

DOUBLE PROMINENCE ERUPTION OBSERVED BY SOLAR ORBITER AND PSP

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On behalf of HSO Connect & Solar Orbiter & PSP Teams



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Abstract

A pair of off-limb eruptions was observed by the Extreme Ultraviolet Imager (EUI) onboard Solar Orbiter (SolO) on 2021 April 23/24. At the time, the spacecraft was at 0.87 AU from the Sun. As seen from Earth, SolO was roughly near the Sun's east limb (as seen from the Earth) and in quadrature with Parker Solar Probe (PSP), which was at the Sun's far side. The eruptions are remarkably well observed in the Full Sun Imager (FSI) in both its EUI/FSI174 and EUI/FSI304 channels. The first eruption starts as a slowly growing prominence eruption culminating in an apparent untwisting and ejection from April 23 22:25 UTC onwards. This eruption is immediately followed by a yet more spectacular and faster eruption from the same source region less than 4 hours later. The absence of any corresponding signature in Earth-bound datasets confirms this eruption pair is back-sided from the Earth. STEREO-A COR2 observations confirm that the prominence eruptions observed by EUI/FSI correspond to a complicated interaction of 2-3 coronal mass ejections. In this paper we will use the favourable quadrature orientation of SolO and PSP to link SolO's extreme ultraviolet and coronagraphic observations with PSP's off-limb and in-situ observations. We will highlight the lessons learned for upcoming PSP and Solar Orbiter quadratures such as in February 2022.



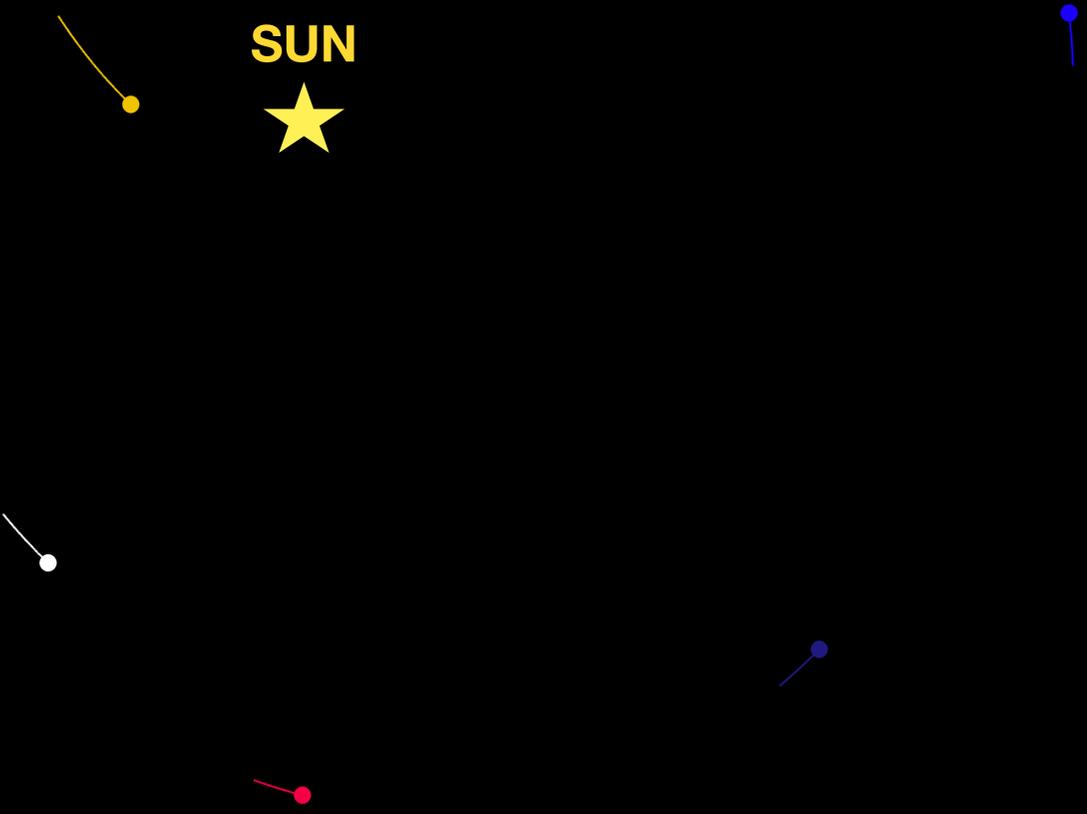
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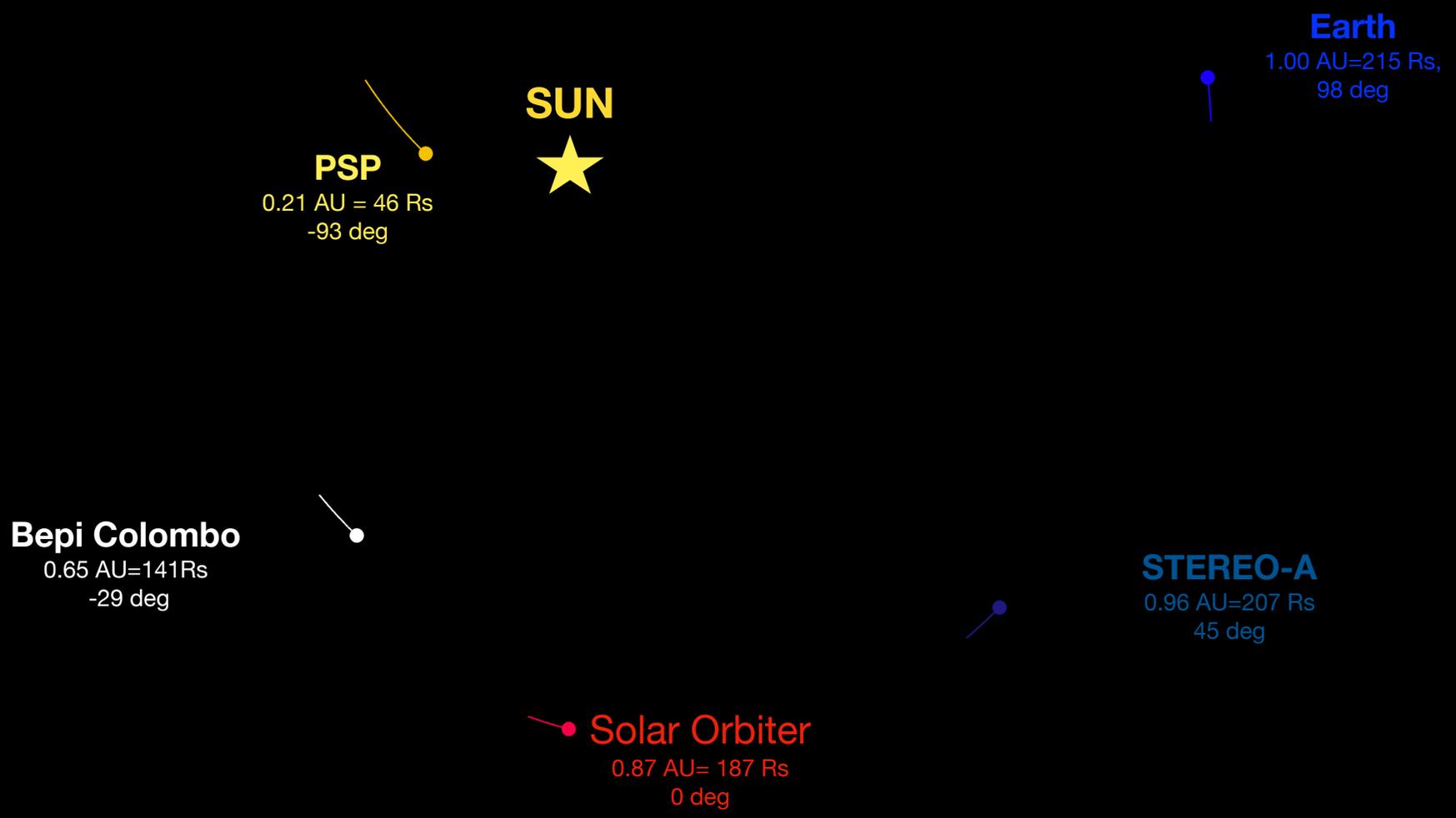
A spiral constellation of spacecraft at increasing solar distance and solar longitude

2021 April 24



A spiral constellation of spacecraft at increasing solar distance and solar longitude

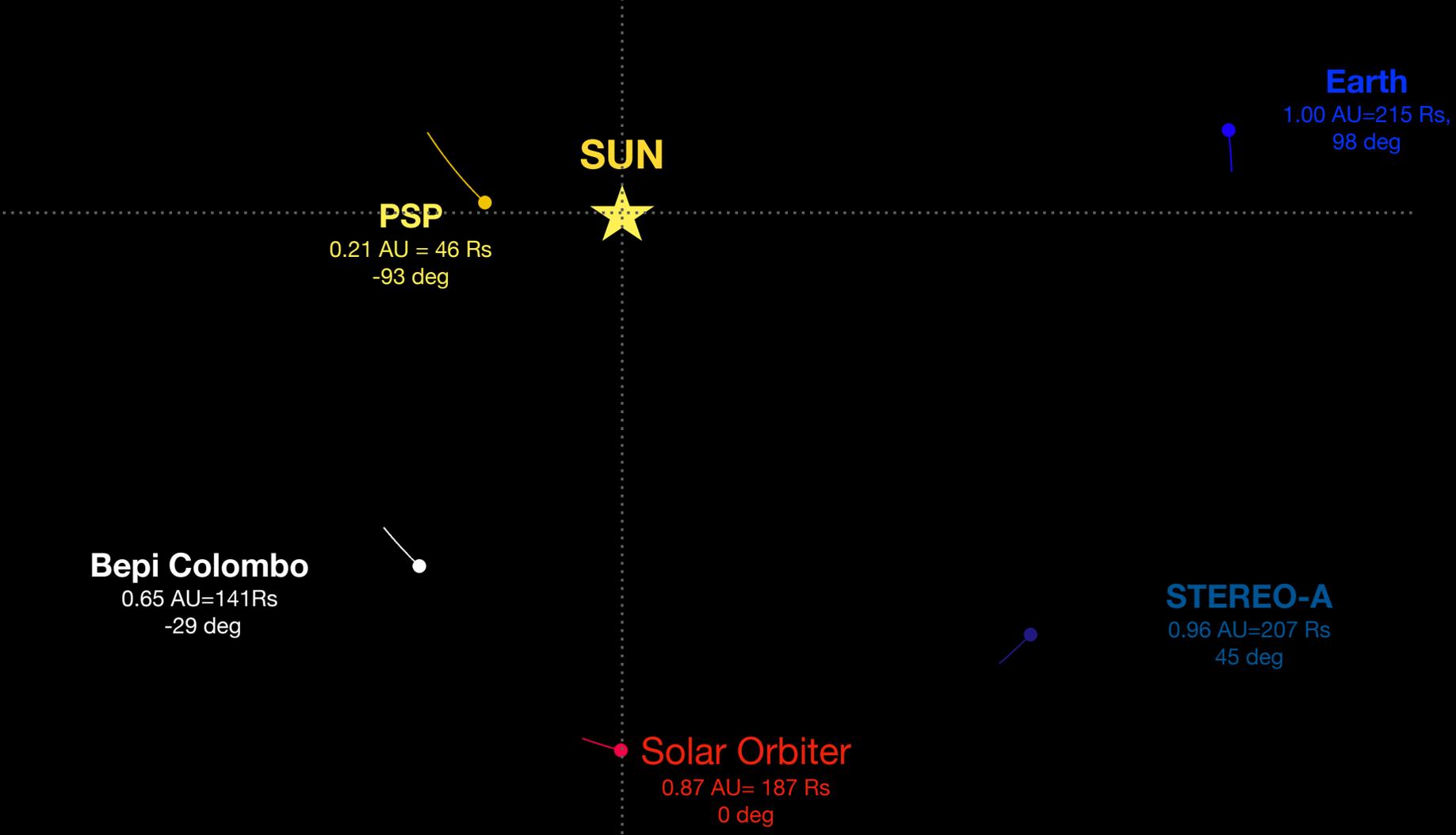
2021 April 24

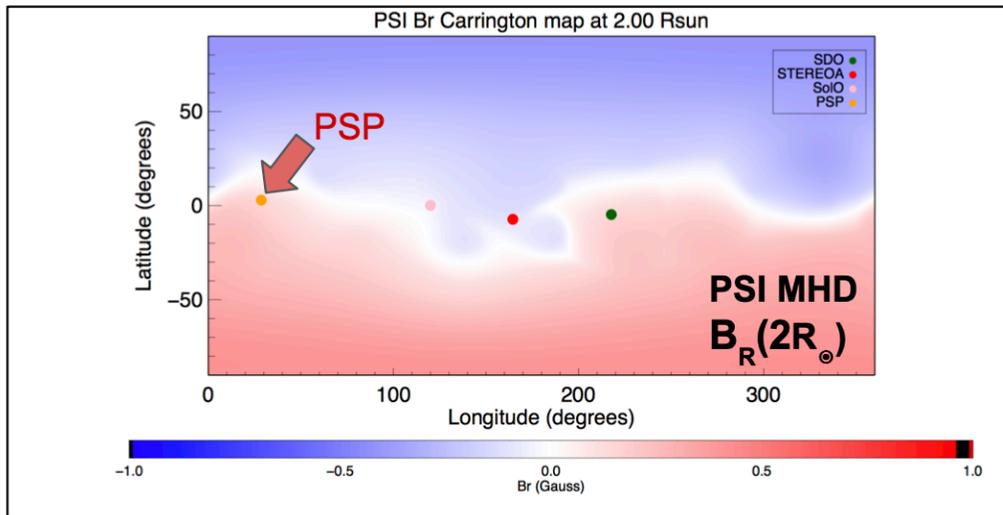
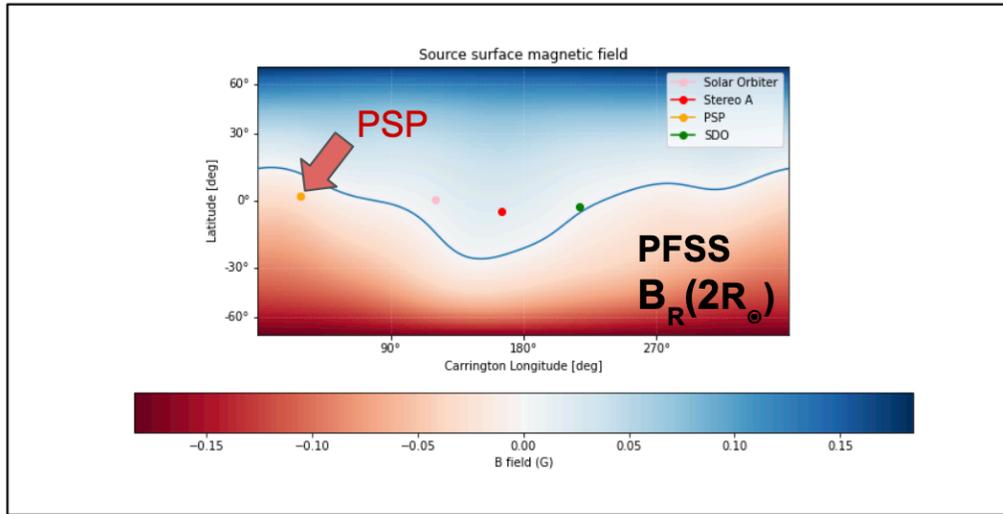


A spiral constellation of spacecraft at increasing solar distance and solar longitude

2021 April 24

Parker Solar Probe and Solar Orbiter in quadrature



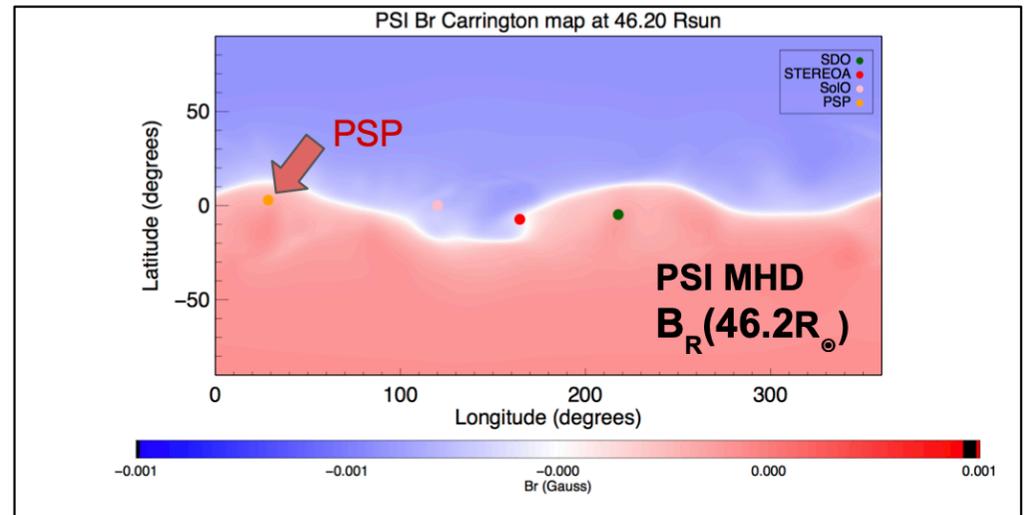


CURRENT SHEET AT $2R_\odot$

The top image is the B_R at $2R_\odot$ calculated using a PFSS model while the bottom image from a PSI MHD model.

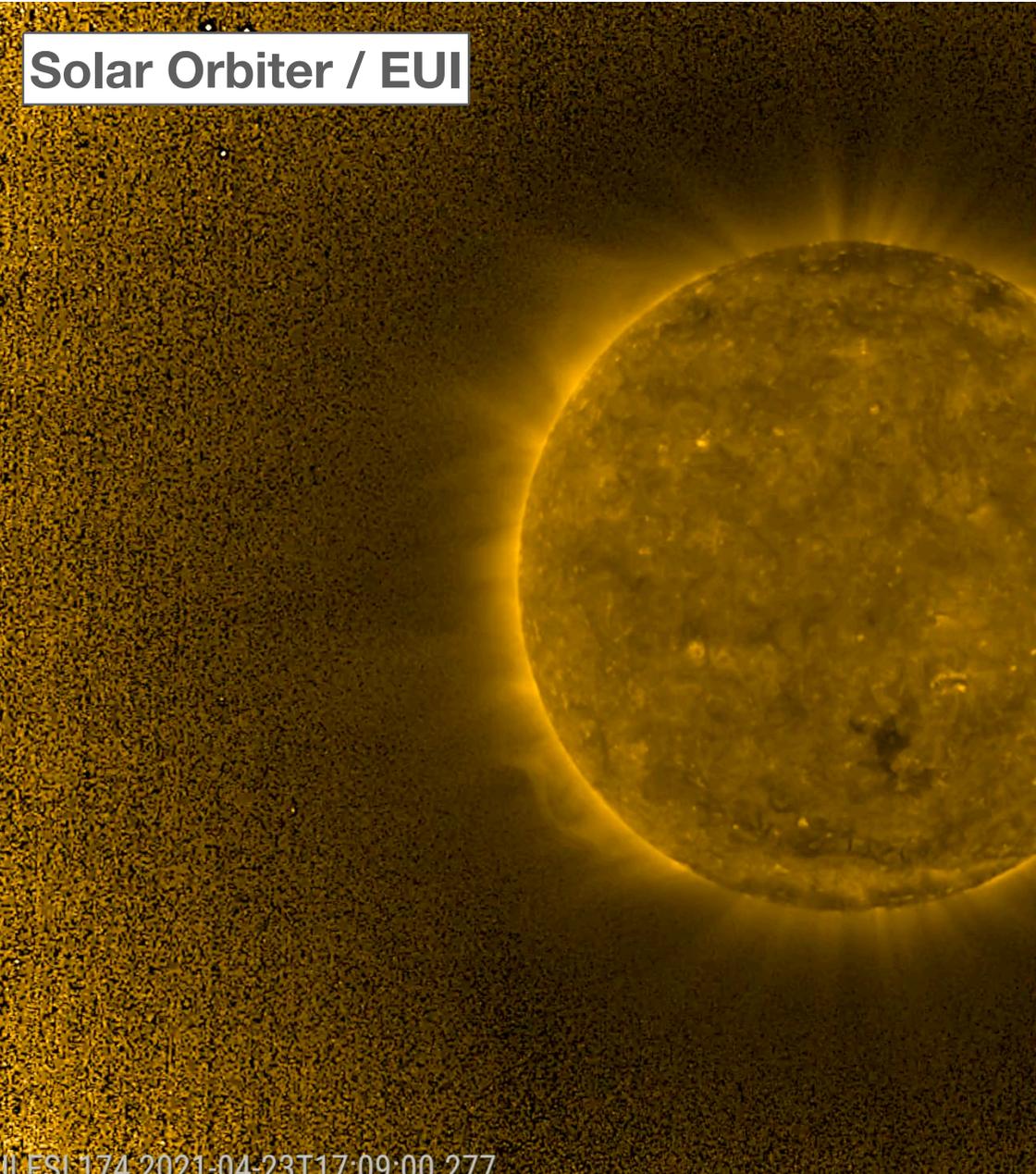
NOTE: The boundary conditions are different, the PFSS uses a HMI Carrington map while PSI MHD model uses an ADAPT B_r field.

According to the models, PSP was not crossing over the current sheet and was in positive polarity which is consistent with in situ observations.

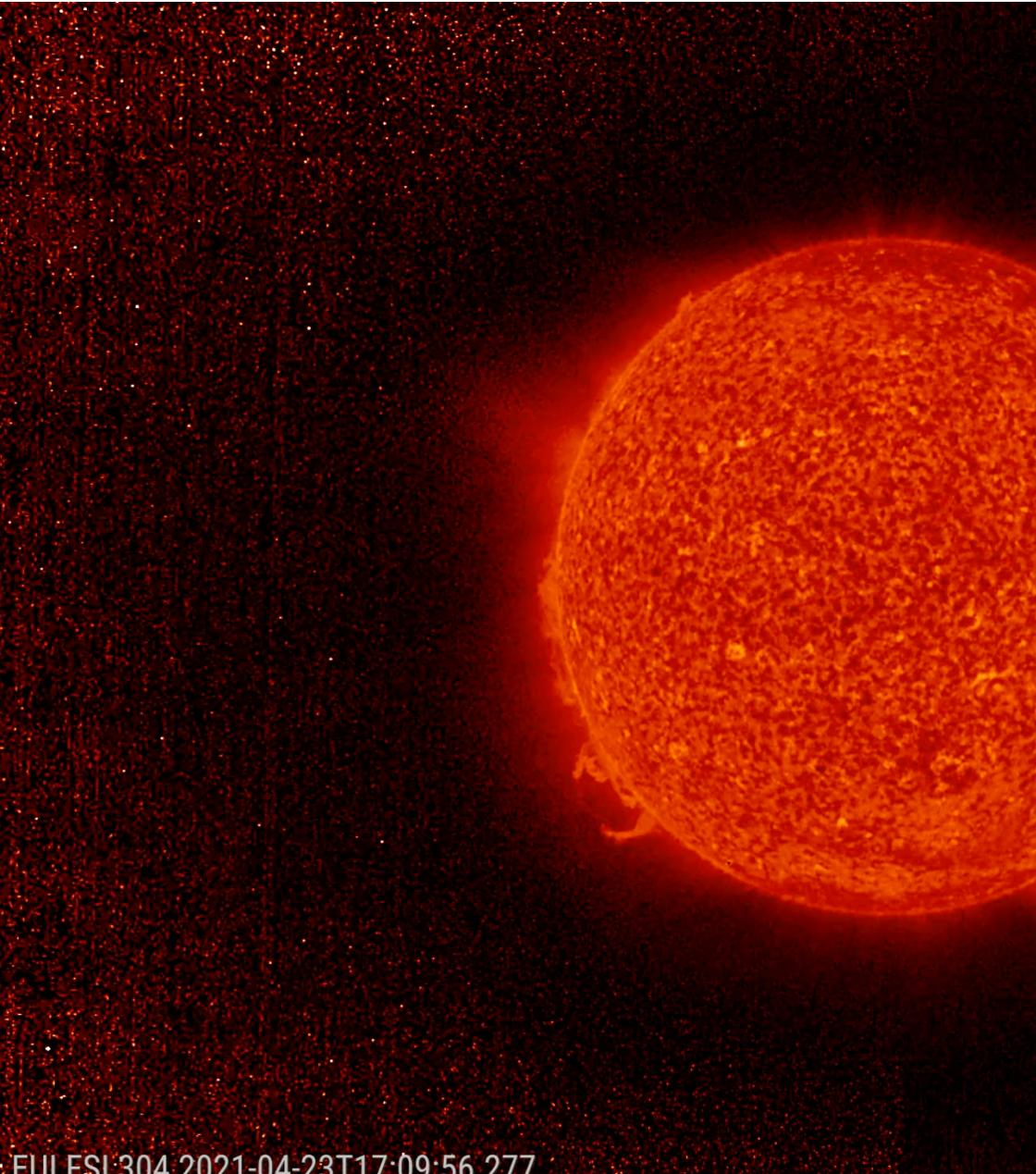


CURRENT SHEET AT $46.2R_\odot$

Solar Orbiter / EUI

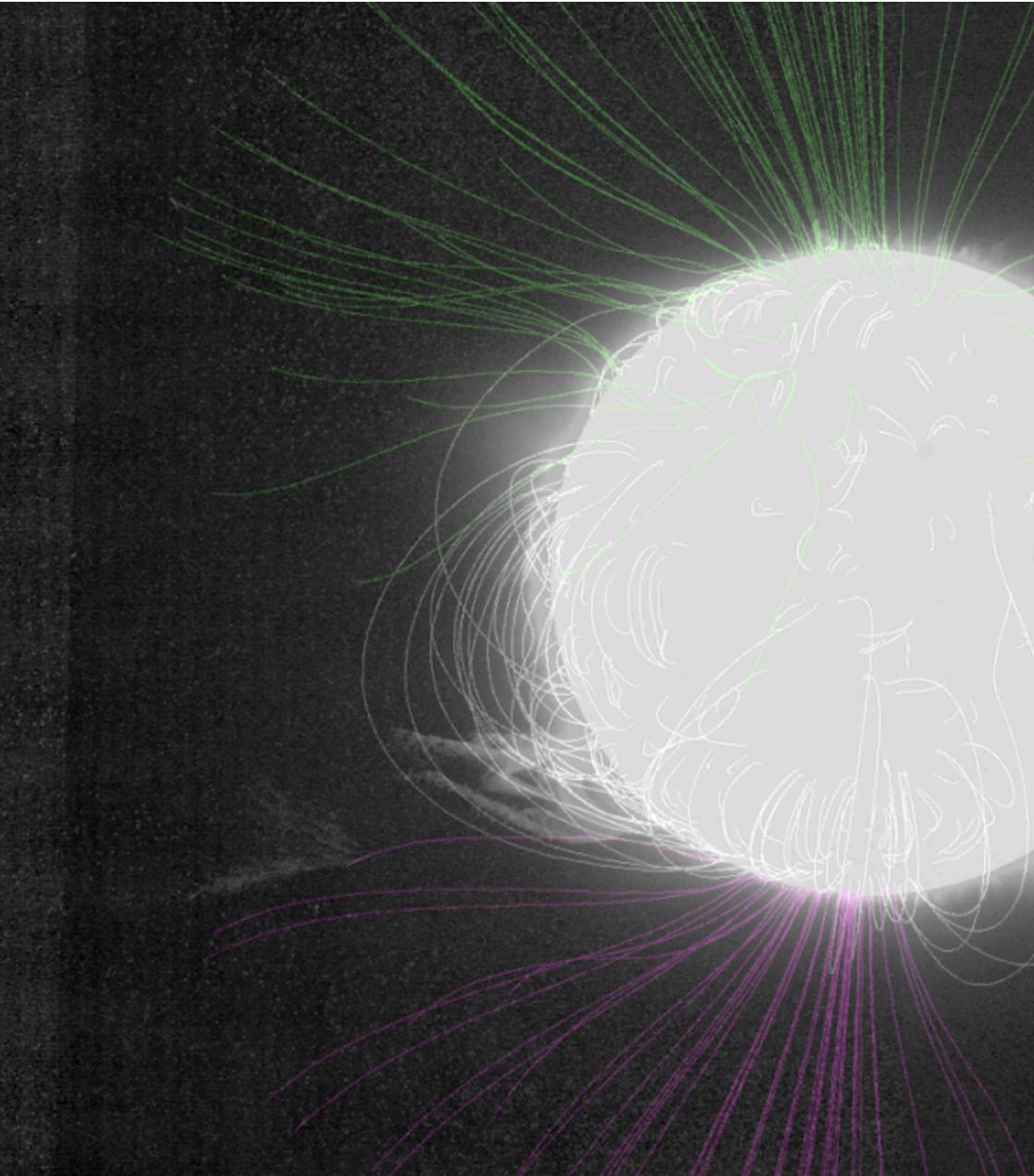
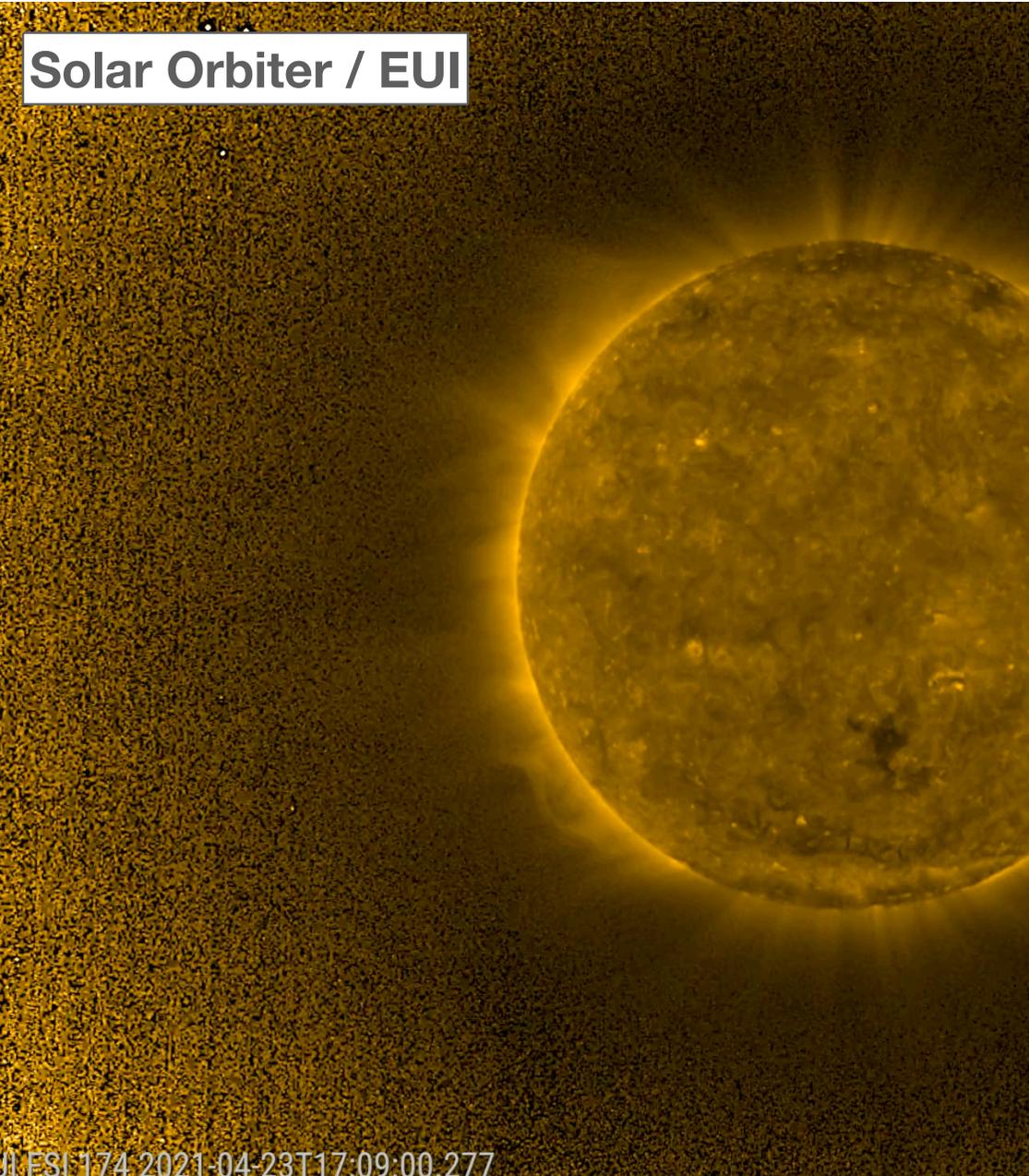


EUI FSI 174 2021-04-23T17:09:00.277

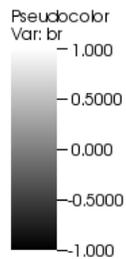


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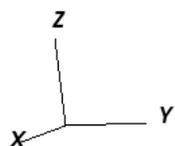
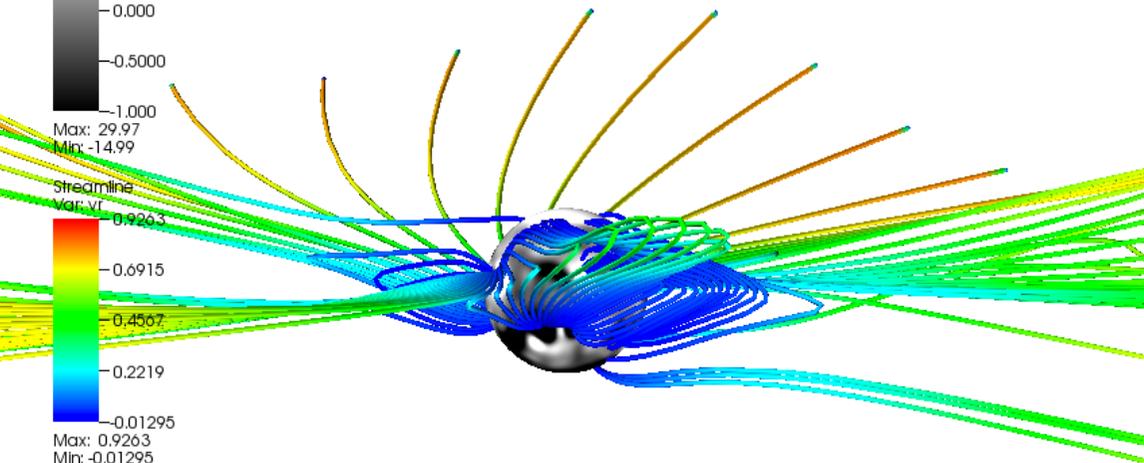
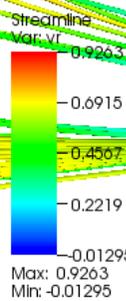
Solar Orbiter / EUI



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Cycle: 2 Time:0

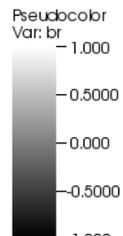


Max: 29.97
Min: -14.99

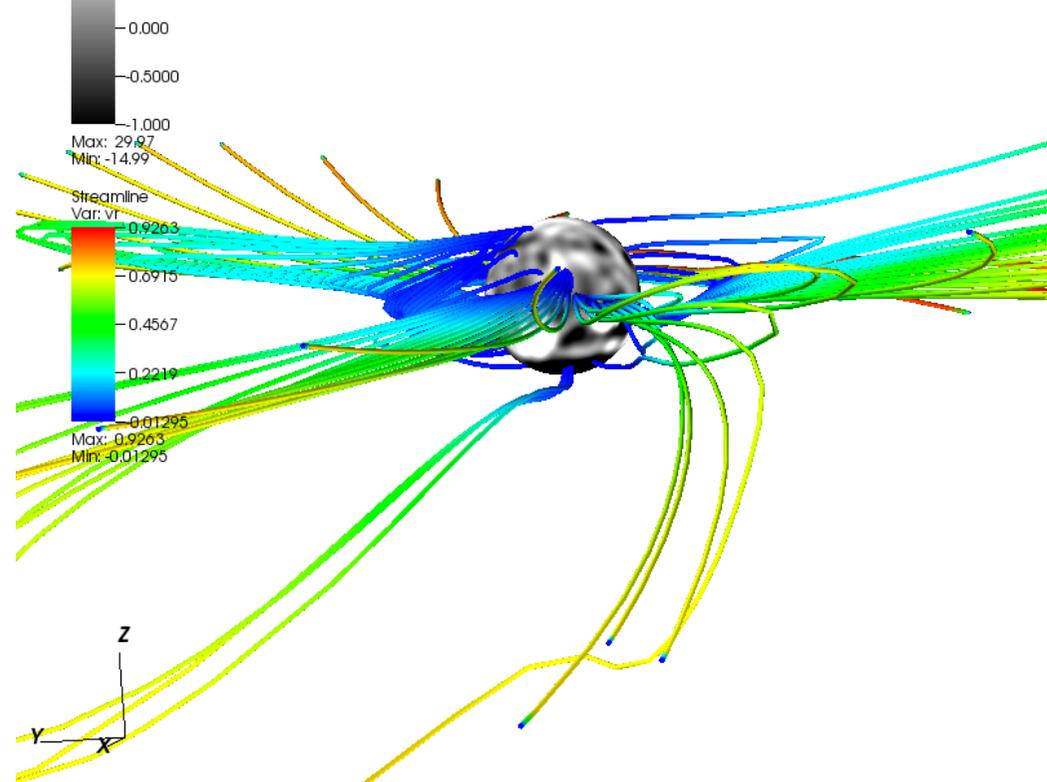
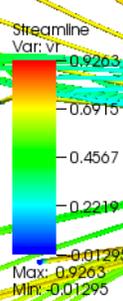


Parker Solar Probe view

DB: psp_20210504_merged.silo
Cycle: 2 Time:0

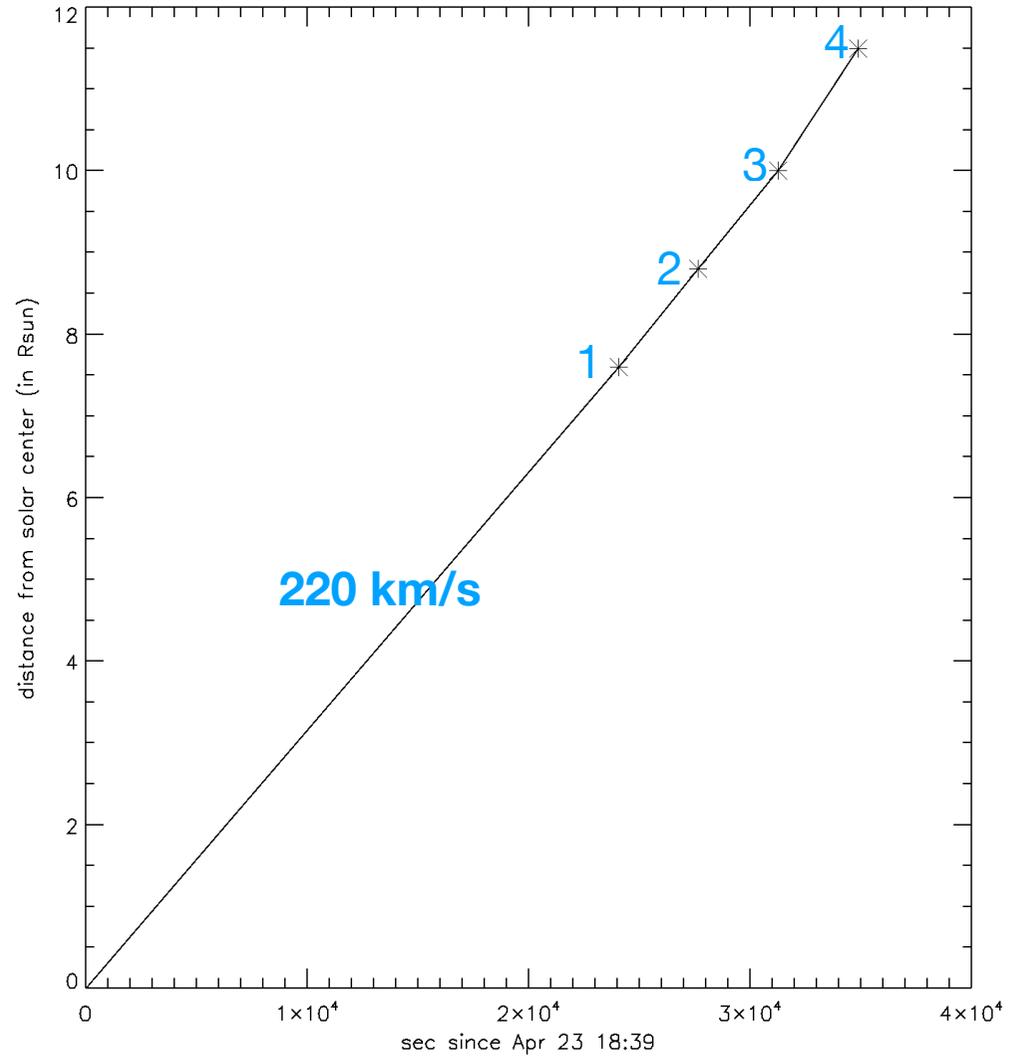
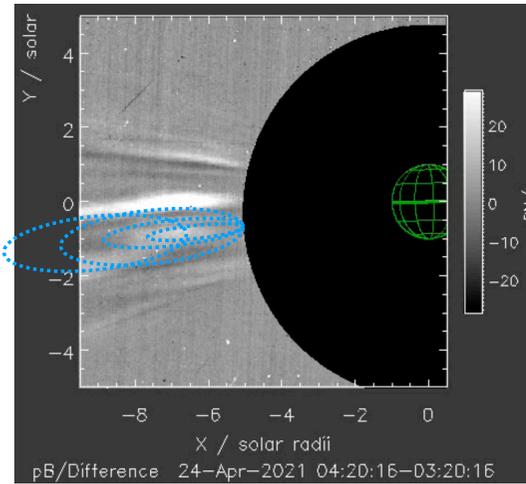
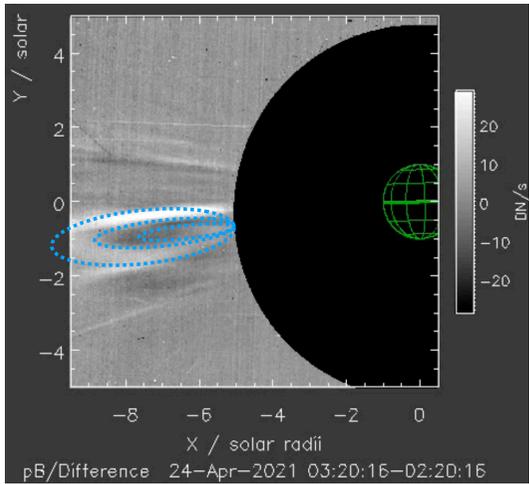
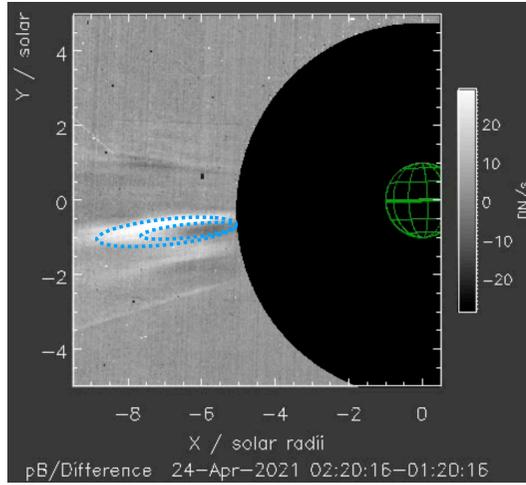
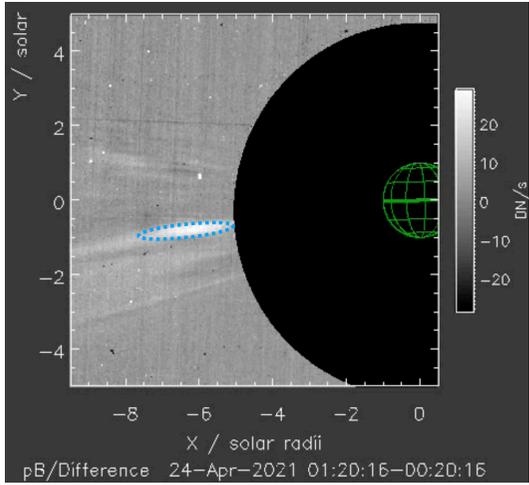


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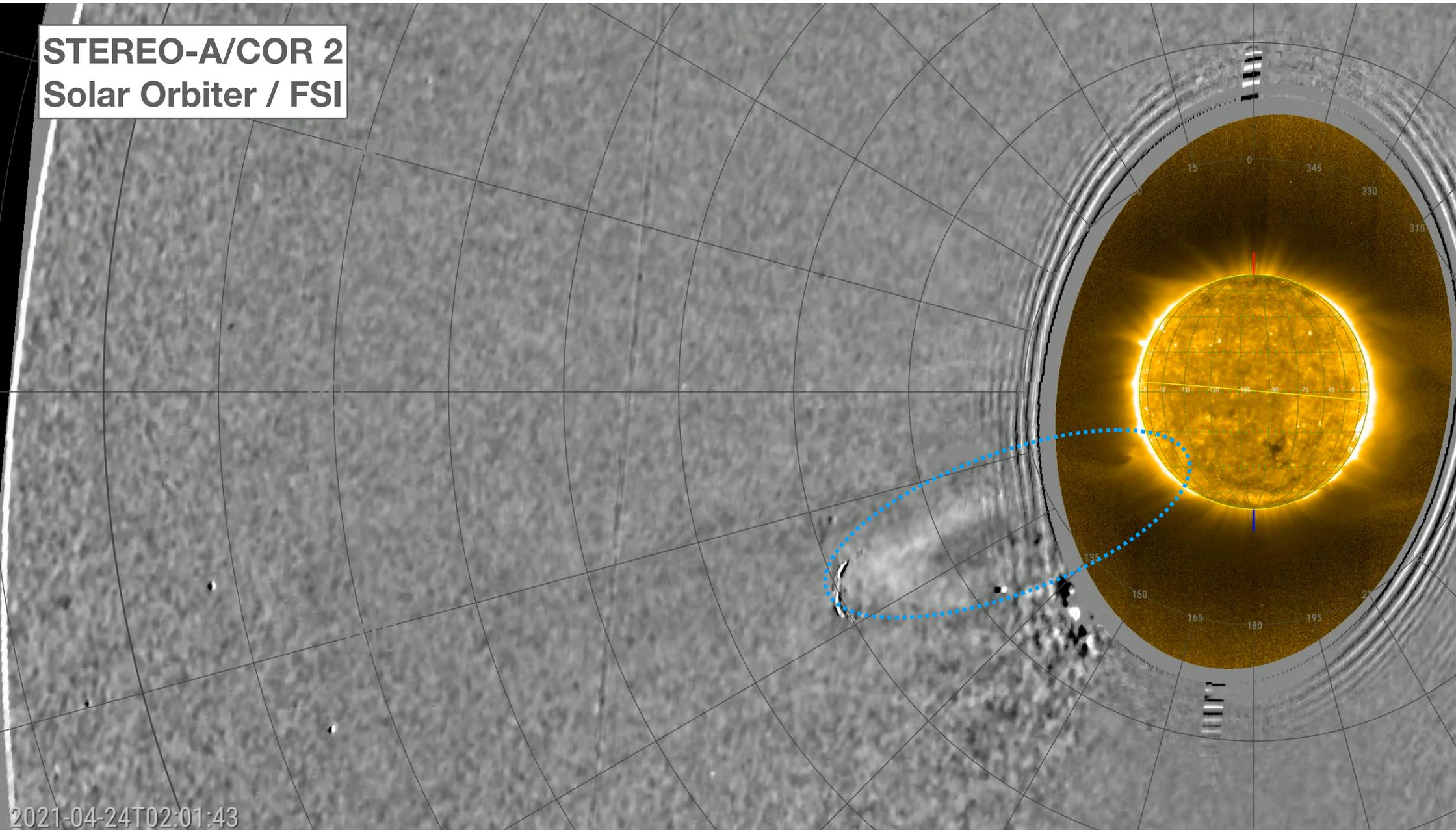


Solar Orbiter view

Solar Orbiter / METIS

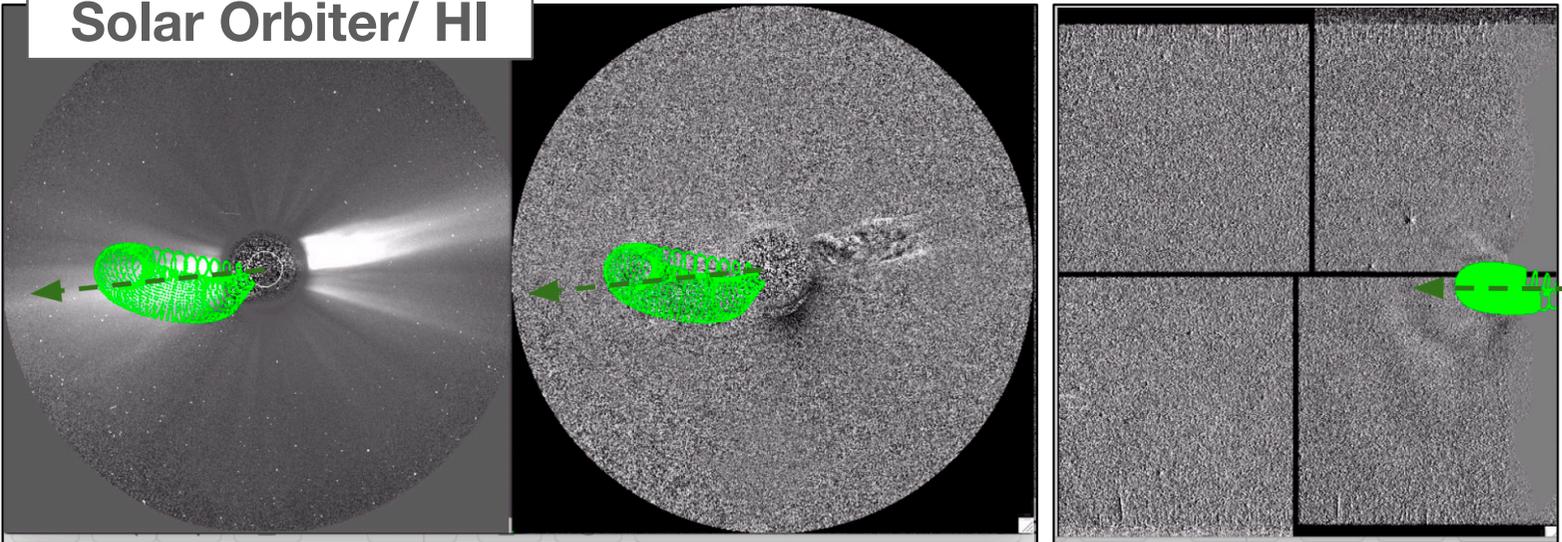


STEREO-A/COR 2
Solar Orbiter / FSI



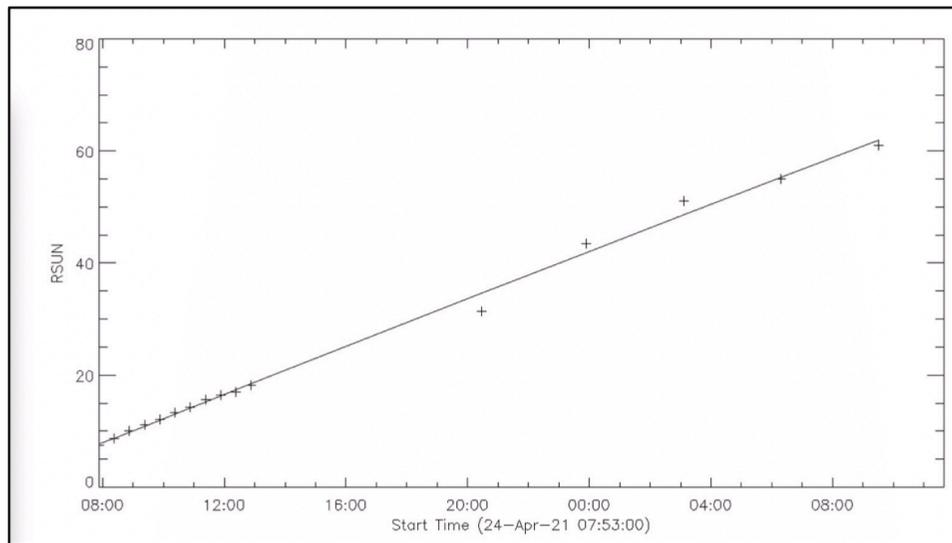
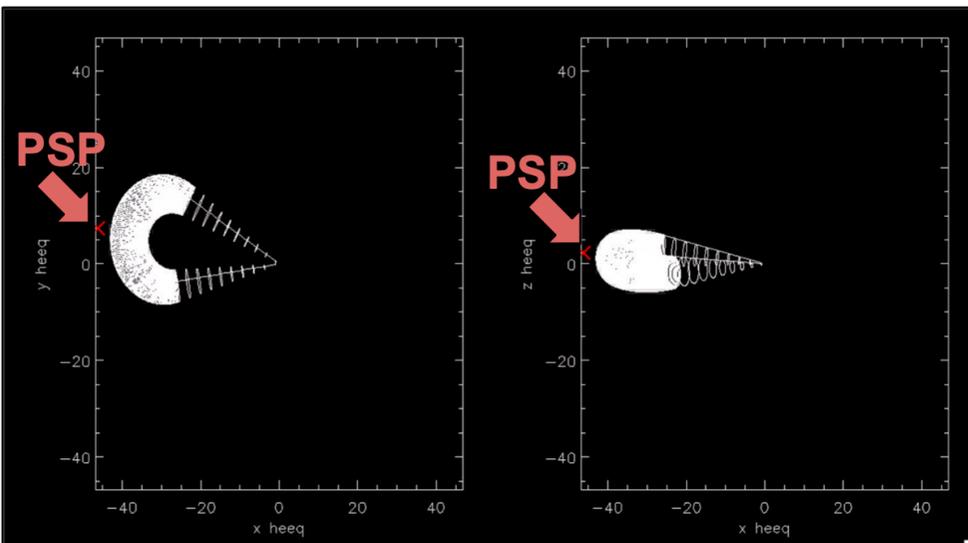
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**STEREO-A / COR 2
Solar Orbiter/ HI**



GCS IN SoloHI

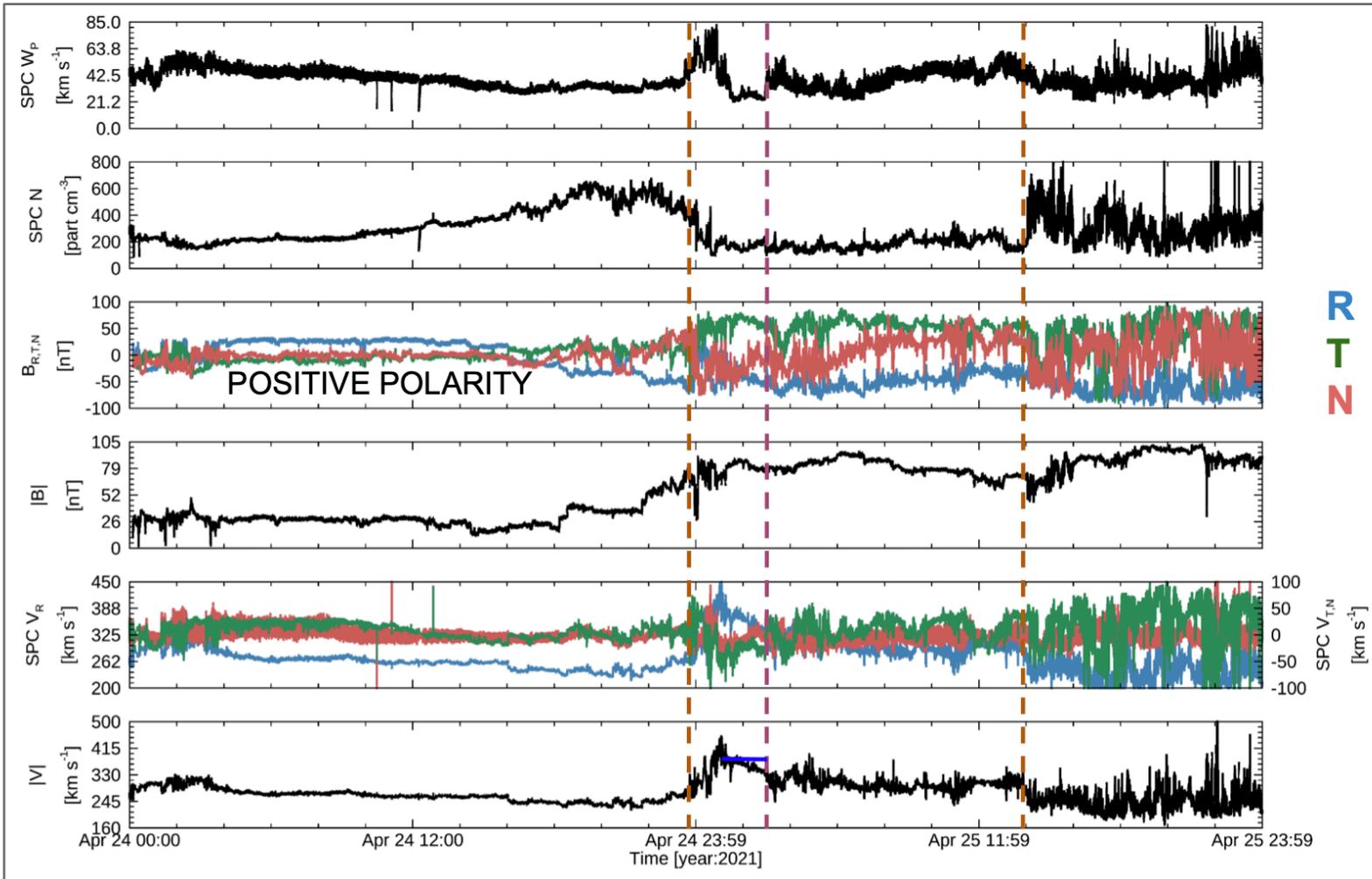
We applied the Gradual Cylinder Shell model in Solo coronagraph images and found that the direction of propagation of the transient assure its passage through PSP.



The derived height time plot of the **GCS fitting**. The line is a 2nd degree polynomial

Average speed 408 km/s.

At PSP (46.2 R_☉) [SWEAP and FIELDS]



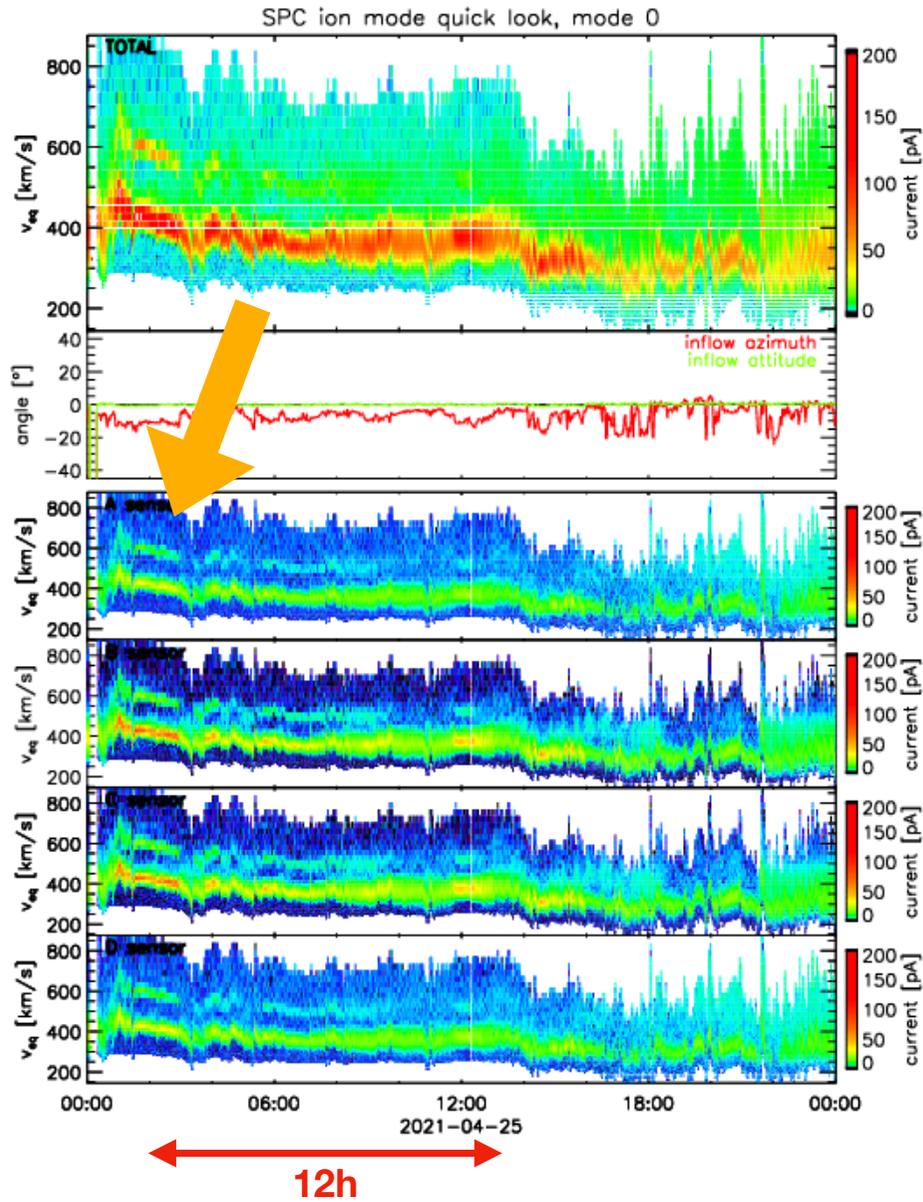
On April 25, 2021 00:00 UT (within vertical **yellow lines**), PSP/SPC and FIELDS instrument, observed the arrival and 12 hour passage of a structure with:

- High **B** ~90 nT.
- Arrival **V** ~ 500 km s⁻¹
- Low density <300 part cm⁻³

R
T
N

Tracking back the patch shown in horizontal **blue line**, on **April 25, 2021 01:00 to 02:00 UT** at a speed of 420 km/s, we predicted its **passage at 10 R_☉, 16.26 hours before with a speed of 412 km/s (April 24, 2021 08:40 UT)**.

Coinciding with the remote sensing observations.



At PSP (46.2 R_{sun}) [SPC]

On April 25th, 2021 ~01:00 UT, PSP/SPC instrument detected the arrival of a structure characterized by a sudden increase of the solar wind speed from ~250 km/s up to ~500 km/s. Then, it maintained a constant speed of ~400 km/s from ~06:00 to 14:00 UT. Since its arrival, the trace of helium within the structure is clearly noticeable.

On the left side, we show the Quick-Looks (QL) of PSP/SPC data. From top to bottom, the equivalent speed considering the four quarters of the plate of the Faraday cup; the second panel the inflow azimuth (red) and altitude (green) giving an idea the orientation of the plate relative to the incident flow. The four bottom panels correspond to the speed computed in each quarter of the instrument plate.

Lepri et al. 2021 showed that the ratio of He⁺/He²⁺ measured by ACE/SWICS which shows an enhancement concurrent with the **passage of prominence plasma**.

SUMMARY

- On April 25th, 2021 ~01:00 UT, Parker Solar Probe Faraday Cup (PSP/SPC) detected the arrival of a cool temperature and low density transient, characterized by the sudden increase of the speed from 250-300 km/s up to 500 km/s containing Helium.
- The structure maintained constant speed from ~06:00 to 14:00 UT with a coherent magnetic field configuration although no clear signatures of a flux-rope . PSP was at $\sim 46 R_{\odot}$.
- This patch of constant speed was traced back to $10 R_{\odot}$ computing the transit time and speed using the well-known Bernoulli's equation and predicting the passage of the structure at $10 R_{\odot}$, 16.26 h (on April 24, 2021 08:40 UT) before being measure by PSP/SPC at a speed of ~ 412 km/s.
- STEREO-A/COR and Solo/HI (both heliospheric imagers) observed on ~April 24, 2021 08:38 UT, the passage of the perturbation near the limb of the Sun. We applied the GCS model to the observations to determine the propagation direction of the transient.
- Few hours before, STEREO-A and Solo, observed at EUV imagers the launch of prominence material (several structures) to space from the solar corona (~ April 23th, 2021 23:00 UT - April 24th, 2021 01:00 UT). It seems that the prominence material is also drag deflected by the presence of open magnetic fields towards PSP.
- We attempt to track down the prominences from the Sun to PSP using remote sensing and in situ measurements from multi-spacecraft point of view. We combine the observations from STEREO-A, Solar Orbiter, PSP, SDO and SOHO.



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