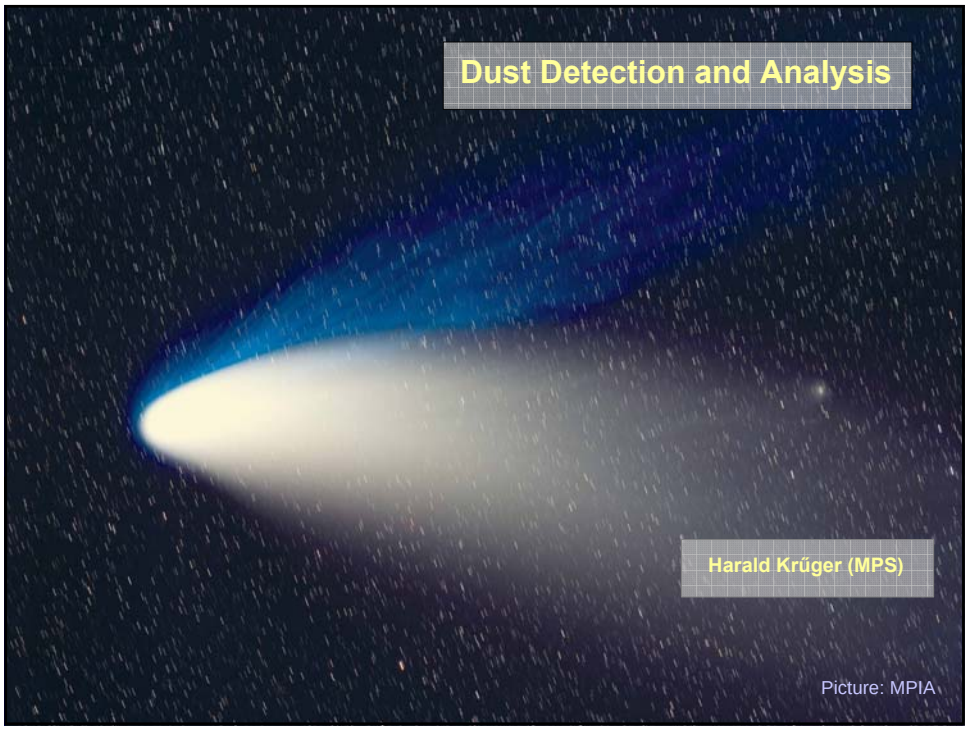
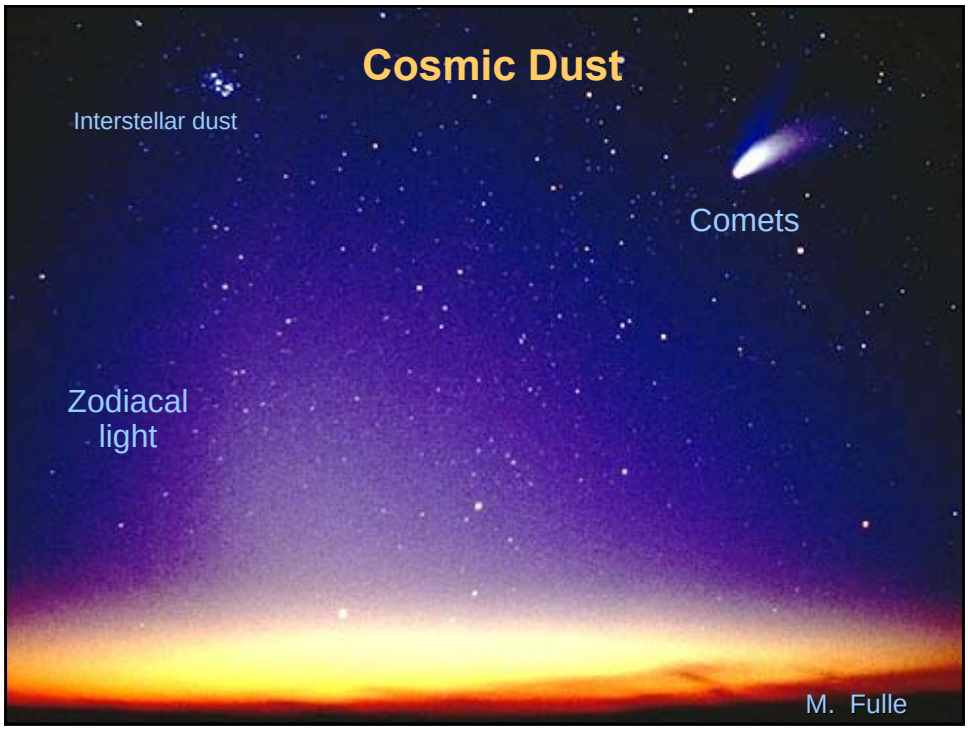


Outline

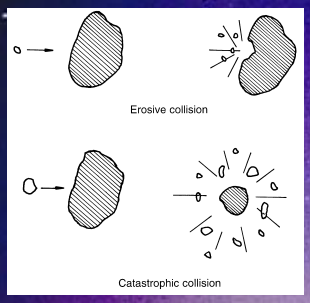
- Dust in the solar system
- How do we measure cosmic dust?
- Impact Detectors (e.g. Cassini/CDA)
- Dust Collectors (e.g. Rosetta/Cosima)


Cosmic Dust
M. Fulle


Cosmic Dust
Interstellar dust
Comets
Zodiacal light
M. Fulle

Dust Sources in the Solar System

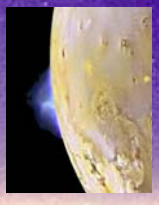
Collisions: asteroids, meteorites



Comets

Halley
Giotto HMC

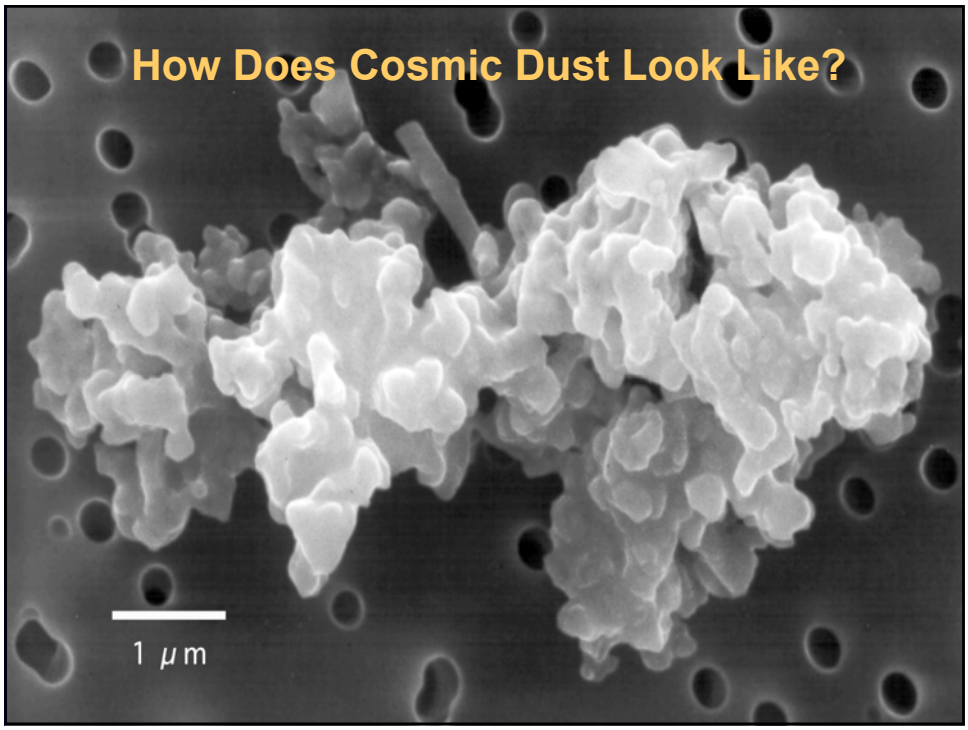
Volcanoes



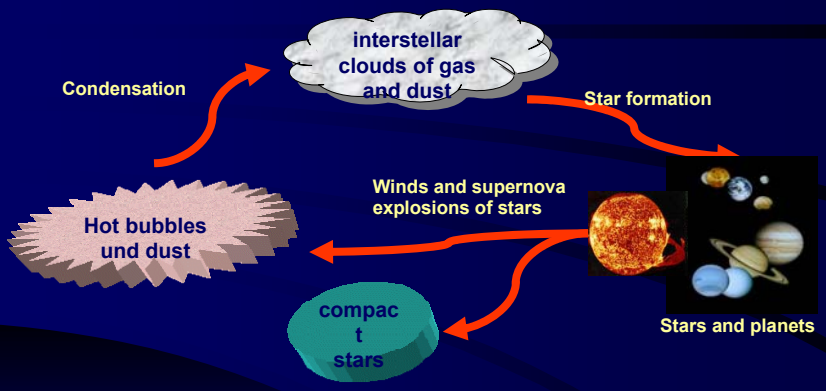
Io
Galileo

M. Fulle

How Does Cosmic Dust Look Like?



The Cosmic Cycle of Matter



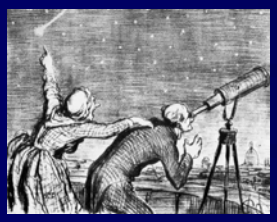
The cosmic cycle of matter:

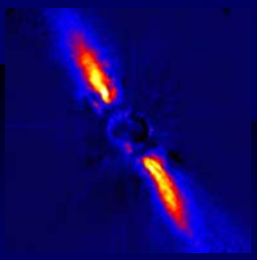
- Heavy elements are produced in stars and supernova explosions and ejected into interstellar space
- Form building blocks for the next generation of stars and planets.
- Also our solar system including the Earth was fromed from such primitve matter.

How Do We Measure Space Dust?

Investigation Techniques for Space Dust

Astronomical Observations
(Collective particle properties)



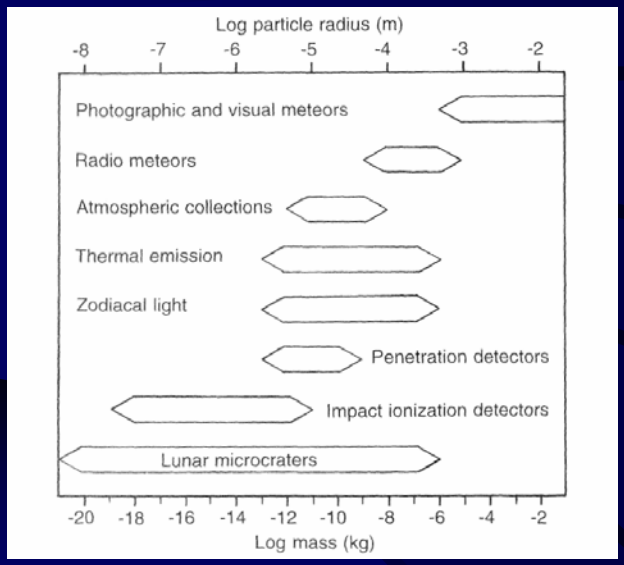


β Pictoris

In-Situ Investigations
(Measurement of individual grains)

Galileo at Jupiter

Investigation Techniques for Space Dust



In-Situ Dust Detection Techniques

Impact speed: v > 1 km/sec

Impact Ionisation Detection

e.g. Galileo, Ulysses, Cassini, Giotto, VeGa 1/2, Stardust (CIDA)

Each dust impact counted!

Dust Flux, impact direction, speed, mass, composition (m/Δm ~ 100)

Impact speed: v < 1 km/sec

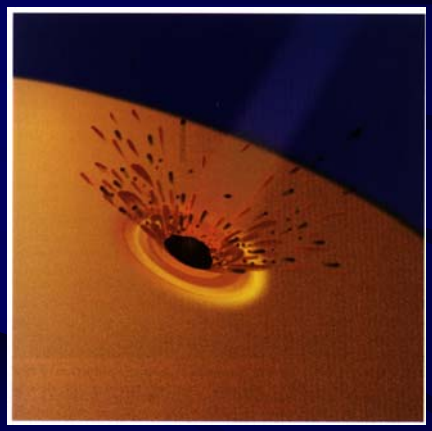
Dust Collection

e.g. Stardust (Aerogel collector), Rosetta/Cosima

Grains are collected and identified!

Dust composition (m/Δm up to 2000 in case of Cosima).
Grain extraction and analysis in the laboratory (Stardust)

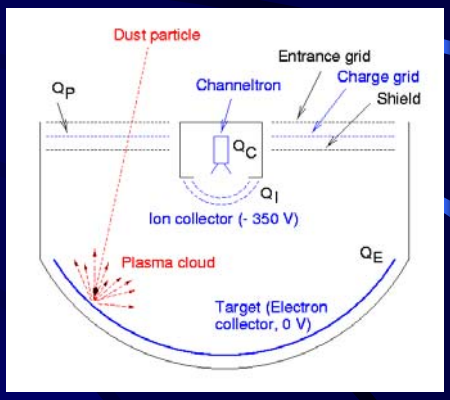
Dust Impact Detection



Impact Ionization Dust Detection

- *Multi-coincidence impact ionization detection*
- *Measurement of up to 3 charge signals: target, ion collector, channeltron*
- *Impact charge: $Q \sim m\, v^{3.5}$*
- *Impact speed derived from charge rise time*
- *Particle mass derived from charge amplitude*
- *Mass range: 10^{-19} - 10^{-9} kg (~ 0.1 - 10 µm radii)*
- *Speed range: 2 - 70 km s^{-1}*
- *Calibration: dust accelerator*

Galileo/
Ulysses



Cassini Cosmic Dust Analyser

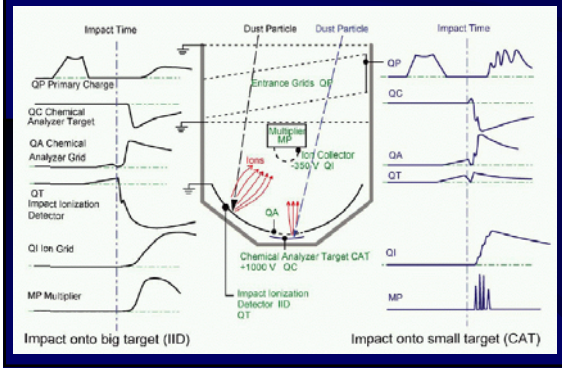
Cassini/CDA
MPIK Heidelberg

Cassini Cosmic Dust Analyser

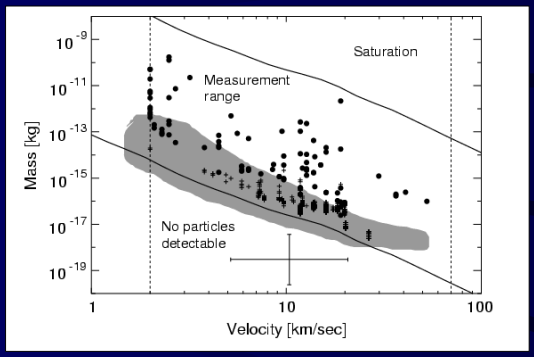
- Impact Ionisation Detector
- Sensor area 0.1 m²
- Mass, speed, impact direction, charge, composition
- Calibrated: 2 – 100 km/sec
- Grain sizes: ~ 0.1 – 10 µm

CDA

Cassini



Instrument Calibration



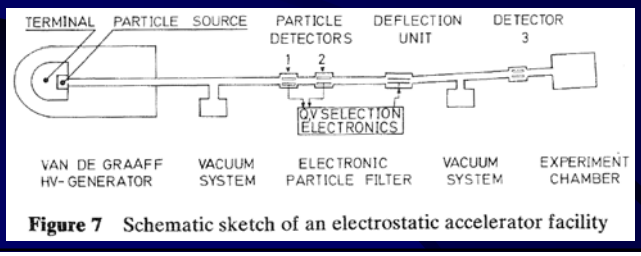
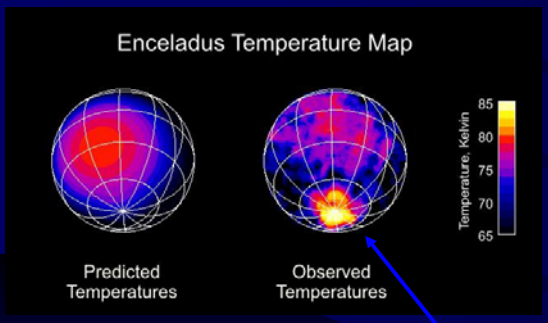


Figure 7 Schematic sketch of an electrostatic accelerator facility

Dust Ejection from Enceladus

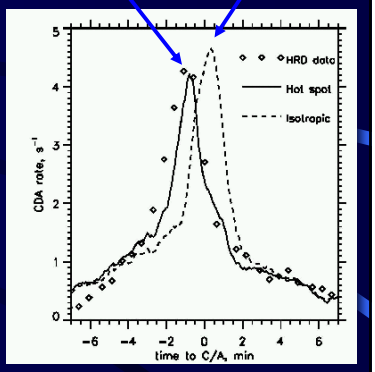


NASA/JPL

Hot spot at south pole

Measured

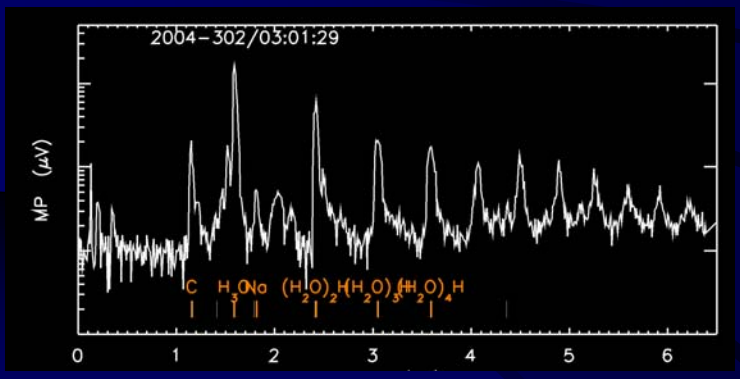
Expected



Spahn et al., 2006

Water Ice in Saturn's E Ring

- First in-situ detection of water ice in Saturn's dust ring
- Peak at H_3O^+ and following $H_3O^+(H_2O)_x$ lines (hydronium ion)

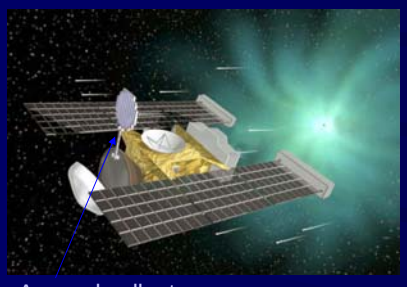


Srama, 2004

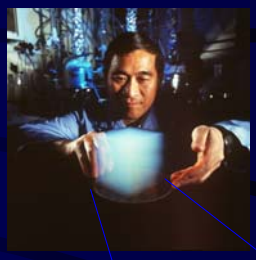
Dust Collection

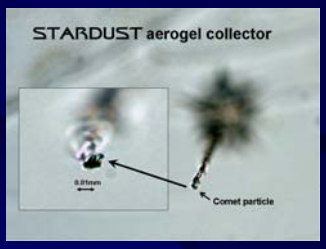
Stardust

Sample Return of Cometary Particles



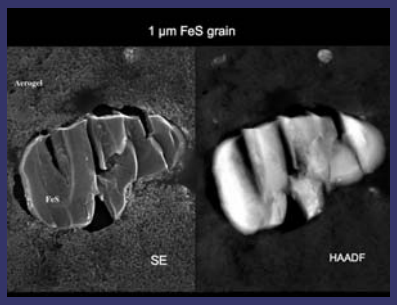
Aerogel collector

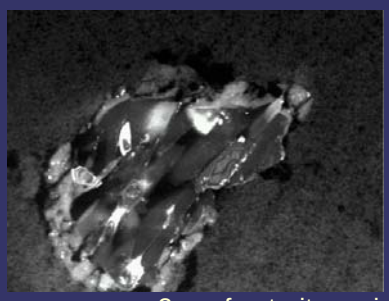




Stardust Return Capsule

- Mg-rich silicates (olivine, pyroxene), Ca-Al-rich minerals (diopside, anorthite, spinel), grains must have been formed at T > 1400 K.
- FeS
- No hydrated minerals, no carbonates, no magnetite yet
- High temperature phases similar to CAIs
- Crystalline and amorphous silicates found
- X wind model (Shu et al. 1996)



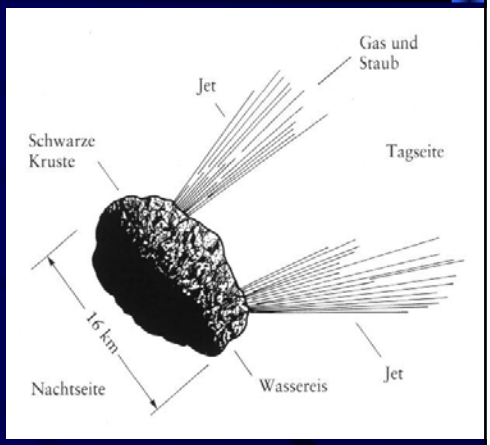


2 μm forsterite grain

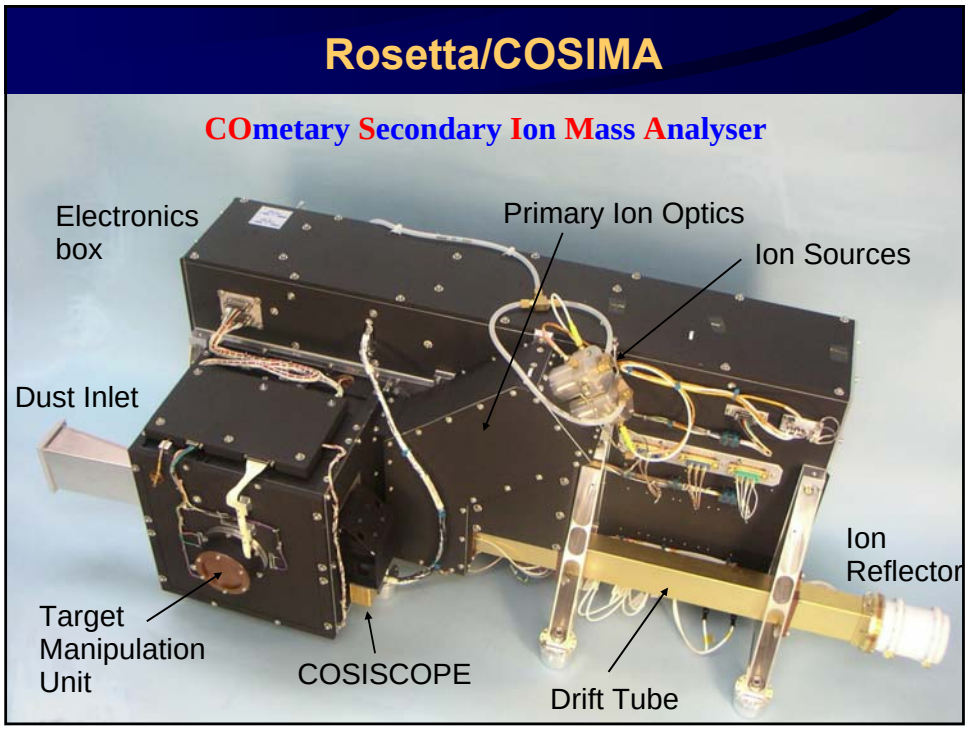
Comets: Remainders from the Formation of the Solar System

Nucleus of Halley's comet

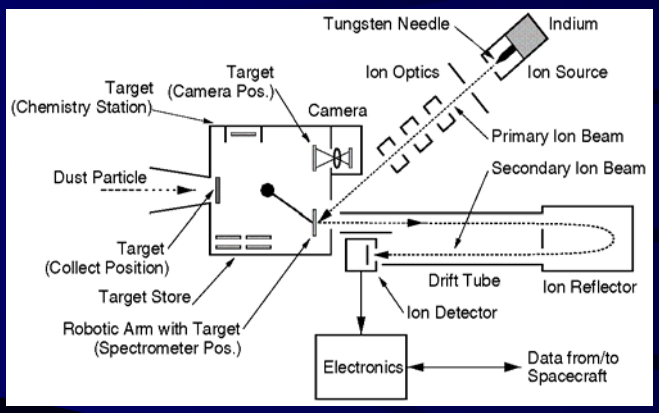
Giotto, HMC




Rosetta: Voyage to Comet
Churyumov-Gerasimenkov
In-Situ analysis of material from
the early solar system

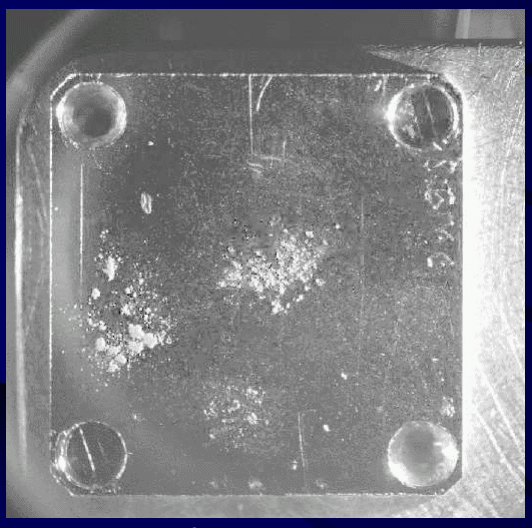

Rosetta/COSIMA
COmetary Secondary Ion Mass Analyser
Electronics box
Primary Ion Optics
Ion Sources
Dust Inlet
Ion Reflector
Target Manipulation Unit
COSISCOPE
Drift Tube

COSIMA Functional Principle



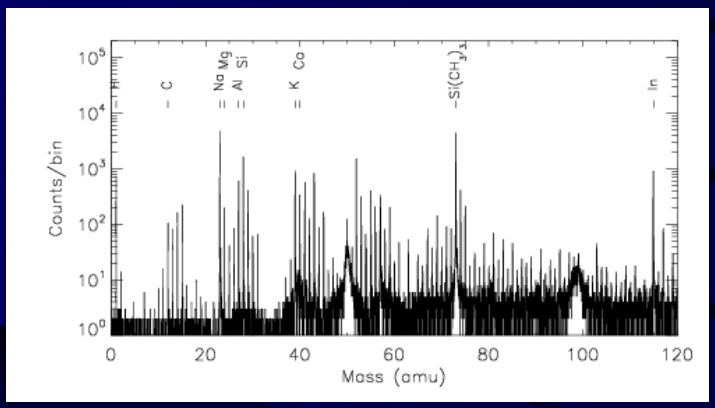
- Dust is collected on metal black targets which are stored in Target Manipulation Unit
- Dust grains are located by microscopic camera COSISCOPE
- A pulsed Indium ion beam partially ionizes the dust grains
- Secondary ions are accelerated by electric field and travel through drift tube with ion reflector
- Ions are detected by ion detector; flight times are recorded by T/D converter
- Mass spectra calculated from the time- of- flight spectra

COSIMA Target

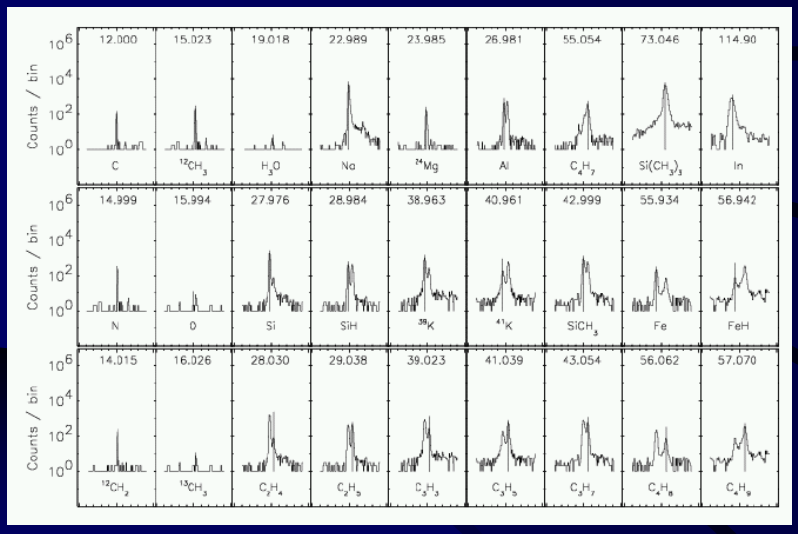


Cosima target (1x1 cm^2) prepared with clinopyroxene powder

COSIMA Spectrum



COSIMA Spectrum



COSIMA Specifications

Atomic mass range	1...4000 Da
Rel. Atomic mass resolution m/Δm at m=100	~ 2000
Mass	19.8 kg
Indium ion pulse duration	~ 5 ns
Indium ion energy	8 keV
Power consumption from 28 V DC	20.4 W

Credits: Max-Planck-Institut für Kernphysik, Heidelberg (H. Fechtig, E. Grün, J. Kissel)


The End