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The Software Correlator Status of Chinese VLBI Network

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Slide#: 1

Outline

- ◆ The history of CVN software correlator.
- ◆ The development status of CVN software correlator.
- ◆ The future work.

◆ The history of CVN software correlator

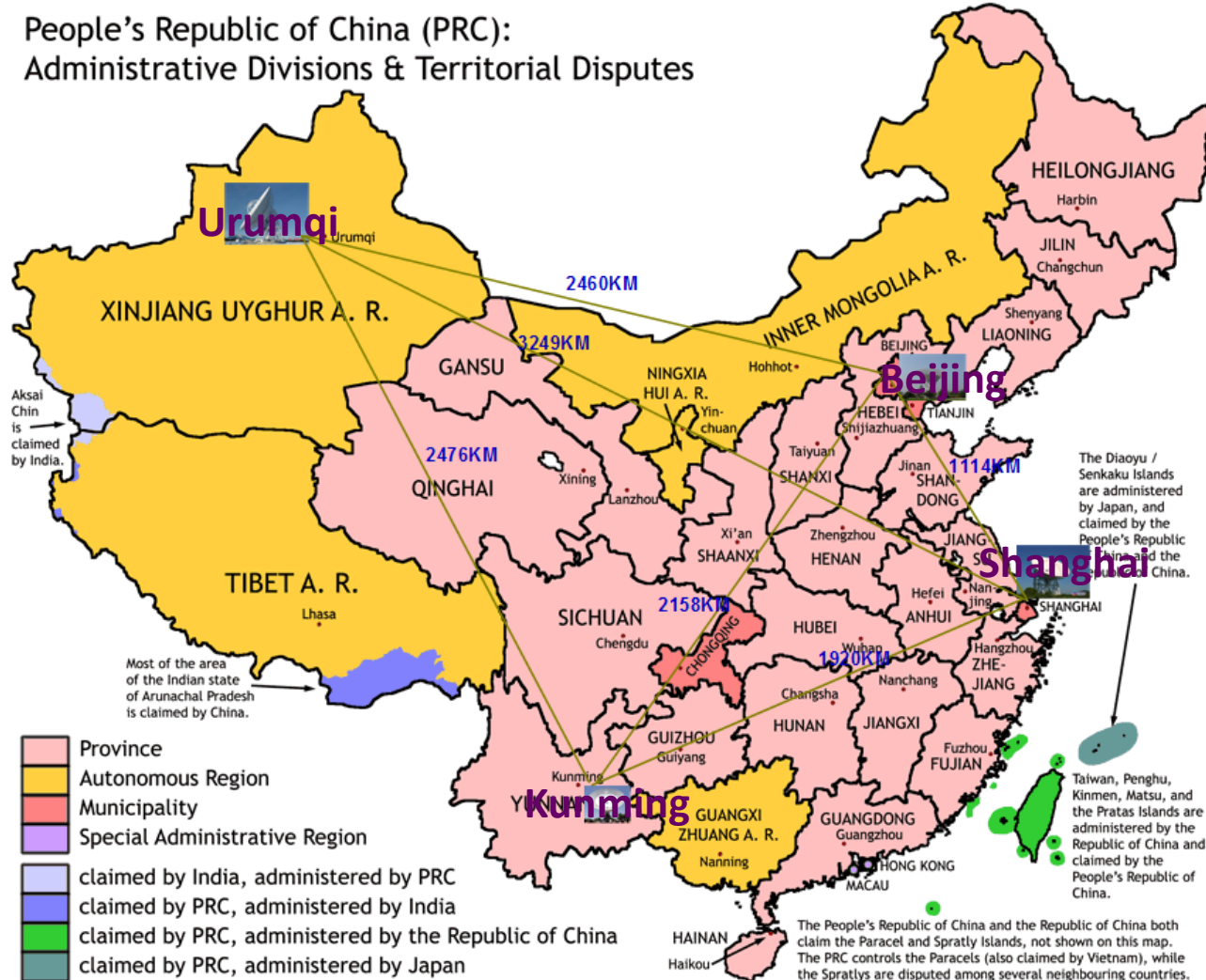
- Development was begun in 2007.
- The early version implement parallel using Pthread.
 - It took part in CE-1, CE-2 mission as a primary equipment and did good jobs in 2007 and 2010.
- The newer version implement parallel and distributed computing using MPI and OpenMP.
 - It executed the CE-2 extended mission of flying over the second Solar-terrestrial Lagrange point. Last year, the real-time parallel version software correlator completed the CE-3 task successfully based on e-VLBI technology.

◆ The development status of CVN software correlator

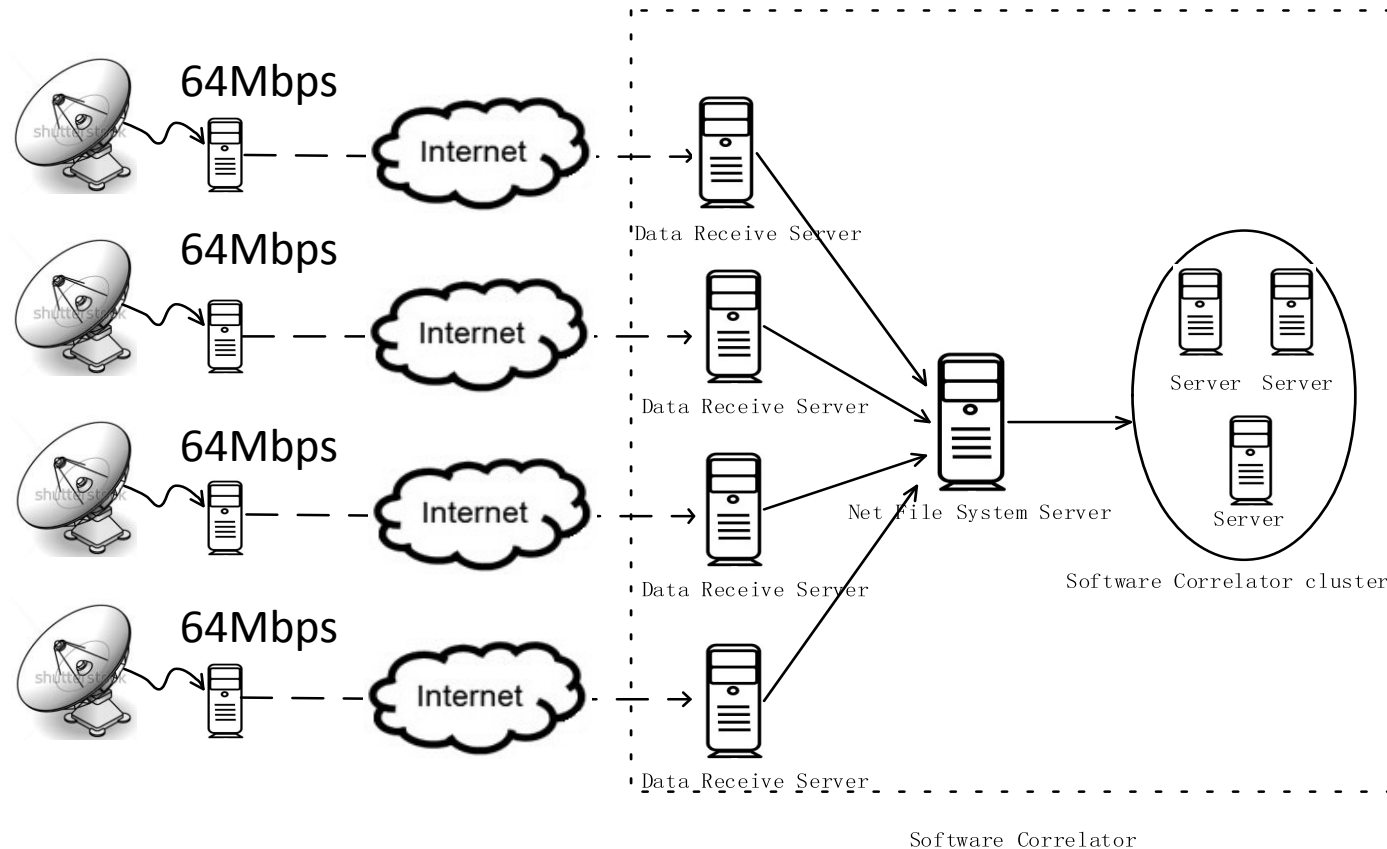
Get the data over network by TCP/IP protocol

Enables real-time (applied in the Chinese lunar exploration).

People's Republic of China (PRC):
Administrative Divisions & Territorial Disputes



➤ Data flow diagram



Data Flow Diagram in Chang'E 3 Mission based on e-VLBI technology

The Software Correlator Status of CVN

Slide#: 5

➤ Specifications

Specifications of CVN software correlator

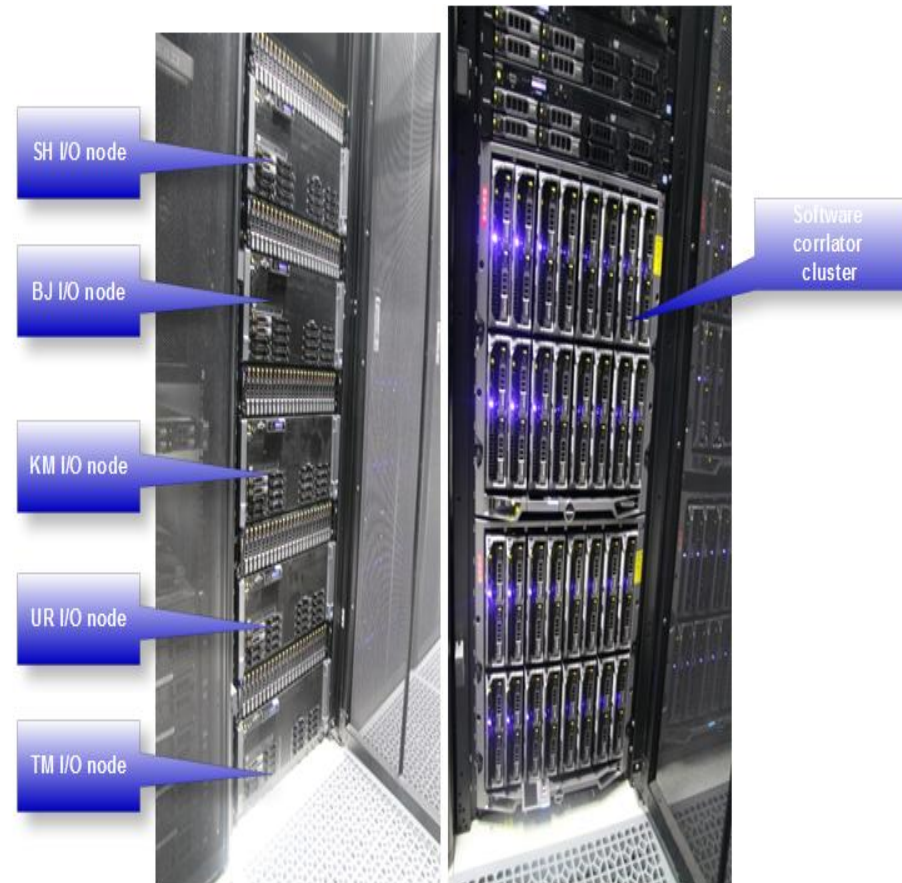
Processing Mode	Real-time & post-processing
Station number	1~20
Real-time fast fringe search	4 stations
IF number	1,2,4,8,16
Frequency channel	24~16384/IF
Integration period	0.1~60 second
Maximum data speed	About 1.9Gbps/station, totally 4 stations

Test method of maximum data speed: read the data from Mark5 and write to the hard disk. Use 128 cores totally . The following powerpoint will introduce the performance of the computing platform which the test was done on.

➤ Computing platform

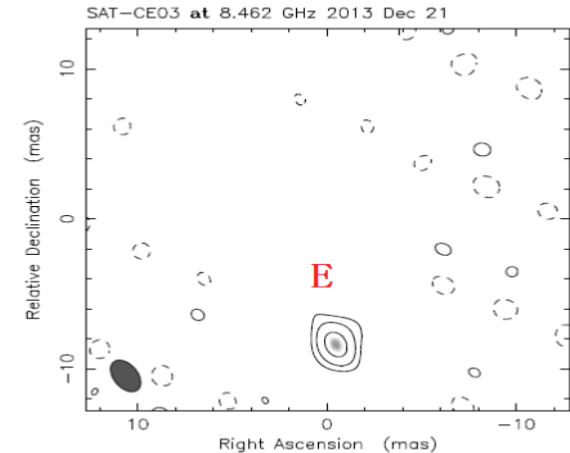
Standard Linux cluster

- Five I/O nodes
 - E7-4820*4/ 128GB/ 300GB+12TB
- 32 compute nodes,
12cores/node
 - E5-2640*2/ 32GB/ 300GB
- 2 manage nodes
 - E5-2620*2/ 24GB/ 900GB+214GB
- Management network
 - 10G Ethernet
- Compute network
 - InfiniBand



➤ Input and output data format

- Input data format
 - Mark 5A ,Mark 5B
 - Now adding VDIF
 - Adding the new input data format is easy
- Output data format
 - CVN specific data format
 - Converted into FITS-IDI
can be loaded by AIPS directly



➤ The structure and algorithm

- FX correlator

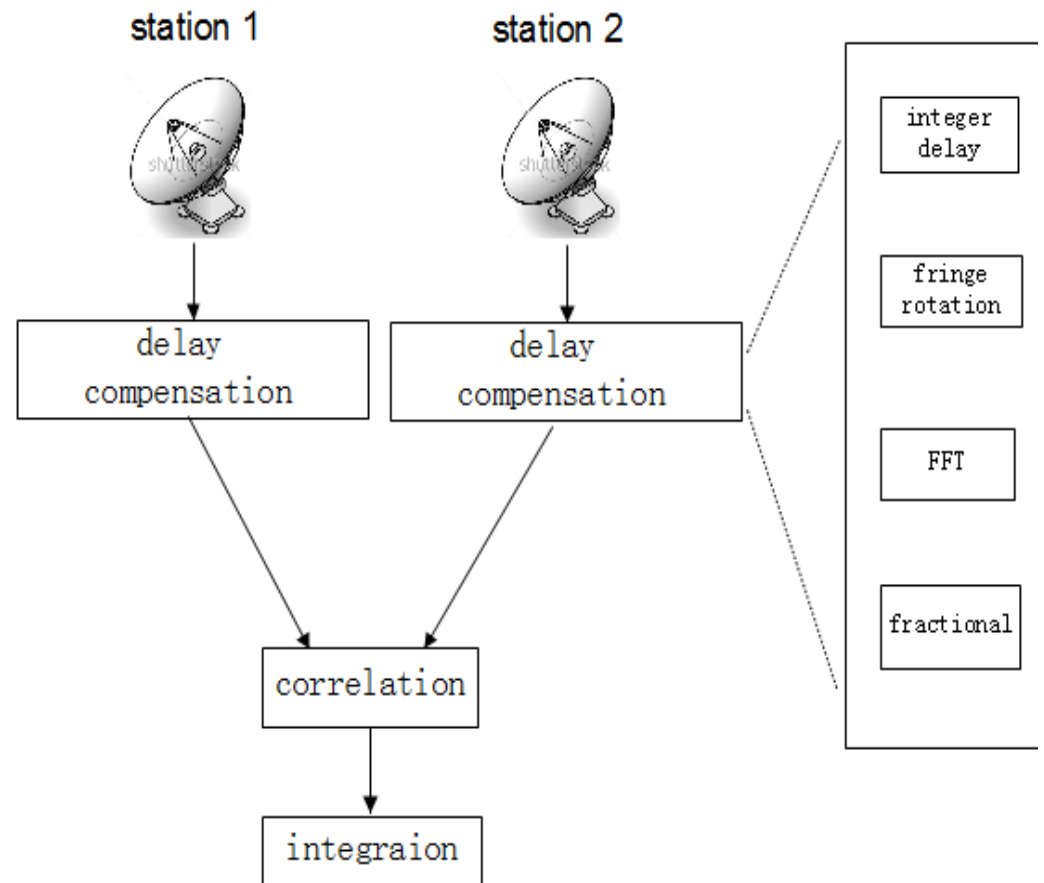
- Parallization

By time

Based on MPI and OpenMP

- Runs on standard linux clusters

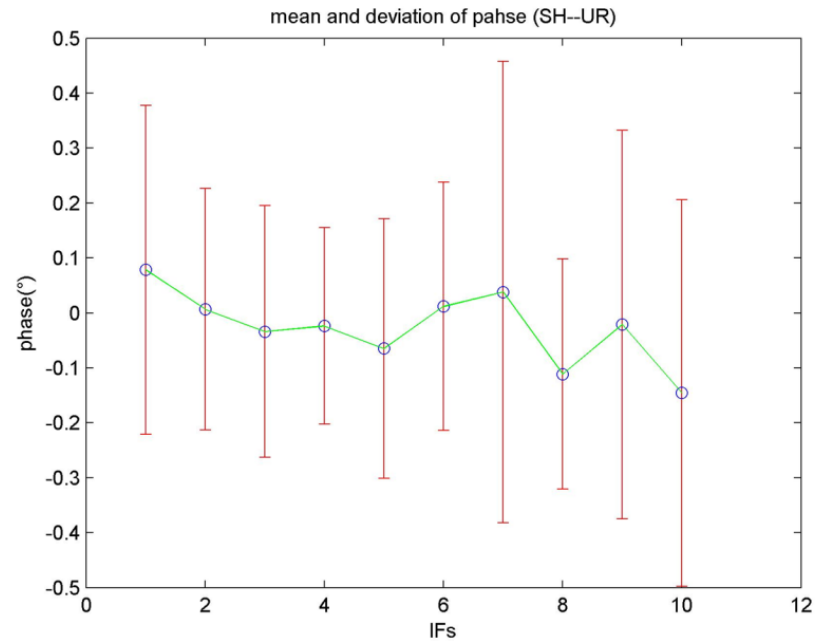
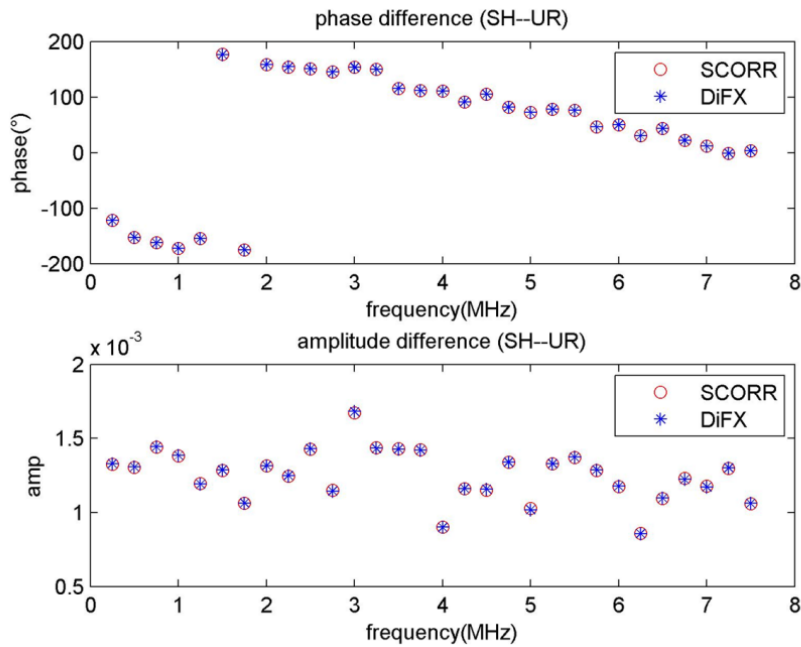
Algorithm



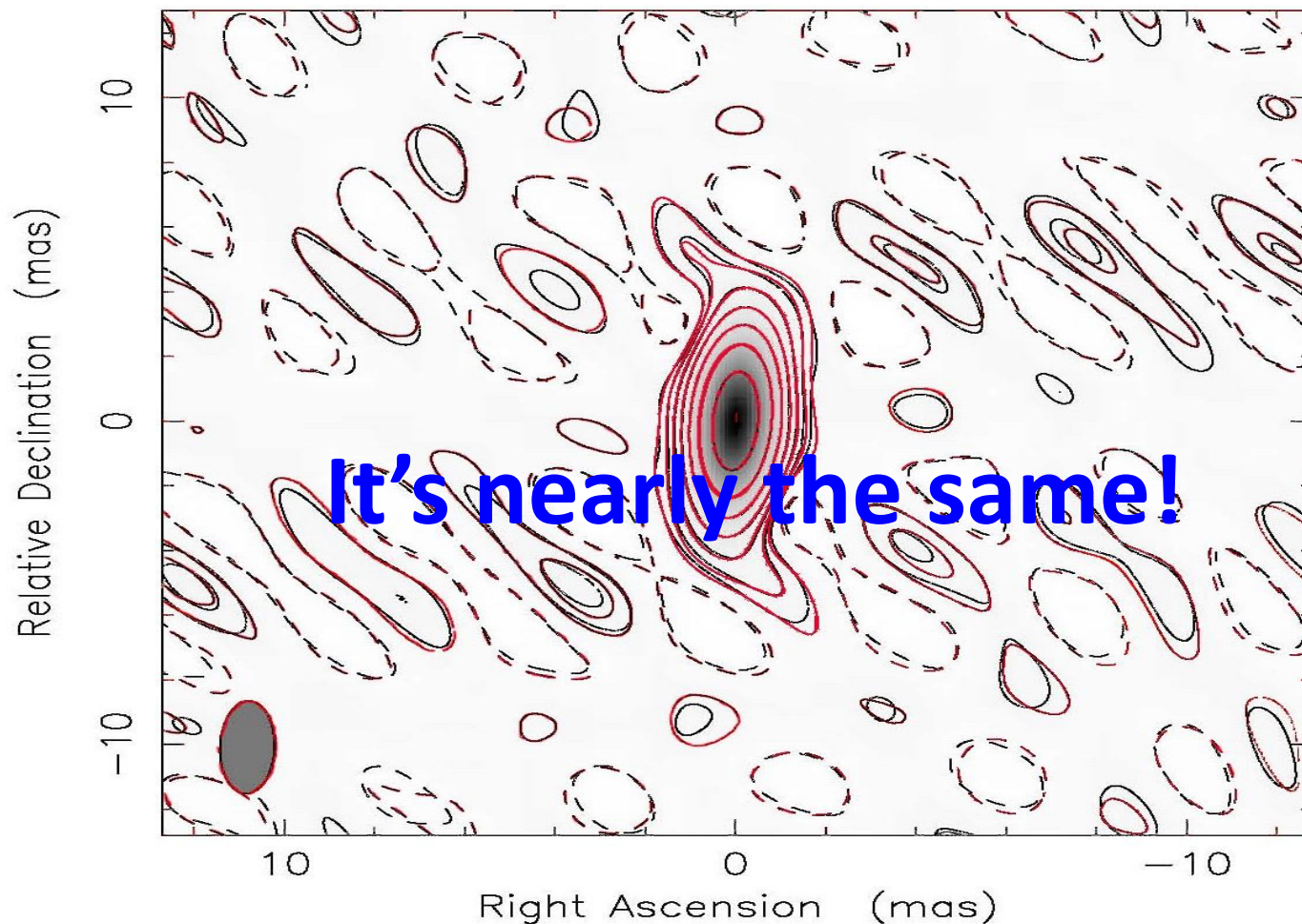
➤ Software Engineer

- Written in C
 - with Python scripts
 - with Matlab to show the intermedia result
- Optionally uses Intel IPP library
- GPU version is in development

➤ Compared to the DIFX's result



Clean RR map. Array: KSTU
4C39.25 at 8.476 GHz 2013 Nov 07

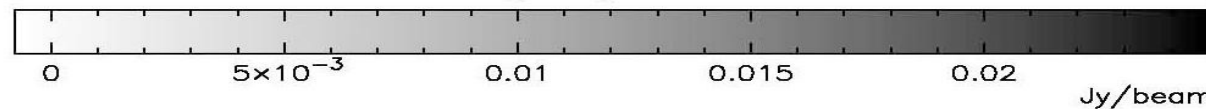


Map center: RA: 09 27 03.014, Dec: +39 02 20.852 (2000.0)

Map peak: 0.0249 Jy/beam

Contours %: -1 1 2 4 8 16 32 64

Beam FWHM: 2.88 x 1.21 (mas) at -1.34°



➤ The development of GPU version

This result is based on monitoring and control signals. Currently, this version can only run on the single GPU development board.

GPU: C2070(compute ability 2.0)

Raw Data: 4 Stations, 2Bit Sampling,
64Mbps/Station, FFT points: 1024

Speed: about 300Mbps/Station

➤ Functions

- For spacecraft tracking: Chinese lunar exploration

- Phase calibration tone extraction

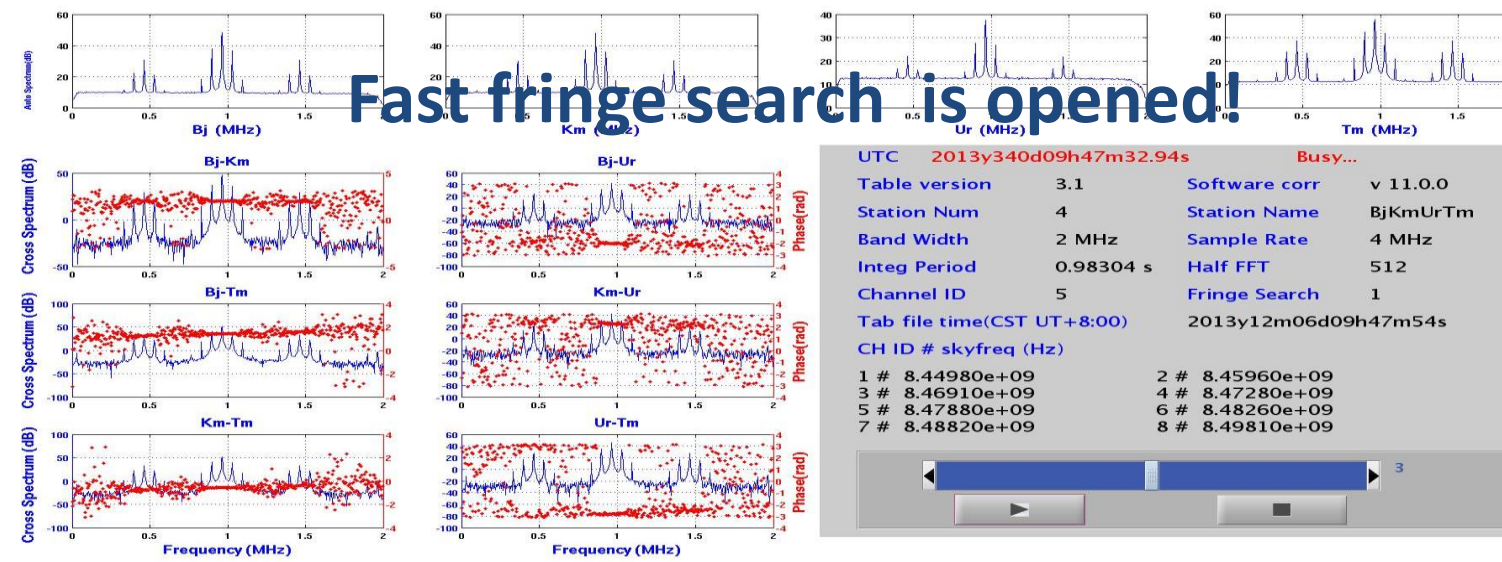
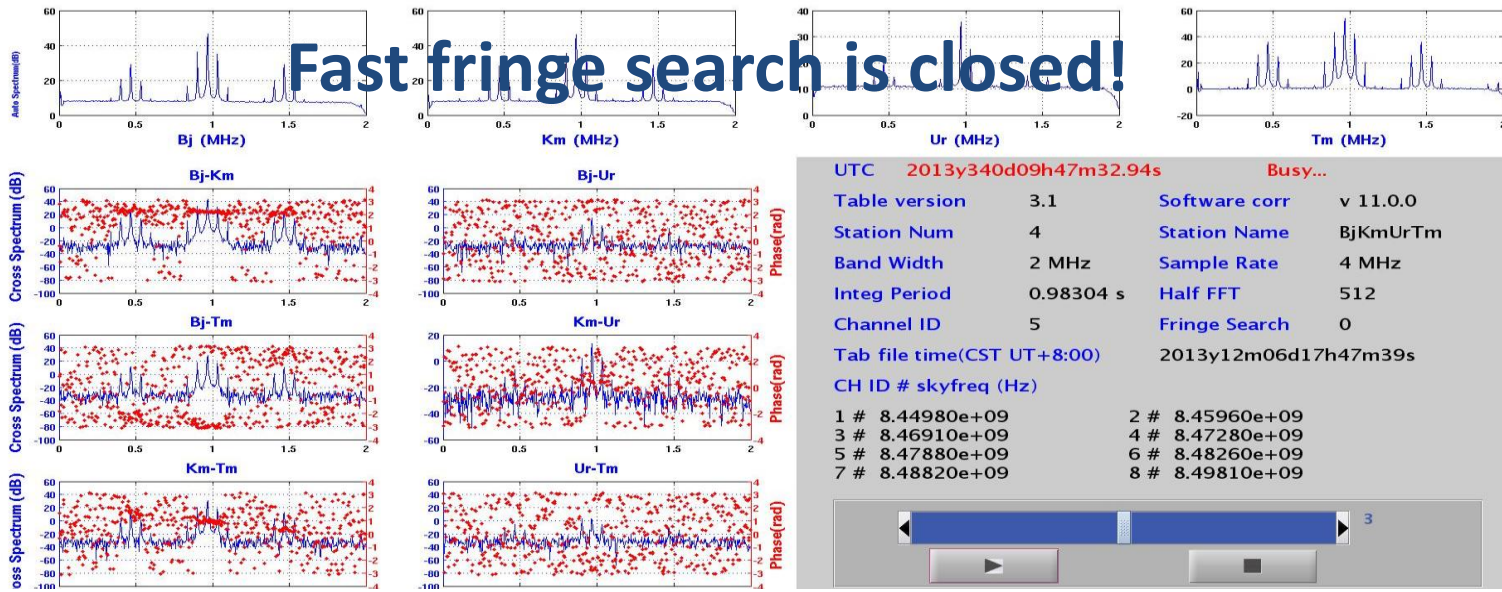
- PCAL tones are injected at the front end of a VLBI antenna in order to provide a convenient means to estimate instrumental delays

- fast fringe search

- In general, during orbital maneuver phases, the accurate orbit cannot be provided in advance, so the correlator can not work properly in such conditions. Fast fringe search module firstly extracts the main carrier frequencies from the signals of different stations, produces the delay-rate, and then compensates the delay and delay-rate.

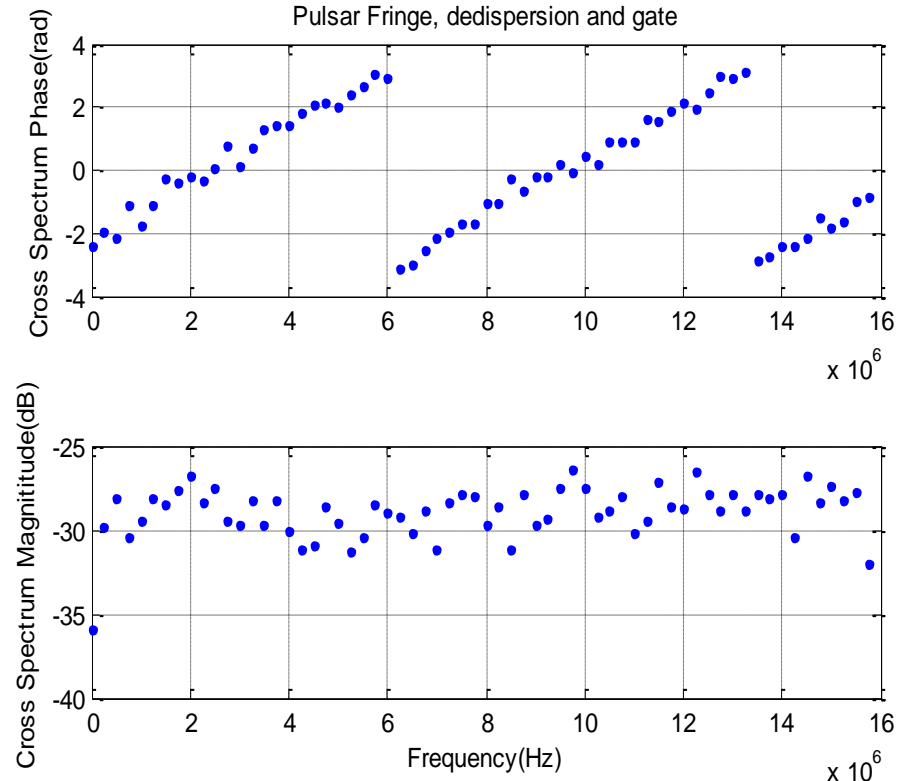
- Real-time visibility monitoring

The result of CVN software correlator using the fast fringe search function. The show tool is real-time monitoring tool developed by ourselves.



➤ Continue ...

- For geodesy
 - Used in Crustal Movement Observation Network of China
- For astronomy
 - Pulsar
 - be in the experimental stage.



Pulsar Fringe using CVN software correlation

The future work

- Develop the high speed GPU-based software correlator for VGOS
- Add new functions
 - the pulsar function
 - the multiple phase centers function
 - the polarization function

Thanks you very much!