The MICADO first light imager for the ELT: Ongoing realization of the MICADO calibration assembly

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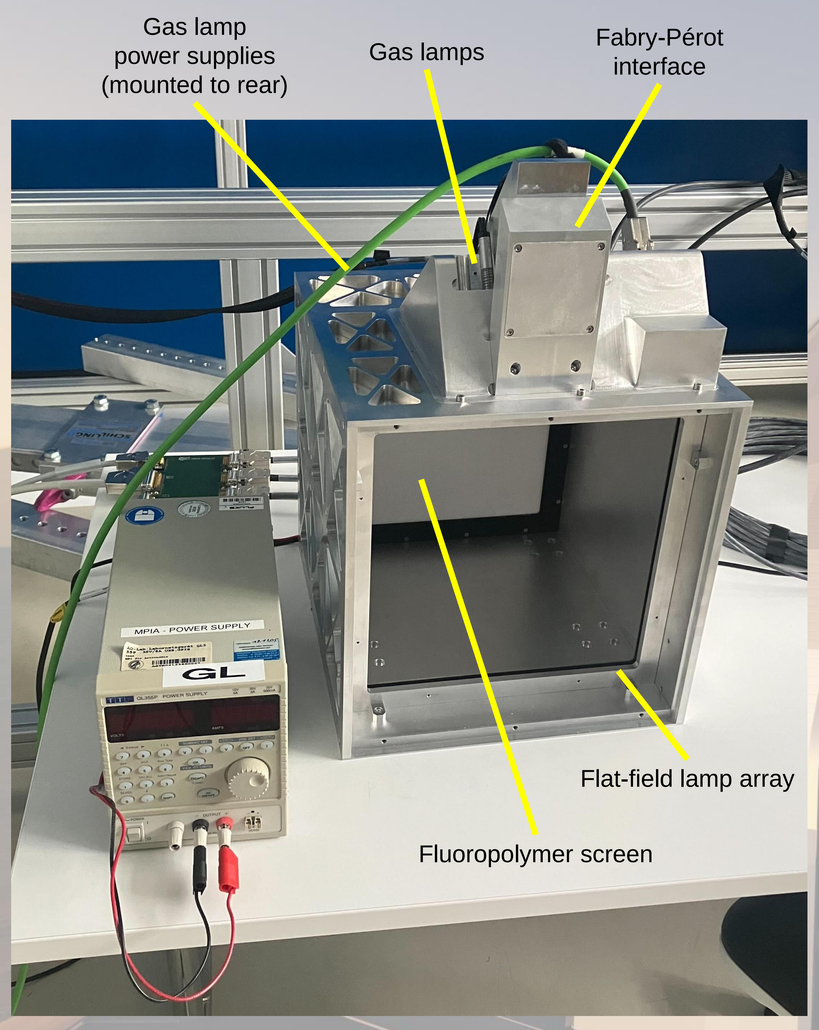
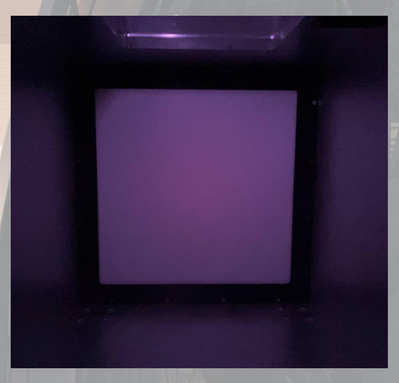
MICADO (Multi-AO Imaging CAmera for Deep Observations) will be a first-light instrument at the Extremely Large Telescope (ELT). The instrument will enable spectroscopy (R ≤ 20,000) and diffraction-limited imaging (~4 – 10 mas) at near-infrared wavelengths (0.8 – 2.4 μm). The MICADO Calibration Assembly (MCA) is deployed to rigorously understand the instrument's performance over its operational lifespan and to provide a reference for data reduction. The MCA is a collection of three independent units affixed to a common mount at a homologous image plane to that of the ELT. The MCA will be in use during both operational phases of MICADO: with the "stand-alone" relay-optics mode when MICADO is first commissioned (where a pivoting mirror in the relay optics train is employed to select the calibration unit in-use) and then a few years later moved to a new mount (on a translation stage) once the Multiconjugate adaptive Optics Relay For ELT Observations (MORFEO) instrument is installed.

Flat-field and wavelength Calibration Unit

The Flatfield and wavelength Calibration Unit (FCU) is composed of a nearly-Lambertian fluoropolymer screen, placed 20-cm behind the ELT focal plane, and illuminated by either an array of tunable, miniature tungsten lamps for detector non-linearity characterization and broadband flat-fielding (globally providing > 90% flatness across the MICADO FoV and with local P-V uniformity of 99.9%), or one of four gas lamps (Ne, Ar, Kr, Xe) for spectral calibration. An interface for a possible future fiber-fed Fabry-Pérot resonator is also present. Fabrication of the hardware is complete; the exterior box is currently undergoing IR black painting treatment. Functionality verification will occur in the latter half of 2024.

FCU enclosure



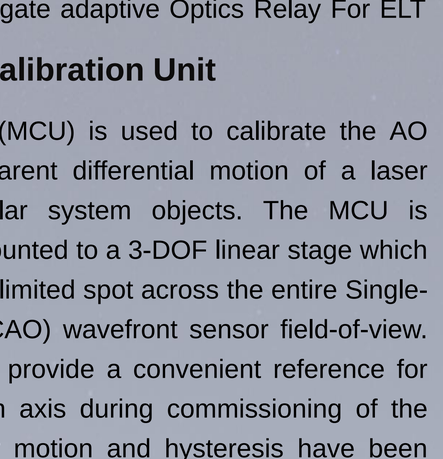


^ Illumination of the FCU prototype pseudo-Lambertian screen by gas lamp. Full screen will extend to edges of box

Movable Calibration Unit

The Movable Calibration Unit (MCU) is used to calibrate the AO system by simulating the apparent differential motion of a laser guide star when tracking solar system objects. The MCU is comprised of a fiber optic tip mounted to a 3-DOF linear stage which continuously slews a diffraction limited spot across the entire Single-Conjugate Adaptive Optics (SCAO) wavefront sensor field-of-view. The MCU will also be used to provide a convenient reference for determining the optical rotation axis during commissioning of the MICADO field derotator. Motor motion and hysteresis have been fully characterized across the ELT operational temperature range. The 30-m fiber is injected with light from a pair of independently flux-tunable, broadband (SLED) light sources in visible and NIR to be sensitive to SCAO and the MICADO detector, respectively (the light is separated by a dichroic within MICADO). The MCU is the first of the three units to be fully built and validated.

MCU, as built

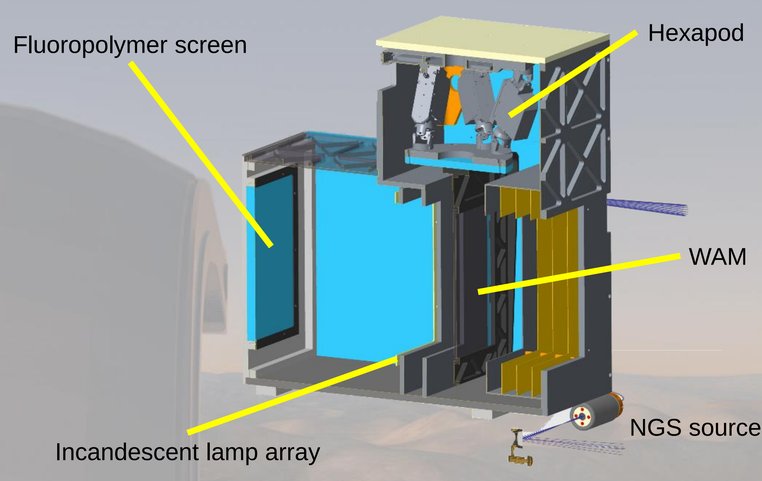


MCA in MICADO Stand-alone Mode

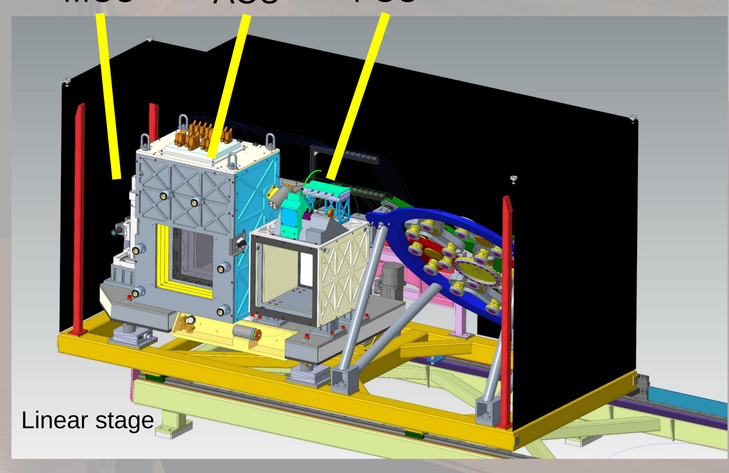
Astrometric Calibration Unit

The Astrometric Calibration Unit (ACU) includes a back-illuminated pinhole mask (Warm Astrometric Mask; WAM) mounted to a micron precision 6-DOF hexapod, used for determining the diffraction pattern and sub-pixel instrumental distortion as measured at the MICADO detector plane. The WAM consists of >60k 30-μm diameter holes in a grid pattern with pseudo-random jitter in the hole position. Determination of the final manufactured hole centroid positions to 30 nm precision (via direct measurement of a small subset of holes, followed by a bootstrap characterization of the remaining holes during MICADO preliminary acceptance testing) will thus enable MICADO to conduct precision astrometry with ≤ 50 μas resolution. The WAM will also be instrumental in determining the exact relative displacements and orientations of the nine MICADO detectors as well as ensuring continuity of astrometric calibration when MICADO transitions from "stand-alone" mode to MORFEO mode after its first few years of operation. The ACU additionally includes three fixed natural guide star (NGS) point sources for MCAO calibration. This calibration unit will also serve as the alignment reference for the MCA as a whole. Production of the WAM is underway; the rest of the unit will be fabricated in early 2025.

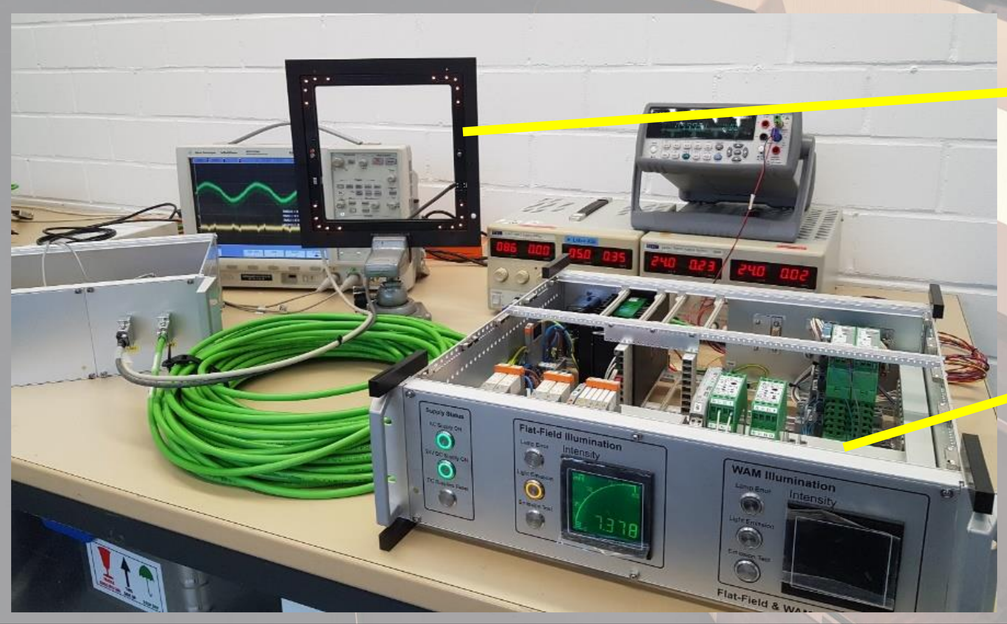
Internals of the ACU

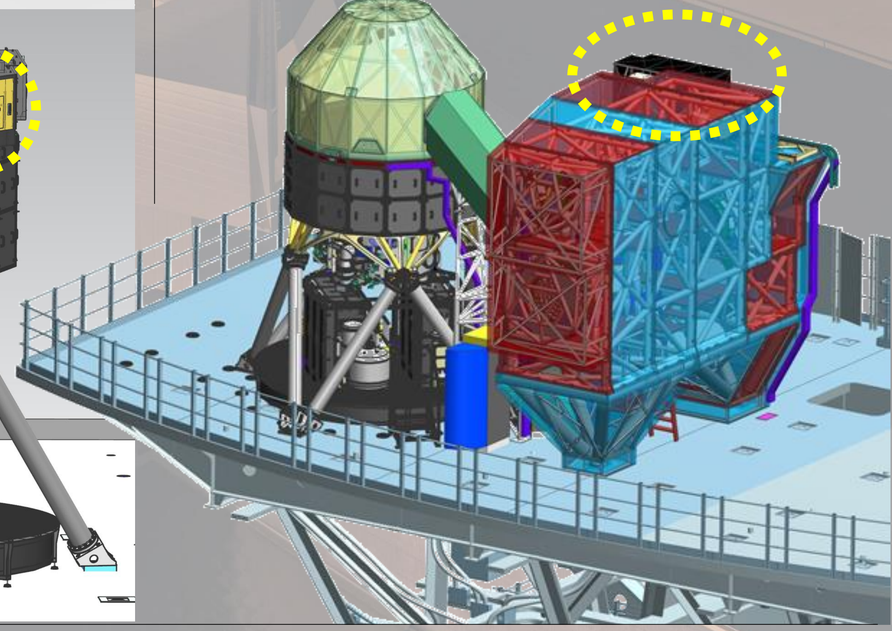


MCA in MORFEO



MCA Electronics





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