ASTEの現状とCapabilities

南谷　哲宏

ASTE Project / NAOJ Chile

National Astronomical Observatory of Japan, NAOJ

Observatorio Astronómico Nacional de Japón

Thanks to ASTE members,
Profs. Kohno, Oka, Tosaki

国立天文台 NAOJ National Astronomical Observatory of Japan

Atacama Submillimeter Telescope Experiment

- The prime objectives of ASTE Project
  - **Promote science** with the submm single-dish telescope
  - **Promote development** of instruments and techniques for astronomical observations

  ➔ A precursor to ALMA and Submm Astronomy in terms of Science and Instrumentation
- 10-m sub-mm telescope at Pampa la Bola 4800m alt. (within the ALMA Site)
  - Since 2002
  - Surface accuracy: 19μm (→ ~40μm?)
  - Pointing accuracy: ~2″ (rms)
- Site infrastructure
  - Diesel generator (150kW-220V ×2)
  - Fuel tank (15kL ×2, consumption 300L/d)
  - Satellite network (1Mbps)
  - Monitor (weather station, web cameras, etc.)
- https://aste.nao.ac.jp/index_e.html

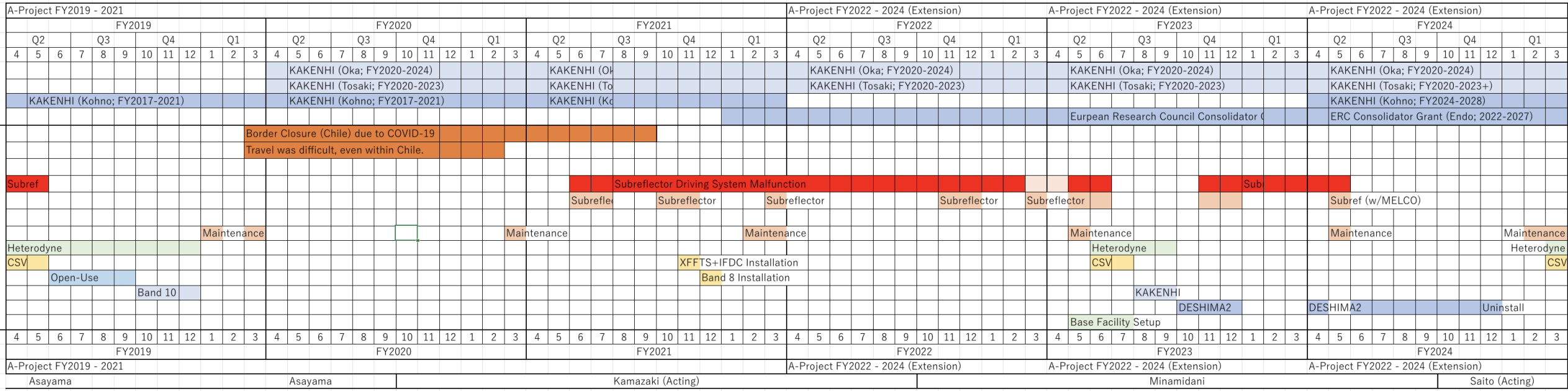


Atacama Submillimeter Telescope Experiment

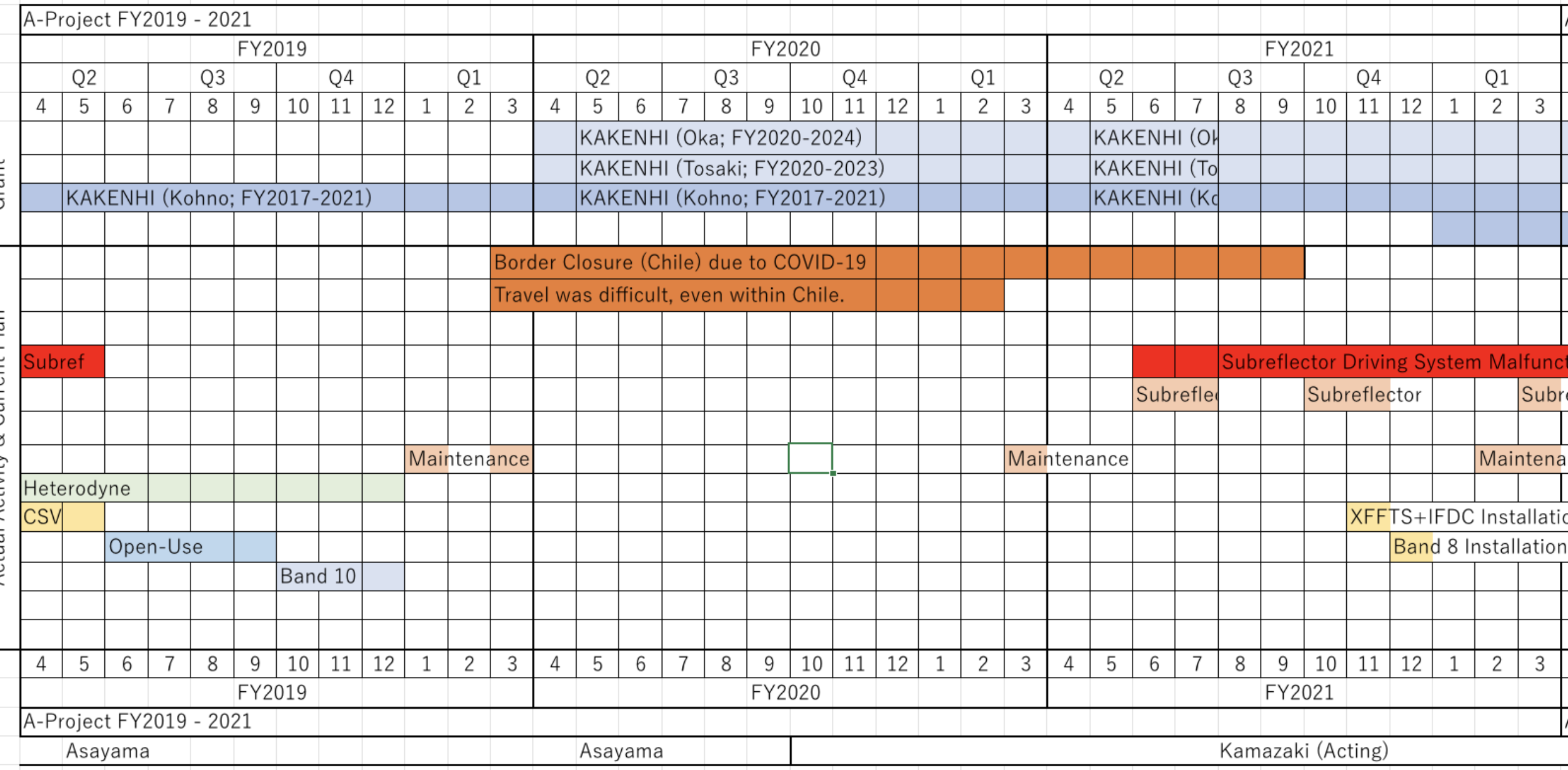
- Antenna System
  - Surface accuracy: 19μm (→ ~40μm?)
  - Pointing accuracy: ~2″ (rms)
- Heterodyne Receiver System
  - Frontends:
    - DASH345 (321-376GHz)
    - CAT8W (387-498GHz)
    - CAT10 (790-940GHz)
  - Backend: XFFTS
- DESHIMA
- Remote Operation
- https://aste.nao.ac.jp/index_e.html
- https://www2.nao.ac.jp/~aste-www/aste_wiki/pukiwiki/index.php?ASTE%20Wiki



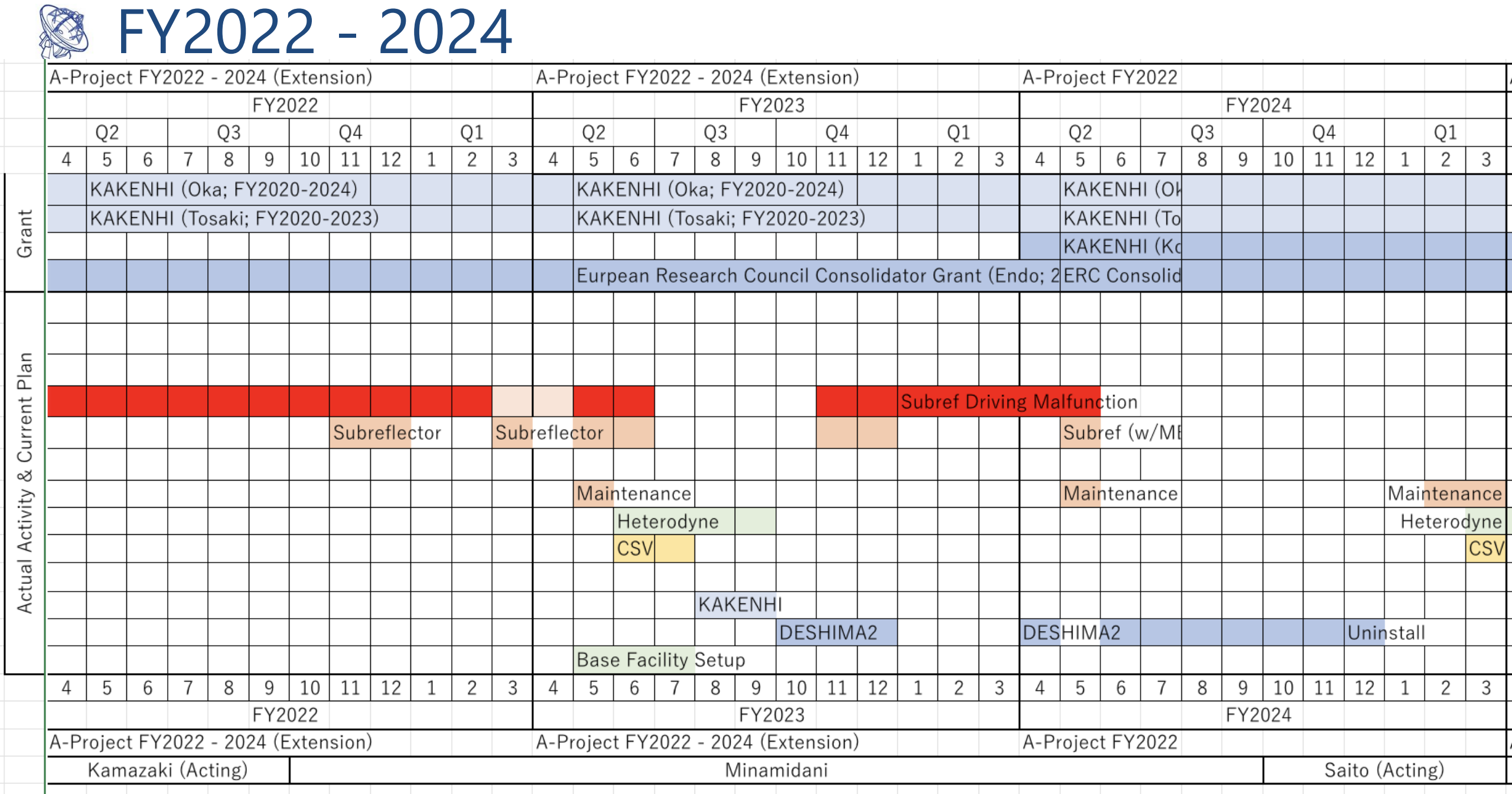
FY2019 - 2024


A-Project FY2019 - 2021
A-Project FY2022 - 2024 (Extension)
A-Project FY2022 - 2024 (Extension)
A-Project FY2022 - 2024 (Extension)
FY2019
FY2020
FY2021
FY2022
FY2023
FY2024
Grant
KAKENHI (Kohno; FY2017-2021)
KAKENHI (Oka; FY2020-2024)
KAKENHI (Tosaki; FY2020-2023)
KAKENHI (Kohno; FY2017-2021)
KAKENHI (Tosaki; FY2020-2023+)
KAKENHI (Kohno; FY2024-2028)
ERC Consolidator Grant (Endo; 2022-2027)
Actual Activity & Current Plan
Border Closure (Chile) due to COVID-19
Travel was difficult, even within Chile.
Subref
Subreflector Driving System Malfunction
Subreflector
Subref (w/MELCO)
Maintenance
Heterodyne
CSV
Open-Use
Band 10
XFFTS+IFDC Installation
Band 8 Installation
KAKENHI
DESHIMA2
Uninstall
Base Facility Setup
Asayama
Kamazaki (Acting)
Minamidani
Saito (Acting)

FY2019 - 2021


A-Project FY2019 - 2021
FY2019
FY2020
FY2021
Q2 Q3 Q4 Q1
4 5 6 7 8 9 10 11 12 1 2 3
Grant
KAKENHI (Oka; FY2020-2024)
KAKENHI (Tosaki; FY2020-2023)
KAKENHI (Kohno; FY2017-2021)
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FY2022 - 2024


A-Project FY2022 - 2024 (Extension)
A-Project FY2022 - 2024 (Extension)
A-Project FY2022
FY2022
FY2023
FY2024
Q2 Q3 Q4 Q1
4 5 6 7 8 9 10 11 12 1 2 3
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KAKENHI (Tosaki; FY2020-2023)
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Heterodyne
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CSV
KAKENHI
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Uninstall
Base Facility Setup
Kamazaki (Acting)
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Saito (Acting)

ASTE Scientific Goals and Missions (-2025.3)

The primary scientific goals of this project are:

1. to measure the redshift distribution and luminosity function of dust-enshrouded hyper luminous star-burst galaxies (HyLIRG) in the early universe (beyond the redshift of 3) using a novel submillimeter wave ultra-wideband spectrograph DESHIMA in order to unveil the role of HyLIRG in the cosmic star-formation history; and
2. to provide wide-field mapping of molecular clouds in the nearby star-forming regions by observing several [CI] and CO emission lines in the unexplored frequency range corresponding to the ALMA Band 8 and 10, aiming to establish the validity of these molecular lines as the useful tool to derive the physical and chemical environments. This will contribute to obtain robust measurements of the molecular gas mass even in extra-galaxies observed with ALMA, offering insights to the understanding of the physical process governing the star-formation-rate density in the cosmic history.

2020-2024, Grant-in-Aid for Scientific Research (A)

“Search for Missing Black Holes in the Galaxy based on Submillimeter-wave Observations”

「サブミリ波観測に基づく銀河系内ミッシング・ブラックホールの探査」

Tomoharu Oka (Keio University)
Shunya Takekawa (Kanagawa University)
Shogo Nishiyama (Miyagi Univ. of Education)
Mariko Nomura (Hirosaki University)
Takafumi Kojima (NAOJ)
Hironori Matsumoto (Osaka University)

Objectives

- Search for inactive/invisible black holes traced by warm/dense high-velocity compact clouds (HVCCs)
- Resolving the “missing black hole” problem by increasing the number of candidates
- Creation of the “black hole astronomy”

Strategy

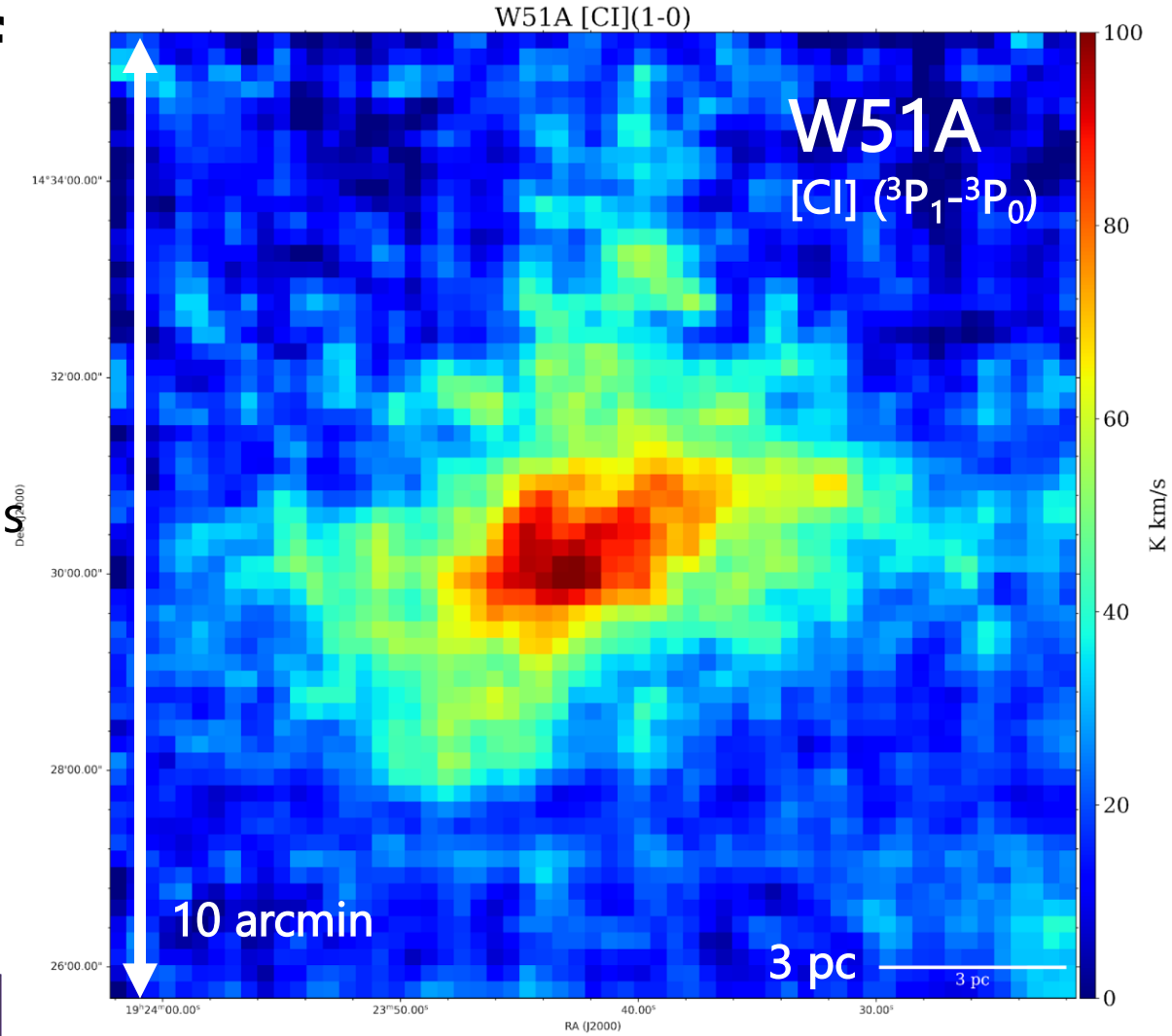
- Search for gravitationally-kicked HVCCs
- High resolution imaging with ALMA
- Search for IR/X-ray counterparts
- Examination of RIAF model



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Science demonstration using CAT8W + XFFTS

- **Wide area [CI] ($^3P_1$-$^3P_0$) mapping of W51A**
  - Observations in 2023 season
  - 10 arcmin x 10 arcmin
  - Beam size ~17 arcsec
    - Under sampling
    - Nyquist sampling map of the central 3'x3' has also been taken
  - Noise level: dTa* ~0.3 K (dv = 1.0 km/s)

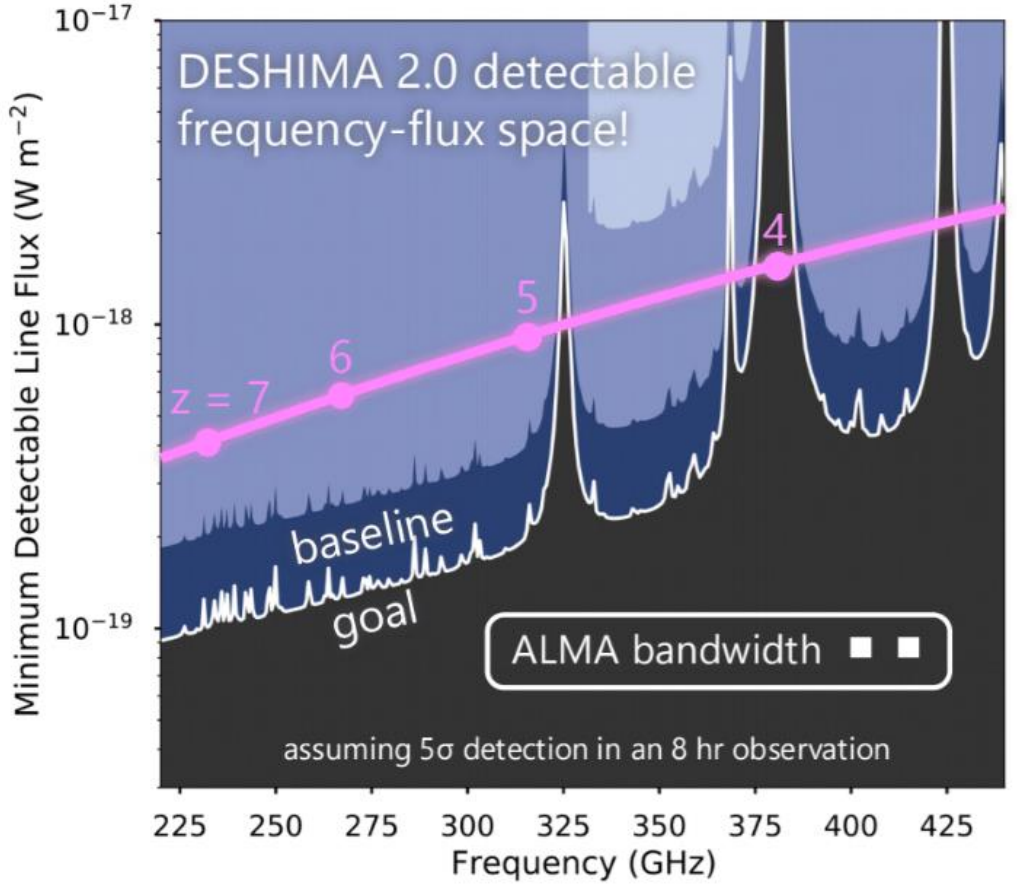


Fujita, S., Ikeda, S. (Institute of Statistical Mathematics)
International Leading Research
藤田真司, 池田思朗 (統計数理研); 国際先導研究 23K20035
Tosaki, T. (Joetsu University of Education), Kiban-A
濤崎智佳 (上越教育大学), 基盤A 20H00172
et al., in prep.

FY24 Highlights (see also Nishimura's presentation)

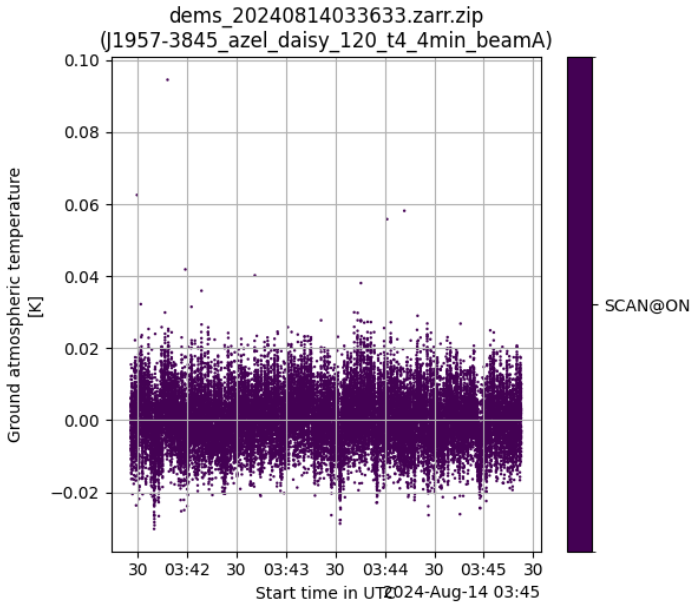


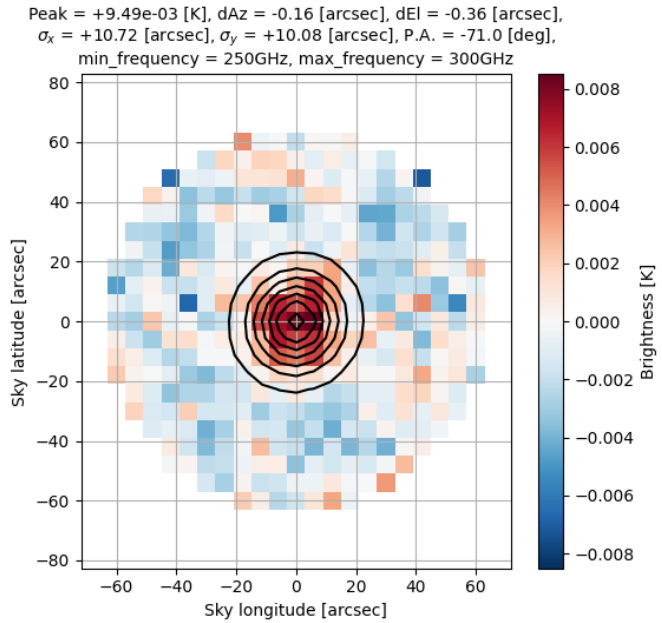
DESHIMA 2.0

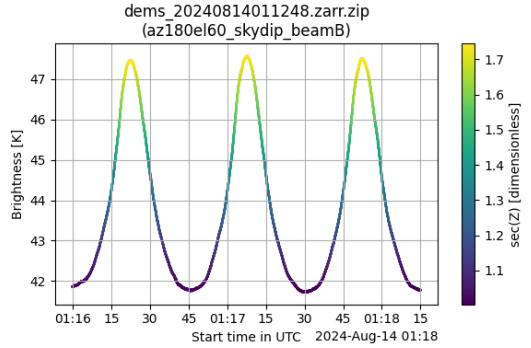


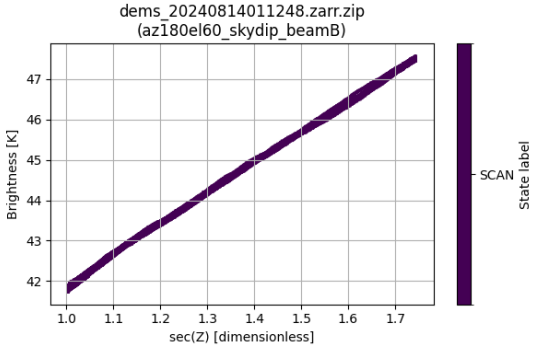
- Ready to observe the ionized/atomic carbon and CO lines from ultra-bright high-z galaxies

DESHIMA 2.0 Initial Data



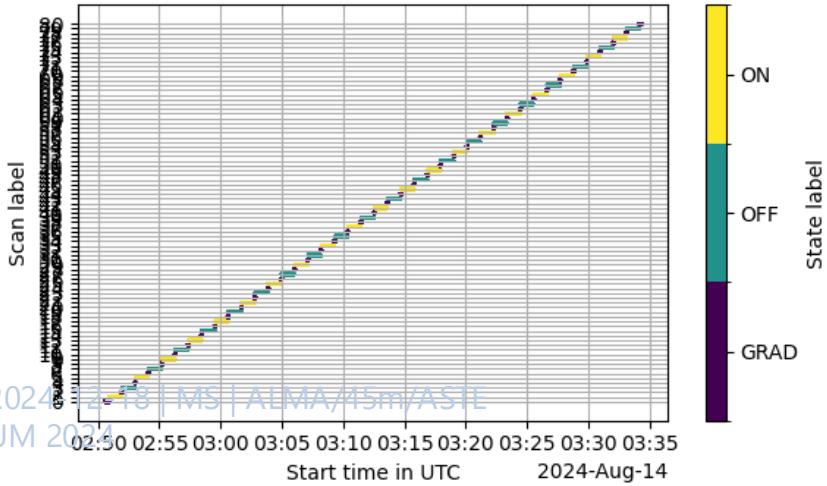


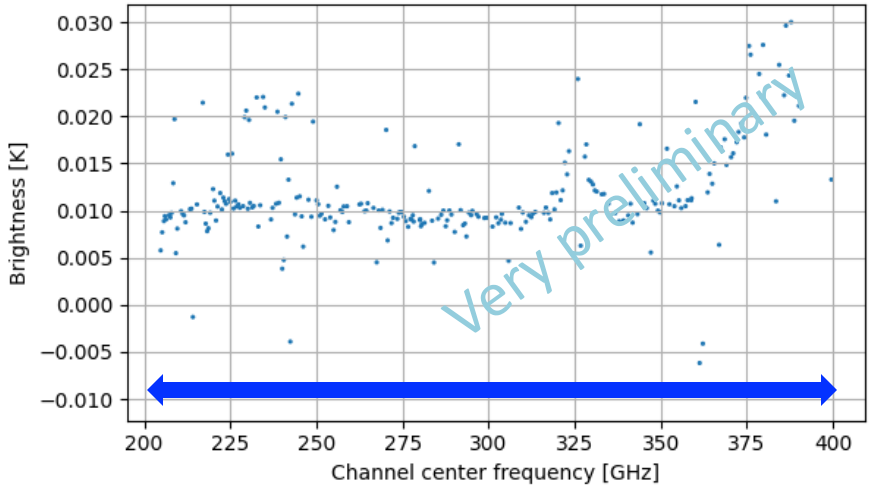




A few Jy point source can be easily detected as pointing and flux calibrators

Skydip observations behave quite well under good weathers





A high-redshift dusty galaxy
200 – 400 GHz
(z = 3.8 – 8.5 for [CII] 158μm)
spectrum in one shot
(just for your eyes)

External Review of ASTE

- ASTE Project Review: Mar 25 and 26, 2024
- External Evaluation Comiittee
  - Paola Andreani（ESO）; Chair
  - Lars-Åke Nyman（Onsala Space Observatory/ Chalmers University of Technology, Sweden）
  - Takeshi Sakai（The Univ. of Electro-Communications）
  - Kengo Tachihara（Nagoya University）
  - Kenta Fujisawa（Yamaguchi University）from NAOJ Review committee



- Review item
  - Achievement status of the Purpose of establishment and Primary Science Goals
  - Response to the recommendations from in the FY2018 Project Review
  - Status of Operations and management structure
  - Comparison with similar projects
  - Future plan
- Review Report available in NAOJ web site
  - 外部評価報告書 | 国立天文台(NAOJ)

External Review of ASTE

- The committee wishes to congratulate the ASTE staff for the achievements of the Observatory despite the reductions in manpower and budget, as well as the challenges faced in the last years related to pandemic and telescope repairs.
- 20 recommendations are passed to the ASTE project; 2 closed, 3 pending, some partially closed. Remaining open items are under consideration with NAOJ top management.
- ASTE will report the recommendations status to the Advisory Committee for Research and Management in Mar 2025.

Response to notable recommendation

- Address the telescope issues as soon as possible and resume observations to complete the scientific goals.
  - Fixed the subrelector malfunction problem and resumed science operation since May 2024.
- Update the website content soon.
  - Partially done.
- Increase the manpower by at least a scientist and an engineer.
  - Project associate professor is under hiring process.
- Deliver the data to the users through the JVO
  - ASTE JVO project just began.
  - Start with demo science data

8. Cost Assessments, Budget Line, and Status

- ASTE Baseline Operation Cost per Year: ~ 72 MJPY

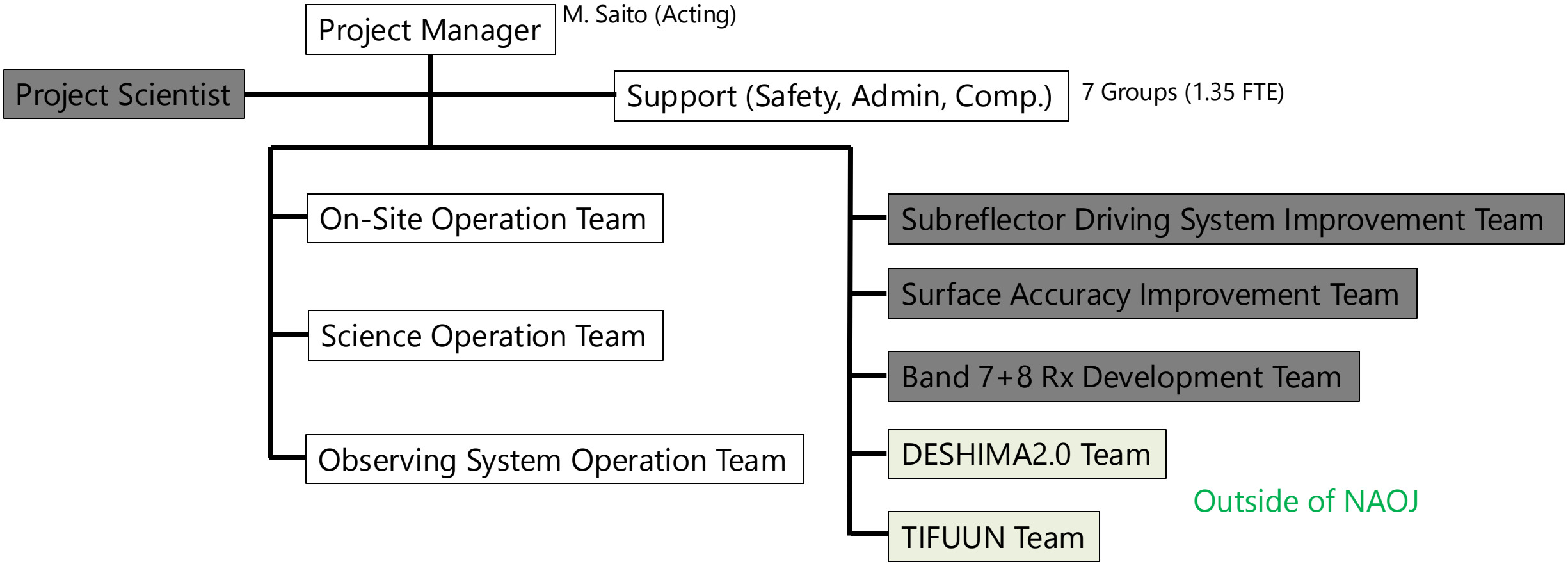
Category	Amount (MJPY)	Notes
Antenna Maintenance		
Generator Operation Diesel Fuel Maintenance		10 months operation # partially covered by external funds
Network to the Site		
Car @ Site		10 months operation # partially covered by external funds
Travels to Site		10 months operation # partially covered by external funds
Base Facility @ SPdA		
Oxygen, AWS, etc.		10 months operation # partially covered by external funds
HR		Only Contracted Staff (incl. Chile local)
Total	72	

Costs in Chile are very much influenced by the inflation in Chile and currency exchange rates between JPY and CLP.

17. Project Organization

Current

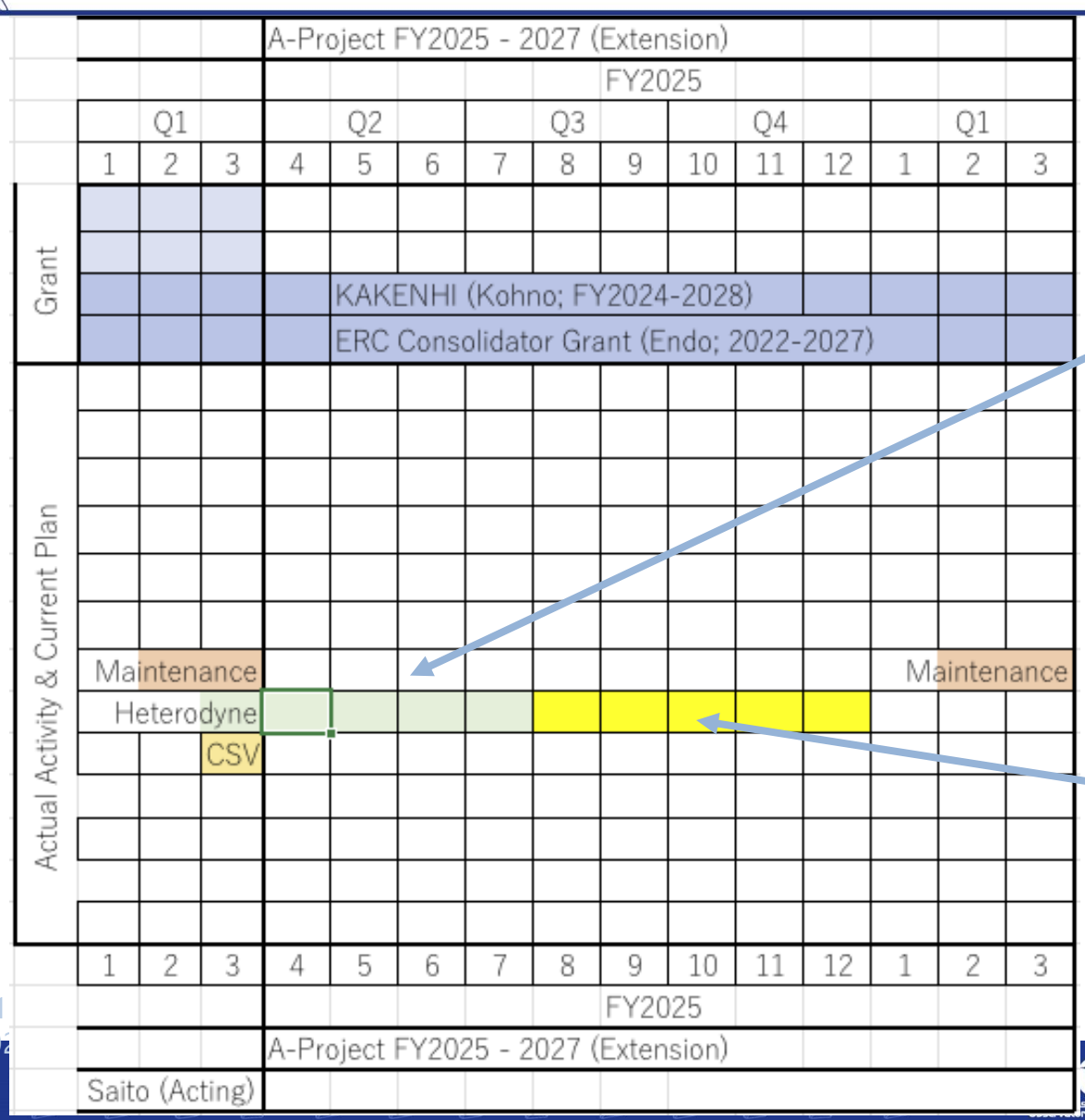
NAOJ:8 Persons (4.05 FTE) + 7 groups (1.35FTE)



External Funding in FY2024

- KAKENHI Grant-in-Aid for Scientific Research (A) “Search for Missing Black Holes in the Galaxy based on Submillimeter-wave Observations” FY2021-2024 led by Prof. Oka (Keio Univ.)
- KAKENHI Grant-in-Aid for Scientific Research (A) ALMA受信機を活用した中性炭素原子輝線の広域分光撮像による低金属量分子雲の研究” FY2021-2023->2024 led by Prof. Tosaki (Joetsu Univ. of Education)
- KAKENHI Grant-in-Aid Specially Promoted Research （特推） “Formation Processes of Heavy Elements in the Early Universe Elucidated by Superconducting Nanoelectronics, Large-Scale Numerical Simulations, and Data Science” FY2024-2028 led by Prof. Kohno (U. Tokyo)
- NINS Open Mix Lab (OML) “中性炭素輝線を用いた星間水素の精密定量” FY2023-2024 led by Prof. Sano (Gifu Univ.)

Plan: CY2025 -



- Heterodyne
  - KAKENHI Projects
  - Open-Use Programs carried over from 2020.
  - Chilean Time

This period is t.b.c.

Plan: Probable Open Use Concept in FY2025

- Heterodyne observation are planned from Mar to July 2025 to cover carry-over projects, remaining Kakenhi observations and Chile time.
- **If the budget allows**, open use call will take place at the beginning of FY2025 in consultation with JSAC.
- The open use window will be a few months from August to Dec for targets with LST of 18 – 10 h.

From FY2026, a dedicated period of flagship instrument such as TIFOON or multi-beam heterodyne rx may be set for two years or so to avoid overhead of installation, removal, optics alignment, etc.

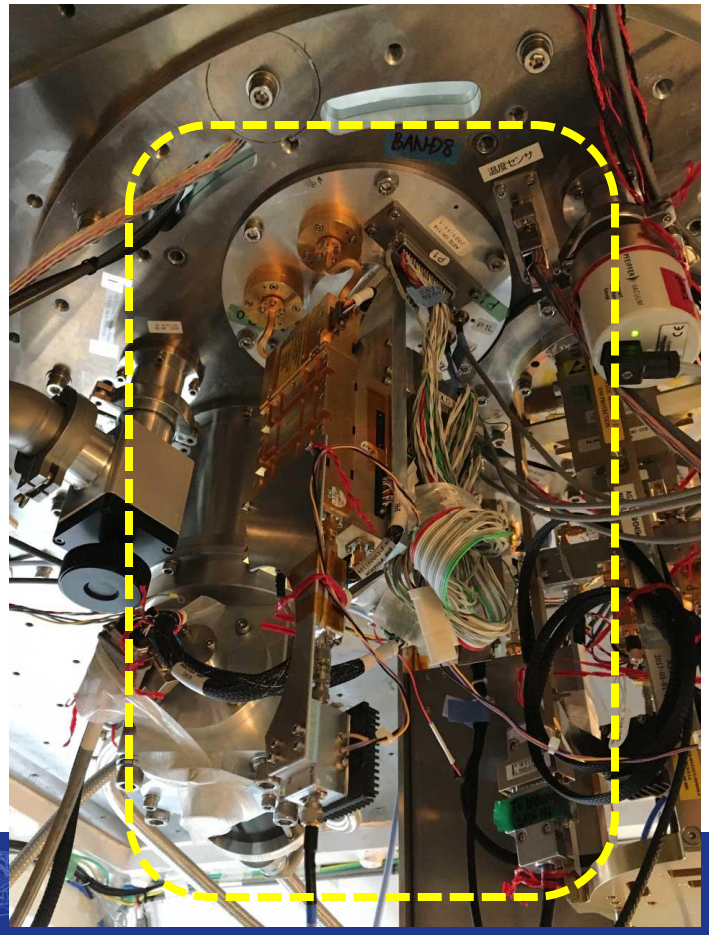
Wide-IF-bandwidth Band8 receiver - CAT8W

- **Wide-IF-bandwidth Band8 receiver (CAT8W)**
  - Supported by the KAKENHI project (P.I. Oka; Keio U.)
  - The previous Band8 receiver cartridge was upgraded with SIS mixers employing high-*Jc* junctions developed by ATC
  - Same RF range, but IF bandwidth is expanded from 4-8 GHz to 4-18 GHz

    e.g.) Simultaneous observations of CO and [CI] in Band 8 become available.
    - Trec ~150-250 K,
    - IRR ~10-15 dB at Mitaka

  - Tsys ~ 600 – 1000 K (492 GHz)
  - Issue in FY2023
    - one Pol. -> DSB

Receiver	CAT8W
Beam	1
RF range	387-498 GHz
IF range	4-18 GHz
Sideband	USB, LSB
Polarizations	X, Y



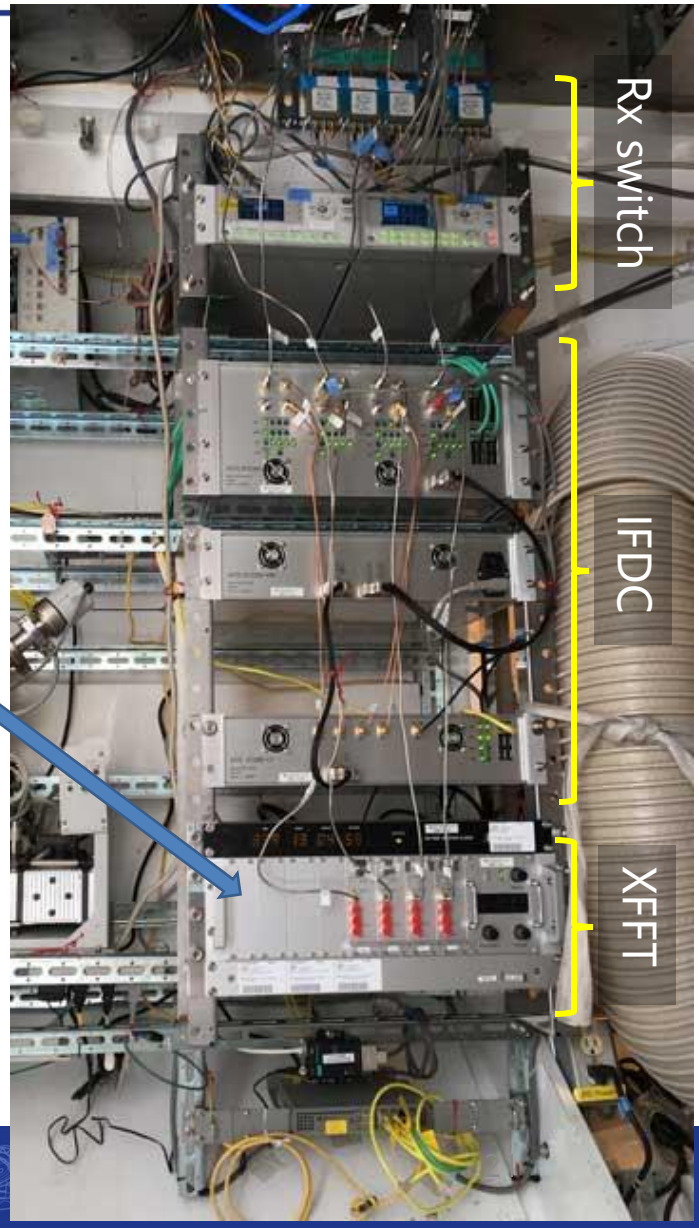
Recent Upgrade: Digital Spectrometer and IF Down Converter

- **RPG eXtended bandwidth FFT Spectrometer (XFFTS)**
  - Supported by the KAKENHI project (P.I. Tosaki; JUEN)
  - 2.5 GHz BW / 32K channels [/Spw]
    - Δv=0.047 km/s, velo. width ~1500 km/s@492 GHz
  - 10-bit ADC, 5Gsps
    - Good linearity
- **IF Down Converter (IFDC)**
  - 4 spectral windows (2.5 GHz BW) from 4 IF signals of a receiver
  - Support of IF BW = 4-8GHz (**DASH345**, **CAT10**) and 4-18 GHz (**CAT8W**)



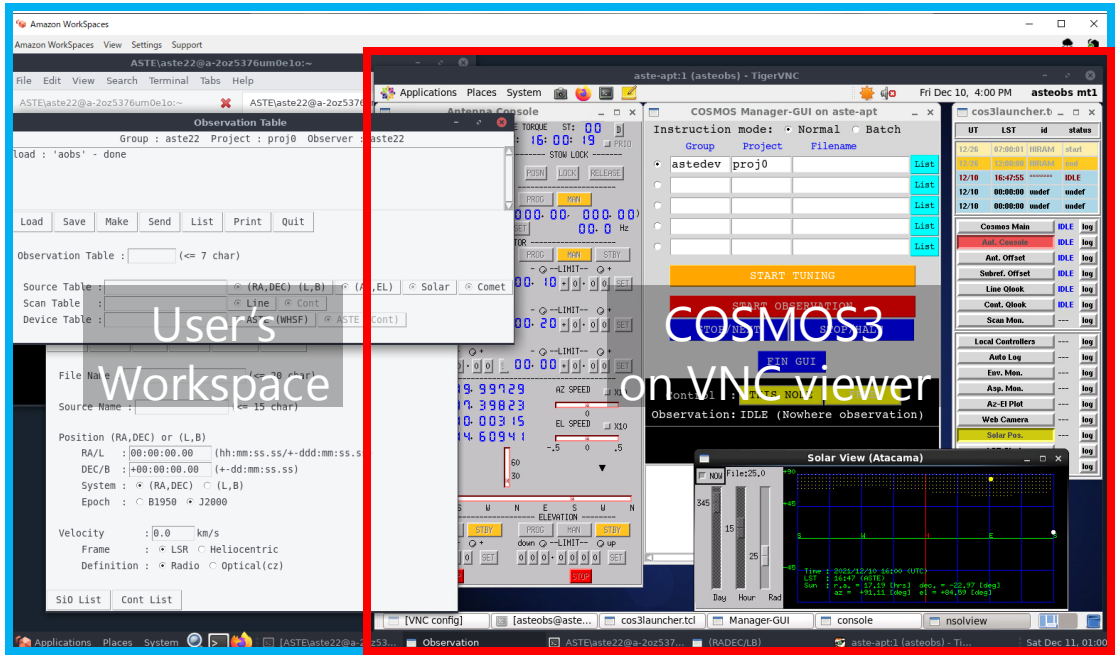
x4

Spectrometer	XFFTS
IF bandwidth	2.5 GHz
# of channels	32,768
# of IFs	4



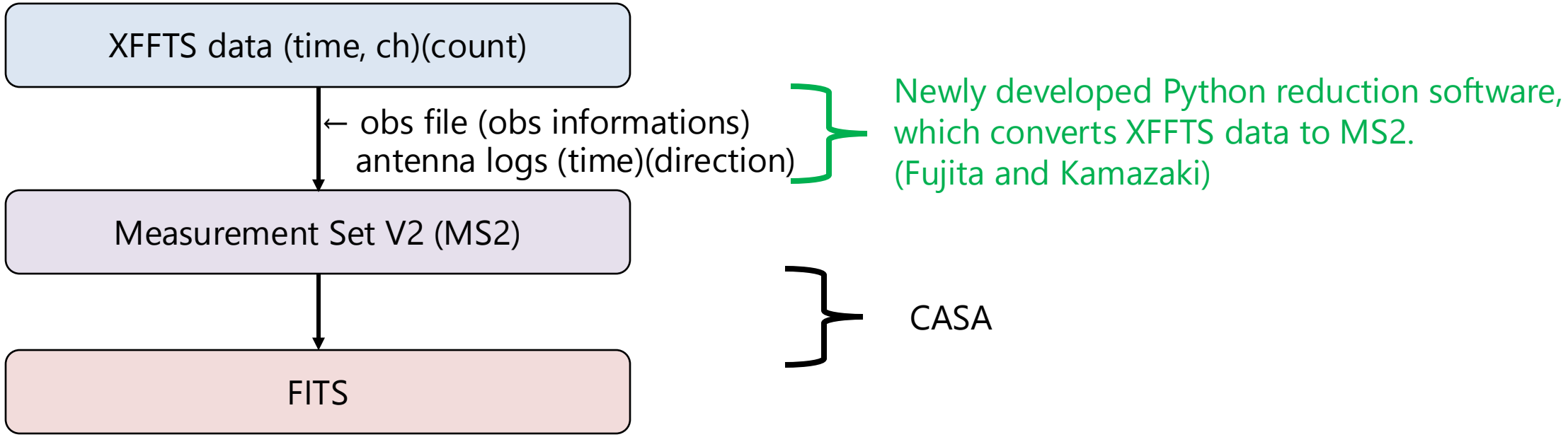
Recent Update: User's Workspace, Remote Control Terminal

- **Amazon Workspaces – Virtual Desktop Infrastructure**
  - A workspace is provided for a user
    - Observation preparation
    - VNC viewer to access the remote-control Virtual PC (on Amazon Web Services)
  - A user can connect its own workspace using AWS client (Win, Mac, Linux, …) from EA, EU, Chile.



Recent Update: Data Reduction with CASA

- **Data reduction with CASA**
  - XFFTS data are reduced with CASA.
    - No plan to update NEWSTAR and NOSTAR to support XFFTS data.

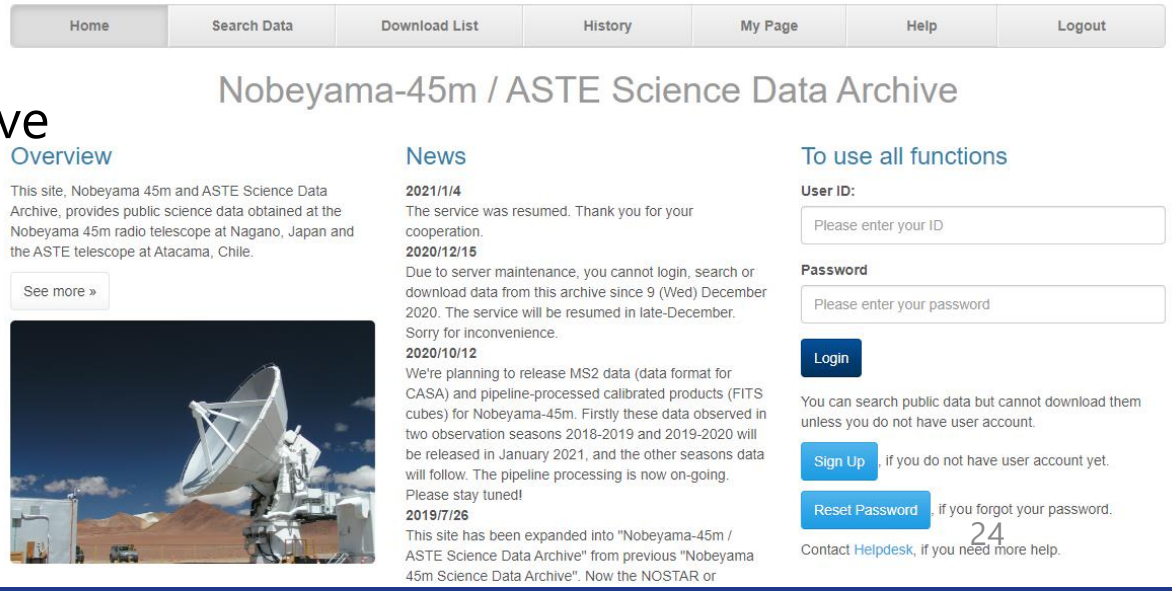


Recent Update: Data Reduction with CASA

- **Data reduction with CASA**
  - XFFTS data are reduced with CASA.
    - No plan to update NEWSTAR and NOSTAR to support XFFTS data.
  - MSv2 data generator (aka MERGE2) for WHSF and MAC is also under testing.

  - These CASA MSv2 format data will be delivered and distributed through the NRO/ASTE Science Data Archive.

    Nobeyama-45m/ASTE Science Data Archive
    (https://nobeyama-archive.nao.ac.jp/)



Summary

- The prime objectives of ASTE Project
  - **Promote science** with the submm single-dish telescope
  - **Promote development** of instruments and techniques for astronomical observations

  ➔ A precursor to ALMA and submm astronomy in terms of science and instrumentation
- 2024 Dec. –
  - 2024 Dec 27, ASTE Science Workshop in Mitaka
  - 2025 Feb. Mount Heterodyne system
  - 2025 Mar-Dec Carry over, Chile time, and new open-use obs?