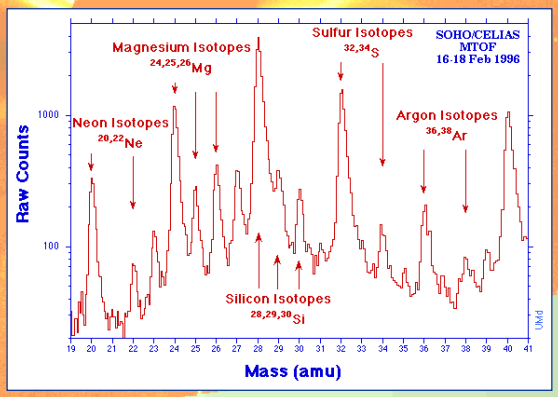
Space Instrumentation (4)

Lectures for the IMPRS June 23 to June 27 at MPAe Lindau
Compiled/organized by Rainer Schwenn, MPAe,
supported by Drs. Curdt, Gandorfer, Hilchenbach, Hoekzema, Richter, Schühle

Tue, 24.6., 15:00 Modern particle analyzers in planetary research: TOF, ENA (RS)



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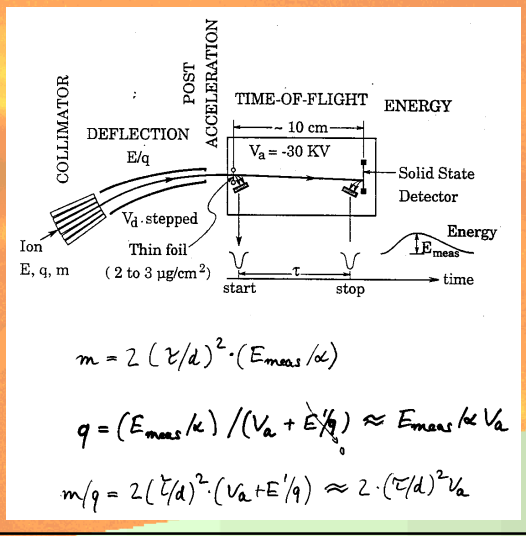
The principle of time-of-flight (TOF) instruments

From the 3 independently measured quantities (E/q, τ, E_{total}) the 3 desired quantities E, q, m can be uniquely derived.



$m = 2\,(\tau/d)^2 \cdot (E_{meas}/\alpha)$

$q = (E_{meas}/\alpha)\,/\,(V_a + E'/q) \approx E_{meas}/\alpha V_a$

$m/q = 2(\tau/d)^2 \cdot (V_a + E'/q) \approx 2 \cdot (\tau/d)^2 V_a$

Ulysses SWICS

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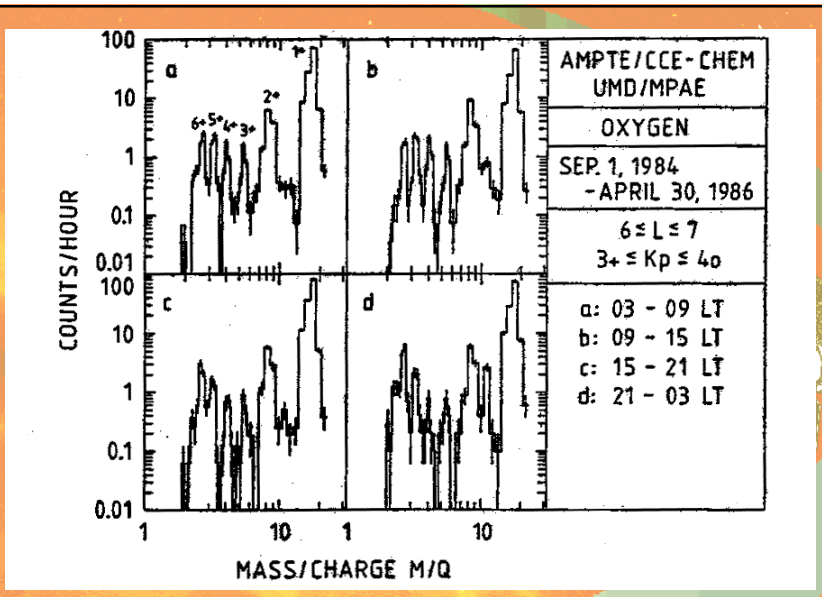
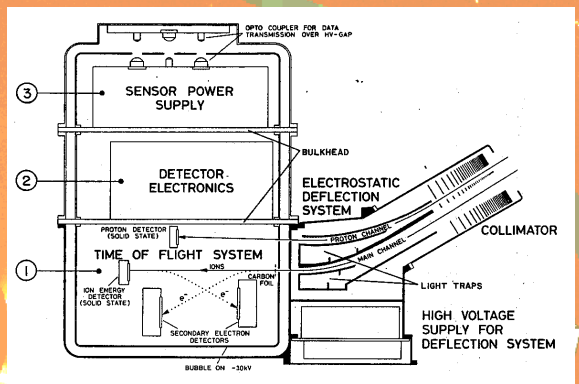
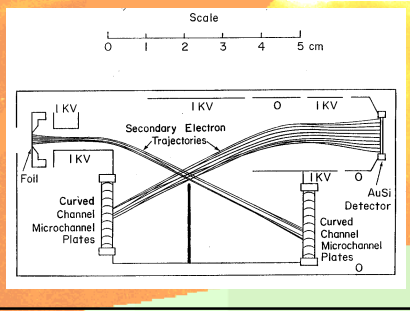
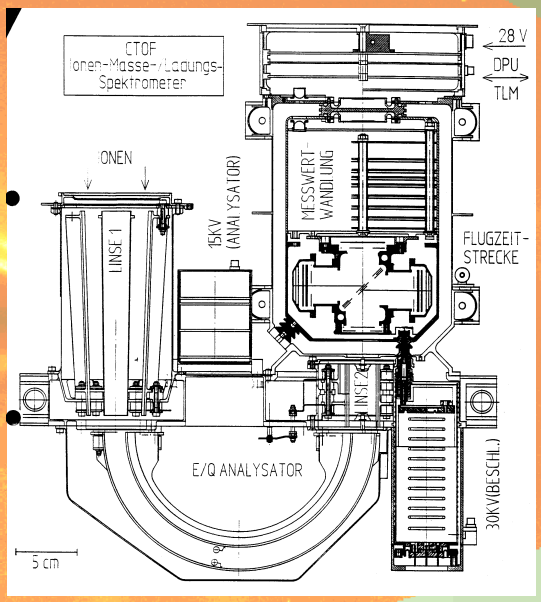


The first TOF measurements revealed: There are two populations of oxygen ions in the magnetosphere: highly ionized (from solar wind) and singly ionized (from the ionosphere)





The SWICS instrument on Ulysses



The CTOF instrument on SOHO

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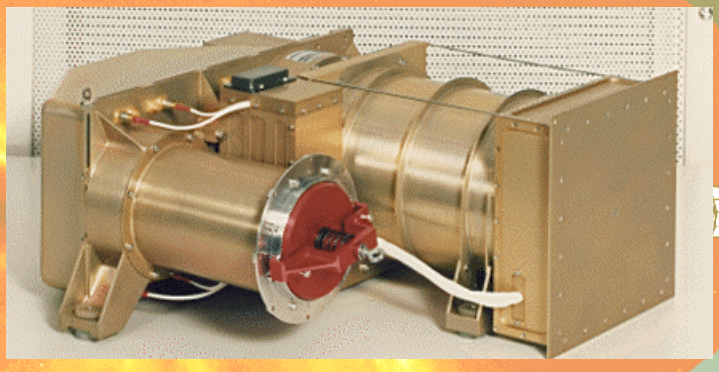

The CTOF instrument on SOHO

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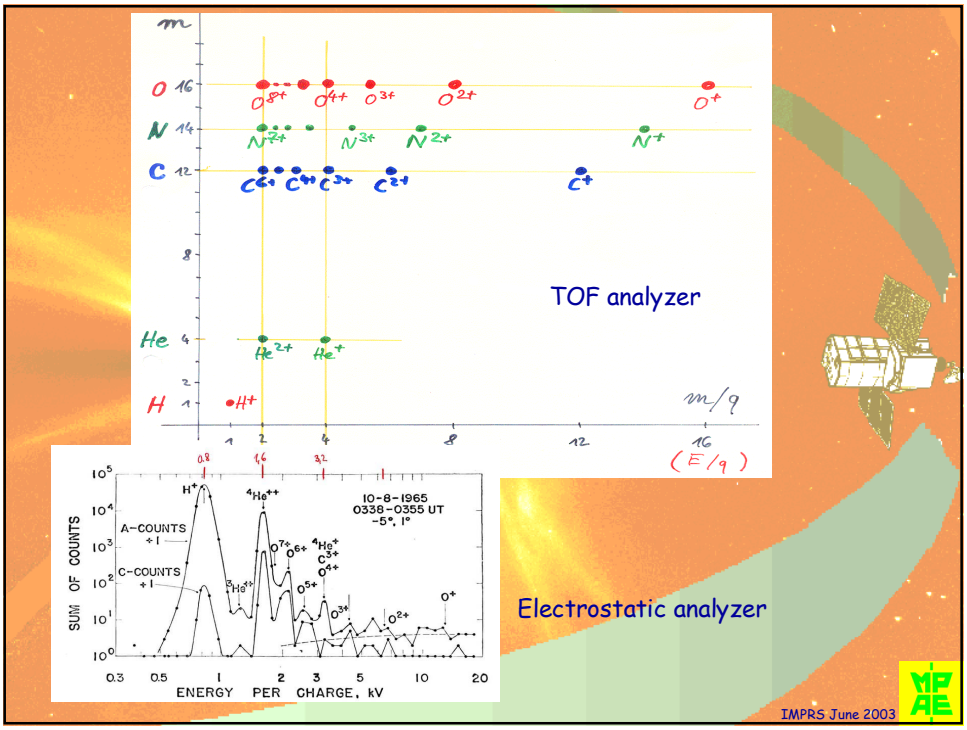
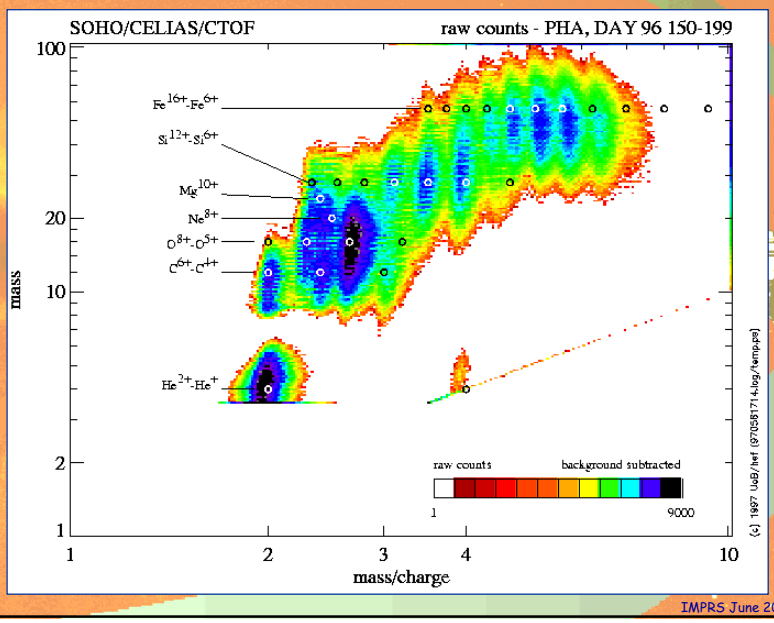


The solar wind element composition as revealed by modern TOF instrumentation on SOHO



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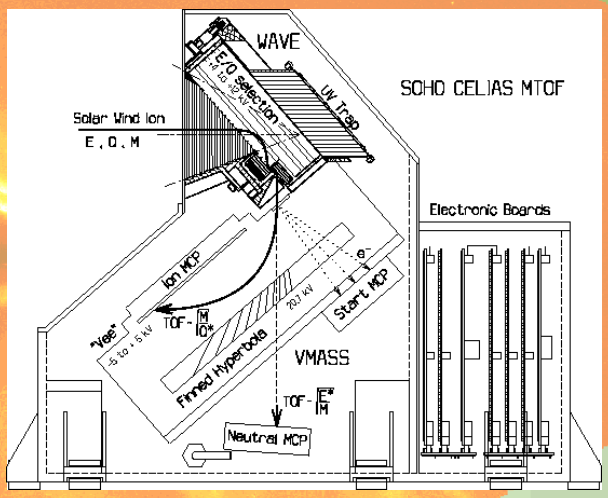
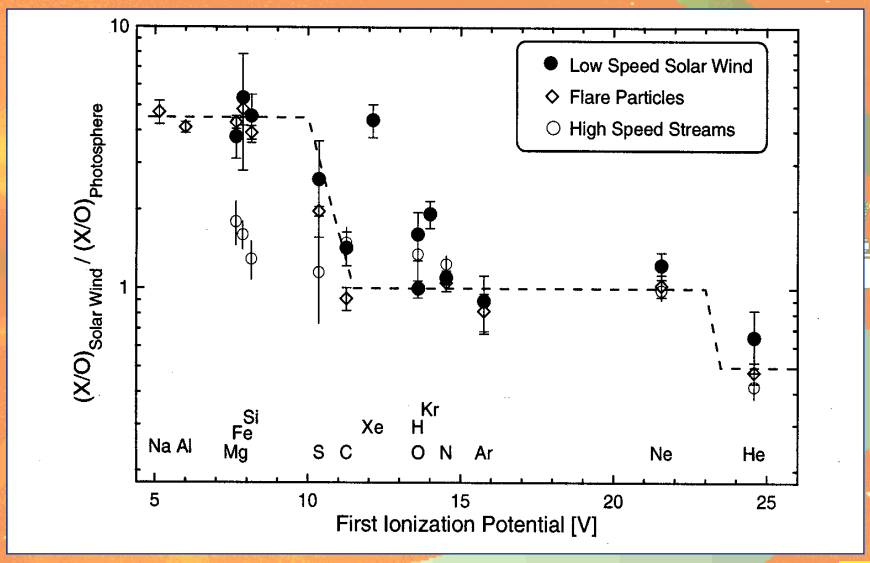


http://umtof.umd.edu/pm/instrument.html

The solar wind element composition as revealed by modern TOF instrumentation on SOHO



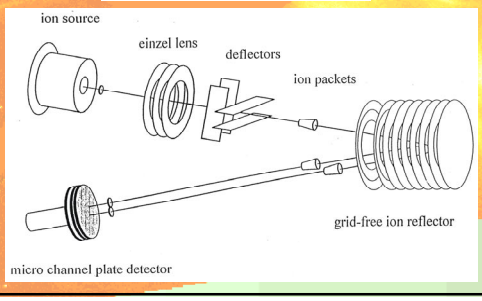
Elemental abundances and the FIP effect

ROSINA/RTOF auf ROSETTA
Reflektron-Time-of-Flight-Spektrometer

Instrument parameters

- Mass range: 1-1000 amu
- Mass resolution m/Δm=500 (1% Level)
- High time resolution by simultaneous mesurement of different masses

http://www.phim.unibe.ch/rosina/rosina.html



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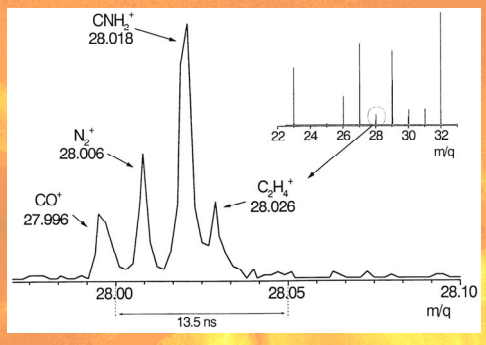
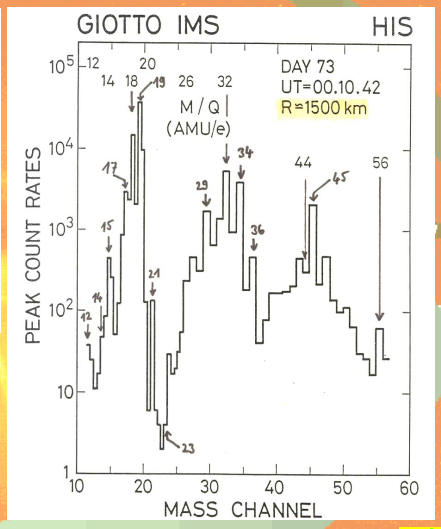
ROSINA/RTOF auf ROSETTA
Reflektron-Time-of-Flight-Spektrometer



Comparison of a mass spectrum obtained with the IMS-HIS sensor at comet Halley with a laboratory spectrum obtained by RTOF on the Rosetta mission



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Time-of-flight analyzer with a floatable drift tube

Simultaneous energy distribution and ion/neutral fraction measurements using a linear time-of-flight

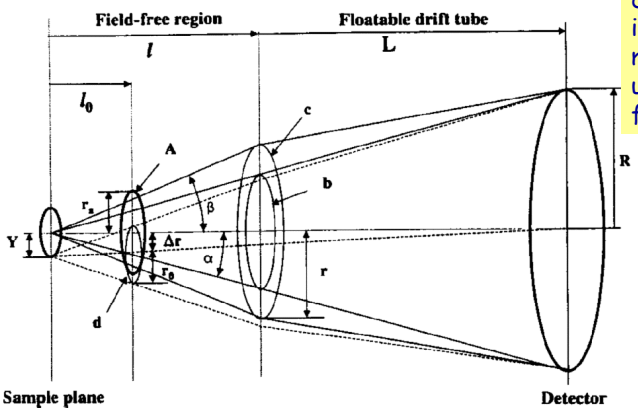

FIG. 1. Geometrical diagram of the linear TOF analyzer with a floatable drift tube, consisting of two field-free sections of length l and L with potential difference U between them. Aperture A is the smallest angular acceptance aperture of the apparatus.

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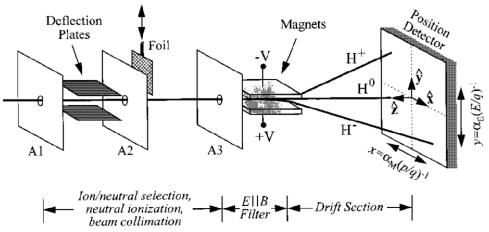

FIG. 1. **E||B** spectrograph for measurement of ion and neutral atom mass-per-charge and energy-per-charge distributions.

E!!B energy-mass spectrograph for measurement of ions and neutral atoms

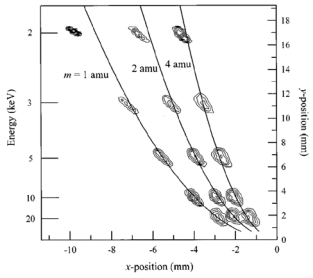

FIG. 3. Spectrograph of H^+, H_2^+, and $^4He^+$ beams incident at 2, 3, 5, 10, and 20 keV. Each contour line represents linear increments of 200 counts. The data closely follows the empirical fit of Eqs. (1) and (2) (solid lines).

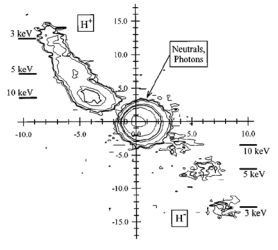

FIG. 4. Spectrograph of 3, 5, and 10 keV H after transiting a nominal 1 $\mu g/cm^2$ carbon foil, simulating neutral atom measurements. Contours are logarithmically spaced. Positive and negative ions are observed in the second and fourth quadrants, respectively. Neutral atoms exiting the foil are observed in the center of the detector; photons that can stimulate the detector would also be observed in the center of the detector.

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Mass spectroscopy using a rotating electric field

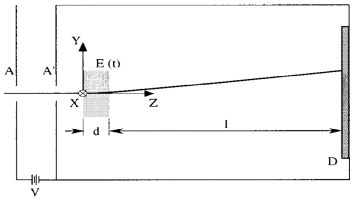
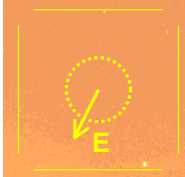


FIG. 1. Schematic of the REFIMS showing apertures A and A′, region of time-dependent electric field (shaded), and position-sensitive detector D. The bias voltage V accelerates ions into the analyzer. Also shown is the coordinate system used and the geometrical parameters l and d. Cylindrical symmetry about the z axis is implied.



time-of-flight → phase

Rev. Sci. Instrum., Vol. 69, No. 6, June 1998

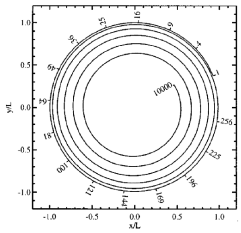


FIG. 2. Locus of points in the r–α plane for masses spanning the range 1–10 000 amu. This is the coordinate system that rotates with the direction of the deflection field, not one that is fixed in the laboratory frame. Here $l = 10\,d$ and $\omega = 0.4\ \omega_q$. Tick marks on the curve indicate the positions of several masses (in amu).

J. H. Clemmons and F. A. Herrero

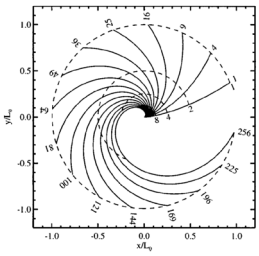


FIG. 7. r–α plane for several indicative masses between 1 and 256 amu (solid lines) for the energy range 1–100 ϵ. Broken traces indicate the positions of several energies (in units of ϵ). (After Fig. II.21 of Ref. 7.)

Rev. Sci. Instrum., Vol. 69, No. 6, June 1998

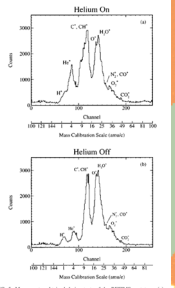


FIG. 5. Mass spectra obtained during tests of the REFIMS prototype. (a) Spectrum taken while helium leak valve was open. (b) Spectrum taken after closing leak valve. (From Ref. 7, Fig. II.21.)

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