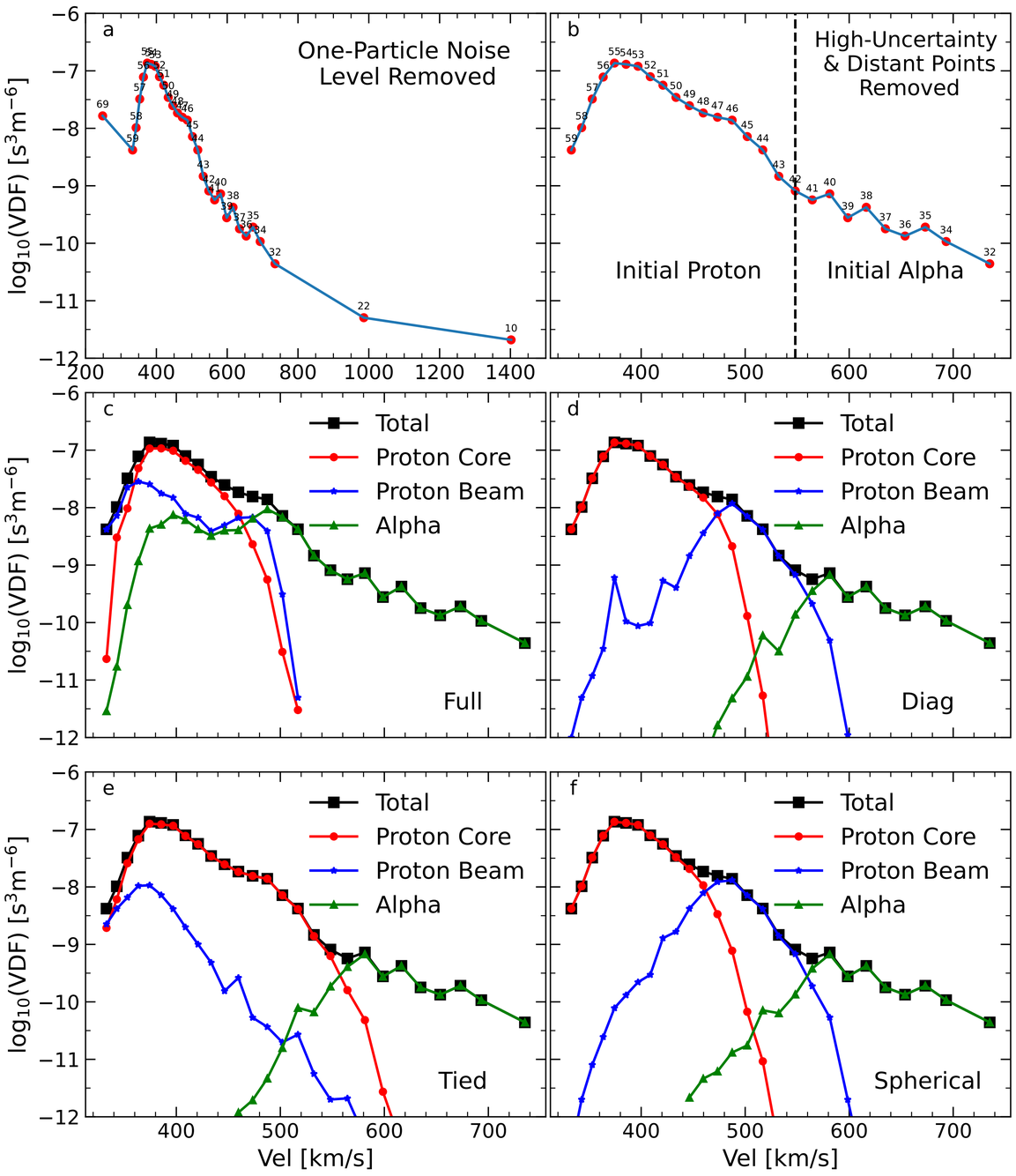
A Pipeline for Separating Solar Orbiter Proton Alpha-particle Sensor (PAS) Measurements

Hao Ran[1] *, Daniel Verscharen[1], Georgios Nicolaou[1], Jesse Coburn[1], Charalambos Ioannou[1], and Xiangyu Wu[1]

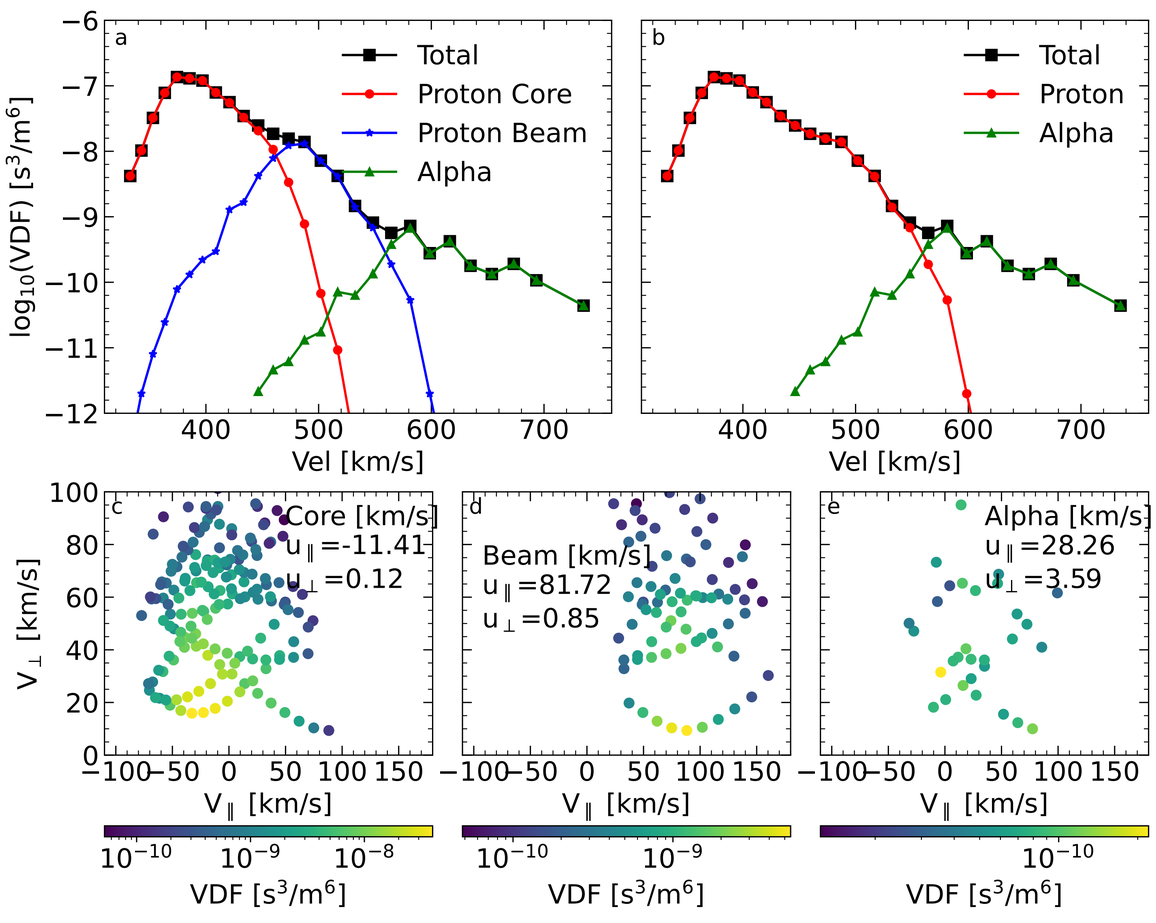
[1]Mullard Space Science Laboratory, University College London *hao.ran.24@ucl.ac.uk

Pre-processing



Pre-processing of the data and results for different covariance types.

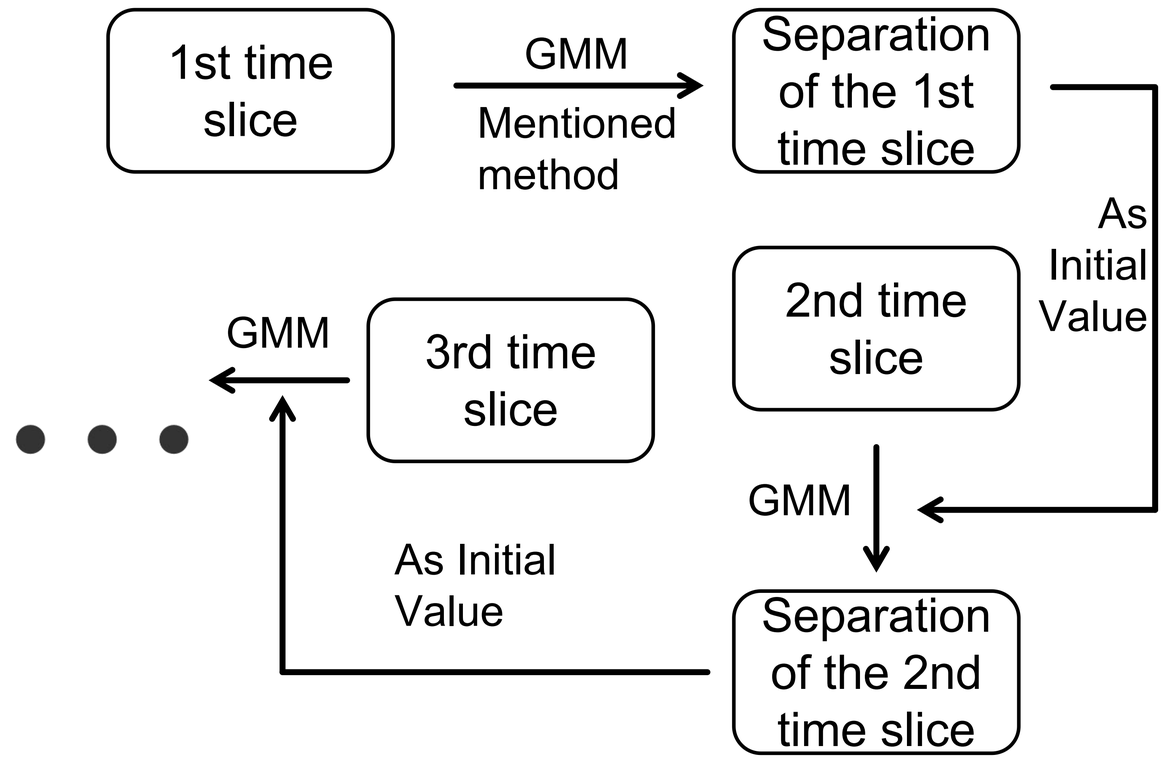
- Remove one-particle noise (PSD/count) and filter out measurements with high uncertainty or those far from the bulk population.
- Input database X = [$V_\parallel$, $V_{\perp1}$, $V_{\perp2}$, $|V|$, PSD] into Gaussian Mixture Model (GMM; *Reynolds et al., 2009*; *De Marco et al., 2023*). Set initial values according to panel (b).
- 4 covariance types: 'Full' model too complex, 'Tied' is not physically sensible. Choose between 'diag' and 'spherical' to maximize alignment between $\mathbf{V}_{\alpha p}$ and $\mathbf{B}$.



Results for separating PAS measurements at 13:45:33 UTC on 28th February 2022.

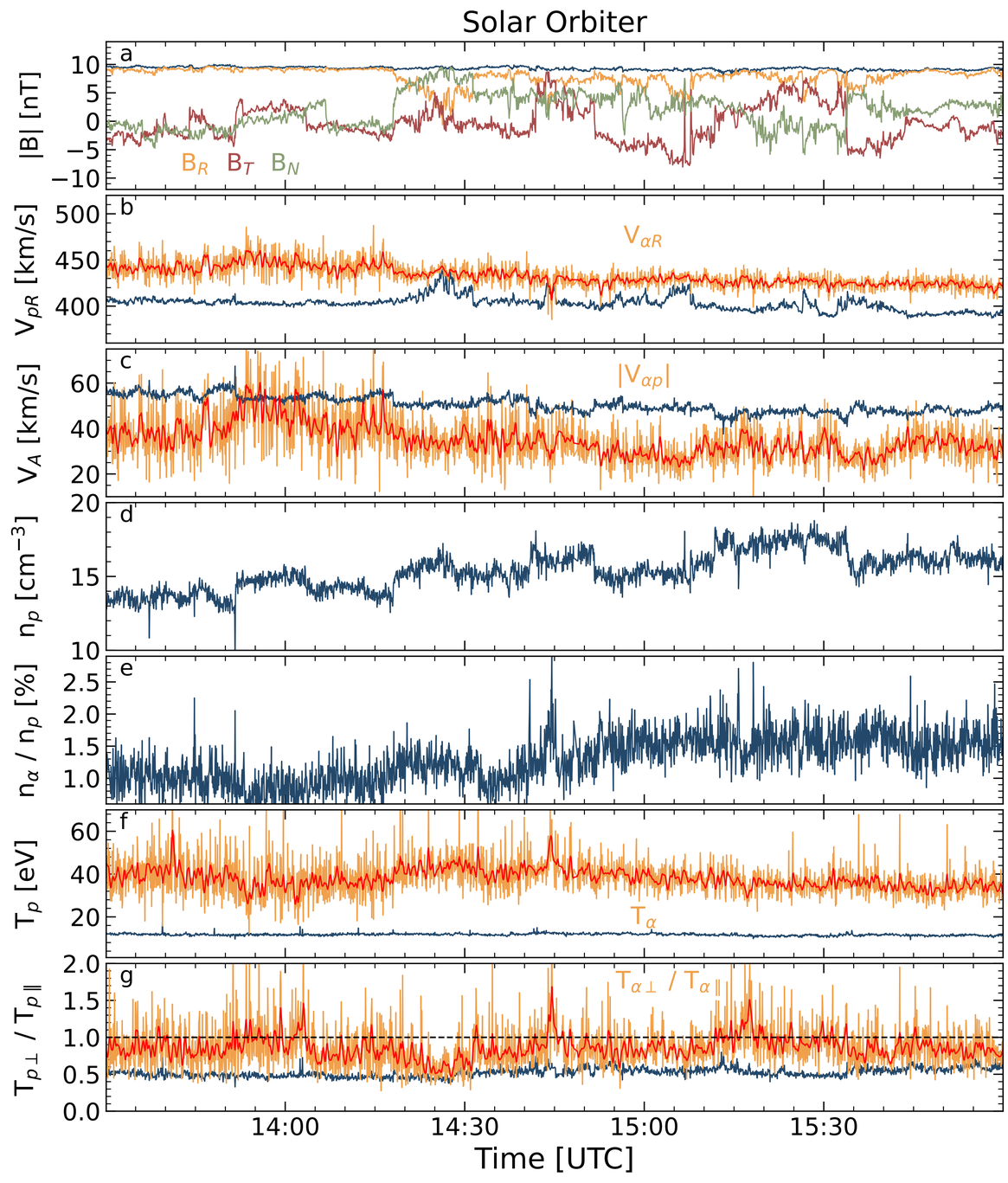
- Corresponds to the 'Spherical' covariance type.
- Overlapping data points are separated.
- Measurement points for each component are shown in the lower panels, with bulk velocities in the proton-rest frame indicated. These velocities are well aligned with $\mathbf{B}$.

Iteration



- Apply the method to separate ion populations in the first time slice.
- Use the previous time slice's result as the initial condition for the next.

Results for an example interval



Solar wind properties observed by SO from 13:30 to 16:00 UTC on 28th February 2022. The distance between SO and the Sun is 0.59 au.

Future steps

- Develop an error estimation method.
- Code will be shared via the website linked in the QR code below.
- Further discussion is warmly welcomed!

Email: hao.ran.24@ucl.ac.uk
Affiliation:
Mullard Space Science Laboratory,
University College London, UK