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# Future Development of 45m

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# Outline

- Current System of Nobeyama 45-m Telescope
- Recent Issues & Actions (incl. on-going activities)
- Near Future System
- Future Development
  - NRO Activities
  - Development Proposal
- Summary

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# Nobeyama 45-m Telescope

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## Nobeyama Radio Observatory (NRO)


- Diameter: 45m
- Surface accuracy: 100um rms
- 6 -> 5 Receivers
- Frequency coverage: 20 – 116GHz
- Beam size: 15” @ 115GHz
- Pointing accuracy: ~ 3”
- Main beam efficiency: ~ 0.45 @ 115GHz
- Aperture efficiency: ~ 0.36 @ 115GHz

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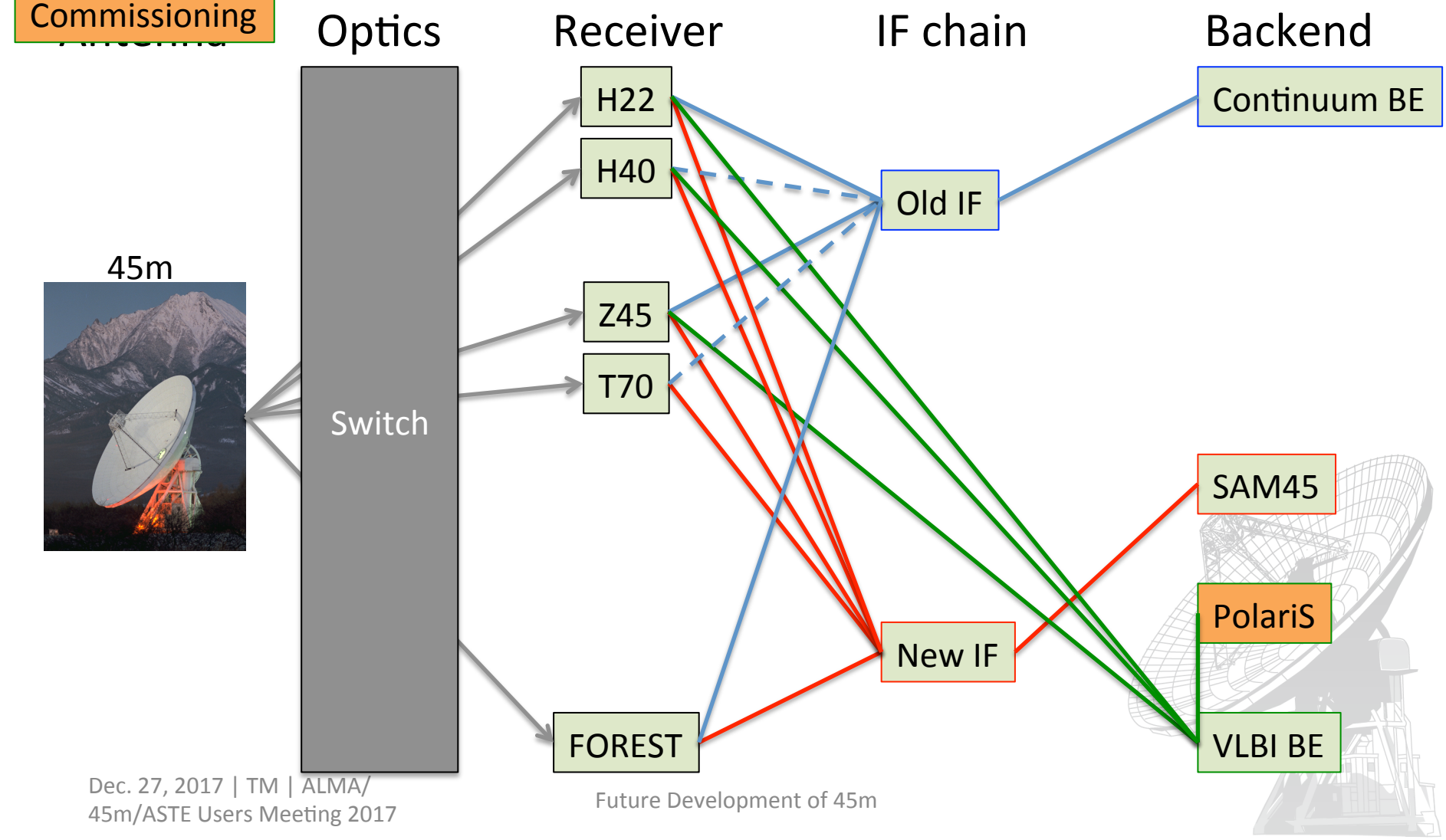
OPEN USE

Internal Use

Commissioning

# 2017-2018 System



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# Receivers

| | H22 OPEN USE | H40 OPEN USE | Z45 OPEN USE | T70 OPEN USE | FOREST OPEN USE |
|---|---|---|---|---|---|
| # of Beams | 1 | 1 | 1 | 1 | 4 |
| Polarization | RHCP/LHCP | LHCP | H/V | H/V | H/V |
| Rx.type | HEMT | HEMT | HEMT | SIS (2SB) | SIS (2SB) |
| RF freq. [GHz] | 20-25 | 42-44 | 42-46 | 71 - 92 | 80 - 116 |
| IF B.W[GHz] | 5-7<br>2 | 5-7<br>2 | 4-8<br>4 | 4-8<br>4 | 4-12<br>8 |
| Tsys[K] | 100 | 250 | 100 | 120 - 270 | 150 - 300 |
| IF chain | Old/New | Old/New | Old/new | New | Old/New |
| Continuum BE | OPEN USE | Internal | OPEN USE | Internal | OPEN USE |
| VLBI BE | ○ | ○ | ○ | x | x |

# Backend (Spectral Line)

| | OCTAD-A + SAM45 OPEN USE | PolariS Commissioning |
|---|---|---|
| Type | F-FX type correlator | Software |
| IF chain | New | (VLBI BE) |
| # of Array | 16 | 4 |
| # of ch / array | 4096 | 131072 / 65536 |
| Freq. Coverage (BW) (MHz) | 2000 (1600 eff) / 1000 / 500 / 250 / 125 / 63 / 31 / 16 | 8 / 4 |
| Freq. Resolution (kHz) | ~ BW / 4096 x 2 | 0.061 |
| Channel separation (kHz) | BW / 4096 | |

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# Recent Issue

- How to keep competitive position in the world ?
  - Attractive capabilities
    - e.g.) Large-area mapping @ 3mm band
  - Stable operation
    - e.g.) Decommissioning old receivers, backend, etc.
  - Operation efficiency

# Recent Issues & Actions (FY2014 -)

Blue: Done
Green: Done (updated)
Red: on-going

- Antenna
  - Replacing sub-ref. servo system (FY2015 done)
  - Surface adjustment (FY2015 done)
- Optics
  - Put (Stick) metal foils to M2 and M3 (FY2015 done)
  - Replace chopper wheel mechanism (FY2016 done)
  - Replace beam switching mechanism (FY2017-2018)
  - Replace mirror switching mechanism (FY2017-2018) : **M4, New-beamguide (T70) is done (FY2017)**
- Receiver – IF - Backend
  - **So many frontends ➔ Decommissioning of** S40, S80, S100, **TZ**
    - S40: Low demand(?) / Replace H40/Z45 CLNA to wider one? ➔ FY2016 done
    - S80/S100: After checking consistency among 3mm RXs (FY2015-2016) ➔ FY2016 done
    - **TZ: FOREST covers TZ capability (Deep integration, ON-ON mode) (FY2017)**
  - Commissioning of Z45 (Season2015-2016) ➔ Open to Community Season 2016-2017
  - Decommissioning of Old IF system
    - ~~Check consistency between AOS and SAM45 (Season2015-2016)~~
    - Relocate Continuum Backend (FY2015 - 2016)
  - ~~Applying 3-bit linearity correction to OCTAD-A + SAM45 spectrometer (FY2015)~~
  - Commissioning of SAM45 spectral window mode (Season2015-2016) ➔ Open to Community Season 2016-2017
  - ~~Commissioning of ROACH spectrometer (Season2015-2016)~~
- Monitor & Control
  - Expand remote observation: Hokkaido, Nagoya, Kagoshima, ASIAA, KASI
  - Metrology system (Wind / Thermal)
- Observing/Reduction/Analysis Softwares
  - **New programs for generating observing script (nobs): released for Season2017-2018**
  - Toward CASA

# Recent Issues & Actions (FY2014 -)

- Optics
  - Replace mirror switching mechanism (FY2017-2018) :

    **M4, New-beamguide (T70) is done (FY2017)**
- Receiver – IF - Backend
  - **So many frontends ➔ Decommissioning of** S40, S80, S100, **TZ**
    - **TZ: FOREST covers TZ capability (Deep integration, ON-ON mode) (FY2017)**
- Monitor & Control
  - Expand remote observation: **Hokkaido**, Nagoya, **Kagoshima**, **ASIAA**, KASI
- Observing/Reduction/Analysis Softwares
  - **New programs for generating observing script (nobs): released for Season2017-2018**

# Recent Issues & Actions (FY2014 -)

- Optics
  - Replace beam switching mechanism (FY2017-2018)
  - Replace mirror switching mechanism (FY2017-2018) :
    Old-beamguide (H22, H40, Z45)
- Receiver – IF – Backend
  - Decommissioning of Old IF system
    - Relocate Continuum Backend (FY2015 – 2016) ➔ FY2018
- Monitor & Control
  - Expand remote observation: Hokkaido, Nagoya, Kagoshima, ASIAA, KASI
  - Metrology system (Wind / Thermal)
- Observing/Reduction/Analysis Softwares
  - Toward CASA

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# Near Future System

Antenna

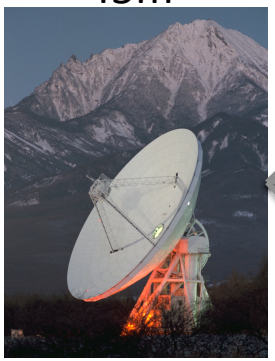
Optics

Receiver

IF chain

Backend

45m



Switch

H22

H40

Z45

T70

FOREST

New IF

Continuum BE

SAM45

PolariS

VLBI BE

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# Future Development

- Does 45-m telescope have enough capability ?
  - Highly depend on the demands from community.
  - Competitive ?

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# Future Development

- Near Future
  - Toward more productive system
    - Improve Aperture efficiency > 0.4 @ 110 GHz
    - Wideband FOREST: 67 – 116 GHz
    - Expand remote observation: incl. Korea, Taiwan
    - Auto-observation (queue obs, auto-pointing)
    - Reduction with pipeline
    - Stable system ➔ higher sensitivity

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# Future Development

- Further Future (2022.03.31)
  - Achieve the highest capability (in a few(?) particular fields)
    - Heterodyne Camera (> 100pixels) @ 3mm band
    - Auto-obs, reduction, archive system
    - Massive data reduction with users
    - Wide-field imaging line survey
    - Transient object

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# K-GPU Spectrometer

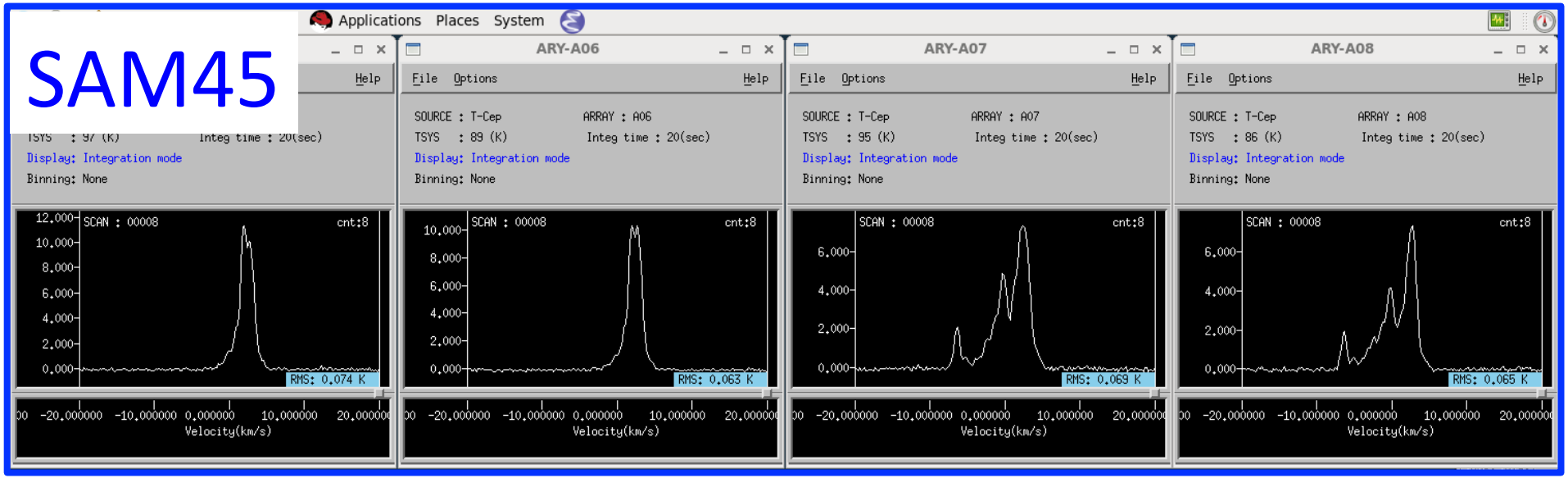
- KASI developing TP spectrometer for ACA
- SAM45 spectrometer ~ ACA correlator
- Considering to replace SAM45 to K-GPU spectrometer is quite natural.

# First Spectra with 45-m Telescope (Dec. 25, 2017)

## K-GPU Spectrometer

**Quite consistent with SAM45 output !!**

SAM45



# Data Reduction with CASA

- Version > 5.0.0
- Basic functions were implemented.
- 45-m Telescope can generate MS2 format from Season 2017-2018
  - Commissioning will be done with these data.
- Pipeline will be developed, and commissioning may be done in FY2018

# Nobeyama 45-m Science Data Archive

- https://nobeyama-archive.nao.ac.jp/
- Version 1 was released on Aug. 21, 2017
- Formats: NEWSTAR (PoSW), nostar (OTF)

- Preparing for version 2

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# Development Proposal

- NRO receive proposals for instruments, software and/or new observing mode on the Nobeyama 45-m Telescope to increase capabilities for science operations (Open-Use).
- Progress will be reviewed every year.
- Acceptance review will be organized before offering to community.
- http://www.nro.nao.ac.jp/~nro45mrt/html/prop/prop_instrument-e.html

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# Development Proposal

- FY2017
  - Call for Proposal: May 9, 2017
  - Deadline: June 15, 2017
  - 8 proposals → 3 proposals are accepted.
  - http://www.nro.nao.ac.jp/~nro45mrt/html/prop/accept_development.html
    - HINOTORI (H. Imai et al.)
    - FMLO: (A. Taniguchi et al.)
    - 7mm (30-50GHz) Rx: (Chau-Ching Chiong & F. Nakamura et al.)
- FY2018
  - Call for Proposal: May, 2018
  - Deadline: June, 2018
  - Review: July, 2018

# Summary

- Nobeyama 45-m Telescope: One of the largest radio telescope which covering 20 – 115GHz.
- On-going/planned updates will be finished in coming 2 years
- Future Developments
  - Near Future: Toward more productive system
  - Further Future (2022.03.31):
    Achieve the highest capability (in a few(?) particular fields)
  - NRO Activities
    - K-GPU spectrometer
    - Toward auto-observation system
      - Nobeyama 45-m Science Data Archive
      - Data Reduction with CASA
  - Development Proposal
  - Highly depend on the demands from community.
  - Competitive ?
  - Cooperation with universities and/or other projects in NAOJ is essential.