THE MERCURY RADIOMETER AND THERMAL INFRARED IMAGING SPECTROMETER (MERTIS) ONBOARD BEPI COLOMBO: LATEST DATA FORMAT IN VIEW OF UPCOMING FLYBYS DATA.

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Abstract

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 [1]. 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) in November 2018 and several checkouts, collecting thousands of measurements of its internal calibration bodies and deep space. Those data show a performance comparable with ground-based measurements. Scientific data will arrive well before the 2025 arrival at Mercury: MERTIS will be observing the Earth-Moon system in April 2020 and Venus in October 2020. Venus will be visited again on August 2021 and the first Mercury flyby will occur on October 2021. MERTIS archival data are stored in Planetary Data System v4 format (PDS4) [2] format, that actually describe 2 physical formats for each MERTIS channel. Each channel will be stored in Flexible Image Transport System (FITS) [3] and in pure ASCII, to maximize both machine and human interaction.

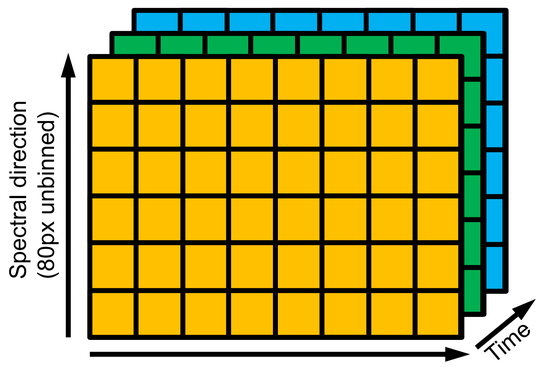
The Mission and the Instrument

BepiColombo [2] spacecraft comprises two separate orbiters: the Mercury Planetary Orbiter (MPO), focused on 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 suite of instruments complementary to the NASA MESSENGER mission, BepiColombo will be able to observe both the northern and southern hemispheres at high spatial resolution. 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) with only 3kg of mass and an average 10 W power consumption [1,4]. 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. A pointing device allows viewing the planet (through the planet-baffle), deep space (through the space-baffle), and two internal black bodies at 300 K and 700 K temperature, respectively. MERTIS was developed at DLR in collaboration with the Westfälische Wilhelm-Universität Münster 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' 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 Spectroscopy Laboratory and IRIS laboratories. As confirmed by the NASA MESSENGER mission, due to the iron-poor nature of the surface the thermal infrared is the most useful wavelength range to study Mercury's surface composition. Silicates as well as sulfides have characteristic spectral features in this range that MERTIS can map with high signal-to-noise ratio.

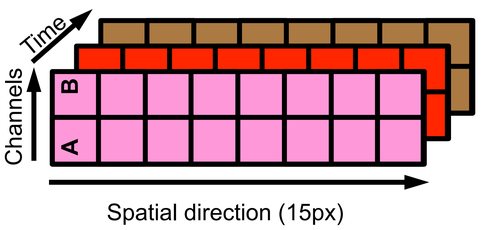
MERTIS Data per Acqusition

MERTIS produces several data for each observation. We describe only scientific data relevant to the end user.

TIS Spectrometer

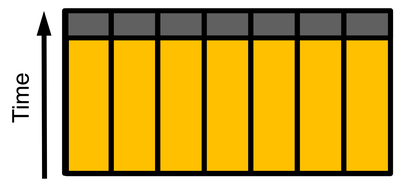


TIR Radiometer

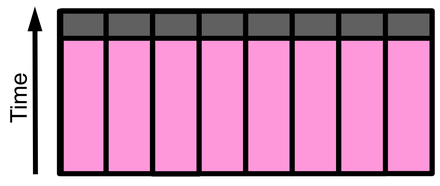


Both sensors deliver 2D arrays of data per observation, multiple observation are assembled as multiple layers. Not-CCD data relevant to each sensor are collected in tables, one row per observation.

TIS Metadata



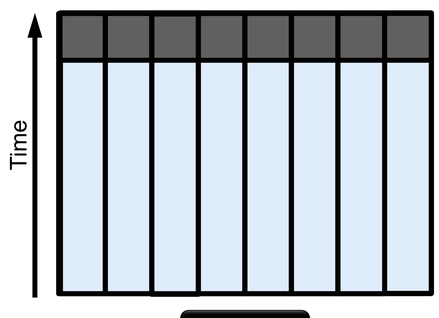
TIR Metadata



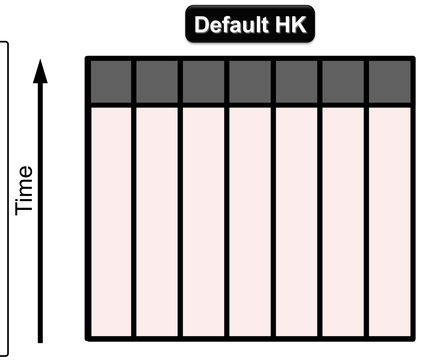
Housekeeping data (relevant to the whole instrument) are simple table, one row per observation.

HouseKeeping

Extended HK



Default HK



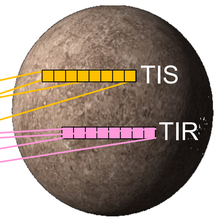
MERTIS Iinstantaneous Field of View

MERTIS two channel IFOV are Arrays projected on the surface, spacecraft movement results in brooming the surface (push-broom).

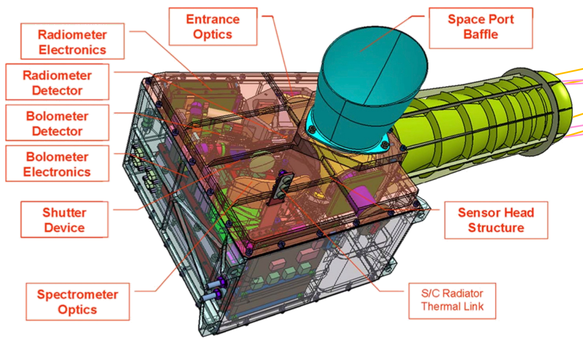
TIS channel disperse light in they direction obtaining the spectrum of incoming light for each pixel between 7-14 µm
Full CCD size is 160x120 pixel (spatial x spectral), but only a central area of 100x80 is exposed to incoming radiation.
The masked are used to evaluate the level of thermal electronic noise.
TIS could operate with several binning and masking mode, to increase SNR and reduce downlink required bandwidth.
The most typical mode at Mercury will bin two pixel in spectral direction (1x2 mode) resulting in an 100x40 array of data.

TIR channel is composed of two contiguous 15 arrays capturing different wavelength (7-14 µm and 7-40 µm).

Spatially this result in a 1D array on the surface of fixed aperture (4° degrees).



< This is FALSE
Channels are co-linear.
Only for clarity.

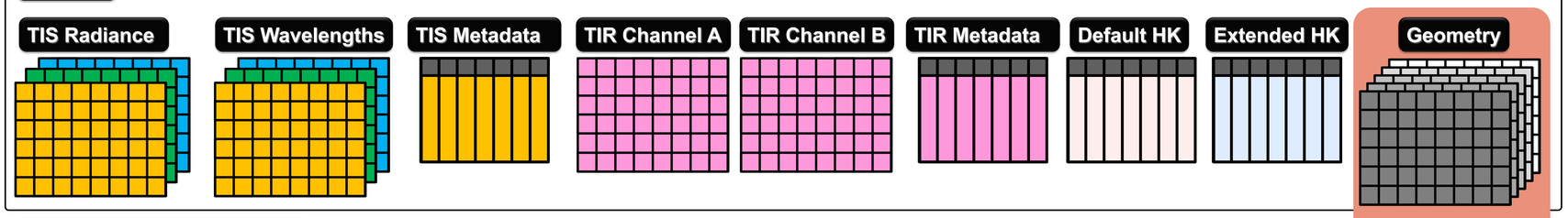


< Schematic view of the MERTIS instrument. Clearly visible is the planet baffle (gray), the space port baffle (bluish–greenish) and the housing structure. Dimensions of the instrument are approximately 180x180x130 mm3. The external baffles are 200 and 90 mm long, the diameter is 75 mm. Total mass is on the order of 3.0 kg.

MERTIS Physical Data Format

MERTIS data are stored in PDS4 format. The physical data format is Binary FITS and ASCII for all products, each one with accompanying PDS4 XML label. Each box represents one single physical file.

FITS File

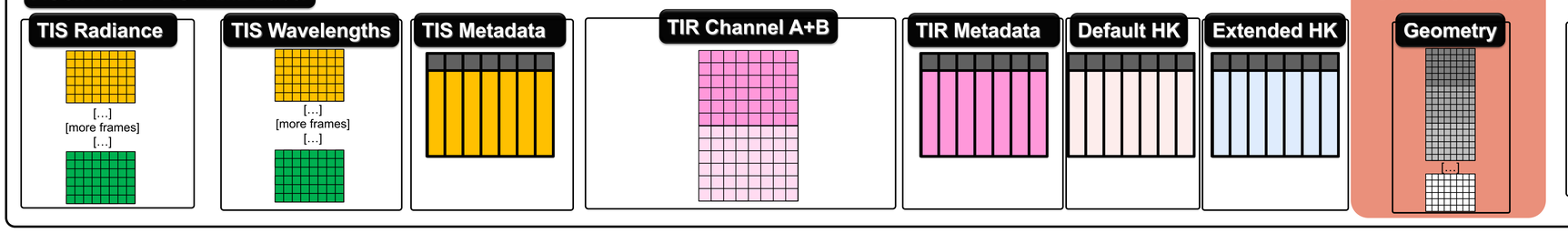


PDS4 XML Label

PDS4 Label file describing the FITS file content

[TIR channels are unstacked and stored per channel]

ASCII File + PDS4 XML Label



PDS4 XML Label

PDS4 Label file describing all the ASCII files content

References

[1] Hiesinger, H. and Helbert, J., Planet. Space Sci. 58, (2010).
[2] NASA Planetary Data System, pds.nasa.gov
[3] FITS Support Office, fits.gsfc.nasa.gov
[4] Instrument User Manual (FM), MER-DLR-MA-001 (2017).
[5] Python PDS4 Tools, SBN sbndev.astro.umd.edu/wiki
[6] The ESA's Planetary Science Archive PSA, archives.esac.esa.int/psa
[7] Astropy Coll. , AJ 156, 123 (2018).