

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 30GHz 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 FY2025, followed by engineering observations.

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) → 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.

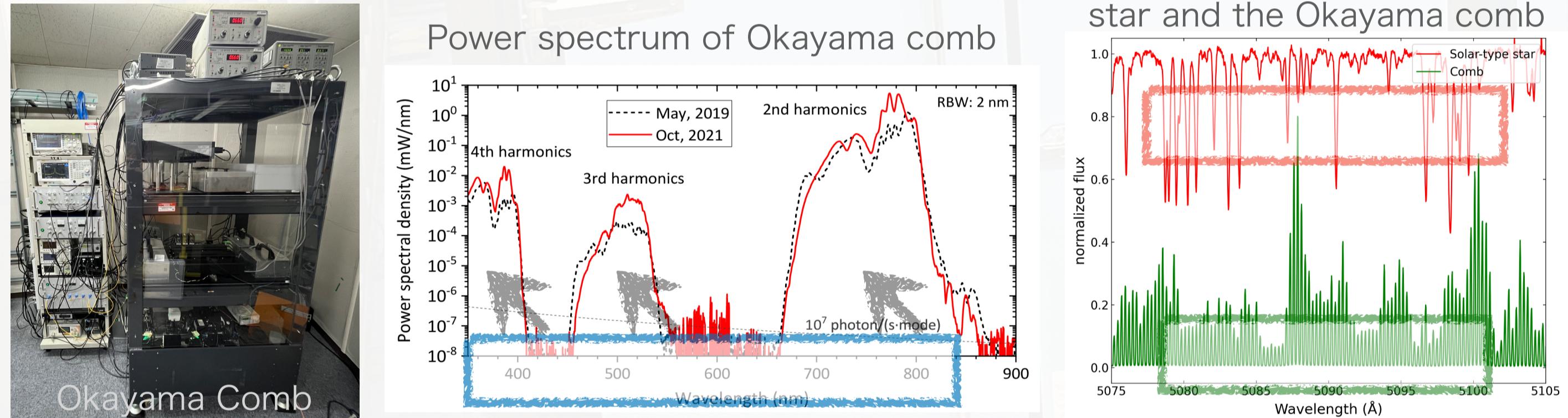
Science goals of the astrocomb

- * Search for and detect (Earth-like) planets around 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
 - * ~10cm/s precision and stability levels are required for a long period.



Laser Frequency Comb

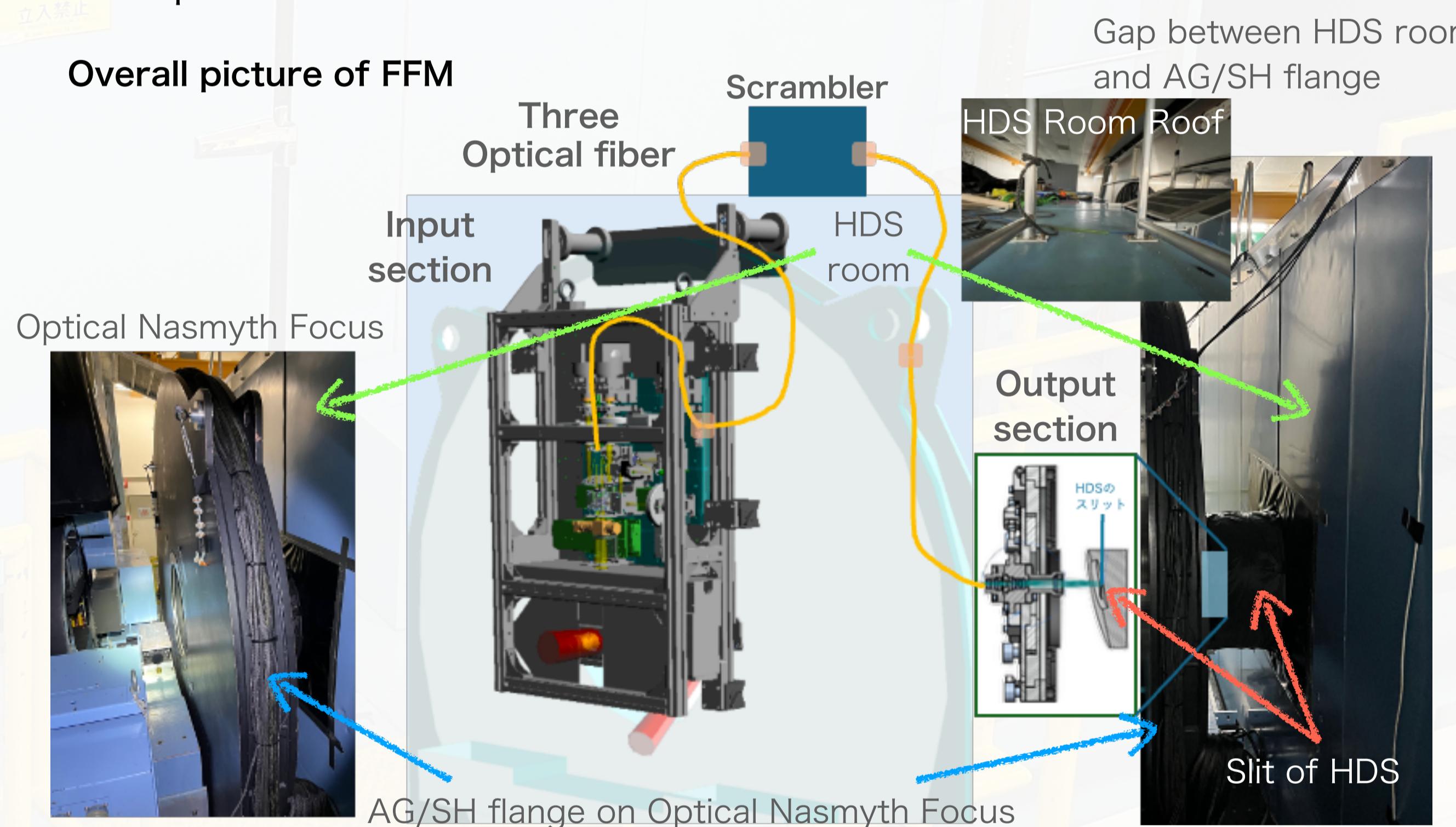
- * Next version of **Okayama comb**
 - * Nakamura et al., Optics Express, 31(12), 20274-20285, 2023
 - * Okayama comb has been operated at the Okayama 188cm telescope dome since 2019.



- * Mode spacing frequency
 - * 30GHz ~ **0.25 Å** @500nm (line spacing)
 - * Generates emission lines at suitable uniform frequency intervals
- * Target wavelength bands for the HDS comb (3 bands)
 - * **350 - 430 nm**, **450 - 570 nm**, **630 - 875 nm** (possible)
- * Long term operability : 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**
 - * Set three fibers for **object, sky(backup)** and **comb**
 - * Three beams of the lights are injected into HDS simultaneously.
 - * Input section is installed on the AG/SH flange of NsOpt.
 - * Mode change stage between slit and fiber modes
 - * Subplate system with fiber input ports and optical systems etc.
 - * Output section is installed in front of the HDS slit.



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 of comb lines on HDS set-ups (recommended) :
 - * **BlueGreen band** : 335 - 500 nm or 390 - 555 nm or 439 - 606 nm
 - * **Red Band** : 650 - 900 nm (Please be careful for Telluric lines and frin
- * Radial Velocity precision : **~0.8 m/s = 80 cm/s** (Goal)

Schedule & Timeline

Technology transfer to comb manufacturer from AIST team : 2021-2022

Production of comb equipment : 2021-2025

FFM fabrication (Now) : until End of 2025

Installation on Subaru Telescope : Feb

Engineering observation start : **S26B-**

Updated in 2025 : FFM Input section

- * holds the optical system
- * switches the obs. mode
- * subplate feeds into fibers
- * guiding objects
- * optical axis alignment

