

すばる望遠鏡広帯域分光器NINJA 開発報告2025

PIタイプ観測装置
2026年度観測予定

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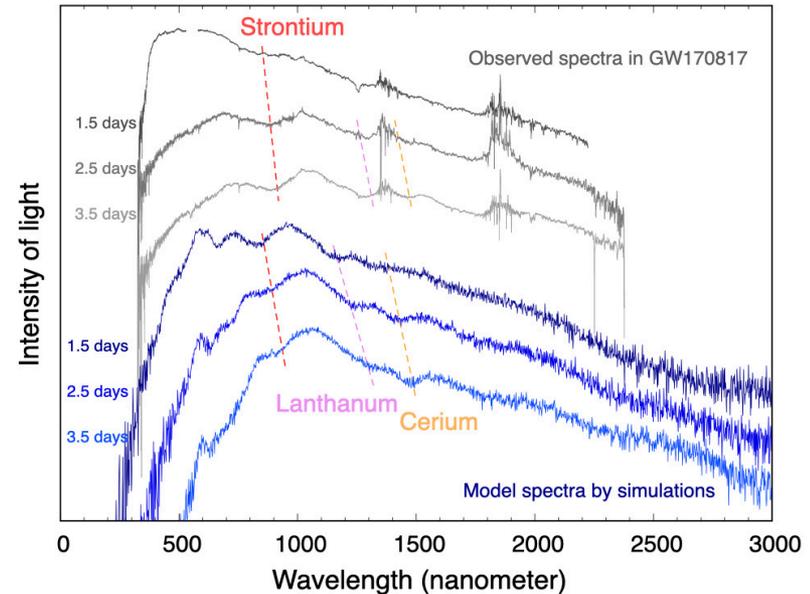
<https://www4.nao.ac.jp/atc/ninja/>

* Students

- Origin of heavy elements
 - Reveal heavy element nucleosynthesis in neutron star mergers.
 - 400-2500nm, R~1000

→ Follow-up of the counterparts of GW events with Subaru

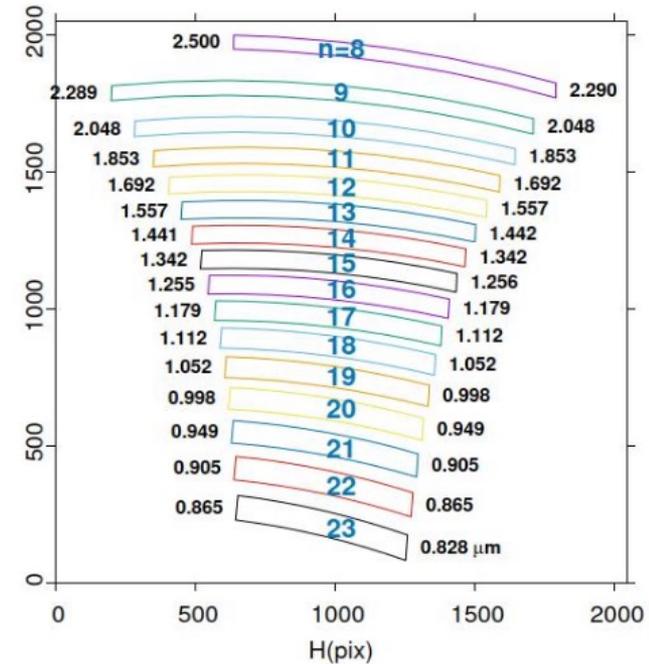
- Characterizing quasars at $z > 6$
 - Characterizing quasars in the epoch of cosmic reionization.
 - 800-2500nm, R~1000-2000
- Galaxy formation at $z > 10$
 - Detect emission lines of the bright galaxies that are not identified by the shallow low resolution Roman grism spectra.
 - 800-2200nm, R>3000
- Initial Mass Functions of metal poor galaxies
 - Reveal IMFs of extremely metal poor galaxies (EMPGs).
 - 360-1300nm, R~5000
- Physical process of quenching galaxies at $z > 2$
 - 1000-2500nm, R~4000



Domoto et al. 2022 and NAOJ

Observing mode	Single Spectroscopy
Wavelength coverage	830 – 2500 nm
Spectral resolution	1000-5000
Slit length	5"
Sensor	HAWAII-2RG (2048 x 2048 pix)
Pixel scale	0.1 arcsec/pix
Sensitivity	Reaches 22 AB mag (5σ) in NIR in 2 hours for follow-up of GW counterparts in O5 (2028-)
Low background	readout noise < 4e-
High throughput	> 0.3
High observational efficiency	Wide spectral coverage in a single exposure

- High sensitivity
 - Optical design is optimized for Laser-Tomographic Adaptive Optics (LTAO).
 - High throughput and low background (optics, detector readout system, thermal design of the cryostat)
 - Slit selectable
 - 0.35" R~3300 (with LTAO, nominal condition)
 - 0.21" R~5500 (with LTAO, good condition)
 - 0.5" R~2310 (without LTAO, seeing)
 - 0.7" R~1650 (without LTAO, seeing)
- High observational efficiency
 - Covers 0.83 – 2.5 μm (NIR) in a single exposure.
 - Eschell optics adopted.
 - Slit viewer equipped for efficient target acquisition.
- Design capable of supporting ToO observations.
- Interfaces to the Subaru Telescope
 - To be installed in NsIR.
 - The light passes through AO3K (AO188), LTAO, and Ns Beam Switcher.
 - Use the light from port #2 of Ns Beam Switcher.
 - To be placed on the common platform.



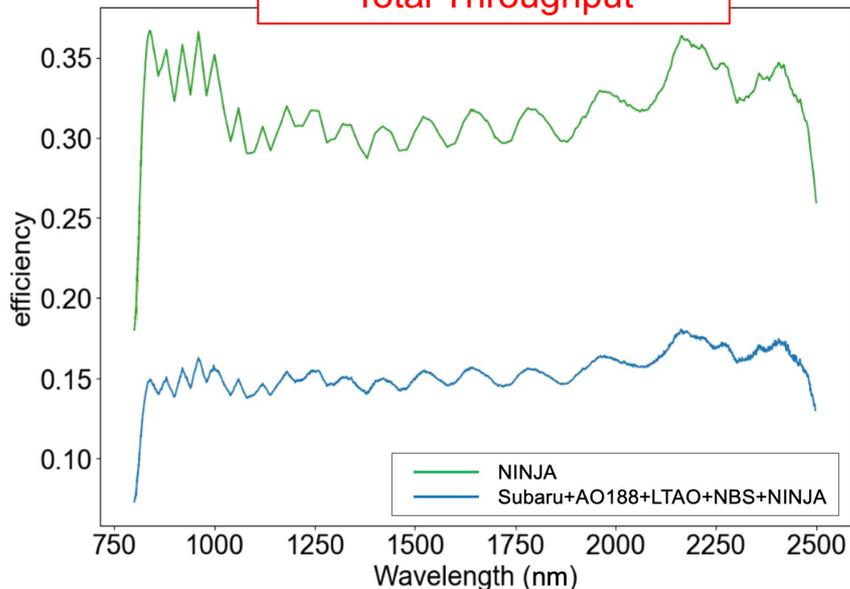
Designed spectra on a H2RG

Expected Performance



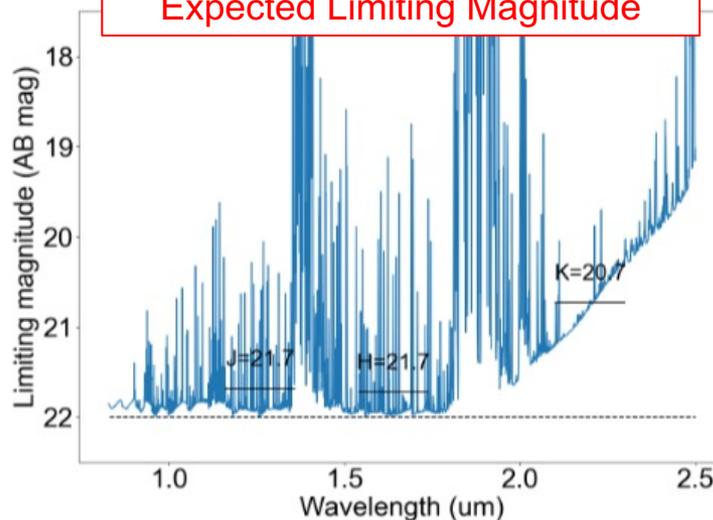
- Thanks for LTAO, 0.5 mag deeper sensitivity than VLT/X-shooter is expected.

Total Throughput

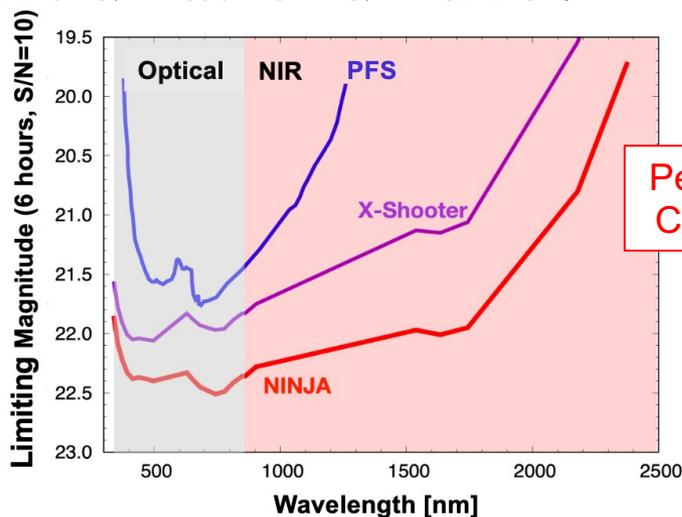


NINJA throughput

Expected Limiting Magnitude

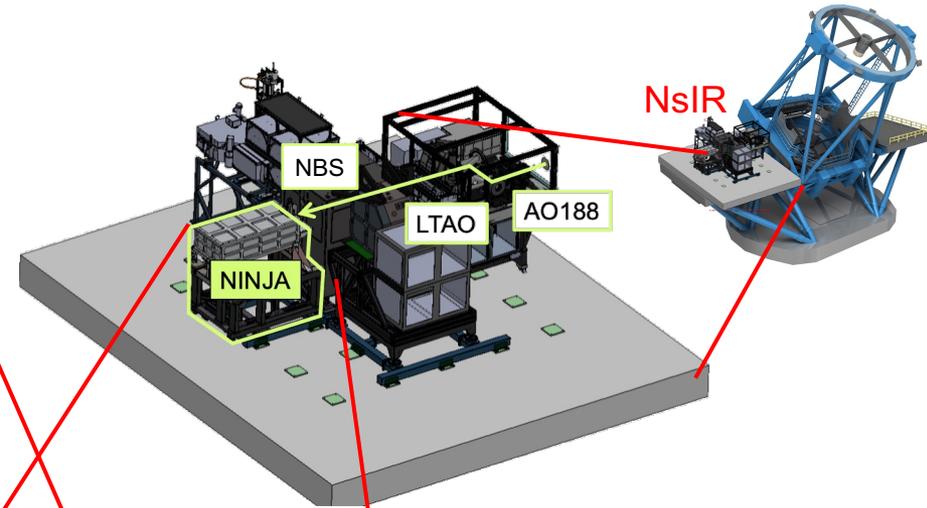
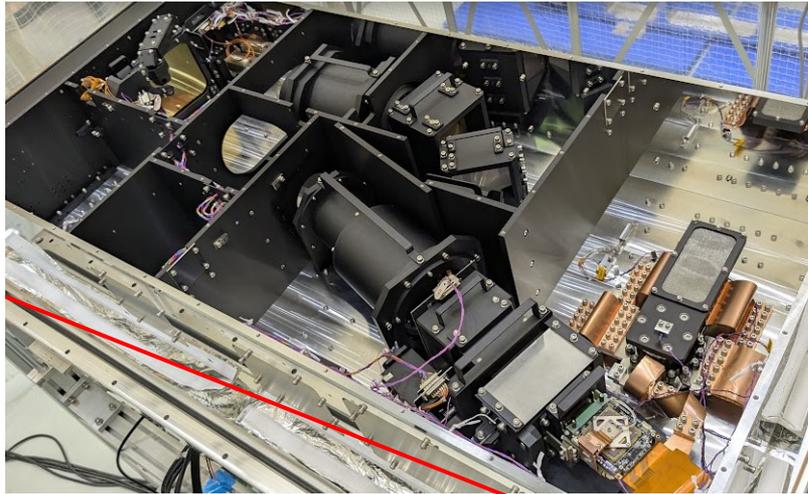


Estimated limiting magnitude (exp=2hours, SN=10, R=3300, EE=0.75, N read=4e- rms. T inst=278K)

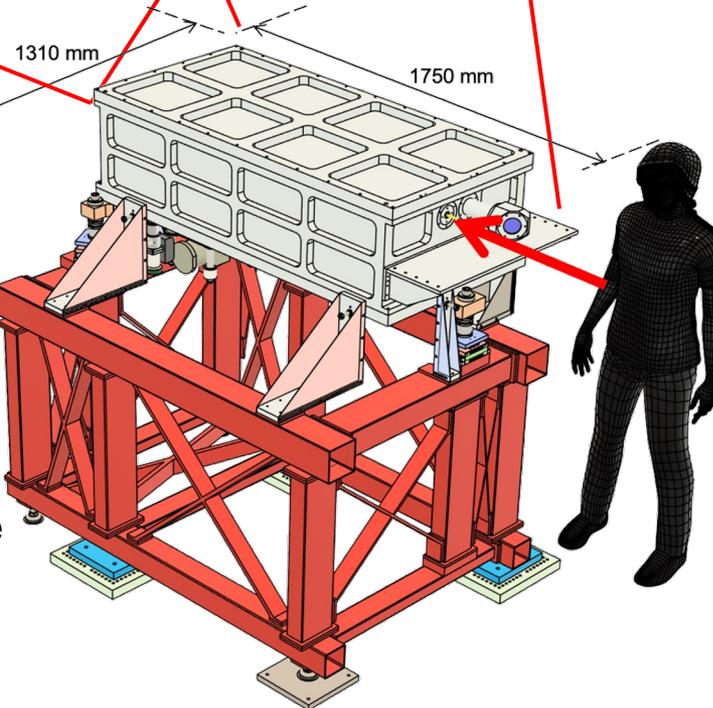


Performance Comparison

Expected Performance Comparison



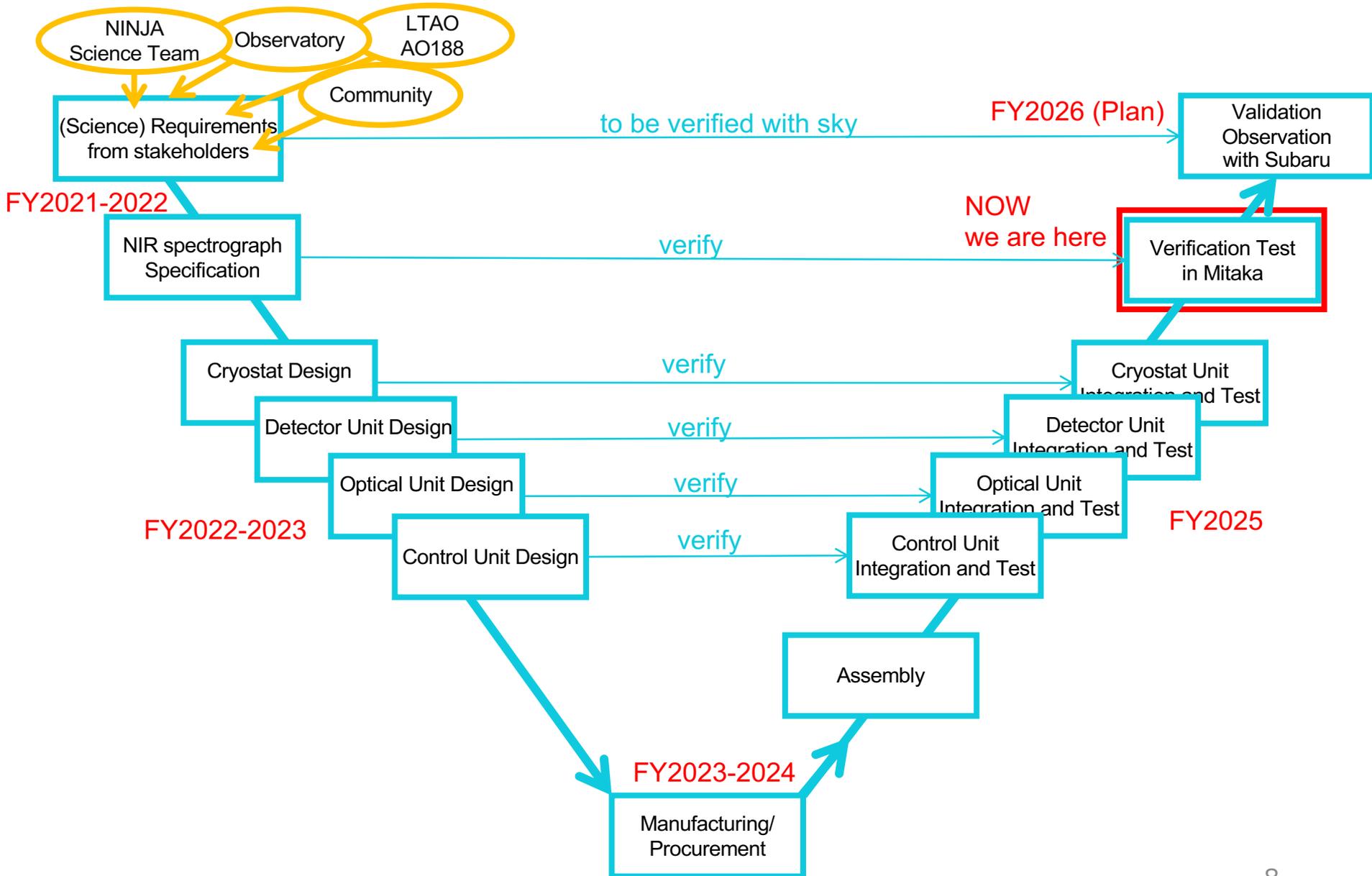
- Size: 1.7(D) x 1.3 (W) x 1.7 (H) m
- Weight on the common platform: ~800 kg (TBC)
- Power consumption: ~2.5kW (TBC, not including a compressor)
- Heat dissipation to NsIR air: ~500 W (TBC)
- One cryocooler is used (Helium cycle and 3P200V power required)



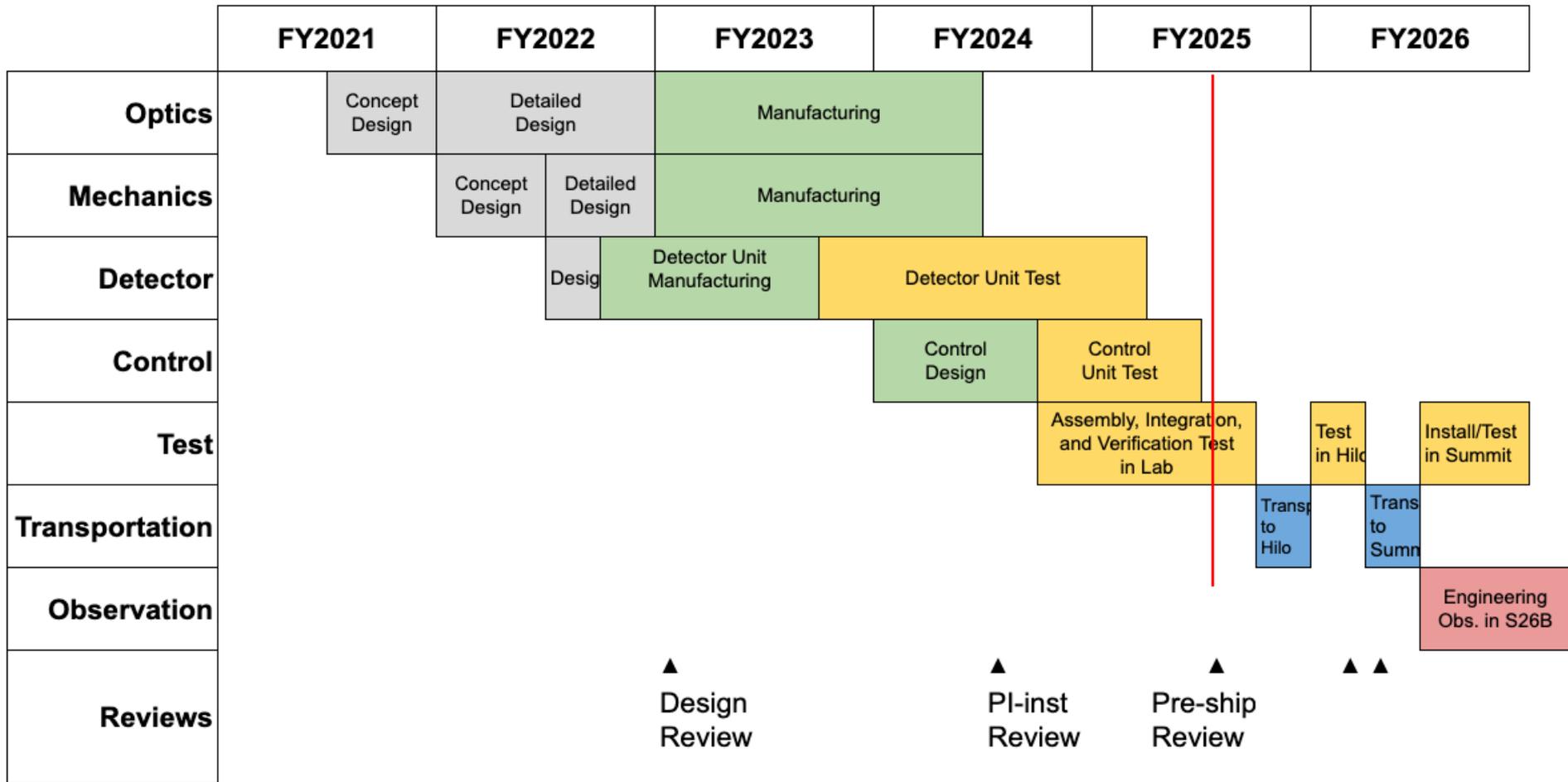
Current Status in the Process of Subaru's PI-type Instrument



Current Status in the Development Process



Current Status: Schedule



■ Optics

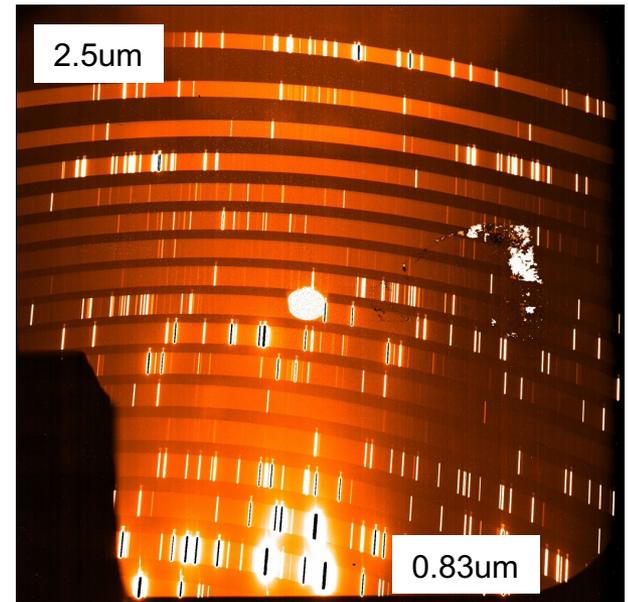
- First spectra obtained in September 2025.
- Full spectra obtained as designed.
- Inspection and mitigation of internal reflections, ghost images, stray light, flare, and so on.

■ Detector

- Operation of an H2RG combination with a SIDECAR ASIC and MACIE has been successfully introduced.
- Performing detector characterization to determine key operating parameters such as bias voltage and preamp setting.
- A readout noise of lower than $4e^-$ was achieved with multi-sampling, meeting the requirement.

■ Thermal and Mechanical

- The optical bench is stably operating at 75K under thermal control as designed.
- Moving mechanisms, including the slit exchange unit, slit viewer, atmospheric distortion correction, and detector dithering unit, are operating properly under vacuum and cryogenic conditions without any significant issues.



First spectra in lab Sep. 2025

- Operation Program
 - Classic program
 - ToO program
 - Typical observation of the counterpart of a GW event is expected to be a few hours to 5 hours per night.
 - It will continue for up to one week if a target is a kilonova.
 - We need further discussion to realize the NINJA ToO mode with the observatory and the community.
- Technical Challenges
 - Target acquisition to the fine slit
 - Position accuracy requirement $\sim 0.1''$.
 - If a target object is faint and a reference star is not near the target, we need "blind offset". AO3K (AO188) AU2 will be used as a guide.
 - Under investigation of the position accuracy of AO3K (AO188) AU2.
- Technical Risk
 - Combination with the LTAO (PI-type instrument, not yet completed, not funded for future operation)
 - [With LTAO but not good PSF]
 - Take the same exposure with a wider slit (Difficult to subtract OH lines).
 - Take a longer exposure with a fine slit (Observable objects are limited).
 - [Without LTAO]
 - NINJA observation available.
 - The limiting magnitude will be degraded.

- NINJA is undergoing system verification testing in the lab.
 - Each sub-system (optical unit, detector units, opt-mechanical units, cryostat) meets the requirements at the sub-system level.
 - Followed by control software development.
 - Test in Mitaka will be wrapped up at the end of 2026.
- NINJA will be transported to Hilo in Q1, 2026, after transportation review.
- Target of a first light (engineering observation) is planned in 2026.
- Only the development has been funded by Kakenhi until FY2026 (including the planned extended term). We need to secure funding for the science operation.
- We have also initiated efforts to secure funding for the development of the optical arm, to enable simultaneous spectroscopy in the optical and NIR ultimately.
- We encourage that the gopira community will actively make use of NINJA!

NINJA specifications

	NINJA NIR
Mode	Single Spectroscopy
Wavelength coverage	830 – 2500 nm
Slit width	0.35" R~3300 0.21" R~5500 0.5" R~2310 0.7" R~1650
Slit length	5"
Sensor	HAWAII-2RG (2048 x 2048 pix)
Pixel scale	0.1 arcsec/pix
First light	2026 (TBD)