

Landers and Instrumentation

- Overview
 - Why landers?
- History
 - first landers
- Details (Philae)
 - Science the driver
 - Technology the brakesman

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

Moon: Luna 9 (1966, USSR)

- payload
 - camera
 - radiation monitor

Venus: Venera 7 (1970, USSR)

- payload
 - thermometer
 - barometer
- first images
 - Venera 9 (1975)

Mars: Mars 3 (1971, USSR)

- payload
 - camera
 - gamma and x-ray spectrometer
 - thermometer
 - barometer
 - wind velocity
 - penetrometer

Jupiter: Galileo (1995, USA)

- payload
 - MS
 - temperature, pressure, deceleration
 - Helium interferometer
 - radiation
 - lightning / radio emission
 - did it land?

Asteroid: NEAR (2001, USA)

- payload
 - camera
 - magnetometer
 - gamma and X-ray spectrometer
 - not really a designed lander

Comets: Deep Impact (2005, USA)

- payload
 - camera
 - lander???

Titan: Cassini/Huygens (2005, USA / EU)

- payload
 - camera
 - GC-MS
 - wind speed
 - microphone

Comets: Philae (2014(?)EU)

- Science (ideal: → instrument)
- Instruments
- Infrastructure (short)

Philae

- Science: big questions
 - Rise and decay of Solar systems
 - Where do comets come from?
 - How did they influence the Earth?

Philae

- Science: little questions
 - Nucleus composition
 - elements
 - isotopes
 - minerals
 - molecules
 - Mechanical properties
 - strength (break~)
 - porosity
 - sound velocity
 - damping

Philae

■ Science: little questions

- Thermal properties
 - temperatures (depth)
 - conductivity
 - capacity
- shapes and structures
 - large scale
 - microscopic scale

Philae

■ Science: little questions

- Inner structure
 - layers
 - cracks
 - caves
 - dielectric constant
- Electric and magnetic properties
 - conductivity
 - permeability
 - susceptibility
 - permanent magnetic field

Philae

■ Science: little questions

- Plasma interaction
 - solar wind interaction
- Dynamics
 - breaking up
 - outbursts
 - quakes
 - ablation
 - pressure changes

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

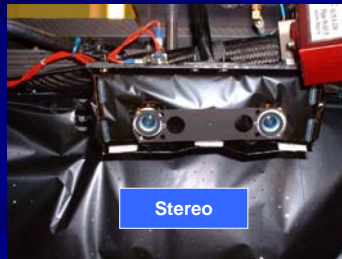
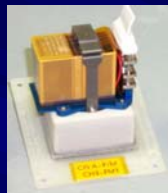
■ semiconductor physics, electronics, optics

ÇIVA

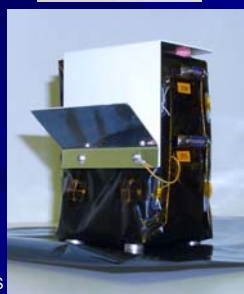
J-P. Bibring, IAS Paris



Panorama



Stereo



Visible μ -scope



IR μ -scope

MPS

Space Instrum

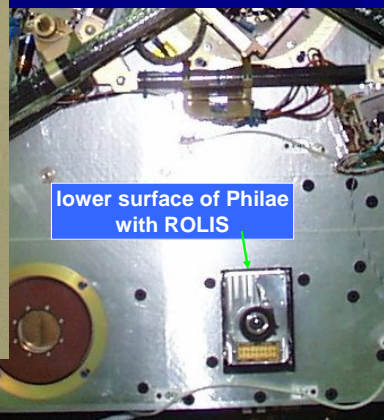
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ROLIS

S. Mottola, DLR Berlin



MPS



lower surface of Philae with ROLIS

Space Instrum

Sesame

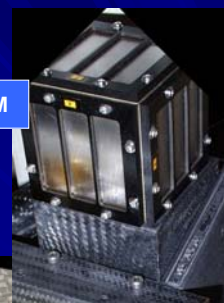
- electrical and mechanical (Surface Electrical, Sounding, and Acoustical Monitoring Experiment)
 - dust impact monitor
 - electrical sensors
 - mechanical sensors
- electrodynamics, mechanics,

SESAME

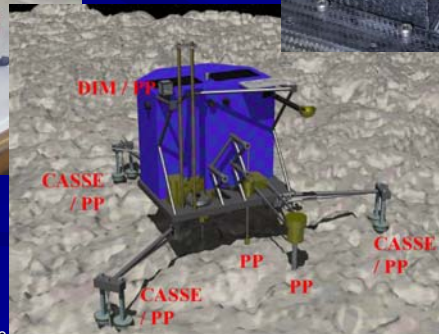
D. Möhlmann, DLR Berlin



DIM



CASSE

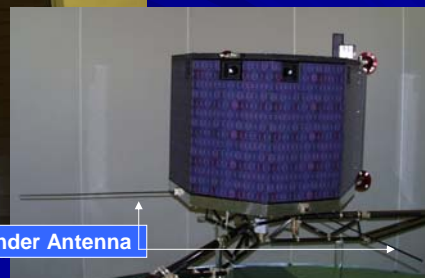


Consert

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

CONSERT

W. Kofman, CEPHAG Grenoble

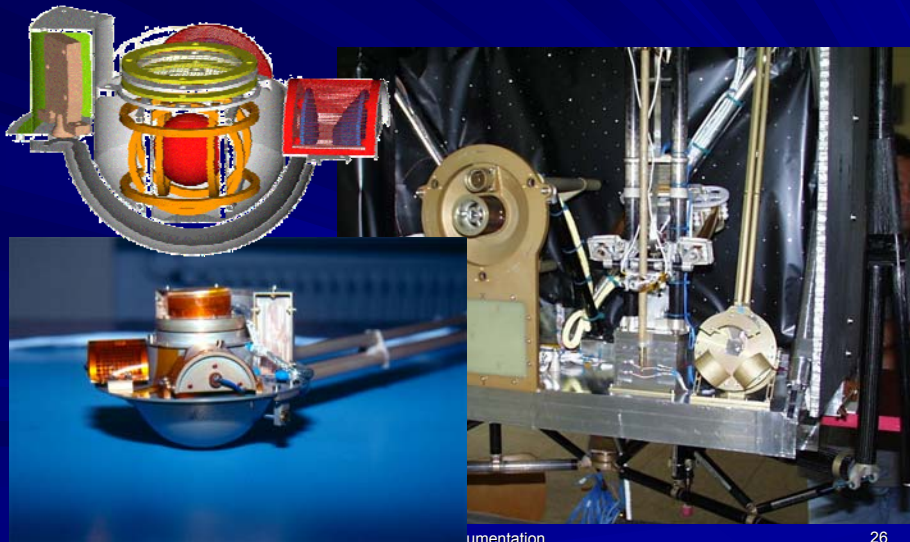


Romap

- 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

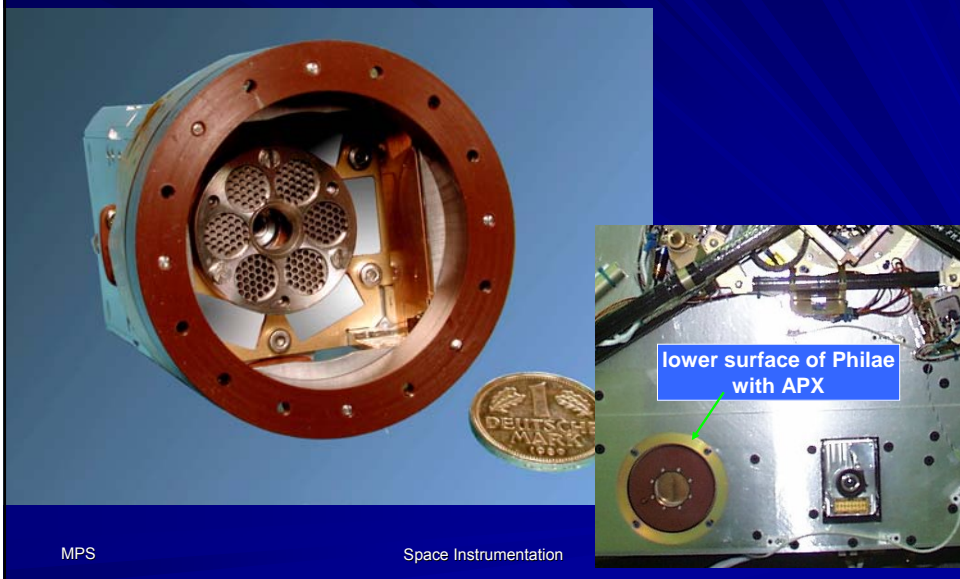


APX(S)

- **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)

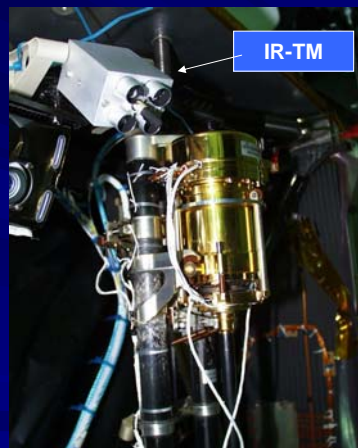
MPS

Space Instrumentation

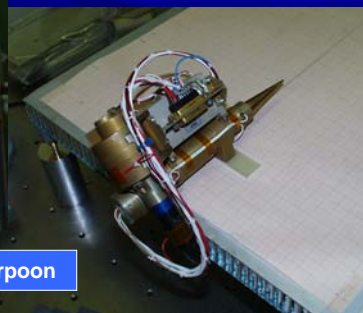
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MUPUS

T. Spohn, Universität Münster, DLR Berlin



Harpoon
M. Thiel,
MPE Garching



PEN

Harpoon

MPS

Space Instrumentation

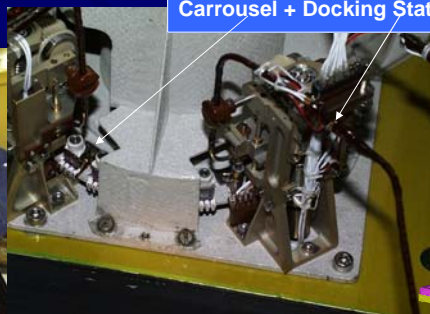
SD2

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

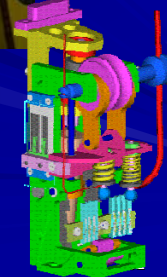
Drill (SD²)

A. Finzi, Politecnico di Milano

Carrousel + Docking Stations



Docking Stations
R. Roll, MPS

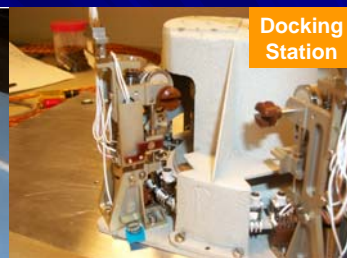


Ptolemy

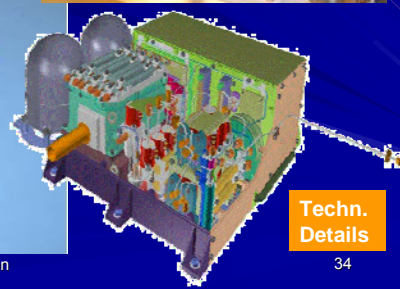
- isotopes (MODULUS = Ptolemy + BERENICE)
 - combustion
 - GC
 - MS (ion trap)
- chemistry, electrodynamics

PTOLEMY

I. Wright, Open University Milton Keynes



Docking Station



Techn. Details

COSAC

- **molecules** (COmetary SAmping and CComposition experiment)
 - GC
 - MS (time of flight)
 - pressure sensor
- chemistry, e-dynamics, mechanics (TS)

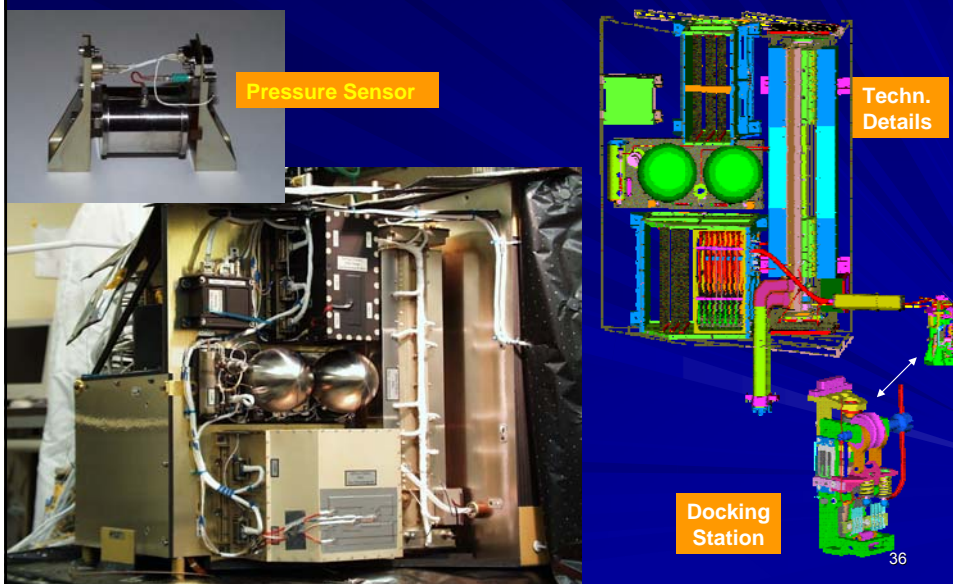
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Space Instrumentation

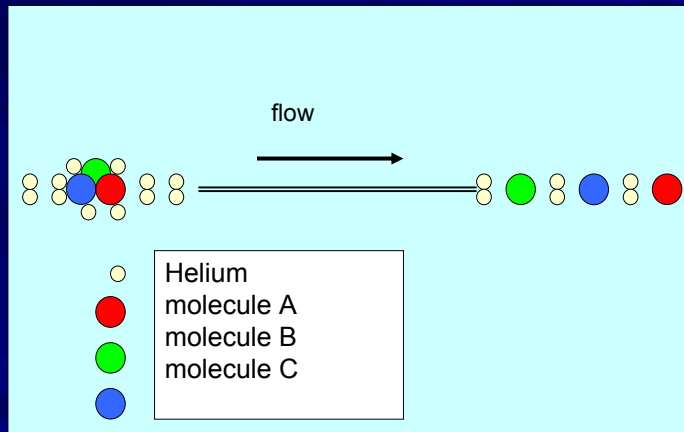
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COSAC

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



GC

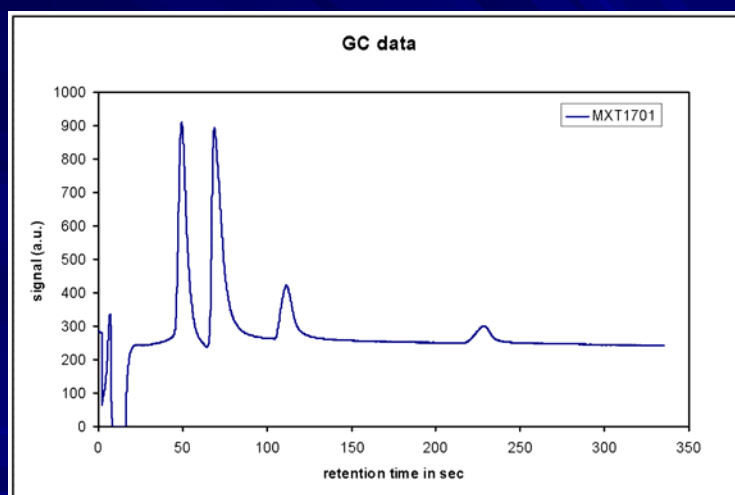


MPS

Space Instrumentation

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data (GC only)



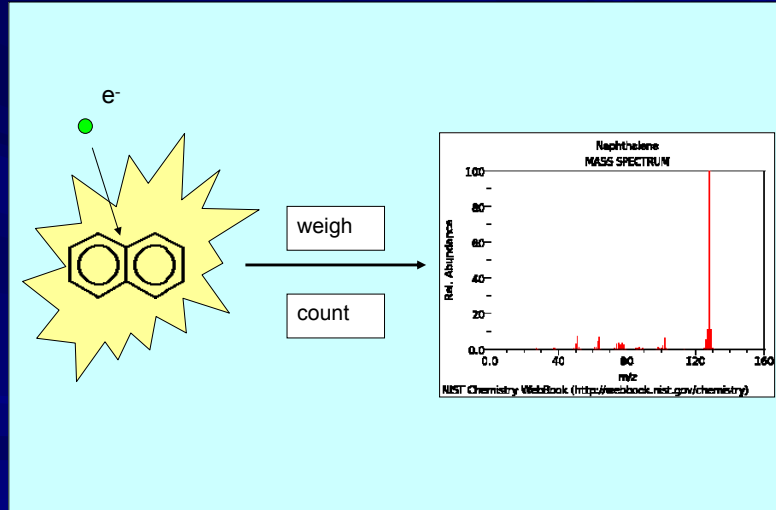
data obtained from the COSAC flight spare instrument at MPS

MPS

Space Instrumentation

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MS

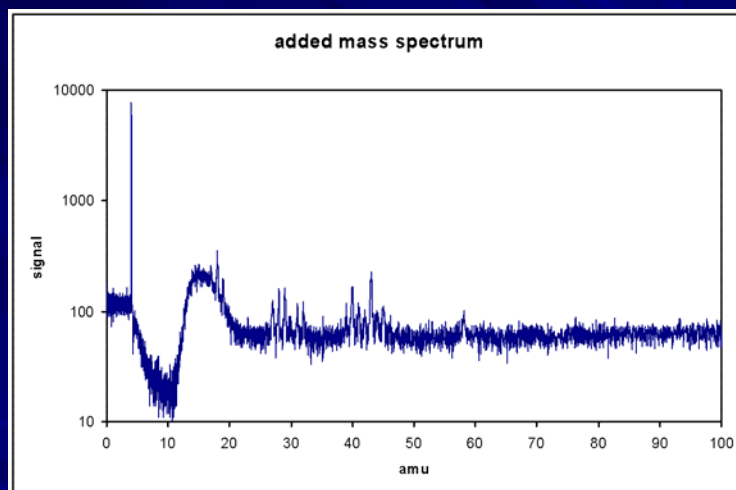


MPS

Space Instrumentation

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data (MS only)



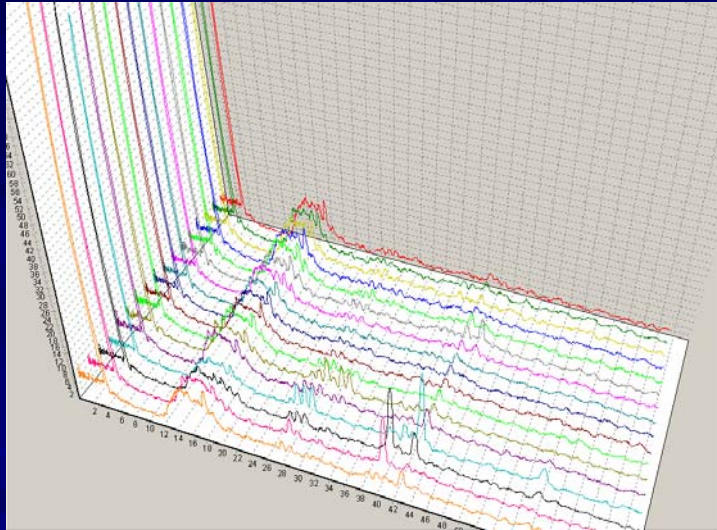
data obtained from the COSAC flight spare instrument, same sample

MPS

Space Instrumentation

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data (GC/MS)



data obtained from the COSAC flight spare instrument, same sample

MPS

Space Instrumentation

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hardware



MPS

Space Instrumentation

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conclusion

- Landers are fun.
- You need all your undergraduate physics twice per day.
- Find a catchy acronym.
- acknowledgements to Reinhard Roll

End