PO-13P

ULTIMATE-Subaru: the next-generation wide-field AO and near-infrared instruments for the Subaru telescope

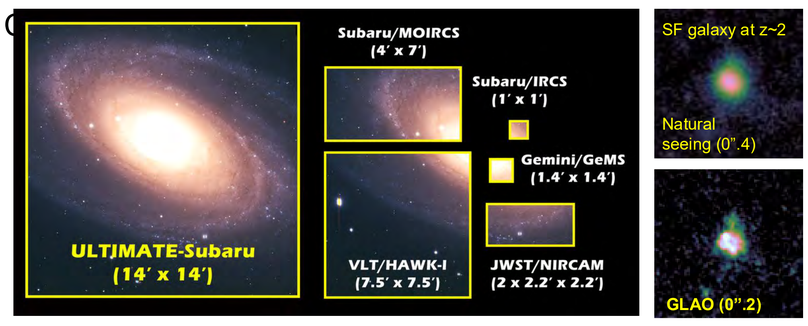
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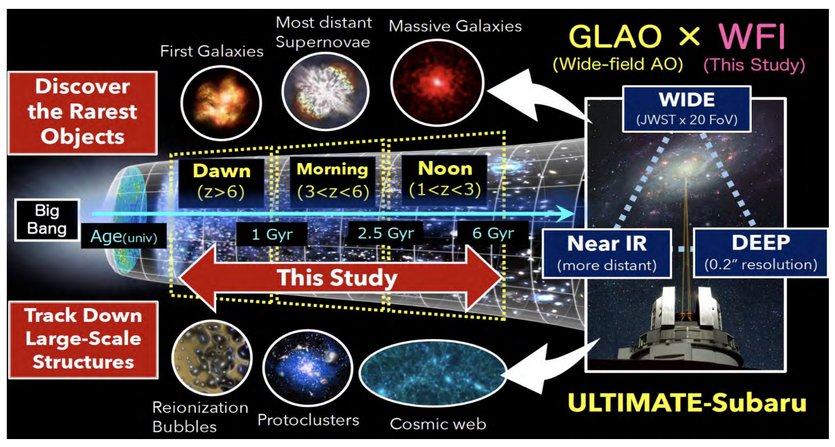
INTRODUCTION

ULTIMATE-Subaru is the next-generation facility instrument program of the Subaru. The ULTIMATE-Subaru instrument includes **Ground-Layer Adaptive Optics (GLAO)** and **wide-field NIR imager (WFI).** The GLAO mainly consists of an adaptive secondary mirror, a laser guide star facility to generate 4 LGSs, 8 WFSs for laser (x 4) and natural (x4) guide stars, and their real-time control system. The GLAO compensates only the ground-layer atmospheric turbulence, providing **~ 0.2 arcsec image size at K band (2.2 micron) over 20 arcmin** field of view at the C



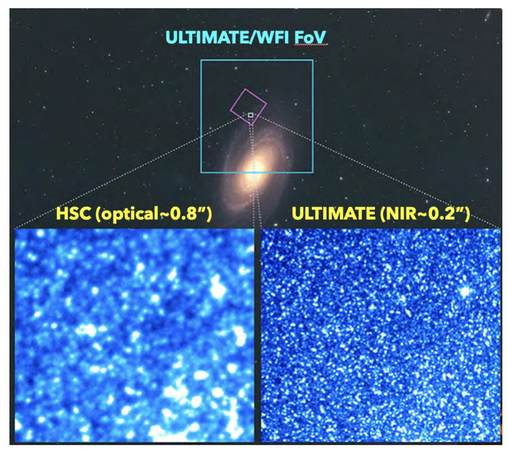
Science Case

Exploring high-redshift universe
with wide-field and high-resolution NIR survey

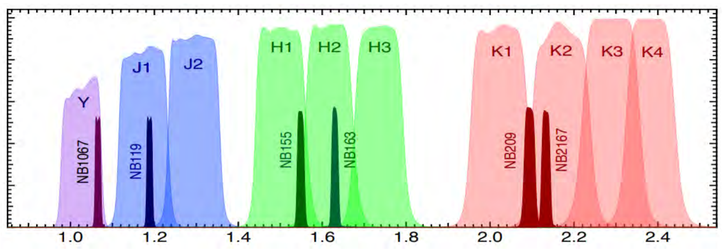


- Conduct ~ 300 nights scale large survey with ULTIMATE in the framework of the Subaru Strategic Program (SSP).
- Utilizing a wide-variety of medium and narrow band filters in addition to the regular broad band in NIR.
- Complementary to Satellite-based surveys (Euclid, Roman).
- Provide unique targets to follow-up with 30-m class telescopes.

Spatially-resolved NIR imaging of
Dense/Obscured Regions in the local Universe



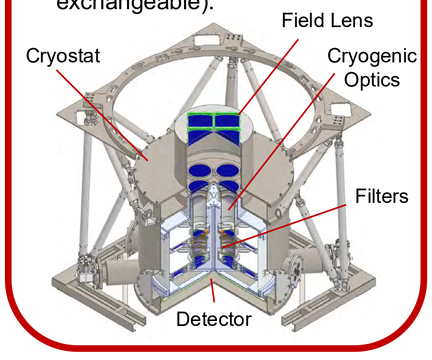
Wide variety of Medium and Narrow band filters



ULTIMATE-Subaru Instrument Overview

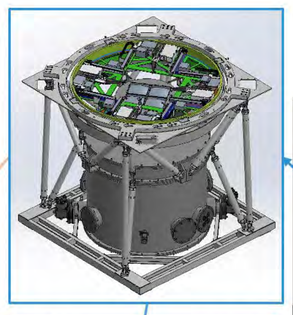
Wide Field NIR Imager

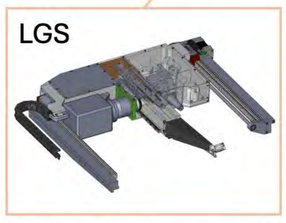
- Consists of 4 identical optical barrels.
- One Hawaii-4RG (4Kx4K pixels) per barrel.
- Each covers 6'.8x6'.8 FoV (0."1/pixel sampling).
  → Effective FoV = 13'.6x13'.6
- Support many filters (up to 15 at a time, exchangeable).



Wide-Field Imager (WFI)

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

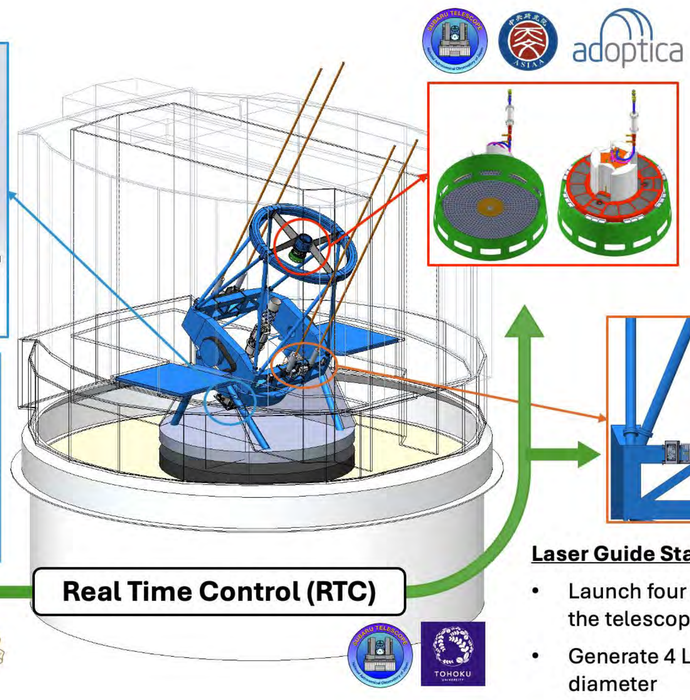






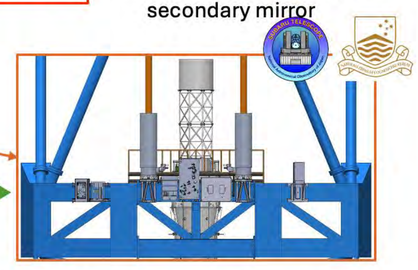
Wavefront Sensor (WFS)

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



Adaptive Secondary Mirror (ASM)

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

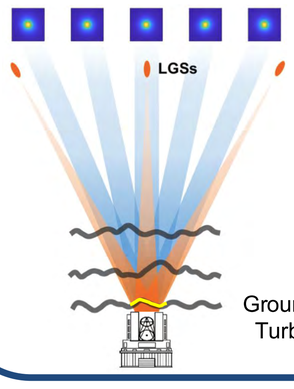


Laser Guide Star Facility (LGSF)

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

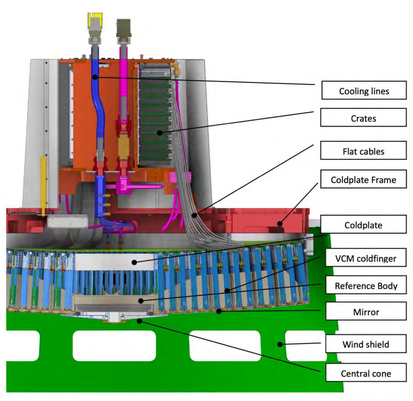
GLAO key subsystems:

- ASM to correct the wavefront error.
- Four LGS-WFS to measure the ground layer turbulence.
- Four NGS-WFS to measure tip/tilt and focus error.
- LGSF to generate the four LGSs outside of the science FoV.
- RTC to compute the ASM shape based on the WFS measurements.



Early Production, Prototyping, and Final Design

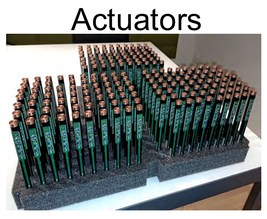
Adaptive Secondary Mirror: Production Status



Cold Plate and Frame



Actuators



Electric Crates



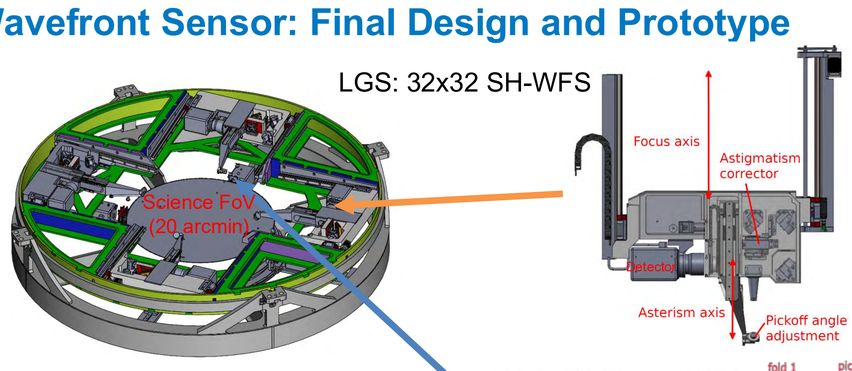
- Well-established design by AdOptica/Italy
- Mechanical/Electrical fabrication completed.
- Optical fabrication to be completed in ~ 1 year.
- To be delivered to Subaru by the end of 2027 after assembly, integration, and test at the AdOptica.

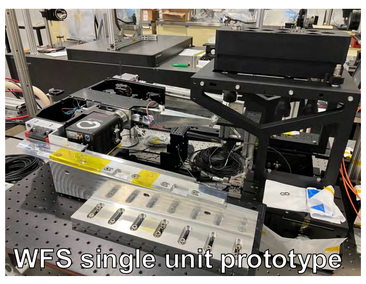
WFI: Final Design and Prototype

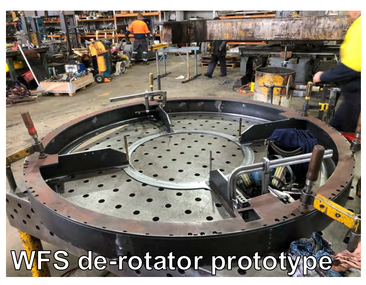


- Cryostat/Optics are currently in final design phase
- Start the production of the cryostat and two optical barrels in FY2026.
- First Hawaii-4RG detector delivered to Subaru.
- **Additional funding is required to procure the remaining three detectors and two optical barrels.**
- **Seeking for collaborations to complete the WFI and to start wide-field survey with ULTIMATE.**

Wavefront Sensor: Final Design and Prototype

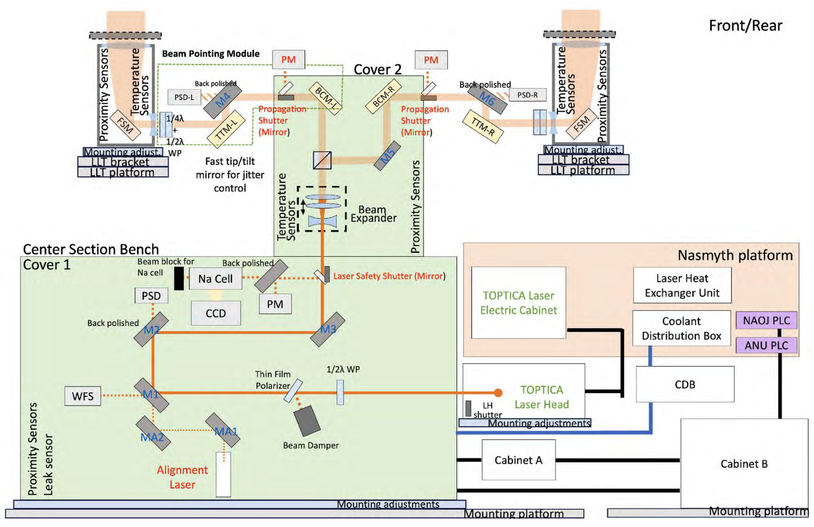




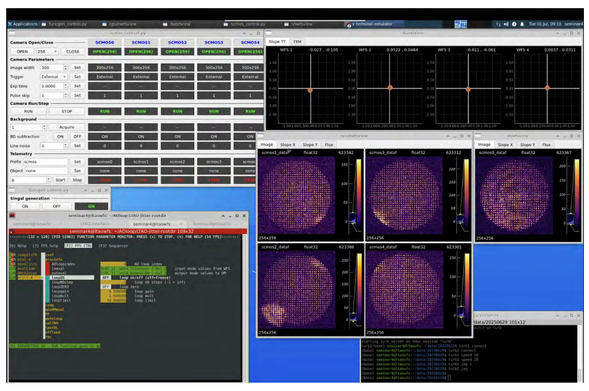


- WFS covering 20' FoV
- Acquire the LGS asterism from 4 to 20 arcmin in diameter, depending on the GL-turbulence
- Prototype tests ongoing to validate the performance of the LGS/NGS WFSs using light sources simulating the telescope and to validate the LGS WFS de-rotator mechanism.

Laser Guide Star Facility: Final Design

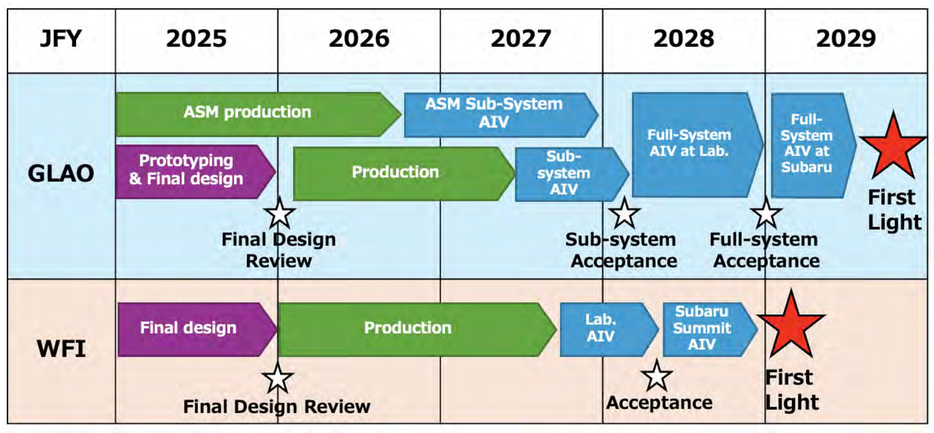


Real-Time Control System: Prototype



- On-sky prototype with the prototype instrument (ULTIMATE-START in LTAO mode).
- Implement the same RTC for the GLAO.

Schedule



Summary

- ULTIMATE is a new wide-field AO-assisted NIR survey instrument at the Subaru Telescope.
- GLAO provides a factor of 2 seeing improvement with a median seeing of 0.2" in K-band across 20' FoV in diameter.
- WFI provides a wide-field imaging capability in NIR up to 14' x 14' FoV with various BB, MB, and NB filters.
- The project is currently in the final design phase. Production will start in FY2026.
- The first light observation is targeted in FY2029.

Acknowledgement

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