The Bonn Astro/Geo Mark IV Correlator

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Abstract

The Bonn MK IV VLBI correlator is operated jointly by the MPIfR (Bonn), the GIUB (Bonn) and the BKG (Frankfurt). In 2002 the data processor was oversubscribed, but the throughput could be increased after two annoying bugs in the system were fixed. Two Mark 5P system were installed in the second half of the year.

1. Introduction

The Bonn MK IV correlator is jointly operated by the *MPIfR*[1] and by the *BKG*[2] in cooperation with the *GIUB*[3]. It is a major correlator for geodetic observations, and MPIfR's astronomical projects.

2. Present Status and Capabilities

The correlator in Bonn is one of four world-wide MK IV VLBI data processors. It consists of the standard 16 station capable correlator unit and nine Honeywell/Metrum 96 tape drives, each of which is connected to the correlator via a standard MK IV station unit and high speed data links.

The tape units are all equipped with digitally-switched equaliser boards developed in Bonn which allow playback of thin (and thick) tapes recorded at normal (80/135 ips) and double speed (160/270 ips).

The supported formats are MK IIIA, MK IV and VLBA, both MK IV and VLBA with 1- or 2-bit sampling and barrel-rolling. Fan-in modes are not supported while all the fan-out modes 1:1 and 1:2 and 1:4 are possible. Up to 16 frequency channels can be used, both upper and lower sidebands. Channel bandwidths of 2, 4, 8 and 16 MHz are available. Observing modes with up to 512 Mbits/s have been correlated successfully. This has to be done in two correlation passes, as 512 Mbits/s are recorded with 2 heads simultaneously, while the correlator tape units possess only 1 playback head.

The correlation is done in a scan-based way; the overhead for each scan is about 2 to 3 minutes. It takes less than about 5 seconds to synchronise the tapes. Up to two of the phase-cal tones can be extracted, but only one is used by the fringe-fitting software to align different frequency channels. The geometric correlator model is CALC 8. The pre-averaging time is flexible from 0.5 to 5 seconds. Shorter pre-averaging times are possible, but have not yet been tested.

The installed computer power is sufficient to handle all nine tape units in a correlator mode with 32 lags, auto-correlations and 1 s pre-averaging. Full polarisation correlation is possible with 8 stations simultaneously. For improved spectral line resolution, correlator modes with up to 4096 lags are available. Correlation setup, data inspection, fringe-fitting, and data export is done with a separate workstation. Per year about 300 to 400 GBytes of correlated data are generated. The

[1] Max-Planck-Institut für Radioastronomie, Bonn, Germany, http://www.mpifr-bonn.mpg.de
[2] Bundesamt für Kartographie und Geodäsie, Frankfurt, Germany, http://www.ifag.de/Geodaesie/gf_e.htm
[3] Geodetic Institute, University of Bonn, Germany, http://giub.geod.uni-bonn.de/vlbi

total disk space available for data handling at the correlator is 380 GBytes. Data security is guaranteed by using a file system with redundancy (RAID level 5) and by daily back-up of the data on MPIfR's backup server.

The year 2002 saw a heavy geodetic load on the Bonn correlator, while astronomical correlation stayed at about the level of 2001. In addition, two long standing problems in the station units each caused an unnecessarily large amount of re-correlation and of interrupted and repeated correlations respectively [1]. As a result the correlation of lower priority geodetic projects had to be delayed (see section on statistics below).

Finally in the summer of 2002 one of those problems, which caused occasional slips of one or even more bytes in the data stream of a track, was solved by Metrum UK under contract to JIVE, Dwingeloo (one of the partners who developed the MK IV correlator). As a result the required re-correlation could be reduced drastically. In autumn then the MK IV group at Haystack Observatory found a workaround for the second problem which increased the correlation throughput by up to 20% for geodetic correlation.

In July the first Mark 5P unit arrived from Haystack. It was successfully tested both for recording in Effelsberg and playback at the correlator. After the remedy of a few initial minor problems, correlation with the Mark 5 system went smoothly and more reliably than with the MK IV tape units. As no time is needed for positioning to the beginning of the scans, a small increase in correlator throughput has been observed as well, which will further increase with the introduction of more Mark 5 systems.

In September a second Mark 5P unit was put into operation, and just before Christmas two Mark 5A units arrived, so that the correlator is already well equipped for correlation of Mark 5 data, given that about 25 systems are installed now world-wide.

The software of the Mark 5 systems is still under development, and for instance cannot yet handle missing or broken disks in a recorded disk-set. The correlator software itself is fairly stable now, although it seems that occasionally scans scheduled for correlation do not get correlated even though they are listed in a correlator batch file. This latter problem is presently under investigation. Other minor problems are that occasionally the phase-cal signal is not extracted correctly so that scans have to be re-correlated or that correlations are performed with the playback heads offset by one head pitch.

Further improvements in the correlator software are needed to bring the data processor closer to the original specifications: pulsar astrometry cannot be done as gating is not yet implemented in the station units, and the correlator power is somewhat limited as the correlator-internal processors (DSPs) cannot yet be used to control the correlation process.

The correlation processing factor is lower than it has to be as the setup time for each scan is at least 2 minutes so that a scan of 40 seconds takes 3 minutes on the correlator (see also statistics below). It is clear that a reduction of the setup time would allow increasing the amount of geodetic observing significantly.

An up-to-date list of correlator capabilities can be found on the Internet under http://www.mpifr-bonn.mpg.de/EVN/MK4CORstatus.

3. Correlator Operations and Statistics

The people in the geodetic group at the Bonn correlator are

- Arno Müskens : group leader, overall experiment supervision, scheduling of T2 series

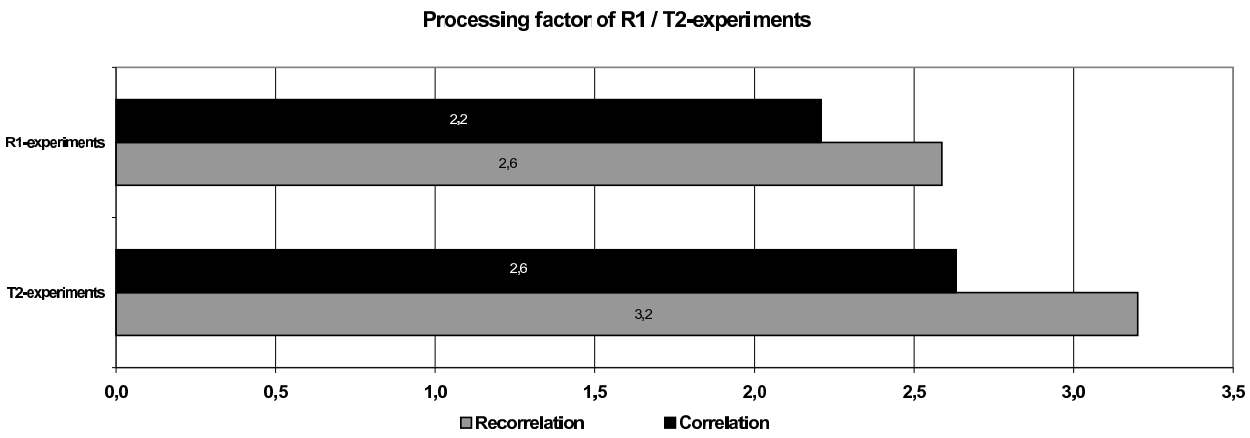

Figure 1. The diagram shows the averaged processing factors (correlation time/observing time) for both the R1 and T2 series of experiments. The overall processing factor including the re-correlation is shown in gray.

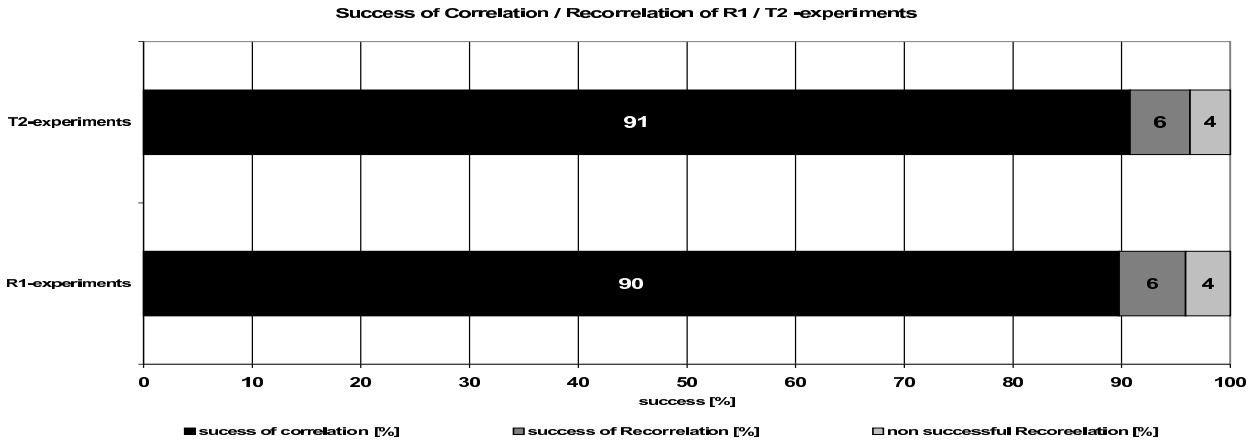

Figure 2. The diagram shows what fraction of scans were formally processed correctly in the inital correlation, in the re-correlation and what fraction of the scans were lost.

- Izabela Rottmann : experiment supervision (part time)
- Ingrid Benndorf : experiment supervision (part time)
- Alessandra Roy : experiment supervision (part time)
- 10 student operators for the night shifts and the weekends

Experiment supervision includes the preparation of correlator control files, fringe searching, supervision of the correlation process, preparation of the re-correlation, the correlator report, database generation, archiving, and the supervision of tape shipments.

MPIfR supports IVS correlation with

- Walter Alef : correlator manager, correlator software maintenance and upgrades, and computer system administration
- David Graham : technical development, consultant

- Heinz Fuchs : correlator operator, responsible for correlator operator scheduling, daily operations, and tape shipping.
- Hermann Sturm : correlator operator, correlator support software, tape shipping
- Michael Wunderlich : engineer, playback drive maintenance, Mark 5 support
- Arno Freihold : engineer, correlator maintenance
- Rolf Märtens : technician, playback drive maintenance, Mark 5 support

The Bonn group correlated in 2002:

- T2 experiments : 12
- R1 experiments : 26
- EURO experiments : 4
- CONT02 experiments : 2
- OHIG experiments : 6

In 2002 correlator operations had to be further streamlined and optimised, as the demand for (geodetic) correlation time increased in 2002. Special consideration was given to the amount of re-correlation and its success rate. Unfortunately the processing factor could not be reduced below a factor of about 3! (see Fig 1). From Fig 2 it can also be seen that not much can be gained by further reducing the time spent on re-correlation.

Despite all these efforts the share of geodetic correlation increased to 70% of the total correlator time, which is far more than the agreed 50%. GIUB and BKG agreed with MPIfR to provide a full position to MPIfR as a compensation which will officially increase the allowed amount of geodetic correlation to 60%. It is expected that the backlog of geodetic correlation can be reduced within the first quarter of 2003.

4. Outlook

In 2003 BKG will provide another four Mark 5 units to the correlator. As all of these units will be installed in parallel to the tape units, any combination of MK IV and Mark 5 recorders can then be handled at the correlator.

As an option for extending the correlator capacity MPIfR is investigating whether a tenth station unit can be installed on the correlator. The biggest problem might be the procurement of receivers/transmitters for the high-speed serial links.

References

[1] Müskens, A. & Alef, W., in "International VLBI Service for Geodesy and Astrometry 2002 Annual Report", eds. N. R. Vandenberg and K. D. Baver, NASA/TP-2002-210001, 2002.