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

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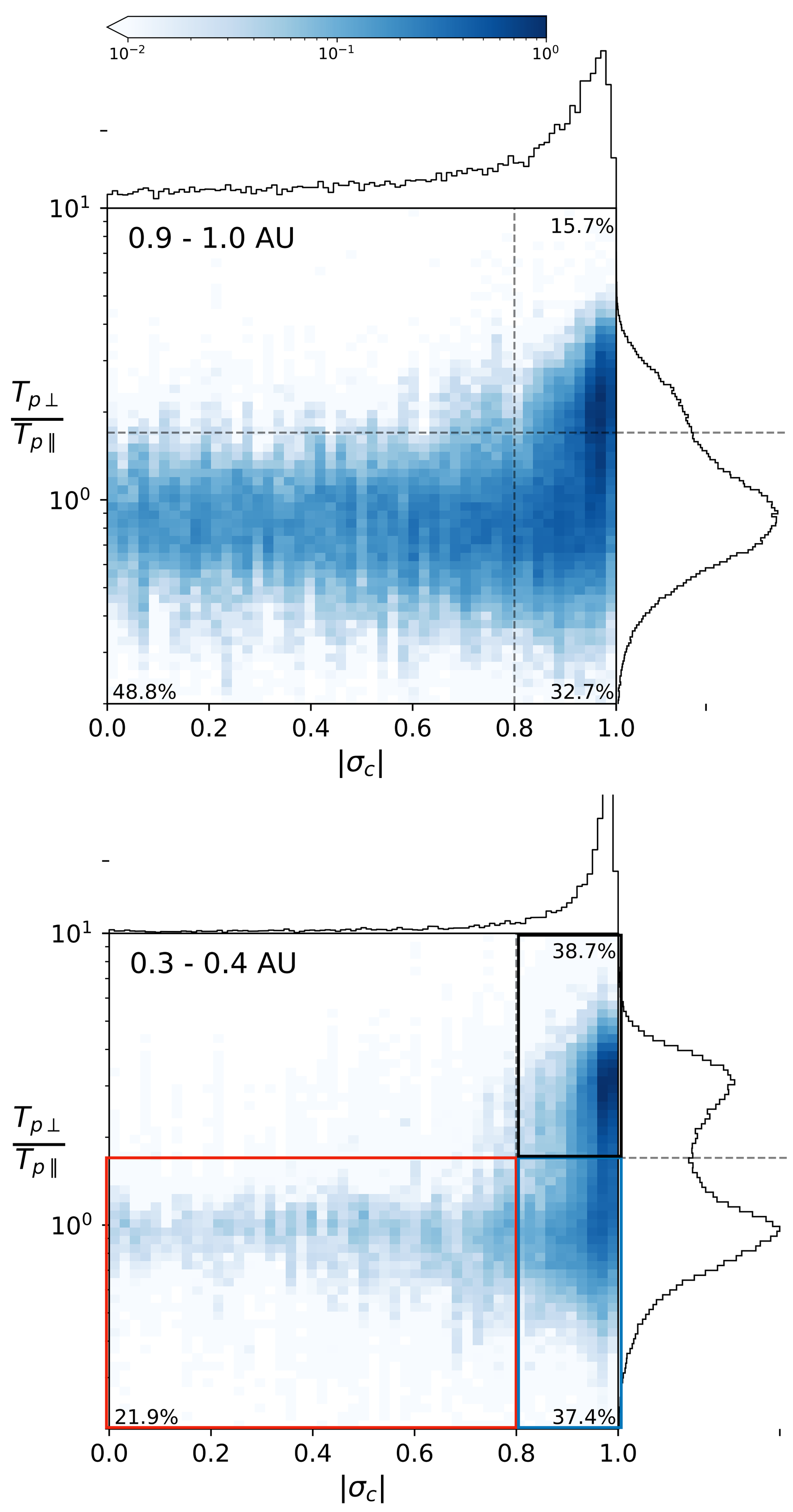
## Context

- Robustly identifying solar source of in-situ solar wind measurements is still an open problem
- Clear that splitting by speed (slow/fast) does not match possible solar sources [Stakhiv et al. 2016, D'Amicis et al. 2015, 2016]

## Method

- Some 'slow' solar wind has same properties as 'fast' solar wind [Marsch et al. 1981, D'Amicis et al. 2015]
  - Strongly Alfvénic [Bruno et al. 2007]
  - $T_{p\perp}/T_{p\parallel} > 1$ in inner heliosphere [Matteini et al. 2007]
- ∴ instead of splitting wind by speed, we investigate distribution of $T_{p\perp}/T_{p\parallel}$ and Alfvénicity

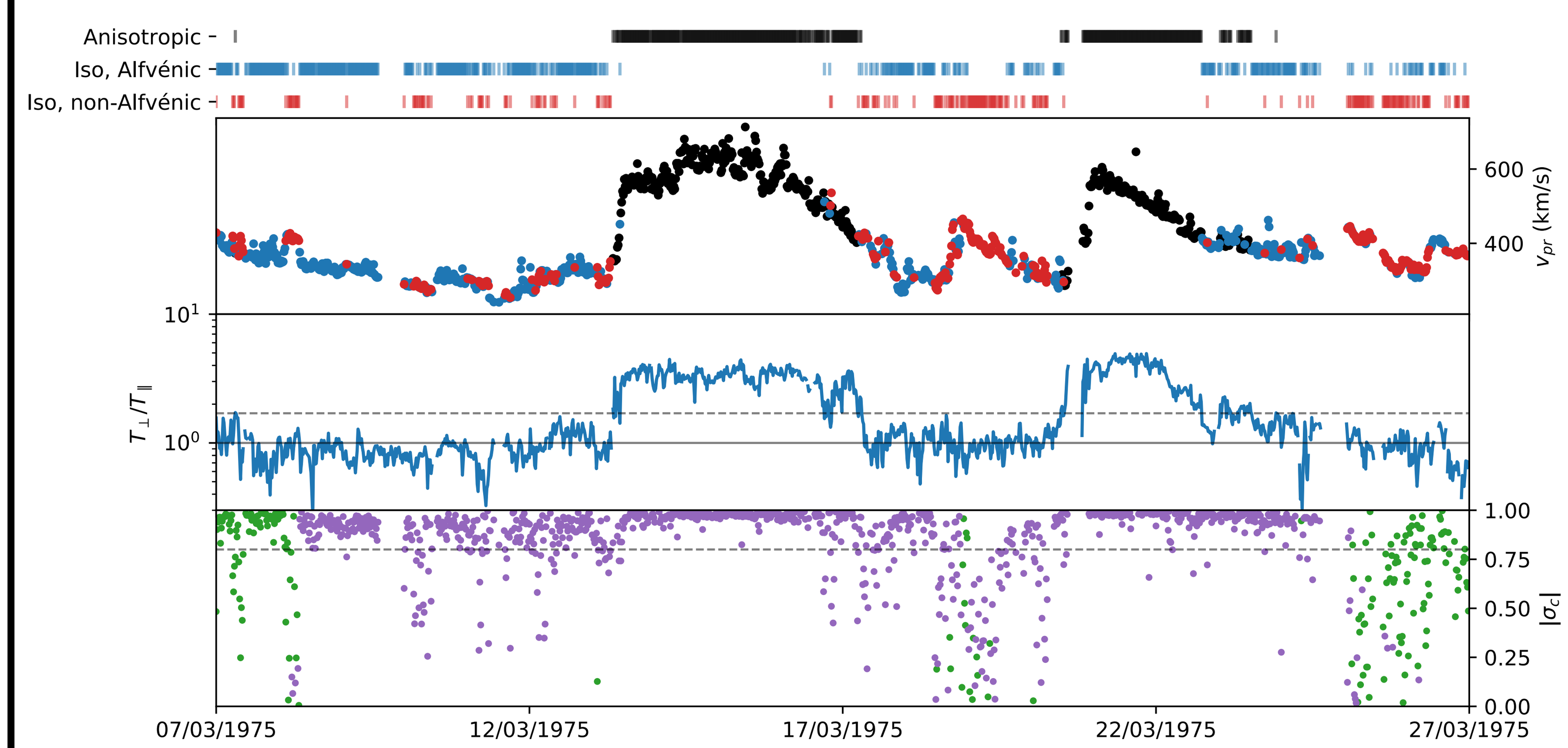
## Global properties at 0.3 AU




- Much larger Alfvénic fraction (80%) compared to 1 AU (50%)
- $T_{p\perp}/T_{p\parallel}$ is bimodal
- All anisotropic wind is Alfvénic

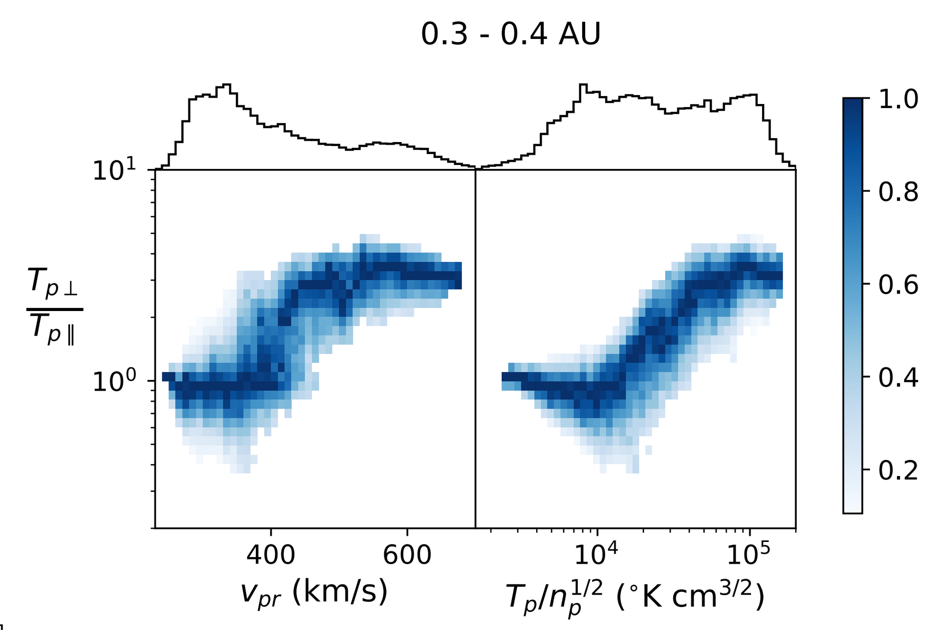
<u>Split solar wind into 3 categories</u>
Anisotropic
Isotropic + Alfvénic
Isotropic + non-Alfvénic

## Classification timeseries




## Mapping categories to solar sources

- $T_{p\perp}/T_{p\parallel}$ vs. $v_{pr}$ is non-monotinic
- $T_{p\perp}/T_{p\parallel}$ vs. entropy is monotonic
- ∴ use to $T_{p\perp}/T_{p\parallel}$ infer entropy
- Entropy is correlated with heavy charge states [Pagel et al. 2004, Stakhiv et al. 2016]




(Radial speed) (Entropy)

$T_{p\perp}/T_{p\parallel}$ → Entropy → Heavy charge states → Solar origin

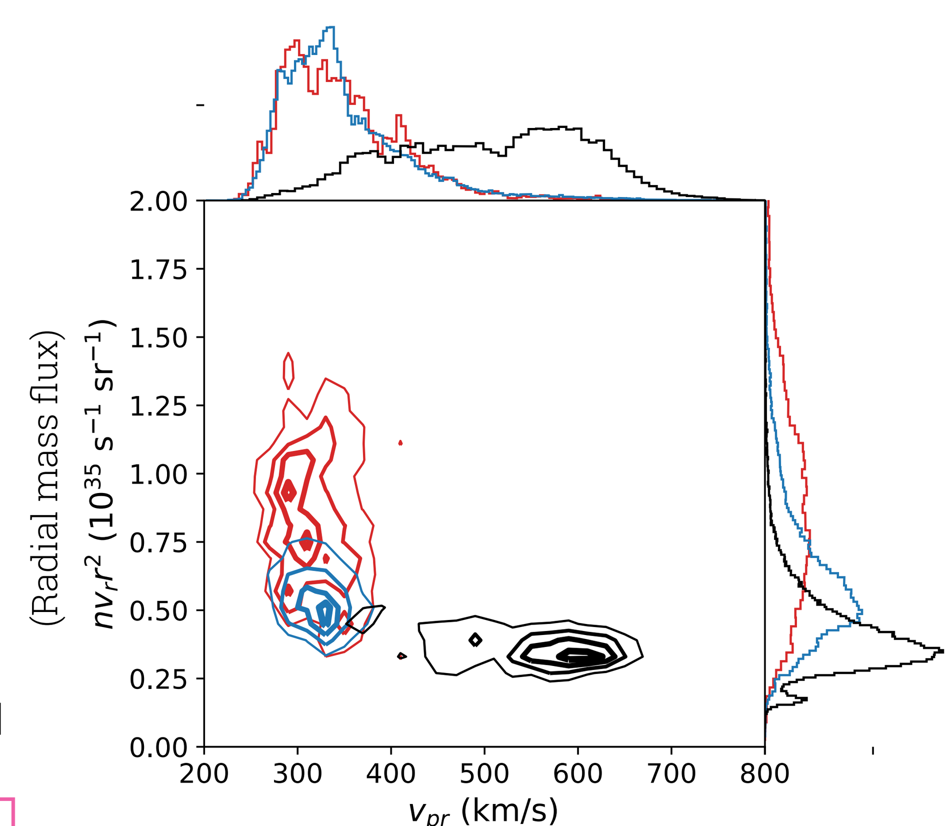
$T_{p\perp}/T_{p\parallel} > 1$ → Coronal hole wind
$T_{p\perp}/T_{p\parallel} = 1$ → non-Coronal hole wind

- Alfvénic has constant mass flux → steady state
- Active regions have open flux + significant mass output [Brooks et al. 2015]

Isotropic + Alfvénic
→ Active region wind

- non-Alfvénic has varying mass flux → non-steady-state release
- Some slow wind is small number density structures [Sheeley et al. 1997, Viall et al. 2015]

Isotropic + non-Alfvénic
→ Transient structures




(Radial speed)

## Suggested categorisation

Anisotropic → Coronal holes
Isotropic + Alfvénic → Active regions
Isotropic + non-Alfvénic → Small scale transients

These are testable predictions for Parker Solar Probe & Solar Orbiter with heavy ions & PFSS backmapping

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