The Giant Magellan Telescope: Exploring the Universe's First Light

Status Update 2025 & Taiwan's Contribution

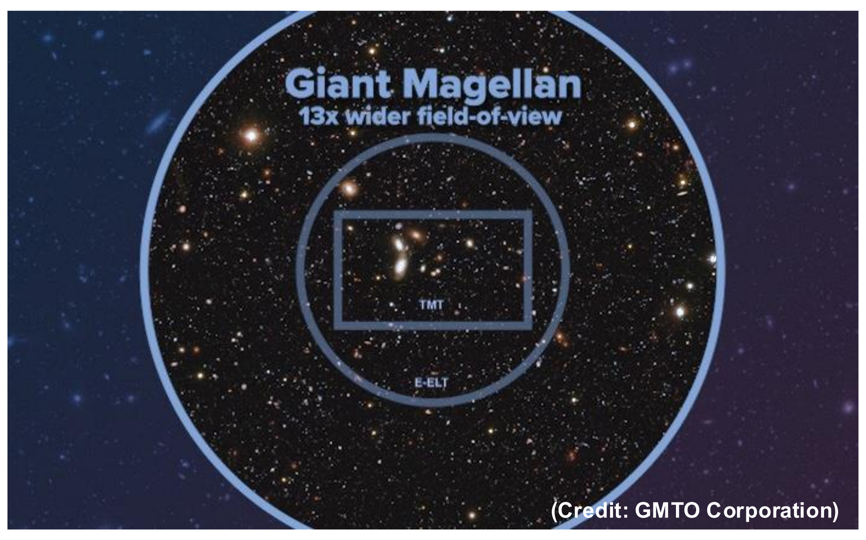
GIANT MAGELLAN TELESCOPE

NSTC 國家科學及技術委員會 National Science and Technology Council

What is GMT?

The Giant Magellan Telescope (GMT) is a next-generation extremely large telescope. It combines **seven 8.4-meter primary mirror** segments to create a single optical surface.

- **Light Collection Area – 368 m^2**
- **FoV – Largest** one in the extremely large telescopes, suitable for surveys
- **Power – Up to 200 times** more powerful than existing research telescope
- **Wavelength Range – 320 ~ 25000 nm**
- **Technology –** Advanced adaptive optics (AO) using 7 adaptive secondary mirrors to correct atmospheric turbulence in real-time
- **Location:** Las Campanas Observatory (LCO), Chile. Chosen for its clear, dark skies and stable airflow.
  – **2,514 m** altitude
  – **300+ nights** of clear sky
  – **160 km** from city lights



(Credit: GMTO Corporation)

Key Science Cases

The GMT aims to answer fundamental questions in astrophysics

1. Exoplanets & Planet Formation: Are we alone in the Universe?
With GMT's extreme sensitivity and spectral resolution, we can characterize the atmospheres of Earth-like exoplanets and search for key biosignature gases.
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2. The Birth of Stars: Where and how are stars born?
GMT's high angular resolution in the near-infrared can peer into dusty stellar nurseries to reveal how protostars form and accrete mass.

3. The Death of Stars: How do stars die?
By resolving supernova remnants and late-stage stellar outflows, GMT helps uncover the physical processes that end stellar lives and enrich the interstellar medium.

4. Building the Milky Way and its Neighbors: How did galaxies grow and evolve?
Precise stellar spectroscopy and astrometry with GMT can map the motions and chemical fingerprints of stars to reconstruct the assembly history of the Milky Way and nearby galaxies.

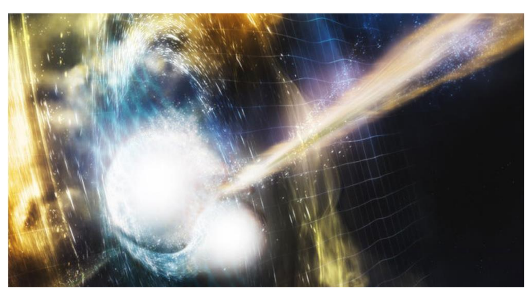



Image Credit: GMTO Corporation

5. The Growth of Galaxies Over Cosmic Time: How do stars form in galaxies over cosmic time?
GMT can measure star-formation rates, metallicities, and feedback signatures across cosmic epochs to track how galaxies build up their stellar populations.

6. Building Galaxies from Cosmic Gas: How does the gas that feeds star formation get into galaxies?
Using absorption-line spectroscopy of background sources, GMT can trace gas inflows, outflows, and the circumgalactic medium that regulate star formation.

7. Cosmology and the Dark Universe: How did the universe form and grow?
GMT observations of distant galaxies and large-scale structure provide constraints on dark matter and dark energy through galaxy evolution and precision cosmological probes.

8. First Light and Reionization: What were the first sources of light and how did they transform the universe?
GMT can detect and characterize the earliest galaxies and quasars, probing how their radiation reionized the intergalactic medium in the first billion years.


Image Credit: GMTO Corporation

Partners

Current Partners: 16 international institutions

- In **June 2025**, the **NSF advanced GMT into the Final Design Phase**, a key step toward federal construction funding
- GMT is the first **U.S. Extremely Large Telescope Program**
- **MIT joins GMT international consortium** as its **16th member**
- GMT has secured **1B USD** with MIT's participation to the total of 2.5B USD


(Credit: GMTO Corporation)

Current Partners of GMT

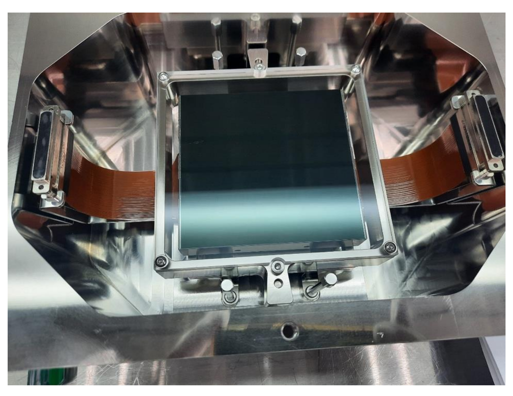
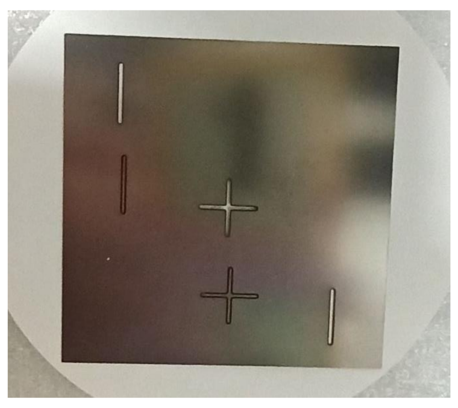
Taiwan's Contribution

Taiwan (ASIAA) in the GMT Consortium

- **Taiwan** officially joined GMT in Feb **2024** via ASIAA
- **10M cash (NSTC) and 10M in-kind (ASIAA)** contribution to the 2.5B project
- **Shiang-Yu Wang** is our founding representative and **Yen-Ting Lin** is our science advisory committee member
- Taiwan contributes recognized expertise **in instrumentation and detector technologies**, including low-noise, compact detector electronics and precision detector characterization
- ASIAA will also provide advanced precision manufacturing capabilities, such as precision laser cutting technology, supporting GMT's instrument development
- This partnership strengthens **Taiwan's long-term foundation** in astronomy, **helping train the next generation and deepening collaboration with other consortium countries**, ahead of GMT operations in the early 2030s

G-CLEF Instrument

- **ASIAA have settled on the development items for the G-CLEF instrument (GMT-Consortium Large Earth Finder)**
  – Red channel CCD and its control electronics
  – CCD characterization
  – High precision spectral calibration source
  – G-CLEF will be installed at Magellan once ready in 2027

G-CLEF CCD (left) and Slit sample (right) (Image Credit: ASIAA)

Next Step

- ASIAA/TARA will participate in the **On-Instrument Wavefront Sensing (OIWFS) of Giant Magellan Telescope Near-Infrared Spectrograph (GMTNIRS)** instrument build and in the interface control design
- **GMTNIRS Meeting** will be held at ASIAA on **March 10-13 2026**

What is GMTNIRS?

- **GMTNIRS** is a **first-generation** GMT instrument: a **high-resolution near-IR spectrograph** with **R ≈ 65,000–80,000**
- It provides **simultaneous coverage** of the **J, H, K, L, and M** bands using **six spectrograph channels** (with the **L band shared by two channels**)

What is GMTNIR?

- By using **silicon immersion gratings**, GMTNIRS achieves a **compact optical design** while maintaining high performance
- The instrument will be mounted on the **GMT instrument rotator upper disk** and will operate in **AO mode**


GMT laser guide star (LGS) and GMTNIRS (Credit: GMTO)

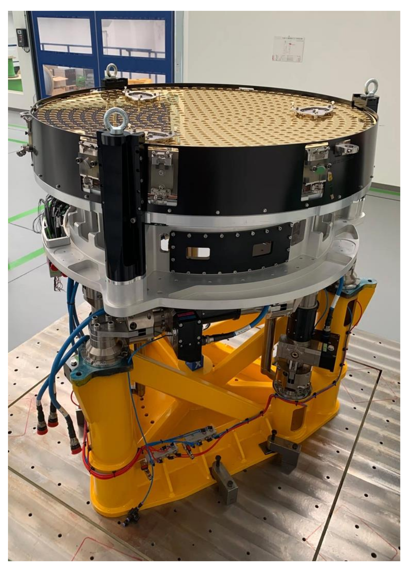
What is OIWFS?

- GMTNIRS must include an internal wavefront-sensing system to measure **focus**, **tip-tilt**, **low-order aberrations**, and **pupil position (chief-ray angle)**, and **send these measurements to the GMT wavefront control system**.
- **Why this is needed?**
  – The OIWFS helps detect and correct wavefront errors that may **not be fully sensed by external WFS**
- **Role in LTAO mode**
  – In **LTAO**, high-bandwidth sensing using **laser guide stars** must be **supplemented by natural guide star measurements** for **tip-tilt and focus**.
- **Role in LTAO & NGAO modes**
  – In both **LTAO** and **NGAO**, the instrument must sense **slowly varying low-order non-common-path aberrations (NCPA)** and **pupil misalignment** between the external WFS and GMTNIRS using an internal **low-order "truth" sensor**.

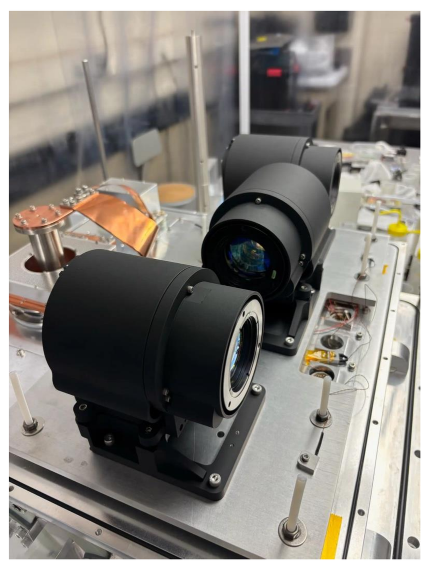
The Year in Photos 2025

Daytime view of construction site at Las Campanas Peak (Credit: GMTO)

The ultra-stable vacuum chamber for the G-CLEF (Credit: CfA)



GMT Active Secondary Mirror (Credit: AdOptica)



J/H/K spectrograph cameras for the GMTNIRS (Credit: The University of Texas at Austin)

GMT adaptive optics and phasing sensor (Credit: Damien Jemison, GMTO)

Supporting system prototype integrated with a 8.4-meter mirror (Credit: GMTO)

Information

GMT Website

For Scientists