



**KVN**

The most Powerful  
mm-VLBI Network System

# Korean VLBI Network

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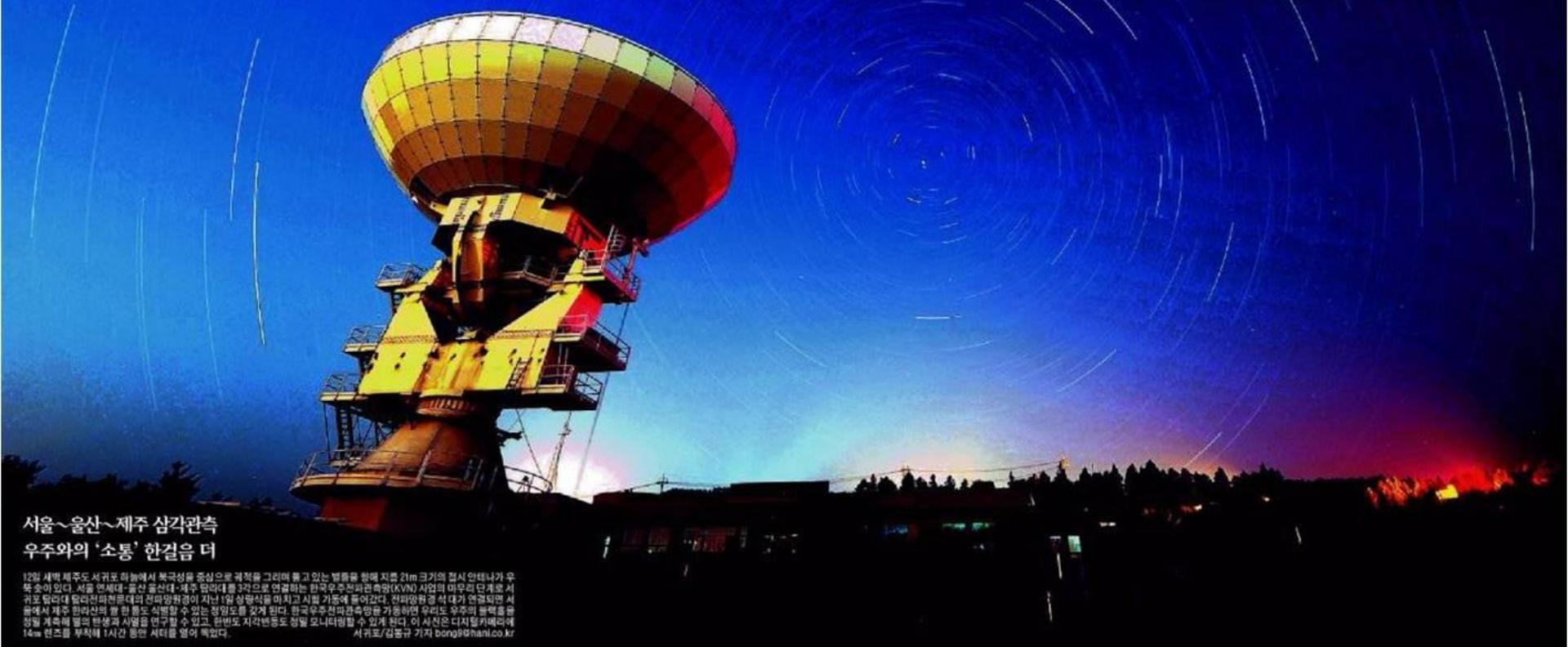
Korea Astronomy  
& Space Science Institute (KASI)

# KVN

## The First VLBI Facility in Korea

### mm-VLBI (22/43/86/129 GHz)

### Multi-frequency Receiving System

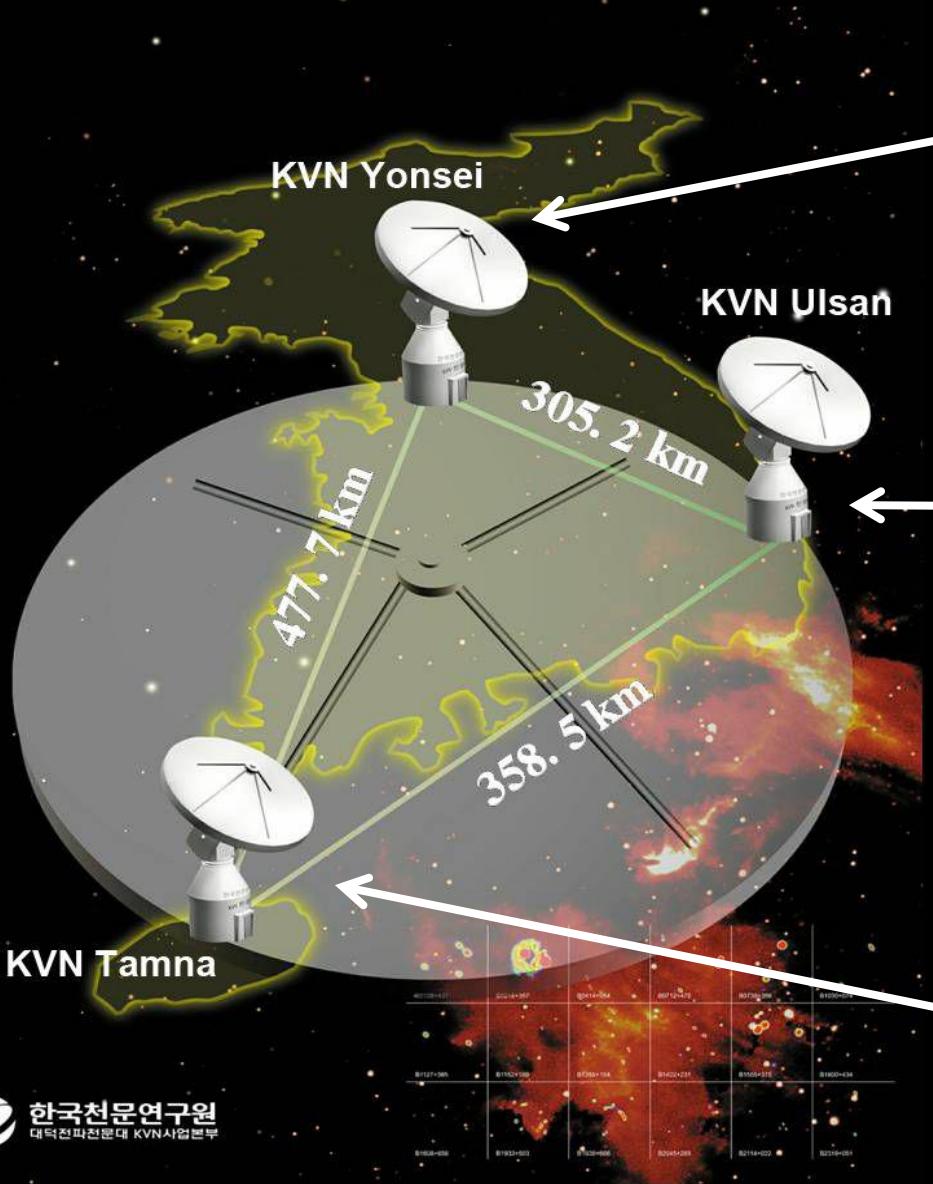


서울~울산~제주 삼각관측  
우주와의 ‘소통’ 한걸음 더

12일 새벽 제주도 서귀포 하늘에서 별극성을 중심으로 궤적을 그리며 빛고 있는 별들을 향해 지름 21m 크기의 접시 안테나가 우뚝 솟아 있다. 서울 연세대·울산 울산대·제주 덤비대를 3각으로 연결하는 한국우주천문관측망(KVN) 사업의 마지막 단계로 서귀포 덤비대 달라전파천문대와 전파망원경이 지난 1월 상용식을 마치고 시험 기동에 들어갔다. 전파망원경 척대가 연결되면 서울에서 제주 한라산의 광활한 풍도 석별할 수 있는 청암도를 갖게 된다. 한국우주천문관측망을 가동하면 우리도 우주의 물체들을 정밀하게 해 별의 탄생과 사생을 연구할 수 있고, 한반도 지각변동도 정밀 모니터링할 수 있게 된다. 이 사진은 디지털카메라에 14mm 렌즈를 부착해 1시간 동안 셔터를 열어 촬겼다.

서귀포/김종규 기자 bong9@hani.kr

# KVN 한국우주전파관측망 Korean VLBI Network



한국천문연구원  
대덕전파천문대 KVN사업본부

# KVN

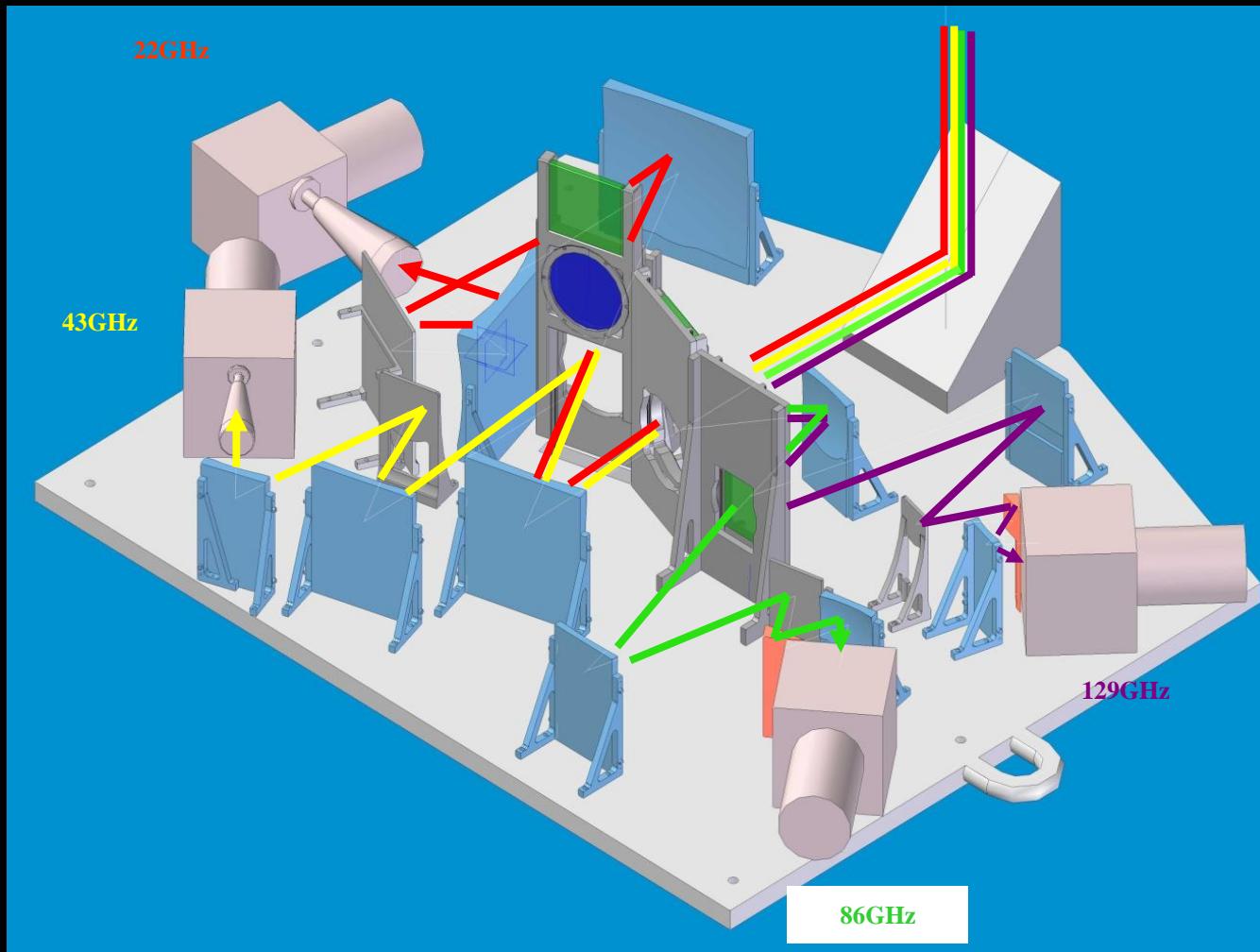
The most Powerful  
mm-VLBI Network System

## Specifications

- Three 21m antennas  
  @ Seoul, Ulsan, Jeju island
- Alt-Az mount, shaped Cassegrain
- Fast slewing speed : 3 deg/sec (AZ/EL)
- First simultaneous multi-frequency receiving system @ 22/43/86/129GHz
- Dual Polarization  
  ~ Circular Pol (LCP & RCP)
- High surface accuracy  
  ~ panel < 65 micron  
  ~ total < 150 micron
- High pointing accuracy  
  ~ < 4 arcseconds in RMS
- High aperture efficiency  
  ~ 65/60/50/40% @ 22/43/86/129 GHz

# Multi-Frequency Receiving System

Beams from antenna

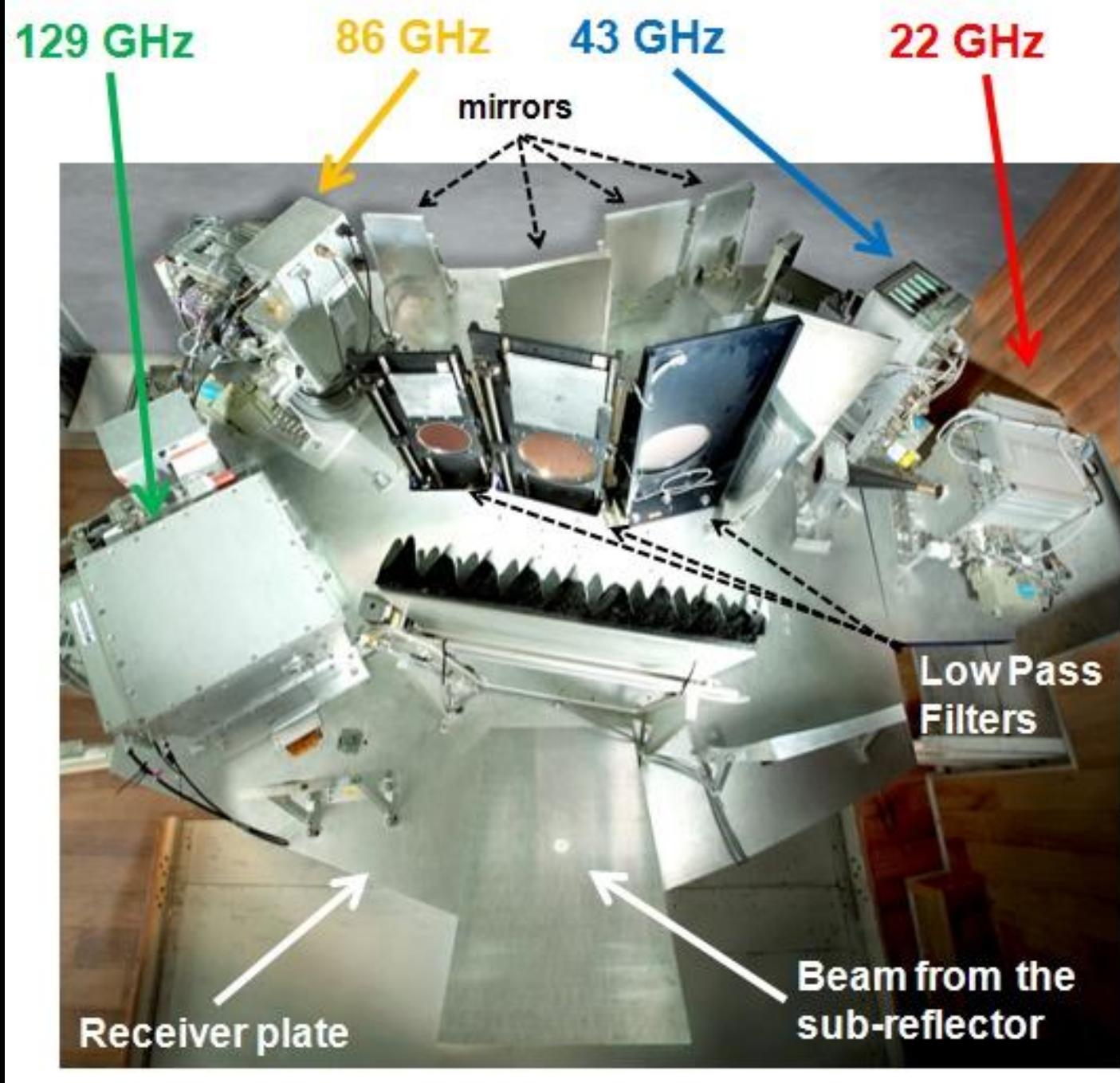


Frequency	22 GHz	43 GHz	86 GHz	129 GHz
Freq. Range	21.25-23.25	42.11-44.11	85-95	125-140
Rx Noise (K)	35	80	100	50
Polarization	LHCP & RHCP			

Han et al. (2008)

# Multi-Frequency Receiving System

4CH Receivers  
@ Yonsei  
Han et al. (2008)



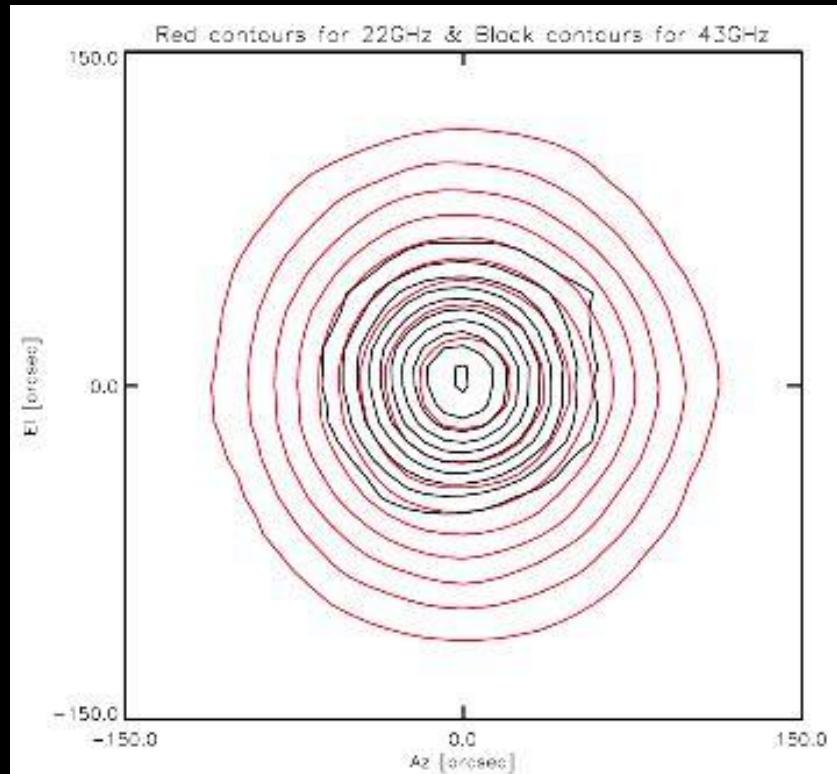
# Pointing Accuracy & Aperture Efficiencies

## Pointing Accuracy

Station	After Cladding	
	Az offset(rms) ["]	El offset(rms) ["]
Yonsei	1.69	2.63
Ulsan	2.82	2.27
Tamna	1.97	2.84

## Aperture Efficiency

Frequency	Aperture Efficiency
22 GHz	65
43 GHz	60
86 GHz	50
129 GHz	40

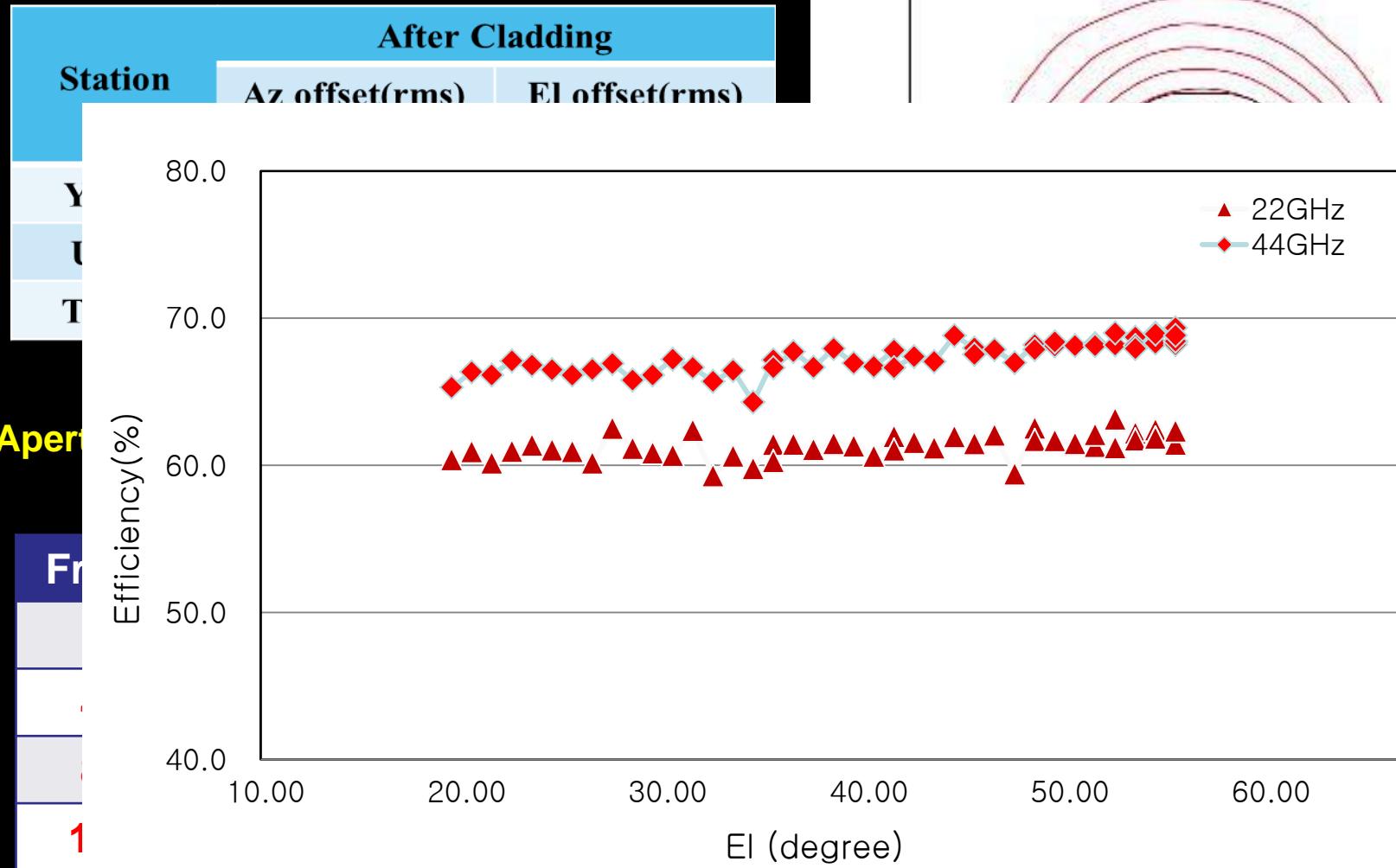


## Beam Alignment

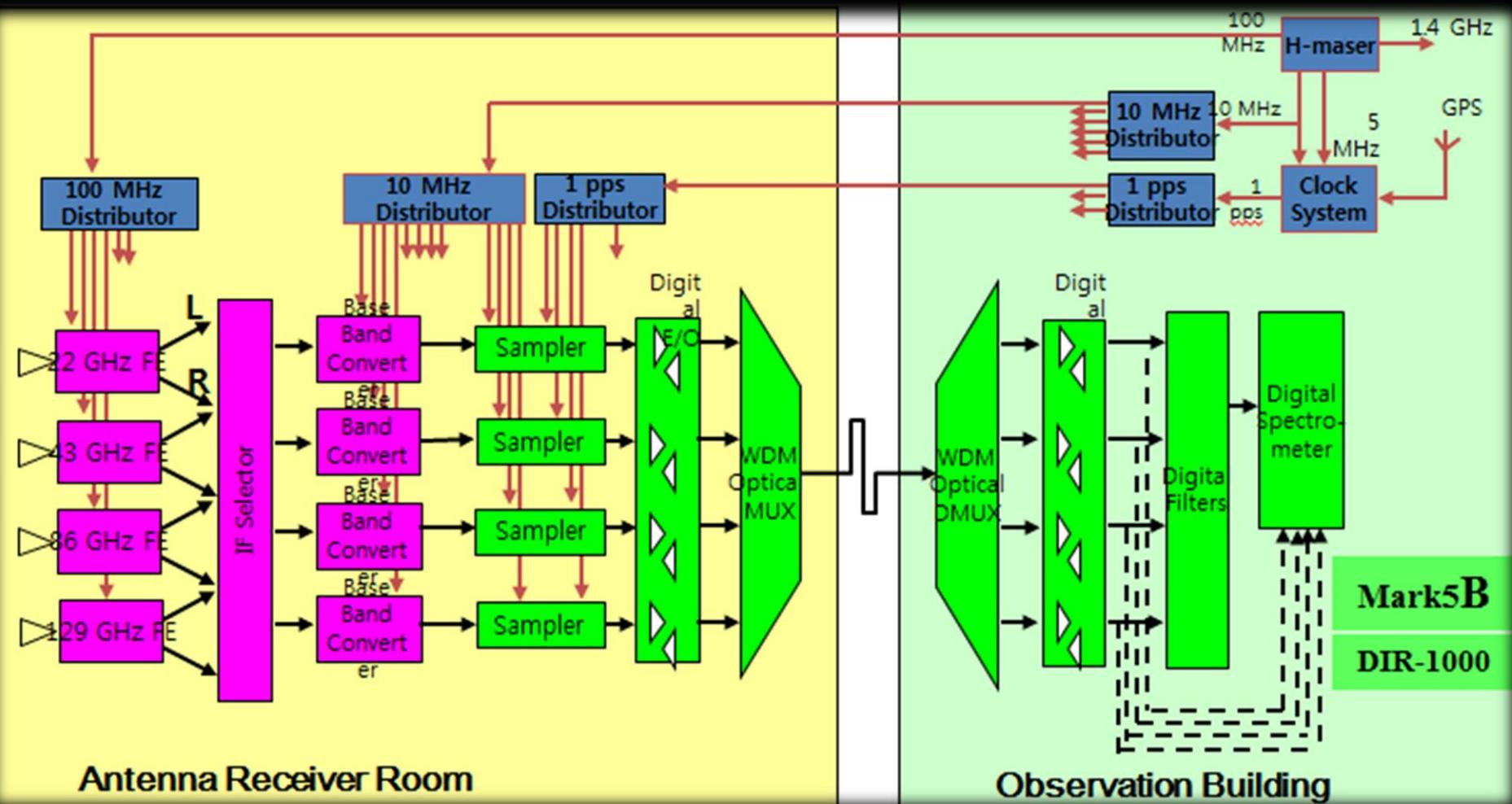
22/43 GHz offset < 3" (AZ/EL)  
43/86 GHz offset < 2"  
86/129 GHz offset < 1"

# Pointing Accuracy & Aperture Efficiencies

## Pointing Accuracy



# KVN DAS System



# Reference Signal Distribution



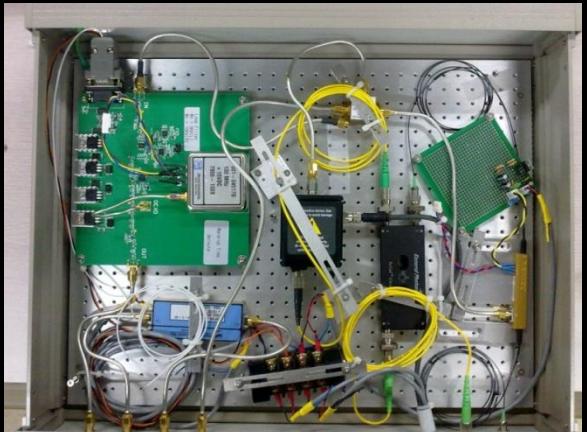
Frequency instability, $\sigma_y(2, \tau)$ :	
1 s	$\leq 2 \cdot 10^{-13}$ (in 2 Hz meas.)
10 s	$\leq 3 \cdot 10^{-14}$
$10^2$ s	$\leq 7 \cdot 10^{-15}$
$10^3$ s	$\leq 2.5 \cdot 10^{-15}$
1 h	$\leq 1 \cdot 10^{-15}$
1 day	$\leq 7 \cdot 10^{-16}$

Optical cable  
from H-maser to Vertex Room



**Reference signal distribution stability**  
 $\sim < 2 \times 10^{-16} @ 1000$  s

**RTS Antenna Module**  
: Photo Diode & Modulator



**RTS Control Room Module**  
: Photo Diode & Modulator



Circulator  
Photo Diode  
Mach-Zehnder  
Modulator

# Recording System

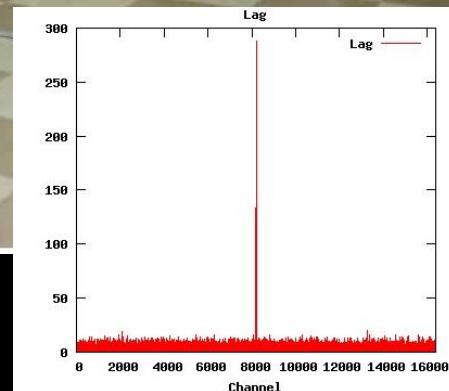
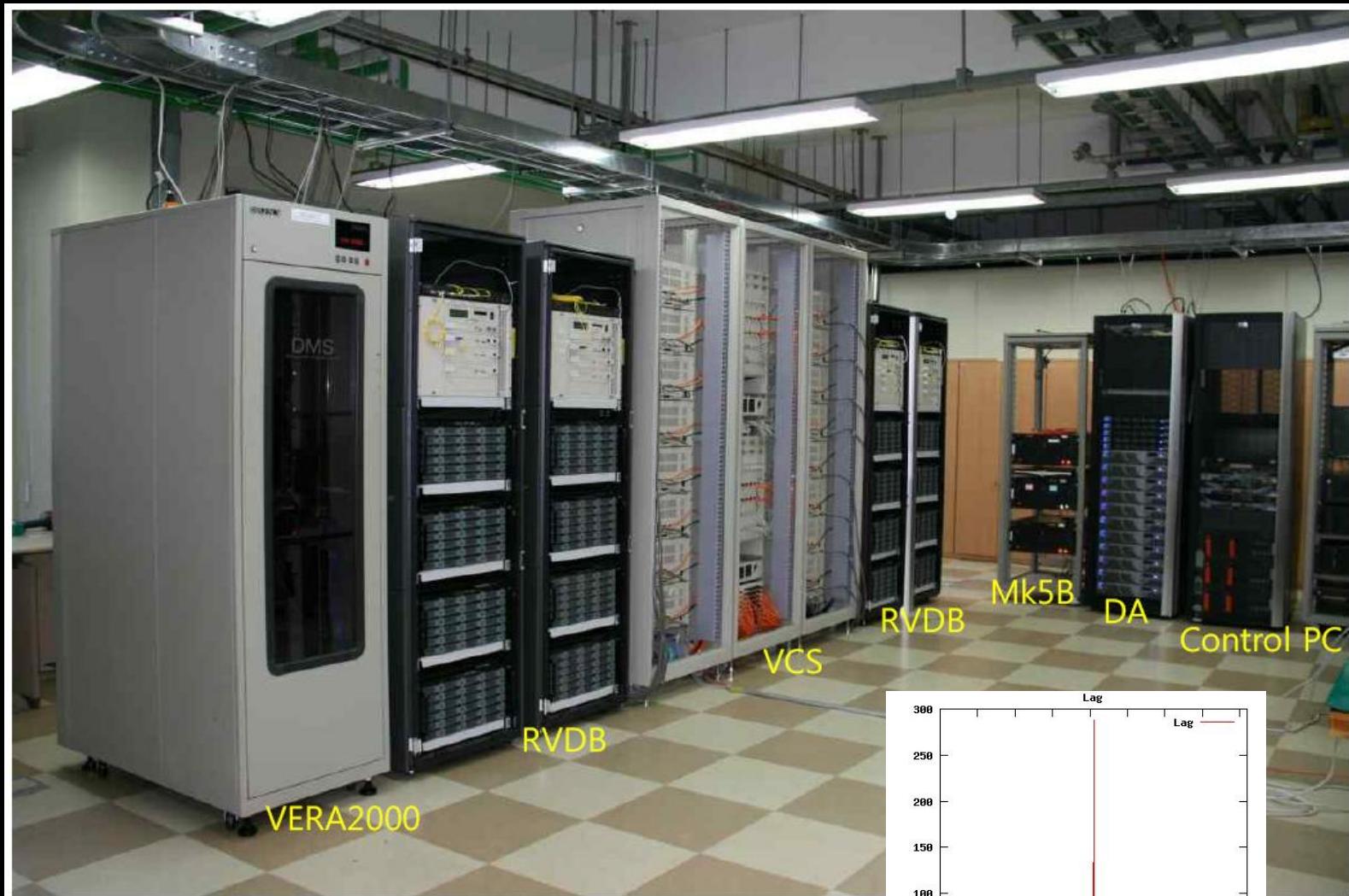


Mark5B Recorder (1 Gbps)



Sampler, Optical Fiber Transmitter,  
Digital Spectrometer

# KJCC (Korea Japan Cross Correlator)

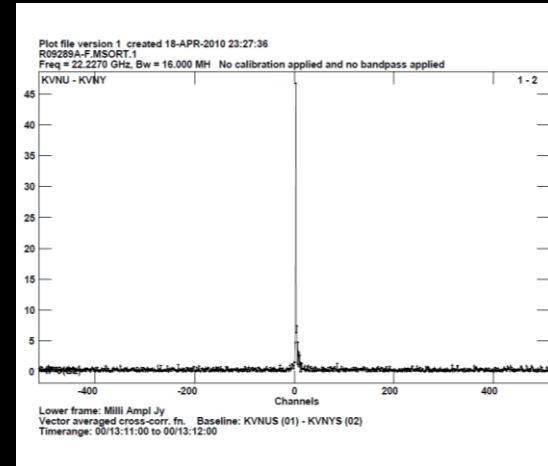


# DiFX Software Correlator



- 5 nodes linux cluster (5x8=40 cores)
- 100TB storage
- Mark5B / Mark5B+ / Mark5C
- 10G connections
- KREONET (Mark5B at each station)
- Quick Fringe Check
- Test e-VLBI

KVN-DiFX Correlator

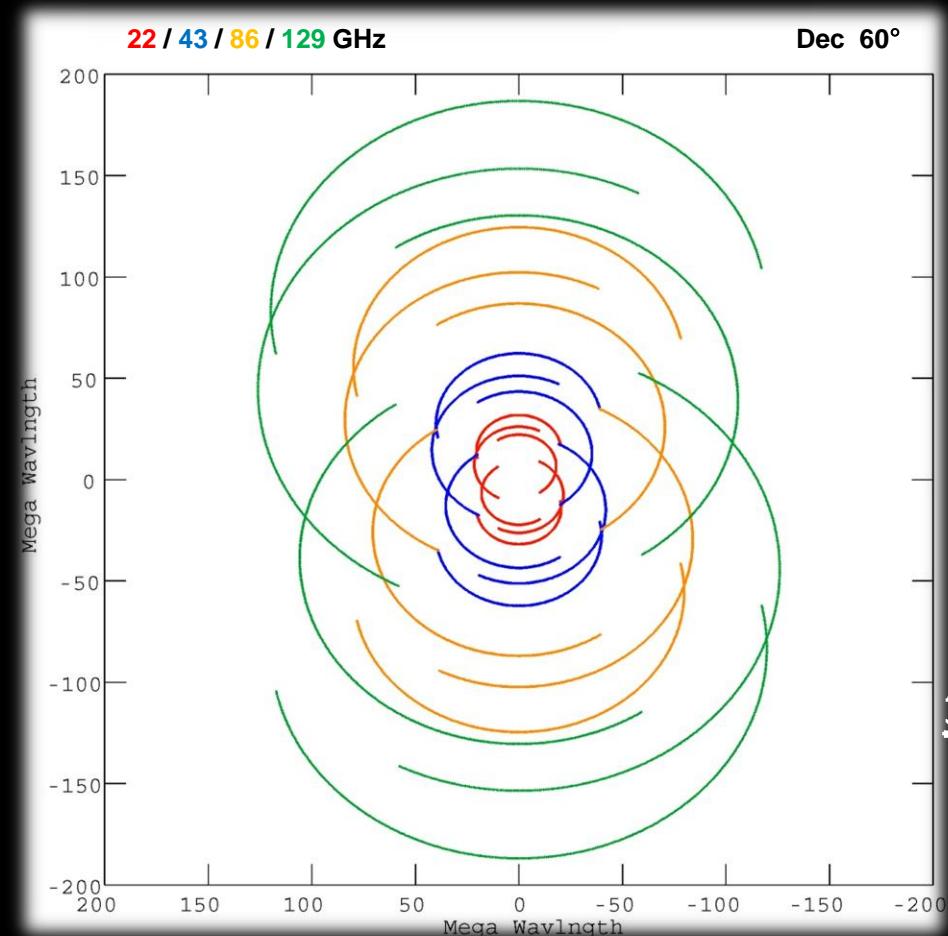


- Source NRAO150
- Scan 8 13:11:00 – 13:12:00 (UT)
- 1 min cross-correlation function plot

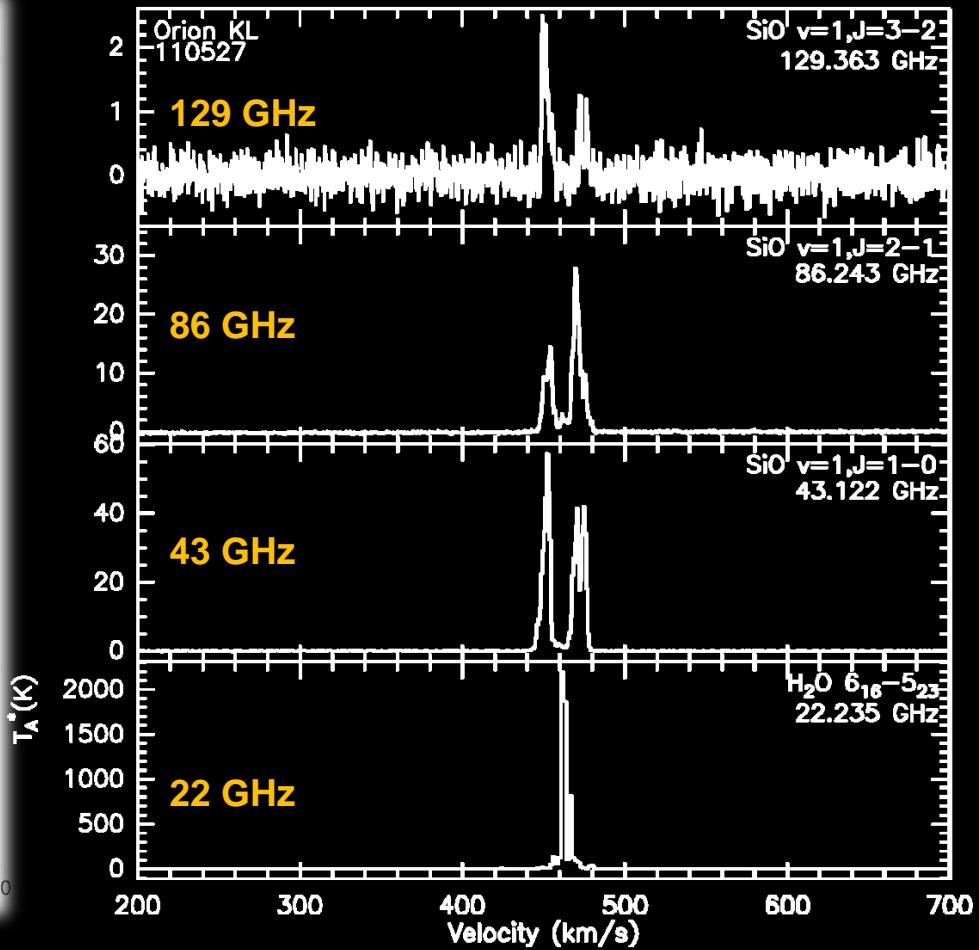
# KVN ACTIVITIES

Multi-Freq. Obs.  
E-VLBI  
GMVA  
EAVN

# First Light from 22/43/86/129 GHz Simultaneous Single Dish Observation

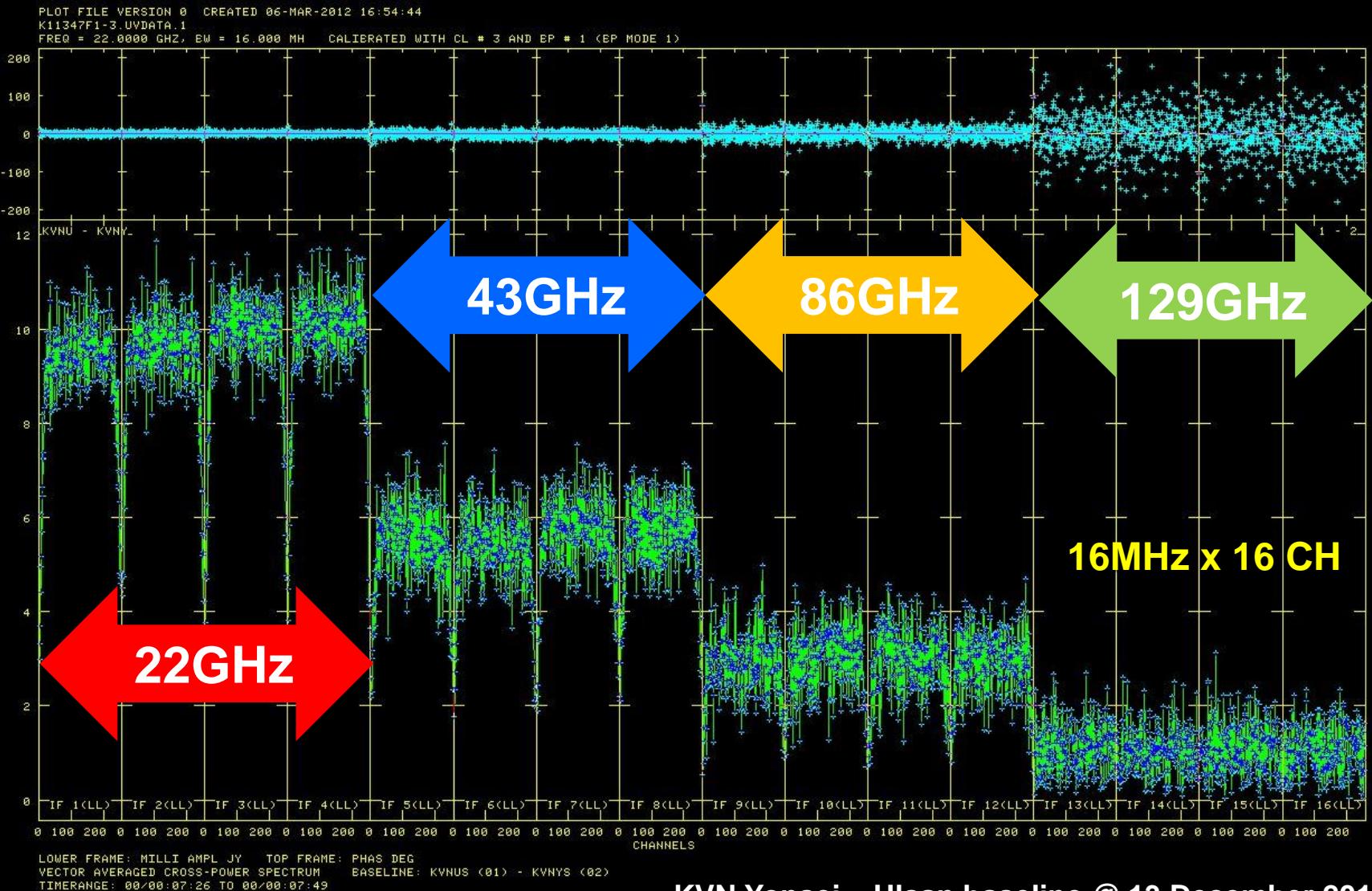


4Ch UV coverages



H<sub>2</sub>O/SiO Maser in Orion KL

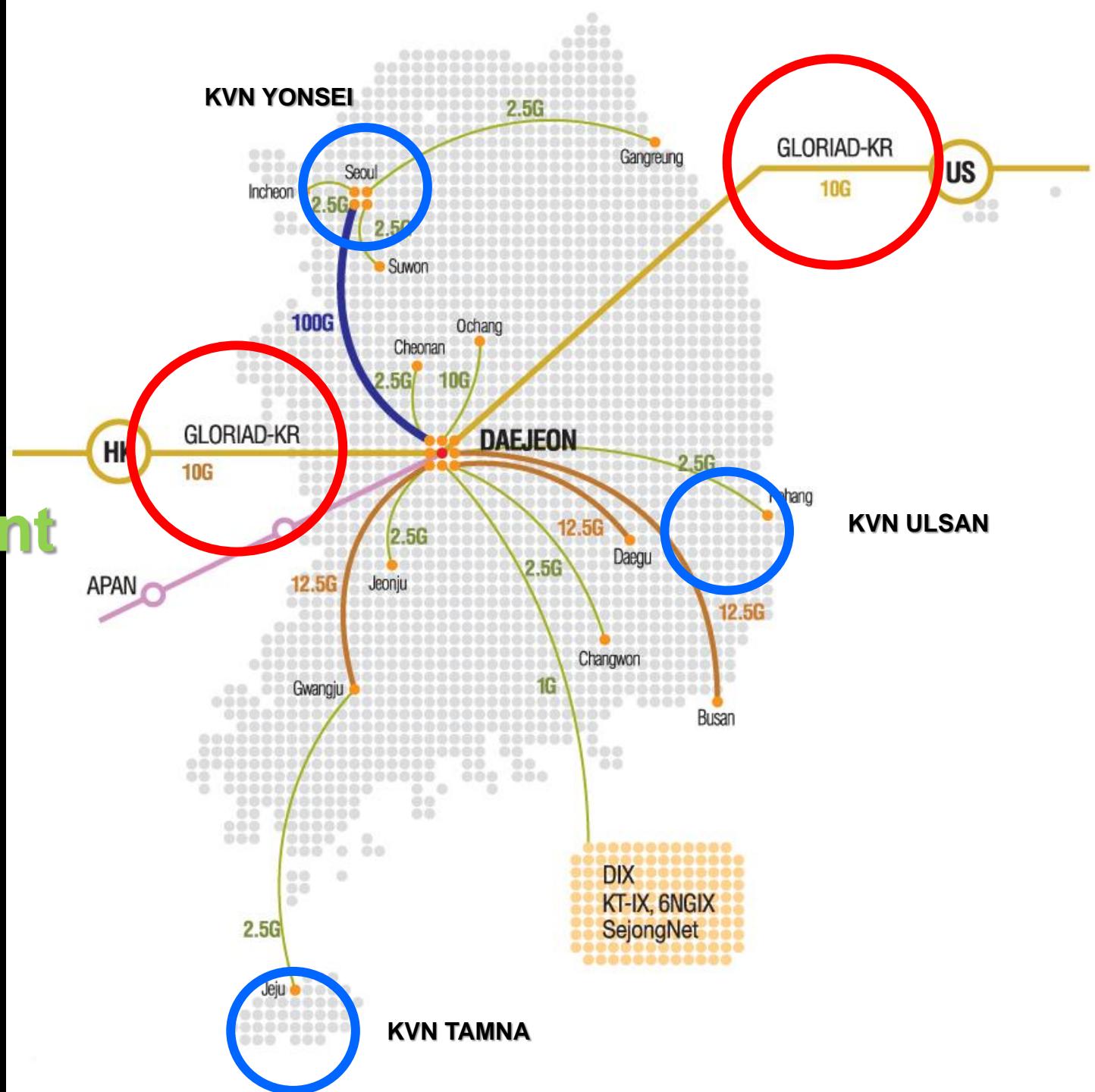
# First 4CH-Fringes from 22/43/86/129 GHz Simultaneous VLBI Observation



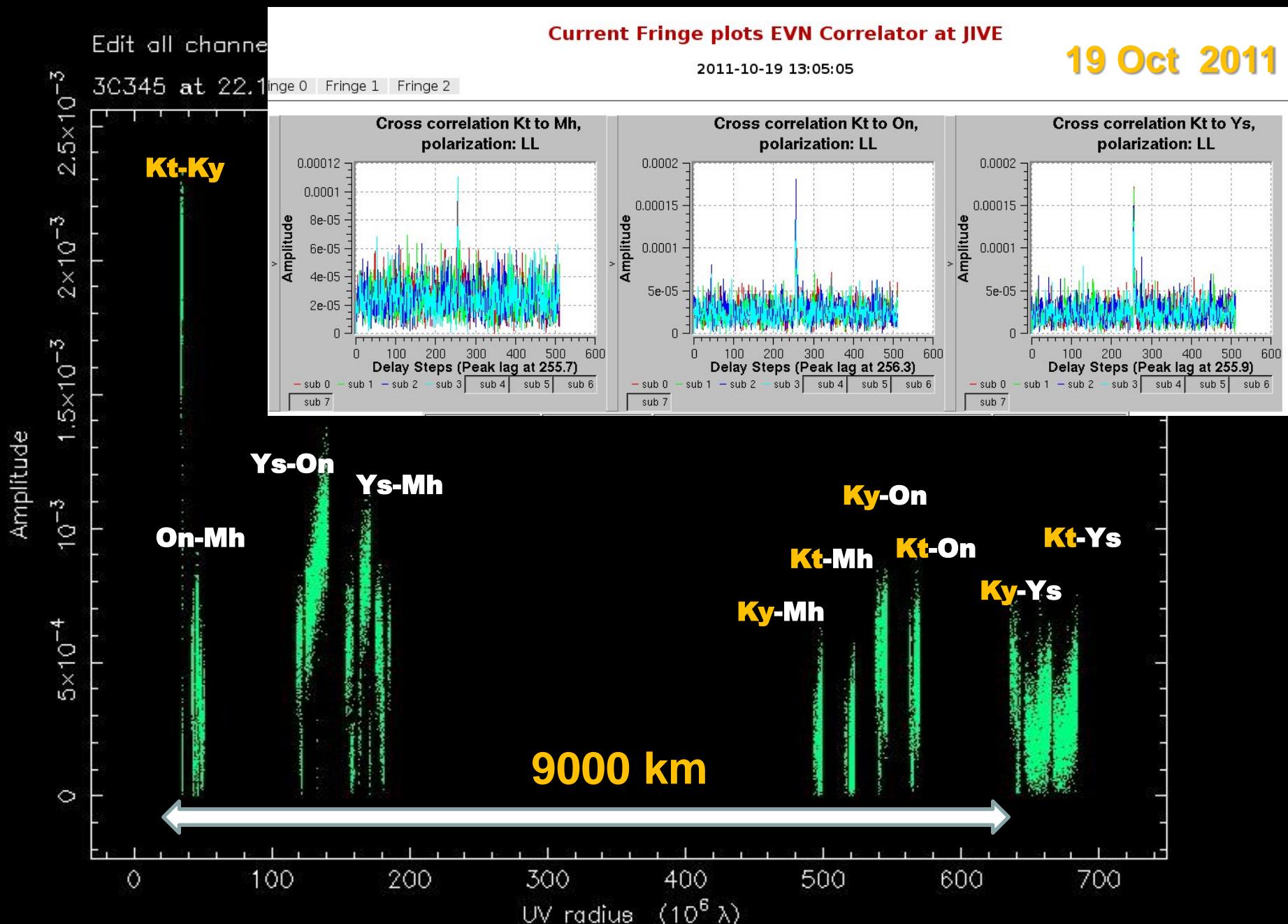
KVN Yonsei – Ulsan baseline @ 13 December 2011

# KREONET

Korea  
Research  
Environment  
Open  
NETwork



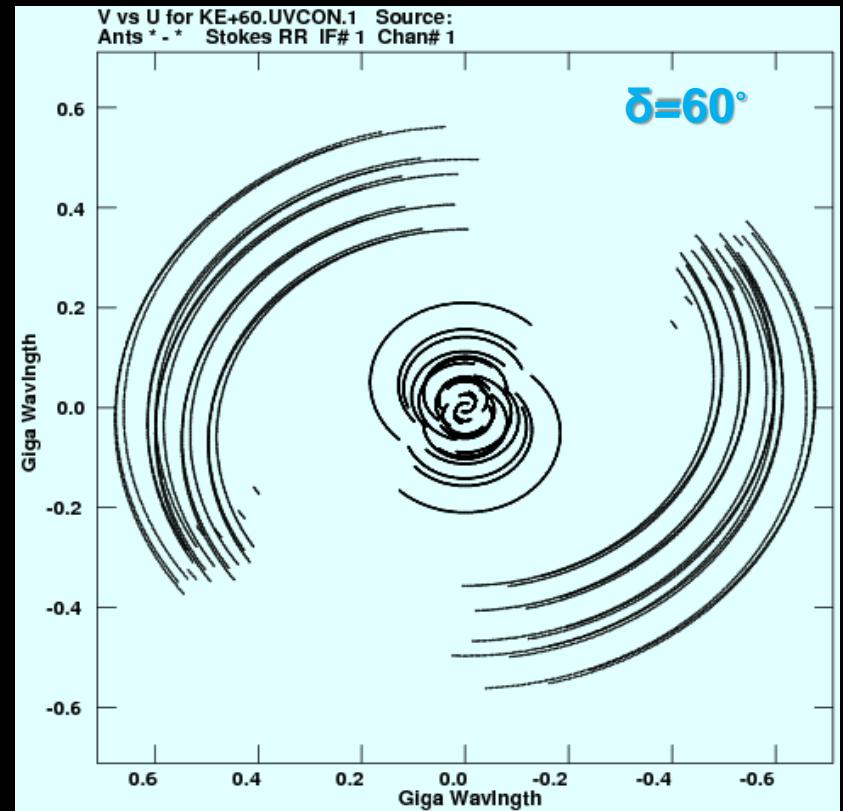
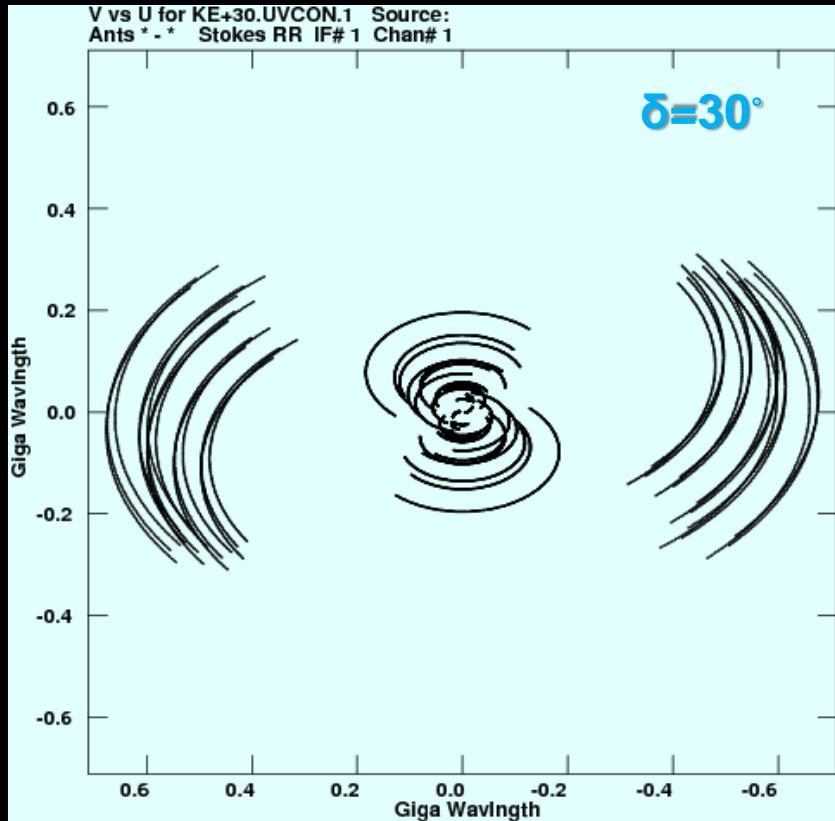
# First e-VLBI Fringes with the EVN



# UV Coverage btw EVN & KVN @ K band

KVN(Yonsei, Ulsan, Tamna)

EVN (Effelsburg, Onsala, Yebes, Medicina, Metsahovi)



UV coverage with the 0.6 GIGA wavelength extend!

## Korean connection makes an 8000-km telescope

Australian and Korean radio telescopes have been linked for the first time, forming a system that acts as a telescope 8000 km across.

15 March 2012



### LBA-KVN K-band e-VLBI Experiment (9 Mar 2012)

The radio telescope at Ulsan, Korea - used in the Australia-Korea linkup. Photo: Korean Astronomy and Space Science Institute.

Australian and Korean radio telescopes have been linked together for the first time, forming a system acting as a gigantic telescope more than 8000 kilometres across and with 100 times the resolving power of the Hubble Space Telescope.

"This is another step in Australia's ongoing collaboration with Asia in the field of radio astronomy," said CSIRO's Astronomy and Space Science Chief, Dr Philip Diamond.

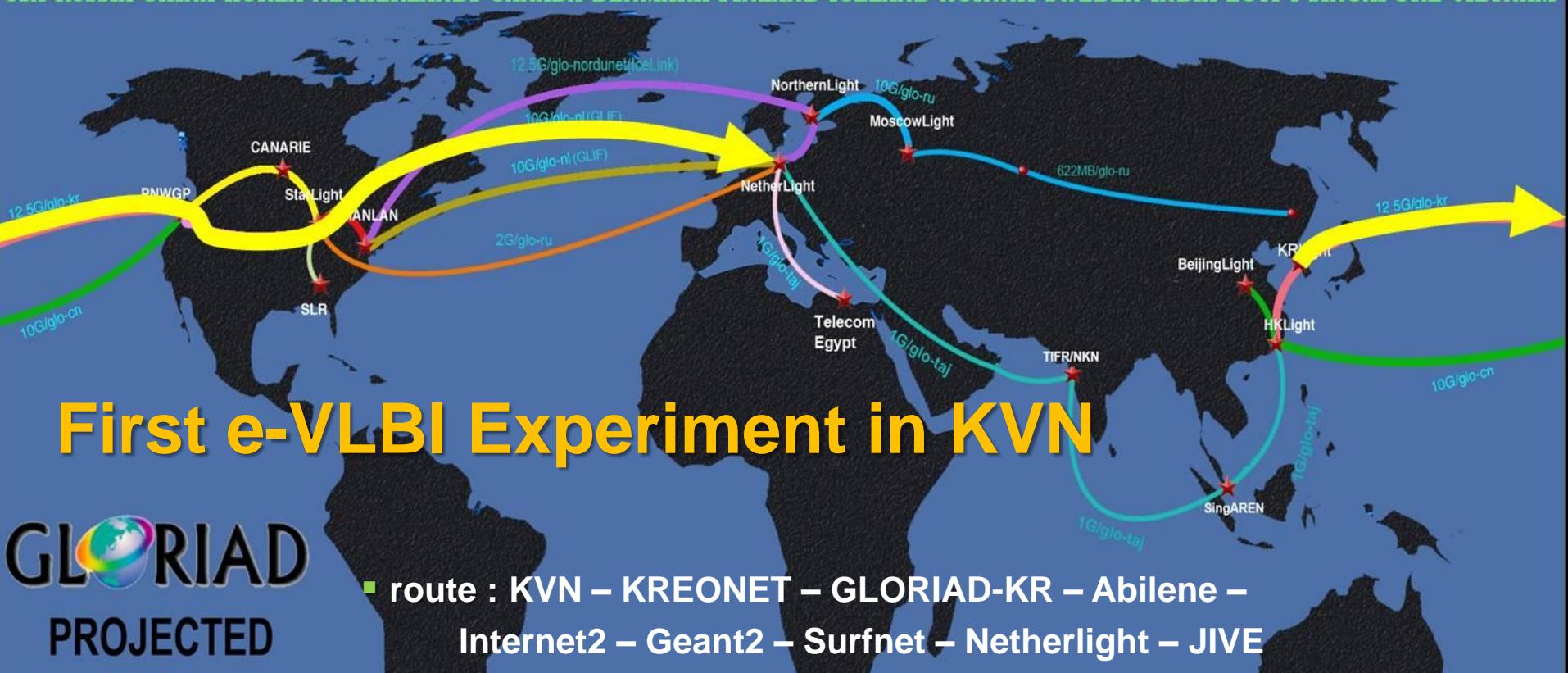
Australia has been making similar linkups with Japan and China for many years, and now is also doing initial tests with telescopes in India.

Combining signals from widely separated telescopes in this way is the technique that will underlie the coming international mega-scope, the Square Kilometre Array or SKA.

"Australia has many decades of experience with these long-distance linkups," said Dr Diamond, who sits on the Australia-New Zealand SKA Coordination Committee.

**“This is another step in Australia's ongoing collaboration with Asia in the field of radio astronomy”**

Dr Philip Diamond



- e-VLBI Experiment was planned between JIVE & ATNF
- First trial has been made with the JIVE (EVN stations)
- 22 Sep 2011 Formatter Test with the JIVE
- 19 Oct 2011 First e-VLBI Experiment with the JIVE & EVN stations
- LBA-KVN K-band e-VLBI Experiment
- 9 Mar 2012 First e-VLBI Experiment with the CSIRO, LBA stations

# GMVA : Test participation @ 86GHz

Date	UT	Source	Partner
2012 May 18	13–21	0176+714	All GMVA
May 18	22–24	3C84	VLBA only
May 19	11–14	OJ287/3C345	All Europe
May 19	16–17	3C273/3C279	Europe (excl. EB)
May 20	17–19	3C454.3	VLBA only
May 22	16–18	BLLAC	VLBA only

# Scientific Activities

- **AGN**

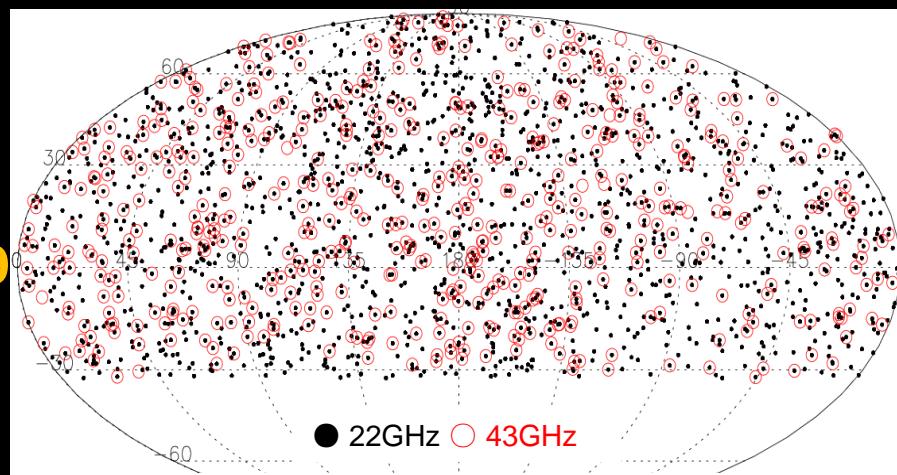
- **Surveys**
  - K/Q band fringe detection survey
  - KVN calibrator survey
  - (High frequency) weak AGN survey
- **Polarization monitoring of bright AGNs**
- **IDV monitoring**
- **Astrometry**

KVN Calibrator Survey (J. A. Lee et al)

- **Star Formation & Evolved Stars**

- **Maser Surveys (22/43/44/86/129 (H<sub>2</sub>O, SiO, CH<sub>3</sub>OH))**
- **Astrometry**

- **K-band Geodesy**



Frequency	flux $\geq 1\text{Jy}$	1Jy>flux $\geq 500\text{mJy}$	500mJy > flux	Total #
K band	216	393	1192	1801
Q band	158	180	217	555

VSOP2

# East Asian VLBI Network

## Korea-Japan Joint VLBI Network

CVN

KVN

VERA/JVN

# KVN+VERA Activities

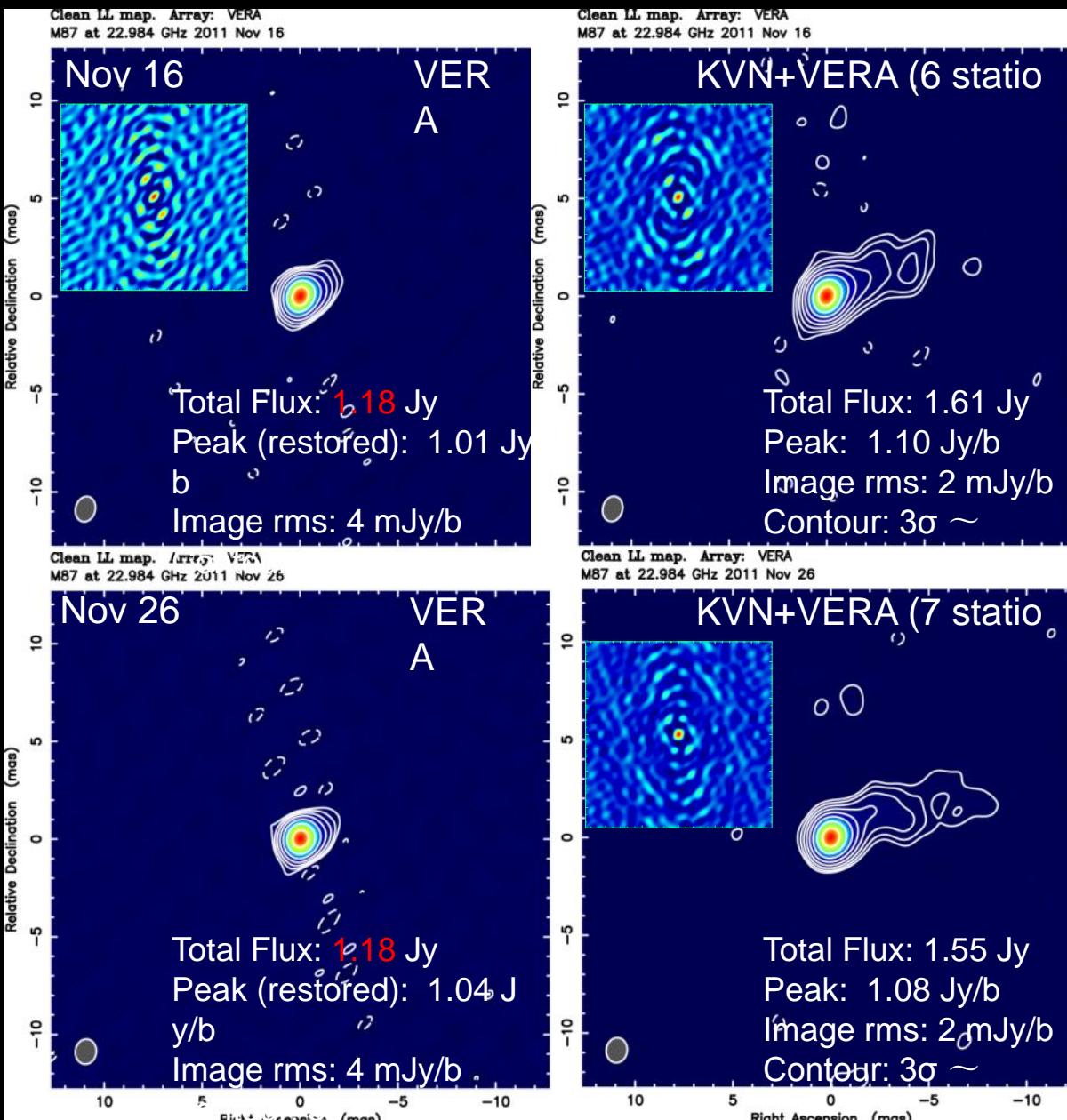
- **KVN+VERA Network**

- Complementary cooperation
- Korea-Japan Joint VLBI Correlator (KJJVC)
- Share the half of total observation time  
(2,500Hr/yr)

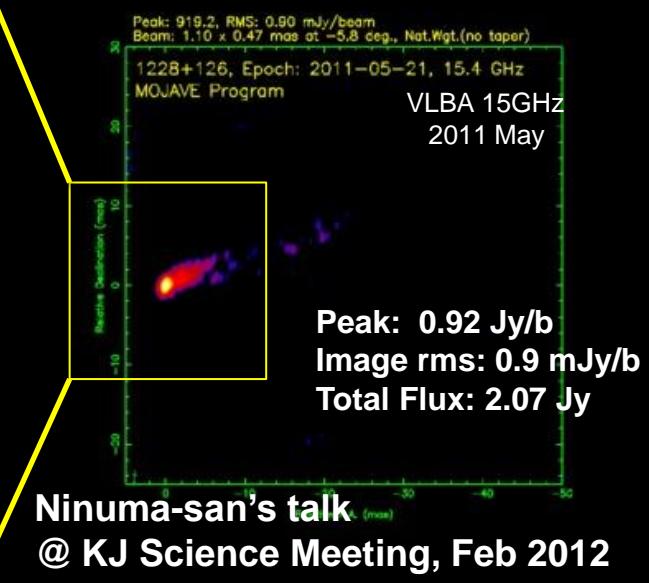
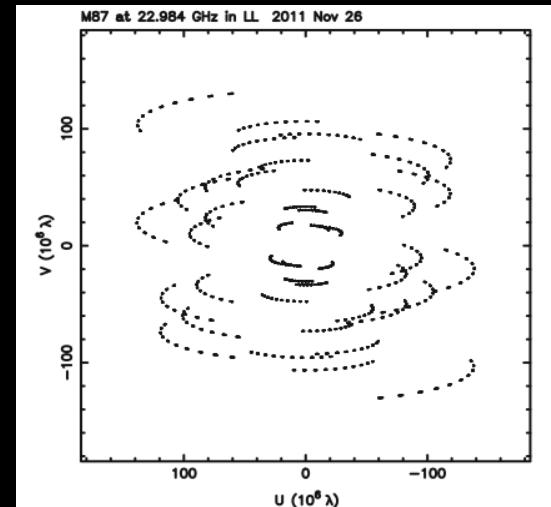
- **Scientific Working Groups**

- Active Galactic Nuclei (Galactic center)
- Star Formation
- Evolved Stars
- Astrometry

# KVN+VERA Scientific Test Observation (M87)



KVN+VERA can produce an extended structure very well



# Near Future Upgrades

- Installation of a 6.7 GHz receiver ( up to 8.6 GHz)  
@ KVN Ulsan (~ Dec. 2012)
- 2Gbps observations with Mark5B+
- P-cal system ( 22/43 ~ 2012, 86/129 ~ 2013)

# Thank you for your attention



## 서울~울산~제주 삼각관측 우주와의 '소통' 한걸음 더

12일 새벽 제주도 서귀포 하늘에서 북극성을 중심으로 궤적을 그리며 흘고 있는 별들을 앞에 지름 21m 크기의 점시 안테나가 우뚝 솟아 있다. 서울 연세대·울산 울산대·제주 덤비대를 3곳으로 연결하는 한국우주전파관측망(KVN) 사업의 마무리 단계로 서귀포 덤비대 달라전파전환대와 전파망원경이 지난 1월 성능식을 마치고 시험 기동에 들어갔다. 전파망원경 척대가 연결되면 서울에서 제주 한라산의 광활한 풍도 석별할 수 있는 청암도를 갖게 된다. 한국우주전파관측망은 가능한 우리도 우주의 물액들을 정밀 계측해 별의 탄생과 사멸을 연구할 수 있고, 한번도 지각변동도 정밀 모니터링할 수 있게 된다. 이 사진은 디지털카메라에 14mm 렌즈를 부착해 1시간 동안 셔터를 열어 촬었다.

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