

Velocity Distribution Functions of Pickup Ions with Ulysses/SWICS

Master Thesis Results

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November 19, 2019

Outline

Ulysses SWICS

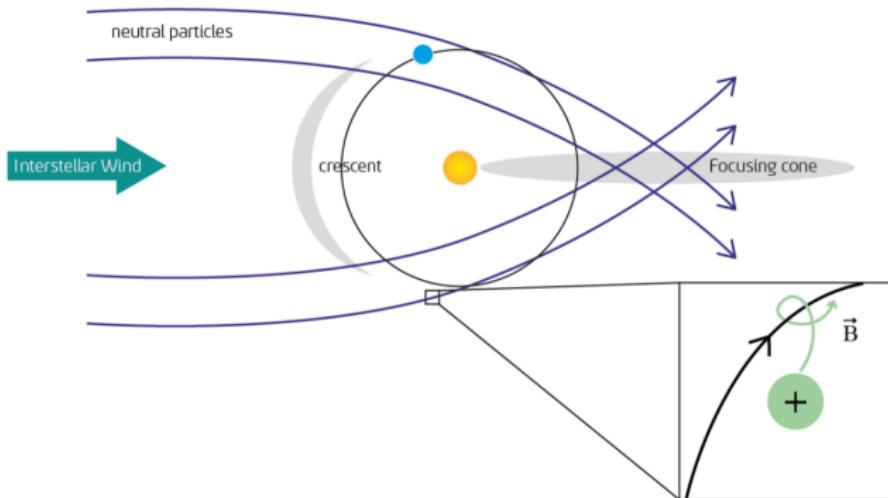
Principle of Measurement

Outlook & Conclusion

The Pickup Process

Pickup Ions:

Former neutrals that get ionised within the heliosphere



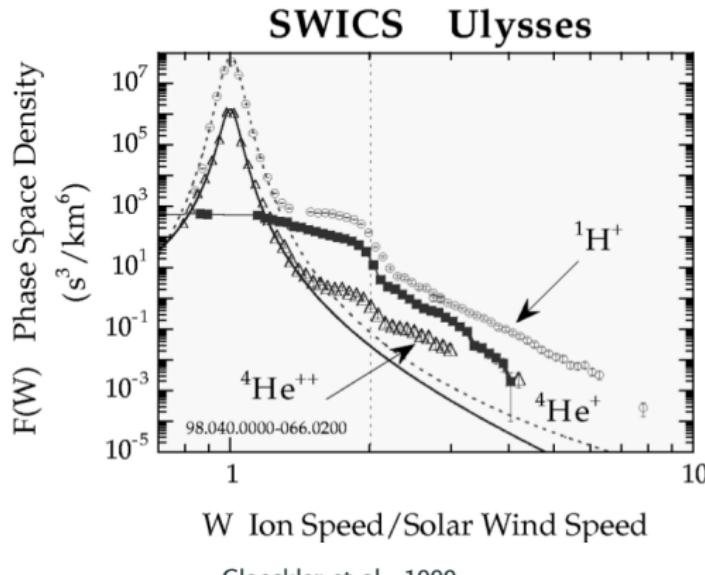
PUI – Measurement

Observed PUIs:

H^{1+} , ${}^3\text{He}^{1+}$, He^{1+} ,
 He^{2+} , C^{1+} , N^{1+} , O^{1+} ,
 Ne^{1+} , Mg^{1+} , Si^{1+} , Fe^{1+}

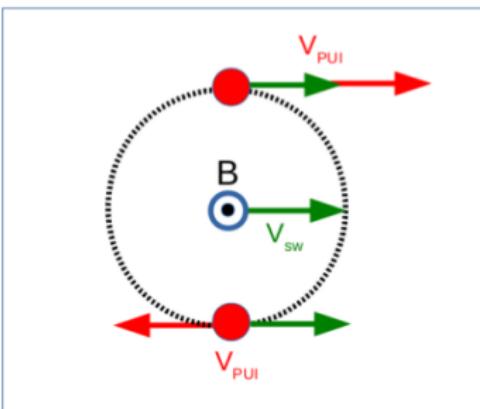
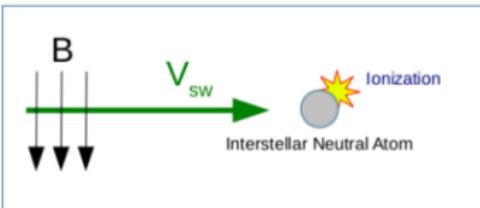
PUI or Solar Wind?

- Charge state
- Velocity distribution function (VDF)

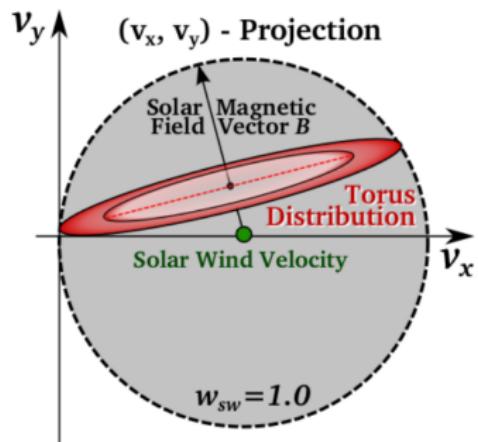


Gloeckler et al., 1999

The Pickup Process



Velocity Space:

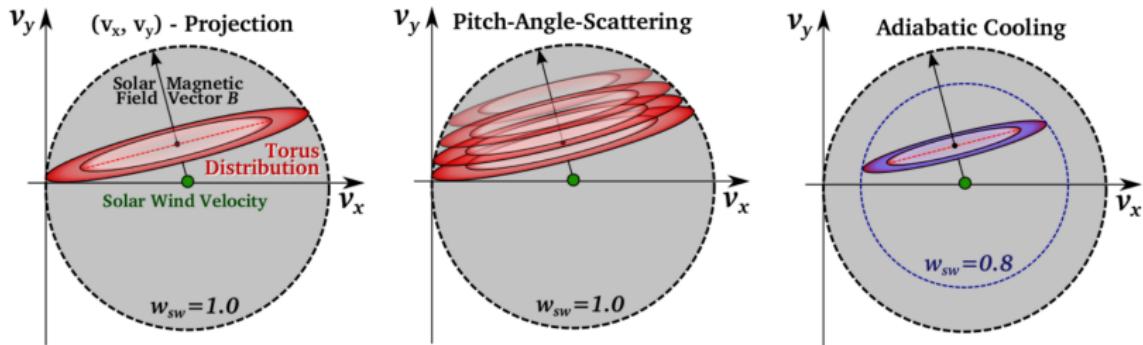


Drews et al., 2016

Taut, Drews et al., AGU Fall Meeting 2014

→ Anisotropic torus VDF

Evolution of the VDF

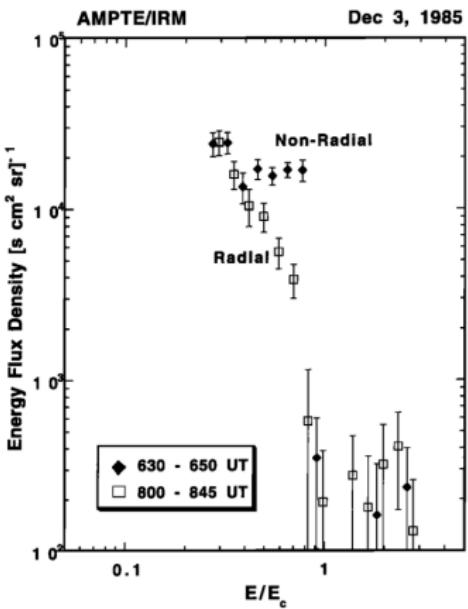


Drews, Berger et al., 2016

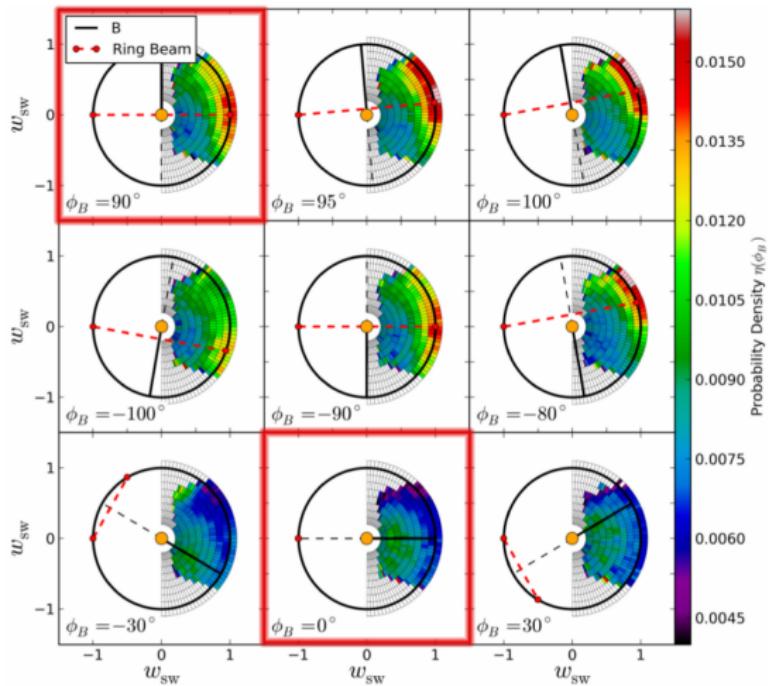
Modification of the initial torus-shaped VDF by:

- Pitch-angle scattering
→ isotropisation
- acceleration & deceleration

Anisotropic features of the VDF



Moebius et al., 1998



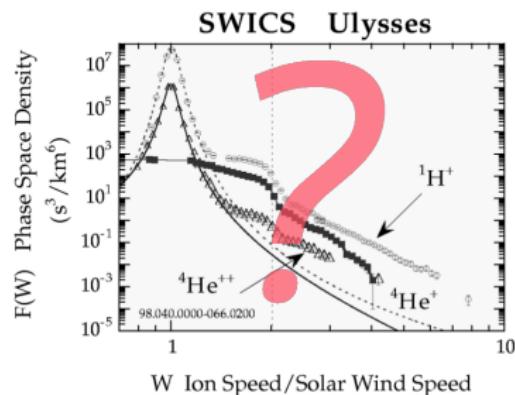
Drews, Berger et al., 2015

Motivation

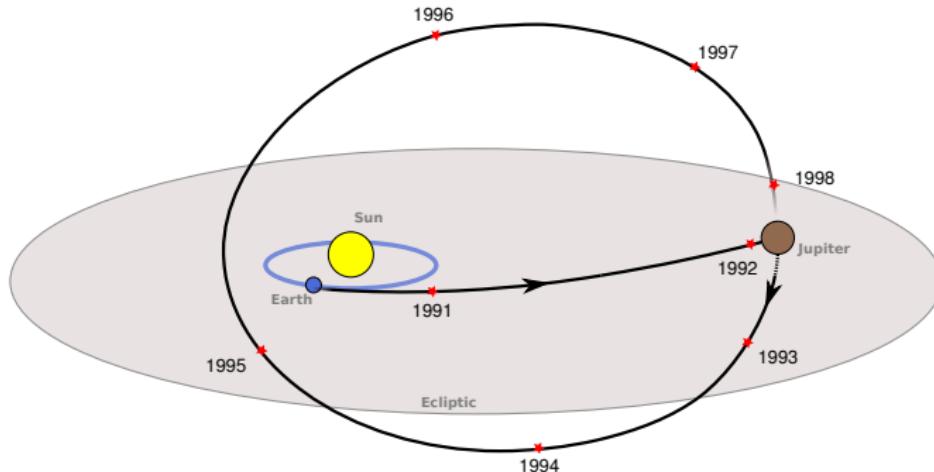
Problem:

Ambiguity of 1D reduced data

For fully understanding the
PUI transport in phase space
we need to analyse the **3D**
velocity distribution function

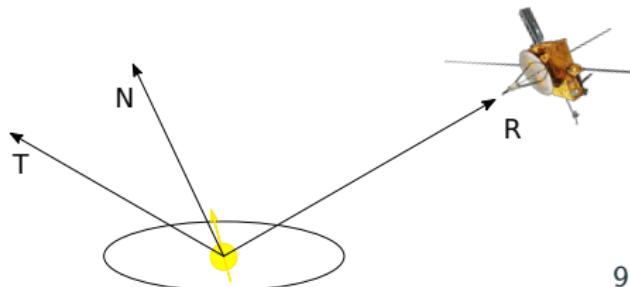


Ulysses Spacecraft (1990 – 2009)



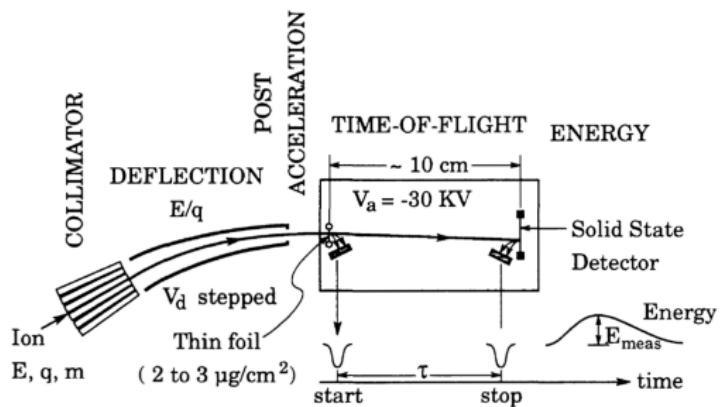
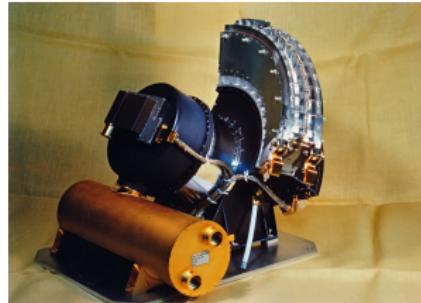
adapted from www.cosmos.esa.int, 2019

- Highly inclined orbit;
orbital period: 6.2 years
- spin-stabilized



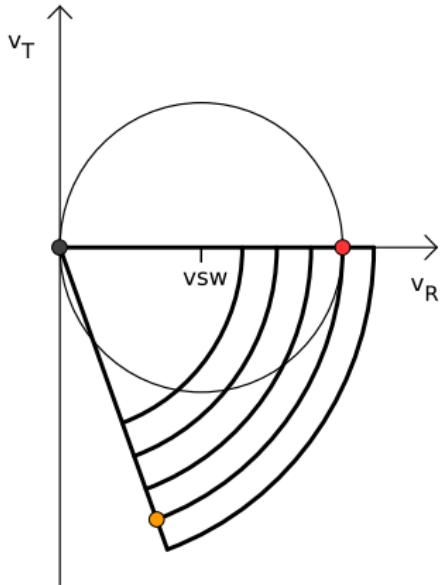
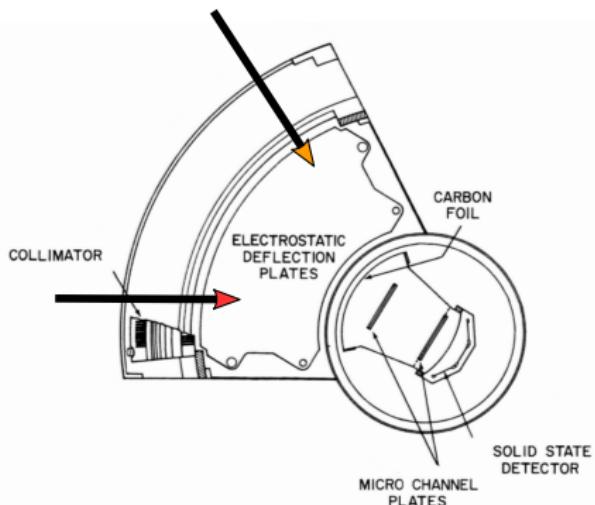
The Solar Wind Ion Composition Spectrometer

- Time-of-flight mass spectrometer
- $\left\{ \frac{E}{q}, T_{OF}, E_{SSD} \right\}$
 $\Rightarrow \left\{ \frac{M}{q}, M, |v| \right\}$
- identification & energy of the ion



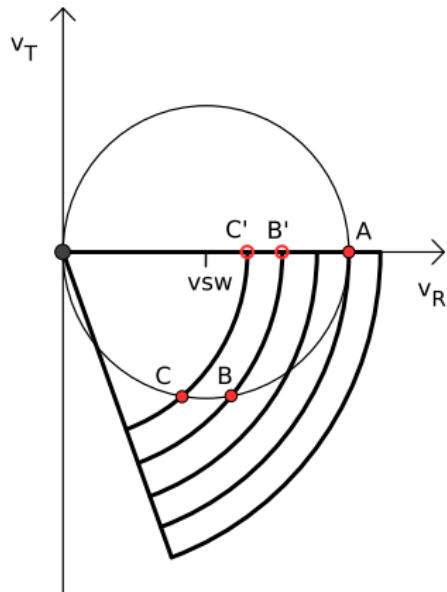
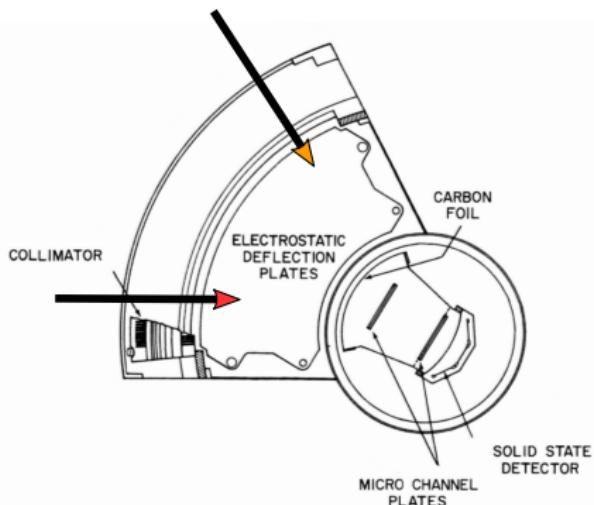
Gloeckler, Geiss et al., 1992

EpQ measurement



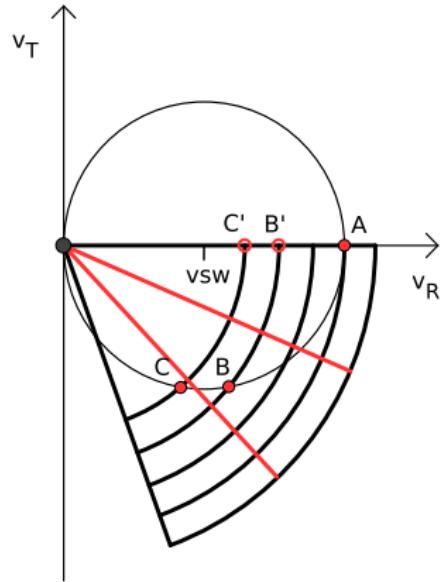
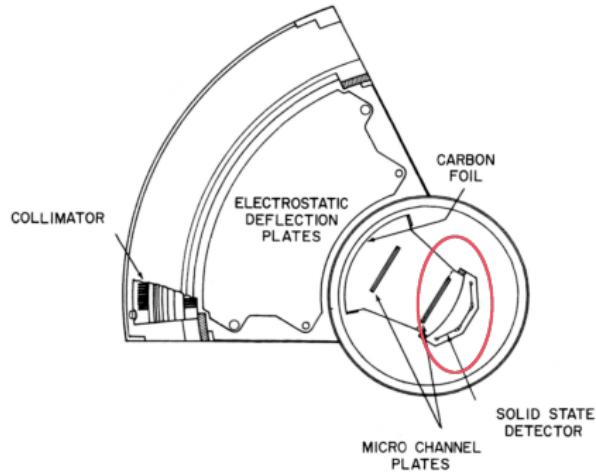
- For constant $\frac{m}{q}$: $\frac{E}{q}$ -step $\hat{=}$ absolute value of velocity
- Integration over EpQ shells \rightarrow loss of information!

EpQ measurement



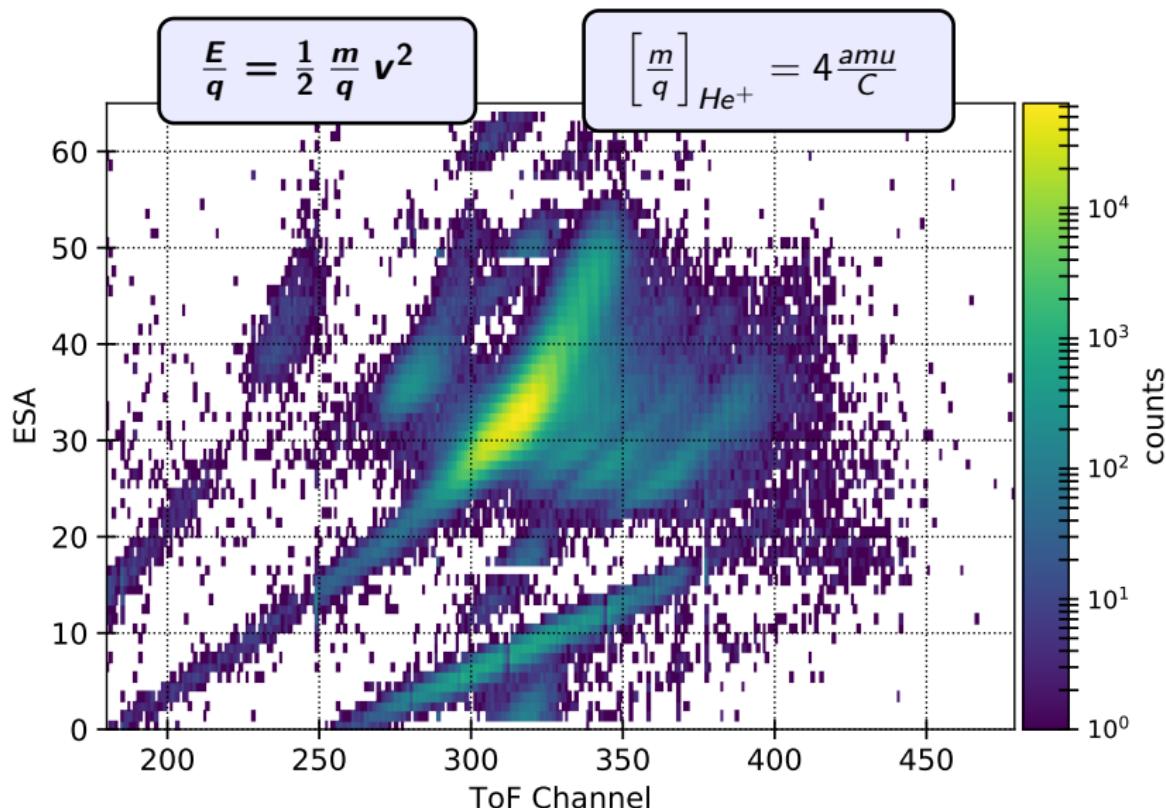
- For constant $\frac{m}{q}$: $\frac{E}{q}$ -step $\hat{=}$ absolute value of velocity
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Angular resolution

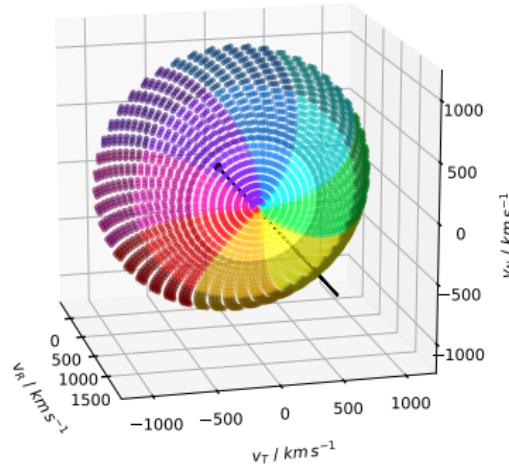
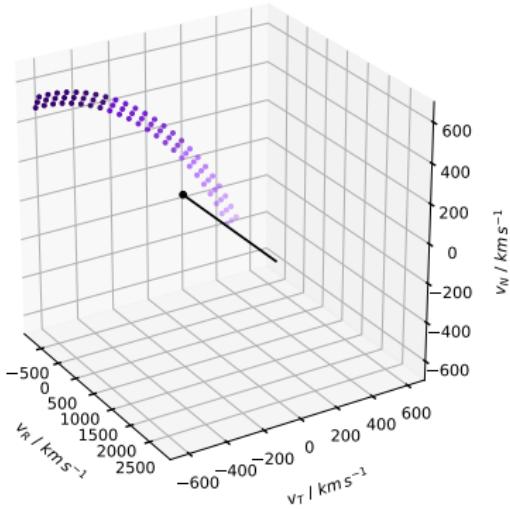


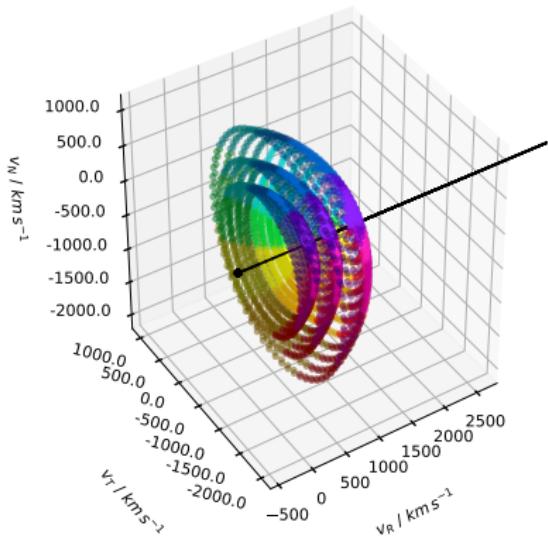
- SWICS: **3 detectors**
Rough distinction between angles of incidence
- 3rd dimension: spin of the SC
Divided into **8 sectors**

PHA data

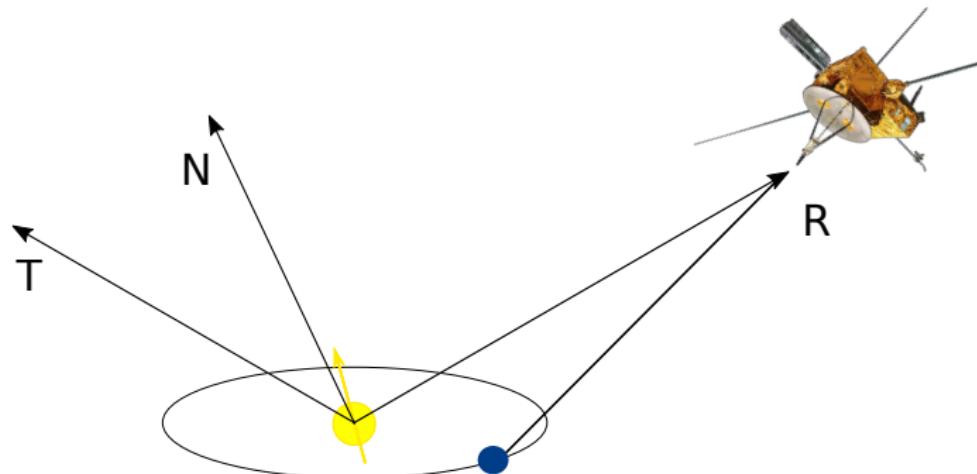


Virtual Collimator

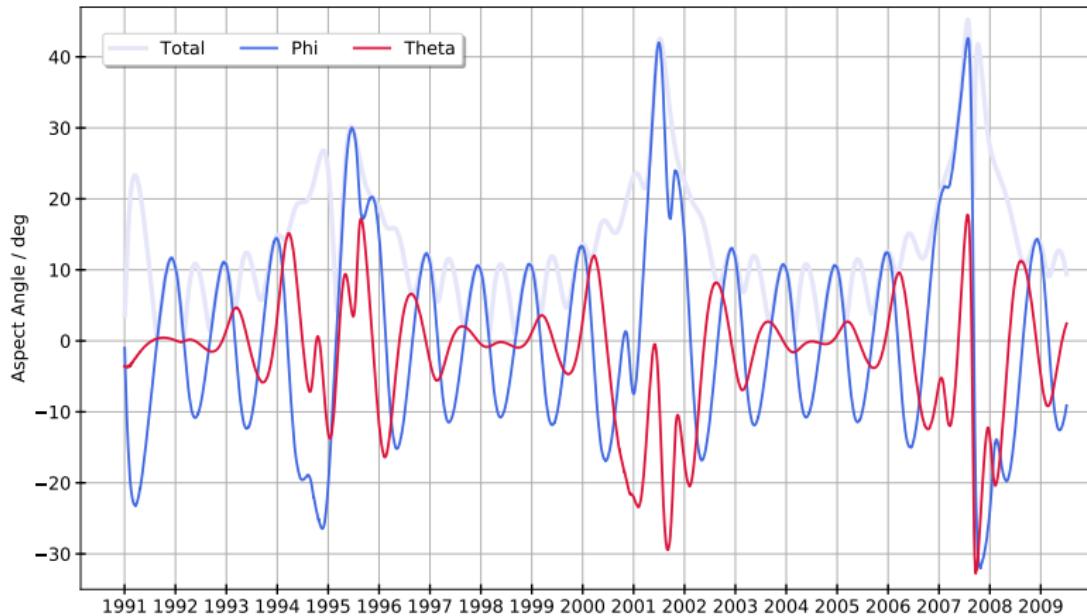




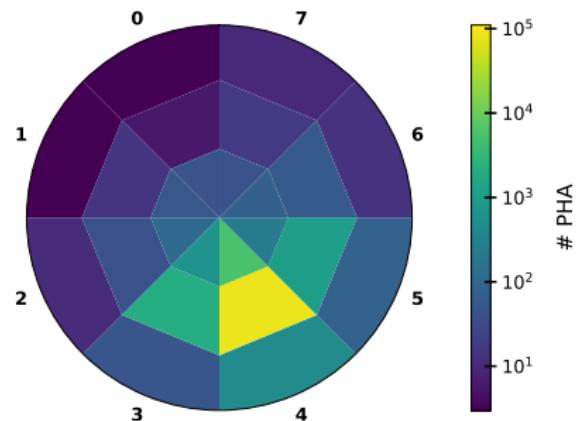
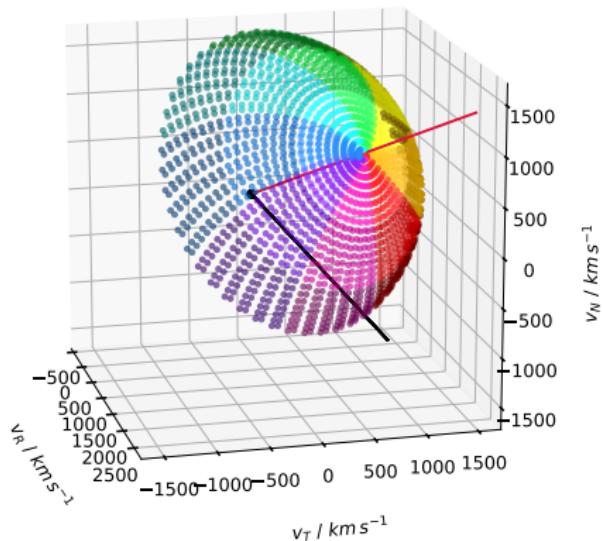
Aspect Angle



Aspect Angle

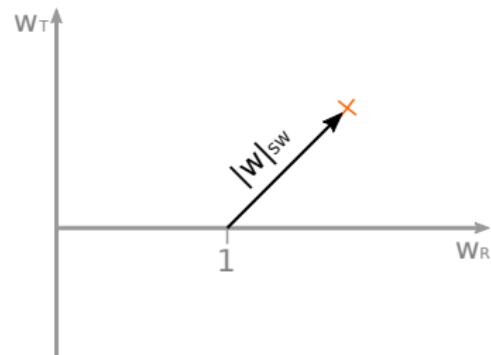
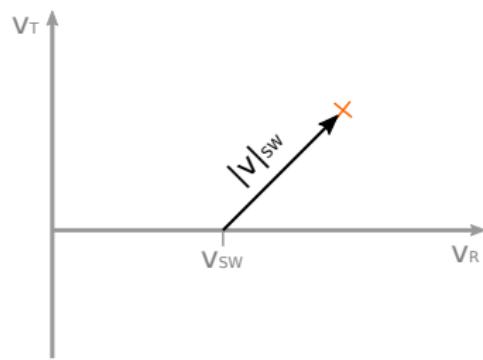
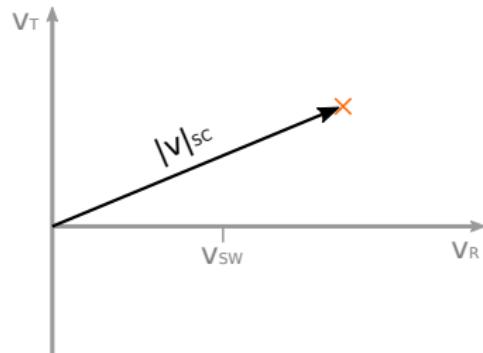


Aspect Angle

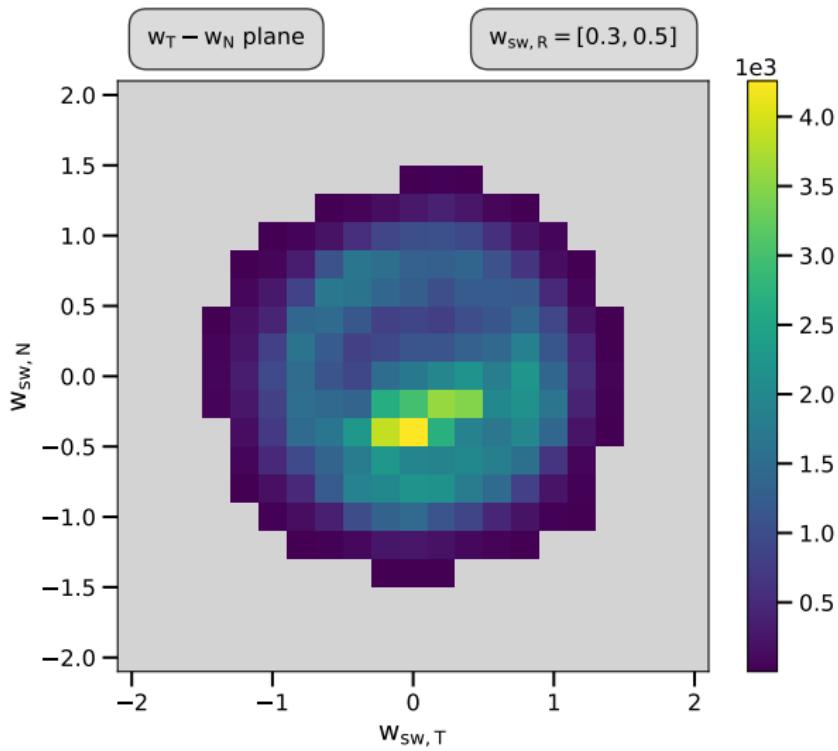
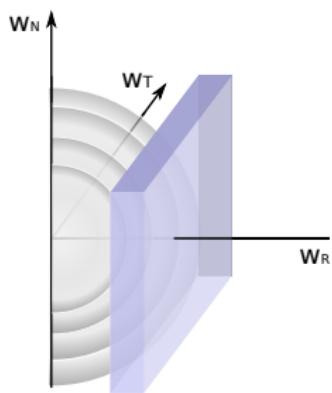


⇒ Plausibility check with solar wind He²⁺

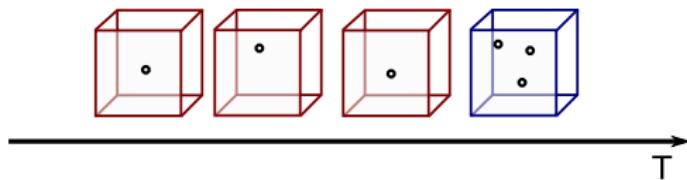
Transition



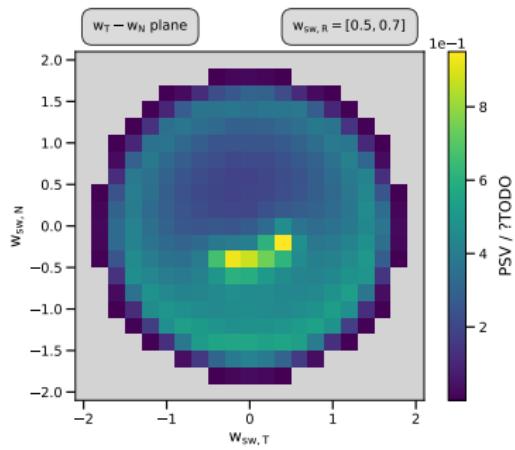
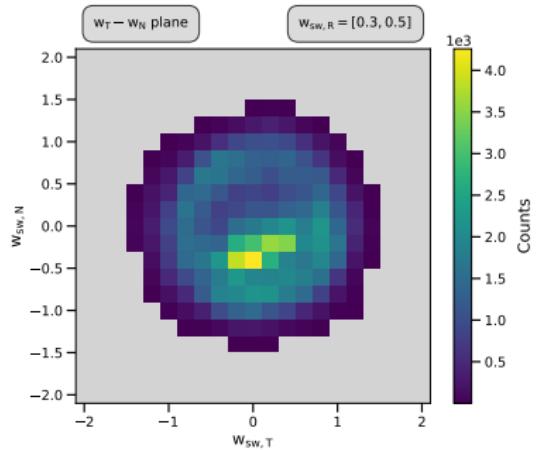
Slice Counts



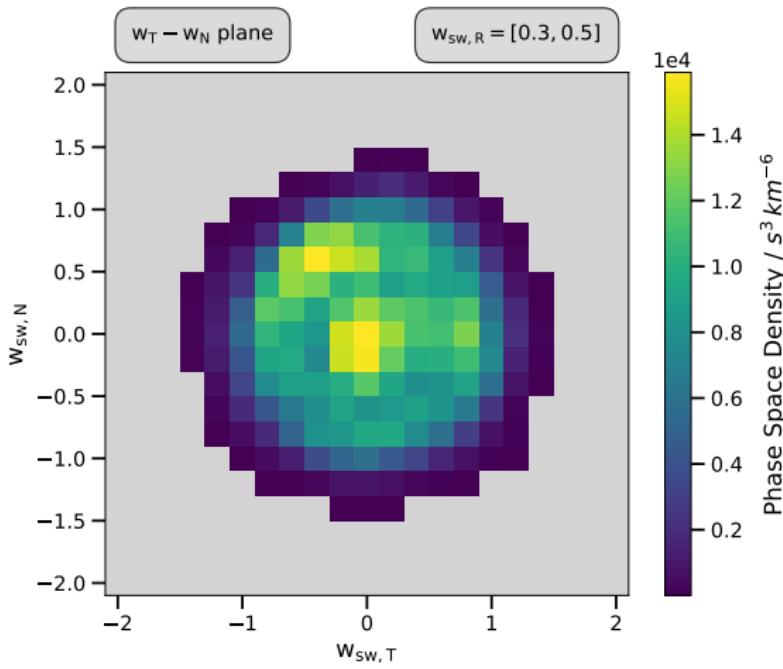
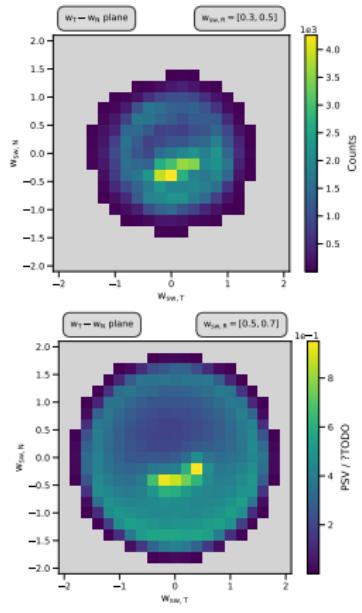
Einschub: Counts zu PSD



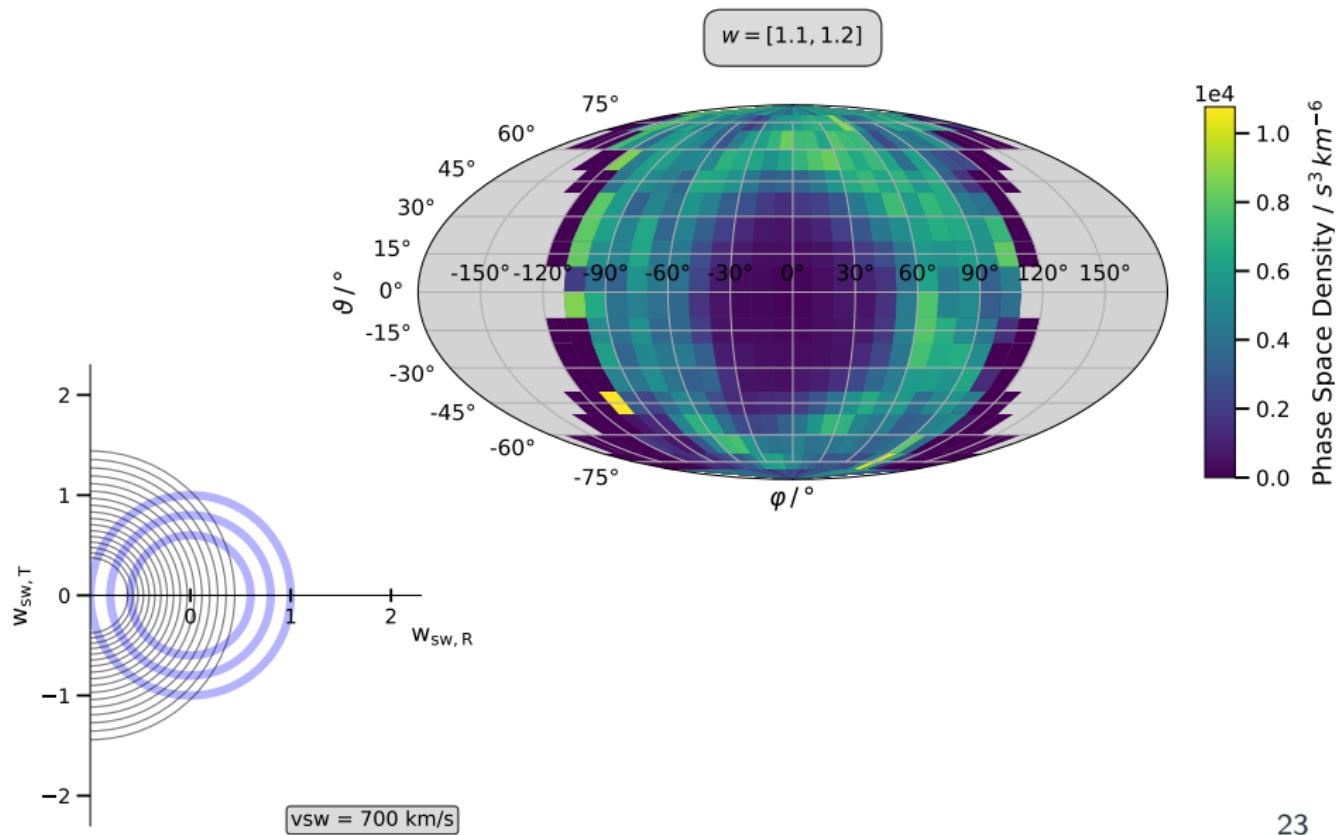
Formel PSD...



Slice PSD



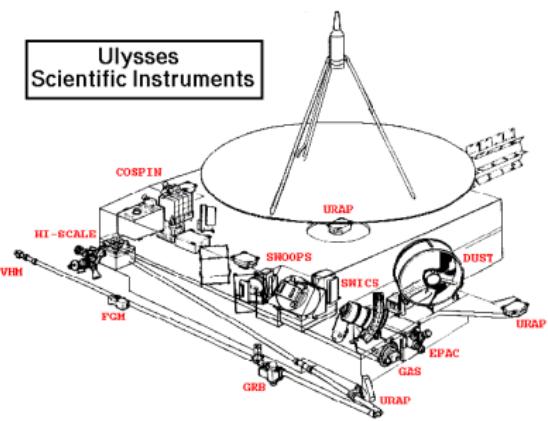
Skymap



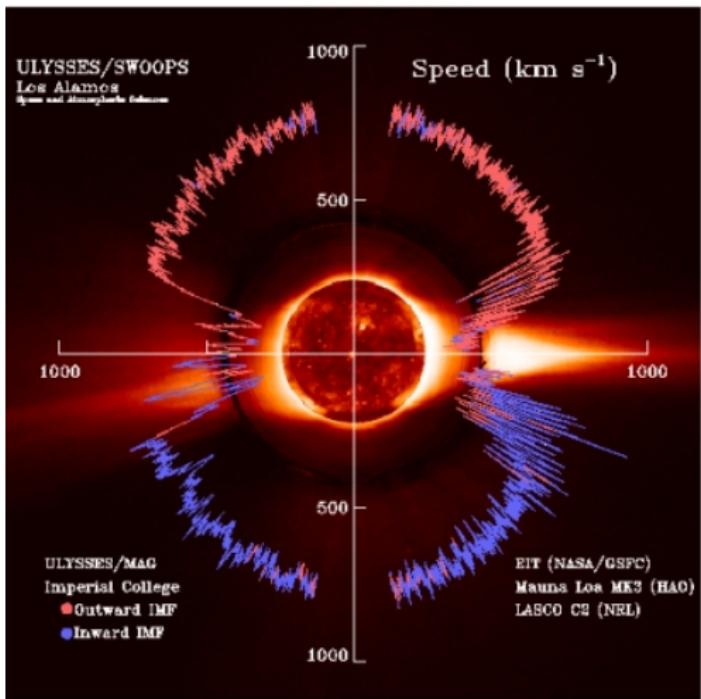
1D

Conclusion

BACKUP

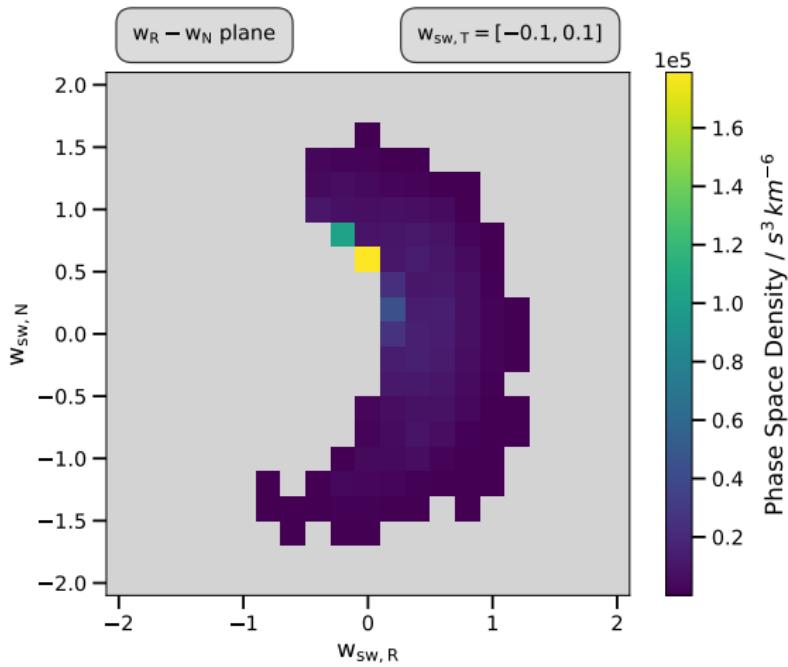
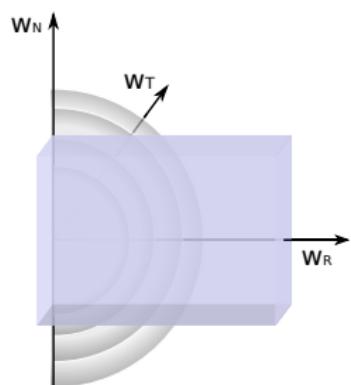


www.cosmos.esa.int, 2019



McComas et al., 2000

Cartesian Cut: T



Cartesian Cut: N

