The MASCOT Radiometer MARA for the Hayabusa 2 Mission

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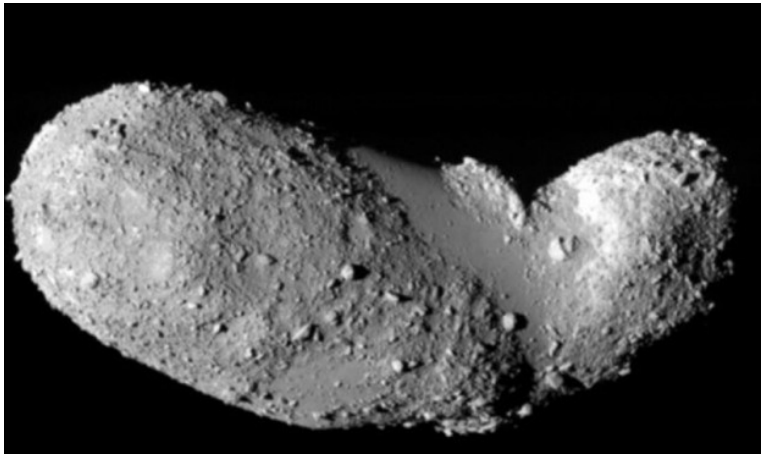
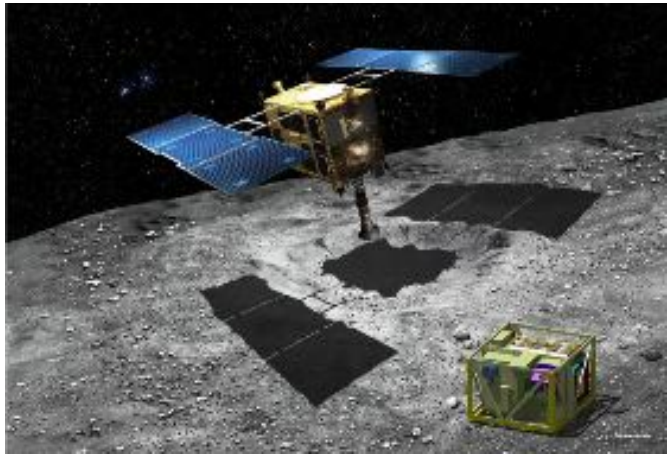
MASCOT on Hayabusa II





- Target asteroid is C-type 1999JU3
- Hayabusa II to be launched in 2014, asteroid rendezvous in 2018
- Hayabusa primary mission goal is sample return in 2020
- MASCOT is a mobile lander to be deployed by Hayabusa II
- MASCOT carries a magnetometer, a camera, an infrared hyperspectral microscope (MicrOmega), and a radiometer
- Low cost instrument on low cost lander on low cost mission

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MAscot RAdiometer (MARA) Science Goals

- Radiometric determination of the *surface brightness temperature* for a full asteroid rotation, possibly at multiple sites
- *Derivation of surface thermal inertia*
- Determination of band ratios in selected wavelength channels, constrain the landing site mineralogy

- Strong heritage from Rosetta MUPUS-TM (sensors), Bepi-Colombo MERTIS Radiometer (electronics) , follow up on HP^3-InSight
- Agressive schedule (2.5 yrs), limited resources (Mass, Energy, €)
- No changes to key systems, so far on track (QM delivery 24.6.)

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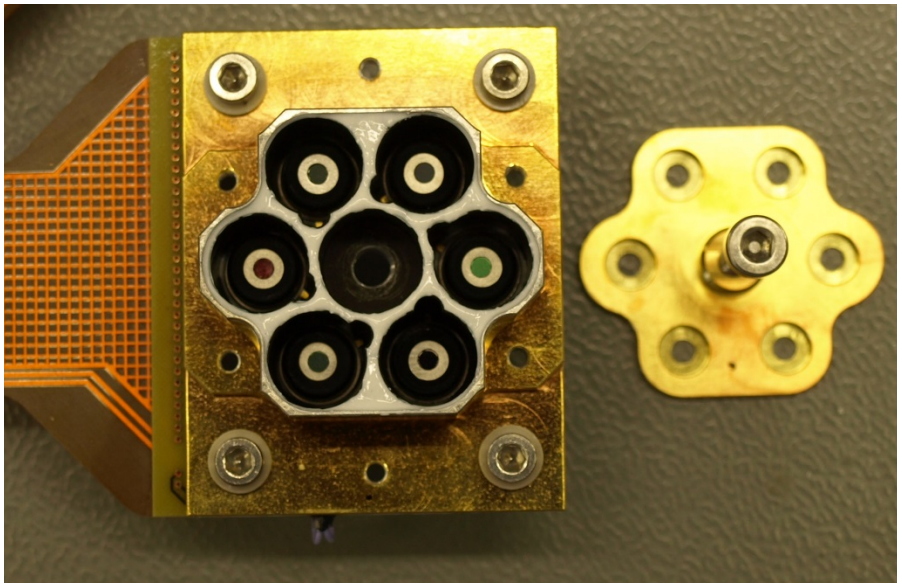
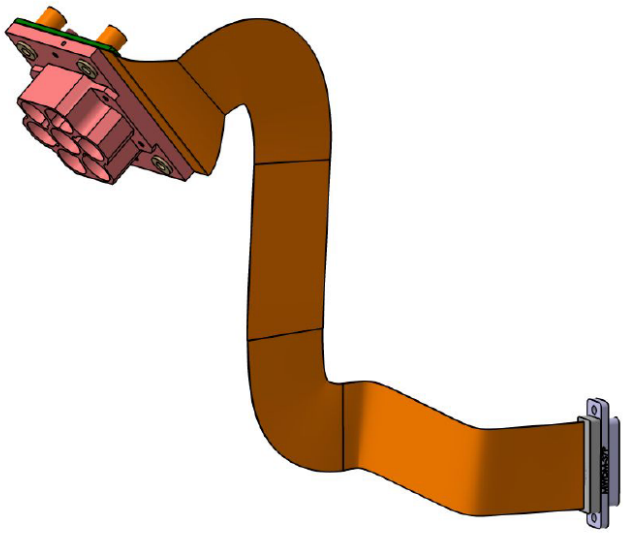
MARA Sensor Head





- Sensor head has 6 thermopile sensors, each with a FoV of 20°
- Each sensor has an individual absorber, filter, and PT100 sensor
- The sensor head is temperature controlled for good S/N
- Gold-coating is used to lower emissivity and save power during heating.

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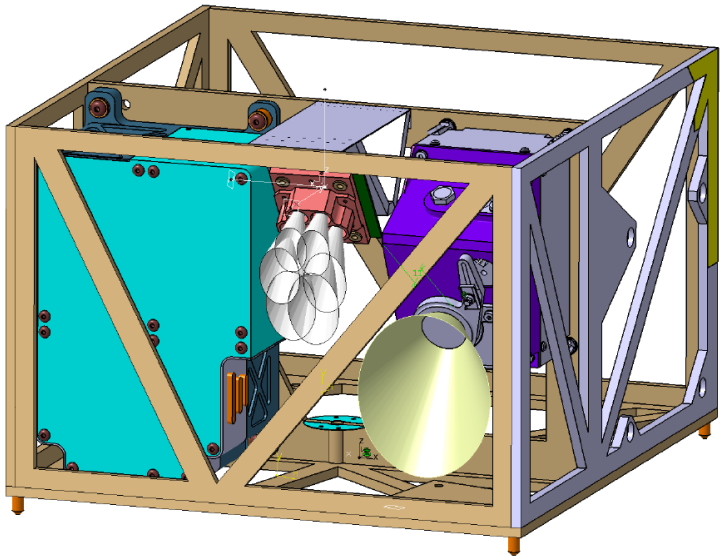
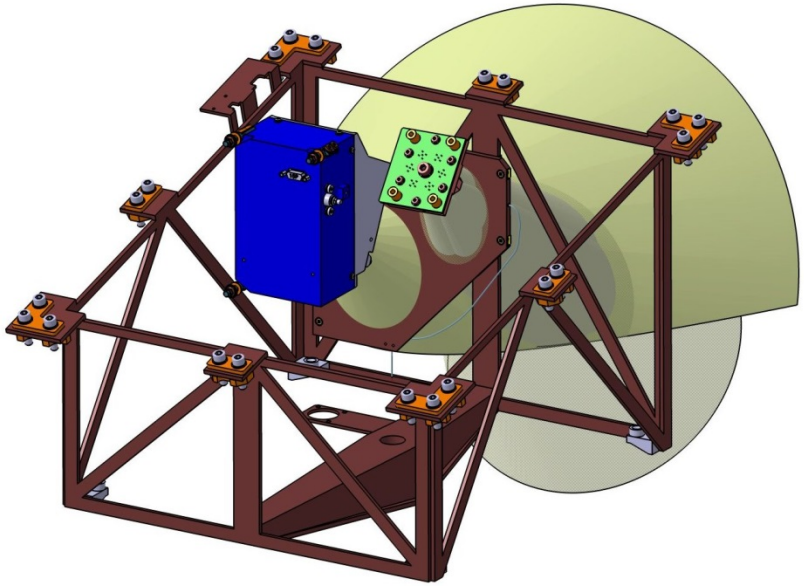
MARA Accommodation





- Sensor Head is mounted inside the MASCOT Payload Compartment
- MARA electronics are mounted insided the warm electronics box
- MARA has a common FoV with the MASCOT CAM
- An inflight calibration target is mounted in the MARA FoV during cruise

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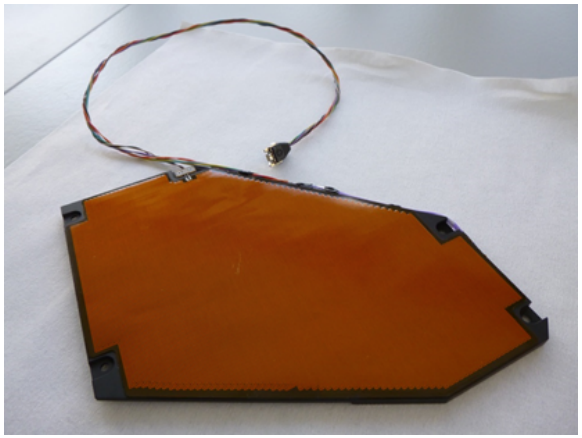
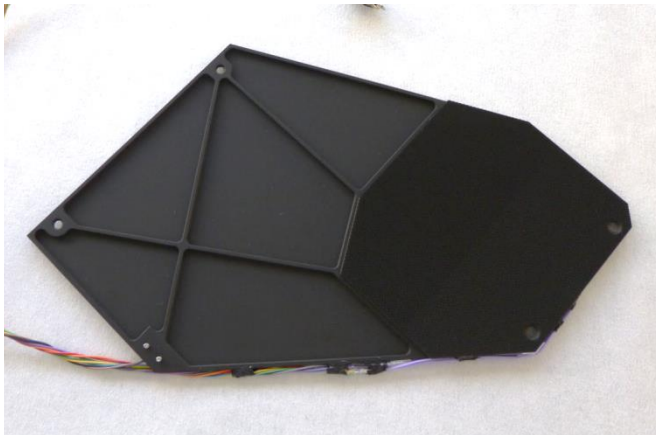
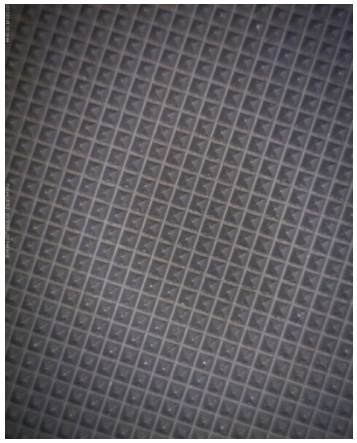
Onboard Calibration Target







- The calibration target will stay on the orbiter after separation.
- The CalTarget surface is structured to increase emissivity to >0.95
- The target can be temperature controlled for in-cruise calibration checks and possible recalibration.

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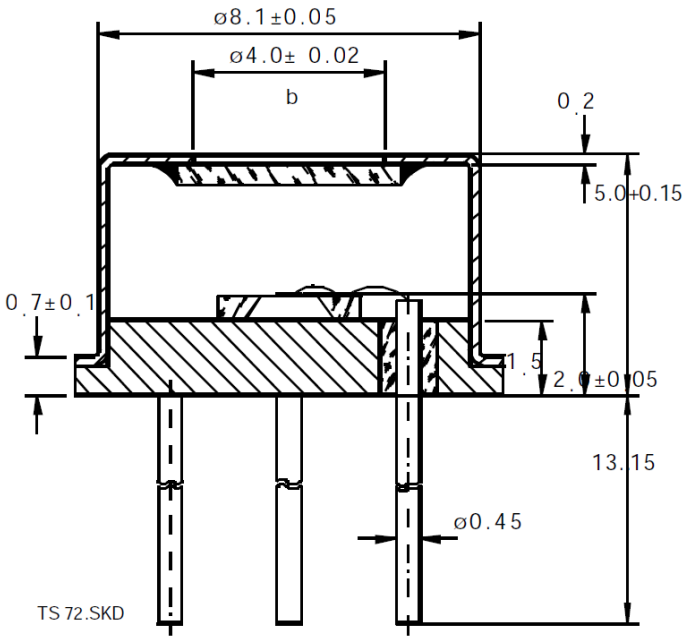
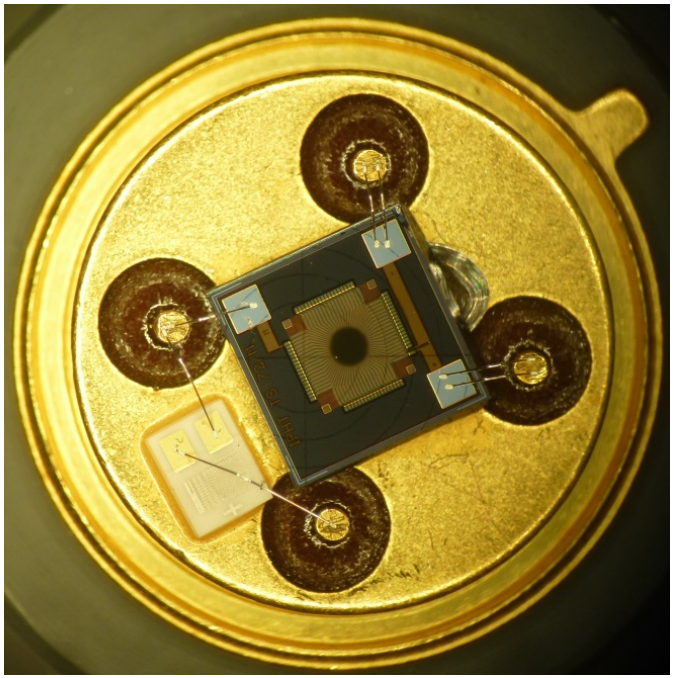
Thermopile Sensors





- TO-39 housing with individual IR Filter, same technology as MUPUS-TM Sensors, built by IPHT (Jena)
- Thermopile voltage generated by 72 Bismuth-Antimony thermopair junctions, absorber size is 0.5 mm diameter
- Cold junction temperature measured by bonded mini-Pt-100

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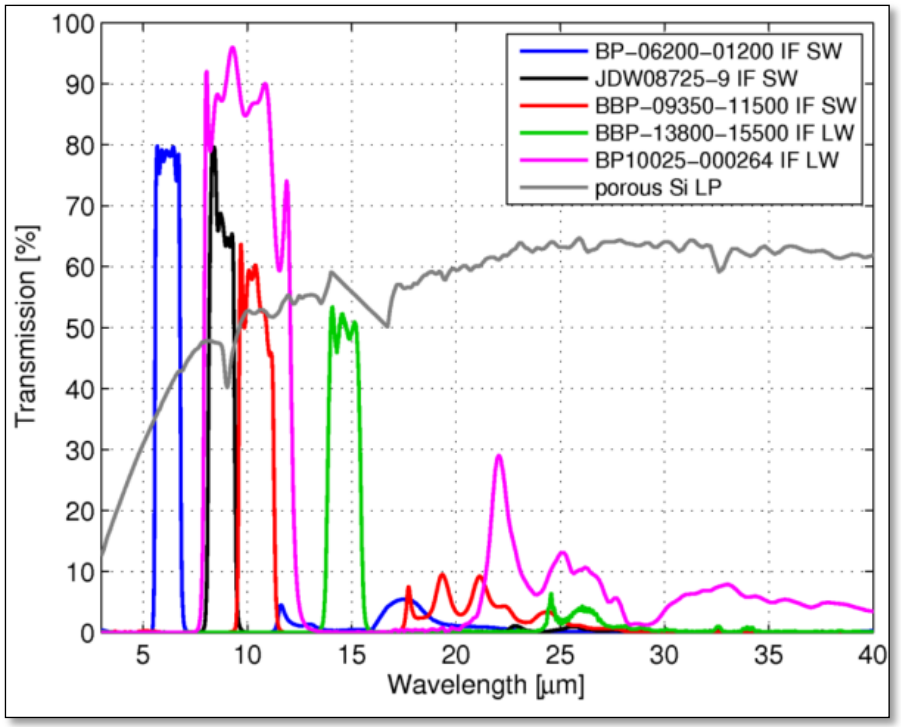
Measurement Approach



- Measure the radiative flux emitted by the asteroid using thermopile sensors.
- Use one long-pass channel for surface brightness temperature determination
- Use one channel identical to the S/C thermal mapper

- Use 4 bandpass filters to constrain emissivity ratios and compare the results to laboratory spectra to constrain asteroid surface mineralogy

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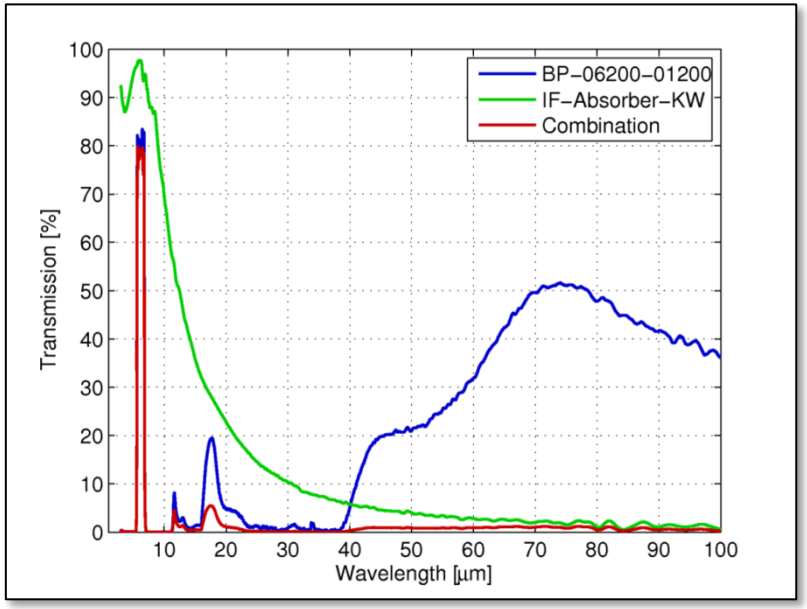
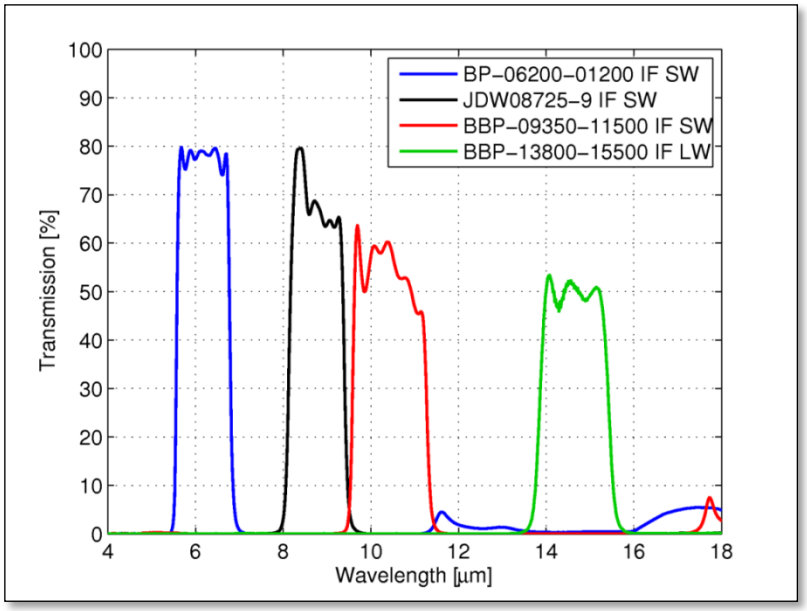
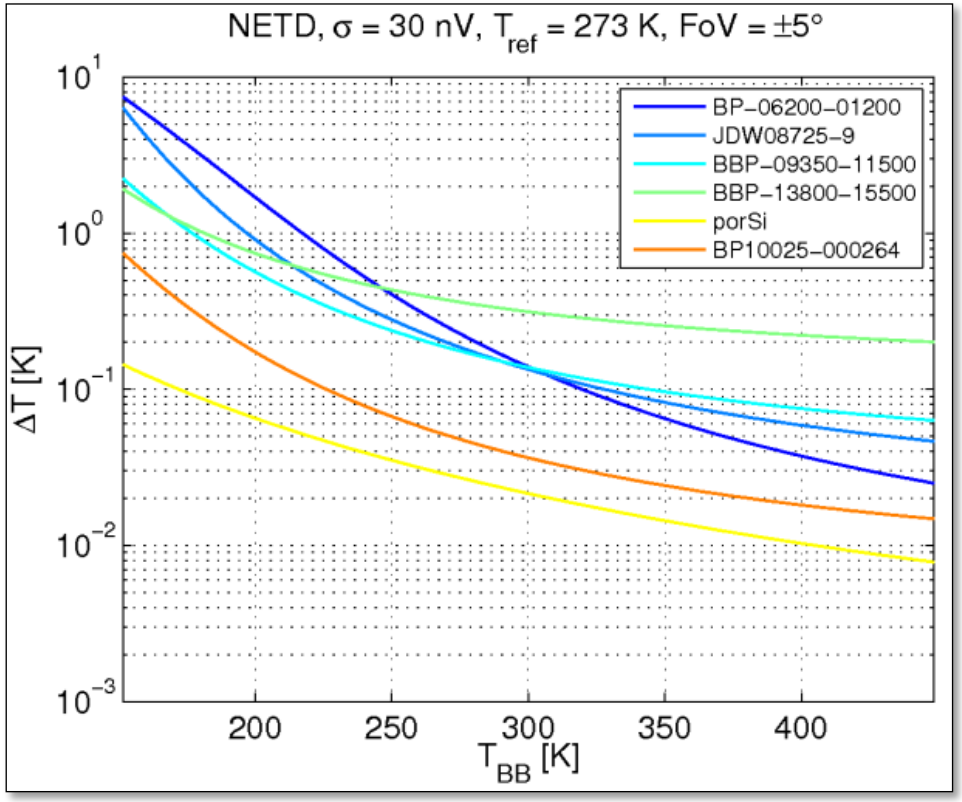
MARA Bandpass Filters





- Use of different absorber surfaces allows for blocking long wavelength contributions
- In this way, clean band-passes are obtained

Expected Temperature Performance



- Electronics Noise is 30 nV for an integration time of 1s per channel
- NETD <0.2 K at 150 K
- Bandpasses yield large S/N only for daytime temperatures due to small FOV
- Instrument performance critically depends on thermal stabilization.

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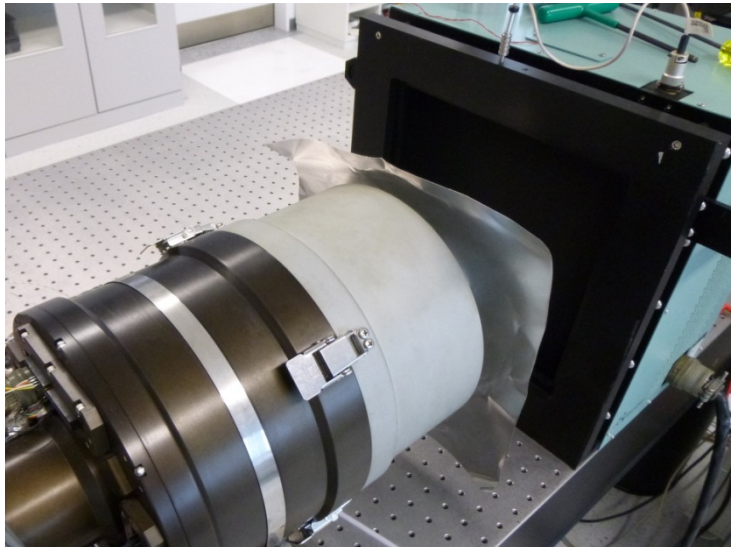
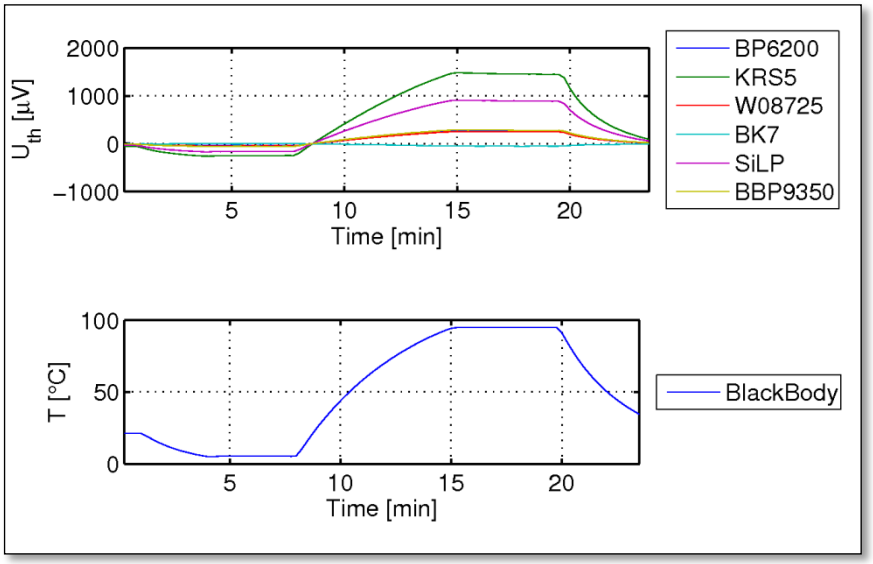
Laboratory Testing





- Preliminary lab tests use a small vacuum cryostat.
- MARA views a black-body through a KRS-5 window
- Setup can be used to deterimine instrument sensitivity between +5 and +95 °C.
- Measured thermopile voltages are between a few and 1000 µV.

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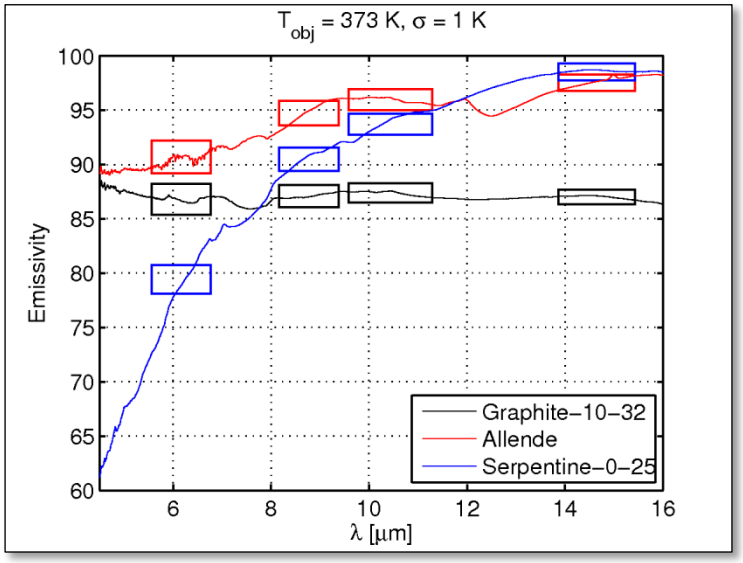
Mineralogical Chariacterization

Graphite Allende (CV) Serpentinite

- Laboratory spectra measured in the Planetary Emissivity Lab at DLR



- MARA will determine band ratios using the four bandpass channels
- Measurement uncertainties should allow for a robust determination of spectral slope

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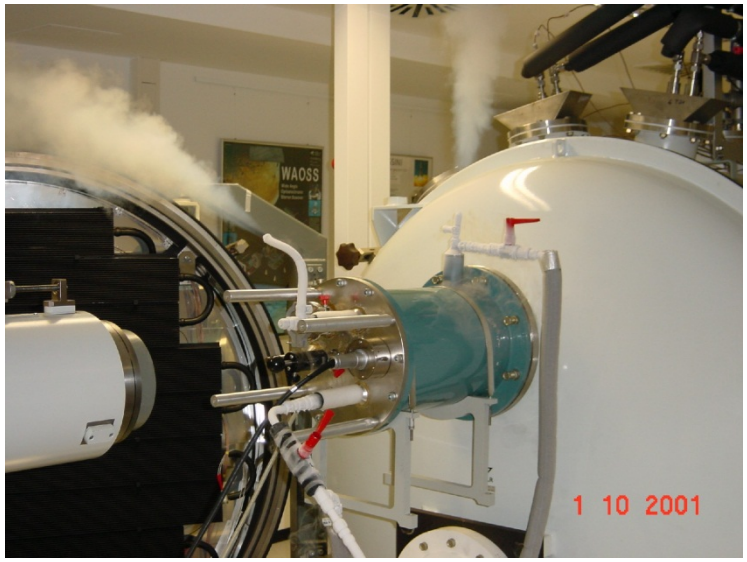
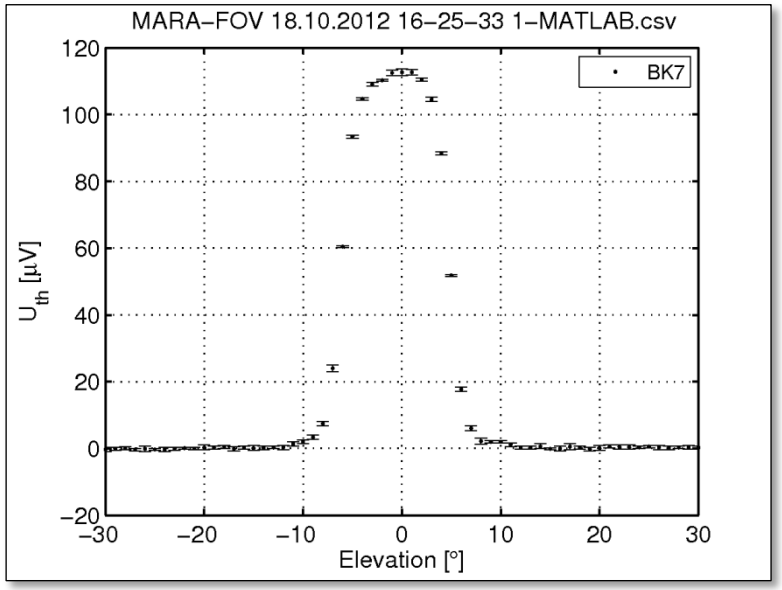
Radiometric Calibration



- MARA will be radiometrically calibrated using the low+high temperature cavity black bodies inside the SSR at DLR (Berlin).
  - Aperture = 100 mm, ε > 0.995
  - LTBB: 100-400 K
  - HTBB: 300-900 K

- It is planned to cross-calibrate MARA and the orbiter TIR using the JAXA calibration facilities

Geometric Calibration



- The MARA FoV is limited by the MASCOT structure.
- Field of view characterization will be done using the DLR pan-tilt unit and collimated blackbody.
- Tests on the engineering model confirmed a FoV of 20 deg.

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Engineering Budgets

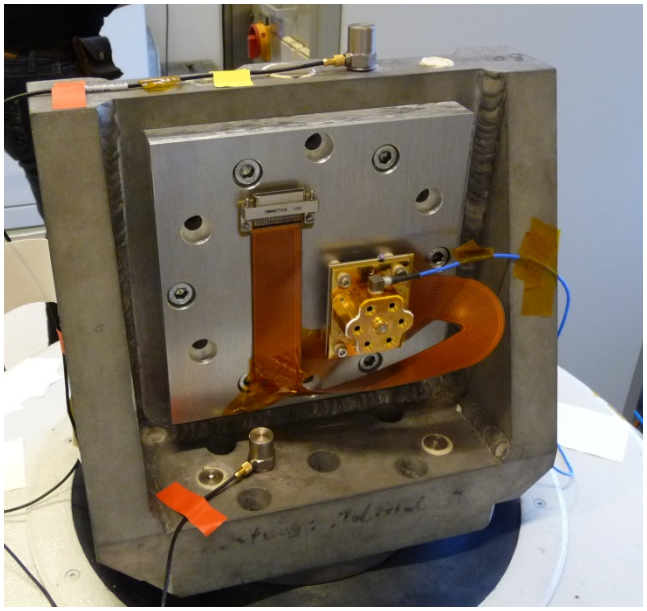
- Thermopile sensor mass: 1.2 g
- Sensor head total mass: 90 g
- Calibration target: 100 g
- Electronics: 100 g
- **Total Mass: 290 g**

- Electronics Power dissipation: 0.7 W
- Temperature Control Power dissipation: 1-2 W, depending on thermal environment
- **Average Power dissipation: 1.7 W**

Summary

- MASCOT will investigate 1999JU3 at multiple (2-3) sites
- MARA will measure the asteroids surface temperature for a full day-night cycle at at least one location.
- The instrument weights 290 g and uses 1.7 W on average

- A long-pass channel measures surface brightness temperature
- 4 bandpass channels constrain mineralogy and emissivity
- One channel provides ground truth for the orbiter thermal mapper (TM)



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