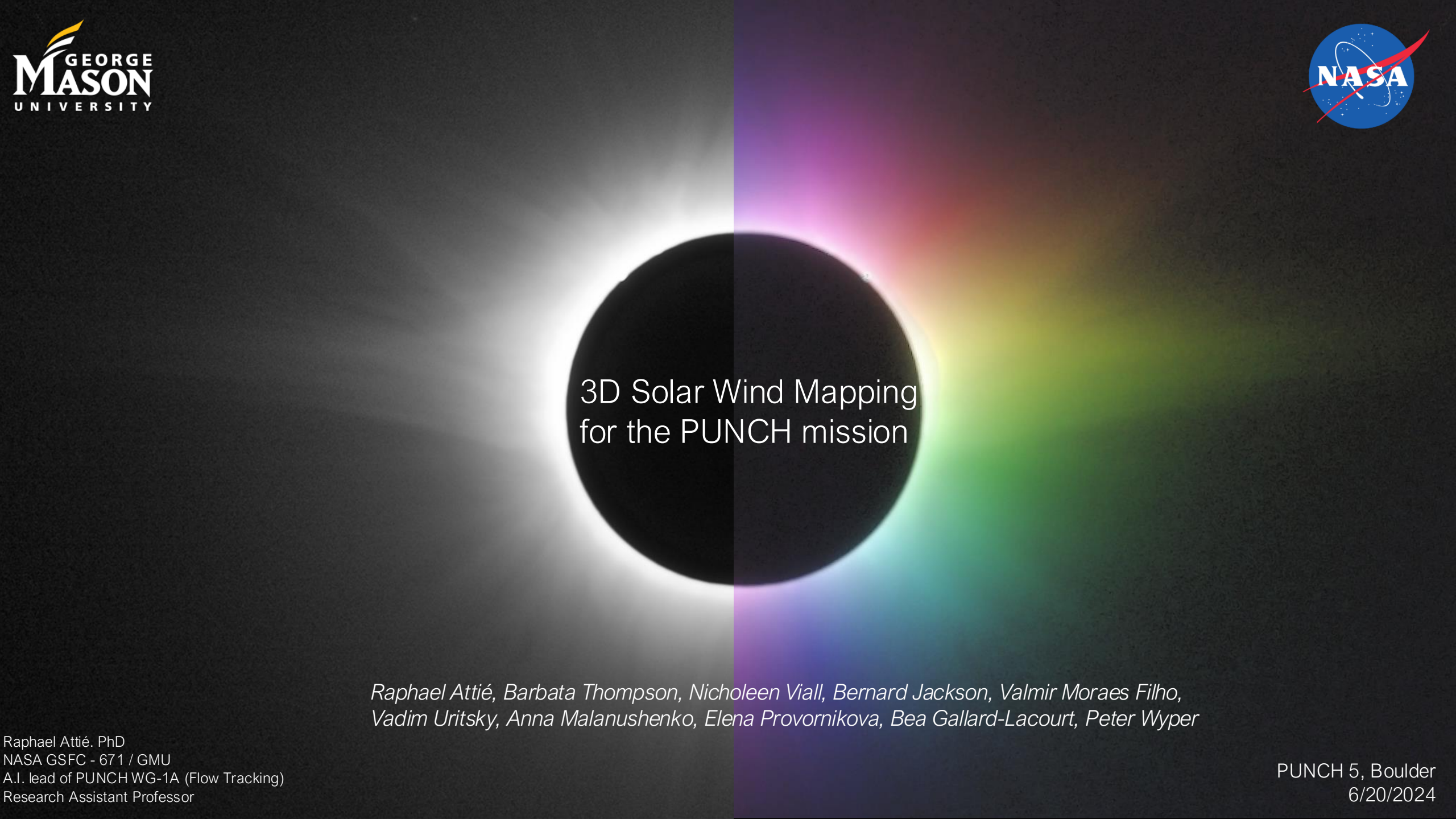

3D Solar Wind Mapping for the PUNCH mission

Raphael Attié, Barbata Thompson, Nicholeen Viall, Bernard Jackson, Valmir Moraes Filho, Vadim Uritsky, Anna Malanushenko, Elena Provornikova, Bea Gallard-Lacourt, Peter Wyper

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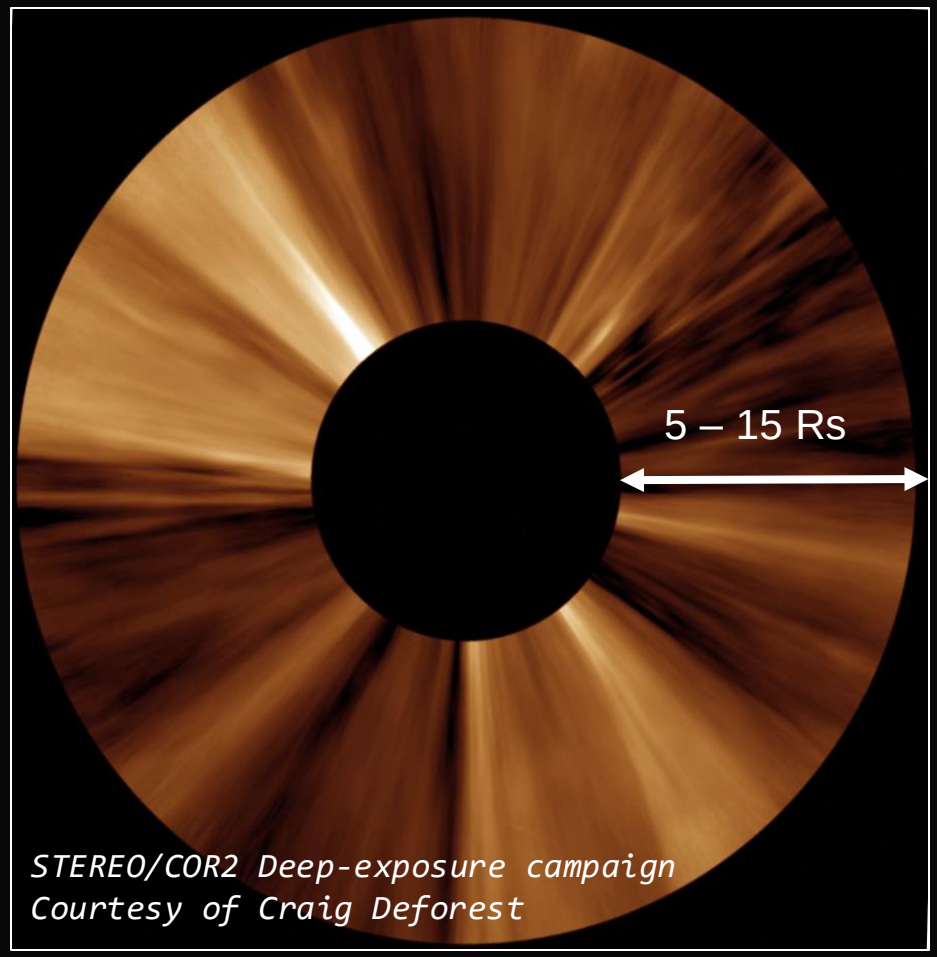
NASA GSFC - 671 / GMU
A.I. lead of PUNCH WG-1A (Flow Tracking)
Research Assistant Professor

PUNCH 5, Boulder
6/20/2024

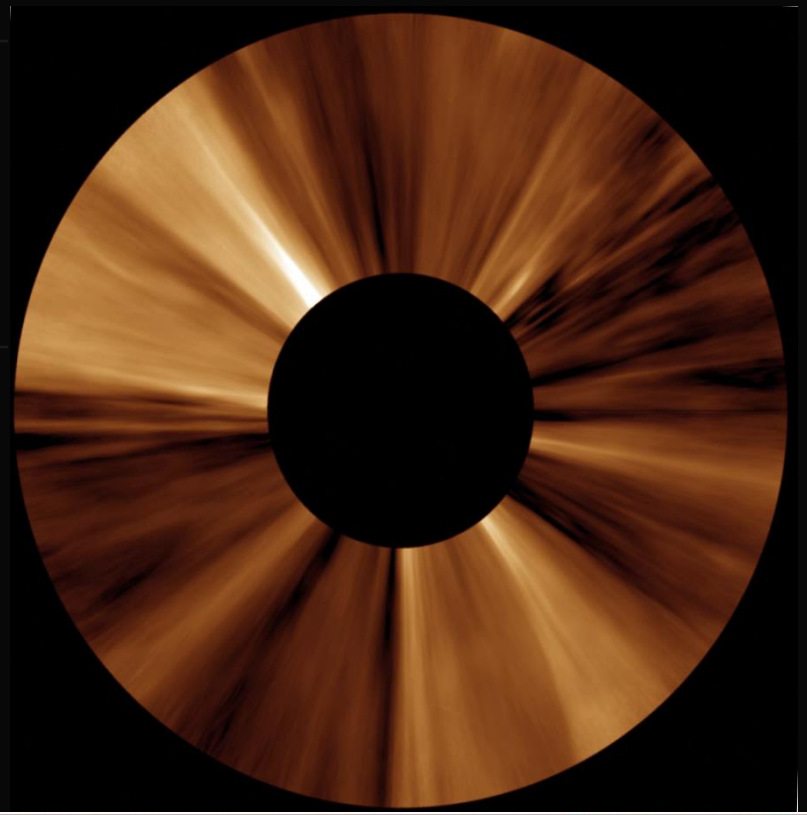
Mapping Solar Wind Flows with PUNCH

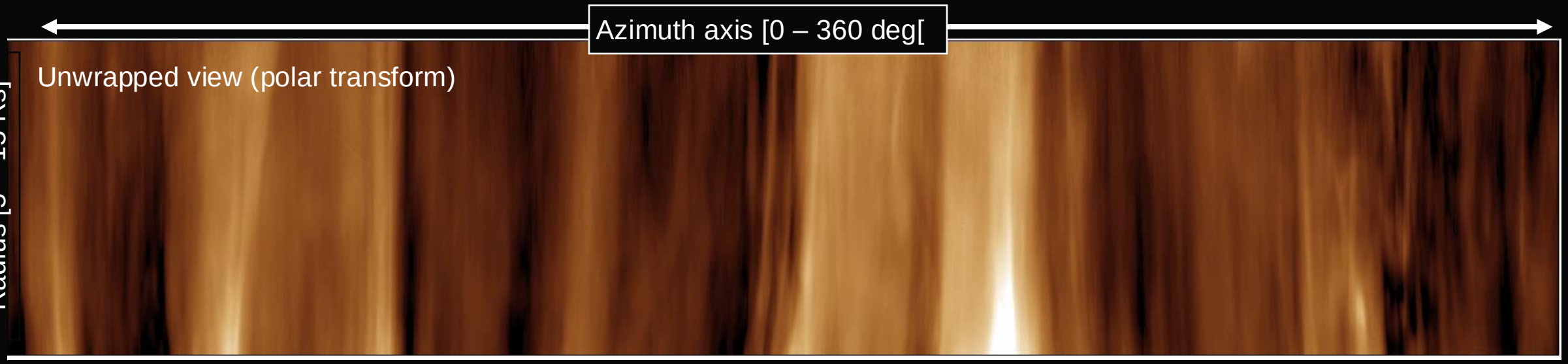
- Understand the interplay between the corona and planetary environments
- Solar Wind: relatively small changes near the sun's surface feed planet-wide space weather effects.
- Address critical lack of flow maps in the solar wind with quantifiable uncertainties

MAPPING SOLAR WIND FLOWS: **HOW?**

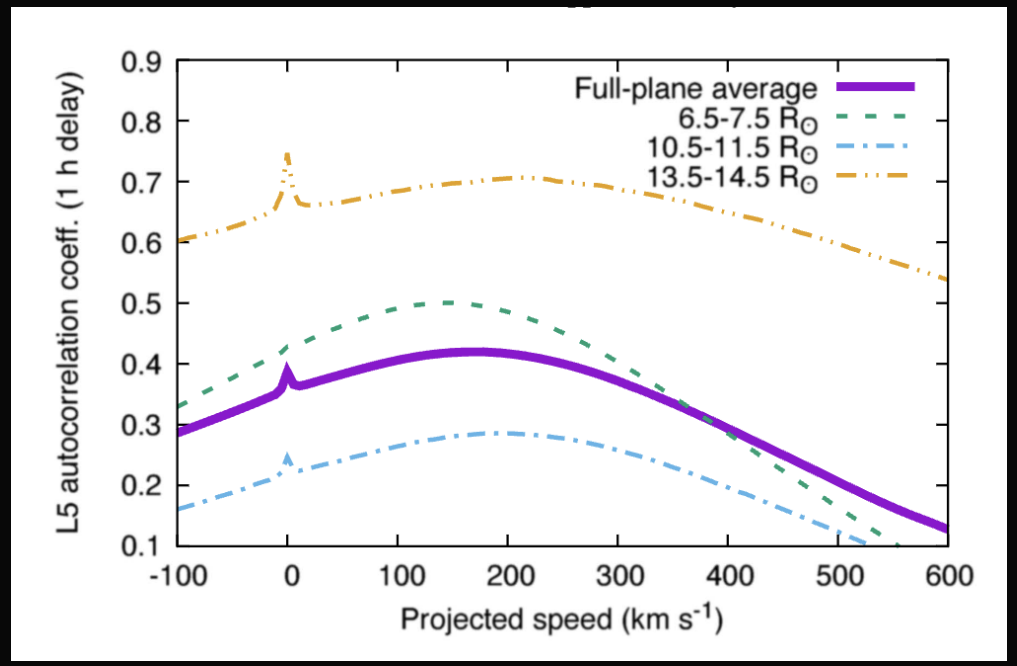


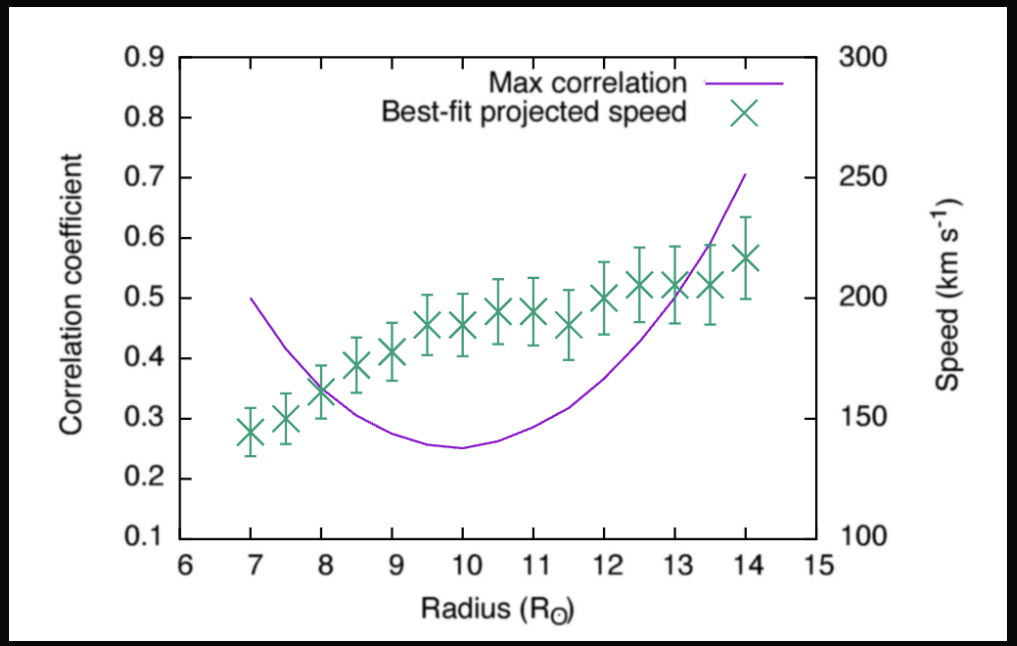
MAPPING SOLAR WIND FLOWS: **HOW?**

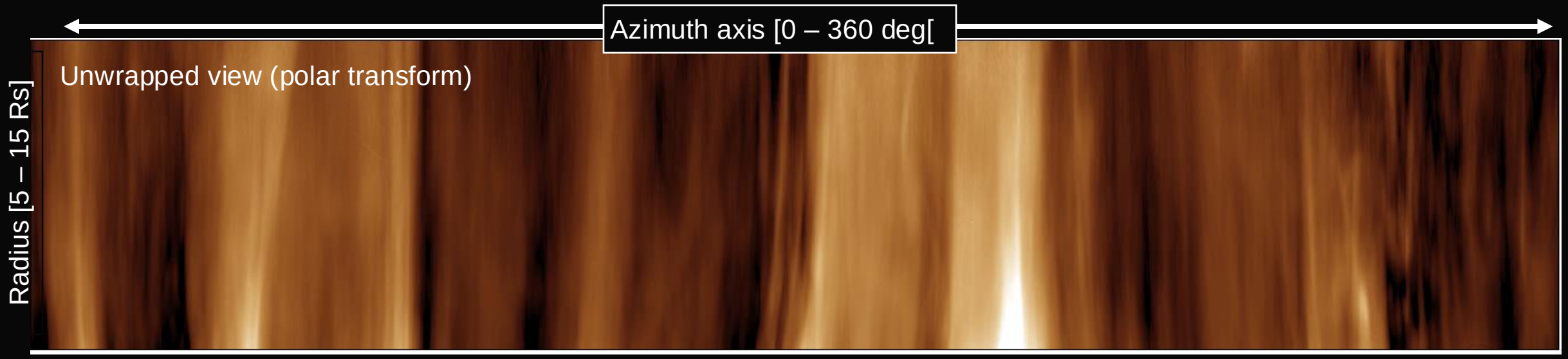




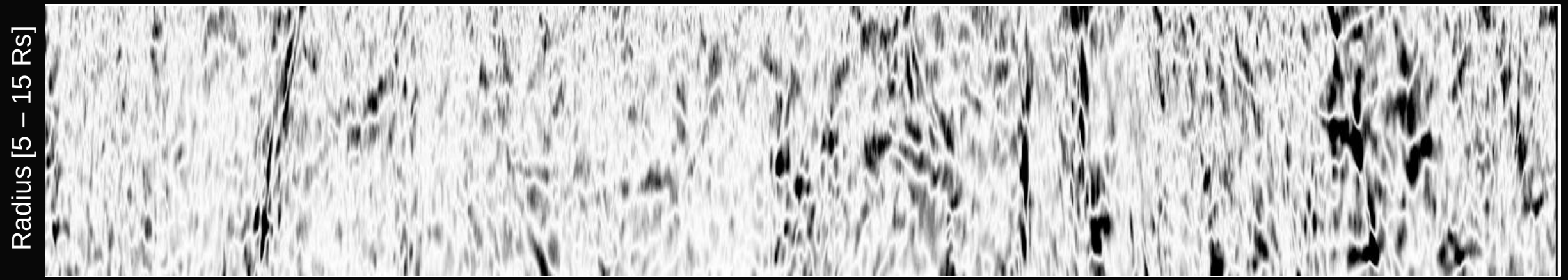
Dense flow maps @ PUNCH SOC: correlation tracking (Deforest et al., 2018)





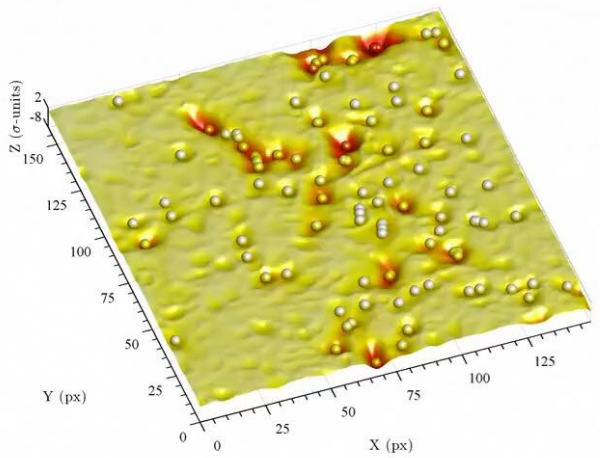


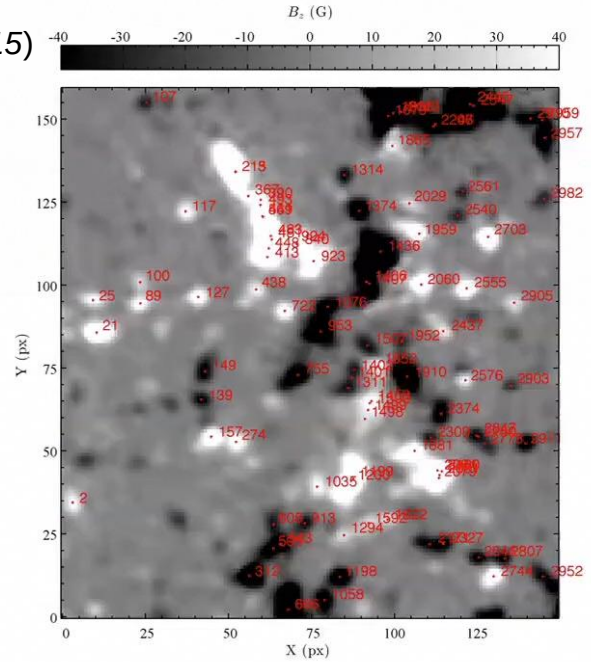
More advanced tracking tools for Lagrangian 2D motion vectors of PDS and CMEs will also be available publically – currently not planned to "**run**" within SOC.

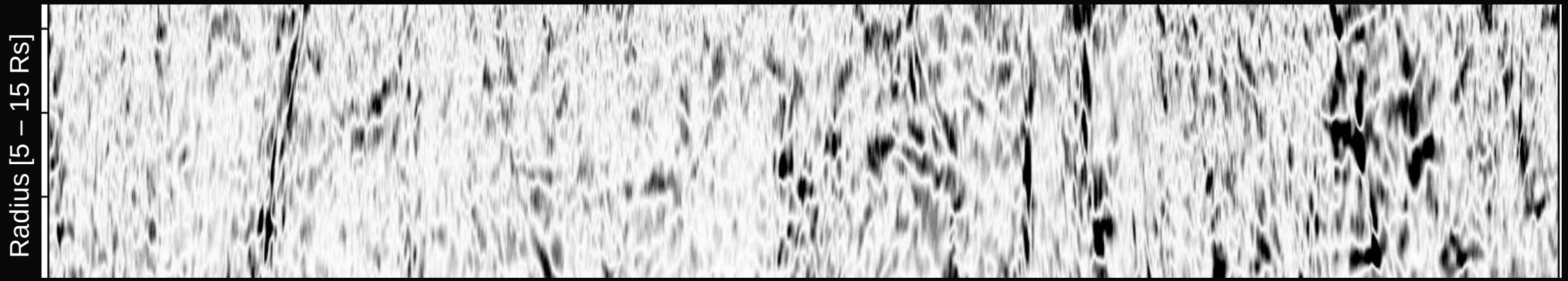


Filtered version, resolving more density structures

Magnetic Balltracking (*Attie & Innes, 2015*)
Tracking of Moving Magnetic Fragments







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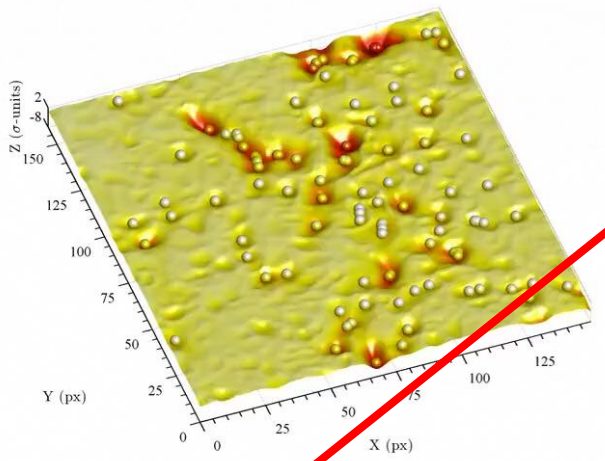
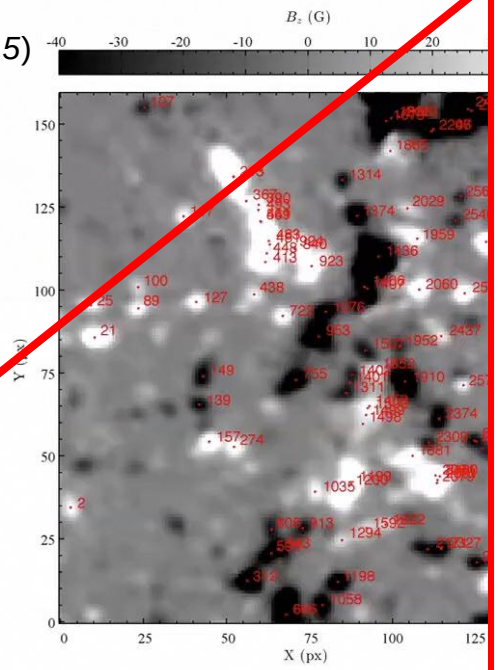
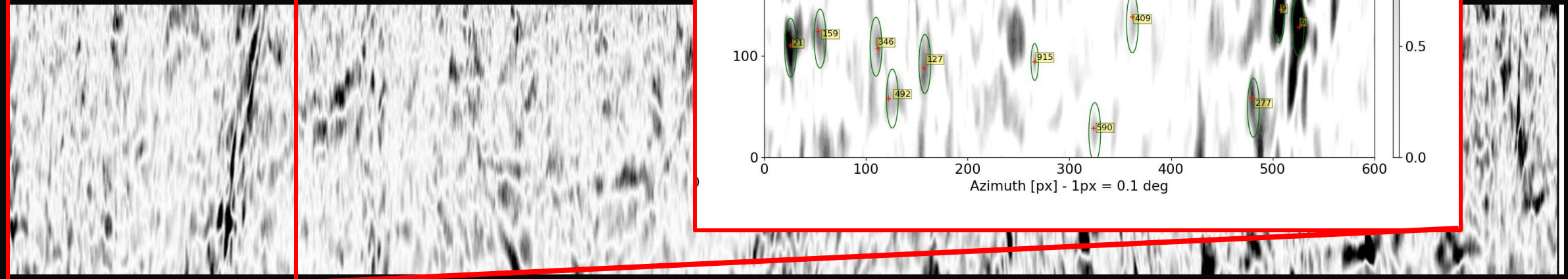


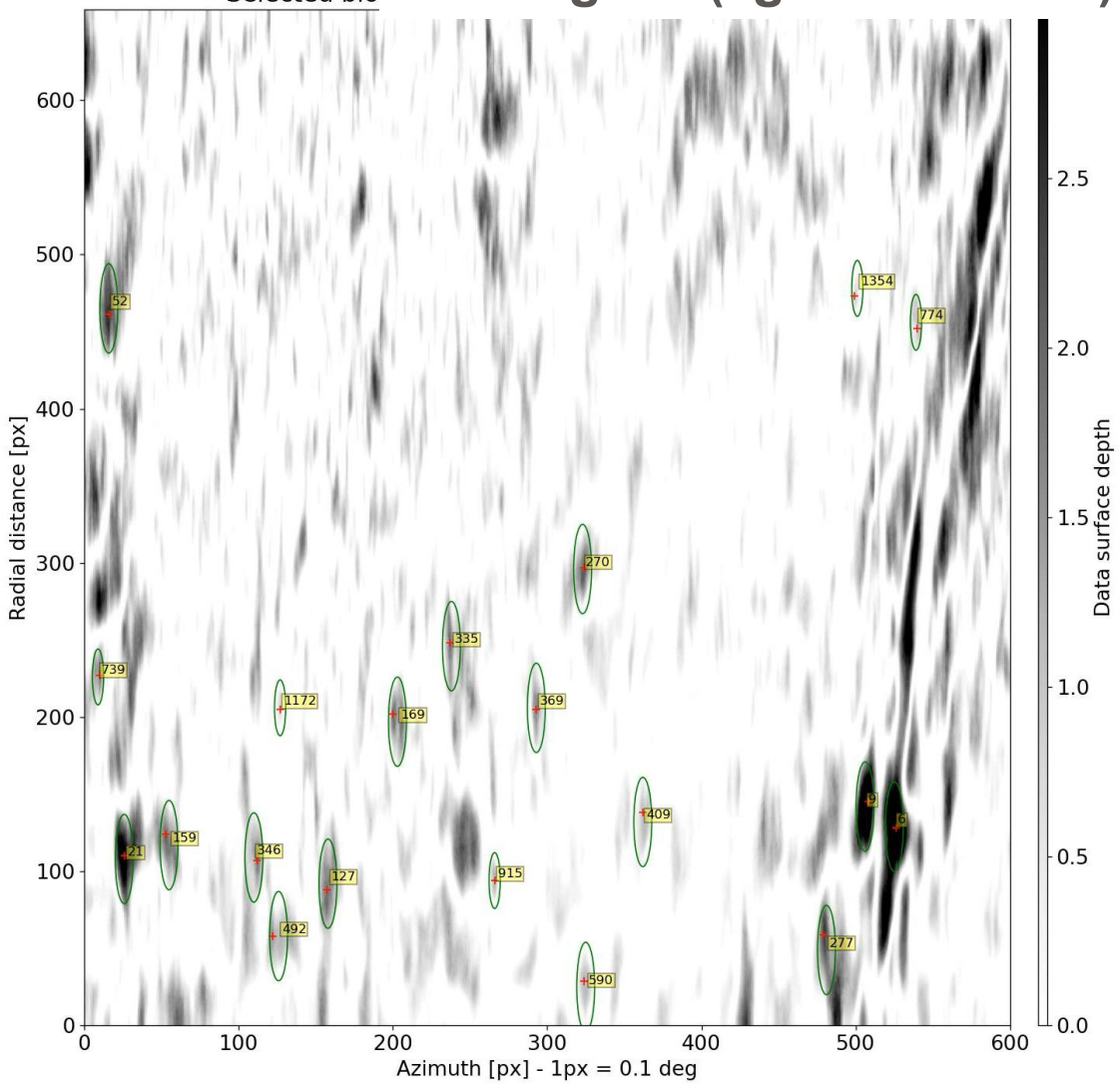


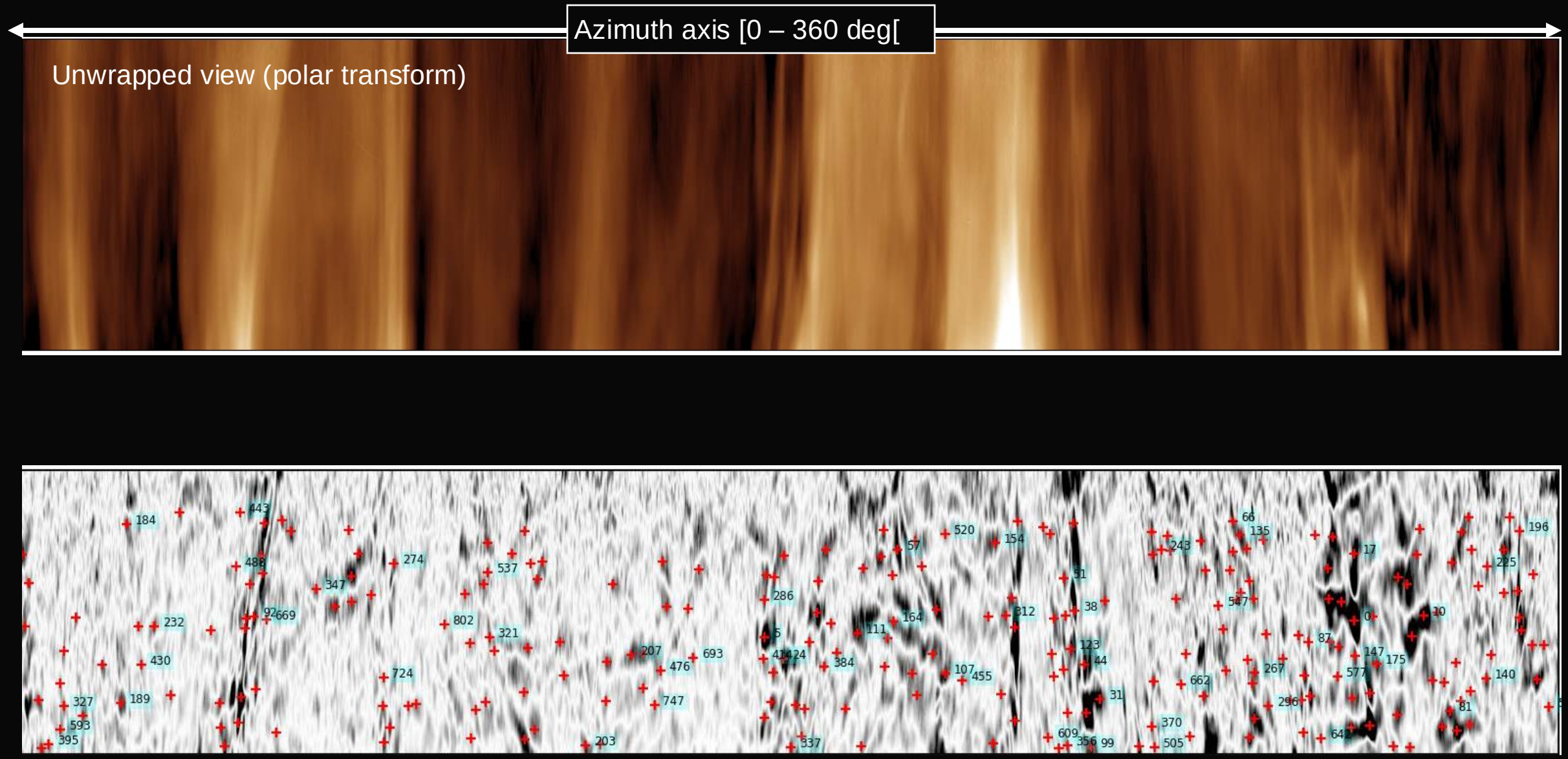
Radius [5 – 15 Rs]



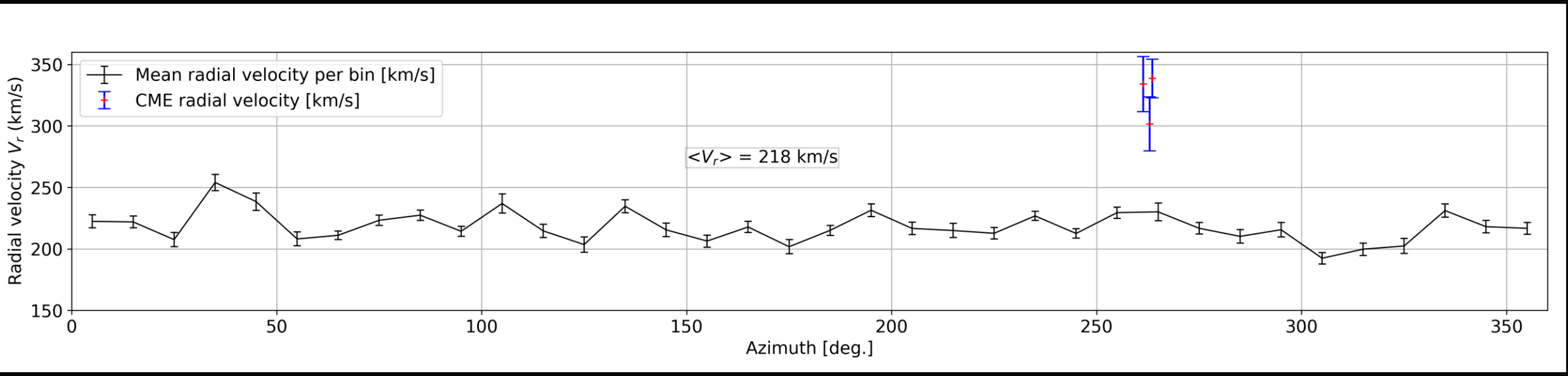
Selected blo

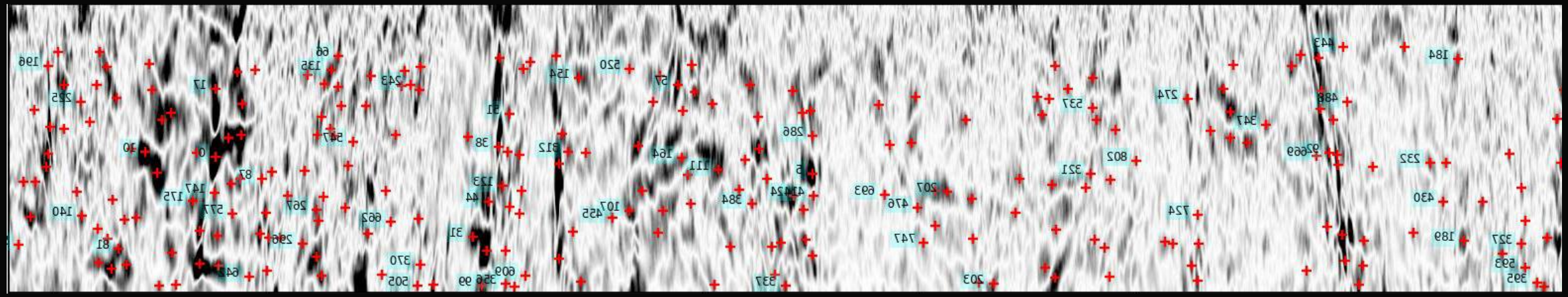
Training set (“ground truth”)





Magnetic Balltracking applied to plasma density structures in the solar wind





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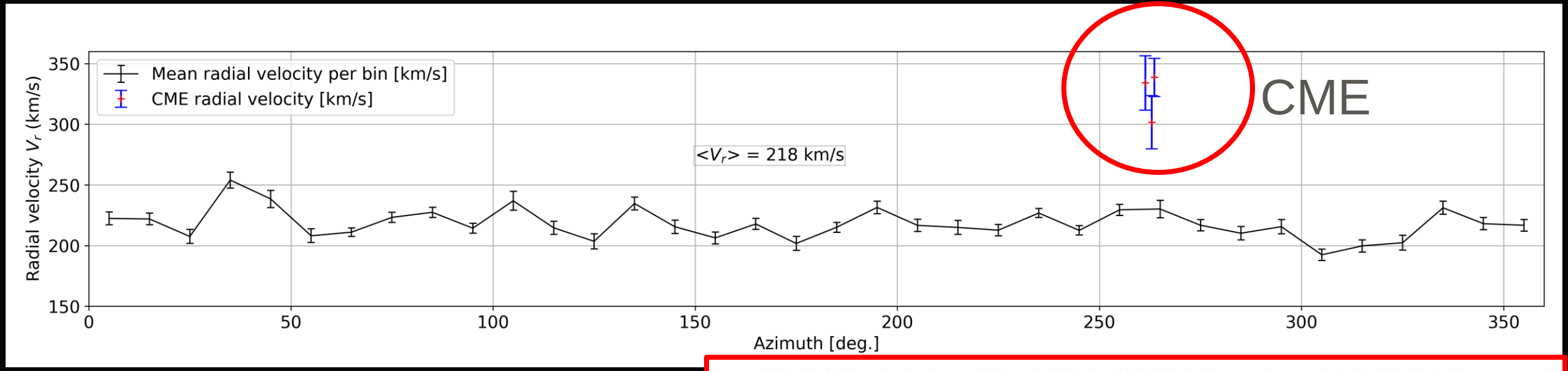
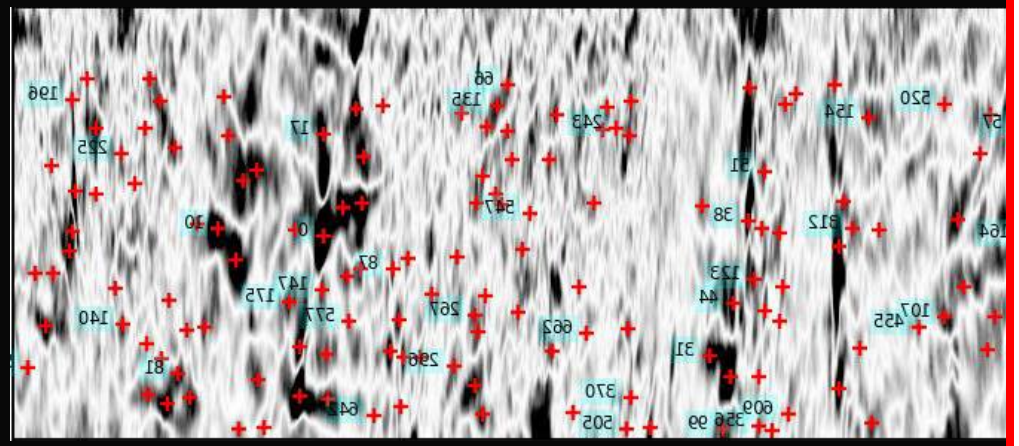
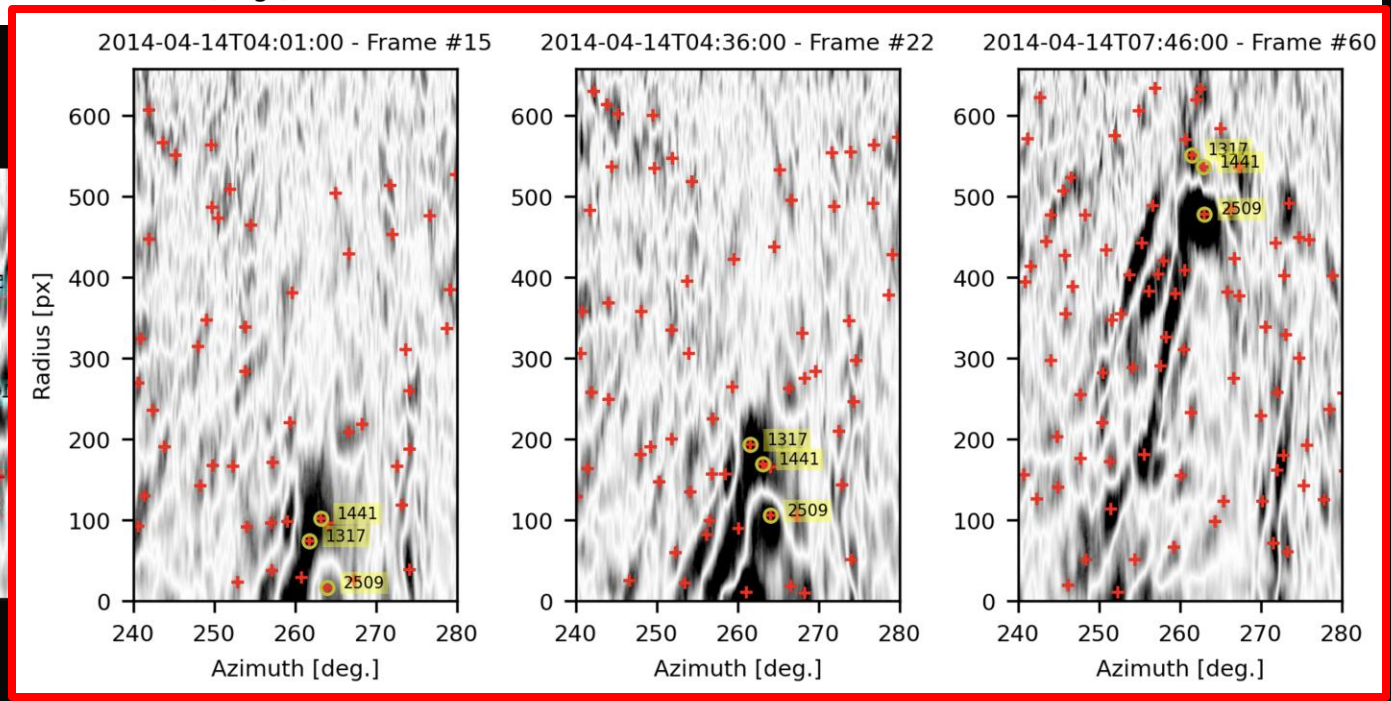
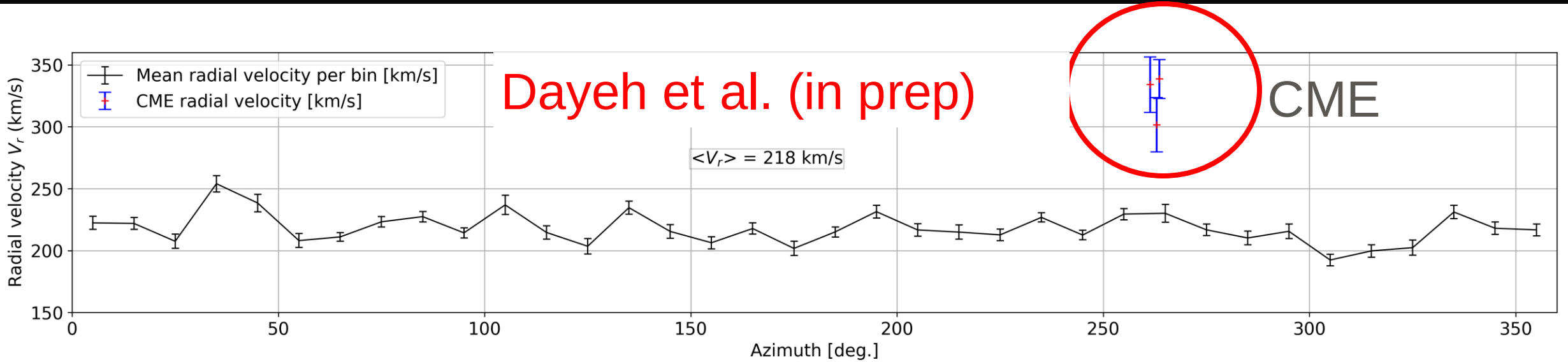
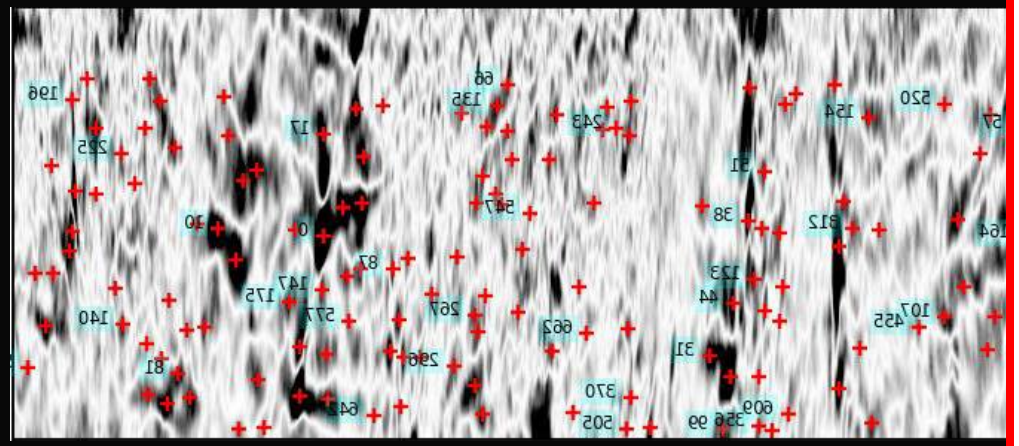


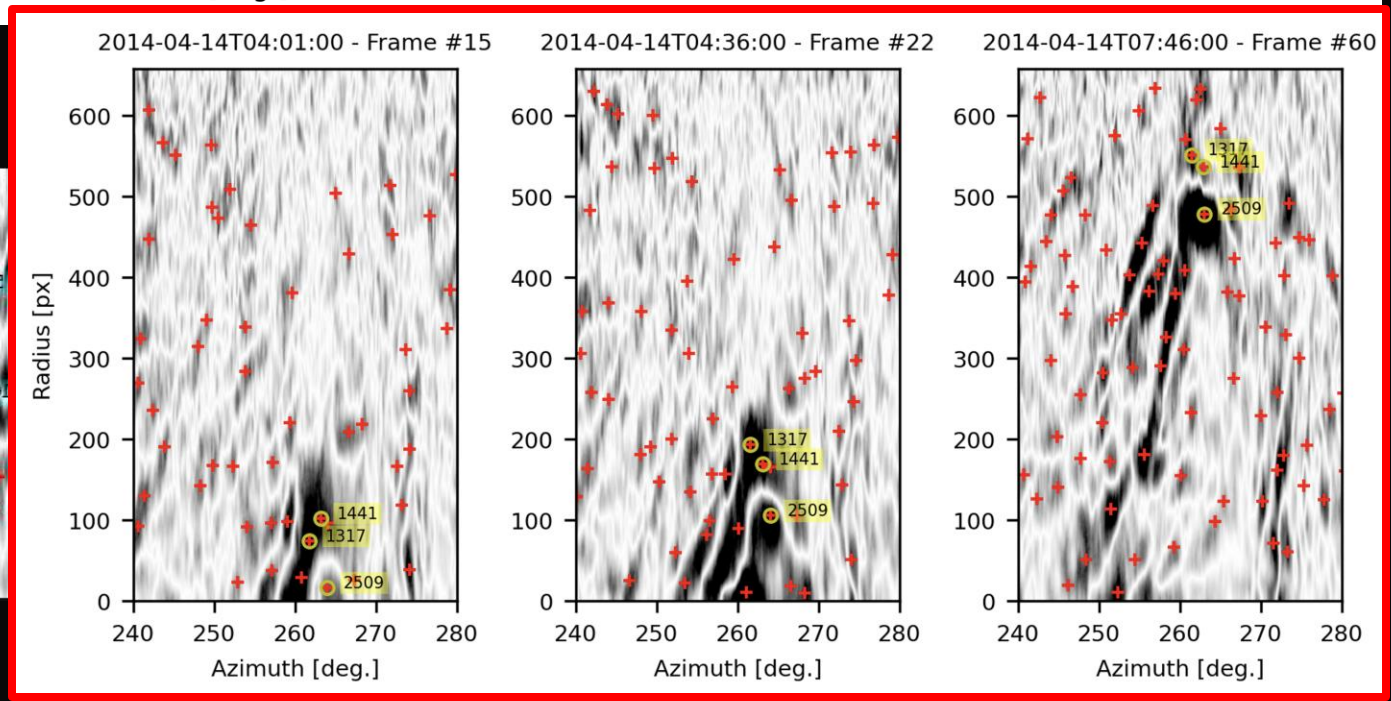




Magnetic Balltracking applied to plasma density structures in the solar wind

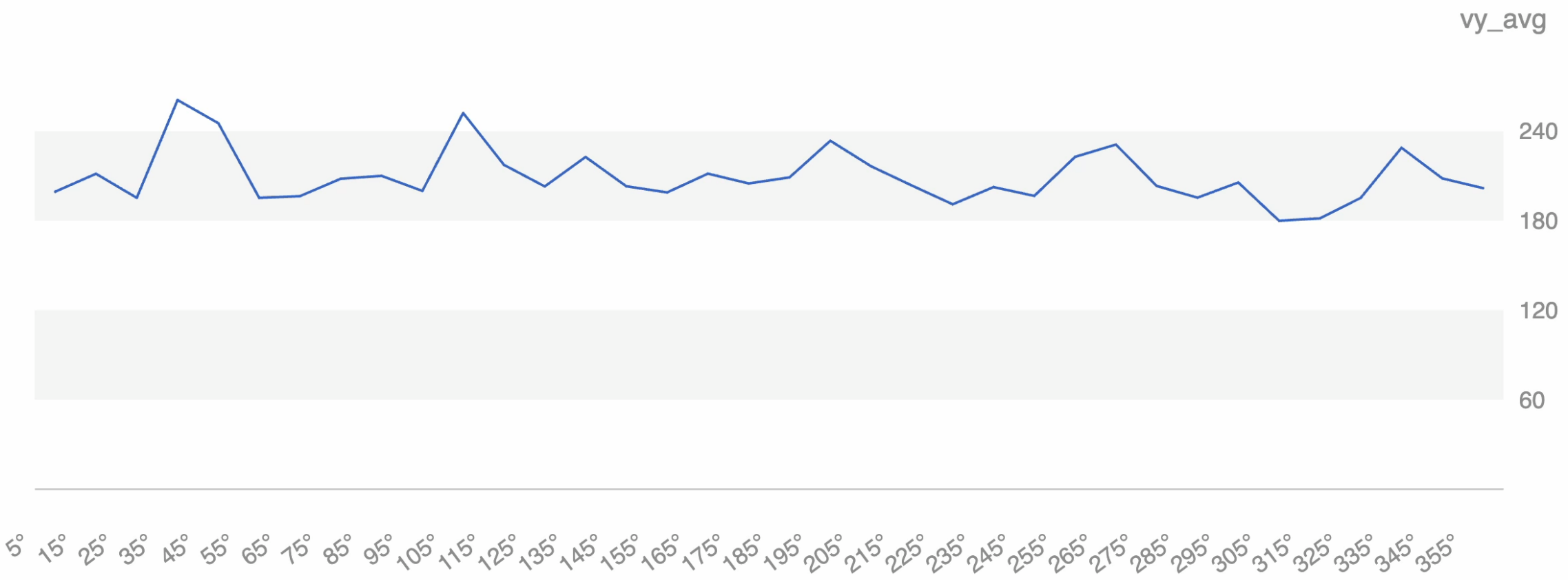




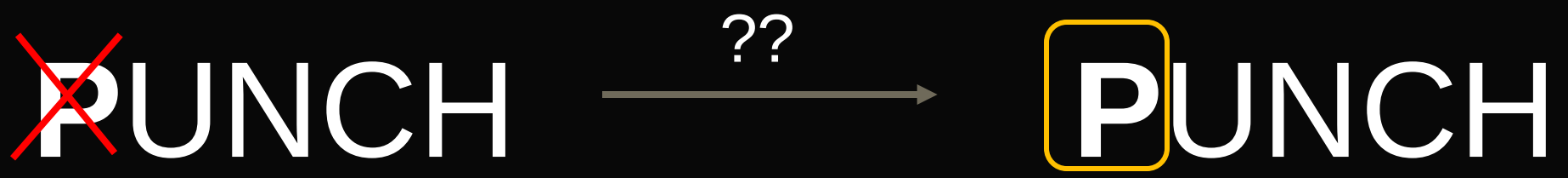


Magnetic Balltracking applied to plasma density structures in the solar wind

Averaged radial velocity (km/s) [0-360 deg.]



3D velocity?



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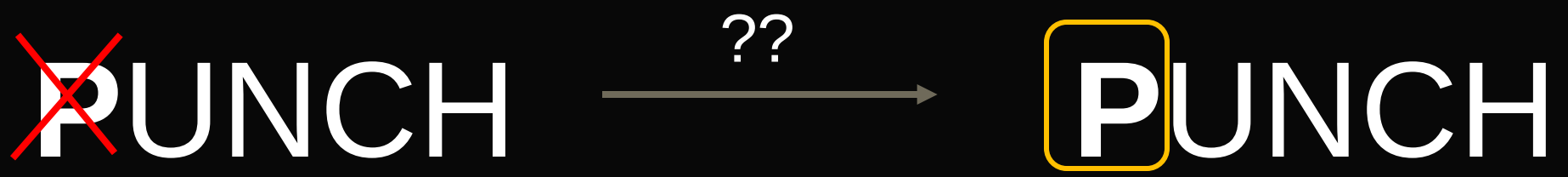


3D Tomography

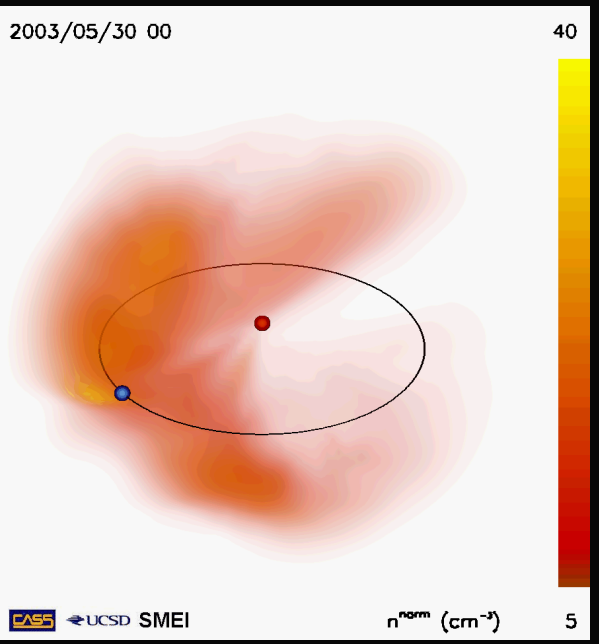
~~PUNCH~~ → 3D - Tomography! → PUNCH → Flow Tracking → 3D Flow maps

SMEI Pseudo pB Analysis: 12-Hour 3-D Reconstructions

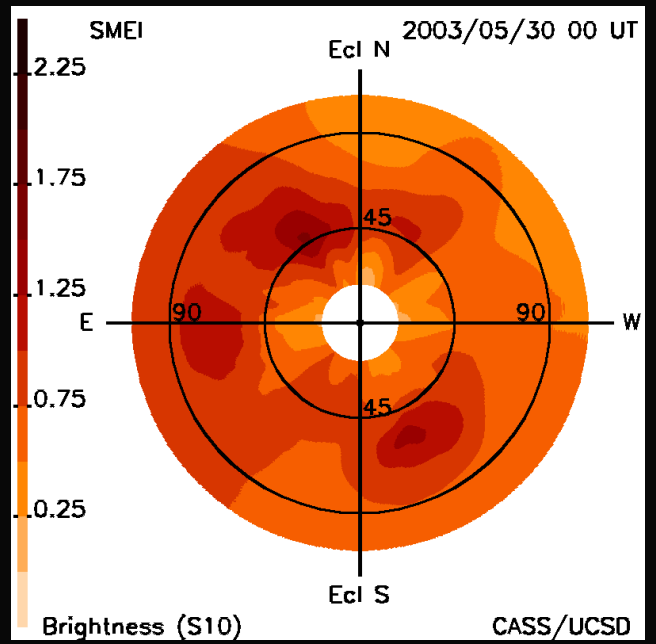
Month-long Time Series

6-days CME

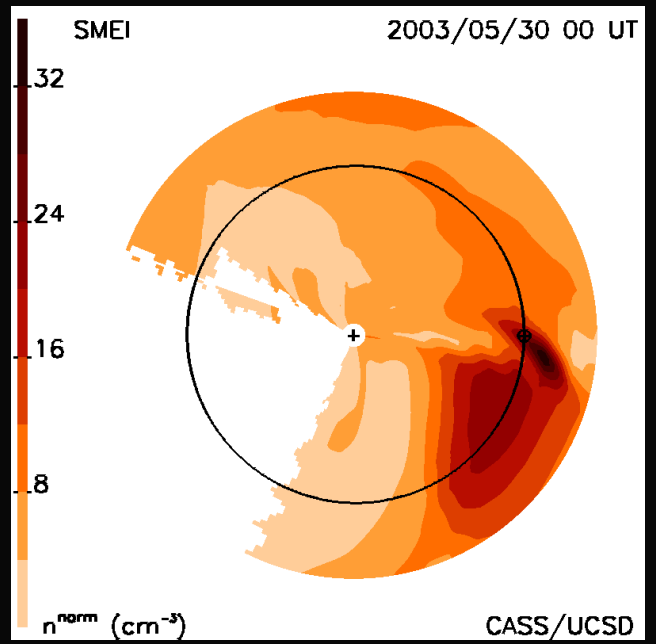
Sample CME Views



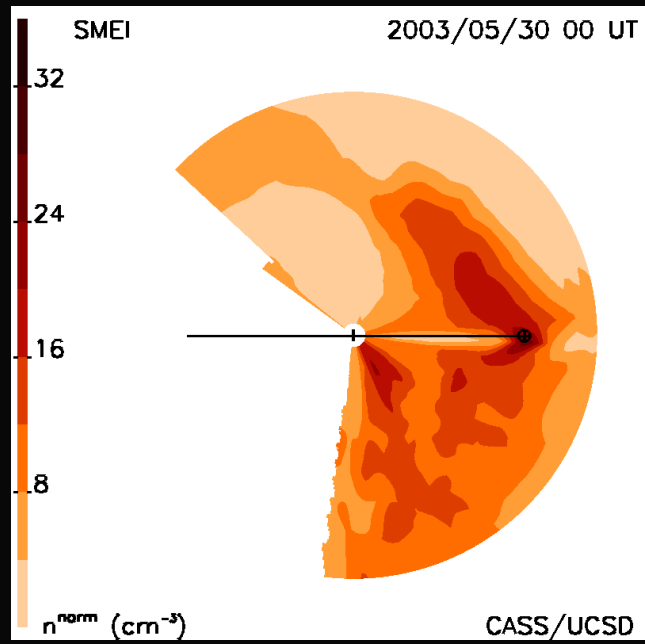
Remote View



Skymap



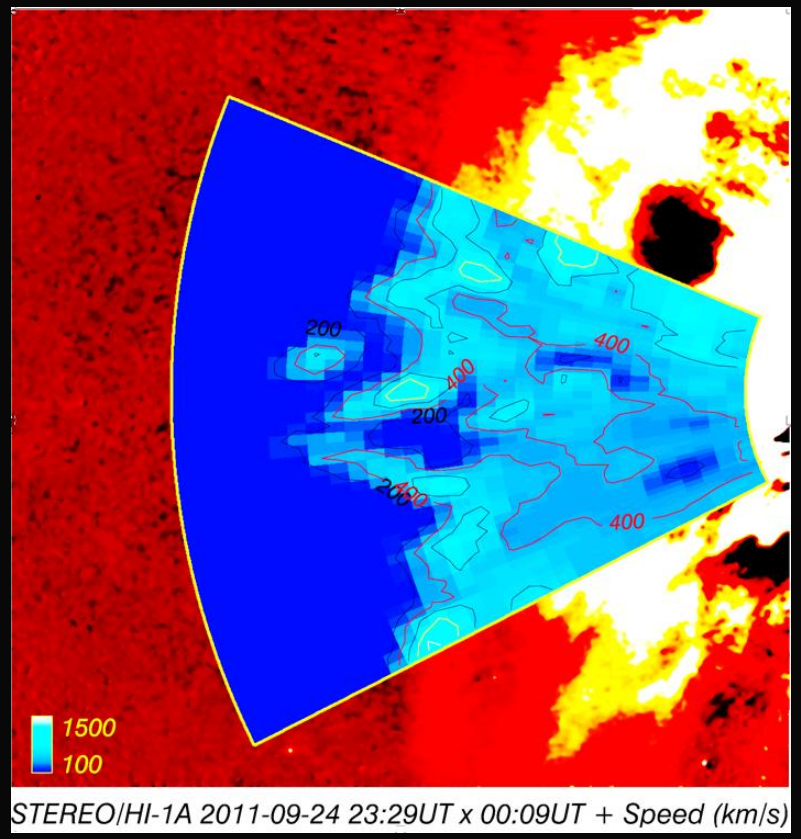
Ecliptic Cut



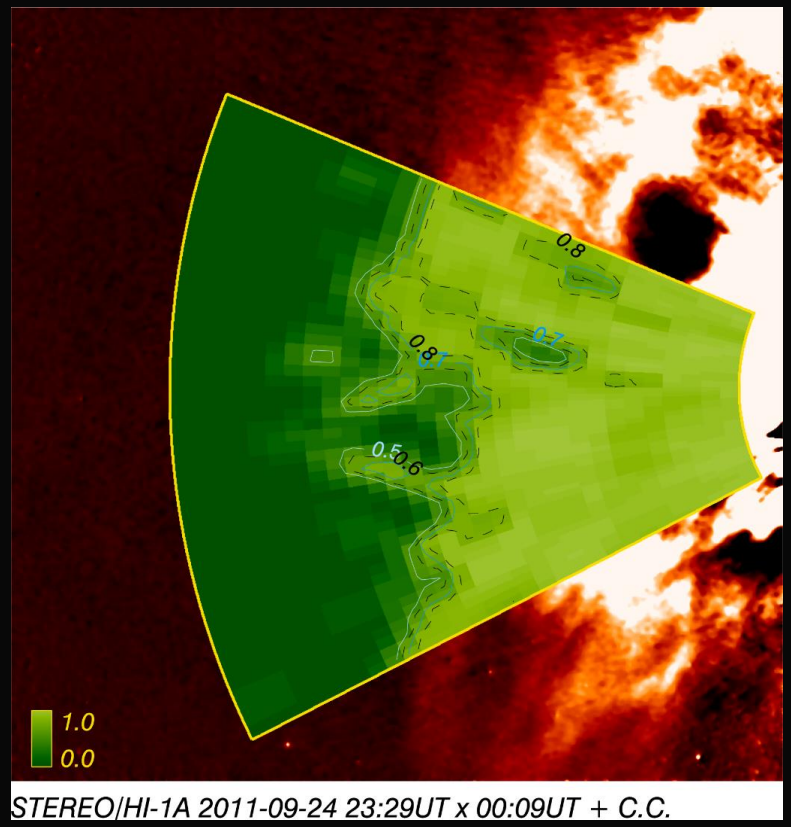
Meridional

Jackson et al., 2020 doi: 10.3389/fspas.2020.568429

Heliospheric Thomson Scattering Flow Speeds



Speed Within the CME



Correlation Strength (0.0 – 1.0)

STEREO HI-A Camera 1

More testing underway for PUNCH/SOC implementation

(Courtesy of Bernard Jackson)

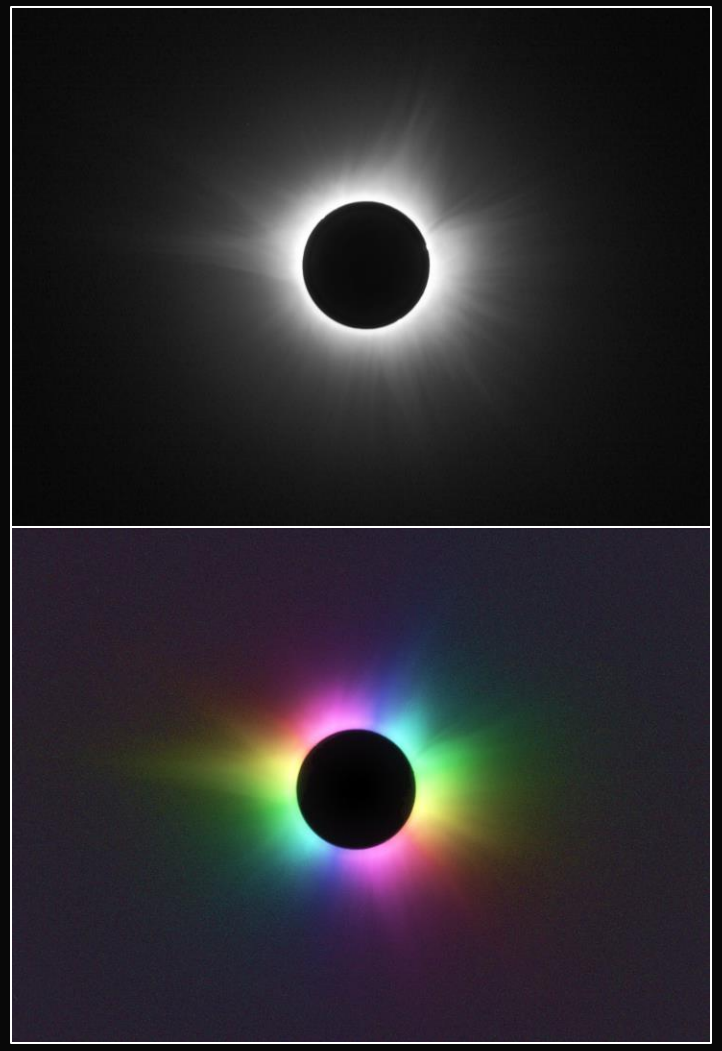
Sanity check, Accuracy estimates

More testing with “ground truth” PUNCH-like data:

- GAMERA simulation (CMEs, large scale structures)
- MHD Jet/Jetlet simulations (Peter Wyper)
- Flow Tracking Challenge (Valmir Moraes Filho, Vadim Uritsky)

Summary

- Dense “Euler” flow field with correlation tracking:
  - **Accurate, average speed** of the solar wind in the heliosphere over at least 4 different radial bins till 180 Rs, and 1400 azimuthal bins (?)
  - very accurate large-scale solar wind acceleration-deceleration with radial distances



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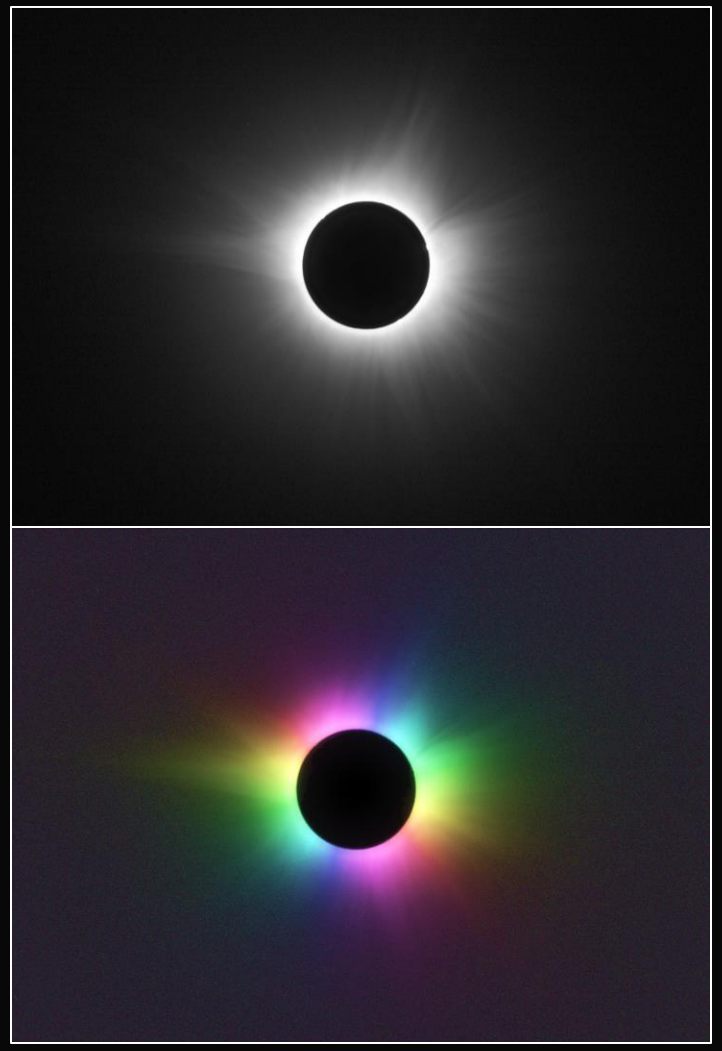

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  - very accurate large-scale solar wind acceleration-deceleration with radial distances

- Balltracked flows + 3D tomography:
  - More “granular” forecast of heliospheric structure arrival at 1 AU from its release near the solar surface
  - Provide various heating or momentum parameters over heliospheric distances used in 3-D MHD models.