

Rosetta



ESA's Comet Lander Mission

Andrew Morse

Open University

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Keck Institute for Space Studies

Pasadena

Rosetta mission

- 1993 ESA approve Rosetta mission as a cornerstone mission for its long term science programme.
 Target comet 46P Wirtanen.
- 2002 Jan 2003 launch postponed
- 2003 Feb 2004 launch planned.
 New target 67P Churyumov-Gerasimenko
- 2004 March 2nd Launch

Objectives:

Rendezvous with a comet and study the nucleus for more than one year as it passes through perihelion.

Investigate the origin of comets, the relationship between cometary and interstellar material and its implication with regard to the origin of the solar system

67P/Churyumov-Gerasimenko

Discovered September 1969 by Klim Churyumov and Svetana Gerasimenko

Perihelion 1.28 AU
Aphelion 5.74 AU
Orbital Period 6.57 years
Most recent perihelion,
2008 magnitude 12

Chosen as new Rosetta
target, March 2003

Estimated size of nucleus 3 x 5 km
Rotation period ~12 hours

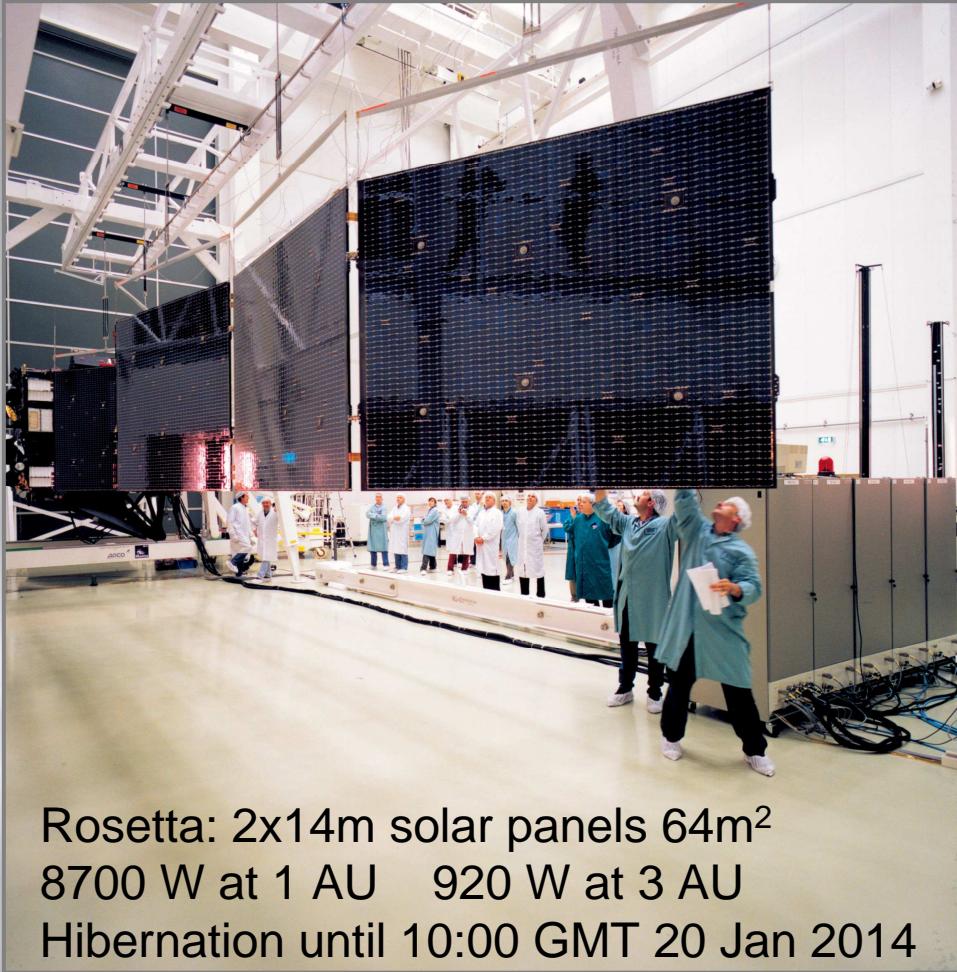


Gas production rate 220kg s^{-1}

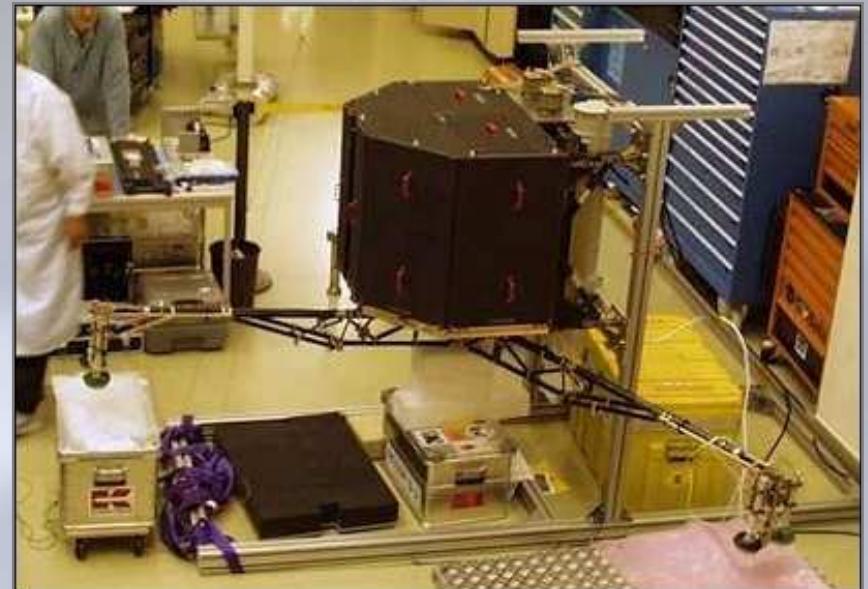
History:

- Before 1840, Perihelion 4.0 AU
- 1840 Close encounter with Jupiter, perihelion 3.0 AU
- 1959 Close encounter with Jupiter, perihelion 1.29 AU
- 2007 Encounter with Jupiter, perihelion 1.25AU

Rosetta Power

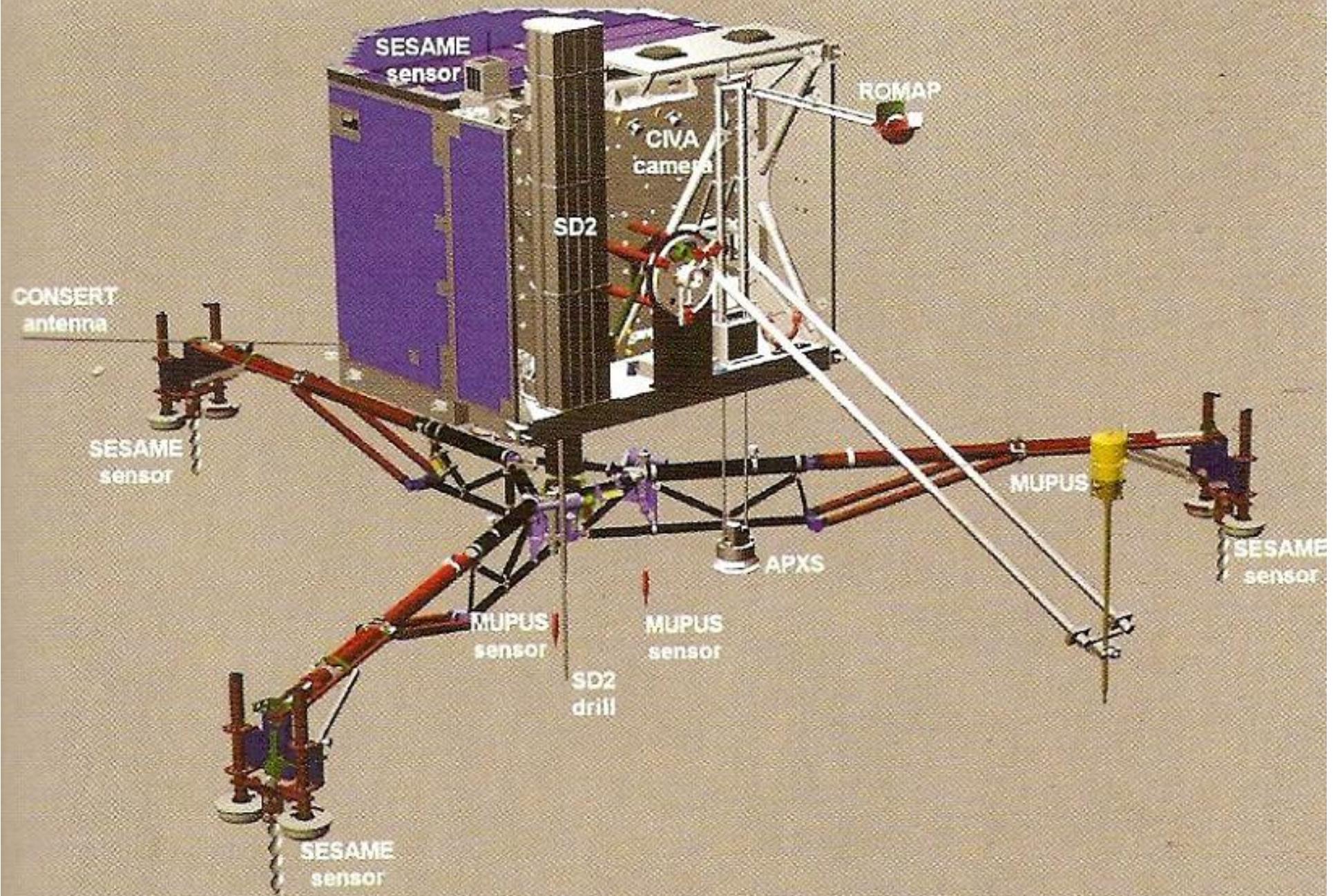


Rosetta: 2x14m solar panels 64m²
8700 W at 1 AU 920 W at 3 AU
Hibernation until 10:00 GMT 20 Jan 2014



Philae: Solar panels 10 W
Primary batteries 1000 Wh
Secondary batteries 100 Wh

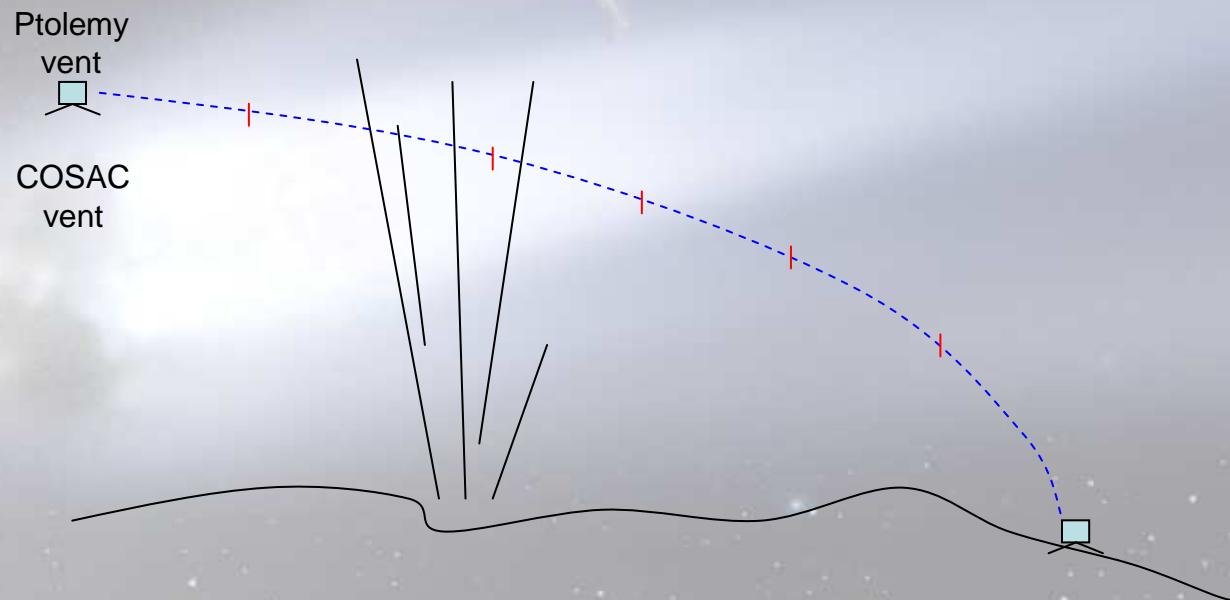
Philae Lander



Separation Descent & Landing

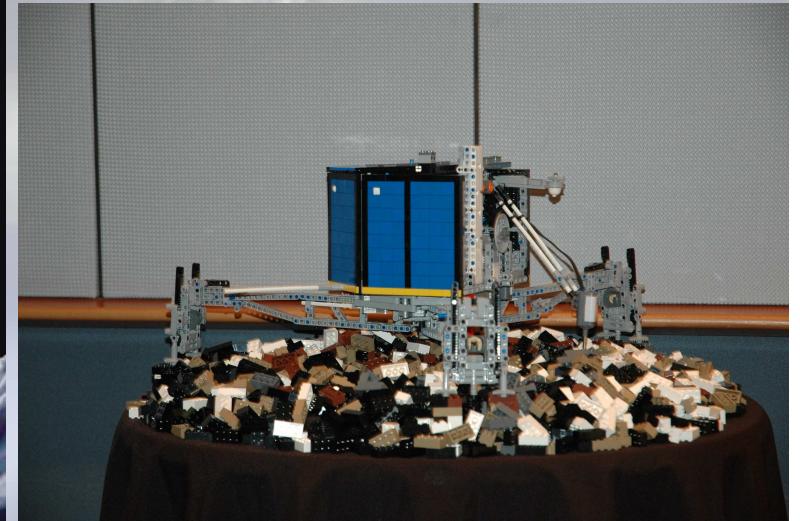
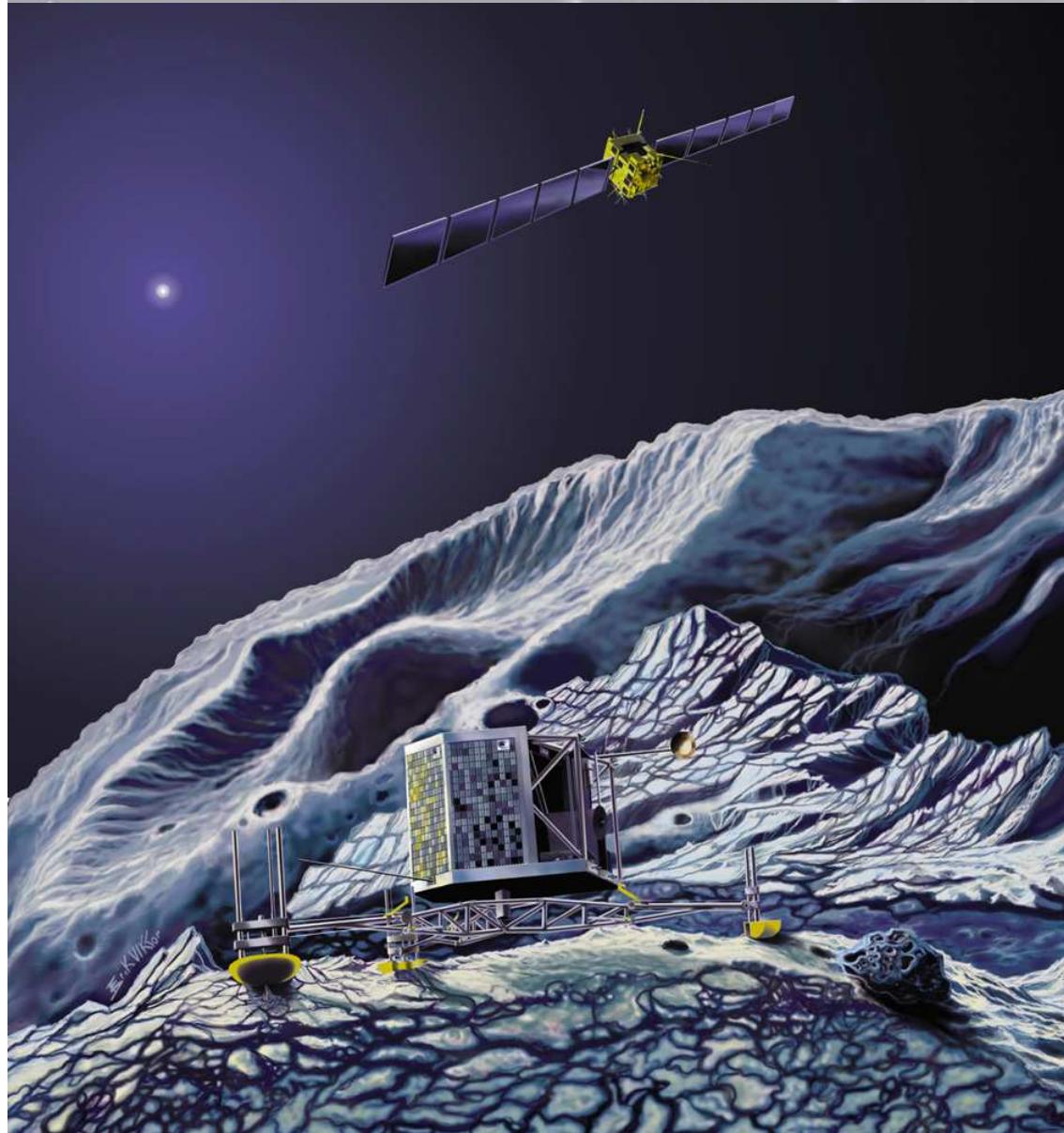
Distance 2.7 AU
Height 2 km
Duration 30 min

- Try and get measurement if Lander is passing over an interesting area
- Mean free path at 10^{-7} mBar ~ 100 m
 - Ion molecule reactions



Comet activity at 3.5AU (ICES model) $6 \times 10^{24} - 6 \times 10^{26} - 6 \times 10^{28} \text{ s}^{-1}$
Composition 90% H₂O, 9% CO₂, 1% organics
Partial pressure H₂O 1 km from surface $\sim 10^{-9} - 10^{-7} - 10^{-5}$ mbar

Rosetta Lander on the comet



Weight on comet ~10 g

Attached by harpoon & ice screws



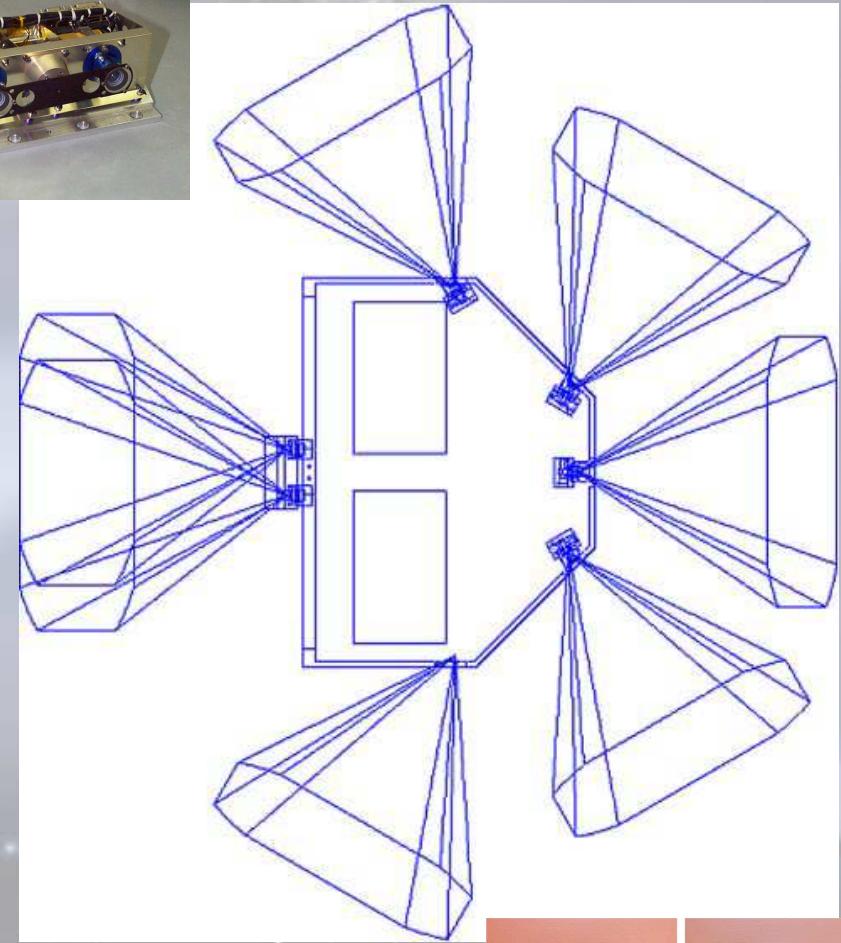
Lander Payload....

- 11 Instruments
- Rosetta Bible

CIVA Comet Infrared and Visible Analyser

Panoramic Cameras

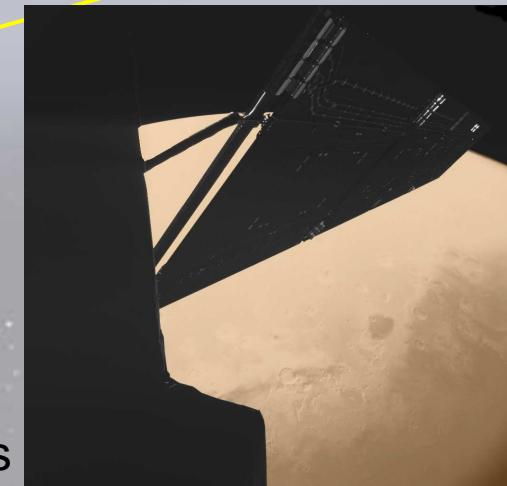
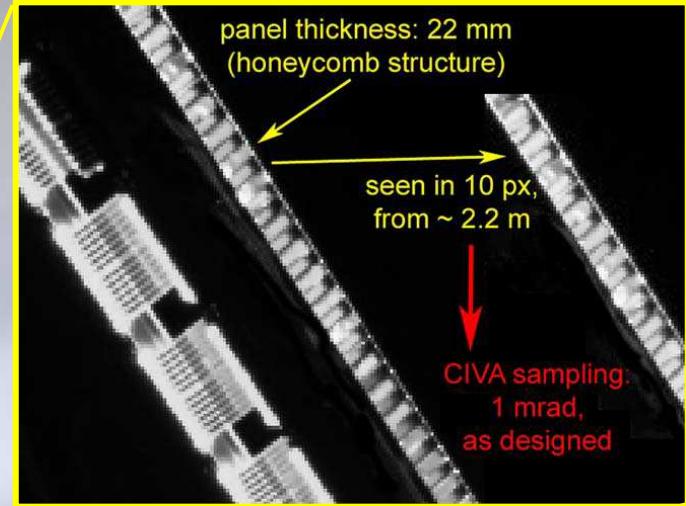
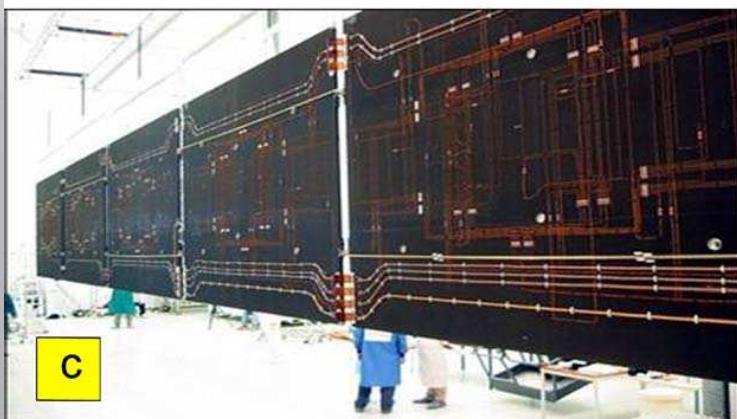
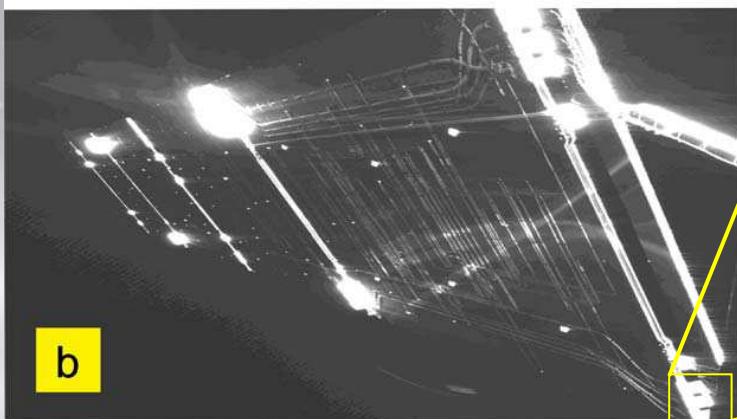
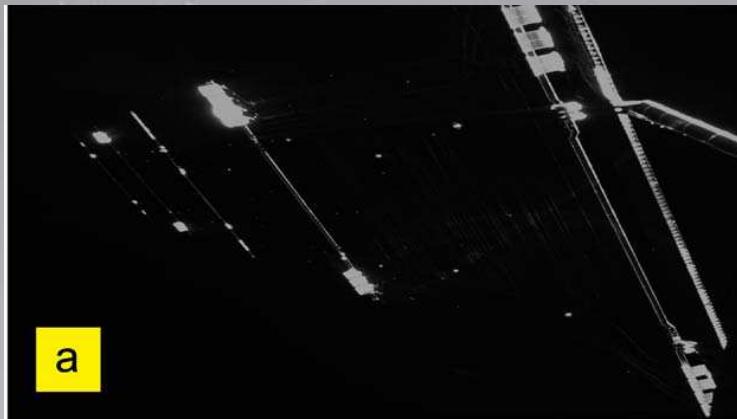
- Total 7 cameras
- 5 single, 1 stereoscopic pair
- FOV 60°
- Resolution ~1mm @ 1m
 ~2m at horizon
- Topography
- Albedo
- Surface features, vents, jets
- Surface changes



Bibring et al. 2007

CIVA-P Panoramic camera

Rosetta solar panels



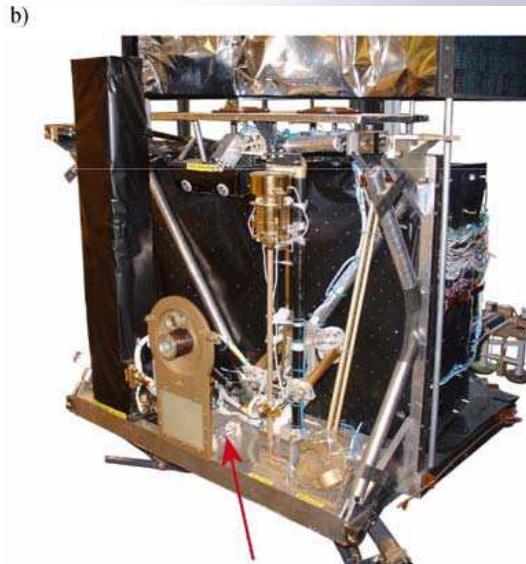
ROLIS ROsetta Lander Imaging System

Downward looking camera

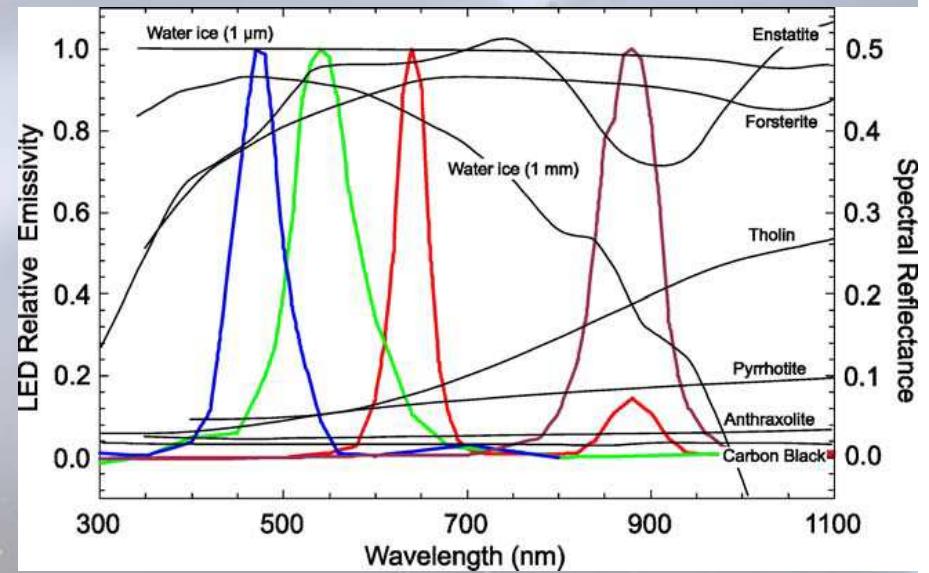
Operation during SDL

Resolution 0.3mm/pixel @30cm

Can image drill bore hole and APXS site



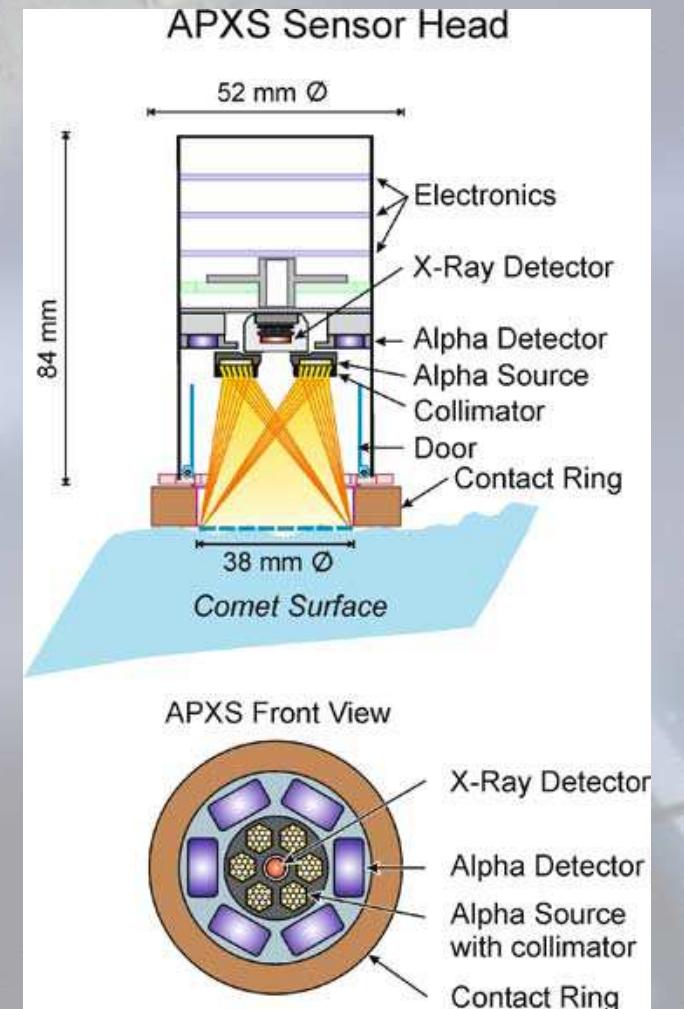
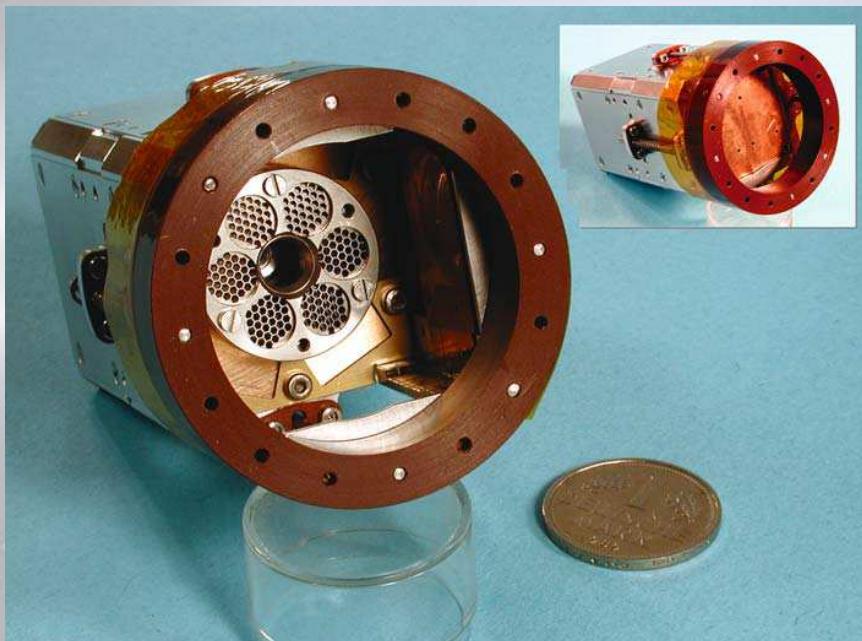
Multispectral imaging
LEDs 470, 530, 640 and 870 nm



Mottola et al. 2007

APXS Alpha Particle X-ray Spectrometer

- Predecessor of MER APXS
- Curium 244 alpha source
- Elemental composition $z \geq 23$
- Alpha spectrum carbon and oxygen

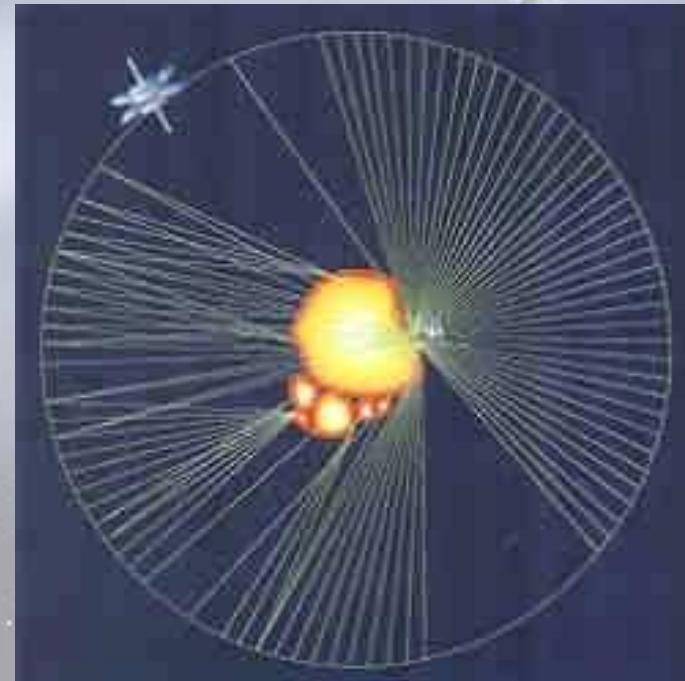
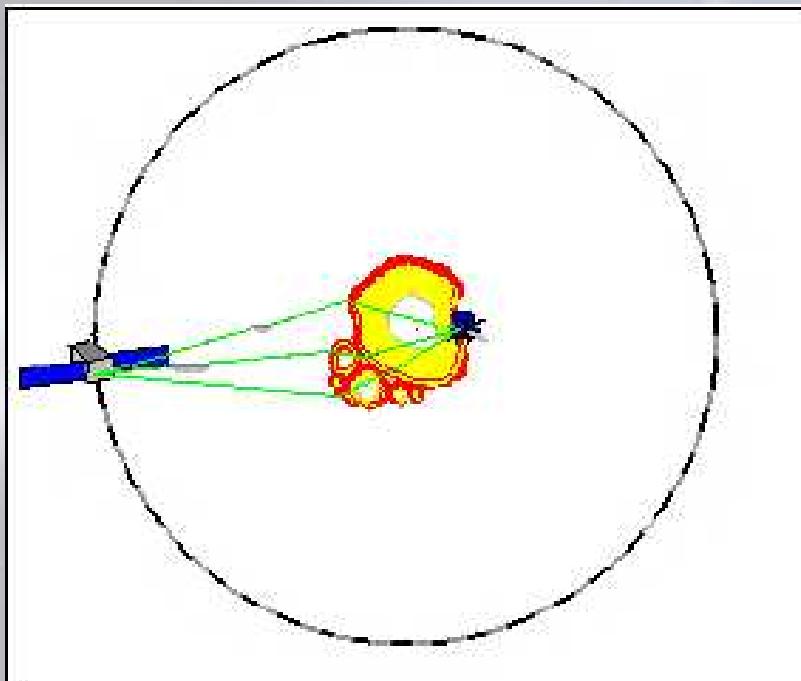


Klingelhöfer et al. 2007

CONCERT

Comet Nucleus Sounding Experiment by Radio-wave Transmission

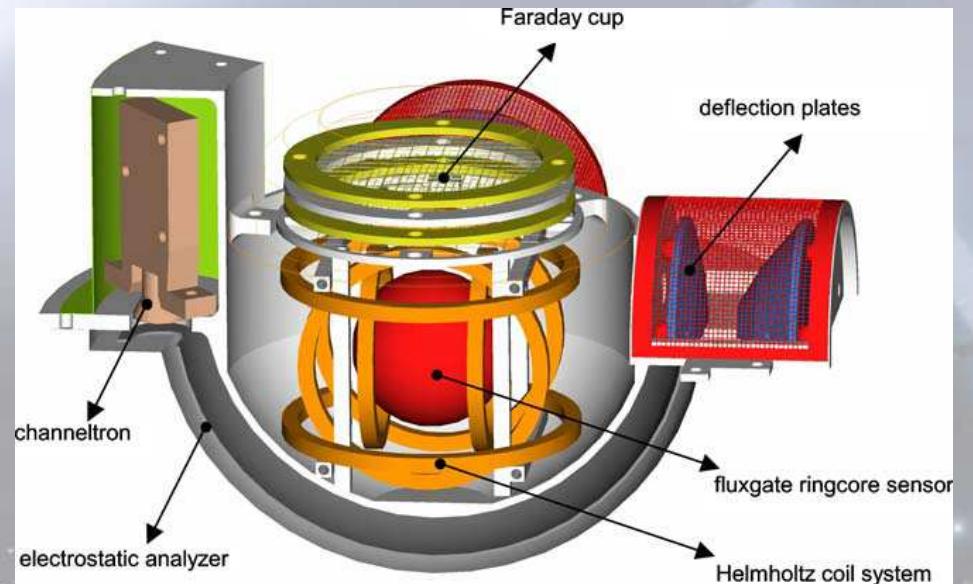
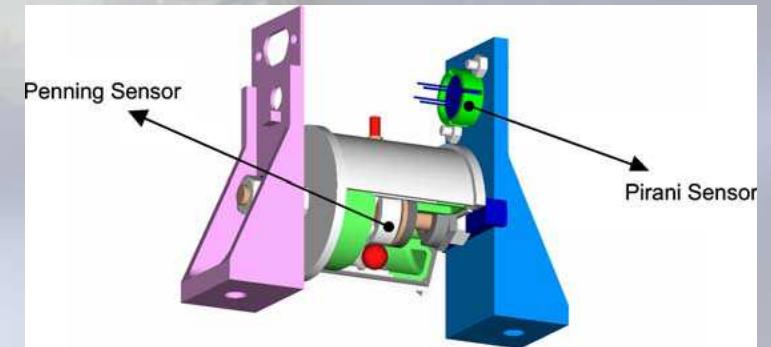
- Internal structure of comet
- Change in velocity and amplitude of radio signal during comet orbit



ROMAP

ROsetta MAgnetmoeter and Plasma monitor

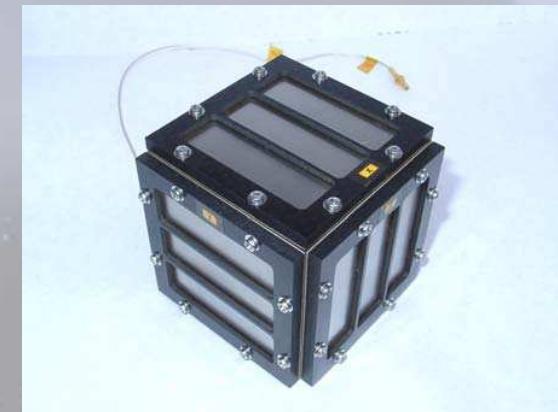
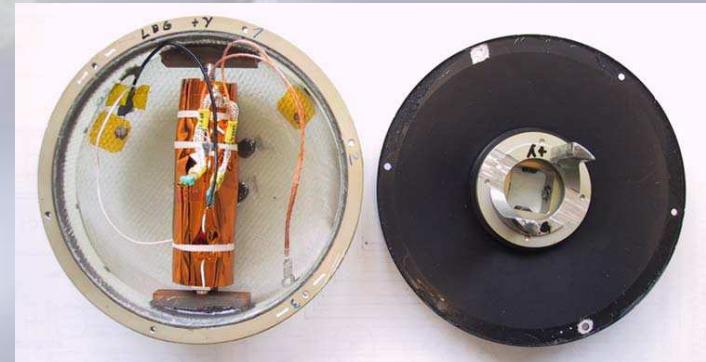
- Magnetic properties of comet
- Interaction with solar wind
- Pirani sensor 10^{-3} – 10 mbar
- Penning sensor 10^{-8} – 10^{-3} mbar
- Magnetometer
 - Range ± 2000 nT
 - Resolution 10 pT
- Plasma monitor



SESAME

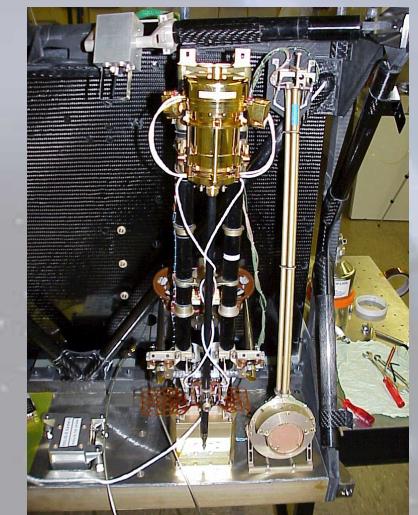
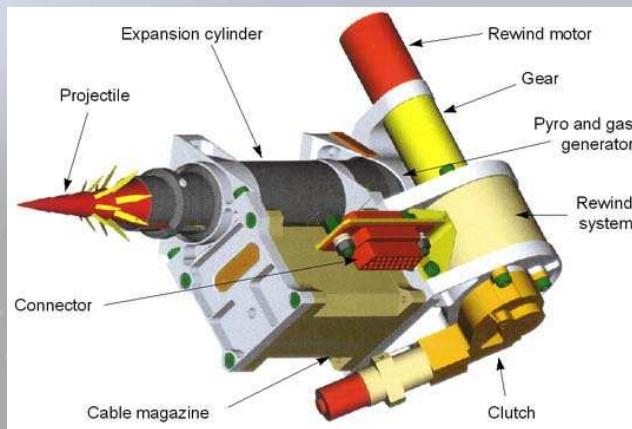
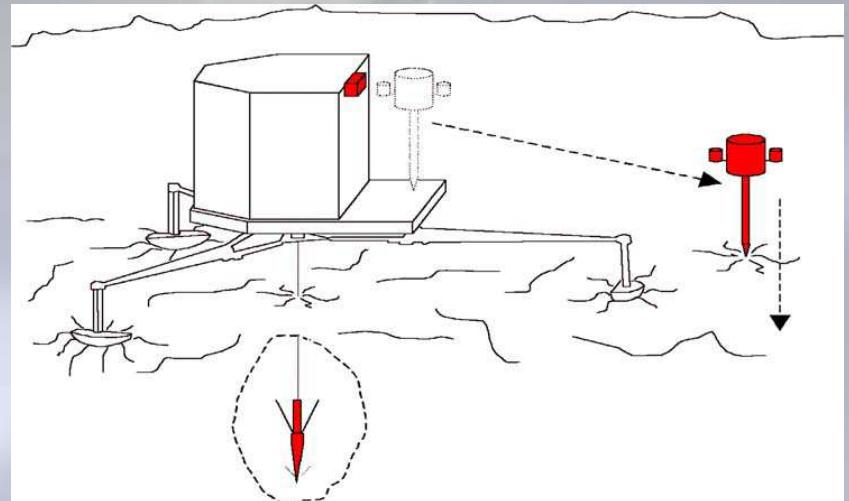
Surface Electric Sounding and Acoustic Monitoring Experiment

- CASSE Comet Acoustic Surface Sounding Experiment
 - Frequency from ~3 Hz to 3.3 kHz
 - Vertical structure
- PP Permitivity Probe
 - Water ice content
- DIM Dust Impact Monitor
 - Mechanical properties
 - Properties on impacting dust grains



MUPUS MULTi PUrpose Sensor package

- Physical Properties of surface layers, depth ~30cm
 - Density
 - Porosity
 - Cohesion
 - Thermal diffusivity
 - Thermal conductivity
 - Temperature
- Anchor
 - Temperature
 - Accelerometer
- MUPUS Penetrator
- Thermal Mapper



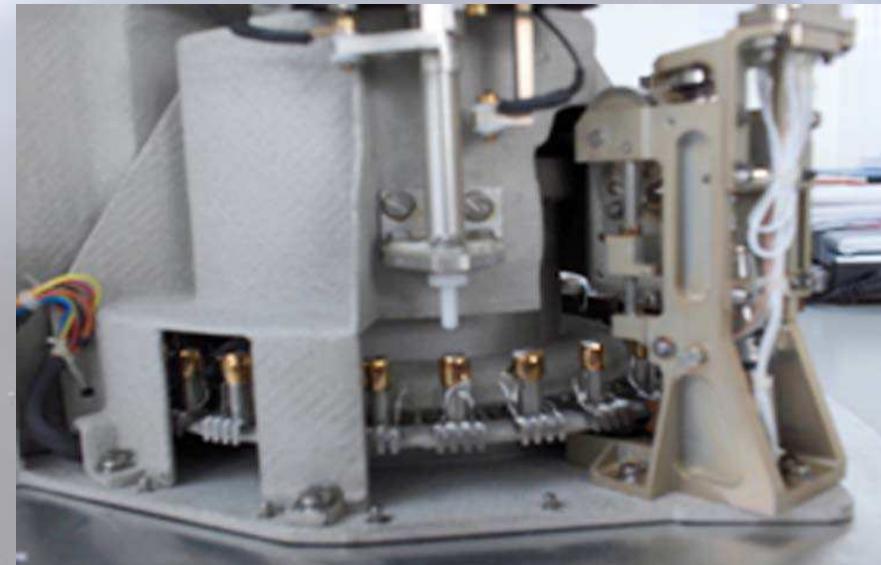
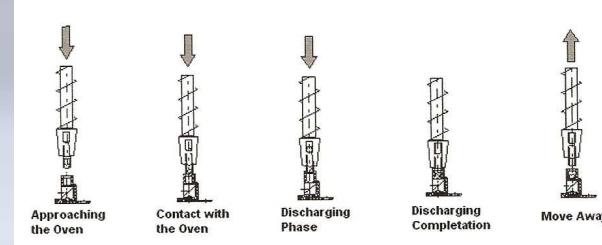
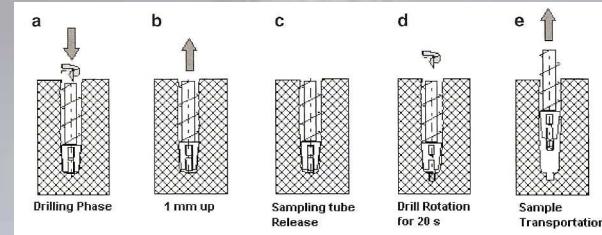
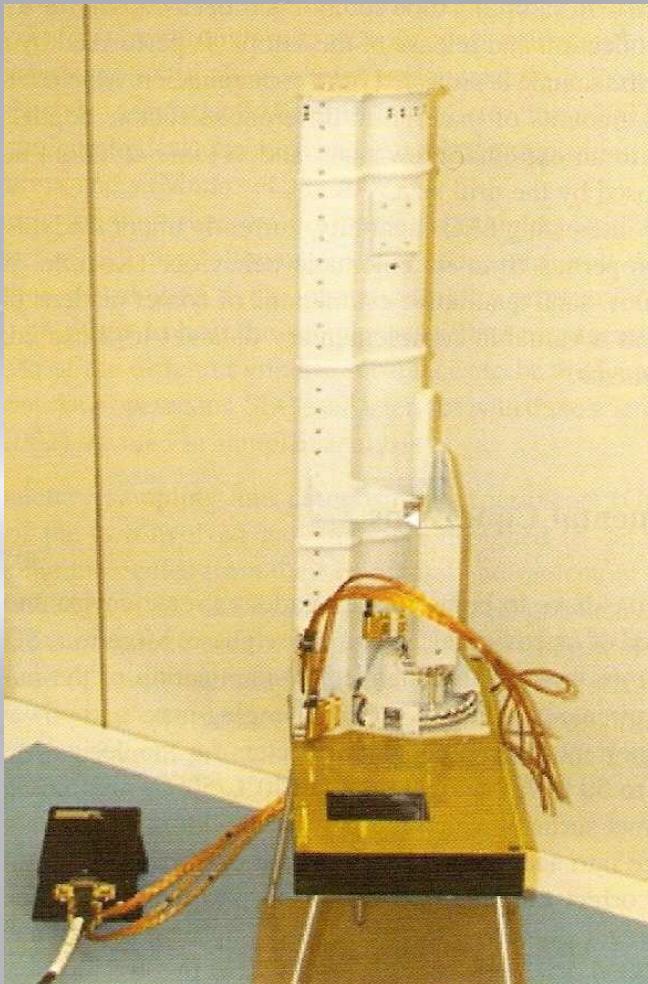
Spohn et al. 2007

SD2 Sampler, drill & distribution system

Drill to ~ 30 cm depth

Collect sample

Deliver to oven on carousel



Finzi et al. 2007



SD2 - Sample drilling and distribution system

Collects surface and comet subsurface samples

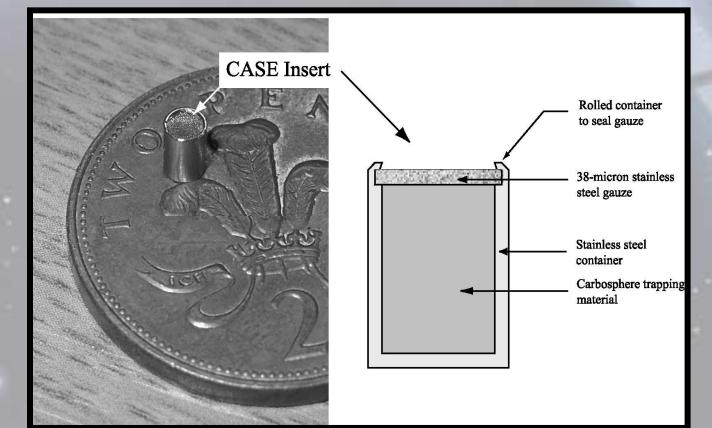
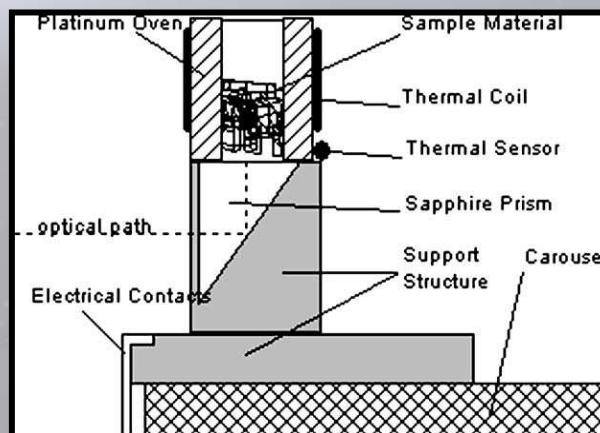
Drilling depth up to 30cm

Sample size $20\text{mm}^3 \sim 3\text{mg}$

Sample placed in one of 26 ovens on a carousel

16 Medium Temperature Ovens (max 180°C) for CIVA microscope, COSAC and Ptolemy

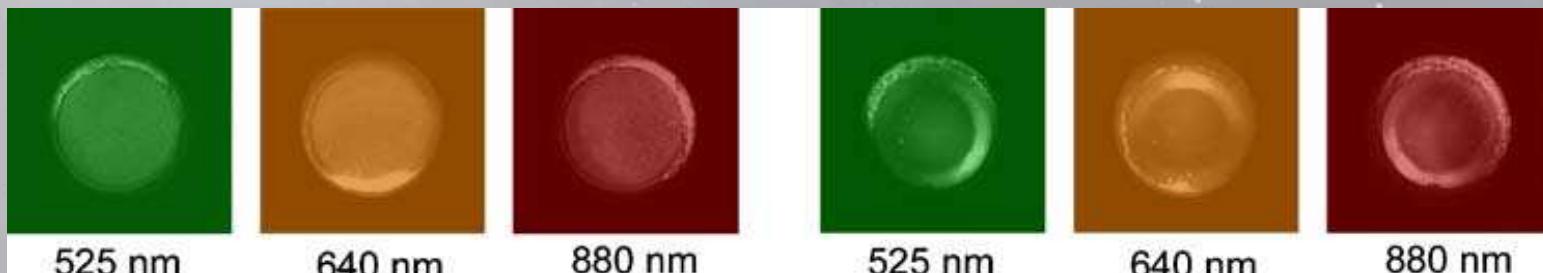
10 High Temperature Ovens (max 800°C) for COSAC and Ptolemy



CIVA Comet Infrared and Visible Analyser

Microscope Cameras Medium Temperature Ovens with window

- CIVA M/V - Visible
- FOV 3mm
- Resolution 7 μ m
- Illumination 3 LEDs
525nm, 640nm and 880nm
- + daylight illumination
- CIVA M/I - Infrared
- FOV 3mm
- Resolution 40 μ m
- Spectral range 1-4 μ m
3nm steps
- Detection of UCAMMs?



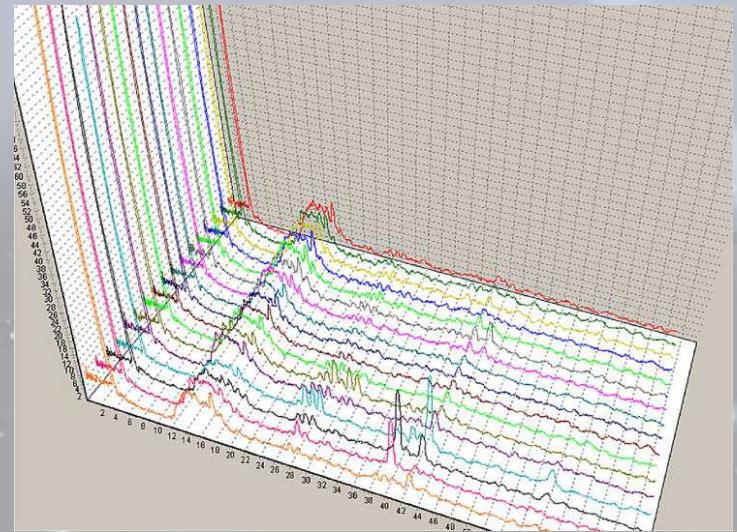
In flight calibration

Bibring et al. 2007

COSAC

COmet Sampling And Composition experiment

- GC-MS
- Pyrolysis >600°C
- Chemical processing
- 8 GC columns
 - 5 chemical composition
 - 3 Chiral
- Thermal conductivity detector
- Time Of Flight MS
 - Mass range 2-350 amu
 - Mass resolution 350



Goesmann et al. 2007

Ptolemy

Chemical processing

Hydrogen gas and control

Mass Spectrometer box

Sample
Inlet

3 GC
Columns

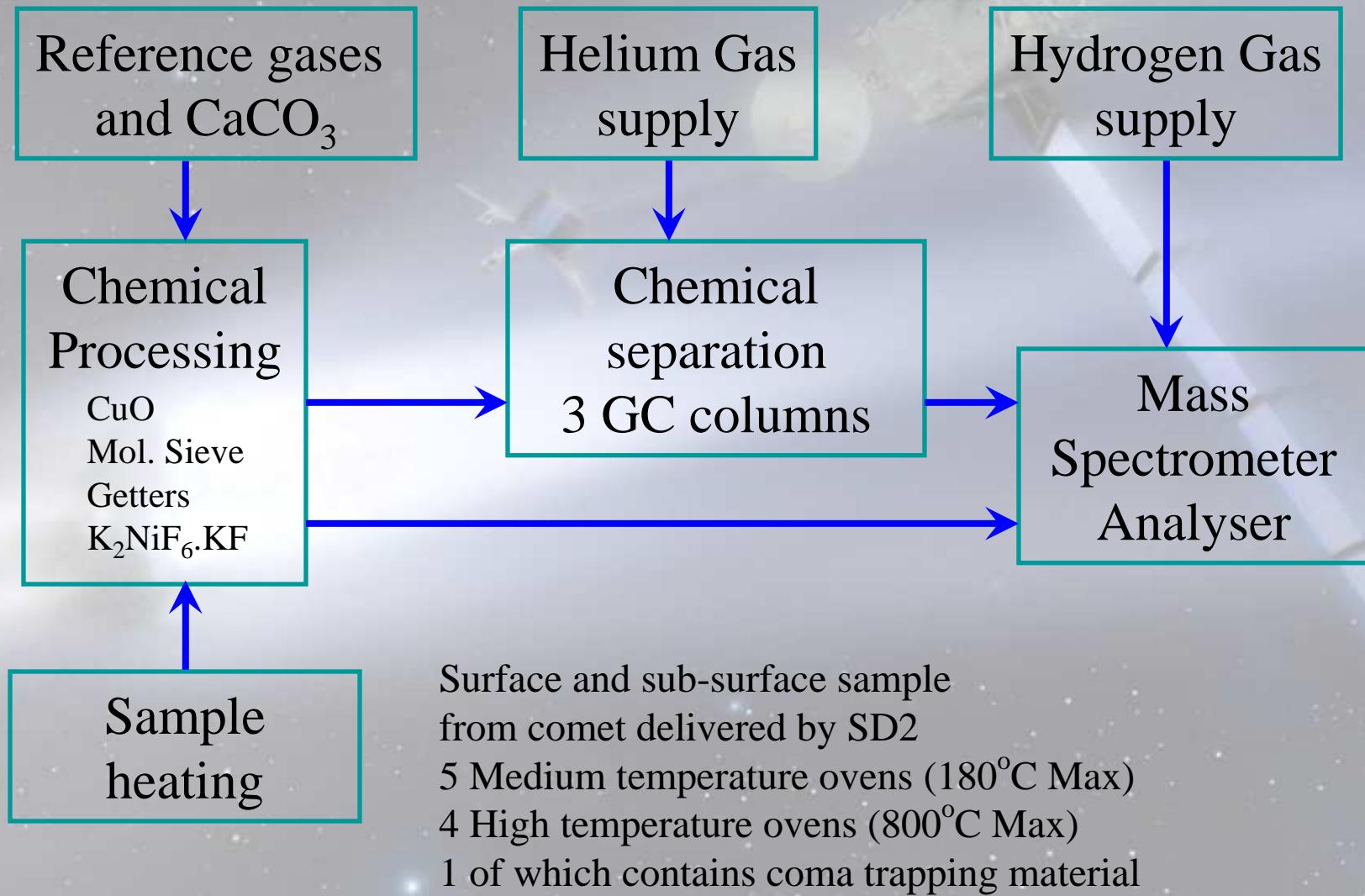
Helium
control

Electronics/computer

QM Post Vibration Test: E-Box Panels Removed to Reveal PCBs 2002/ 1/ 3

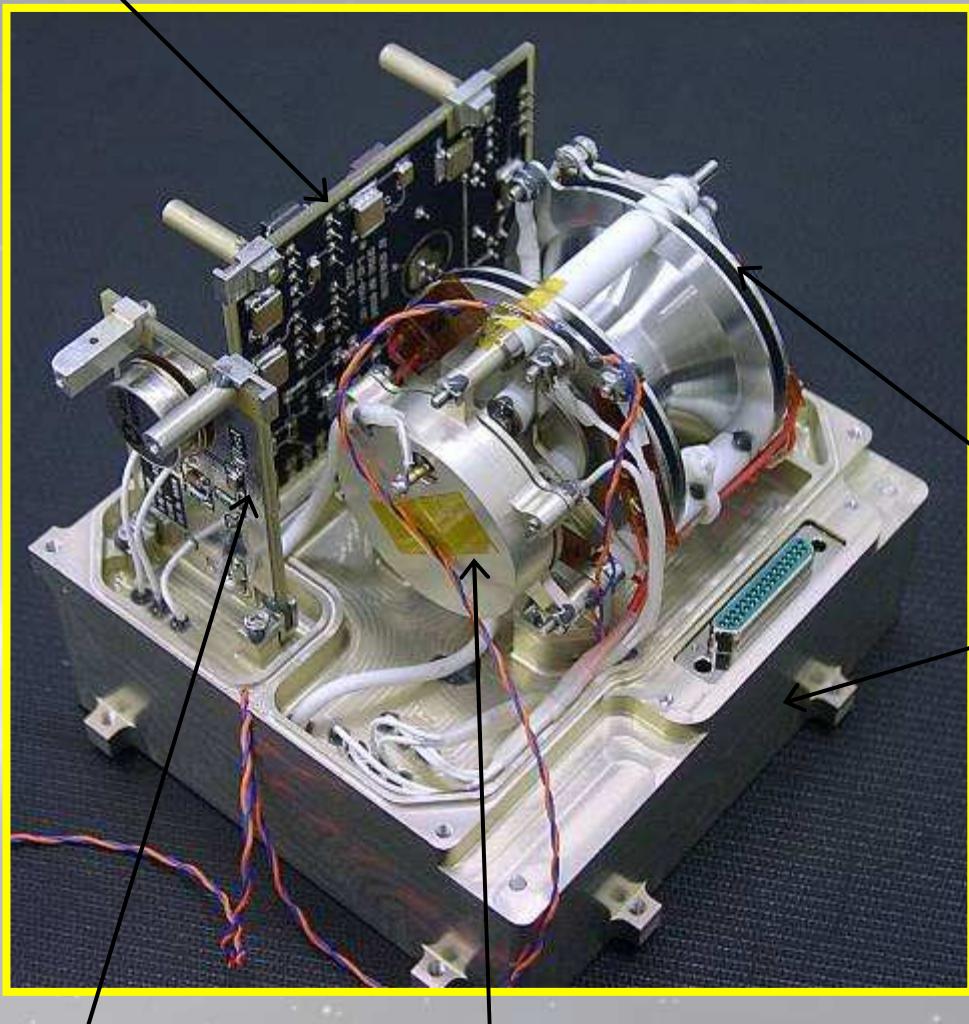


Ptolemy - System Diagram



Ptolemy Mass Spectrometer - Ion Trap

RF electronics



Ion counting
electronics

Ceramic spiral electron
multiplier (H Lauche MPAe)

Compact mass spectrometer
No permanent magnets
Operate at 10^{-3} mbar

Field effect electron
source - nanotips

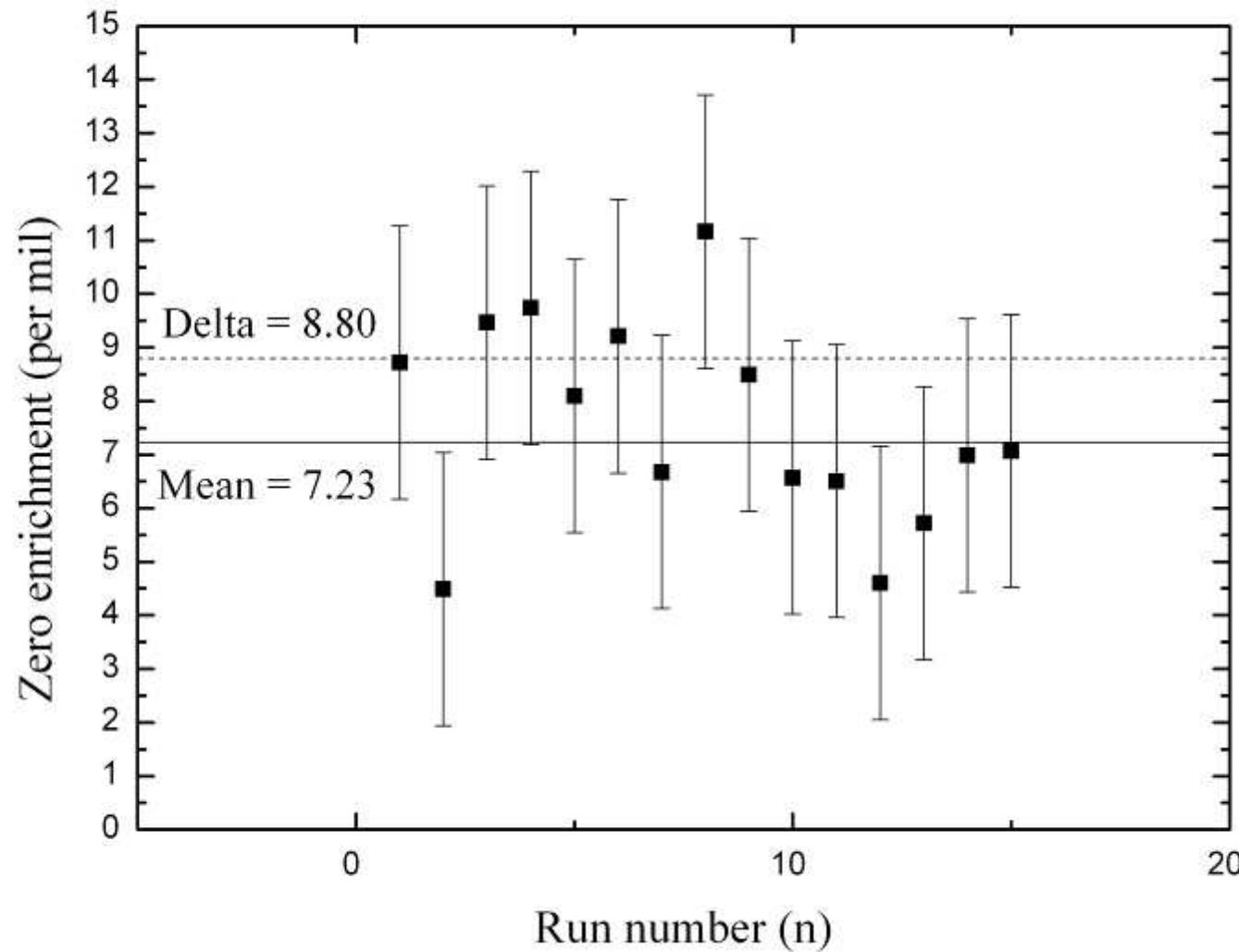
Drive electronics

Mass range 10 to 150 amu
Resolving Power better than unit

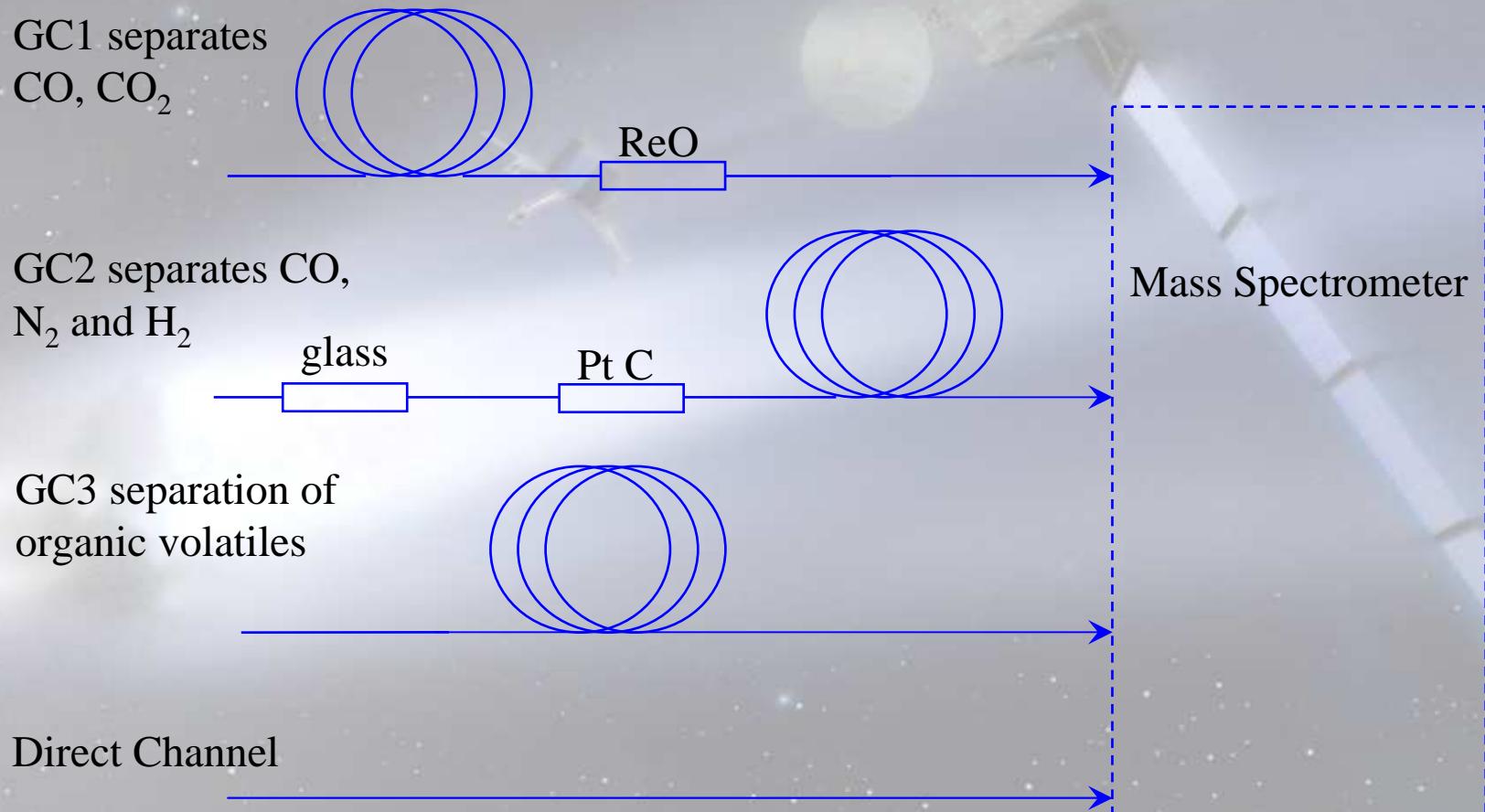
Volume 10 x 9 x 9 cm
Electrode mass 50g
Overall mass < 500g
Power ~ 1W

Measurement of ^{13}C isotope ratios

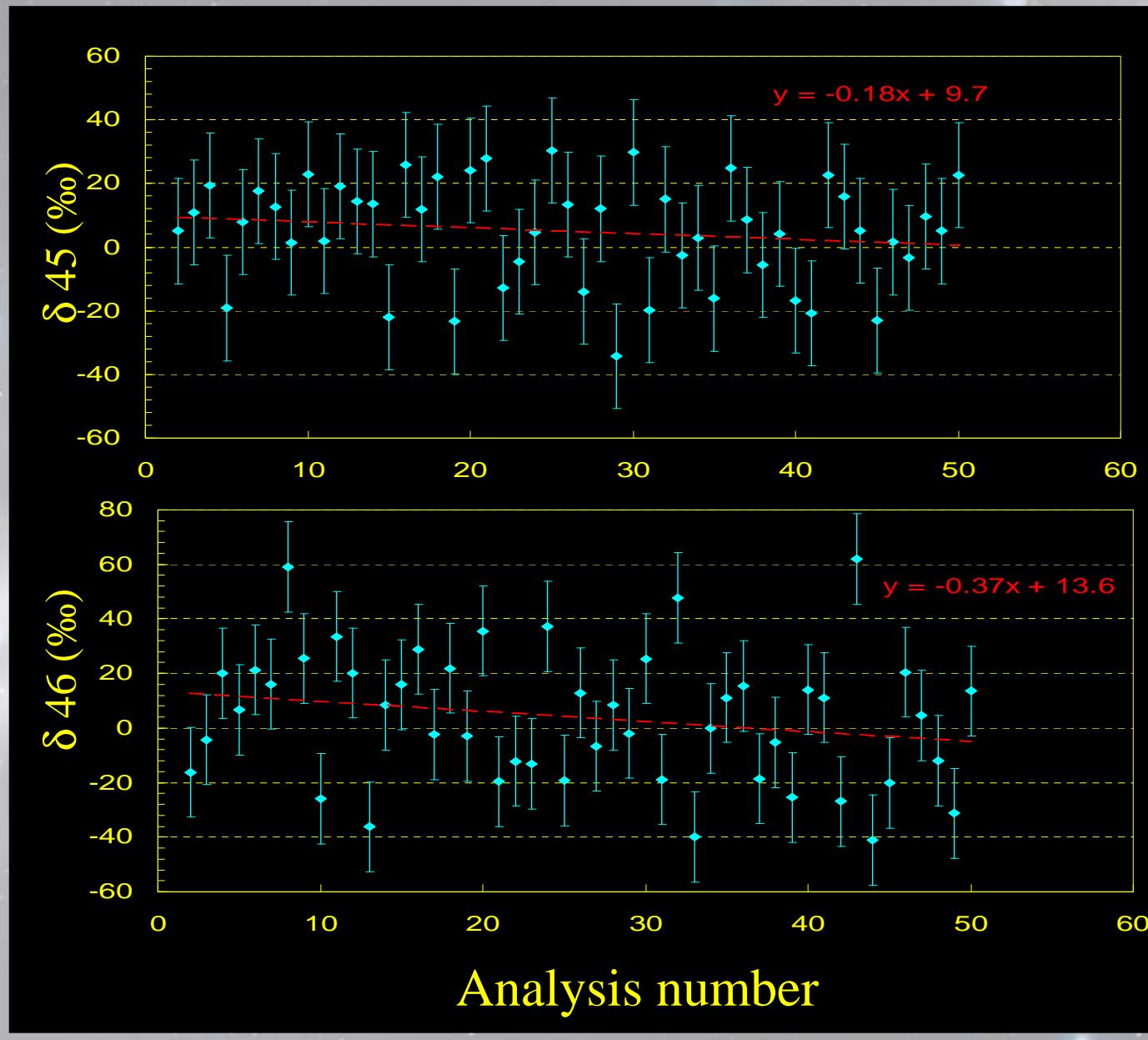
Comparison of a sample gas 8.8 per mil heavier than a reference gas



GC Columns



Zero Enrichment analysis of CO₂



Sample size 20 nmol
Analysis time 5
minutes per sample

δ_{45}
1 σ error 17 ‰
average 5.0 ‰

δ_{46}
1 σ error 25 ‰
average 4.0 ‰

Payload Summary

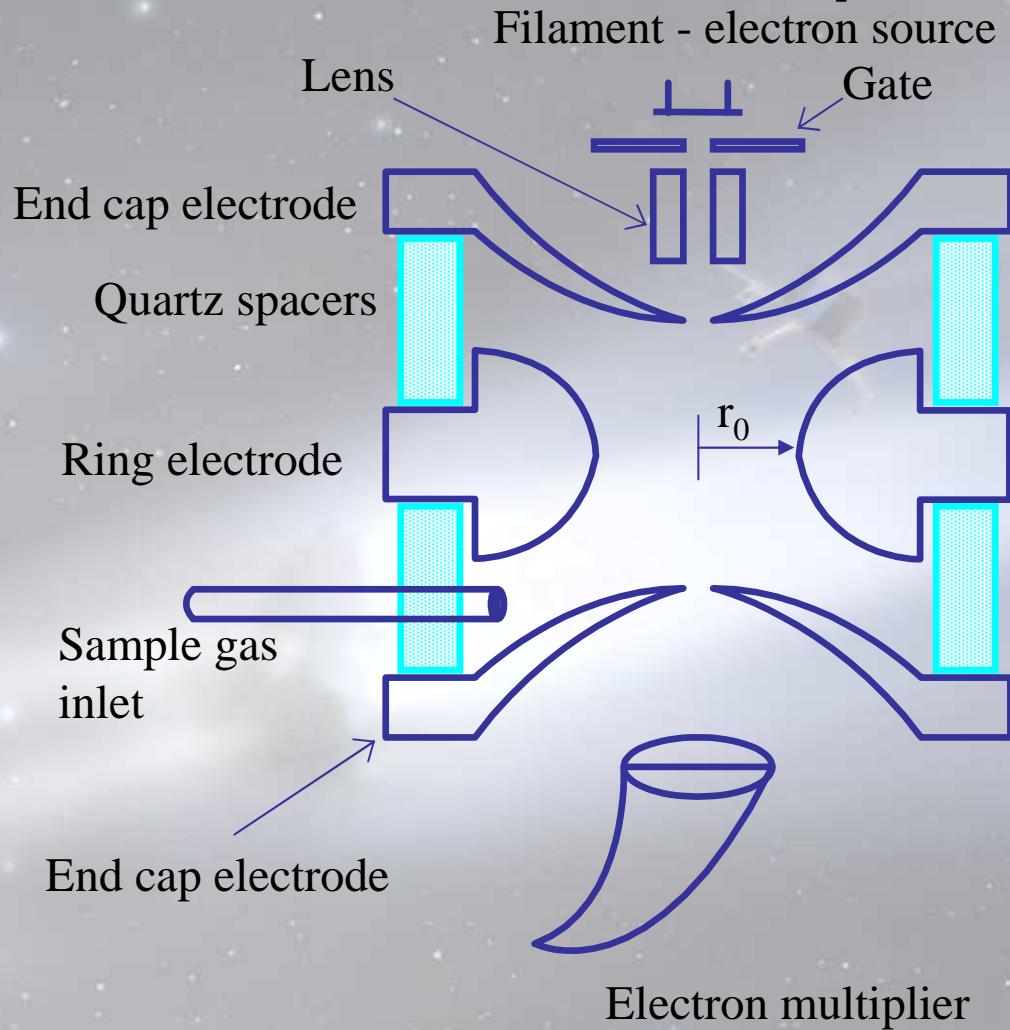
Instrument	Investigations	Mass (kg)	
• CIVA	Cameras, microscope	3.4	<input checked="" type="checkbox"/>
• ROLIS	Descent camera	1.4	
• APXS	Elemental Composition	1.3	
• CONSERT	Internal Structure	1.8	
• ROMAP	Magnetic and Plasma	0.7	<input checked="" type="checkbox"/>
• SESAME	Structure, dust impact	1.8	<input checked="" type="checkbox"/>
• MUPUS	Physical properties	2.2	
• SD2	Sample acquisition, structure	4.7	
• COSAC	Molecular composition	4.9	<input checked="" type="checkbox"/>
• Ptolemy	Isotopic composition	4.5	<input checked="" type="checkbox"/>
Total		26.7	

Science before SDL

Additional Slides



Mass Spectrometer

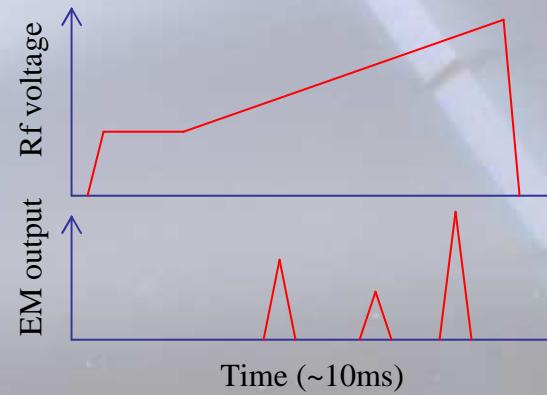


Advantages:

- Compact design
- No magnets
- Operate at 10^{-3} mbar

$$V_{ej} = \frac{m r_0^2 \Omega^2}{4e}$$

Scan function:

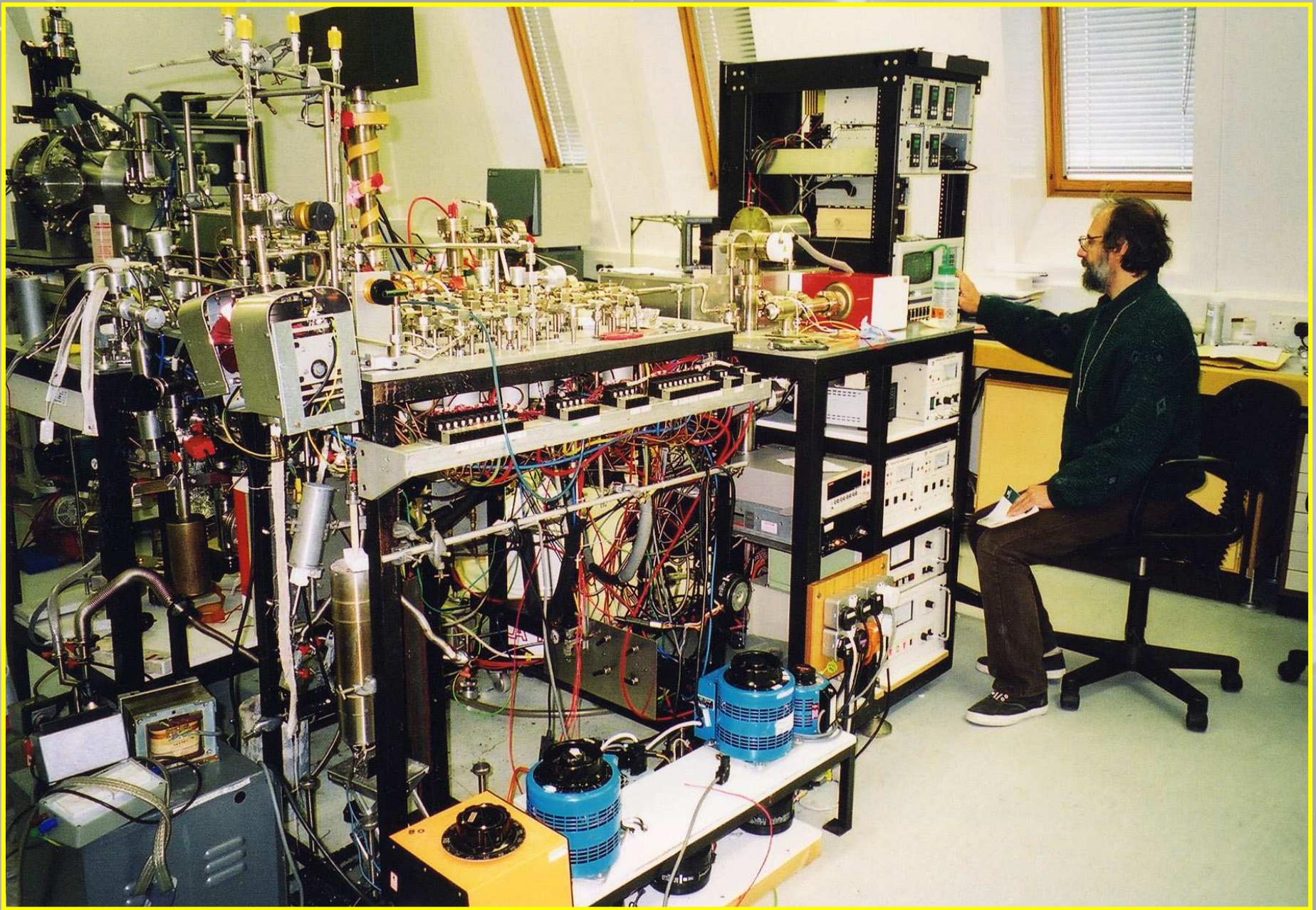


$$R_o = 8\text{mm}$$

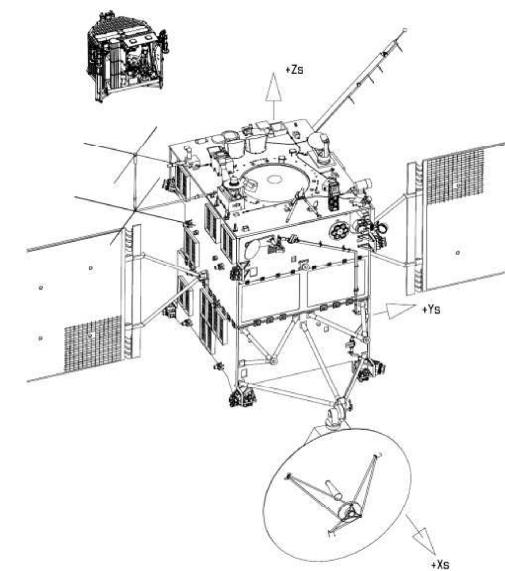
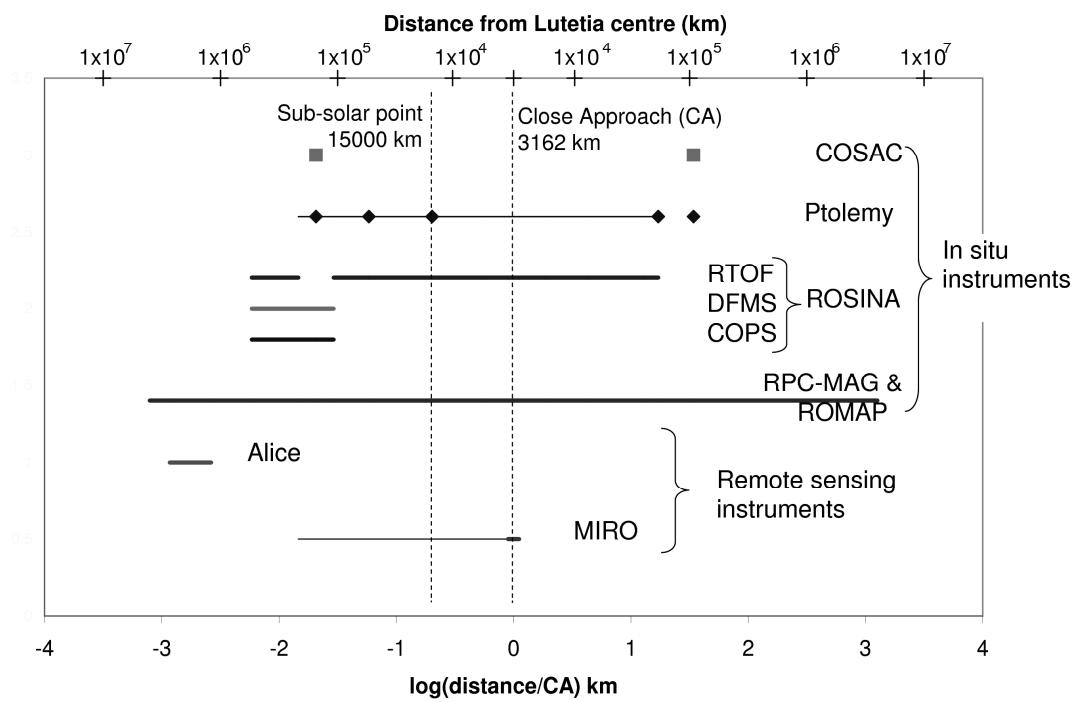
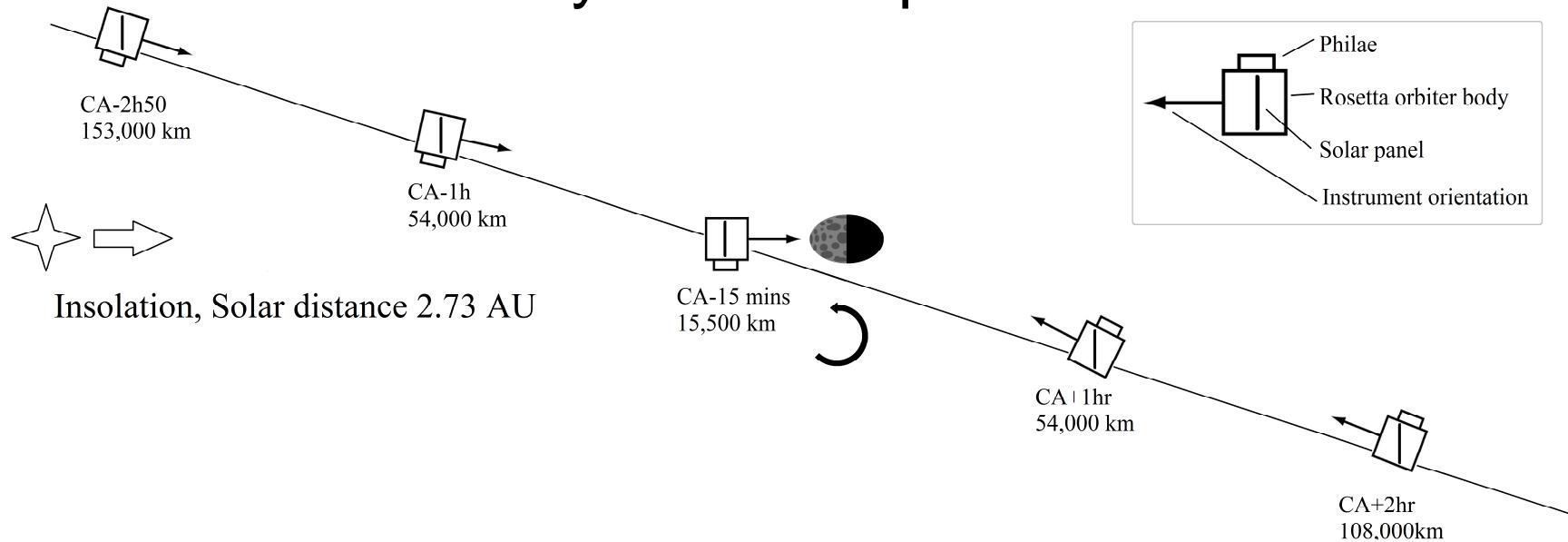
Frequency $\sim 0.55\text{MHz}$

1.8 V/amu

Mass Spectrometer – Open University

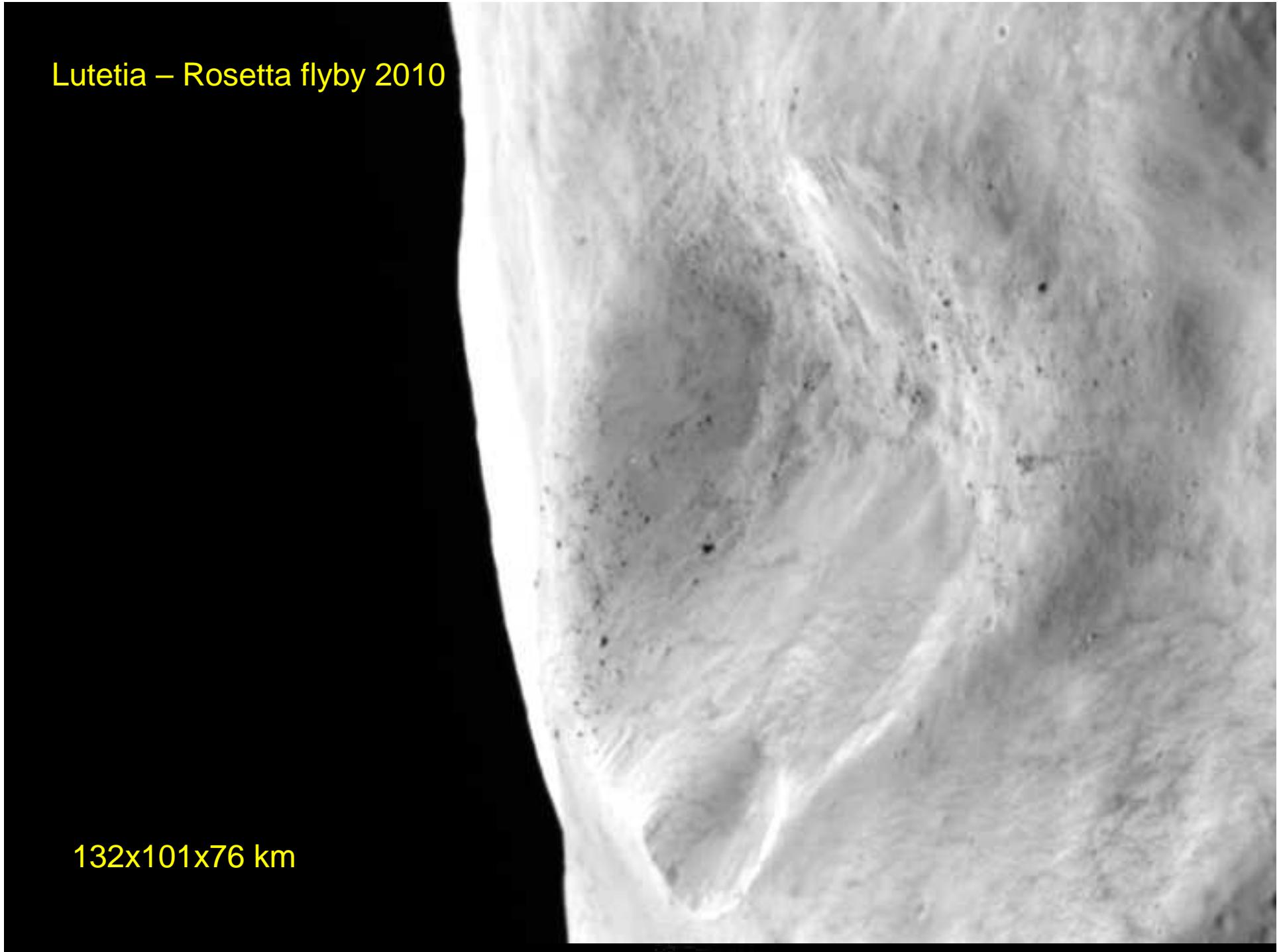


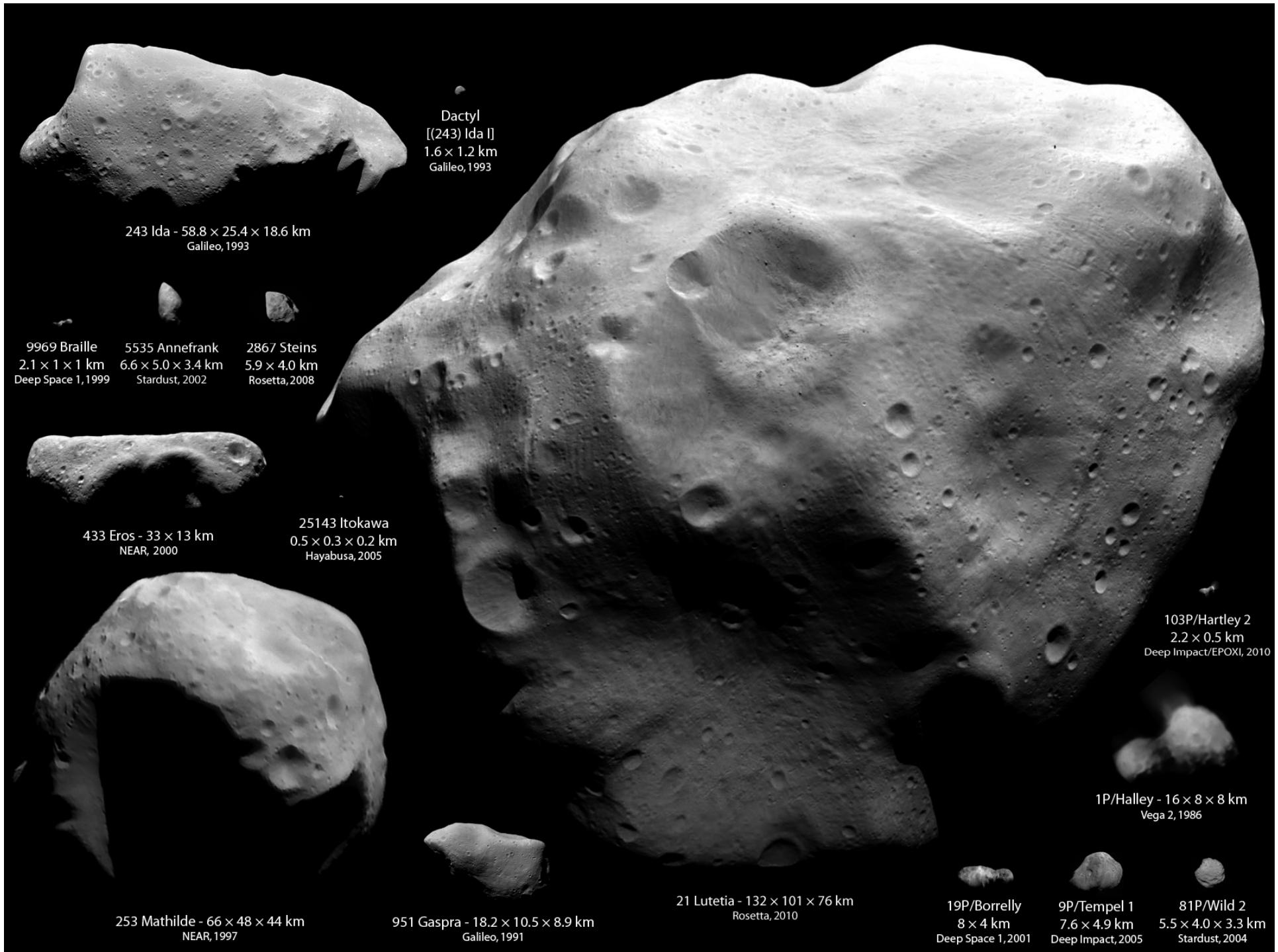
Ptolemy Lutetia Operations

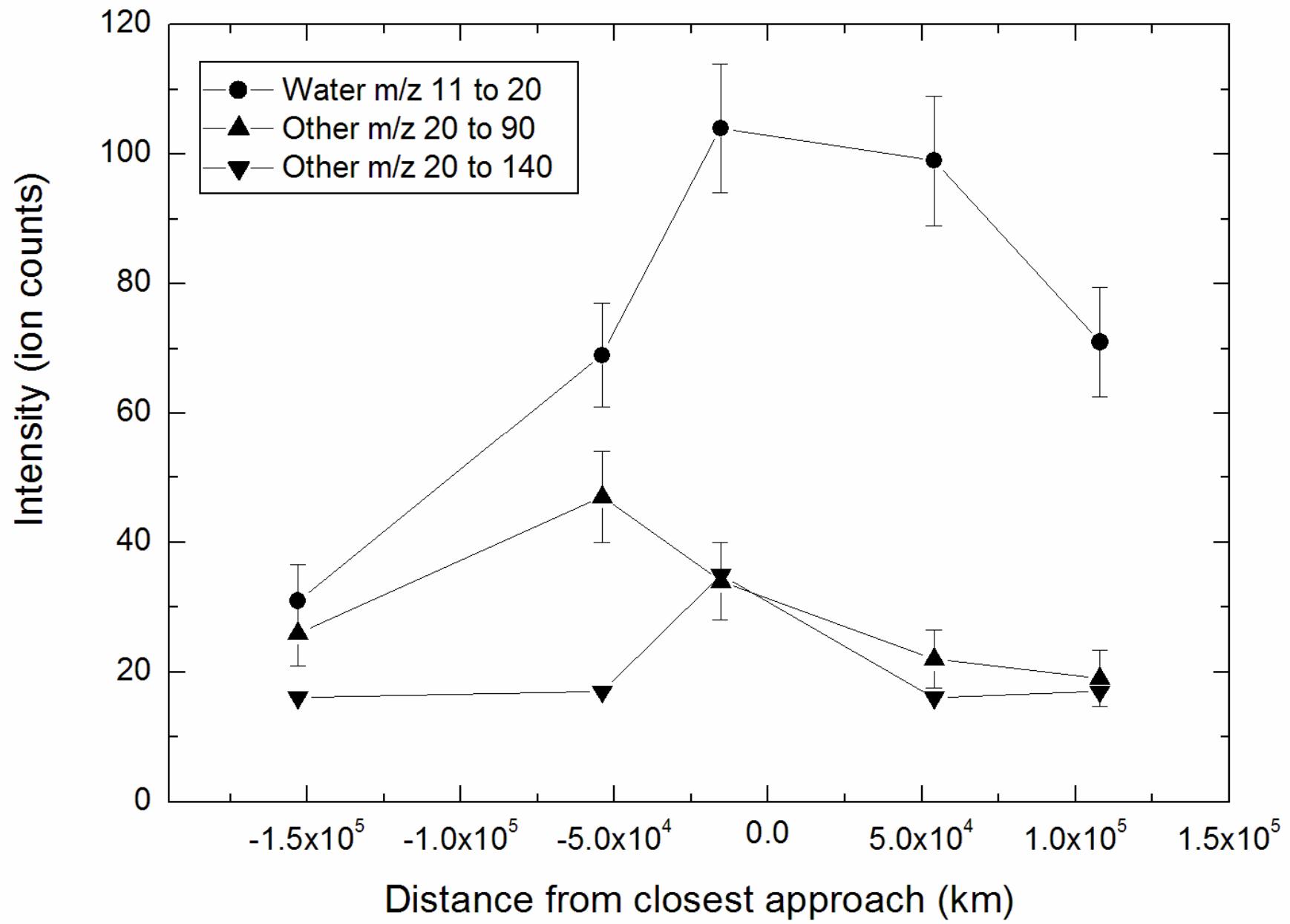


Lutetia – Rosetta flyby 2010

132x101x76 km







Ptolemy Mass Spectra

