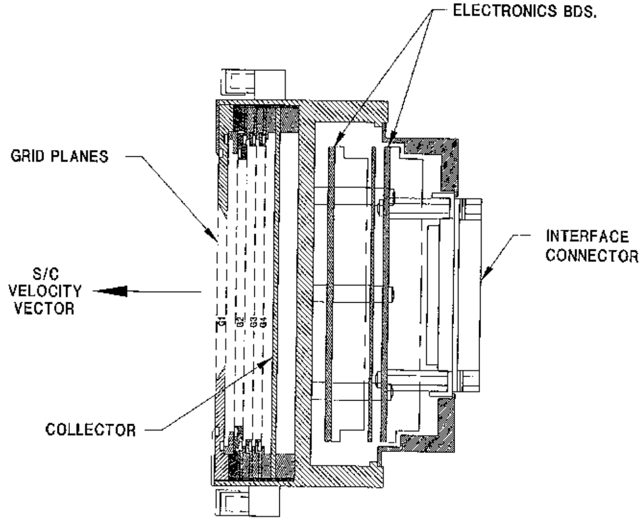
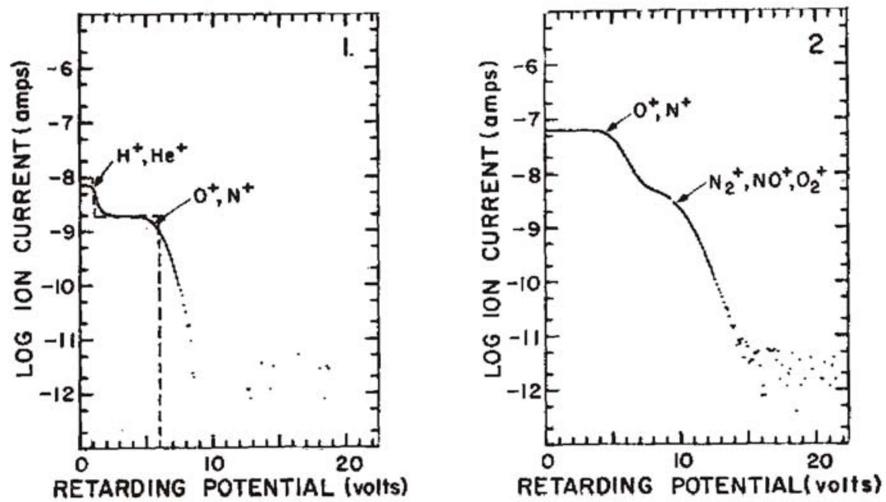
Retarding Potential Analyzers





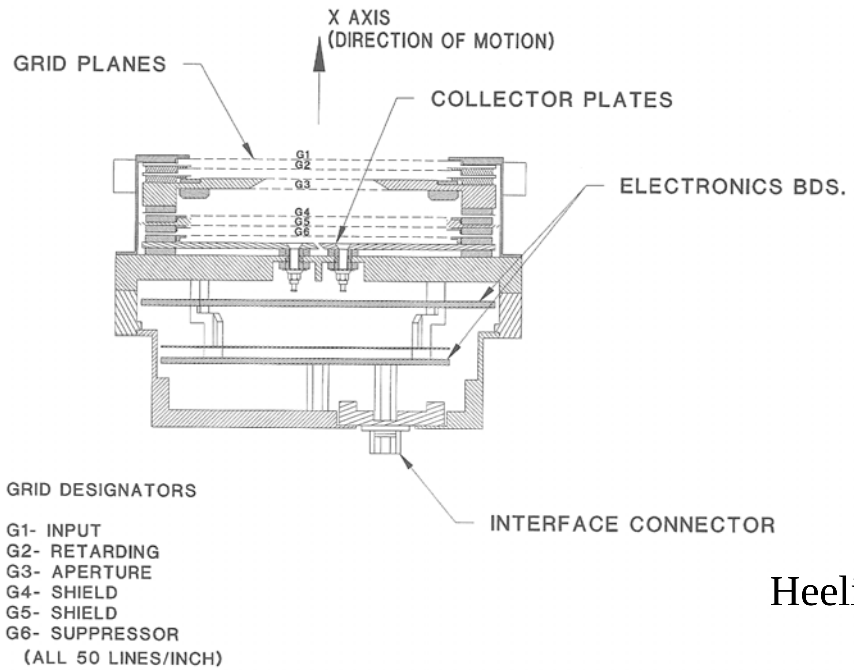
GRID DESCRIPTION

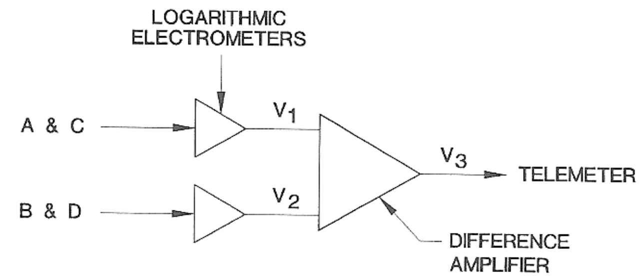
G1- DUAL APERTURE
G2- DUAL RETARDING
G3- SUPPRESSOR
G4- SHIELD

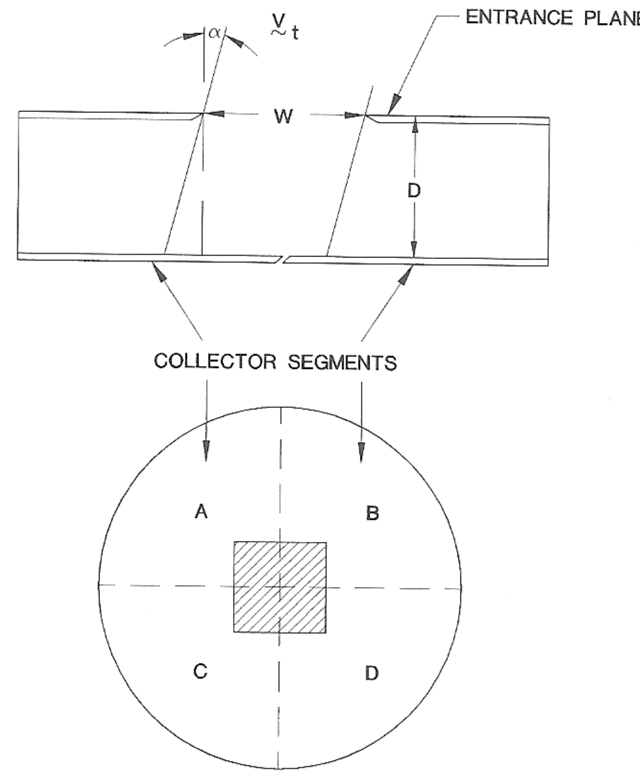
Heelis and Hanson, 1998

- In the ionosphere, mount along ram velocity, measure species densities
  - Ram speed (7.5km/s) is high or supersonic relative to ion thermal speed or motion
  - Spacecraft charging is negative and small relative to motional energy
  - I-V curve has steps at $qV_{ret} = \frac{1}{2}m(V_{sr}+V_r)^2 - q\psi_s$; where: ψ_s = sensor potential relative to plasma, V_{sr}= ram speed
  - Homework #1 Show that the thermal width of the steps is m $V_{sr}\,V_{th}$, where V_{th} is the ion species thermal speed. Show that for sensor potential of –0.8V, the step functions are at 1.1V for H^+ and 6V for O^+.
- Ions can be further differentiated with mass spectrograph behind RPA
  - See: Chappell et al., The retarding ion mass spectrometer on DE-1, Space Sci. Instr. 4, 477, 1981

RPA/Ion Drift Meters



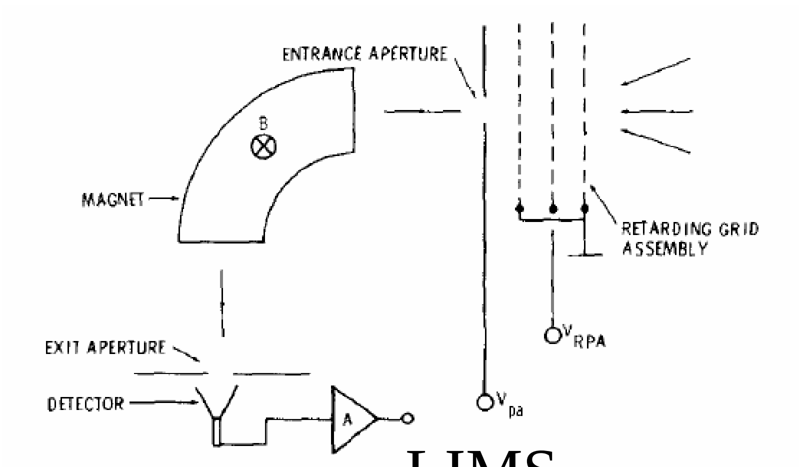




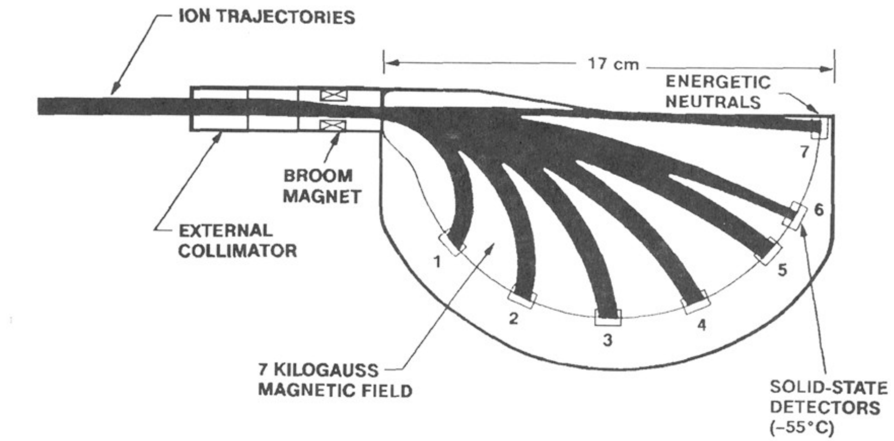
Heelis and Hanson, 1998

- In the ionosphere, mounted along ram velocity, measure species velocity
  - G2 retards lower energy H^+, but allows higher energy O^+ through
  - Collimated beam comes through and falls asymmetrically on collectors
  - G6 suppresses electrons, G3-5 are grounded to remove distortions
  - Homework #2: Determine transverse velocity V_t as function of ram speed, W, D.
- Issues: V_t error can be significant when ram direction angle is large
- Further reading:
  - Heelis and Hanson, Measurements of Thermal Ion Drift Velocity and Temperature Using Planar Sensors, in Measurement Techniques in Space Plasmas: Particles, Geophys. Monogr. Ser. 102, AGU, 1998

Magnetic Spectrographs



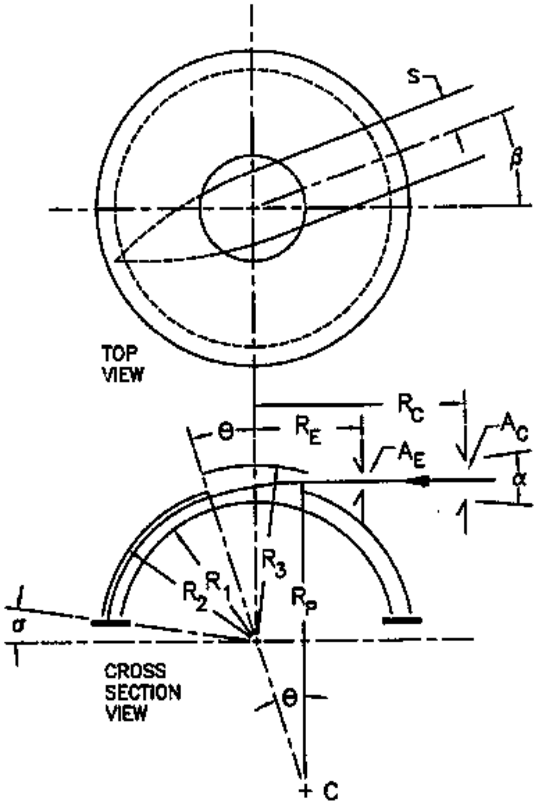
LIMS

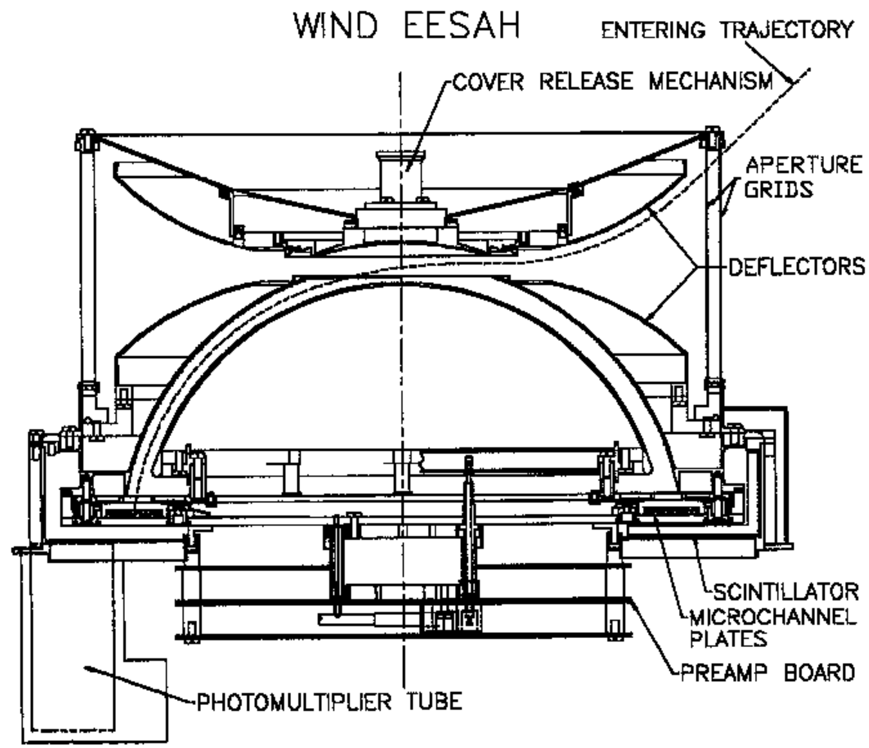


Magnetic Spectrograph on CRRES

- For low energy particles (left):
  - post-acceleration V_{pa} behind an RPA provides V, T and m/q
  - Homework #3 Show that in LIMS: $m/q=(Br_c)^2/(2V_{pa})$, where B is magnetic field, r_c magnet curvature
- For higher energy particles (right):
  - Broom magnet clears electrons
  - High field bends high energy ions
  - Ions that were not bent assumed neutrals (ENAs)
- Further reading:
  - Reasoner et al., Light ion mass spectrometer for space-plasma investigations: Rev. Sci. Instr. 53(4), p. 441, 1982.

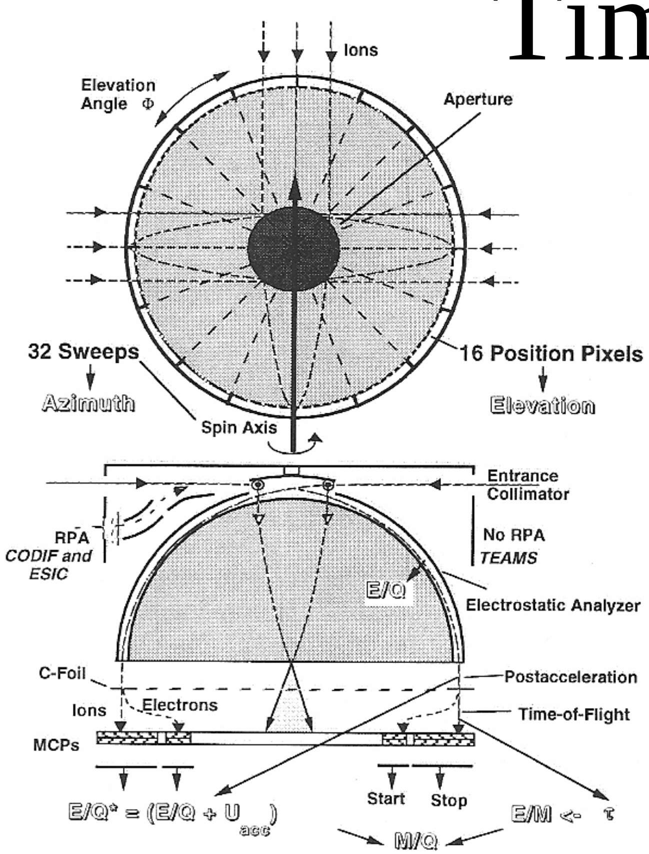
Electrostatic Analyzers

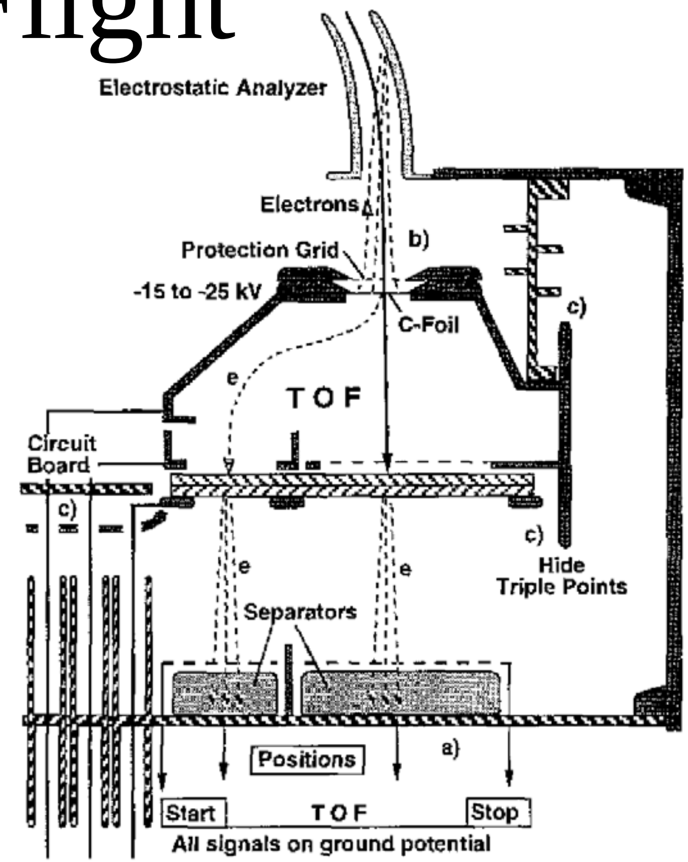




- Electrostatic deflection analyzes velocity distribution
  - Analyzer constant, $K=R_1/\Delta$, where $\Delta=R_2-R_1$; Outer shell is at 0 Volts, inner shell at potential V.
  - Electrostatic deflection at entrance aperture can measure incoming ions from different directions if spacecraft non-spinning
  - Homework #4 Show that the energy E of the particles of charge q, incident on the MCP is $E=-K\,q\,V/2$
- Further reading:
  - Carlson et al., The electron and ion plasma experiment for FAST: Space Sci. Rev. 98, 33, 2001.
  - McFadden et al., The THEMIS ESA plasma instrument and in-flight calibration, Space Sci. Rev., in press

Time of Flight





- Electrostatic deflection => energy per charge: E/Q. Time of flight, τ, => energy per mass E/M
  - Post-acceleration U_{ACC} provides sufficient energy for optimal McP operation and timing electrons at foil
  - Electrons generated at carbon foil result in energy loss α
  - Homework #5. Show $M/Q=2(E/Q + qU_{ACC})/(d/t)^2 * \alpha$
- Further reading:
  - Moebius et al., 3D plasma distribution analyzer with time-of-flight mass discrimination for Cluster, FAST and Equator-S, in Space Sci. Rev., in Measurement Techniques in Space Plasmas: Particles, Geophys. Monogr. Ser. 102, AGU, 1998