Subaru Users Meeting 2026 @ NAOJ, June 17-19, 2026

ULTIMATE-Subaru

すばる広視野補償光学プロジェクト

https://ultimate.naoj.org/index.html
https://ultimate.naoj.org/superirnet/index.html

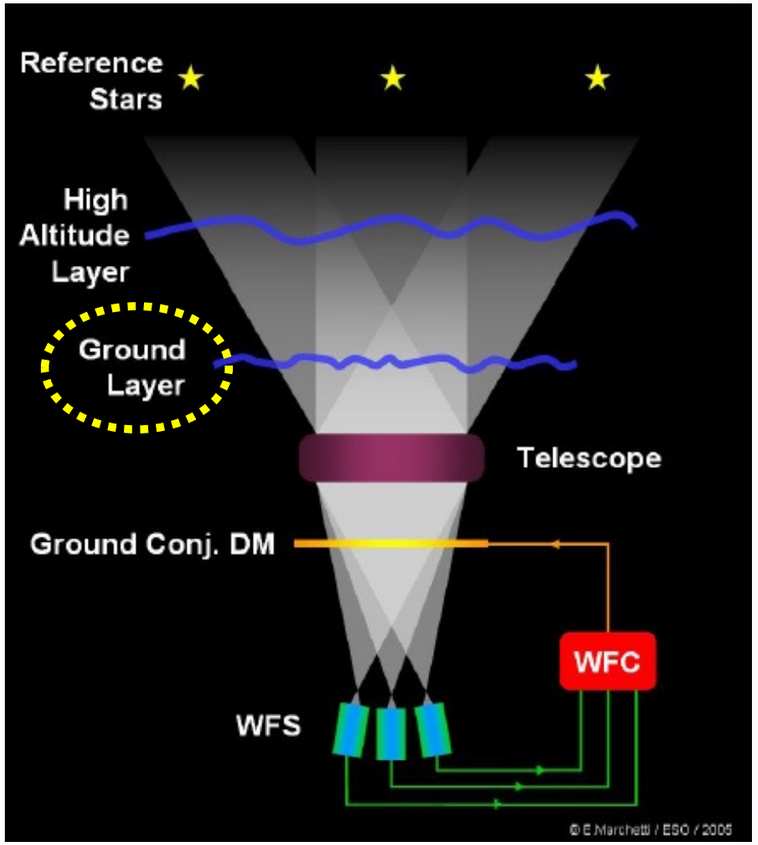
Yusei Koyama (NAOJ/Subaru)

ULTIMATE-Subaru collaboration

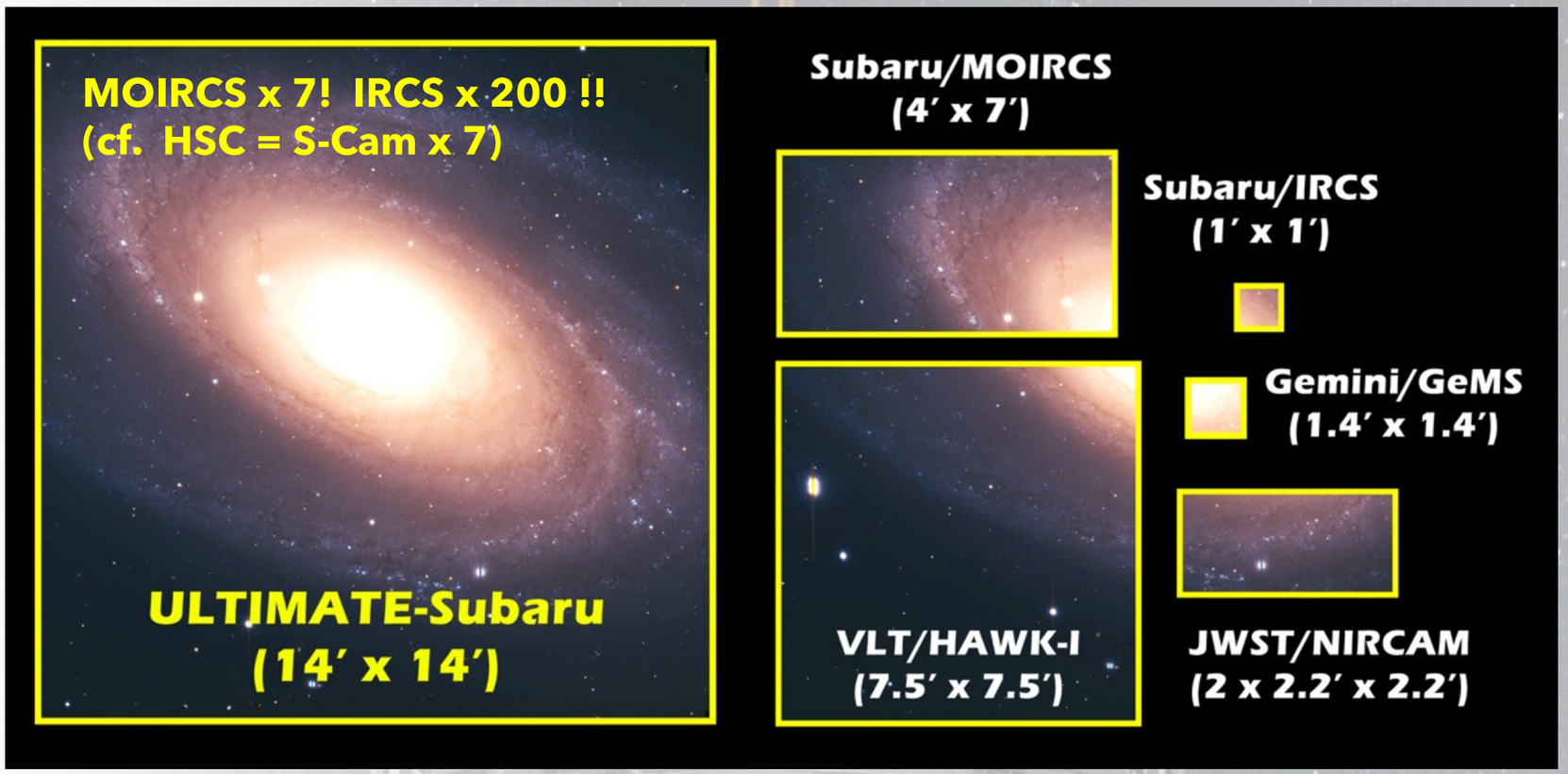
ULTIMATE-Subaru

すばる広視野補償光学プロジェクト

- Wide-field adaptive optics (**GLAO**) and wide-field IR imager (**WFI**).
- Improved image quality (**FWHM~0.2" in K-band**) over ~20-arcmin FoV.
- Primary wide-field instrument for **bright nights** of Subaru in 2030s-.



Concept of Ground-Layer AO ©ESO

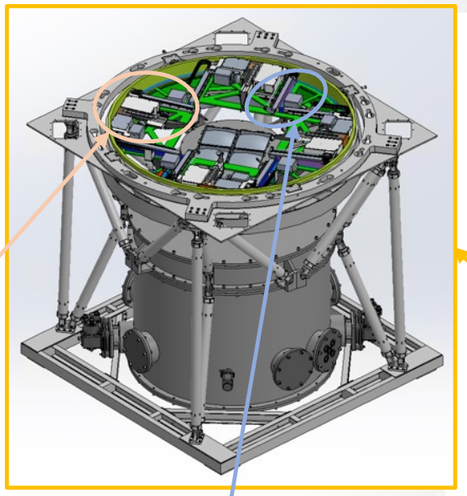


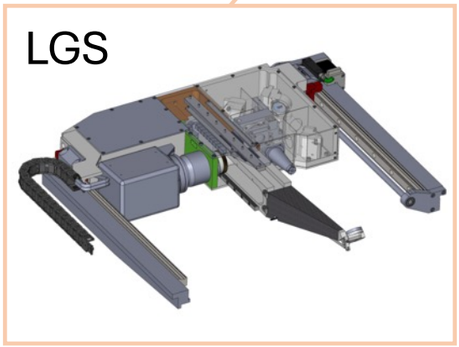
ULTIMATE-Subaru development

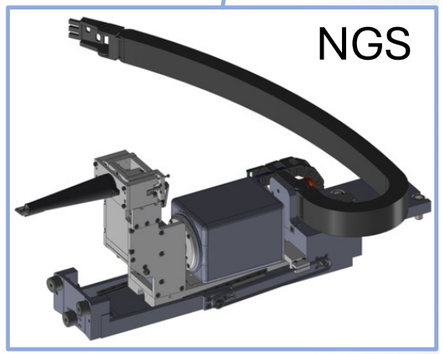
GLAO Final Design Review, on July 29-31 @ NAOJ

Wide-Field Imager (WFI)

- Cassegrain instrument
- FoV ~ 14' x 14'
- λ: 0.9 – 2.5 um

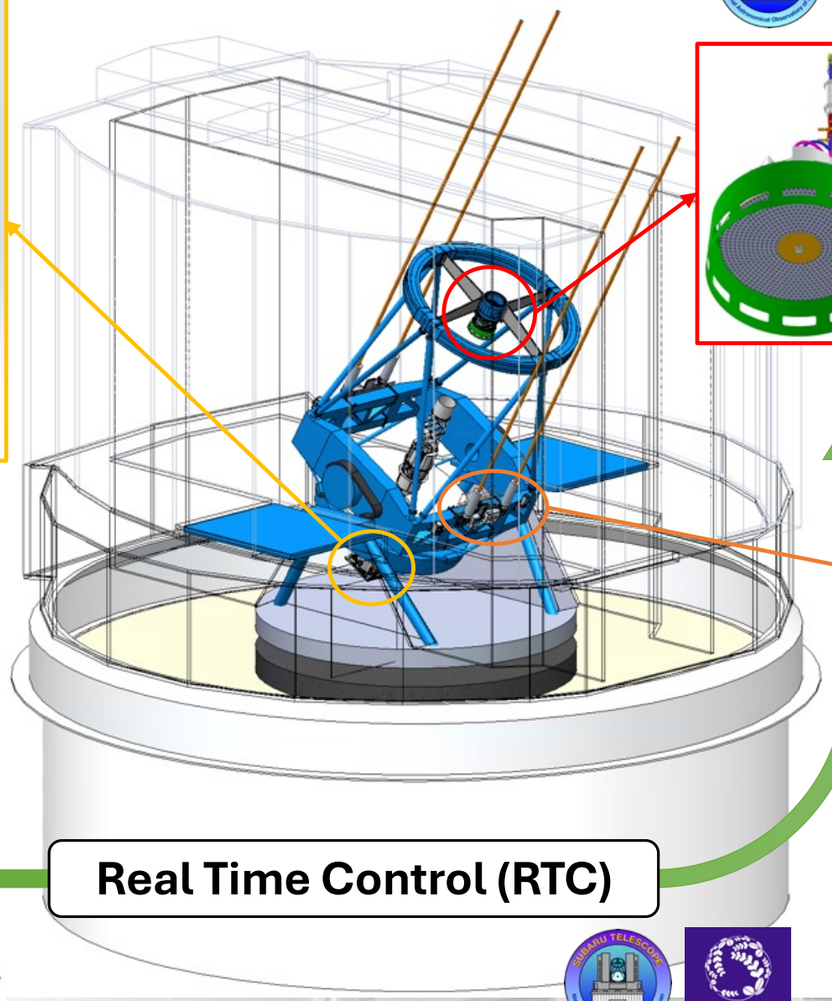




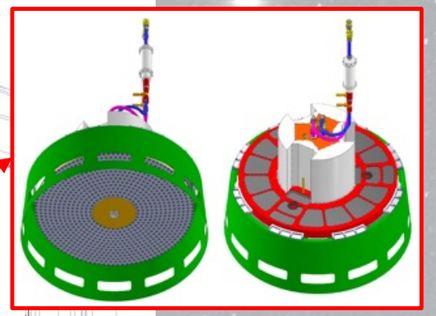


Wavefront Sensor (WFS)

- 4 Laser Guide Star (LGS) WFS
- 4 Natural Guide Star (NGS) WFS

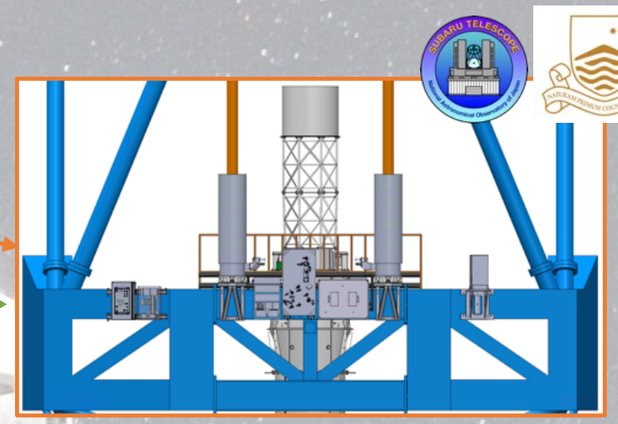


Real Time Control (RTC)



Adaptive Secondary Mirror

- 924 actuators over 1.2 m optical surface
- Control up to 1 kHz (~2 kHz goal)
- Replace the existing IR secondary mirror



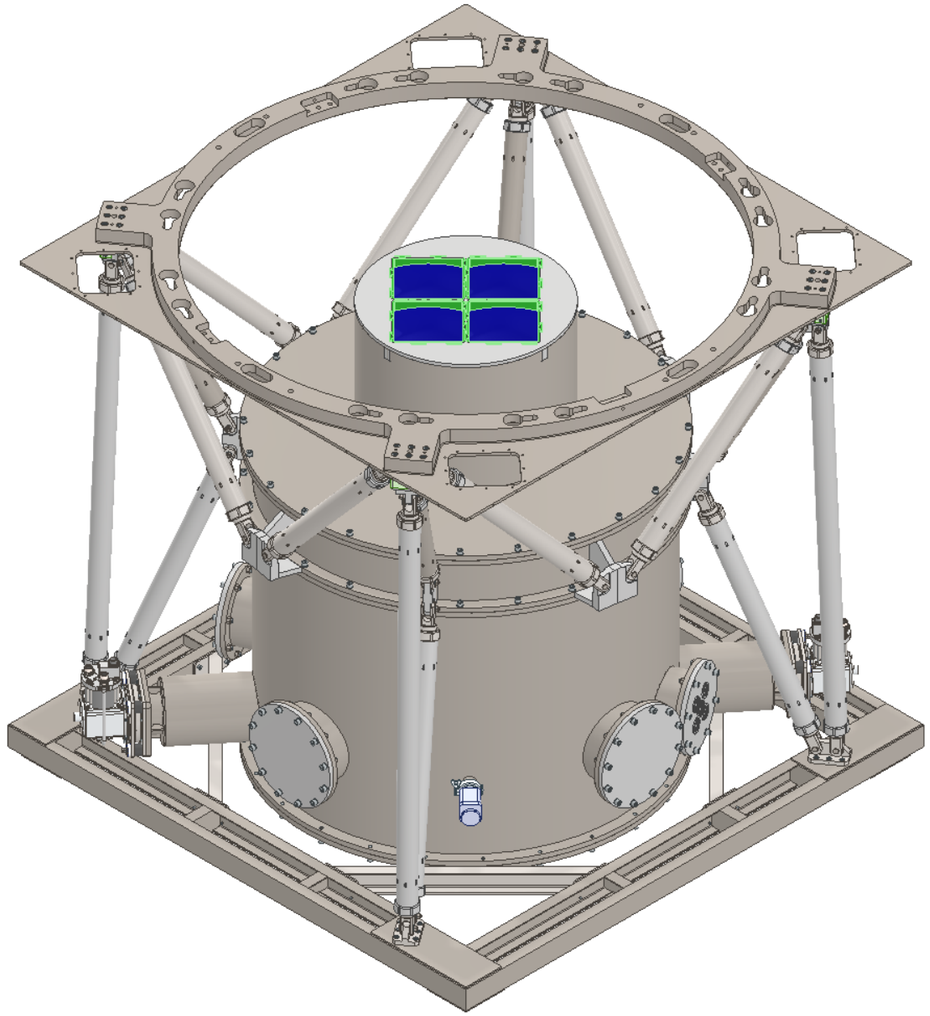
Laser Guide Star Facility

- Launch four laser beams from the side of the telescope.
- Generate 4 LGS constellation within < 20' diameter

Wide-Field Imager (WFI)

Final Design phase, funded by JSPS KAKENHI (PI: T. Kodama, FY2024-FY2030), but not full amount

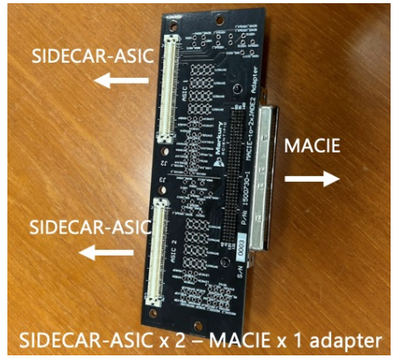
Size	~ 2 x 2 x 1.91 m^3
Weight	~ 3 ton
Field of view	**~ 14' x 14'**
Spatial sampling	0.1"/pixel
Filters	**3 Broad-band (BB)** **10 Medium-band (MB)** **Many Narrow-band (NB)**
Expected limiting mag. (good seeing, airmass=1, 1 hour, 5σ, point source)	Y: 25.6 mag(AB) J: 25.5 mag(AB) H: 25.2 mag(AB) Ks: 25.4 mag(AB)



- In the Final Design Phase
- JSPS KAKENHI (Grant-in-Aid Specially Promoted Research)
  - PI: T. Kodama (Tohoku Univ.)
  - Total ~4.5M USD (700M JPY)
  - 7 years (2024 – 2030)

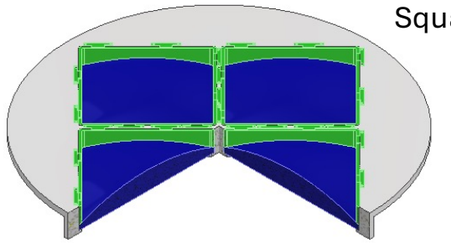
  → A part of the instrument can be completed (1/4~1/2 FoV)

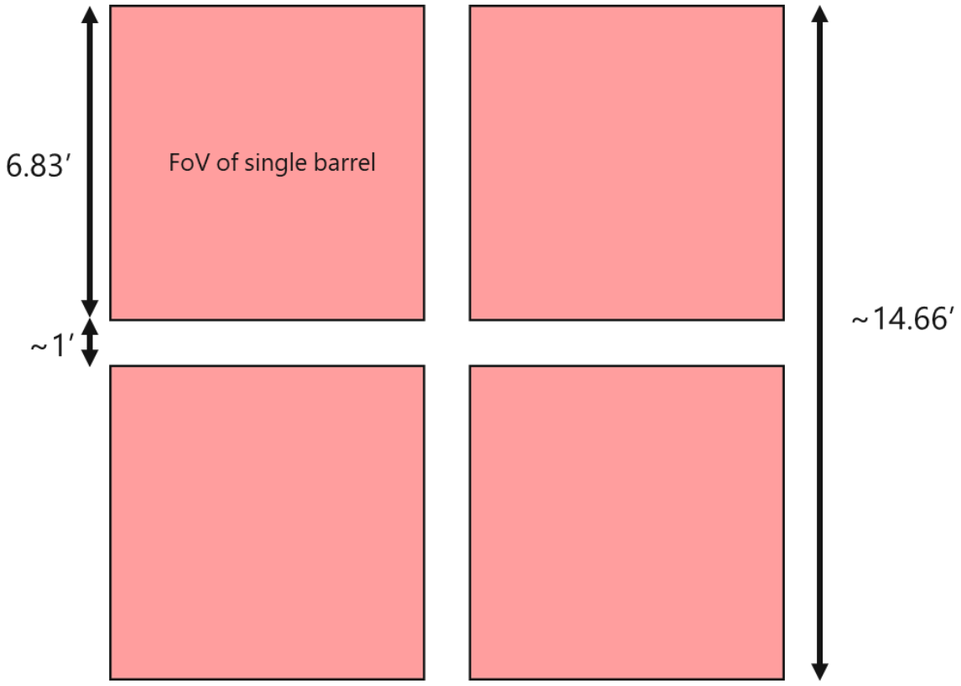
Wide-Field Imager (WFI)

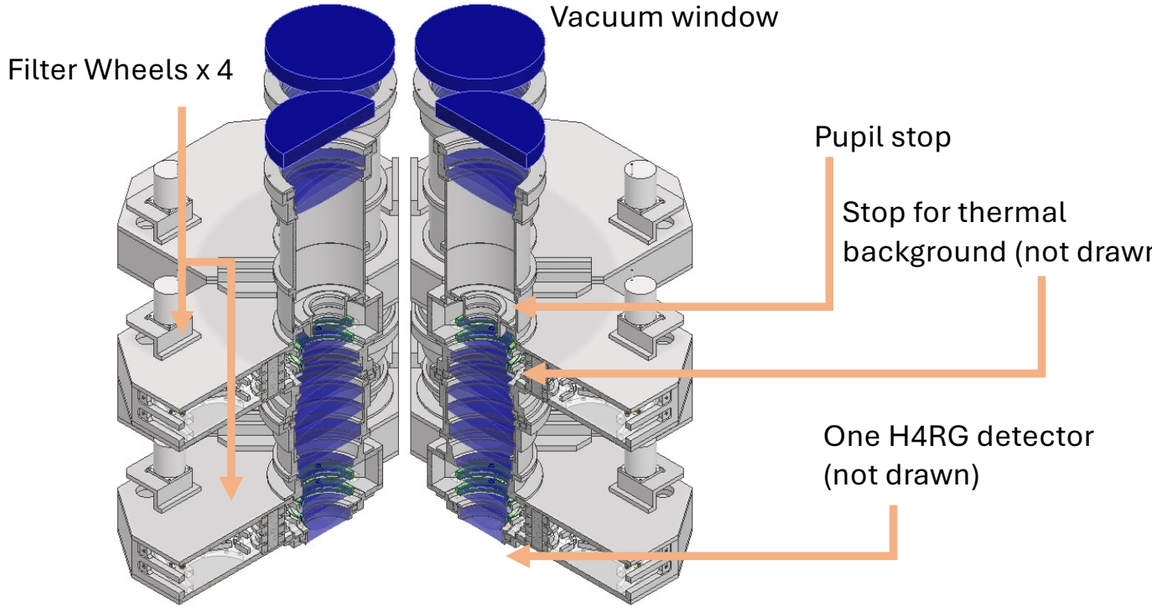


4-barrel Optics to cover the wide FoV (~14’ x 14’):

- Four filter wheels per barrel
- One HAWAII-4RG detector (4K x 4K pixels) per barrel
- Each covers 6.83’ x 6.83’ → Effective 13.66’ x 13.66’



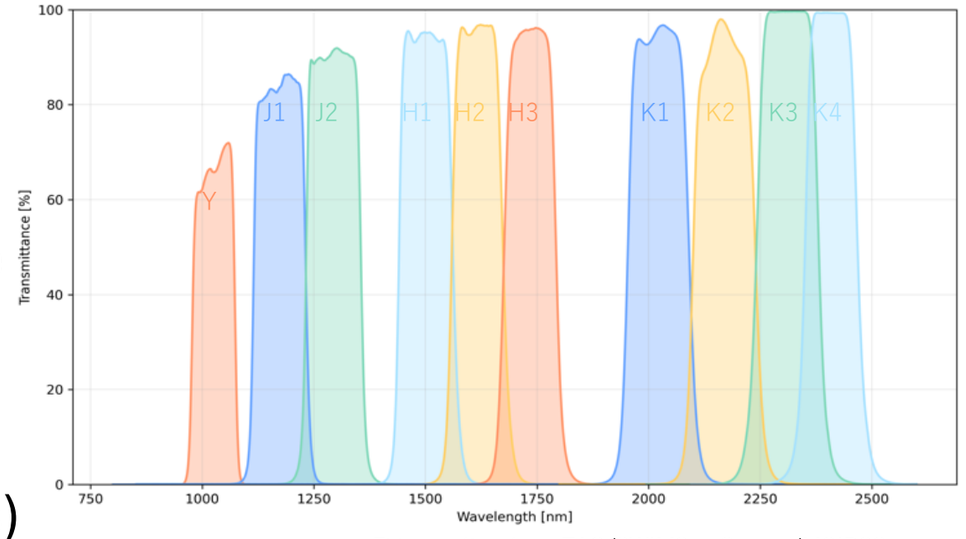




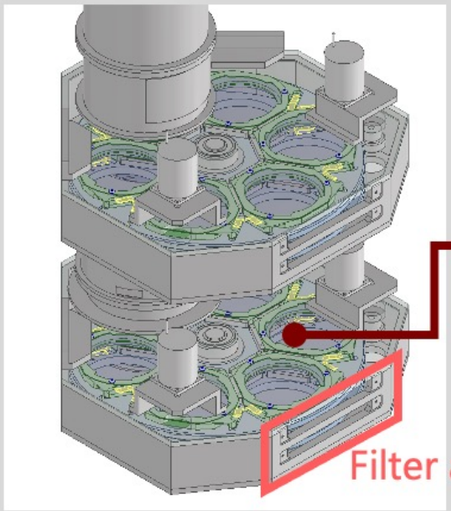
Wide-Field Imager (WFI) – Filters

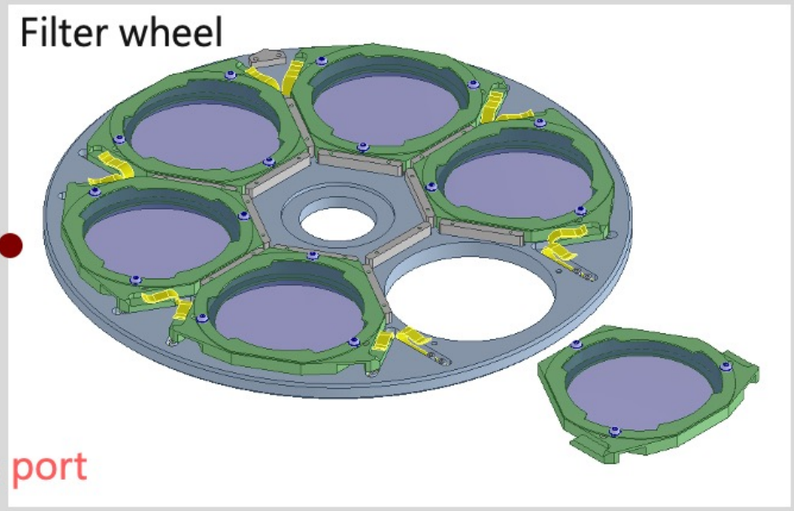
A variety of BB/MB/NB filters:

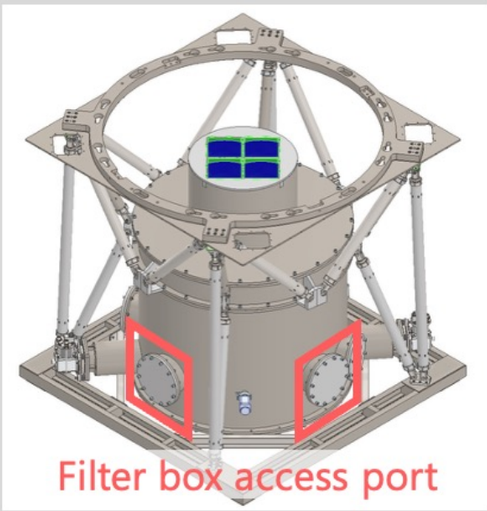
- Not available for space telescopes (Euclid, Roman)
- Dual MB filters (two pass-bands in one filter) to reduce the number of filters.
  - # See P20 (I. Tanaka) for triple-band filters for MOIRCS.
- Exchangeable filter wheels for NBs, to maximize the number of filters to be installed simultaneously (9 NBs)



Filter profiles from TAO/SWIMS or Subaru/MOIRCS

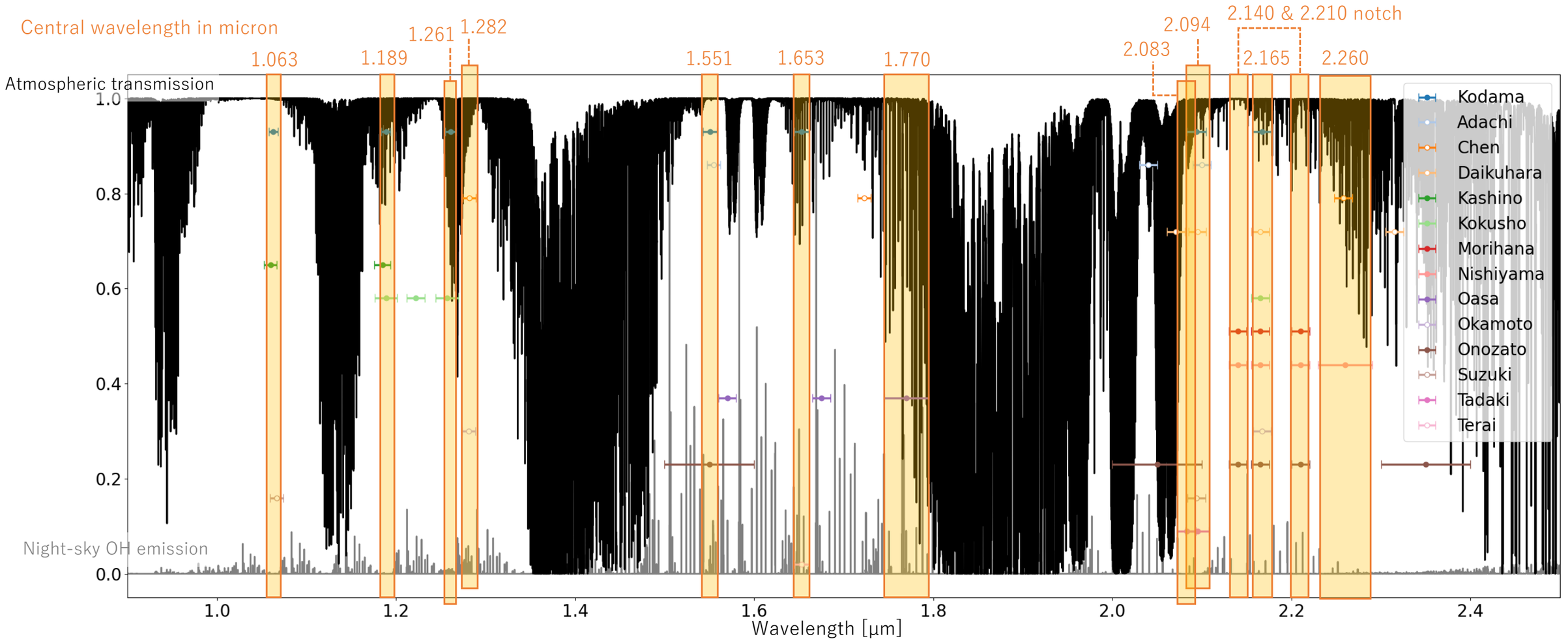






Wide-Field Imager (WFI) – Filters

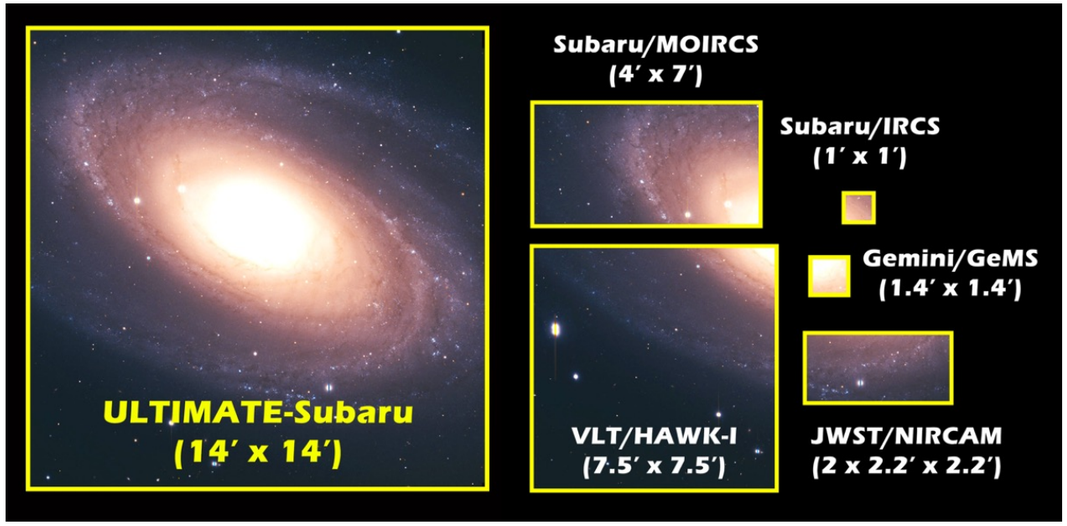
- “Starting Lineup” of NB filters, following the community discussion (Sep 2025)
- We can add carry-in filters – we are happy to discuss grant proposals with you !



ULTIMATE-Subaru : unique science capabilities

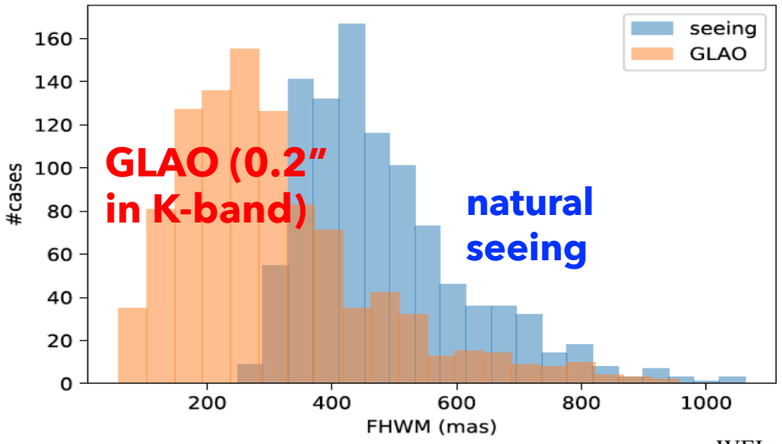
すばる広視野補償光学プロジェクト

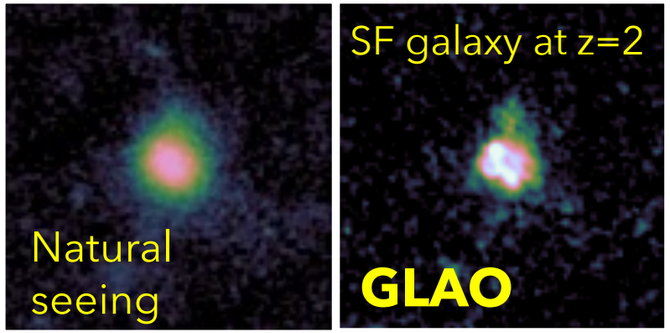
① Widest AO imaging on 8-10m telescope



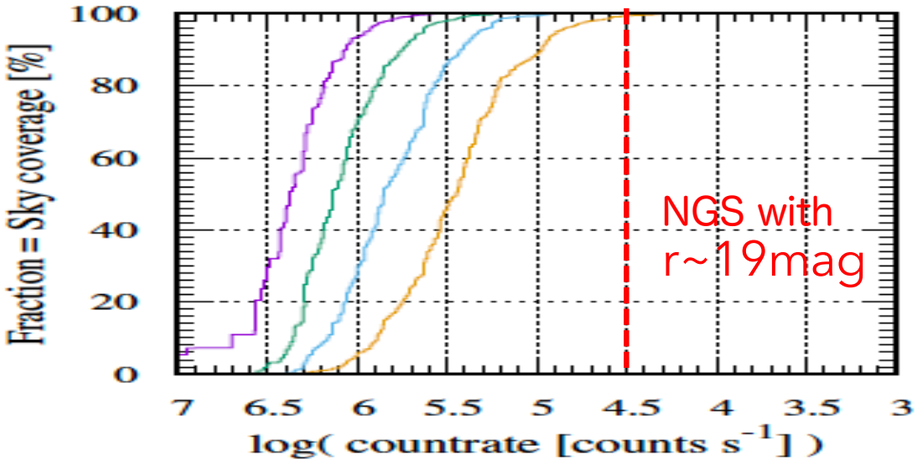
② Space telescope image quality

Comparable to HST/Roman, higher image quality than existing GLAO on VLT





③ All-sky coverage

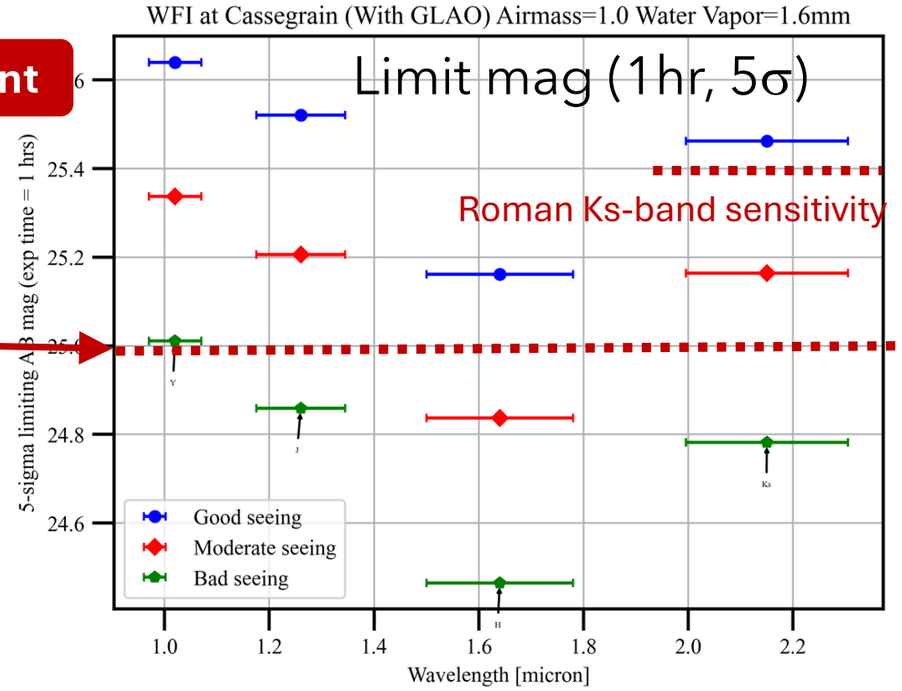


Full performance everywhere – no worry about guide star availability

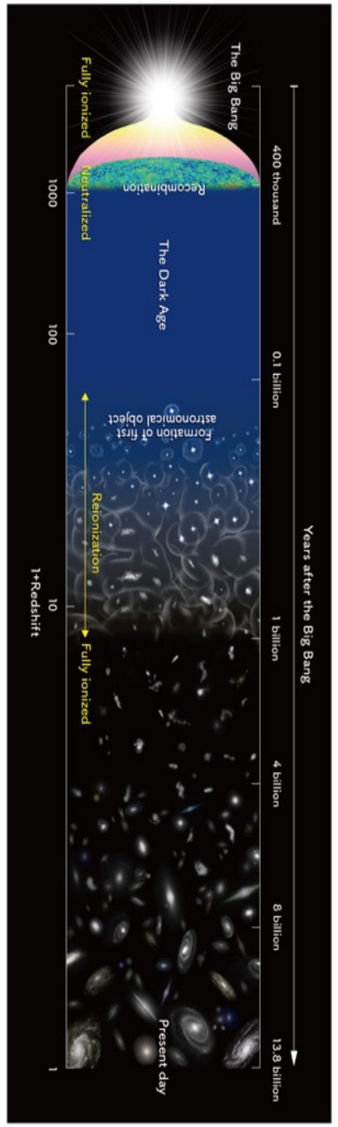
④ Sensitivity enhancement

Broad-band sensitivity of ~25-26 mag (AB) in reasonable observing time.

25 mag



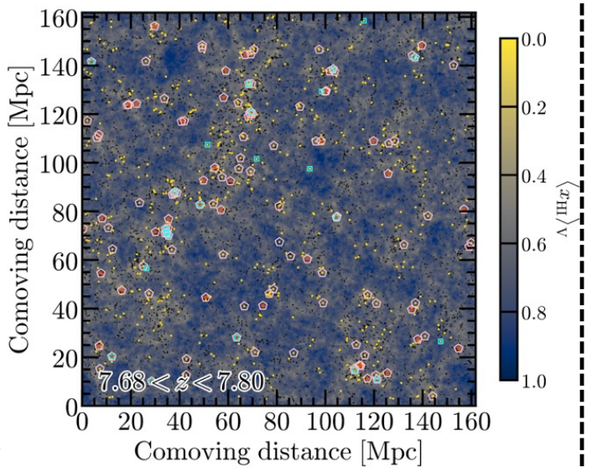
ULTIMATE for high-redshift universe



1) Cosmic Reionization Bubble

Deep & Wide NB

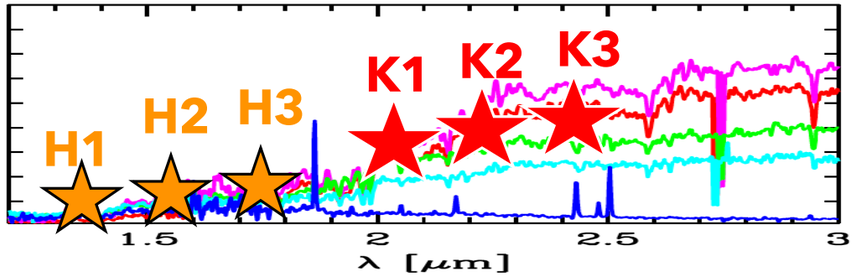
Unprecedentedly deep and wide NB imaging to search Lyα emitters in the epoch of cosmic reionization (at z>>7), to identify ionized bubbles in the very early universe.



2) First Massive Galaxies

Deep & Wide MB

Understand the nature and environment of massive (quenched) galaxies by detecting the most massive galaxies at z~4-5 with deep/wide MB(K) imaging.

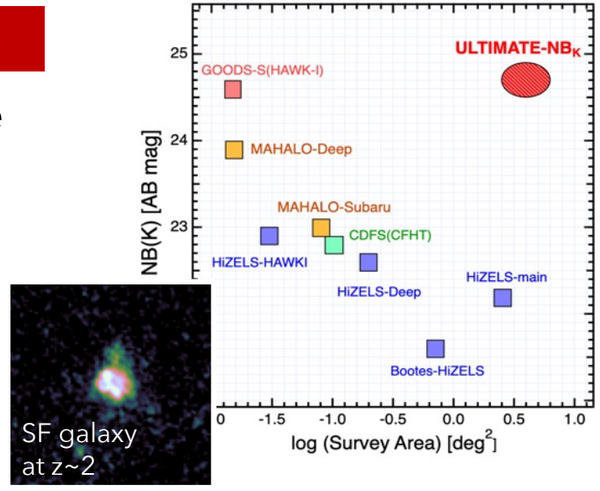


SEDs of z=4 galaxy

3) Build-up of the Hubble Sequence

Sharp & Wide NB

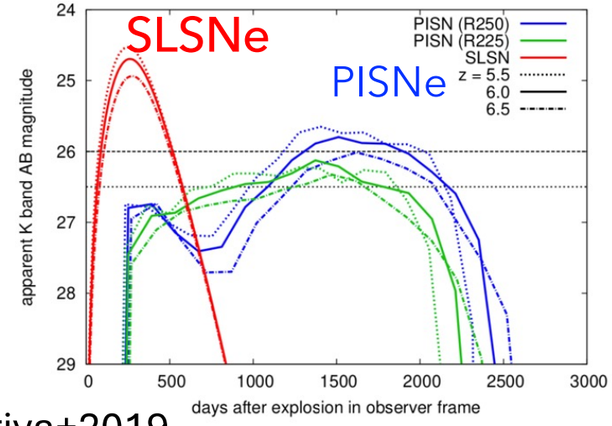
Stellar build-up inside the galaxies at the cosmic noon (z~2-3) epoch with deep and sharp NB(Hα/[OIII]) imaging in K-band.



4) Supernovae Explosion in early universe

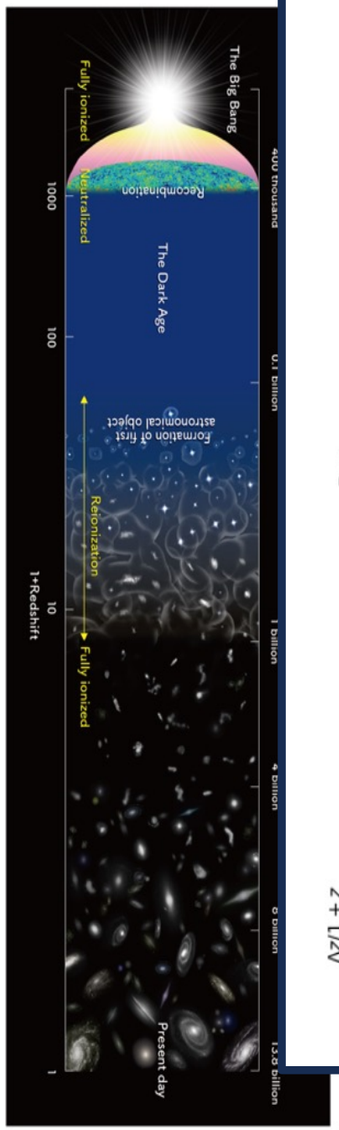
Deep & Wide K/MB

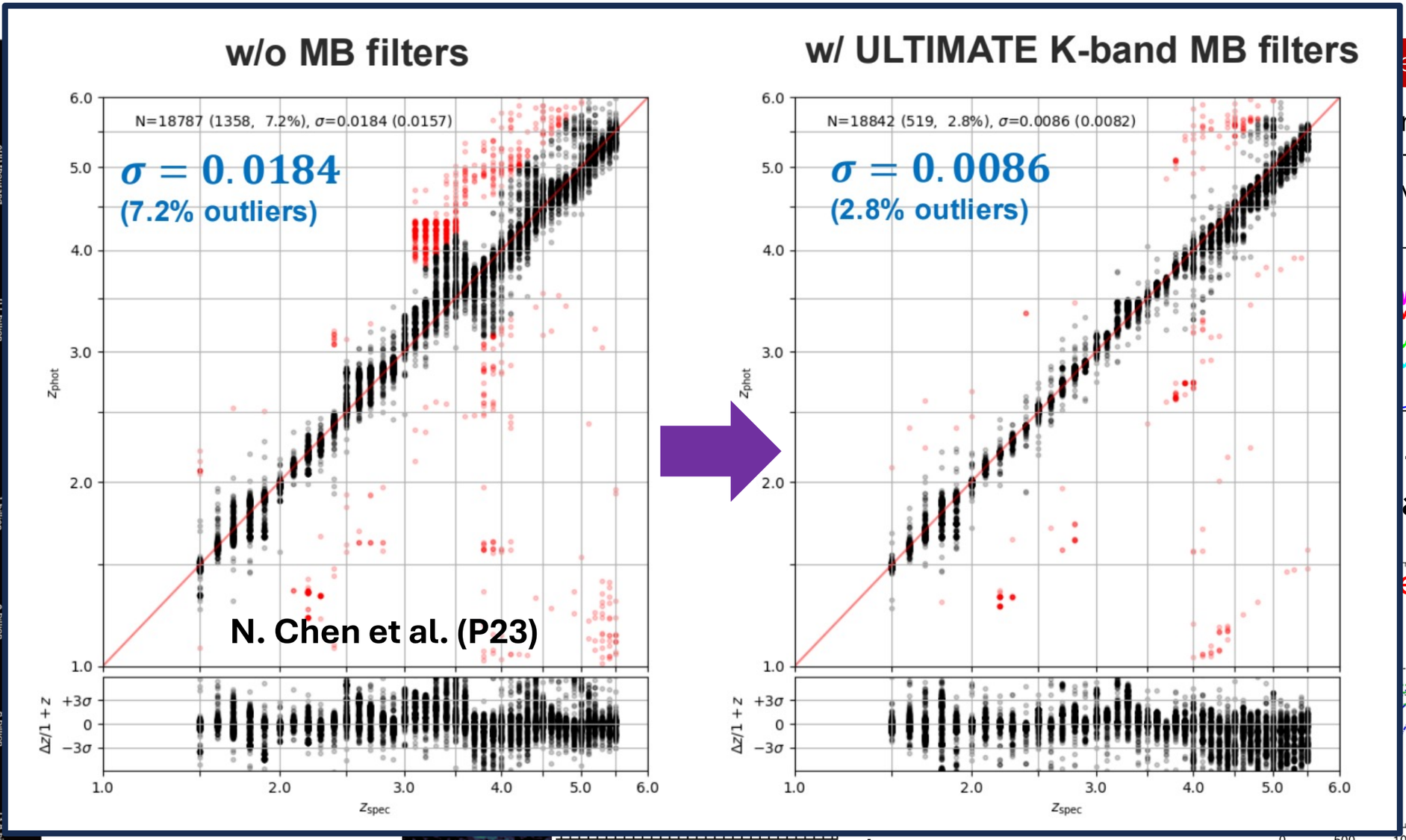
SNe search at z>6 by visiting ~1-deg^2 every 180-days down to K > 26 mag will allow us to detect SNe at z>6.



Moriya+2019

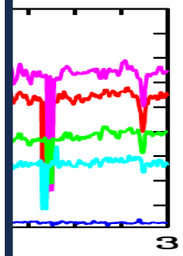
ULTIMATE for high-redshift universe





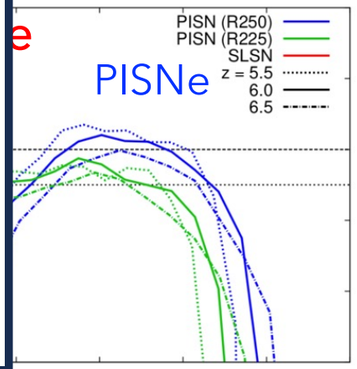
eep & Wide MB

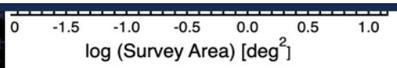
nment of massive
the most massive
MB(K) imaging.



SEDs of
z=4
galaxy

arly universe





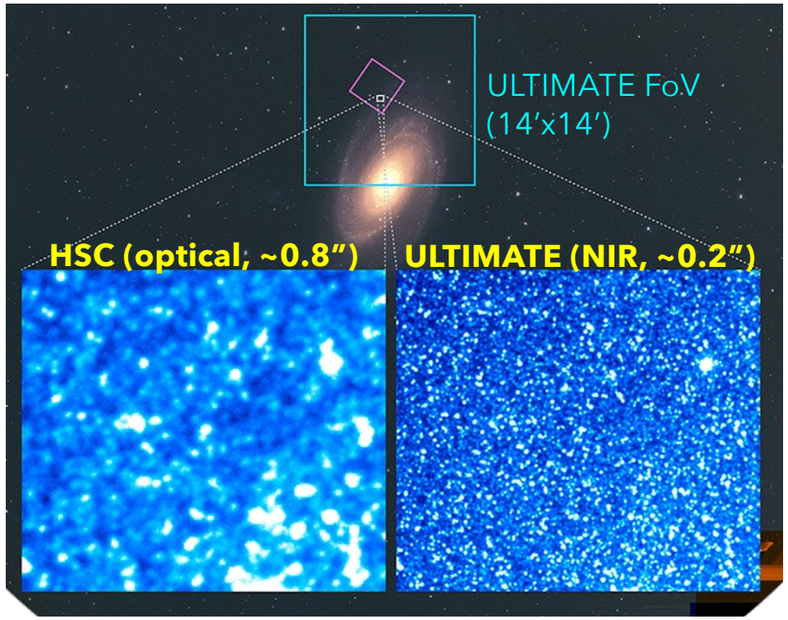
Moriya+2019

ULTIMATE for the Local Universe

1) Nearby Galaxies

Sharp & Wide JHK + NB

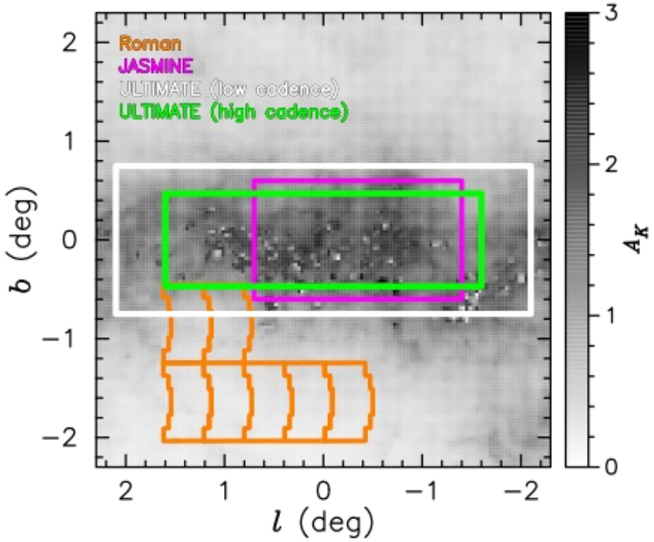
Spatially resolve nearby galaxies (D<10Mpc) into individual stars and star-forming regions, to study galaxy formation history (galactic archaeology) and ISM physics.



2) Galactic Center

Sharp & Wide JHK + NB

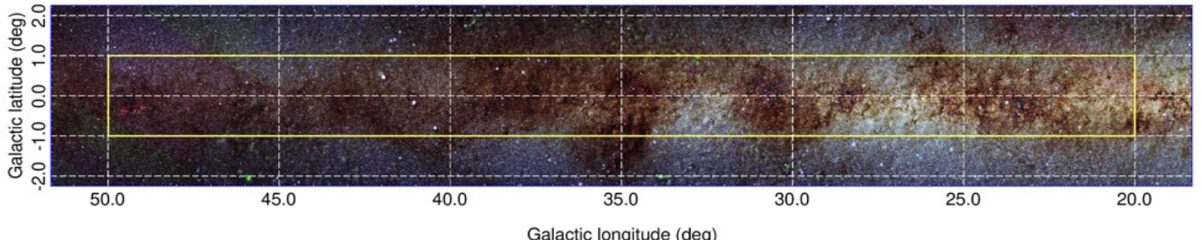
High/low cadence survey toward the Galactic Center with ULTIMATE, to reveal hidden objects (blackholes and free-floating planets) in the Galactic Center with microlensing and astrometric approach.



3) Galactic Plane

Sharp & Wide NB/MB

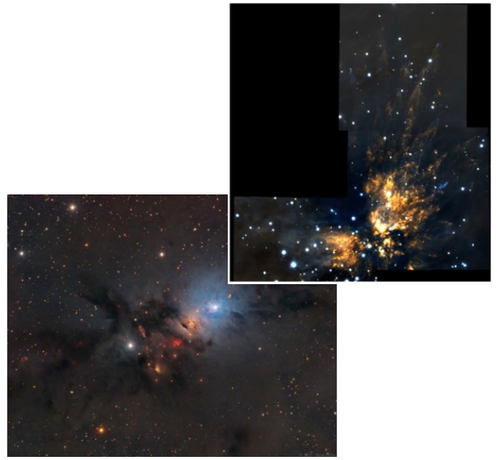
- Reveal MW structure and hidden stellar evolution.
- Paβ/Brγ imaging for cataclysmic variables, to reveal the Galactic Diffuse X-ray Emission



4) Star Forming Regions

Sharp & Deep JHK + NB

Sharp/deep imaging of SF regions in a variety of environment within the Milky Way to study the variety/universality of IMF.



ULTIMATE Science Core Team

Y. Koyama

Project Scientist

It’s not too late to join the science team – we are starting serious discussion on ULTIMATE survey design

A. Inoue
D. Kashino

Cosmic Dawn

S. Okamoto

Nearby Galaxies

K. Morihana
T. Kamizuka

Galactic Plane

T. Kodama

Massive Galaxies

T. Moriya

Time Domain Astronomy

Y. Takagi

Star Formation

K. Tadaki
H. Kusakabe

Cosmic Noon

S. Nishiyama
D. Suzuki

Galactic Center

T. Terai

Solar System

SUPER-IRNET: JSPS Core-to-Core Program

FY2021-FY2025, PI: M. Yoshida (NAOJ)

Japan Society for the Promotion of Science 日本学術振興会 — Core-to-Core Program 研究拠点形成事業

Promote wide-field IR astronomy with 5 countries – concluded in March 2026.

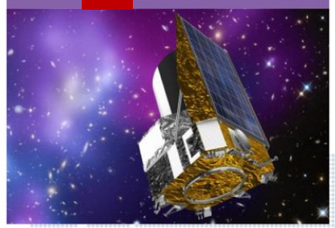
SUPER IRNET

euclid

cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

esa

Euclid



CNES

France

Synergy observations + Science collaboration

Synergy observations + Science collaboration

Roman

NASA

U.S.A.

ROMAN SPACE TELESCOPE

NASA

collaboration

ULTIMATE-Subaru

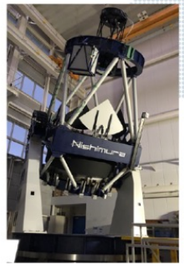
collaboration

Subaru Telescope NAOJ

Japan

Development + Science collaboration

Development + Science collaboration



PRIME telescope

PRIME

Osaka Univ./South Africa

大阪大学 OSAKA UNIVERSITY

ASIAA

Taiwan

中央研究院 ASIAA

SUBARU TELESCOPE

国立天文台 NAOJ National Astronomical Observatory of Japan

ULTIMATE Subaru

SWIMS(TAO)

Univ. of Tokyo/Chile

THE UNIVERSITY OF TOKYO

SWIMS Simultaneous-color Wide field Infrared Multi-object Spectrograph

ANU

Australia

Australian National University

SUPER-IRNET: JSPS Core-to-Core Program

FY2021-FY2025, PI: M. Yoshida (NAOJ)

JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE 日本学術振興会

Core-to-Core Program 研究拠点形成事業

Promote wide-field IR astronomy with 5 countries – concluded in March 2026.

PRIME telescope

SWIMS Simultaneous-color Wide field Infrared Multi-object Spectrograph

Australia

Final SUPER-IRNET Workshop (March 16-19, 2026 @ UOsaka Nakanoshima Center in Osaka)

Now we are “SUPER-IRNET-2.0” !!

Approved as a new JSPS Core-to-Core Program (FY2026-FY2030), with upgraded concepts and new partner countries across 5 continents!

Japan: ISAS/JAXA

PI: Michitoshi Yoshida (NAOJ) → Toru Yamada (JAXA)

France: CNRS

Denis Burgarella

UK: Edinburgh

Andy Taylor

USA: NASA

Julie McEnery
Jason Rhodes

Australia/ANU

Noelia Martinez Rey
Tayyaba Zafar (Macquarie)

Taiwan: ASIAA

Shiang-Yu Wang

Korea: KASI

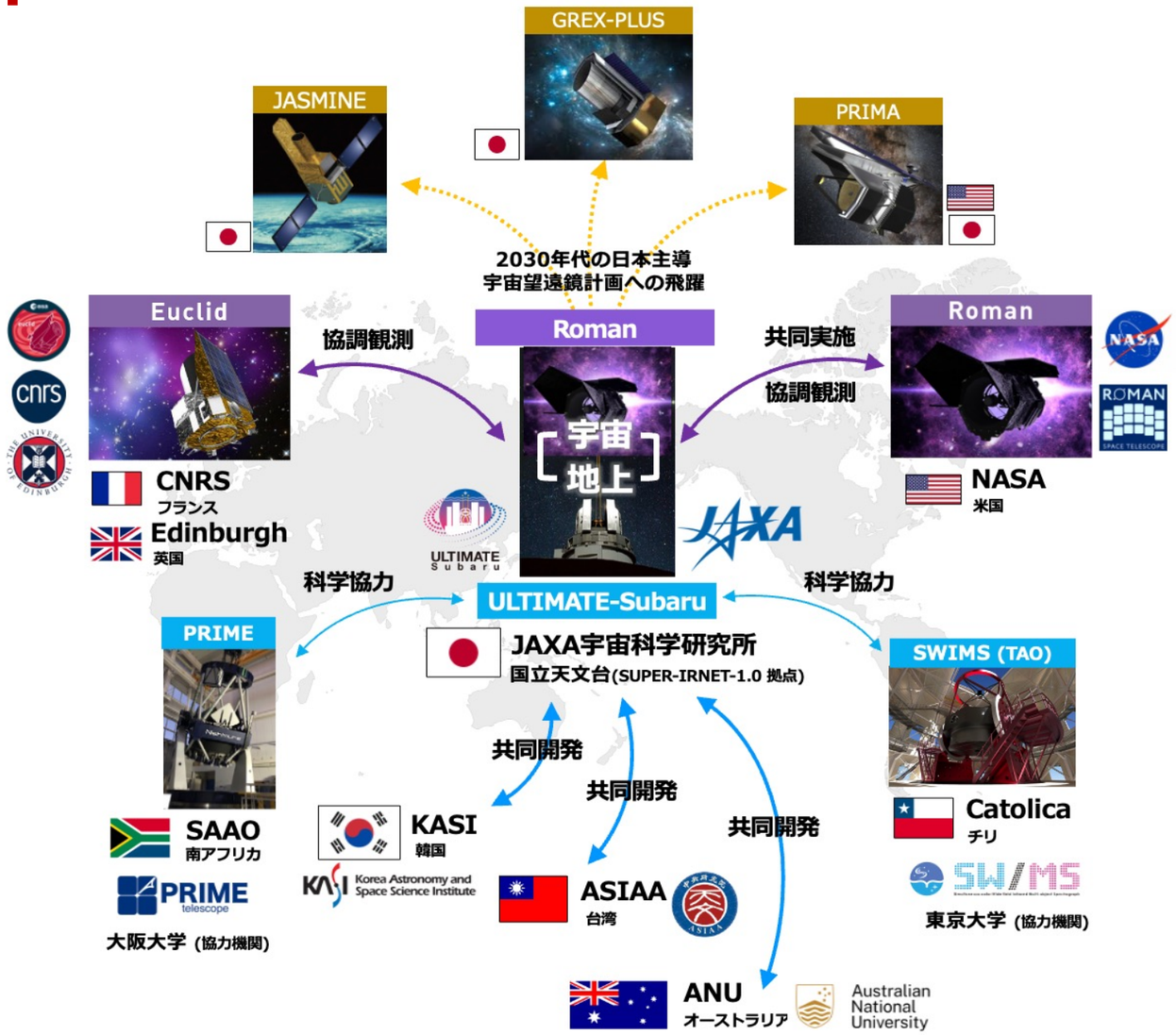
Ho-Gyu Lee

South Africa: SAAO

David Buckley

Chile: Catlica

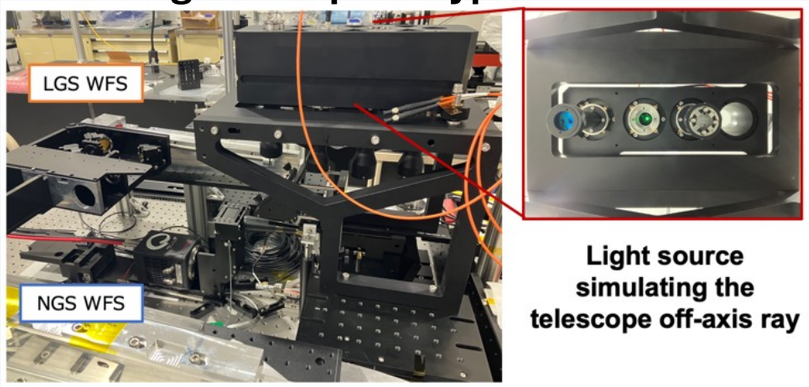
Felipe Barrientos



Summary (1)

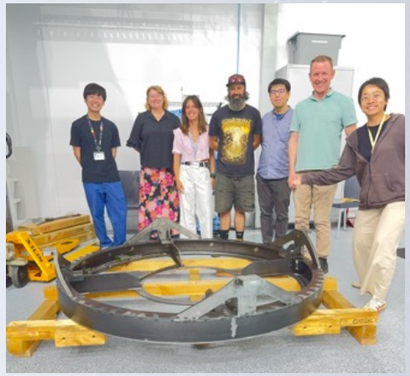
- GLAO and WFI are both completing their **final design phase**.
- Prototyping test and early procurement for long-lead items are ongoing

WFS Single-unit prototype



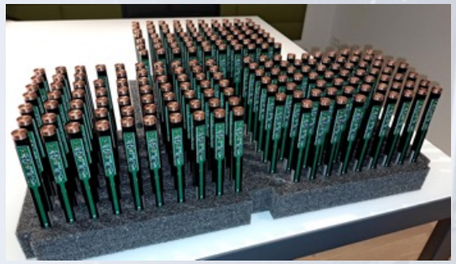
Light source simulating the telescope off-axis ray

WFS Adapter Flange Test Production

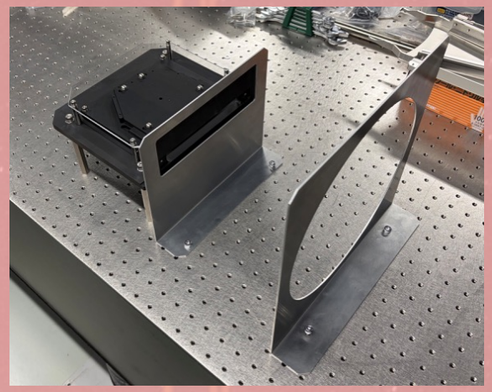


ASM Cold Plate and Frame

ASM Actuators

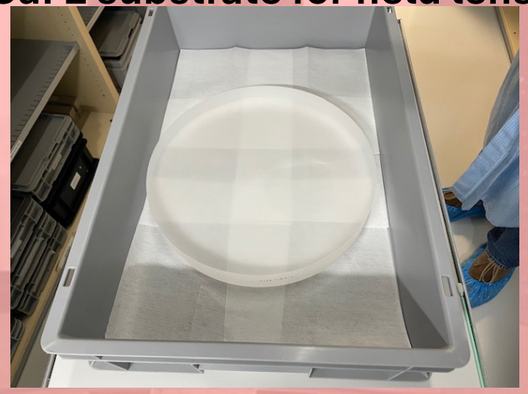


GLAO prototype and production



Prototype for filter wheel to validate filter exchange procedure

CaF2 substrate for field lens



First H4RG-15 for WFI

WFI prototype and production

Summary (2)

- The first set of NB filters for ULTIMATE-WFI are now defined, but importantly, the WFI filters are exchangeable – we always encourage "**carry-in filters**" through KAKENHI or other funding programs.

- **SUPER-IRNET-2.0** is a JSPS Core-to-Core program to promote wide-field IR science, to connect people working in different projects, following the success of SUPER-IRNET-1.0.

- ULTIMATE is not fully funded – we always welcome **international partners**. Please talk to us if you are interested in ULTIMATE and/or SUPER-IRNET-2.0.