Poster No. 33

Laguna: An Optical Instrument Complex for the TAO 6.5 m Telescope

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Abstract

We are developing an optical instrument complex, Laguna, for the TAO 6.5 m Telescope. Laguna consists of CAM, SPEC, and SPAD subsystems that cover different fields of view (FoVs). Similar to space telescopes, the subsystems can be switched simply by changing the target position without requiring the movement of fold mirrors or other mechanisms. This design reduces the risk of observation interruptions caused by mechanical failures, which is particularly important given the limited accessibility of the telescope site. Laguna-CAM is a tricolor camera with CMOS sensors, providing a 4-arcmin FoV. Laguna-SPEC will combine a low-dispersion prism spectrograph for the 300–400 nm range with an echelle spectrograph for the 400-1000 nm range. A dichroic mirror will split the incoming light, enabling simultaneous observations across different wavelength ranges. Laguna-SPAD is designed as a polarimeter using a SPAD sensor with effectively zero readout noise. The optics for Laguna-CAM have already been delivered, while those for SPEC and SPAD are currently under design.

1. Introduction

- Follow-up observations by multi-messengers influence the understanding of newly discovered transients because each messenger reveals a different aspect.
- We will carry out follow-up observations in optical with new instrument.

IceCube (NSF)

LIGO (Caltech/MIT)

Features of optical observations

- Good spatial resolution, ordered in 1’’, helps us to identify the newly discovered transient sources.
- The optical instrument is easy to produce and operate.
- Optical light is a tracer of ~10^4 K materials and ionized gas.

- The time resolution of standard CCDs, the detector used frequently, is lower than 1 frame per second.
- Too many sources, including transients and non-transients, in a field of view occasionally prevent finding the target.
- Optical light is severely affected by dust extinction.

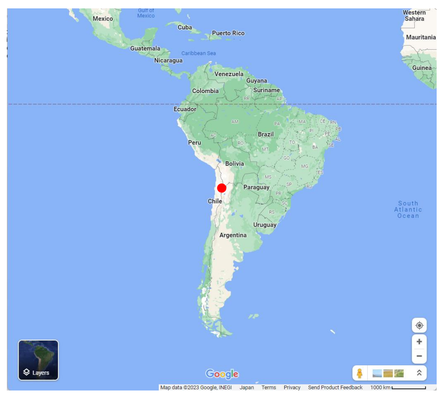
2. TAO 6.5-m Telescope

- TAO stands for the Univ. of Tokyo Atacama Observatory.

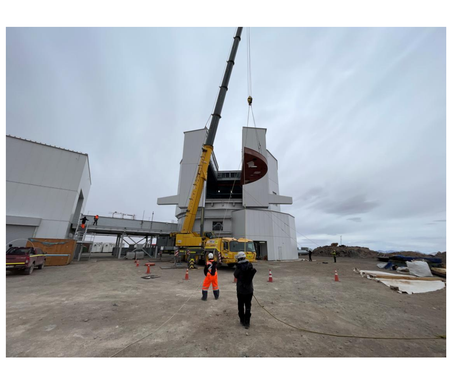
- We are constructing a 6.5-m telescope on the summit of Cerro Chajnantor at Atacama in northern Chile.
  - A large aperture provides deep images and spectra in a short time.
  - Good seeing (spatial resolution), ~0.7’’.
  - At the highest altitude observatory, 5640 m, which has high transparency even in mid-infrared wavelengths.
  - TAO is in the Southern Hemisphere, 23 degrees south and can access the southern sky. We will cover all the sky with TAO, Subaru, and other Japanese telescopes.
  - TAO telescope is a university telescope, so the telescope schedule will be flexible and accept Time of Opportunity (ToO) observations.

- NIR and MIR instruments, NICE, SWIMS, and MIMIZUKU, will be connected to the telescope, but an optical instrument has yet to be constructed.

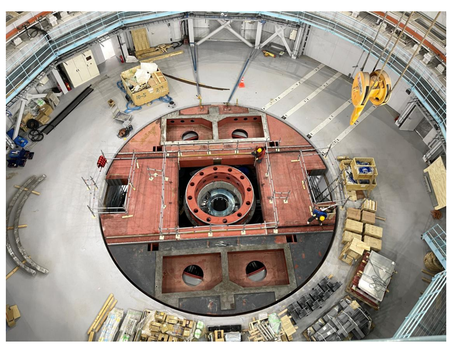
We are developing an optical instrument complex, Laguna, which can perform imaging and spectroscopy.



Location of TAO site (red circle)



Telescope enclosure with the telescope turntable install work

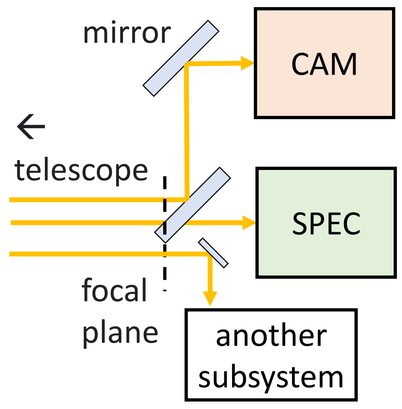


Telescope turntable installed in the enclosure

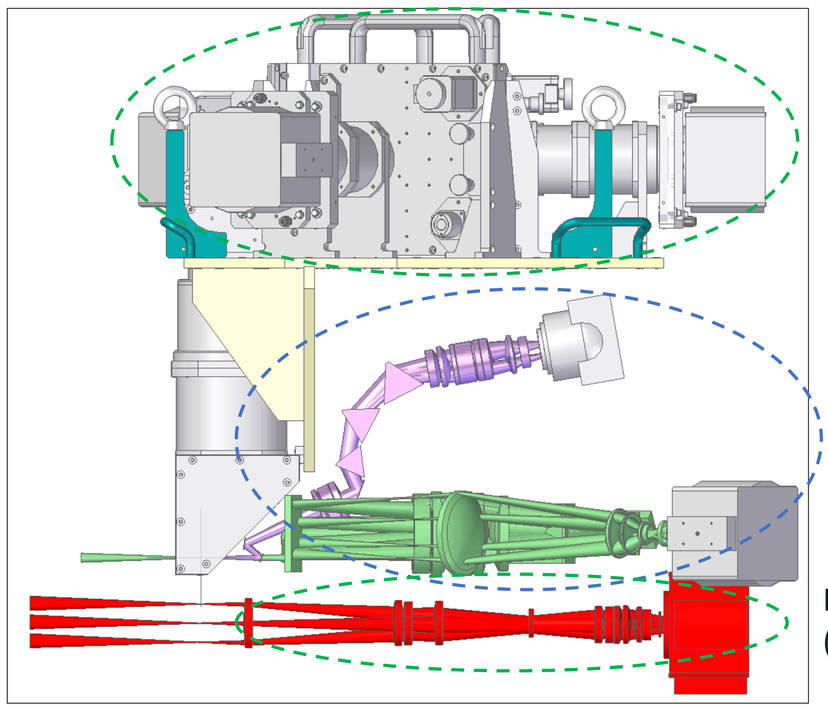
3. Laguna

Overall concept

- Laguna consists of CAM, SPEC, and another subsystems.
- FoV of each subsystem is separated as space telescopes.
- Observers can change the observation mode by changing the target position without moving the mirrors to reduce the trouble risk such as the mirror stack.



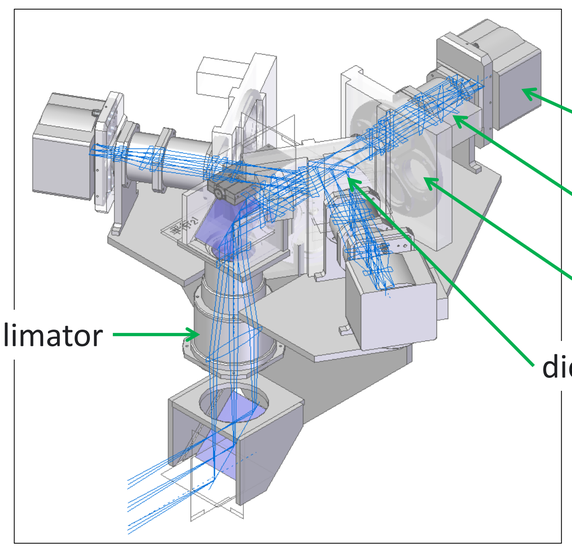
Conceptual diagram of Laguna



3D model of Laguna

Laguna-CAM

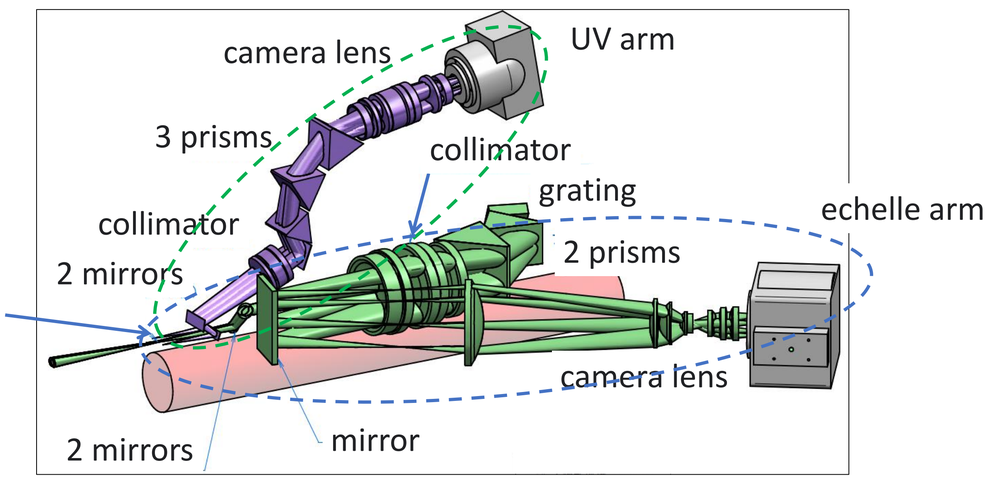
- Delivered in March 2025, as shown in the right figure.
- The imager can obtain 3 band images simultaneously with using dichroic mirrors.
- Detectors: CMOS sensors, which can obtain images in up to ~100 fps.
- FoV: ~4-arcminute diameter
- Pixel scale: ~0.16 arcsec / pixel



3D model of Laguna-CAM

Laguna-SPEC

- A combination of an echelle spectrograph and a prism spectrograph.
- Wavelength: 300-1000 nm; 300-400 nm for UV arm and 400-1000 nm for echelle arm
- Spectral resolution: ~300 (UV), ~1400 (echelle)



3D view of Laguna-SPEC optics