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Urumqi - A Pivotal VLBI node in Central Asia

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Abstract

We summarize the pivotal role of the Very Long Baseline Interferometry (VLBI) station at Urumqi currently as in both globally and regionally coordinated observations and its future development perspectives.

1. The antenna

The Nanshan station of Xinjiang Astronomical Observatory (XAO) locates in the Tianshan Mountain range which is about 70 km south to Urumqi. The original 25-metre azimuthal telescope reached its design life there after two decades service and was refurbished in 2014. The primary and secondary reflectors and their supporting system were redesigned and rebuilt. The steel angles are replaced with steel pipes in the supporting structure for extra stability. The new feed cabin was devised slightly bigger than the original to contain extra horns for higher frequencies, so the primary reflector was extended to 26 metres to compensate the bigger feed hole at the bottom of the dish. The new height of the elevation bearing also allows this diameter increase. A significant improvement of the reflector's surface accuracy is achieved after the reconstruction. The secondary reflector was mounted on a Stewart platform and its beam can mechanically sweep over the horn apertures without moving the chunky feed horns. Besides the L-, S-, C- and X-band receivers equipped with conventional VLBI stations, the Nanshan station also has the K- and Q-band receivers installed. The K-band receiver has already been actively engaged in VLBI and spectral line observations, while the Q-band receiver is currently under test.

2. The backends

The analogue baseband converter (ABBC) turned obsolete in last decade, now Nanshan station is equipped with digital baseband converter (DBBC) like DBBC2, Chinese data acquisition system (CDAS) and ROACH [1] digital backend (RDBE). The Mark 6 data recording system is currently replacing Mark 5b on-site, especially in astrometric observations. The majority of astrophysical observations are still done with DBBC2 and Mark 5b there. Some customized prototypes of digital backends based on ROACH2 are also installed for testing purpose.

3. The networks

The Nanshan station joined the European VLBI network (EVN) and the International VLBI service (IVS) soon after it was built. It also participated the heterogeneous low-frequency VLBI network (LFVN) observations at the L band. In recent years, the East-Asia VLBI network (EAVN) observations never misses the Nanshan station out. The geographical location of Urumqi has defined its unique status in the global VLBI networks. Since there are very few stations in the vast Eurasian continent, Urumqi is playing a big role as filling the global coverage for the IVS, extending east-west baselines for the EVN and the EAVN, even the south-north baselines for the long baseline array (LBA) in Australia. Figure 1 shows the current distributions of major radio telescope arrays and networks in the world.

4. The development prospects

Though originally built for interferometry, the 26 metre antenna can actually be an all-purpose radio telescope with proper backends installed.

4.1 Single-dish capability

Right after the establishment of the NanshanVLBI station, the 25 meter telescope installed the analogue filter bank (AFB) and started pulsar observations. After replacing the AFB with the digital filter bank (DFB), the telescope can observe not only the time-domain phenomena, like pulsars, but also the spectral domain objects, like molecular lines and masers. It also has a continuum backend for total power measurement which is used for observations on intra-day variations (IDV) of quasars.

Due to the fast progress of electronic technology, the development of digital backends for both interferometry and single-dish observations turns to fuse on a common hardware stratum. Currently an integrated multi-purpose digital backend based on ROACH2/SNAP2 [2] is under development, which has more customizable features and be adapted to specified observation need, like the fast radio burst (FRB) search and the wideband VLBI observation .

4.2 Local network

The proposed Qitai radio telescope (QTT) has a fully-steerable 110 metre aperture and is the most important upgrade of the observational equipment at XAO for the next decade. It locates about 200 km east to Urumqi, which has roughly the same geographical importance in the global network. However, its designed active surface allows the observed frequency range going from 150 MHz up to 115 GHz. Those aspects will make it a super power in single-dish observations on objects like pulsars and molecular lines, apart from merely contributing as a major weighted node in VLBI observations.
In addition to the QTT which is under construction, there is a 13 metre wideband telescope built at Kashi station according to the VLBI global observation system (VGOS) standard. Another one is being built at Nanshan station now. There are also some radio telescopes of deep space network around at our cooperative institutes in south Xinjiang province. So there is a plan to coordinate the locale radio telescopes to form a joint observational force. Moreover, some potential sites for radio observation along the rim of the Tarim basin are being investigated as well. The plan for Urumqi is to become a regional center for observation, coordination and correlation.

5. The observation scheduling

5.1 Routine experiments

The observations coordinated by EVN and IVS are routine duties for the 26 meter telescope at Nanshan station. We also have Chinese VLBI network (CVN) routine observations for crustal movement monitoring and Chinese lunar exploration programme (CLEP). The EAVN observations are currently scheduled to fit the spare time slots according to proposals. As a cooperative ground station in EVN for RadioAstron [3], the 26 meter telescope also take the out-of-session EVN observations joint with RadioAstron.

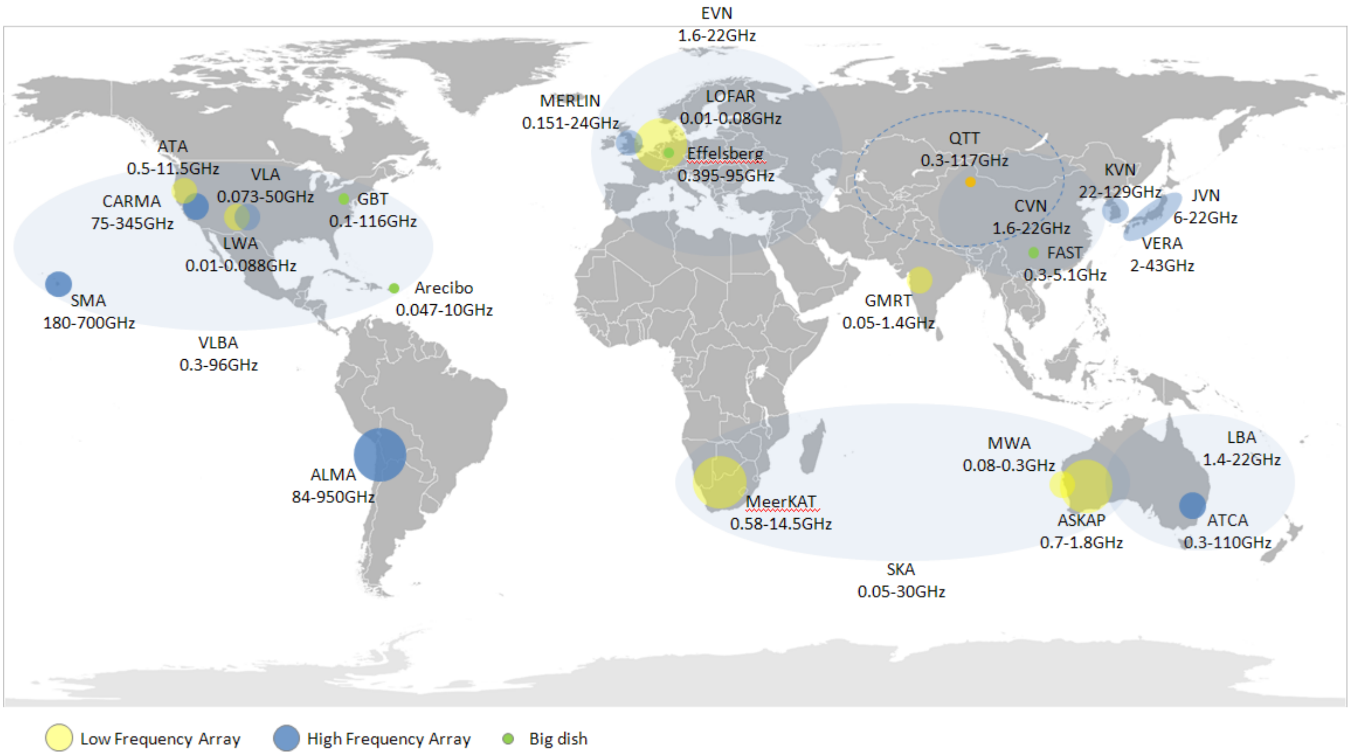

Figure 1. The geographical distribution of major radio telescope arrays

5.2 Triggered responses

As a member station of the EVN, Urumqi accords with its policy on target of opportunity (ToO) proposals. So the unpredictable events can be scheduled dynamically and given the priority to be observed within or outside the route sessions. Limited by the bandwidth of the internet link to Europe, the Nanshan station cannot join e-VLBI observations currently as in the first wave of triggered responses. However, as a pivot station in central Asia, the Nanshan station didn't miss the phenomenal follow-up observations on the electromagnetic counterpart of the gravitational wave event GW170817 last year. The highest resolution of the jet structure of EM170817 has been achieved by the global VLBI network in which Urumqi is involved as a collaborator [4].

6. The observational achievements

As a participant in joint observations, Urumqi has contributed to many astronomical achievements obtained with global VLBI network, such as the discovery of the super massive black hole pairs in the X-ray source [5], the correlation between the source structure change and the IDV activity in the active galactic nucleus (AGN) [6]. Other than those, there are many researches been accomplished by the 25 metre telescope as a principal investigation tool here, such as pulsar glitches and mode changes [7,8], molecular line surveys [9,10].

7. Acknowledgements

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