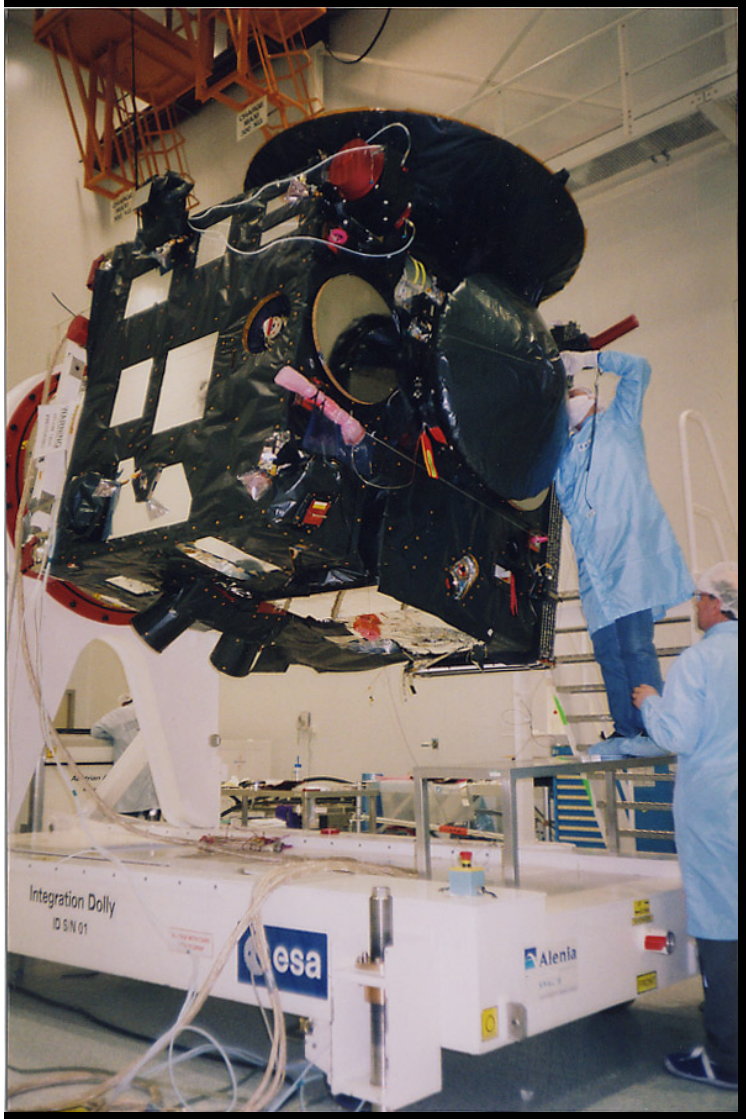
ESA's Mars Program
European plans for Mars Exploration

François Forget
LMD-CNRS, Paris, France

Interdisciplinary Scientist on ESA Mars Express
Member of the ESA Solar System Working Group

History : Mars Exploration in Europe

- 1970-1996 : Mission of opportunity on Russian (and US) missions :
  - Phobos 1 & 2 (1988-1989) : several european instruments on Orbiters and Landers
  - Mars 1996 : Major instruments on the orbiter, landers, penetrators
- Dramatic loss of Mars 96 : reflight of main european instruments on **ESA Mars Express**

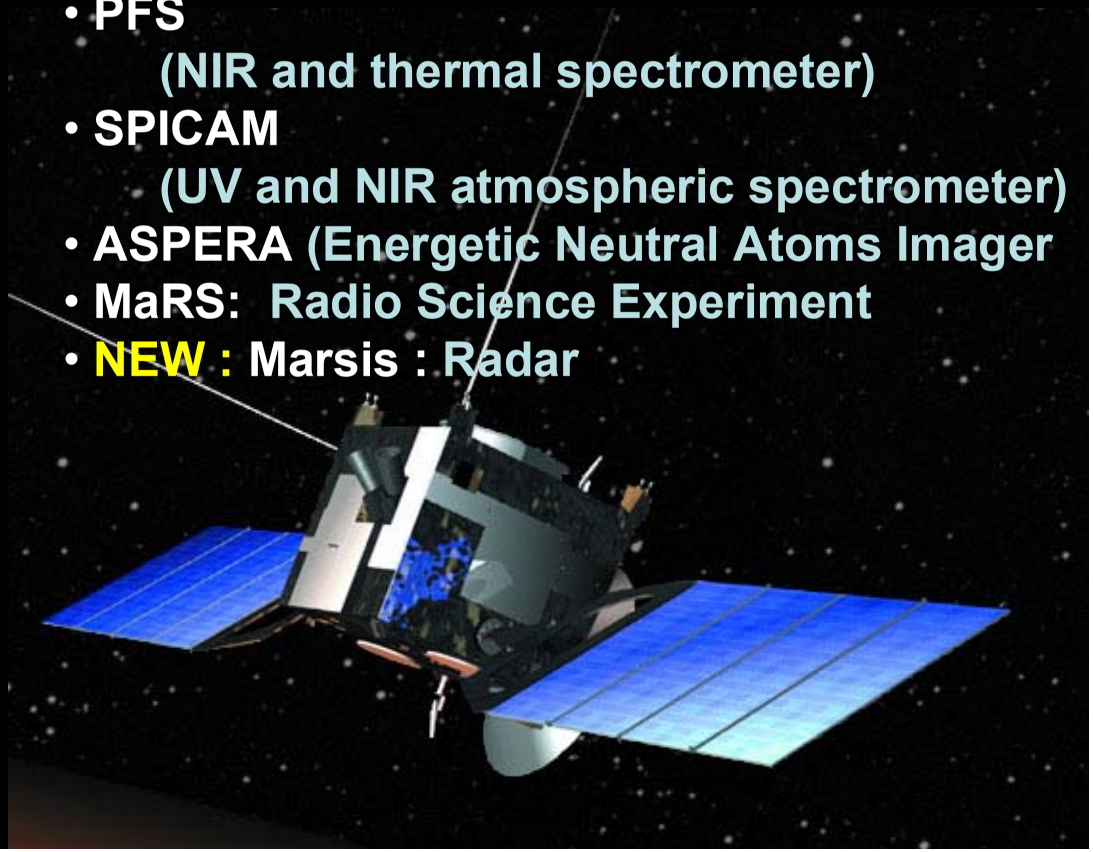


Mars Express :
In orbit since december 25, 2003

- 3-axis stabilized orbiter
- 7 main Instruments

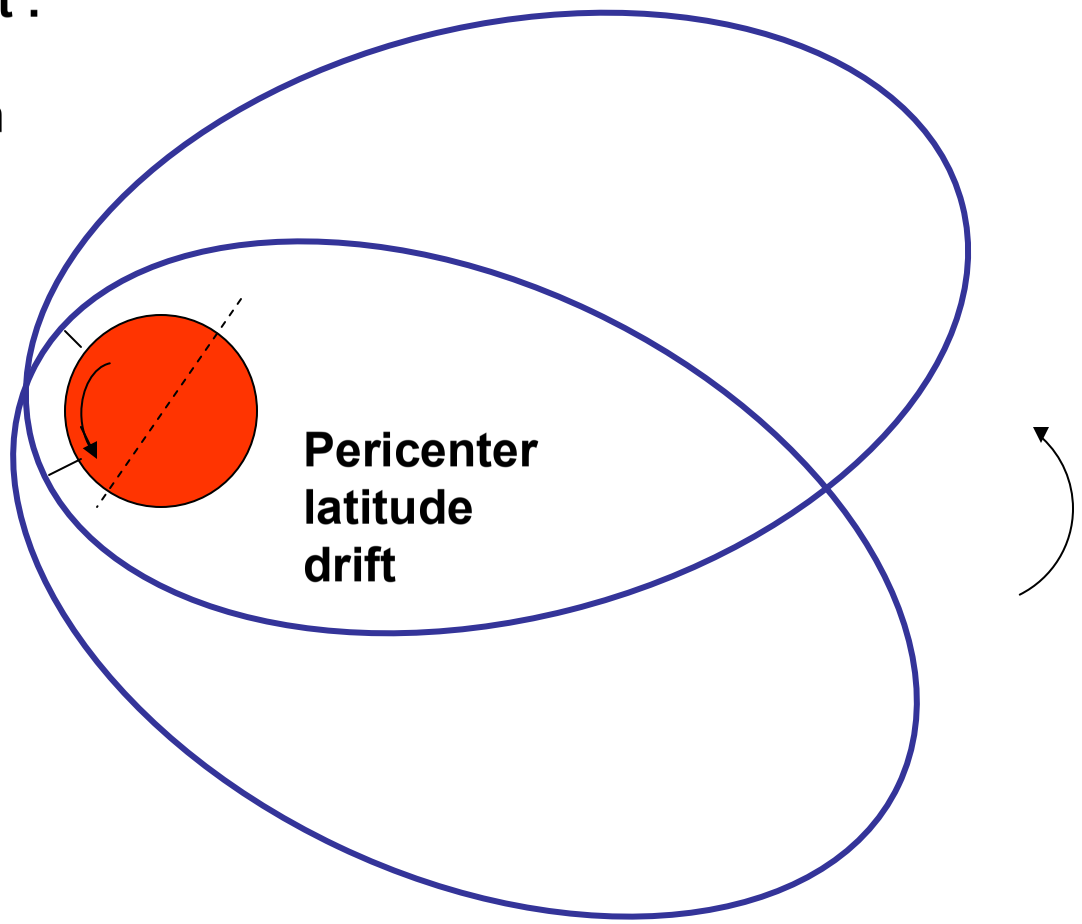
(most reflight from Mars 96):

- HRSC (camera)
- OMEGA
  (imaging Vis and NIR spectrometer)
- PFS
  (NIR and thermal spectrometer)
- SPICAM
  (UV and NIR atmospheric spectrometer)
- ASPERA (Energetic Neutral Atoms Imager
- MaRS: Radio Science Experiment
- NEW : Marsis : Radar



Mars Express Orbit

Mars Express Orbit :
Excentric :
260 km – 10100 km

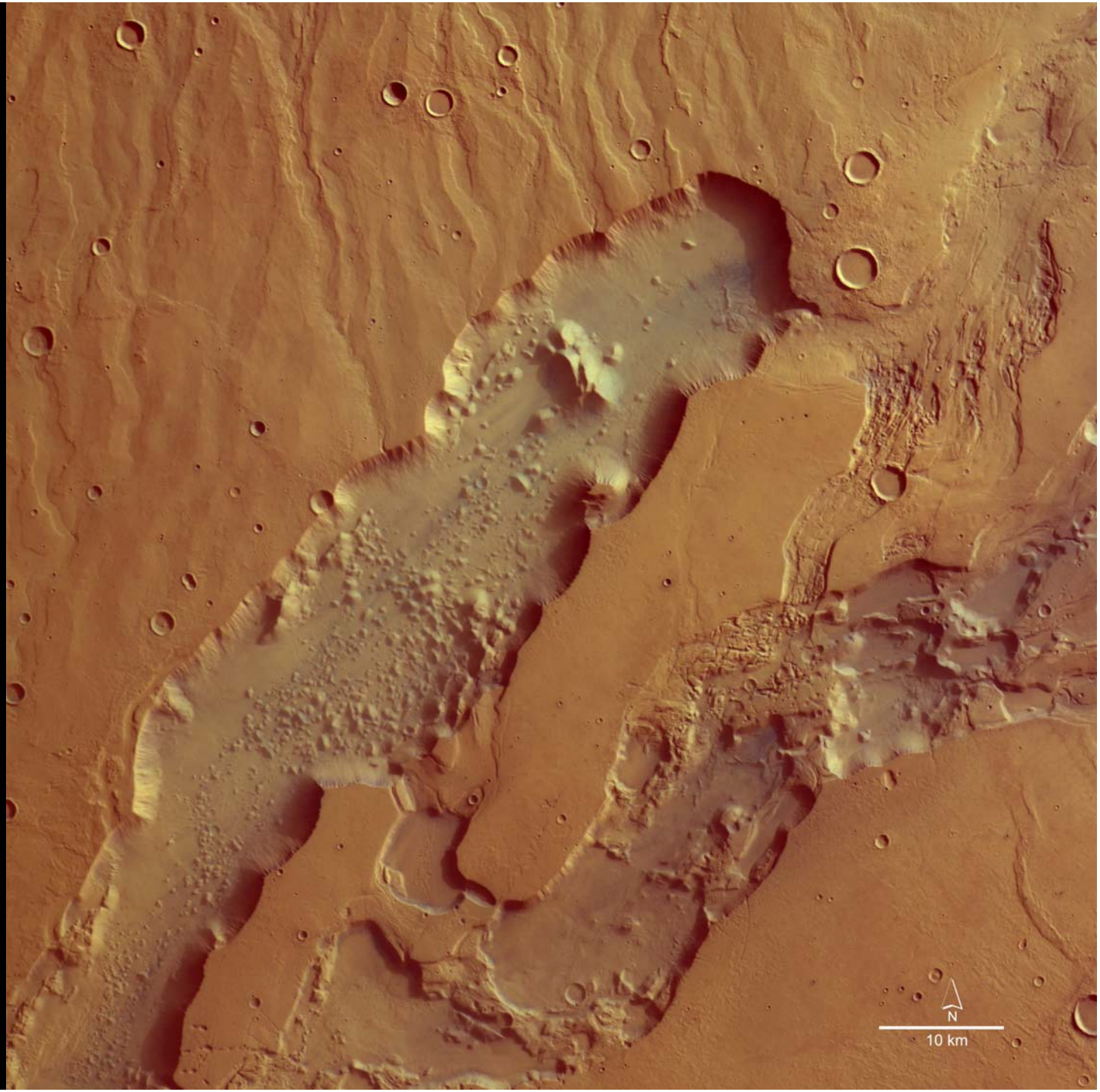


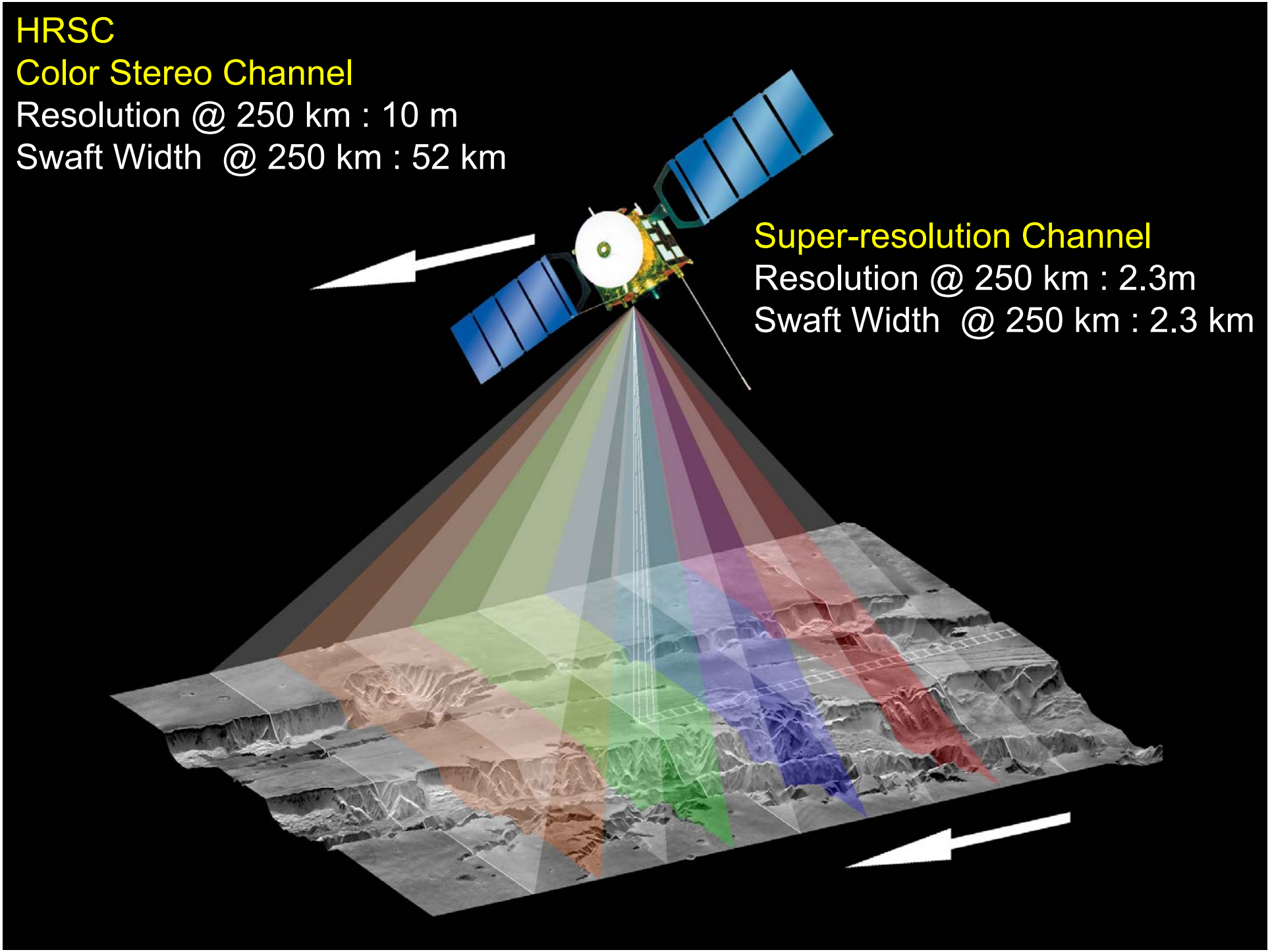
A few preliminary results from Mars Express

Pictures from Camera HRSC

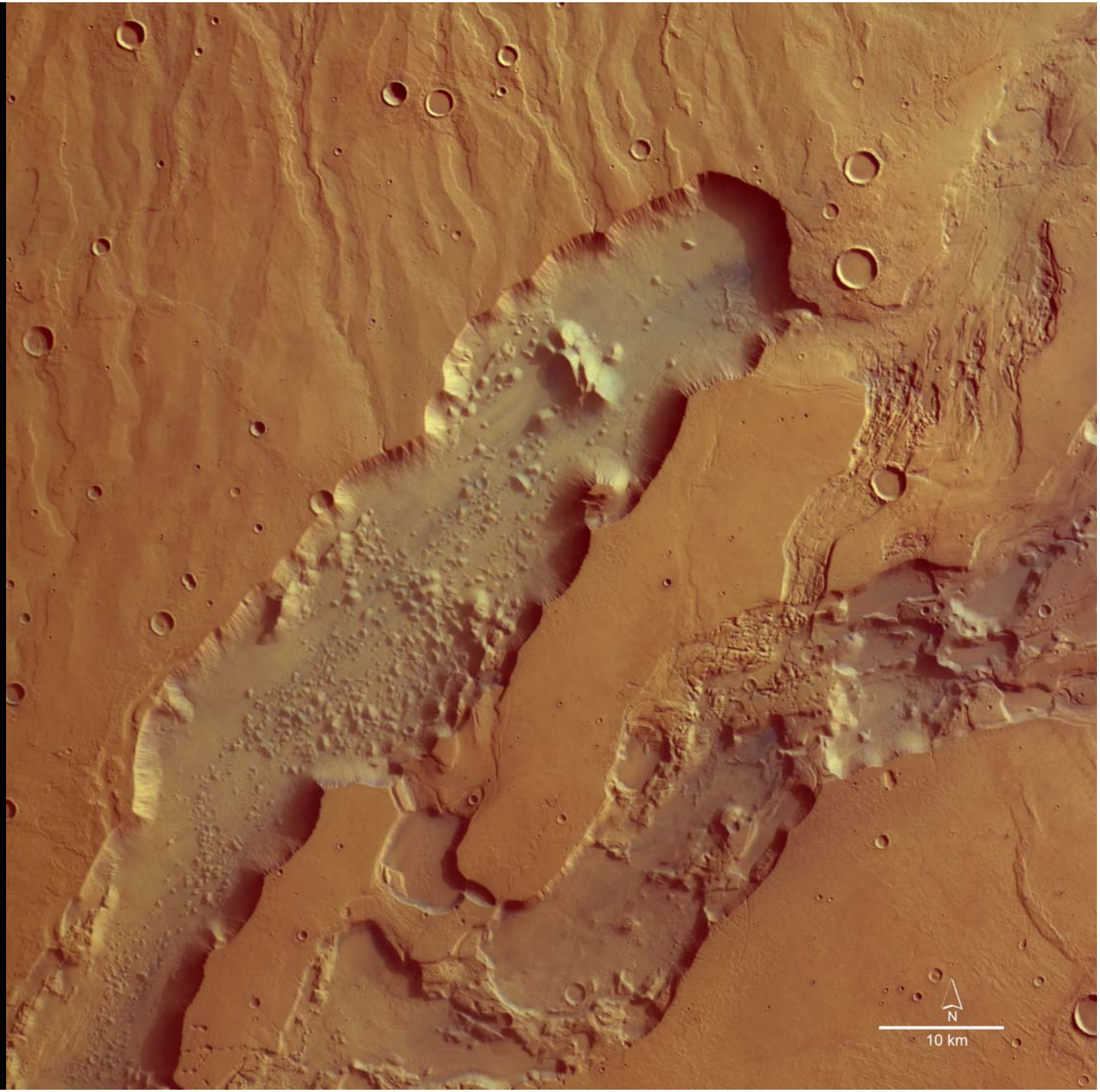
PI: G. Neukum, Germany

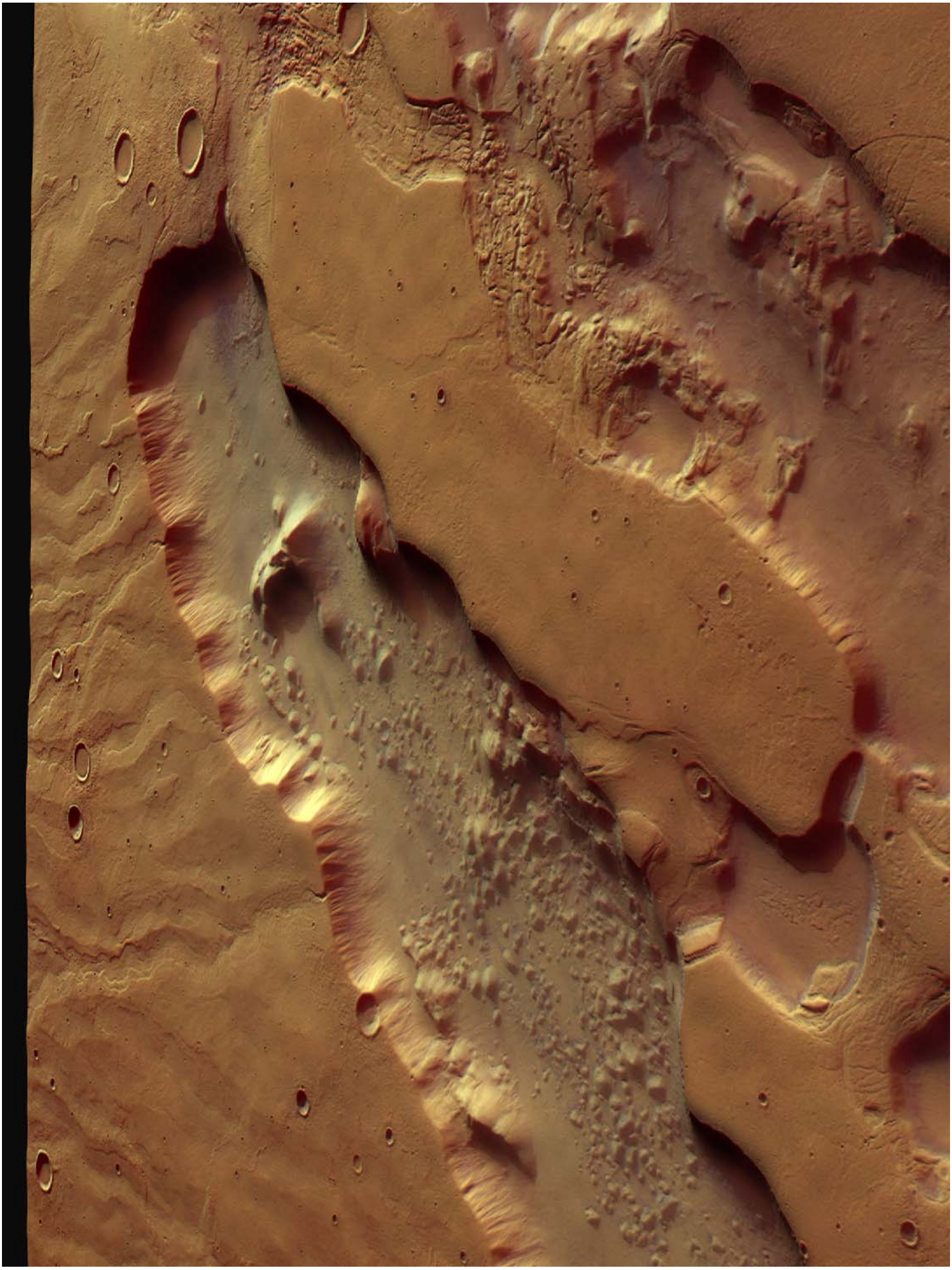
Niger vallis

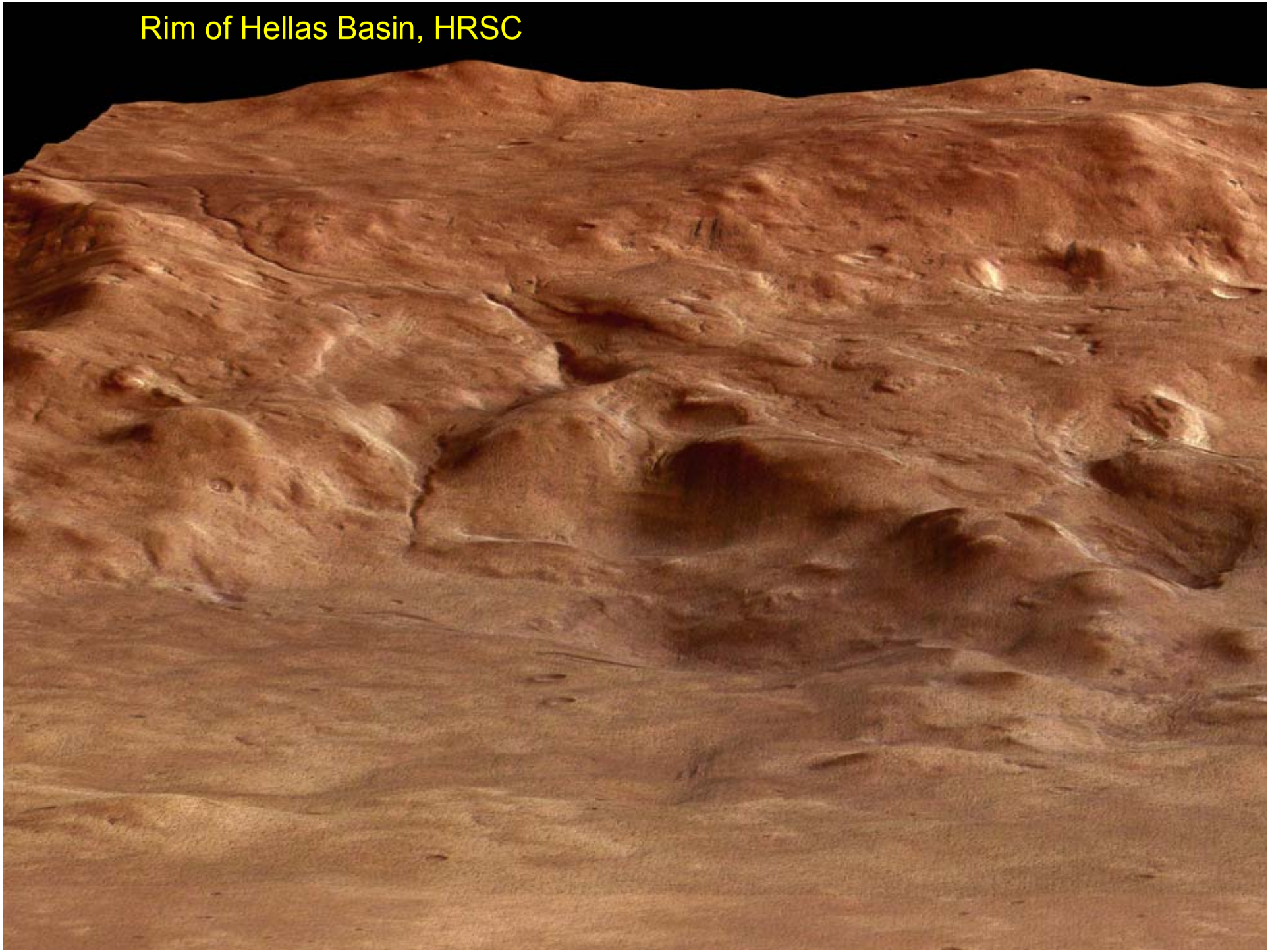


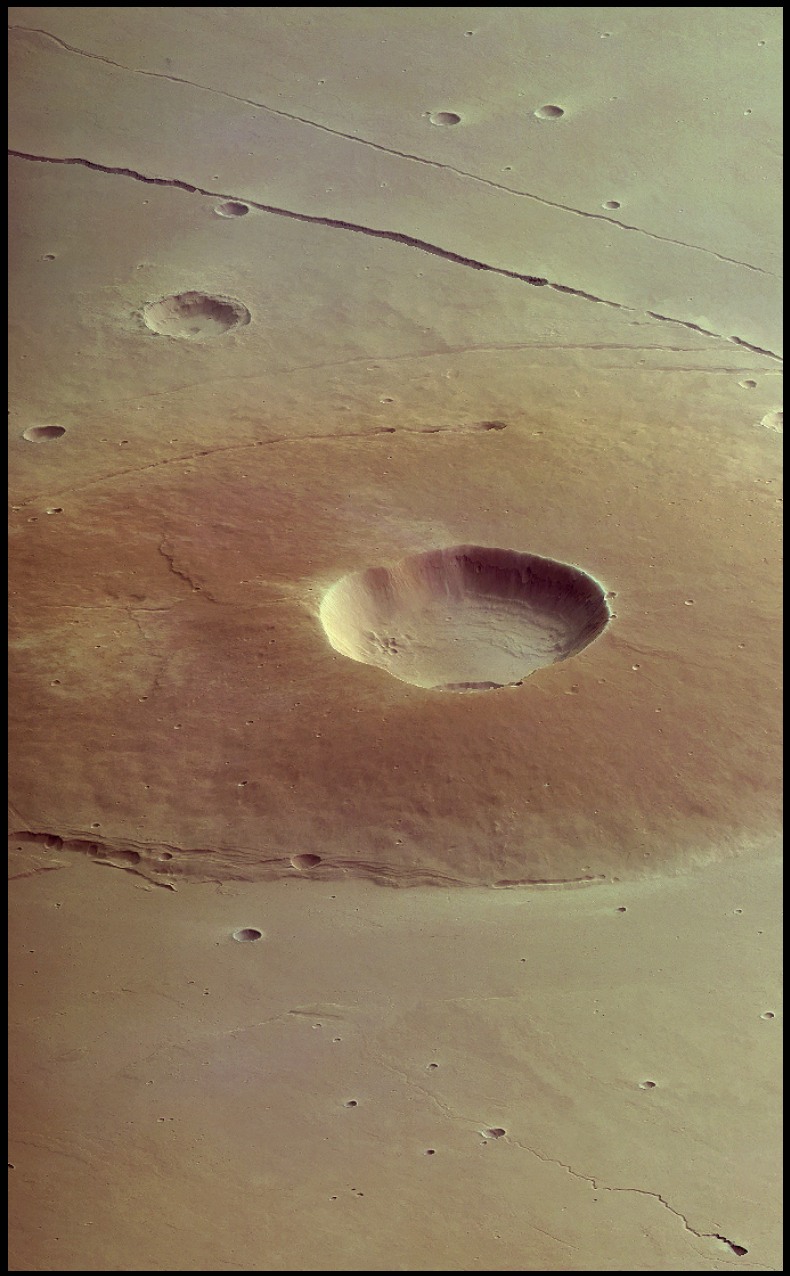

HRSC
Color Stereo Channel
Resolution @ 250 km : 10 m
Swaft Width @ 250 km : 52 km
Super-resolution Channel
Resolution @ 250 km : 2.3m
Swaft Width @ 250 km : 2.3 km

Niger vallis
Mars Express
HRSC





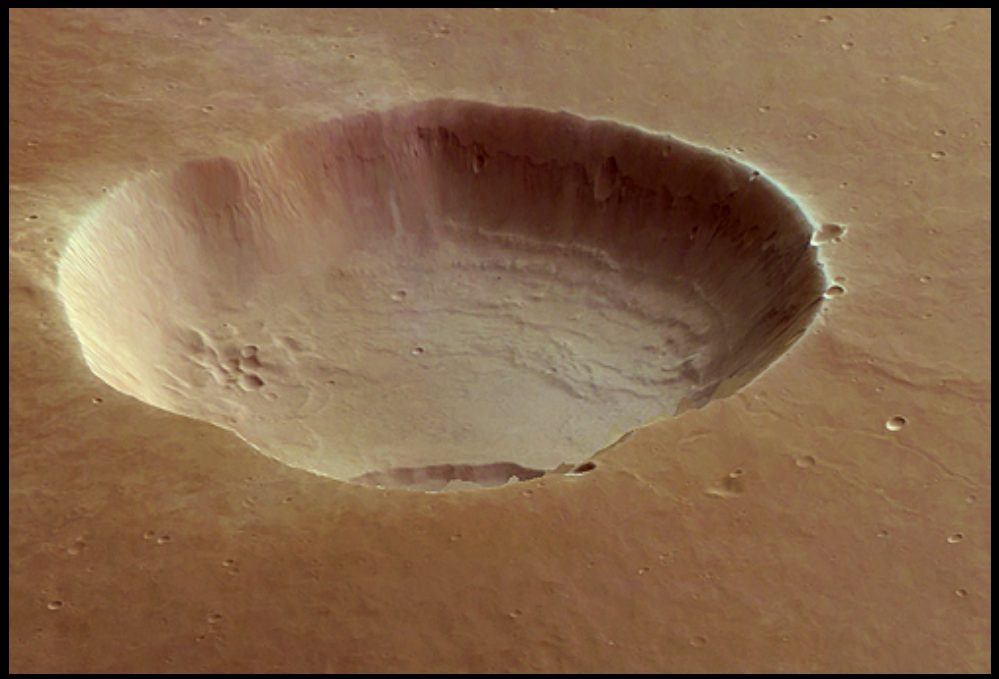

Rim of Hellas Basin, HRSC



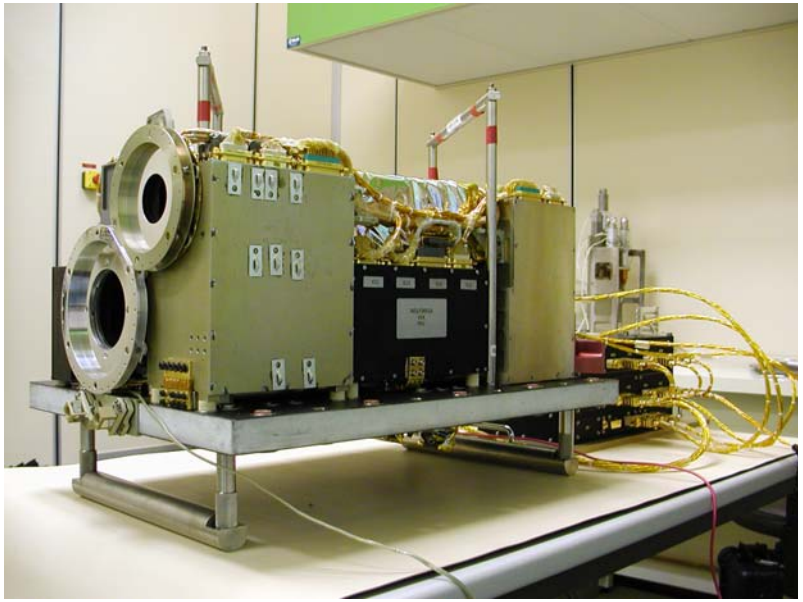
Albor Tholus

Orbit 0032

(HRSC team)



OMEGA : NIR spectral imager



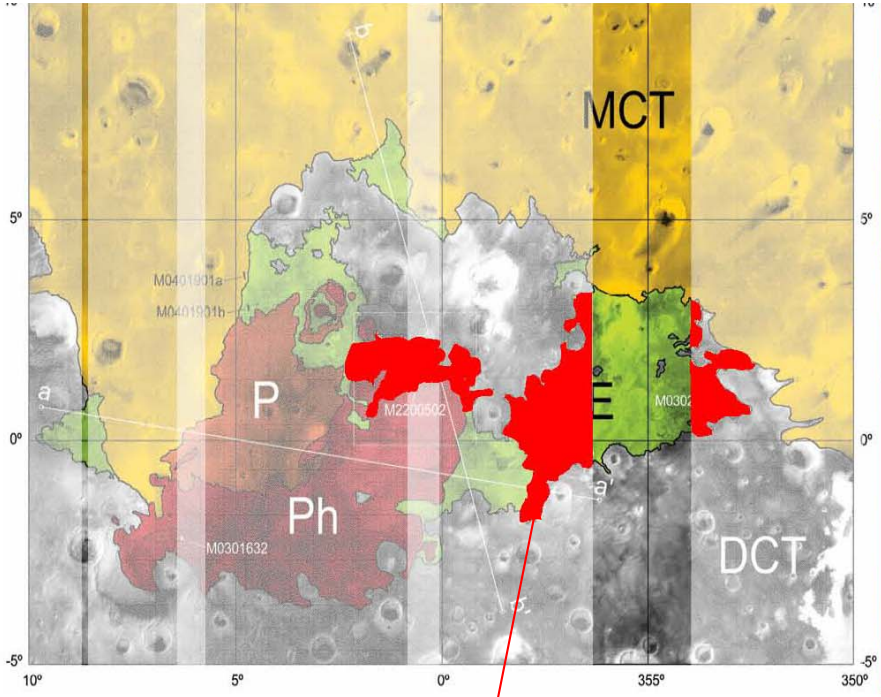
- PI : Jean-Pierre Bibring (IAS, France)
- OMEGA IS A VIS-NIR SPECTRAL IMAGER : For each resolved pixel (300 m to 4 km depending on spacecraft altitude), OMEGA acquires the spectrum in 352 (up to 400) contiguous spectral elements, from 0.35 to 5.15 µm.

Remote detection of sulfates in Terra meridiani and around Valles Marineris by Mars Express / OMEGA

(Courtesy of Aline Gendrin & OMEGA TEAM)

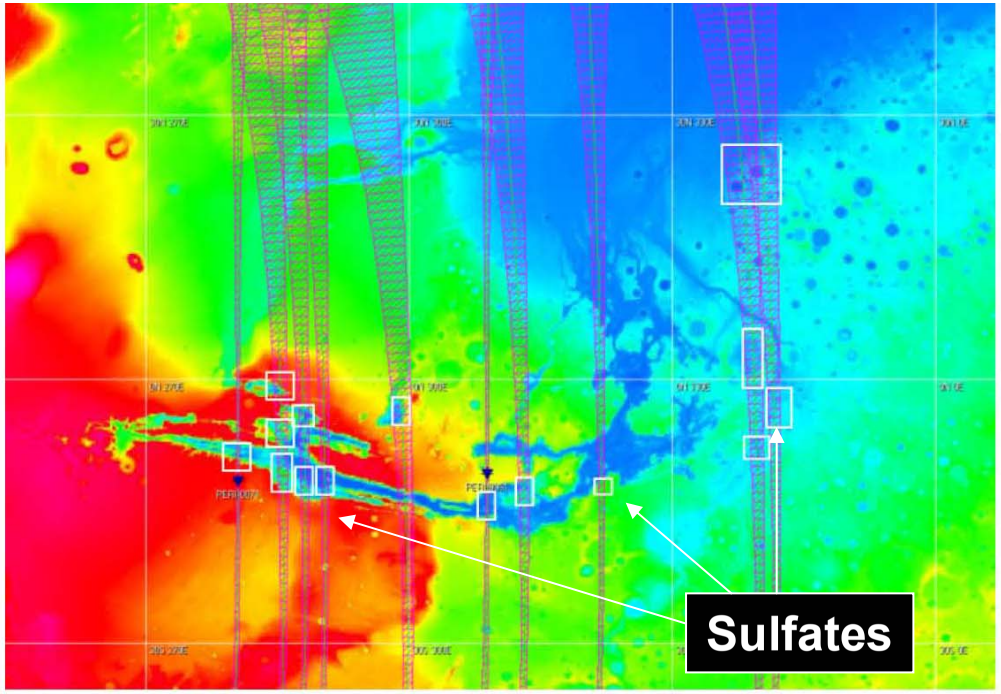
kieserite (MgSO4, H2O) , gypsum (CaSO4, 2 H2O)

Terra Meridiani



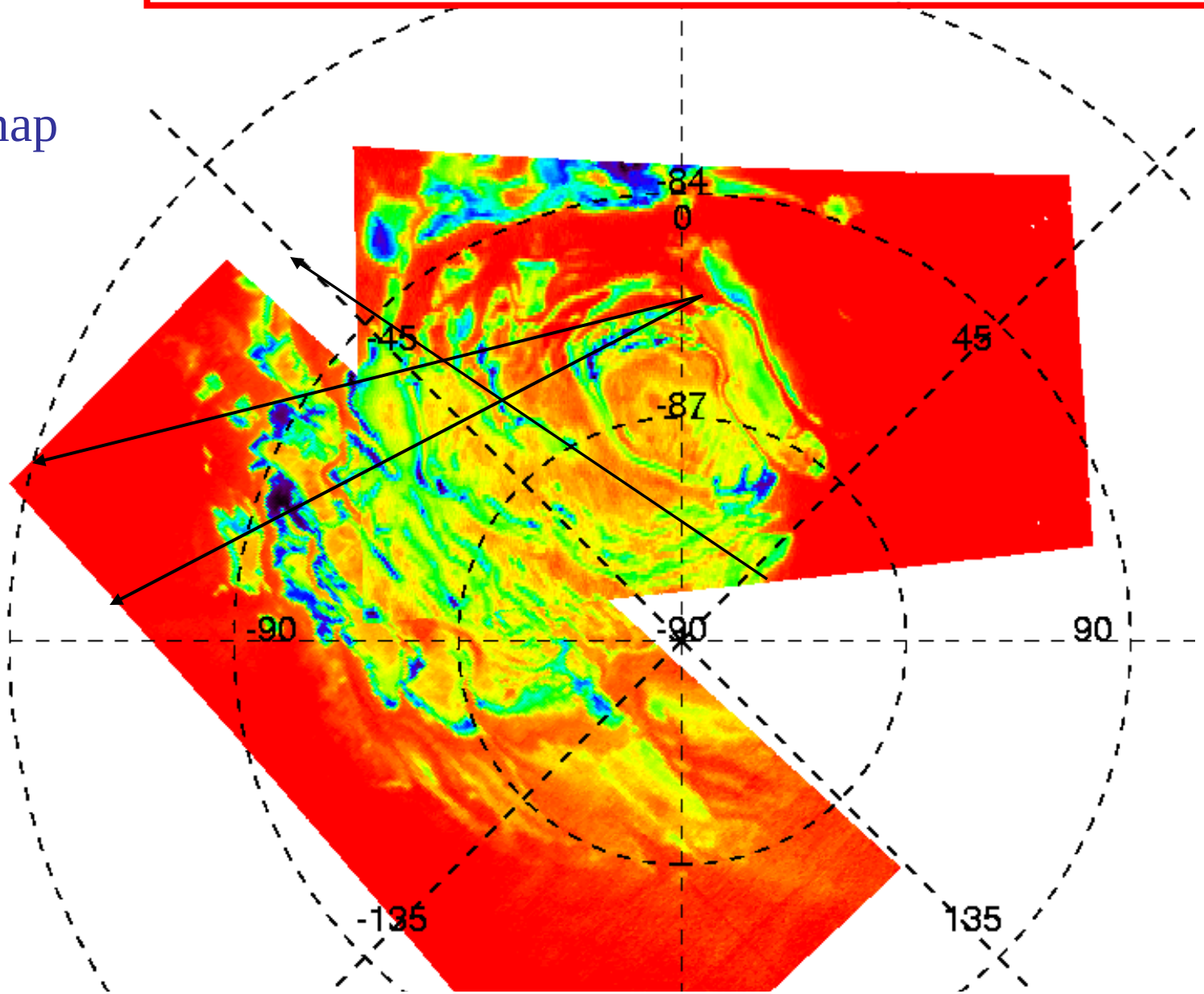
Sulfates

Around Valles Marineris

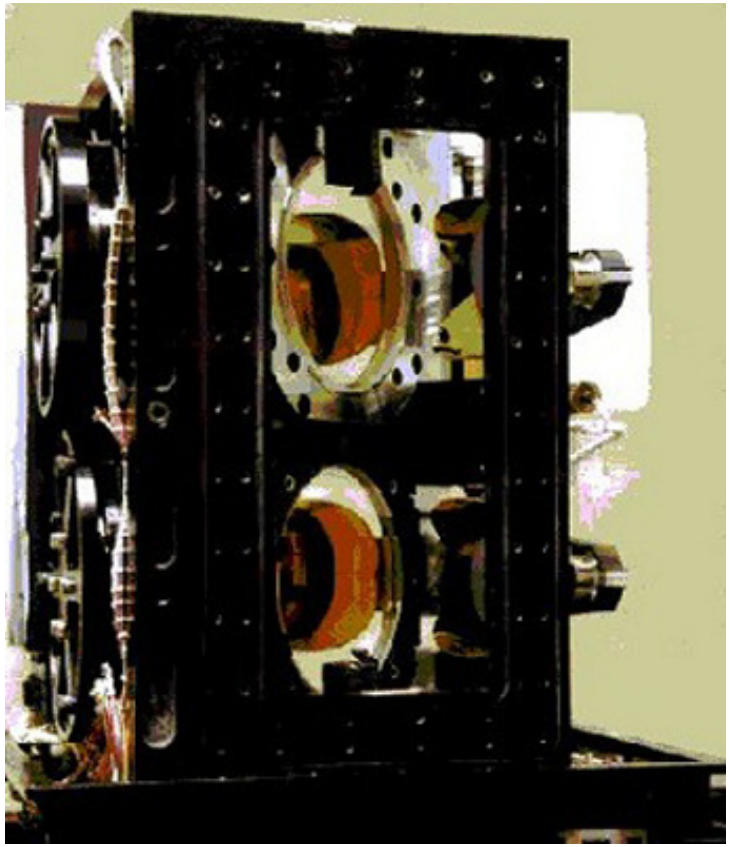


WATER ICE seen by Mars Express OMEGA on the residual CO2 ice cap

H_2O map



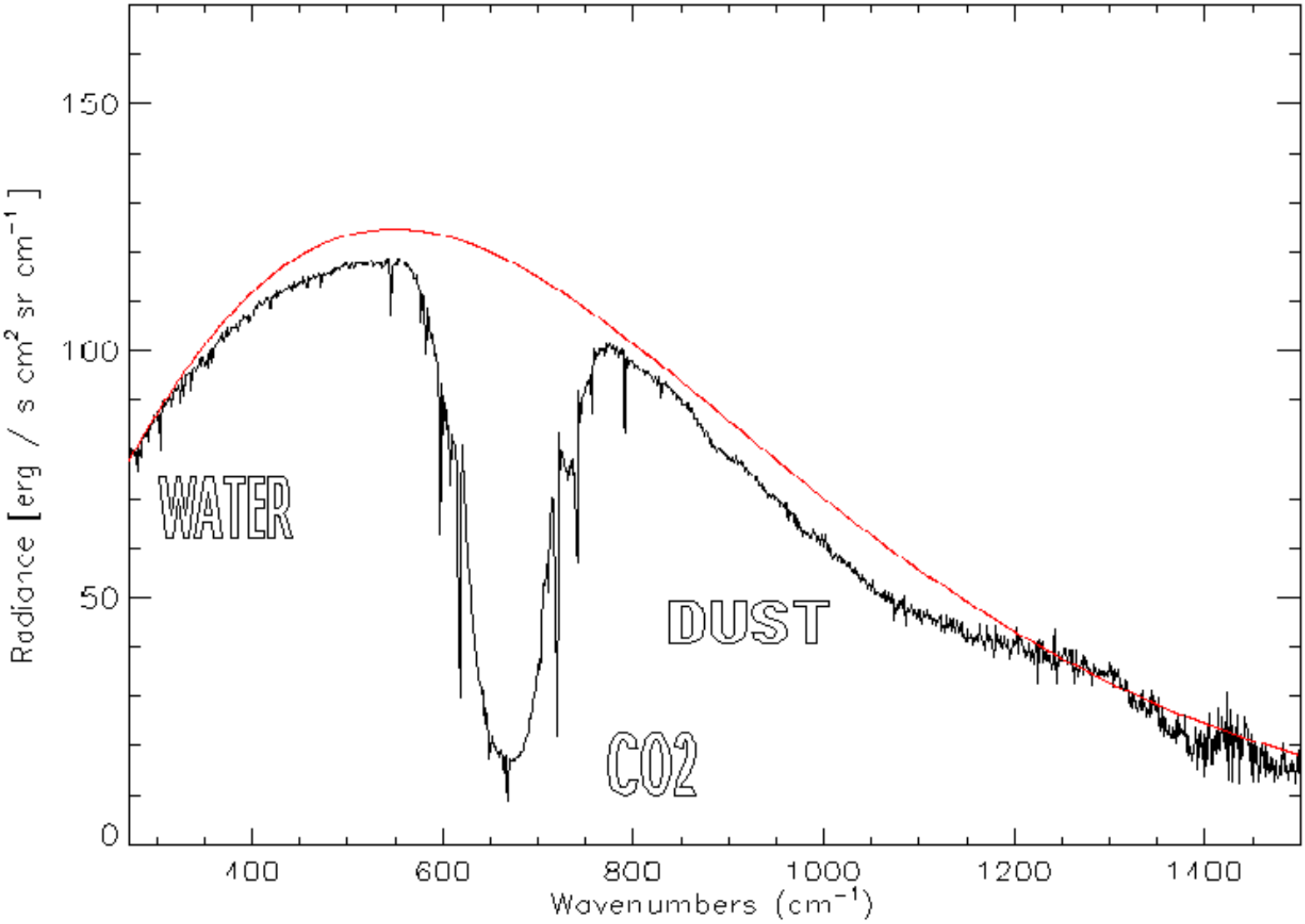
PFS : planetary fourier NIR – IR spectrometer



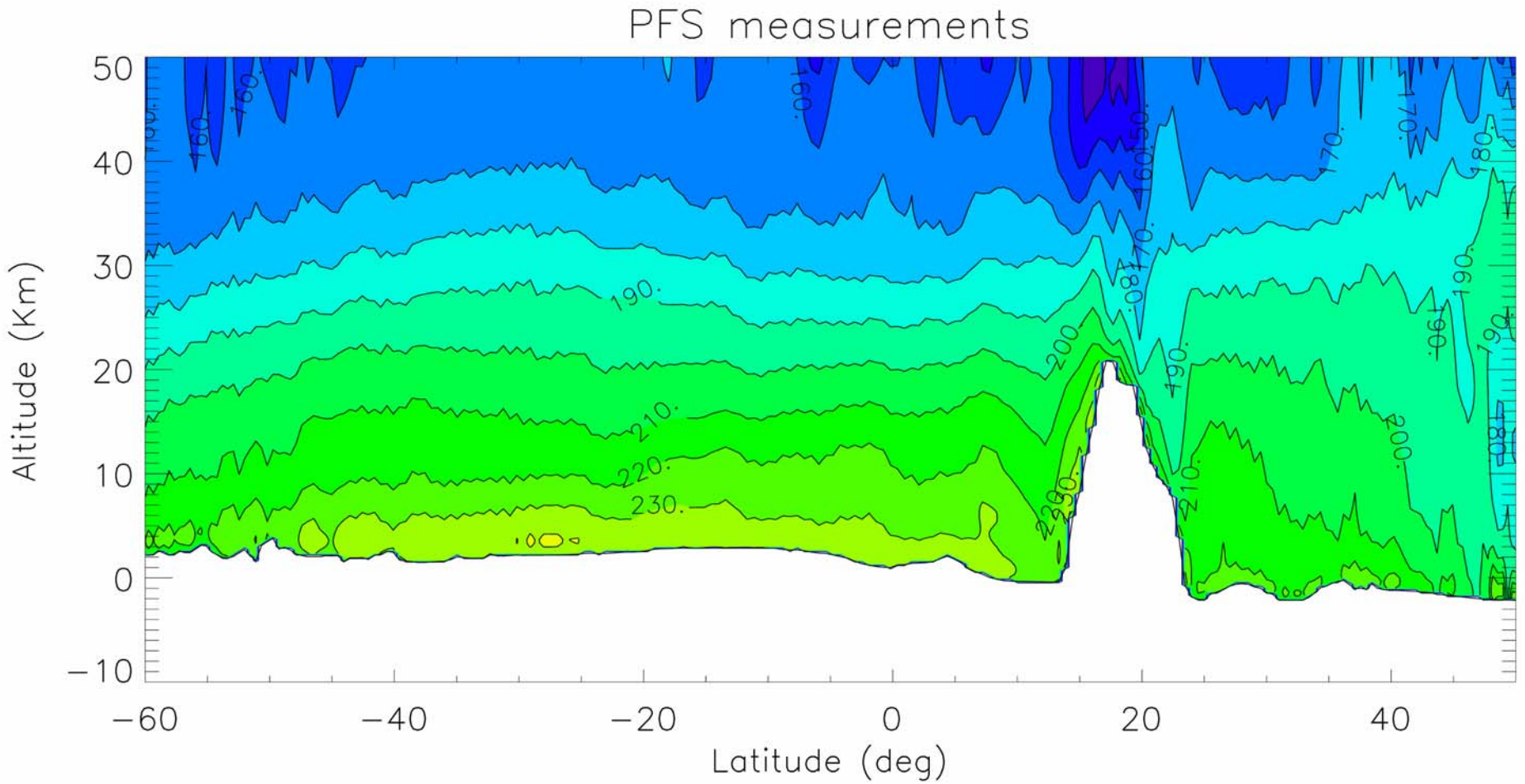
- **PI :** Victorio Formisano (IFSI, Italy)

Spectral channel	**1.2 -5 µm** 200-2000 cm-1	5-50 **µm** 2000 – 8200 cm-1
Spectral resolution	2 cm-1	2 cm-1
Effective Field of view	1.6° (10 to 50 km)	2.8 ° (20 to 100km

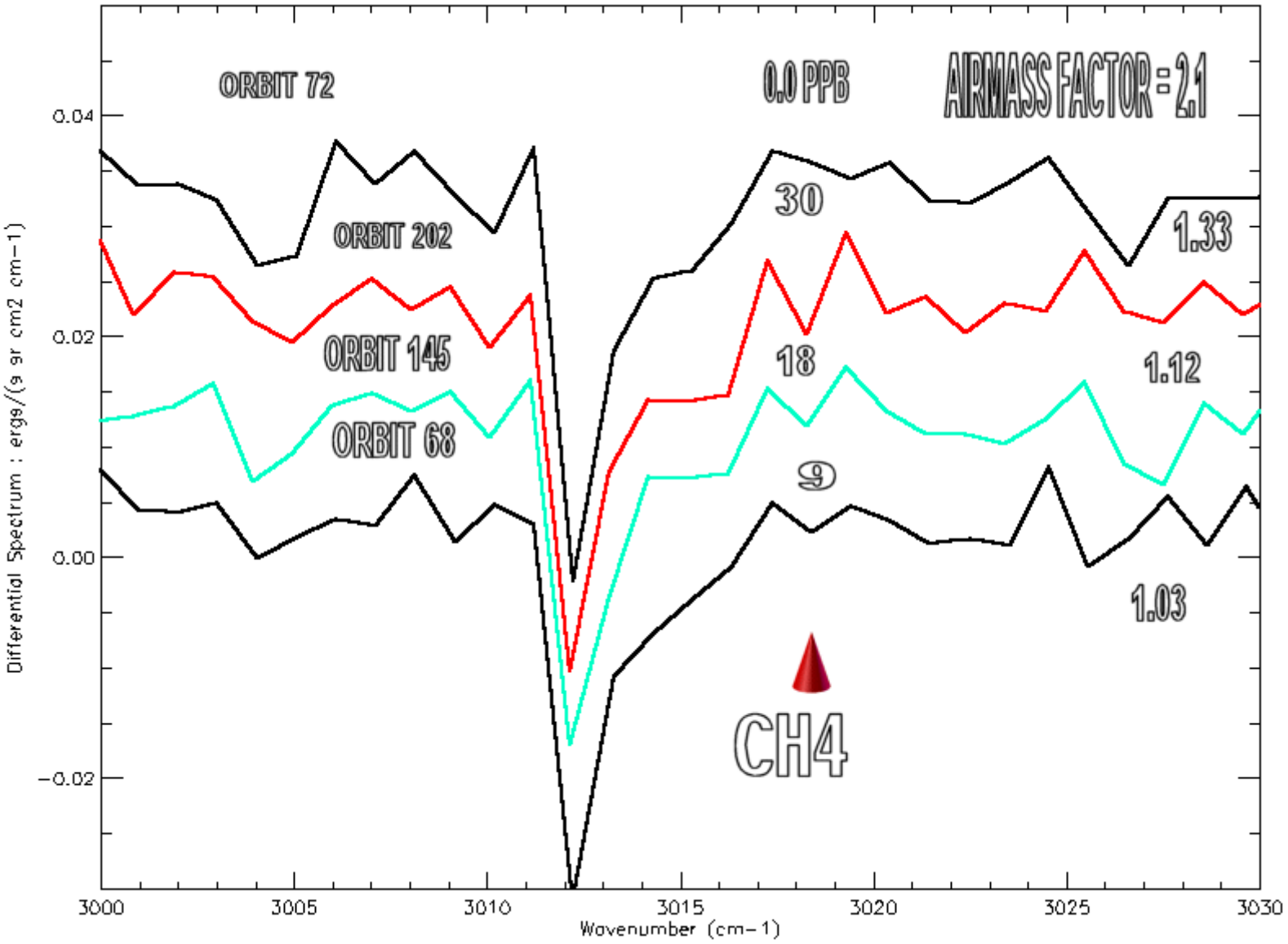
PFS Thermal infrared spectra of Mars atmosphere
(Courtesy of V. Formisano / PFS team)



PFS Atmospheric temperature of Mars atmosphere
Ex : around Olympus Mons
(Courtesy of D. Grassi / PFS team)

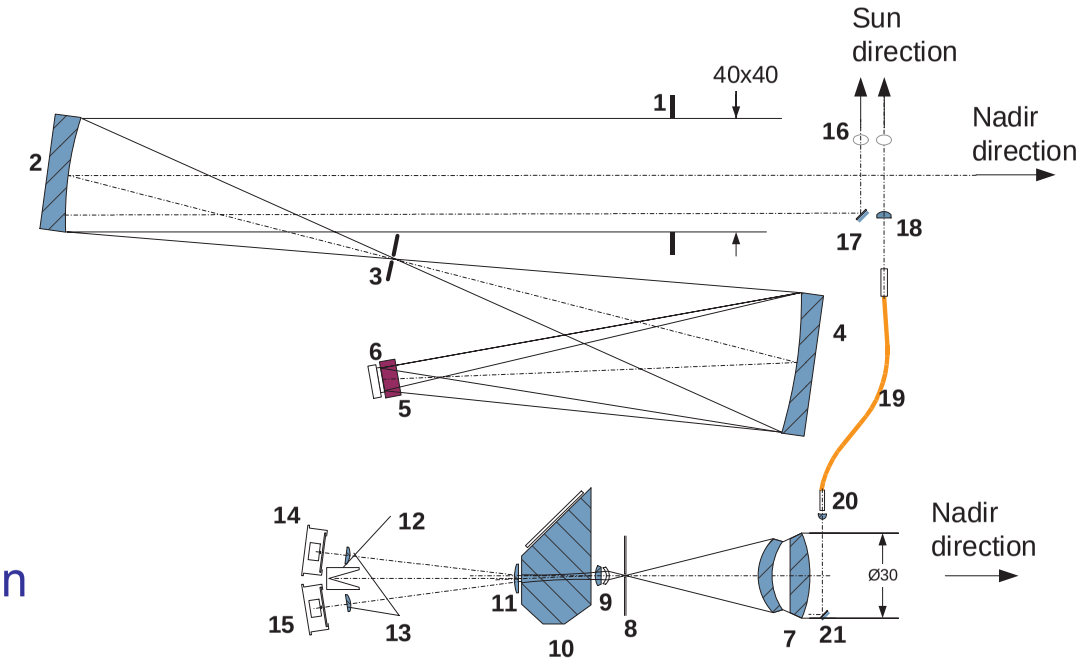


PFS Solar Channel : detection of Methane on Mars (?)



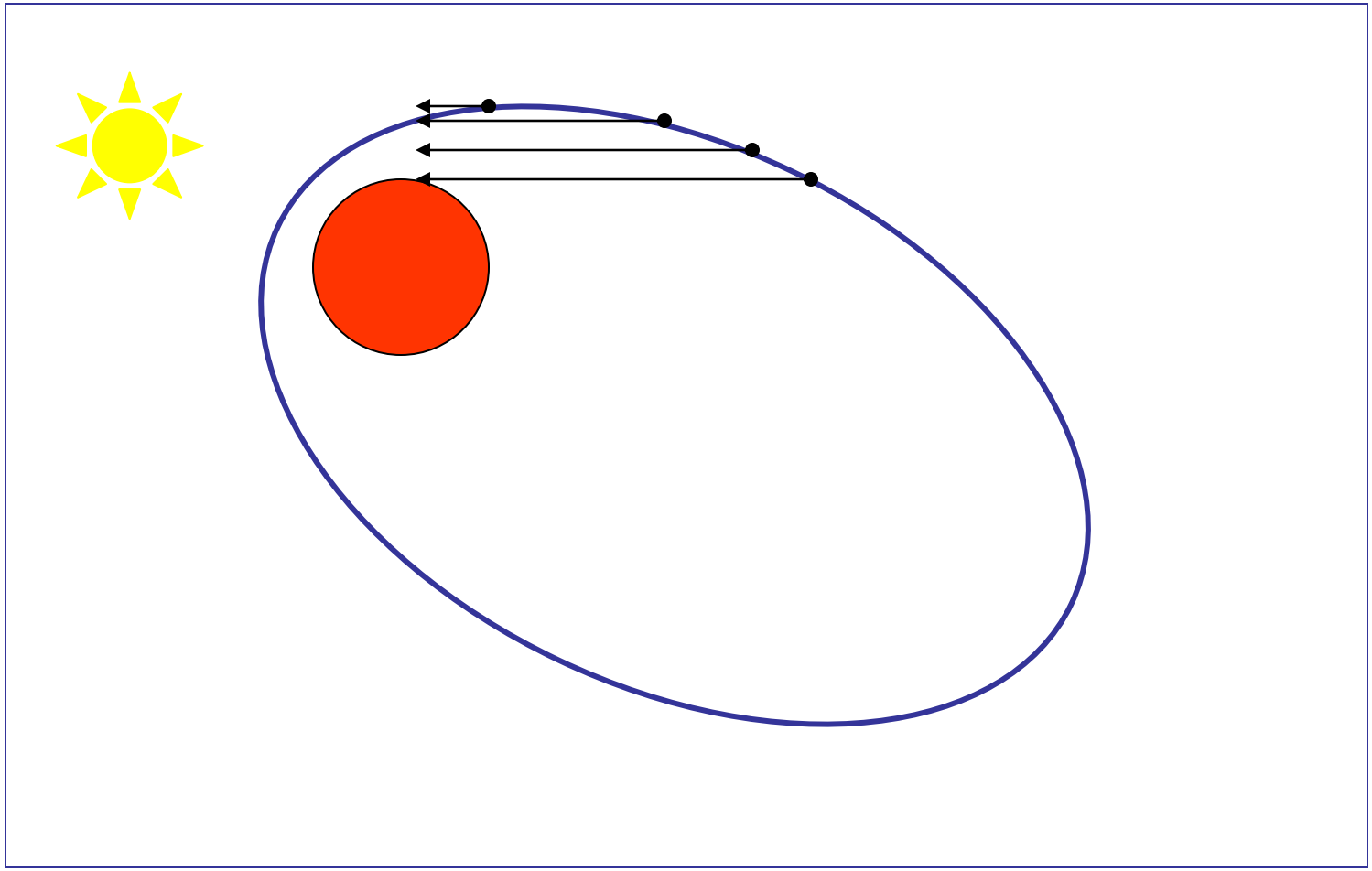
SPICAM: UV and IR Atmospheric Spectrometer

- PI: Jean-Loup Bertaux (France)
- Lighweight spectrometer (4.7 kg)
- Two sensors,
  - UV (118-320 nm, resolution 0.8 nm)
  - NIR (1-1.7 micron, resolution 0.5-1.2 nm)
- 3 modes :
  - Stellar or solar occultation (only UV)
  - Limb sounding (only UV)
  - Nadir pointing (NIR + UV)



Observation : Ozone Mapping and profiles , Water vapor mapping
Temperature profile up to 130 km, Aerosol and clouds. Airglow measurements

SPICAM: Solar / Stellar occultation : A unique instrument to observe the Martian atmosphere up to 130 km !



A new instrument : Radar MARSIS

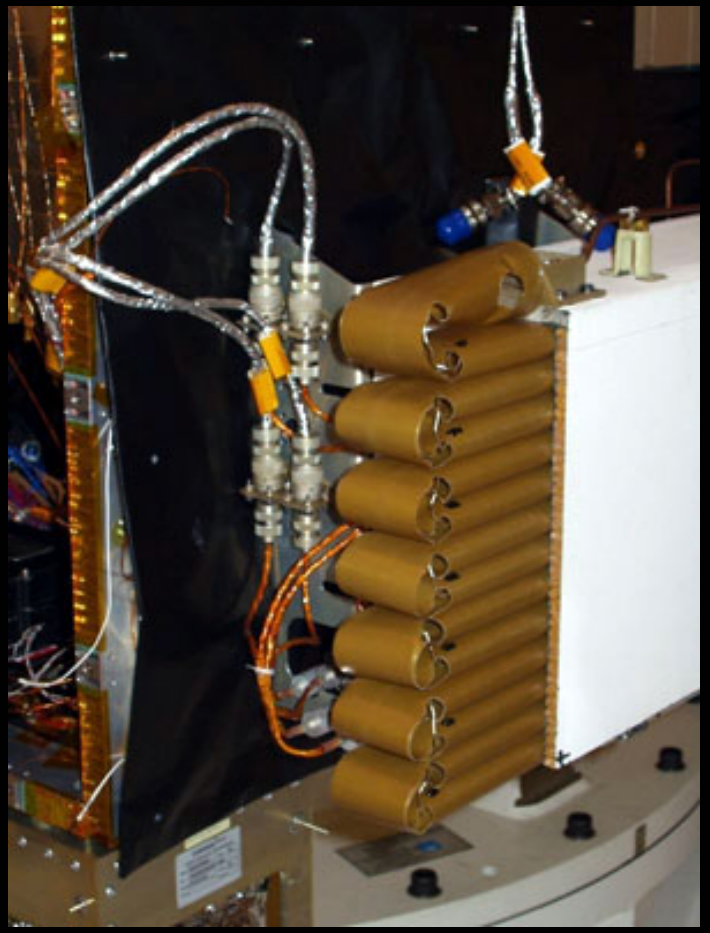
- PI : G. Picardi (University of Rome)
- Subsurface radar sounding : 1.8, 3,4,5 MHz

MARSIS radar booms deployment postponed

- Initially planned in April 2004

- Concerns that the boom might swing back Problem under review

- Current « Radar » season is lost



Folded Boom (ESA)

Beagle 2 lander

“Principal Principal investigator” : Colin Pillinger

Landing site : Isidis Planitia : 11.6°N, 90.75°E

Beagle 2 probe

Diameter : 92.4 cm
Total mass : 69 kg

Lander mass : 33.2 kg

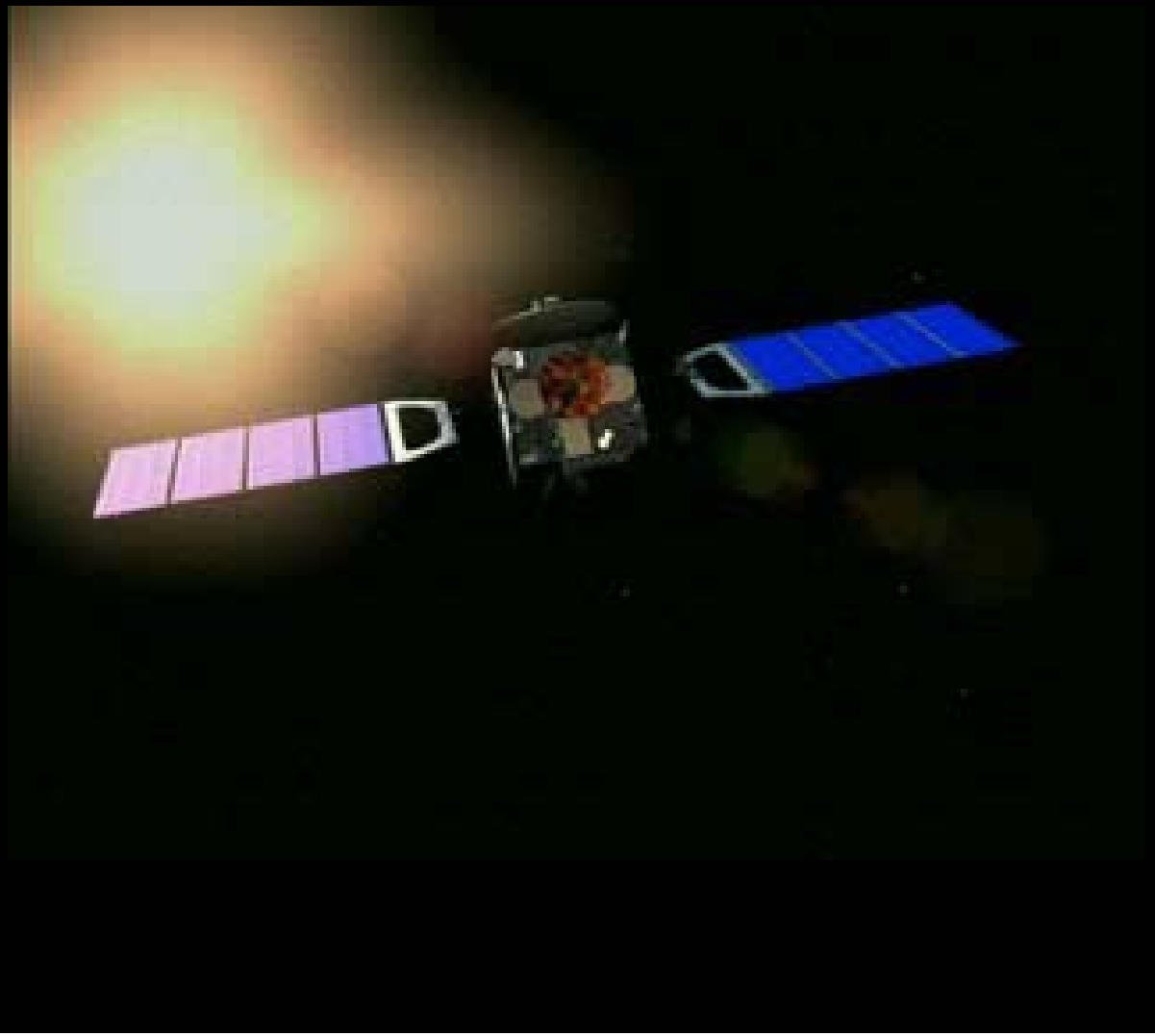
Beagle 2 entry,descent, landing

Entry : 5.4 km/s

• Accelerometer
→ pilot parachute
→ extract main parachute (10 m)
→ release of back cover and schield

• Radar altimeter
- deployment of 3 airbags around z=200 m

- No retro rocket

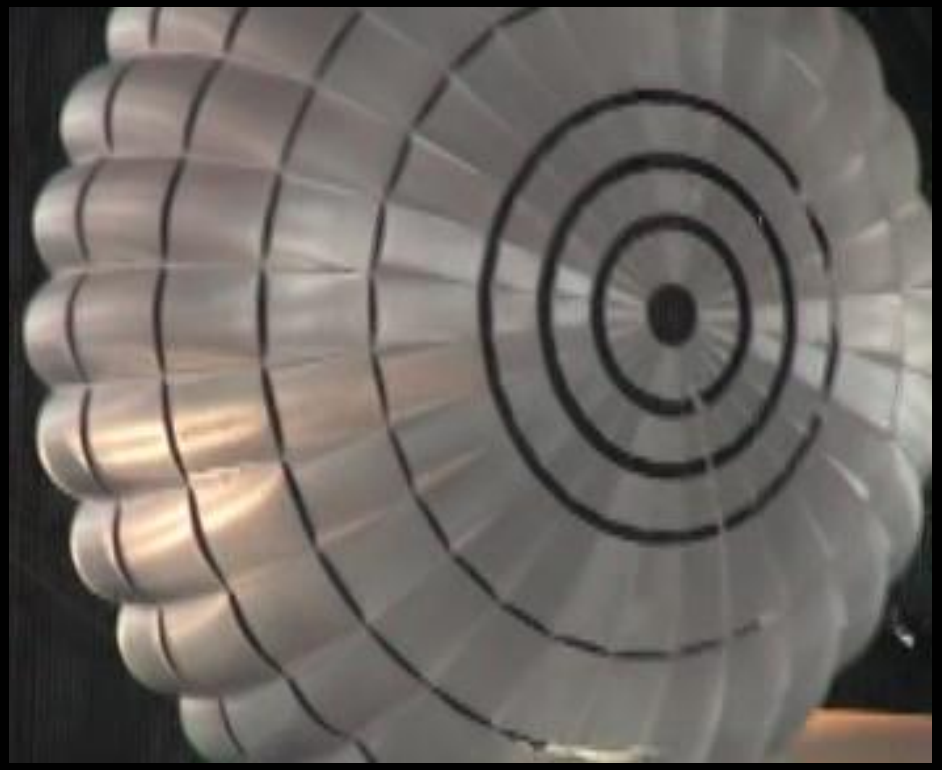


Beagle 2 entry,descent, landing

10 m main parachute
Ringsail design

Redesigned, develop and deliver in a few weeks !

(Astrium, Analyticom)

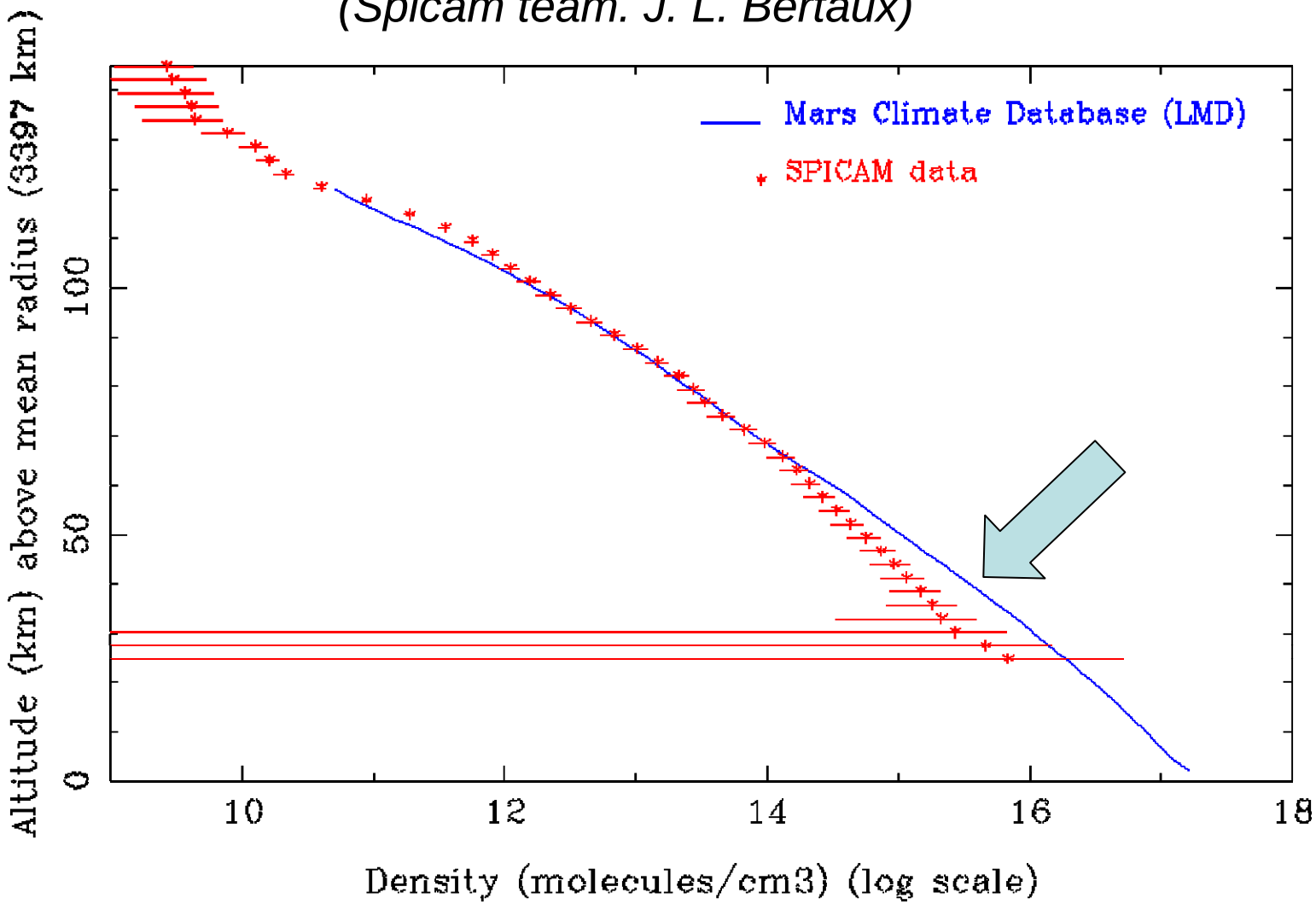


What happened to Beagle 2 ?

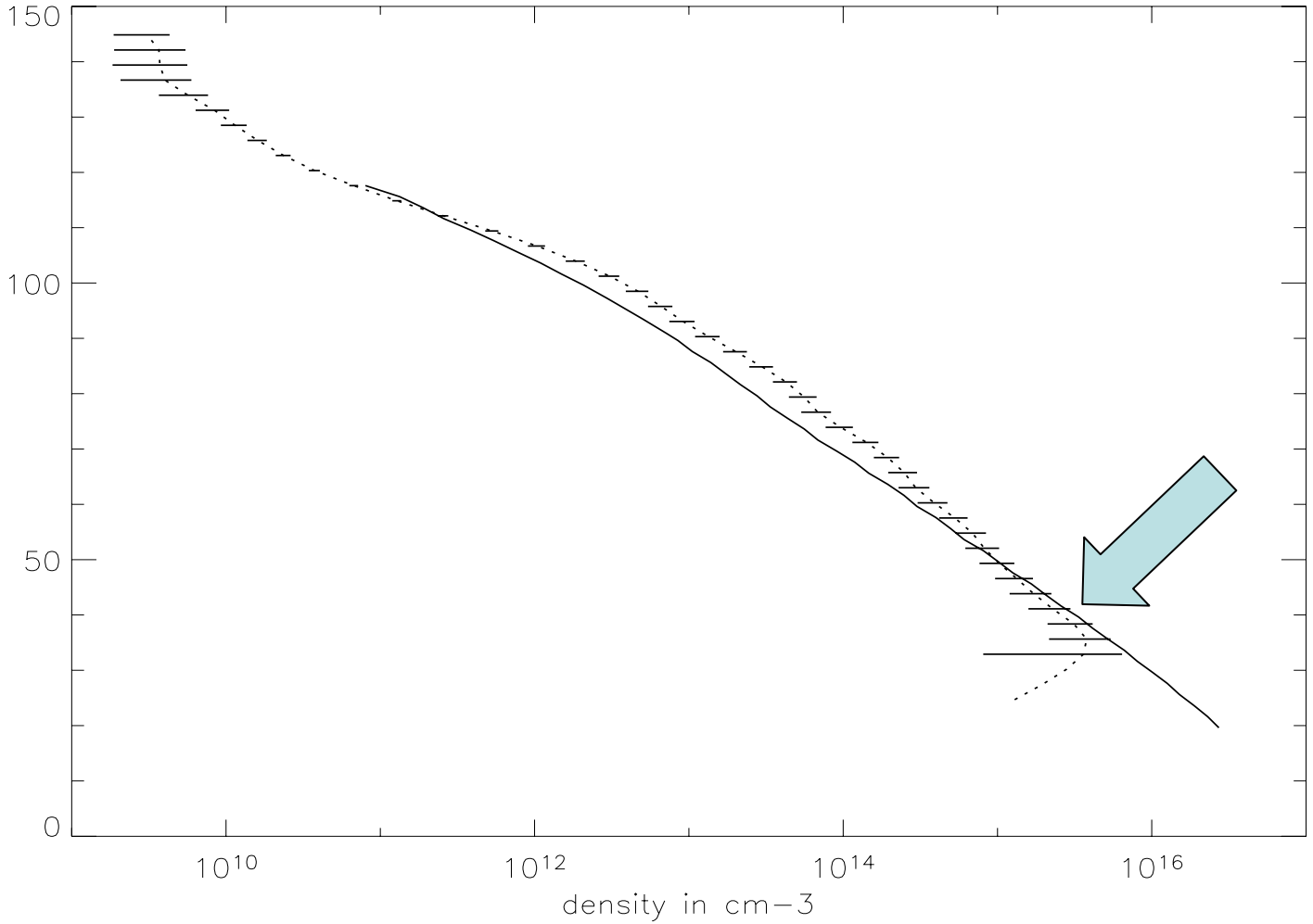
- Many possible problems during EDL, no telemetry (like Polar Lander)

A very preliminary density profile retrieved with Mars Express SPICAM data

(Spicam team. J. L. Bertaux)



Same SPICAM observation after some corrections *(Spicam team. J. L. Bertaux)*



What happened to Beagle 2 ?

- Many possible problems during EDL, no telemetry (like Polar Lander)
- Commission of Inquiry :
  - Identified a few credible causes for Beagle 2's loss
  - proposed a set of 19 Recommendations
    - Future Lander will be under ESA responsability / major agency
    - Better communication, Better testing, More margins…
    - Design to avoid collision between EDL elements…

European Mars Exploration in the future ?

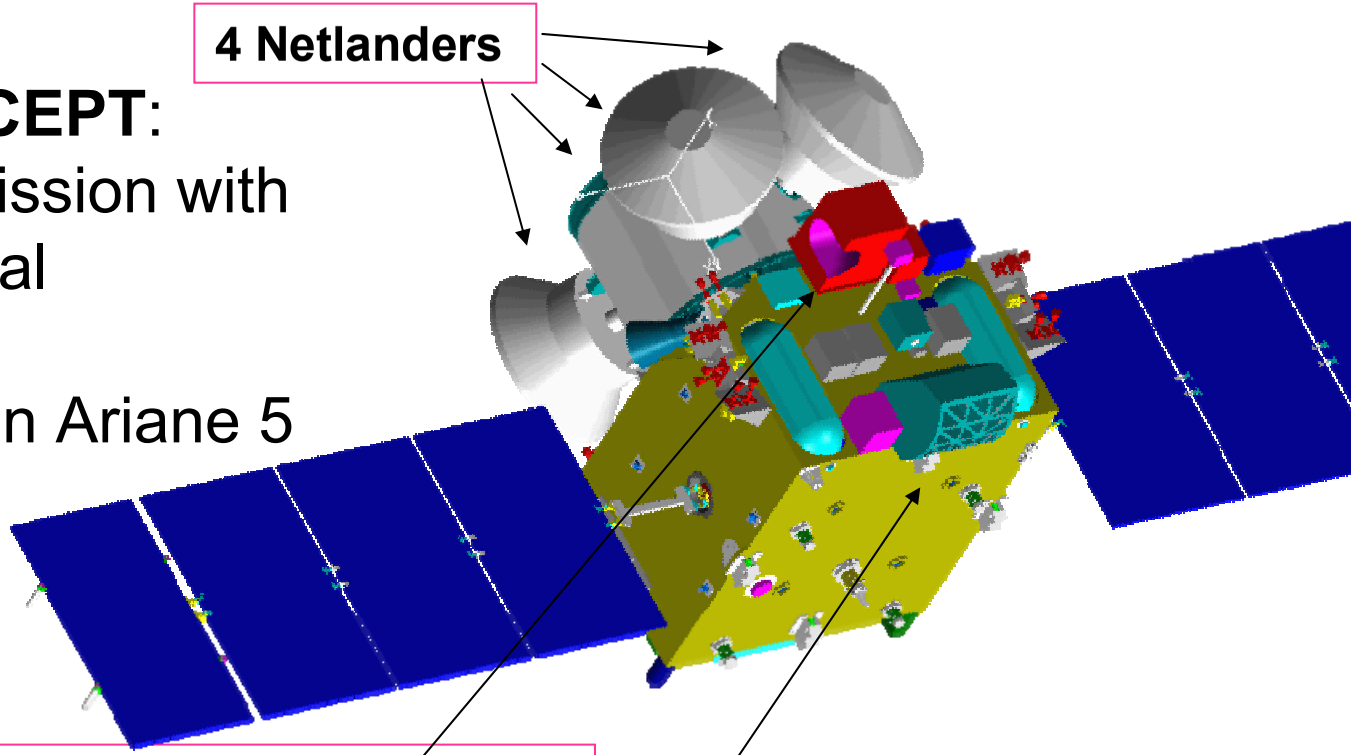
French led projects for 2007-2009 (cancelled in 2003)

- Preparation of Mars Sample Return
- Netlander

2002 : The Mars Premier mission

ORIGINAL CONCEPT:

- A french-lead mission with strong international participation
- Launch : 2007 on Ariane 5

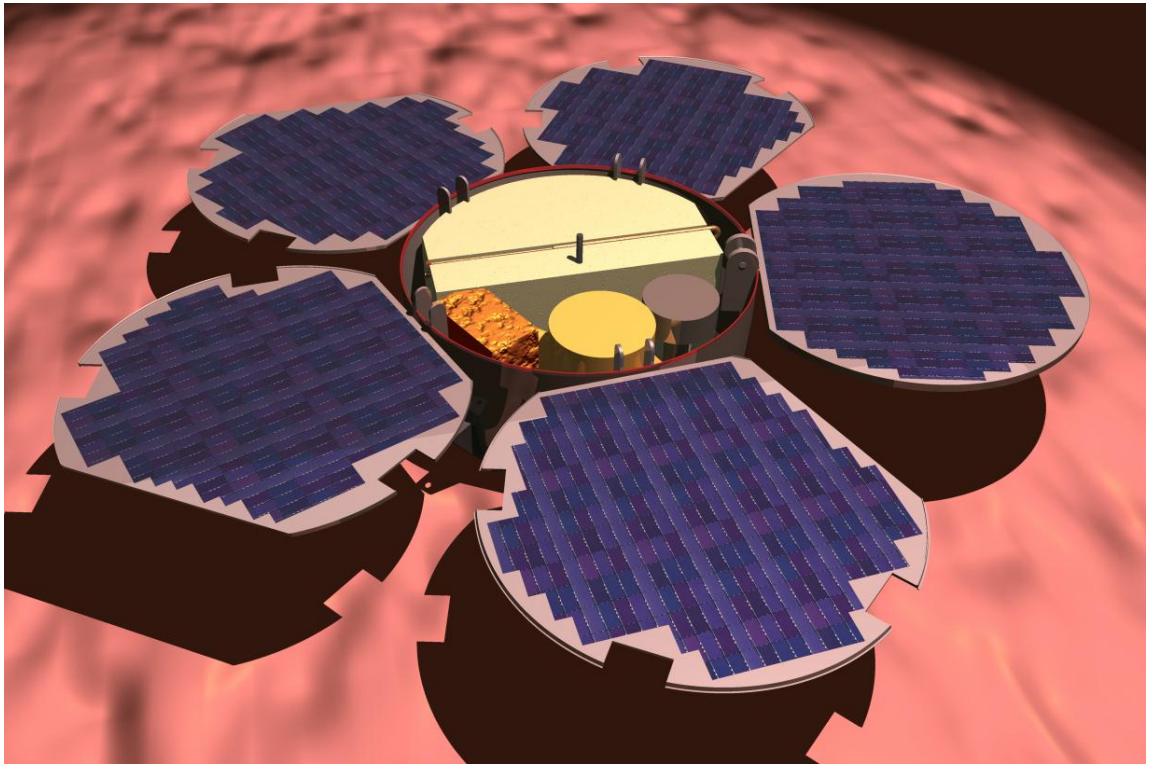


1 versatile **orbiter** similar to a future Mars Sample Return Orbiter performing:

- Orbital Science
- Mars Orbit Rendez-vous demo (preparation of MSR

4 Netlanders

- 4 × landers
- 30 kg surface module
- Target lifetime: 1 Mars year
- Implemented by a consortium of national agencies, managed by CNES



Payload:

SEIS : seismometer
GPR: Ground Penetrating Radar (2 MHz)
MAG : tri-axial flux Magnetometer
PanCam : Panoramic, stereoscopic multi-spectral Camera
ELF : Electric Field sensor
ATMIS : Atmospheric Package
NEIGE : Ionosphere and Geodesy Experiment
MIC : Acoustic Microphone
SPICE: soil sensor

The future : Mars science and exploration at ESA

- Little room for a Mars project in the Mandatory « Scientific program » of the agency before 2015
- BUT : Broad interest for Mars as a «Long term Exploration objectives » (human mission program) → **« Inspiration »**


AURORA
MARE AUSTRALE
MARE ERYTHRAEUM
MARE ACIDALIUM
esa

Official Rationale for the Aurora Programme

- In the coming decades the scientific and human exploration of the solar system is expected to progress further beyond the low Earth orbits. Possibly a first international human mission to Mars may become a reality by the years 2020-2030
- To decide in which areas of expertise Europe wants to have a lead in the future requires a detailed analysis of the European technology strengths and an assessment of its strategic value
- The Aurora Programme, recently presented and approved at the Ministerial Conference in Edinburgh in November 2001, is the response of Europe to these challenging goals

Official Objectives of the Aurora Programme

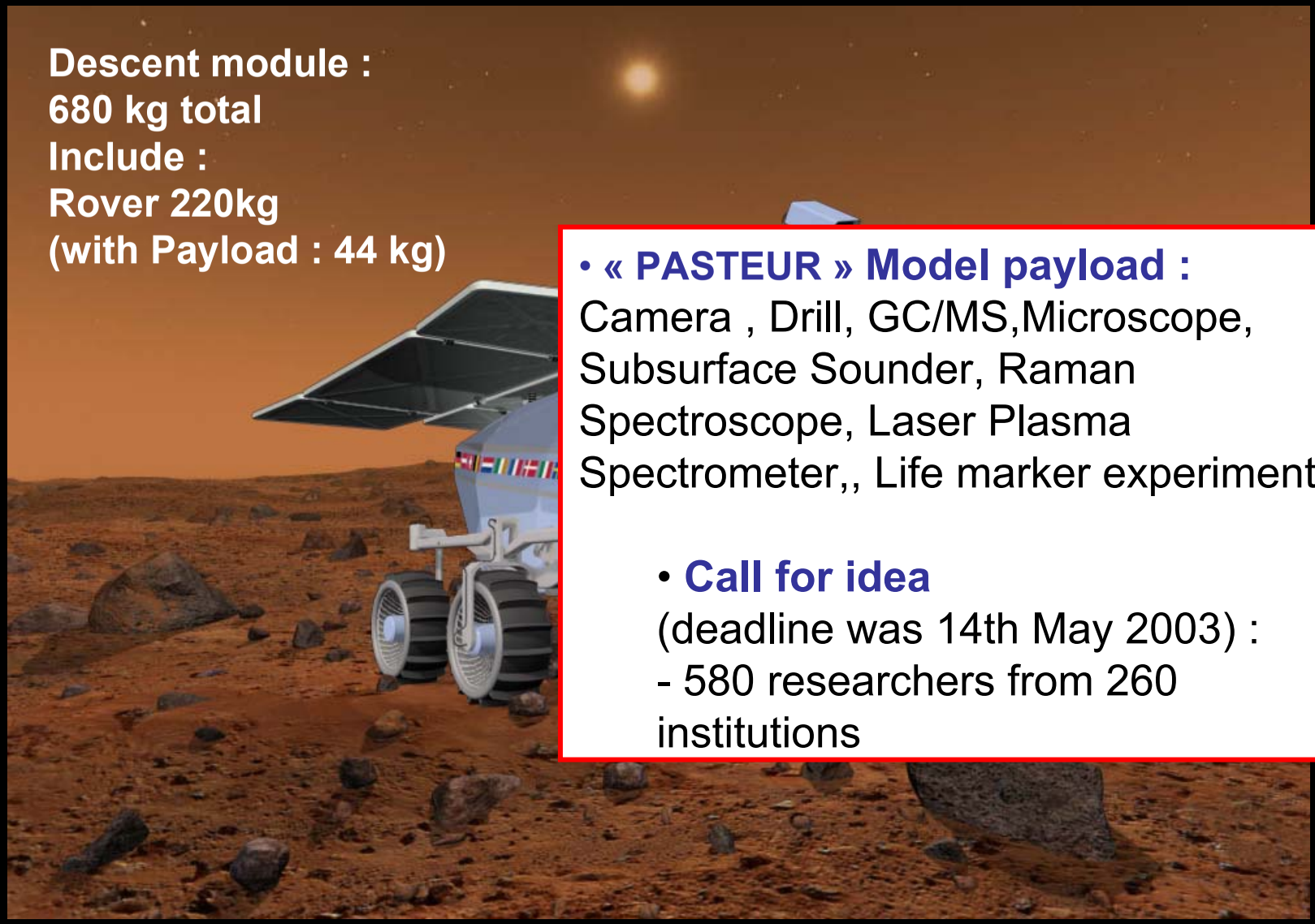
- Continue the European effort after Mars Express and Beagle 2 towards a more systematic planetary exploration programme, focused on Mars, Moon and Asteroids.
- Formulate, and then implement, a European Long Term Plan for the robotic and human exploration of the Solar System bodies holding promise for traces of life
- Provide for missions and technologies complementary to the existing ESA and national programs in Europe and Canada and foster the development of a coherent, unified European approach for Exploration. Cooperation with other international partners will be sought

Aurora Preparatory Period (2001-2005)

- Two classes of missions are prepared:
  - ***Arrow Missions*, (smaller missions, with a short development time, technology driven) :**
    - **Atmospheric re-entry test**
  - ***Flagship Missions*, (major missions driving to in-situ analysis soft landing or sample return)**
    - **Exomars Rover in 2009 (optimistic)**
    - **Mars Sample Return Mission in … 2011 (very optimistic)**

- **NEXT KEY STEP : Ministerial Conference in June 2005 : next 5 years Funding of Aurora ?**

Official project for 2009 : The « Exomars rover »



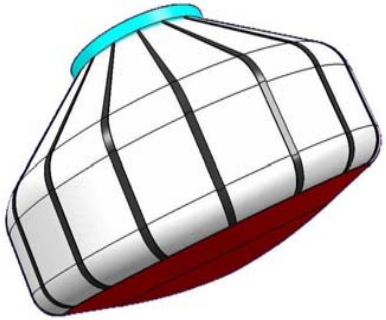
Descent module :
680 kg total
Include :
Rover 220kg
(with Payload : 44 kg)

- **« PASTEUR » Model payload :**
  Camera , Drill, GC/MS,Microscope, Subsurface Sounder, Raman Spectroscope, Laser Plasma Spectrometer,, Life marker experiment

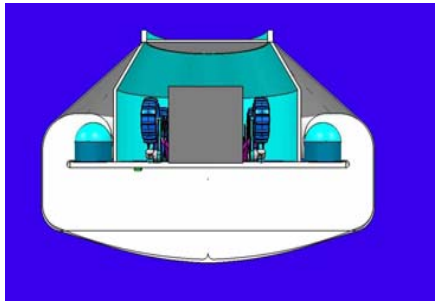
- **Call for idea**
  (deadline was 14th May 2003) :
  - 580 researchers from 260 institutions

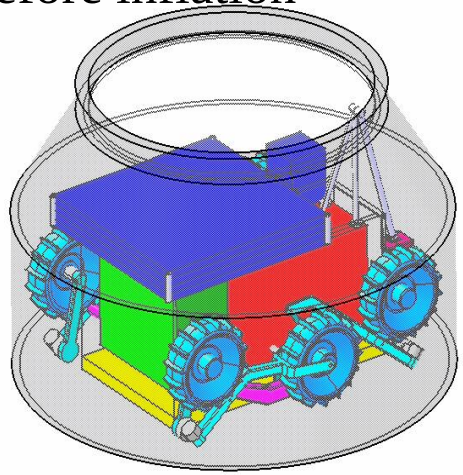
Exomars : example of Descent and Landing System

Descent Module with Inflatable Braking Device
(Babakin Space Centre concept), see “ExoMars 09” CDF study
Courtesy of ESTEC teams

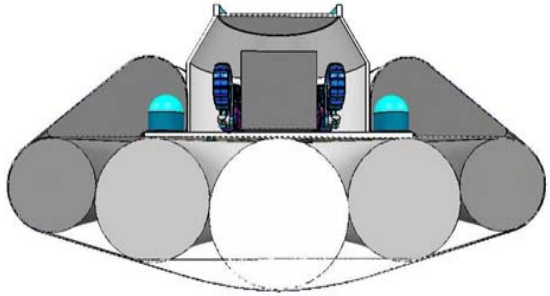


1. Descent Module before inflation

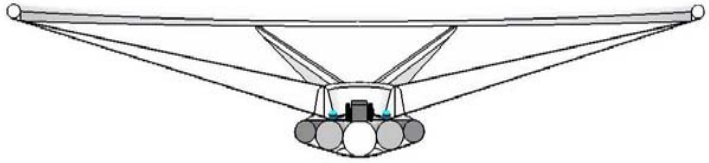




2. After front shield inflation

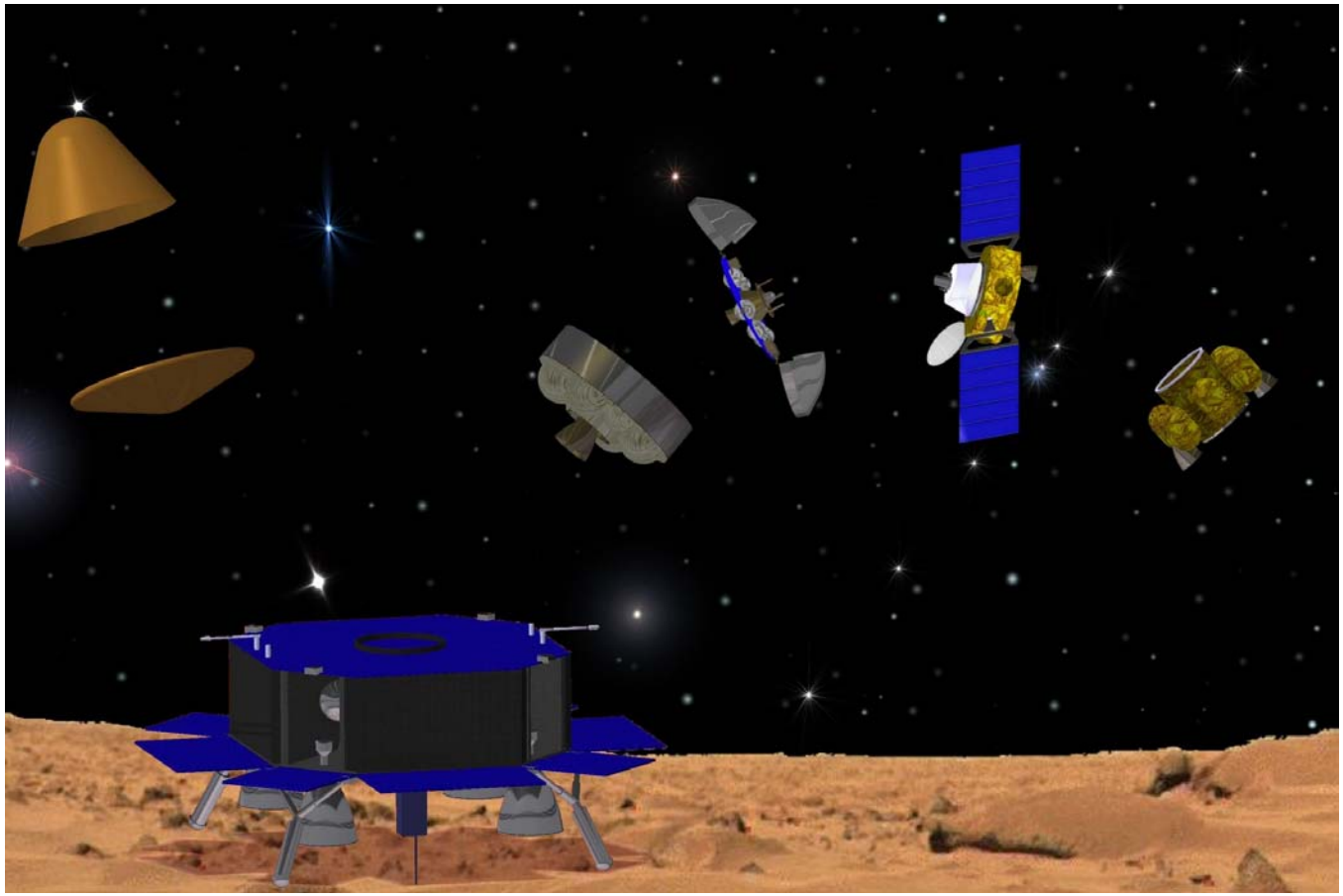


3. After braking device inflation



Illustrations of ESA ExoMars09 CDF Report

After Exomars : Mars Sample return…



Other ideas may still arise and become reality after the *Cosmic Vision 2015* programming process

Non Official concluding comments:

August 2004 : things have changed since 2001 when Aurora was programmed…

Context in 2001:

- Beagle 2 in 2003 : lost
- Netlander in 2007 : cancelled in 2003

Now :

→ Ambitious Exomars now first in line for european landing on Mars

→ Excellent payload available for simple landers (from Beagle 2, Netlander, Exomars ideas)

→ Many groups suggest that ESA send small to mid-size landers as soon as possible…