A CME followed by a prominence eruption as observed by the remote sensing instruments on-board Solar Orbiter

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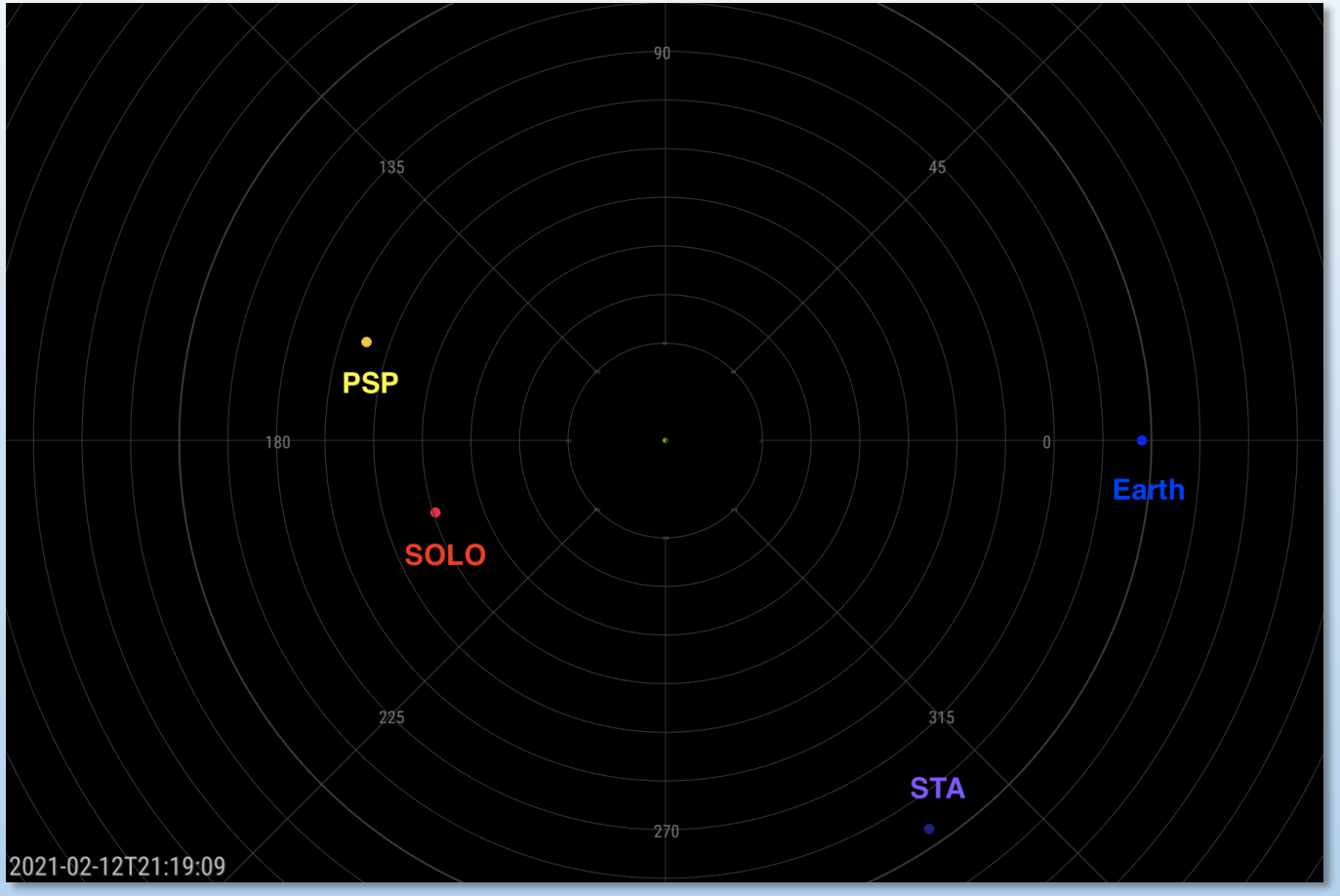
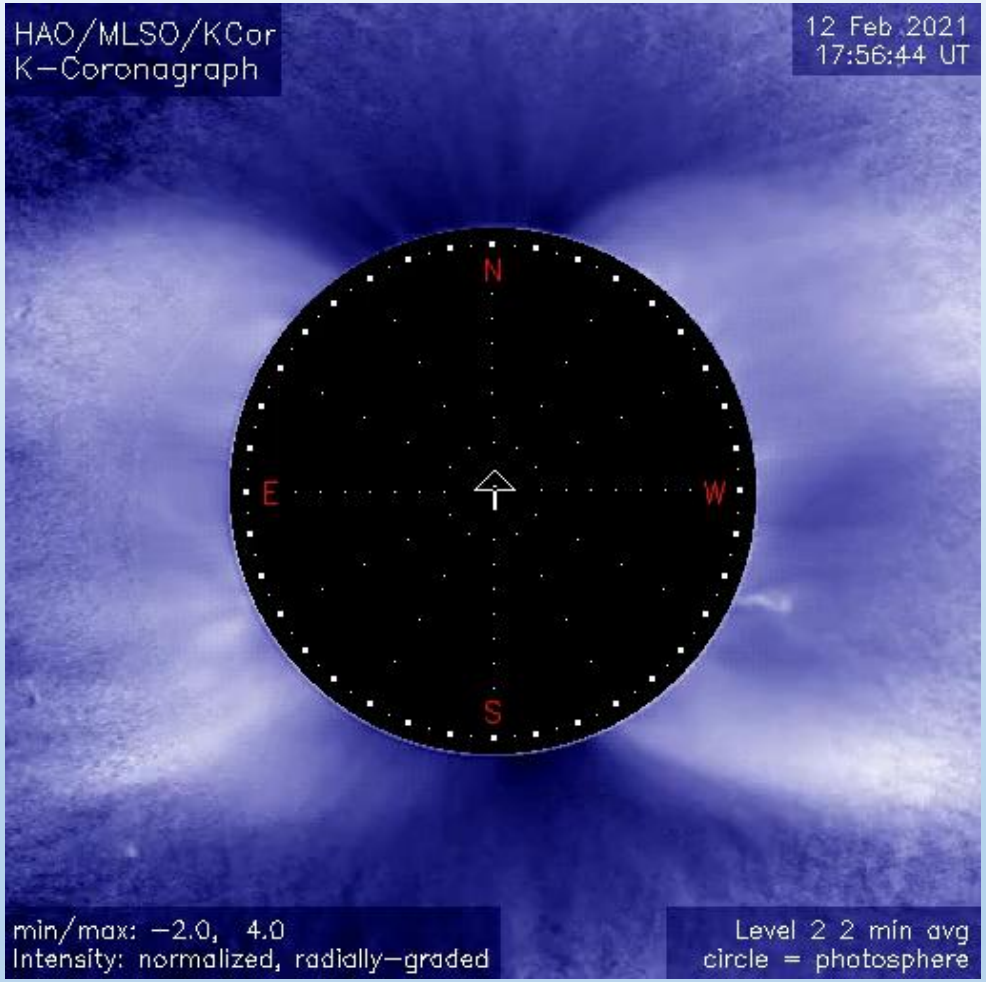
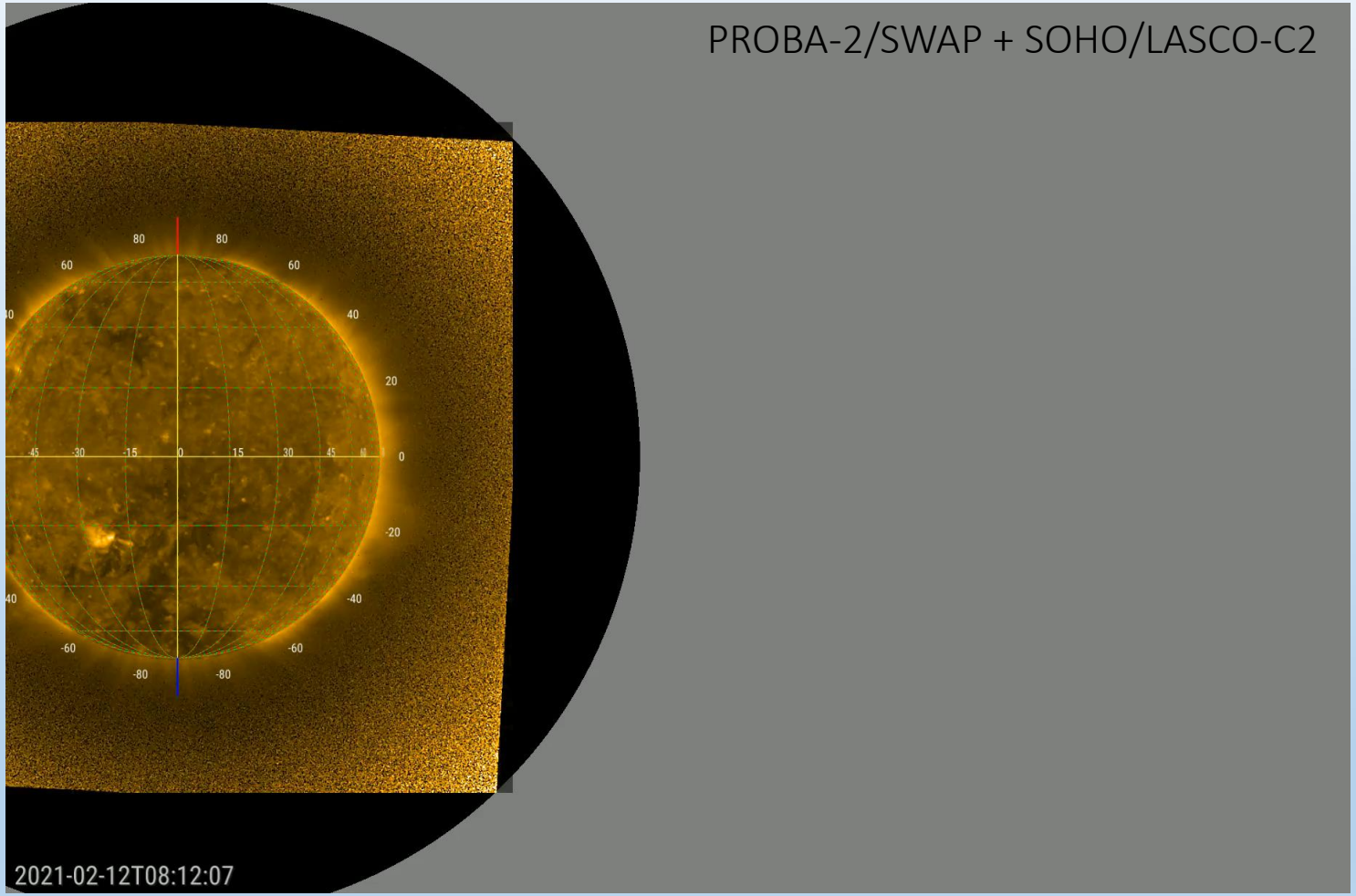
Spacecraft configuration (12/02/2021)



Date [yyyy-mm-dd]	Sep. angle SOLO - Earth [deg]	Sep. angle SOLO - STA [deg]	Sep. angle SOLO - PSP [deg]	dist_PSP_Sun [AU]	lon_SOLO HEEQ [deg]	lat_SOLO HEEQ [deg]	dist_SOLO_Sun [AU]
2021-02-12	163,73	108,86	33,56	0,64	-164,66	1,14	0,5

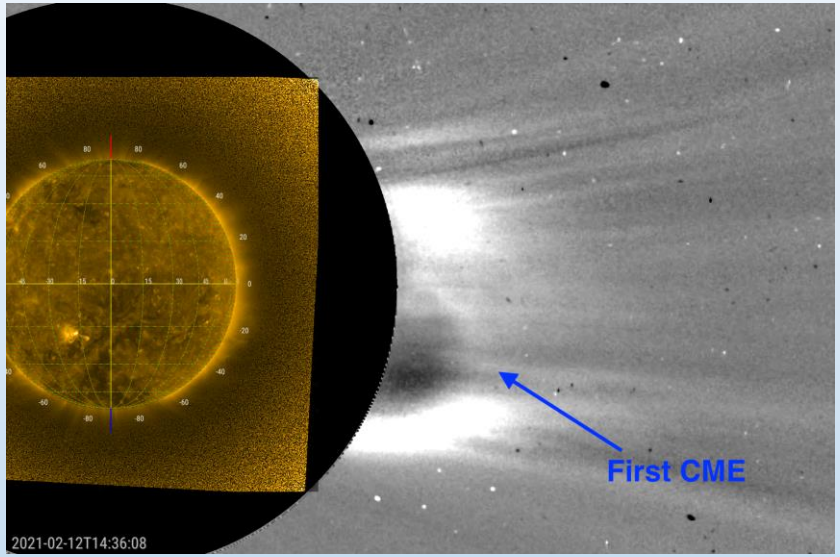
Sun-Earth line observations

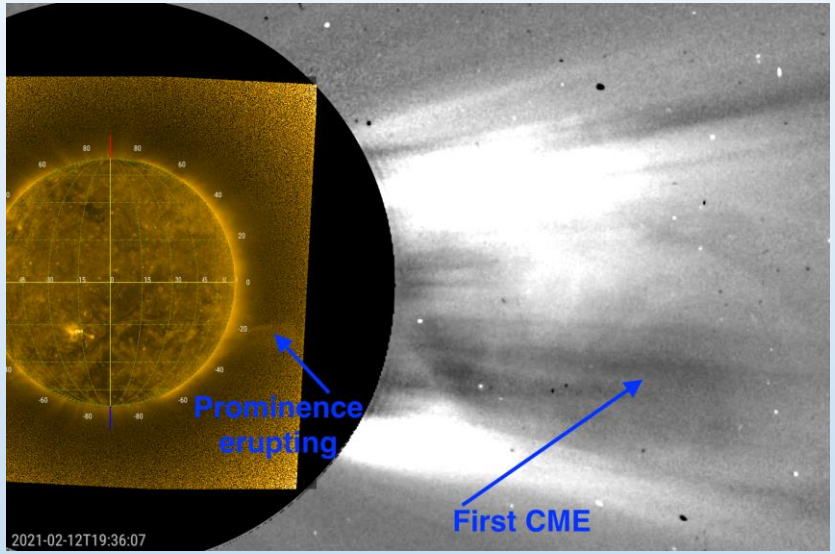


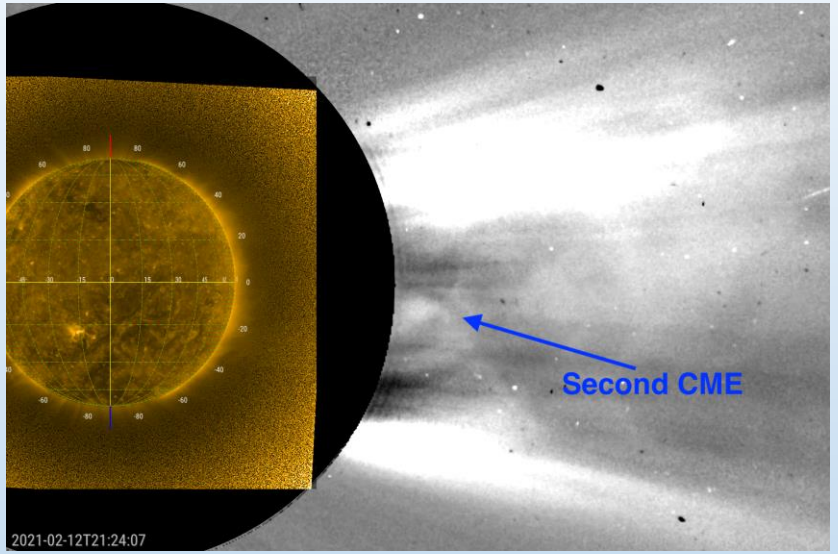


On February 12, 2021 two subsequent eruptions occurred above the West limb, as seen along the Sun-Earth line.

Sun-Earth line observations







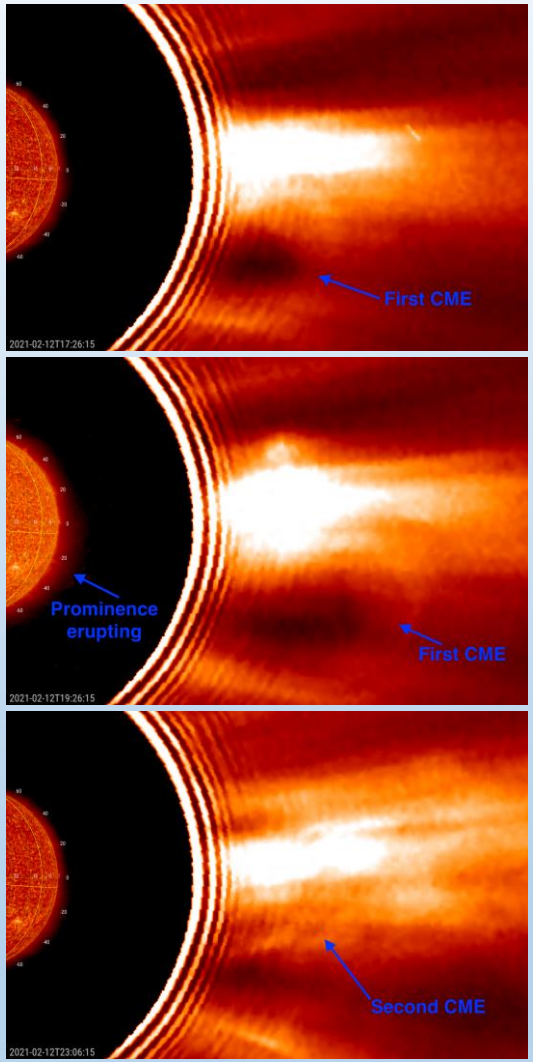
The first event appeared in the SOHO/LASCO-C2 images as a typical Coronal Mass Ejection (CME), starting around 12:48 UT with a projected speed on the order of **120 km/s**, as provided by CACTUS catalog.

This slow CME was followed ~7 hours later by a smaller and collimated prominence eruption, originating Southward with respect to the CME, and propagating much faster at ~**380 km/s**.

The EUV images by SWAP and AIA show some activity before the first CME at longitudes between 30°-45° West, while the prominence originates close to the West limb.

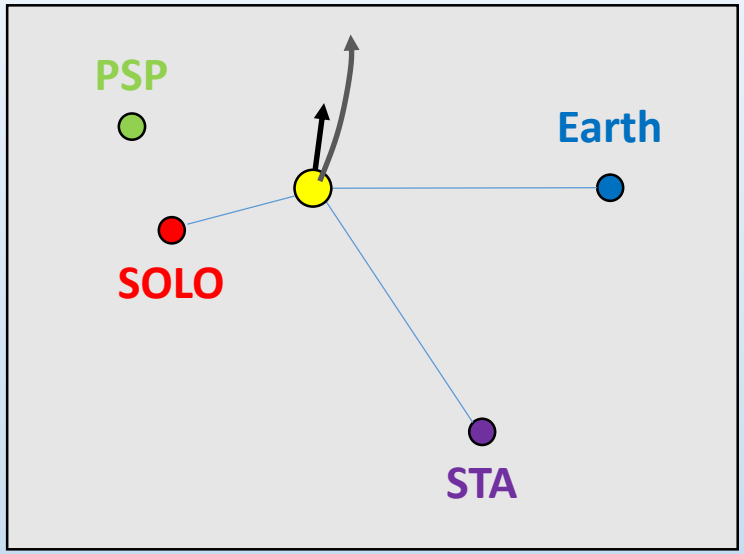
The subsequent evolution shows a **merging between the two eruptions** starting already in the LASCO-C2 field-of-view and being observed later on by LASCO-C3, making it difficult to distinguish between the two events.

STEREO-A observations



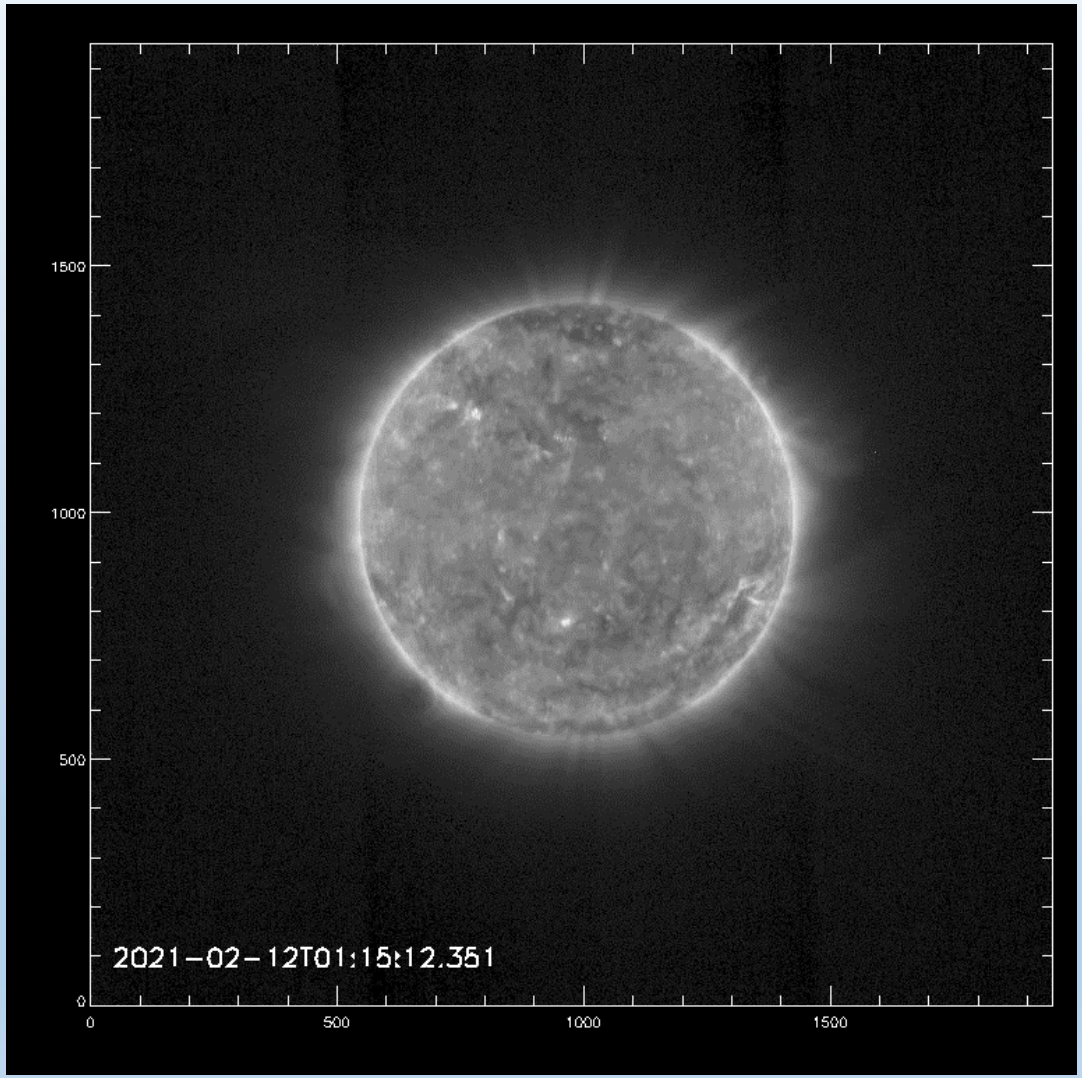
The two subsequent eruptions were also observed by STEREO-A instruments propagating above the South-West limb, with the prominence source region behind the limb

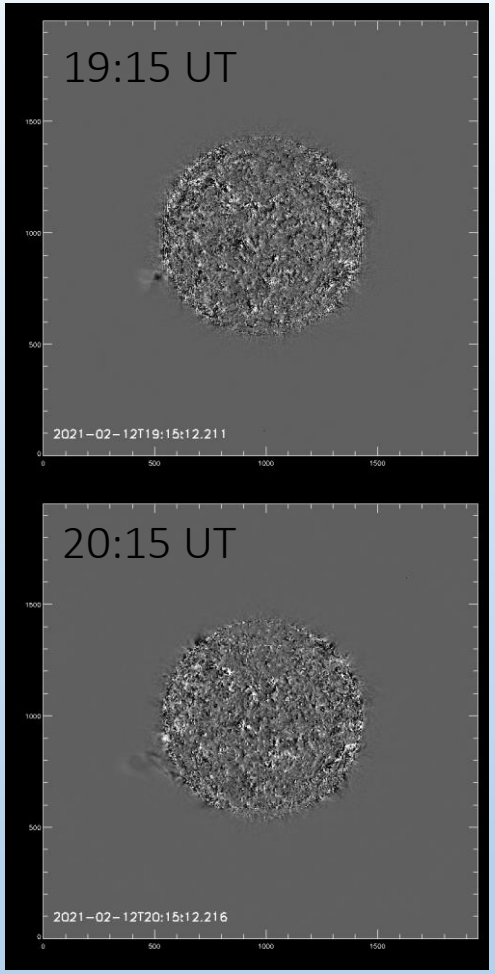
Solar Orbiter observations: FSI



Location of different spacecraft and propagation directions of the two eruptions.

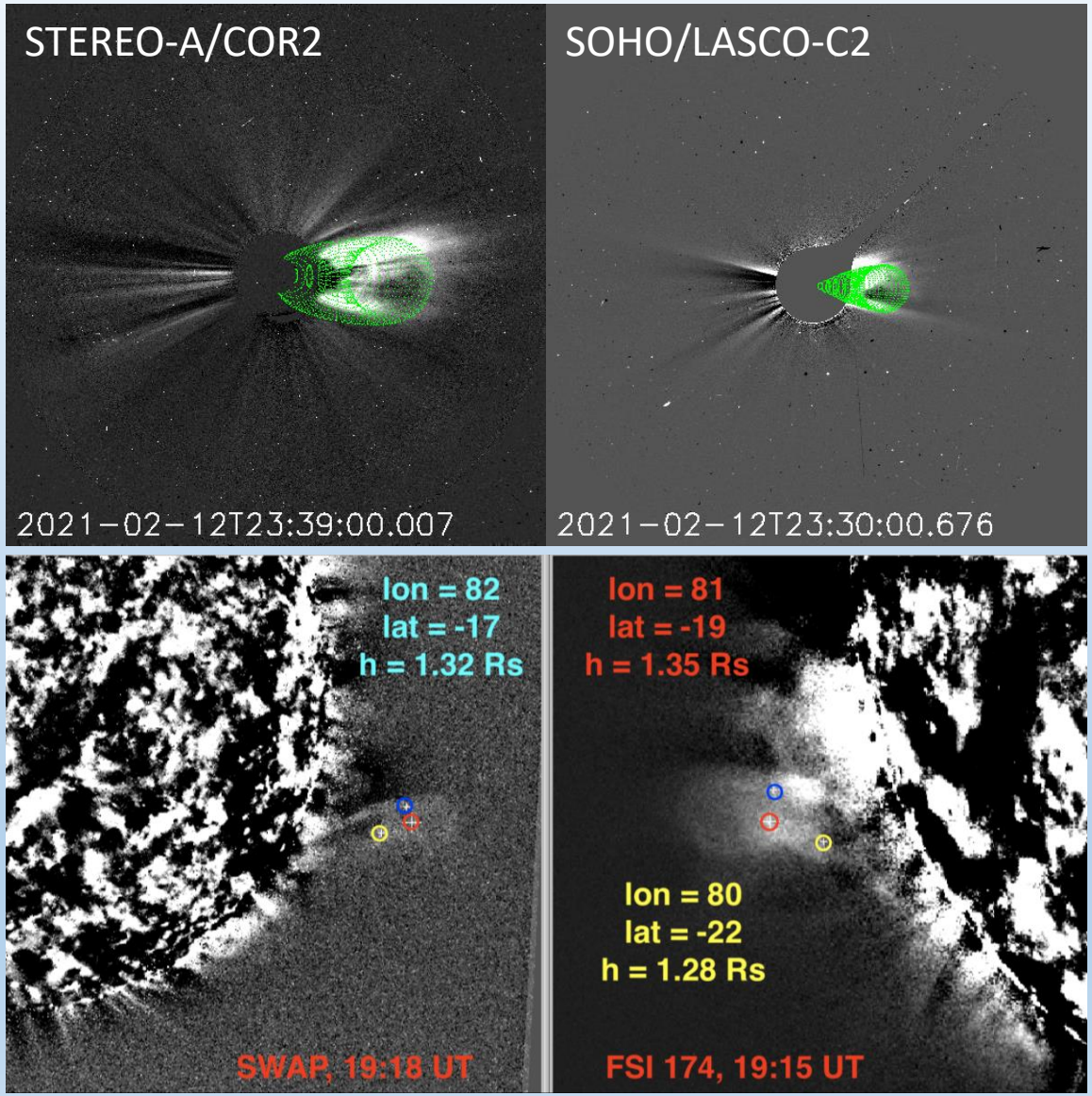
The arrows show the approximate locations of source regions on the Sun and the propagation directions for the first CME (gray) and the trailing prominence (black).





SOLO/FSI running difference images

3D reconstructions

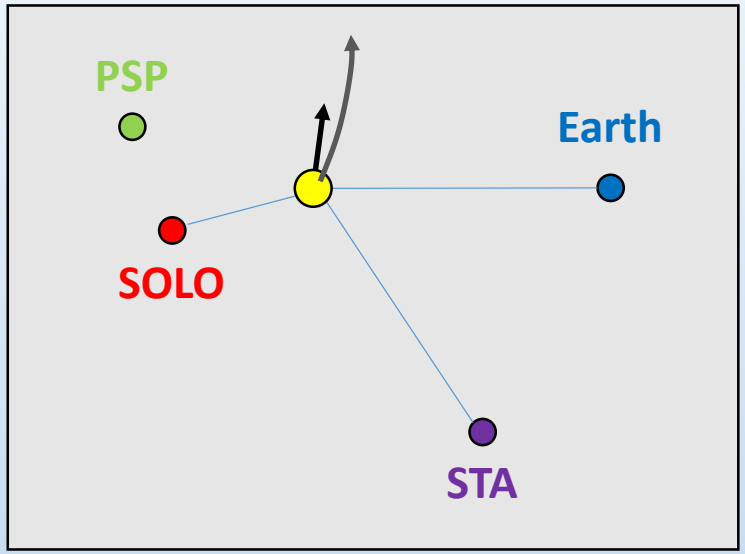


Date [yyyy-mm-dd]	Time (COR2) [UT]	lon [deg]	lat [deg]	Tilt [deg]	h [Rs]	ratio	Half angle [deg]	Comments
2021-02-12	16:39	61	-6	0	5.31	0.4	30	C2+COR2-A, C2: 16:36 UT
2021-02-12	20:39	78	-6	5	7.42	0.32	30	C3+COR2-A, C3: 20:30 UT
2021-02-12	23:39	80	-6	5	10.43	0.32	30	C3+COR2-A, C3: 23:30 UT

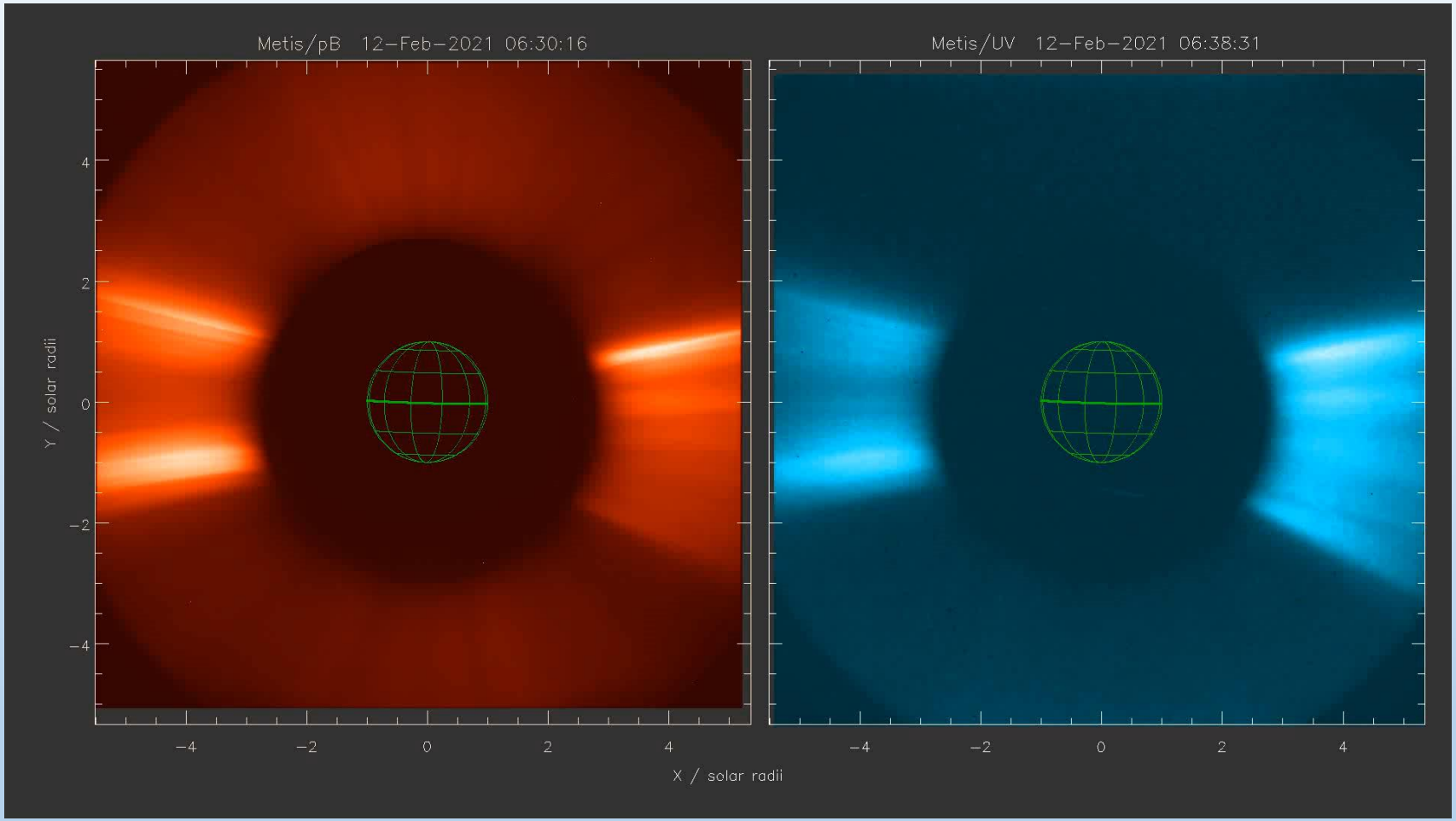
Reconstructions in 3D via triangulation (for the prominence) and GCS fitting (for the CME) shows that:

- the prominence originates from 80° West and 20° South propagating Northward
- the CME originates from ~ 30° - 45° West (AIA images) propagating Westward

Solar Orbiter observations: METIS

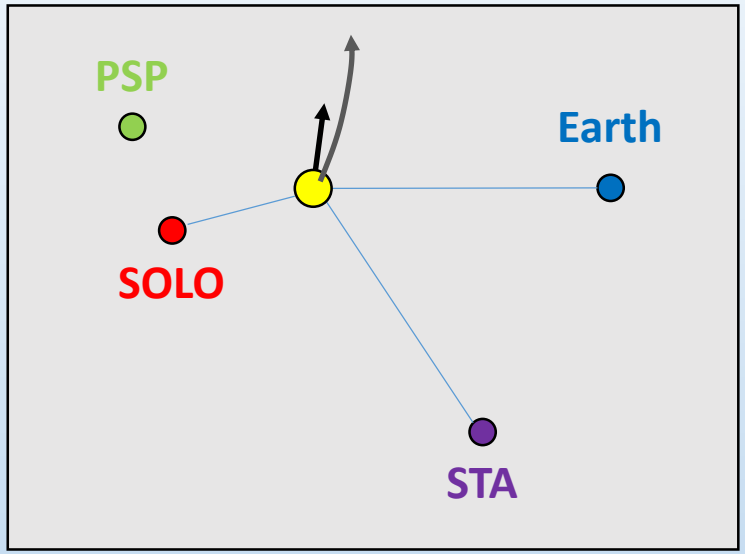


SOLO/METIS images show the first CME as a quite faint front enclosing a darker cavity followed by multiple filamentary features without evident core, while the prominence results in a clear expanding plasma blob.



SOLO/METIS images acquired with the VL (left) and UV Lyman-alpha (right) channels

Solar Orbiter observations: METIS



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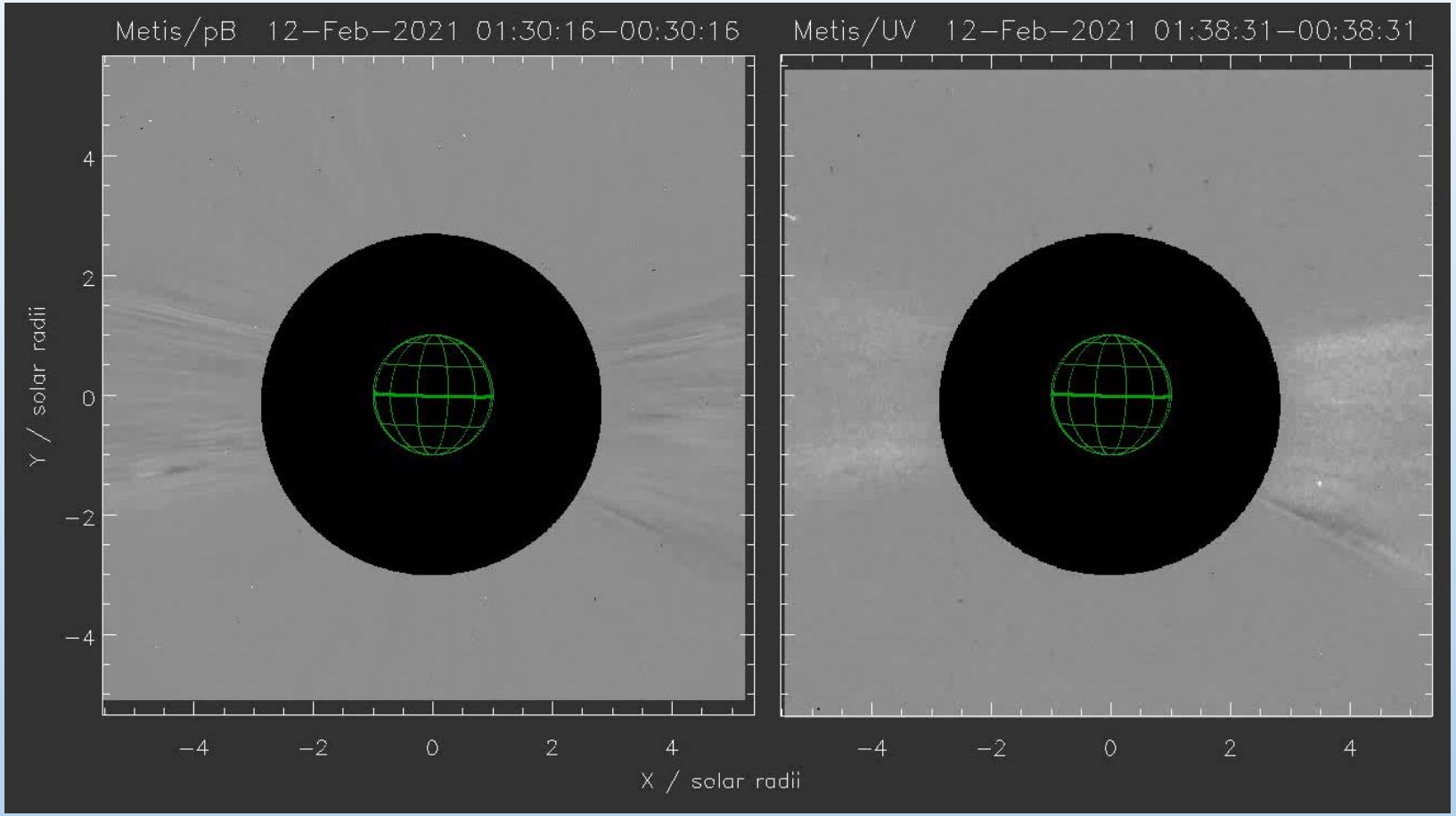
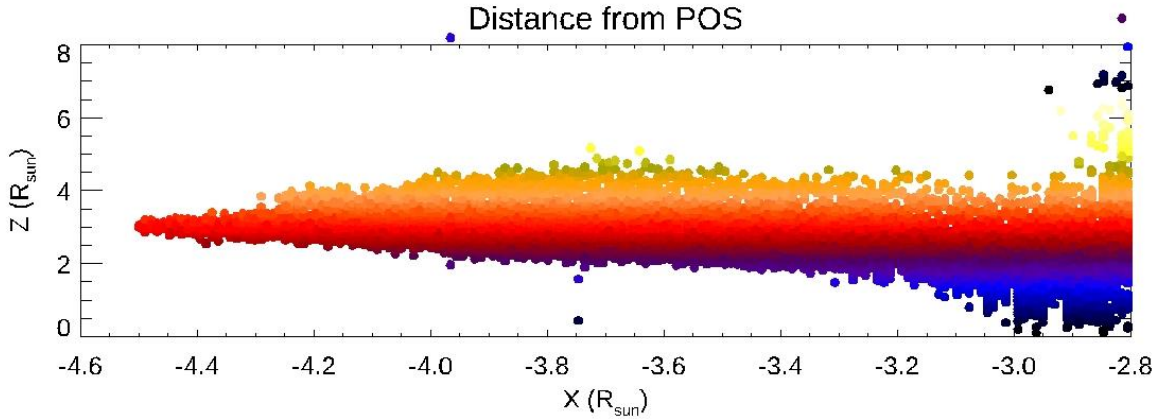


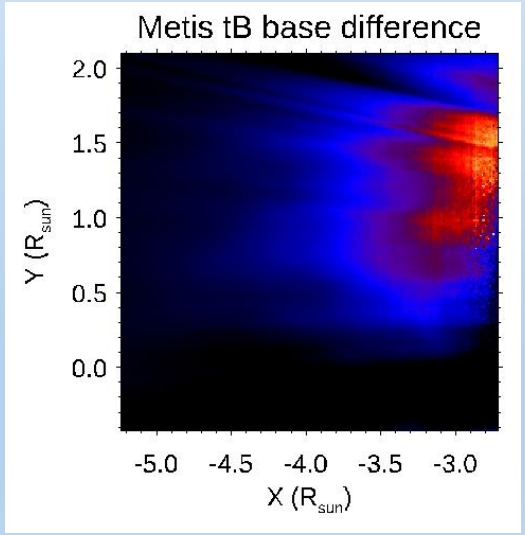
SOLO/METIS running difference images with the VL (left) and UV Lyman-alpha (right) channels

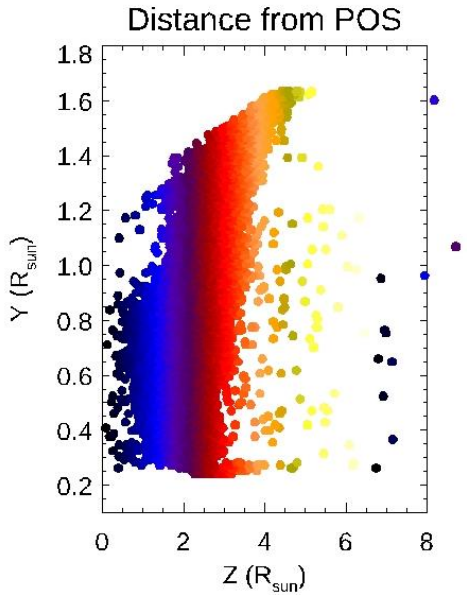
Polarization ratio technique with METIS

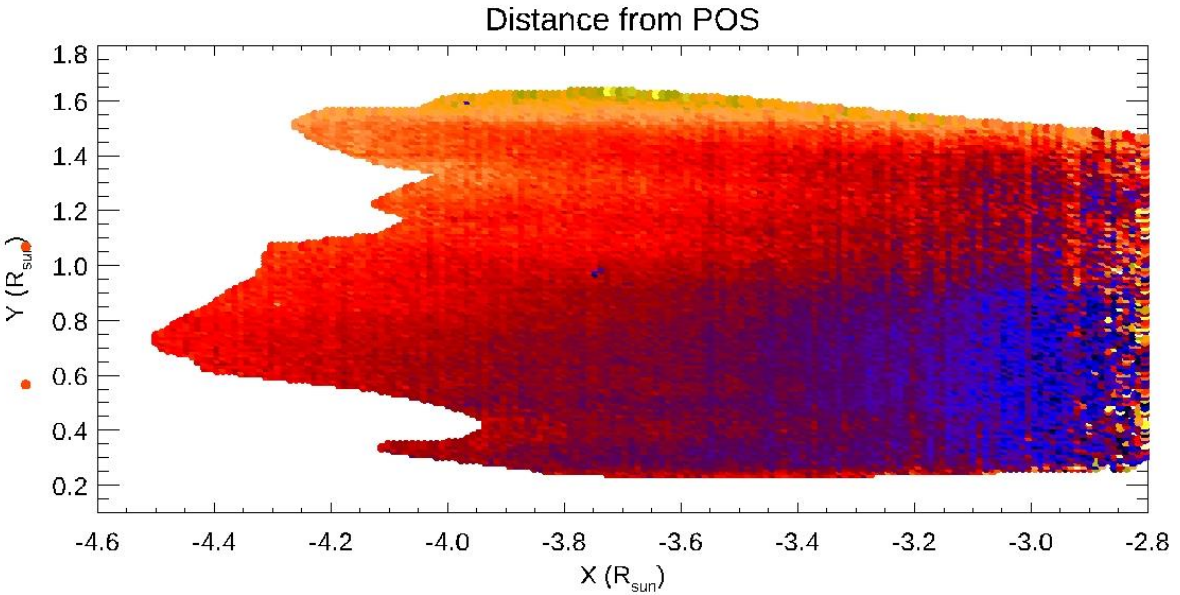
- Average distance from the POS: 2.64 Rsun
- Average position on the POS: 3.65 Rsun
- Average POS position angle: 36°

behind the limb as seen from SOLO/METIS, corresponding to a longitude in the Stonyhurst coordinates of $2\pi - \theta_{SOLO\text{-}E} - \pi/2 - \theta_{CME} = 70°$.





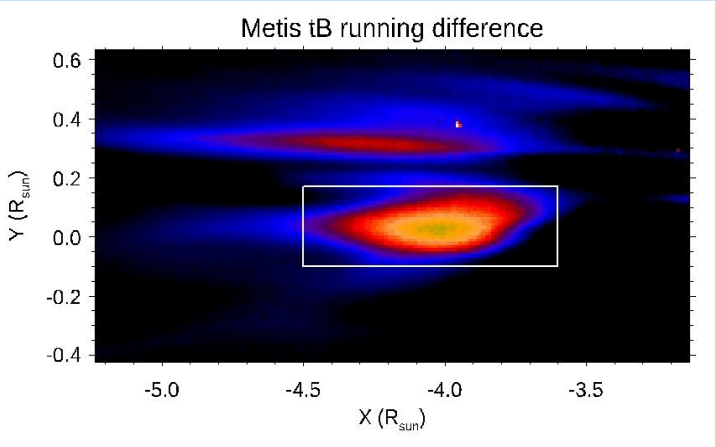


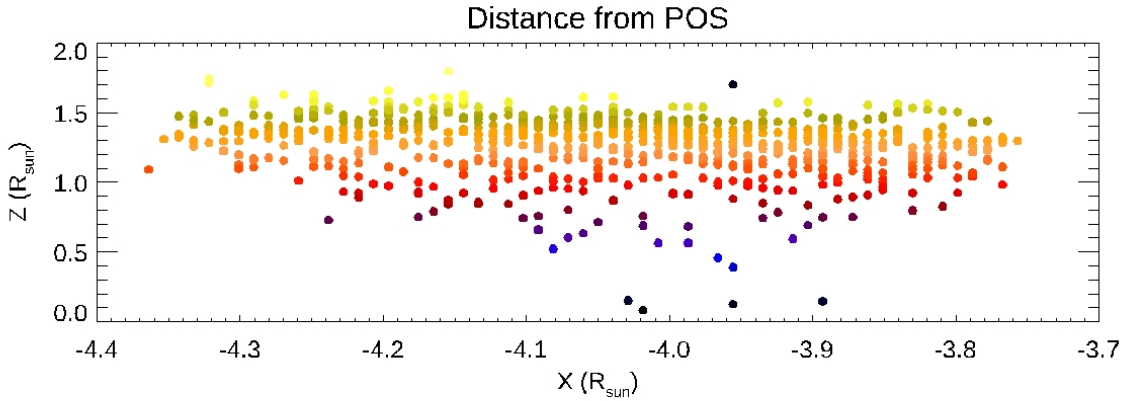


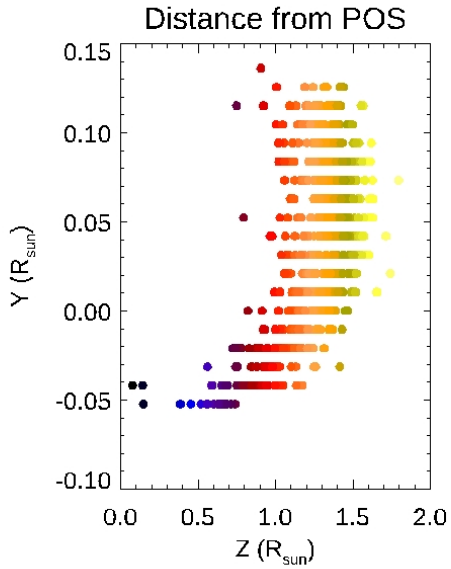
Polarization ratio technique with METIS

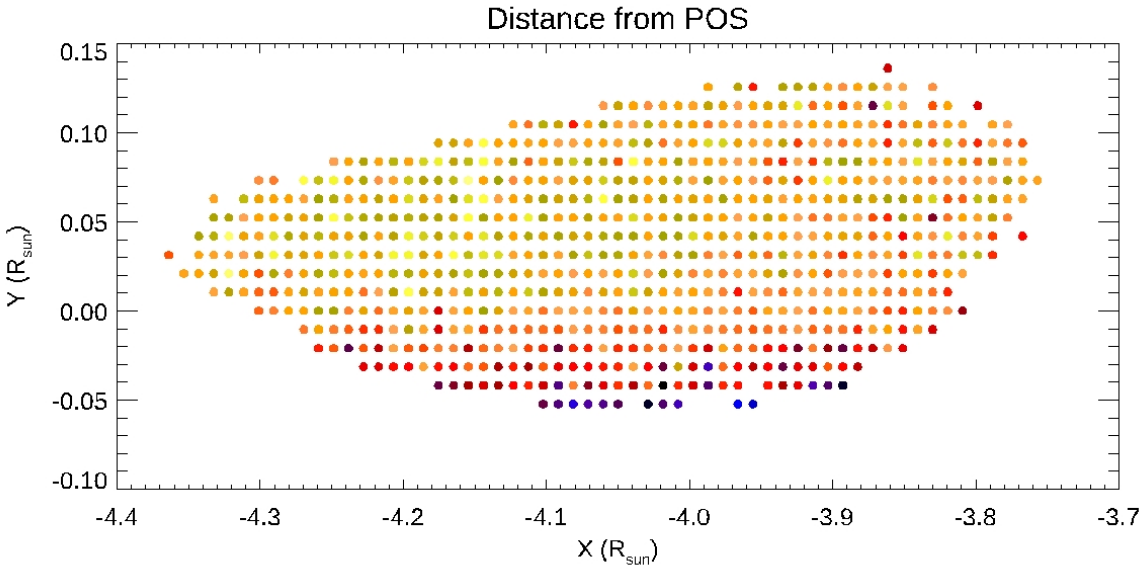
- Average distance from the POS: 1.26 Rsun
- Average position on the POS: 4.04 Rsun
- Average POS position angle: 17°

behind the limb as seen from SOLO/METIS, corresponding to a longitude in the Stonyhurst coordinates of $2\pi - \theta_{SOLO\text{-}E} - \pi/2 - \theta_{CME} = 89°$.



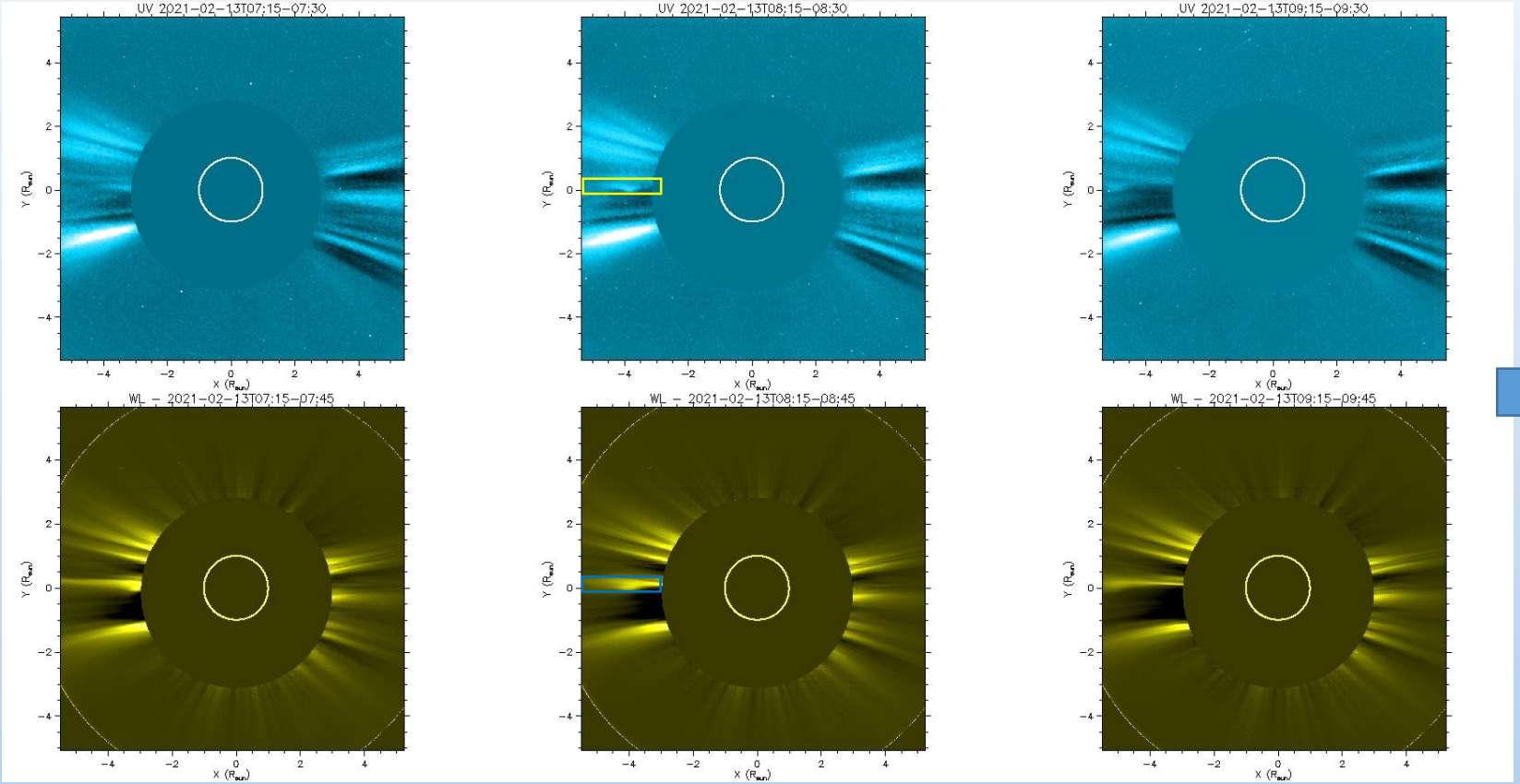


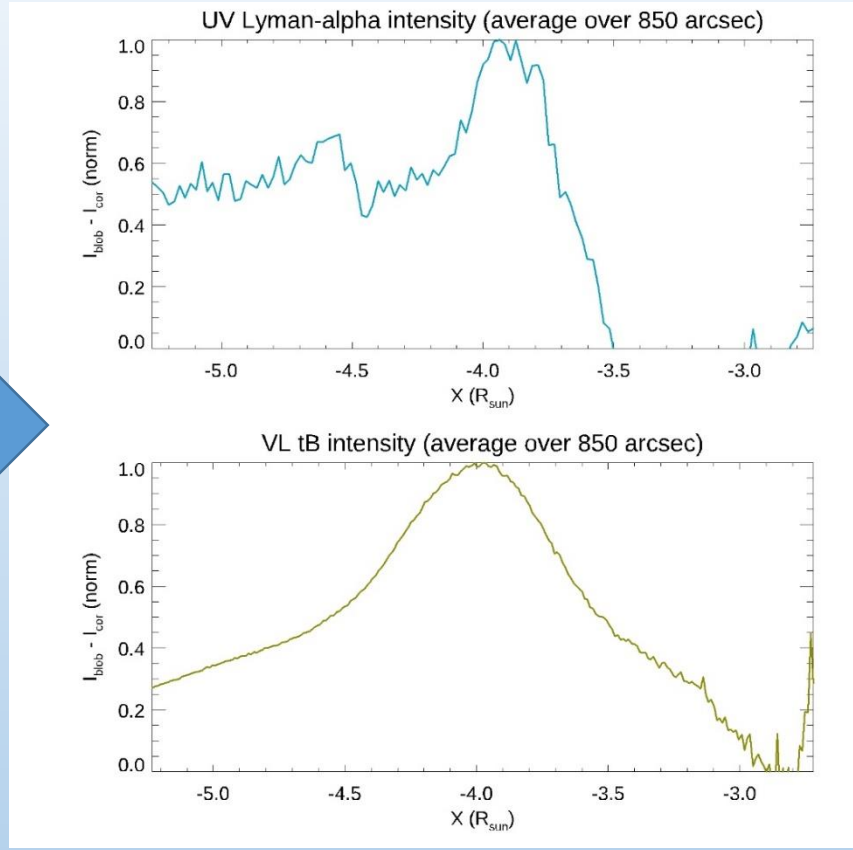




It is the first time that this technique is applied to pB and tB images derived from a polarized sequence acquired with 4 different orientations of the linear polarizer → significant reduction of polarization errors, hence **smaller dispersion along the LOS.**

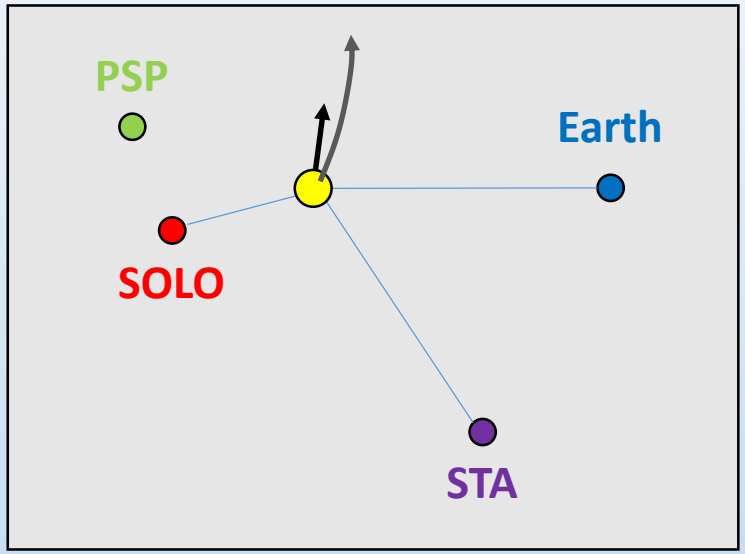
Comparison between VL and UV METIS channels





Comparison between normalized VL and UV intensities across the blob (after subtraction of an average pre-CME image) → **differences in the emission distribution**. Considering that the outward propagation speed is almost constant across the blob, these could be related with variations of H ionization fraction, hence **plasma temperatures**, but different acquisition times have also to be taken into account (15 min for UV, 30 min for the VL polarized sequence).

Solar Orbiter observations: HI



The southern part of the first CME was also observed by SOLO/HI, while the subsequent prominence eruption most probably propagated out of the instrument field-of-view.

Summary and conclusions

- A sequence of **two eruptions** (a slow CME followed by an erupting prominence) was observed on February 12, 2021 by many different instruments from the ground and space, including those on-board **Solar Orbiter**.
- Combination of images acquired by different view-points with triangulation and GCS fitting technique allowed to **reconstruct the 3D trajectory and source region** of both events → the first CME originates from the Western hemisphere (as seen from the Earth) and then propagates Westward, while the prominence erupt close to the West limb (as seen from the Earth) propagating Northward.
- The **prominence expands much faster than the CME** and eventually **merges** with it in LASCO-C3 FoV.
- The two eruptions were observed by **FSI**, **METIS**, and **HI** telescopes on-board **Solar Orbiter**.
- Images acquired in the **METIS** channels shows **differences and similarities** → interpretation in progress.
- The **polarization ratio technique** applied to **METIS** images provides values for the 3D location of the CME front and erupting prominence in very nice agreement with 3D reconstructions with other methods.
- Differences in the UV and WL inensity distributions could be related with **temperature variations across the blob**, but the different length of acquisition intervals for UV and WL have also to be taken into account.
- The prominence was likely destabilized by the occurrence of nearby CME being eventually channelled along fieldlines resulting from the post-CME rearrangement. The analysis is still in progress.