I. Products

Journal publications

1. Pecora et al. "Inferring Solar Wind Spectral Evolution from Remote Sensing Observations: The Role of Line-of-Sight Integration" in prep.

Presentations

1. PUNCH 7 science meeting, 12-14 May 2026, SWRI, Boulder, Colorado. **Invited presentation.**
2. Solar and Heliospheric Italian Community (SoHe-5), 10–12 Sep 2025, Cosenza, Italy. **Invited presentation**.
3. Fourth annual Parker Solar Probe conference, 5–9 May 2025, Johns Hopkins APL, Laurel, Maryland. **Contributed presentation.**
4. PUNCH 6 science meeting, 25–26 Feb 2025, Cal Poly, San Luis Obispo, US-CA. **Poster presentation.**

II. Participants & Other Collaborating Organizations

University Research Team Member

Name .... Francesco Pecora
Project Role .... PI
Nearest person month worked 1
Contribution to Project .... The PI is applying the methodology developed in the preparatory study Pecora et al. 2024 *In: Solar Physics* 299.10 (Oct. 2024), p. 137. issn: 1573-093X. doi: 10.1007/s11207-024-02382-z.
This work featured numerical simulations to quantify the effects of line-of-sight integration performed by white-light imagers on usual turbulence spectral scalings.
Currently, we are applying this methodology to Parker Solar Probe's WISPR imager to validate the technique on real data. PUNCH science team is finalizing the pipeline to clean images in order to be ready for scientific analyses. Once this final product is ready, we will investigate these data sets.
Funding Support .... This grant and NASA PUNCH.

Name .... Jiaming (Victoria) Wang
Project Role .... Graduate student
Nearest person month worked 2
Contribution to Project .... The student has been learning fundamental aspects of white-light imagers, the methodology of image acquisition, and related problems that are

different from those of in-situ measurement analyses with which she is more familiar. She is also learning the theoretical foundations of large-scale structures originating from the Sun that are observable with PUNCH at an unprecedented resolution. These structures are fundamental to understanding the solar wind as they contain a large fraction of the energy that then produces the turbulent cascade.
Funding Support .... This grant and NASA PUNCH.

III. Changes/Problems

The work plan is going as expected, with no changes or problems to report.

IV. Impact

The solar wind is turbulent. One of PUNCH's major objectives is to study that turbulent flow. However, obtaining quantitative information about in-situ processes from our images can be challenging.
PUNCH images integrate all light along the line of sight between the observer and infinity, so the structure of local turbulence is blurred. We therefore expect its measurements to relate differently from previous in-situ data to the underlying turbulent environment of the outer corona and inner heliosphere.
To understand these differences, in Pecora et al. 2024, we mimic the action of PUNCH observation itself (using the FORWARD tool, Gibson et al. 2016), processing "ground truth" magnetohydrodynamic simulations of turbulence to obtain synthetic white-light (PUNCH-like) images. Direct 1-to-1 comparison of the simulation to "PUNCHified" images of the same shows how PUNCH observations change the spatial spectrum of the turbulence.
By simple integration (projection) of the simulated densities from 3D to 2D, we can match the PUNCH-specific variation from the more sophisticated FORWARD model images.
Compiling a catalog of simulations with different properties that match PUNCH remote observations will be the key to determining the properties of the solar wind simultaneously across the vast PUNCH field of view, yielding coverage impossible to attain with in-situ spacecraft alone.
With this project, we are preparing for PUNCH's new observations, applying the methodology tested in controlled simulation environments to Parker Solar Probe data first, and then to PUNCH to observe the evolution of the turbulent solar wind in regions inaccessible to spacecraft.

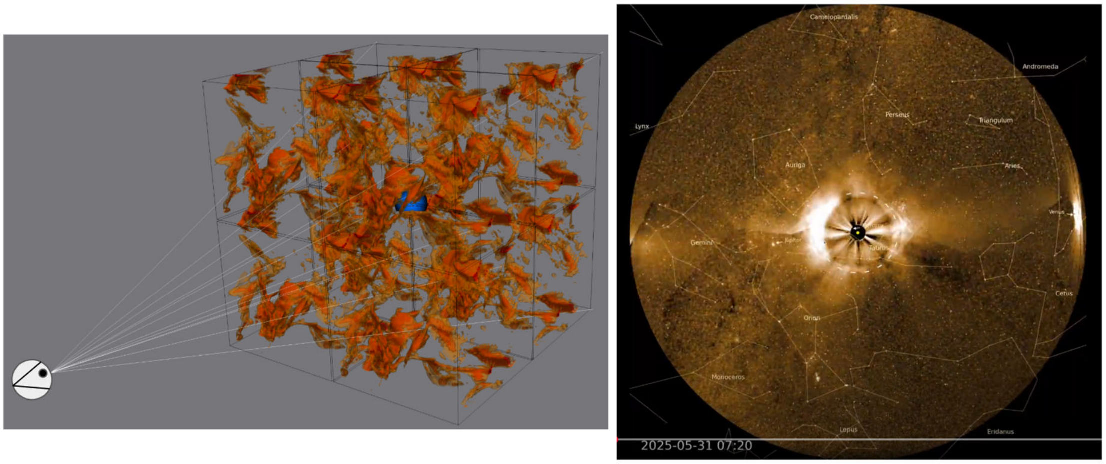

Figure 1. (Left) Simulation of the turbulent solar wind around the sun (blue sphere). High-density regions are represented by orange surfaces. This setup was used to quantify the effects of line-of-sight integration on turbulence scaling. (Right) PUNCH initial observations (with artifacts still present). Brighter regions correspond to higher density.