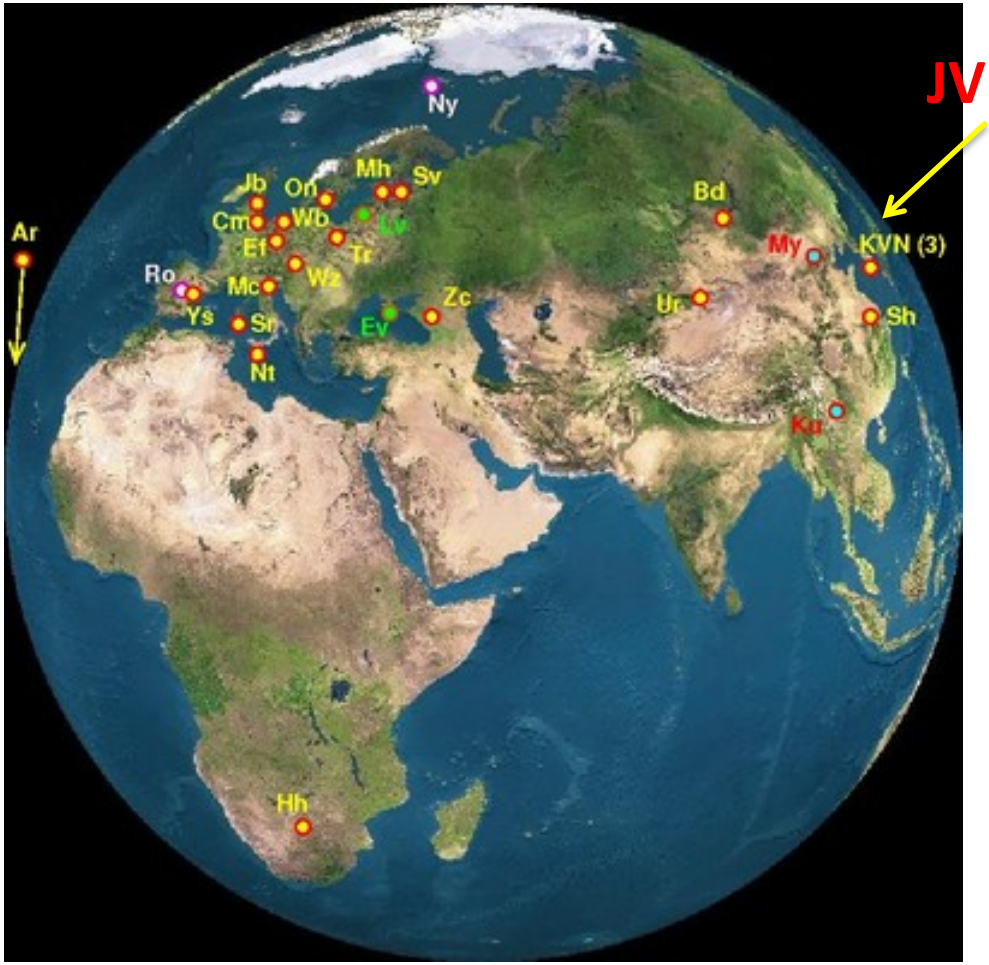
Status of VLBI in Japan and East Asia

Yoshiaki Hagiwara (NAOJ)

EatingVLBI 2014. 13-14 October, IRA, Bologna

EVN map (European view)



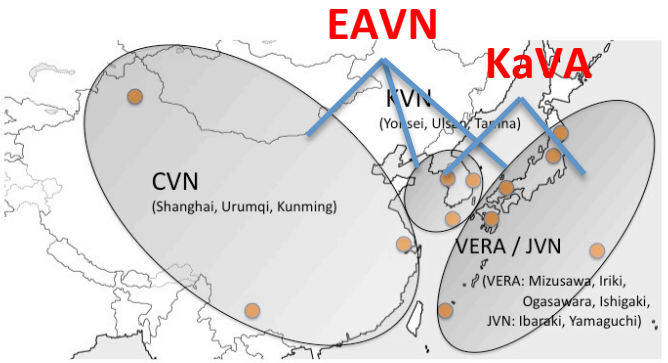
JVN/VERA (13)

EVN Home page

Talk Outline

- **VLBI activities in Japan**
  - VERA (VLBI Exploration of Radio Astrometry)
  - Japanese VLBI Network (JVN) – University-led VLBI

- **International Collaboration**
  - KVN and VERA Array (KaVA)
  - East Asia VLBI Network (EAVN)

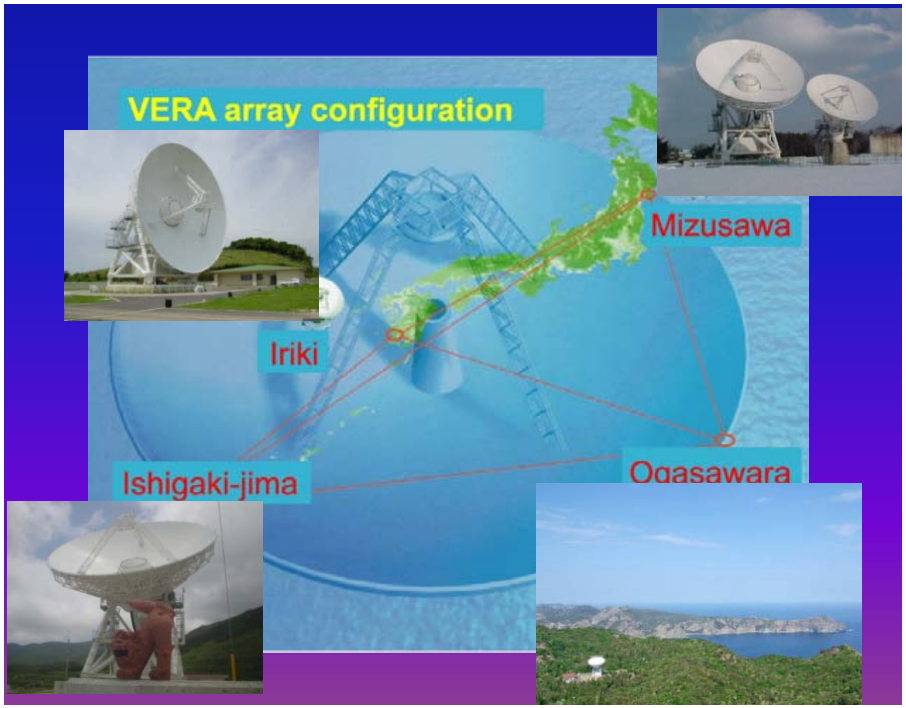


VERA Overview

- **Maser astrometry at 10 microarcsec level**
- Antenna diameter 20m
- Telescopes equipped with "dual-beam" system (one for a target (maser), the other for a referencing source.
- **4 stations over the country**

  (B_{max} = 2300 km, B_{min} = 1000 km)
- **Bands: 2,8,6.7,22,43GHz**
- Array operation since 2005
- Parallax measurement in 2007
- Open Use Time (~~~ 400 hrs/year)~~

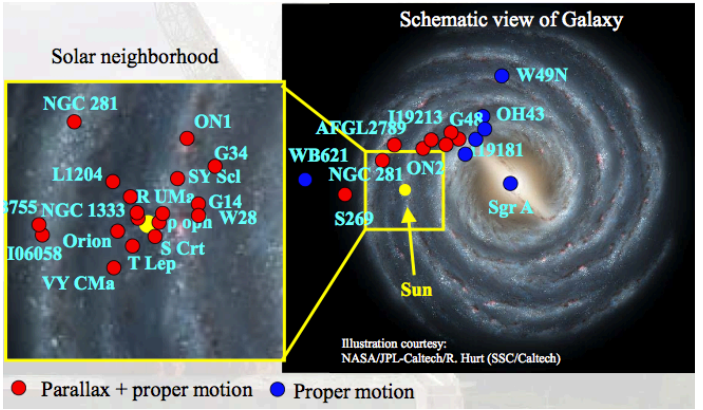
  => 700 hrs / year (VERA, VERA+KVN)



VERA Astrometry

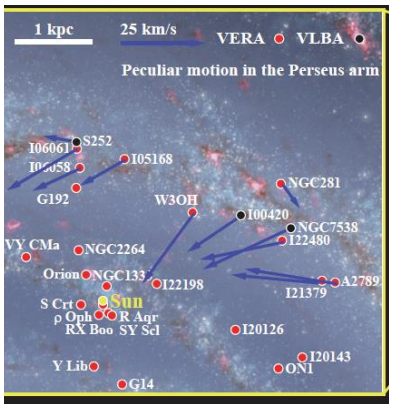
- ~200 maser sources out of 400 listed sources have been monitored for trigonometric parallax measurement

- Observations of
  40 maser sources per year



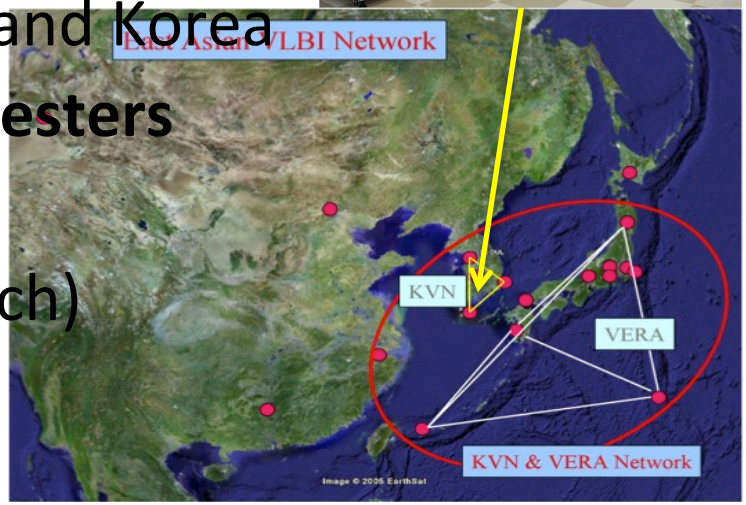
- Planning observations of 250-400 sources from 2014-2022
  - ~ 60 sources/y with monitoring period of 1.5 -2 years

- Astrometry at higher Accuracy
  using VERA+KVN (KaVA)



Japan-Korea Collaboration (KaVA: KVN and VERA Array)

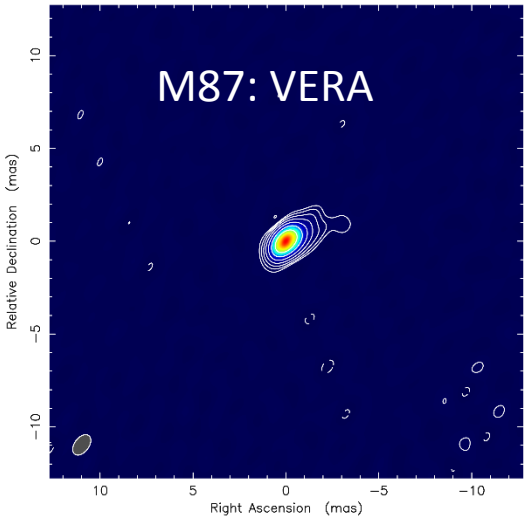
- **KaVA status**
  - 7 telescopes: VERA: 4 20m, KVN :3 21m
  - Baseline 2300 km, hardware correlator at KASI
  - **Proposal-based observations started (RSO)**
    - AO: twice a year , limited to Japan and Korea
    - **280 hrs allocated in two 2013 Semesters**
  - Bands: 22 GHz and 43 GHz
  - Recording mode: 1Gbps (16MHz x 16ch)
  - From 2014 Semester, AO opened to China and Taiwan

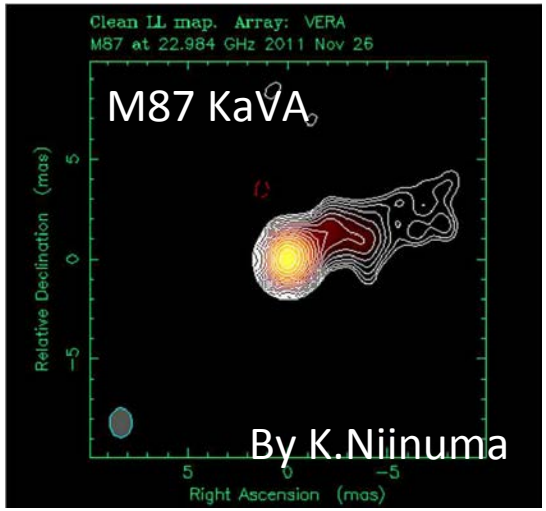


(KaVA: KVN and VERA Array)

- **Science activities**

  - AGN, Astrometry, SFR, Evolved Stars WGs meet F2F twice a year
  - Key Science Program discussion on-going (Jan 2015)
  - Publications : Niinuma+, in press (AGN mapping, this meeting)
    Matsumoto+ 2014 (44GHz Methanol maser)
    Zhao+ (Monitoring SgrA*, this meeting)

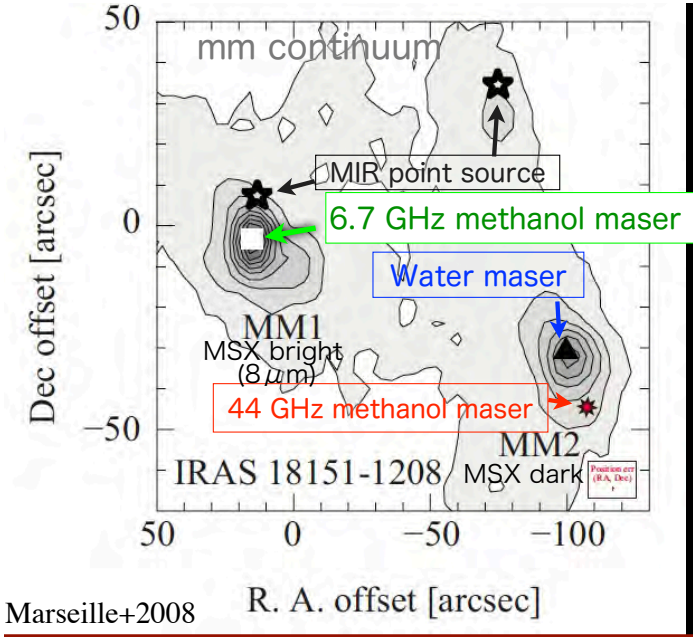




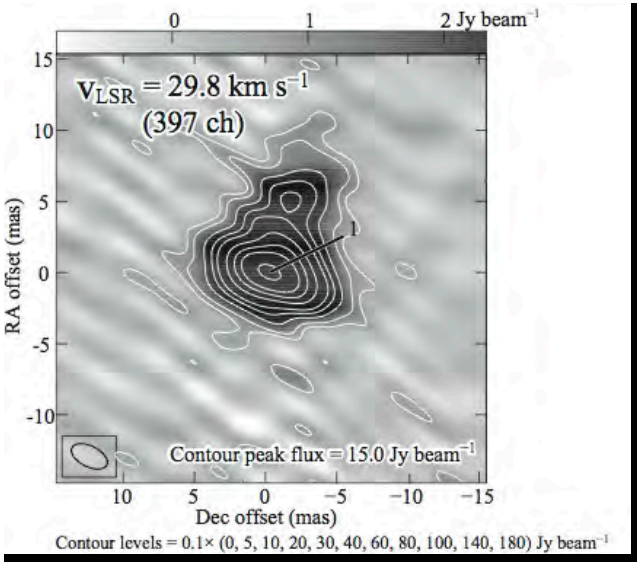
KaVA Science high lights

(Matsumoto et al. 2014)

- 44GHz CH_3OH maser in the massive star-forming region, G18.34+1.78 SW, imaged by KaVA (short-BL) in 2012-2013.
- Three maser spots associate with G18.34+1.78 SW (left)
  - spot size ~ 3 mas (8AU@2.7kpc) with brightness temp. ~ 9 10^9 K
- One of the resolved maser features shown below (right).



Marseille+2008

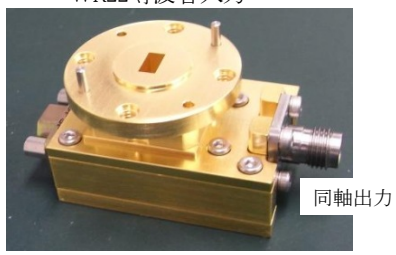


Instrumentation

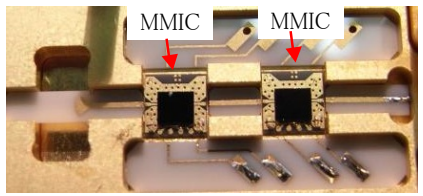
- New digital backend (OCTADISK)
- New receiver (Q-band InP LNA)
- RF Direct Sampler (20-50GHz) under developing
- Software correlator “ Softcos” (to be presented by Oyama san, tomorrow)
- e-VLBI

Wide-band digital backend and new Q-band LNA

- 2Gbps recording has started using the disk-based recording system (OCTADISK) since 2014 Semester
  <= Previously, the recording rate was 1Gbps with tapes
- New 43 GHz InP LNA installed (Trx: 70 K => 40 K)
  - Advantage for line source
  - Advantage for astrometry



LNAの外観



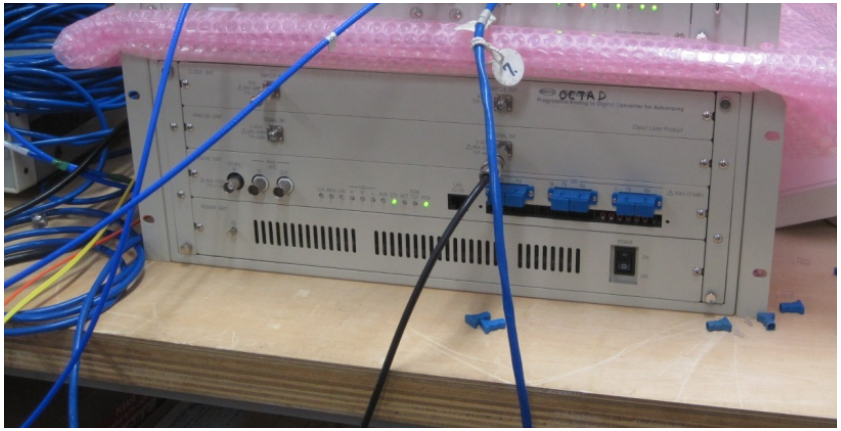
LNAの内部

New InP LNA

OCTADISK enables > 8 Gbps recording

RF direct sampler (OCTAD)

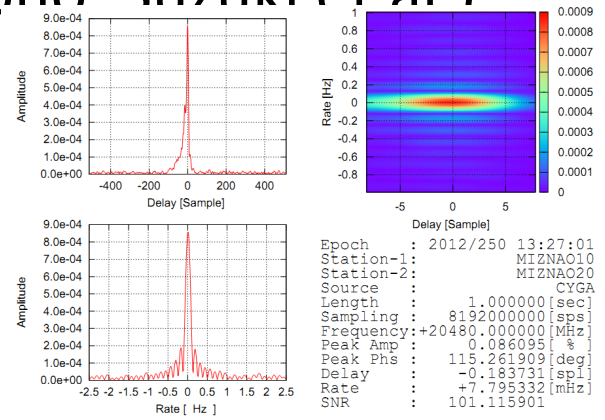
- Direct RF sampling
  - 20-50GHz
- Wide bandwidth
  - 8.192 Gsps-3bit



- Next generation system for VERA
  (- Potential application to SKA-high)
- Fringe test observation (Oyama, Kono, Suzuki et al.)

-Mizusawa 10m - VERA 20m BL=60m

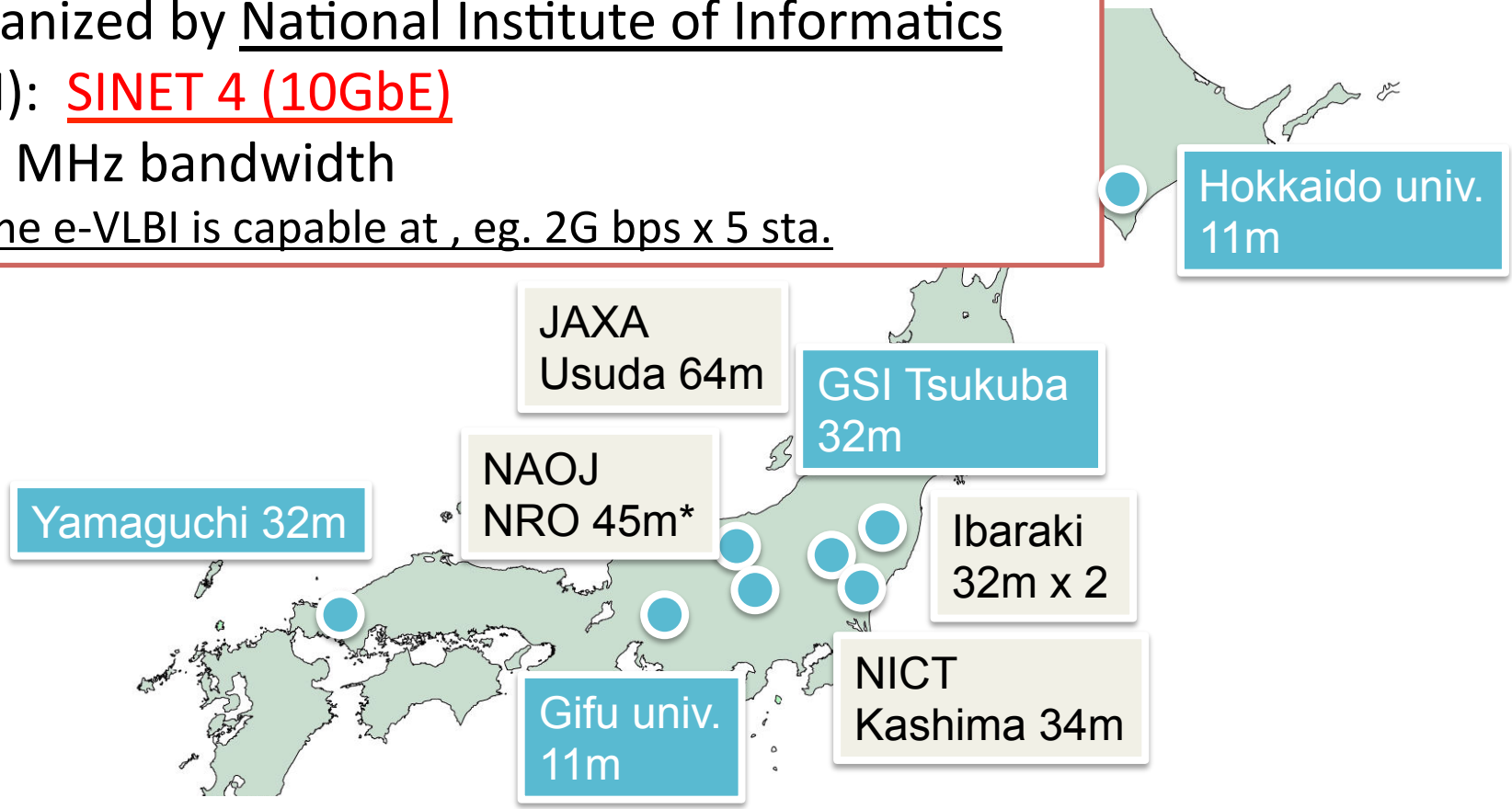
- 16 Gbp/s with 2 OCTAD



e-VLBI Network in Japan

Academic Fiber Network available for researchers
- Organized by National Institute of Informatics (NII): SINET 4 (10GbE)
- 512 MHz bandwidth

Real time e-VLBI is capable at , eg. 2G bps x 5 sta.



Blue: Currently connected by 10GbE
Others: Used to be connected by 10GbE

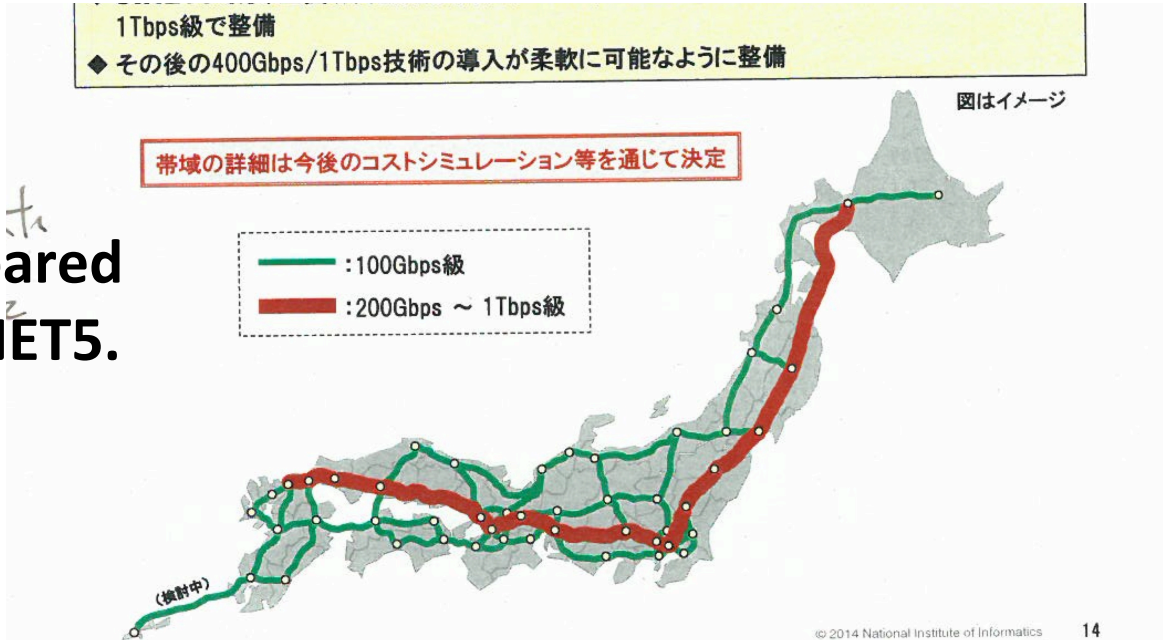
New Fiber network Concept : SINET5

SINET 5 Concept

- 100 Gbs class network over the country
- 200 Gbps – 1Tb connection for major cities

NAOJ plans

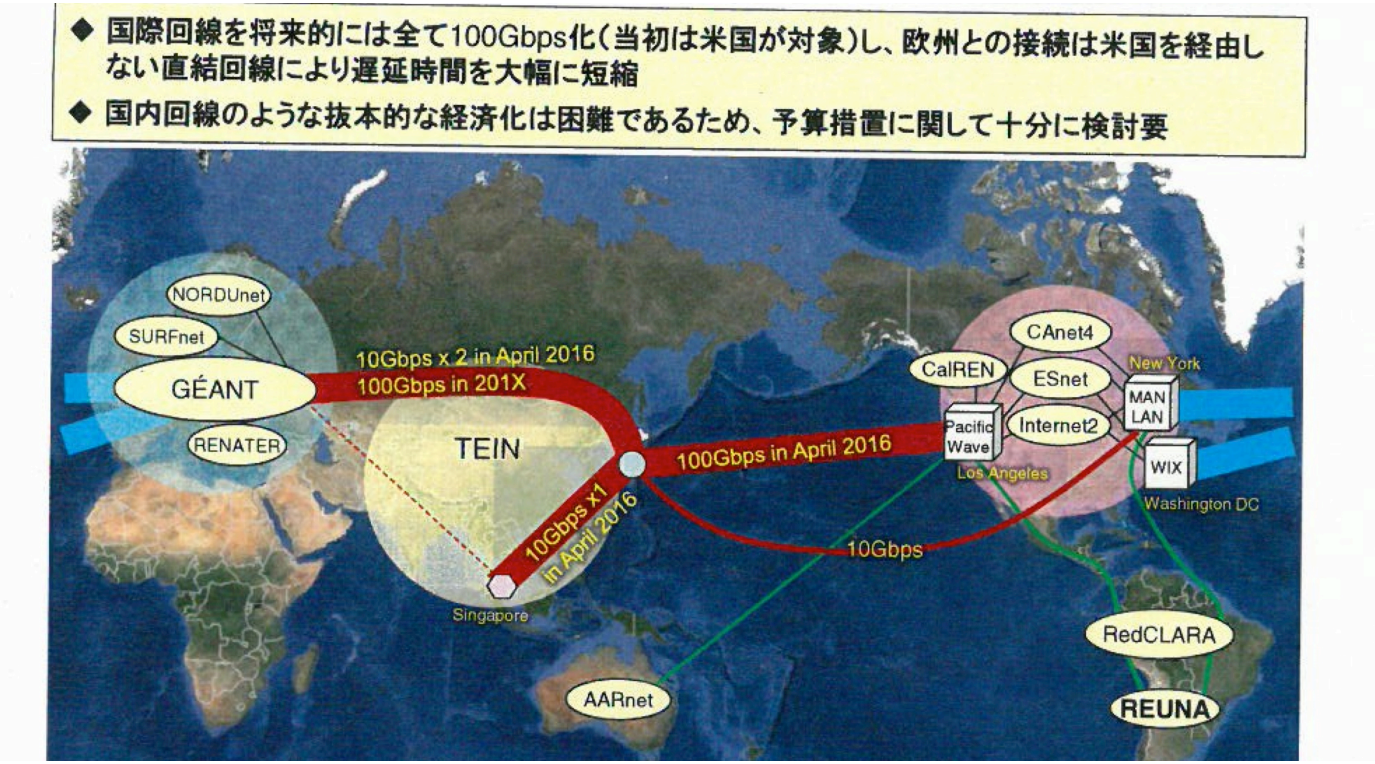
- maybe,
40 Gbps I/F prepared
to access the SINET5.



International

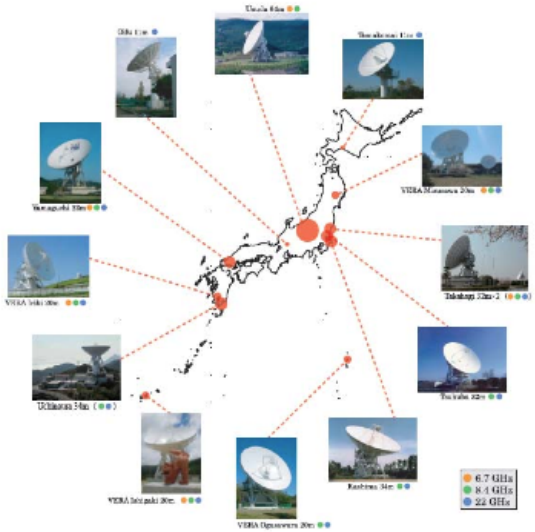
NII is interested in connection at 100 Gbps with the SINET5 to the pan European fiber network (GEANT) via Russia

-> We may be able to propose using this for e-VLBI between EU and East Asia



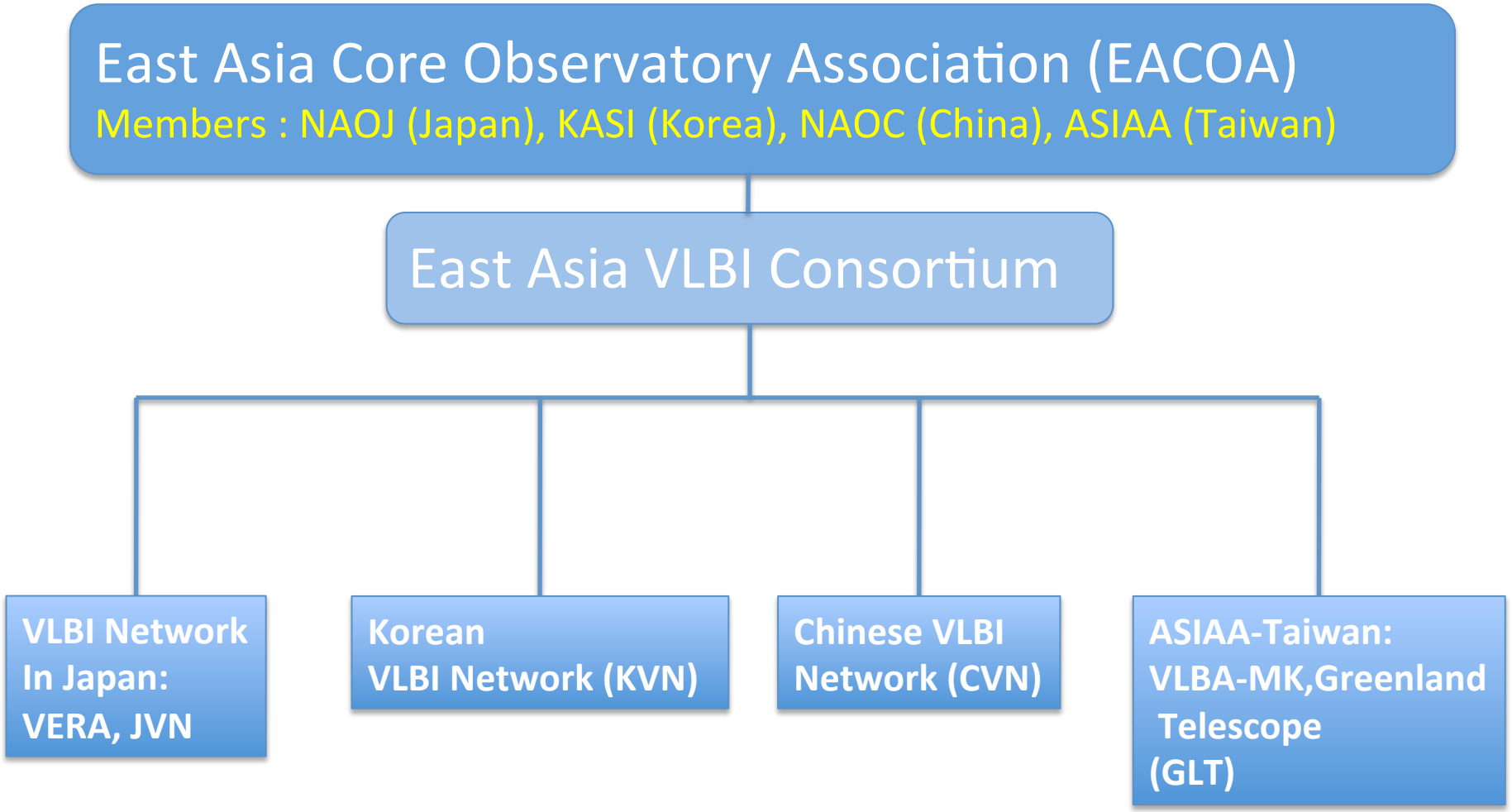
Japanese VLBI Network (JVN)

- **13 telescopes (University telescopes, VERA, etc.)**
- **Organized by university group**
- **Baseline 50 – 2,500 km**
- ~~Recording rates was 128 Mbps with tapes using the recorder~~
  => 2 Gbps disk-based recording has just begun since mid-2014
- Bands: 6.7, 8, 22 GHz
  (Not all telescopes support all bands)
- Correlation at NAOJ with software correlator
- 2013 observation: ~ 200 hrs
- Proposal-based observations but within researchers based in Japan

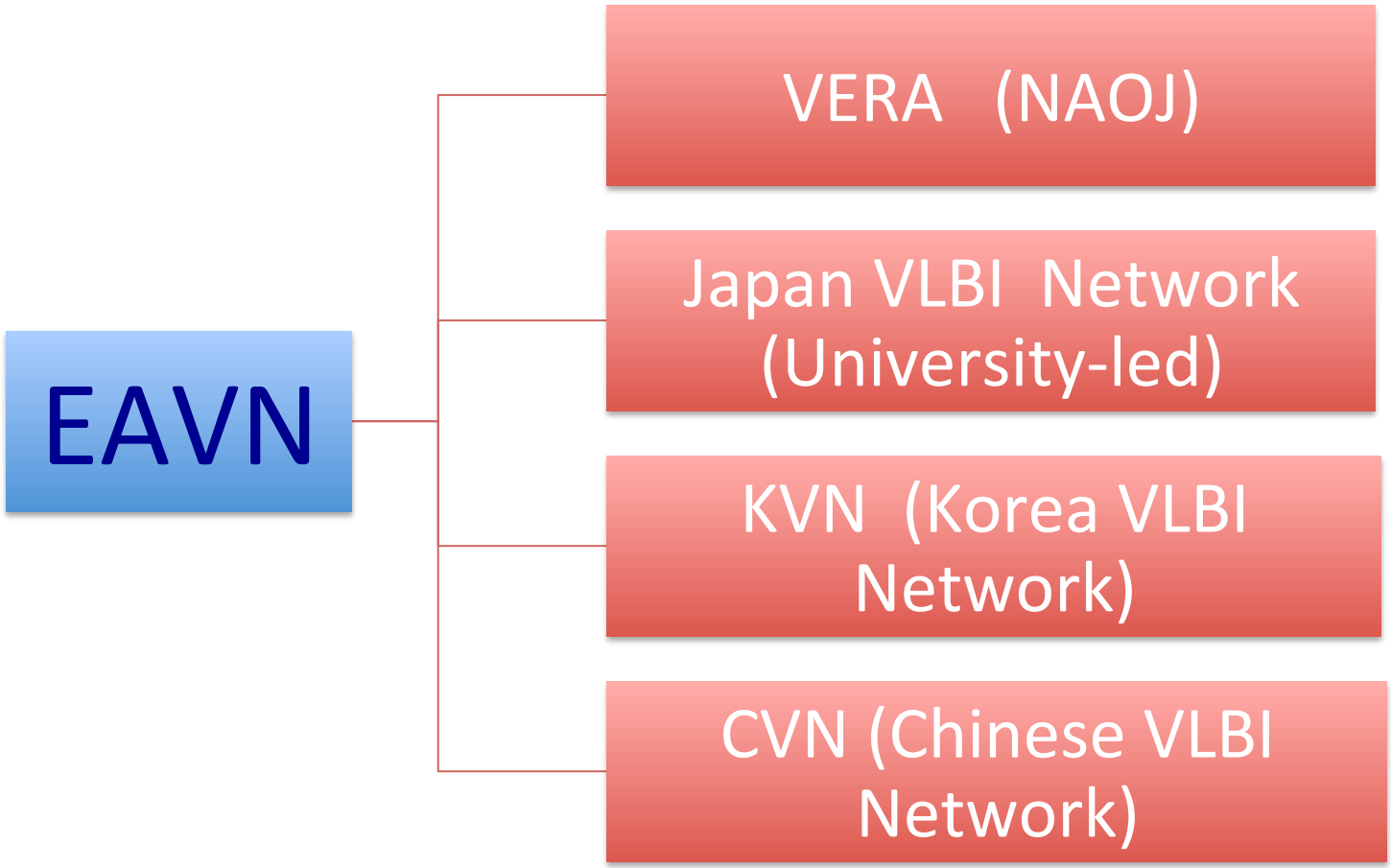


JVN 13 Telescopes

VLBI collaboration in East Asia

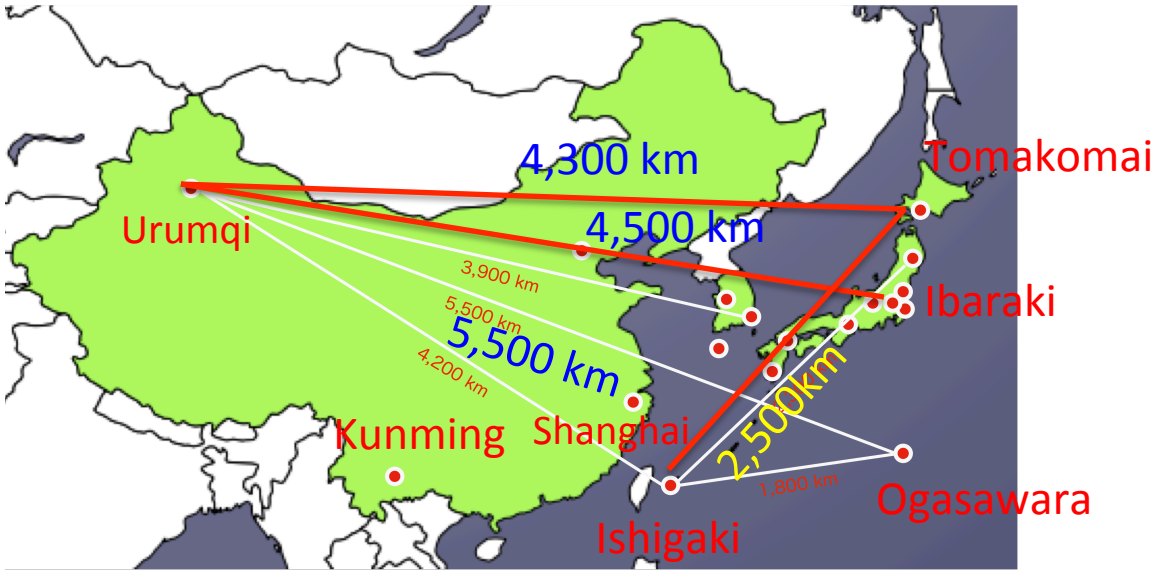


East Asia VLBI Network (EAVN)



What is EAVN?

1. Local VLBI Network in East Asia, constituting of > 10 telescopes
2. The longest baseline is 5,500 km between Urumqi and VERA-Ogasawara, in stead of 2,500 km by the JVN
3. Typical observing bands are 2,6.7,8, 22, 43 GHz
4. Some telescopes with a big aperture participate (Tm65m, Km40m)



Performance of EAVN

VLBI array	EAVN (2013)	VLBA (+GBT100m)	"Full-"EAVN
#Telescope	13	10 +1 (GBT)	16 (KAS34, UDSC64, Tukuba32)
Eff. Aperture [m^2]	8 GHz: 4,800 22 GHz: 1,800	8 GHz: 3,400 (8,970) 22 GHz: 3,040 (8,380)	8 GHz: 7,280 22 GHz: 5,200
Max. Baseline [km]	5,500 km	8,600 km	5,500 km
Bands	2.2, 6.7, 8, 22, (43) GHz	1.4-1.6, 5, 6.7, 8,15,22,43, 86 GHz	2.2, 6.7, 8, 22, 43 GHz
Polarimetry	△ (not VERA)	○	△
Rec. Rate	1 Gb/s	2 Gb/s	1 Gb/s (2-8 Gb/s)
Note	8 GHz帯は上海65m鏡が参加	"Global"-VLBI with the EVN	To be extended to South-east Asia, Au

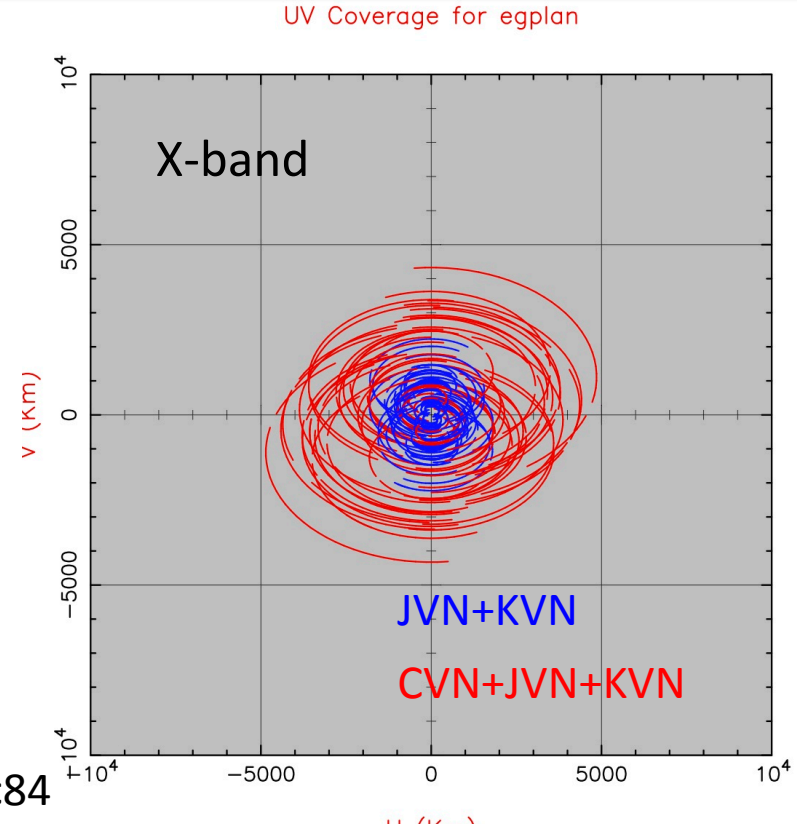
VLBI experiments

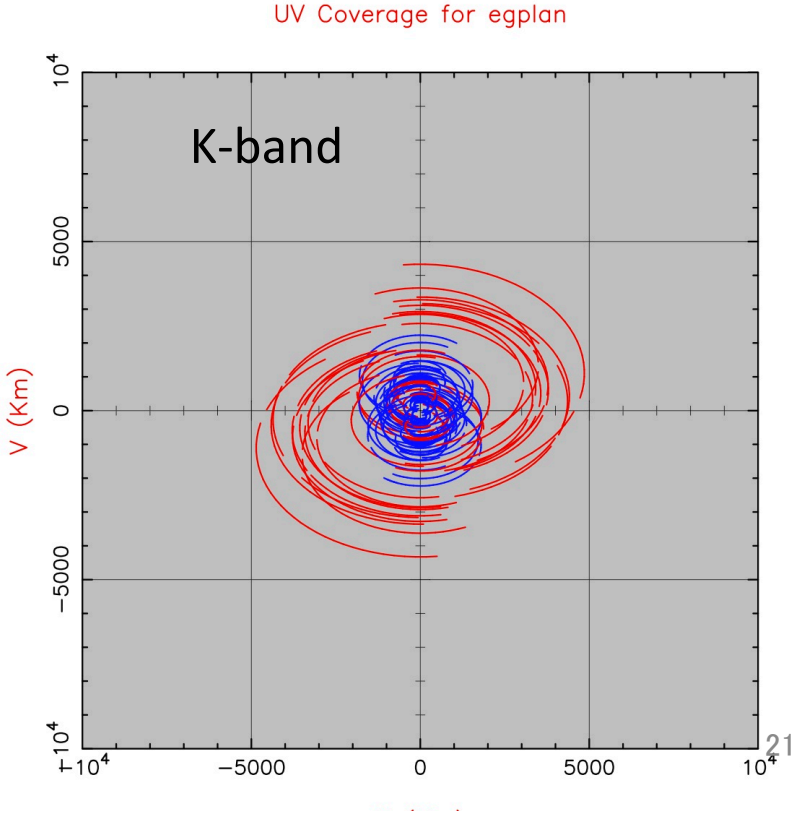
- Task force organized for conducting VLBI experiments
- Members selected from CVN, KVN , VERA, JVN
  (June 2013)
- Fringe experiments undergoing, aiming to detect fringes among all the EAVN telescopes
- Regular telecon meeting twice/months
  A face-to-face meeting held at SHAO in July
  2014

Tentative (u,v) coverage

CVN : Sh25m,Tm65m(X), Ur25m(X/K), Km 40m(X)
KVN: 3 sta.
VERA: 3 sta.
JVN: Yamaguchi(X)、Takahagi(K), Hitachi (X)

X-band: 11 sta.
K-band: 9 sta.

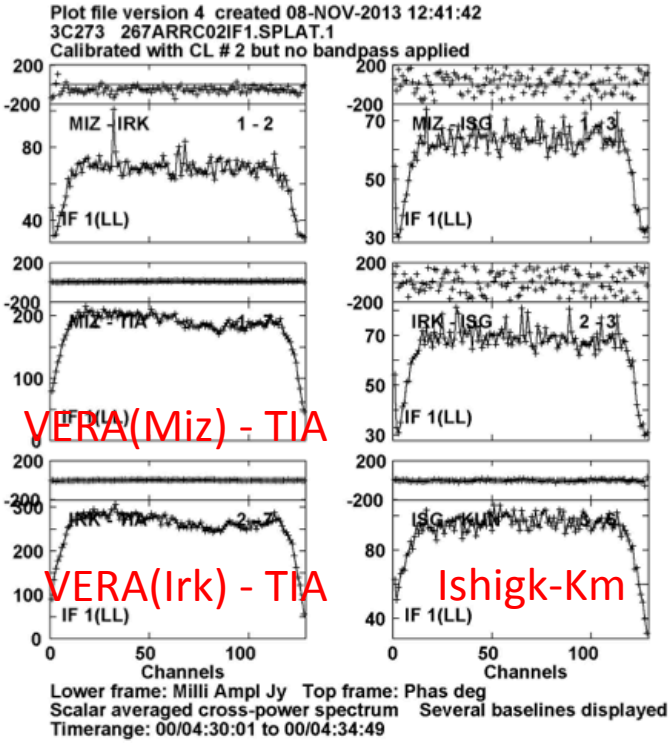




3c84

Some results of FT

- Results of the 1st fringe test, September 2013
- 3C273, 8 GHz(partly succeeded), 22 GHz (failed)

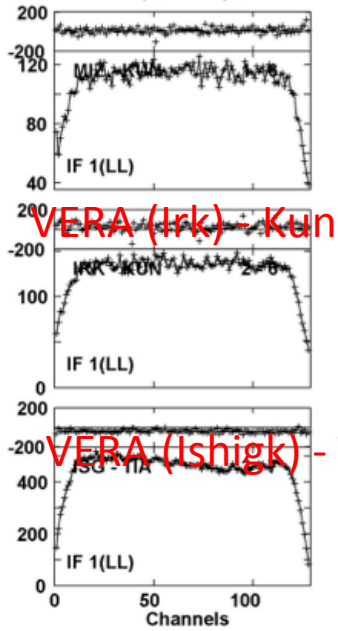


VERA(Miz) - TIA

VERA(Irk) - TIA

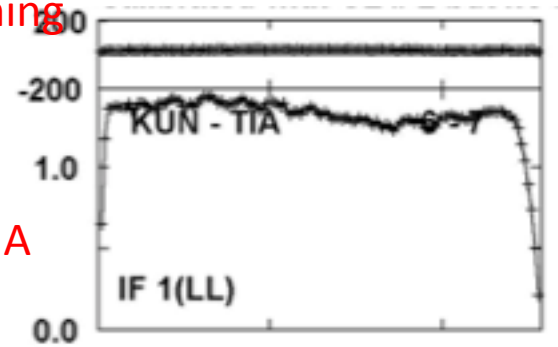
Ishigk-Km

VERA (Miz) - Kunming



VERA (Irk) - Kunming

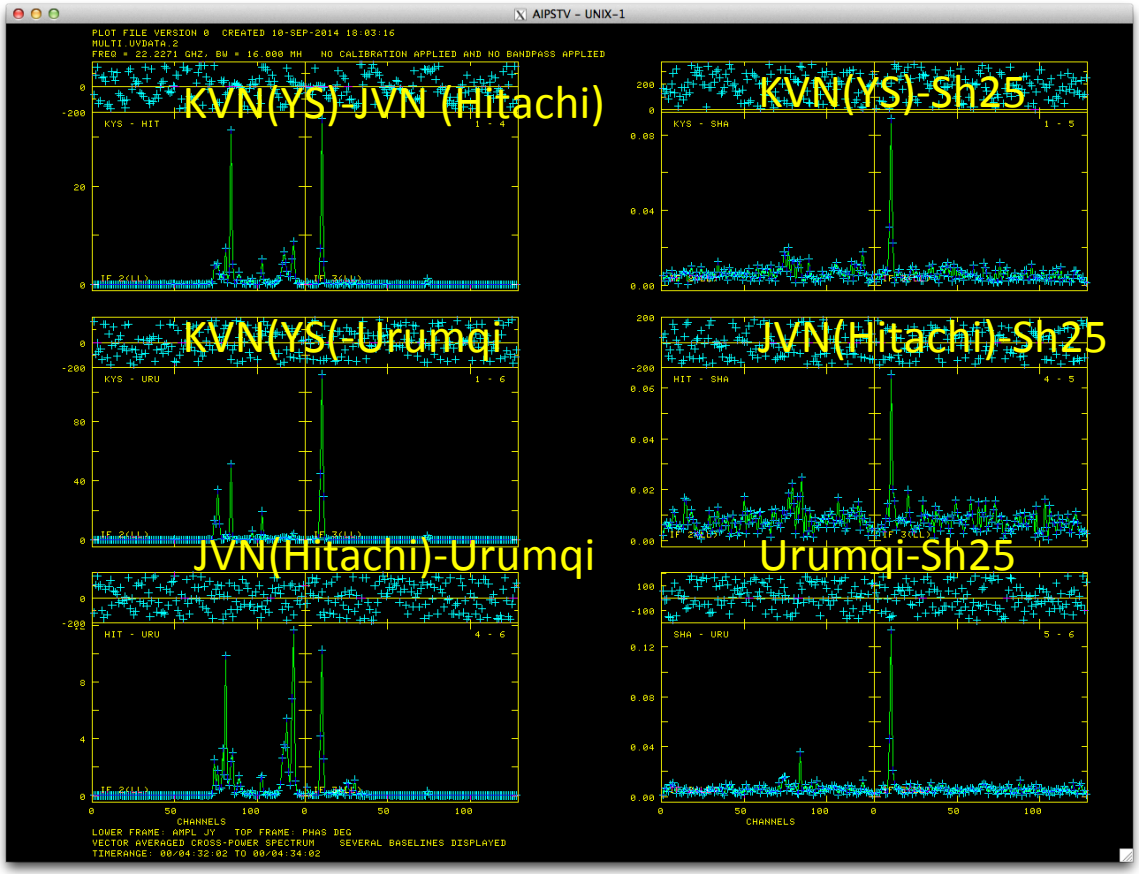
VERA (Ishigk) - TIA



TIA- (Tian ma)65m

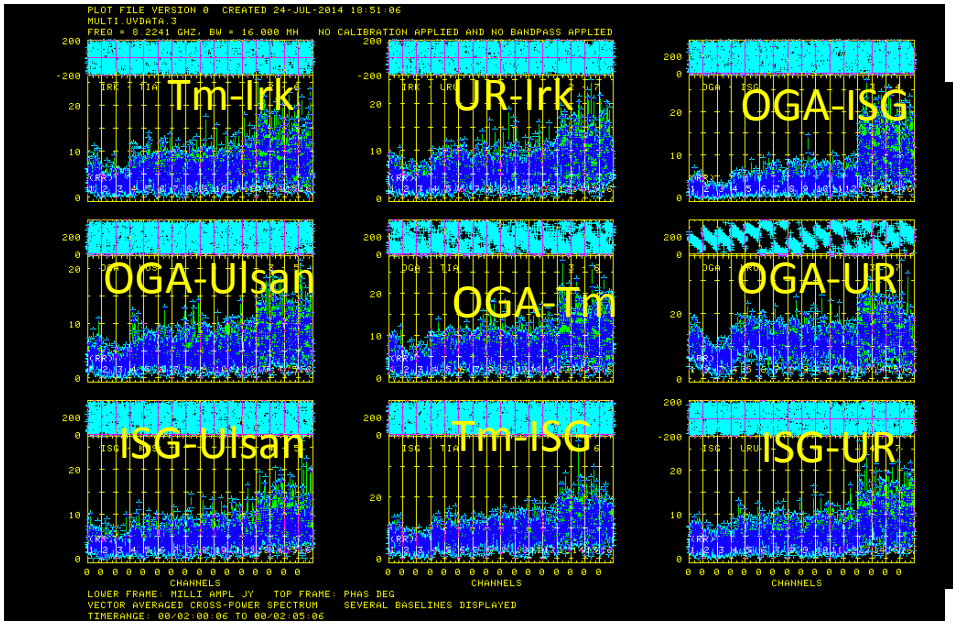
Some results of FT

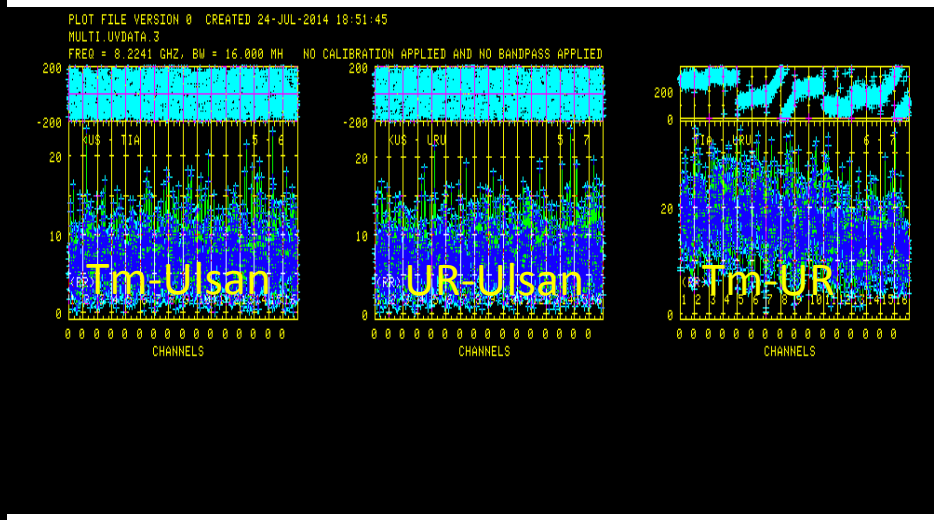
- Results of the 3rd fringe test, January 2014
- W49N (maser), 22 GHz, VERA failed in recording



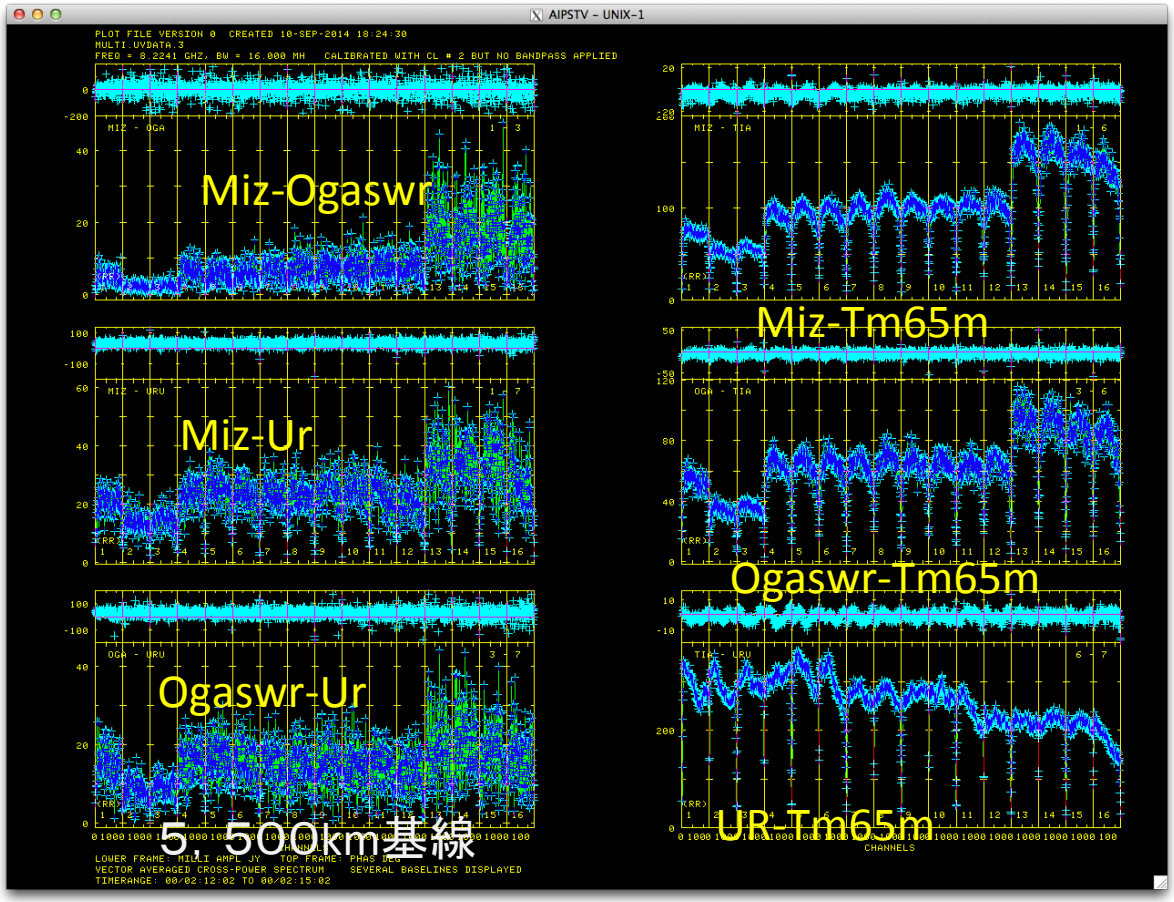
Some results of FT

- Results of the 3rd fringe test, January 2014
- 3C345, 8 GHz, no data of JVN
- Raw data





- After fringe-fitting – Only 6 baselines detected fringes



1Gbps:
16 MHz x 16IFs

Issues to be solved

- Scheduling file format of VERA differs from CVN/KVN
- Polarization matching (VERA), channelization
- Operation mistakes often happens
- Media shipping time takes long (~ 1 month)
- JVN backend has no dBBC (once data recorded with BW=512 MHz and then go through dBBC at NAOJ)
- …….

Time line

Fiscal Year	2013	2014	2015
Actions	Three fringe experiments done	Further fringe experiments Ftp-based data-transfer on-going	Imaging test
Bands	8、22 GHz	(6.7)、8、22 GHz	6.7、8、22 GHz
Purposes	Fringe detection from all the EAVN stations. (not yet)	Fringe detection Increasing # telescopes	Evaluate array performance Science commissioning

Organizing EAVN , and then ?

How can EAVN survive in the next decade?

- The same question can be made to VLBI in the world

- VLBI should continue developing its unique capability

- New science areas to be explored by adding new capabilities
  (e.g. submm VLBI technology, wide-band reception)

- Global connectivity
  - front-end and back-end (this is true for Japanese VLBI, although)
  - Linking EAVN with EVN+VLBA realizes “True” global VLBI
    => EATING-VLBI can trigger this action

Summary

Many VLBI activities in east-Asia happen

- Regional collaboration ongoing
- The VLBI in east Asia is going to be more developed.
- We might think it's time to think of "true" global VLBI – Only one but powerful VLBI network in the work

Finally….

VERA Proposal Deadline is close, 6 November, JST 17:00