Landers and Instrumentation

- Overview (1 page)
  - Why landers?
- History (1 page)
  - first landers
- A Lander (Philae) (19 pages)
  - Instrumentation overview
- Instrument examples (22 pages)
  - Cosac (reality)
  - MOMA (becoming real)
  - Macroscope (a concept)

Why landers?

- The closest thing to ‘being there’
- human way of perceiving our environment (imagine an exploring spacecraft designed by bats)
  - optical information (one, first lander without camera)
  - acoustical information
  - chemical senses
  - rest

1st Landers

Where	Name	When	Who	What
Moon	Lunar 9	1966	USSR	Camera, radiation monitor
Venus	Venera 7	1970	USSR	T, p, (1st images: Venera 9, 1975)
Mars	Mars 3	1971	USSR	Camera, γ- and x-ray spectrometer, T, p, wind velocity , penetrometer
Jupiter	Galileo	1995	USA	MS, T, p, deceleration, Helium interferometer, radiation, lightning / radio emission, did it land?
Asteroid	NEAR	2001	USA	Camera, magnetometer, γ- and X-ray spectrometer, not really a lander
Comet	deep impact	2005	USA	Camera, lander???
Titan	Cassini / Huygens	2005	USA / EU	Camera, GC-MS, wind speed, microphone

Philae

- Instruments ('payload')
  - Civa-Rolis — camera and microscope
  - Sesame — electrical and mechanical
  - Consert — tomograph
  - Romap — magnetometer
  - APXS — elements
  - Mupus — thermal
  - SD2 — drill and mechanical
  - Ptolemy — isotopes
  - Cosac — molecules

Philae

- Infrastructure ('sub-systems')
  - Landing
    - eject (separation)
    - control (descent)
    - land, damp, anchor (landing)
  - infrastructure
    - power
    - communication
    - thermal
    - (motion)

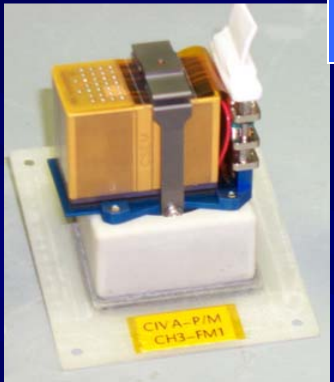
Civa-Rolis

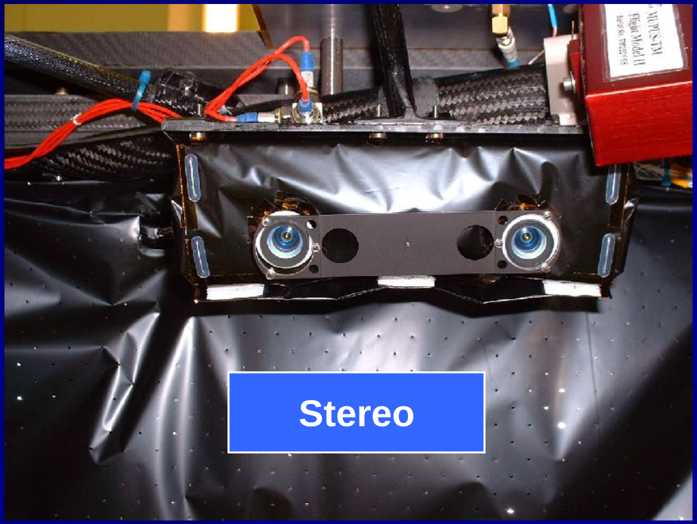
- camera and microscope (Comet nucleus Infrared and Visible Analyzer – ROsetta Lander Imaging System)
- set of CCD cameras
  - panorama
  - stereo
  - microscope vis/IR
  - down looking
- semiconductor physics, electronics, optics

ÇIVA

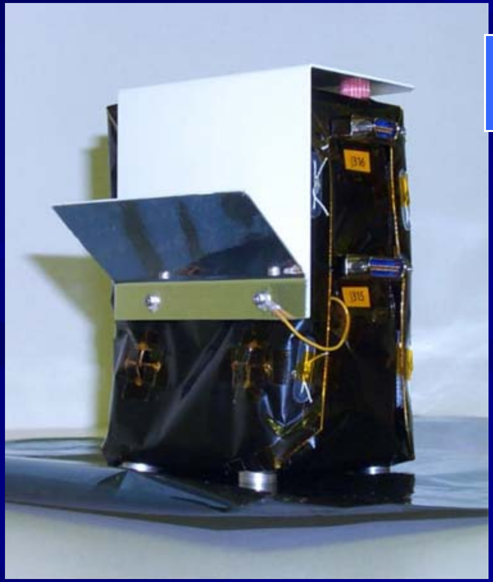
J-P. Bibring, IAS Paris

Panorama





Stereo

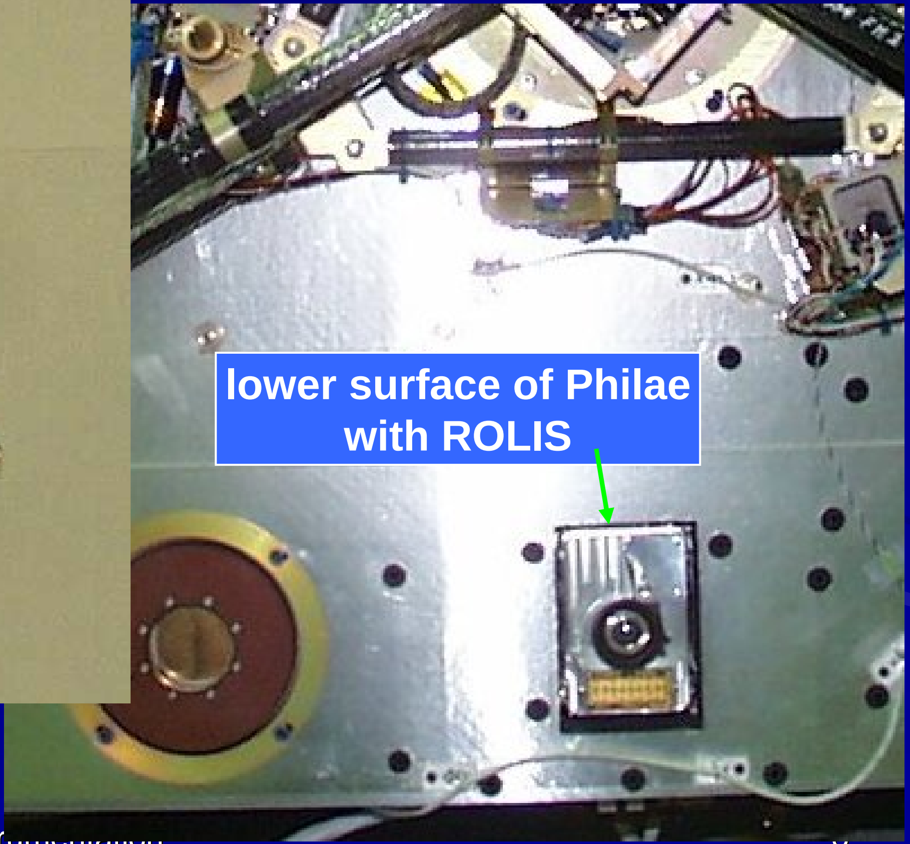


Visible µ-scope

IR µ-scope

ROLIS

S. Mottola, DLR Berlin



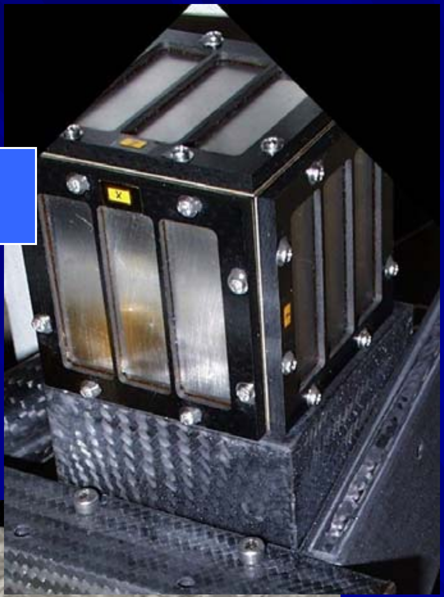
Sesame

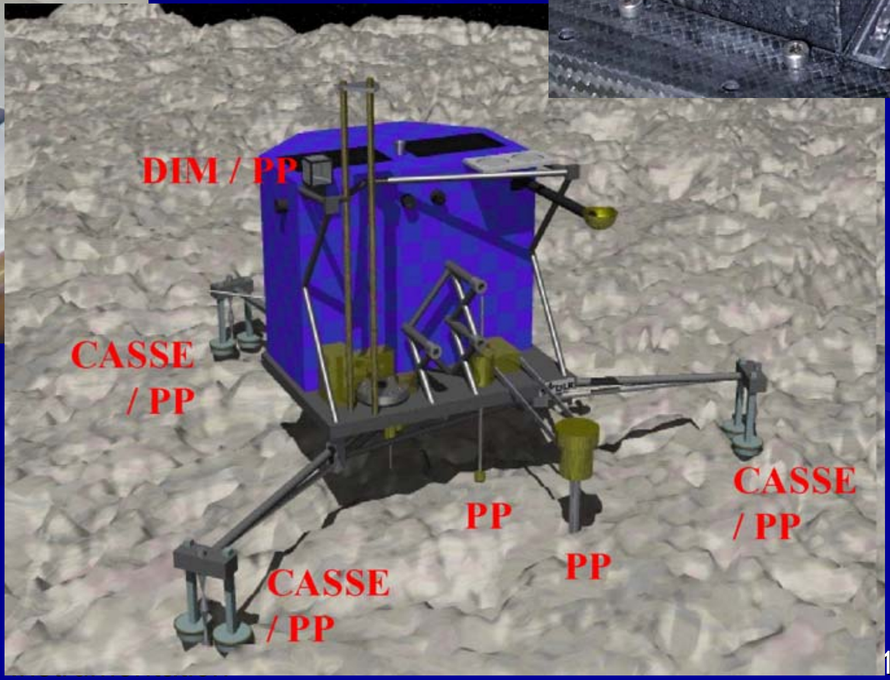
- electrical and mechanical (Surface Electrical, Sounding, and Acoustical Monitoring Experiment)
  - dust impact monitor
  - electrical sensors
  - mechanical sensors
- electrodynamics, mechanics,

SESAME

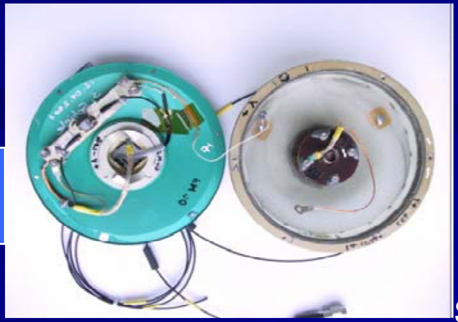
D. Möhlmann, DLR Berlin

DIM





CASSE

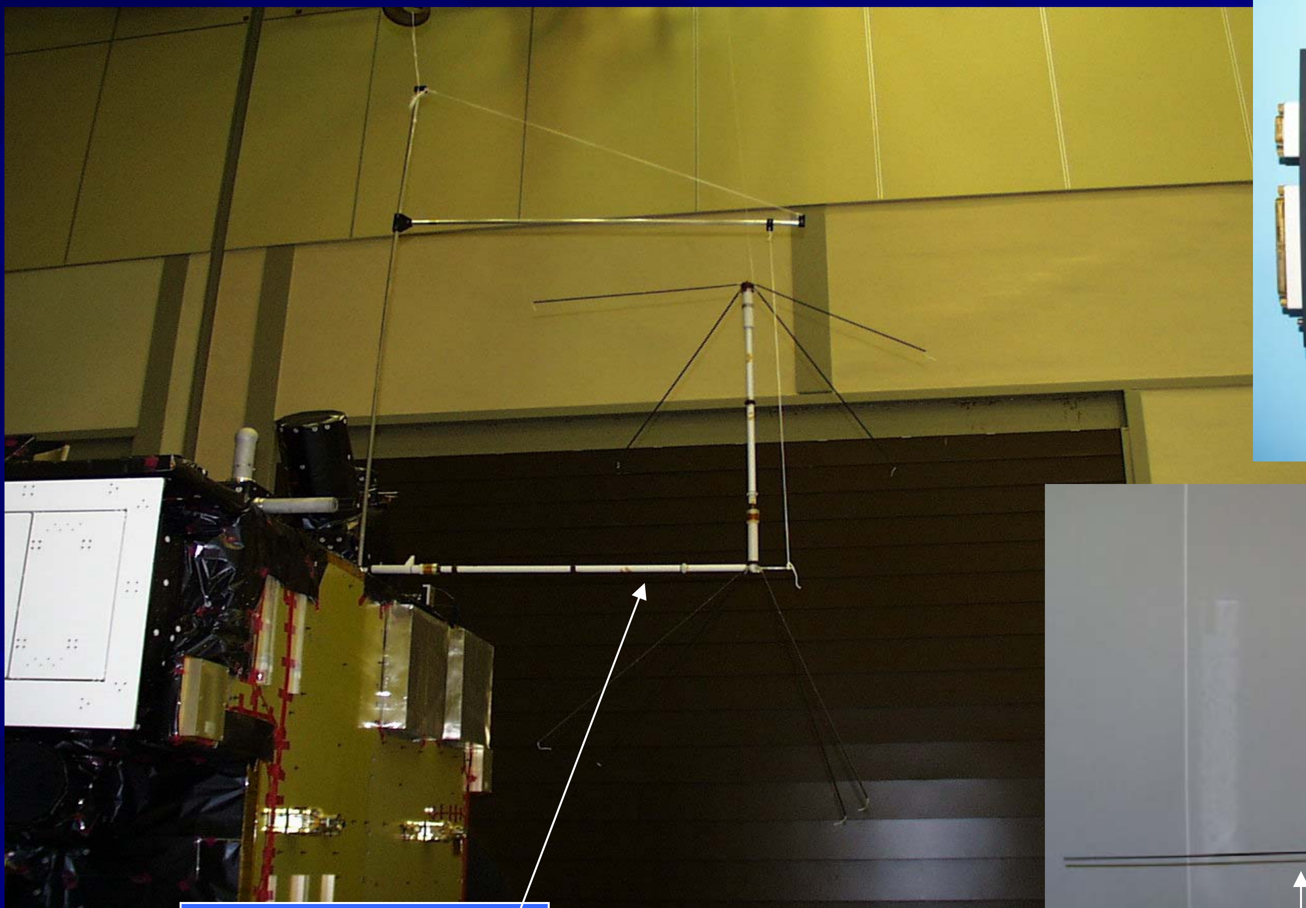


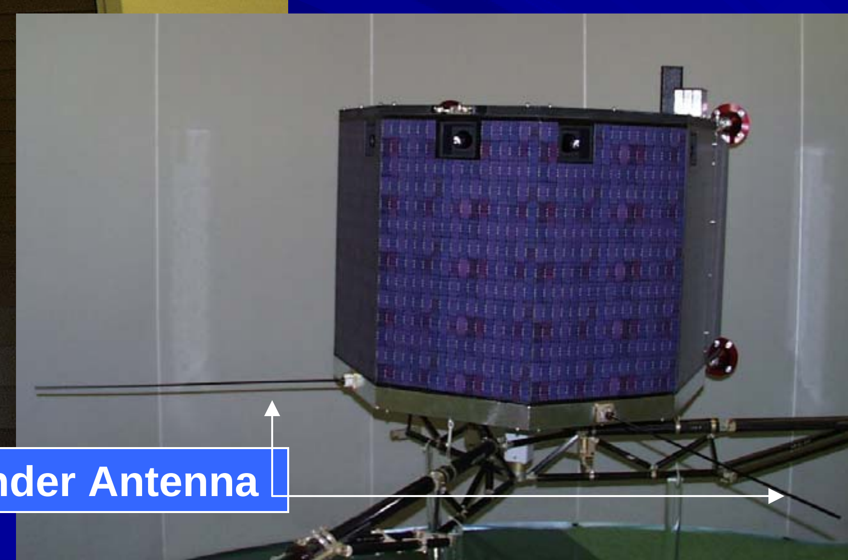
Consert

- tomograph (COmet Nuclear Sounding Experiment by Radiowave Transmission)
  - transmitter and receiver for electromagnetic waves
  - careful synchronisation
- electrodynamics

CONSERT

W. Kofman, CEPHAG Grenoble



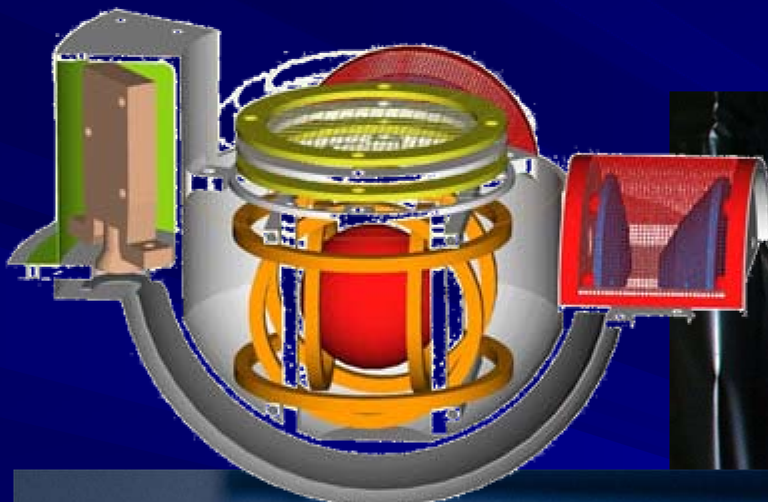


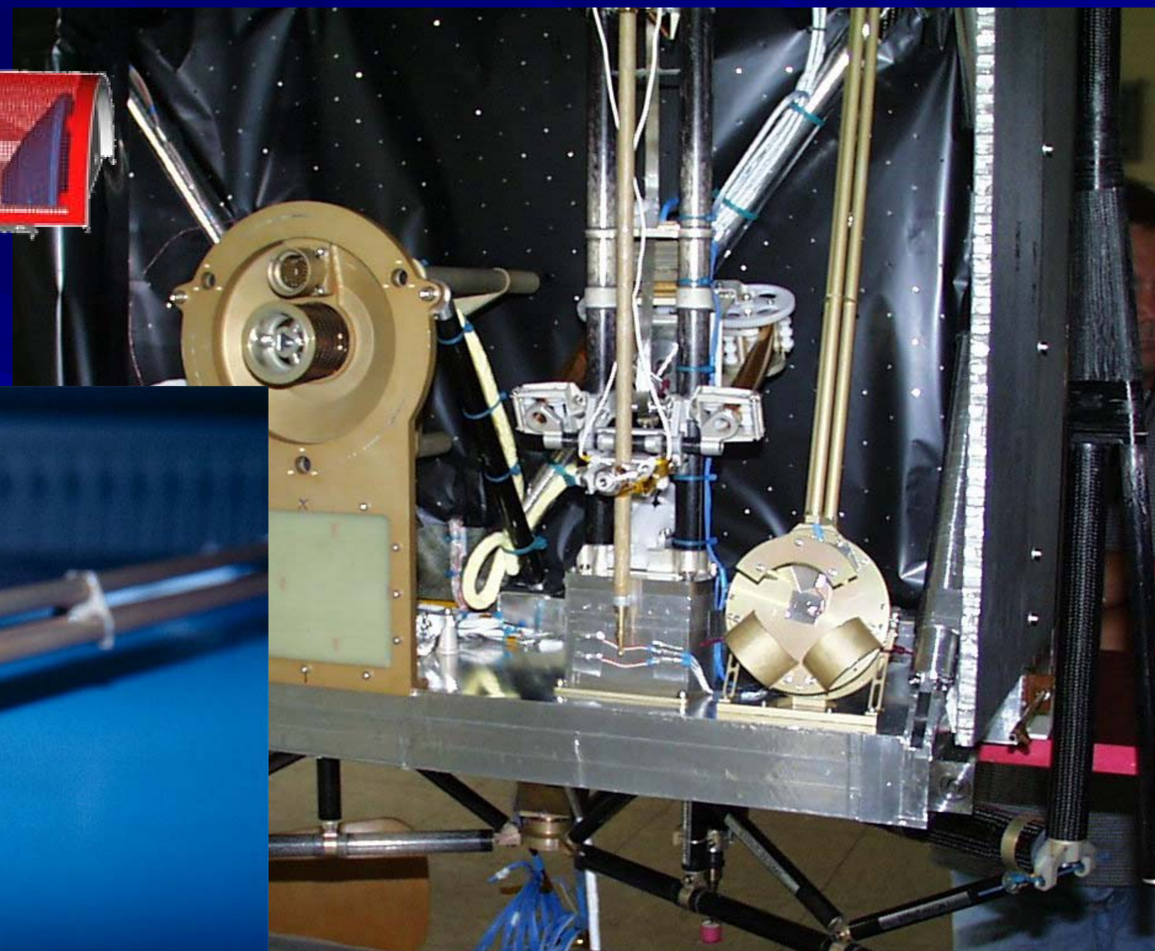
Romap

- magnetometer (ROsetta lander MAgnetometer and Plasma monitor)
  - fluxgate magnetometer (Förster-Sonde)
  - ion sensor
- solid state physics, electronics, mechanisms (boom)

ROMAP

U. Auster, Techn. Universität Braunschweig



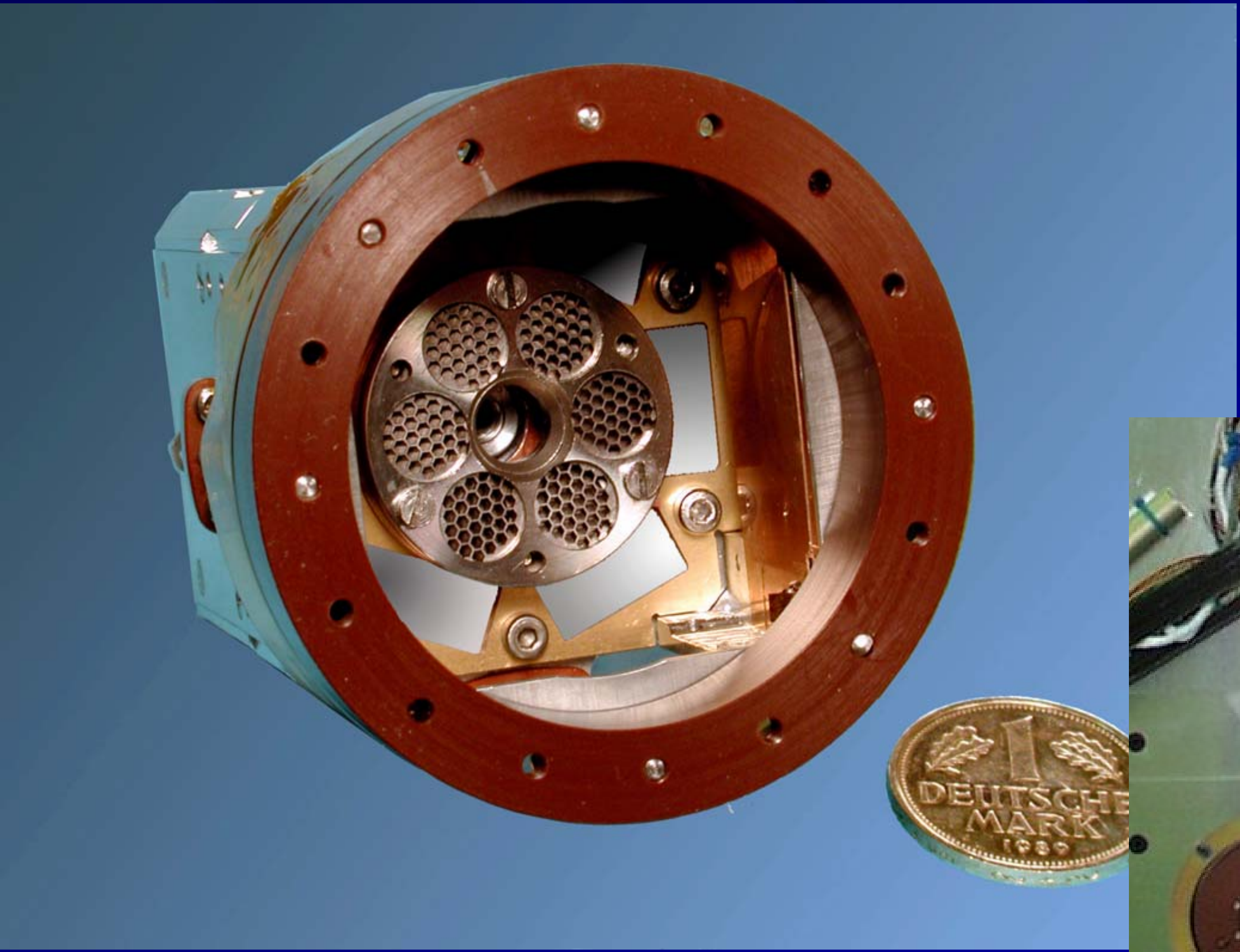


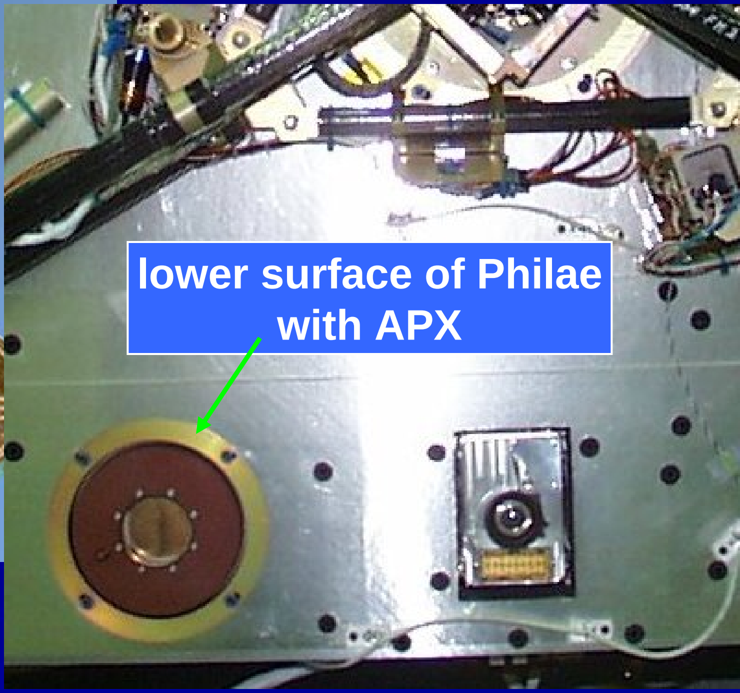
APX(S)

- elements (Alpha Proton (Particle) X-ray Spectrometer)
  - energy dispersive X-ray analysis (SEM)
- semiconductor physics, electronics, mechanisms (deploy)

APX

R. Rieder, MPCh Mainz; G. Klingelhöfer



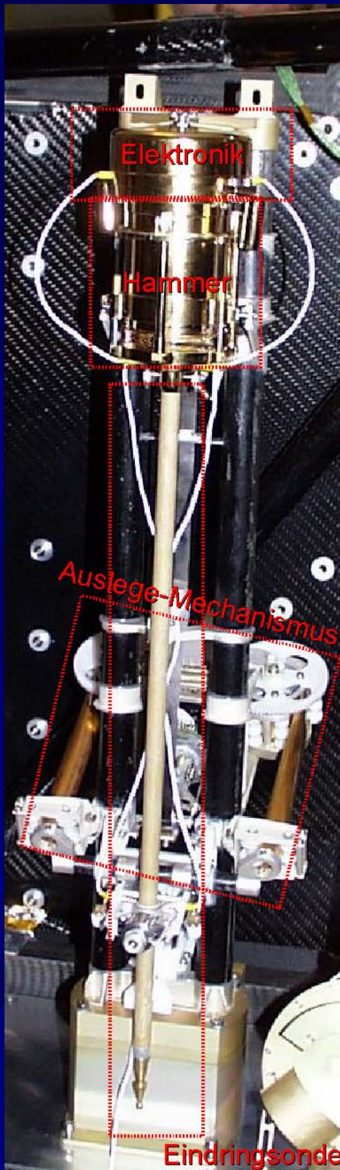


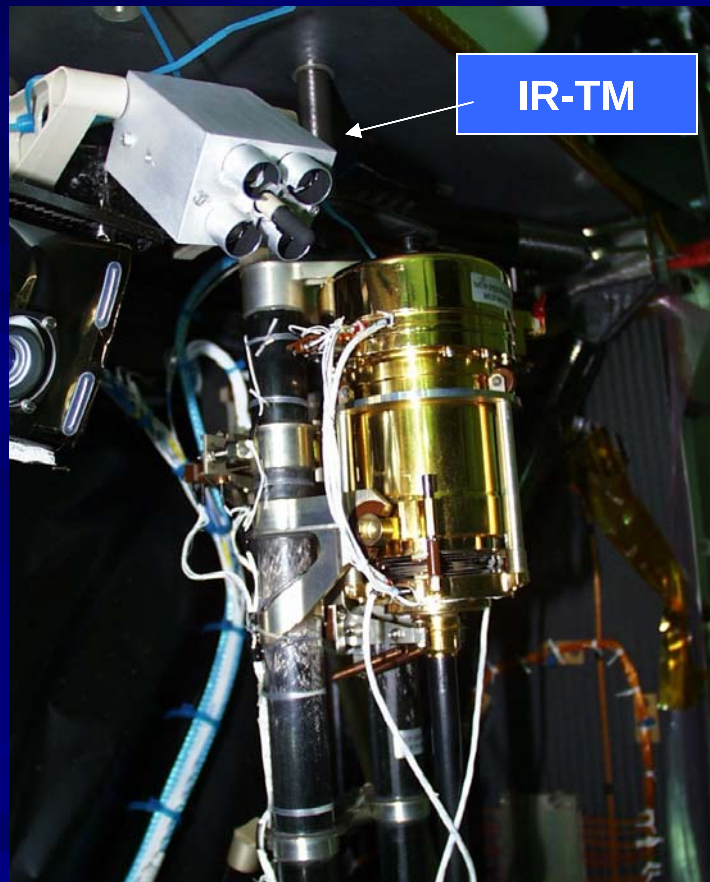
Mupus

- thermal (MUlti PUrpose Sensors for surface and sub-surface science)
  - thermometer
  - IR thermometer
  - accelerometer
- solid state physics, thermal radiation, fracture mechanics, mechanics (deploy)

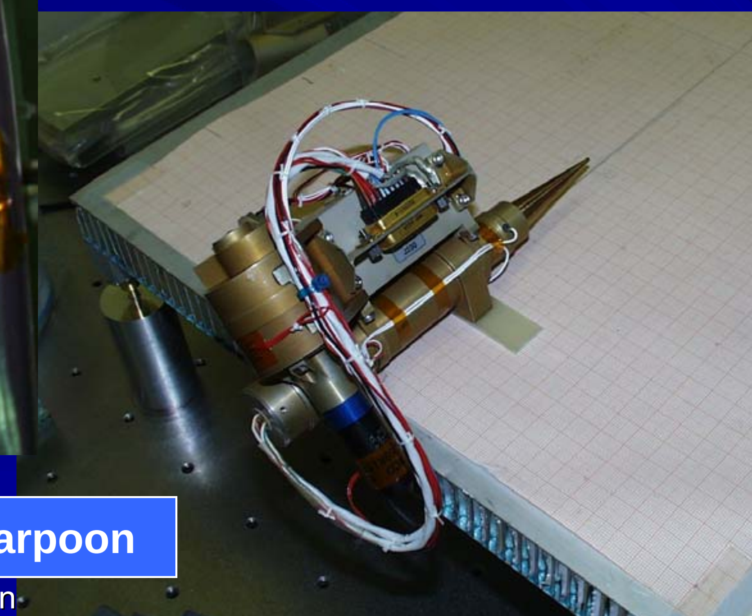
MUPUS

T. Spohn, Universität Münster, DLR Berlin





Harpoon
M. Thiel,
MPE Garching



PEN

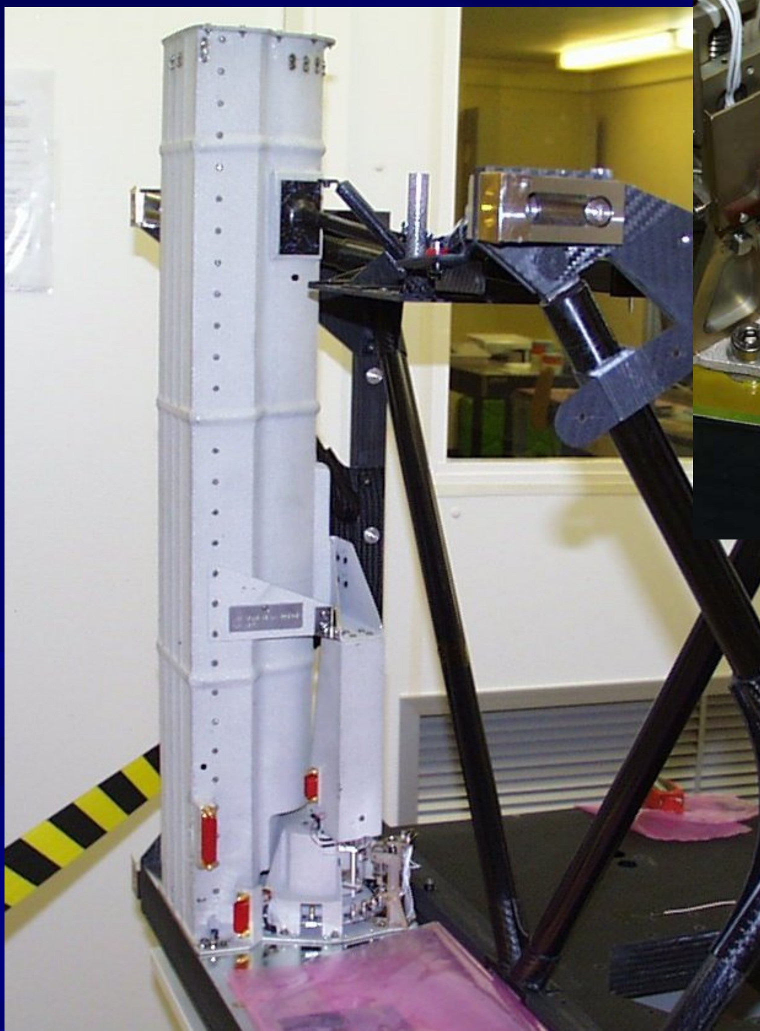
Harpoon

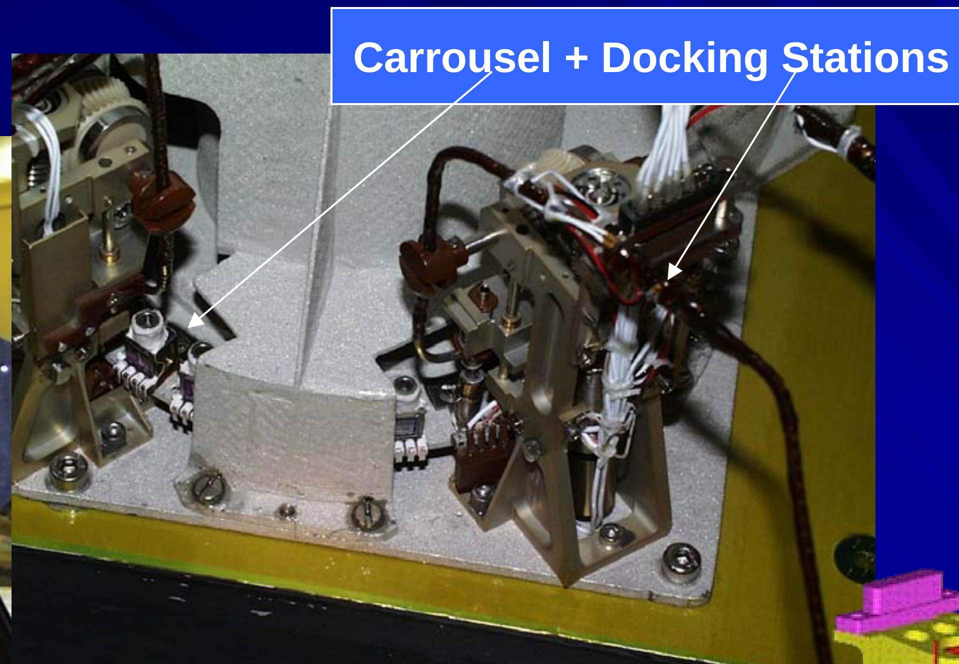
SD2

- drill and mechanical (Sample Drill and Distribution)
  - drill
  - sample retrieval
- mechanics (a lot!)

Drill (SD²)

A. Finzi, Politecnico di Milano





Docking Stations

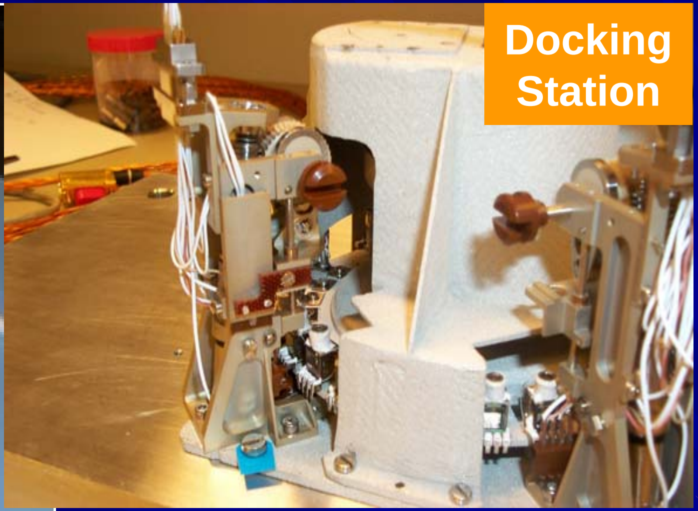
R. Roll, MPS

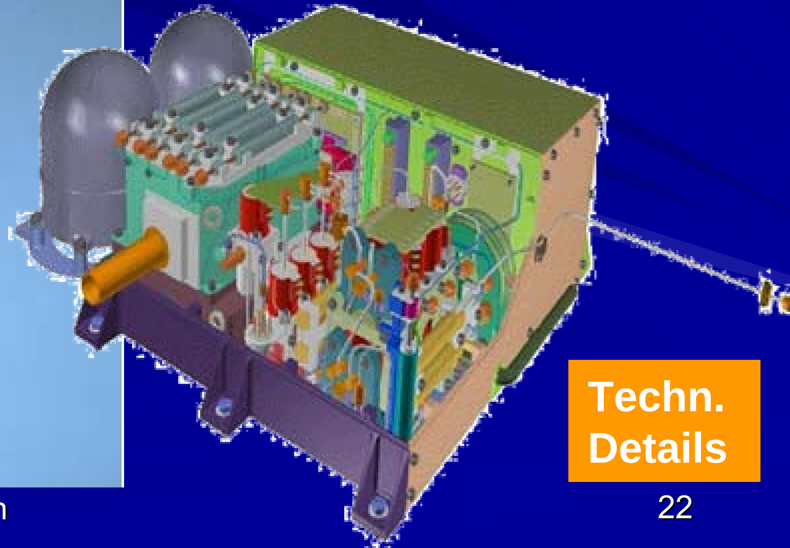
Ptolemy

- isotopes (MODULUS = Ptolemy + BERENICE)
  - combustion
  - GC
  - MS (ion trap)
- chemistry, electrodynamics

PTOLEMY

I. Wright, Open University Milton Keynes



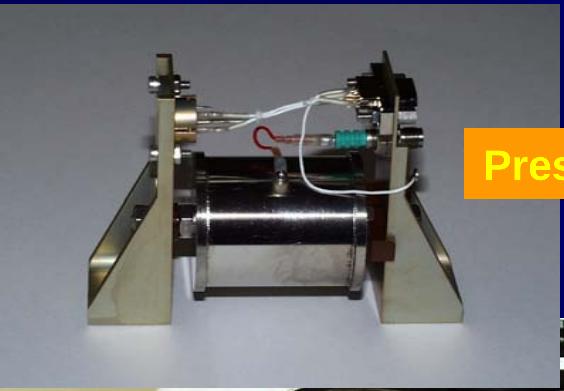


1st instrument example: Cosac

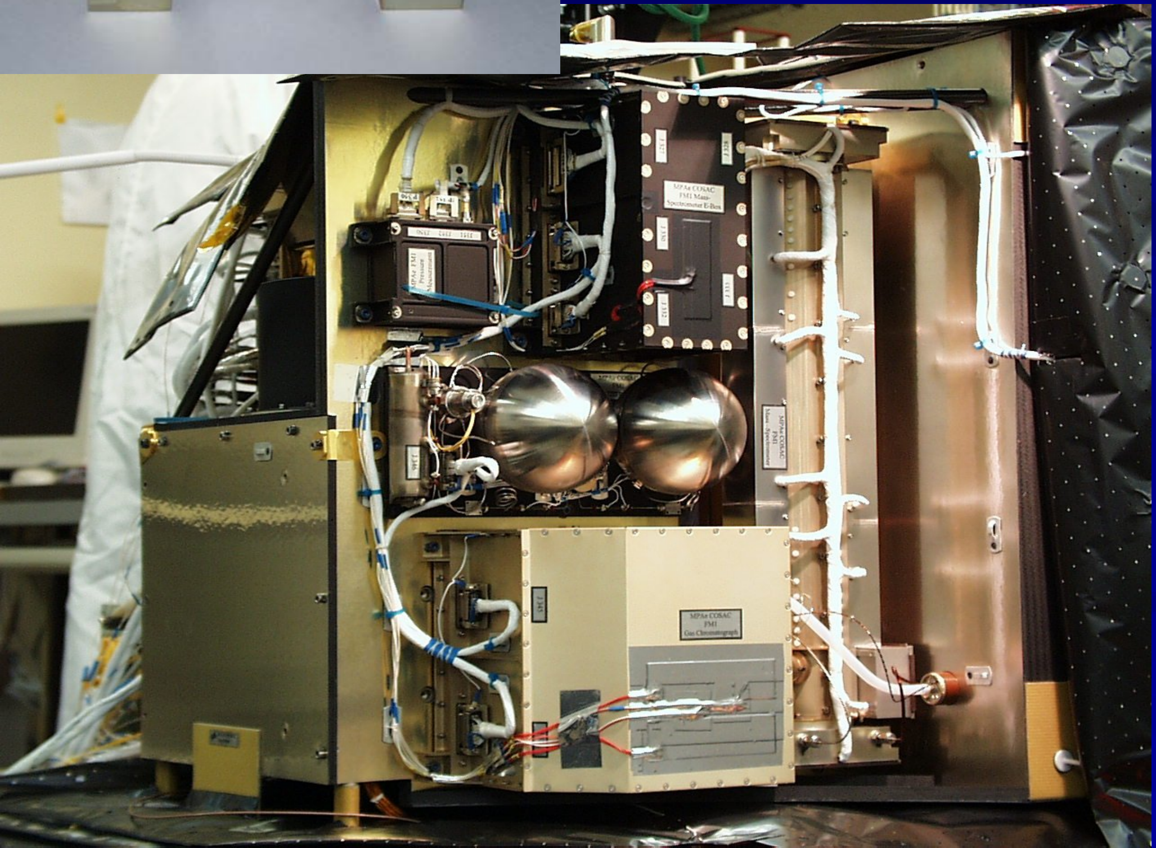
- Flying on Rosetta (existing hardware)
- molecules (COmetary SAmpling and Composition experiment)
  - GC
  - MS (time of flight)
  - pressure sensor
- chemistry, e-dynamics, mechanics (TS)

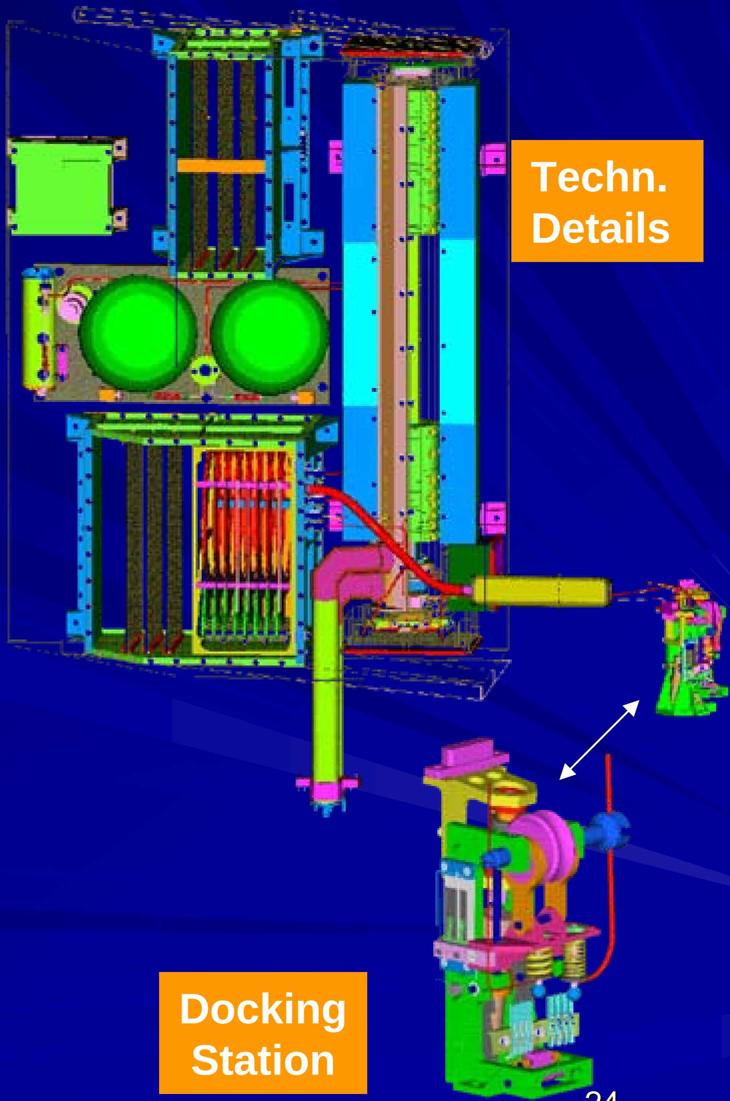
Cosac

H. Rosenbauer, F. Goesmann, R. Roll, MPS



Pressure Sensor

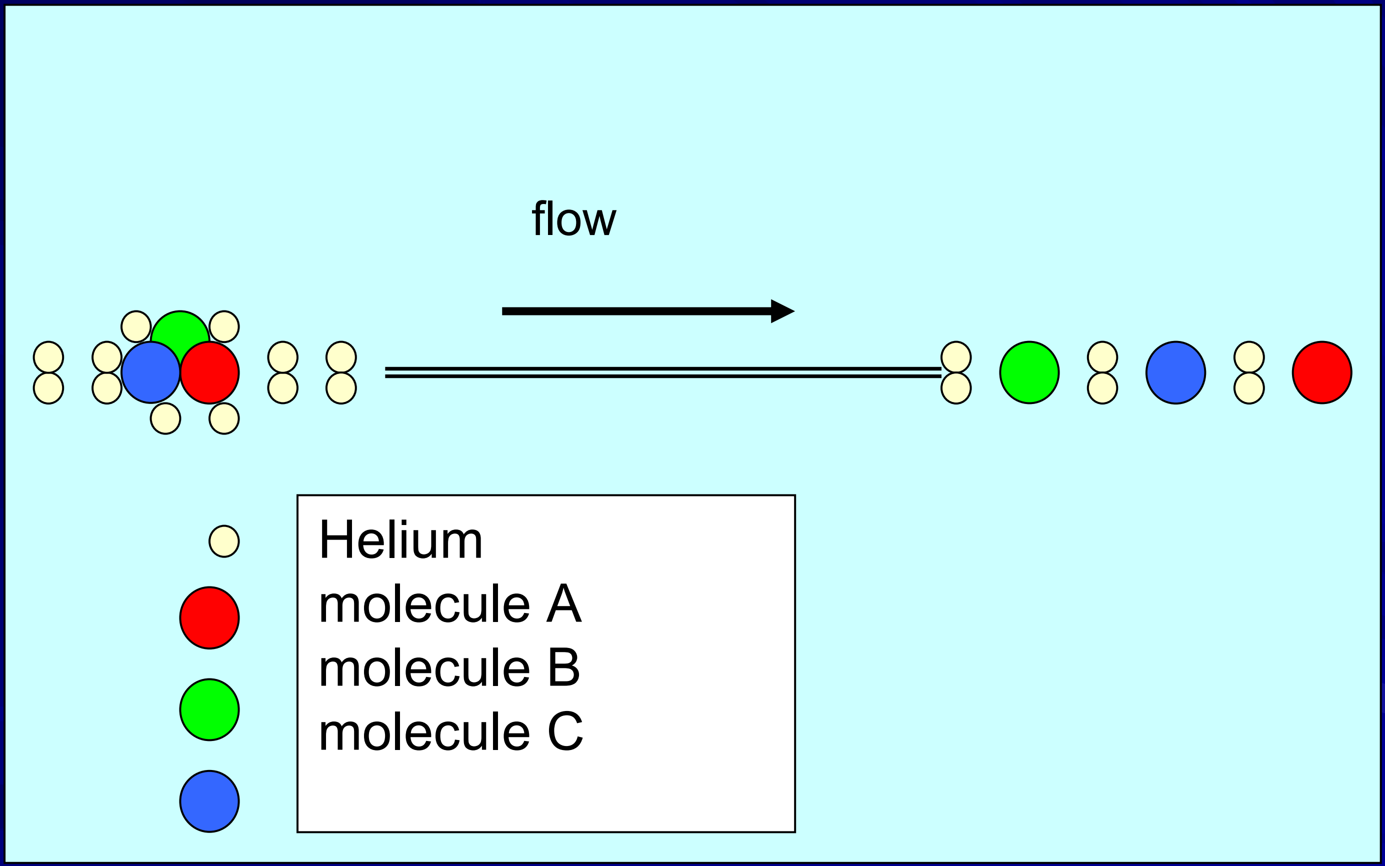




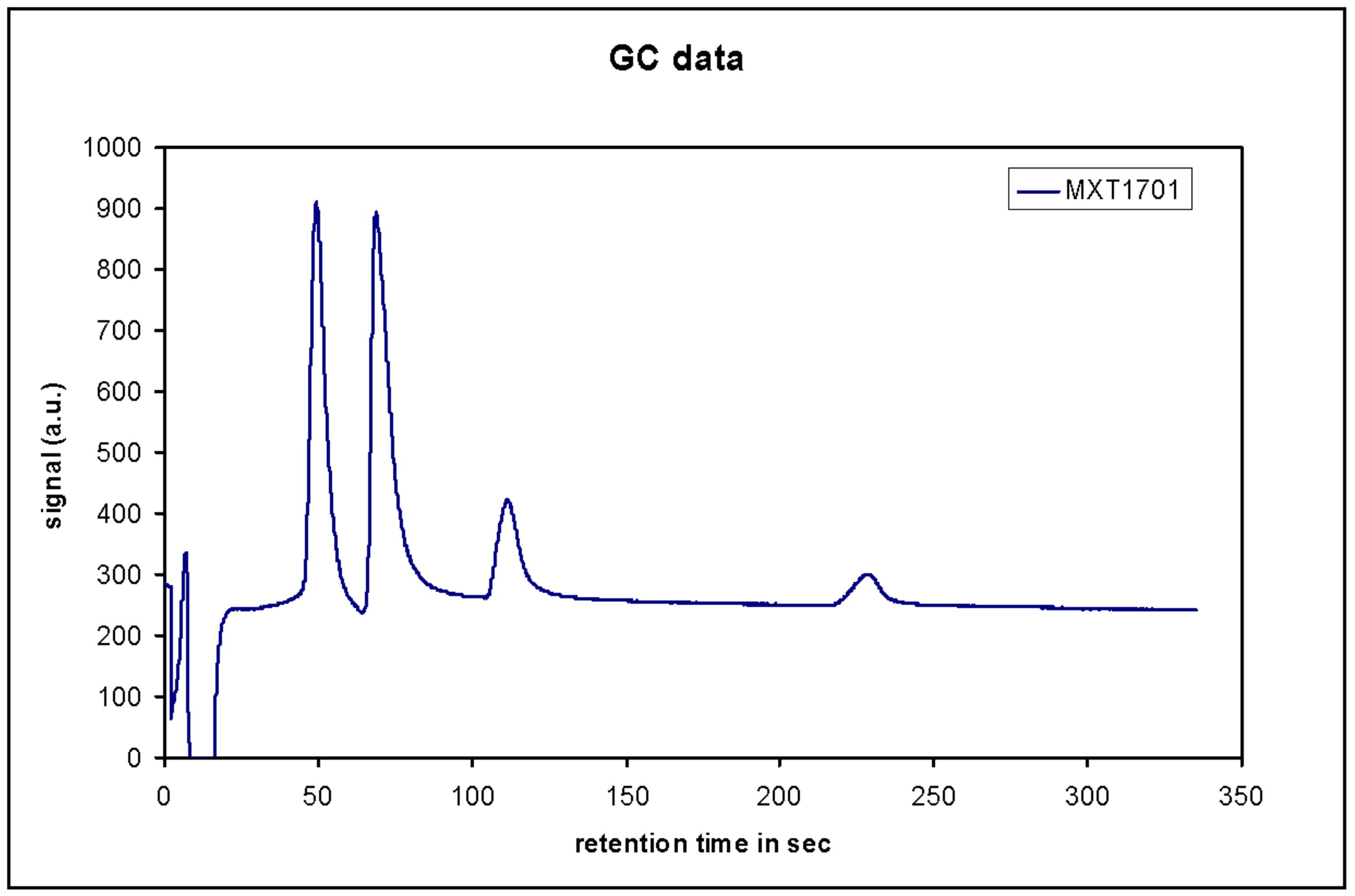
Techn. Details

Docking Station

GC

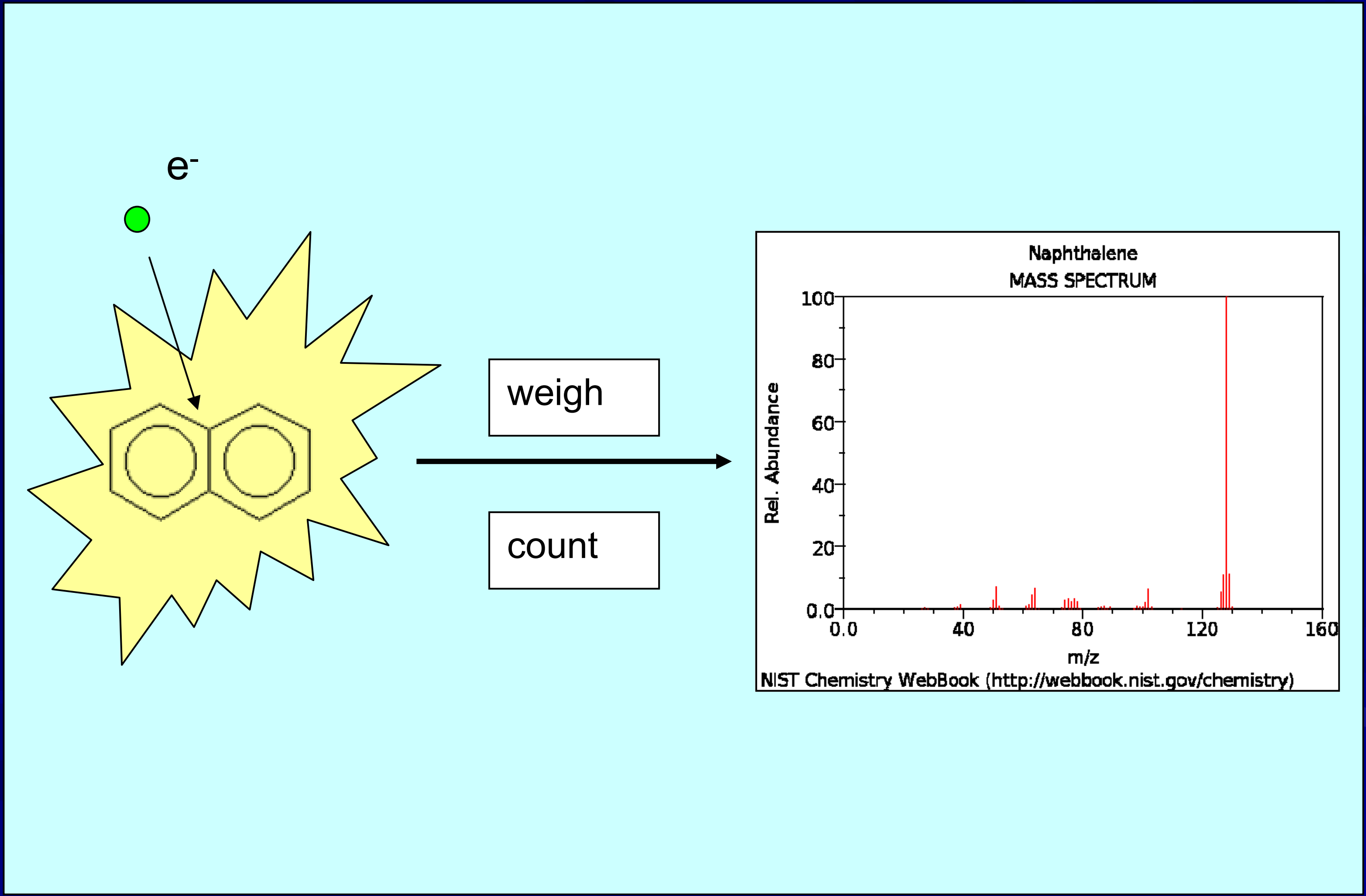


data (GC only)



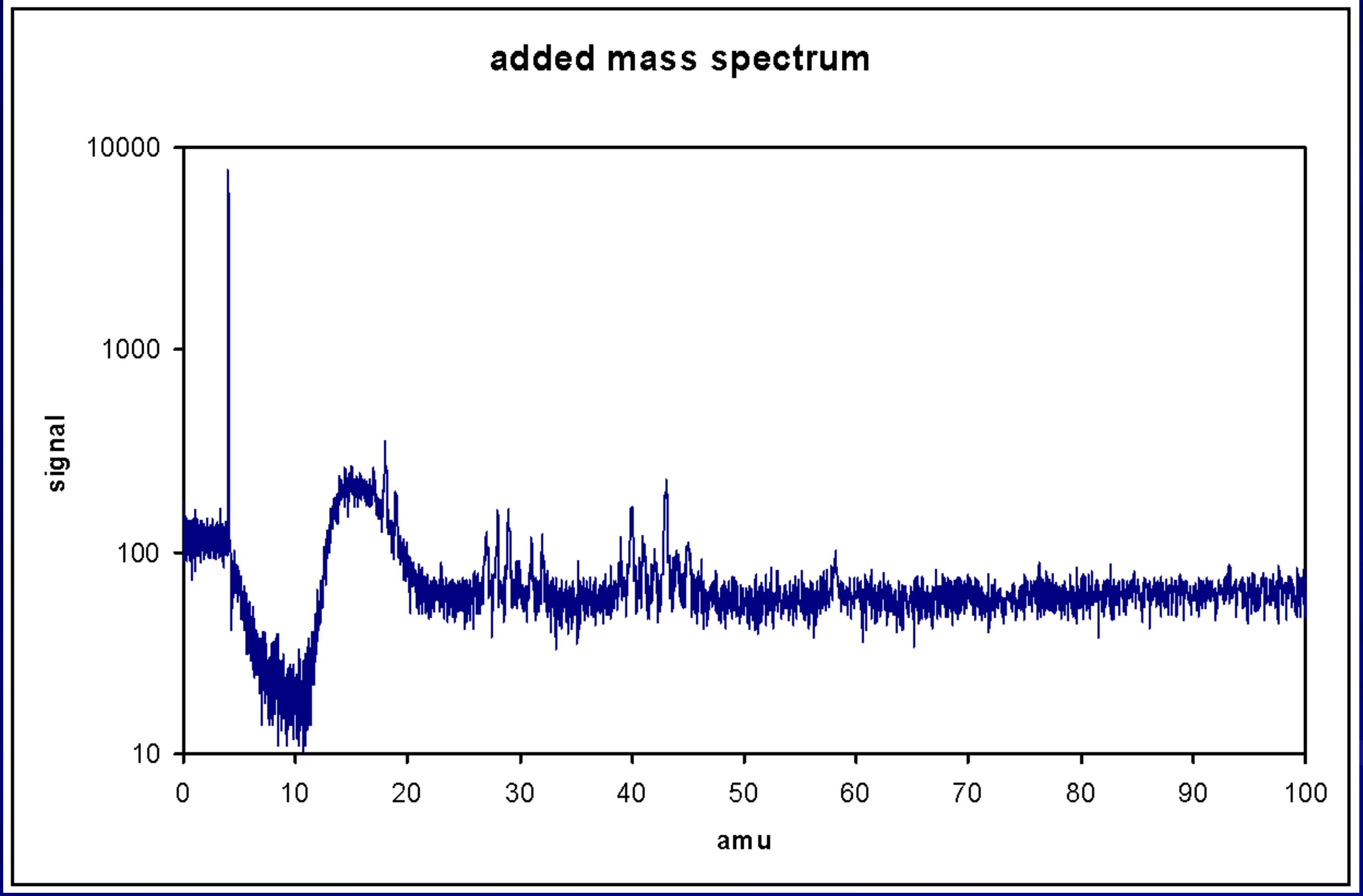
data obtained from the Cosac flight spare instrument at MPS

MS



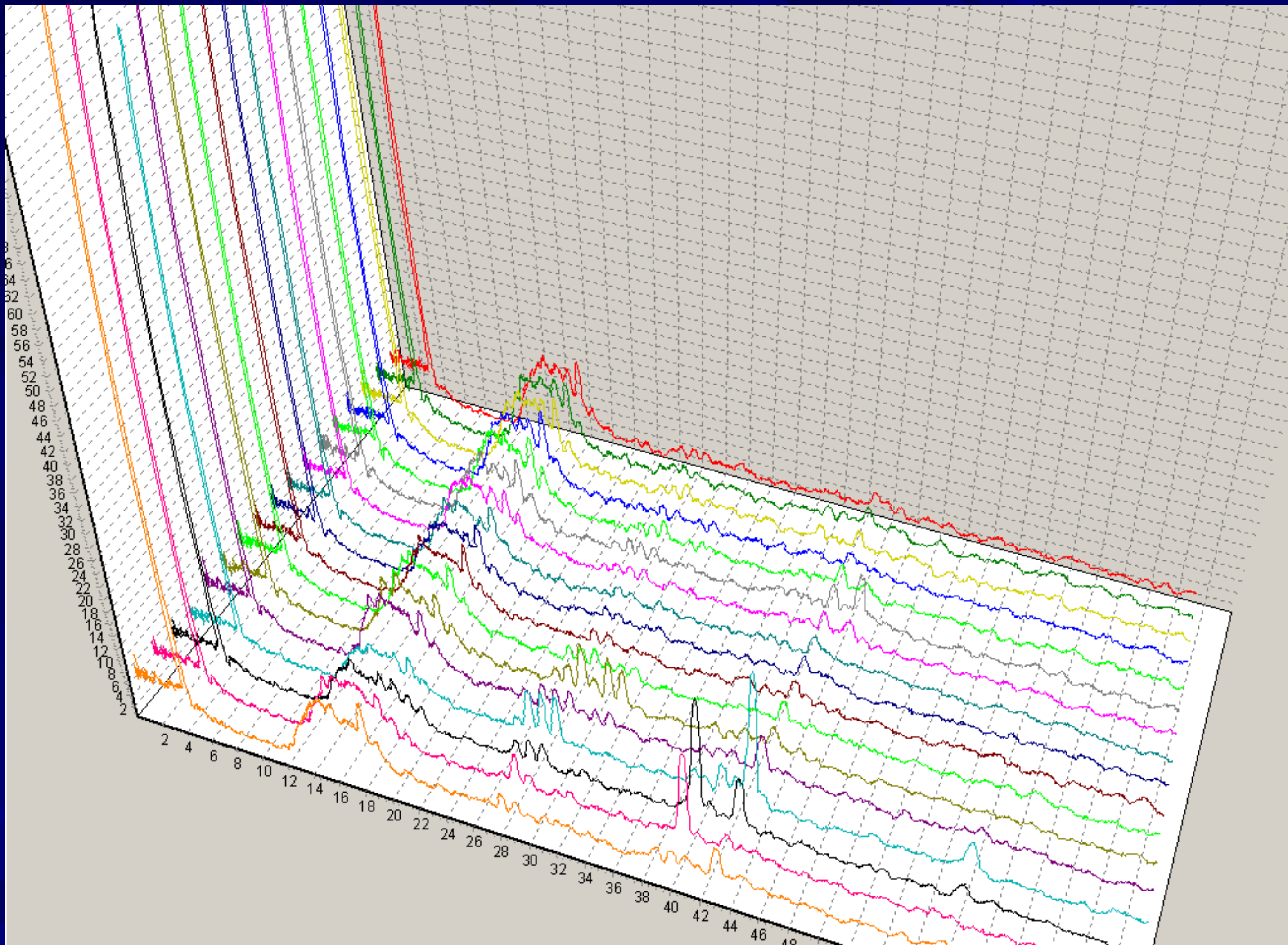
e-
weigh
count
Naphthalene
MASS SPECTRUM
Rel. Abundance
100
80
60
40
20
0.0
0.0
40
80
120
160
m/z
NIST Chemistry WebBook (http://webbook.nist.gov/chemistry)

data (MS only)



data obtained from the Cosac flight spare instrument, same sample

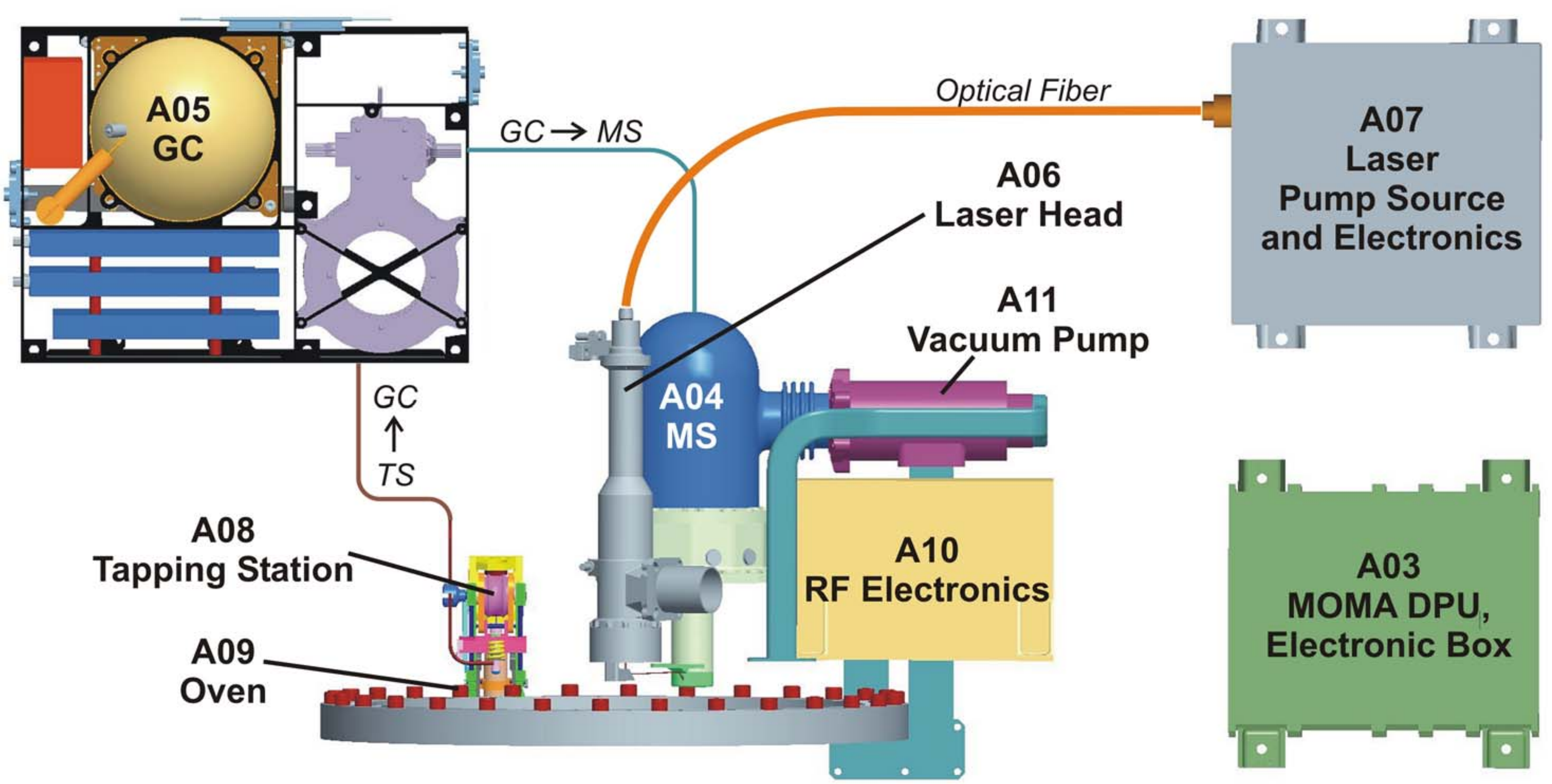
data (GC/MS)



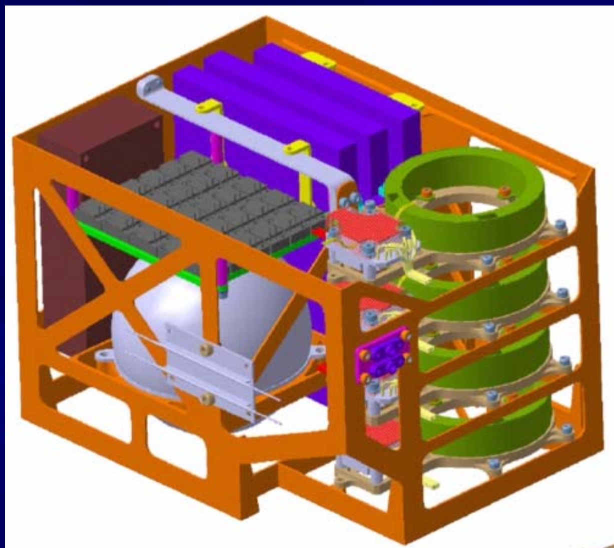
data obtained from the Cosac flight spare instrument, same sample

2nd instrument example: MOMA

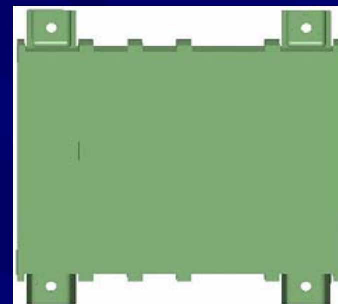
Mars organic molecule analyser; under construction for ExoMars (launch 2018)



A05
Gas Chromatograph

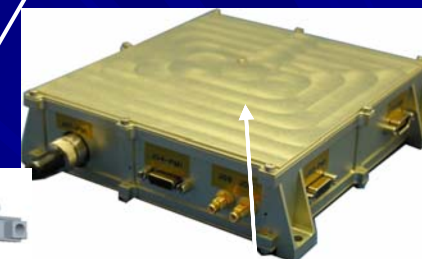


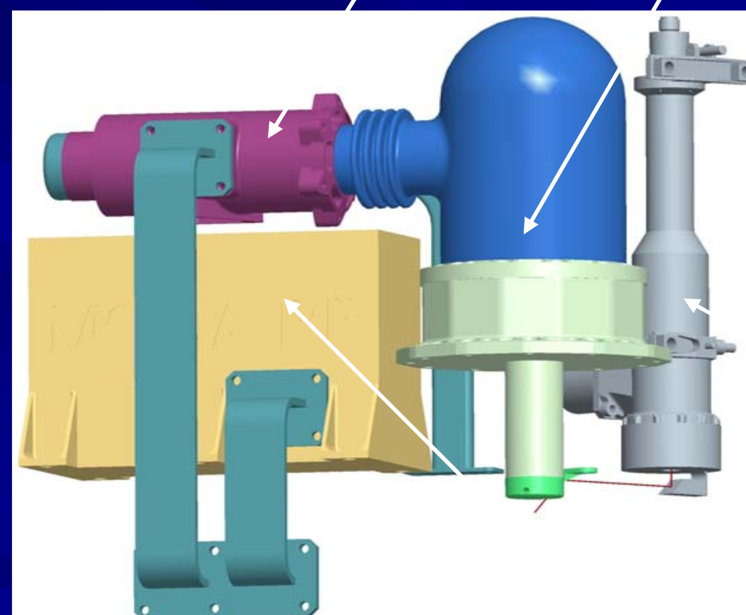
A03
Main Electronic Box



A11
Vacuum Pump

A04
Mass Spectrometer





A07
Laser Pump Unit

A06
Laser Head

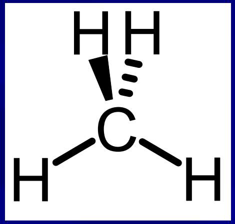
A09
Oven

A08
Tapping Station

A10
RF Electronics

MOMA, Scientific Goals

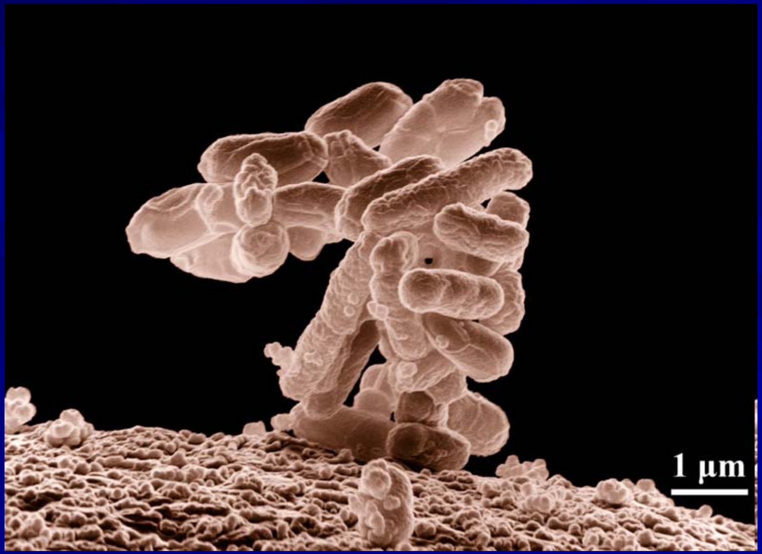
- detect organic molecules on Mars from meteorites
- detect organic molecules from Martian sources
- detect molecules indication past life
- find present life



MOMA, Scientific Goals

Signs of past and present life

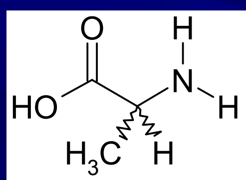
Definition of life: difficult and always earth centered

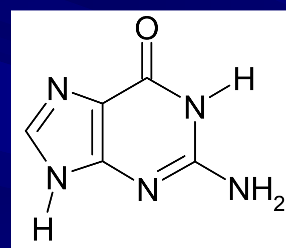


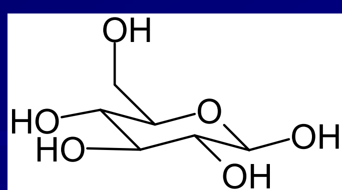
MOMA, Scientific Goals

Present life:

indicated by organic molecules which have a short half life on Mars

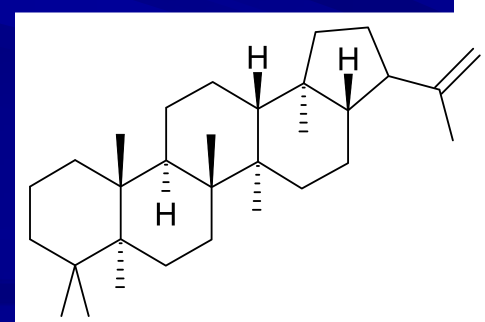


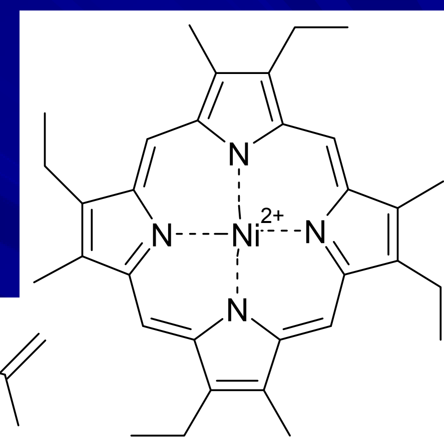




Past life:

indicated by persistent Biomarkers in the bedrock

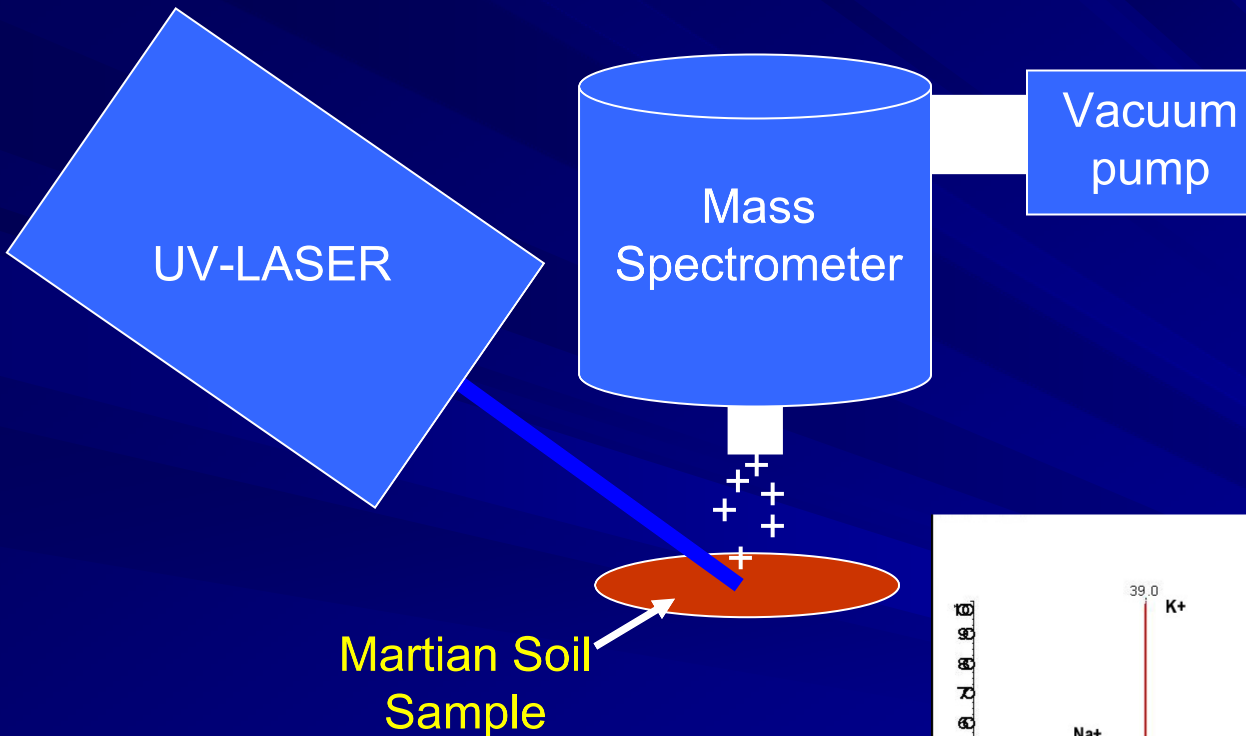


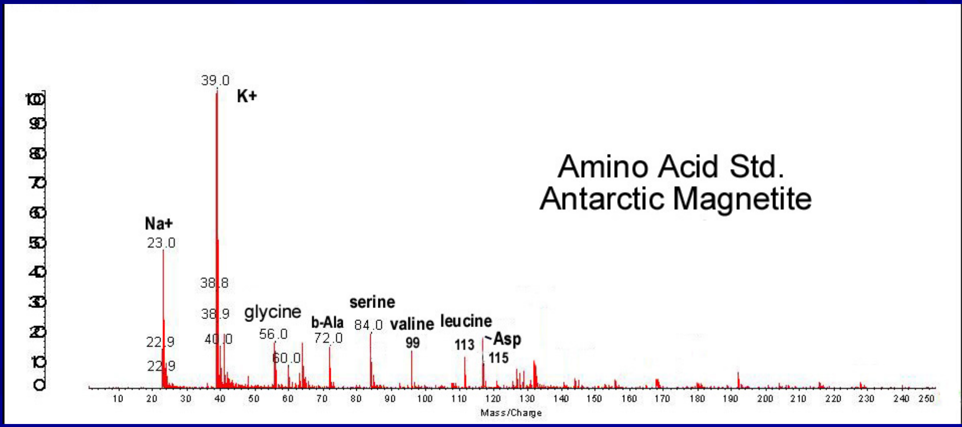


MOMA, measurement principles

Laser Desorption - Mass Spectrometer

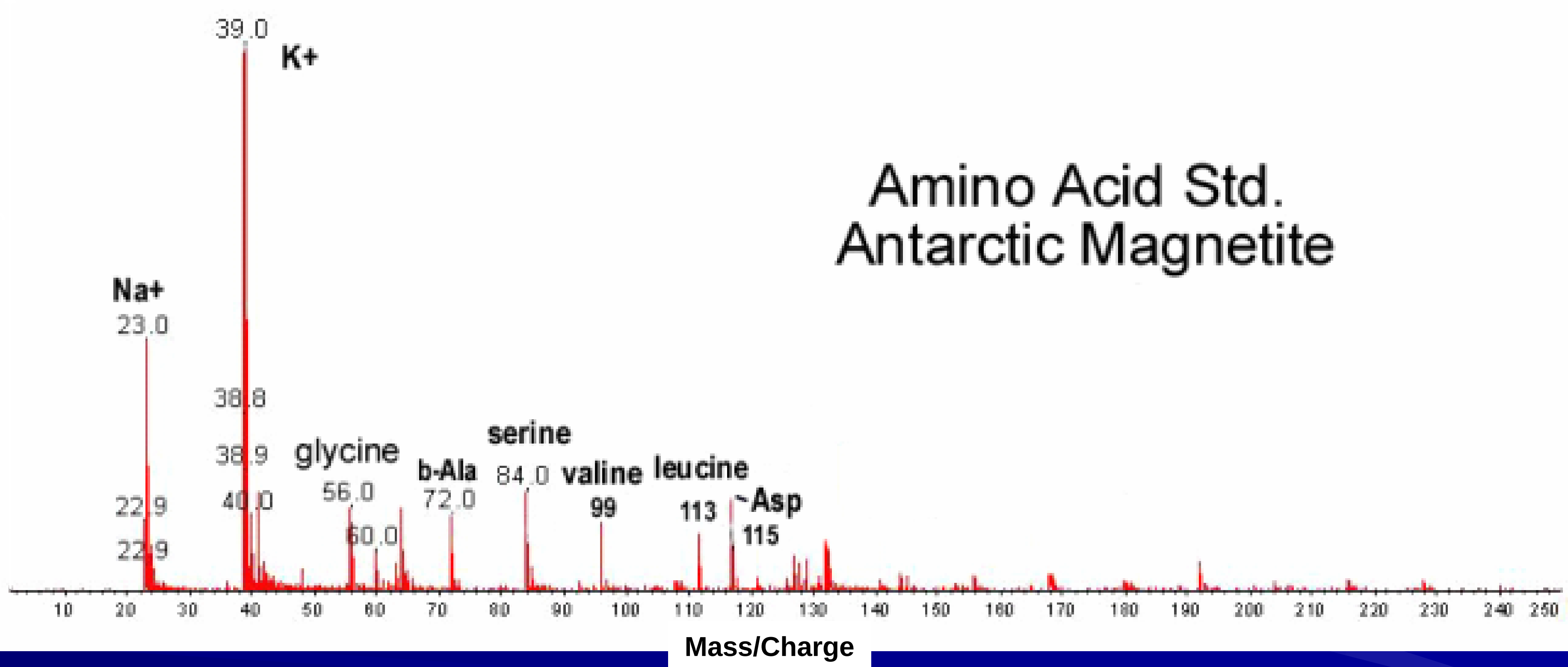
- mild conditions
- wide mass range





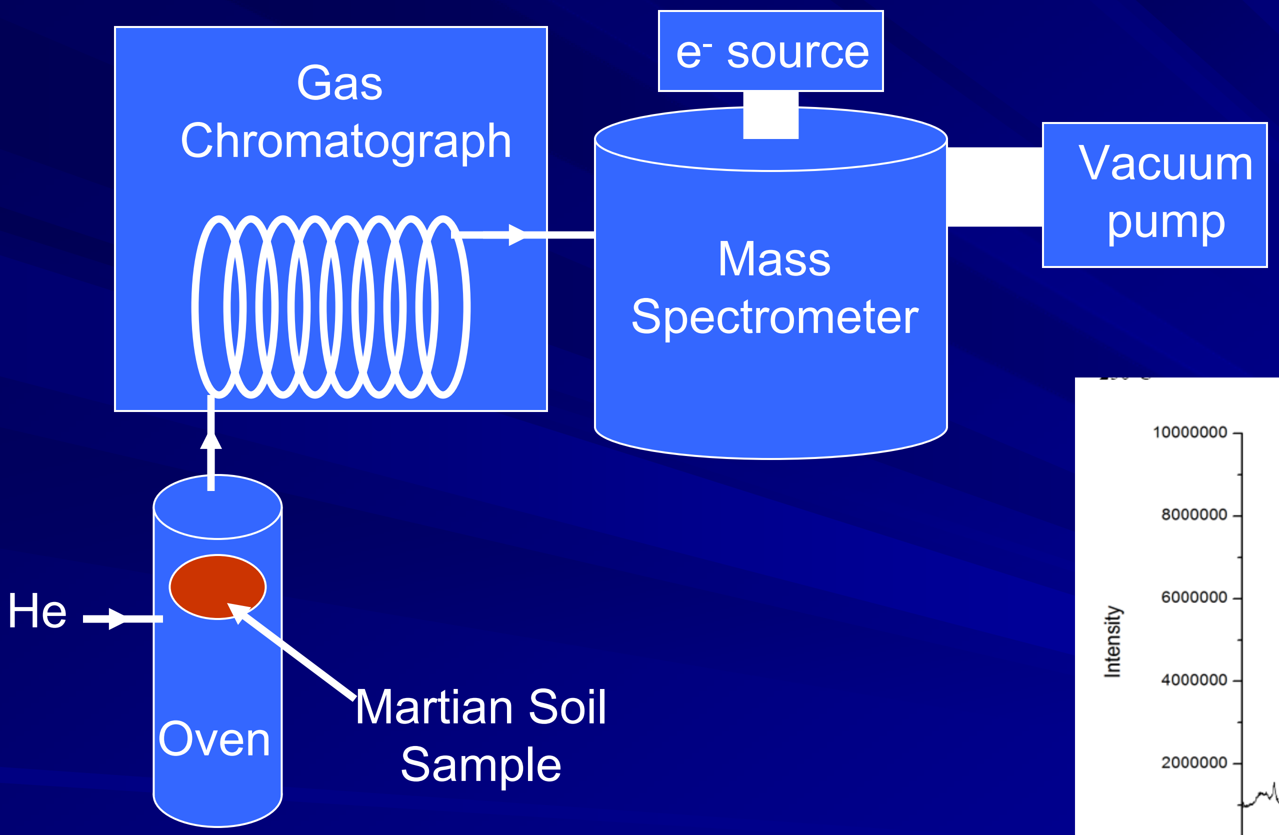
MOMA, measurement principles

Mass Spectrum Example

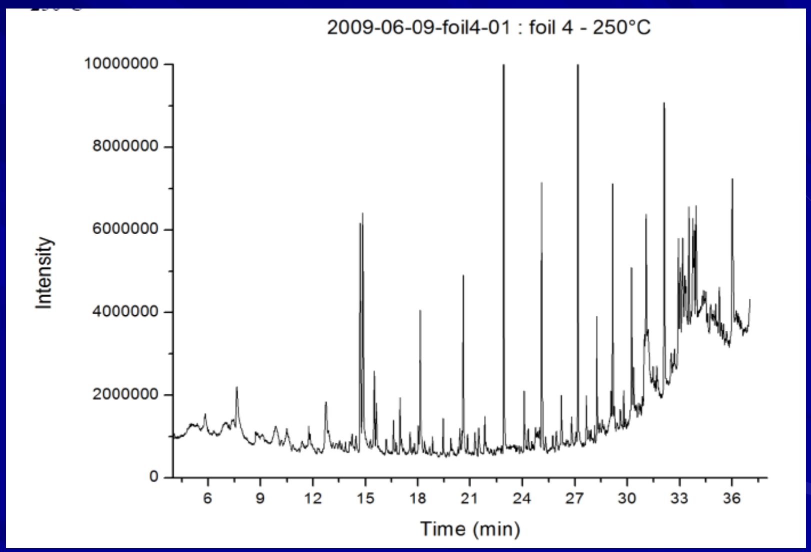


MOMA, measurement principles

Gas Chromatograph – Mass Spectrometer

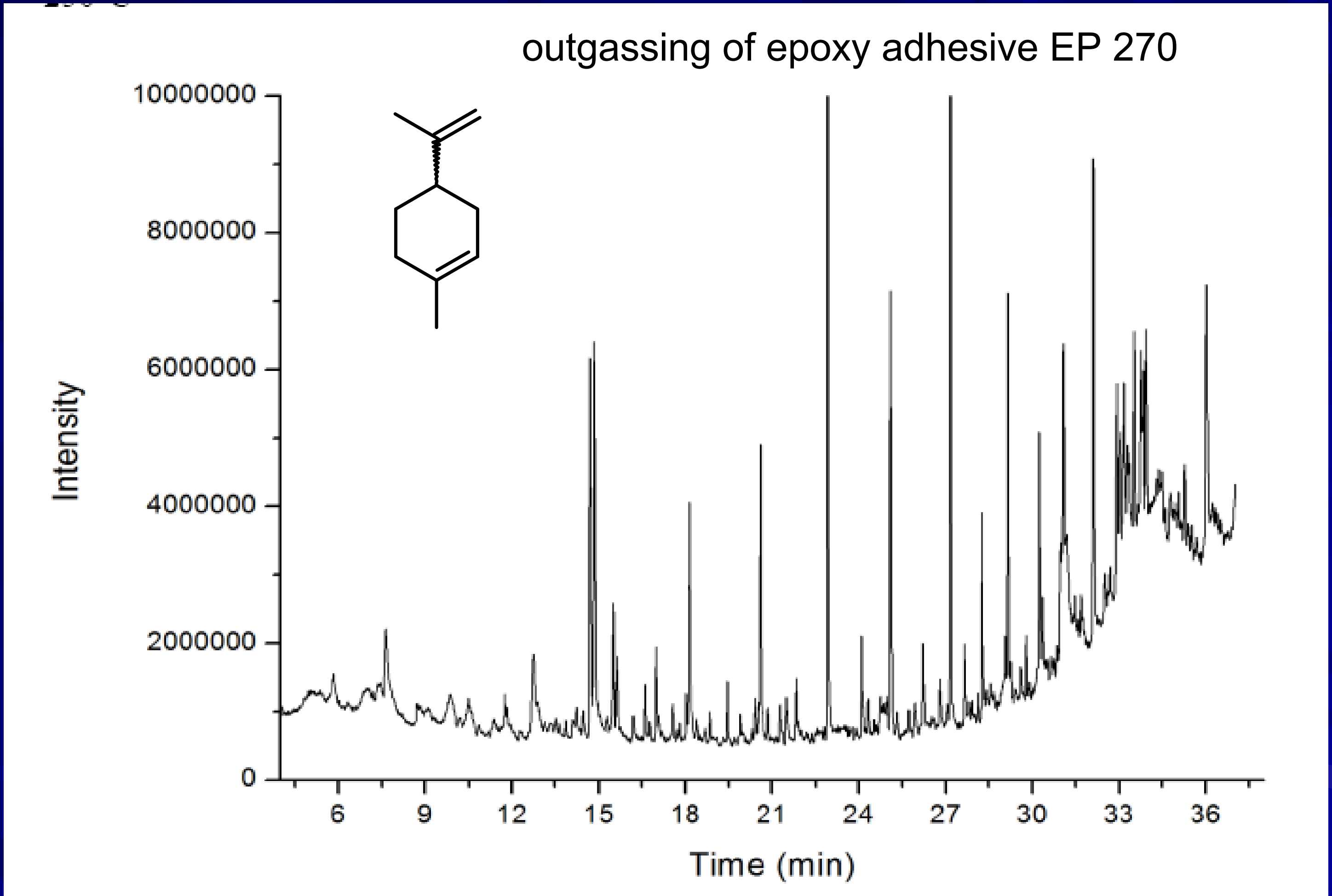


- separation of compounds
- chiral separation possible



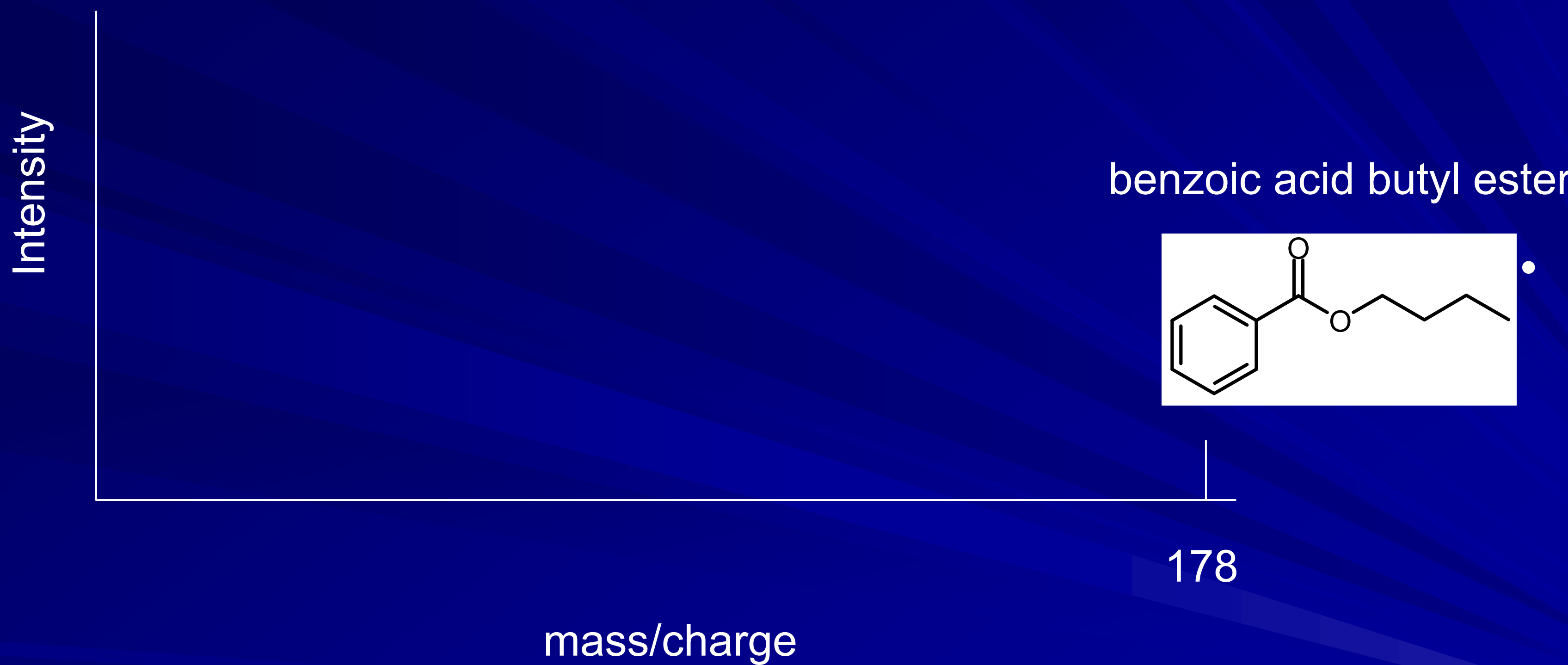
MOMA, measurement principles

GC Chromatogram Example



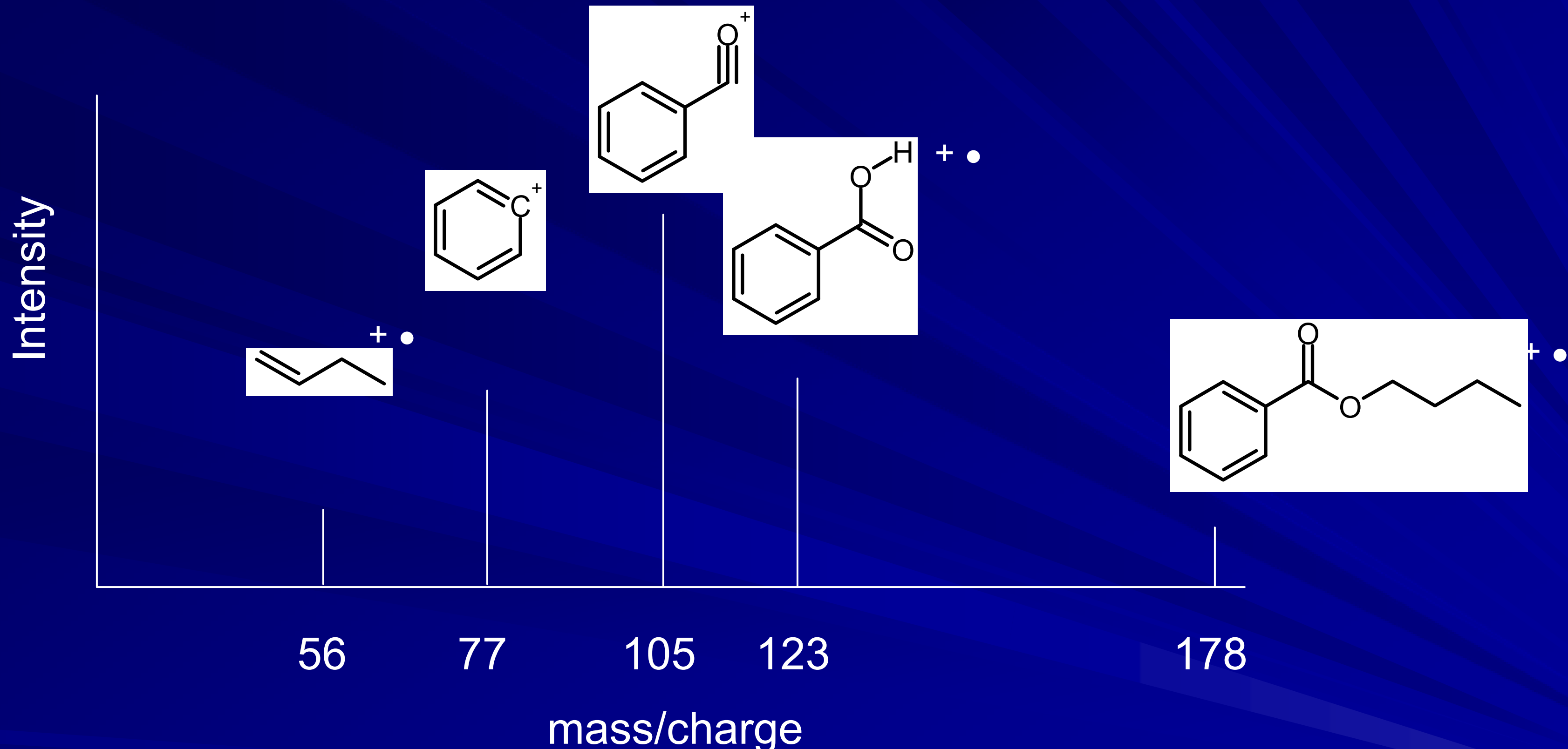
MOMA, measurement principles

Fragmentation Pattern

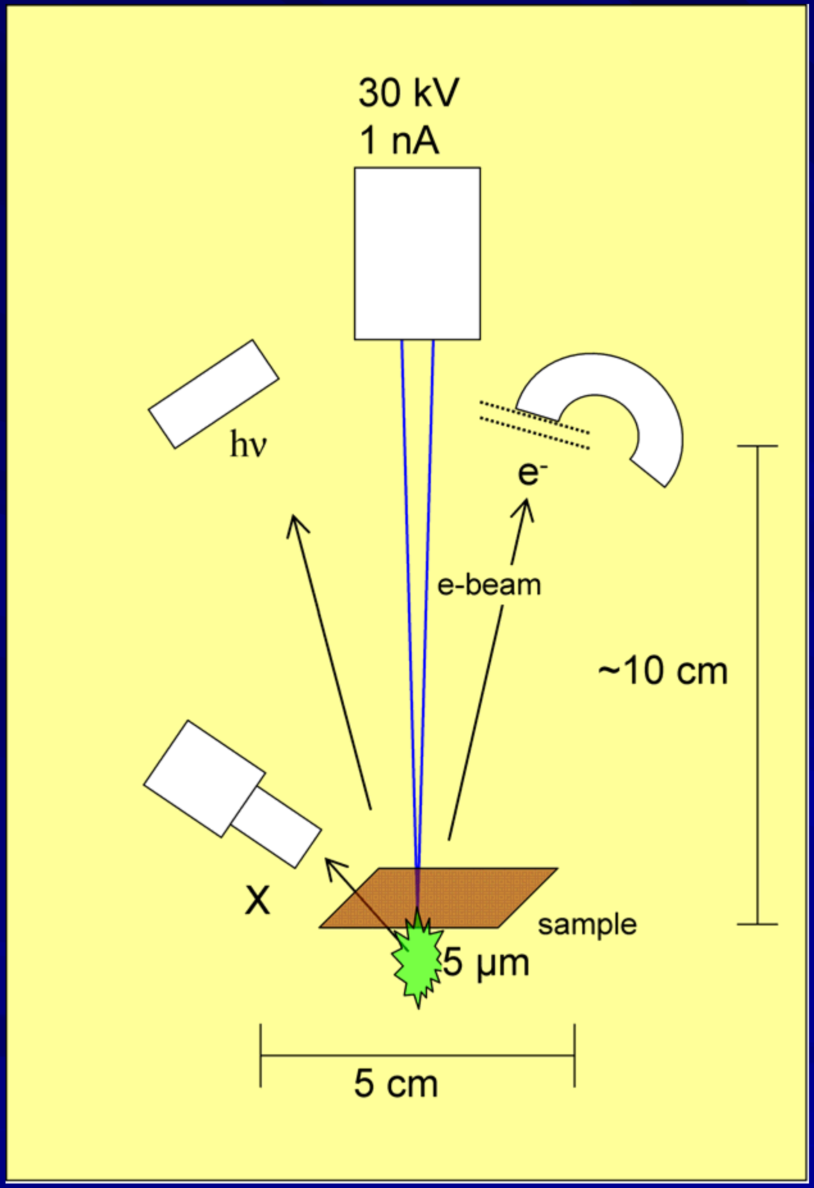


MOMA, measurement principles

Fragmentation Pattern

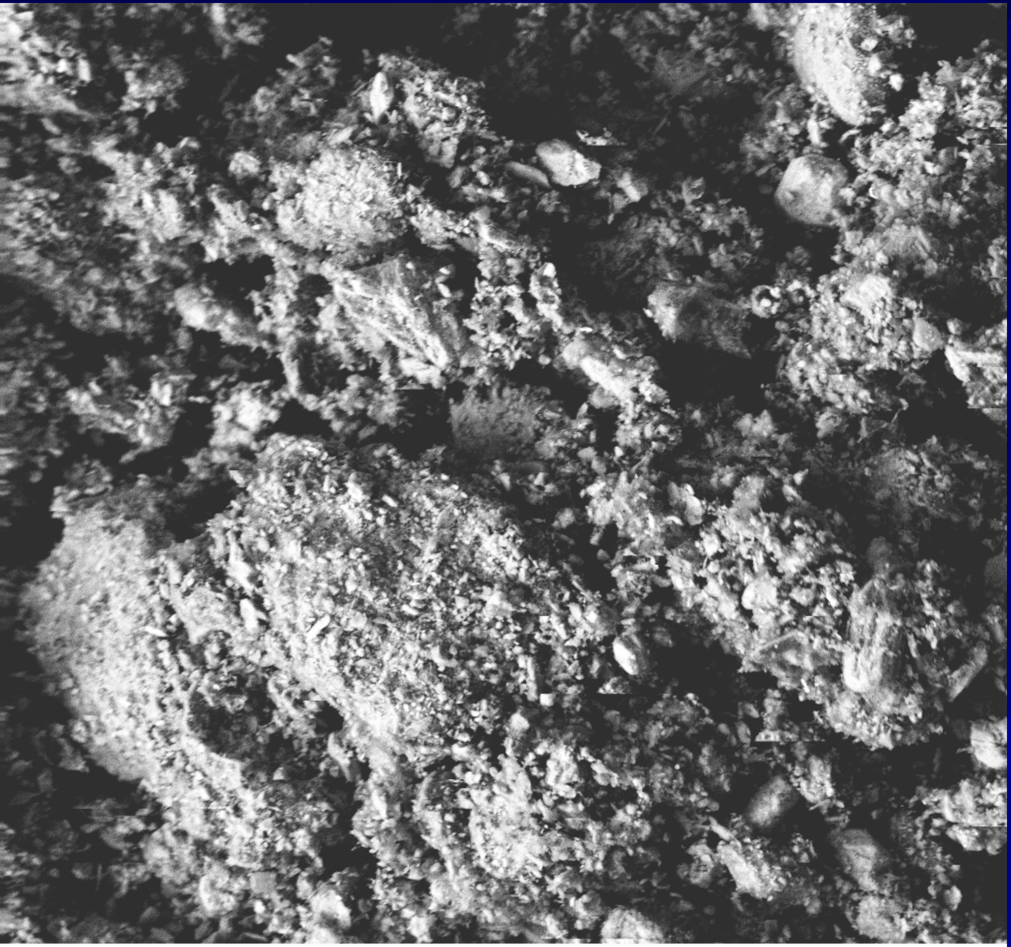


3rd example: electron microscope



schematic
overview

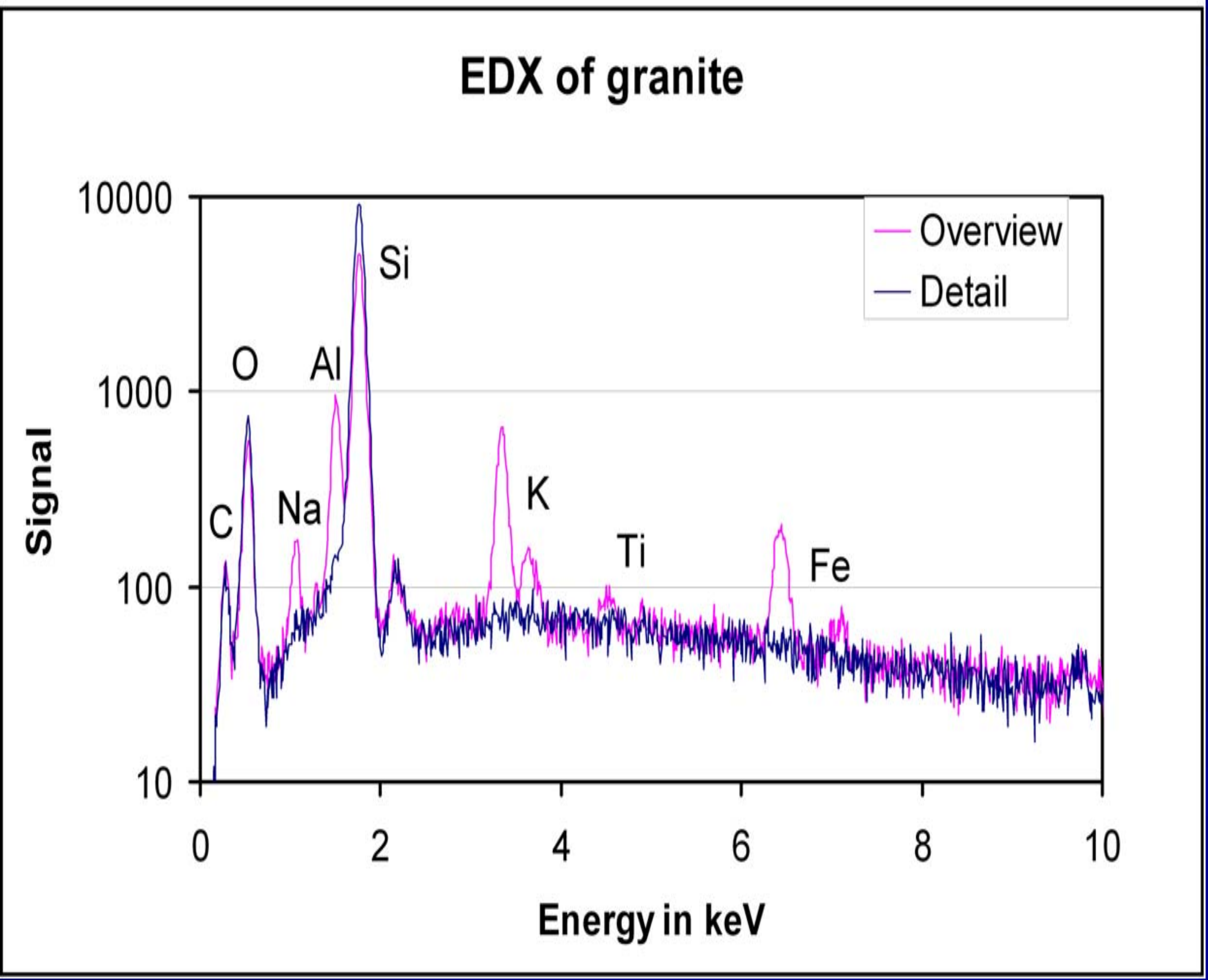
information gained 1


30 kV backscattered electrons 100μm

images

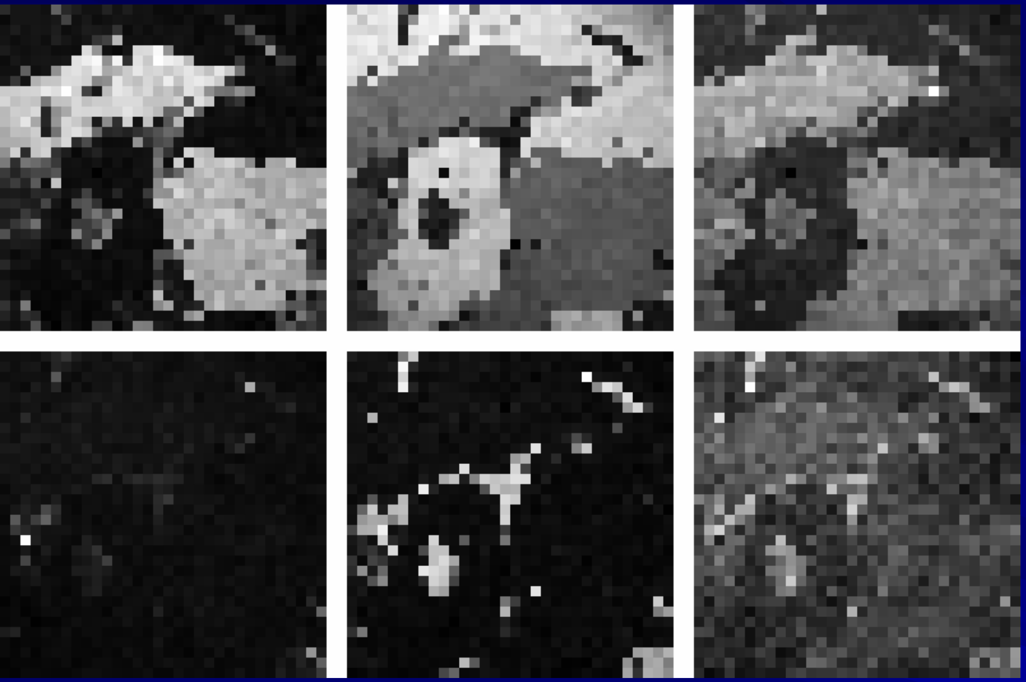
backscattered electron image of a powdery soil sample taken with a Leitz-Amray SEM.

information gained 2



composition
Two EDX spectra of granite obtained with a commercial SEM in 100s. The overview spectrum contains all elements present in granite, the detail spectrum contains Si and O only, indicating a quartz grain.

information gained 3



elemental distribution

images of the granite for K, Si, Al, Ti, Fe, Mg (top left to bottom right). The resolution is 32 by 32 pixels, scanning an area of about 5 by 5 mm, each taking about one second to measure. The areas can be identified in the right image taken with an optical microscope.

conclusion

- ➔ Landers are fun.
- ➔ Instrument design and manufacture are a challenging task.
- ➔ You need all your undergraduate physics twice per day.

End