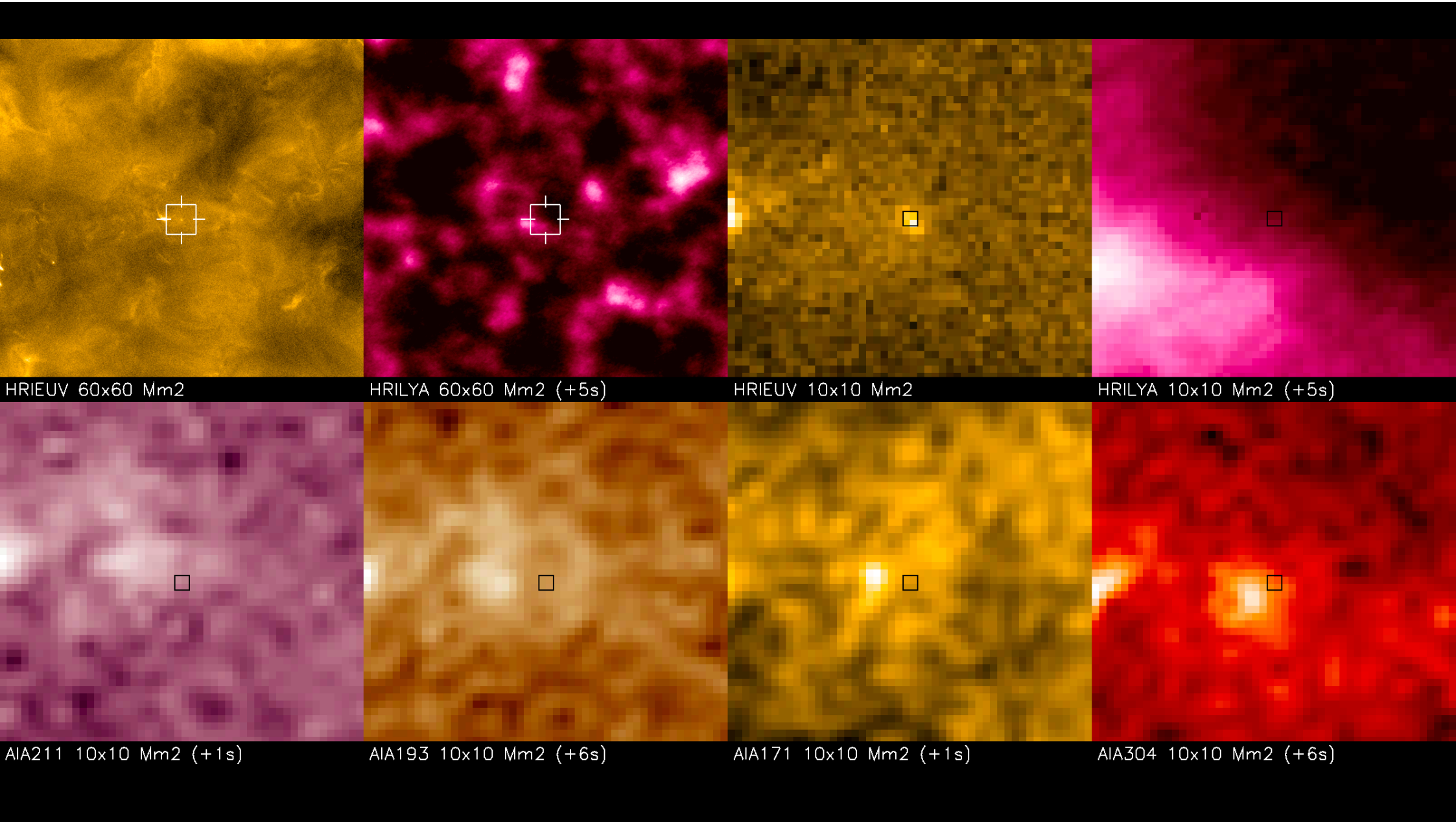
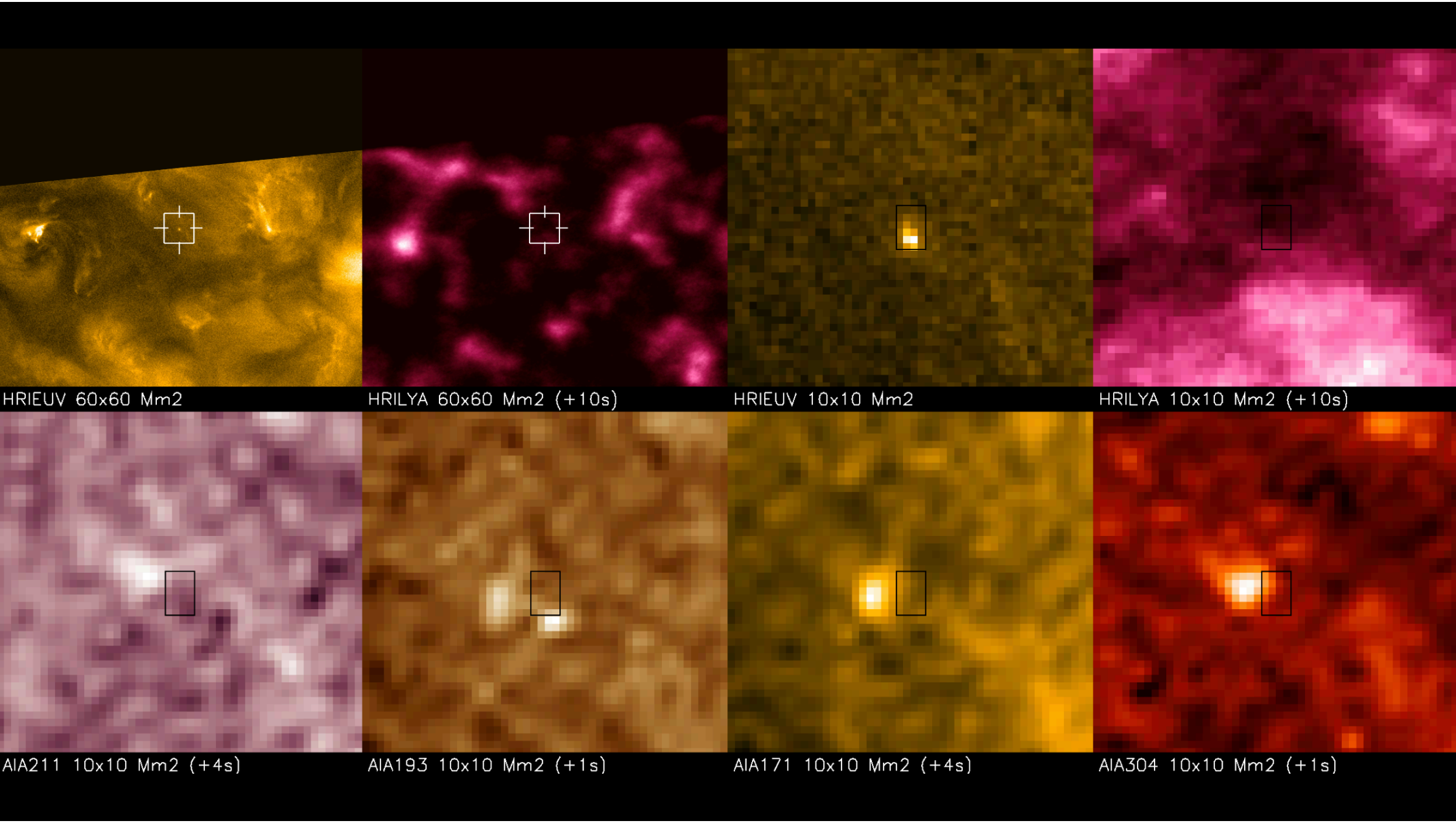
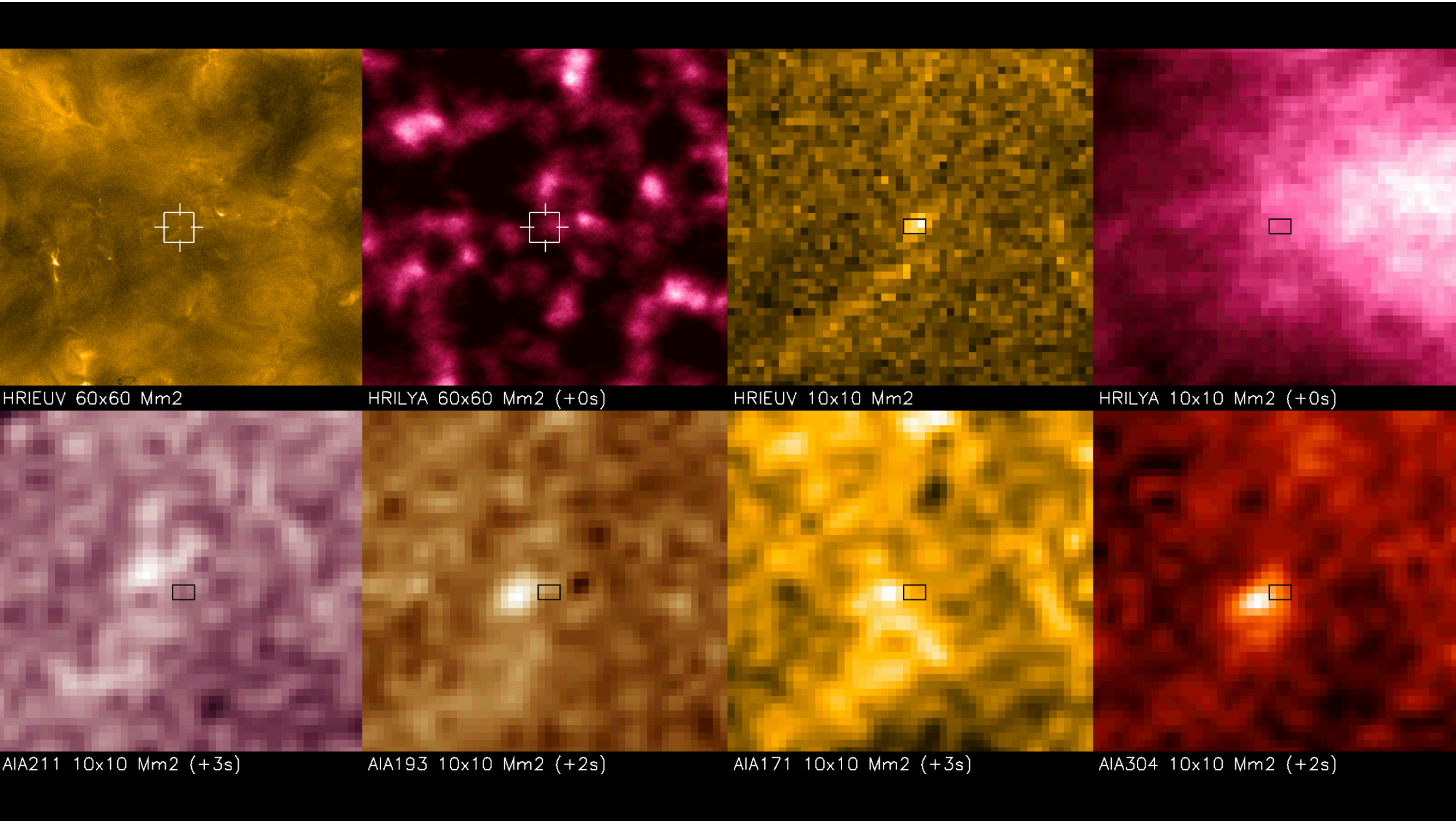
HRILYA 10x10 Mm2 (+0s)


HRIEUV 60x60 Mm2
HRILYA 60x60 Mm2 (+0s)
HRIEUV 10x10 Mm2
HRILYA 10x10 Mm2 (+0s)
AIA211 10x10 Mm2 (+0s)
AIA193 10x10 Mm2 (+5s)
AIA171 10x10 Mm2 (+0s)
AIA304 10x10 Mm2 (+5s)


HRIEUV 60x60 Mm2
HRILYA 60x60 Mm2 (+5s)
HRIEUV 10x10 Mm2
HRILYA 10x10 Mm2 (+5s)
AIA211 10x10 Mm2 (+1s)
AIA193 10x10 Mm2 (+6s)
AIA171 10x10 Mm2 (+1s)
AIA304 10x10 Mm2 (+6s)


HRIEUV 60x60 Mm2
HRILYA 60x60 Mm2 (+10s)
HRIEUV 10x10 Mm2
HRILYA 10x10 Mm2 (+10s)
AIA211 10x10 Mm2 (+4s)
AIA193 10x10 Mm2 (+1s)
AIA171 10x10 Mm2 (+4s)
AIA304 10x10 Mm2 (+1s)


HRIEUV 60x60 Mm2
HRILYA 60x60 Mm2 (+0s)
HRIEUV 10x10 Mm2
HRILYA 10x10 Mm2 (+0s)
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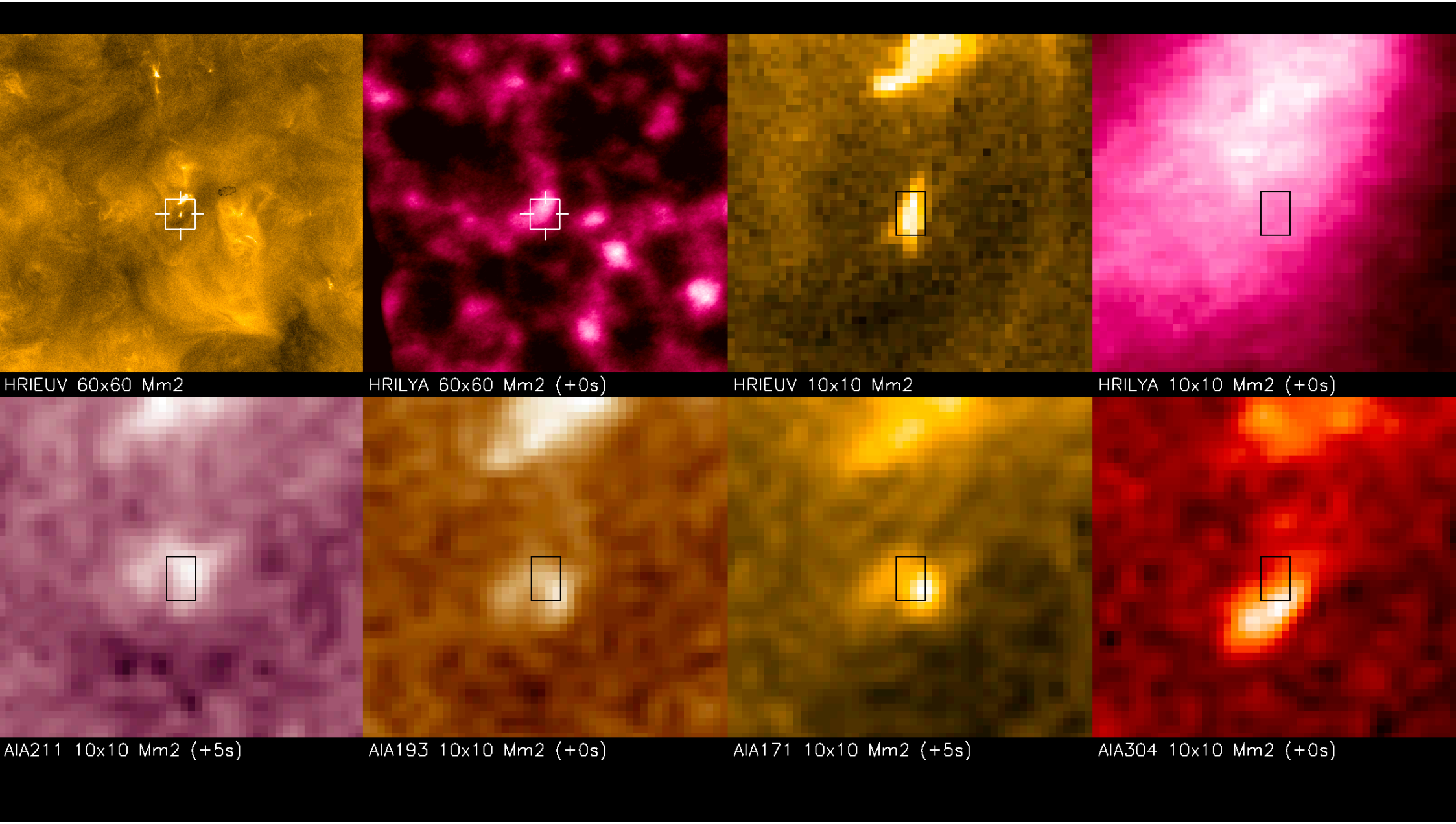
AIA193 10x10 Mm2 (+2s)
AIA171 10x10 Mm2 (+3s)
AIA304 10x10 Mm2 (+2s)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HRILYA 60x60 Mm2 (+0s)
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AIA193 10x10 Mm2 (+0s)
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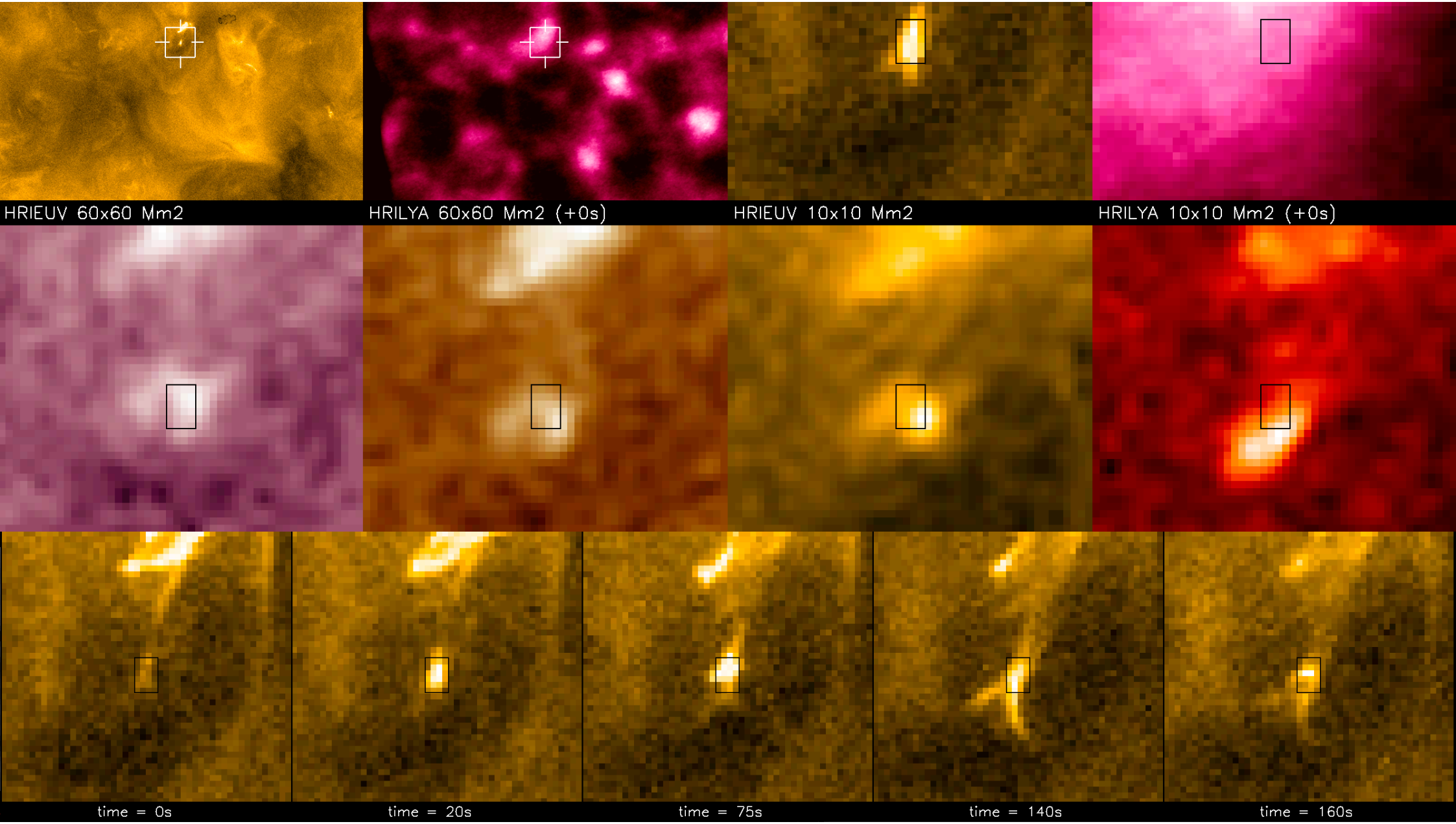
AIA304 10x10 Mm2 (+0s)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HRILYA 60x60 Mm2 (+0s)
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HRILYA 10x10 Mm2 (+0s)
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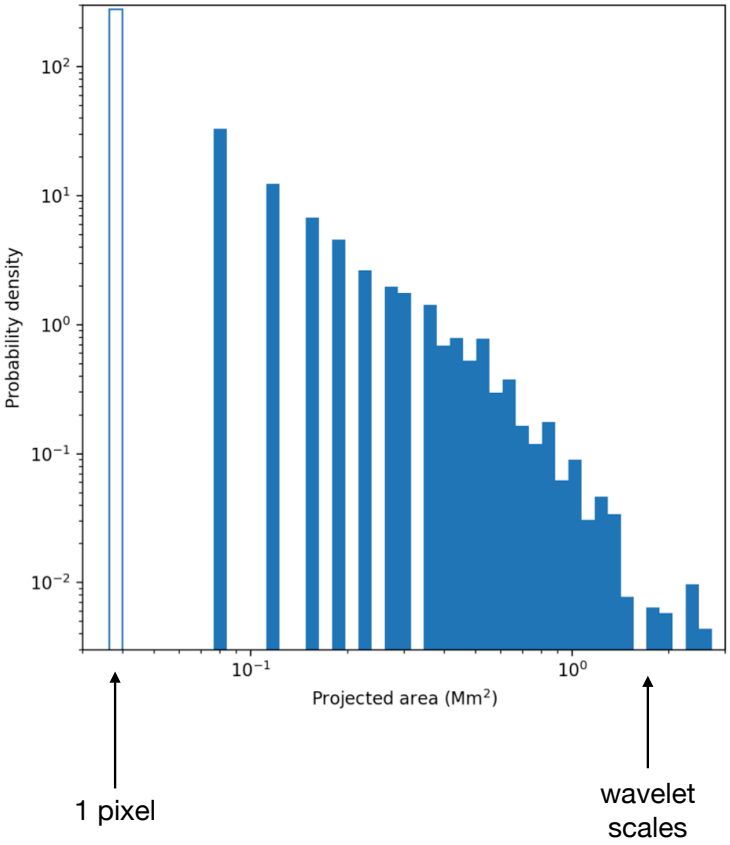
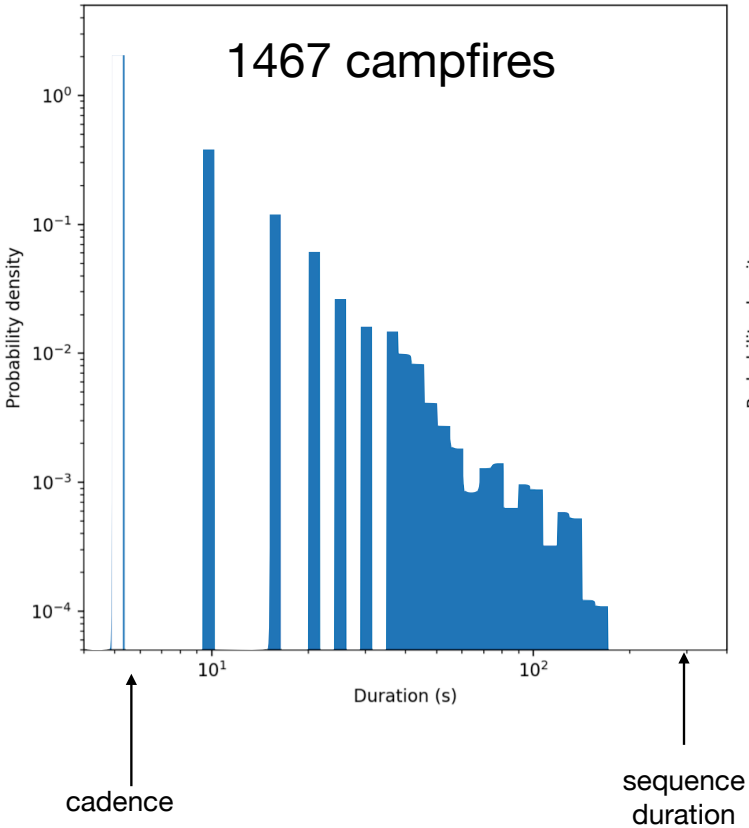
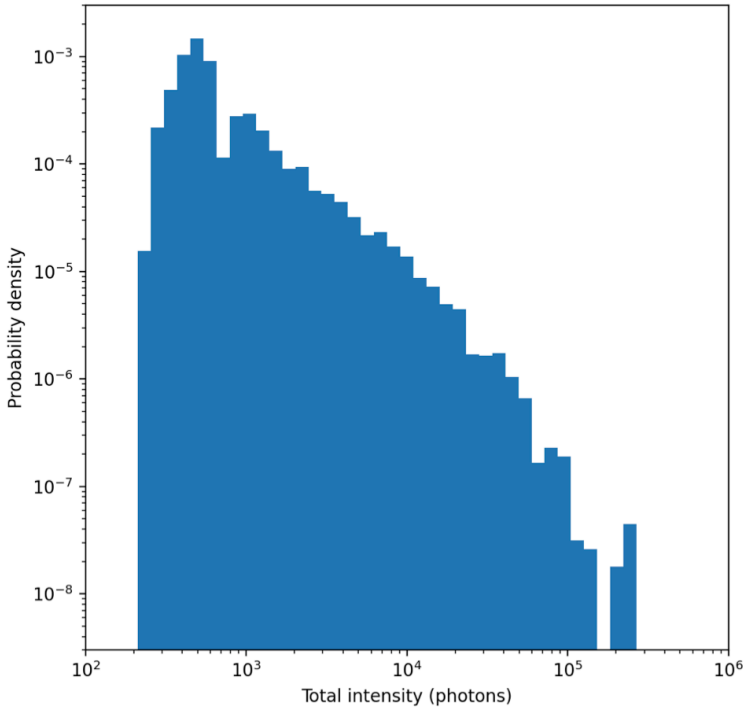
time = 20s
time = 75s
time = 140s
time = 160s

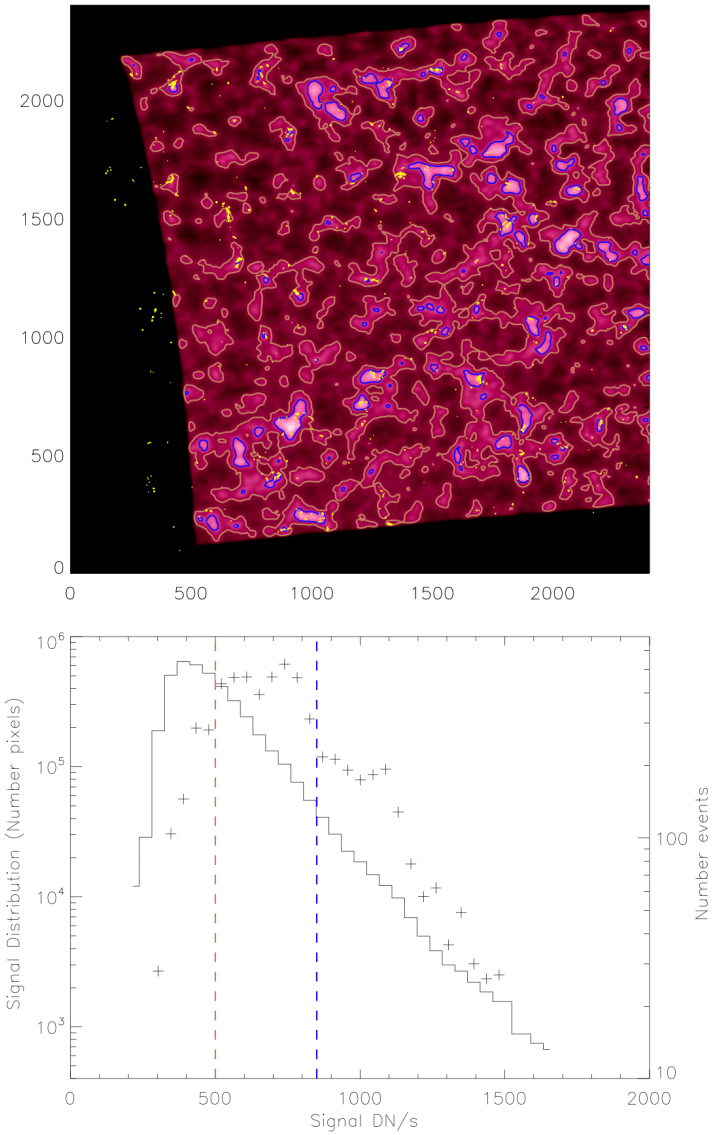




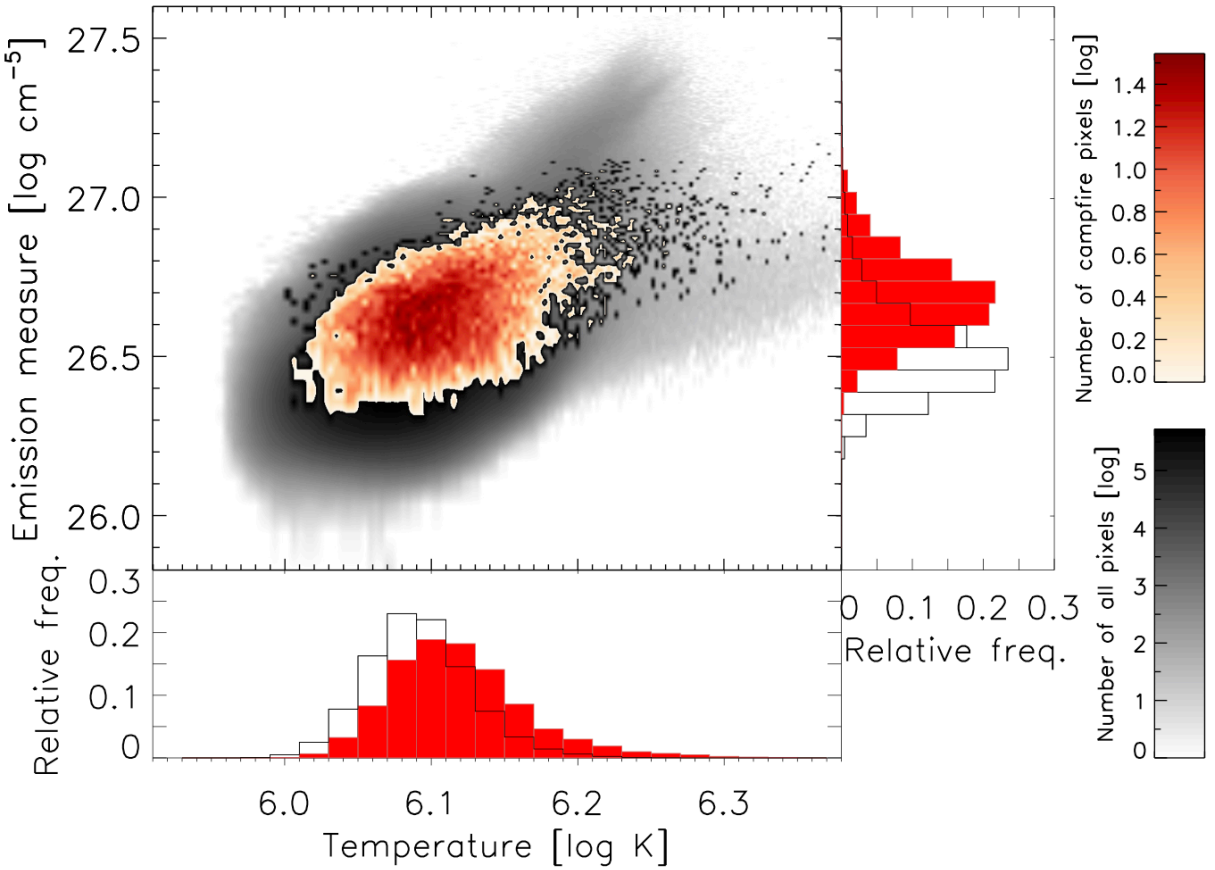


F. Auchère
wavelet based detection scheme

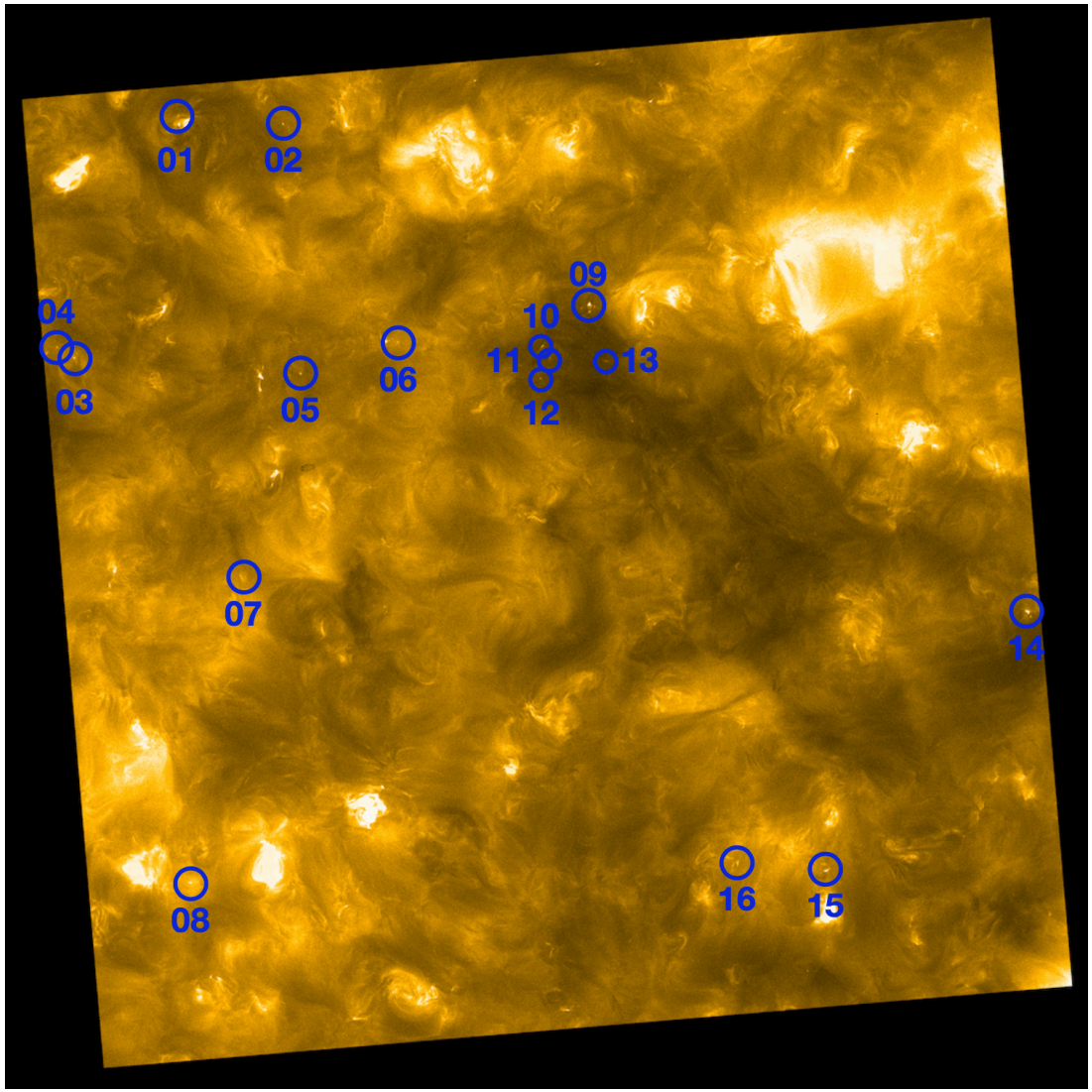
R. Aznar Cuadrado
campfires live at the edge of the chromospheric network

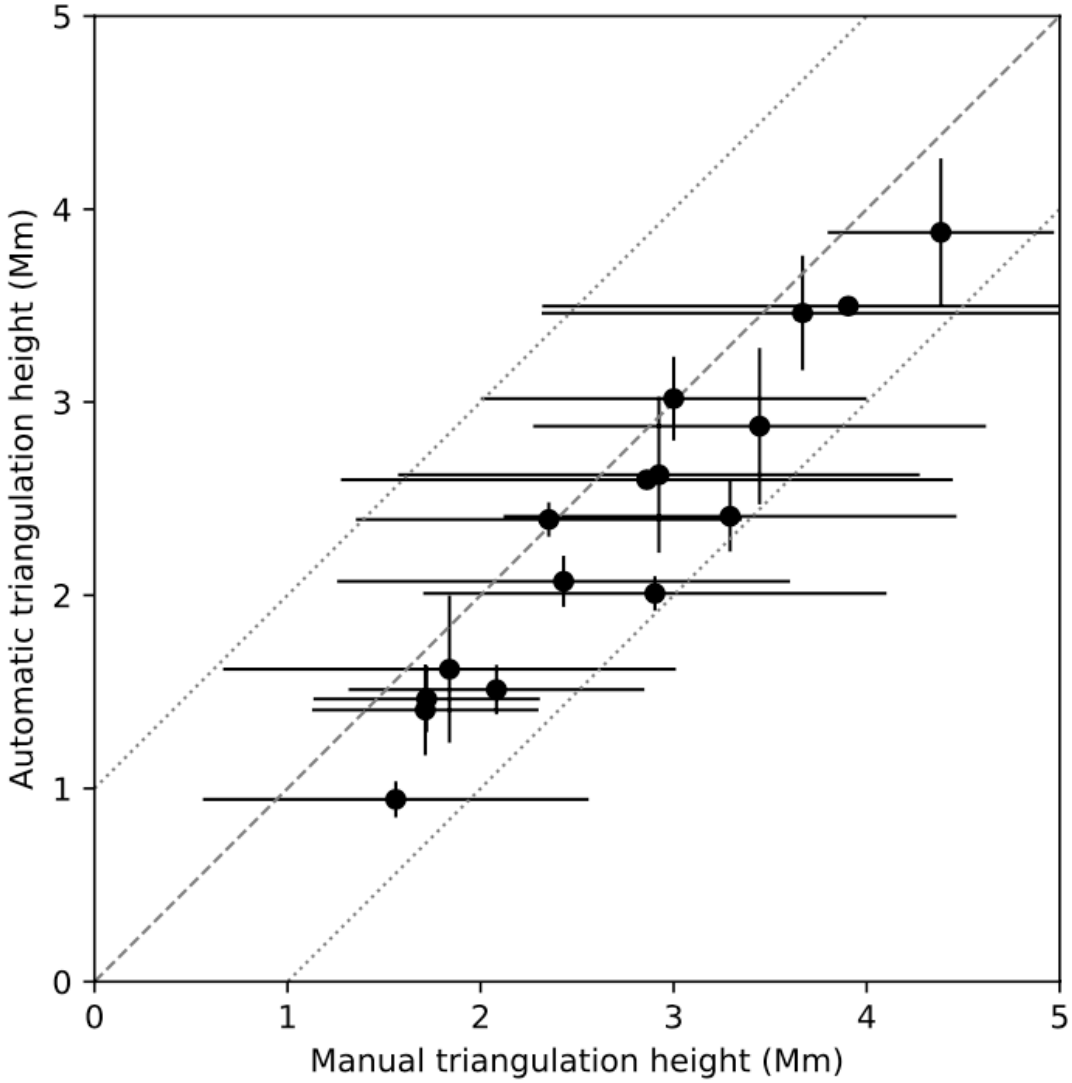


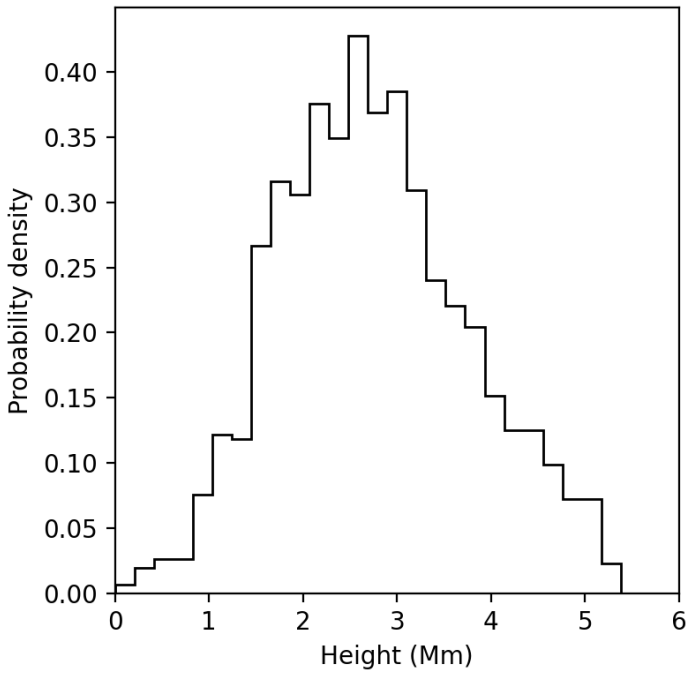
P. Antolin
campfires have coronal temperatures



A. Zhukov, M. Mierla, F. Auchère et al
manual and automatic campfire triangulation



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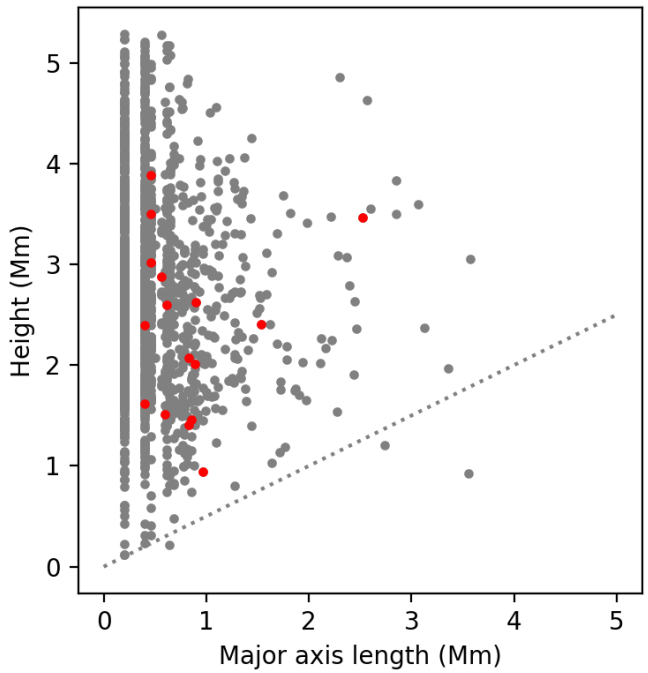
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0
1
2
3
4
5
6
Height (Mm)


Height (Mm)
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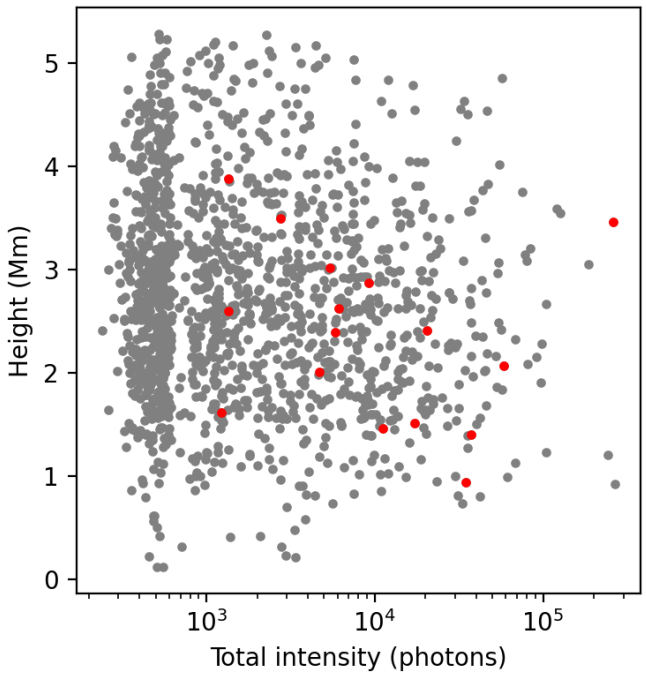
2
3
4
5
0
1
2
3
4
5
Major axis length (Mm)


Height (Mm)
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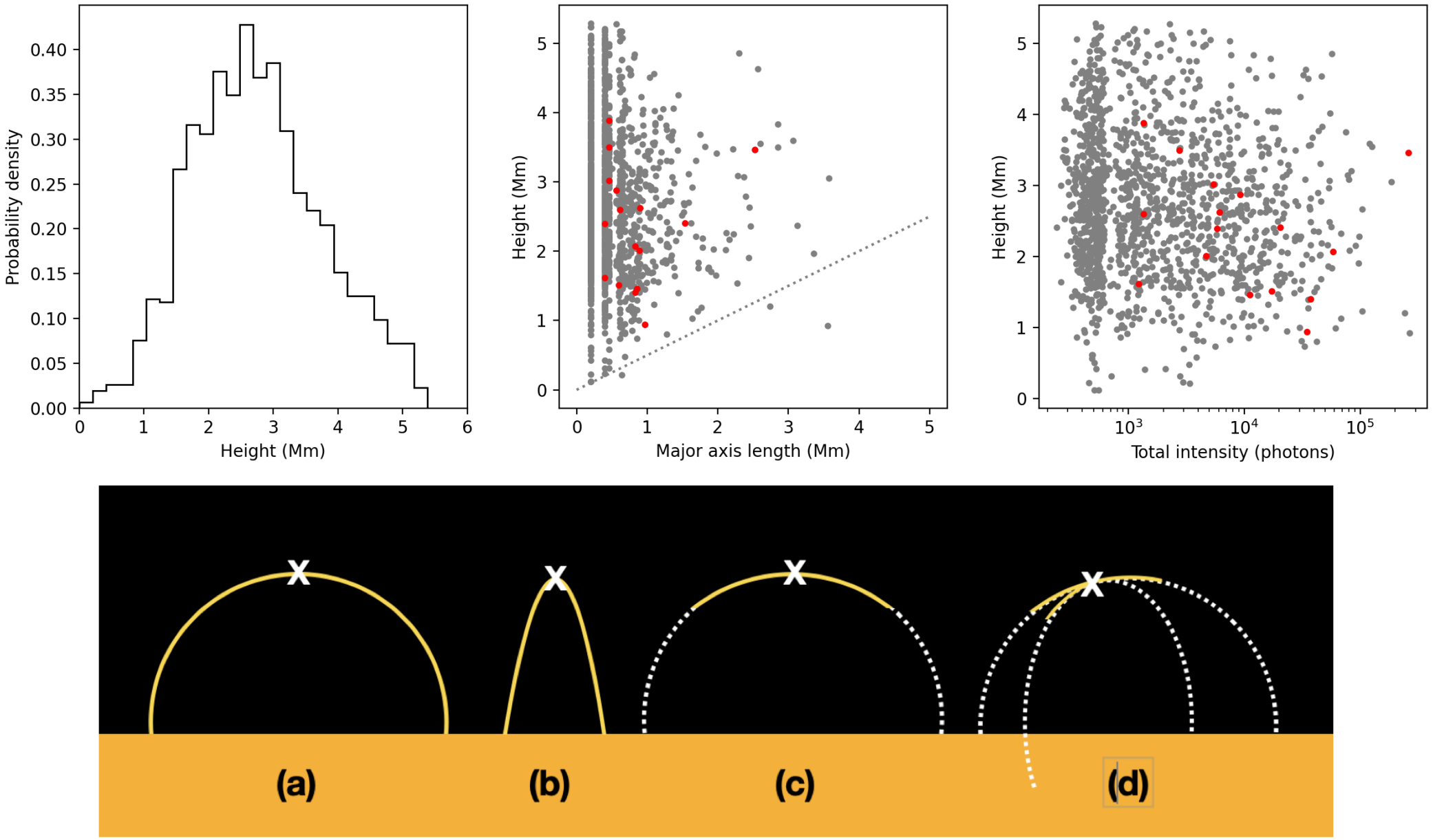
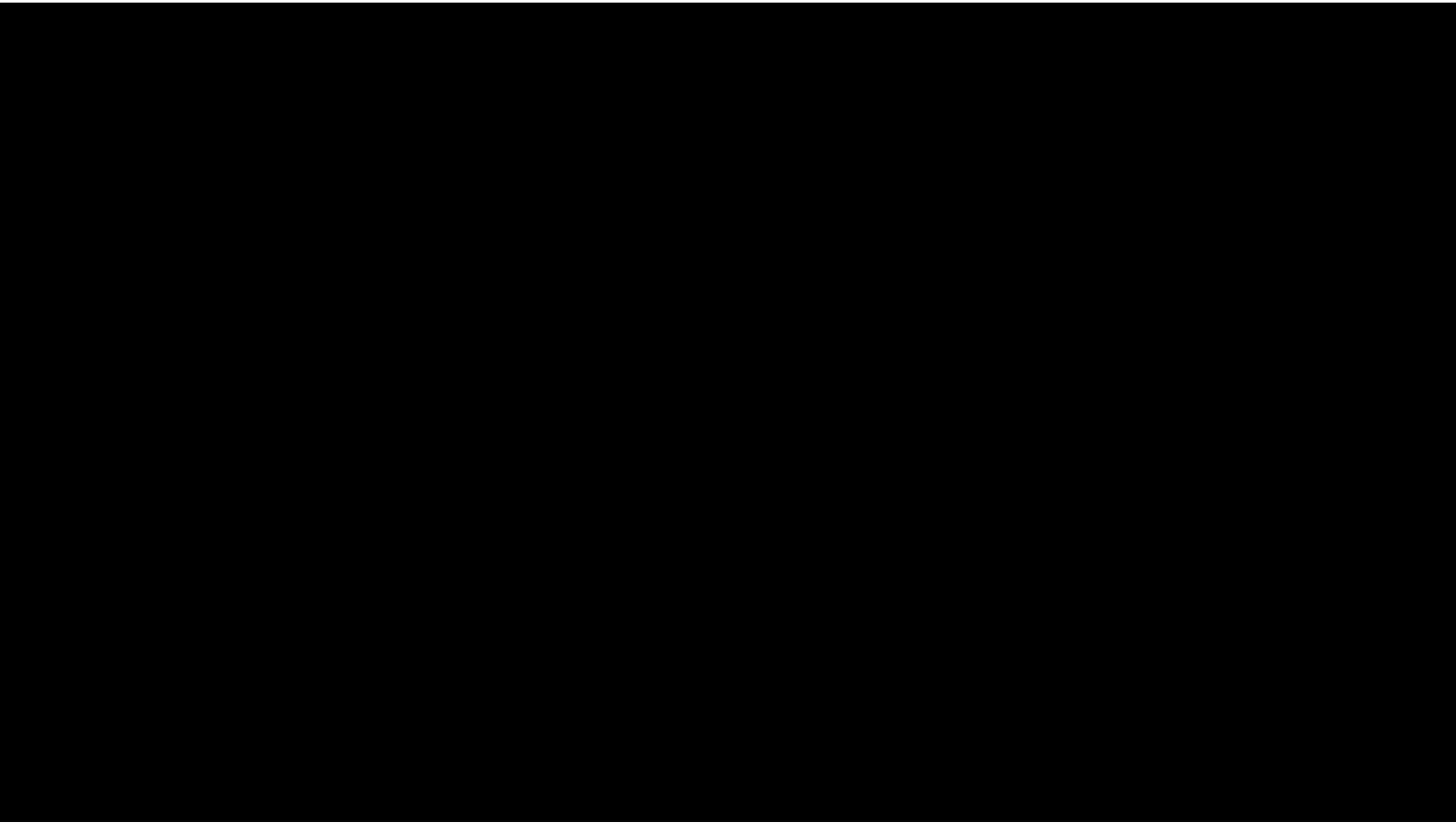
1
2
3
4
5
10^3
10^4
10^5
Total intensity (photons)


Probability density
Height (Mm)
Height (Mm)
Major axis length (Mm)
Height (Mm)
Total intensity (photons)
(a)
(b)
(c)
(d)

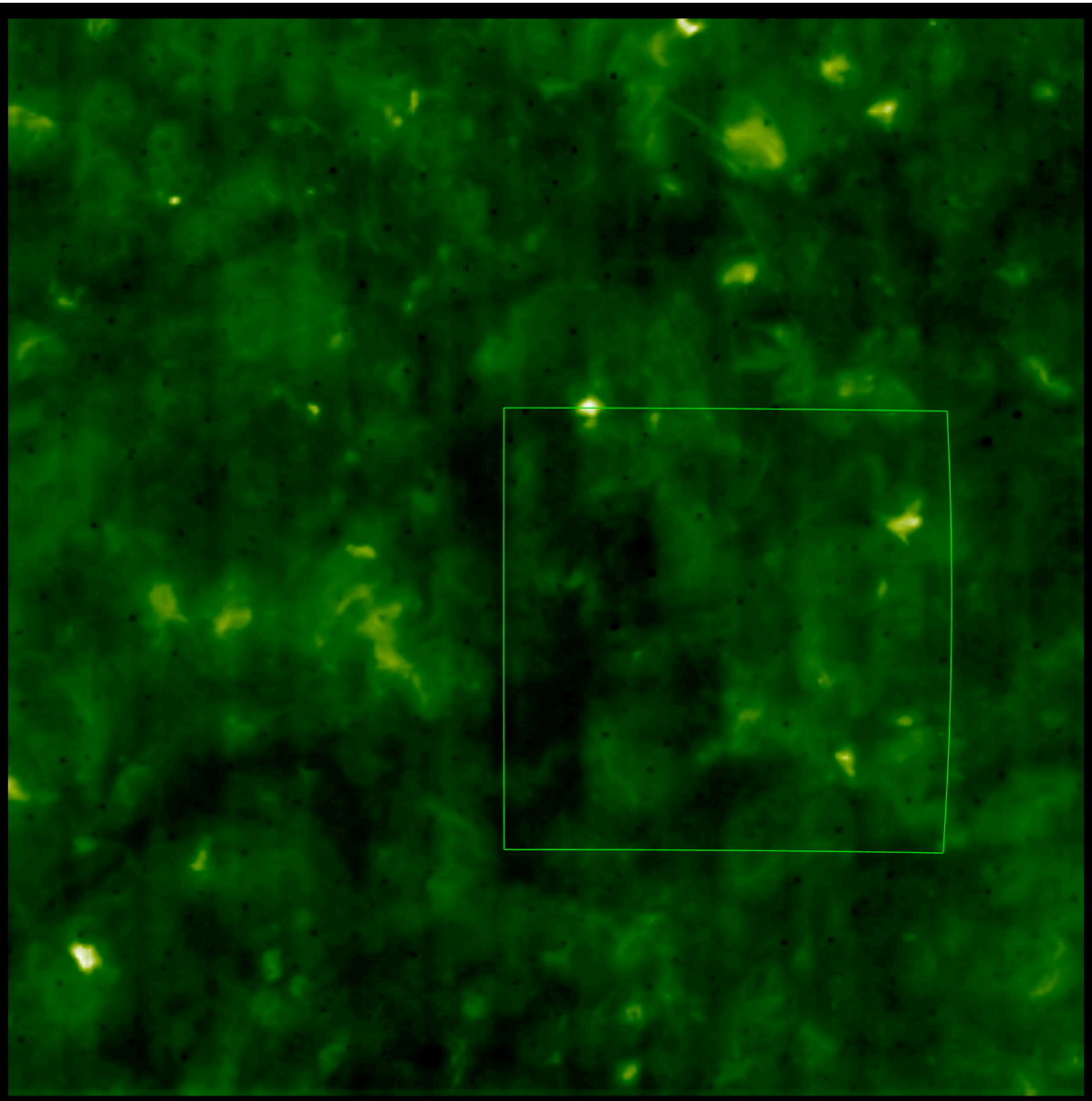
Other results

- MURAM simulations show that campfire-like brightenings are driven by component reconnection and/or flux-rope eruption (Chen et al, 2021, AA)
- majority of campfires are flux-cancelletion events between bipolar elements (Kahil et al, 2022, AA), often preceded with a cool plasma eruption (Panesar et all, ApJ)
- not all campfires might actually reach coronal temperatures (Dolliou et al, 2023, AA), (Nelson et al, 2023, AA), (Huang et al, 2023, AA)
- larger campfires show jet-like motions (Zhenyong et al, 2021, ApJLett), (Mandal et al, 2021, AALett), (Chitta et al 2021, AALett)
- campfires are in the picoflare like regimes and line-up with the nano/micro/ regular flares in the powerlaw histogram (Podladchikova et al, unpublished)



Overview

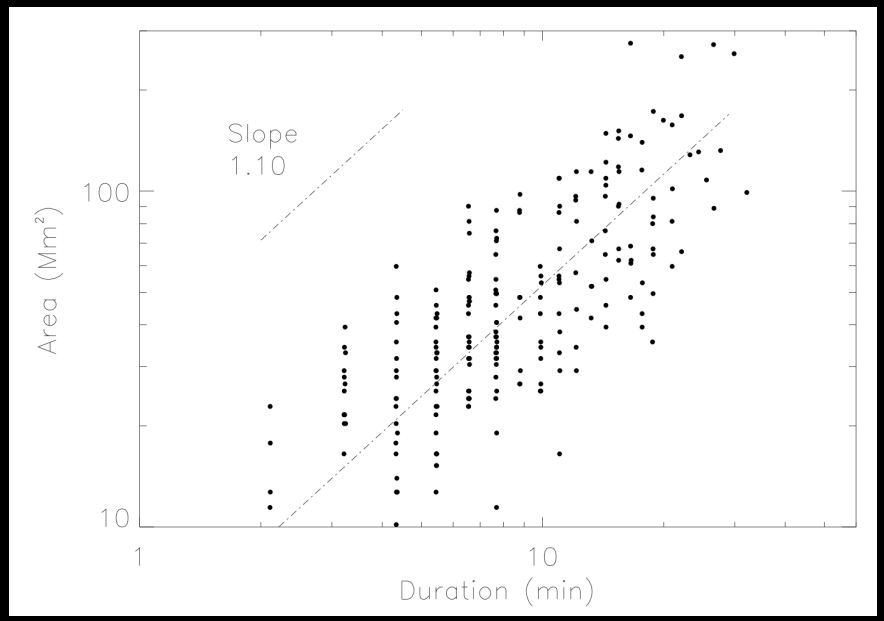
1. Campfires
2. Link with other coronal EUV brightenings
3. Data availability



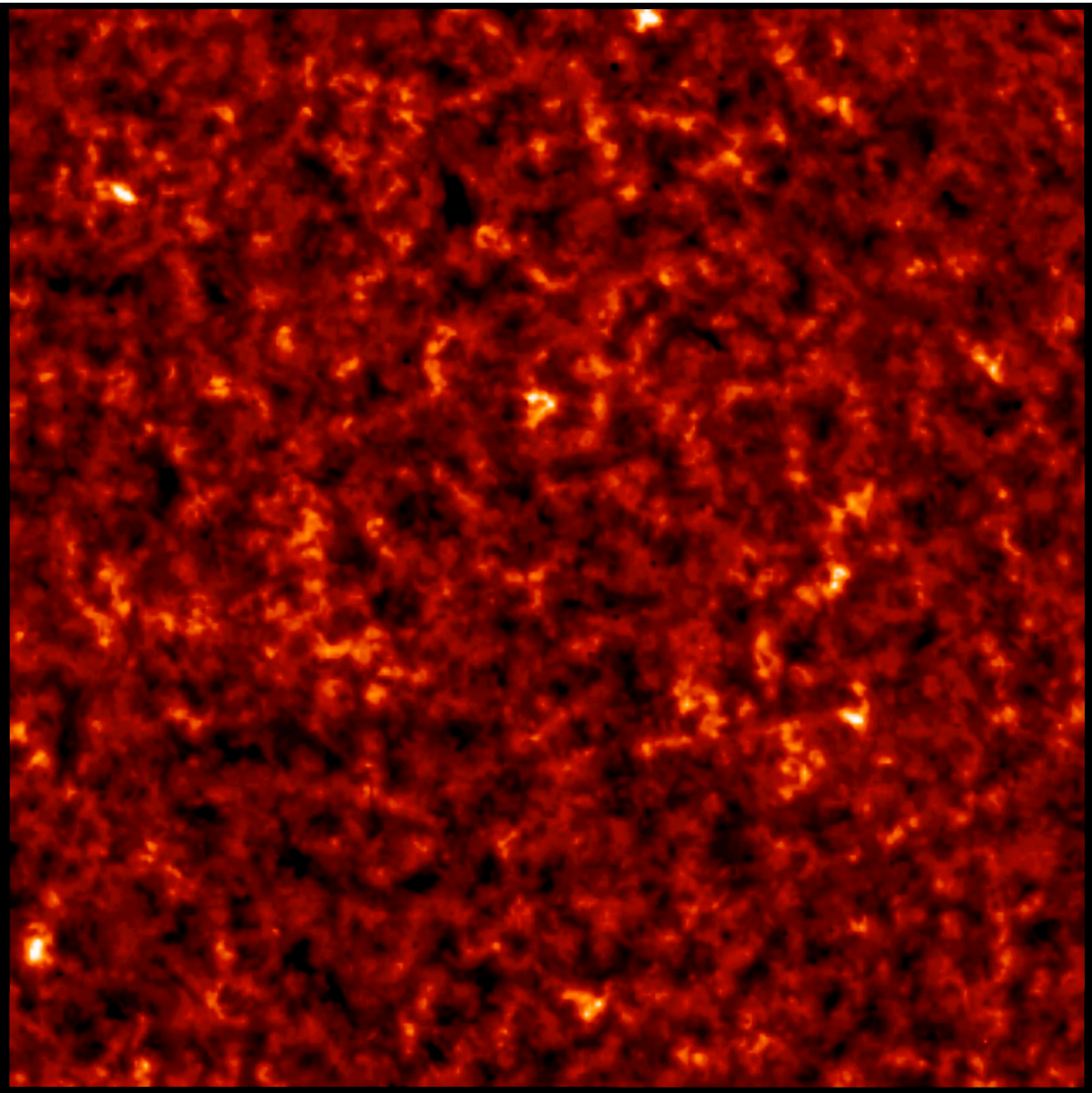
EIT Fe XII 19.5nm ~ 1.5MK peak formation T

320x 320 pixels, 2.62”/pix = 1890 km/pix

55 images, 1 image per min



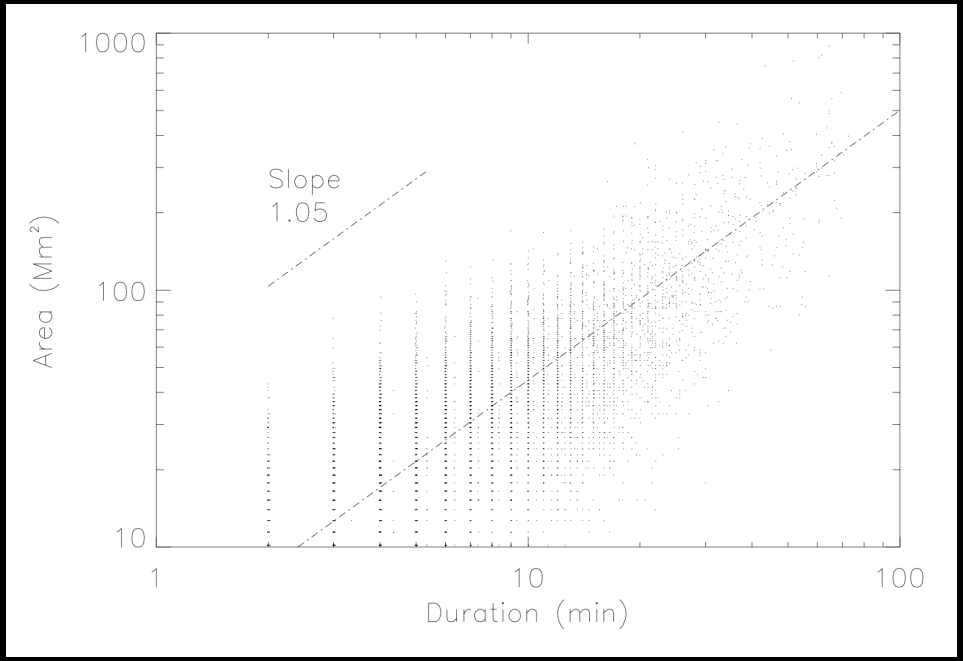
228 events, 2/s

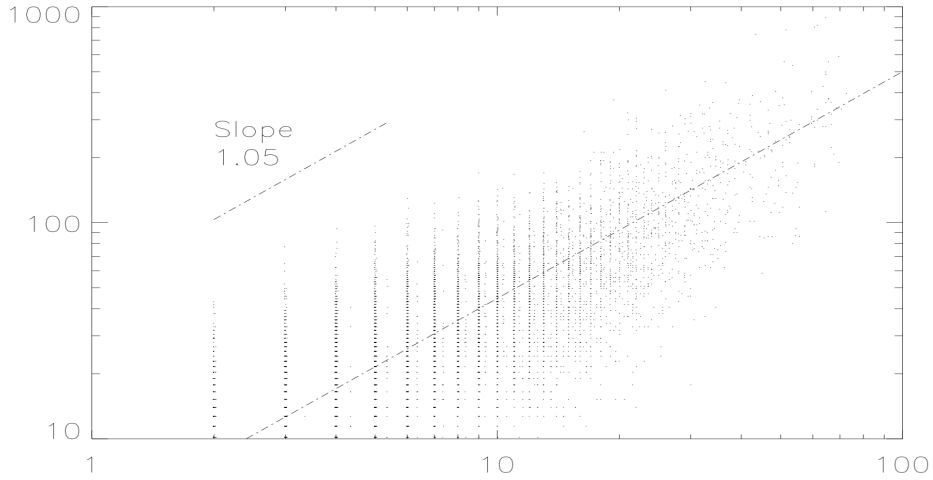


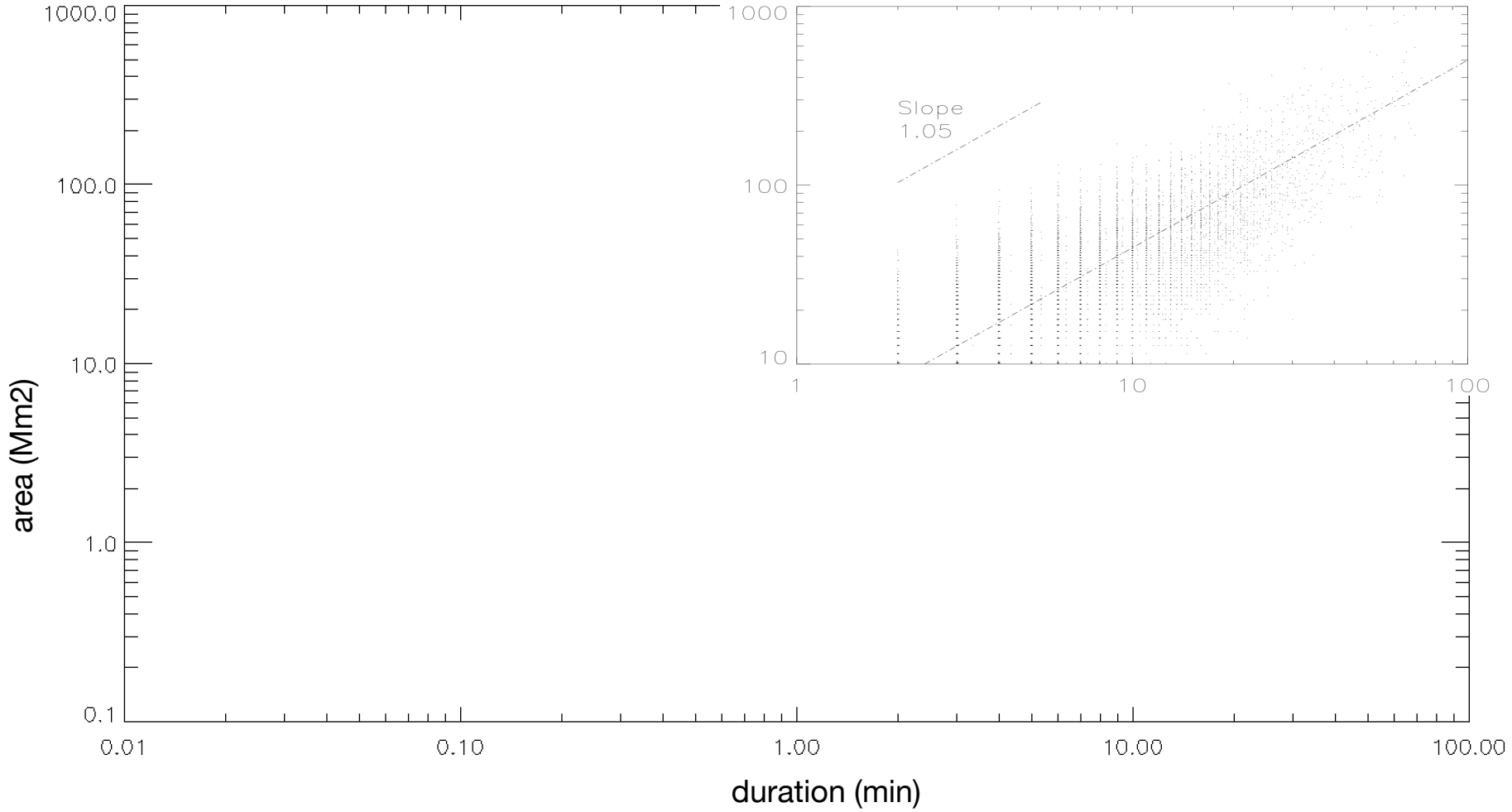
EIT He II 30.4nm ~ 80000K peak formation T

320x 320 pixels, 2.62”/pix = 1890 km/pix

173 images, 1 image per min




1000
100
10
1
10
100
Slope
1.05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1.00
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duration (min)
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100
10
1
10
100
Slope
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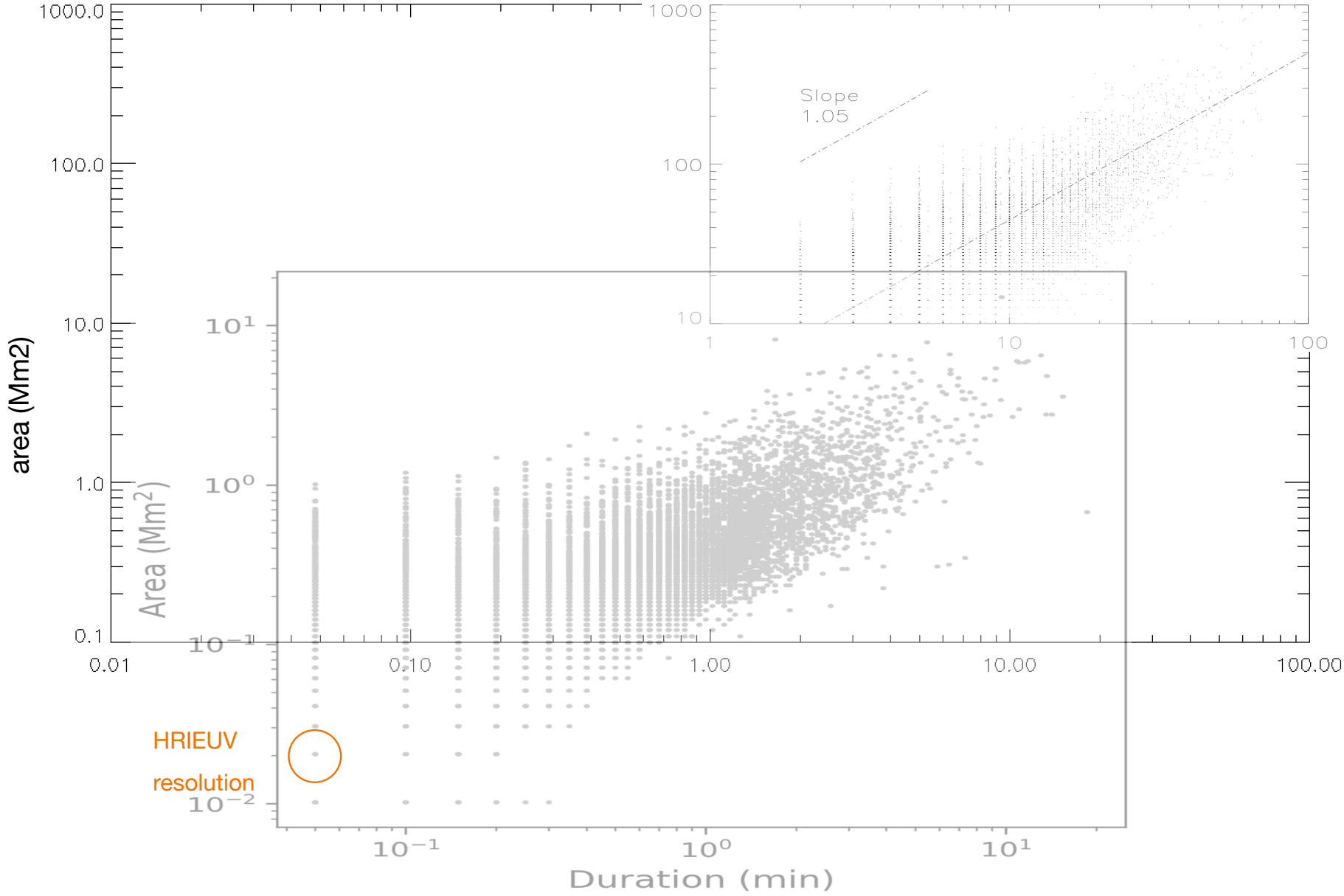
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1
10
100
Slope
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10^{1}
10^{0}
10^{-1}
Area (Mm^2)
HRIEUV
resolution
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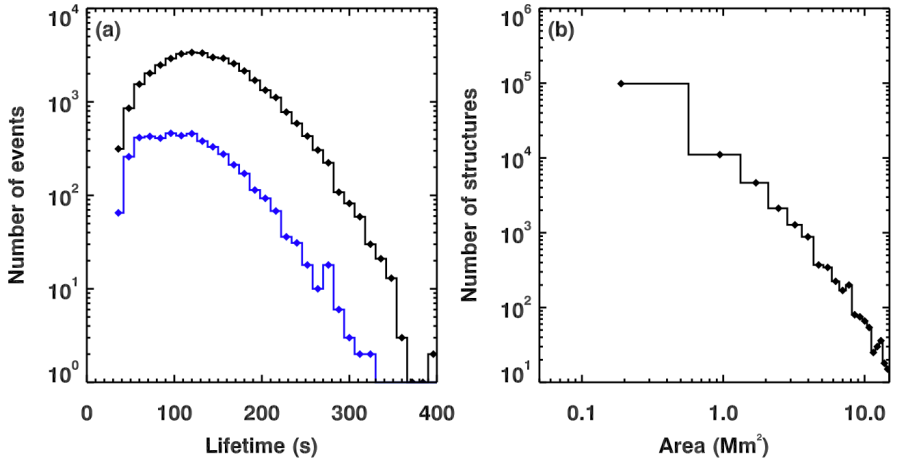
10^{-1}
10^{0}
10^{1}
Duration (min)

Chitta, Peter & Young 2021



Explosive events

O IV (1.3×10^5 K) and Si IV (8×10^4 K)

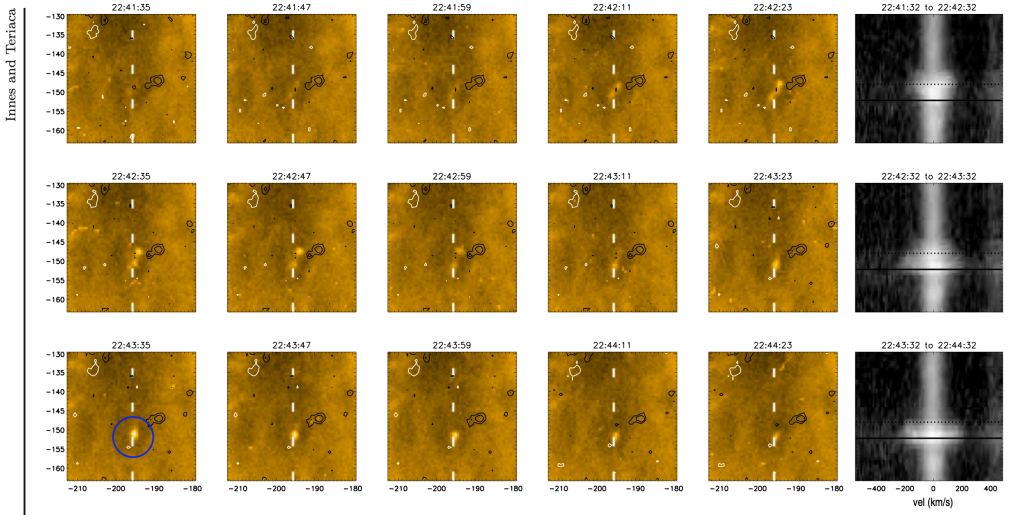
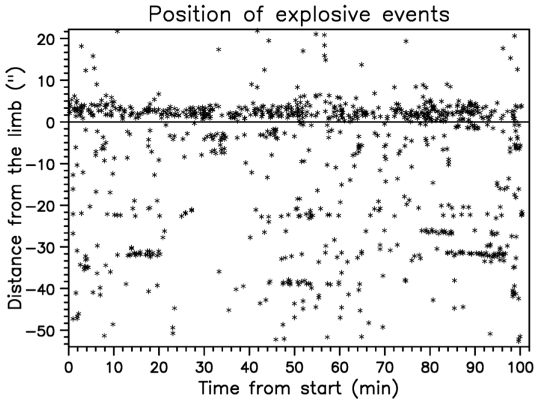


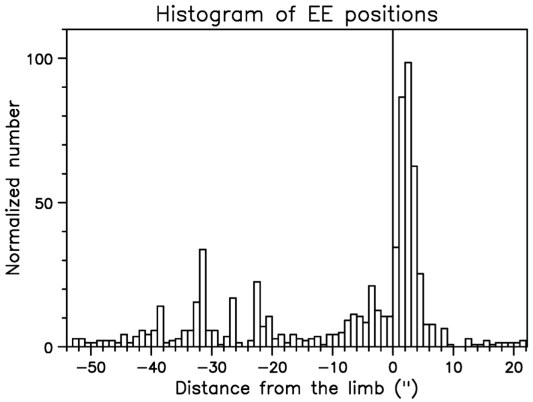
Figure 4.: The five 171Å AIA images along each row shows the evolution during the SUMER O VI exposure on the right. The vertical light blue dashed line in the middle of each 171Å image indicates the position of the SUMER slit. Line-of-sight magnetic field contours at +/-20, 50 G are overplotted in white/black. On the SUMER spectra horizontal black solid and dotted lines indicate the position of the profiles shown in Figure 5. The blue circle in the bottom row surrounds the 'splash'.

Innes and Teriaca, 2012

Table 4. The properties of UV explosive events due to Innes et al. (1997).

Property	Value
Global frequency	$500\ s^{-1}$
Velocity	$150\ km\ s^{-1}$
Area	$2.3 \times 10^6\ km^2$
Mean Lifetime	60 s





Allesandrakis & Vial, 2023

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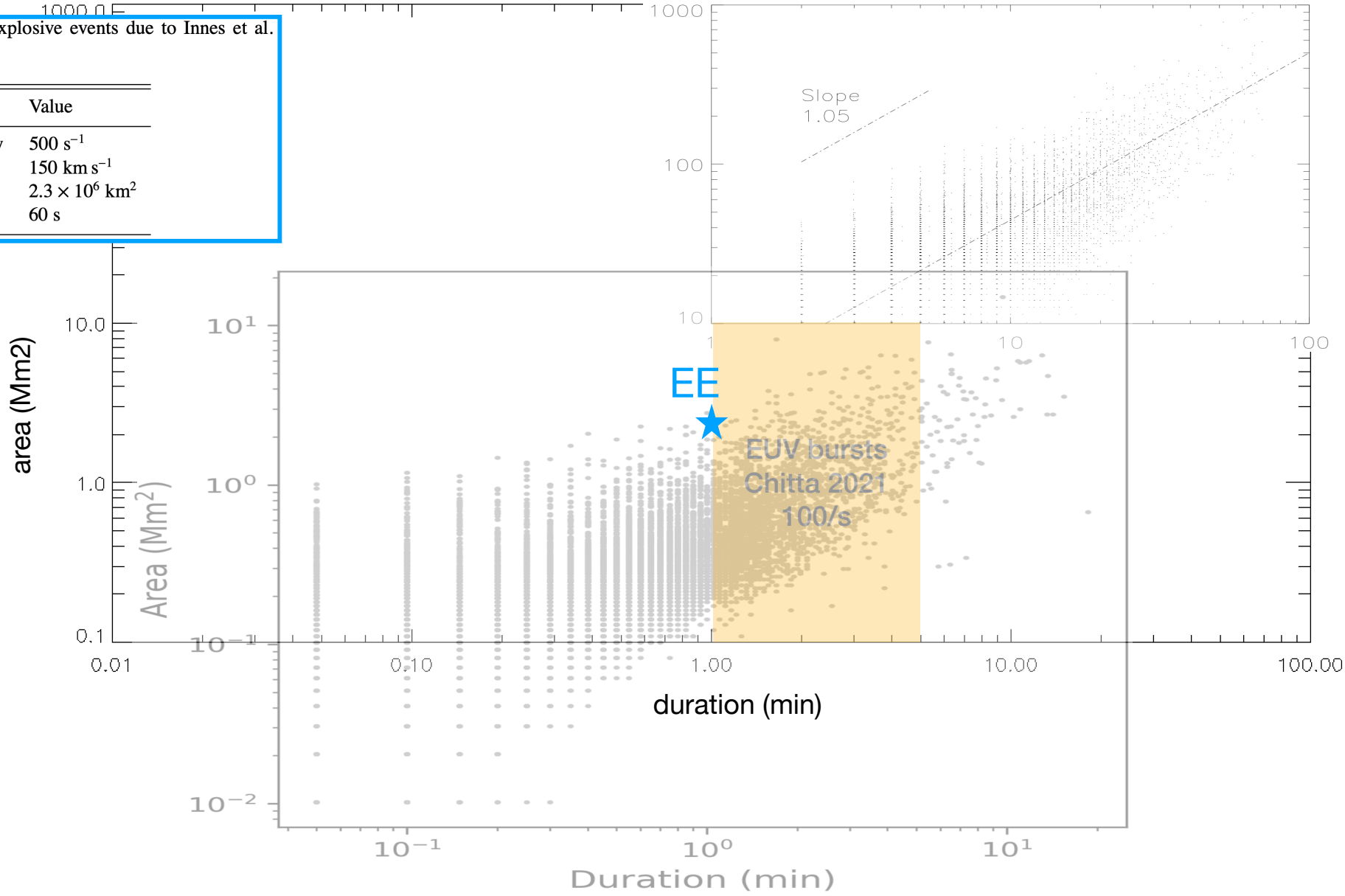


Blinkers

EUV BLINKERS:
THE SIGNIFICANCE OF VARIATIONS
IN THE EXTREME ULTRAVIOLET QUIET SUN

RICHARD A. HARRISON
Space Science Department, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire OX11 0QX, U.K.

(Received 8 January 1997; accepted 12 June 1997)

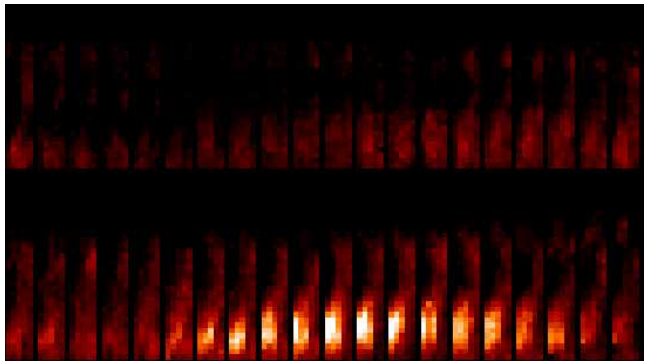
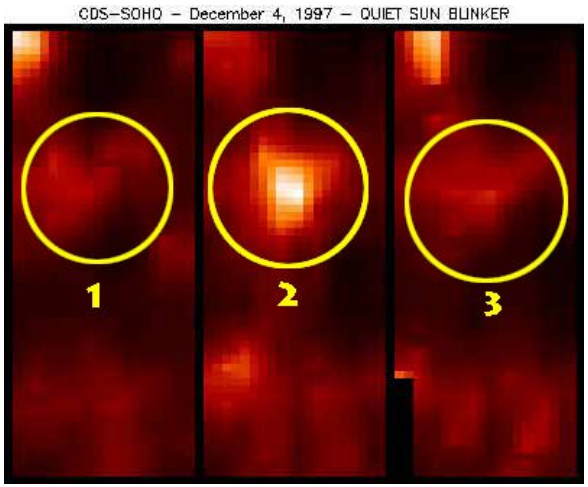


Table 1. The properties of EUV blinkers due to Bewsher et al. (2002).

Property	Value
Global frequency	10–20 s^{-1}
Mean intensity enhancement (O V)	70–80%
Mean Area	2–3 × 10^7 km^2
Mean Lifetime	16.4 min



Astronomy & Astrophysics manuscript no. blinkers˙fin
October 11, 2018

What is the true nature of blinkers?

S. Subramanian[1], M. S. Madjarska[1], J. G. Doyle[1] and D. Bewsher[2]

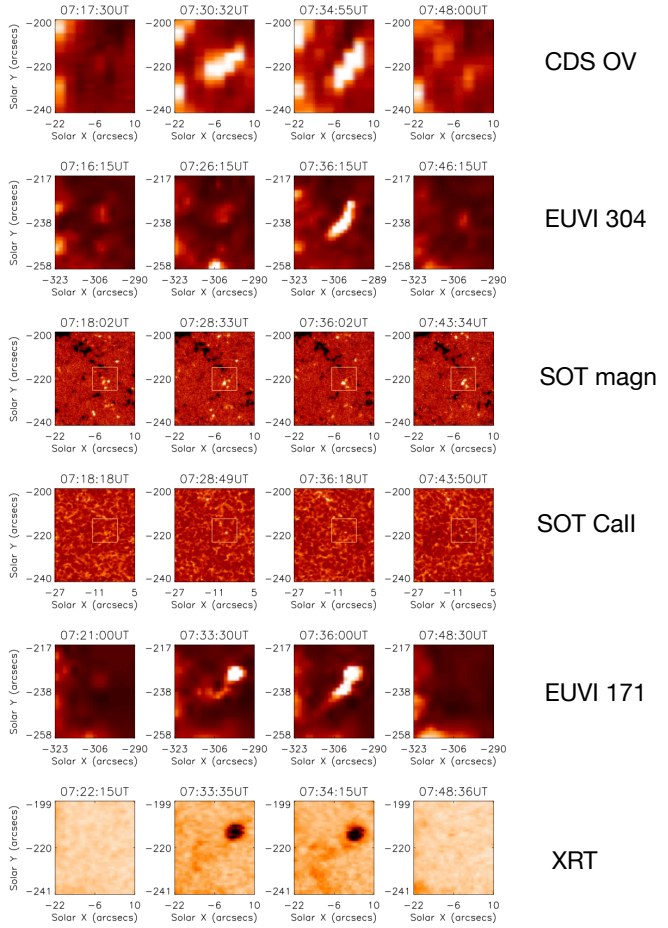
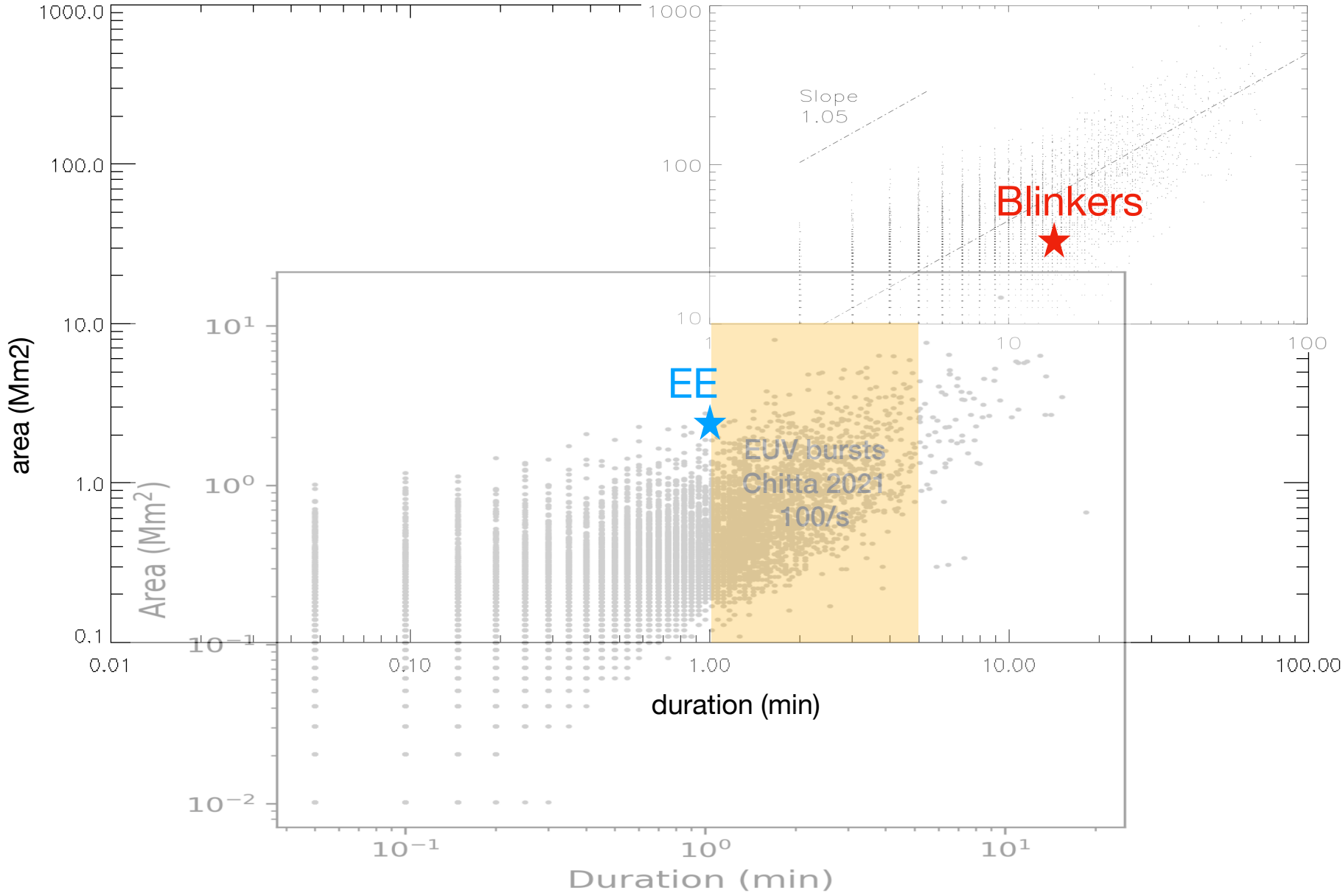


Fig. 2: Blinker group 1 from top in CDS O v 629 Å, EUVI 304 Å, SOT FG magnetograms, SOT Ca ii H, EUVI 171 Å and XRT Al_poly. The corresponding magnetogram field-of-view from which the lightcurve of the positive flux was derived, is outlined by the white box on the SOT FG magnetograms and Ca ii H images.


1000.0
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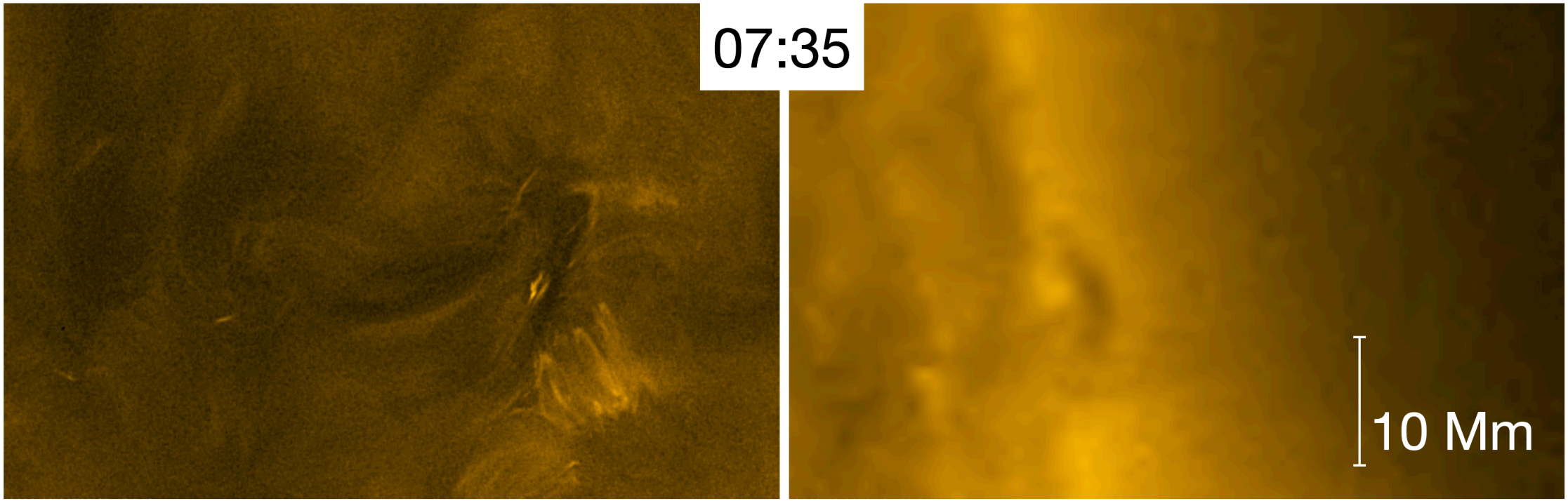
1.0
0.1
0.01
0.10
1.00
10.00
100.00
area (Mm2)
duration (min)
1000
100
10
Slope
1.05
Blinkers
EE
EUV bursts
Chitta 2021
100/s
10^{1}
10^{0}
10^{-1}
10^{-2}
Area (Mm^2)
10^{-1}
10^{0}
10^{1}
Duration (min)

March 28

EUI @ disc center

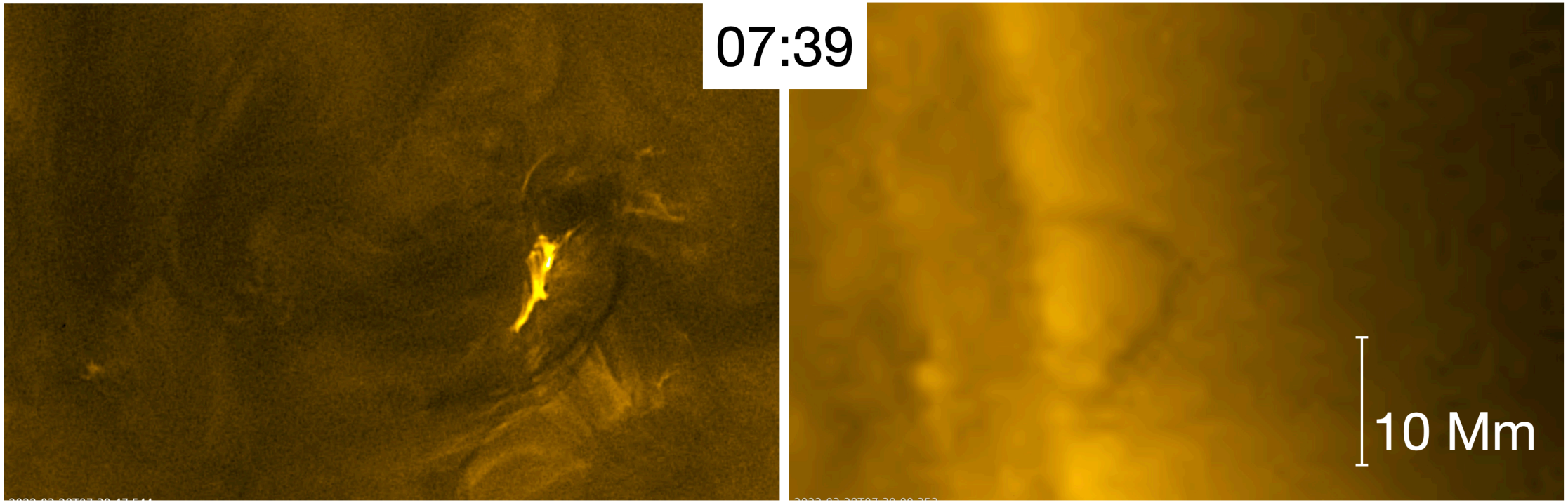
AIA @ limb



March 28

EUI @ disc center

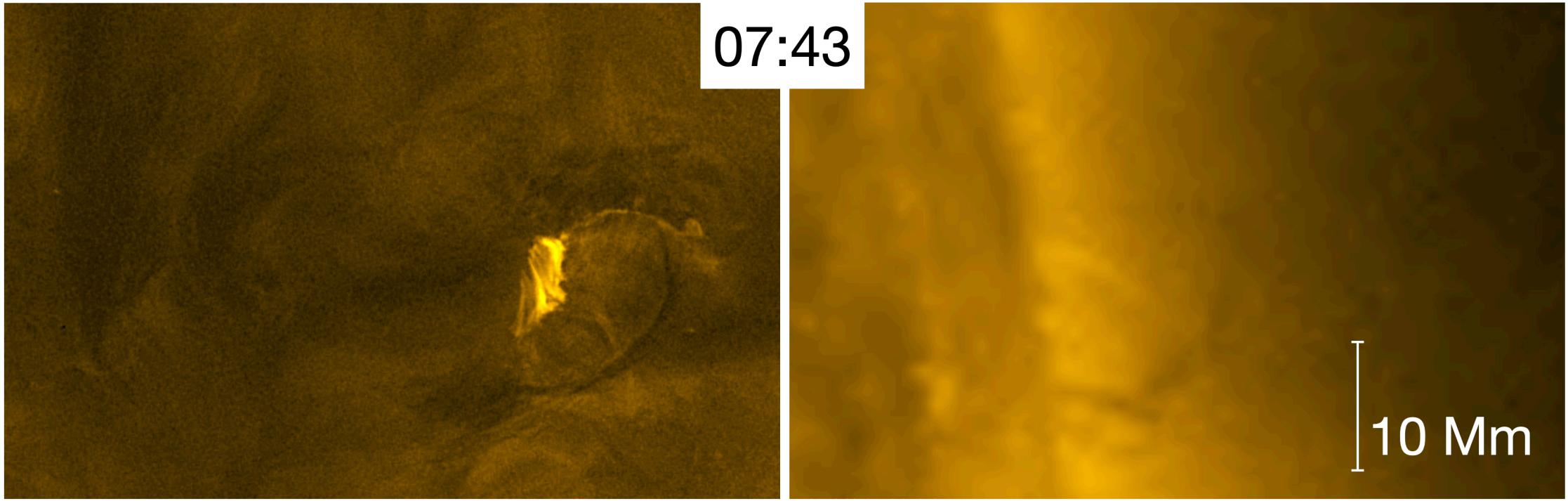
AIA @ limb

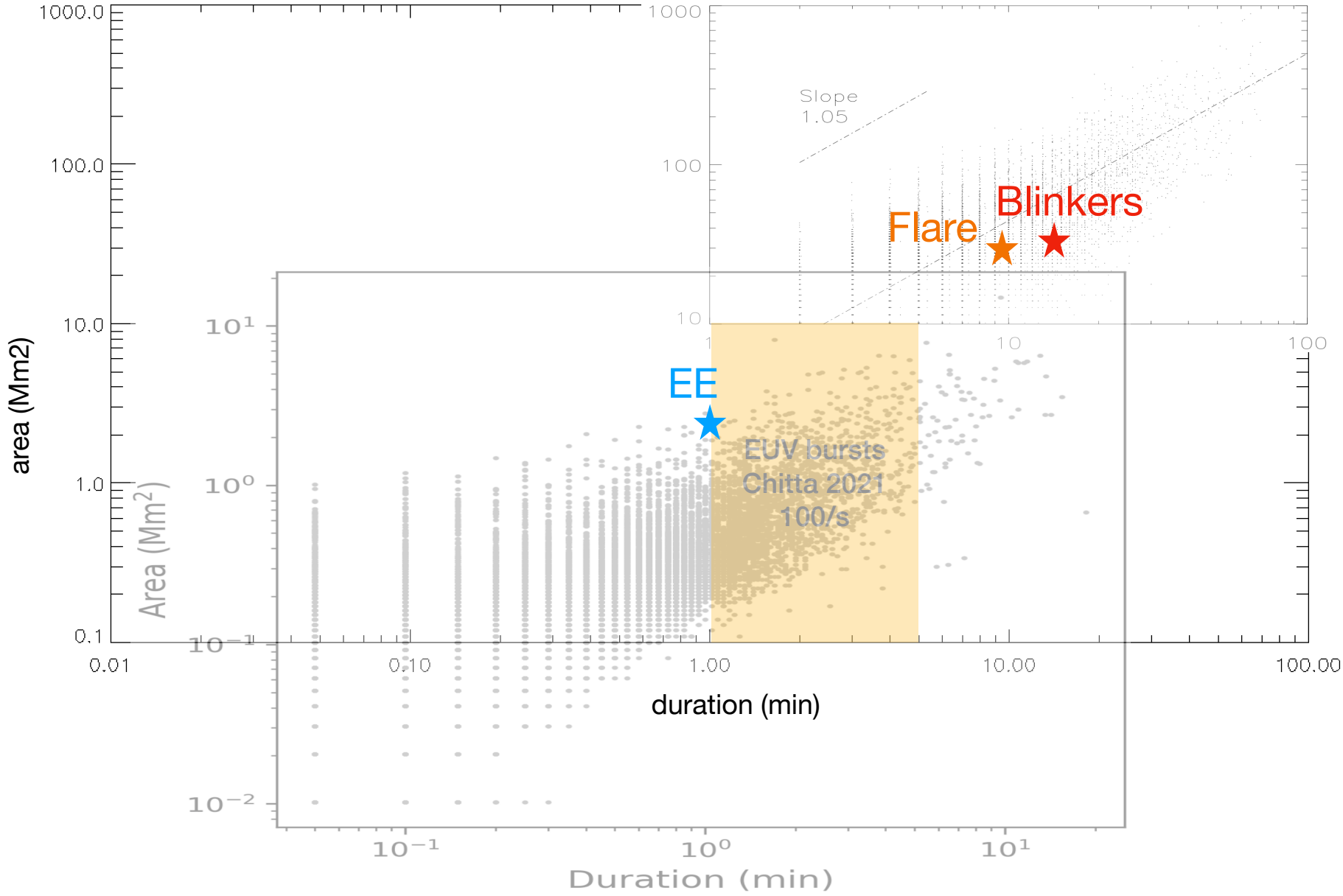


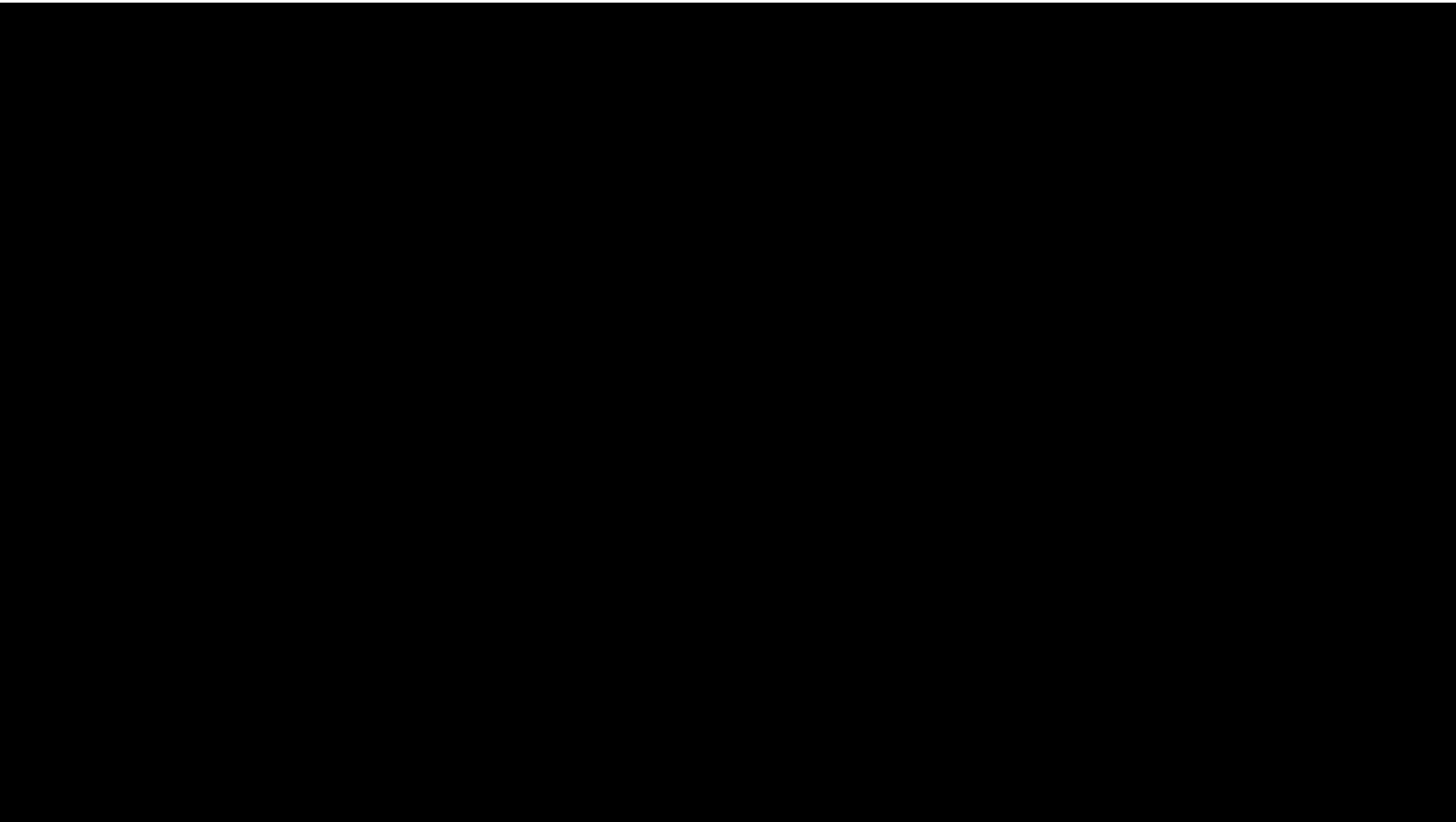
March 28

EUI @ disc center

AIA @ limb



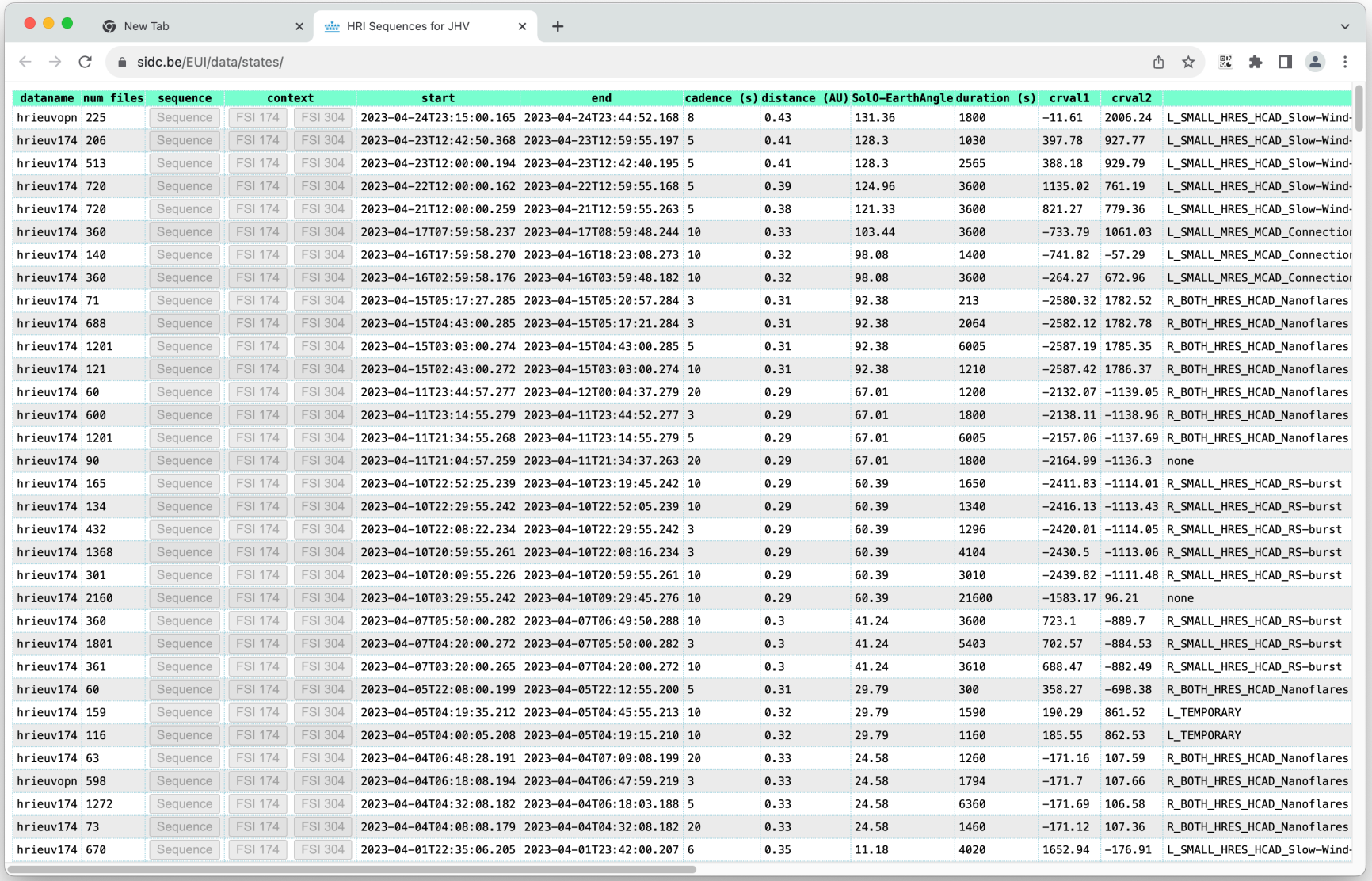

1000.0
100.0
10.0
1.0
0.1
area (Mm2)
0.01
0.10
1.00
10.00
100.00
duration (min)
1000
100
10
Slope
1.05
Flare
Blinkers
EE
EUV bursts
Chitta 2021
100/s
Area (Mm^2)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-1}
10^{0}
10^{1}
Duration (min)



Overview

1. Campfires
2. Link with other coronal EUV brightenings
3. Data availability

https://www.sidc.be/EUI/data/states/ (use Chrome)



dataname	num files	sequence	context		start	end	cadence (s)	distance (AU)	SolO-EarthAngle	duration (s)	crval1	crval2	
hrieuvopn	225	Sequence	FSI 174	FSI 304	2023-04-24T23:15:00.165	2023-04-24T23:44:52.168	8	0.43	131.36	1800	-11.61	2006.24	L_SMALL_HRES_HCAD_Slow-Wind-
hrieuv174	206	Sequence	FSI 174	FSI 304	2023-04-23T12:42:50.368	2023-04-23T12:59:55.197	5	0.41	128.3	1030	397.78	927.77	L_SMALL_HRES_HCAD_Slow-Wind-
hrieuv174	513	Sequence	FSI 174	FSI 304	2023-04-23T12:00:00.194	2023-04-23T12:42:40.195	5	0.41	128.3	2565	388.18	929.79	L_SMALL_HRES_HCAD_Slow-Wind-
hrieuv174	720	Sequence	FSI 174	FSI 304	2023-04-22T12:00:00.162	2023-04-22T12:59:55.168	5	0.39	124.96	3600	1135.02	761.19	L_SMALL_HRES_HCAD_Slow-Wind-
hrieuv174	720	Sequence	FSI 174	FSI 304	2023-04-21T12:00:00.259	2023-04-21T12:59:55.263	5	0.38	121.33	3600	821.27	779.36	L_SMALL_HRES_HCAD_Slow-Wind-
hrieuv174	360	Sequence	FSI 174	FSI 304	2023-04-17T07:59:58.237	2023-04-17T08:59:48.244	10	0.33	103.44	3600	-733.79	1061.03	L_SMALL_MRES_MCAD_Connectior
hrieuv174	140	Sequence	FSI 174	FSI 304	2023-04-16T17:59:58.270	2023-04-16T18:23:08.273	10	0.32	98.08	1400	-741.82	-57.29	L_SMALL_MRES_MCAD_Connectior
hrieuv174	360	Sequence	FSI 174	FSI 304	2023-04-16T02:59:58.176	2023-04-16T03:59:48.182	10	0.32	98.08	3600	-264.27	672.96	L_SMALL_MRES_MCAD_Connectior
hrieuv174	71	Sequence	FSI 174	FSI 304	2023-04-15T05:17:27.285	2023-04-15T05:20:57.284	3	0.31	92.38	213	-2580.32	1782.52	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	688	Sequence	FSI 174	FSI 304	2023-04-15T04:43:00.285	2023-04-15T05:17:21.284	3	0.31	92.38	2064	-2582.12	1782.78	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	1201	Sequence	FSI 174	FSI 304	2023-04-15T03:03:00.274	2023-04-15T04:43:00.285	5	0.31	92.38	6005	-2587.19	1785.35	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	121	Sequence	FSI 174	FSI 304	2023-04-15T02:43:00.272	2023-04-15T03:03:00.274	10	0.31	92.38	1210	-2587.42	1786.37	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	60	Sequence	FSI 174	FSI 304	2023-04-11T23:44:57.277	2023-04-12T00:04:37.279	20	0.29	67.01	1200	-2132.07	-1139.05	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	600	Sequence	FSI 174	FSI 304	2023-04-11T23:14:55.279	2023-04-11T23:44:52.277	3	0.29	67.01	1800	-2138.11	-1138.96	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	1201	Sequence	FSI 174	FSI 304	2023-04-11T21:34:55.268	2023-04-11T23:14:55.279	5	0.29	67.01	6005	-2157.06	-1137.69	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	90	Sequence	FSI 174	FSI 304	2023-04-11T21:04:57.259	2023-04-11T21:34:37.263	20	0.29	67.01	1800	-2164.99	-1136.3	none
hrieuv174	165	Sequence	FSI 174	FSI 304	2023-04-10T22:52:25.239	2023-04-10T23:19:45.242	10	0.29	60.39	1650	-2411.83	-1114.01	R_SMALL_HRES_HCAD_RS-burst
hrieuv174	134	Sequence	FSI 174	FSI 304	2023-04-10T22:29:55.242	2023-04-10T22:52:05.239	10	0.29	60.39	1340	-2416.13	-1113.43	R_SMALL_HRES_HCAD_RS-burst
hrieuv174	432	Sequence	FSI 174	FSI 304	2023-04-10T22:08:22.234	2023-04-10T22:29:55.242	3	0.29	60.39	1296	-2420.01	-1114.05	R_SMALL_HRES_HCAD_RS-burst
hrieuv174	1368	Sequence	FSI 174	FSI 304	2023-04-10T20:59:55.261	2023-04-10T22:08:16.234	3	0.29	60.39	4104	-2430.5	-1113.06	R_SMALL_HRES_HCAD_RS-burst
hrieuv174	301	Sequence	FSI 174	FSI 304	2023-04-10T20:09:55.226	2023-04-10T20:59:55.261	10	0.29	60.39	3010	-2439.82	-1111.48	R_SMALL_HRES_HCAD_RS-burst
hrieuv174	2160	Sequence	FSI 174	FSI 304	2023-04-10T03:29:55.242	2023-04-10T09:29:45.276	10	0.29	60.39	21600	-1583.17	96.21	none
hrieuv174	360	Sequence	FSI 174	FSI 304	2023-04-07T05:50:00.282	2023-04-07T06:49:50.288	10	0.3	41.24	3600	723.1	-889.7	R_SMALL_HRES_HCAD_RS-burst
hrieuv174	1801	Sequence	FSI 174	FSI 304	2023-04-07T04:20:00.272	2023-04-07T05:50:00.282	3	0.3	41.24	5403	702.57	-884.53	R_SMALL_HRES_HCAD_RS-burst
hrieuv174	361	Sequence	FSI 174	FSI 304	2023-04-07T03:20:00.265	2023-04-07T04:20:00.272	10	0.3	41.24	3610	688.47	-882.49	R_SMALL_HRES_HCAD_RS-burst
hrieuv174	60	Sequence	FSI 174	FSI 304	2023-04-05T22:08:00.199	2023-04-05T22:12:55.200	5	0.31	29.79	300	358.27	-698.38	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	159	Sequence	FSI 174	FSI 304	2023-04-05T04:19:35.212	2023-04-05T04:45:55.213	10	0.32	29.79	1590	190.29	861.52	L_TEMPORARY
hrieuv174	116	Sequence	FSI 174	FSI 304	2023-04-05T04:00:05.208	2023-04-05T04:19:15.210	10	0.32	29.79	1160	185.55	862.53	L_TEMPORARY
hrieuv174	63	Sequence	FSI 174	FSI 304	2023-04-04T06:48:28.191	2023-04-04T07:09:08.199	20	0.33	24.58	1260	-171.16	107.59	R_BOTH_HRES_HCAD_Nanoflares
hrieuvopn	598	Sequence	FSI 174	FSI 304	2023-04-04T06:18:08.194	2023-04-04T06:47:59.219	3	0.33	24.58	1794	-171.7	107.66	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	1272	Sequence	FSI 174	FSI 304	2023-04-04T04:32:08.182	2023-04-04T06:18:03.188	5	0.33	24.58	6360	-171.69	106.58	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	73	Sequence	FSI 174	FSI 304	2023-04-04T04:08:08.179	2023-04-04T04:32:08.182	20	0.33	24.58	1460	-171.12	107.36	R_BOTH_HRES_HCAD_Nanoflares
hrieuv174	670	Sequence	FSI 174	FSI 304	2023-04-01T22:35:06.205	2023-04-01T23:42:00.207	6	0.35	11.18	4020	1652.94	-176.91	L_SMALL_HRES_HCAD_Slow-Wind-

https://www.sidc.be/EUI/data/releases/202301_release_6.0/