Two distinct eruptive events observed by Metis on October 28, 2021

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Description of the events

On October 28, 2021 the first X-class solar flare of Solar Cycle 25 occurred, along with a fast halo CME from Earth's perspective (f2 and f3). A few hours before, a slower CME had erupted from a quiet Sun region behind the NW solar limb (f1).

Solar Orbiter facts:

- SolO almost aligned with Sun-Earth line (<~4°,Fig. 1)
- Metis detected the 2 CMEs in VL and UV channels (Fig. 2)
- $d_{S/C} = 0.8\ au$,
- $FoV_{Metis} = [4.8\ -10.3]\ R_{\odot}$

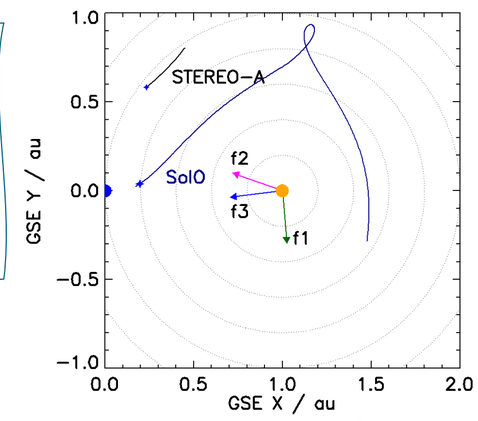


Figure 1: Position of the solar observatories in GSE coordinate system. The colored arrows represent the propagation directions of the features.The dots representing Earth (blue) and Sun (yellow) are not in scale.

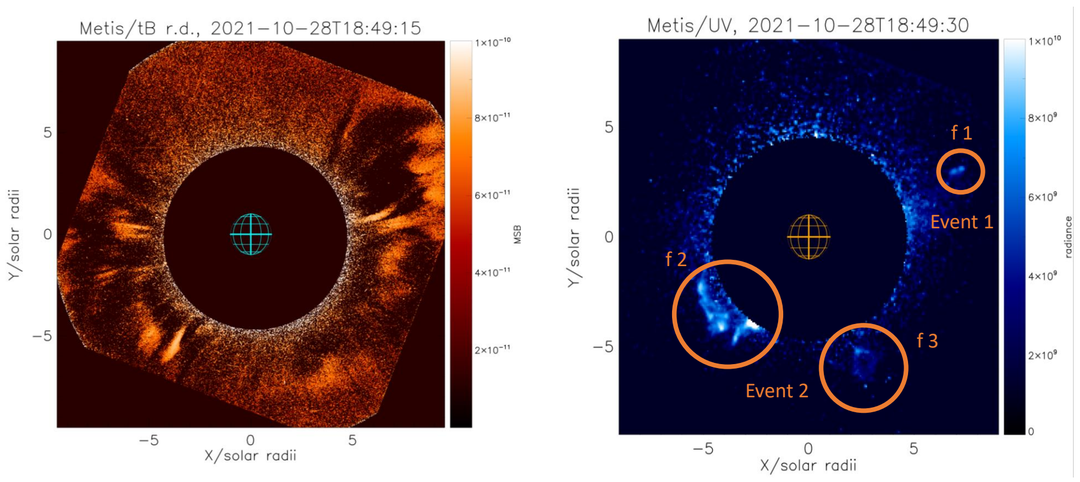


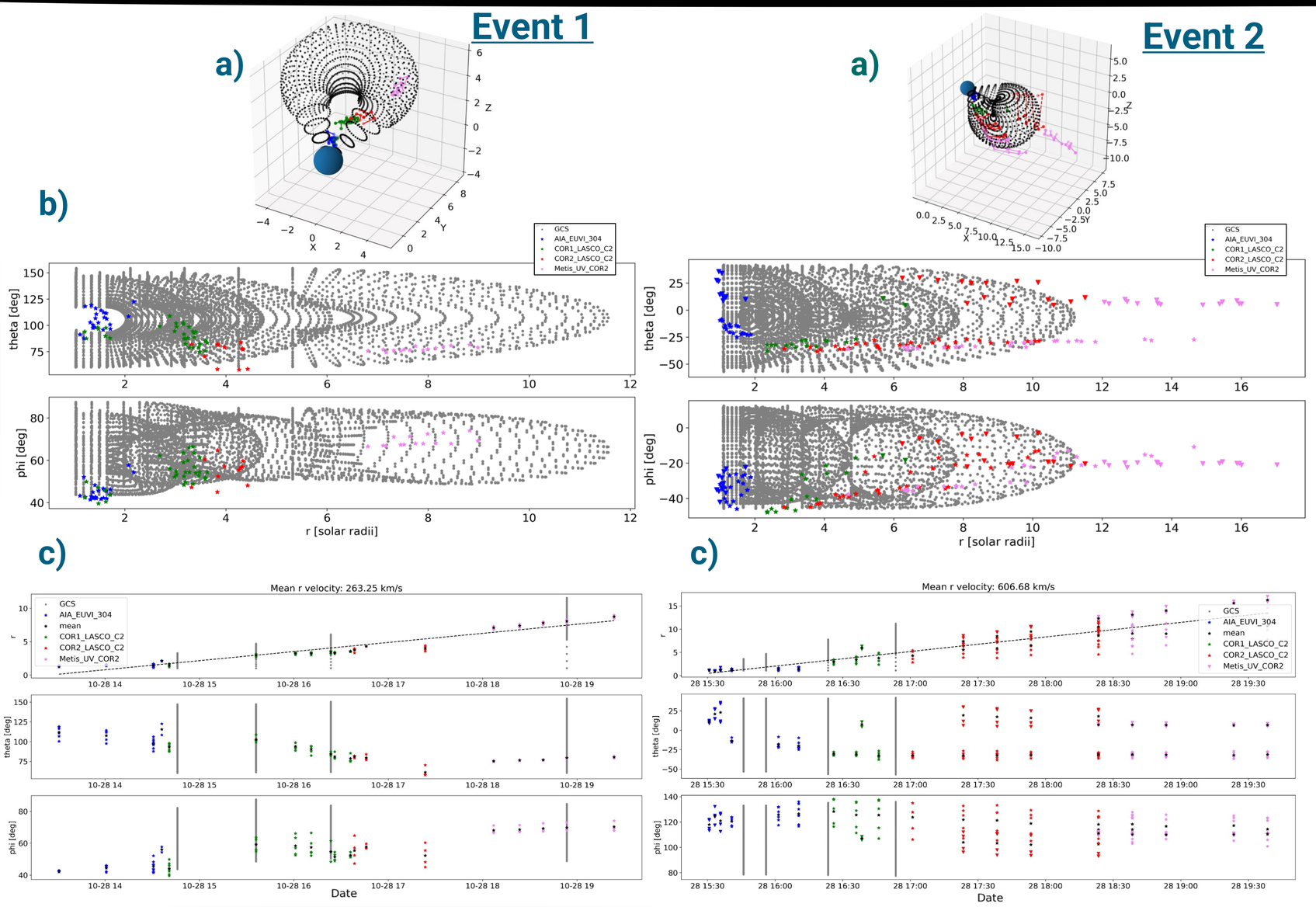
Figure 2: Metis tB running difference (left) and UV (right) images, acquired on October 28, 2021

Figure 3: Origins of event 1 (top) and event 2 (bottom) showed in ST-A/EUVI 304

- Event 1 involves a quiescent filament (NW CME),
- Event 2 an active filament (SE/SW fast halo CME) (Fig. 3)

Follow-up study of Russano et al. (2023). The events are characterized by a very high brightness in UV at those distances.
There are many CMEs without emission in UV. Why do these two CMEs, so different in nature, show UV emission?

Event 1



Event 2

Methodology

- Inspection of many data sets from numerous remote sensing instruments and use of several techniques of enhancement.
- Characterization of the prominence evolution with the tie-point triangulation, adapted triangulation tool by Nisticò (2023).
- 3D reconstruction of CME's outer envelope (GCS reconstruction).

Figure 4:
a) 3D representation of the prominence and its outer shell;
b) Polar coordinates (ϑ,φ) of the triangulation points (colored) and the GCS reconstruction (grey) with respect to the radial distance r; the plot contains the velocity best fit (dashed black line);
c) Evolution of the polar coordinates (r,ϑ,φ) of the triangulation points (colored) and the GCS reconstruction (grey) with time;
for Event 1 (left) and Event 2 (right)

Mass calculation

Mass calculation was performed by applying the "excess brightness method" (e.g. Vourlidas et al. 2000) on sectors of total brightness images from various coronagraphs. The boundaries of the sectors were determined from Metis UV images.

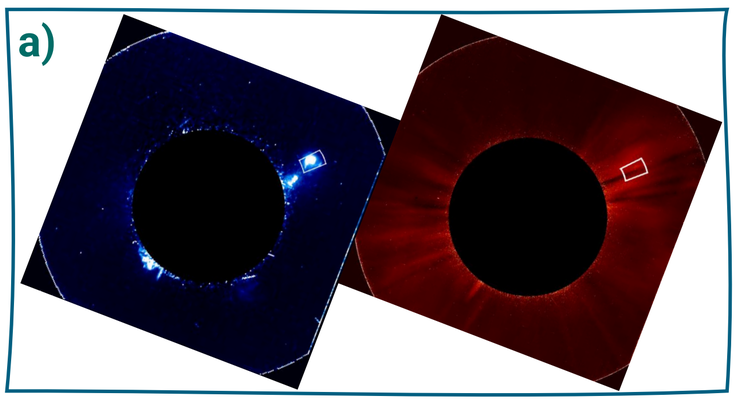


Figure 5 a) Examples of the sectors used left: Metis UV, right: Metis tB;

Figure 5 b) Mass of CME cores VS time;

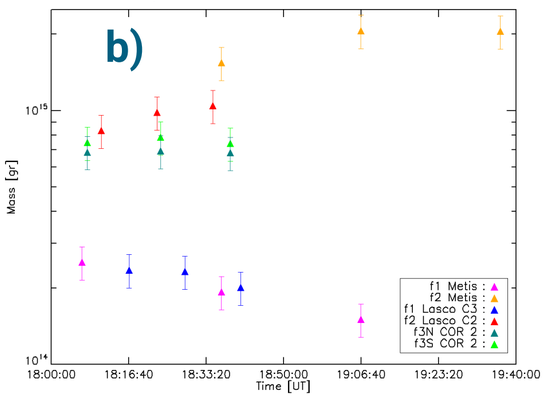
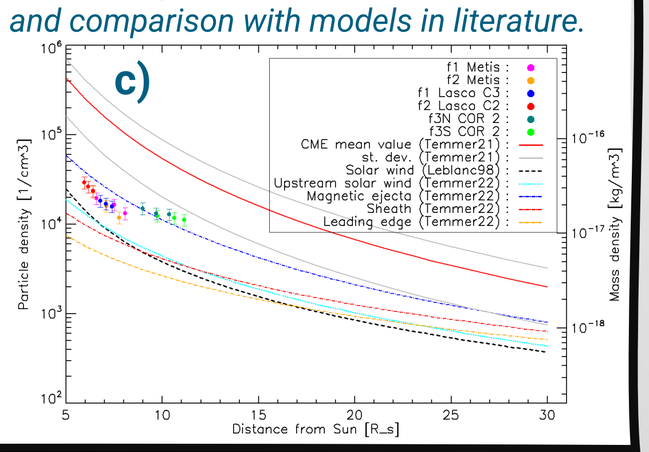


Figure 5 c) Particle density VS distance and comparison with models in literature.



Conclusions

Triangulation and GCS reconstruction were applied :

- Good agreement in the evolution among all imagers triangulation
- Reconstructed prominences lie within the GCS shells
- Metis enabled tracking of the features at farther distances with higher spatial resolution, also when using the UV channel

Mass measurements from Metis and Lasco C2 are consistent for Event 1. Mass density of the core of Event 1 and Event 2 are similar, this can explain why the slower CME is as bright as the fast halo CME.

References

- *Nisticò 2023, Sol. Phys., Vol. 298:36*
- *Russano et al. 2024, A&A, Vol. 683, A191*
- *Vourlidas et al. 2000, ApJ, Vol. 534*
- *Leblanc et al. 1998, Sol. Phys., Vol. 183*
- *Temmer et al. 2021, JGR: Space Phys., Vol. 126*
- *Temmer & Bothmer 2022, A&A, Vol. 665, A70*