

He^+ Pickup Ion Measurements with Ulysses SWICS

MNF-phys-1321

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November 29, 2021

Outline

Pickup Ions

Basics

Velocity Distribution Function

Ulysses SWICS

Principle of Measurement

Trajectory

Outlook & Conclusion

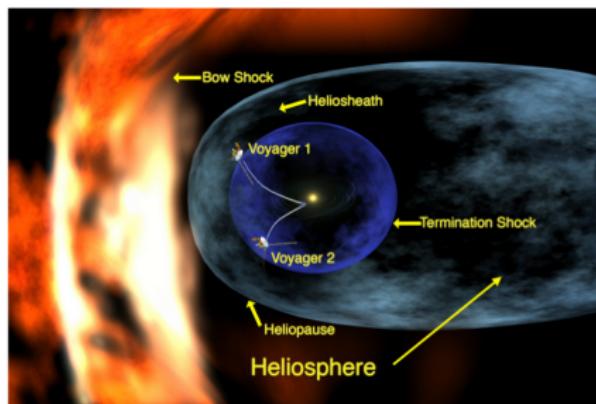
Pickup Ions Basics

Pickup Ions:

Former neutrals that get ionised within the heliosphere

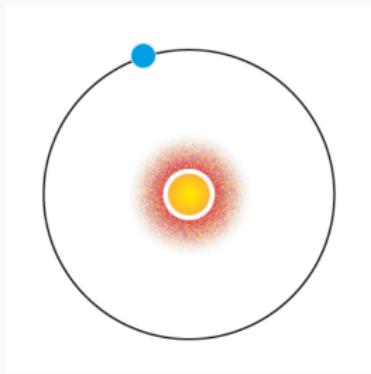
Origin of the neutrals:

- LISM



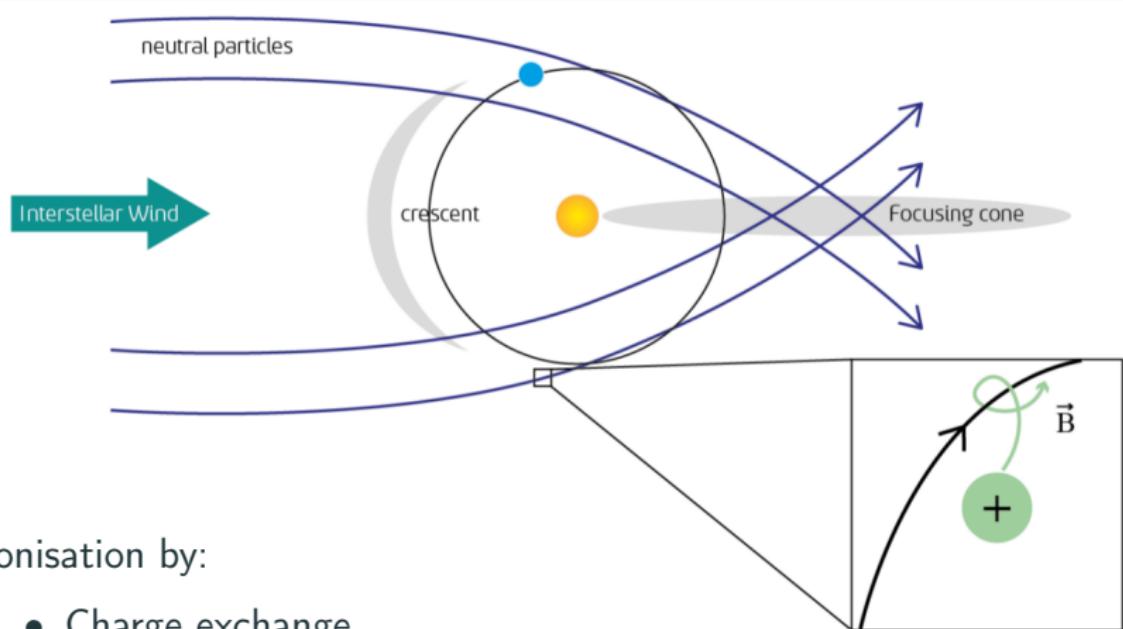
from <http://science.nasa.gov>

- Inner Source



Taut 2018

The Pickup Process



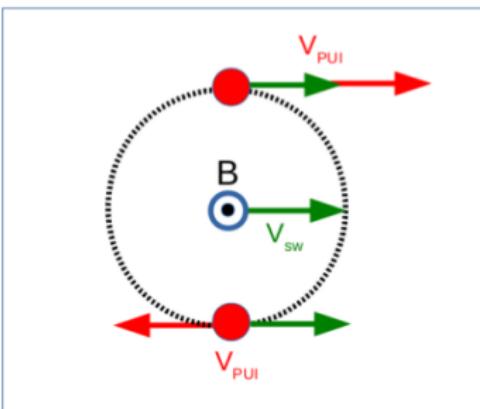
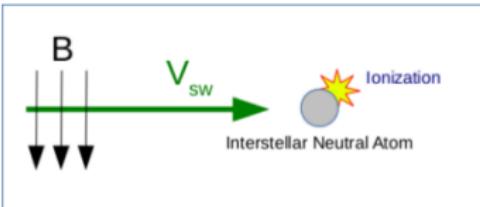
Ionisation by:

- Charge exchange
- Photoionisation
- Electron impact

Taut, Drews et al., AGU fall meeting 2014

→ Newborn ion is subjected to electromagnetic forces

The Pickup Process

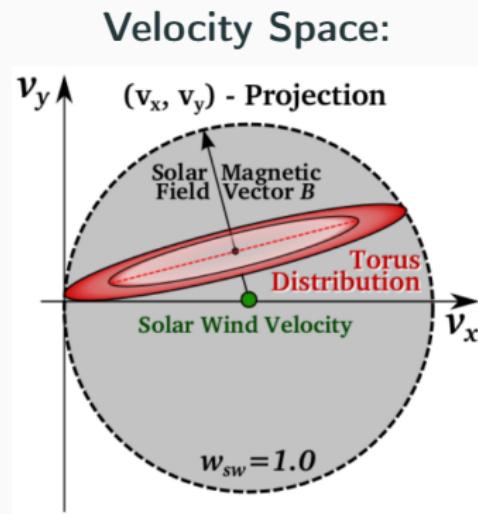
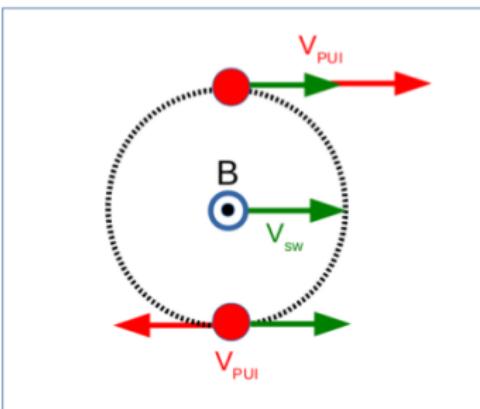
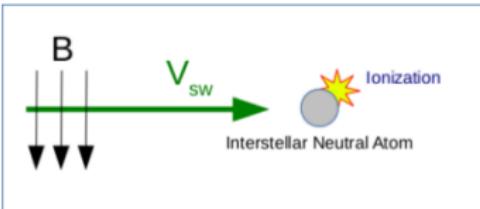


Assumptions:

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

Relative motion
→ Gyro-motion

The Pickup Process

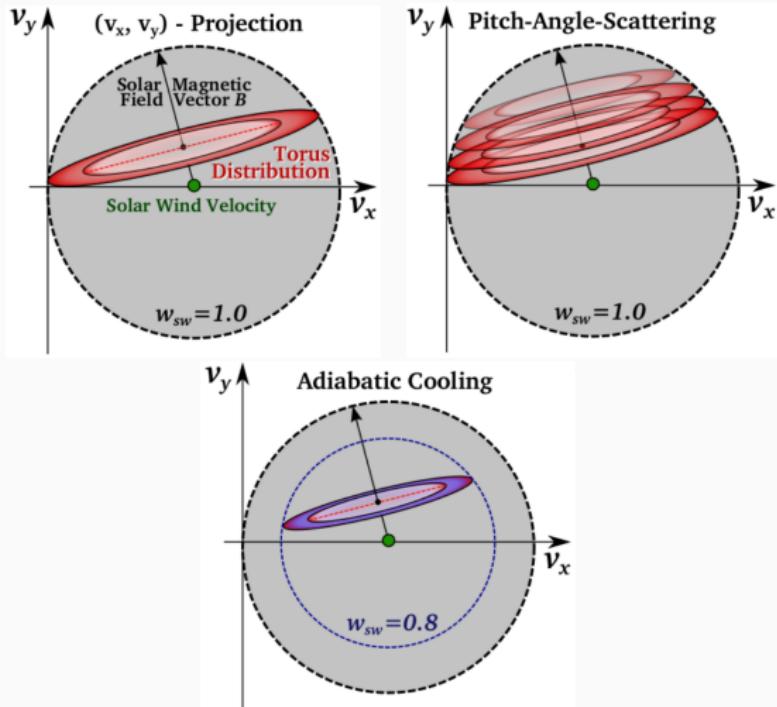


Drews et al., 2016

→ Anisotropic torus VDF

Taut, Drews et al., AGU Fall Meeting 2014

Evolution of the VDF



Drews, Berger et al., 2016

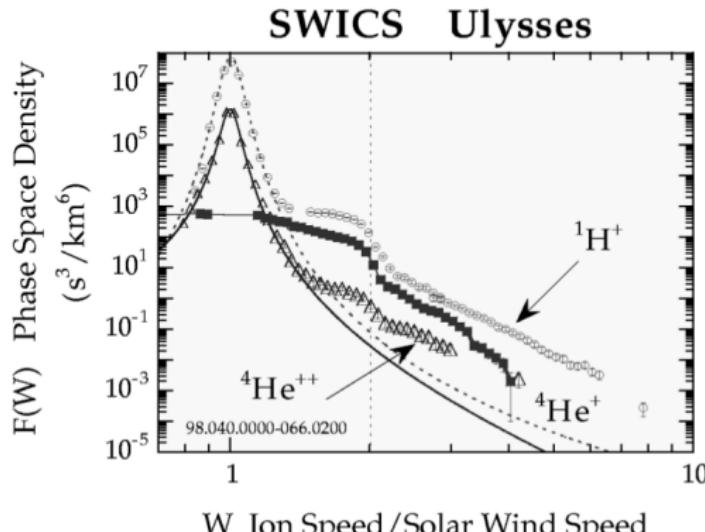
PUI – Measurement

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?

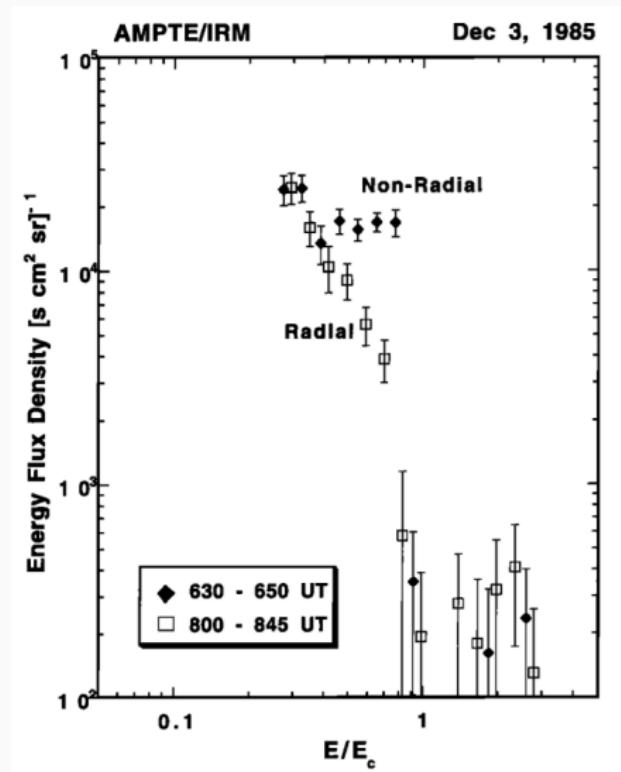
- Charge state
- Velocity distribution function (VDF)



Gloeckler et al., 1999

Anisotropic features of the VDF

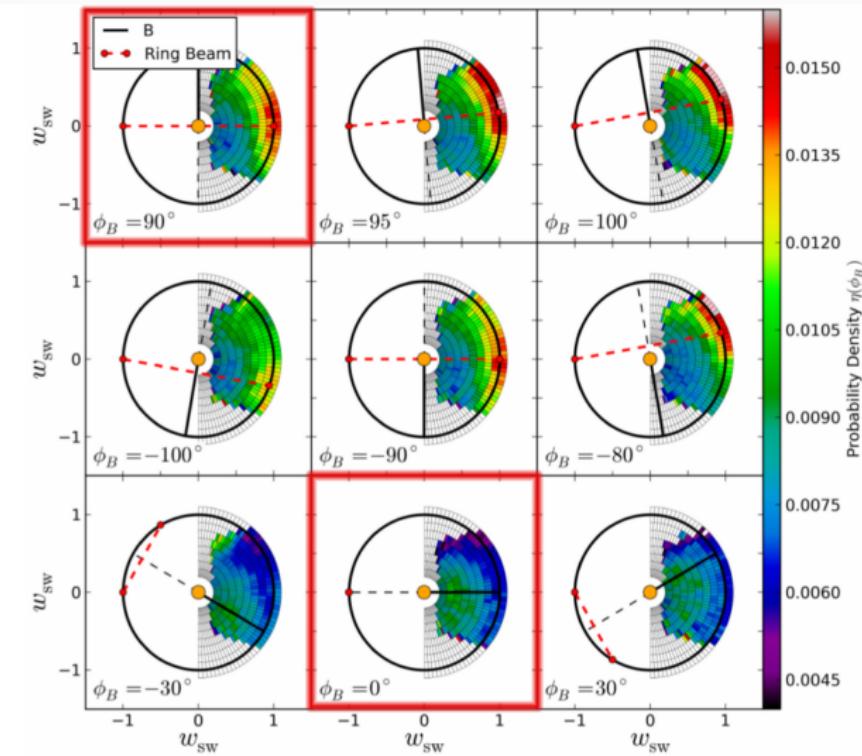
1D measurements
discover anisotropic
features of the VDF



Moebius et al., 1998

Anisotropic features of the VDF

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

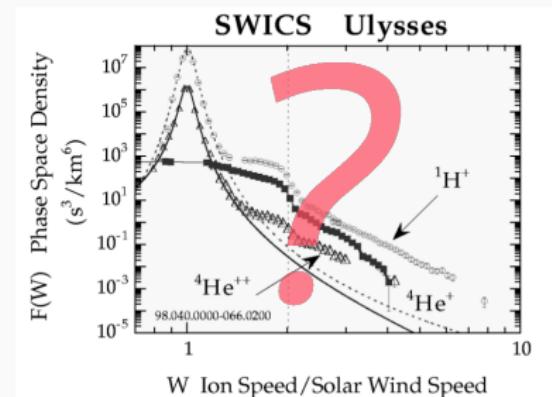


Motivation

Problem:

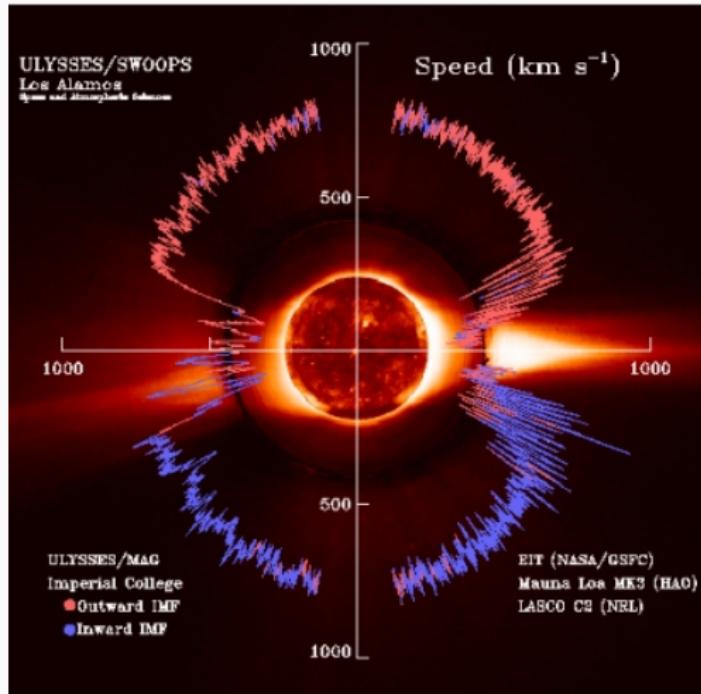
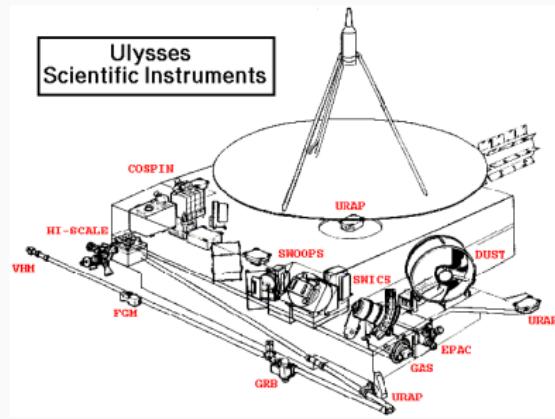
Ambiguity of 1D reduced data

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



ULYSSES Spacecraft

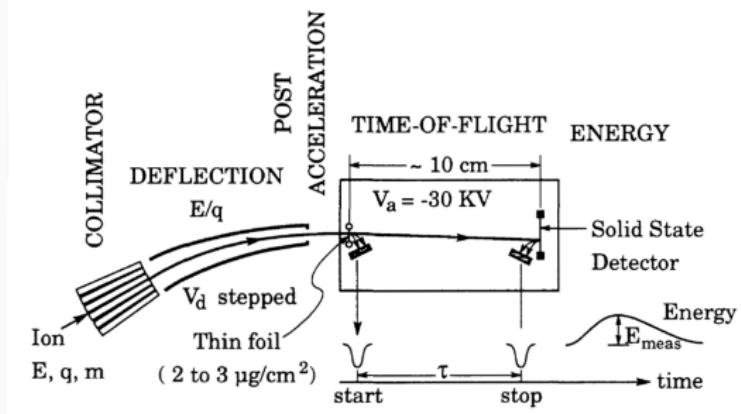
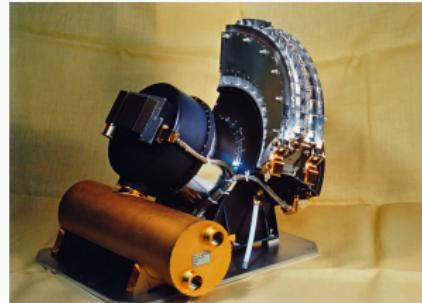
- Launched 1990 (– 2009)
- Highly inclined orbits above the solar poles
→ unique data!



www.esa.int, 2019

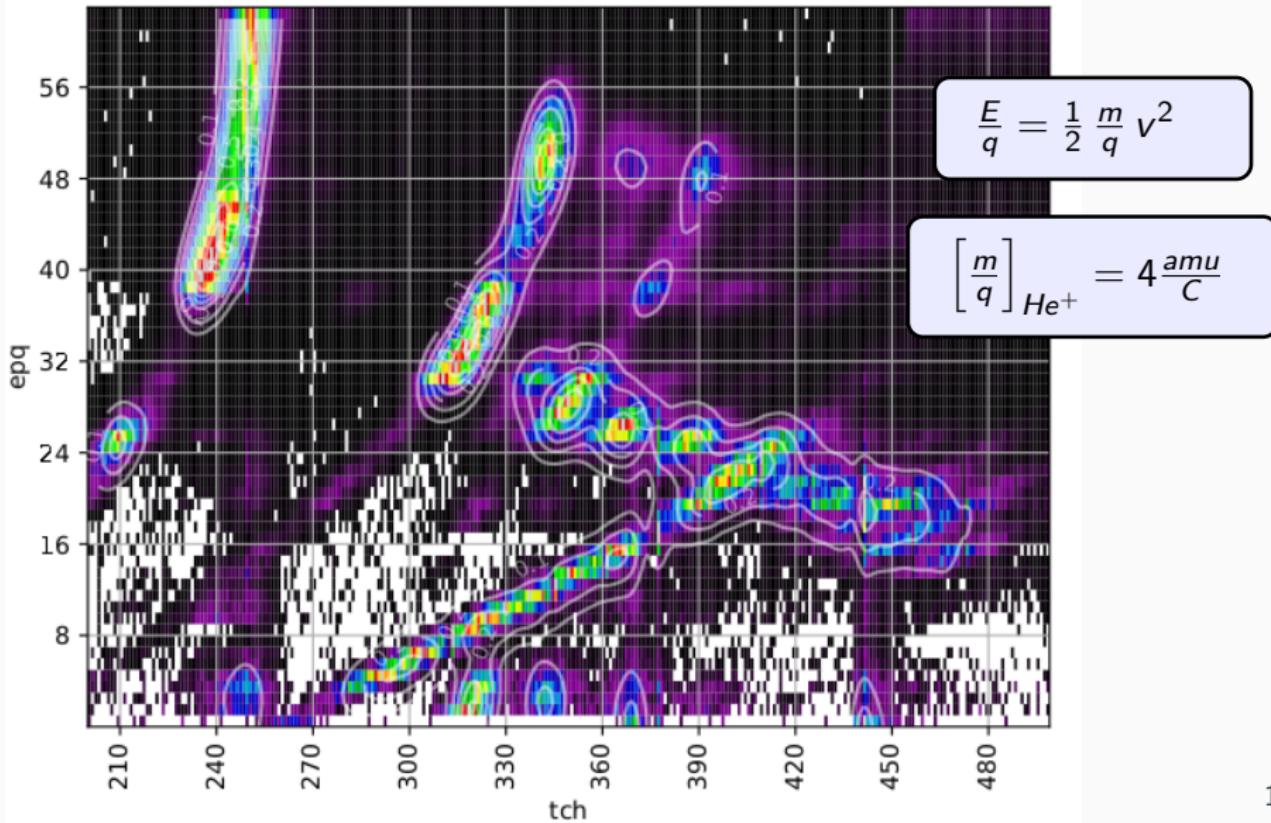
The Solar Wind Ion Composition Spectrometer

- 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

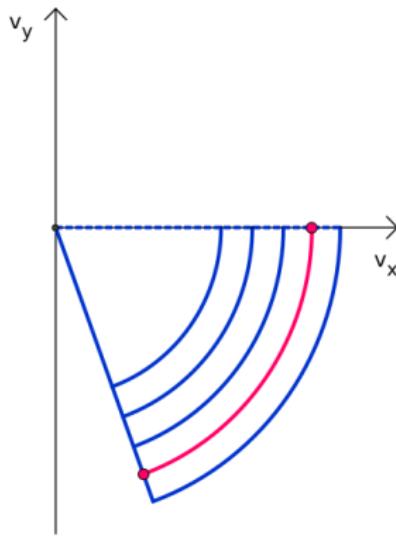
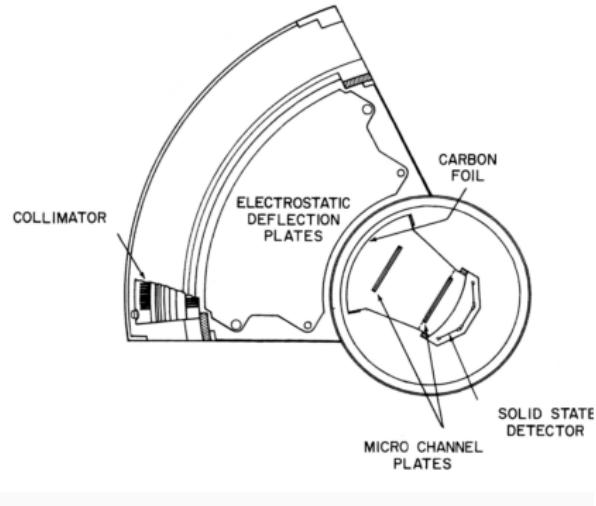


Gloeckler, Geiss et al., 1992

PHA data



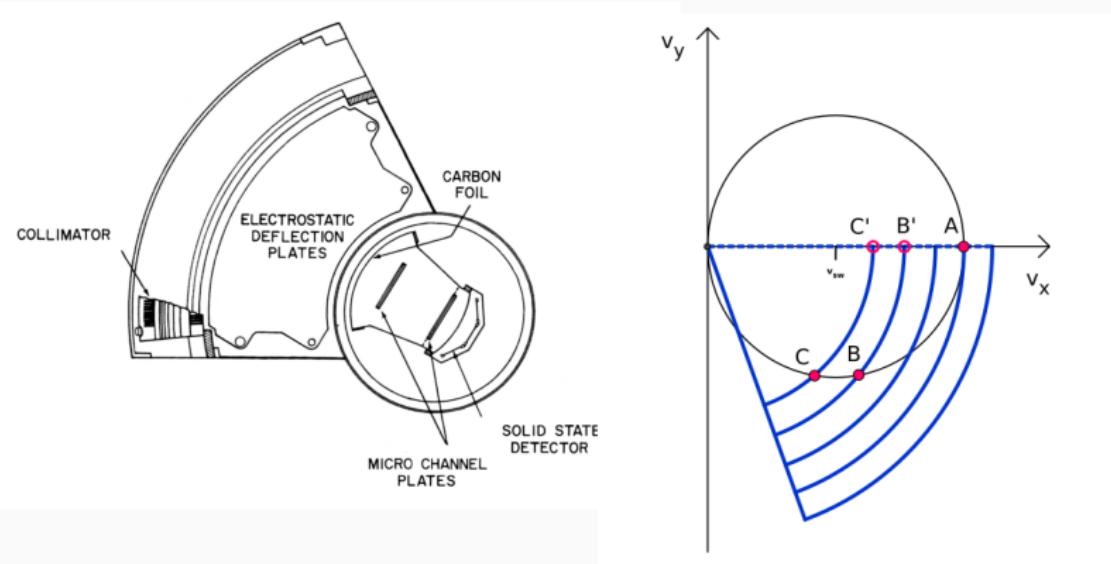
EpQ measurement



Gloeckler, Geiss et al., 1992

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

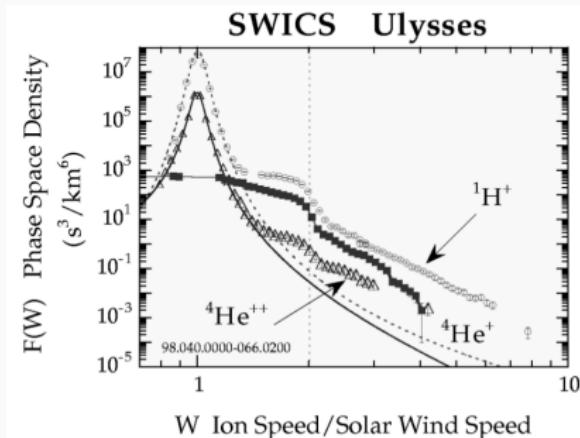
EpQ measurement



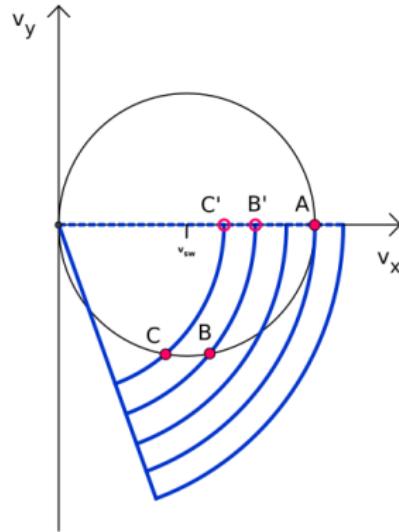
Gloeckler, Geiss et al., 1992

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

EpQ measurement

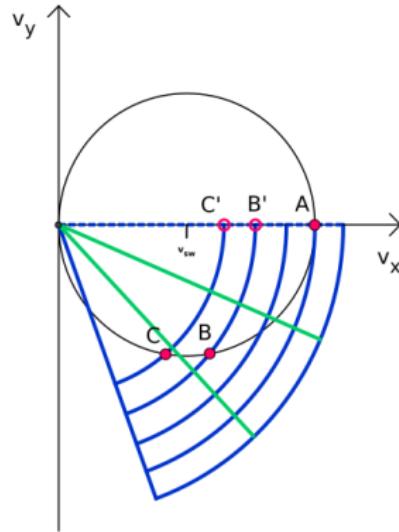
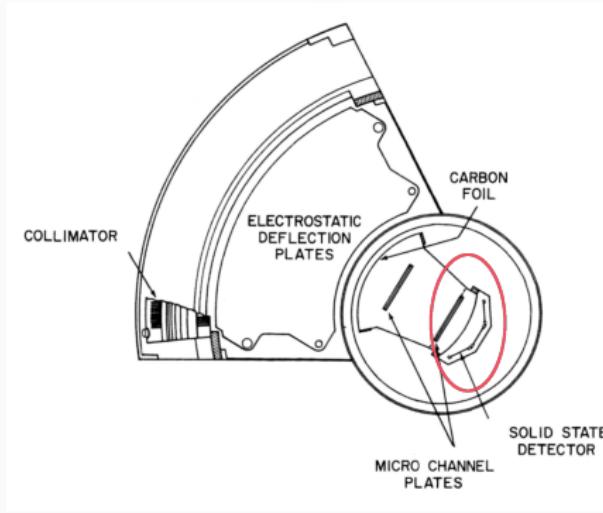


Gloeckler, Geiss et al., 1992



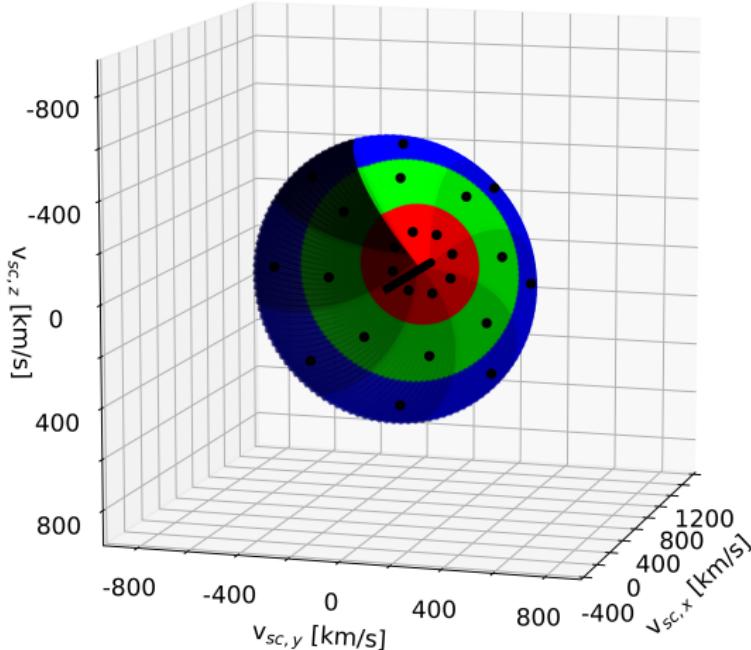
- For constant $\frac{m}{q}$: $\frac{E}{q}$ -step $\hat{=}$ absolute value of velocity
- Integration over EpQ shells \rightarrow loss of information!

Angular resolution



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

Virtual Collimator

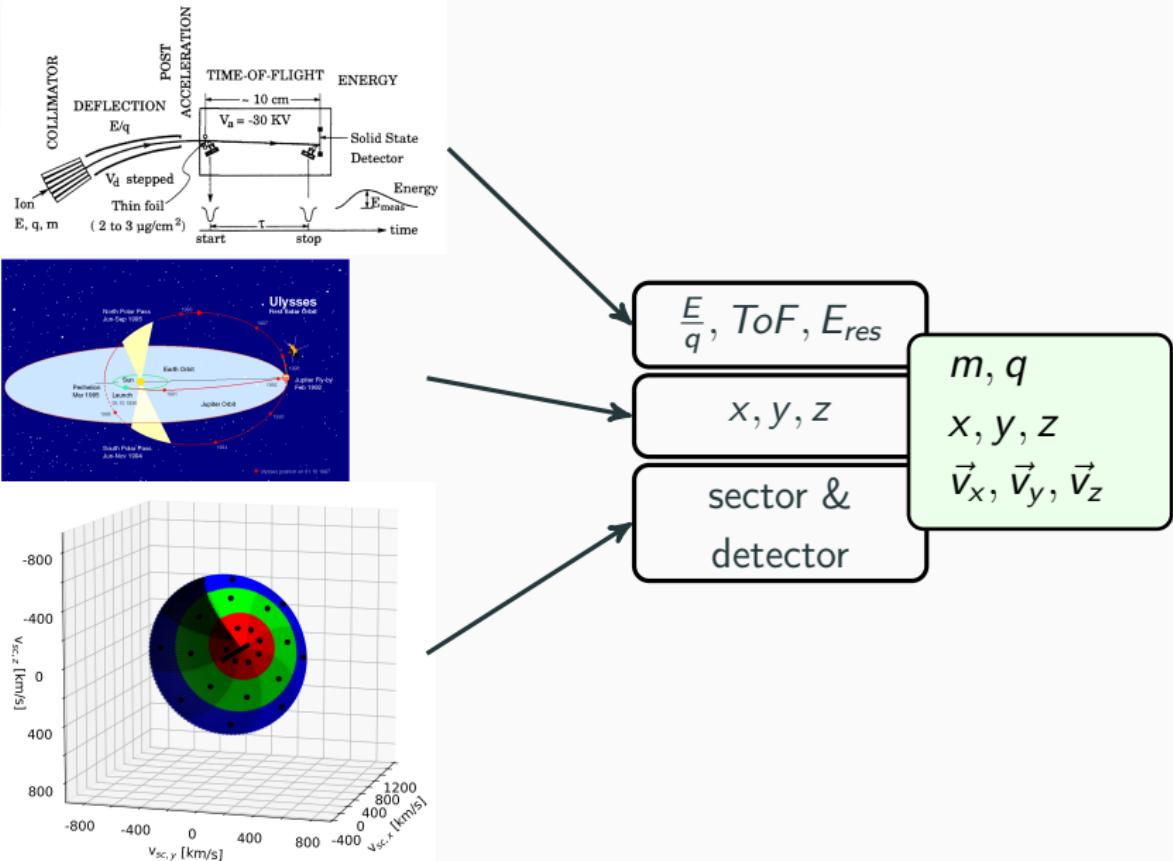


Velocity Space
acceptance

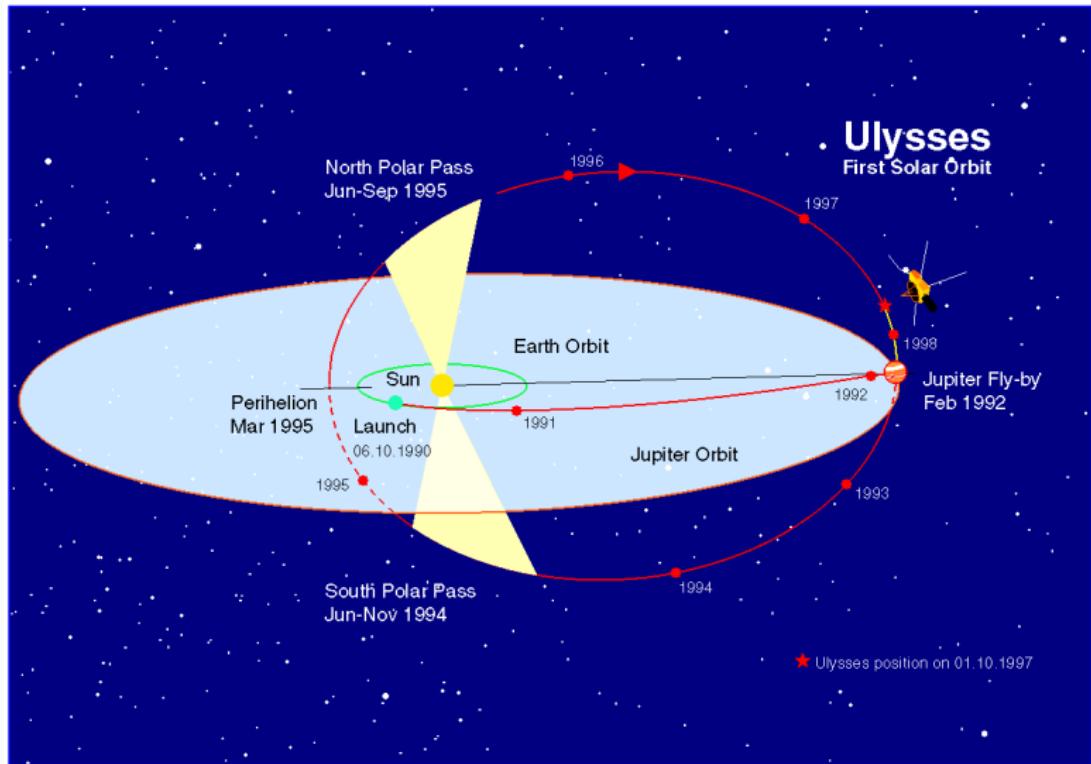
- for one species
- for one $\frac{E}{q}$ -step

→ Spherical dome

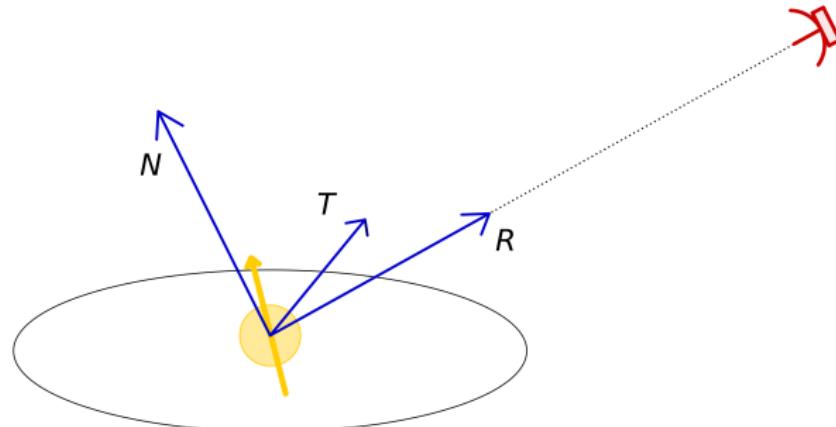
Conclusion of the Measurement



Ulysses Trajectory

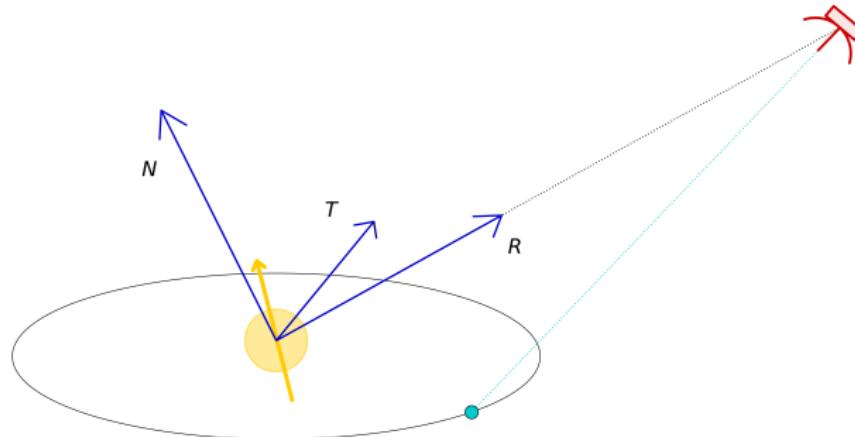


Ulysses Trajectory – Coordinate System



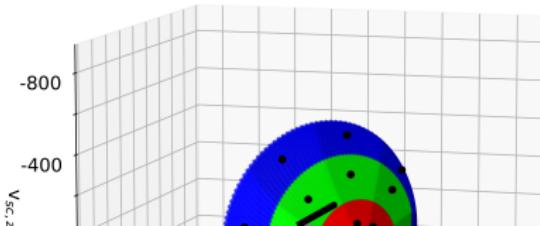
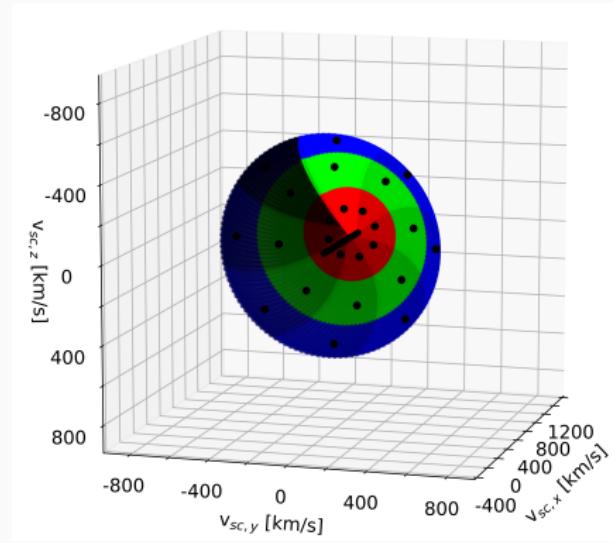
Spacecraft orientated coordinate system:
Radial Tangential Normal

Ulysses Trajectory – Aspect Angle

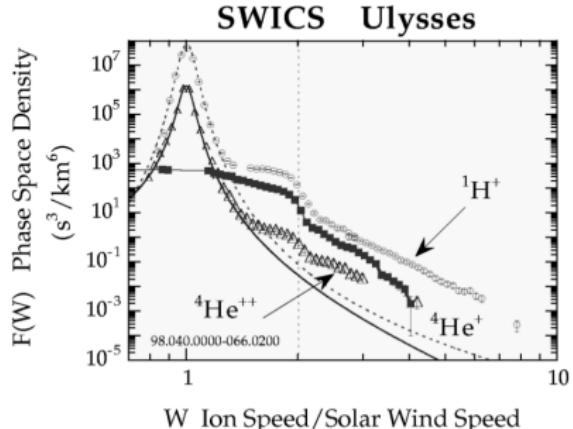
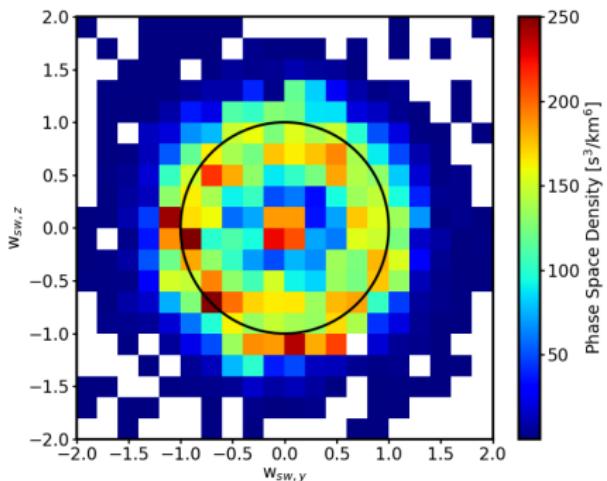


Aspect Angle: Angle between Ulysses' antenna (\rightarrow earth) and
viewing line Ulysses \leftrightarrow sun

VDF – Aspect Angle



Outlook: ACE SWICS – 3D measurement

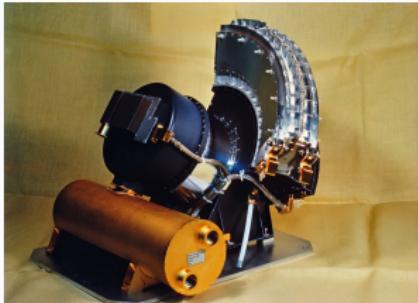


Gloeckler et al., 1999

Berger, AGU Fall Meeting 2018

Conclusion

- Pickup Ions basic concepts
- Ulysses SWICS
 - Principle of measurement
 - Data & Software
 - Coordinate Systems



Next:

Creating and analysing 3D VDFs based on Ulysses SWICS data