The Bonn Astro/Geo Mark IV Correlator

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Abstract

The Bonn Mark IV VLBI correlator is operated jointly by the MPIfR (Bonn), the GIUB (Bonn) and the BKG (Frankfurt). In the course of 2003 eight Mark 5A systems have been installed. The amount of data recorded with Mark 5A has reached 40%.

1. Introduction

The Bonn Mark IV correlator is hosted at the Max-Planck-Institut für Radioastronomie (*MPIfR*)[1], Bonn, Germany. It is jointly operated by the MPIfR 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 Mark IV VLBI data processors. It has been operational since 2000. 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 Mark IV station unit and high speed data links.

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

In the course of 2003 eight Mark 5 disc-recorder units were added to the data processor. The tape drives were re-arranged to make space for a rack which can hold seven Mark 5 units (see Fig 1). The Mark 5 units are connected to the station units in parallel to the tape drives. Data from the tape units is fed into input for head one and data from Mark 5 into input for head two. As the tape drives are equipped with only one playback head the second input is otherwise unused. Playback from tape or disc can be selected via a simple software switch. With this setup all 32-track modes can be correlated from both tapes and discs. 64-track modes can be correlated with modest re-cabling with either one or two correlation passes depending on the details of the experiment.

The supported formats on tape and disc are Mark IIIA, Mark IV and VLBA, both Mark 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 512 and 1024 Mbits/s have been correlated successfully without major problems, where 1024 Mbits/s can only be realized with Mark 5 systems.

The correlation is done in a scan-based way; the overhead for each scan is about 2 to 3 minutes for tapes and 1 minute for the disc recordings. It takes less than about 5 seconds to synchronize

[1] http://www.mpifr-bonn.mpg.de/div/vlbicor/index_e.html
[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

Figure 1. Tape drives with stations units on top, Mark 5 units in a rack, and the correlator surrounded by two more tape drives, Mark 5 units, and station units. The correlator control console is visible on the desk in the center.

the tapes while the synchronization of Mark 5 systems is instantaneous. 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 1 to 5 seconds. Shorter pre-averaging times are possible, but can only be sustained by correlating fewer stations simultaneously.

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 polarization correlation is possible with 8 stations simultaneously. For improved spectral line resolution, correlator modes with up to 1024 complex lags have been used. 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 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 a 120 GB disk of a low-end Linux PC.

The correlator software has become fairly stable in the last two years, and the only major changes provided by Haystack addressed the handling of Mark 5 data. The track-finding software for the tape drives was modified in Bonn to avoid accidental correlation with one head-pitch offset.

The software of the Mark 5 systems is still under constant development and has to be upgraded regularly, but the reliability of the disk systems is already higher than that of the tape drives.

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 and OHIG series

- Izabela Rottmann : experiment supervision (part time; left in 2003)
- Alessandra Roy : experiment supervision (part time)
- Alexandra Höfer : experiment supervision (started in late 2003)
- 10 student operators for the night shifts and the weekends (60 hrs / week)
- Alan Roy : measurement and correction of tropospheric path length variations

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, correlator and playback drive maintenance, Mark 5 support
- Arno Freihold : engineer, correlator maintenance, digital BBC development
- Rolf Märtens : technician, playback drive maintenance, Mark 5 support

The Bonn group correlated in 2003:

- T2 experiments : 8
- R1 experiments : 30
- EURO experiments : 5
- CONT02 experiments : 1
- OHIG experiments : 3

Experience with IVS-R and other 24 hour observations shows it has been possible to reduce the processing factor (correlation time/observe time) by about 20 to 30% (see Fig 2), and the amount of re-processing by almost 75%. This is mostly due to reduced setup time and less operator interaction now that up to four stations record on Mark 5 systems, to more stable station unit software, and improved track-finding software.

The geodetic backlog from 2002 vanished towards the end of 2003 with the help of the improved throughput and less geodetic observing and correlation. The overall usage of the correlator in 2003 for geodetic correlation was 57% compared to 70% in 2002.

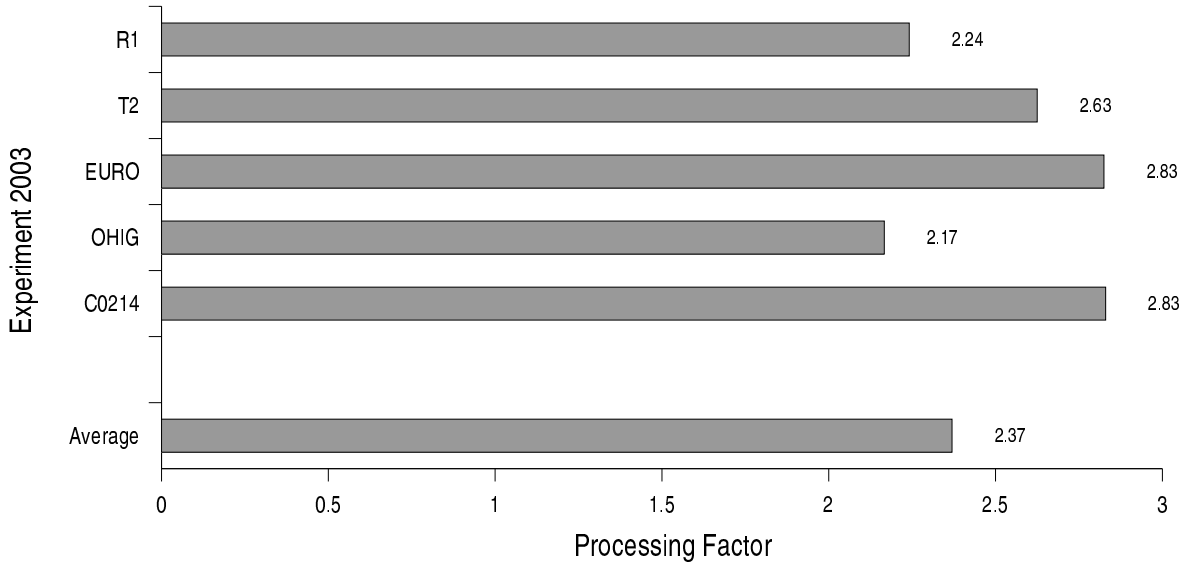

Figure 2. The processing factor could be reduced by about 20 to 30% compared to 2002. This is mostly due to the conversion of 2 to 4 stations to Mark 5 recording system.

4. Outlook

It is expected that in the course of 2004 all geodetic and EVN observations will be done exclusively with Mark 5. The tape drives will still be maintained because of joint 3mm-observations with the VLBA which does not yet have funding for Mark 5.

MPIfR will support the development of the Mark 5B system by re-designing the serial high-speed data links between the correlator and the planned station unit part of the Mark 5B units. It is also planned to fully upgrade the correlator to Mark 5B systems in 2004/2005.

The development of fully digital base-band converters (dBBCs) is also supported at MPIfR. This project lead by Gino Tuccari from Noto will eventually allow replacing the aged analog BBCs with new hardware. Improved bandpass characteristics as well as higher data-rates will help to increase the precision of the geodetic observables.