

# 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

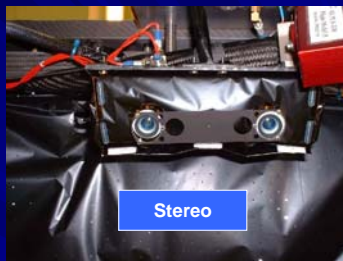
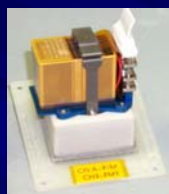
#### ■ semiconductor physics, electronics, optics

# ÇIVA

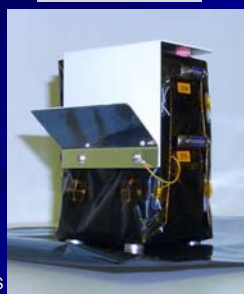
J-P. Bibring, IAS Paris



Panorama



Stereo



Visible  $\mu$ -scope



IR  $\mu$ -scope

MPS

Space Instrum

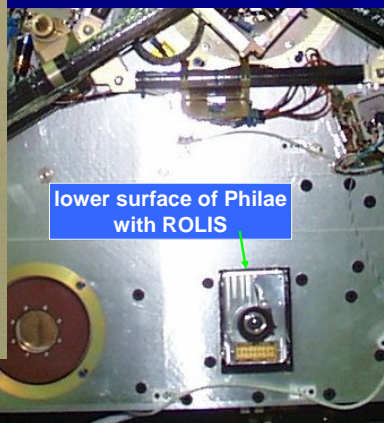
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# ROLIS

S. Mottola, DLR Berlin



MPS



lower surface of Philae with ROLIS

Space Instrum

# Sesame

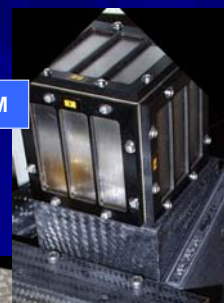
- electrical and mechanical (Surface Electrical, Sounding, and Acoustical Monitoring Experiment)
  - dust impact monitor
  - electrical sensors
  - mechanical sensors
- electrodynamics, mechanics,

# SESAME

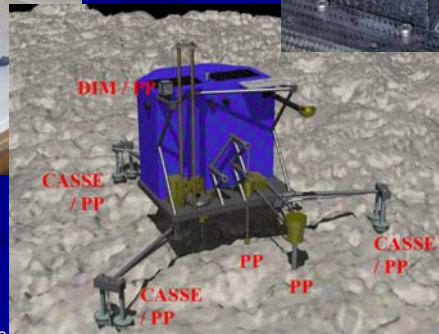
D. Möhlmann, DLR Berlin



DIM



CASSE



# Consert

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

# CONSERT

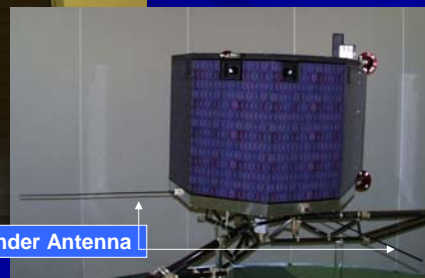
W. Kofman, CEPHAG Grenoble



Orbiter Antenna



Electronics Box



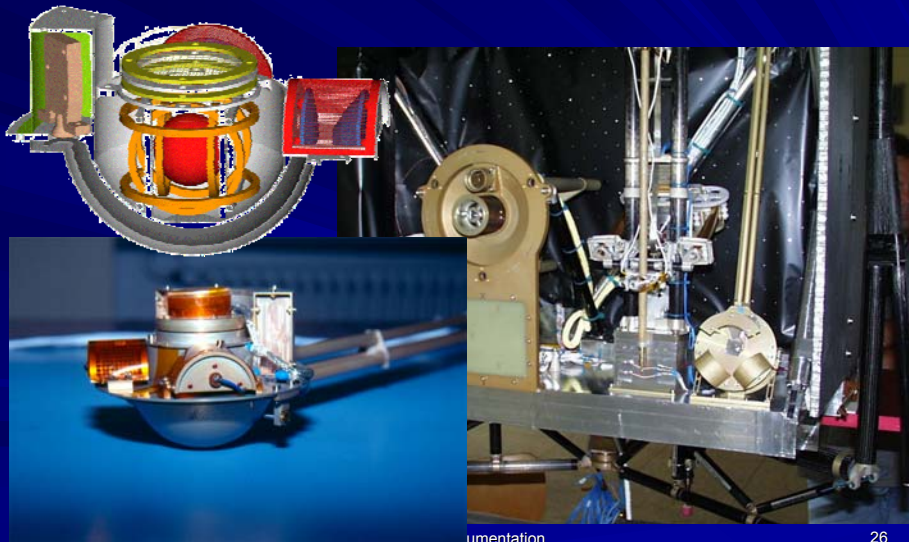
Lander Antenna

# 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



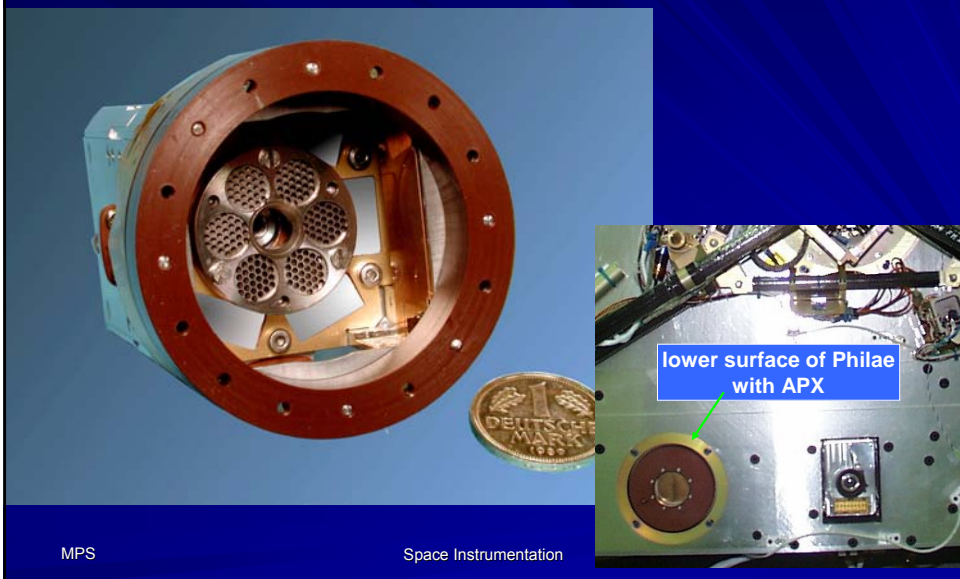


# APX(S)

- **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)

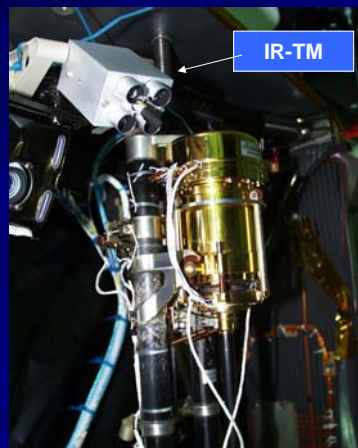
MPS

Space Instrumentation

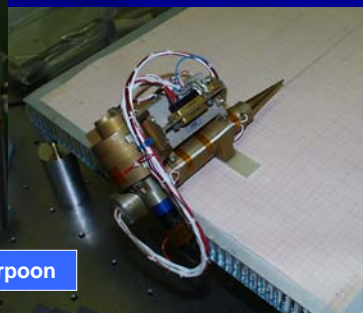
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# MUPUS

T. Spohn, Universität Münster, DLR Berlin



Harpoon  
M. Thiel,  
MPE Garching



PEN

Harpoon

MPS

Space Instrumentation

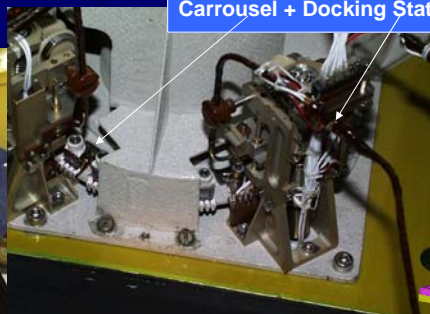
# SD2

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

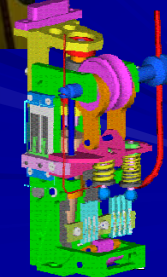
# Drill (SD<sup>2</sup>)

A. Finzi, Politecnico di Milano

Carrousel + Docking Stations



Docking Stations  
R. Roll, MPS



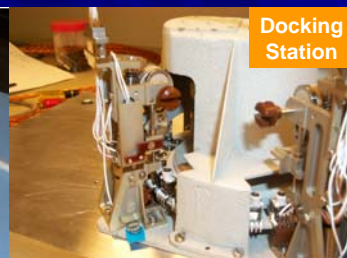


# Ptolemy

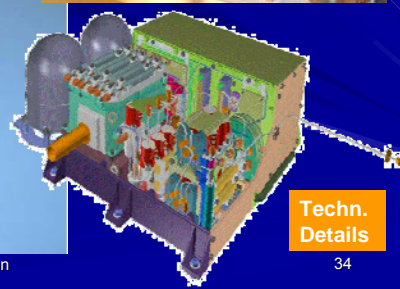
- isotopes (MODULUS = Ptolemy + BERENICE)
  - combustion
  - GC
  - MS (ion trap)
- chemistry, electrodynamics

# 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)

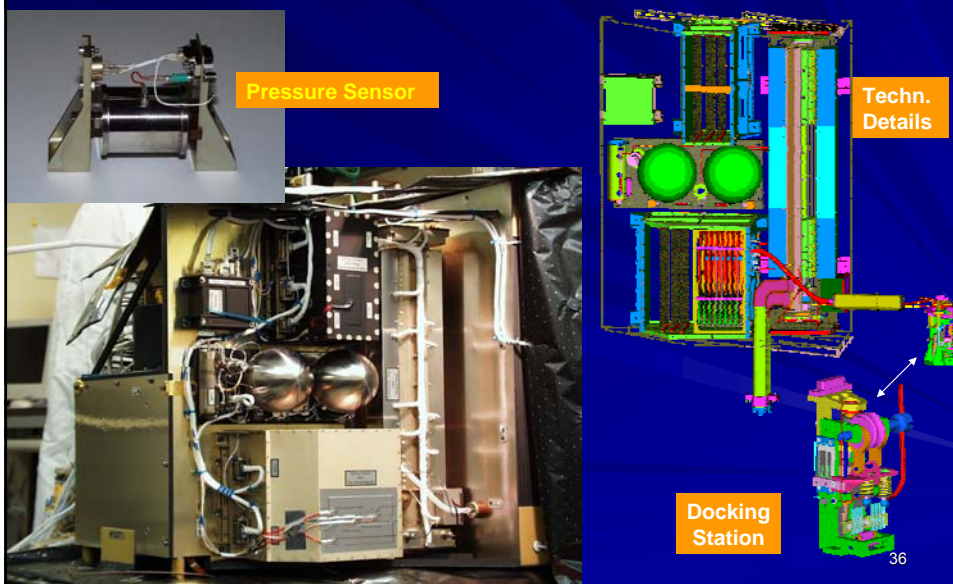
MPS

Space Instrumentation

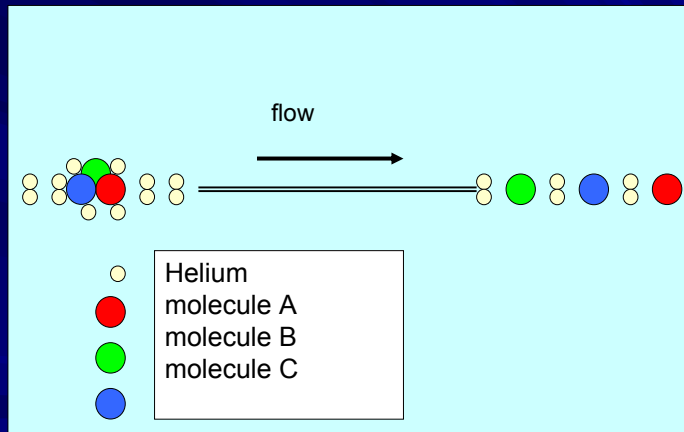
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# COSAC

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



# GC

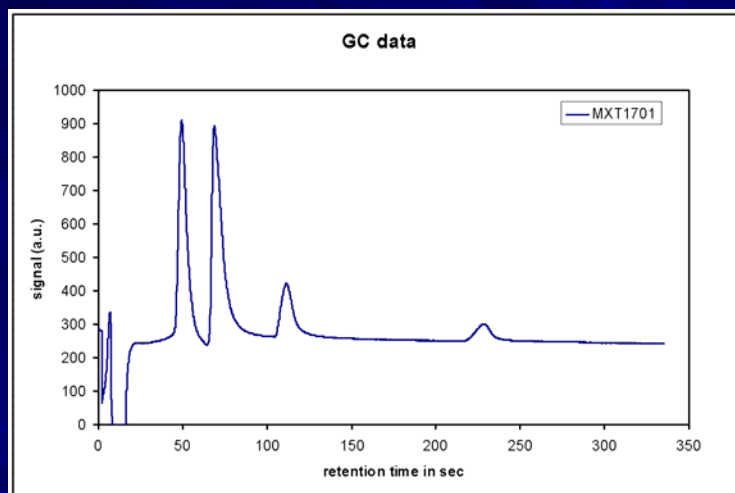


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Space Instrumentation

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# data (GC only)



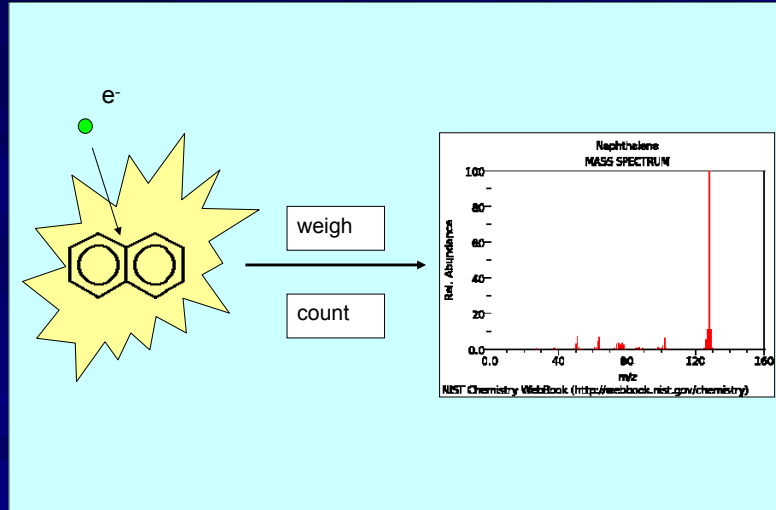
data obtained from the COSAC flight spare instrument at MPS

MPS

Space Instrumentation

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# MS

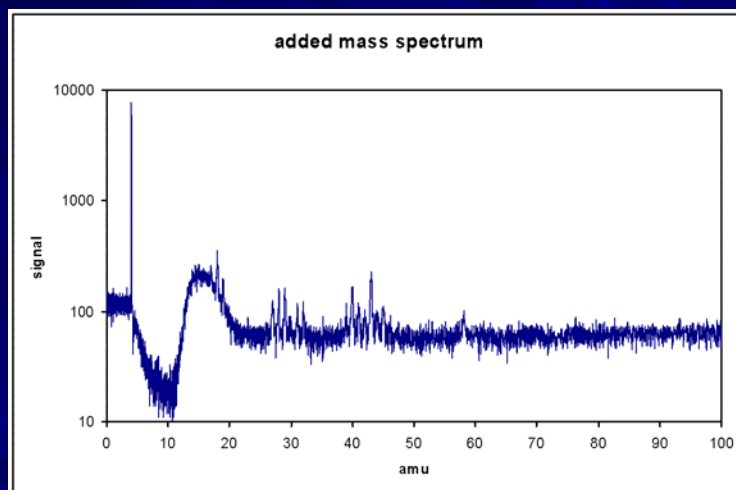


MPS

Space Instrumentation

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# data (MS only)



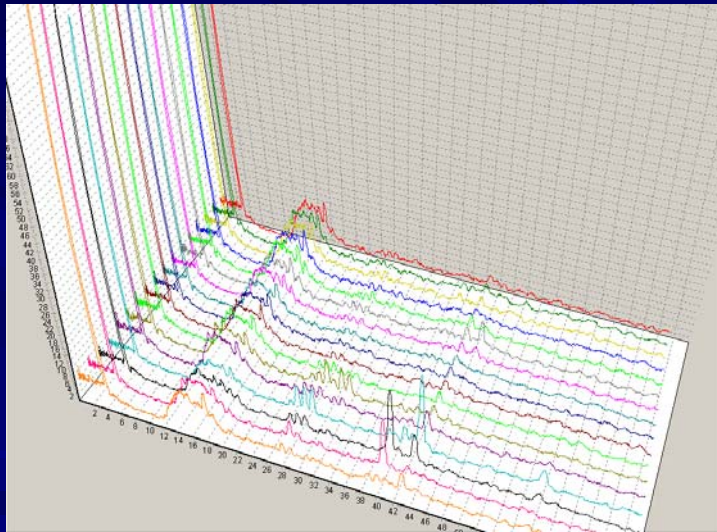
data obtained from the COSAC flight spare instrument, same sample

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