# Stereoscopy of extreme-UV quiet Sun brightenings ("campfires") observed by Solar Orbiter/EUI

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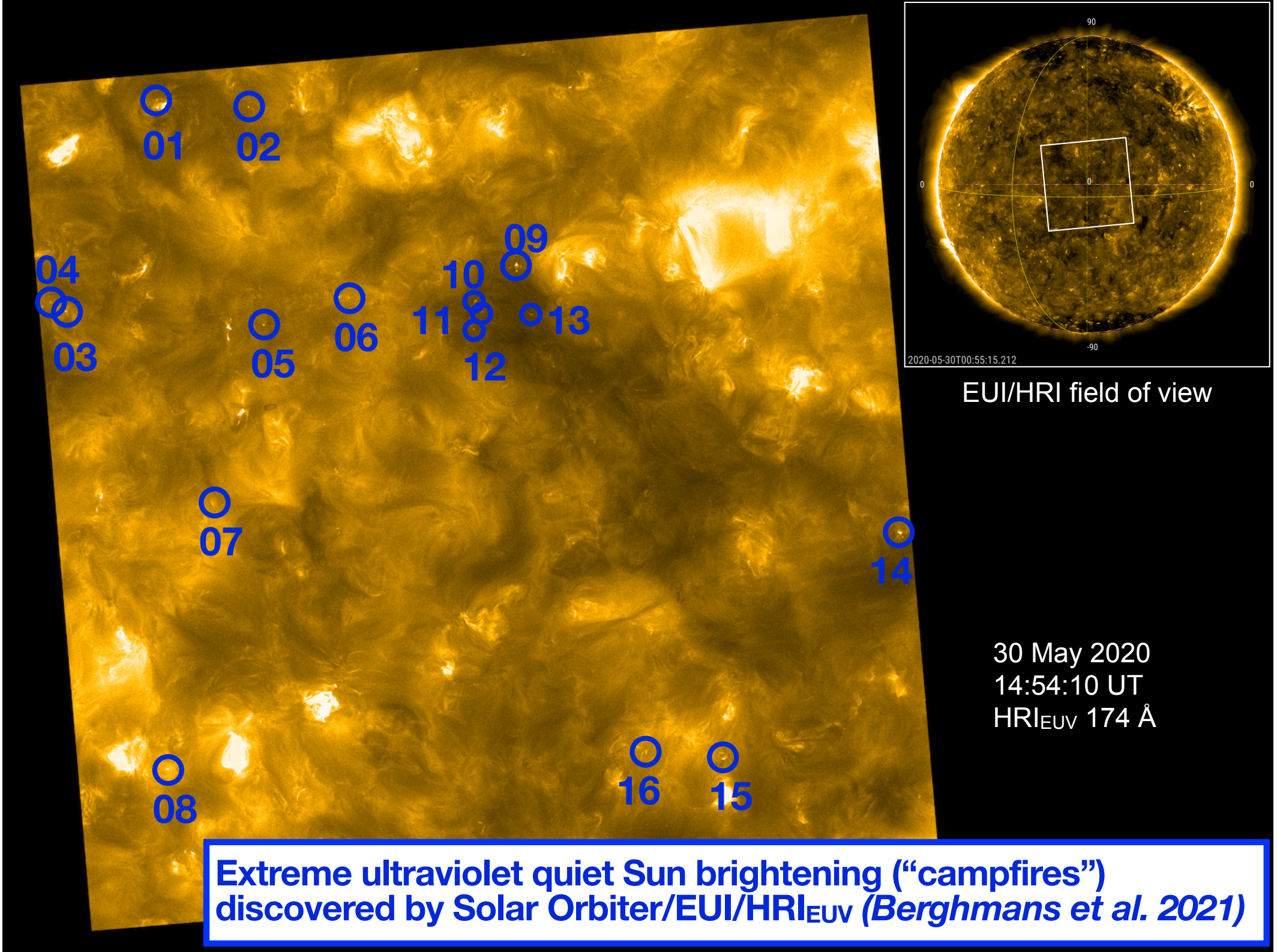
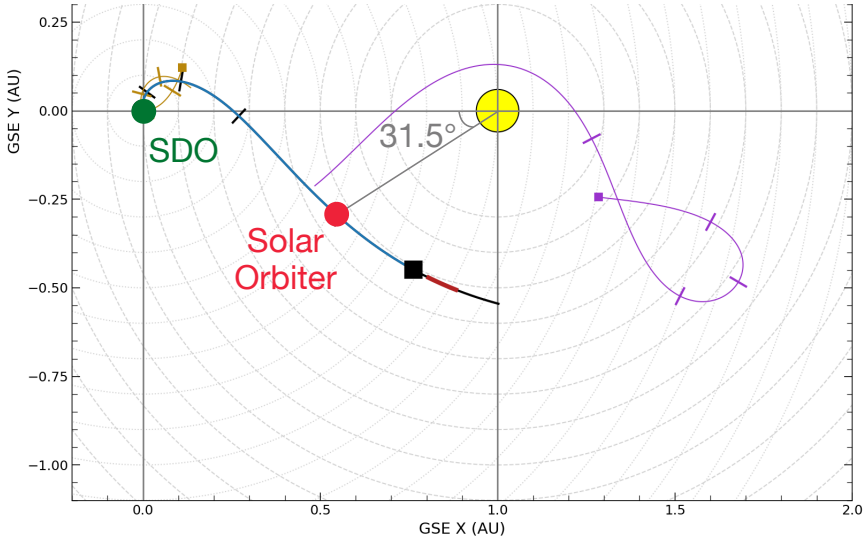
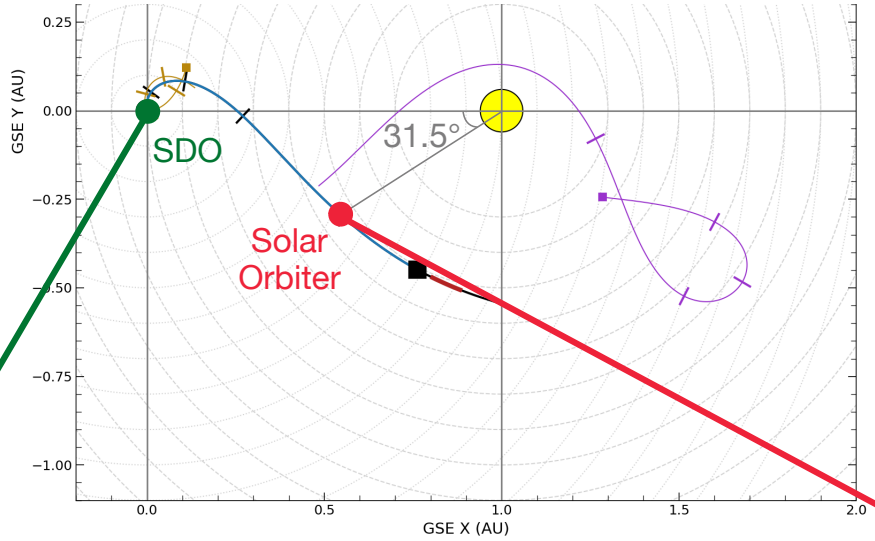
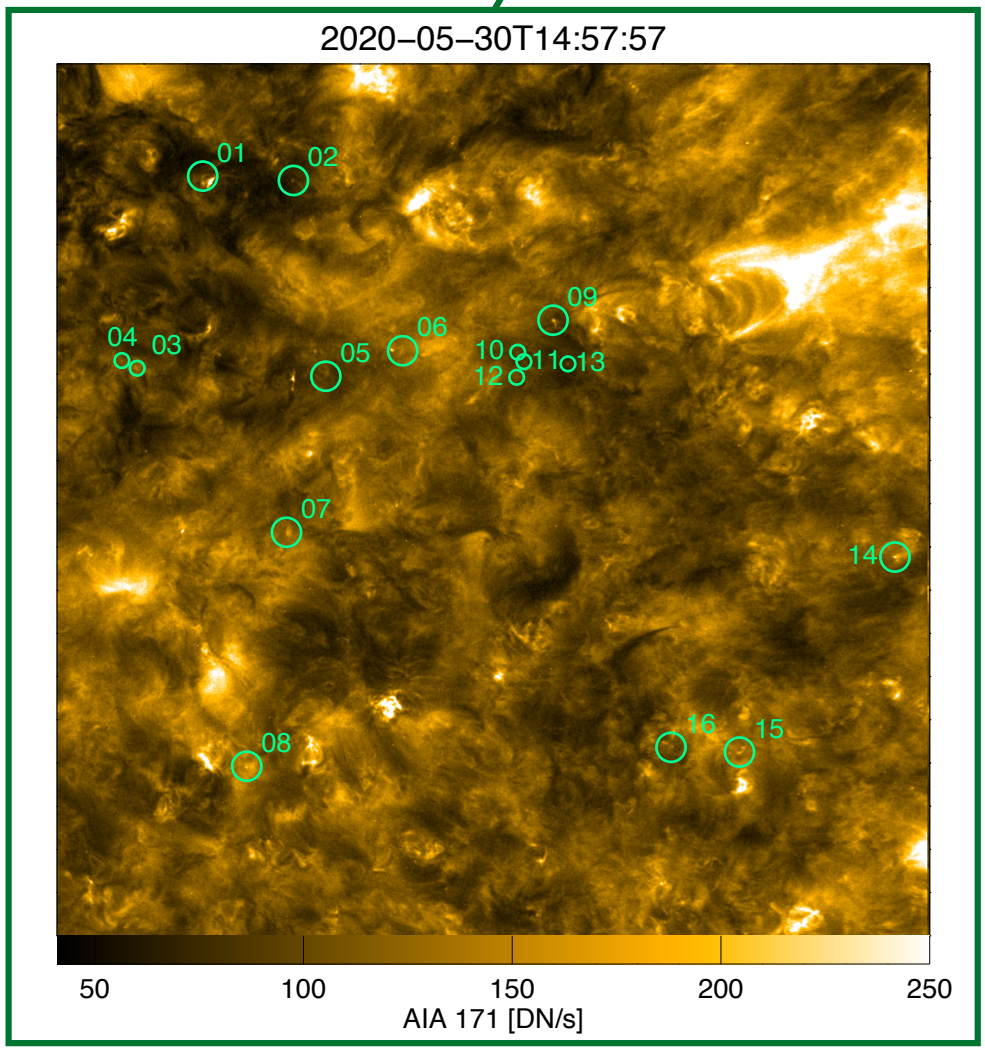
**ESPM-16, 08 September 2021**

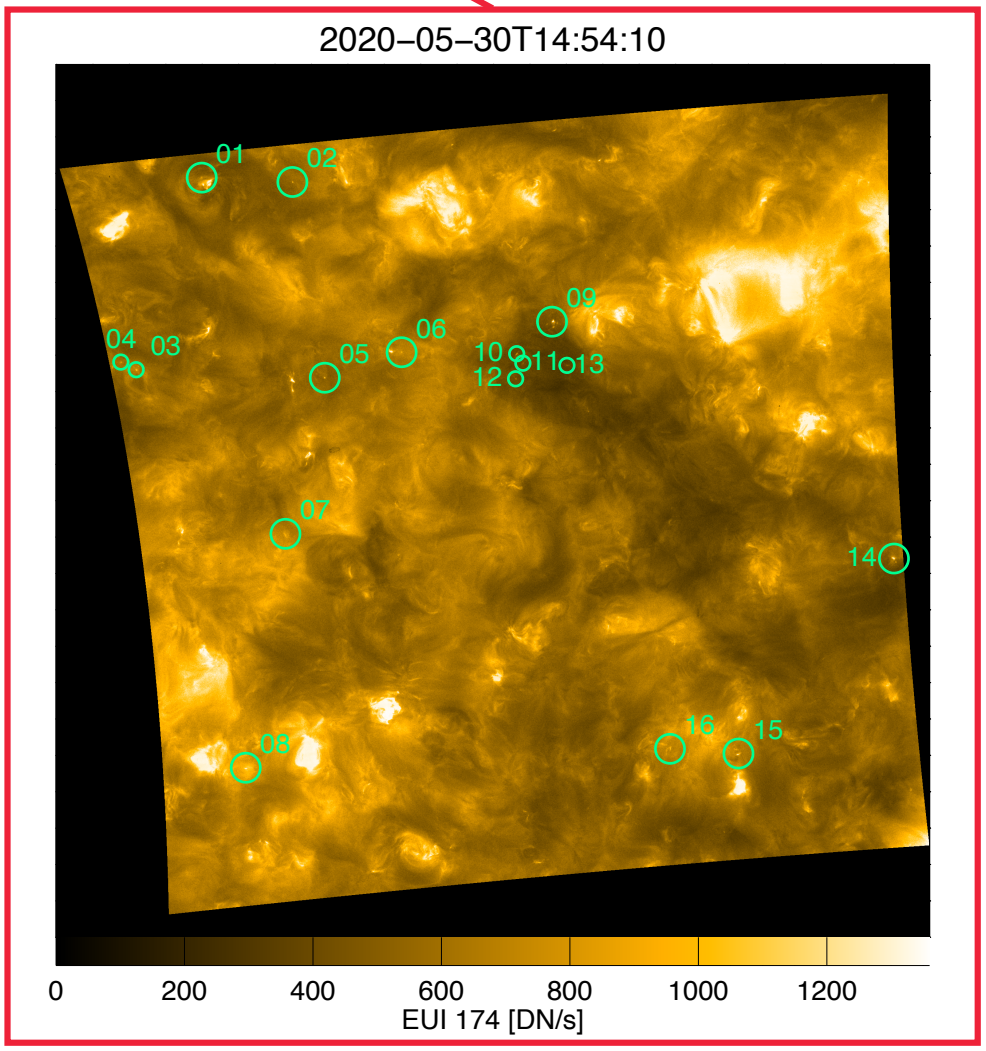

01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
90
0
0
-90
2020-05-30T00:55:15.212
EUI/HRI field of view
30 May 2020
14:54:10 UT
HRIEUV 174 Å
Extreme ultraviolet quiet Sun brightening ("campfires")
discovered by Solar Orbiter/EUI/HRIEUV (Berghmans et al. 2021)



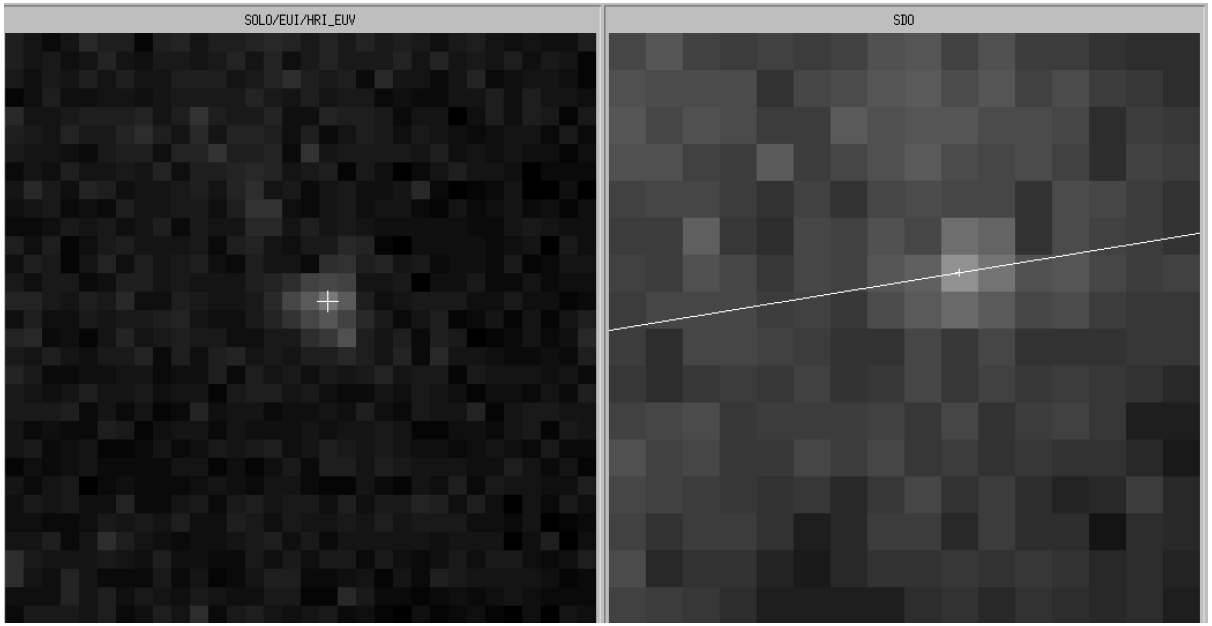

# Triangulation of campfires using SDO/AIA and Solar Orbiter/EUI/HRI data


SDO
Solar
Orbiter
31.5°
GSE Y (AU)
GSE X (AU)
0.25
0.00
−0.25
−0.50
−0.75
−1.00
0.0
0.5
1.0
1.5
2.0


2020–05–30T14:57:57
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
50
100
150
200
250
AIA 171 [DN/s]

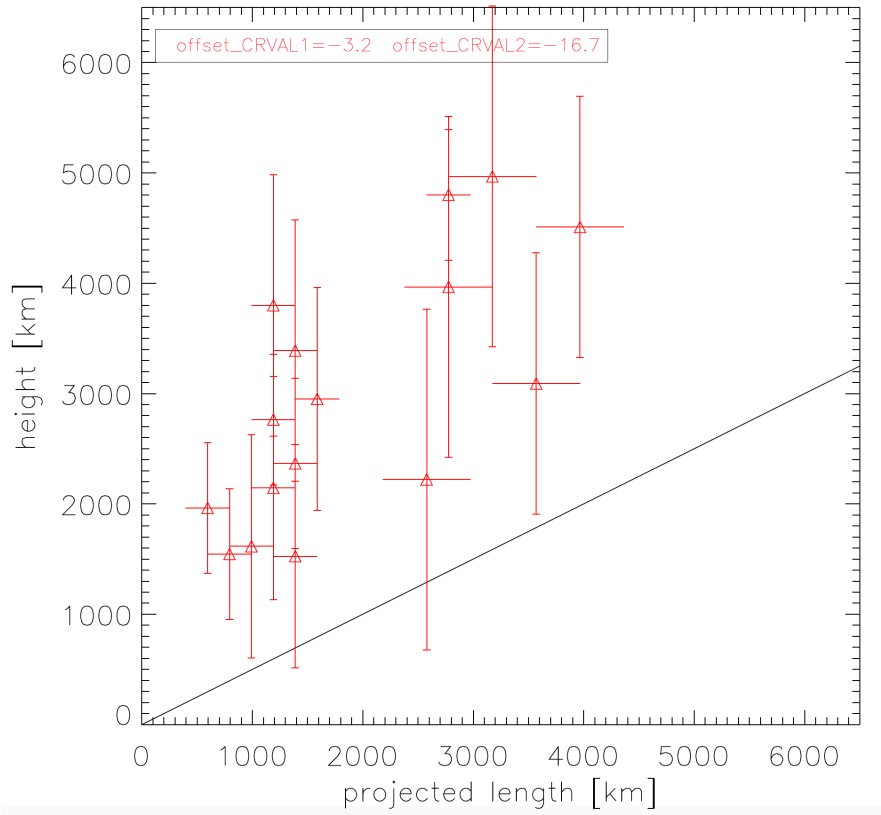

2020–05–30T14:54:10
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
0
200
400
600
800
1000
1200
EUI 174 [DN/s]

# Manual tie-pointing



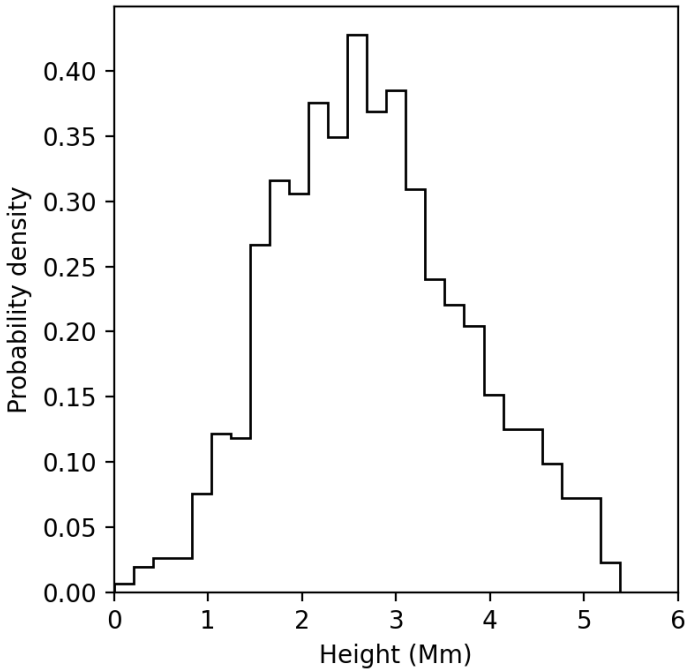

Solar Orbiter
EUI/HRI$_{EUV}$ 174 Å

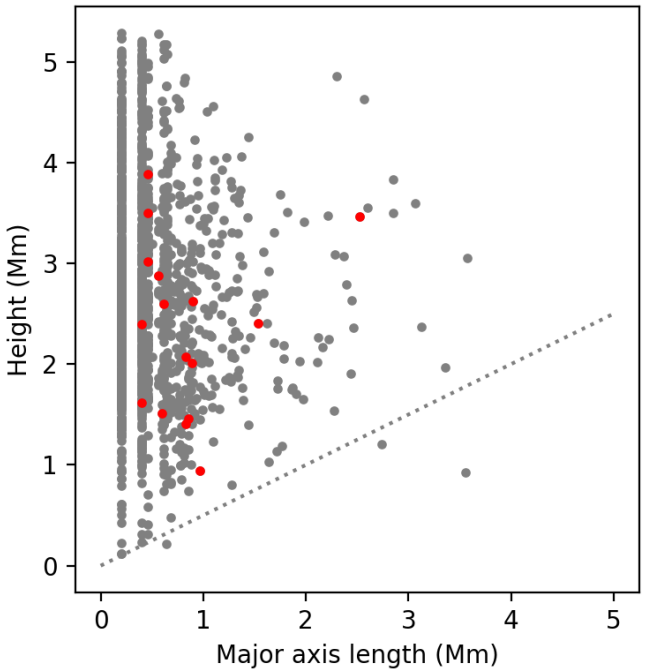
SDO
AIA 171 Å

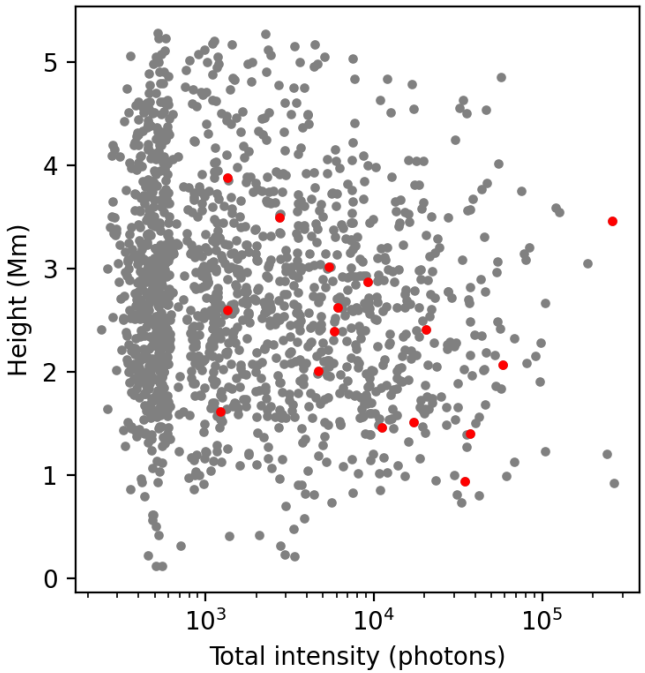


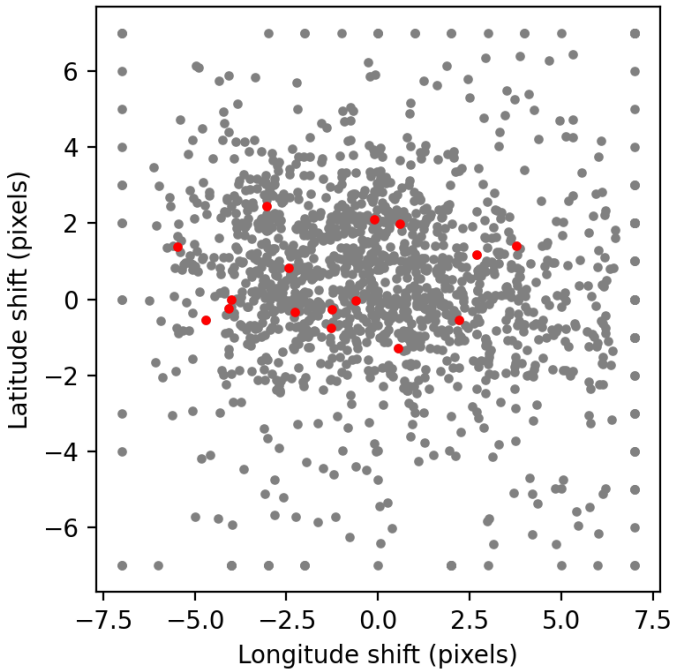

- Tie-pointing: identification of the corresponding feature in the two images.
- Triangulation: two corresponding points from an image pair are back-projected along the respective lines of sight to obtain their 3D coordinates.

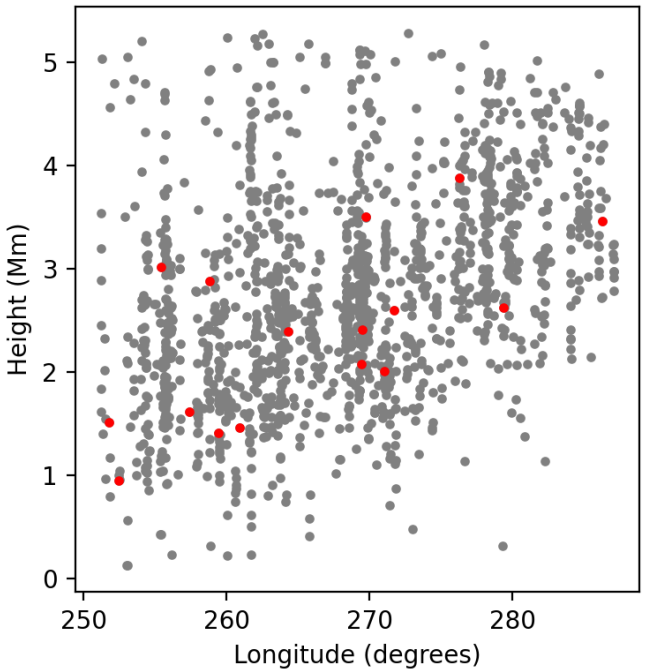
# Automatic tie-pointing

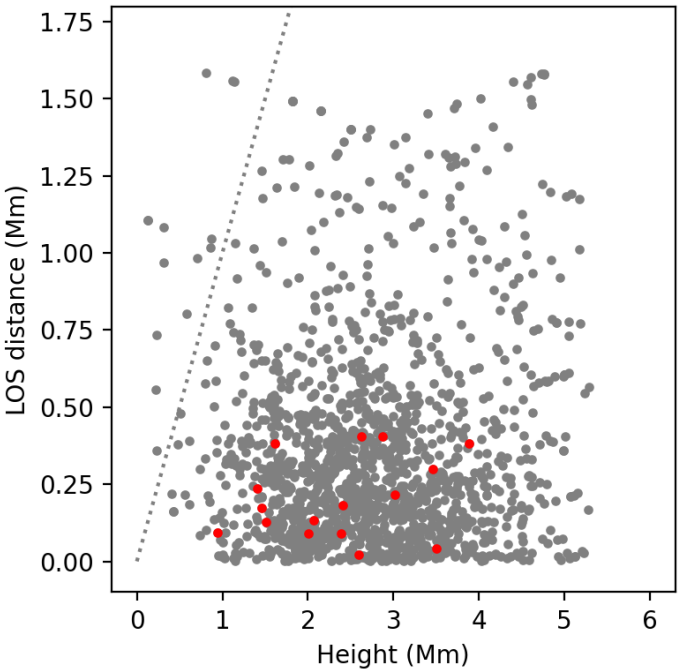


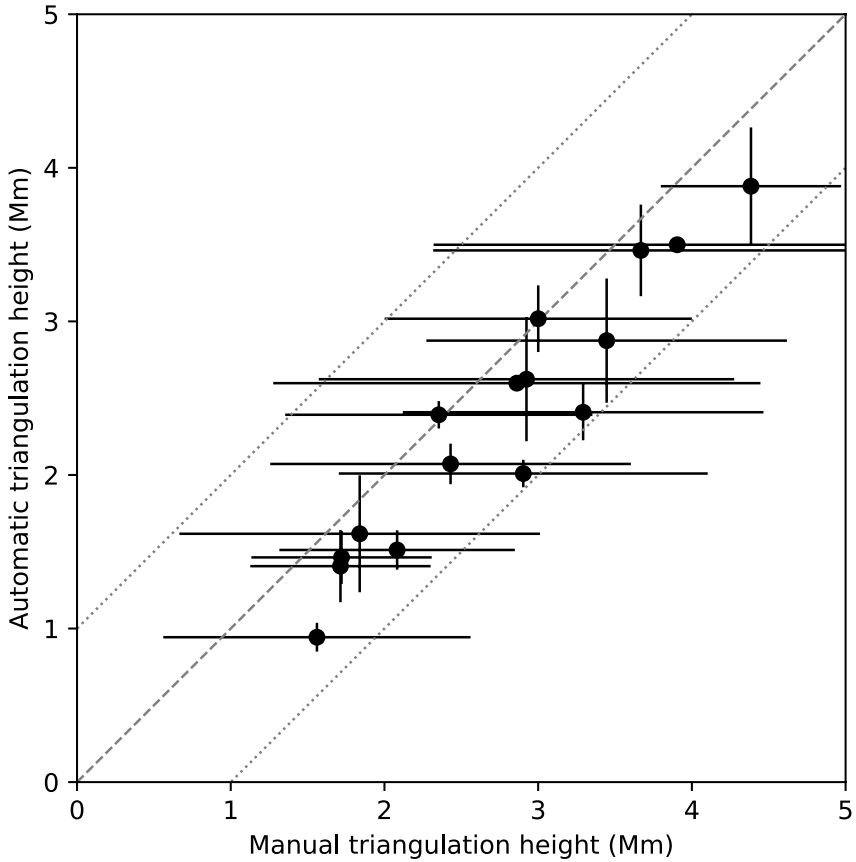



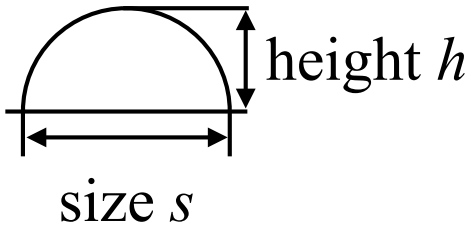



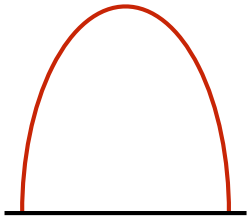
# Comparison of manually and automatically derived heights



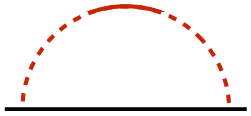

- The results of the manual and automatic methods are consistent with each other (correlation coefficient of 0.86).

# Height of campfires: interpretation

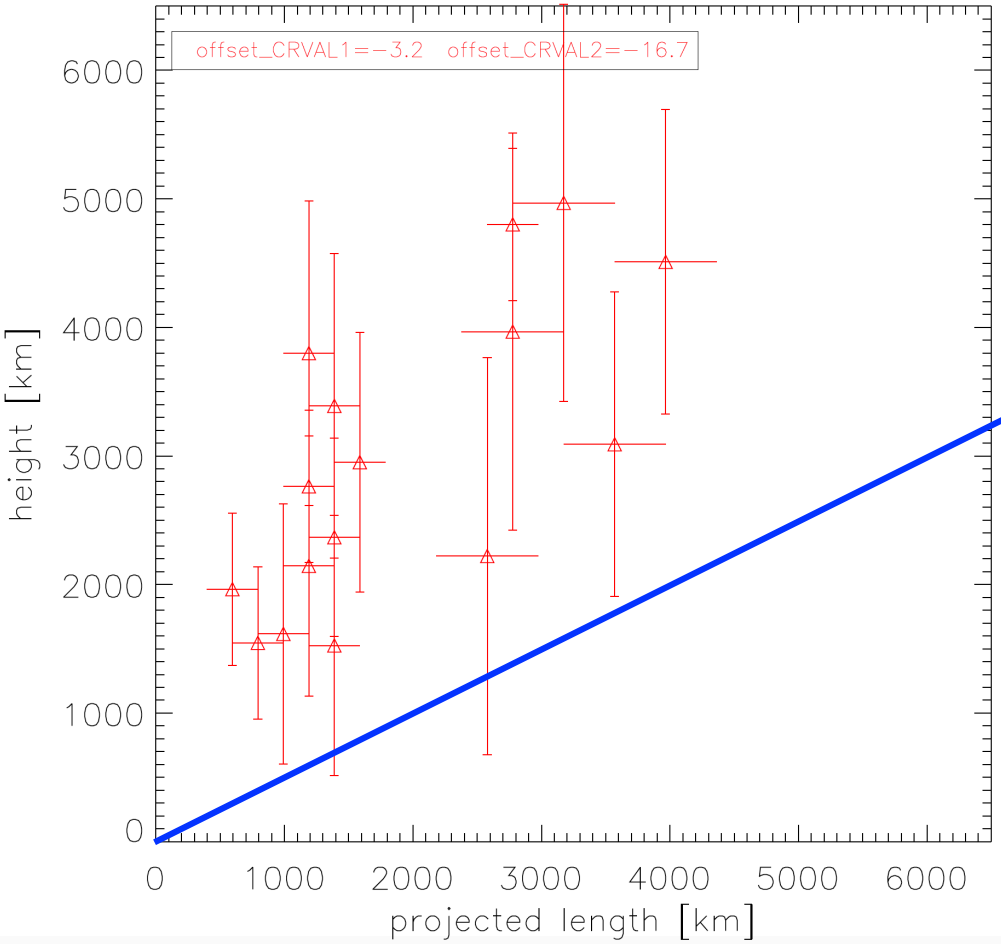


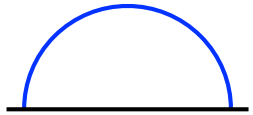



$2h > s$
tall loop



$2h > s$
apex emission;
high "footpoints"



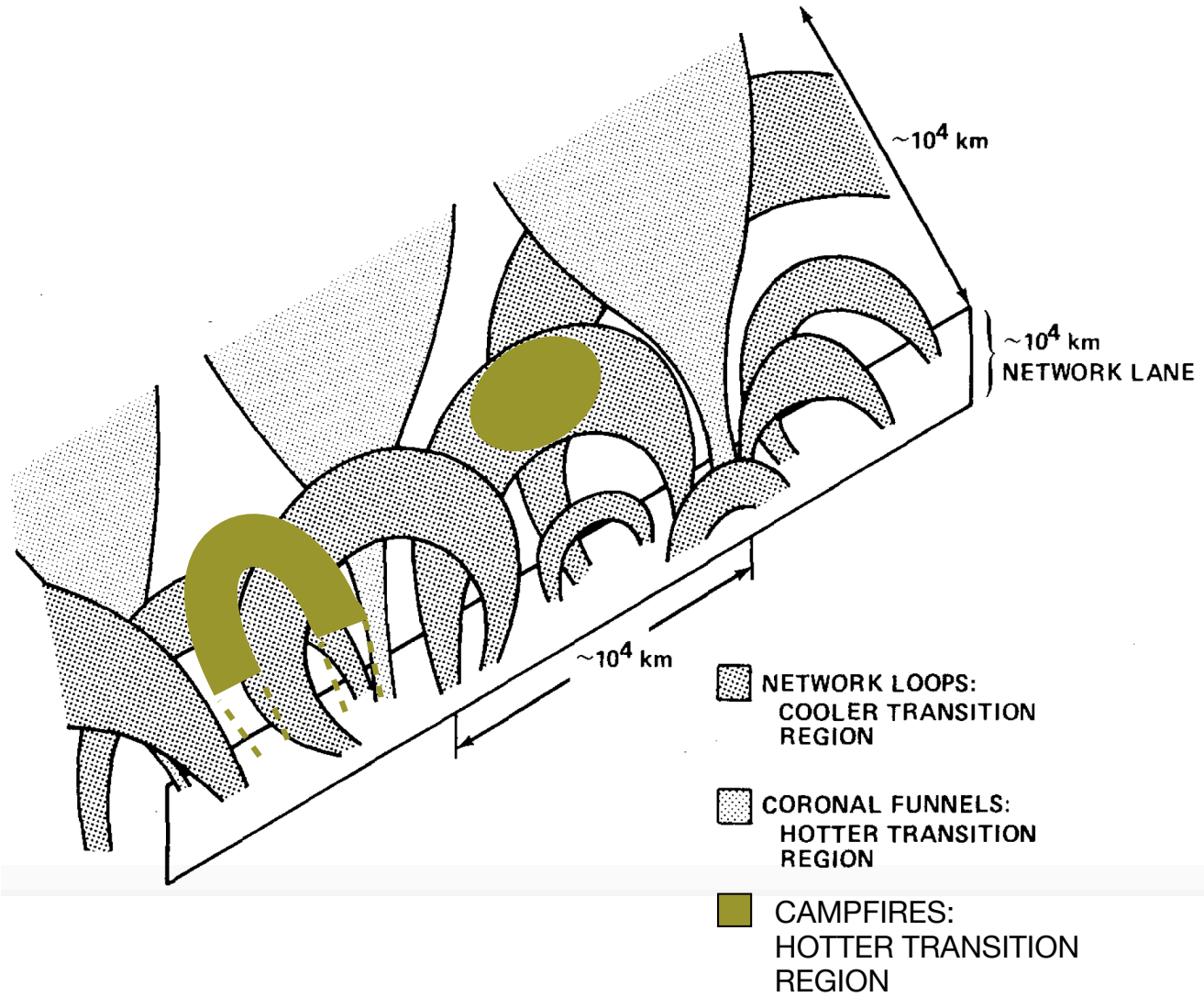
$2h = s$
semi-circular
loop

$2h < s$
low loop

# Campfires: interpretation

- EUI identified a new component of the "unresolved fine structure" (UFS, see Feldman et al. 1983) of the transition region in the quiet Sun: campfires.
- Campfires represent hotter ($T$ ~ 1 MK as shown by the DEM analysis, see *Berghmans et al. 2021*) emission of the low-lying loops or their apexes (heights below 6000 km).
- Campfires are probably magnetically closed structures that are heated internally (not by the heat flux from the corona like the hotter transition region in funnels).

*(after Dowdy et al. 1986)*



# Conclusions

- Favorable positions of Solar Orbiter and SDO spacecraft on 30 May 2020 (angular separation around 31.5 degrees) were used for the first stereoscopy of structures in the solar atmosphere at such a high resolution (400 km for HRIEUV, 880 km for AIA).
- Using manual and automatic triangulation techniques, we determined that the campfire heights are in the range between 1000 km and 5000 km above the photospheric surface.
    - *The random errors are between 600 km and 1500 km, and the systematic error is around 900 km.*
- The EUI observations and our triangulation provide the first clear evidence that small-scale coronal structures emitting around 174 Å do exist at such low heights in quiet Sun regions.
- The low height of EUI campfires suggests that they belong to the previously unresolved fine structure of the transition region and low corona of the quiet Sun.
- Campfires are probably the bright apexes of low-lying small-scale network loops that are heated to temperatures around 1 MK.
- More details: Zhukov et al. 2021, Astronomy & Astrophysics, in press (arXiv:2109.02169).