Site Selection for the Tianlai experiment
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Abstract

The Tianlai project plans to build a compact cylinder array to map the 21cm emission from redshift 0 to 3, corresponding to frequency 350-1420MHz. The full array is designed to have a size of about 100m x 100m in dimension. A site with minimum radio frequency interference (RFI) and convenience of logisitics support is desired. This project is also constrained by its low budget, so attention have to be paid to reduce the cost for the construction and operation. We have conducted site surveys in many places in China, obtained radio spectrum measurement at more than a hundred potential site locations. This paper describes the site selection and survey method. We have tentatively selected a site in Hongliuxia, Balikun County, Xinjiang Autonomous Region, which have very low RFI and is potentially good for other low frequency radio experiments.

1. Introduction

The Tianlai project is a 21cm intensity mapping experiment [1,2], which aims to quickly survey the neutral hydrogen distribution on large scales with relatively low angular resolution. If successful, the experiment can measure the baryon acoustic oscillations (BAO) in the matter power spectrum, and use it to probe the nature of dark energy [3] (Also see Chen et al.'s paper in this proceeding [4]).

However, the redshifted 21cm signal is very weak, compared with the Galactic synchrotron foreground, for example, the expected signal to noise is only of the order of 10^{-5}[5]. In principle, the signal can still be recovered because it varies with frequency, while the foreground is smooth in spectrum, but it does requires very high sensitivity and precision in the observation. As the redshifted 21cm line lays in the low frequency part of the radio spectrum, where the RFI is strong, it is vital to find a site with minimum RFI to build the array, so as to allow the best measurement possible.

There are many existing sites in China with astronomical facilities. While it would be convenient to choose one of these from a logistic point of view, these sites were selected and built many years ago, the RFI condition have deteriorated over the years and are no longer satisfactory. We therefore decide to look for new sites.

2. Selection Criteria

In searching for a site, we have the following considerations (1) it should have minimum RFI; (2) it should have enough flat space to build the array, (3) it should be safe and economical to construct array and support its operation. With the three basic conditions set above, we considered in what kind of place it is likely to find sites which can satisfice our conditions.

(1) Low RFI. As RFI are generated by people, we should look for places with low population density, and also with some surrounding hills to shield it from radio waves generated in distance. It should also be located in some distance away from airport, radar, town, communication tower, and highway. We should also anticipate the effect of economical development, and select sites which are less likely affected by the economical development in the foreseeable future.

(2) It should have enough flat space to build the array, we require at least a space of 100m north-south and 100m east-west, of course larger space is preferable.

(3) Safety and Economy. We look for sites with accessible road, or easy to drive to, so that construction can be done. It should also be not too far from electricity and internet connections. Finally, we will have people staying at the site, this means that it can not be too far from a village or a town where food and supply can be obtained. The site must also be safe, so the geological and hydrological conditions must also be considered, we must avoid sites with the potential of landslide or flood.

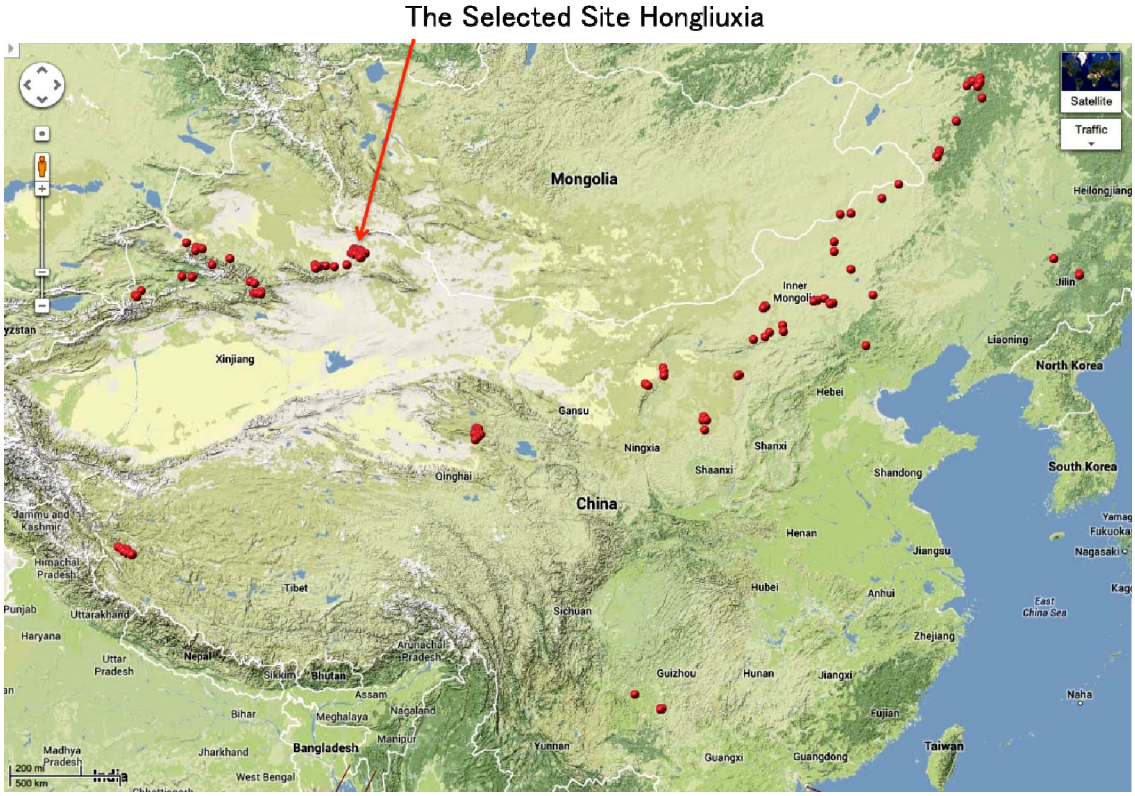

Figure 1. The site surveyed throughout China

We look for potential sites with these criteria. The general areas (province) of potential sites to be looked are selected mainly by the fact that they have some existing astronomical institution or facility, from which we can get local contact and information. Within each general area, we would at one time look for a number of sites. Before going on a field trip, we carefully examine the area in maps and satellite imagery provided by the Google Earth, and consider uninhabited sites which have a flat openning of at least 100m, preferably surrounded by hills. In each area to be investigated, we usually pre-select a dozen or two potential sites on map, mark their coordinates, find possible roads to them, and then make a trip to the area with an SUV for on-site inspection and RFI measurement, which usually last one to two weeks. Because we are limited by time and man power, instead of taking long, continous monitoring on every site, we usually make a visual inspection of the site and then take one measurement of the radio spectrum to see if there is strong RFI, and reject the ones which have strong interference. Only the ones with minimum interference during this measurement would be considered further, and later revisited and monitored for longer time. The sites investigated are shown in Fig.1, more details are given in Sec.4.

3. Instrument for site survey

For the measurement of the radio environment, we use a simple portable disk-cone antenna (Fig.2) which have good ominidirection and broad band response below 2GHz. The signal is amplified by a low noise amplifier (LNA) powered by batteries, and a portable spectrum analyzer. The gain of the LNA is about 30 dB, its noise figure is about 1dB which corresponds to 75K noise temperature. During the course of surveys, we used several different spectrum analyzer, including Micronix spectrum analyzer 8.5GHz MSA358 and Anritsu MS2036c, The spectrum analyzer is also shielded in a copper net to avoid its own radio emission be picked up by the antenna. We usually take the following

settings for the spectrum analyzer: 1). RBW=VBW=10kHz, 2) detection method: Peak, 3) frequency span: 200MHz, 4) attenuation level: 0 dB

Fig.2 Portable survey Equipments (left): disk-cone antenna and LNA(upper right) and spectrometer (lower right)

4. Sites

We first looked the sites in Inner Mongolia, the major advantage is that it is relatively close to Beijing. Unfortunately, the RFI is still relatively strong. We suspect that this is because that the terrain is too flat and the radio waves can travel far. Another place searched early on is the area around the Five hundred meter Aperture Spherical Telescope (FAST) site in Guizhou. However, the terrain is very steep, it is difficult to find large flat openings, and the Karst depressions are mostly without accessible road. If we are to build the array in one of these, we would need to build a road, which is beyond our small budget. The North-East China forest has flat sites and road, but are far from power lines. We also found low RFI sites in Ali, Tibet, but they are too remote and cost for construction and operation would be prohabitively high. Qinghai may have good sites, but we started looking for sites there relatively late, and the sites we visited so far are not as good as the ones we found in Xinjiang.

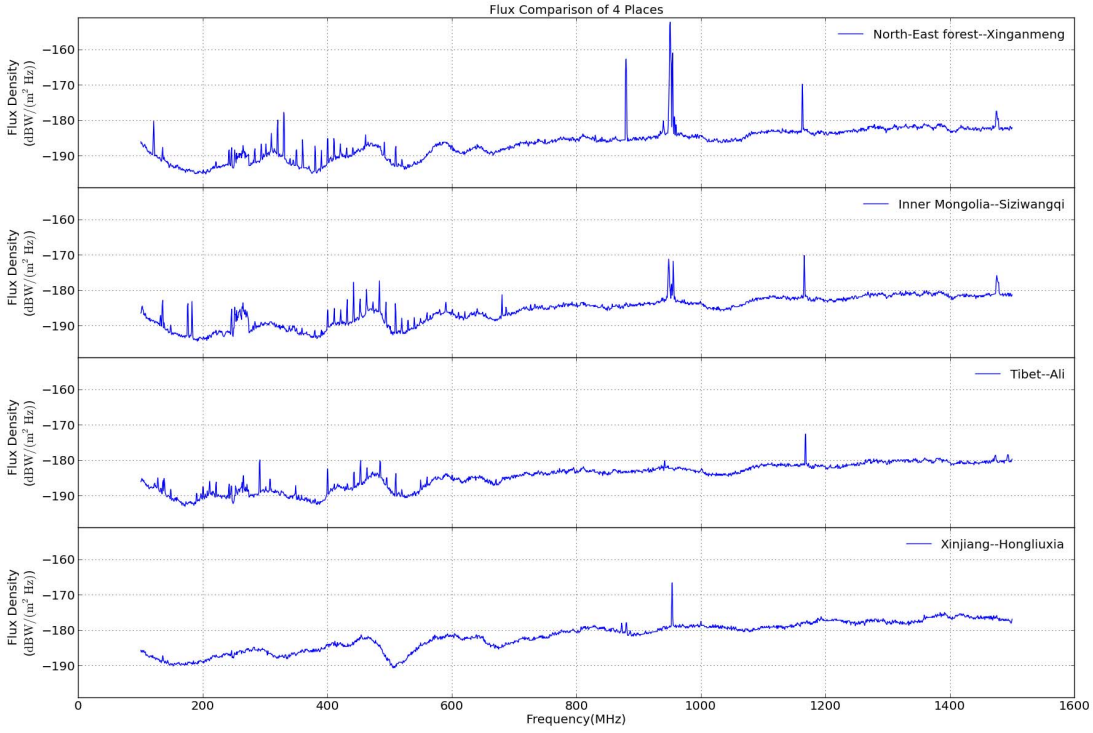

Fig.3. Comparison of RFI spectrum at four sites we survey

Among the places we visited, Xinjiang offers the overall best sites. The places have relatively low population density, and have huge mountains which could help shield the radio wave. At the same time, the terrain is generally not too steep, one can often get to the site with an SUV or truck. A comparison of RFI spectra at several places are shown in Fig.3. The major disadvantage of the sites in Xinjiang are that they are relatively far from Beijing, getting to the site cost time (4 hour flight to the capital city Urumuqi, then another half day's drive) and money. Another disadvantage is that it is relatively cold during winter, which limits the season for construction work.

We eventually chose a site at Hongliuxia, Balikun County, Xinjiang, the coordinates are (as obtained from Google Map) 44.165N, 91.796E, with an altitude of 1500m. Surrounded by hills and inhabited by only a few nomads, the place have one of the lowest RFI plots we have seen. This site can be reached with SUV, it is a few km from a nearby village. Power line and internet can be connected from about 10km away.

5. Conclusion

The Tianlai experiment is a risky, low cost experiment in its early stage, it is necessary to find a site which has relatively good radio environment, yet at the same time is within reach, so that the cost for construction and operation to be affordable. Time and human power are limiting factors. We need to choose a site quickly. As this is a small project, only a small group of people have been involved, and they also have to work on technical development and conduct scientific research, and only devote a very limited time to site search, so a comprehensive search with optimal result is not possible. Instead, we decide to search as many sites as is possible in time and feasible in economy, and choose the best among them.

In the end, after evaluating the many sites we visited, we found the Hongliuxia site in Xinjiang as the best one, providing both a low RFI environment, and relatively good logistic support. This site is located in a generally low RFI area, it is also potentially a good site for other low frequency radio telescopes.

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