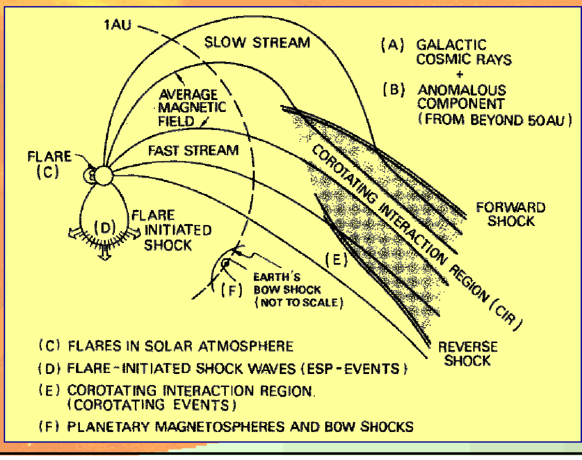
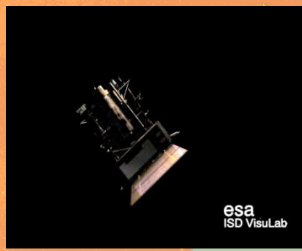
Space Instrumentation (5)

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

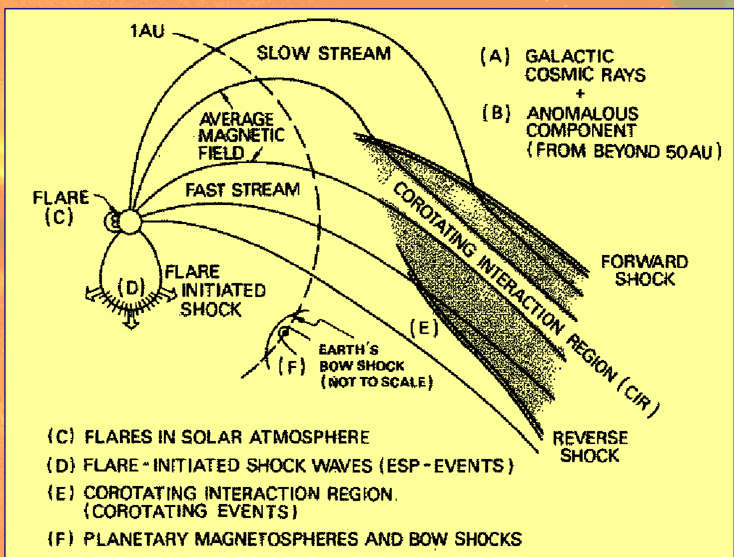
Tue, 24.6., 16:00 Energetic particles. Detection of interstellar gas. (RS)





Energetic particles in the solar system

The heliosphere is flooded with those particles, from at least 6 different sources!



Galactic Cosmic Rays hitting the Earth

Spaceship Earth as a spectrometer for GCRs!

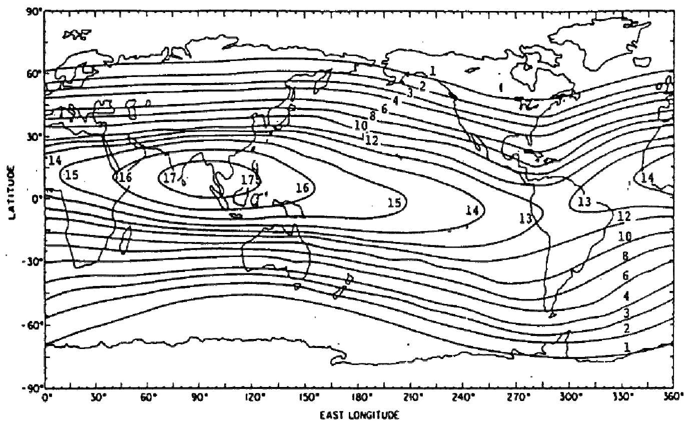


Fig. 2. Isorigidity contours of vertical cosmic ray effective cutoff rigidities, in units of gigavolts.

In order to penetrate the magnetic shield of the Earth down to the atmosphere, GCRs must have energies above 1 GeV (polar latitudes) and 20 GeV (at the equator)

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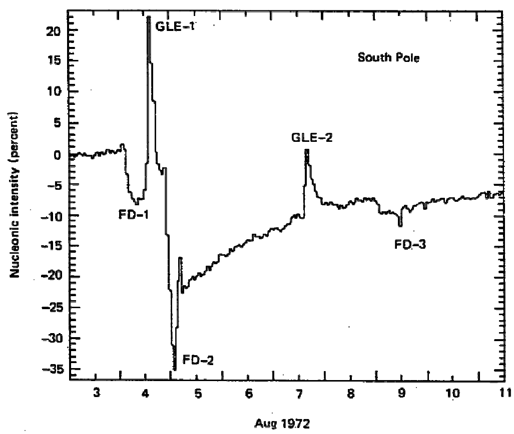
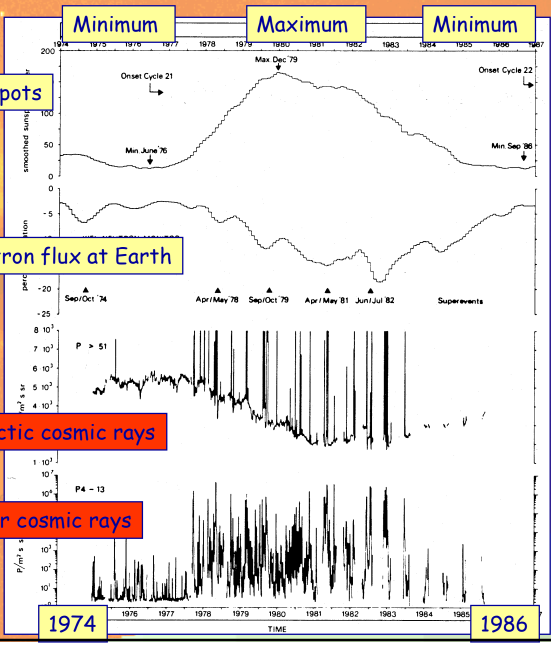


Figure 2.36. Response of South Pole neutron monitor to August 1972 solar flares, exhibiting ground-level enhancements (GLE) and Forbush decreases (FD). From Pomerantz and Duggal (1973).

„Forbush decreases" of GCRs are known since the 1940s

The GCRs are effectively shielded by magnetic clouds following coronal mass ejections (CMEs)

SCR and GCR through the solar cycle

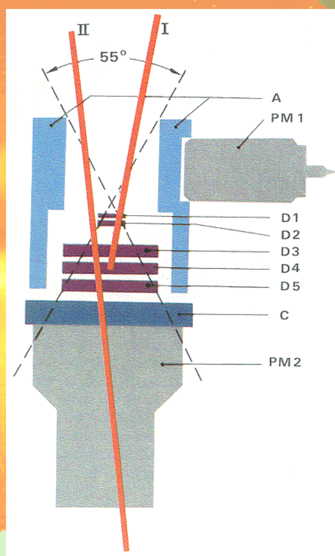


The active sun keeps the galactic cosmic rays (GCRs) away from the Earth much better than the inactive Sun. That might have impact on our terrestrial weather.

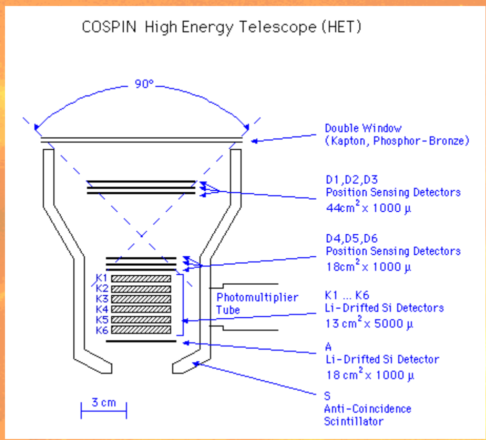
The detector system for the high energy cosmic ray instrument uses detection techniques which have been known for decades. 5 semiconductor detectors (D1 – D5), large silicon diodes, utilize the ionization of fast charged particles in the silicon. The particle generates electrons and positive ions which propagate to the electrodes of the detector within fractions of a millisecond due to the bias of several hundred volts. Highly sensitive amplifiers perform further analog processing. In the disc-like Cerenkov-detector C consisting of sapphire and in the hollow cylindrical scintillator A light is generated in response to the penetration of a charged particle, which is transformed into electrical pulses by the photomultipliers PM 1 and PM 2.

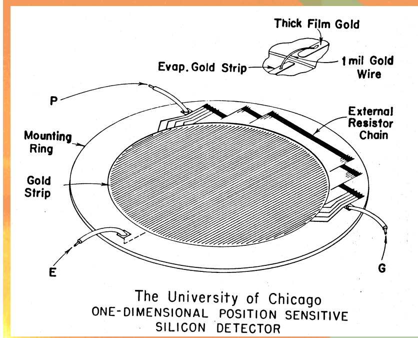
The tracks I and II symbolize the traces of particles which either stop in one of the semiconductor detectors (I) or penetrate the whole detector system (II). Each particle penetrating detector A is excluded. Only particles entering the detector system from above or below are used for further analysis. The pulses appearing at the output of the semiconductor detectors or the phototubes enable us to decide on charge, mass and velocity of the particles. This determines the element (or isotope of light elements) and its energy. The trajectory of the particle is determined using the spin of the space probe.

The Helios E6 cosmic ray detector (Uni Kiel)

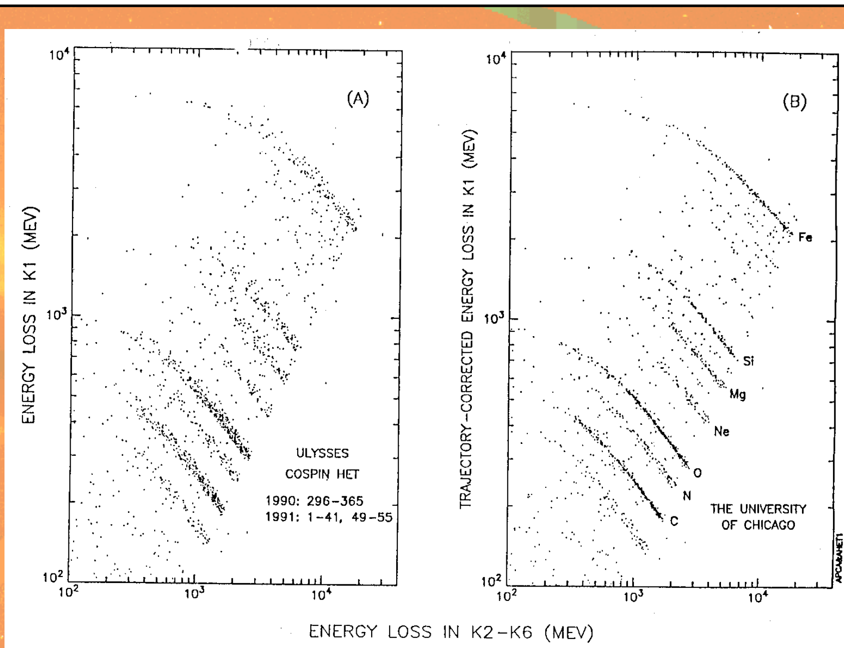


The High Energy Telescope HET on Ulysses

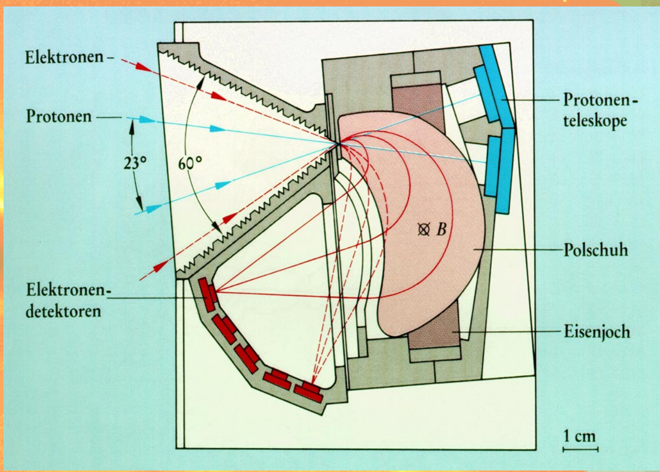




http://ulysses.uchicago.edu/WWW/Simpson/UlyDocs/HETsktch.html

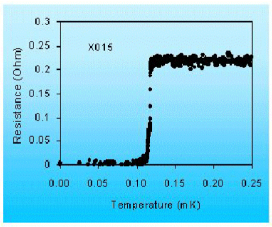


Ulysses COSPIN HET: de/dx vs E spectra



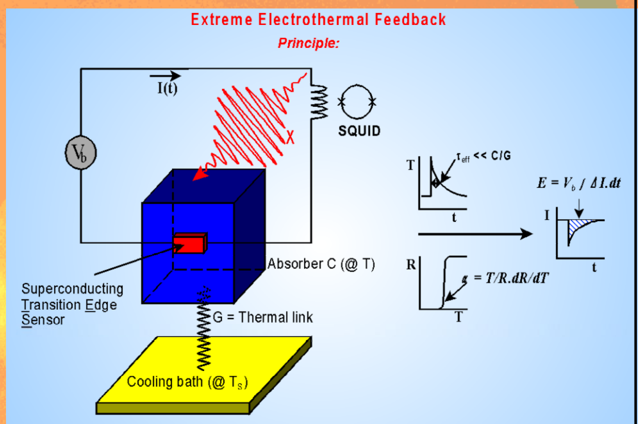
Solid state detectors (SSD):

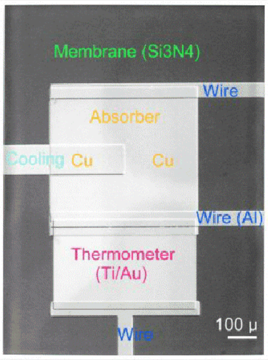
- Elektrons and Ions with energies of 10 keV to MeV
- High time and spacial reolution



Micro-Calorimeter

Stacks will be used for the Advanced Cosmic-Ray Composition Experiment for the Space Station (ACCESS 2005)





Focussing of interstellar neutral gas by the Sun

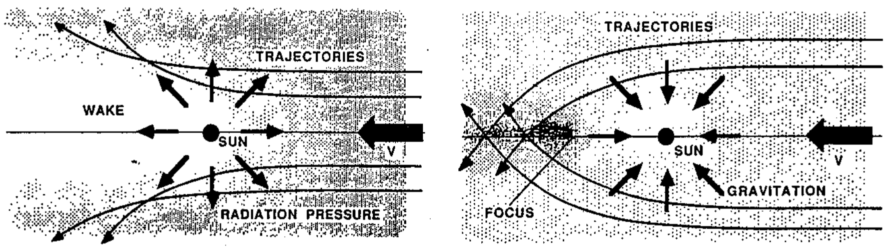
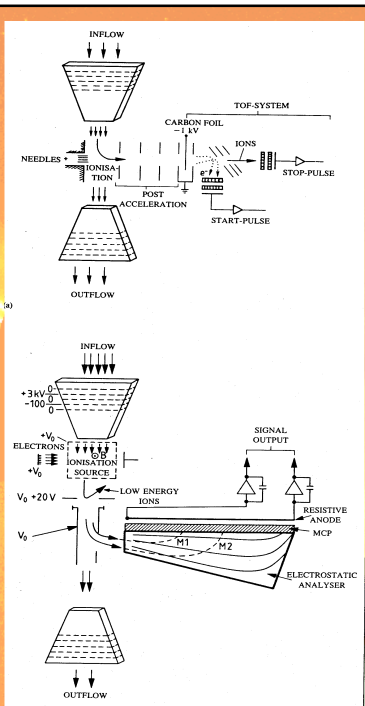
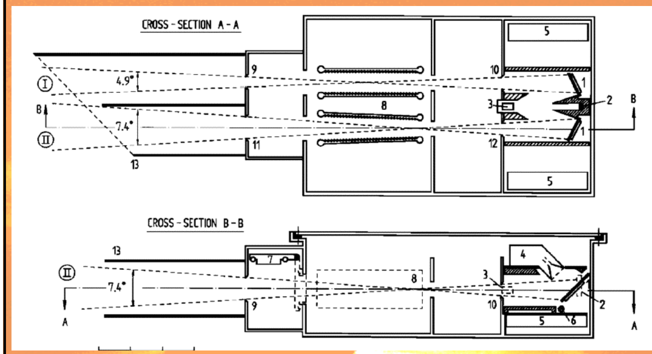


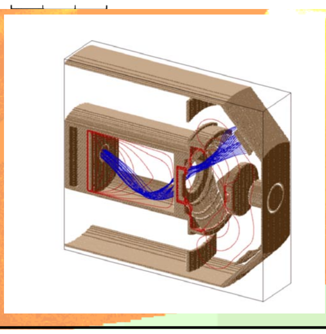
Fig. 2. Schematic of wake formation (left) and focusing (right) of the interstellar wind due to gravitation and radiation pressure of the sun.



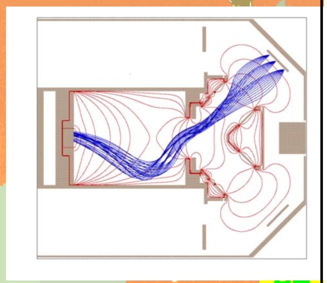
How to measure neutral particles with low energies? Ionize them first!
For example, by letting them pass through extreme electric fields.

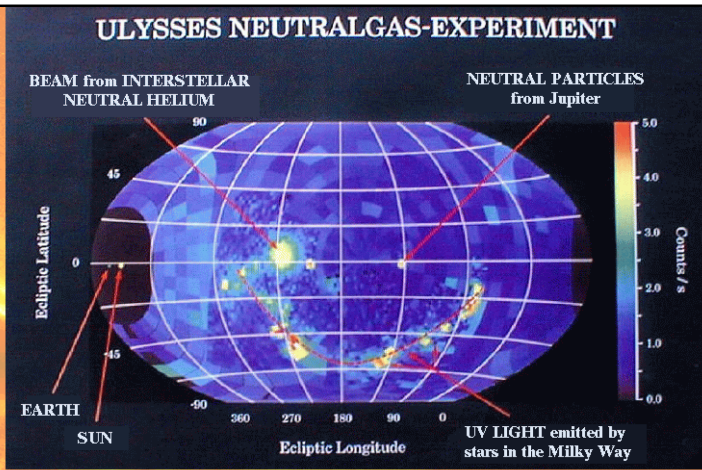


Interstellar helium Detector: GAS on Ulysses



NIHEAD
Interplanetary
Pathfinder 1998





Interstellar neutral gas flow into the heliosphere

Velocity: 25.3 ± 0.4 km/s

Flow Direction

ecliptic longitude : 73.9 ± 0.8o

ecliptic latitude: -5.6 ± 0.4o

Temperature: 7000 ± 600K

The flow of neutral gas into the solar system can be interpreted as the solar system moving through the interstellar medium in a direction about towards the star Antares (Alpha-Scorpii).

Neutral Particle Detectors

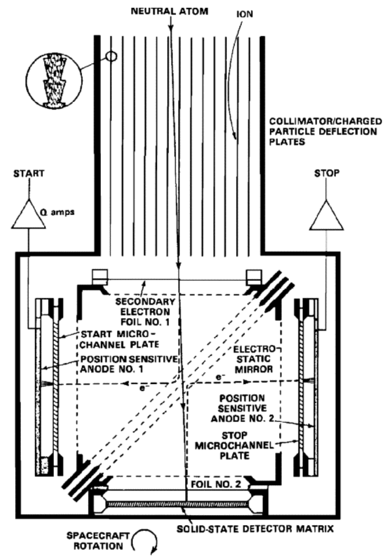


FIG. 28. Schematic of the high-energy ENA imager, which consists of a collimator/deflector, an imaging TOF detector for measuring the arrival direction and velocity of the incoming neutrals, and a solid state detector for measuring their energy. (After Ref. 111.)

Cheng 1993

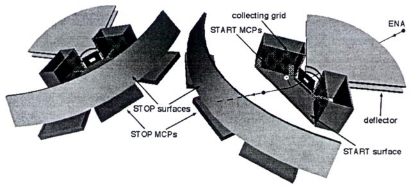


Figure 3.3.1. *Three-dimensional view of the NPD principal components.*

ASPERA-3
Mars Express
2003

Rev. Sci. Instrum., Vol. 71, No. 1, January 2000 Linear pulse amplifier 295

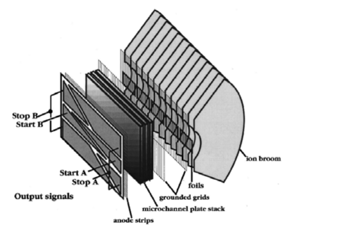
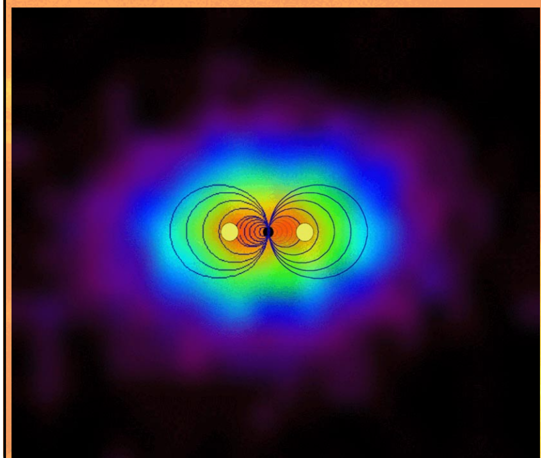
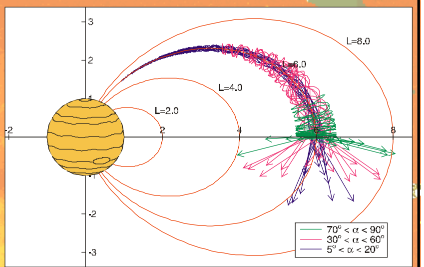


FIG. 1. Diagram of the MENA detector head, illustrating its principal components. An incoming atom enters at the right through the ion rejecting broom. When it passes through the grating/foil assembly it produces a few start electrons whose time and position are sensed on the start electrodes. Later, when the atom itself reaches the MCF, the stop time and position are sensed. The MENA amplifiers receive and amplify the A and B start and stop signals.

MENA
IMAGE
2000

ENA Imaging at Saturn/Titan by Cassini/MIMI





Measured MIMI/INCA images during the Cassini flyby at Jupiter

http://saturn.jpl.nasa.gov/index.cfm

IMPRS June 2003