Fringes on the EVN MkIV data processor at JIVE

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Abstract

The highlight of the 4th EVN/JIVE Symposium was the inauguration of the new EVN MkIV data processor at JIVE. This paper deals with the state of the processor in October 1998 and how it was used for fringe detection experiments.

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1 Introduction

1.1 System description

The new EVN MkIV data processor at JIVE is intended to handle the majority of data from the European VLBI Network (EVN) as well as other VLBI arrays. The data processor is based on the MkIV tape standard (Whitney et al., 1999) and can also process MkIIIA and VLBA tape formats. The assembly of the data processor is largely finished, culminating in its inauguration which was held on October 22 1998 during the 4th EVN/JIVE Symposium. During the inauguration, the correlation of a 16 station experiment was successfully demonstrated.

The EVN MkIV data processor can simultaneously correlate 16 stations using data playback units (DPU) developed by Metrum Information Storage Ltd (formally Penny & Giles Data Systems Ltd). Attached to each DPU is a

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station unit (SU) which formats the data coming from tape and sends it to the correlator. The SUs can deal with 64 input data tracks and produce up to 16 recombined 2-bit data streams to be sent to the correlator on 2 high speed serial lines. The correlator is based on 1024 custom designed chips grouped into 8 functional segments. Each segment receives inputs from 8 different stations and can configure it's 128 chips flexibly to form products between all 8 inputs, which contain up to 8 sub-bands. A Data Distributor Unit (DDU) is necessary to flexibly connect the 32 SU outputs to all the 64 correlator inputs, to form all baselines between 16 stations. The DDU also enables recirculation to produce high spectral resolution data (see Casse (1999) for a more detailed review).

The EVN MkIV recorders and the JIVE playback units can be fitted with two head-stacks which can write to or read from the tape simultaneously, allowing the recording of 64 data tracks. This doubles the recording rate at a given speed. When recording at "quad-speed" (320 ips) on thin tape, a data rate of 1 Gb/s is achievable. At this data rate, the correlator has sufficient capacity to handle all baselines for a 16 station experiment with 64 frequency points per baseline. At lower data rates, or with less stations, a greater number of frequency points is achievable.

1.2 Current hardware setup

Currently (November 1998) the DPUs are equipped with a single (triple-cap) head, so up to 32 tracks can be read back simultaneously (2 heads operations will be implemented in 1999).

The only major hardware component which is not completed is the DDU. This means only 8 SUs can be connected to each correlator segment and it is impossible to form all 120 cross products between 16 stations. In effect the current setup is two separate 8 station correlators. All combinations between the first 8 stations are possible, as well as between the last 8 stations, but not across the two segments.

Only a limited number of correlator configurations are available. The most frequently used ones produce either 64 complex lags for 4 sub-bands on each baseline, or a single baseband with 256 complex lags. These modes are sufficient for many experiments, but only use 1/16 of the final correlator capacity.

1.3 Current software

The most vital parts of the control software are completed. All the hardware is steered by messages from the Central Control Computer (CCC). The software is designed following object-oriented methods and has matching processes for all components running on the hardware, communicating with all hardware using a standard Ethernet network and TCP/IP sockets.

Real time fringe display is already possible, and work on a self-contained local output format is in progress. This format will be used for archiving but data will be transfered to AIPS++ for inspection and then exported in UVFITS format. Even without the final form of the data format, the data can currently be exported into an AIPS++ "measurement-set". However, several key labels on the data are still missing, preventing calibration and mapping.

The data processor will eventually run from VEX formatted log and schedule files. Source positions, station positions and other auxiliary data will be stored in local databases and used to augment the schedule and the logs. Currently, the data processor runs automatically from the MkIV schedule files without taking log files or auxiliary databases into consideration. The "CALC" model is used to calculate the correlator model which is converted into the polynomial coefficients necessary for correlation. In the future a choice between different models will be possible, such as the "GLORIA" model.

2 Fringe Detection

First fringes for the JIVE correlator where obtained in July 1997 on a Jodrell Bank – Cambridge baseline with the data from both stations recorded on a single tape. This was simple 1-bit sampled data in MkIIIA format. During 1998 the number of tape playback units was increased from 1 up to the full complement of 16. This process combined testing new hardware as it was delivered, debugging the online control software and accessing the data produced by the correlator.

2.1 Experiments

Two experiments were used to test and debug the data processor, both were observed in May 1998. The first, FR002, was a 6 station multi-mode experiment observed with the EVN at 18 cm on thick tape. These tapes were used to test double speed, 2-bit and fanout modes. Fan-out implies writing the data from a single sub-band onto multiple tracks on the tape, allowing an increase of 2 or 4 in the bandwidth of individual sub-bands at a given speed. Fringes have been obtained for all modes recorded on the tapes which range from simple 1-bit no fanout, a fanout of 1:4 (8 MHz bandwidth), and a 2-bit double speed mode (4 MHz bandwidth). Both MkIV and VLBA formatted data have been successfully processed. The VLBA data was always recorded with data modulation enabled, but without barrel-rolling.

The second experiment, GL034, was a global 18 station experiment, observed to test the imaging capability of the data processor. The stations which took part were Jodrell Bank, Westerbork, Effelsberg, Onsala, Medicina, Noto, Torun, Shanghai, Cambridge and all of the VLBA except Mauna Kea. The experiment was recorded on thin tape in a 2-bit double speed mode with no fanout. Eight 4 MHz sub-bands were recorded giving a total data rate of 128 Mb/s. The target source was 3C380 (J1829+4844).

2.2 Processing results

The GL034 tapes were spun during the inauguration of the data processor. Although all 18 stations observed successfully for most of the experiment, it still proved difficult to find scans where all stations participated, because of limited mutual visibility between Shanghai, Europe and the USA. In particular it turned out that not all stations observed simultaneously during any of the calibrator scans, forcing us to demonstrate the 16 station capability on a relatively faint and resolved radio source.

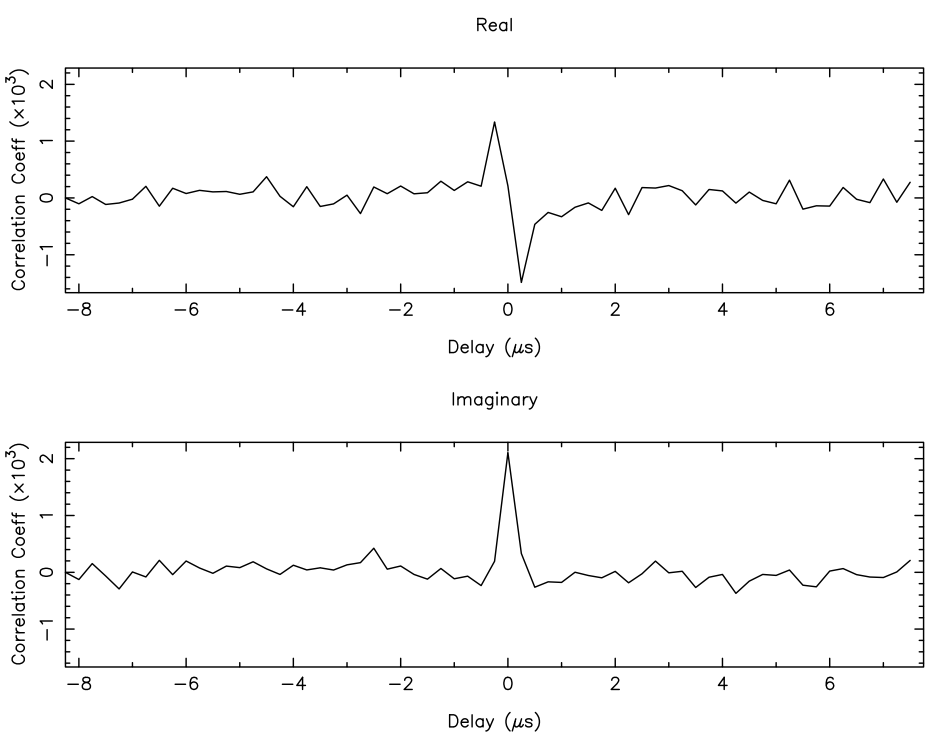

Fig. 1. Real (upper) and imaginary (lower) lag spectrum of the source 3C345 for a four second integration between Effelsberg (Germany) and Hancock (New Hampshire, USA). The bandwidth of the data was 4 MHz. The horizontal scale is residual delay in microseconds and the vertical scale is the correlation coefficient.

After some initial problems with the correlator model, fringe finding for the GL034 tapes posed no major problems. Clock offsets were based on values found at the Socorro and Bonn correlators for experiments observed in the same EVN session. These gave a good estimate of the offsets appropriate for the JIVE correlator. As clock rates at Bonn and Socorro were quite low, these were ignored with no ill-effect.

Analysis of the data was done in the AIPS++ package. Once the raw data were transfered into an AIPS++ measurement-set, the AIPS++/Glish environment provided a powerful tool for visual and numerical analysis and inspection of the data. A suite of Glish functions have been written to plot the lag and spectral data (for example time variations, closure phase and amplitude etc.) and calculate statistics on the data. Using AIPS++ enables analysis of the data before the final output data format is implemented and allows for fast implementation of new analysis routines.

2.3 Commissioning phase

Although the construction of most of the data processor is complete, the system is not yet running in a production mode, but rather is going through a commissioning phase. There are many aspects that need to be verified and smoothed out before the processor will produce data usable for astronomical purposes. For instance, several internal corrections to the data need to be switched on and tested, and the final output format needs to be implemented. In early 1999 software enhancements will enable the full processing of GL034, allowing us to make the first image. [2]

The first user experiments have been observed, and a release of the data is planned for the early half of 1999. The observable modes are still limited while we concentrate on producing "clean" data that can be easily processed by astronomers.

The construction of the DDU and a conglomeration of software to allow the data processor to be run by operators are the major milestones of the commissioning phase. It is planned that the EVN MkIV data processor will be operational by the summer of 1999.

[2] Note added by the editor: On April 7, 1999 the EVN MkIV data processor at JIVE generated its first astronomical image.

3 Acknowledgments

Finding fringes on the EVN MkIV data processor at JIVE was a team effort. Many people contributed to the process of understanding the workings of the data processor and the authors acknowledge the work of all team members to implement and test software and hardware.

References

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