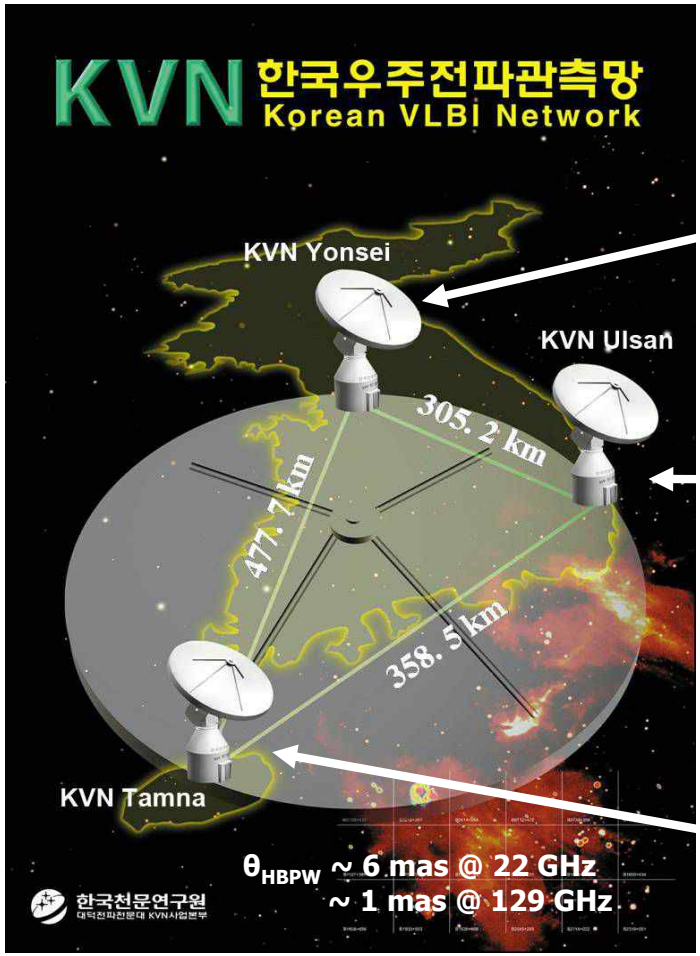
Korean VLBI Network (KVN)
KVN and VERA Array (KaVA)
and
Extended-KVN (E-KVN)

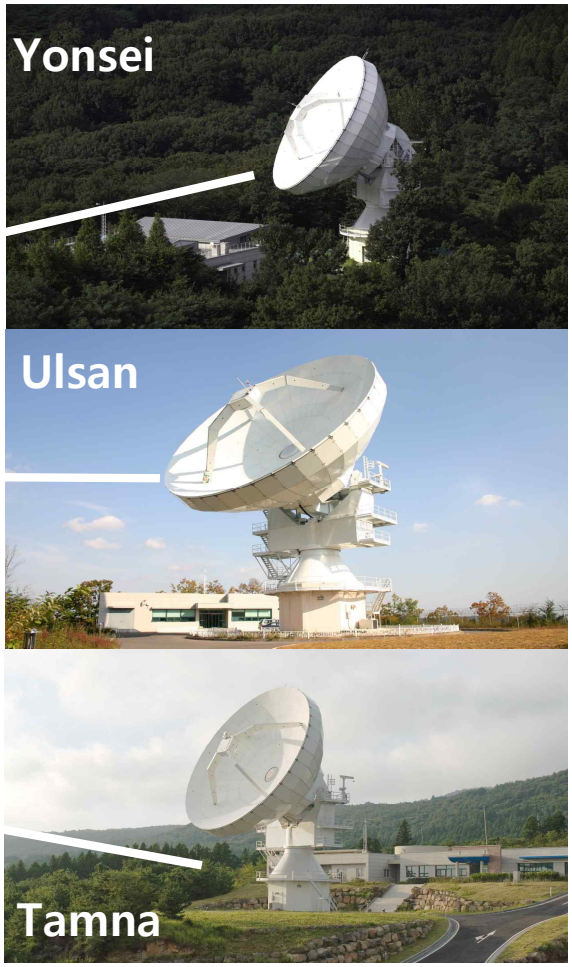
Taehyun Jung & Do-Young Byun (KASI)

On behalf of KVN and KaVA Operation TEAM

2018 September 26 @ VERA UM, Miataka, Japan

Korean VLBI Network (KVN)



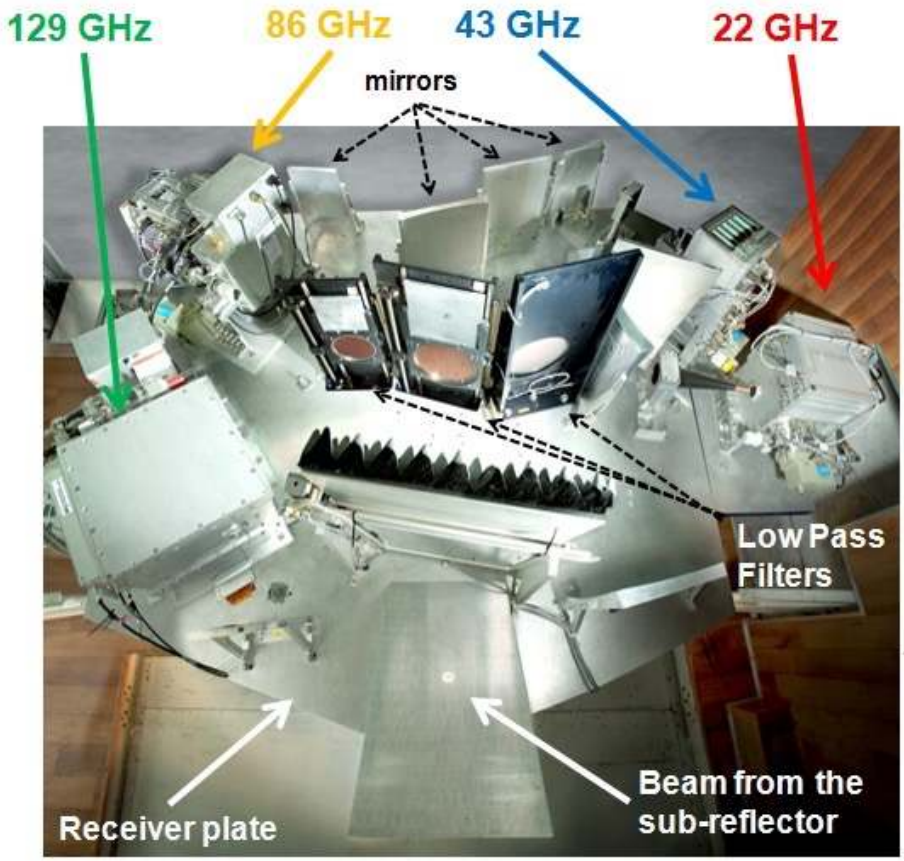


- 3 Telescopes (D = 21m)
- 22/43/86/129GHz
- Baseline 300 - 500 km
- Θ = 1 - 6 mas

- Science Targets
  AGN/SF/Evolved Star
  + microquasar

Multi-Frequency Receiving System

- Simultaneous Multi-frequency Observation
  - @ 22/43/86/129GHz
  - Dual Pol : LCP & RCP
- (Source) Frequency Phase Transfer
  - Weak Source Detection
  - Chromatic Astrometry
- Multi-Frequency Observation
  - Efficient (Obs, Cal + Sci)
  - SED & Rotation Measure



KVN Multi-Frequency Observations

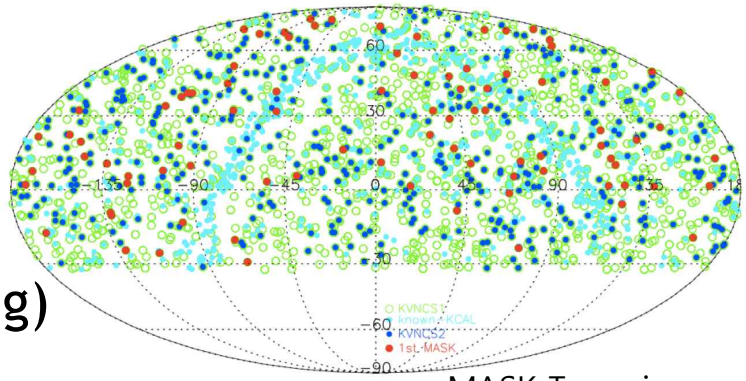
- Largest number of New detections Ever! (on-going)
  - ~300 AGNs(>70%) @ 86GHz
    ~250 AGNs(>50%) @ 130GHz
  - ~80 high-z AGNs (z = 2.5-6.5)

- M/F Images/Astrometry
  - Evolved Stars & AGNs

- Multi-Frequency Polarimetry
  - AGN jet structure and magnetic fields from M/F Rotation Measure

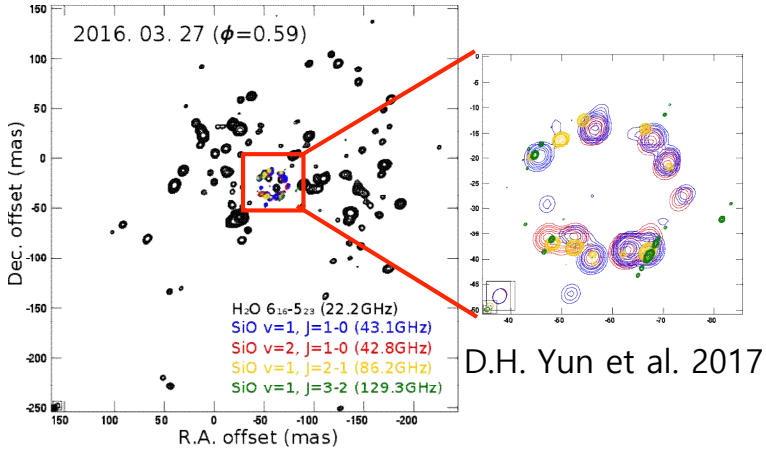
- Demonstration on the performance of simultaneous M/F
  - Tropospheric / Ionospheric phase calibration
  - New standard of mm-VLBI

MASK: Multi-Frequency AGN Survey with KVN



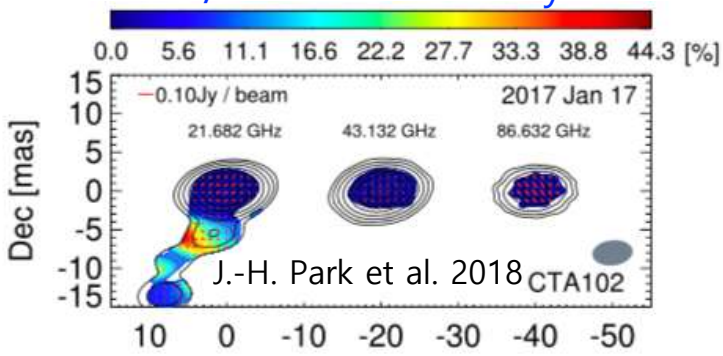
MASK Team in prep

M/F maser maps of Vx Sgr



D.H. Yun et al. 2017

M/F VLBI Polarimetry

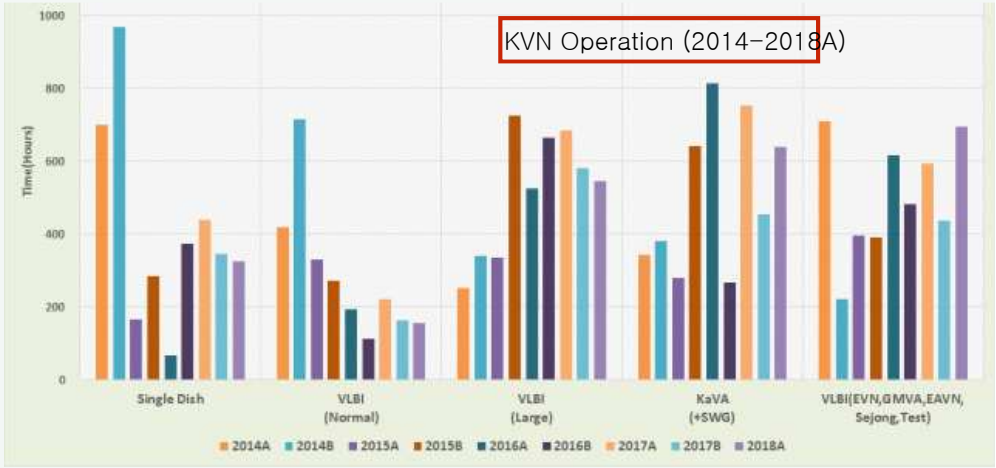


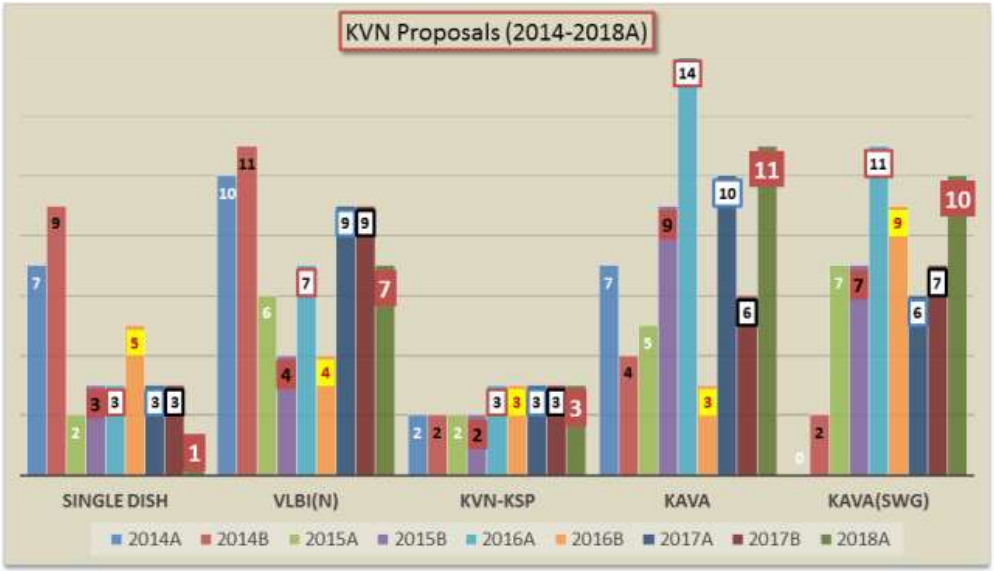
KVN Operation & Publications

- VLBI ~ 4000h/yr (+ SD 500-1000 h/yr/site)
  - KVN Only : 2500h
  - KaVA (KVN and VERA Array) : 1000h
  - EAVN/EVN/GMVA/Sejong > 300h (>600 in 2018A)

- KVN Key Science Projects : 1000h/yr
- KaVA Large Programs : 500h/yr
- Global Common Use : 1000h/yr
  - KVN : 500h/yr + KaVA : 500h/yr

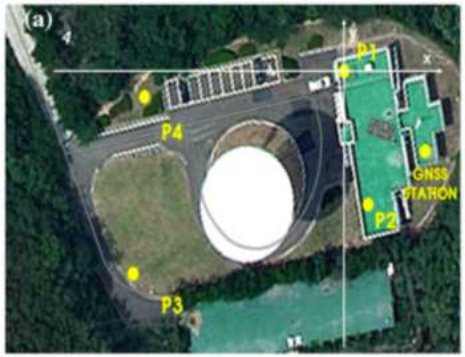
- Total 101 refereed papers since 2013
  - SCI 78 (SD & VLBI)
  - ~20 papers in 2018
  - https://radio.kasi.re.kr/kvn/publicatio

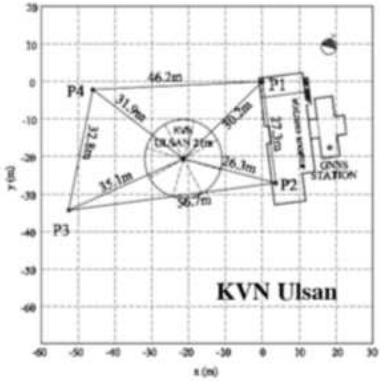


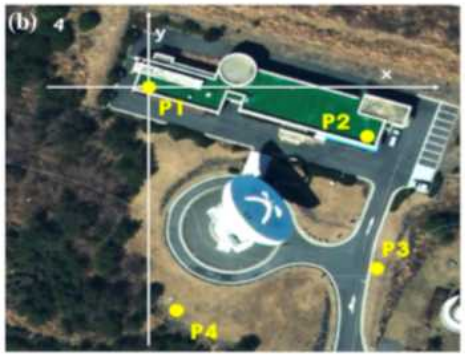


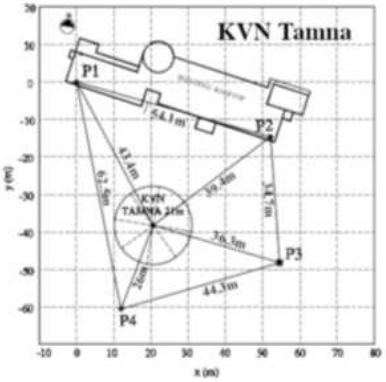
KVN System Updates

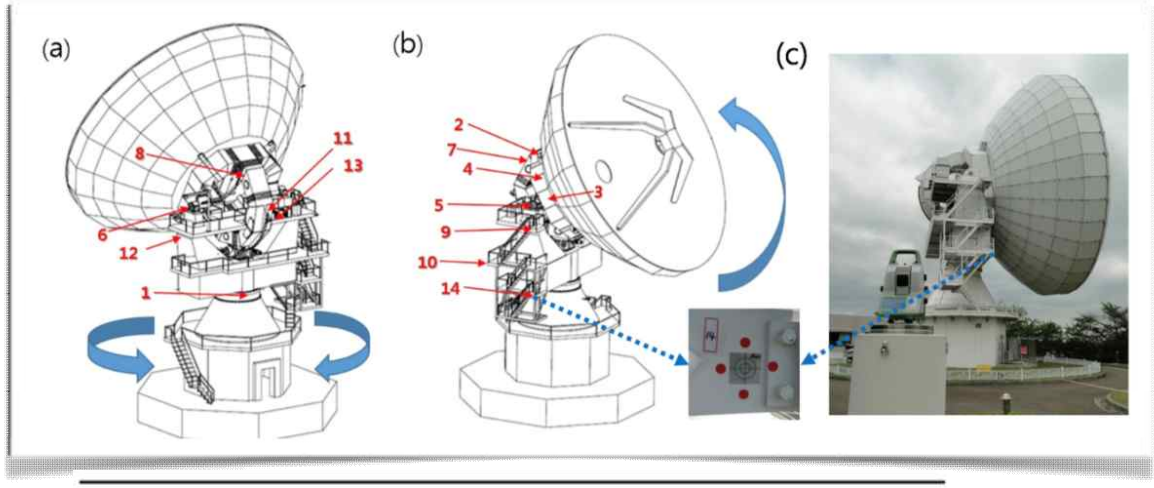
- Precise Reference Position (IVP) of KVN Ulsan & Tamna Telescope
  - Astrometry & Geodesy
  - Reference Frames and Fundamental Physics
  - Applications for geophysics and space navigation (VLBI tracking)











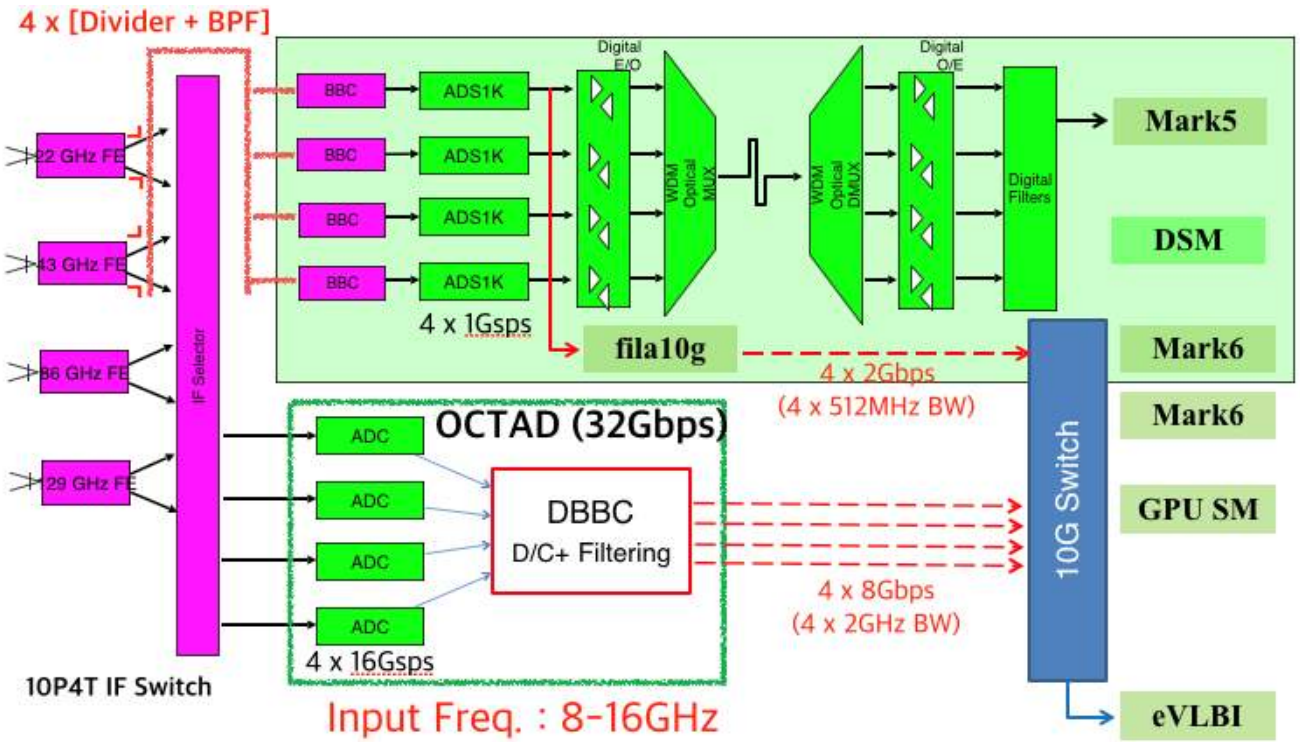
IVP	Ulsan 2017 Nov. 23, UT12:00	Tamna 2017 Dec. 06, UT12:00
X	-3287268.72004	-3171731.72457
Y	4023450.07902	4292678.45749
Z	3687379.93904	3481038.73301

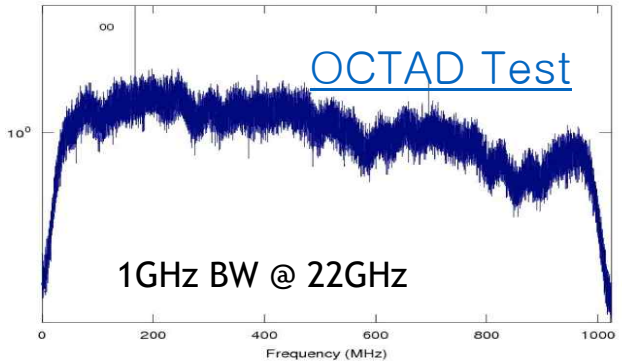
Axis offset (mm) : 0. 86

2.43

Yoo et al. (submitted)

KVN System Updates (in progress)



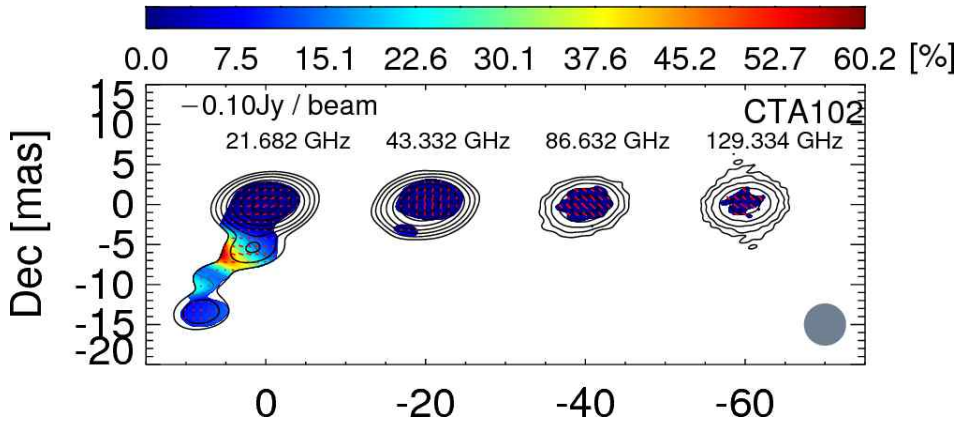


VN 4-Frequency Full Polarizatio

KDAS (4Ch)+ OCTAD (4Ch)+ 2x Mark6

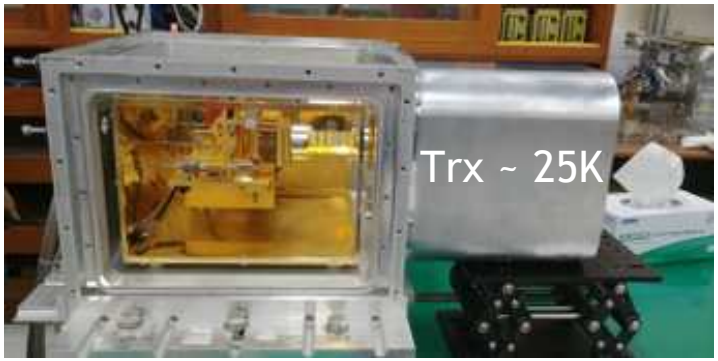
16Gbps (512MHz x 8 Channel)

22L/R, 43L/R, 86L/R, 129L/R



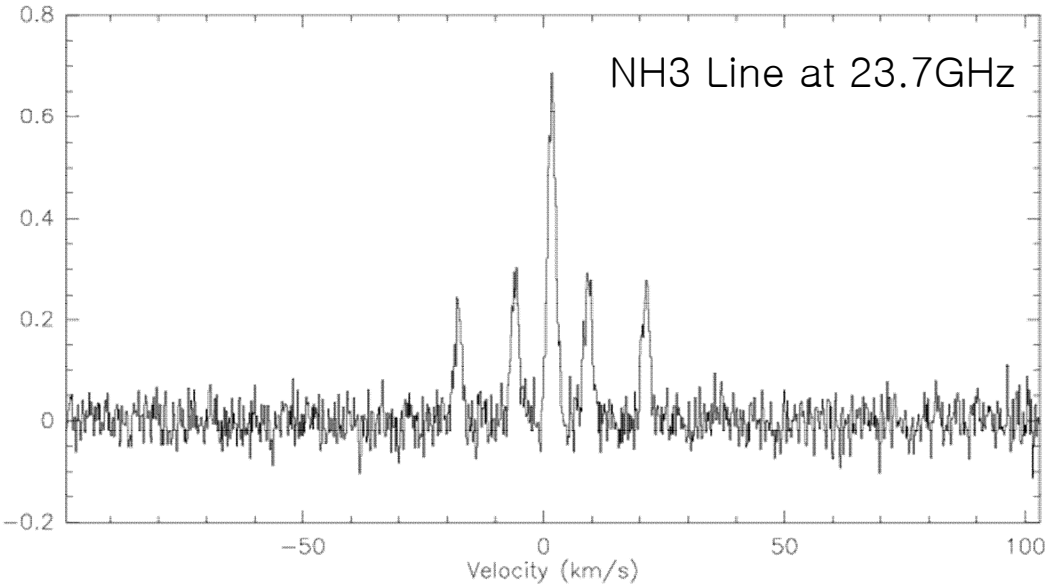
KVN System Updates

- Receiver Upgrade to support wide frequency range
  - K-band: 21.25 - 23.25 GHz —> 18 - 26 GHz (all KVN)
    - compact feed horn, Wideband compact polarizer, New LNA, Trx~25K
  - W-band: 85 - 95 GHz —> 85 - 116 GHz (KUS) (KYS/KTN 2019B~)
  - Q-band: 42.1- 44.1 GHz —> 35 - 50 GHz (2019B~)



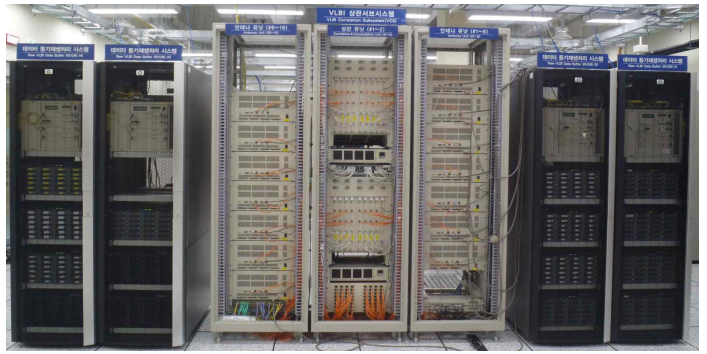
KUS 2018.7 KTN 2018.7

First Light with upgraded 22GHz Rx



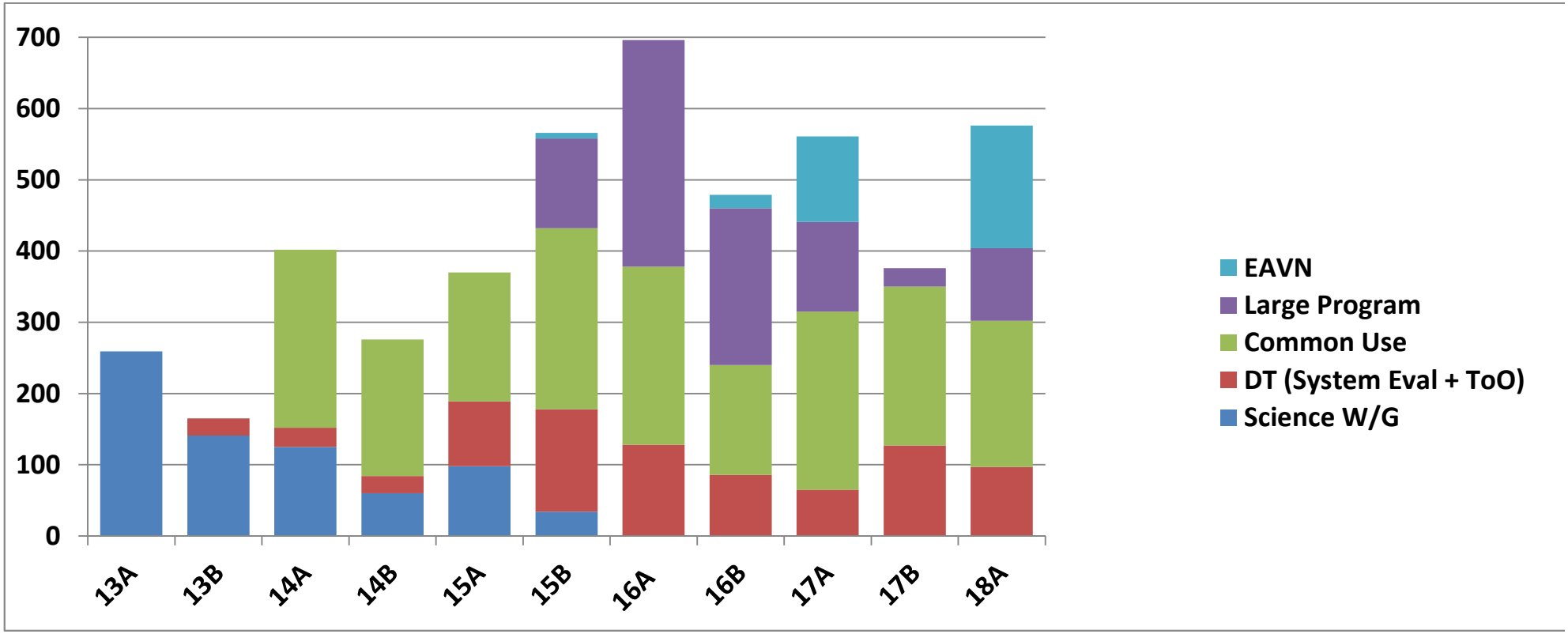
KaVA : KVN and VERA Array

- 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



Daejeon Correlator@KJCC

Operation Time of KaVA



- Steady operation of ~ 500 hours in a season since 2015B
- Start 2nd phase of KaVA Large Programs since 2018A
- EAVN Observations ~ 120h in 2017A and 170h in 2018A

Large Programs

	15B	16A	16B	17A	Total
ESTEMA	126	80	52	**42**	300
AGN	-	168	60	**60 +123 (EAVN)**	411
SFR	-	70	108	**23**	201
Total	126	318	220	**248**	912

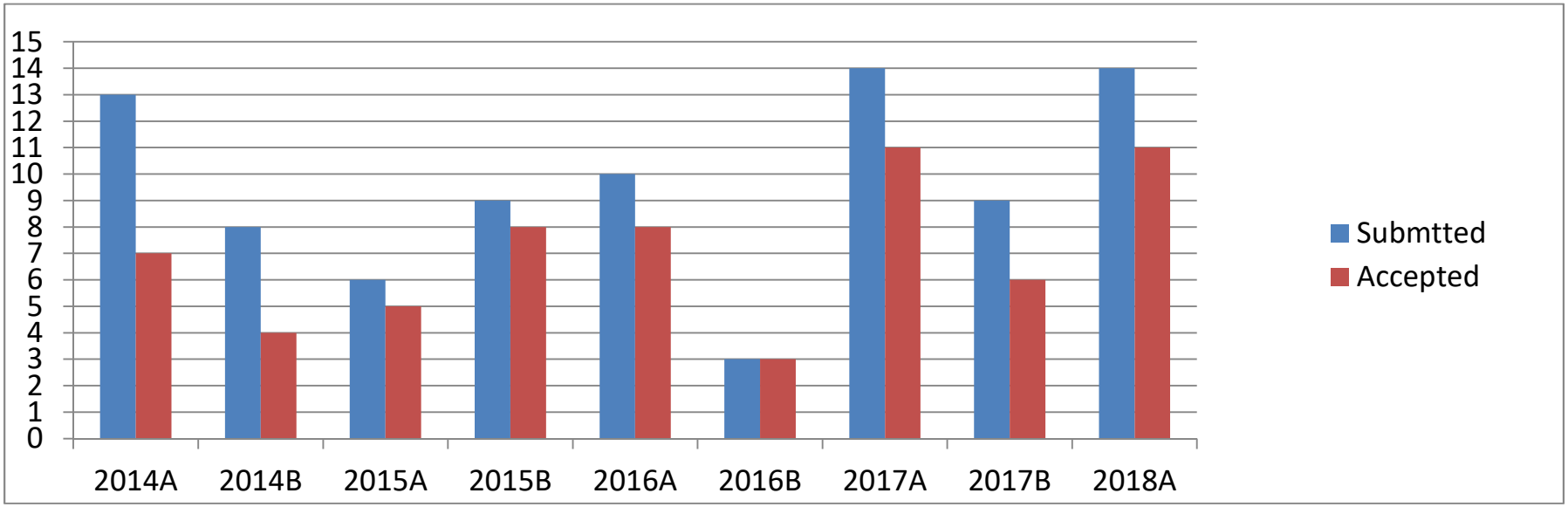
- 1st phase of KaVA LPs were finished in 2017A
- 2nd phase of KaVA PLs were resumed in 2018A
- Imaging Survey —> Intensive Monitoring / (Astrometry)

2nd phase of KaVA Large Programs

- ~170h / program /yr
- Evolved Star
  - EAVN Synthesis of Stellar Masers Animations (ESTEMA)
  - P.I.: S.-H. Cho (KASI), Hiroshi Imai (Kagoshima Unv.)
- AGN
  - Exploring the vicinity of supermassive blackhole with KaVA
  - P.I. : Motoki Kino, B. W. Sohn (KASI)
- Star Formation
  - Understanding high-mass star formation through KaVA observations of water and methanol masers
  - P.I. : Tomoya Hirota (NAOJ), K.-T. Kim (KASI)

KaVA/EAVN Common Use CfP

- 250h / semester
  - share 100h for EAVN from 2018B
- 2018B: First Year of EAVN CfP announcement
  - 6 for EAVN + 8 for KaVA



KaVA Upgrade Activities

- New Modes from 2018A
  - C2 (2 IFs x 128MHz BW)
  - Wide-Field Imaging (Q-band only)

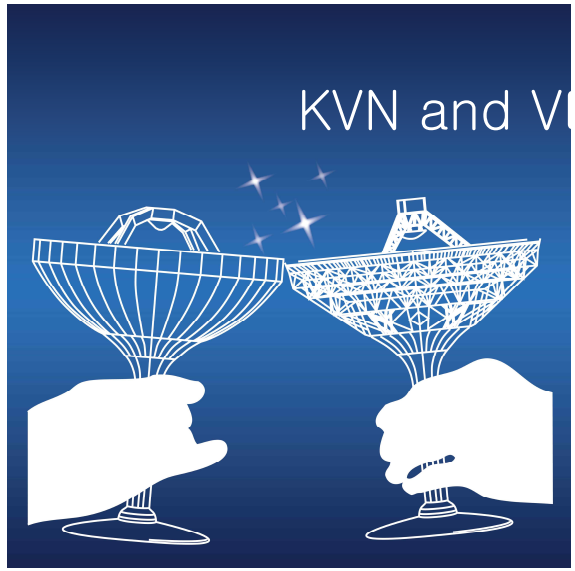
- Under the test
  - Phase referencing for high precision astrometry
  - K/Q Simultaneous Observations
  - 2Gbps mode
  - Polarization

Notice to KVN & KaVA Users

- KVN and KaVA(+EAVN) Common Use
  - ~ 500h/yr for each KVN and KaVA(+EAVN)
  - Proposal Deadline and operation period
    - Nov 1 for A semester (Jan 16 - June 15)
    - June 1 for B semester (Aug 15 - Jan 15)
  - max observation period of 1-year per project
    - max 100h / proposal

- Homepage
  - KVN: http://kvn.kasi.re.kr
  - KaVA: http://kava.kasi.re.kr
  - EAVN: http://eavn.kasi.re.kr
  - Web administrator: Jae-Sik Shin

- Scheduling
  - KaVA: 5-day sessions with 2-week interval
  - KVN: scheduled inbetween KaVA sessions
  - Obs schedule file (.vex) submission: one week in advance
  - New KaVA/EAVN scheduler: Kiyoaki Wajima

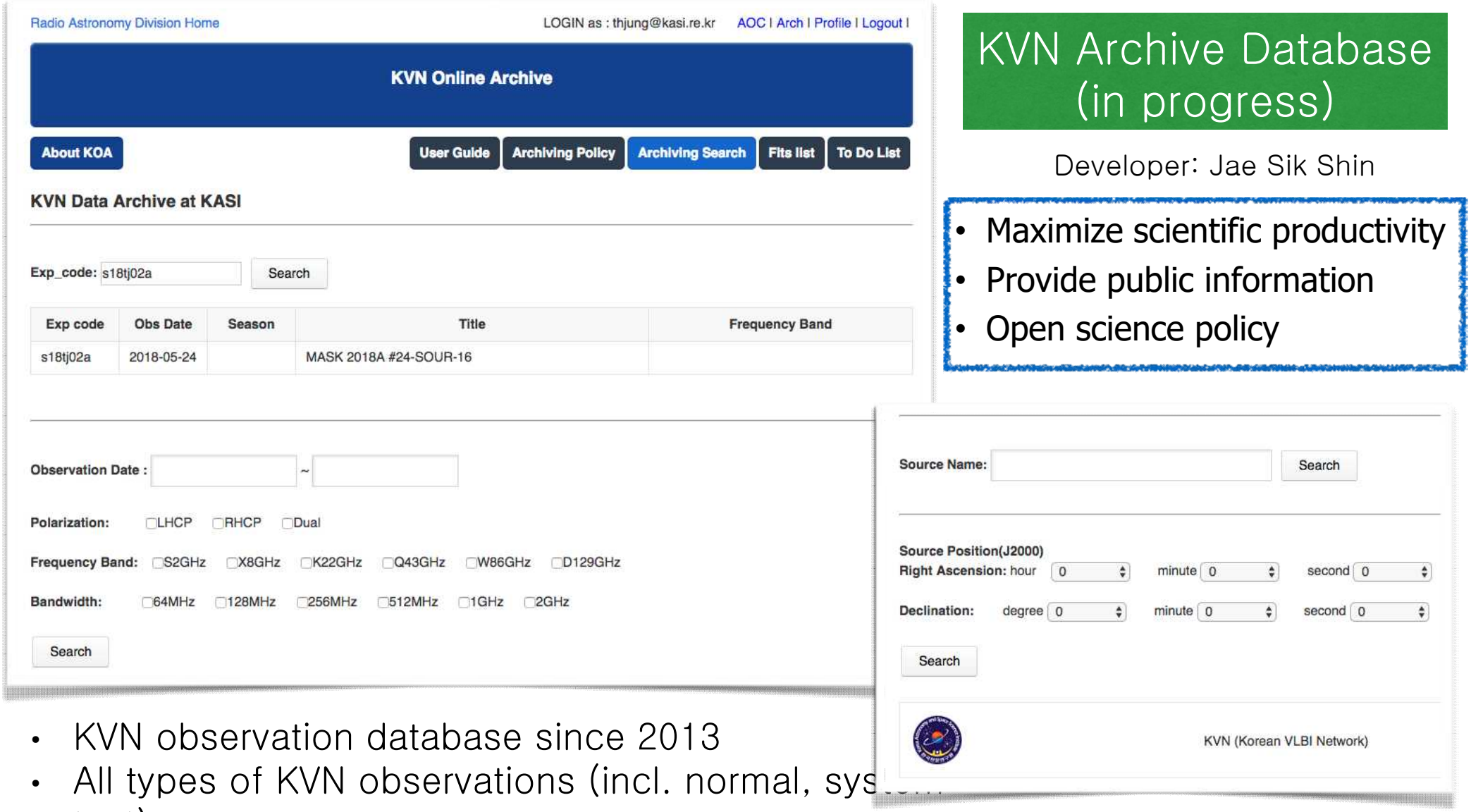


- User Support
  - KVN: Chungsik Oh (kvnhelp@kasi.re.kr)
  - KaVA: Tomoya Hirota & Chungsik Oh (kavahelp@kasi.re.kr)

KVN Archive Database (in progress)

Developer: Jae Sik Shin

- Maximize scientific productivity
- Provide public information
- Open science policy



- KVN observation database since 2013
- All types of KVN observations (incl. normal, sys… test)
- Various options for data search (src/date/freq/position)
- Download link (2019~)
- Calibrated (pipeline processed) data (after 2019 mid)
- Extended to KaVA/EAVN

Extended-KVN

- 2002 IVS Proceedings (Minh)
- 4 in South + 2 in North

Current Limitations

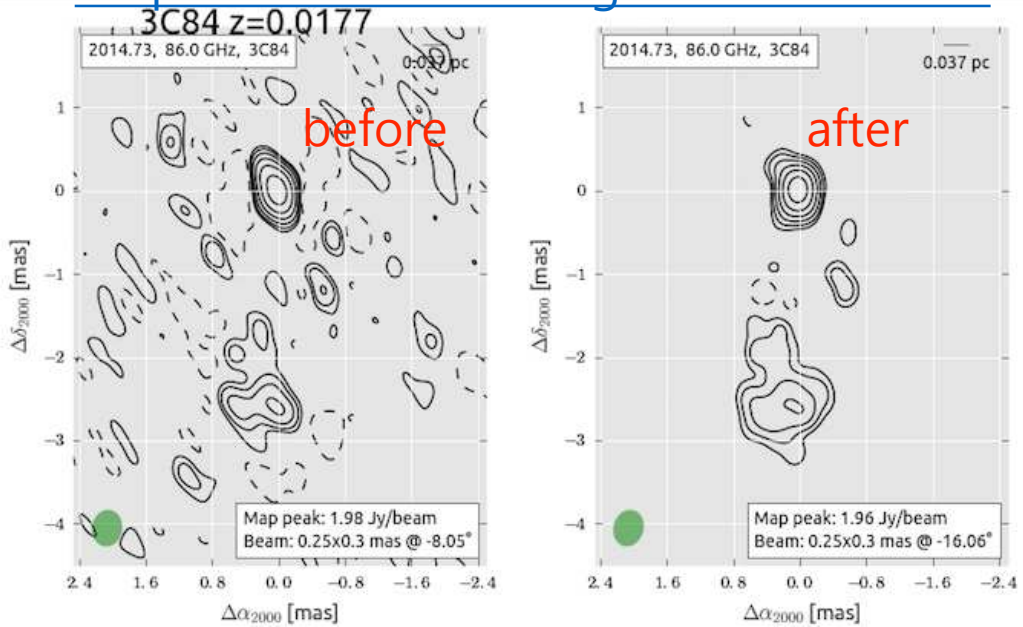
- **Limitation of 3-station KVN**
  - Poor UV-coverage
  - No amplitude self-cal
  - Lower success rates

  at high frequencies (86/129GHz)

# of stations	3	4	5	6
# of baselines	3	6	10	15
# of phase closure	1	2	10	20
# of amp. closure	**N/A**	1	5	15

- **In proportional to # of baseline**
  - Accuracy of VLBI observables (delay, rate, amplitude)
  - Image fidelity / dynamic range
  - Imaging speed

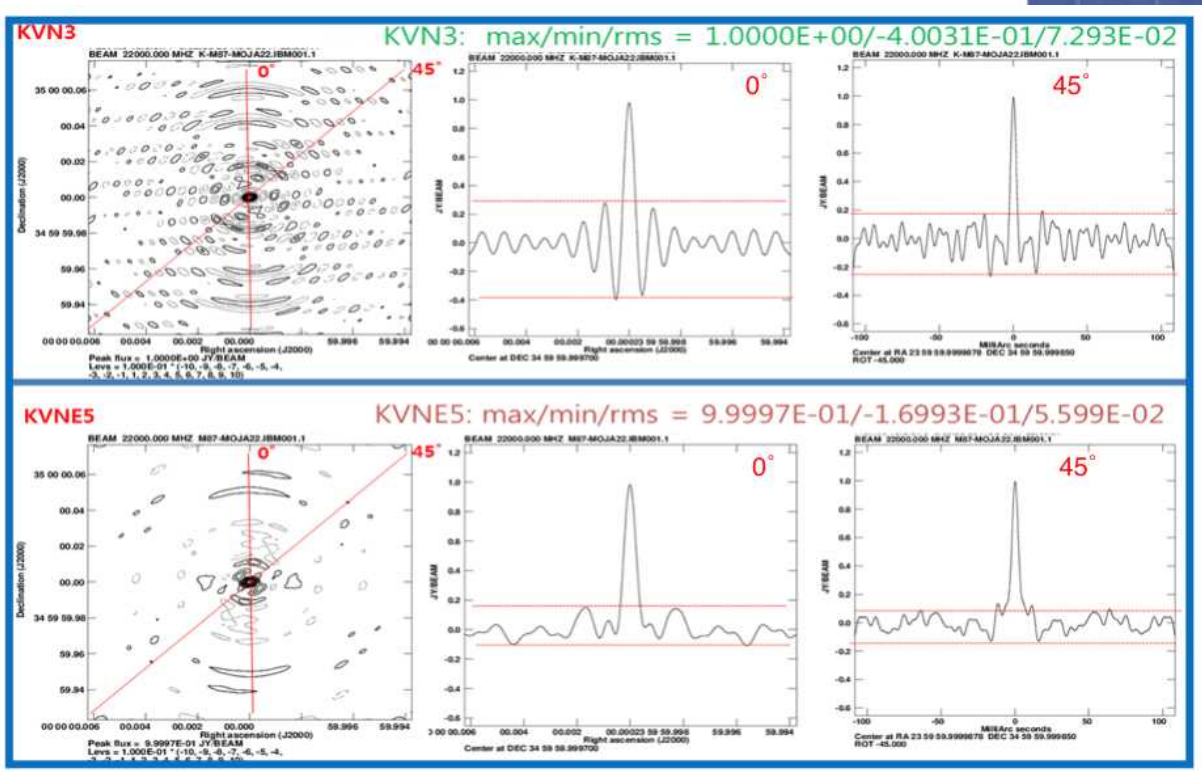
Amplitude self-cal using VLBA 6 stations

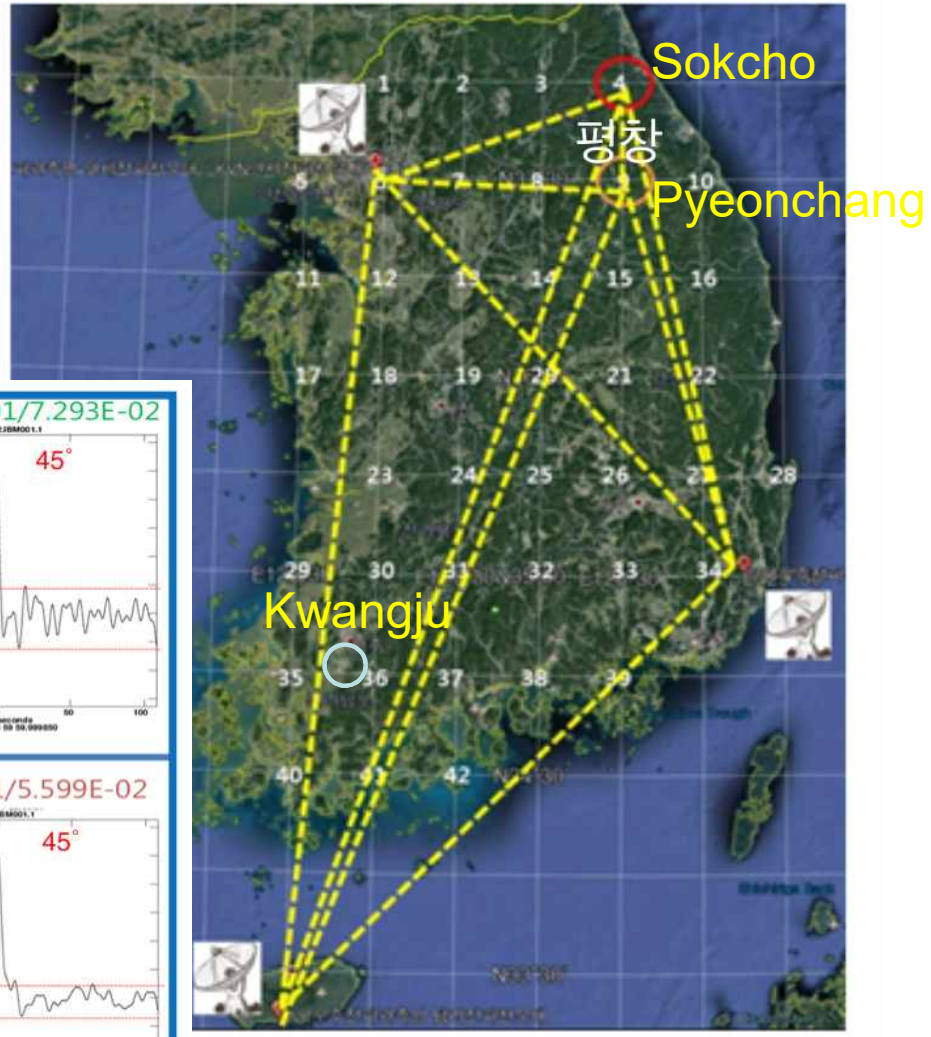


6 times better dynamic range

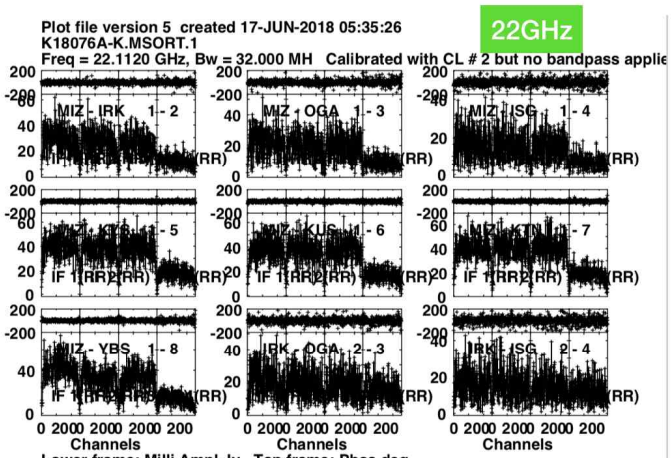
UV simulation for site selection

- UV-coverage & beam pattern
- baselines ~ 50 - 500 km
- high success rates
- candidates : **Pyeonchang** + Sokcho
  (+ Kwangju)

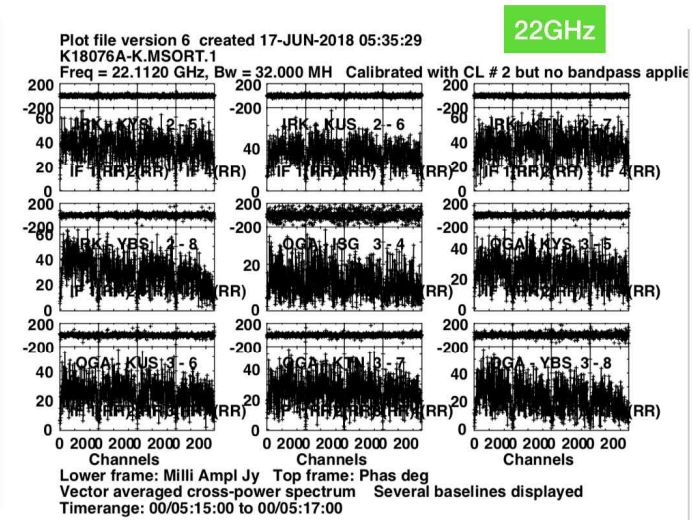




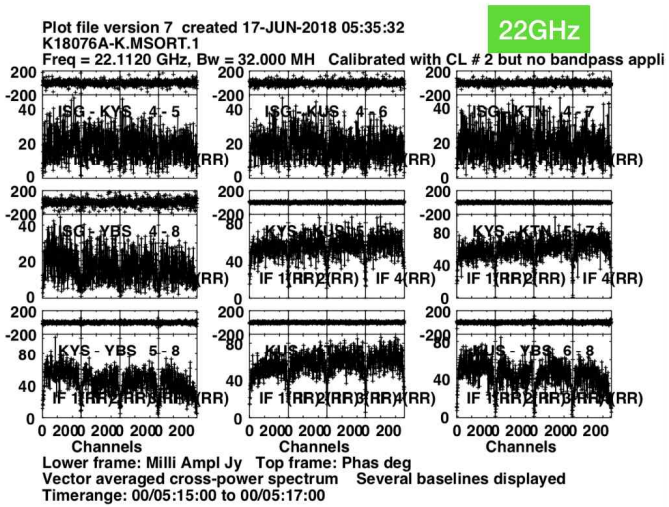
KaVA+Yebes (Spain)
Simul. Dual-Freq. VLBI Obs. Campaign



22GHz



22GHz

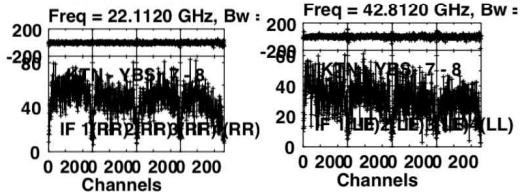


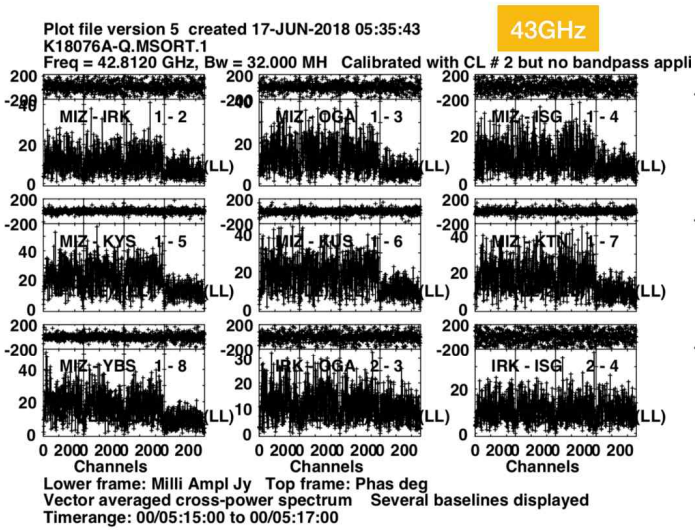
22GHz

KaVA+Yebes 22/43 GHz Simultaneous Observation Campaign

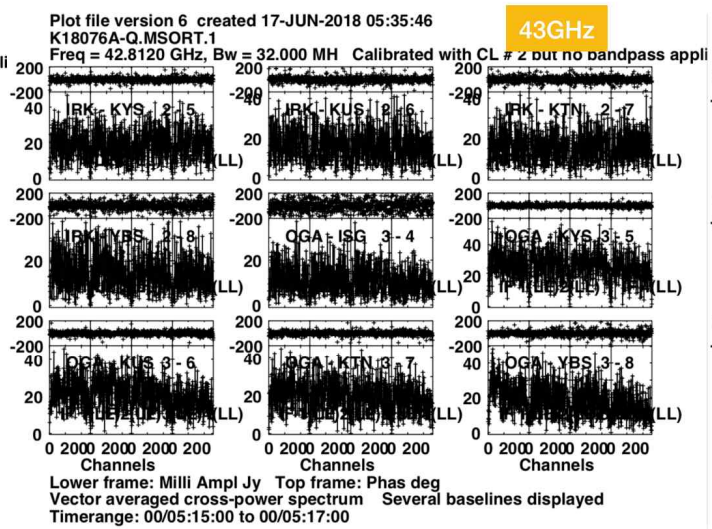
First FRINGE Detection at All KaVA+Yebes Baselines

2018. 03. 16 - 18 (7 epochs, 56 hours)

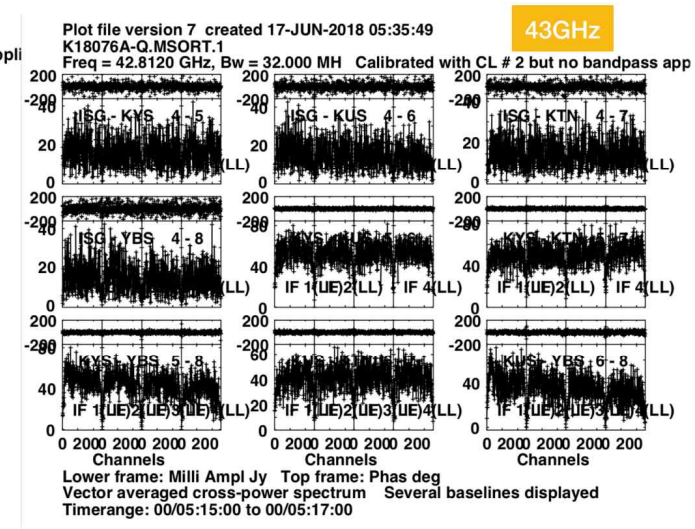




43GHz



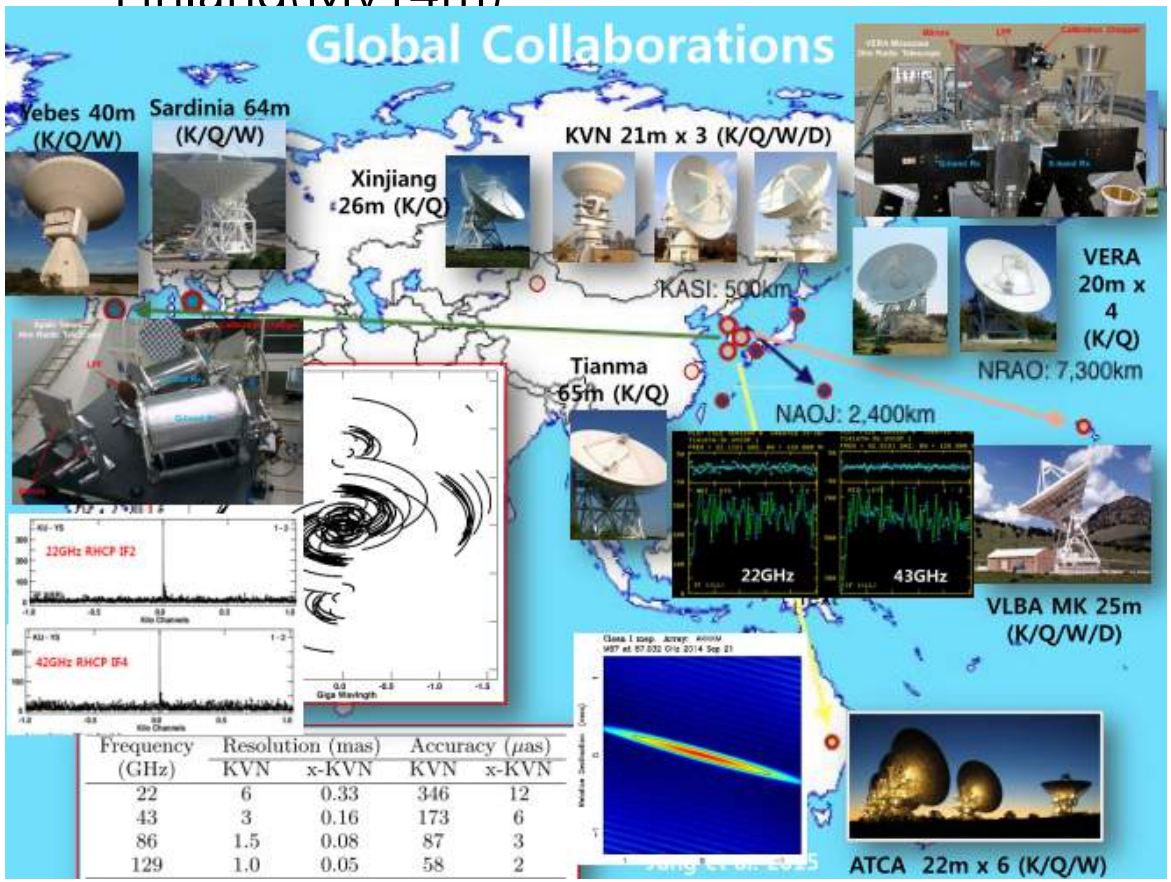
43GHz



43GHz

Global Collaborations on Simultaneous Multi-Frequency VLBI

- VERA, NRO45m, Yebes 40m, ATCA, Mopra 22m, Tianma 65m, Thai 40m, Effelsburg 100m, Millimetron (22/43/86/230GHz), QTT(110m?)
- Compact Triple-band Receiver : Italy (Sd64m, Nt32m, Md32m), Finland(My14m)

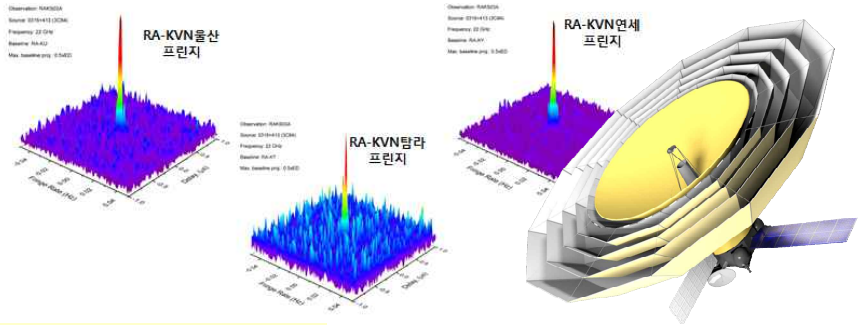


Frequency (GHz)	Resolution (mas) KVN	Resolution (mas) x-KVN	Accuracy (μas) KVN	Accuracy (μas) x-KVN
22	6	0.33	346	12
43	3	0.16	173	6
86	1.5	0.08	87	3
129	1.0	0.05	58	2

Jung+2015

KVN-RadioAstron 첫 프린지 검출

- 2013년 9월 21일 RadioAstron과 KVN 연세, 울산, 탐라 세 기선 모두에서 성공적으로 22GHz 프린지를 검출
  → The First Ground-Space VLBI Fringe Detection in Korea !
- 3C84, K-band (22GHz), baseline projections ~ 0.5 Earth Diameters



Millimetron

우주공간 VLBI를 위한 러시아 위성과 협력

Thank You

EAVN