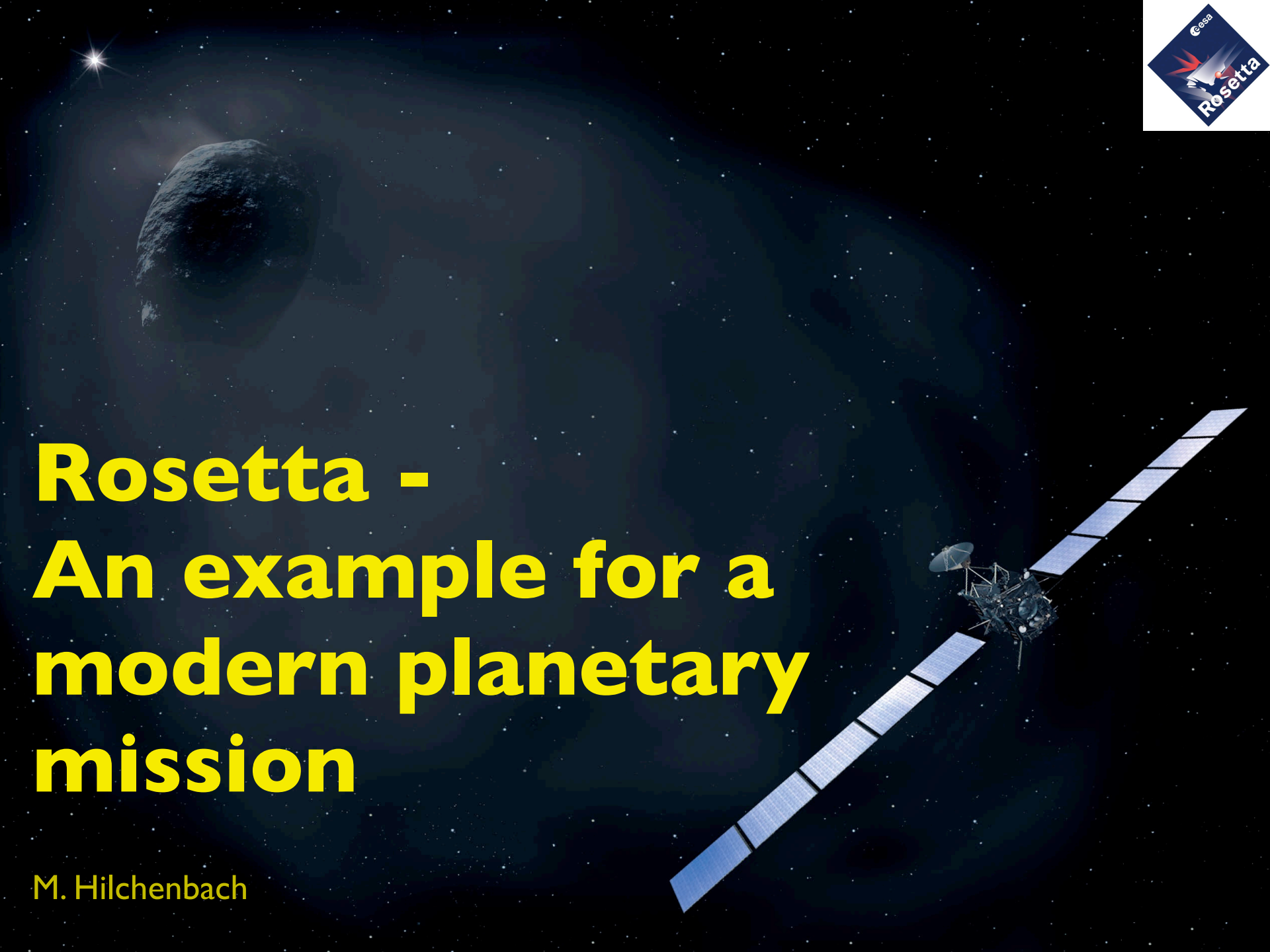


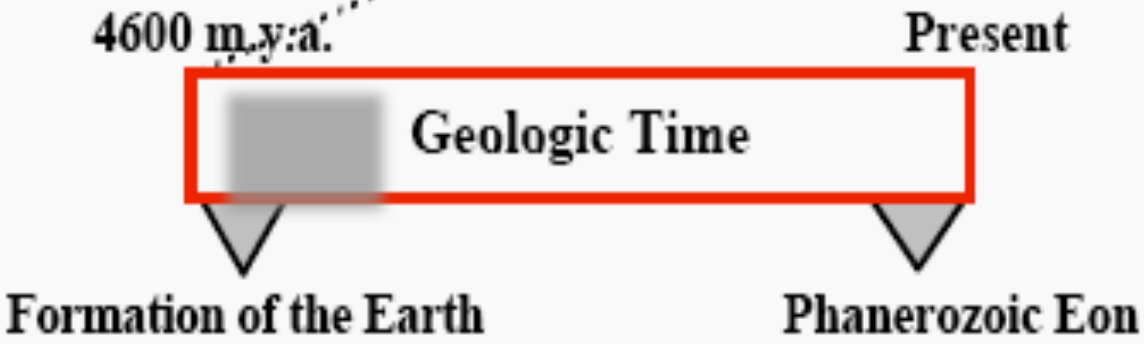
Rosetta - An example for a modern planetary mission

M. Hilchenbach

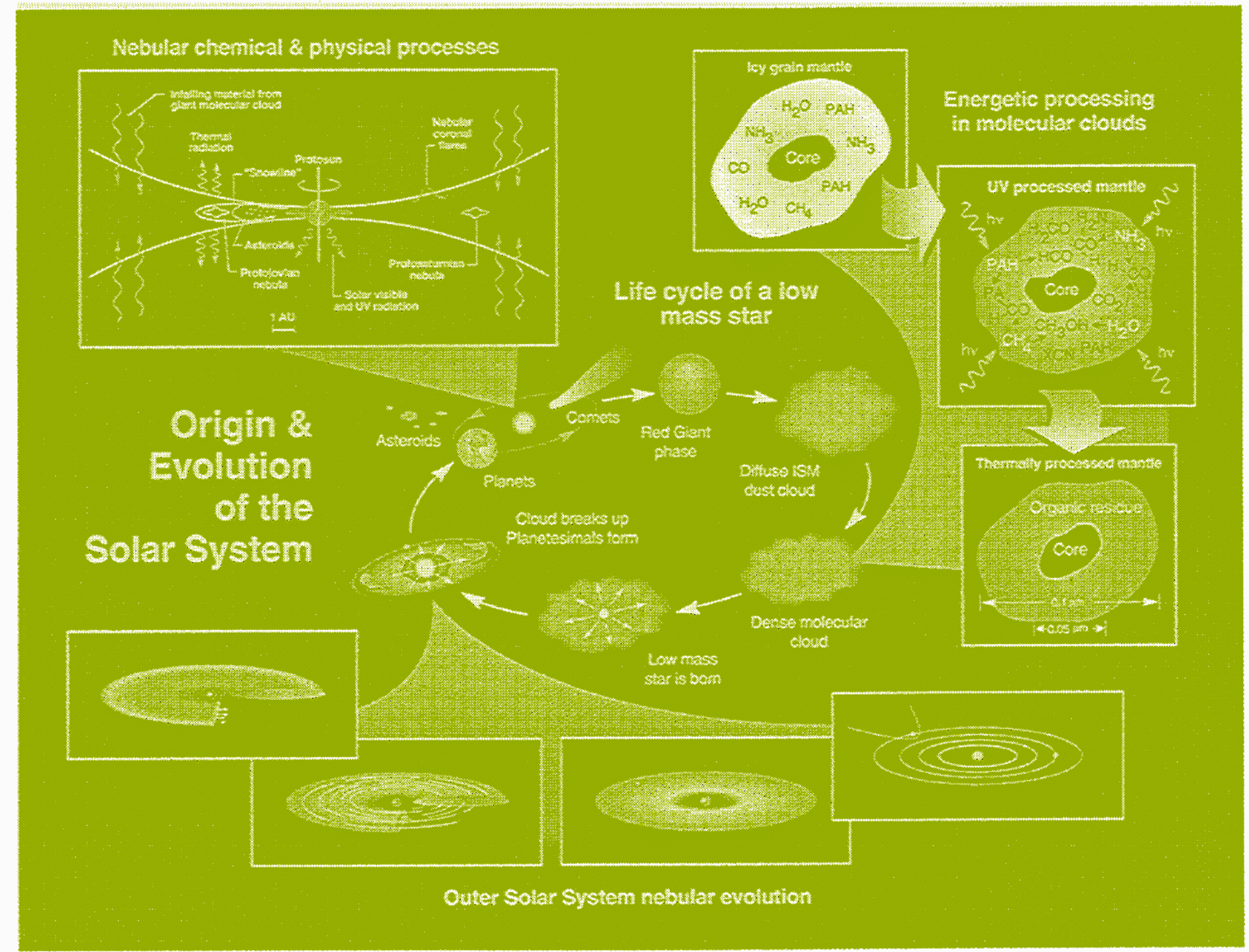
Outline

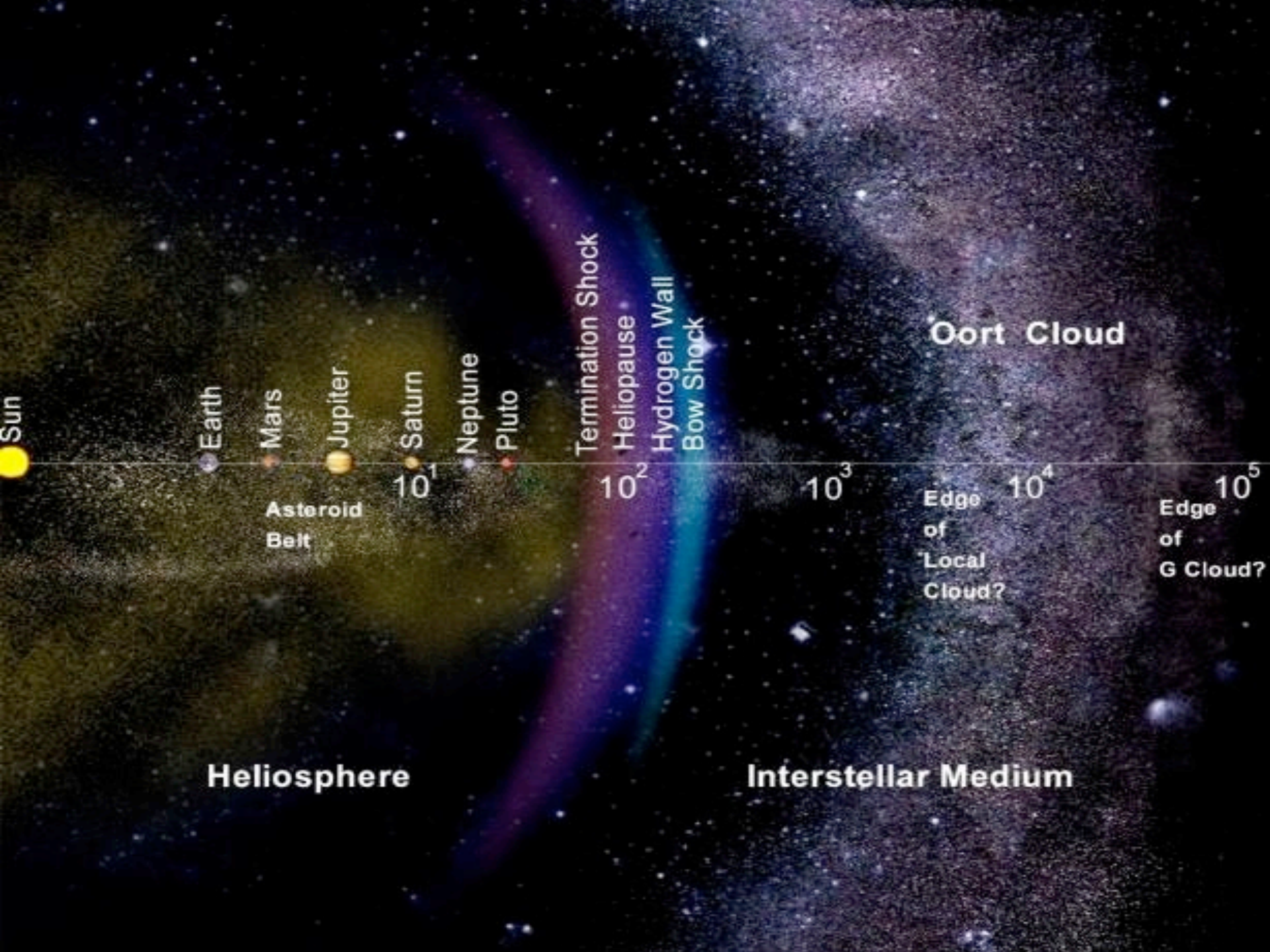
- **timeline, matter and comets**
- schedule and management approach for new missions
- Rosetta mission and payload
- Rosetta mission highlights up to 2010

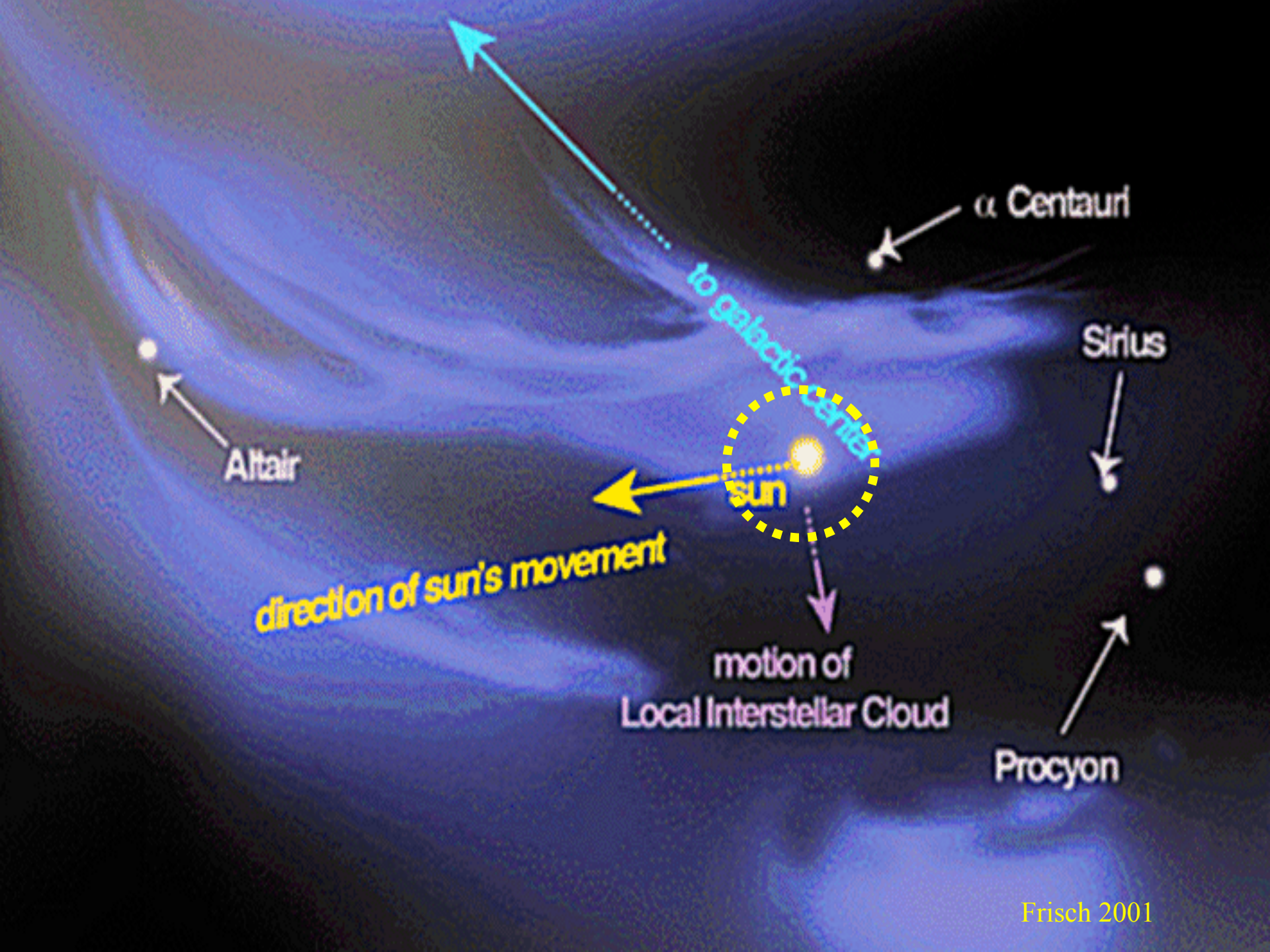
Cosmological Timeline



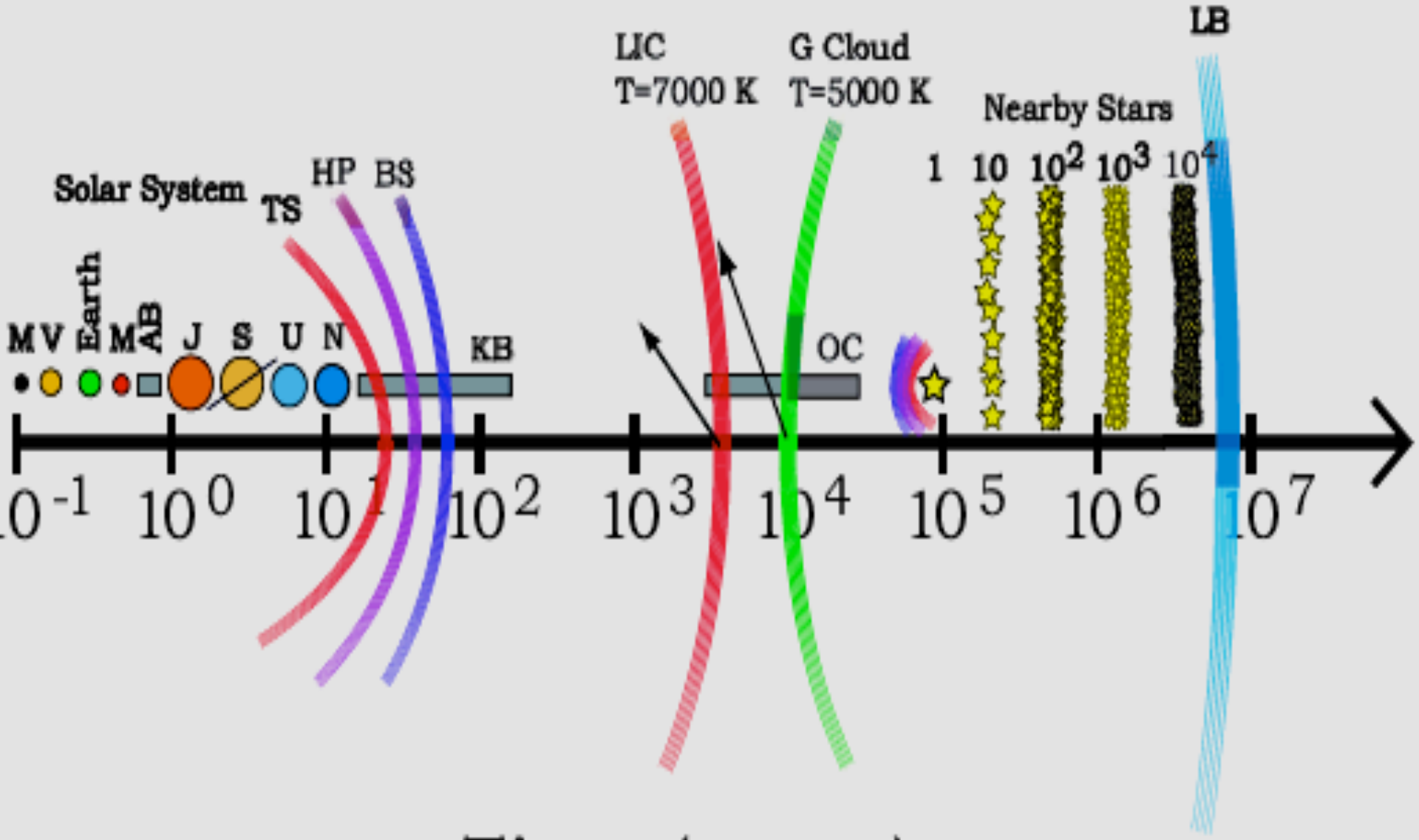
All dates are in millions of years ago (m.y.a.).


Nebular chemical & physical processes
Infalling material from giant molecular cloud
Thermal radiation
Protosun
"Snowline"
Nebular compact flows
Asteroids
Protojovian nebula
Protosaturnian nebula
Solar visible and UV radiation
1 AU
Icy grain mantle
H_2O
PAH
NH_3
NH_3
CO
Core
PAH
H_2O
CH_4
Energetic processing in molecular clouds
UV processed mantle
hν
hν
hν
hν
NH_3
PAH
Core
H_2O
CH_4
Life cycle of a low mass star
Origin & Evolution of the Solar System
Asteroids
Comets
Red Giant phase
Planets
Diffuse ISM dust cloud
Cloud breaks up Planetesimals form
Dense molecular cloud
Low mass star is born
Thermally processed mantle
Organic residue
Core
0.1 μm
0.05 μm
Outer Solar System nebular evolution


Sun
Earth
Mars
Jupiter
Saturn
Neptune
Pluto
Termination Shock
Heliopause
Hydrogen Wall
Bow Shock
Oort Cloud
10^1
10^2
10^3
10^4
10^5
Asteroid Belt
Edge of Local Cloud?
Edge of G Cloud?
Heliosphere
Interstellar Medium

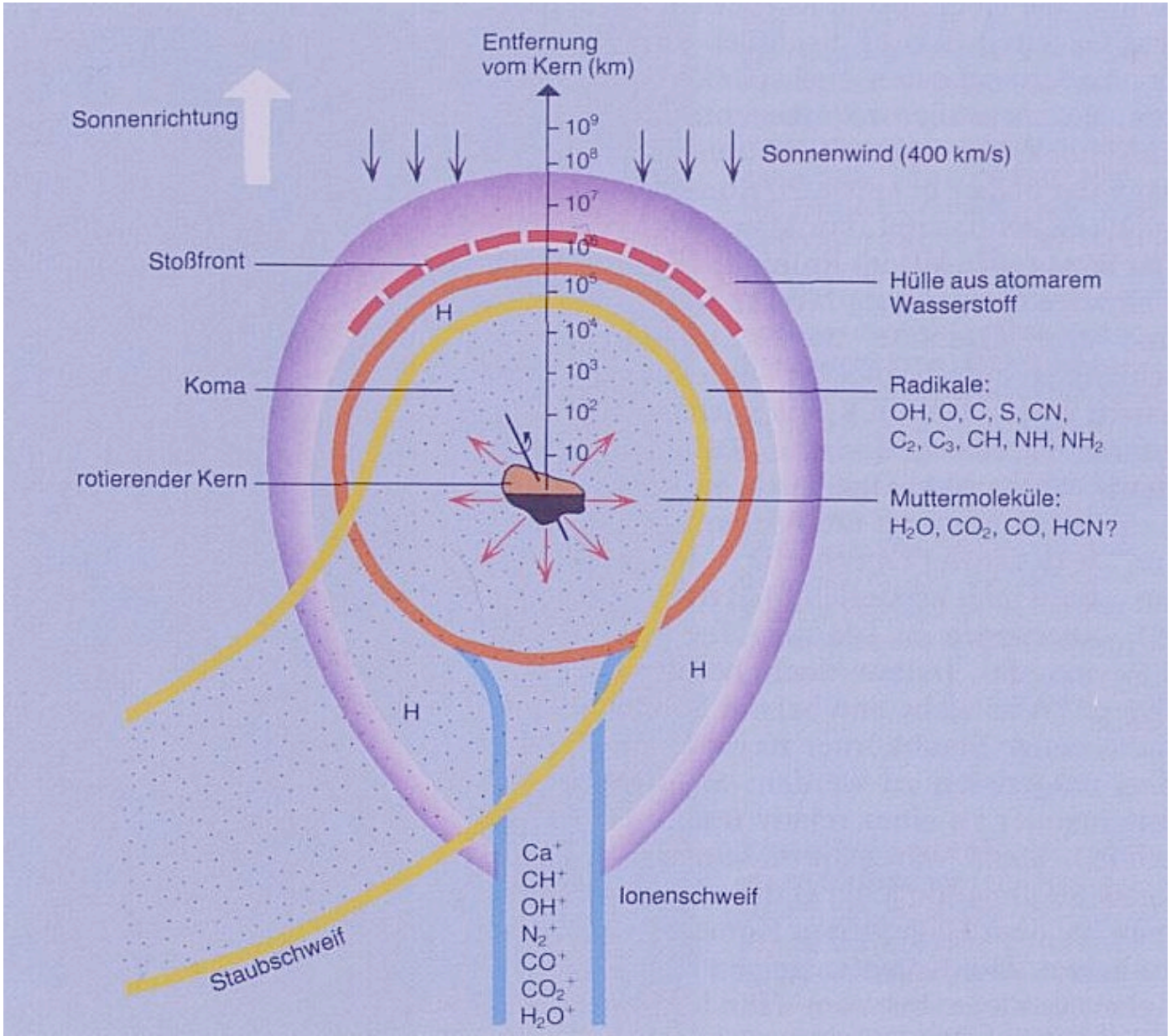

α Centauri
to galactic center
Sirius
Altair
sun
direction of sun's movement
motion of
Local Interstellar Cloud
Procyon

Frisch 2001

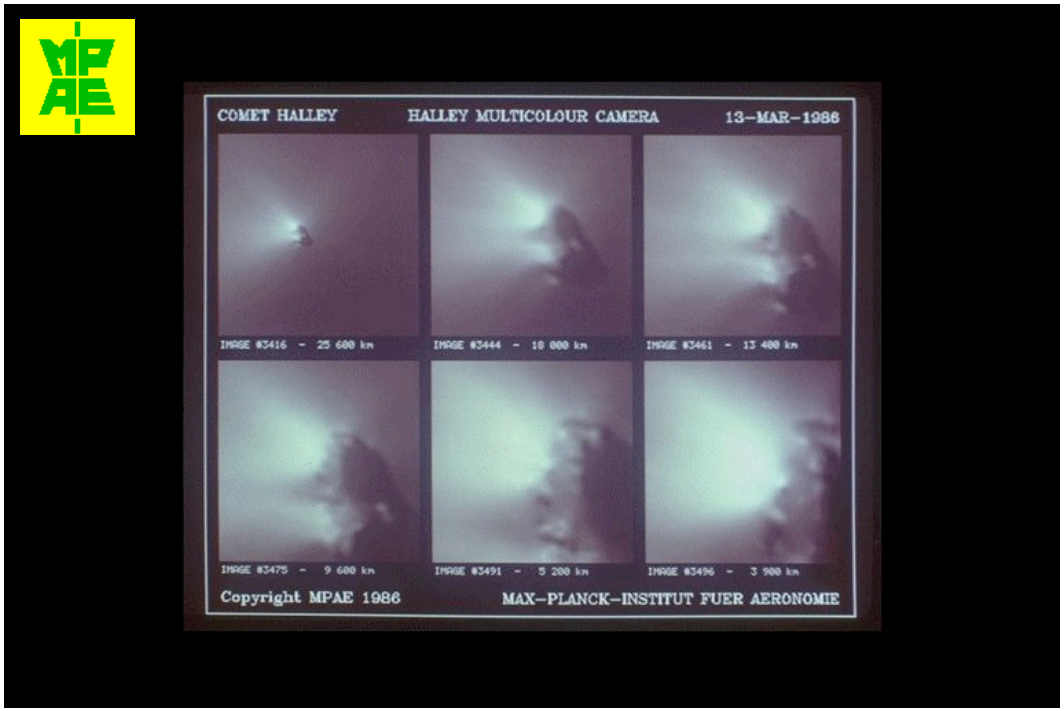


Redfill 1998

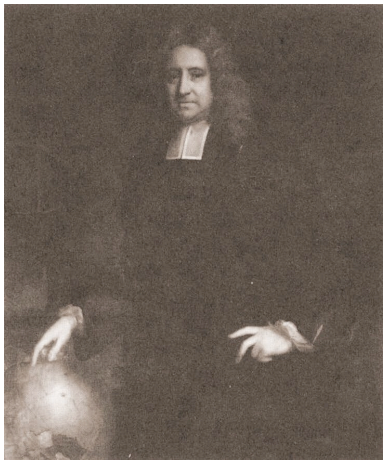
Comets – greatest and tiniest cheaters in the solar system



Famous comet: Halley



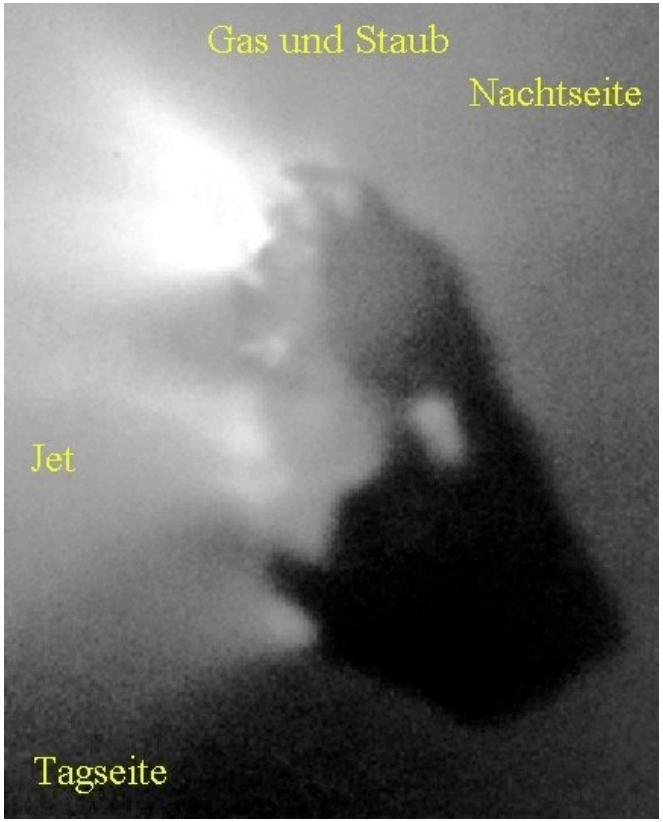
Comet Halley (March 13, 1986)



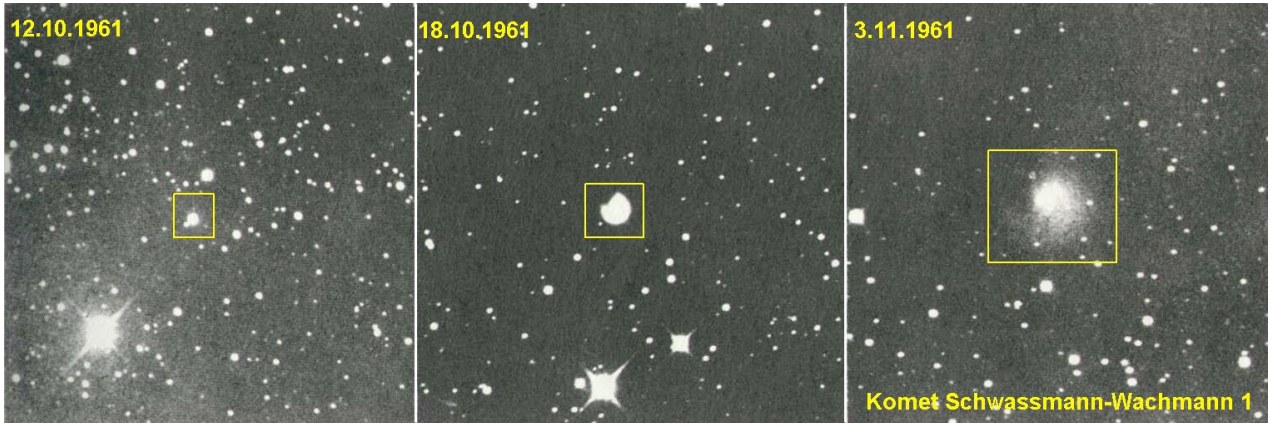
Edmond Halley, painted byThomas Murray

„dirty snowbal“ ?

nucleus, gas and dust 1986

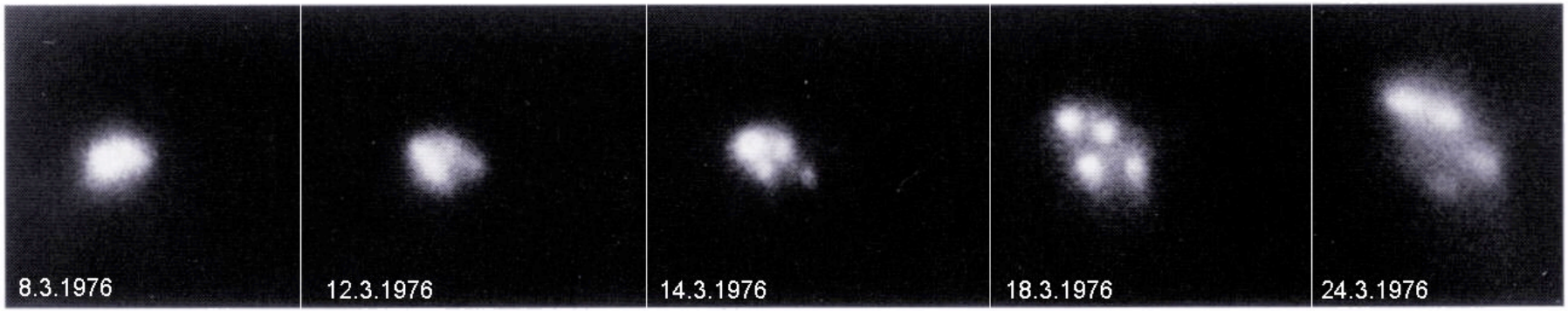


Comets

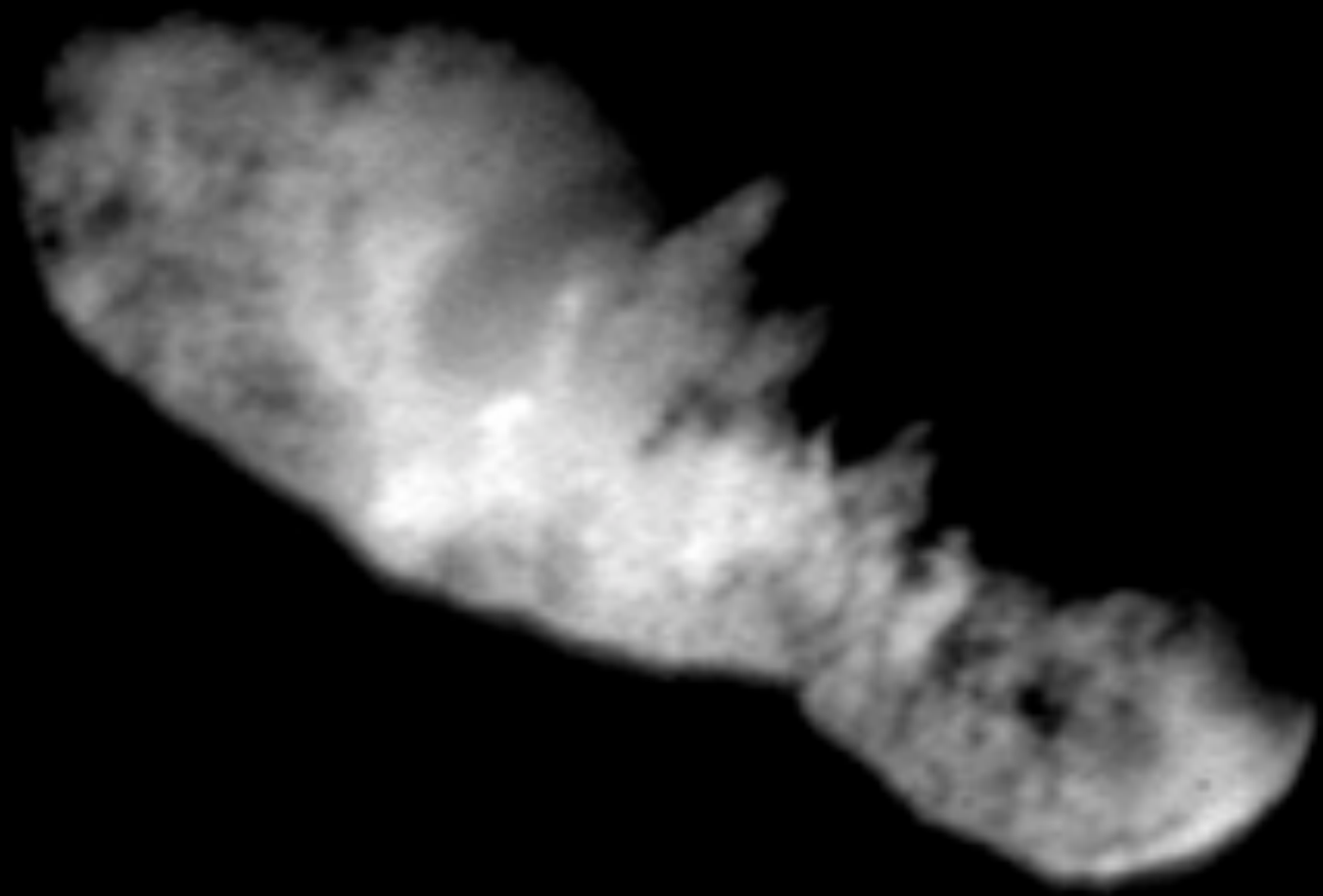


Schwassmann-Wachmann 1,
outburst beyond Jupiter's orbit

Comet West, 1976

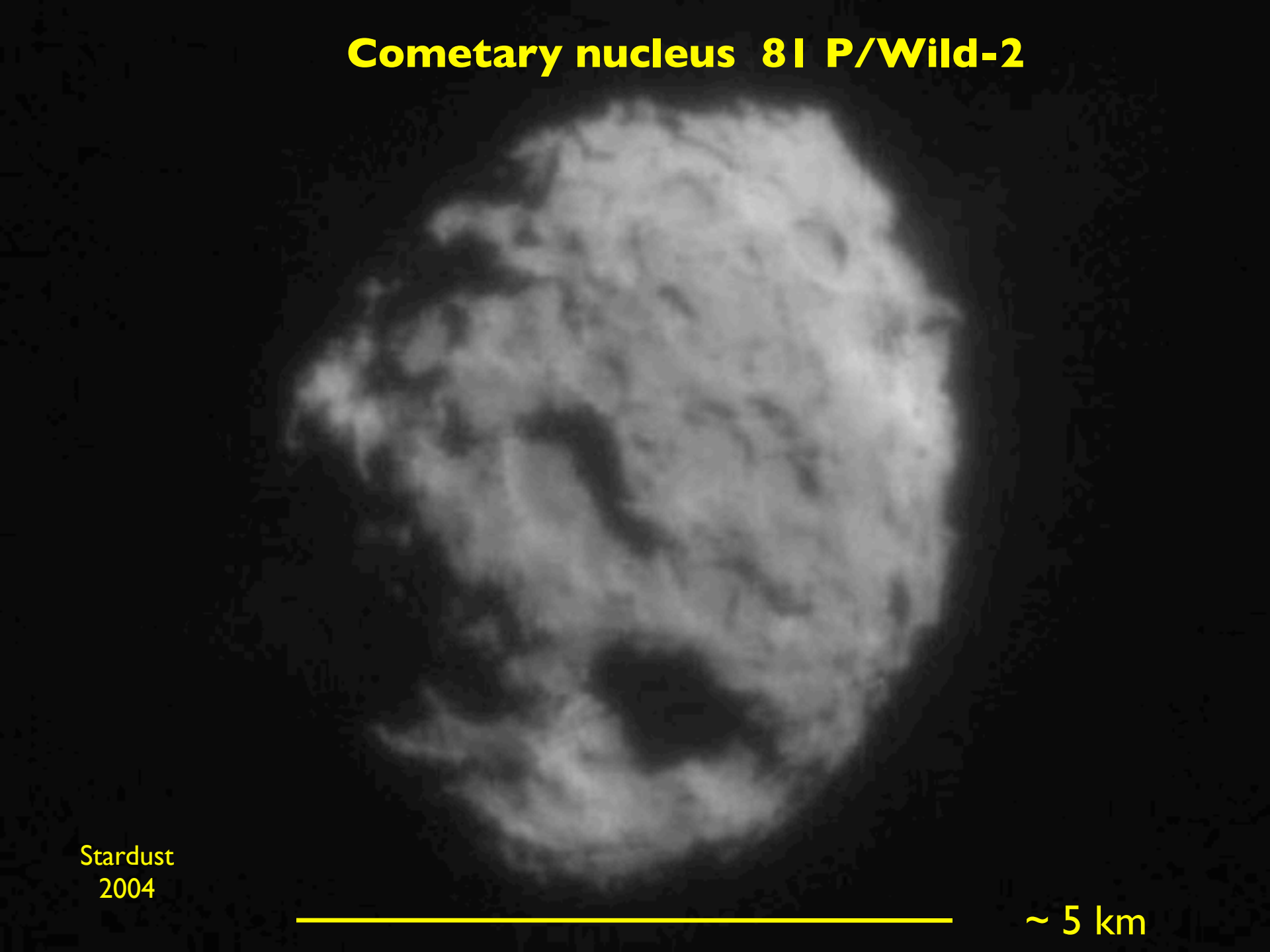


Cometary nucleus 19 P/Borelly



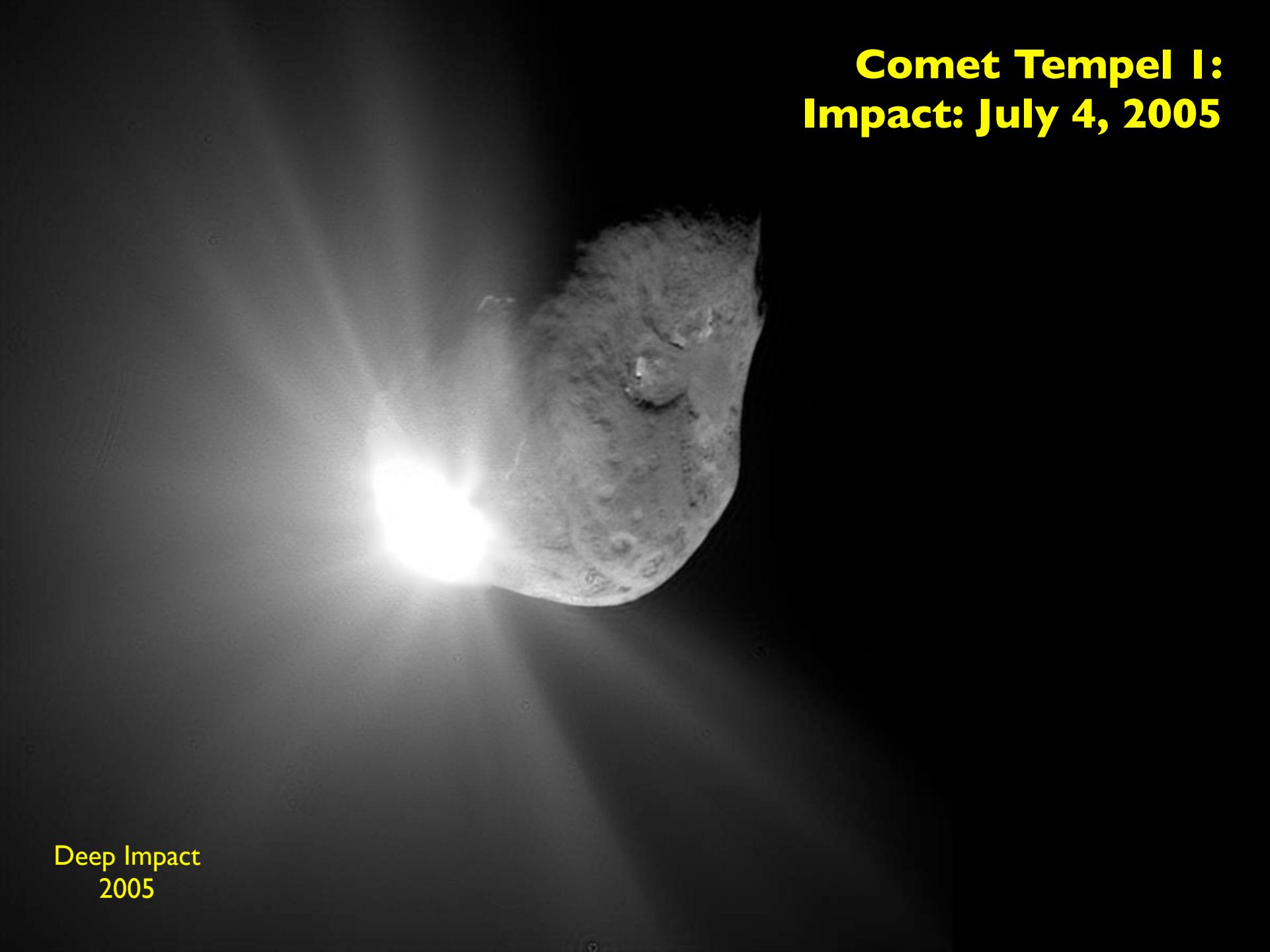
Deep space 1
2001

Cometary nucleus 81 P/Wild-2

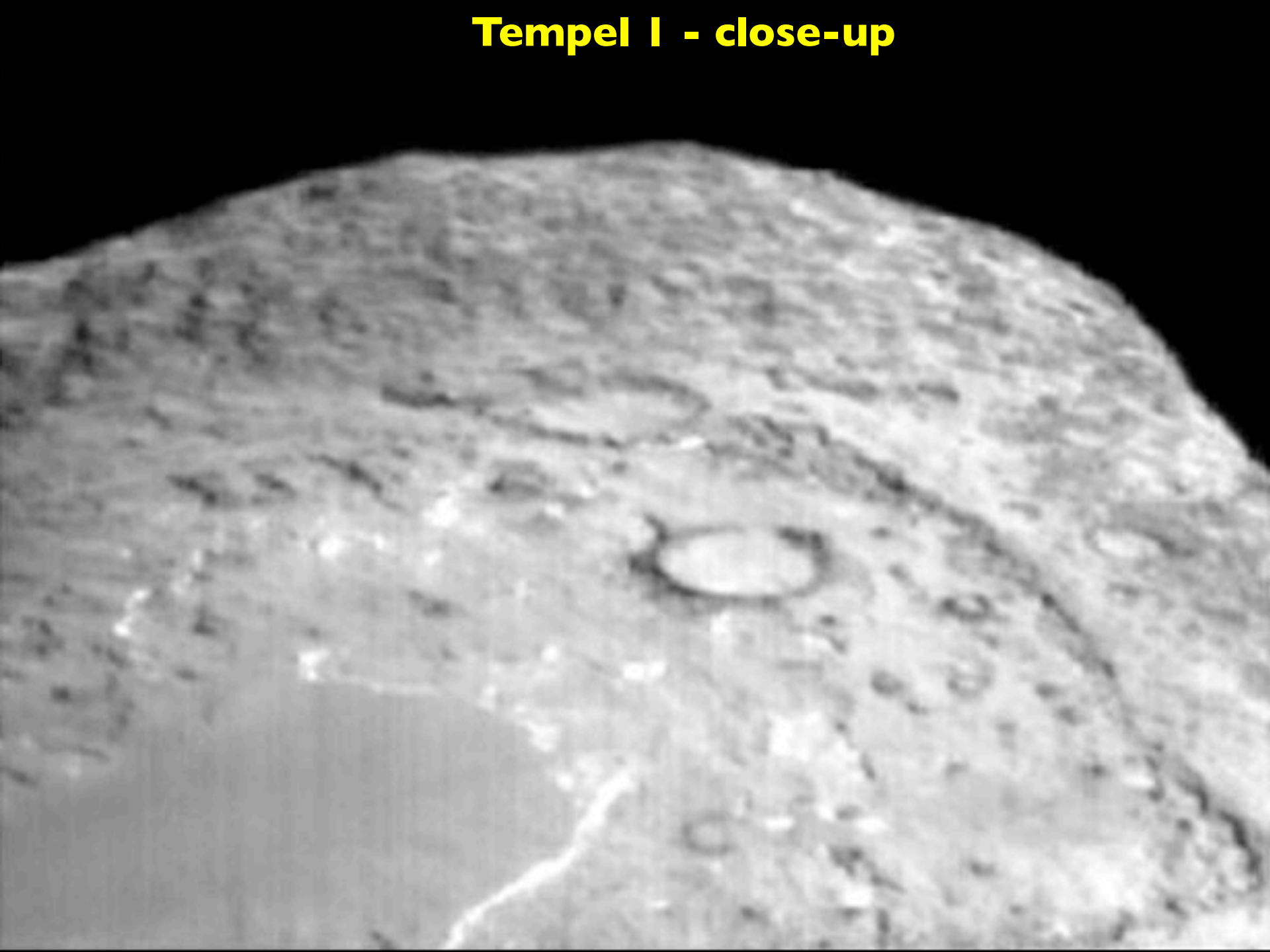


Stardust
2004

~ 5 km


Comet Tempel 1:
Impact: July 4, 2005
Deep Impact
2005

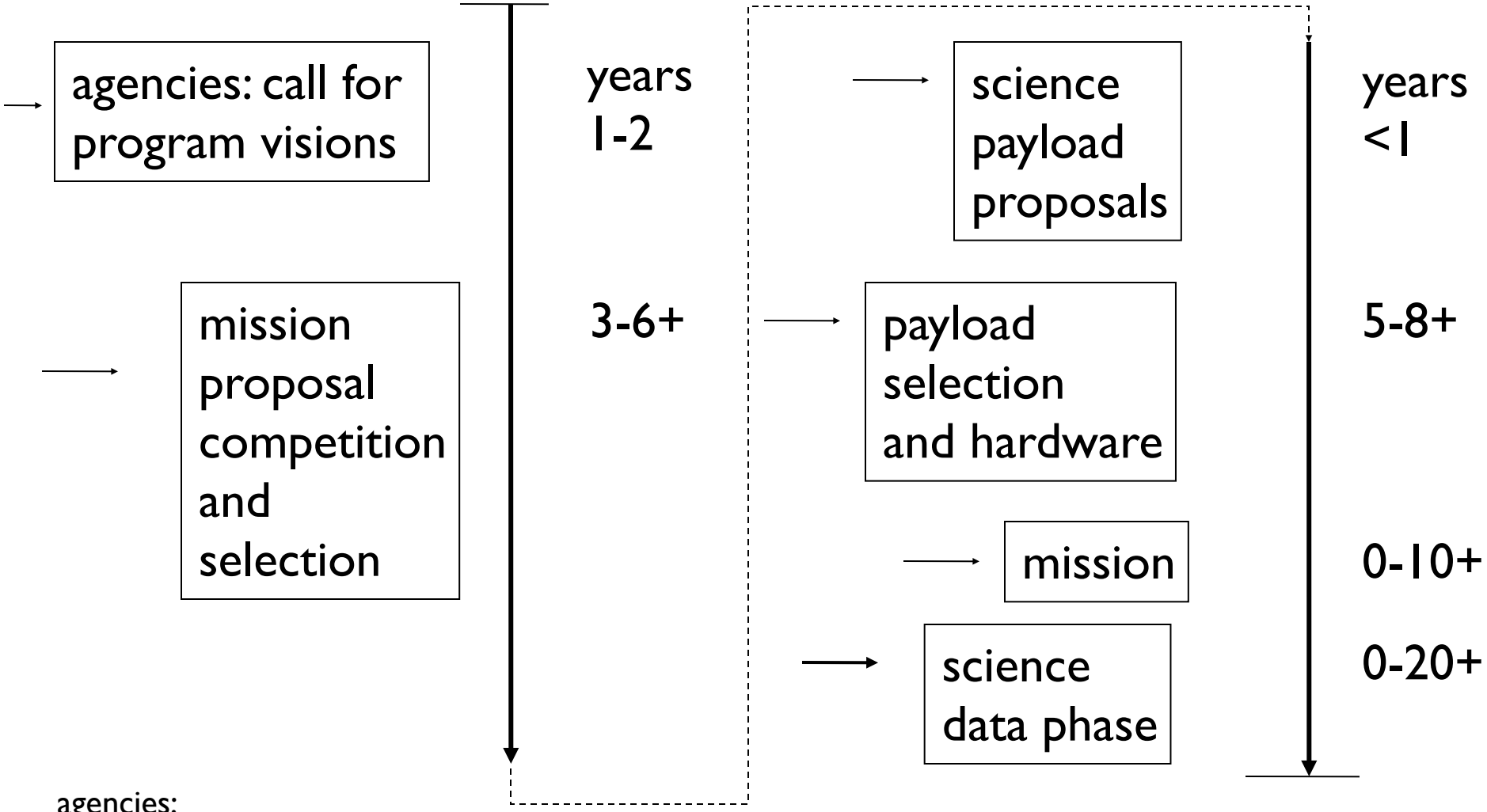
Tempel 1 - close-up



Outline

- timeline, matter and comets
- **schedule and management approach for new missions**
- Rosetta mission and payload
- Rosetta mission highlights up to 2010

Timeline for new space missions



agencies:

ESA, NASA, DLR, CNES etc.

Children's Books Online: the Rosetta Project, Inc.

www.childrensbooksonline.org

The largest collection of illustrated antique children's books on the World Wide Web.

Maine-based, volunteer-driven, not-for-profit, giving books away for free since 1997.

Space missions: General management approach

payload:
scientific institutes
and/ or industry

satellite:
agency contracted to industry

mission operation:
agency

mission science return:
scientific institutes

Outline

- timeline, matter and comets
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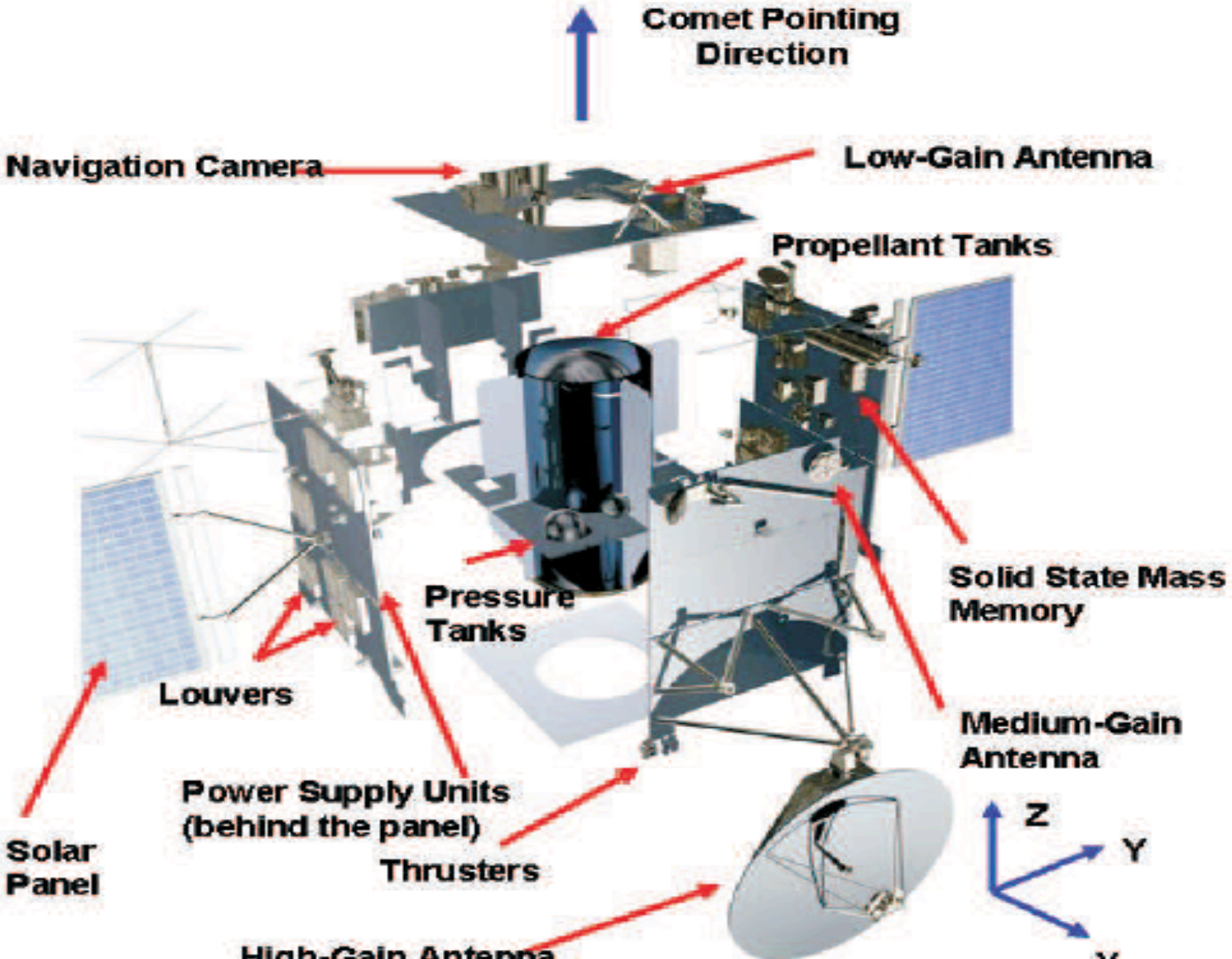
- Rosetta mission highlights up to 2010

Science goals of Rosetta mission

- a global characterization of the nucleus,
- the determination of its dynamic properties,
- the surface morphology and composition,
- the determination of chemical, mineralogical and isotopic compositions of volatiles and refractories in the cometary nucleus,
- the determination of the physical properties and interrelation of volatiles and refractories in the cometary nucleus,
- studies of the development of cometary activity and the processes in the surface layer of the nucleus and inner coma, that is dust/gas interaction,
- studies of the evolution of the interaction region of the solar wind and the outgassing comet during perihelion approach.


Mission Rosetta :
orbiter and lander
© Erik Viktor 2000

Rosetta


Comet Pointing Direction
Navigation Camera
Low-Gain Antenna
Propellant Tanks
Solid State Mass Memory
Pressure Tanks
Louvers
Medium-Gain Antenna
Power Supply Units (behind the panel)
Solar Panel
Thrusters
Z
Y

Design Depends on Individual Who Defines Problem

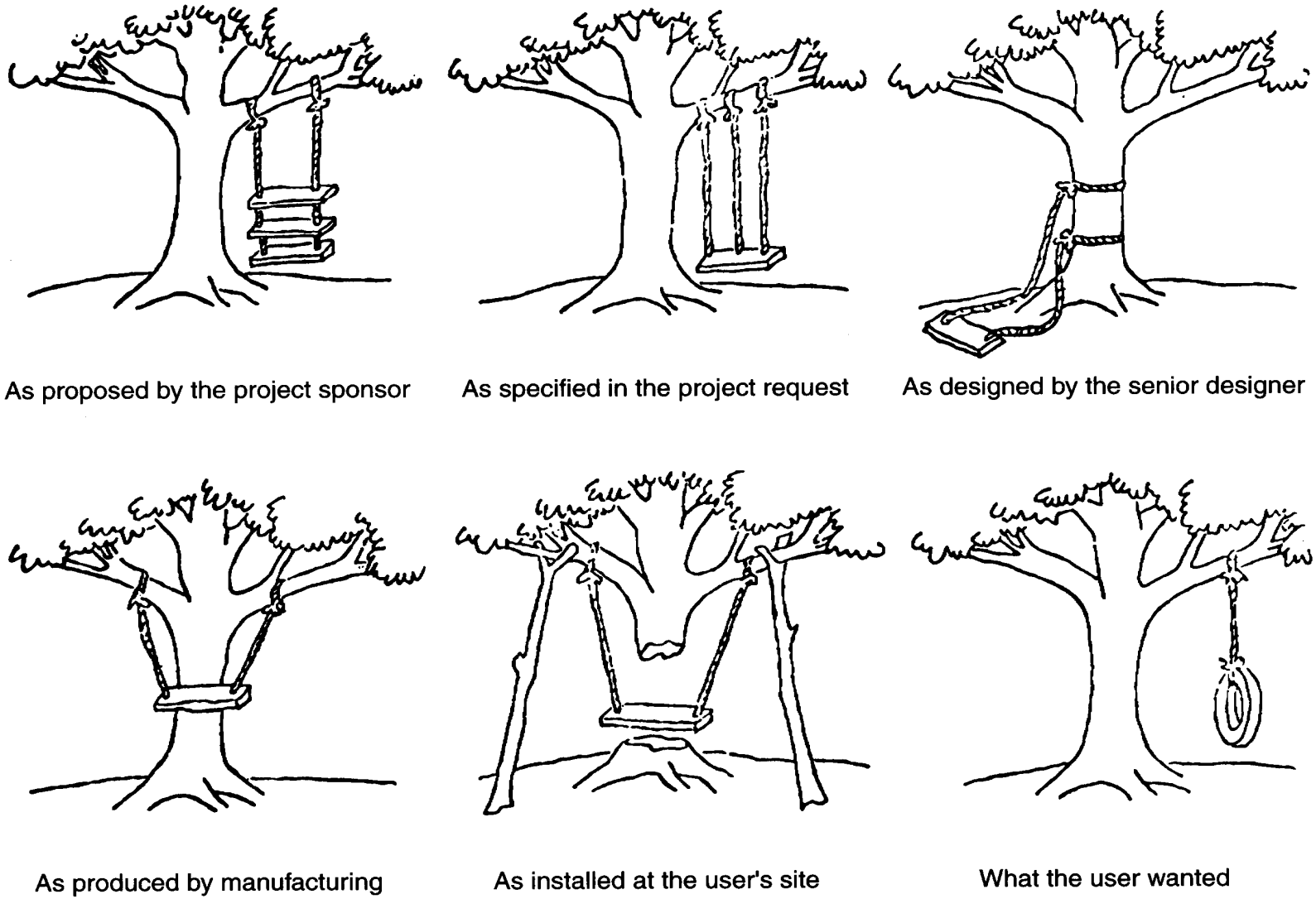


FIGURE 1.4
Note how the design depends on the viewpoint of the individual who defines the problem.

update of landing gear
Oct 2003

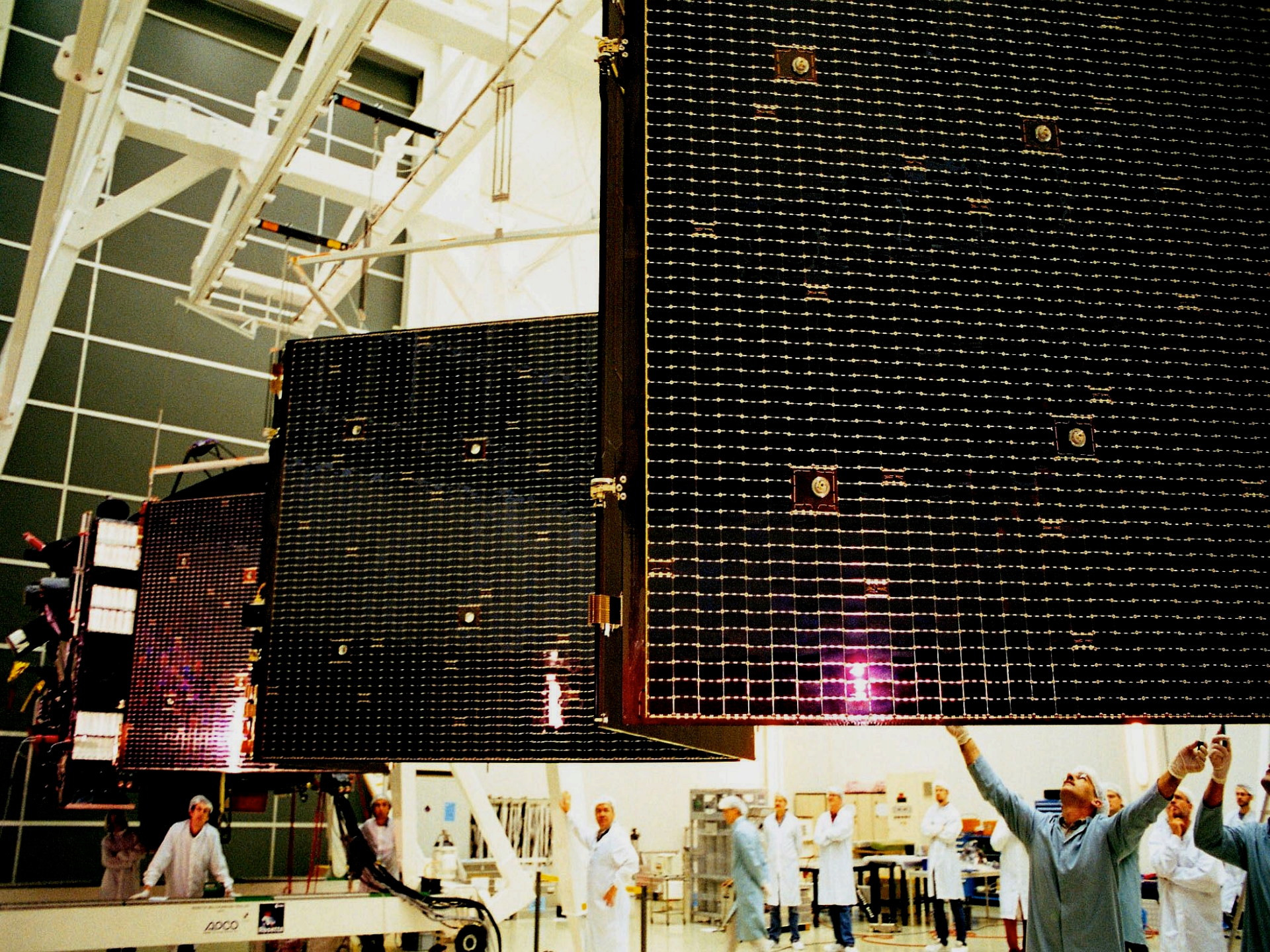
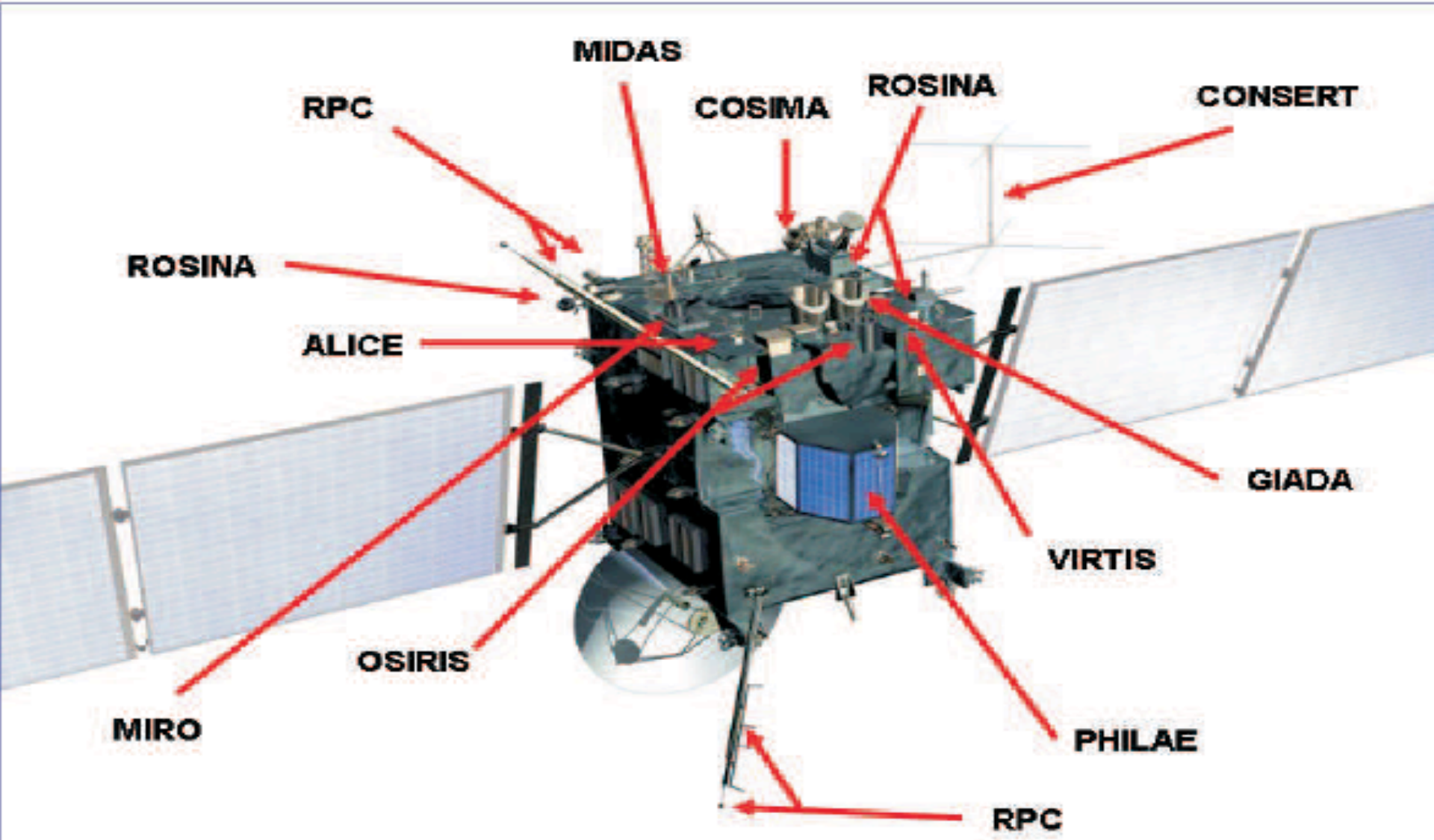


Table 2 Spacecraft Properties

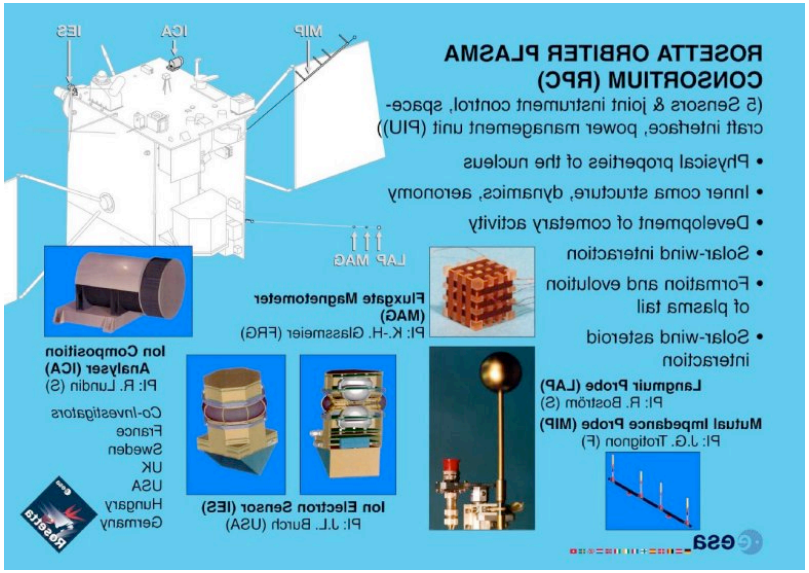
Size: main structure	2.8 x 2.1 x 2.0 m^3
Span of solar arrays	32 m
Launch mass: - total	2900 kg
- propellant	1720 kg
- science payload	165 kg
- lander PHILAE	100 kg
Solar array output	850 W at 3.40 AU
	395 W at 5.25 AU
Propulsion subsystem	24 bipropellant
	10 N thrusters
Operational life time	12 years
Prime contractor	Alenia Spazio, Italy

Rosetta Orbiter Experiments and Philae

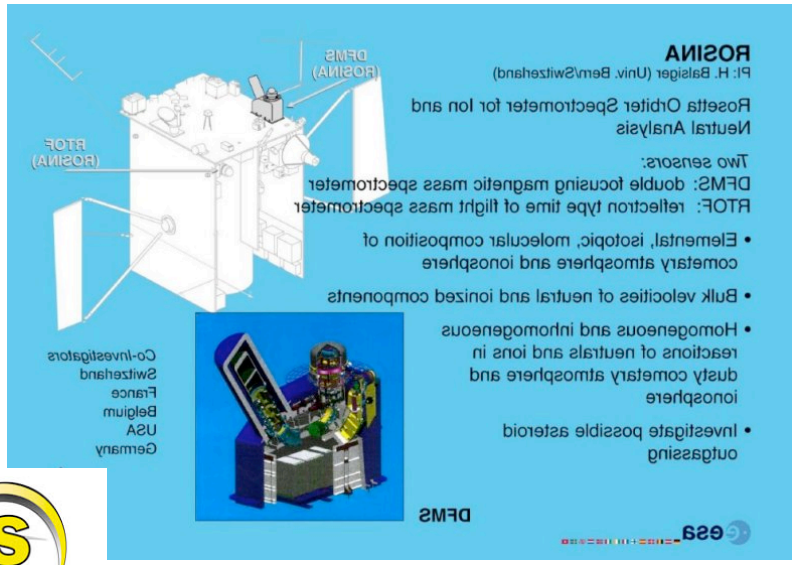


Plasma- and neutral particle measurements onboard ROSETTA

RPC: Plasma- and magnet field



ROSINA: abundance and velocity of gas and ions

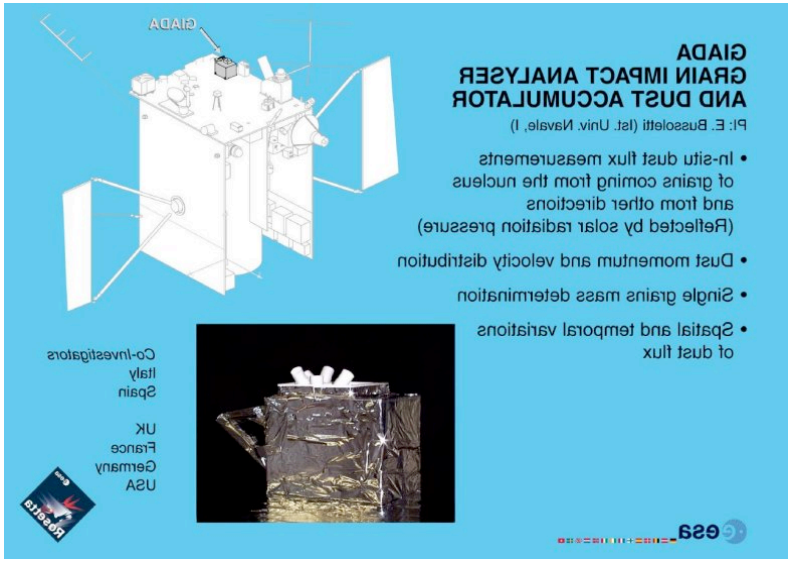


MPS

Dust measurements onboard ROSETTA

MIDAS: Dustmicroscope

GIADA: Dust flux measurements

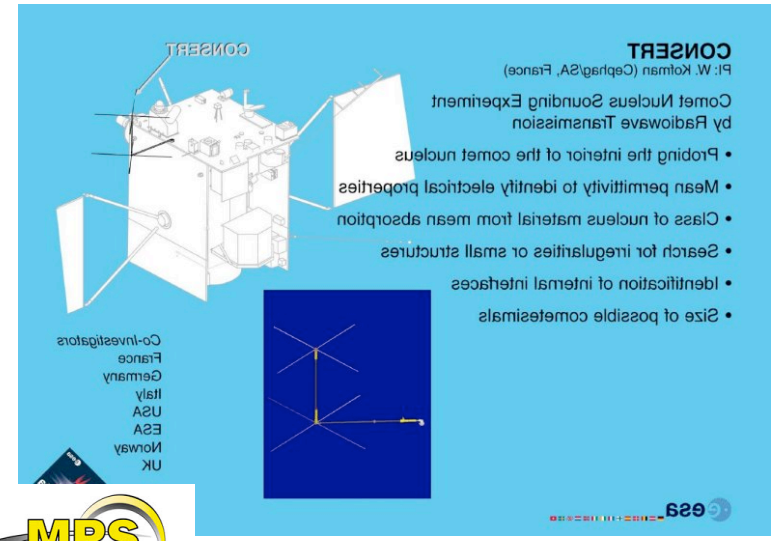


COSIMA: Element abundancies

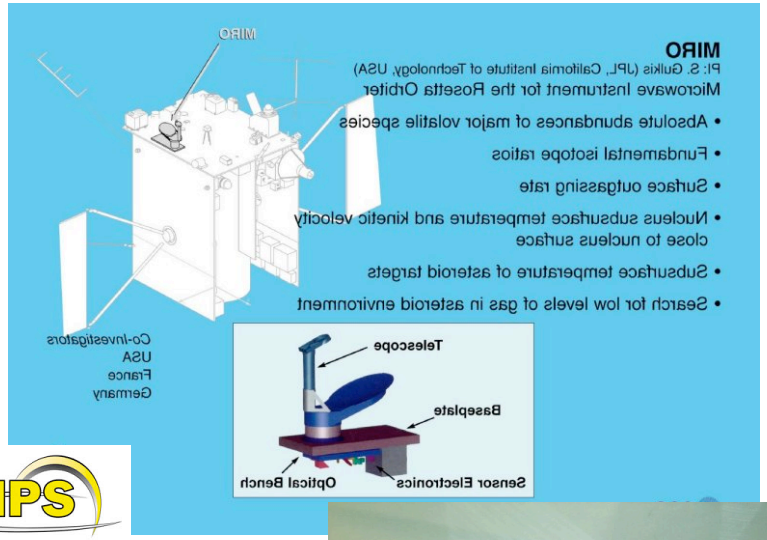
MPS

Elektromagnetic waves onboard ROSETTA (I)

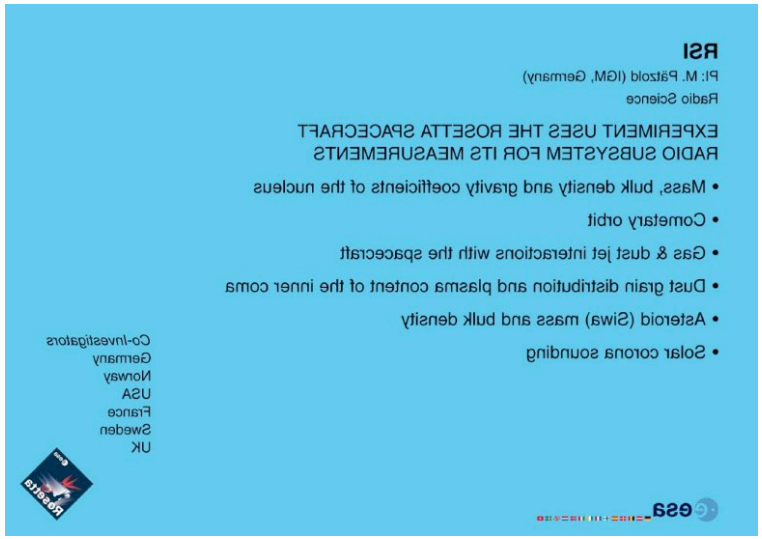
CONSERT: radiowavetransmission („tomography“)



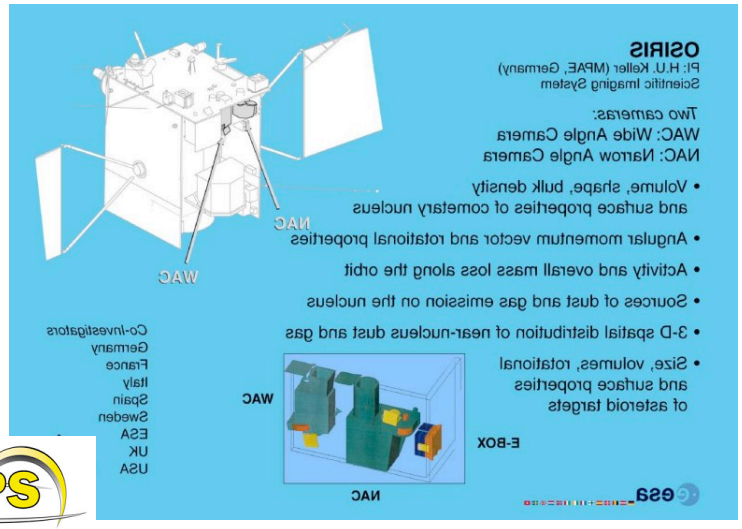
MIRO: microwavemeasurements



RSI: mass and density

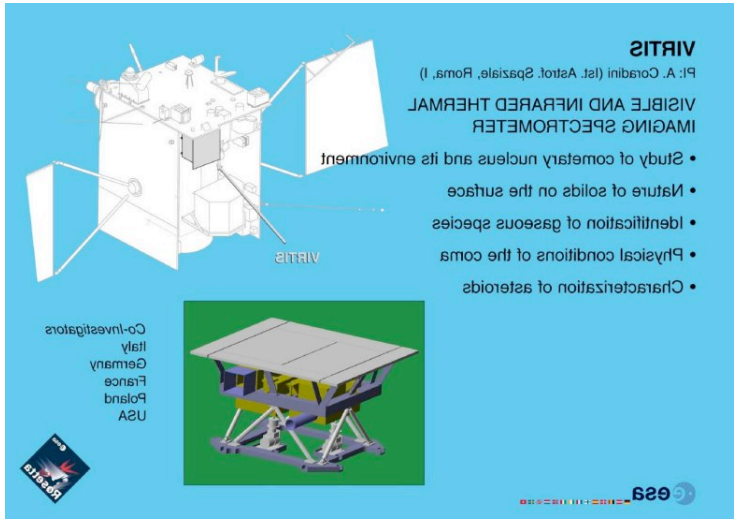


OSIRIS: The ROSETTA cameras

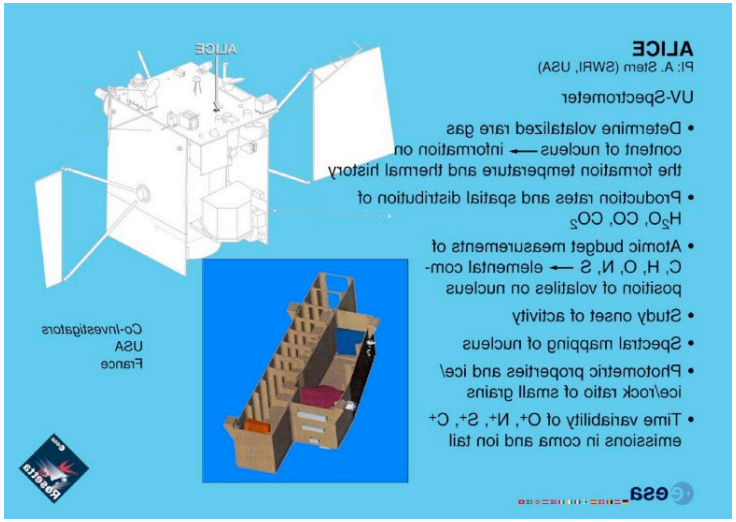


Elektromagnetic waves onboard ROSETTA (II)

VIRTIS: Infrared spectrometer



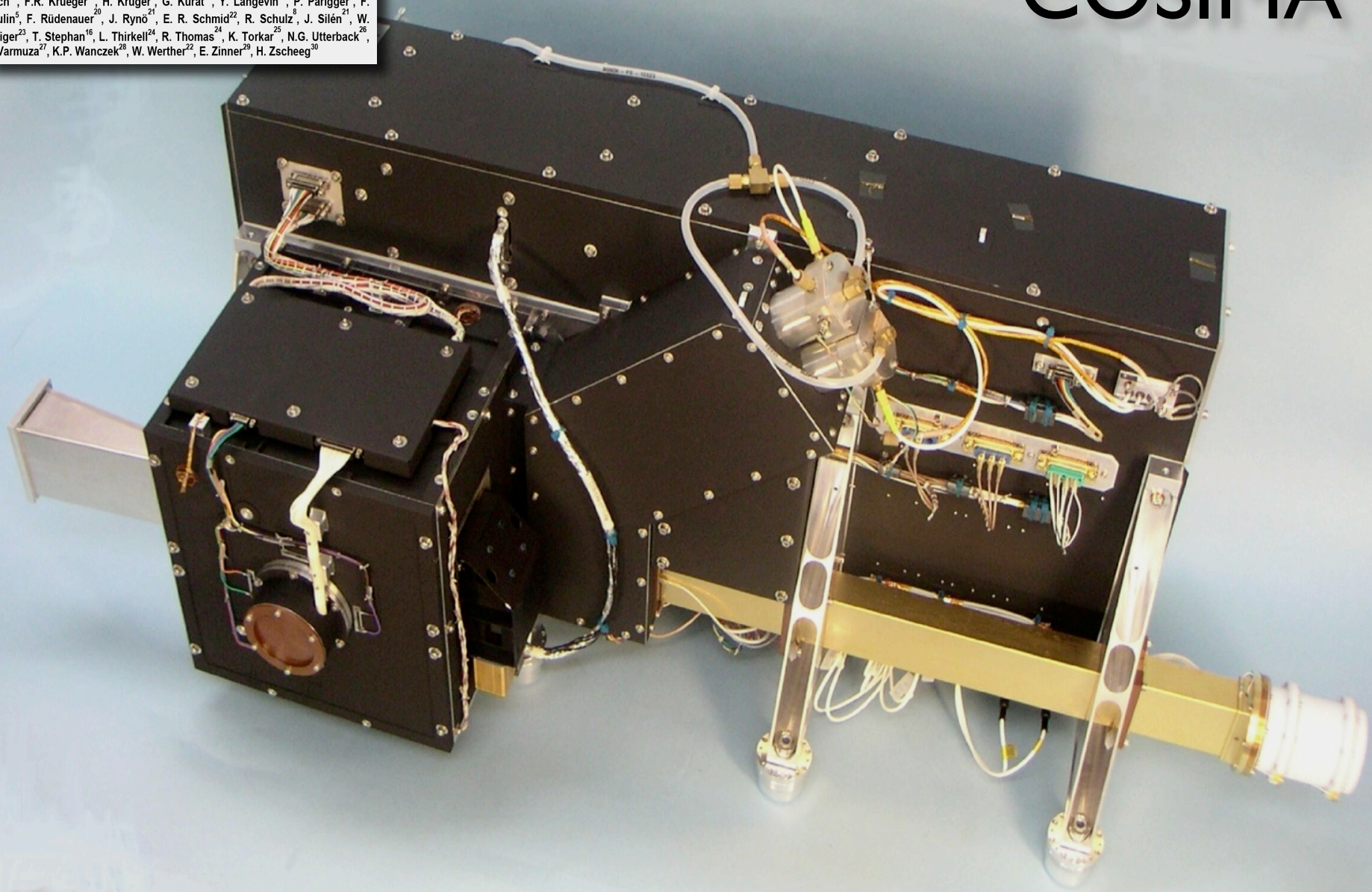
ALICE: UV spectrometer

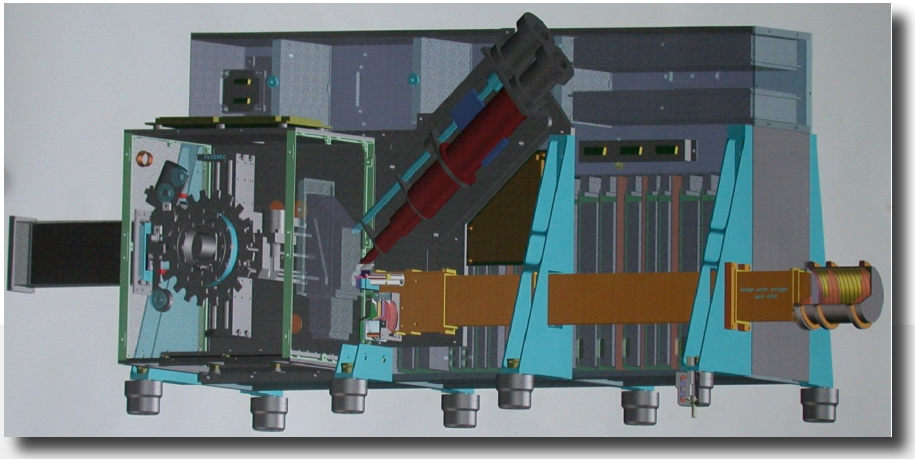


Rosetta COSIMA

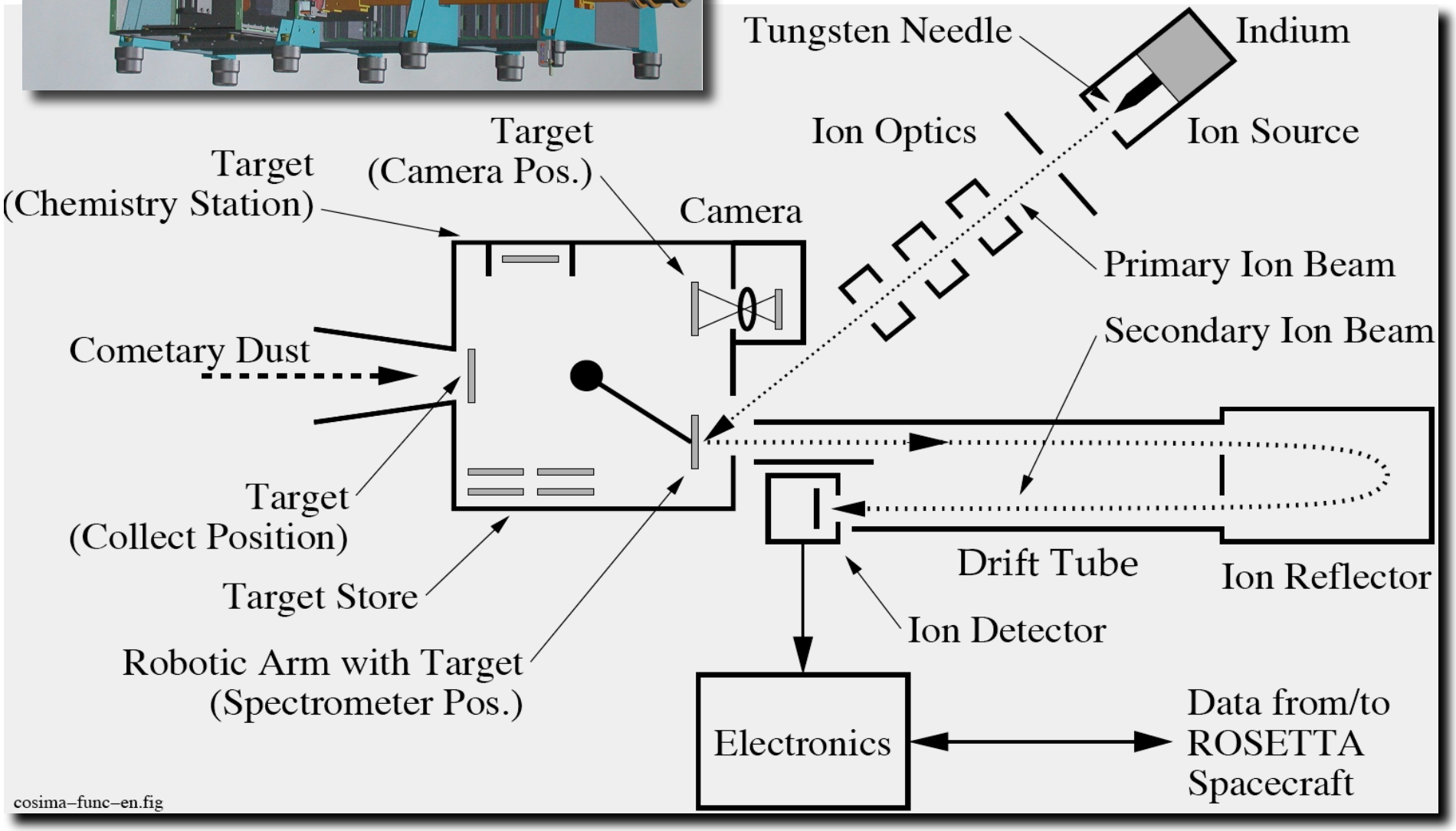
COSIMA, a High Resolution Time-of-Flight Secondary Ion Mass Spectrometer for the Analysis of Cometary Dust Particles

J. Kissel[1], K. Altwegg[2], B.C. Clark[3], L. Colangeli[4], H. Cottin[5], S. Czempiel[6], J. Eibl[6], C. Engrand[7], H.M. Fehringer[8], B. Feuerbacher[9], M. Fomenkova[10], A. Glasmachers[11], J. M. Greenberg[12], E. Grün[13], G. Haerendel[6], H. Henkel[14], M. Hilchenbach[1], H. von Hoerner[14], H. Höfner[6], K. Hornung[15], E.K. Jessberger[16], A. Koch[14], F.R. Krueger[17], H. Krüger[1], G. Kurat[18], Y. Langevin[19], P. Parigger[6], F. Raulin[5], F. Rüdenauer[20], J. Rynö[21], E. R. Schmid[22], R. Schulz[8], J. Silén[21], W. Steiger[23], T. Stephan[16], L. Thirkell[24], R. Thomas[24], K. Torkar[25], N.G. Utterback[26], K. Varmuza[27], K.P. Wanczek[28], W. Werther[22], E. Zinner[29], H. Zscheeg[30]



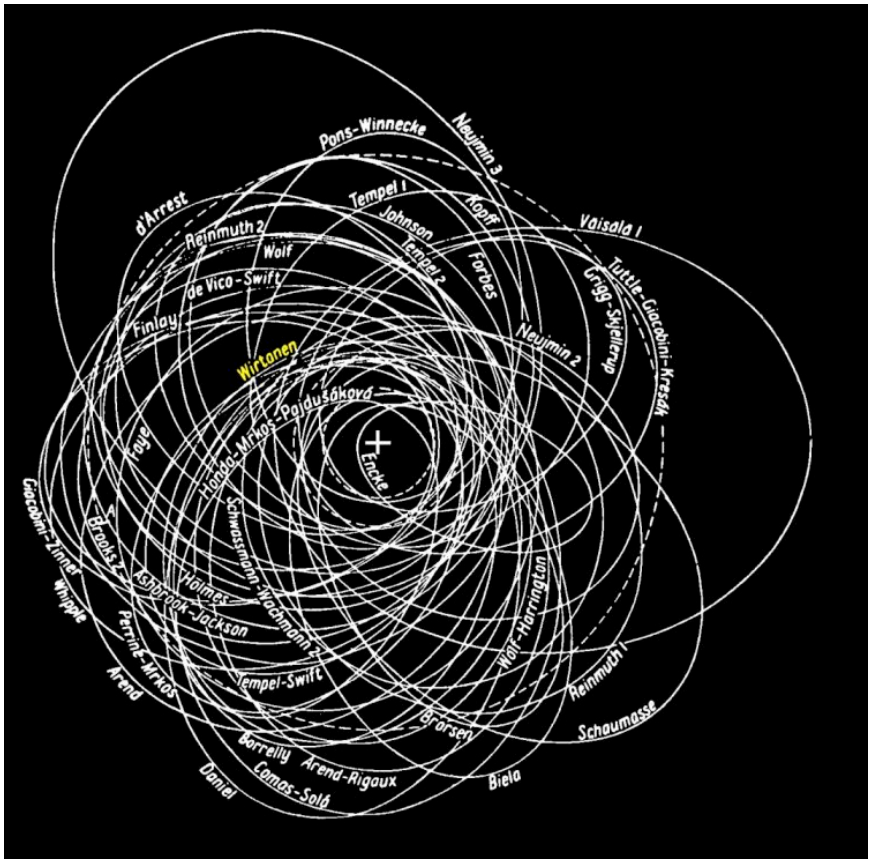


COSIMA-functional diagram



Selection of target comet for the Rosetta mission - I

Selection of target comet for the Rosetta mission - II



2003

conditions:

periodic comet, „new“ in the inner solar system and target comet should not fall apart*, and rocket should be ready for launch in time....

*unpredictable...

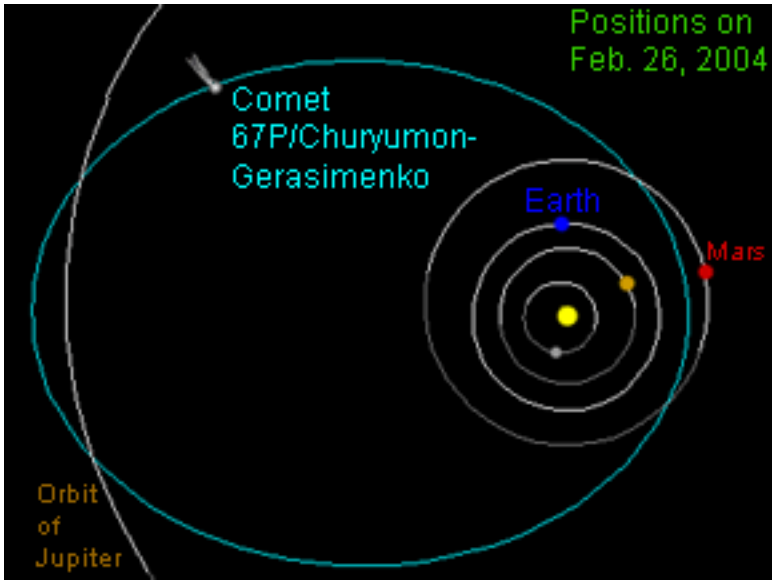
Target comet for Rosetta in 2003 :

67P/Churyumov-Gerasimenko

size	=	3 x 5 km
perihelion	=	1.292 AU
aphelion	=	5.730 AU

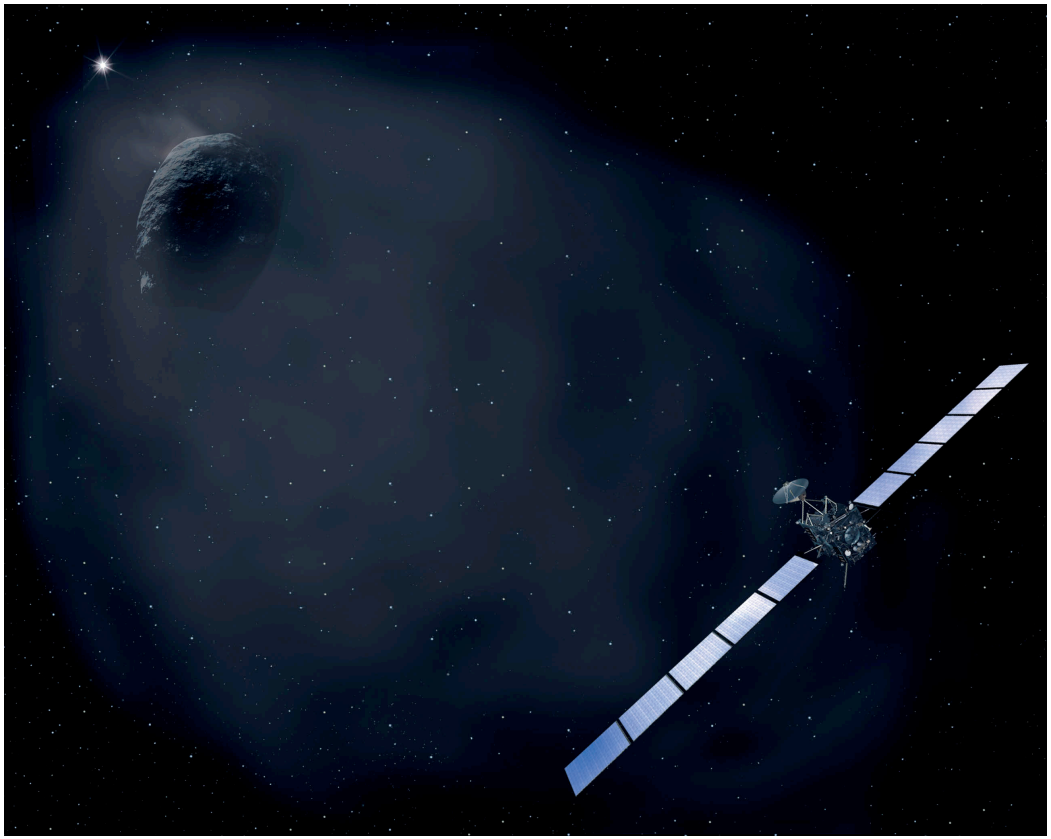
67P/Churyumov-Gerasimenko
February 1st 2003

Approaching comet 67P/Churyumov-Gerasimenko

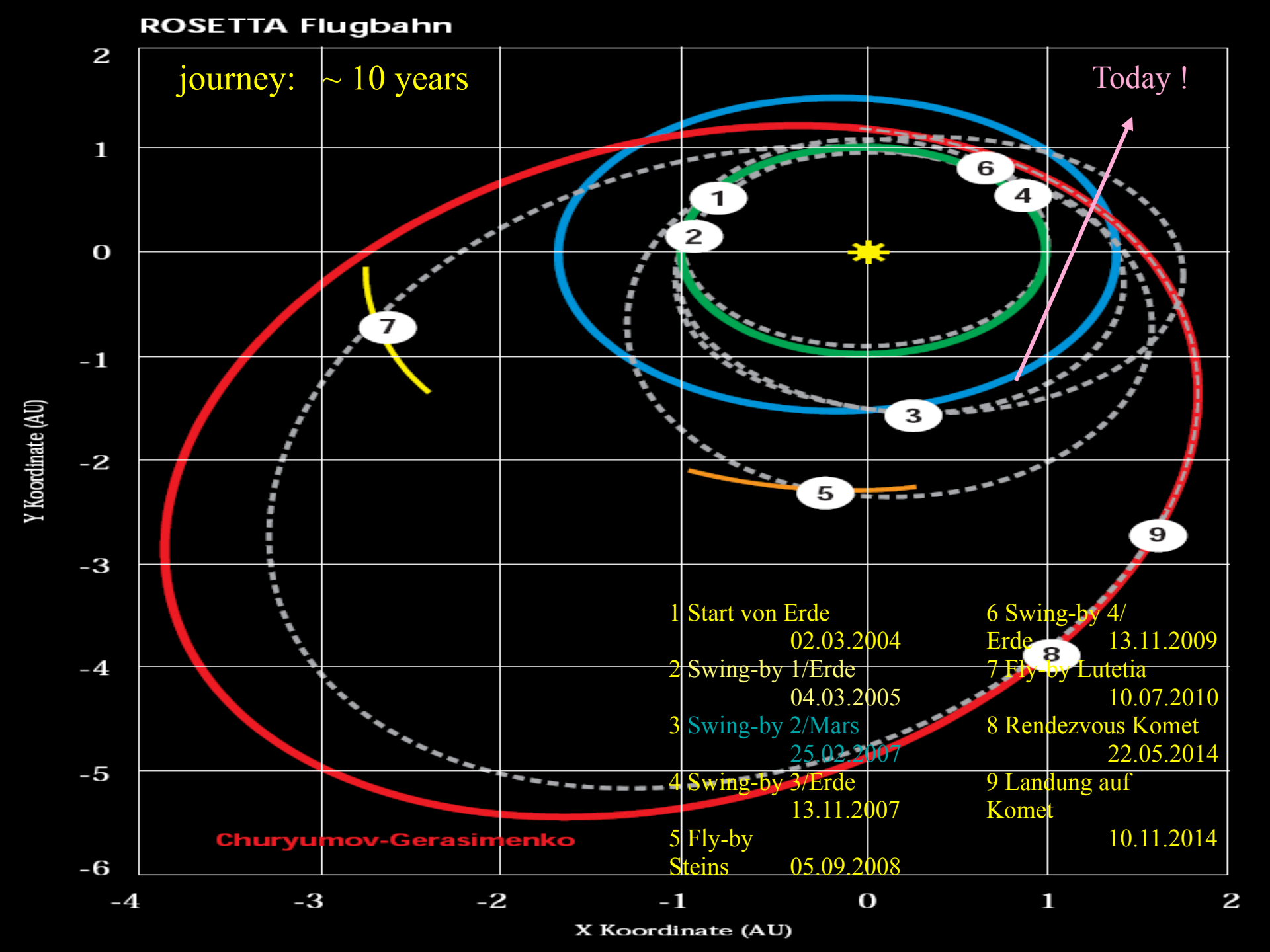


Journey to comet (2004-2014)

Launch of
Ariane V
2004



Science at comet
(2014/2015: 12 month)


ROSETTA Flugbahn
journey: ~ 10 years
Today !
1
2
3
4
5
6
7
8
9
Churyumov-Gerasimenko
1 Start von Erde 02.03.2004
2 Swing-by 1/Erde 04.03.2005
3 Swing-by 2/Mars 25.02.2007
4 Swing-by 3/Erde 13.11.2007
5 Fly-by Steins 05.09.2008
6 Swing-by 4/ Erde 13.11.2009
7 Fly-by Lutetia 10.07.2010
8 Rendezvous Komet 22.05.2014
9 Landung auf Komet 10.11.2014
Y Koordinate (AU)
X Koordinate (AU)
2
1
0
-1
-2
-3
-4
-5
-6
-4
-3
-2
-1
0
1
2


.. ...and in Nov 2014 ....

Outline

- timeline, matter and comets
- schedule and management approach for new missions
- Rosetta mission and payload
- **Rosetta mission highlights up to 2010**

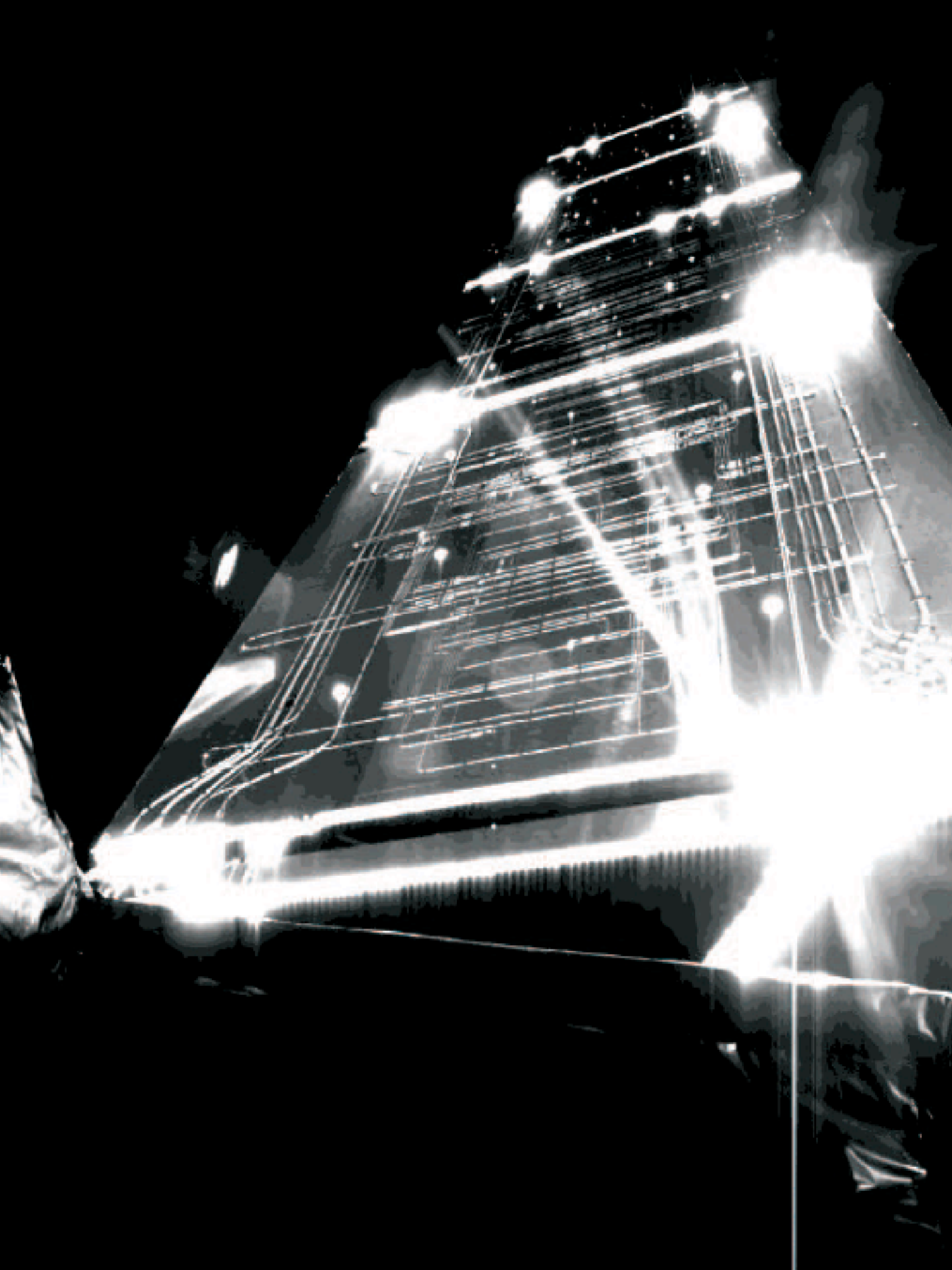
Mission operation

- **Mission Operations Centre**: European Space Operations Centre (ESOC), Darmstadt, Germany
- **Prime Ground Station**: New Norcia, near Perth, Australia
- **Science Operations Centre**: Space Astronomy Centre (ESAC), Madrid, Spain
- **Lander Control Centre**: DLR, Cologne, Germany
- **Lander Science Centre**: CNES, Toulouse, France
- Planned operational duration: 12 years

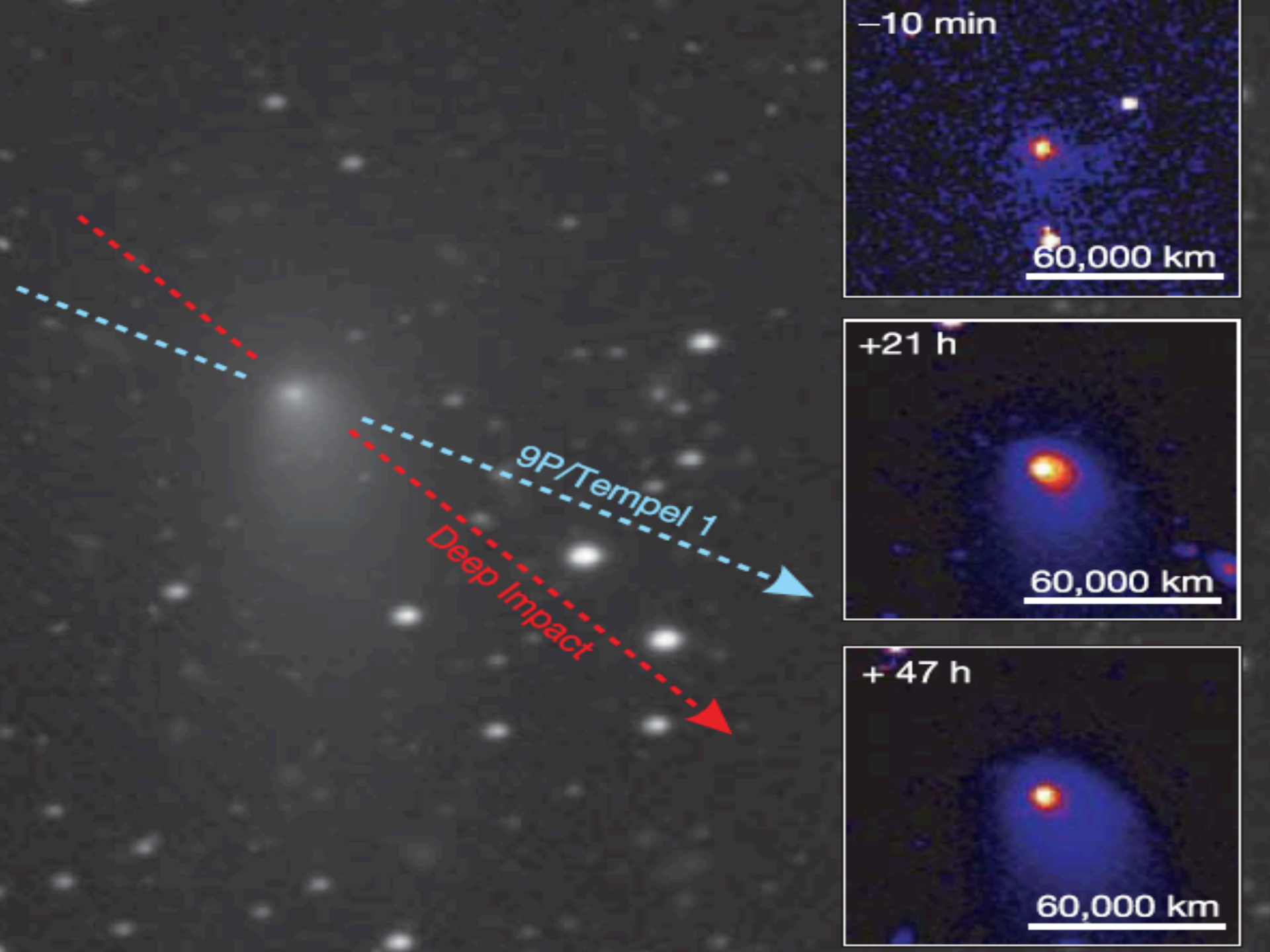
Outlook and milestones towards comet 67P/Churyumov-Gerasimenko

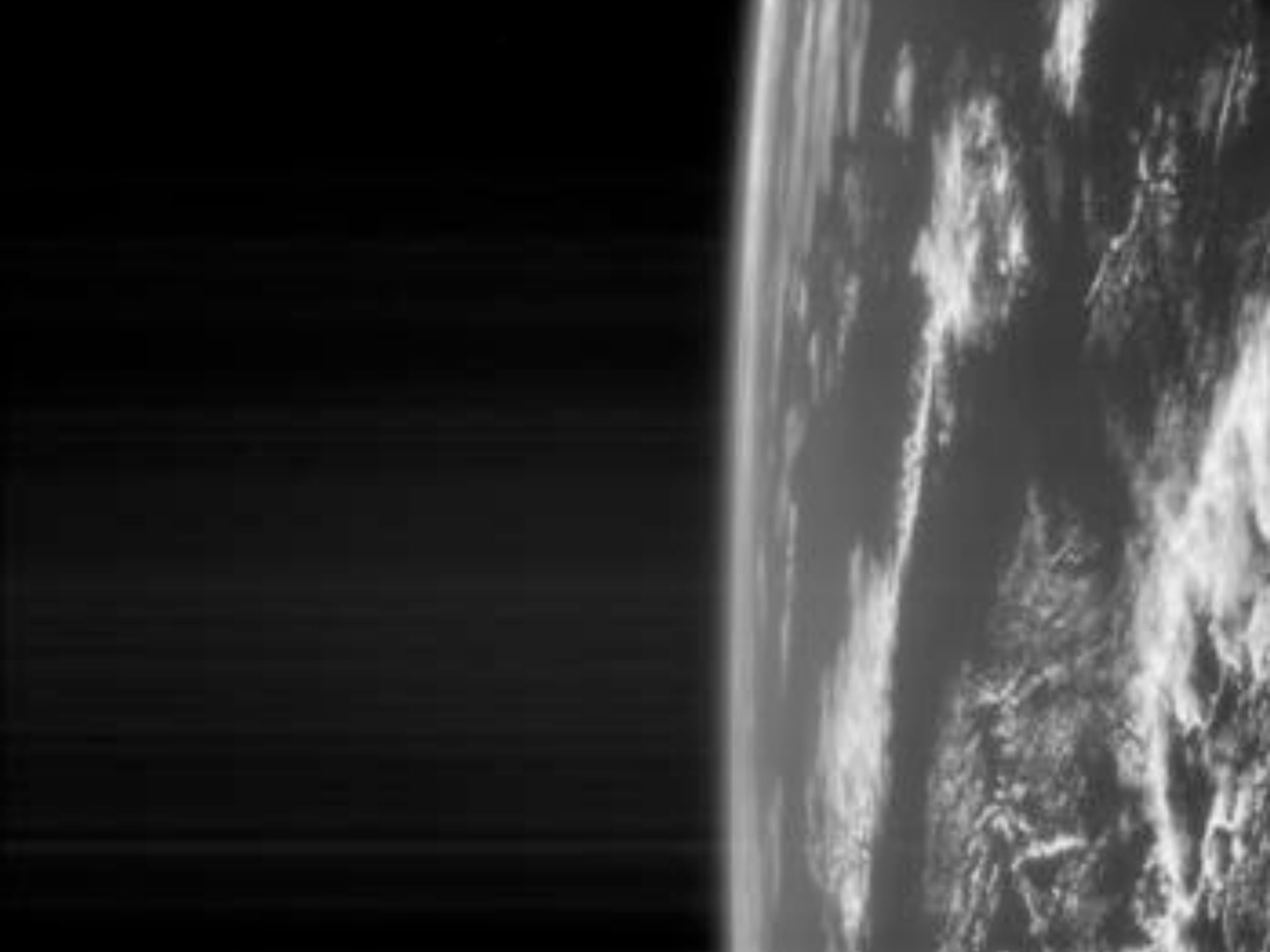
Table 1 Milestones of the ROSETTA Mission

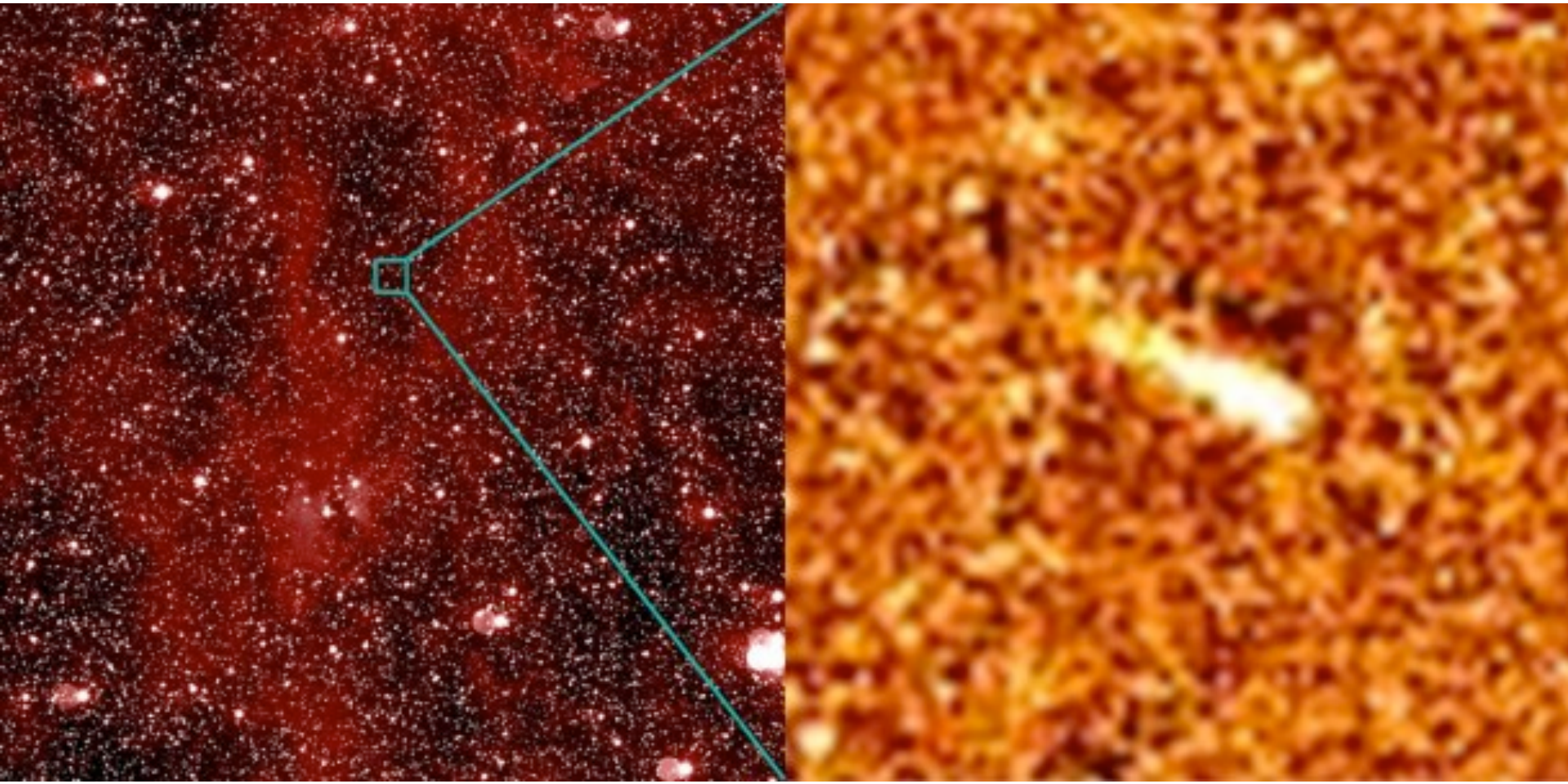
Mission Event	Nominal Date
Launch	March 2, 2004
First Earth Gravity Assist	March 4, 2005
Mars Gravity Assist	February 25, 2007
Second Earth Gravity Assist	November 13, 2007
2867 Steins Flyby	September 5, 2008
Third Earth Gravity Assist	November 13, 2009
21 Lutetia Flyby	July 10, 2010
Rendevous Manoeuvre 1 and Start of Hibernation	January 23, 2011
Exit Hibernation	January, 2014
Comet Rendezvous Maneuver Between 4.5 and 4.0 AU	Spring, 2014
Start of Near-Nucleus Operations at 3.25 AU	August 22, 2014
PHILAE Deployment	November, 2015
Perihelion Passage	August, 2015
End of Nominal Mission	December 31, 2015




M42 Orion Nebula - Osiris NAC Color Composite
Rosetta
©2004 MPS for OSIRIS Team
MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA


9P/Tempel 1
Deep Impact
−10 min
60,000 km
+21 h
60,000 km
+ 47 h
60,000 km





Outlook and milestones towards comet 67P/Churyumov-Gerasimenko

Table 1 Milestones of the ROSETTA Mission

Mission Event	Nominal Date
Launch	March 2, 2004
First Earth Gravity Assist	March 4, 2005
Mars Gravity Assist	February 25, 2007
Second Earth Gravity Assist	November 13, 2007
2867 Steins Flyby	September 5, 2008
Third Earth Gravity Assist	November 13, 2009
21 Lutetia Flyby	July 10, 2010
Rendevous Manoeuvre 1 and Start of Hibernation	January 23, 2011
Exit Hibernation	January, 2014
Comet Rendezvous Maneuver Between 4.5 and 4.0 AU	Spring, 2014
Start of Near-Nucleus Operations at 3.25 AU	August 22, 2014
PHILAE Deployment	November, 2015
Perihelion Passage	August, 2015
End of Nominal Mission	December 31, 2015