bi-Maxwellian fits to the proton core in PAS

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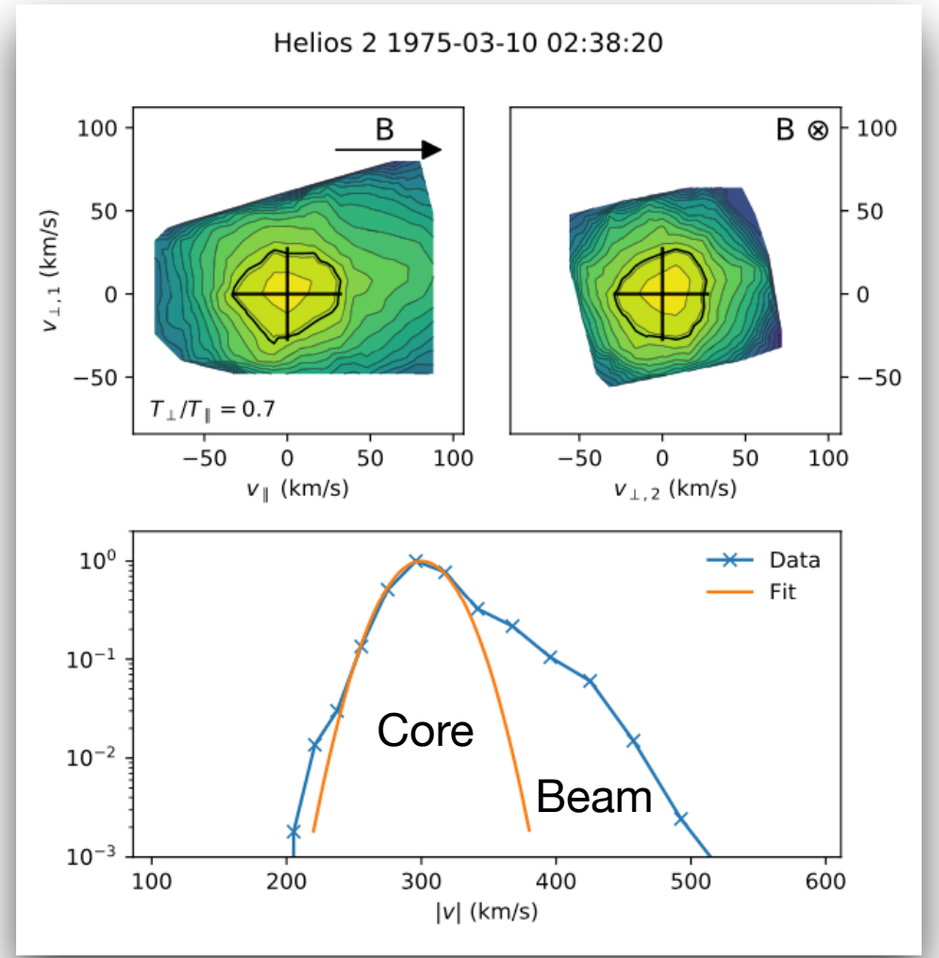
Background

- 1D distributions give accurate |v|, total n_p and **radial** T_p

- But to resolve anisotropies, and fully distinguish populations (core, beam, alphas) need 3D distributions

- I have done this for Helios *[Stansby et al. 2018, 2019]*

- SWA/PAS has similar L2 data product



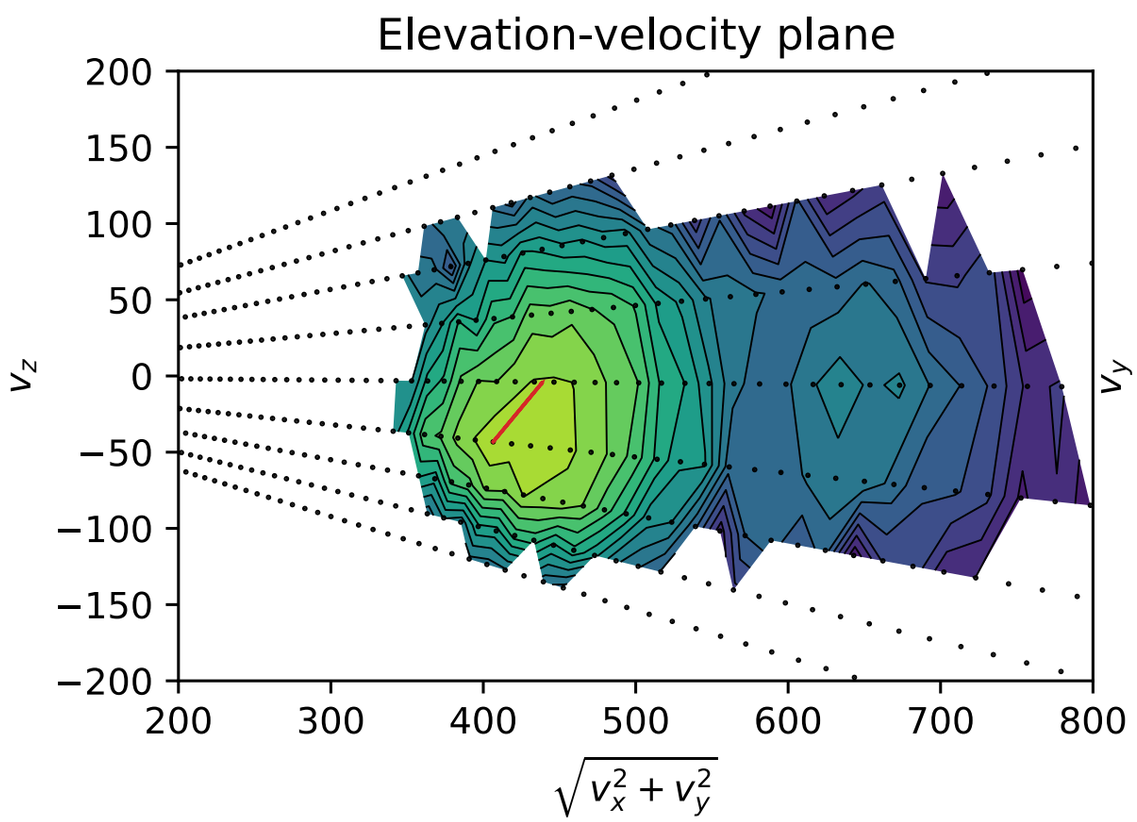
Fitting

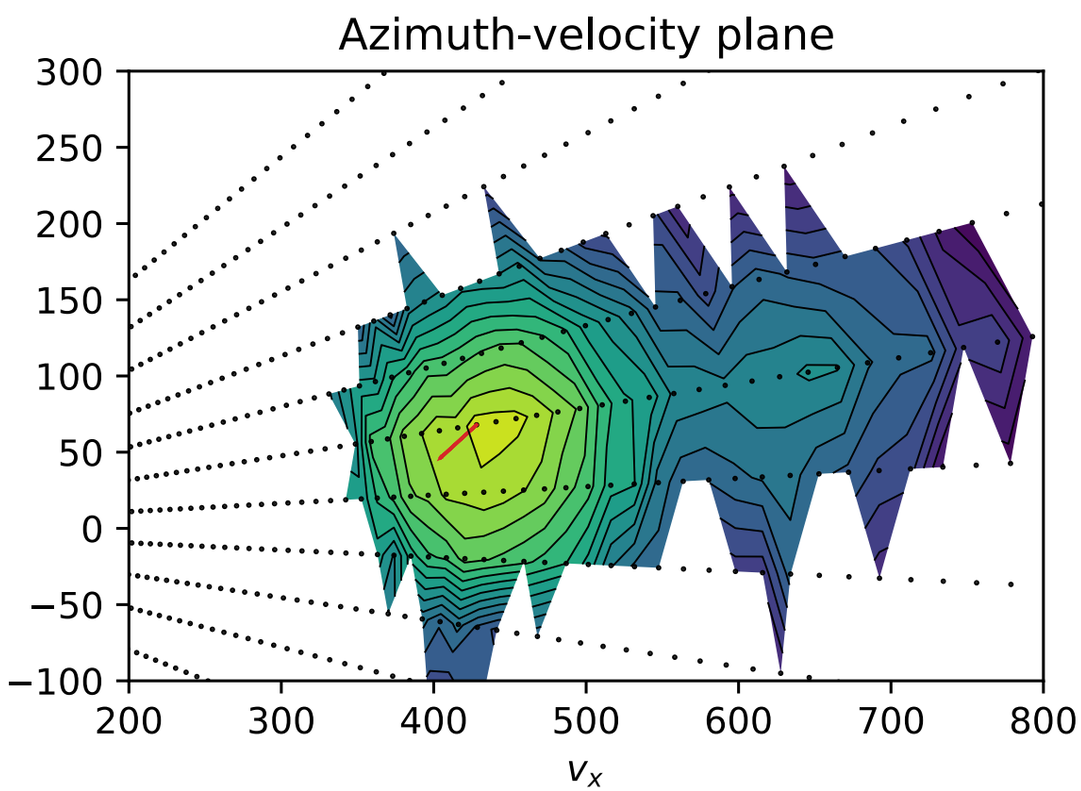
- Take L2 PAS distribution functions + L2 MAG vectors
- Rotate into field aligned frame
- Fit **n, v_x, v_y, v_z, T_{perp}, T_{par}**

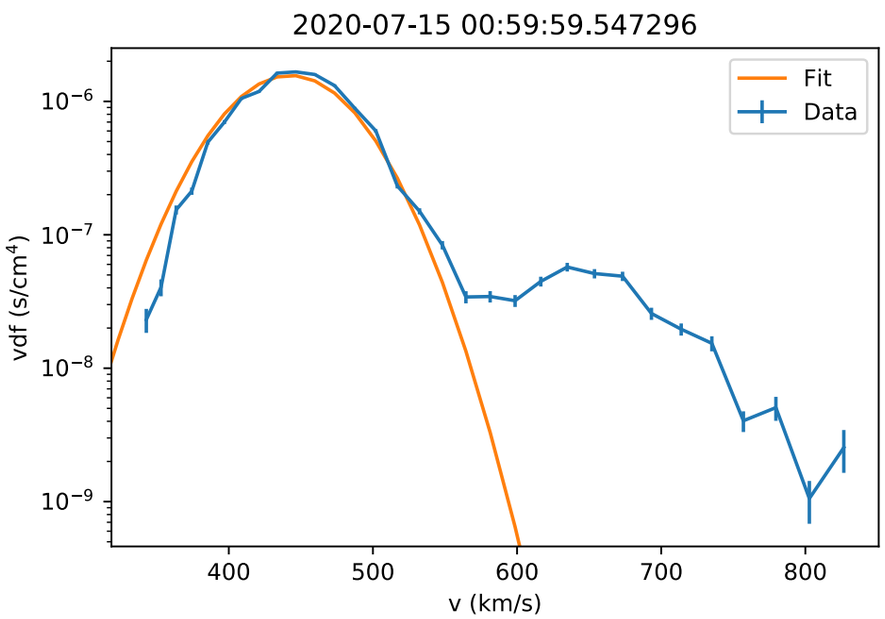
$$f_{\mathrm{fit}}(v_{\parallel}, v_{\perp 1}, v_{\perp 2}) = \underline{A} \cdot \exp - \left\{ \left(\frac{v_{\parallel} - \underline{u}_{\parallel}}{\underline{w}_{\parallel}} \right)^2 + \left(\frac{v_{\perp 1} - \underline{u}_{\perp 1}}{\underline{w}_{\perp}} \right)^2 + \left(\frac{v_{\perp 2} - \underline{u}_{\perp 2}}{\underline{w}_{\perp}} \right)^2 \right\}.$$

- Done for all distributions with public MAG data (2nd half of 07/2020)

~Fast example

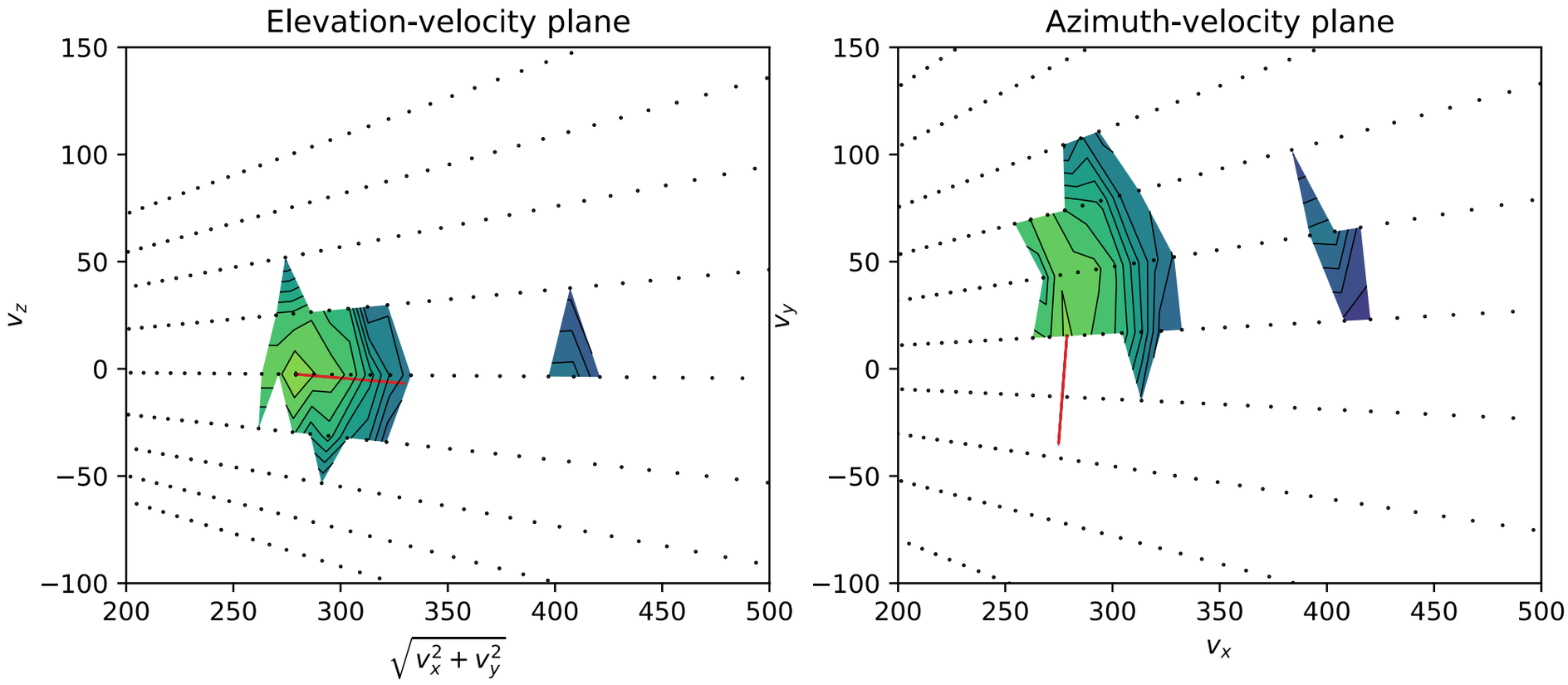


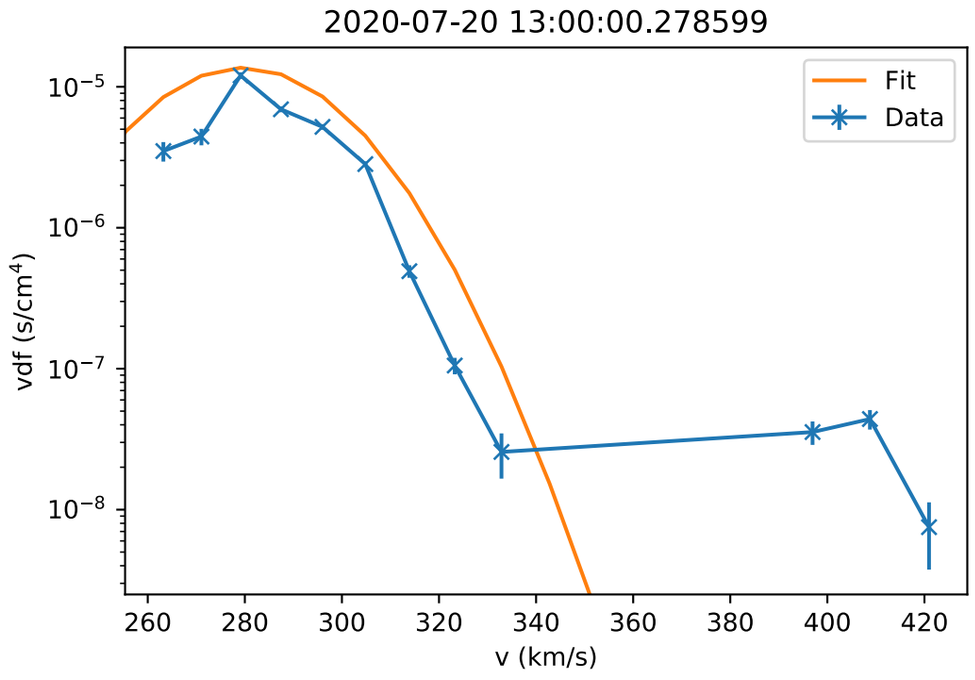





```
A = 1.690459e-08 s3 / m6
n = 15.51 1 / cm3
v = [-434.78941796   54.90008874   28.49262148] km / s
v_par = 52.32 km / s
v_perp = 56.13 km / s
```

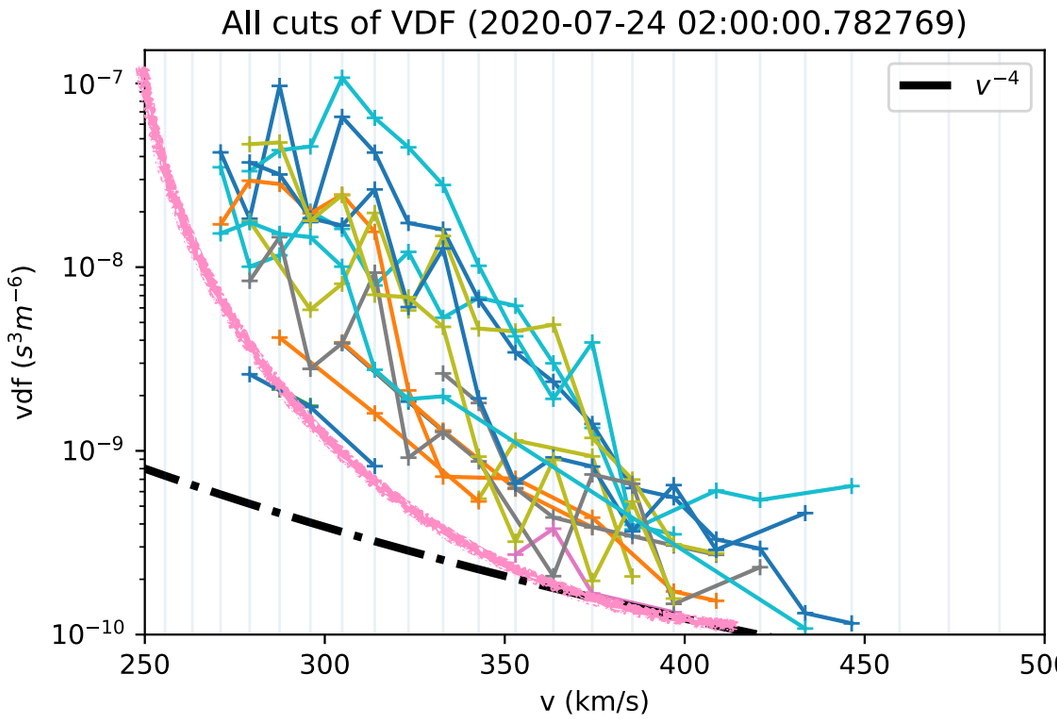
Slow example





- Relatively few points to fit to
- Very sensitive to (mis) calibration of elevation bins

Low speed cutoff

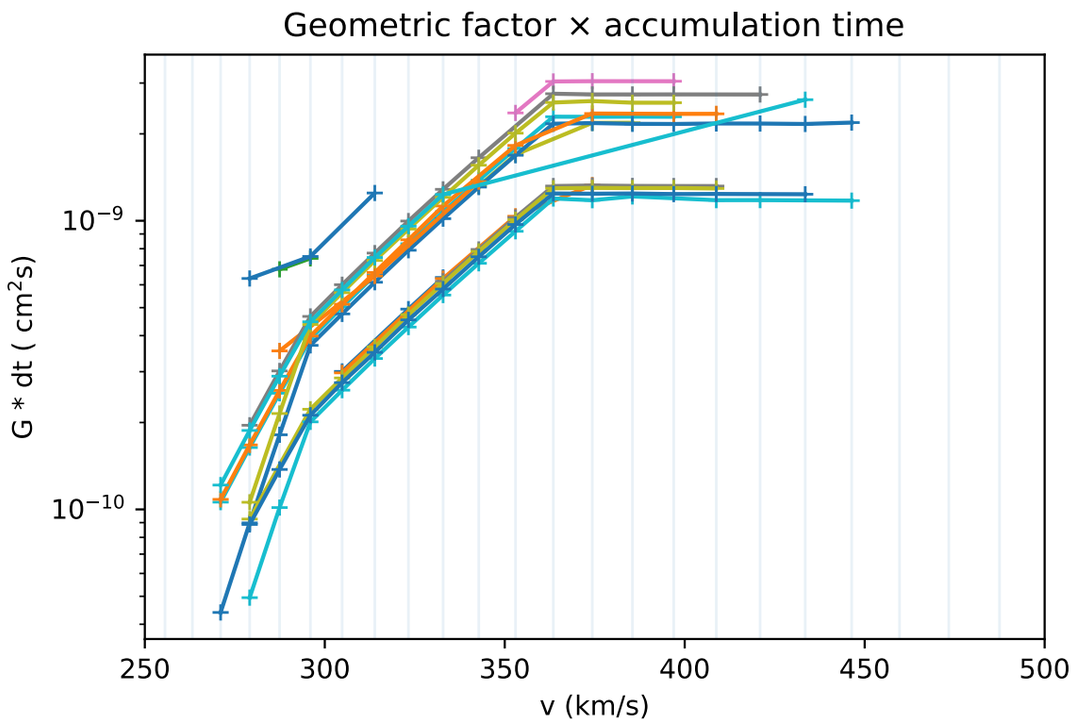


$$vdf\left(\mathbf{v}\right) = \frac{2}{\left|\mathbf{v}\right|^4}\frac{1}{G\left(\mathbf{v}\right)Q\left(\mathbf{v}\right)}C\left(\mathbf{v}\right)$$

Speed

Counts

Geometric factor, detection efficiency

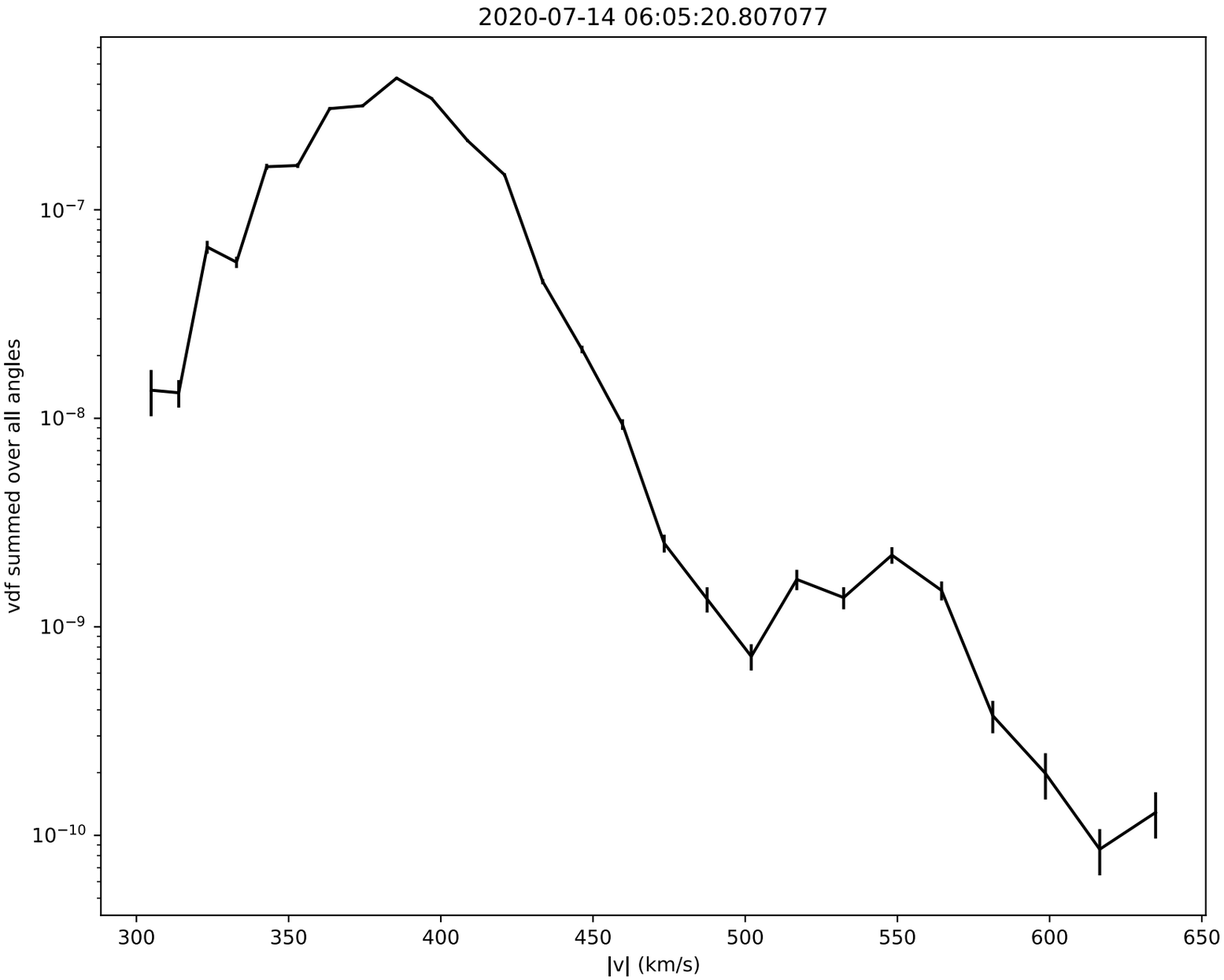


$$\frac{vdf \cdot v^4}{2C} = \frac{1}{GQ}$$

The “detector efficiency” falls off steeply below 350 km/s

Challenging to constrain bi-Max fits at low velocities

Sawtooth effect



- Distributions are not smooth
- Plotting even (odd) bins is better
- A feature/bug of deflector particle instruments? (cf. EAS, PSP SPAN-e, MMS)

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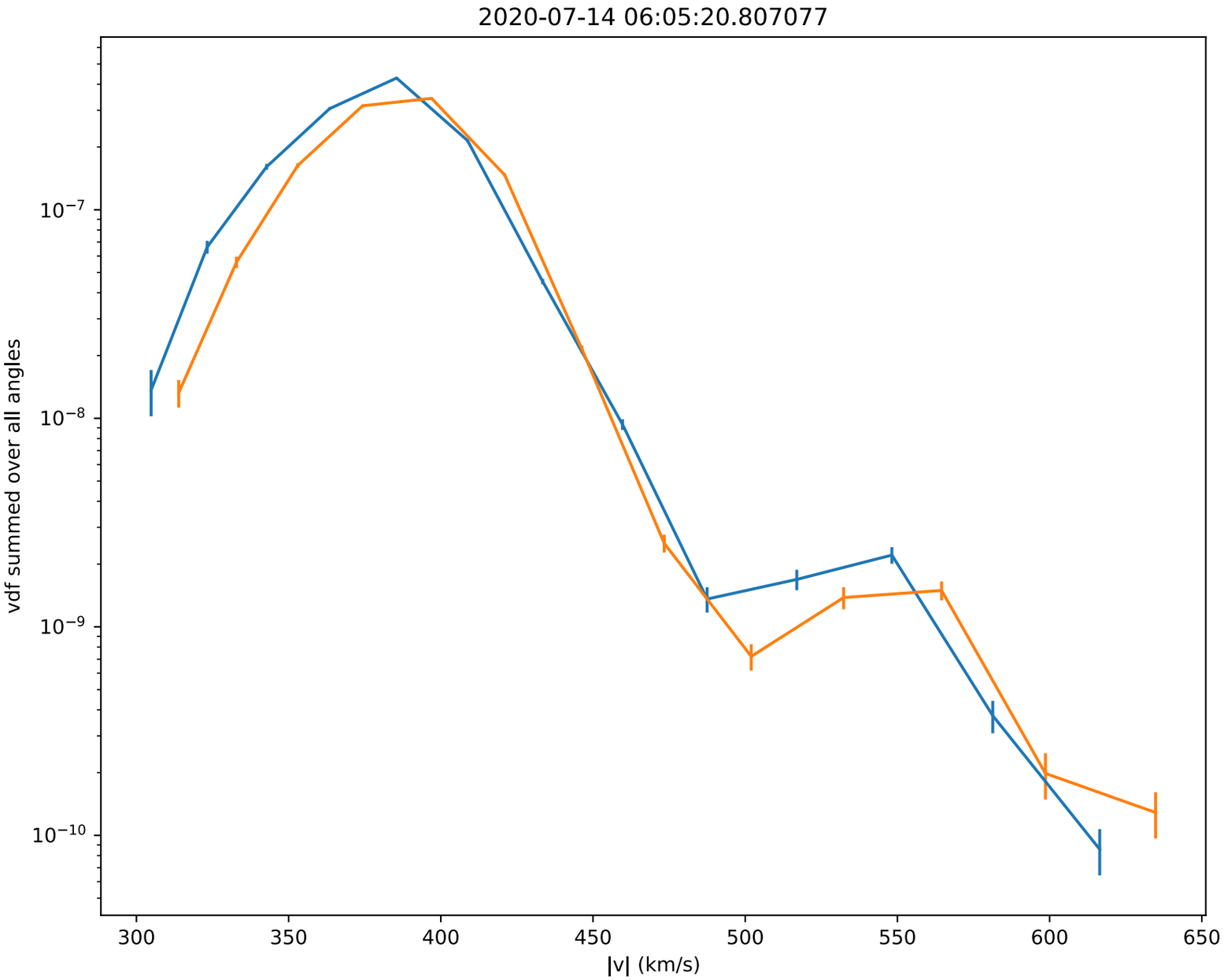

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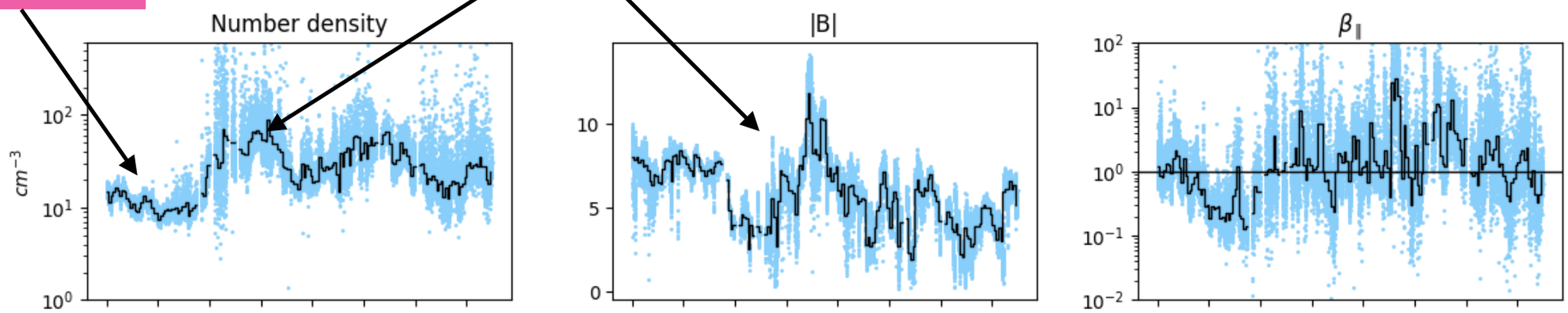
Timeseries (~0.7 AU)

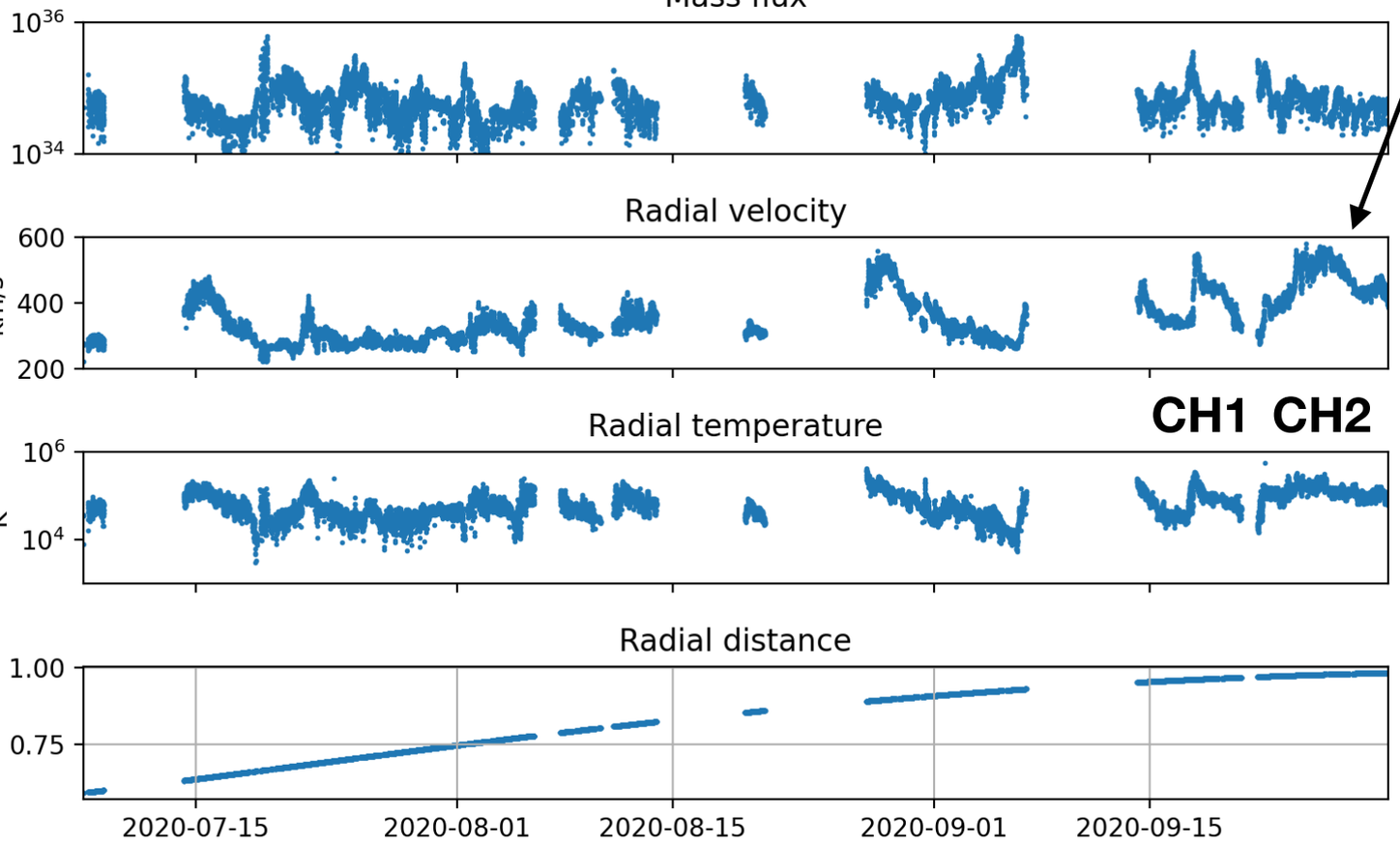
Fitting better in fast wind

CIR

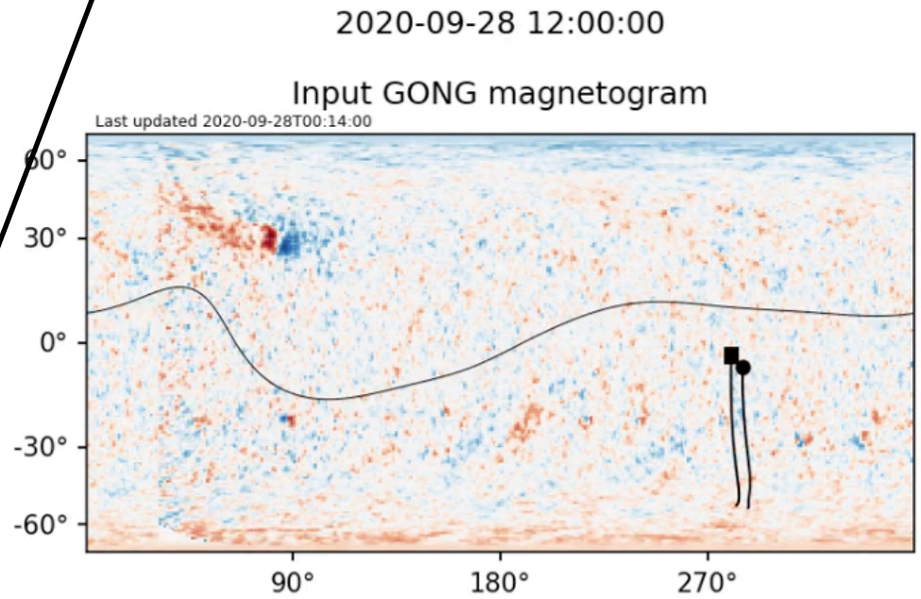
T-v relation

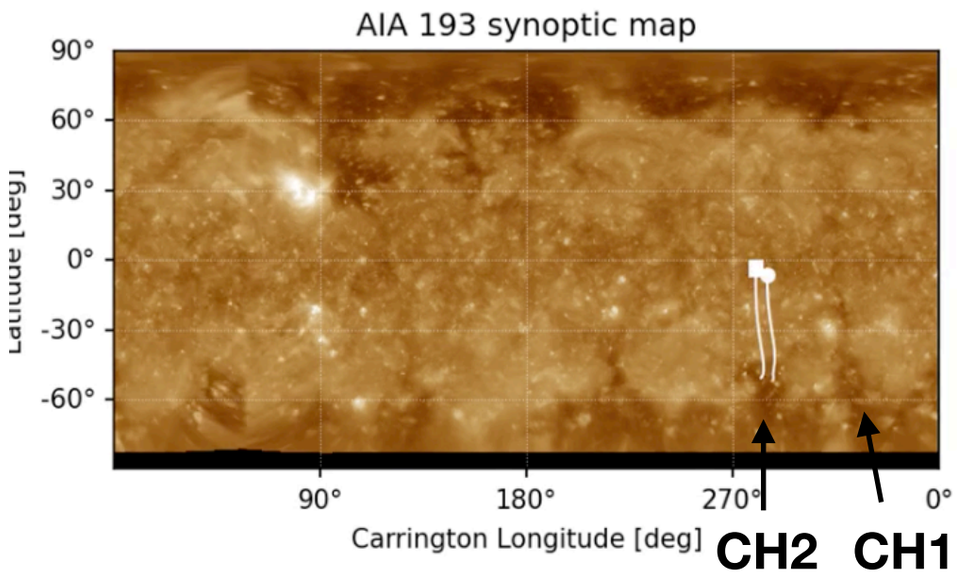


Science thoughts



PSP/SolO CH lineup





● Solar Orbiter r = 0.979 AU
■ PSP r = 0.109 AU

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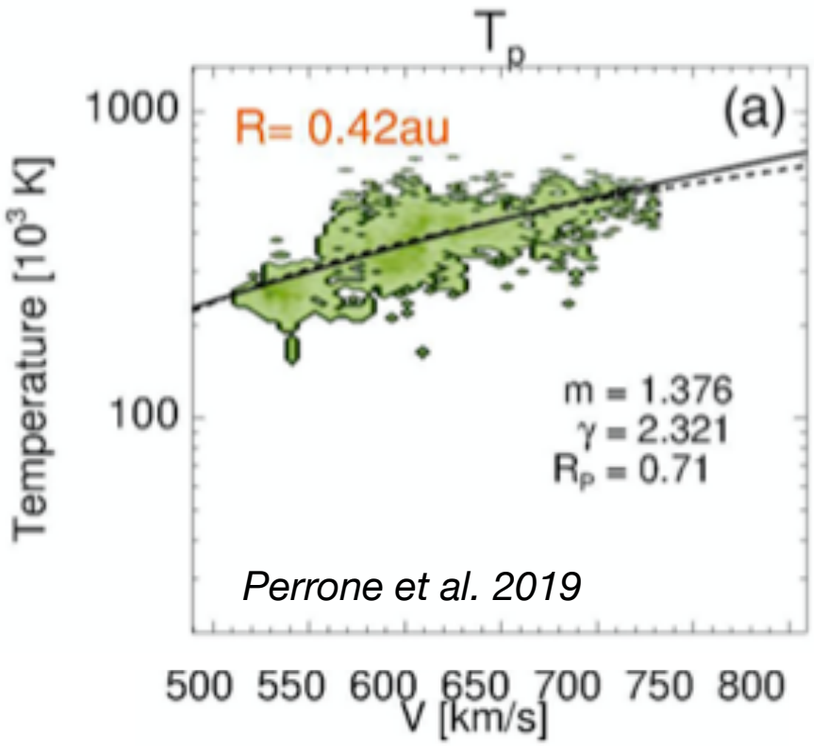
Science thoughts

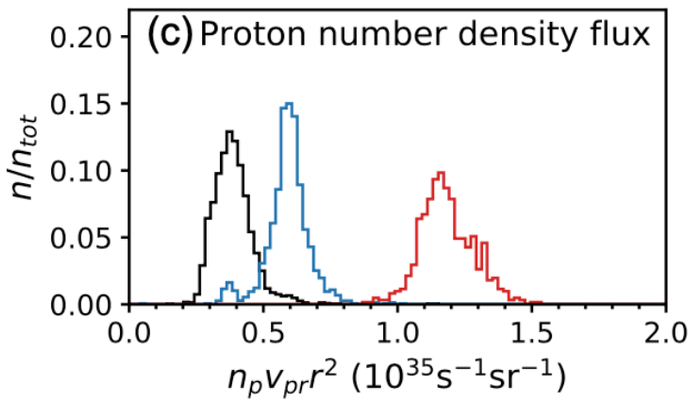
UCL

Solar wind differences over 50 years

(comparing to Helios)

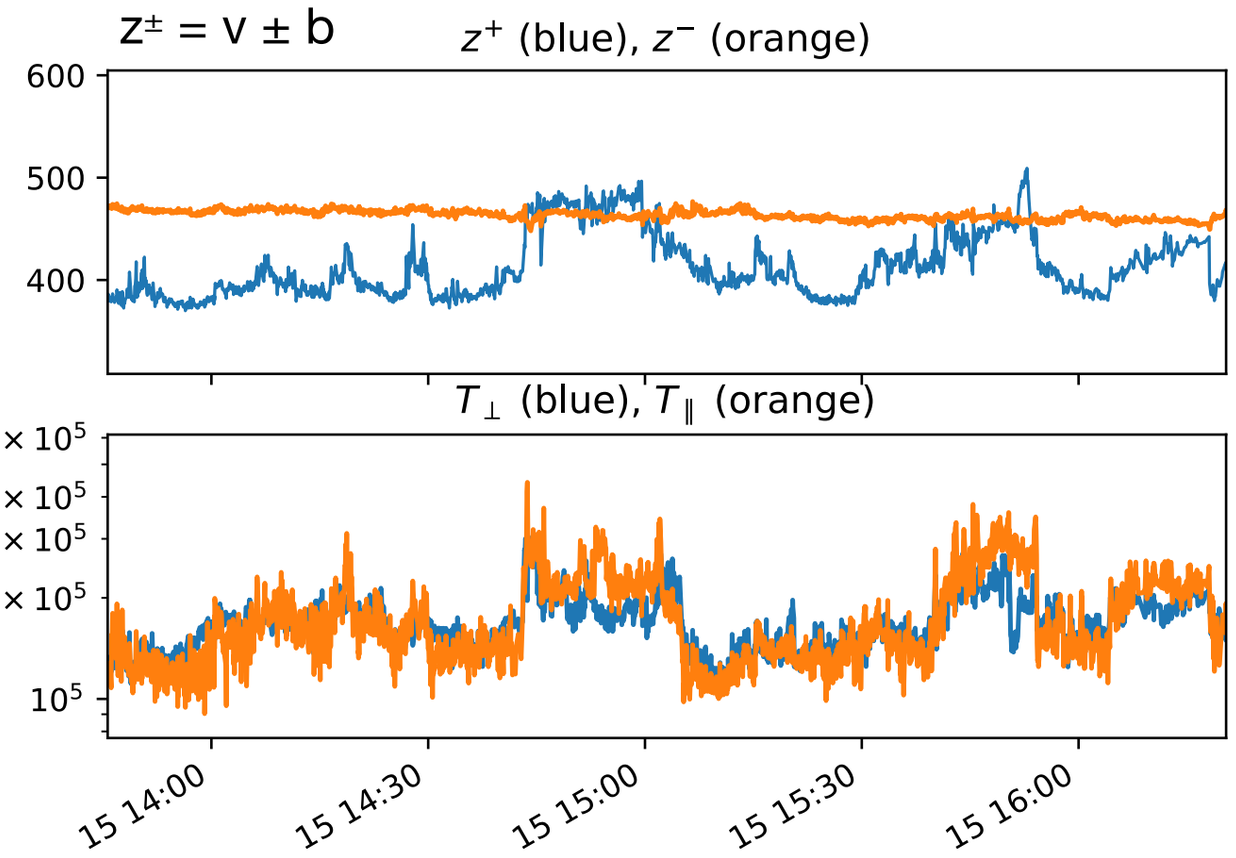


Perrone et al. 2019

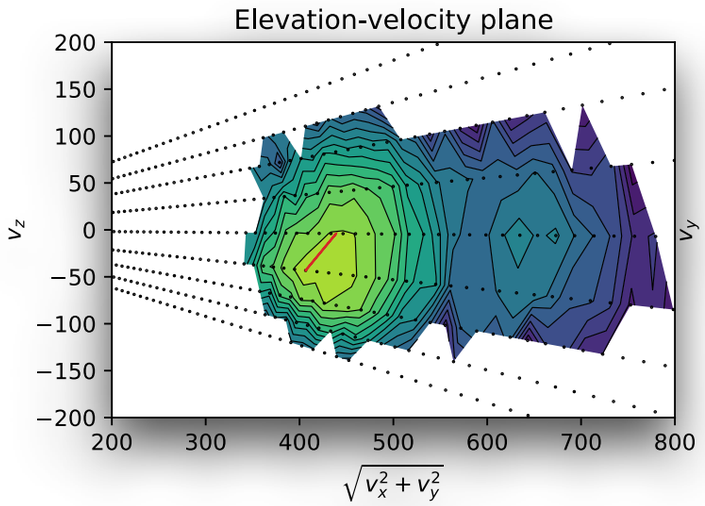


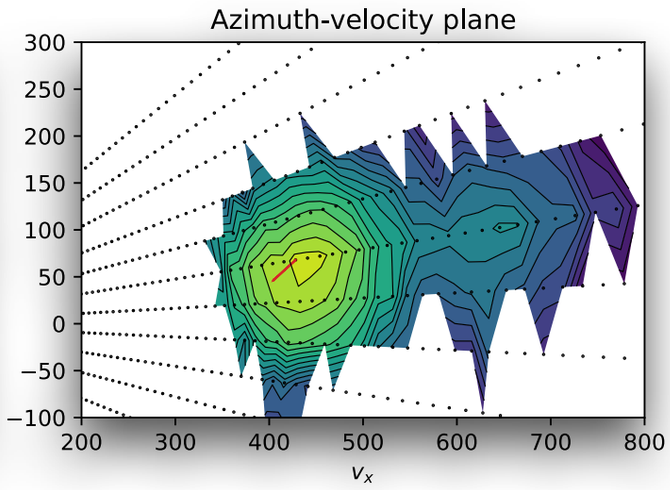
Stansby et al. 2020

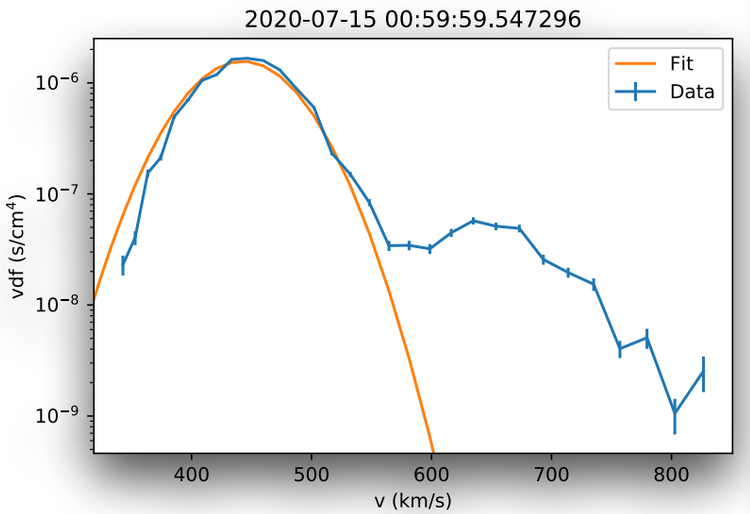
Small scale switchback properties (+ turbulence)



Summary







- bi-Maxwellian fitting working well for fast (> 350 km/s) wind
- Fits will improve with elevation bin calibration
- I will work on comparison to Helios
- Happy to share fits & collaborate with others

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