2020 Annual Report of Subaru Telescope

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National Astronomical Observatory of Japan

Subaru Telescope in 2020

Subaru in 2020

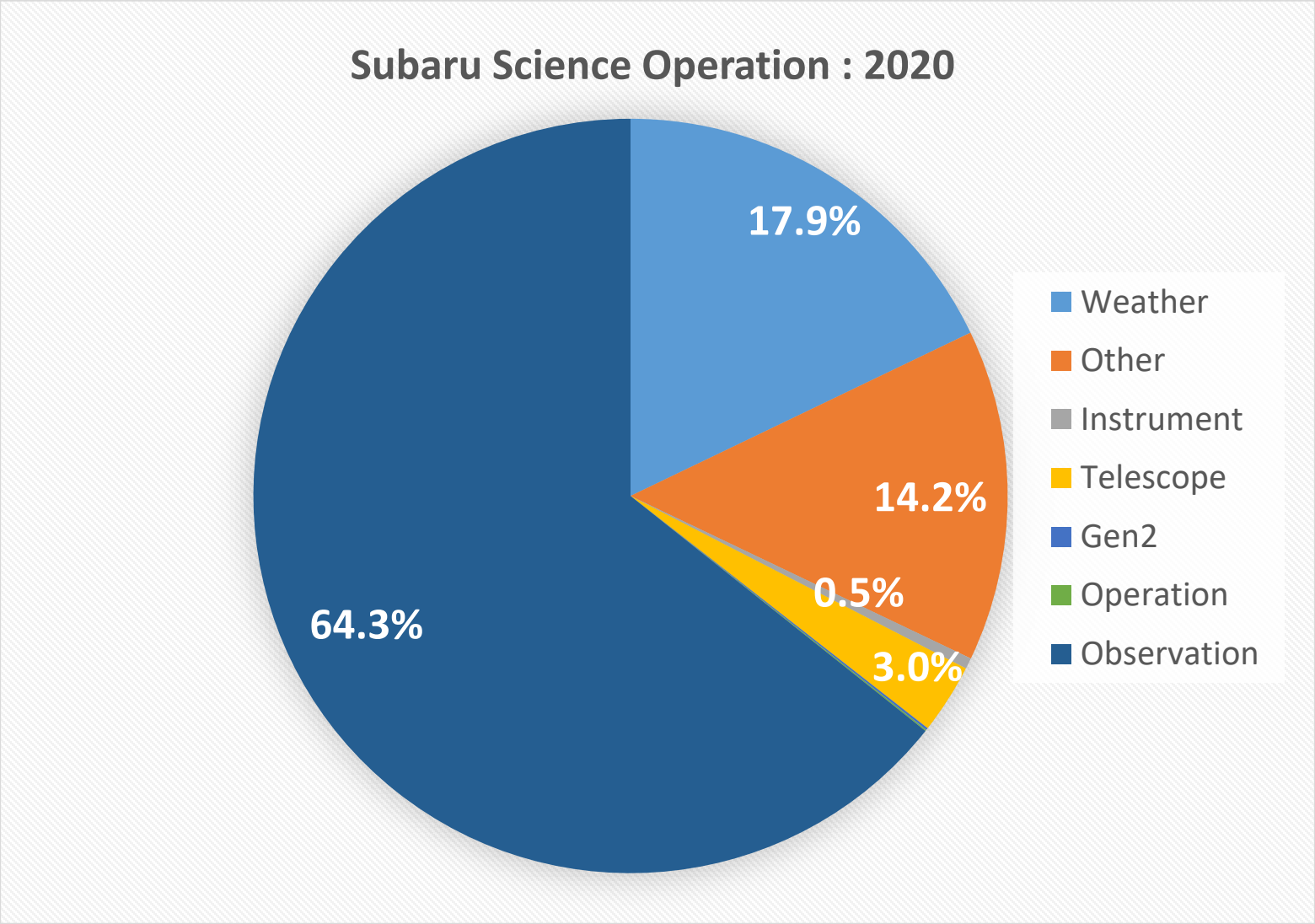
- COVID-19 pandemic & telescope operation
- Science
  - 157 science papers were published.
  - HSC SSP has been almost completed (~90%).
  - IRD SSP continues ➔ the first science paper was published.
  - Collaborations with NASA New Horizons and JAXA Hayabusa 2
- Instrumentation
  - COMICS was decommissioned
  - PFS development: installation of Fiber Cable B #1 and SuNSS, significant progress in development of PFI (Prime Focus Instrument) and Spectrograph Module 2
  - Laser guide star system refurbishment
- Full remote observation project was begun.
- The dome main shutter controllers were refurbished by inhouse development.
- International partnership process was regrettably suspended due to COVID-19.

Telescope operation

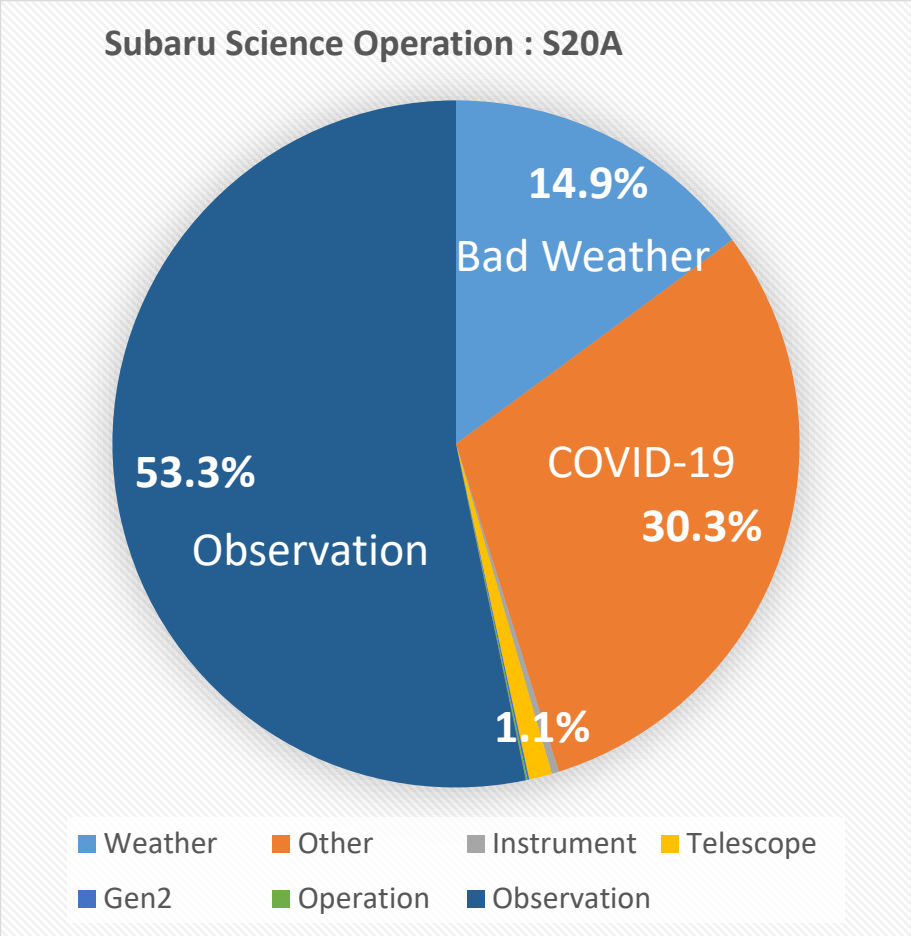
COVID-19 pandemic

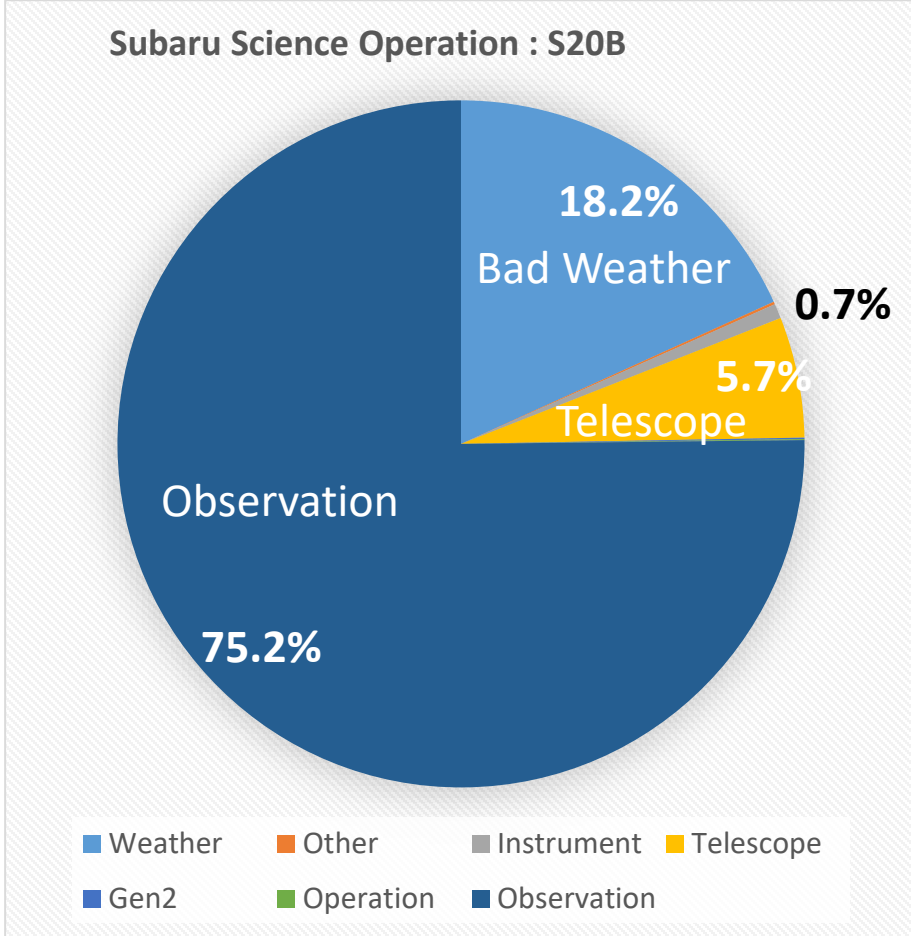
- We lost 55 observation nights from March 24 to May 17.
- All the onsite works including summit work and Hilo Base work were severely affected, leading significant changes in our work style: teleworking, remote observation, restriction on summit work, and social distancing in the workplace.

Telescope time statistics in 2020



Telescope time in S20A & S20B





Recent troubles with telescope & dome

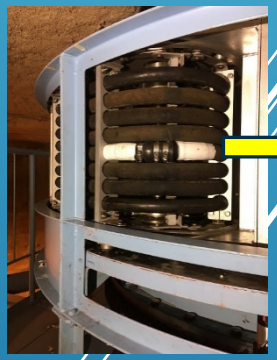
- Leakage of the glycol on the coude pit area on 10/12 ➔ renewal of the coolant hoses from 11/30 to 12/3.
- POpt2 hexapod trouble on 10/23 ➔ fixed on 10/26
- Telescope elevation encoder reading trouble on 11/4 ➔ fixed on 11/5
- Unstable behavior of the dome main shutter ➔ fixed.

COOLANT LEAKED FROM AZ CABLE WRAPPER

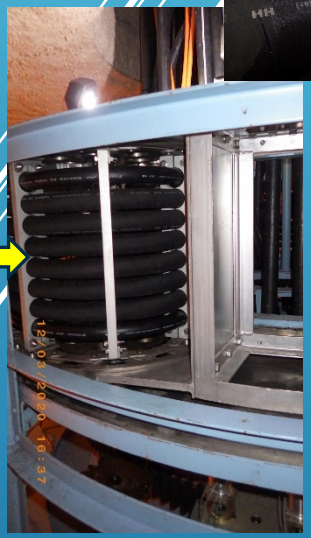
(Oct. 12, 2020)

Leaked point is about 12m climbing up from floor level.

Left : Leak point
Right : It's zoom up.



Temporary patch



Tow hydrostatic oil line and 6 coolant line replace is complete 11/30 ~ 12/03.

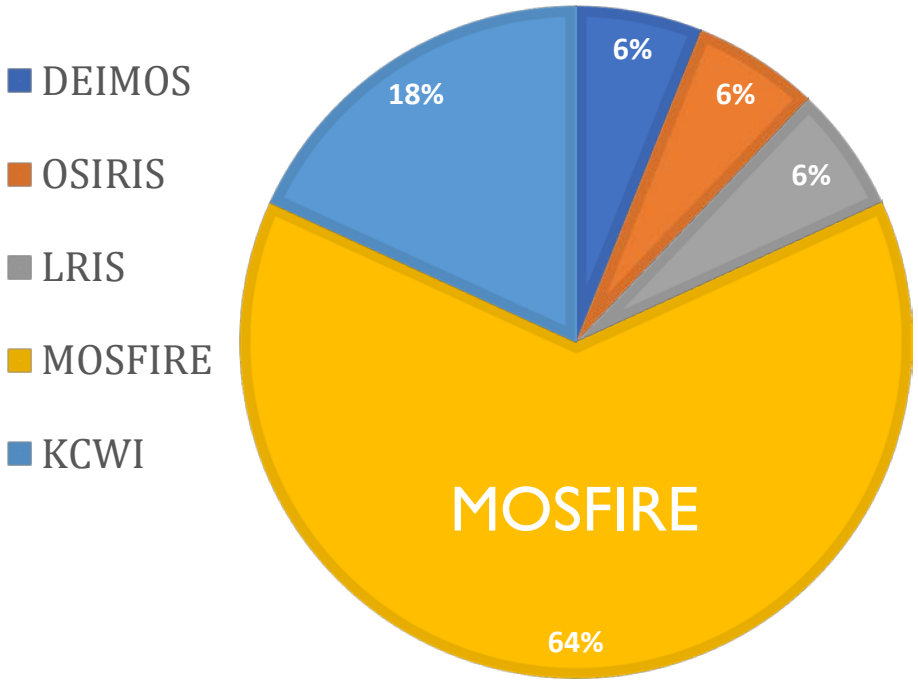
Time exchange

(by Yusei Koyama)

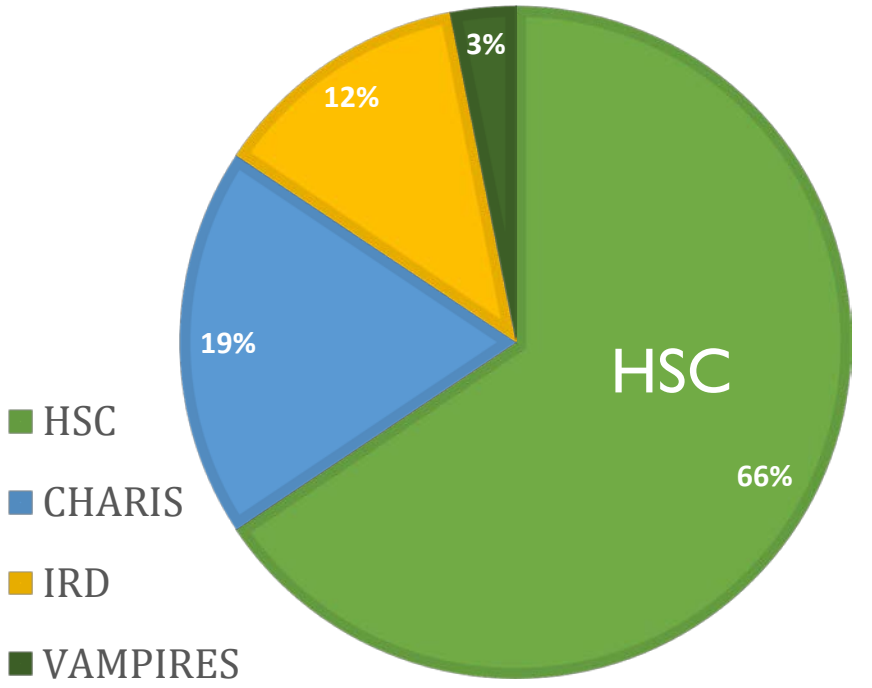
Subaru-Keck exchange demands

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

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

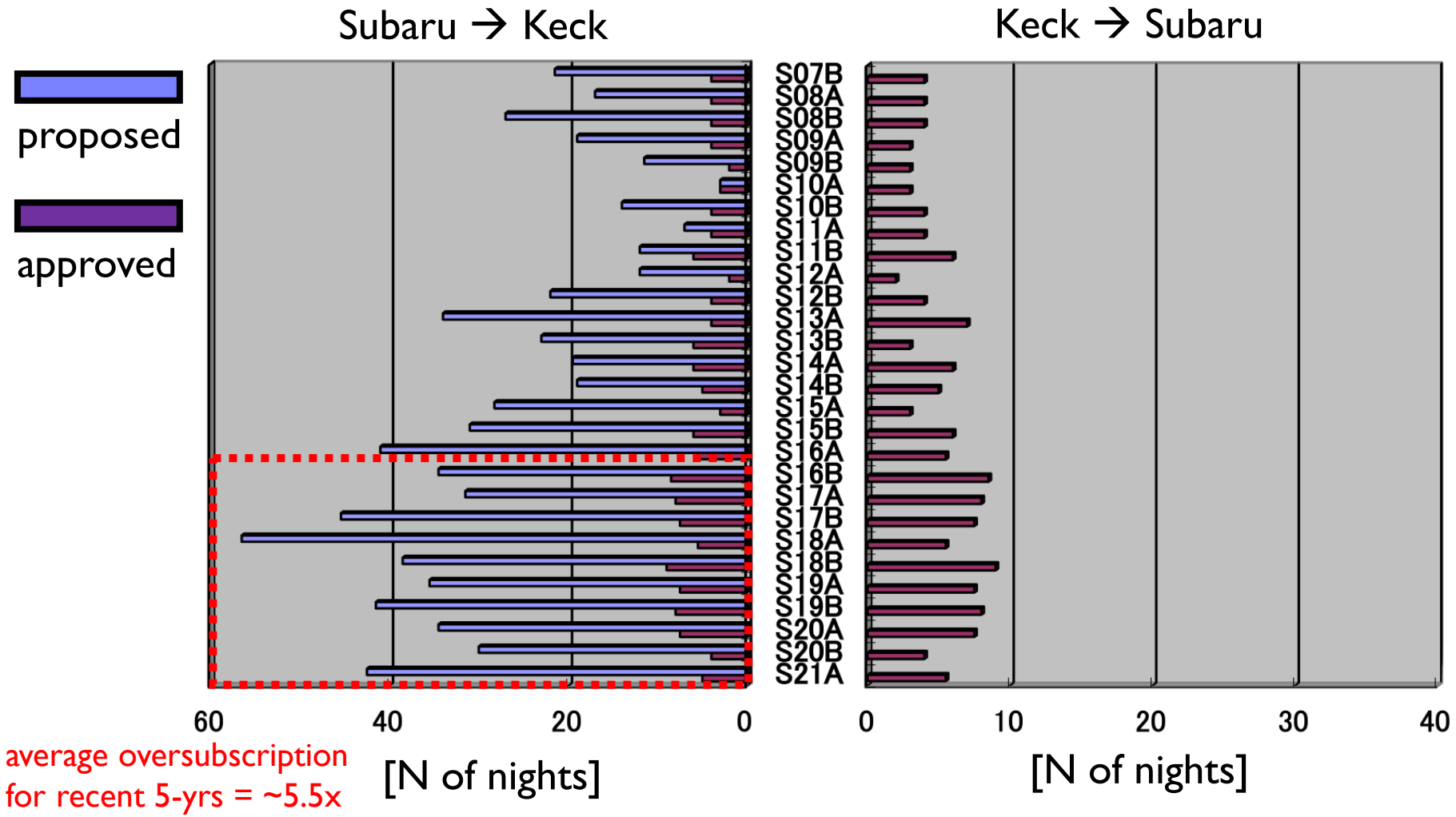


Keck → Subaru
(approved in S20A/S20B/S21A)



Subaru-Keck exchange oversubscription

Statistics since 2007B (note: N of Keck→Subaru proposals is not available)

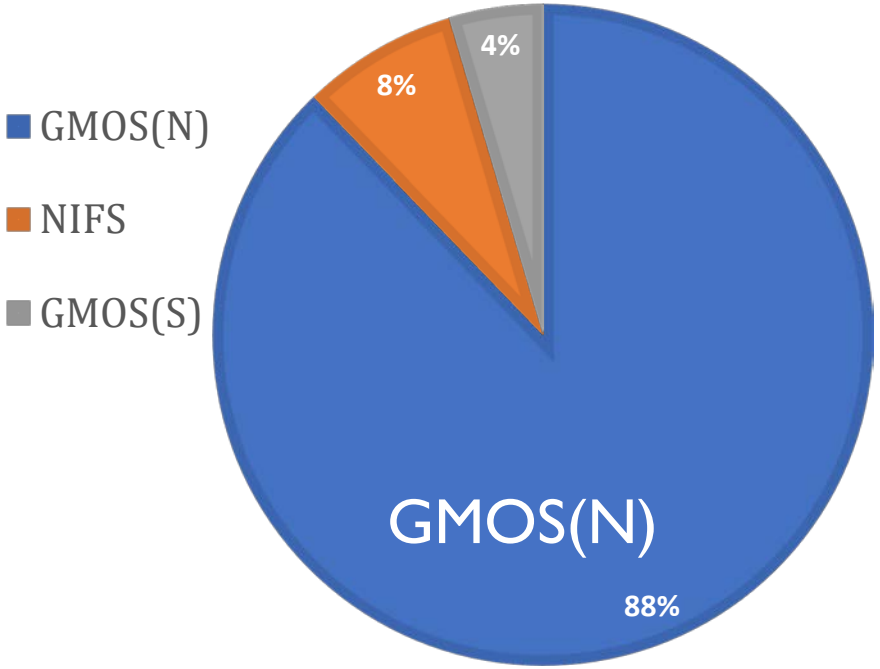


average oversubscription for recent 5-yrs = ~5.5x

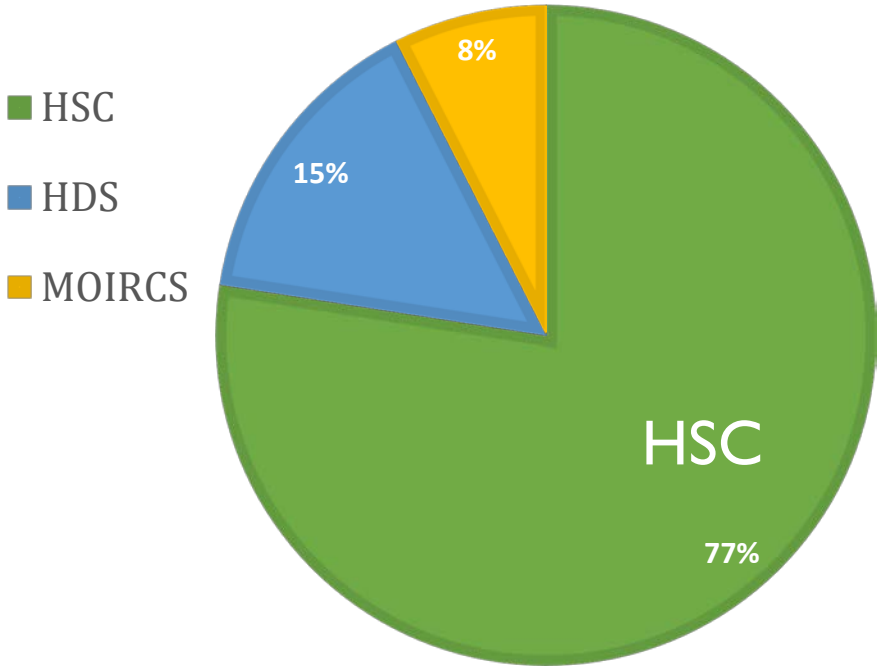
Subaru-Gemini exchange demands

We approved 7.5n (S20A), 4.0n (S20B), 5.0n (S21A) for Subaru→Gemini normal programs.

Subaru → Gemini
(approved in S20A/S20B/S21A)



Gemini → Subaru
(approved in S20A/S20B/S21A)

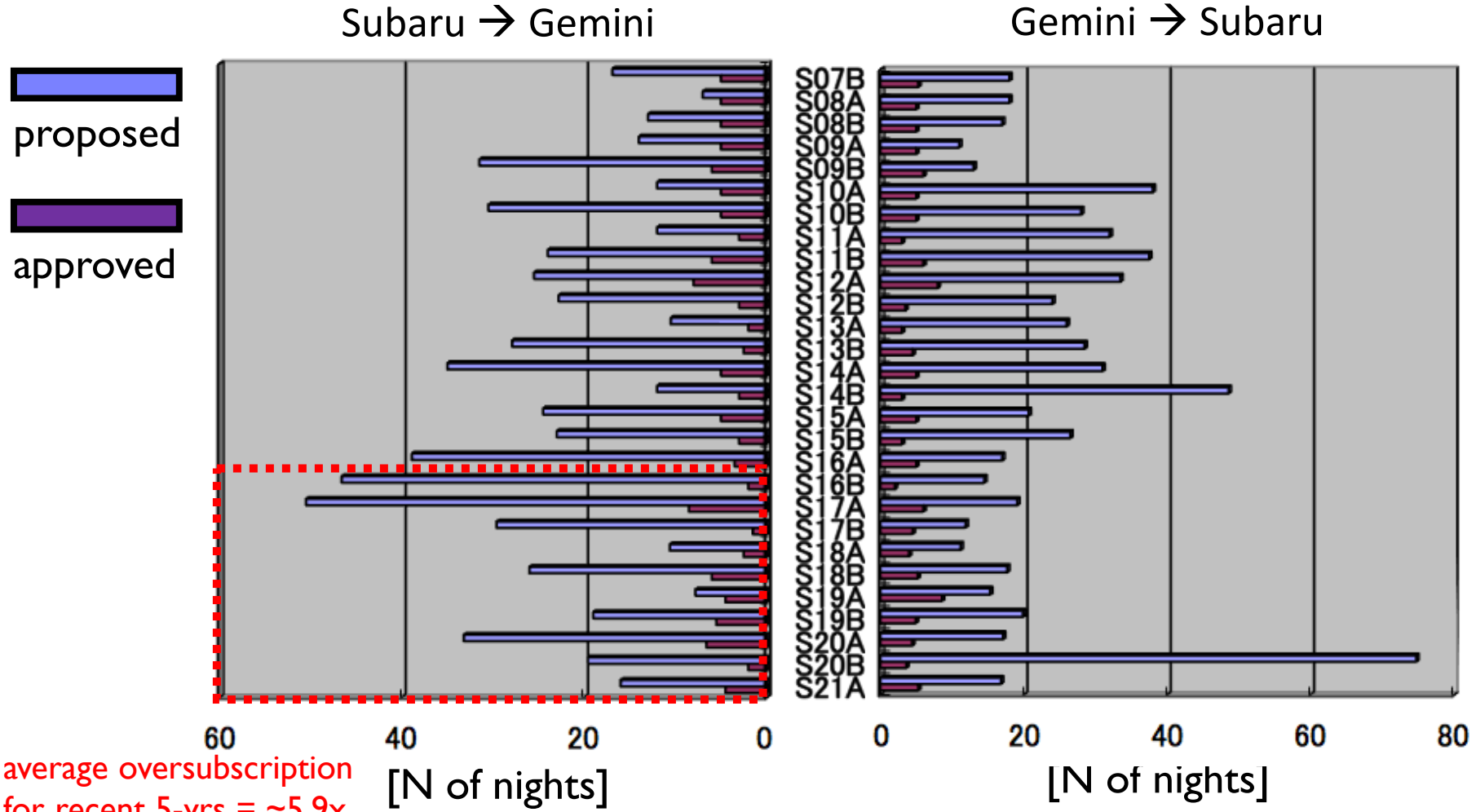


Note 1: In addition, Subaru users are awarded typically ~1.5-2.0-nights Gemini FT time in each semester.

Note 2: Subaru (Gemini) users can now propose Gemini LLP (Subaru Intensive) through time exchange.

Subaru-Gemini exchange oversubscription

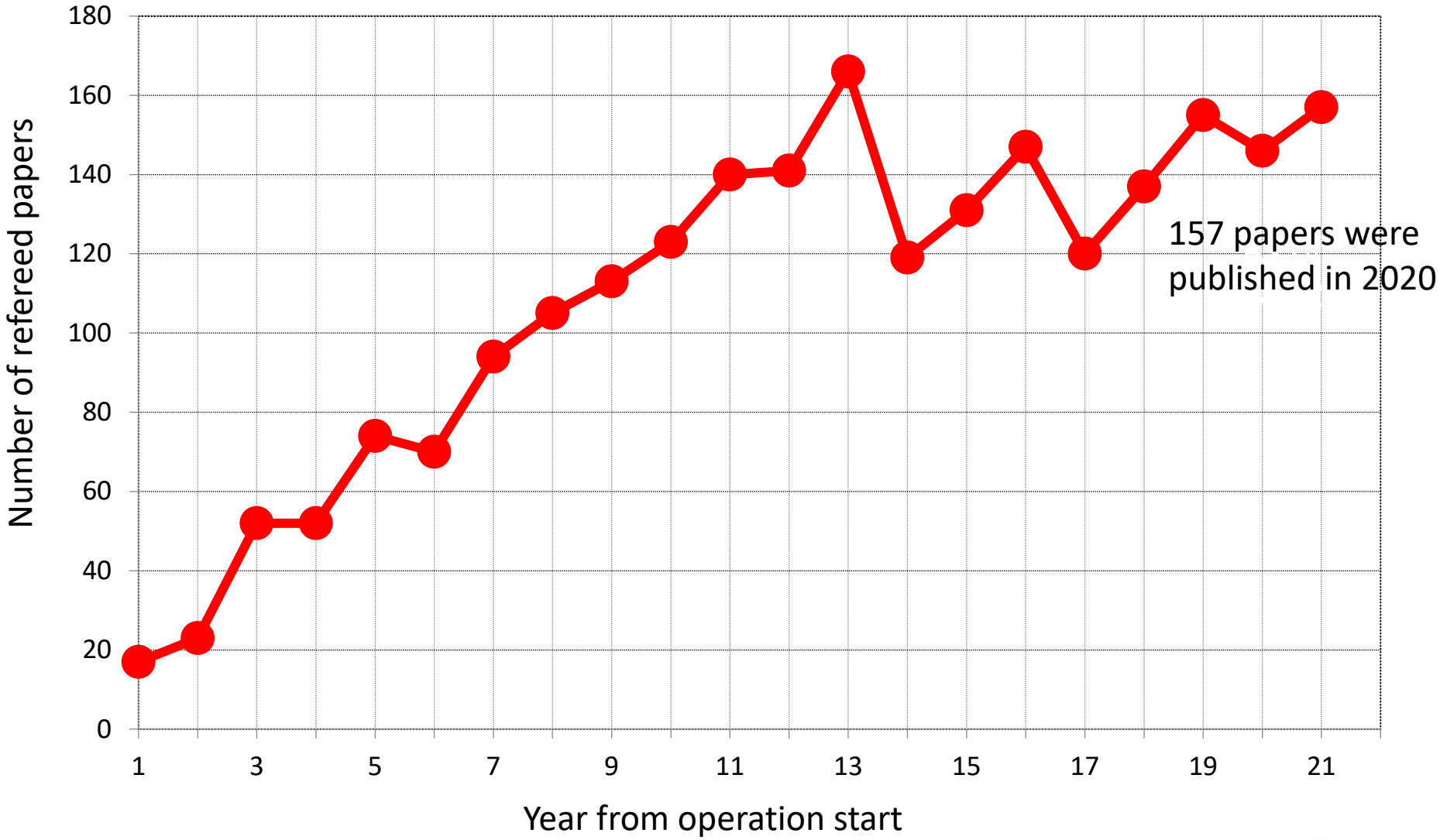
Statistics since 2007B (note: Gemini FT is not included)



average oversubscription for recent 5-yrs = ~5.9x

Science

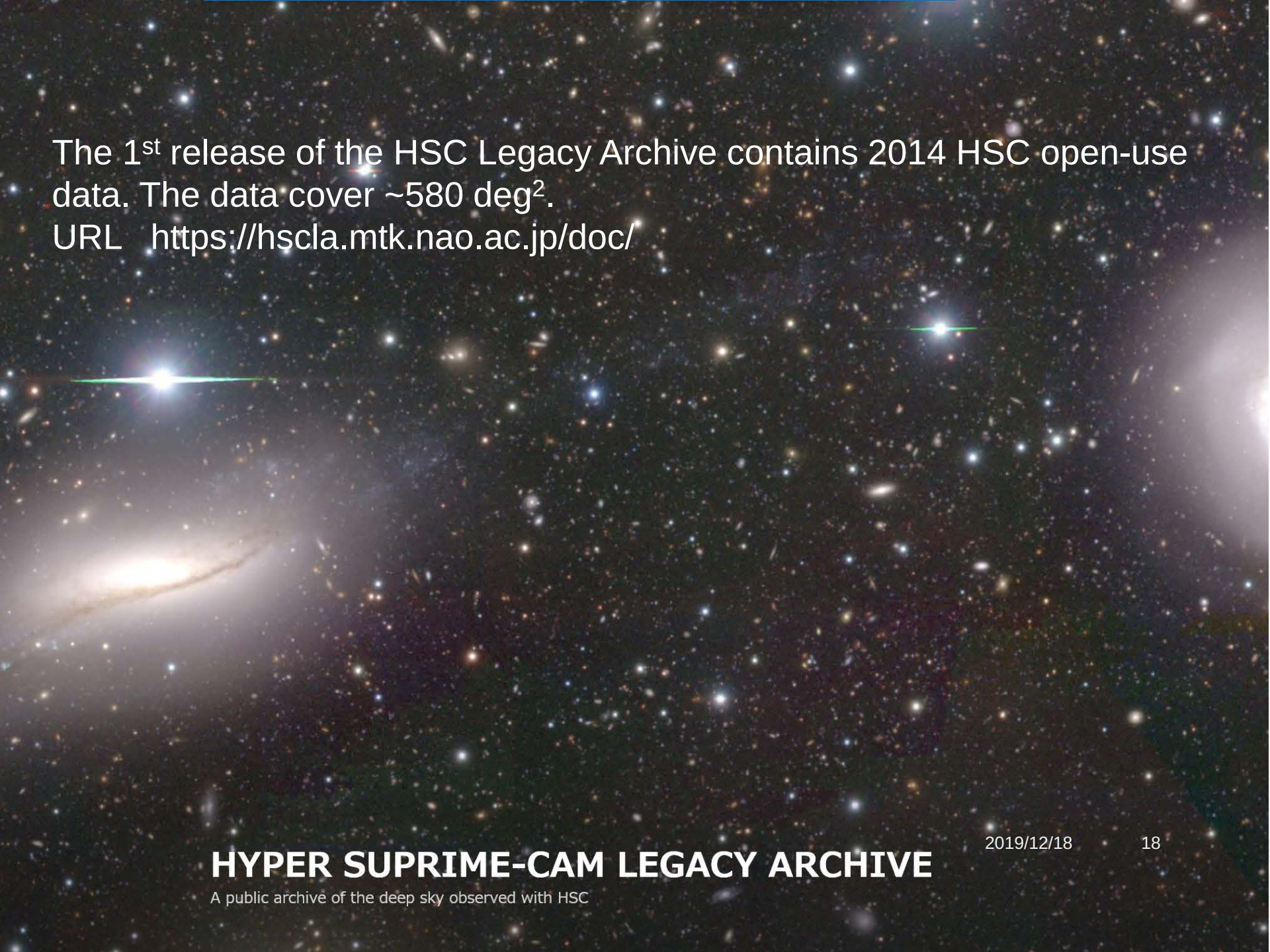
Number of Publications



Subaru Strategic Programs

- Exceptionally large project using unique/expedient instruments of Subaru Telescope
- HSC SSP (2014 - 2021)　300+30 nights　ongoing
  - “Wide-field imaging with **Hyper Suprime-Cam**: Cosmology and Galaxy Evolution”
  - HSC Legacy Archive was released on January 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
  - Large international **PFS** collaboration

The 1st release of the HSC Legacy Archive contains 2014 HSC open-use data. The data cover ~580 deg^2.
URL https://hscla.mtk.nao.ac.jp/doc/



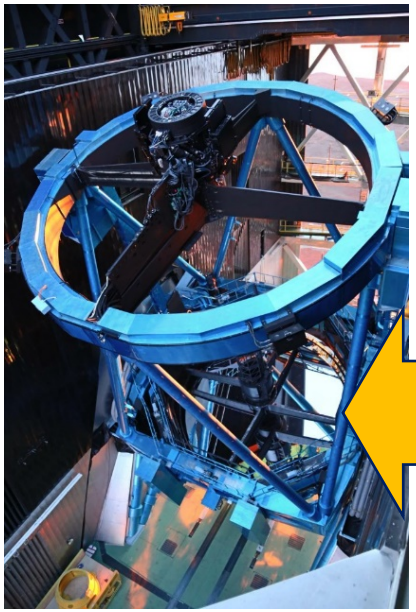
Subaru Press/Web Release 2020

1. Dec. 17 : The Subaru Telescope Photographs the Next Target Asteroid for Hayabusa2 (HSC)
2. Dec. 14 : Spectroscopic Confirmation of the Most Distant Galaxy at Redshift 10.957 (Keck)
3. Dec. 10 : SCExAO/CHARIS Nets its First Discovery (SCExAO + CHARIS)
4. Nov. 12 : More than Meets the Eye: Complete Imaging of a Cluster Collision (HSC)
5. Oct. 27 : Galaxies in the Infant Universe were Surprisingly Mature (S-Cam & HSC)
6. Oct. 7 : Green Light Unveils the Presence of an Old and Metal-Poor Halo in a Giant Elliptical Galaxy (S-Cam)
7. Oct. 5 : Evolutionary Status of Extremely Li-Enhanced Red Giants (HDS)
8. Sep. 15 : Unraveling a Spiral Stream of Dusty Embers from a Massive Binary Stellar Forge (COMICS)
9. Sep. 3 : The Orbital Planes of “Young Planets” Are Not Inclined? : New Knowledge About the Evolution of Planetary Systems (IRD)
10. Aug. 26 : Rare Encounters between Cosmic Heavyweights (HSC)
11. Aug. 10 : Subaru Galaxy Zoo Project with Artificial Intelligence (HSC)
12. July 31 : Machine Learning Finds a Surprising Early Galaxy – Breaking the Lowest Oxygen Abundance Record (HSC & FOCAS)
13. May 13 : TRAPPIST-1 Planetary Orbits not Misaligned: First Scientific Result by the New Spectrograph on the Subaru Telescope (IRD)
14. Apr. 21 : Subaru Telescope Captures First-ever Photographic Proof of Power-packed Jet Emerging from Colliding Galaxies (IRCS + AO188)
15. Apr. 13 : Aurora Light from Comet 21P/Giacobini-Zinner Tells Us about Its Birthplace in the Early Solar System (HDS)
16. Feb. 19 : Dramatic Starbursts Hidden in Protoclusters at 12 Billion Years Ago (HSC)
17. Feb. 10 : Distant Giant Planets from Differently than ‘Failed Stars’ (HiCIAO)
18. Jan. 8 : Cosmic Magnifying Glasses Yield Independent Measure of Universe’s Expansion (HSC)

Collaboration with the NASA New Horizons mission

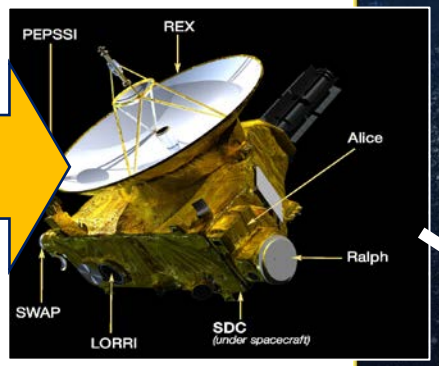
Explore trans-Neptunian objects (Kuiper Belt Objects: KBO) by collaboration of Subaru HSC and NASA New Horizons.

- Search for KBO with wide field imaging of Subaru HSC ➔ Follow-up observations with New Horizons spacecraft.
- 15 half nights (0.5 x 15) of HSC were allocated to this project. About 70 new KBOs were found and New Horizons follow-up was started.

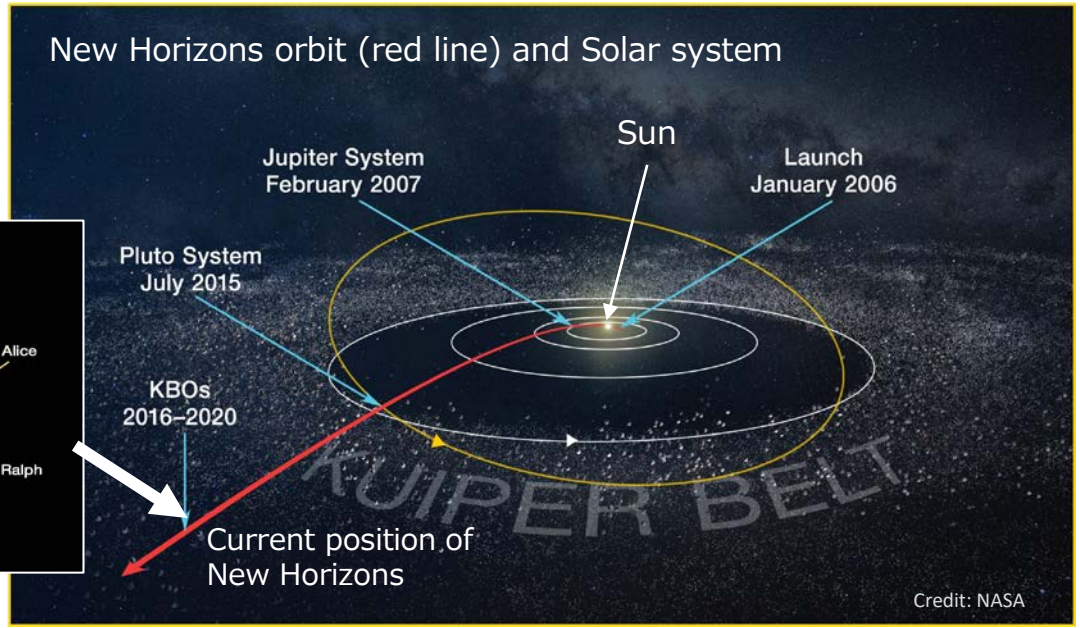


Subaru HSC

New Horizons



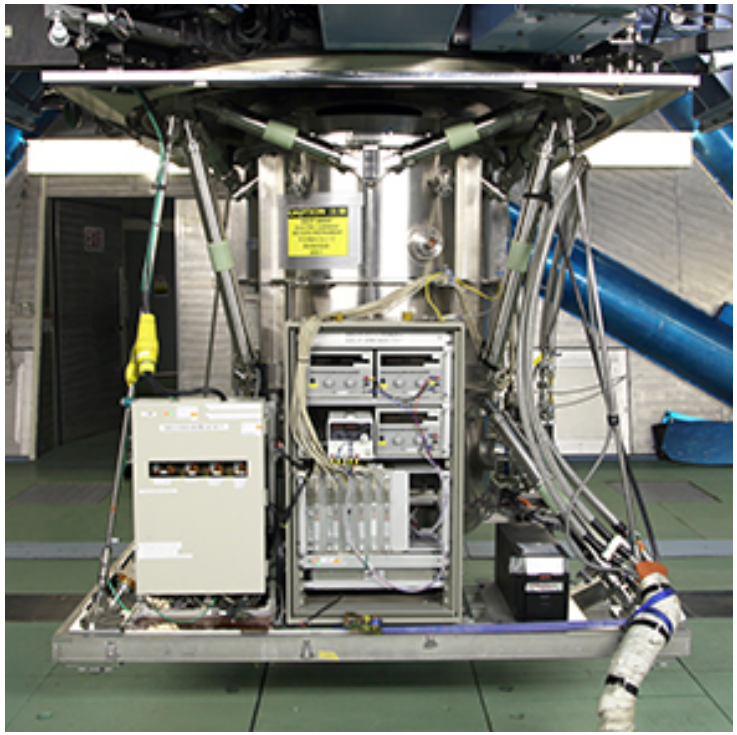
Credit: NASA



Instrumentation & Telescope/Facility Maintenance

COMICS was retired on 7/30

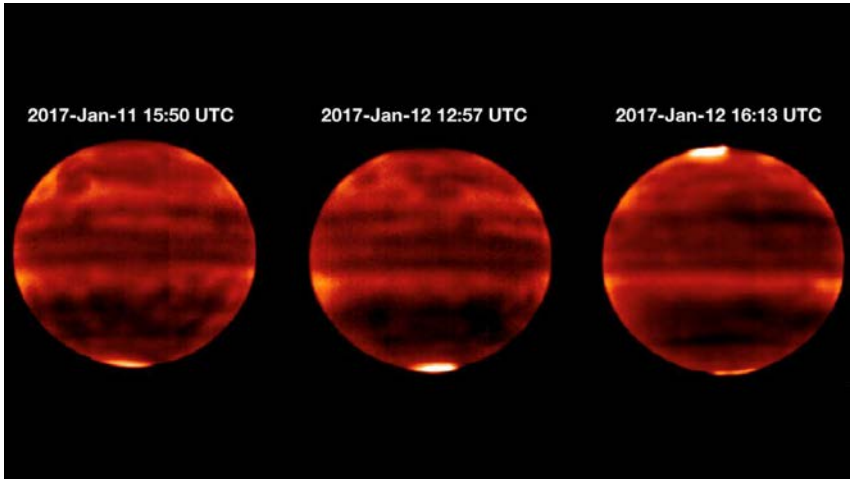
- The last open-use observation using Cooled Mid Infrared Camera and Spectrometer (COMICS) was performed on July 30, 2020.
- COMICS is one of the first generation instruments of Subaru Telescope. It started science observations in 2001.
- Its unique capability (mid-infrared (7.5-13.5 um) imaging and spectroscopy with diffraction limited spatial resolution) produced many science papers.



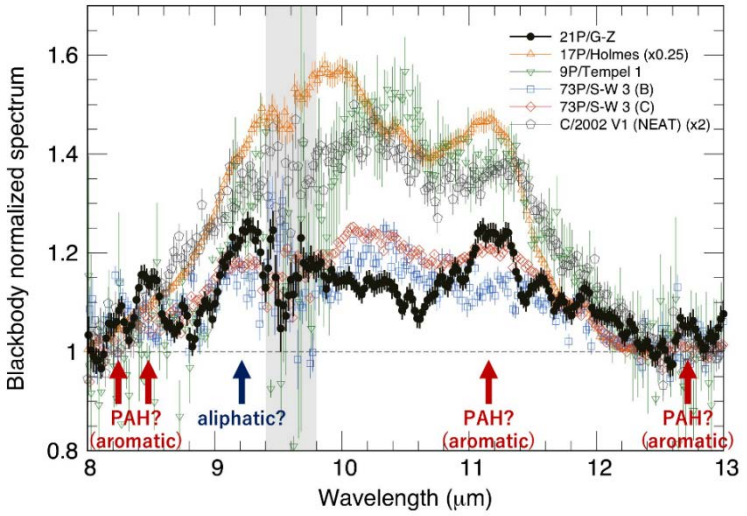
Recent science results of COMICS

Jupiter' stratosphere is heated up by Solar wind plasma (aurora)

(Sinclair, J. A. et al. 2019)



COMICS identified the mid-infrared emission band from organic molecules in Comet 21P/Giacobini-Zinner (Ootsubo, T. et al. 2019)



PFS (Prime Focus Spectrograph)

(under development; science operation from 2023)

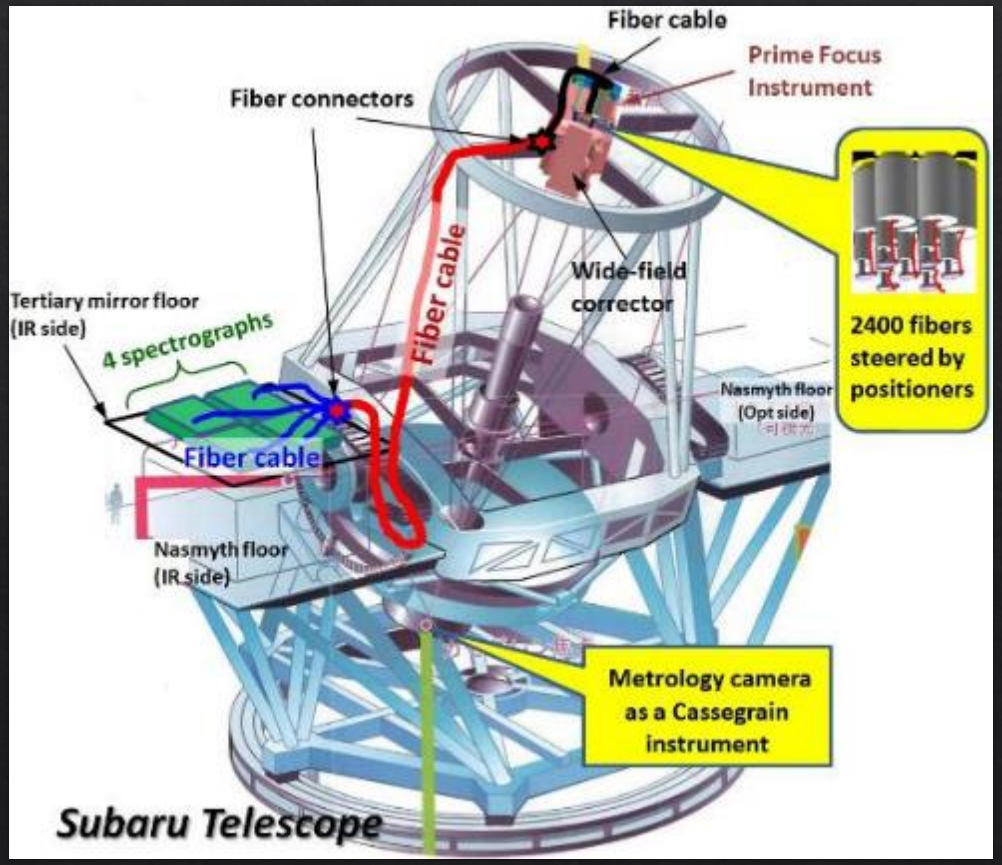
A fiber fed multi-object spectrograph attached to the prime focus of Subaru

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

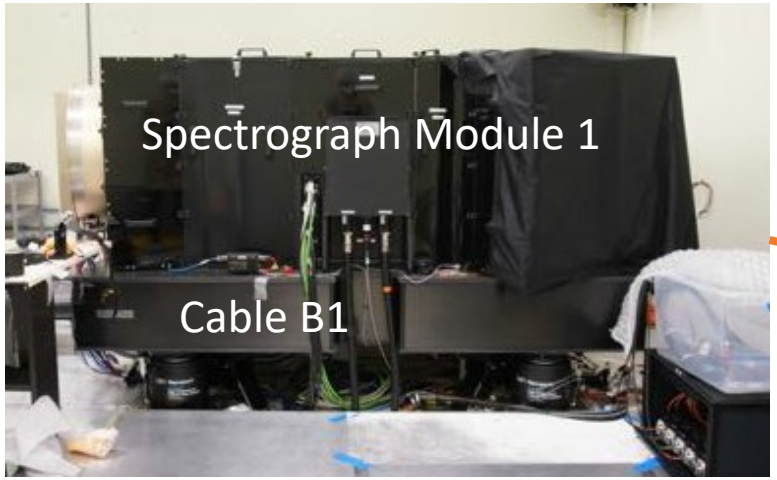
Sensitivity

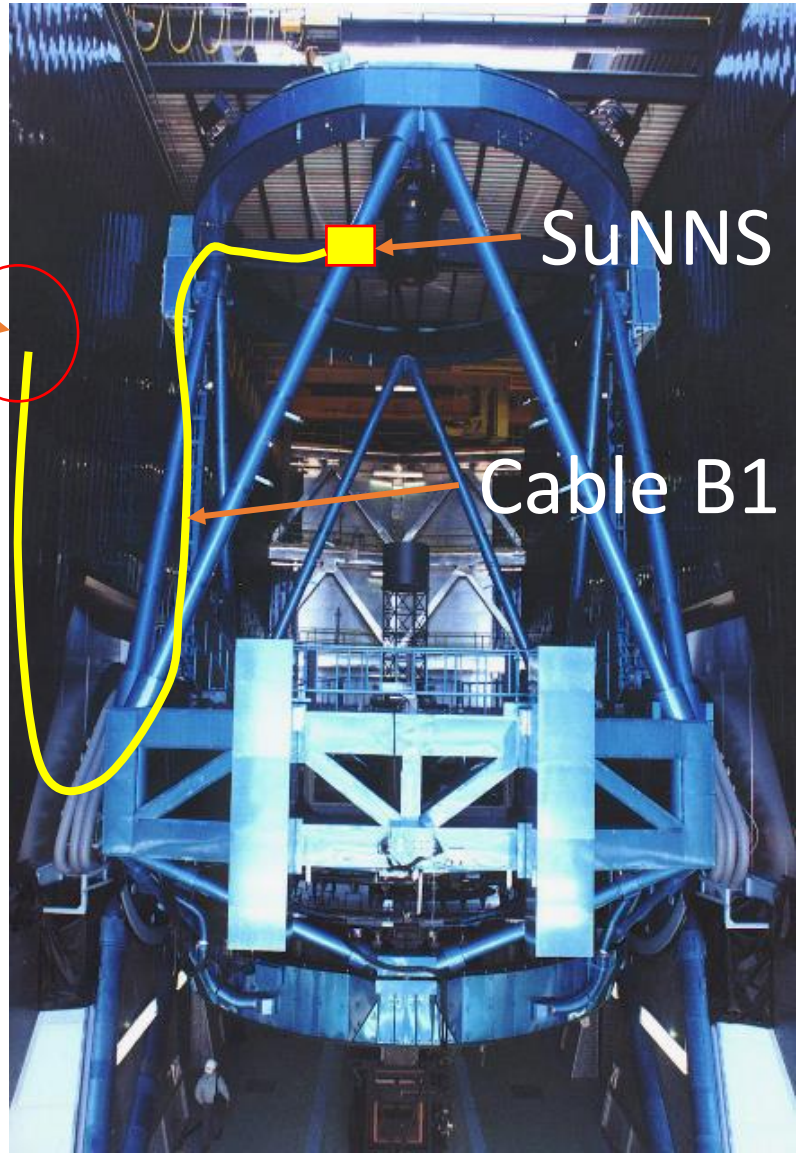
Band	magnitude
Blue (0.38 – 0.65 μm)	22.5
Red (0.65 – 0.97 μm)	22.4
NIR (0.97 – 1.26 μm)	21.4

S/N = 5 @ 1 hour exposure



PFS installation status





The first major fiber cable, “Cable B1”, and a small telescope for commissioning, “SuNNS”, were successfully installed to the Subaru Telescope in February 2021.

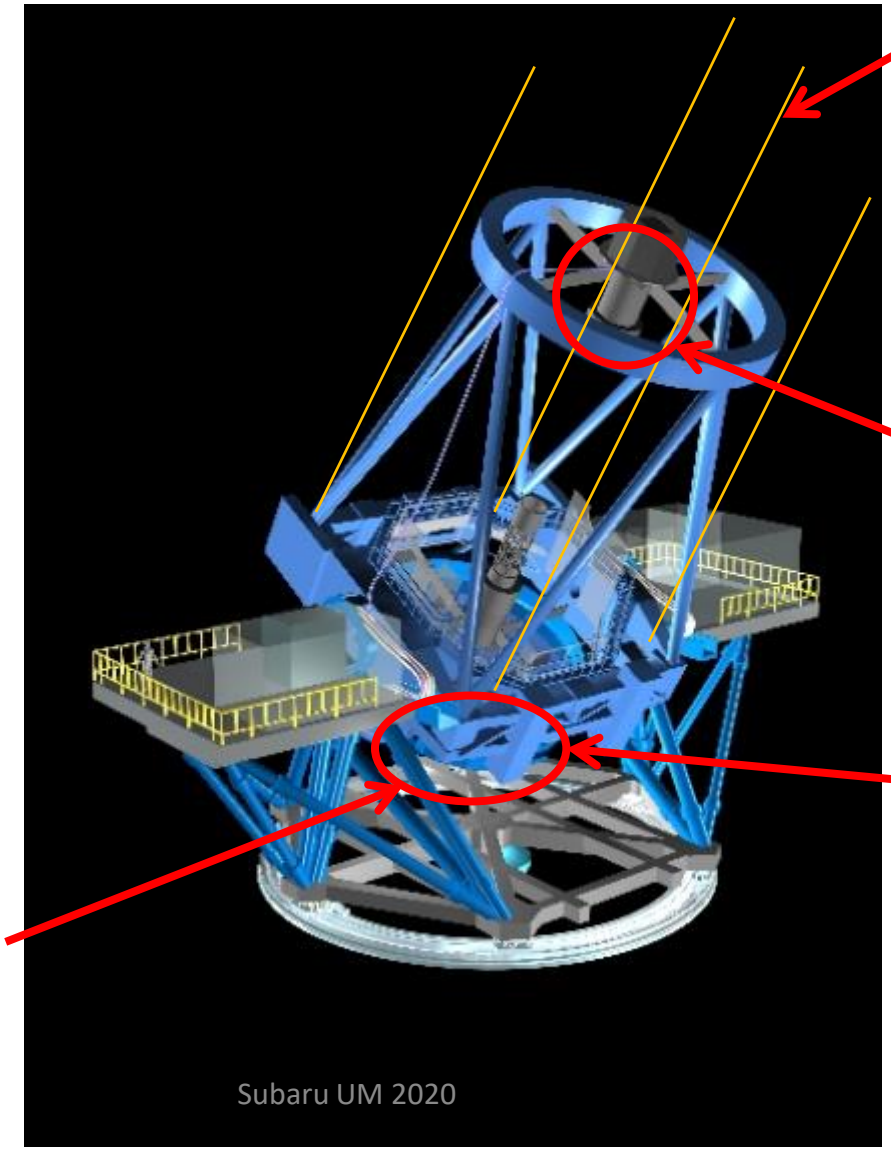
ULTIMATE-Subaru

(preliminary design phase)

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

New Laser Guide Star system (a part of the GLAO) is now being installed.

Science Operation: 2026



New capabilities of SCExAO

- Fast polarization differential imaging in IR
  - https://www.naoj.org/Projects/SCEXAO/scexaoWEB/030openuse.web/043fastPDI.web/indexm.html
- MKID Exoplanet Camera
  - https://www.naoj.org/Projects/SCEXAO/scexaoWEB/030openuse.web/042mec.web/indexm.html

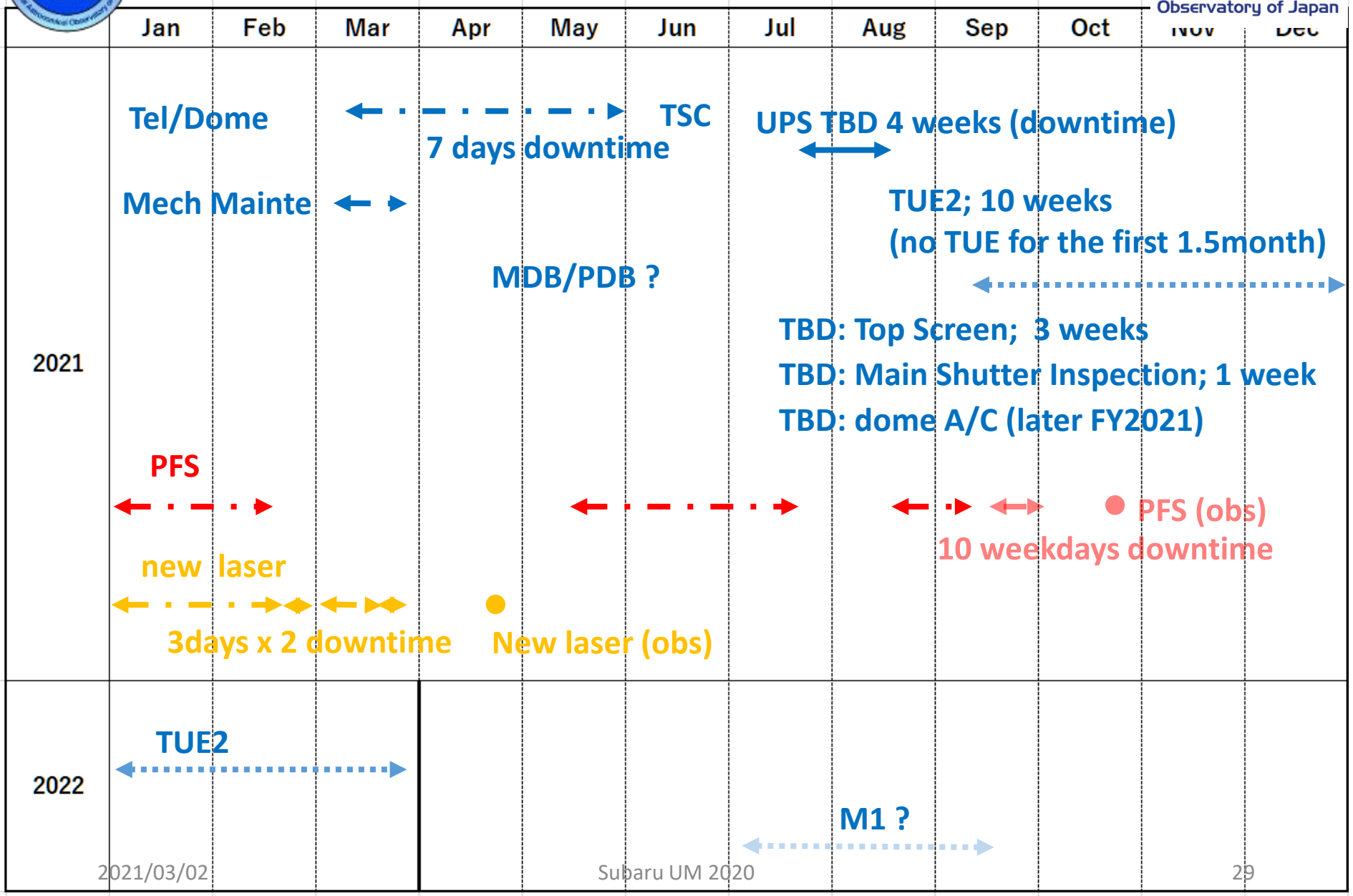
- These functions will be open to the community from S21B.

On-going Major Facility Projects

(Riki Lee)

- Power Distribution Upgrades
  - Electrical System Analysis recently completed
    - Problems Identified by Infrared Inspection: 17
      - Critical: 4, Severe: 6, Alert: 7
    - Equipment Problems: 5
      - Majority of problems involve National Electrical Code violations
  - Contracts are being evaluated for repair and de-energized maintenance
    - Goal is to conduct de-energized maintenance during UPS upgrade effort
  - Sparing of Critical Breakers
    - Critical breakers with long procurement lead times are being identified and will be spared to reduce probability of lengthy shutdown due to failure
- Summit PACU/ACCU (air conditioner) Upgrade
  - Engineers are designing option to decrease the number of of ACCUs (air compressor) in the summit machine room for Chiller upgrade.
- Repair of Fallen Manhole Cover in Lower Summit Lot
  - Engineering drawings are completed. Proposals from contractors are being solicited

Major summit work plan in 2021 & 2022



Good News

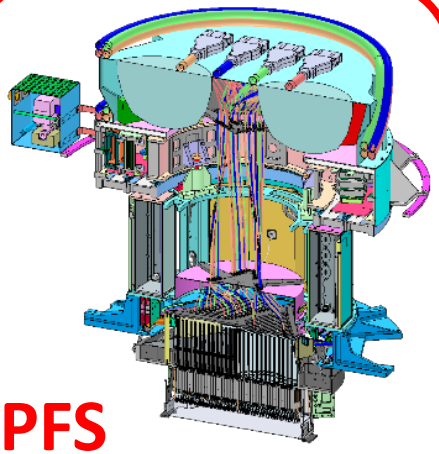
Subaru Telescope was successfully selected as a large-scale science facility in “Roadmap 2020” of MEXT (Ministry of Education, Culture, Sports, Science and Technology, Japan).

Subaru Future Plan

Subaru2 Concept

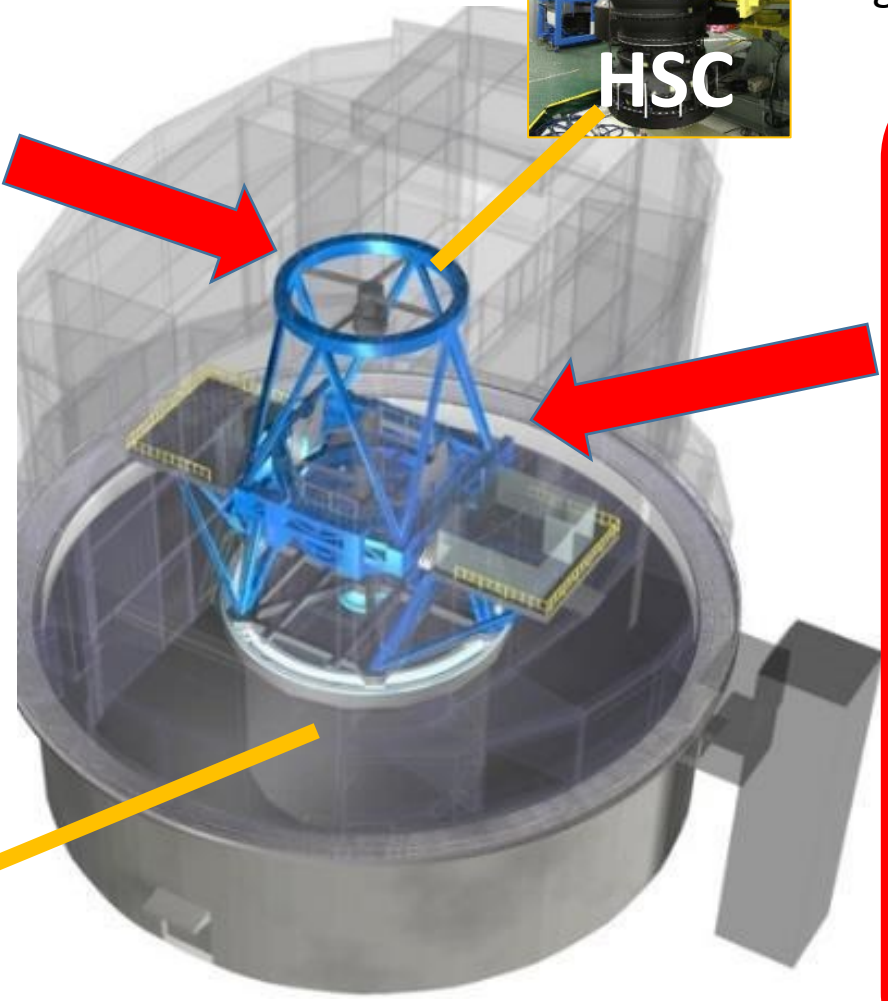
National Astronomical Observatory of Japan

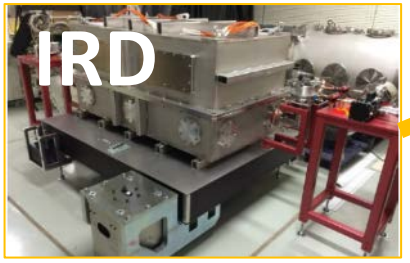
Wide field (1.5 deg)
imaging



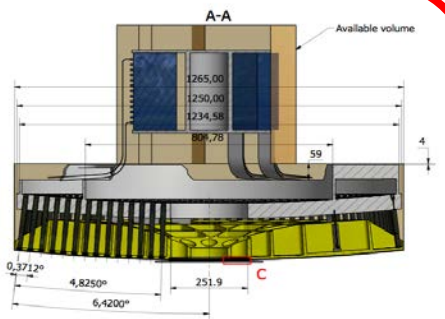
PFS

Wide field (1.3 deg)
multi object (2,400)
spectroscopy

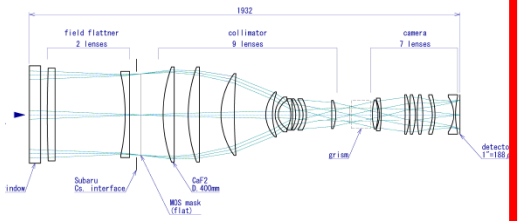




Precise radial velocity
(2m/s) measurement



GLAO + Wide-field IR Instrument



ULTIMATE-Subaru

Wide field (20 arcmin)
high spatial resolution
(0.2 arcsec)
Infrared observation

Wide-field capability of Subaru2

HSC (operational)

Optical
(0.38 – 1.1 um)

FoV
1.7 deg2

Seeing limited
(> 0.4")
Imager

Limiting mag. with 1h exp.

Band	mag
g	27.8
r	27.2
i	26.5
z	25.9

PFS (2022 -)

Optical – J-band
(0.38 – 1.26 um)

FoV
1.3 deg2

2,400 fibers
1.05" ϕ
Multi-object sp.
0.38 – 1.26 um

Limiting mag. with 1h exp.

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

ULTIMATE (2026 -)

Near-Infrared
(0.9 – 2.5 um)

FoV
20' ϕ

GLAO supported
0.2" resolution
(in K-band)

Imager (14'x14')
Multi-object sp.
(w/ MOIRCS)
IFU sp.

Limiting mag. using GLAO with 4h exp.

Band	mag
J	26.3
H	25.5
Ks	26.4
NB1340	26.1

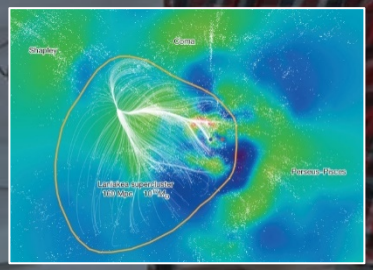
Summary

- A mid-infrared instrument COMICS was decommissioned.
- Much (~20 – 30 %) of the machine time was lost due to the COVID-19 in S20A.
- The number of science publications was 157 in 2020.
- Two large programs (Subaru Strategic Programs) are running using HSC (330 nights from 2014 to 2021) and IRD (175 nights from 2019 to 2025).
- Development of Prime Focus Spectrograph (PFS) is going well. Science observation of PFS will start in 2023.
- Conceptual design of the Wide field infrared observation facility, ULTIMATE, was done successfully. The ULTIMATE project is now preliminary design phase.

A Hua He Inoa

Hawaiian nomenclature campaign

- Major discoveries from Maunakea and Haleakala are being given Hawaiian names.
- If you discover a new interesting astronomical object / phenomenon, please let us know to give it Hawaiian name.
- Examples:
  - Laniakea: the galaxy superclusters
  - Oumuamua: the first detected interstellar object passing through the Solar system
  - Powehi: the first black hole to be photographed (SMBH of M87)




Thank you