Determining the origin of number density structures in the slow solar wind

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Introduction

'Number density structures' are part of the slow solar wind. They have previously been detected using remote sensing out to 0.3 AU (*Sheeley 1997, Rouillard 2010*) and using in-situ measurements at 1 AU (*Kepko 2016*).

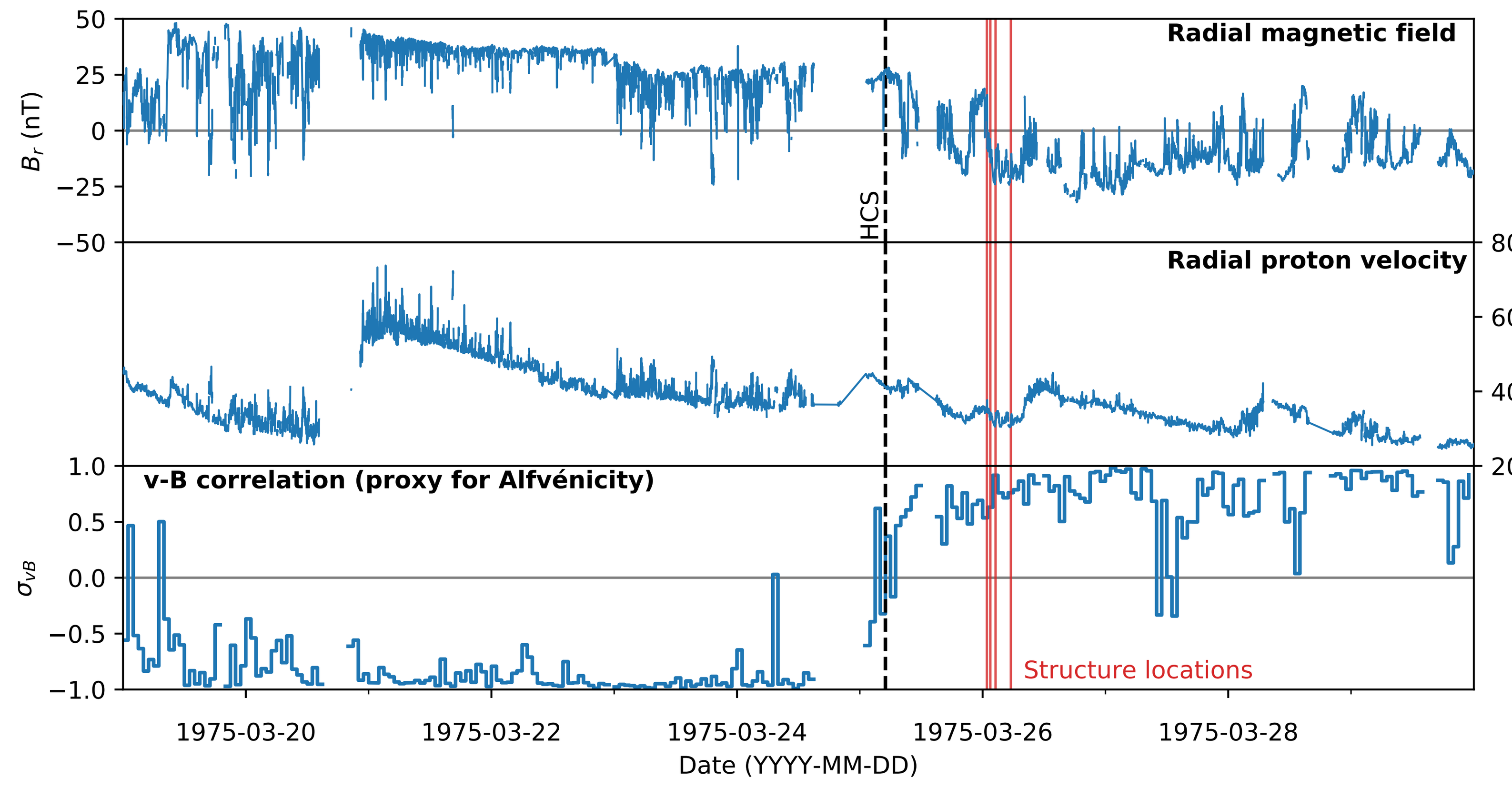
Where do they come from and how do they evolve in the heliosphere? We present observations of 81 high density and high beta structures observed between 0.3 and 0.5 AU to help answer these questions.

New Helios plasma dataset

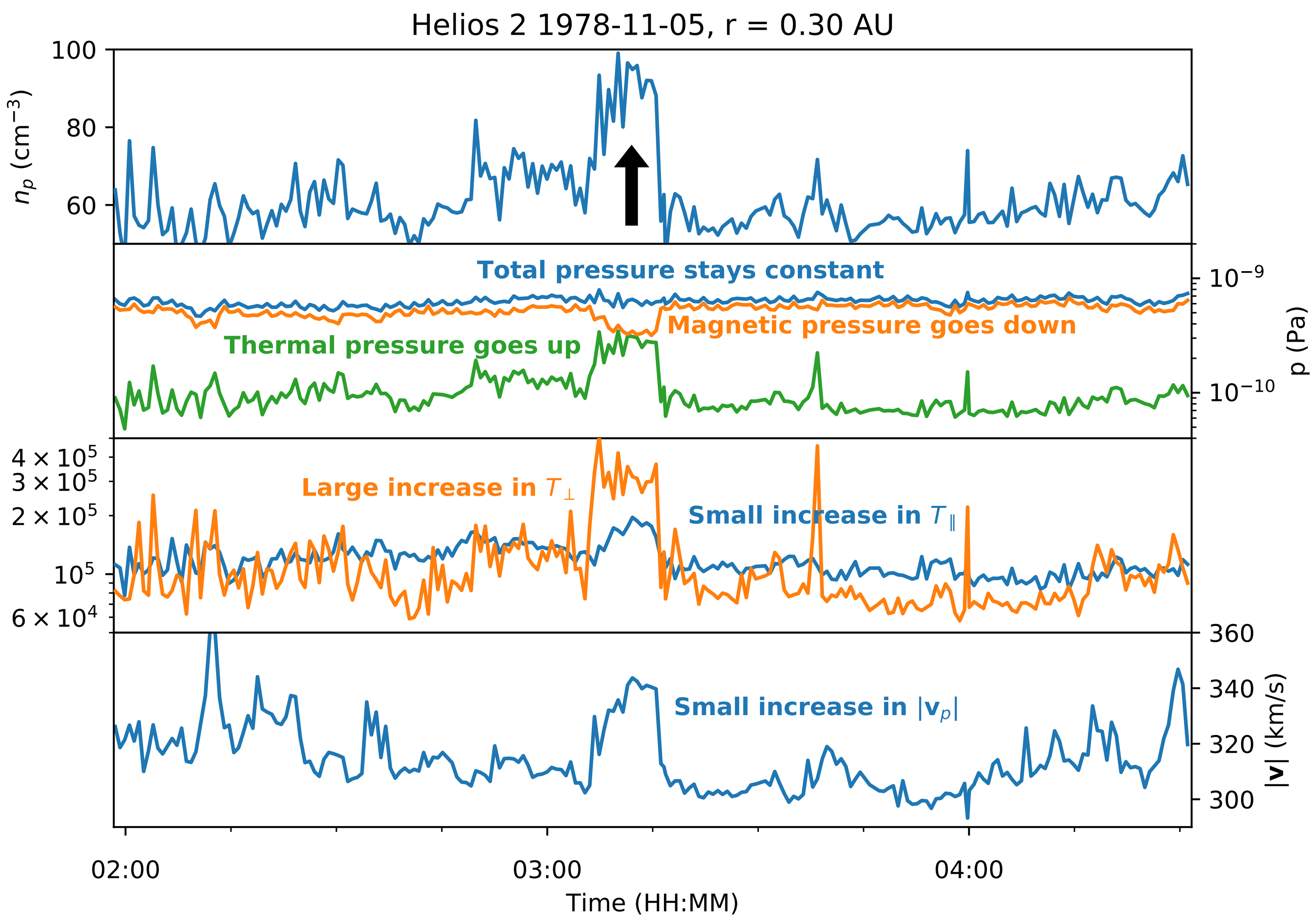
- Currently available proton moments not reproducible from original distribution functions, and temperatures are unreliable
- Have completely re-analysed 3D Helios ion distribution functions
  → fitted bi-Maxwellians to proton core population to provide
  → **more accurate** n_p, $\mathbf{v}_p$, and **brand new** $T_{p\perp}$ and $T_{p\parallel}$

New Helios plasma data set **freely available** at
`https://dstansby.github.io/helios`

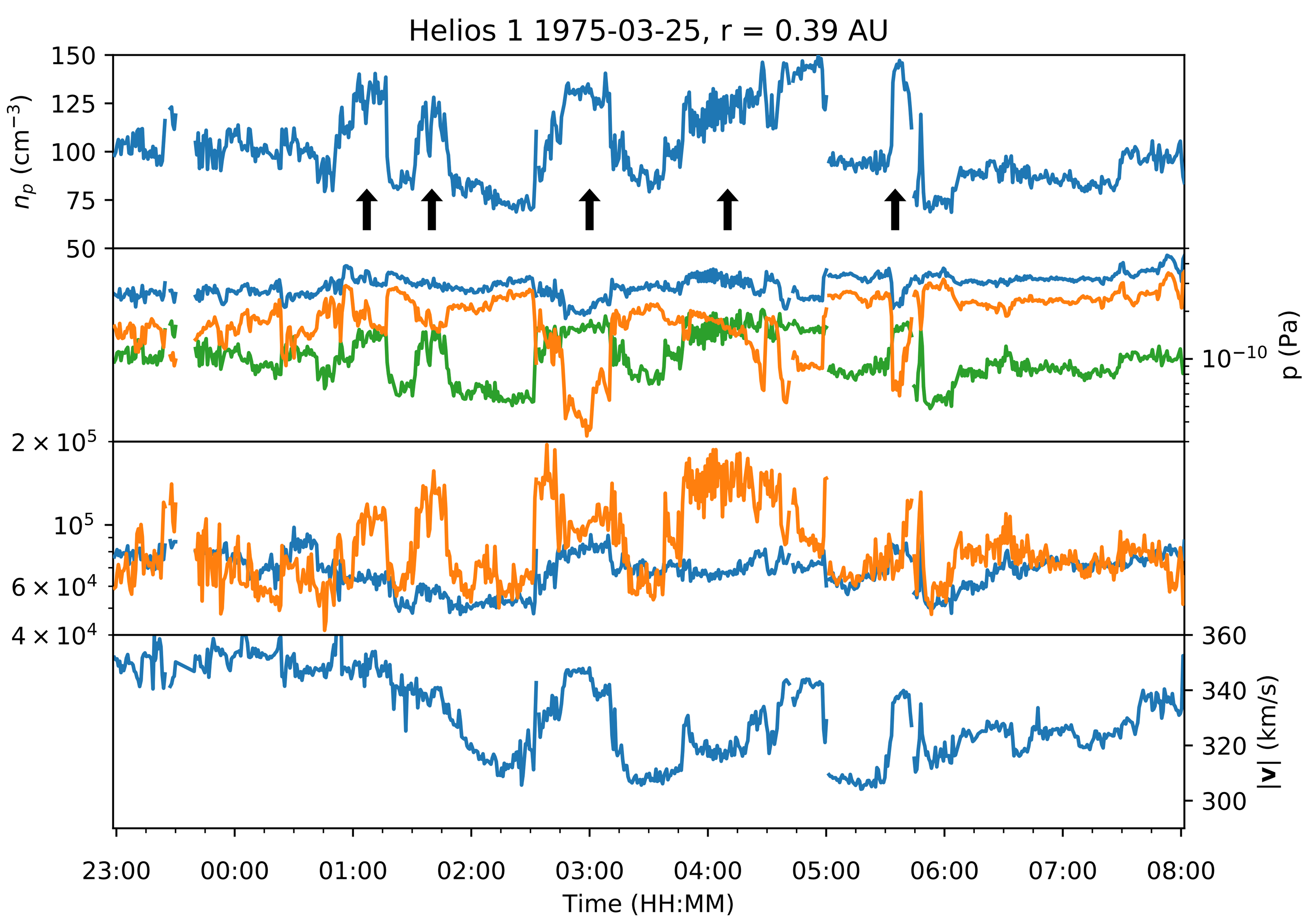
Context



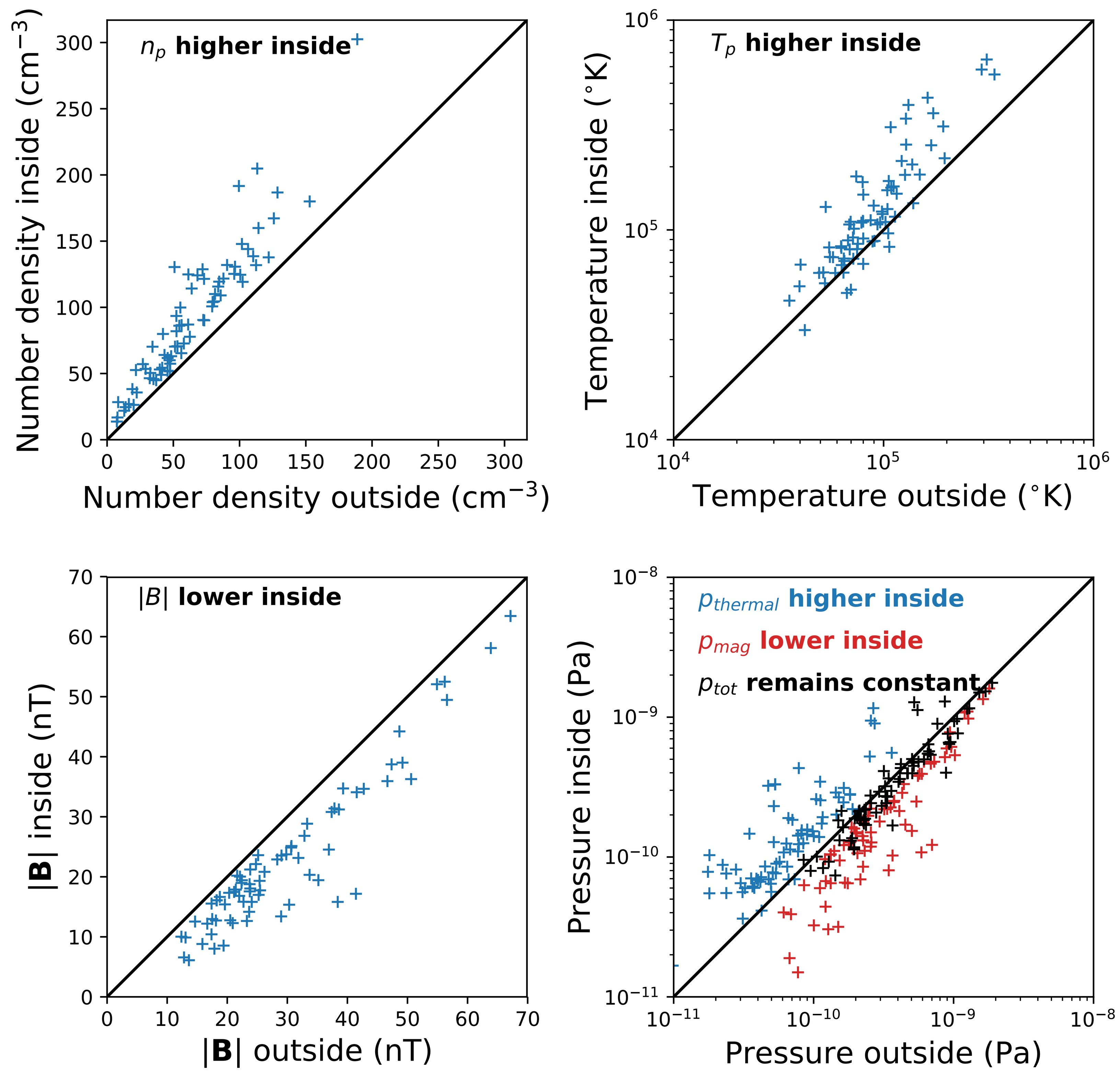
An isolated density structure



A train of density structures



Structure statistics

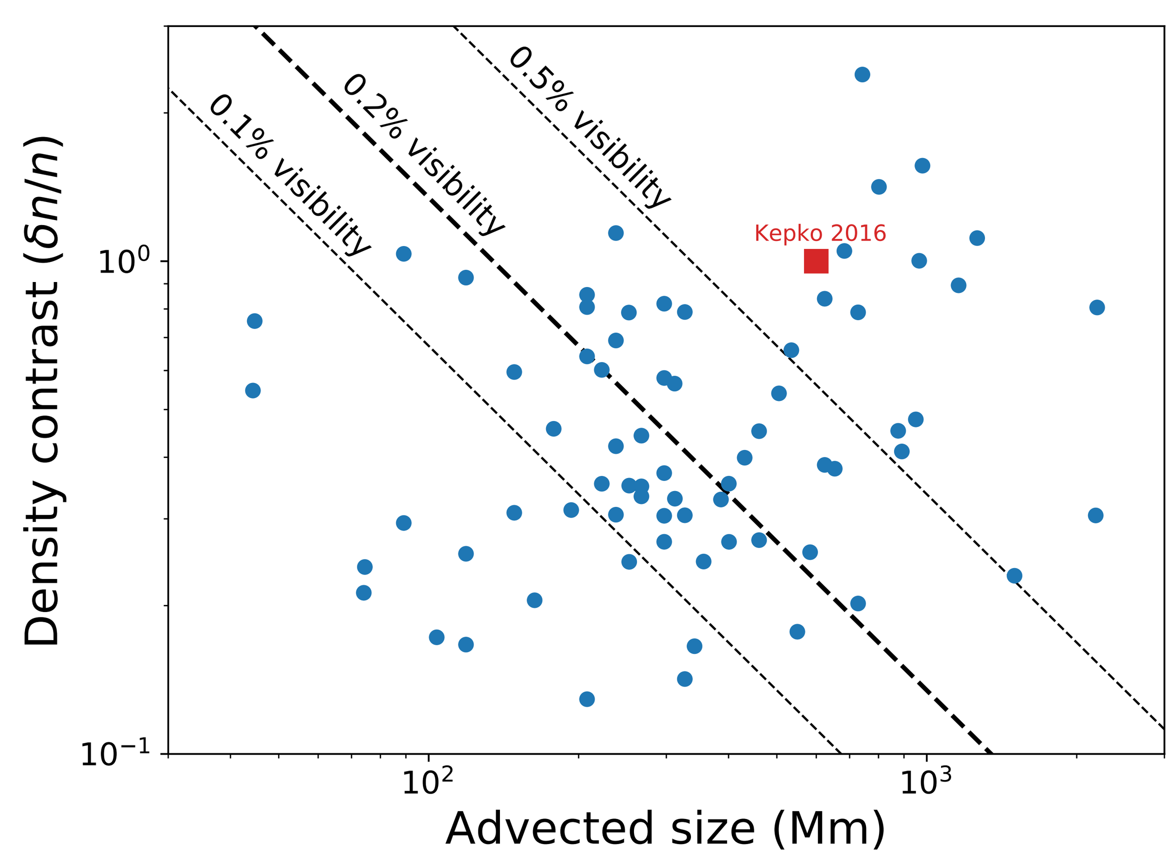


Viewing structures in white-light imagers

For a 1 AU viewer, relative change in intensity in the presence of a simple step-function shaped structure is (*Howard 2009*)

$$\frac{\delta I}{I_0} \approx 0.66 \frac{l}{r_0} \frac{\delta n_e}{n_e}$$

- l: line-of-sight size of structure; r_0: Distance from Sun-centre to structure
- δn_e: Electron number density increase; n_e: Background electron number density
- Assume r_0 = 0.3 AU for most favourable viewing conditions



→ 50% of structures observable in-situ not visible in WL-imaging ($\delta I / I_0 < 0.2\%$)
→ Structure sizes range from 50 Mm to 2000 Mm
→ 50 Mm is instrumental limit; PSP/SO have capability to measure even smaller scales

Acknowledgements

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References

1. Sheeley et. al. (1997) ApJ doi:10.1086/304338
2. Rouillard et. al. (2010) JGR doi:10.1029/2009JA014471
3. Kepko et. al. (2016) GRL doi:10.1002/2016GL068607
4. Howard & Tappin (2009) SSR doi:10.1007/s11214-009-9542-5

Conclusions

- Structures are contained within Alfvenic slow solar wind ⇒ surrounding plasma comes from open field line regions
- Structures have sizes ranging from 50 Mm to 2000 Mm ⇒ **no single characteristic scale size**
- Pressure balance → first in-situ confirmation that these are 'structures' and not time-dependent phenomena
- Predict structure properties don't significantly develop during transport ⇒ **high** n_p, T_p **are a reflection of solar source**

Number density structures in the slow solar wind originate from a hot, dense solar source