Calibration and preparation of MIRS instrument observations for the JAXA MMX space mission

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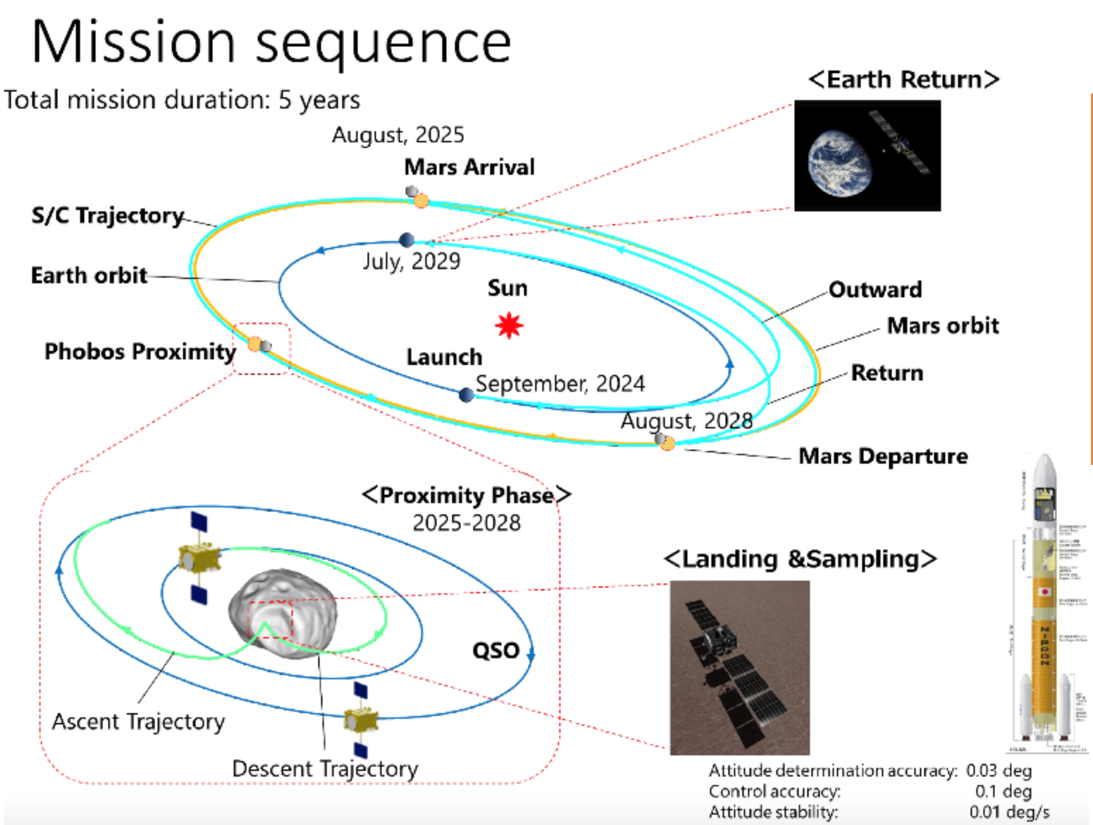
MMX-Martian Moons eXploration

- JAXA's mission
- First sample return mission Phobos's satellite
- To collect at least 10g regolith on Phobos's surface → on two differents sites
- Return sample on Earth → first arrival/departure to the martian system



Launch	**2024/9**
Mars arrival	**2025/8**
Mars departure	**2028/8**
Earth return	**2029/9**

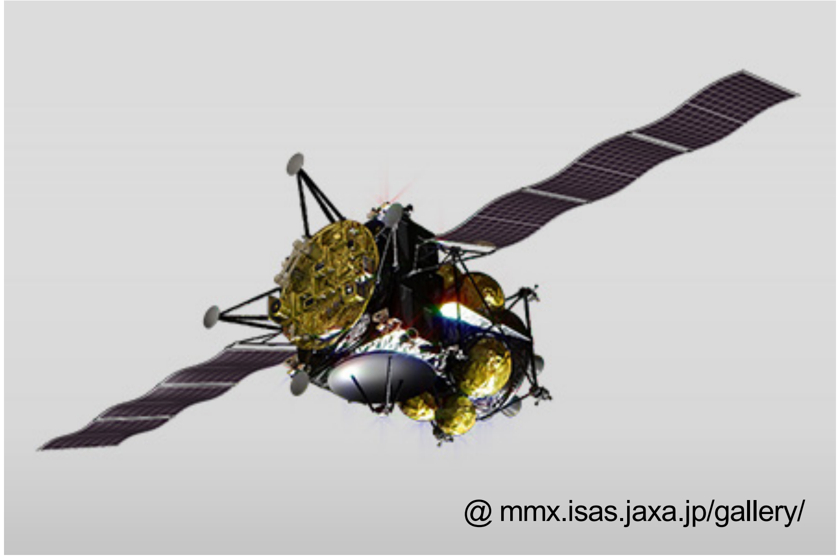
QSO Phobos

Main objectives

- Understanding the origin of the Martian moons
- To constrain processes for planetary formation and material transport in the region connecting the inner and outer solar systems
- To reveal the evolutionary processes of the Martian system in the circum-Martian environments

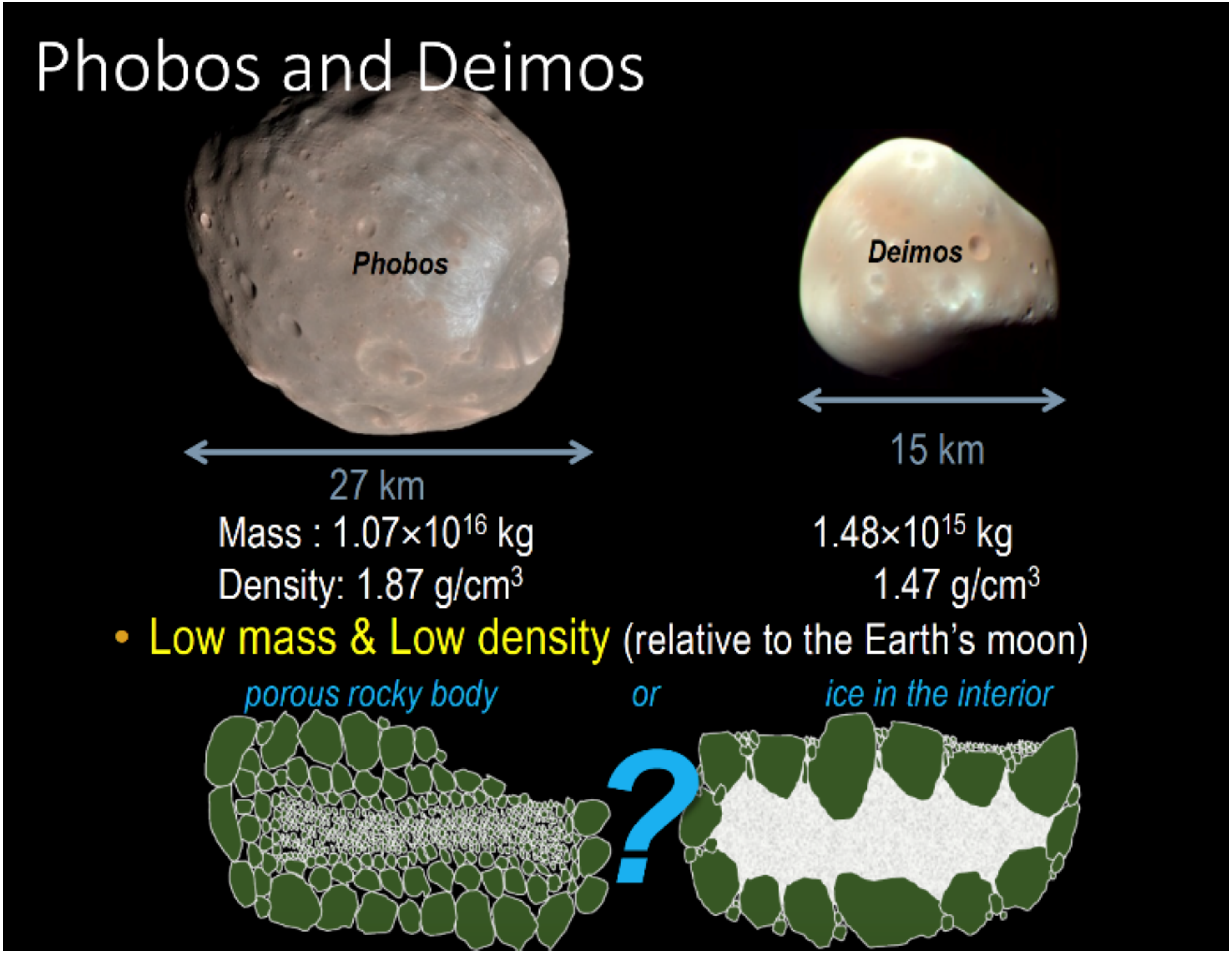
Instruments on board

OROCHI (Optical Radiometer cOmposed of CHromatic Imagers)	Wide-angle camera
TENGOO (Telescopic Nadir Imager for Geomorphology)	Narrow angle camera
LIDAR (LIght Detector and Ranging)	Laser altimeter
CMDM (Circum-Martian Dust Monitor)	Dust detector
MSA (Mass Spectrum Analyzer)	Mass spectrometer
MEGANE	Gamma rays and Neutrons Spectrometer - NASA
MIRS (MMX InfraRed Spectrometer ([0.9-3.6μm])	Imaging spectrometer - CNES



+ Rover (CNES,DLR)

Phobos and Deimos : The Origin



Hypothesis

2 hypothesis

- Captured asteroids
- Giant impact

Capture of asteroid

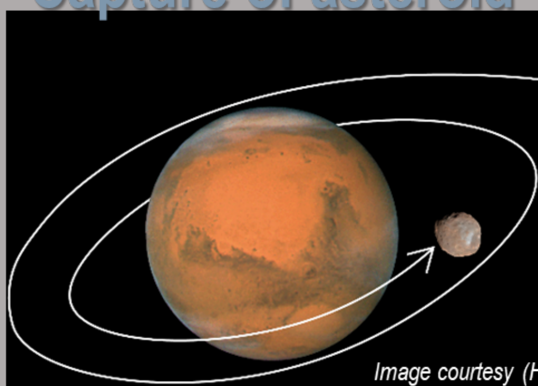


Image courtesy (Hiro Kurokawa)

Consistent with D- or T-type IR spectra

in situ formation by an impact

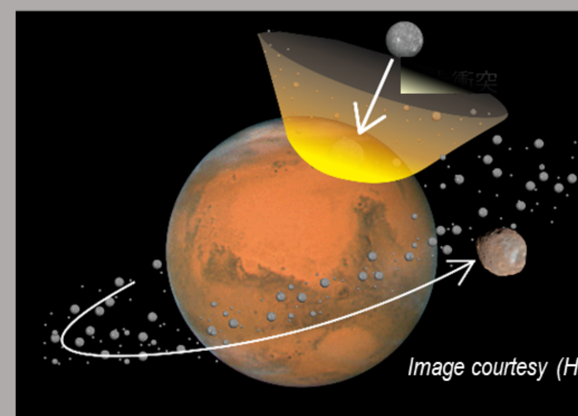
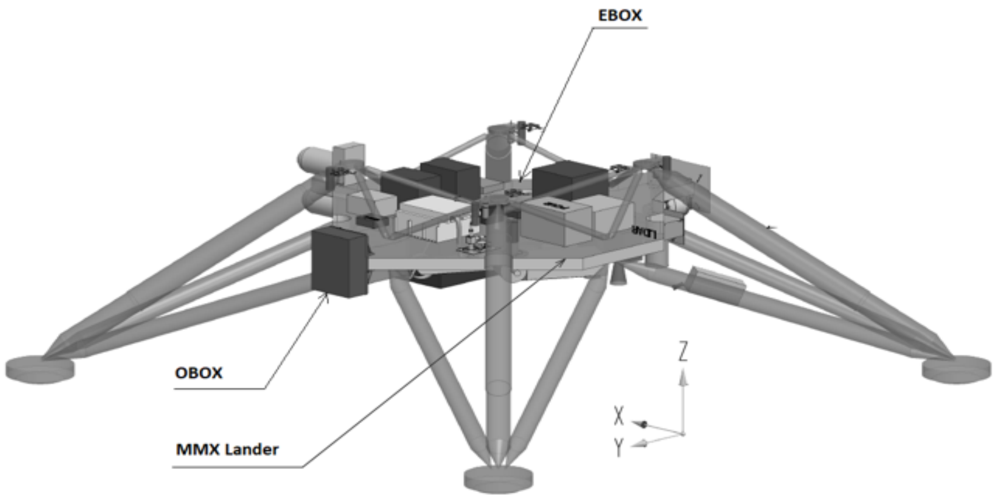


Image courtesy (Hiro Kurokawa)

Consistent with low eccentricity & inclination

MIRS

Mass	11,9 kg
Volume (instrument)	320x150x400 mm^3



MIRS on MMX Lander

Characteristics :

Spectral band	[0.9-3.6μm]
Spectral resolution	20nm
iFOV	0.35 mrad
FOV	+/- 1.65°
SNR	> 100 in[2.7- 3.2μm] in less than $T_{int} = 2s$
Detector	256x256 (using 256x250), pixels = 30 μm

MIRS objectives - Phobos

To characterize Phobos and Deimos ‘s surfaces and the atmopsheric composition of Mars → identifying characteristic spectral signatures in the near infrared range

Phobos :

- To study the surface distribution of the constituent materials of Phobos
- Hydrated and other minerals must be identified :
  - Spectroscopically at a ground resolution of 20m
  - Spatial resolution of 1 m
  - 50 m around the sampling point

Water (ice)	[3,0-3,2 µm]
Hydrated silicate minerals	[2.7-2.8 µm]
Organic matter	[3.3.-3.5 µm]

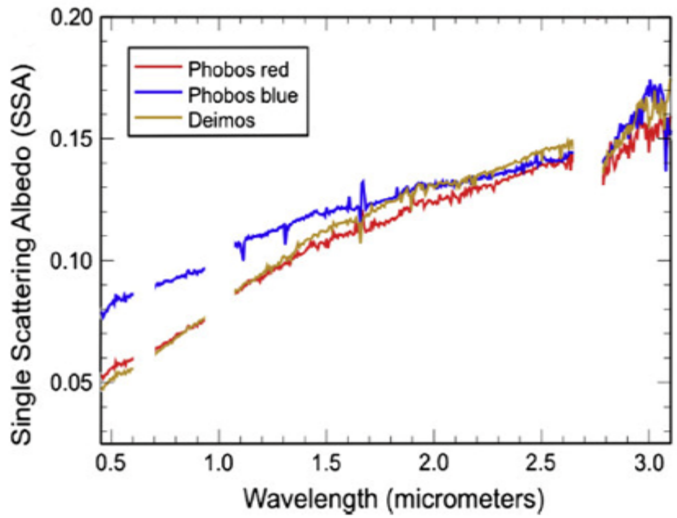
MIRS Objectives - Deimos

Deimos :

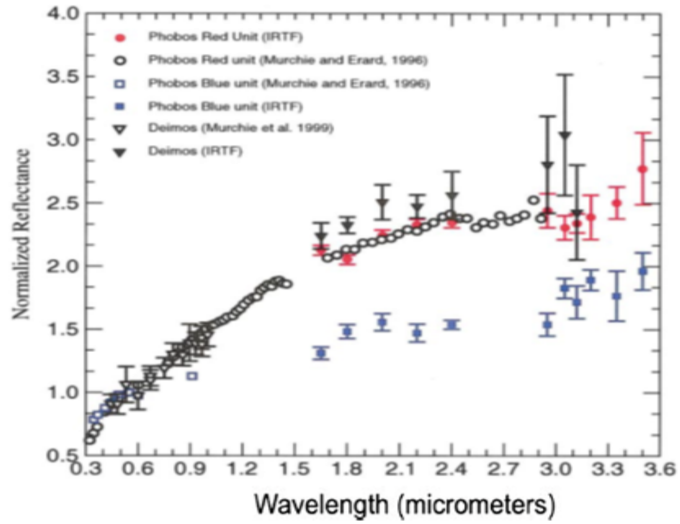
- To study the surface distribution of the constituent materials of Deimos **from spectroscopic information**
- Hydrated and other minerals must be identified:

  - Horizontal spatial resolution > 100m

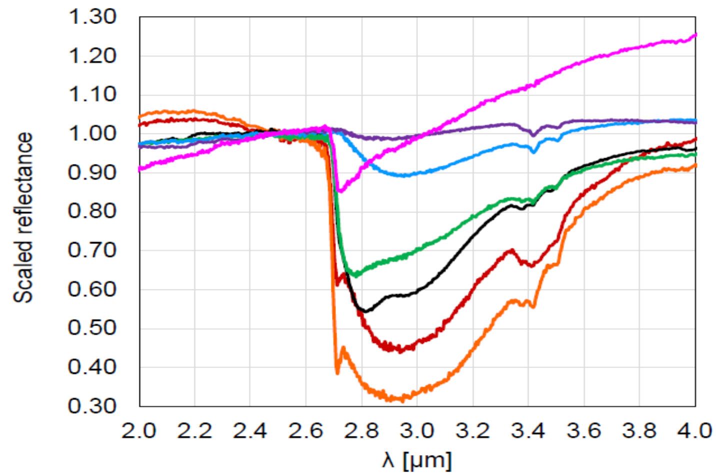
Similarities with asteroids?



Phobos (blue and red units) and Deimos 's spectra derived from CRISM-MRO spectra, extracted from Fraeman et al. (2014)

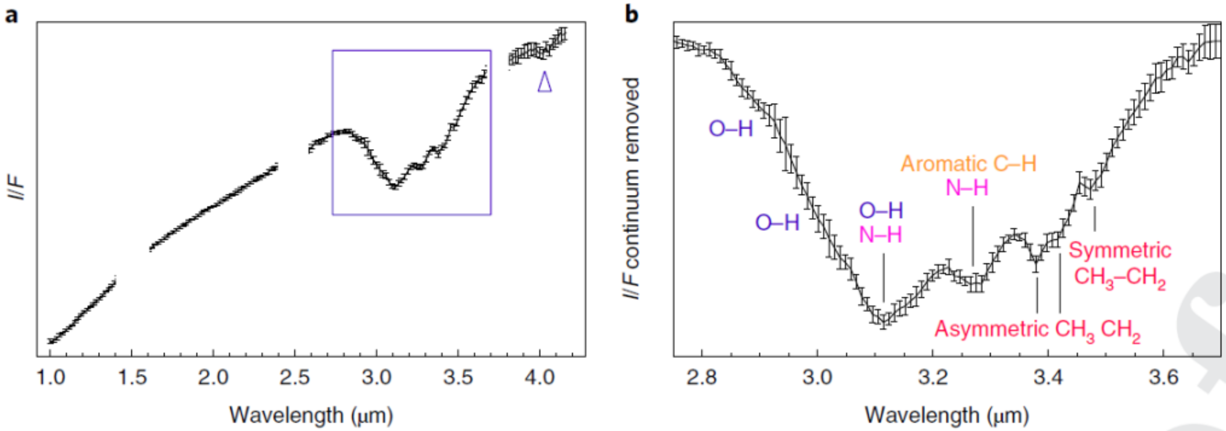


Combination of several spectra the 0.3-3.6 microns range of Phobos and Deimos extracted from Rivkin et al. (2012)

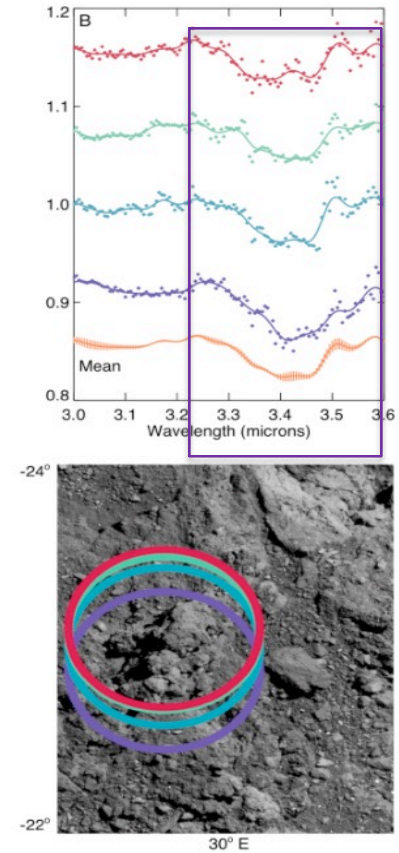


Similarities with asteroids ?

- Many organics have been detected on the surface of many asteroids/comets :



67P Churyumov-Gerasimenko spectra



- We can expect absorption features in the [3.2-3.4μm] regions

MIRS objectives – Mars atmosphere

- **Mars atmosphere** : Dust and water transport processes near the Martian surface

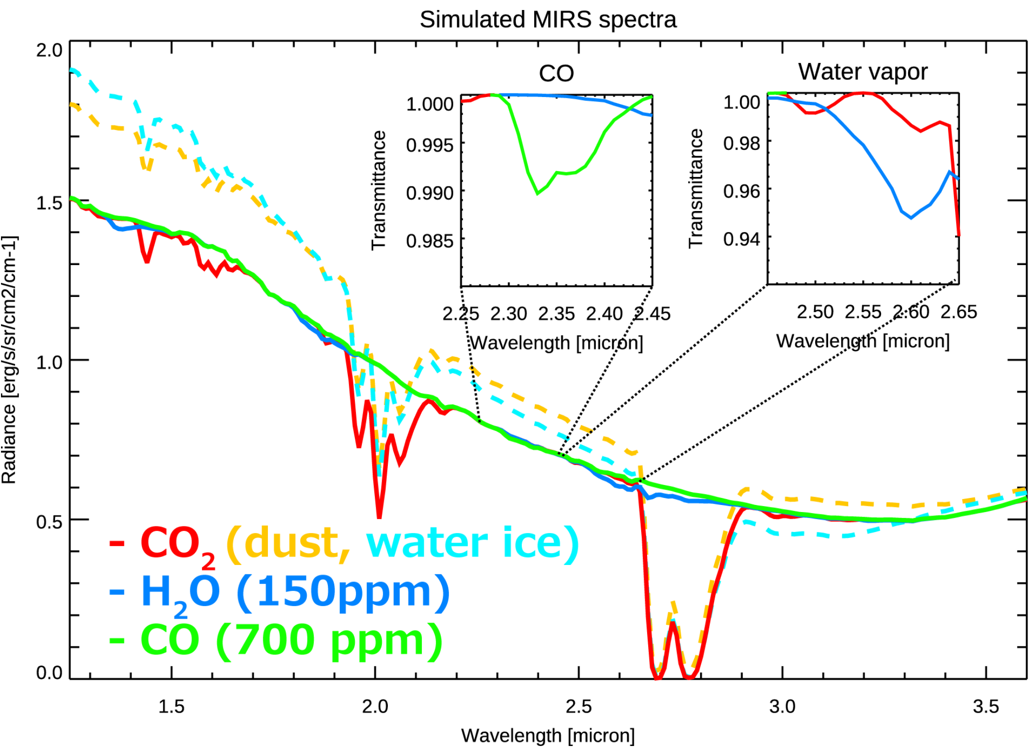
    - Continuous observations of dust storms, ice clouds and water vapour will be conducted for mid and low latitudes from the high-altitude equatorial orbit during different seasons with a time resolution of 1 hour

    - MIRS contribution: To determine the distribution of the amount of water vapour with :

        - spatial resolution :10 km
        - absolute spectral radiometric accuracy of 10%
        - a relative spectral radiometric accuracy of 1%

→ These observations will be made over several successive days in different seasons.

MIRS objectives – Mars atmosphere



Barucci et al., 2020

Science Target	Parameters	Spectral range
Ice cloud formation and evolution	Water ice clouds	1.5, 2 and 3 µm bands
	CO_2 ice clouds	0.9-3.6 µm
Dust clouds/storms formation and evolution	Dust	CO_2 2.7 µm bands Or 0.9-3.6 µm
Water cycle	H_2O	2.6 µm band
Atmospheric composition and dynamics	Surface pressure	CO_2 2.0 µm band
	CO	2.3 µm band
Limb observations for middle atmosphere	O_2 day-glow (water index)	1.27 µm band

Possible signatures of organics in Mars's satellites spectra in general

Wavelength (µm)	Assignment
1.21	2nd overtone of CH_3 asymmetric stretch
1.39-1.41	1st overtone of OH stretch
1.69-1.76	1st overtones and comb. of CH_2 and CH_3 stretching modes
2.15-2.17	combination of aromatic C-H stretch and C=C stretch
2.27	combinations of CH_2 asymmetric stretch and symmetric bend
2.31	combinations of CH_3 asymmetric stretch and symmetric bend
2.35	combinations of CH_3 asymmetric stretch and symmetric bend
2.46	CH_2
2.94-3.12	N-H and NH_2 group (stretch)
3.27-3.29	aromatic CH stretch or Fermi resonance
3.38-3.39	aliphatic CH_3 asymmetric stretch
3.41-3.42	aliphatic CH_2 asymmetric stretch
3.48-3.50	aliphatic CH_3 symmetric stretch
3.50	aliphatic CH_2 symmetric stretch

Course of my thesis

Participation ground calibrations:
- Radiometric
- Geometric
- Spectral

→ Calibration bench

Oct 2020-Mar 2021

Bibliography:
- IR spectro on Ryugu and Bennu
- Calibrations on others instruments (SIMBYO-SYS,MAJIS, SuperCam..)

2021-2022

2022-early 2023

Data analysis:
Cubes reconstructions

2023

Mars :
- Writing thesis

October:
- Oral defense

My specific work

Main performances	value
Dark signal	62 500 e-/s
QE including window transmittance	> 63 %
Window reflectivity	< 4%
Power consumption during cooldown	<12W (~ 5W)
Detector temperature	110K

My specific work

- I will work **on the detector alone** and then **on the instrument** (with the detector implemented).

  Implementation of measures :
  ✓ Radiometric
  ✓ Geometric
  ✓ Spectral
  → Installation of a calibration bench according MIRS requirements

- To analyze/ investigate possible locations for sample collection on Phobos

→ Instrumentation + Planetology

Coming Soon

- To Provide an initial set of specifications at the end of March-early april to establish the first tests (proviosional list according to MIRS requirements)
- To set up the bench for the calibration of the detector alone first (with optics and on the instrument then)
- To start the tests
- Work on Phobos's spectrum

Finally : - Intimate knowledge of the instrument

- Competence in spectroscopy IR

The end

THANK YOU !