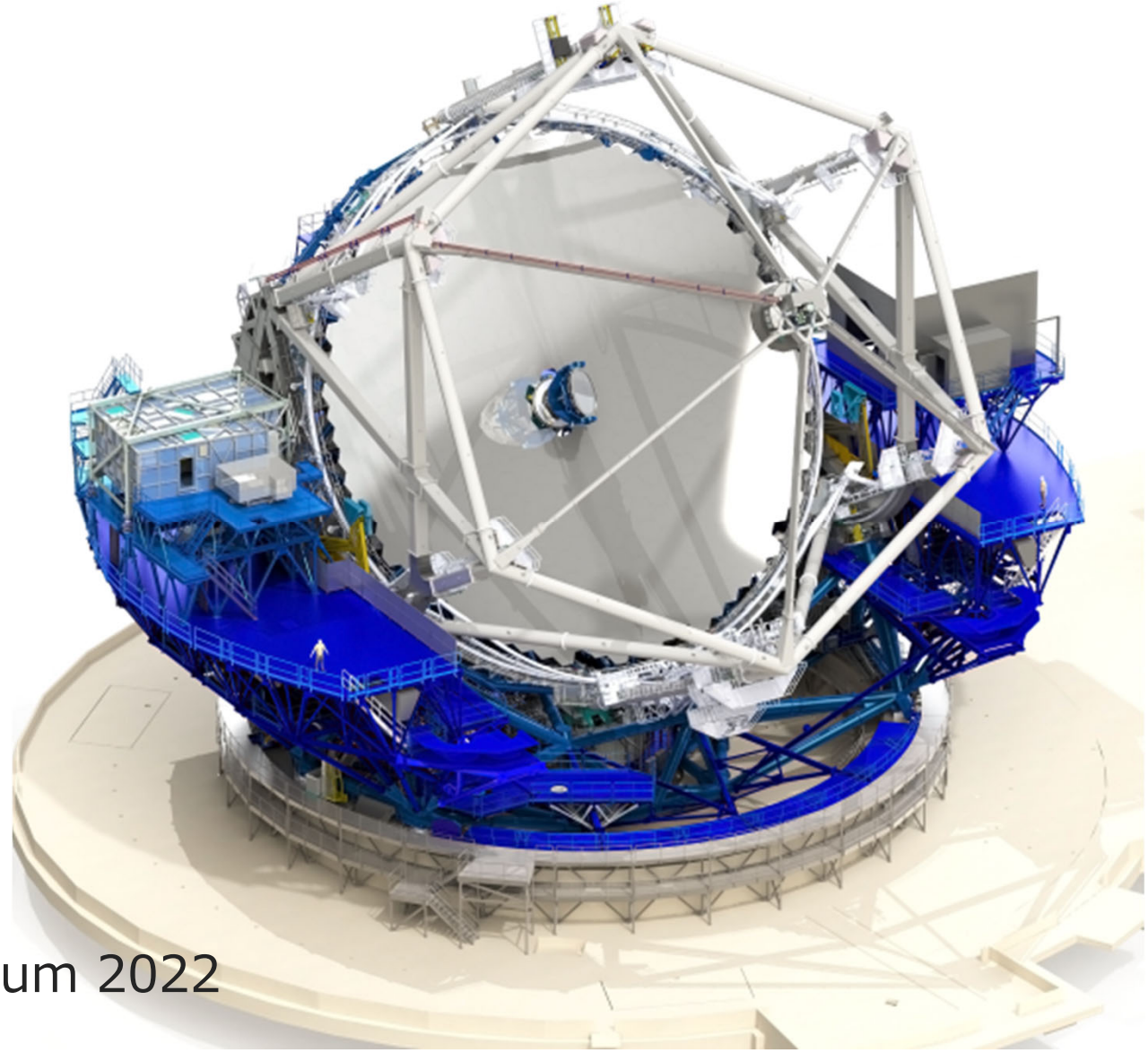
*Provisional translation

国立天文台
現状と課題
(NAOJ current status and challenges)



Saku Tsuneta (NAOJ)
NAOJ Future Planning Symposium 2022
December 7, 2022

Contents

Profile of NAOJ

Number of Employees（as of April 1, 2022）

Total 516

- Research and Academic Staff 230
- Engineering Staff 90
- Administrative Staff 196
  (including Research Support Staff)

<Staff Ratio> Female 30.2% Non-Japanese 6.2%

- Research: 11.3% 9.6%
- Engineering: 20.0% 5.6%
- Administrative: 57.1% 2.6%

[% of Female and gender balance target value]
***From "Action Plan for Promoting Gender Equality at the National Institutes of Natural Sciences."**

- **Goal 1** Ratio of female researchers: 11.5%
  [17% by the end of FY2027]
  Lecturer or higher 9.2%
  [12% by the end of FY2027]
- **Goal 2** Ratio of female in management positions (section manager and above): 12.5%
  [18% by the end of FY2025]

Number of Students（as of April 1, 2022）

Graduate Students 74

- Students from SOKENDAI (5-year doctoral program) 32
- Students from Cooperative Universities 28
- Visiting Graduate Students 14

FY2022 budget

Operating expenses grant, etc. **Approx. 9.47 billion yen**

- Large-scale academic frontier promotion projects (3 projects) Approx. 3.51 billion yen
- Other operating expenses grants, Approx. 5.96 billion yen

(Of which, Inherited personnel expenses, annual salary system, and part-time personnel expenses (employment through operating expenses grants) Approx. 3.75 billion yen

Grants-in-Aid for Scientific Research (as of May 31 2022) **Approx. 540 million yen**

Facility maintenance budget

FY 2022 initial budget

- Subaru Telescope anti-aging measures Approx. 350 million yen

FY 2021 supplementary budget

- Subaru Telescope's anti-aging measures Approx. 800 million yen
- ALMA project's anti-aging measures Approx. 390 million yen

Publications

Source: InCites (article, review) as of May 20, 2022

Citation index (2017-2021 average)

- **# of peer-reviewed papers/year: 612**
- % of citations Top 10% papers: 16.1% (Average of all fields in Japan: 8.0%)
- % of citations Top 1% papers: 3.2% (Average of all fields in Japan: 1.0%)
- % of International collaboration: 79.8% (Average of all fields in Japan: 34.0%)

Publications in Astronomy & Astrophysics in Japan

World share (2021) : 9.0 %

- Among the 19 fields of natural sciences (ESI22), Space science ranks the first
- % of Japanese members in the International Astronomical Union: 5.5 %
  (Approximately 1/4 of US members: as of May 1, 2022)

Rate of increase （2011→2021） : +47.1%

- Among the 19 fields of natural science (ESI22), Space science ranks the 3rd

Large Observation Facility of NAOJ

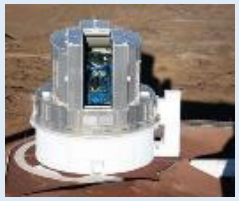
Subaru Telescope - 2

- Open-use observations by domestic and foreign researchers -

(Subaru upgraded to Subaru 2)

[Features]
- The only large telescope in the world capable of wide field observations.
- 8.2 meters in diameter, one of the largest monolithic mirrors.
- Developing new science instruments using cutting-edge technologies.

[Site]
- A site at an altitude of 4,200 m on Maunakea (Hawai'i, US).



[Construction]
- Cost: ~39.5 Billion JPY
- Period: JFY 1991 ~ 1999

ALMA - 2

mm & sub-mm Radio Astronomy with NSF/NRAO and ESO

(ALMA=Atacama Large Millimeter/sub-millimeter Array)

[Features]
- Radio interferometer by combining fifty 12 m and twelve 7 m antennas, complemented with four 12 m antennas operated as single-dish (66 antennas in total) across 16 km wide area.
- Frequency coverage: 35-950 GHz

[Site]
- A site at an altitude of 5,000 m at Atacama Desert (Chile).

[Construction]
- Cost: ~25.1 Billion JPY
- Period: JFY 2004 ~ 2013

TMT

- with the US, Canada, China, & India -

(TMT＝Thirty Meter Telescope)

[Features]
- Aperture of 30 m enabling ~3x spatial resolution, ~10x light-collecting power, and ~100x sensitivity than 8-10m class telescopes. (~5x spatial resolution and ~20x sensitivity than *James Webb Space Telescope* for Near Infrared spectroscopy)
- Japan produces a telescope structure, primary mirror segments, and science instruments.
- Japan offers a unique scientific strategy, using TMT with the wide-field Subaru Telescope.

[Site]
- A site at an altitude of 4,012 m on Maunakea (Hawai'i, US).

[Construction]
- Cost: about 37.5 billion yen + domestic expenses of 4 billion yen
- Construction period: Aiming for completion in 2033

New astronomy by NAOJ through the promotion of these three large-scale projects

① Are there other planets other than Earth that harbor life? (Subaru, ALMA, TMT)
② What is the true nature of dark matter and dark energy? (Subaru, TMT)
③ How did the universe begin? (ALMA, Subaru, TMT)

Theme of this symposium: Existing projects and future plans

Subaru Telescope - 2
- Open-use observations by domestic and foreign researchers -

(Subaru upgraded to Subaru 2)

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[Construction]
- Cost: about 37.5 billion yen + domestic expenses of 4 billion yen
- Construction period: Aiming for completion in 2033

Future Project ?

New Astronomy by NAOJ through the promotion of these three large-scale projects

① Are there other planets other than Earth that harbor life? (Subaru, ALMA, TMT)
② What is the true nature of dark matter and dark energy? (Subaru, TMT)
③ How did the universe begin? (ALMA, Subaru, TMT)

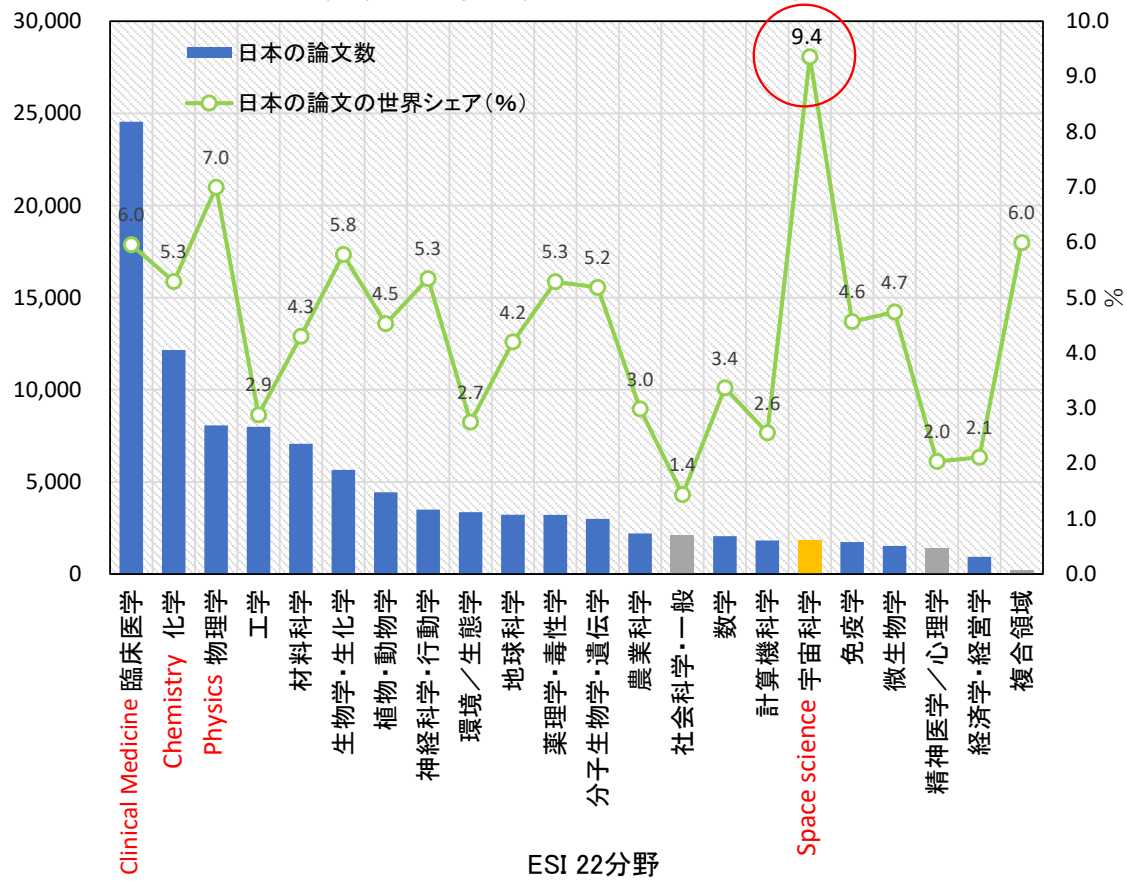
?

Consistency (science case) with existing projects(?)
Scale and structure of the project(?)

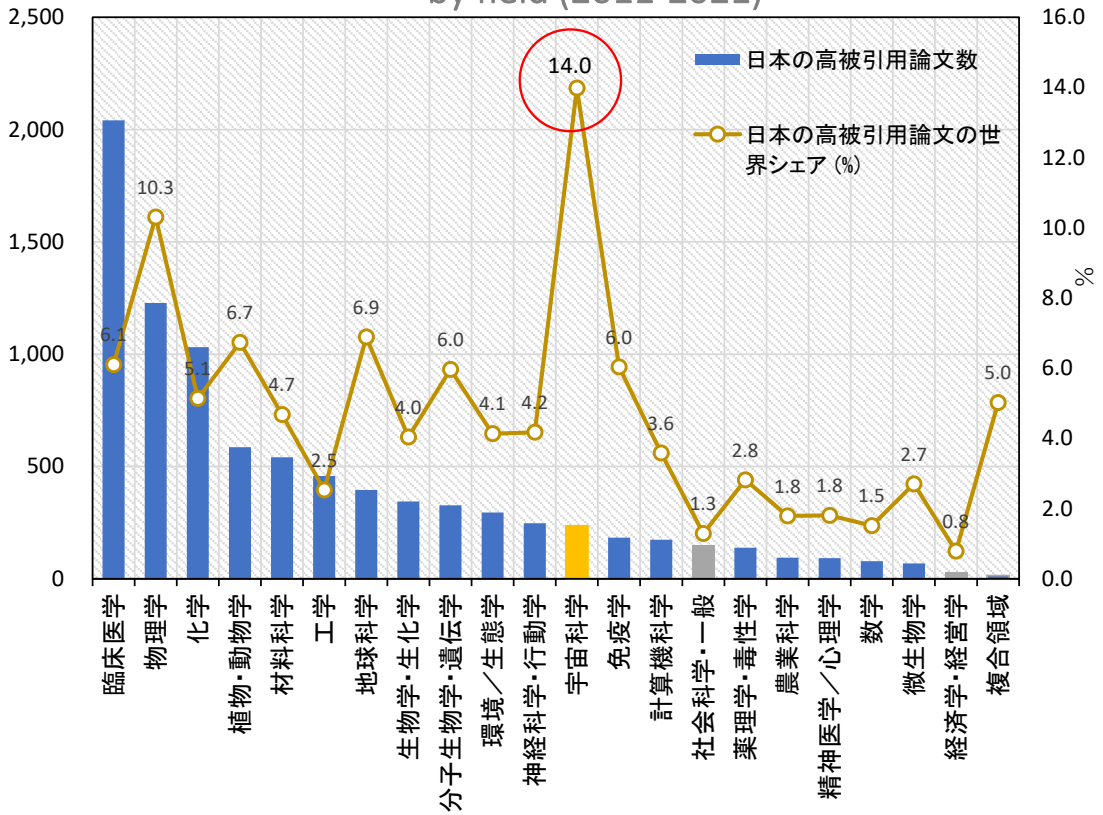
Number of papers in the field of Space Science in Japan (1)

Space science (astronomy): World share of the number of papers by field is the highest

Number of papers by Japanese authors by field (2021)



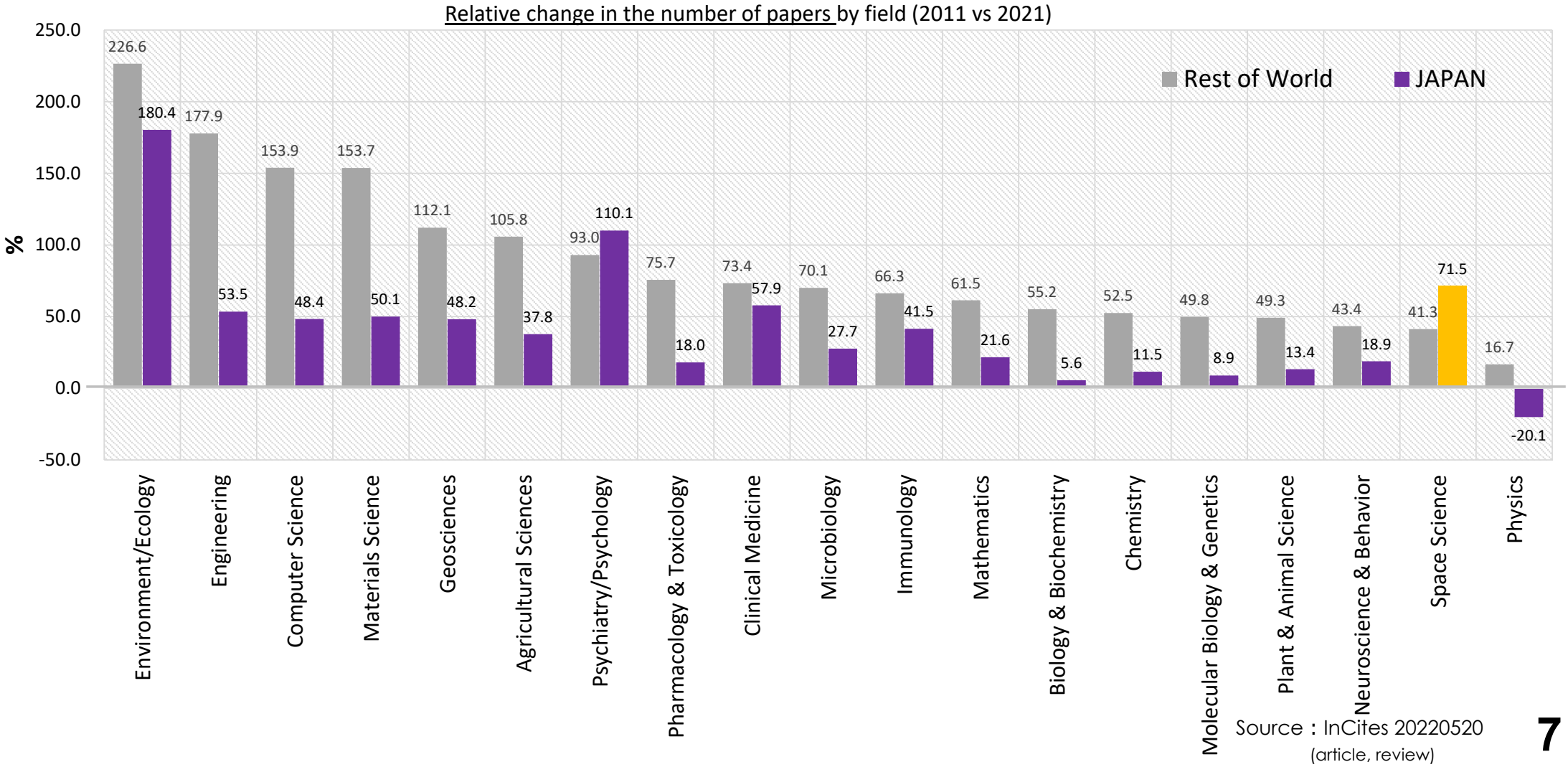
Number of highly cited papers by Japanese authors by field (2011-2021)



Source ：InCites 20220520
(article, review)

Number of papers in the field of Space Science in Japan (2)

Space science (astronomy): The rate of increase in the number of papers in the past 10 years has surpassed the world



Source：InCites 20220520
(article, review)

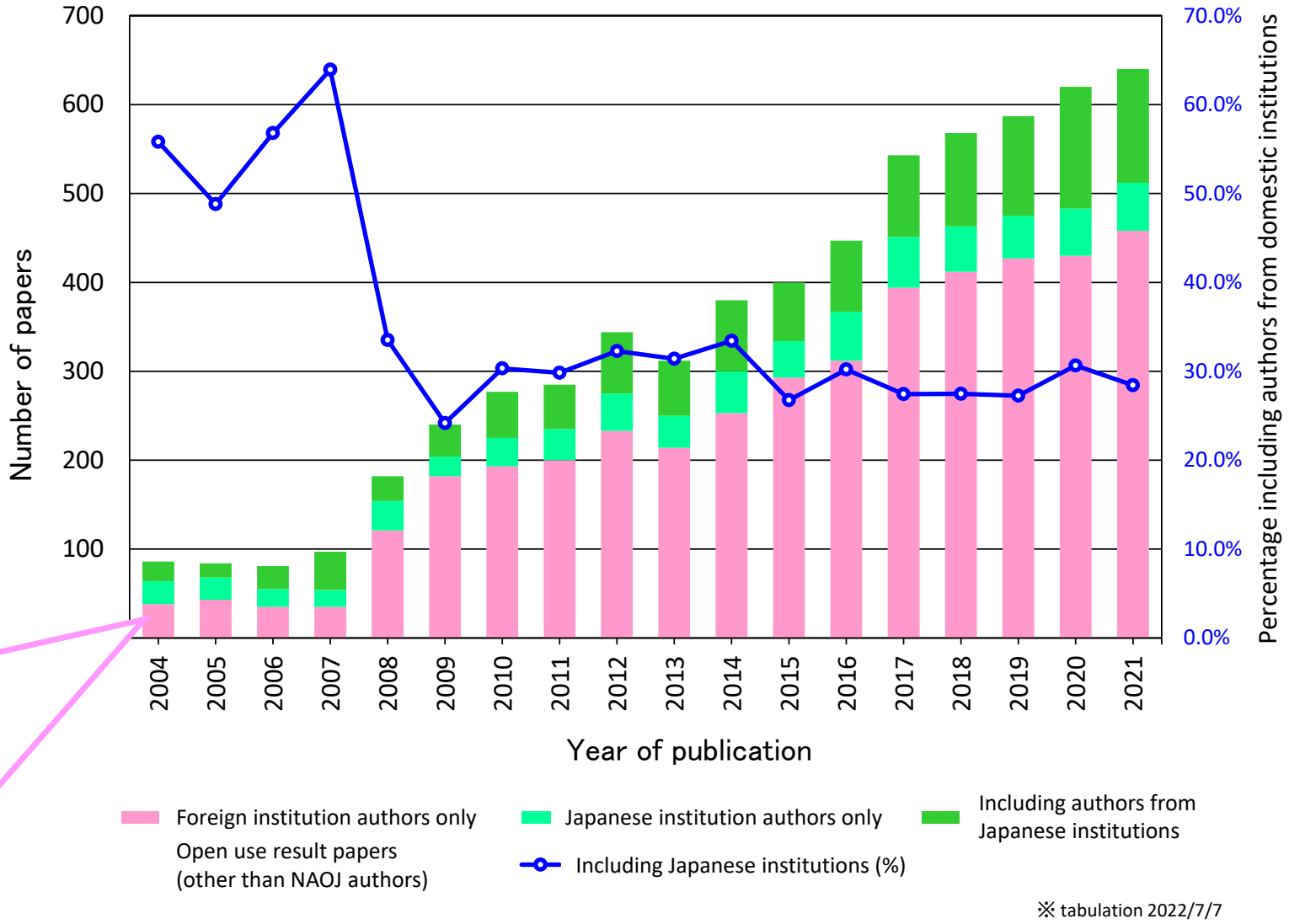
Changes in the number of joint research papers, not including NAOJ authors

Authors from overseas institutions only: 4,436 in total

■ Breakdown of facilities / equipment (with duplication)

- ALMA 1,962 (44 %)
- Hinode 1,230 (28 %)
- Subaru 667 (15 %)
- ADC 245 (6 %)
- NoRH 175 (4 %)
- NoRP 113 (3 %)
- CfCA 92 (2 %)

(CfCA includes Japanese)

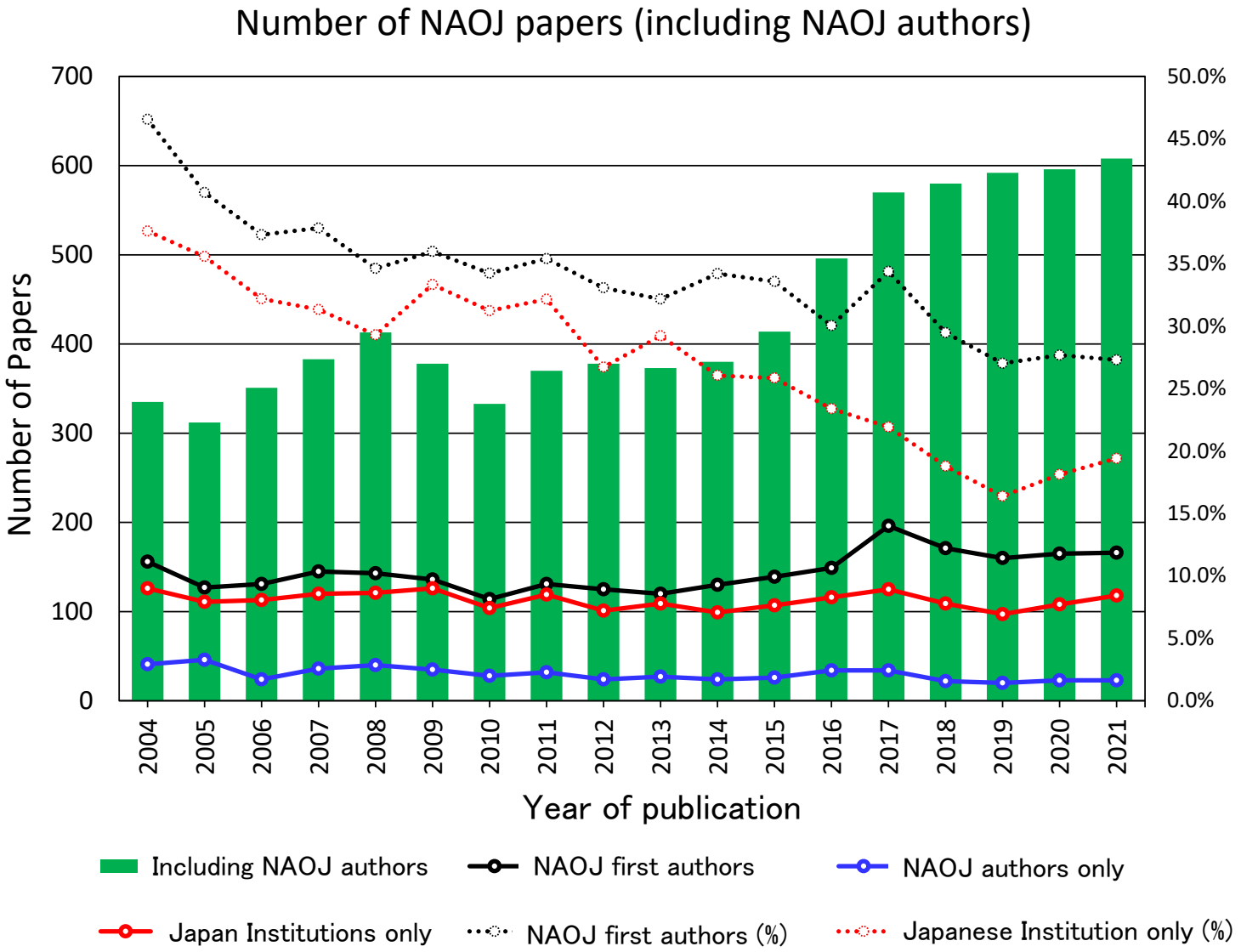


※ tabulation 2022/7/7

[Reference] Changes in the number of papers including NAOJ authors

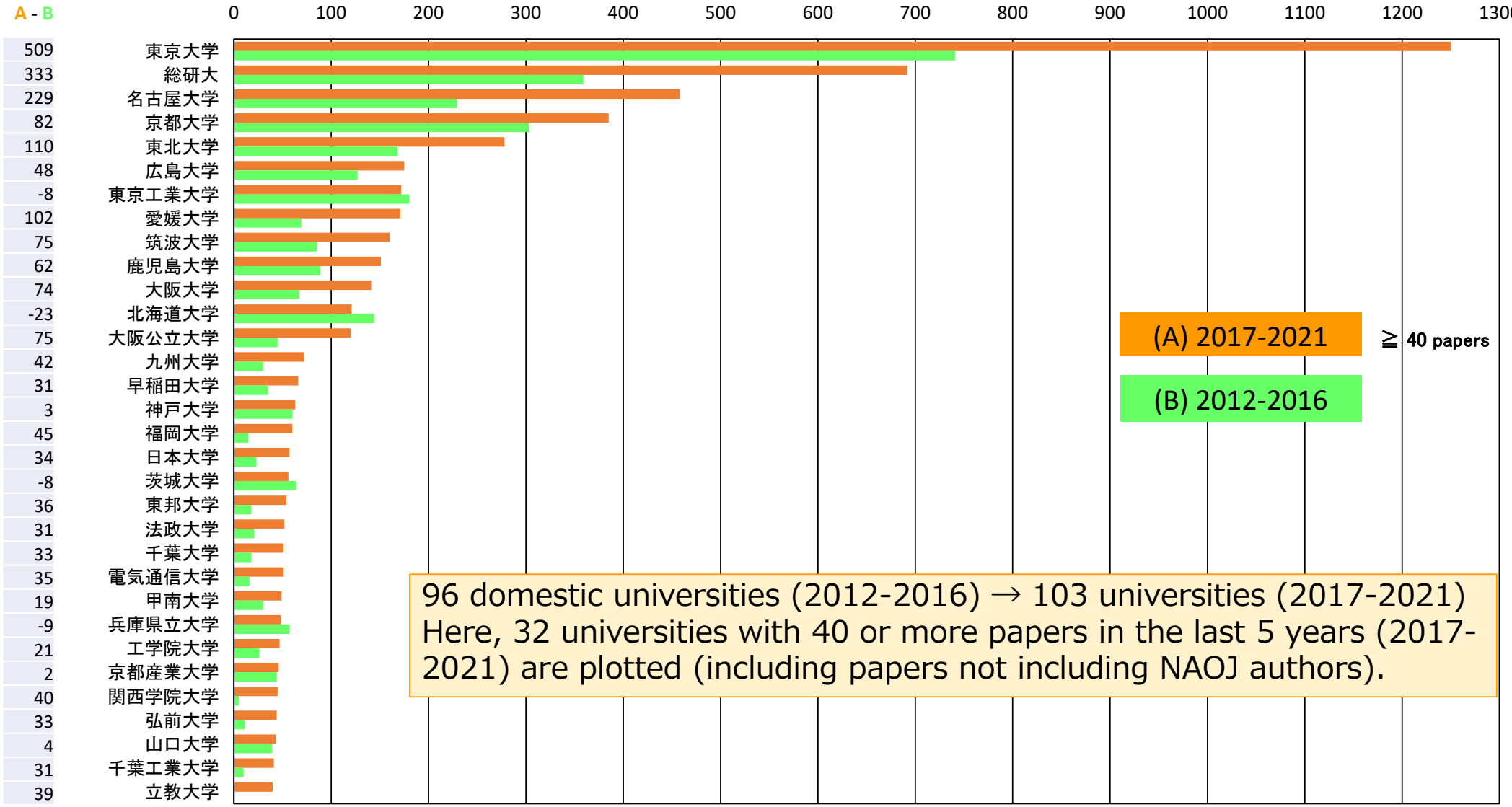
・The percentage of papers with NAOJ as the first author is on a downward trend. Reflecting the plateauing of the number of NAOJ researchers (the number of inherited staff members is gradually declining), the number of NAOJ first-author papers has stagnated. In contrast, the number of NAOJ papers has increased.

・ With the progress of international joint usage and joint research, the percentage of papers published only by Japanese institutions is on a downward trend (a slight recovery during the COVID-19 crisis).



Source: Web of Science Core Collection
Article & Review Only as of 2022/7/7

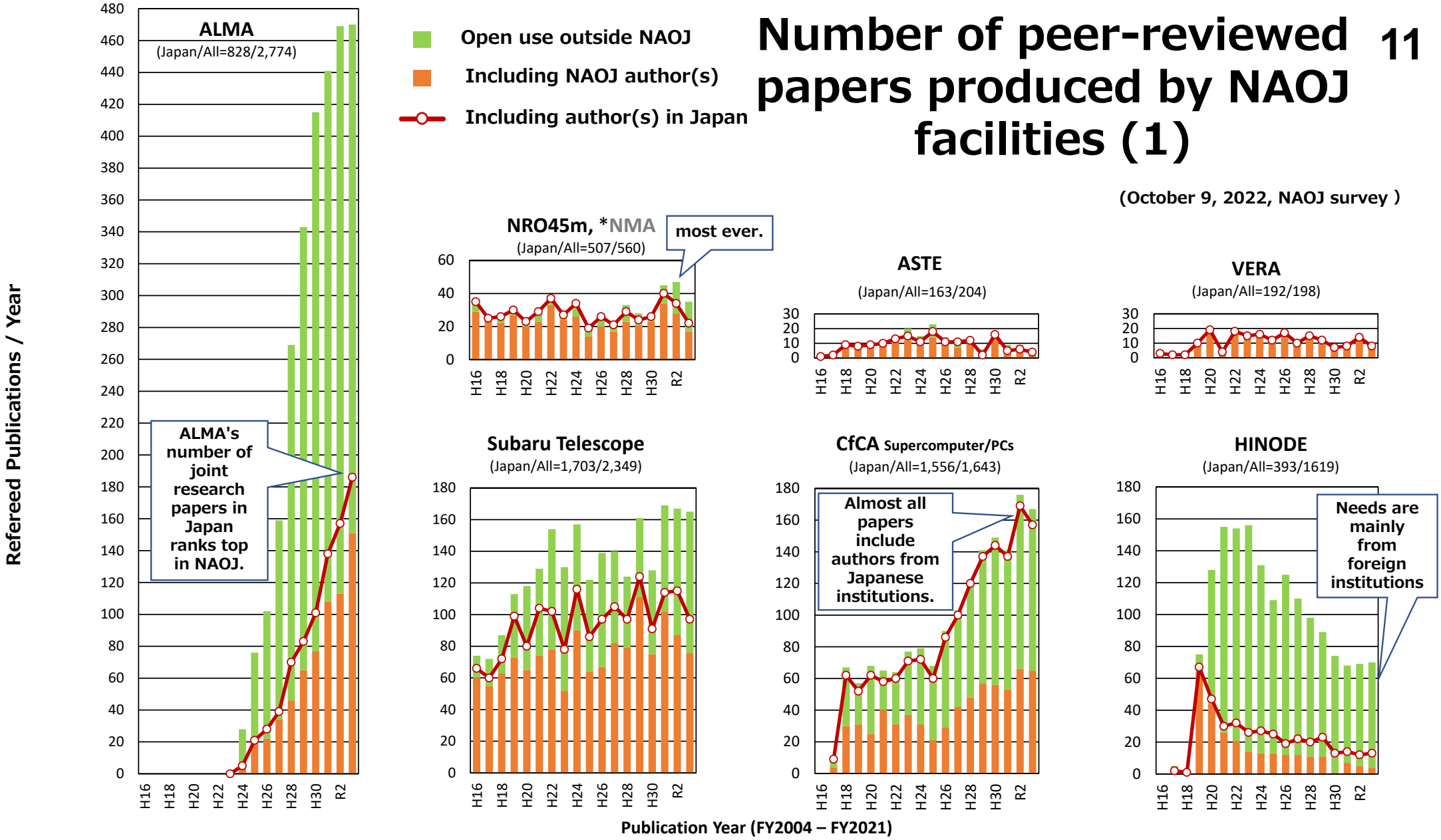
Changes in the number of papers published by domestic universities using facilities and equipment of NAOJ (every 5 years)



Source: InCites (article, review only: 2022-07-07)

Number of peer-reviewed papers produced by NAOJ facilities (1)

(October 9, 2022, NAOJ survey)



Number of peer-reviewed 12 papers produced by NAOJ facilities (2)

(October 9, 2022, NAOJ survey)

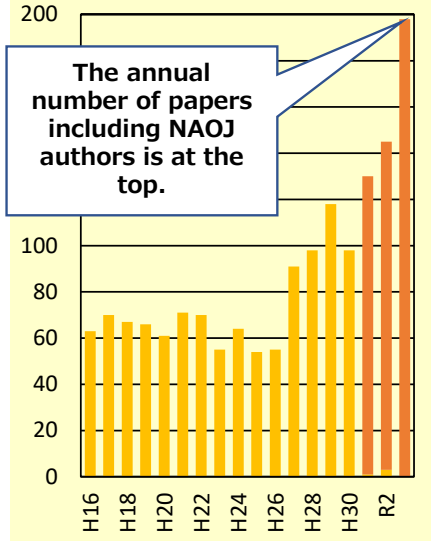
Open use outside NAOJ

Including NAOJ author(s)

Including author(s) in Japan

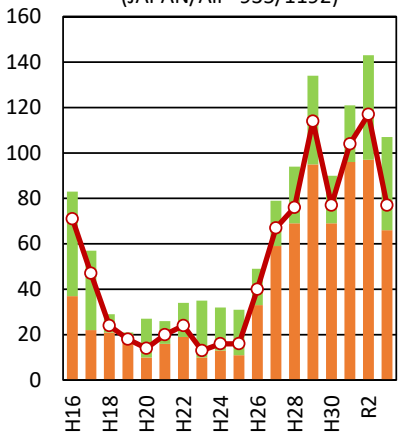
Refereed Publications / Year

[Reference] Theory → Science
(Japan = 1571)

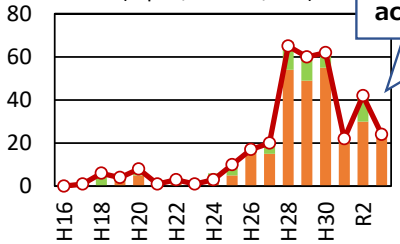


The annual number of papers including NAOJ authors is at the top.

ADC
(JAPAN/All= 935/1192)



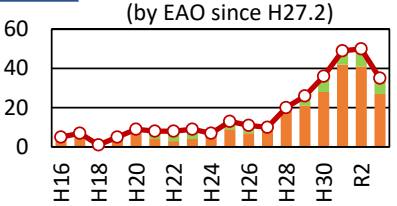
RCC Fund
(Japan/All=349/357)



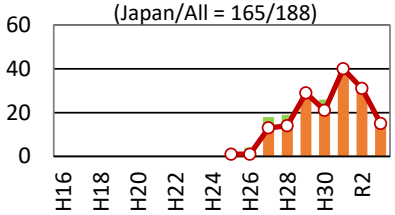
The number of papers supported by the Research Exchange Committee (with acknowledgments).

Only papers containing authors from domestic institutions are counted.

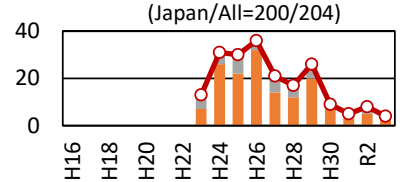
JCMT (Japan = 309)
(by EAO since H27.2)



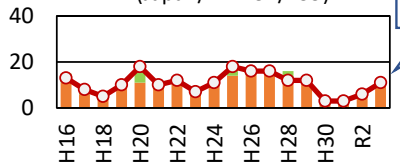
EACOA Fellow
(Japan/All = 165/188)



OISTER
(Japan/All=200/204)

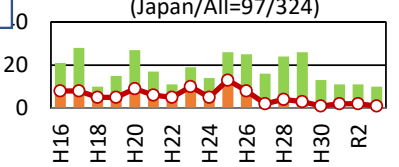


Okayama (*188cm, **SEIMEI**)
(Japan/All=191/199)

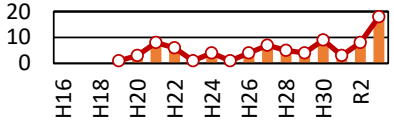


Kyoto University Seimei Telescope

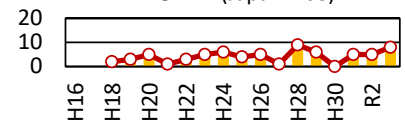
***NoRH, NoRP**
(Japan/All=97/324)



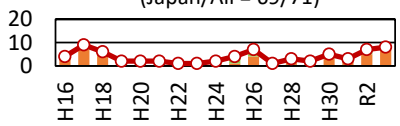
ATC (Japan = 82)



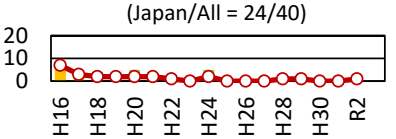
JVN (Japan = 68)



TAMA300, KAGRA
(Japan/All = 69/71)

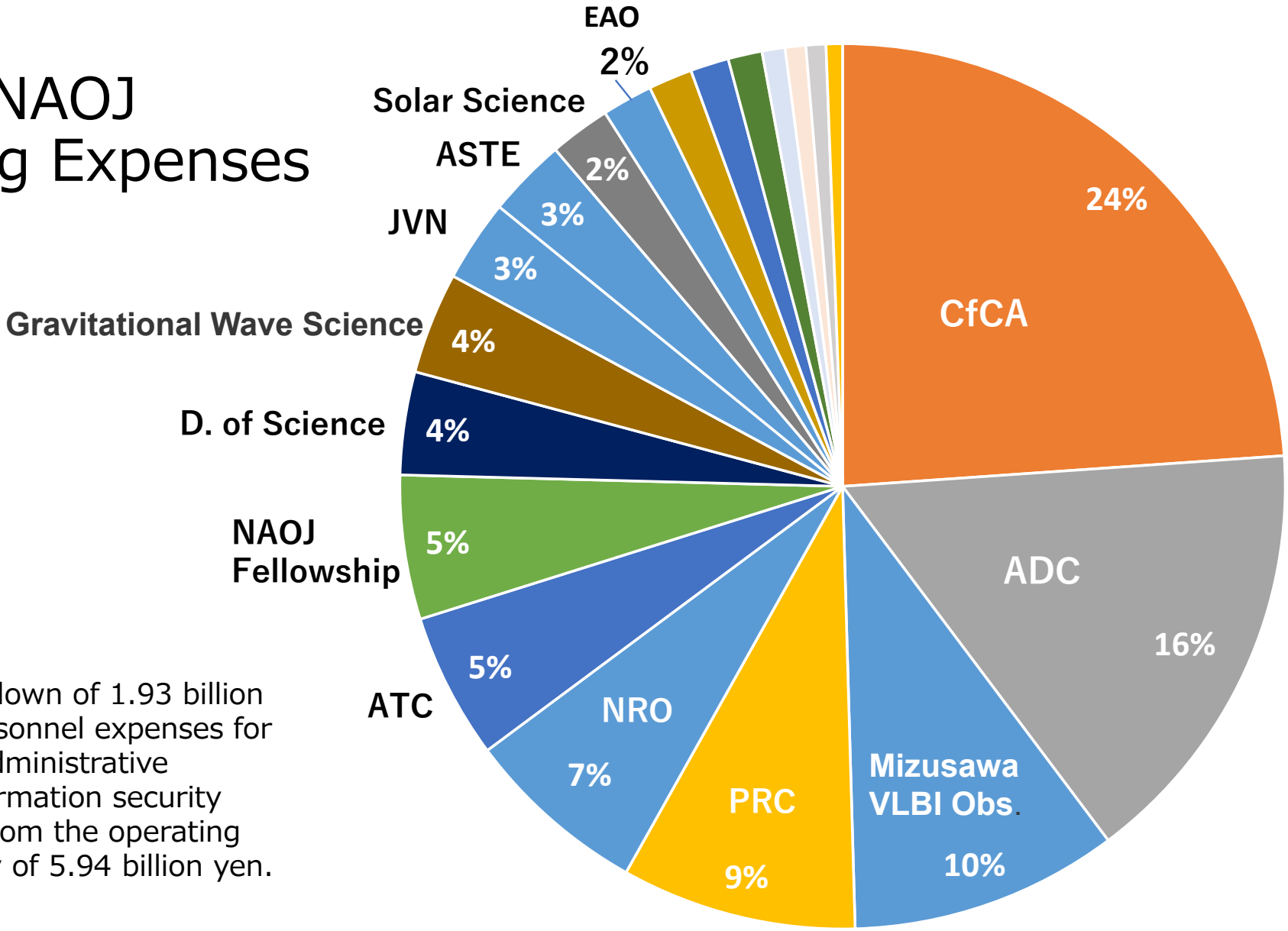


SOBS
(Japan/All = 24/40)



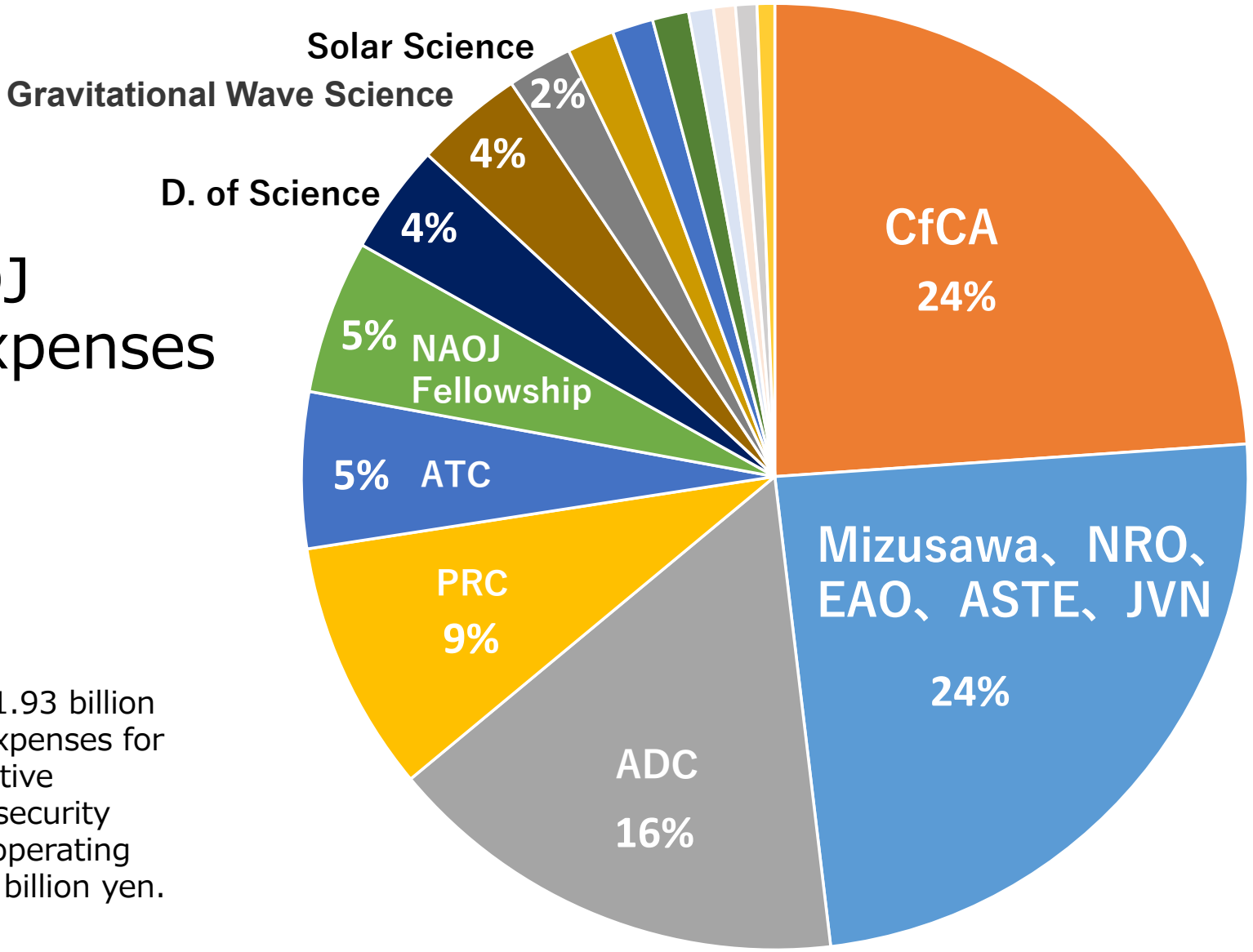
Publication Year (FY2004 – FY2021)

FY2022 NAOJ Operating Expenses Grant



Note) The breakdown of 1.93 billion yen excludes personnel expenses for inherited staff, administrative department, information security expenses, etc., from the operating expenses subsidy of 5.94 billion yen.

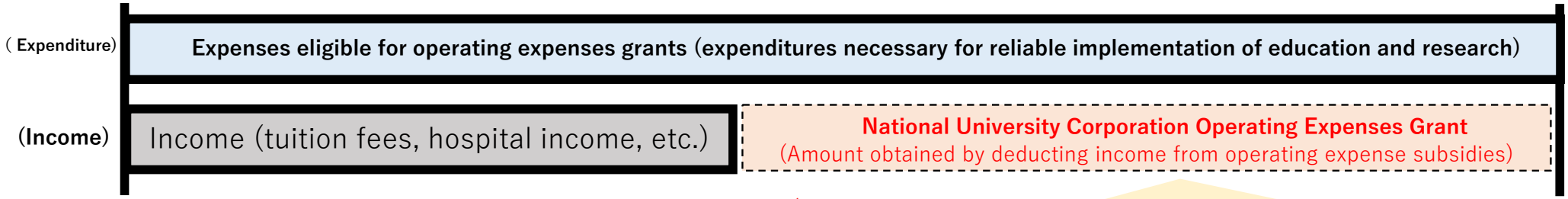
FY2022 NAOJ Operating Expenses Grant



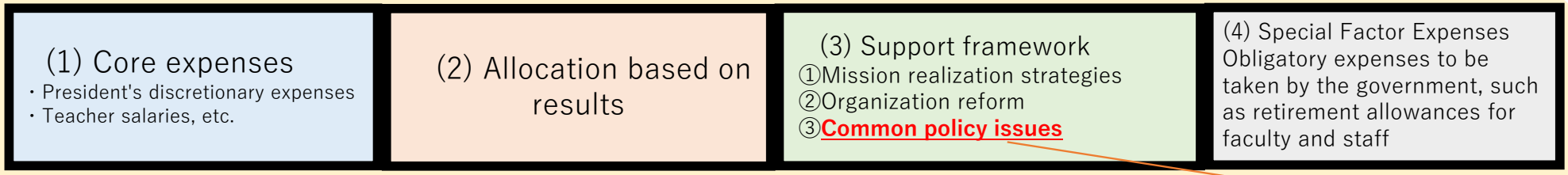
Note) The breakdown of 1.93 billion yen excludes personnel expenses for inherited staff, administrative department, information security expenses, etc., from the operating expenses subsidy of 5.94 billion yen.

Management Expenses Grants and Frontier Budget

National University Corporation Expenditures and Income



National University Corporation Operating Expenses Subsidy Composition (Under Higher Education Bureau National University Corporation Support Division)



Support for large-scale academic research projects (**Frontier budget**) is one of the business categories of **"③ Common Policy Issues."**

Operating expenses grant （（1）、（2））	Frontier budget （Part of (3) ③）
use is not specified	Usage is specified (limited to the project concerned, diversion between projects is not possible even within the frontier budget)
Some measures have been decided during the medium-term target period, although they are decreasing.	Annual budget request is required, required amount can be requested (increase can be requested)
Fixed amount reduction by coefficient (same operating expenses subsidy calculation rule for the same medium-term target period), redistribution based on evaluation of activity results, etc.	New project measures must be reviewed by the Science Council and listed on the Roadmap.
Personnel costs, CfCA, ADC, network costs, etc., PRC, Mizusawa VLBI Observatory, Nobeyama Radio Observatory, NAOJ Fellows, ATC, etc.	Subaru Telescope, ALMA, and TMT

* Details of the mission realization strategy are unknown at this time. As for educational and research organizational reforms and special factor expenses, their uses are limited, and measures will be taken upon request for an estimated amount.
* The frontier budget includes the National University Corporation Operating Expenses Grant (under the auspices of the National University Corporation Support Division, Higher Education Bureau), as well as the National University Corporation Advanced Research Promotion Subsidy (University Research Infrastructure Development Division, Research Promotion Bureau (former Academic Institutions Division) (outside the number in the above).

Evaluation of the Scientific Research Department
Evaluation by the National University Corporation Evaluation Committee

* Results of evaluation at the end of the fourth year:
●Overall
Document 1 Evaluation results of work performance related to the 3rd mid-term target period (fourth-year terminal evaluation) (National University Corporation Evaluation Committee)

● Status of education and research
Document 2 Evaluation results regarding the achievement status of mid-term goals (University Reform Support and Degree Awarding Organization)

Document 3 **Analysis of the current state of research (University Reform Support and Degree Awarding Organization)**

Document 3
https://www.niad.ac.jp/sub_hyouka/kokudai2020/3_2020_88_sizen_kagaku_3.pdf
(Underlined is National Astronomical Observatory of Japan)

Analysis item Ⅰ　Status of research activities

[Judgment] Remarkably high quality

[Reason for the evaluation]
The basic quality of research activities has been achieved.
NAOJ **established an exploratory project** responsible for the next generation of astronomy. It has **established a device development project and a study group for future plans** to strengthen its research system. Specifically, **in April 2019, four research departments (theoretical, optical/infrared, radio, and solar astronomical plasma) were integrated to establish the "Division of Science,"** "Fundamental Polarization Theory of Planetary Disks Demonstrated by ALMA," and Study of Supernova Explosions Forming Neutron Star Binaries as Gravitational Wave Sources". NAOJ has **made research achievements that transcend the boundaries between theory and observation**.

[Excellent point]
○Encouraged the establishment of emerging projects that will lead the next generation of astronomy and strengthened the system by establishing a study group for equipment development projects and future plans.

[Distinctive points]
○ The research system was reviewed, and in April 2019, **the four research departments (Theory, Optical and Infrared, Radio, and Solar Plasma) were integrated to establish the "Division of Science." In addition to consolidating clerical work, researchers will conduct research based on free ideas under new keywords in astronomy, such as the fusing of theoretical and observational study, multi-wavelength astronomy, and multi-messenger astronomy. Many results have been produced that transcend the boundary between theory and observation.**

分析項目Ⅱ　研究成果の状況

[Judgment] Remarkably high quality

[Reason for the evaluation]
Academically outstanding research achievements and socially, economically, and culturally outstanding research achievements were evaluated as 19 cases and 4 cases, respectively. and judged to be of noteworthy high quality.
In particular, NAOJ is utilizing the performance of the Subaru Telescope's ultra-wide-field prime focus camera to conduct large-scale statistical research using samples of 580,000 distant galaxies. A comparative study with cosmological models shows that the birth and evolution of the universe and stars are explained by two factors: structural formation due to gravity and the expansion of the universe. In addition, NAOJ conducted large-scale quasar exploration observations targeting the dawn of the universe, discovered nearly 100 supermassive black holes, and made precise measurements of their number density, etc., to make detailed comparisons with theoretical models regarding the origin of supermassive black holes. making it possible.

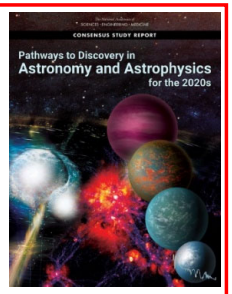
NSF's Formal process begins for TMT construction

For the completion and operation of TMT, the formal participation of the NSF and the investment of the US federal budget are indispensable. To this end, we have proposed the United States Extremely Large Telescope Program (US-ELT Program), which combines TMT and GMT, and is progressing as follows.

① Considerations and Suggestions by the Community

- Scientific Review/International meetings
- Proposal for US Decadal Survey (Astro 2020)* (Completed)
- Review by Panel (Completed)
- Astro 2020 Released (November 2021) (Completed)

US Decadal Survey (Astro 2020): A future planning evaluation process by the US science community, sponsored by NSF and NASA and conducted by the National Academy of Sciences.



As a ground-based telescope plan, the US-ELT program combining TMT and GMT was identified as the highest priority.

② Review by NSF

- TIO Submits NSF MREFC Design Stage Proposal as Part of US-ELT Program (Completed)
- NSF formed a team in charge of Hawai'i issues and conducted informal dialogues with Native Hawaiians and other stakeholders (completed)
- NSF environmental review in Hawai'i and the Section 106 process under the National Historic Preservation Act (ongoing)
- PDR by NSF (Nov. 2022～)
- FDR by NSF, Participation formal decision by NSF Director
- Approved by the National Science Board (NSB)

③ Federal Government / Congressional Approval

【from now on 】

- Federal Office of Management and Budget (OMB) Prepares Budget with NSF
- Deliberation and approval by Congress
- Injection of US federal funds (MREFC budget)

※ NSB: Consisting of representatives from academia and industry, it sets policy for NSF and advises the President and Congress on science and technology policy.

- **Environmental Impact Study (EIS):** Scoping meetings were held on August 9-12 on Hawai'i Island (Hilo, Na'alehu, Kona and Kamuela). A draft evaluation report will be prepared in the summer of 2023
- **National Historic Sites** Section 106 of National Historic Preservation Act (NHPA): Work to identify heritage sites to begin in winter 2022; An agreement document will be drawn up in the summer.
- **The Preliminary Design Review (PDR)** is a key gateway for NSF to adopt and implement major construction projects. The PDR decides on budget proposals for requests to the Office of Management and Budget of the United States Office of the President and to the United States Congress. All projects that have passed NSF's PDR have been realized, including ALMA, DKIST, and the Rubin Observatory.

Multilateral efforts for consensus building in Hawai'i (the construction site)

Enhancing U.S. Federal Government Engagement

- Informal Dialogue in Hawai'i (~2020)
- Announcement of plans for environmental impact assessment in Hawai'i
- Successful briefing and opinion exchange meetings on Hawai'i Island
- Holding workshops
- Conclusion of agreement documents

Cooperation between State Government and State Legislature

- Establishment of a working group under the Hawai'i Legislature to consider a new management organization for Mauna Kea
- Hawai'i New Law, **Act 255**
- Establishment of the Mauna Kea Stewardship and Oversight Authority **(MKSOA)** to replace the University of Hawai'i
- Activities of MKSOA

TIO policy change

- ・Renewal of TMT International Observatory (TIO) Executive Office
- ・Renewal of the Hawai'i Outreach Team
- ・Significant increase in NAOJ's involvement in TIO management
- grassroots dialogue with the opposition
- Educational and vocational training programs to be proposed to NSF
- Ongoing Support for Educational Activities in Hawai'i County

Mauna Kea Observatories

- Mauna Kea Observatories(MKO)
- Decommission of existing telescopes, which was an issue
- Agreed to establish Maunakea Alliance to develop astronomy in Hawai'i 2022.10.26
- Mauna Kea Observatories including TMT respond to various issues with one voice

Direct dialogue with hardline opposition

- **ho'oponopono** (held 6 times) 2019～2020
- Activities of Hawai'i Executive Collaborative
- Alleviation of long-standing issues in Hawai'i through future-oriented dialogue

Significant improvement in the situation surrounding TMT

Direct dialogue and educational support efforts by the TMT International Observatory (TIO) in Hawai'i have fostered a relationship of trust with the local community. With the establishment of a new management organization for Mauna Kea by the State of Hawai'i government and the start of the NSF budgeting process, the move toward resuming construction on site accelerated.

From June 2021
Direct dialogue by TIO in Hawai'i

- TMT project leaders transferred to Hawai'i to build trust with the indigenous people through direct dialogue based on listening and respect and educational support that meets the needs of wider communities ➡ ***Changes in voices of grassroots communities***

(Example) We have improved our relationship with an indigenous elder, who was once a TMT protester arrested in 2019 for blocking the road, to an extent where he now supports TIO's stance and has friendly conversation with us.

November 2021
Highest rating at Astro2020

- In the Astro2020 (evaluated by the National Academy of Sciences), the US-ELT (the United States Extremely Large Telescope) program, which combines TMT and GMT, was ranked as the top priority plan for a ground-based telescope plan.

From July 2022

Indigenous Participation in Mauna Kea Management

- Hawai'i state law was passed (July 2022) to establish a new management organization for Mauna Kea with the participation of indigenous people whose voices have been neglected until now. A path will be opened for the Native Hawaiian community to share benefits (land rent, observation time) fairly ➡ ***Moving toward sublimating the TMT issue into larger issues surrounding Maunakea management and the indigenous people***

From July 2022
NSF budgeting process begins

- **Environmental Impact Assessment in Hawai'i, National Historic Preservation Act Process** (July 2022-)
- **Preliminary design review (PDR) of the TMT project** (from November 2022)

Resumption of construction in Hawai'i

Federal budget

Large-scale academic frontier promotion project

- In 2012, the “Large-scale Academic Frontier Promotion Project” was established.
- **To provide stable and continuous support for large-scale projects that are attracting attention from around the world, it will provide support to respond swiftly and appropriately to international competition and cooperation based on the "Roadmap” etc. to promote.**
- The fiscal 2022 budget is 33.7 billion yen.
- Currently, it is promoting 14 projects based on the annual plan.

The flow of target project selection so far

- **The Science Council of Japan** has formulated a **”Master plan"** based on the wishes of the broad science research community.
- **The Ministry of Education, Culture, Sports, Science, and Technology (MEXT)** formulated a **”Roadmap”** from the perspective of clarifying priorities in promoting large-scale projects, referring to the master plan.
- Based on the roadmap, **the MEXT** will consider new projects that should be started immediately, consult with the Council for Science and Technology, and make **budget requests**.

Large-scale academic frontier promotion project

List of large-scale academic research projects

“Efforts to Strengthen Research Capabilities of Universities
- Toward the Formation of Diverse Research Universities –
September 16, 2020, National University Research Institutes and Centers Conference Standing Committee (2nd meeting)
From University Research Infrastructure Development Division, Research Promotion Bureau

Relationship between the Master Plan of the Science Council of Japan and the Roadmap of the Science Council of the MEXT

(September 2, 2010, MEXT Council for Science and Technology, Science Subcommittee, Research Environment Infrastructure Subcommittee, Working Group on Large-Scale Scientific Research Projects)

https://www.mext.go.jp/component/b_menu/shingi/toushin/__icsFiles/afieldfile/2010/10/29/1298715_2.pdf

2. Formulation of roadmap

○ **The Science Council of Japan proposed a "Master Plan" (March 2010)**

・・・**Consists of 43 research plans in 7 fields (each plan is evaluated from a scientific perspective)**

○ **The working group sets the evaluation perspective, conducts interviews, etc., for each research plan, and formulates a Roadmap.**

[Contents of Roadmap]

・Outline of the plan ・implementation body ・required expenses ・plan period ・evaluation results ・main advantages, etc. ・main issues and points to consider, etc.

*The Roadmap does not guarantee budget measures, but it is material that should be fully considered when promoting related measures.

*The Roadmap will be revised periodically based on future revisions to the Master Plan.

(2) Consideration based on the Master Plan

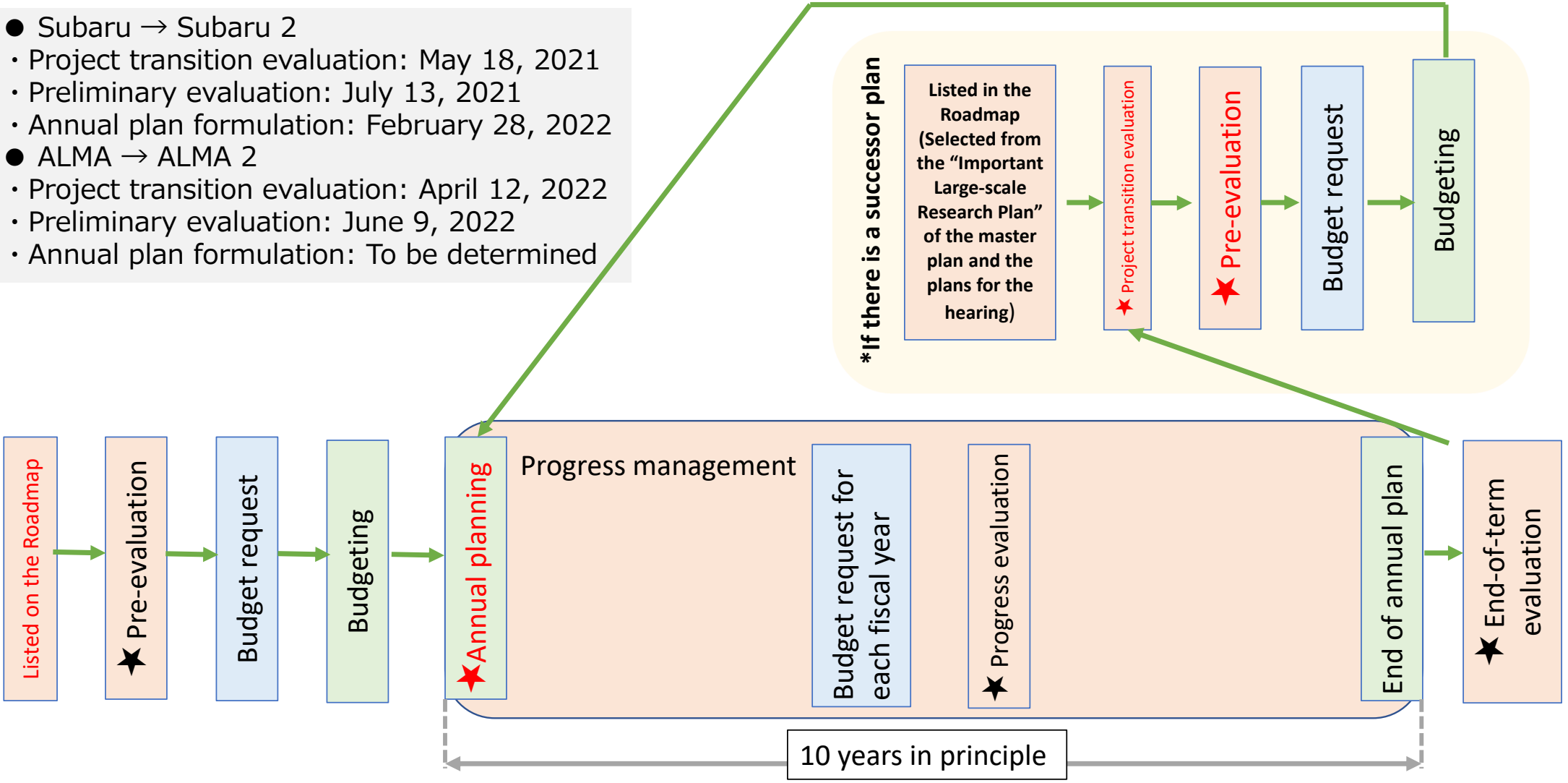
○The roadmap does not guarantee budgetary measures, but it is appropriate to use it as a material that should be fully considered when promoting related measures.

○Based on the Master Plan evaluated purely from a scientific point of view, the evaluation results, prominent advantages, issues, and points to consider for each research plan are organized from the viewpoint of clarifying the priority in promoting large-scale projects.

Large-scale project promotion (frontier project management) flow

★ indicates working group hearings

- Subaru → Subaru 2
  - Project transition evaluation: May 18, 2021
  - Preliminary evaluation: July 13, 2021
  - Annual plan formulation: February 28, 2022
- ALMA → ALMA 2
  - Project transition evaluation: April 12, 2022
  - Preliminary evaluation: June 9, 2022
  - Annual plan formulation: To be determined



Working Group on Large-Scale Academic Research Projects "Project Transition Evaluation (Report)" and "Preliminary Evaluation (Report)" [Excerpt]

"Research on joint use of the Large Optical Infrared Telescope Subaru" (June 15, 2021)
(https://www.mext.go.jp/content/20210819-mxt_gakkikan-000017209_1.pdf)

Subaru → Subaru 2
Project transition evaluation

4. Project progress evaluation and future considerations
(1) Evaluation based on project achievement status
・・・From a comprehensive point of view, the "Research on the Joint Use of the Large Optical and Infrared Telescope Subaru" has achieved its initial objectives and produced excellent results that lead the field of astronomy. It can be evaluated that **it is appropriate to shift to a succession plan** while taking advantage of the results.

"Promoting international joint research with the ultra-wide-field large optical infrared telescope "Subaru 2"" (July 28, 2021)
(https://www.mext.go.jp/content/20210819-mxt_gakkikan-000017306_1.pdf)

Subaru 2
Prior evaluation

3. summary
(1) Comprehensive evaluation
・・・Highly urgent and strategic, it can be evaluated as a plan that can gain the consensus of domestic and international research communities and the support of society and the public.
To achieve the four scientific goals based on the excellent results NAOJ has achieved so far, **develop new observation equipment, such as PFS and ULTIMATE, and implement measures to address the aging of existing equipment**, which will become an essential factor in the future. As a telescope that other telescopes cannot replace, it is hoped that Japan will continue to play a leading role, lead the world in astronomy, and maintain its international competitiveness.
Considering the above, we evaluate that **this plan should be actively promoted and started as soon as possible.**

Working Group on Large-Scale Academic Research Projects "Project Transition Evaluation (Report)" and "Preliminary Evaluation (Report)" [Excerpt]

"Promotion of international joint research using the large radio telescope ALMA" (May 23, 2022)
(https://www.mext.go.jp/content/20220523-mxt_gakkikan-000025944_1.pdf)

ALMA → ALMA 2
Project transition evaluation

4. Project progress evaluation and future considerations
(1) Evaluation based on project achievement status
・・・From a comprehensive point of view, the ``promotion of international joint use research using the large radio telescope ALMA'' has achieved its initial objectives and produced excellent results that lead the field of astronomy. It can be evaluated that it is appropriate to shift to a succession plan while using its importance, results, ripple effects, etc.

"Large-scale Millimeter-wave Submillimeter Telescope ALMA 2 Project for Exploring the Origins of the Universe and Life" (July 28, 2022)
(https://www.mext.go.jp/content/20220728-mxt_gakkikan-000025951_1.pdf)

ALMA 2
Prior evaluation

3. Summary
(1) Comprehensive evaluation
・・・Highly urgent and strategic, it can be evaluated as a plan that can gain the consensus of domestic and international research communities and the support of society and the public.
To achieve the three scientific goals based on the excellent achievements so far, NAOJ will **improve the performance of the telescope** (doubling the resolution, sensitivity, and frequency band) and appropriately promote maintenance and management, including *measures against aging*. As a result, it is expected that Japan will continue to lead cutting-edge radio astronomy research in strong collaboration with the United States and Europe and maintain its international competitiveness.
Considering the above comprehensively, we evaluate that **this plan should be actively promoted and should be started as soon as possible.**

Completion date of the current plan for large-scale academic frontier promotion projects

	Subaru ➡ Subaru 2		ALMA ➡ ALMA 2		TMT (※2)
End of Current Annual Plan	FY2021	FY2031	FY2022	FY2032	**FY2021**
Succession plan	Subaru 2	–	ALMA 2	–	–
Road Map status	Listed as Subaru 2 on RM2020	–	Listed as ALMA 2 on RM2020	–	–

(*1) A large-scale project working group conducts business transition evaluation, and preliminary assessment formulates an annual plan, and shifts to the next plan.
(*2) As a result of the reevaluation of progress by the large-scale project working group in FY2019, it was decided that if the outlook for project completion by the end of FY2021 became apparent, a new progress evaluation would be conducted.

“Roadmap 2020” Listed Plans

*Working Group on Large Scientific Research Projects
Research Environment Infrastructure Subcommittee,
Science Committee, Council for Science and Technology

The MEXT's Council for Science and Technology* reviewed 60 plans and listed 15 on Roadmap 2020.

- **Model Building in the Humanities through Data-Driven Problem Solving**
  (National Institute of Japanese Literature, National Institutes for the Humanities)
- **Establishment of world-leading research and training center for infectious diseases with a high containment laboratory (BSL-4)**
  (Nagasaki University)
- **Human Glycome Project**
  (Tokai National Higher Education and Research System; Nagoya University and Gifu University)
- **Establishment of strategic center for elucidating basis of human diseases and their prevention**
  (The University of Tokyo Medical Genomics Research Initiative)
- **High Magnetic Field Collaboratory-Formation of Unified Next Generation All Japan Facility**
  (The University of Tokyo The Institute for Solid State Physics)
- **Super B-Factory Project at KEK**
  (High Energy Accelerator Research Organization)
- **Quest for the origin and evolution of universe and matter with high-intensity proton beams**
  (High Energy Accelerator Research Organization)
- **ALMA2: A Giant Millimeter/submillimeter Telescope in Search of our Cosmic Origins**
  (National Institutes of Natural Sciences National Astronomical Observatory of Japan)
- **Large-scale Cryogenic Gravitationalwave Telescope KAGRA**
  (The University of Tokyo, Institute for Cosmic Ray Research)
- **Subaru 2 - Super Wide Field Large Optical-Infrared Telescope**
  (National Institutes of Natural Sciences National Astronomical Observatory of Japan)
- **LiteBIRD - A Satellite for Exploring the Universe before the Hot Big Bang with Measurements of Cosmic Microwave Background Polarization**
  (Japan Aerospace Exploration Agency)
- **New developments in neutrino physics at “Super-Kamiokande”**
  (The University of Tokyo, Institute for Cosmic Ray Research)
- **Next-generation academic research platform for promoting research data utilization, circulation, and management**
  (Research Organization of Information and Systems, National Institute of Informatics)
- **Attosecond Laser Facility (ALFA)**
  (The University of Tokyo)
- **Building and Developing “Spintronics Research Infrastructure and Network”**
  (The University of Tokyo)

“Efforts to Strengthen Research Capabilities of Universities
- Toward the Formation of Diverse Research Universities -
September 16, 2020 National University Research Institutes and Centers Conference Standing Committee (2nd meeting)
From University Research Infrastructure Development Division, Research Promotion Bureau

*Underlined are successor plans (8 plans) for large-scale academic frontier promotion projects.
*Parentheses are implementing organization (core institution) .

"Roadmap 2020" Listed Plans

*Working Group on Large Scientific Research Projects Research Environment Infrastructure Subcommittee, Science Committee, Council for Science and Technology

The MEXT's Council for Science and Technology* reviewed 60 plans and listed 15 on Roadmap 2020.

1. Ended project

- TMT (Master Plan 2020 rejected)
- SPICA (Master Plan 2020 rejected)
- LHD (Nuclear Fusion) (Master Plan 2020 was not adopted. Frontier project ends FY2022, but the budget is requested for an academic research infrastructure project from FY2022)

2. Plan to end

- KAGRA (gravitational waves) (Frontier project ends FY2022, end-of-term evaluation in FY2023)

(Note) LiteBIRD has been listed in both Master Plan and Roadmap for three consecutive times from 2014 to 2017 and 2020.

- **Quest for the origin and evolution of universe and matter with high-intensity proton beams**
  (High Energy Accelerator Research Organization)
- **ALMA2: A Giant Millimeter/submillimeter Telescope in Search of our Cosmic Origins**
  (National Institutes of Natural Sciences National Astronomical Observatory of Japan)

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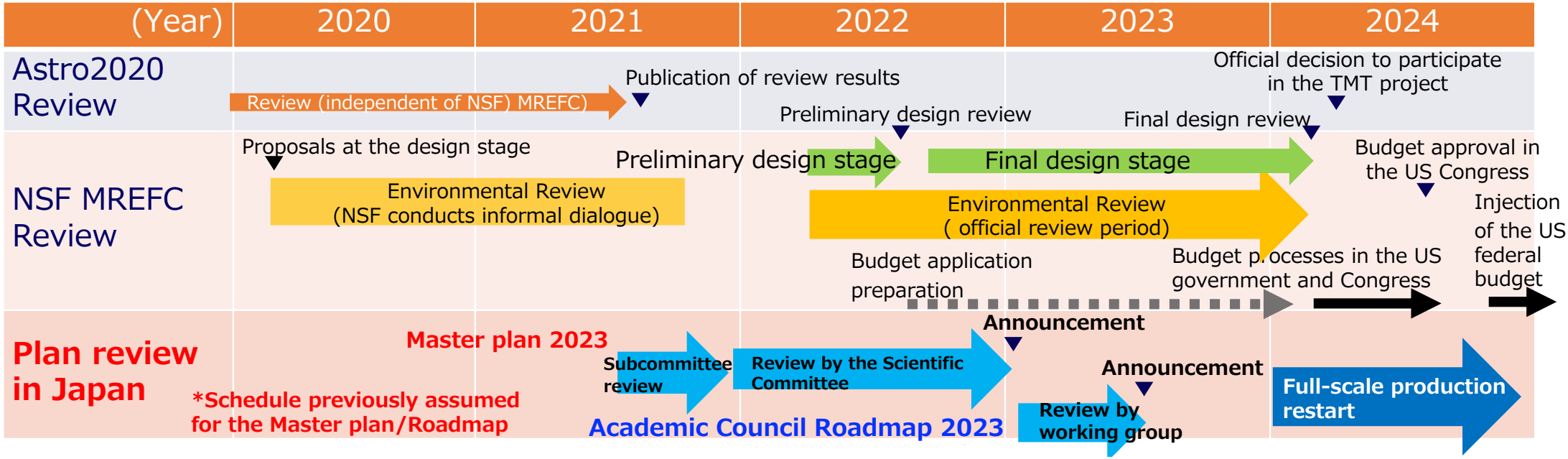
*Parentheses are implementing organization (core institution) .

TMT not adopted in the 2020 master plan of the Science Council of Japan, which damages the international continuity of large-scale international cooperation projects TMT

As an international cooperation project, many countries have already invested heavily in TMT, and despite the suspension of construction, preparations are progressing steadily. **To be consistent with the TIO master schedule, it was essential for the TMT plan to be adopted in the Master Plan 2020 in Japan, positioned in the Roadmap 2020, and continuously budgeted as a frontier promotion project. As the US-ELT program by the US NSF progresses, the situation in Japan is viewed with unease.**

A schedule for recovery which had been planned

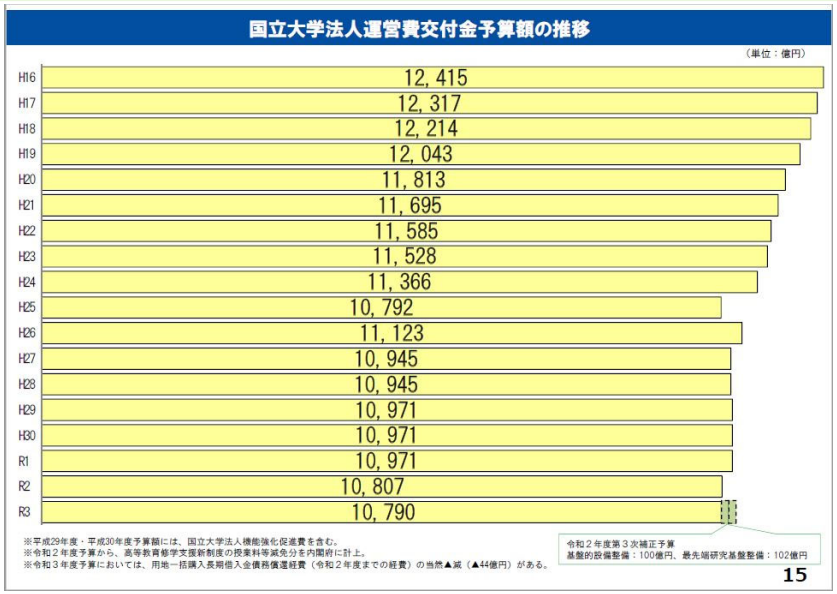


The gap between the Future Science Promotion Concept and the Science Council

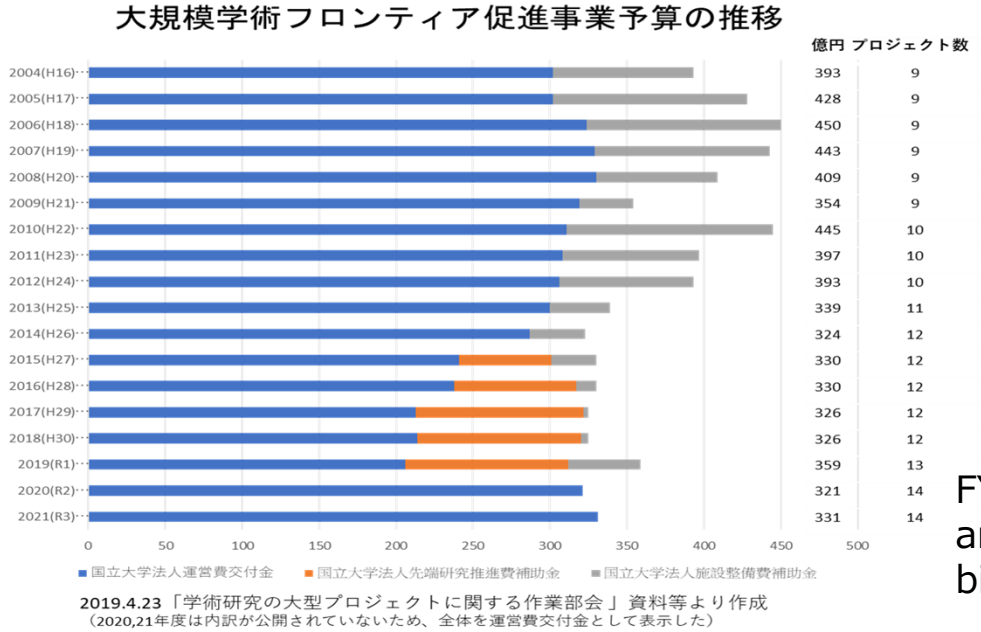
So far	Science Council of Japan "Future Academic Promotion Concept"	Council for Science and Technology, MEXT "Roadmap"
•April 2021: Submission of letter of intent (LOI) as a large-scale plan for Master Plan 2023. • September 2021: The Coordinating Committee for Optical and Infrared Astronomy recommends TMT as the top priority large-scale project in Master Plan 2023 • ～Science Council of Japan decided not to formulate a master plan～ • January 2022: The Astronomy and Astrophysics Subcommittee of the Science Council of Japan decides on the ranking of plans to be recommended as priority large-scale projects. • September 2022: Hearing and review by the Subcommittee on Research Planning and Research Funding of the Committee for Scientists. • January 2023: Formulate and publish Master Plan 2023. • January 2023: A working group of the Council for Science establishes perspectives for evaluation. • Spring 2023: Hearings about each research plan at the working group • Summer 2023: Formulation and publication of Roadmap 2023	• April 2021: Submission of letter of intent (LOI) as a large-scale plan for Master Plan 2023. • September 2021: The Optical and Infrared Astronomy Coordinating Committee recommends TMT as the first priority large-scale project in Master Plan 2023. • ～～Science Council of Japan decided not to formulate a master plan～～ • June 2022: The Science Council of Japan announced a policy to formulate a “Future Science Promotion Concept” (“Grand Vision” + “Academic Research Concept”) instead. • June-December 2022: Widely soliciting "Academic medium- to long-term research strategies" ("vision proposal" + "scientific research plan proposal") toward the creation of the plan • From December 2022: Start evaluation of public offering proposals, consideration of grand vision, etc. (planned) • Around summer 2023: Science Council of Japan will formulate and publishes "Future Science Promotion Concept" (planned)	～～Science Council of Japan decided not to formulate a master plan～～ ・November 2022: The working group of the Science Council of the MEXT started deliberations on the basic policy of formulating its own roadmap because the master plan was not formulated. ・December 2022: Compilation of road map 2023 formulation policy (draft) and solicitation of opinions (planned) ・After January 2023: Discuss and formulate roadmap 2023 (planned) (The schedule for public offering, document review, hearing review, roadmap formulation, and publication is undecided.)

Issues of large-scale academic frontier promotion projects

- **The budget has not increased since the establishment of the project in 2012:** The purpose of the establishment of the project is to “strategically and systematically promote large-scale projects through stable and continuous support,” but national university corporation operating expenses are on the decline. Since it was established in 2012, the budget has not increased even though the number of projects has increased because it is within the scope of the National University Corporation Operating Expenses Grant.
- **Academic research and operating expenses are essential:** If the facility can be used widely for non-academic purposes, it may be possible to secure separate operating expenses, but joint users are mainly universities. Support from the national government is indispensable for the implementation and execution of research even after the completion of the development and installation of research facilities.
- **There is no exit strategy for the end of the government support program:** No new project can be launched: As they are academic research projects, as described above, operational support after development and after completed installation, it isn't easy to end the support program. Therefore, the possibility of new large-scale projects being adopted is also low.
- **Increasing in subsidization, and settlement is required on a business-by-business basis:** For example, ALMA is a national university corporation's advanced research subsidy, and TMT is a facility maintenance subsidy. The operating expense subsidy that can be used for operation will decrease. On the one hand, in particular, Subaru's recurring operational expenses have not been secured.



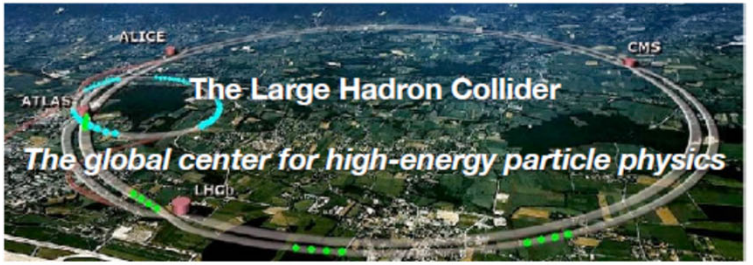
(2021.6.18「第４期中期目標期間における国立大学法人運営費交付金の在り方に関する検討会」資料より)



2019.4.23「学術研究の大型プロジェクトに関する作業部会」資料等より作成
（2020,21年度は内訳が公開されていないため、全体を運営費交付金として表示した）

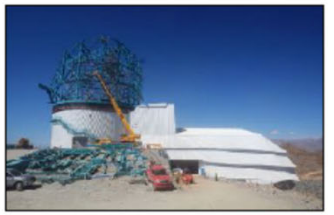
FY2022 budget amount is 33.7 billion yen

The scientific landscape has changed since NSF's inception in 1950



ALMA required a partnership of North America, Europe and Japan to raise $1.4B

DKIST $0.3B

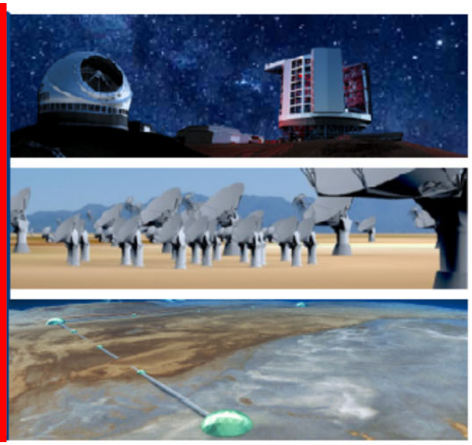


LSST $0.7B

To remain globally competitive in 2030 - 2040, the expected scale of NSF investment in the next generation of large ground-based facilities

USELT Program	~$1.5 to $2 billion
ngVLA	~$2.5 billion
Cosmic Explorer	>$2 billion

$1B - $2 billion per project



It's getting harder to stay globally competitive in ground-based astrophysics, without the NSF

Conditions for international cooperation (1)
A balance between investment amount and return

Number of ALMA papers

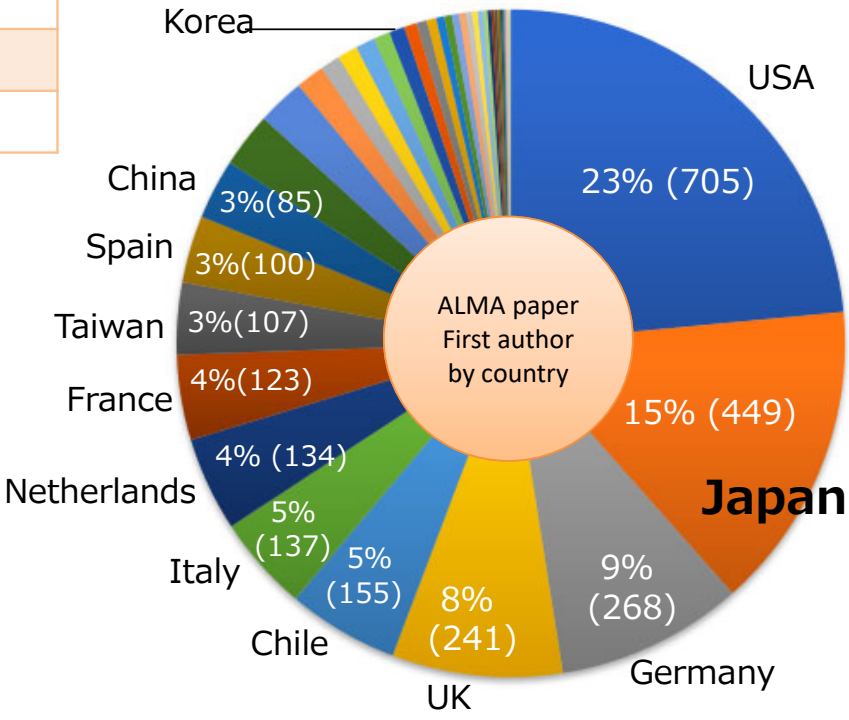
Percentage of Top 1% and Top 10% papers
(after the start of open-use observation)

year of publication		Top 1%	Top 10%
2012～2021	ALMA: the whole world	2.7%	23.1%
	ALMA : Japanese institution (first author)	2.7%	14.8%
	ALMA : Japanese institution (including co-authored)	2.5%	20.3%
	Astronomy and astrophysics as a whole: the whole world	1.0%	9.7%

※From：InCites 2022/5/27

As of Nov 29, 2022

Achievements in East Asia (Telescope time ratio is 21.4%)	
Nature、Science	22.8% (23)
All papers	19.2% (577)



Budget allocation and telescope time ratio

	【Japan】	【USA】	【Europe】
Budget sharing ratio	25%	37.5%	37.5%

<Telescope time ratio>

Allocate 5% of telescope time to researchers outside Japan, the United States, Europe, and Chile (Open Skies). To allocate the remaining 95% to Chile (10%), Japan (22.5%), the United States (33.75%), and Europe (33.75%), we have:

Chile 9.5%	21.4%	32.1%	32.1%

Conditions for international cooperation (2)

Contribute with advanced Japanese technology (minimize cash contribution)

East Asia	US & Europe
Construction Period	
   ② ACA antenna *Achieving accurate images that cannot be drawn with only 50 units in the US and Europe 12 units : 7m antennas 4 units : 12m antennas ③ Receiver system Band 4,8,10 ④ Signal transmission / conversion/evaluation unit For ACA ⑤ High dispersion correlator For ACA	① Site construction Infrastructure construction (U.S. and Europe) ②12m antenna 25 units (U.S.) 25 units (Europe) ③ Receiver system Band 3,6 (U.S.) Band 7,9 (Europe) ④ Signal transmission / conversion / evaluation unit For US and European antennas ⑤ Basic correlator For US and European antennas   
Items planned during the construction phase and aimed at completion of development	
 ③ Receiver system Band 1 ⑤ High dispersion correlator ACA spectrometer	③ Receiver system Band 5 (Europe + U.S.) Band 2 (Europe + Japan)

State-of-the-art technology owned by NAOJ

High sensitivity, large pixel visible Infrared sensor technology

Developed large-pixel optical CCD sensor with high sensitivity, low noise, and wide wavelength band. We are currently developing a high-sensitivity infrared sensor and a high-speed optical CMOS sensor. 。

(The sensor is Hamamatsu Photonics, the optical system is jointly developed with Canon, etc., and the ultra-low noise electrical system is manufactured in-house by NAOJ.)

Subaru Telescope

Andromeda Nebula imaged with HSC

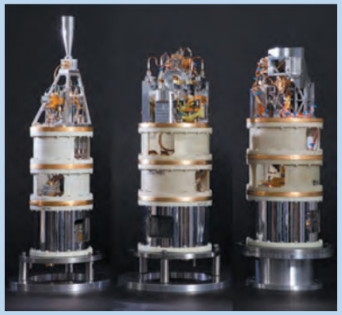
Application to space debris detection

Adaptive optics technology that overcomes atmospheric fluctuations

10x higher resolution

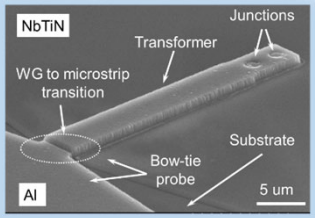
It measures the fluctuation of star images more than 1,000 times per second, and controls the deformable mirror with millisecond response time and accuracy of several nanometers to correct the disturbance of light. ⇒Achieving a resolution comparable to that of a space telescope from the ground

Ultra-sensitive radio wave reception system (radio waves, terahertz range)



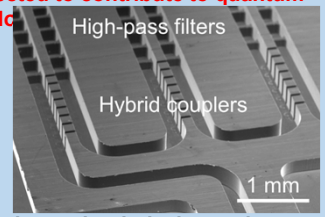
World's highest performance ALMA receiver

ALMA (Chile)



Superconducting device design and fabrication technology

⇒ Expected to contribute to quantum technolc

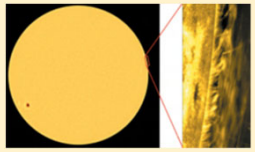


Terahertz circuit design and evaluation technology

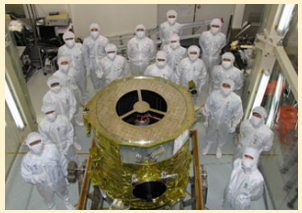
⇒ Expected to contribute to B5G/6G technology

Space telescope technology

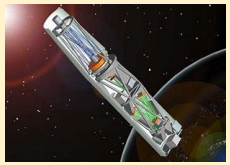
Developed a high-resolution optical telescope system for space (ultraviolet, visible light, and infrared imaging/spectroscopic equipment)



High-resolution solar observation by HINODE



HINODE satellite telescope



NASA CLASP Rocket Mounted Telescope

Anti-vibration technology that suppresses vibration to one billionth of an atom

Reflector of KAGRA's laser interferometer

Photonic Technology (Fusion of light and radio waves)

Distribute frequency and time signals with atomic clock precision over a wide area.

⇒ Contribution to 6G ultra-high-speed communication

Advanced Technology Center Supporting Development

Realize the world's most advanced performance by developing technology that companies cannot do and repeating trial and error.

metal 3d printer

Mass production of ALMA receiver horn

Superconducting element development clean room

(Started joint research with NEC on low-loss, low-noise superconducting device technology)

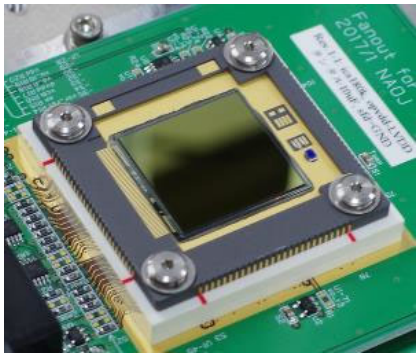
Ground/satellite observation equipment Shared clean room

From “Technology for Astronomy” to “Technology Supporting Life and Society”

Private enterprises

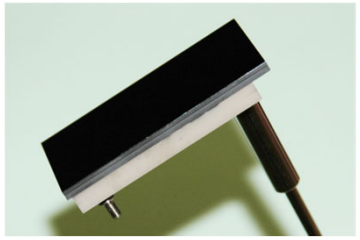
near-infrared image sensor

Development and commercialization of high-sensitivity, low-noise near-infrared image sensors



Fully depleted CCD

Commercialization of a large-scale image sensor with high sensitivity to red and X-rays



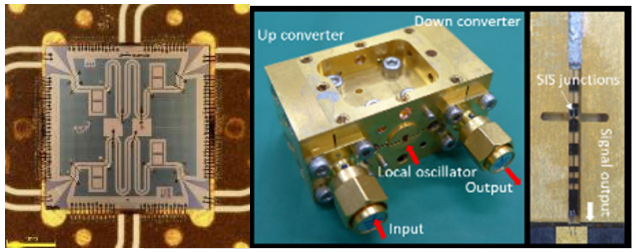
NICT 国立研究開発法人 情報通信研究機構

NAOJ 国立天文台

Fault-tolerant general-purpose quantum computer

The realization of an ultra-low power consumption qubit amplifier using a superconducting mixer is on track.

MOONSHOT RESEARCH & DEVELOPMENT PROGRAM



NICT qubit

NAOJ readout amplifier

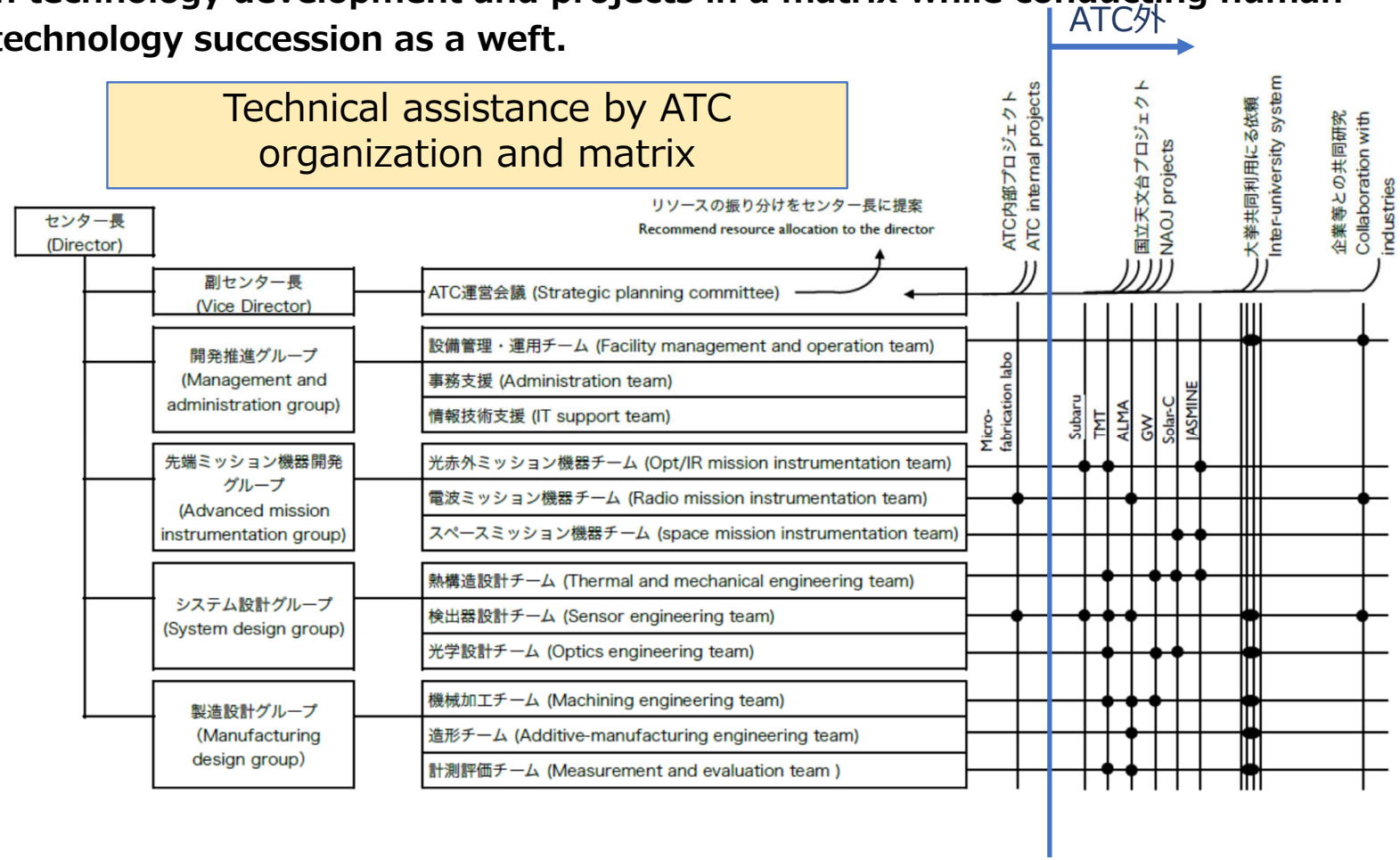
Contribution to Beyond 5G/6G

Proposing basic technologies such as high-speed spectrum measurement, material evaluation, and inter-base station synchronization technology

Importance of Advanced Technology Center
The pool of technologies required to realize plans for the future

- **Rather than vertically dividing each project, we clarified a system in which a group of experts in each technical field participates in technology development and projects in a matrix while conducting human resource development and technology succession as a weft.**

- **Achieved results in the development of superconducting devices that manufacturers cannot manufacture, complete depletion layer type CCD/near-infrared imagers, Subaru ultra-wide-field cameras, and devices mounted on satellites and observation rockets that manufacturers can only achieve in cooperation with the National Astronomical Observatory of Japan.**
- **Further improvement of capabilities as a group of specialized engineers and development of system engineers are issued.**
- **As a critical organization of NAOJ, further, expansion is necessary, referring to overseas large-scale development research institutes such as SRON, NRAO, SwRI, APL, and JPL.**



Future Vision and Reorganization of Astronomical Data Center
Big Data, Astroinformatics, Open Science

- "To better understand the universe, all acquired observational data must be preserved in a usable form and made available to the public.": A large amount of observational data produced by Subaru, ALMA, Nobeyama, Okayama, Mizusawa, and university-owned telescopes have been archived and released in their way due to historical circumstances, but there is a need to aim at consolidating multiple archives. (Note) The value created by data aggregation: The 4-th Paradigm = data-intensive science
- In doing so, it is necessary to take into consideration the growing volume of observed data, the slowdown in the rate of decrease in storage capacity unit prices, the development of data science, and the growing social demand for revalidation.
- Even in the age of massive data, where it is technically and economically impossible to leave all raw data, we are also verifying technologies such as lossy data compression that can selectively leave only vital information to ensure the revalidation of scientific results.
- Strengthen cooperation between astronomical supercomputers, archive systems, and analysis systems, establish a "regional data center" for the Rubin Observatory, the ESA Euclid satellite, etc., and promote cooperation between the observation facilities of NAOJ and these advanced observation facilities.
- Furthermore, utilizing these computer resources will make it a research base for astronomical big data and AI analysis called astroinformatics.
- By publishing and sharing the aggregated huge astronomical data assets as open data through the observatory, NAOJ will become a hub for research institutes and industries pioneering data analysis technology.
- To accept data from university telescopes and continue to open the archives to the public in the era of vast amounts of data, it is essential to secure an operational budget. Therefore, it is also necessary to make NAOJ's efforts visible by concluding MOUs at the request of university presidents.

Operational System of Joint ALMA Observatory

Importance of human contribution (minimize cash contribution)

From budget request materials

Japan (NINS/NAOJ) Share rate 25%

U.S. (NSF/AUI/NRAO) Share rate 37.5%

Europe (ESO) Share rate 37.5%

Japan, the United States, and Europe have an international responsibility to bear operating expenses, local staff (approximately 220 people in total), and international staff (approximately 40 people in total) according to their share.

Joint ALMA Observatory, Chile (Jointly operated by Japan, the United States, and Europe)

◆ Implementation of observation ◆ Distribution of observation data to each regional center ◆ Operation and maintenance of observation equipment

- ALMA Director
  - Engineering Department — **Chief: Norikazu Mizuno**
  - Scientific operations department
  - Administration
  - Computing department

Japan Breakdown: Operating Expenses and Local Staff
Fulfilling its international responsibilities by sharing 25% of employment costs and dispatching 10 international staff

The technical department, which is the largest group (about 140 Chilean staff), is led by Japanese staff.

Professor Mizuno speaks Spanish fluently, and his success in bringing together locally hired staff has attracted the attention of the United States and Europe.

Five NAOJ staff members in Pasadena and three NAOJ staff members in Hawai'i perform their duties at TMT International Observatory and are highly regarded by TIO. These will be added to the observation time allocation as Japan's contribution.

Effective in reducing operating costs of TMT International Observatory (TIO) and creating opportunities for NAOJ staff to be active in international projects.

Items in red indicate the work that TIO has already approved as Japan's contribution, and other personnel contributions are scheduled to be discussed and approved in the future.

The Importance of Personnel Contributions: Examples of Personnel Contributions to TMT

Ryuji Suzuki: Assistant Professor
He is a Systems engineer of the IRIS imaging system, which is a responsibility of Japan. In addition, he is the IRIS Chief Systems Engineer for the entire IRIS, including the United States and Canadian departments.

Saeko Hayashi: Associate Professor
Based on her experience at the Subaru Telescope, a work package manager for the conceptual design of coating equipment for secondary and tertiary mirrors in charge of India.

Yuko Kakazu: Specialist
(Office for International Affairs)
As a member of TIO, arrange meetings with local stakeholders such as schools and chambers of commerce, and focus on building relationships with the local community through dialogue.

Chikako Yasui: Assistant Professor
As a member of TIO's science operation team, she is compiling the Detailed Science Case of TMT and the list of observation modes required for the first-phase observation equipment and creating a science operation plan.

Hiroshi Terada: Associate Professor
As a member of TIO's systems engineering team, he contributed significantly to raising perfection in subsystem design. His management ability is highly recognized, and he has been appointed as a project manager of MODHIS.

Takashi Nakamoto: Research Engineer
He is a systems engineer developing the control system and software for IRIS. He is in charge of designing and developing the primary mirror CO2 cleaning system's control system. He is also responsible for the observatory safety system.

Junichi Noumaru: Associate Professor
Utilizing his experience at the Subaru Telescope as the site manager of the TMT project, he plans to lead transportation and on-site installation adjustment work in cooperation with TIO before and after the resumption of on-site construction work.

Tomonori Usuda: TMT Project Manager
In conjunction with TIO Project Manager (PM) transfer of F. Liu to Hilo, NAOJ PM also moved to Hilo in July 2021, and has been focusing on building relationships with the local community with PM Liu and D. Simons, Director of University of Hawai'i Institute for Astronomy.

Strategic efforts to nurture young talent
Human resource development is essential for the future of the research field

- Launched the **Junior Fellows system** (starting in 2020) and started supporting graduate students
- Launch of **tenure track system** (from 2020)
  - Two tenure-track assistant professors are seconded to the Institute of Statistical Mathematics for five years. They are expected to play a leading role in new astronomy developments that fully use data science in the age of big data.
- Review of **the researcher system** (from 2021)
  - We improved the open recruitment system for project researchers and increased the options for applicants, such as enabling applications in a broader range of fields.
- Establishment of **the Graduate Education Office** (from 2022)
  - Moved graduate education from a volunteer base to an organized effort
  - Clarification of contact points and implementation system for graduate school education
- **Appointment of young people**
  - Young, female, and foreign national researchers in their 40s to early 50s are selected one after another for management class of executives and international projects (Gonzalez, Fukagawa, Mizuno, Aoki, Iono, Saito, Motohara)

summary

- The cost for a large-scale ground-based astronomy project is a huge amount, at ～ US$2 billion. In ALMA/TMT, Japan contributed about 20% of the total project cost, maintaining a balance with the return (observation time). Considering the balance between the in-kind contribution of Japan's advanced technology and the securing of observation time commensurate with the size of the community, a similar level of contribution to the total project cost would be preferable in the future. This level of in-kind contribution is necessary to make a presence of Japan.
- On the other hand, judging from the size of the project (budget), the sophistication of the advanced technology to be developed, and the response to internationalization, the launch of the new project seems to be at a turning point. In addition, with the globalization of projects, the shortage of international management (project manager) personnel and system technology personnel has become an issue.
- It is necessary to strengthen the large-scale international cooperation projects, the Advanced Technology Center, which conducts technological development, and the Astronomical Data Center, which aims to utilize the huge amount of accumulated data.
- In prioritizing future plans, the respective roles and interrelationships of the Science Council of Japan and the Science and Technology Council of the MEXT need to be clarified.