2021 Annual Report of Subaru Telescope

Michitoshi YOSHIDA
Director, Subaru Telescope
National Astronomical Observatory of Japan

Subaru Telescope in 2021

Takato-san passed away (May 14, 2021)

- Professor Naruhisa Takato (高遠徳尚) died in Taiwan on May 14th (May 13th HST).
- He is an excellent astronomer and specialist of astronomical instrumentation.
- He became an assistant professor of Subaru Telescope in 2002. He was promoted to a Professor position in 2018 and was the leader of the PFS A-project since 2019. The leader of the A-project is now Julien Rousselle.
- Takato-san was involved in many instrumentation projects of Subaru: AO, CIAO, FMOS, HiCIAO, HSC, IRD, and PFS.

May his soul rest in peace.

Subaru in 2021

- COVID-19 pandemic
  - Delta variant in summer, then Omicron variant in winter.
  - Most of the staff members got vaccinated.
- Science
  - 152 science papers were published. 16 press and web releases on science.
  - HSC SSP was completed in December 2021.
  - IRD SSP continues.
- Instrumentation
  - Visiting instrument SWIMS was in operation for open-use.
  - PFS development: PFI was delivered to Hawaii. on-telescope engineering run using PFI, Cable B1, SM1, and MCS was done in September. First end-to-end on-sky test observation was done in November.
  - Laser guide star system refurbishment continues.
- Telescope
  - The telescope control software (TSC) was upgraded.
- Dome & Summit Facility
  - UPS replacement was done in July – August.
  - Top Screen overhaul was done in December.
- Full remote observation project continues.
- Subaru2 was approved as a frontier science project of MEXT
- International partnership process was regrettably suspended due to COVID-19.

New members since 3/2021

Yutaka Hayano
Head of Engineering &
Vice Director

Akira Arai
Support Astronomer

Jennifer Bragg
Research Intern

Wilfred Gee
Research Intern

Tomoyuki Furuhata
Administration Chief

Kumiko Usuda-Sato
Outreach Specialist

Jonathan Laverty
Night Operator

Koichi Sawatari
Telescope Engineer

New members since 3/2021

Teiji Chiba
Day Crew

Erin Dailey
Night Operator

Ken Hirano
Engineer

Terry Henninger
Day Crew

Raymond Adams
Day Crew

Michael Kerns
Day Crew

New members since 3/2021

- Yuki Moritani (PFS Assistant Professor) @Mitaka
- Naoki Kobayakawa (Senior Specialist) @Mitaka
- Ken Mawatari (Project Research Staff) @Mitaka
- Miyuki Sai (Administrative Supporter) @Mitaka
- Ken Wong (Project Research Staff) @Mitaka
- Chihiro Tokoku (Senior Specialist) @Mitaka
- Shizuka Nakajima (Research Supporter) @Mitaka

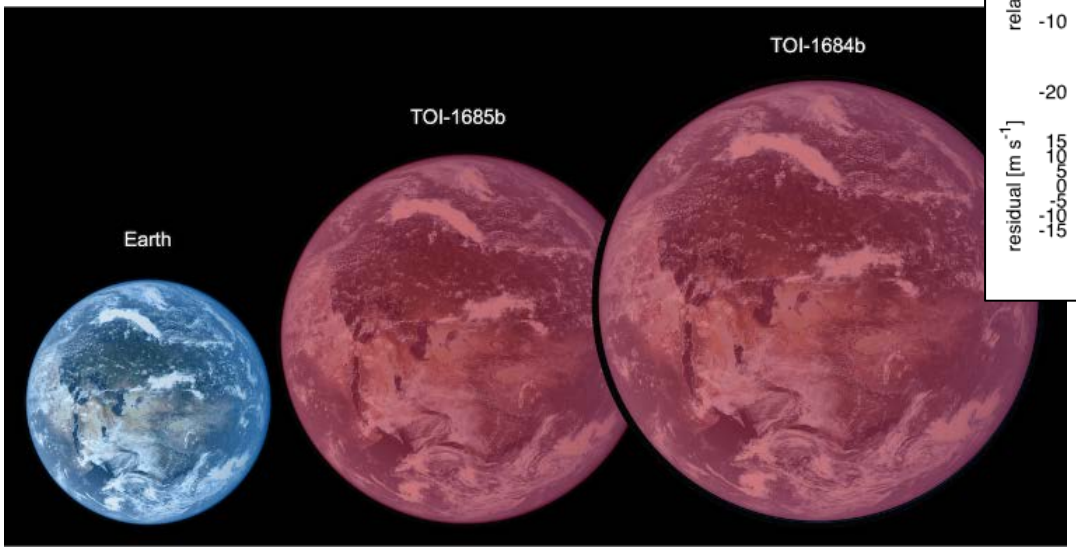
People left from Hilo since 3/2021

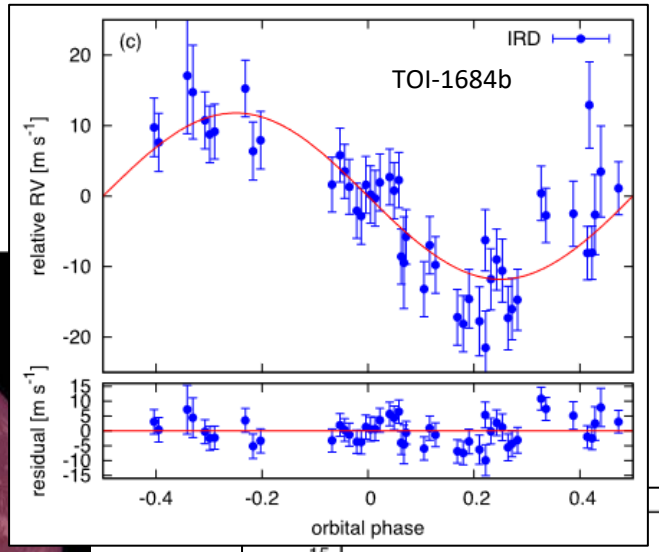
- Marita Morris (Night Operator) → Keck
- Hideaki Fujiwara (Outreach Specialist) → Tohoku University
- Robin Spencer (Day Crew) → Retirement
- Dex Alpiche (Day Crew) → Private company
- Christophe Clergeon (AO Scientist) → Gemini
- Philip Tait (Instrument Software Engineer) → Retirement
- Tetsuo Nishimura (Advisor) → Retirement
- Matthew Wahl (Night Operator) → Keck
- Yoji Seto (Administration Chief) → Mitaka

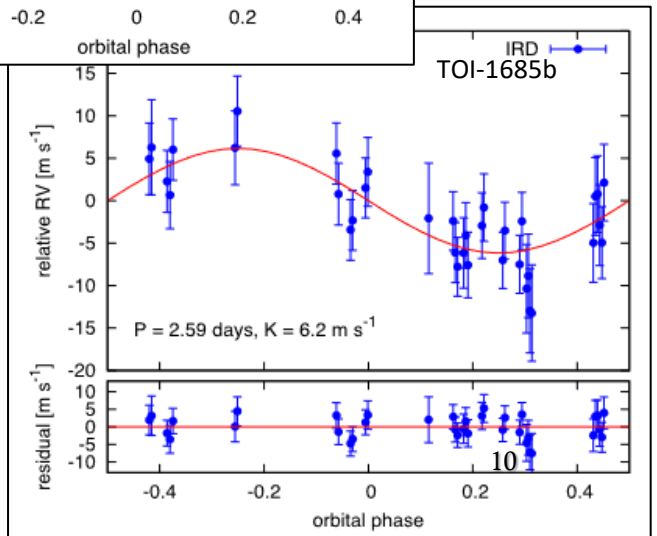
Science

"Bare" Super-Earths Offer Clues to Evolution of Hot Atmospheres (Hirano, T. et al. 2021)

Two rocky super-Earth exoplanets lacking thick primordial atmospheres in very close orbits around two different red dwarf stars were discovered by series of observations with Subaru IRD, TESS and other instruments. These planets provide a chance to investigate the evolution of the atmospheres of hot rocky planets.

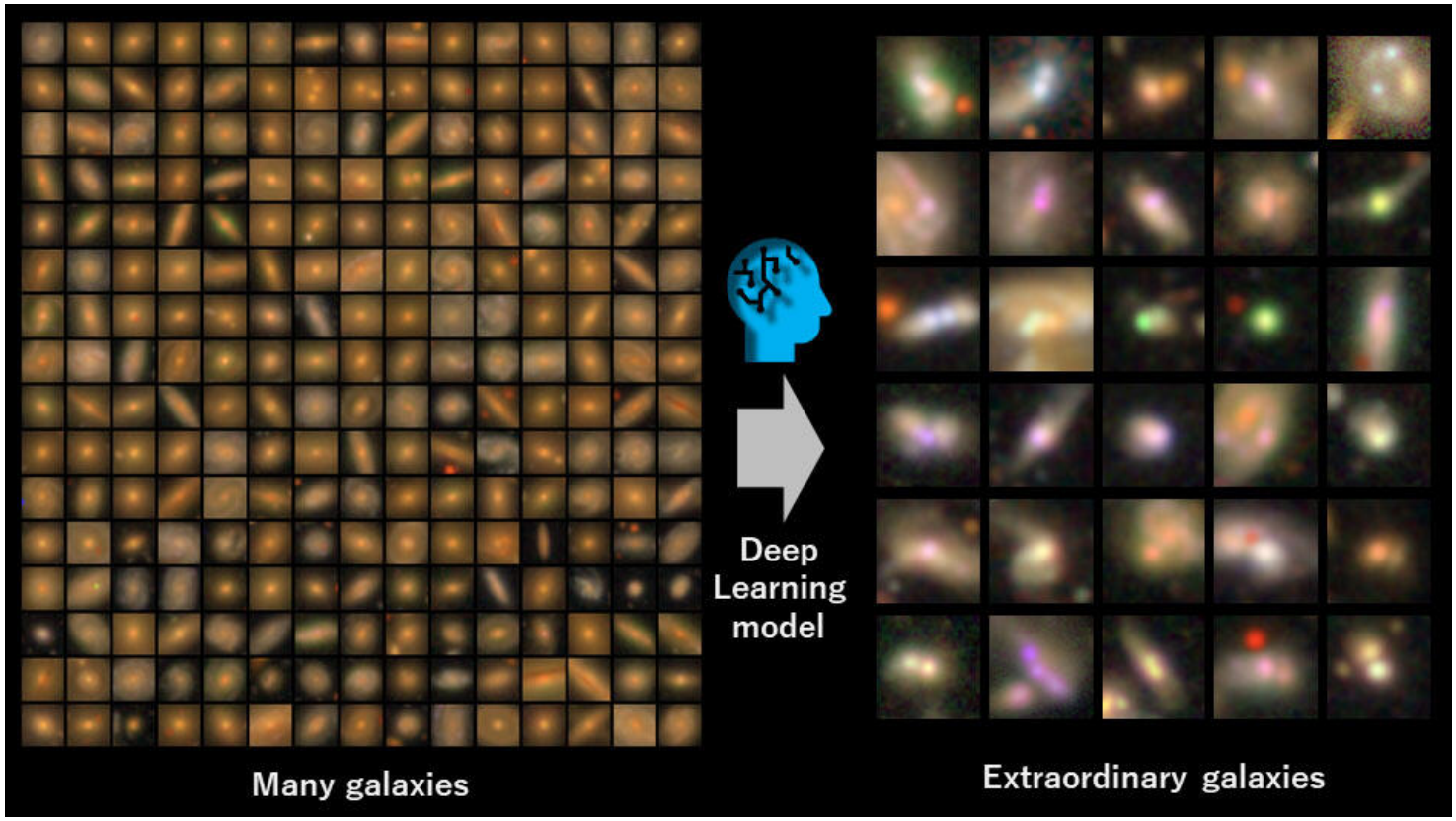






Artificial Intelligence "Swimming" in Big Data from the Subaru Telescope (Tanaka et al. 2021)

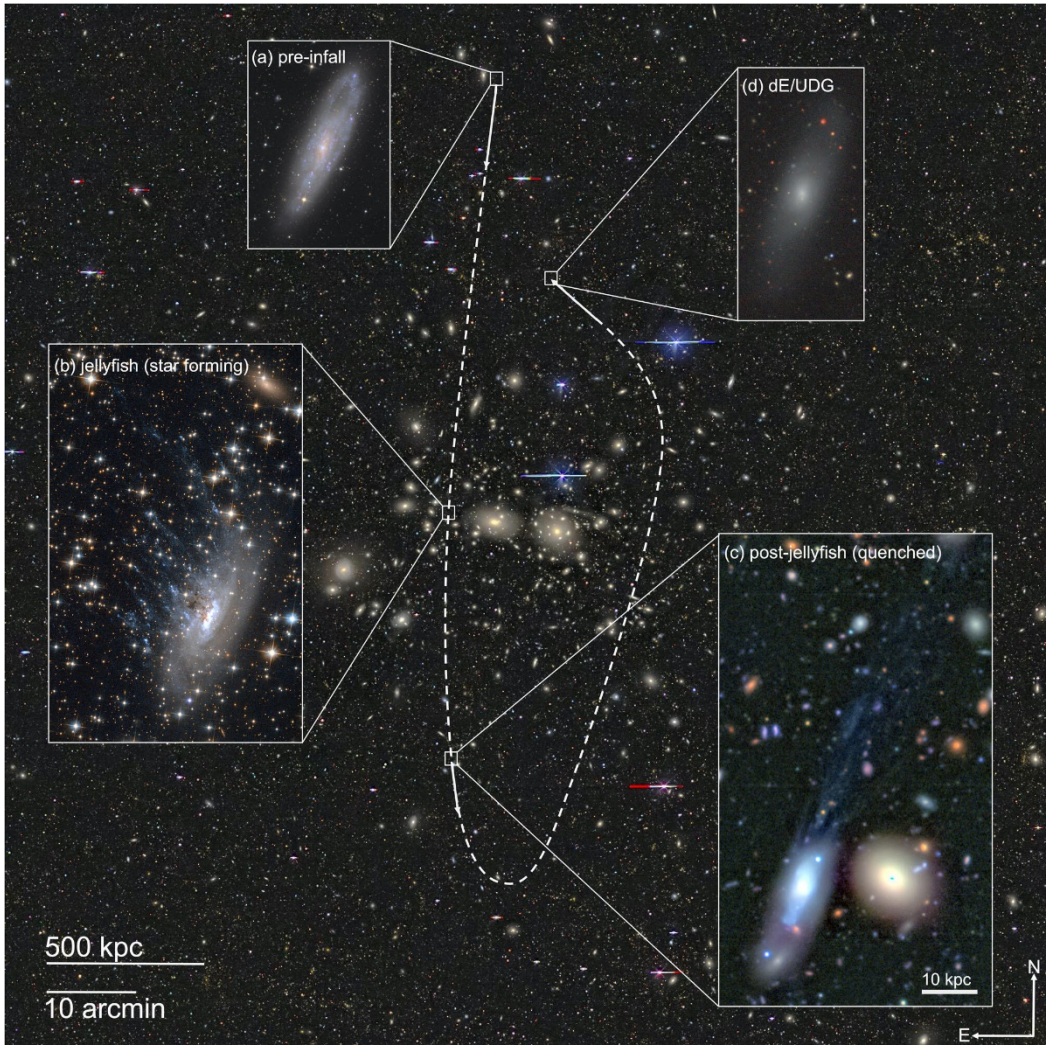
A new program called SWIMMY, applying artificial intelligence to astronomical Big Data, has proven its ability to find interesting galaxies for follow-up study. SWIMMY has the advantage that rather than needing to be taught to identity unusual galaxies, it starts with the assumption that all galaxies are normal and flags ones that it can model correctly. This means it has the potential to find unique examples that the astronomers don't yet know about, the so called "unknown unknowns." SWIMMY will help process Big Data coming out of the Subaru Telescope and other survey programs.



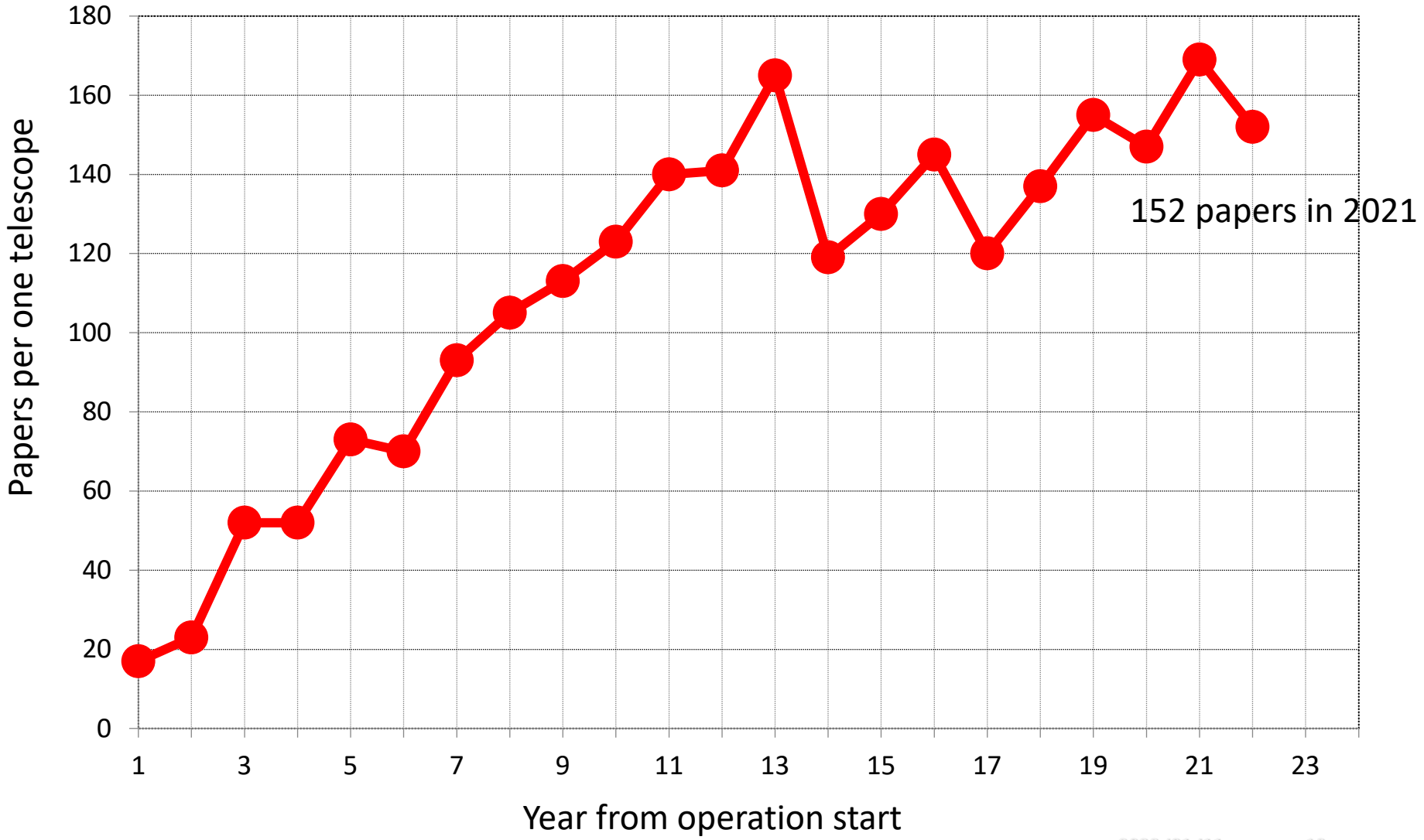
Tails Tell the Tale of Galaxy Evolution

(Grishin et al. 2021)

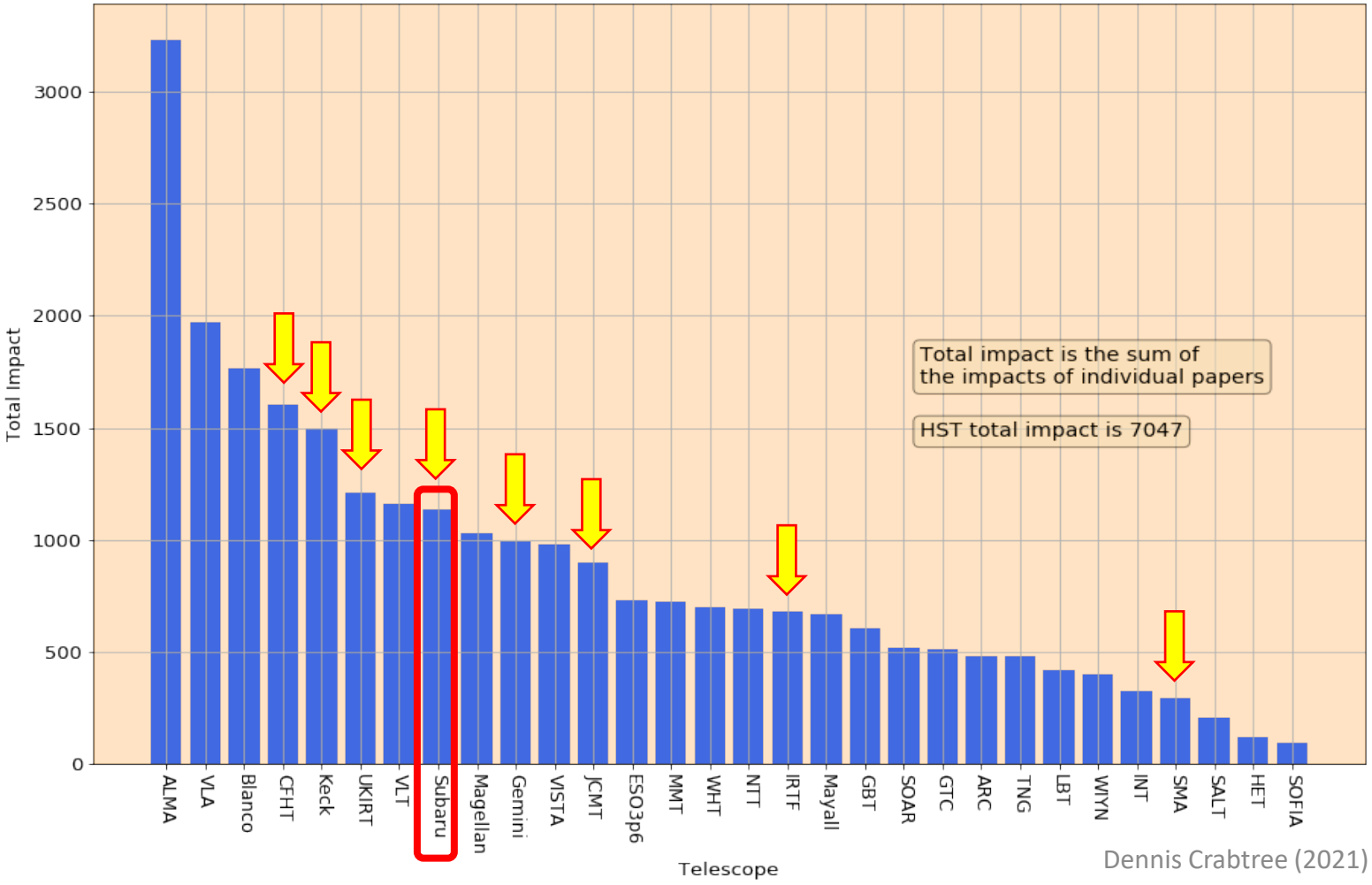
Many tails of gas and/or stars trailing behind a sample of young galaxies without current star formation were found in clusters of galaxies using Subaru HSC. Based on this result, the observation team concludes that about half of the ultra-diffuse galaxies in the Coma cluster are likely to have evolved through collisions with external gas. Ultra-diffuse galaxies together with similar dwarf elliptical galaxies account for about 80% of the members of galaxy clusters, so understanding their evolution is an important part of modeling the evolution of the Universe.



Number of Publications



Total impact per telescope 2015 - 2019



Dennis Crabtree (2021)

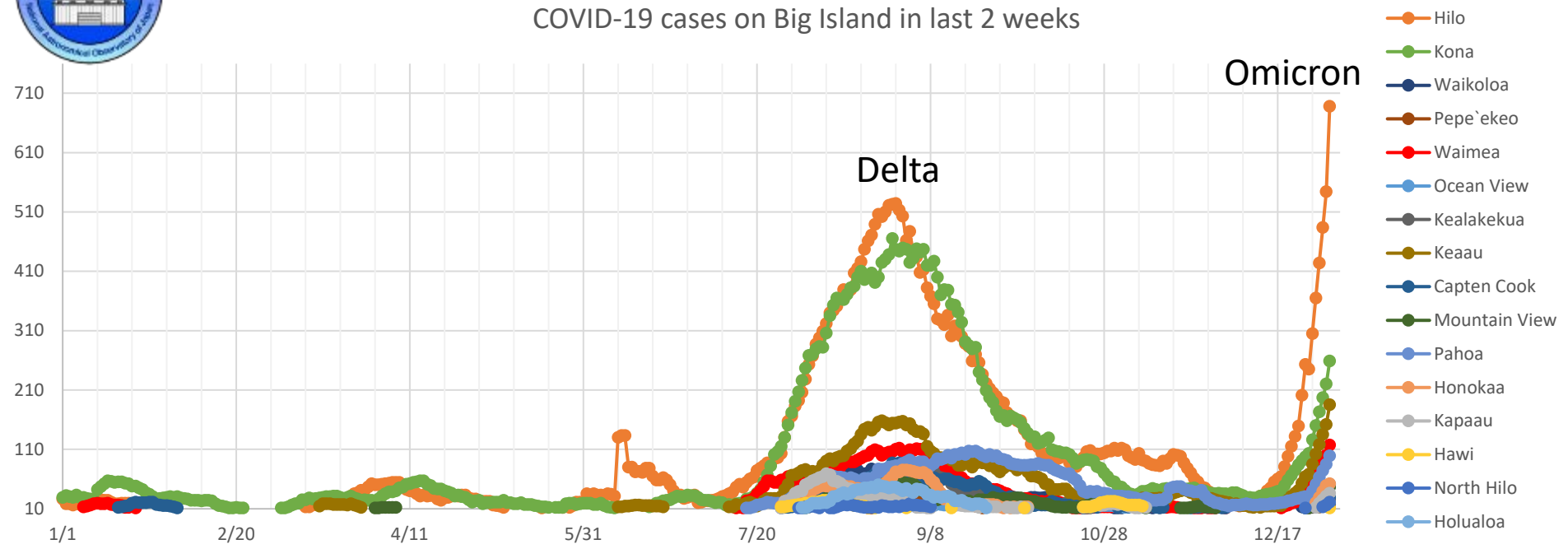
Subaru Press/Web Release 2021

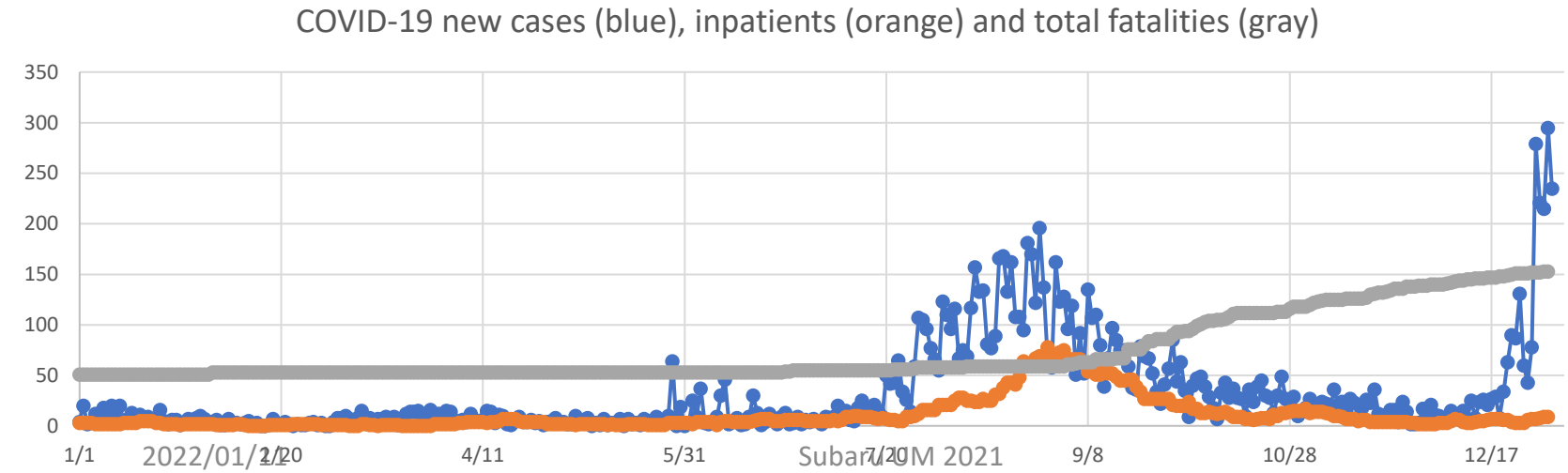
1. Record Breaking Distant Solar-System Object (Feb. 10)
2. Flipped-Over Exoplanets Prove New Disk-Tilt Mechanism (Feb. 15)
3. Exploring Comet Thermal History: Burnt-out Comet Covered with Talcum Powder (Apr. 5)
4. Subaru Telescope Observes Farthest Gamma-ray Emitting Active Galaxy (Apr. 22)
5. Astronomers Detect New Chemical Signature in an Exoplanet's Atmosphere using Subaru Telescope (Apr. 26)
6. Observation, Simulation, and AI Join Forces to Reveal a Clear Universe (July 1)
7. Small Amount of Lithium Production in Classical Nova (July 6)
8. "Bare" Super-Earths Offer Clues to Evolution of Hot Atmospheres (Sep. 26)
9. Orphan Cloud in a Cluster of Galaxies (Oct. 6)
10. New Research Links the Compositions of Rocky Exoplanets and those of their Host Stars (Oct. 14)
11. Infant Planet Discovered using Maunakea Telescopes (Oct. 22)
12. Superstructure Harboring Forming Massive Galaxies Found in Distant Beacons of Light in the Sub-millimeter Sky (Oct. 26)
13. Artificial Intelligence "Swimming" in Big Data from the Subaru Telescope (Nov. 23)
14. Tails Tell the Tale of Galaxy Evolution (Dec. 5)
15. Discovery of a Hundred New Free-Floating Planets Roaming Our Galaxy (Dec. 22)

Solar system Exoplanets Stars Galaxies Cosmology

Telescope operation & Open Use

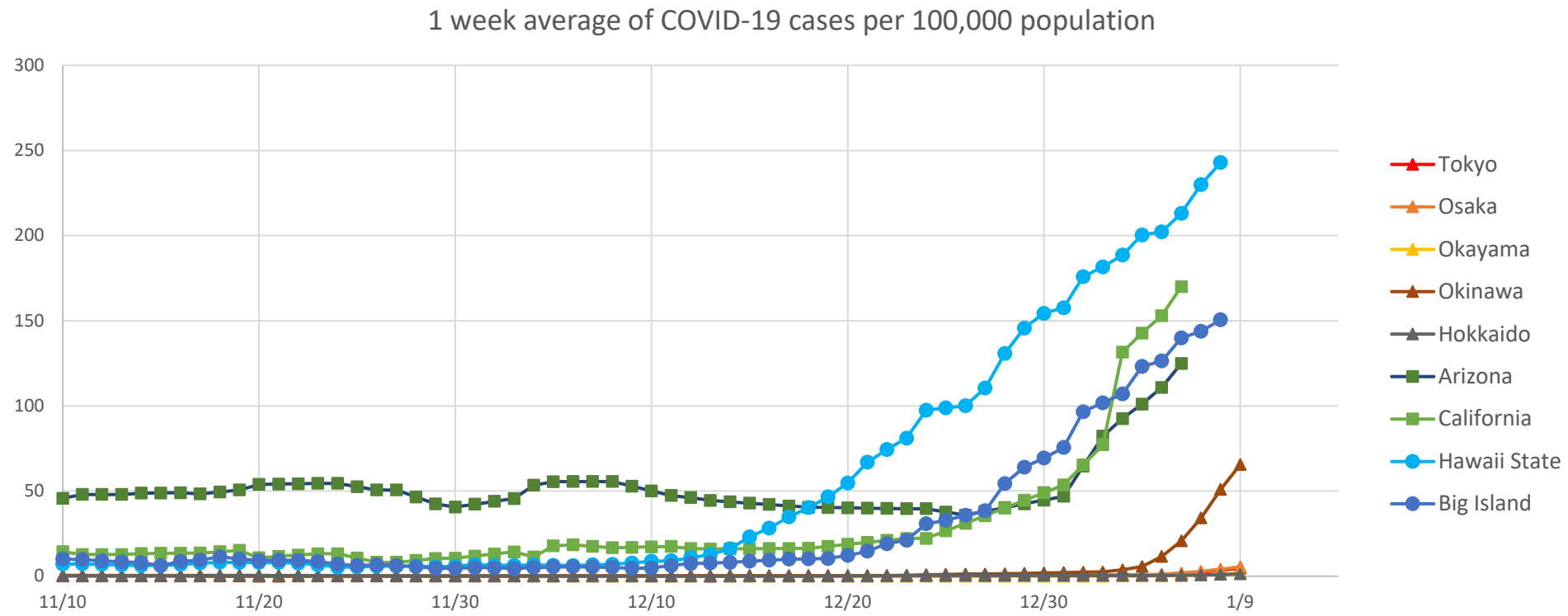
Situation on the Big Island in 2021





Recent COVID-19 Situation

- The situation is very bad. The number of infections is still rapidly increasing in Hawaii.

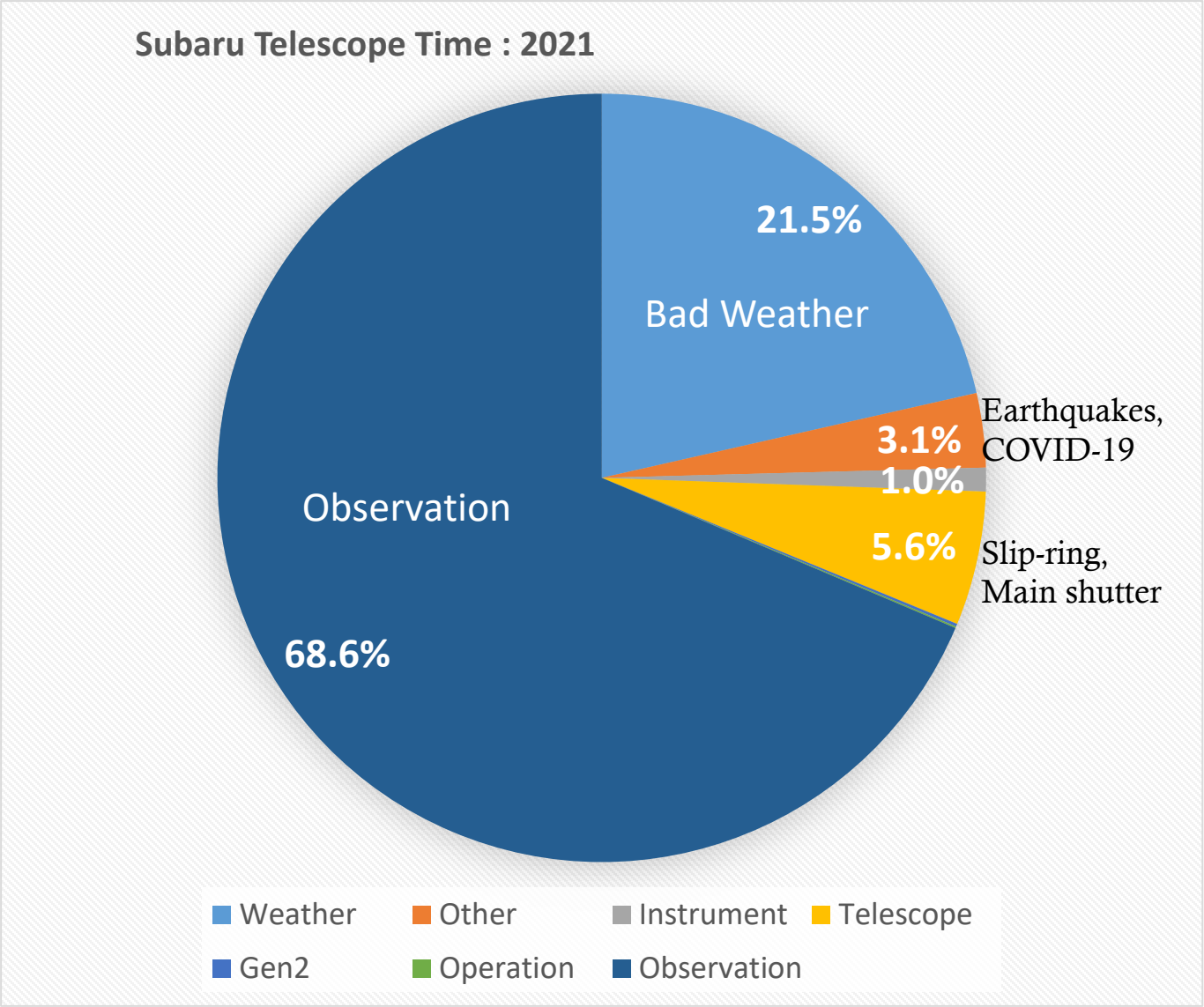


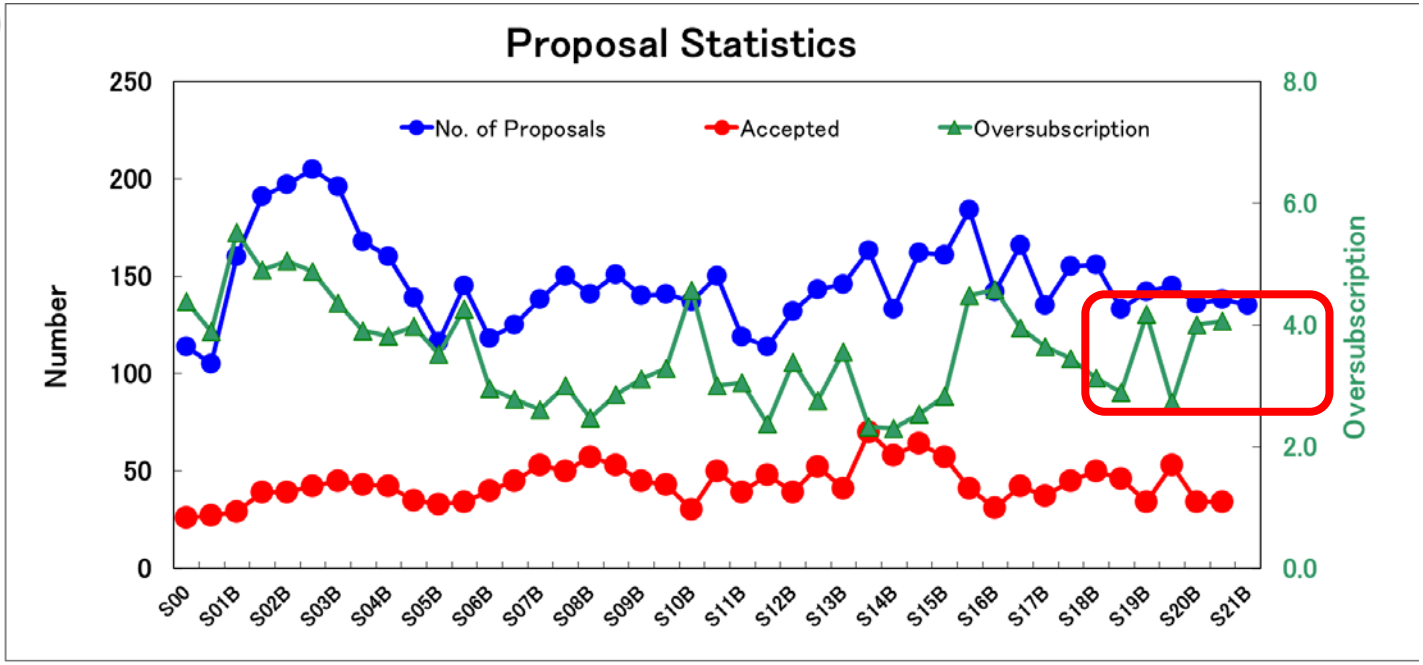
- Some employees of Subaru Telescope were found to be COVID-19 positive last week. They did not get severe disease. We asked them and close contact persons to them to do self-quarantine immediately. So far, further wide spread of cases has not been observed inside Subaru.
- The vaccine will protect people from severe illness due to COVID-19. We strongly recommend our employees to get the “booster shot” of COVID-19 vaccine ASAP.

Subaru Telescope Policy

- We continue the following COVID-19 countermeasure policy (Guideline Rev.14 issued on Jan.10, 2021).
  - The maximum number of people working in the summit facility is 20.
  - The maximum number of people in a meeting room at Hilo Base is 10.
  - The number of people per vehicle is limited to 4.
  - Telework is recommended.

Telescope Time Statistics in 2021




Proposal Statistics
No. of Proposals
Accepted
Oversubscription
Number
Oversubscription
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200
150
100
50
0
8.0
6.0
4.0
2.0
0.0
S00
S01B
S02B
S03B
S04B
S05B
S06B
S07B
S08B
S09B
S10B
S11B
S12B
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S16B
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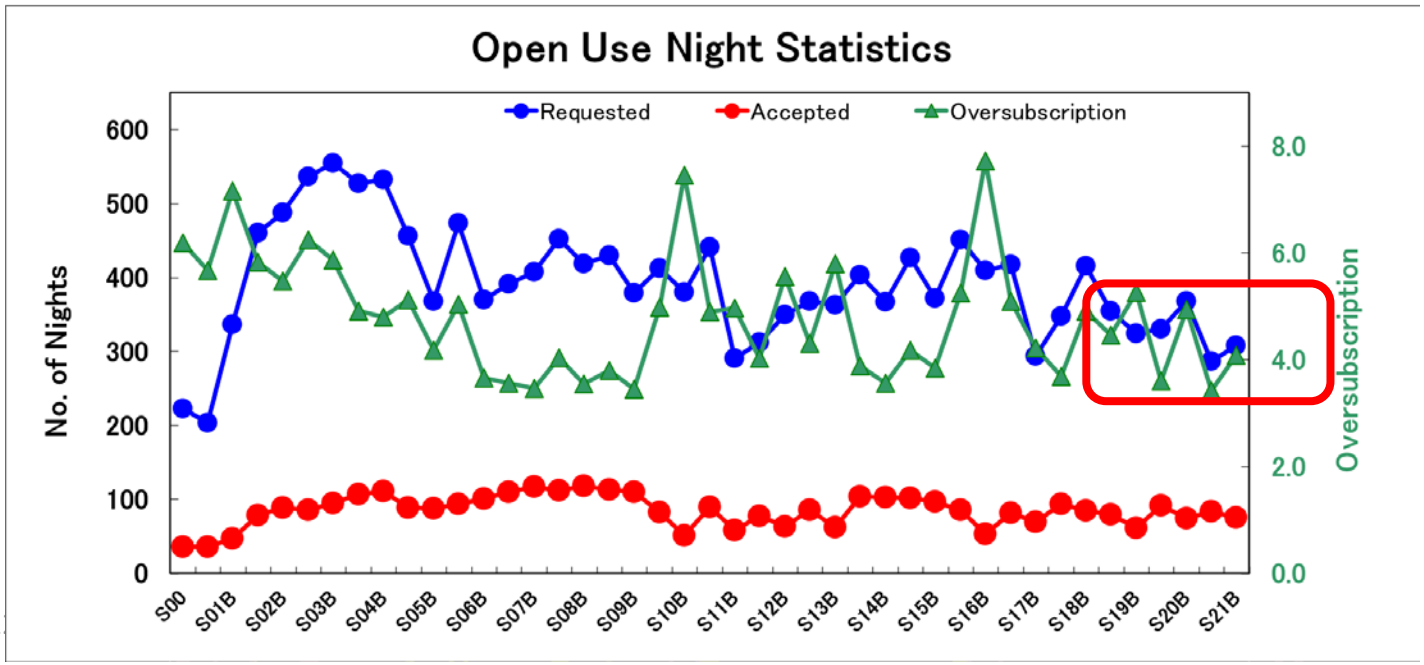
S18B
S19B
S20B
S21B


Open Use Night Statistics
Requested
Accepted
Oversubscription
No. of Nights
Oversubscription
600
500
400
300
200
100
0
8.0
6.0
4.0
2.0
0.0
S00
S01B
S02B
S03B
S04B
S05B
S06B
S07B
S08B
S09B
S10B
S11B
S12B
S13B
S14B
S15B
S16B
S17B
S18B
S19B
S20B
S21B

Subaru Strategic Programs

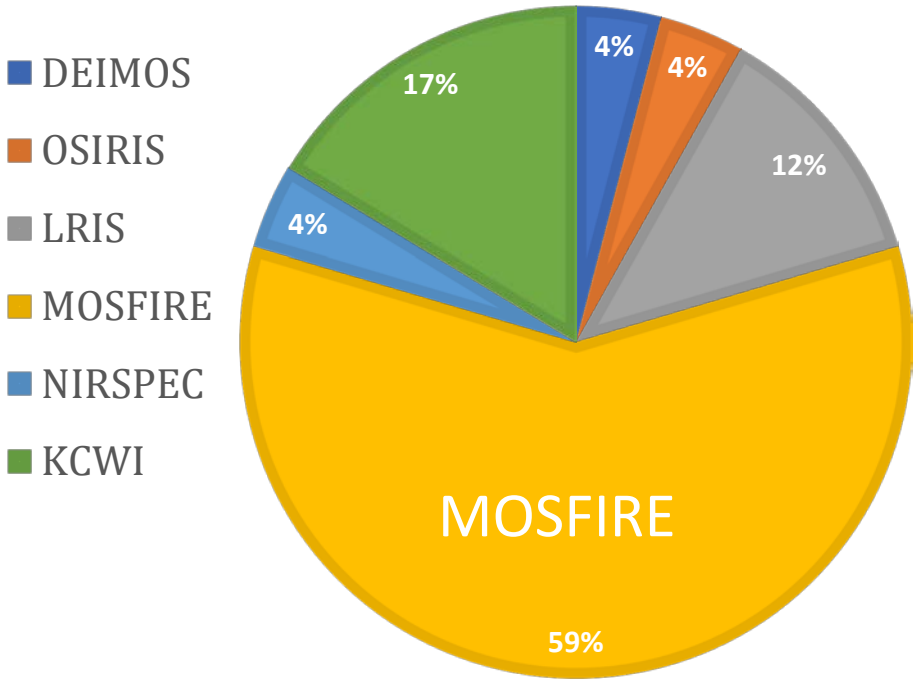
- Exceptionally large project using unique/expedient instruments of Subaru Telescope
- HSC SSP (2014 - 2021)　300+30 nights　completed
  - “Wide-field imaging with **Hyper Suprime-Cam**: Cosmology and Galaxy Evolution”
  - 3rd Public Data Release on August 13, 2021.
- IRD SSP (2019 - 2025)　175 nights　ongoing
  - “Search for Planets like Earth around Late-M Dwarfs: Precise Radial Velocity Survey with **IRD**”
- PFS SSP (2023 - 2027?)　360 nights　in preparation
  - Cosmology, galaxy evolution, and galaxy archaeology

Time exchange

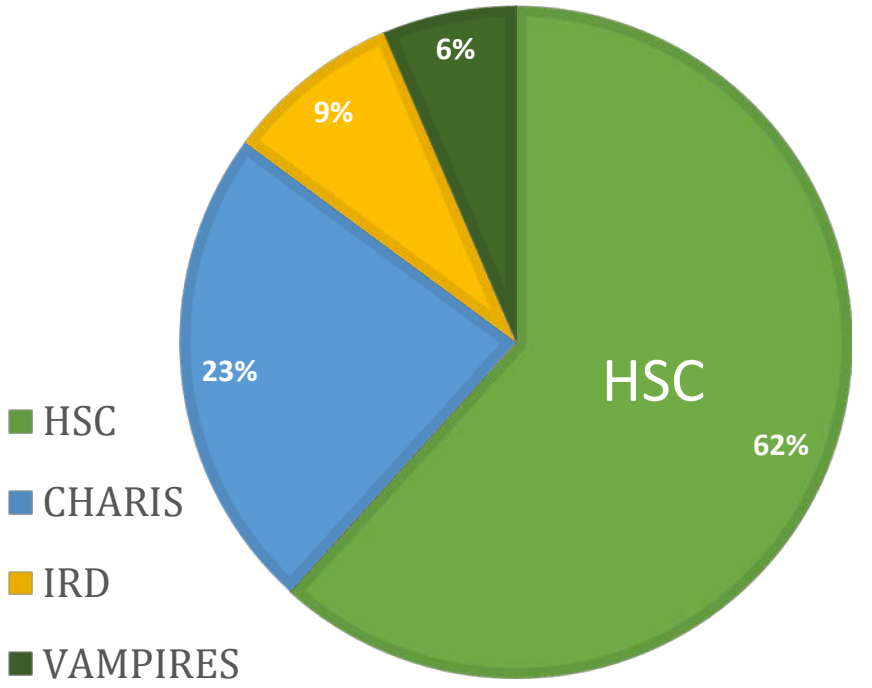
Subaru-Keck exchange

We exchanged 7.5n (S20A), 4.0n (S20B), 5.0n (S21A), 8.0n (S21B) with Keck.

Subaru → Keck
(approved in S20A/S20B/S21A/S21B)



Keck → Subaru
(approved in S20A/S20B/S21A/S21B)

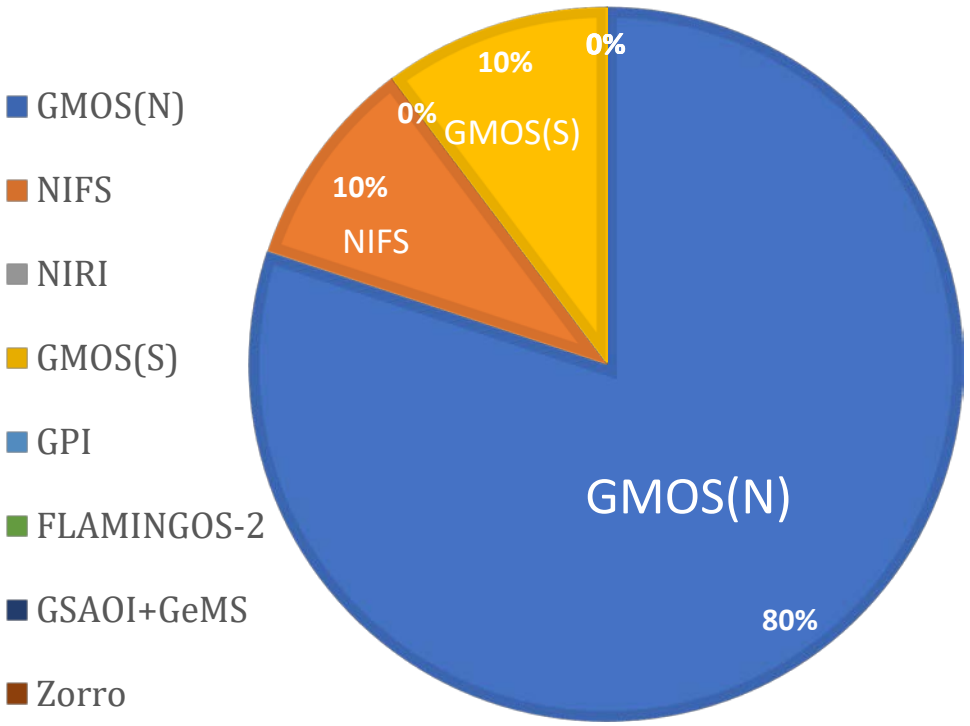


Subaru-Gemini exchange

Subaru → Gemini

(**approved** in S20A/S20B/S21A/S21B)

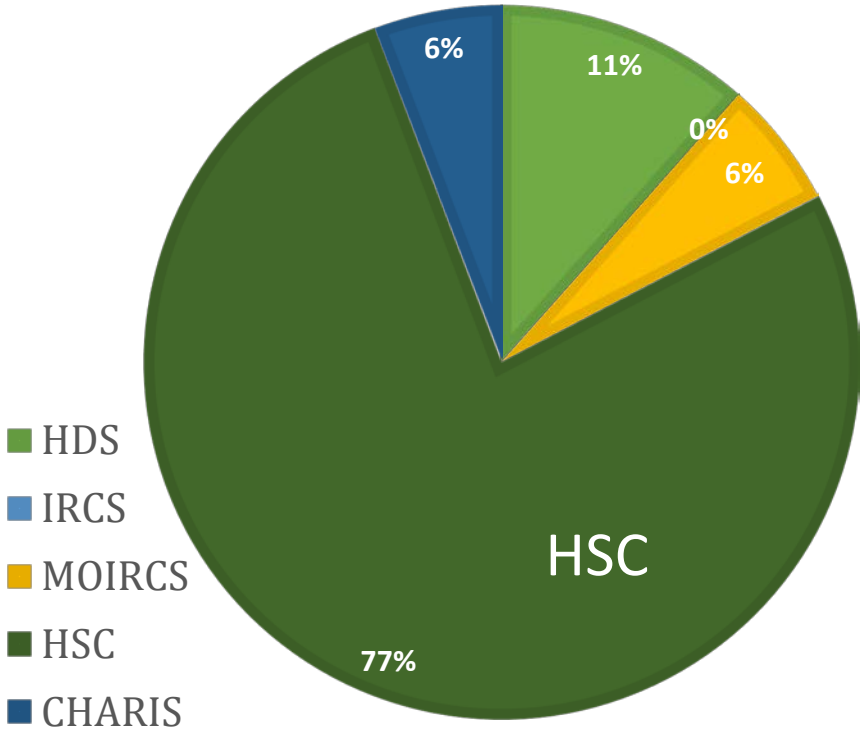
N (approved) = 3.5 /semester
N (approved nights) = 3.9 n/semester



Gemini → Subaru

(**approved** in S20A/S20B/S21A/S21B)

N (approved) = 3.3 /semester
N (approved nights) = 4.3 n /semester



 # Note: Subaru →Gemini FT request is not included.

Instrumentation & Maintenance

Instrument Suit of Subaru

➔ Hattori's talk

Optical
Near-Infrared
AO

- facility instruments
  - Hyper Suprime-Cam: HSC [Pr]
  - Faint Object Camera and Spectrograph: FOCAS [Cs]
  - High Dispersion Spectrograph: HDS [Ns]
  - Multi-Object Infrared Camera and Spectrograph: MOIRCS [Cs]
  - InfraRed camera and spectrograph: IRCS [Ns]
- visiting instruments
  - InfraRed Doppler: IRD [Coude]
  - Coronagraphic High Angular Resolution Imaging Spectrograph (CHARIS) [Ns]
  - Simultaneous-color Wide-field Infrared Multi-object Spectrograph (SWIMS) [Cs]
  - Subaru Coronagraphic Extreme Adaptive Optics: SCExAO [Ns]
- adaptive optics
  - Subaru 188-elements Adaptive Optics system: AO188 [Ns]

PFS (Prime Focus Spectrograph)

→ Tamura's talk

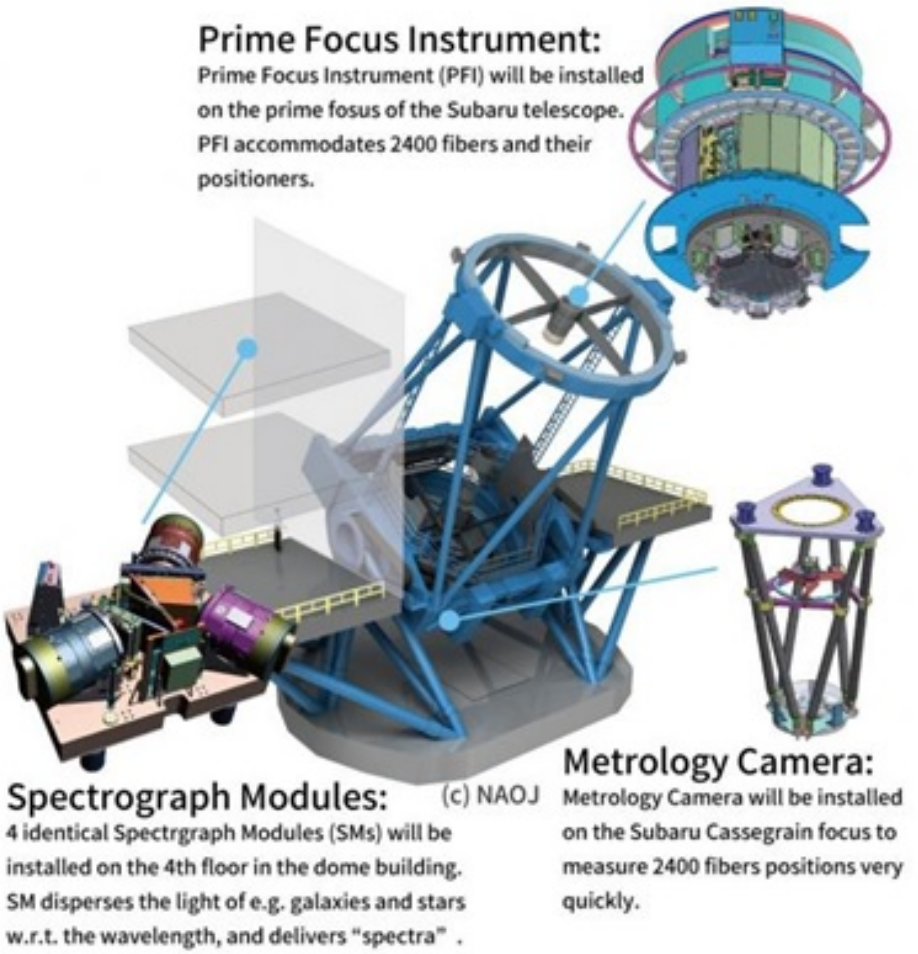
National Astronomical Observatory of Japan

(under development; science operation from 2023)

A fiber fed multi-object spectrograph attached to the prime focus of Subaru

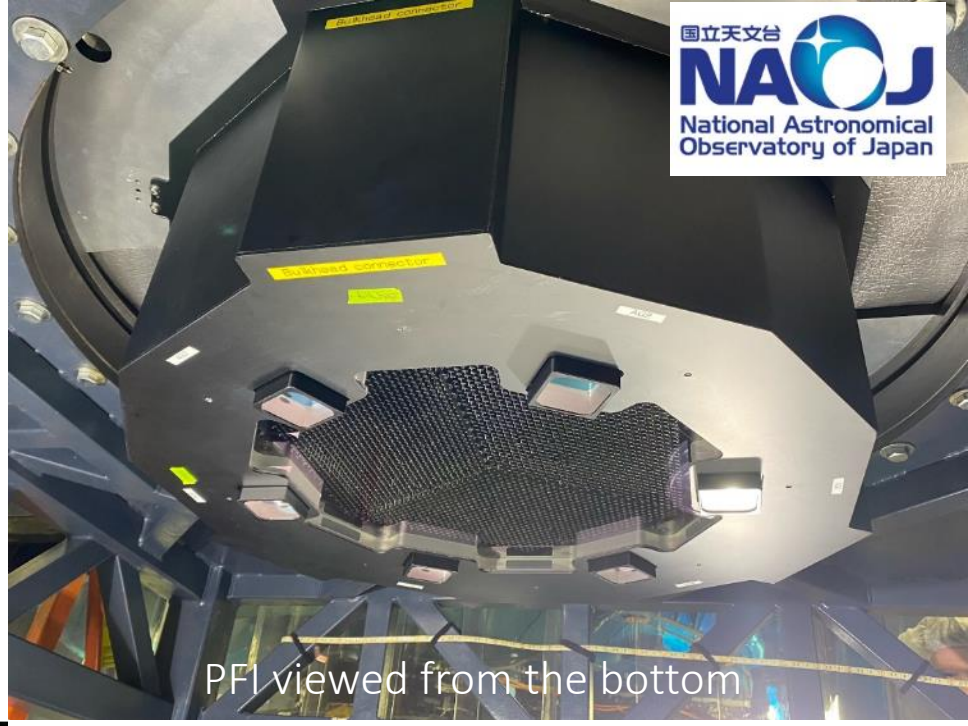
- 2,400 fibers FOV: 1.25 deg^2
- λ range: 0.38 – 1.26 μm
- Spec. R: 2,300 – 5,000

Band	magnitude
Blue (0.38 – 0.65 μm)	22.5
Red (0.65 – 0.97 μm)	22.4
NIR (0.97 – 1.26 μm)	21.4

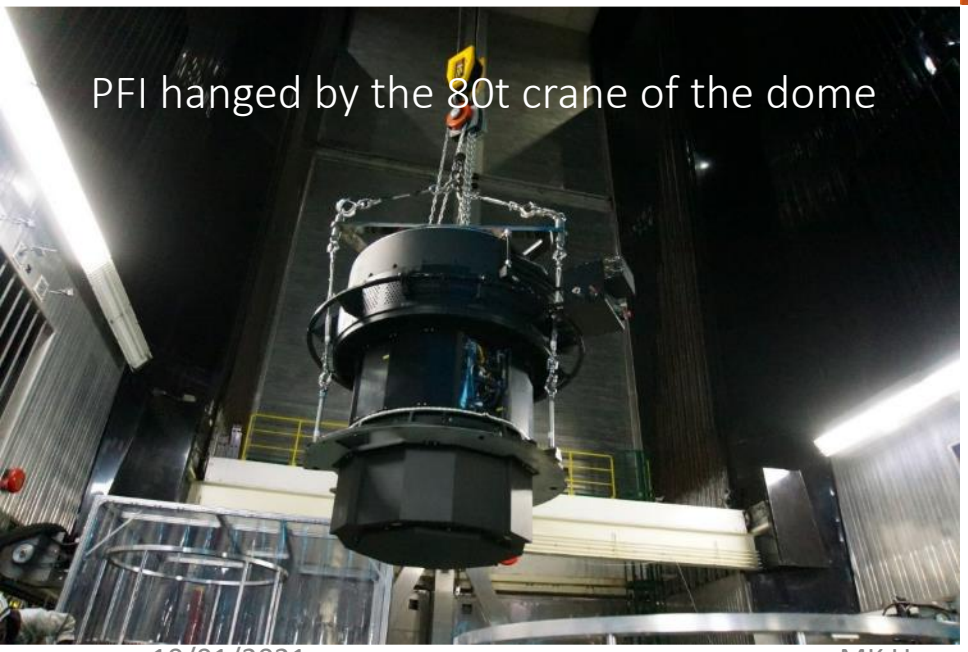


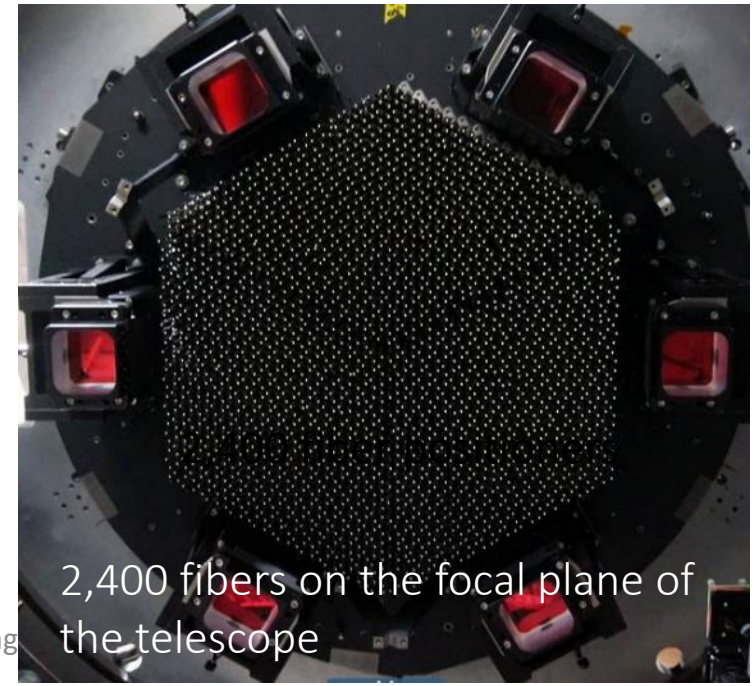
PFI Came to Subaru
(June 2021)

- PFI was mounted on the test stand in the clean booth inside the Subaru enclosure.
- The PFS team is doing AIT of PFI in the clean booth and on the telescope.

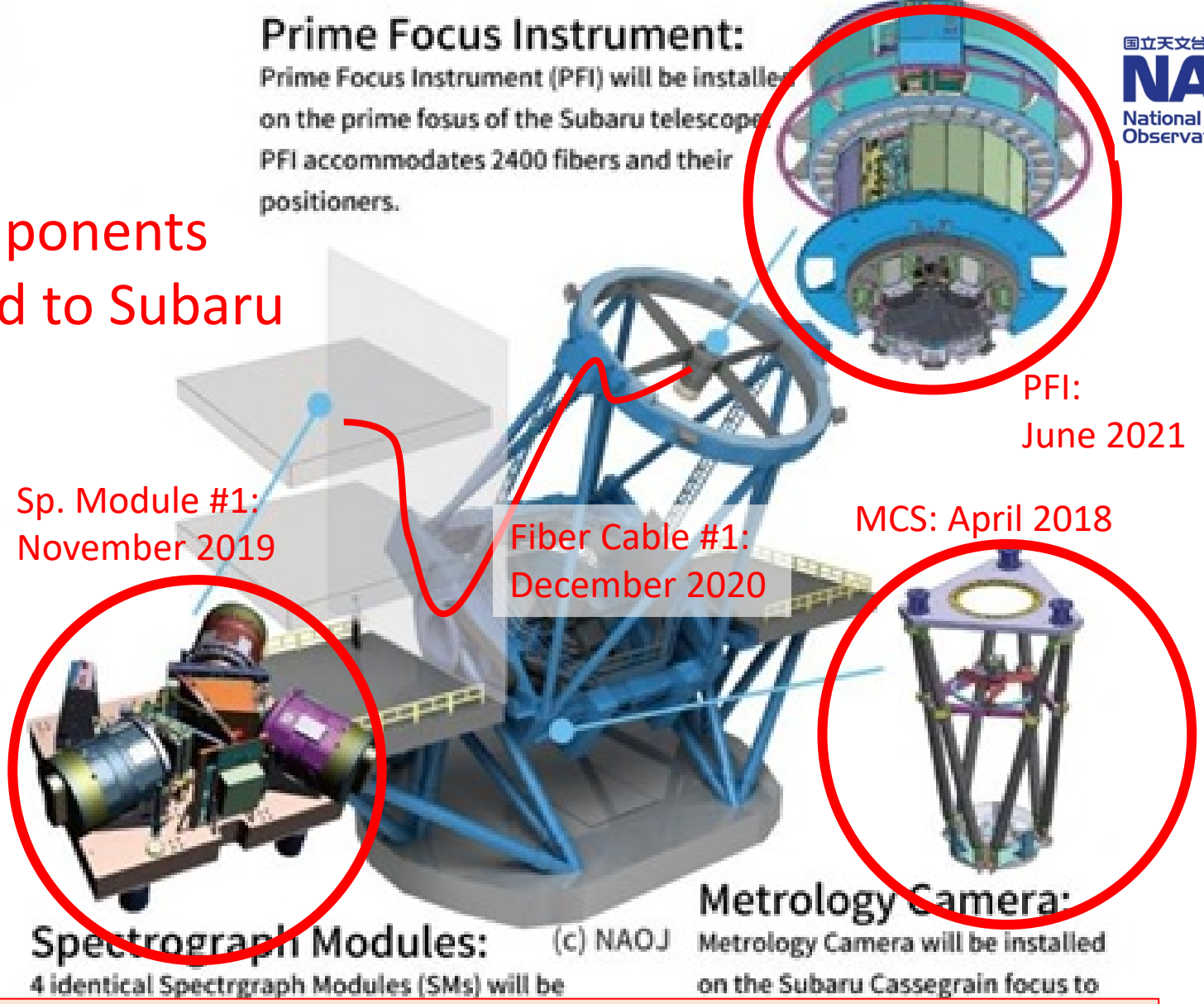


PFI viewed from the bottom


PFI hanged by the 80t crane of the dome


2,400 fibers on the focal plane of the telescope

PFS components delivered to Subaru



Four major components were delivered to Subaru.
On-sky engineering observation was done in November.

ULTIMATE-Subaru

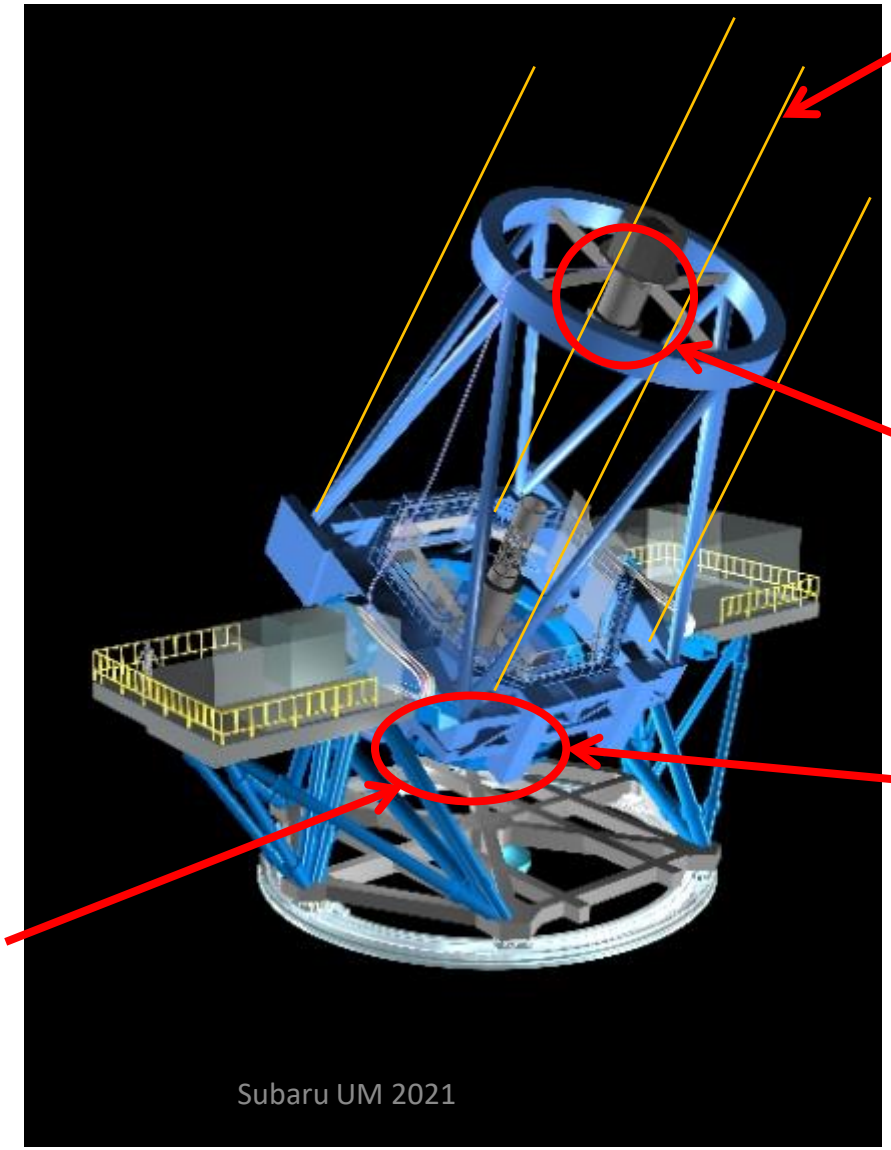
(preliminary design phase)

➔ Minowa's talk

Wide field near-infrared observation facility using ground layer adaptive optics (GLAO) system

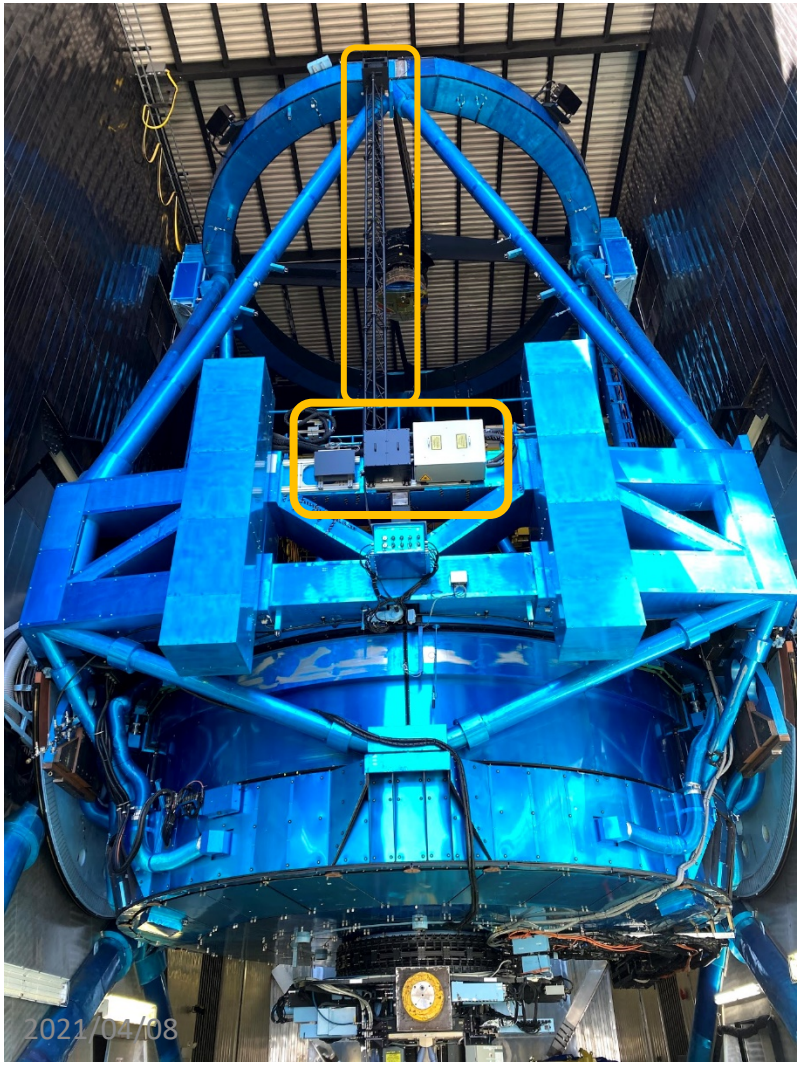
The instrument Conceptual Design Review was successfully done in June, 2021.

Science Operation: 2027



New Laser Guide Star System

The new laser system and a laser relay truss were installed to the telescope.
Optical alignment and commissioning runs are scheduled in this spring.



UPS replacement was completed!
(July & August, 2021)

- On 2021/08/11 16:44, Hirofumi Okita wrote:

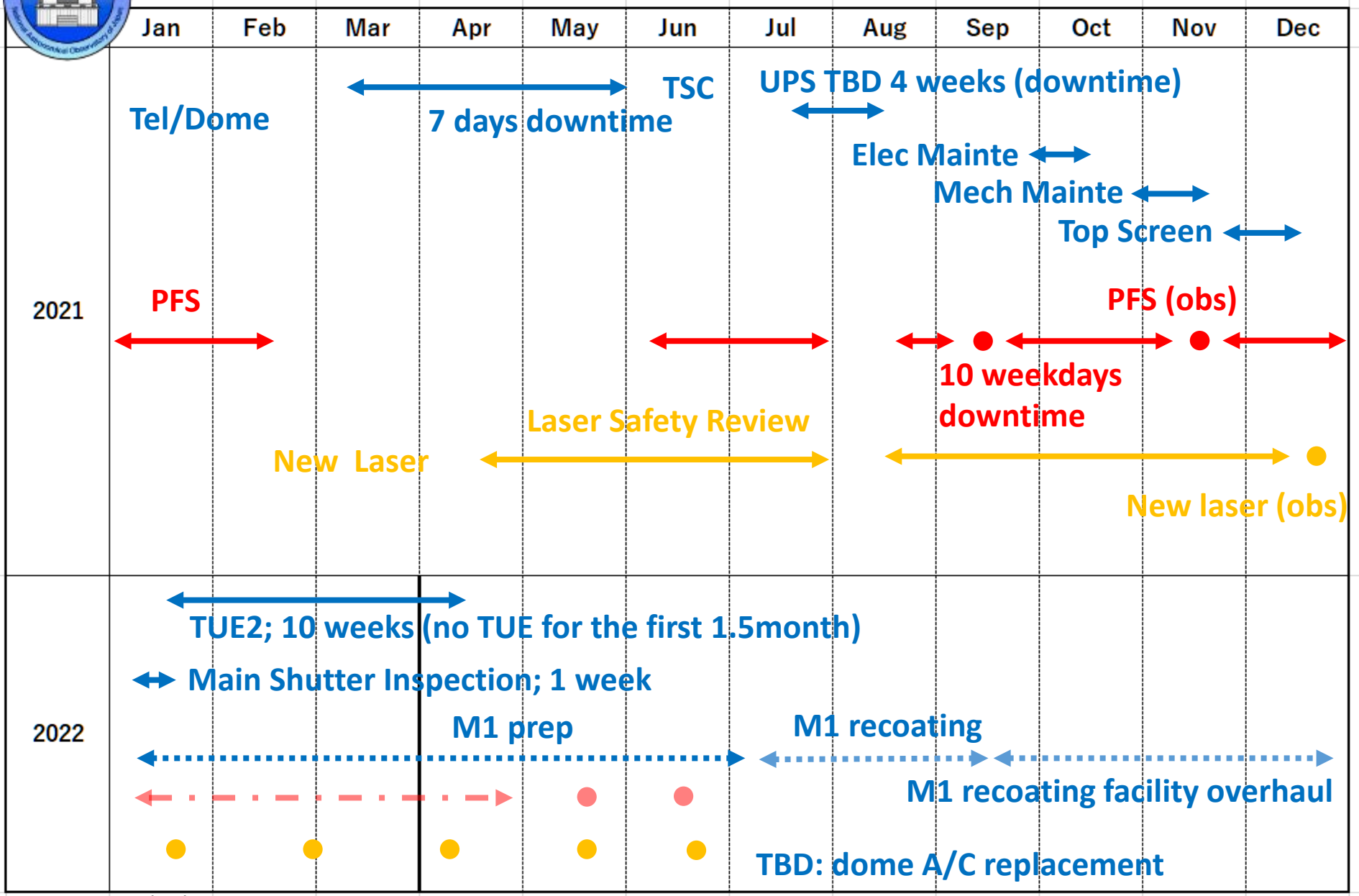
  Dear all,

  We have finished the telescope/instrument recovery work and we can resume observation from tonight, so far. DC2 is doing the precheck now.

  Thank you for your cooperation during the UPS downtime.

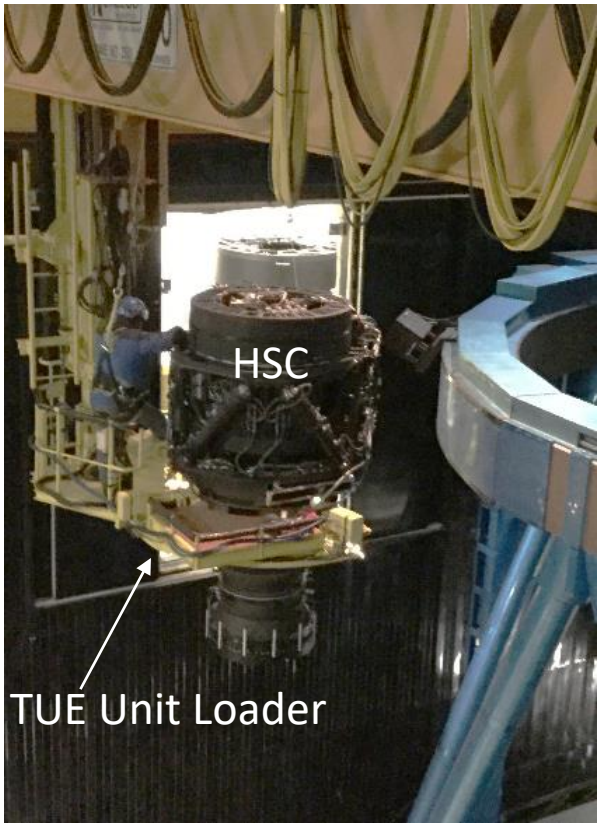
  Best regards,
  Hirofumi Okita

major summit work plan in 2021 & 2022



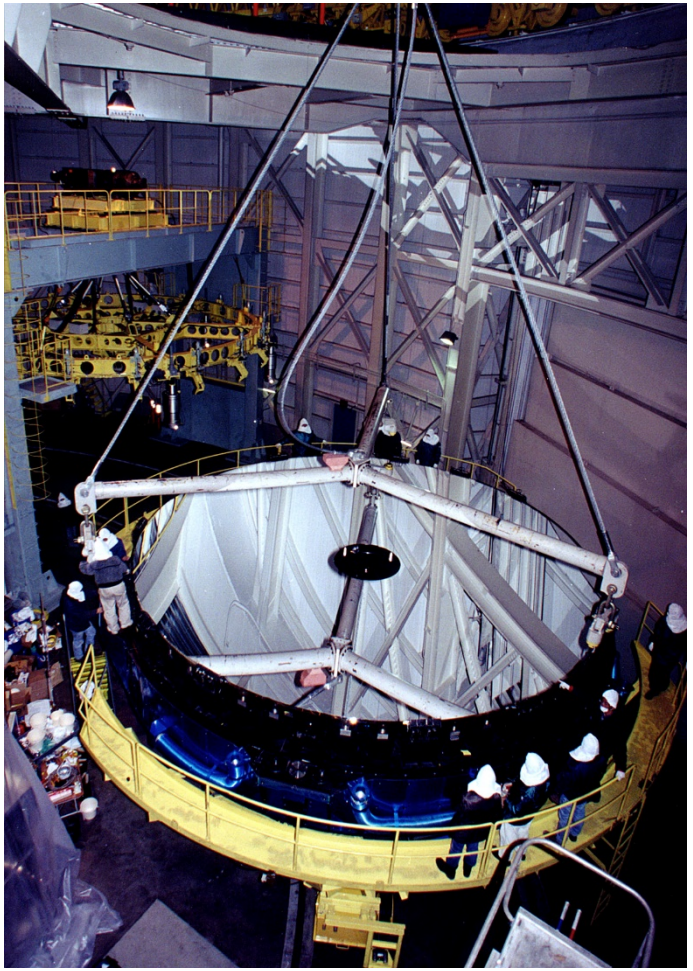
Big maintenance works in 2022

Top Unit Exchanger (TUE) overhaul (TUE2)



TUE is loading HSC to the prime focus.

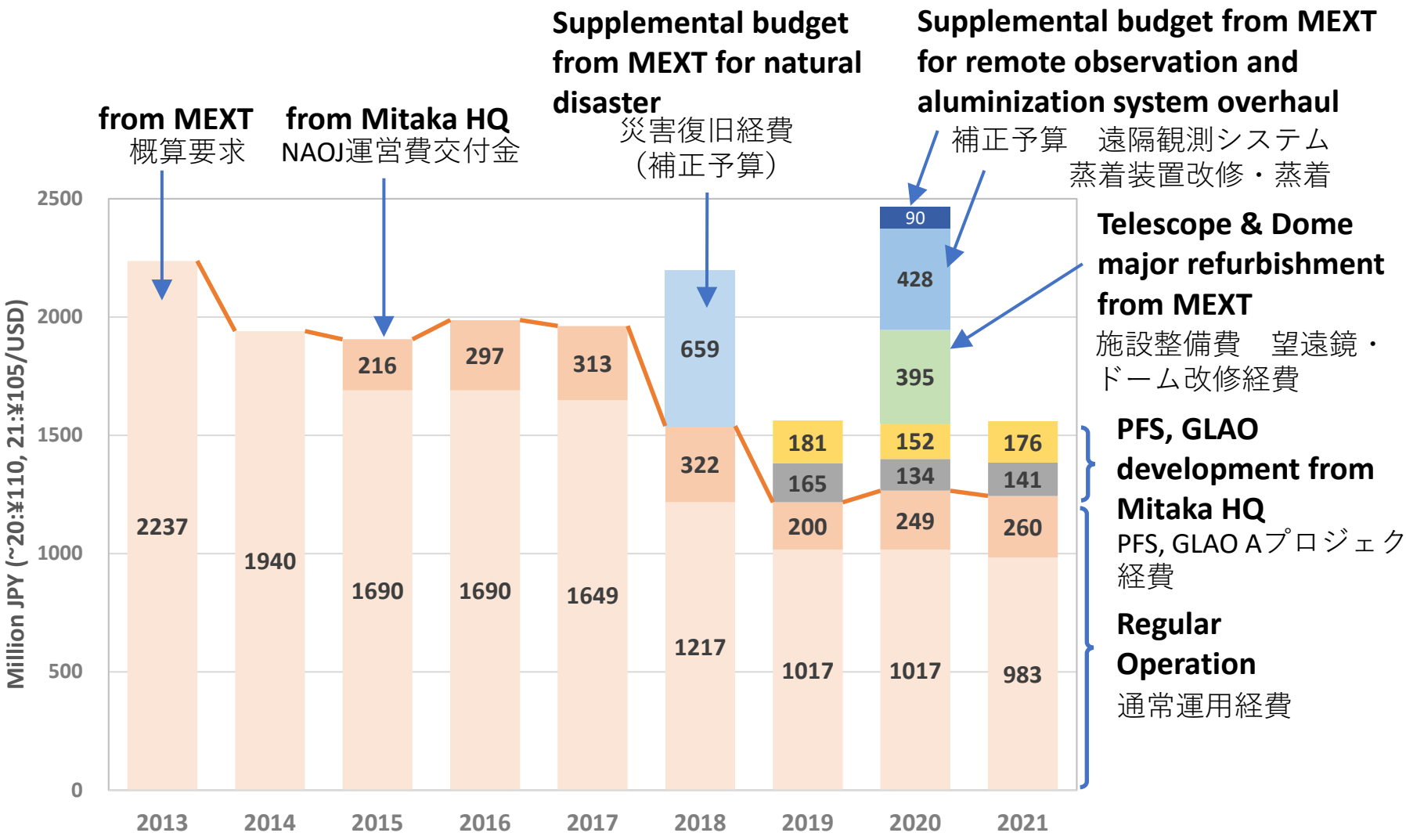
Primary Mirror Recoating



Financial Situation of Subaru

Subaru Telescope annual budget from FY2013 to FY2021

(Salary of NAOJ permanent staff is not included)

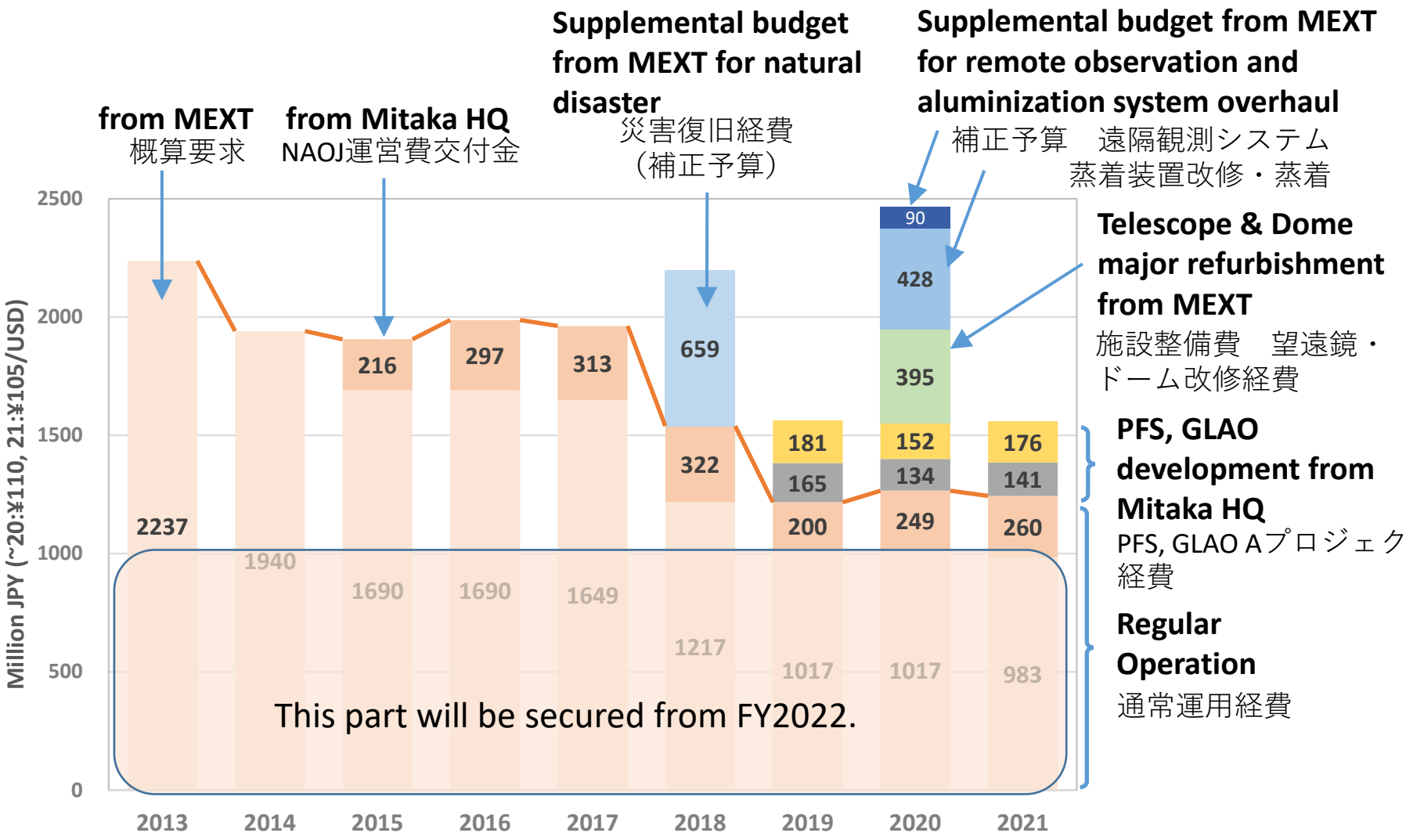


Good News

Subaru Telescope (with the “Subaru2” concept) was successfully selected as a large-scale science facility to be supported by “Frontier science project fund” of MEXT (Ministry of Education, Culture, Sports, Science and Technology, Japan) from 2022.

Subaru Telescope annual budget from FY2013 to FY2021

(Salary of NAOJ permanent staff is not included)



FY2021 supplemental budget (2021年度補正予算)

- Total of ~7 million USD (8 oku-yen)
  - $2.6 M (3 oku-yen) for GLAO development.
  - $4.3 M (5 oku-yen) for repair and refurbishment of the summit facility temperature control system (air conditioner, chiller, etc.) and the telescope control system.

- This budget can be used in FY2022 and FY2023.

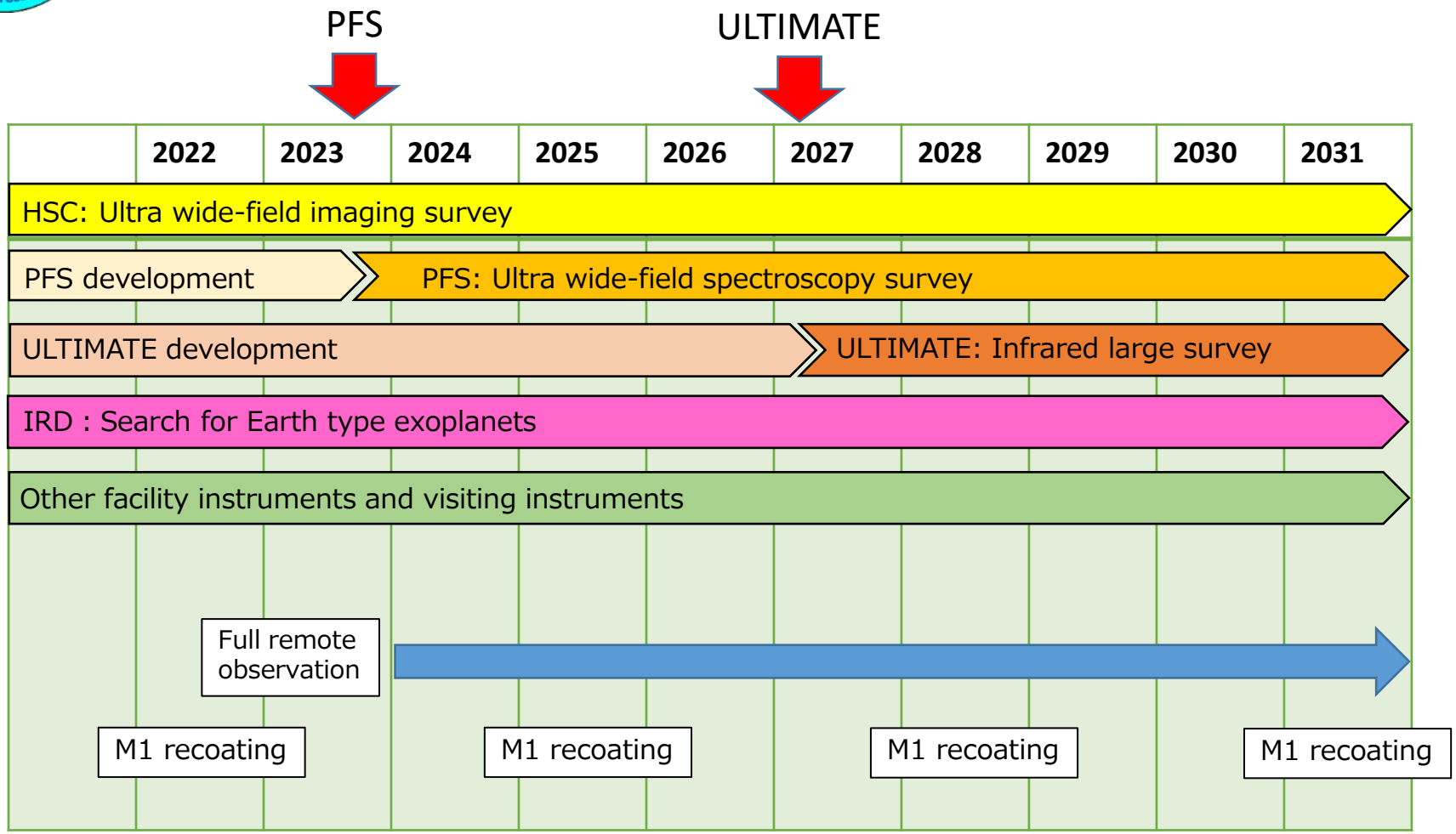
Subaru Future Plan

Subaru 2 Project (Subaru's future)

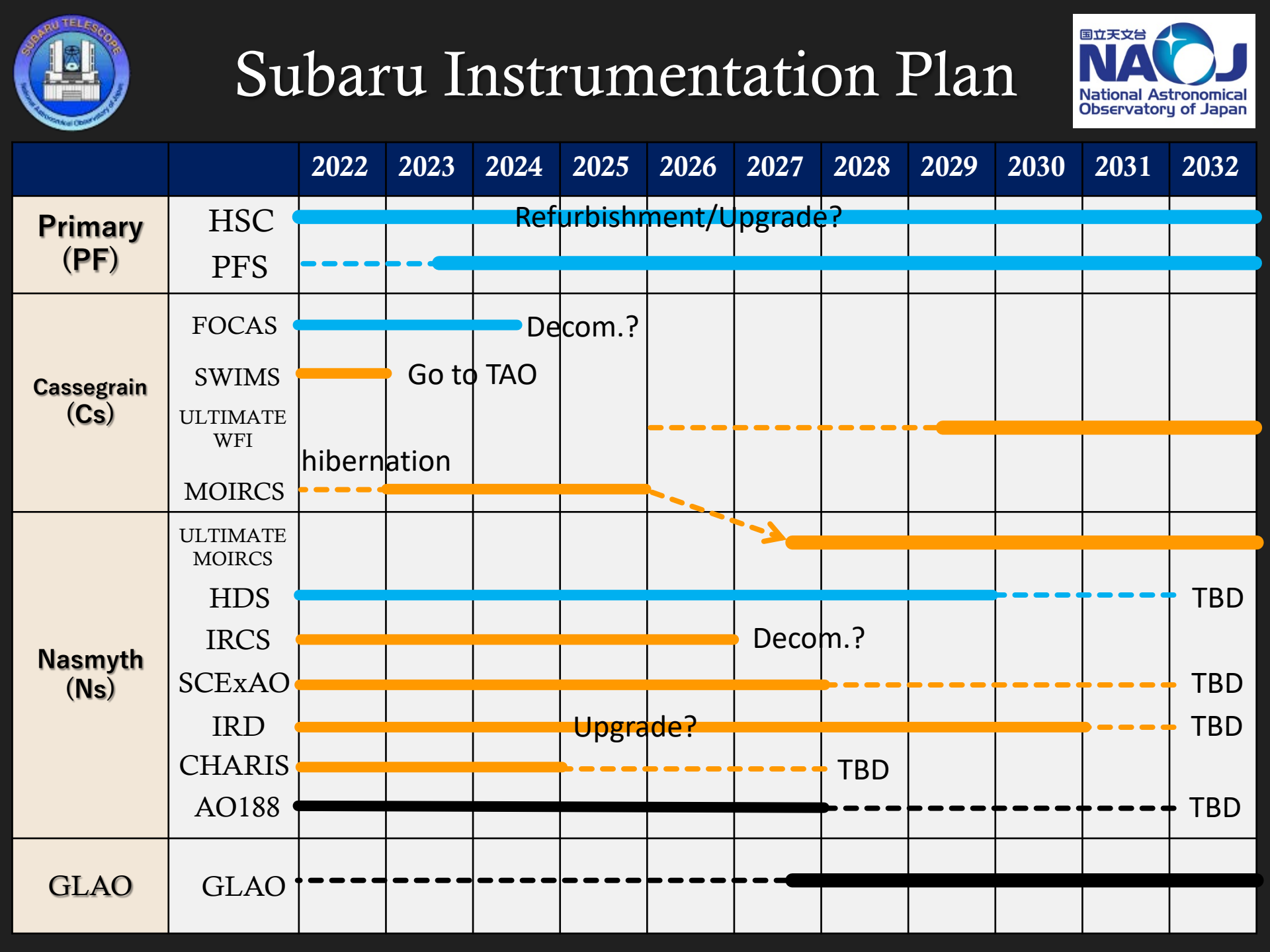
Enhance the wide field observation capability of Subaru by developing next generation instruments, PFS and ULTIMATE-Subaru, in the 2020s.

Spectroscopy field of view ➔ 50 times larger
Infrared observation field of view ➔ 10 times larger
Spectroscopic multiplicity ➔ 20 times more
Infrared image quality ➔ 2 times better

Subaru2 Timeline



Subaru Instrumentation Plan




Thank you