



Preliminary Analyses of Halo CMEs with PUNCH Observations



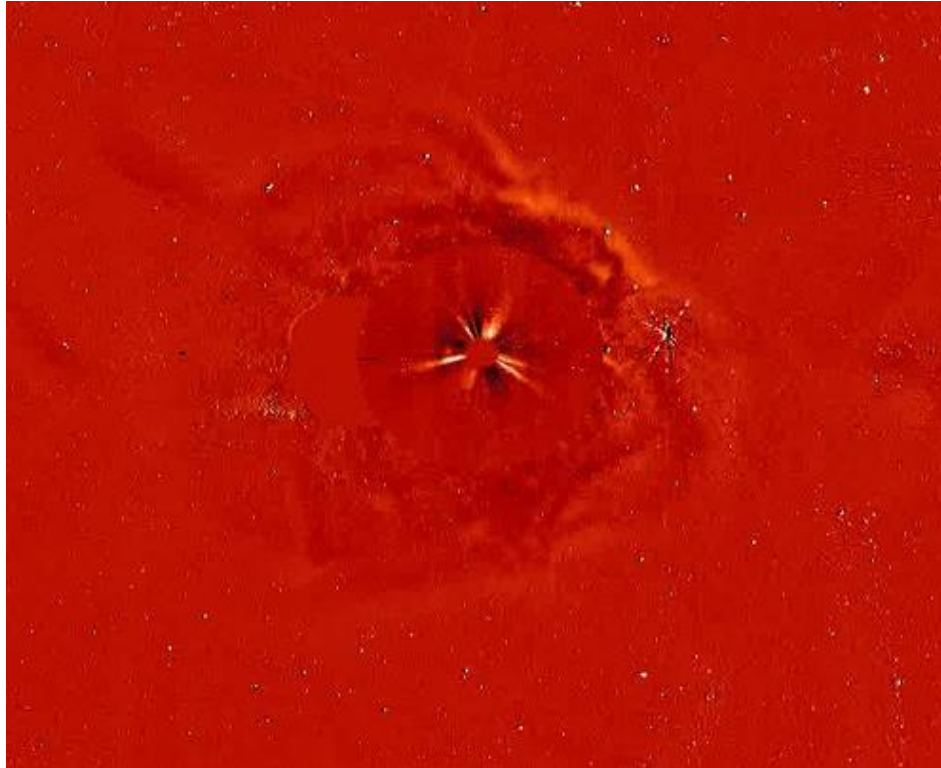
Dave Webb and Tom Kuchar
ISR, Boston College

- **PUNCH WFIs reached final orbit configurations on 1 August 2025.**
- **About 25 halo CMEs detected since then.**
- **We highlight 5 Earthward-directed halo CMEs observed by PUNCH, with emphasis on the Remembrance Day series of ~3 from 9-12 November 2025.**
- **Next two slides show PUNCH images for the halo CMEs on 30 Aug. – 2 Sept. 2025 and 21 – 23 Sept. 2025.**

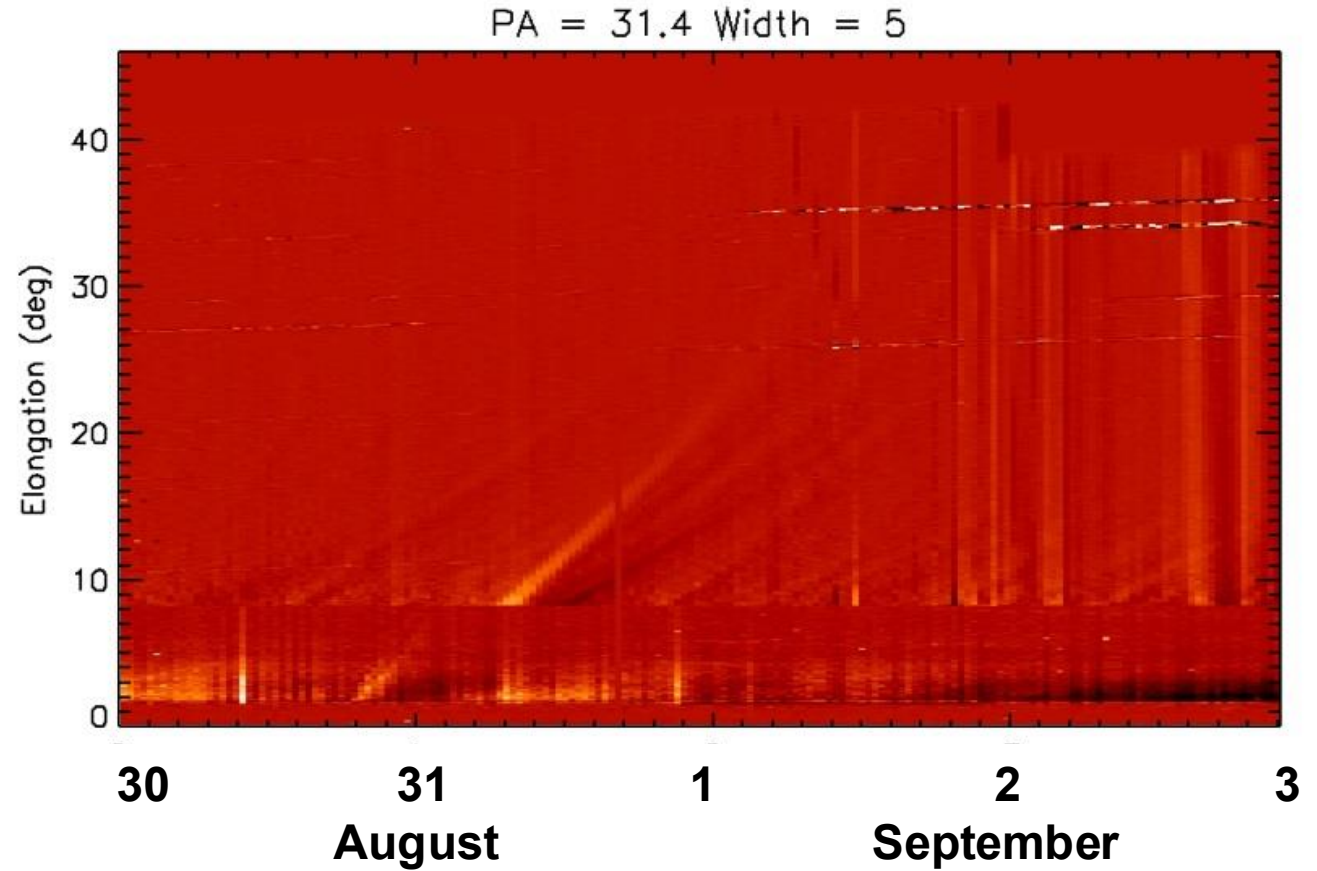
PUNCH Diff. Image & Elongation-Time Plot (ver. L3-0k)

Earthward halo CME; 30 Aug. – 2 Sept. 2025

ISR/BC - T. Kuchar



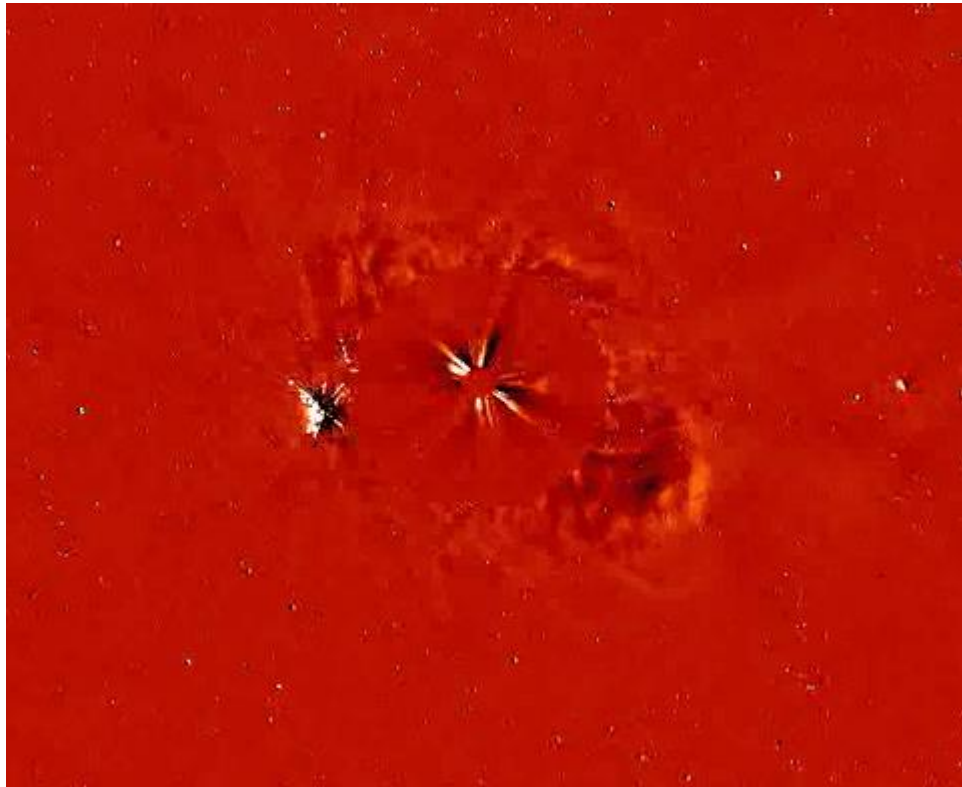
**31 Aug. 2025, 14:04 UT
LASCO C3 & PUNCH WFIs**



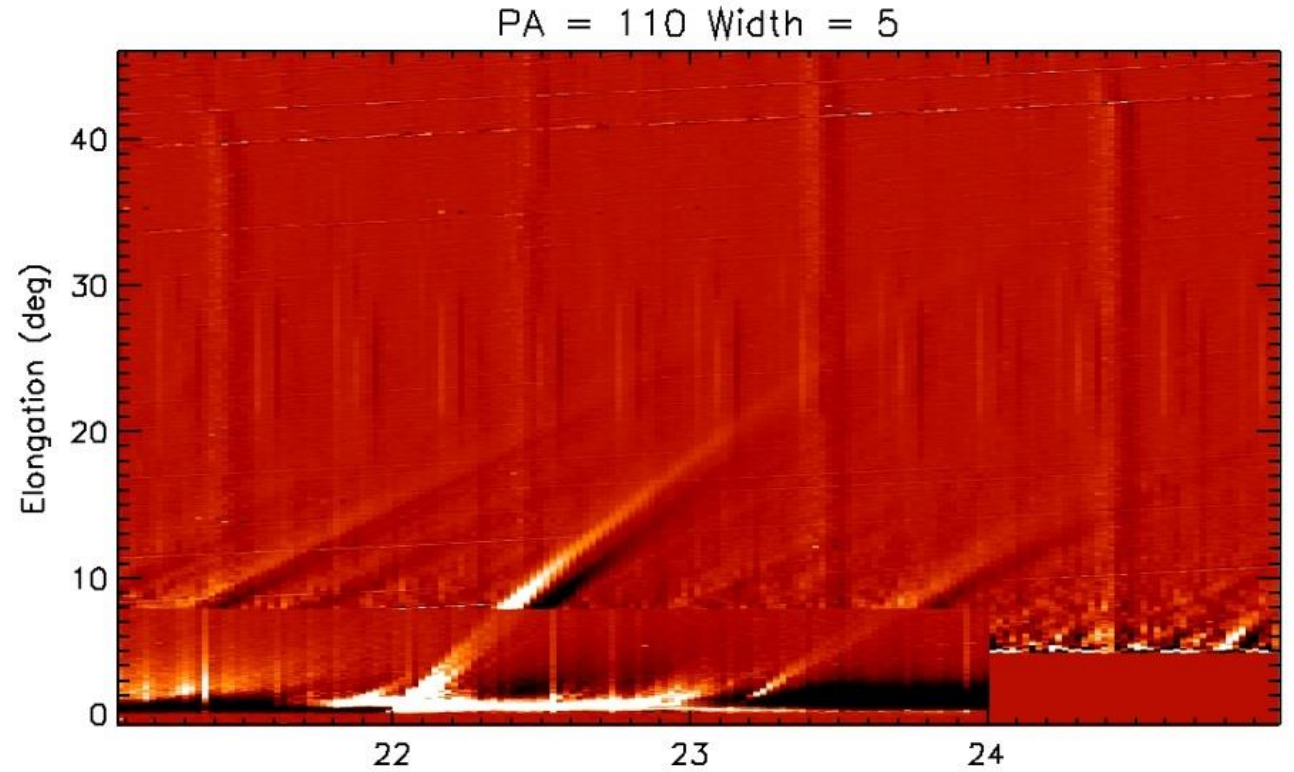
PUNCH Diff. Image & Elongation-Time Plot

Composite Halo CME; 21-23 Sept. 2025

ISR/BC - T. Kuchar



**22 Sept. 2025, 18:52 UT
LASCO C3 & PUNCH WFIs**



September 2025

9-12 November 2025 Sun to Earth Events

Date	LASCO C2/C3	C3 Outer	Cent PA	Ang. Width	Speed (km/s)	Surf. Activity	P Start	P Last E
11/9/2025	07:24/08:30	13:54	72	150/360	988/641	X1.7;N27E03;193,07:00	~13:54	?
11/10/2025	9:36/09:42	12:42	320	360	1102	X1.2;N23W14;193,09:03	~12:00	~17:00 33°
11/11/2025	10:24/10:30	14:42	334	180/360	1671/1852	X5;N23W24;193,09:51	~15:52	~12:03 28°

➤ **All 3 events had long-duration X-Flares, EUV waves, coronal dimmings & PEAs**

- On Nov. 9, 06:06 UT a possible assoc. filament at N34E04 erupted.
- The Nov. 10 and 11 events were associated with SEP events at 1 AU.

➤ **Full halo CMEs, Earth-directed**

- All 3 events produced large loop CMEs which expanded to near or full symmetric Halo CMEs.

➤ **Also observed at STEREO-A at 1 AU and 46° west of Sun-Earth line**

- COR-2A shows bright CME, NE limb: Nov. 9, 06:53-10:38 UT.
- COR-2A shows asymmetric Halo CME brightest E limb: Nov. 10, 10:23-11:38 UT.
- COR-2A shows asymmetric Halo CME brightest NE limb: Nov. 11, 09:23- >15:23 UT.
- CMEs also observed in HI1 and HI2 FoVs.

➤ **Bepi Colombo was at 0.3 AU bet. Earth & Sun, and Solar Orbiter was at 0.8 AU, ~18° E of Earth.**

- *We are analyzing data from these missions and 1 AU in-situ data.*

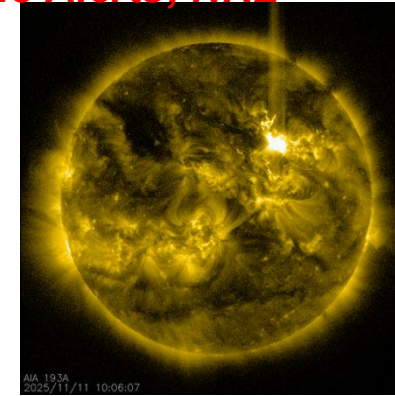
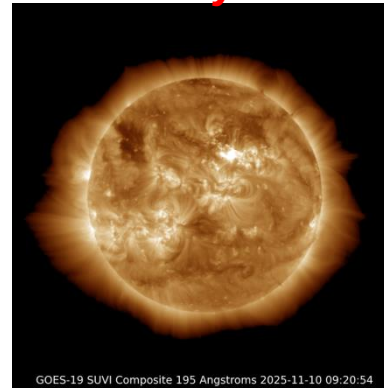
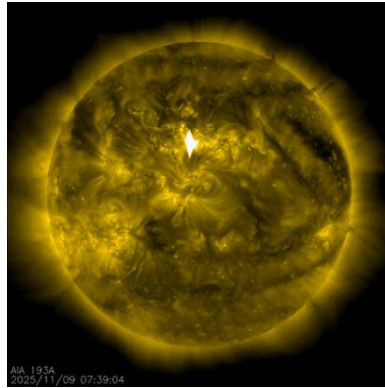
➤ **IP Shocks & Geostorms at Earth**

- Shock 1 AU arrival Nov. 11, 22:11UT Geostorm peak Nov. 12, 00UT, Kp=8.7 → 10UT, Dst=-209nT
- Shock 1 AU arrival Nov. 12, 18:52UT Geostorm peak Nov. 13, 00UT, Kp=7.3 → 08UT, Dst=-143nT

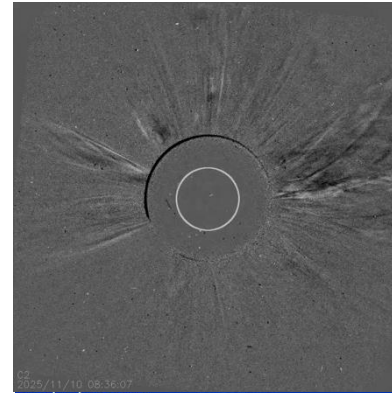
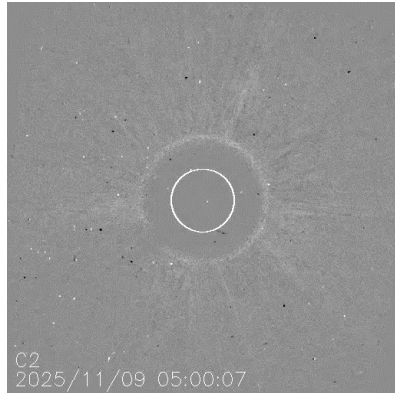
Surface 195Å & LASCO C3 Images/movies: Nov. 9 – 11, 2025

Courtesy LASCO Halo Alerts; NRL

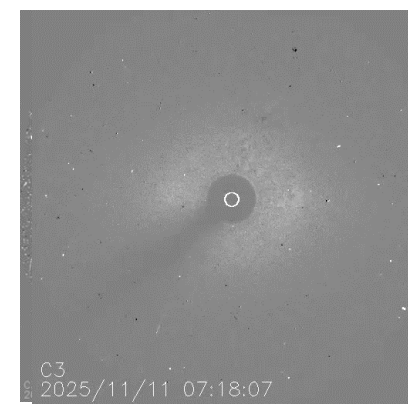
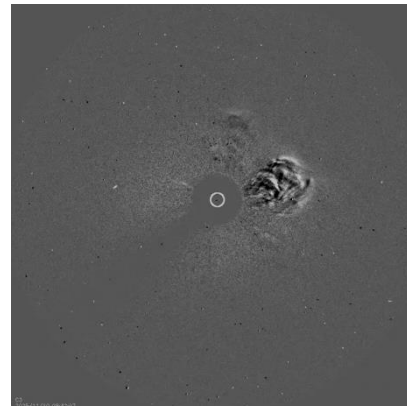
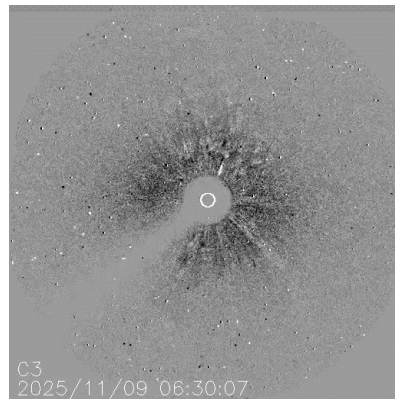
SUVI or
SDO



LASCO C2
Diff. Movies



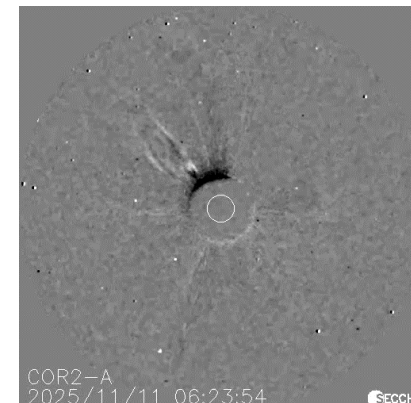
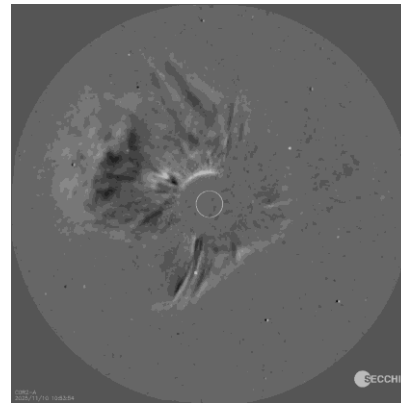
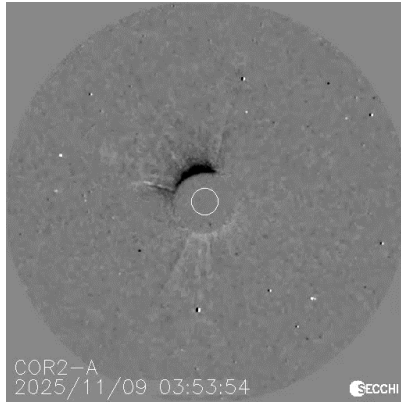
LASCO C3
Diff. Movies



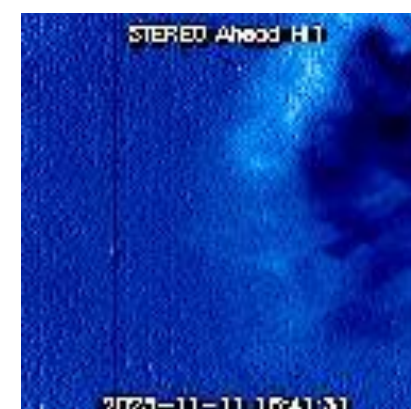
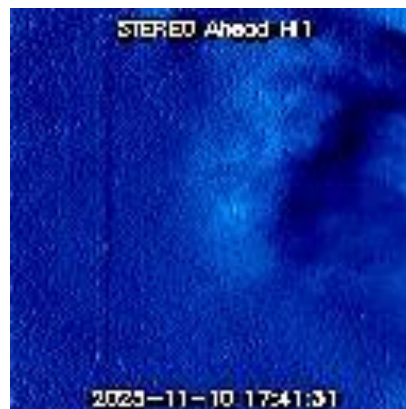
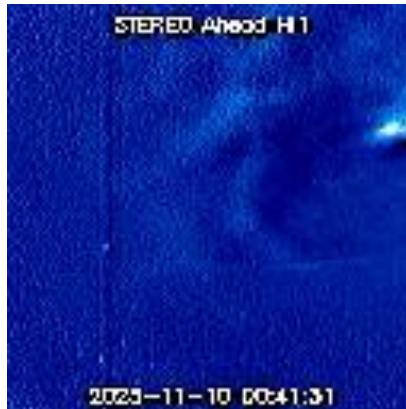
- AR source region is just N of Sun center.
- Resulting halo CME material surrounds the solar disk (360°), therefore Earth directed.

STEREO-A Images-Videos at 1 AU and 46° West of Earth

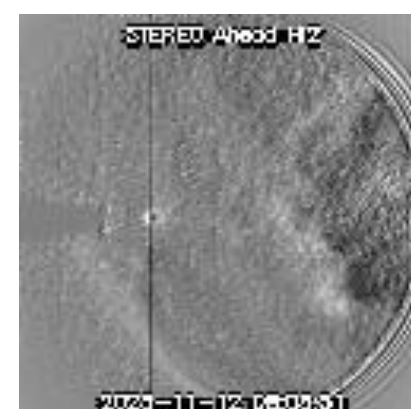
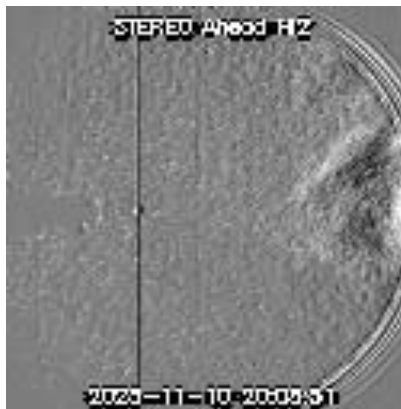
**COR2A
Diff.**



HI1-A



**HI2-A
Diff.**

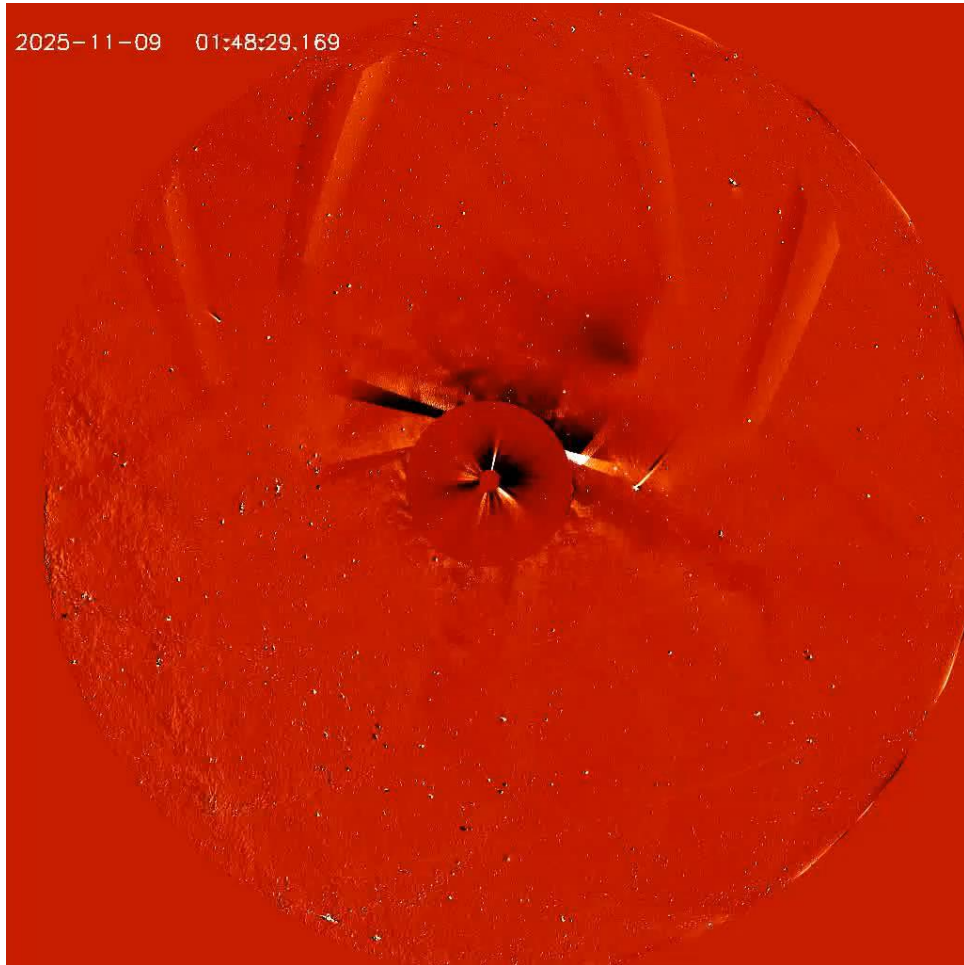


- **CMEs directed from Sun E-NE of ST-A.**
- **Therefore, towards Earth (and PUNCH).**

Courtesy LASCO Halo Alerts; NRL

PUNCH Video & Elongation (ϵ) -Time Plots (ver. L3-0k)

(PUNCH: T. Kuchar; STEREO: M. Bauer)



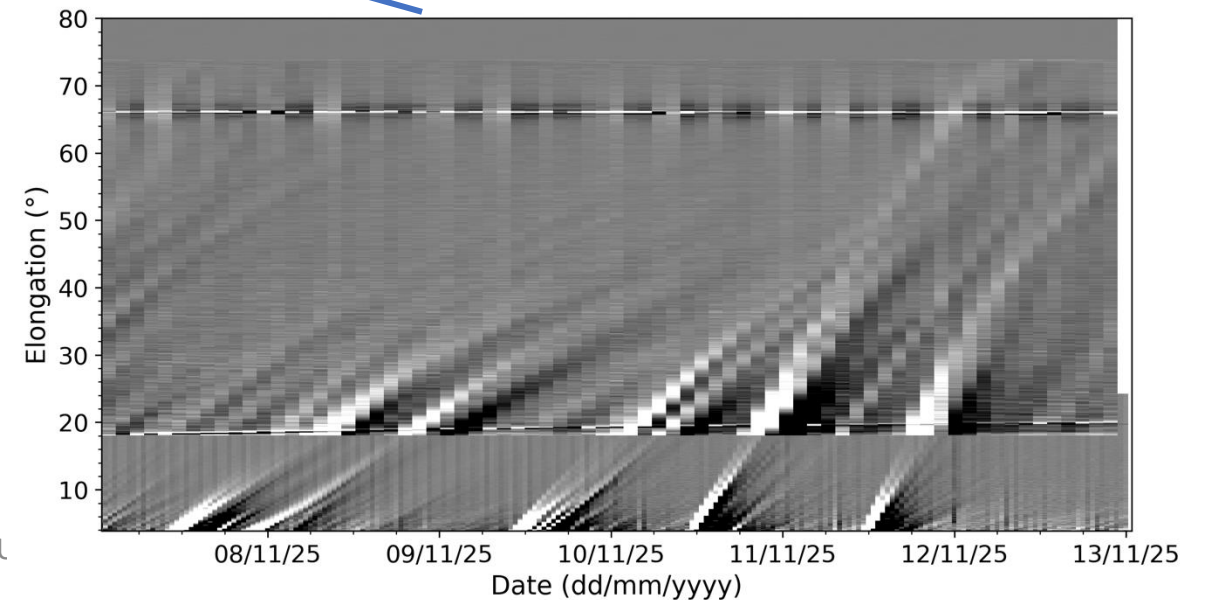
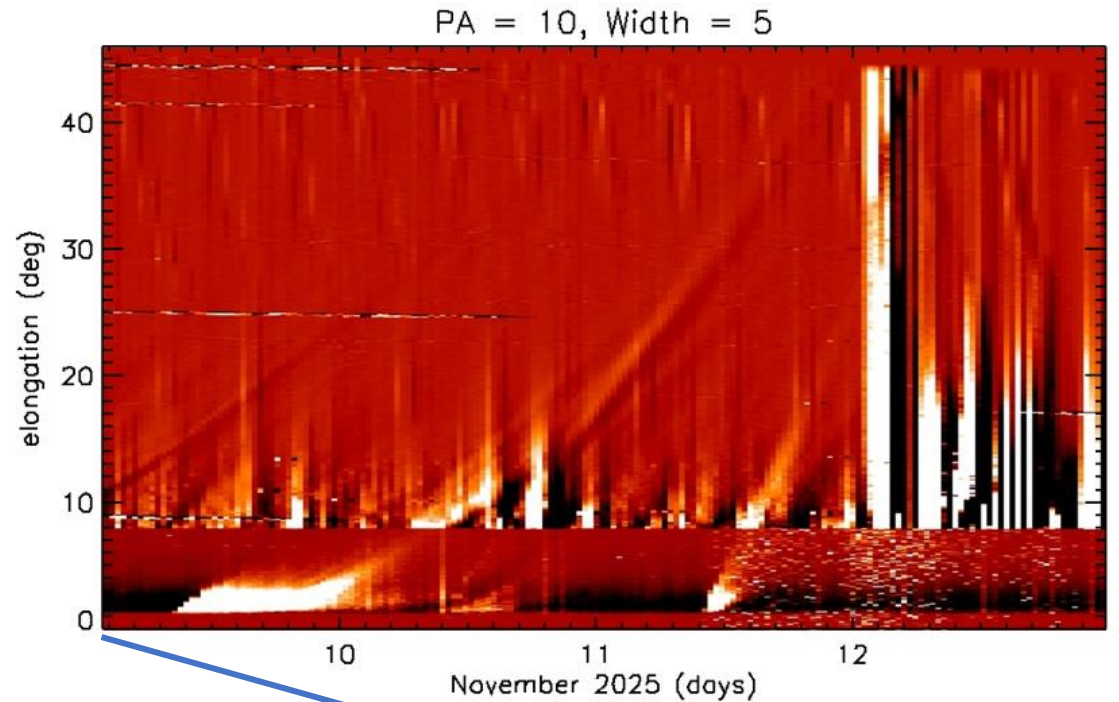
PUNCH Difference Image Video 9-12 Nov. 2025.

Top Right: ϵ - Time plot at PA = 10°.

Right: STEREO-A HI- & HI2 ϵ - T plot.

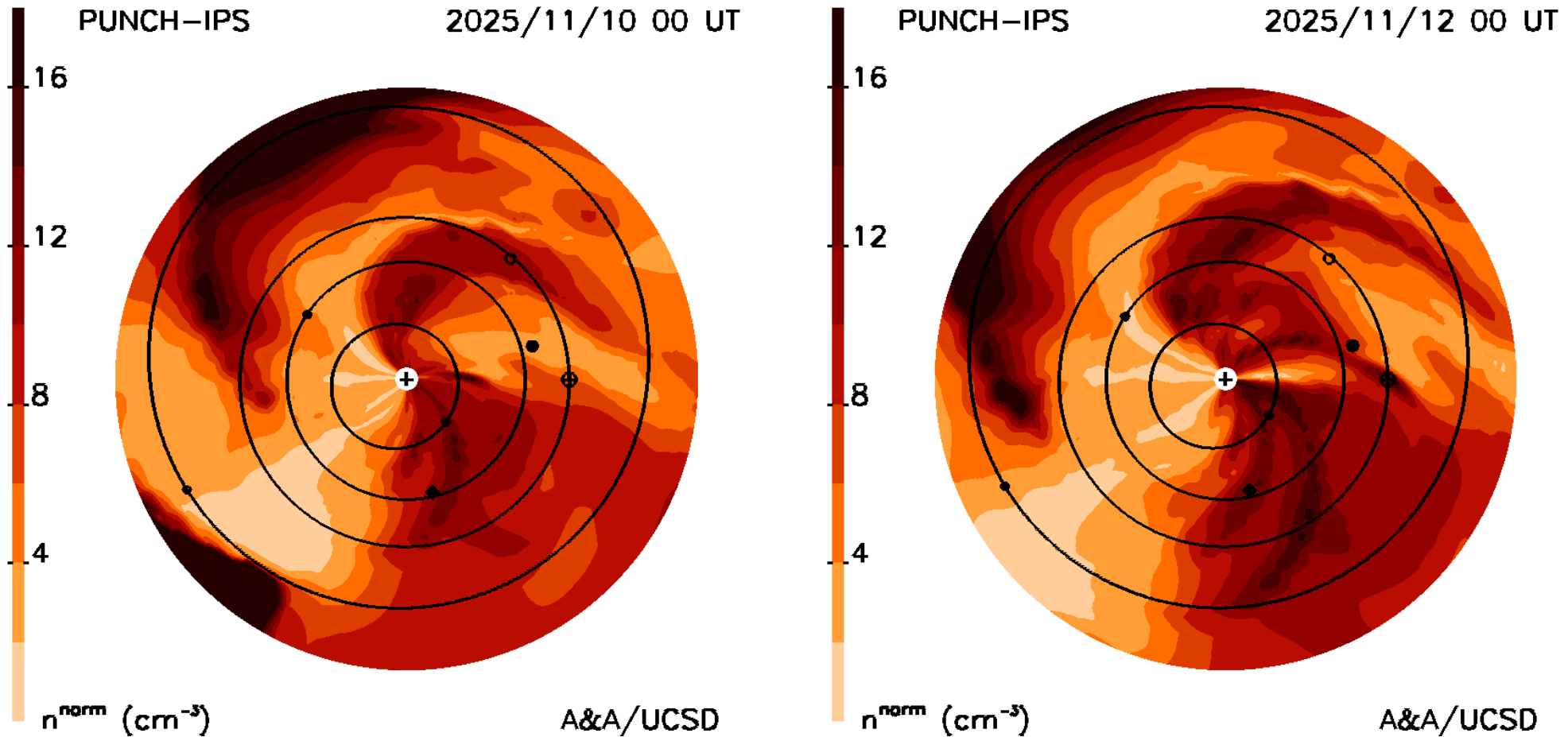
6/10/2026

Webb PL



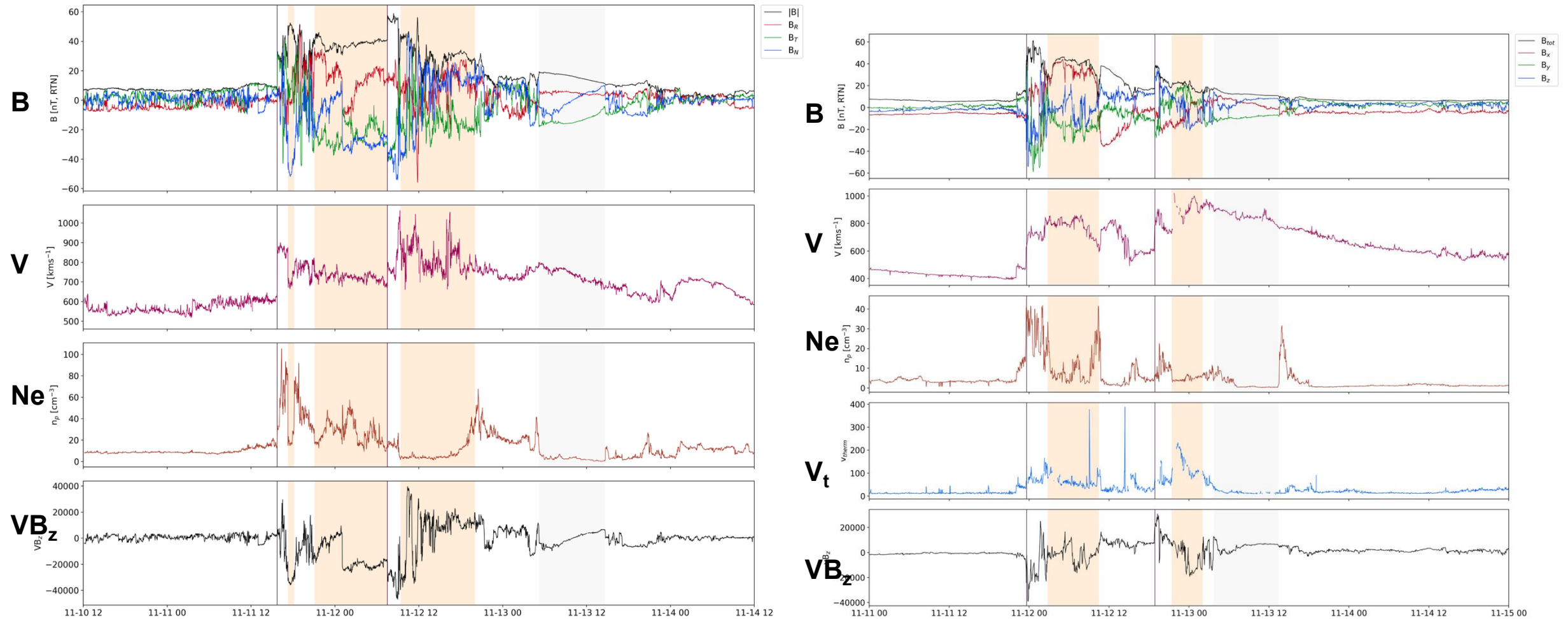
Prelim. UCSD 3D PUNCH tomographic analysis results (ver. L3,0i) using a median filter to remove stellar residuals, and a minimum map to remove stray light. Images are in normalized e-density (brightness) units in the ecliptic plane. From Nov. 10 to 12 the CME material passes over Earth and west towards ST-A.

Courtesy B. Jackson and the UCSD team



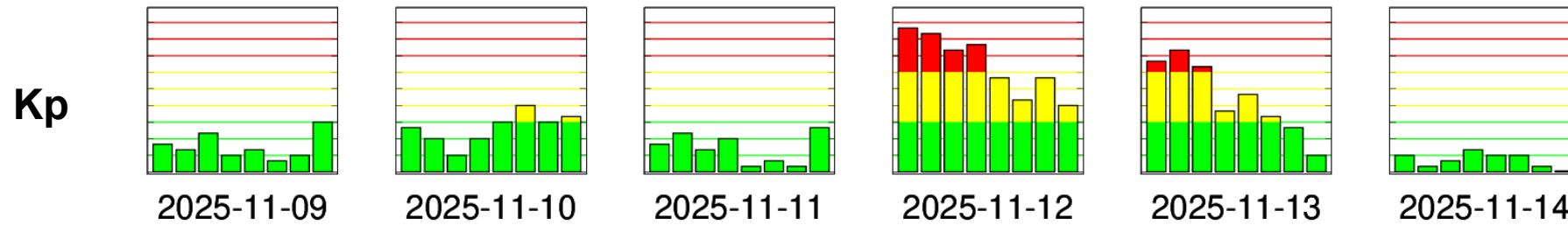
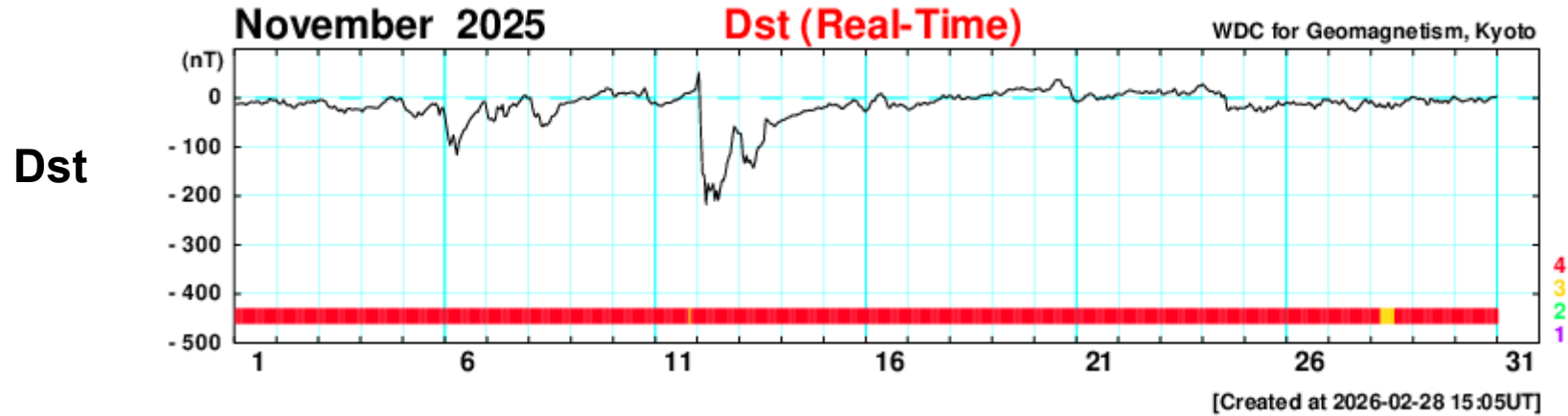
In-situ Solar Wind from Solar Orbiter and Wind

Courtesy Emma Davies; MAG: Imperial College London



Left: SoLO (0.8 AU) magnetic field, velocity, density parameters from 10-14 Nov. Right: Same parameters for Wind at Earth + thermal vel. Both bottom panels show VB_z a strong indicator of geostorms. Two IP shocks are noted by vertical lines and the trailing magnetic ejecta are shaded.

Geostorm Observations



Two geostorm peaks:
Nov. 12, 00UT (Kp = 8.7) 10UT (Dst = -209nT)
Nov. 13, 00UT (Kp = 7.3) 08UT (Dst = -143nT)

SEPs & Ground Level Enhancement (GLE)

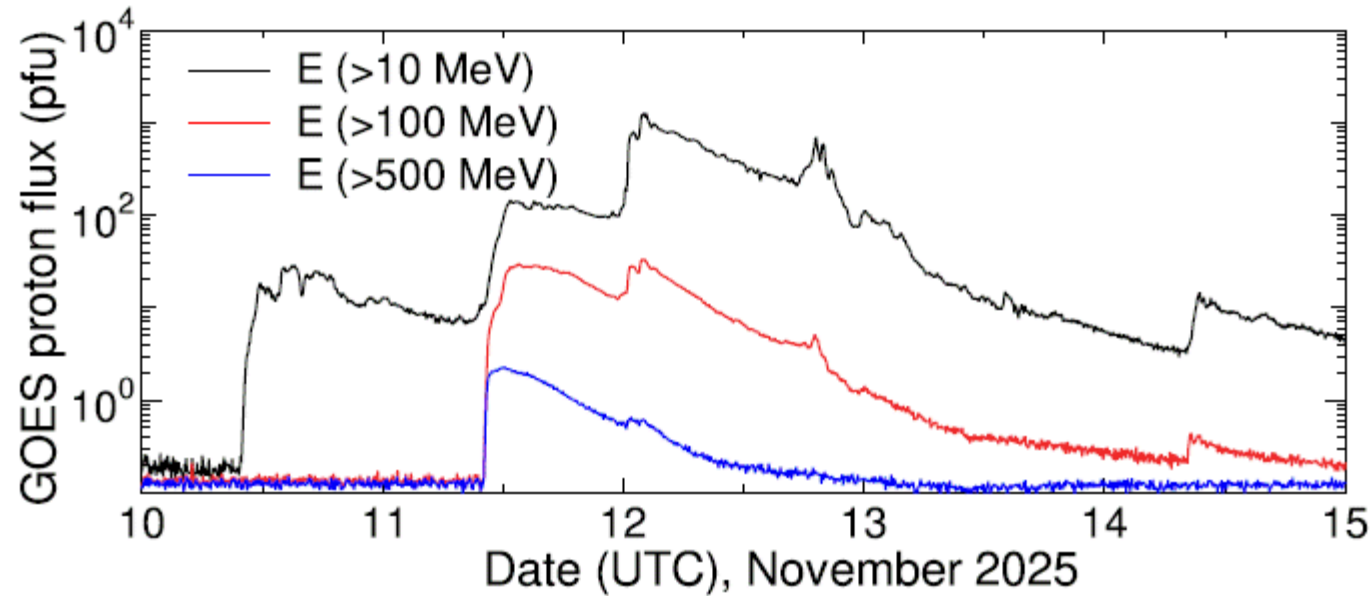


Figure 1. Temporal evolution of GOES integral proton fluxes above 10, 100, and 500 MeV during 10–15 November 2025 (UTC). The fluxes are reported in proton flux units (pfu; $1 \text{ cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$) and were derived from real-time NOAA/Space Weather Prediction Center (SWPC) GOES 7-day JSON data archived at the time of acquisition (SWPC, 2025a). For each time step, the primary (GOES-18) and secondary (GOES-19) proton flux products were averaged.

There were several SEP events from Nov. 10-14 and a GLE on Nov. 11-12. The GLE had the hardest spectrum since a GLE in 2000, suggesting a high radiation dose (*T. Sato+, Space Weather, 24, 2026*). Figure shows GOES proton fluxes above the energies shown.

Future Work

- **More simulations and modeling to better understand solar sources and overall evolution of events.**
- **Use combined B and polarization data when available to study CME trajectories and internal structures.**
- **Combine PUNCH and other mission data, e.g.,**
 - **STEREO-A imaging & in-situ**
 - **Solar Orbiter imaging & in-situ**
 - **Bepi Columbo in-situ (early phases near Sun)**
- **Study IP shock and ICME structures, and SEP events and the GLE at Earth.**



Thanks for Listening!



Remembrance Day, 2025 Project Members

Sarah Gibson, NCAR HAO
Emma Davies, Geosphere, Austria
Christian Möstl, Geosphere, Austria
Barbara Thompson, NASA GSFC
Ritesh Patel, SWRI, Boulder, CO
Bernard Jackson, UCSD
Heather Elliott, SWRI, Austin, TX
Anna Malanushenko, NCAR HAO
Samaiyah Farid, NCAR HAO
Sarah Kovac, NCAR HAO
Douglas Biesecker, NOAA SWPC
Maike Bauer, Geosphere, Austria
Justin LeLouedec, Geosphere, Austria
Tanja Amerstorfer, Geosphere, Austria



LASCO C2 – C3 Height-Time Plots

