# Japanese VLBI Network Update

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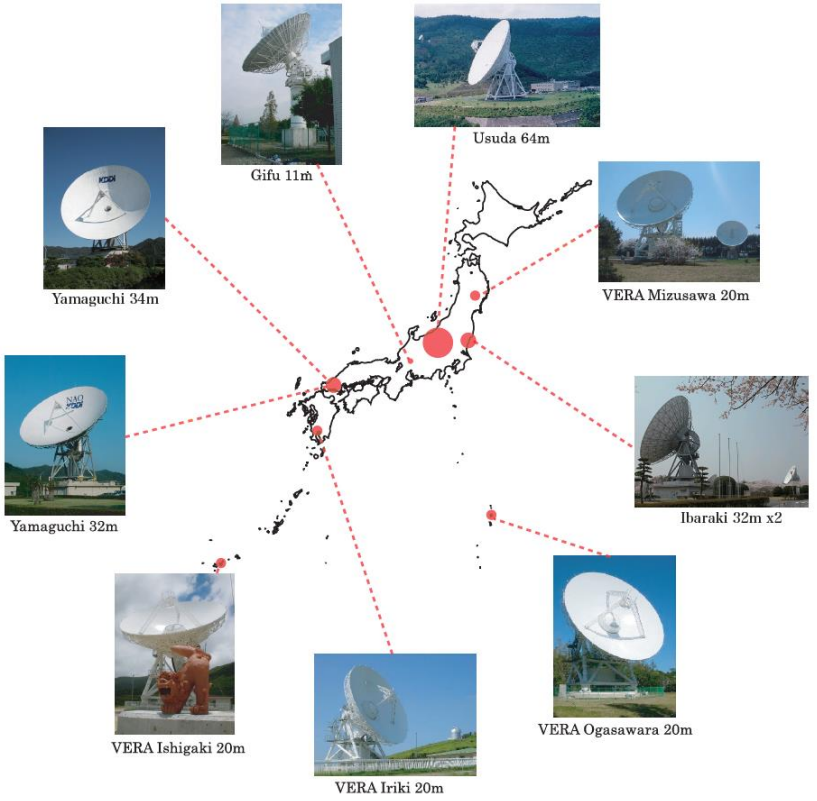
- Collaboration Network of 6 Universities and Research Institutes
  - NAOJ (VERA)
  - Ibaraki, Tsukuba, Gifu, Osaka-pref., Yamaguchi, Kagoshima University
  - JAXA, NICT
- Network
  - 9 telescopes (11m ~ 64m)
    - Usually 6 telescopes for imaging observation
  - Baseline 50 - 2500 km
  - Frequency 6/8/22 GHz
  - Sensitivity 3 mJy (6/8 GHz, Ibaraki-Yamaguchi)
- Status
  - 200hr/yr, 30 observations/yr in total
  - Imaging observation (~6 telescopes)
  - Detection observation (Ibaraki-Yamaguchi)
  - Collaboration with Yamaguchi Interferometer




Japanese VLBI Network (JVN)

# Activities in 2020

- Participation to EAVN (Ibaraki & Yamaguchi)
  - Takahagi 32m (Ibaraki) @ 22 GHz (2020A~)
  - Hitachi 32m (Ibaraki) & Yamaguchi 32m or 34m @ 6 GHz (2021A~)
- Ibaraki-Yamaguchi single baseline observation
  - High sensitivity (~3 mJy), fringe-detection observation (non-imaging)
  - Surveys of various categories of astronomical objects
  - First results to be published soon
- Future plan
  - Working group of future VLBI astronomy of Japan (in VLBI consortium of Japan)
    - For VERA/Mizusawa observatory
    - For JVN
  - Status: under discussion

# JVN Observation
# 2019 Oct – 2020 Sep

| Program | Band | Detection / Imaging | Number of observation | Observation time (hr) |
|---|---|---|---|---|
| High-z quasar | X | Detection | 8 | 56.5 |
| BHs at the galactic center | X | Detection | 4 | 20 |
| Phase referencing with JVN | X | Phase referencing | 1 | 4 |
| Gamma-ray objects | X | Detection | 4 | 41 |
| Micro-quasars | X | Detection | 1 | 4 |
| ECHII region | X | Detection | 5 | 40.5 |
| High-z quasar | C | Imaging | 3 | 36 |
| Methanol maser monitoring | C | Imaging | 1 | 6 |
| Absorption of methanol | C | Detection | 5 | 20 |
| EAVN test observation | C | Imaging | 1 | 10 |

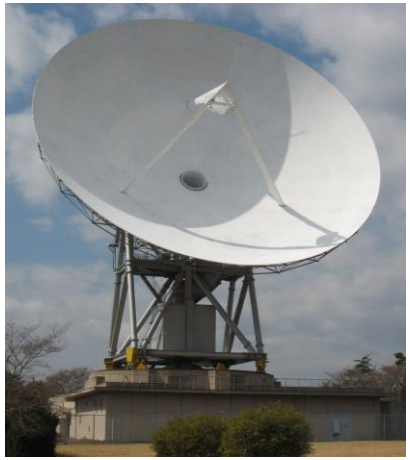
# Summary of JVN Observation
# 2019 Oct – 2020 Sep

| band | Number of obs. | Obs. time (hr) |
|---|---|---|
| C-band | 10 | 72 |
| X-band | 23 | 166 |
| Total | 33 | 238 |

Total number and observation time is restricted by our man-power (Ibaraki and Yamaguchi are operated by research staffs; Yonekura-san, Motogi-san, Sawada-Satoh-san…)

# Participation to EAVN (Ibaraki & Yamaguchi)

- JVN telescopes participating to EAVN sessions
  - Takahagi 32m (Ibaraki) @ 22 GHz (2020A~)
  - Hitachi 32m (Ibaraki) & Yamaguchi 32m or 34m @ 6 GHz (2021A~)
  - Good sensitivity and short baselines
- Data transportation
  - Observatory (recording) -> Mizusawa (data copy/filtering) -> KJCC (correlation)
  - Data copy process may take some time and make the process complex (Hope this process works well…)

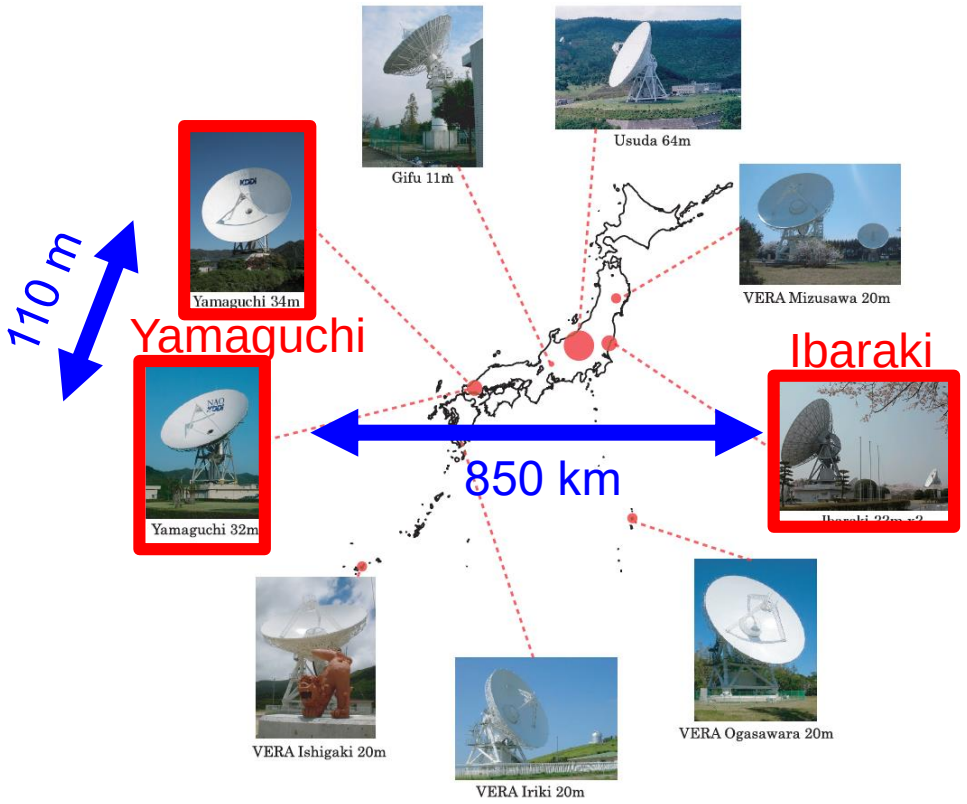


Ibaraki (Hitachi)


Yamaguchi (32m)

# Ibaraki-Yamaguchi single baseline observation & Yamaguchi Interferometer (YI)

- Ibaraki-Yamaguchi
  - Fringe detection oriented VLBI
  - Non-imaging, fringe detection
  - High sensitivity with 32/34m
    - ~3 mJy @ 6/8 GHz
    - $T_{bmin}$ ~ $10^7$ K
- Yamaguchi Interferometer
  - Total flux density observation
  - High sensitivity of ~3mJy
  - Long available time
    - 200~300 hr/yr (~1000 hr in future)
- Status: Steady Operation

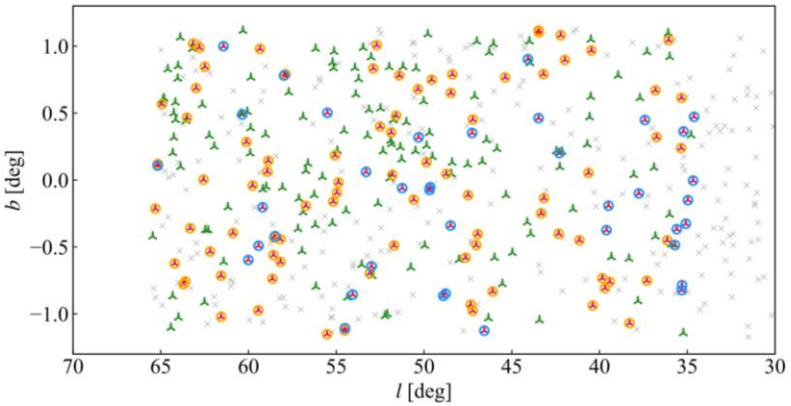



Survey of various categories of astronomical objects to create “VLBI source” catalogs

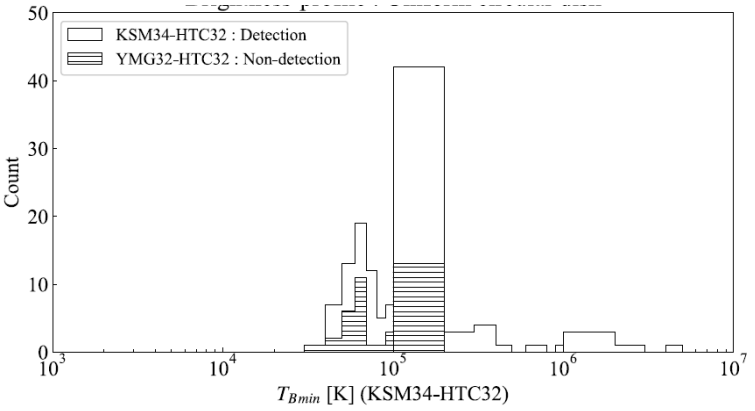
# Highlights of 2020

# A Search for Extremely Compact HII region (ECHII) (Motogi & Ogura)

- Finding the earliest phase of Ultra-Compact HII region
- VLBI observation of thermal object ($T_b$ ~ $10^{4\text{-}5}$ K)
  - Ibaraki-Kashima-Yamaguchi
  - Target 662 objects (from CORNISH)
  - 390 observed, 255 valid observation




Target source distribution



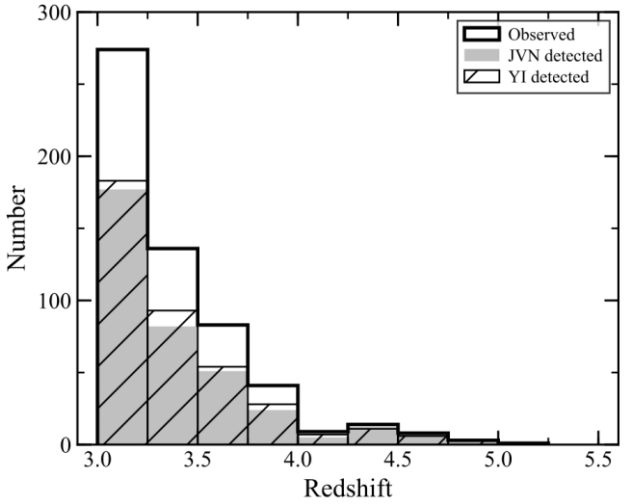

Distribution of brightness temperature

Lowest brightness objects (a few × $10^4$ K) might be thermal

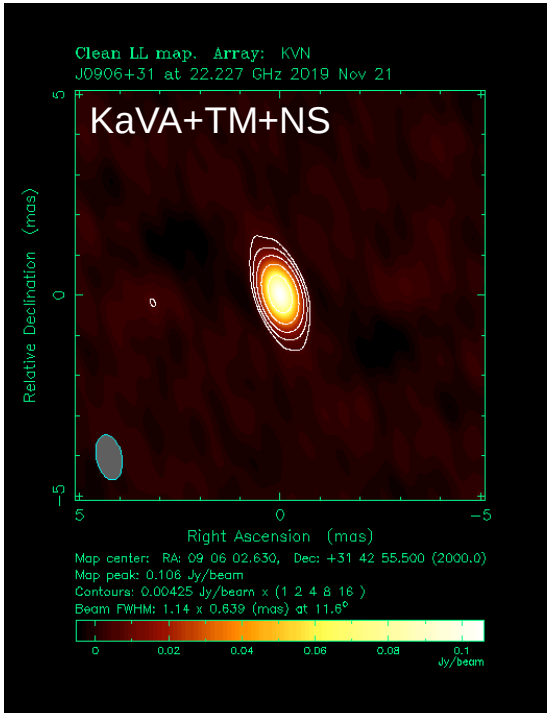
- 122 were detected by Ibaraki-Kashima
- 38 out of 122 were not detected Ibaraki-Yamaguchi (i.e., low-brightness)

# Survey and Imaging Observation of High-z AGNs (Furuya)

- Radio properties of high-z AGN jets
  - Structure and spectrum
    - Blazar (Large Doppler)
    - CSS/GPS/HFP (Young jet)
  - Luminosity function
    - Evolution in the cosmological time



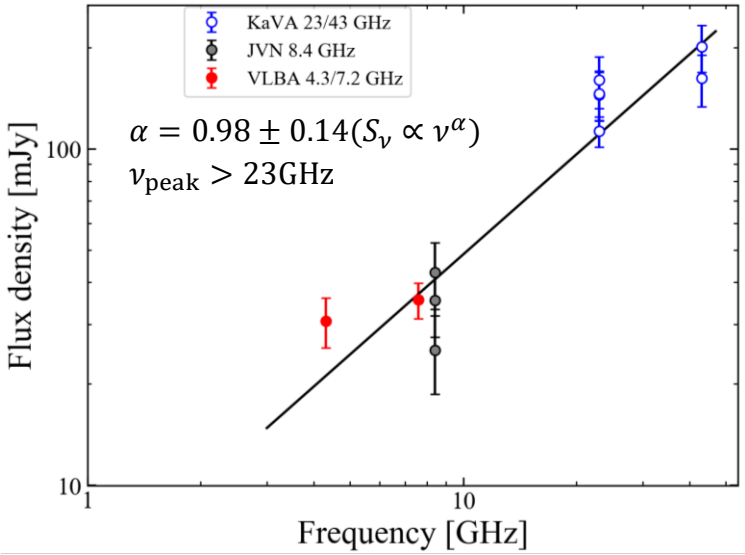

- JVN Survey
  - Large and uniform sample survey
  - Selected from SDSS/FIRST survey
  - 570 AGNs with z>3 were observed
  - 363 detected by JVN (Ibaraki-Yamaguchi)
  - ~80% of them show flat spectrum

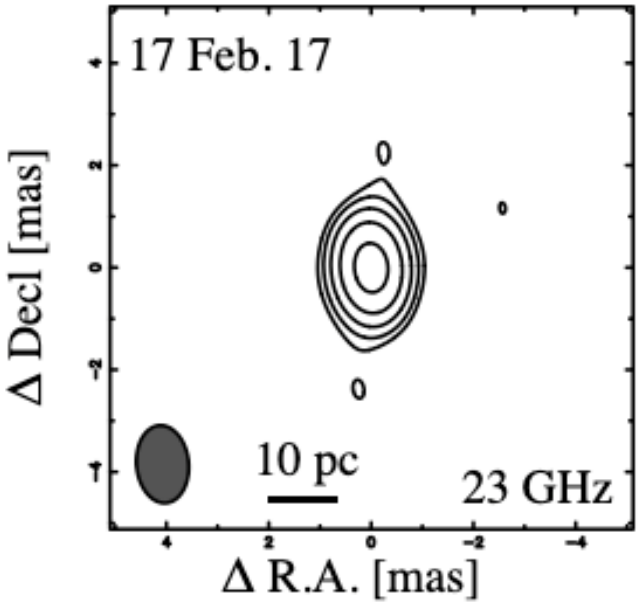



- EAVN Imaging
  - Imaging by EAVN at 22 GHz for 8 sources
  - An example (J0906+31) ->

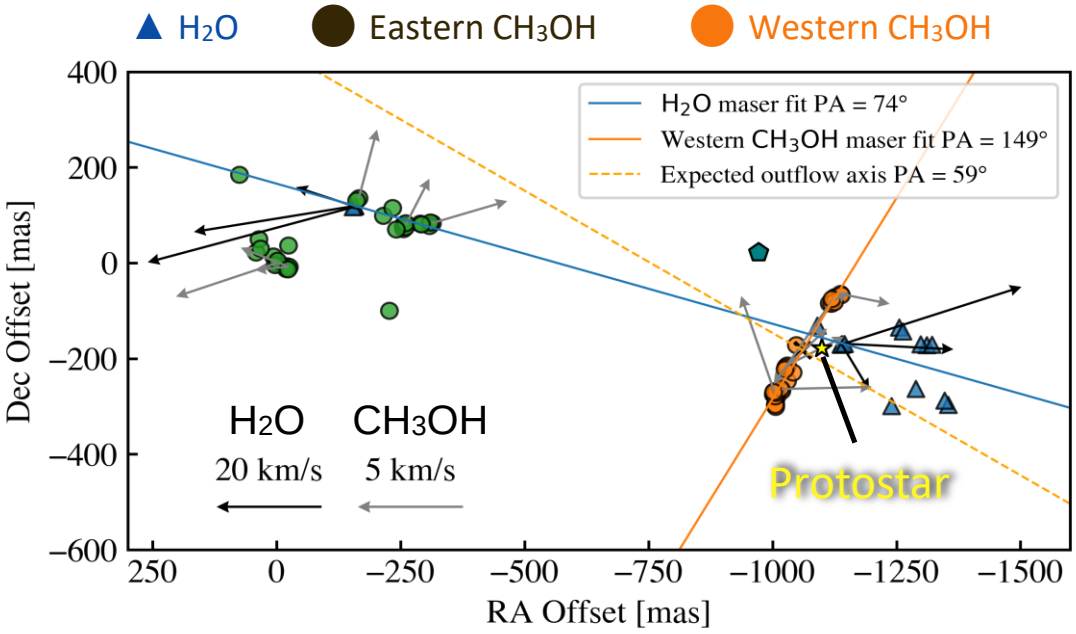
# γ-ray emitting HFP candidate NVSS J112914-052856 (Fujimoto)

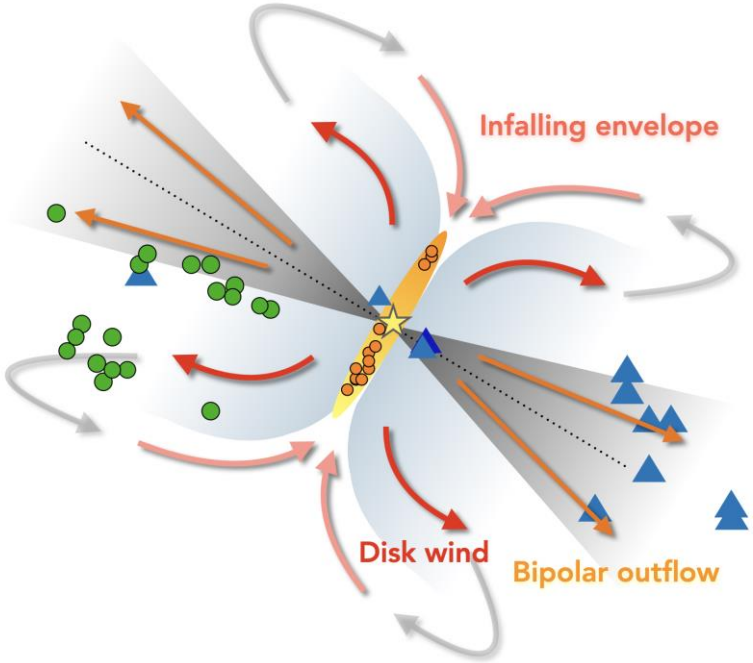
- VLBI Observation of gamma-ray emitting AGN candidate
- Gamma-ray AGN
  - Most of gamma-ray emitting AGNs are Blazars
  - Gamma-ray is emanated by strong Doppler boosting
- Is there non-Blazar gamma-ray AGNs?
  - JVN survey
    - To find gamma-ray emitting AGN candidates
    - The brightest object NVSS J112914-052856
  - KaVA/EAVN imaging at 23/43 GHz
    - Compact structure (<10 pc) ->
    - Inverted spectrum up to 43 GHz
- Very young AGN jet (HFP) with gamma-ray emission



# 6.7 GHz $CH_3OH$ masers JVN observation in G59.783+0.065: a disk - outflow system around high-mass protostar (Nakamura)




- 6.7 GHz methanol maser has been considered as a tracer of disk around high-mass protostar
- JVN (6.7 GHz) and VERA (22 GHz) monitoring observations of a high-mass protostar G59.783+0.065
- Revealed that the western part of the methanol maser emission is associated with the disk, and the eastern part is with the outflow!

# Future Plan

# Discussion on the future JVN (6-7 years)

- Discussion to be completed in this year
  - Start the new program from 2022
- Scientific programs (tentative)

1. Pulsar and Galactic compact objects
   - How are pulsars and black holes created and evolved?
   - How is black hole jet created?
2. The instant of birth of high-mass star
   - Radio jet embedded in IRDC
   - Periodicity of maser around high-mass YSO
   - Accretion burst of 6.7 GHz methanol maser
3. AGN: VLBI with high energy gamma-ray and neutrino
   - Where is the high energy photon created?
   - Does Blazars accelerate cosmic-rays?