Current status of Korean VLBI Network and future plan for e-VLBI

Sohn, Bong Won
(KVN/KASI)

KVN in Madrid

Recent Progress in Korean VLBI Network (KVN) Project

B. W. Sohn (KVN/KASI)

KVN at Torun 2006

Outline

- KVN project and current status
- Test observations
- e-VLBI

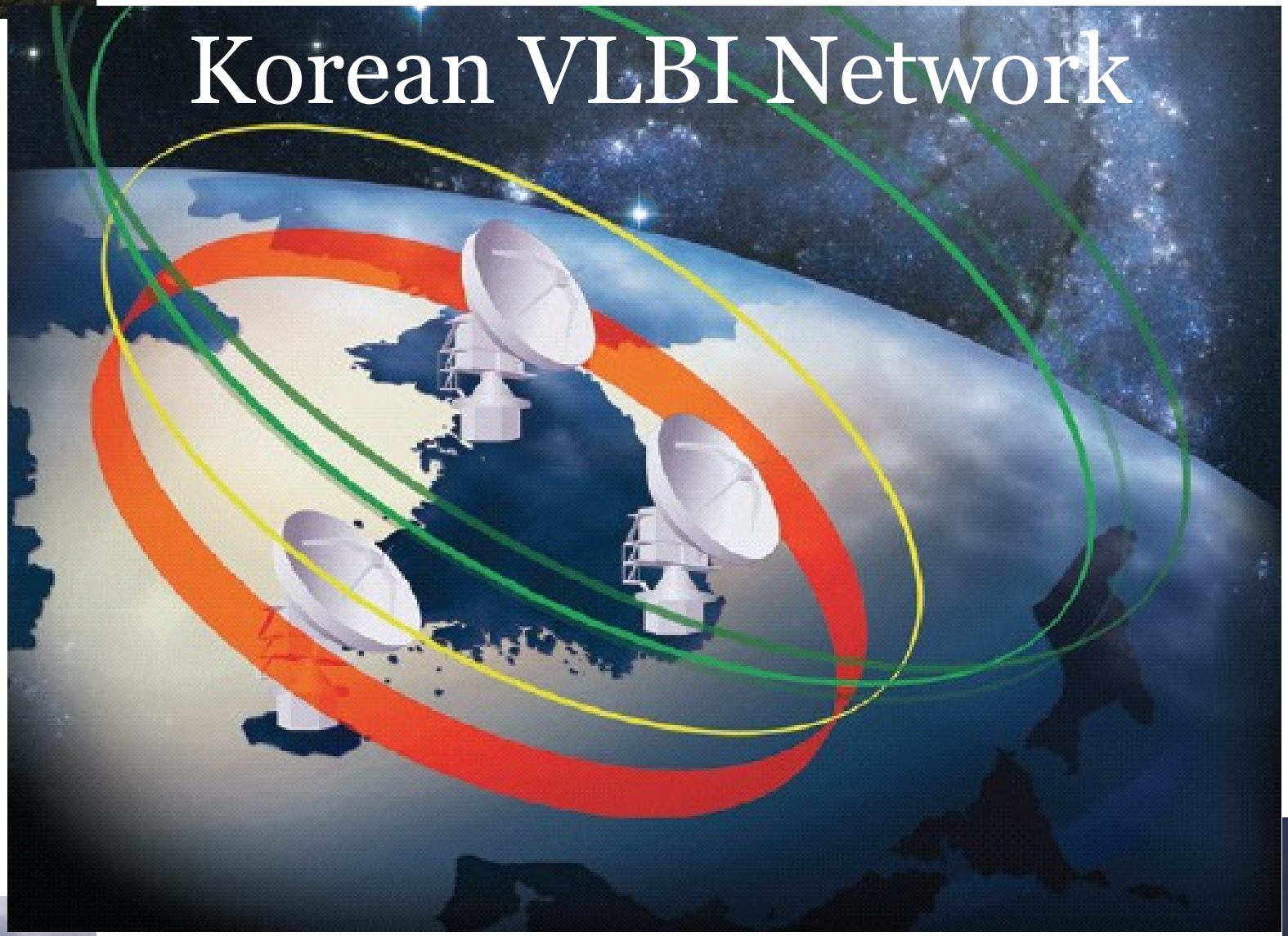
*This talk is mainly a summary of KVN-related talks on East-Asian VLBI workshop(EAVW) held in Seoul on 19-21 March, 2009.


2009 East Asia VLBI Workshop
KVN
18-20 March 2009, LG Convention Hall, Ewha Womans University, Seoul, Korea
Hosted by the Korea Astronomy & Space Science Institute, Sponsored by the Institute for the Early Universe

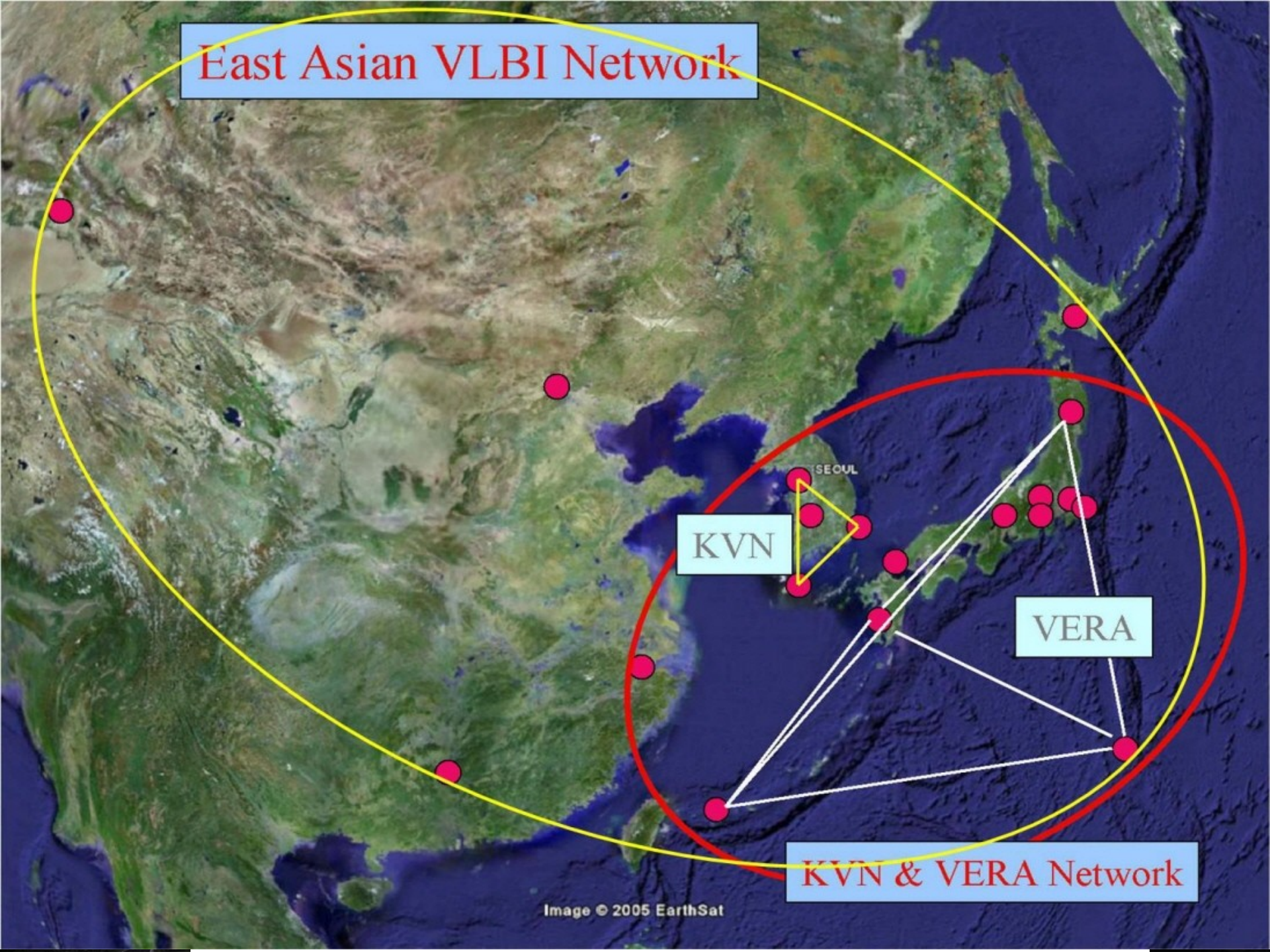
Korean VLBI Network

- Dedicated mm-VLBI facility
  - 3 x 21m telescopes (Seoul, Ulsan, and Jeju)
  - Shaped Cassegrain type
  - Surface accuracy: RMS < 150μm
  - Fast slewing: 3°/sec, 3°/sec²
- *Simultaneous* multi-frequency observation from 22GHz up to 129GHz
  - Multi-frequency Phase referencing
  - Simultaneous or fast position switching observation
- Construction: 2001-2008
  - 2/8 GHz receivers (TBD)
  - 22 and 43 GHz receivers in 1st stage (2008/2009)
  - 86 and 129 GHz receivers in 2nd stage (2011)

Korean VLBI Network



KVN in Madrid


East Asian VLBI Network
SEOUL
KVN
VERA
KVN & VERA Network
Image © 2005 EarthSat

e-VLBI consideration

- Sites
  - Located in University campus
  - Easy to be connected to KREONET (national research network of KISTI)
- Data Acquisition System
  - VSI- specification
- Correlator (KJJVC)
  - Optical fiber input
  - Raw Data Buffer System

Antenna Construction

- Construction plan

Ulsan Station

- *December* 2006

Yonsei Station

- April 2007

Tamna Station

- October 2007

S.Y. Choi et al.

KVN Ulsan Observatory

KV ory

KVN inMadrid

KVN Yonsei Observatory

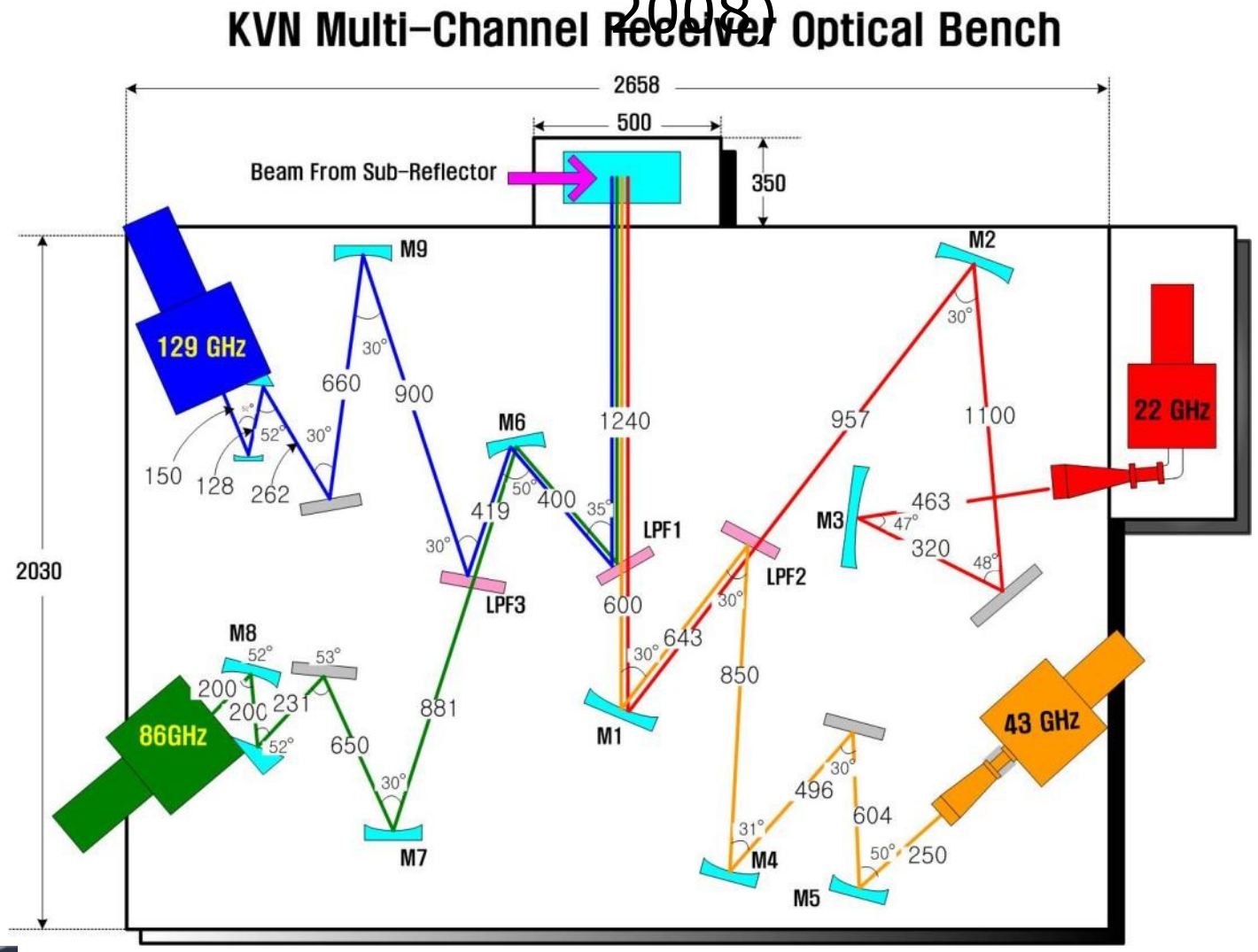
KVN Tamna Observatory

KVN in Madrid

KVN Tamna Observatory

KVN in Madrid

Quasi-optical circuit for Multi-band receivers (Han et al. 2008)

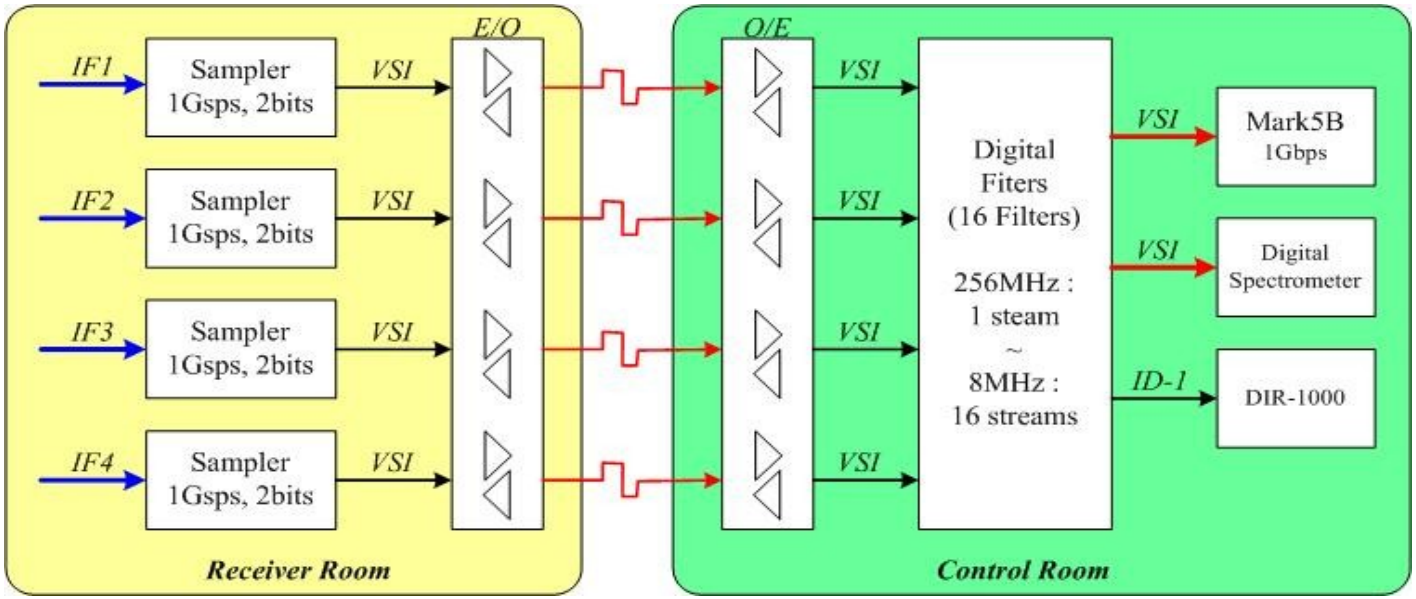


Quasi-optical circuit installed in receiver room of KVN Yonsei

Han et al. at EAWV09

Receiver and DAS System

Freq. Band	S band	X band	K Band	Q Band
Freq. Range			21.5 ~23.5 GHz	42 ~ 44 GHz
Rx Noise			~ 50 K	~ 100 K
1st IF / BW			8.5G/2GHz	8.5G/2GHz
IF Power			-20 dBm	-20 dBm
Polarization			LCP/RCP	LCP/RCP



*** 86, 129 GHz Receivers will be installed in 2011.**

Korea-Japan Collaboration for new correlator and data center development

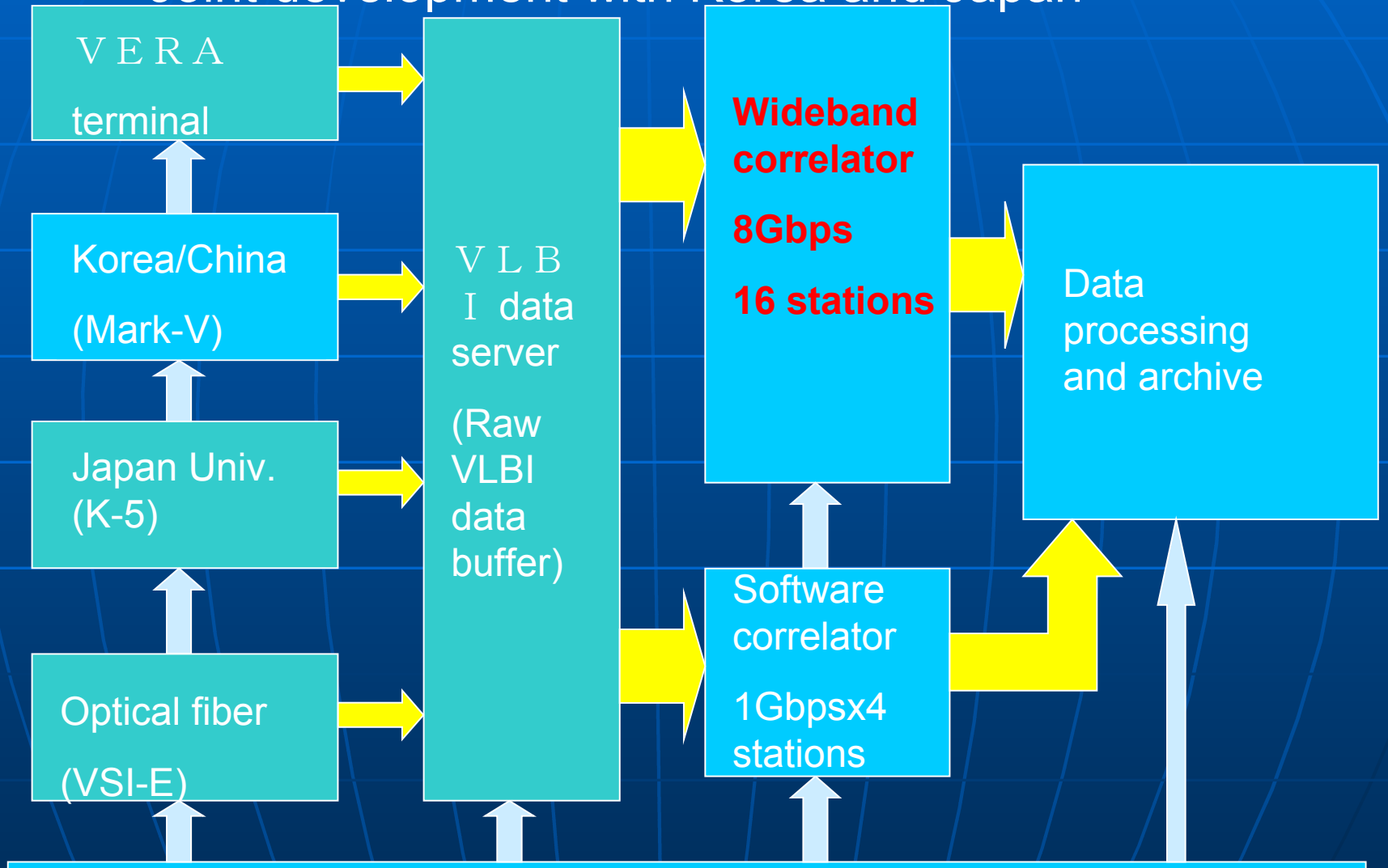
- 2005-2009
  - KASI and NAOJ signed MOU for development
- Correlator at Seoul
- 8Gbps x 16 stations
- Usage
  - KVN
  - East Asia VLBI network
  - VSOP-2

Summary of Specifications

# of Antennas	16
# of Inputs / Antenna	4 bands (4Fx1P, 2Fx2P,1Fx2P+2Fx1P)
Max. # of Correlations / Input	120 Cross + 16 Auto
Subarray	2 case (12 + 4, 8 + 8)
Bandwidth for each Input	512 MHz
Digitization for each Input	1 Gsps by 2bits/sample
Clock for Input data	128 MHz
Max. Delay compensation	32,000 km → 36,000 km(?)
Max. Fringe Tracking	860 kHz
FFT points	1,048,576, w.r.t. multi-channel stream
Word length in FFT	16+16 bits fixed point for real & imag. Re-quantization to 4+4 bits fixed point
Minimum Integration Time	~ 25 msec
Data compression (Flexible Binning)	8,192 channels

New Correlator at Seoul

-Joint development with Korea and Japan –



100GHz pointing test

Results: Pointing Accuracy

K. T. Kim et al. (09EAVW)

- Ulsan Ant.: 27 data sets, 93%
  - R-Cas (6), Orion-KL (6), X-Cyg (7), R-Leo (8)
  - 25 sets have <4″ RMS, 2 sets still have (4″-5″) RMS
- Yonsei Ant.: 34 data sets, 94%
  - R-Cas (8), Orion-KL (8), X-Cyg (8), R-Leo (10)
  - 32 sets have <4″ RMS, 2 sets still have (4″-5″) RMS
- Tamna Ant. I: 26 data sets, 2008 Sep, 31%
  - IK-Tau (11), Orion-KL (4), TX-Cam (5), R-Leo (6)
  - 8 sets have <4″ RMS, 10 sets still have (4″-5″) RMS

Results: Pointing Accuracy

- Tamna Ant. II: 27 data sets, 2008 Dec, 67%
  R-Cas (9), Orion-KL (9), R-Leo (9)
  18 sets have <4″ RMS, 5 sets still have (4″-5″) RMS

After excluding 2 outliers in each for the 9 sets,

24 sets have <4″ RMS, 2 sets still have (4″-5″) RMS

89%

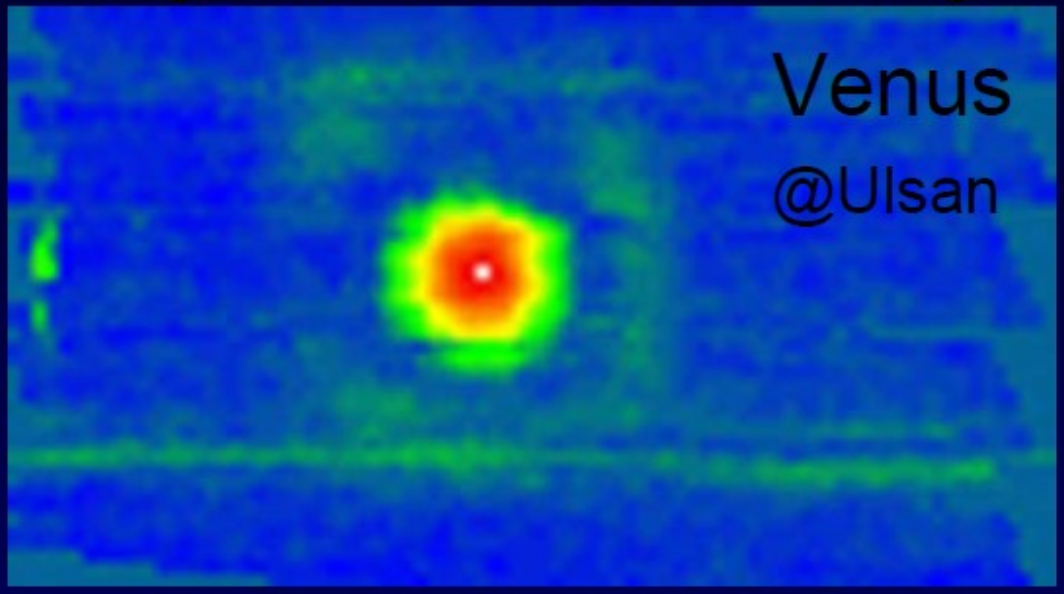
K. T. Kim et al. at EAVW 09

…				
17194	314.87	57.04	1.06	−2.90
17199	314.72	56.78	−4.18	−3.62
17204	314.57	56.52	−9.71	−10.89
17209	314.42	56.26	0.00	3.57
17214	314.28	55.99	−0.57	−7.97
17219	314.14	55.73	5.29	−4.40
17224	314.01	55.47	1.55	−4.63
17229	313.88	55.20	0.36	−1.96

R-Cas
Data Set #3
4.7″ -> 3.9″

Results: Aperture Efficiency

K. T. Kim et al.



- Estimated Aperture Eff.:
  - ~43% @ Ulsan/Yonsei: wrong panel alignment?
  - 51% @ Tamna: new procedure of panel align.
  - After applying New procedure to Yonsei/Ulsan similar efficiency @ Yonsei
- Estimated beamsize: ~30″ for All, ~ diffraction limit
  - nearly uniform illumination of the main reflector

Summary

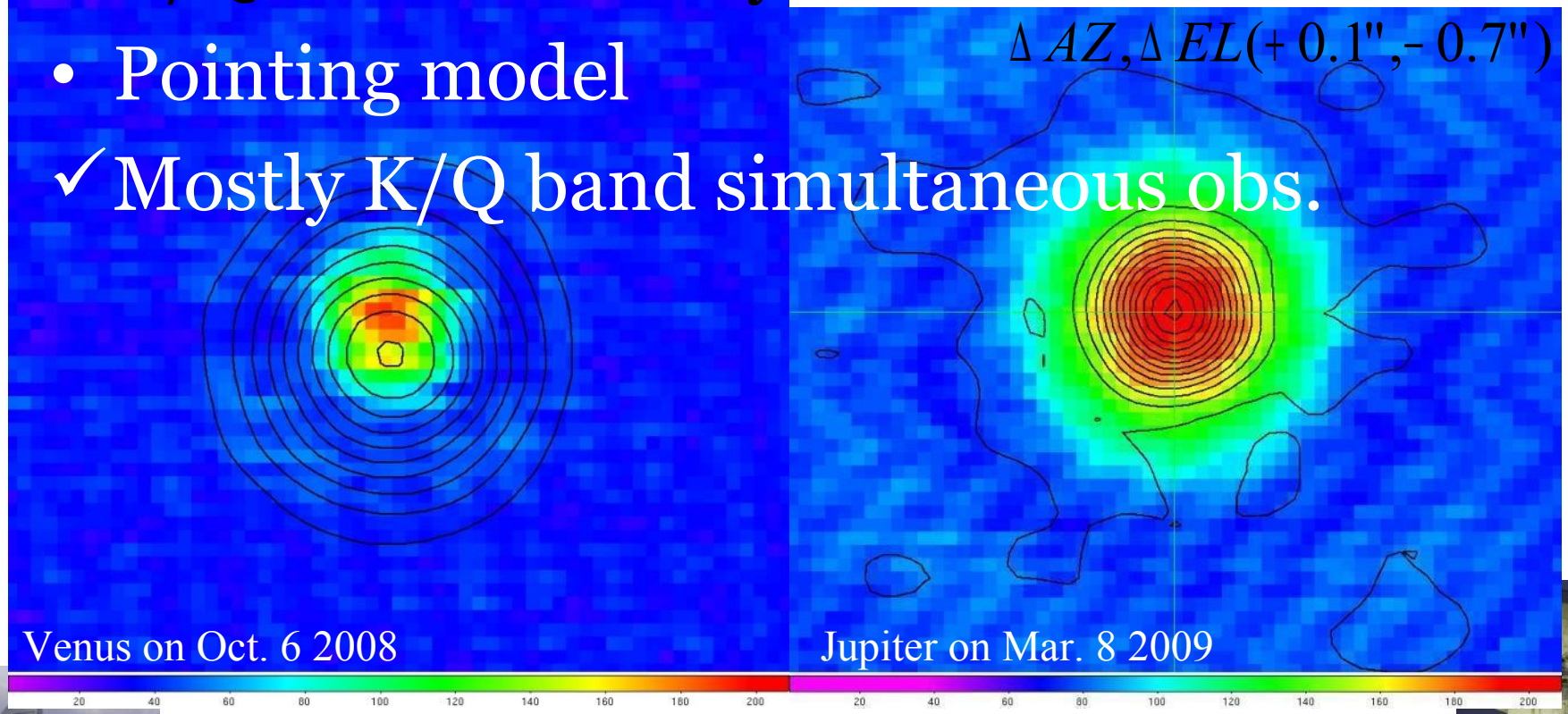
K. T. Kim et al. at EAVW 09

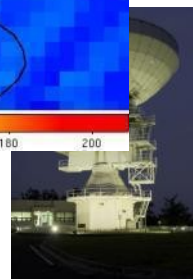
- All KVN Ants have
  pointing accuracy of ~4″ RMS for the entire Sky
  cf) short-timescale pointing instability @Tamna
- They have beam sizes of ~30″.
- After new panel alignment procedure applied, Tamna/Yonsei Ants have aperture efficiency of 51% and Ulsan Ant is also expected to have 51%.
- Tamna Ant has pointing instability on <1 min scales by atmospheric Anomalous Refraction until early Nov

K/Q band test

S.S. Lee et al. EAVW09

- Beam offset
- K/Q band efficiency
- Pointing model
- ✓Mostly K/Q band simultaneous obs.





KVN Aperture efficiencies

Frequencies	Planets	Aperture eff. (%)	EL (°)		HPBW (“)	T_B (K)
22GHz	Jupiter	64	30	LPF2	140	134+-4*
	Venus	68	30	LPF2	140	505+-25**
43GHz	Jupiter	64.4	30	LPF2	70	150***
	Venus	68.8	32	LPF2	70	450+-32***

S.S. Lee et al. EAVW09

** : Page et al. 2003 ApJS 148, 39*

*** : Butler et al. 2001 Icarus 154, 226*

**** : Greve et al. 1994 A&A 286, 654*

Sub-reflector was optimized in position.

Aperture efficiencies are values of single measurements.

VLBI tests so far

1st fringe test at K-band on 1st/3rd of Nov., 2008

- Maser: W49N, Ori-KL, Continuum: J2148+0657, NRAO150
- Maser(LCP)-Maser(RCP)-AGN(RCP)-AGN(LCP); VERA LCP (10 min per scan)
- fringes detected from all observed sources; K band

2nd fringe test at K/Q band on 12/13th of March, 2009

- After re-installation of 22 and 43 GHz receivers
- fringes detected from all observed sources; K/Q bands

Image sensitivity experiment on 18th April, 2009

- good UV-coverages, 1 hour of observation time per source
- NRAO150, 4C39.35, J0646+4451, 3C236

Image sensitivity experiment on 20/22th May, 2009

- good UV-coverages, 1 hour of observation time per source
- NRAO150, J0646+4451, 3C236, KV2327+1524, J1502+106
- Sheshan participated, East-Asain fringe detected!

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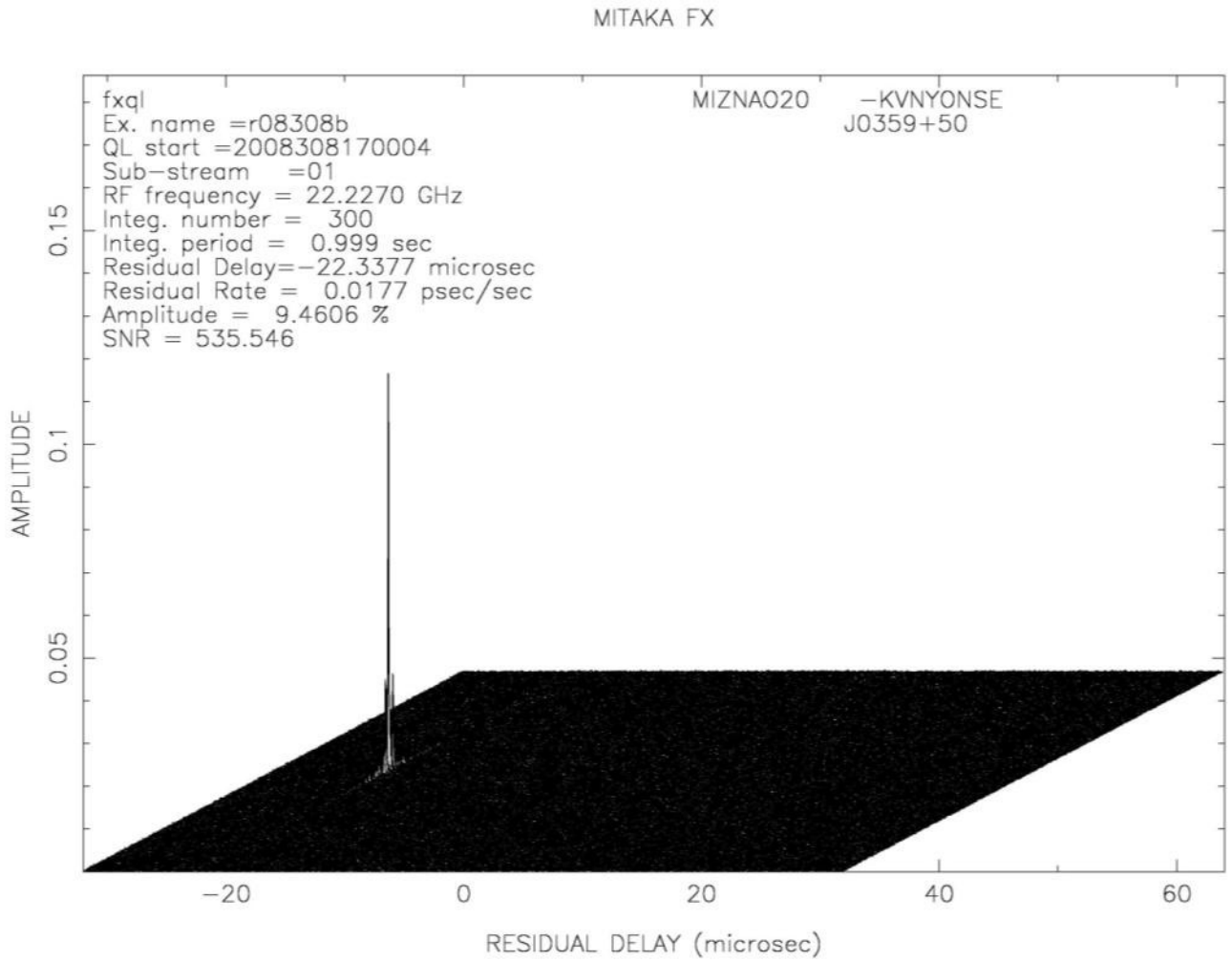
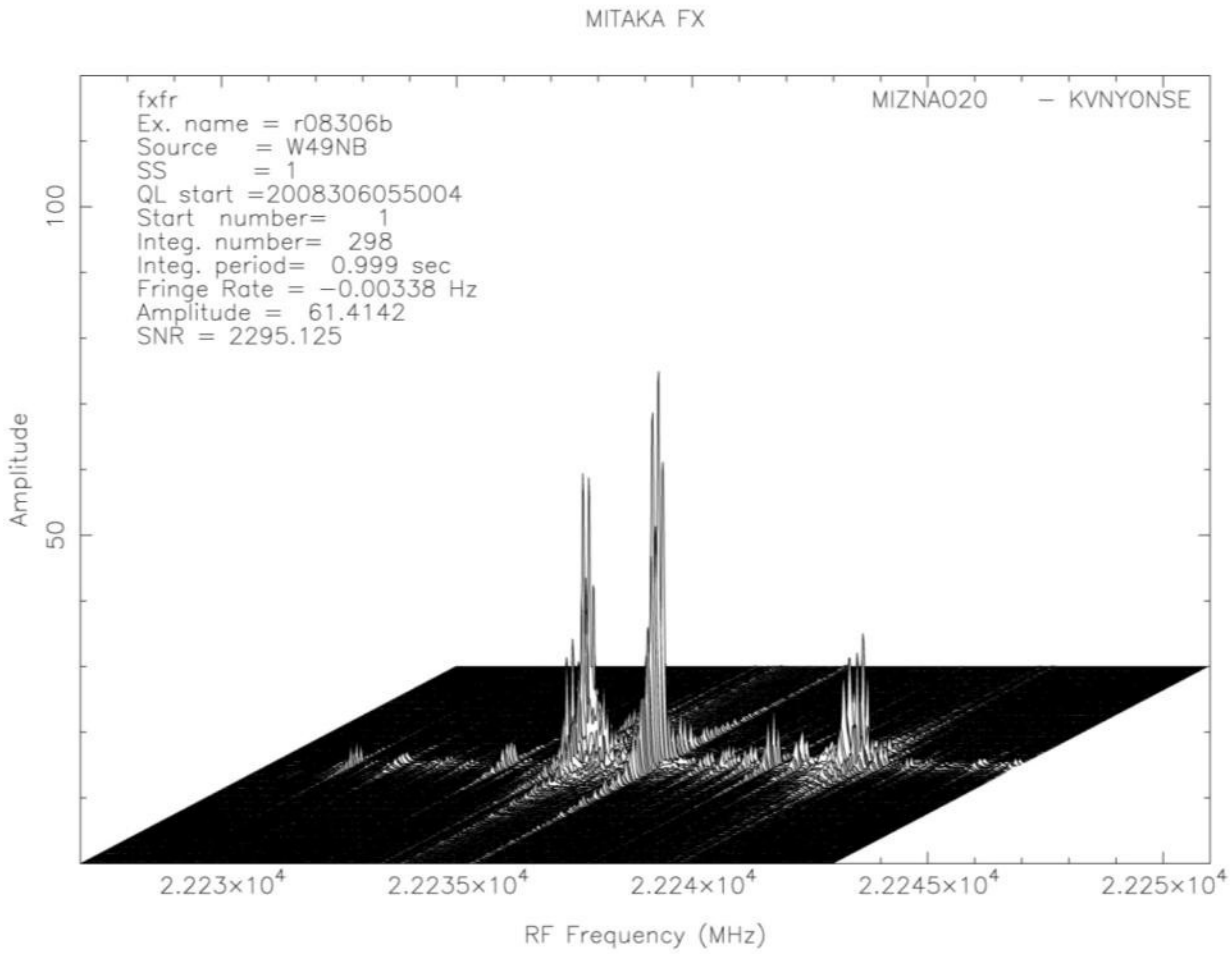
Correlated data just arrived!

People convinced for e-VLBI!



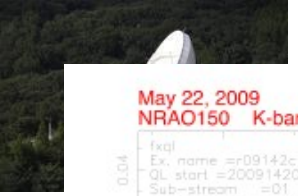
NRAO150 3rd November 2008

KVN in Madrid



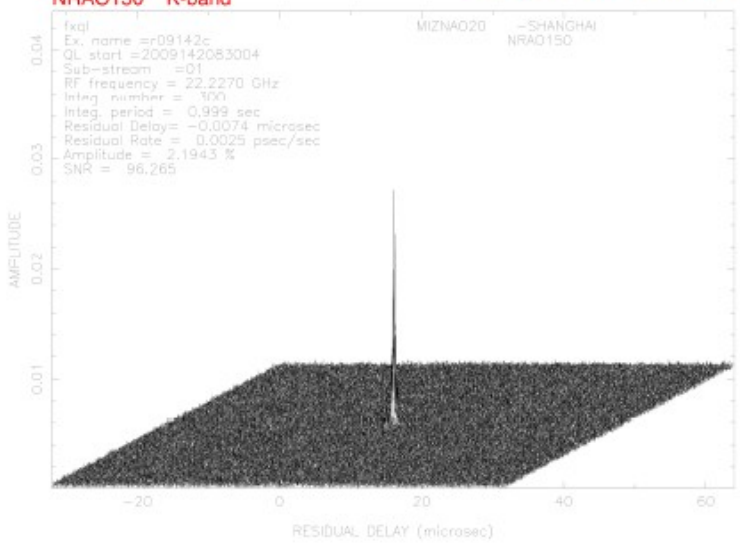
W49N water maser (1st November 2008)

KVN in Madrid



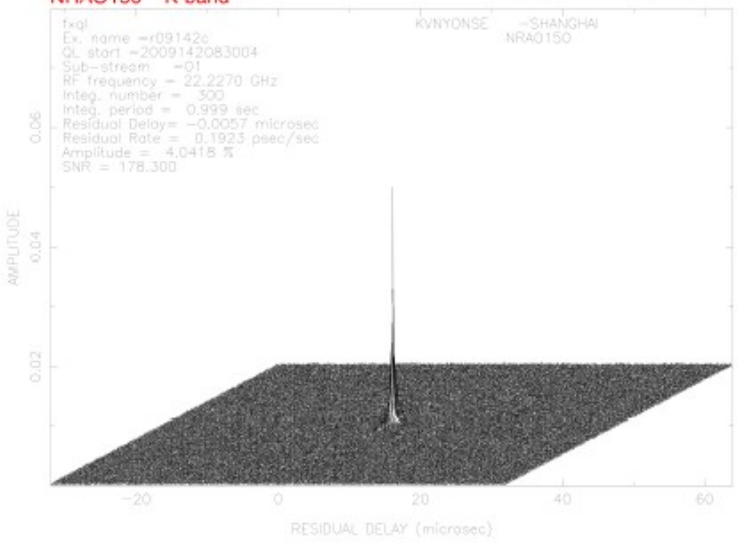
May 22, 2009
NRAO150 K-band

MITAKA FX Shanghai - VERA Mizusawa



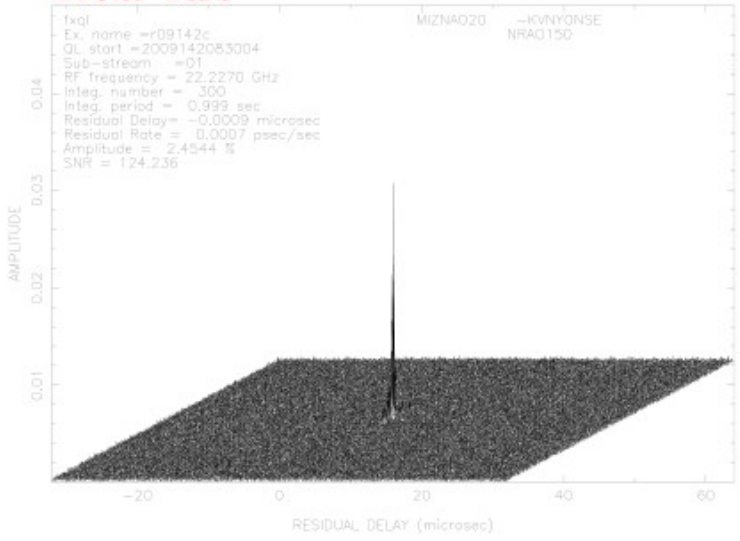
May 22, 2009
NRAO150 K-band

MITAKA FX Shanghai - KVN Yonsei



May 22, 2009
NRAO150 K-band

MITAKA FX KVN Yonsei - VERA Mizusawa



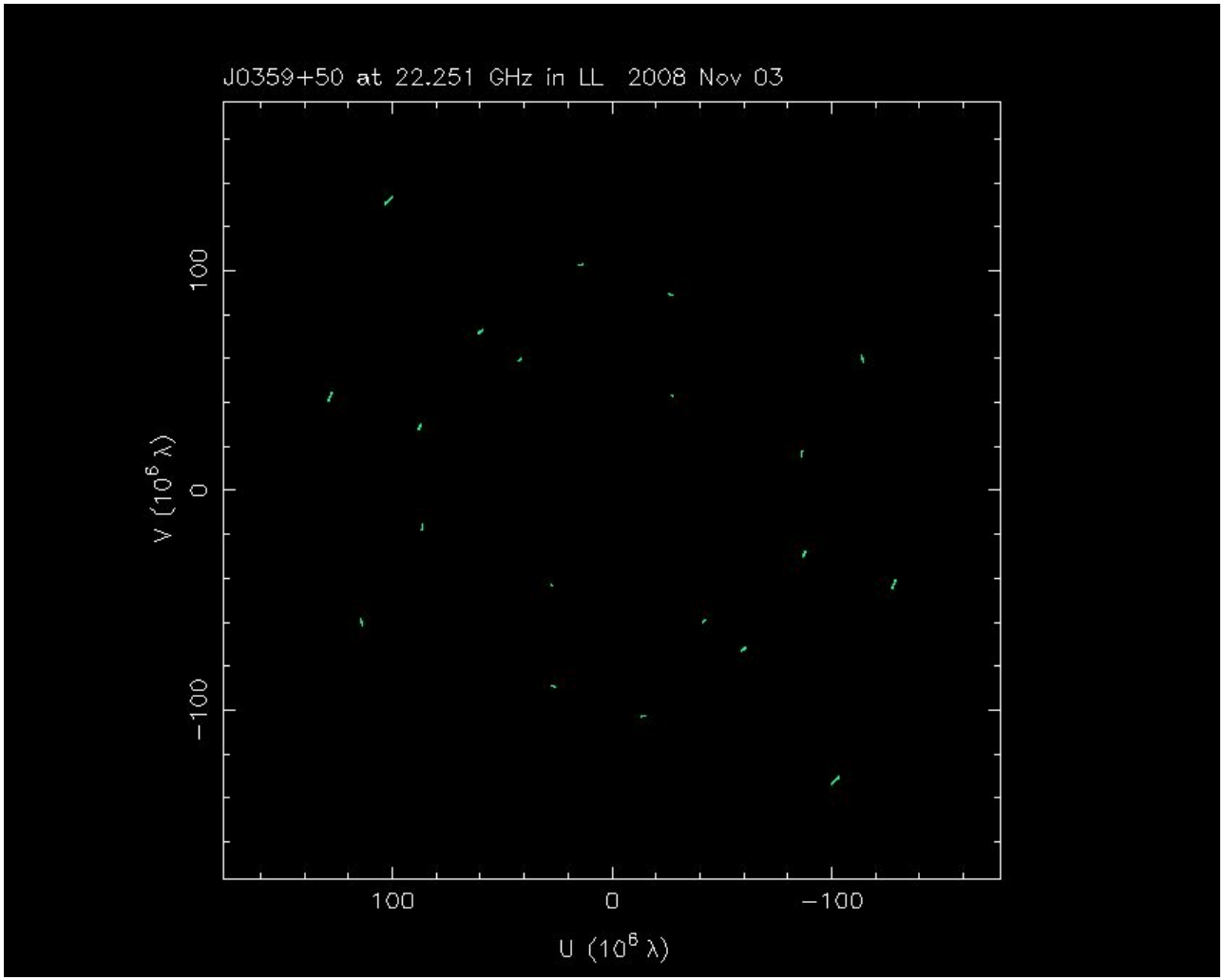
EAVN 22GHz observation[Korea - China - Japan]
on May 22, 2009

KVN in Madrid

KVN-VERA observation

- Delay offset stabilized
- One session per month so far
- Aiming two session per week: 2010~
- 3 KVN and 4 VERA telescopes + …
- Cable-cal system to be installed (Sep.)

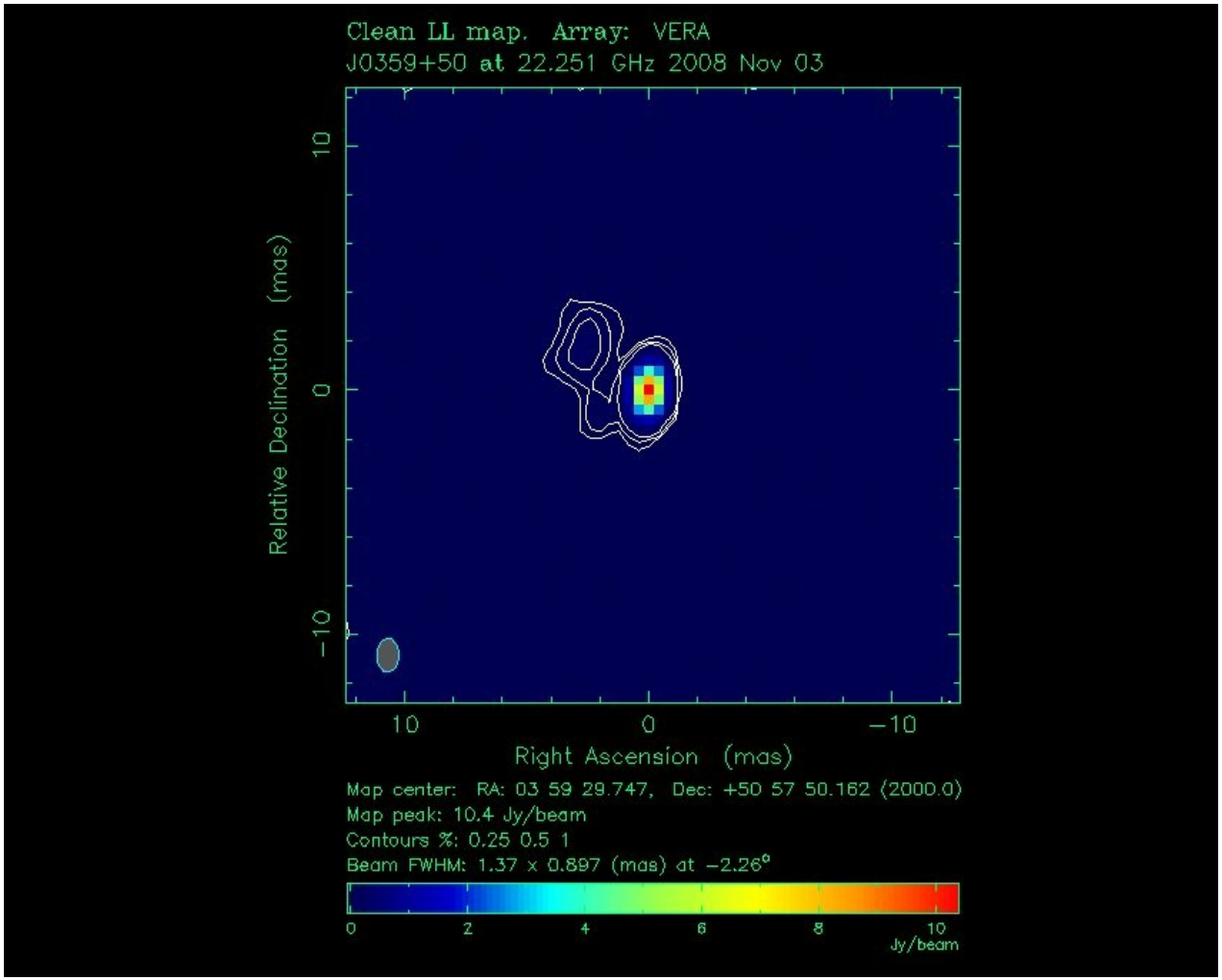
NRAO150 on 3rd Nov. 2008



10 minutes observation (YS, MZ, IR, IS, OG)

KVN in Madrid

NRAO150 on 3rd Nov. 2008

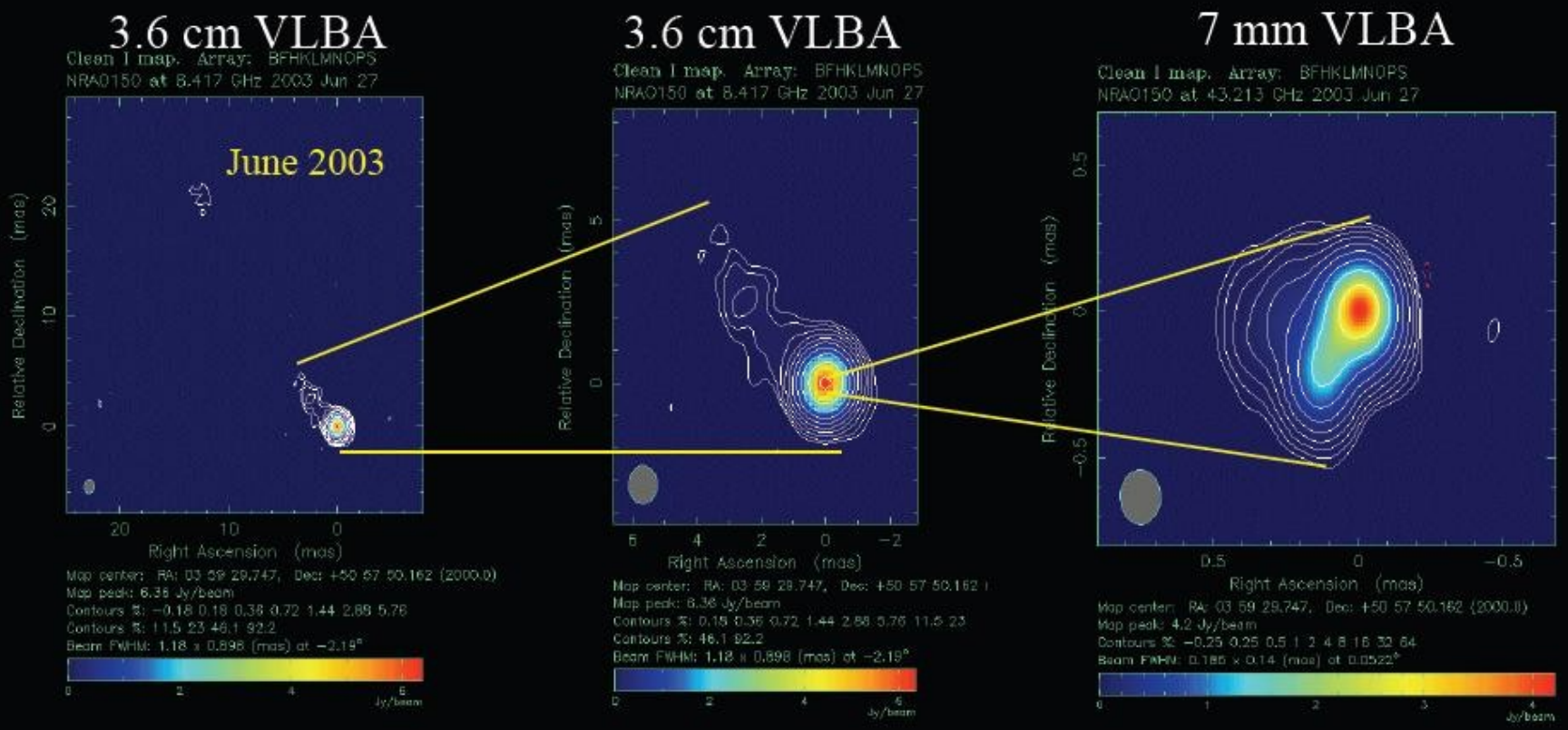


10 minutes observation (YS, MZ, IR, IS, OG)

Is the structure real?

KVN in Madrid

mm-VLBI: 120º inner to outer jet misalignment

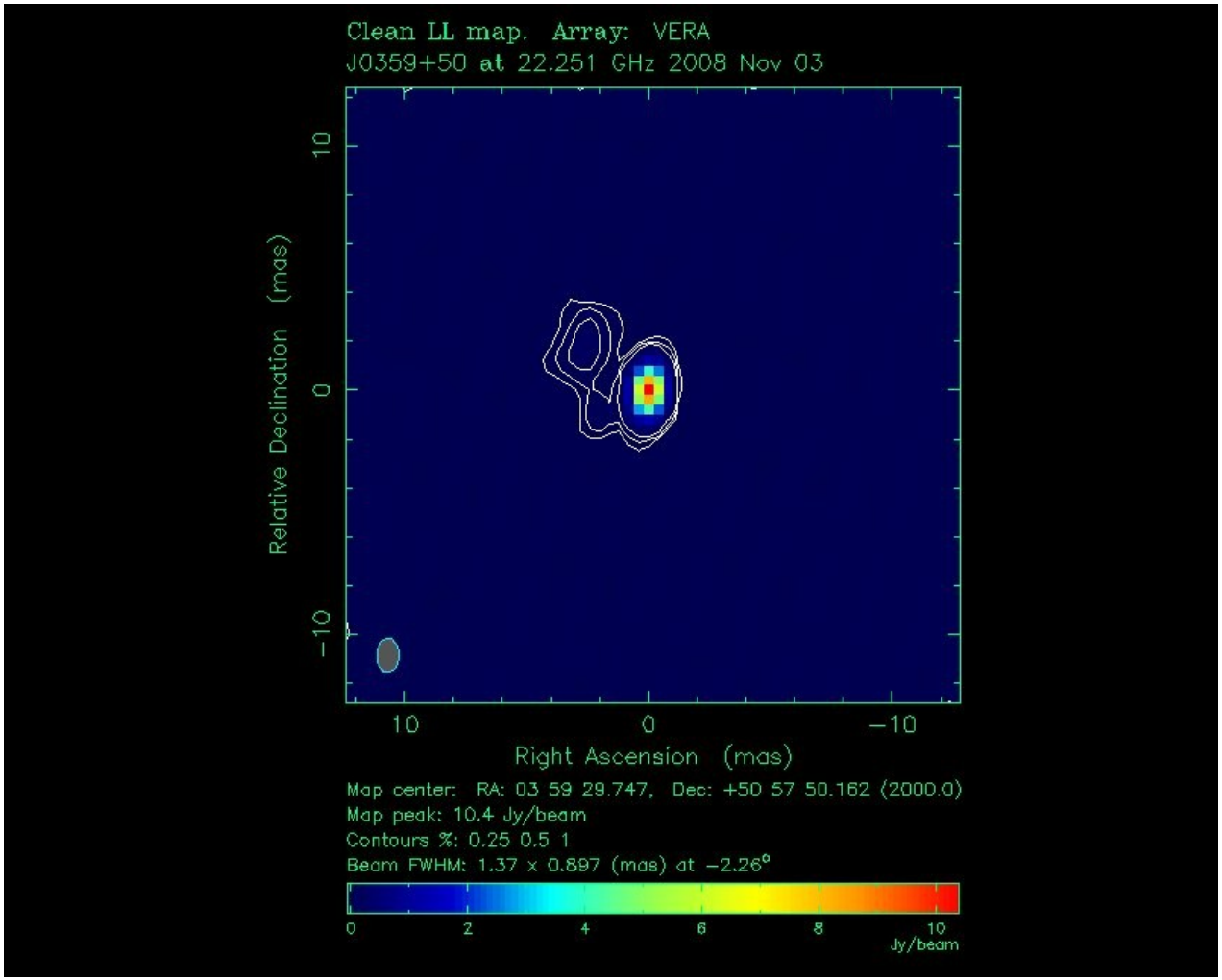


Agudo et al. (2008)

- New 7 mm and 3.6 cm-VLBA observations reveal a strong misalignment (of ~120º) within the first 0.5 mas

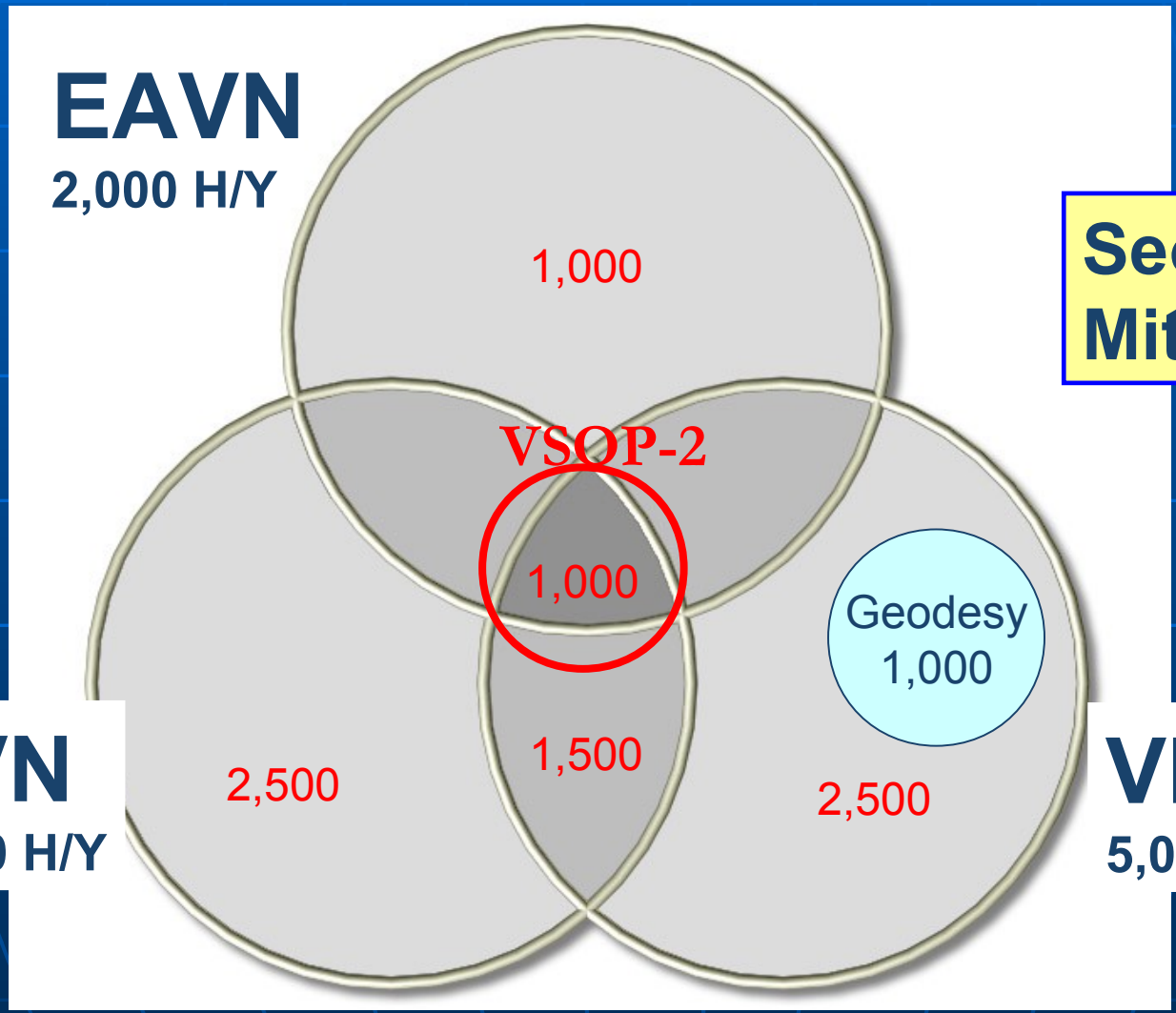
- Likely produced by a jet bent, alignment of the jet with line of sight and projection effects

NRAO150 on 3rd Nov. 2008



Seems to be real, monitored monthly at K-band since March 2009 (just begin to analyze!)

Scientific Operation draft (2010~)



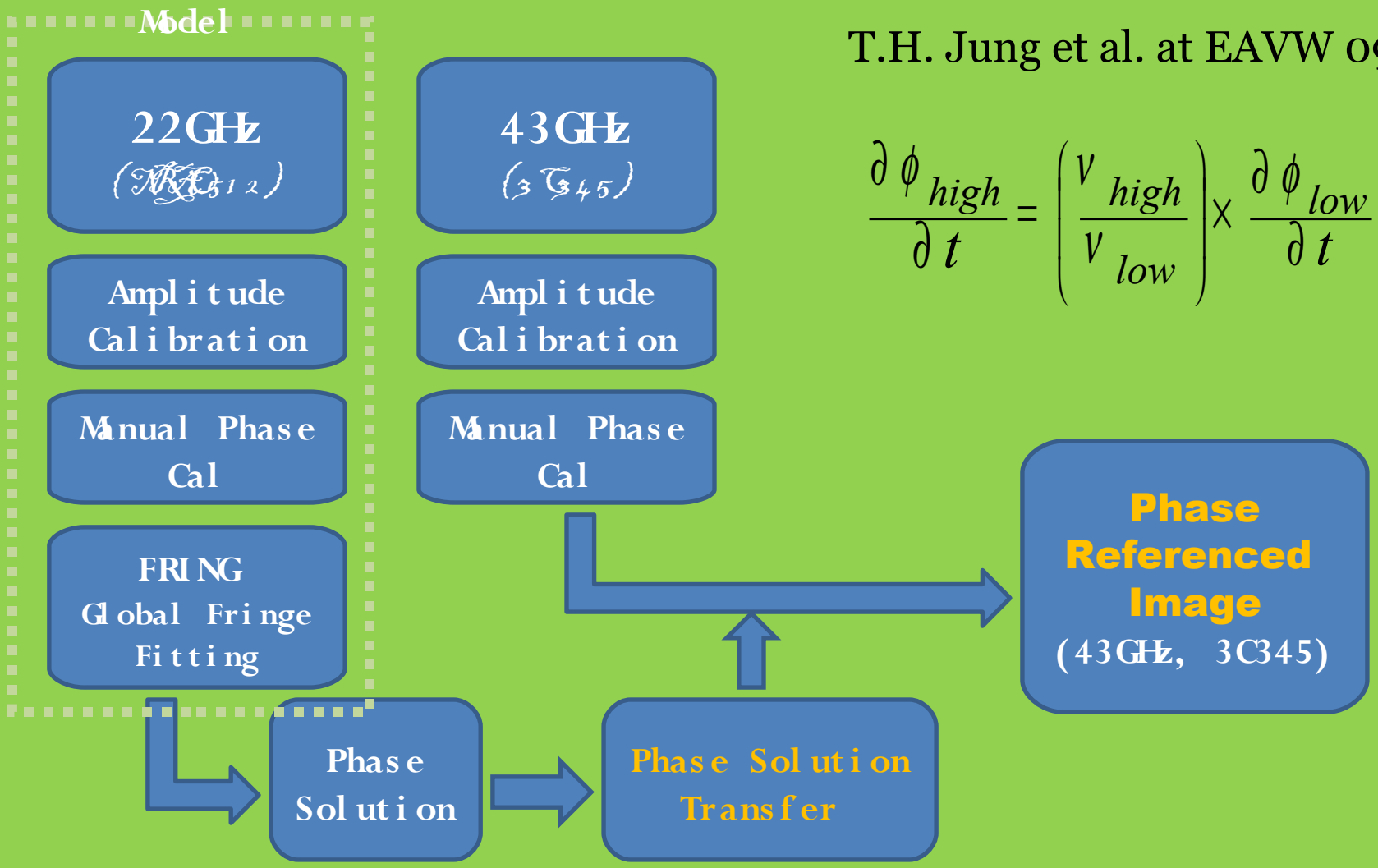
Seoul 6,000 H/Y
Mitaka 2,500 H/Y

Kobayashi at EAVW09

KVN(EAVN) Science

- AGN
  - Extremely young compact objects (HFPs)
  - Core-shift, optically thick region
- Star forming regions
  - H2O maser survey
- AGB stars
  - Twin maser survey (H2O and SiO)
- K-band metrology
  - K-band ICRF, Geodesy

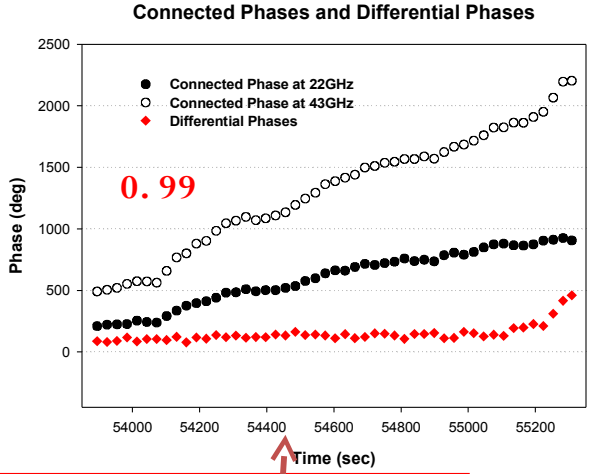
Multi-Frequency Phase Referencing

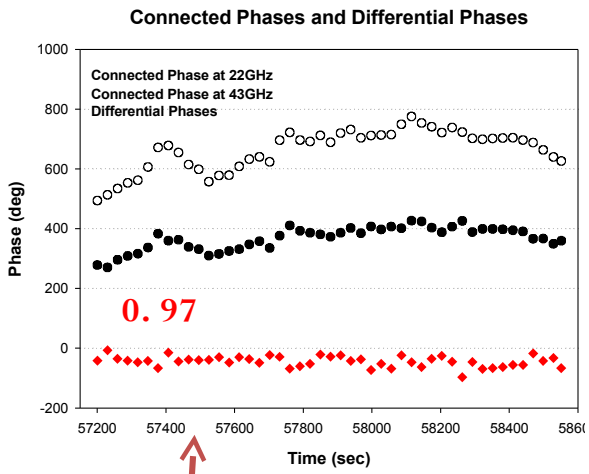


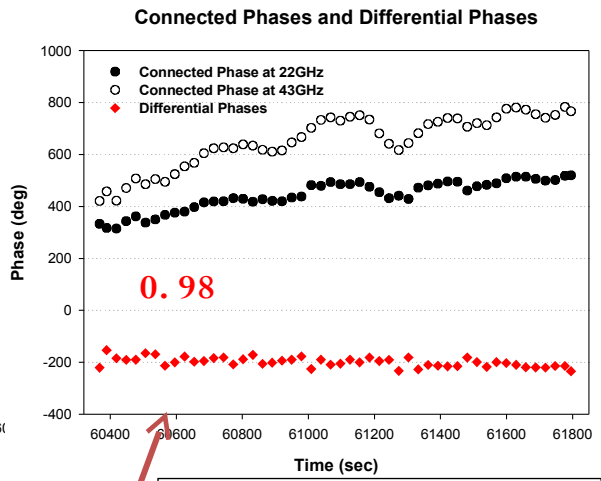
T.H. Jung et al. at EAVW 09

$$\frac{\partial \phi_{high}}{\partial t} = \left(\frac{\nu_{high}}{\nu_{low}} \right) \times \frac{\partial \phi_{low}}{\partial t}$$

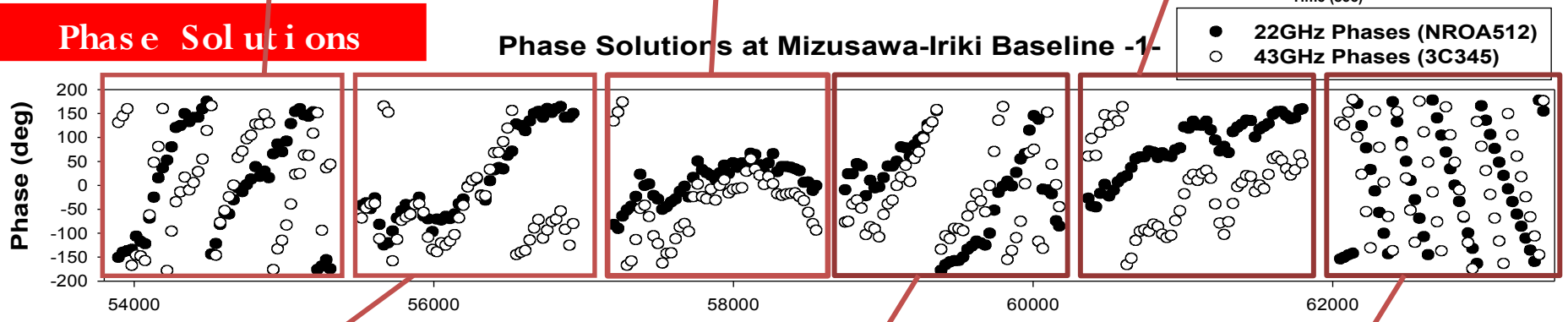
T.H. Jung et al. at EAVW 09

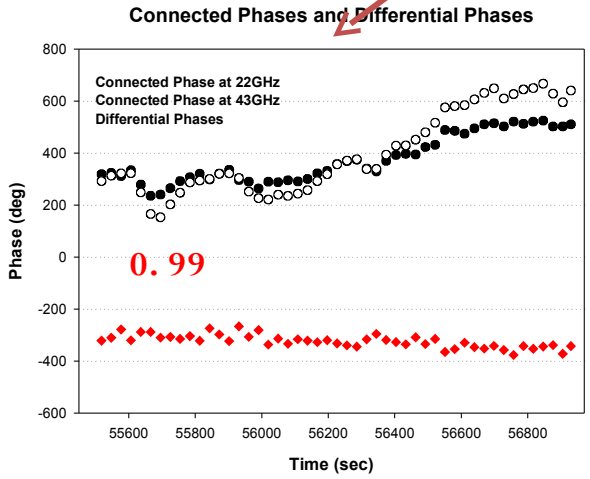


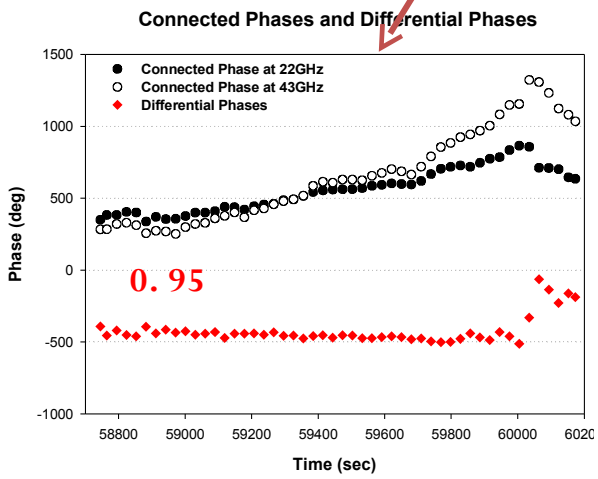


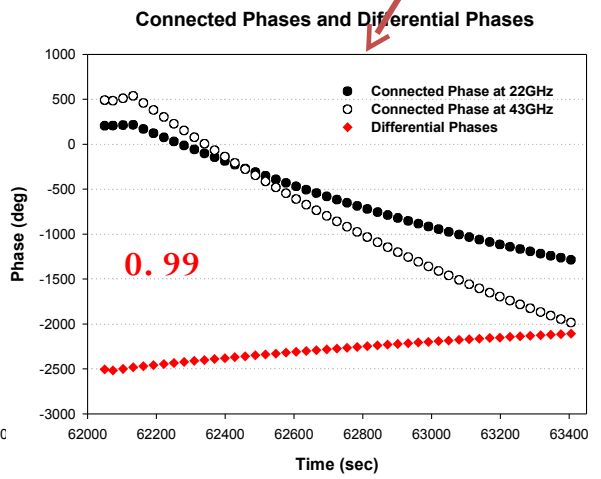


Phase Solutions



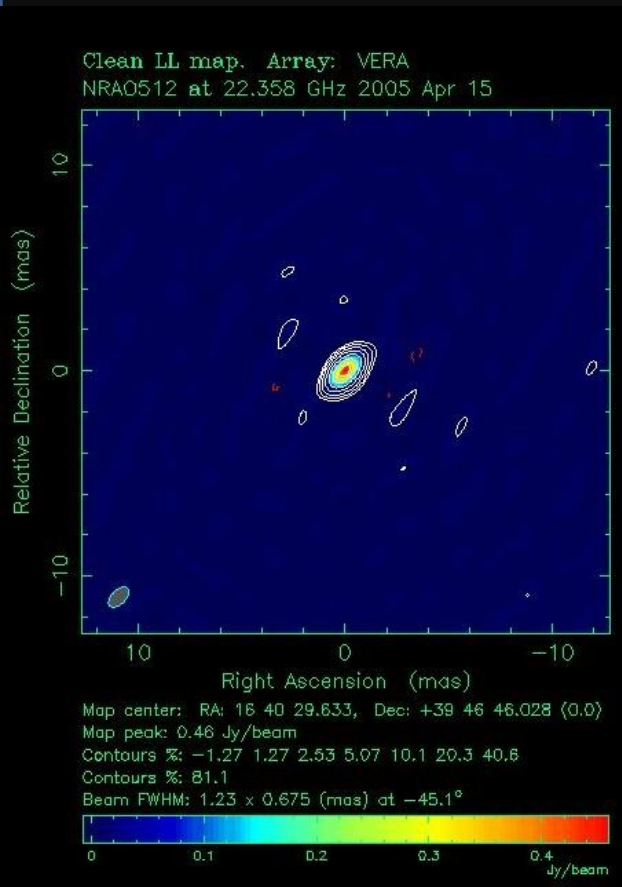




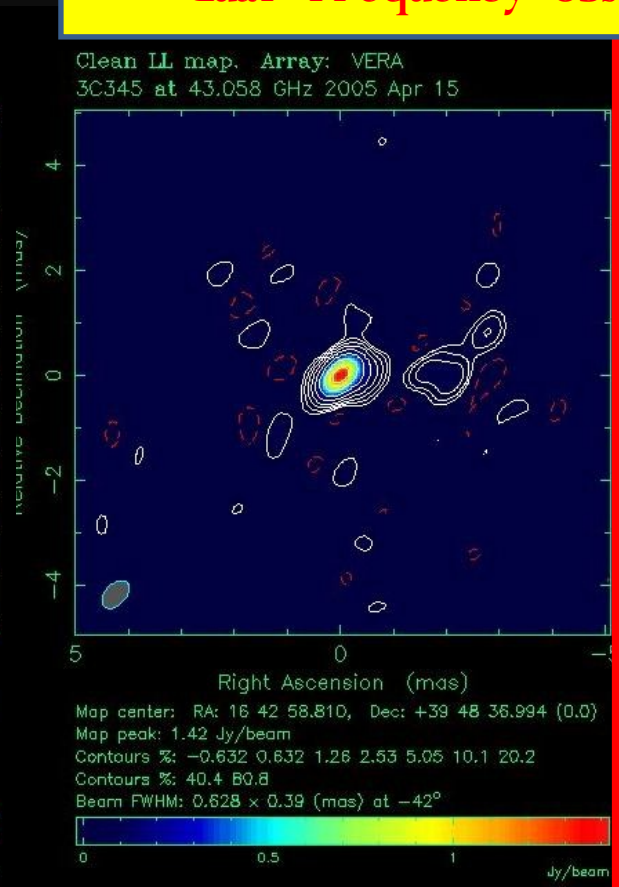


Images

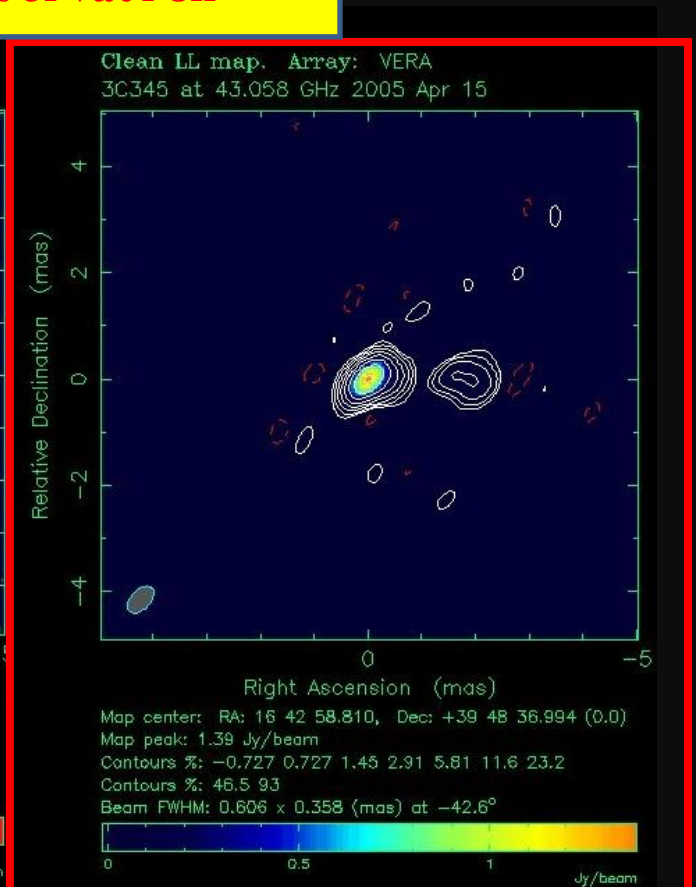
The FIRST phase referenced image from the 22 & 43 GHz simultaneous dual-frequency observation



NRAO512 (22GHz)
phase model



3C345 (43GHz)
original



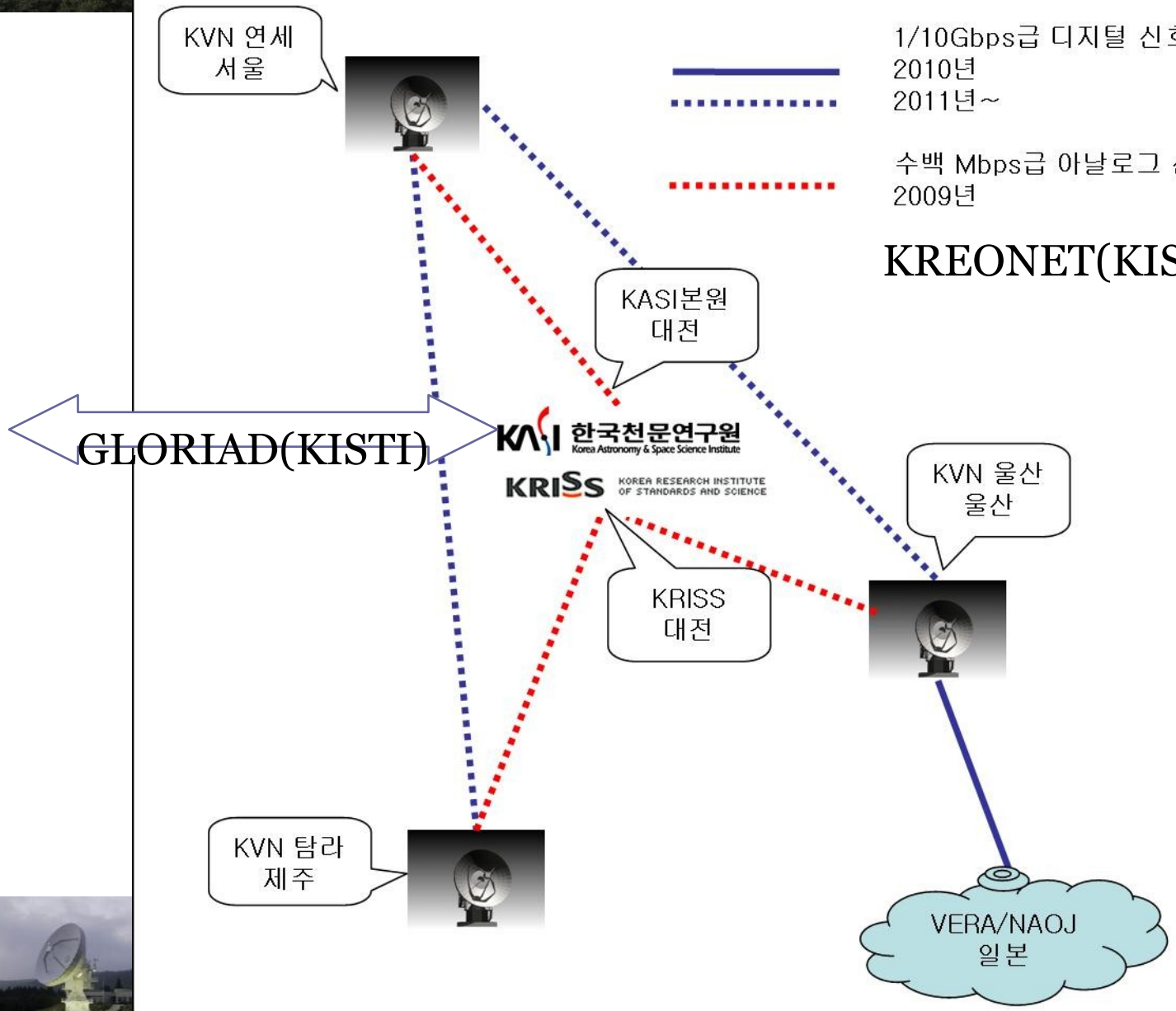
3C345 (43GHz)
phase referenced

T.H. Jung et al. at EAVW 09

e-VLBI consideration

- Sites
  - Located in University campus
  - Easy to be connected to KREONET (national research network of KISTI)
- Data Acquisition System
  - VSI- specification
- Correlator (KJJVC)
  - Optical fiber input
  - Raw Data Buffer System

KVN 광케이블 구성 개념도(예상)



Summary

- KVN project and current status
  - All three telescopes are constructed
  - K/Q receivers installed
  - 86 and 129GHz in 2011
- Test observations
  - Aperture eff. 50%@100GHz, 70%@K&Q
  - First fringe (Nov. 2008) KVN Yonsei - VERA
  - on-going KVN-VERA tests
  - KVN-VERA-Sheshan fringes (May 2009)
- e-VLBI (discussion with KISTI)
  - Proposal accepted for e-VLBI test
  - GLORIAD, K-J high speed network available
  - Discussions on dedicated line(s)


Thank you!