The East-Asian VLBI Network (EAVN): Recent Developments and Future Prospective

Contents

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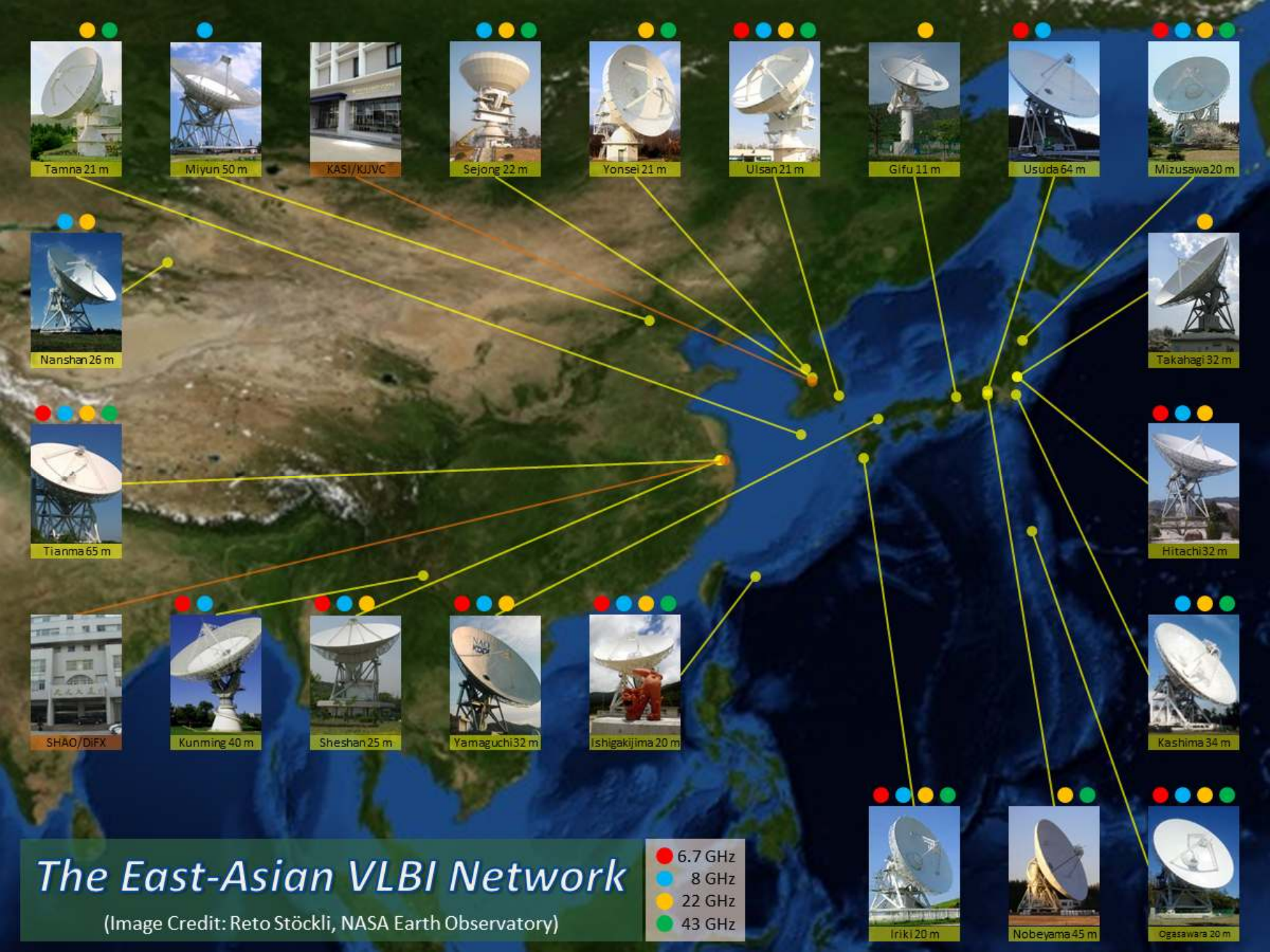
The East-Asian VLBI Network (EAVN)

- VLBI arrays operated at each East-Asian country: CVN (China), KVN (Korea), JVN and VERA (Japan)

➡ Launch of 'the East-Asian VLBI Network' (2013 –)

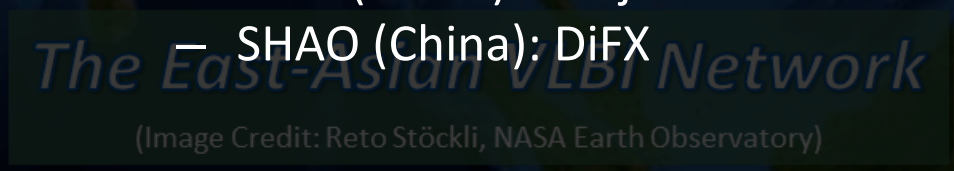
  - EAVN activities are conducted by 'East Asia VLBI Consortium' under EACOA

- Main characteristics of EAVN
  - (Mildly) high angular resolution at cm- ~ mm-wavelengths
  - High sensitivity thanks to large-aperture antennas (Tianma 65 m, Nobeyama 45 m, etc.)
  - Long common-sky time with Australian telescopes → high angular resolution in north-south direction


Tamna 21 m
Miyun 50 m
KASI/KJVC
Sejong 22 m
Yonsei 21 m
Ulsan 21 m
Gifu 11 m
Usuda 64 m
Mizusawa 20 m
Nanshan 26 m
Takahagi 32 m
Tianma 65 m
Hitachi 32 m
SHAO/DiFX
Kunming 40 m
Sheshan 25 m
Yamaguchi 32 m
Ishigakijima 20 m
Kashima 34 m
Iriki 20 m
Nobeyama 45 m
Ogasawara 20 m
The East-Asian VLBI Network
(Image Credit: Reto Stöckli, NASA Earth Observatory)
6.7 GHz
8 GHz
22 GHz
43 GHz

EAVN: Specifications (as of 2017 July 7)

- Number of (potential) telescopes: 20 (17 telescopes have participated in previous EAVN observations one or more times)
  - Korea: 4, China: 5, Japan: 11
- (Possible) frequency coverage:
  - 6.7 GHz (11 stations), 8 GHz (15), 22 GHz (17), 43 GHz (11)
- (Expected) angular resolution:
  - 2.4 mas (6.7 GHz; Ogasawara – Kunming)
  - 1.5 mas (8 GHz; Ogasawara – Nanshan)
  - 0.6 mas（22 GHz; Ogasawara – Nanshan)
  - 0.7 mas (43 GHz; Ogasawara – Tianma)
- Sensitivity for 7-σ fringe detection (τ = 60 s, B = 256 MHz):
  - 1.6 mJy (8 GHz; Tianma – KVN)
  - 9.5 mJy (22 GHz; Tianma – KVN)
- (Expected) recording rate: $\geqq$ 1 Gbps (= 256 MHz BW)
- (Currently-used) correlator:
  - KJCC (Korea): Daejeon Hardware Correlator and DiFX
  - SHAO (China): DiFX

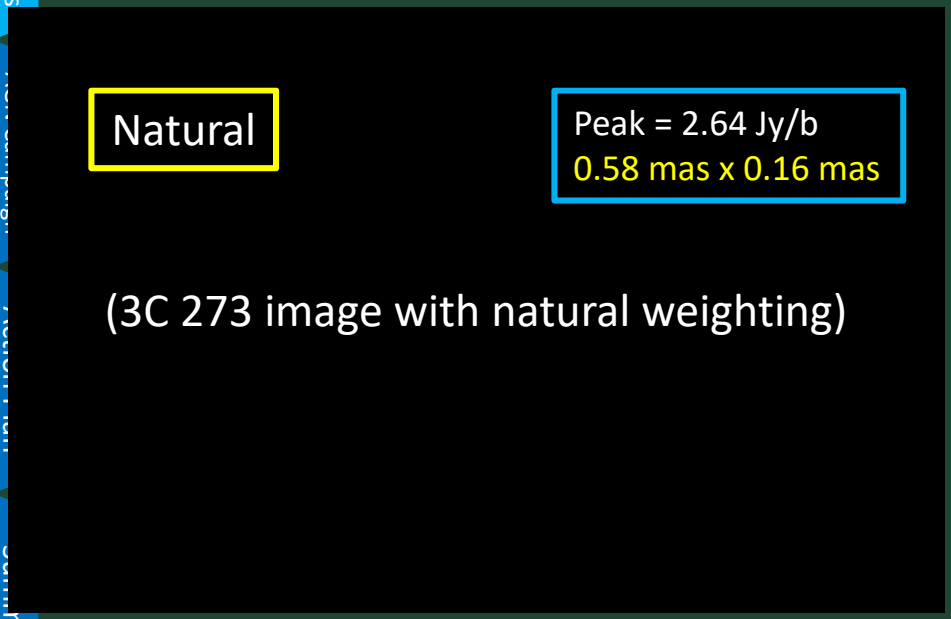


Major Achievements

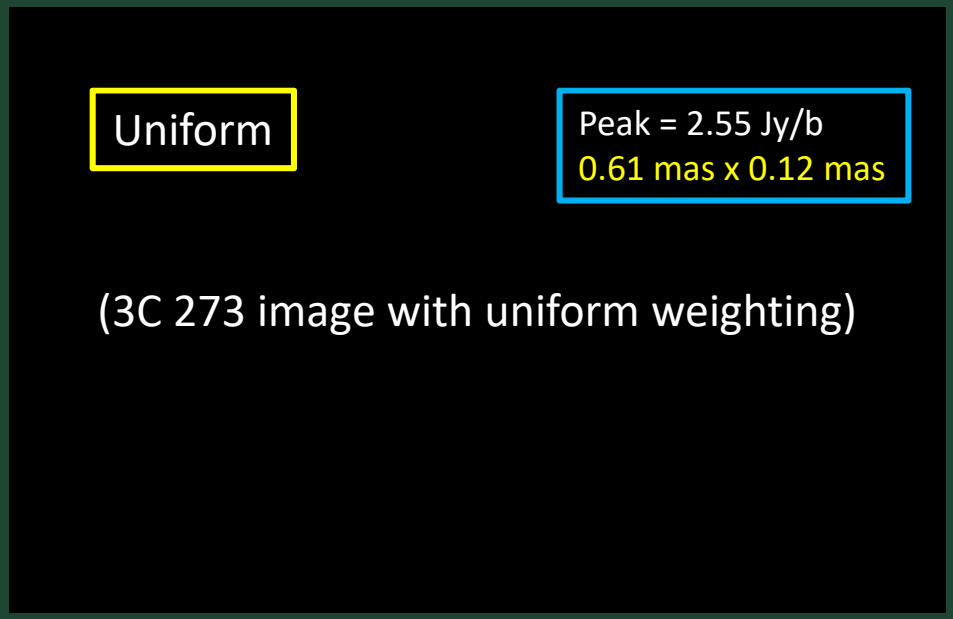
- Fringe test observation
  - 15 times at 6.7/8/22/43 GHz (single polarization, 1 Gbps)
  - Fringe detection at all frequencies for all participated stations (KR: 4, JP: 8, CN: 4, AU: 1)
- International collaboration
  - Test observations with Australia (ATCA) and Italy (Medicina and Noto)
  - Launch of 'EAVN Science Working Group' in three science topics (AGN, evolved stars, star formation)
- 'EAVN AGN Campaign' in 2017 spring
  - First conduct of science commissioning with EAVN

Preliminary Results of Imaging Test

- First 43 GHz image of 3C 273 by EAVN+ATCA on 2016 Mar 20
  - Very high angular resolution (~ 0.1 mas) can be obtained in the north-south direction



(3C 273 image with natural weighting)



(3C 273 image with uniform weighting)

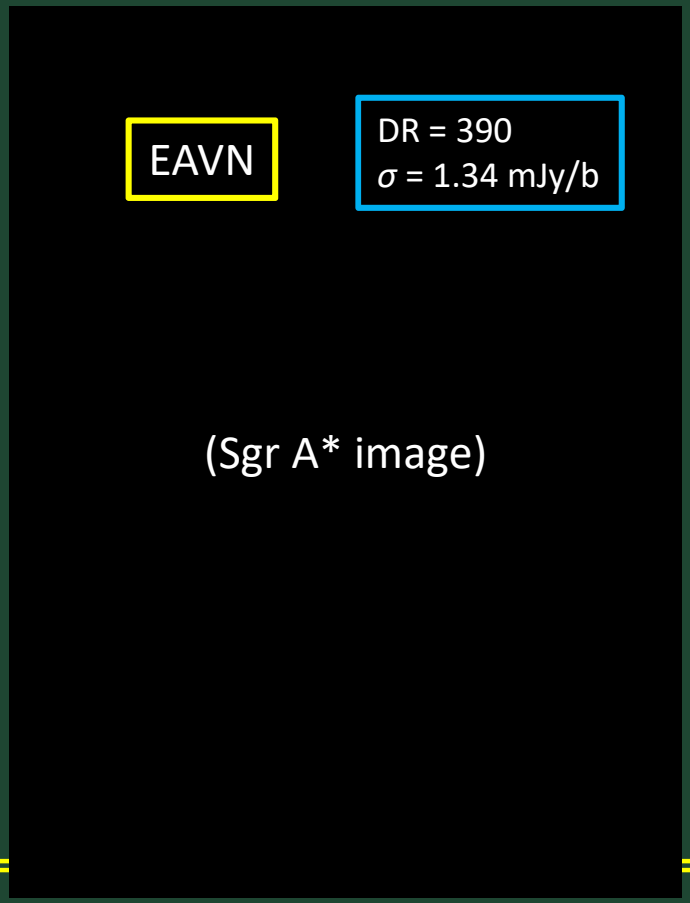
(Image courtesy: Dr. Richard Dodson (ICRAR))

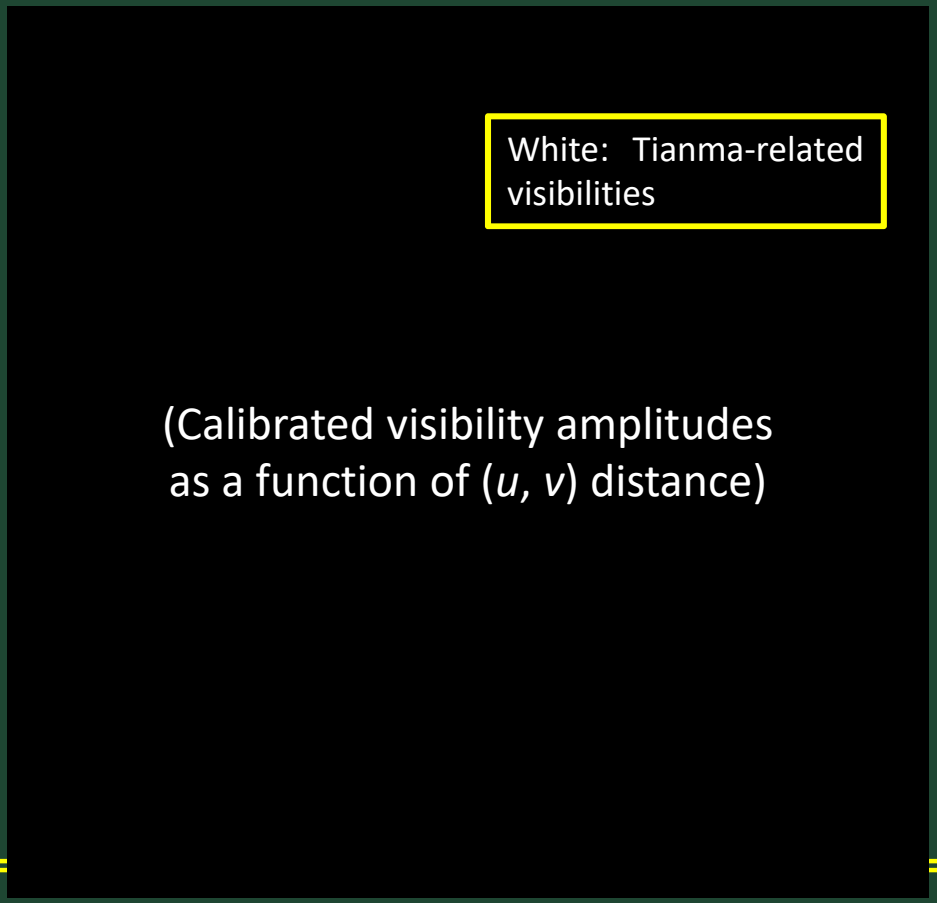
EAVN(+Italy) AGN Campaign

- Main purpose
  - To evaluate system performance of EAVN
  - To check up on the array operation and availability of schedule files at each station
  - To conduct VLBI monitoring quasi-simultaneously with EHT+ALMA campaign
- Brief summary of the Campaign
  - Total observing time: 140 hours (17 sessions)
    - 22 GHz: 40 hours (5 sessions); 43 GHz: 100 hours (12 sessions)
  - Number of participating telescopes: 15 (Italy: 2, China: 2, Korea: 4, Japan: 7), KaVA and Tianma (8 stations in total) participated in all 17-epoch observations.
  - Observation mode: 1 Gbps (part of telescopes recorded the data with 2 Gbps), 256 MHz BW, LHCP

Preliminary Results of EAVN AGN Campaign

- First 43 GHz image of Sgr A* by EAVN (KaVA+Tianma) on 2017 Apr 6 (on-source time: 10 hours)
  - Clearly reconstructed a Gaussian structure of the source

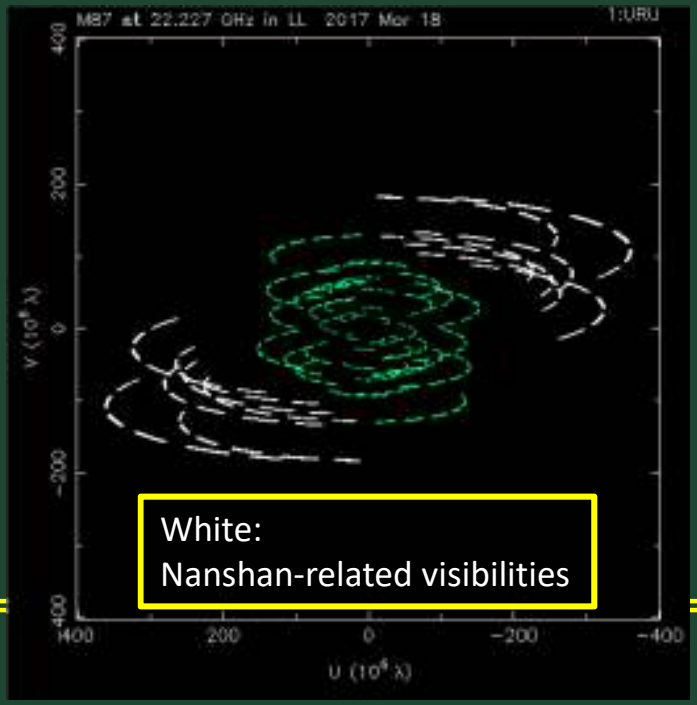




(Image courtesy: Dr. Guang-Yao Zhao (KASI))

Preliminary Results of EAVN AGN Campaign

- First 22 GHz image of M87 with the maximum baseline length (~ 5,500 km) of EAVN (KaVA + Tianma + Nanshan (Urumqi)) on 2017 Mar 18 (on-source time: 7 hours)



White:
Nanshan-related visibilities

KaVA

(M87 image with KaVA)

EAVN

(M87 image with EAVN)

(Image courtesy: Dr. Kazuhiro Hada (NAOJ))

Action Plan for EAVN

Year	2015	2016	2017	2018	2019
Actions	・Further fringe tests ・Imaging tests, performanc e evaluation	・Imaging tests ・Science commissioning observations at 22/43 GHz ・Fringe tests at 6.7 GHz ・Launch of EAVN Science WG	・Performance evaluation and science commissioning at 6.7/22/43 GHz ・Practice of the array operation (scheduling, telescope operation, data handling, etc.)	・(Early or Late 2018) Risk-shared open-use at 22/43 GHz ・(Late 2018) Risk-shared open- use at 6.7 GHz ・Performance evaluation of 2 Gbps mode	・Performance evaluation for extending observation modes (8 GHz, 2-pol., etc.)
Freq.	8/22 GHz	6.7/22/43 GHz	6.7/22/43 GHz	6.7/22/43 GHz	6.7/8/22/43 GHz
Purposes	・Evaluation of array perform e ar ima cap	・Evaluation of array performance and array	・Initial scientific outputs from EAVN ・Confirmation of	・Regular operation of EAVN ・Conformation of	・Confirmation of performance for various ion modes

Basic capabilities (simple imaging with single polarization) and array operation scheme could be confirmed through test observations.

Short-Term Agenda

- High-speed (≧2 Gbps) data acquisition
  - KVN: operational
  - CVN, JVN, VERA: performance evaluation ongoing
- Dual- (triple-)band simultaneous receiving system
  - KaVA: operational shortly
  - Nobeyama 45 m: HINOTORI Project (22/43/86 GHz receiving system: system development ongoing led by Dr. Hiroshi Imai (Kagoshima Univ.)
- Dual-polarization capability

We are planning to start EAVN common-use operation from (early or late) 2018 with basic observation modes (simple imaging with 1 Gbps (256 MHz Bandwidth), single polarization) at (6.7)/22/43 GHz.

Summary

- The East-Asian VLBI Network (EAVN) project, a new international VLBI array in East Asia, has been started in 2013. Clear fringes have been successfully detected at 6.7, 8, 22, and 43 GHz.

- 17-epoch observations for 'the EAVN AGN Campaign' has been carried out concurrently with the Event Horizon Telescope campaign. High-fidelity images were obtained for Sgr A* and M87 with EAVN.

- We are planning to start EAVN common-use operation from (early or late) 2018 with basic observation modes.