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The 2024 May 14 CME and Its Type II Radio Bursts

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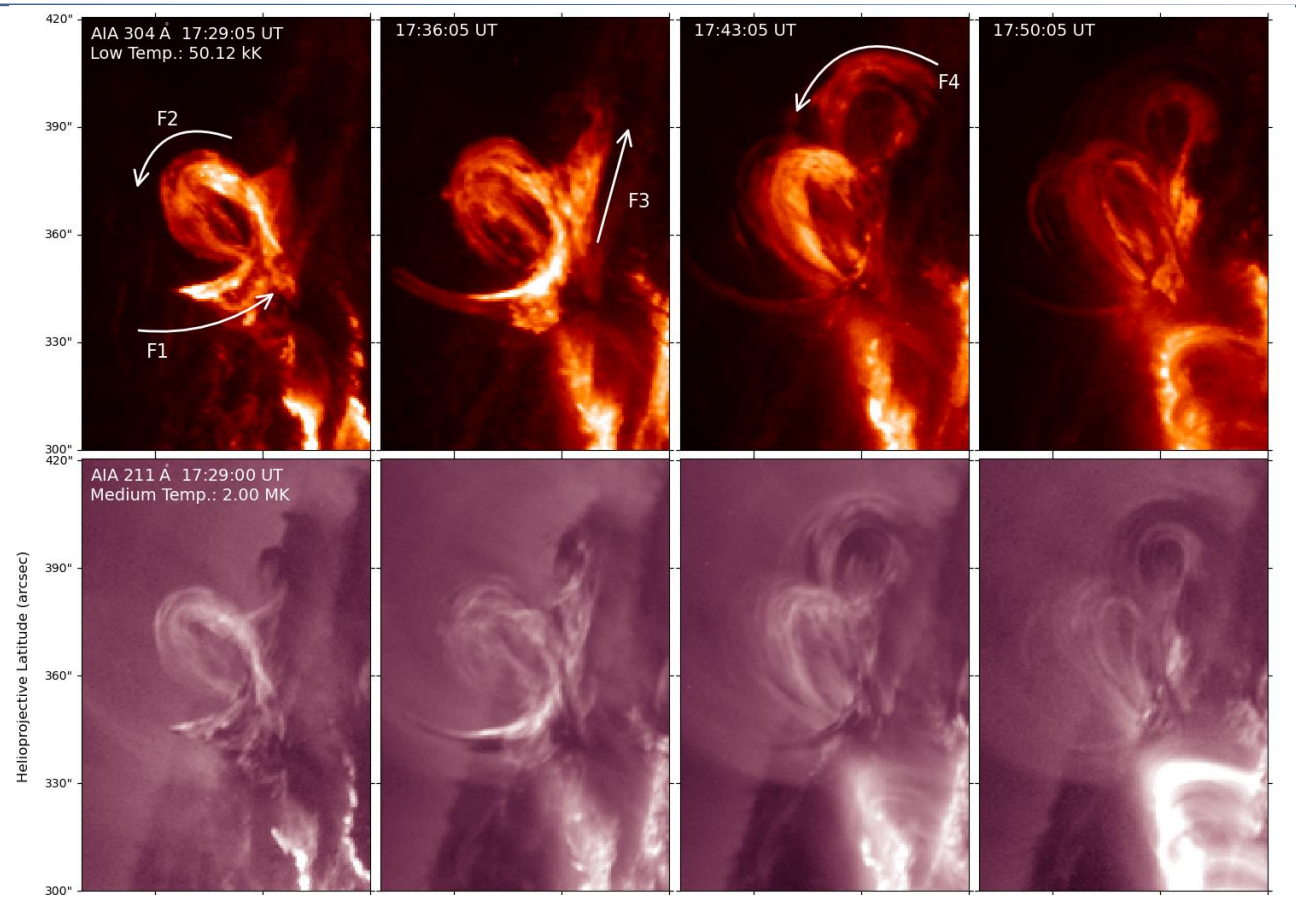
Helical Flows Along Coronal Loops Following the Launch of a Coronal Mass Ejection

Link to the paper
(Nedal+2025, A&A)



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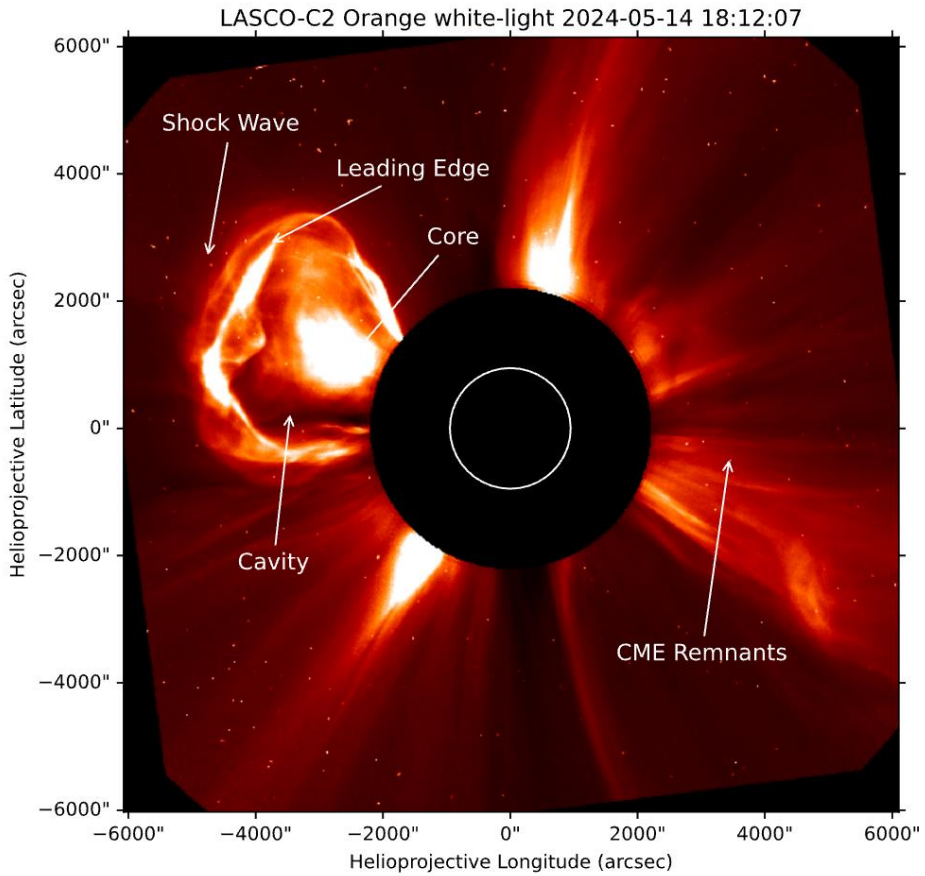
Overview

- **Event**: CME on 14 May 2024 from AR13680 (N17E72), M4.5 flare
- **Instruments**: GOES/SUVI 195 Å
  SOHO/LASCO C2–C3
  I-LOFAR (10–240 MHz; 2 ms; 156.25 kHz)
- **Focus**: four type II bursts observed between ~17:30–17:48 UT; link radio lanes to CME/shock kinematics and coronal conditions
- CME tracked in SUVI & LASCO C2/C3; running-ratio (RR) images used to highlight the leading edge



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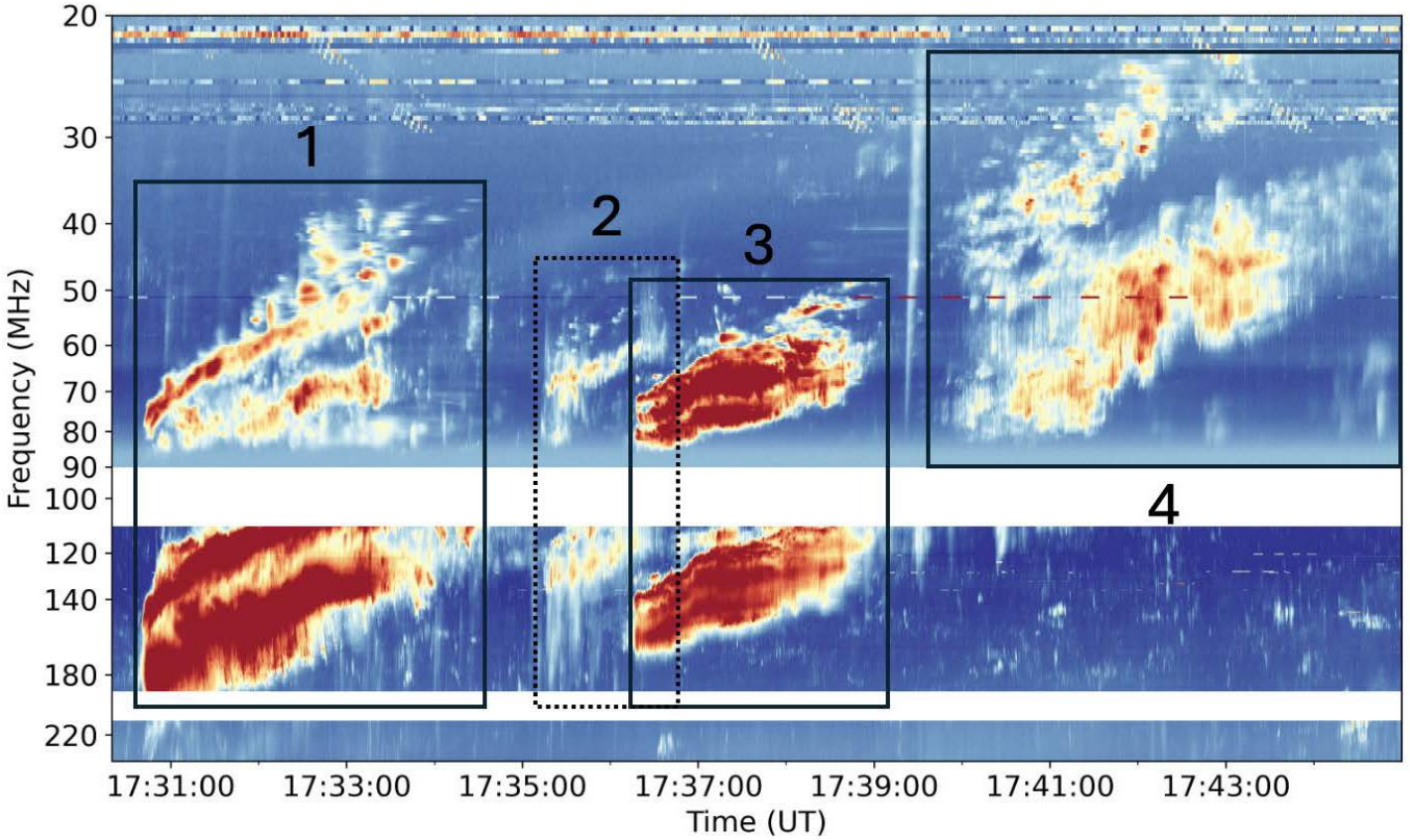
Observations – radio

- I-LOFAR dynamic spectrum (17:30–17:48 UT)
- I-LOFAR dynamic spectrum; four short-lived type II bursts with F and H lanes and fine structures:
  - bandsplitting
  - herringbones
  - fragmentation



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Observations – radio

Definitions used for lane labels:
L=lower, M=middle, U=upper;
F=fundamental, H=harmonic

LF: lower-fundamental sub-band

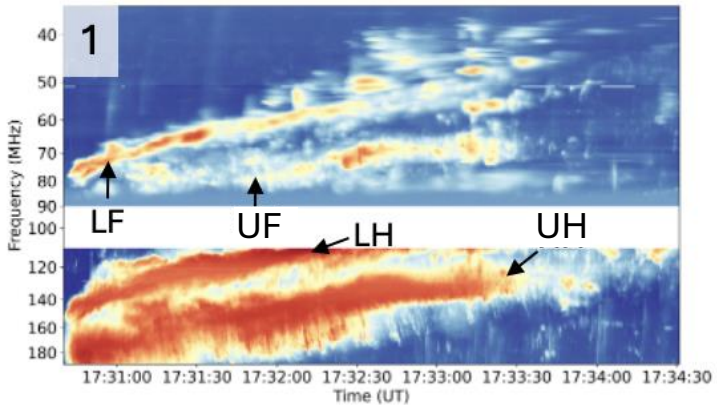
LH: lower-harmonic sub-band

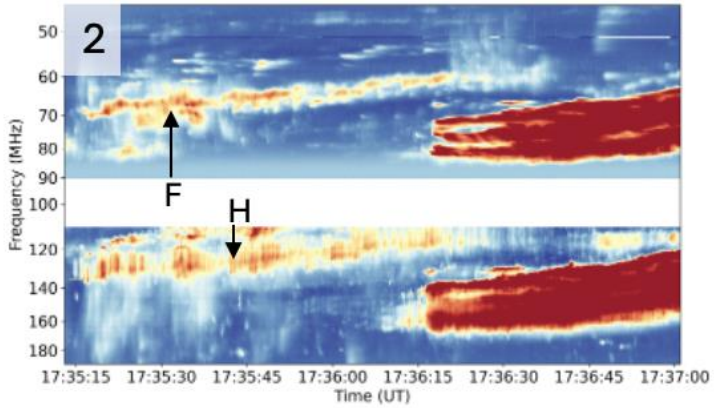
MF: middle-fundamental sub-band

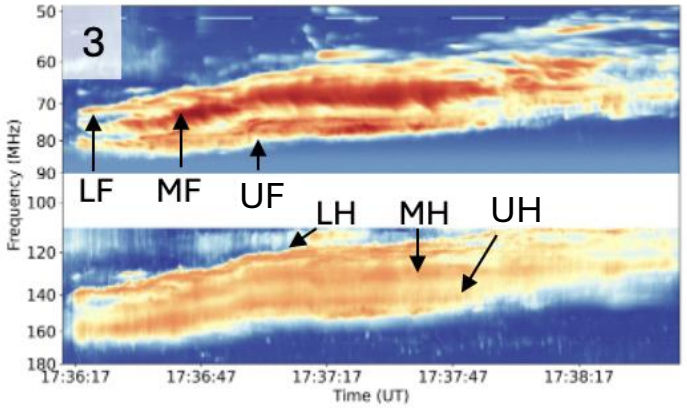
MH: middle-harmonic sub-band

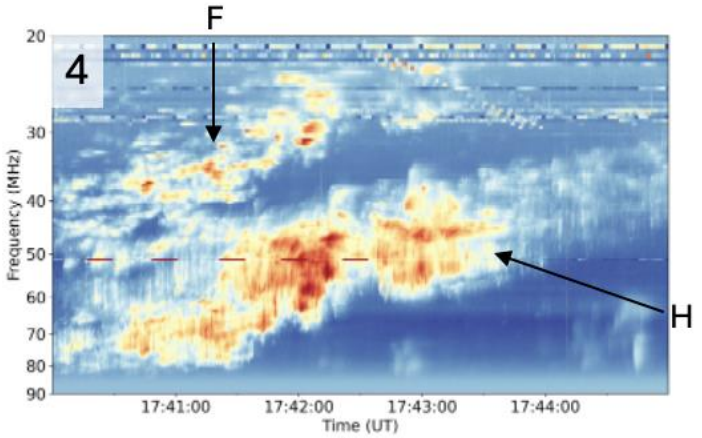
UF: upper-fundamental sub-band

UH: upper-harmonic sub-band









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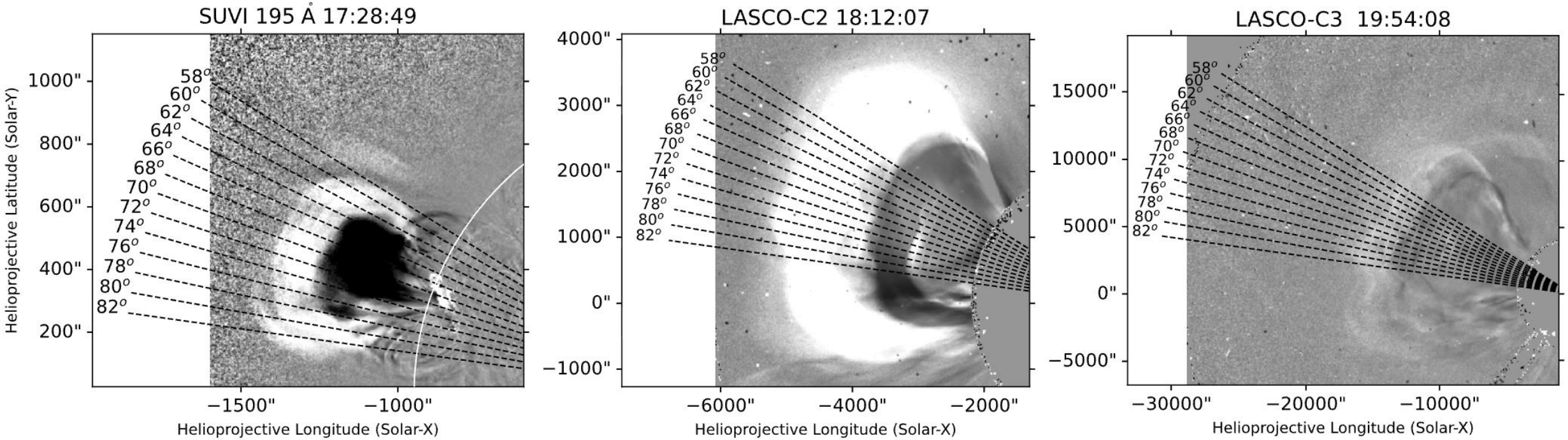
EUV & WL Observations

- CME leading edge tracked in SUVI 195 Å from ~1.17–1.92 $R_\odot$
- In LASCO C2 from ~1.5–6 $R_\odot$, and in LASCO C3 from ~3.7–30 $R_\odot$



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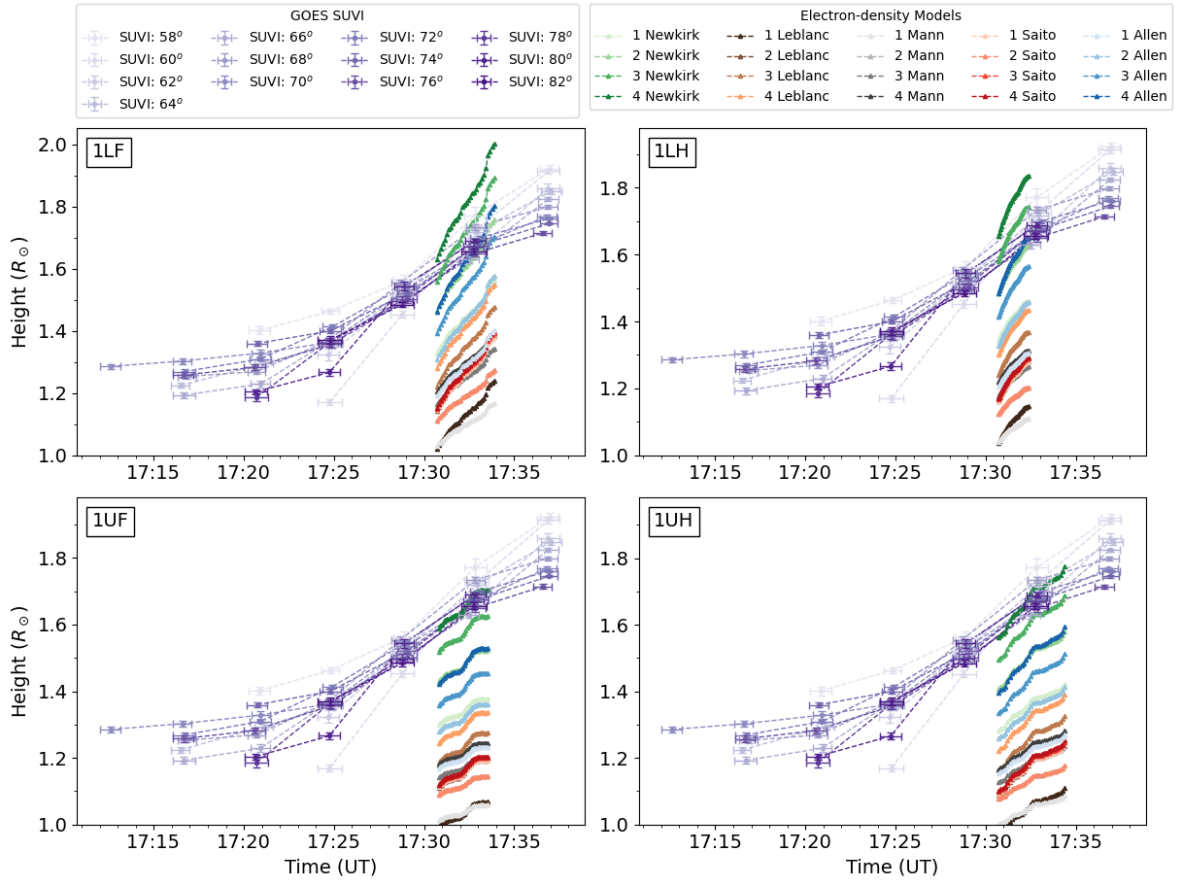
Results – radial kinematics

- Converted radio frequencies to heights using five density models (Newkirk, Leblanc, Mann, Saito, Allen)
- Newkirk model best matches EUV-derived heights within 17:30–17:38 UT



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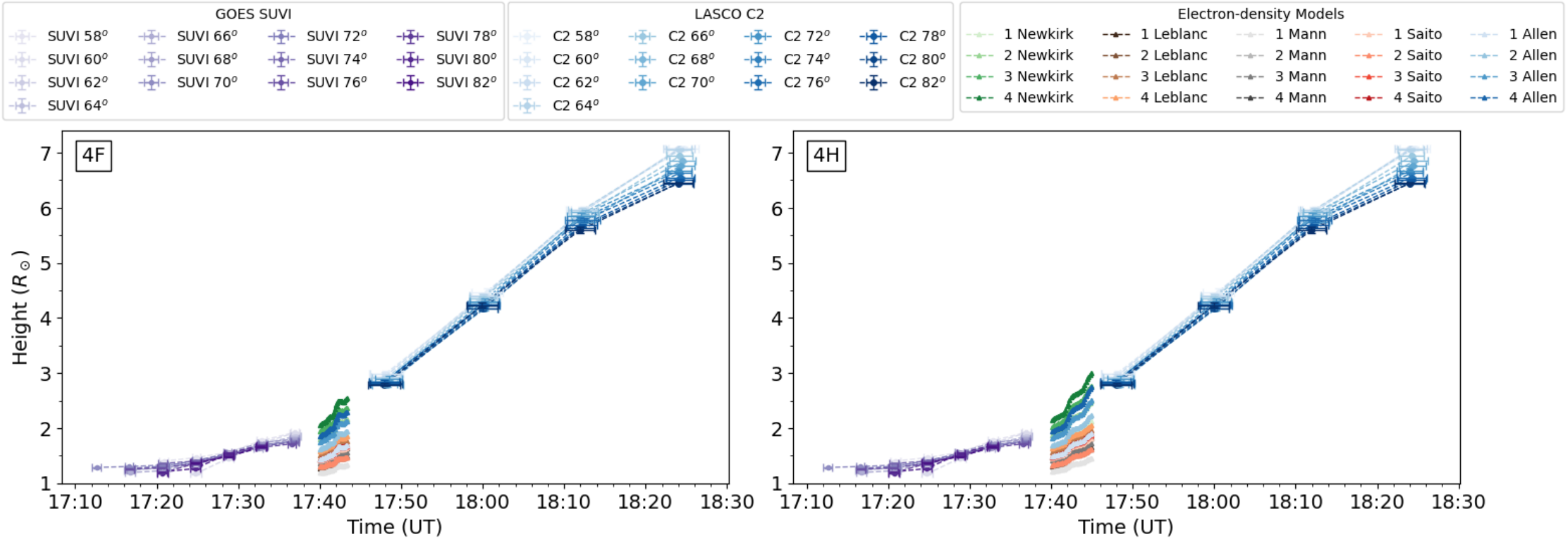
- Fundamental (F) and Harmonic (H) sub-bands of type II burst no. 4
- CME heights from SUVI and LASCO C2 shown for context only — no temporal overlap with radio heights
- CME experienced clear acceleration during the SUVI–LASCO C2 gap; this acceleration likely triggered the fourth type II burst



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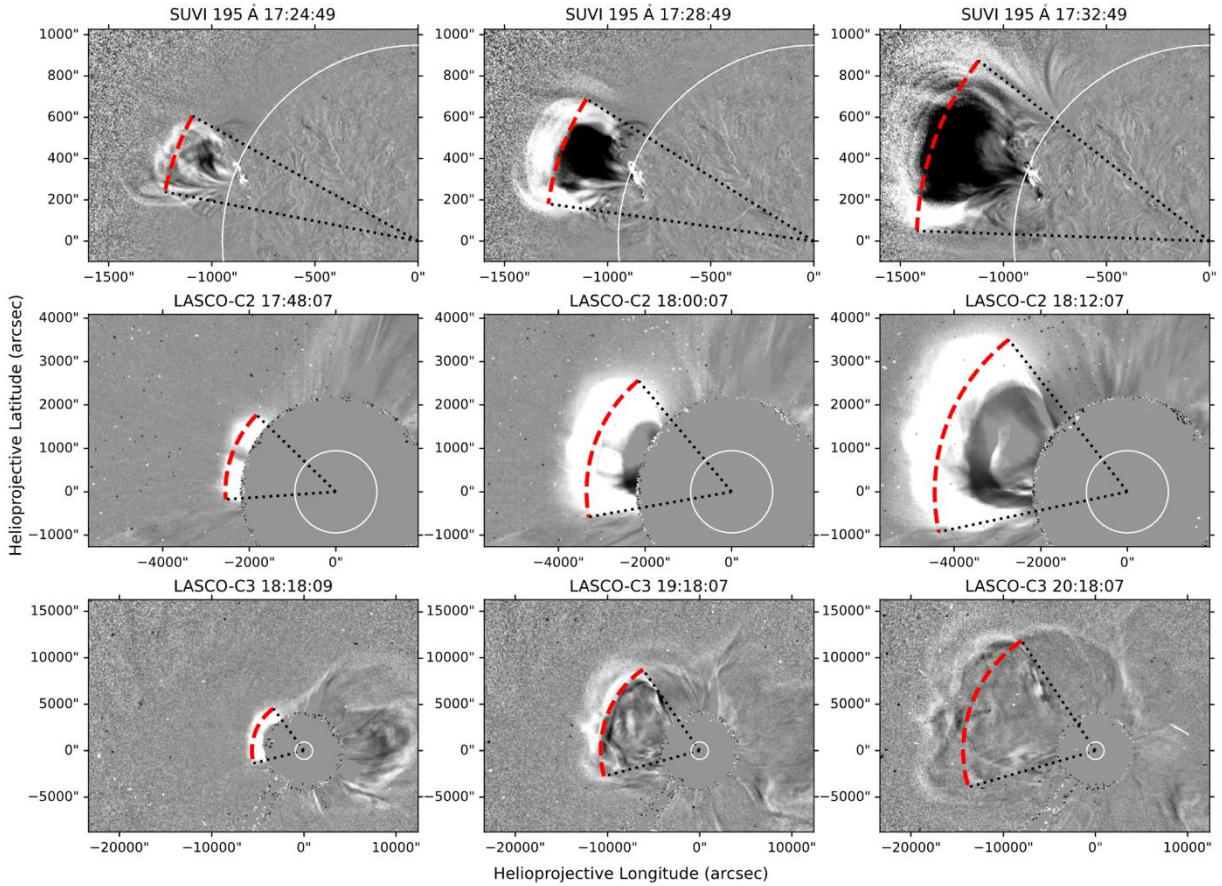
Results – lateral kinematics

- Curved triangular envelope fitted to the CME width to quantify lateral expansion
- Lateral expansion speed generally exceeds radial speed; angular width increases notably in LASCO C2 FOV



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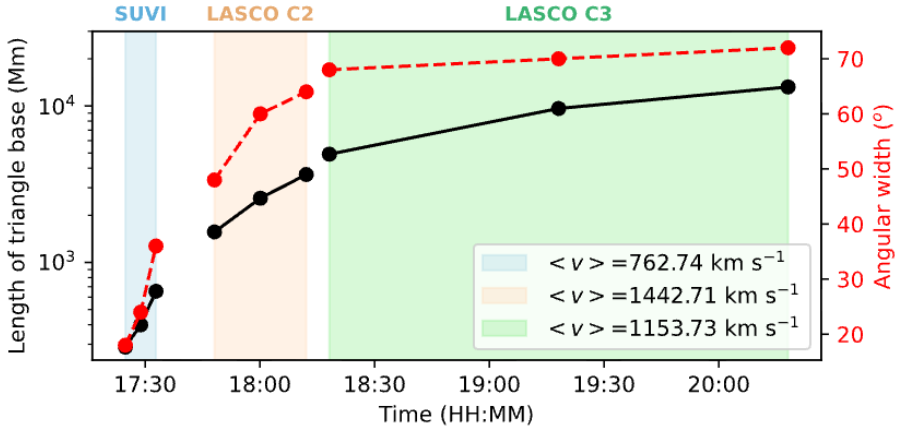
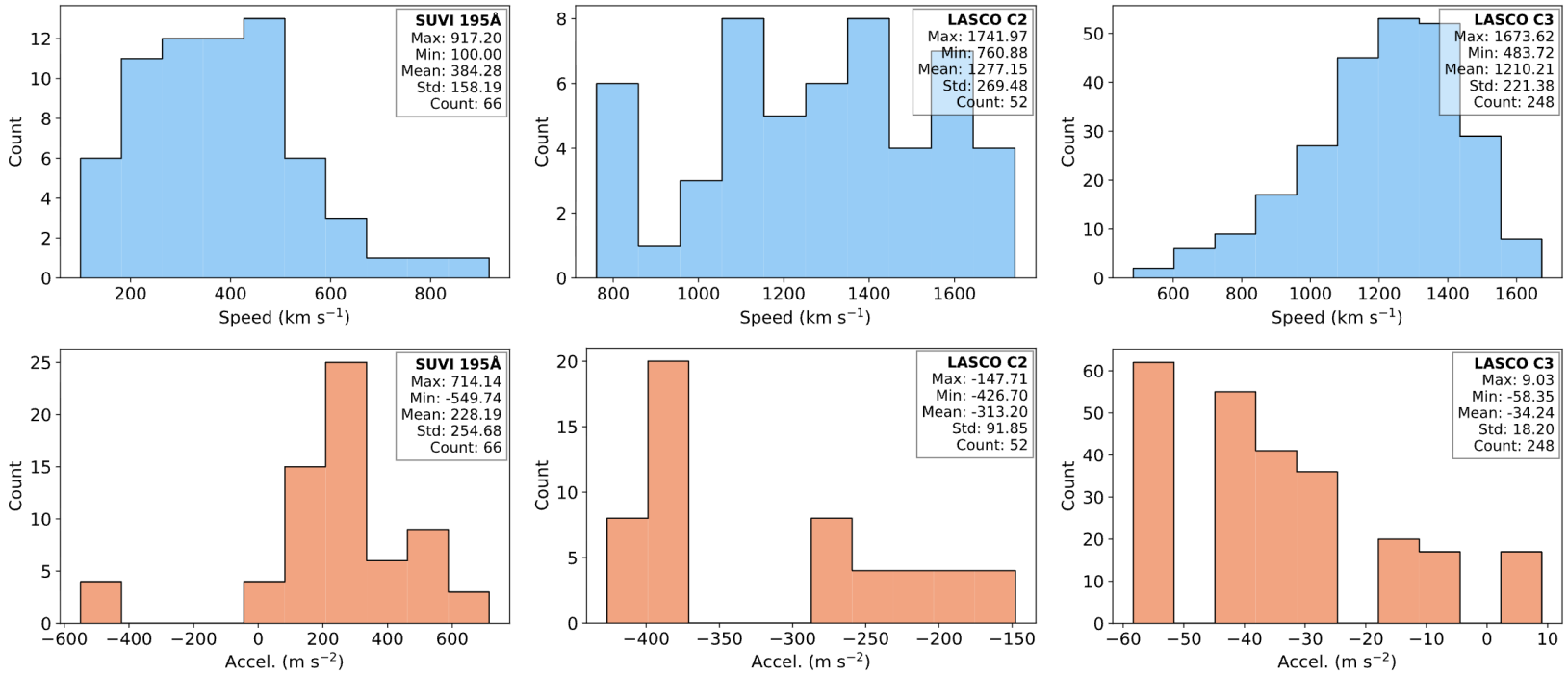
Results

- Angular width and triangle-base vs time (CME lateral expansion)
- Speed and acceleration histograms in SUVI & LASCO
- Lateral expansion peaks in LASCO C2
  lateral > radial propagation





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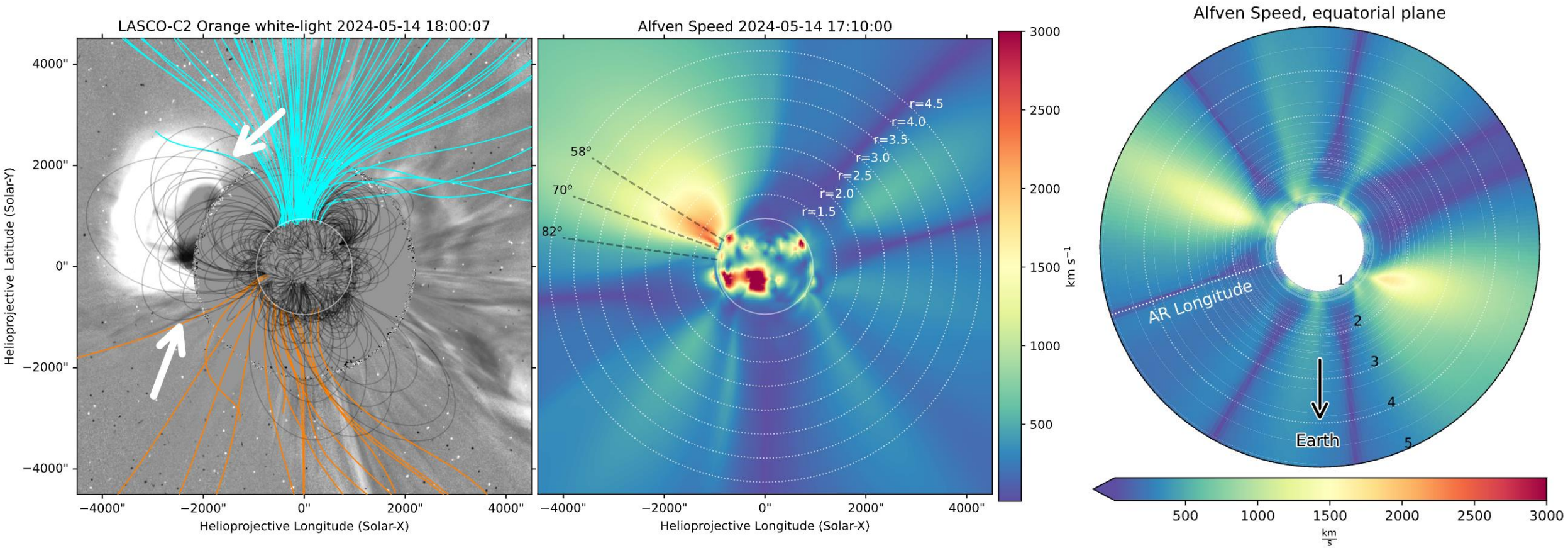
Modeling

- PFSS (GONG magnetogram) shows closed field concentrations and open lines at flanks
- Shock shoulders align with open field lines—candidate regions for type II generation
- MAS MHD solution via FORWARD produced 2D maps of coronal parameters
- FORWARD map shows regions of low Alfvén speed along the CME path



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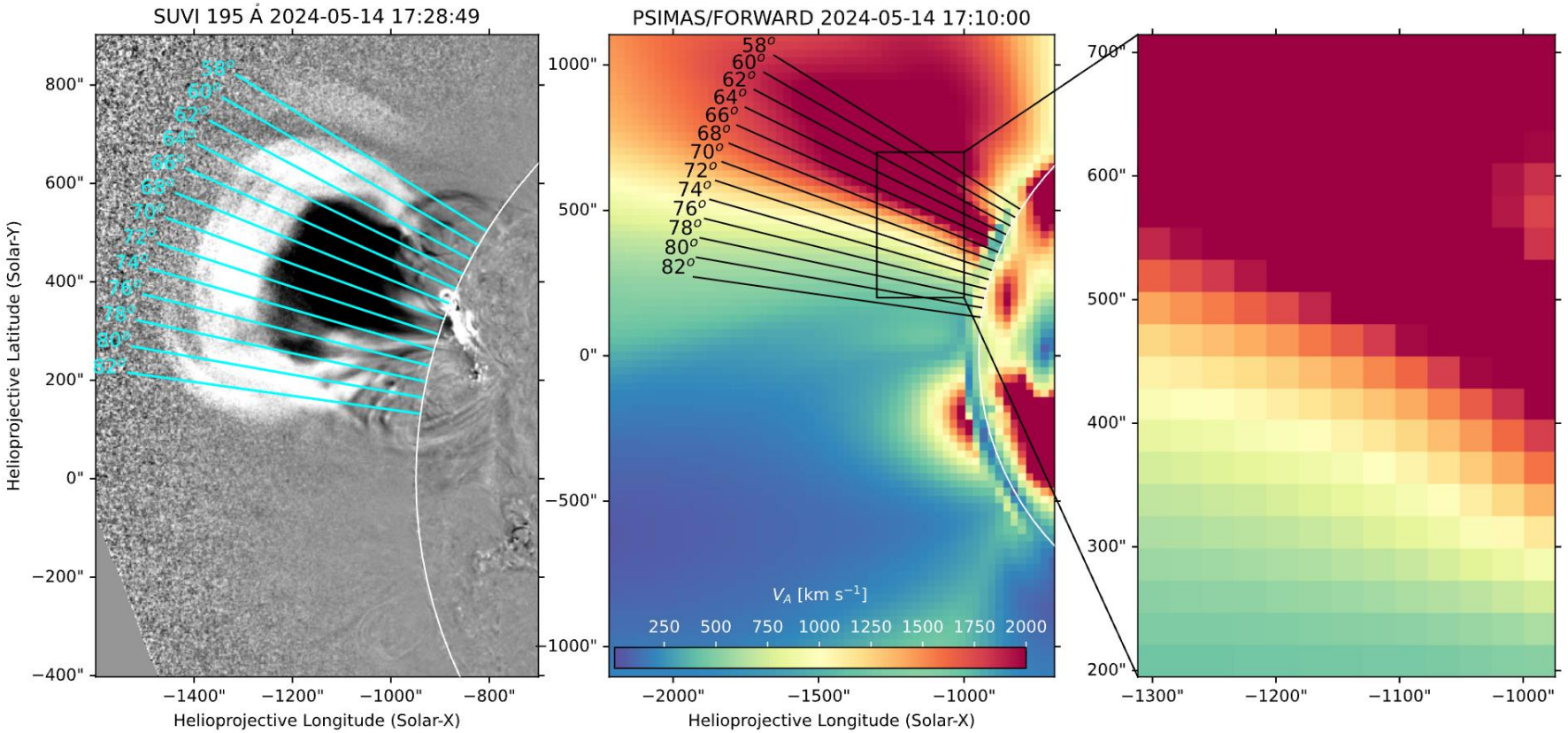
Modeling

- SUVI RR image with radial slits used for height–time stacks
- MAS v_A map, zoomed on the same region, shows v_A transition and pixelation at this scale
- Pixelation explains the wiggly traced v_A profile



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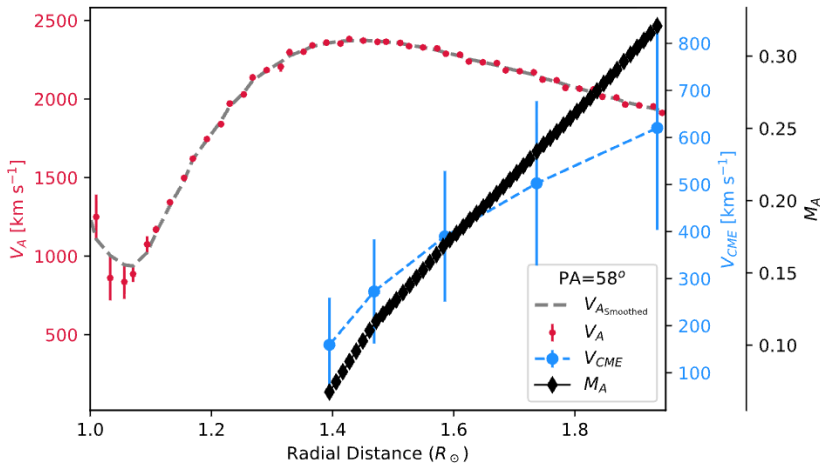
Modeling

Alfvén speed vs CME speed plotted for three representative slits

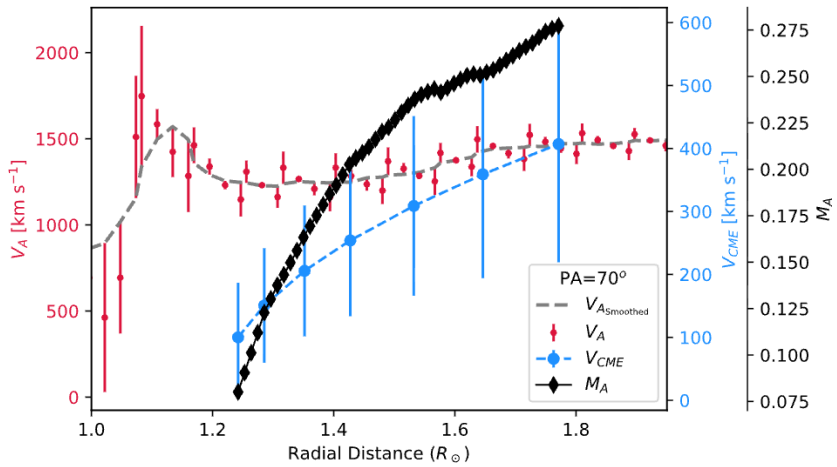
Local Mach number computed as $M_A = v_{CME} / v_A$

Bottom flank shows highest M_A (up to ≈ 1.2), supporting local shock formation

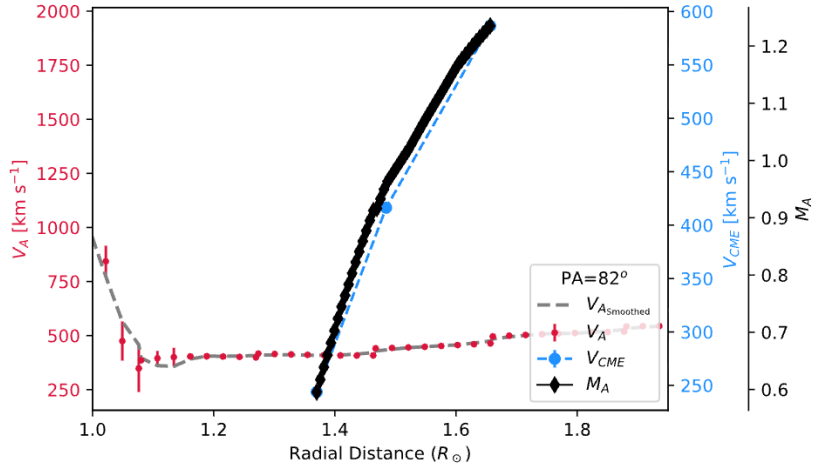
Upper flank



Central flank



Lower flank



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Conclusions

- Four type II bursts with multi-lane structure, band-splitting, herringbones, and fragmentation were observed between ~17:30–17:48 UT
- Drift rates −361 to −78 kHz s^{-1}; radial velocities ≈ 443–2075 km s^{-1}; M_A ≈ 3.21–3.57 (from band-splitting); M_A up to ~1.2 (from MAS/FORWARD map)
- 4× Newkirk model best reproduces EUV heights between 17:30–17:38 UT; other models underestimated heights
- Modeling (PFSS + MAS/FORWARD) shows low Alfvén speed regions and magnetic topology at CME flanks consistent with shock formation
- Type II emission most likely originated from the CME bottom flank, where low Alfvén speed and magnetic configuration facilitated shock generation

(Nedal+2025, submitted to A&A, in revision)

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