

Velocity Distribution Functions of Pickup Ions with Ulysses/SWICS

Master Thesis

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November 17, 2019

Outline

Pickup Ions

Basics

Velocity Distribution Function

Ulysses SWICS

Principle of Measurement

Outlook & Conclusion

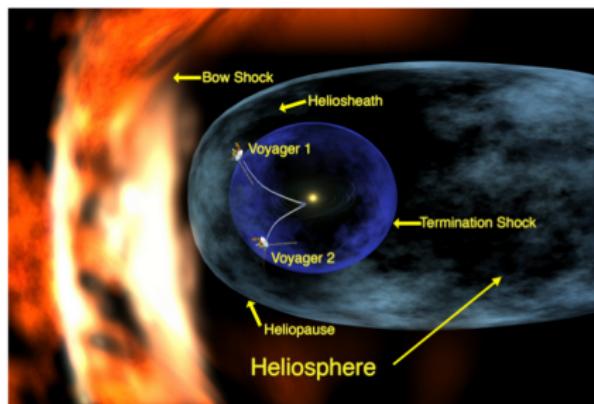
Pickup Ions Basics

Pickup Ions:

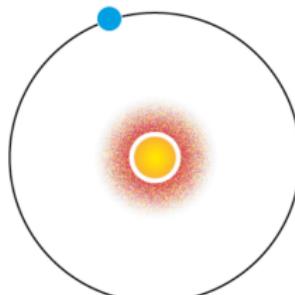
Former neutrals that get ionised within the heliosphere

Origin of the neutrals:

- LISM



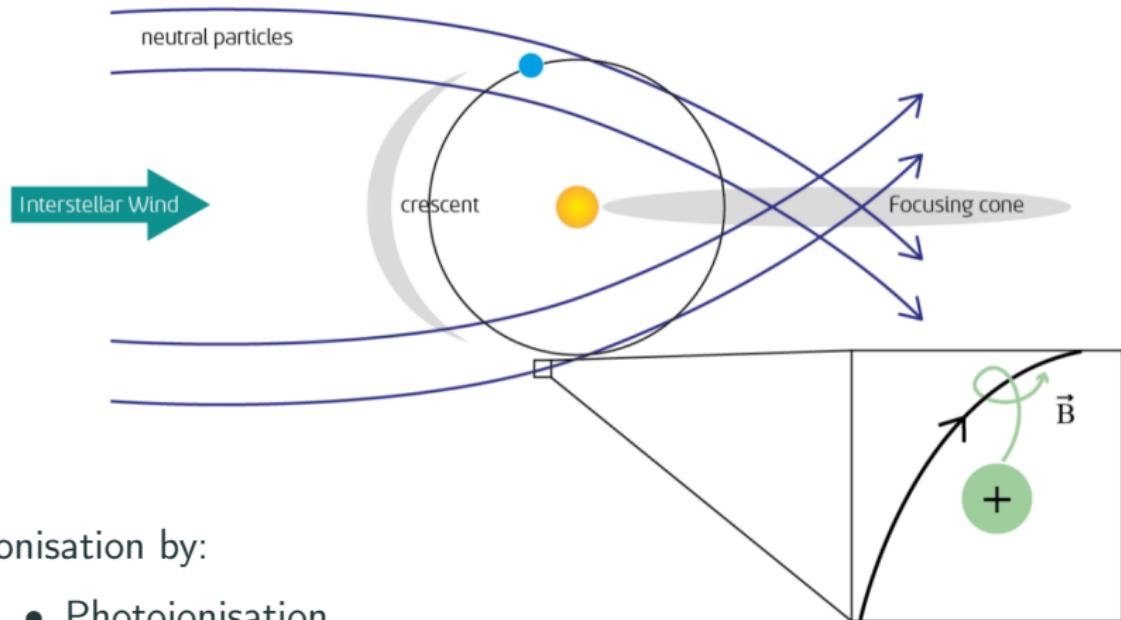
- Inner Source



from <http://science.nasa.gov>

Taut 2018

The Pickup Process



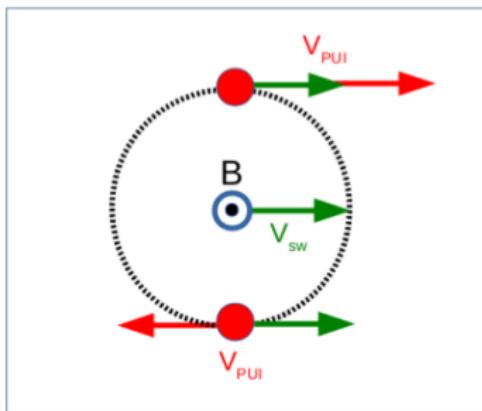
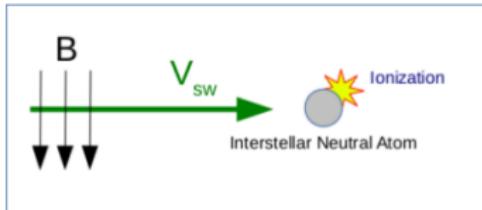
Ionisation by:

- Photoionisation
- Charge exchange
- Electron impact

Taut, Drews et al., AGU fall meeting 2014

→ Newborn ion is subjected to electromagnetic forces

The Pickup Process

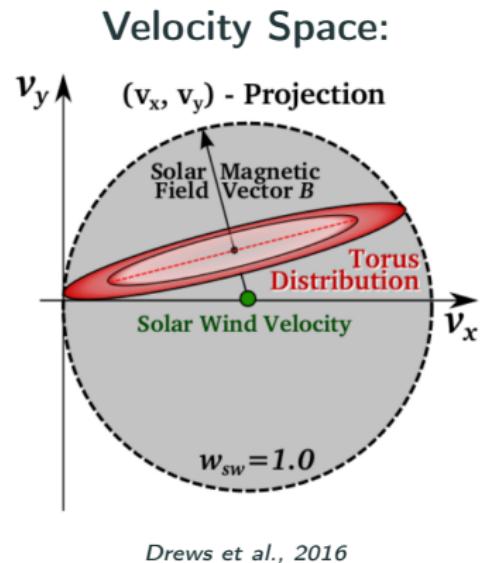
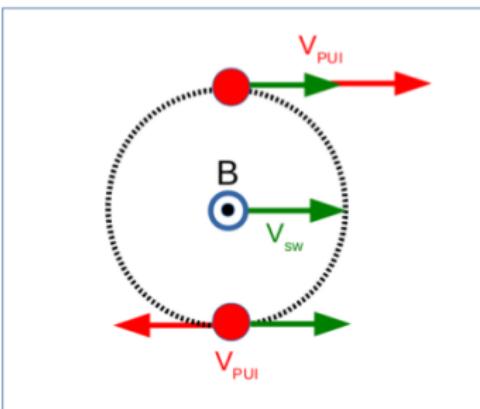
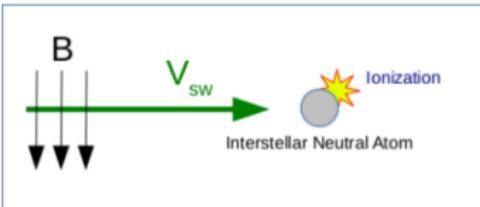


Assumptions:

- particle at rest
- $\vec{B} \perp \vec{v}_{sw}$

Relative motion
→ Gyro-motion

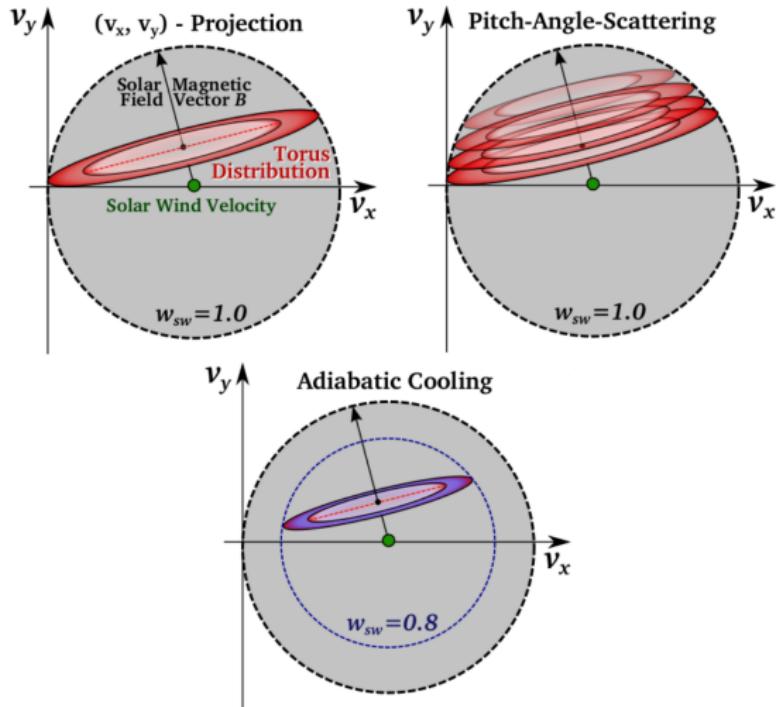
The Pickup Process



→ Anisotropic torus VDF

Taut, Drews et al., AGU Fall Meeting 2014

Evolution of the VDF



Drews, Berger et al., 2016

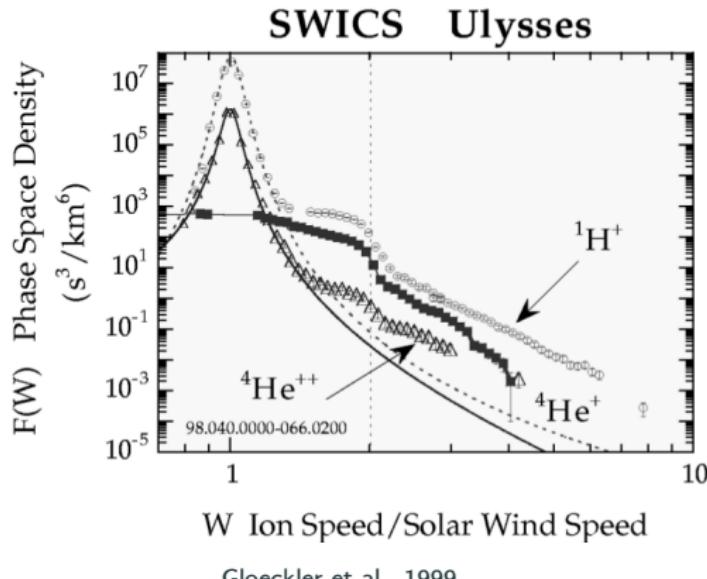
PUI – Measurement

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+}

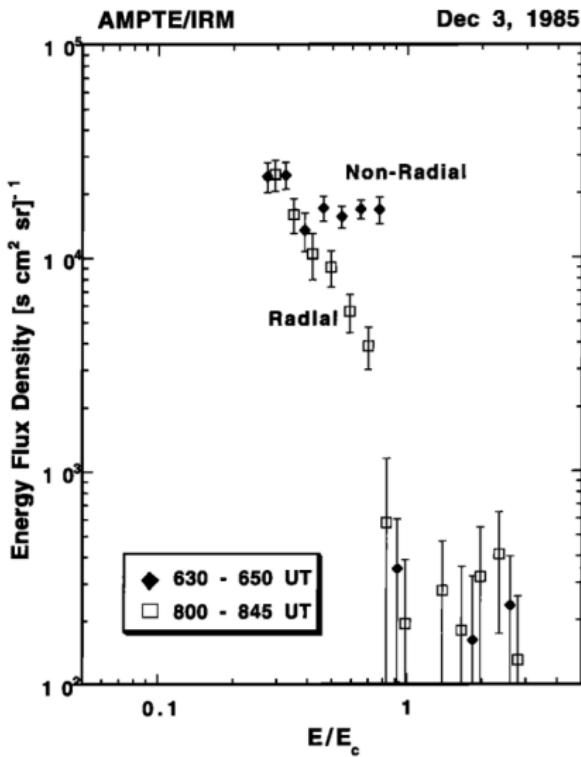
PUI or Solar Wind?

- Charge state
- Velocity distribution function (VDF)



Anisotropic features of the VDF

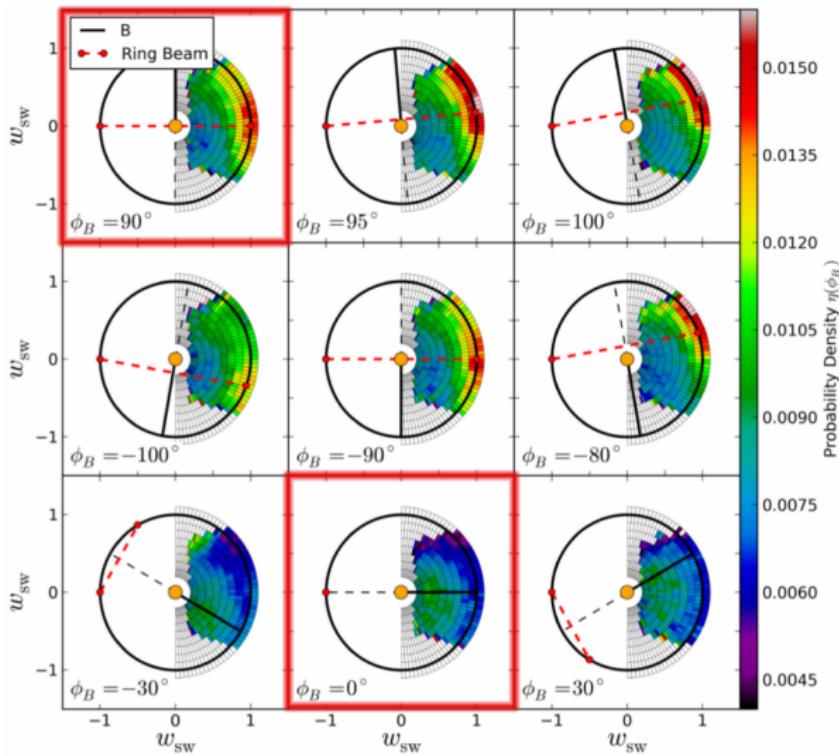
1D measurements
discover anisotropic
features of the VDF



Moebius et al., 1998

Anisotropic features of the VDF

- STEREO / PLASTIC:
angular resolution
→
2D measurement
 - anisotropic feature
 - \vec{B} -dependency

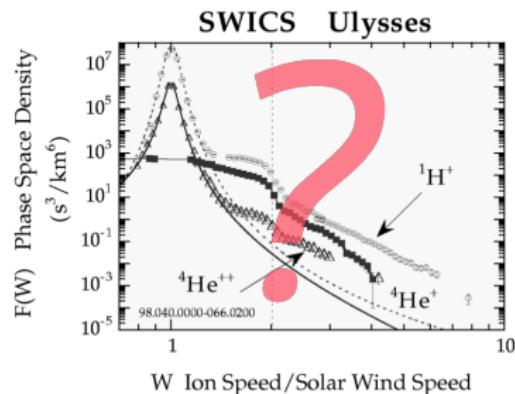


Motivation

Problem:

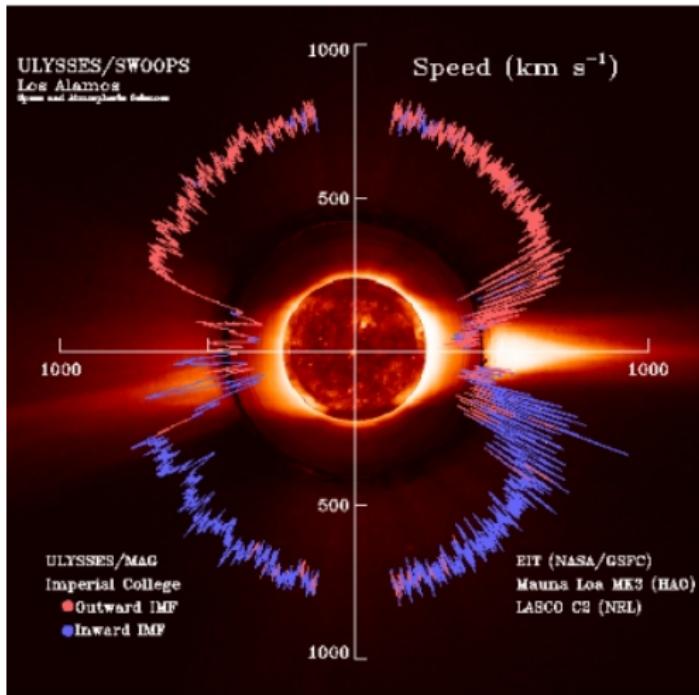
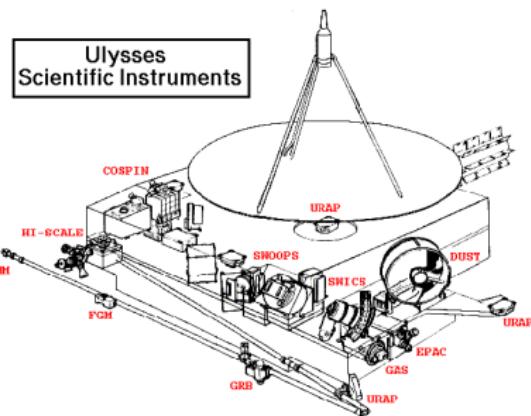
Ambiguity of 1D reduced data

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



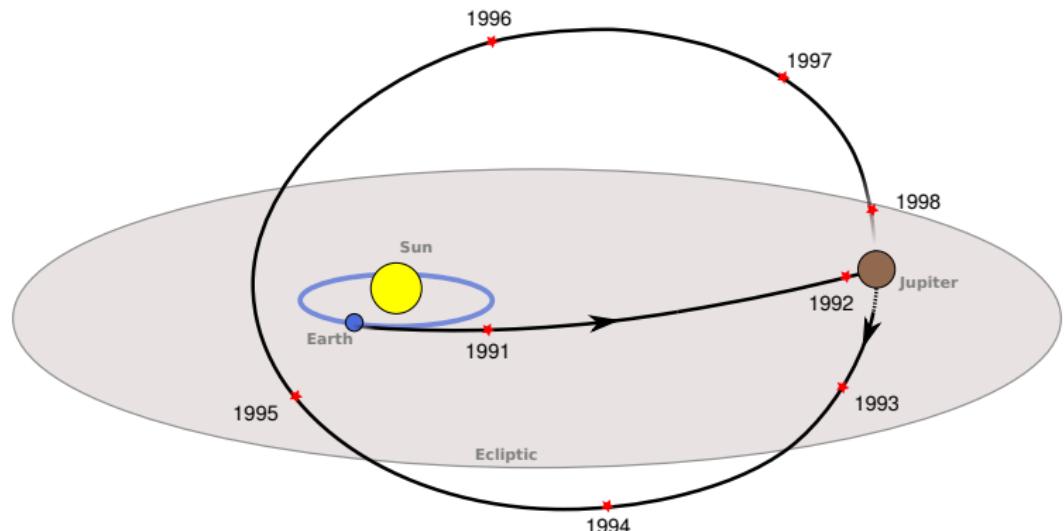
Ulysses Spacecraft

- Launched 1990 (– 2009)
- Highly inclined orbits above the solar poles
→ unique data!

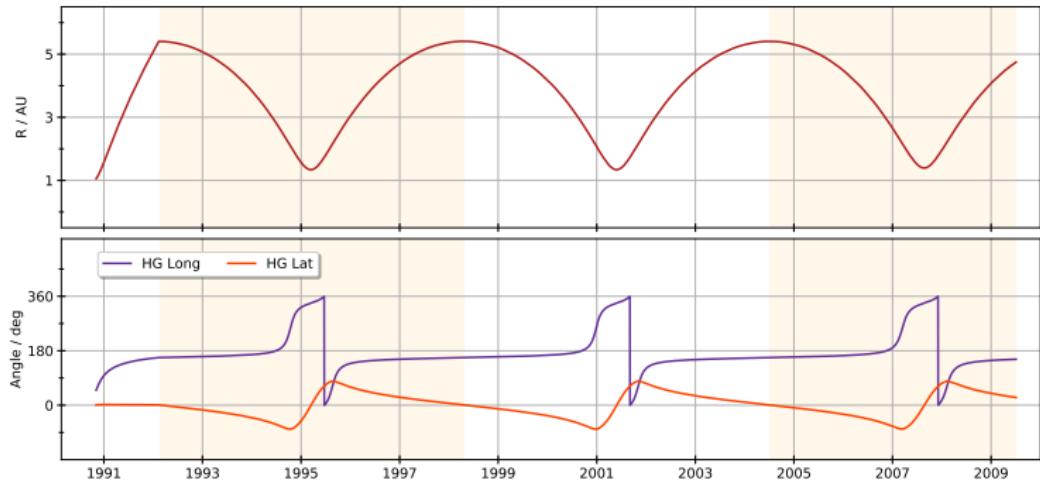


www.esa.int, 2019

Ulysses Orbit

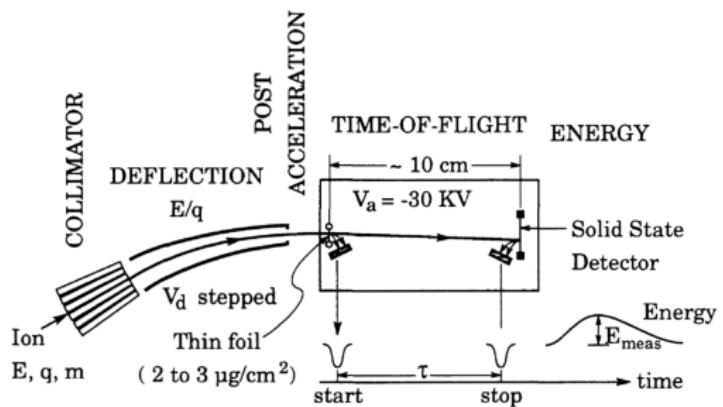
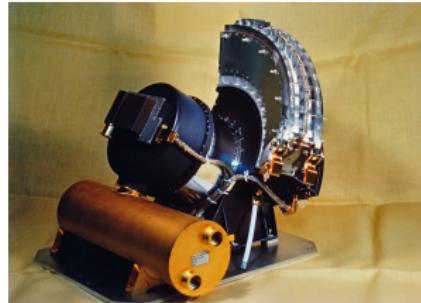


adapted from TODO



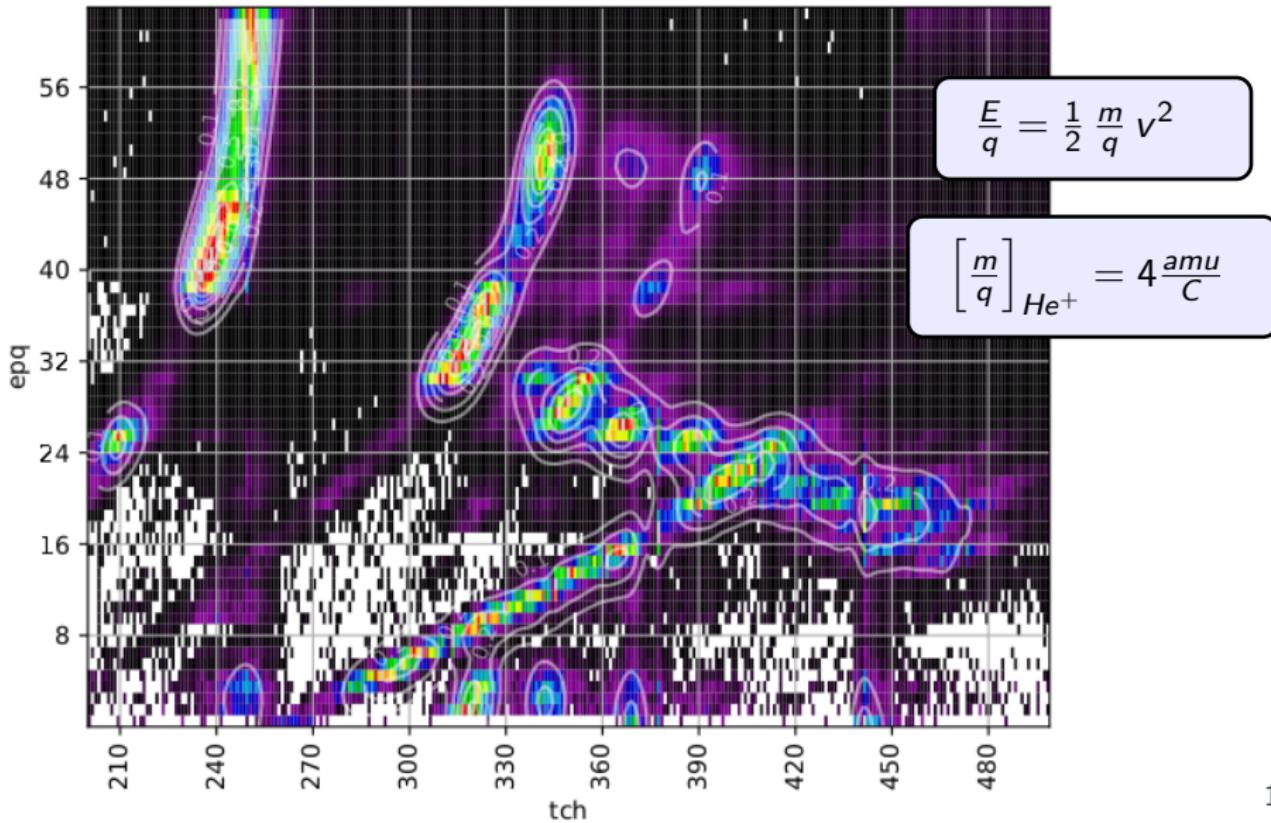
The Solar Wind Ion Composition Spectrometer

- 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

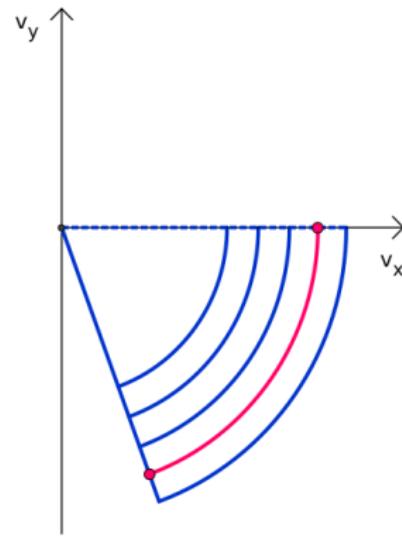
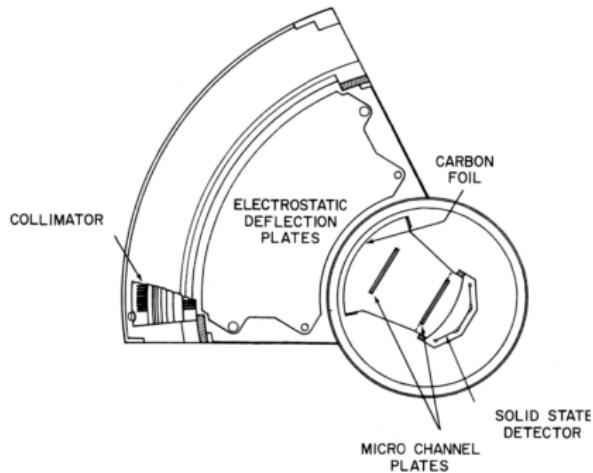


Gloeckler, Geiss et al., 1992

PHA data



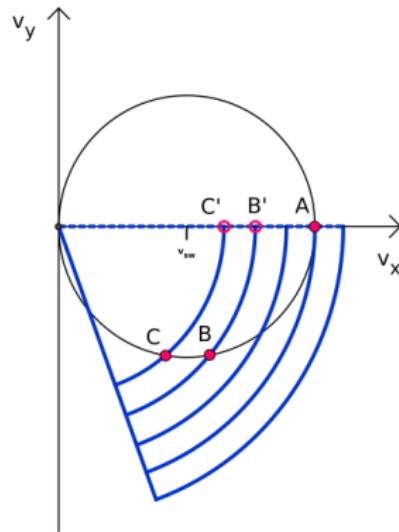
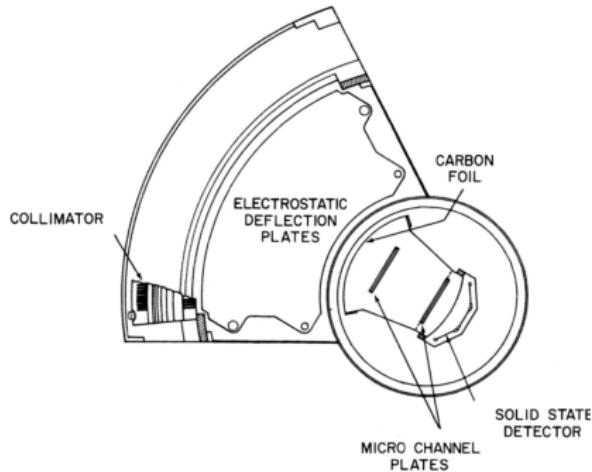
EpQ measurement



Gloeckler, Geiss et al., 1992

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

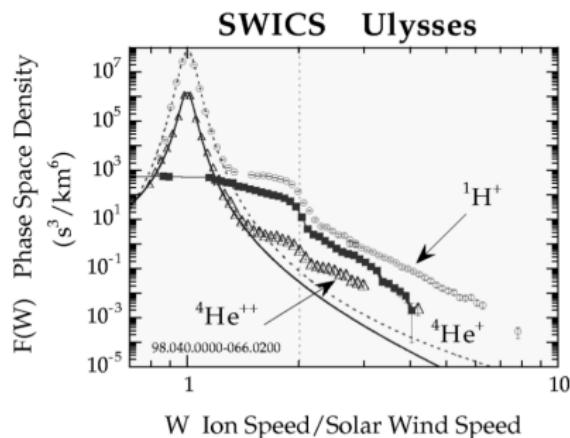
EpQ measurement



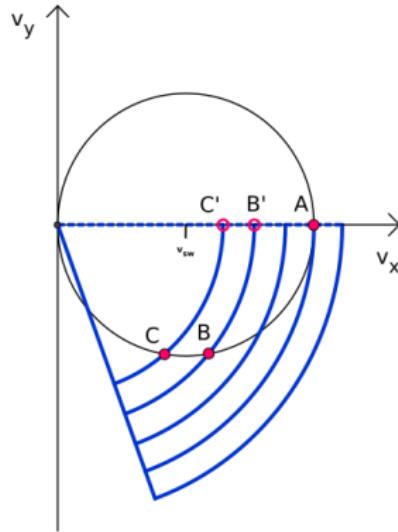
Gloeckler, Geiss et al., 1992

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EpQ measurement

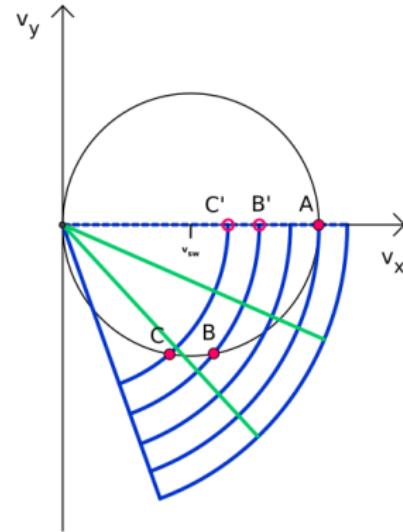
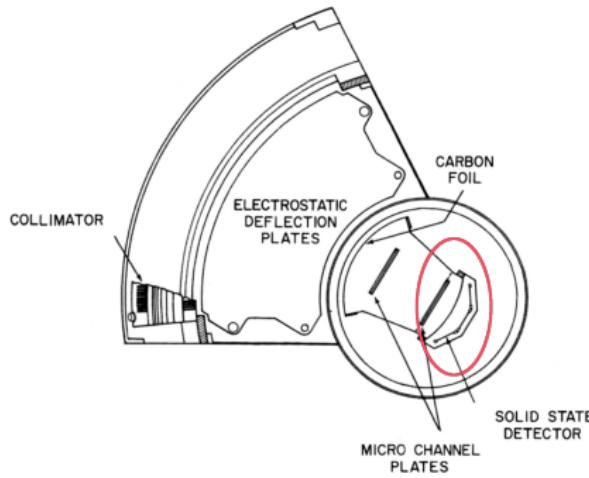


Gloeckler, Geiss et al., 1992



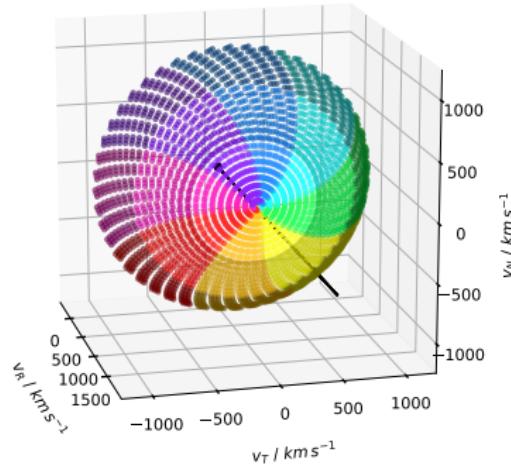
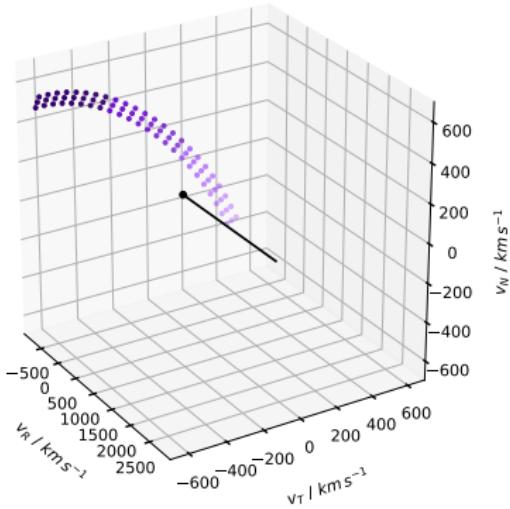
- For constant $\frac{m}{q}$: $\frac{E}{q}$ -step $\hat{=}$ absolute value of velocity
- Integration over EpQ shells \rightarrow loss of information!

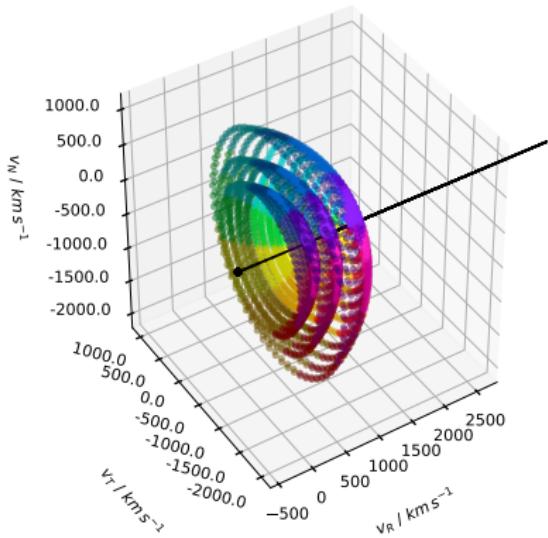
Angular resolution

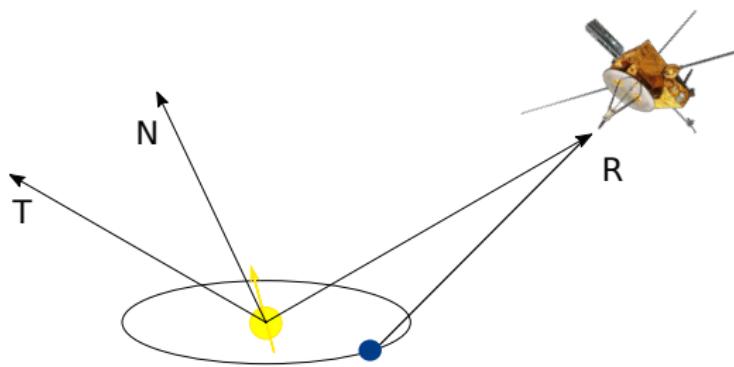


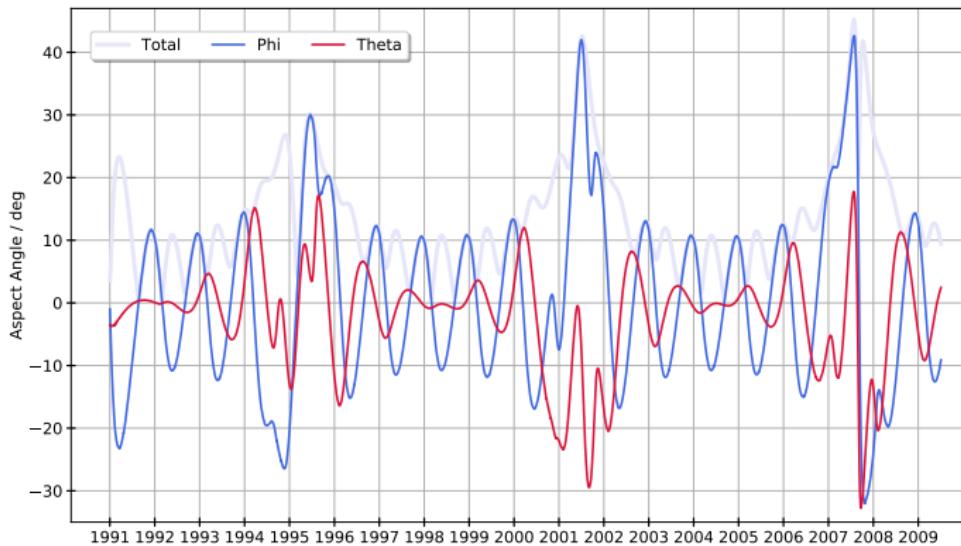
- SWICS: **3 detectors**
Rough distinction between angles of incidence
- 3rd dimension: spin of the SC
Divided into **8 sectors**

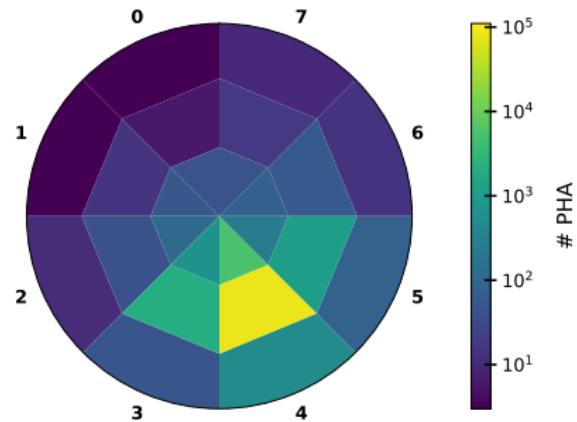
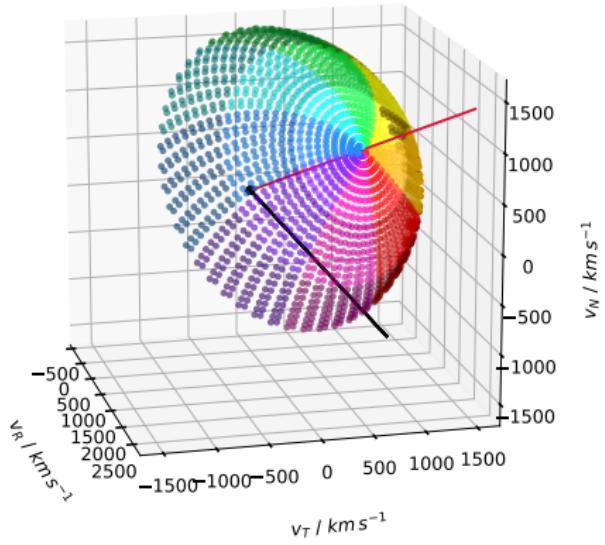
Virtual Collimator











Conclusion