# Spectrometer ISEM for ExoMars-2020 space mission: from qualification prototype to flight model


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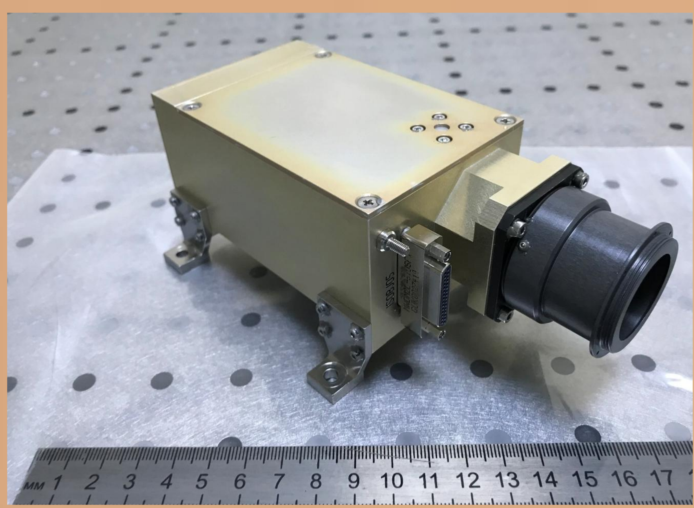
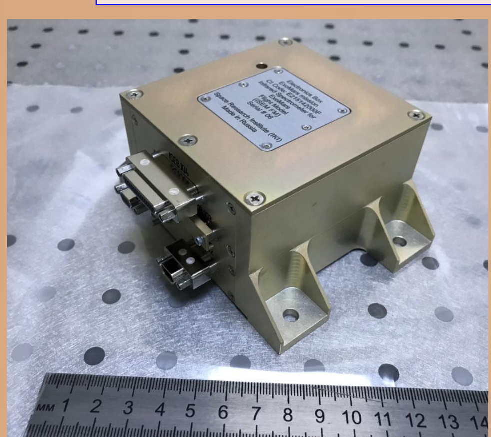
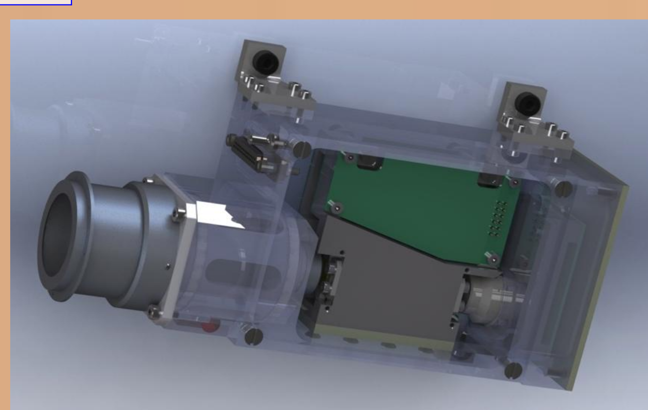


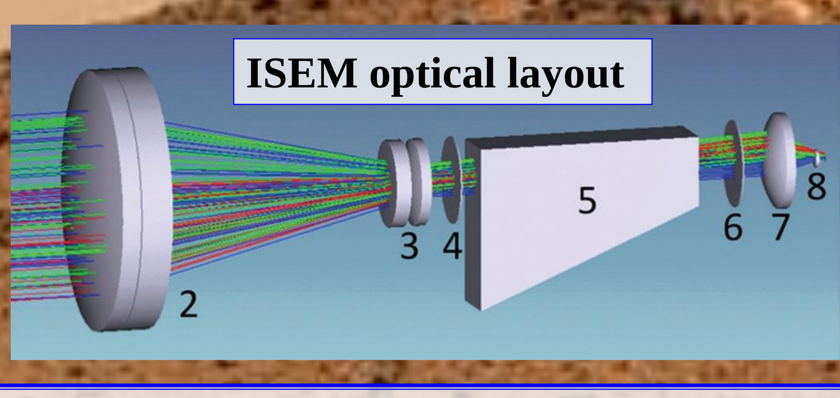
ISEM FM Optical box



ISEM FM Electronics box



Optical box: internal view




ISEM optical layout


## Abstract

The Infrared Spectrometer for ExoMars (ISEM) is an experiment onboard ExoMars rover planned for the launch in 2020. ISEM is mounted on the rover's mast together with panoramic stereo camera (PanCam), and the High Resolution camera (HRC). The field of view (FOV) of ISEM (1°) is within the FOV of HRC (5°). The AOTF-based spectrometer will provide measurements in the spectral range of 1.15-3.3 µm with spectral resolution better than 25 cm$^{-1}$. The spectral range of the spectrometer allows assessing the surface composition of selected surface areas and rocks on Mars primarily supporting the selection of the drilling sites. The uppermost few millimeters of the surface will be studied allowing to discriminate between various classes of silicates, oxides, hydrated minerals and carbonates, and to identify aqueous alteration products. A number of atmospheric studies are also planned to characterize the dust properties and the gaseous composition.


## Science objectives

The main science objectives of ISEM include geological investigation and study a composition of Martian soils in the uppermost few millimeters of the surface; characterization the composition of surface materials, discriminating between various classes of silicates, oxides, hydrated minerals and carbonates; identification and mapping of the distribution of aqueous alteration products on Mars; real-time assessment of surface composition in selected areas, in support of identifying and selection of the most promising drilling sites; studies of variations of the atmospheric dust properties and of the atmospheric gaseous composition

## Principles and key components of the ISEM spectrometer

ISEM is AOTF-based spectrometer. The instrument is mounted on the mast of ExoMars Rover in the field of view of High Resolution Camera.

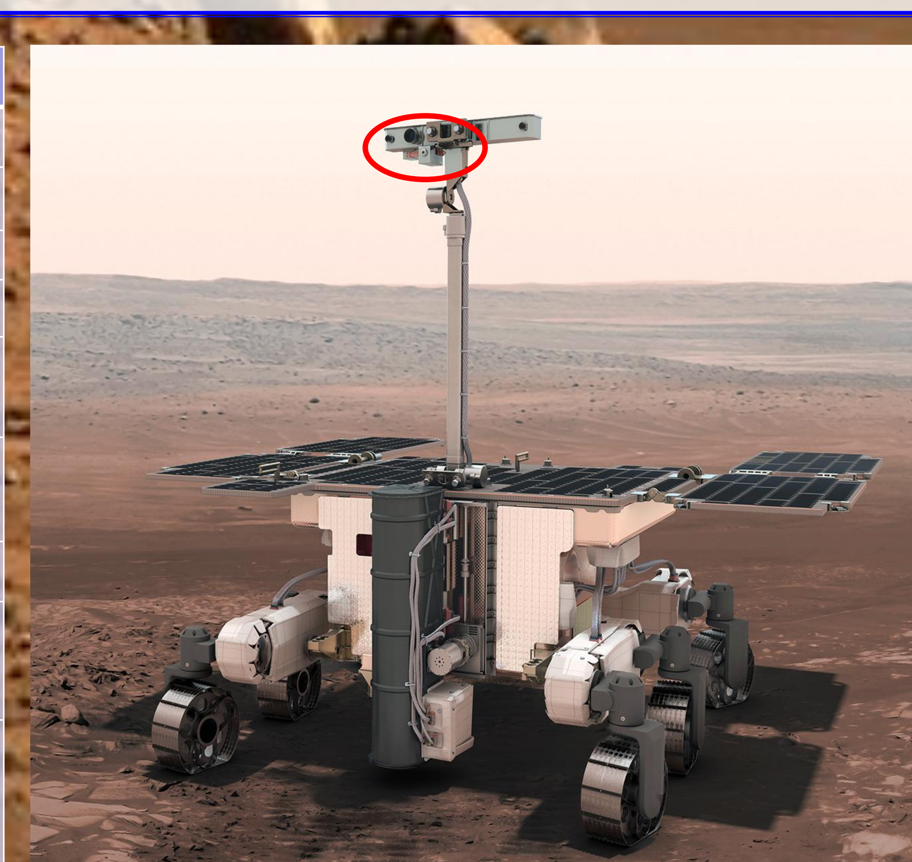
The design is based on acousto-optic tunable filter (AOTF), already implemented in many space mssions [1-3]. This approach allows flexible access to any part of selected spectral domain, contains no moving parts, is compact and light.

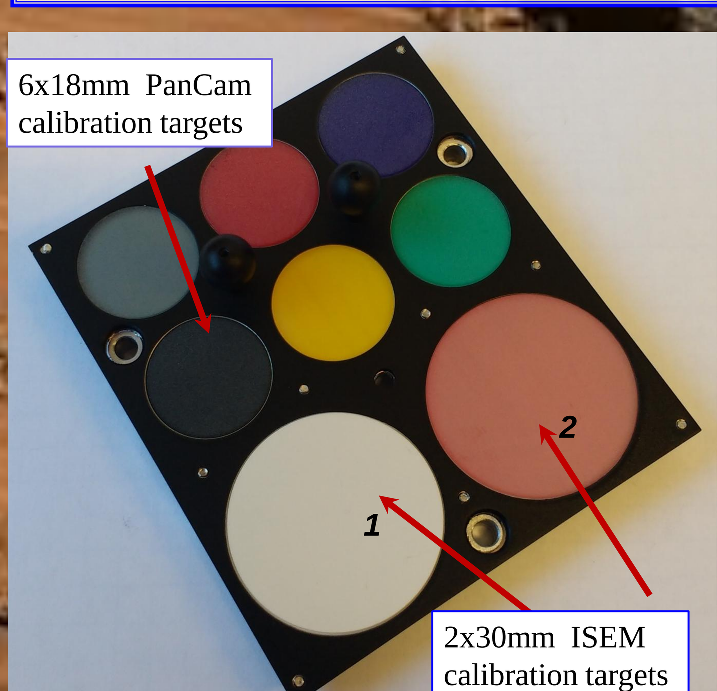
❑ The AOTF crystal is of paratellurite ($TeO_2$), specifically cut and oriented, providing a wide angular aperture. The tuning of the optical wavelength is produced by appropriate frequency of the ultrasound acoustic wave in the AOTF crystal by integrated piezotransducer. The passband is 25 cm$^{-1}$, the linear aperture 4x6 mm, the angular aperture ±3°, and the diffraction angle is ~6.6°.

❑ Entrance reflective telescope: lens ø17 mm, working F/# 3.6, field of view 1°.

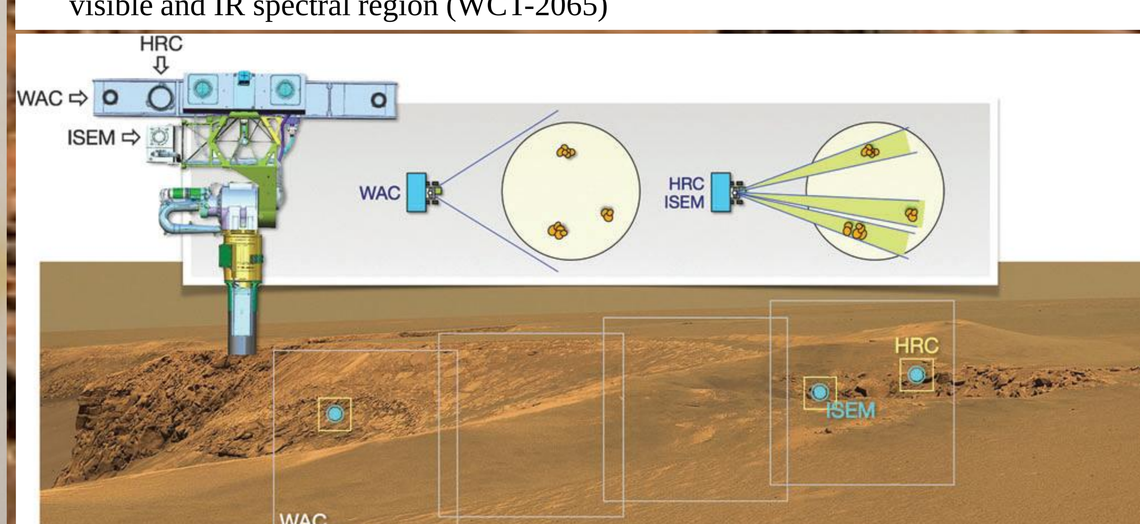
❑ Single-pixel InAs detector Judson Teledyne J12TE3-66D-R01M, three-stage thermo-electrically cooled.

| | |
|---|---|
| **Spectral range** | **1.15-3.3 µm** |
| **Field of view** | 1° |
| **Spectral resolution** | better than 25 cm$^{-1}$ |
| **Power consumption** | 12 W |
| **Power supply** | 28 V |
| **Operation temperatures** | –50°…+50°C |
| **Storage temperatures** | –130°…+60°C |
| **Output interface** | RS-422 |
| **Overall dimension** | 170x80x96 mm (optical box)<br>92x116x55 mm (electronic box) |
| **Mass** | 0.7 kg (optical box)<br>0.6 kg (electronic box) |



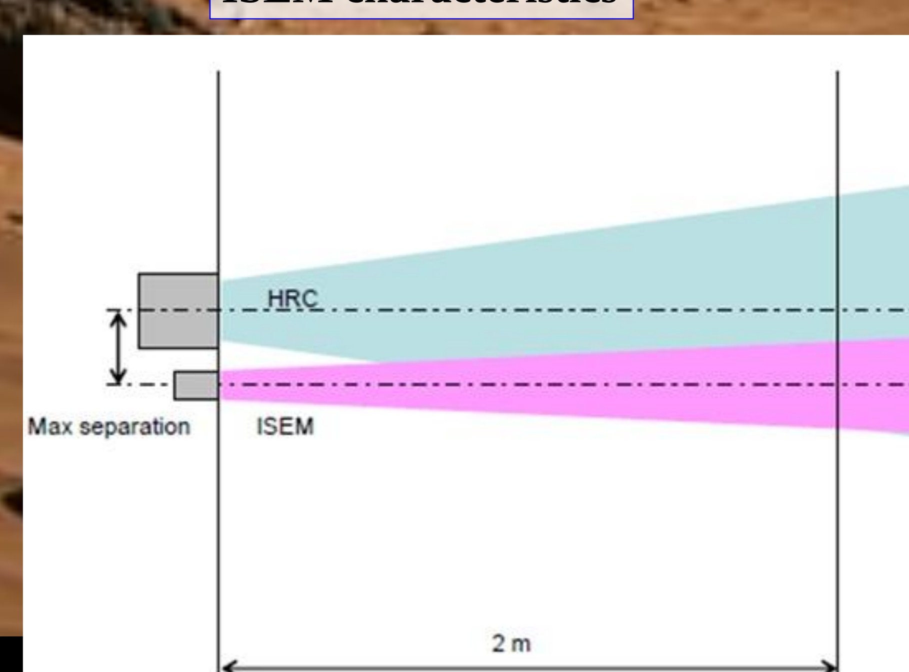



**ISEM calibration targets material**:
1) Diffuser with reflectance coefficient near 100% in the 400-3000nm spectral range
2) Diffuser with known reflectance spectrum containing deep absorption areas both in visible and IR spectral region (WCT-2065)



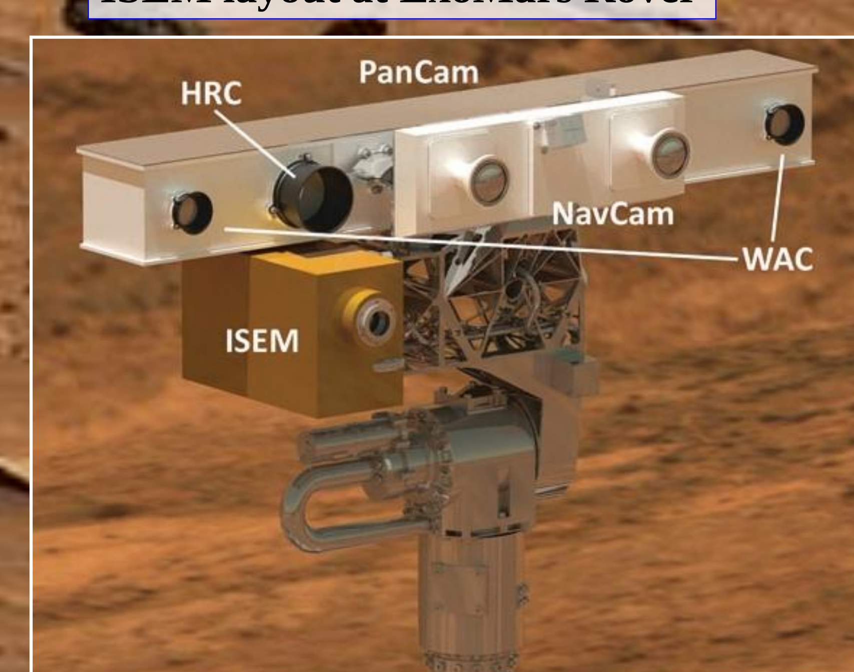

Observation scenario with WAC, HRC and ISEM

ISEM characteristics

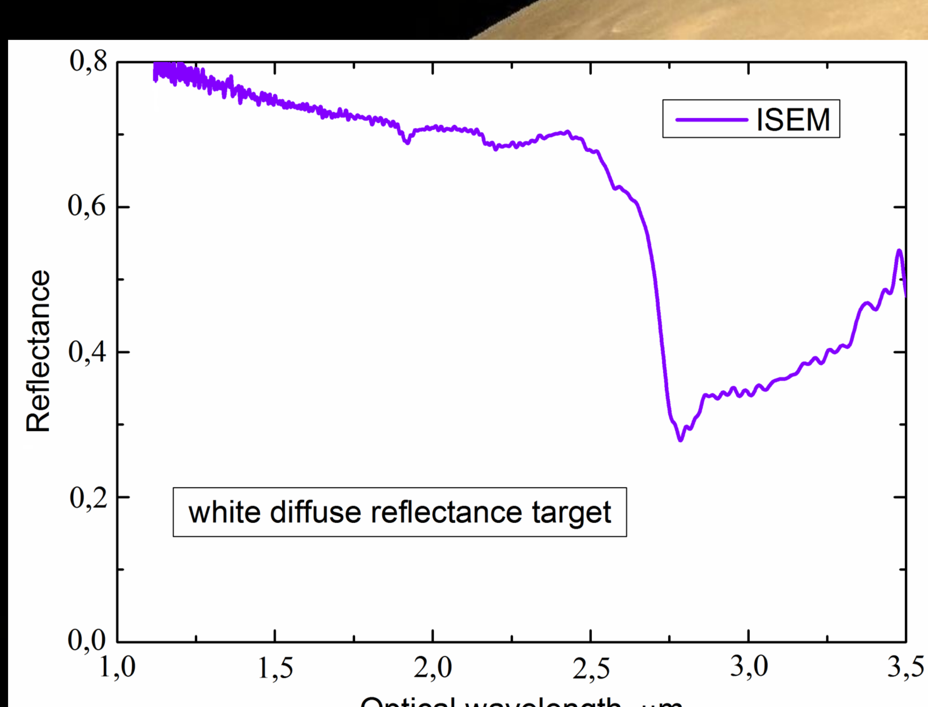


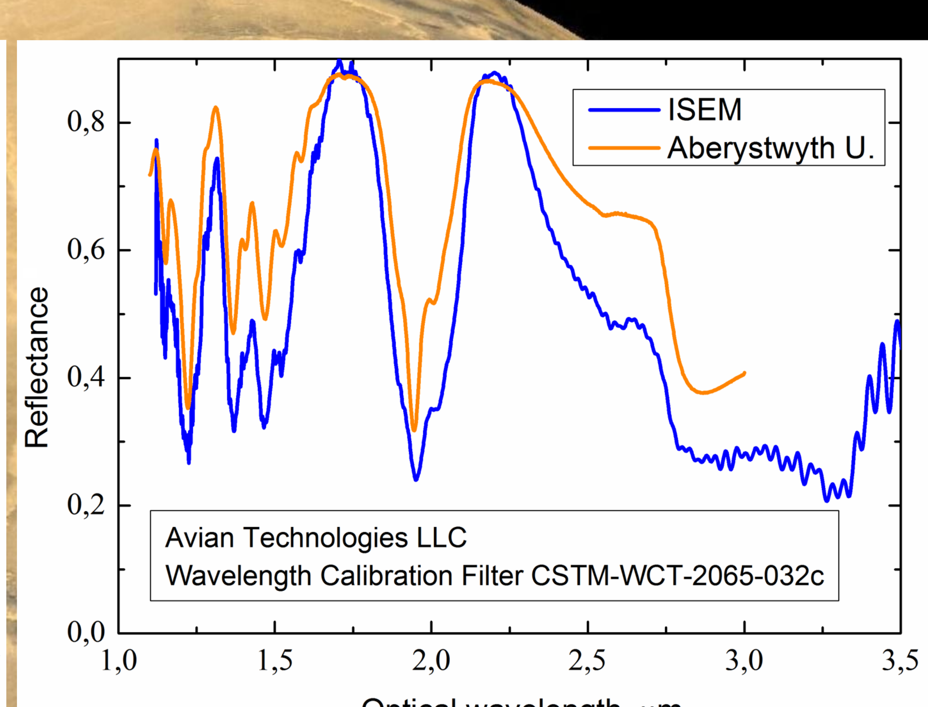

The optical axes and FOW's of ISEM and HRC

ISEM layout at ExoMars Rover

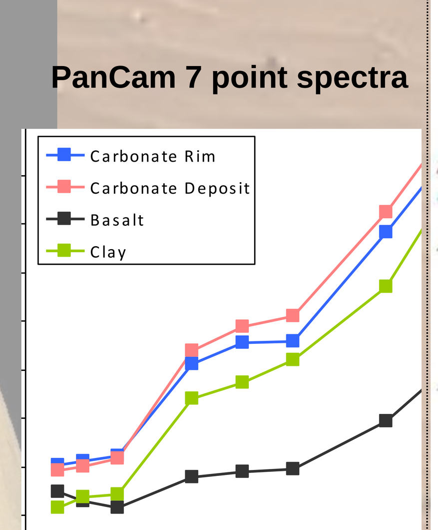


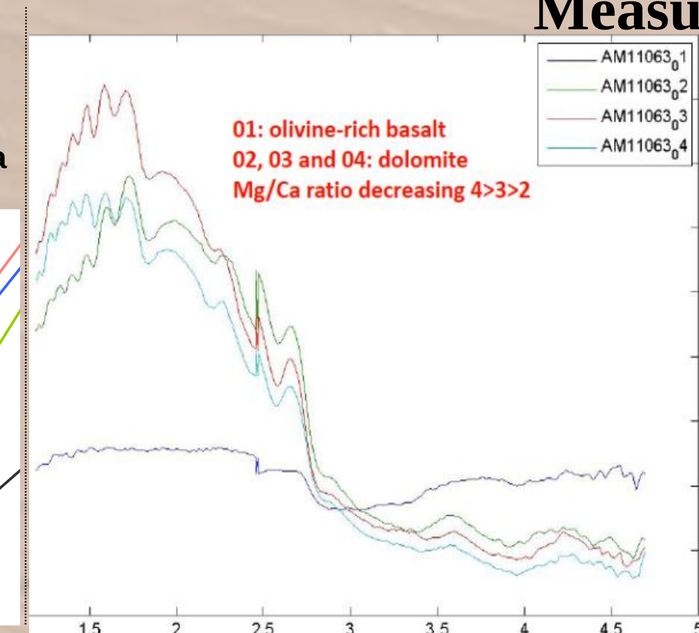

ISEM implementation on the Rover's Mast



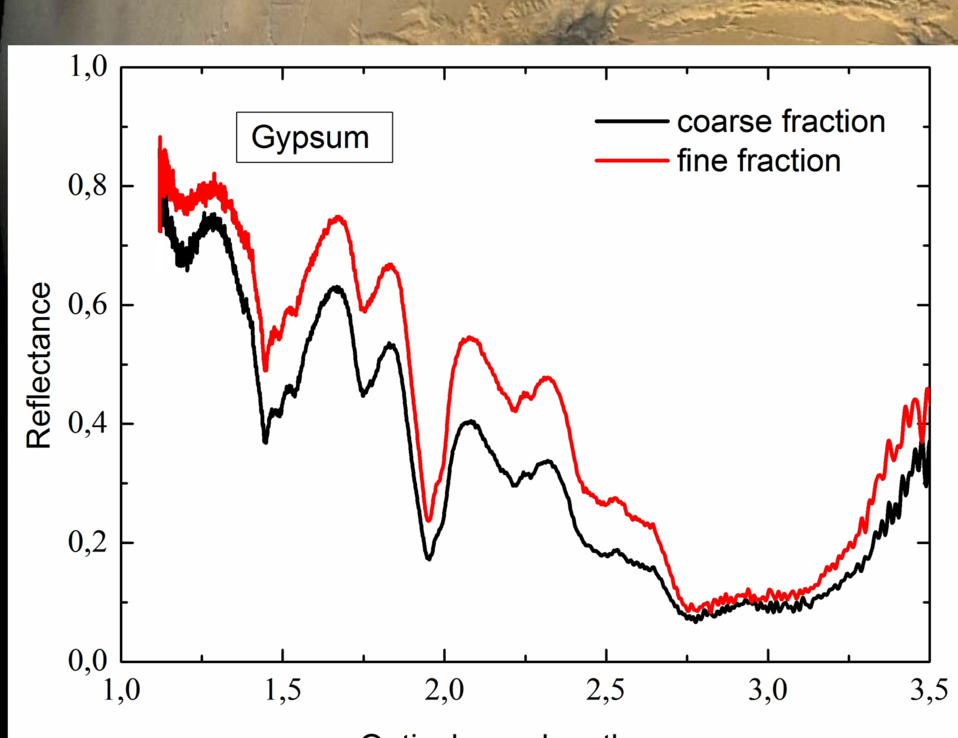



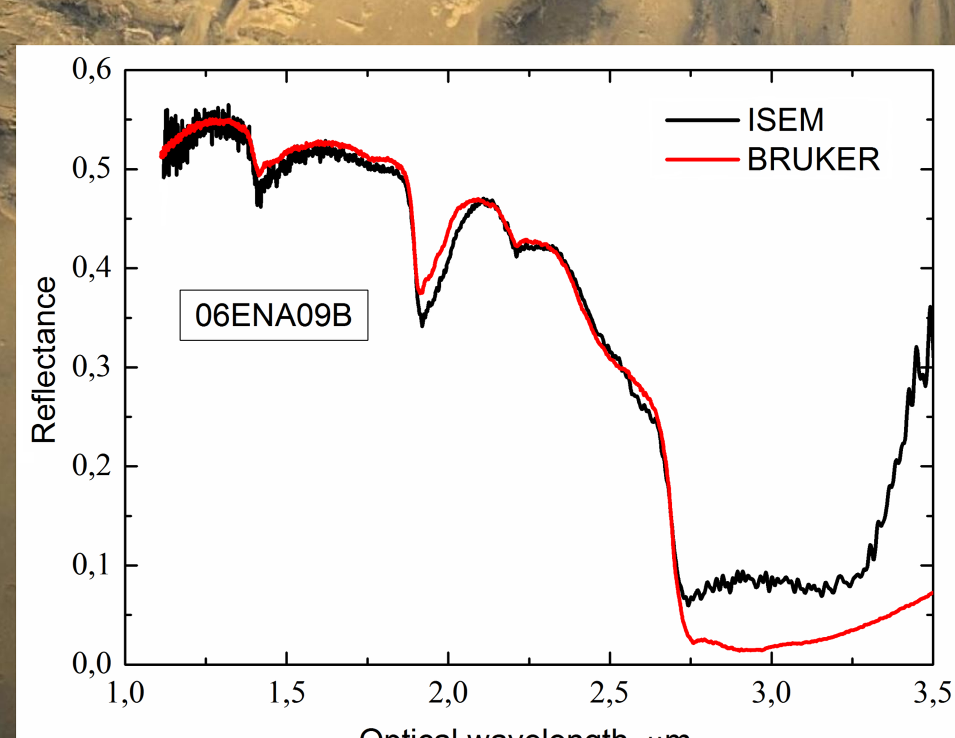

## Measurements and science goals

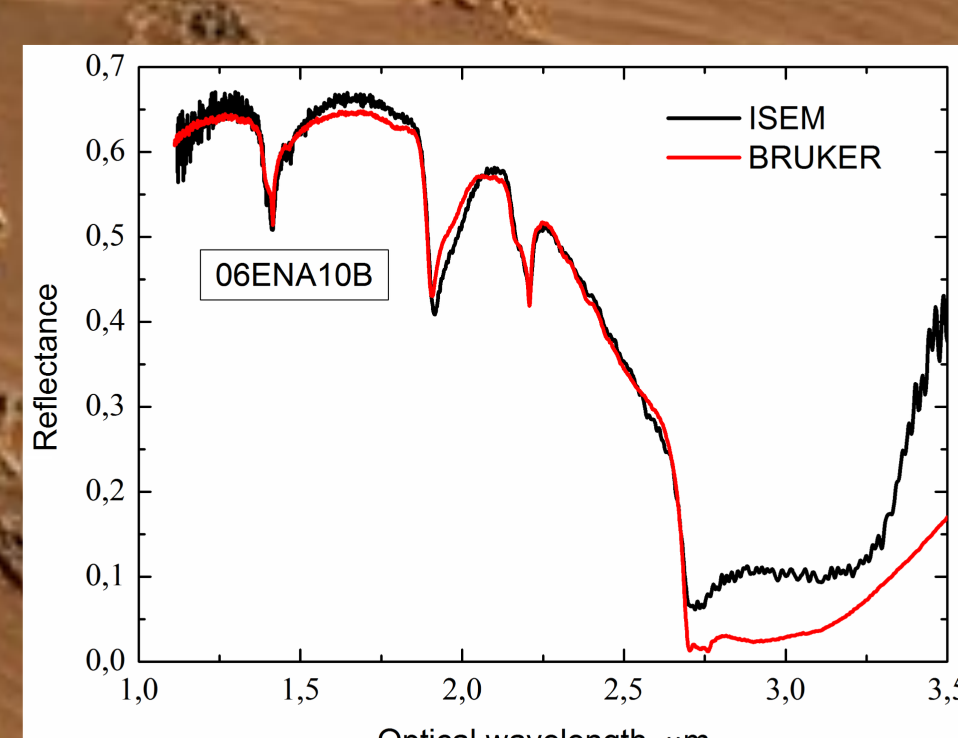



❑ ISEM spectral range 1.15-3.3 µm is optimal for $H_2O$/OH mineral detection.
❑ One of most acceptable band for ISEM studies is ~3 µm.
❑ Characterization the composition of Martian surface materials, discriminating between various classes of silicates, oxides, hydrated minerals and carbonates.
❑ Identification and mapping of the distribution of aqueous alteration products on Mars

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|---|---|---|
| **06ENA09b** | Smectite (MLM) | 69,81% |
| | Bassanite | 9,15% |
| | Jarosite | 8,33% |
| | Albite | 6,5% |
| | Gypsum | 6,21% |
| **06ENA10b** | Smectite (MLM) | 74,35% |
| | Kaolinite | 16,1% |
| | Hematite | 5,7% |
| | Anatase | 2,6% |
| | Goethite | 1,25% |

## References


[1] O. Korablev, A.Ivanov, A. Fedorova et al.,Development of a mast or robotic arm-mounted infrared AOTFspectrometer for surface Moon and Mars probes, Proc. of SPIE, Vol. 9608, p. 960807-1.
[2] O. Korablev, Y. Dobrolensky, N. Evdokimova et al., "Infrared Spectrometer for ExoMars: A Mast-Mounted Instrument for the Rover", Astrobiology, Vol. 17, N 6 and 7, 2017, p. 542.
[3] O. Korablev, D. Belyaev, Y. Dobrolenskiy, A. Trokhimovskiy, Y. Kalinnikov, "Acousto-optic tunable filter spectrometers in space missions", Applied Optics, Vol. 57, N 10, 2018, p. 119.