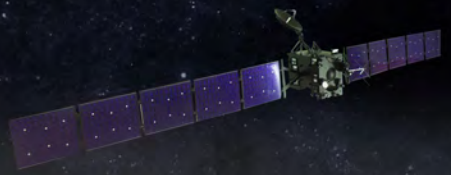
Rosetta Mission Status Update

Hal Weaver (JHU/APL)
On behalf of the Rosetta Team

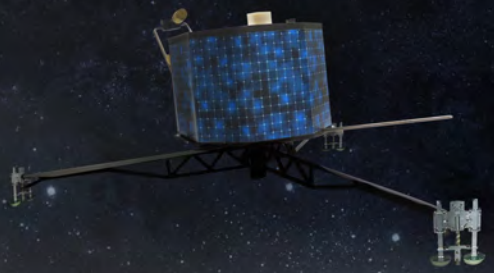
Rosetta is homing in on its target!

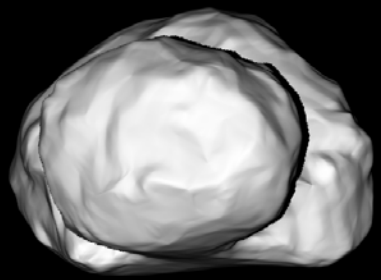
Orbiter (11 instruments)



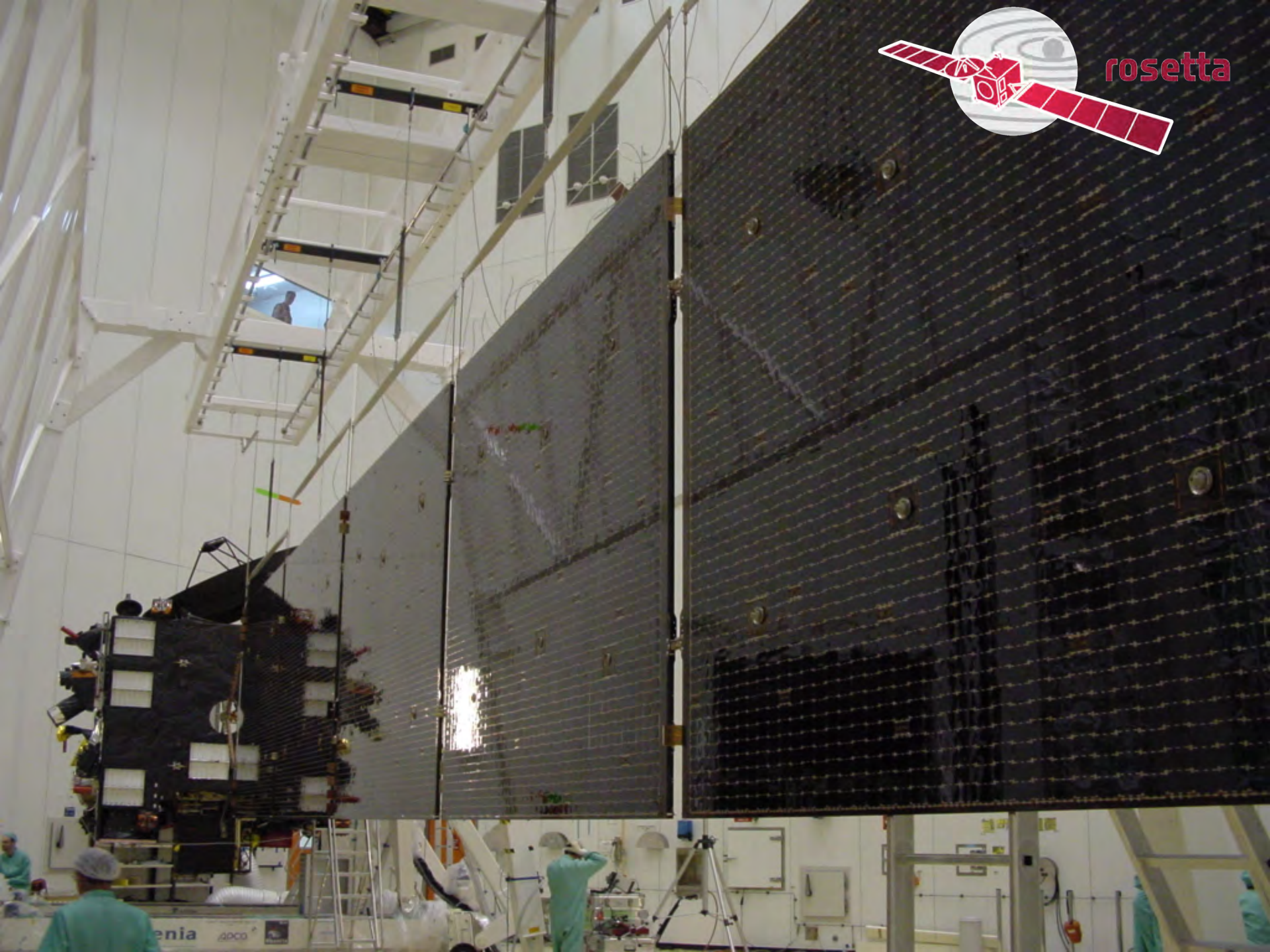
- Exited Hibernation on Jan 20th
- Rendezvous with 67P/C-G on Aug 6th
- Philae Landing in early November
- Orbiter Escort through Dec 31st, 2015

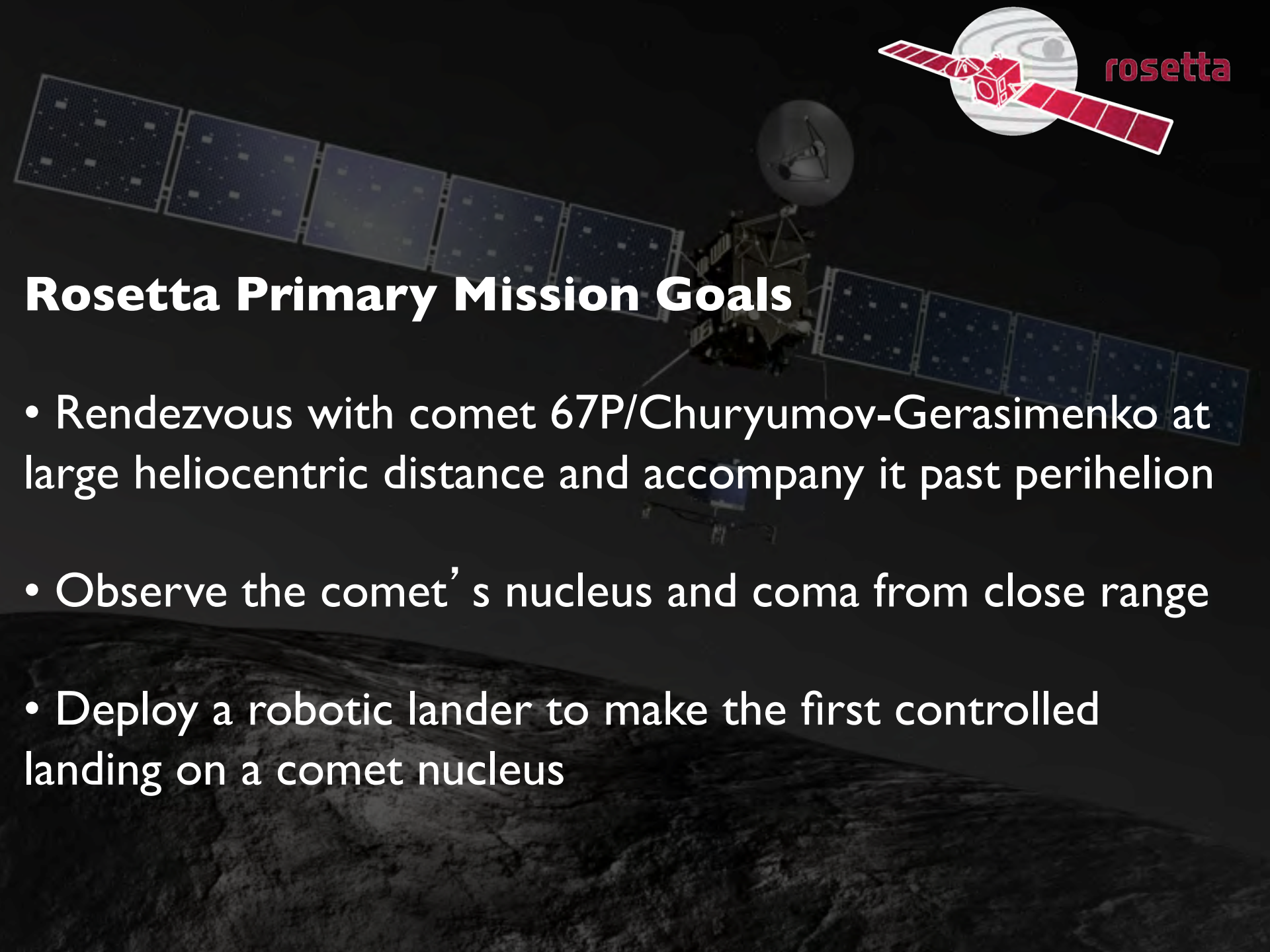
Philae Lander (10 instruments)





rosetta
Rosetta- 2.8 m x 2.1 m x 2.0 m
32 m
Philae - 0.85m x 0.85m
(1.3 high and 1.46 m legs)


rosetta

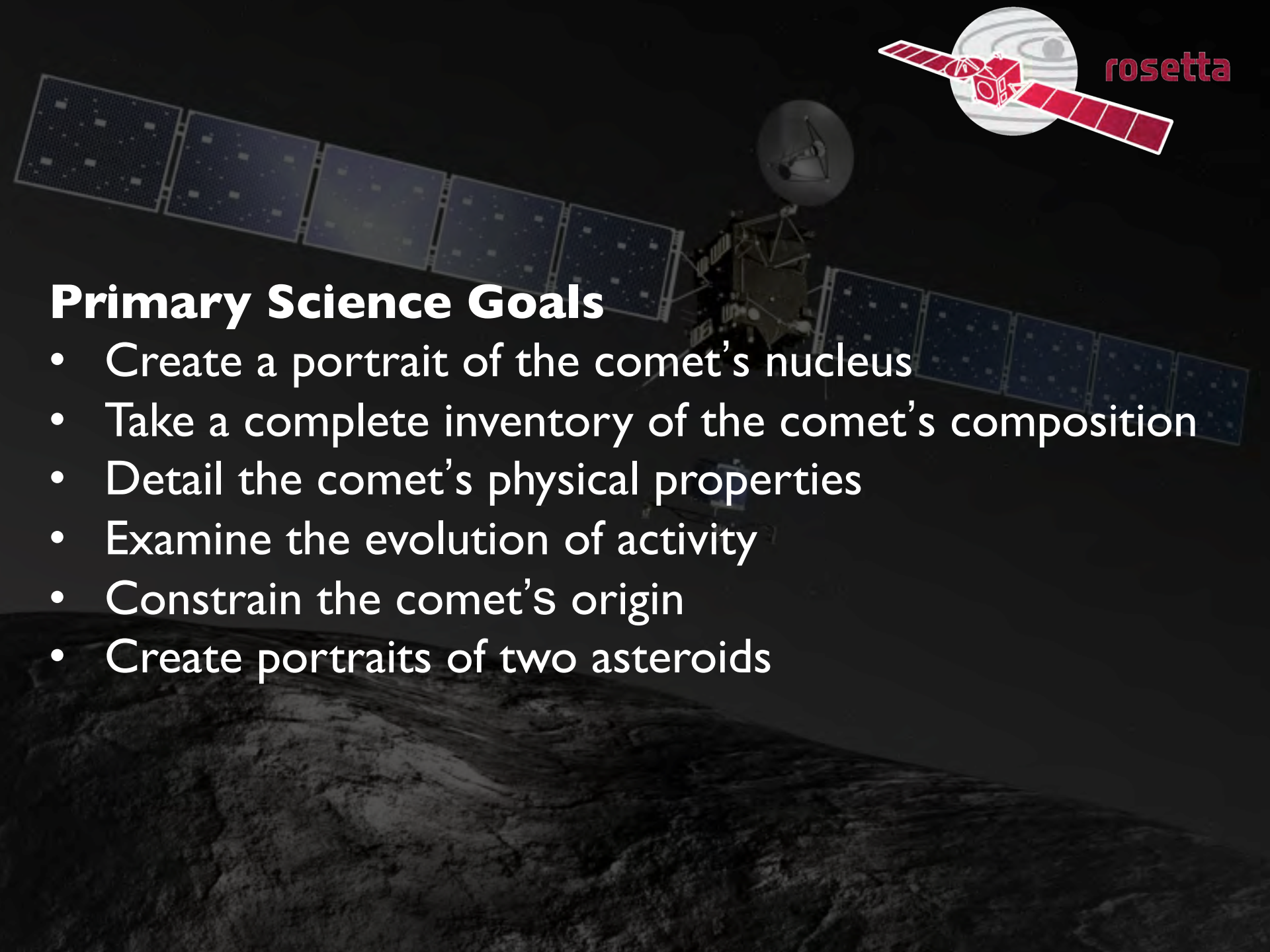


Rosetta Primary Mission Goals

- Rendezvous with comet 67P/Churyumov-Gerasimenko at large heliocentric distance and accompany it past perihelion

- Observe the comet's nucleus and coma from close range

- Deploy a robotic lander to make the first controlled landing on a comet nucleus

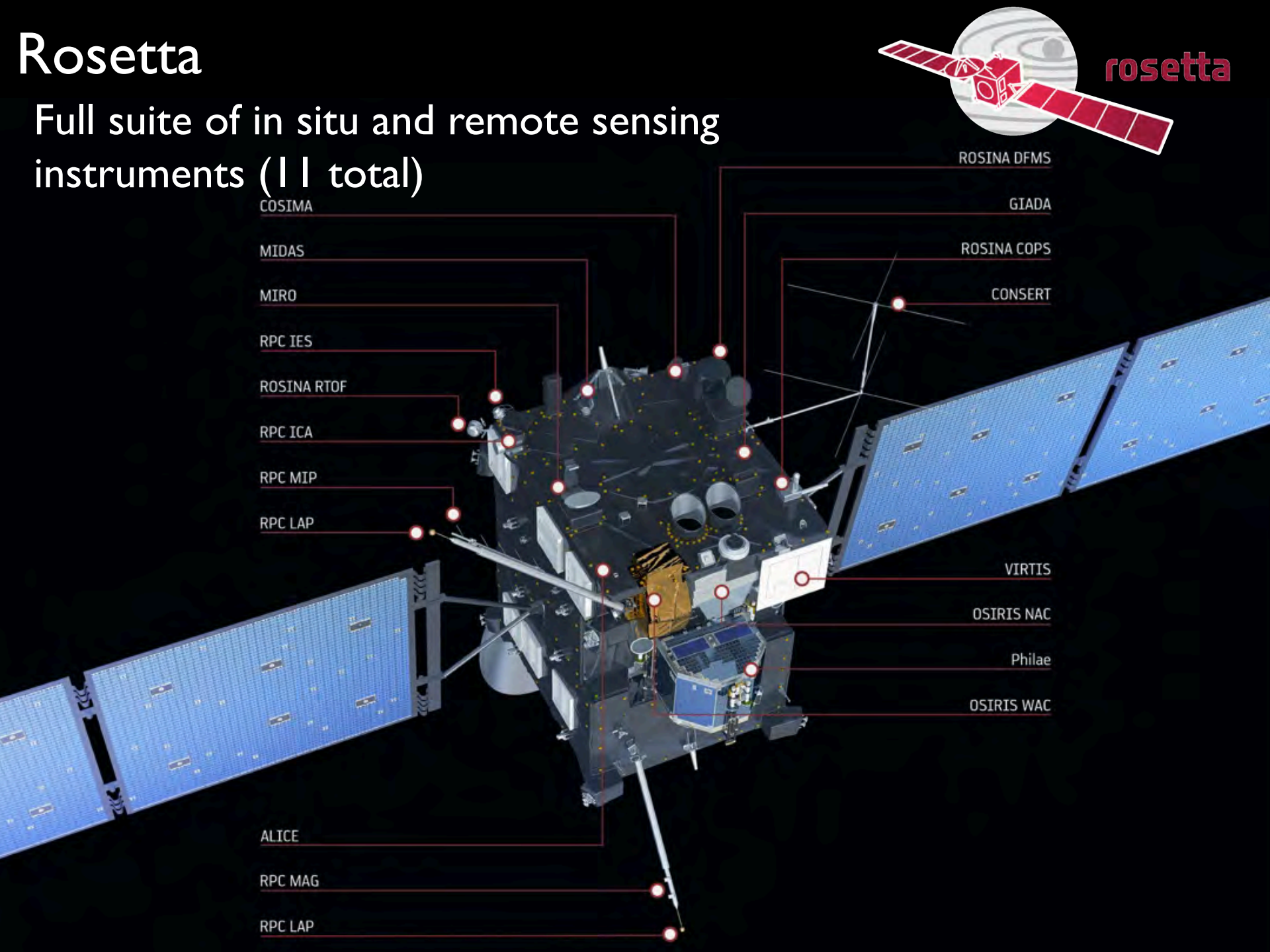


Primary Science Goals

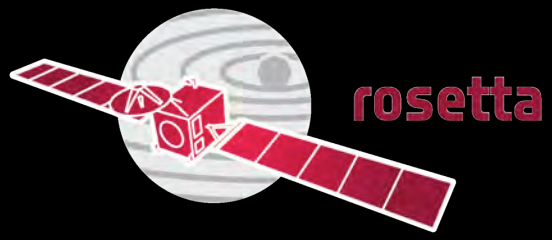
- Create a portrait of the comet's nucleus
- Take a complete inventory of the comet's composition
- Detail the comet's physical properties
- Examine the evolution of activity
- Constrain the comet's origin
- Create portraits of two asteroids

Rosetta

Full suite of in situ and remote sensing instruments (11 total)

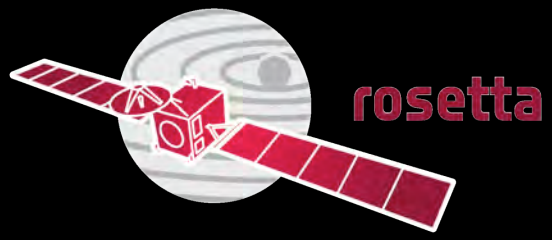


Rosetta



OSIRIS *(H. Sierks, DE)*	Camera (250–1000nm) Wide-angle (12° FOV) Narrow angle (2.5° FOV)
ALICE *(A. Stern, US)*	UV spectrometer (70–205nm)
VIRTIS *(F. Cappacioni, IT)*	VIS and IR mapping spectrometer (250–5000nm)
MIRO *(S. Gulkis, US)*	Microwave spectrometer

Rosetta



ROSINA *(K. Altwegg, CH)*

Neutral gas- and ion mass spectrometer
Chemical composition of gas in coma

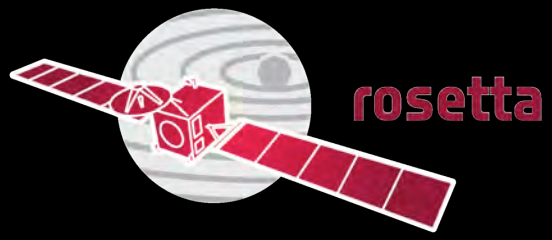
COSIMA *(M. Hilchenbach, DE)*

Solid mass spectrometer
Chemical composition of coma dust

MIDAS *(M. Bentley, AT)*

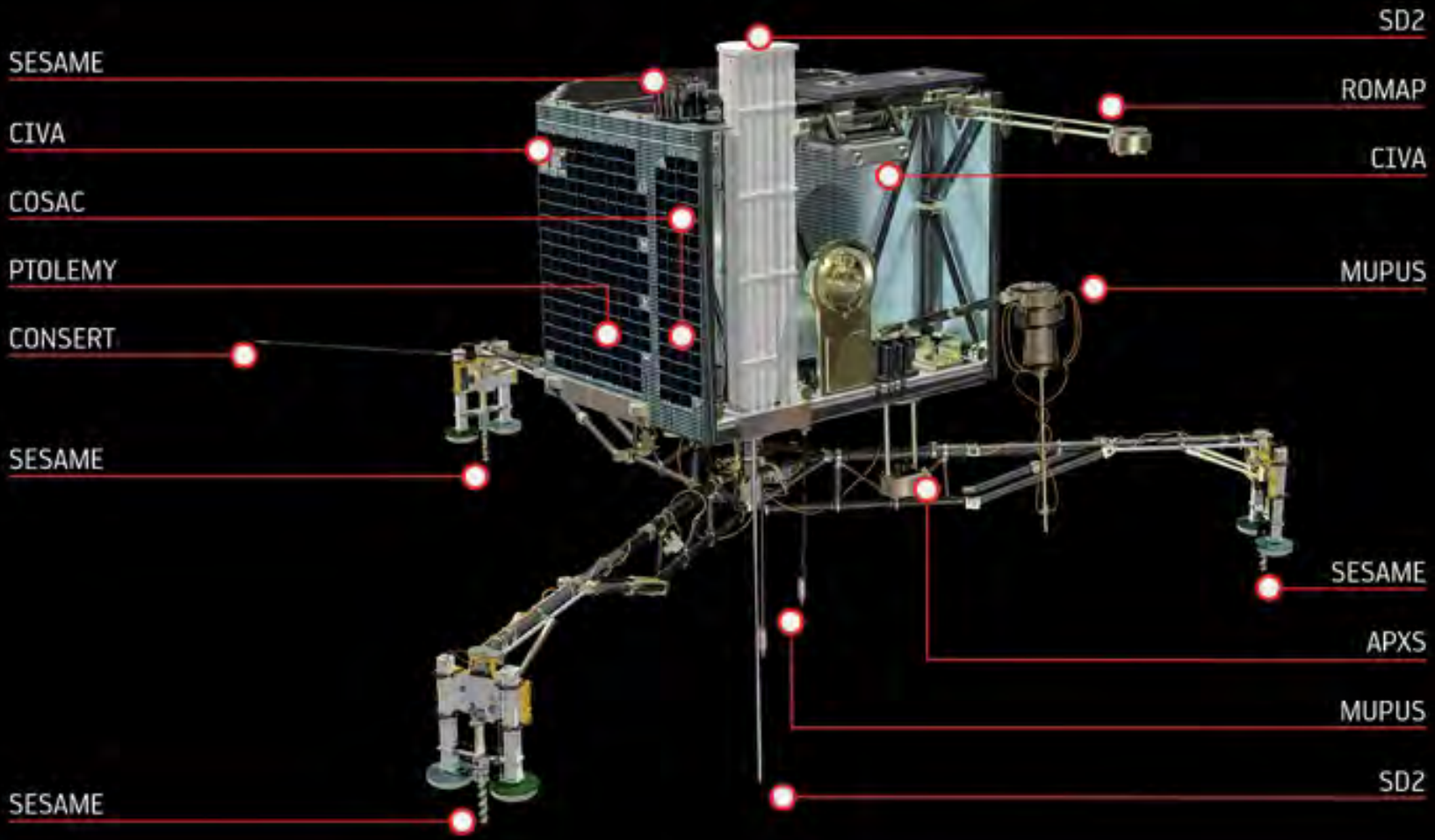
Atomic force microscope
Shape and size of dust grains

Rosetta

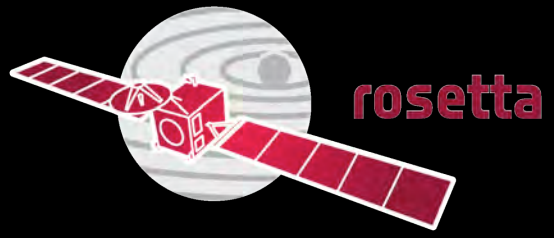


CONSERT *(W. Kofmann, FR)*	Radio transmitter on lander and receiver on orbiter Tomography of nucleus
GIADA *(A. Rotundi, IT)*	Grain impact analyser and dust collector
RPC *(Several PI's)*	Rosetta plasma consortium Five plasma instruments
RSI *(M. Pätzold, DE)*	Radio science investigation

Philae (10 instruments)

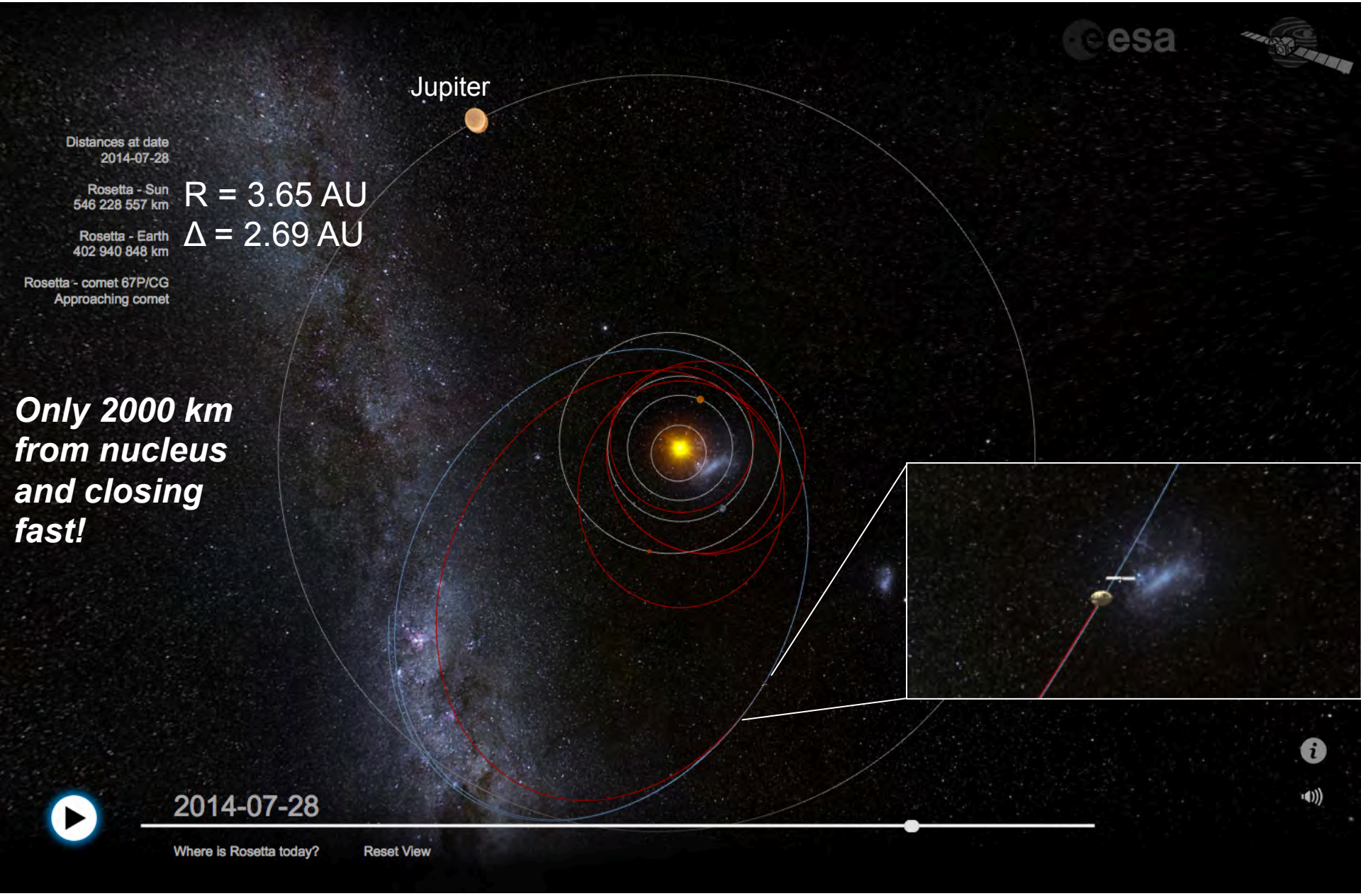


Philae



APXS	Alpha X-ray spectrometer: composition
ÇIVA	Six micro-cameras: surface imaging
CONSERT	Radio tomography of nucleus
COSAC	Evolved gas analyser: organics
PTOLEMY	Evolved gas analyser: isotopic ratios
MUPUS	Probe on anchor: structure, properties
ROLIS	Imaging system: descent and landing
ROMAP	Magnetometer/plasma monitor
SD2	Drill to 20cm: deliver to analysis ovens
SESAME	Probes comet outer layers

Where is Rosetta Now?



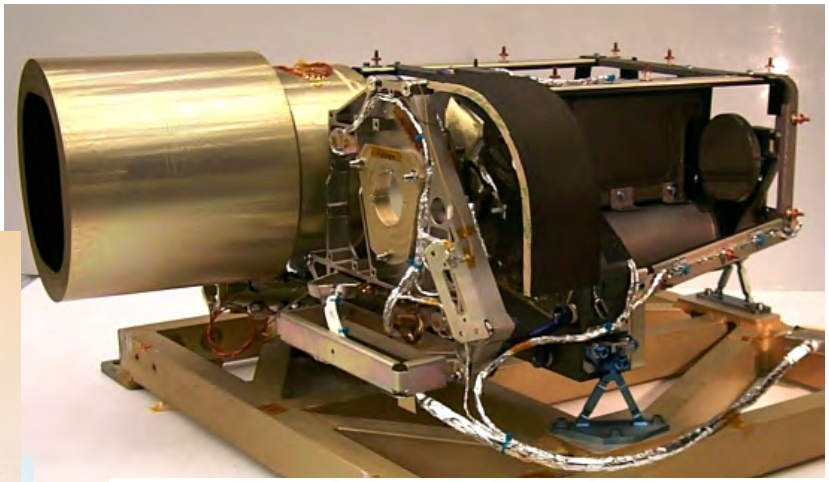
Rosetta Mission

SELECTION OF EARLY SCIENCE RESULTS

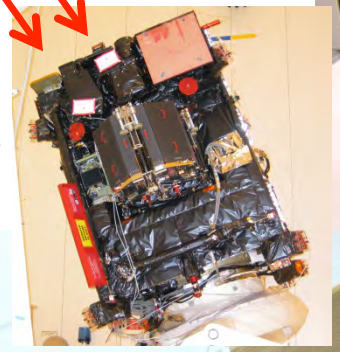
PI is Holger Sierks (MPS/Germany)

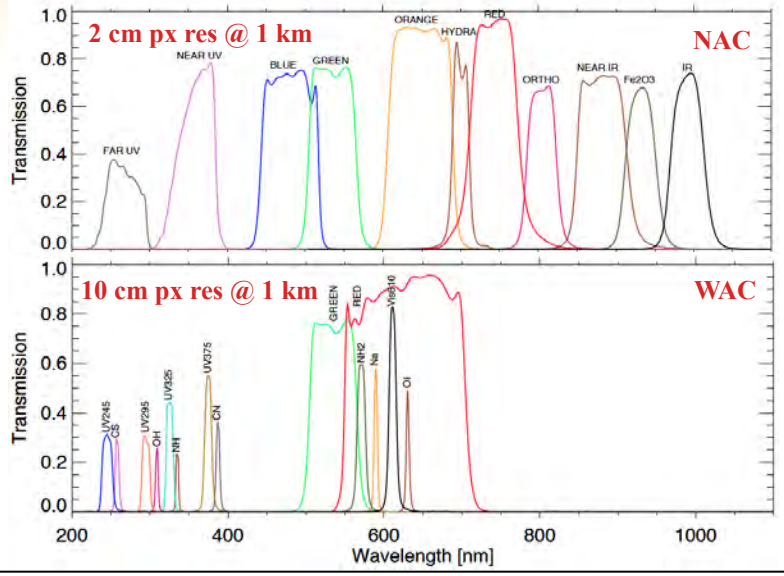
OSIRIS - Scientific Imaging System

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

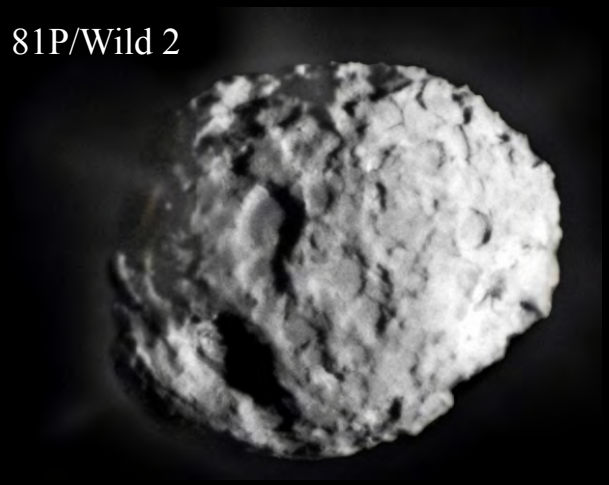


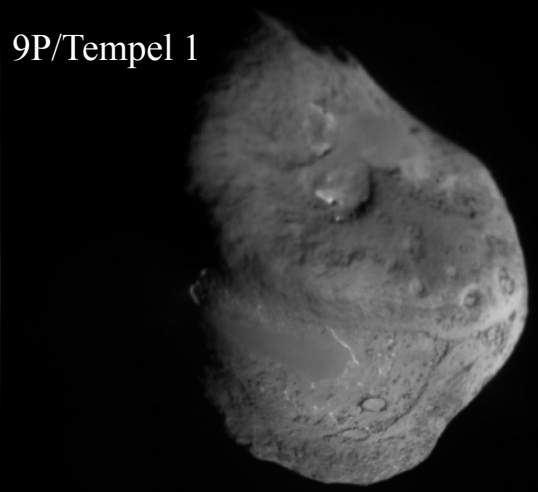
WAC – Wide Angle Camera
FOV 12°, IFOV 101 µrad/px
Al bench, 2k x 2k BI E2V CCD, AB
2-mirror off-axis, f/5.6, 140mm





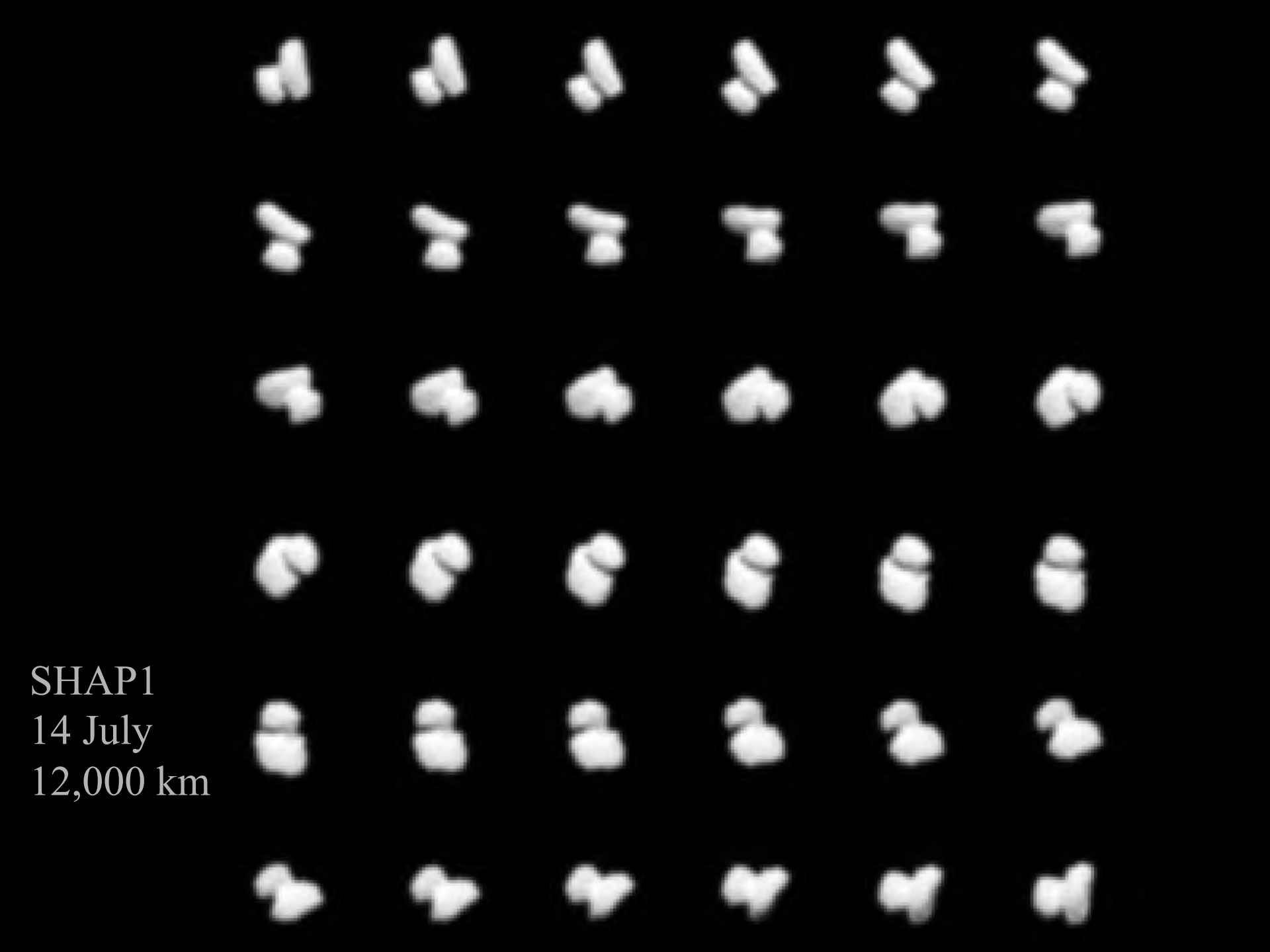
1P/Halley

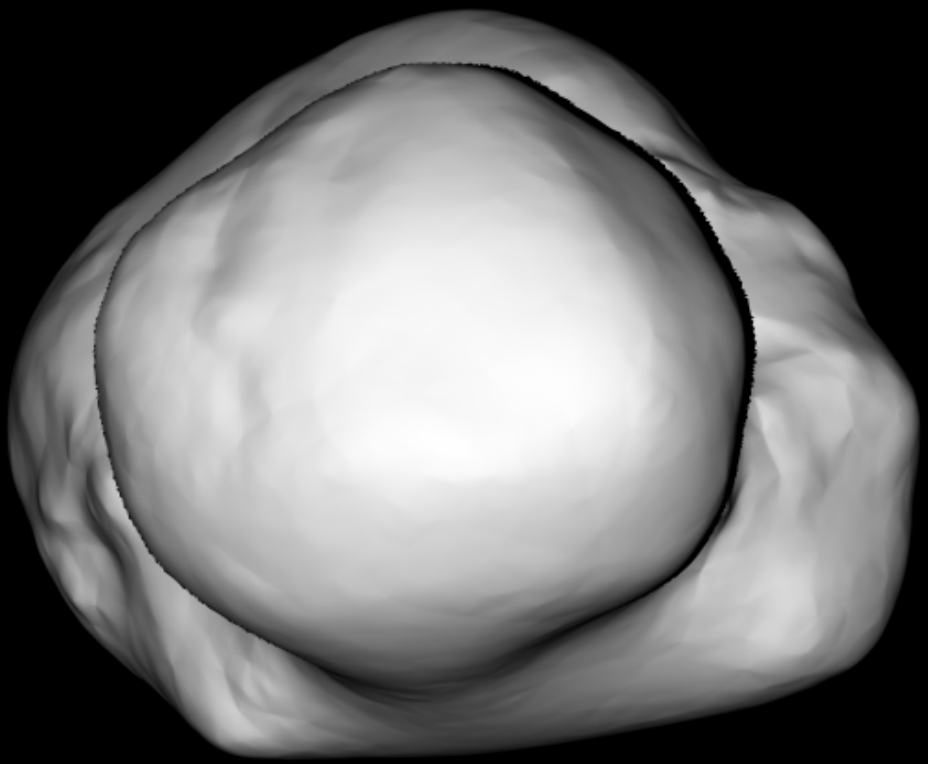

81P/Wild 2


9P/Tempel 1

19P/Borelly

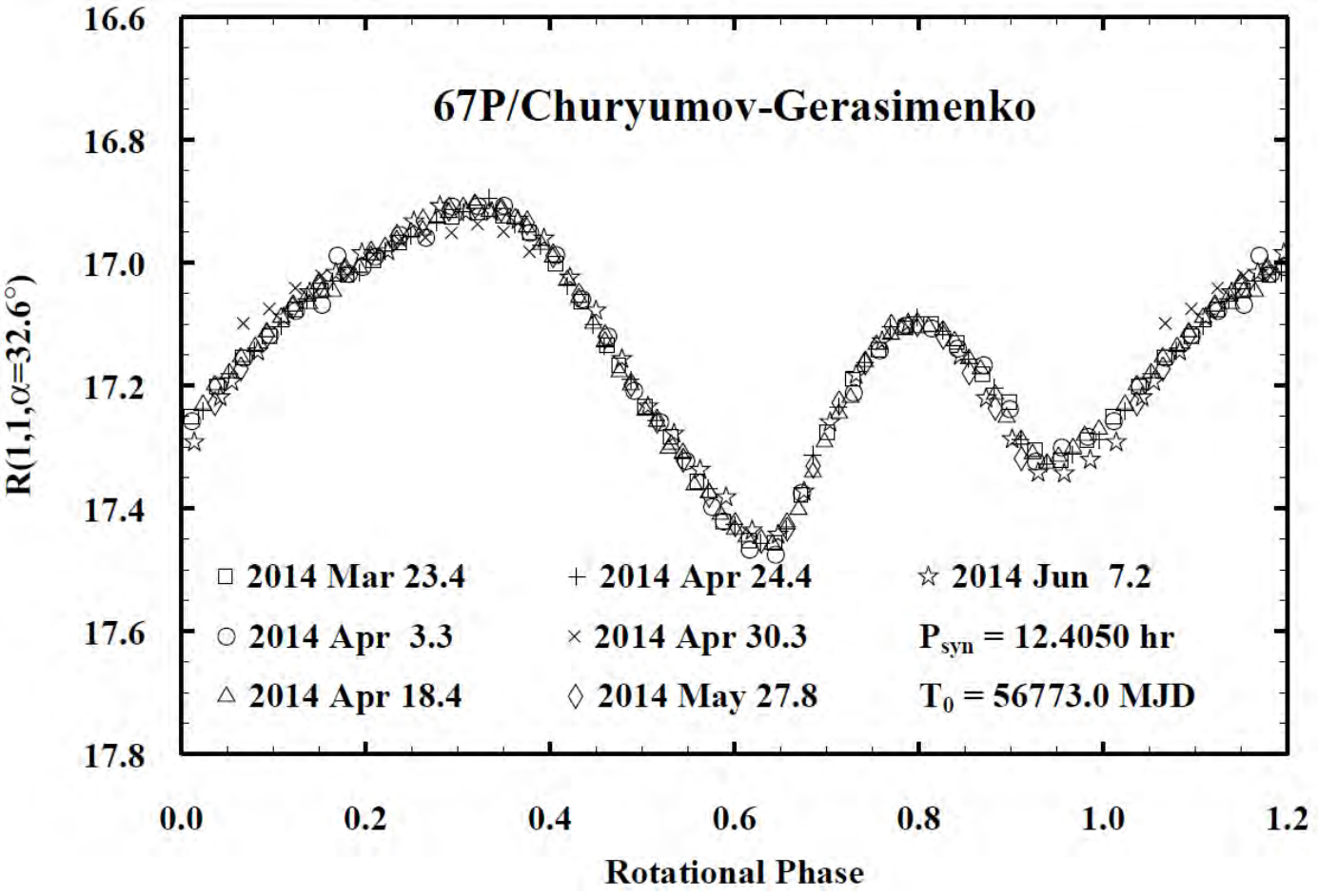
103P/Hartley 2


SHAP1
14 July
12,000 km



SHAP1 Shape Model, July 23

67P/C-G Composite Light Curve (LC1-5)



OSIRIS Science To Date

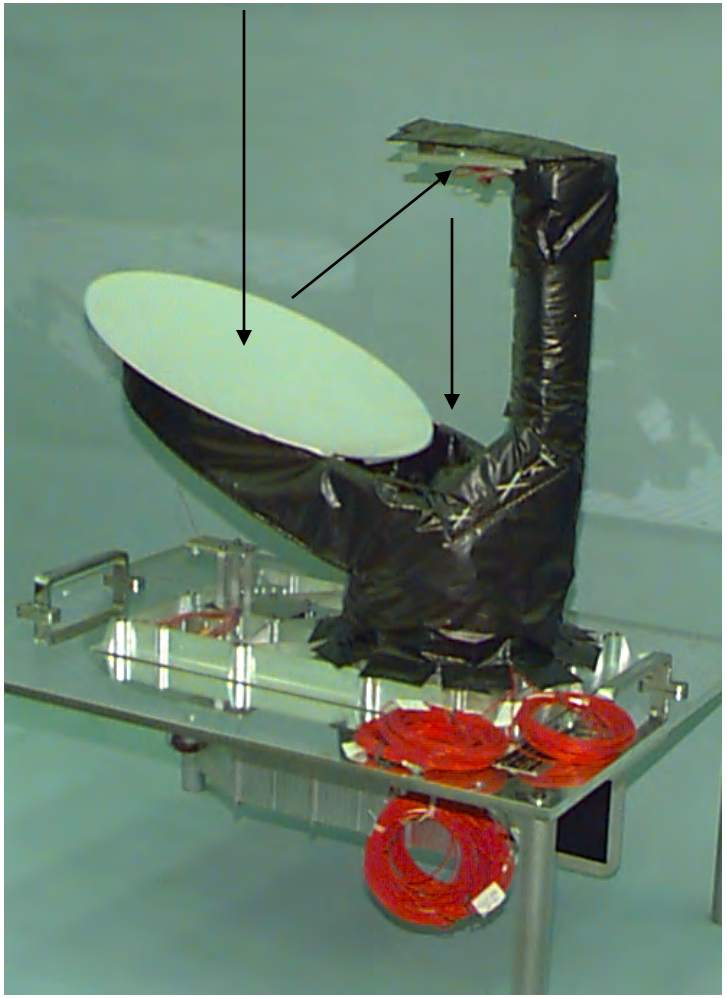
- detection of nucleus 2,000 km off predict (10,000 km search corridor)
- rotation period from light curves 12.4 h, last apparition was 12.7 h from ground based
- determination of rotational axis and sense of rotation (pro-grade)
- no excited state found to date (upper limit few degrees)
- detection of early activity, an outburst, activity wake-up II
- approach imaging sequence
- ***nucleus seems to be a contact binary***
- first determination of size, volume, surface area
- first structures visible (depressions, highs)
- some areas appear brighter than others
- first color spectrum fits ground based
- no color variations on surface to date
- no satellite found to date
- no gas detected by OSIRIS to date
- low dust activity seen by OSIRIS to date

OSIRIS Science in 6 Months

- high resolution images of full lit surface
- high resolution shape model
- state of rotation
- digital terrain models of landing site candidates (stereo)
- full characterization of landing site (topo, surface, colors, boulders)
- lander ground truth in topo, composition, activity
- color variations of surface
- first composition results
- phase function surface (and dust tbc)
- are the two bodies identical?
- first characterization of global activity
- first characterization of local activity by limb views, jet structures
- dust grains, snow balls
- gas detection and analysis

MIRO Instrument Overview

PI is Sam Gulkis (JPL)



STRUCTURAL THERMAL MODEL

Telescope

30 cm diameter

Boresight along z-axis of s/c

Receivers (two)

Two bands

190 GHz (1.6 mm)

563 GHz(0.5 mm)

Continuum - both bands

Spectroscopic (563 GHz only)

pre-tuned specific frequencies

Single linear polarization(crossed)

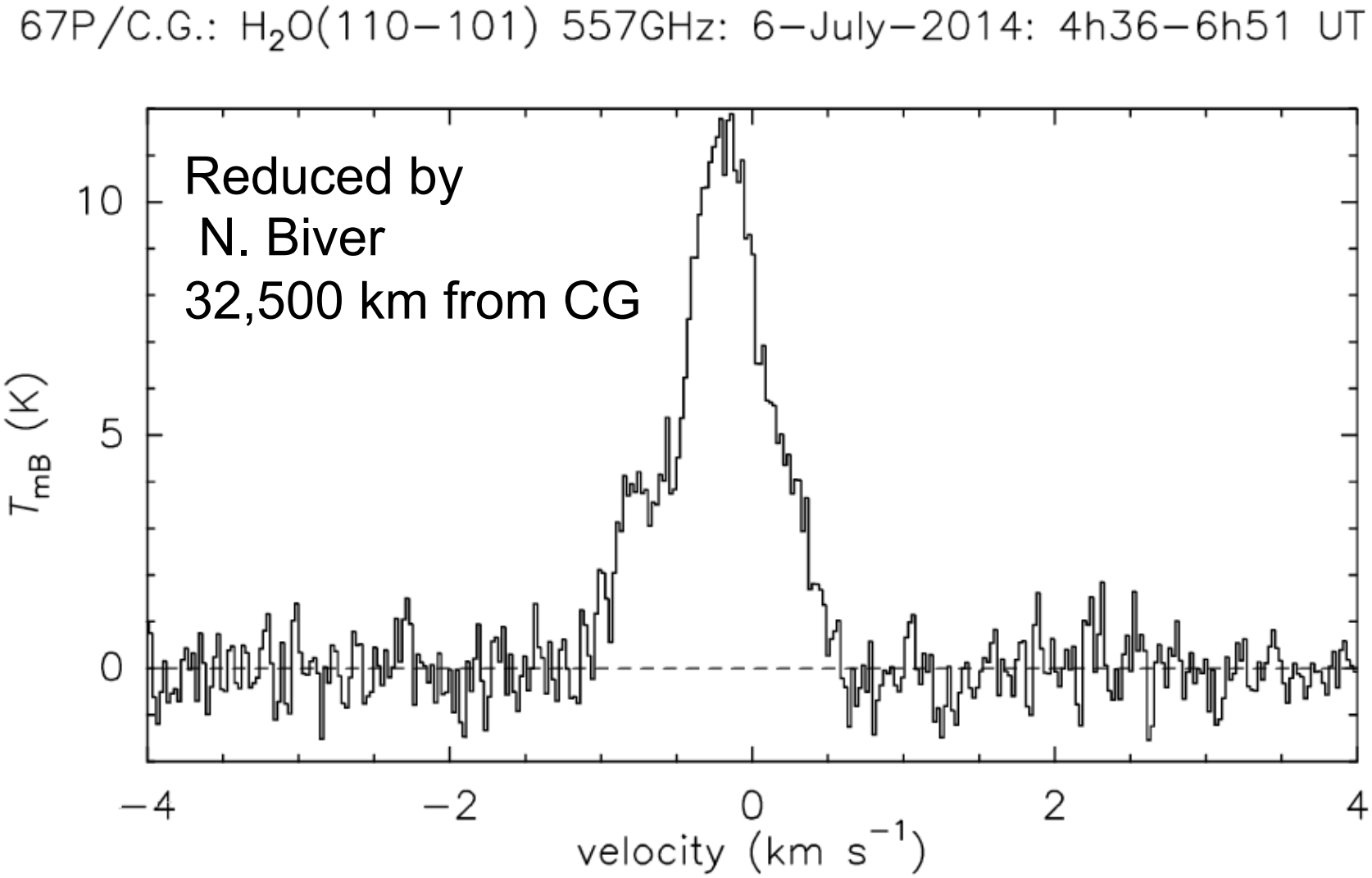
Flip-mirror calibration(warm-cold-sky)

Half Power Beam Widths

Submillimeter HPBW- 7.5 arc min

Millimeter HPBW- 23.8 arc min

Ground State Water Line at 556.936 GHz measured with MIRO instrument on July 6, 2014 – Gas Production Rate 1-3 x 10^25 mol/s



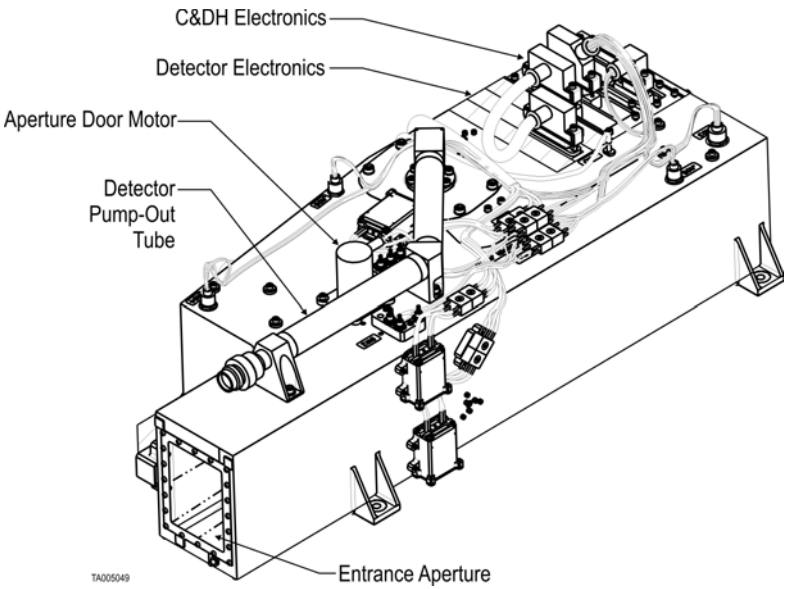
Expected Data obtained with MIRO instrument within next few weeks or months

- Detect thermal emission from nucleus at 0.5 mm and 1.6 mm wavelengths by end of July 2014
- Confirmation of detection of H2-18O isotope of water by end of July 2014
- Anticipate detection of CO, NH3, and CH3OH before landing on 11 Nov 2014

Rosetta
Alice

Alice Far-ultraviolet Spectrograph

PI is Alan Stern (SwRI)



Primary Science Objectives

- Determine the production rates and spatial distributions of the key parent species H_2O, CO, and CO_2, thereby elucidating the nature of cometary activity and the nucleus/coma coupling.
- Determine the noble gas (He, Ne, Ar, Kr) and N_2 content of the nucleus to provide information on its formation temperature and thermal evolution.
- Determine the inventory of elemental abundances (C, H, O, N, S) in the coma for comparison to other objects in the solar system and to the ISM as a means to investigate the origin and evolution of the solar system.
- Study the onset and evolution of cometary nuclear activity.

Secondary Science Objectives

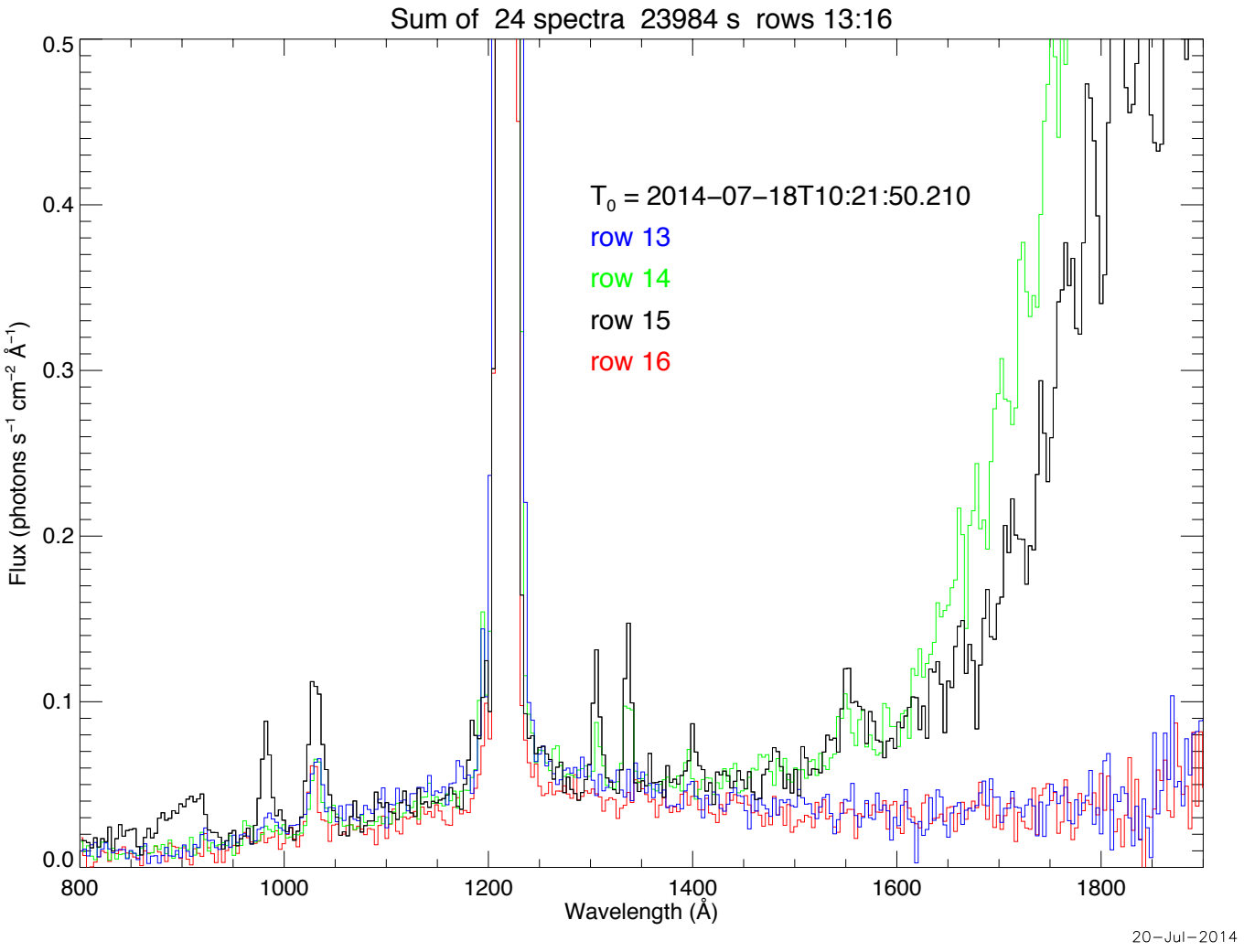
- Determine the Map the nucleus at FUV wavelengths and characterize any icy UV absorbers on its surface.
- Measure photometric properties of small grains in the coma to investigate their size distribution and temporal variation.
- Map the temporal variability of O II, C II, and N II emissions in the coma and ion tail near perihelion to connect nuclear activity to changes in tail morphology and structure, and coupling to the solar wind.

Rosetta Alice

Alice Far-ultraviolet Spectrograph

First FUV reflectance spectra from the surface of a comet nucleus!

Waiting for CO…

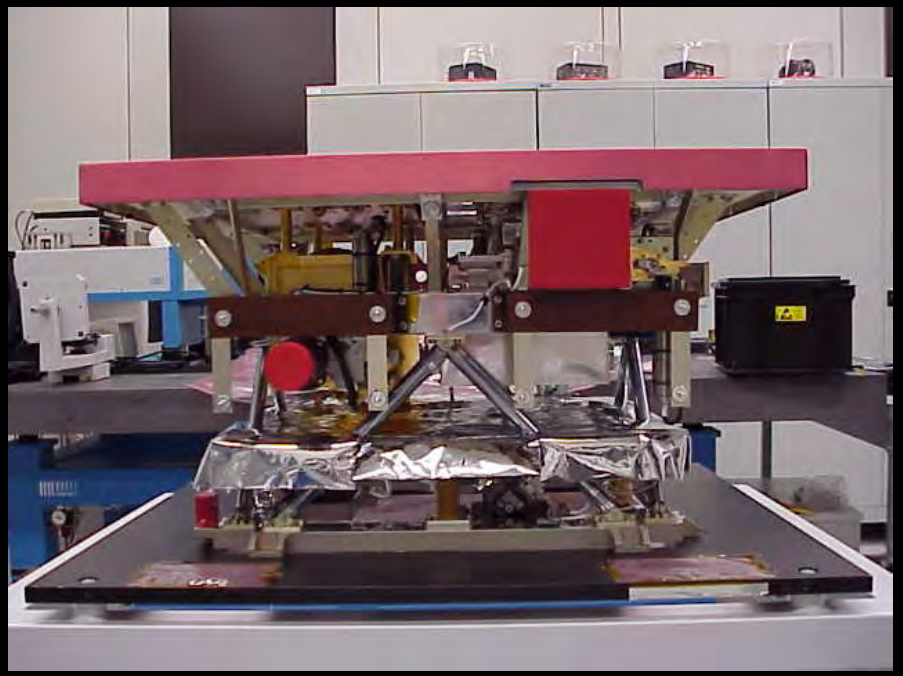


VIRTIS

Visible, InfraRed and Thermal Imaging Spectrometer

PI is Fabrizio Cappacioni (IAPS/INAF)

VIRTIS combines an imaging spectrometer (M) and a high resolution spectrometer (H).



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.

Plan for the next 6 months

Look for an ESA Release on VIRTIS results later this week!

- The scientific activity of VIRTIS has started on the 26th of June with the observation of 5 stars candidates for coma occultation (to determine dust optical depth) during the escort phase.
- The first observations of the nucleus has been performed on the 13th of July for VIRTIS-M and on the 25th of July for VIRTIS-H.
- Integrated spectra were acquired in the full VIRTIS range and the surface temperature has been measured.
- During the Global Mapping phase, running throughout August and September, more than 3 million VIRTIS-M spectra shall be acquired to probe surface composition and thermal inertia properties of the illuminated hemisphere.
- From August and extending through the lander delivery period, coma observations shall be performed with goals of determining CO_2 production rates, from measurement of fluorescence emission, and dust properties, from scattering at various phase angles

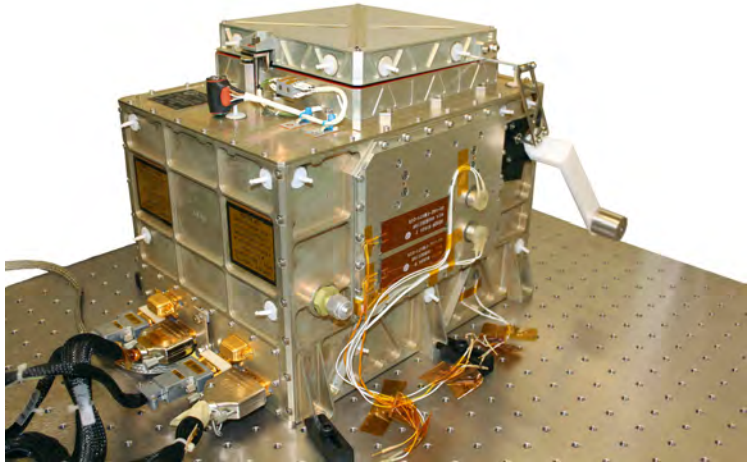
GIADA

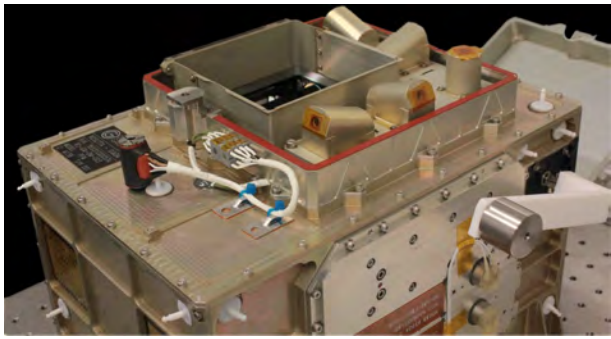
PI is Alessandra Rotundi (U Napoli/Italy)

Grain Impact Analyser and Dust Accumulator

Scientific Objectives

- To characterize the dust physical properties: Number, Mass, Momentum, Morphology, Optical Properties, Size Distribution, Velocity Distribution, Density, Icy grains
- To study the interrelation of volatiles and refractory component





GIADA Status

- GIADA is an in situ instrument, and the distance between the S/C and the comet has been too large so far to detect dust grains
- Simulations suggest detection of dust grains should start at the end of July or the beginning of August
- The next 6 months will be the best period for GIADA measurements because of the planned trajectories (bound orbits and close to the nucleus, < 30 km)
- Reconstruct the 3D+t dust environment of 67P/C-G and study the dust/gas coupling in the acceleration region

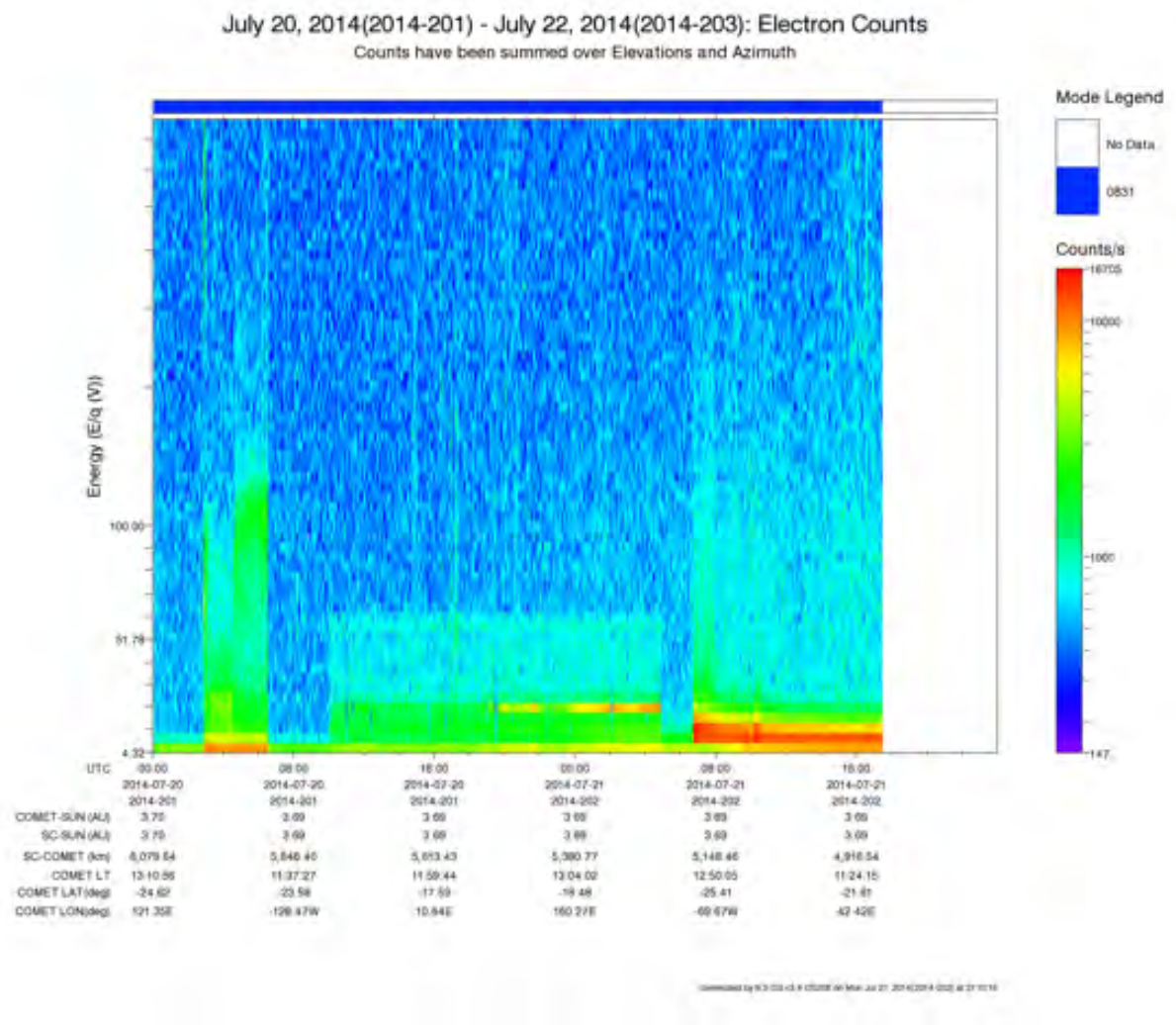
GIADA:
GIADA was built by a consortium from Italy and Spain under the scientific responsibility of the Università di Napoli "Parthenope", IT, and INAF-Osservatorio Astronomico di Capodimonte, IT, developing a Principal Investigator proposal supported by University of Kent, UK. GIADA is presently managed and operated by the Istituto di Astrofisica e Planetologia Spaziali of INAF, IT. The instrument development for ESA has been managed and funded by the Italian Space Agency ASI, IT, with a financial contribution by MEC, ES. The scientific team includes members from IT, ES, UK, FR, DE, USA. We thank ESA for the outstanding work and NASA for science support.
GIADA data Credit
ESA/Rosetta/GIADA/Univ Parthenope NA/INAF-OAC/IAA/INAF-IAPS

Plasma Near the Comet

Unexpected electron signature seen in IES spectrum on July 20th

Comet plasma signatures expected from IES/RPC soon!

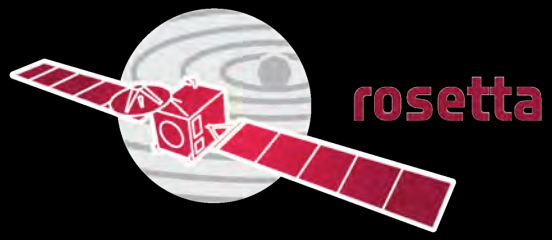
IES PI is James Burch (SwRI)



More exciting Rosetta results soon!

Backup

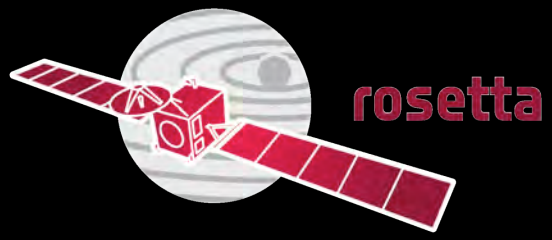
Rosetta science



Nucleus structure

- Cameras will provide images down to tens of cm resolution: Structural differences will become visible
- CONSERT will study the interior structure of the nucleus
- Lander will provide ground truth at one position on the nucleus

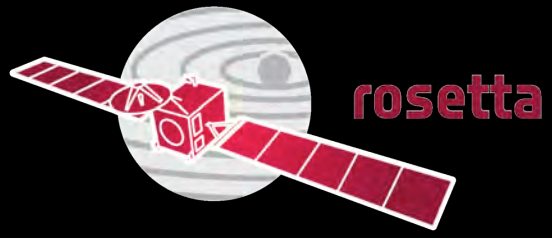
Rosetta science



How does cometary activity work?

- Images and spectra taken of active regions at dm – m scales near nadir (surface) and at the limb (inner coma)
  Will help understand interaction surface-> coma
- Near-IR and sub-mm spectra will investigate presence of surface ice at high resolution
- ROSINA will measure the gas production and composition throughout the orbit
- GIADA will measure the dust flux and size distribution throughout the orbit
  Largest sizes may be accessible through imaging
- MIDAS will measure the structure of individual dust particles
- COSIMA will measure the composition of individual dust particles
- Lander may provide full information at one point on the surface (if landing on an active area)

Rosetta science



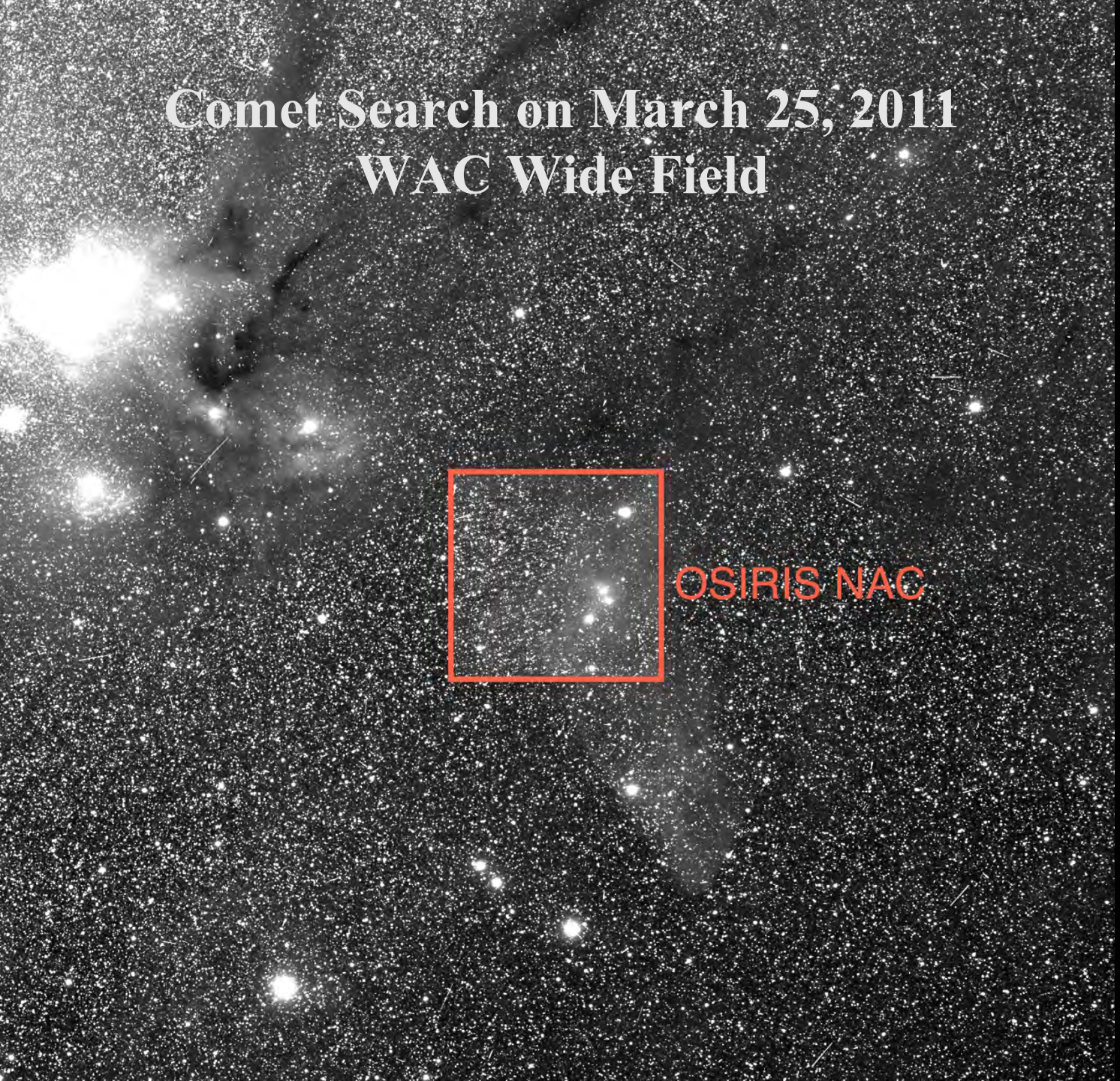
Composition

- ROSINA will measure the composition of many species and isotopes, incl. D/H
  Orders of magnitude more sensitive composition measurement than anything before

- Lander will provide composition and isotope ratios for nucleus material at one point of the surface

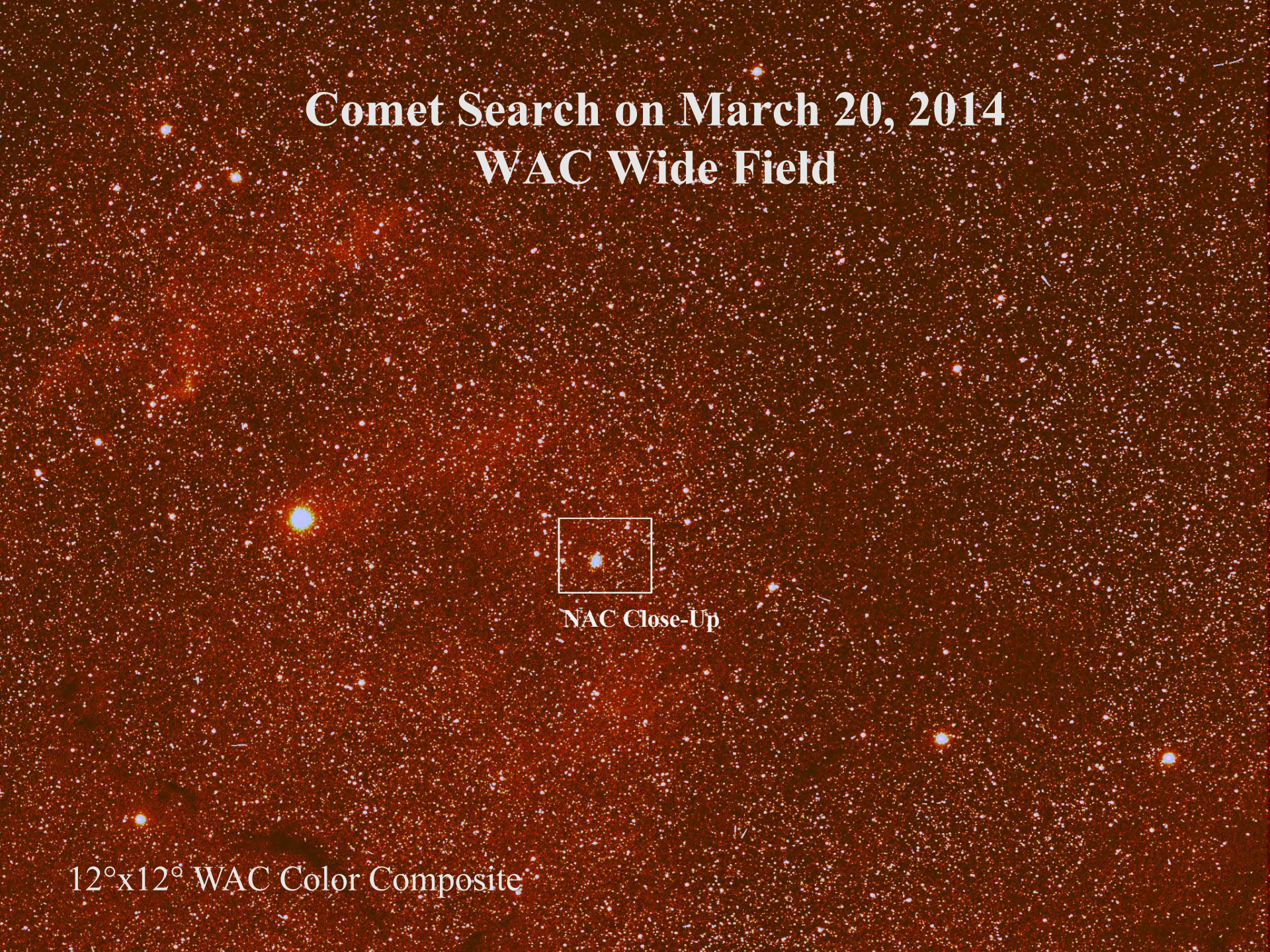
- Additional composition information from remote sensing instruments

Comet Search on March 25, 2011
WAC Wide Field



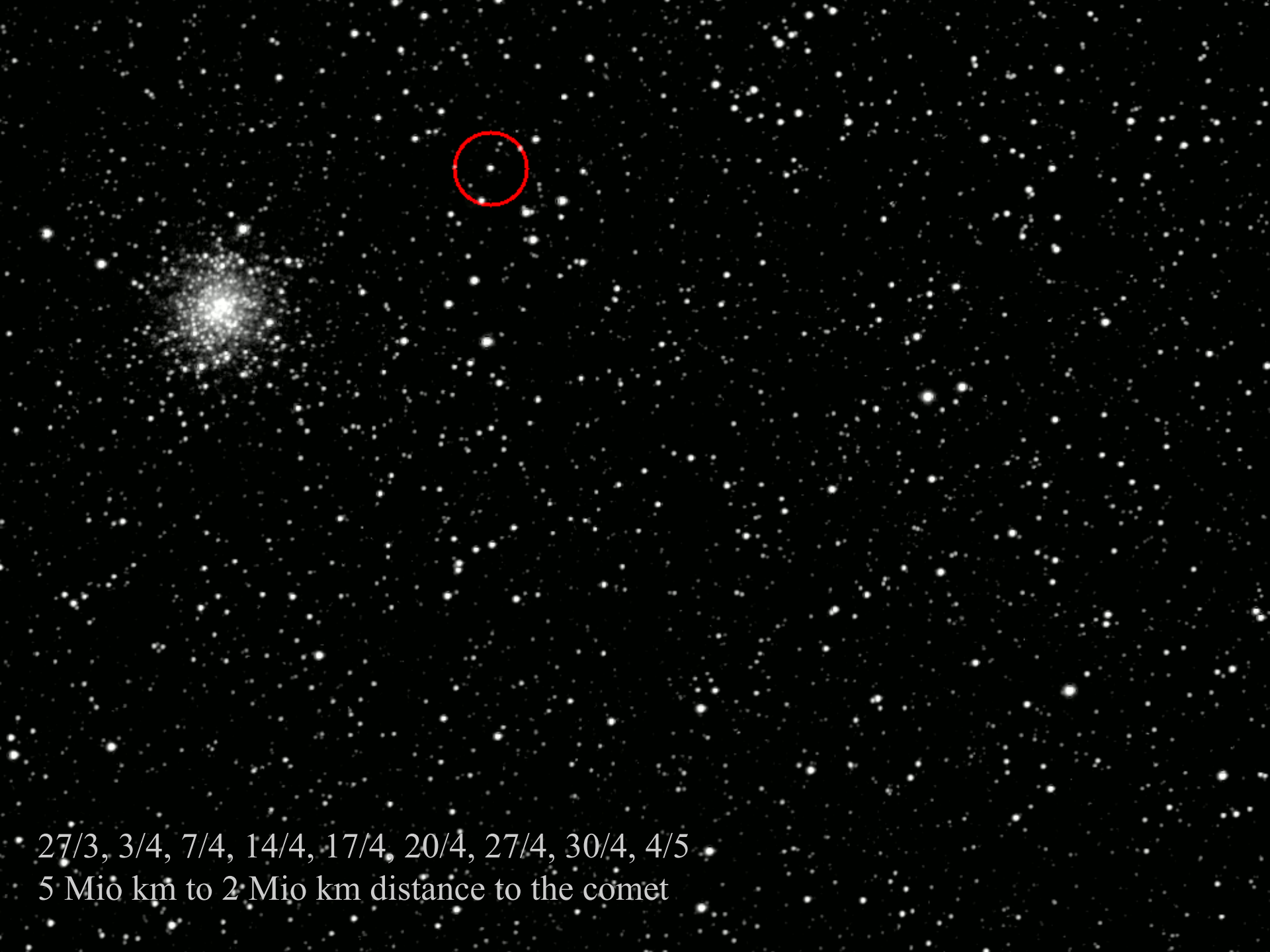
Rosetta's first view of Comet Churyumov-Gerasimenko

- 25th March 2011
- 163 million km from C-G
- comet at 5.1 AU (640 Mio km) from Sun
- spacecraft at 4.14 AU from Sun
- 52*15min (13h) exposures, clear filter
- R=20.9
- ~ a million times fainter than the faintest stars visible to the naked eye

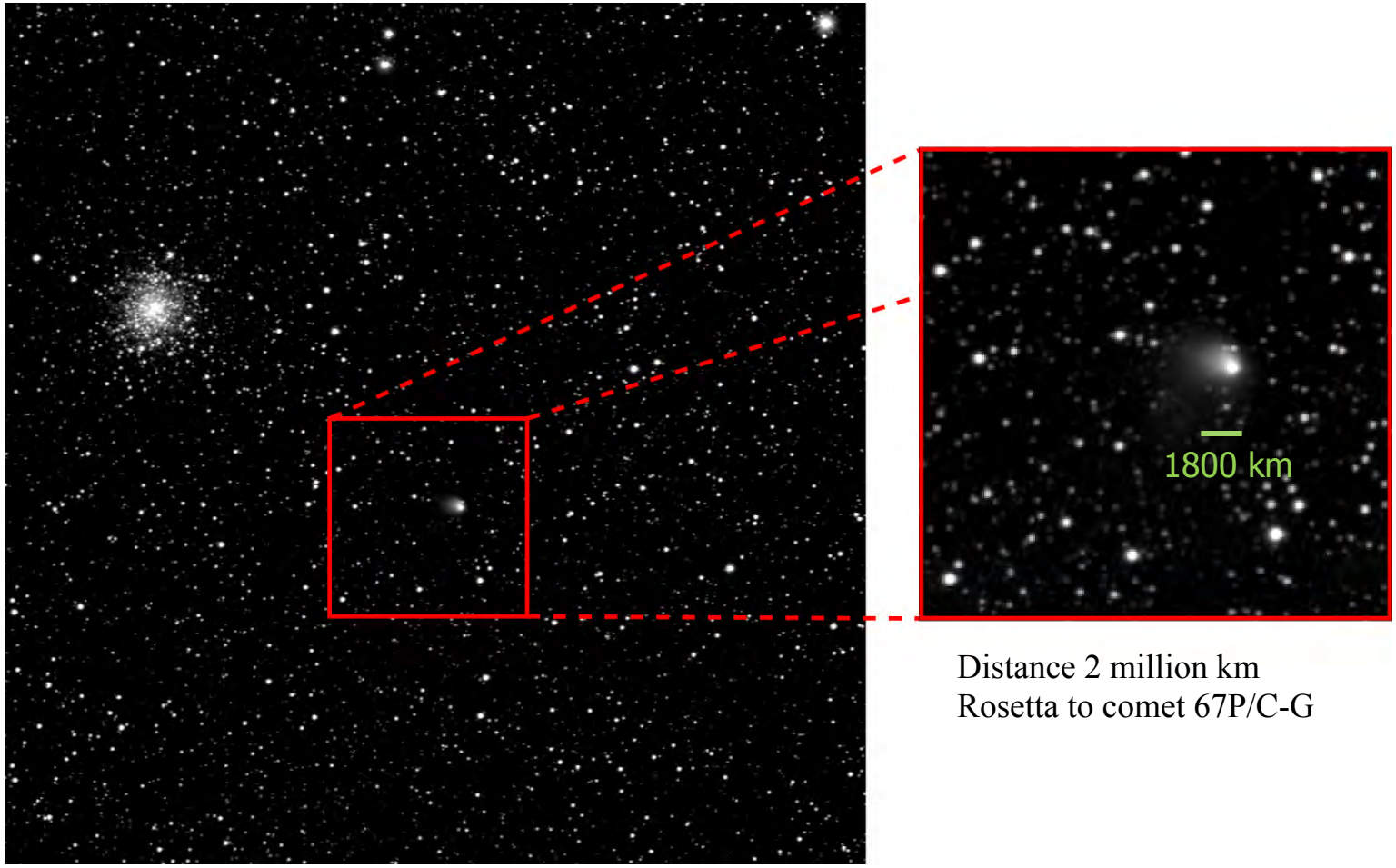

Comet Search on March 20, 2014
WAC Wide Field
NAC Close-Up
12°x12° WAC Color Composite

Comet in NAC View on March 21, 2014

30/4/2014 LC sequence

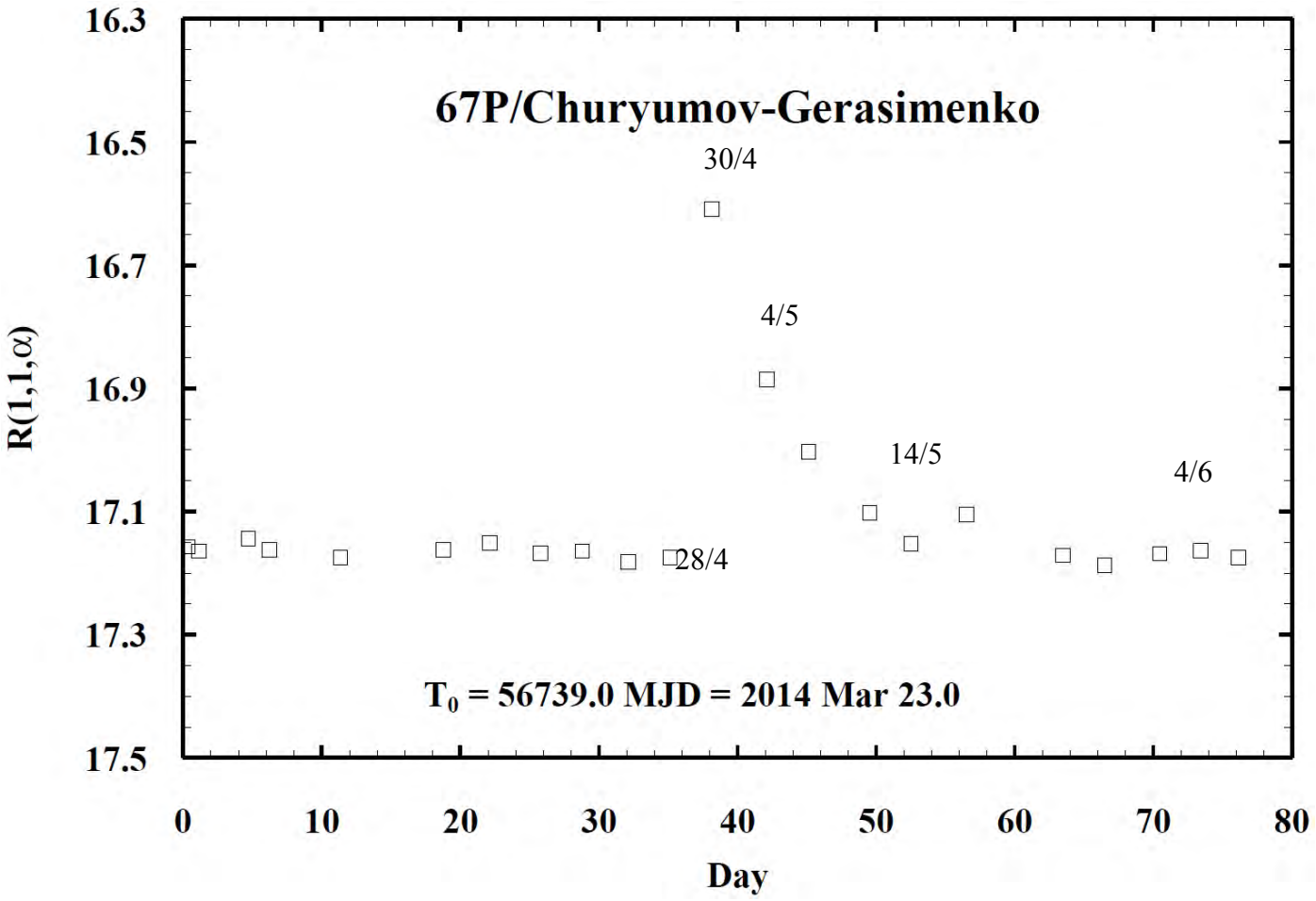

27/3, 3/4, 7/4, 14/4, 17/4, 20/4, 27/4, 30/4, 4/5
5 Mio km to 2 Mio km distance to the comet

Comet Wake-up

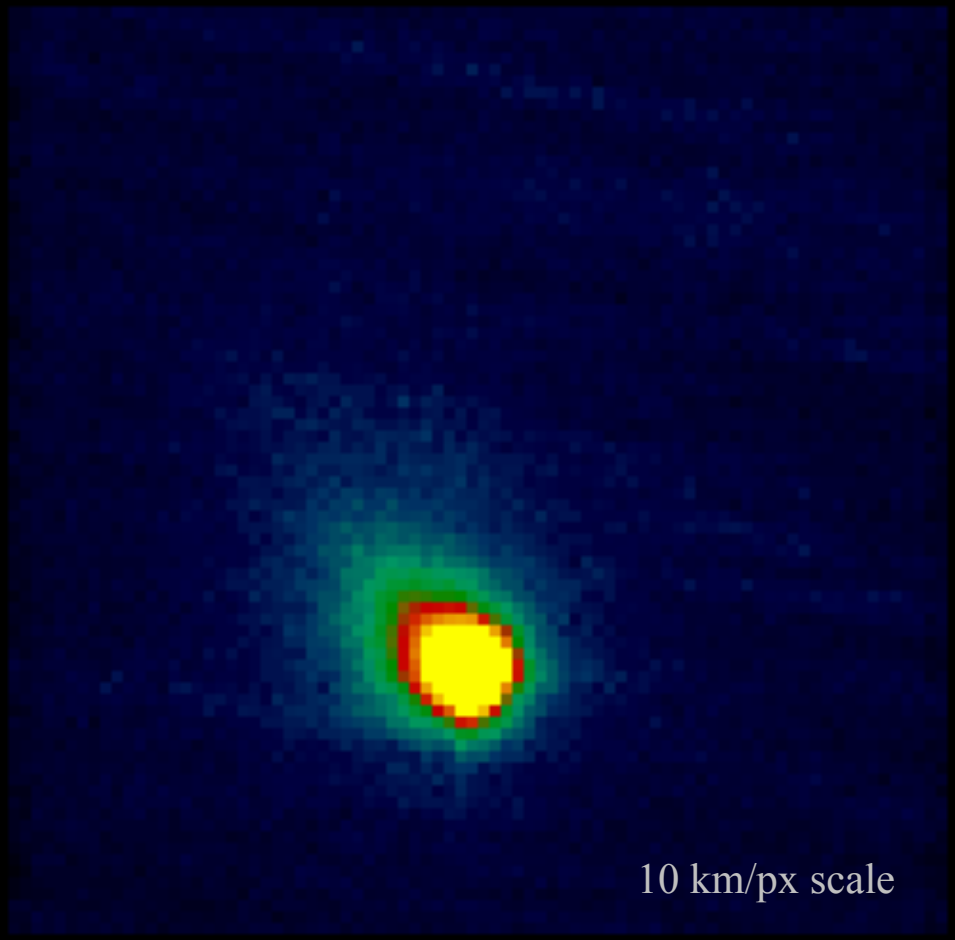


Distance 2 million km
Rosetta to comet 67P/C-G

Outburst!

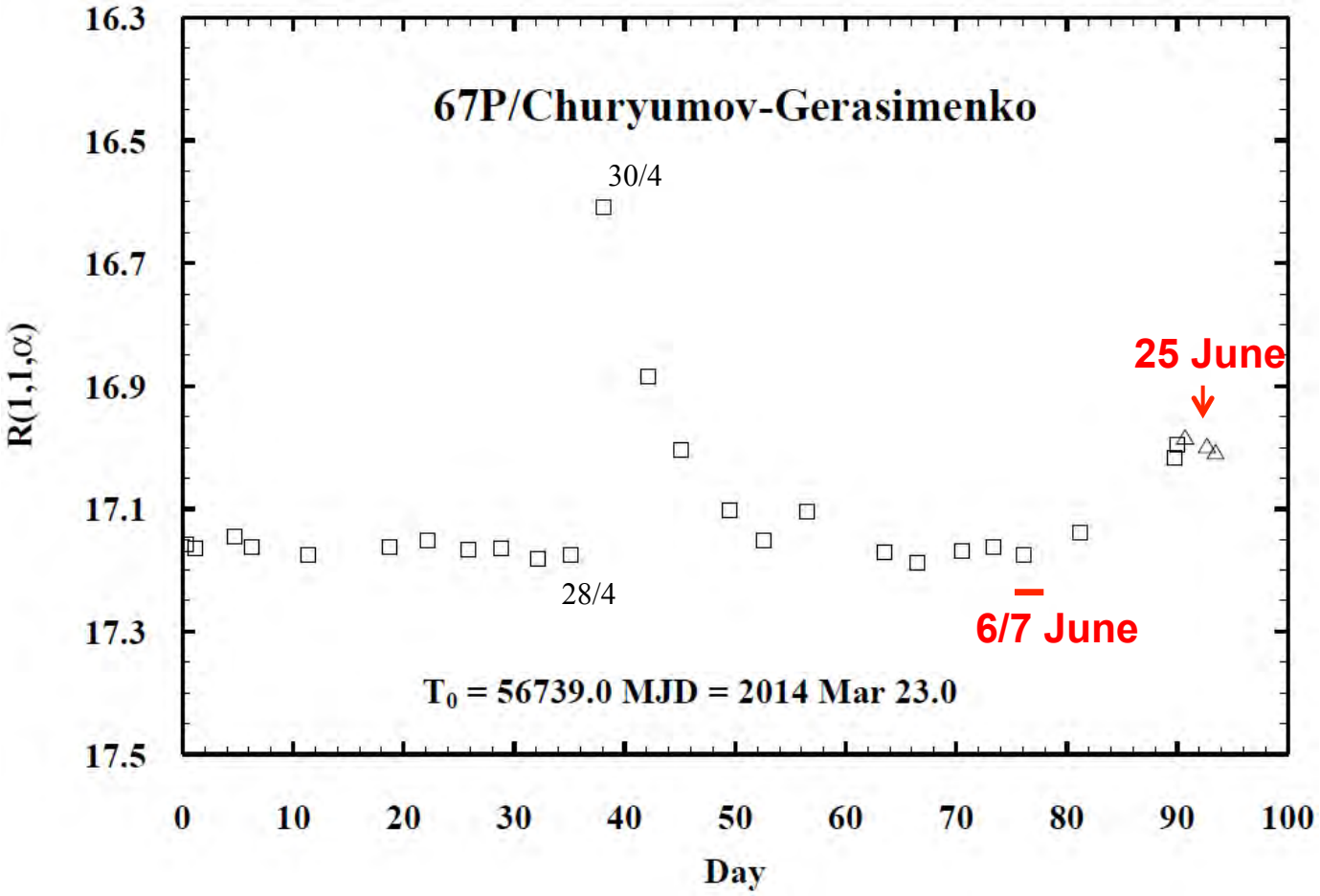

67P/Churyumov-Gerasimenko
30/4
4/5
14/5
4/6
28/4
T0 = 56739.0 MJD = 2014 Mar 23.0
R(1,1,α)
Day
16.3
16.5
16.7
16.9
17.1
17.3
17.5
0
10
20
30
40
50
60
70
80

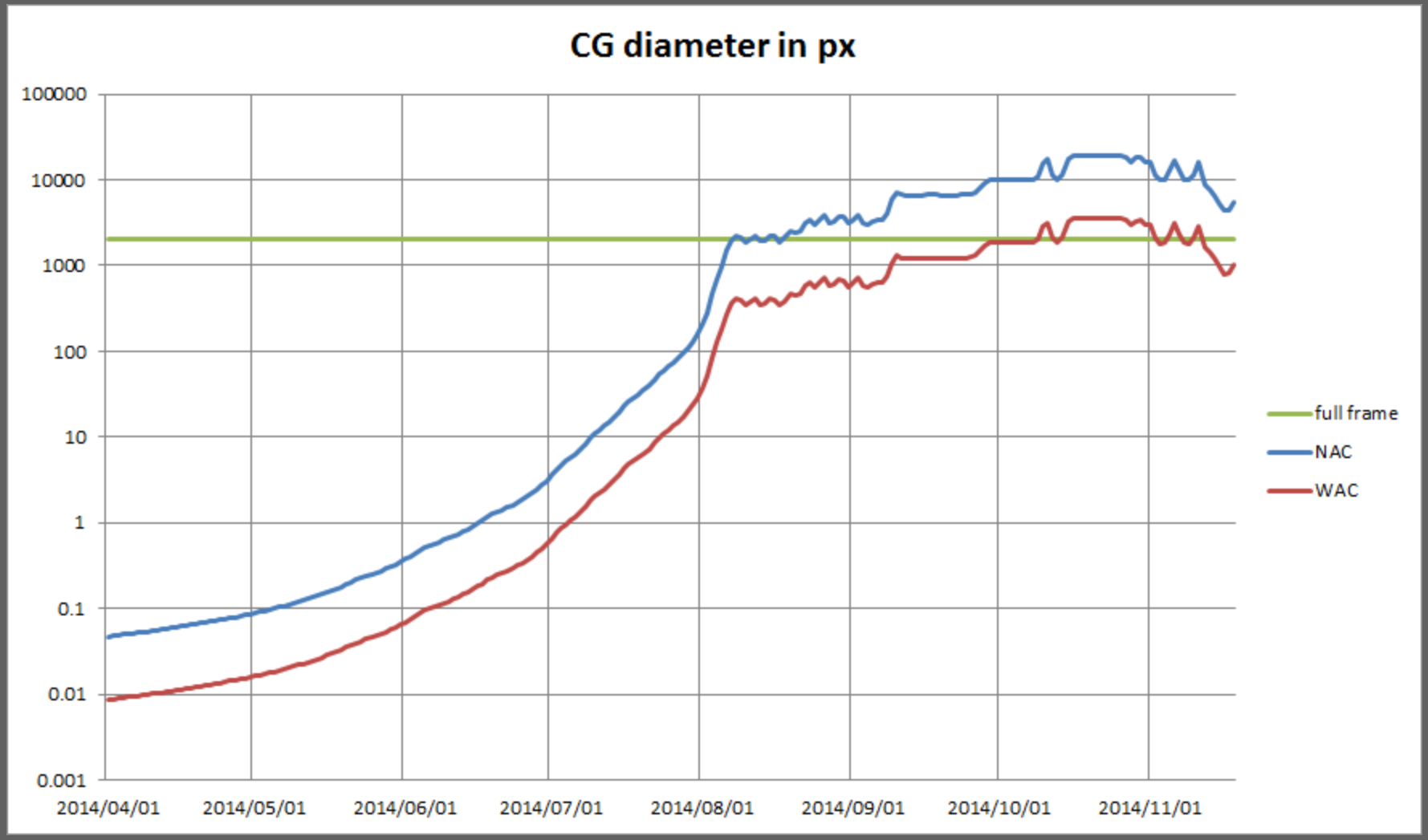
Activity Wake-Up II

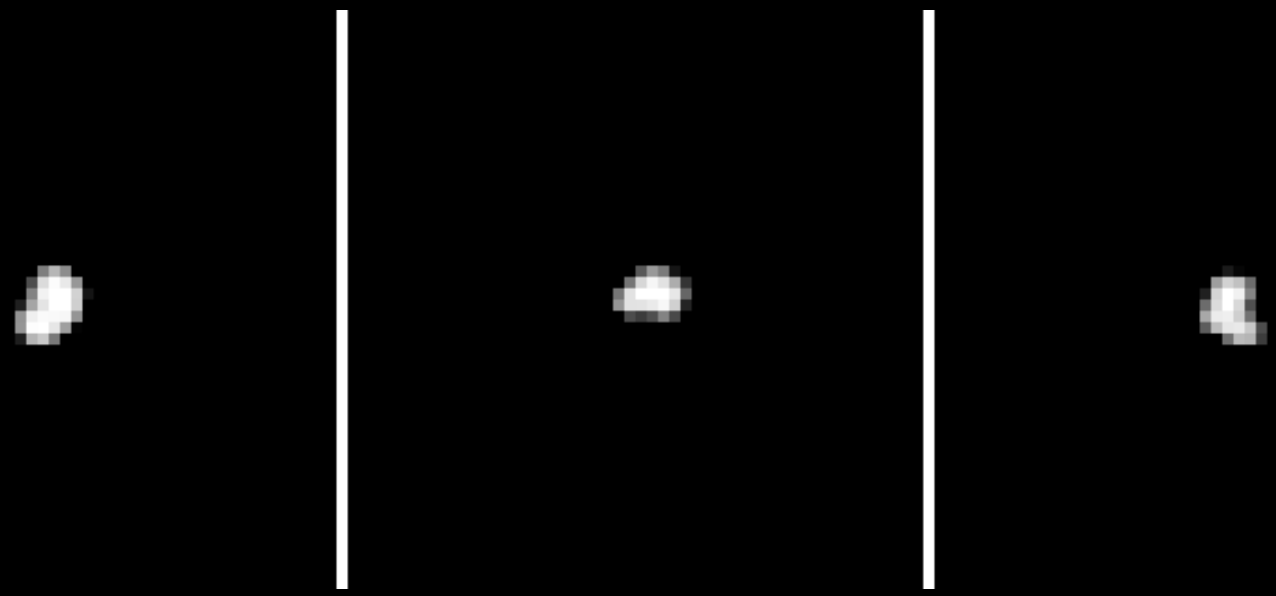


WAC Image taken on June 25, 2014 (110.000 km)

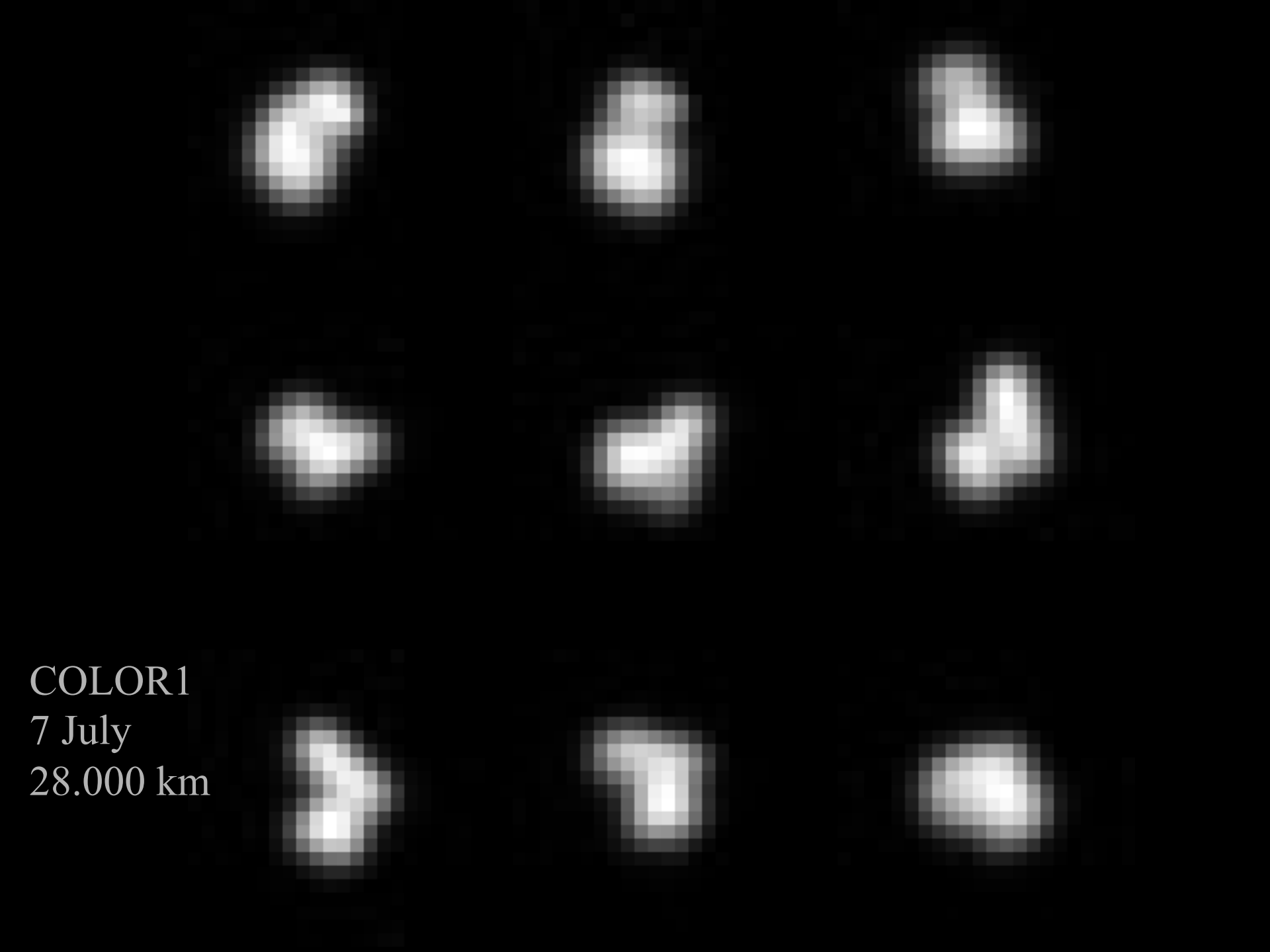
Activity Wake-Up II

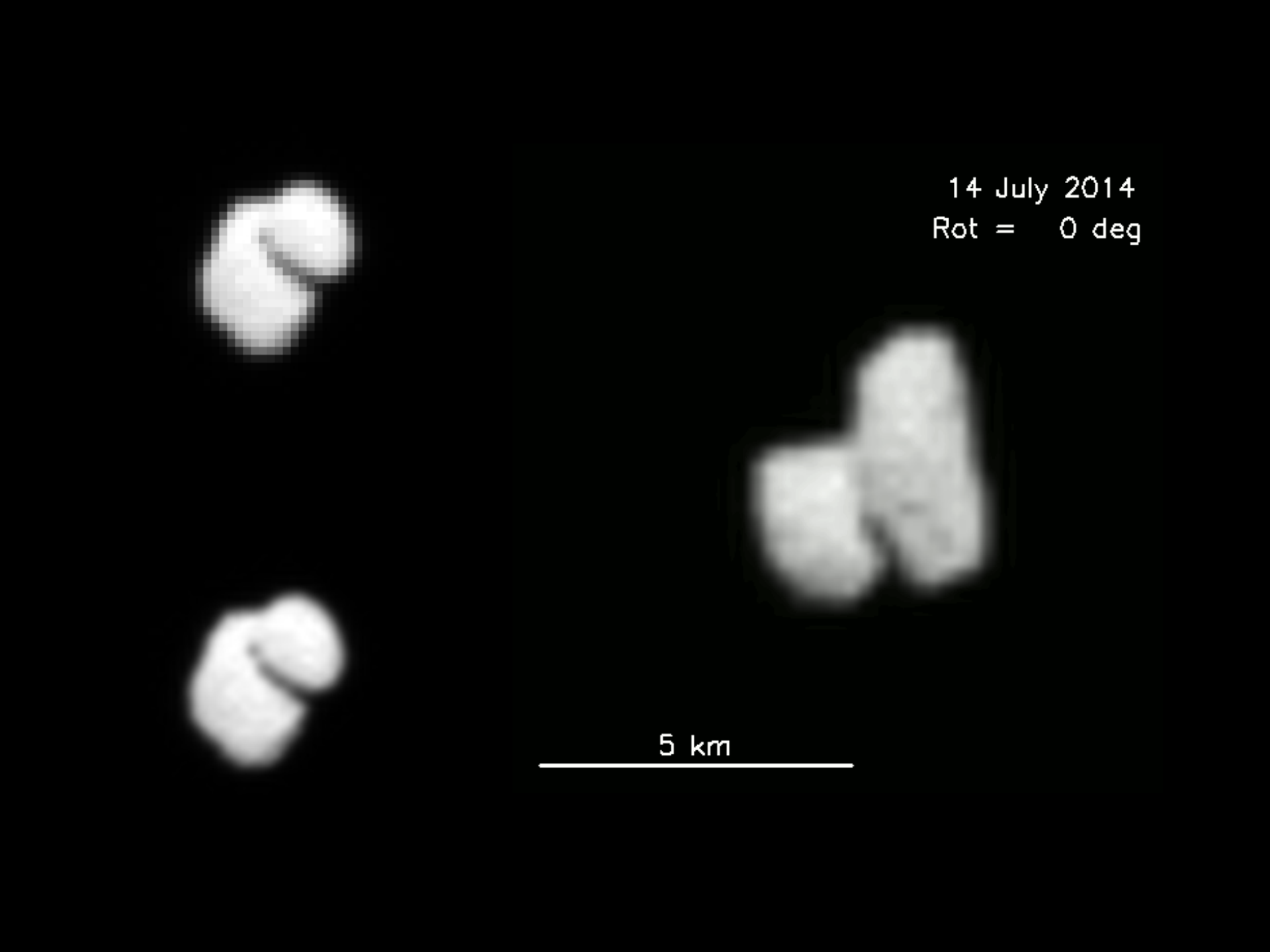



CG diameter in px
100000
10000
1000
100
10
1
0.1
0.01
0.001
2014/04/01
2014/05/01
2014/06/01
2014/07/01
2014/08/01
2014/09/01
2014/10/01
2014/11/01
full frame
NAC
WAC

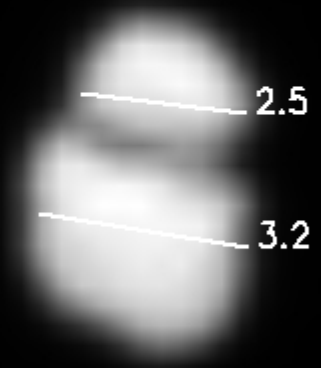


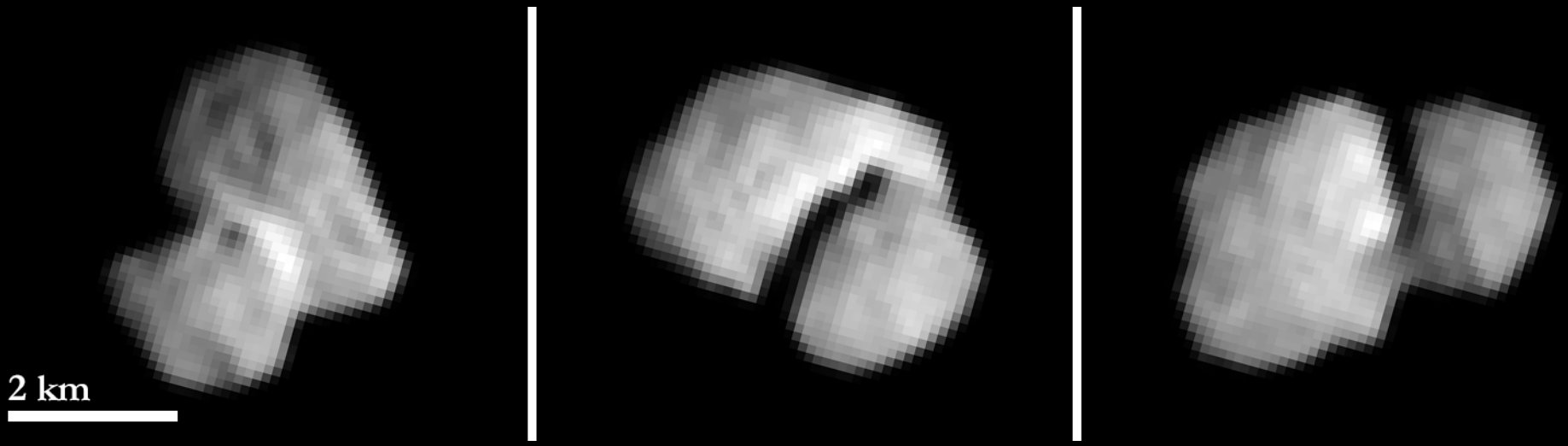
The three faces of the comet
Images taken 4 h apart on 4 July from ~37.000 km distance
(RPMOD6 sequence)


COLOR1
7 July
28.000 km


14 July 2014
Rot = 0 deg
5 km

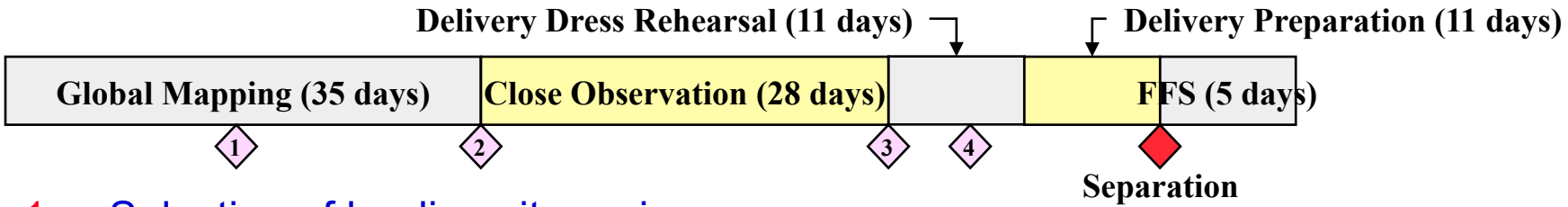
4.1
1.3
2.0
2.5


2.5
3.2



Satellite search sequence, July 20 (5.800 km)

Landing Site Selection Milestones



1. Selection of landing site regions
   - Limited selection criteria: crude comet geometry and illumination profile
   - Input to flight dynamics analyses
2. Selection of candidate landing sites
   - Preliminary but global analysis of the comet characteristics
   - A list of landing sites will be established for a more precise examination during the following Close Observation phase
3. Classification of the best landing sites
   - Precise analysis of the candidate landing sites taking into account many scientific and technical aspects
   - Best 5 landing sites identified and ranked
4. Final selection of the landing site
   - An evaluation taking into account the latest operational conditions and constraints will drive the final landing site selection