Imperial College London

Science & Technology Facilities Council

Using temperature anisotropy as an in-situ diagnostic for solar wind origin

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This is a work in progress that has yet to be published;
If you have any questions or comments, please get in touch on
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Introduction

Q: What are the sources of the solar wind?

In situ timeseries data

?

Coronal holes

?

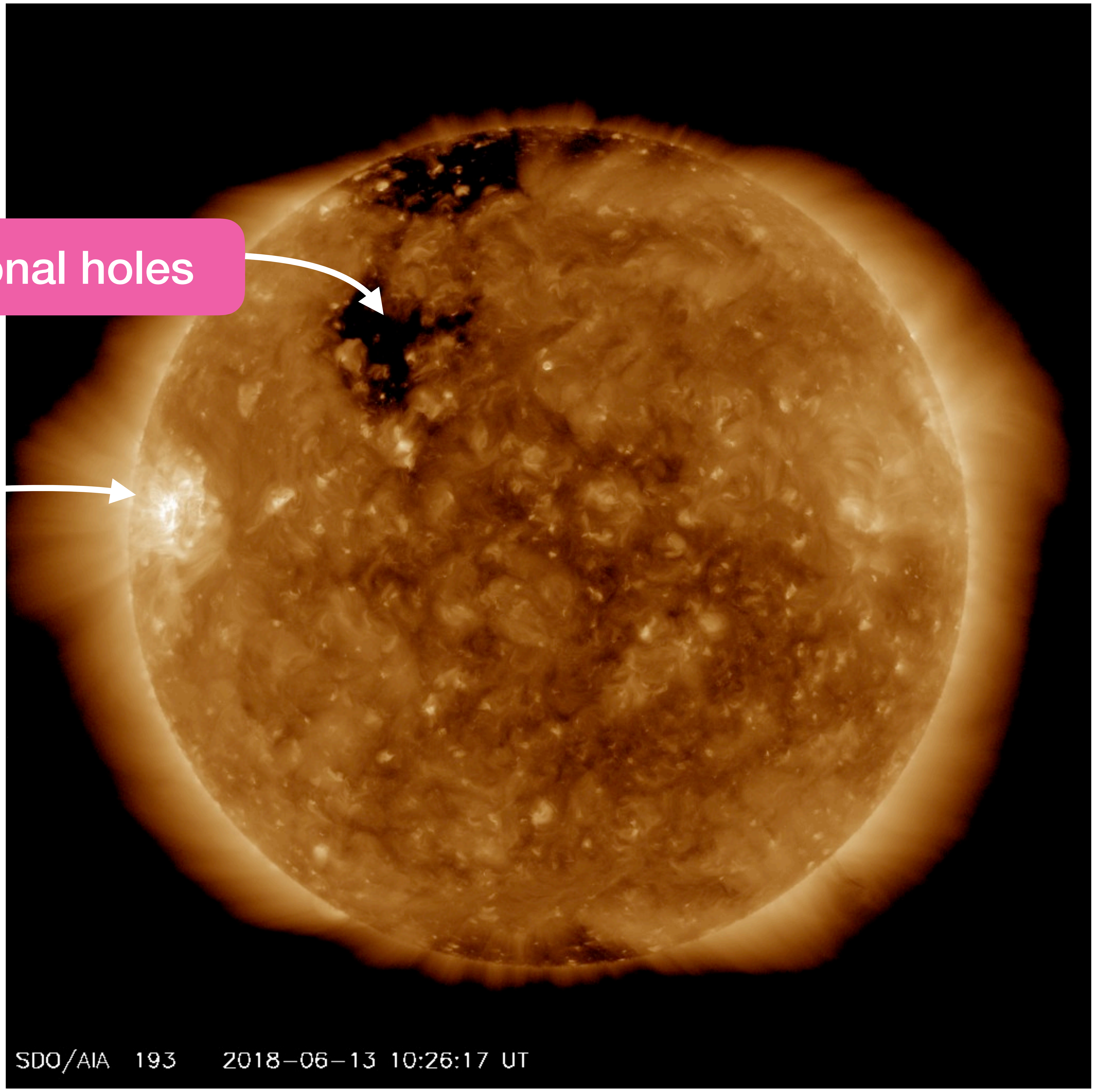
Active regions

*(e.g. Brooks 2015
Harra et al. 2018)*

?

Transient structures

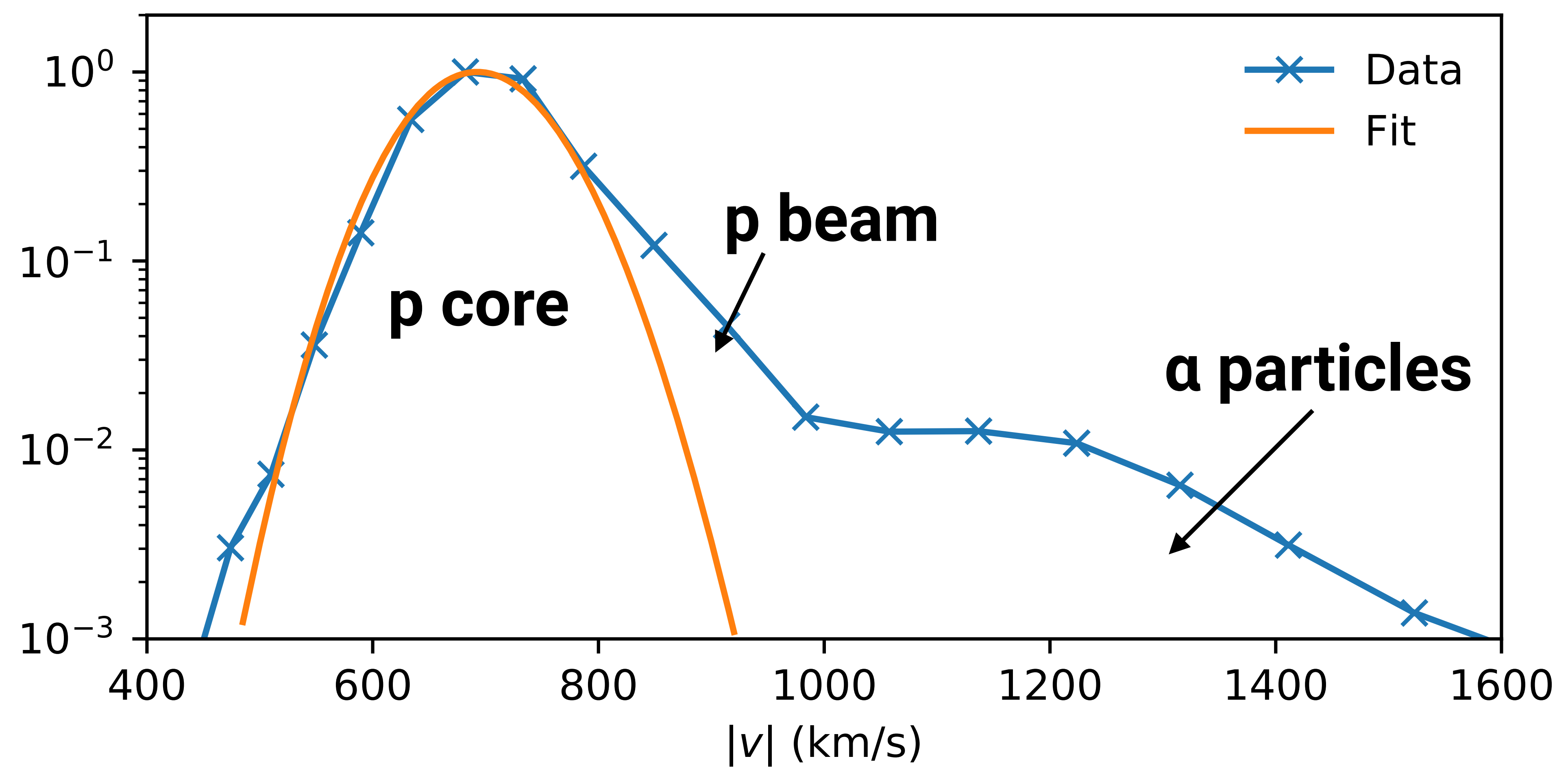
*(e.g. Sheeley et al. 1997
Viall et al. 2015
Stansby et al. 2018)*



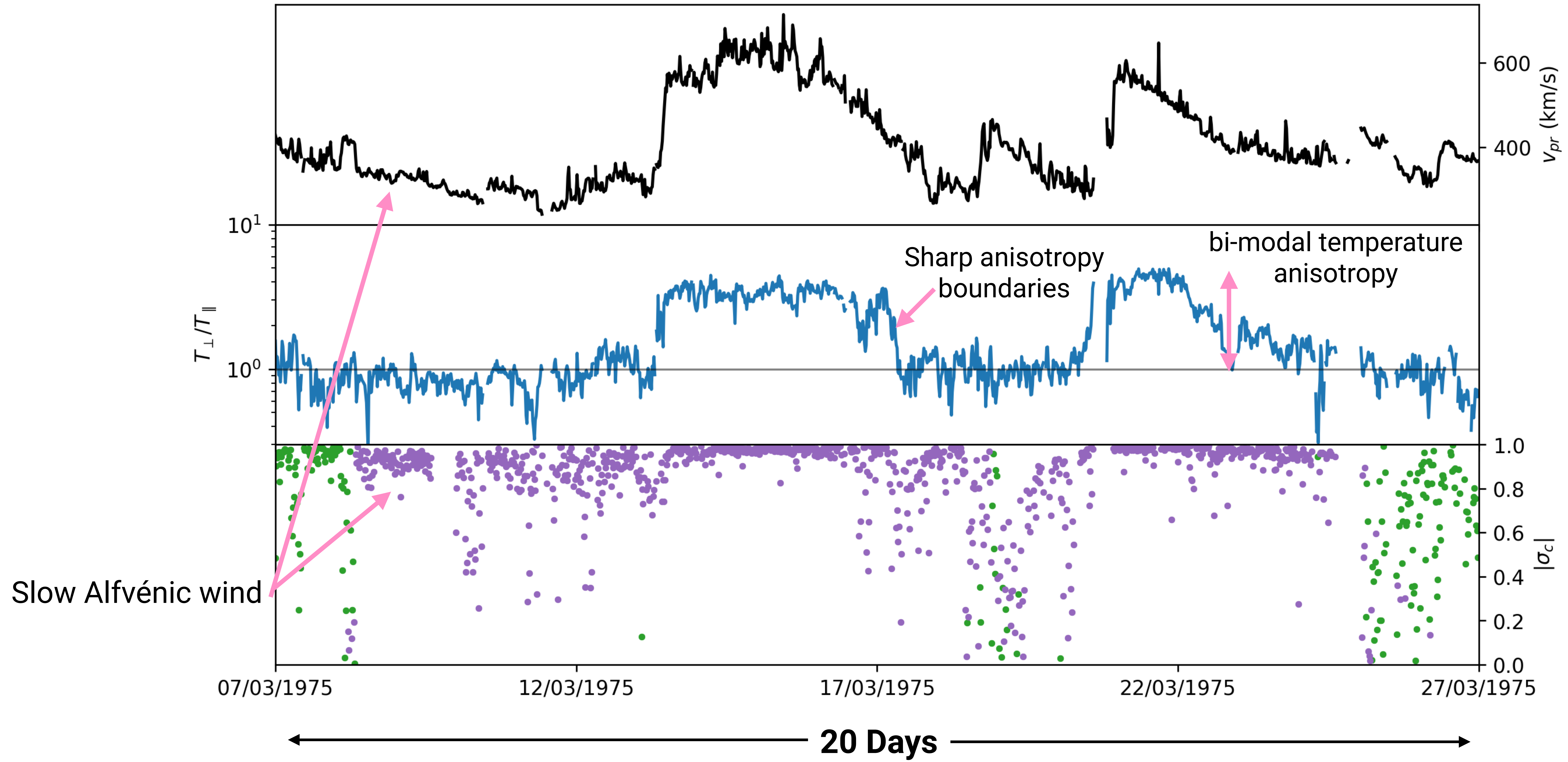
New method to map in-situ to source, using only magnetic field and proton measurements

Data

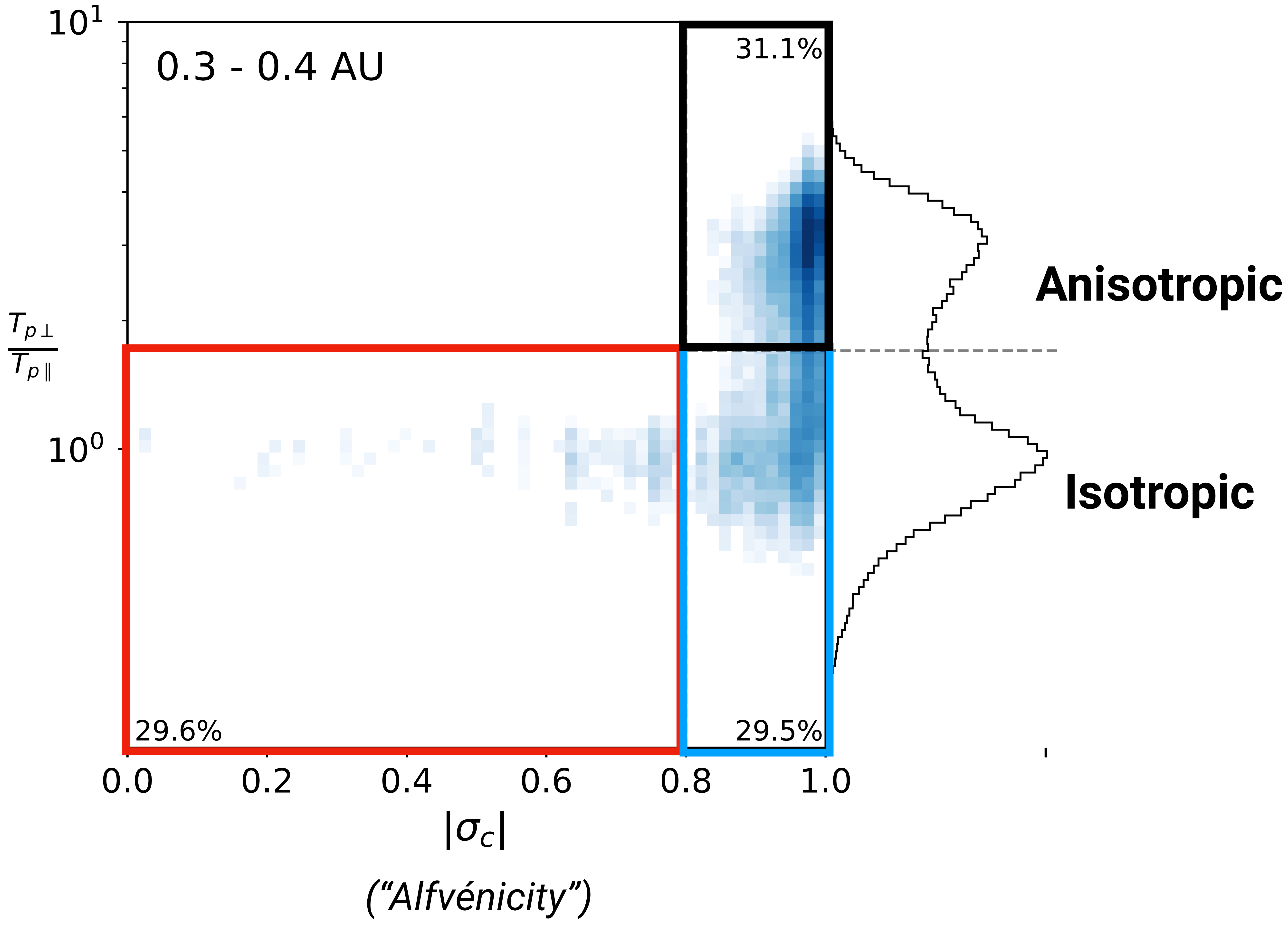
- Proton data from Helios (**0.3 AU - 1.0 AU**) at **solar minimum** (between cycles 20 and 21)
- bi-Maxwellian fits to proton core population
- First general availability of $T_{p\perp}, T_{p||}$ for inner heliosphere
- See *Stansby et. al.* poster this evening for more details

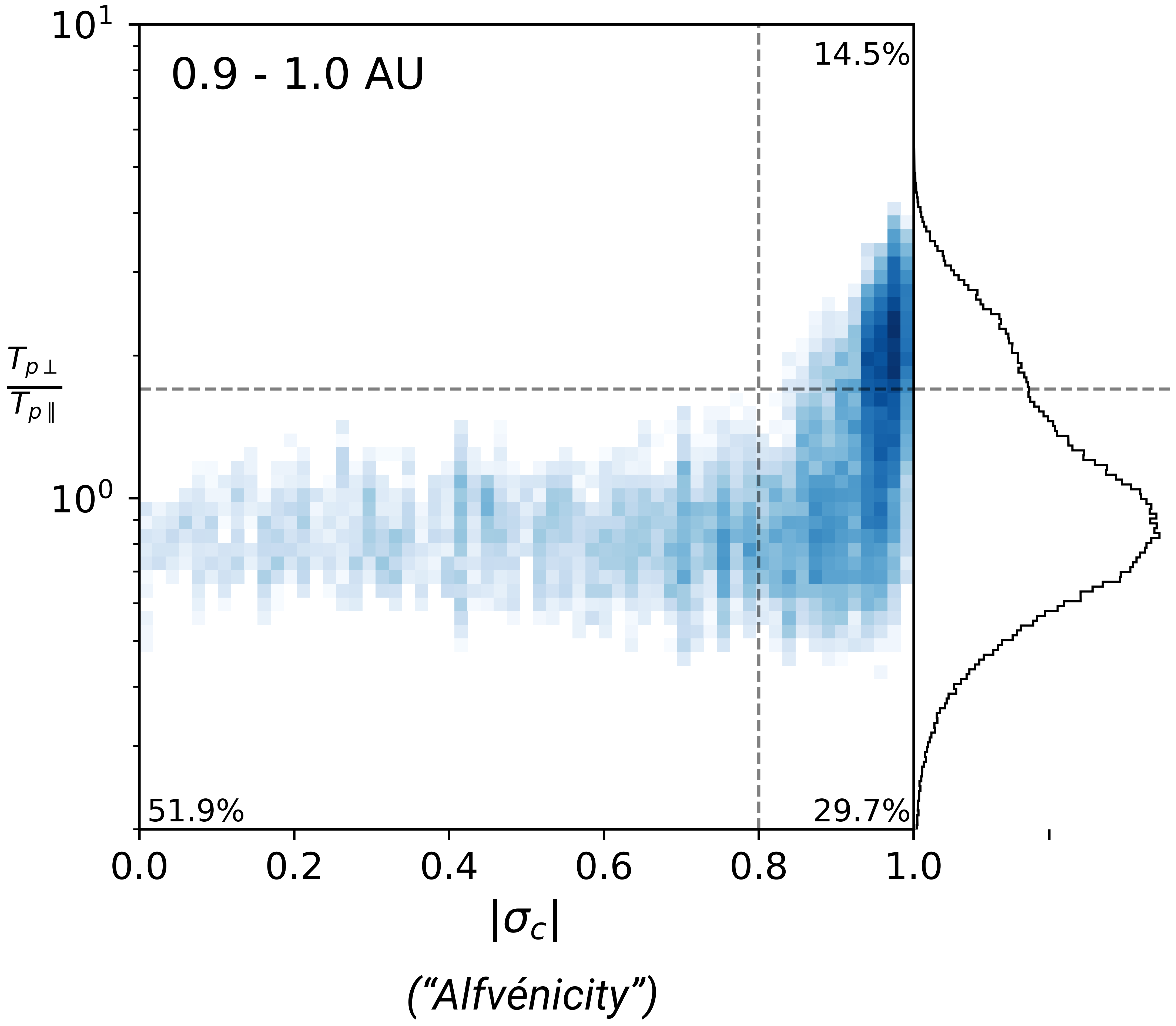


Properties of the solar wind at 0.3 AU

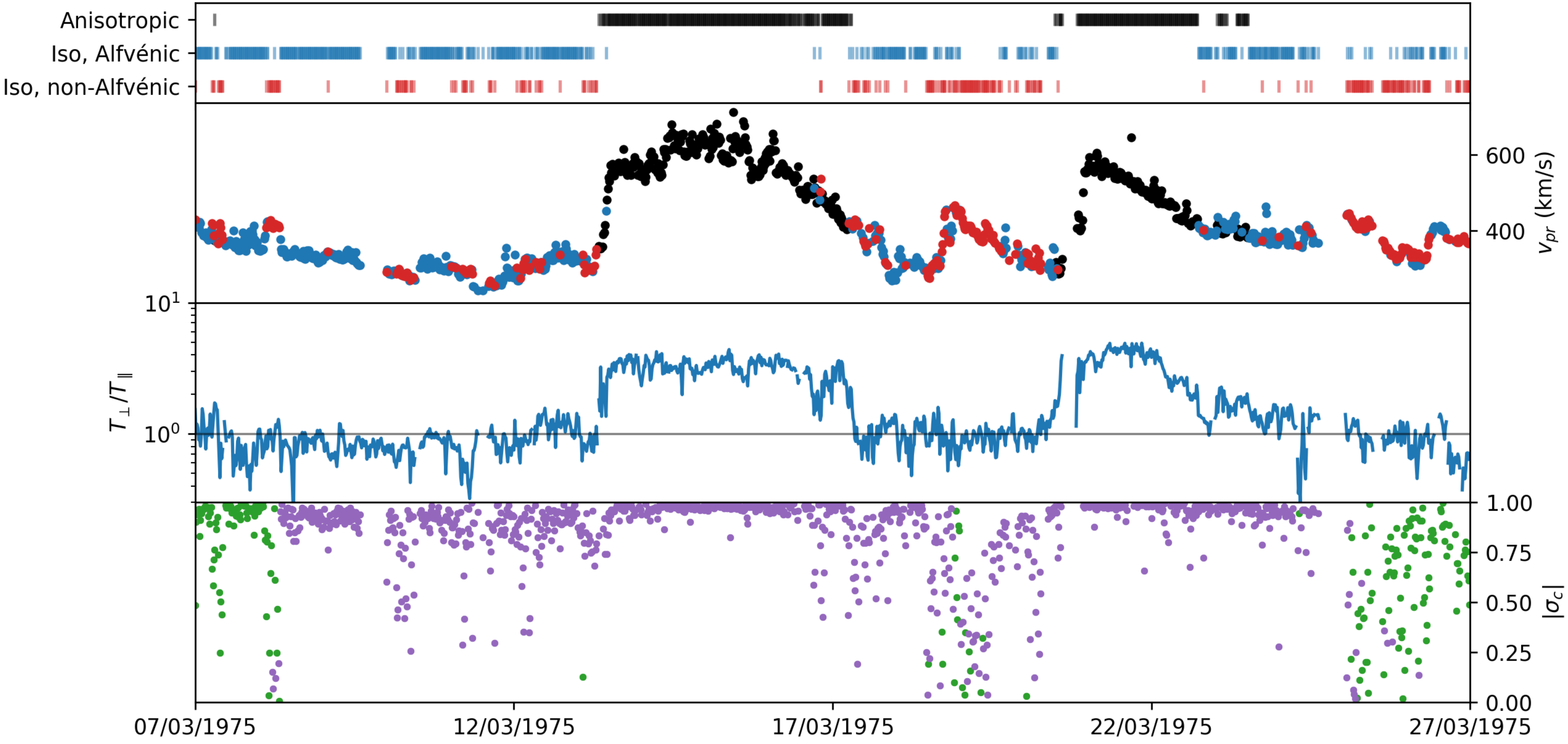


The difference between 1 AU and 0.3 AU



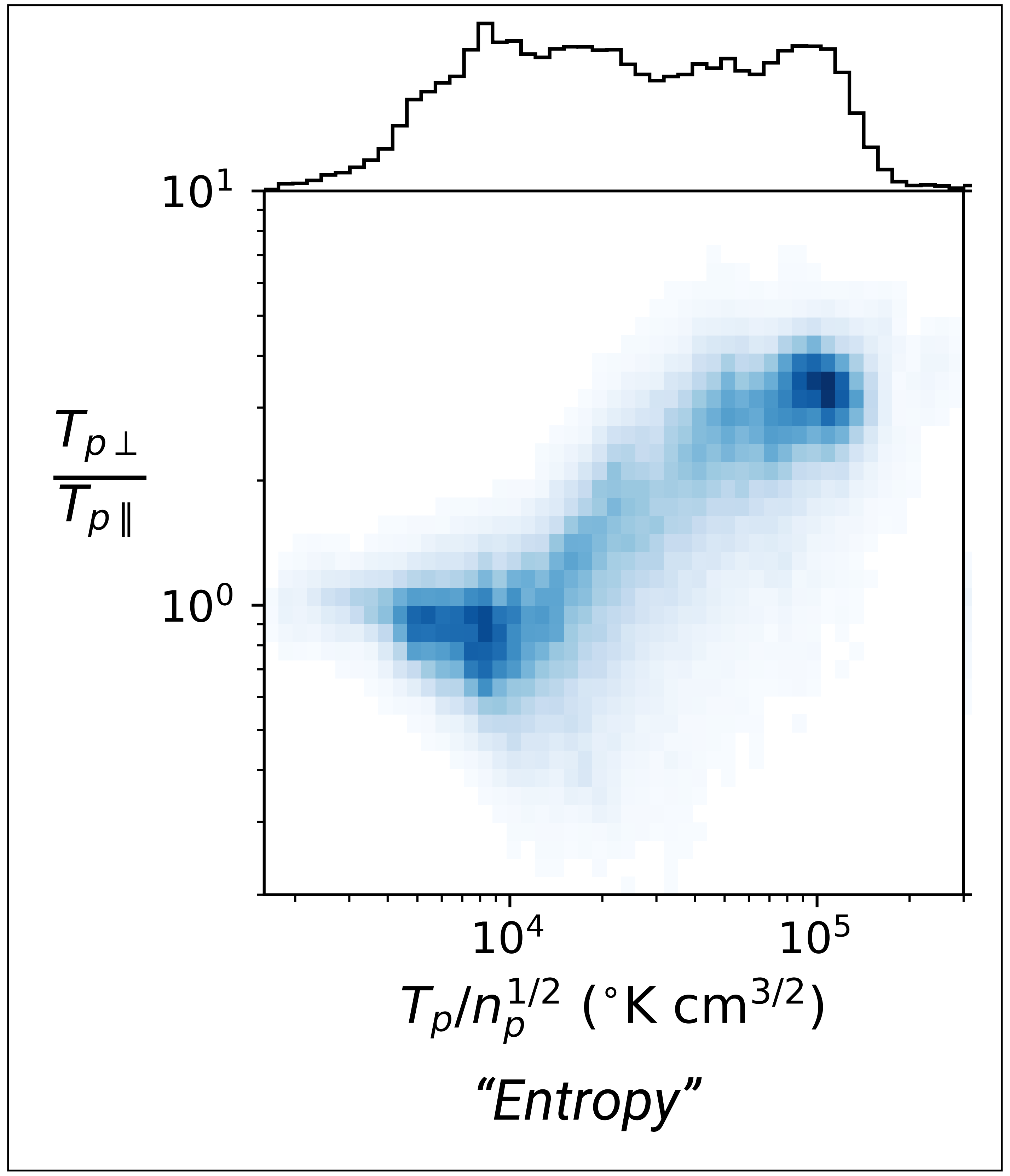


Categorising solar wind at 0.3 AU



20 Days

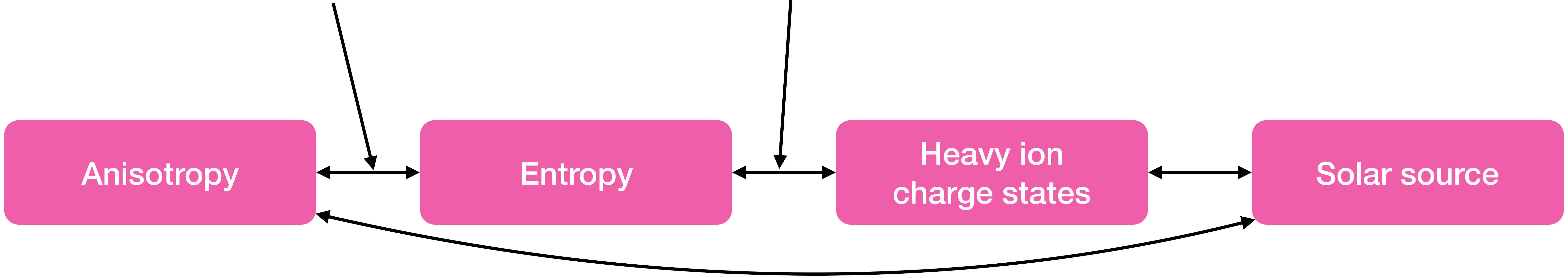
Using $T_\perp/T_\parallel$ to infer composition



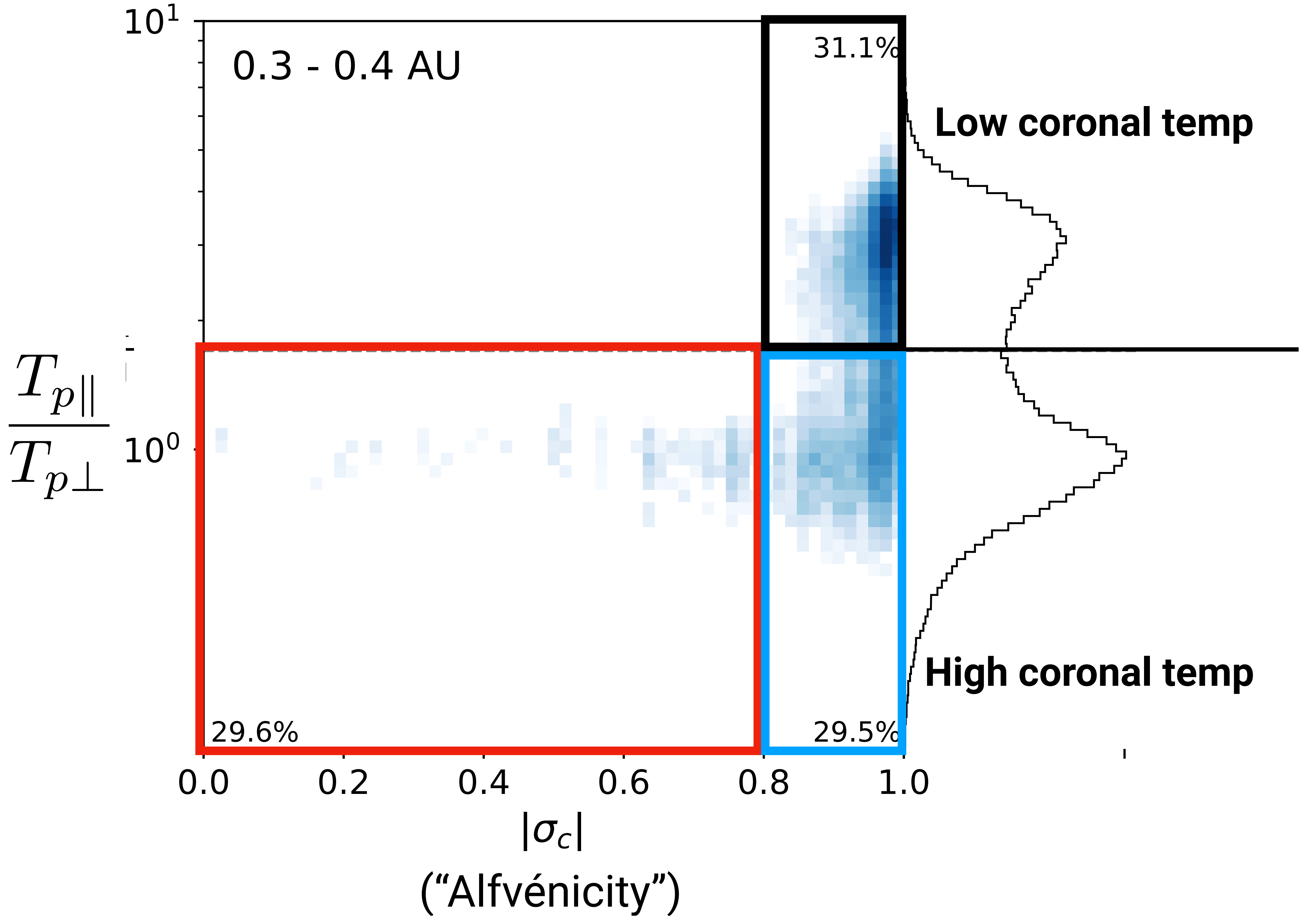
- Ulysses and ACE show entropy and O^{7+}/O^{6+} are statistically correlated
  [Pagel et. al. 2004, Stakhiv et. al. 2015, 2016]

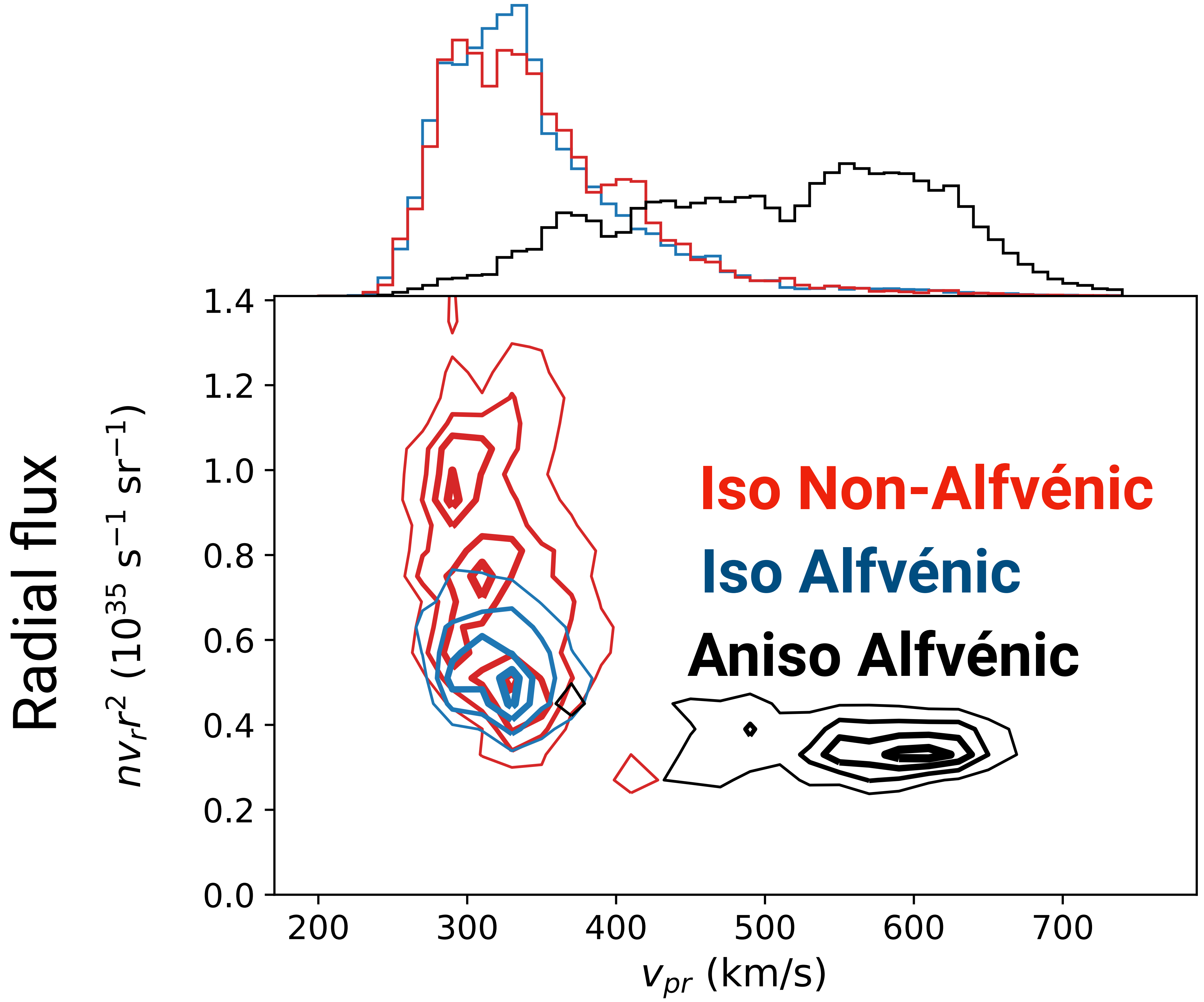
- Also sharp O^{7+}/O^{6+} boundaries at leading + trailing edges of high speed streams
  [Burton et. al. 1999, Borovsky et. al. 2016]

- Helios saw **sharp anisotropy boundaries** in the **leading and trailing edges** at 0.3 AU



Mapping measurements to sources





Coronal holes
- Low coronal temp
- Constant mass flux
- Includes high speeds

Active regions
- High coronal temp
- Alfvénic + constant mass flux

⇒ quasi-steady open flux

Small transients
- High coronal temp
- non-Alfvénic + variable mass flux

⇒ intermittent source

Conclusions

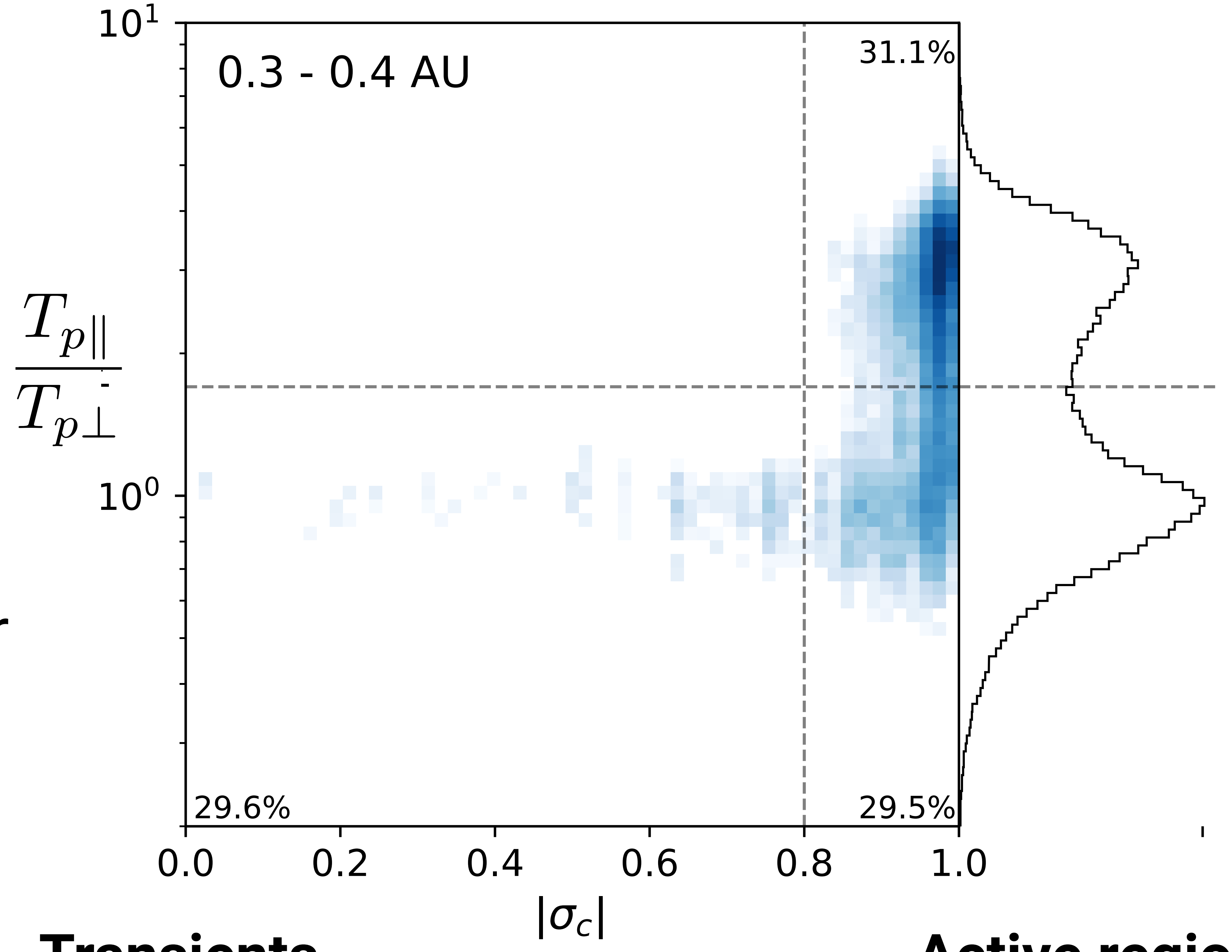
- $T_{p\perp}/T_{p||}$ provides key tool for mapping in-situ to solar sources (inside ~0.8 AU)
  (Important for Parker Solar Probe without heavy ions)

- 50% of slow solar wind is strongly Alfvénic at 0.3 AU
  ⇒ **be cautious making predictions with 1 AU data!**

- Helios measured an even mix of solar sources at solar min
  ⇒ **predict PSP will also measure even mix of sources**

Paper in prep; download these slides at
davidstansby.com/SW15

Coronal holes



Transients

Active regions

("Alfvénicity")