Subaru UM FY2025 @ NAOJ, October 29th, 2025

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)

Kosuke Kushibiki (NAOJ/ATC)

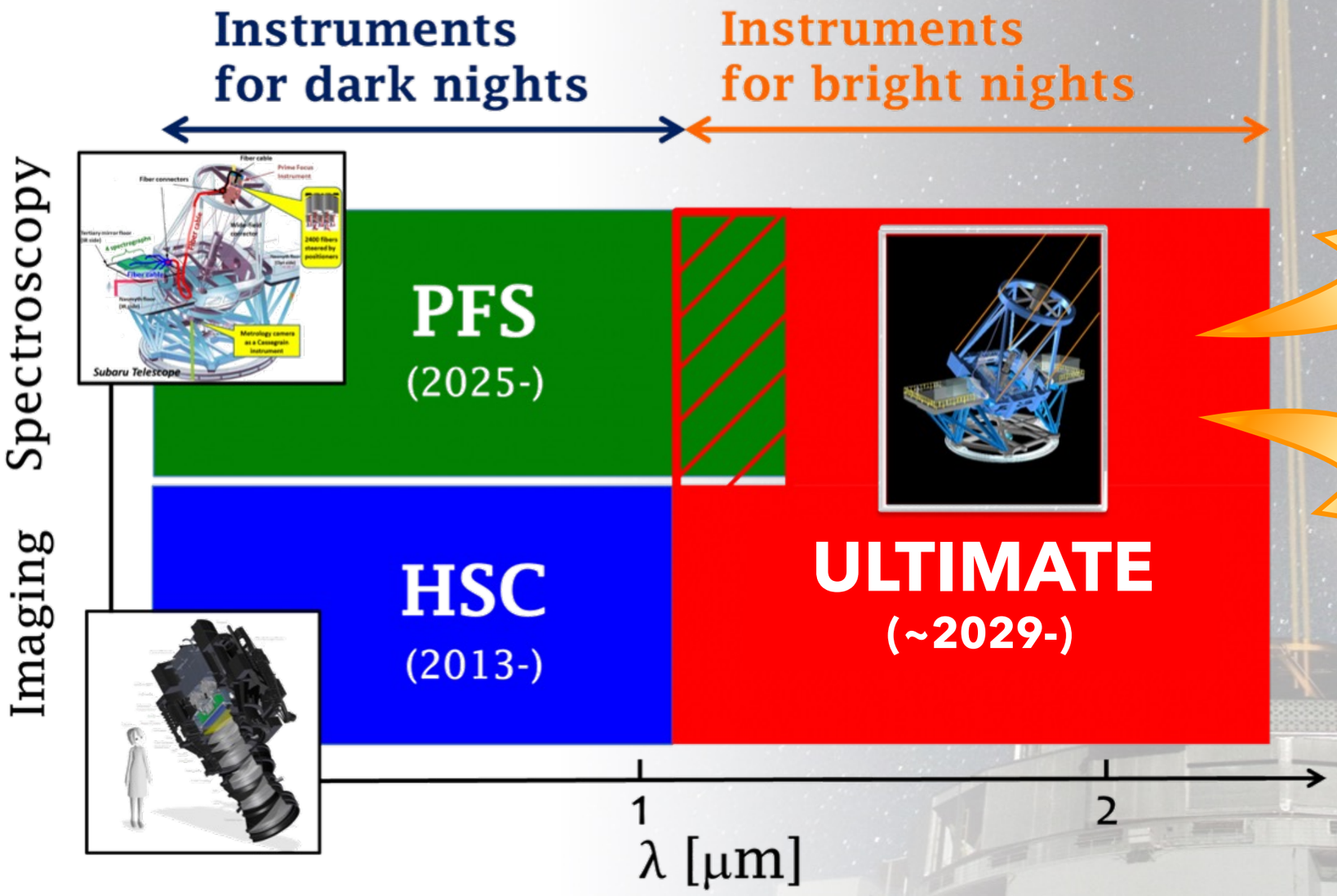
ULTIMATE-Subaru collaboration

This Session:

- Project overview & status (10min, Yusei Koyama)
- WFI development status (10min, Kosuke Kushibiki)

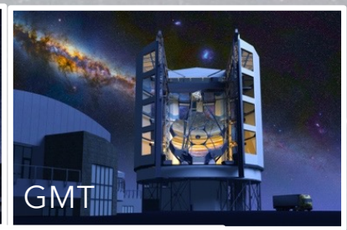
- Messages from ULTIMATE project team (10min)
  - Invitation to ULTIMATE-SSP designing activity
  - Budget situation
  - International Collaboration

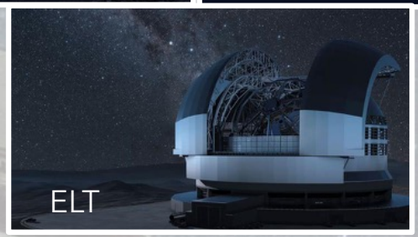
ULTIMATE in the context of “Subaru-2.0”



Great synergy with future space telescopes

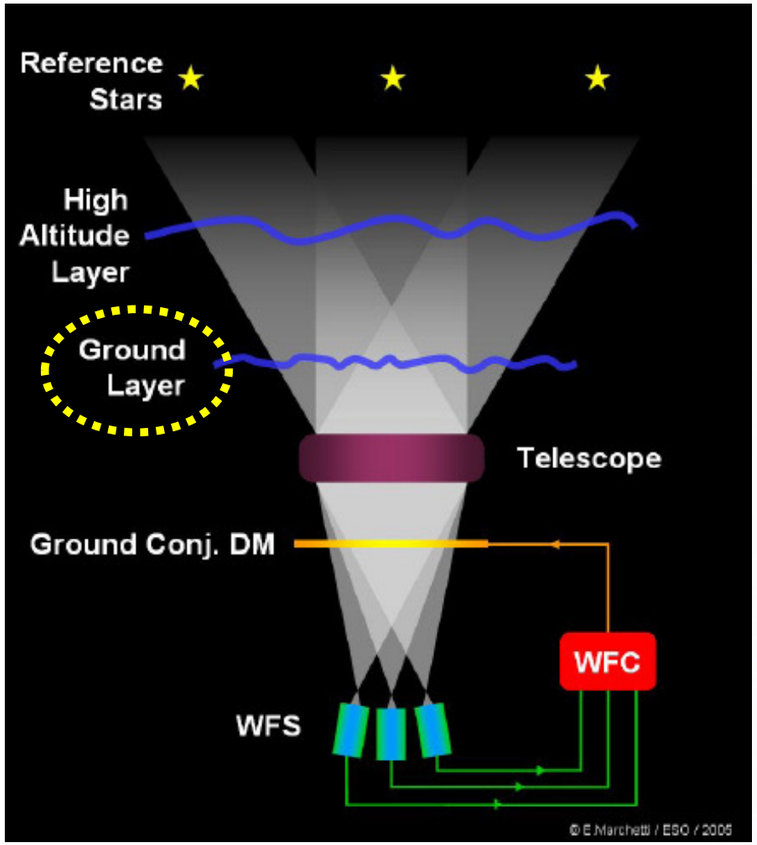
Excellent target provider for 30m -class telescopes



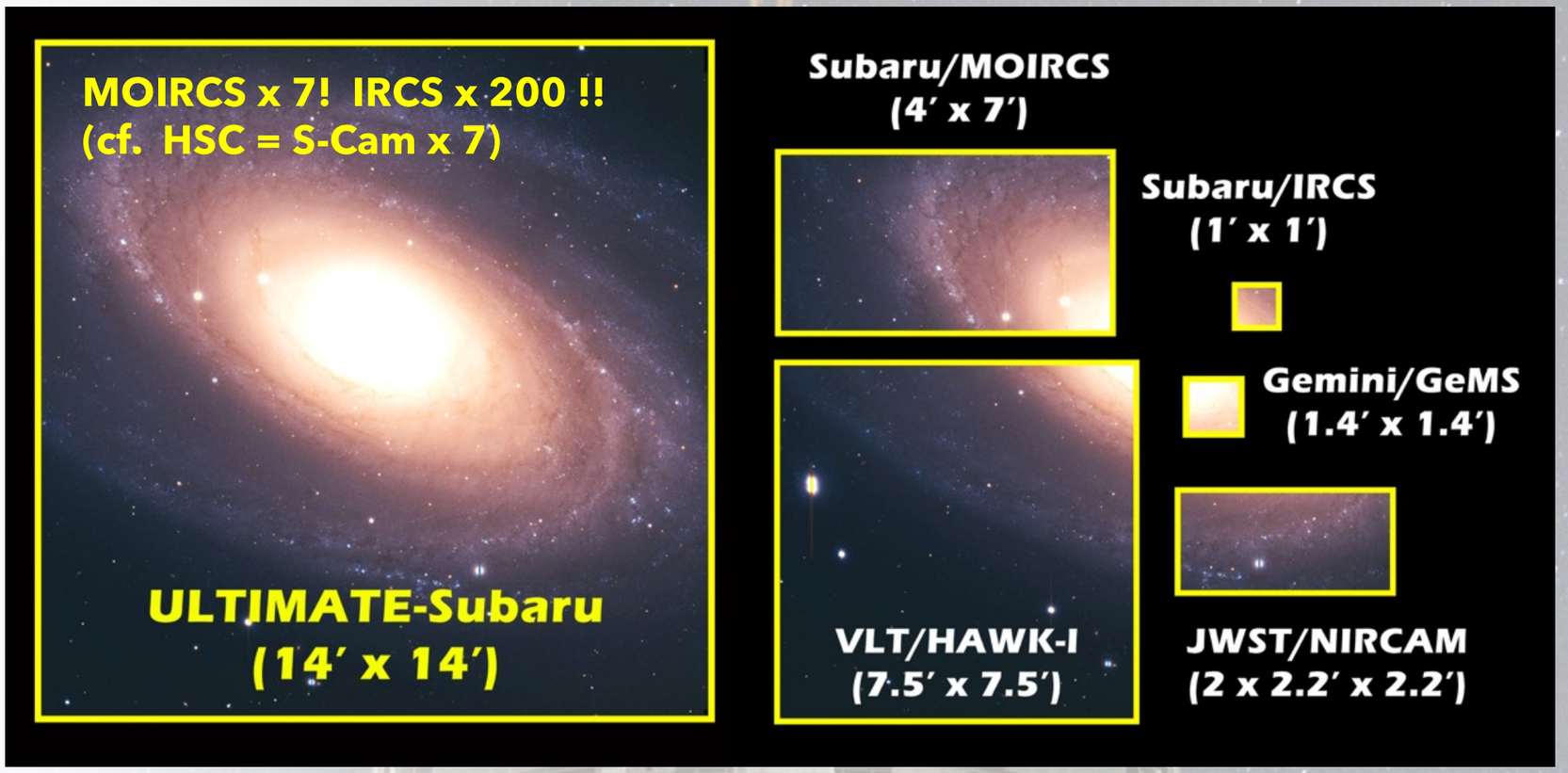


ULTIMATE-Subaru
すばる広視野補償光学プロジェクト

- Wide-field adaptive optics (**GLAO**) and wide-field IR imager (**WFI**).
- Improved image quality (**FWHM~0.2" in K-band**) over ~20-arcmin FoV.



Concept of Ground-Layer AO ©ESO

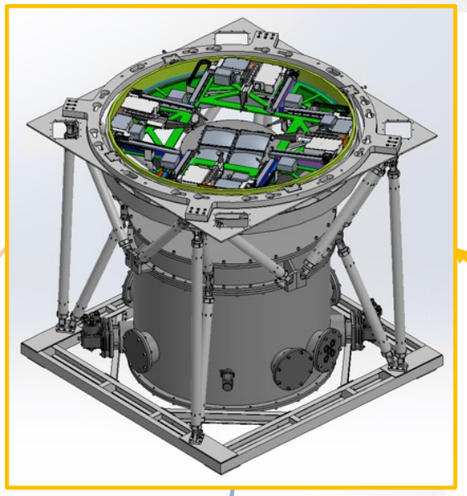


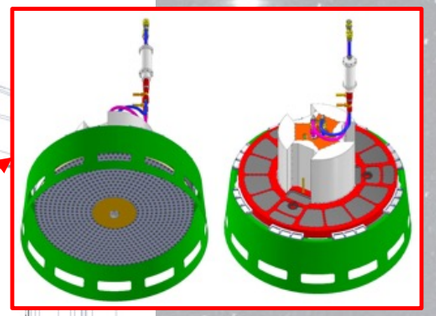
ULTIMATE-Subaru GLAO system

GLAO in Final Design phase, to be completed in FY2025

Wide-Field Imager (WFI)

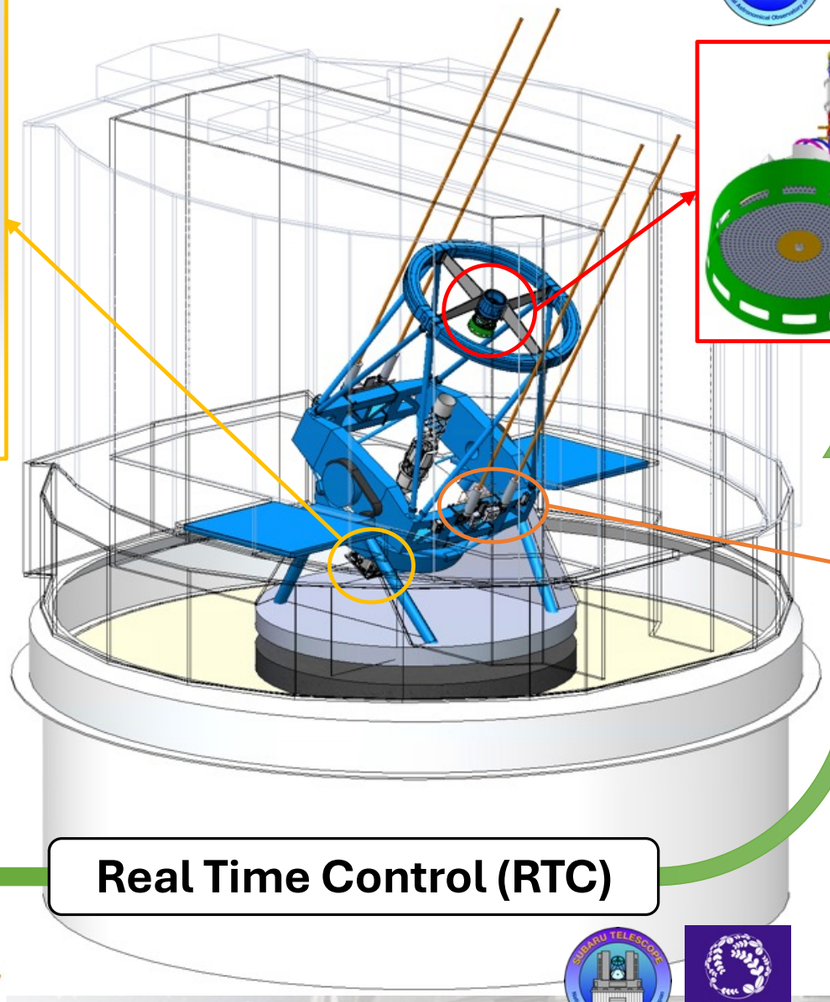
- Cassegrain instrument
- FoV ~ 14' x 14'
- λ: 0.9 – 2.5 um

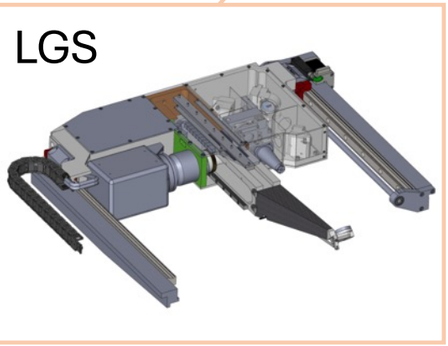


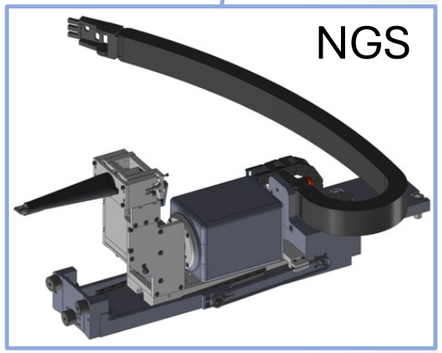


Adaptive Secondary Mirror

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



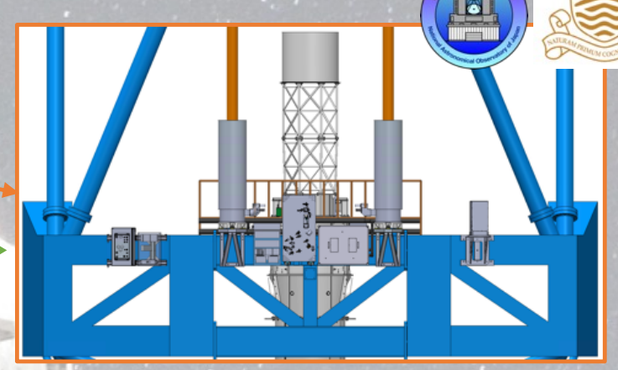




Wavefront Sensor (WFS)

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

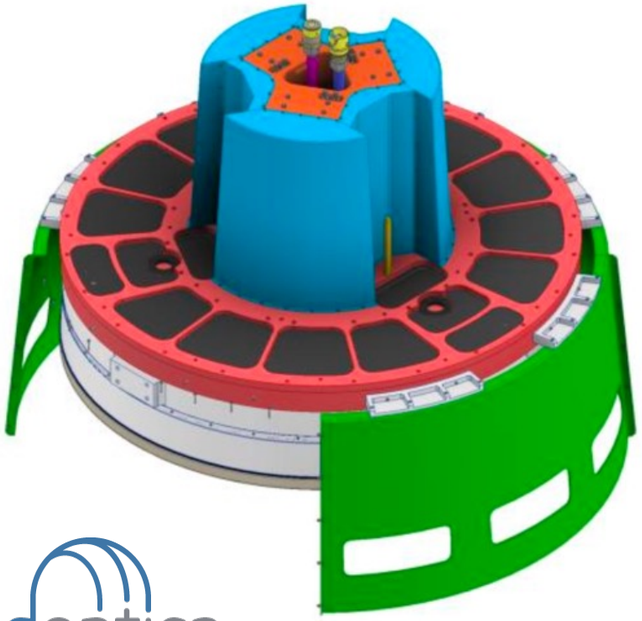
Real Time Control (RTC)

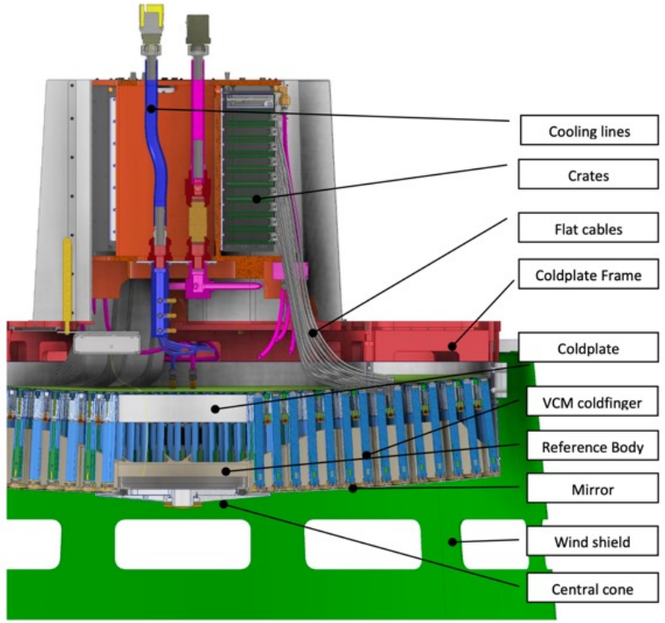


Laser Guide Star Facility

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

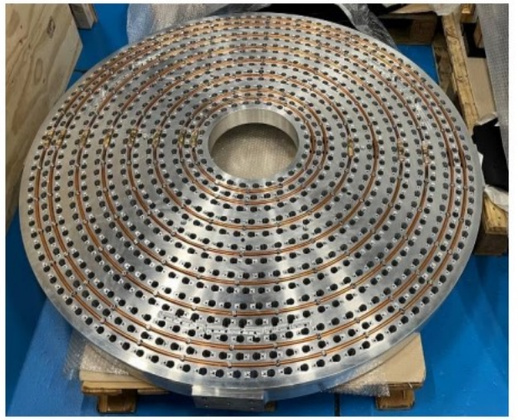
Adaptive Secondary Mirror



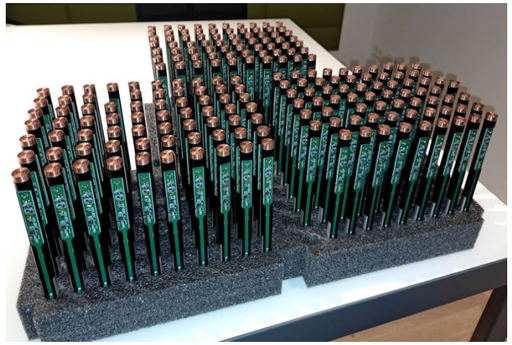


924 actuators over 1.26 m diameter
Technology developed by AdOptica

Cold Plate and Frame



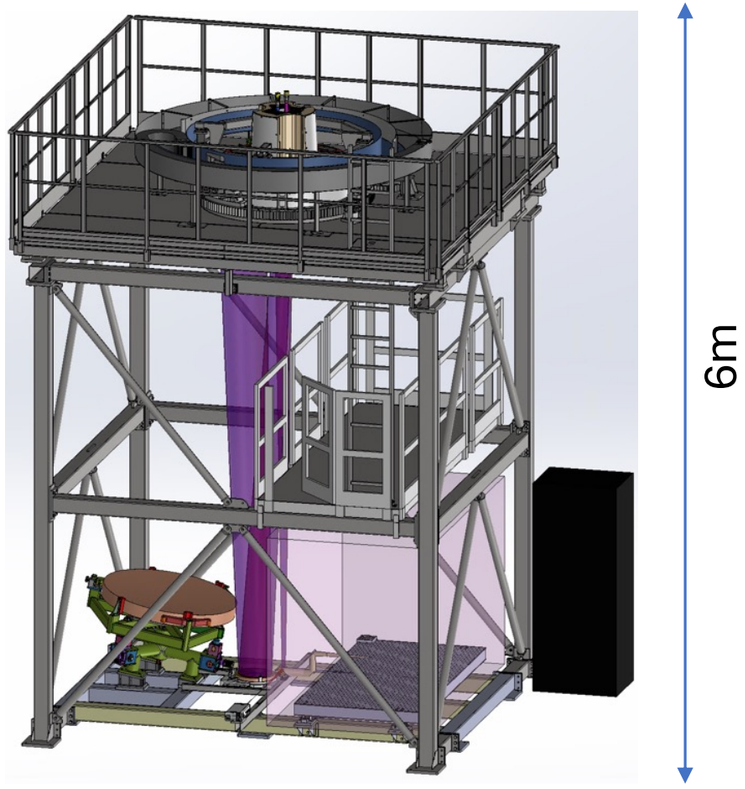
Actuators

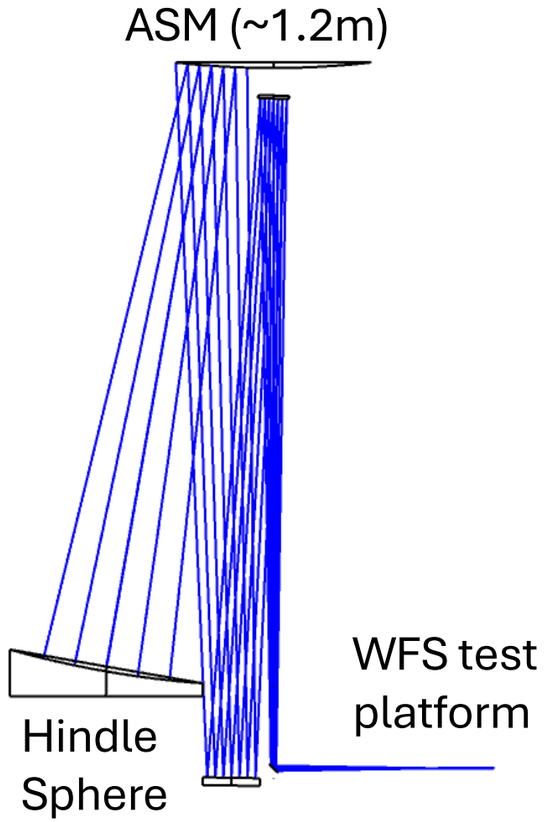


Electric Crates

- Mechanical and Electrical fabrication completed, Optical fabrication to be completed in ~ 1 year
- Assembly, Integration, Test will be in completed in 2025-2026
- System verification in 2027 to be delivered by the end of 2027

Optical Test Tower for characterizing ASM

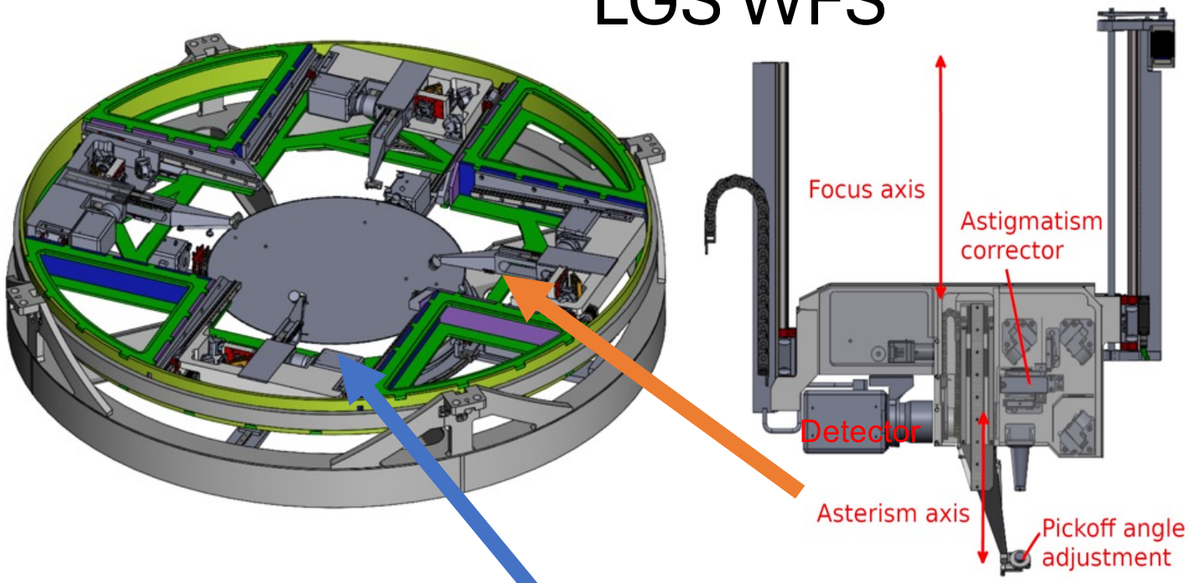




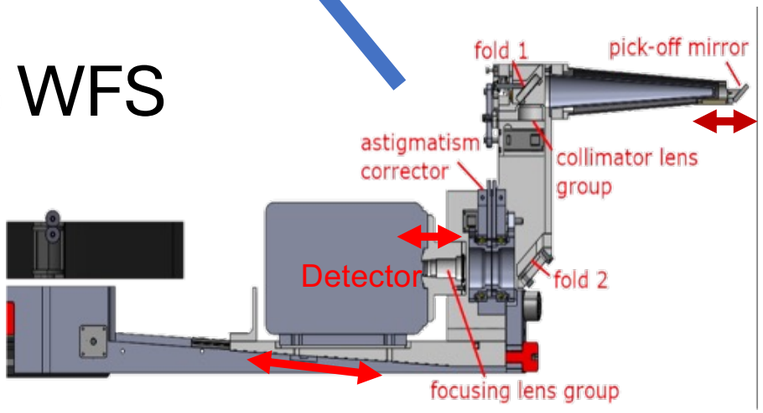
- A large optical test tower (OTT) for calibrating the ASM will be implemented at the Subaru Hilo base facility.
- Stitching Hindle Sphere to null out the aspheric surface.

Wavefront Sensor Prototype

LGS WFS

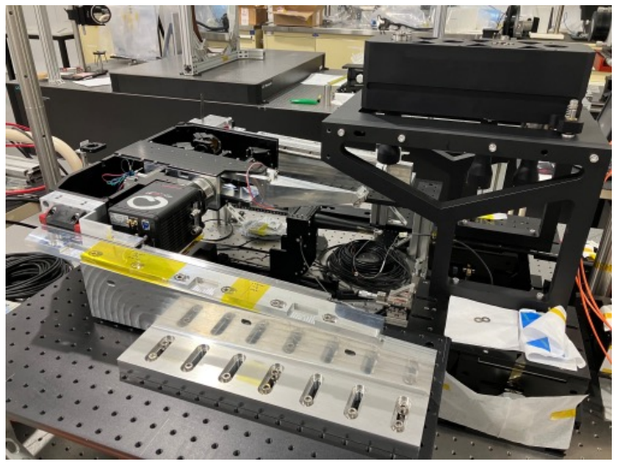


NGS WFS



- GLAO WFS covering 20’ FoV
- Single unit Prototype to validate the performance using light sources simulating the telescope.
- Prototype the WFS adapter flange to validate the LGS WFS de-rotator

Single unit prototype



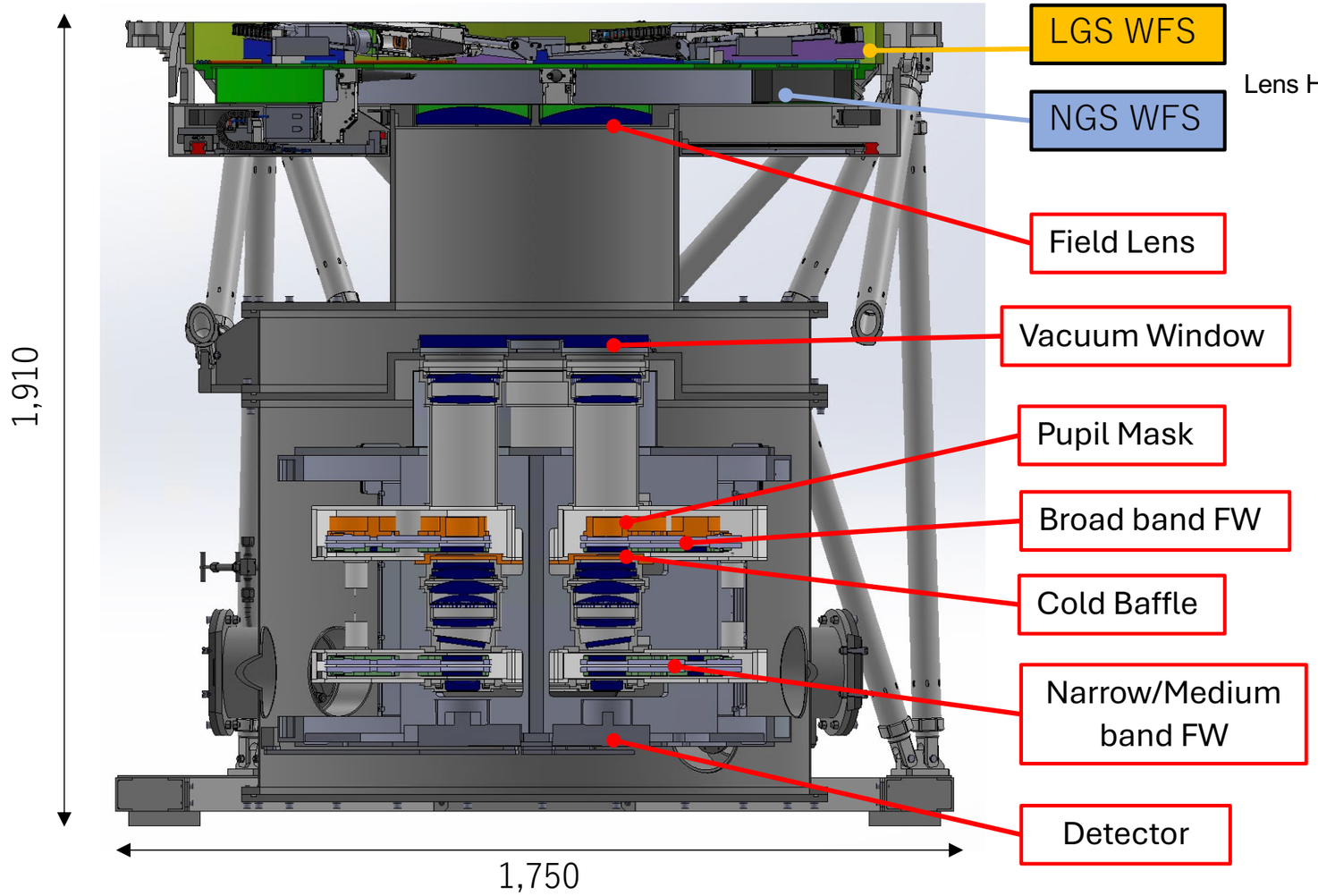
WFS de-rotator prototype

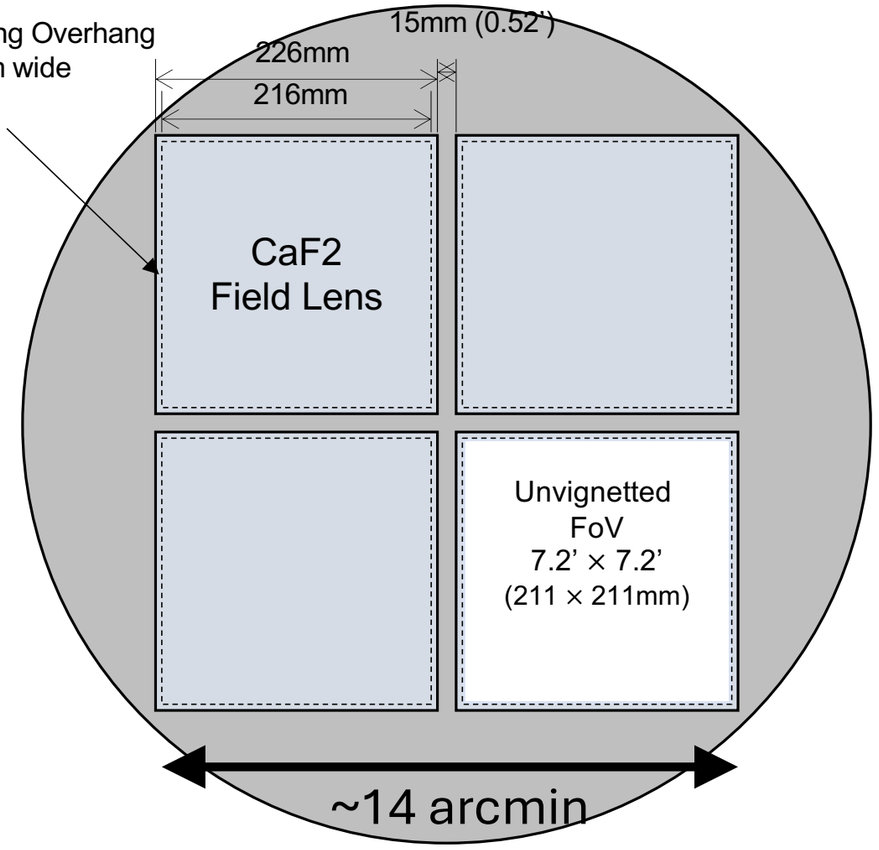
Wide-Field Imager (WFI)

- 4 barrel design to cover the full GLAO FoV (14’ x 14’).
- Start commissioning observations in early 2029 (end of FY2028).

Final Design phase, funded (partly) by JSPS KAKENHI (PI: T. Kodama, FY2024-FY2030)

See Kushibiki-san’s talk

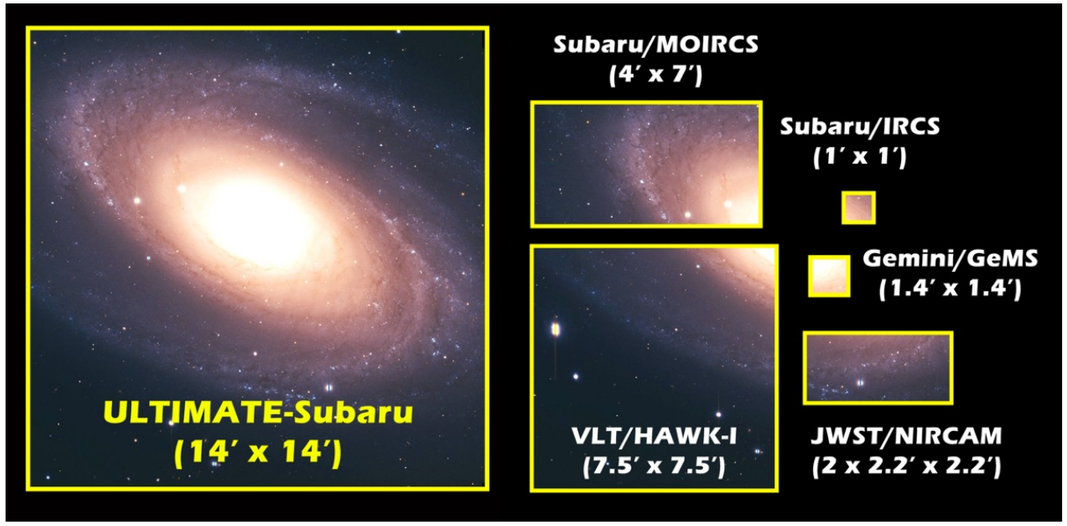




ULTIMATE-Subaru : unique science capabilities

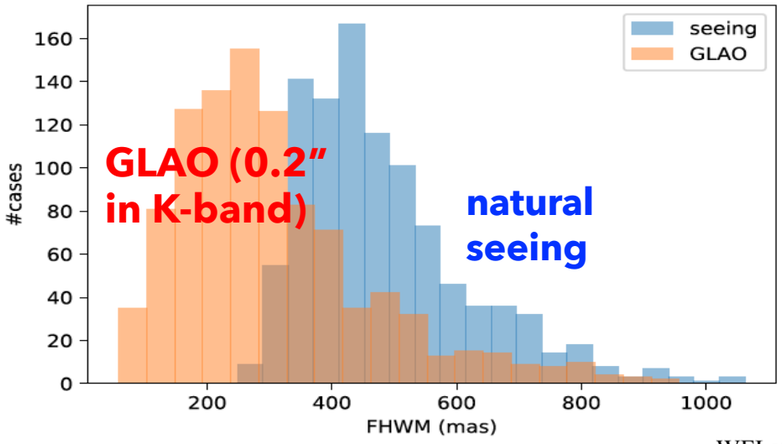
すばる広視野補償光学プロジェクト

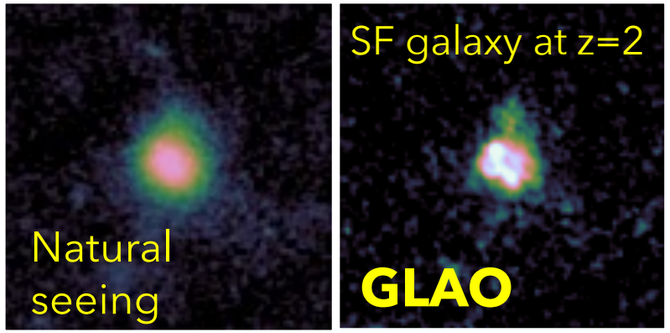
① Widest AO imaging on 8-10m telescope



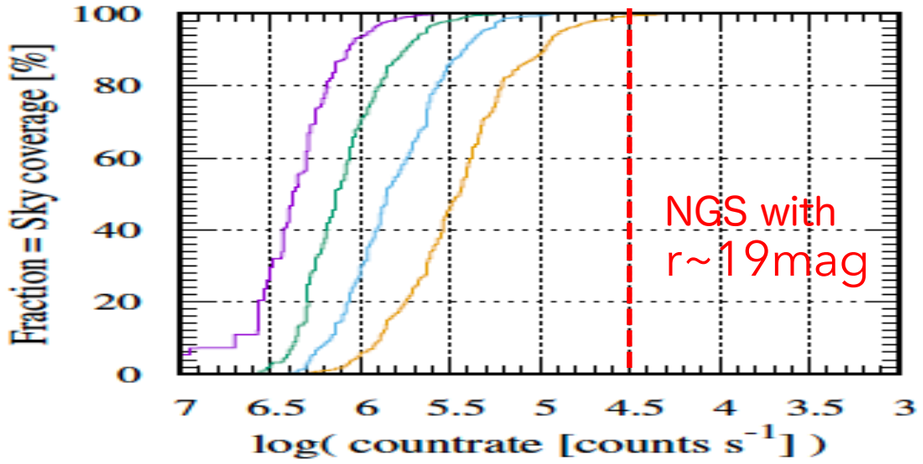
② Space telescope image quality

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





③ All-sky coverage

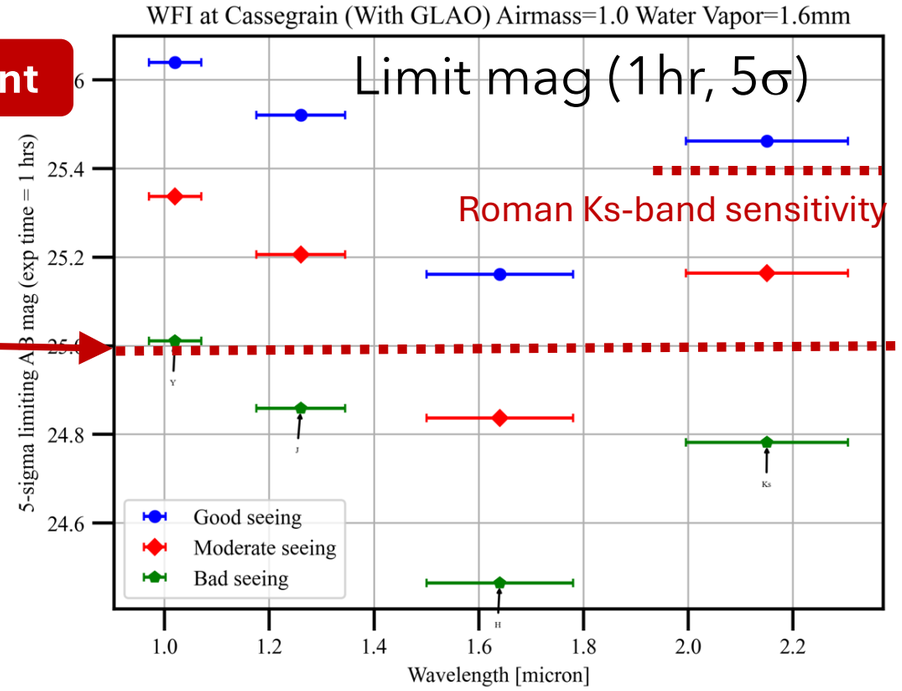


Full performance everywhere – no worry about guide star availability

④ Sensitivity enhancement

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

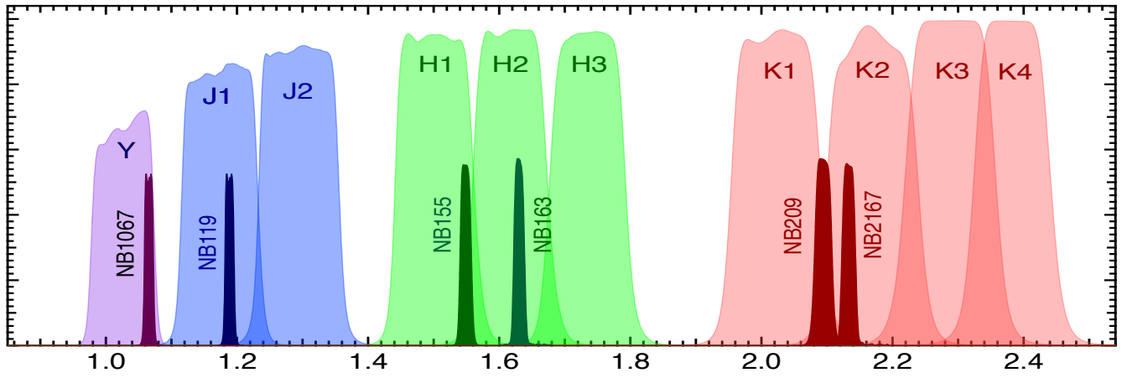
25 mag

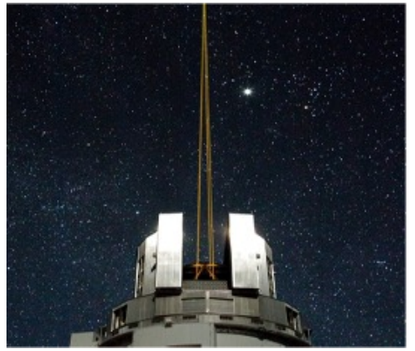


Variety of MB/NB filters on ULTIMATE-WFI

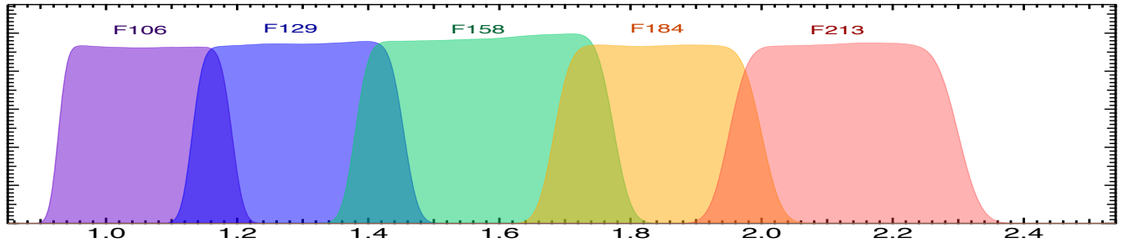
- WFI has 3 filter wheels to accommodate max. 15 filters per barrel
- WFI can accept new carry-in filters at any time.

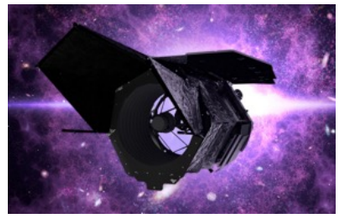
ULTIMATE



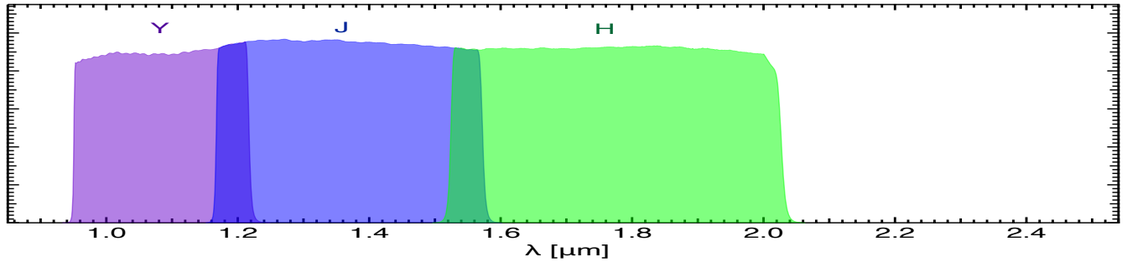


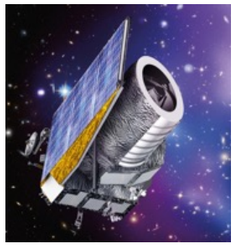
Roman



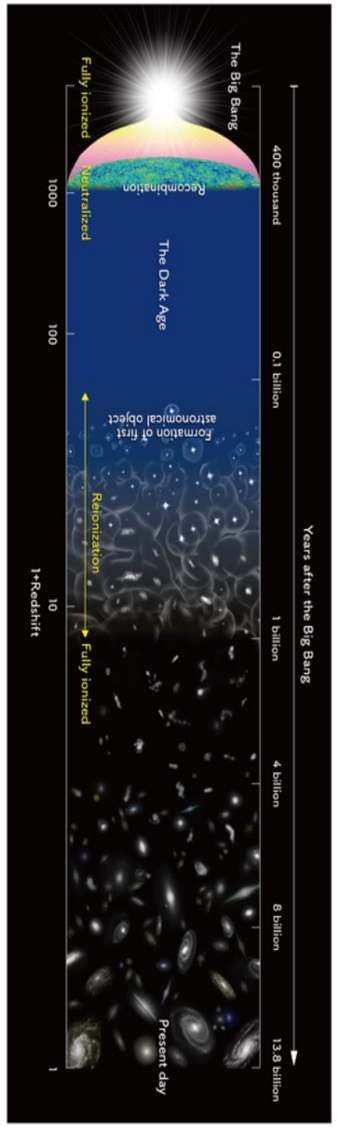


Euclid





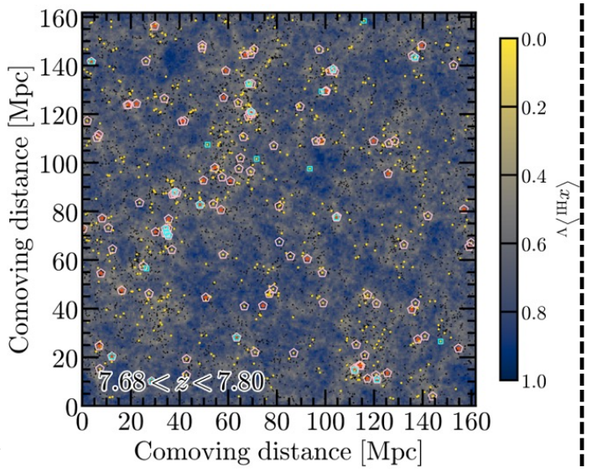
ULTIMATE for high-redshift universe



1) Cosmic Reionization Bubble

Deep & Wide NB

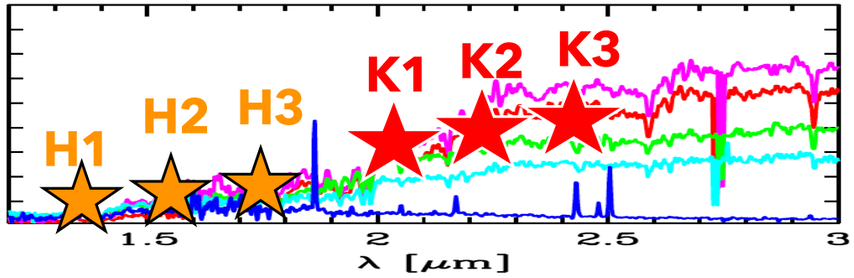
Unprecedentedly deep and wide NB imaging to search Lyα emitters in the epoch of cosmic reionization (at z>>7), to identify ionized bubbles in the very early universe.



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.

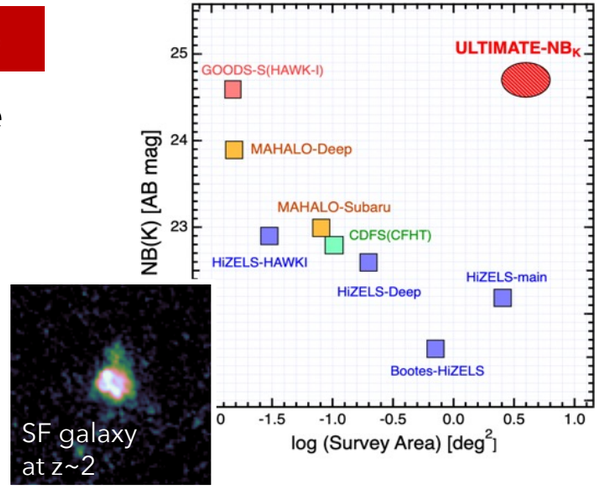


SEDs of z=4 galaxy

3) Build-up of the Hubble Sequence

Sharp & Wide NB

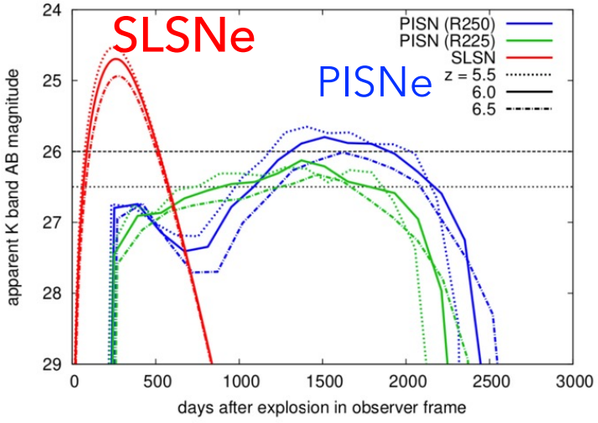
Stellar build-up inside the galaxies at the cosmic noon (z~2-3) epoch with deep and sharp NB(Hα/[OIII]) imaging in K-band.



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.

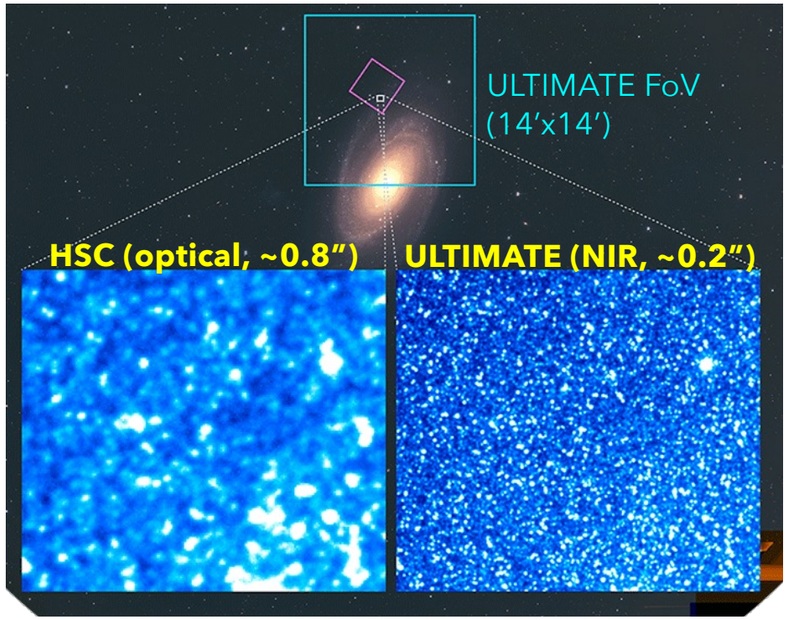


ULTIMATE for the Local Universe

1) Nearby Galaxies

Sharp & Wide JHK + NB

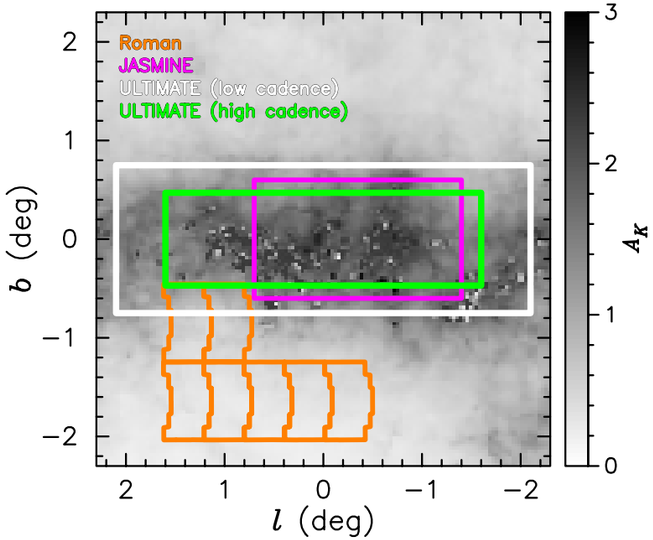
Spatially resolve nearby galaxies (D<10Mpc) into individual stars and star-forming regions, to study galaxy formation history (galactic archaeology) and ISM physics.



2) Galactic Center

Sharp & Wide JHK + NB

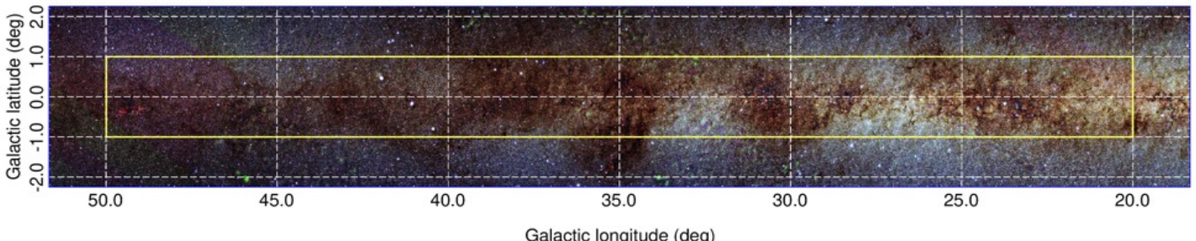
High/low cadence survey toward the Galactic Center with ULTIMATE, to reveal hidden objects (blackholes and free-floating planets) in the Galactic Center with microlensing and astrometric approach.



3) Galactic Plane

Sharp & Wide NB/MB

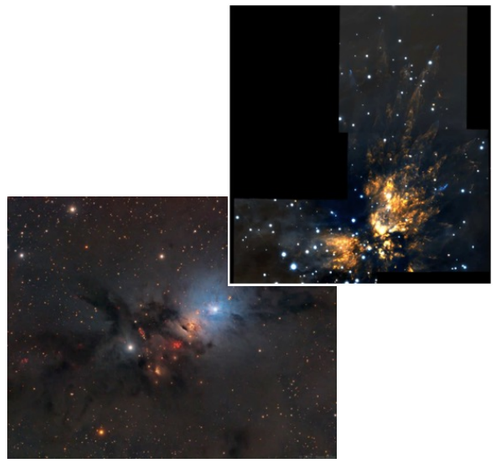
- Reveal MW structure and hidden stellar evolution.
- Paβ/Brγ imaging for cataclysmic variables, to reveal the Galactic Diffuse X-ray Emission



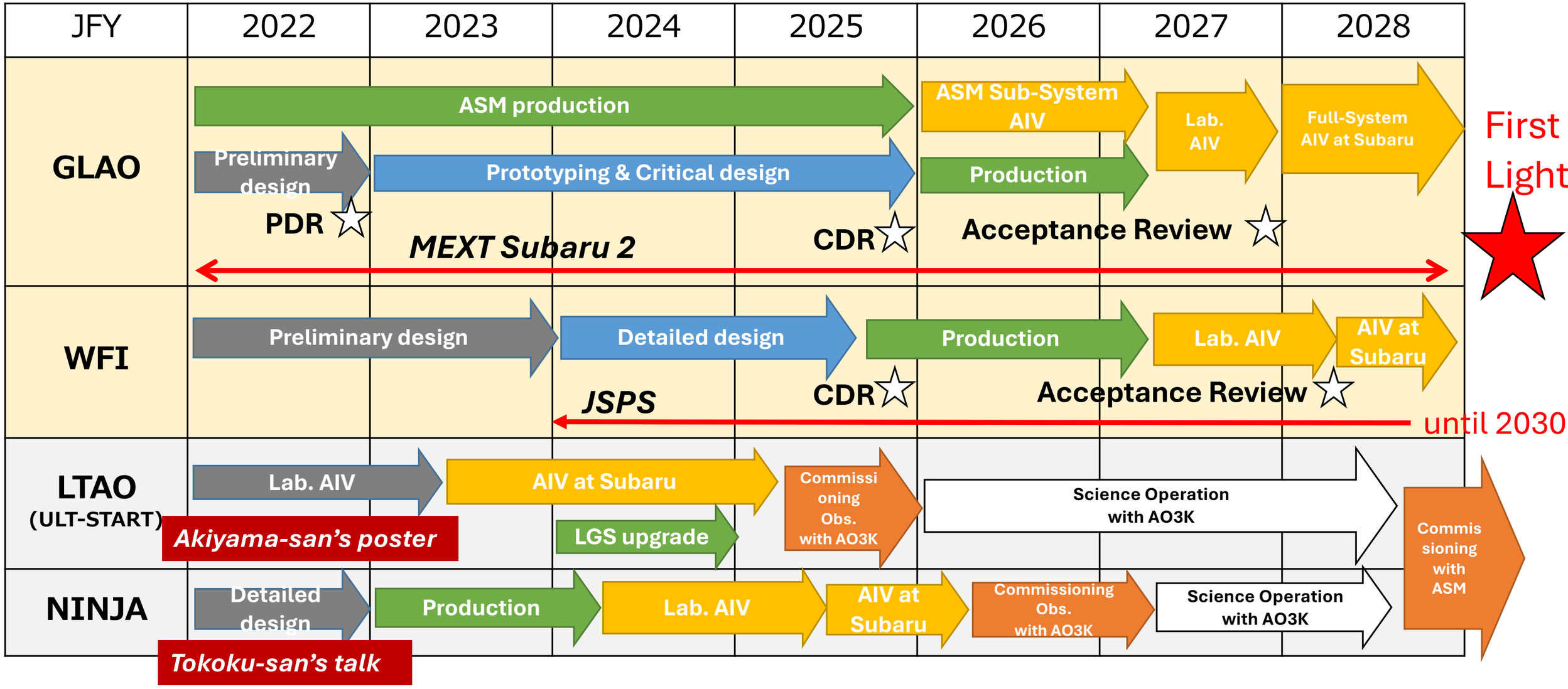
4) Star Forming Regions

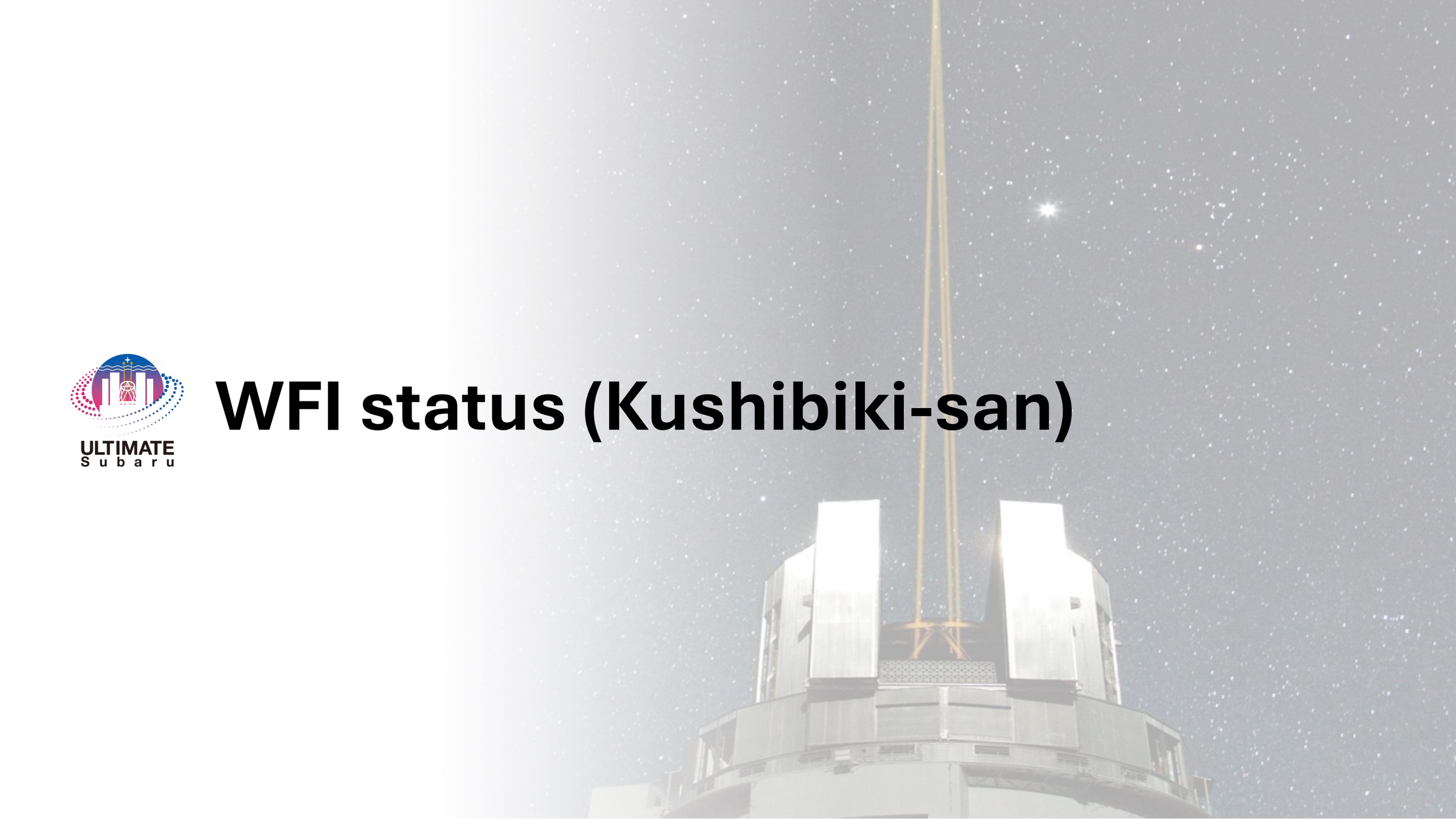
Sharp & Deep JHK + NB

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



ULTIMATE timeline





WFI status (Kushibiki-san)

Messages from ULTIMATE team

SSP survey design team kick-off

- 2025: Format official SSP team
- 2026:
- 2027:

Proposal Writing Phase
(define the survey, sophisticate the science)

- 2028: Proposal Submission & Review
- 2029: Start Survey in S29B (in the earliest case)

ULTIMATE budget situation summary

- **GLAO:**
  - Supported and funded by MEXT Frontier Budget (Subaru-2)
  - But annual budget allocation is uncertain.
- **WFI:**
  - Development with external budget
    - KAKENHI: Kodama, Miyazaki (+ Akiyama, Yoshida) …
  - Secured 1 detector + 2 optics
  - But still need 3 detectors (!) + 2 optics…

ULTIMATE Collaboration Policy (draft)

- **ULTIMATE Premium partner**:
  - Total $>2M USD (equivalent to 1 WFI detector) contribution
  - Full access to SSP for 10 staffs and 30 juniors (postdocs/students)
  - Cash contribution or in-kind contribution in instrumentation.
- **ULTIMATE partner**:
  - Total $300K USD contribution
  - Full access to SSP for 1 faculty staff + 3 juniors (in the same group)
  - Cash contribution or in-kind contribution in instrumentation.

 # Macquarie University (Australia) decided to join as the first (official) Partner, based on their contribution to hire a postdoc with co-funding with NAOJ.

 # We are also talking with other potential partners.

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, > 200 scientists signed up from 5 countries.

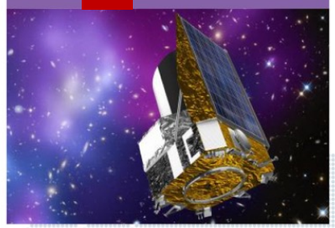
SUPER IRNET

euclid

cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

esa

Euclid



Synergy observations + Science collaboration

Synergy observations + Science collaboration

Roman

ROMAN SPACE TELESCOPE

NASA

CNES

France

NASA

U.S.A.

collaboration

ULTIMATE-Subaru

collaboration

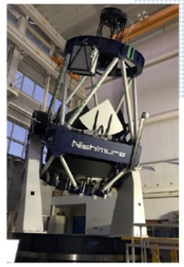
Subaru Telescope

NAOJ

Japan

Development + Science collaboration

Development + Science collaboration



PRIME telescope

PRIME

Osaka Univ./South Africa

大阪大学 OSAKA UNIVERSITY

ASIAA

Taiwan

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: ISPS Core-to-Core Program

FY202

Promo

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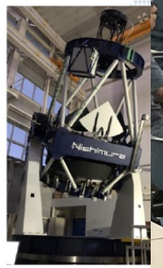
SUPER IRNET

SUPER-IRNET Special Session in the ASJ Meeting
September 9th, 2025 @ Shimonoseki



PRIME telescope

PRIME

Osaka Univ./South

大阪大

OSAKA UNIVE

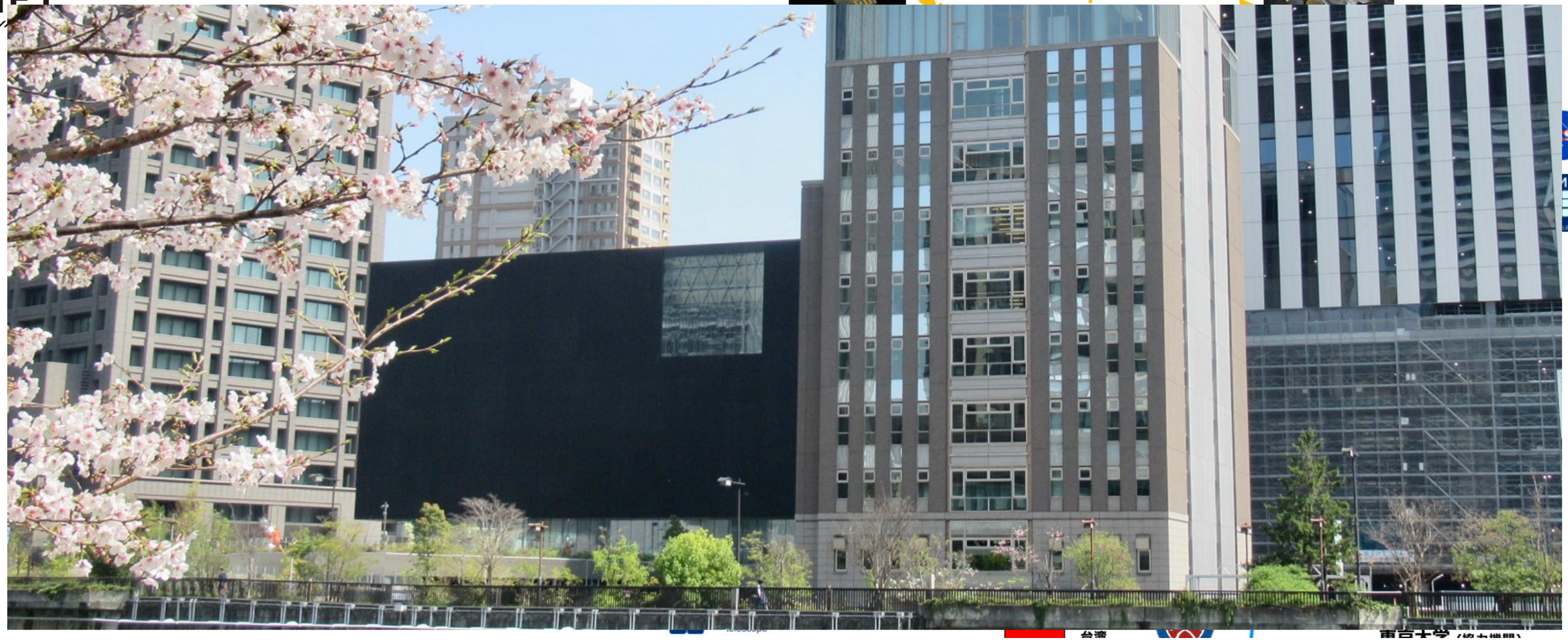
Australia

SWIMS
Simultaneous-color Wide field Infrared Multi-object Spectrograph

SUPER-IRNET-2.0 ?

- SUPER-IRNET is now evolving to a larger research network connecting five continents!
- New proposal submitted to JSPS with more countries and with upgraded concepts – now under review.

SUPER-IRNET-2.0 ?



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The 3rd SUPER-IRNET Workshop "*Beyond the S-U-P-E-R: toward the Bright Future*"
(**March 16-19**, @ Univ. of Osaka Nakanoshima Center)