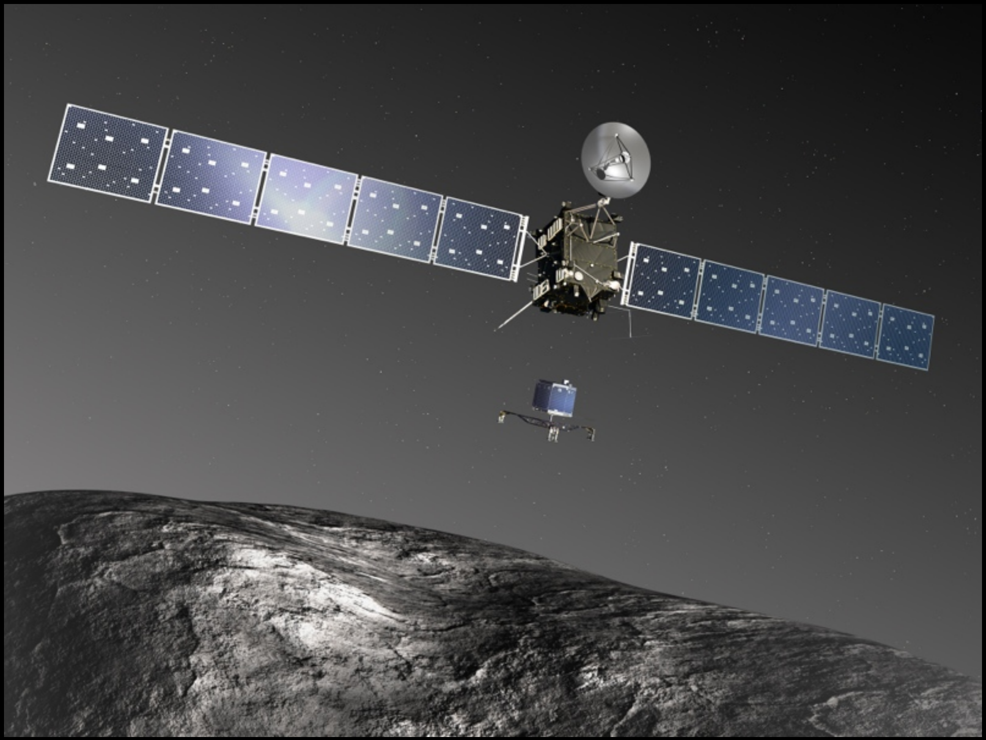
Rosetta – The ESA's cornerstone mission to escort a comet



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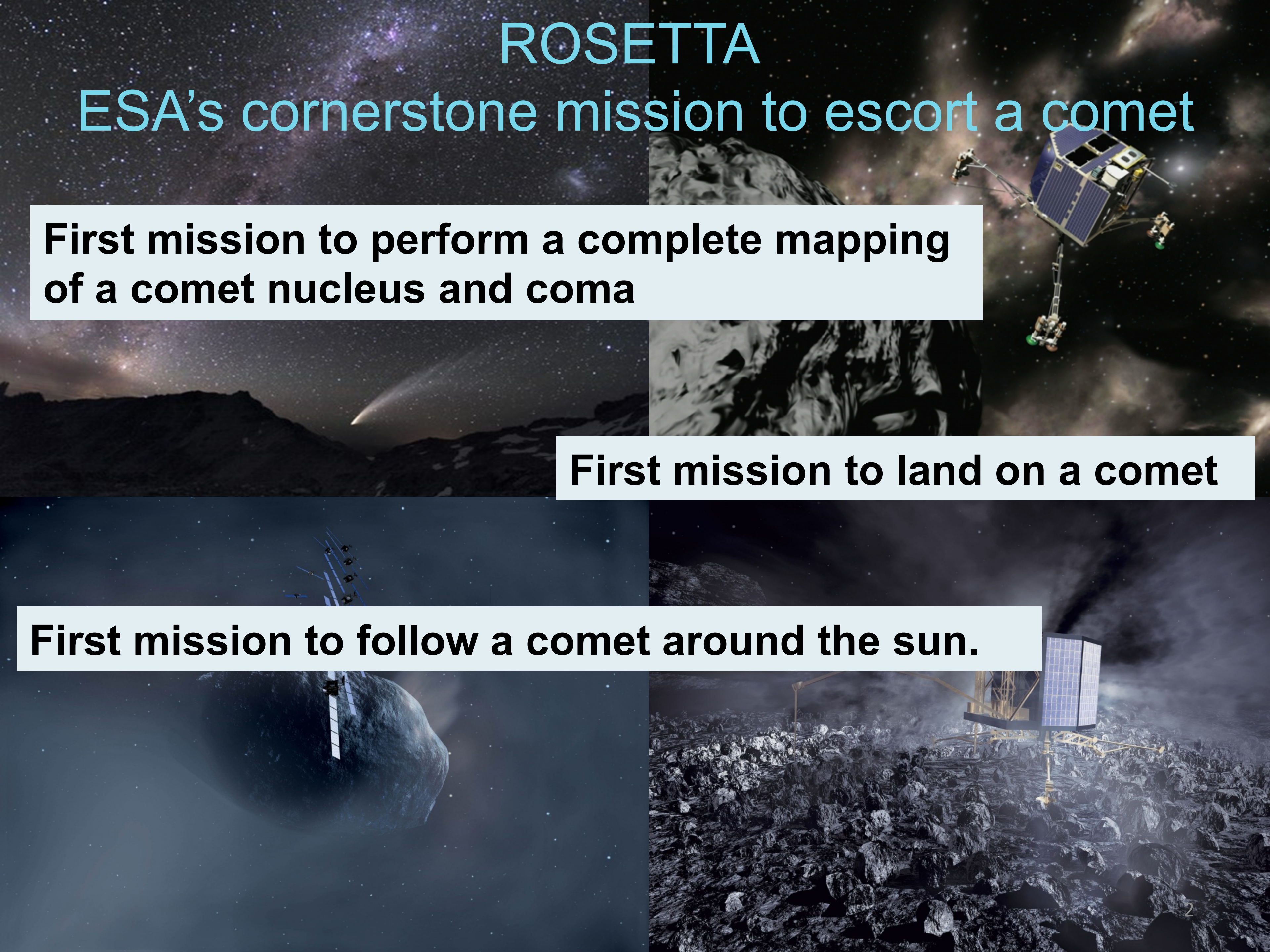
LVIII Congresso della Società Astronomica Italiana

Milano 13-16 Maggio 2014

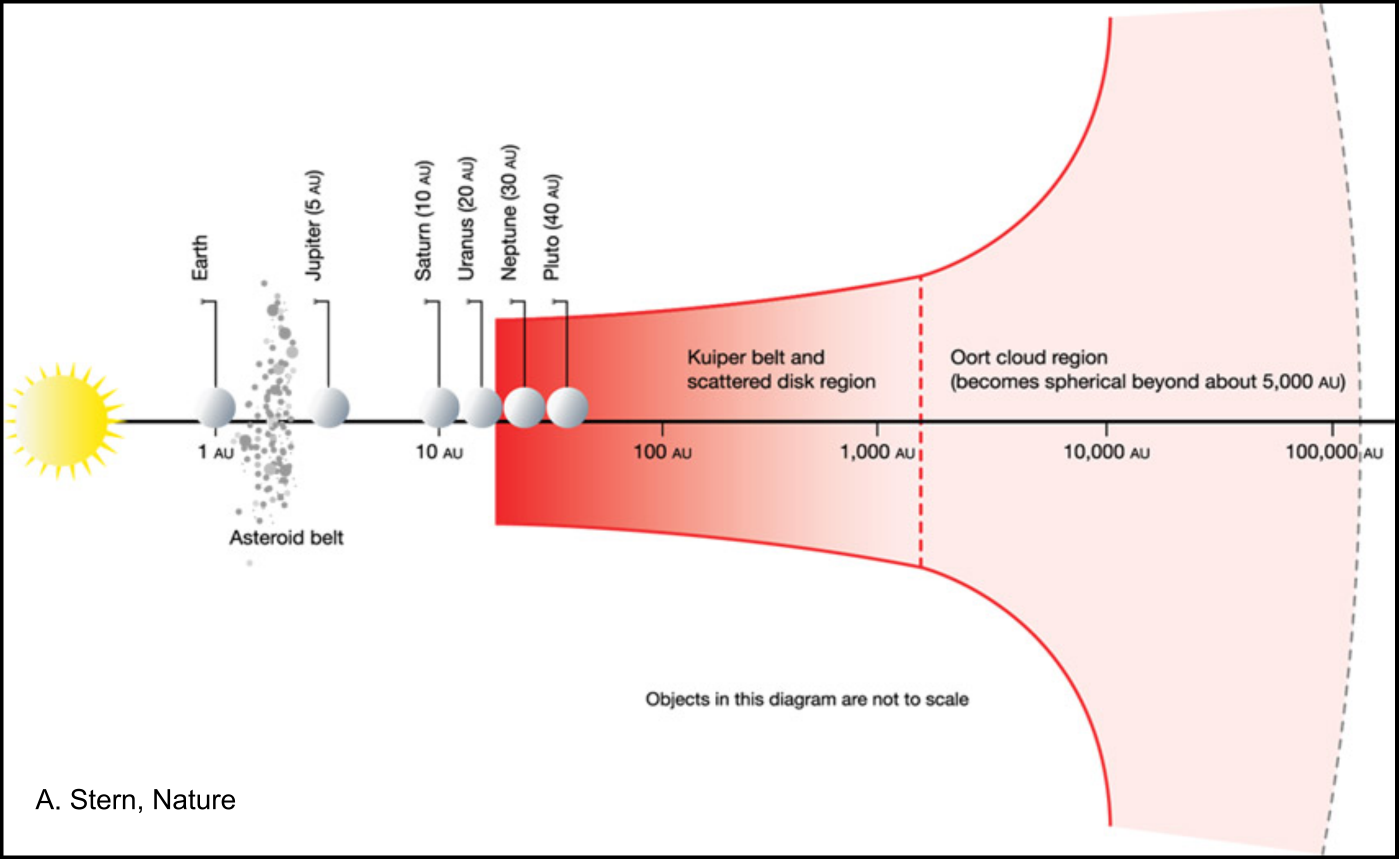

ROSETTA
ESA’s cornerstone mission to escort a comet
First mission to perform a complete mapping of a comet nucleus and coma
First mission to land on a comet
First mission to follow a comet around the sun.

Why Are We Interested in Comets?

Comets are heterogeneous aggregates of dust (crystalline and glassy silicates, iron oxides), organic compounds (CHON particles), ices and trapped volatiles.

They formed early in the Solar System history and have spent most of their life in a cold environment; are unlikely to be deeply thermally altered.

Can be the Rosetta stones to the understanding of the solar system formation.



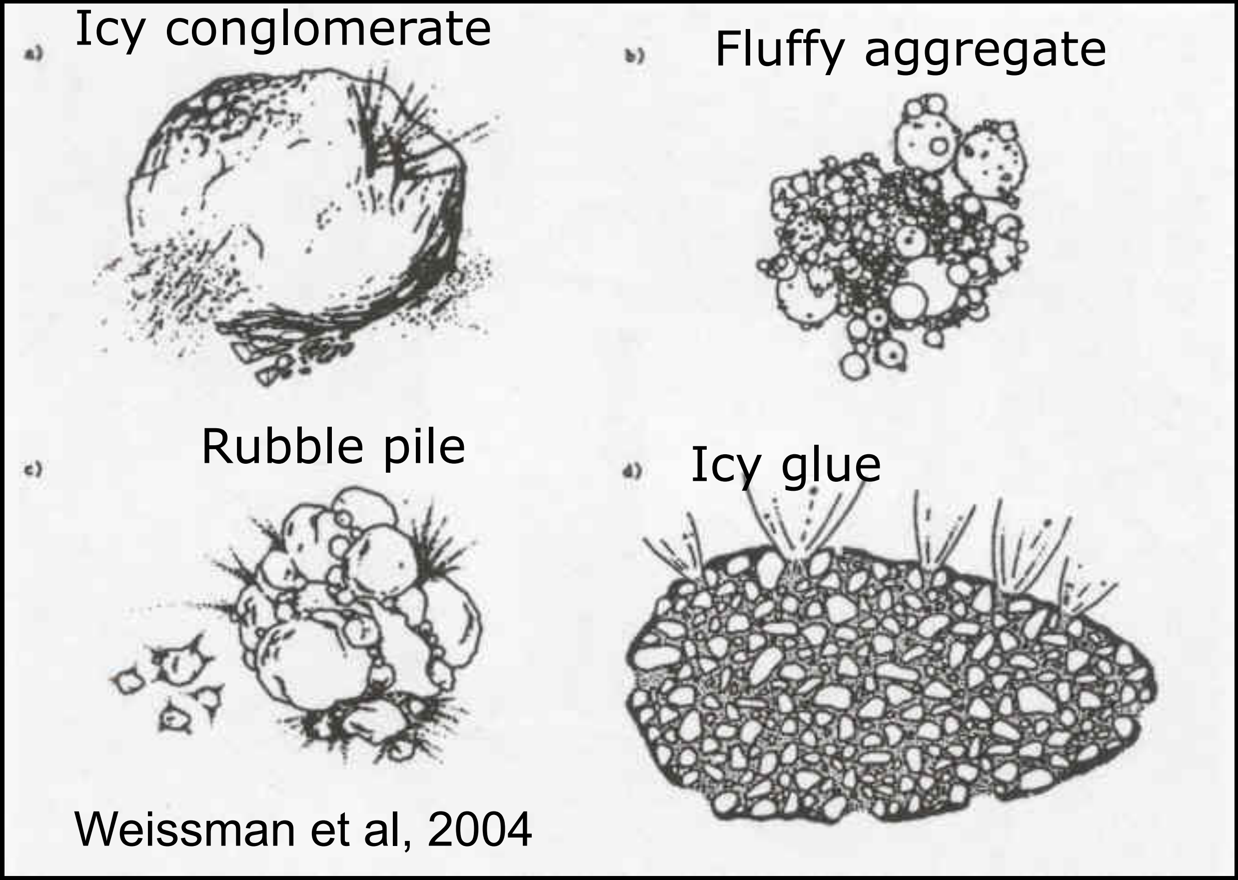
Why Are We Interested in Comets?

How do comets work?

Basic idea: On approach to the sun, ice evaporates and carries dust with it

However:

- Little amount of ice is found on surface
- Activity limited to few areas
- Localised outburst drive rejuvenation?



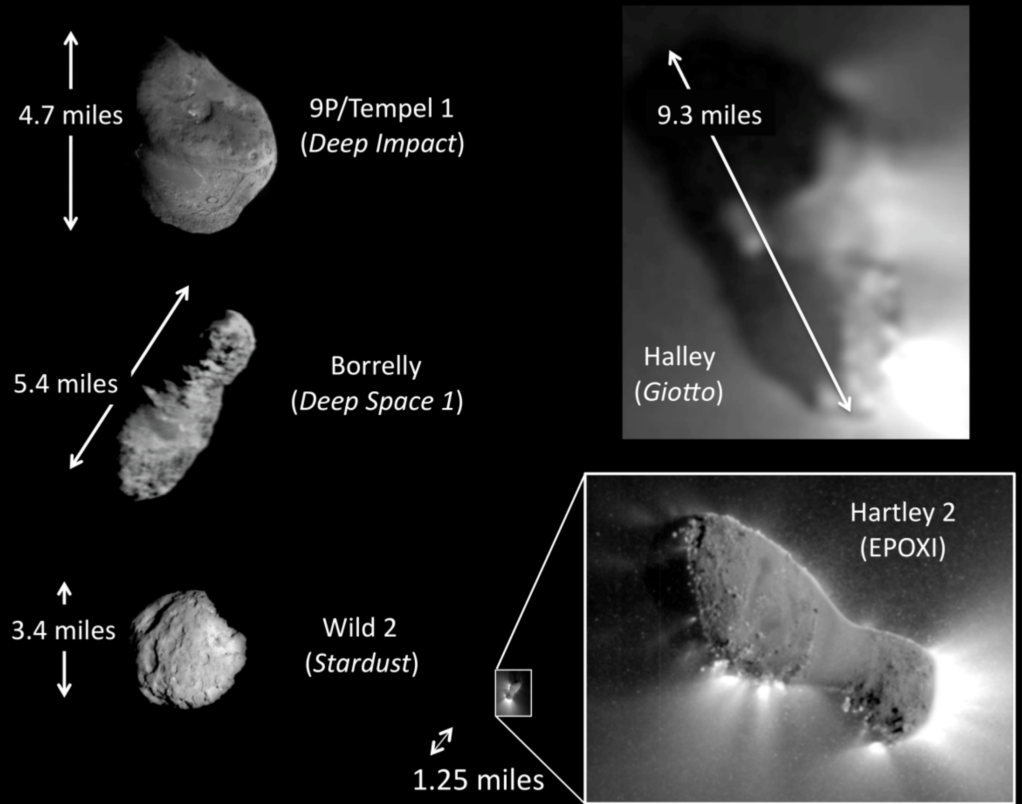
Weissman et al, 2004

Why Are We Interested in Comets?

Comets show marked differences; what do we see is the result of evolution or of different formation conditions?

1P/Halley: Highly active, low albedo, relatively little geological information about the surface

19P/Borrelly: Diverse geology, different types of terrain, no ice found on surface!

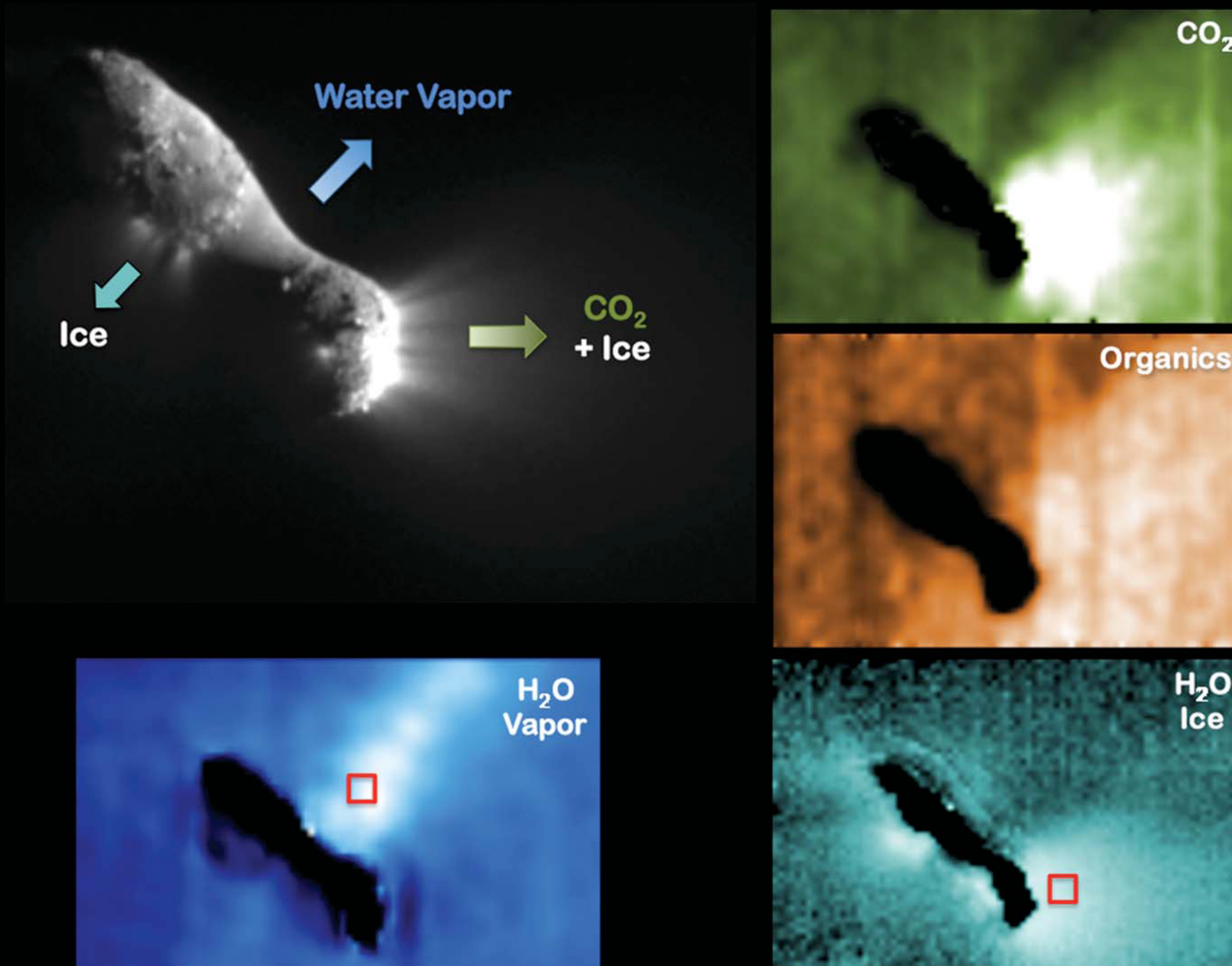


81P/Wild: Rugged terrain, impact craters ?

9P/Tempel 1: Diverse terrain, primordial layers found?, impact craters ? very little ice found on surface

103P/Hartley 2: Hyperactive, diverse terrain, extreme shape, ice blocks (cm-dm sized) emitted from nucleus

Why Are We Interested in Comets?

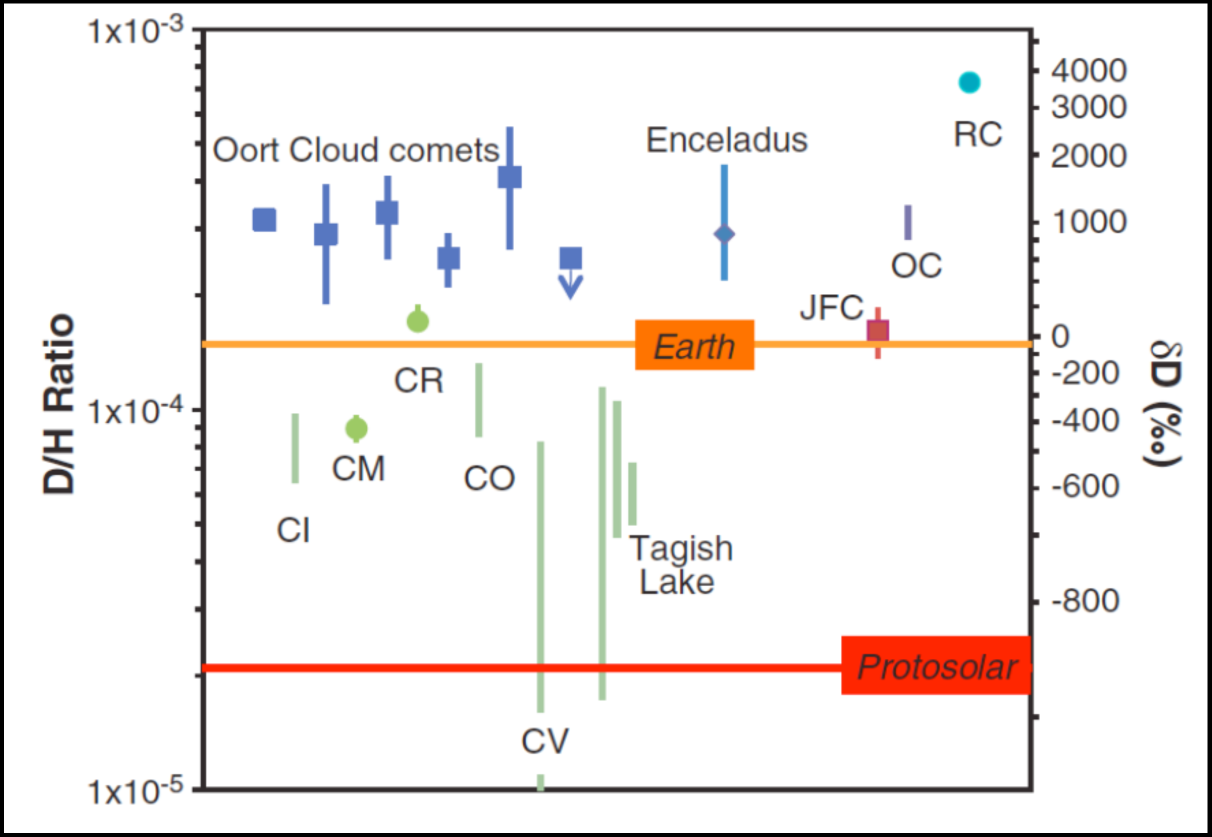


Why are we interested in comets?

Earth's bulk composition similar to Enstatite Chondrites suggests a dry proto-Earth with subsequent delivery of volatiles.

Comets were excluded as carriers on the basis of six observations of Oort cloud comets.

The D/H value in carbonaceous chondrites, led to models in which primitive asteroids were assumed to be the main source of volatiles.

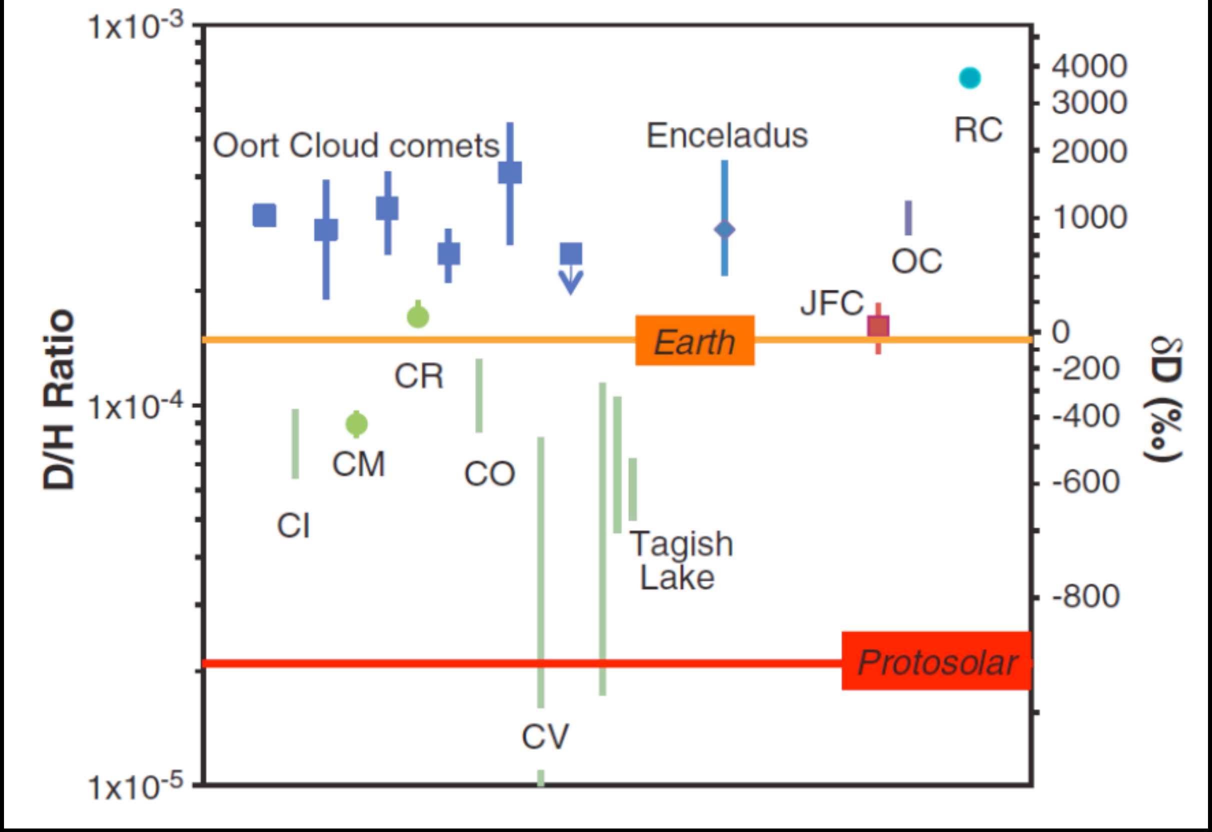


Why are we interested in comets?

D/H ratio in the Jupiter-family comet 103P/Hartley 2, originated in the Kuiper belt, is compatible with Earth value (Hartogh et al, Nature 2011).

However, D/H tends to increase with heliocentric distance.

The emerging picture is that of of a complex dynamical evolution of the early Solar System with extensive radial mixing of cometesimals.

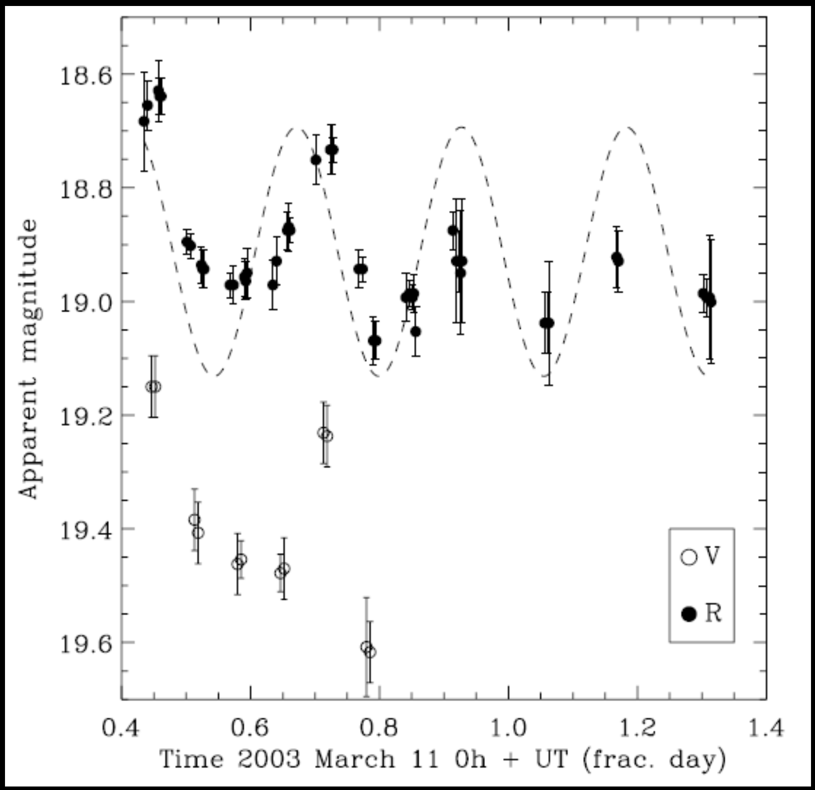


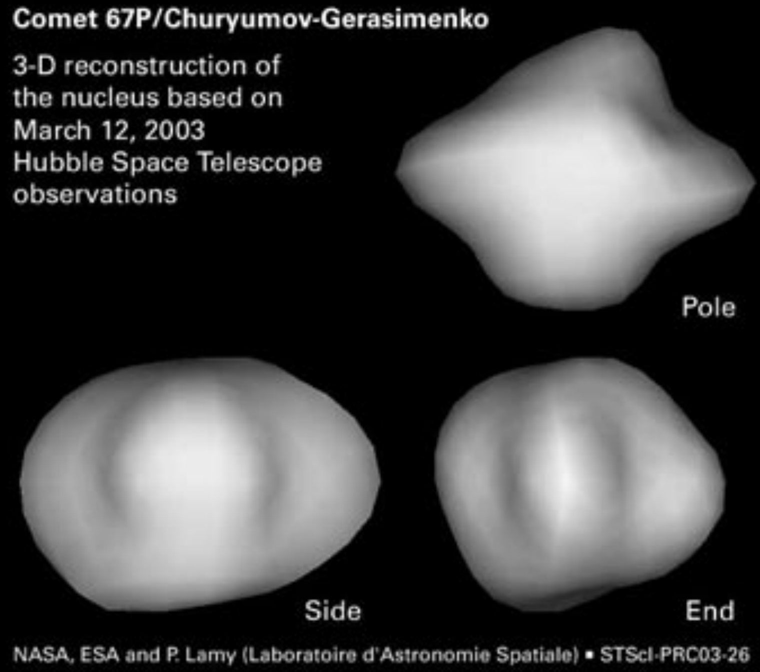
Comet 67P/Churyumov-Gerasimenko

Comet 67P/Churyumov-Gerasimenko has a nucleus about 4 -5 km wide.

Orbits around the Sun with a period of 6.45 years on an elliptic orbit with perihelion at 1.24AU (13 August 2015) and aphelion at 5.68AU.

Until 1959 the perihelion distance was about 2.7 AU. A close encounter with Jupiter Moved to its present distance

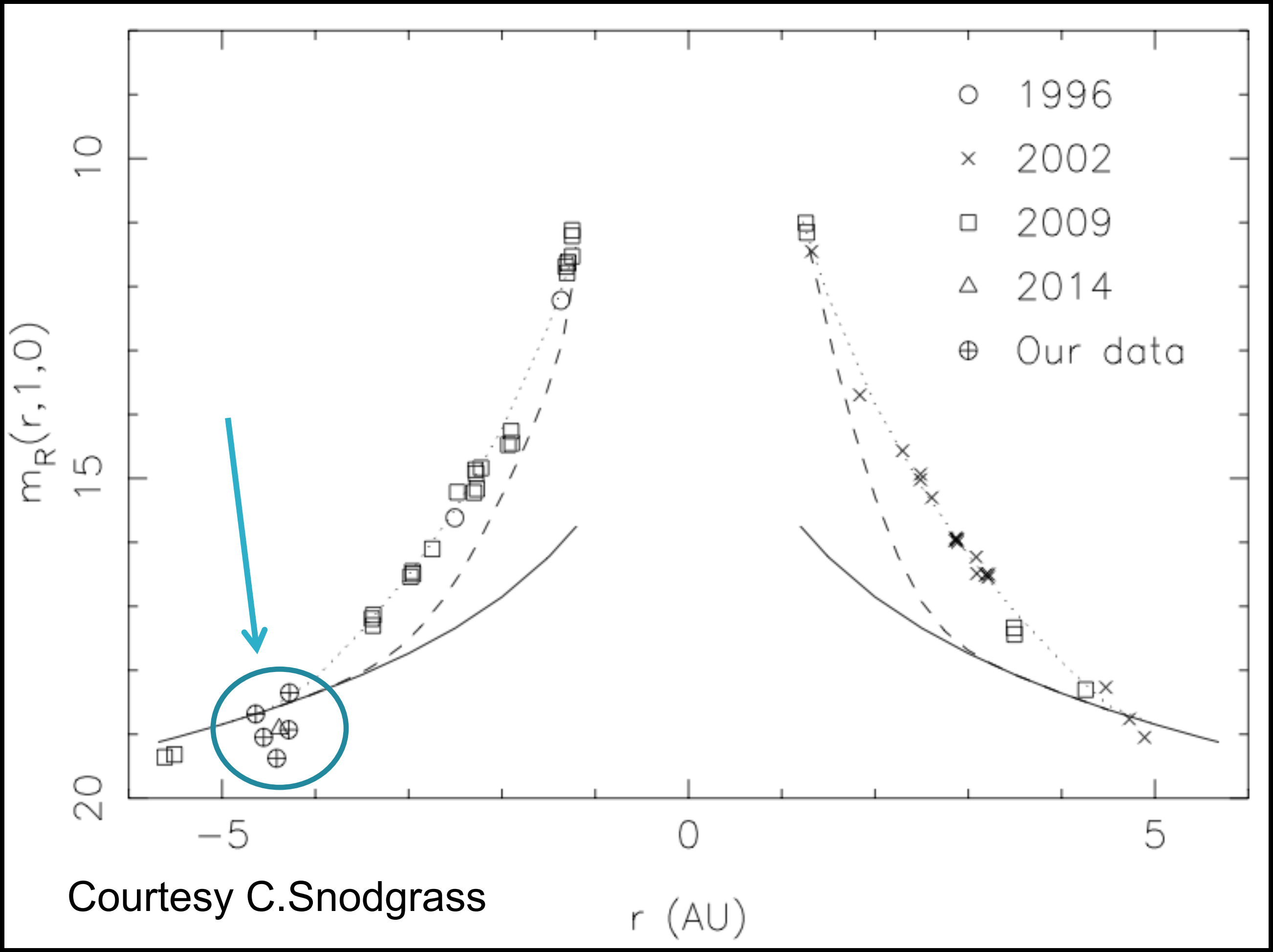




Ground Based Observations

In February 2014 still no sign of activity from ground

Expected start of visible activity around mid March



Latest Rosetta Osiris images

Comet 67P has begun to develop a dust coma in late April. Images taken between March 24th and May 4th from a distance between 5 to 2 million km. At the end of this sequence 67P is still at about 4.1AU from the Sun.

Images released today at 12:00

ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

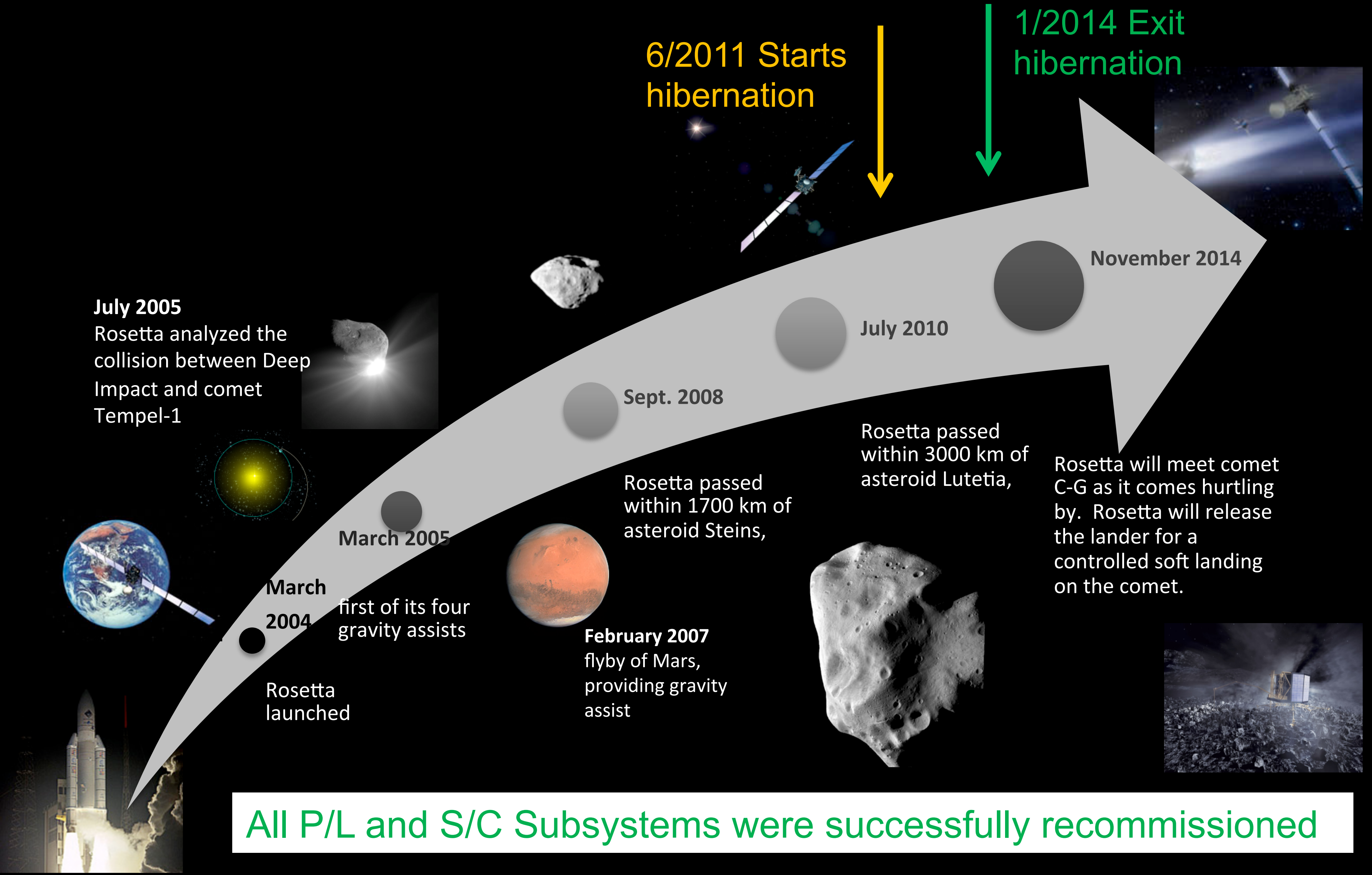
Latest Rosetta Osiris images

The dust that the comet is already emitting is clearly visible as an evolving coma and reaches approximately 1300 km into space.

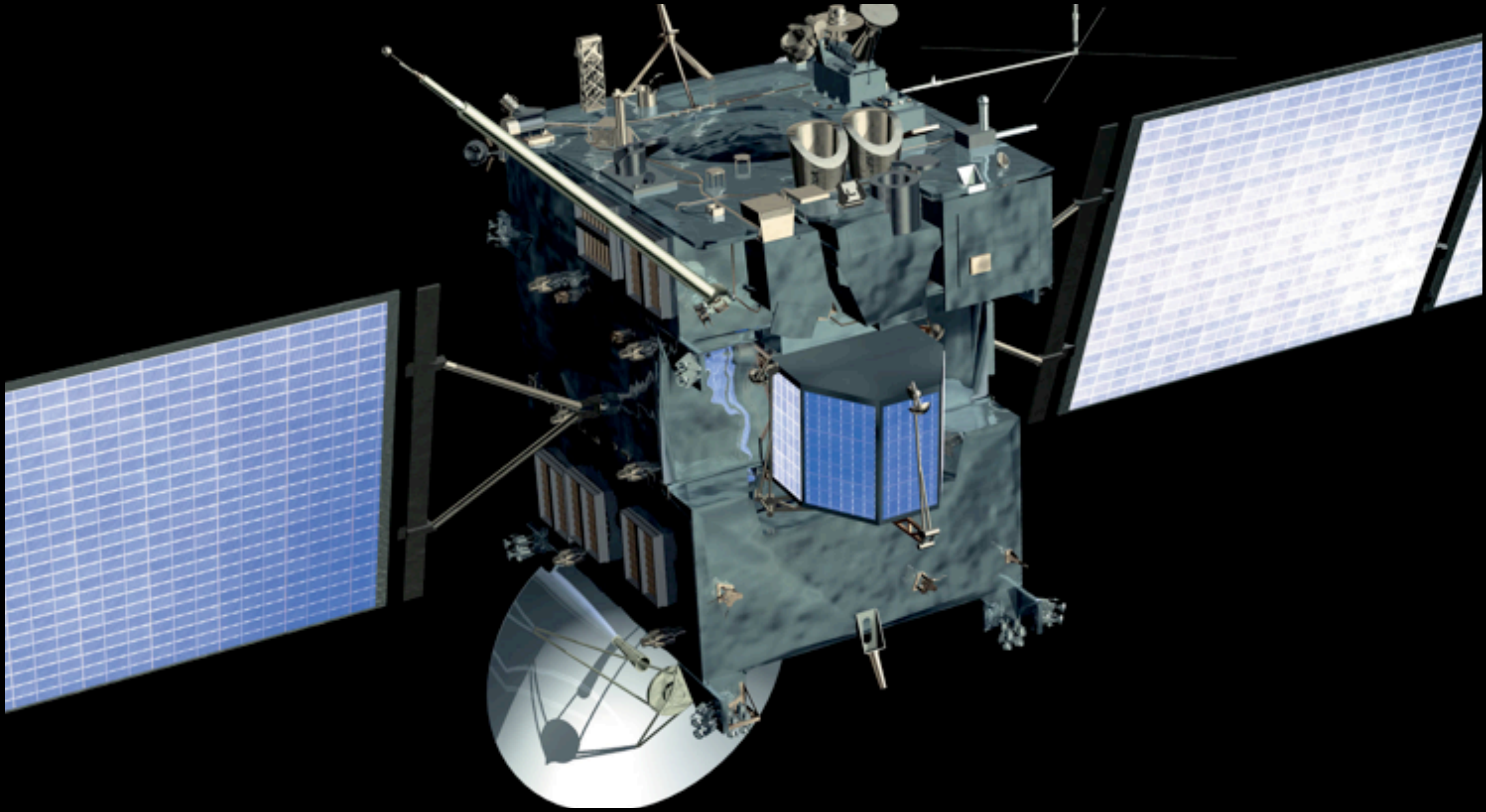
From light curves observations the orbital period has been shortened by 20min from 12.7hr to 12.4hr

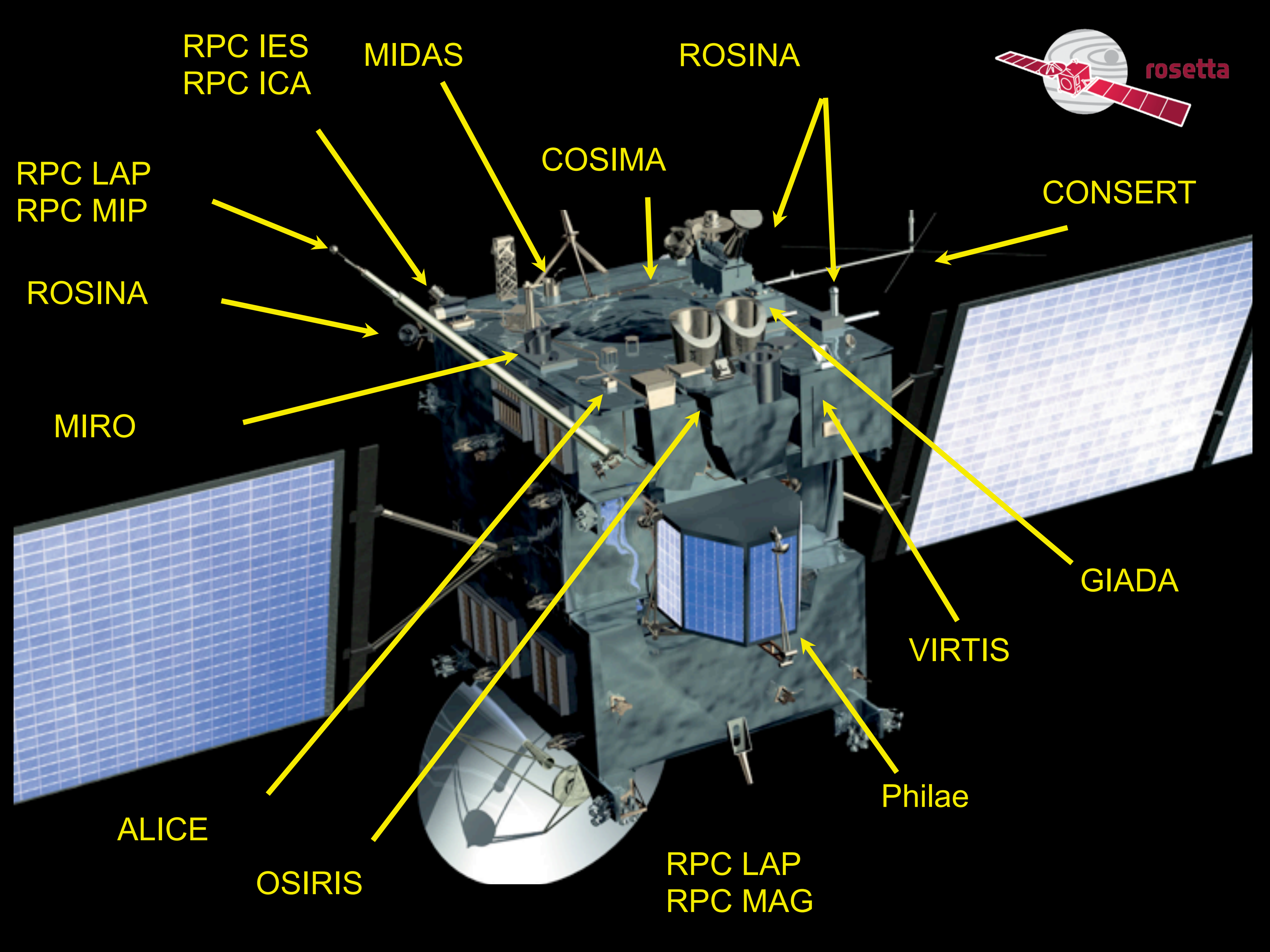
ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

Rosetta Journey to comet 67P/ Churyumov-Gerasimenko



Full suite of in-situ and remote sensing instruments




RPC IES
RPC ICA
MIDAS
ROSINA
rosetta
COSIMA
CONSERT
RPC LAP
RPC MIP
ROSINA
MIRO
GIADA
VIRTIS
Philae
ALICE
OSIRIS
RPC LAP
RPC MAG

Remote Sensing from Orbiter

OSIRIS *(H. Sierks, DE)*
(WAC Co-PI *C. Barbieri, I*)

Camera (250–1000nm)
- Wide-angle (12° FOV, 125μrad res)
- Narrow angle (2.5° FOV, 12.5μrad)

ALICE *(A. Stern, US)*

UV spectrometer (70–205nm)

VIRTIS *(F. Capaccioni, I)*

VIS -IR spectrometer (250–5000 μm)
- VR-Mapper 250μrad res
- VR-HighRes 2-5 μm, $\lambda/\Delta\lambda$@3 μm = 3000

MIRO *(S. Gulkis, US)*

Microwave spectrometer

Orbiter In situ instruments

rosetta

ROSINA *(K. Altwegg, CH)*	Neutral gas- and ion mass spectrometer Chemical composition of gas in coma
COSIMA *(M. Hilchenbach, DE)*	Solid mass spectrometer Chemical composition of coma dust
MIDAS *(M. Bentley, AT)*	Atomic force microscope Shape and size of dust grains
GIADA *(A. Rotundi, I)*	Grain impact analyzer and dust collector

Orbiter In situ instruments

CONSERT *(W. Kofmann, FR)*	Radio transmitter on lander and receiver on orbiter Tomography of nucleus
RPC *(Several PI's)*	Rosetta plasma consortium Five plasma instruments
RSI *(M. Pätzold, DE)*	Radio science investigation

Science from the Lander Philae

Remote Sensing Experiments:

CIVA: Panoramic imaging and microscopy (VIS and NIR)

ROLIS: Downward imaging

APXS: X-ray spectroscopy

Composition Analysis:

COSAC: Molecular composition and chirality

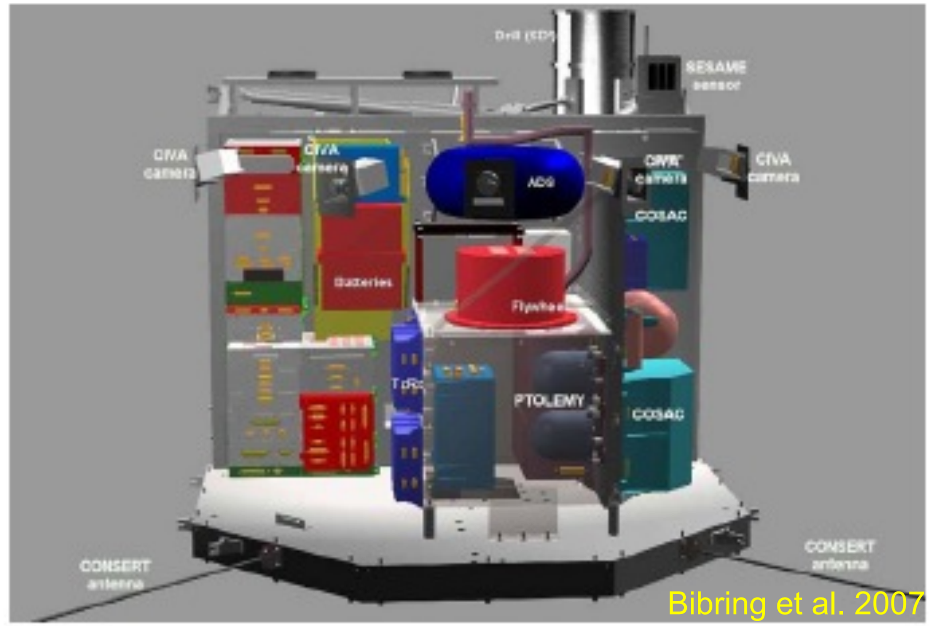
PTOLEMY: Isotopic composition

Large Scale Structure:

SESAME: Dust environment (impacts)

ROMAP: Magnetic field

CONSERT: (lander unit)



Bibring et al. 2007

Physical Properties:

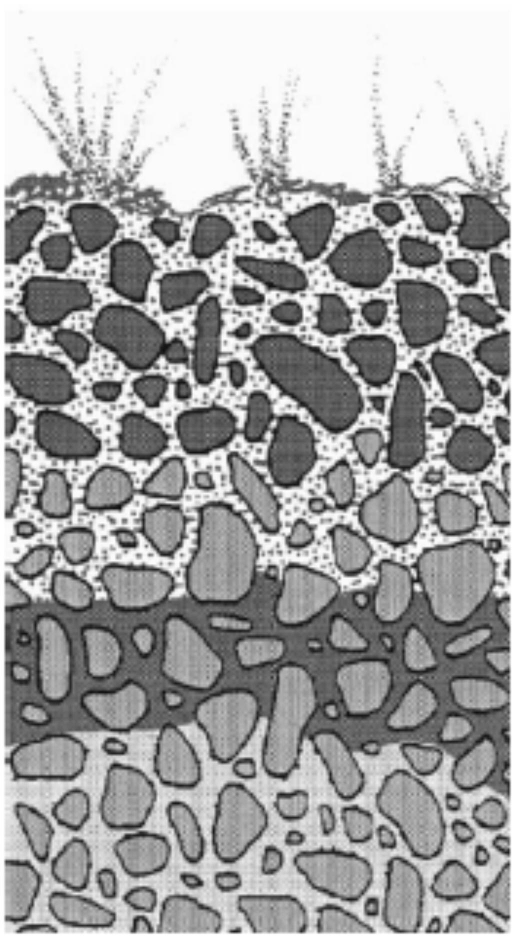
MUPUS: Porosity, Density, Thermal

SESAME: Seismic and acoustic properties

SAMPLER SD2: Drill to 20cm depth and transfer of samples to P/L

(A. Ercoli Finzi, IT)

Nucleus thermal properties: a synergistic approach



Prialnik

Surface T controlled by roughness: Osiris (dm, m scale), CIVA-P, ROLIS (mm, cm scale)

measure T in the top few µm: VIRTIS, MUPUS

Heat transport determined by thermal conductivity, porosity, density: MUPUS, SESAME

Measure T down to 10s cm: MIRO, MUPUS

Results at the landing site will provide calibration and ground truth for a global analysis with MIRO, VIRTIS and OSIRIS

Events for 2014-2015

• 20 January 2014	S/C wakes up from hibernation
• February	S/C subsys powered and successfully tested
• March/April	P/L powered and successfully tested
• 21 May	Major rendezvous manoeuvre
• 6 August	“Orbit” insertion
• August/October	Nucleus Imaging and composition Mapping; coma characterisation
• Mid September	select 5 landing areas
• Mid October	select the landing site
• 11 November	Lander Delivery
• December 2014	Start Escort mission
• August 2015	Perihelion passage
• December 2015	End of Nominal mission

Rosetta 2014-2015

From June onwards :

- Characterization of the nucleus (global surface mapping, global composition, etc.)
- Support for the selection of landing site

17/08/14-26/08/14: TGM phase (‘Transition to Global Mapping’)

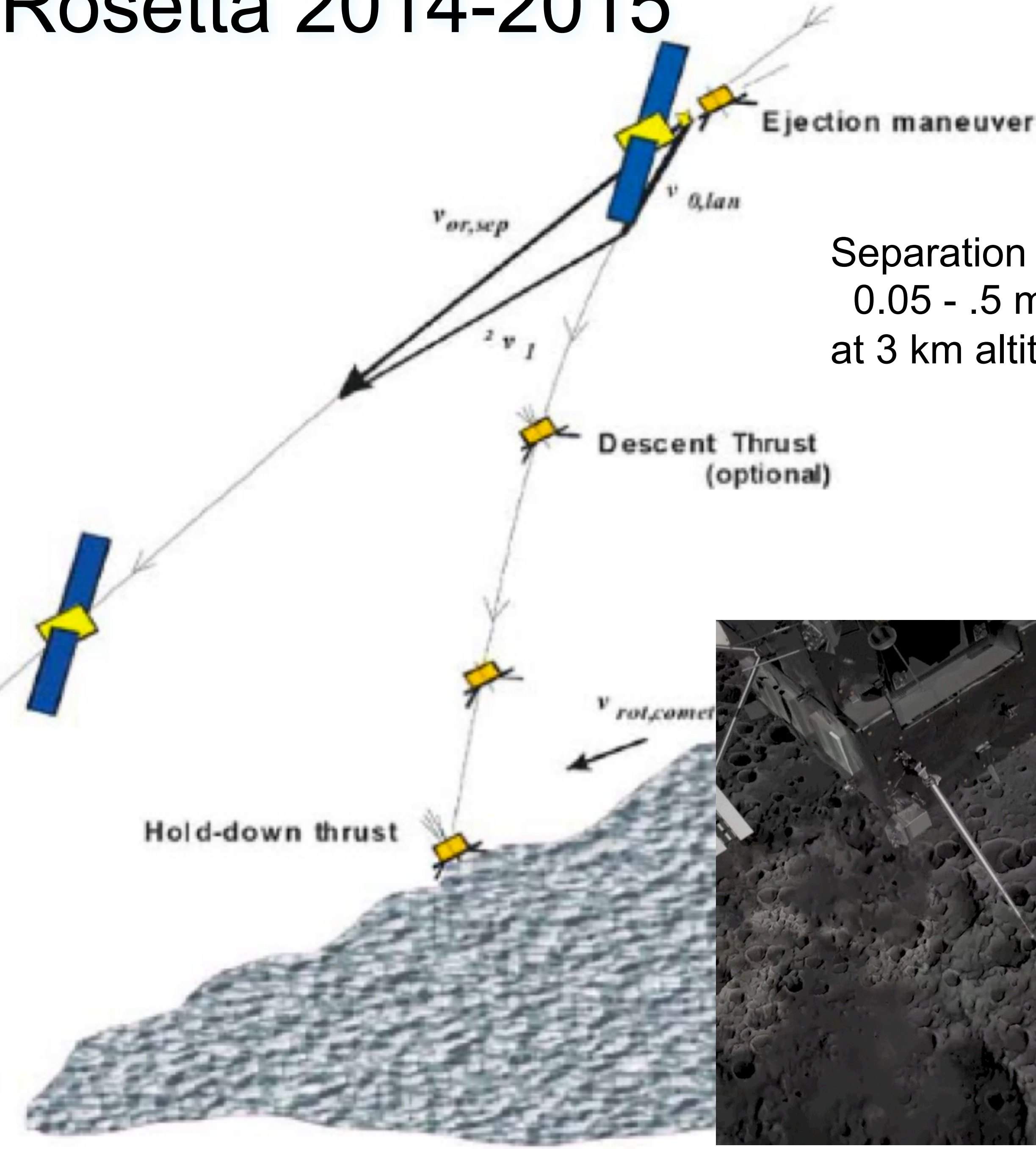
27/08/14-23/09/14: GMP phase (‘Global Mapping Phase’)

24/09/14-25/10/14: COP phase (‘Close Observation Phase’)

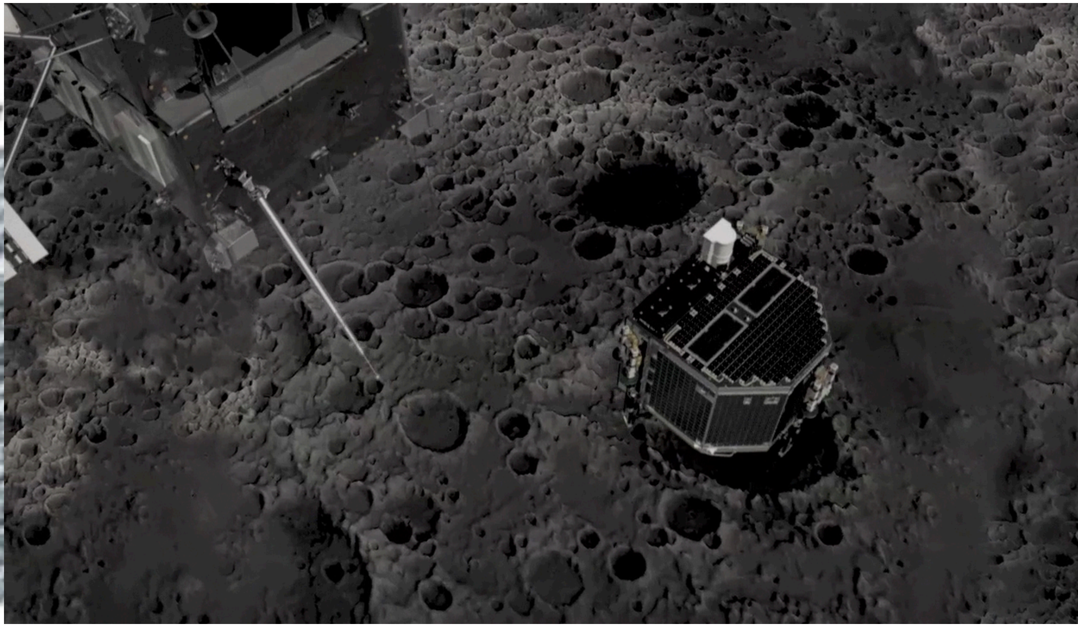
26/10/14-11/11/14: Landing preparation and Landing

Also will provide us with information to tune the escort phase operations, as best we can, to the activity of the orbit.

Rosetta 2014-2015



Separation velocity
0.05 - .5 m/s
at 3 km altitude



Rosetta 2014-2015

- Monitor nucleus topography and composition changes
- Monitor changes in thermal and physical properties of nucleus materials
- Monitor coma composition, flux changes in gas and dust
- Monitor the evolution of the physical properties of the dust
- Monitor interaction between dust and gas in acceleration regions
- Investigate Nucleus-Inner Coma relationships
- Monitor jets activities

Following lander deployment - begin Escort phase of mission (12/2014)

- Navigation relies on navigation camera
- ˜1.5 hour round trip communication delay
- bound orbits only possible at a few 10s km

Rosetta 2014-2015

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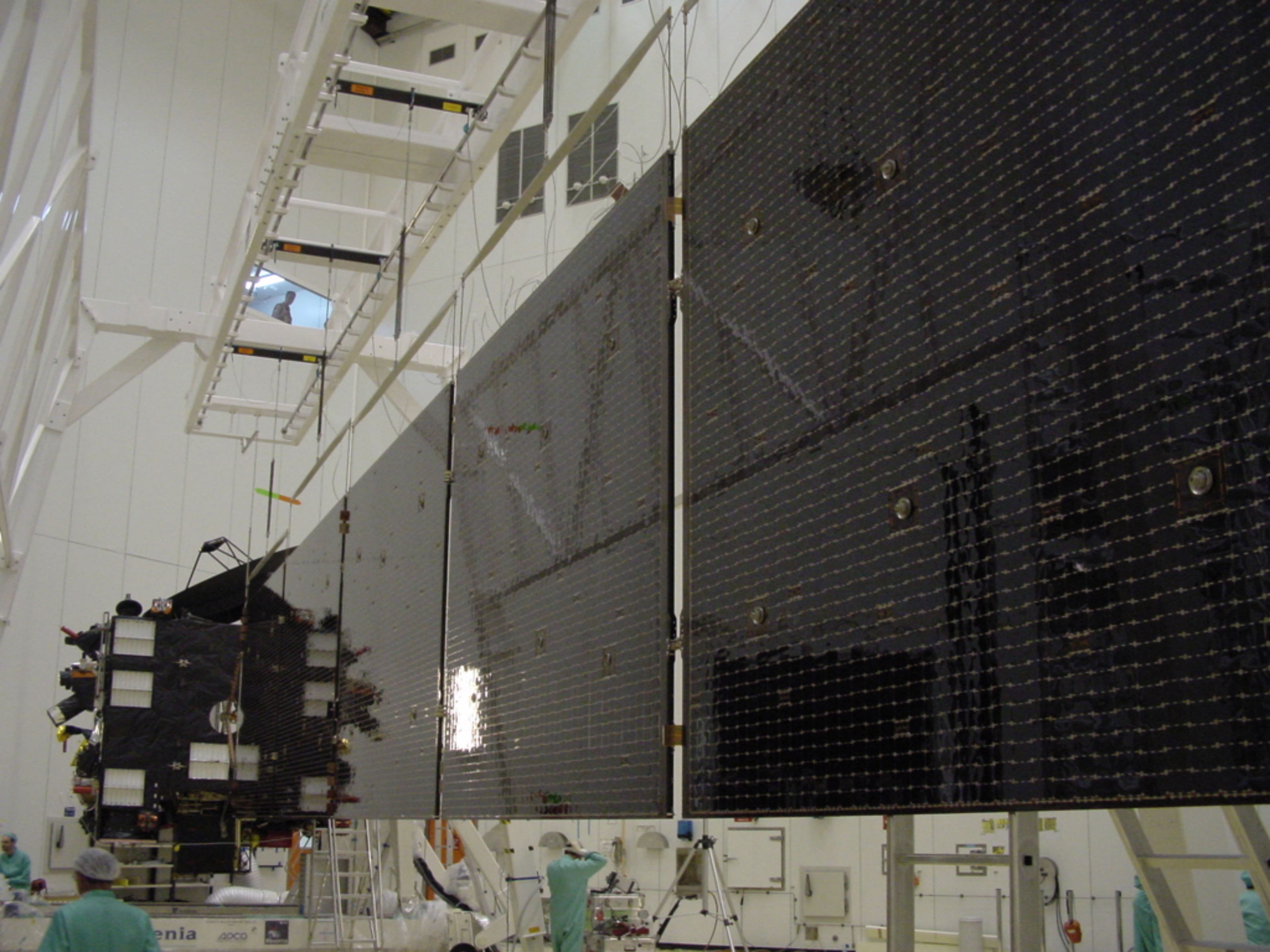


Conclusion

Rosetta is THE sexiest mission ever...

It will be the first mission to shadow a comet, travelling at a relative walking pace with respect to the comet.

In addition, it will deliver a lander, Philae, to the comet to get ground truth from insitu measurements.

Will provide the most detailed study of a comet during its approach to the Sun

its so awesome, some people have even got a tattoo

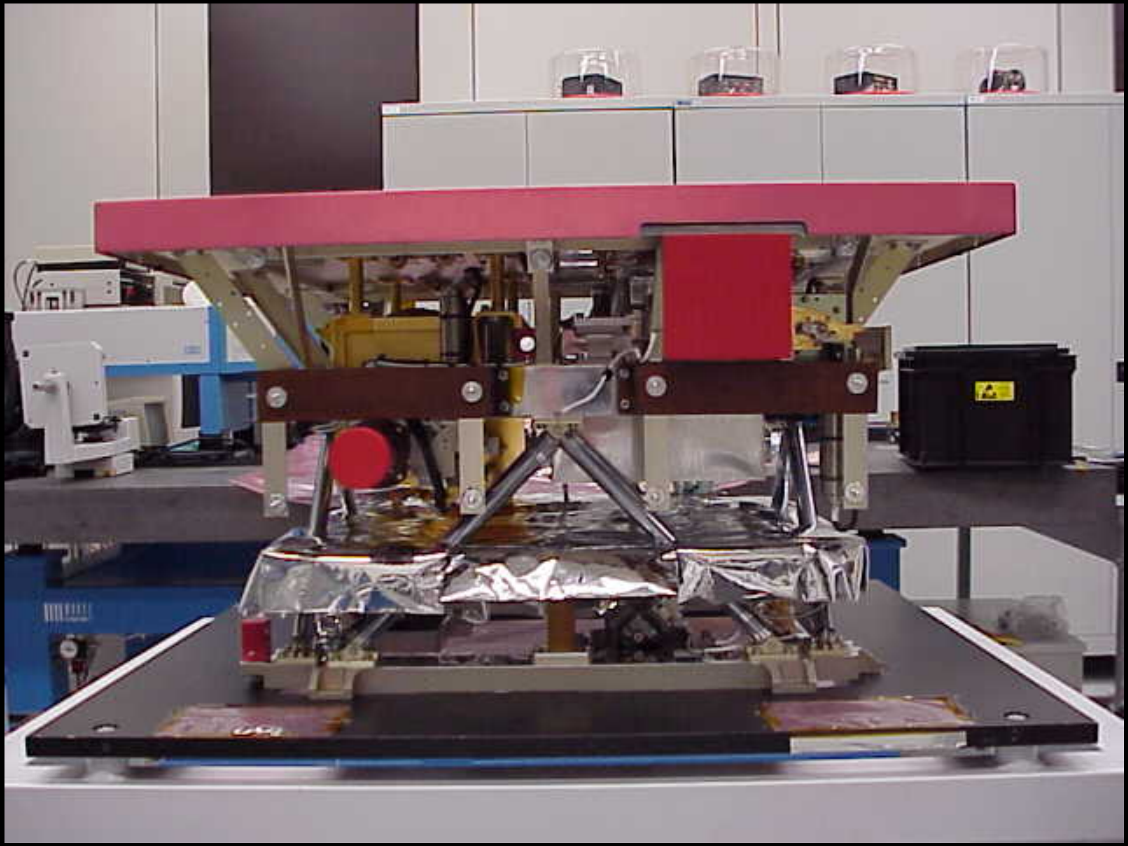
Matt Taylor the Rosetta mission Project Scientist and his tattoo

END

VIRTIS

Visible, InfraRed and Thermal Imaging Spectrometer

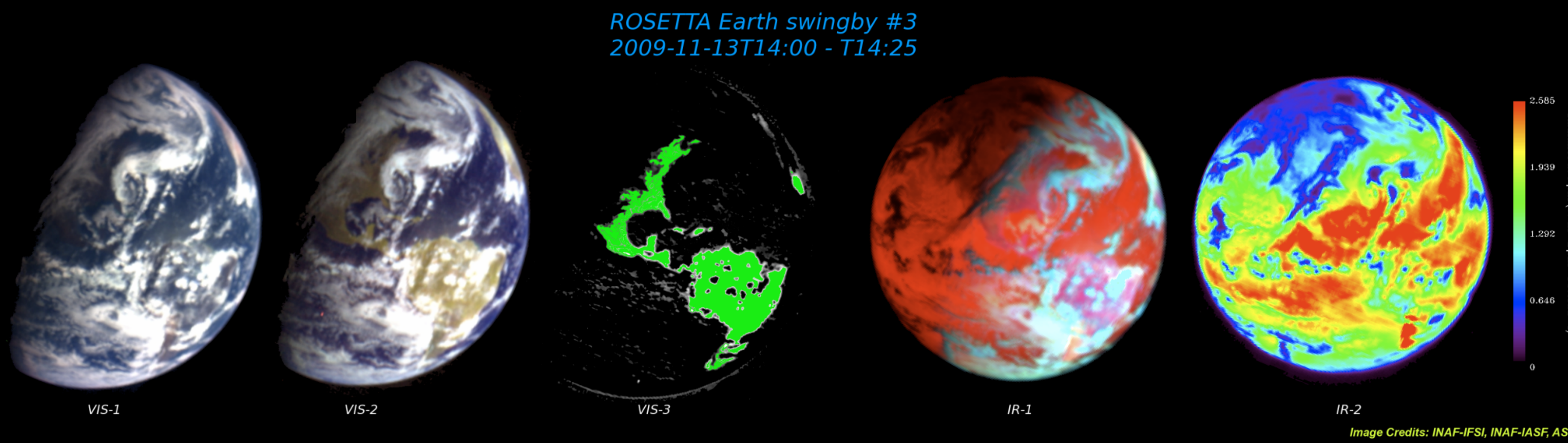
VIRTIS is an imaging spectrometer and a high resolution spectrometer



VIRTIS – M is a slit spectrometer; acquires hyperspectral images with a max spatial resolution of 250μrad, using an internal scan mirror, in the spectral range 0.25-5 μm

VIRTIS –H is a high-resolution infrared spectrometer in the 2-5 μm range. It uses a prism and a grating to achieve a spectral resolution as high as 3000 on a matrix detector identical to the VIRTIS-M IR FPA.

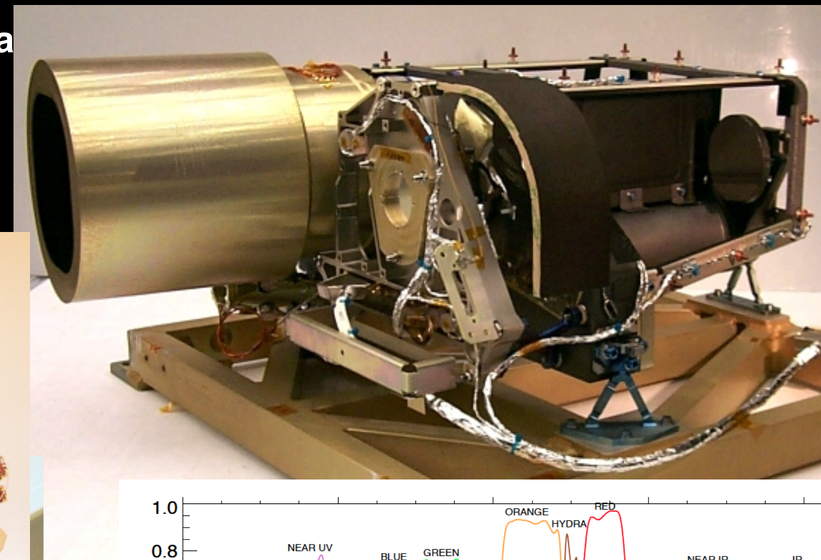
Earth Observation VIRTIS-M



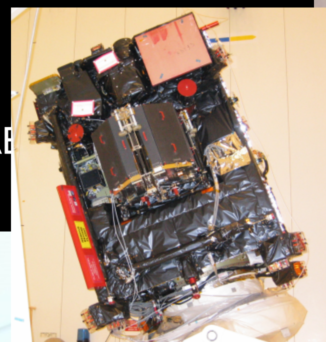
- Fig1. VIS channel; spatial resolution of about 50 km. RGB imaging (0.44, 0.55, 0.7µm).
- Fig 2 VIS Channel; contrast enhanced image (0.474µm, 0.785µm, 1.0µm).
- Fig 3 VIS Channel; contrast enhancement of chlorophyll absorption feature.
- Fig 4 IR Channel; B @1.20µm, G@2.25µm and R@4.92µm. Radiation emitted from the night side clearly shows up in this image. The cyan spots are high altitude clouds, while Oceans appears in red having a thermal emission and inertia larger than the landforms (in pink).
- Fig 5. Thermal emission region at 5.0 µm; the Earth looks fairly uniform on the day and night side. The northern American continent (in the top-left quadrant of the image), mainly at night and during the winter season, appears as the coldest area of this image (in blue).

OSIRIS - Scientific Camera System

NAC – Narrow Angle Camera
FOV 2.2°, IFOV 18.6 µrad/px
SiC, 2k x 2k BI E2V CCD, AB
3-mirror off-axis, f/8, 717mm



WAC – Wide Angle Camera
FOV 12°, IFOV 101 µrad/px
Al bench, 2k x 2k BI E2V CCD, A
2-mirror off-axis, f/5.6, 140mm



plus 3 **E-Boxes**
(35.6 kg total)