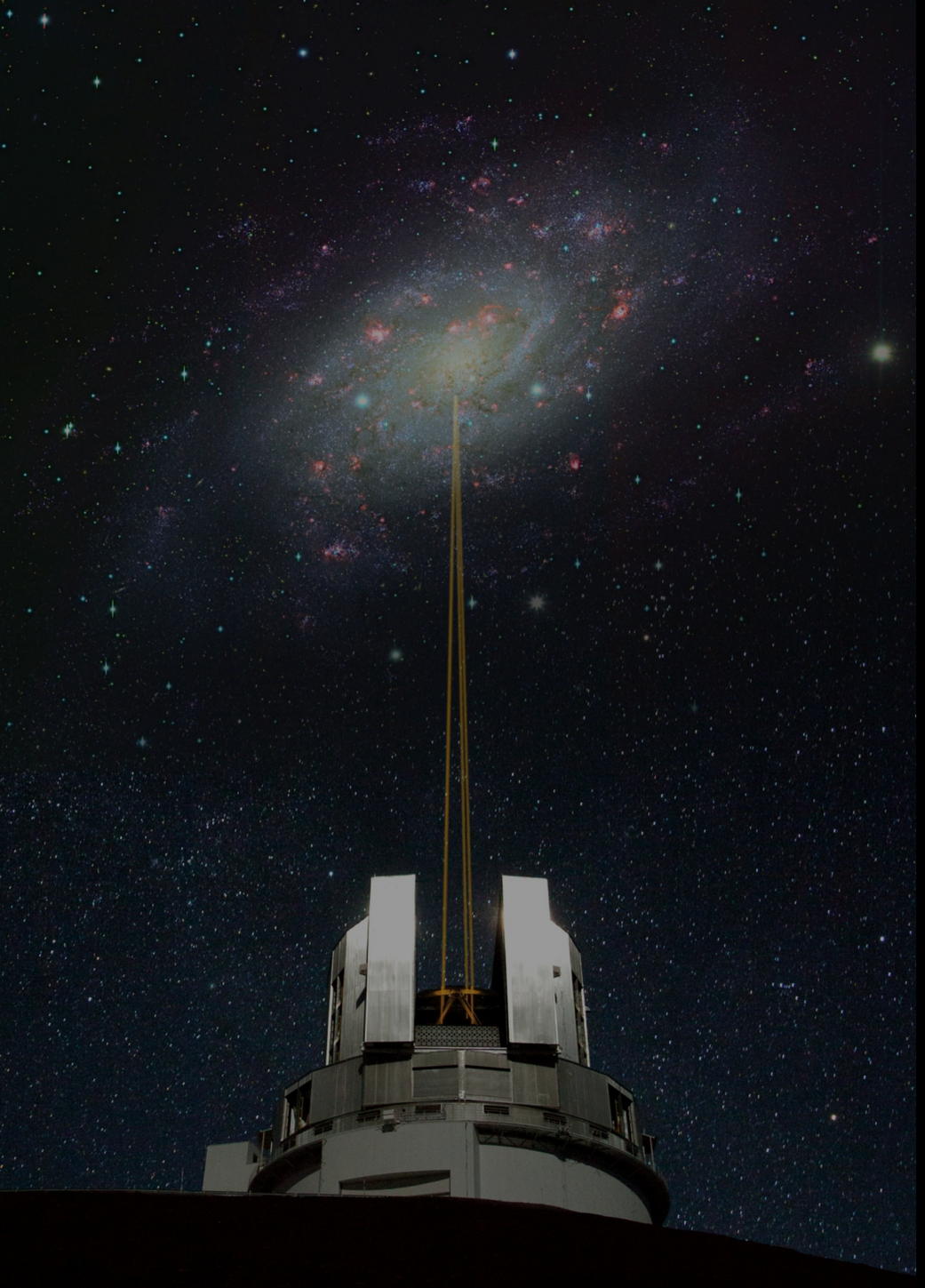


ULTIMATE-Subaru: Project Overview and Current Status

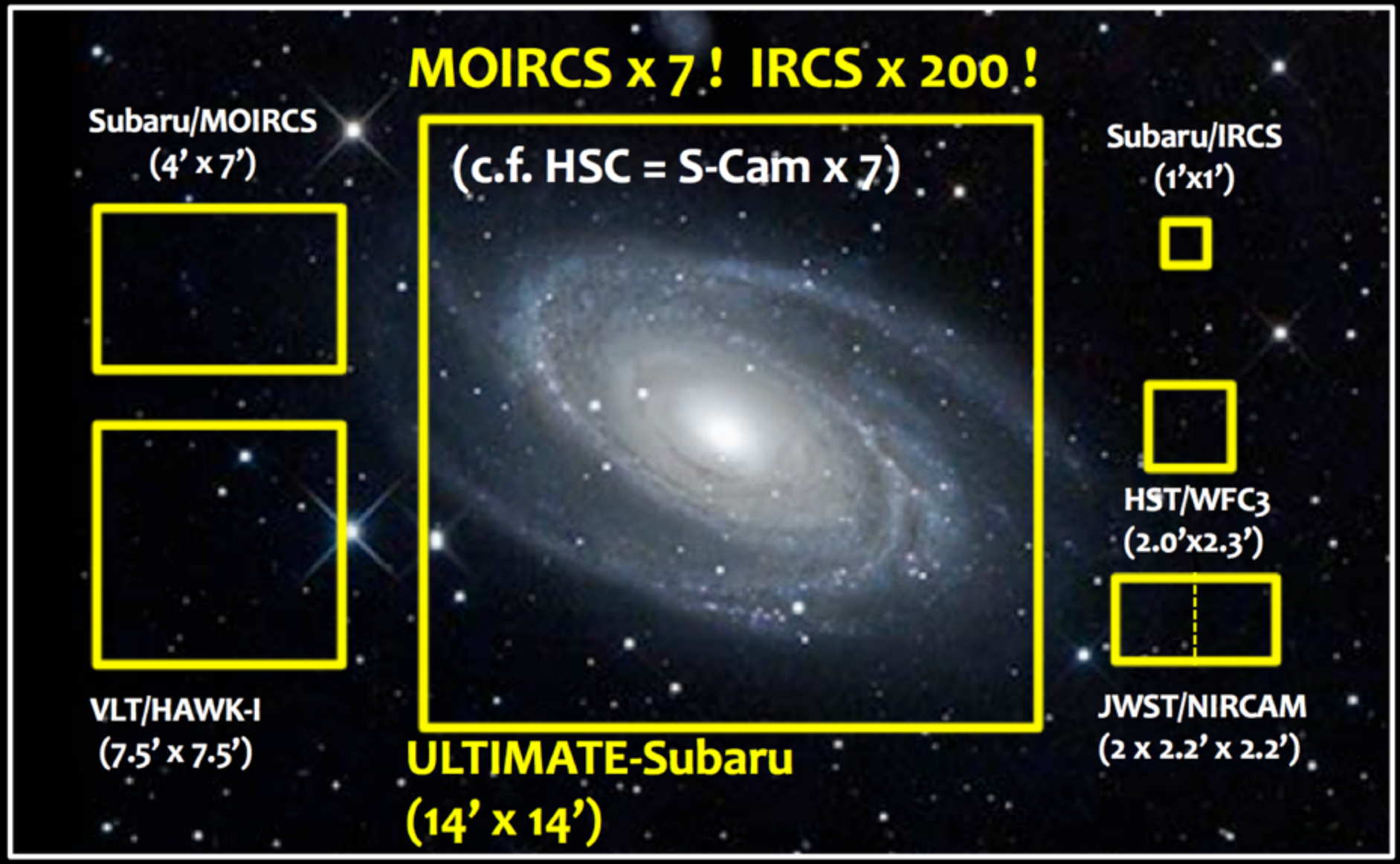
Yosuke Minowa (Subaru Telescope)

ULTIMATE-Subaru team:

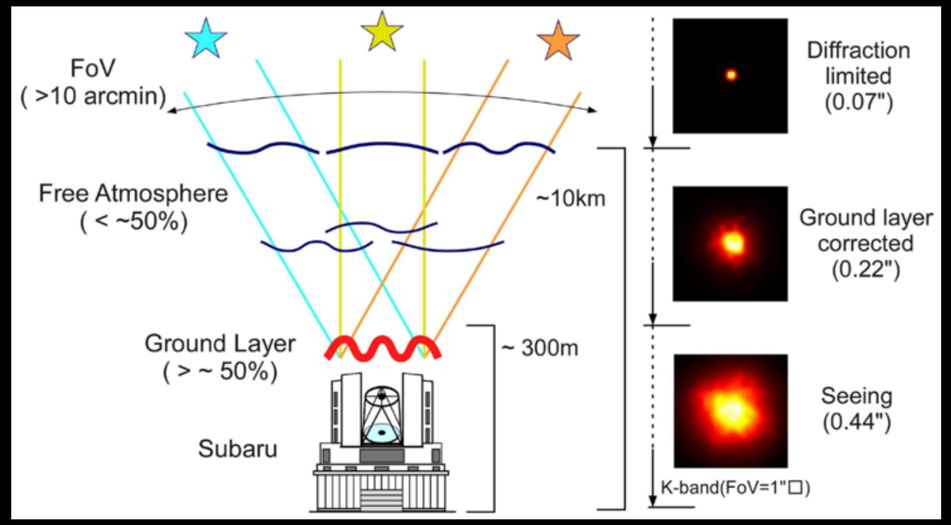
Yusei Koyama, , Kentaro Motohara, Ichi Tanaka, Yoshito Ono, Takashi Hattori,
Christophe Clergeon, Shin Oya, Kenshi Yanagisawa, Yutaka Hayano,
Michitoshi Yoshida (Subaru/NAOJ),
Masayuki Akiyama, Tadayuki Kodama (Tohoku Univ.),
Celine d'Orgeville, Noelia Martinez Rey, Gaston Gausachs, Francois Rigaut (ANU),
Shiang-Yu Wang, Chi-Yi Chou, Masahiko Kimura (ASIAA)

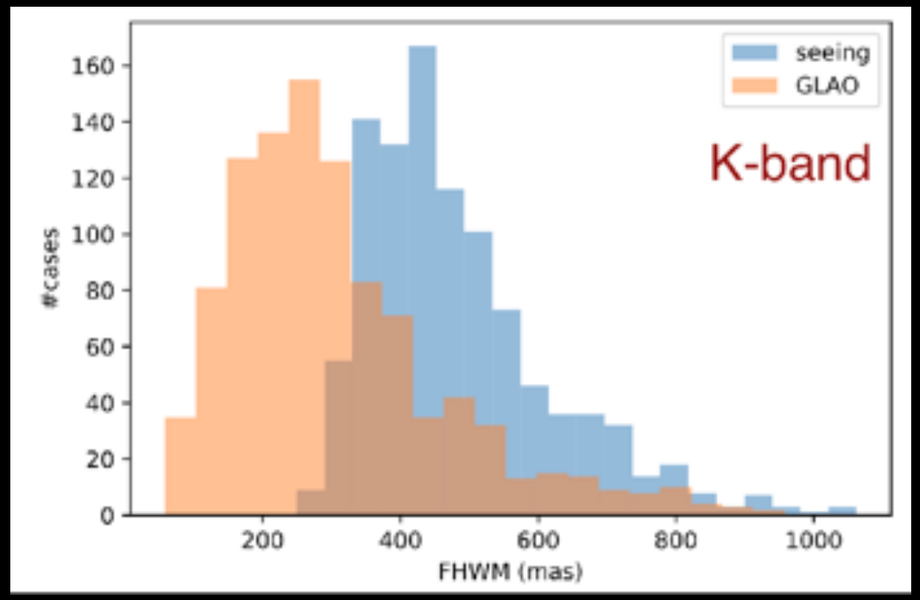
WIDE-FIELD + HIGH-RESOLUTION NIR SURVEYOR WITH GLAO

NIR (K-band) facilities available in 2020s and beyond

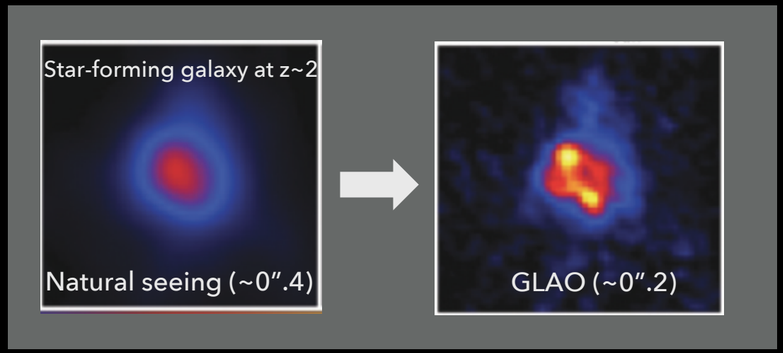


GROUND LAYER ADAPTIVE OPTICS AT SUBARU





- Improves seeing over wide-field of view (up to 20’ at Subaru) by compensating turbulence close to the ground only.
- Expected seeing size with GLAO is FWHM~0”.2 at K-band



- It is possible to further improve the seeing by narrowing field coverage (i.e. increasing the depth of the correcting turbulence layers)
  - GLAO narrow-field mode (<10’):FWHM ~0”.1
  - LTAO mode (several arcsec): diffraction limited

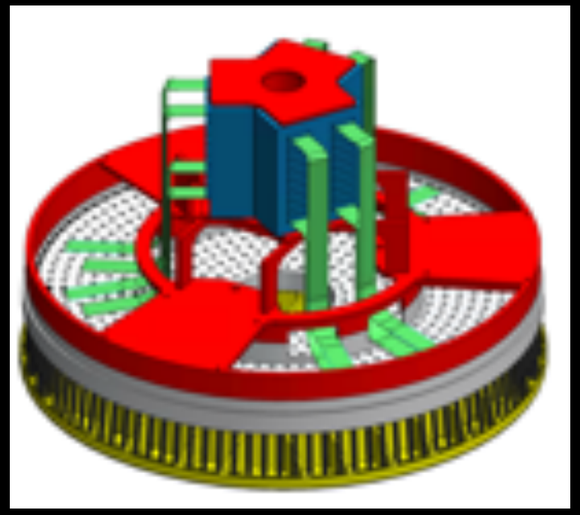
(to be discussed in the ULTIMATE session on March 5th, JST)

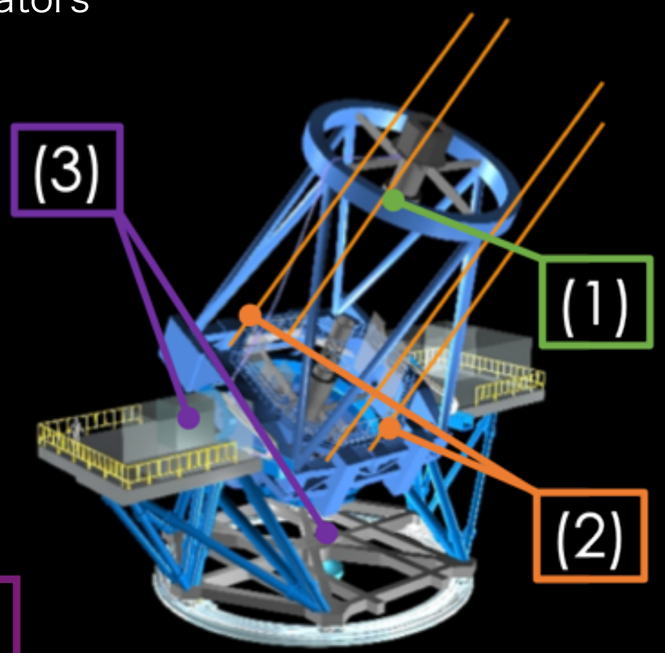
SUBARU GLAO SYSTEM: CONCEPTUAL DESIGN

ULTIMATE Subaru

(1) Adaptive Secondary Mirror

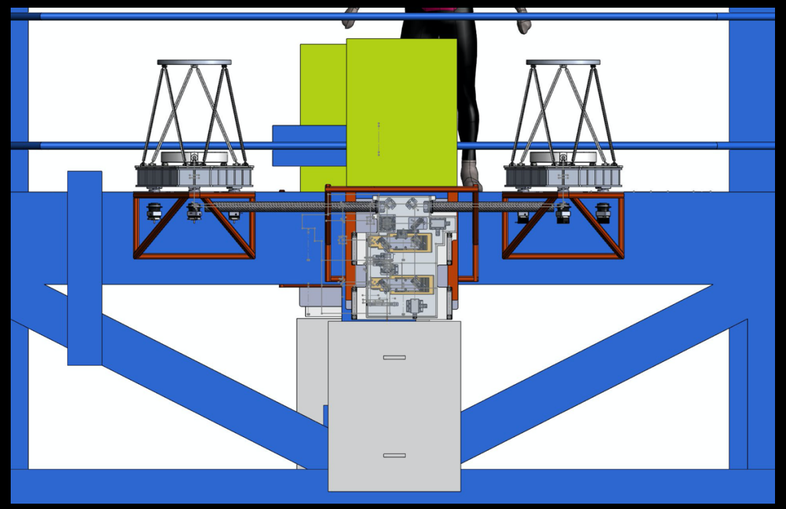
ϕ=1260mm deformable mirror with 924 actuators



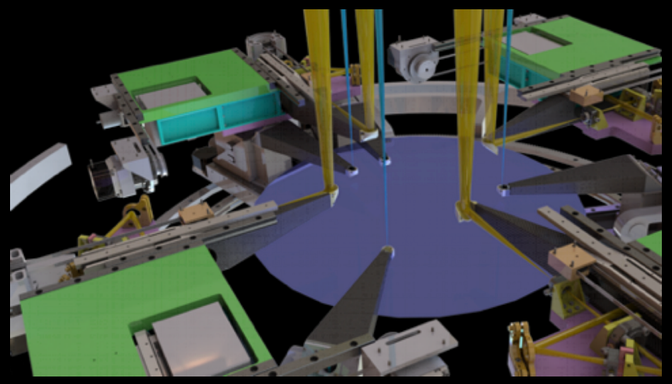


(2) Laser Guide Star Facility

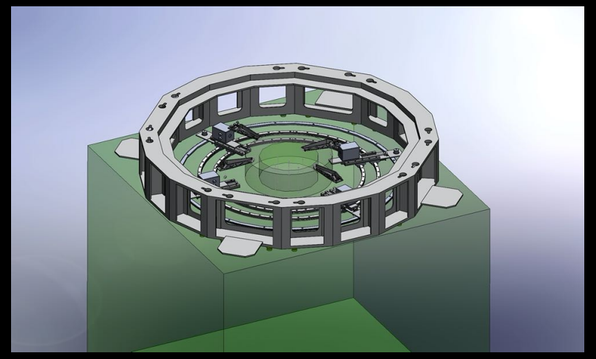
TOPICA fiber laser(589nm) x 2
Generate 4 laser guide stars



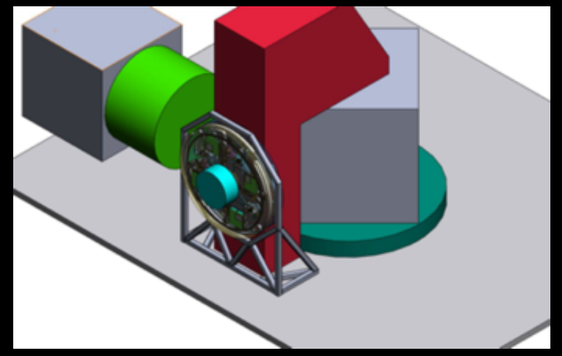
(3) Wavefront Sensors (LGS, NGS)



LGS: 4-32x32 SH WFS



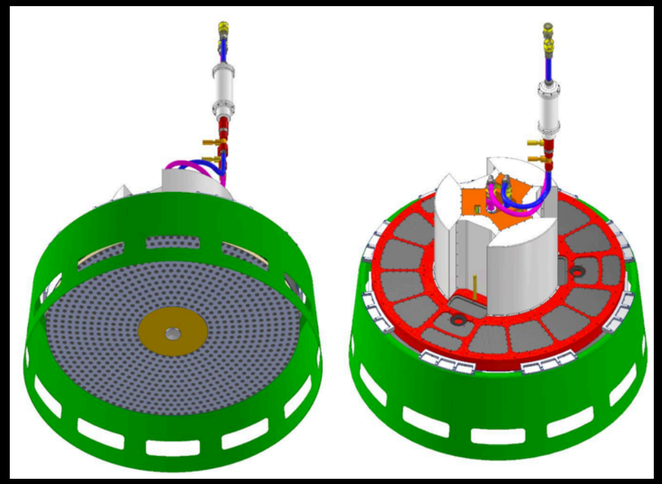
Cs (FoV~20′)

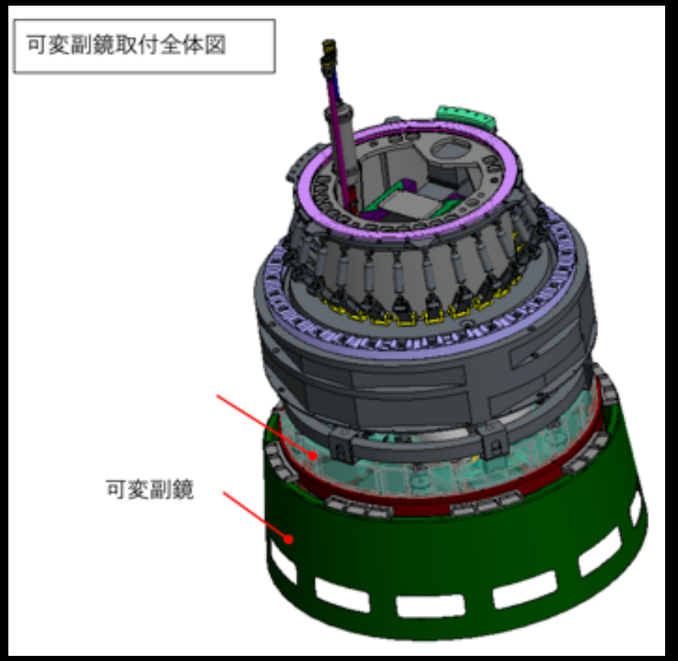


NsIR (FoV~14′)

ADAPTIVE SECONDARY MIRROR PRELIMINARY DESIGN

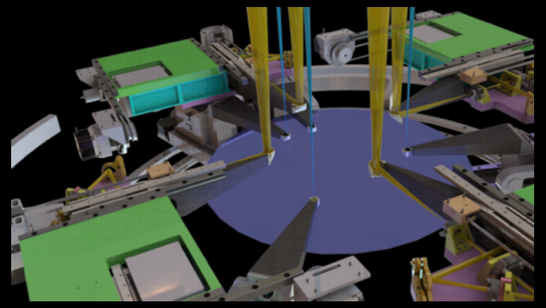
- Preliminary design of the ASM completed.
  - PDR with AdOptica conducted on Dec, 2020
  - All of the requirements not only for the GLAO, but also for the SCAO (more strict requirements) are satisfied with the current design.
  - Determined the specifications for the optical components (thin shell, reference body)
- Interface with the existing IRM2 mount is being confirmed with MELCO
- Final design phase is being started.
  - Mechanical final design in early FY2021
  - Electric/Control final design in mid-late FY2021
- ASM calibration system optical design is ongoing
  - Interferometer to measure the ASM shape
  - Closed-loop simulator in combination with the GLAO WFS

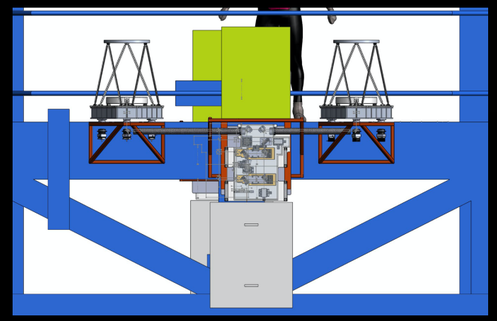




WFS/LGSF PRELIMINARY DESIGN

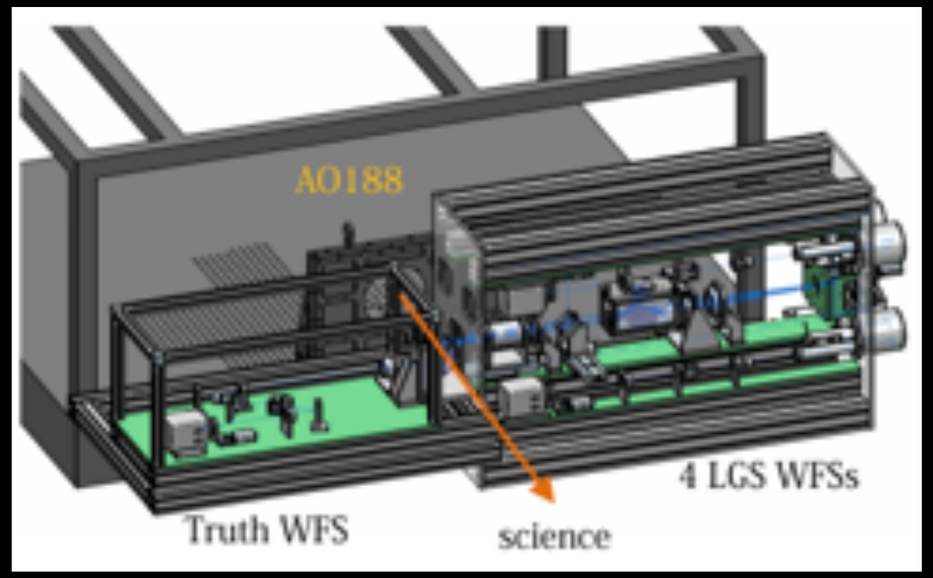
- Preliminary design study of the WFS/LGSF will be conducted in FY2021 in collaboration with ANU based on the CoDR design in 2018.

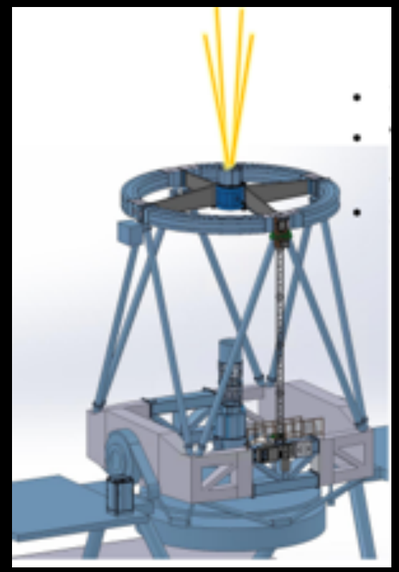




KEY TECHNOLOGY PROTOTYPING

ULTIMATE-START project : Laser Tomography AO system with 4 laser beams





(see poster p02 by M. Akiyama)

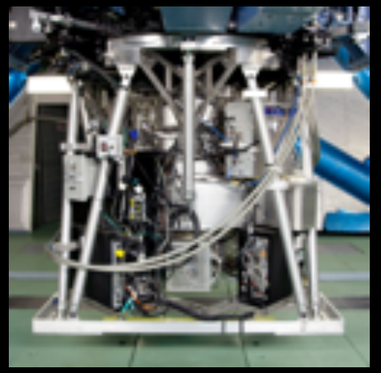
Implementation of the TOPTICA laser at Subaru telescope

(see poster p19 by Y. Minowa)

NEW WIDE-FIELD NIR INSTRUMENTS PLAN FOR ULTIMATE

2025
Phase 1

- Reuse MOIRCS at Ns. IR



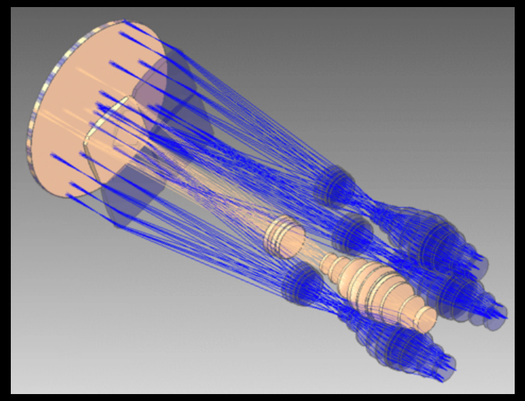
MOIRCS

- GLAO first light instrument
- FoV ~ 4' x 7' (0".12/pix)
- Wavelength: 0.9 - 2.5 um
- Imager/MOS spec (R500-3000)

CoDR scheduled on June, 2021

2027
Phase 2

- Wide-field imager (WFI) at Cs.

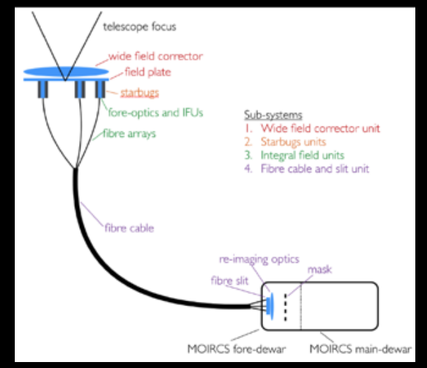


Imager conceptual optical design

- Workhorse instrument for large imaging survey
- FoV ~ 14' x 14' (~0".1/pix)
- Wavelength: 0.9-2.5 um
- Wide-variety of narrow/medium band filters

2030
Phase 3

- Fiber-bundle multi-IFU at Cs



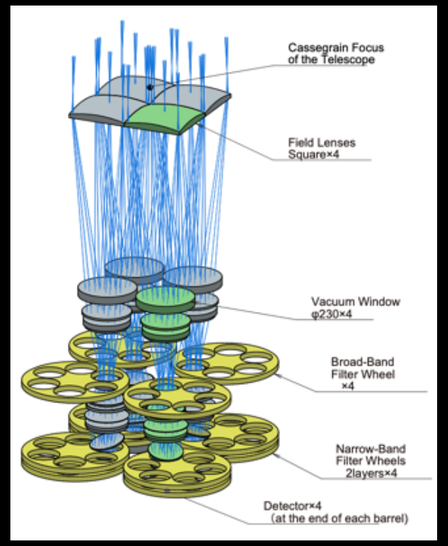
Multi-IFU concept by AAO

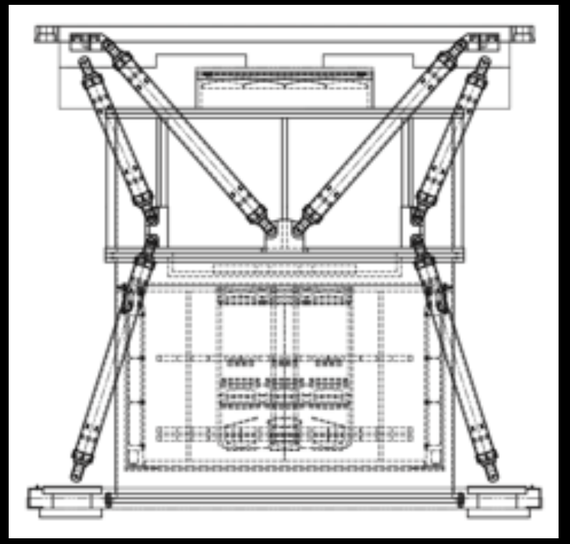
- Unique instrument for large kinematic survey like MANGA/SAMI.
- Feed to the existing spectrograph MOIRCS=R500-3000 or PFS (R=2000-5000)
- Patrol field: ~ 14' x 14'
- IFU FoV: 1".2 x 1".2
- Number of IFUs: 8-13
- Wavelength: 0.9 - 1.8 um

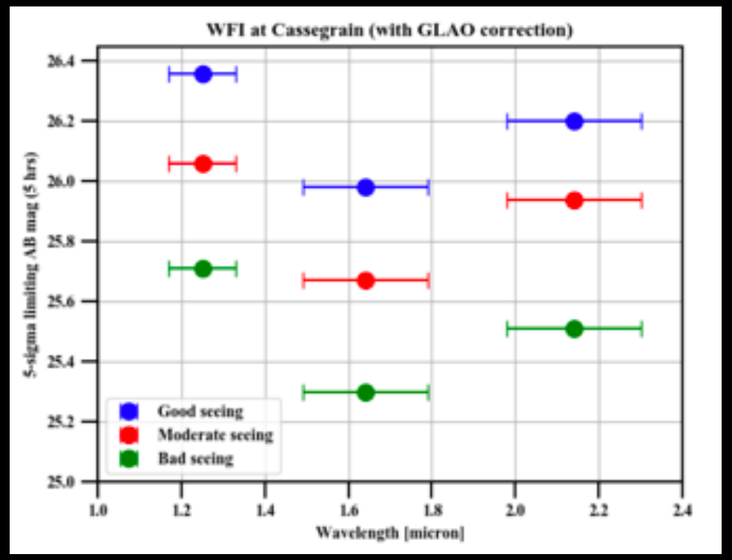
Science instruments for the narrow field mode is planned in parallel to the wide-field instruments (to be discussed in the ULTIMATE session on March 5th, JST)

WIDE-FIELD IMAGER CONCEPTUAL DESIGN

- Completed conceptual optical and structure design that realizes 14’x14’ FoV (Φ~20’) with < 0”.1 image quality at 0.9~2.5 micron.
  - 4 independent barrel design with square field lenses.
  - Equipped with 3 filter wheels that contains max. 15 filters per barrel.
  - Cryostat supported by truss structure to connect to the Subaru Cassegrain interface



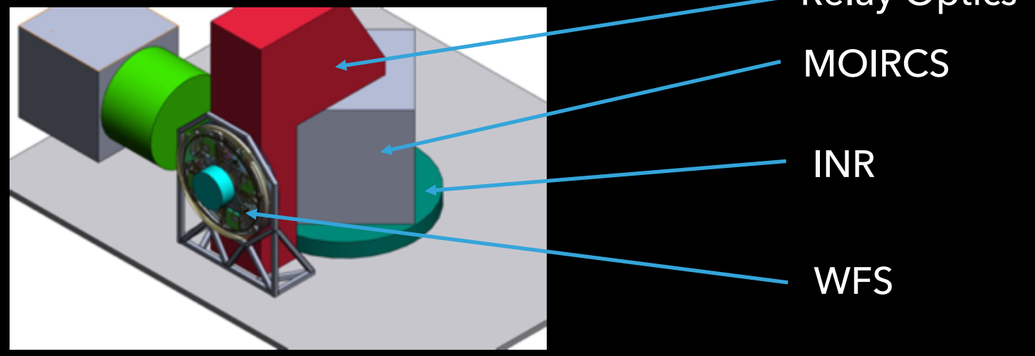


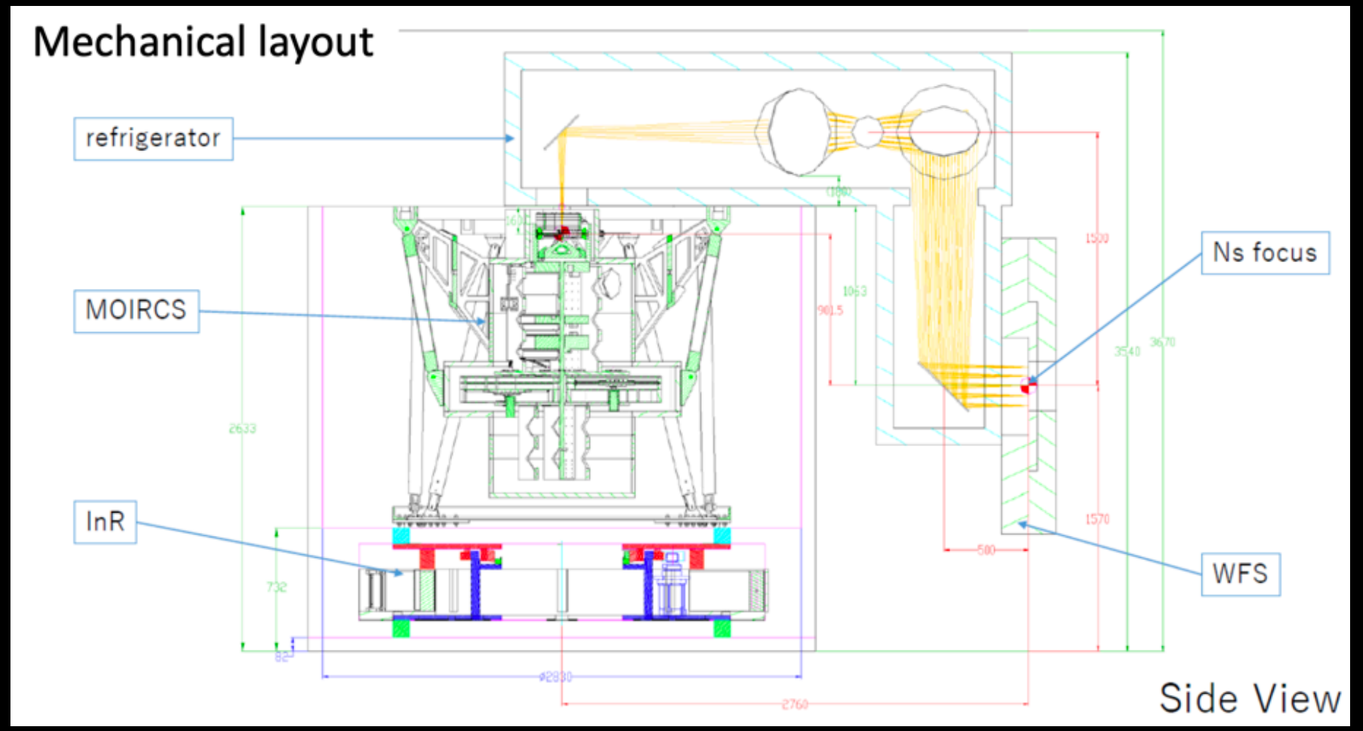


5σ limiting magnitude with 5 hrs integration time

MOIRCS UPGRADE FOR ULTIMATE

- MOIRCS will be relocated to NsIR to feed the GLAO corrected light and to have more stable platform for the MOS observation.
- Asymmetric Offner relay will be used to relay the telescope focus to the MOICS placed upright on the NsIR and to change the focal ratio.
- The relay optics wil be cooled (T<240K) to avoid increasing thermal emission due to the additional reflection surfaces.
- Instrument rotator (INR) below MOIRCS to compensate for the field rotation.
- Conceptual design of the relay optics and the INR by ASIAA





GLAO PROJECT STATUS

- GLAO is officially approved by NAOJ as one of the NAOJ's A project since FY2019
  - 2019-2021 : Preliminary Design Phase
  - 2022-2023 : Final Design Phase
  - 2023-2026 : Manufacturing, Assembly, Integration, and Test phase

- Complete the PDR by the end of FY2021 with a support from NAOJ
- ASM production will be started as soon as the GLAO PDR is completed.
- External fund is essential to start the fabrication of the rest of the systems (WFS, LGSF, Science instruments)