

Construction of the Korean VLBI Network (KVN)

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Abstract. Korea's new VLBI project to construct the Korean VLBI Network (KVN) started in 2001, as a 7-year project that is fully funded by our government. We plan to build 3 new high-precision radio telescopes of 21-m diameter in 3 places in Korea, which will be exclusively used for VLBI observations. We will install the 2/8, 22 and 43 GHz HEMT receivers within 2007 as a first target, and later we will expand the receiving frequency up to 86 and 129 GHz for astronomical, geodetic, and earth science VLBI research. The millimeter-wave VLBI will be the ultimate goal of KVN. For the front-ends, we are going to install a multi-channel receiver system that employs low-pass filters within a quasi-optical beam transportation system. This receiver system will give reliable phase calibrations for millimeter-wave VLBI as well as enable simultaneous multi-frequency band observations. The hard-disk type new Mark 5 will be used as the main recorder of KVN. We have completed the design of the KVN DAS system of 2 Gbps sampling rate, which will use 4 data streams to meet the multi-channel requirement. A VERA type DAS modified for Mark 5 recorder is also under consideration. A new correlator project for KVN was recently approved from Korean government, and will start in the second half of 2004.

1. Introduction

The first radio astronomical project of Korea Astronomy Observatory (KAO) was the construction of the 14-m millimeter wave radio telescope at Daejeon, Korea, which was completed about 15 years ago. With the completion of the radome-enclosed 14-m radio telescope, the Taeduk Radio Astronomy Observatory (TRAO) was inaugurated as a branch of KAO. At present, a dual-channel (100/150 GHz) SIS receiver is being used, which our engineering team made, and we are preparing a multi-channel (15-beam) receiver (made by FCRAO) to be installed in our 14-m telescope. Our main research subjects are studies of interstellar molecular clouds and the physical and chemical processes in dense clouds. In particular, the SiO masers, star-forming regions, and interstellar molecular processes have been the major focus of our radio astronomy group.

Although we have been managing our millimeter-wave telescope and receiver systems successfully so far, our radio group has not yet been involved in any VLBI activities, mainly because of our millimeter-wave single-dish facility. Only recently (from 2001) have we started VLBI experiments, in millimeter wavelengths, with the Nobeyama VLBI group of Japan with encouraging success.

After the completion of 14-m radio telescope project, KAO concentrated its effort mainly on the construction of optical telescopes. By the completion of the optical telescope project, our radio group submitted a proposal for this Korean VLBI Network (KVN) construction project to our government, which was finally approved in 2000.

2. Scientific Goals of KVN

The KVN will be the first VLBI facility in Korea, which will be used for VLBI studies in astronomy, geodesy, earth science, etc. The general VLBI research targets will also be targets for KVN, within the KVN limitations. However, the KVN will be

constructed as an advanced millimeter-wave (up to ~ 150 GHz) VLBI network. Since millimeter-wave VLBI is still in the developing stages around the world, we expect that our KVN will play an important role in promoting millimeter-wave VLBI research activities.

Because of the existing 14-m millimeter-wave telescope facility, the research activities of the present radio astronomy group of KAO are concentrated on interstellar molecular cloud studies. Therefore, one of our main KVN projects will be spectral-line observation focused on the interstellar molecular processes at millimeter wavelengths. At the same time, we are strengthening our VLBI group by increasing its members in high-energy astrophysics and AGN-related research fields, in order to promote research activities in various VLBI subjects.

In geodetic studies, the geodetic society groups in Korea will lead most of the research work. Since the tectonic movement of the Korean peninsula, including several important fault plane movements, has never been measured, the monitoring of these movements will be an important national project, which will be carried out with KVN. KVN will also participate actively in international campaigns for geodetic measurements.

3. Outline of the Project

In 2001, KVN started a 7-year project to construct the first VLBI facilities in Korea, which include 3 new radio telescopes and VLBI receiving systems to be dedicated exclusively to VLBI observations.

3.1. KVN Sites

The three KVN observatory sites, Yonsei University at Seoul, University of Ulsan at Ulsan, and Tamna University at Jeju, have been selected from among the many universities and institutes who wanted to invite our telescopes. Fig. 1 shows the lo-

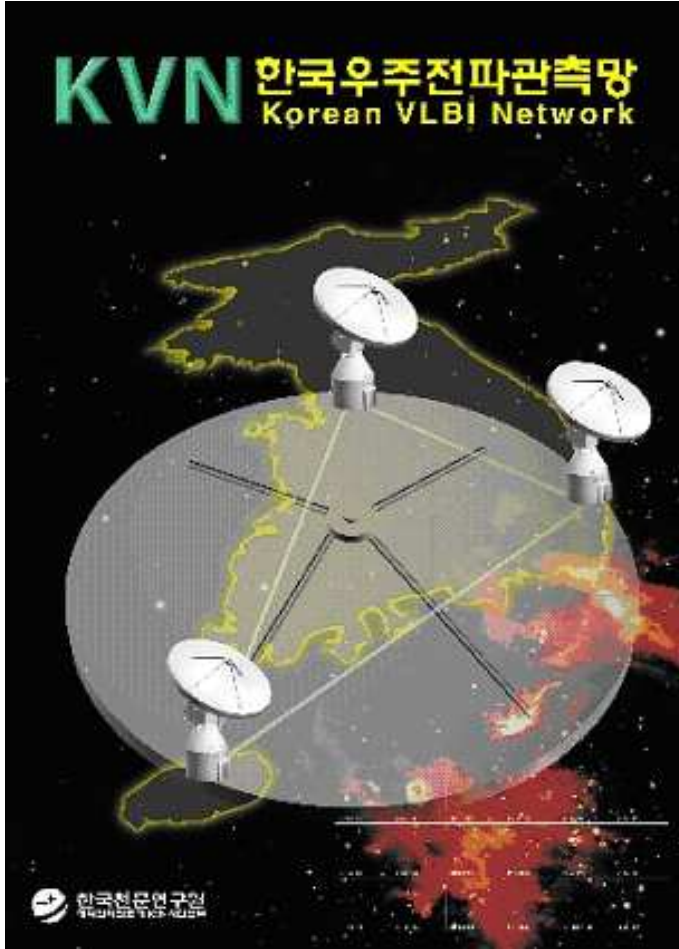


Fig. 1. Locations of KVN observatories

Table 1. Site locations of KVN and TRAO

KVN Site	Longitude ° ' " E	Latitude ° ' " N
Yonsei (Seoul)	126 56 35	37 33 44
Ulsan (Ulsan)	129 15 04	35 32 33
Tamna (Jeju)	126 27 43	33 17 18
TRAO (Daejeon)	127 22 19	36 23 53

cation of these three KVN sites. The maximum baseline length is about 450 km in the north-south direction, and the site parameters are summarized in Table 1 and 2. The site preparation work has already started at all three places. In Fig. 2, we show an example of the UV coverage and the synthesized beam shape for the three KVN antennas, including the existing 14-m radio telescope at TRAO, Daejeon. In future, these 4 antennas will be connected using the optical fiber information networks in Korea, partly for e-VLBI, and partly for the real-time operations of KVN.

Table 2. Baselines of KVN observatories and TRAO

KVN Observatory	Baseline			
	Yonsei	Ulsan	Tamna	TRAO
Yonsei (Seoul)	–	305.2	477.7	135.1
Ulsan (Ulsan)	305.2	–	358.5	194.2
Tamna (Jeju)	477.7	358.5	–	356.0
TRAO (Daejeon)	135.1	194.2	356.0	–

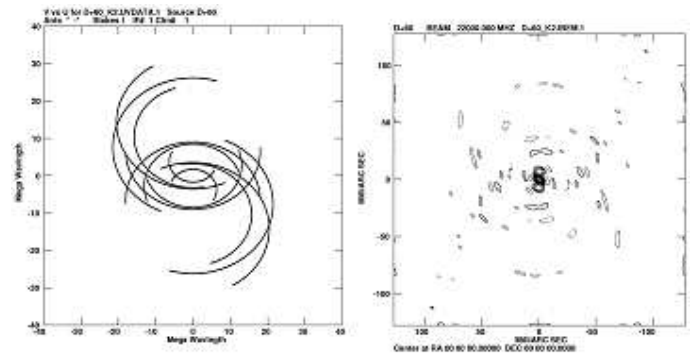


Fig. 2. Example UV coverage and synthesized beam shape for a source at decl.= 60° for KVN and TRAO

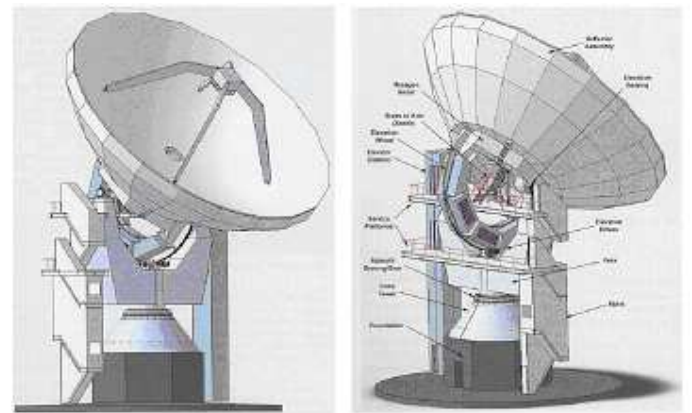


Fig. 3. Bird's-eye view of KVN antenna

3.2. Antennas

We plan to build 3 new high-precision Cassegrain type radio telescopes each of 21-m diameter, having reasonable efficiencies at frequencies above 100 GHz (total rms ≤ 150 μm). Fig. 3 shows bird's-eye view of KVN antenna.

The maximum slewing speed is 3°/sec in both AZ and EL with an acceleration of about 3°/sec². The requested wind speed tolerance is about 10 (20) m/s for precision (limited) observations, and 90 m/s for survival. We plan to start the foundation construction in 2004, and the antenna installations in 2005.

Table 3. KVN receiver specifications

Freq Band	S Band	X Band	K Band	Q Band
Freq [GHz]	2.2 - 2.8	8 - 9	21.5 - 23.5	42 - 44
Rx Noise (K)	< 25	< 25	< 30	< 50
1st IF (GHz)	2.5	8.5	8.5	8.5
IF BW (GHz)	0.6	1	2	2
IF Power (dBm)	-25	-25	-25	-25
Pol. (CP)	full	full	full	full

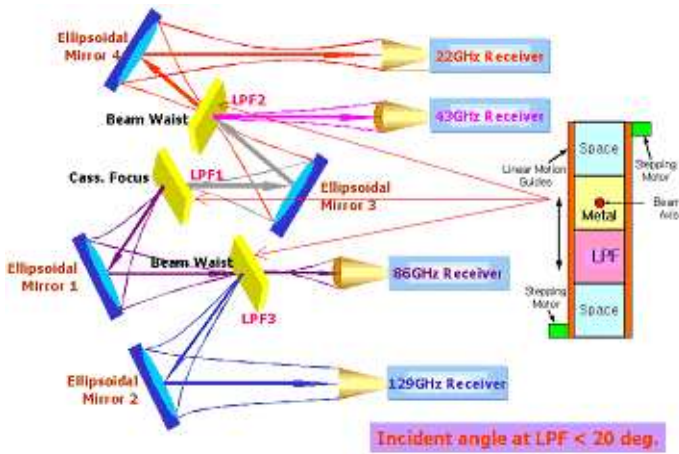


Fig. 4. Conceptual design of KVN quasi-optics

3.3. RF Receivers

For the KVN front-ends, several cryogenic HEMT receivers will be installed at the Cassegrain focus for 2/8, 22, 43, 86 and 129 GHz operations. The 2/8 GHz receivers will be mainly for geodetic observations. The 22 and 43 GHz receivers will be installed first, to set up the antennas and for the initial VLBI observations. Since our main goal will be mm-VLBI, the 86 and 129 GHz receivers will be installed as soon as the full test of the KVN system is completed. Some parameters of the first receivers are summarized in Table 3.

For KVN, which is designed for mm-VLBI, we plan to adopt a multi-channel quasi-optical beam transportation system which can be used for phase calibration in millimeter and sub-millimeter-wave VLBI, without losing observing time, and without the necessity to look for reference sources. In addition, this method enables us to observe several frequencies simultaneously.

Fig. 3 shows the conceptual design of the KVN beam transporting system employing frequency-selective surfaces - low-pass filters (LPFs) (Goldsmith 1998).

The lowest 22 GHz band can be used as a phase calibration reference for the higher frequency band observations, made toward the same source at the same time. Although there are some limitations (Sasao 2003), this multi-channel idea would give very reliable phase corrections in mm-VLBI.

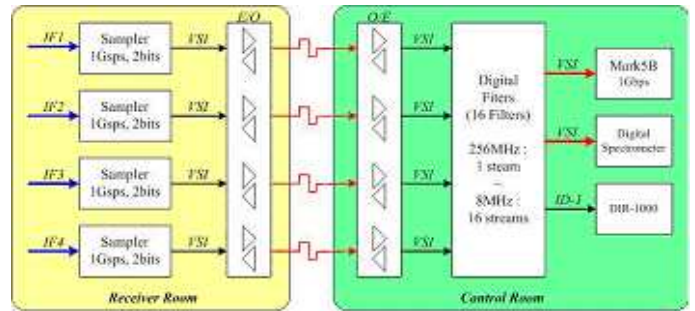


Fig. 5. Schematic diagram of KVN DAS

3.4. KVN DAS and Recorder

We are developing the KVN data acquisition system (KVN DAS). Fig. 5 shows the configuration of KVN DAS. For our multi-channel receiver system, we employ four high-speed samplers operated at 1 Gbps. These four data streams of 2 Gbps will be transported via optical fibers to the operation building, and then distributed among sixteen FIR digital filters. With these filters, we can choose a passband whose center frequency is arbitrarily programmable in the input bandwidth, and then resample the filtered data at 2 bits per sample. These resampled data streams are then formatted and sent to the recorder. We will also prepare the digital spectrometer for single-dish operation and total-power measurements.

As for the KVN recorder, we plan to use the new Mark5 recorder (Whitney 2003). KVN is involved in the development consortium for the Mark5, led by Haystack Observatory of MIT. The characteristics of the Mark5, which has a 1 Gbps rate using a standard PC and 16 hard disks with a VSI interface, are well explained in the Haystack web site. We plan to reproduce the Mark5 for KVN.

We have just started the design of the new KVN correlator, this project is in the very first planning stages, at present.

4. Summary

The construction of KVN is underway as scheduled. The KVN is the first VLBI facility in Korea, which will be used for astronomy, geodesy, and earth science. It is our wish that KVN will be one of the best VLBI systems in the world, and we will actively participate in various VLBI programs after completion. We hope that KVN will play a central role in promoting the VLBI research work of Korean societies and international collaborations, through the KVN Research Center that will be built in Seoul. Various support and manpower exchange programs to stimulate VLBI activities will be organized by the KVN project. Finally, for the success of the KVN project, it must be essential for us to collaborate with, and get many suggestions and supports from, the leading institutes in VLBI research around the world.

References

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