URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

Introduction for QTT Project

N. Wang[(1) (2)]
(1) Xinjiang Astronomical Observatory, Chinese Academy of Sciences,
150, Science 1-Street, Urumqi, Xinjiang 830011, China, e-mail: na.wang@xao.ac.cn
(2) Key Laboratory of Radio Astronomy, Chinese Academy of Sciences, Nanjing 210008, China

The STeerable 110-meter Aperture Radio Telescope (START) is planned to be built in Qitai county, Xinjiang Uygur Autonomous Region. It is also called QiTai radio Telescope (QTT) for short.

QTT is a general-purpose radio telescope [1], which adopts umbrella support, homology symmetric lightweight design [2]. It is a Gregorian type standard parabolic antenna. The surface of main reflector is active to overcome the deformation caused by gravity and environmental loads, this will ensure sensitive observation from 150 MHz up to 115 GHz. According to requirements of early scientific goals, QTT will be equipped with cryogenic receivers adopting ultra-wideband or large field-of-view multibeam technology for both primary and Gregorian focus at different frequencies. These include 40 cm, 15 cm, 5 cm, and 2 cm single-beam receivers, 13/3.6 cm, 3.6/0.9 cm dual-frequency receivers, 20 cm PAF receiver, and 1.3 cm, 7 mm and 3 mm multi-beam receivers. A multi-function signal processing system based on FPGA and GPU will be installed, which enable QTT operate in pulsar, spectral line, continuous and VLBI observing modes. The overall scheme of QTT is shown in Figure 1. QTT will form a world-class observation platform for the detection of low frequency gravitational wave, discovery of black hole and exploration of the life origination in the universe. The early scientific goals of QTT include: pulsar research and gravitational wave detection through Pulsar Time Array (PTA) [2], star formation and evolution studies by means of molecular spectral lines, research on galactic nucleus and structure of galaxies, the formation and feature of dark matter, high-precision VLBI astrometry, astronomical geodynamics and space VLBI research, survey to find unknown objects, Lunar and planetary exploration.

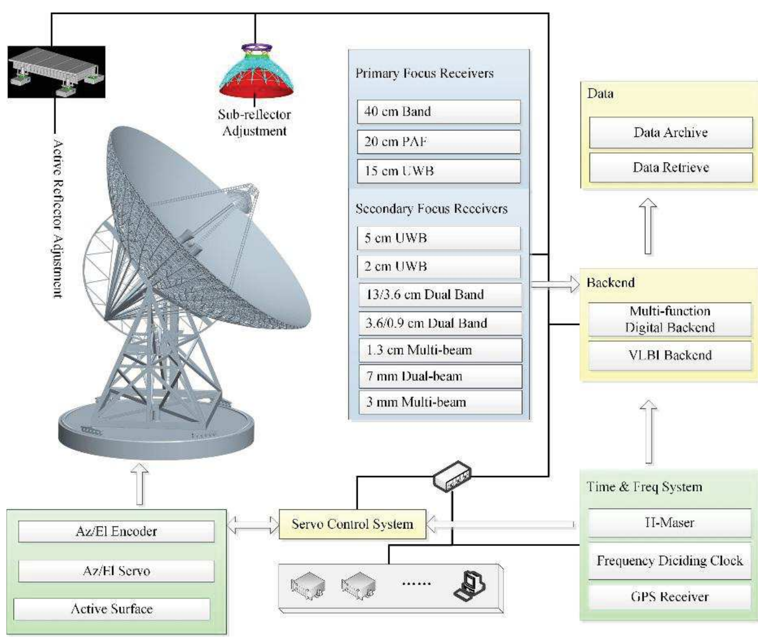

Figure 1. Overall scheme of QTT design.

The QTT site is located in the northern piedmont of eastern Tianshan Mountains (Figure 2), with coordinates 43.6°N, 89.7°W and altitude ~1800 m. The road distance is about 250 km from Urumqi. The site is surrounded by mountain shielding, a good radio environment and relatively easy to establish radio quiet zone and implement long-term protection. The climate of site area is dry and hence low moisture, the mean values of precipitable water vaper are around 14 mm in summer, 7 mm in spring and autumn, and 3 mm in winter, respectively. The winter season is usually four months in a year, this will greatly benefit the observations at high frequencies, e.g. 7 and 3 mm. The maximum wind speeds statistics reveal a mild distribution, the chance of wind speeds greater than 10 m/s is only about 2.5%.

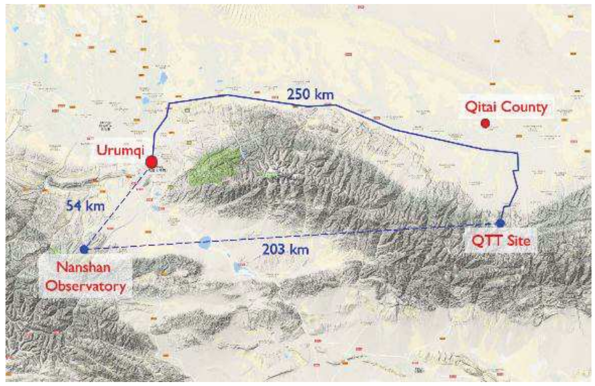

Figure 2. The location of QTT site. The road distance from Urumqi is 250 km and is indicated in solid blue line.

QTT is able to reach three-quarters of the sky, including 12 ° south of the Galactic center. Seated in the center of Eurasia, QTT is important for improving the international VLBI UV coverage. It also constitutes the longest VLBI baseline in China, namely provides the highest resolution, and greatly improves the sensitivity of China's ground and space VLBI networks. The direct distance from QTT to Nanshan Observatory is 203 km, together with the Nanshan 26 radio telescope, they form a short VLBI baseline of high scientific interests.

The key technical challenges for constructing QTT antenna include high pointing accuracy and main reflector surface accuracy. The repeatable pointing accuracy is around 1″ - 2″, hence very high precision servo control is required under complex environment, large inertia and slow drive. The demanded r.m.s. precision of the main reflector surface is 0.6 mm without actuator, and better than 0.2 mm with long-term adjustment to satisfy the 3 mm observations. The main reflector adjustment includes three parts, the active surface control unit, multi-node control network and actuator groups. About two-thousands of actuators are connected to the control unit via Ethernet and fieldbus in multi-node control network.

The equipment of each major system in QTT is connected with ultra-high speed (10Gbps/10GbE) fiber Ethernet and compliance with the IP allocation management of internal network. In order to reduce the radio frequency interference caused by the network, optical fiber transmission is adopted between buildings and inside buildings, and through the photoelectric converter converted into a universal interface connected to the computers. Multi-layer electromagnetic shielding methods are planned to meet QTT electromagnetic compatibility requirements, including high performance Faraday rooms, shielding cabinets and boxes. Furthermore, a low-cost building shielding scheme is applied to minimize the interference generated by various small or scattered electronic devices for example laptop, LED lamp and power switches. Local government has also issued regulatory documents to protect the radio quiet zone.

This project is jointly supported by Chinese Academy of Sciences and Xinjiang Uygur Autonomous Region. Up to now, partial funding is obtained for key technology investigations and preliminary design. The site construction conditions have also been greatly improved.

1. N. Wang, " Xinjiang Qitai 110m Radio Telescope ", SCIENTIA SINICA, Physics, Mechanica & Astronomica, 2014, 44(8), pp. 783-794

2. O. Hachenberg, B. H. Grahl, R. Wielebinski, “The 100-meter Radio Telescope at Effelsberg”. Proc. IEEE, 1973, 61: pp. 1288-1295

3. G. B. Hobbs, M. Bailes, N. D. R. Bhat et al., “Gravitational-wave Detection Using Pulsars: Status of the Parkes Pulsar Timing Array Project”, PASA, 2009, 26: pp. 103-109