East Asian VLBI Network observations of nearby supermassive black holes

East Asia AGN Workshop 2017, Dec/4-6/2017, Kagoshima

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On behalf of

EAVN commissioning team ("Tiger Team") and
EAVN-AGN Science Working Group
Role of \textit{cm-VLBI} in the era of \textit{mm-VLBI}

- \textbf{Millimeter VLBI}
  - Image BH shadow, test GR
- \textbf{Centimeter VLBI}
  - Connect horizon-scale images to the global structures (jets, accretion flows)
  - Broad range of science targets (LLAGN, high-z quasars, extended structures, transit sources)
  - Connection to SKA
The East Asia VLBI Network
KaVA: precursor of EAVN

- First regularly operating international VLBI array in EA (2014-)
- Jet acceleration, propagation, collimation, γ-ray blazars (see poster by Lee T. P3-03)
- Resolution, sensitivity: still not as good as other cmVLBI facilities (e.g., VLBA)
  - Need more stations particularly from China!
“EAVN-AGN campaign” spring 2017

- Largest-ever East Asian joint VLBI campaign
- Two key stations from China (Tianma65, Urumqi)
- Promote EAVN commissioning towards future regular operation
- M87/SgrA* to demo a good EAVN science case. Complement EHT
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<tr>
<th>Date</th>
<th>UT time</th>
<th>Target</th>
<th>Freq.</th>
<th>Stations</th>
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<td>18:55 – 00:55 (6hr)</td>
<td>SgrA</td>
<td>43GHz</td>
<td>KaVA7, TM</td>
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<td>3/18</td>
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- **17 epochs (5 @ 22GHz, 12 @ 43GHz)**
- **KaVA+Tianma65 for all the epochs**
- **Urumqi before/middle/after EHT period**

Milestone  (March 18 2017 @ 22GHz)

First complete EAVN fringes among China-Korea-Japan!
Power of Tianma65

VERA-VERA (MIZ-IRK)  VERA-KVN (MIZ-KUS)  VERA-TIA (MIZ-TIA)

Fringe sensitivity with Tianma: >3 times better than KaVA

(1σ_{TM} \sim 2\text{mJy}@22\text{GHz}, 1\text{Gbps})
SgrA*  
(Guang-Yao Zhao (KASI) et al.)

KaVA+Tianma @ 43GHz

- First KaVA+Tianma image on SgrA*
- Weak signals, uv-coverage, image dynamic range
  - Resolved structures, scattering screen
• Urumqi is a critical station to enhance EAVN resolution
• Jet base of M87 resolved down to ~70Rs (~0.5mas at 22GHz)
• With the forthcoming 43GHz receiver at Urumqi, EAVN can further double resolution
KaVA – EAVN image comparison

- Compared to KaVA
  - ~2-2.5 times higher angular resolution (~0.5mas at 22GHz)
  - ~2-3 times lower image rms noise (~100uJy at 22GHz)
- Almost equivalent imaging performance to VLBA
EAVN+Italy

M87, 22GHz, Apr/3/2017

- M87 KaVA+MC+NT at 22GHz
- E-W resolution 0.14mas (19Rs)!
Current status

- The highest priority is the technical validation of EAVN array
- Already some milestones through this campaign
  - KaVA+Tianma(+Urumqi): quasi-regular operation successful
  - High-resolution, high-sensitivity imaging comparable to VLBA
- Deeper studies on SgrA/M87 promising!

- We hope to start “EAVN open use” from 2018
- Late 2018: KaVA+Tianma65 (22/43GHz)
- Early 2019: KaVA+Tianma+Urumqi
More to come in East Asia

- EAVN will rapidly expand in the next few years
  - FAST 500m
  - Thailand VLBI Network
  - A few more 100m-class radio telescopes in China
  - Wideband recording

- **Towards “micro-Jy VLBI”**

- Much broader range of science targets
  - Much weaker AGNs, much more distant AGNs

- Synergy with ALMA, SKA, TMT, CTA, LIGO/KAGRA
Summary

• VLBI collaboration in East Asia is rapidly growing
• EAVN campaign observations of SgrA*/M87 in concert with EHT
  – Complement EHT (jet propagation, accretion flow, scattering)
  – Accelerate EAVN commissioning
• Data analysis still ongoing, but some preliminary results/images already demonstrated powerful performance of EAVN array
  – First science results will come out soon, stay tuned!
• EAVN will further expand in the next few years!
• EAVN is a large telescope for East Asian community
• If you are interested in, please feel free to contact us. We are happy to support your science!
Appendix
VLBI with FAST (S-band, M87)