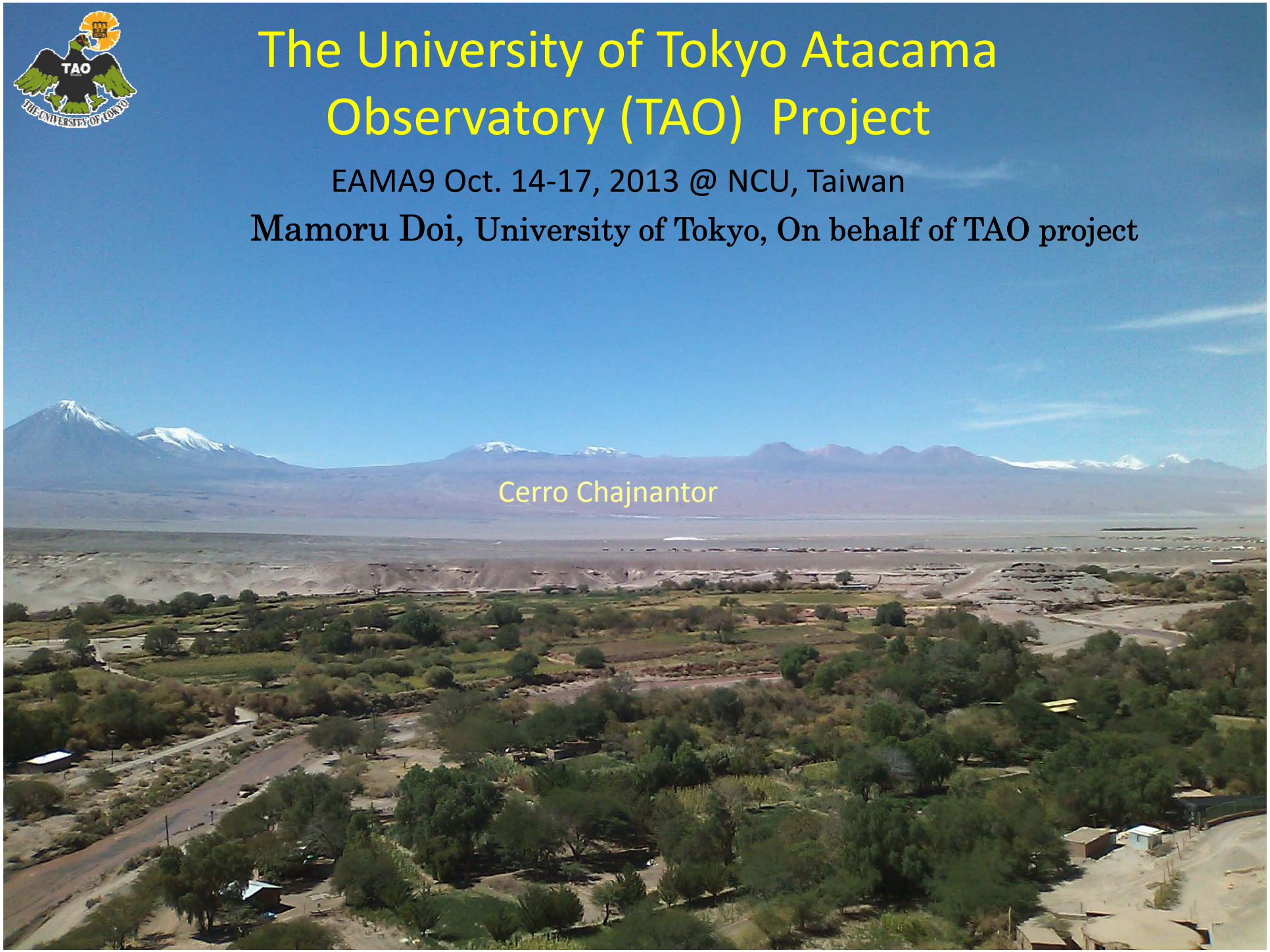
The University of Tokyo Atacama Observatory (TAO) Project

EAMA9 Oct. 14-17, 2013 @ NCU, Taiwan

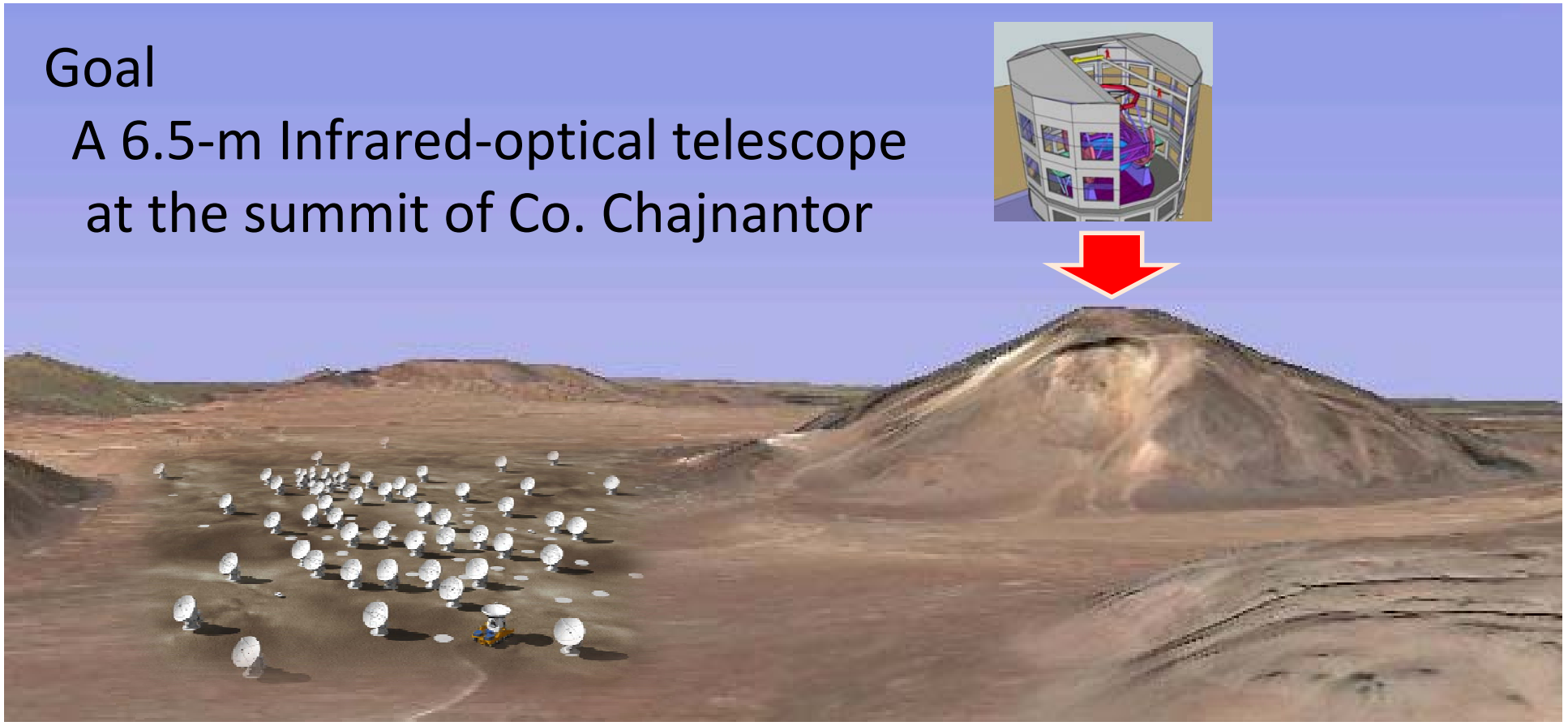
Mamoru Doi, University of Tokyo, On behalf of TAO project



The University of Tokyo Atacama Observatory (TAO) project

Goal

A 6.5-m Infrared-optical telescope at the summit of Co. Chajnantor



The highest astronomical observatory in the world

(Altitude 5,640m)

TAO team

Institute of Astronomy, Graduate School of Science, University of Tokyo

Headquarters at Mitaka, Tokyo

Kiso Observatory at Nagano

1m- Schmidt Telescope

Prof. Yuzuru Yoshii Director & Project Leader

TAO members at IoA

3 Professors, 4 Associate Professors,

5 Assistant Professors, 4 Engineers, 3 postdocs

Dept of Astronomy UT, NOAJ, JAXA, other Japanese universities

Univ. of Chile: Profs. Bronfman, Hamuy, Maza, Ruiz, …,

Univ. of Catolica: Profs. Infante, Vanzi, Shintaro Koshida,

Chilean Government: Ministry of Foreign Affairs, CONICYT , ..

Univ. of Concepción

CCAT(Cerro Chajnantor Atacama Observatory) project

TAO site


Calama
Chile
Bolivia
50km
Argentina
TAO site
San Pedro de
Atacama
ALMA site
23.0S
Arequipa
La Paz
Bolivia
Córdoba
Mendoza
Santiago
Chile
Argentina
TAO site
Co. Chajnantor (5640m)
ALMA site

Chajnantor Summit

TAO（5640m）

CCAT ..Cerro Chajnantor Atacama Obs.(5600m)
25-m submm telescope

Google earth

Feet
meter

600
200

Site Studies (since ~1999)

2006-

Weather station

MIR whole Sky camera

DIMM (seeing monitor)

Clear fraction : ~ 80%

Perceptible water vapor : < 0.38mm @ best 10%

Seeing condition : 0.69 arcsec @ V, median

One of the best sites for the IR astronomy

The miniTAO 1-m telescope
a pathfinder telescope of the TAO project

ANIR
near infrared camera

MAX38
mid infrared camera

Completed in March 2009 Two instruments (NIR, MIR)
Operation ~2months x 2 / year; 10% for Chile community
Remote operation from SPdA has started

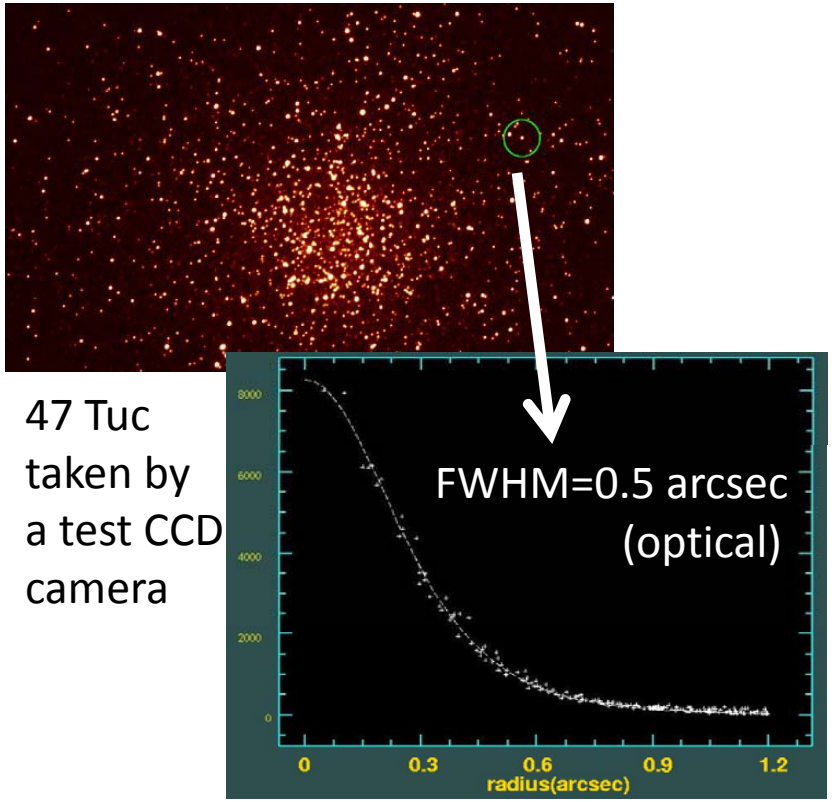
Site condition proved by the miniTAO

seeing

FWHM(median)

∽0.7 arcsec (DIMM)

∽0.8 arcsec (ANIR; somewhat under sampled?)



47 Tuc taken by a test CCD camera

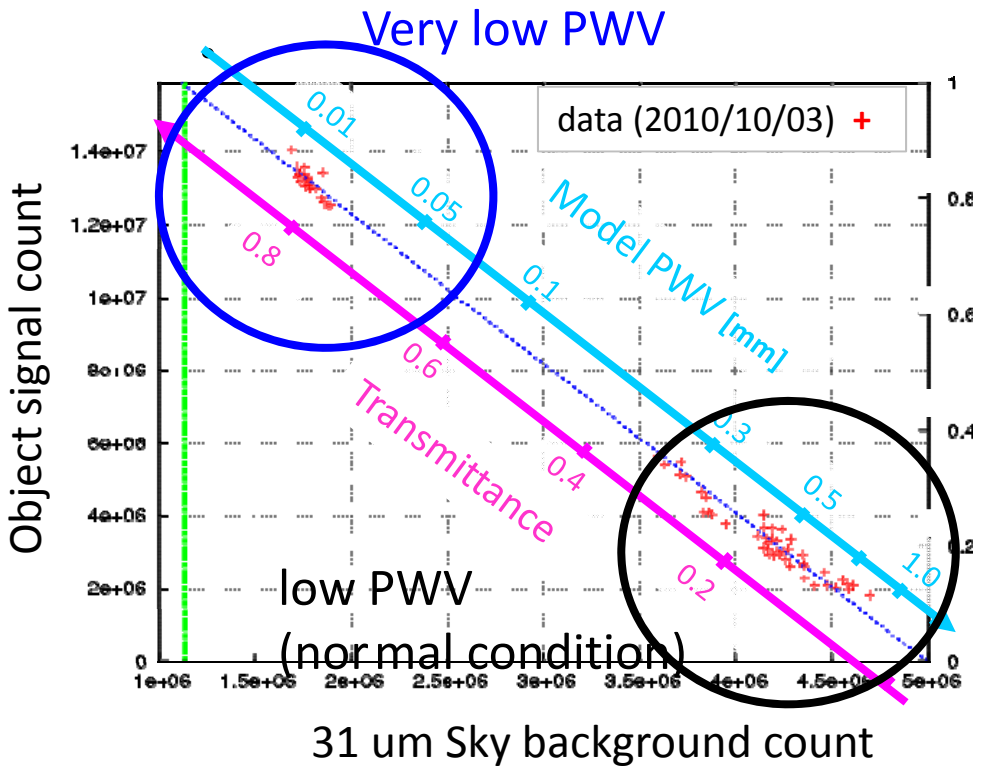
PWV

PWV

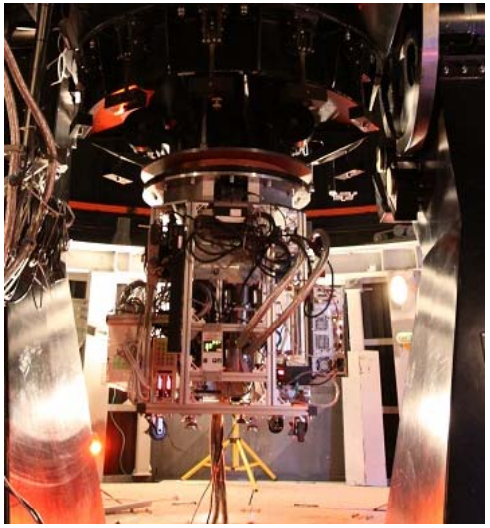
< 0.38 mm (10 %-ile from site studies)

∽0.3 – 1.0 mm (MAX38 & atm. model)

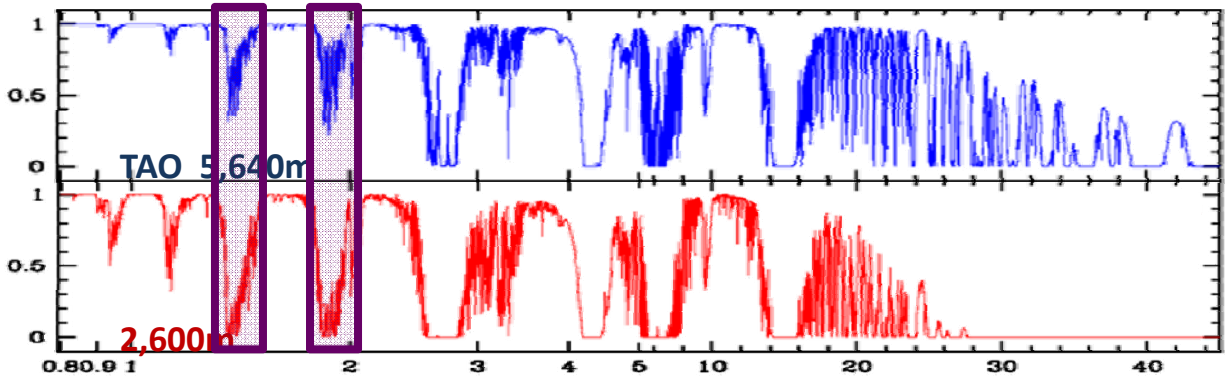
< 0.03 mm is estimated in champion data



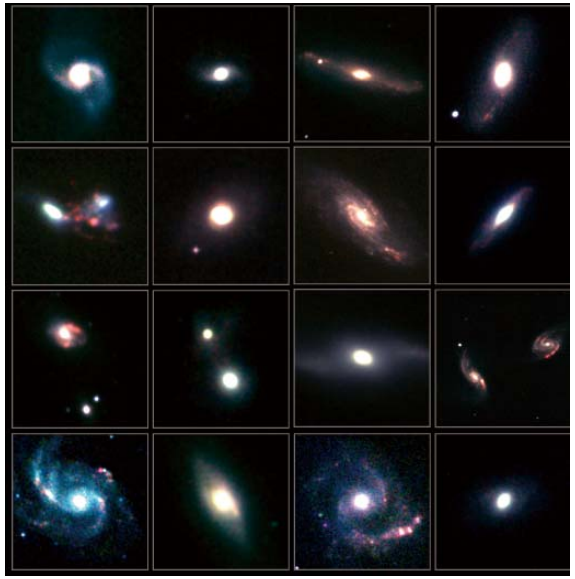
ANIR – an near-IR (& optical) imager



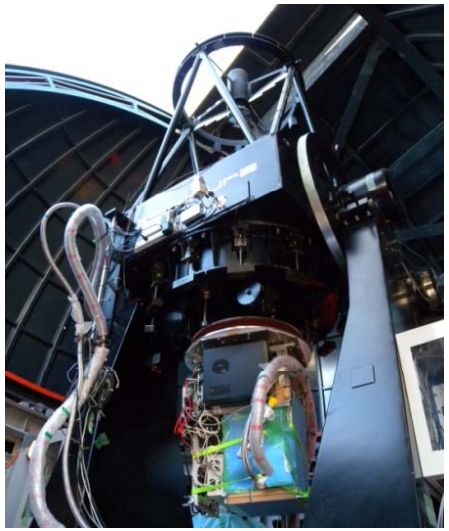
✓Paα (1.875μm) imaging from the ground



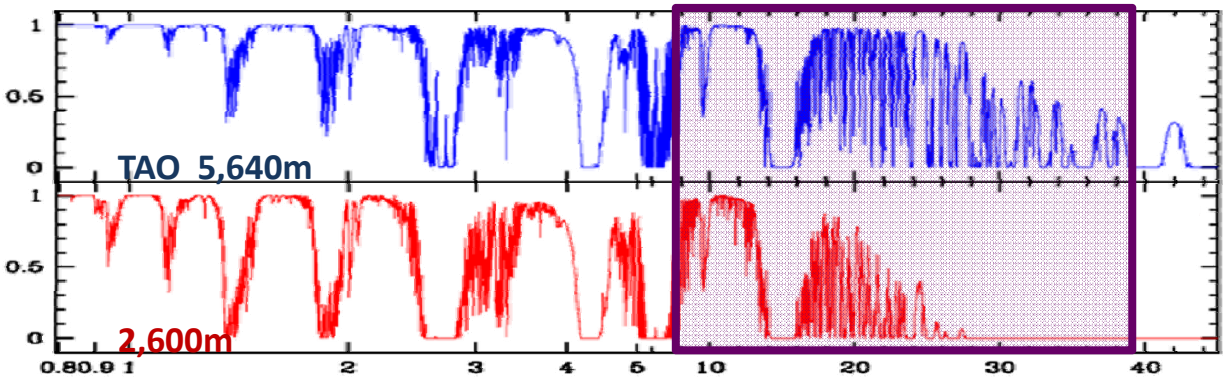
- Galactic HII Region Survey in Paα
- Nearby LIRG and merging galaxies survey



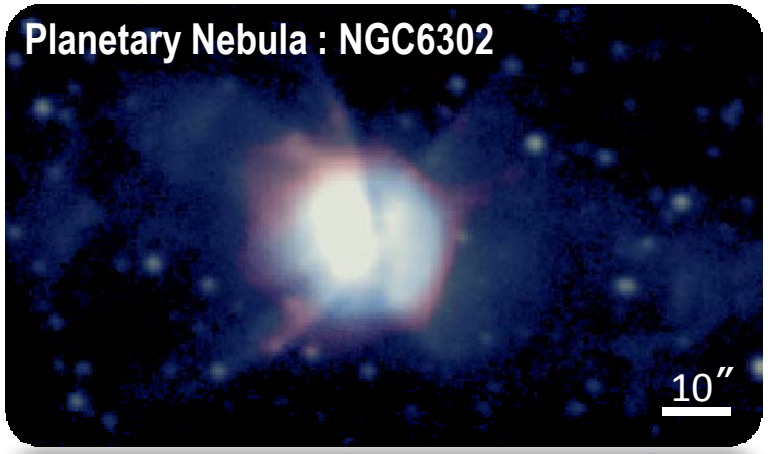
MAX38 – a mid-IR imager & spectrometer



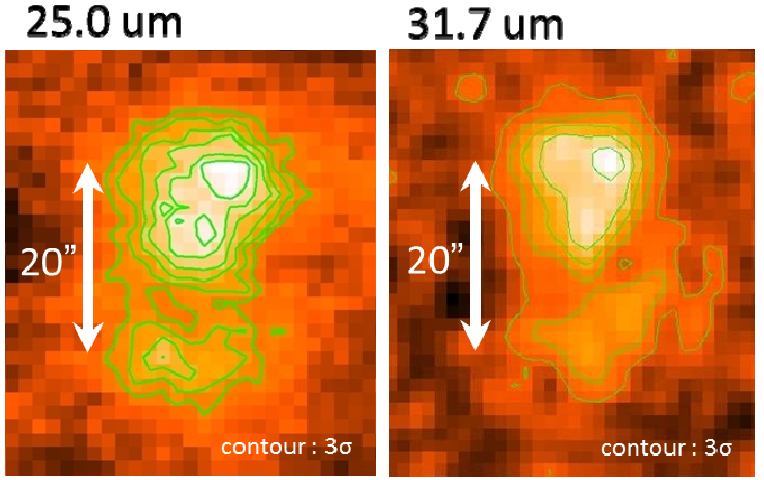
✓ explores 30 micron astronomical windows



- N- and Q-band imaging mode is opened for Chilean time
- Imaging mode at 31/38 micron is being commissioned



blue : Pa-beta (ANIR) , red : **31un**



Observations at the miniTAO

6 observing runs since the first light in 2009

10% Chilean time

Scientific Observing Programs of miniTAO

Solar System

- MIR observations of near earth asteroids
- MIR monitoring of volcanic activity on Io

Stars and Planets

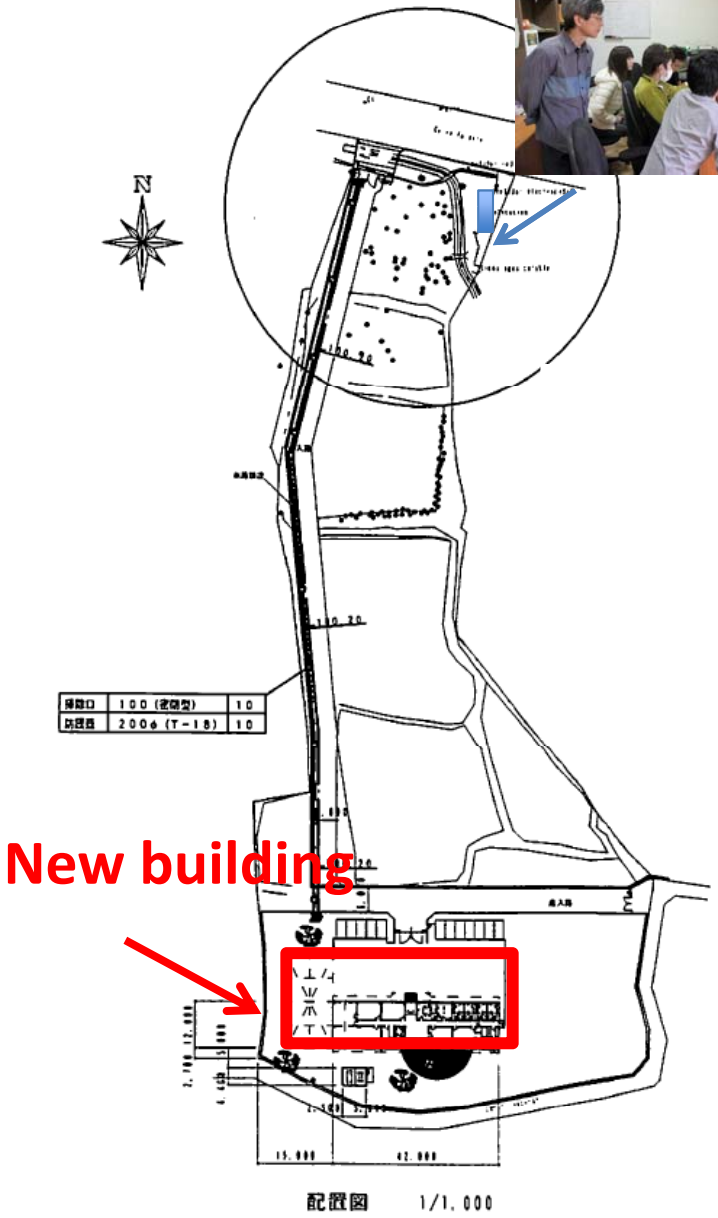
- K-band transit of earth-like planets
- Galactic plane survey with the Paα emission line
- Observations of massive star forming regions
- NIR survey of eclipsing YSO binaries
- Search for WR stars in LMC
- Cold dust around planetary nebulae
- Water line survey of M type stars
- Long term variability of AGB stars
- Observations of supernovae in NIR

Galaxies

- Hidden star-forming activity of colliding galaxy
- Paα imaging survey of LIRGs
- Monitoring of active galactic nuclei
- Infrared observations of gravitational lensing quasars

3 refereed papers published

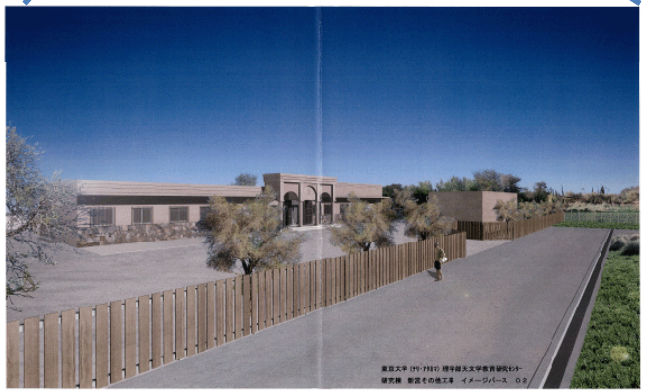
The TAO base facility at SPdA



- A temporal room for remote obs.

→ a new building is being built

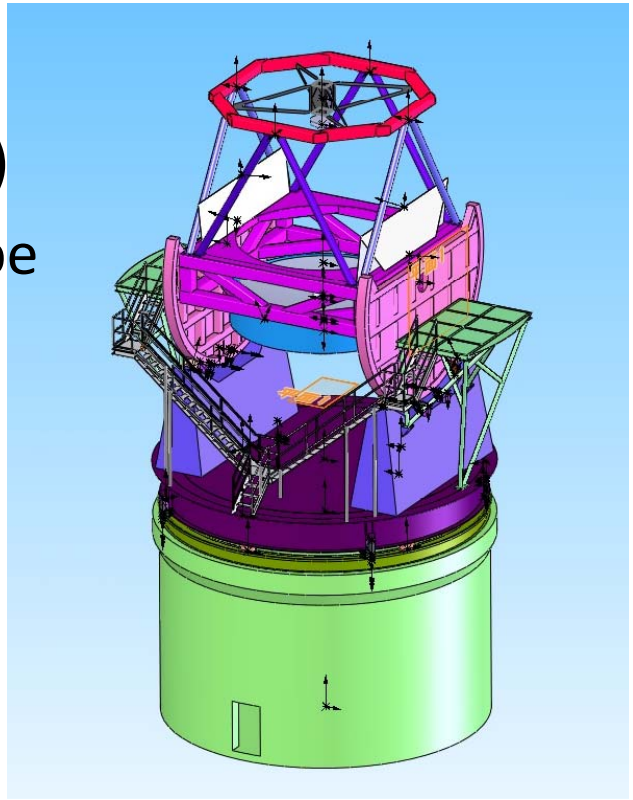
  - Laboratory, accommodations, …
  - to be completed in Feb. 2014

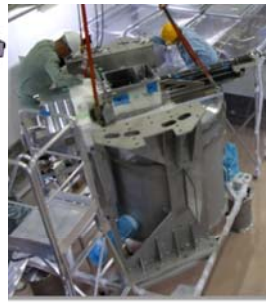


The 6.5-m TAO telescope

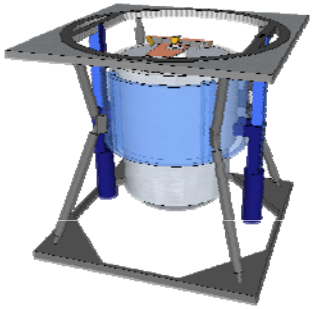
- Best Infrared Telescope on the earth
  - Frontiers in astronomy through the new atmospheric windows
    cosmology; galaxy evolution; exo-planets; …….
  - Two nasmyth, a few bent cassegrai n foci, focal ratio/12 (=Subaru)
  - Telescope construction budget funded in January 2013!
- 1st generation instruments
  - SWIMS (NIR), MIMIZUKU (MIR)
  - Funded by Japanese government (2009)
  - Will be attached on the Subaru telescope for test observations (2014-)

TAO telescope





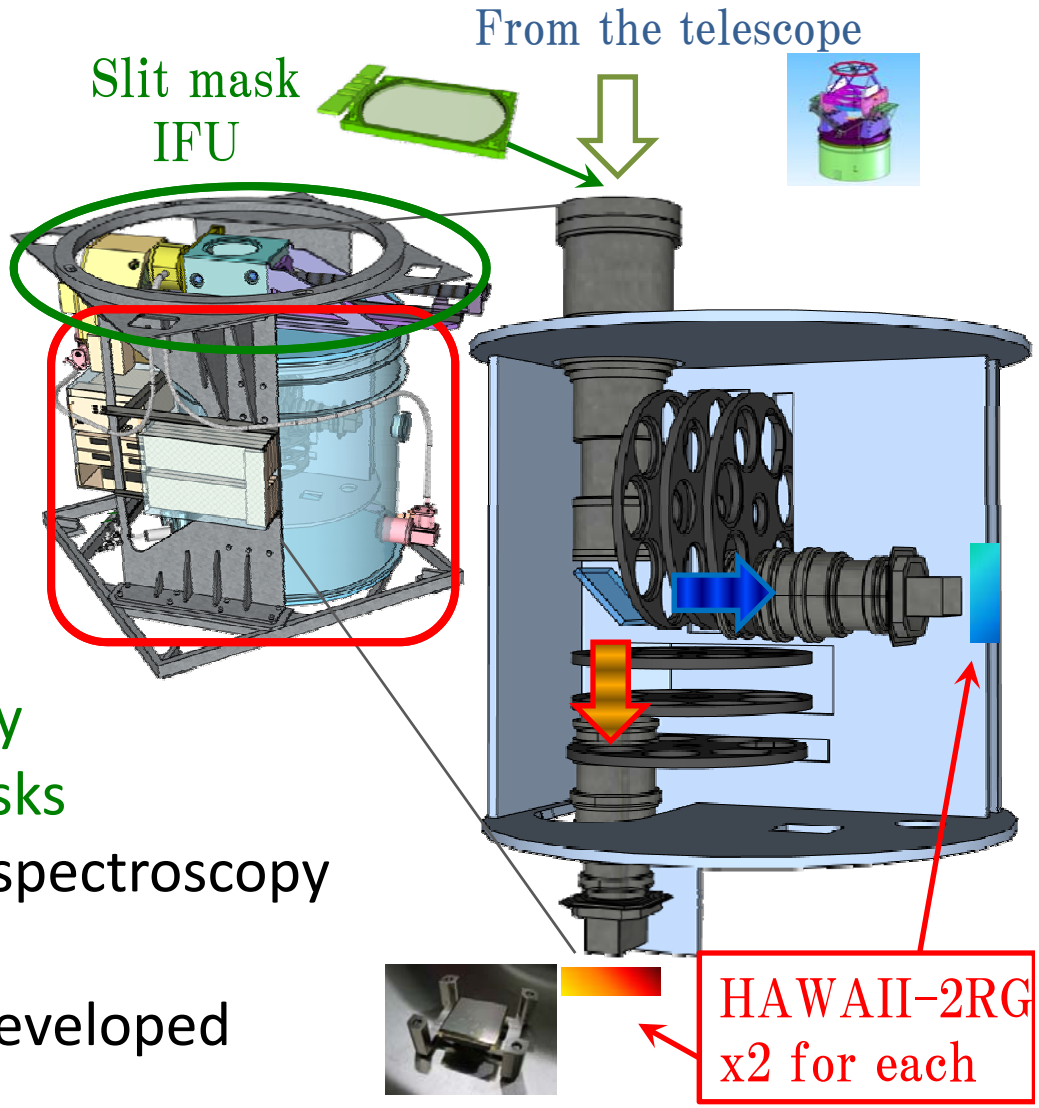
SWIMS



MIMIZUKU

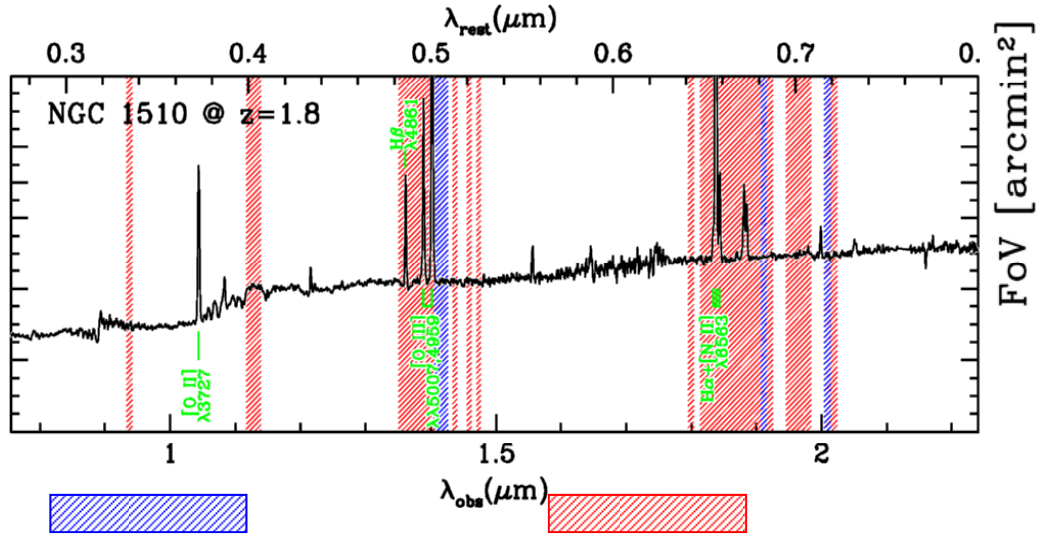
SWIMS (for NIR)

- Simultaneous-band Wide field Infrared MOS Spectrograph
  - Simultaneous imaging/ spectroscopy in 2 bands
    (0.9-1.4 um & 1.4-2.5 um)
  - Wide field of view with good pixel resolution
    9.6' Φ, 0.126 arcsec/pix, with 2x 2kx2k pixels
  - Multi-object spectroscopy with cooled multi-slit masks
    0.9-2.5μm simultaneous spectroscopy for ~30 objects (R~1000)
    IFU modules also being developed

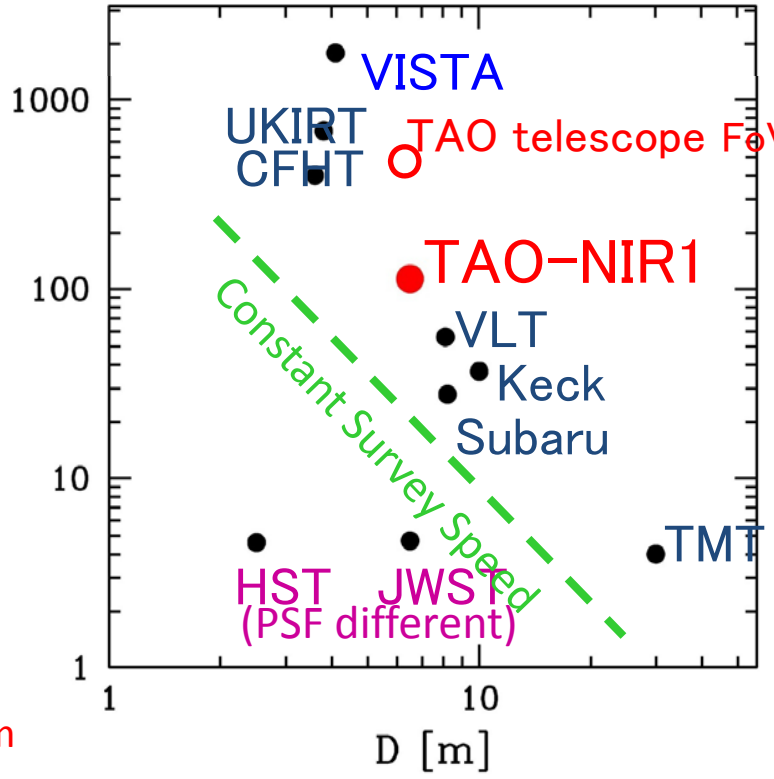


Science drivers for SWIMS

- Features of TAO/SWIMS
  - almost continuous coverage in 0.9 – 2.5 um
  - Wide field imaging and multi-object spectroscopy
- TAO-NIR deep & wide survey
  - Deeper with better image quality than VISTA
  - high-z galaxies, distant clusters, QSOs, SNe, minor planets, ..

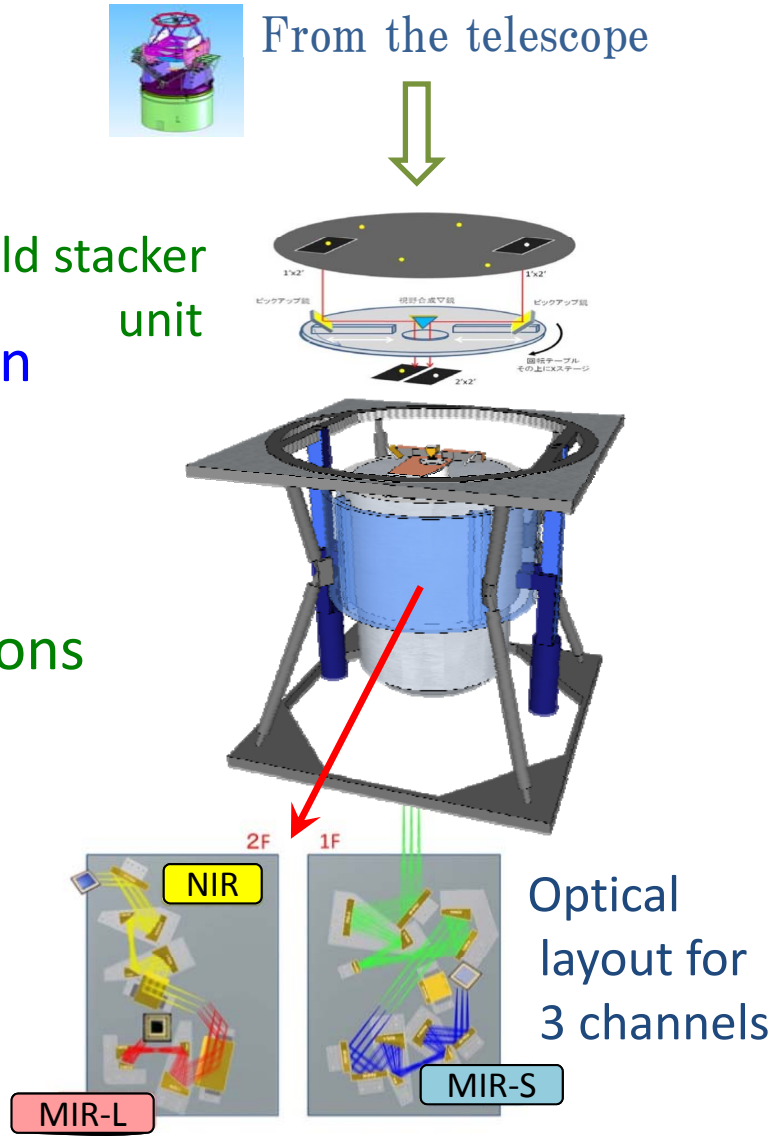


Little transmittance at TAO site Little transmittance at ~2600m



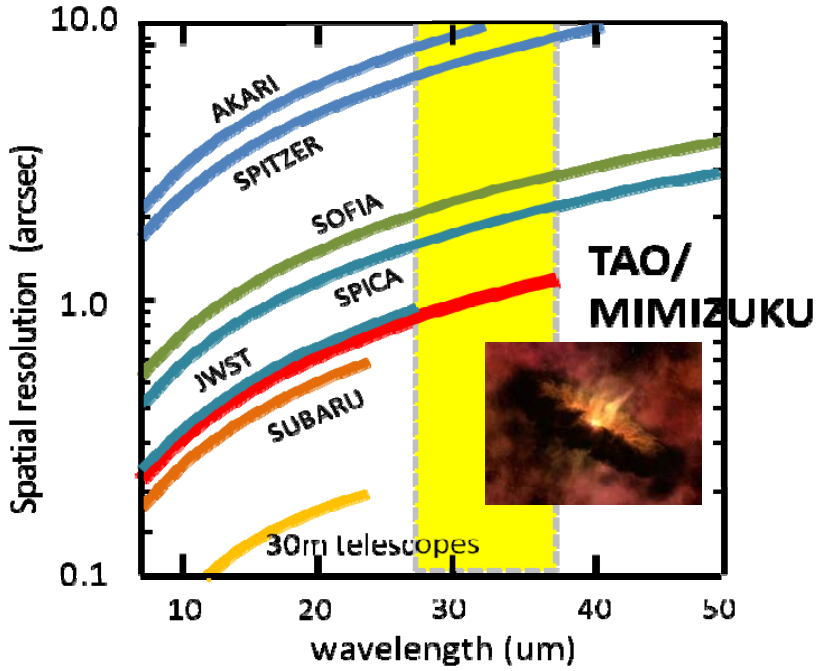
MIMIZUKU (for MIR)

- Mid-Infrared Multi-field Imager for gaZing at the UnKnown Universe
  - Wide wavelength coverage
    - InSb channel : 2-5.6um
    - Si:As channel : 6-26um
    - Si:Sb channel : 25-38um
  - Diffraction limited spatial resolution
    - 0.4 arcsec @ 10 micron
    - 0.8 arcsec @ 20 micron
    - 1.2 arcsec @ 30 micron
  - For accurate monitoring observations
    - simultaneous observations of two discrete fields by the field stacker
  - New technology
    - Internal chopping
    - Mesh filter
    - Moth-eye lens coating

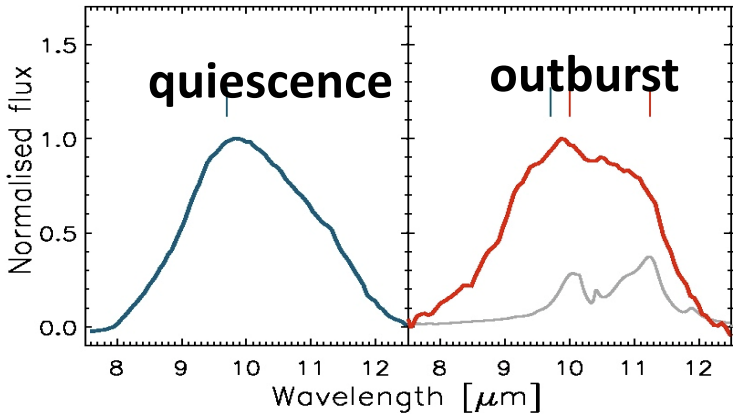


Science drivers for MIMIZUKU

- Features of TAO/MIMIZUKU
  - High sensitivity, high anguler-resolution at 30 um bands
  - Accurate monitoring capability using the field stacker
- Targets
  - Proto-planetary disk and planet formation
  - Dust formation around stars and planetary nebulae



EX Lupi (FU Ori type, T Tauri star)



amorphous silicate

Amorphous
+ crystallized silicate

Abraham+ 2009

Status of the 6.5-m telescope

6.5-m Primary Mirror

contract with Mirror Labo., Univ. of Arizona

delivery by Dec.2014

Telescope mount

contract with Nishimura Co. (Kyoto, Japan)

Enclosure

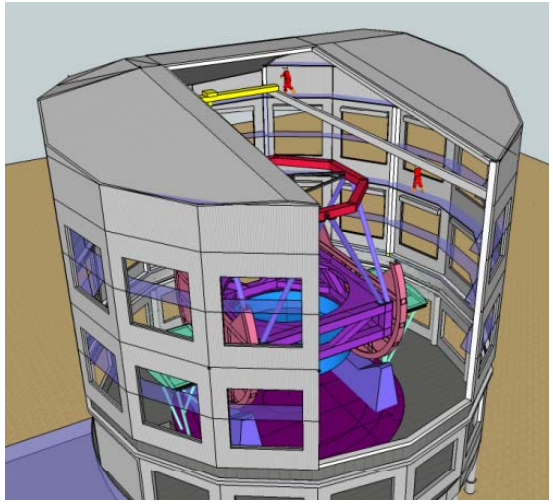
open bid process

Site infrastructure

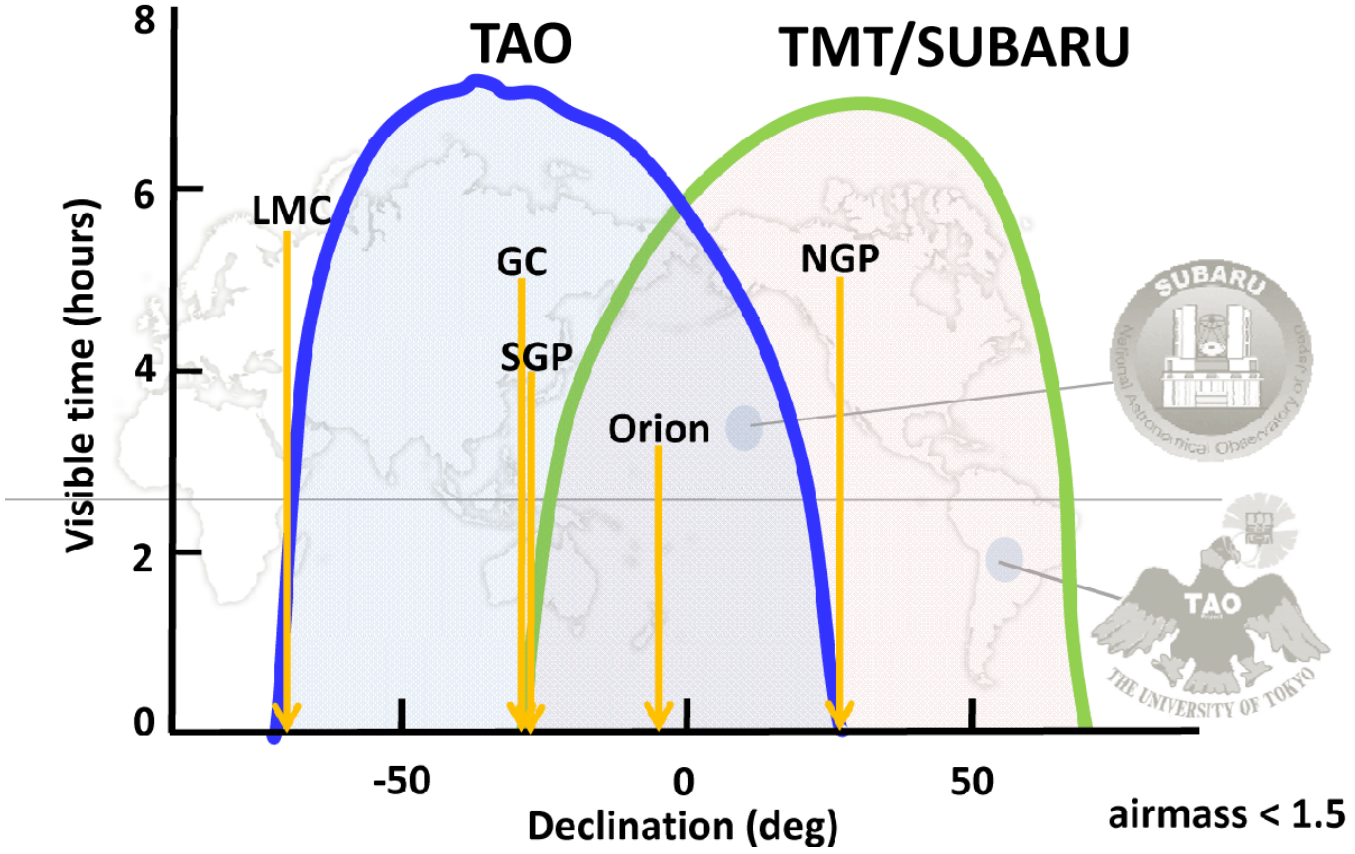
Road, power, network

being prepared with CCAT

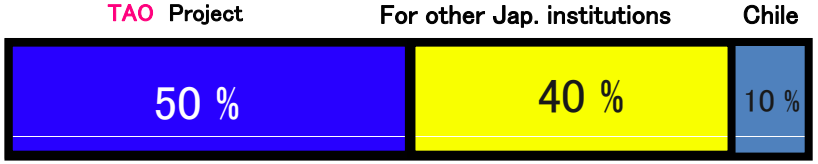
First Light 2017?



TAO and Japanese community



Telescope Time:
40% for other Japanese institutions



Time allocation: to be discussed with Japanese community through NAOJ and GOPIRA

Summary

- The miniTAO pathfinder telescope

  Telescope: NIR and MIR Instruments: in operation

  Site: High transmittance in IR and good seeing

  Remote operation from SPdA since 2011A

  Base Facility at SPdA to be built in Feb. 2014

- TAO (6.5m) in preparation

  Construction budget funded by Japanese government

  Primary, telescope, enclosures, two instruments being built/designed

  TAO first Light 2017?