ROSETTA in orbit around comet Churyumov Gerasimenko 67P

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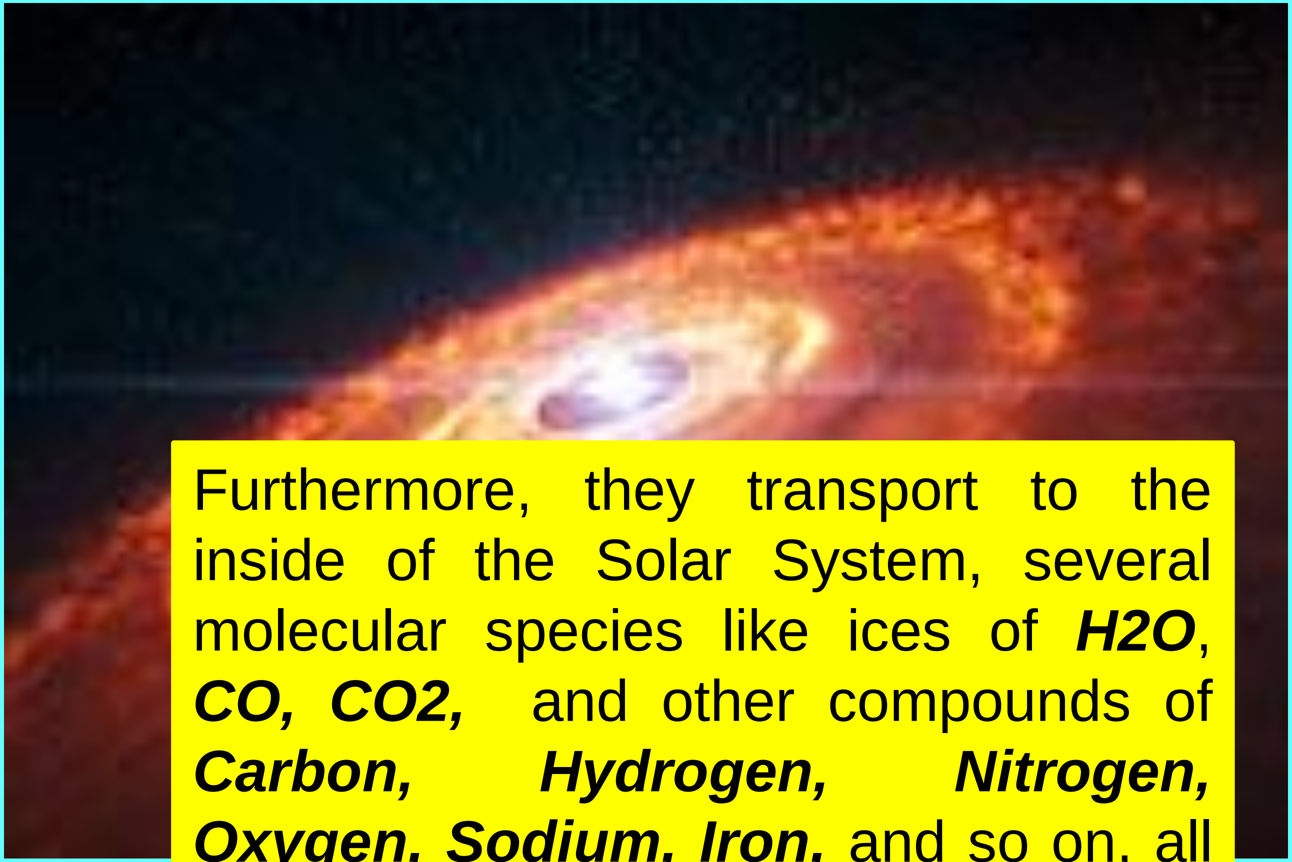
ROSETTA: an European space mission toward two asteroids and a Jupiter's family comet

Following the great success of the GIOTTO mission in 1986, in the new Century the European Space Agency (ESA) undertook a new more ambitious mission named ROSETTA.

Primary scientific objective: ***comet 67P (C-G)***
Secondary scientific objectives: ***two asteroids (Steins, Lutetia).***

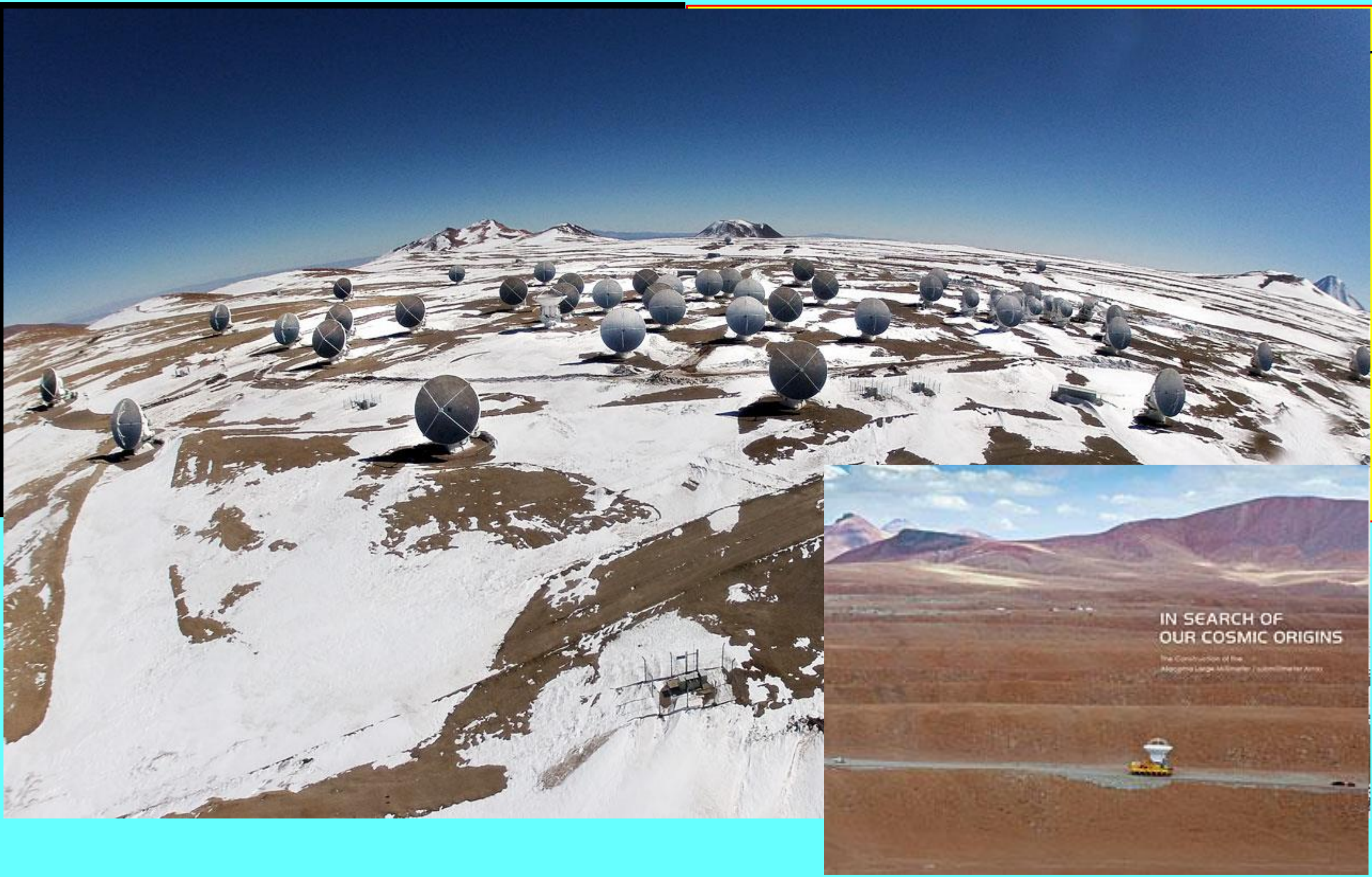
Why asteroids and comets?



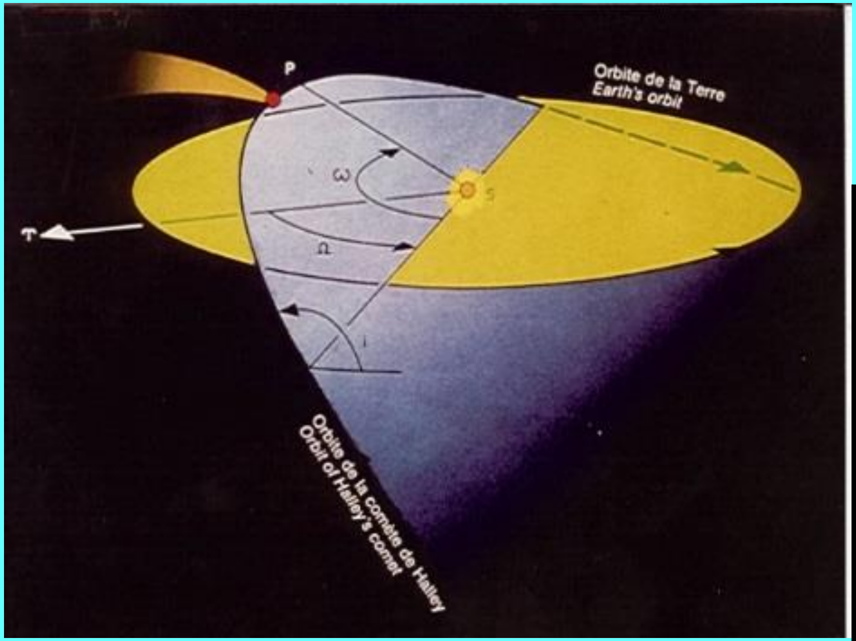
Asteroids and comets are an ensemble of primitive bodies carrying information on the origin of the Solar System some 4.5 billion years ago, and on the subsequent dynamical and chemical evolution ***like veritable 'time capsules'.***

Furthermore, they transport to the inside of the Solar System, several molecular species like ices of ***H_2O***, ***CO, CO_2,*** and other compounds of ***Carbon, Hydrogen, Nitrogen, Oxygen, Sodium, Iron,*** and so on, all of them fundamental ingredients of life as we know it on our Earth.

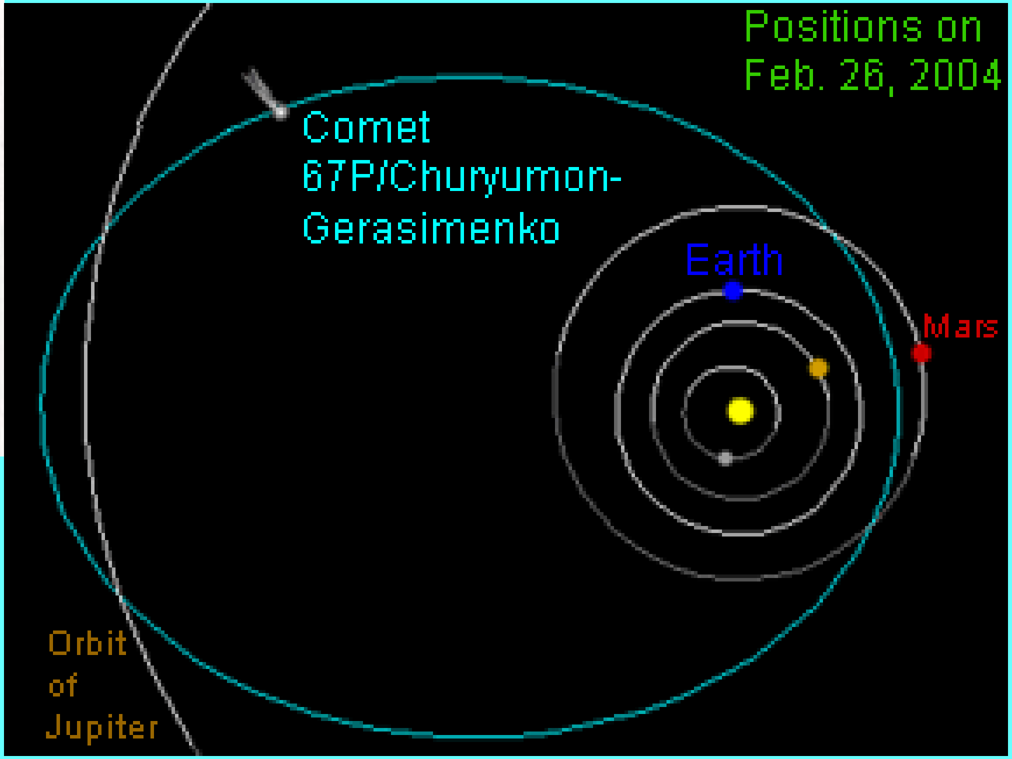
A solar system in its infancy (HL Tauri)



Giotto vs Rosetta: Different Orbits



Halley
P 75 years retrograde



67P, P 6.5 years, direct, I = 11°

Main Differences between Giotto and Rosetta - 1

Giotto:
direct launch to the comet,
very fast 'fly-by',
small distance from Earth
spin stabilized

Rosetta:
'cruise' mission of 11-12 years duration
orbit spanning from Earth to Jupiter
need of 'gravitational assist'
three axis stabilized

Main differences between Giotto and Rosetta - 2

Relative kinetic energy

Giotto: v ≈ 70 km/s, Rosetta: v ≈ 0.5 km/s

Ratio of energies of dust grain impacts ≈ 20.000

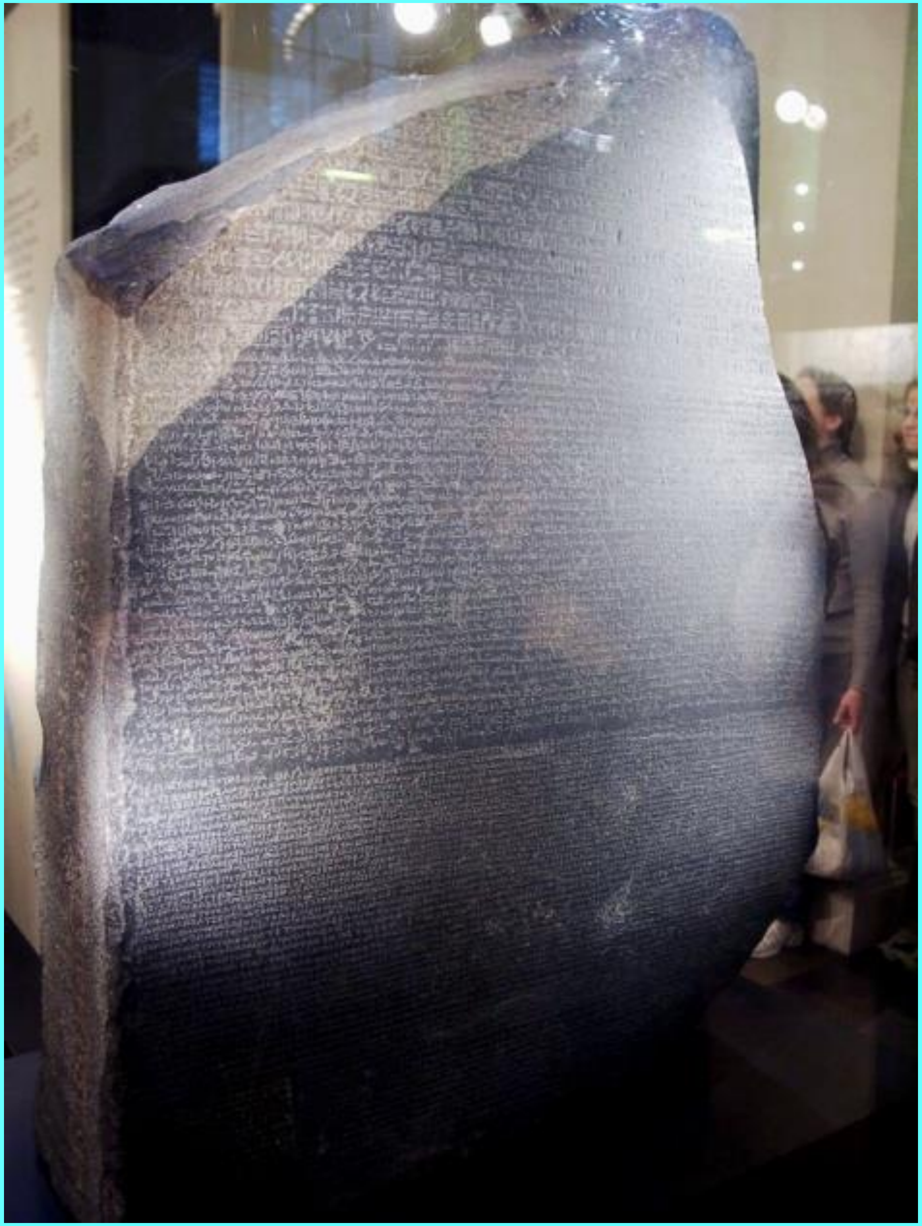
Giotto ≈ 1 year, Rosetta ≈ 12 years or more

Radiation dose (solar wind),

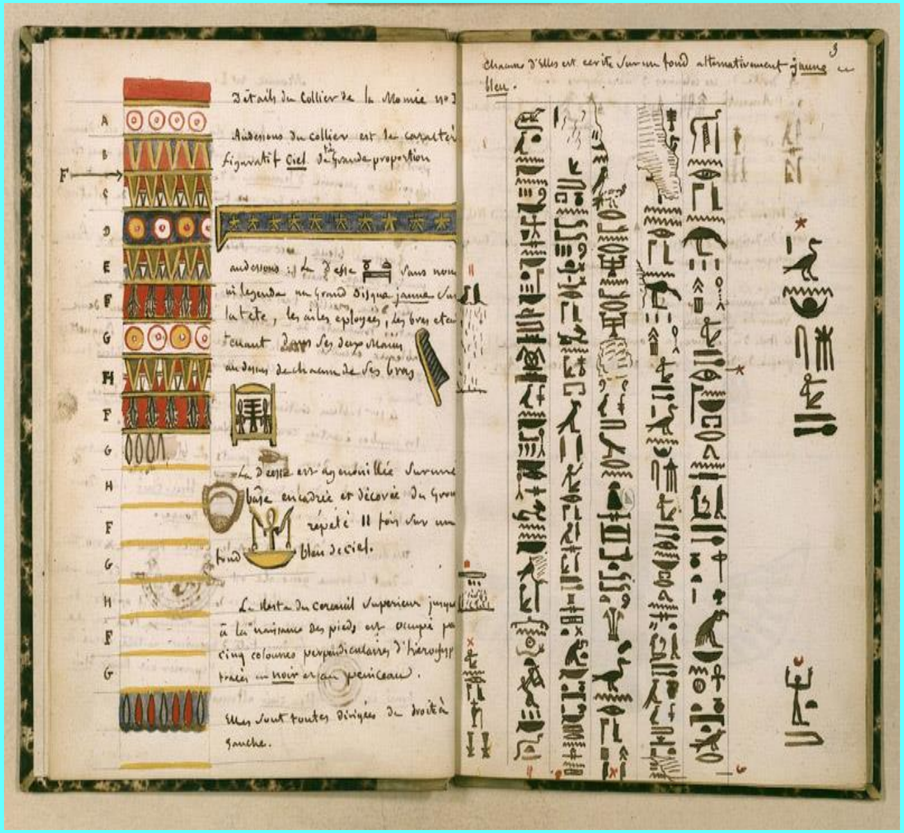
Specs of electronic components MIL, Hard Rad

Mechanisms of OSIRIS:

Shutter 50.000, covers 10.000



Why the name Rosetta



a page of Champollion note book

Egypt: Rosetta and Philae

Launcher Ariane-5 G+,

Mass of payload at launch:
Orbiter: 2900 kg (inclusive of 1670 kg propellant and165 kg scientific payload; Lander (Philae): 100 kg.

Dimensions Orbiter:
2.8 x 2.1 x 2.0 m
2 solar panels 14x2 m each
Dimensions Philae:
1x1x1m with 3 legs of 1m

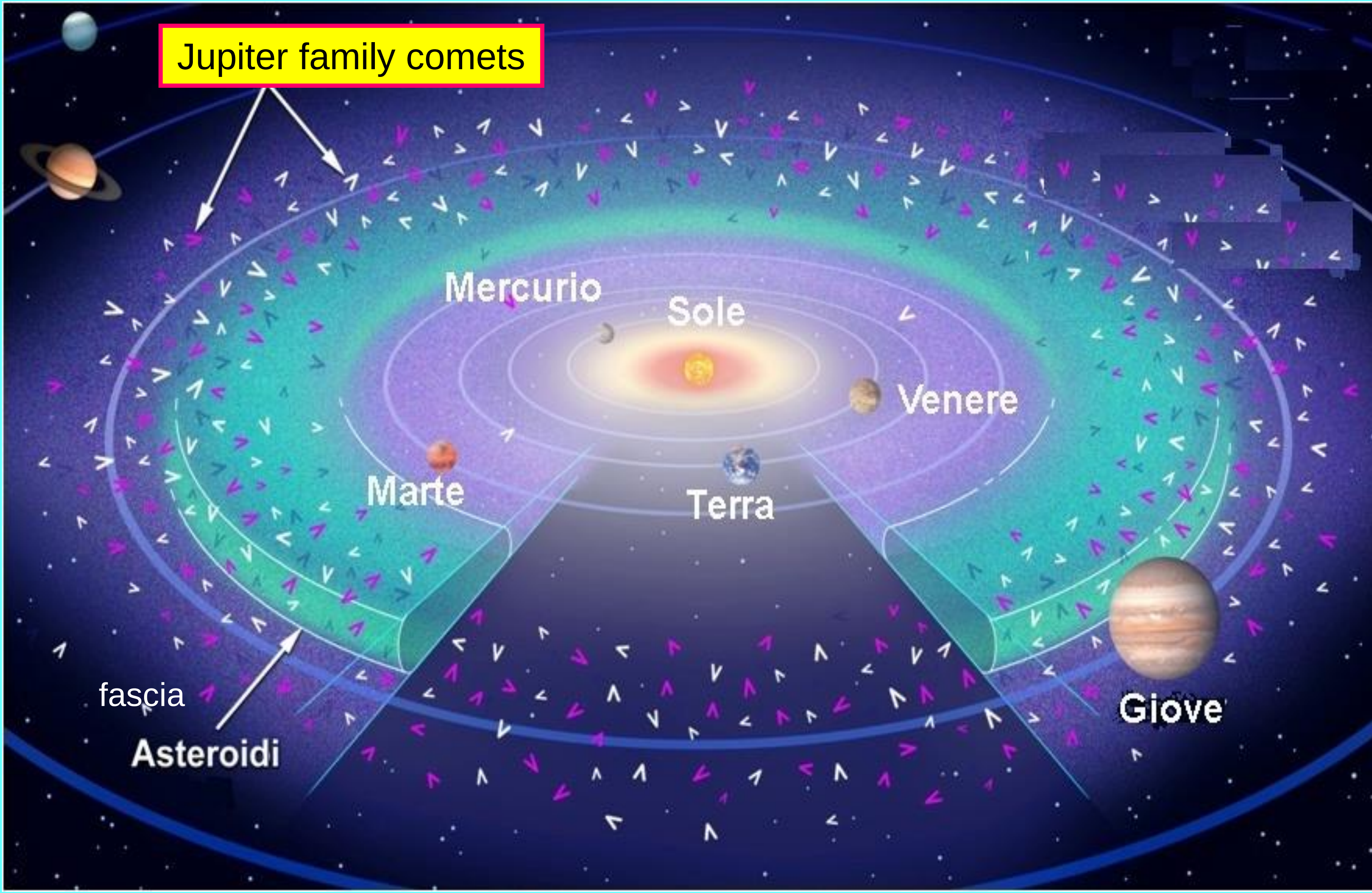
ROSETTA Launch date: 2 March 2004

Journey milestones:

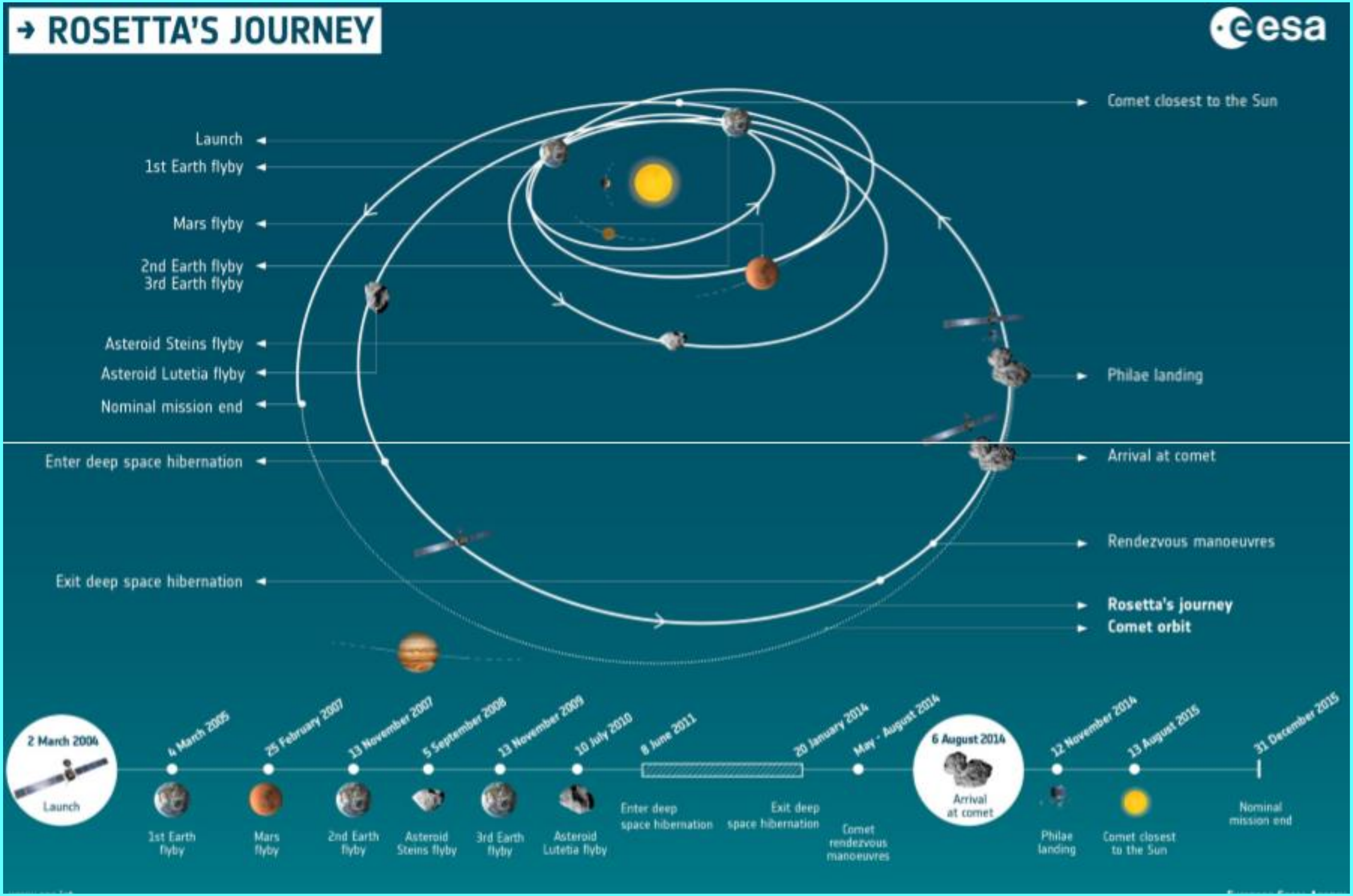
1st Earth gravity assist:	4 March 2005
Mars gravity assist	25 February 2007 (loss of energy)
2nd Earth gravity assist:	13 November 2007
Asteroid Steins flyby:	5 September 2008
3rd Earth gravity assist:	13 November 2009
Asteroid Lutetia flyby:	10 July 2010
Enter deep space hibernation:	8 June 2011
Exit deep space hibernation:	20 January 2014
Comet rendezvous manoeuvres:	May - August 2014 (loss of energy)
Arrival at comet:	6 August 2014
Philae lander delivery:	12 November 2014
Crossing of Mars orbit:	early June, 2015
Closest approach to Sun:	13 August 2015
Mission end:	31 December 2015 (??)

Launch vehicle: Ariane-5 G+, Launch mass: Orbiter: 2900 kg (including 1670 kg propellant and 165 kg science payload); Lander (Philae): 100 kg.
Dimensions: Orbiter: 2.8 x 2.1 x 2.0 m with two 14 metre long solar panels

Journey of Rosetta

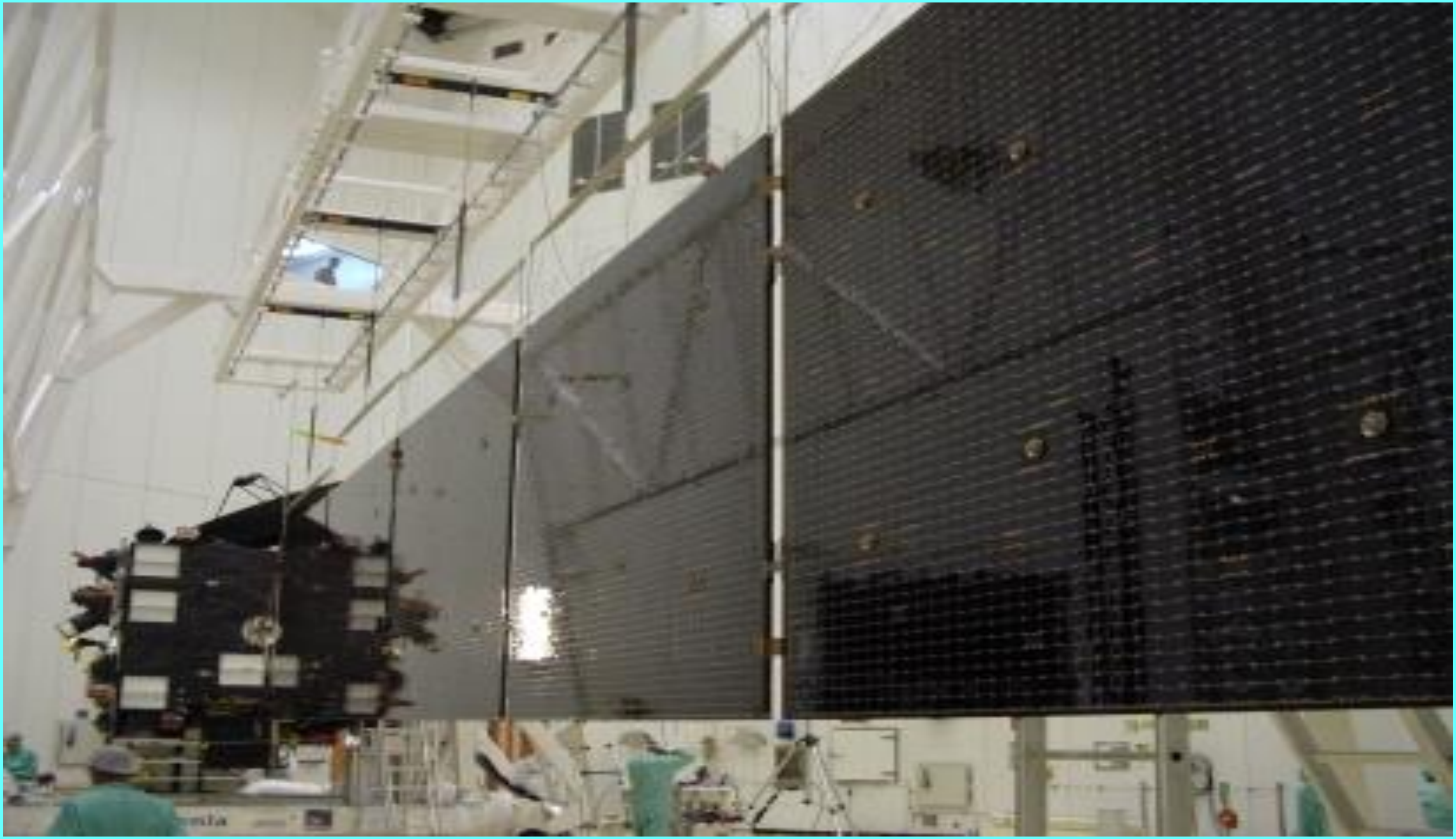


The journey of Rosetta



The Interplanetary Trajectory

The large solar panels (62 sqm)



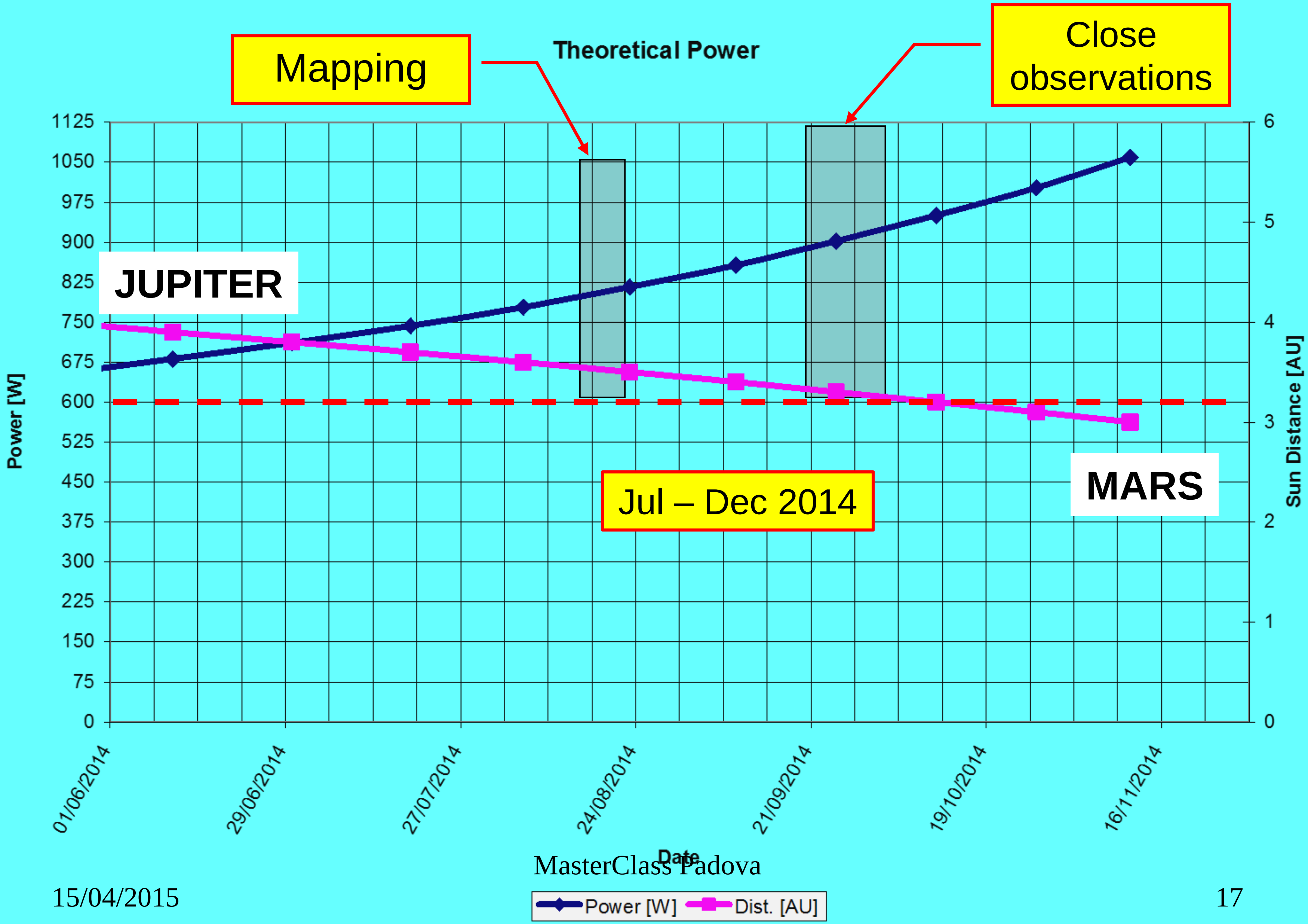
The largest ever launched in Space. Their sensitive area must always face the Sun, so that the Spacecraft is articulated across their plane.

Distance from Sun, power and bit rate, time of flight for signals

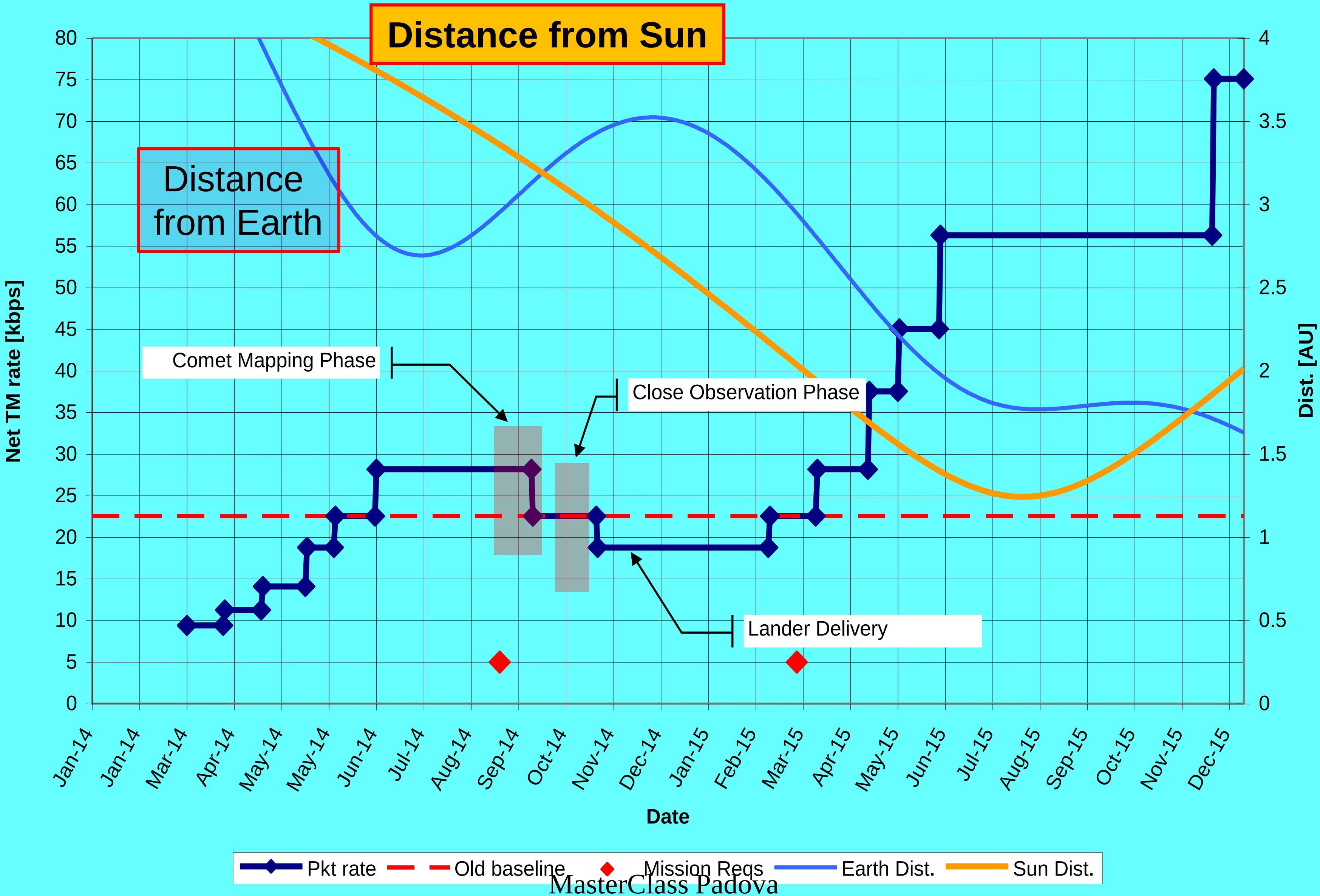
- The Sun- spacecraft distance varies between 180 and 600 million km.
- The light-time (one way) for communications is almost always > 8min
- Signals are transmitted and received in two bands:

  S- (2 GHz) and X- (8 GHz).
- ESA has three parabolic antennae of 35m diameter, in Malargue (Argentina), New Norcia (Australia) and Cerebros (Spain), plus smaller antennae in several other places.
- Support by NASA DSN (in particular the 70m antenna at Goldstone, CA) is needed in several phases of the mission.

Spacecraft Power Availability

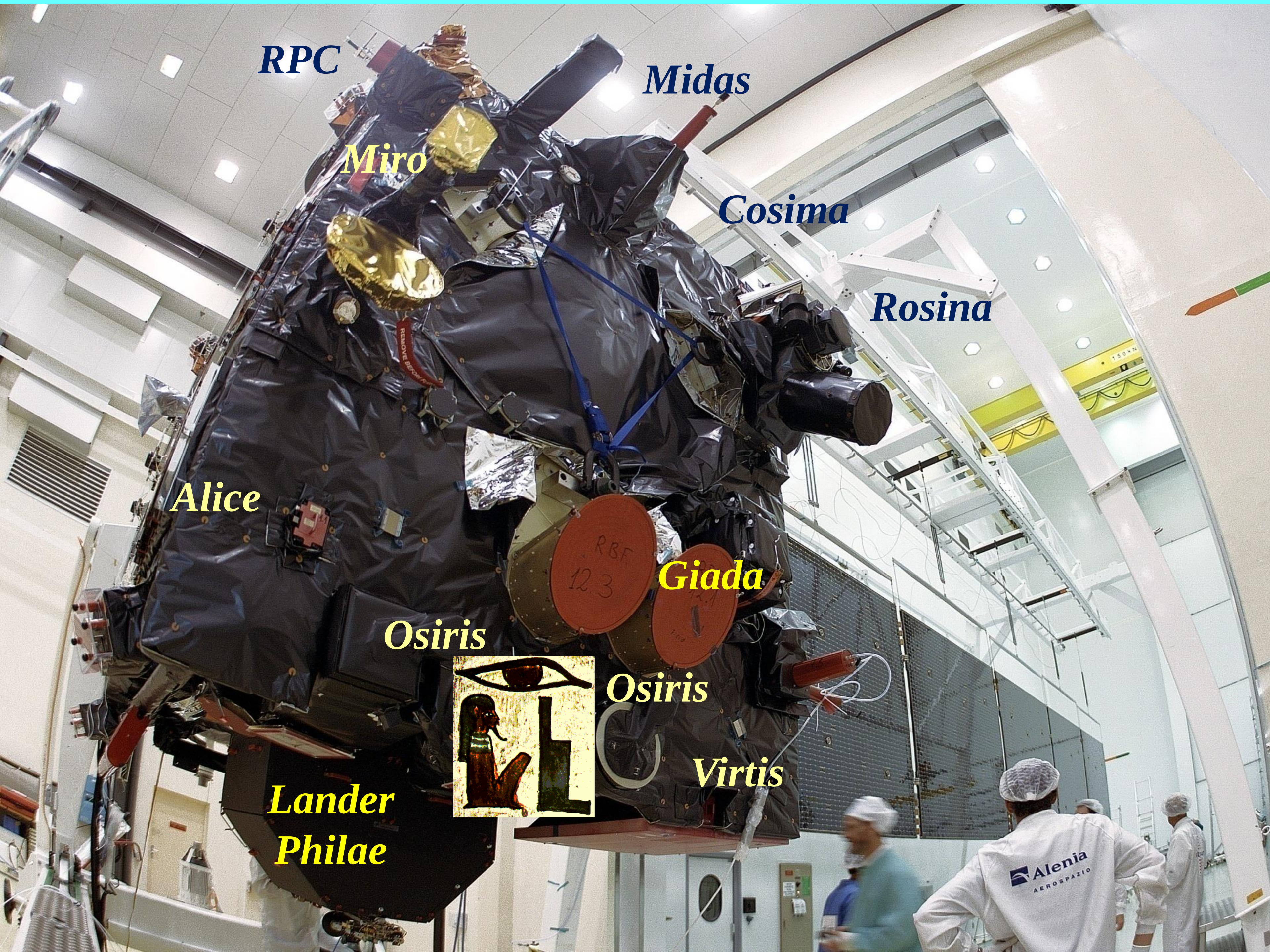


Data Downlink



Severe consequences

- Real-time operation: NO
- Multi-instrument operation: occasional
- Compression algorithms needed for images, very few full frame images
- Long delay between data acquisition and data examination (even months)
- 3D image reconstruction severely hampered


RPC
Midas
Miro
Cosima
Rosina
Alice
Giada
Osiris
Osiris
Virtis
Lander
Philae

Orbiter Instrument complement

11 science instrument packages

ALICE Ultraviolet Imaging Spectrometer (NASA)
CONSERT Comet Nucleus Sounding
COSIMA Cometary Secondary Ion Mass Analyser
GIADA Grain Impact Analyser and Dust Accumulator*
MIDAS Micro-Imaging Analysis System
MIRO Microwave Instrument for the Rosetta Orbiter (NASA)
OSIRIS Rosetta Orbiter Imaging System*
ROSINA Rosetta Orbiter Spectrometer for Ion and Neutral Analysis
RPC Rosetta Plasma Consortium
RSI Radio Science Investigation
VIRTIS Visible and Infrared Mapping Spectrometer*

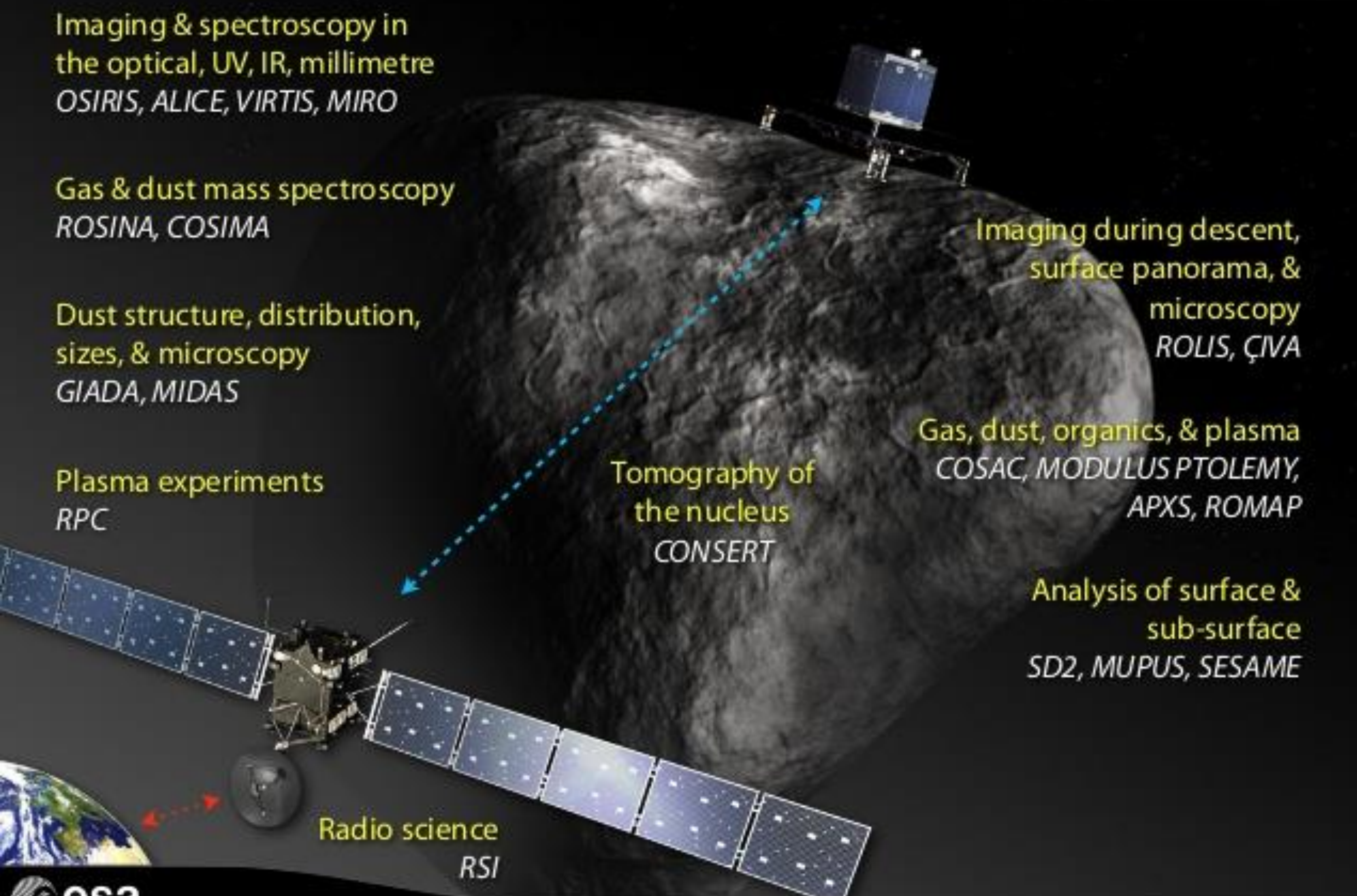
Partnerships: The scientific payload is provided by European scientific consortia + NASA for Alice and MIRO.
*** Italian PI-ship or strong participation**

Philae Instrument complement

10 science instrument packages

APXS Alpha Proton X-ray Spectrometer
ÇIVA / ROLIS Rosetta Lander Imaging System
CONSERT Comet Nucleus Sounding
COSAC Cometary Sampling and Composition experiment
MODULUS PTOLEMY Evolved Gas Analyser
MUPUS Multi-Purpose Sensor for Surface and Subsurface Science
ROMAP RoLand Magnetometer and Plasma Monitor
SD2 Sample and Distribution Device*
SESAME Surface Electrical Sounding and Acoustic Monitoring Experiment

Partnerships: The scientific payload is provided by European scientific consortia
*** Italian PI-ship or strong participation**


Imaging & spectroscopy in the optical, UV, IR, millimetre
OSIRIS, ALICE, VIRTIS, MIRO
Gas & dust mass spectroscopy
ROSINA, COSIMA
Dust structure, distribution, sizes, & microscopy
GIADA, MIDAS
Plasma experiments
RPC
Tomography of the nucleus
CONSERT
Radio science
RSI
Imaging during descent, surface panorama, & microscopy
ROLIS, ÇIVA
Gas, dust, organics, & plasma
COSAC, MODULUS PTOLEMY, APXS, ROMAP
Analysis of surface & sub-surface
SD2, MUPUS, SESAME

OSIRIS

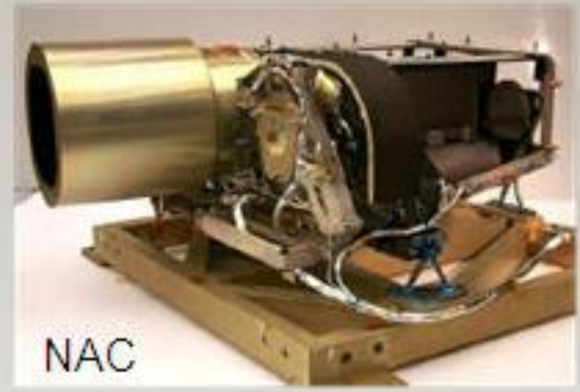
2 high performance cameras

- NAC and WAC
- Optimized for comet observations
- 23 filters from 250 to 1000 nm (UV to IR)

Built by European consortium from:

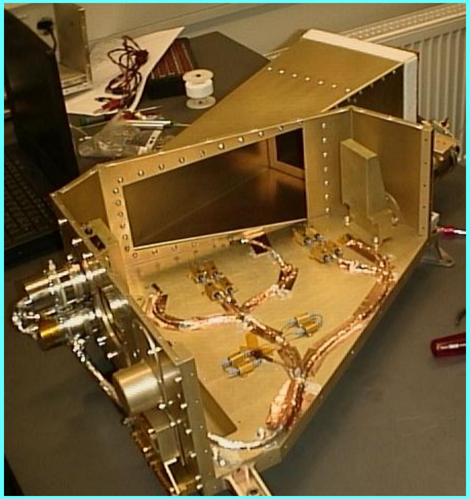
- France, Italy, Spain, Sweden, ESA, Germany

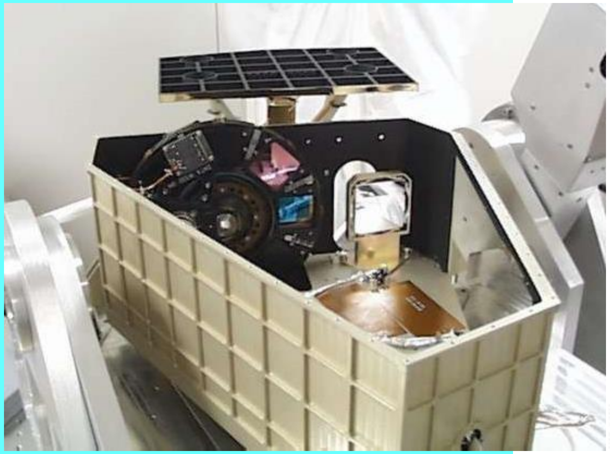
ESA ©2008 MPS for OSIRIS Team
MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA

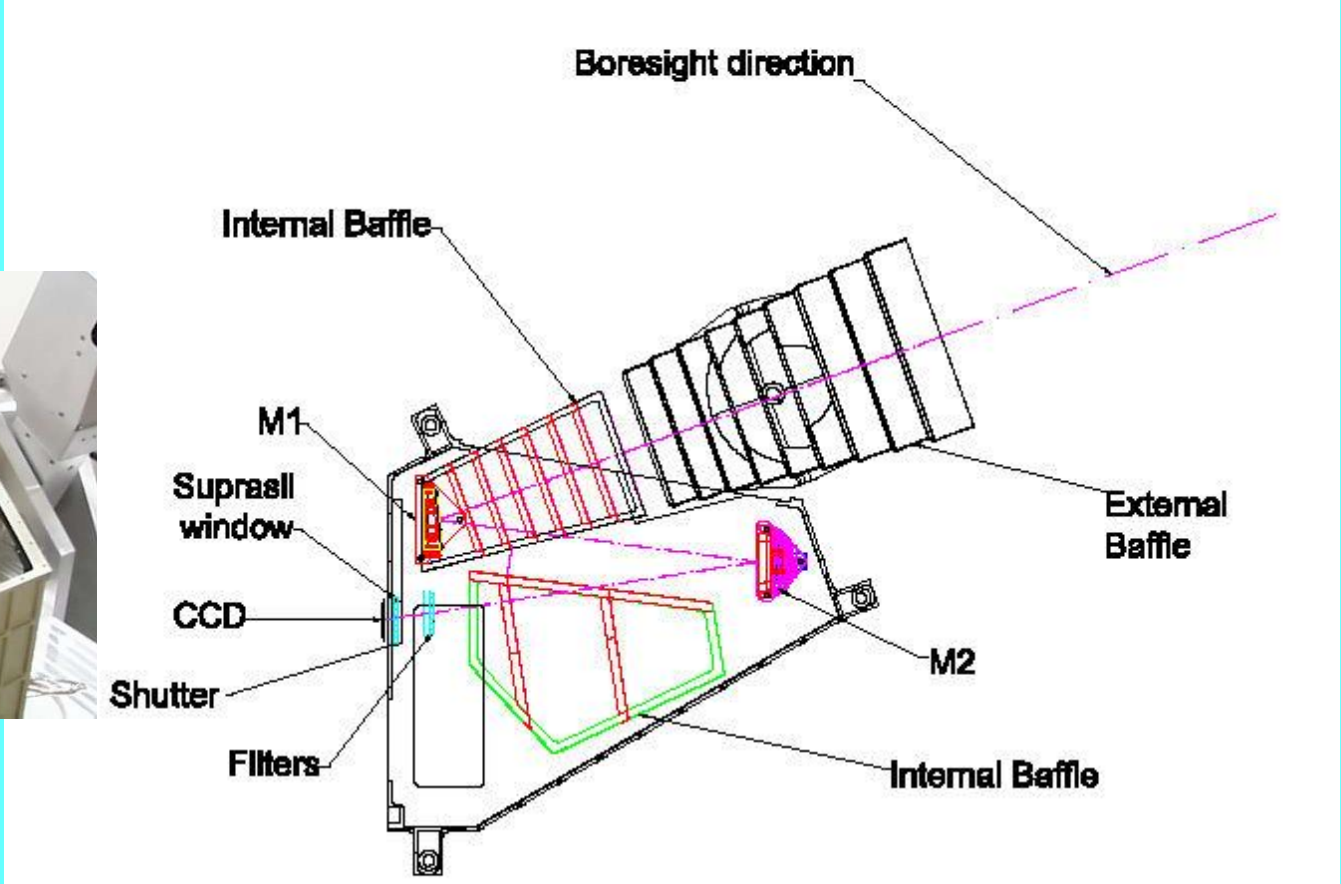


	Resolution (2 pixels)	Field of view	Resolution from 800 km distance (2 px)	Filters
NAC	8 arcsec (40 µrad)	2.2° (2024 x 2024 px)	32 m	12 broad band
WAC	42 arcsec (200 µrad)	12° (2024 x 2024 px)	160 m	12 narrow and 2 broad band

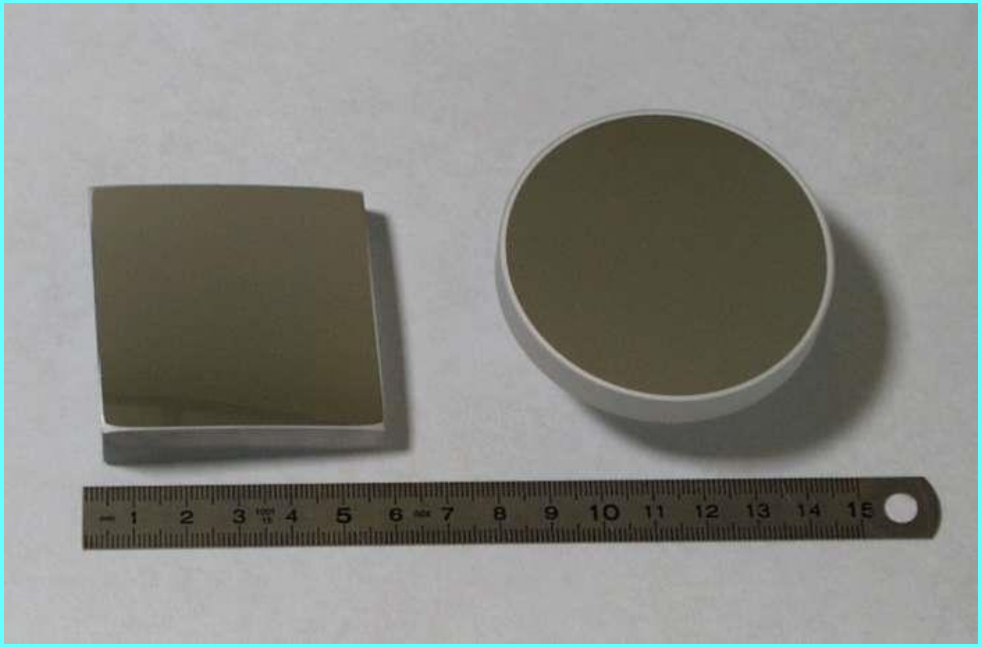
Wide Angle Camera 1







OSIRIS

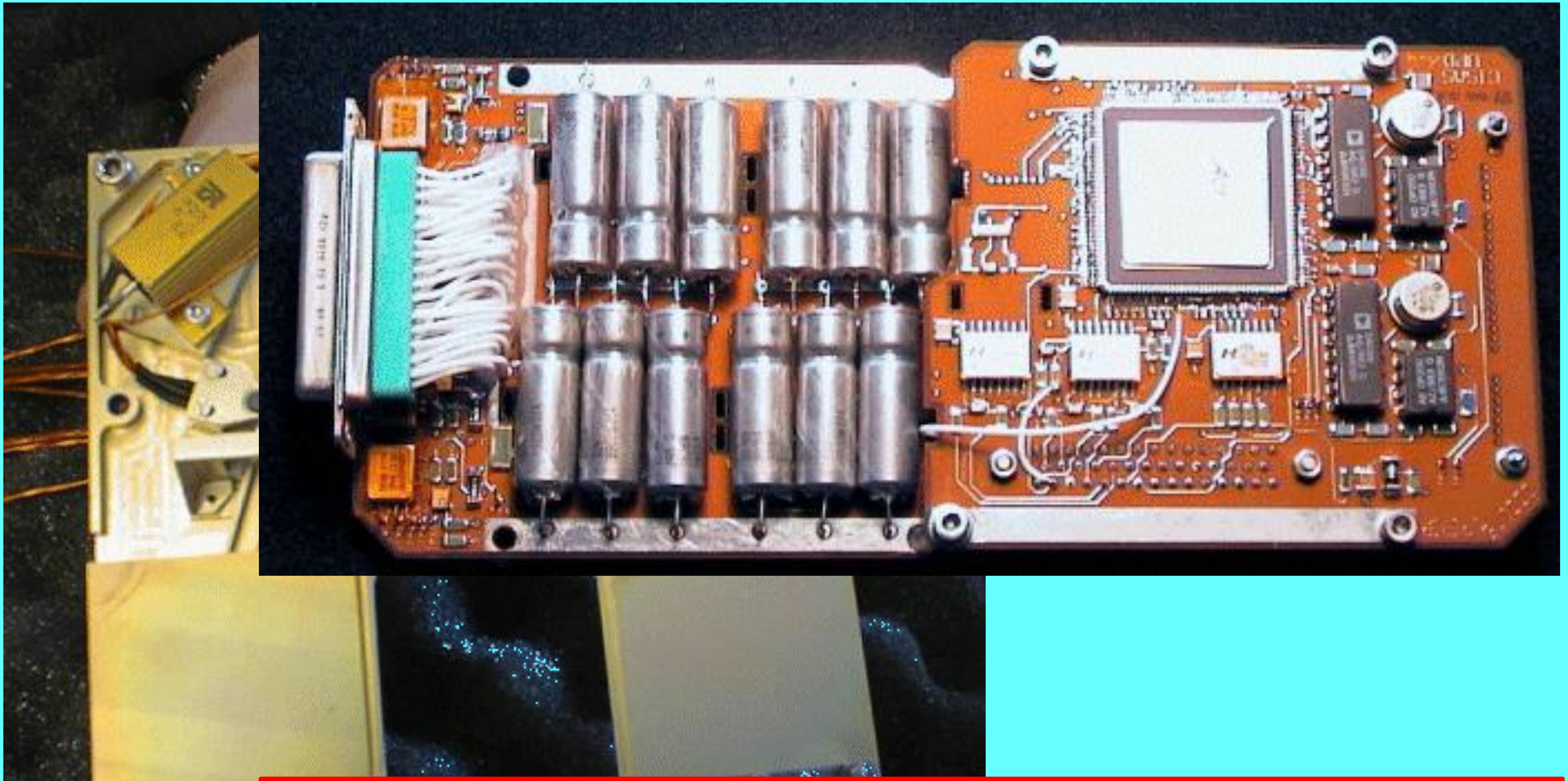


The mirrors of the WAC are more or less as large as the lenses of Galileo's first 'cannocchiale'

Wide Angle Camera 2

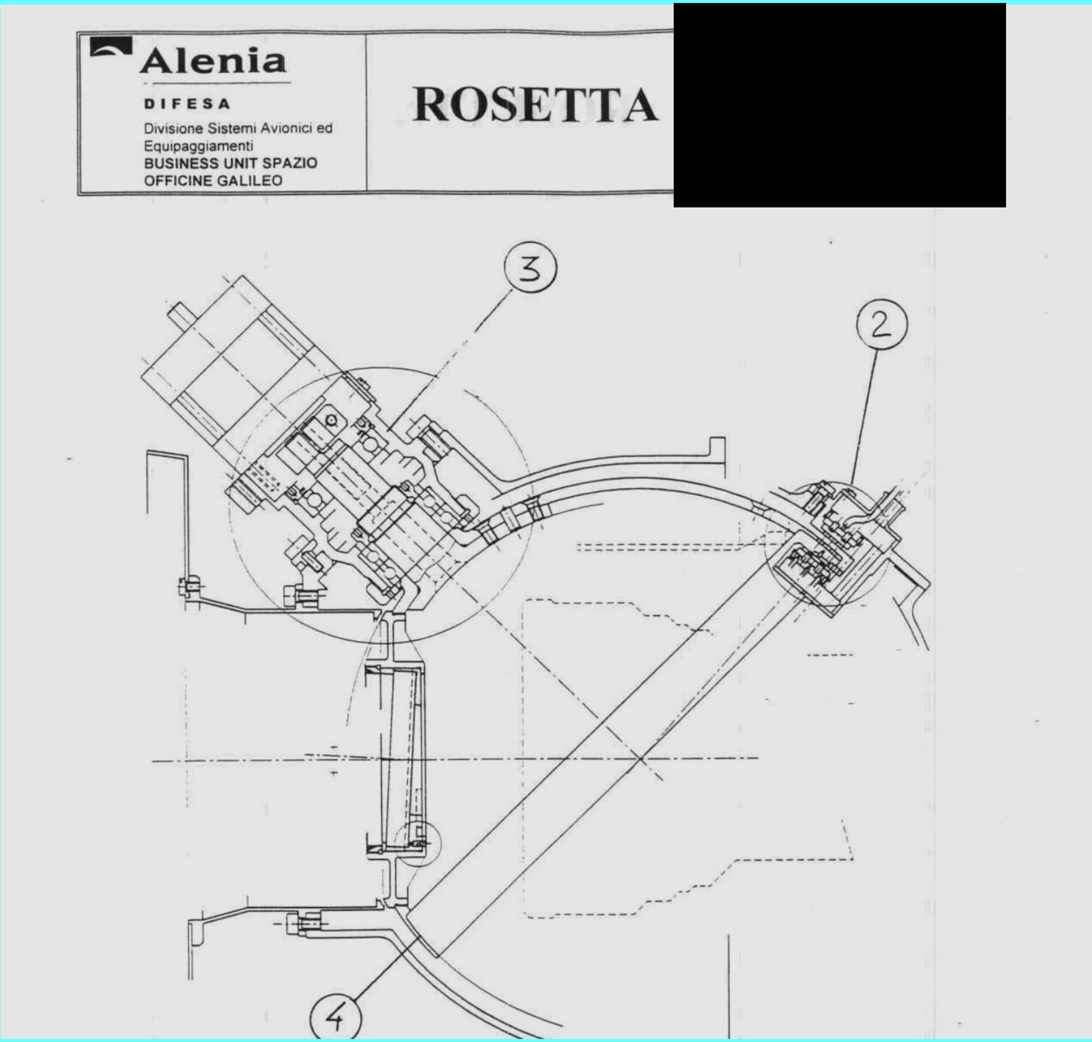
Tests of WAC

Shutters of WAC e NAC



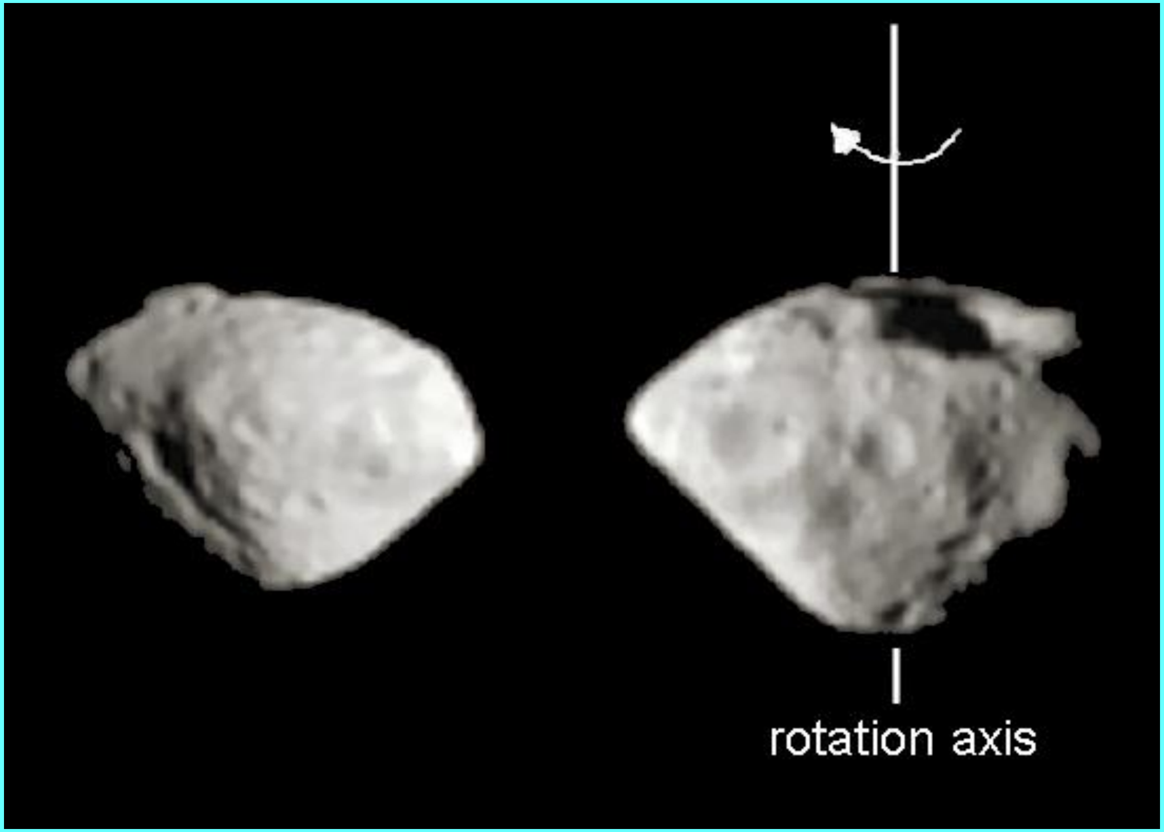
Up to 2 Feb 2015, we obtained 8783 NAC images and 6961 WAC images, with a very low error rate.

The ‘third eye’ of Rosetta



The two navigation cameras (NAVCAM).
Built by SELEX ES, Italy.
Optics made by lenses not mirrors.
CCD with 512x512 px (OSIRIS 2048x2048),
Same spatial resolution of WAC
no color filters but beautiful images.

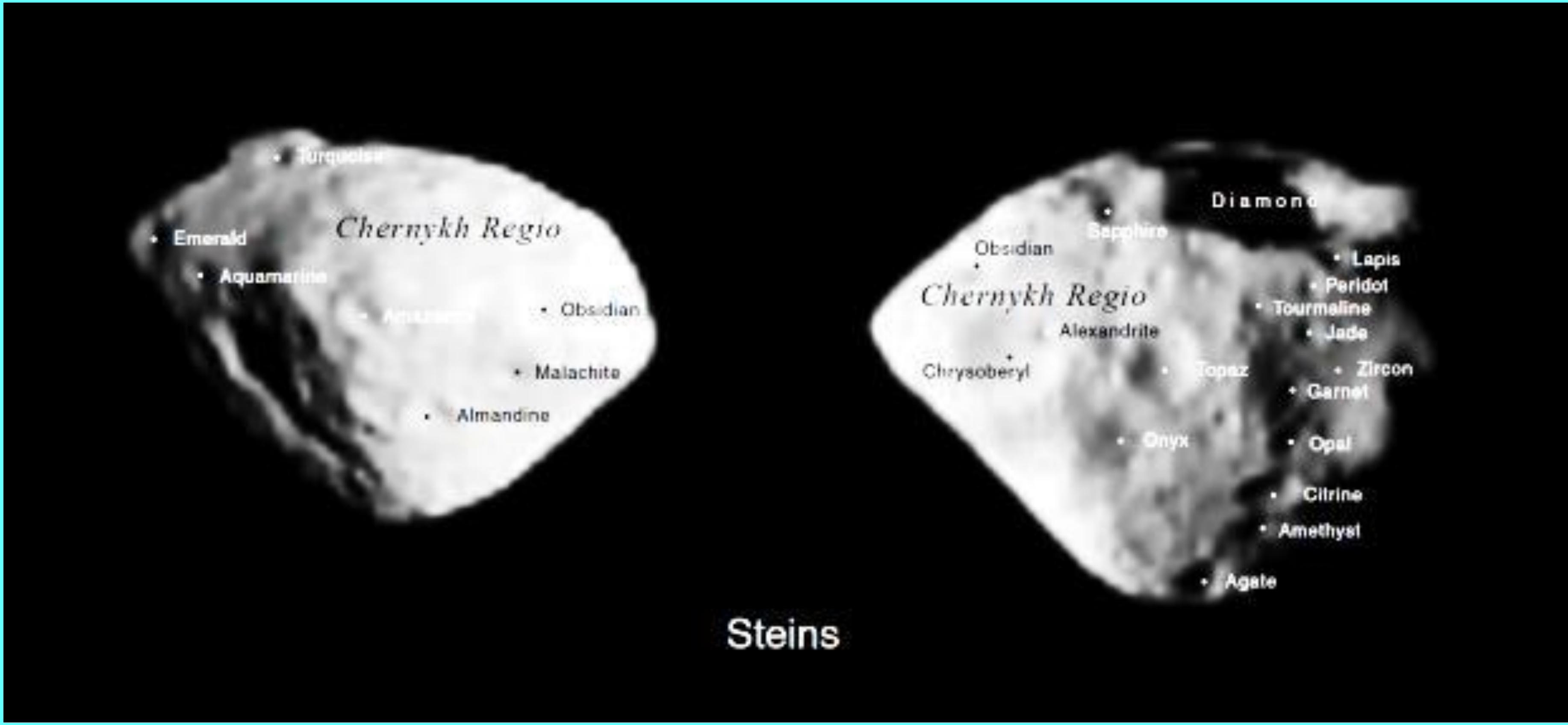
September 2008: Steins



The first asteroid ever reached by a European Spacecraft.
Looks like a 'diamond' in the sky. Many impact craters, one almost destructive.

The rotation axis passes through the large crater on top. Period of rotation about 8 hours.

Names of precious stones on Steins

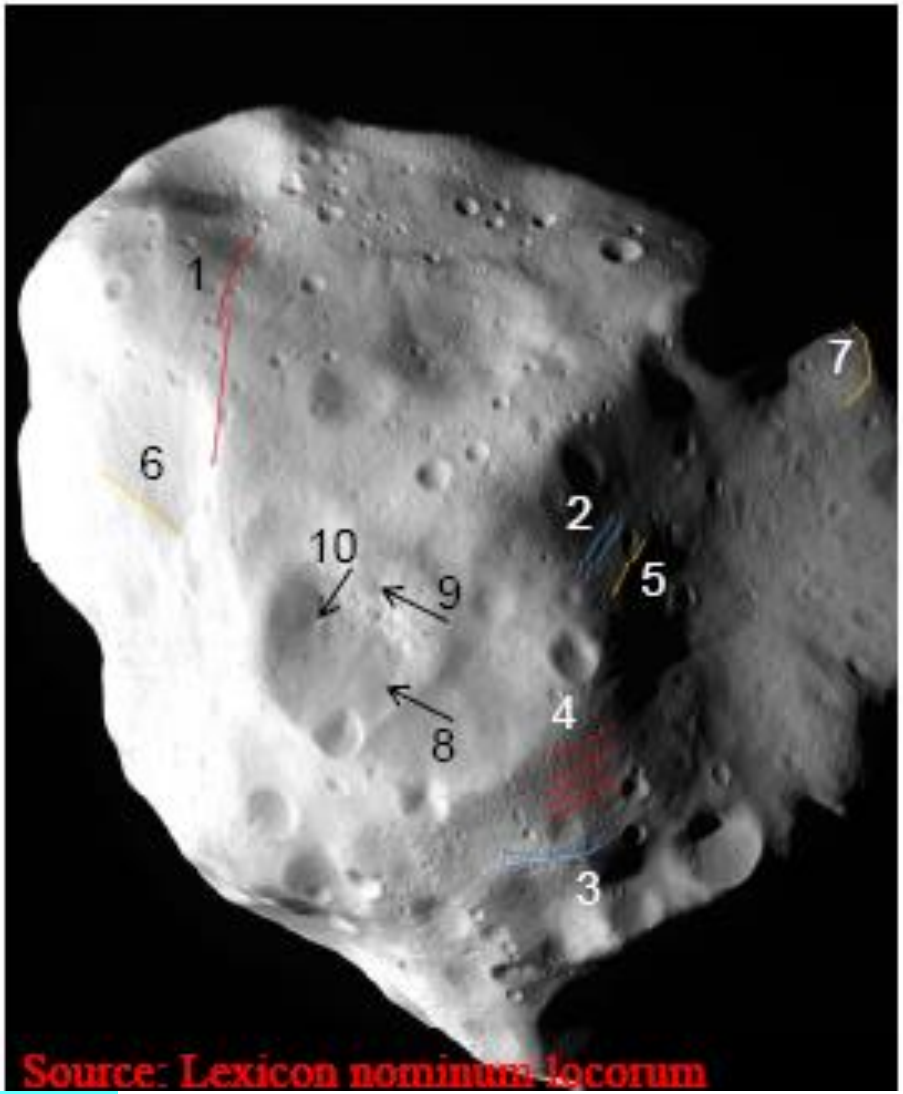


Steins was discovered by Nikolay Stepanovich Chernykh, and named after Kārlis Šteins.

July 10, 2010: Lutetia

A large asteroid, 120 km diameter, for a few months the largest encountered by a Spacecraft, now is the third (after Vesta and Ceres).

Latin names on Lutetia

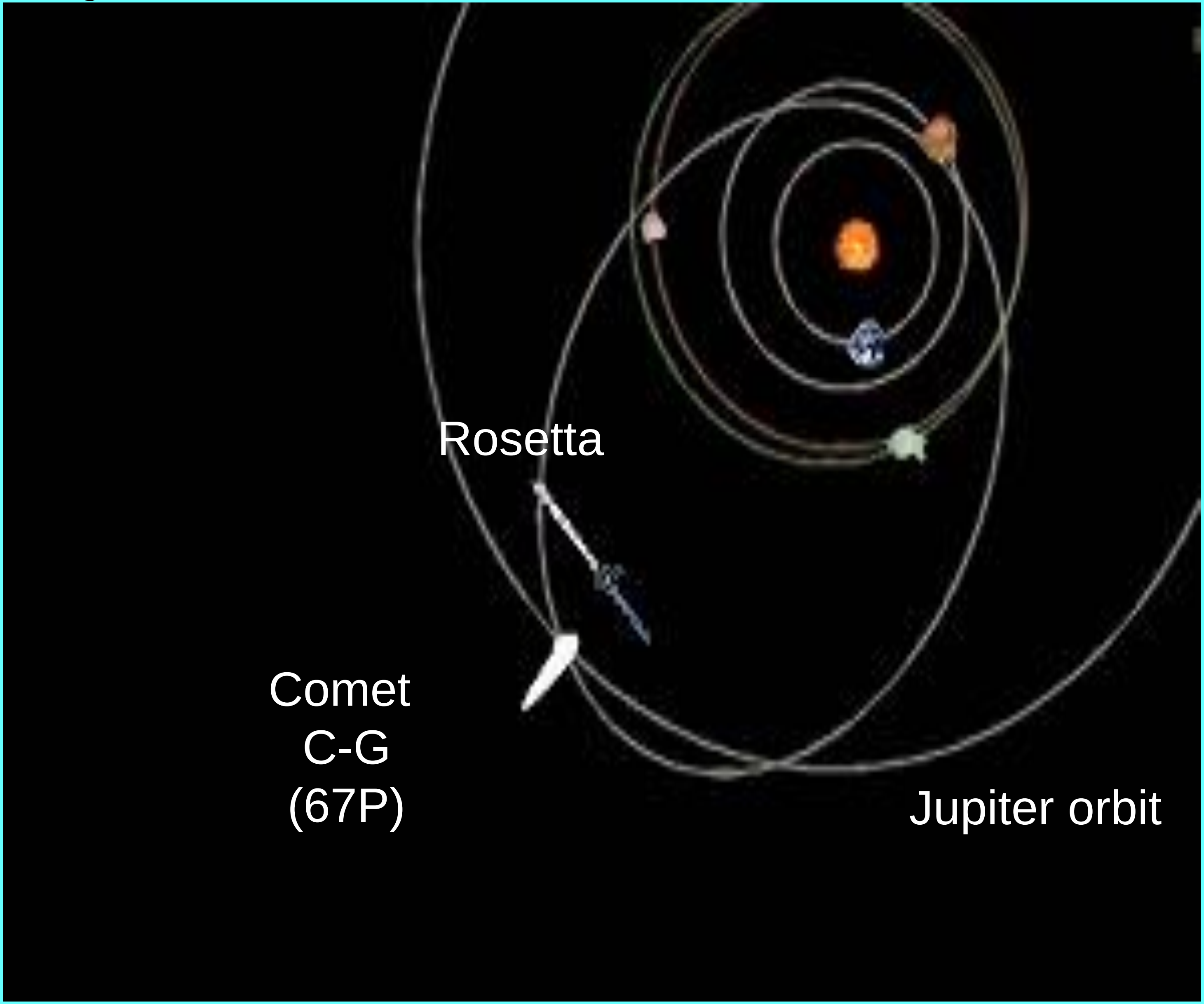


Curvilinear features:
rima, fossa, cavus, dorsum, rupes, labes

1. **Tiberis** rima system (p.309)
2. **Sequana** fossa (p.287)
3. **Hiberus** fossa (p. 107)
4. **Rhodanus** rimae(p.263)
5. **Ticinum** dorsum (p. 310)
6. **Rhenus** rupes (p. 257)
7. **Glana** rupes (p.130)
8. **Danuvius** labes (p. 97)
9. **Gallicum** labes (p. 124)
10. **Sarnus** labes (p. 281)

IAU approved feature types:
- Fault: rima
- Graben: fossa
- Groove: cavus
- Fracture: rima
- Ridge: dorsum
- Scarp: rupes
- Landslide: labes

July 2010, after Lutetia towards comet C-G



There are different types of comets, roughly speaking

the ‘new’ ones

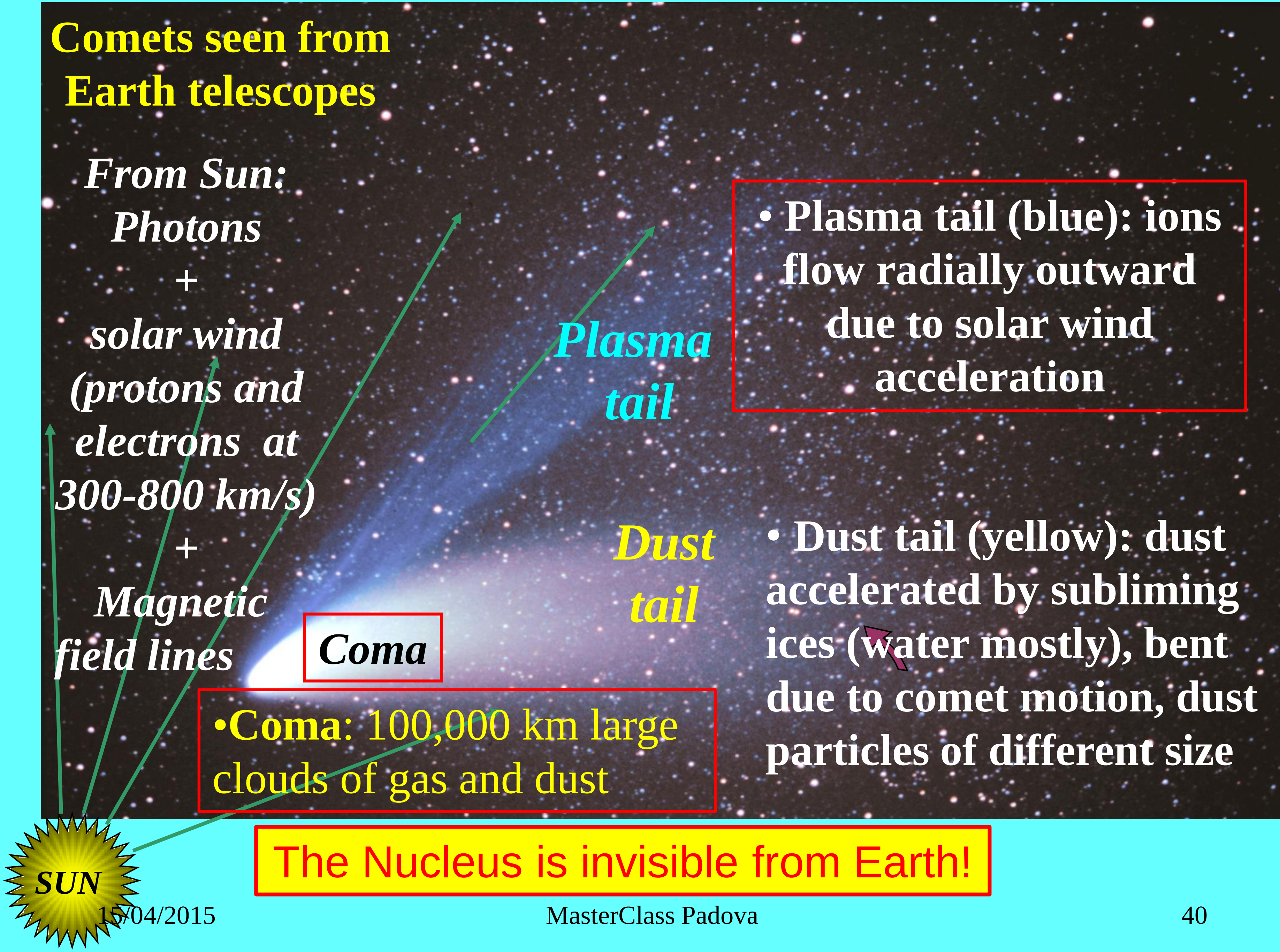
and

the ‘periodic’ ones

Two ‘new’ comets

Comets seen from Earth telescopes

From Sun:
Photons
+
solar wind (protons and electrons at 300-800 km/s)
+
Magnetic field lines



- **Plasma tail (blue): ions flow radially outward due to solar wind acceleration**

- **Dust tail (yellow): dust accelerated by subliming ices (water mostly), bent due to comet motion, dust particles of different size**

•**Coma**: 100,000 km large clouds of gas and dust

The Nucleus is invisible from Earth!

Very complex chemistry

Different processes transform the original molecules present in the inner nuclear regions (‘mothers’), in what can be observed from ground (‘daughters’).

In situ observations from Rosetta may observe the ‘mothers’ and clarify such processes.

Photo dissociation (UV Solar)
Sublimation
Photo ionisation

→

Atoms
Molecules
Ions
***Free electro**ns*

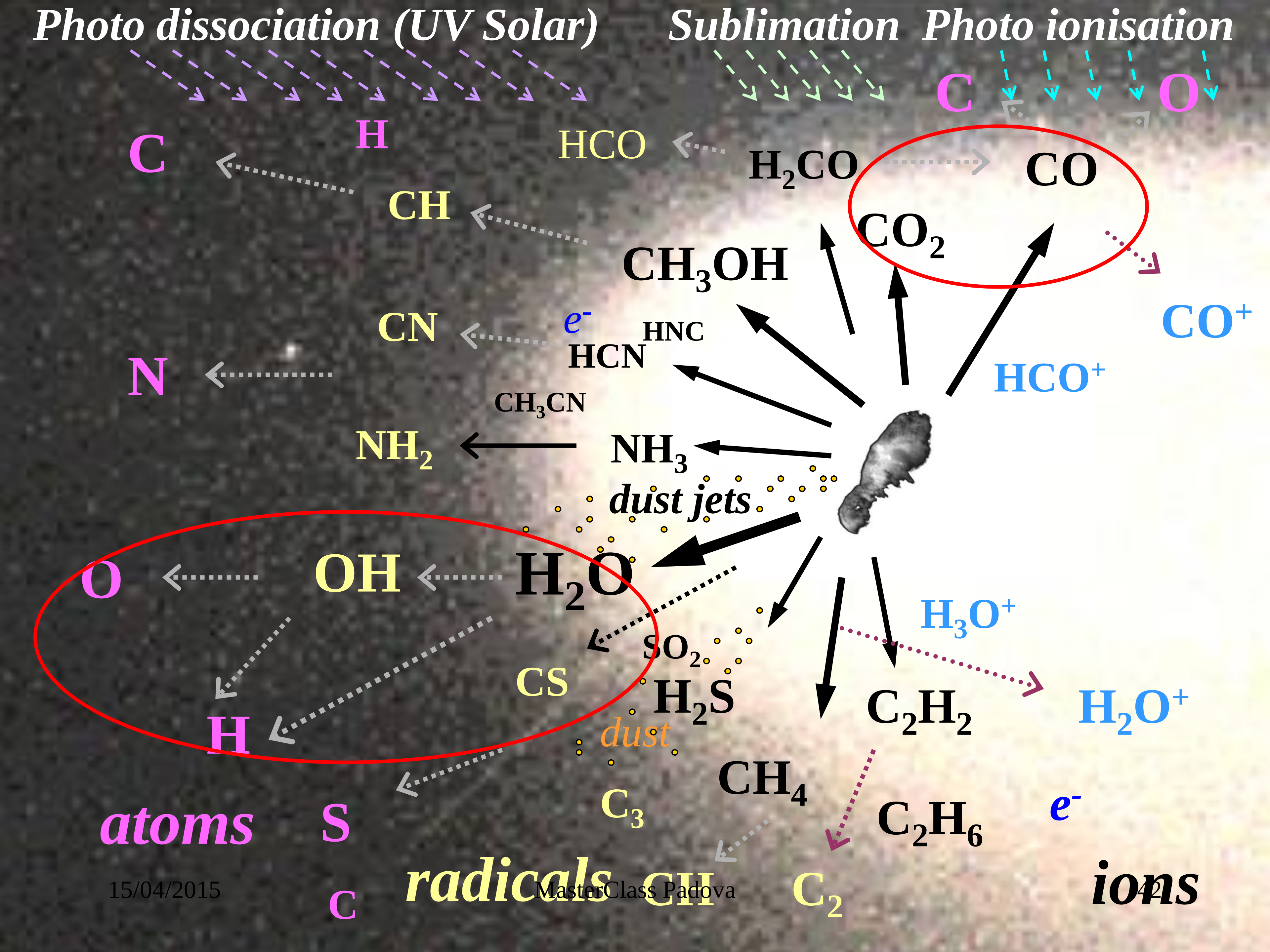
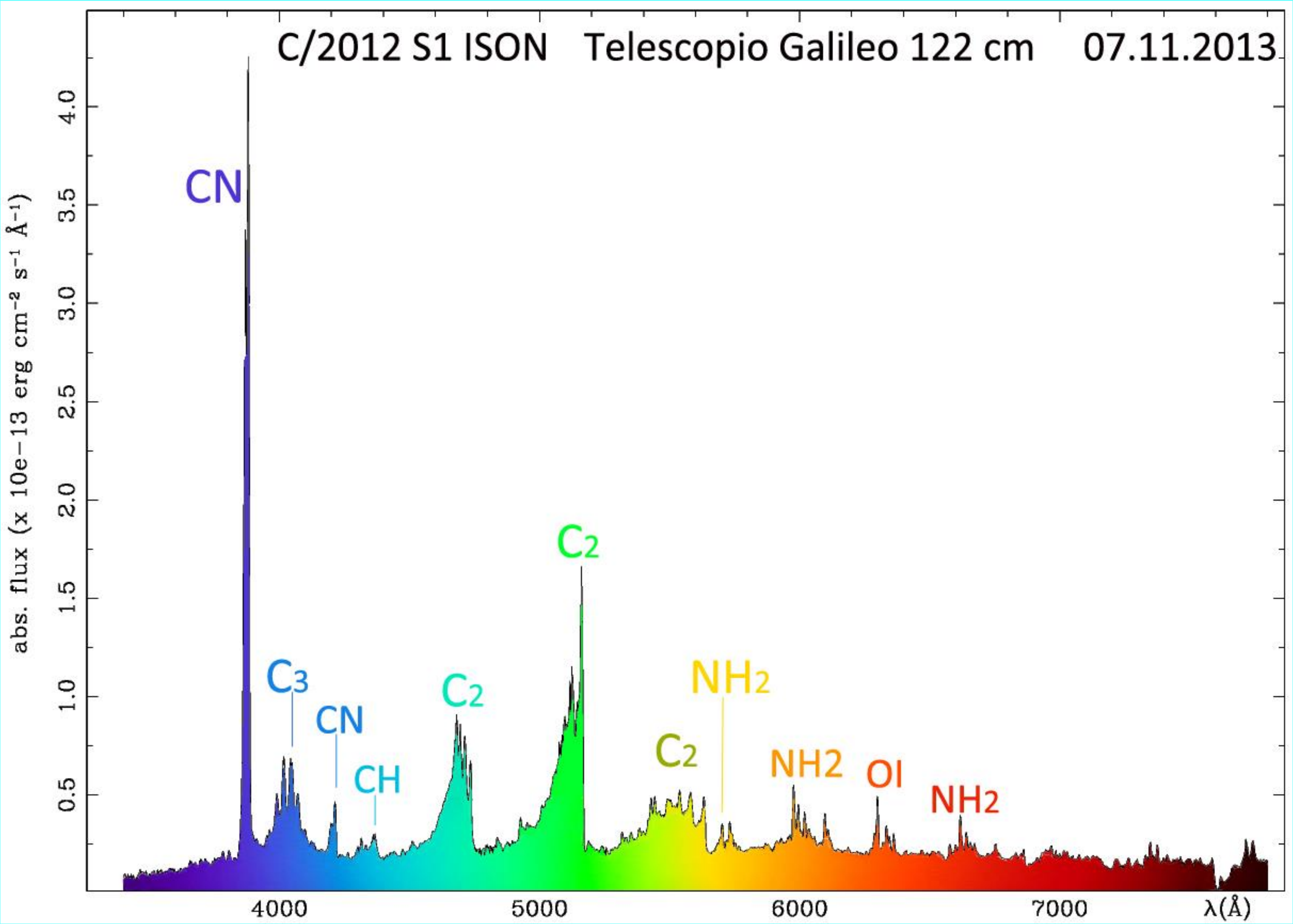
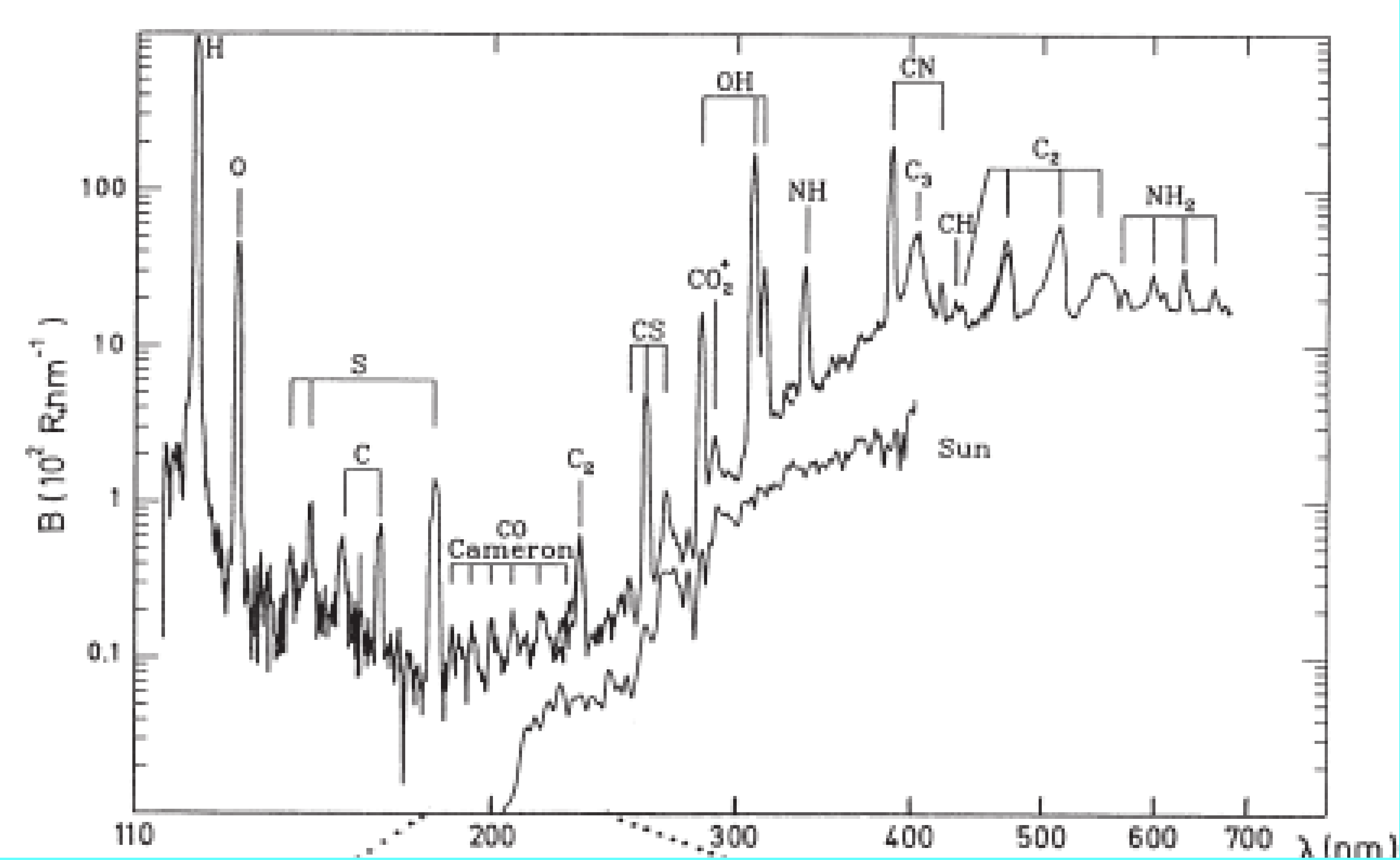


Photo dissociation (UV Solar)
Sublimation
Photo ionisation
C
O
H
HCO
C
CH
H_2CO
CO
CO_2
CH_3OH
CN
e^-
HNC
HCN
N
CO^+
HCO^+
CH_3CN
NH_2
NH_3
dust jets
O
OH
H_2O
H_3O^+
SO_2
CS
H_2S
H
dust
C_2H_2
H_2O^+
CH_4
C_3
C_2H_6
e^-
atoms
S
radicals
CH
C_2
C
ions

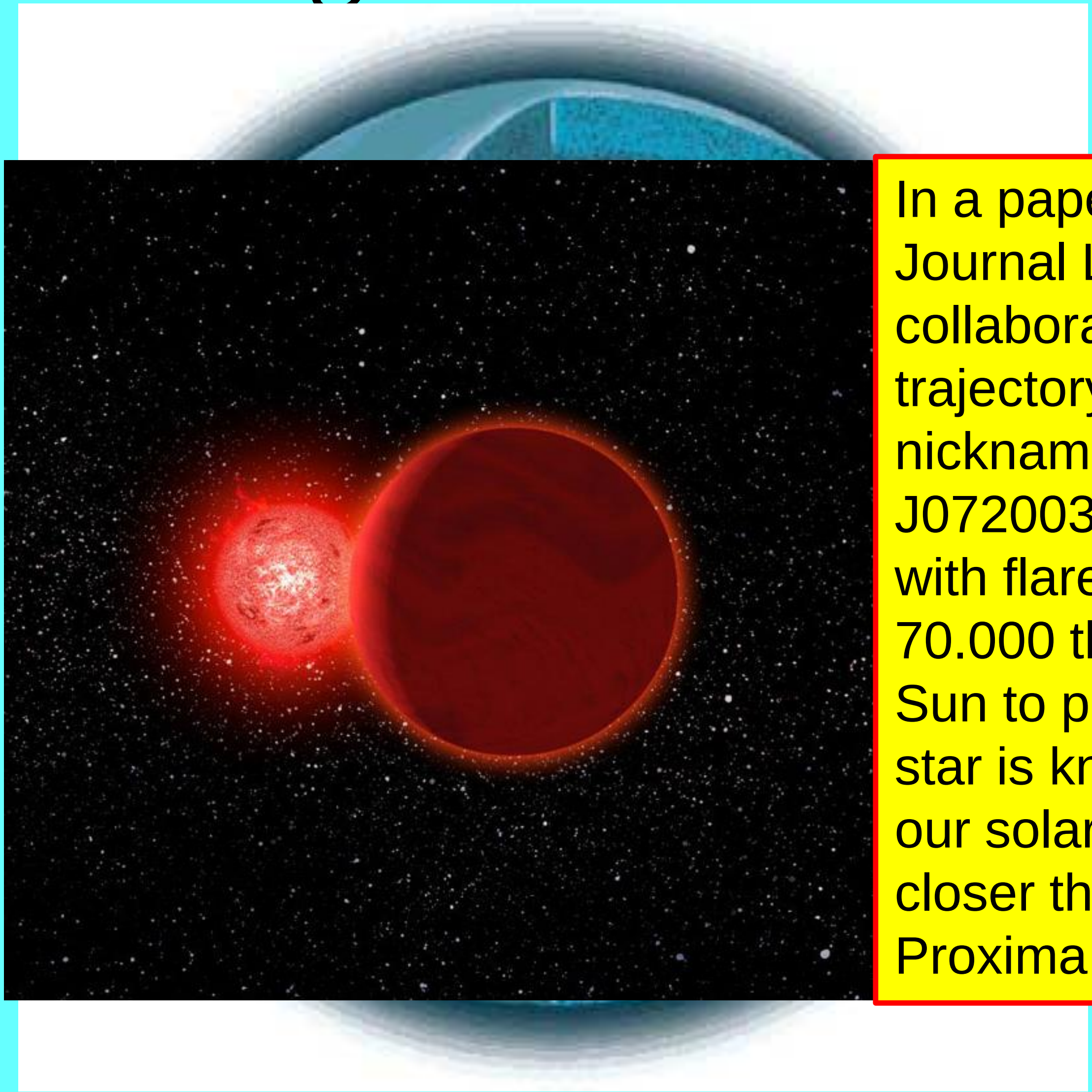


Cometary emission bands. The underlying solar-type spectrum has a maximum at about 5500 A and represents sunlight reflected from the cometary dust grains.

UV-Vis spectrum of comet P/ Hartley 2



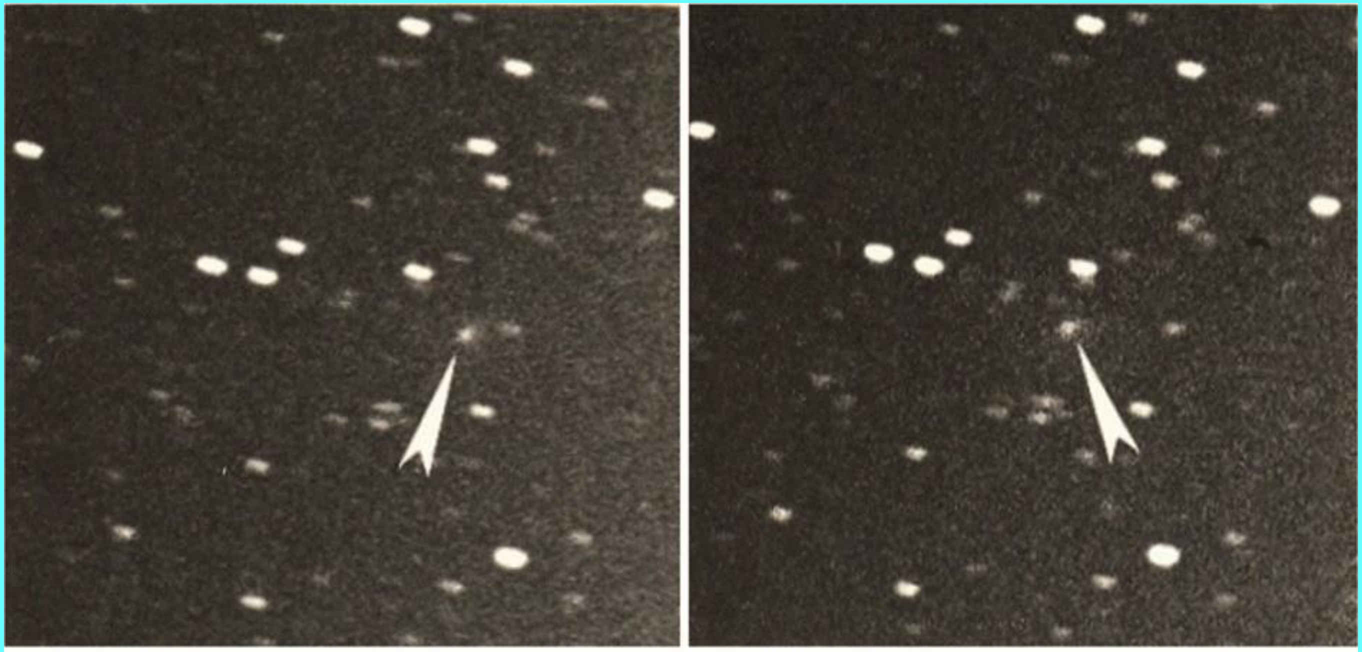
Original location of new comets



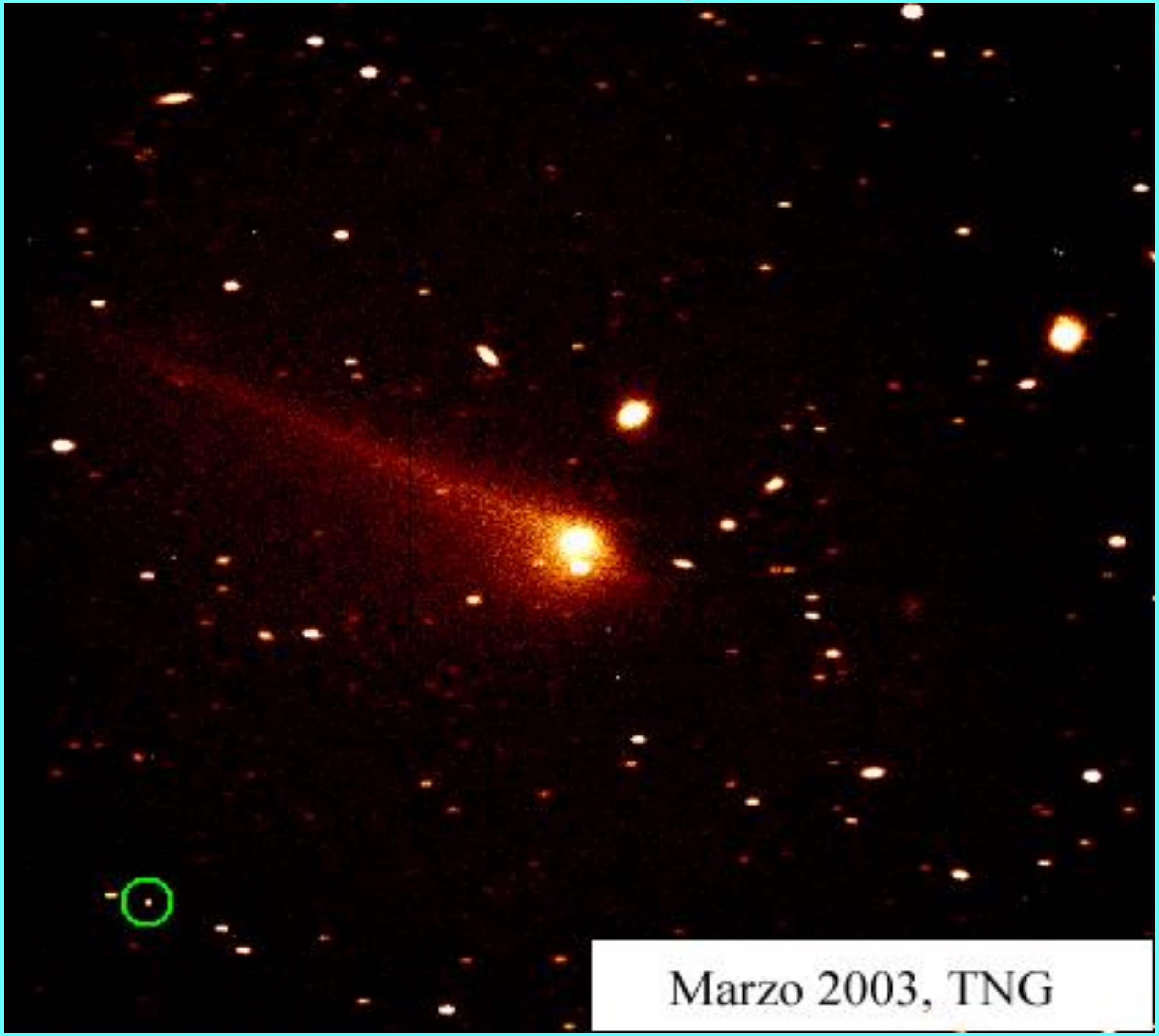
In a paper published in Astrophysical Journal Letters (2015) E. Mamajek and collaborators analyzed the velocity and trajectory of a low-mass star system nicknamed "Scholz's star" (WISE J072003.20-084651.2, a binary system with flare star). They claim that about 70.000 the star passed so close to the Sun to perturb the Oort Cloud. No other star is known to have ever approached our solar system this close - five times closer than the current closest star, Proxima Centauri.

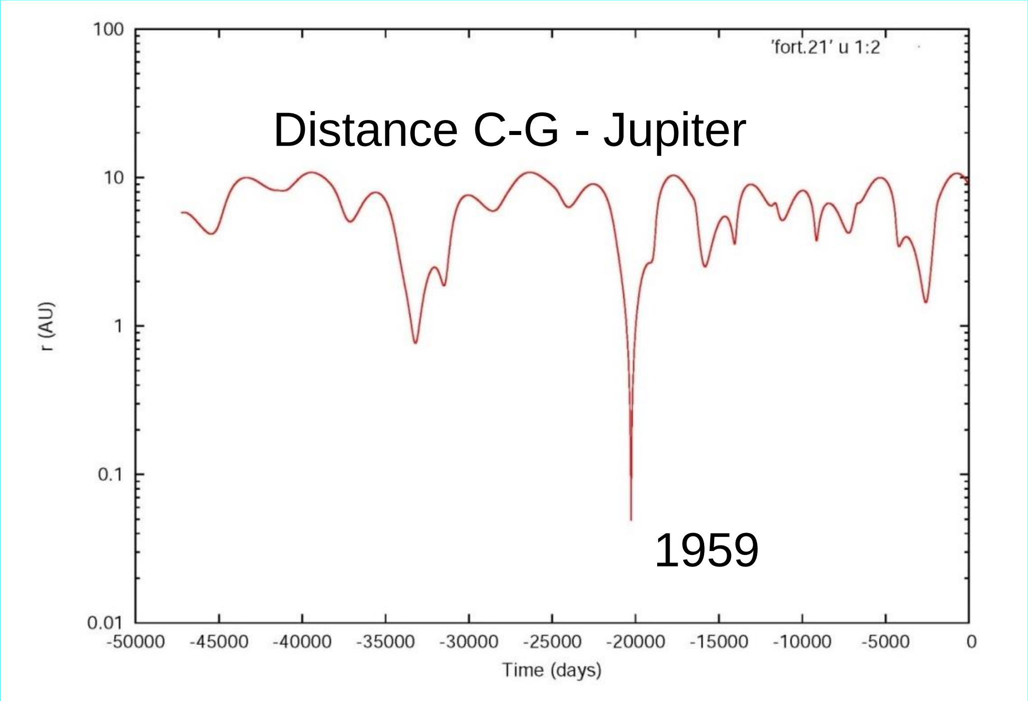
Comet Churyumov-Gerasimenko

67P C-G, the 67th periodic comet, is a small comet of Jupiter family not visible by naked eye. It was discovered in1969.

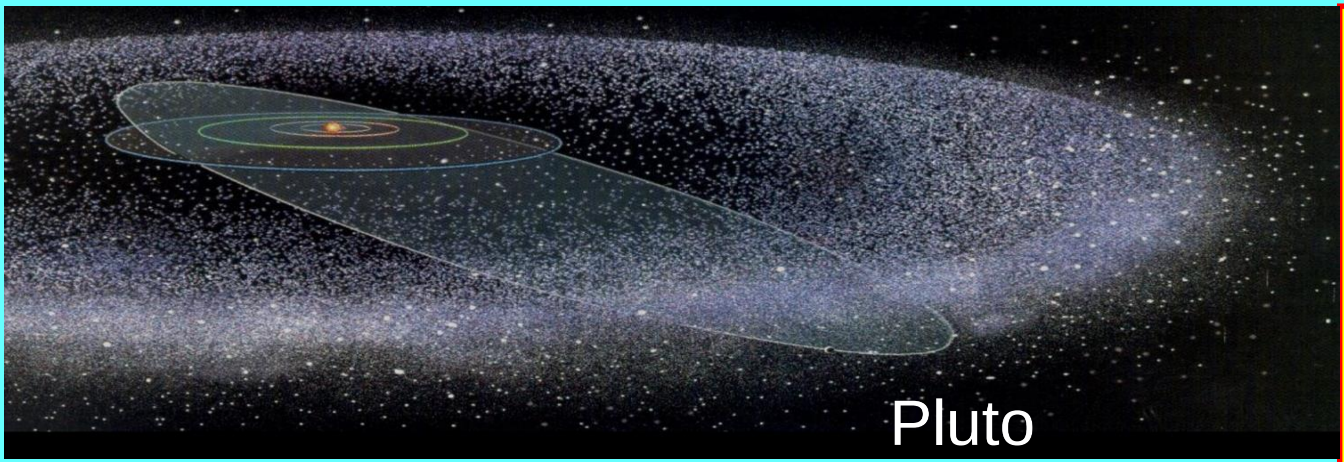


Comet 67P C-G from a ground telescope





The comet was 'captured' by Jupiter in 1959, and since then is part of the family of Jupiter comets. Its orbital period is approximately 6.5 years.



Favored scenario for its origin: born in the outer Kuiper Belt, may be as two or more bodies gently colliding.

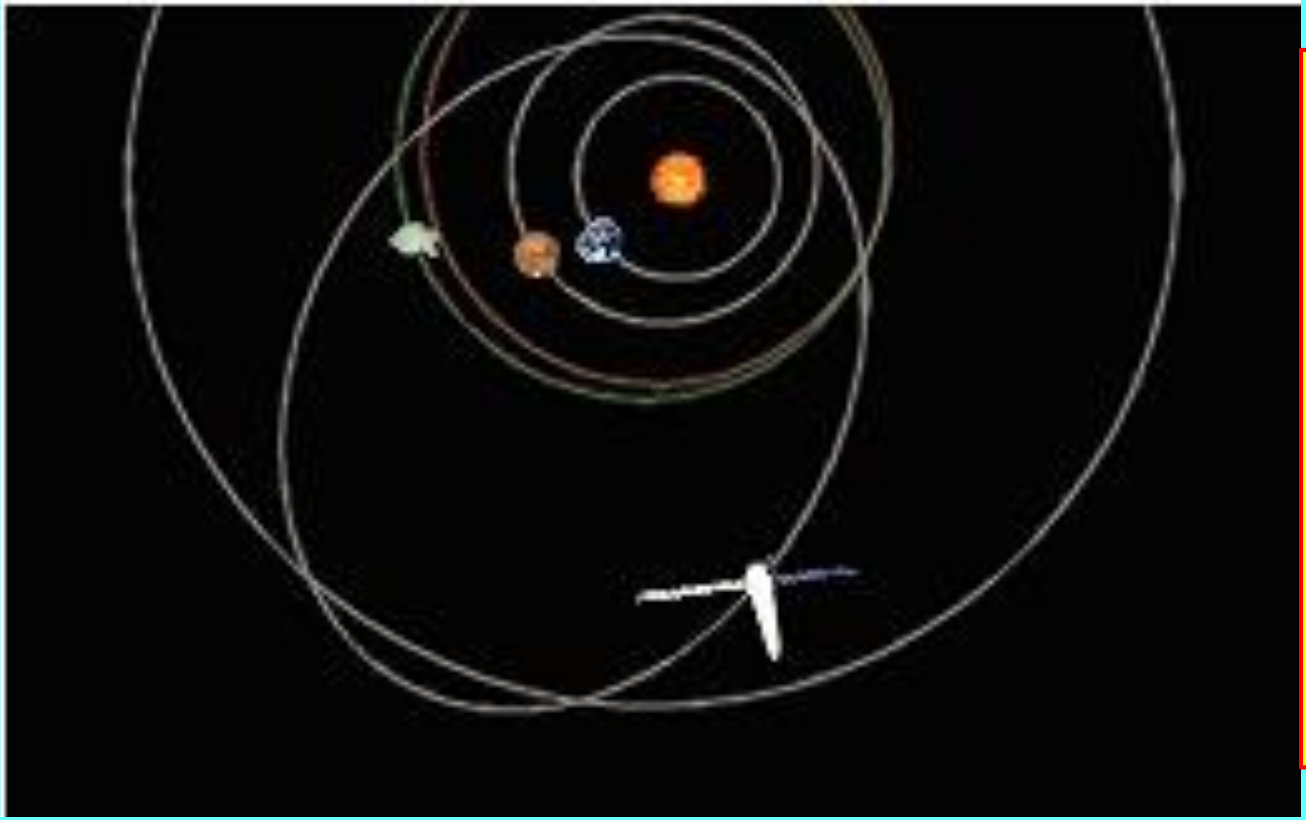
8 June 2011: deep space hibernation of Rosetta

Per sopravvivere al grande freddo di quella zona esterna, ***dove nessuna sonda europea era mai arrivata***, si prese la drastica decisione di ibernare tutto i sottosistemi non indispensabili, tra cui quello di trasmissione di posizione e dati.

Quindi dal giugno 2011 la sonda rimase totalmente silente e incapace anche di ricevere comandi.

Furono lasciati accesi solo alcuni termistori per scaldare le parti più delicate e un timer programmato ***per risvegliarsi esattamente alle ore 10 di tempo universale del 20 gennaio 2014***.

20 Jan 2014, at 10 (UT) o'clock



Il risveglio di Rosetta avvenne grazie a una serie di operazioni pre-programmate e compiute autonomamente, senza nessun comando da terra.

I primi segnali avrebbero dovuto essere ricevuti alle ore 18:30, ma in effetti arrivarono solo alle 19:20, dopo quasi un'ora di spasmodica attesa!

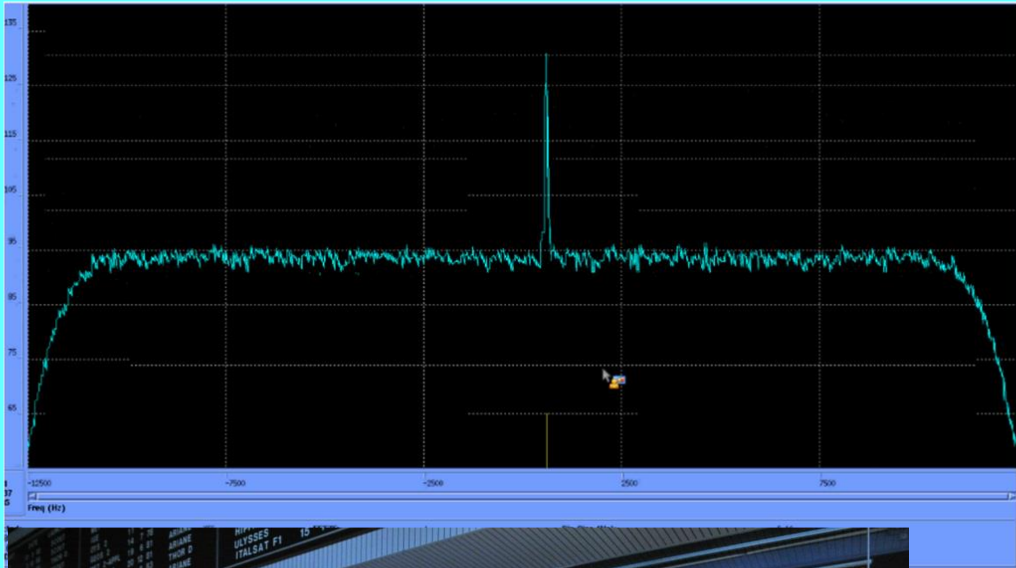
The ‘official’ song

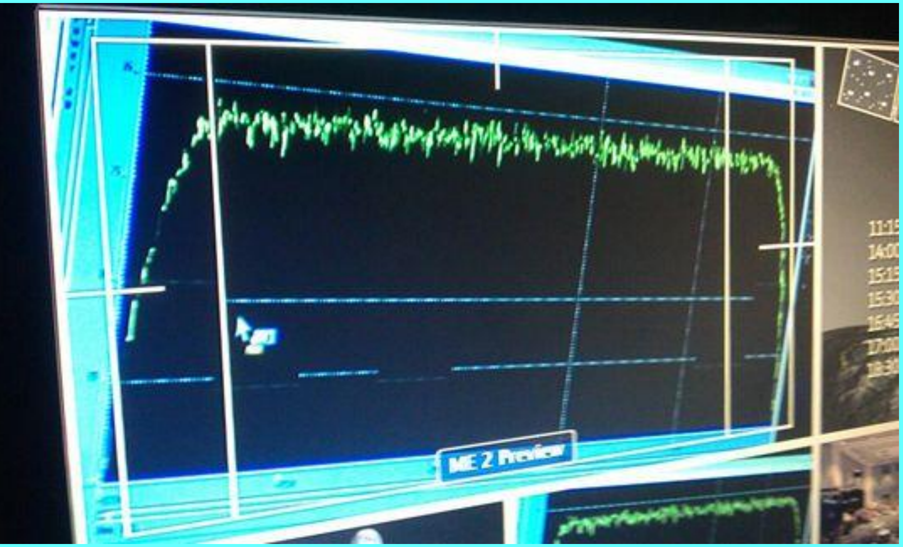
http://www.youtube.com/watch?v=AB3fncWyVN4

20 Jan 2014: operations to wake up

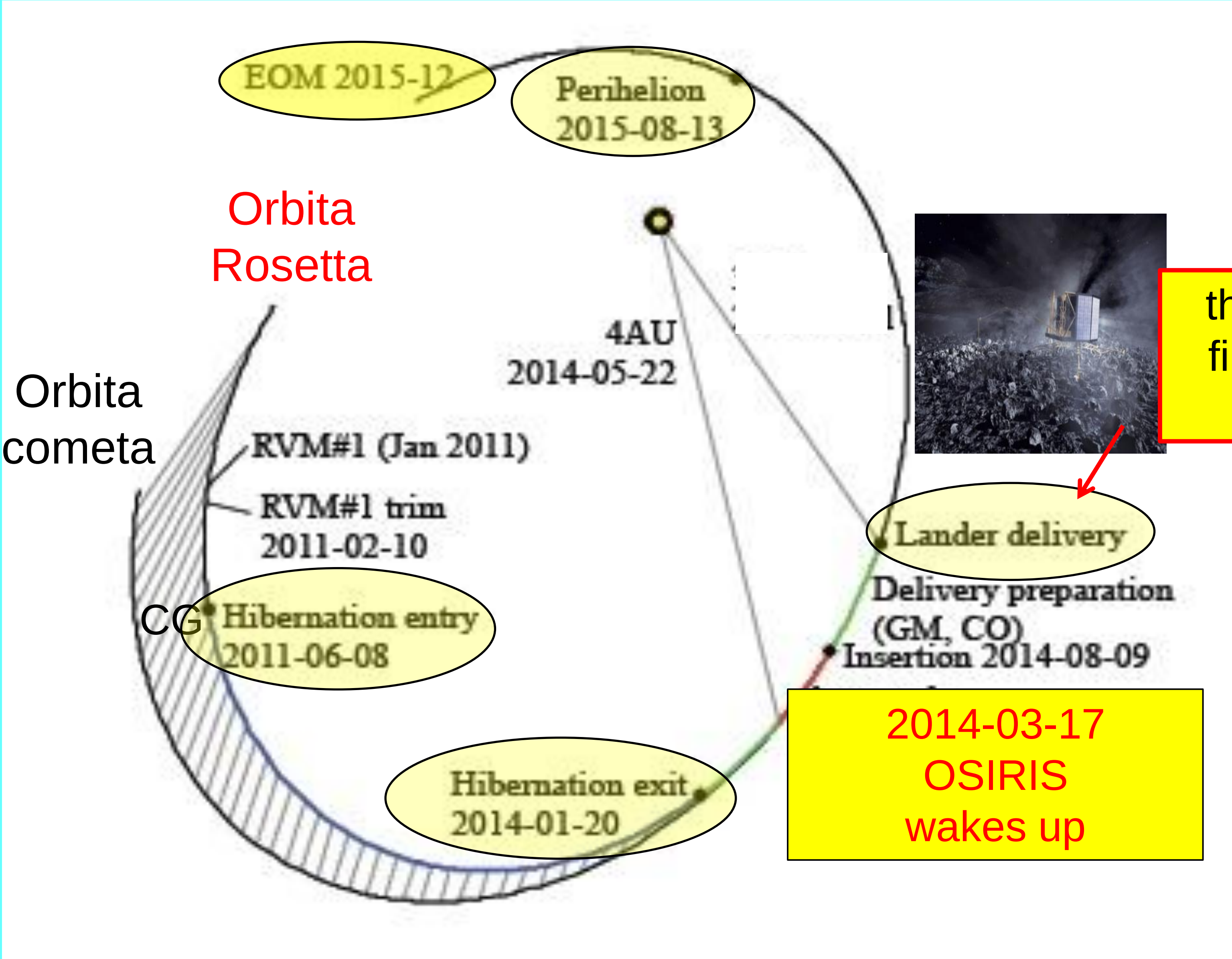
Wake up Rosetta !!

Esultanza ad ESOC, dove il team di controllo di Rosetta è coordinato dall’italiano Andrea Accomazzo.





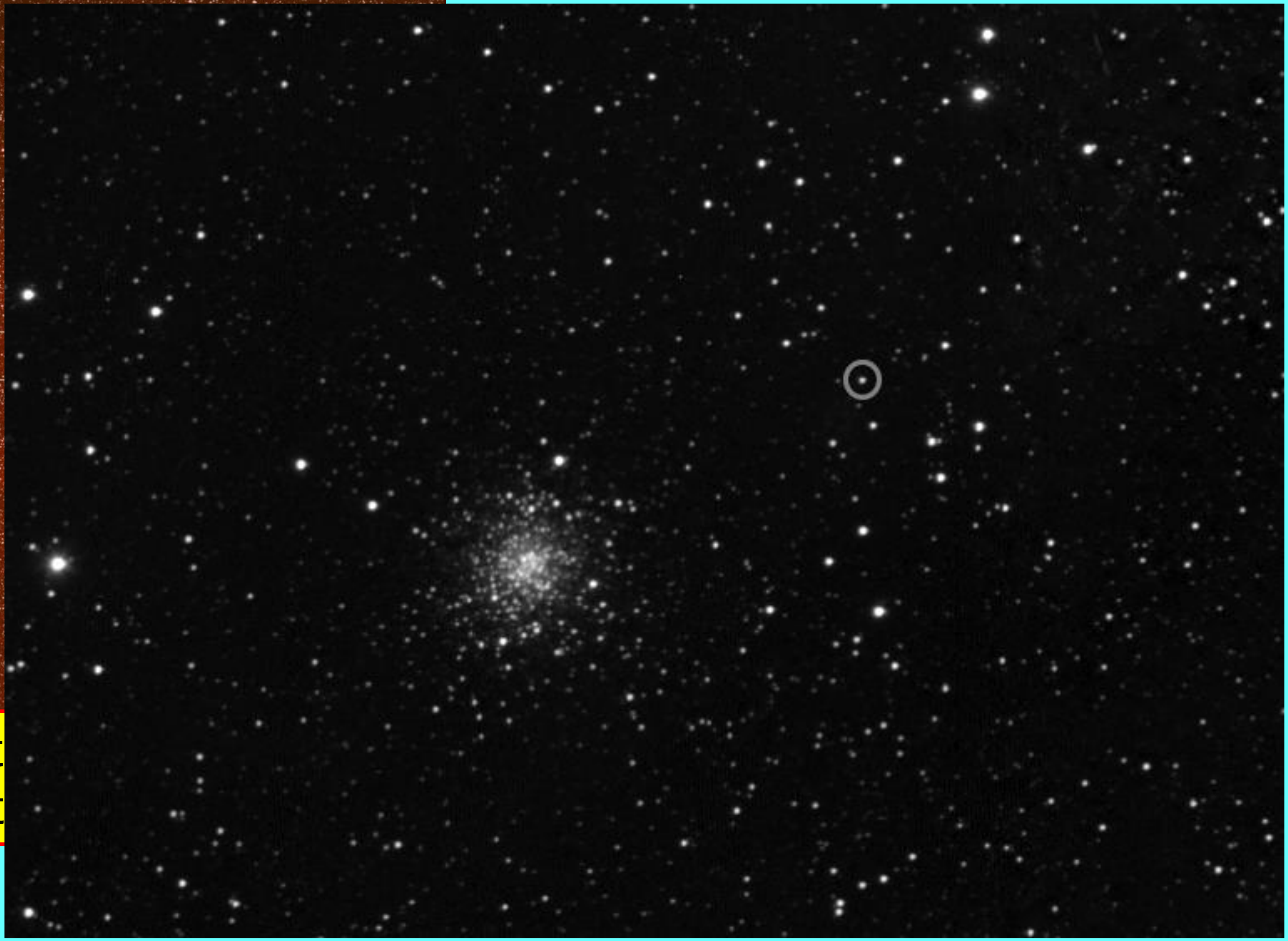
Sequence of events from Jul. 2010 to Dec. 2015



the date was finally set to Nov. 12

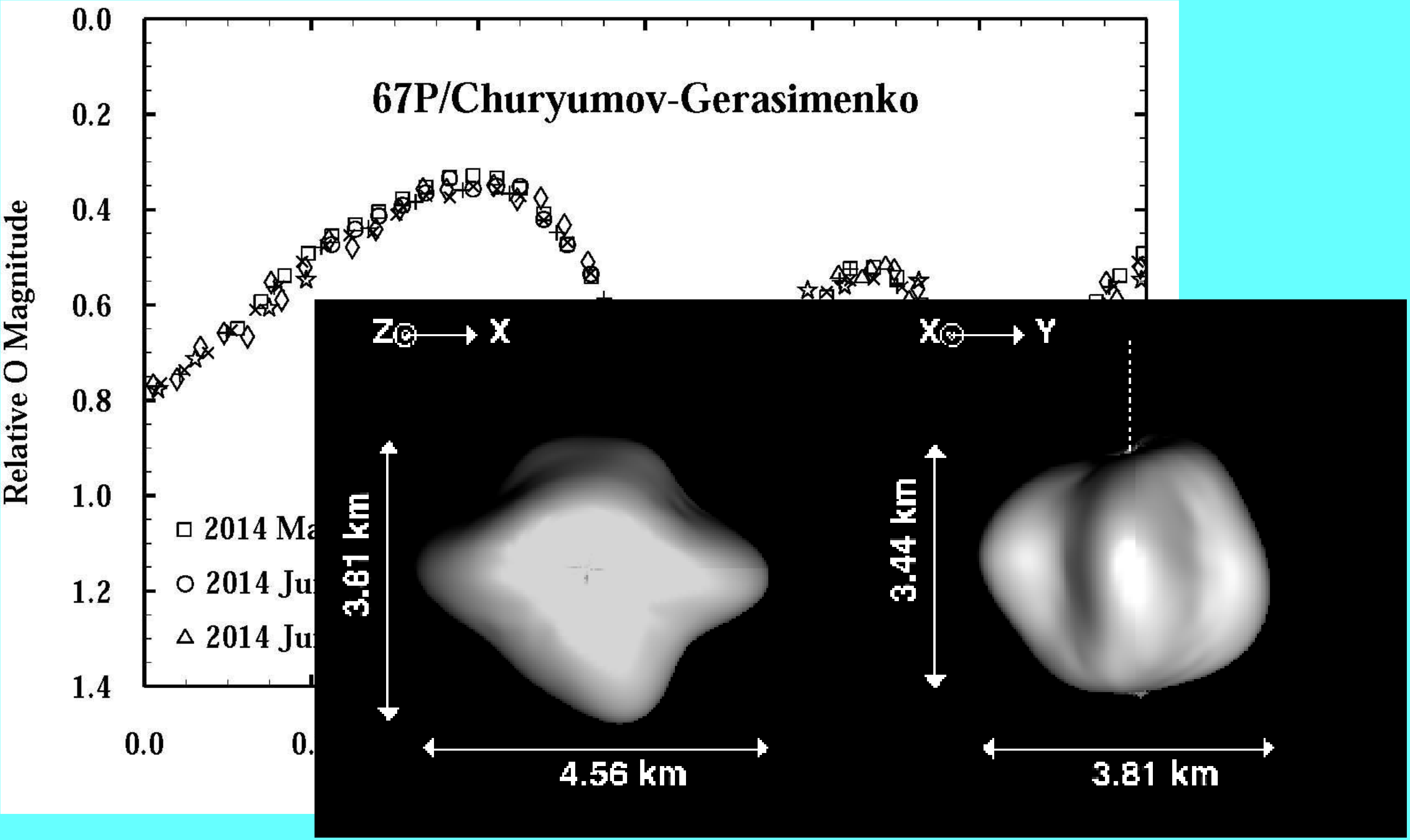
2014-03-17
OSIRIS
wakes up

Osiris finds the comet, 17-20 March 2014



The Spacecraft
was about

Light curve and expected shape



An image from VLT

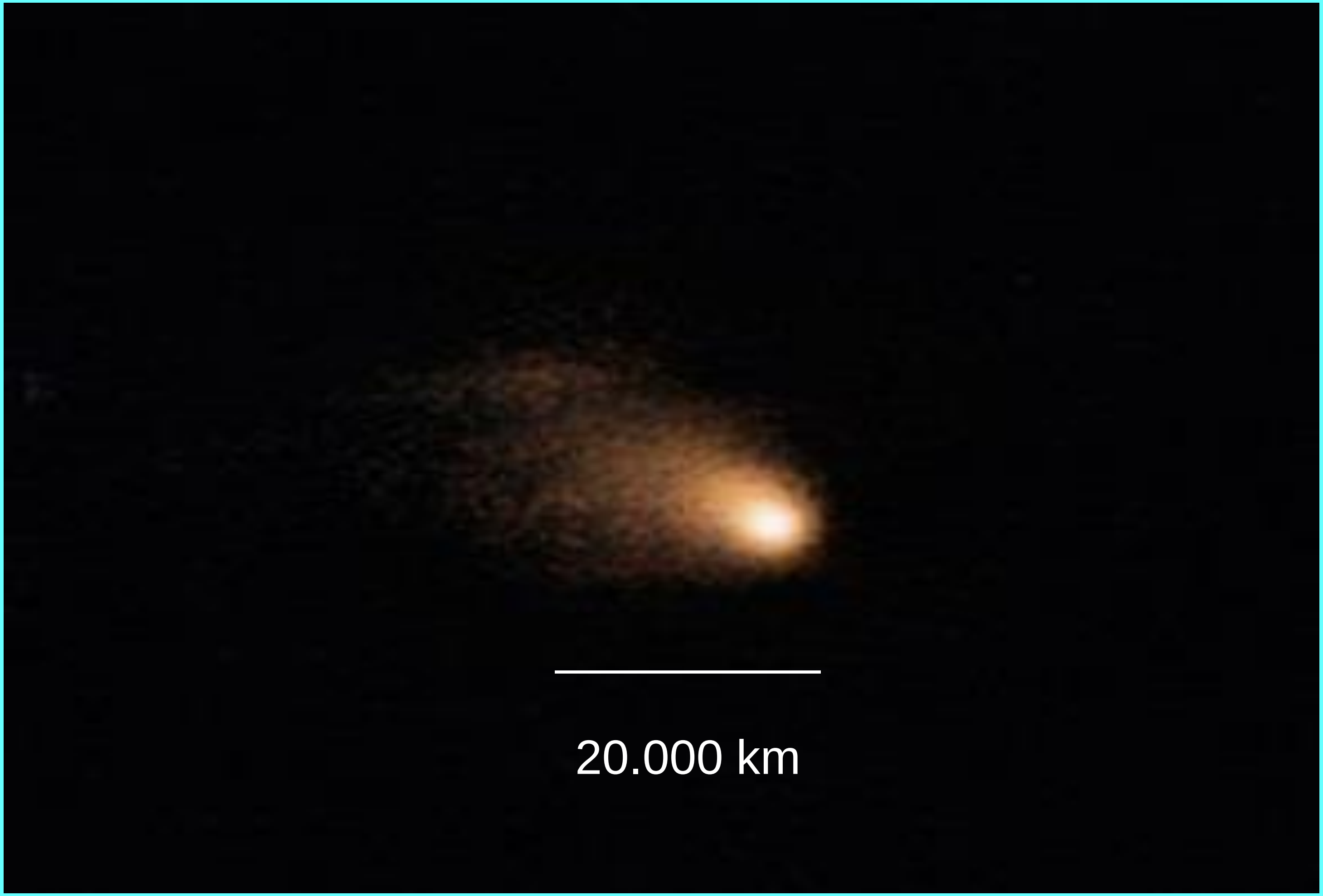
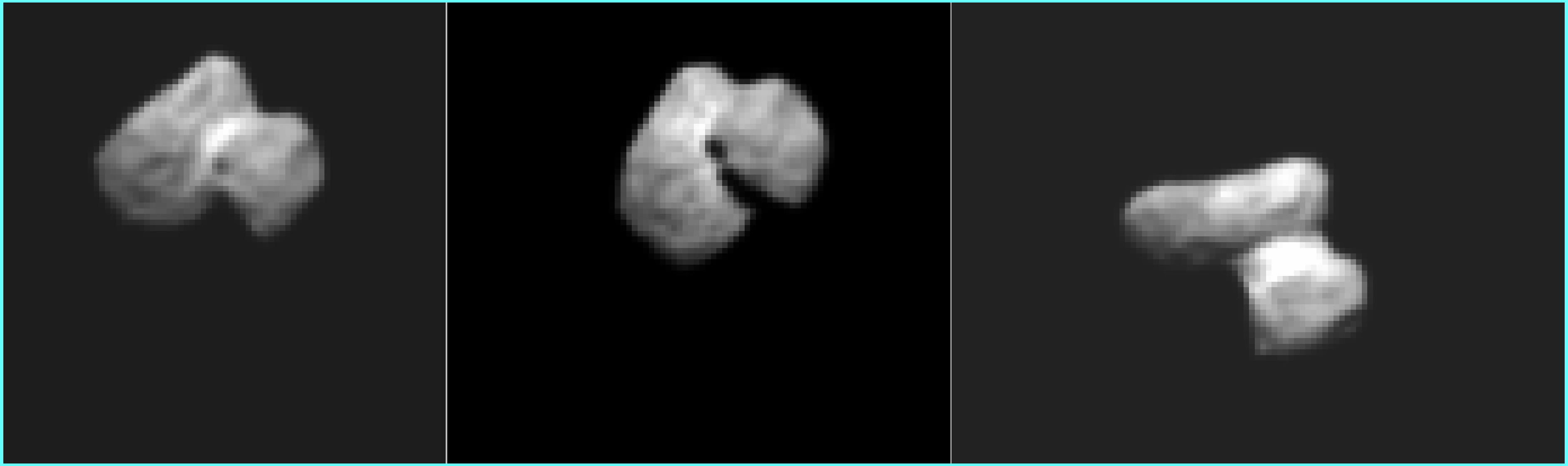


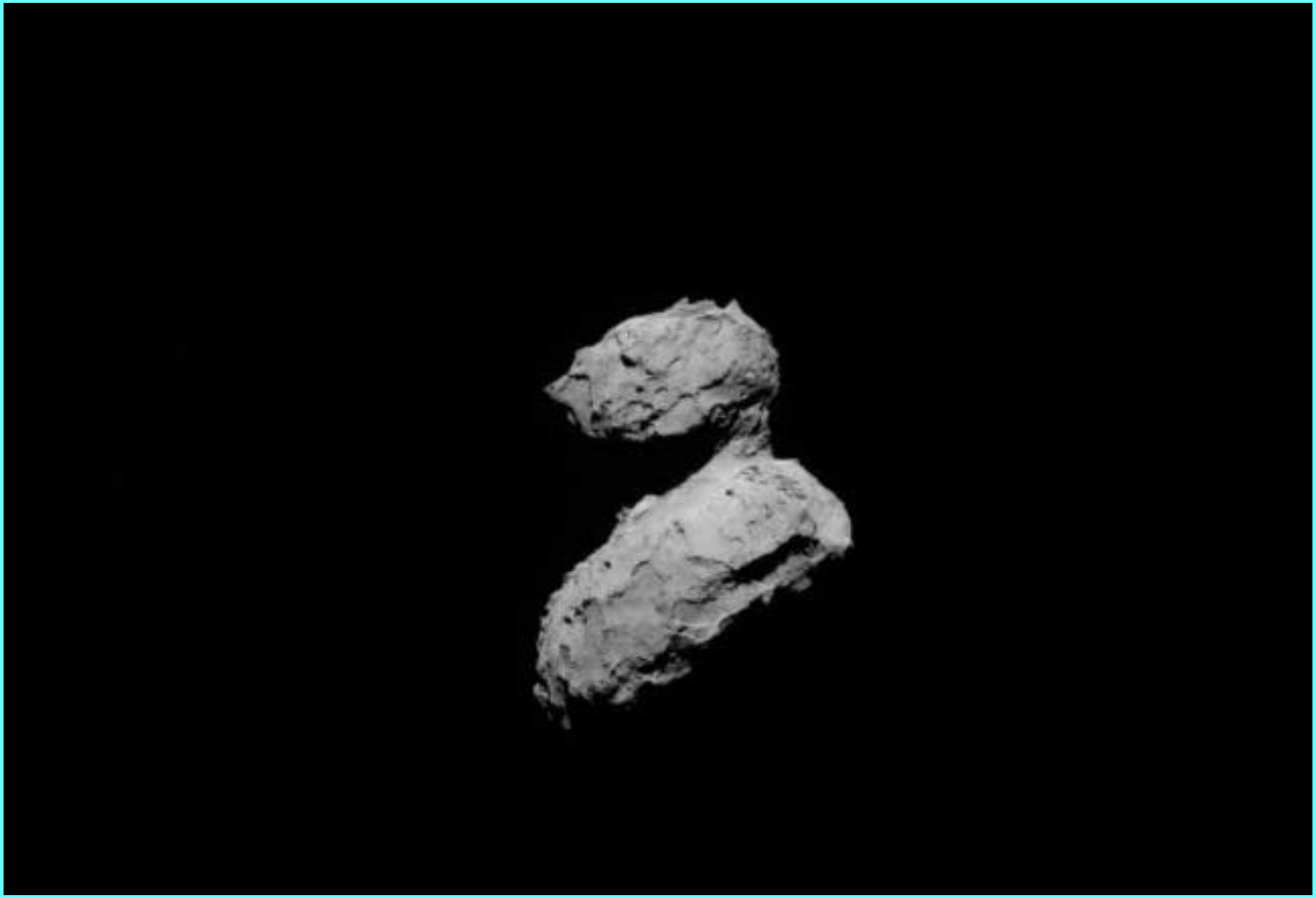
Image from VLT (Chile) early August 2014.
At the end of June Rosetta had entered the coma

The true shape was seen in Jul 7, 2014, when the spacecraft – comet distance was about 3000 km

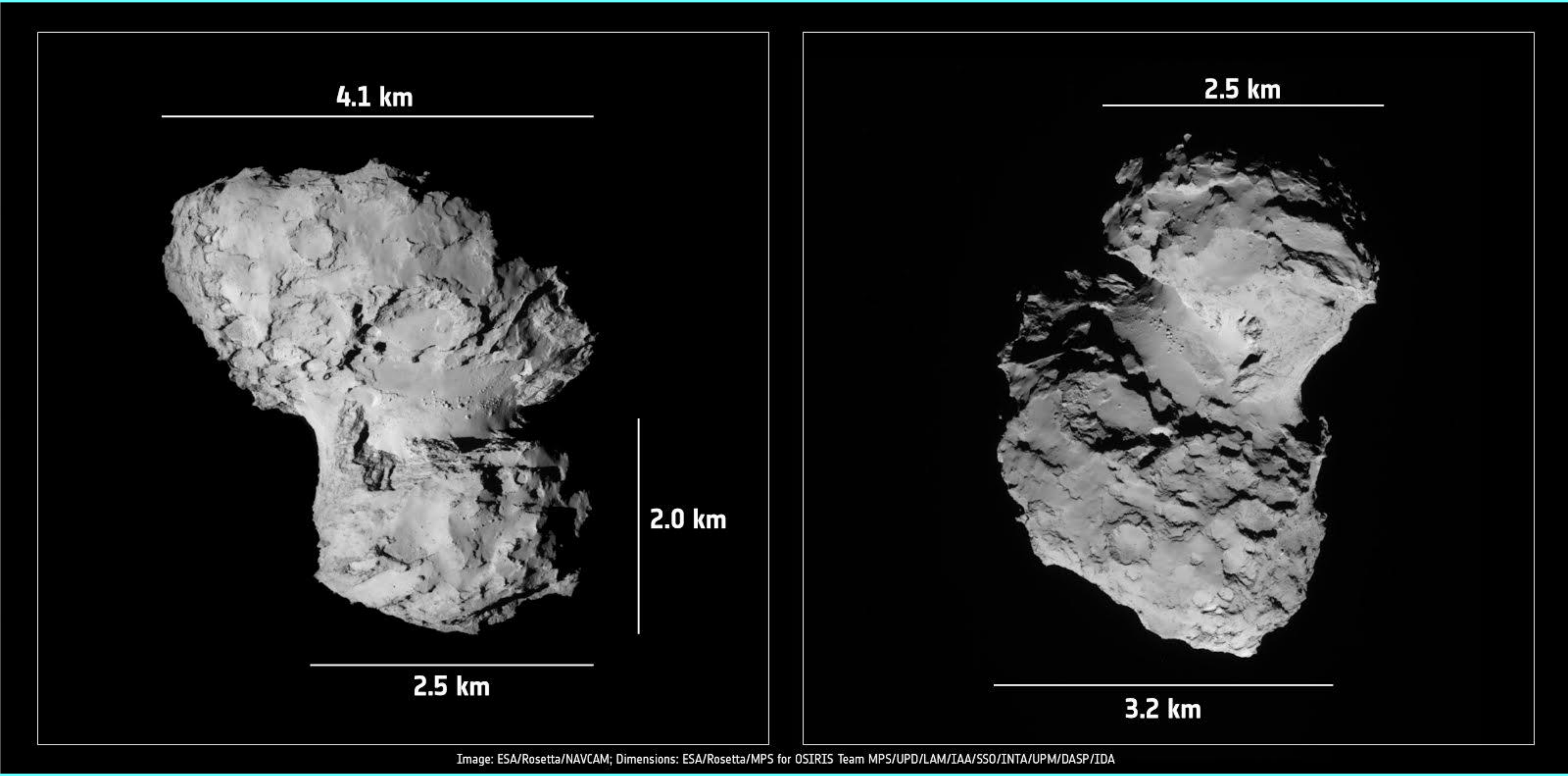


a great surprise indeed!

at 1000 km

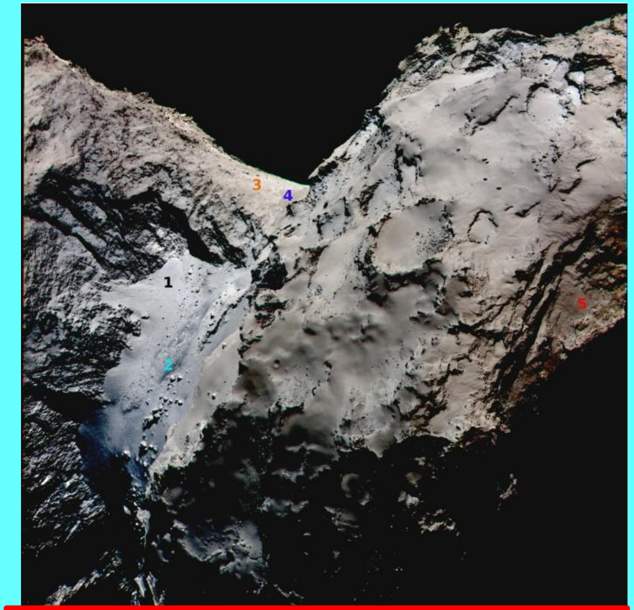


Accurate measurement of dimensions

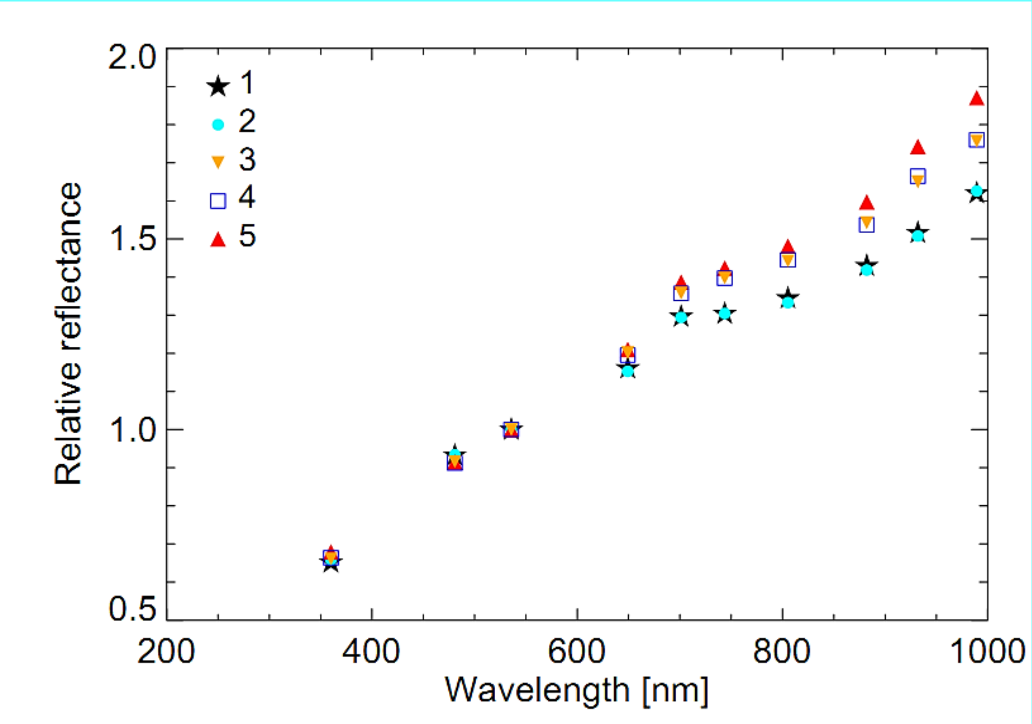


Measurements of reflectivity and colours:

the comet is very dark (reflectivity less than 5%), darker than the darkest lunar features.



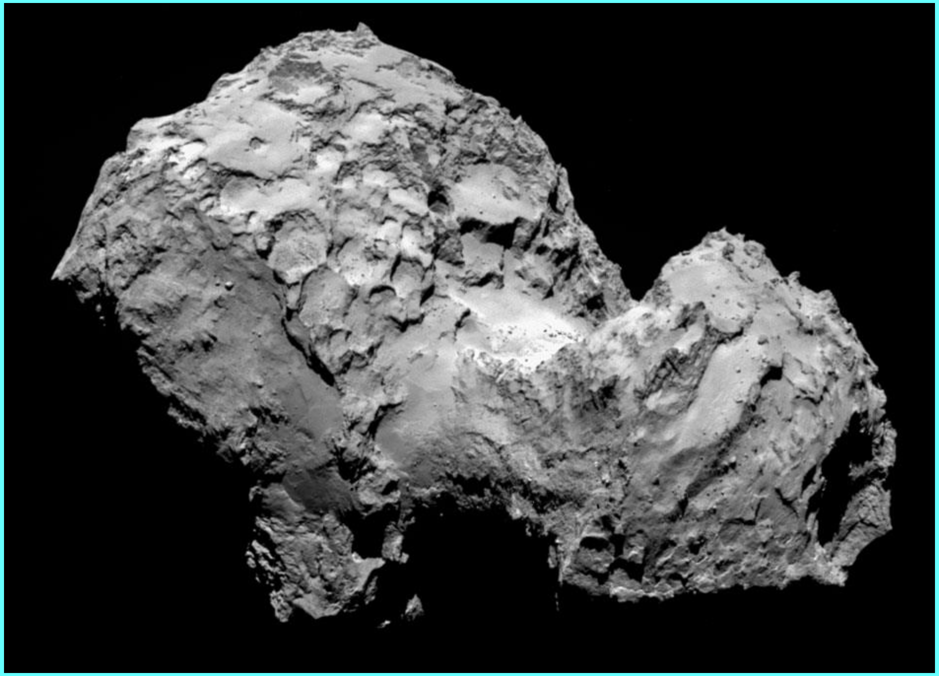
RGB colours of an area of the comet. Colour variations are very small. Visually, the surface would appear a pale grey body with only slight variegation.

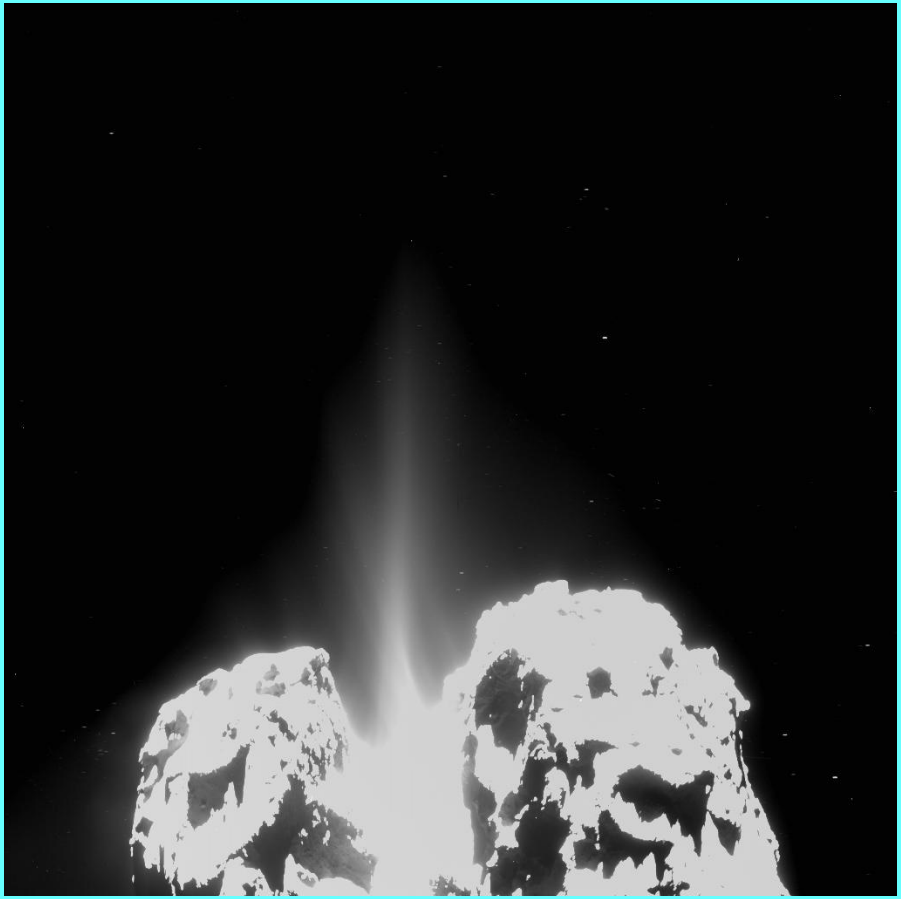


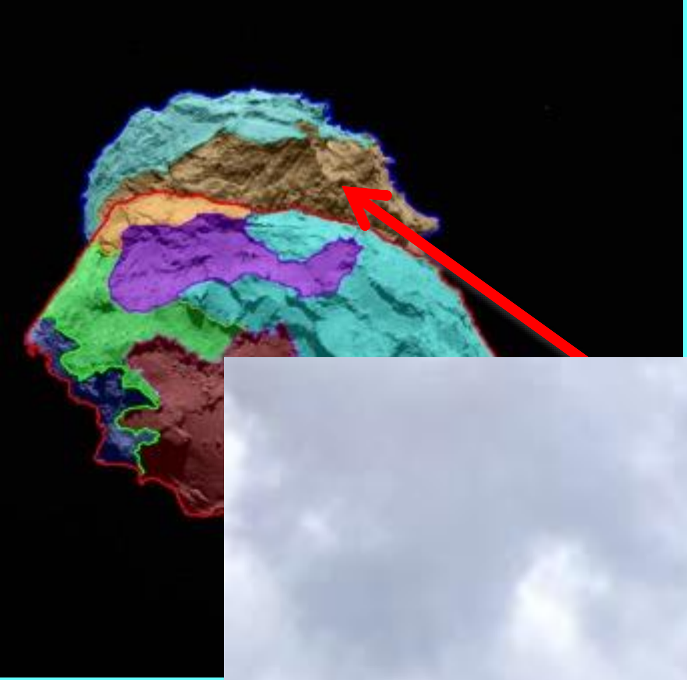
Relative reflectance spectra for 5 different areas located on the comet surface. The slight depression around 850 nm might be due to hydrated minerals or silicates.

Aug 6: orbital insertion

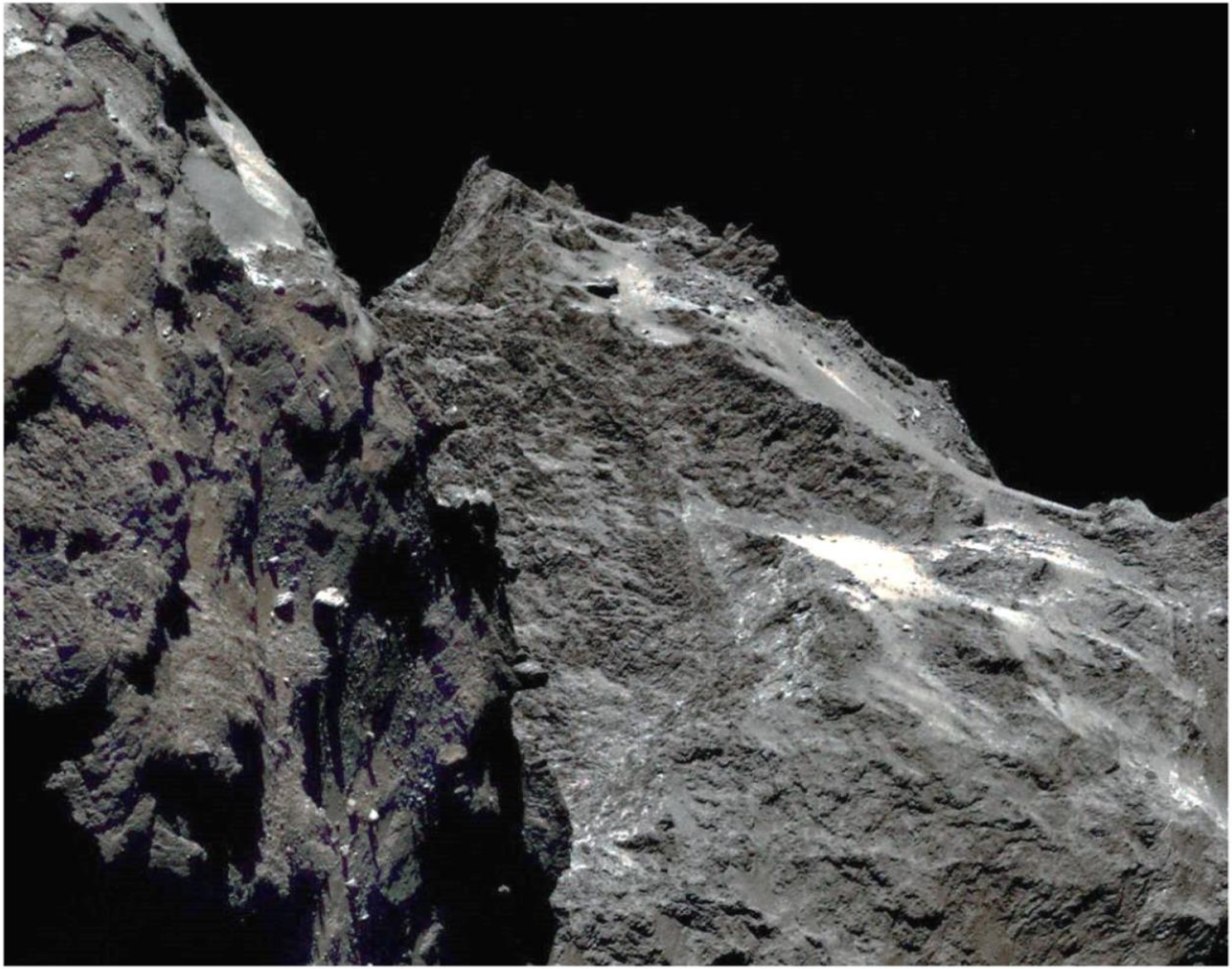
distance 100 km, plenty of details, jets of dust and gas



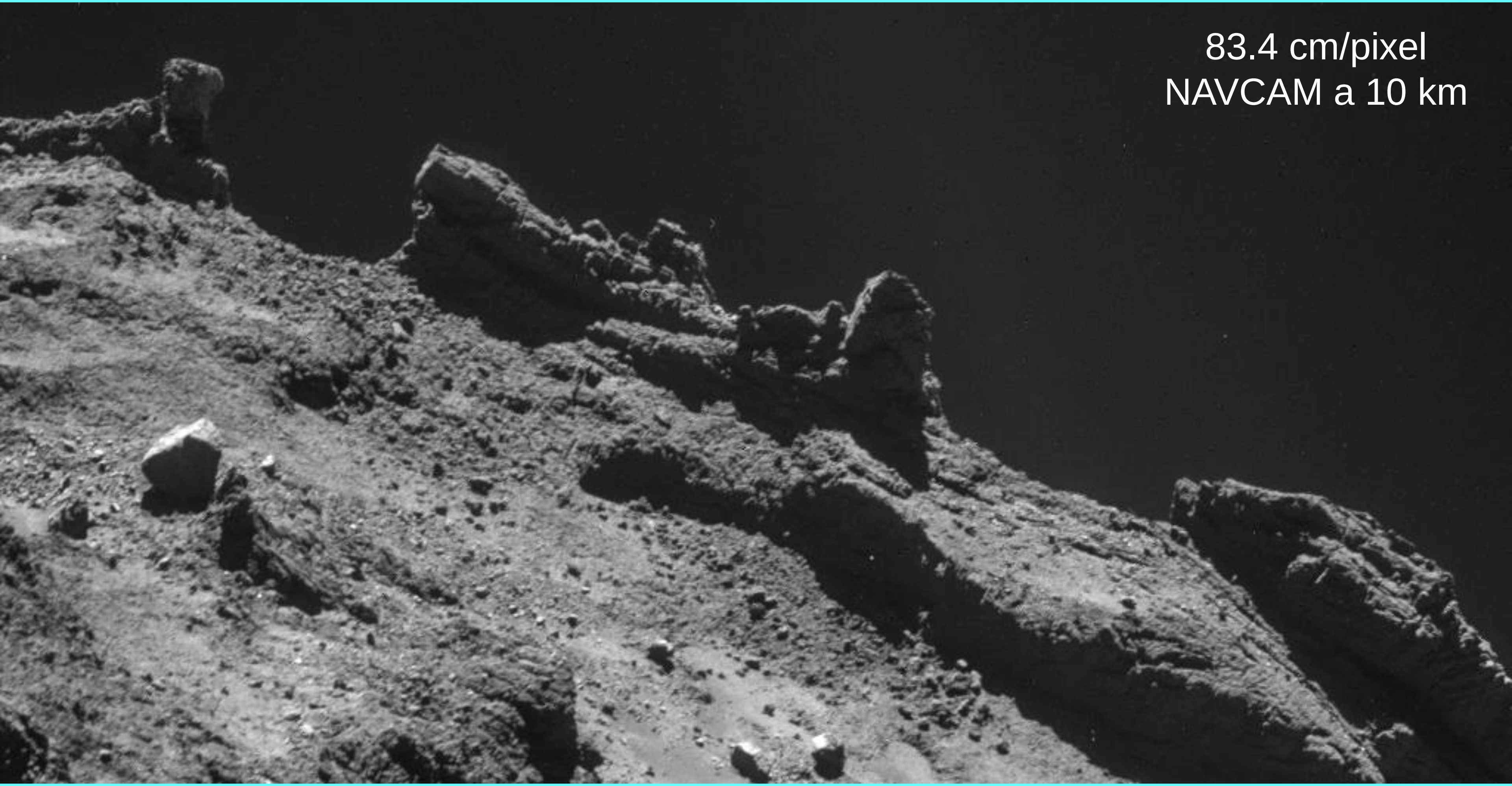




Walls 1000 m high, suggestive similarity to Dolomites (but gravity very different)!

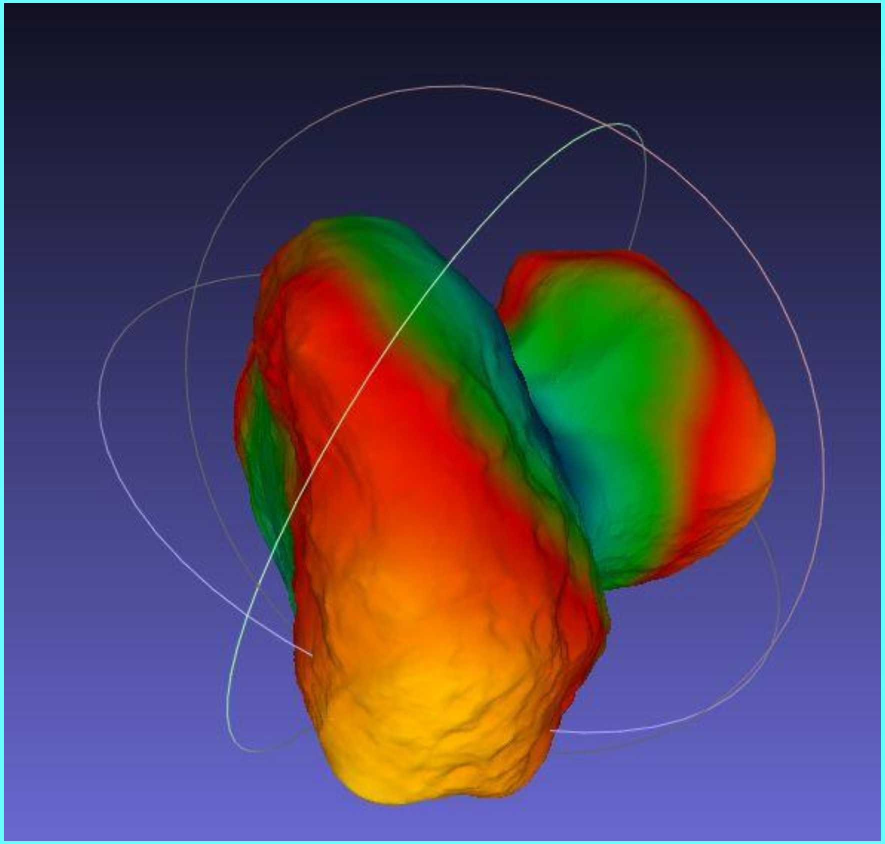


Cuestas

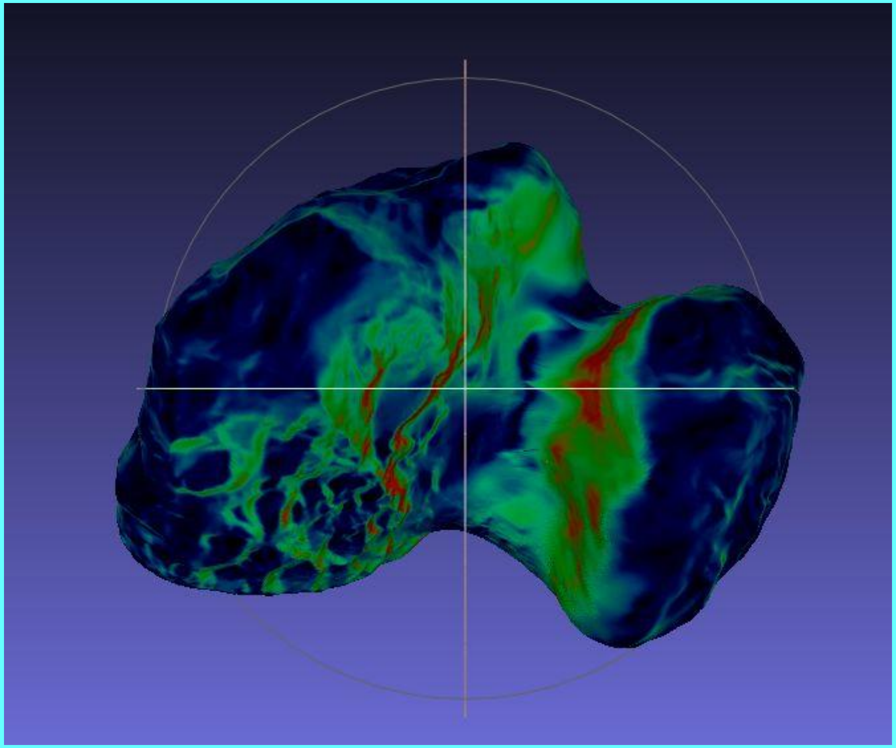


Credits:
www.esa.int/Our_Activities/Space_Science/Rosetta/Highlights/Top_10_at_10_km

Gravity field and slopes



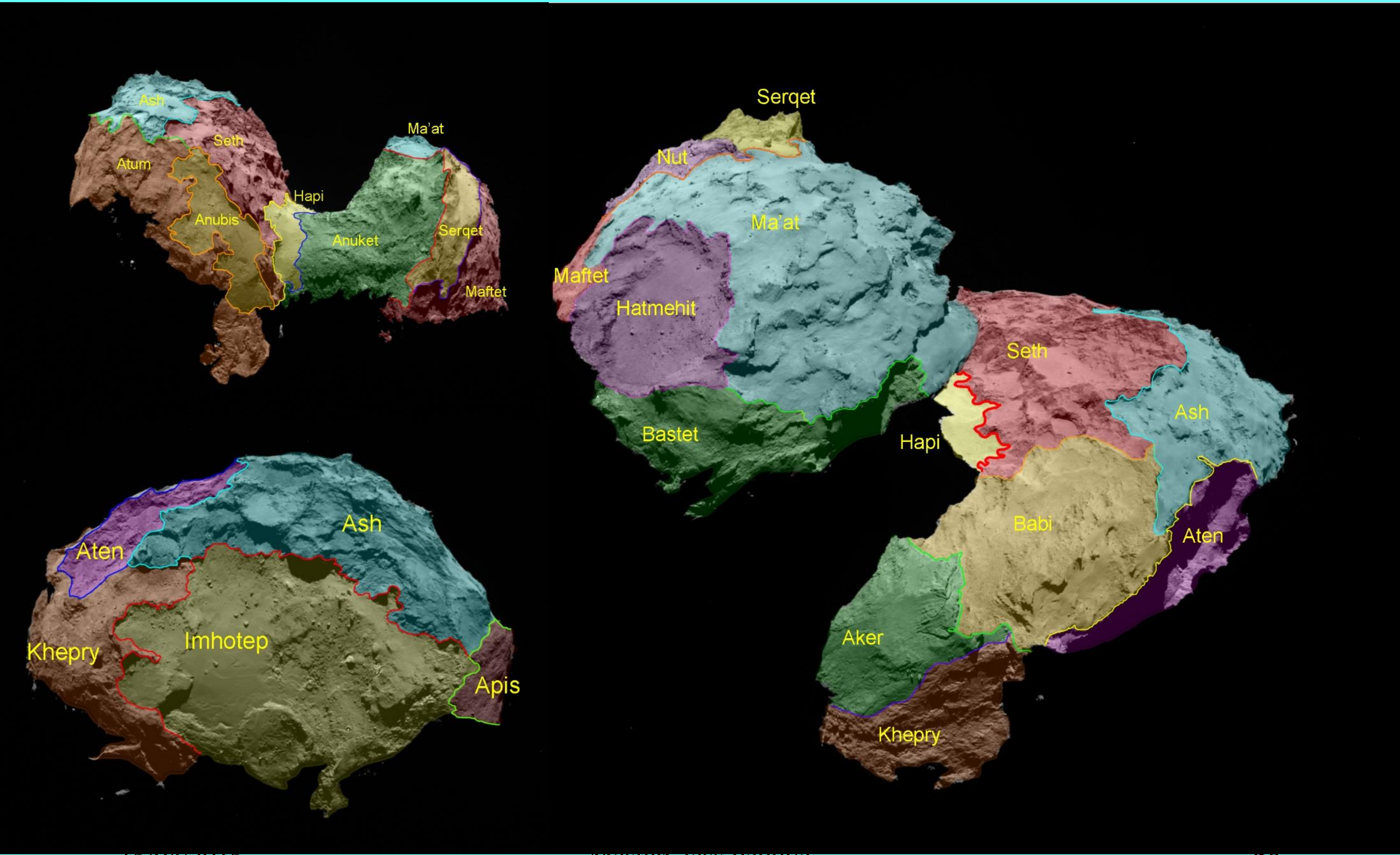
gravità

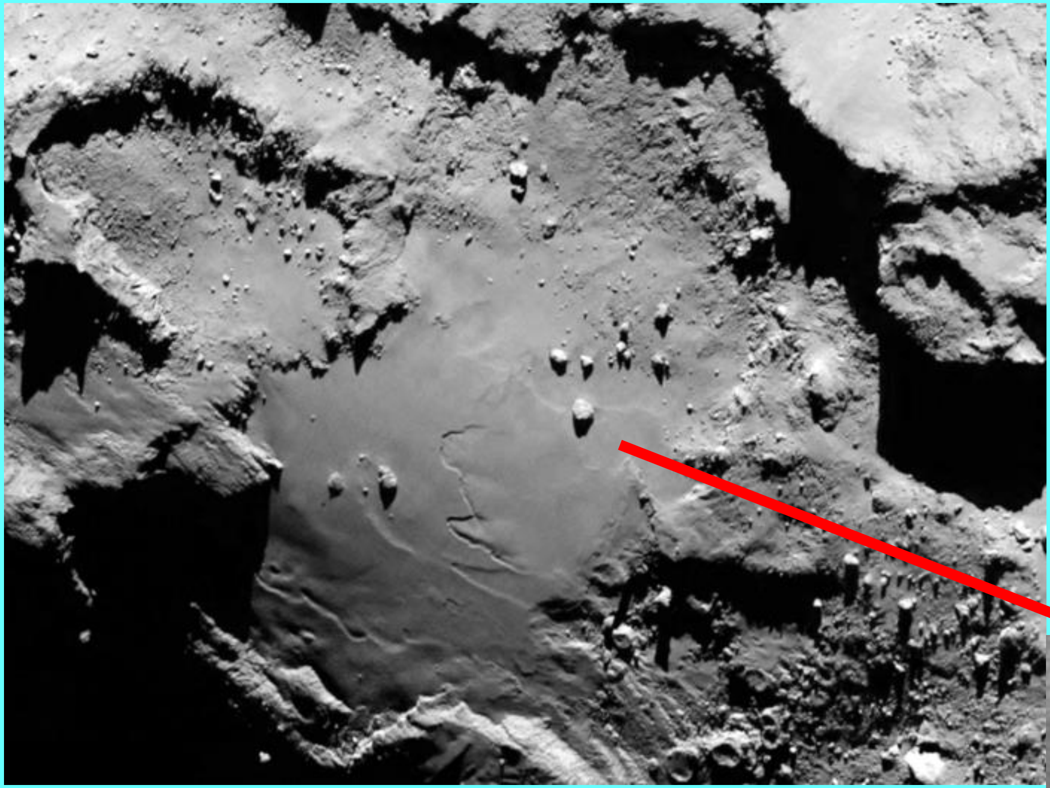


pendenze

Le accelerazioni subite dalla sonda hanno permesso di misurare la massa totale e quindi la densità media, **che è di circa il 45% di quella dell'acqua**, più o meno come la pietra pomice. Il corpo quindi deve essere molto poroso. .

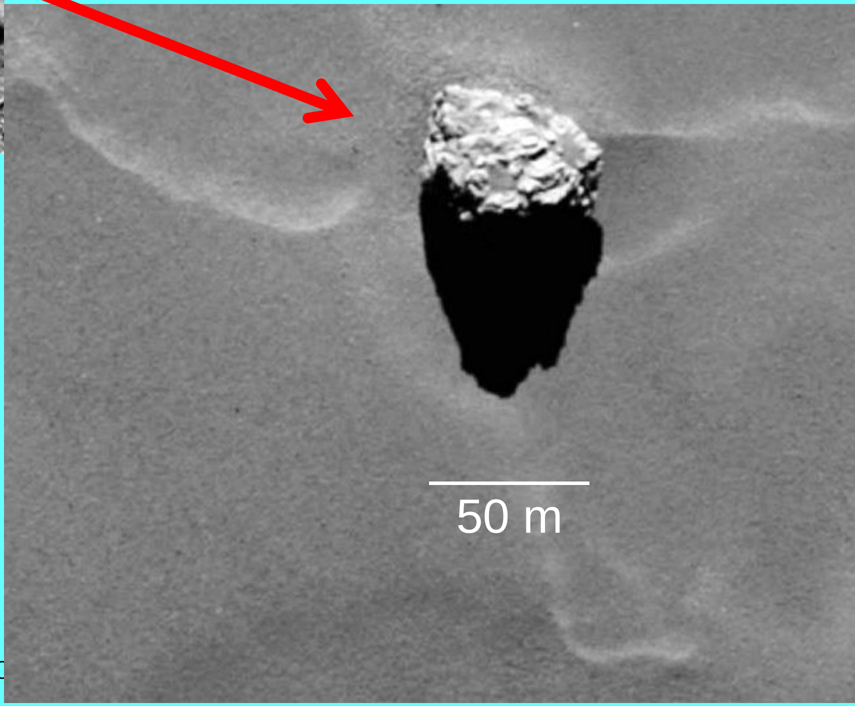
Regions with Egyptian names



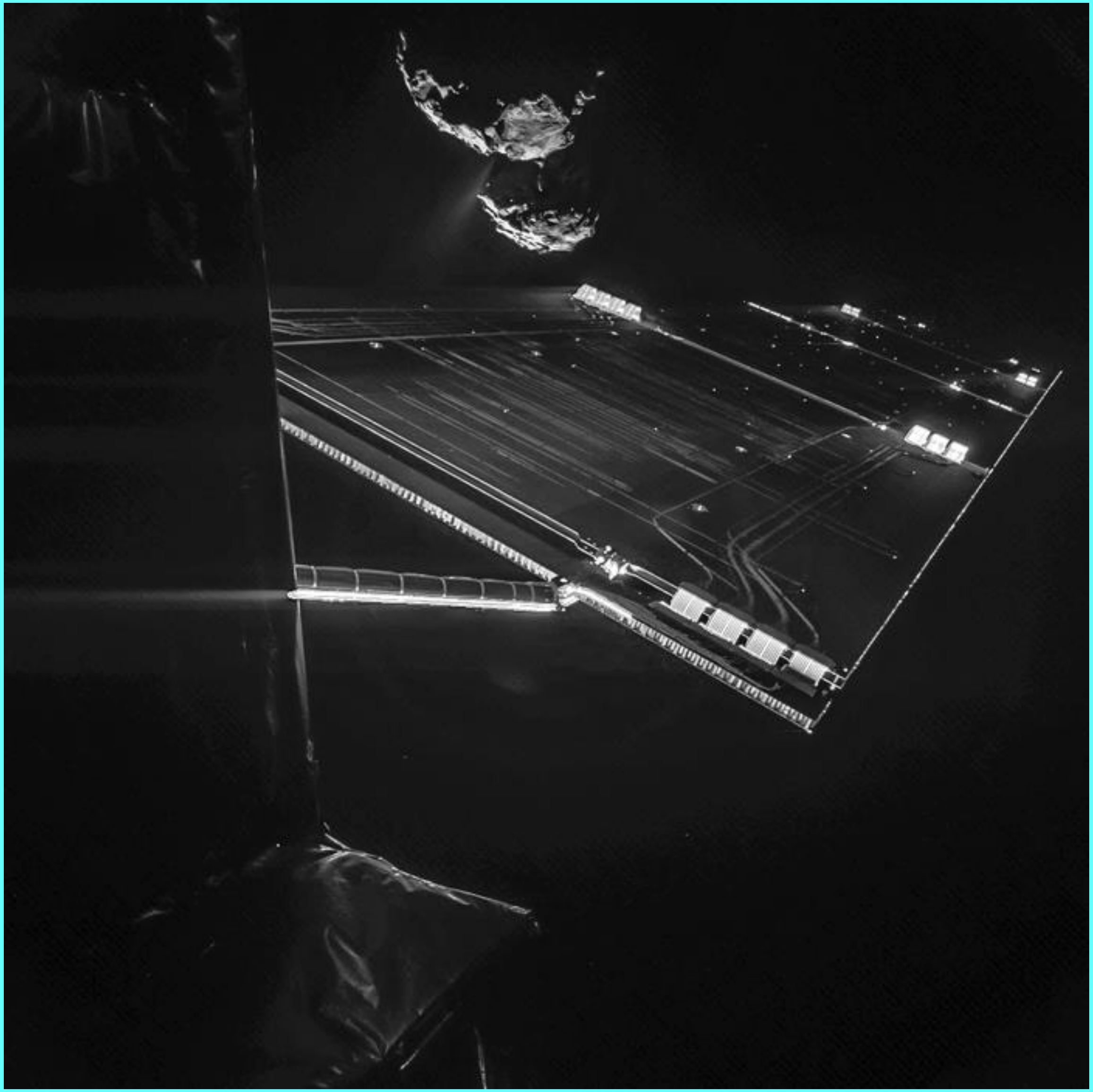


the ‘Giza pyramids’

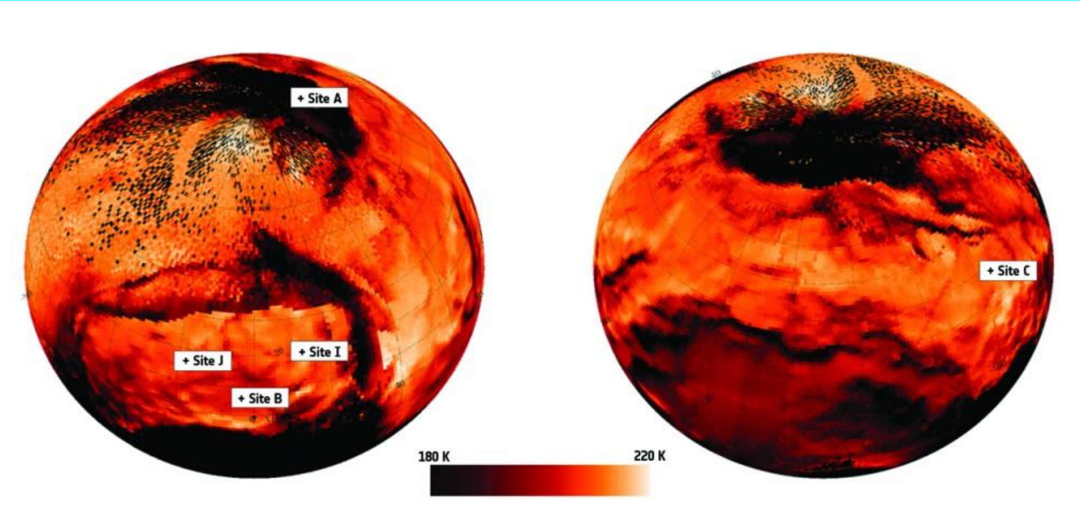
Cheop’s pyramid



A selfie

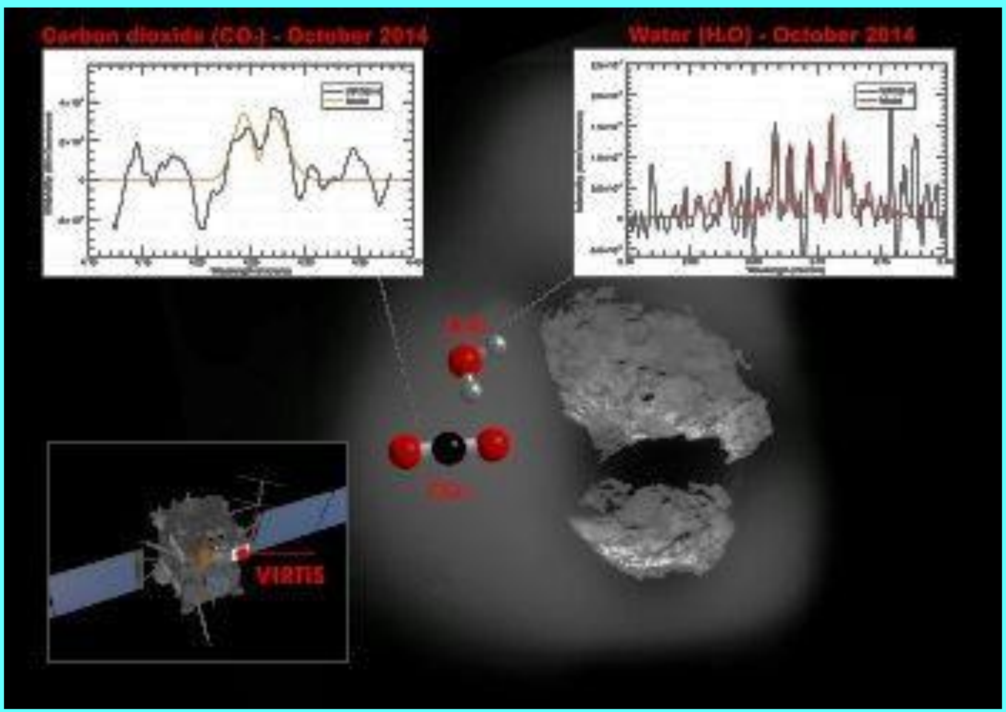


Results from other Rosetta Instruments



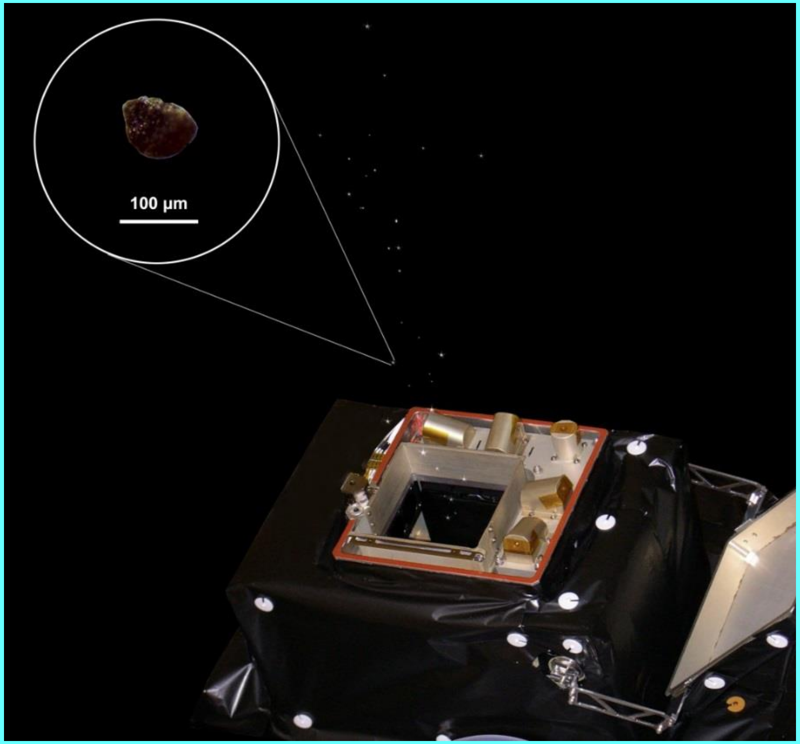
Data from VIRTIS

La temperatura superficiale misurata da VIRTIS (- 70C) è più alta del previsto, come se gran parte della superficie fosse coperta da uno spesso strato di polvere isolante.

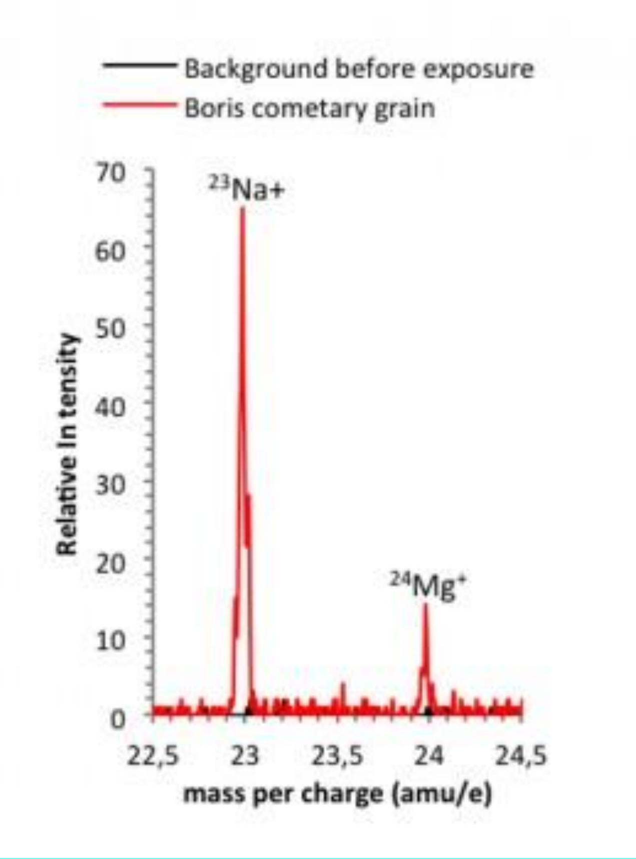


VIRTIS ha misurato anche le abbondanze di vapor acqueo e di anidride carbonica rilasciate dalla cometa

Data on dust grains from GIADA and COSIMA



GIADA raccoglie grani di polvere le cui dimensioni variano da pochi millesimi fino a qualche decimo di millimetro e ne misura velocità a e massa.

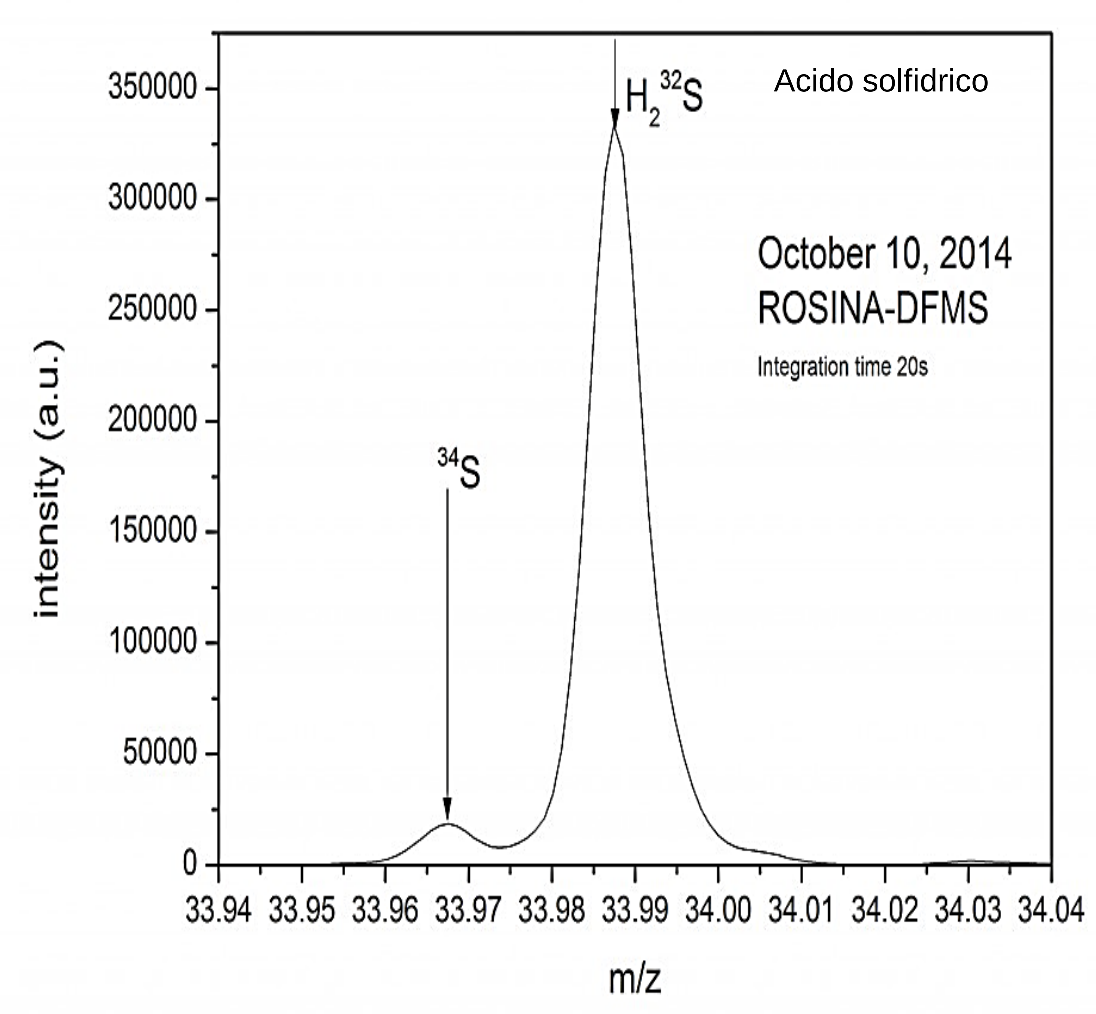


COSIMA riesce a vederne la composizione mineralogica, in questo grano trova Sodio e Magnesio.

Data from ROSINA

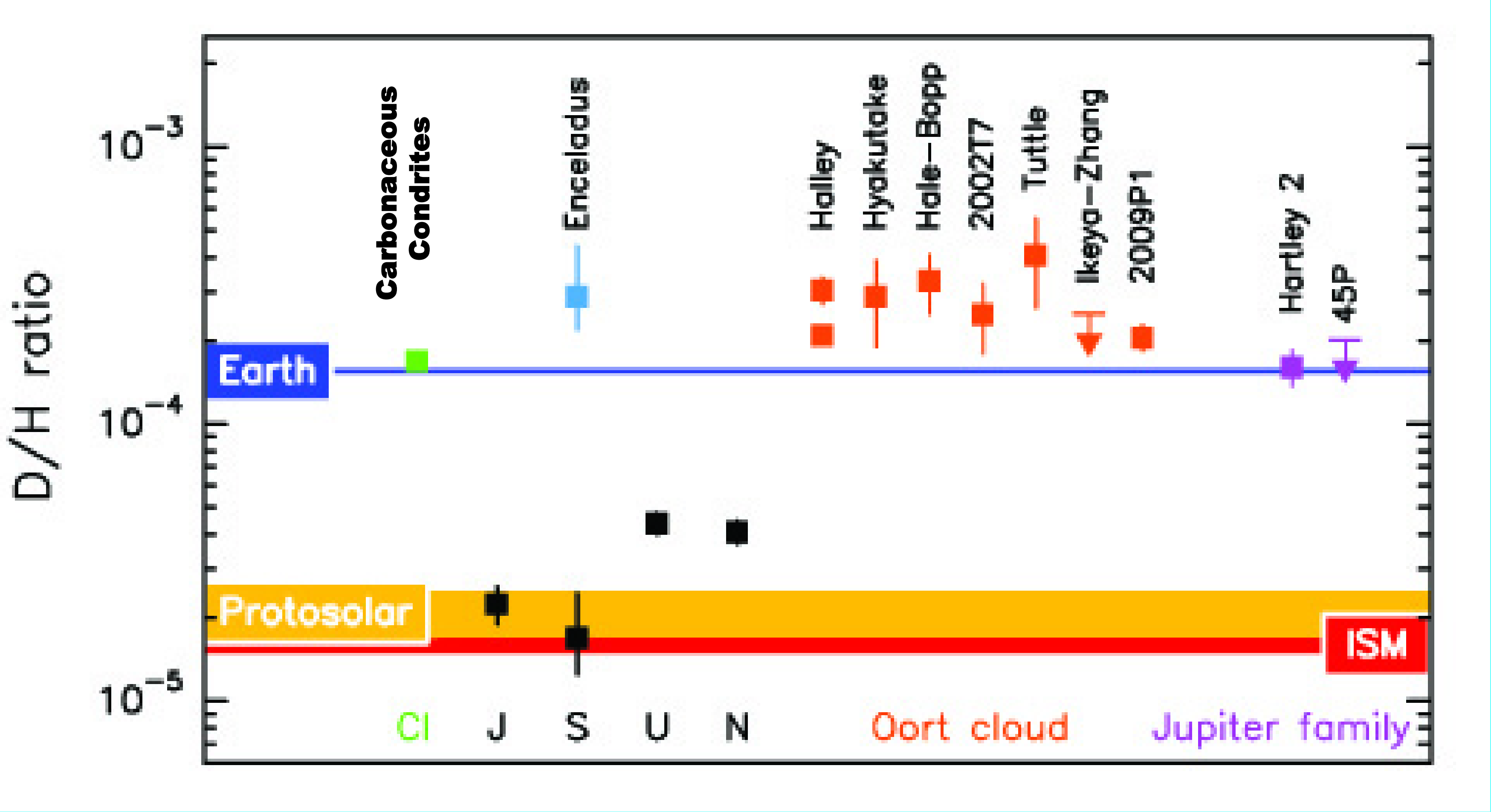
ROSINA's inventory of detected gases:

Water (H_2O)
Carbon monoxide (CO)
Carbon dioxide (CO_2)
Ammonia (NH_3)
Methane (CH_4)
Methanol (CH_3OH)
Formaldehyde (CH_2O)
Hydrogen sulphide (H_2S)
Hydrogen cyanide (HCN)
Sulphur dioxide (SO_2)
Carbon disulphide (CS_2)



H/D ratio by Rosina

Rosina will measure the Deuterium to Hydrogen ratio in this comet.
A comparison with the value of the Earth's oceans will then test if a good fraction of our water is of cometary origin.



Some data from MIRO (mm)

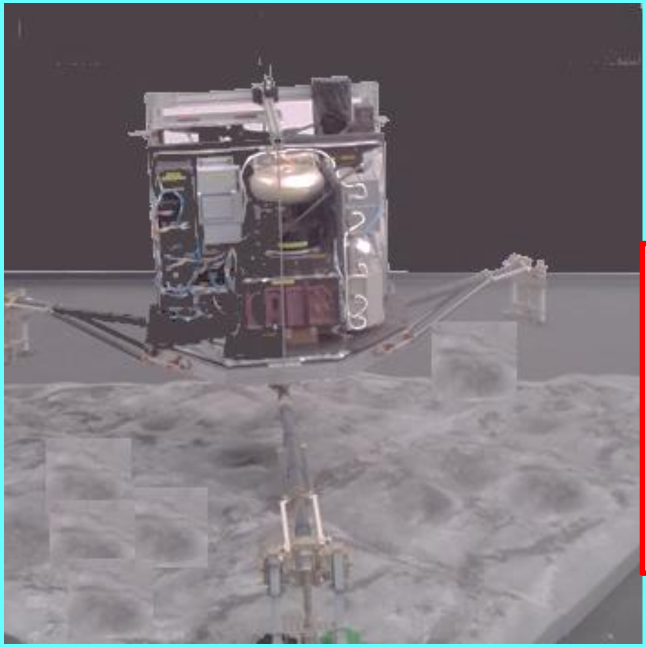
The MIRO team have detected water vapour, ammonia and methanol.

MIRO has measured subsurface temperatures (say 10 cm below the surface) between a maximum of 160 K and a minimum below 30 K.

MIRO subsurface temperatures and VIRTIS surface temperatures will be combined to calculate the temperature gradient in the nucleus, providing indications of the material that lies beneath the surface.

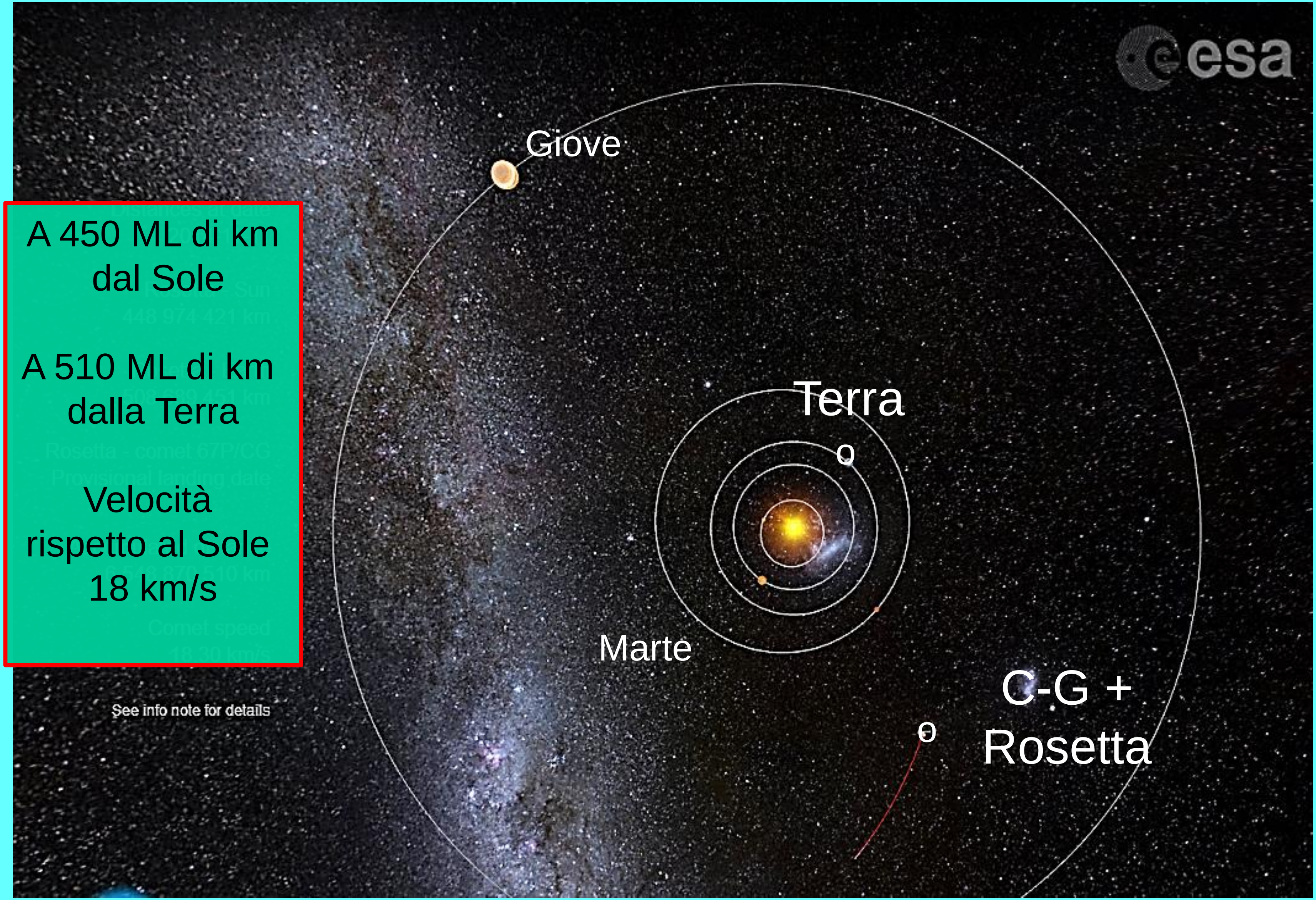
Quando far discendere Philae?

Da tempo si era deciso che Philae sarebbe stato ***rilasciato ben prima che la cometa raggiungesse l'orbita di Marte***, prima cioè che il nucleo si riscaldasse troppo rilasciando una eccessiva quantità di polvere e gas.



Tenendo conto dei vari vincoli orbitali, finalmente si individuò il 12 novembre quale data ideale.

Dove era Rosetta il 12 novembre 2014?

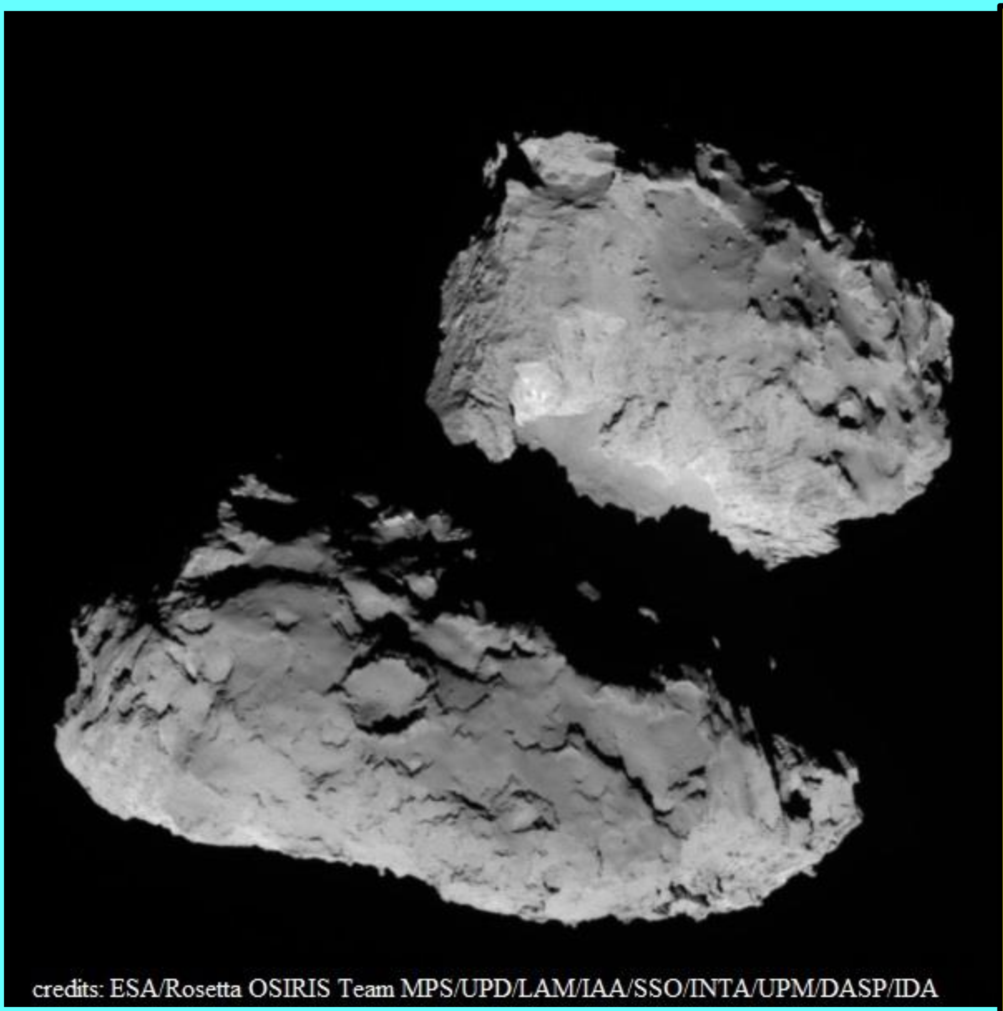


A 450 ML di km dal Sole

A 510 ML di km dalla Terra

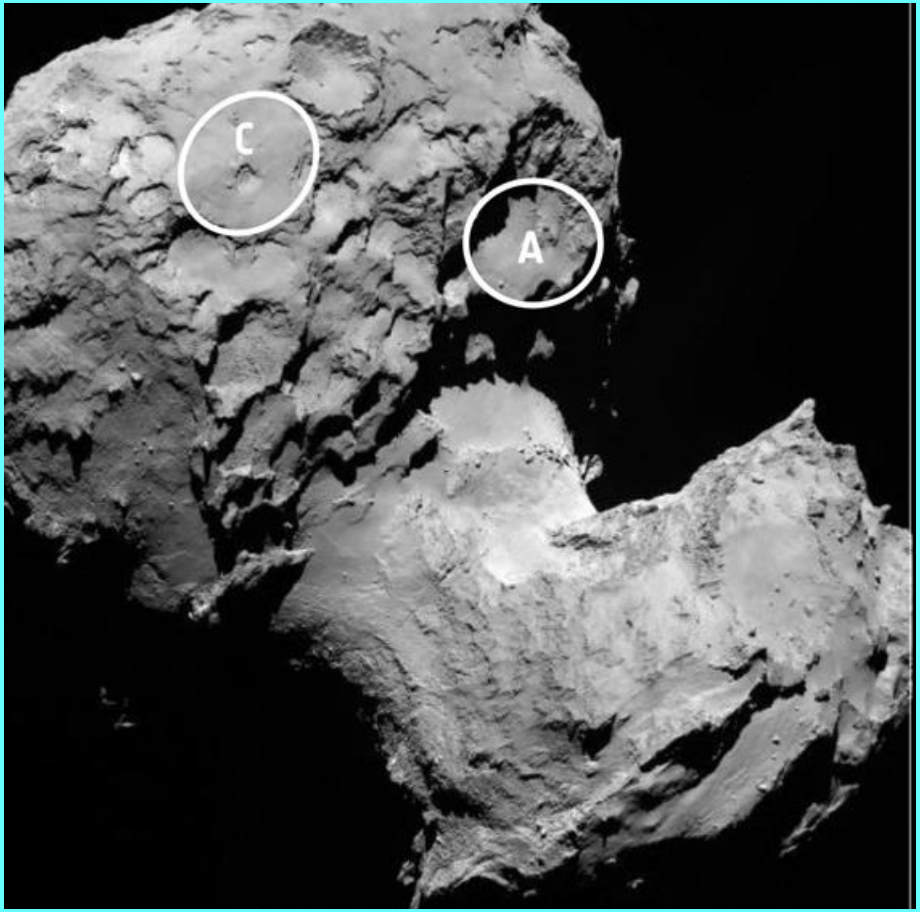
Velocità rispetto al Sole 18 km/s

Dove discendere?



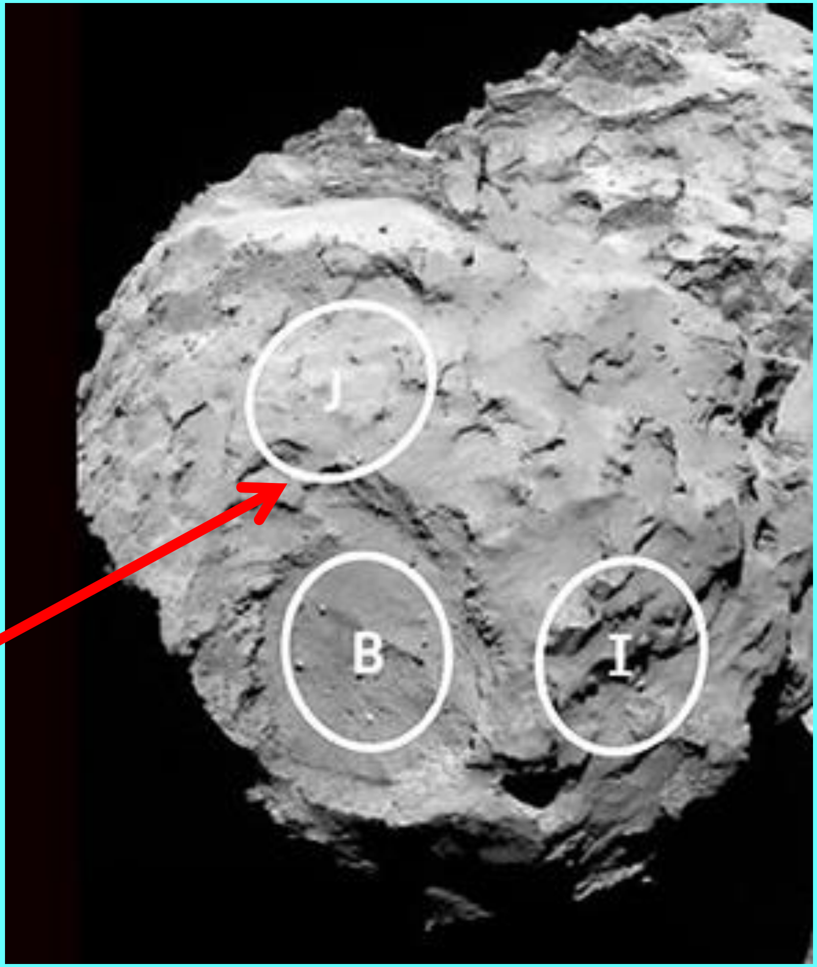
Davvero un bel problema, forma strana e rotante, campo gravitazionale debolissimo, forza centrifuga in certi punti quasi pari a quella gravitazionale, superficie scabra, zone in ombra, etc. etc.

Alla fine di agosto furono scelti 5 siti possibili



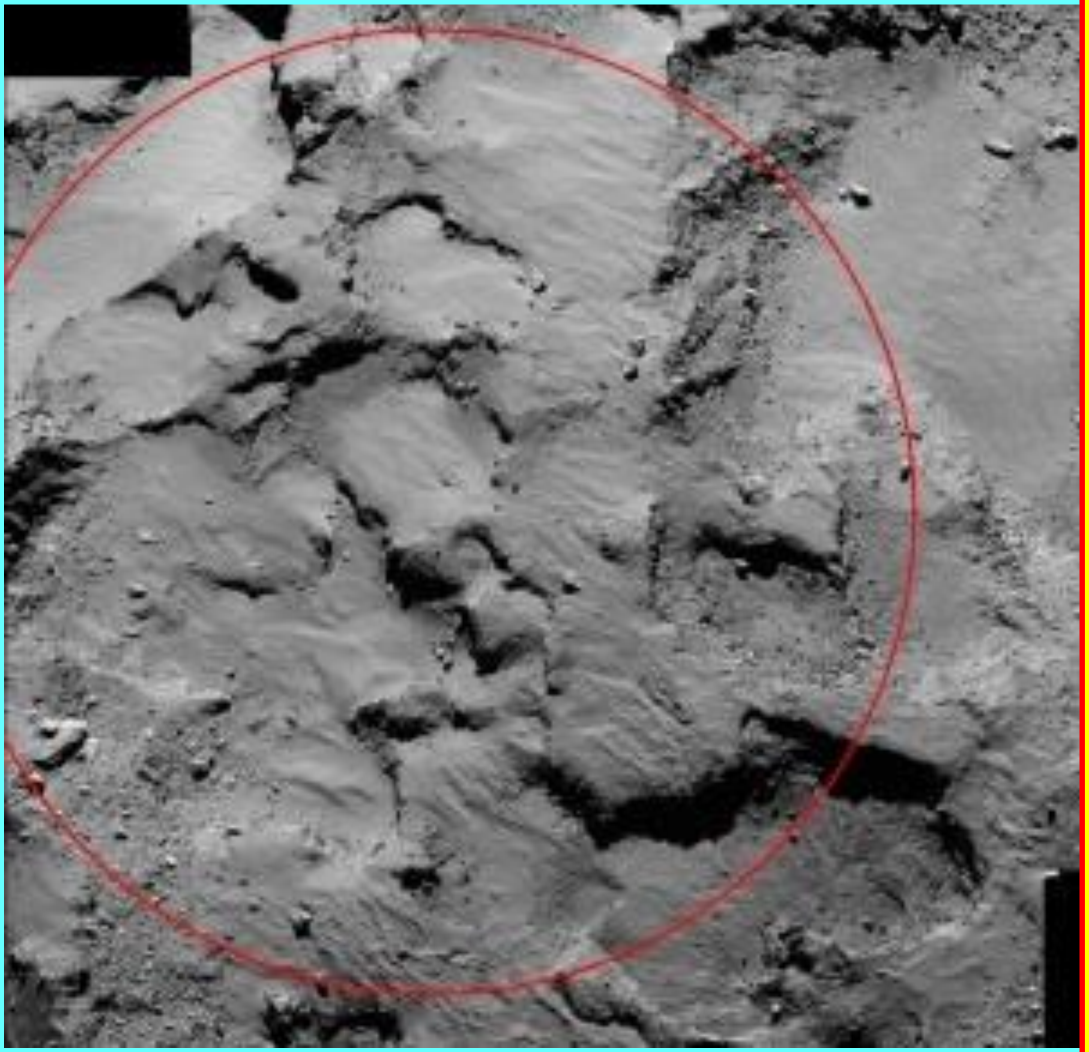
I primi 5 siti

Due siti (A e C) sono situati sul lobo maggiore ('corpo').



Tre siti (B, I e J) sono situati sul lobo minore ('testa'). Finalmente, fu scelto il sito J come prima destinazione.

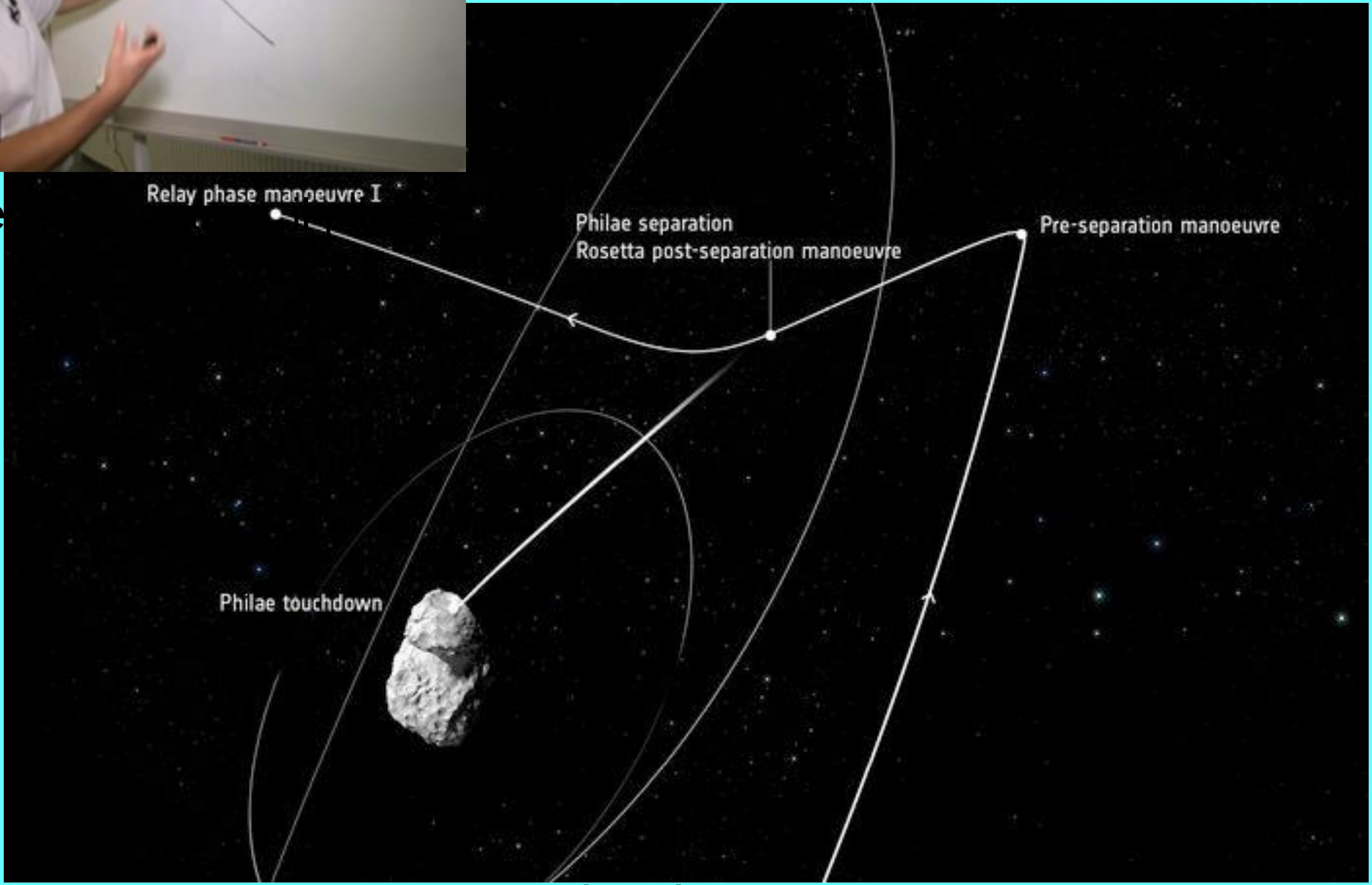
Il sito J, Agilkia



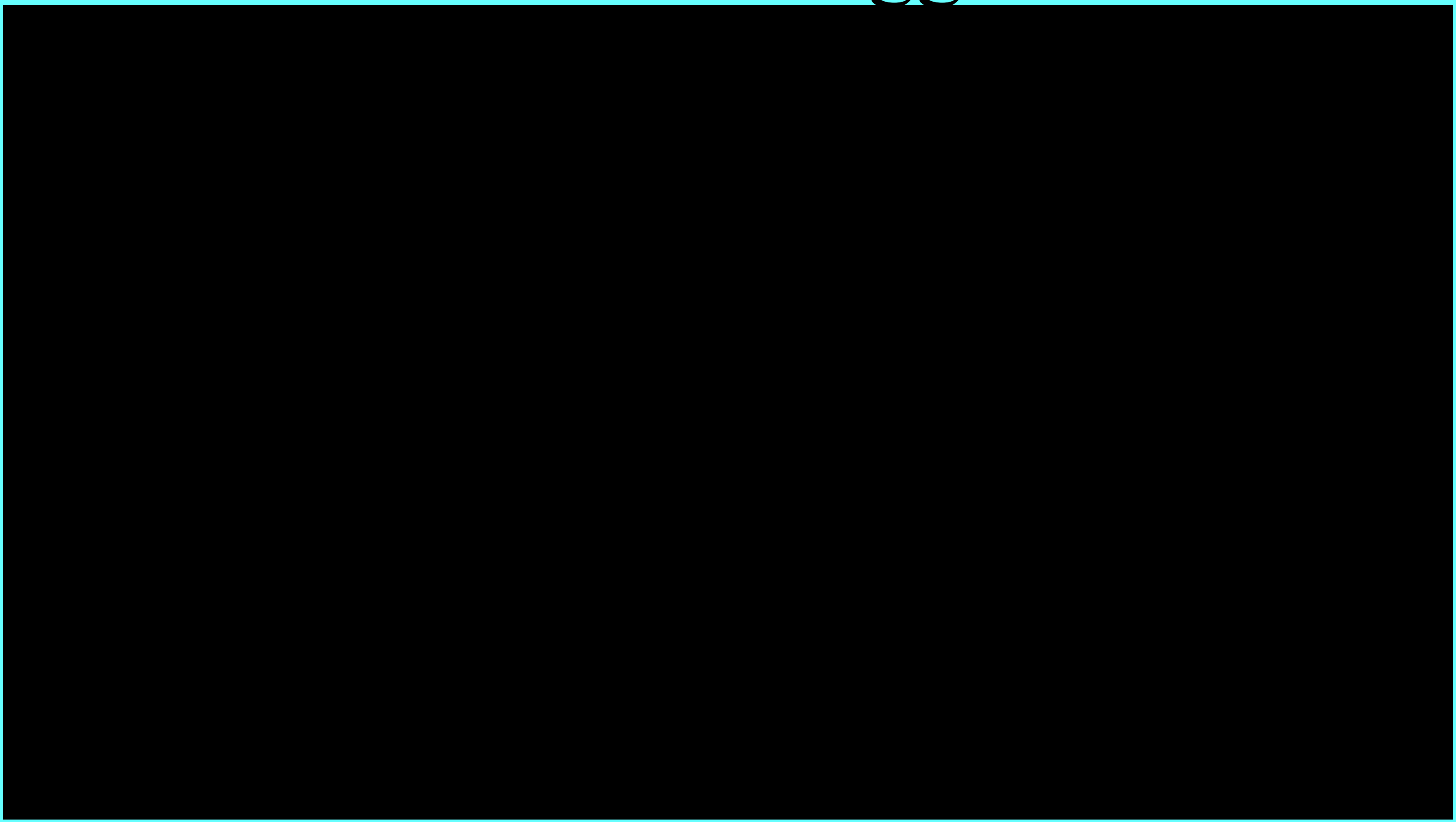
Il cerchio rosso indica l’ellisse di errore dell’atterraggio (500m).
Agilkia è il nome dell’isola sul Nilo dove fu trasportato il tempio di Iside e altri edifici dall’isola di Philae, quando fu costruita la diga di Assuan.

Dettagli dell'orbita di rilascio

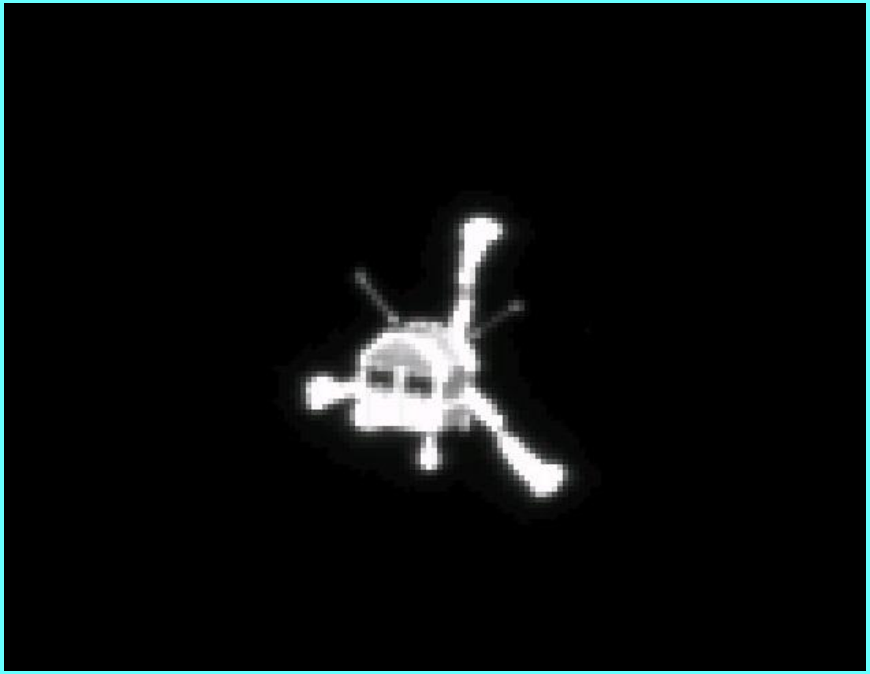
Andre



Simulazione del rilascio e dell’atterraggio



La discesa di Philae vista da Osiris



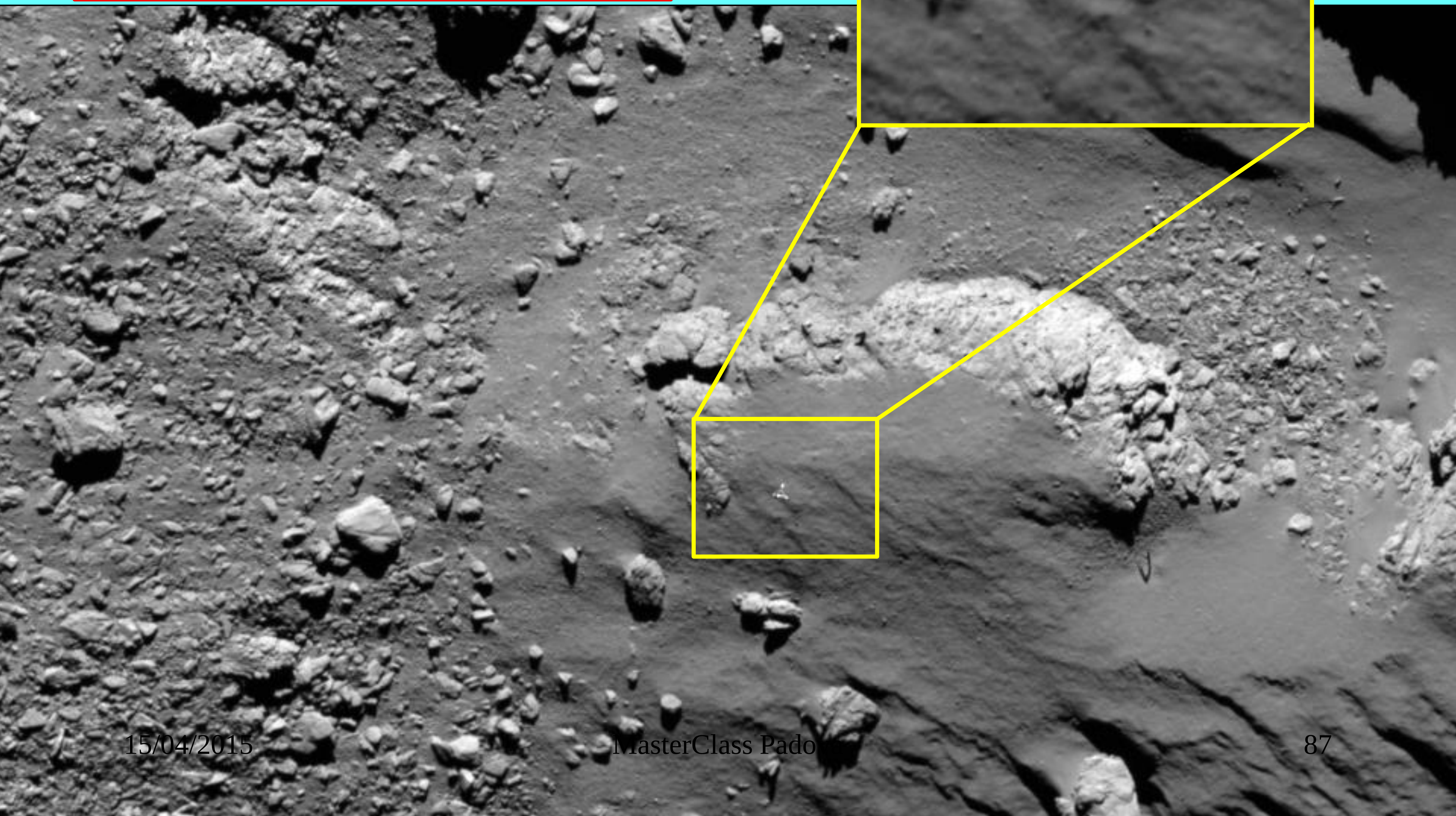
Philae se ne va sempre più lontana e attorno a essa volano grani di polvere cometaria

Il sito di atterraggio visto da Philae da 3 km di altezza

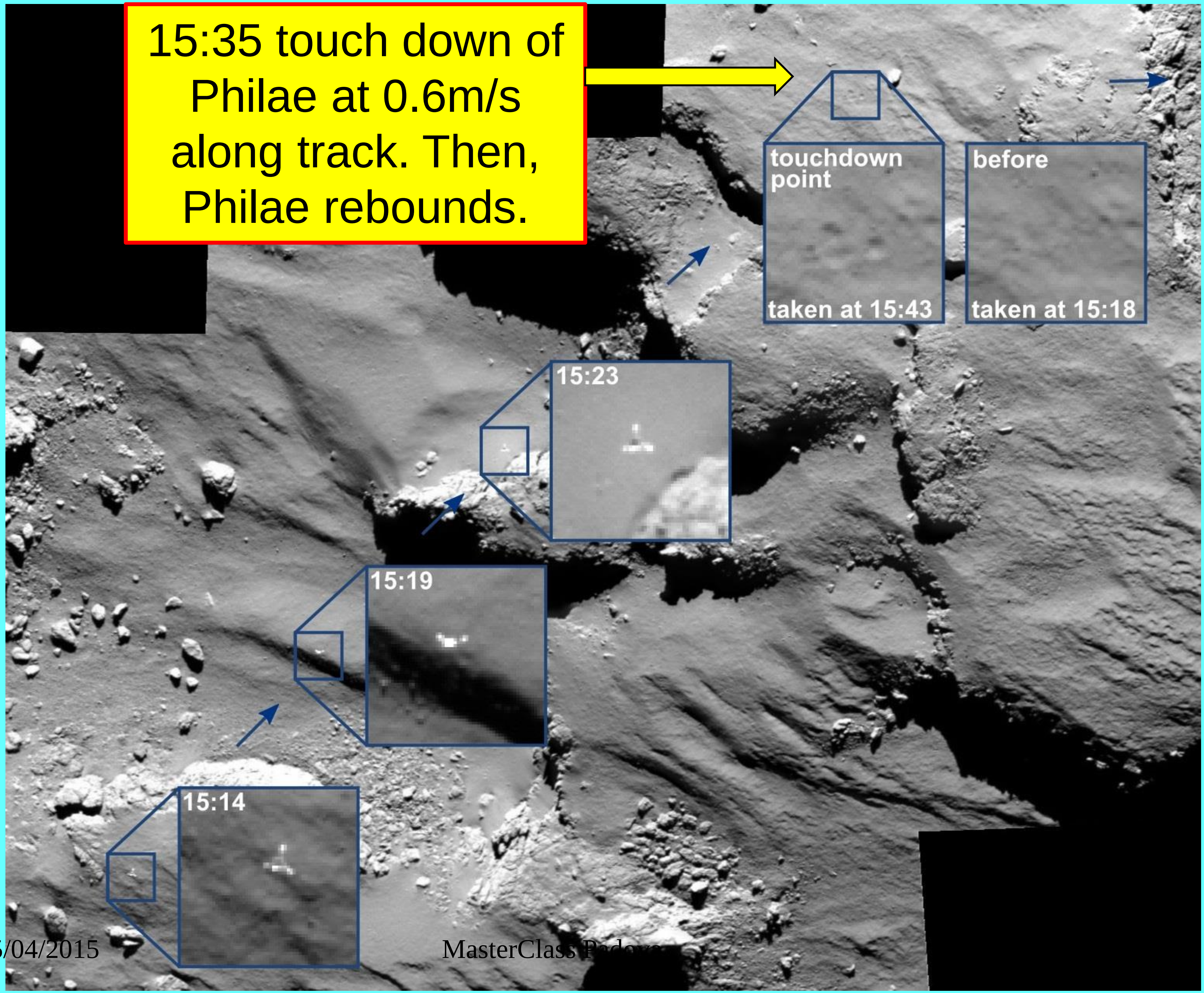
Immagine da 40 m di altezza

Durante la discesa Osiris vede Philae in varie immagini, ecco la prima alle ore 15:14

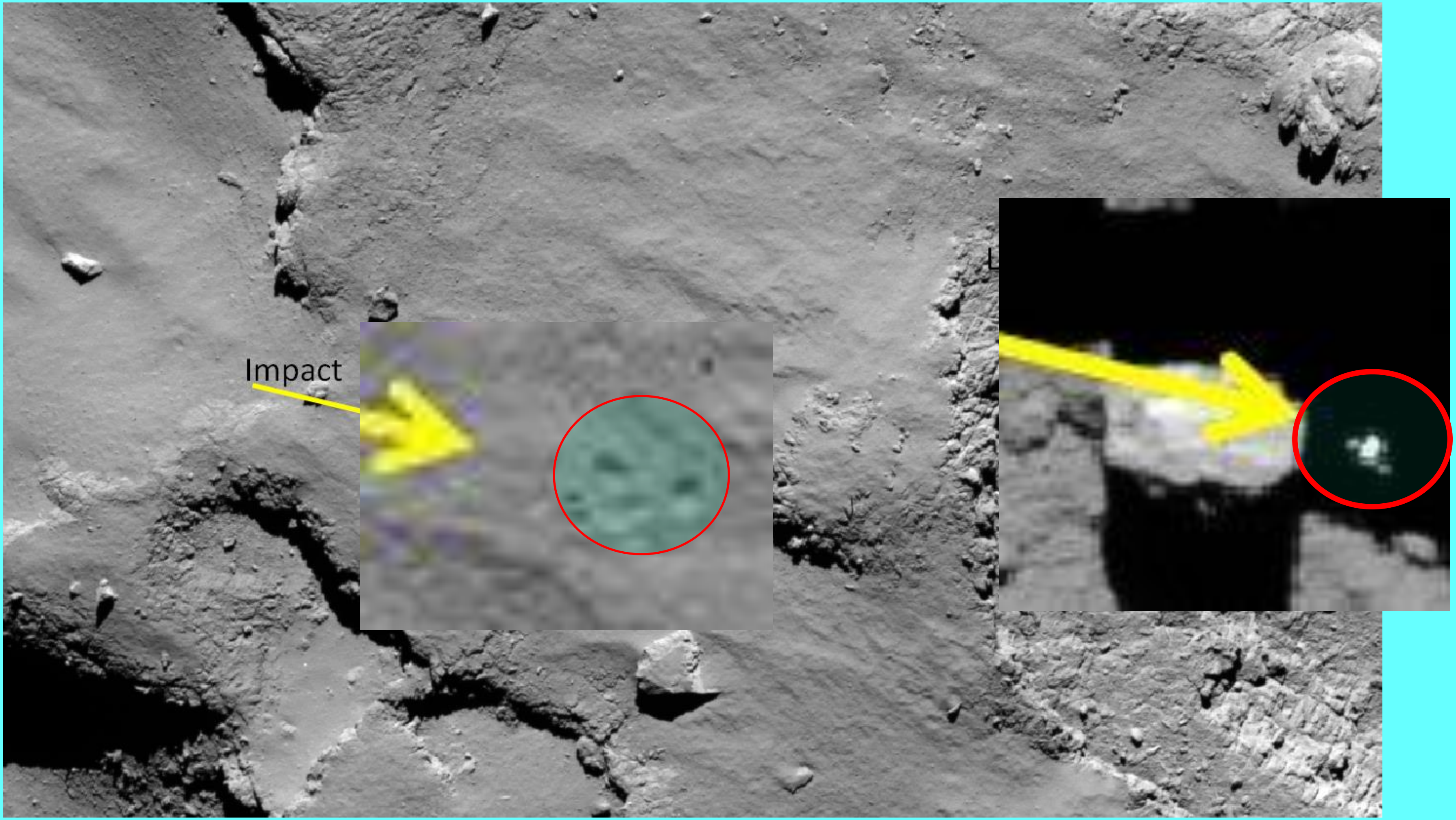
Philae



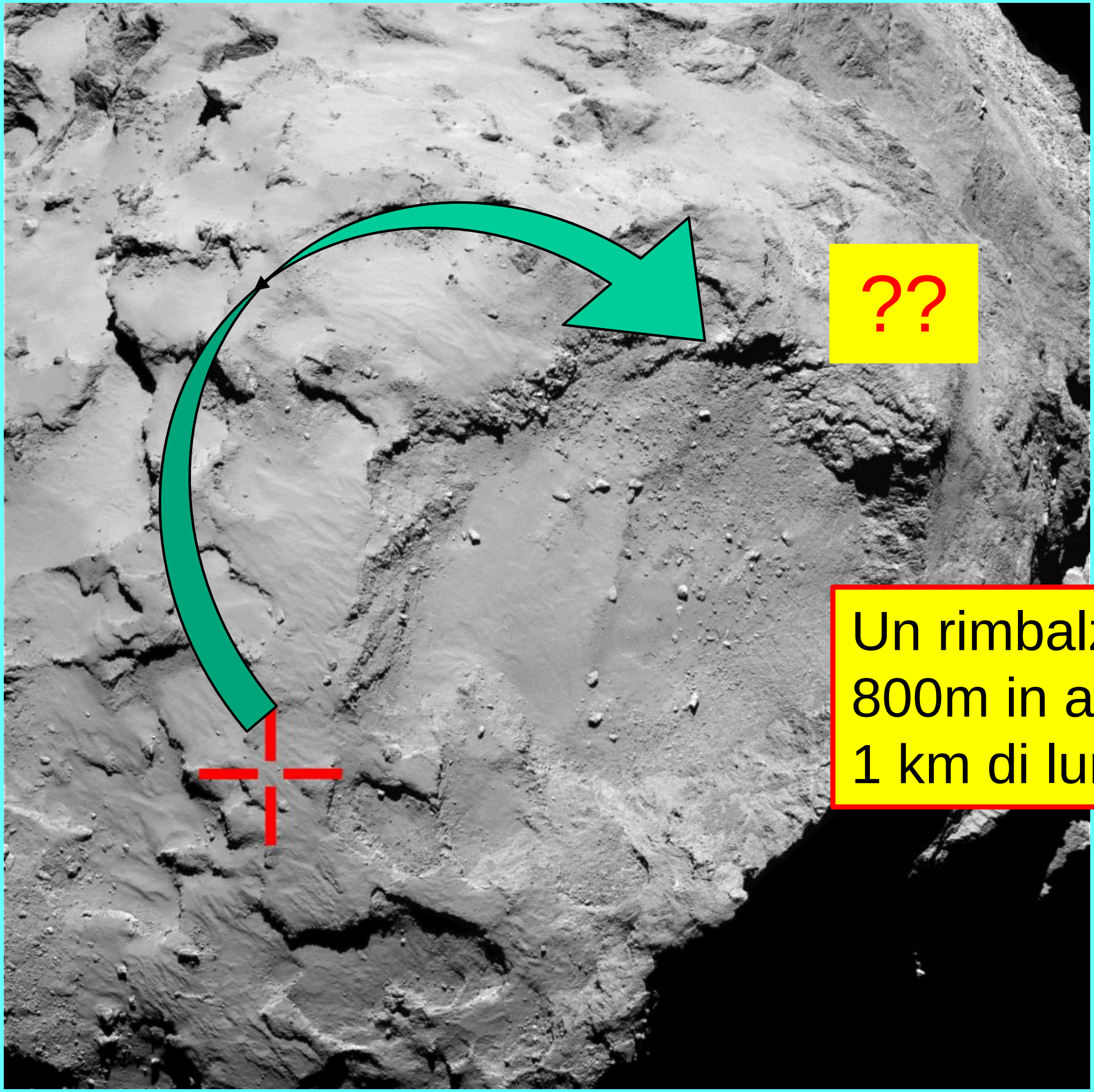
15:35 touch down of Philae at 0.6m/s along track. Then, Philae rebounds.



Osiris vede Philae anche dopo il rimbalzo!!

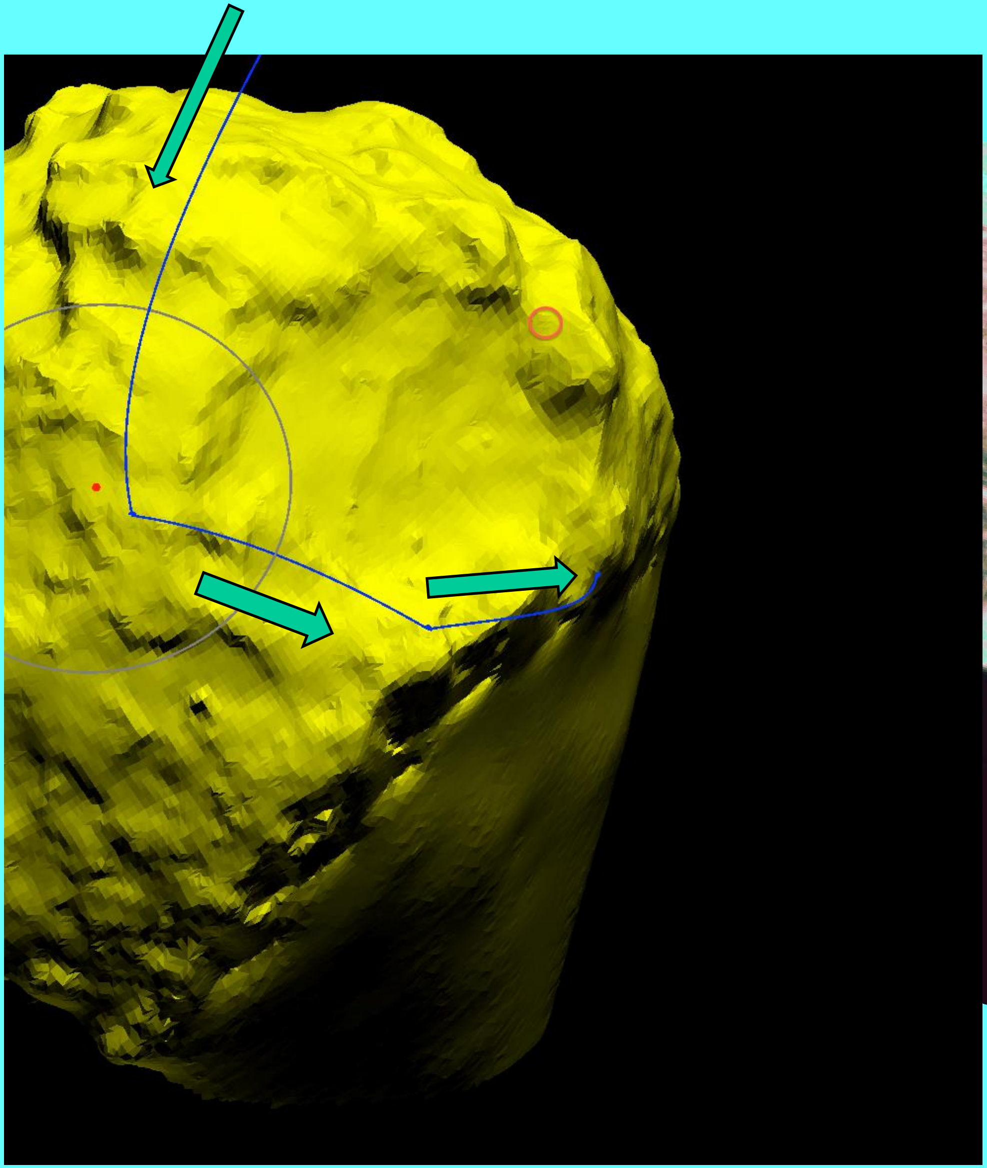


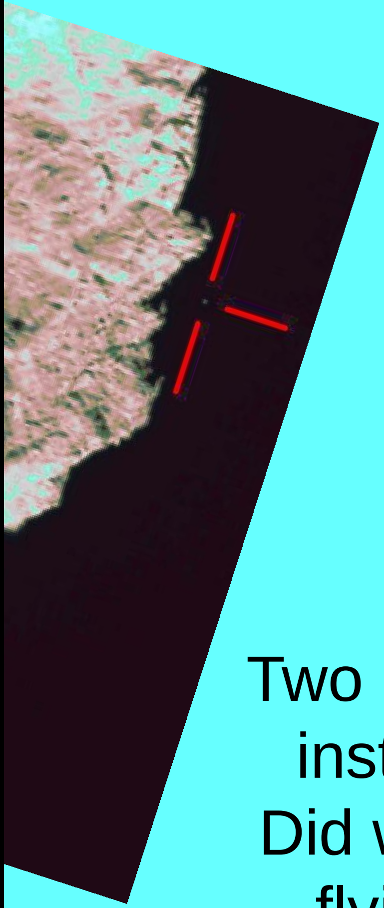
Un grande rimbalzo, e uno di assestamento ??



Un rimbalzo di circa
800m in altezza e oltre
1 km di lunghezza??

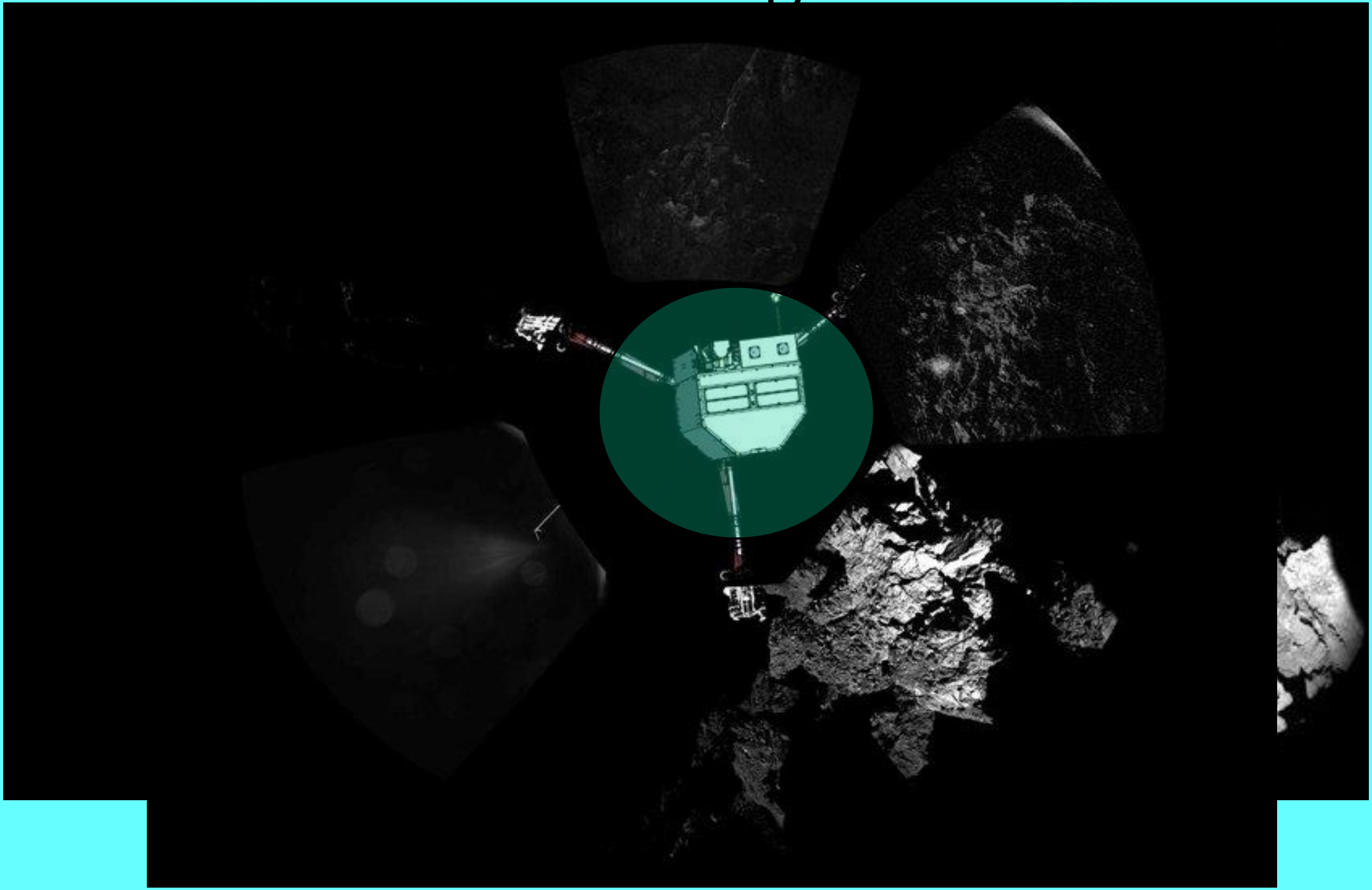
A different reconstruction



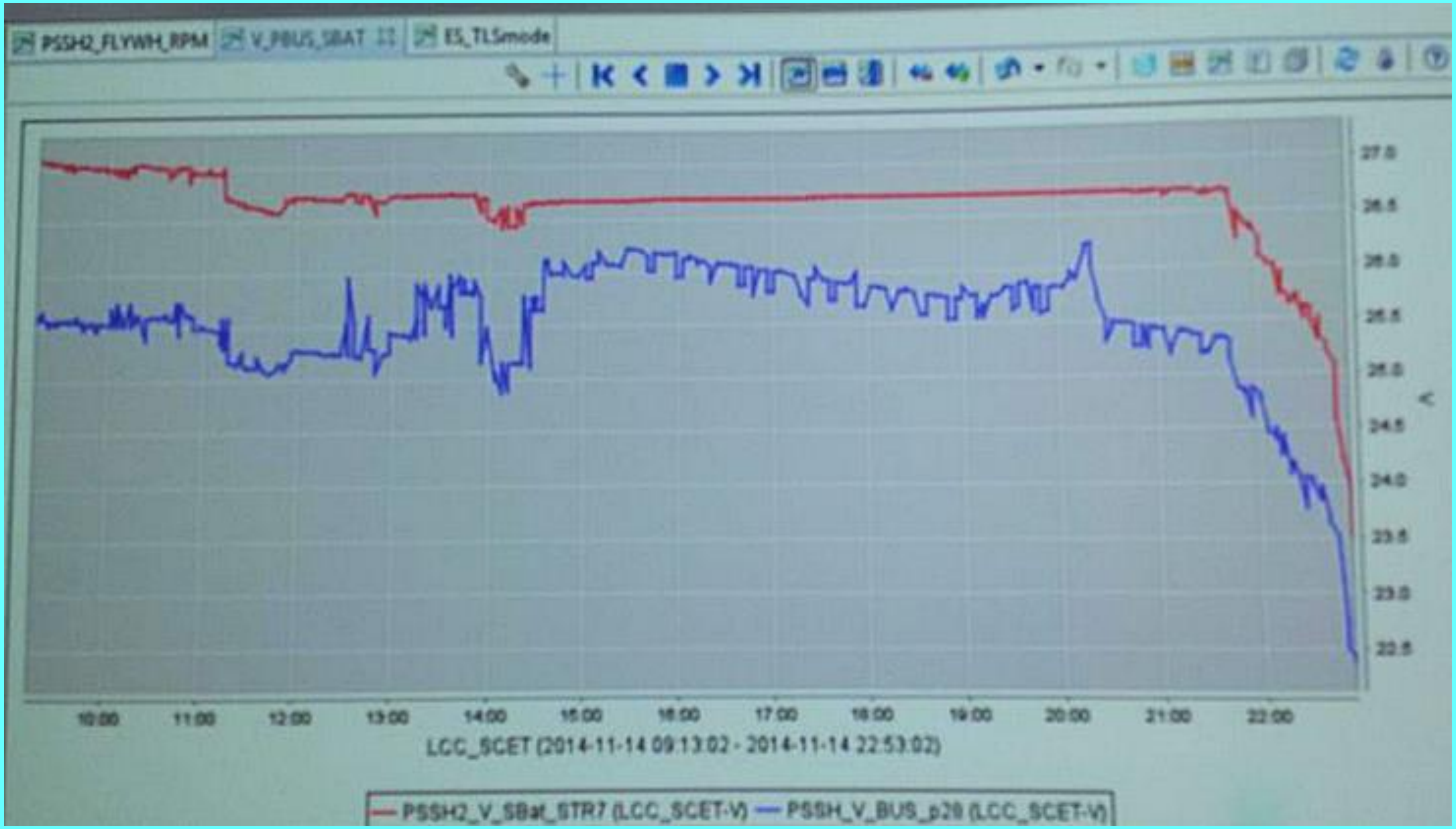


Two large bounces instead of one? Did we see Philae flying over the horizon?

Philae images the surroundings, but where is she hiding??



L’agonia di Philae, prima mattina del 15 novembre



In quel breve lasso di tempo Philae è riuscita a operare tutti gli strumenti, incluso il perforatore. Non so ancora i risultati.

Si risveglierà? Forse, speriamo che il freddo non guasti gli strumenti, con il passare dei giorni ***la cometa si avvicina progressivamente al Sole***, e cambia anche l’aspetto del Sole, ***cioè le stagioni***.

What Philae should have done

The minimum goal of Philae was to operate for ***48 hours***, and very optimistically until March 2015

What did Philae achieve in those few hours?

The lander returned all of its housekeeping data, as well as science data from the targeted instruments, including ROLIS, COSAC, Ptolemy, SD2 and CONSERT. This completed the measurements planned for the final block of experiments on the surface.

In addition, the lander's body was lifted by about 4 cm and rotated about 35° in an attempt to receive more solar energy.

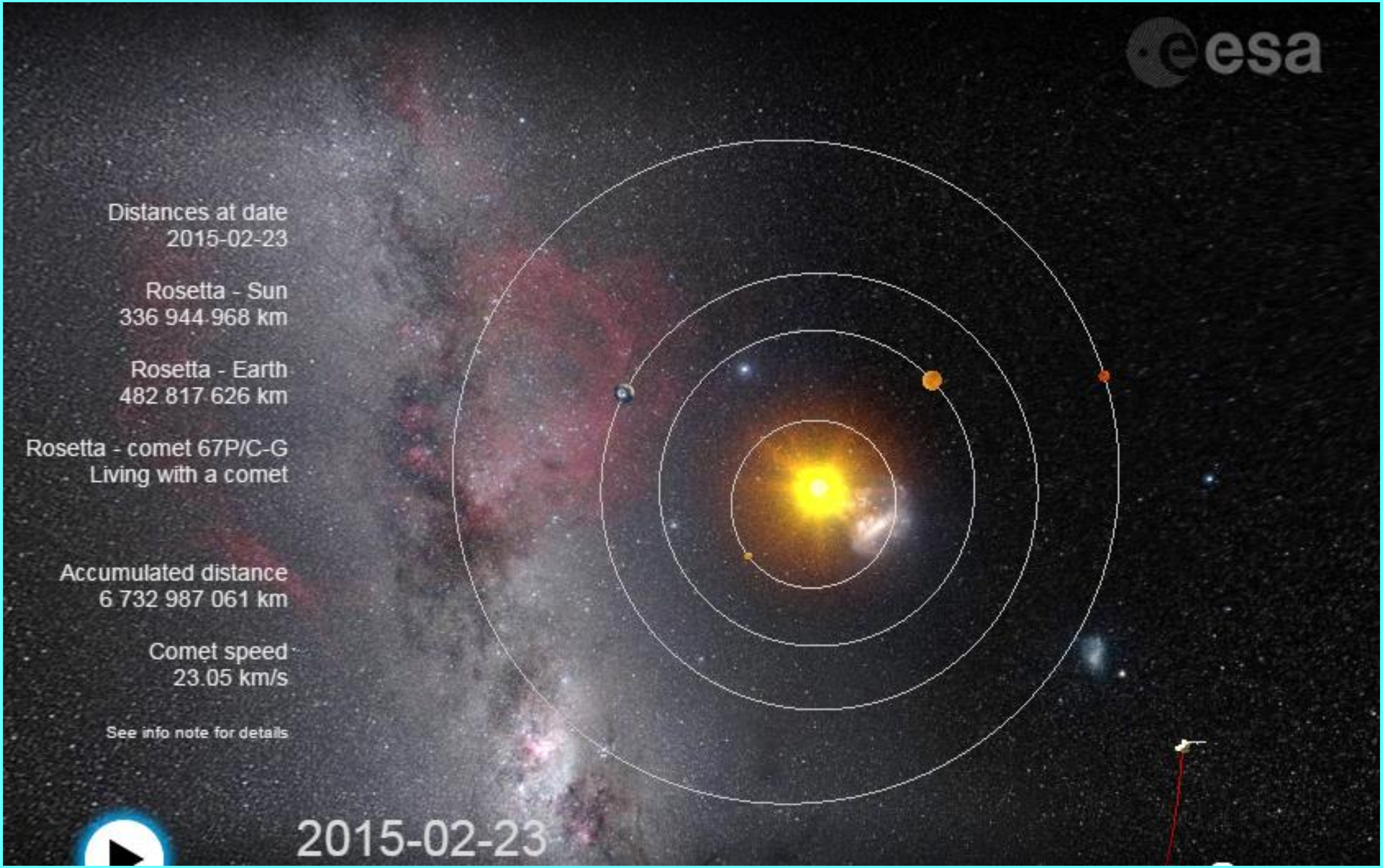
“We still hope that at a later stage of the mission, perhaps when we are nearer to the Sun, that we might have enough solar illumination to wake up the lander and re-establish communication, ”

What did Philae achieve in those few hours?

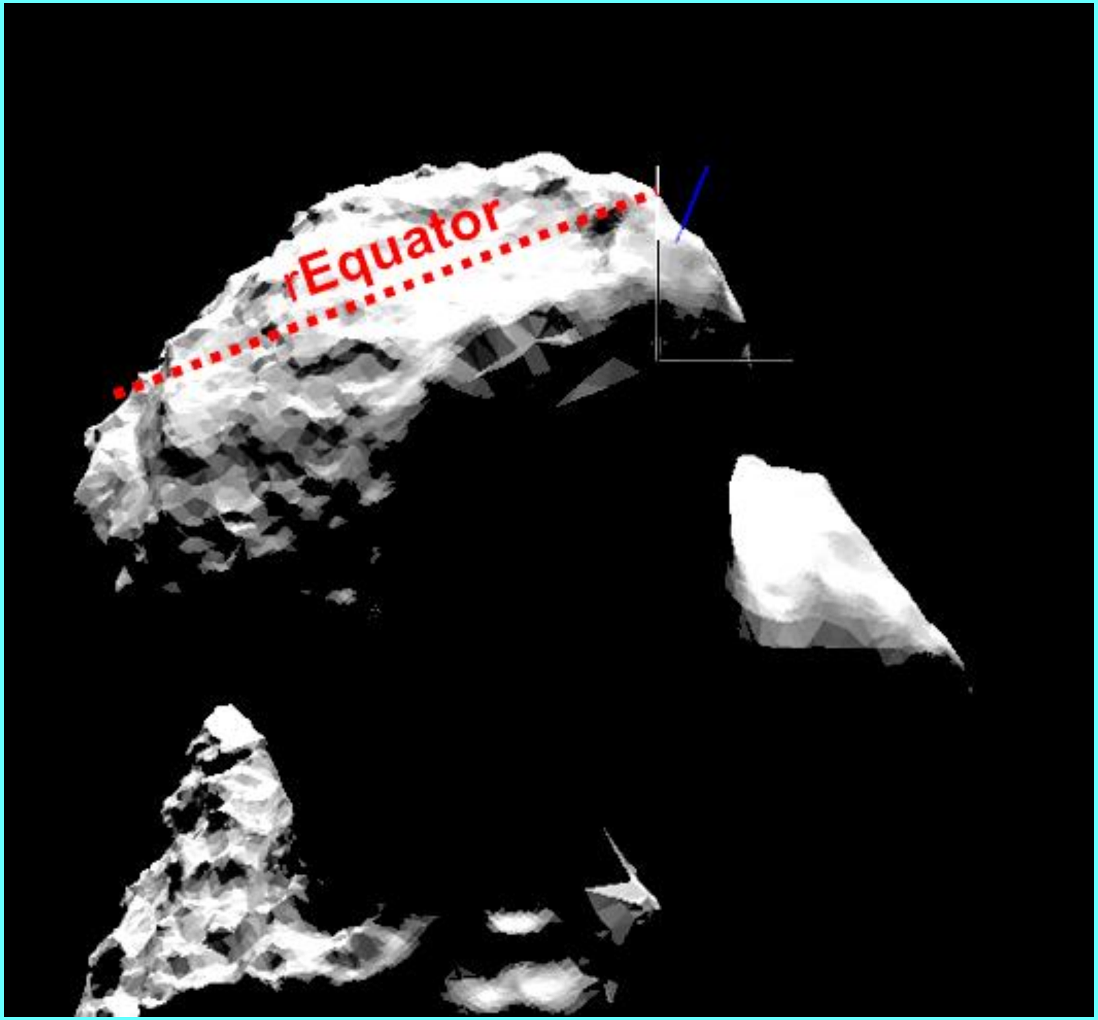
The drill SD2 was deployed as planned, extending 46.9 cm below the balcony of the lander and 56.0 cm from its reference point. However, we do not yet know how much – if any – material was actually delivered to the ovens. Because Philae was not anchored to the comet surface, it is also possible that, if the drill touched a particularly hard surface material, it moved the lander instead of drilling into the surface.

At Philae's final landing spot, the MUPUS probe recorded a temperature of –163°C.
The probe then started to hammer itself into the subsurface, but was unable to make more than a few millimetres of progress. Probably the probe encountered a hard surface with strength comparable to that of solid ice. The team have made the preliminary assessment that the upper layers of the comet's surface consist of dust of 10–20 cm thickness, overlaying mechanically strong ice or ice and dust mixtures.

Where is today Rosetta?

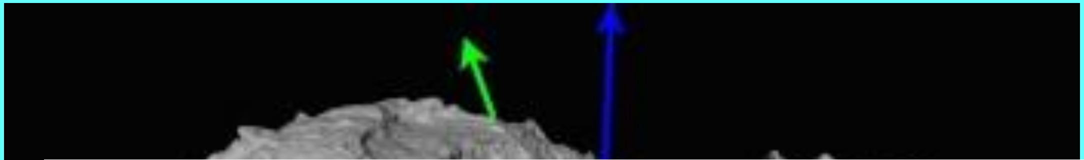


Seasonal changes on the comet

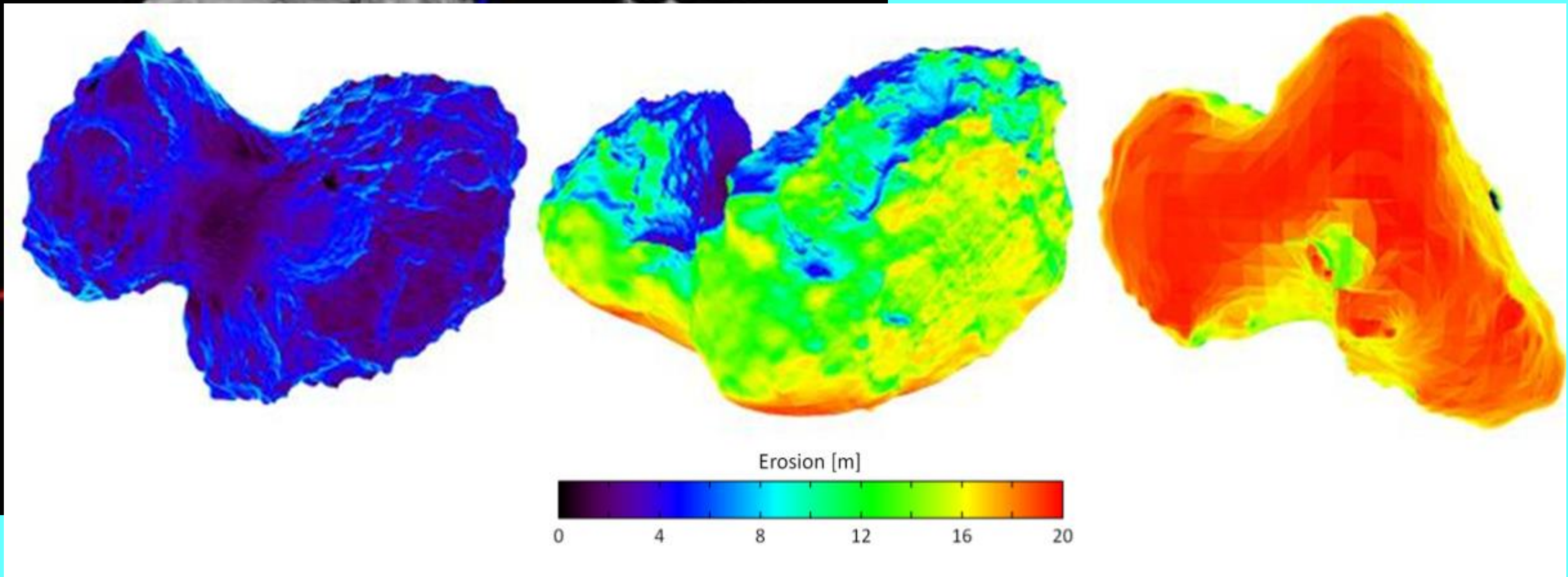


Si risveglierà Philae? Forse. Con il passare dei mesi ***la cometa si avvicina progressivamente al Sole***, e cambia anche l'aspetto del Sole, ***cioè le stagioni***. Cambierà l'altezza del Sole sull'equatore della cometa e probabilmente I pannelli solare saranno illuminati più di ora. Tuttavia aumenterà considerevolmente anche la produzione di polvere, che potrebbe coprire I pannelli. Non è quindi possibile fare previsioni sicure, ***vedremo cosa succederà***.

Insolation on the comet



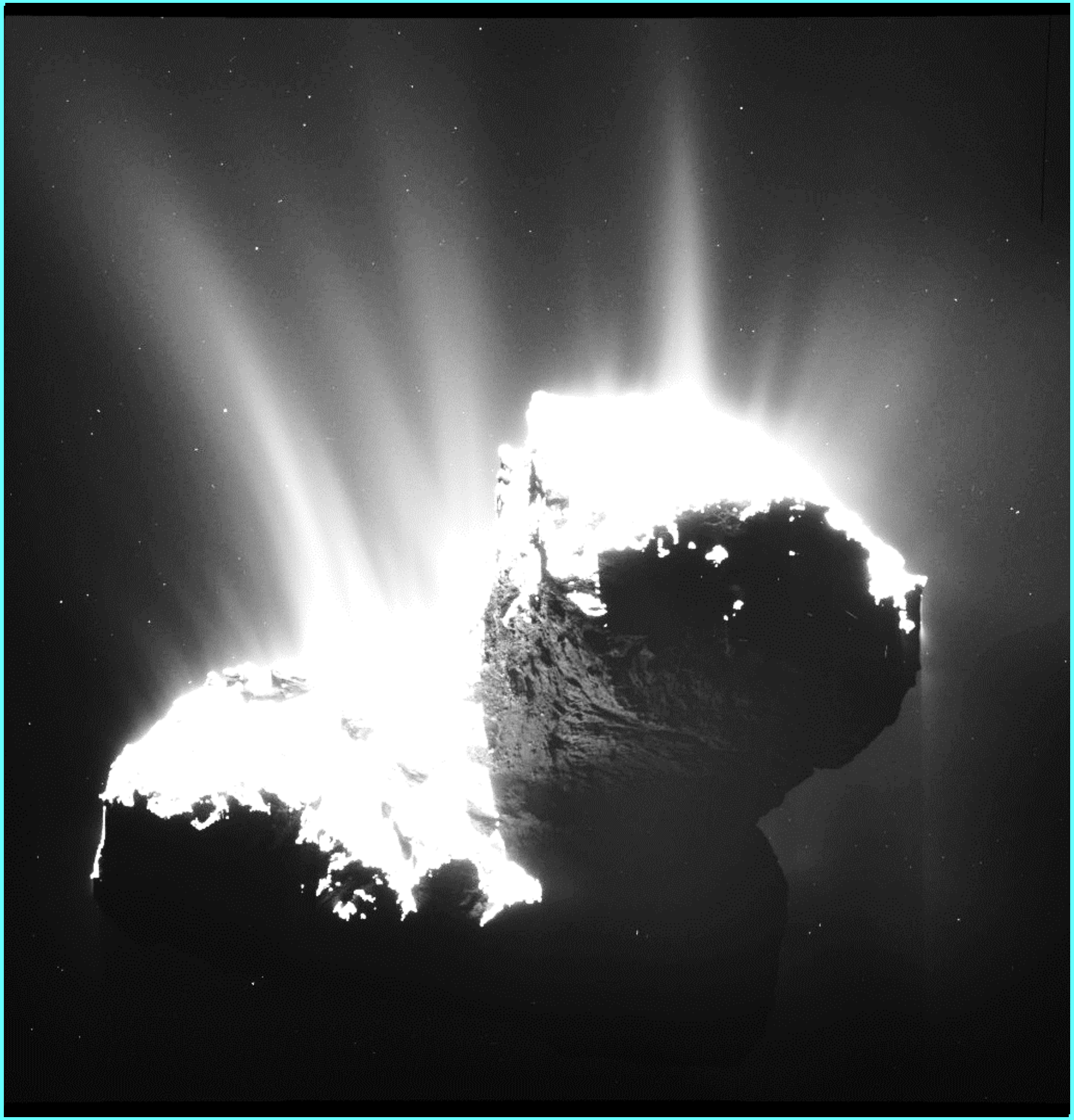
While the northern "hemi-comet" experiences a long



the southern half of Comet 67P/C-G (right image) could lose a dust layer of up to 20 metres during one orbit. Due to the seasonal cycle of the comet, the northern half (left and centre images) is much less subject to erosion.

by 52º.

Aumenta rapidamente l’attività



La zona in ombra diventerà ben visibile a partire da aprile, quando sulla cometa ci si avvicinerà all’equinozio di autunno. Ma già oggi possiamo vederne alcune caratteristiche, grazie alla luce diffusa tutto attorno dai grani di povere.

I “grani di polvere ”

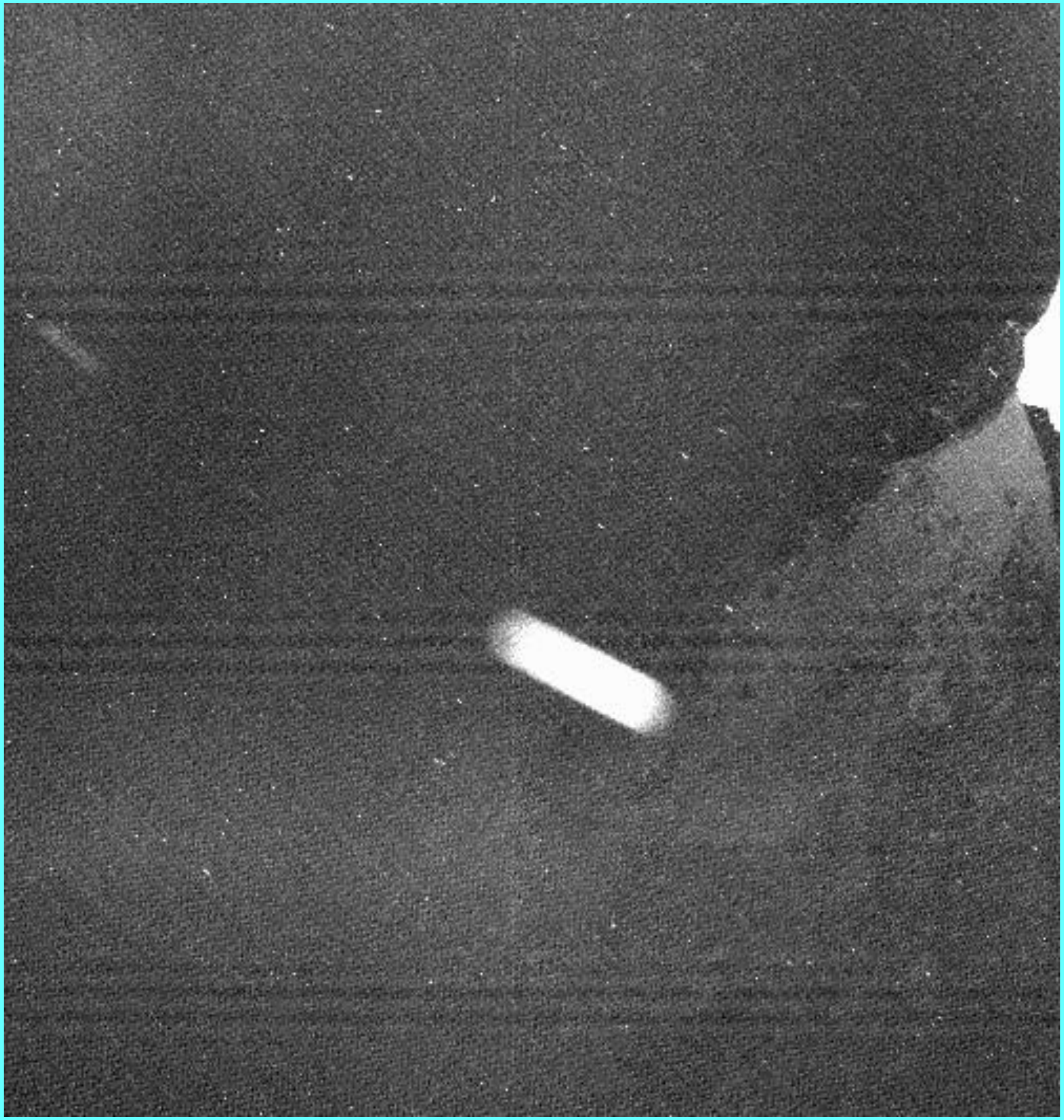
In questa immagine i getti vengono risolti in una miriade di ‘grani di polvere’, alcuni con dimensioni dell'ordine dei cm.

In effetti, la ‘polvere’ è composta di silicati frammisti a ghiacci.

Alcuni di questi grani ruotano su se stessi.

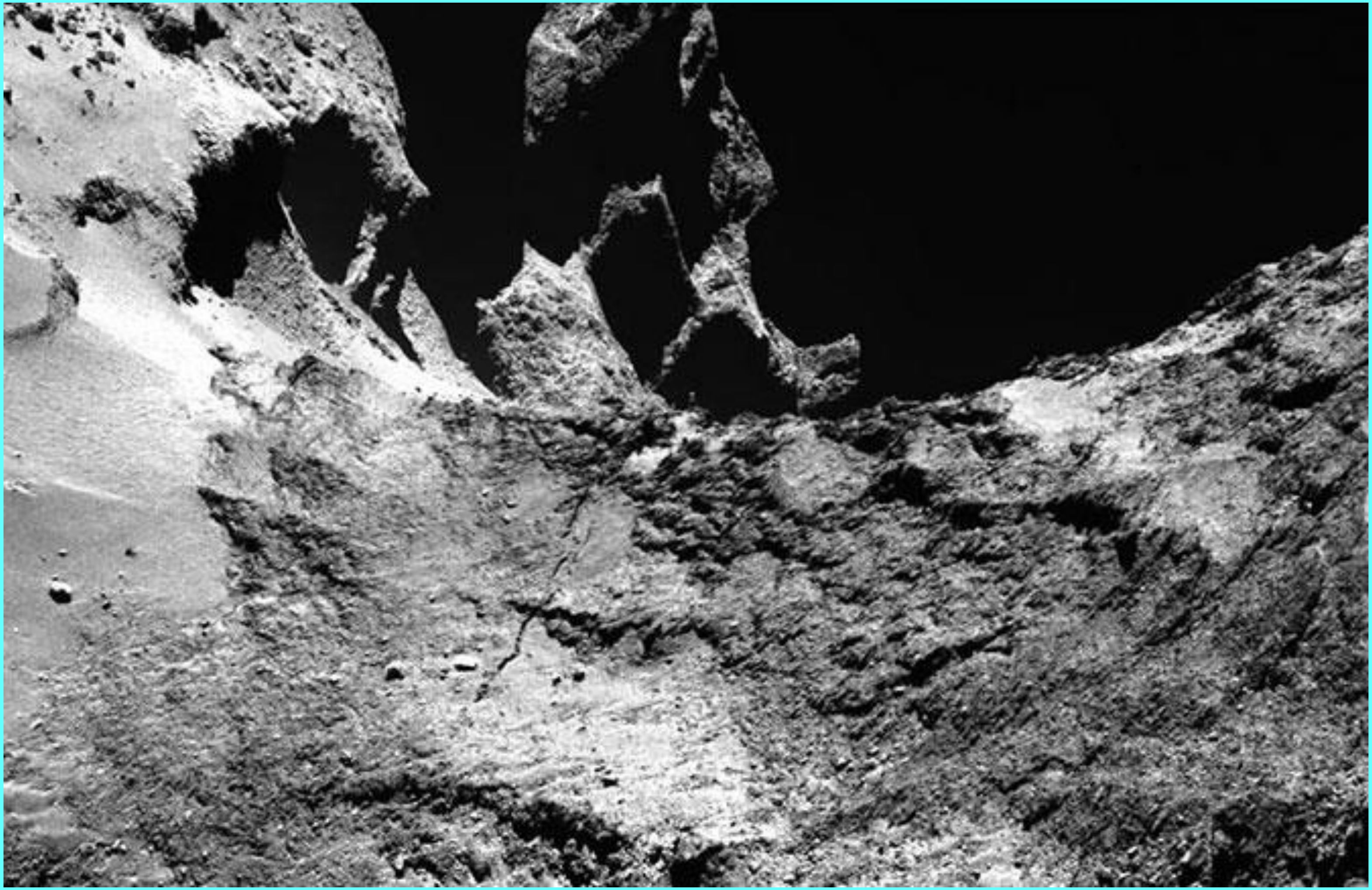
Out of focus Grains

- Dato che conosciamo perfettamente le caratteristiche ottiche della WAC possiamo ricavare dal 'fuori fuoco' la distanza del grano e quindi calcolare velocità e traiettoria.



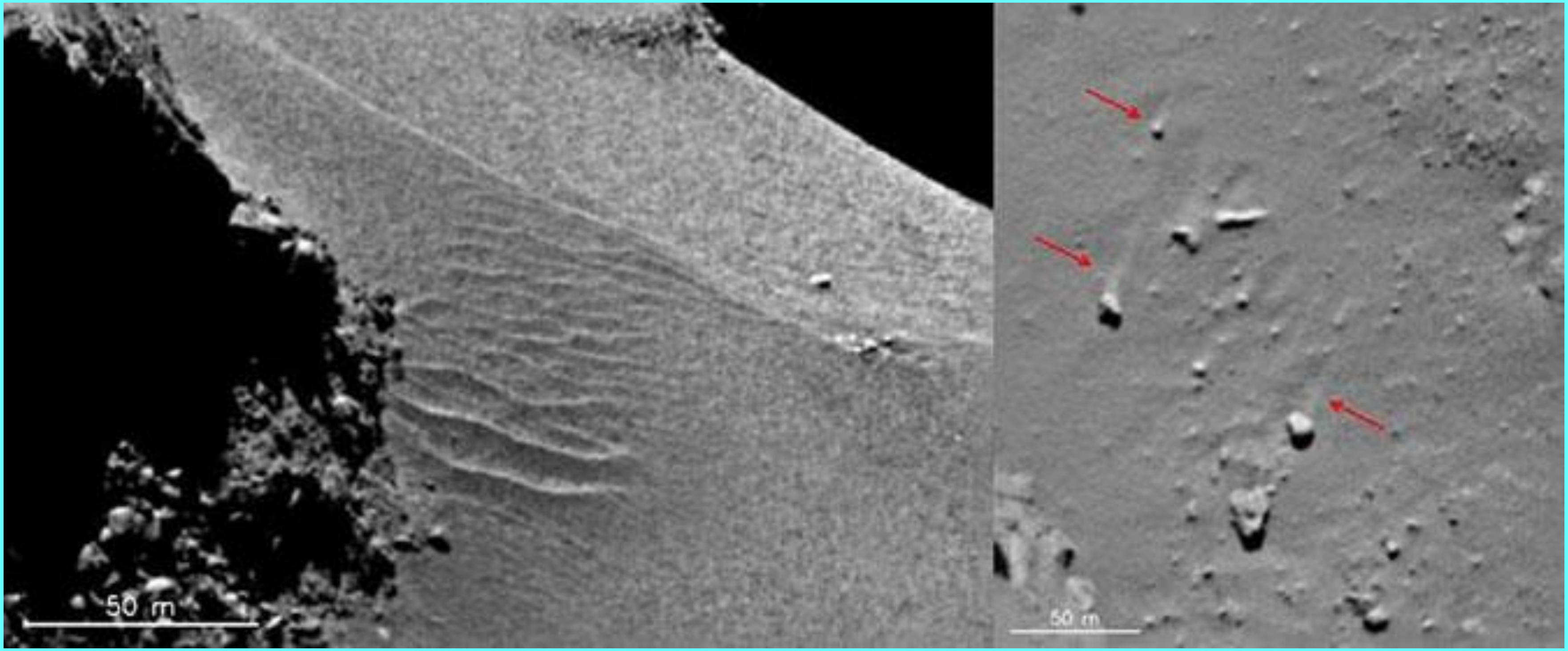

Pozzo naturale di metano
in Siberia
30 m diametro / >70 m profondità

A long fracture

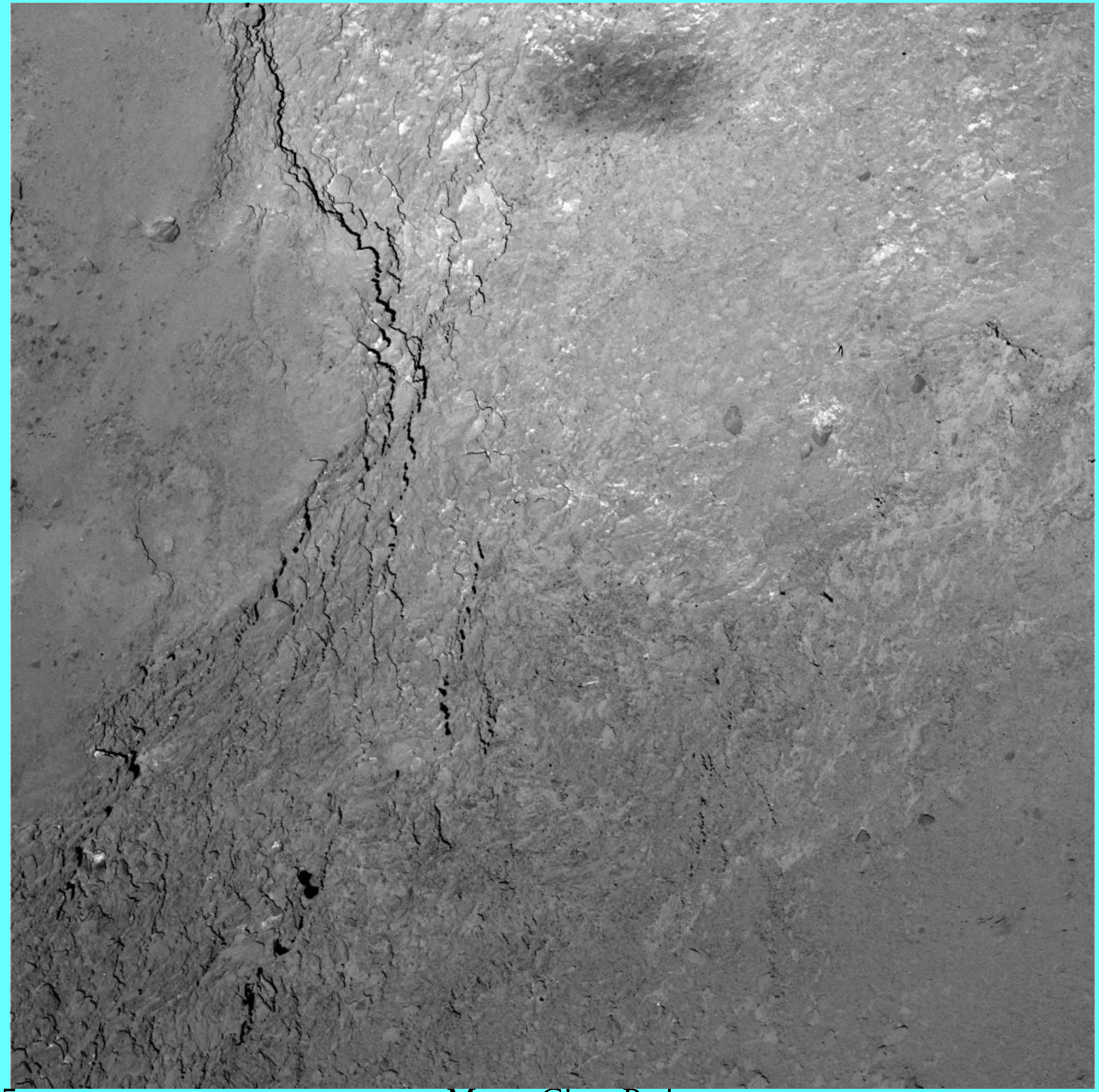


Notice the fracture

It cannot be the wind!



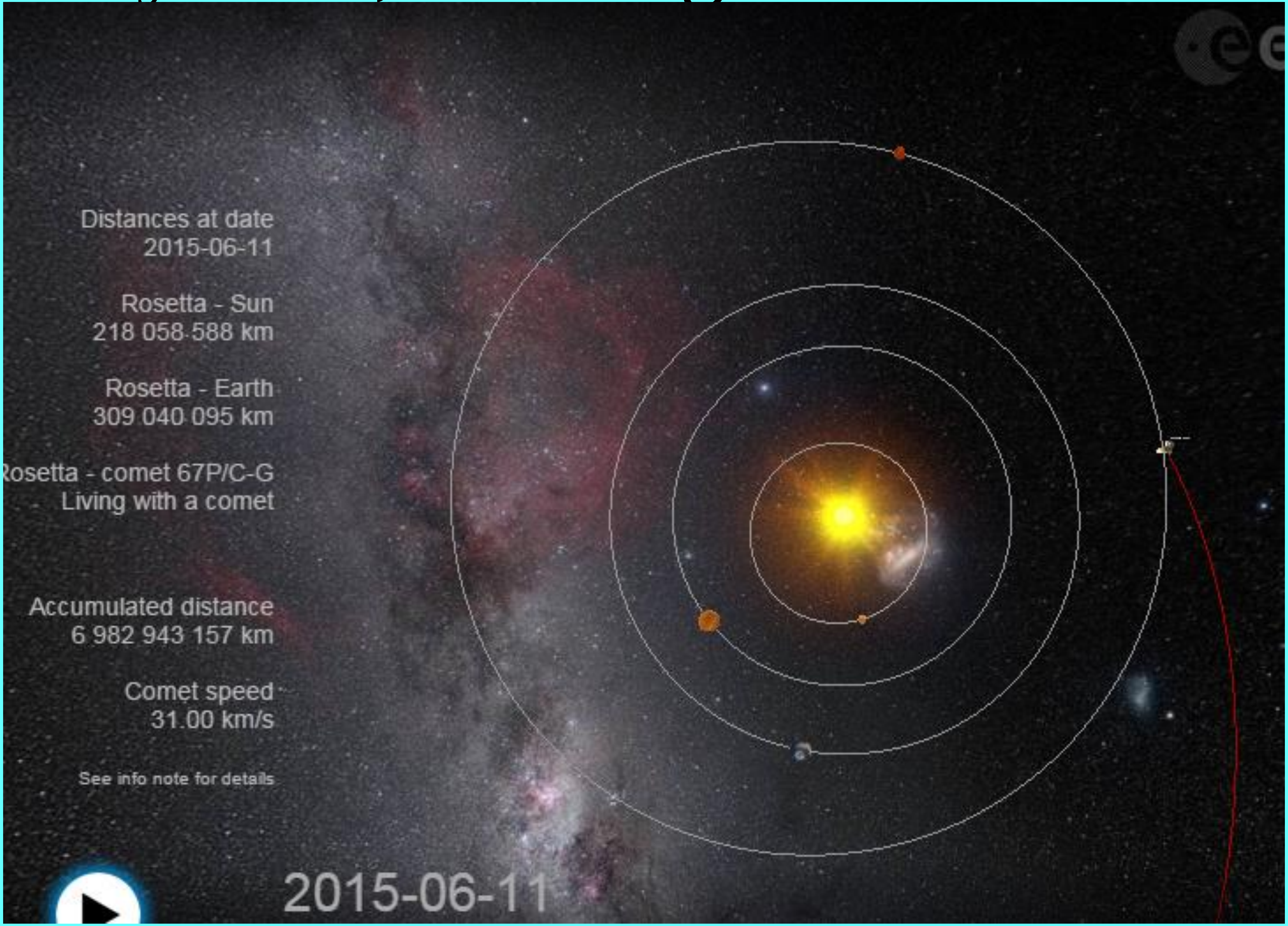
Iconic image: the shadow of Rosetta



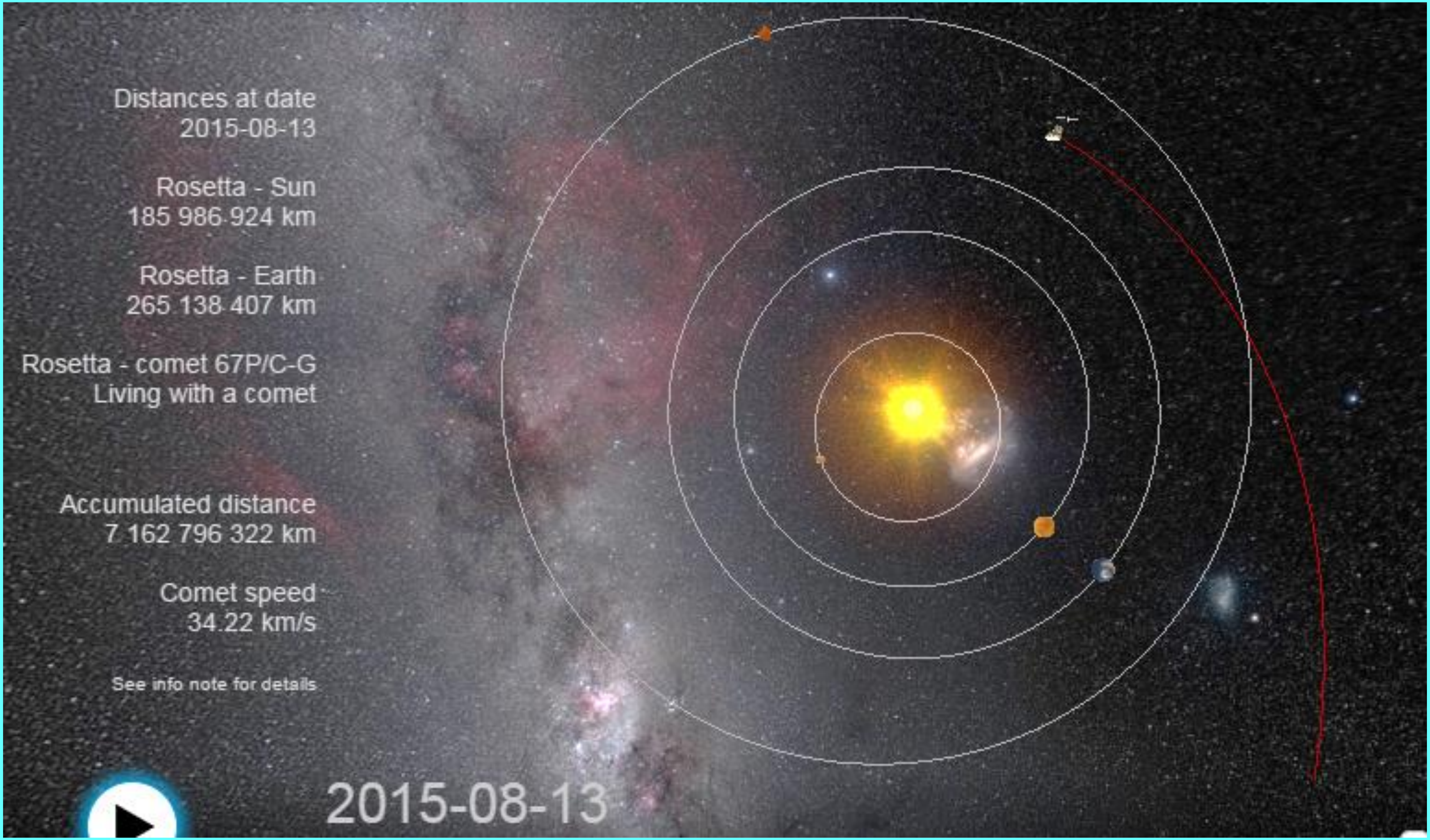
Orbits from February - Mars

Orbits:
http://blogs.esa.int/rosetta/2015/02/13/mission-control-at-closest-approach/
http://blogs.esa.int/rosetta/2015/02/04/rosetta-swoops-in-for-a-close-encounter/

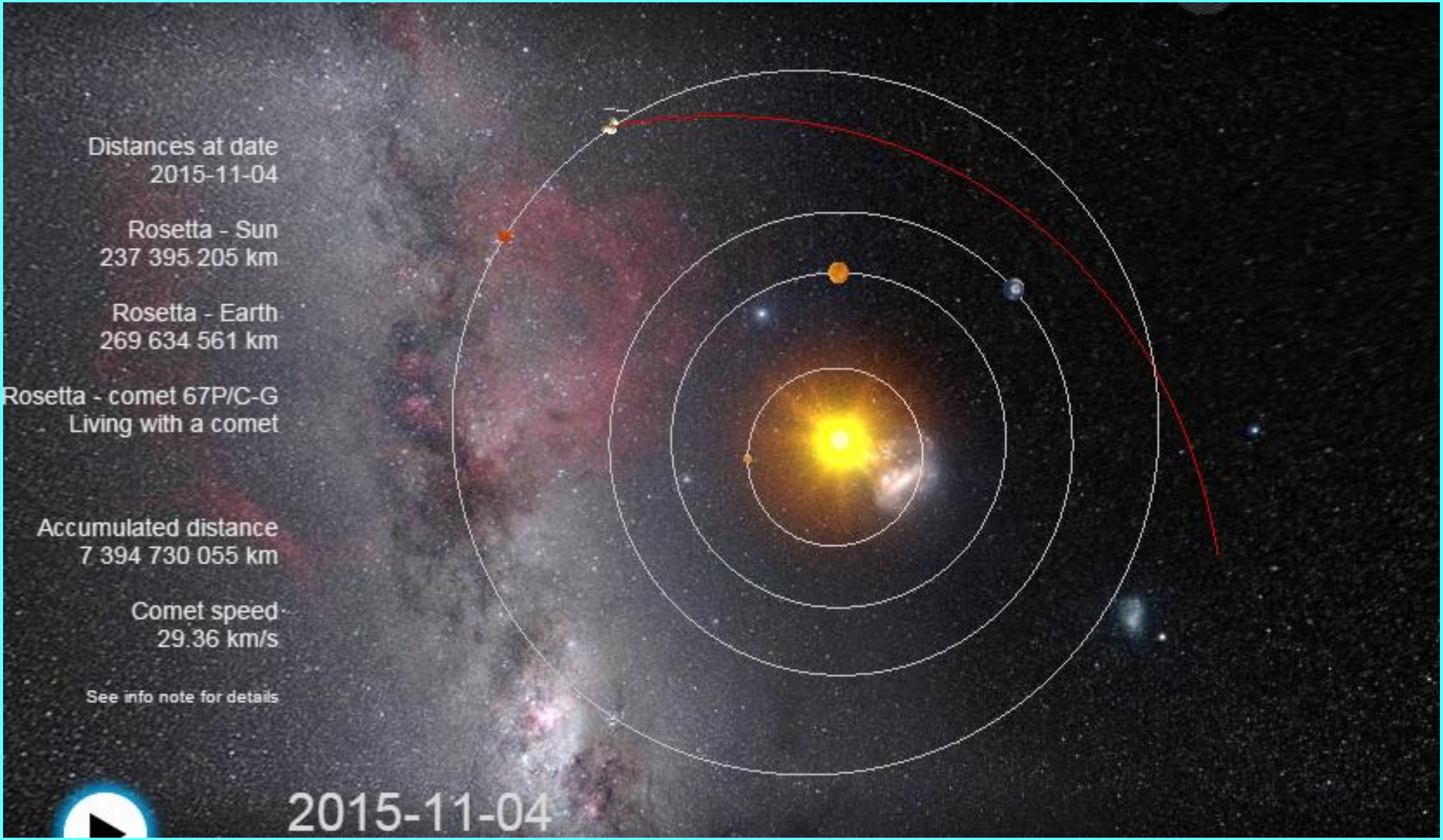
Early June; crossing of Mars orbit



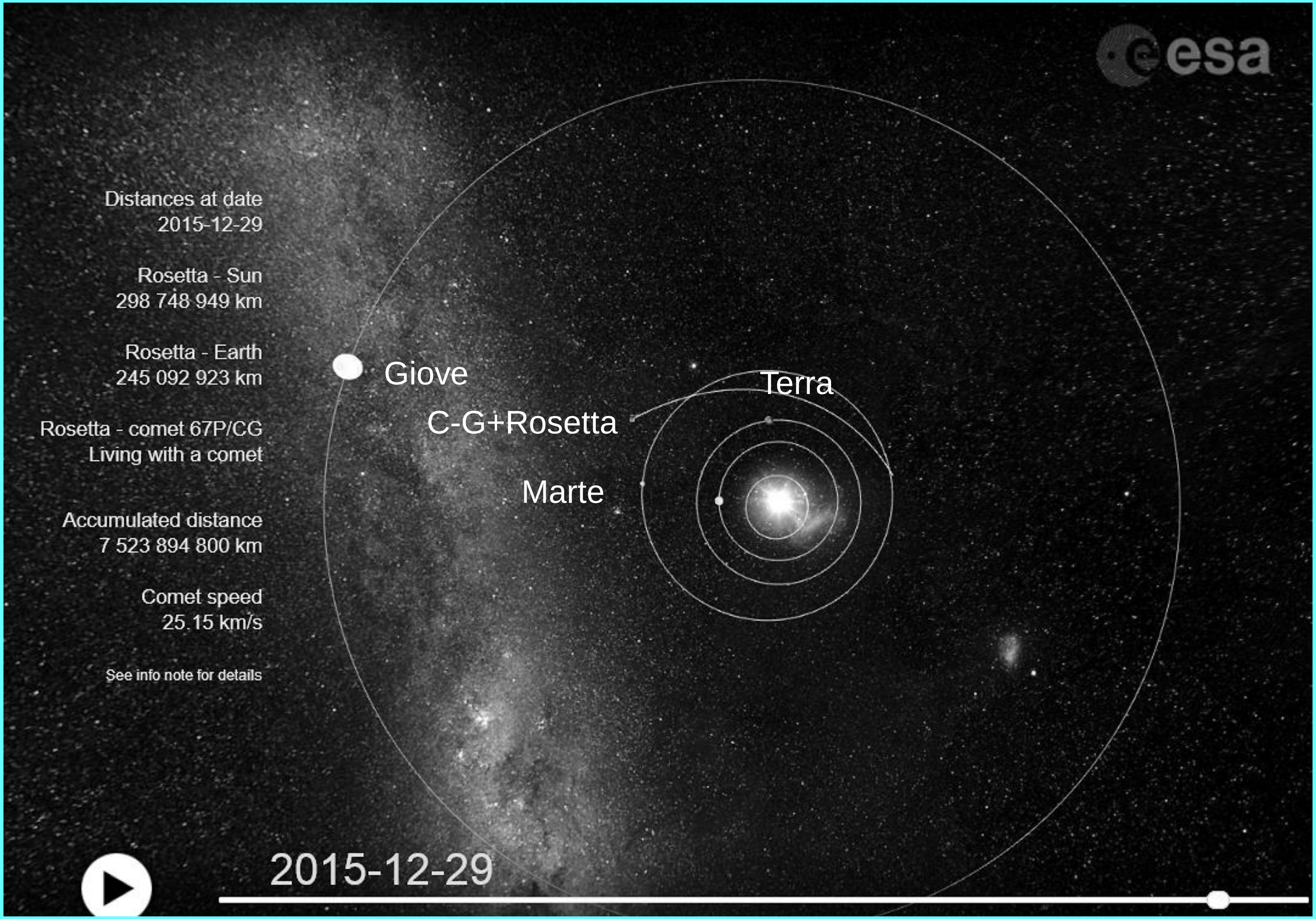
Aug 13 the perihelion



Early November: exit Mars orbit



December 2015, the end (?)



La fine del 2015 è anche la fine nominale della missione, ma si vedrà allora se non valga la pena continuare anche dopo.