Recent Geodetic Activities of the Shanghai VLBI Correlator

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Abstract Recent geodetic activities concerning the Shanghai VLBI Correlator are reported in this paper. A more accurate delay model was implemented in the domestic correlator job generating software, which has been used for the VLBI sessions for tracking satellites and the Chinese domestic geodetic VLBI program. The comparison results of model delays with Calc9.0 will be shown. We also managed to develop an offline software function to convert the correlator output into FITS-IDI format. Furthermore, we obtained some experience in processing a few geodetic sessions with an ad hoc DiFX correlator and the HOPS software, the final results were very promising. A new hardware cluster dedicated to DiFX was constructed. It will expand to a platform of more than 300 cores, 300TB RAID, and eight Mark 5 units by 2014.

Keywords Geodesy, VLBI, correlator, DiFX

1 Introduction

Shanghai Astronomical Observatory (SHAO) organizes the Chinese VLBI network (CVN) and operates the correlator center. The correlators including hardware correlator and software correlator were developed at the beginning of this century. They have already played an important role in the missions of Chinese lunar explorations. Recently, SHAO also adopted the well known DiFX correlator in the correlator center, named SHAO-DiFX. It is aimed to correlate the astrophysical and geodetic VLBI observations.

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2 Activities of Shanghai Correlator

2.1 Events of Domestic Software Correlator

The domestic software correlator (SCORR) is dedicated to the data processing of the Chinese domestic VLBI observing programs, inclusive of the Chinese deep space exploration project for tracking spacecrafts and the CMONOC project for monitoring the Chinese regional crustal movements. Recently, a more accurate delay model was implemented in the correlator job

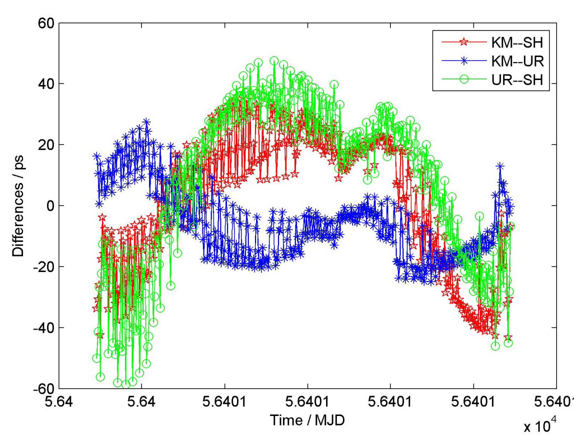

Fig. 1 Comparison results of model delays between SCORR and DiFX-Calc9.0.

generating software, which was used for VLBI sessions of tracking satellites and the Chinese domestic geodetic VLBI observing program. Comparison tests of model delay calculations were carried out between the software in SCORR and DiFX-Calc9.0. Figure 1 shows the comparison results of the model delays in a hypothetical 24-h geodetic experiment. A special schedule file was generated with SKED for the experiment. 360 scans and 67 sources were scheduled. Each scan spanned two minutes and always included the same three Chinese stations. The model delays on the three baselines were calculated separately with the software of the two correlators. The level of the delay differences is in several tens of pico-seconds.

2.2 SHAO-DiFX Correlator

As the DiFX correlator is of high performance and has comprehensive output formats for astrophysics and geodesy, it has been adopted and operated in worldwide correlator centers. Since September 2012, DiFX 2.1 was installed in an ad hoc 36 Intel X5650 (2.67 GHz) core cluster at SHAO. After testing and operating for about one year, a new DiFX platform was constructed in January 2014 (see Figure 2). Features of the DiFX platform are listed in Table 1. The maximum speed of the cluster is about 1 Gbps for each station in a four station correlation pass.

Fig. 2 Diagram of the DiFX platform and Mark 5 units.

Table 1 Deployment of the first stage SHAO-DiFX system.

Device	Parameters
DiFX version	DiFX 2.2, DiFX 2.3 and trunk
Head node	2x6 cores, Intel E5-2620 CPU, (2.0 GHz) 64 GB Memory
Computing nodes	3 nodes, each has 2x8 cores, Intel E5-2609 CPU (2.4 GHz), 64 GB Memory
I/O nodes	3 RAID6 60TB
Network connection	10G Ethernet,1G Internet
Mark 5 units	6, Mark 5A/B/B+
Output formats	FITS and Mark IV
Post processing	HOPS3.8, HOPS3.9, AIPS

3 Some Results

In 2013, four domestic geodetic VLBI experiments were carried out using 16 frequency channels allocated at the S/X bands. Three experiments were recorded at a data rate of 256 Mbps with 8 MHz bandwidth and one at 1024 Mbps with 32 MHz of bandwidth in each channel. The data correlation was performed by both the SCORR and the SHAO-DiFX. The output of the DiFX correlator in Mark IV format was further processed with the HOPS software. Figure 3 shows the fringes of the newly built Tianma 65-m telescope (T6) to the Sheshan 25-m antenna in one of the experiments. The observing was carried out in a way similar to that of IVS sessions. The fringes in both the S and the X bands were detected. The output of DiFX in Mark IV format was processed with HOPS to generate the geodetic database, and the position of the T6 station was estimated with Calc/Solve.

The 1024 Mbps data rate experiment was carried out to detect and estimate the positions of 85 selected faint sources with a higher sensitivity attributed to a wider bandwidth. Through the experiment, 18 out of 85 selected sources were newly determined. One of the fringes at X-band from the Sheshan—Urumqi baseline in the experiment is presented in Figure 4.

Meanwhile, two milli-second pulsar (MSP) VLBI astrometric experiments with CVN were successfully

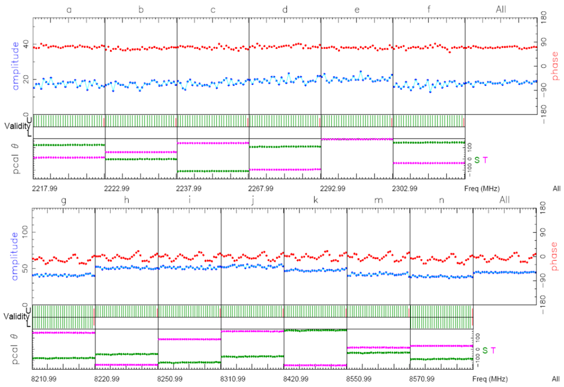

Fig. 3 Fringes of Tianma (T6) 65-m telescope to Sheshan 25 m in S/X band.

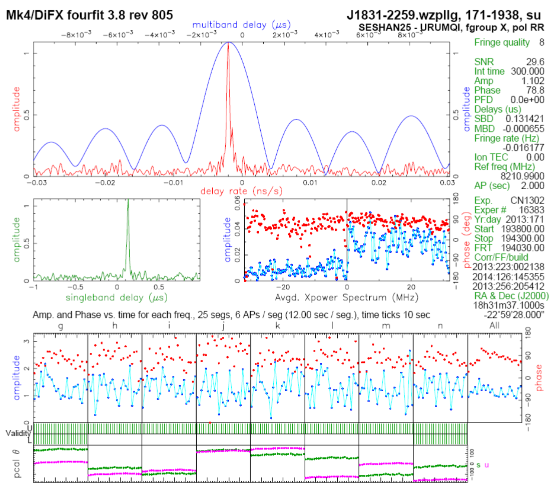

Fig. 4 Fringes of the CVN 1 Gbps observational data.

correlated with the DiFX correlator in 2013. The target pulsar was MSP J1939+2134. The experiments were carried out in S-band with 256 MHz bandwidth in total. The parallaxes of J1939+2134 were reduced through the phase referencing mapping method. The image of the target pulsar is plotted in Figure 5.

Off-line FITS format conversion software was developed and used at the SCORR correlator. Some comparison tests were made between the FITS format outputs of SCORR and DiFX. Figure 6 presents the results for the same geodetic observational data. The outputs of correlating all ten X-band frequency channels in a scan were converted to the FITS format. In Figure 6, the top shows the means and the deviations of the phase differences in each channel. The bottom shows the differences of phases and amplitude in a frequency channel.

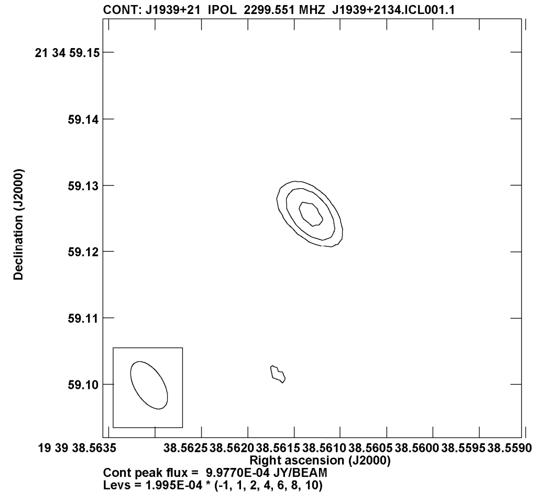

Fig. 5 Image of MSP J1939+2134 with CVN (beam size= 7.95*4.28 mas).

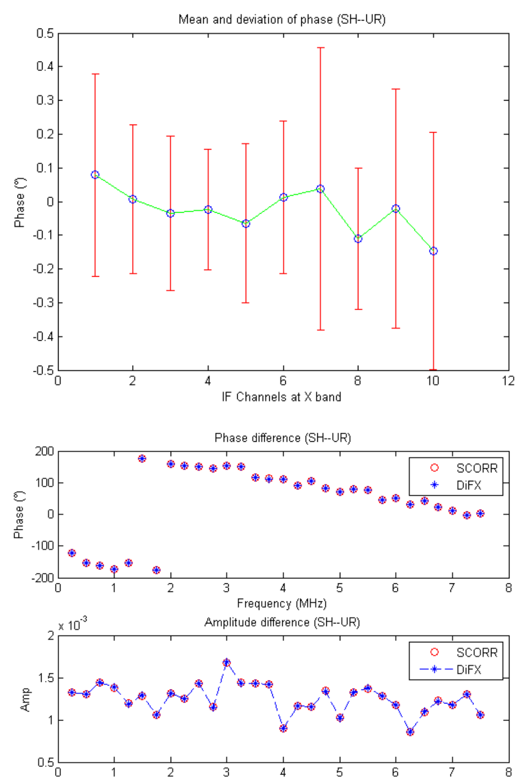

Fig. 6 Comparison results of the FITS format outputs of two correlators.

It implies that the phase differences of the two FITS format outputs are within 0.5 degrees.

4 Conclusions and Future Plans

The precision of delay measurement and reliabilty of SCORR correlator will be improved further for future deep space missions. At the same time, it will provide some support for astronomical and geodetic observations. SHAO-DiFX will be dedicated to correlating astrophysical and geodetic VLBI sessions. More computing nodes and redundant arrays of inexpensive disks (RAID) sources, including 300 cores, 300 TB RAID, and Infiniband network, are planned to be added to the cluster system in 2014. It will provide services for domestic and international VLBI observations. For example, it can process some IVS sessions if possible.

Acknowledgements

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