

A thermal and mid-infrared imager and spectrograph for the E-ELT

Two Mid-infrared instrumentation studies for the next generation telescope E-ELT have been performed by a consortium consisting of the MPIA, the University of Leiden and ASTRON. The first study called [T-OWL](#) discussed scientific capabilities and technical feasibility of a MIR imager and slit-spectrograph for the 100m-project OWL.

[MIDIR](#) is a combined imager and spectrograph for the 42m European Extremely Large Telescope, E-ELT. It will cover the wavelength range from 3 to 20 μ m with a goal to extend the wavelength coverage to 27 μ m if the atmospheric properties of the site are sufficiently good. Because of the naturally high thermal background from telescope and atmosphere the main applications for MIDIR will be imaging and spectroscopy at highest angular resolution and high spectral resolution. In these areas MIDIR will be complementary or even superior to future space facilities like JWST-MIRI. Additional capabilities of MIDIR include quick response times to targets of opportunity and high time resolution (order of milli-seconds). To reach its maximum resolution and sensitivity, MIDIR will require an adaptive optics (AO) system. Due to the thermal emission from additional warm surfaces in the optical train MIDIR requires an IR-optimized and cooled AO system. The combination of an E-ELT at a good site with a dedicated mid-IR instrument enables compelling science cases in numerous areas from the conditions in the early Solar system to Gamma-ray bursts at very high redshift. Including the formation and evolution of proto-planetary disks and the luminous centers of active galaxies MIDIR is best suited to study the origins of life in the Universe and the evolution of galaxies. Because of the instrument's flexibility, the discovery space of MIDIR does not crucially depend on the projection of current science "killer applications" 15 years into the future.

MIDIR is one of eight instruments currently being studied for the E-ELT. This report summarizes the results from a nine months long instrument "Small Study", which has been partially funded by the EU. Table 1 lists the main instrument/AO parameters and requirements on the telescope. Our study shows that a first-rate mid-IR instrument on the E-ELT is scientifically recommended and technically feasible. The guaranteed scientific return and the reduced demands on the wavefront quality (with respect to optical/near-IR instruments) suggest MIDIR as a first-light E-ELT instrument. MIDIR does not require developments of fundamentally new technologies, but extends certain technologies beyond the current state-of-art. However, several issues need to be addressed in more detail in future studies.

<i>Parameter</i>	<i>Value</i>
	<i>Instrument parameters</i>
Wavelength range	3.5 – 20 μ m (goal: 3.5 – 27 μ m)
Instrument modes	<ul style="list-style-type: none"> •broad/narrow-band imaging •low resolution, long slit spectroscopy (R~300) •medium resolution IFU spectroscopy (R~3000) •high resolution IFU spectroscopy (R~50,000)
Field of view	~ 40" \times 40" (imaging) ~1" \times 1" (IFU spectroscopy)
Image quality	diffraction limited at all wavelengths and field positions
Entrance window	~150 – 250 mm \varnothing
Mass	4700 kg (incl. electronics)
Size	3 \times 2.3 m ³ + 1.4 m ³ (without AO)
	<i>Telescope requirements</i>
Acceptable telescope f/#	4.5 – 15
Minimum scientific field size	1.5' \times 1.5'
Straylight baffling	no warm baffles
Thermal emission	optimized for low thermal background and minimum number of surfaces
Maximum zenith angle	60 degrees (limited by AO performance)
Focal station	Cassegrain or Nasmyth
Back focal distance	\geq 500 mm
Instrument attachment	off-line image de-rotation in software, fixed pupil
Chopping	no requirements
Pointing/tracking accuracy	~1" (1- σ)
Telescope site	as high ($h \geq$ 4000m) and dry (PWV \ll 1mm) as possible
	<i>AO requirements</i>
Principle	single-conjugate system, specific to MIDIR
Operation	encapsulated and cooled to TBD Kelvin (mid-IR optimized)
Performance	\geq 50% SR at L&M, 80% SR at N&Q
Correctable FOV	\geq 40" \times 40"
ADC	intern, if required at all (TBD)