

Report from Okayama Branch

Subaru Telescope, NAOJ

Jan 23, 2024 (Subaru UM FY2023)

Akito Tajitsu



Seto Ohashi bridge

Asakuchi city

Seimei Telescope
(Kyoto Univ.)

188cm Telescope

91cm tel.

30mm tel.
(Tohoku Univ.)

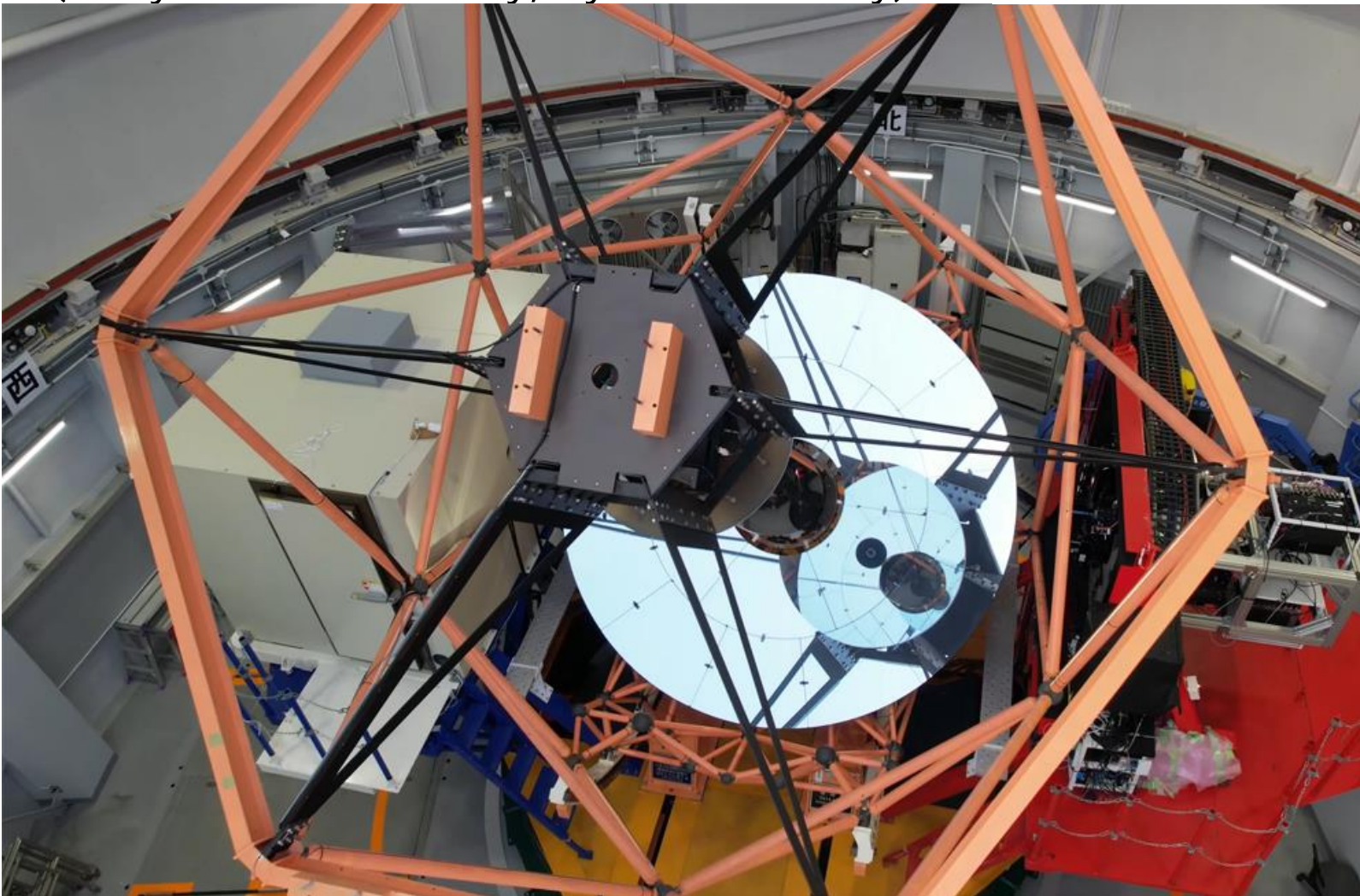
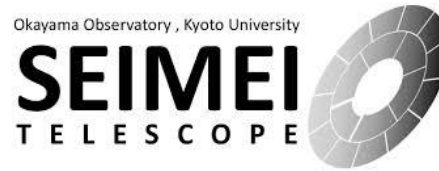
105mm KWS

50cm tel.
(Titech → Kyoto Univ.)



3.8-m Seimei Telescope

(Okayama Observatory, Kyoto University)



50% : Kyoto Univ.

50% : Open Use

conducted by Okayama branch

3 instruments

- **KOOLS-IFU**

Low dispersion optical spectrograph w/IFU

- **TriCCS**

High-speed tricolor optical camera

※ spectroscopic mode will be opened in 24B

- **GAOES-RV**

High dispersion optical spectrograph
for precise RV monitoring

Optimized for ToO.
Full remote obs. is available from 24A.

Seto Ohashi bridge

Asakuchi city

Main part of this talk is dedicated for 188cm telescope.

Seimei Telescope
(Kyoto Univ.)

188cm Telescope

91cm tel.

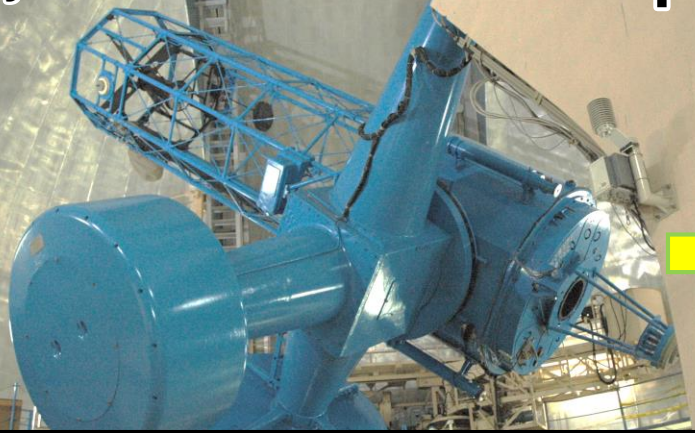
30mm tel.
(Tohoku Univ.)

105mm KWS

50cm tel.
(Titech → Kyoto Univ.)



Okayama 188cm telescope



- From FY2018, operated through a tripartite agreement between

NAOJ

Tokyo Institute of Technology

Asakuchi city.



- ~40 researchers are using for
 - flexible monitoring
 - time critical observation etc.
 Main subject : **exoplanet hunting**

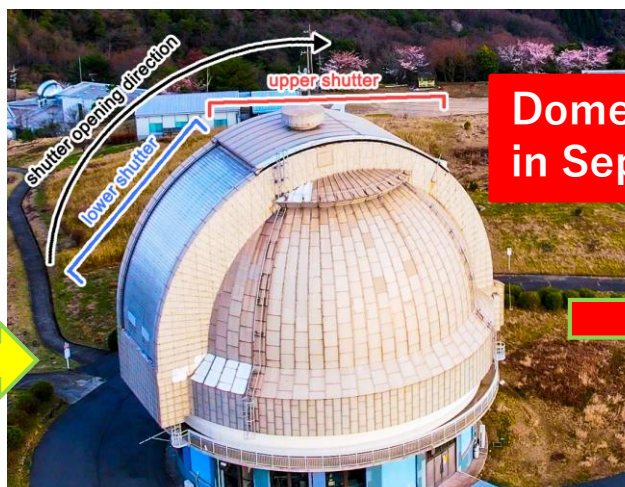
Bun'ei-san's poster P-20

- Automatic queue observation.**

- Based on the **fees paid by telescope users** (researchers & Asakuchi city)

- The fees are used for
 - Operation
 - Maintenance

No budget for operation from NAOJ



The upper door must be connected to the lower door (wire driven) until the upper lands safely.

Dome slit trouble in Sep. 2022



- The upper door of the slit fell and stuck** on the dome structure.
- The upper door might be caught and fastened to a damaged part of the upper door rail.
 - The joint between the upper and the lower doors might be disconnected.
 - After the lower door was opened alone, the upper door fell down freely.
- The main cause is the **aging** of the dome (built in 1960).
- Currently, the dome slit **cannot be closed from 40% open.**

【Accident】

Observations have been suspended until now.

【 Post-accident response 】

- Investigations were immediately initiated with a local company that had performed maintenance in recent years.
- For the areas where the slit doors remain open, measures to prevent the ingress of rainwater will be taken successively. (almost completed in Sep. 2023)
- 188cm telescope and dome rotation function are **confirmed to be undamaged.**
 - **Observable as soon as the dome slit is restored.**
- NAOJ is currently working for its restoration.** As of January 2024, **a specific restoration plan is being fixed.**

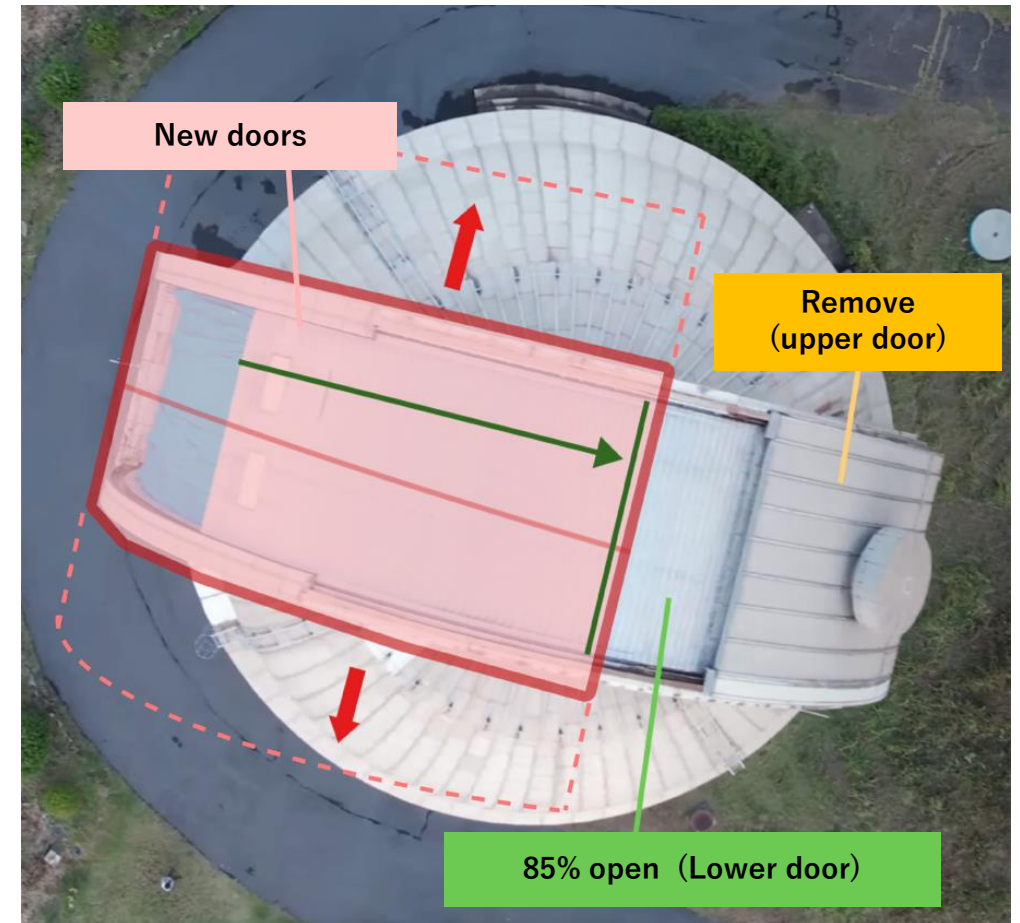
Plan : New horizontal opening/closing doors

Overview

- Damaged **upper door** will be removed.
- **Lower door** will be **opened to zenith** (El ~ 100°) and **fixed**.
- **A new horizontal (sideways opening) doors** will be installed using a crane.

Advantage

- **Prevents similar accidents** by changing the opening mechanism.
- **Cost down for maintenance** (no more wire and rail replacements)
- **Significantly reduces opening/closing time** (11 → 2 min)
- **Reduce costs and construction time** by leaving the lower door.



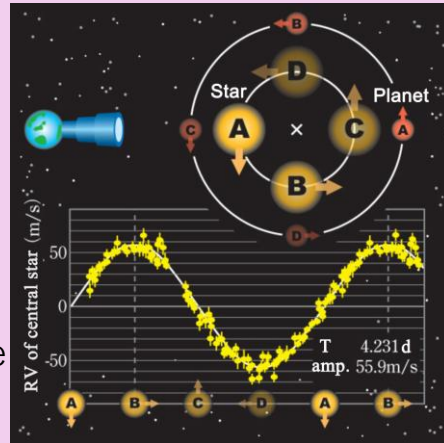
Budgetary support from NAOJ must be essential.
⇒ **We need to reconsider the value of 188cm telescope and get the understanding of “the community”.**

Scientific Results & Future Plans

Long-term, continuous obs. of exoplanets is essential. Subaru is not suitable for this purpose, so a project-dedicated telescope like Okayama is still needed.

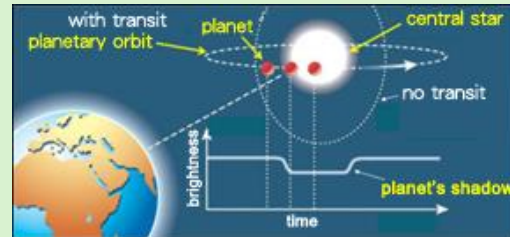
①Doppeler method (w/HIDES)

- ✓ **RV measurements** (hundreds ~ several m/s).
- ✓ It has discovered more than **50 planets** (since the early 2000s). Planets discovered **in giant stars** account for **30%** of the world's discoveries.
- ✓ Stable and precise measurements are required **over a long period** (Saturn ~30 yrs) **of several decades**.



②Transit method (w/MuSCAT)

- ✓ Observe the "**shadow**" when a planet passes in front of a star.
- ✓ **Component analysis** is possible based on the difference in atmospheric opacity depending on wavelength.
- ✓ 188cm tel. began obs. in 2014. It discovered **earth-like planets** with world-class photometry accuracy.
- ✓ **A worldwide network** was built with three identical devices to continue observation 24 hours a day.



Scientific goals for the next 10 years

➤ RV measurements w/HIDES

- The measurements for another 10 years extends the exploring area beyond the orbit of Saturn (half a cycle to 15 years) → **beyond the snow line**.
- Search for terrestrial planets (near or beyond the Earth's orbit) by **improving the RV accuracy** (~several 10 cm/s) using **Astro-comb**.
- Explore **the second solar system** and verify the (non-) specificity of the solar system.

➤ Transit observations w/MuSCAT

- Highly accurate and reliable planet discovery and characterization by **linking three MuSCAT series with space telescopes**.
- **188cm tel. is one of the three longitude bases** (along with Europe and US mainland), **for continuous 24-hour observation**.

Long-term Goals

- Understanding the formation and evolution of planetary systems in solar-like or more massive stars.
- Discovered a second solar system near the sun, leading to detailed research by TMT.

Development base for New technologies : “Astro-comb”

- Okayama Branch has been conducting joint development with AIST since 2014.
- **Wavelength region (visual) : 360 – 900 nm**
- RV measurement accuracy is expected to be in the range of **several tens of cm/s (theoretical limit <10 cm/s)**.
- Improvement of the spectrograph for that high precision also on-going.
- The results be applied to **Subaru and TMT**.



A plan to install the 3rd model of “Astro-comb” into Subaru/HDS is already running!

⇒ See Omiya-san's poster (P18)



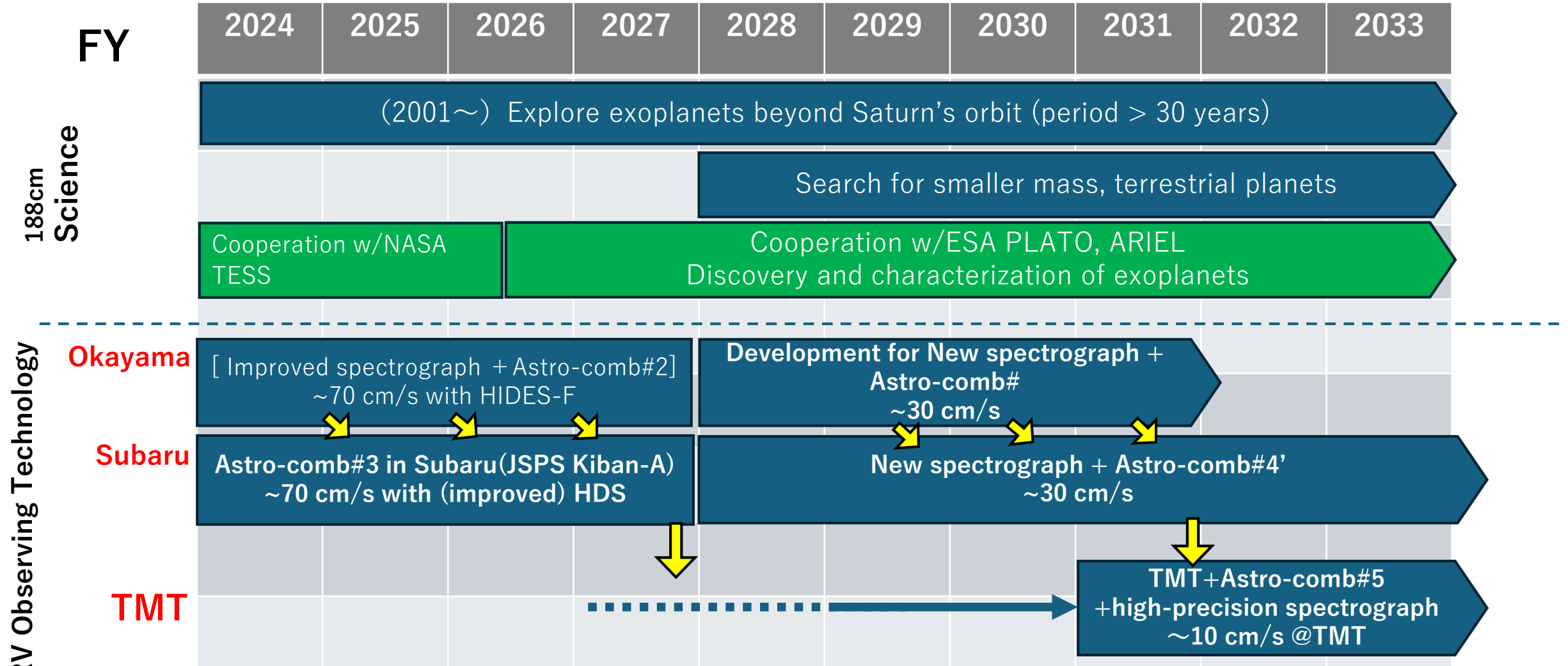
The 2nd model of “Astro-comb” in Okayama.



The spectrum of Astro-comb taken with Okayama HIDES.
Evenly and densely spaced bright lines line up works as a precise light measuring scale.

Continued operation of 188cm telescope for the next 10 years

is essential for its unique science and
developments for exoplanet obs technologies in Subaru 2 and TMT projects



Okayama will conduct improvement/development works, experiments, and long-term high cadence observations, utilizing its flexibility and accessibility.

How are we going to ... ?

- Japanese researchers who are interested in RV monitoring, including Subaru and TMT, have begun discussing how to proceed with the plan.
- Kick-off discussion was held at the Seimei/GAOES-RV Workshop (2023/11/30-12/1).
- We are planning to hold a **workshop for Extreme Precision RV monitoring in FY2023**.

With the aim of realizing ultrahigh-precision optical high-dispersion spectrograph with Astro-comb for Subaru 2 and even TMT, we will discuss

- ✓ status and challenges of the **current instruments**,
- ✓ what to aim for and how far to go with the current instruments.

Okayama/HIDES, Seimei/GAOES-RV, Subaru/HDS & IRD, IRSF & PRIME/SAND

Then, we will discuss about the **next instruments**.

Japanese researchers related to precision RV monitoring will bring their experiences to the meeting, exchange information, and build a cooperative framework for the future.

⇒ **Contact person : Bun'ei Sato (TITech)**