VLBI in China

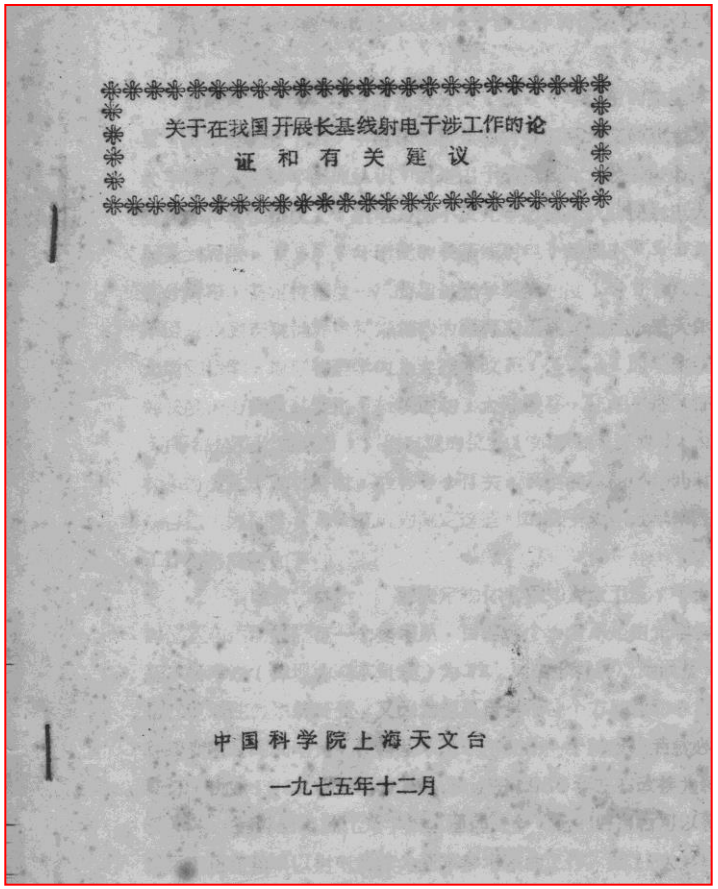
Zhi-Qiang Shen

Shanghai Astronomical Observatory (ShAO)
Chinese Academy of Sciences (CAS)

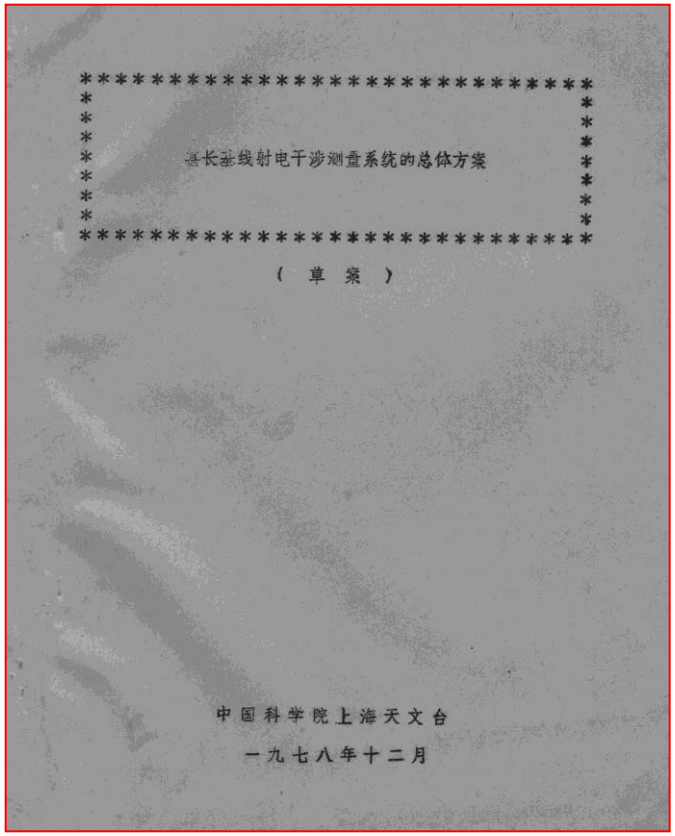
Inaugural Symposium of
Joint Institute for VLBI – European Research Infrastructure Consortium
(Dwingeloo, The Netherlands, 20–21 April 2015)

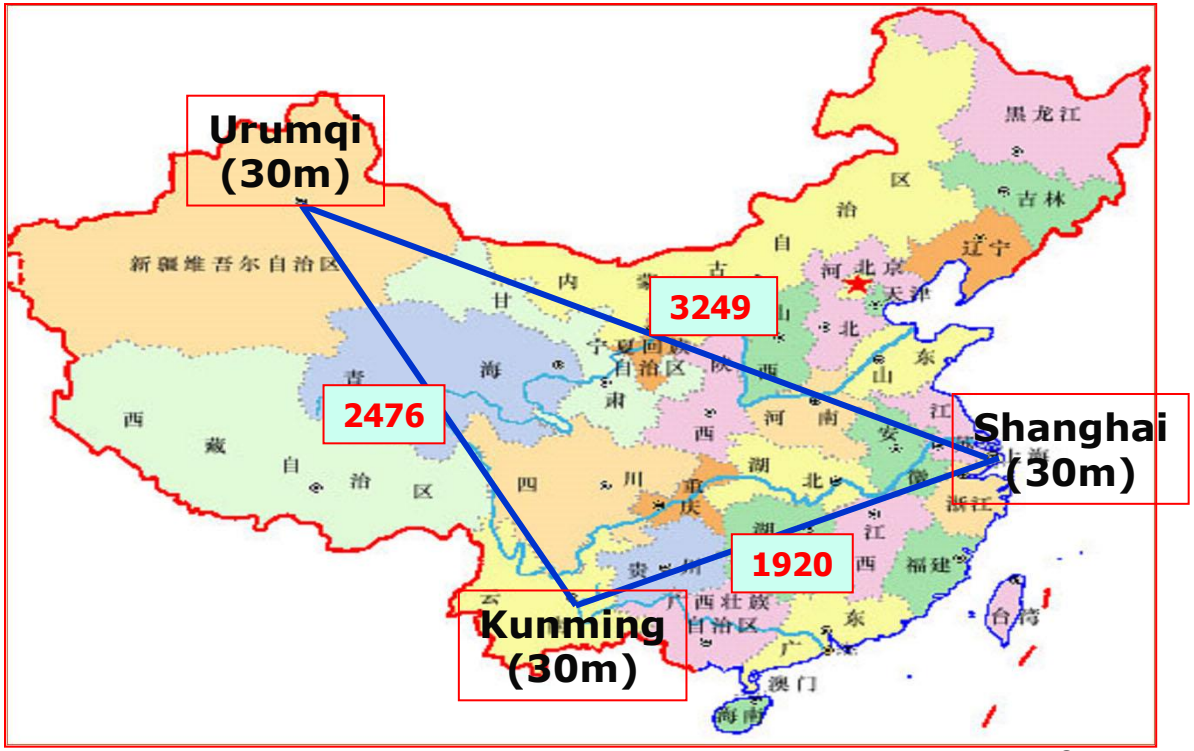
1967 First VLBI Experiments in USA and Canada

1975 A research group in ShAO led by Prof. Ye Shuhua submitted a proposal on the feasibility study of VLBI development in China.



1978 **Submitted the proposal on the "Project of the VLBI System" in China. The initial scheme is to build three 30-m radio telescopes in Shanghai, Urumqi, and Kunming.**



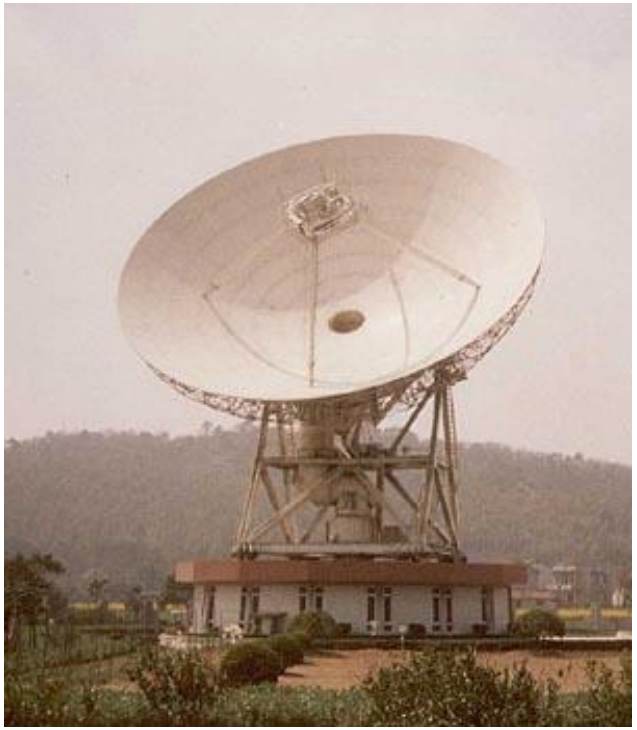


1981 **Completed the construction of a 6-m radio telescope in Shanghai. The first trans-Eurasian continent VLBI experiment was successfully conducted between Shanghai 6-m and Effelsberg 100-m at L-band using MK II recording system in November 1981.**

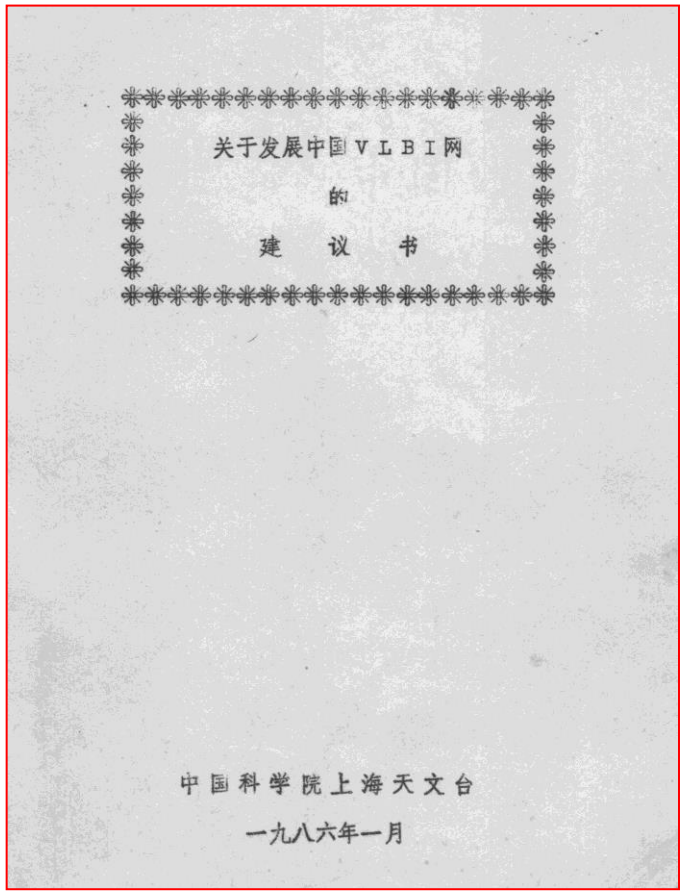
1984/5 **Two X-band VLBI experiments between Shanghai 6-m and Kashima 26-m telescope were successfully performed.**

The accuracy of the baseline measurements is about a few centimeters.

1984−1987 **A first 25m antenna was assembled and tested in the factory in 1984, and installed at Sheshan site (30km from Shanghai) in 1986/1987. Started routine international VLBI experiments in November 1987.**



1986 **Submitted a proposal on the "Development of Chinese VLBI Network". With the approval of the proposal by the CAS, the construction of both the Urumqi VLBI station and the Shanghai VLBI Center was started. In 1994, 60km away from Urumqi, Nanshan 25m radio telescope was built.**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建　议　书

中国科学院上海天文台

一九八六年一月

Shanghai Sheshan and Urumqi Nanshan 25m telescopes became the member of EVN in 1991 and 1994, respectively. They also participate in IVS and APT experiments, and some other VLBI observations, such as VSOP etc.

With the call of the China's Lunar Exploration Program (CLEP) for real time VLBI orbit determination of satellites, two new stations (40-m telescope in Kunming and 50-m telescope in Miyun Beijing) were built in 2006, as well as the Shanghai VLBI data processing center.

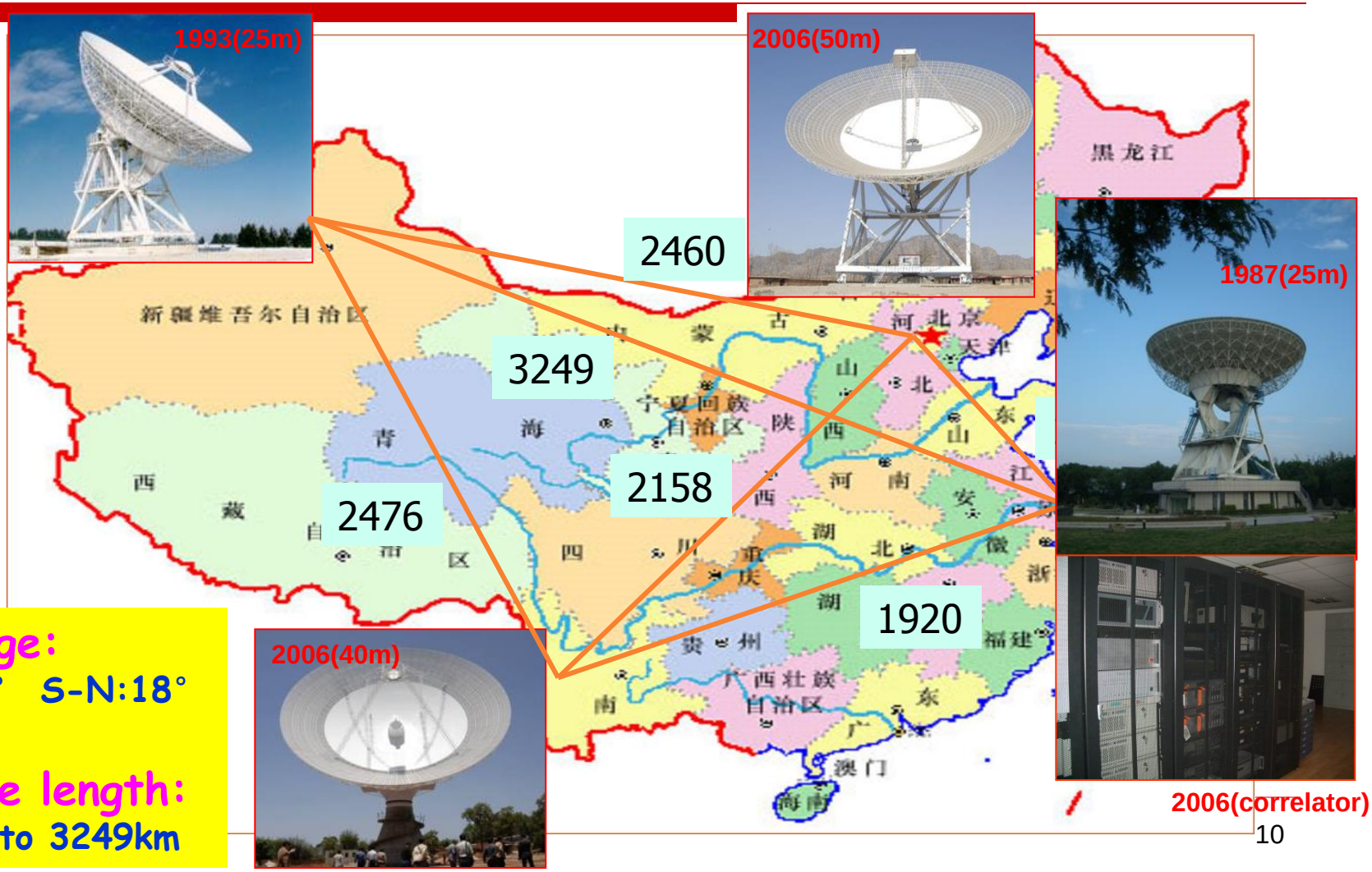
China joined

- EVN CBD meeting，PC meeting，TOG meeting…

  (EVN technical support to Chinese VLBI stations)

- JIVE board
- Continue with JIV-ERIC

Chinese VLBI Network (CVN):
soft/hard-ware correlators



Coverage:
E-W:34° S-N:18°

Baseline length:
1115km to 3249km

CVN -VLBI data processing center

Hardware correlator (5 stations)

Software correlator (4 stations)

Output data: CE format (for satellite tracking)

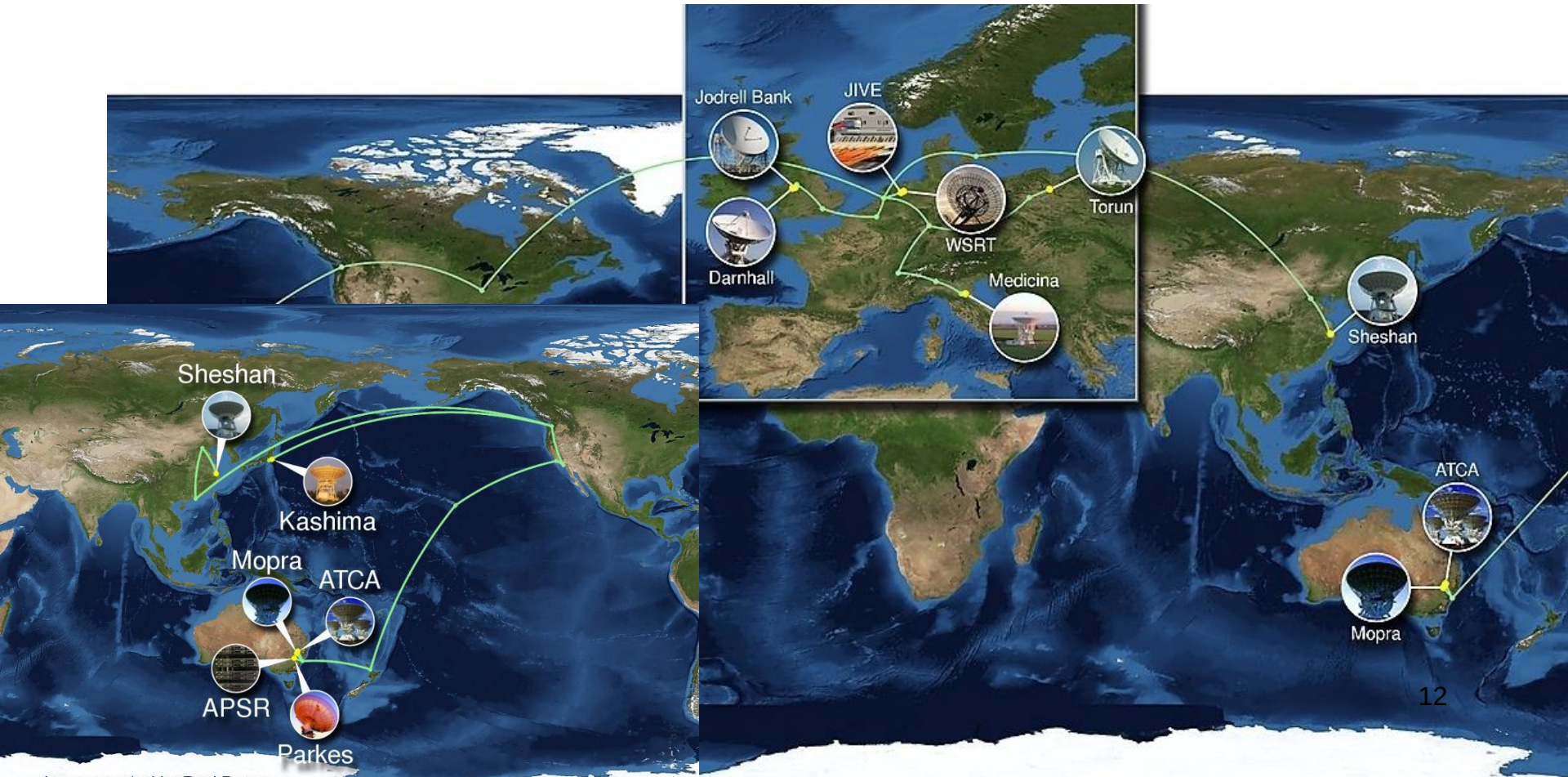
FITS format (for astronomy)

Software for CE data processing

(near real time, in 3-5 min.)

e-VLBI

2007 August 28: Shanghai –Australia & Europe (256Mbps)
2008 June 17: Shanghai –Australia & Japan (512Mbps)
2009 January 6: Shanghai-Urumqi (256Mbps)
2009 January 15-16: IYA marathon obs. (Asia, Australia, Europe, America)
2009 February - : Shanghai 25-m participates in the routine eEVN sessions



CVN (Km+My+Sh+Ur) + Onsala 20-m + Medicina 32-m;

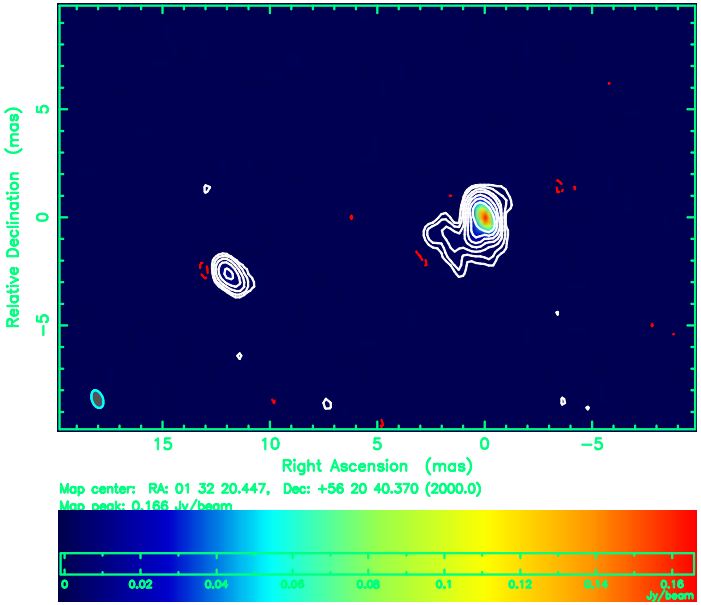
2009 Aug 5-6;

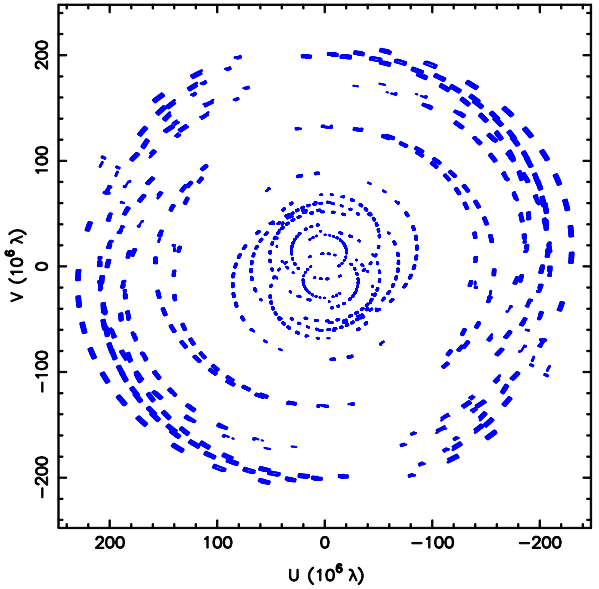
24 hr;

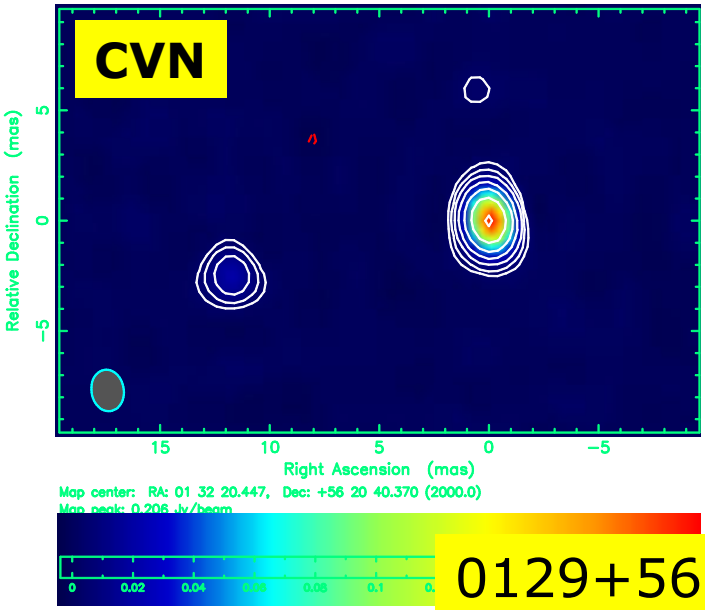
X-band;

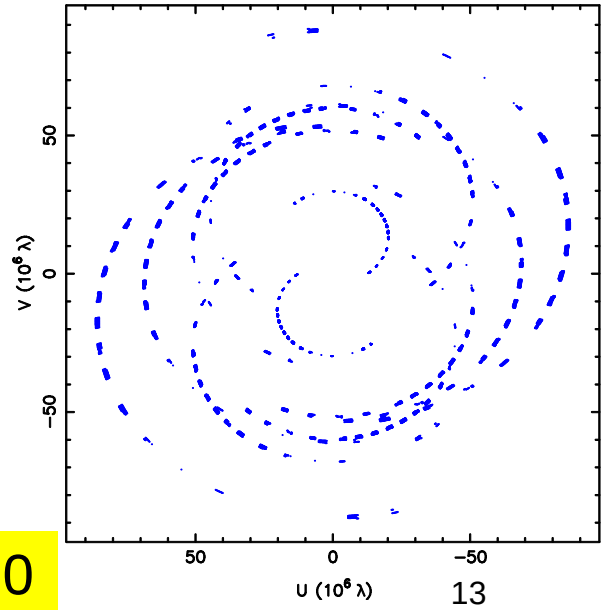
5 GPS sources

JIVE Correlator





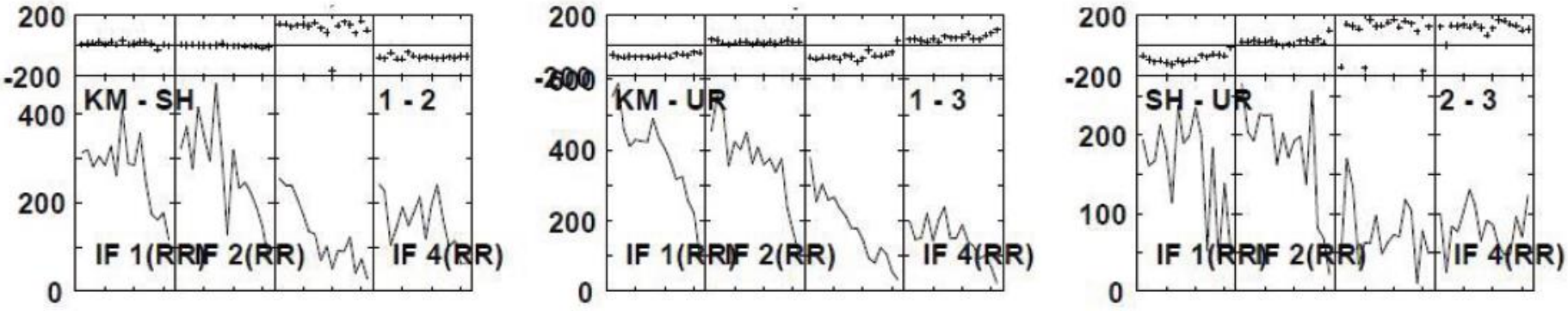




0129+560

CVN study of pulsars

CVN (Km+Sh+Ur); PSR B0329+54 (200 mJy @ 1.4 GHz); phase-ref ~3 hr (2008 Oct 16) @ S-band; software correlator (DiFX)



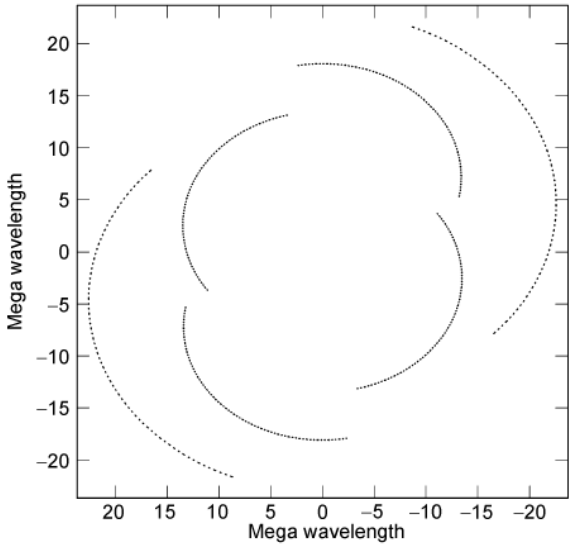


Figure 1 The (u, v) coverage obtained for PSR B0329+54 at 2.2 GHz from 3 baselines formed from the CVN antennas Shanghai Kunming and Urumqi.

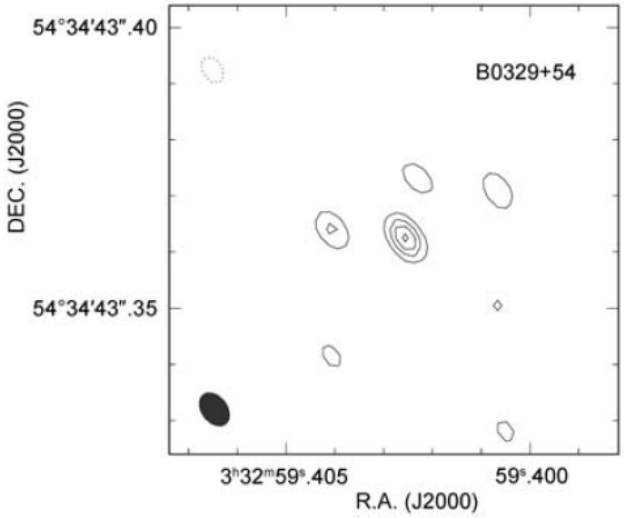


Figure 4 Image of PSR B0329+54 observed with CVN at 2.2 GHz. Contour levels are spaced linearly at 8.0 mJY beam^{-1} (2σ). The peak flux density is 23 mJy beam^{-1}.

(Guo et al. 2010)

VLBI astrometry/geodesy

- With the current CVN geometry and specifications, several dozens of ICRF defining sources could be monitored on a regular base.

- Capable of determining distance of several 1000 km at cm and even mm accuracy.

  Simultaneous observations of CVN and international VLBI antennas could also be used to study crustal motion and deformation.

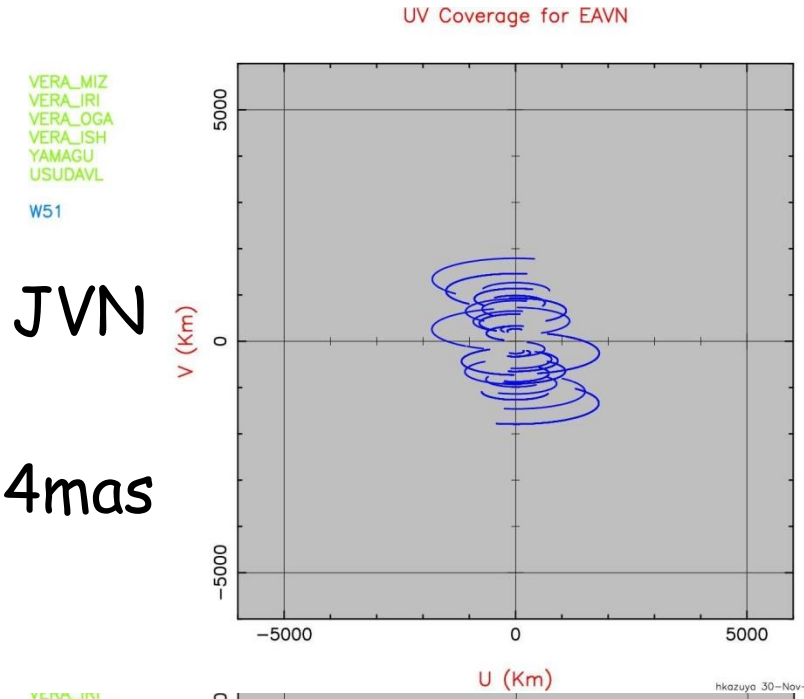
- Regular determination of EOP.

(Li et al. 2008)

UV coverage for W51

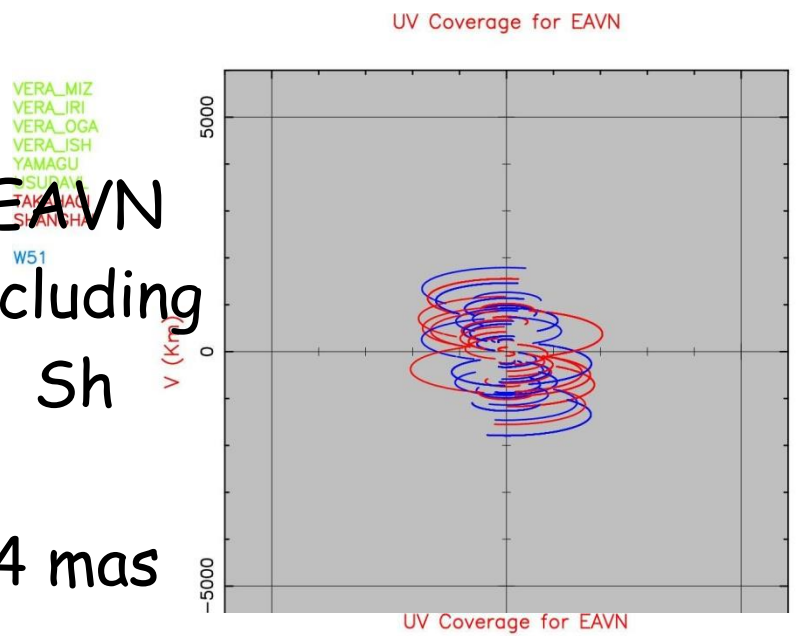
JVN

4mas



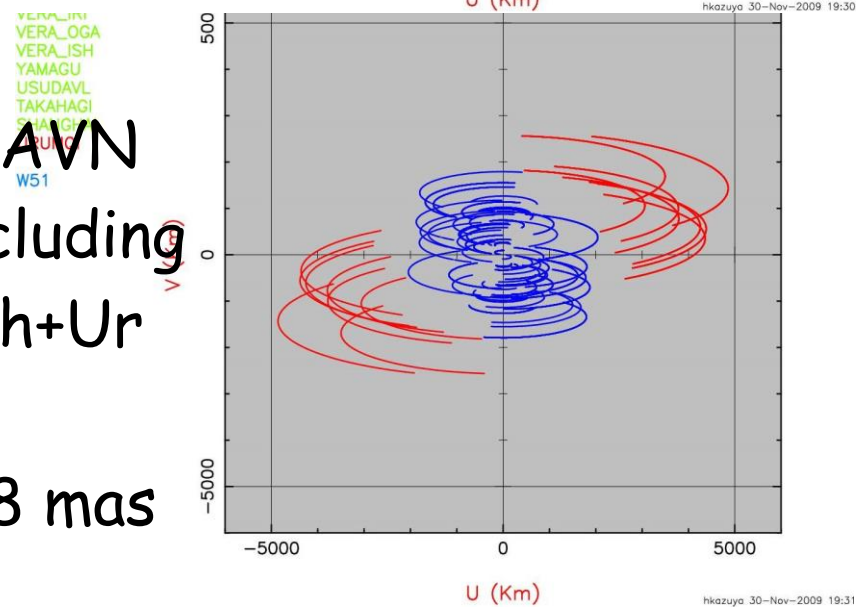
EAVN including Sh

4 mas



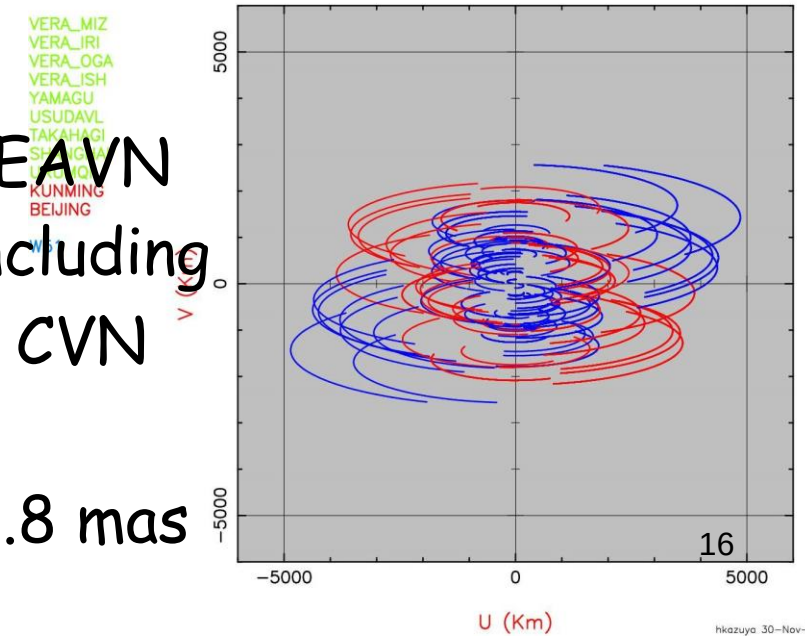
EAVN Including Sh+Ur

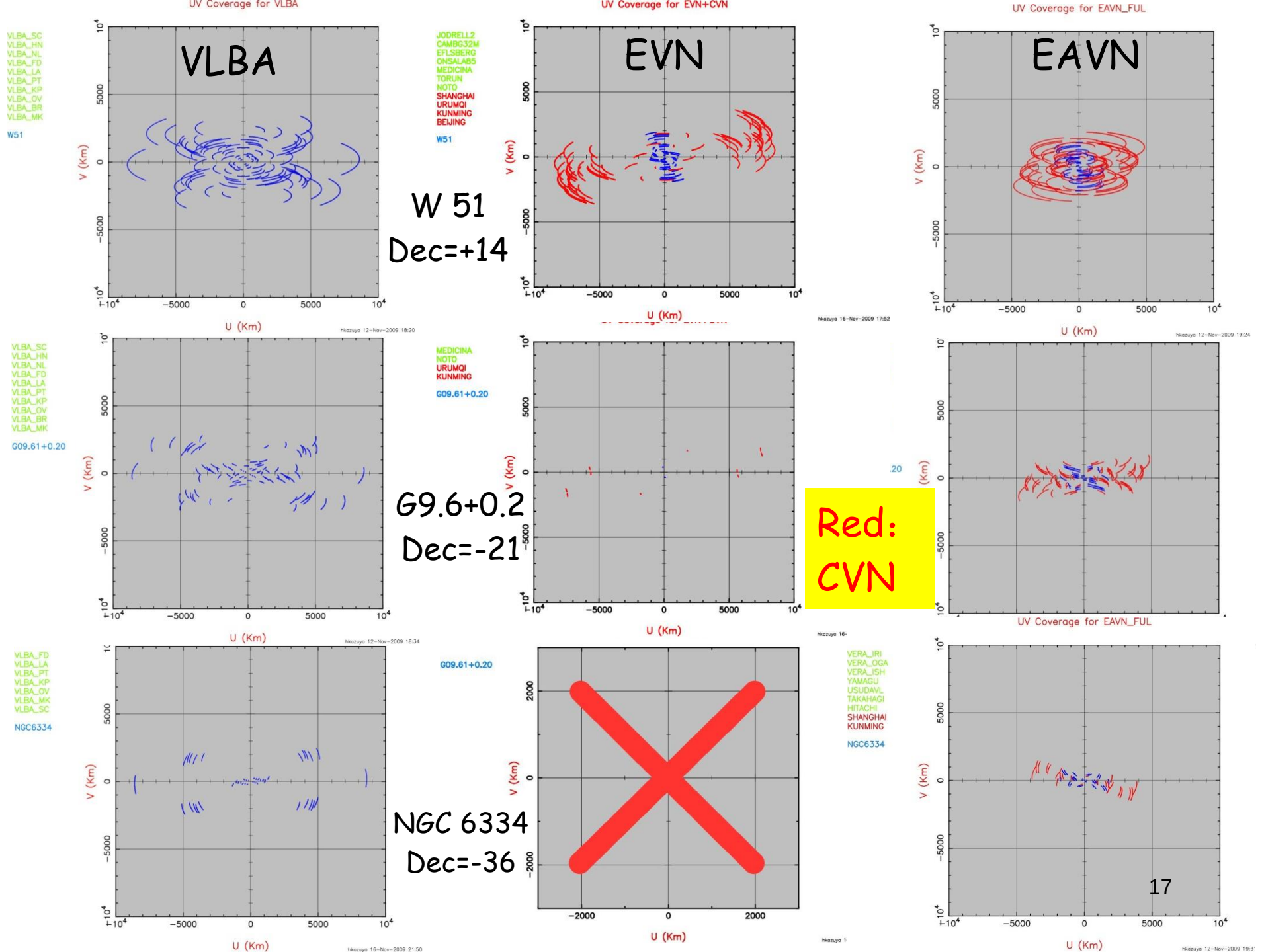
1.8 mas



EAVN including CVN

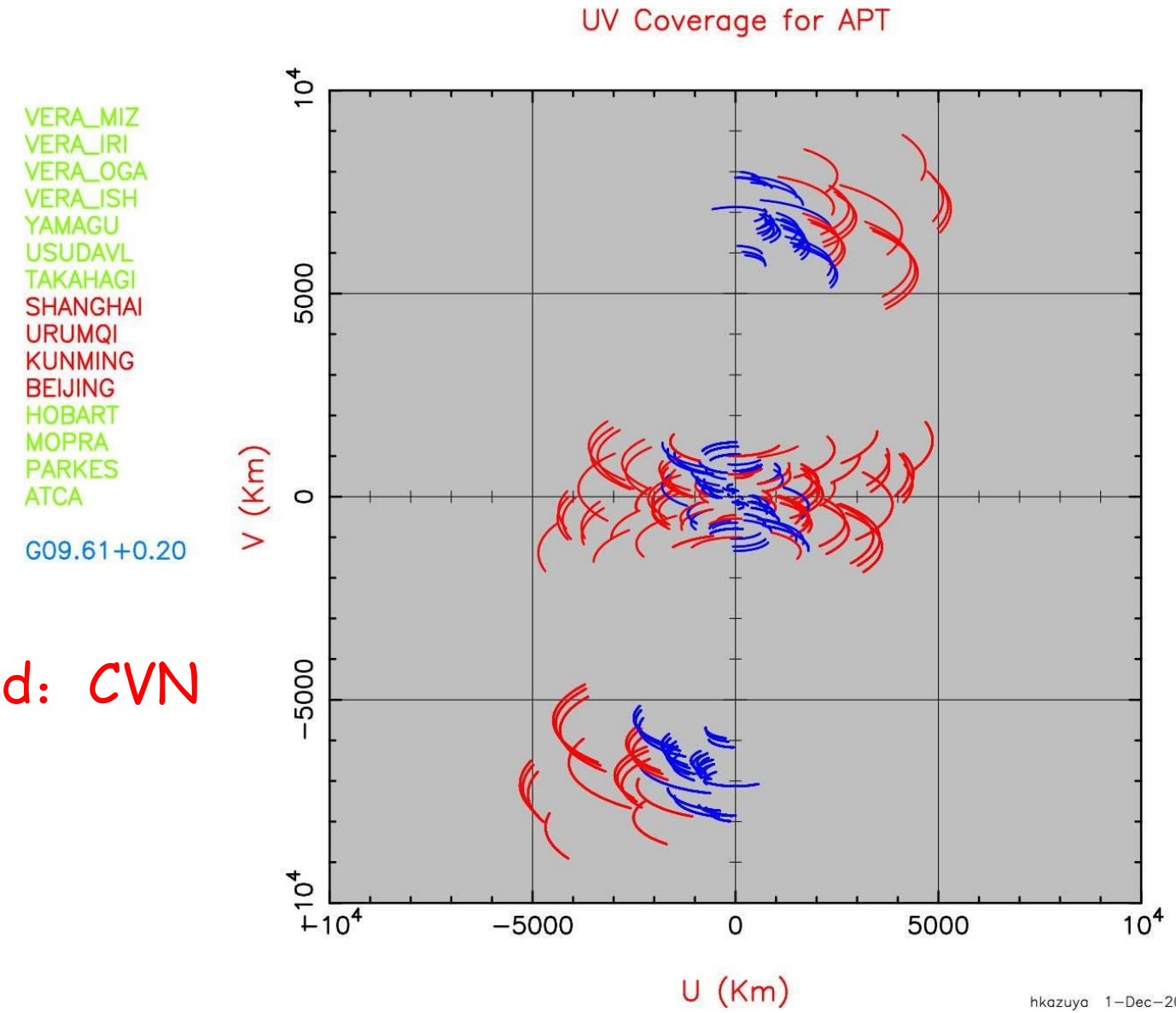
1.8 mas




VLBA
EVN
EAVN
W 51
Dec=+14
G9.6+0.2
Dec=-21
Red:
CVN
NGC 6334
Dec=-36
17

APT

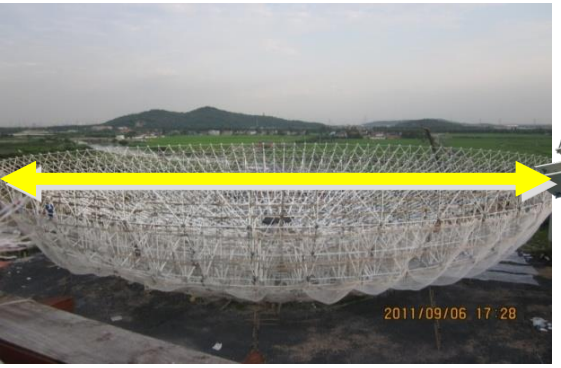
uv coverage for G9.6+0.2 (Declination = -21 deg.)

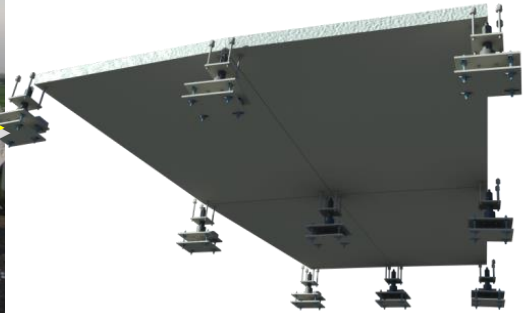


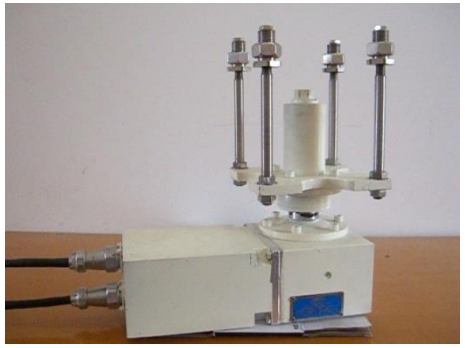
Red: CVN

Shanghai 65m Radio Telescope

- 65-m in diameter, fully steerable radio telescope
- Active surface system installed (3rd in the world)
- Covering 1 – 50 GHz with 8 bands
  - L(1.6GHz), S/X(2.3/8.4GHz), C(5GHz), Ku(15GHz), K(22GHz)
    X/Ka(9/30GHz), Q(43GHz)
- Sensitivity & frequency coverage enable a wide-range of science
- State-of-the-art detector suite for spectroscopy, pulsar observations, continuum, VLBI







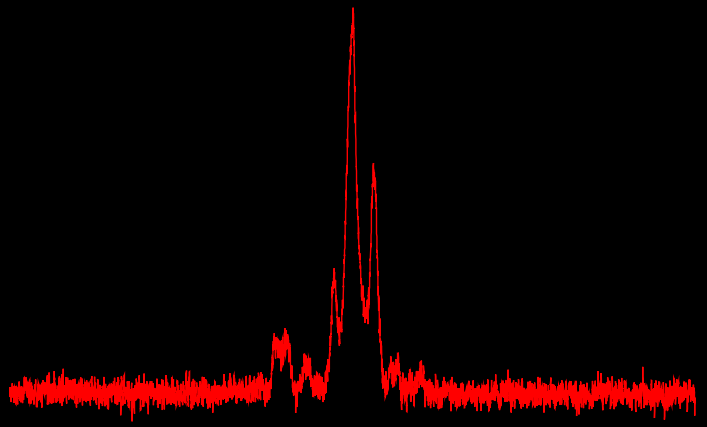
Tian Ma Radio Telescope

Approved in 2008

Site construction started in 2010

First light in October 2012

Named TiamMa in December 2013



First light from W3(OH)

unique two stations in CVN— short spacing

Baseline ~ 6.1 km

Tianma 65 m telescope

Sheshan 25 m telescope

Pseudo Closure Amplitude (PCA) Analysis

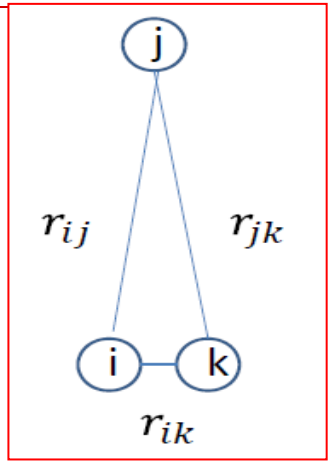
【Definition】

$$PCA_i = \frac{\rho_{ij} \times \rho_{ik}}{\rho_{jk}} = S_0 S_i \times \frac{r_{ij} r_{ik}}{r_{jk}}$$

$$PCA_j = \frac{\rho_{ij} \times \rho_{jk}}{\rho_{ik}} = S_0 S_j \times \frac{r_{ij} r_{jk}}{r_{ik}}$$

$$PCA_k = \frac{\rho_{ik} \times \rho_{jk}}{\rho_{ij}} = S_0 S_k \times \frac{r_{ik} r_{jk}}{r_{ij}}$$

So : Source Flux
Si: Station i Sensitivity



$$r_{ij} \cong r_{jk} \cong r$$
$$r_{ik} \cong 1$$

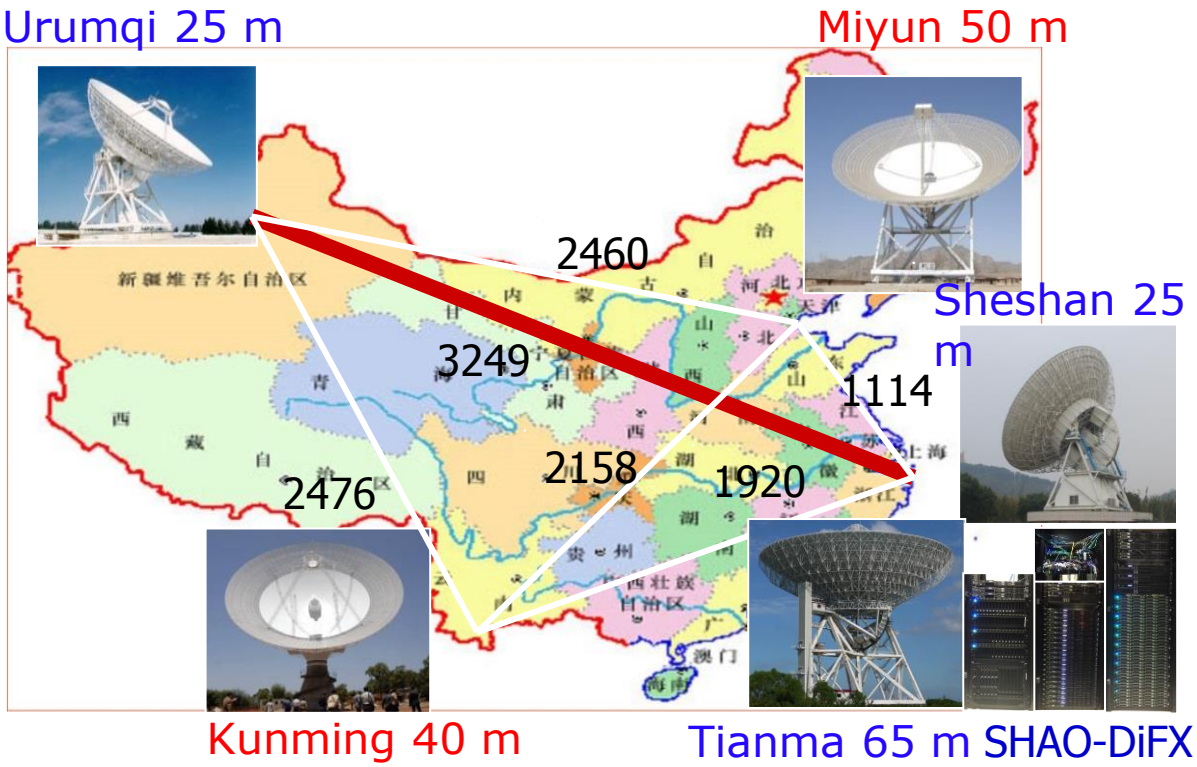
【Remarkable Features on a sharp triangulation】

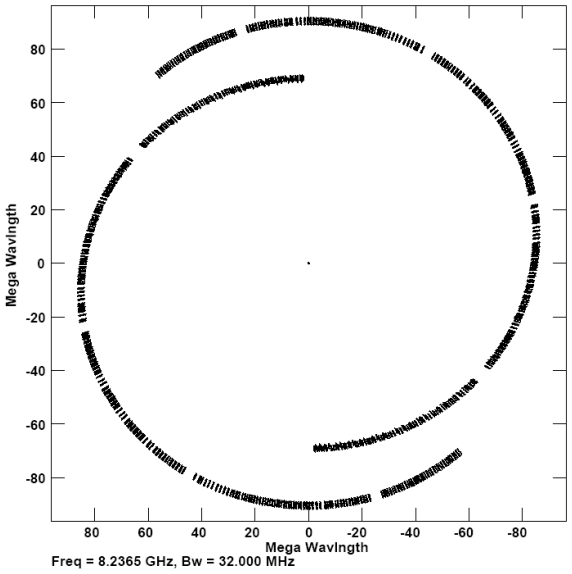
$$PCA_i \cong S_0 S_i \quad \boxed{PCA_j \cong S_0 S_j {r_0}^2} \quad PCA_k \cong S_0 S_k$$

No calibration is necessary for antennae i and j!

CVN observation of M81

X band observation with 3 CVN stations, Tianma 65 m, Sheshan 25 m, and Urumqi 25 m, for about 16.5 hr on Feb 13, 2014.





(u,v) coverage of Tm-Sh-Ur

Detection of a compact jet component

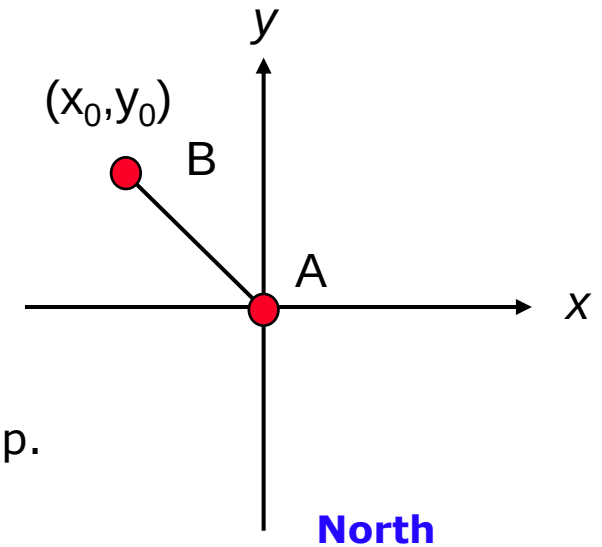
For two point source brightness

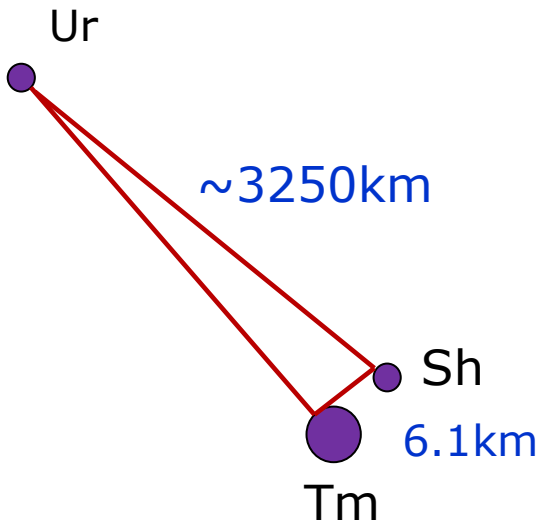
$$T_b(x,y) = A \bullet \delta(0,0) + B \bullet \delta(x - x_0, y - y_0)$$

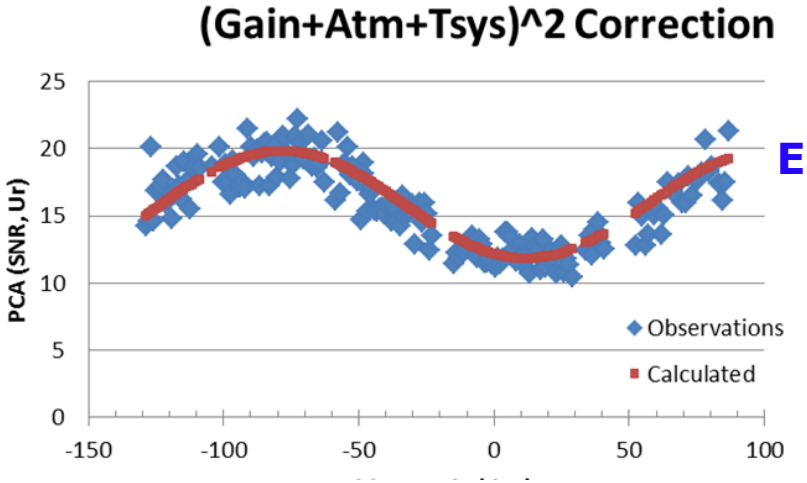
The amplitude of visibility function is given:

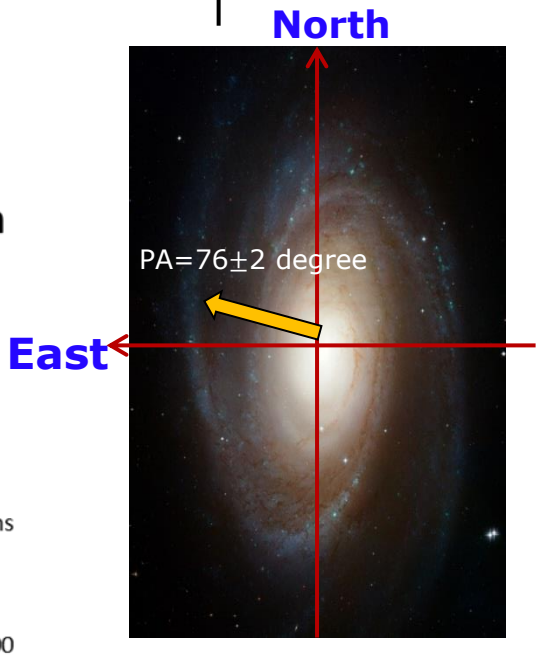
$$|V(u,v)| = C - D \bullet cos2(\theta - PA)$$

PA is a position angle of the 2nd comp. wrt the 1st comp.





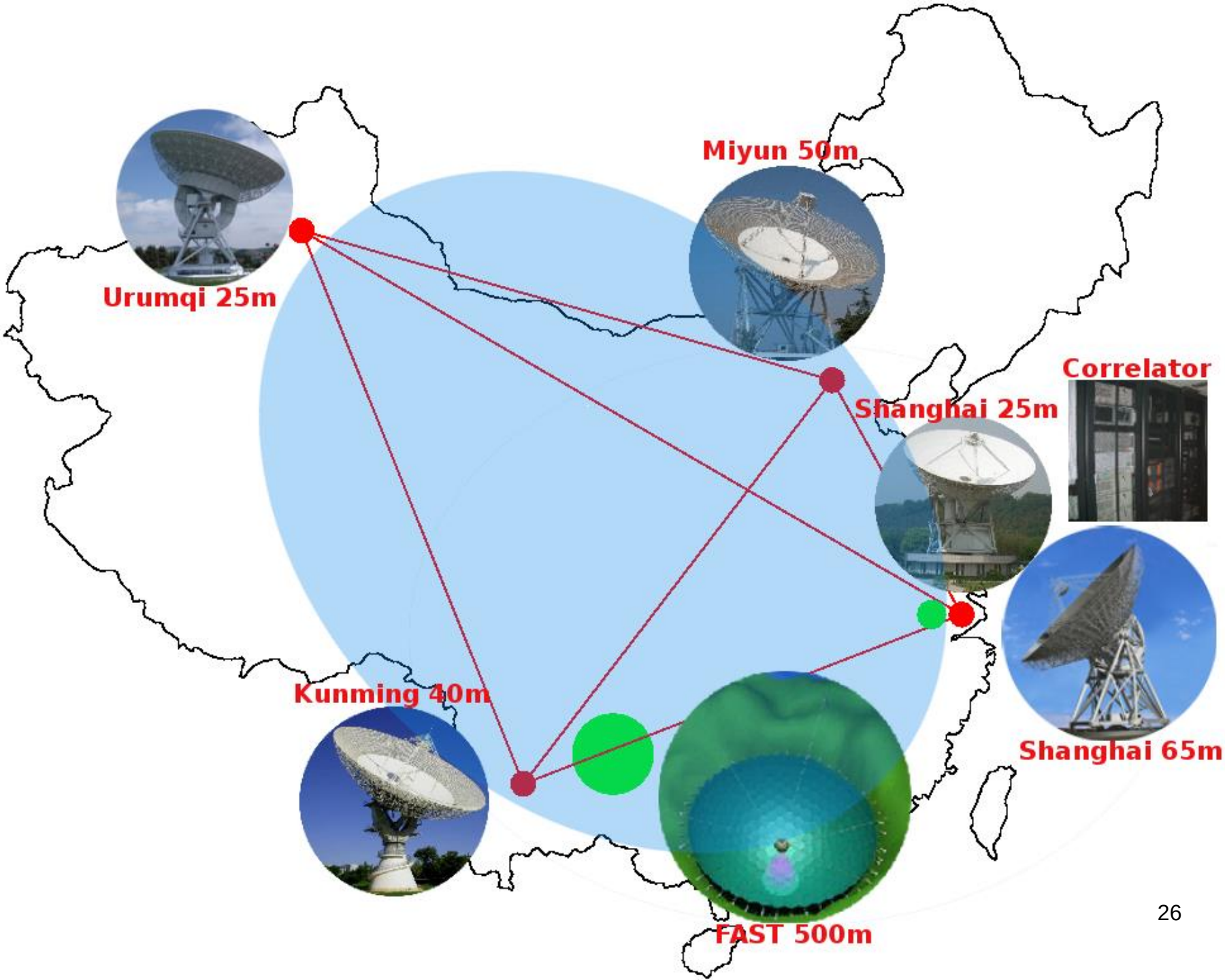




FAST- Five-hundred-meter Aperture Spherical Telescope

Approved in 2007; site construction started in 2011; first light expected in 2016
9 bands from 70 MHz to 3 GHz (8 GHz)

- **Unique Karst depression as the site**
- **Active main reflector**
- **Cable - parallel robot feed support**


Urumqi 25m
Miyun 50m
Correlator
Shanghai 25m
Shanghai 65m
Kunming 40m
FAST 500m

Summary

- It takes 30+ years (1975-2006) for the establishment of the Chinese VLBI network (CVN)!
- Nowadays, the CVN of five VLBI stations plus a correlation center has gradually started performing astrophysical and geodetic observations as well as the VLBI tracking of space probes.
- More activities are expected with the ever-increasing international collaborations, such as EVN etc.