

Pickup Ion Transport Effects? Challenges in the Determination of the Interstellar Flow Longitude Using the Pickup Ion Cutoff

Andreas Taut¹, Lars Berger¹, Christian Drews¹,
Duncan Keilbach¹, Eberhard Möbius², Martin A. Lee²

¹Institut für Experimentelle und Angewandte Physik, CAU Kiel

²Institute for the Study of Earth, Oceans, and Space, University of New Hampshire

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Outline

Pickup Ions

- Pickup Ion VDF

Determining the Interstellar Flow Longitude

Results

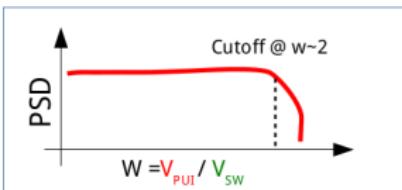
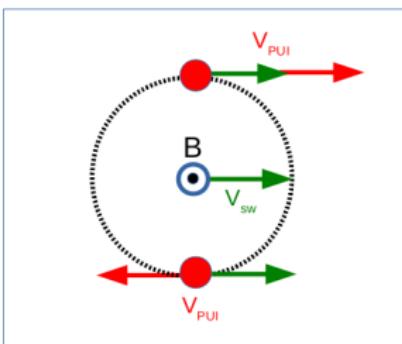
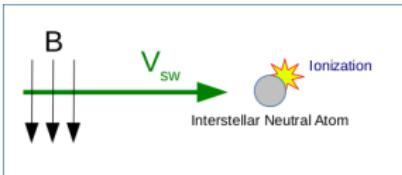
- Dependence on IMF configuration

- PUI Transport Effects

- PUI Torus Effects

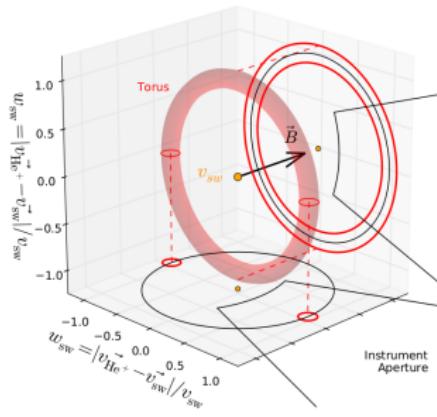
Conclusion & Outlook

PickUp Ions (PUIs)

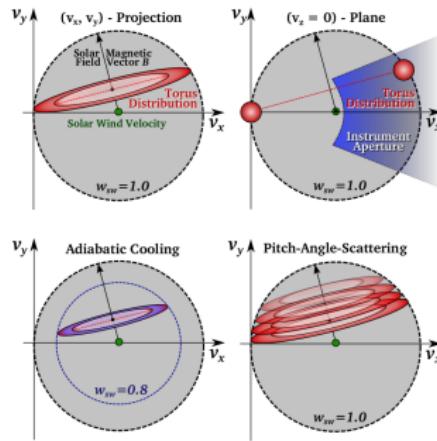


- ▶ created from neutral atoms in the heliosphere
 - ▶ originating from interstellar medium
→ interstellar PUIs
 - ▶ originating in the inner heliosphere
→ inner-source PUIs
- ▶ can be identified by:
 - ▶ low charge state
 - ▶ characteristic VDF
 - ▶ density pattern
- ▶ picked up and swept outward by IMF embedded in the solar wind

PUI VDF

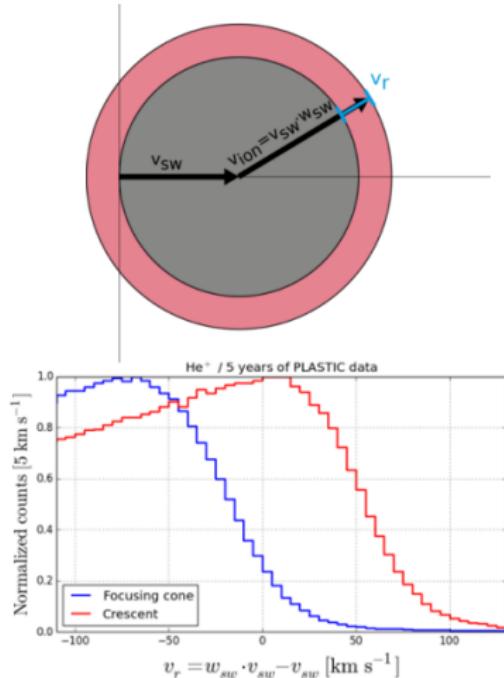
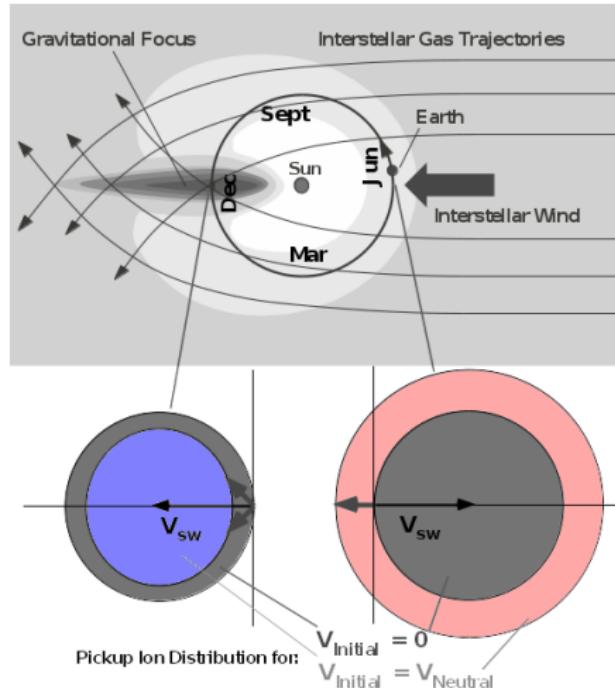


- Gyration about IMF
→ torus in velocity space
- torus inclination depends on IMF configuration



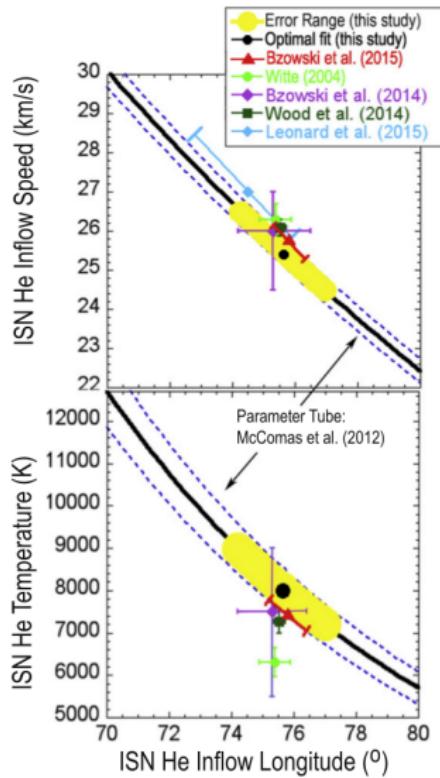
- PLASTIC's aperture covers only part of velocity space
- modification by cooling and pitch-angle scattering

Determining the Interstellar Flow Longitude



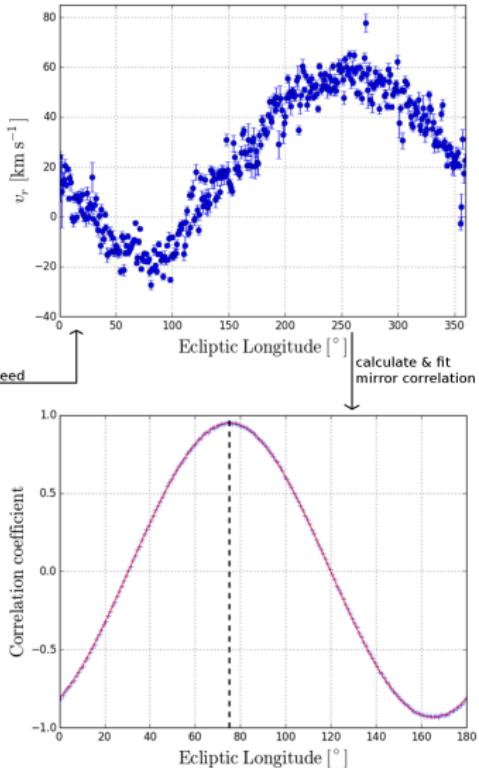
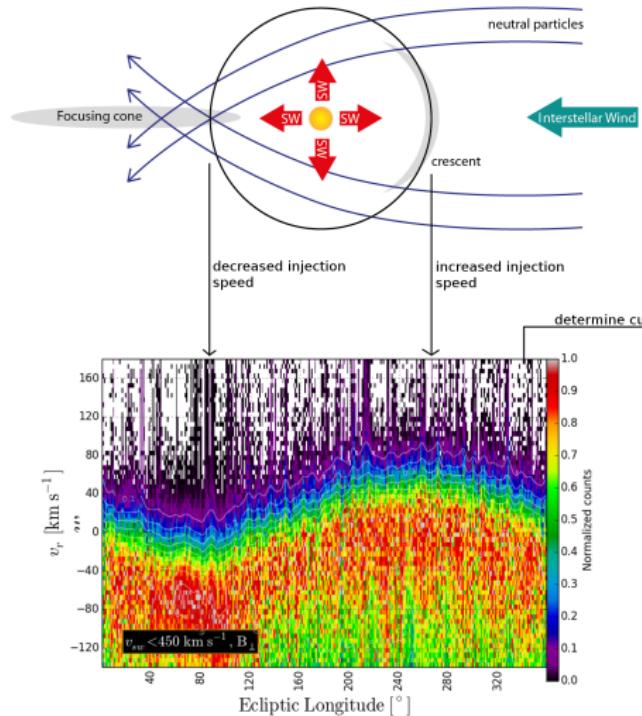
Motivation

- ▶ Neutral particle measurements by IBEX yield a 4-dimensional parameter tube for LISM:
Flow longitude, latitude, and speed + temperature
 - ▶ LISM parameters are crucial to understand the heliospheric structure.
 - ▶ An independent measurement of the flow longitude tightens the parameter tube, thus defining LISM parameters more precisely.
- + understanding the evolution of PUI VDFs

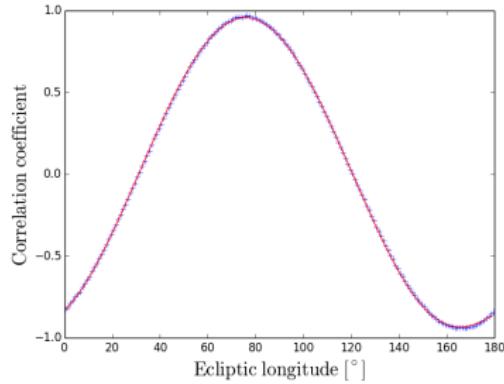
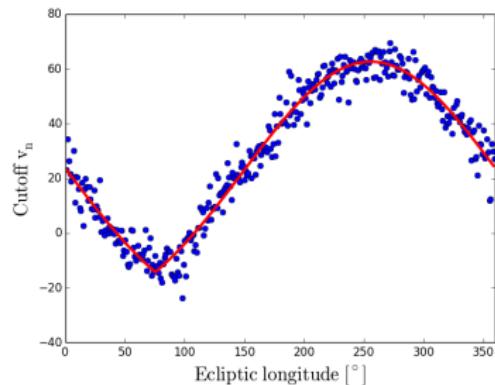


from Schwadron et al., 2015

Determining the Interstellar Flow Longitude



λ_{Flow} Determination Methods



Direct fit:

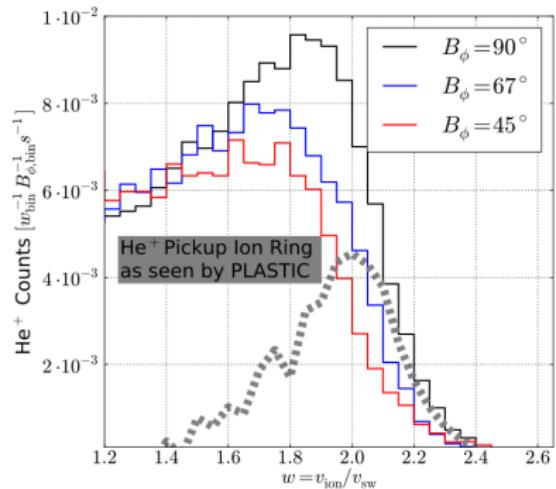
- ▶ 3 parameter fit
 - yields λ_{Flow} and v_{isn}
- ▶ incorporates non-circular orbit
- ▶ copes with data gaps

Fit of mirror-correlation:

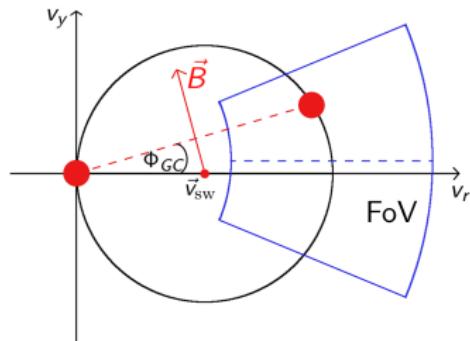
- ▶ fit with cos or polynomial
- ▶ model independent
- ▶ fails if there are data gaps

Differences in the result for λ_{Flow} scale with statistics, but generally $\Delta\lambda_{Flow} < \sigma_{Fit}$

IMF Restrictions



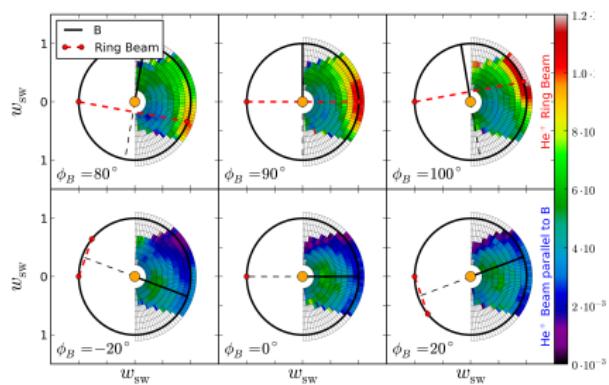
from Drews et al., 2013



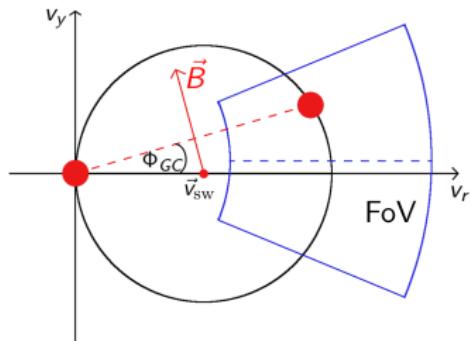
- ▶ $-15^\circ < \Phi_{GC} < 15^\circ$
- ▶ $-15^\circ < \Theta_{GC} < 15^\circ$

$$\rightarrow \lambda_{\text{flow}} = 75.89^\circ \pm 0.41^\circ$$

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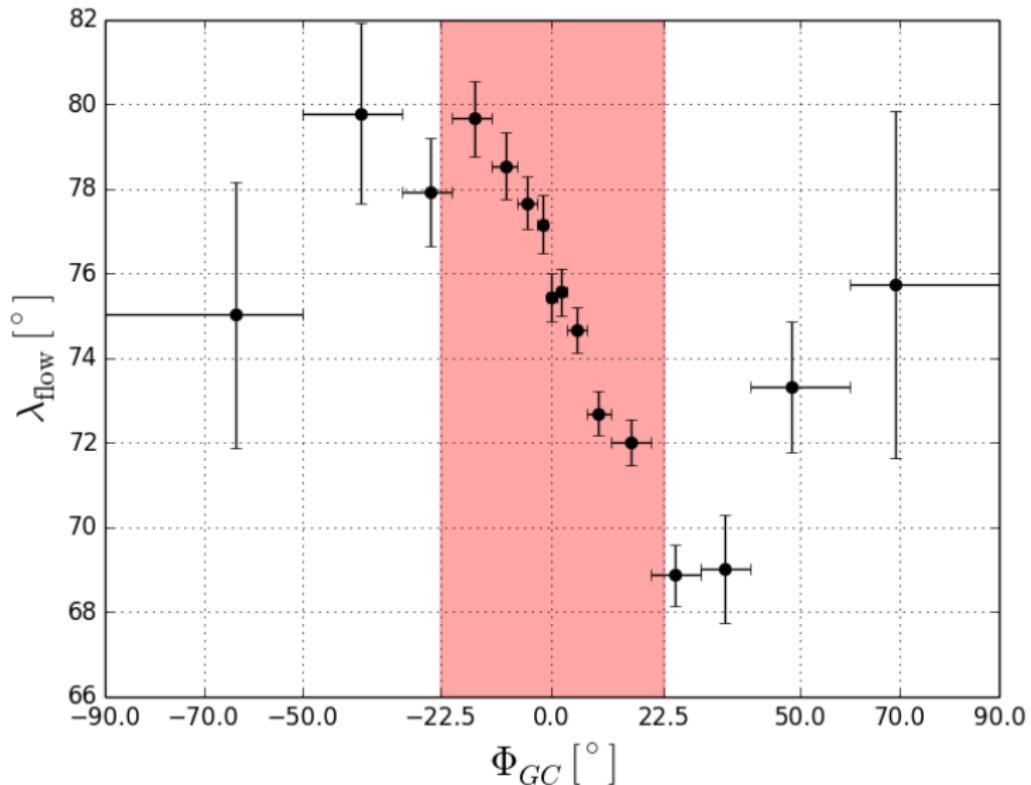
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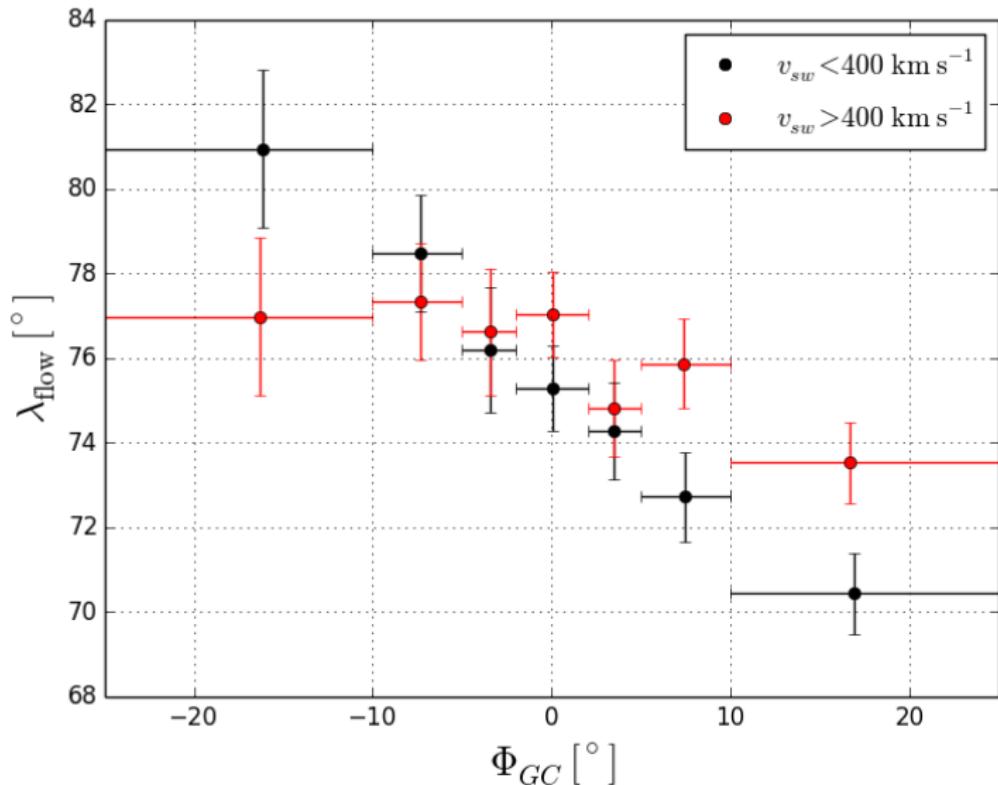
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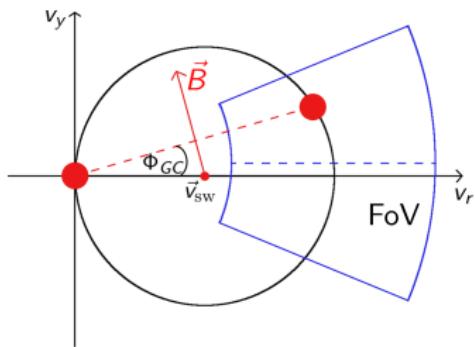
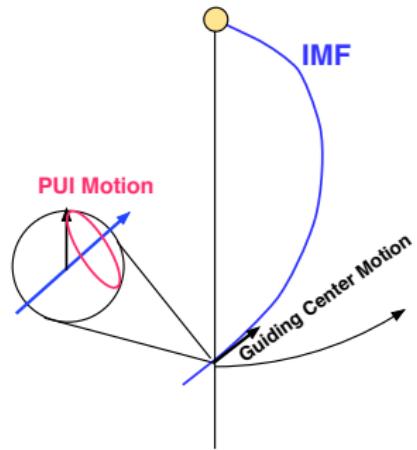
Dependence on IMF Configuration



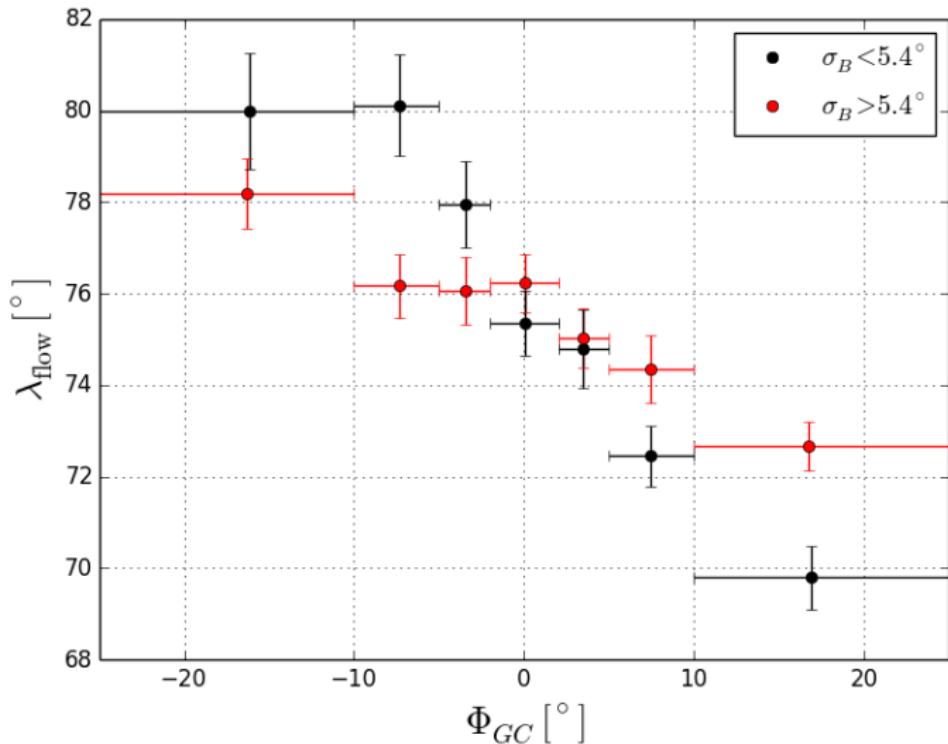
Dependence on v_{sw}



Pickup Ion Transport?

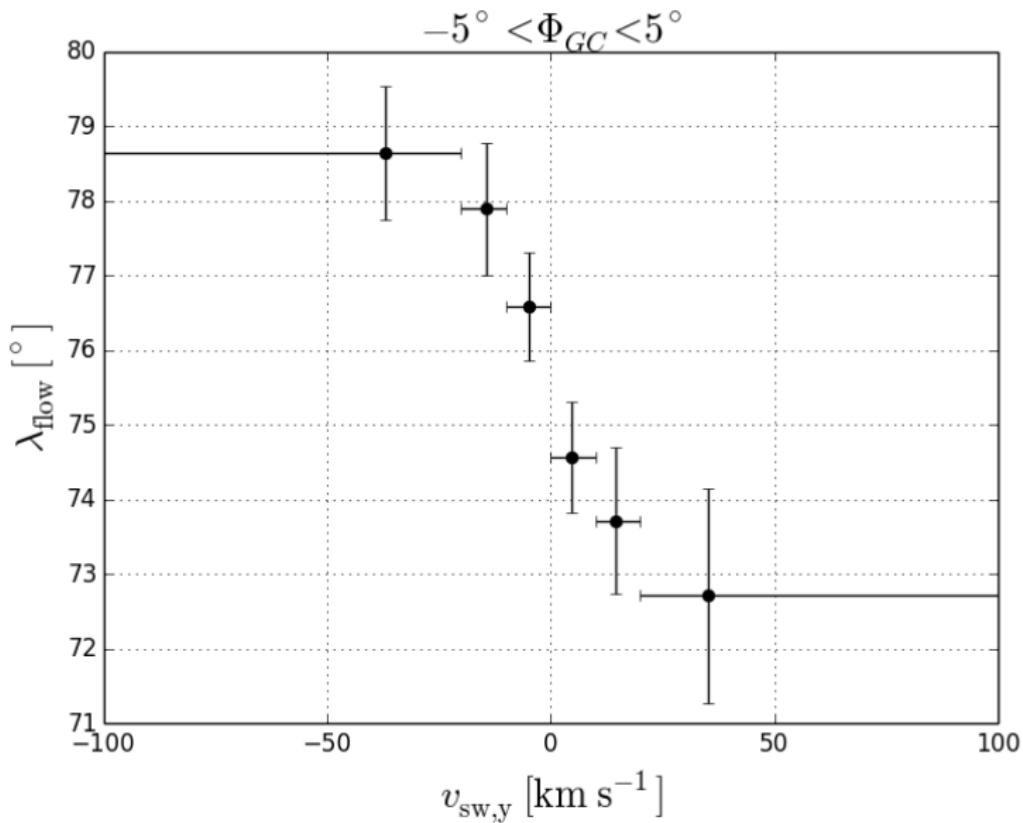


Dependence on IMF variability

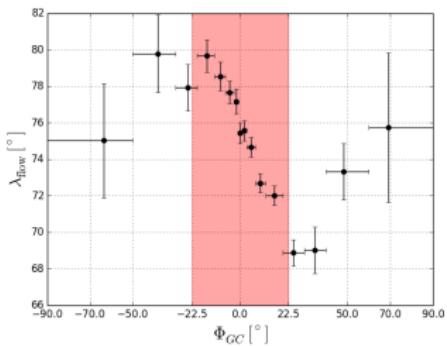
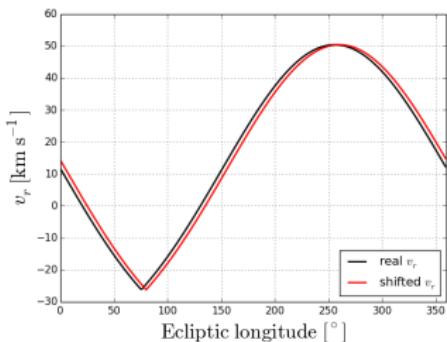
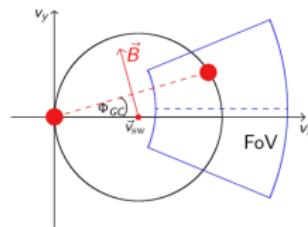
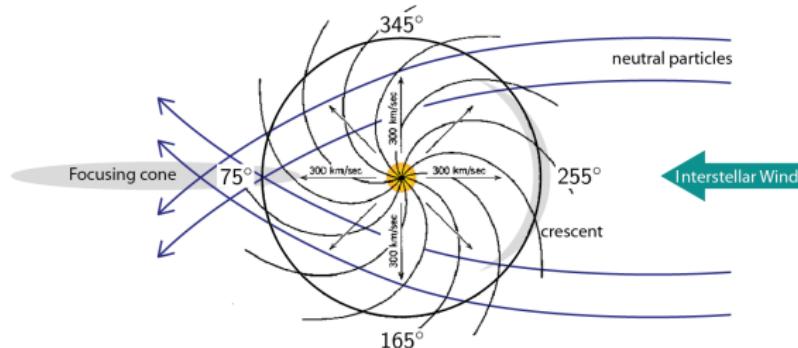


$$\sigma_B = \text{mean}(\triangleleft (\tilde{B}_i, \tilde{B}_{i+1}))_{\pm 15\text{min}}$$

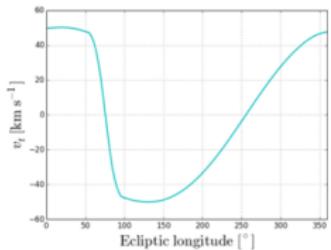
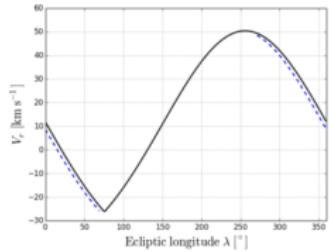
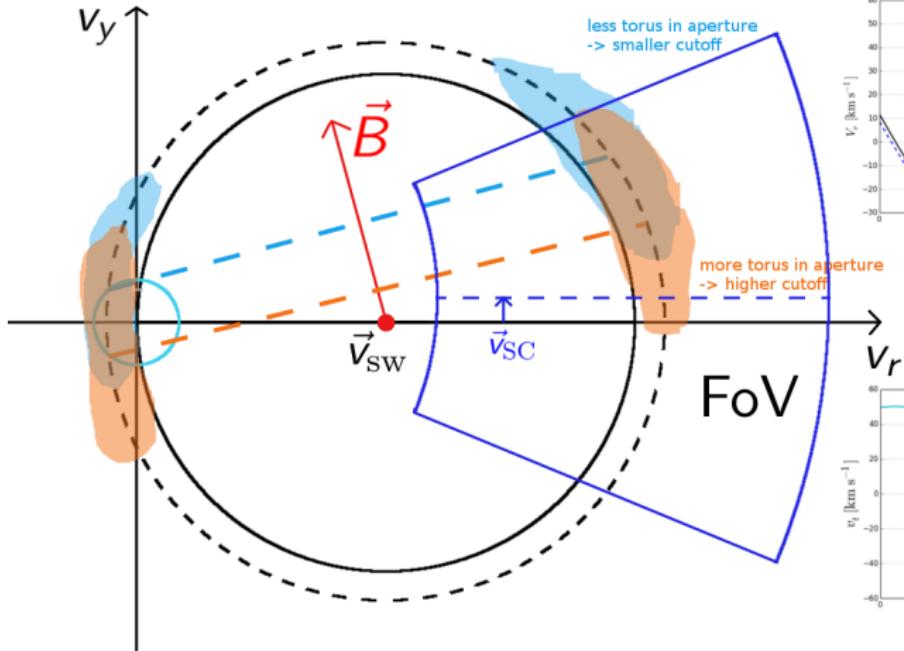
Dependence on $v_{\text{sw},y}$



PUI Transport Effects? → Direction!

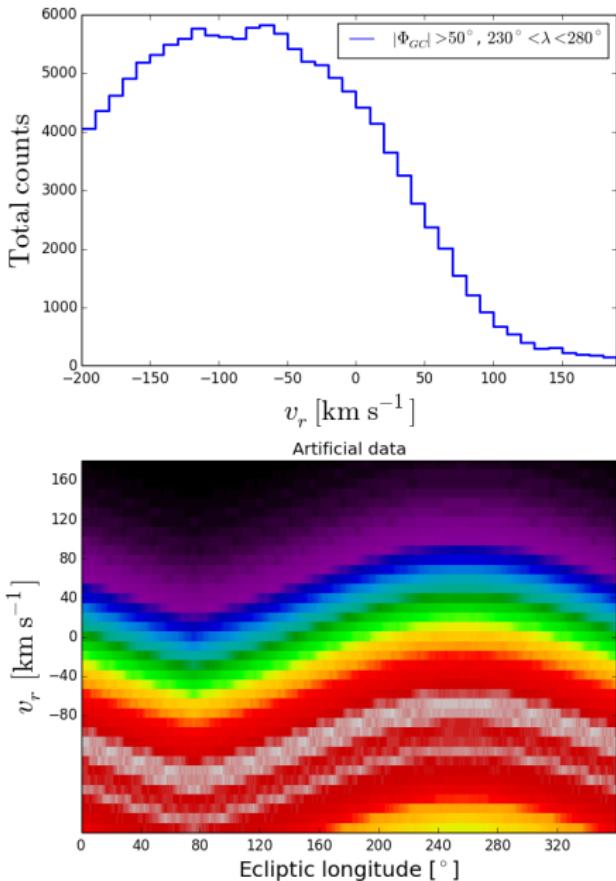


Another Explanation



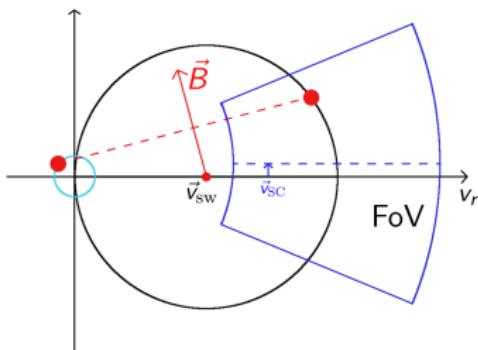
Toy Model

- ▶ Assume and create isotropic background for every λ
- ▶ Calculate torus position for every λ
- ▶ Calculate how much of torus is in aperture
- ▶ Multiply isotropic background with torus signature
- ▶ Perform analysis with this data set



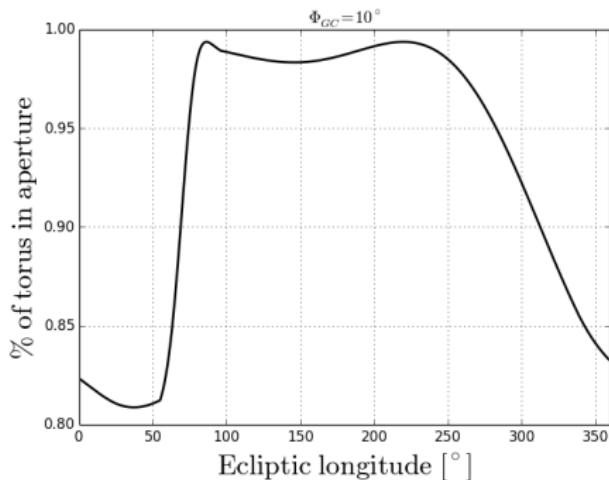
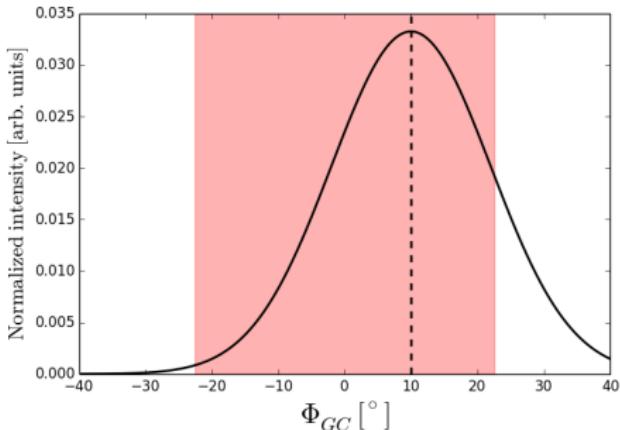
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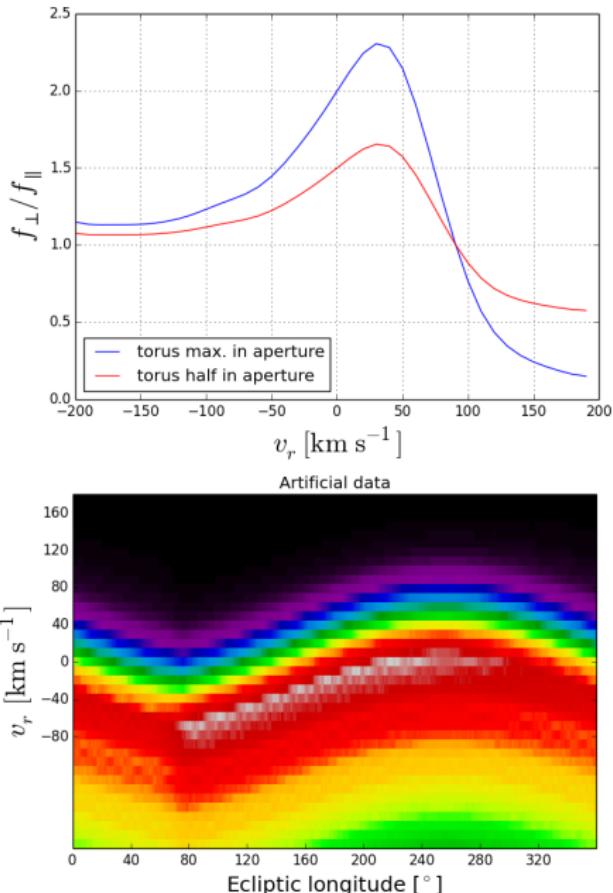
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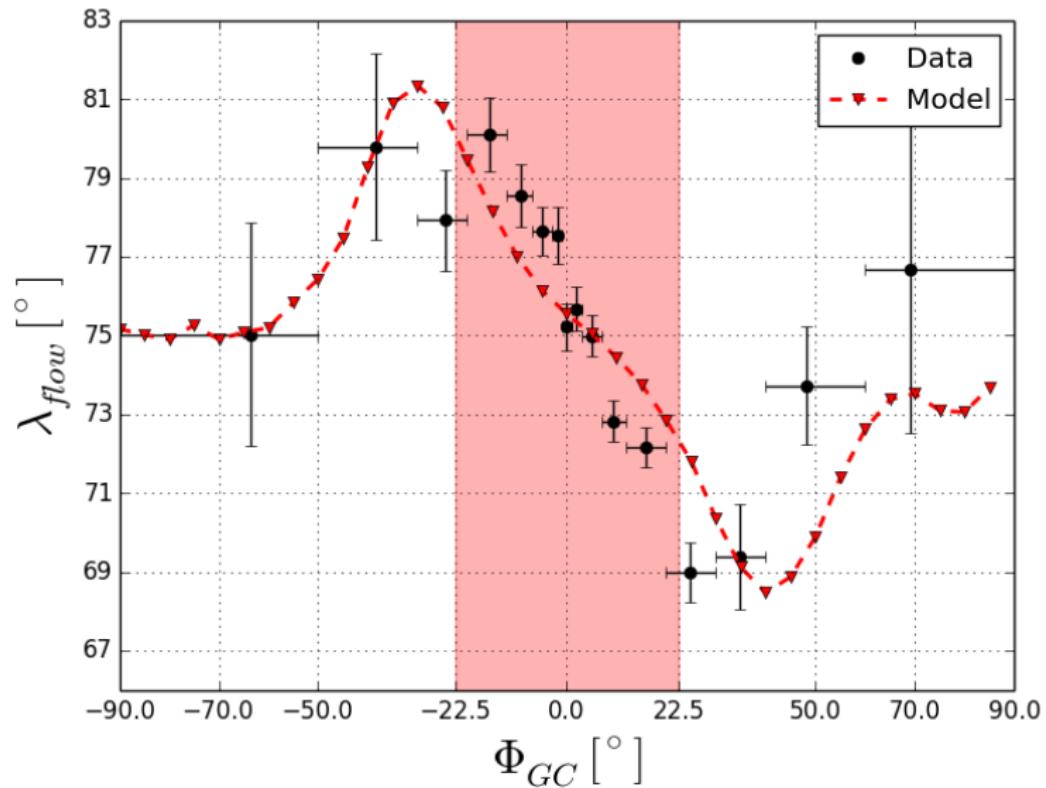


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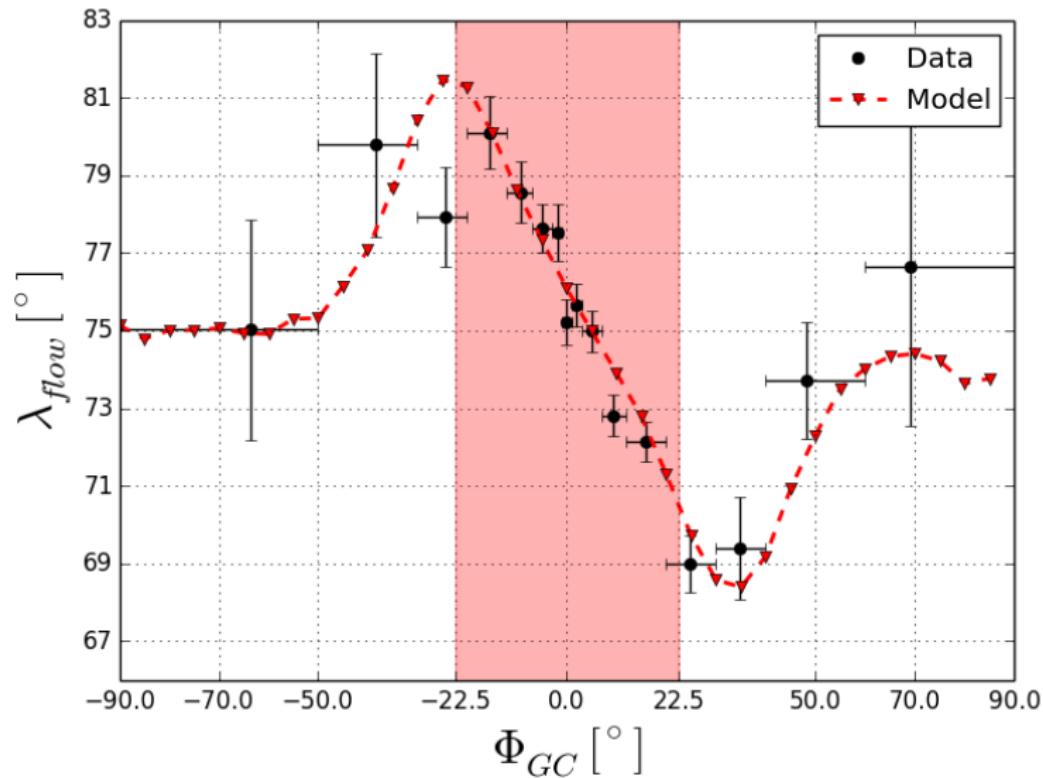


Data vs. Model



Model parameters: $v_{sw} = 350 \text{ km s}^{-1}$, $\lambda_{flow} = 75^\circ$, $\sigma_t = 12^\circ$, full aperture

Data vs. Model



Model parameters: $v_{sw} = 350 \text{ km s}^{-1}$, $\lambda_{flow} = 75 {}^{\circ}$, $\sigma_t = 12 {}^{\circ}$, aperture: $\pm 15 {}^{\circ}$

Conclusion & Outlook

Conclusion:

- ▶ The result for λ_{flow} from the PUI cutoff is systematically influenced by the choice of IMF configurations.
- ▶ strength of effect can be controlled by external parameters: v_{sw} , σ_B
- ▶ First hypothesis: transport effects → predicts opposed direction.
- ▶ New hypothesis: torus coverage depends on ecliptic longitude.

Outlook:

- ▶ What can we learn from this regarding the evolution of PUI VDFs?
- ▶ Can we use this knowledge to retrieve a precise value for λ_{flow} ?