KaVA stands for KVN and VERA Array which is a Korean-Japanese joint VLBI facility

Recent KaVA AGN Large Program results

Sohn, Kino, Hada, Zhao, Niinuma, Jung,
Ilje Cho(UST/KASI), Jongho Park(SNU), Hyunwook Ro(Yonsei/KASI)
And KaVA operation team & AGN WG members
Contents

• KaVA?
• Array performance
• Call for Proposals
• KaVA AGN WG
• KaVA AGN Large Program (AGN LP)
• Recent results of AGN LP – M87 and Sgr A*
• Summary
KaVA stands for KVN and VERA joint Array

- 4 20m VERA and 3 21m KVN
- 22 GHz and 43GHz
- Single Polarization
- 1 Gbps (256MHz)
- 500 hours/year of open use
- Call for Proposal deadline - June and November 1st

- Science WGs
  - AGN, SF, ES
  - Astrometry (new)

- Large Programs by SWGs
  - 3 Large programs

- Upgrading
  - Bandwidth
  - Polarization
  - Phase referencing
Imaging performance (Niinuma+2014)

3C273
32MHz

VERA 23 GHz
(d)
2013 Apr 13
13.5 pc
DR=370

M87
256MHz

VERA only
DR=260

128Mbps test

VERA 23 GHz
(e)
2013 Apr 13
13.5 pc
DR=1300

KVN and VERA Array (2013)
DR=1900

1mas = 0.08pc = 140Rs
## Current array performance

<table>
<thead>
<tr>
<th></th>
<th>KVN</th>
<th>VERA</th>
<th>KaVA</th>
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</thead>
<tbody>
<tr>
<td>Num. of antenna</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Num. of baseline</td>
<td>3</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>Baseline length shortest/longest [km]</td>
<td>305 / 476</td>
<td>1019 / 2270</td>
<td>305 / 2270</td>
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<tr>
<td>Angular resolution at K / Q [mas]</td>
<td>5.6 / 3.0</td>
<td>1.2 / 0.6</td>
<td>1.2 / 0.6</td>
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<tr>
<td>Polarization</td>
<td>LHCP/RHCP</td>
<td>LHCP</td>
<td>LHCP</td>
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<tr>
<td>Recording rate</td>
<td>1Gbps</td>
<td>1Gbps</td>
<td>1Gbps</td>
</tr>
<tr>
<td>$1\sigma$ Baseline sensitivity at K [mJy]</td>
<td>6 (KVN-KVN)</td>
<td>11 (VERA-VERA)</td>
<td>8 (KVN-VERA)</td>
</tr>
<tr>
<td>$1\sigma$ Baseline sensitivity at Q [mJy]</td>
<td>9 (KVN-KVN)</td>
<td>22 (VERA-VERA)</td>
<td>14 (KVN-VERA)</td>
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<tr>
<td>$1\sigma$ Image sensitivity at K [mJy]</td>
<td>0.3</td>
<td>0.4</td>
<td>0.2</td>
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<tr>
<td>$1\sigma$ Image sensitivity at Q [mJy]</td>
<td>0.5</td>
<td>0.8</td>
<td>0.3</td>
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</table>

Baseline sensitivity: 120 sec integration time
Image sensitivity: 4 hr integration time
Bandwidth of 256MHz assumed
Open Use Proposal Statistics (14A to 16B)

Open use ~ 500 hours per year granted
# of proposals 1.5 year cycle? (due to ALMA?)
Dear Colleagues,

We invite proposals for the open use observations of the KaVA, a joint facility of the KVN (Korean VLBI Network) and the VERA (VLBI exploration of Radio Astrometry). The joint array consists of three 6.5-m KVN telescopes and four 20-m VERA telescopes, with baseline lengths ranging from 300 km to 2300 km.

This open-use call will be based on the requirement to provide VLBI observations at 22GHz and 43GHz for astronomers in the world. We support astronomers in the preparation of proposals, scheduling, and data analysis. For that reason, proposers who are not familiar with KaVA are recommended to include at least one collaborator from VERA or KVN. If it is difficult to find collaborators from VERA or KVN, please contact us and one. The contact address for the support is kavaprop@kasi.re.kr.

In order to avoid conflict and/or duplication of the targets between common use proposals and LPs, proposers are highly recommended to visit KaVA Large Program (LP) webpage where KaVA LPs and their source list are presented (http://radio.kasi.re.kr/kava/large_programs.php). If the common use proposals can not be achieved with the data of LPs, then they will be accepted as separate common use observations. Otherwise, we encourage the proposers to collaborate with the science teams of the corresponding KaVA LPs.

Observations will be conducted with single polarization (LCP) and 1-Gbps data rate. Two new observation modes are available from this call, Fast antenna nodding mode and 1-beam hybrid (KVN multi-frequency K/Q/W support) mode. The total available observation time is up to 250 hours and the observations will be scheduled between 15th January 2017 and 15th June 2017. The maximum observing time per proposal is limited to 48 hours.

Please visit radio.kasi.re.kr/kava/proposal_info.php
### KaVA AGN SWG member list (2016 April)

<table>
<thead>
<tr>
<th>Core</th>
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<tbody>
<tr>
<td>Motoki Kino (KASI)</td>
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<td>Bong Won Sohn (KASI)</td>
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<td>Juan-Carlos Algaba (KASI)</td>
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<td>Fumie Tazaki (NAOJ)</td>
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<td>Guang-Yao Zhao (KASI)</td>
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<td>Kazuhiro Hada (NAOJ)</td>
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<td>Kazunori Akiyama (MIT)</td>
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<td>Mareki Honma (NAOJ)</td>
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<td>Kotaro Niinuma (Yamaguchi U)</td>
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<td>Sascha Trippe (SNU)</td>
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<td>Shoko Koyama (MPIfR)</td>
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<td>Kiyoshi Wajima (KASI)</td>
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<td>Noriyuki Kawaguchi (SHAO)</td>
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<td>Satoko Sawada-Satoh (Ibaraki U)</td>
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<td>Jong-Ho Park (SNU)</td>
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<td>Hyemin Yoo (Yonsei U)</td>
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<td>Yongjin Jeong (Yonsei U)</td>
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<td>Ilje Cho (KASI)</td>
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<td>Jeong Ae Lee (KASI)</td>
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<th>Non-core</th>
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<tr>
<td>Jeffrey Hodgson (KASI)</td>
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<td>Se-Jin Oh (KASI)</td>
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<td>Minsun Kim (KASI)</td>
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<td>Sang-Sung Lee (KASI)</td>
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<td>Jan Wagner</td>
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<td>Hiroshi Imai (Kagoshima U)</td>
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<td>Gabor Orosz (Kagoshima U)</td>
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<td>Cheulhong Min (GUAS/NAOJ)</td>
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<td>Akihiro Doi (ISAS/JAXA)</td>
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<td>Tomoya Hirota (NAOJ)</td>
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<td>Yuanwei Wu (NAOJ)</td>
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<td>Richard Dodson (ICRAR)</td>
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<td>Maria Rioja (ICRAR)</td>
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<td>Atsushi Miyazaki (Hosei U)</td>
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Key Science Program of AGNs with KaVA

M. Kino & B.W. Sohn
on behalf of KaVA AGN Sub-WG

[Abstract]
AGN Sub-WG specifies the monitoring programs of Sgr A* and M87 as our Key Science Program (hereafter KSP) because of the largeness of angular sizes of the central super-massive black holes (SMBHs). The KSP is composed of three sub-programs. (i) testing magnetically-driven-jet paradigm by mapping the jet velocity field in M87 at 23 GHz (7*12=84hr biweekly
1), and (ii) probing the closest vicinity of SMBH by monitoring Sgr A* at 43 GHz (6*10=60hr monthly), and (iii) conducting quasi-simultaneous observations with the Event Horizon Telescope at 43 GHz (10*5=50hr weekly). We emphasize that this is the unique VLBI monitoring of M87 and Sgr A* 2).
RECENT RESULTS
of KaVA AGN Large Program
M87 and Sgr A*
M87 - Recent Results from VLBA

A persistent triple-ridge structure

Hada+(2016) VLBA@15GHz deep image

Mertens+(2016) VLBA@43GHz
Jet evolution from 1 mas to 100 mas

Velocity field < 100mas?

Different speed in different periods?
Preliminary result

KaVA M87 movie @22GHz
[Quasi-simultaneous & high-cadence]

First season (8 epochs)

Park & Ro+; 3 components fitting
Preliminary result

KaVA M87 movie @43GHz [Quasi-simultaneous & high-cadence]

First season (8 epochs)

Park & Ro+; 3 components fitting
Preliminary result

KaVA M87 movie spectral index [Quasi-simultaneous & high-cadence]

First season (8 epochs)

Core-shift is < 0.02 mas which is in agreement with Hada+(2011)
KaVA 43GHz Sgr A* Monitoring

Several pilot observations in 2013, regular monitoring since 2014
• Recording rate: 1-Gbps; 256 MHz bandwidth
• Calibrators: NRAO 530; VX Sgr (SiO); OH0548 (SiO)
• On source time for Sgr A*: ~220 min per epoch
• Correlation: Hardware correlator in KJCC

uv coverage for Sgr A*

KaVA

inner part of VLBA

Akiyama+ (2013); Zhao+ (2016)
Sgr A* at 7 mm KaVA:

Zhao+(2016) Preliminary result

- Epochs with good weather and instrumental performance (2013-2014)
Sgr A* at 7 mm KaVA: preliminary results

- Flux variation

- Size variations
Sgr A* at 7 mm KaVA: preliminary results

• Flux vs Size

Zhao+(2016)

Krichbaum+(1998)
KVN Astrometry (SFPR)

[Fig. 3] (Left) SFPR-ed image of Sgr A*. The circle-point at the center is the reference phase center which corresponds to the position of 43 GHz core, and the cross-point is the centroid of 86 GHz core of Sgr A*. (Right) 86 GHz core positions in 4 epochs of data relative to the 43 GHz core. As a result, the dominant shifts are shown as ~0.3 mas to the south in all observations. Shifts to the East-West direction are within 0.05 mas.

Cho+ (2016)

More about KVN SFPR
See Rioja+ (2011; 2015)
Summary

• KaVA
  – KaVA operational
  – 1Gbps, 22 & 43GHz single pol.
  – No more risk-shared!
  – 500 hours of open use per year
  – Wider band, full polarization & Phase referencing will come soon
  – Proposal deadline 1st November 2016

• KaVA AGN Large Program
  – officially launched in 2016A
  – High-cadence monitoring on M87 and Sgr A*
  – Sensitive to extended structures
Thank you!
homophones

KVN and VERA (joint) Array

Sounds like this

Or this ‘Kava’
The other Kava

- Kava is consumed throughout the Pacific Ocean culture. The roots of the plant are used to produce a drink with sedative, anesthetic, euphoriant, and entheogenic properties... [Wikipedia]

Well...

Some Health Benefits Of Kava

- Treat anxiety, stress and depression
- Treatment of TB, insomnia & ADHD
- Relieves headaches and migraines
- Prevent cancer and urinary tract infection
- Treats leprosy, mouth sores & Chronic Fatigue
- Address muscular pain, epilepsy & restlessness
BACKUP SLIDES
TVN with KaVA
TVN+KaVA - Biased view from a KaVA user

- TVN+KaVA: Good UV coverage for low declination sources
- TVN+EAVN: Resolution match low frequency EAVN & high frequency KaVA
- Simultaneous ‘wide band’ & resolution matched VLBI

✓ Centaurs A – nearest radio galaxy
  - KVN+ATCA observation (Mueller+)
    - Simultaneous 3/7mm astrometry (Talks by Jung and Rioja)
    - 3.8Mpc away (0.1 mas ~ 0.002 pc; 2.2 light days)
    - Core size, Brightness temperature, core shift (3 & 7mm)
    - Not capable of imaging as you see its UV coverage...
**Centaurs A – A ‘TVN+KaVA headliner’?**

SMBH 3.8Mpc away

* Virgo A(M87) 16.7Mpc

Imaging of few light days scale
Self-absorbed at low frequency

TVN+KVN+ACTA

Mueller+ (2014) 22GHz