



Current Status of Red-NINJA

Probing the Origin of Heavy Elements with Kilonova Spectroscopy

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Students

Introduction

Near-Infrared and optical Joint spectrograph with Adaptive optics (NINJA) is a new PI-type optical-to-near-infrared spectrograph being developed for the Subaru Telescope.

Development is currently focused on the near-infrared spectrograph, **Red-NINJA**, ahead of the optical spectrograph, **Blue-NINJA**. Engineering first light of Red-NINJA is planned for Subaru semester S26B, while development of Blue-NINJA officially began in 2026.

Scientific Objectives

- The goal of NINJA is to reveal the origin of r-process elements through spectroscopic observations of kilonovae from neutron star mergers.
- GW O5 era: ~50 neutron star mergers per year within 200 Mpc
- Week-long optical-NIR spectroscopy to constrain nucleosynthesis
- NINJA also enables follow-up of supernovae, high-redshift galaxies, and quasars from wide-field surveys.

Red-NINJA Specifications

The Red-NINJA is an echelle spectrograph with a double-pass collimator design, simultaneously covering the full NIR wavelength range on a single HAWAII-2RG detector (Fig. 1).

The spectrograph adopts a 5" slit length for dithering observations. The baseline slit width is 0.35" (R~3300), with additional 0.21", 0.5", and 0.7" slit options for AO and non-AO observations. Slits are selectable via the slit exchange unit. Precise target acquisition onto narrow slits under AO-assisted observations is one of the key technical challenges of the project.

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|-------------------------|--|
| • Observing mode | Echelle Spectroscopy |
| • Wavelength coverage | 0.85 - 2.5 μm |
| • Wavelength resolution | 1650 - 5500 (four slits) |
| • Limiting magnitude | ~ 22 AB mag (J-band, 2 hours exp, S/N=10) |
| • Detector | HAWAII-2RG (2048x2048 pix, 18 μm /pix) |
| • Instrument size | 1310x1750x1680(H) mm |
| • Instrument weight | 900 kg |
| • Focus | IR Nasmyth |

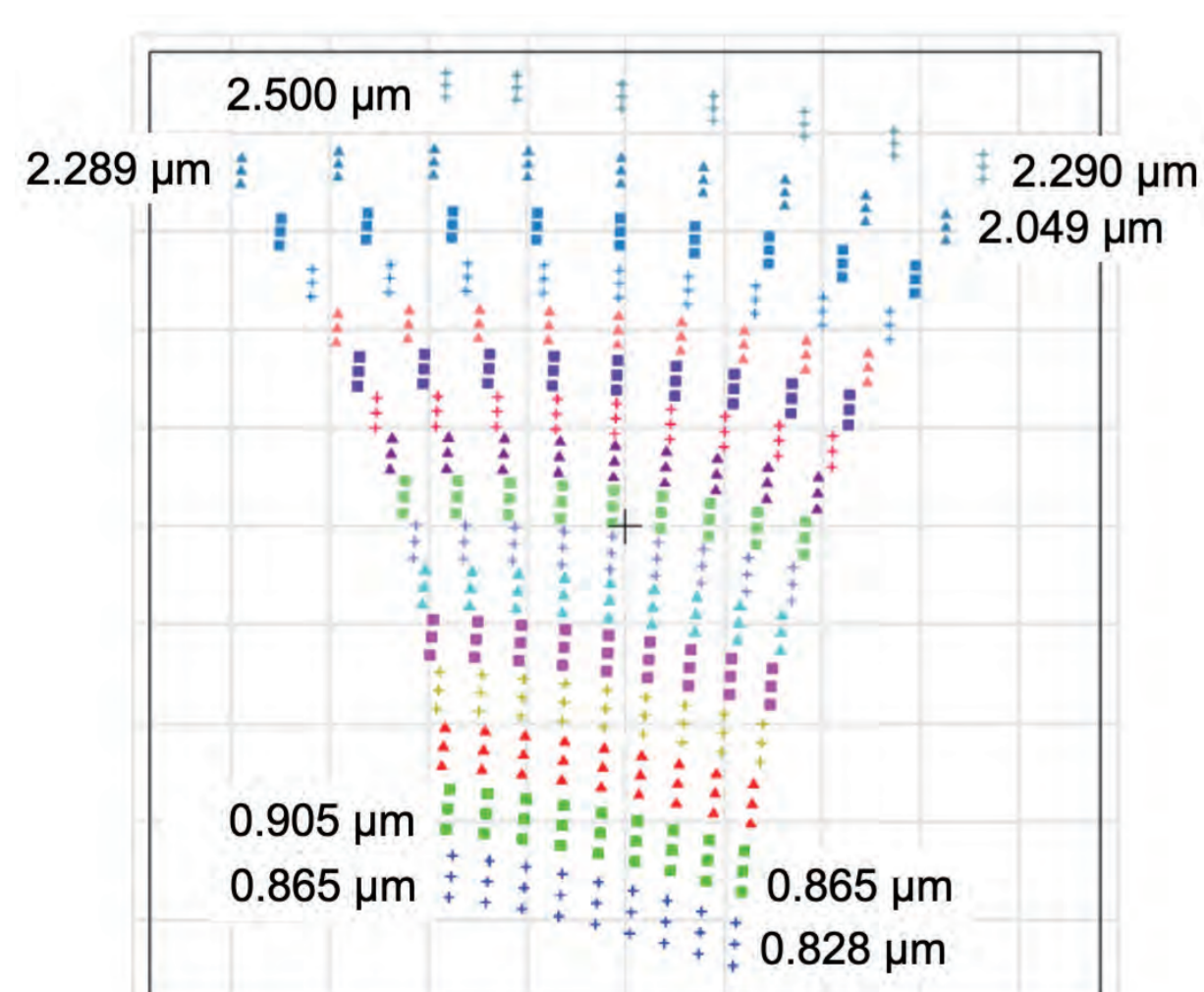


Fig. 1 Echelle format on the H2RG detector.

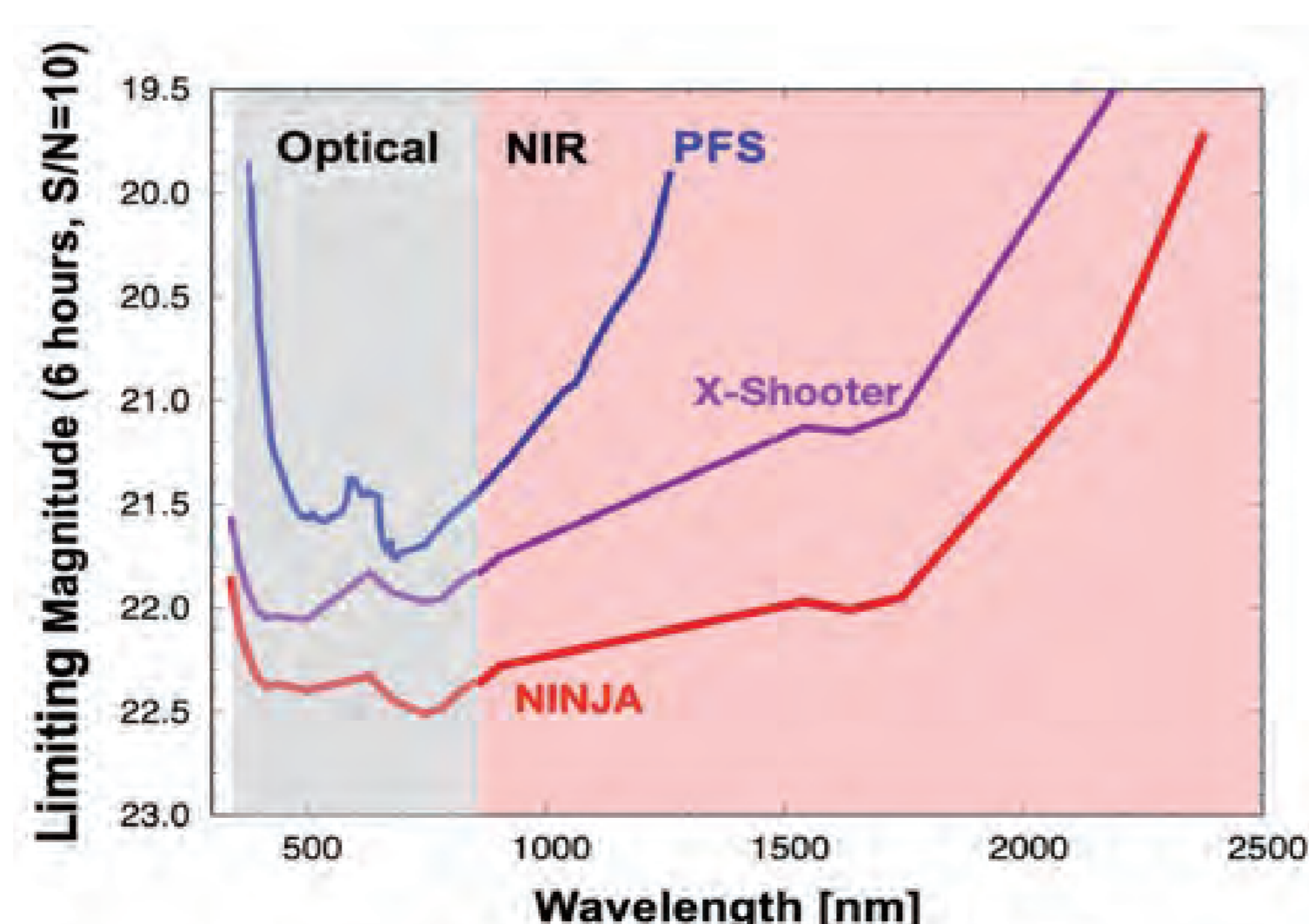


Fig. 2 Expected sensitivity of NINJA compared to existing instruments.

Acknowledgements

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Results of Integration and Testing

Results of integration and testing in Mitaka and Hilo:

- **Detector**
 - Readout noise achieves ~ 11.9±1.3 e- (CDS) → ~ 4 e- (Fowler-20)
 - Dark current ~ 0.012 e-/s/pix (@80K, within acceptable level)
 - Bad pixel fraction ~ 2.7 %
- **Optics**
 - Image quality and wavelength coverage meet design specifications
 - Spectral resolution exceeds design
 - A bright ghost at the detector center is under investigation
- **Mechanisms**
 - All four cryogenic moving systems (slit exchange, slit viewer, ADC, detector dithering stage) verified at 75K.
- **Software**
 - Control system through gen2 under implementation.



Fig. 3 Interior of the Red-NINJA thermal shield after full assembly of the optics, NIR detector, motors, and other components. (October 2025)



Graduate students and early-career researchers play central roles in the assembly and testing of the Red-NINJA.

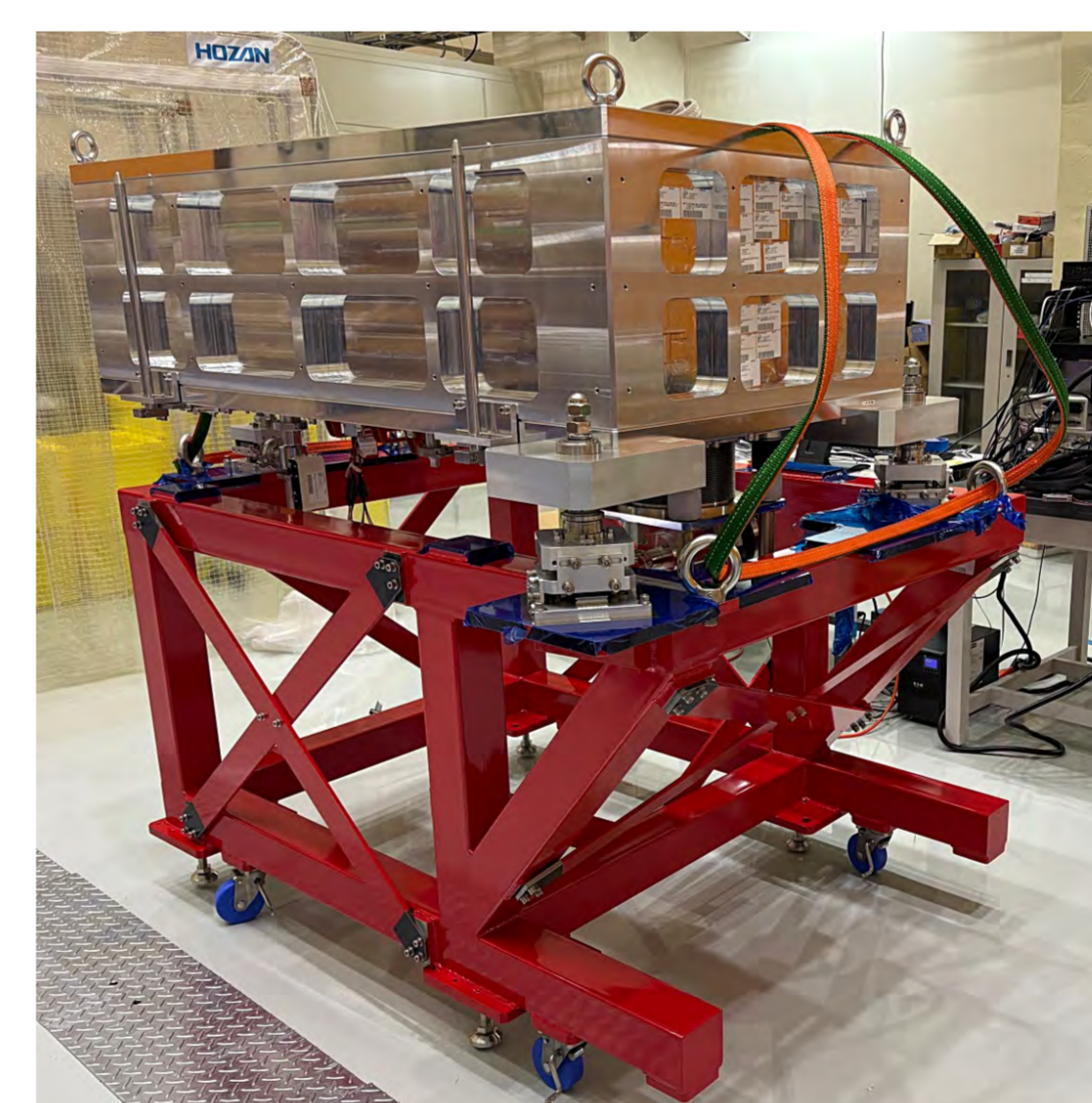


Fig. 4 Assembly rehearsal in the Mitaka laboratory for installing NINJA onto the Nasmyth platform. (January 2026)

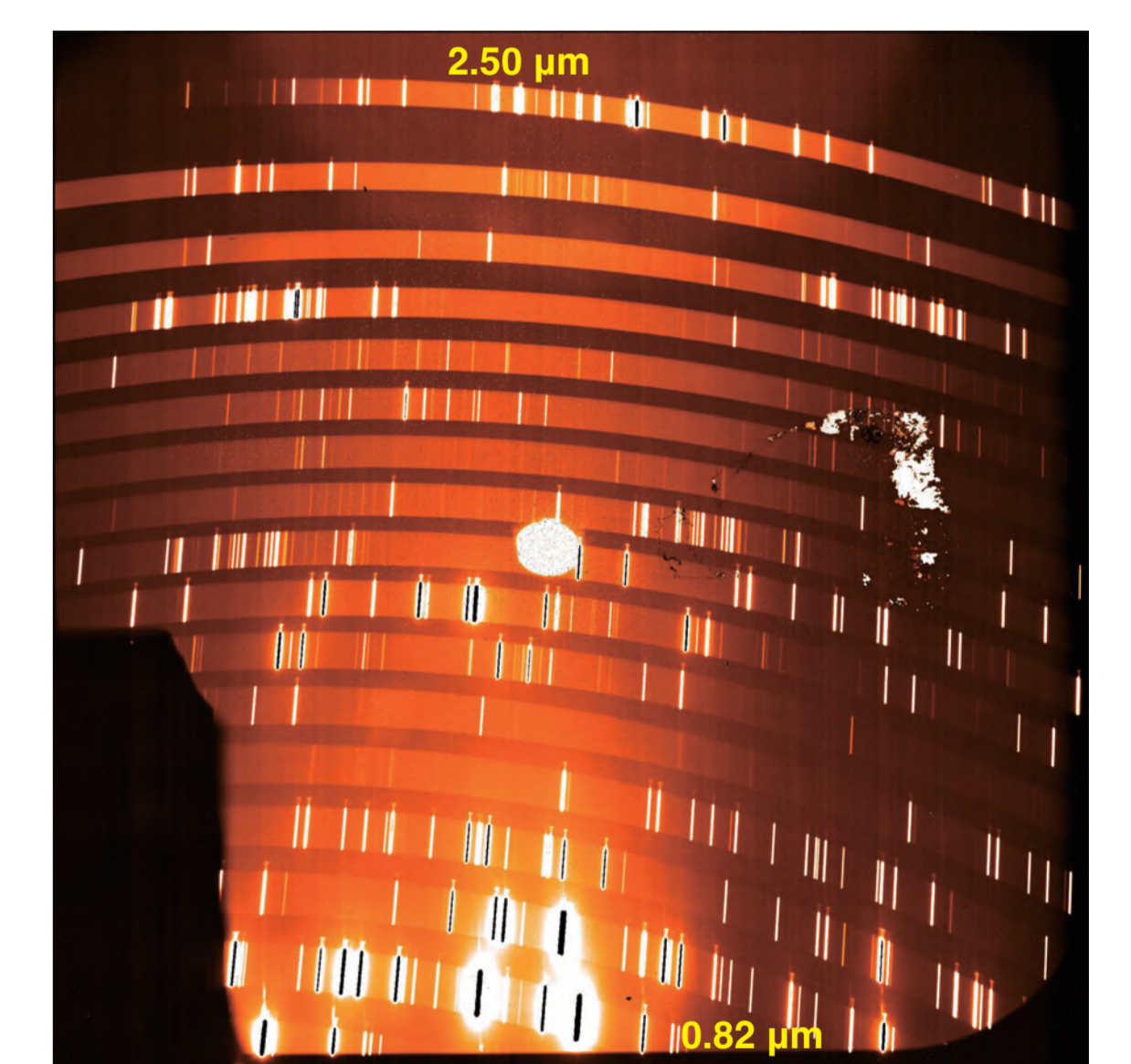
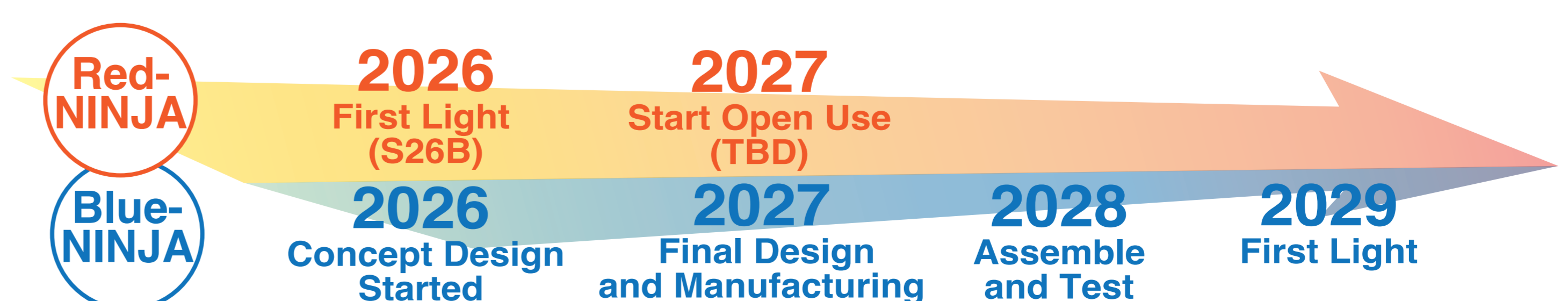


Fig. 5 Spectroscopic data obtained with NINJA using an emission-line source. The spectrum covers wavelengths from approximately 0.85 to 2.5 μm from bottom to top. (October 2025)

Status and Future Timeline

Following verification test in Mitaka, the Red-NINJA was shipped to Hilo in February 2026. Summit delivery planned for June, installation at the IR Nasmyth platform in July 2026. We are currently preparing for commissioning observations and have applied for engineering first light in S26B.

In parallel, **the Blue-NINJA development has secured funding and has entered the conceptual design phase.**



NINJA development timeline (plan)