

The KaVA (KVN and VERA Array)

Do-Young Byun (KASI)
on behalf of KaVA Collaboration

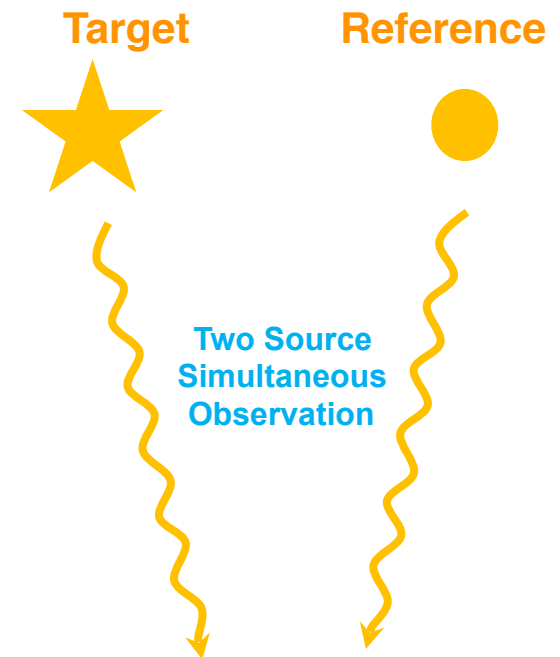
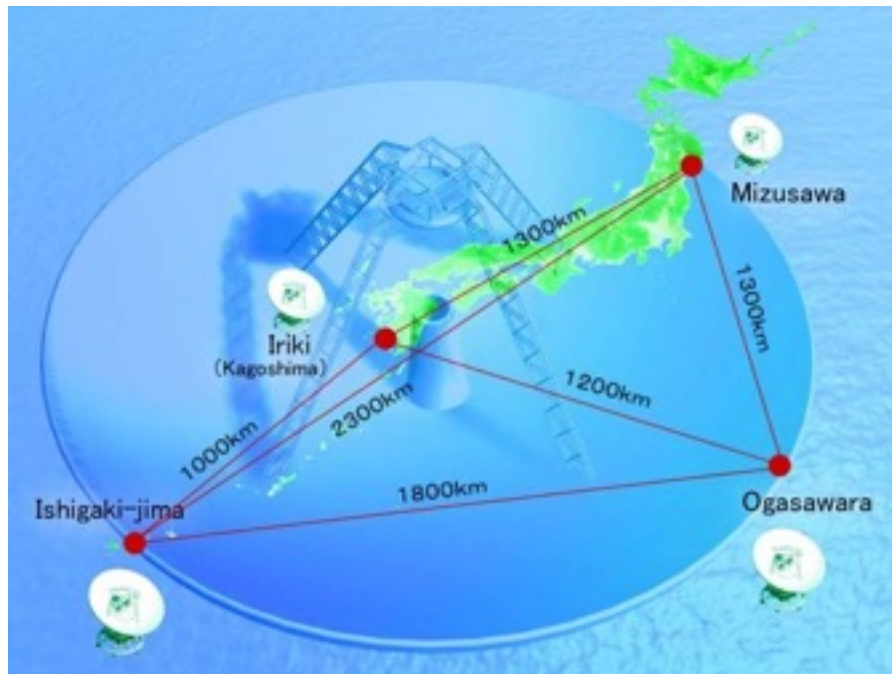
EAMA10 @ Seoul on 27 2016 Sep

Outline

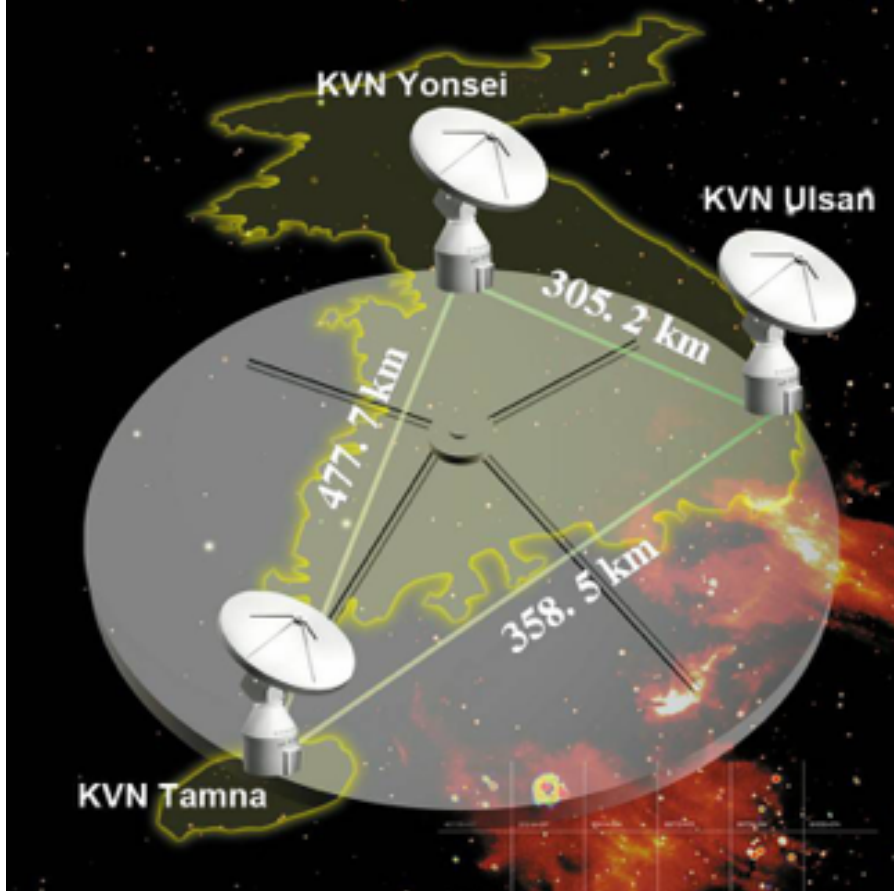
- VERA / KVN
- KaVA
- History of KaVA
- Science Activities
 - KaVA Large Programs
- Upgrade Activities

VERA: VLBI Exploration of Radio Astrometry

- Four 20m antennas in Japan
- Baseline : 1000- 2300 km
- Frequency : 2/8/22/43GHz
- Two Beam System for high precision astrometry
- Galactic 3D structure through annual parallax

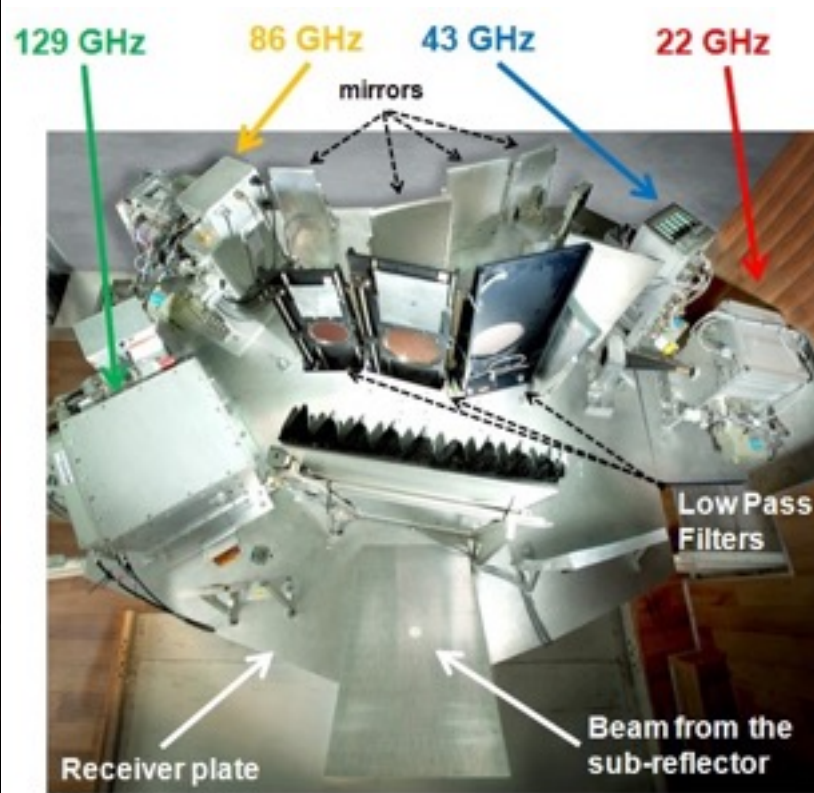


KVN 한국우주전파관측망 Korean VLBI Network



- Three 21m antennas in Korea
- Baseline 300 - 500km
- Simultaneous Multi-frequency @22/43/86/129GHz

—> Talk by TH Jung



KaVA : KVN and VERA Array



- 7 Telescopes (D ~ 20m)
- Baseline : 300 - 2300 km
- Frequency : 22/43(/86/129)GHz
- Beam Size : 1.2/0.6(/1.5/1.0) mas
- Baseline Sensitivity ~ 10/20 mJy



History of KaVA

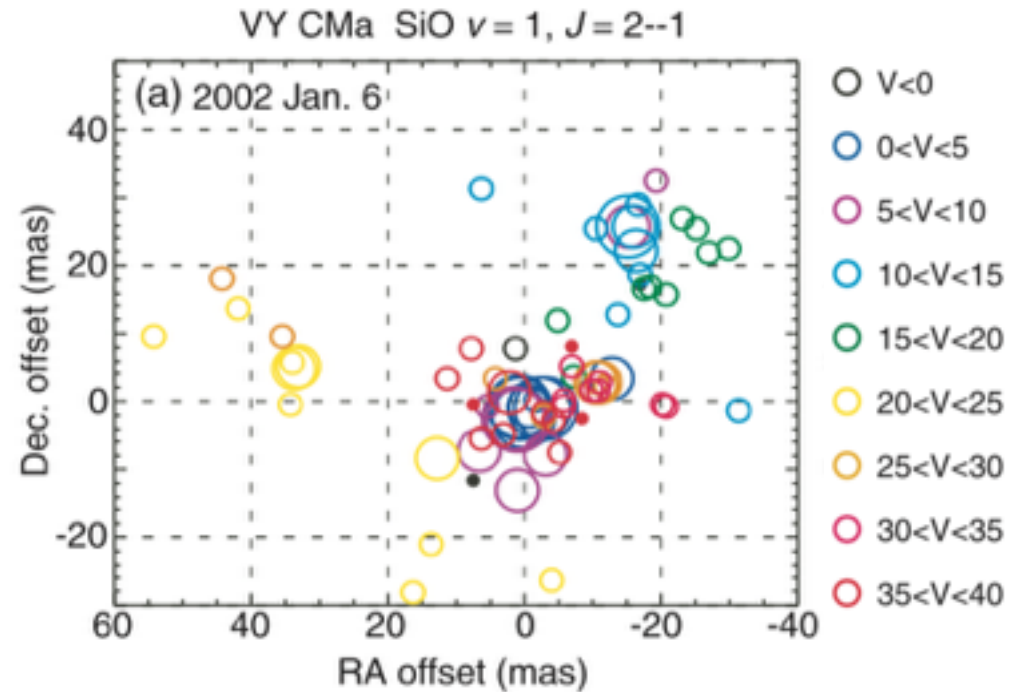
- 2001 KVN project launch



KVN Science Committee Meeting

History of KaVA

- 2001 KVN project launch
- 2002 TRAO-NRO VLBI



Shibata et al, 2004, PASJ

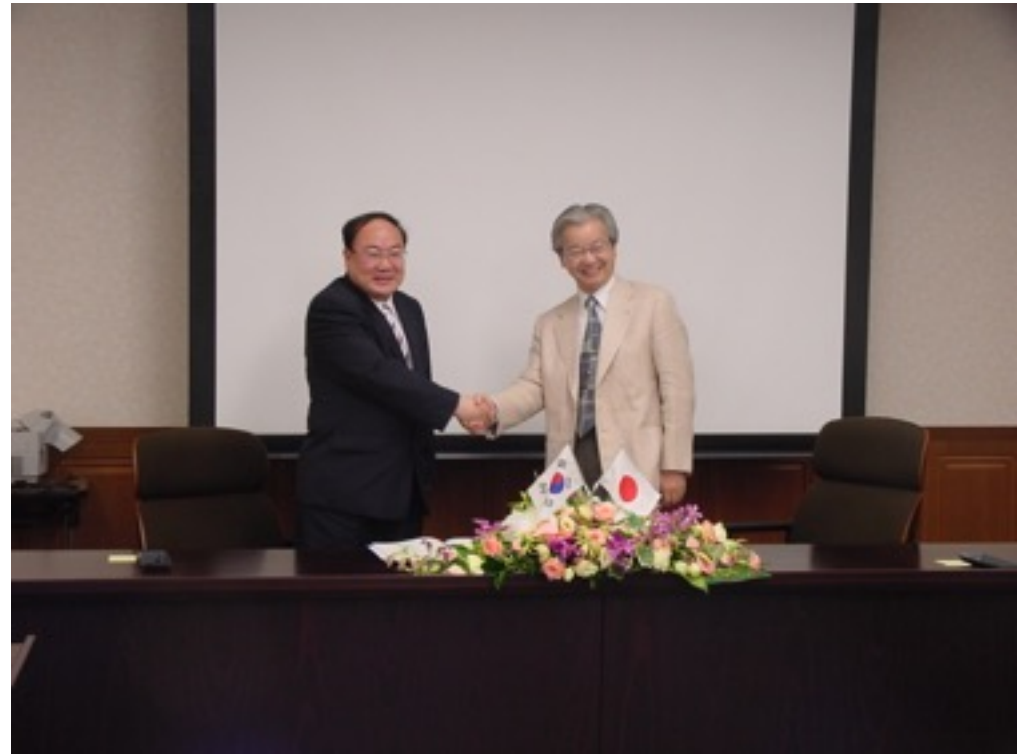
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- 2005 K-J VLBI Correlator



Agreement on VLBI Correlator (7 July 2005)

History of KaVA

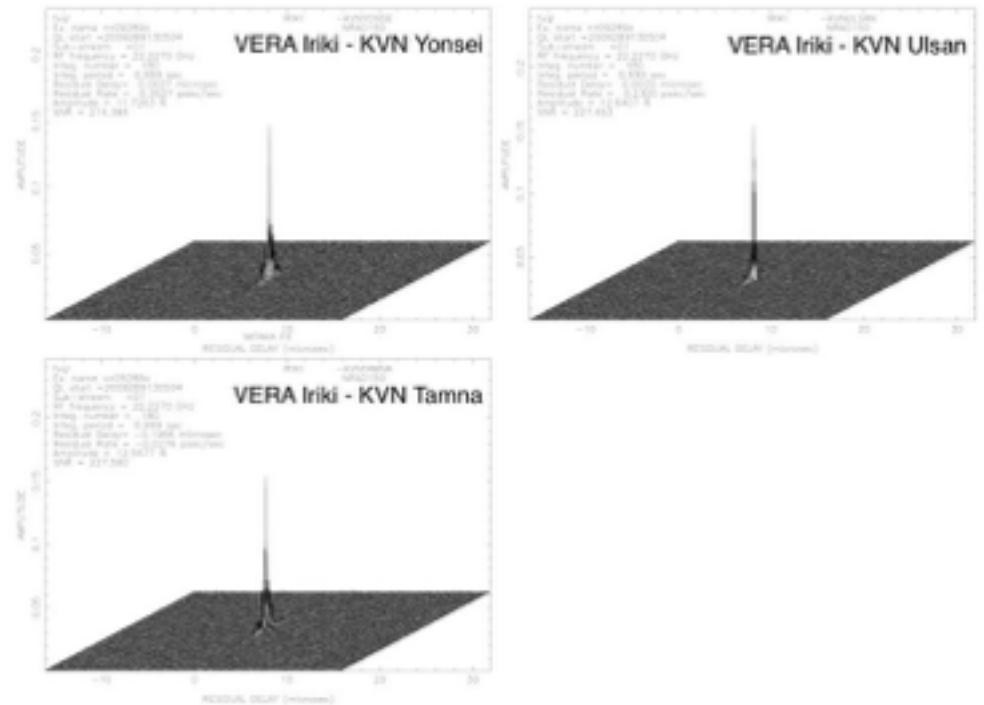
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- 2009 KVN-VERA Fringe

Fringes of KVN-VERA baselines in the K-band



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- 2009 KVN-VERA Fringe
- 2010 KaVA Science WG



4th KVN & VERA Joint Science Working Group Meeting
29-30 Jan 2013 Seoul National University, Seoul, Korea

- AGN / SFR / Evolved Star / Galactic Astrometry
- f-f Meeting twice in a year / monthly telecon
- ~15 members/WG

History of KaVA

Korea-Japan Correlation Center

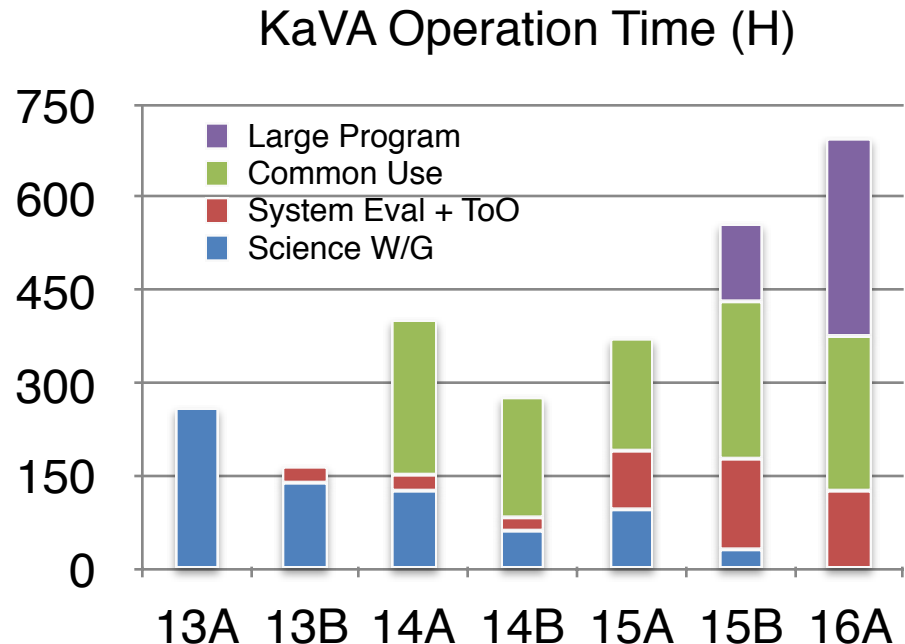
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- 2009 KVN-VERA Fringe
- 2010 KaVA Science WG
- 2013 Daejeon Correlator



- Development : 2005 - 2010
- Commission : 2011 - 2012
- Full Operation : 2013
- (Max) Input : (4 x) 2Gbps x 16 stations

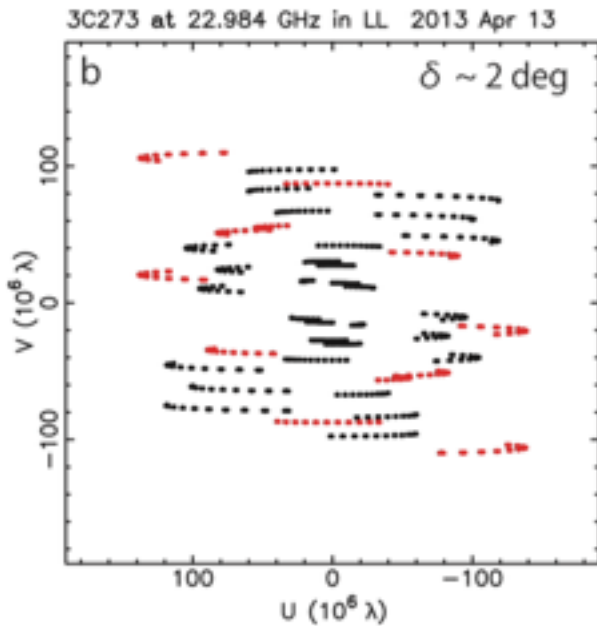
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- 2013 Daejeon Correlator
- 2014 KaVA Common Use
- 2015 KaVA Large Programs

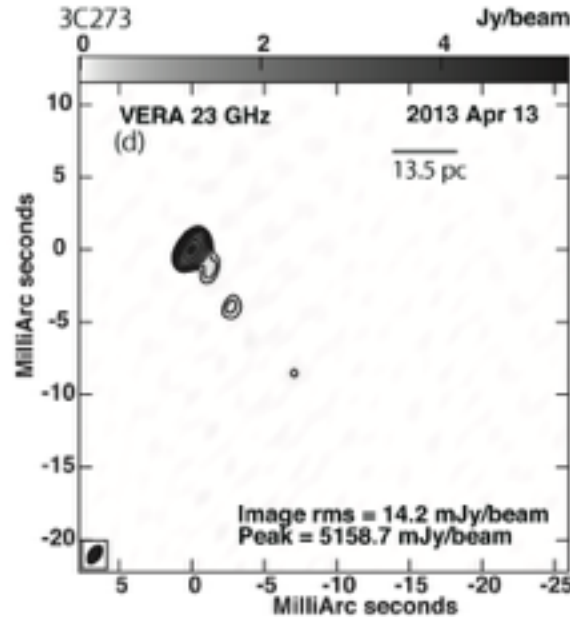


Imaging Capability of KaVA

- Images of 3C273 (Niinuma et al. 2014 PASJ)

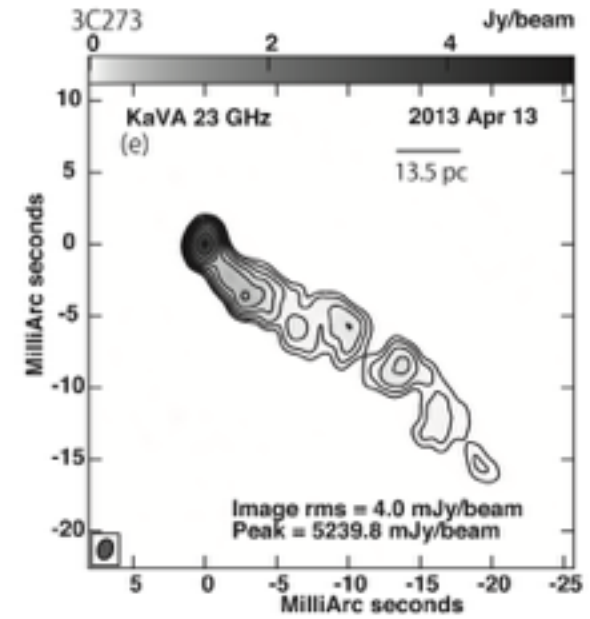


U-V Coverage



VERA

DR ~300

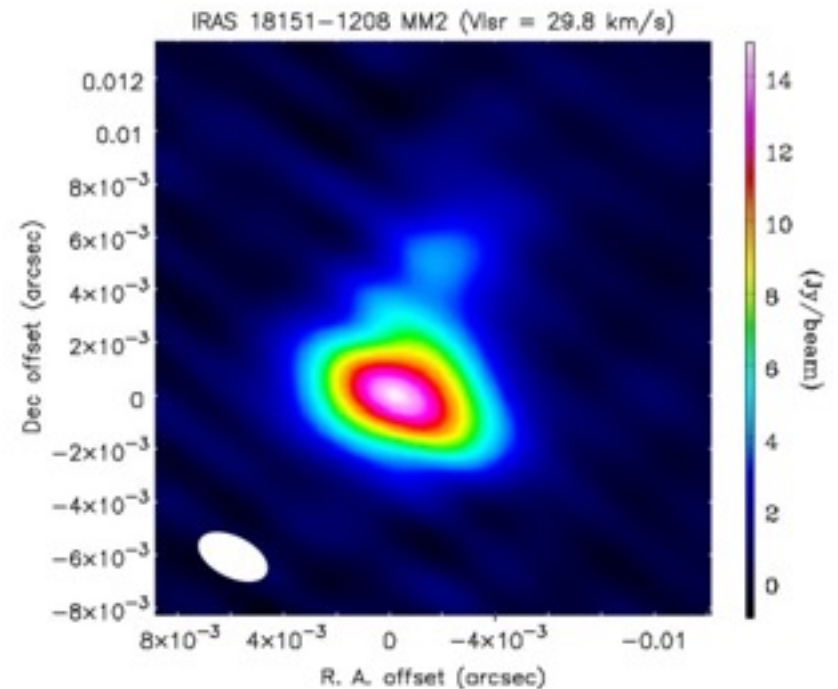
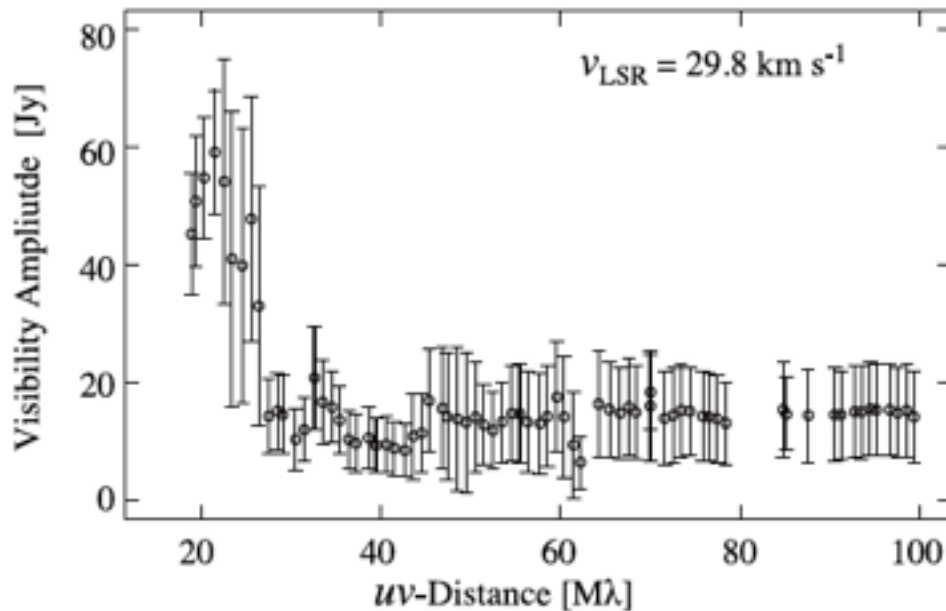


KaVA

DR ~1200

Unique Capability of KaVA

- **First VLBI image of 44 GHz methanol maser** (Matsumoto et al. 2014 ApJL)
 - Advantage to obtain both extended structures and compact components

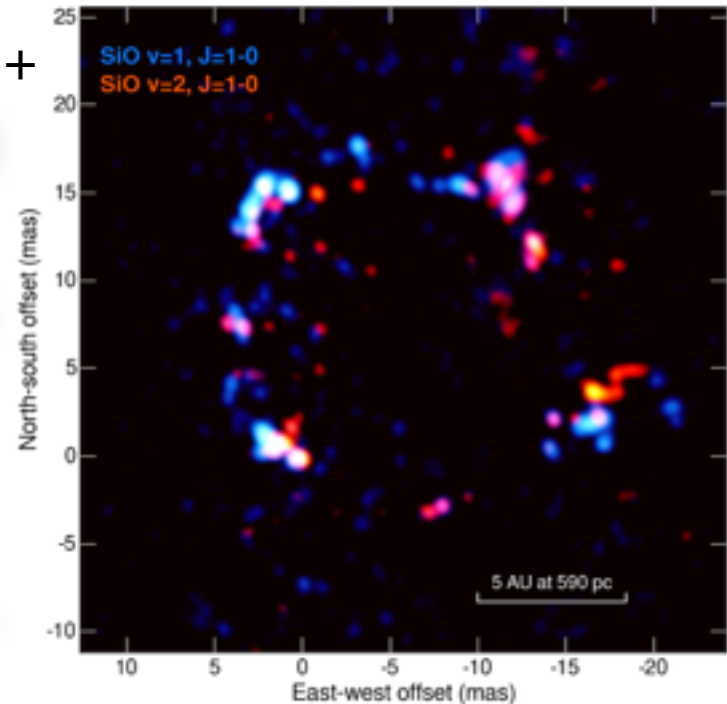


Operation Mode

- Single-Frequency Imaging
 - 22/43GHz w/ 1Gbps recording (256GHz BW)
 - Single Polarization
- Hybrid Modes
 - KVN Multi-frequency (22/43/86/129GHz)
 - +
 - VERA Single or Dual Beam
 - VERA sub-Array
 - (e.g. IRK : 43GHz + the others : 22GHz)

Large Program : ESTEMA

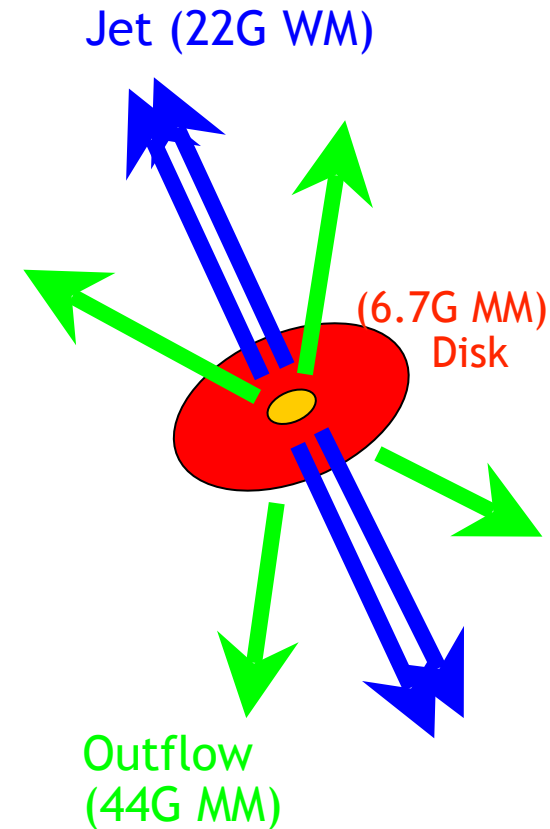
- **Expanded Study on Stellar Masers**
 - H.Imai(Kagoshima Univ.), S.-H.Cho (KASI)+
- Snapshot imaging of 80 H₂O (22GHz) and SiO (43/86/129GHz) maser sources
 - expand the number of stellar masers as VLBI targets
 - maser pumping mechanism, size distribution on ~ 0.1 AU scale
 - maser distribution on ~ 100 AU scale.
- Selection of ~ 20 targets for maser movies in Phase 2 Large Program
 - Mass loss / evolution of asymmetric structure



SiO $v=1$ and 2 , $J=1-0$ maps toward WX Pcs w/ KaVA (Yun et al. 2016 ApJ)

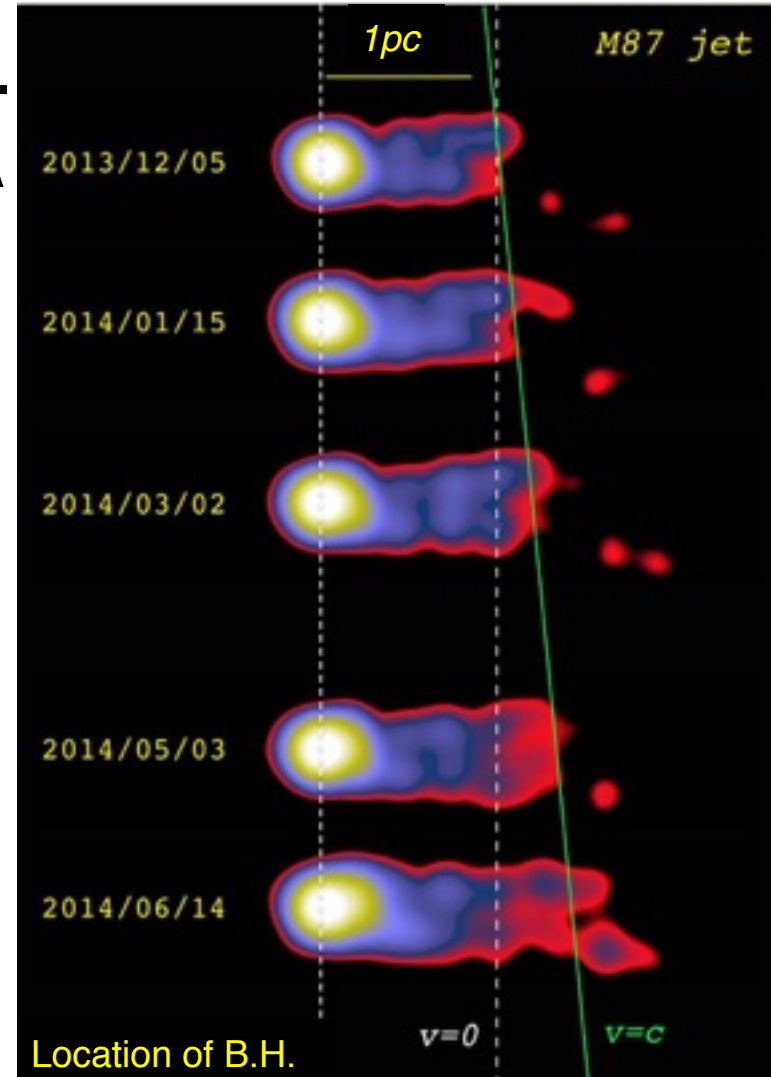
SFR Large Program

- **Understanding high-mass star formation through KaVA observations of water and methanol masers**
 - T. Hirota (NAOJ), K.-T. Kim (KASI) +
 - VLBI monitoring/survey to reveal **3D velocity and spatial structures** in 22 GHz/44 GHz masers in **~100 high-mass YSOs** (HM-YSOs)
 - **Physical and dynamical properties** of **disk-outflow systems** of HM-YSOs
 - **Evolution** of disk-outflow systems of HM-YSOs and **maser evolutionary sequence**
 - Testing **formation scenarios** of HM-YSOs
 - Synergy with JVN 6.7GHz Methanol + ALMA



AGN Large Program

- **Exploring the vicinity of super-massive black hole with KaVA**
 - M. Kino, B. W. Sohn (KASI) +
 - **M87**: biweekly at 22/43GHz
 - **Velocity field of M87 Jet**
 - **SgrA***: monthly at 43GHz
 - G2 encounter
 - **Gas accretion process**
- > **Talk by B. W. Sohn**



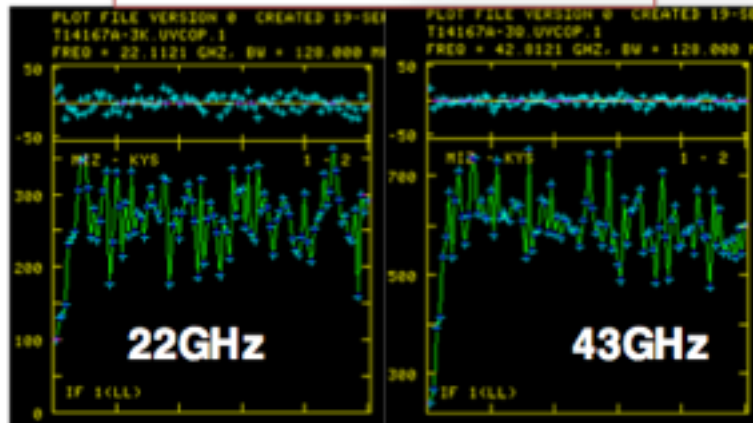
Publications w/ KaVA

1. The First VLBI Image of a 44GHz Methanol Masers with KaVA, N. Matsumoto+, 2014, ApJL (SFR)
2. VLBI observations of bright AGN jets: Evaluation of Imaging Capability, K. Niinuma+, 2014, PASJ (AGN)
3. PaGAN II: The Evolution of AGN Jets of sub-parsec Scales, J. Oh+, 2015, JKAS (AGN / [Common Use](#))
4. Identifying High Frequency Peakers using the Korean VLBI Network , Y. Jeong +, 2016, AN (AGN / [Common Use](#))
5. SiO Masers around WX Psc Mapped with the KVN and VERA Array, Y. Yun +, 2016, ApJ (Evolved Star)
6. VLBI observations of flared optical quasar CGRaBS J0809+5341, T. An +, 2016, PASJ (AGN / [Common Use](#))

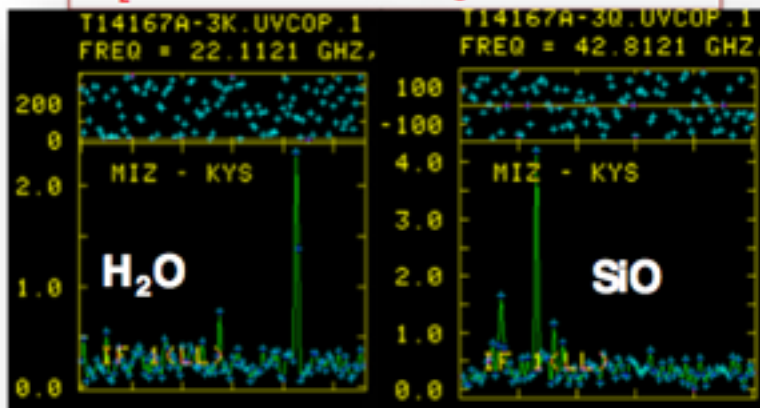
Upgrade Activities

- Phase Referencing for high precision Astrometry
- Wideband operation for high sensitivity
 - VERA : 16Gbps w/ OctaDisk2
 - KVN : 8Gbps w/ Mark6
 - KaVA : 1 Gbps → 2/4/8 Gbps
- Polarization Capability
 - KVN : Dual Polarization
 - VERA : 22GHz Dual-Pol Receivers at VERA MIZ and IRK
- Simultaneous K/Q Multi-Frequency
 - KVN + VERA Mizusawa, Iriki

K/Q simultaneous fringes of OJ287

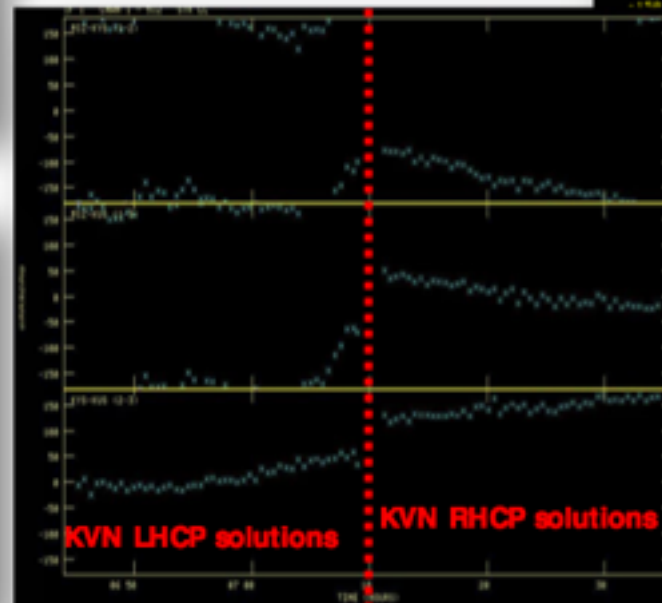


H₂O/SiO Simultaneous fringes of ORION-KL

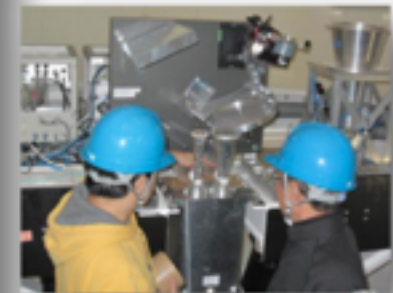
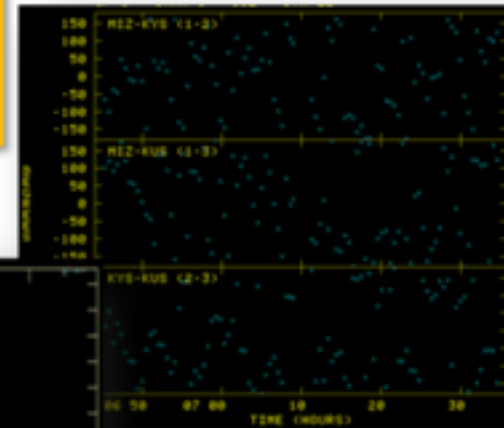


Phase Correction with QO systems (K→Q, OJ287)

Q-band Visibility Phase Calibrated by K-band



Q-band Visibility Phase No calibration applied



- K-band fringe phase solutions of OJ287 were applied to calibrate Q-band data
- Visibility phase of Q-band calibrated by K-band shows more stable phase than raw data although there are high phase rates at MIZ related baselines

→ The feasibility of K/Q simultaneous observing system has been demonstrated !!

Summary

- successful collaboration between Korea and Japan
 - imaging performance
 - steady operation / large programs
 - early science results
- continue to enhance capabilities
 - astrometry, polarization, wideband, multifrequency
- important role as a core array of EAVN
 - collaborations for EAVN and TVN

Thank you
for
your attention !!

