A Near Real Time e-Radar/VLBI Network

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Abstract

A narrow band e-VLBI system is in development as a part of the LFVN (Low Frequency VLBI Network) activity taking advantages of the relatively small portion of band necessary in a certain class of radioastronomy observations.

Data are acquired using a simple dedicate terminal and recorded on disk. The maximum recorded signal band is 48 MHz wide, flexibly scalable up to few kilohertz and then with the concrete possibility to transfer the full amount or portion of it in near real time to a correlation point, using the standard Internet connection, when narrow band acquisitions are appropriate. Radar, spectral lines, low frequency, spacecraft navigation observations could benefit from this inexpensive solution in those stations where large antennas and sensitive receivers are available, and where is still missing the possibility to be supplied with standard VLBI terminals, giving then yet the possibility to perform radio astronomy research. The terminal is at present placed in Noto (Italy), Bear Lakes (Russia), Urumqi (China) and a few other stations, Simeiz (Crimea), Seshan (China), Evpatoria (Ukraine), will get a terminal in the first months of 2004.

A mixed software/dsp correlator is also in development in Noto, based on a shared computing strategy, allowing to improve auto- and cross-correlation performance adding a number of PCs equipped with a dedicated DSP board to improve the correlation capability. During the VLBR03.1 radar session in July 2003, the VLBI data from Noto and Bear Lakes were successfully translated to Noto and processed for detecting the spectrum of the echo signals. This work was supported by INTAS 01-0669, INTAS IA-01-02, RFBR 02-02-17568 and RFBR-02-02-39023 grants.

1. NRTV Acquisition Terminal

The Near Real Time VLBI terminal is a system conceived to get a portion of data coming from a receiver and translate such information through the network in order to have it available for further processing, being auto or cross-correlation. Mainly the system has been thought of for stations having no VLBI equipment at all, so that the first section, as optional, is planned with a digital base-band converter able to process the receiver IF in a way that further acquisition and recording is possible.

The maximum bandwidth is 48 MHz wide, so limited for meeting the actual capability of the internet connection. Indeed main criteria in the development have been to get an inexpensive system with the possibility to transfer data through the standard network. For narrow band the transfer could be almost real time, while for wider bands the data transfer can be realized during the observations intervals and afterwards, saving anyway the long time and cost needed to transfer real disks. Of course this last solution is still possible in case of very bad connection, that anyway is going to be improved everywhere in the radiotelescope sites worldwide.

Figure 1. The entire acquisition terminal is shown: from the left side, an external Firewire/USB2 disk, NRTV Box, a commercial PCI board.

The IF band to be recorded is down-converted using a standard or custom analog base-band converter as available in the radiotelescope. Such down conversion could be possible using a fully digital converter in development and kept available for those stations having no interferometric base-band converter at all. In such case the IF band of interest has to be shifted in the region 80-128 MHz, or 128-166 MHz, and the portion of band to be acquired is then translated to base band (0-48 MHz). Such bandwidth can be decreased so to get: 32-16-8-4-2-1-0.5-0.25-0.125 MHz. The narrower the band the less time needed to transfer data through the network, so the real useful band has to chosen considering the type of observation. For example in case of Radar-VLBI experiments, the Doppler shifted echo carrier reflected by the target body is to be detected, so that a narrow band is particularly efficient. Spectral line emissions observations similarly to the radar ones can benefit by the narrow band selection. In case of continuous emission the wider the band the better the sensitivity, so data transfer takes a longer time due to the network bottleneck.

Baseband converted bands, both in the analog or in the digital domain are then fed into the NRTV Box, where they are assembled in a very simple format with 1 or 2 bit representation, and then sent to a PC ATA disk where they are stored. Access to the recorded data can immediately

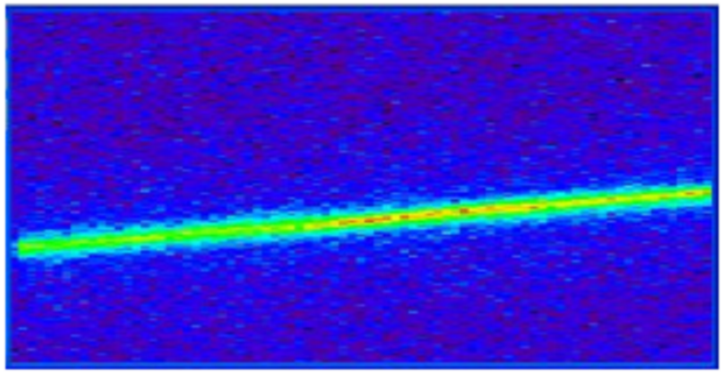

Figure 2. The spectra in time show the echo of the radar signal transmitted by Evpatoria, reflected by Mars, received in Noto. Frequency carrier was 5010.024 MHz, receiving LO was 5010.000 MHz. Vertical axis 238037,11-262329,11 Hz, horizontal axis day 207/208-time 2304-0025

be realized in order to transfer data after writing, in samples for data analysis, or in full for data processing. The control software supports data acquisition by means of manual, time triggered, custom scheduling, or Field System interface.

Data sent through the network are collected in a correlation point where a first analysis is done immediately after the observation. This is particularly useful to recognize possible problems in the receiving system or in case of Radar observations, for detecting transmitter failures in the pointing or emitted power. Autocorrelation is then performed with data coming from the different stations.

A software system is used to perform the correlation process, and this instrument is widely upgradable, being done with more PCs working in parallel in network. Time sharing is possible processing different slots of recorded time with different computers. This correlator is going to be increased as soon as more machines will be available in the cluster, during their down time.

The NRTV system is expected to be used in conjunction with other systems and correlators, in particular in that situations when a quick process is worth to be considered.

2. Low Frequency VLBI Network Project

The LFVN project was started in 1996, having the purpose to arrange the international VLBI cooperation with participation of former Soviet Union radio telescopes. During the project 18 VLBI experiments were carried out using various combinations of radio telescopes and correlators in Canada, China, Urumqi, England, India, Italy, Japan, Latvia, Poland, Russia, South Africa, Ukraine, and USA.

Main directions of LFVN activity are:

- Learning the VLBI radar method, combination of classic radar and VLBI: study of shortperiodic variation of proper rotation for the Earth group planets, improving the orbits of asteroids crossing the Earth orbit, measuring the space debris population at geo-stationary and high-elliptic orbits;

- Developing new methods of the solar investigations: mapping the solar wind irregularities, measuring the spatially-temporary structure of solar spikes;
- Mastering the near-real time differential VLBI technique for determining the satellite and deep space mission coordinates;
- Traditional VLBI astronomic observations as AGN and OH-maser imaging and investigation of active stars and stellar coronae structures.

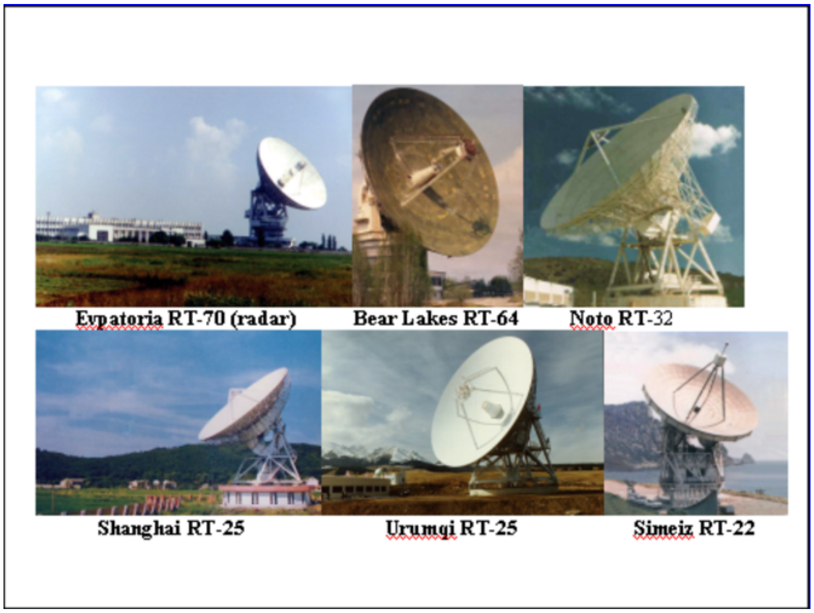

Figure 3. Some Radiotelescopes involved in the LFVN Project

3. Acknowledgements

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