

Astrocomb and Fiber Feed Module for HDS

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Abstract

An astrocomb for HDS "HDS comb" is a laser frequency comb designed for HDS wavelength calibration, and currently under construction. The comb produces many comb-like emission lines with precise wavelengths of a mode spacing $\sim 30\text{GHz}$ in three wavelength bands (350 nm - 420 nm, 450 nm - 560 nm, 660 nm - 900 nm). We are also constructing a Fiber Feed Module (FFM) to deliver stellar and HDS comb lights from the Opt. Nasmyth focus to the slit of the spectrograph via optical fibers. The FFM is mounted on AG/SH flange on Optical Nasmyth side. It is equipped with a system for changing observation modes, light injection systems, a fiber and scrambler system, and a light output system for ingesting the lights on the slit.

We plan to install the HDS comb and the FFM on the Subaru telescope in 2025, followed by engineering observations.. In this poster we report on status and specification of the HDS comb and the FFM in 2024.

Astrocomb (天文コム)

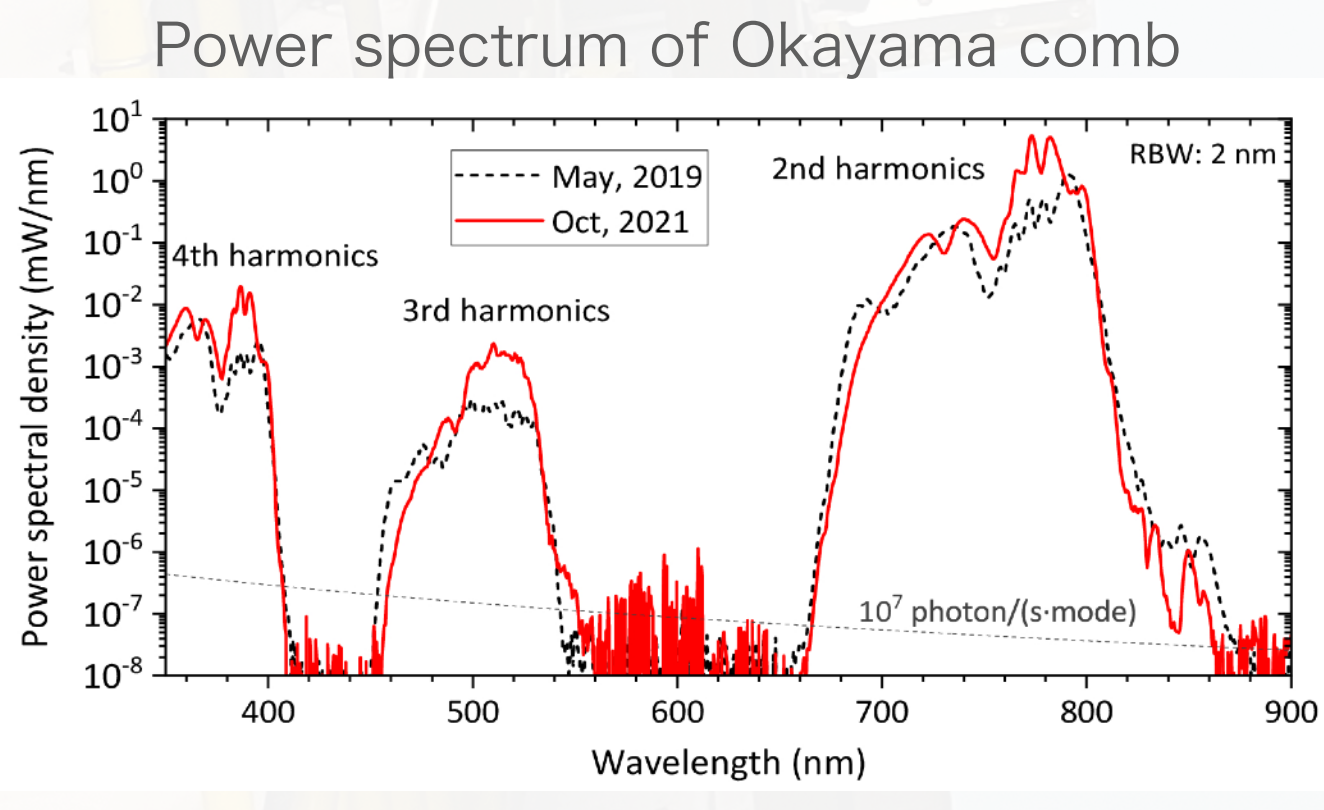
- * A laser frequency comb (光周波数コム) for very precise wavelength calibration of high dispersion spectrographs and RV measurements
 - * Murphy et al. 2007, Steinmetz et al. 2008, Li et al. 2008 etc.
 - * A few hundred MHz (typical comb) \rightarrow A few ten GHz (astronomy)
- * Produce **many comb-like** emission lines with a **precise** wavelength in wide wavelength ranges in optical to infrared.
- * Long-term stability with high precisions is required from astronomy.

Science goals of the astrocomb

- * Search for (Earth-like) planets around normal stars
 - * By using the Doppler method with very precise RV measurements
 - * RV precision and stability of **<10cm/s** are required to detect Earth-like planets in the habitable zone around solar-type stars.
 - * **Optical** astrocomb is needed for RV monitors of solar-type stars.
- * Direct measurements of accelerated expansion of the universe
 - * $\sim 10\text{cm/s}$ precision and stability levels are required for a long period.

“HDS comb” = Astrocomb for HDS

Laser Frequency Comb

- * Next version of **Okayama comb**
 - * Nakamura et al., Optics Express, 31(12), 20274-20285, 2023
 - * Okayama comb has been operated at the Okayama188cm telescope dome since 2019.
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- * Mode spacing frequency
 - * 30GHz (variable) \sim **0.25 Å** @500nm (line spacing)
 - * Generates emission lines at suitable uniform frequency intervals
- * Target wavelength bands (3 bands)
 - * **350 - 420** nm, **453 - 560** nm, **664 - 900** nm (estimates)
- * Long term stability : Various innovations (see paper above)
- * Manufactured by a Japanese company
 - * Easier experimentation and improvement, and **lower cost!**



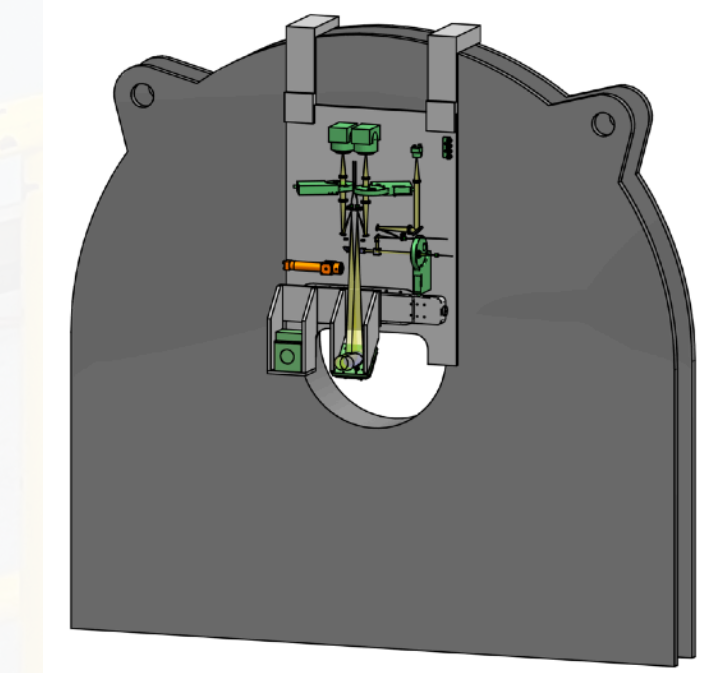
Fiber-Feed Module (FFM)

- * Fiber-Feed module for comb and stellar lights into HDS (3 fibers)
 - * Fibers for **object**, **sky(backup)** and **comb**
 - * Three beams of the lights are injected into HDS simultaneously.
 - * Injection optics is installed at the AG/SH flange of NsOpt.
 - * Fiber output optics will be installed in front of the HDS slit.

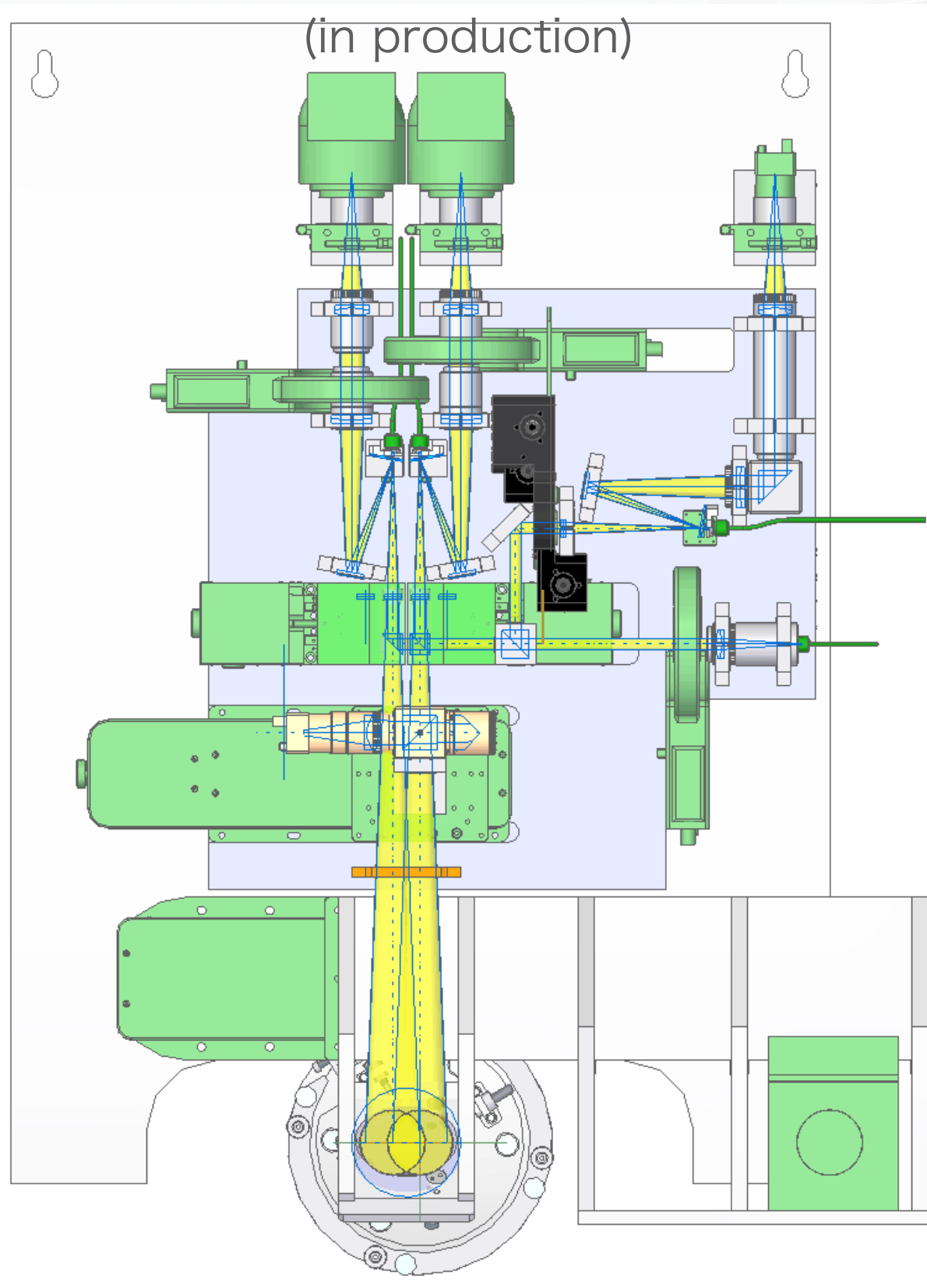
AG/SH flange of NsOpt



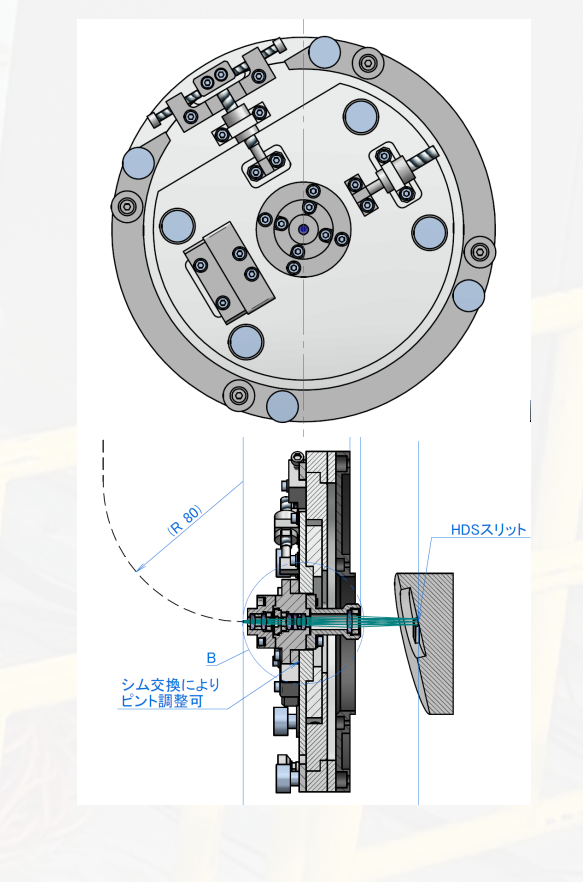
Image of FFM on AG/SH flange



Injection optics of the fibre feed module



Fiber output optics

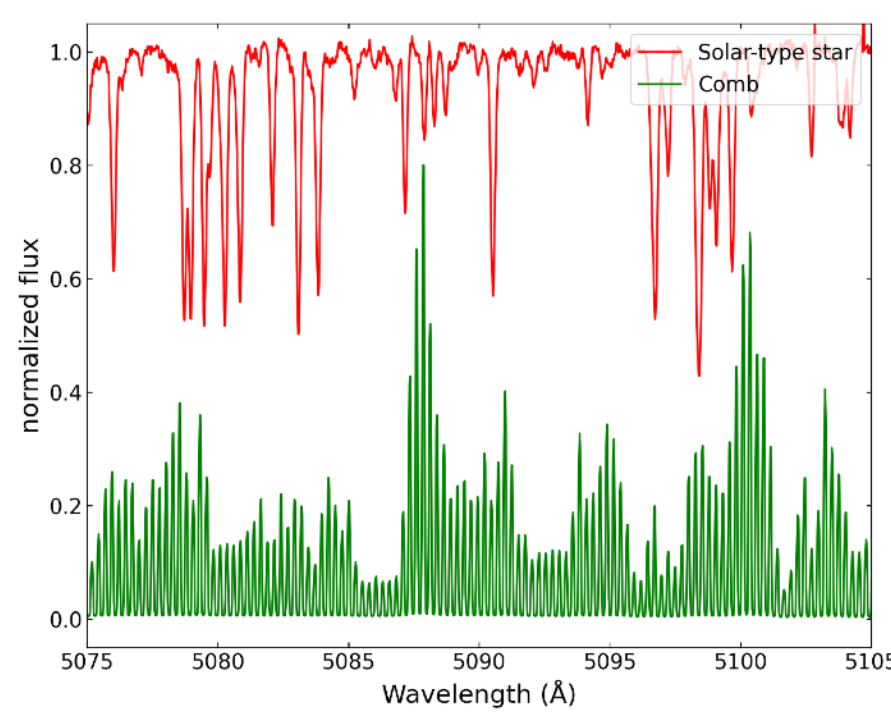


Fiber output positions

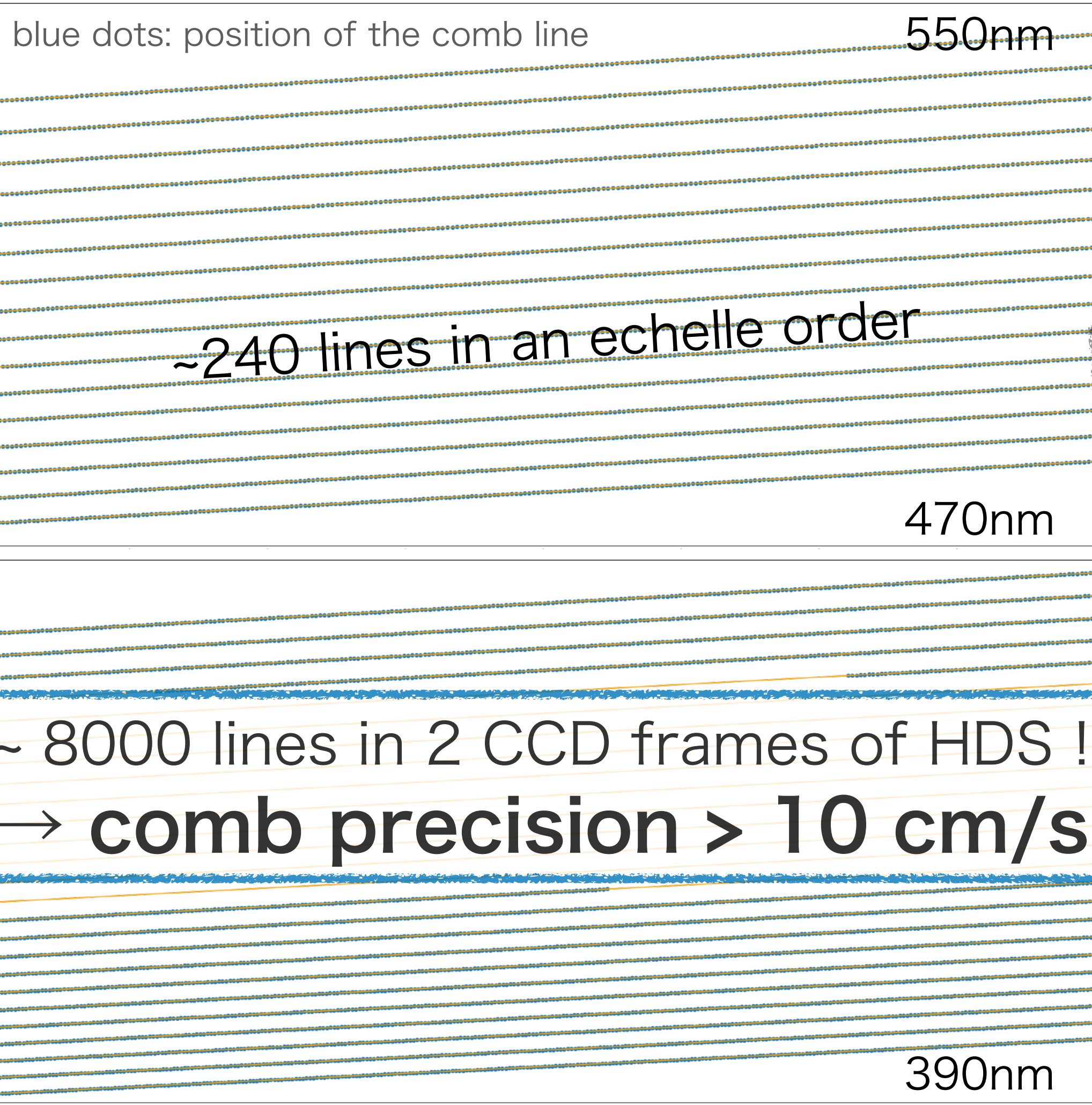
Set-ups of HDS and HDS comb

- * Main goals
 - * Operation of our astrocomb instrument at the summit of Mauna Kea
 - * Establishing the use of our comb as a instrument for precision RV
 - * Discovery, verification and characterization of (short-period) exoplanets
- * Resolution : **>36,000 (variable)** # Determined by the slit width
- * Wavelength coverages (example) :
 - * **BlueGreen band** : **335 - 500 nm**, **390 - 555 nm**, **439 - 606 nm**
 - * **Red Band** : **650 - 900 nm** (Careful for Telluric lines and fringe)
- * Radial Velocity precision : **$\sim 0.8 \text{ m/s} = 80 \text{ cm/s}$** (Goal)

Spectra of star and the Okayama comb



Simulation of 2D data for the HDS comb



Schedule & Timeline

- Technology transfer to comb manufacturer from AIST team : **2021-2022**
- Production of comb equipment : **2021~2024**
- Fibre feed module fabrication : **~Summer 2025**
- Installation on Subaru Telescope : **2025 (planned)**
- Engineering observation start : **S26A-**
- Science observation (open-use) : **S27B-**

