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The calibration setup for the MIST-A IR spectrometer aboard the EMA mission

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MIST-A is the Middle-Wave Infrared (MWIR) Imaging Spectrometer that will be launched in 2028 aboard the Emirates Mission to the Asteroid belt (EMA). The mission will perform six fly-bys during its journey before reaching 269 Justitia in 2034. The main aim of the project is to study the asteroids' origin and evolution, focusing on the examination of the water, organic matter and minerals stored in them and their possible use as resources for future space exploration missions.

MIST-A operates in the 2-5 μm spectral range with a 9 nm/band sampling and its main objective is the identification of the asteroids' surface composition and thermo-physical properties. MIST-A's performances are specifically optimal to detect diagnostic spectral features of primitive asteroids, typically located in the 2.7-4.0 μm range, indicating the presence of hydrated minerals, organic matter, salts and carbonates.

The calibration process is a fundamental step to ensure the reliability of the measurements performed by the instrument.

MIST-A is composed by two units: the Optical Head (OH) and the Electronics Unit (EU).

The design of the OH was inherited from the JIRAM (Jovian IR Auroral Mapper) instrument. It consists of a modified Schmidt telescope equipped with a flat mirror on a 1-axis steerable mechanism at its entrance and joined to the entrance slit of a Littrow spectrometer. The Hybrid-Thinned HgCdTe photodetector of the spectrometer is housed in a thermomechanical structure that also accommodates order-sorting filters and a coldshield and that maintains a temperature < 90 K through an active cryocooler. The rest of the OH operates at a cryogenic temperature of 135 K, reached by means of a passive radiator. The OH is mounted on isostatic legs that thermally isolate it from the spacecraft and its external walls are covered by Multi-Layer Insulation (MLI).

The OH also houses the Internal Calibration Unit (ICU) which is mounted into the telescope's entrance baffle and consists of a flat diffuser with a golden coating illuminated by two IR emitters. A polystyrene filter is placed in front of these sources so that its absorption bands can be used as reference for checking the spectral response in flight.

The EU includes the power converter and distribution unit, the proximity electronics, the scan mirror drive and the CPU board, which contains the command and process control and the data compression software.

MIST-A's calibration campaign will cover the spectral, geometric, spatial and radiometric calibration processes and the characterization of the internal calibration sources.

During the spectral calibration we will characterize the instrument’s spectral responsivity and resolution and its full operative spectral range. The instrument’s boresight alignment, its field of view (FOV) and instantaneous field of view (IFOV) will be tested in the geometric calibration along with the scan mirror’s performances. To define the uniformity of the instrument’s response we will then perform flat-field measurements which additionally will help us check the presence of a vignetting effect. Finally, the radiometric calibration procedure will cover the characterization of the instrument's responsivity and Noise-Equivalent Spectral Radiance.

All these tests will be performed at the nominal OH and detector temperatures. Further measurements taken at warmer and colder temperatures will be used to characterize any observed deviation.

The laboratory setup currently under development in INAF-IAPS, Rome, for the calibration of MIST-A is an evolution of the configuration previously used for the JIRAM instrument.

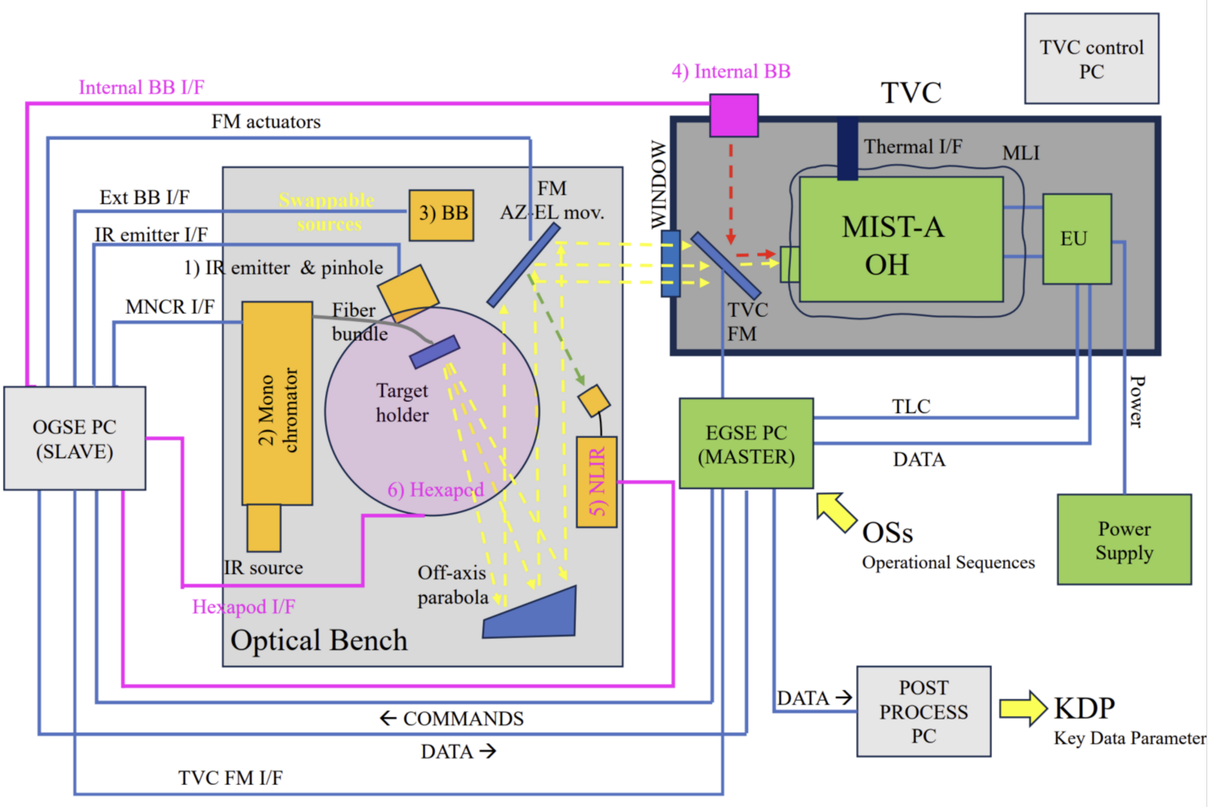

Fig. Laboratory setup used for the calibration campaign of the MIST-A instrument.

MIST-A's Optical Head and Electronics Unit are housed inside a thermo-vacuum chamber (TVC) which maintains their operating temperatures of 130-140 K. The EU is connected to the Power Supply placed outside the TVC.

MIST-A is controlled and monitored by means of the Electrical Ground Support Equipment (EGSE) with relative Master PC, which is electrically connected to the EU. The Optical Ground Support Equipment (OGSE) commands the devices mounted on the optical bench (e.g. folding mirror actuators, Black Body controller, monochromator) via Labview S/W and it can be used both as a standalone system for the characterization and tests of the optical bench, or coupled as a slave to the EGSE to control the bench through commands given by the Master. The EGSE is also connected to the Data Processing PC which receives and elaborates data from MIST-A and the optical bench.

An off-axis collimator is placed on the optical bench with its folding mirror and target holder structure which can support different targets and sources according to calibration requirements. The bench is mounted on a hexapod, operated through the OGSE, which can be used to traslate the optical beam within MIST-A's FOV while maintaining the folding mirror's alignment to the instrument's boresight.

The optical bench also houses the monochromator that will be used during the spatial and geometric calibration. This instrument is equipped with a IR source and its exit slit is coupled through a IR fiber bundle with the target holder on the collimator's focal plane. The configuration chosen for the radiometric calibration involves instead a black body placed inside the TVC and controlled by the OGSE. A movable folding mirror, commanded through the EGSE, redirects the black body's signal on MIST-A's entrance pupil.

Our team at INAF-IAPS is currently working on the integration and testing of the described optical bench setup. We will successively focus on the definition of the Calibration Plan and OGSE User Manual, which will include information on the calibration of the optical bench devices, before proceeding with the integration of the OGSE.

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