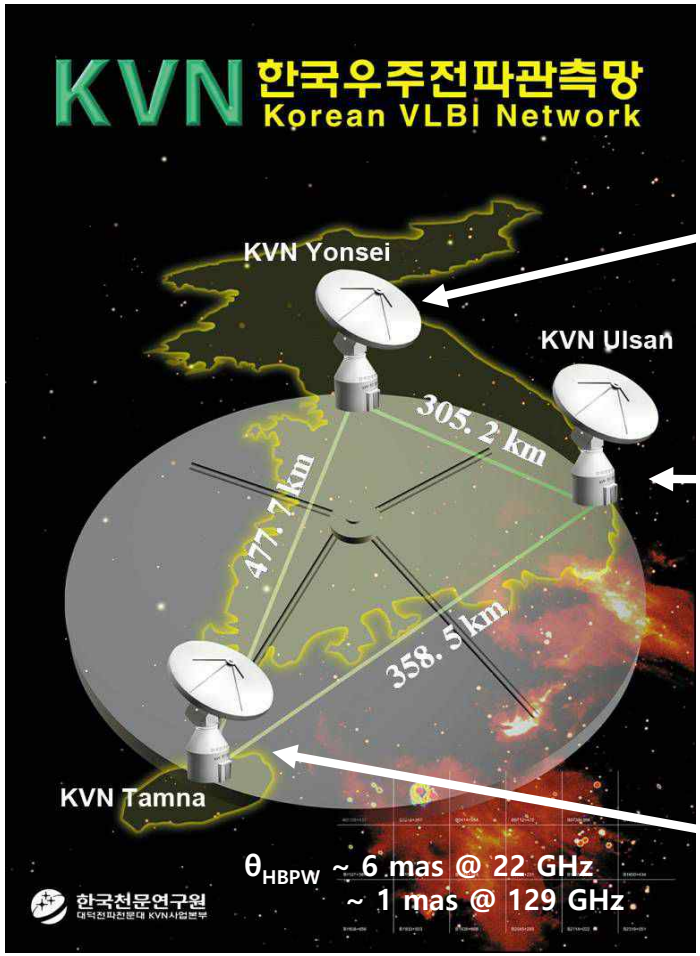
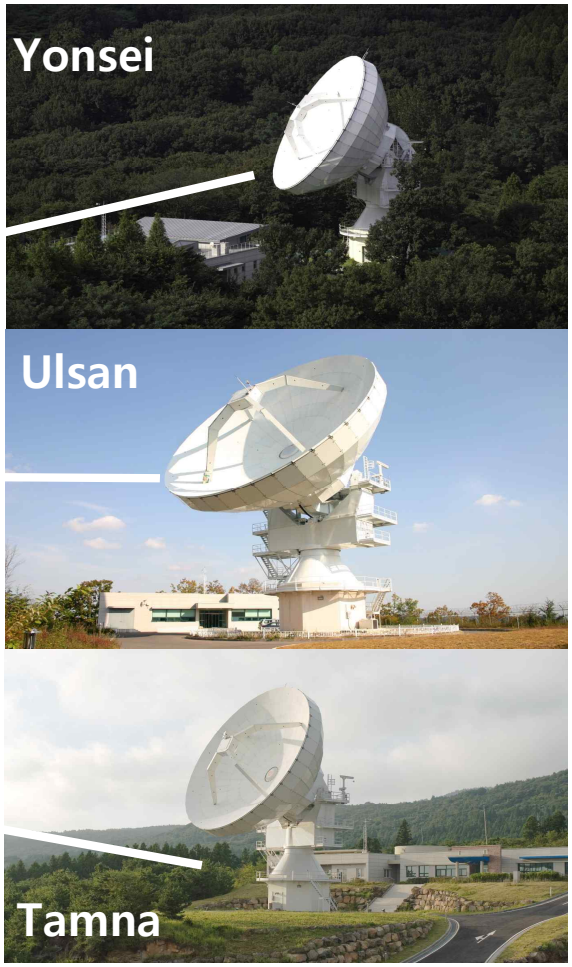
Korean VLBI Network
Current Status and Plan

Se-Jin Oh
On behalf of KVN

Korean VLBI Network (KVN)



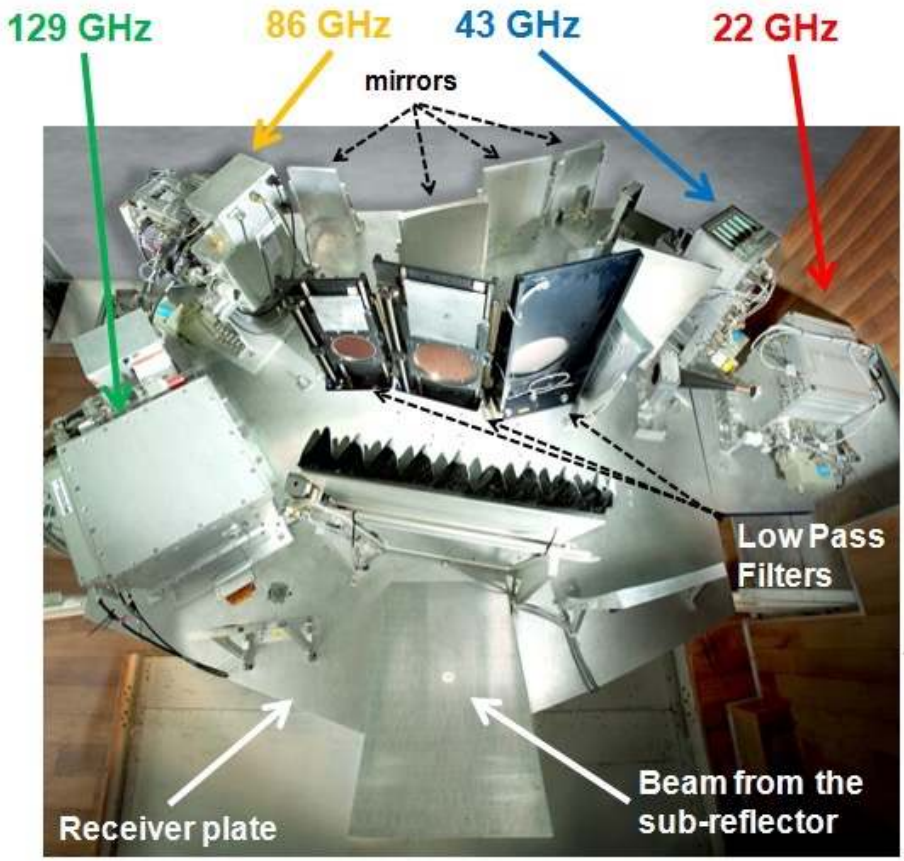


- 3 Telescopes (D = 21m)
- 22/43/86/129GHz
- 300 - 500 km
- Θ = 1 - 6 mas

- Science Targets
  AGN/SF/Evolved Star
  + micro quasar

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
  - SED
  - Rotation Measure



KVN Multi-Frequency Observations

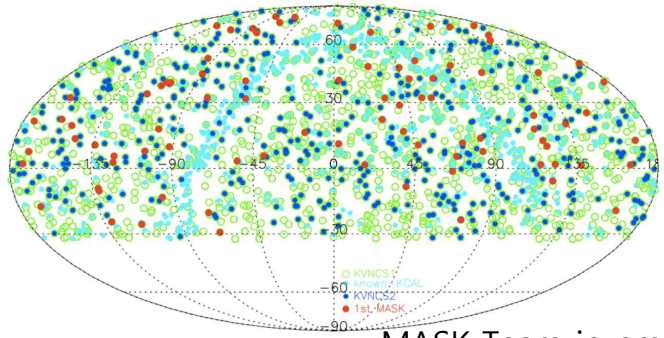
- Largest number of New detections Ever! (on-going)
  - ~574 AGNs(>80%) @ 43GHz
    ~428 AGNs(>60%) @ 86GHz
    ~281 AGNs(>50%) @ 130GHz
  - ~80 high-z AGNs (z = 2.5-6.5)

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

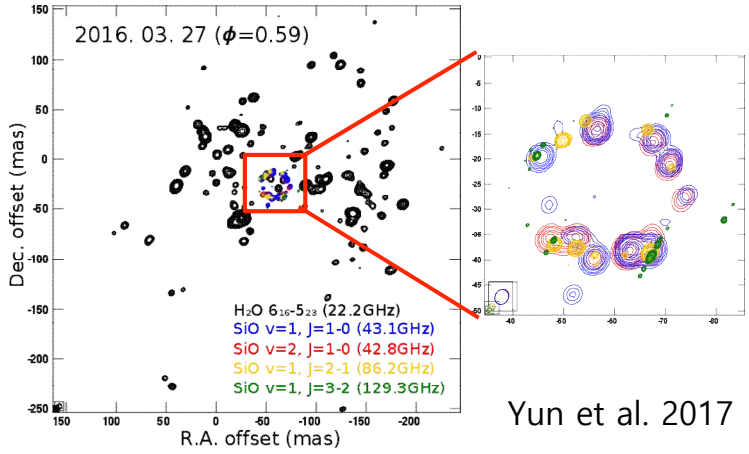
- Multi-Frequency Polarimetry
  - AGN jet structure and magnetic fields from M/F Rotation Measure

- Demonstration on the performance of simultaneous M/F
  - Tropospheric / Ionospheric phase calibration
  - Ideal system for mm-VLBI observation

MASK: Multi-Frequency AGN Survey with KVN



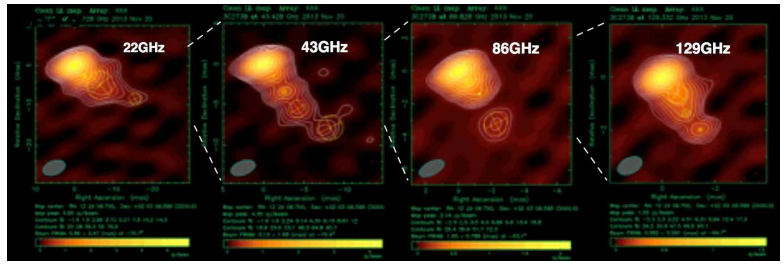
MASK Team in prep



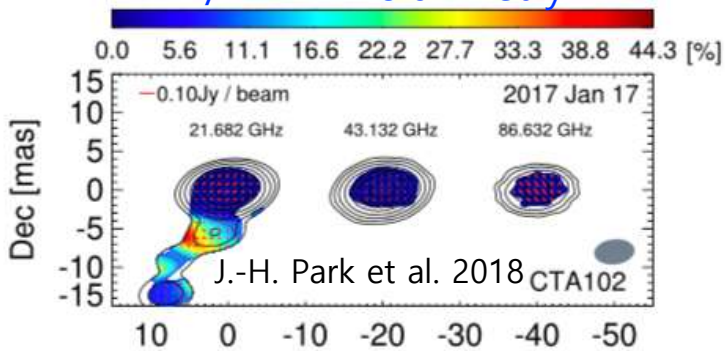
Yun et al. 2017

M/F maser maps of Vx Sgr

iMOGABA

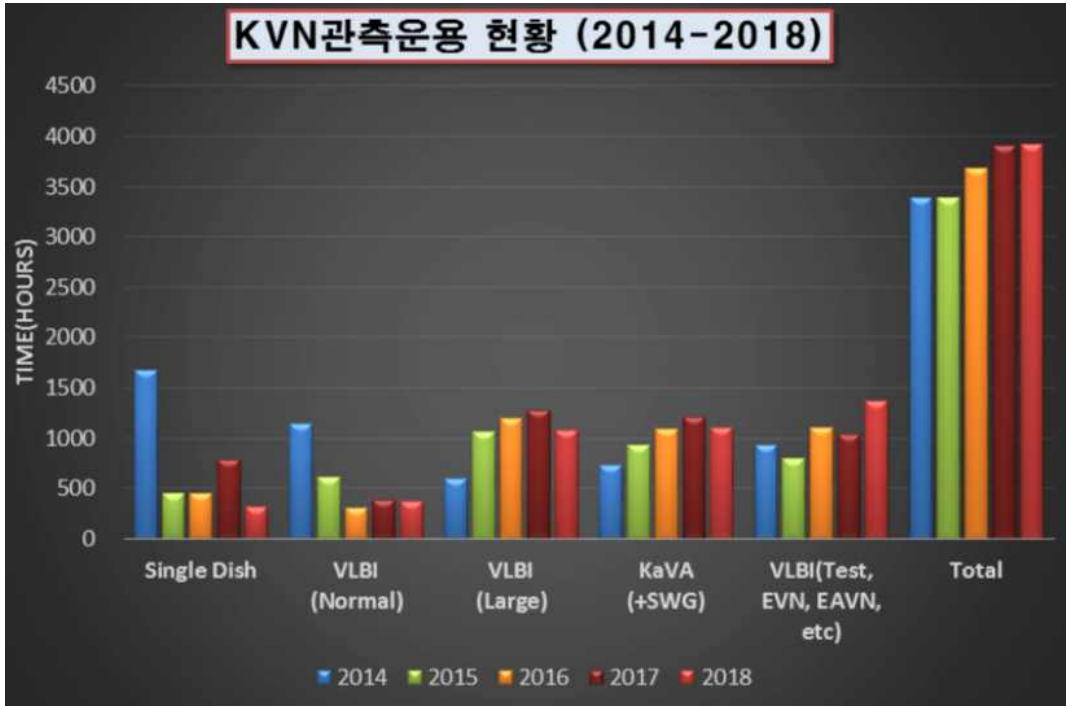


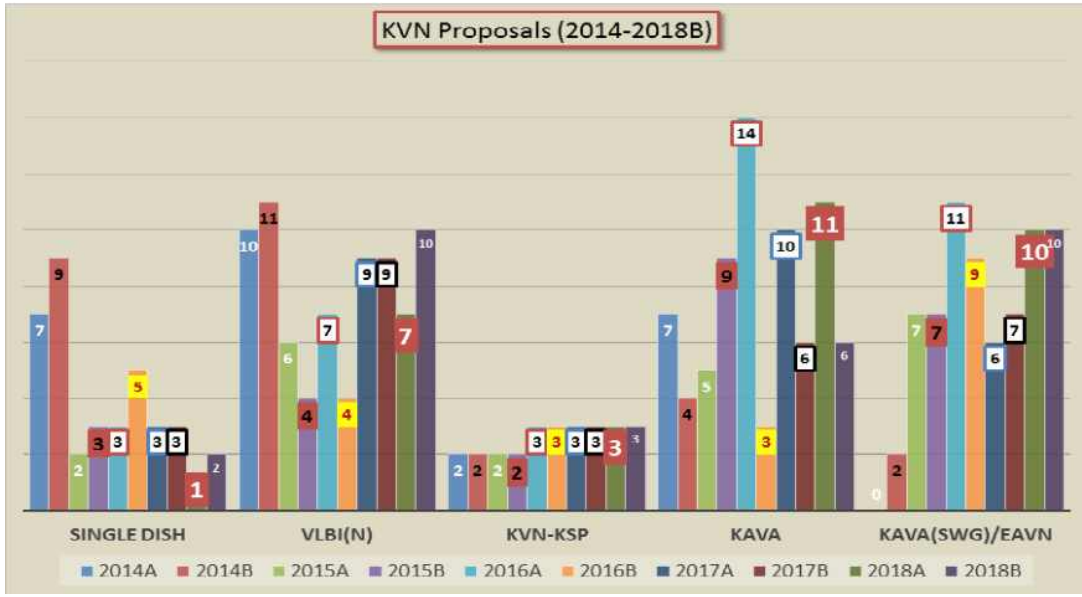
M/F VLBI Polarimetry



KVN Operation Status

- VLBI > 3500h/yr (+ SD 500-1000 h/yr/site)
  - KVN Only : 2500h
  - KaVA (KVN and VERA Array) : 1000h
  - EAVN/EVN/GMVA/Sejong > 300h
- KVN Key Science Projects : 1000h/yr
  - Evolved Star(1) & AGN (2)
- KaVA Large Programs : 500h/yr
  - AGN, Star formation, Evolved stars, Galactic astrometry
- Global Common Use : 1000h/yr
  - KVN(500h/yr) + KaVA/EAVN (500h/yr)
- Proposals status
  - 2018B: KVN(16), EAVN (14)
  - 2019A: KVN (12), EAVN (19)
  - 2019B: KVN (8), EAVN (24)
- Total 122 refereed papers using KVN (from 2013)
  - Toal 95 SCI papers (14 SCI papers/yr)

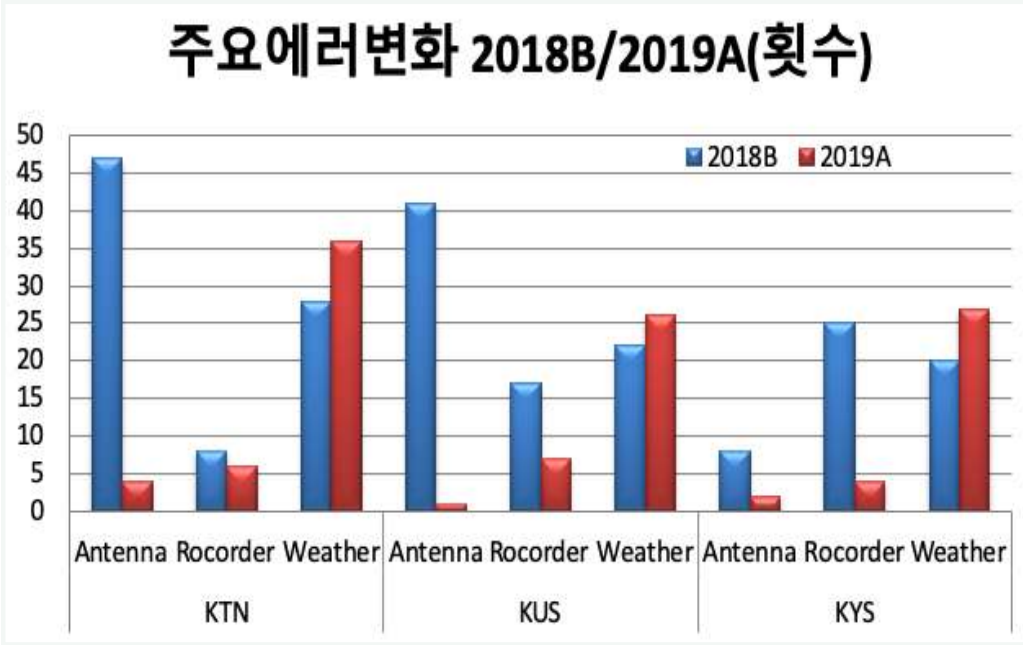




KVN Operation Statistics 2018B/2019A

	# of Obs	Total Time Allocated	Actual Obs Time	Success w/ minor err	Cancel	Fail
2019A	246	2010	1866	232	8	6
2018B	231	2030	1924	218	11	2

2018B Error counts	KTN	KUS	KYS	Sum
Antenna control failures	47	41	8	96
Problems with recorder	8	17	25	50
Severe weather condition	28	22	20	70
Other problems	55	54	37	146
Sum	138	134	90	362
2019A Error counts	KTN	KUS	KYS	Sum
Antenna control failures	4	1	2	7
Problems with recorder	6	7	4	17
Severe weather condition	36	26	27	89
Other Problems	25	22	37	84
Sum	71	56	70	197



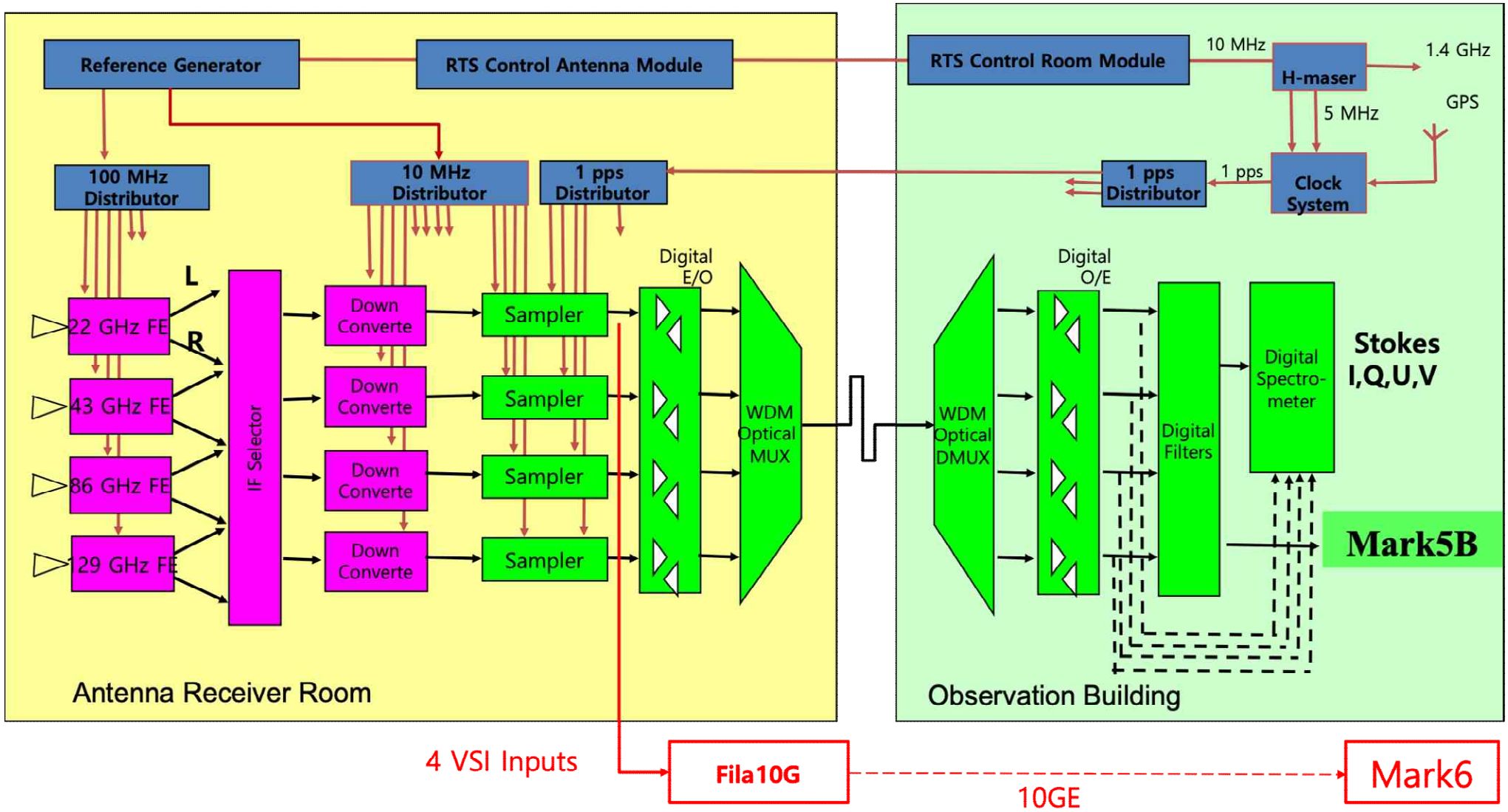
KVN System Upgrade Plan

KVN System Upgrade: Receiver

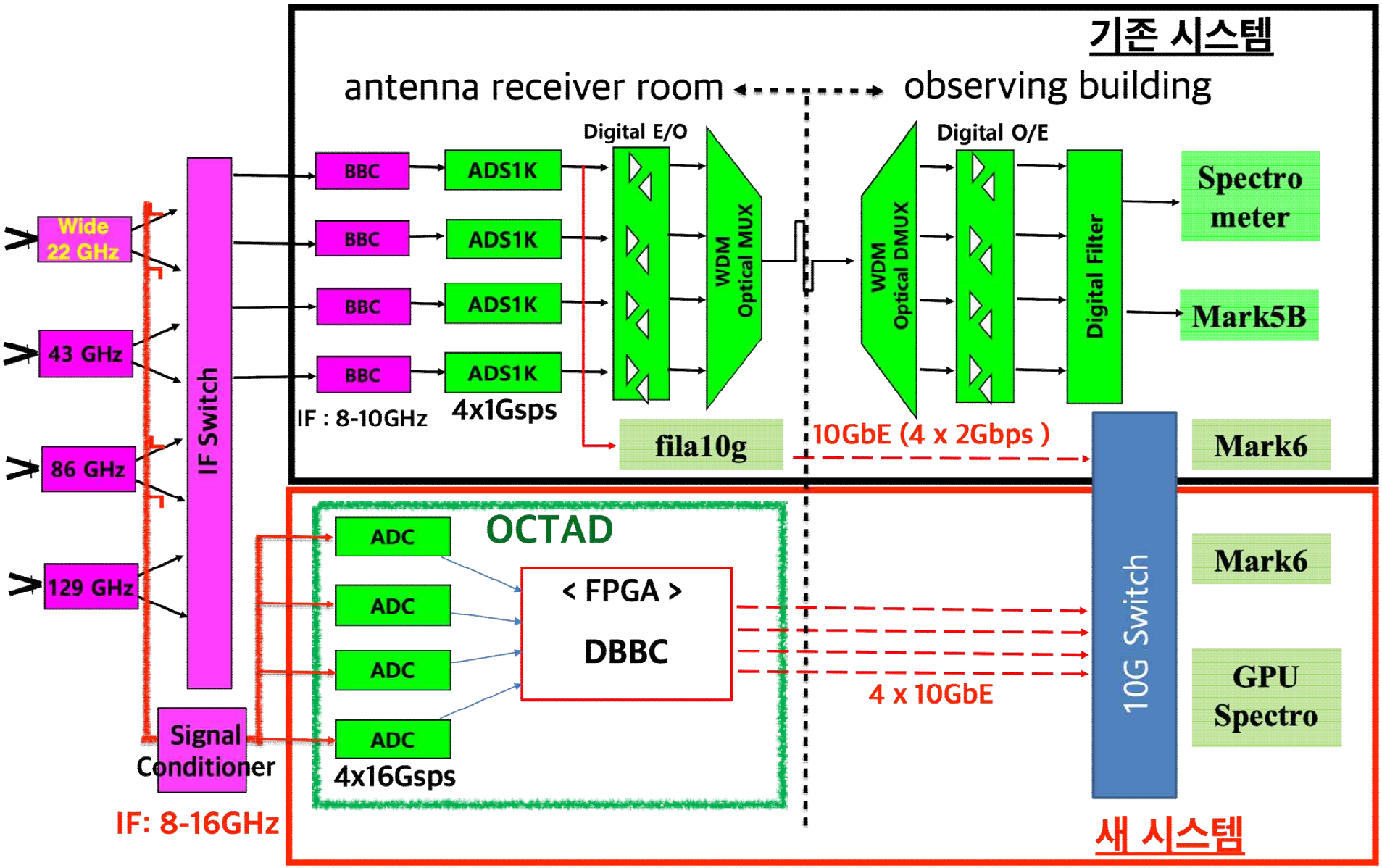
- Upgrade current Rx by replacing narrow band components ~ LNA, Feed Horn, Polarizer, tunable LO etc
- Instantaneous Bandwidth = 8GHz

KVN Receiver	Freq. (old)	Freq. (new)	Trx (new)	Installation
K-band	21.24 - 23.25	18 - 26	< 40	Completed in '18 (all KVN stations)
Q-band	42.10 - 44.10	35 - 50	< 50	KYS ('19 Sep) KUS ('20) KTN ('20 or '21)
W-band	85 - 95	85 - 116	< 80	KYS ('19 Sep) KUS (done, '18) KTN ('20)
D-band	125 - 142	125 - 172	< 60	'23 ~

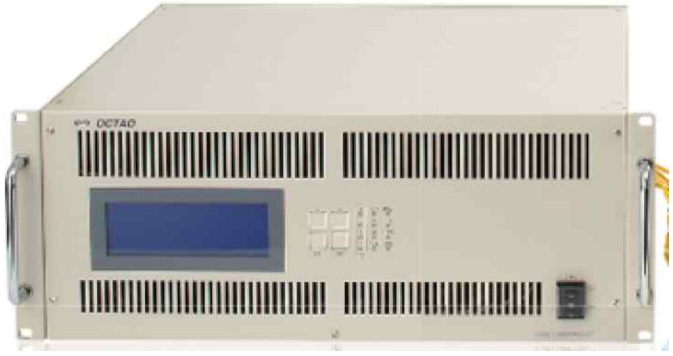
KVN System Upgrade: (old) DAS



KVN System Upgrade: (new!) DAS



OCTAD



- 4 ADC (4 x 16Gsps)
- Input Freq. 8 - 16GHz
- Digital Down Conversion
- Digital Filtering
- 4 x 10GbE output
- VDIF format

KYS

KUS

KTN

Bandwidth (MHz)	Max Num of Channels	Max Data Rate (Gbps)
8192	1	32
4096	2	32
2048	4	32
1024	8	32
512	16	32
256	16	16
128	16	8
64	16	4
32	16	2
16	16	1

KVN 4-Frequency Full Polarization

K-DAS (4 CH)+ OCTAD (4 CH) or
OCTAD (8 CH) with Mark6

22 R/L, 43 R/L, 86 R/L, 129 R/L
Data rate: 1, 2, 4, 8, 16, 32 Gbps

Mark 6

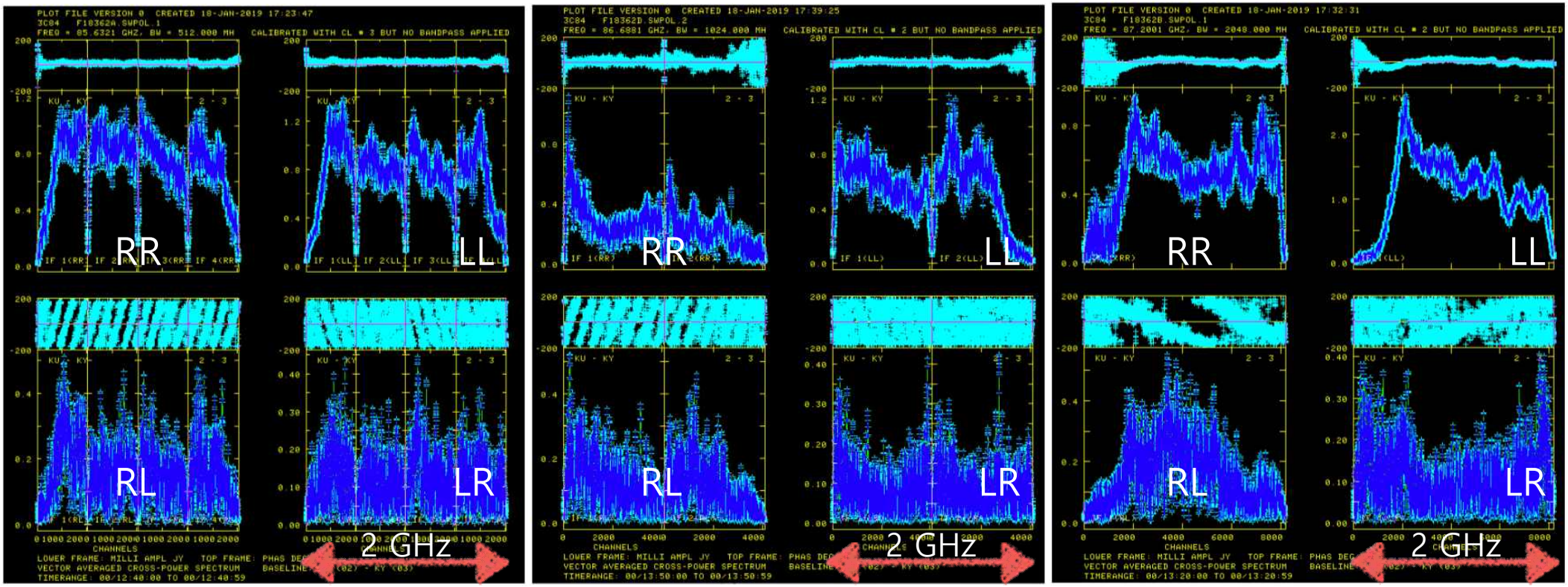
- Max 16Gbps recording
- 4 disk modules with 8 HDDs each
- 4 10GbE input

16Gbps Fringes with 32Gbps mode
KYS-KUS with 22/86GHz Dual-Pol (f18324 & f18362)

f18362 fringe test

32Gbps setup in simultaneous K/W observation —> W-band fringes (16Gbps) detected!

512 MHz x 8 Channels x 2 Pols 1024 MHz x 4 Channels x 2 Pols 2048 MHz x 2 Channels x 2 Pols



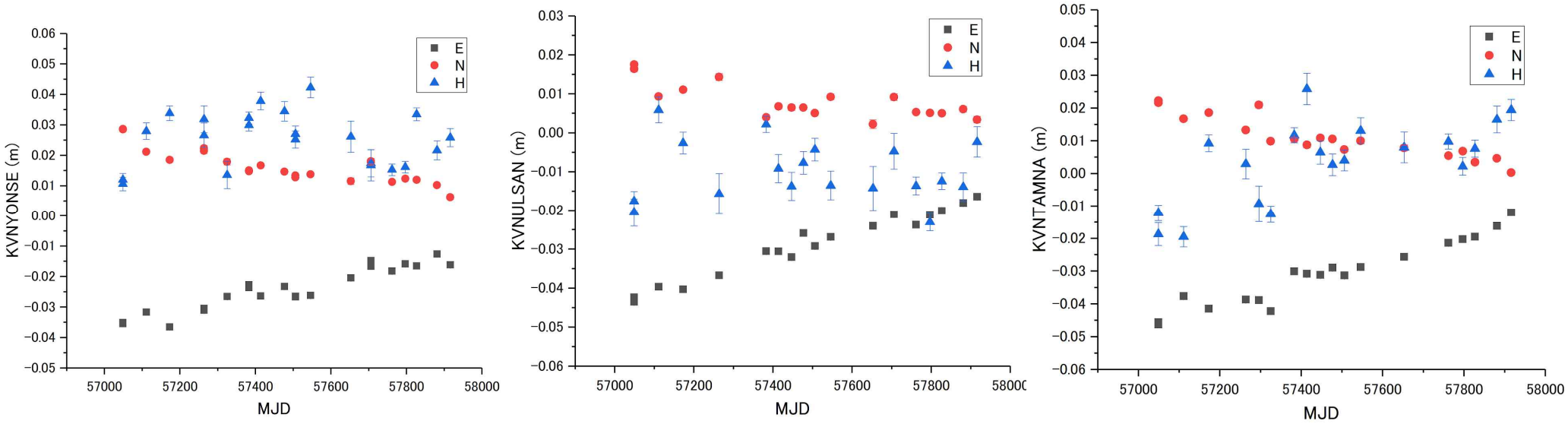
- Signal Chain: K/W-band Rx (2 Pol) —> OCTAD —> 10G switch —> Mark6 (2EA)

- 2048 channels / IF
- Partial fringe detection at K-band Pol data (f18324)

KVN Antenna Position Updates

- The accuracy of KVN antenna positions are much improved (~ a few mm level) based on KaVA K-band geodesy
- Daily antenna positions of KVN is available
- Great advantage for VLBI astrometry/geodesy

ENH coordinates of KVN
Analyzed by Dr. Jike (NAOJ)

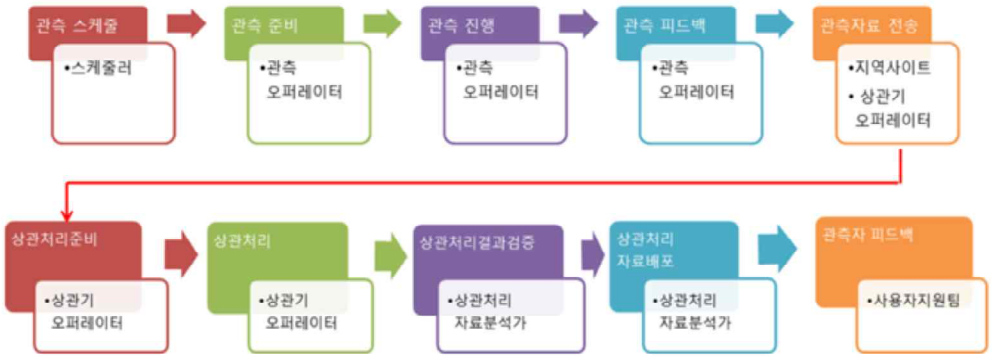


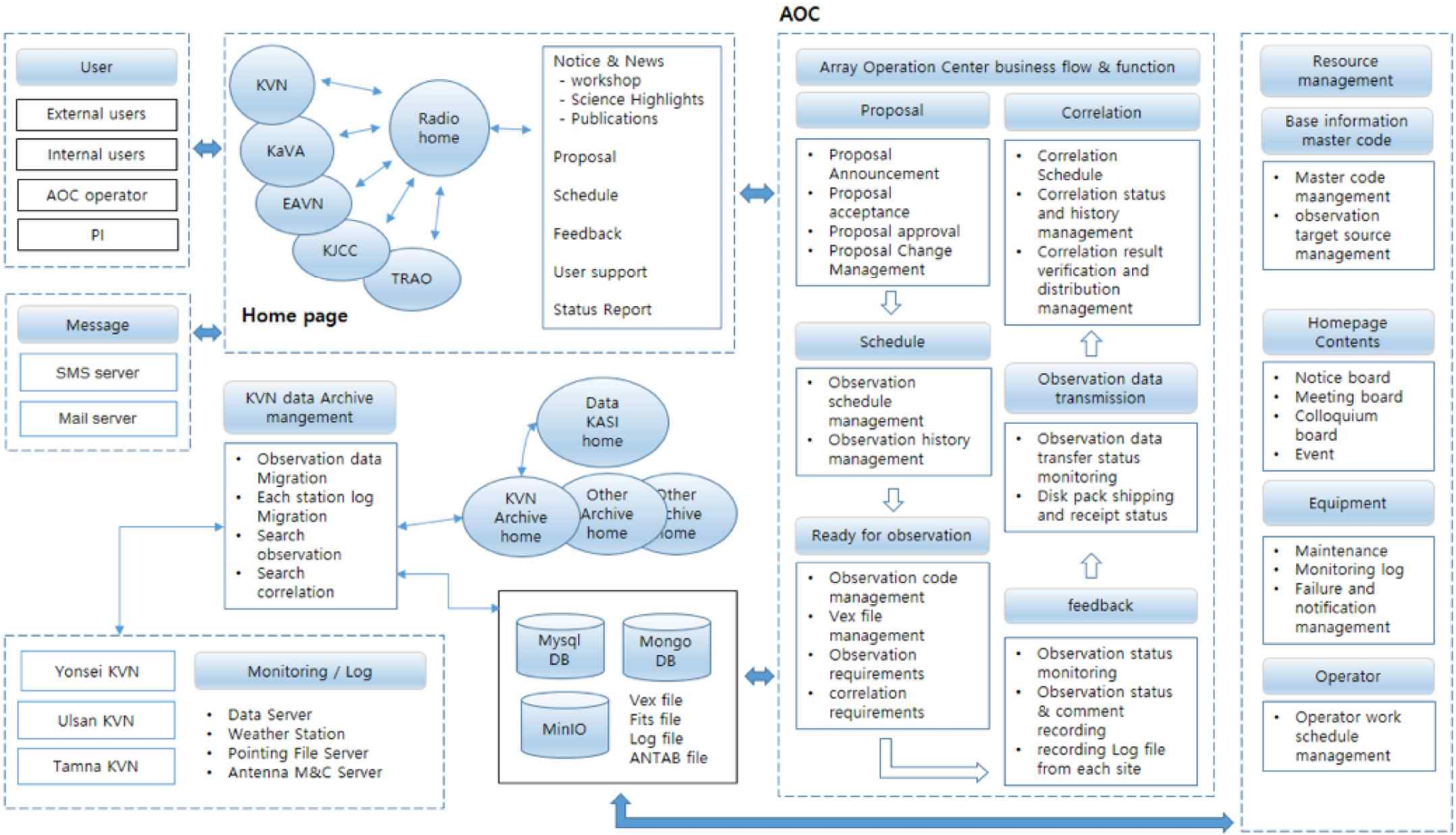
Example: Daily IVP of KVN Yonsei radio telescope (2015. 1. 1 ~ 2020.12.31)

kvnyonse.xyz14

2015/01/01	1	57023	-3042280.9740	4045902.6891	3867374.3521
2015/01/02	2	57024	-3042280.9740	4045902.6891	3867374.3521
2015/01/03	3	57025	-3042280.9740	4045902.6891	3867374.3521
2015/01/04	4	57026	-3042280.9741	4045902.6890	3867374.3521
2015/01/05	5	57027	-3042280.9741	4045902.6890	3867374.3520
2015/01/06	6	57028	-3042280.9741	4045902.6890	3867374.3520
2015/01/07	7	57029	-3042280.9741	4045902.6890	3867374.3520
2015/01/08	8	57030	-3042280.9742	4045902.6890	3867374.3520
2015/01/09	9	57031	-3042280.9742	4045902.6890	3867374.3520
2015/01/10	10	57032	-3042280.9742	4045902.6890	3867374.3520
2015/01/11	11	57033	-3042280.9742	4045902.6890	3867374.3519
2015/01/12	12	57034	-3042280.9743	4045902.6890	3867374.3519
2015/01/13	13	57035	-3042280.9743	4045902.6890	3867374.3519
2015/01/14	14	57036	-3042280.9743	4045902.6889	3867374.3519
2015/01/15	15	57037	-3042280.9743	4045902.6889	3867374.3519
...					
2020/12/16	351	59199	-3042281.0314	4045902.6671	3867374.3145
2020/12/17	352	59200	-3042281.0314	4045902.6671	3867374.3145
2020/12/18	353	59201	-3042281.0315	4045902.6671	3867374.3144
2020/12/19	354	59202	-3042281.0315	4045902.6671	3867374.3144
2020/12/20	355	59203	-3042281.0315	4045902.6671	3867374.3144
2020/12/21	356	59204	-3042281.0315	4045902.6671	3867374.3144
2020/12/22	357	59205	-3042281.0316	4045902.6671	3867374.3144
2020/12/23	358	59206	-3042281.0316	4045902.6671	3867374.3144
2020/12/24	359	59207	-3042281.0316	4045902.6670	3867374.3143
2020/12/25	360	59208	-3042281.0317	4045902.6670	3867374.3143
2020/12/26	361	59209	-3042281.0317	4045902.6670	3867374.3143
2020/12/27	362	59210	-3042281.0317	4045902.6670	3867374.3143
2020/12/28	363	59211	-3042281.0317	4045902.6670	3867374.3143
2020/12/29	364	59212	-3042281.0318	4045902.6670	3867374.3143
2020/12/30	365	59213	-3042281.0318	4045902.6670	3867374.3142
2020/12/31	366	59214	-3042281.0318	4045902.6670	3867374.3142

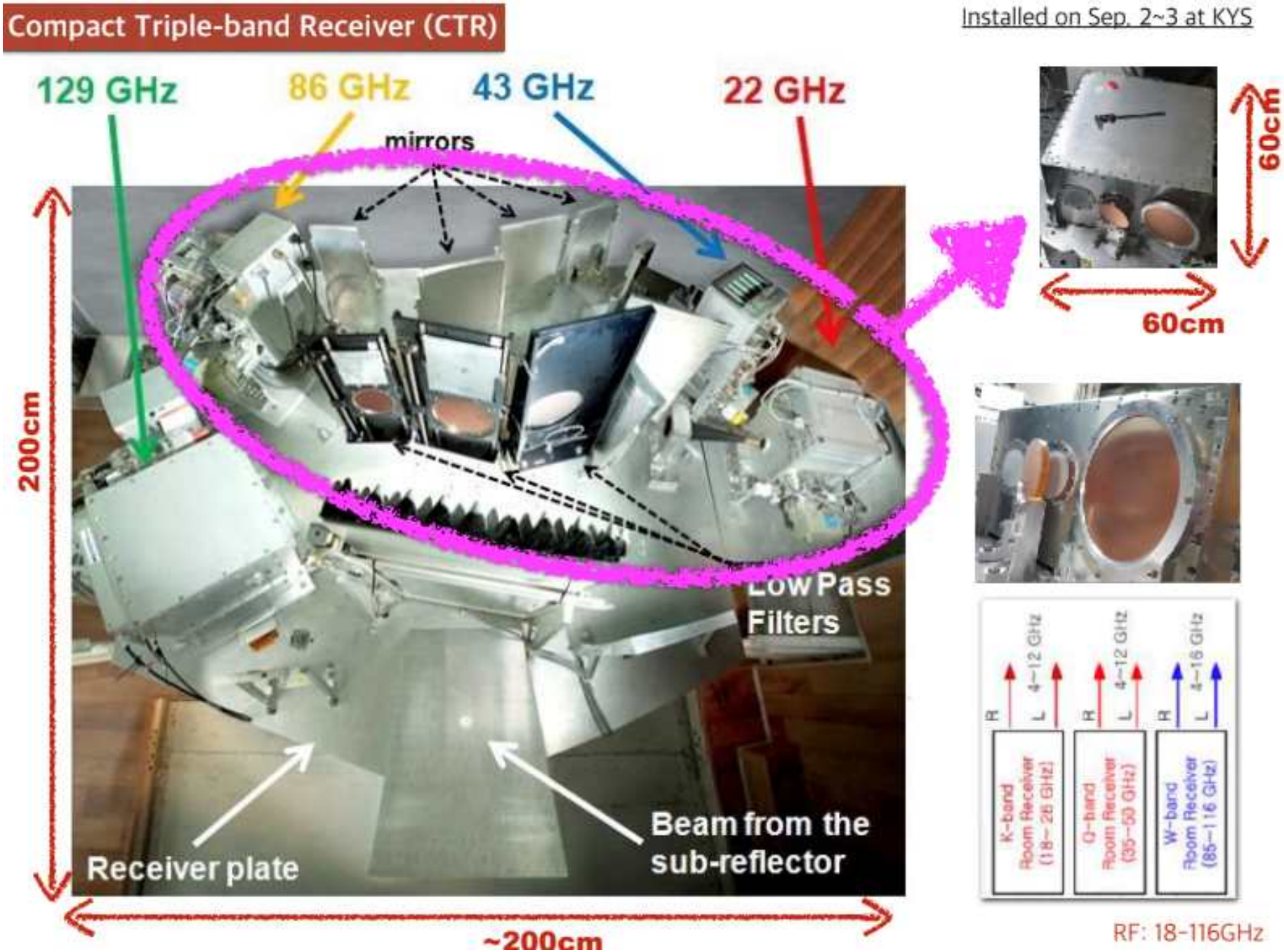
“Web-based” Operation KVN / EAVN





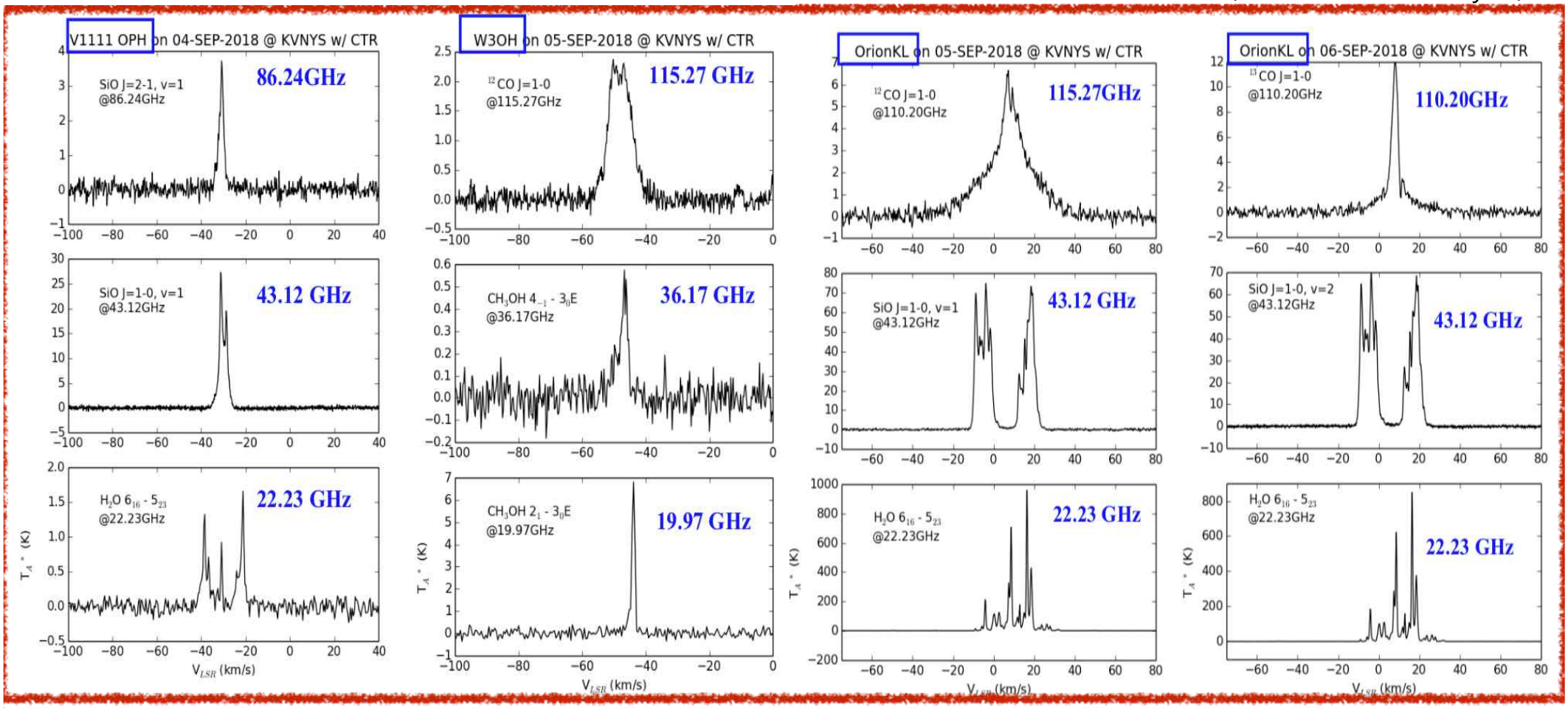
Notice to Users

(S. T. Han)



Compact Triple-band Receiver (CTR)

(S. T. Han & D. Y. Byun)



- **Pointing offset among 3 channels : less than 3 arcsec to conduct simultaneous observations**
- **Aperture efficiencies : Obtained as much as we could (K- : 68 %, Q-: 66 %, W-band : 50%)**
- **Receiver noise temperatures : Not bad, but have to be improved (OMT, Polarizer and LNA)**

❖ **CTR is tailorable for use in telescopes with a small receiver cabin.**

❖ **Ultimately this concept may lead to development of much more compact multi-frequency receiver systems for mm-wave and sub-mm radio telescopes**

Simultaneous Multi-Freq. VLBI System in Globe

KVN (K/Q/W/D)
VERA (K/Q)
Sejong (K/Q/W)

Yebes 40m (Spain, K/Q/W)

Nobeyama 45m (Japan, K/Q/W)

Metsahovi 14m
(Finland, K/Q/W)

Tianma 65m
(China, K/Q)

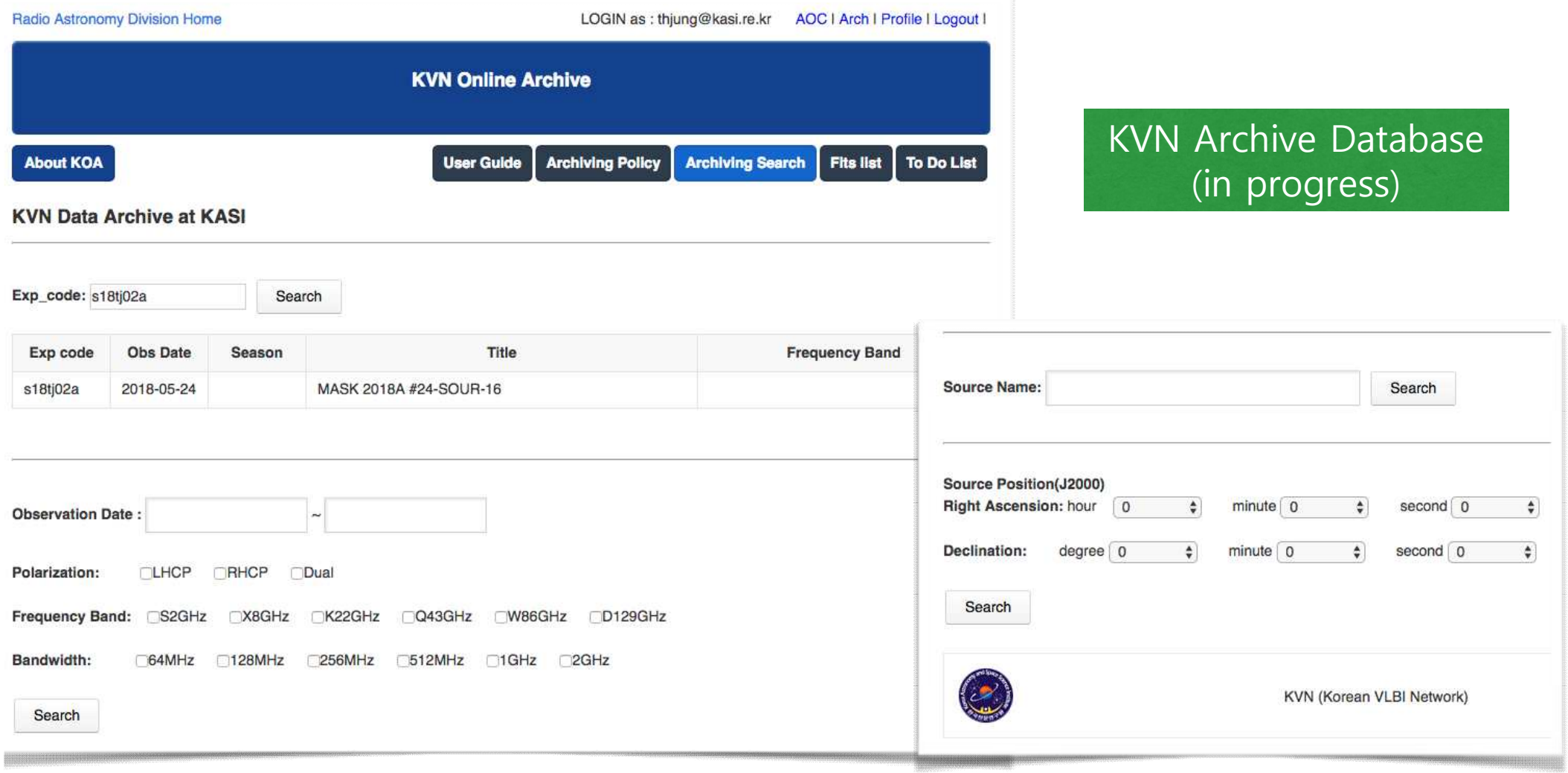
E-KVN
(K/Q/W/D+230GHz)

"Standard System" in mm-VLBI

VLBA MK 25m
(USA, K/Q/W)

Sardenia 64m, Noto 32m, Medicina 32m (Italia, K/Q/W Mopra 22m (Australia, K/Q/W)

ATCA 22m x5
(Australia, Q/W)



KVN Archive Database (in progress)

- KVN observation database since 2013
- All types of KVN observations (incl. normal, system test)
- Various options for data search (src/date/freq/position)
- Download link
- Calibrated (pipeline processed) data (after 2019 mid)
- Developer: Jae Sik Shin


The Most Powerful Eyes
in the Universe
서울~울산~제주 삼각관측
우주와의 '소통' 한걸음 더
12일 새벽 제주도 서귀포 하늘에서 북극성을 중심으로 궤적을 그리며 돌고 있는 별들을 향해 지름 21m 크기의 접시 안테나가 우뚝 솟아 있다. 서울 연세대-울산 울산대-제주 탐라대를 3각으로 연결하는 한국우주전파관측망(KVN) 사업의 마무리 단계로 서귀포 탐라대 탐라전파천문대의 전파망원경이 지난 1일 성능식을 마치고 시험 가동에 들어갔다. 전파망원경 석 대가 연결되면 서울에서 제주 한라산의 쌀 한 톨도 식별할 수 있는 정밀도를 갖게 된다. 한국우주전파관측망을 가동하면 우리도 우주의 블랙홀을 정밀 계측해 별의 탄생과 사멸을 연구할 수 있고, 한반도 지각변동도 정밀 모니터링할 수 있게 된다. 이 사진은 디지털카메라에 14㎜ 렌즈를 부착해 1시간 동안 셔터를 열어 찍었다.
서귀포/김봉규 기자 bong9@hani.co.kr
Thank you !