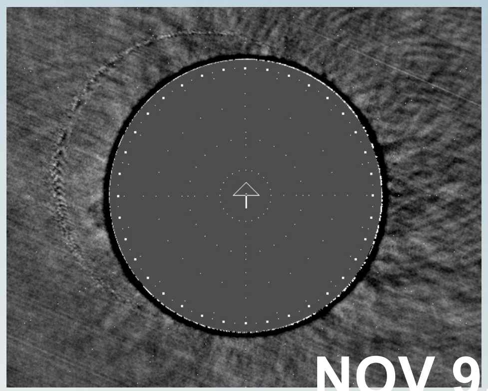
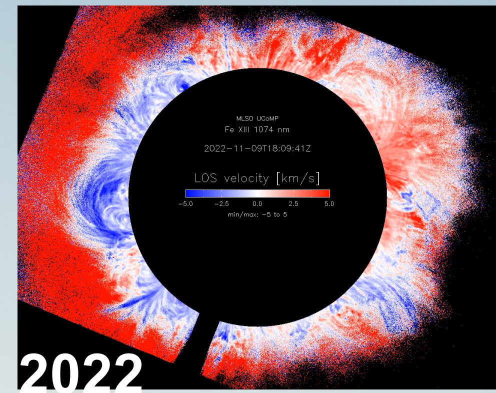
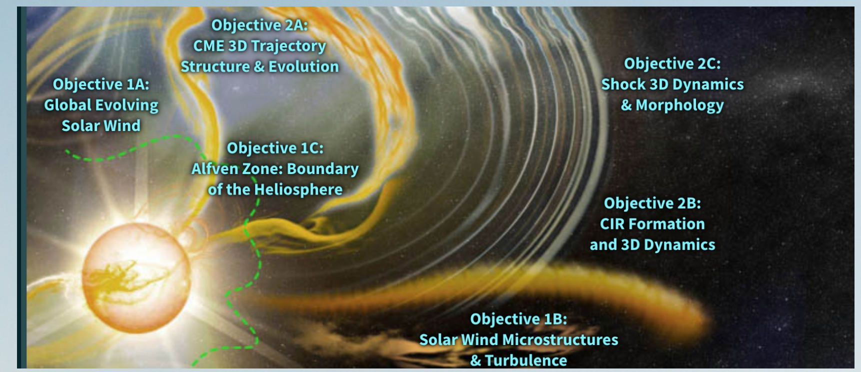




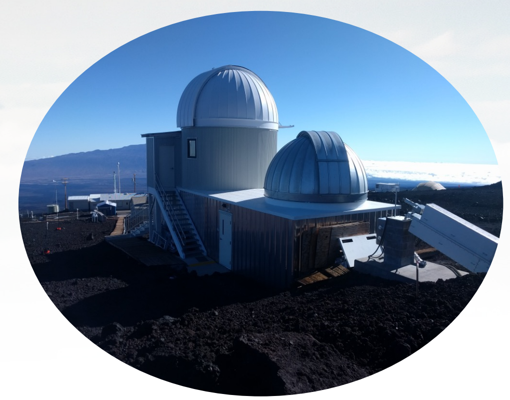
NOV 9, 2022



Mauna Loa Solar Observatory (MLSO) - PUNCH Synergy: Coronal Jets

https://www2.hao.ucar.edu/mlso/mlso-home-page

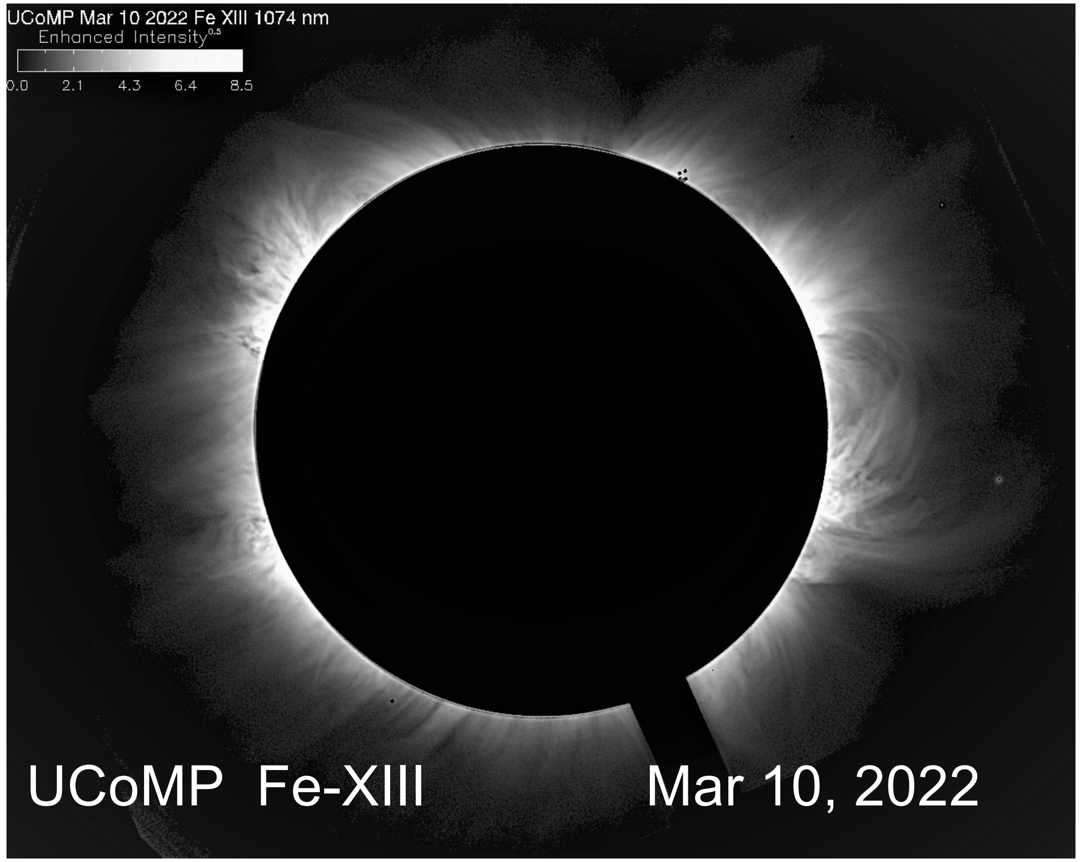
Samaiyah Farid with MLSO team
(many slides from the Mauna Loa Team)
sfarid@ucar.edu
NSF NCAR High Altitude Observatory (HAO)



NCAR

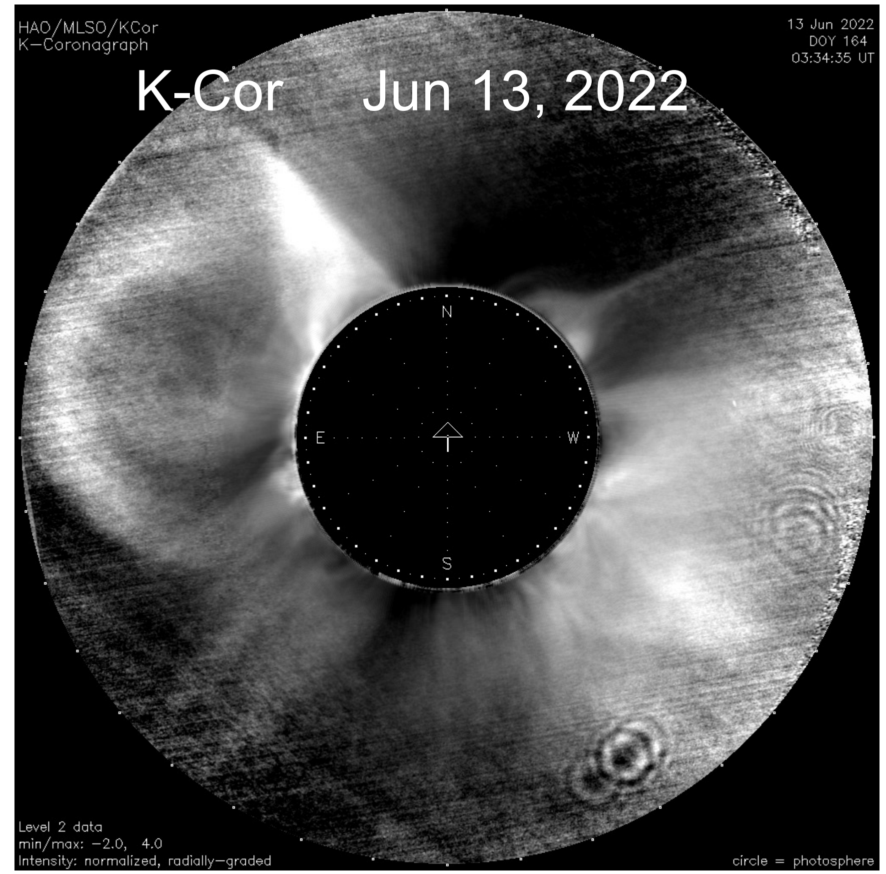
This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsored by the National Science Foundation under Cooperative Agreement No. 1852977.

Muano Loa Solar Observatory (MLSO) Operates Two Coronagraphs



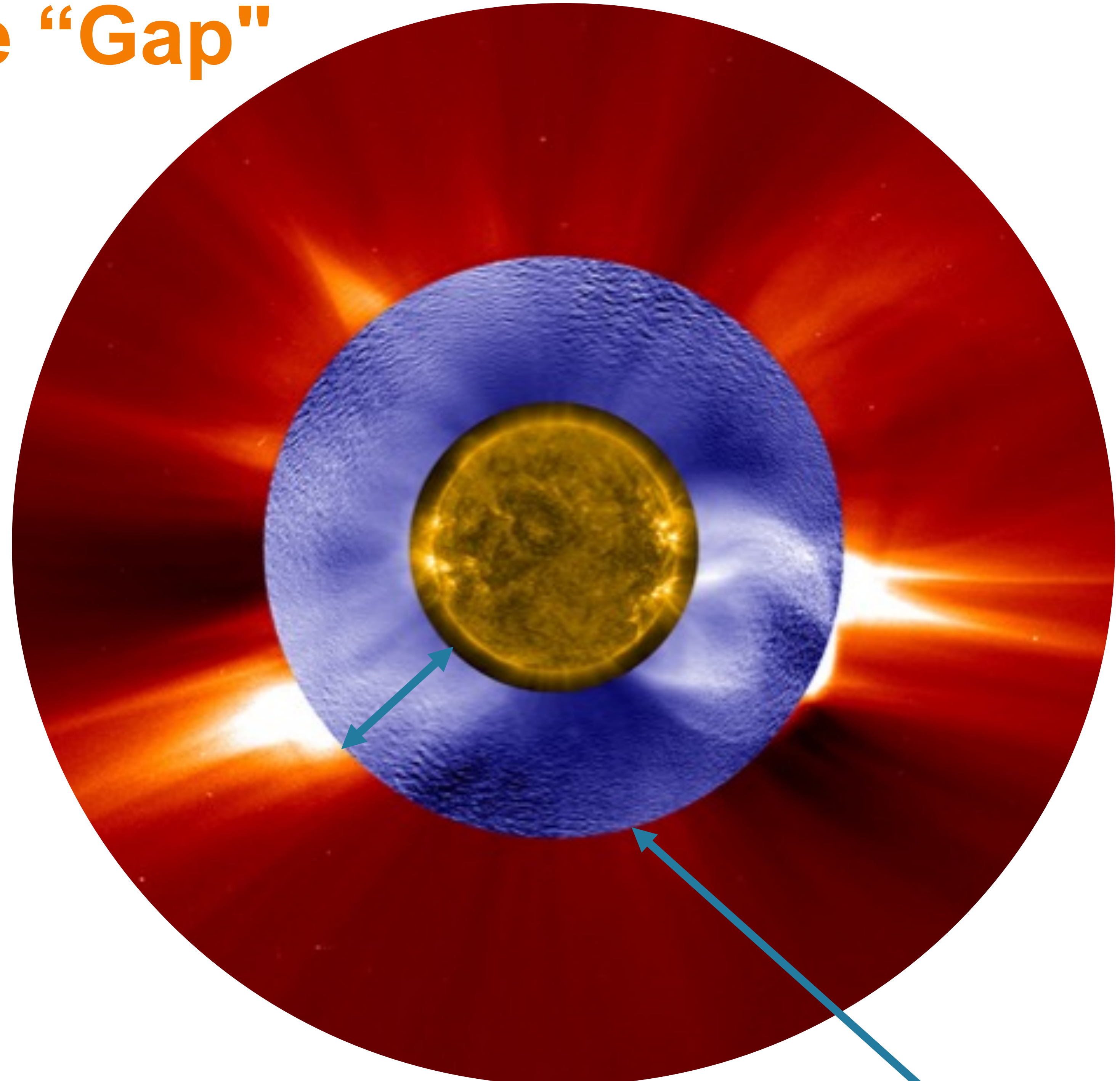
Upgraded Coronal Multi-Channel Polarimeter (UCoMP): 9 coronal emission lines in intensity and polarization to provide magnetic field and plasma diagnostics needed to understand the formation of CMEs and the solar wind.

COSMO K-Cor: Designed to study the onset and dynamics of coronal mass ejections (CMEs) and the evolution of magnetically closed and open coronal structures over time scales of seconds to decades

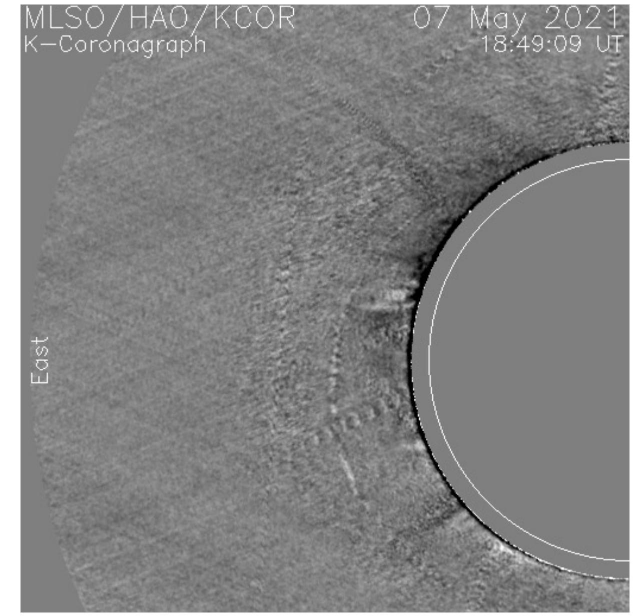


MLSO: Filling the “Gap"

- Observes the low and middle corona in polarized brightness (white light)from 1.05 to 3 Rsun at 15 sec cadence.
- Ideal for tracking the onset and dynamics of young, solar wind, CMEs, waves, and dynamic events
- PUNCH NFI FOV starts ~ 6 Rs



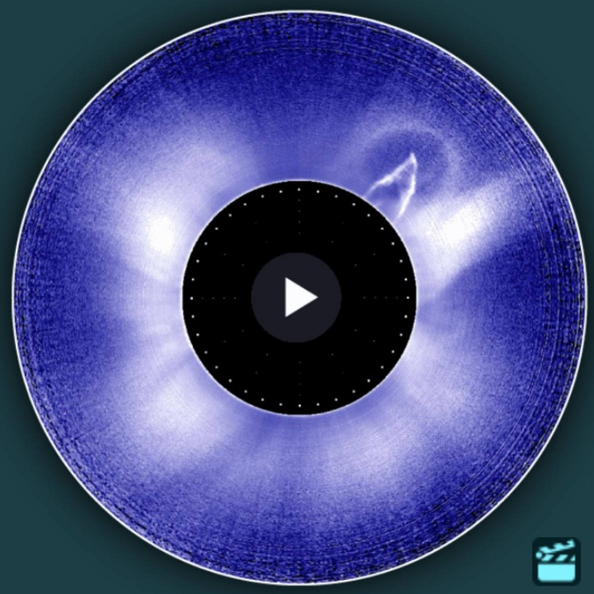
AIA EUV (Gold); K-Cor (blue); LASCO C2 (red)



K-Cor CME May 7, 2021

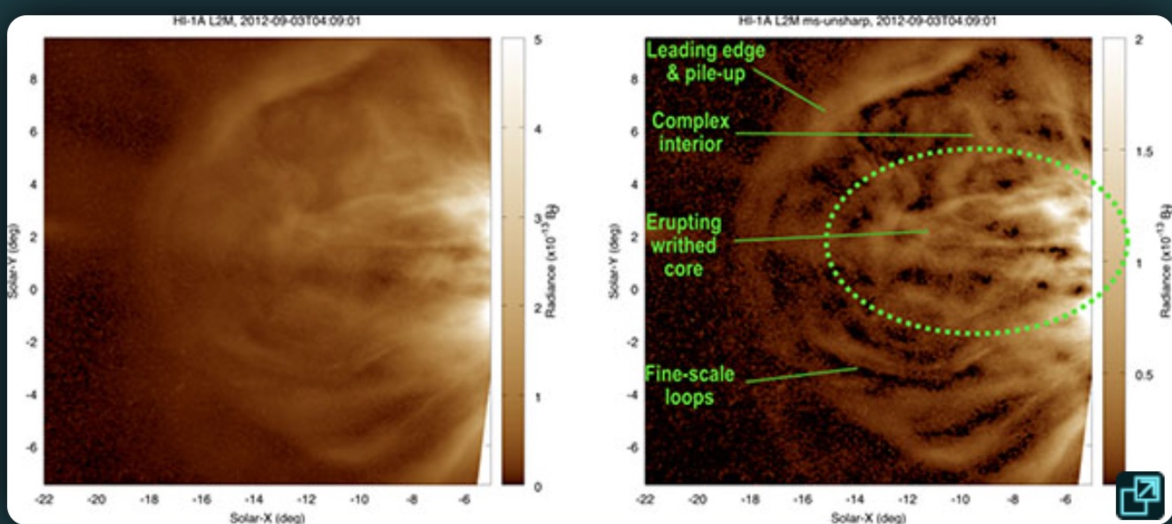
MLSO+PUNCH synergy (PUNCH Science objectives 1A, 1B,2A, 2C)

How do coronal mass ejections (CMEs) propagate and evolve in the solar wind?



Tracking CMEs' Evolving Structure in 3D

- CME magnetic structures are known to change in the solar wind due to distortion, deflection, rotation, CME-CME interactions, and magnetic reconnection/erosion.
- Current white-light imagers can track only the largest components of CME structure beyond 20 Rsun.
- We thus know almost nothing about how the sub-structures of CMEs interact with each other or with the solar wind.



•Track CMEs across the solar system in 3D to determine propagation effects including possible deflection.

•Analyze 3D substructure evolution to relate CME origin to heliospheric structure and geoeffectiveness.

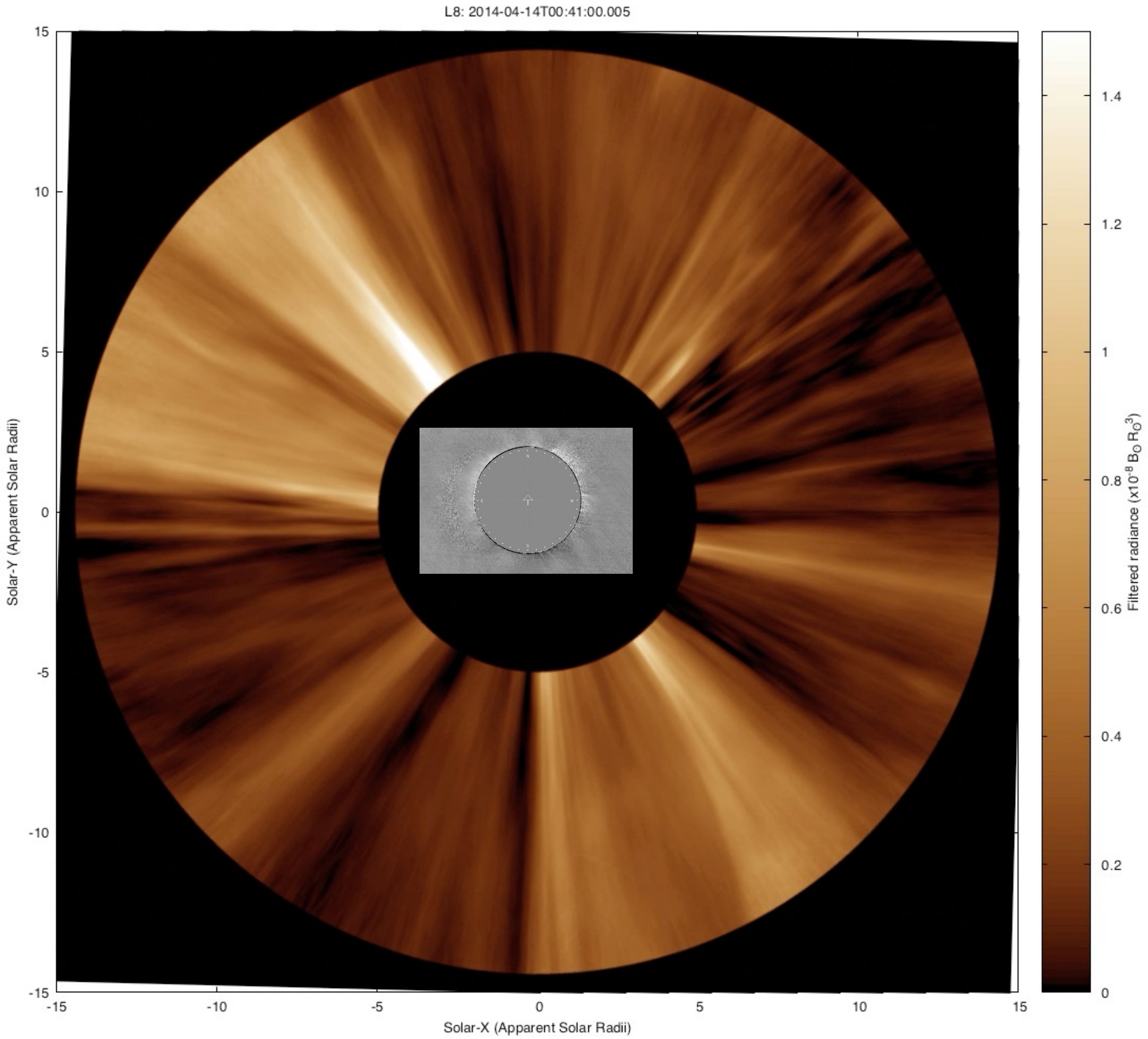
•Measure CME chirality and relate to measured in-situ magnetic chirality.

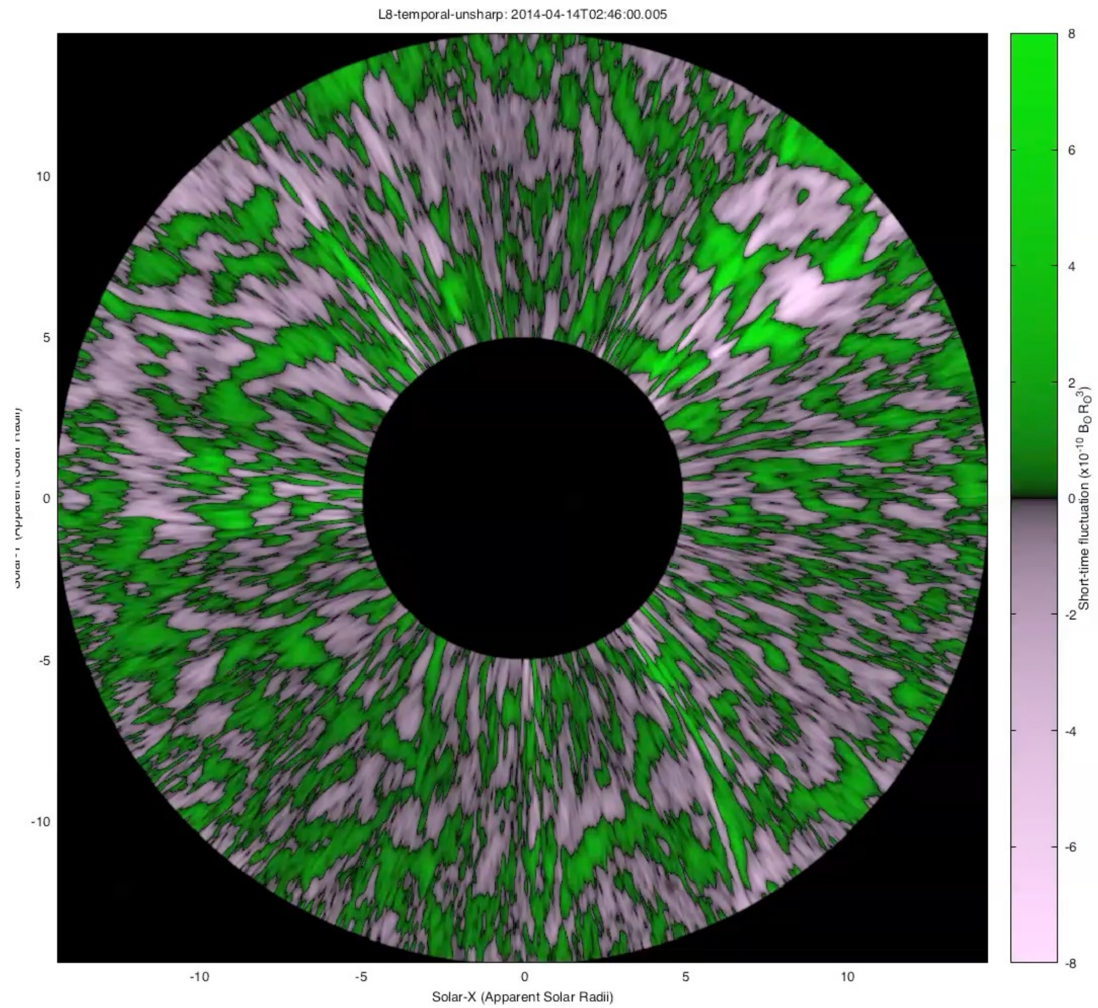
•Identify CMEs that suggest formation of shocks & SEPs.

See poster by Joan Burkepile!

PUNCH Science Objective 1B: Solar Wind Microstructures and Turbulence

How do the dynamic structures observed in MLSO/Kcor & LASCO-C2 correlate to fluxuations in the solar wind (Deforest et al 2018))? Jets? Plumes? Streamer eruptions?



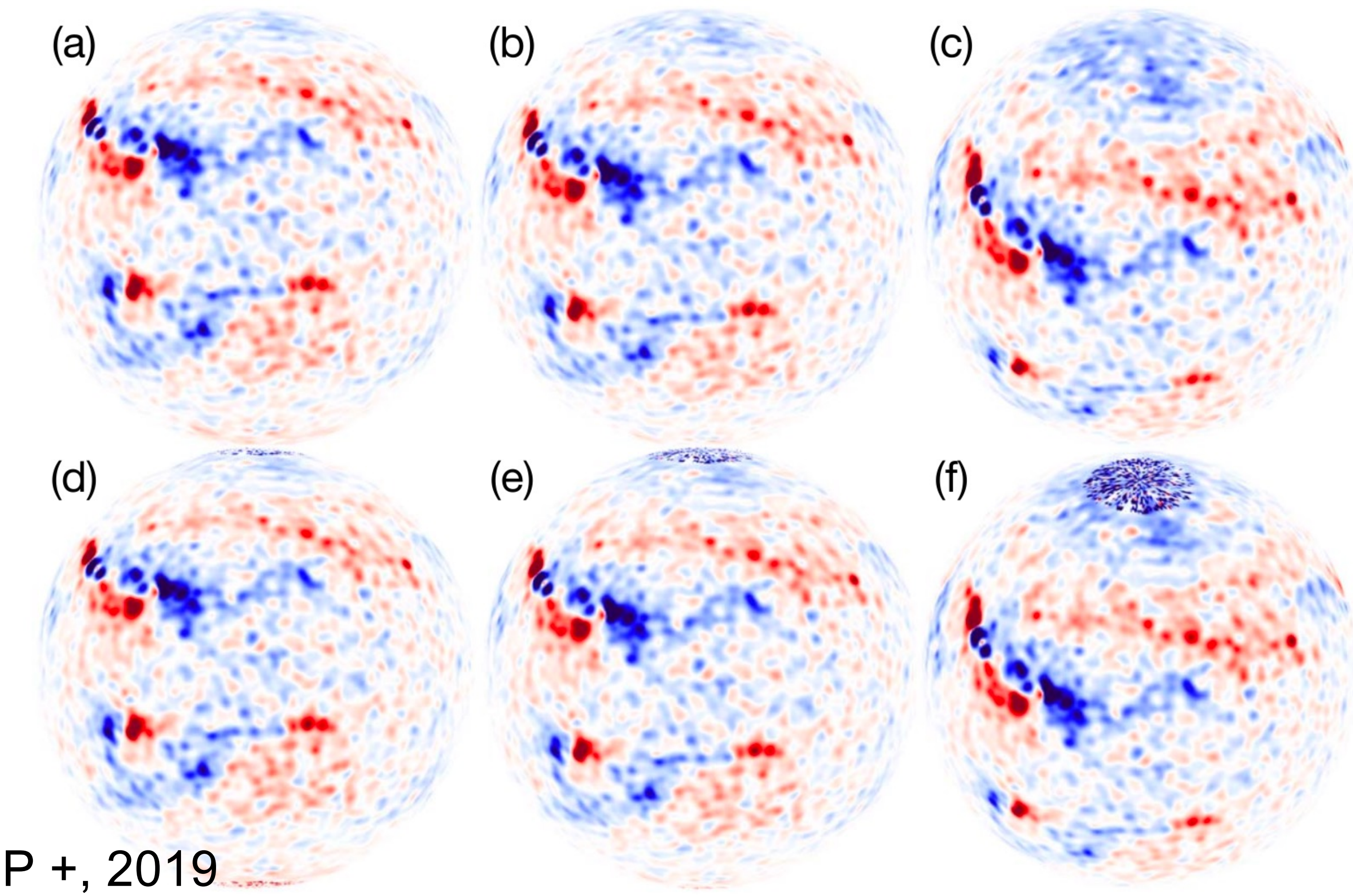


DeForest et al. 2018)

How does the evolution of the polar magnetic field affect solar wind dynamics and structure at 10Rs?

Punch (1A) Objective Global Evolving Solar Wind

Understanding Evolution and Restructuring of the PCHB and its influence on the solar wind and global magnetic field



Riley,P +, 2019

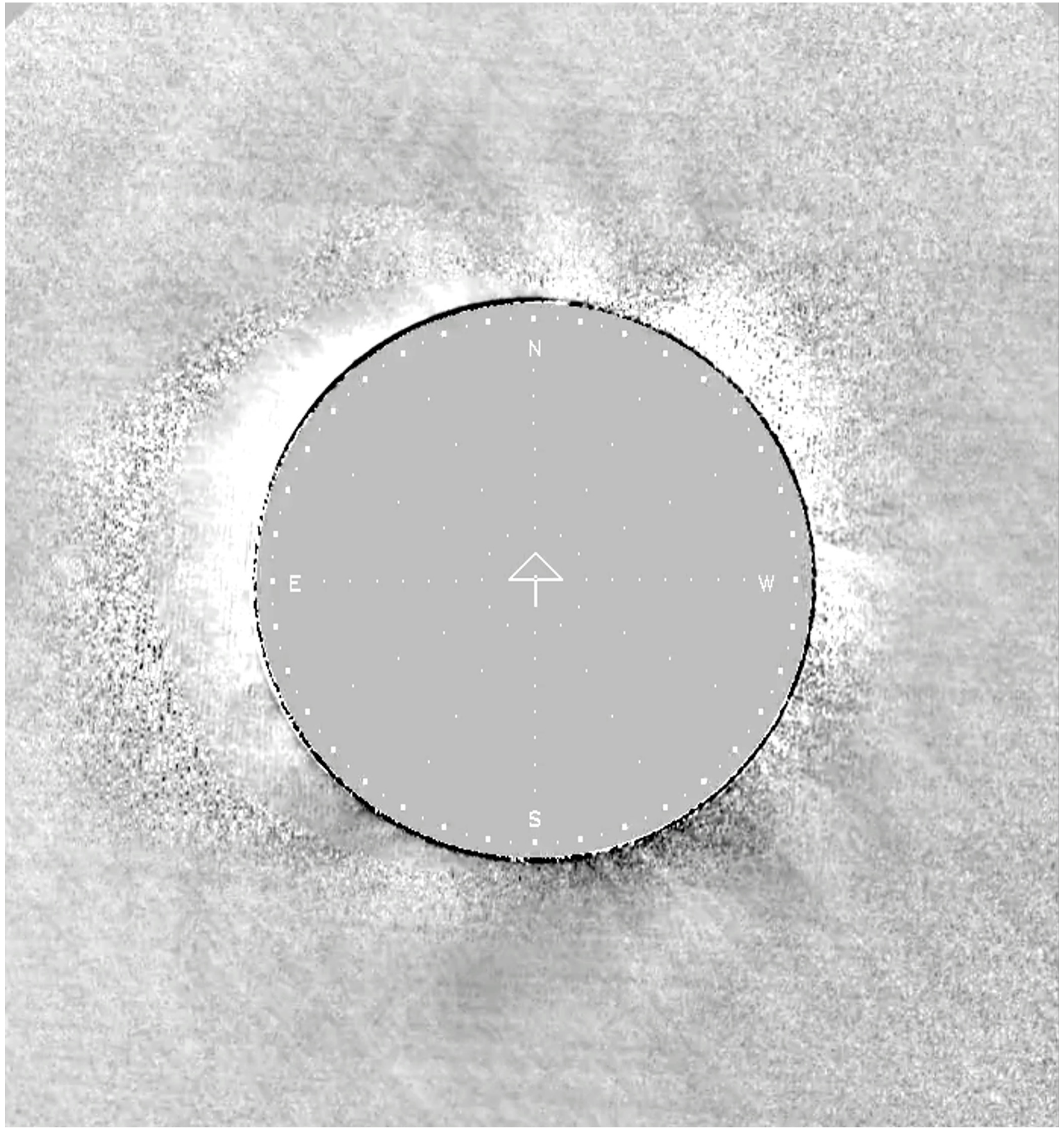
Figure 3. Line-of-sight component of the photospheric magnetic field, centered at Carrington longitude 0°, for different viewing angles (latitudes). Panels (a) and (d) show the view from Earth without and with small spots added to the polar regions, when the Earth is in the solar equatorial plane. Panels (b) and (e) show the same two cases but for when the Earth's position is 7°25 above the solar equatorial plane. Panels (c) and (f) show the views that *Solar Orbiter* would identify from a vantage point of 30° above the solar equatorial plane.

Understanding the global structure at PUNCH radius.

Open Flux Problem?

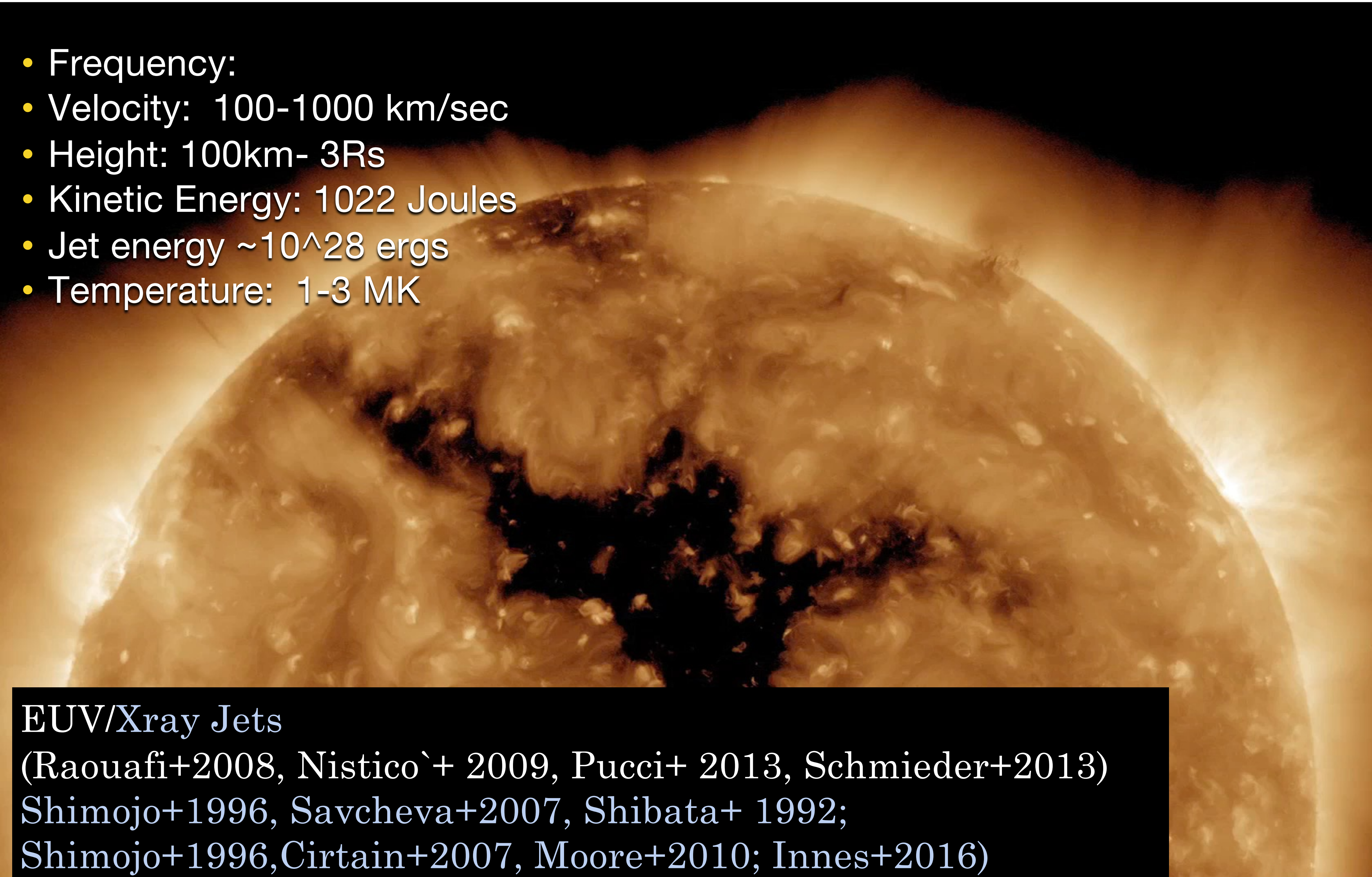
Kcor observes Extended White Light Jets, Rays, slow streamer eruptions, etc

- White light jets (narrow CMEs) Wang+1998,Moore+ 2015,Panesar+2016b
- Small jets as a source of the solar wind? Raouafi et.al 2023, Moore +2011
- Parker Solar Probe Switchbacks ? Sterling & Moore 2020
- Source of extended blobs? Yu+ 2014,2016



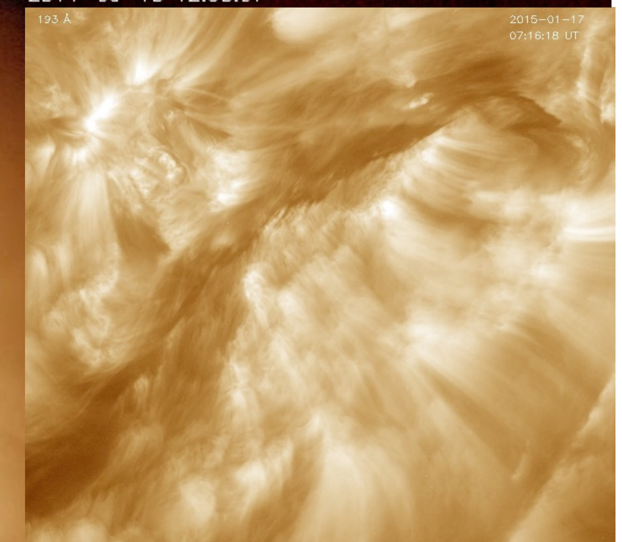
- **How do these eruptions relate to observations in PUNCH FOV?**

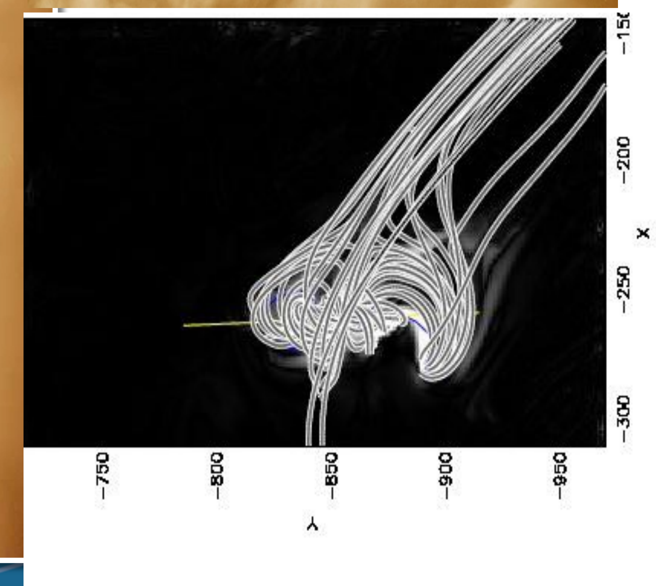
Why Coronal Jets? :: They are Small but Mighty!



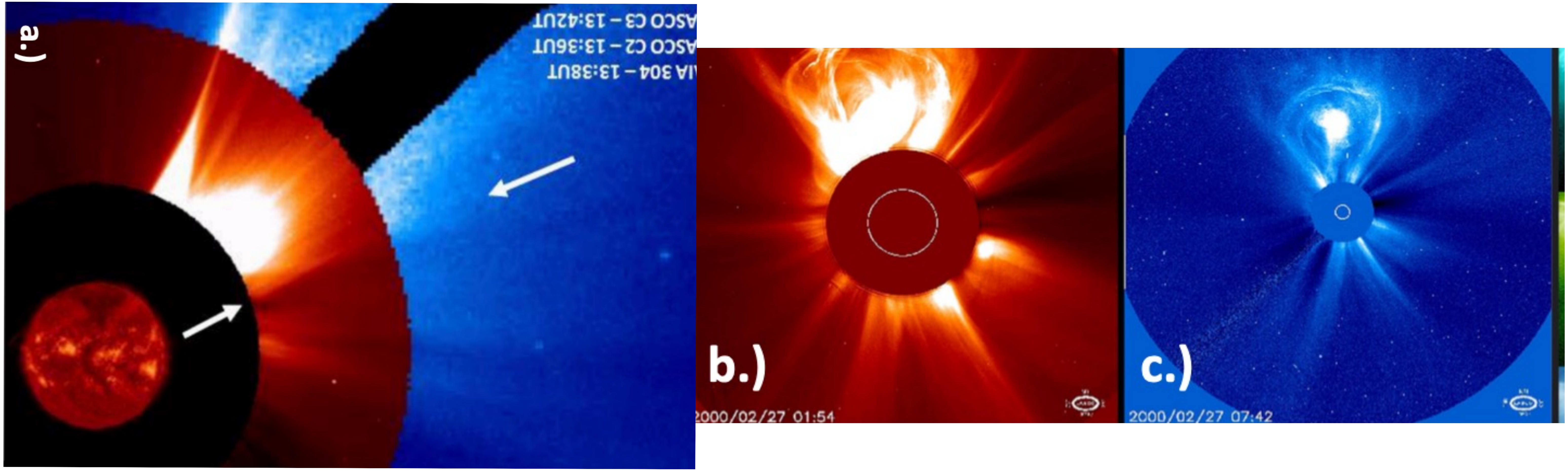
- Frequency:
- Velocity: 100-1000 km/sec
- Height: 100km- 3Rs
- Kinetic Energy: 1022 Joules
- Jet energy ~10^28 ergs
- Temperature: 1-3 MK

EUV/Xray Jets
(Raouafi+2008, Nistico`+ 2009, Pucci+ 2013, Schmieder+2013)
Shimojo+1996, Savcheva+2007, Shibata+ 1992;
Shimojo+1996,Cirtain+2007, Moore+2010; Innes+2016)





Sibling of Coronal Jets : Extended White Light Jets

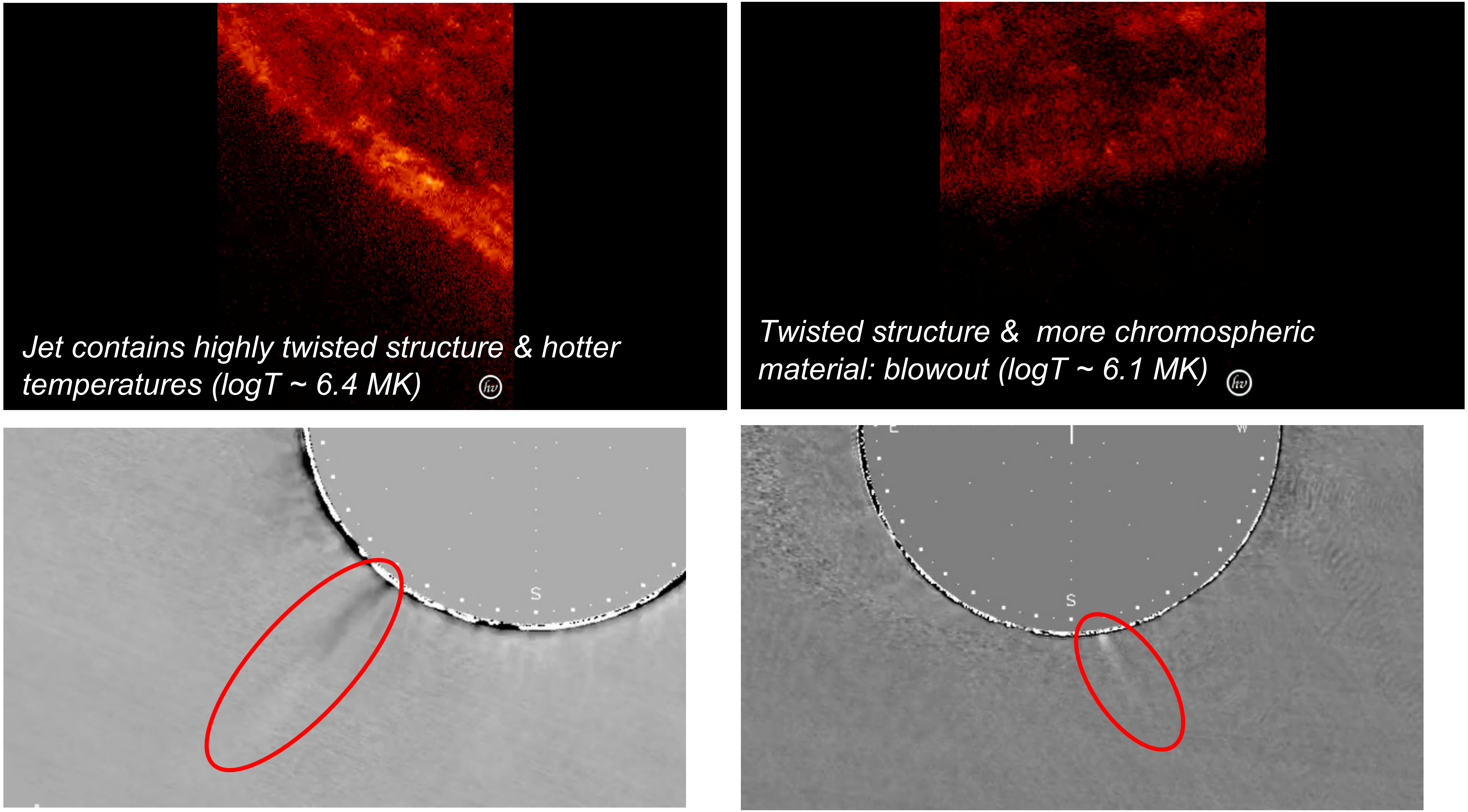


PUNCH (1B): Determining possible regions of density fluxuations in the (young) solar wind (puffs, blobs, rays, etc) and connecting them to the solar wind.

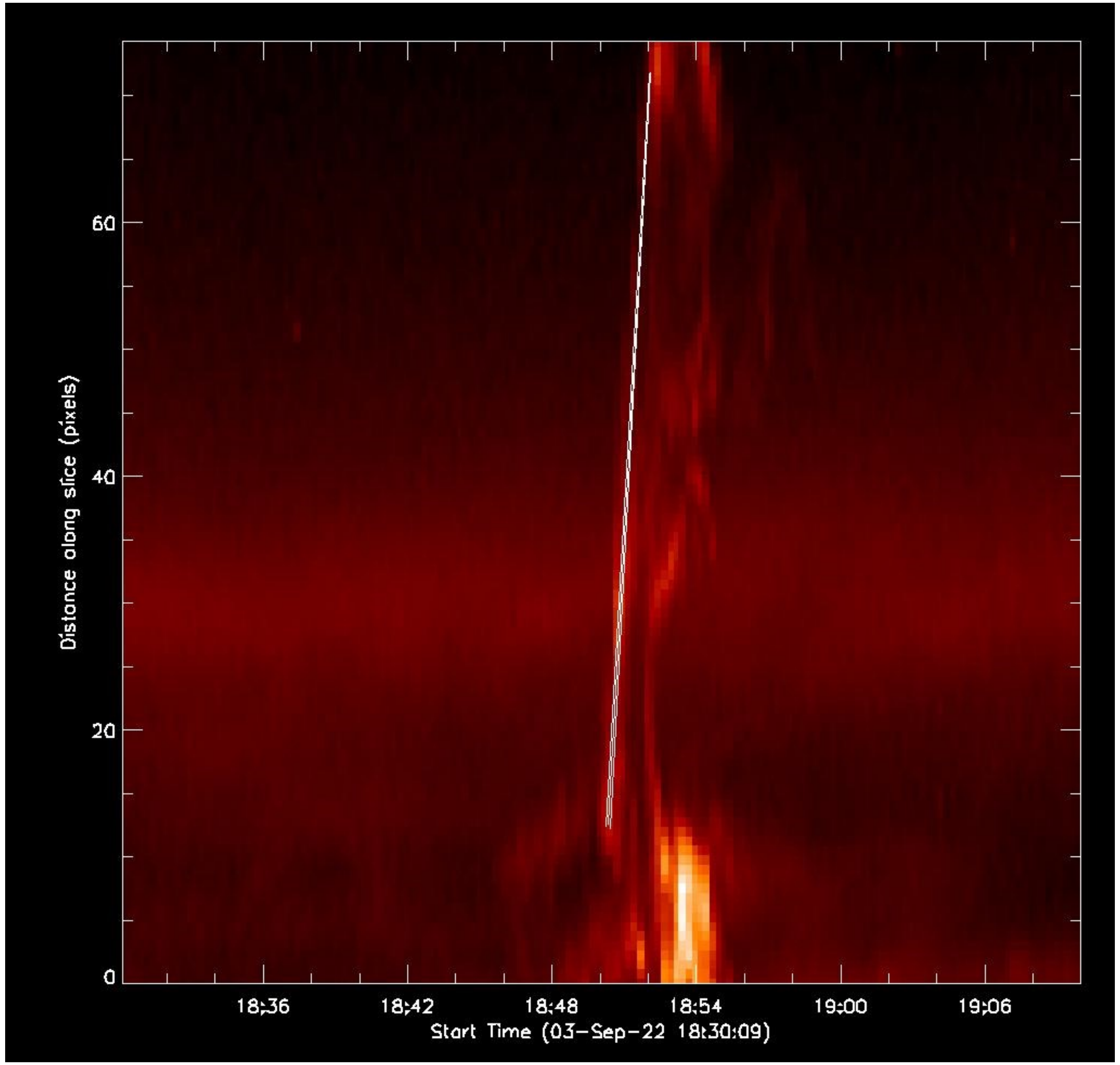
09/03/2022 | 07/21/ 2020

AIA

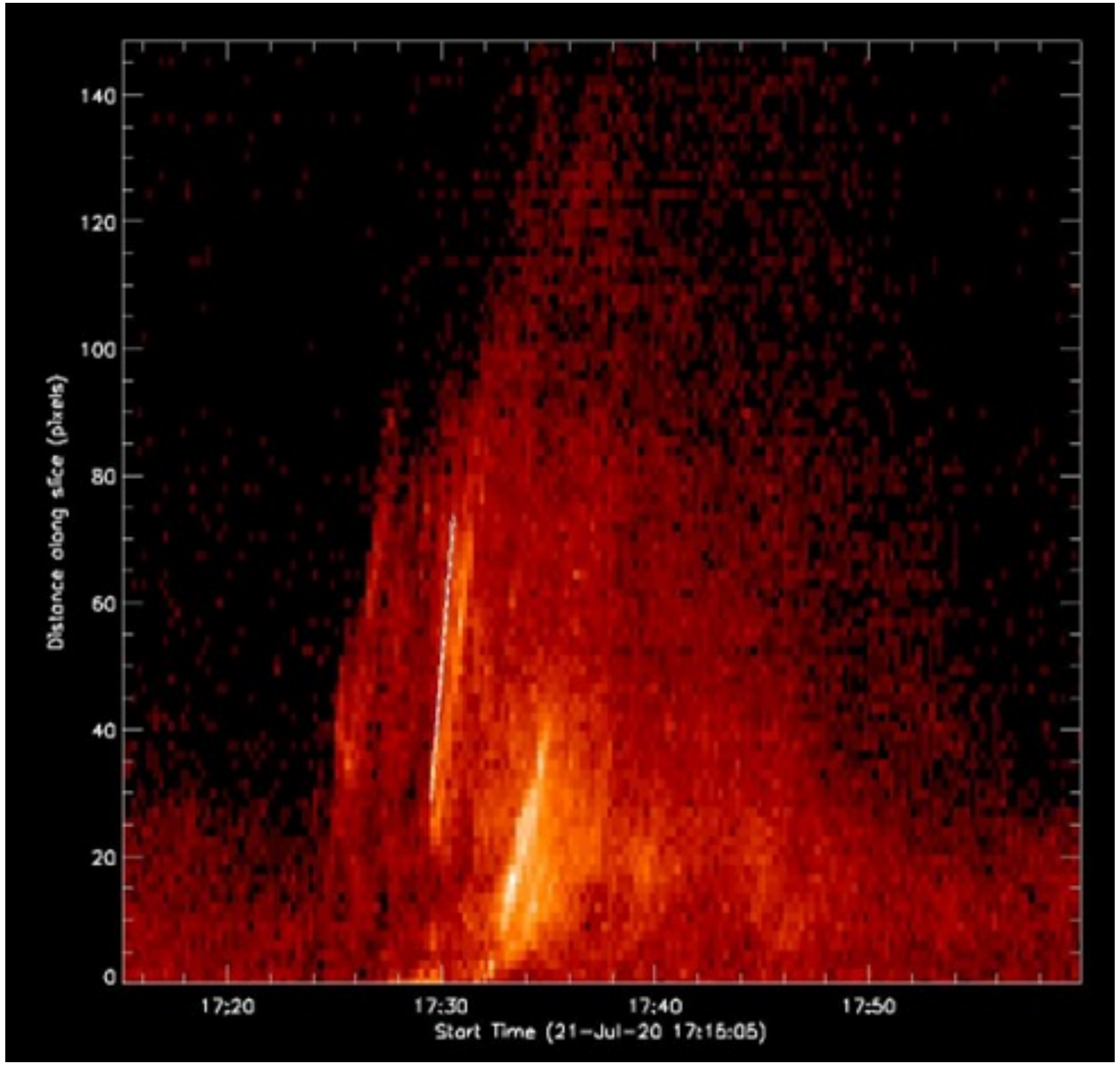
Kcor PB



Plane of Sky Velocity (AIA-193A)

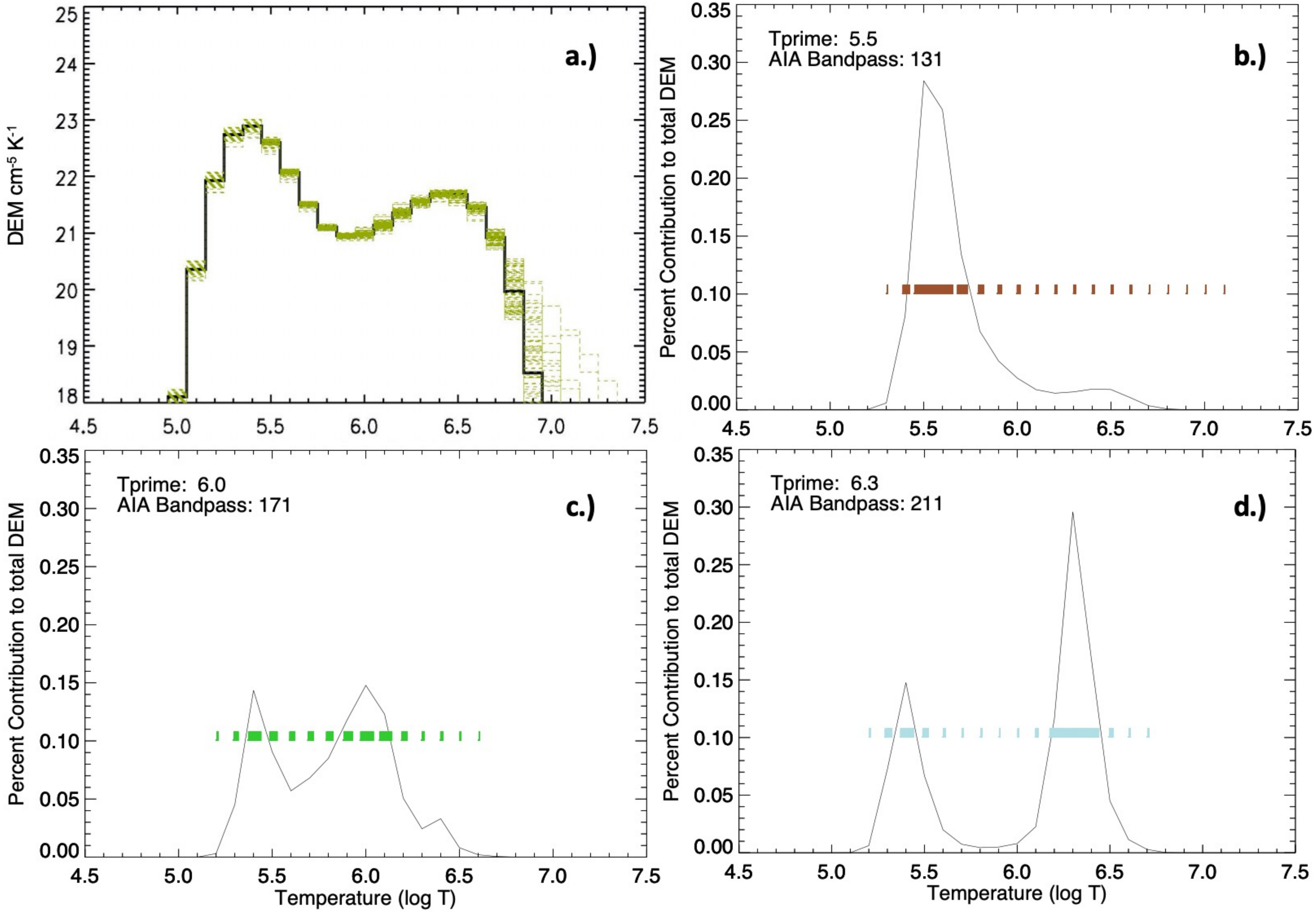


September 3rd, 2022 Jet



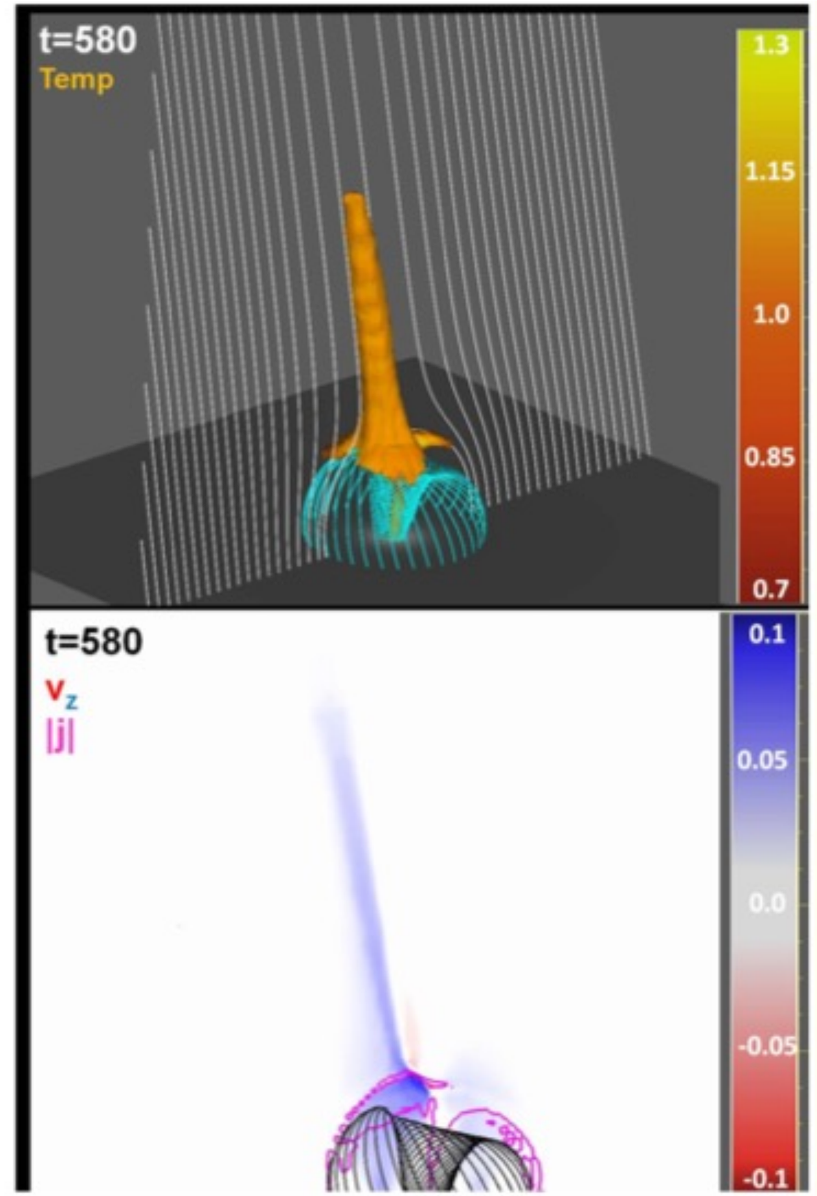
July 21st, 2020 Jet

Temperature Contribution Method per AIA Filter

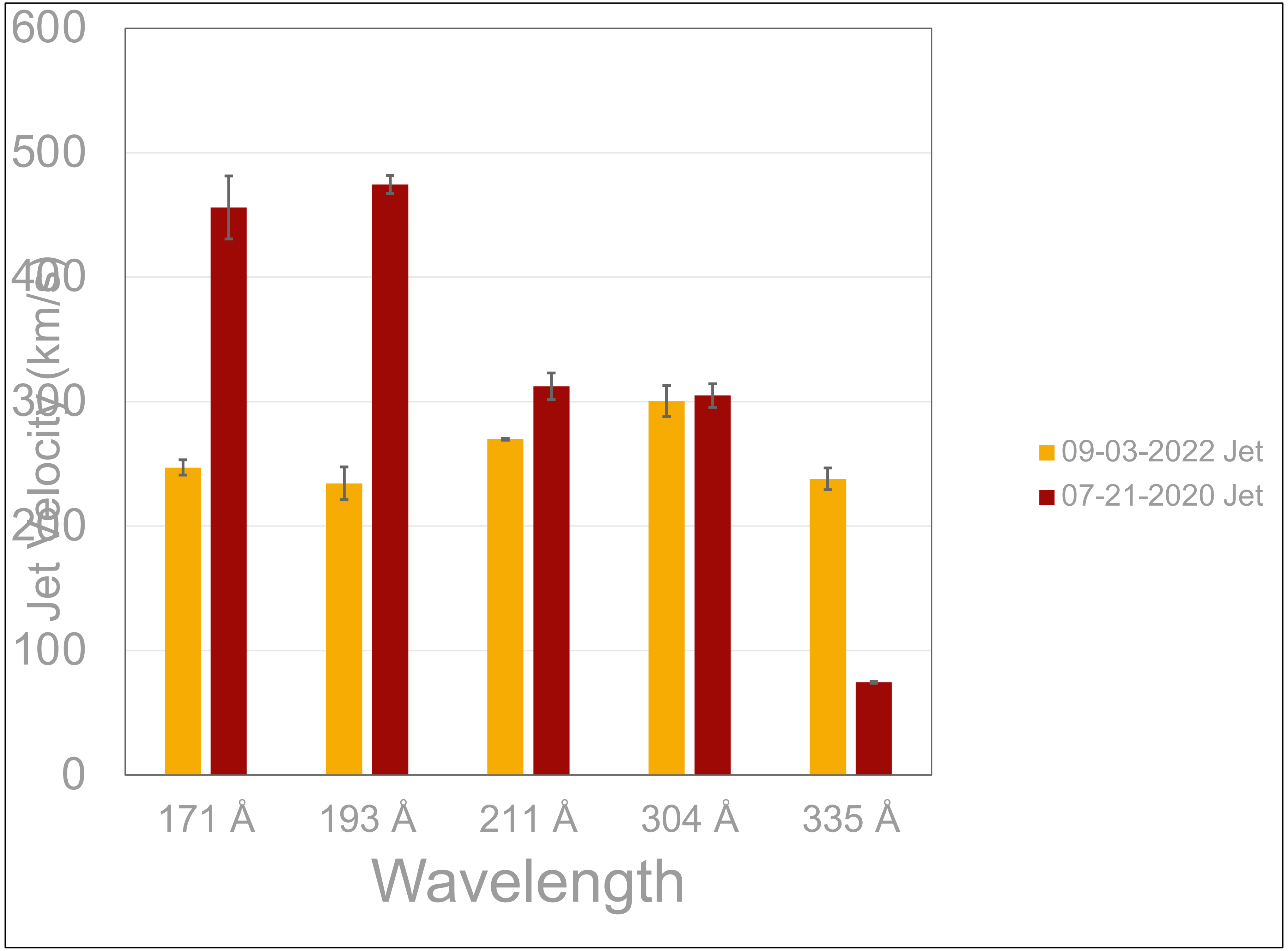


Farid+ 2024 in review

Chromopsheric Evaporation? Abundances?

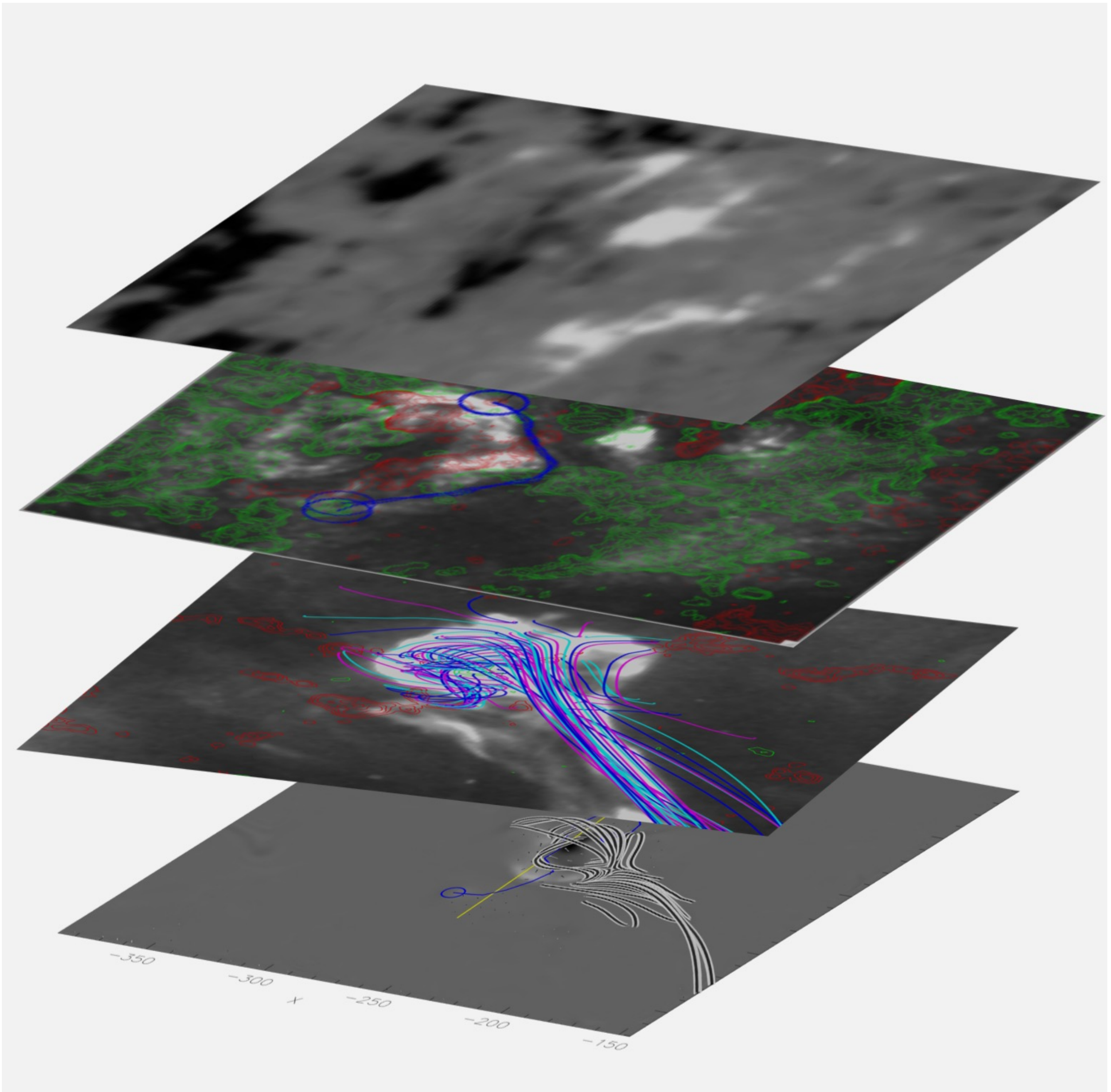


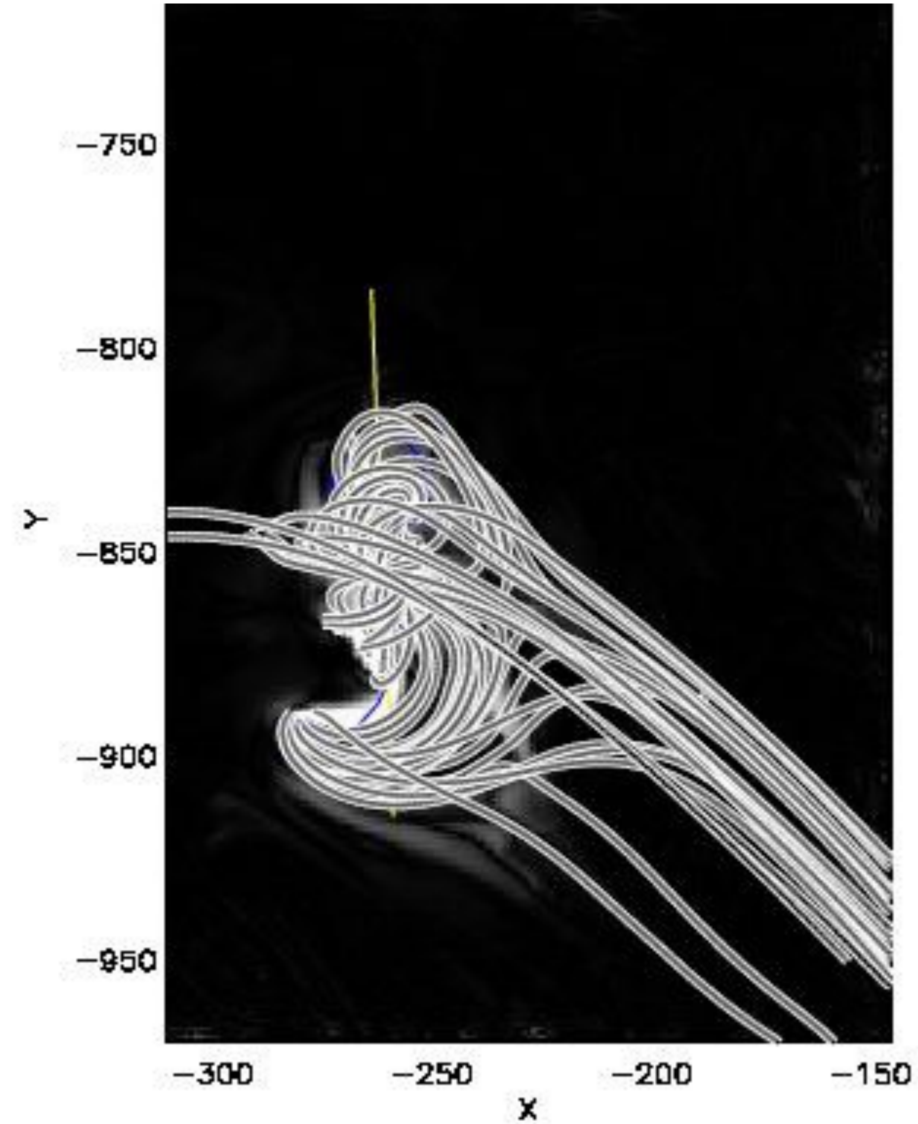
Pariat, et.al ,2015



Temperature via Weber2004+ & Farid+, 2024 in prep) Method

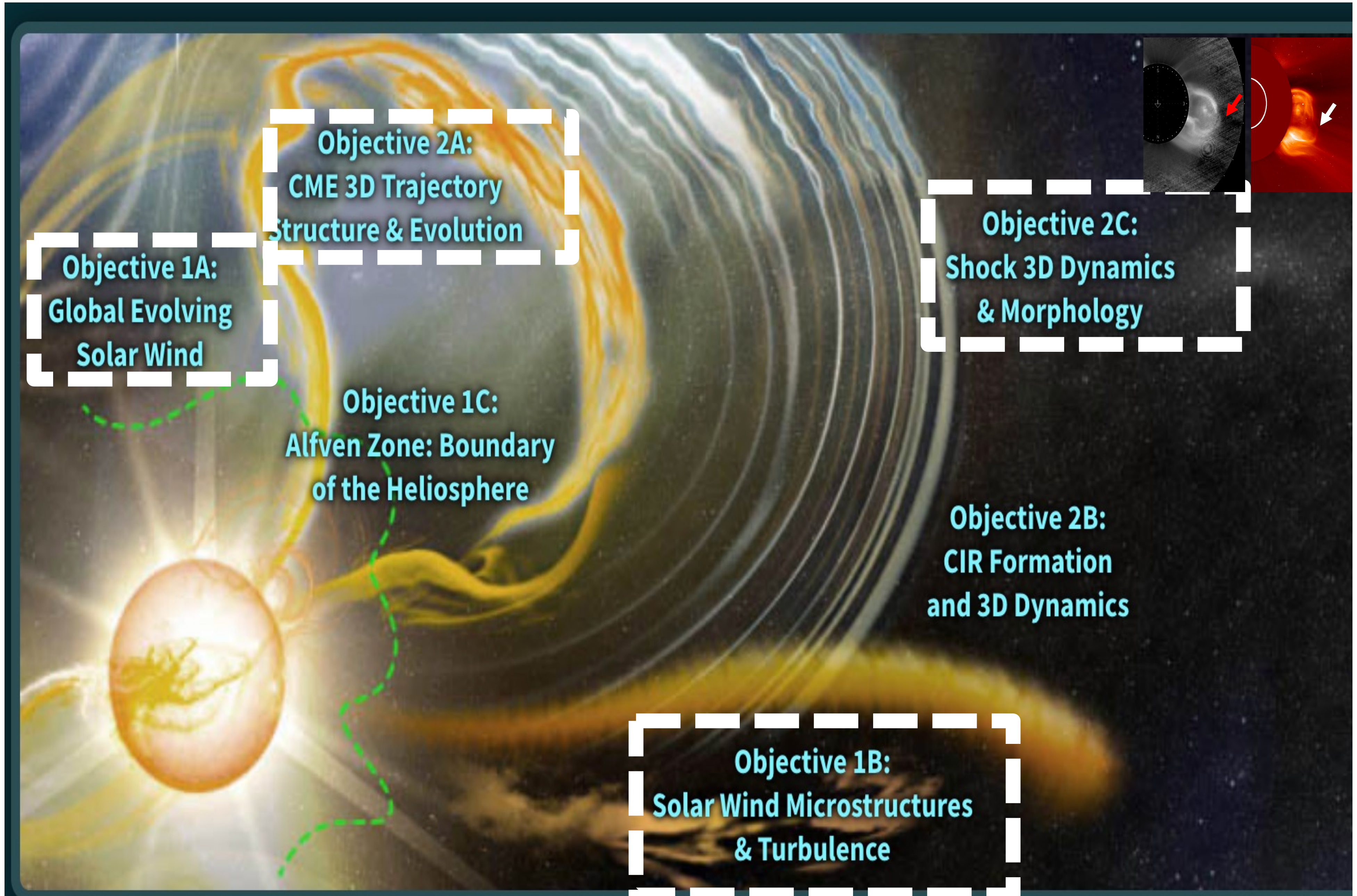
NLFFF topological models with flux insertion method-> twist, K.E., heliospheric location, evolution





PUNCH+MLSO+MHD modeling needed to determine if jets are source of switchbacks.

Summary:



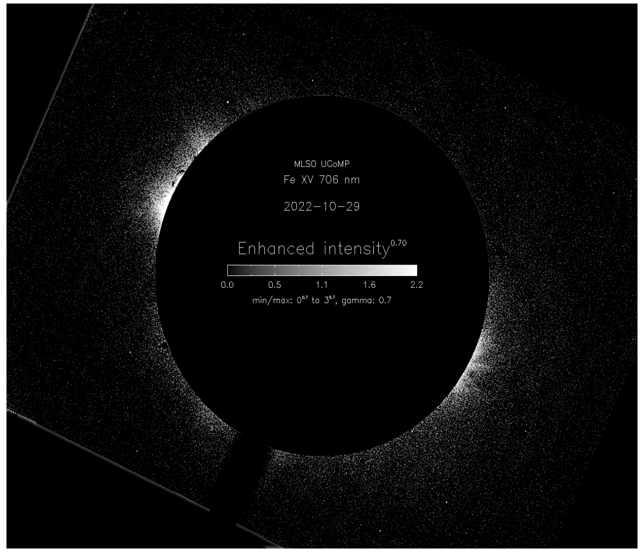
See Joan Burkepile's Poster!

- Extended jets appear to accelerate quickly from EUV to K-Cor FOV, as expected.
- The velocity in the 09/2022 jet is much higher than normal white-light jets, but consistent with other extended jet studies (Wang et al. 1998; Paraschiv et al. 2010; Moore et al. 2015)
- 09/2022 jet appears to be much hotter (log T~6.4) and is a highly twisted structure near an active region.
- 3D Modeling is needed to predict twist, location, etc. May be able to use a combination of NLFFF and MHD models to study properties of jets and flows in the outer heliosphere.

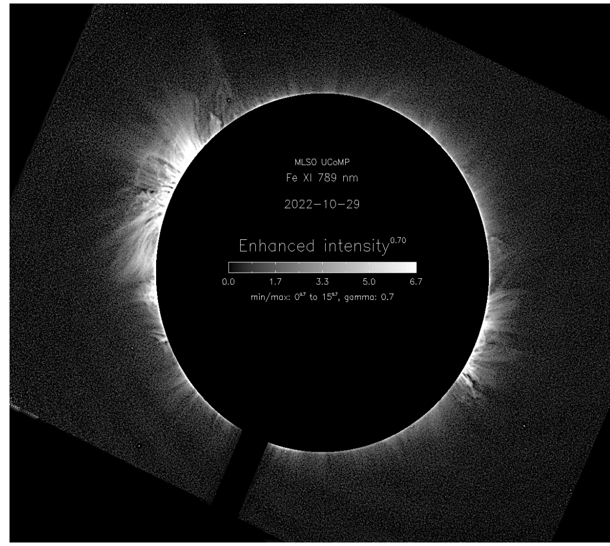
MLSO - UCOMP

https://www2.hao.ucar.edu/mlso

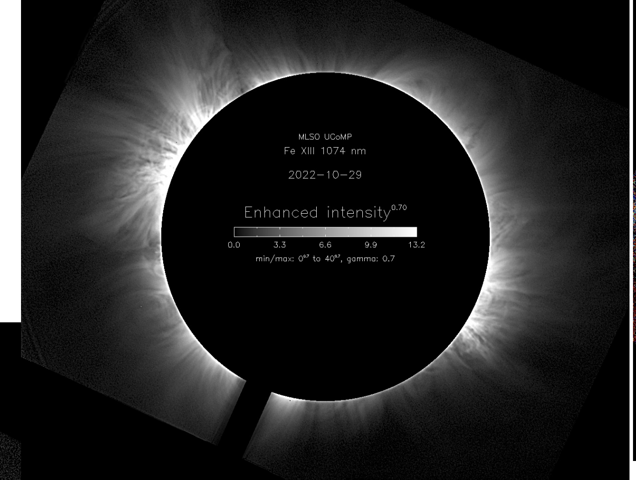
Fe X – 637.4 nm

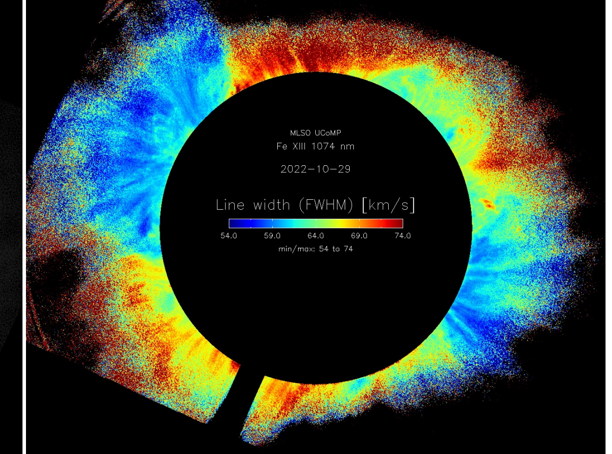


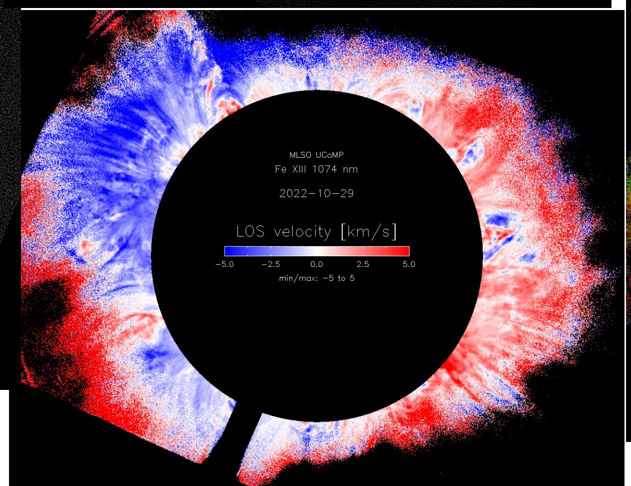
Fe XV – 706.2 nm

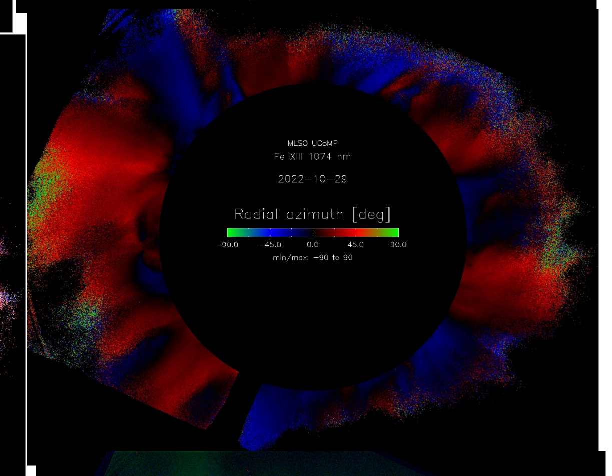


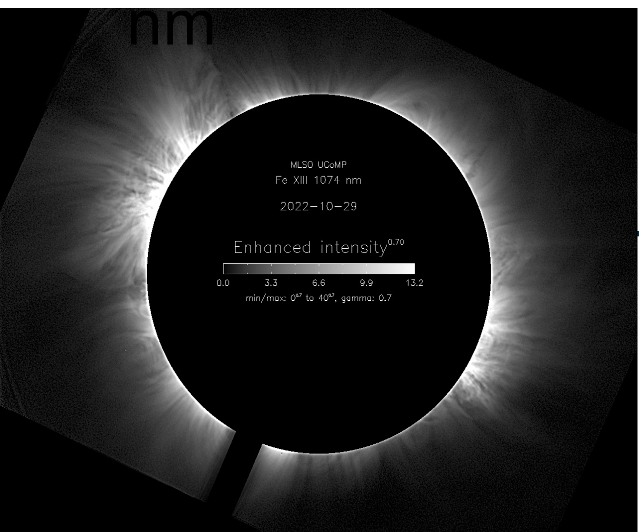
Fe XI – 789.4 nm



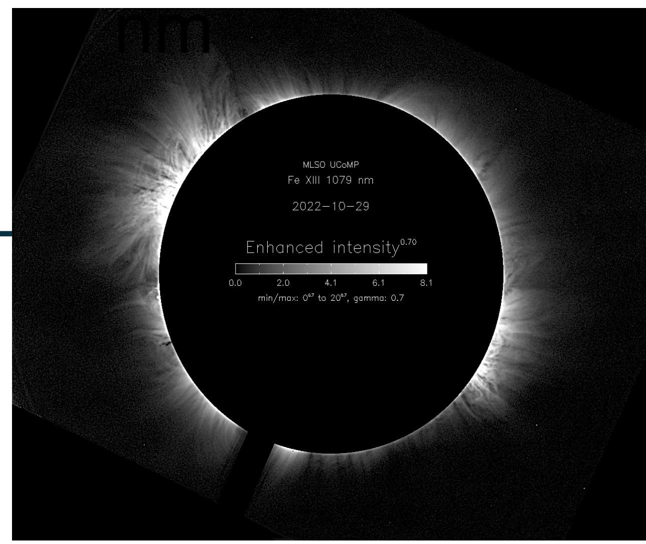




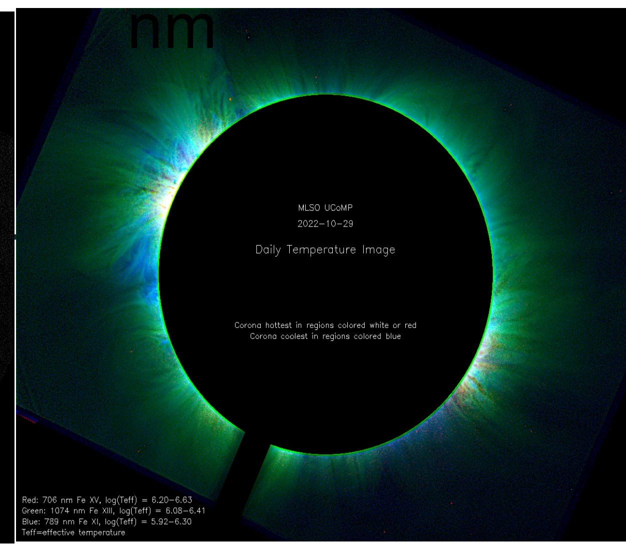




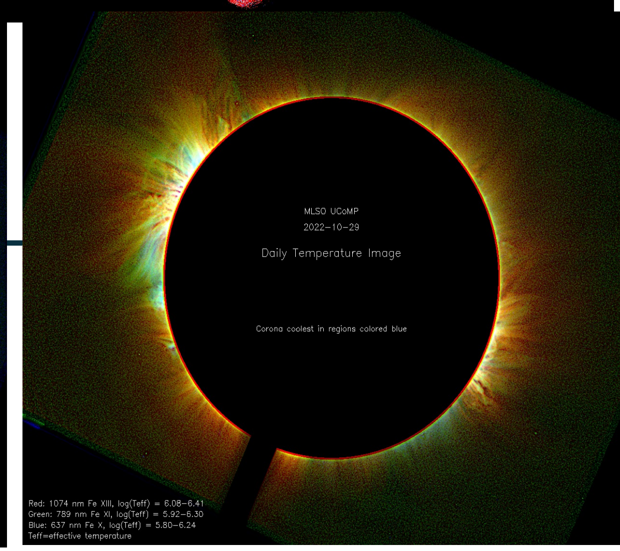
Fe XIII – 1074.7 nm



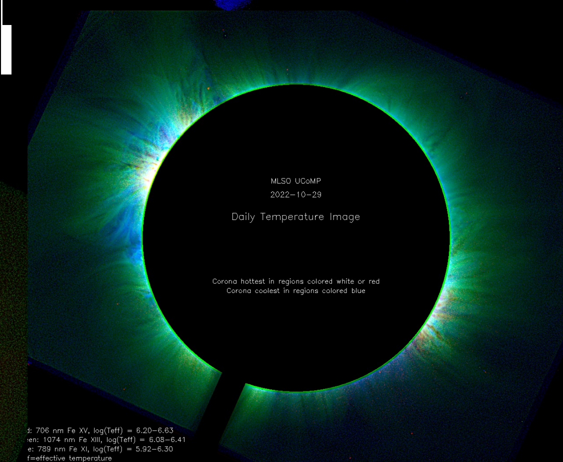
Fe XIII – 1079.8 nm

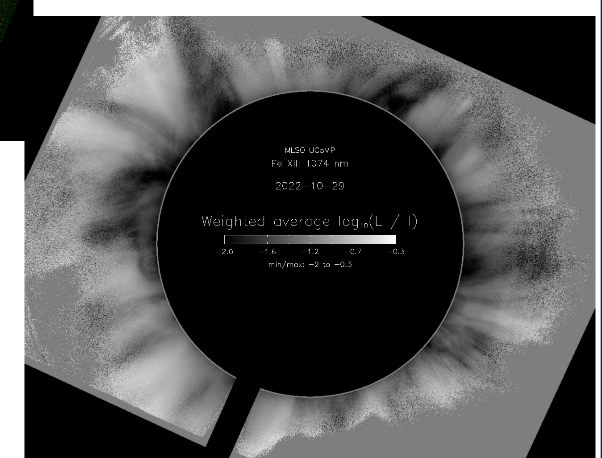


'Temperature'
Fe X – Fe XI – Fe XIII



'Temperature'
Fe XI – Fe XIIII – Fe XV





MLSO+PUNCH synergy (Punch Objective 1B)

PUNCH (1B): Determining possible regions of density fluxuations in the (young) solar wind (puffs, blobs, rays, etc) and connecting them to the solar wind: Jets 2