THE MERCURY RADIOMETER AND THERMAL INFRARED IMAGING SPECTROMETER (MERTIS) ONBOARD BEPI COLOMBO: FIRST INFLIGHT CALIBRATION RESULTS

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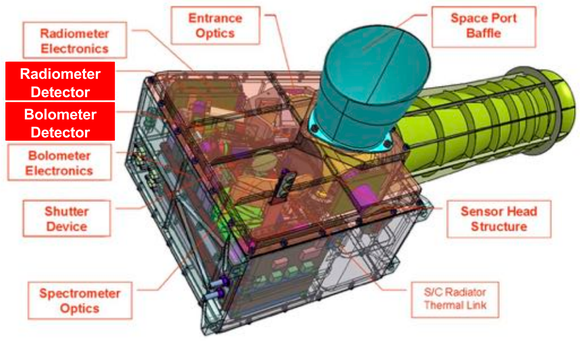
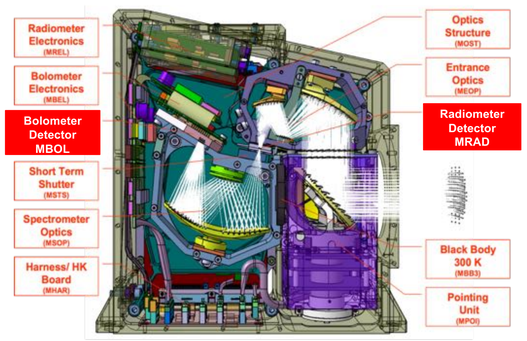
Abstract

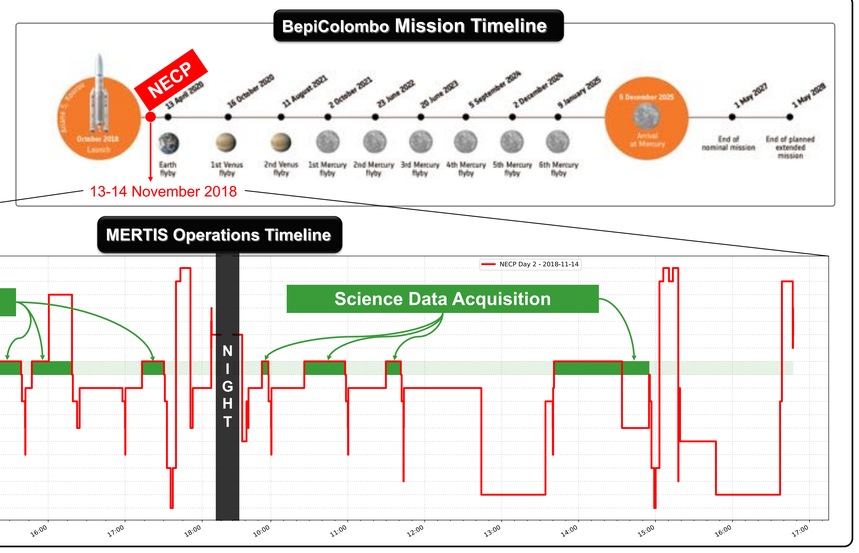
The MErcury Radiometer and Thermal Infrared Spectrometer (MERTIS) is an instrument to study the mineralogy and temperature distribution of Mercury's surface in unprecedented detail. During the nominal mission, MERTIS will map the whole surface at 500 m scale, combining a push-broom IR grating spectrometer (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). 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.

Instrument and Operations

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.



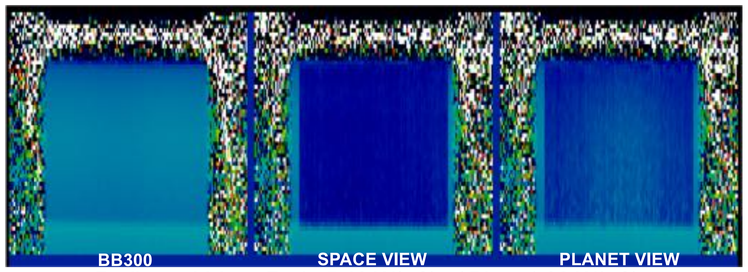




TIS Spectrometer

Inflight Band Radiance Differental Images

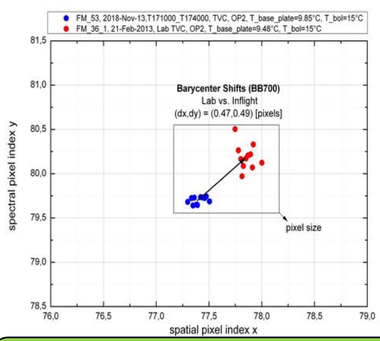
- First inflight images (calibrated, band radiances [W/m²/sr])
- Simple difference images (1 scene – 1 dark)
- Binning: spatial x spectral = 1 x 2
- Datatake from 13-Nov-2018
- OP-Point 2
- BB300 @ 9.09° C
- SSD ca. 89 nm



Radiance Values Red : 5,46 W/m²/sr / Blue -1.38 W/m²/sr

Barycenter Shift - BB700 - InFlight vs. OnGround@TVC

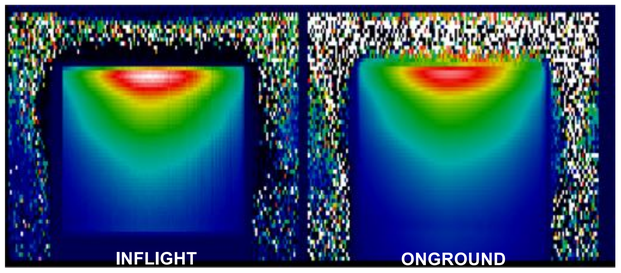
- TIS BB700 – Image Barycenters ; Inflight , BepiColombo NECP ,13-Nov-2018 vs . Lab, 21-Feb-2013, in TVC
- Very similar temperature conditions with T_base_plate as reference: Inflight: 9.85° C vs TVC @ Lab: 9.48° C
- Identical Detector OP-Settings (V_Skim, V_Fid, T_bolometer=15° C)@OP2
- Inflight images were binned (1 x 2) = (spatial x spectral) and „unbinned" before calculations , Lab Images unbinned
- Barycenter calculations over whole scene window with threshold selection of 30 % highest signal values
- Inflight measurements seem to have less noise (probably due to low image offsets, edge of linear region)
- **Very little image shift of ca. half a pixel: (dx , dy) = (0.47 , 0.49) (pixel index units)**



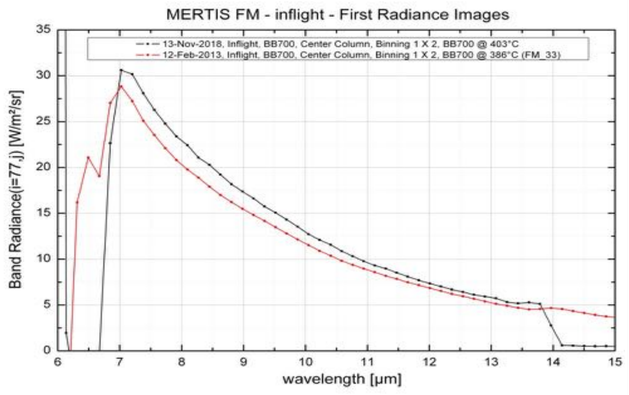
Calibrated BB700 TIR Images : inflight vs. onground

- BB700-2018-Nov-13 @ 403.20° C
- BB700-2013-Feb-12 @ 386.22° C
- Binning: spatial x spectral = 1 x 2
- SSD ca. 89 nm
- Stripes in inflight image probably due to too low image offset (non-linearities)

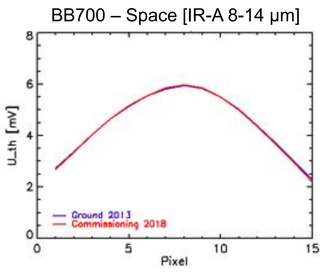
⇒Check / Adapt OP-Settings (V_Skim,V_FID,...)

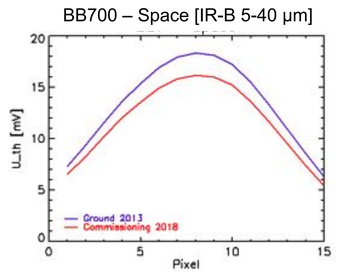


Radiance Values (Red, Blue) : (41.56, -3.63) W/m²/sr



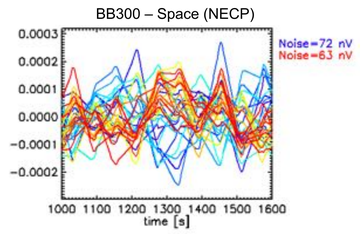
TIR Radiometer

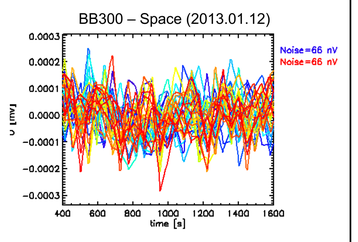




RAD fully functional after launch
Sensitivity decrease of broadband channel by B (5-40 µm) 12% already observed on ground

TIR / Radiometer Noise Performances





MERTIS TIR Status summary

- MERTIS RAD fully functional after launch
- Noise performance unchanged
- Noise" determined from standard deviation of difference between BB3 and space view, Electronics + thermal noise
- Noise dominated by electronics noise
- Thermopile noise < 100 nV
- Pt-1000 noise < 2 mK
- Inflight calibration unit of MERTIS provides a means for correction for observed changes in sensitivity

MERTIS TIS Status summary

- MERTIS TIS fully functional after launch
- Performance comparable with last measurements on ground
- Very small image shift after launch (less than 0.5 pixel)
- Slight change in the parameters for the ADC – adjustments of working points suggested
- Review onboard during next check out
- macropixel calculation and pixel indexing, windowing and dead pixel mask (no doubts, but good practice)

MERTIS NECP Status summary

- MERTIS NECP was successful performed on November 13 and 14
- Both channels of MERTIS are fully operational
- The spectrometer shows performance comparable with the on ground testing
- Some adjustments of working points is recommended to optimize performance
- The radiometer shows a slight degradation of performance for the long wavelength channel
- This was already observed on ground
- Monitoring of the behavior is recommended

References

[1] Hiesinger, H. and Helbert, J., Planet. Space Sci. 58, (2010). [2] Benkhoff, J. et al, Planet. Space Sci., 58, (2010). [3] Walter, I. et al, Proc.SPIE , 8154 (2011). [4] Peter, G. et al , Proc.SPIE, 8867 (2013). [5] Zeh, T. et al, ProcSPIE, 7808 (2010). [6] D'Amore, M. et al, Proc.SPIE, 10765 (2018).