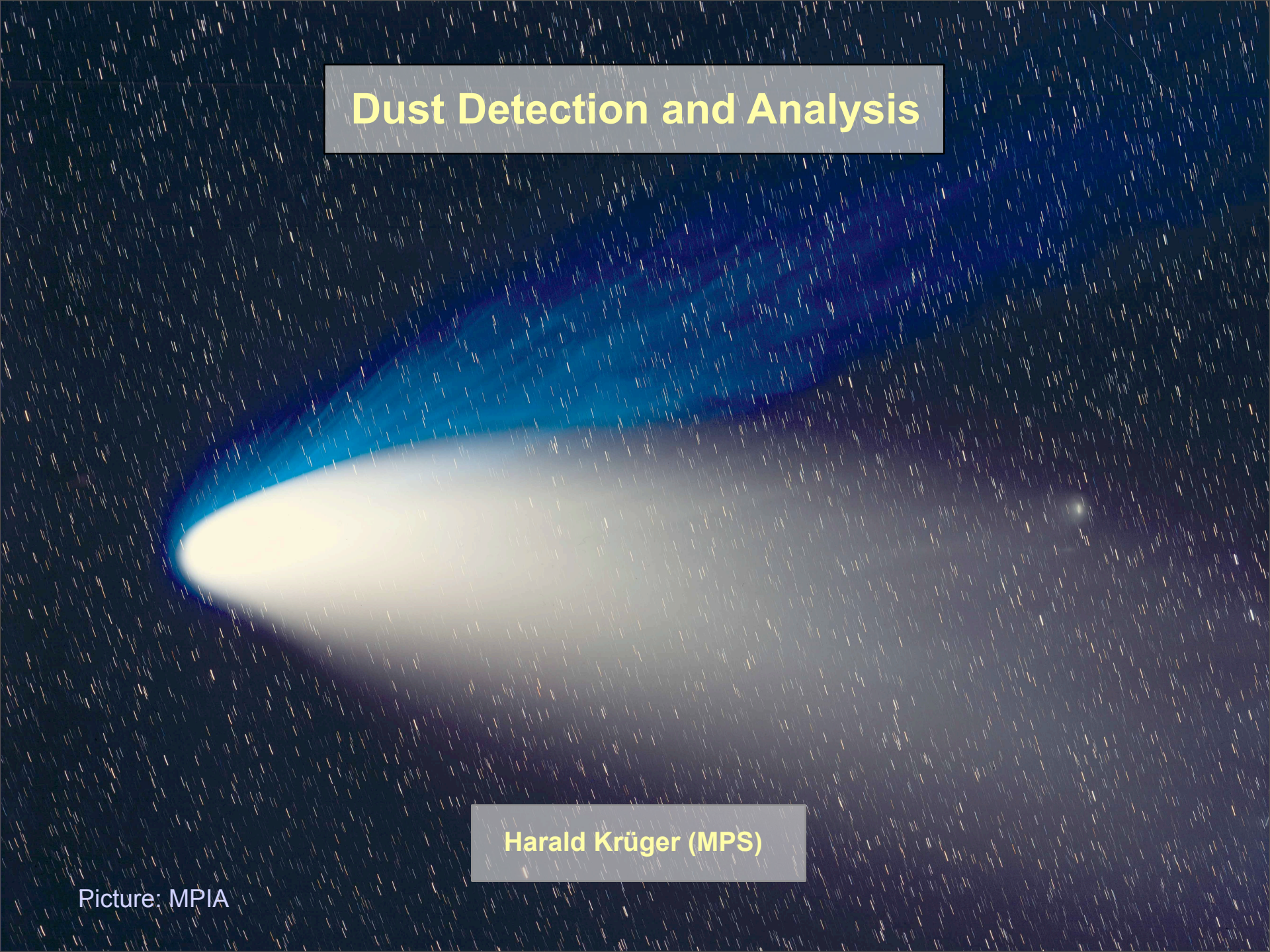
Dust Detection and Analysis



Harald Krüger (MPS)

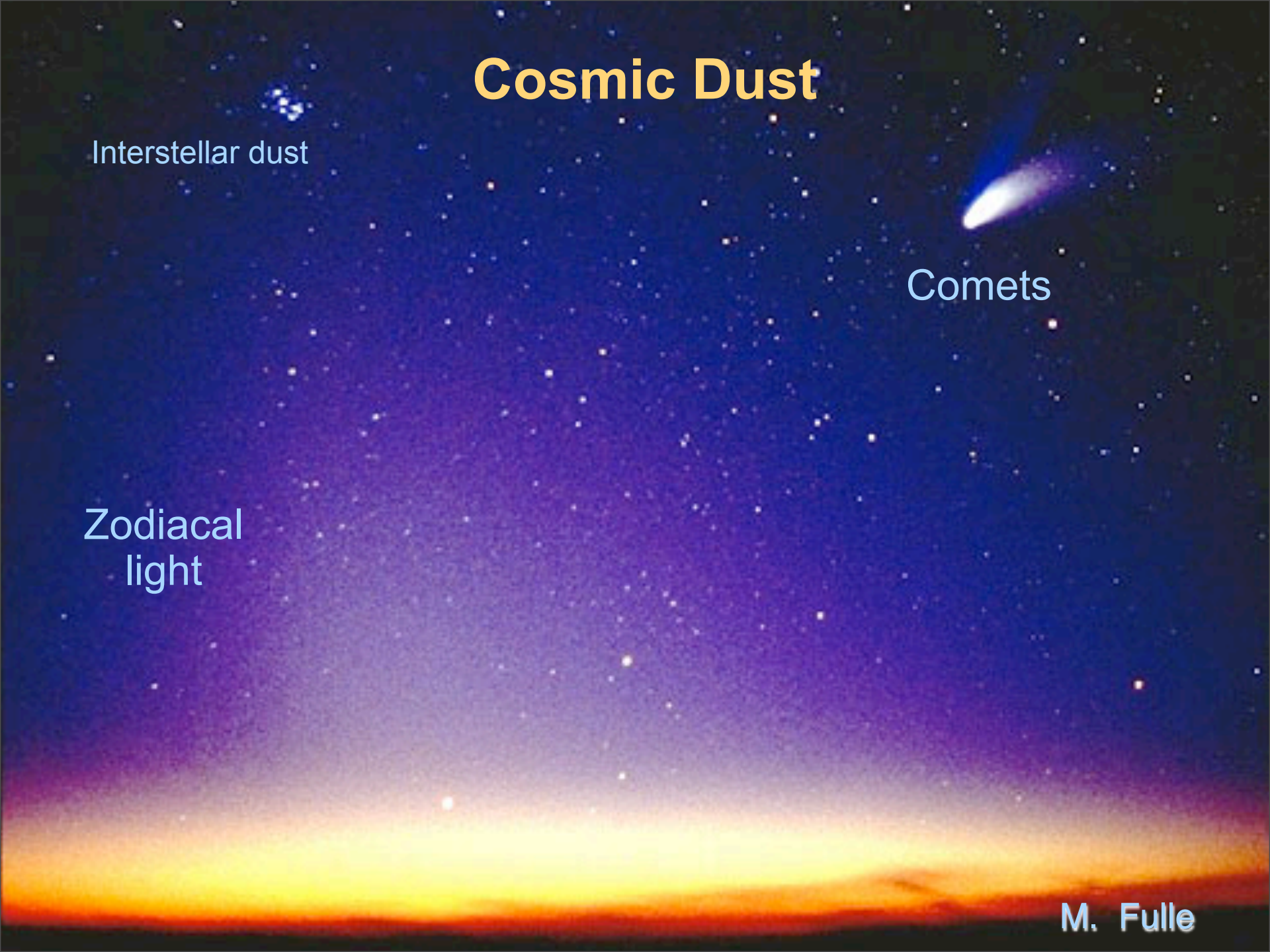
Picture: MPIA

Outline

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

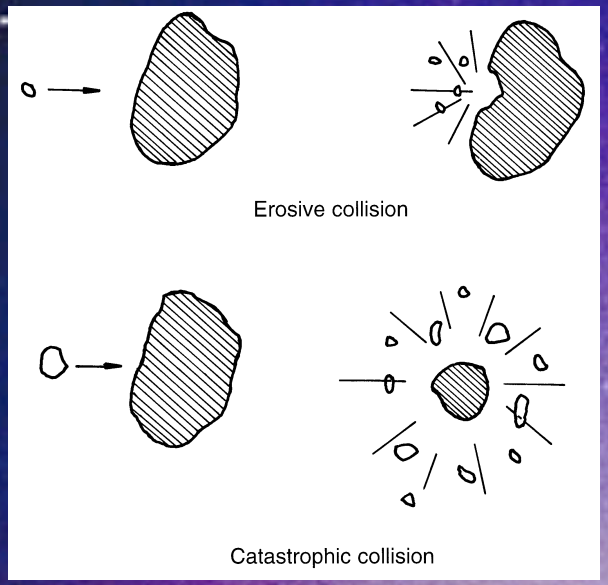
Cosmic Dust

M. Fulle


Cosmic Dust
Interstellar dust
Comets
Zodiacal light
M. Fulle

Dust Sources in the Solar System

Collisions: asteroids, meteorites

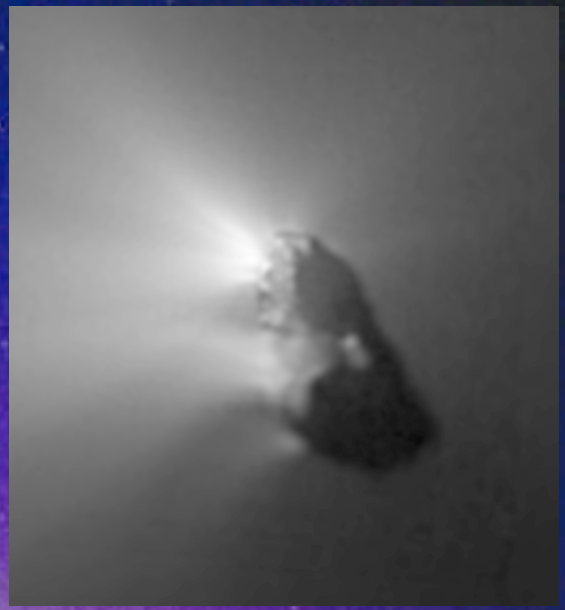


Volcanoes

Io
Galileo

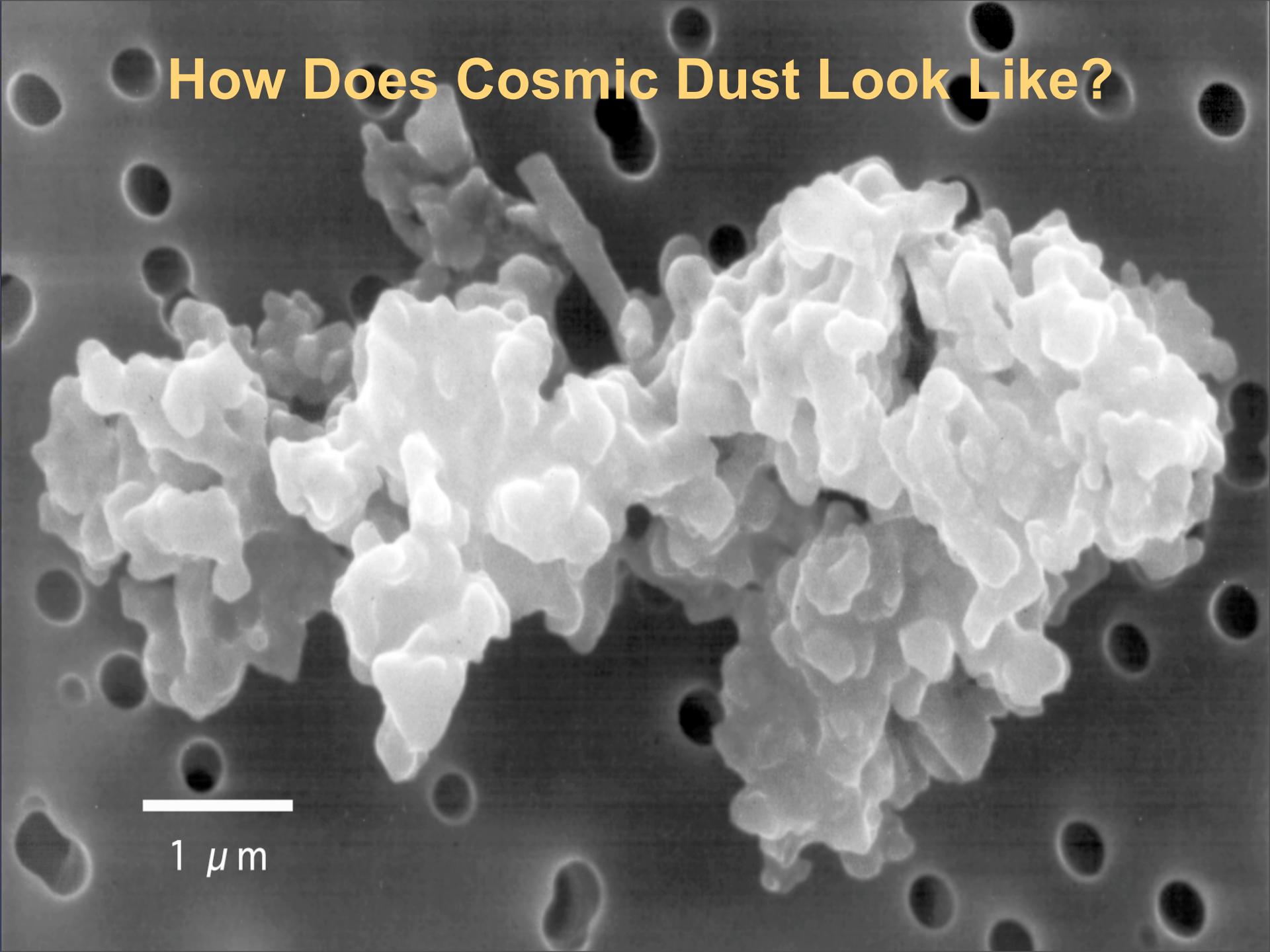
Comets

Halley
Giotto HMC



M. Fulle

How Does Cosmic Dust Look Like?

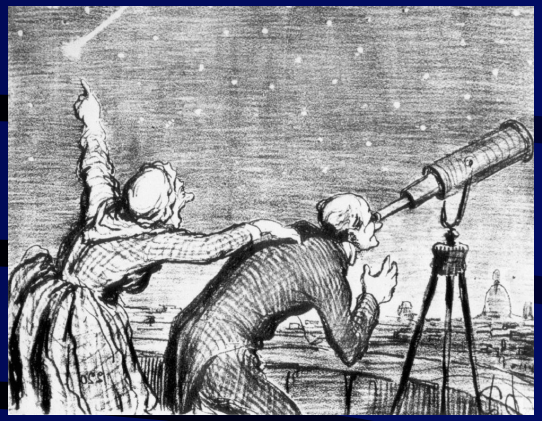


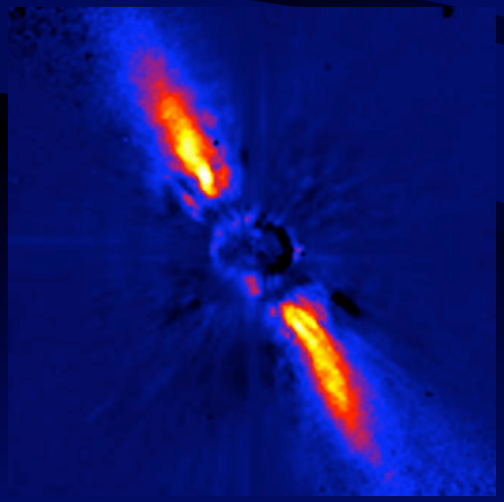
How Do We Measure Space Dust?

Investigation Techniques for Space Dust

Astronomical Observations

(Collective particle properties)

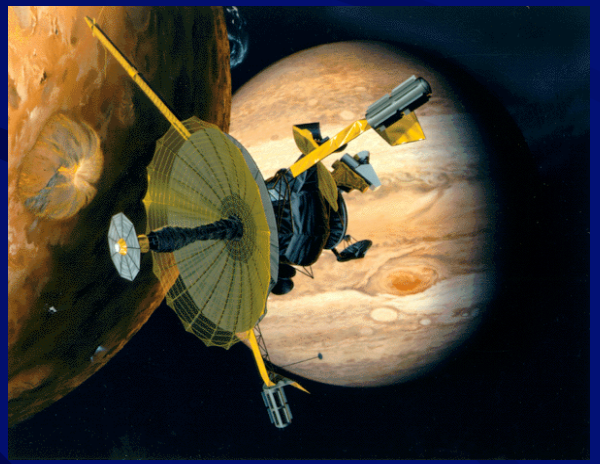




β Pictoris

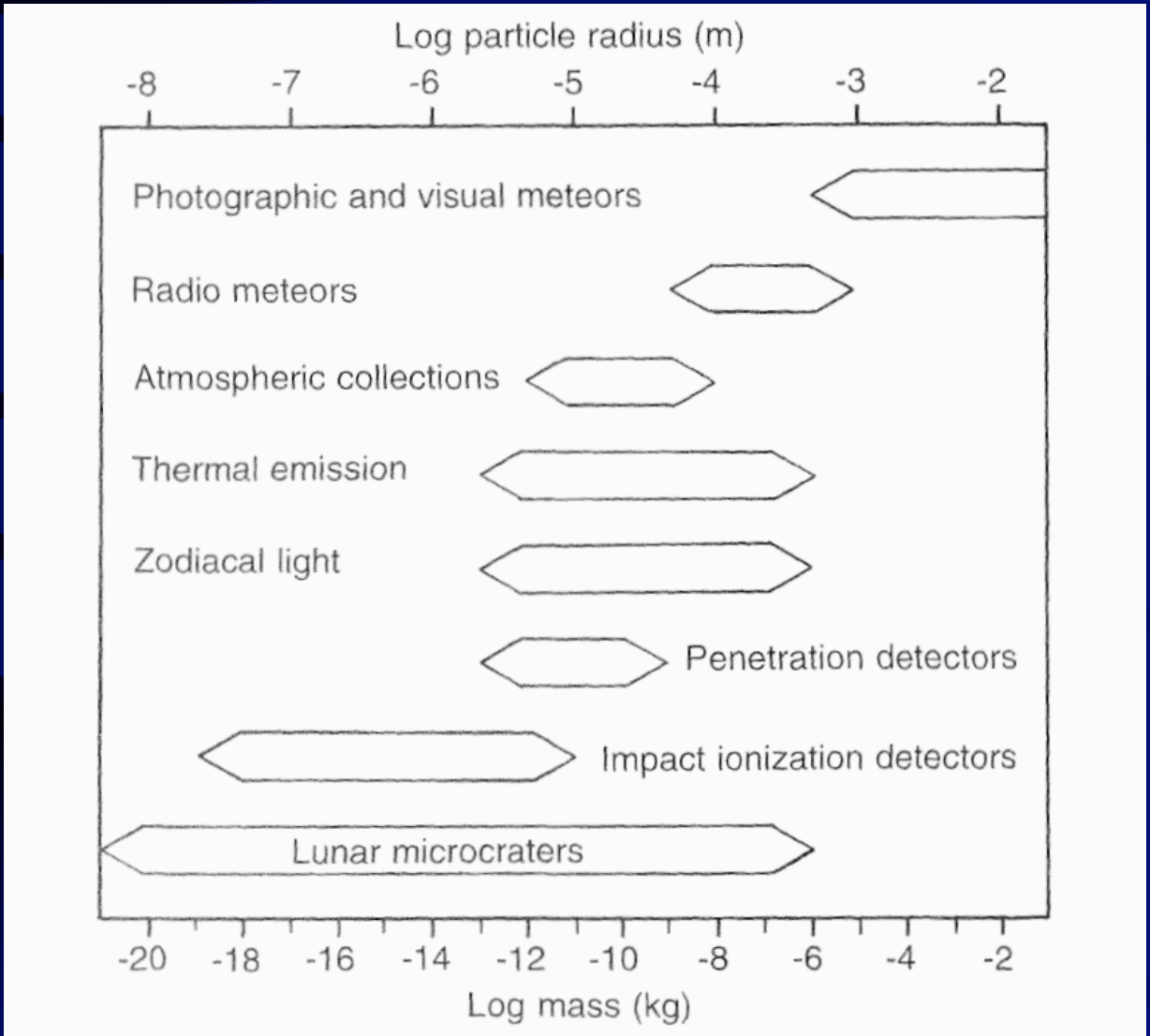
In-Situ Investigations

(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

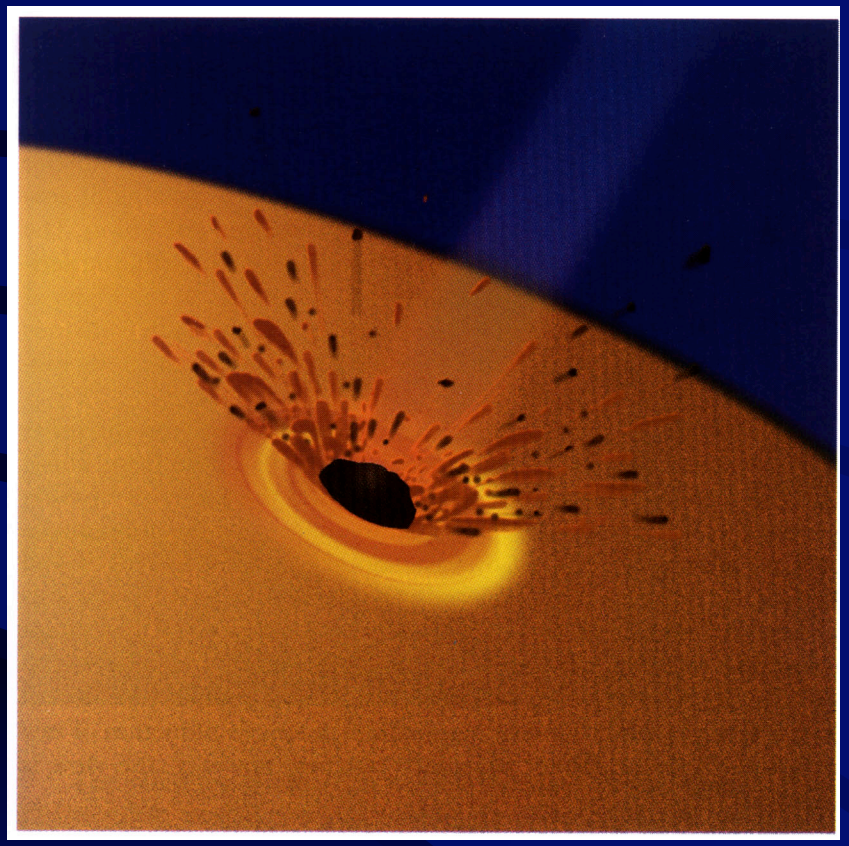
Dust Collection

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



Cassini Cosmic Dust Analyser

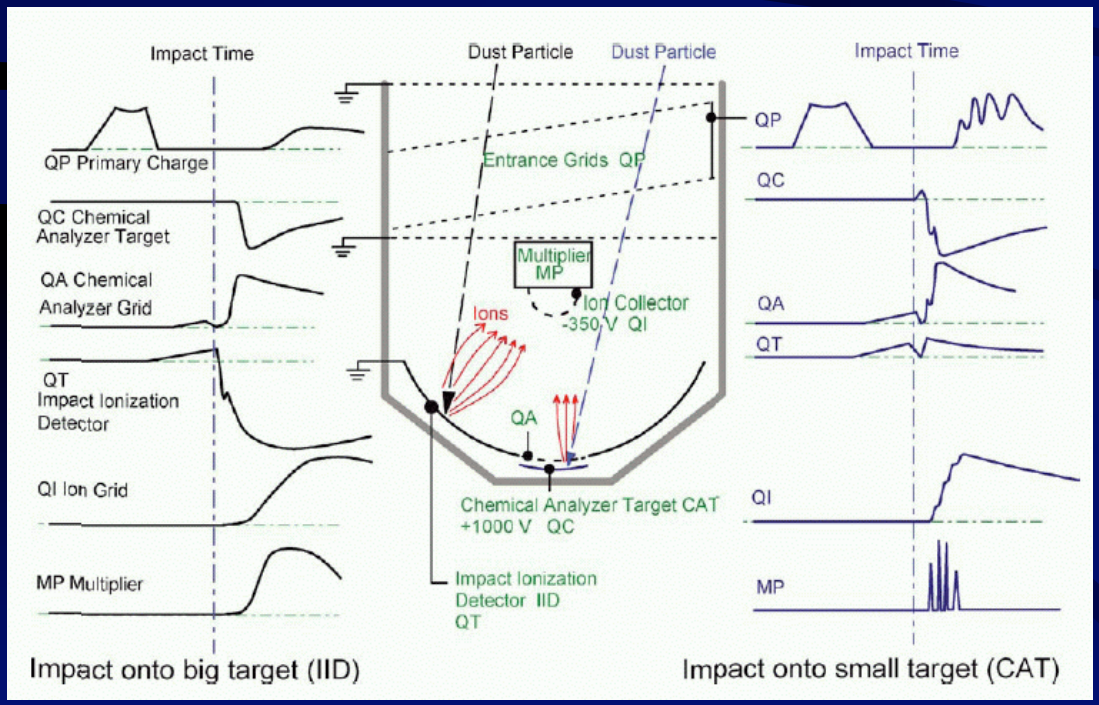
Cassini/CDA
MPIK Heidelberg

Cassini Cosmic Dust Analyser

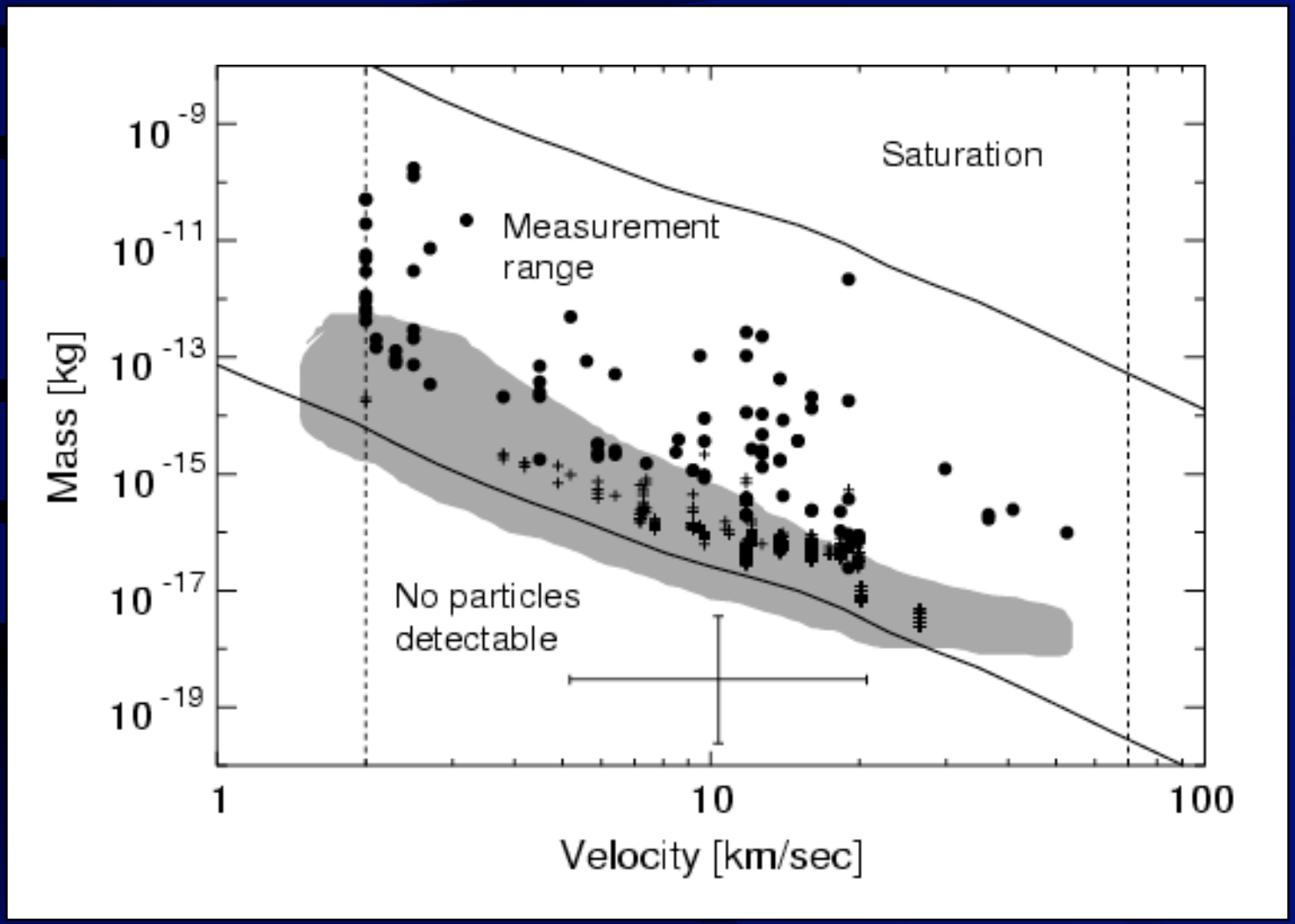
- Impact Ionisation Detector
- Sensor area 0.1 m^2
- Mass, speed, impact direction, charge, composition
- Calibrated speed: 2 – 100 km/sec
- Grain sizes: ~ 0.1 – 10 µm

CDA

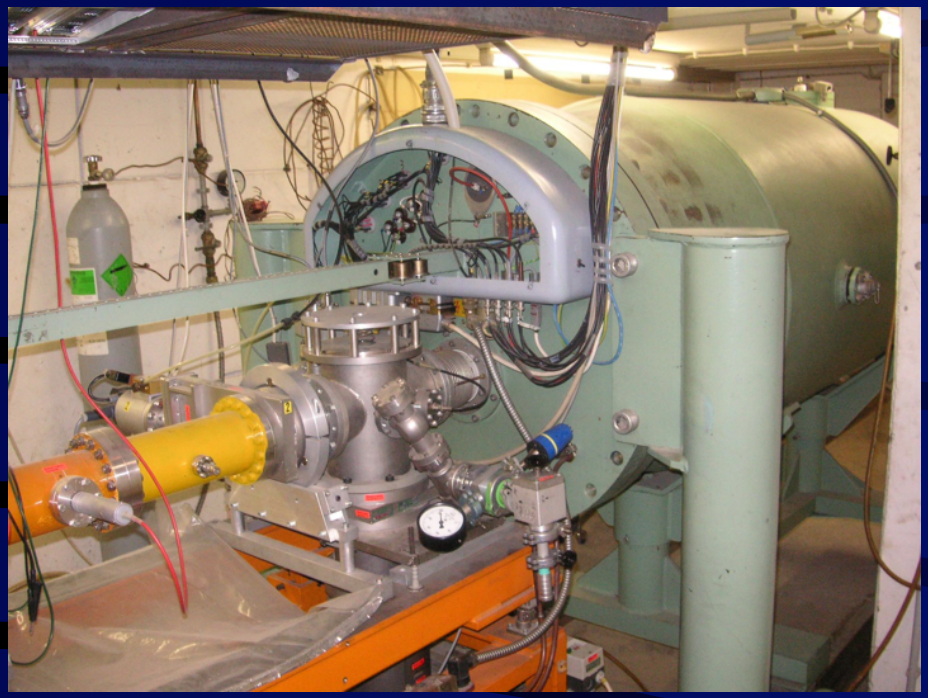
Cassini

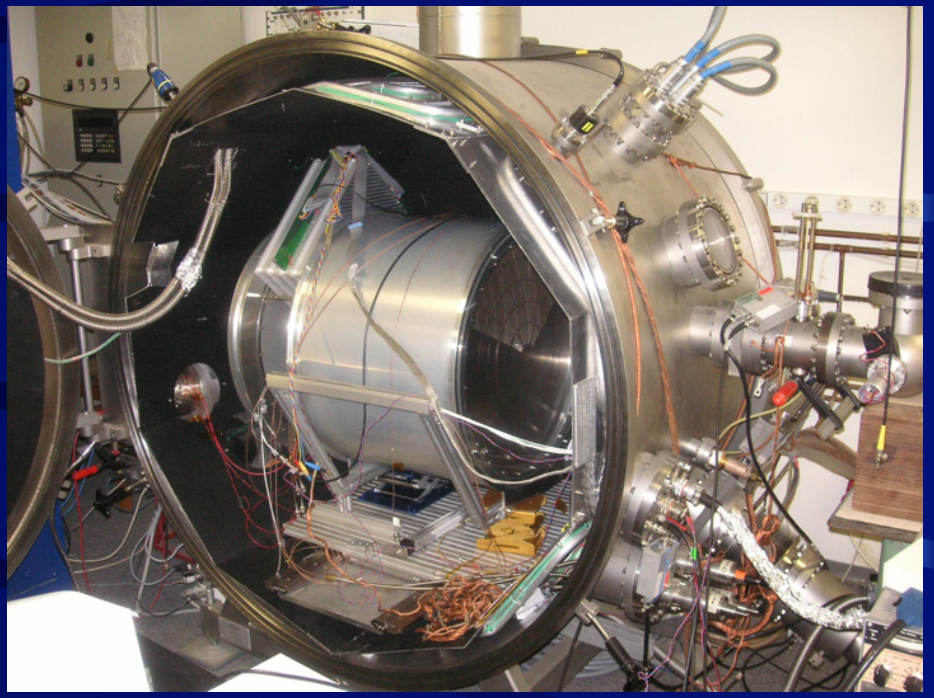


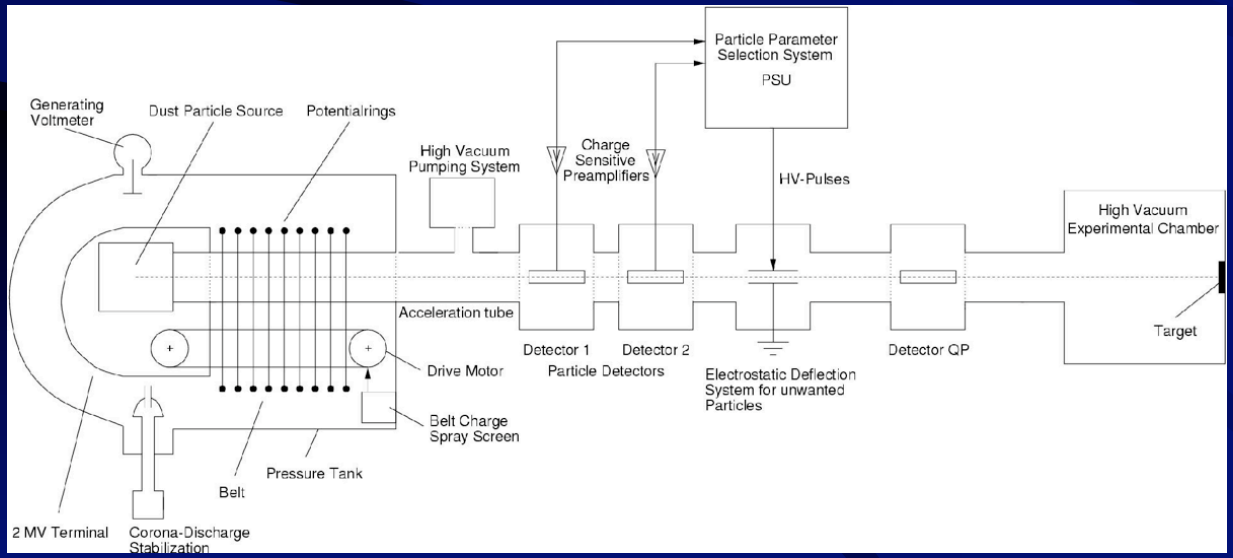
Instrument Calibration



Instrument Calibration: Dust Accelerator

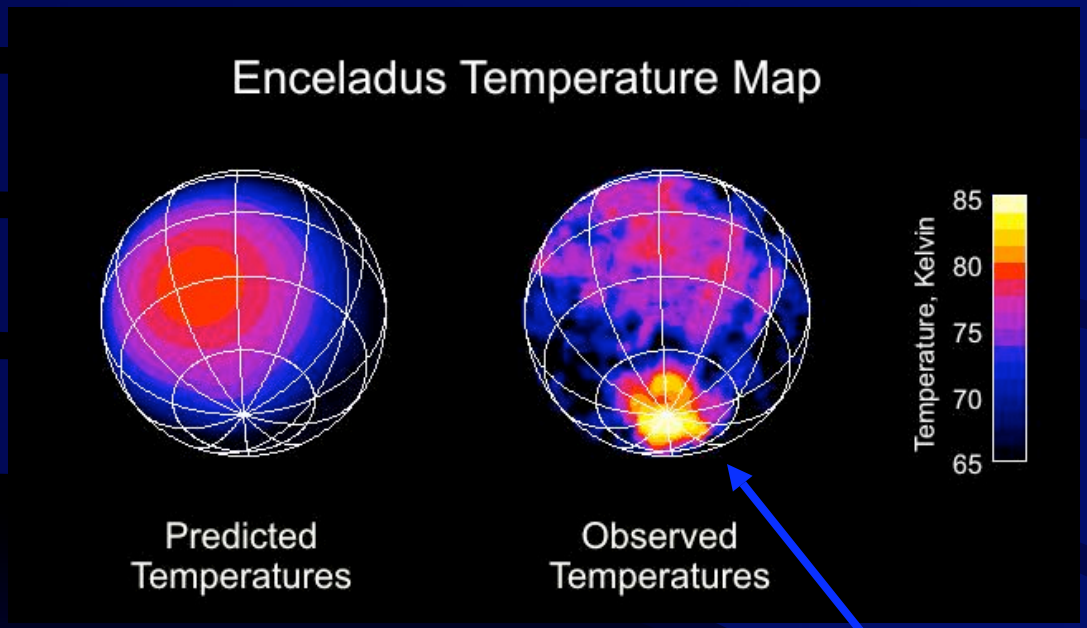






MPIK Heidelberg

Dust Ejection from Enceladus

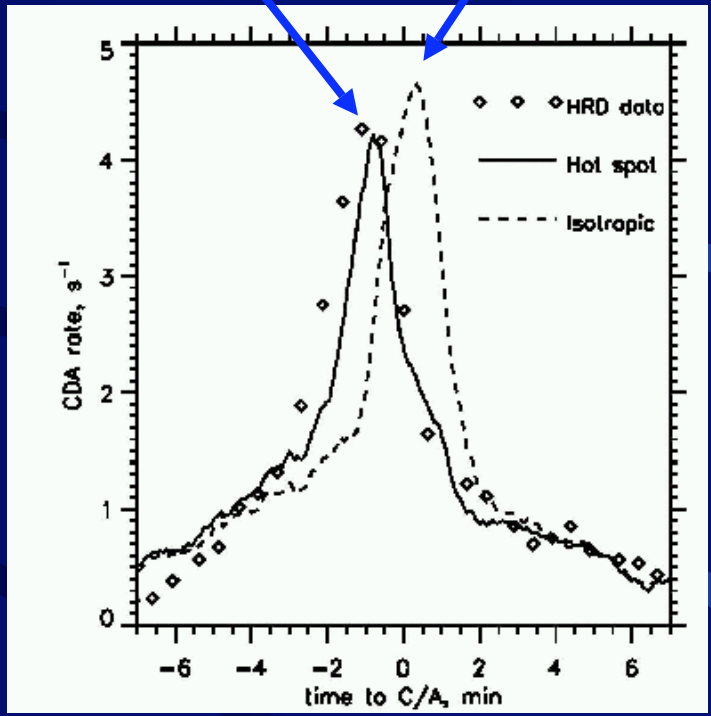


NASA/JPL

Hot spot at south pole

Measured

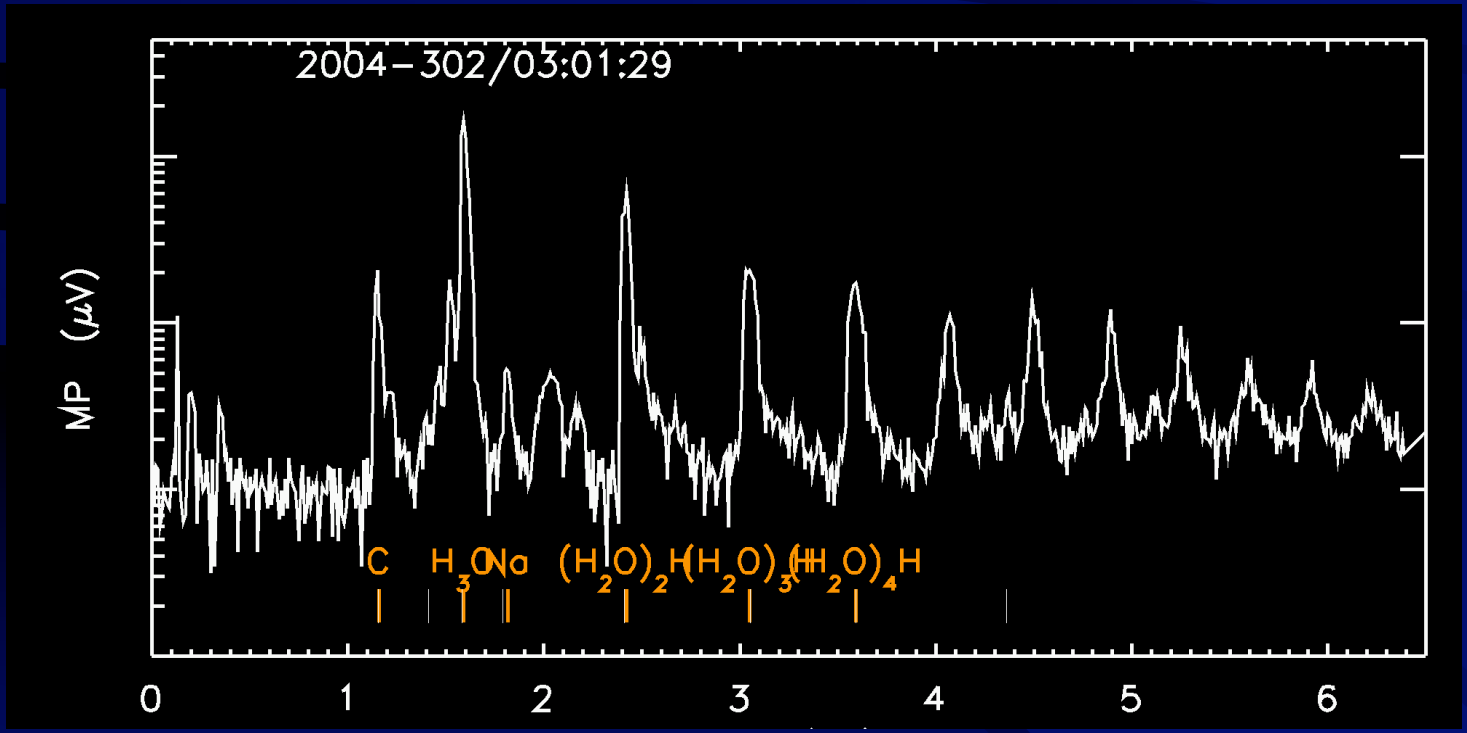
Expected



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)

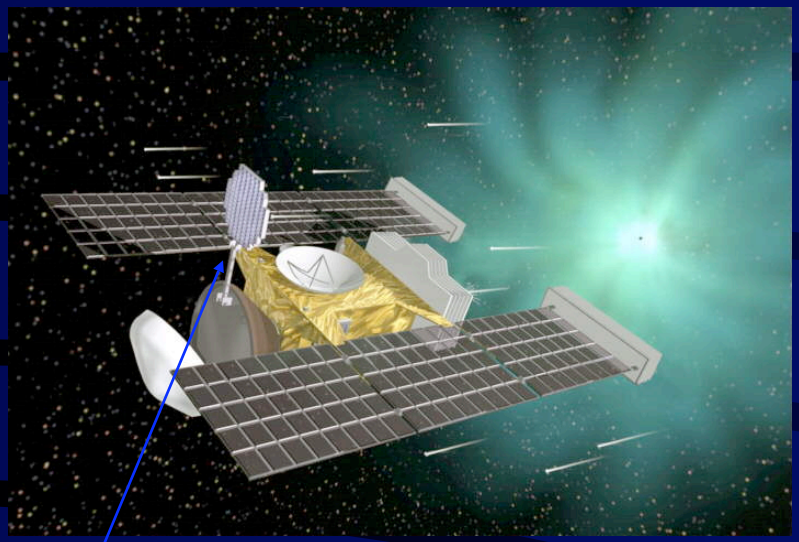


Srama, 2004

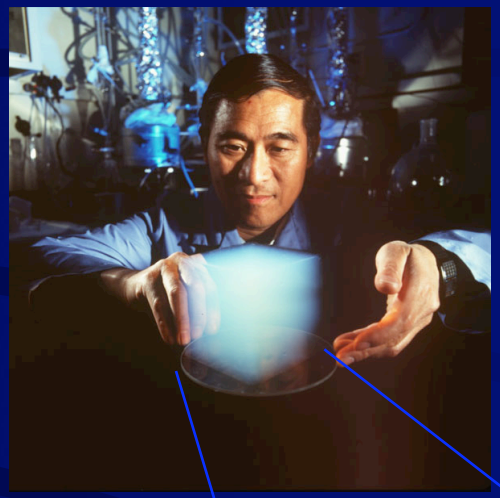
Dust Collection

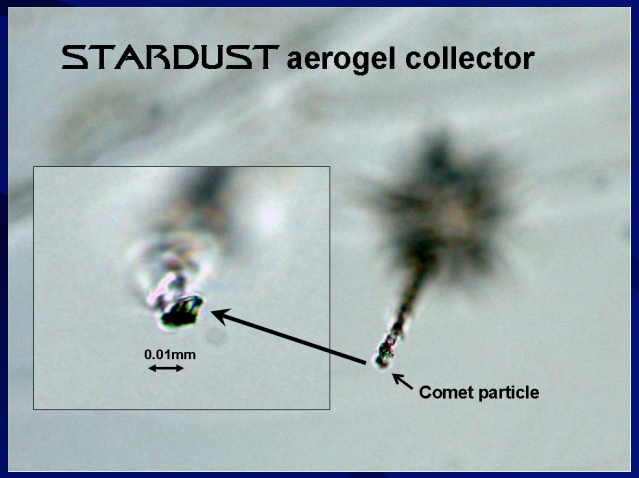
Stardust

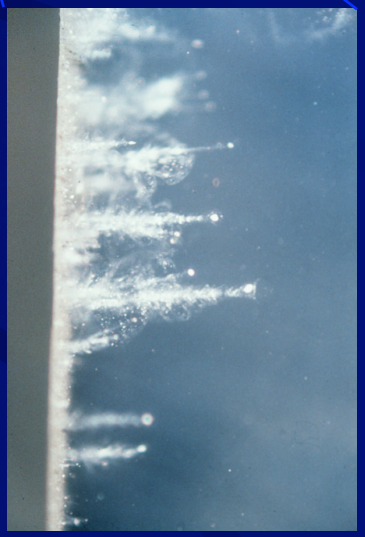
Sample Return of Cometary Particles



Aerogel collector

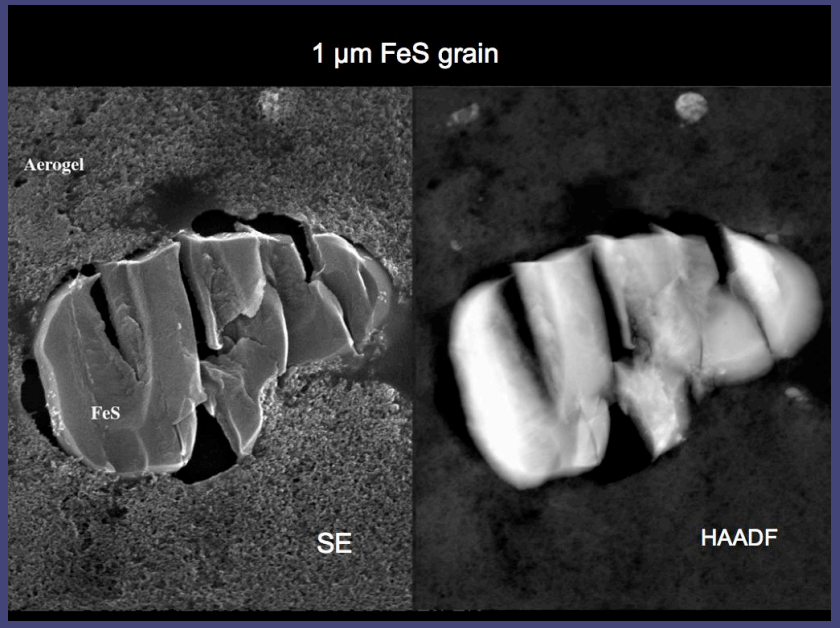


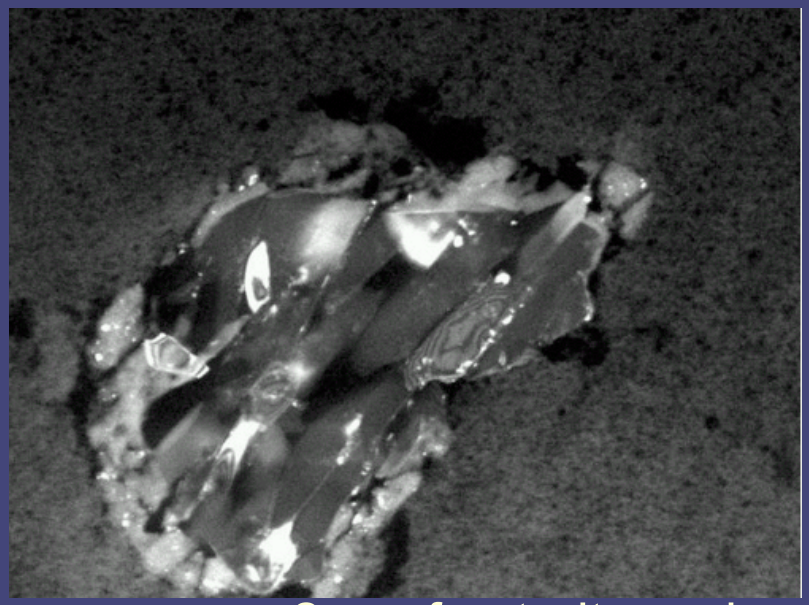




Stardust Return Capsule

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





2 µm forsterite grain

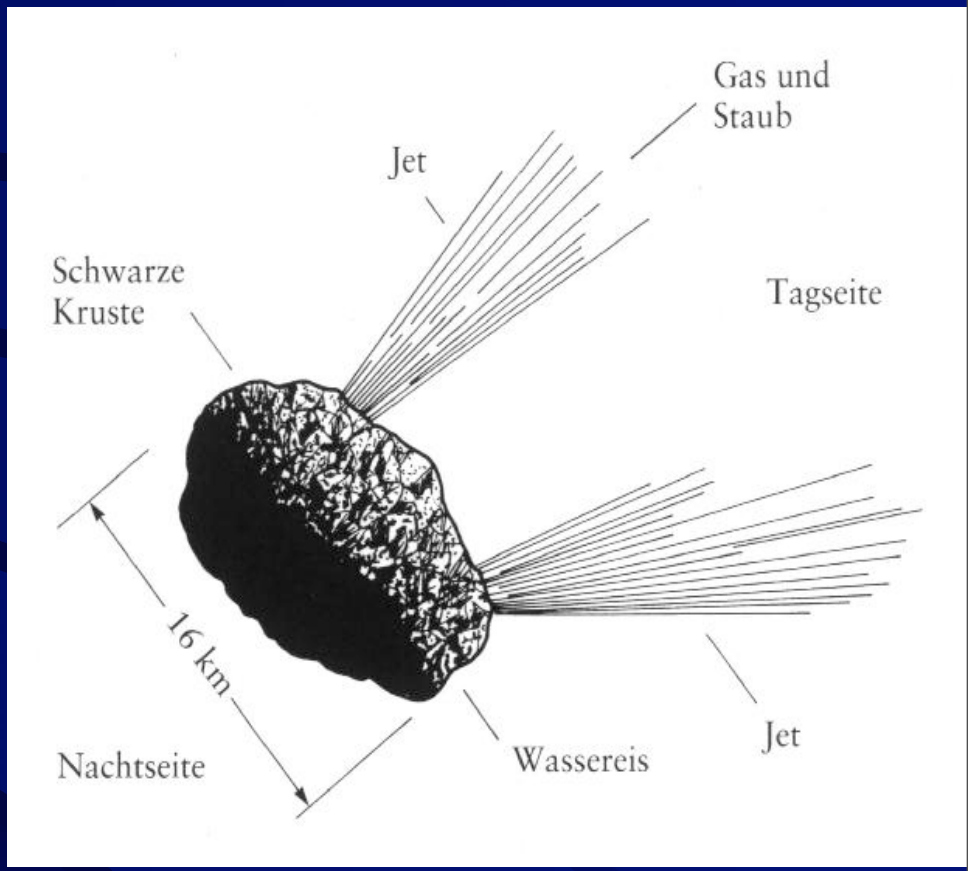
Rosetta: Voyage to Comet Churyumov-Gerasimenkov

In-Situ analysis of material from the early solar system

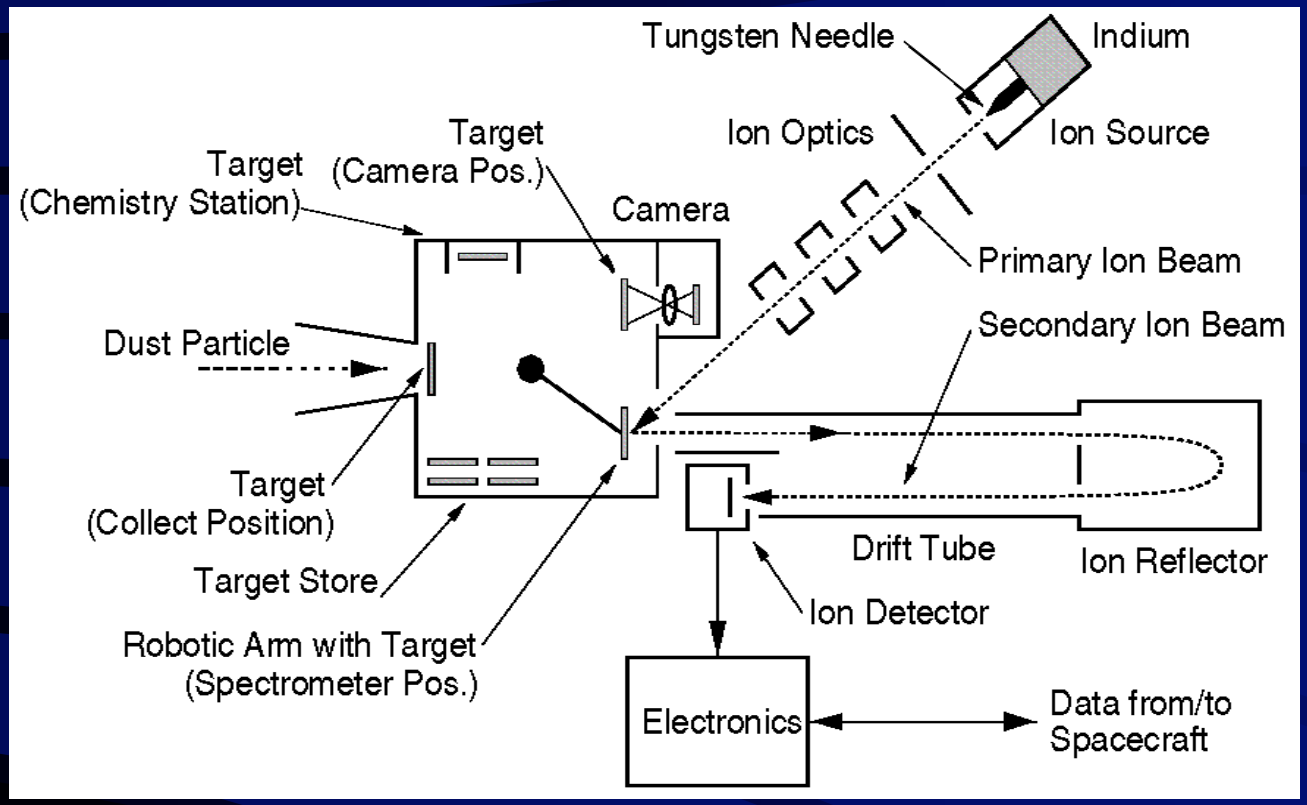
Comets: Remainders from the Formation of the Solar System

Nucleus of Halley's comet

Giotto, HMC



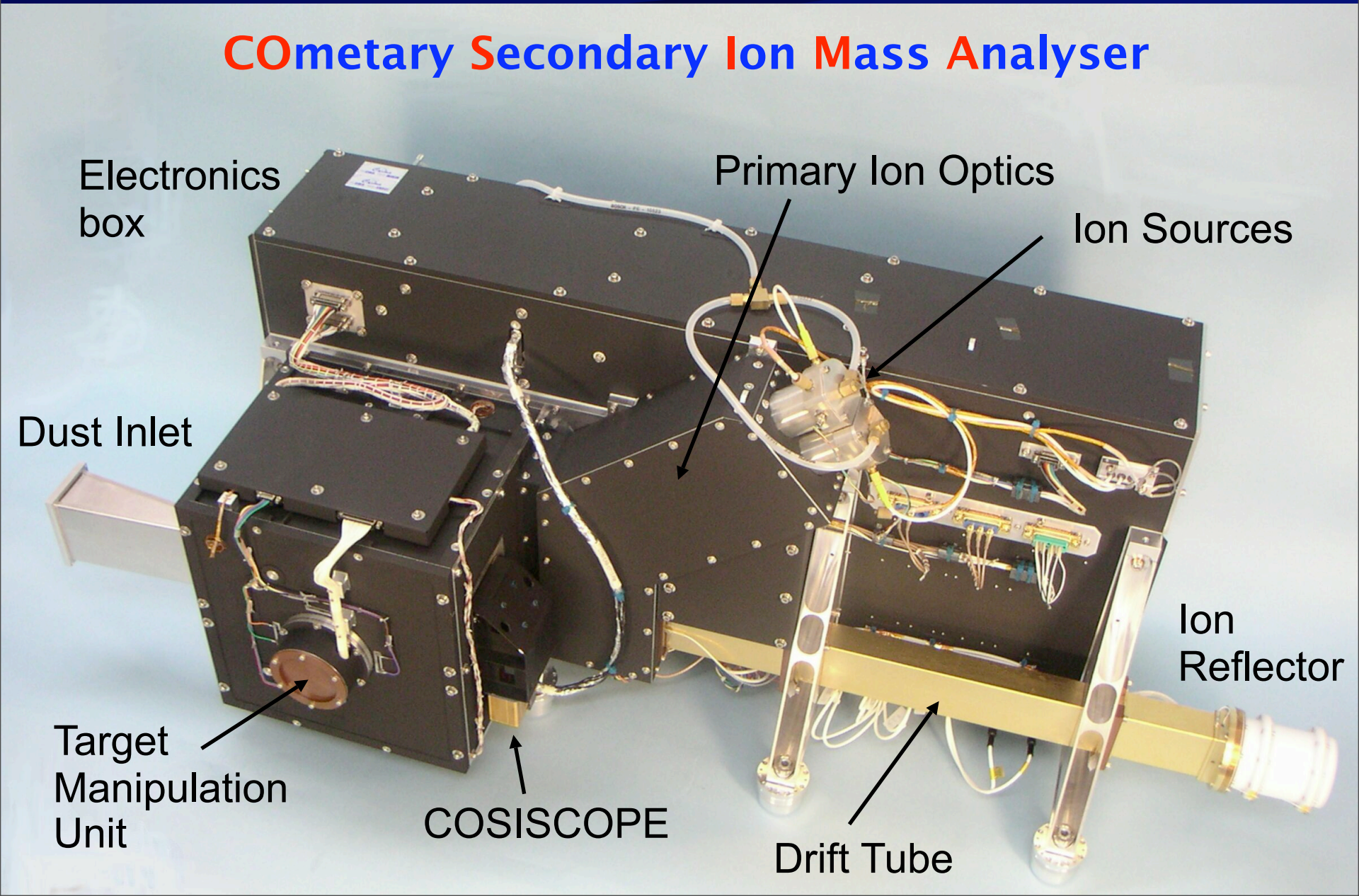
COSIMA Functional Principle

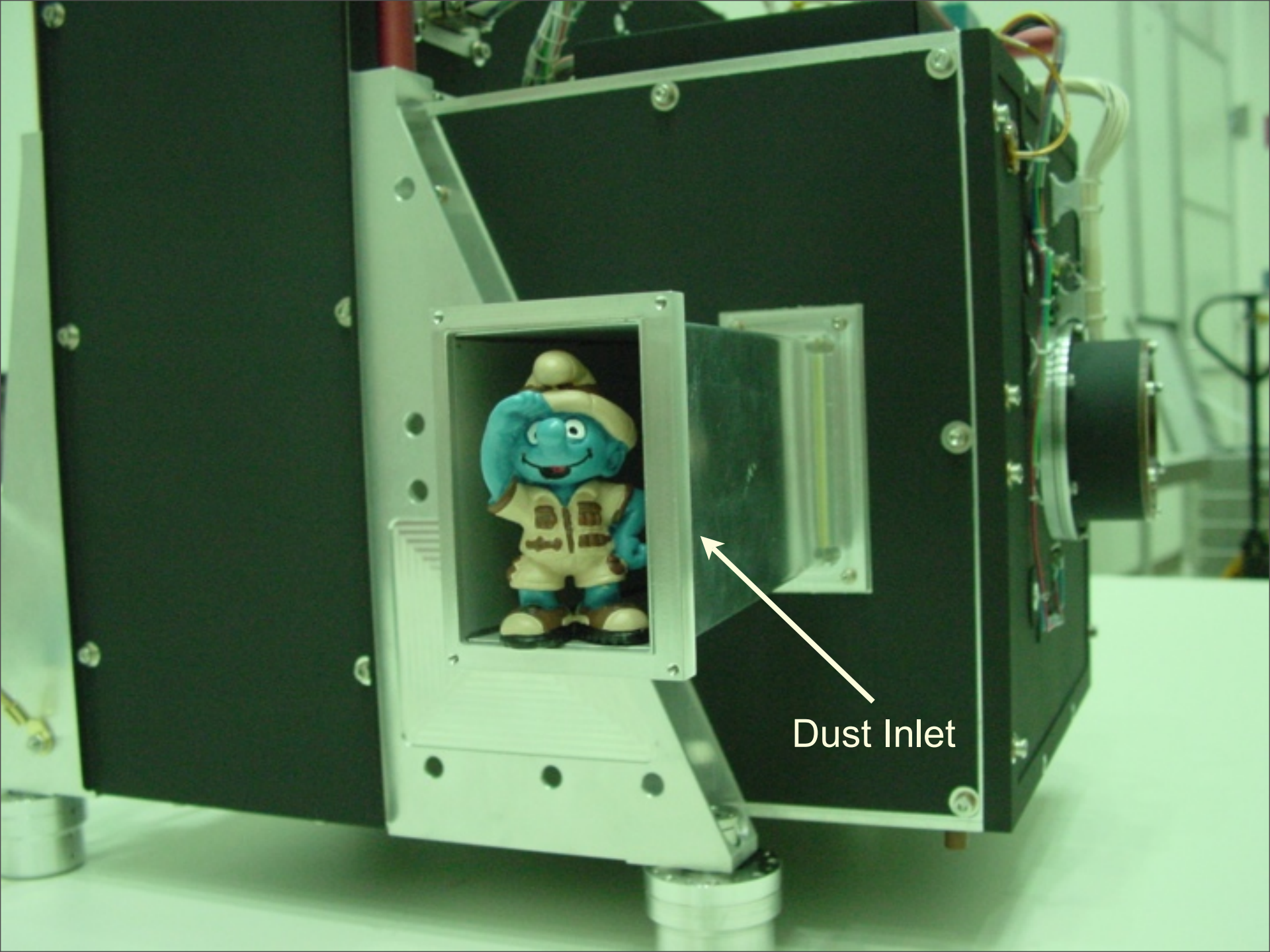


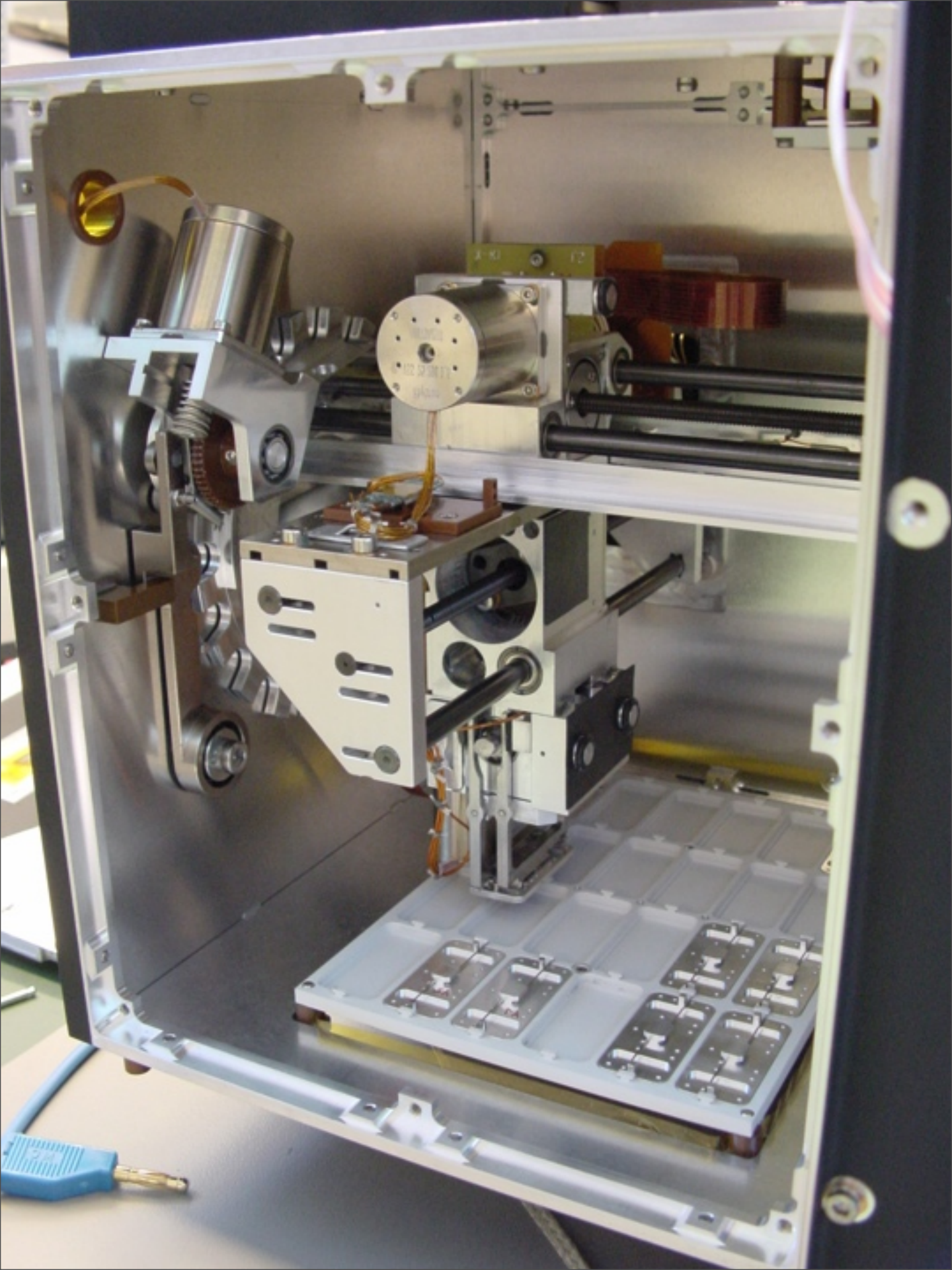
- Dust is collected on metal black targets which are stored in Target Manipulation Unit
- Dust grains are located by microscopic camera COSISCOPE
- A pulsed Indium ion beam partially ionizes the dust grains
- Secondary ions are accelerated by electric field and travel through drift tube with ion reflector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

Rosetta/COSIMA

COmetary Secondary Ion Mass Analyser



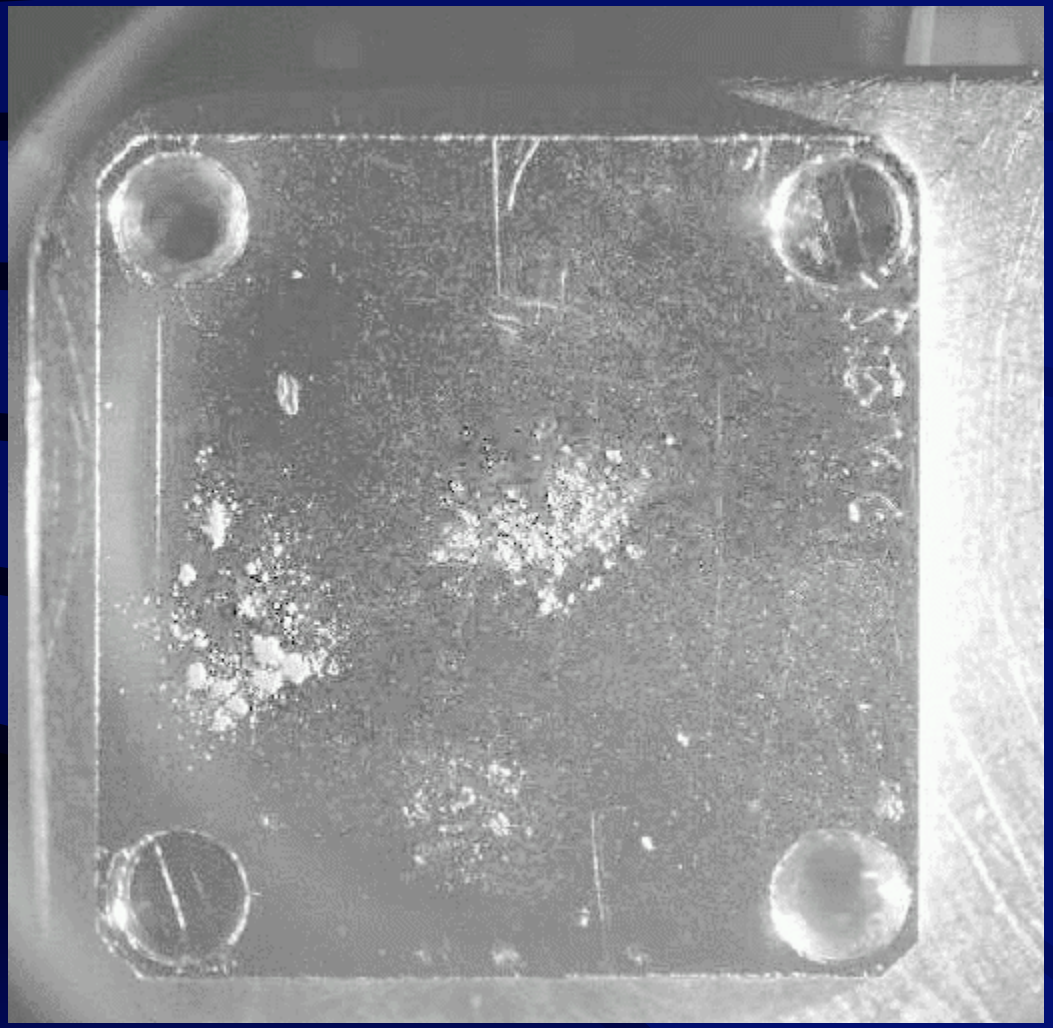

Dust Inlet



COSIMA Specifications

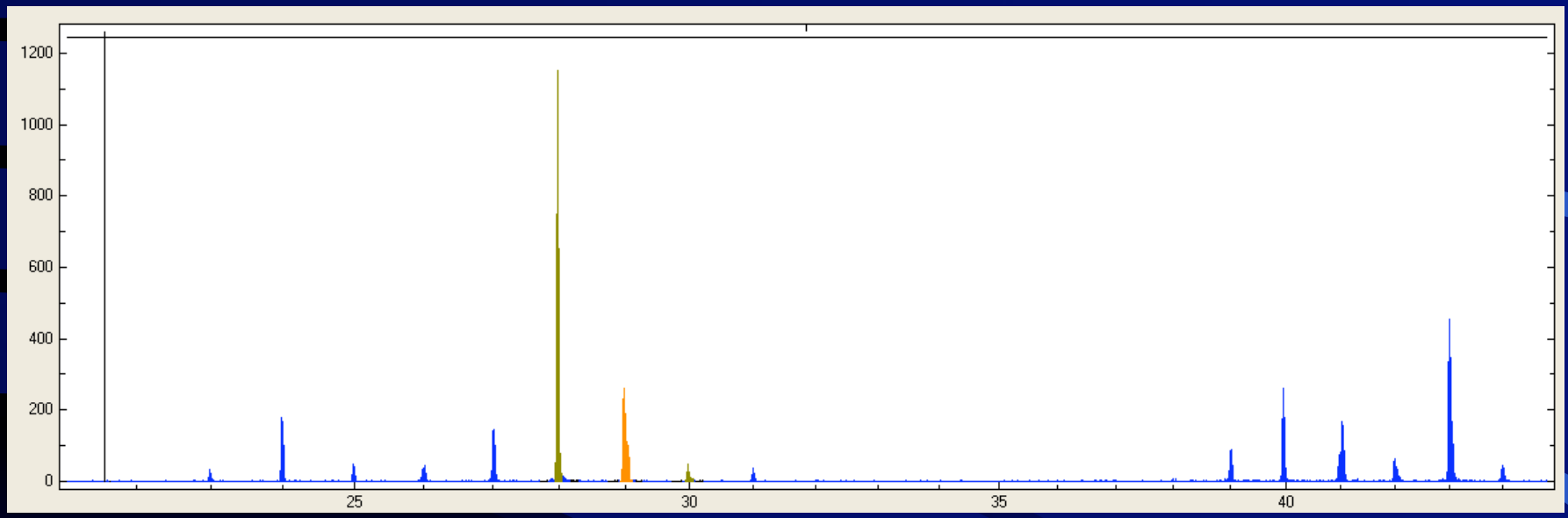
Atomic mass range	1...4000 Da
Rel. Atomic mass resolution m/Δm at m=100	~ 2000
Mass	19.8 kg
Indium ion pulse duration	~ 5 ns
Indium ion energy	8 keV
Power consumption from 28 V DC	20.4 W

COSIMA Target

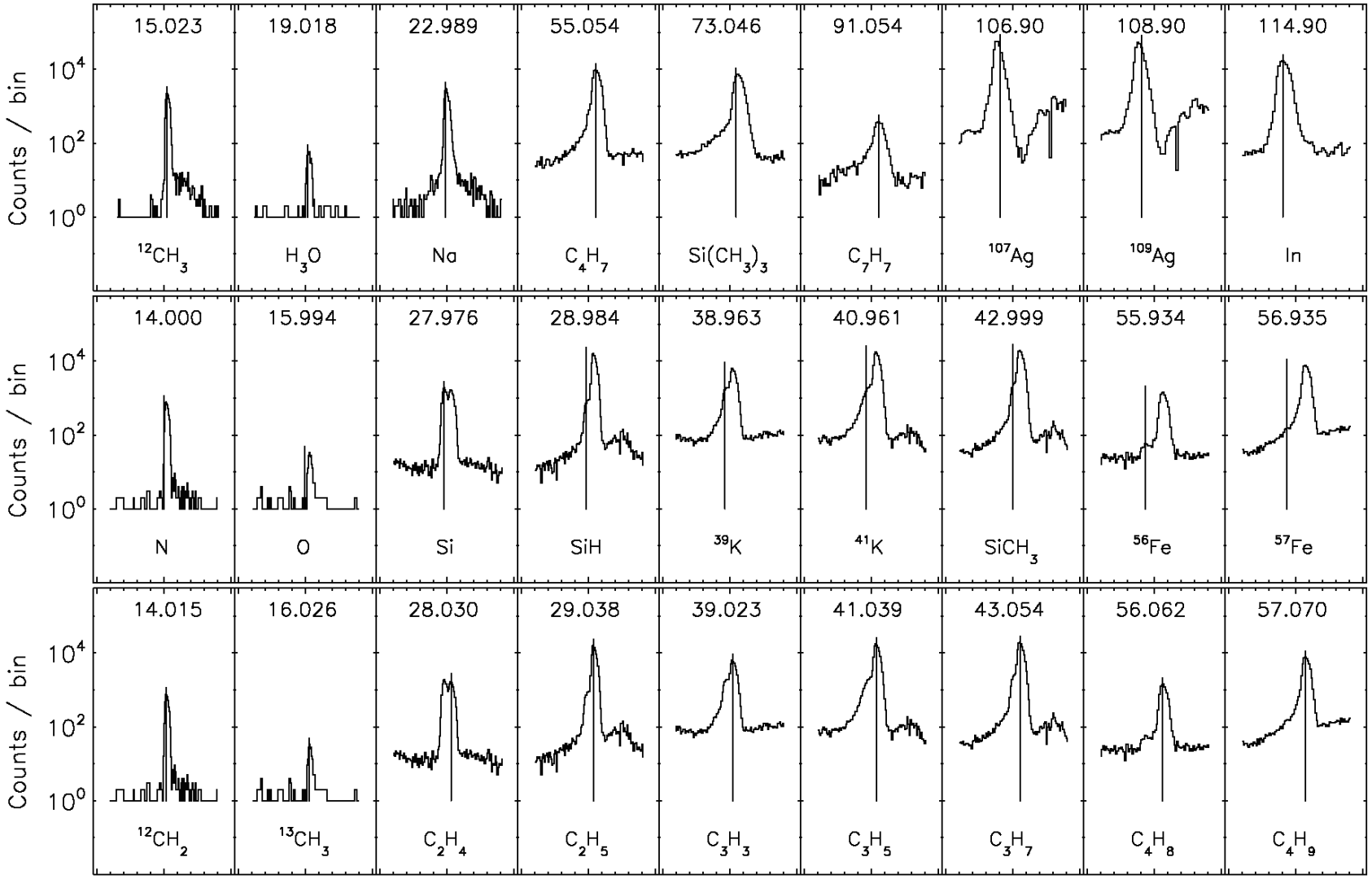


Cosima target (1x1 cm^2) prepared with clinopyroxene powder

COSIMA Spectrum



COSIMA Spectrum



The End