THE MERCURY RADIOMETER AND THERMAL INFRARED IMAGING SPECTROMETER (MERTIS) ONBOARD BEPI COLOMBO: FIRST INFLIGHT CALIBRATION RESULTS. M. D'Amore[1], J. Helbert[1], A. Maturilli[1], I. Varatharajan[1], B. Ulmer[2], T. Säuberlich[1], R. Berlin[1], G. Peter[1], I. Walter[1], H. Hiesinger[3] , [1]German Aerospace Center, Berlin, Germany (mario.damore@dlr.de), [2]Ingenieurbüro Bernd Ulmer, Frankfurt (Oder), Germany, [3]Westfälische Wilhelms-Universität Münster, Institut für Planetologie, Münster, Germany.

Introduction: The MErcury Radiometer and Thermal Infrared Spectrometer (MERTIS) is an instrument to study the mineralogy and temperature distribution of Mercury's surface in unprecedented detail.

During the nominal mission, MERTIS will map the whole surface at 500 m scale, combining a push-broom IR grating spectrometer (TIS) with a radiometer (TIR) sharing the same optics, instrument electronics and in-flight calibration components for the whole wavelength range of 7-14µm (TIS) and 7-40µm (TIR) [1].

MERTIS successfully completed its planned tests of the Near Earth Commissioning Phase (NECP) between 13 and 14 November, collecting thousands of measurements of its internal calibration bodies and deep space. The data collected during NECP in particular, are going to be used to verify the operational performances of onboard sub-modules, in particular the spectrometer and radiometer sensor sensitivity. A preliminary look at calibrated data shows a performance comparable with ground-based measurements.

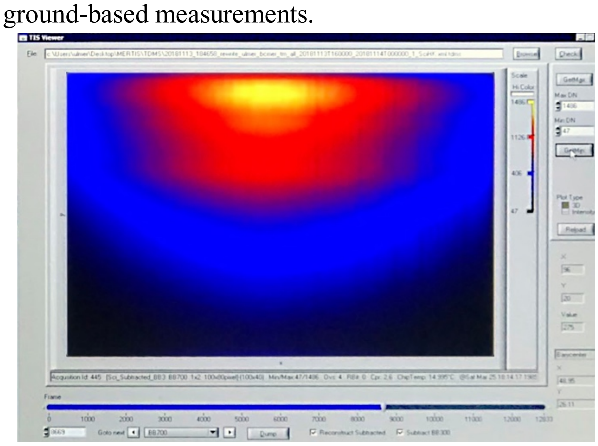

Fig. 2 : First quicklook of TIS spectrometer acquisition.

The Mission and the Instrument: BepiColombo[2] is a dual spacecraft mission to Mercury that has been launched in October 2018 and is jointly carried out by the European Space Agency (ESA) and the Japanese Aerospace Exploration Agency (JAXA).

The spacecraft comprises two separate orbiters: the Mercury Planetary Orbiter (MPO) , which have a suite of instruments dedicated to complement the NASA/MESSENGER observations of the surface and internal composition, and the Mercury Magnetospheric Orbiter (MMO), which will study the particle science in the extreme thermal environment. In addition to a complementary suite of instruments, BepiColombo will be able to observe both the northern and southern hemispheres at high spatial resolution. BepiColombo uses an innovative solar electric propulsion system and its trajectory toward Mercury is a combination of low-thrust arcs and flybys at Earth, Venus, and Mercury. This will allow to reach Mercury with low relative velocity. The Spacecraft was successfully launched on the 20th of October 2018, 01:45 UTC , from the ESA Guiana Space Centre using an Ariane 5 rocket and will reach its mappings orbit at Mercury in 2026.

The MERTIS instrument was proposed in 2003 as payload of the Mercury Planetary Orbiter spacecraft of the ESA-JAXA BepiColombo mission and the final Flight Model (FM) was delivered in 2013. MERTIS is an innovative and compact spectrometer, that combines a push-broom IR grating spectrometer (TIS) with a radiometer (TIR) in only 3Kg of mass and an average 10 W power consumption [1,3,4]. TIS operates between 7 and 14 µm and will record the day-side emissivity spectra from Mercury, whereas TIR is going to measure the surface temperature at the day- and night side in the spectral range from 7-40 µm corresponding to temperatures from 80- 700 K. TIR is implemented by an in-plane separation arrangement, while TIS is an imaging spectrometer with an uncooled micro-bolometer array. The optical design of MERTIS combines a three mirror anastigmatic lens (TMA) with a modified Offner grating spectrometer. A pointing device allows viewing the planet (planet-baffle), deep space (space-baffle), and two internal black bodies at 300 K and 700 K temperature, respectively. MERTIS was developed at DLR in collaboration of the University of Munster and industry partners. The MPO operational plan foreseen a 2.3 hour low eccentricity orbit that allows MERTIS to achieve its 500 meters global mapping scientific goal. MERTIS's design and performance drivers have been changed and fine-tuned in response to the NASA/MESSENGER mission and with the data obtained from the Planetary Emissivity Laboratory and IRIS laboratory. One of the main conclusions was that TIR is the most useful wavelength to image Mercury. With a high Signal-to-Noise Ratio (SNR), some surface minerals, mainly feldspar can be identified due to their characteristic spectral features in this range. MERTIS scientific objectives are: 1. Study of Mercury's surface composition; 2. Identification of rock-forming minerals; 3. Mapping of surface mineralogy; 4. Study of surface temperature and thermal inertia. The MERTIS spectrometer aims to capture data on the mineralogy whereas the radiometer surveys the thermal inertia of the planet. The incoming radiation is guided via a baffle, protruding from the instrument[5]. The radiation is then fed to the spectrometer and bolometer in the instrument. Thermal instability can cause highly inaccurate readings; hence MERTIS's mode of operation is designed to avoid this.

Instrument Commissioning : A few weeks after launch, BepiColompbo started the payload Near Earth Commissioning Phase (NECP). MERTIS first command was sent on the 13th Nov. 2018, 10:51:11 UTC and switched off at the end of the last ground station pass on the 14th Nov 2018 16:46:47 UTC for a total operation time of 1 days 05:55. The night between the 13th and 14th was used to reach high thermal stability and not to perform any science, because the spacecraft was out of ground station visibility. Effective operation time was or ~7:45 hours on the first day and ~7 hours on the second day. The operation plan developed for the NECP was aiming to verify the operational performances of all the instrument sub-modules, in particular the spectrometer and radiometer sensor sensitivities, the pointing unit (MPOI), and the thermal stability of the whole instrument. Figure 1 shows the actual list of Telecommands (TCs) sent to the MERTIS instrument on day 1 and 2. Almost half of the first day was used to set and check the thermal stability of the instrument, sending TC and dumping housekeeping (HK) parameters. Some live adjustments of onboard parameters were needed to reach an operative status. Once the instrument reached a satisfactory status, the Science Mode was enabled at 14:16 to 14:56, looking at deep space, effectively acquiring the first MERTIS data ever in space. After that, another 3 data sessions were performed, changing the TIS binning and executing the normal operation/calibration cycle of 60 seconds: the 300K Blackbody/700K Blackbody/Deep space/Planet View. The latter position is currently obstructed by the MTM structure and will be freed after Mercury orbit insertion. In each measurement session a TIS acquisition took 100 milliseconds, plus the time to rotate the MPOI to different positions. The instrument was left on and in thermally stable condition during the night to start with highly stable thermal condition on the 2nd day. The second day had similar data operation pattern, with a much higher housekeeping generation rate, each second instead each 20 seconds, as default for the nominal mission. The total amount of scientific data and housekeeping data is on the order of 1.15 GB, for a total of around 120k TIS and 15k TIR acquisitions. The MERTIS Team is using those data to develop and test a complete ingestion, calibration and transformation pipeline for MERTIS data, from raw telemetry level data to calibrated products and higher-level derived products[5]. The next important dates for MERTIS are the Earth/Moon flyby on 6 April 2020 and the first Venus flyby on 12 October 2020. Both those encounters will be important both for further instrument calibration refinement and for possible unprecedented measurement in the thermal infrared of the Moon and Venus.

References:

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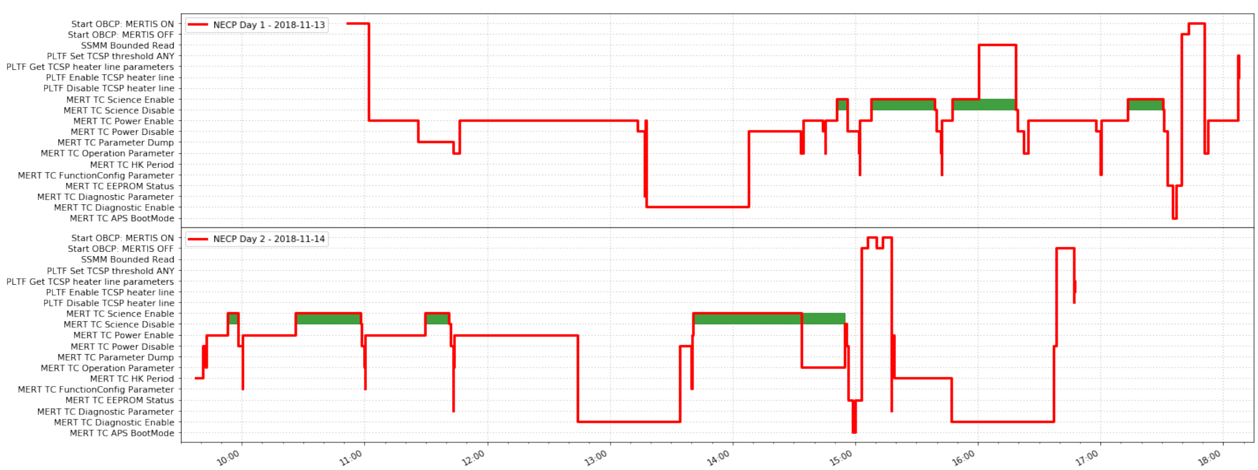

Fig. 1 : List of Telecommand sent to MERTIS instrument in the two commisioning days (top/bottom panel) versus UTC time. The green area is the timeframe of actual data acquisition (between MERTIS Science Enable/Disable commands).