The Bonn Astro/Geo Mark IV Correlator

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Abstract

The Bonn Mark IV VLBI correlator is operated jointly by the MPIfR and the IGGB in Bonn and the BKG in Frankfurt. In 2007, e-VLBI transfers became routine for geodetic experiments and, thanks to that, a new intensive series (INT3) was introduced and is correlated in Bonn. Three Mark 5B units have been installed and are in regular use for stream correlation. In late December, the first phase of a Linux cluster dedicated for the software correlator, which will become the long-term future replacement for the hardware correlator, has been installed.

1. Introduction

The Bonn Mark IV correlator is hosted at the Max-Planck-Institut für Radioastronomie (MPIfR) (http://www.mpifr-bonn.mpg.de/div/vlbicor/) Bonn, Germany. It is operated jointly by the MPIfR and by Bundesamt für Kartographie und Geodäsie (BKG) (http://www.bkg.bund.de/) in cooperation with the Institut für Geodäsie und Geoinformation der Universität Bonn (IGGB) (http://www.gib.geod.uni-bonn.de). It is a major correlator for geodetic observations and MPIfR's astronomical projects, for instance those involving millimeter wavelengths and astrometry.

2. Present Status and Capabilities

Figure 1. The left-most rack contains the two correlator crates. The racks second and third from left contain two station units with two rack-mounted Mark 5A playback units. The right-most rack contains three Mark 5B units and a Mark 5A unit dedicated for e-VLBI.

The Bonn correlator (Fig 1) is one of the four Mark IV VLBI data processors in the world. It has been operational since 2000. A summary of the Bonn correlator capabilities is presented in Table 1.

The correlator is controlled by a dedicated Linux workstation and an HP workstation connected to a Linux file server. Correlation setup, data inspection, fringe-fitting, and data export are done on a second Linux machine connected to the Linux file server. In 2007, about 700 Gbyte of correlated

Table 1. Correlator Capabilities

Playback Units	
Number available:	1 Mark IV tape drive, 8 Mark 5A systems, 3 Mark 5B systems (interchangeable)
Tape types:	Thick, thin
Playback speeds:	80 ips, 160 ips (thin tapes); 135 ips, 270 ips (thick tapes) up to 1024 Mbit/s (Mark 5A)
Formats:	Mark III/Mark IV/VLBA (Mark IV/VLBA w/wo barrel roll, data demod.)
Sampling:	One bit; two bit
Fan-out:	1:1 1:2 1:4
Fan-in:	Not supported
No. channels:	$\leq$ 16 USB and/or LSB
Bandwidth/channel:	(2, 4, 8, 16) MHz
Signal:	Mono, dual frequency; dual polarization
Modes:	128-16-1 128-16-2 128-8-1 128-8-2 128-4-1 128-4-2 128-2-2 256-16-1 256-16-2 256-8-1 256-8-2 256-4-2 512-16-2 512-8-2 1024-16-2
Correlation	
Geometric Model:	CALC 8
Number of boards:	16
Phase cal:	Two tones (Mark 5A/tape), 16 tones (Mark 5B) extraction at selectable frequencies
Pre-average times:	0.2 s to 5 s
Lags per channel:	32 minimum, 2048 maximum; 1024 tested and used
Maximum output:	10 stations: 45 baselines, 16 channels, 32 lags with autocorrelation function (ACF) parallel-hand polarizations only 8 stations: 28 baselines, 16 channels, 32 lags with ACF full pol.
Fringe-fit:	Off-line FOURFIT
Export:	Database, MK4IN to AIPS

data were generated. The total disk space available for data handling at the correlator is more than 10 Tbyte. Data security is guaranteed by using a file system with redundancy (RAID level 5) and by daily back-up of the data on a PC disk.

3. Staff

The people in the geodetic group at the Bonn correlator are:

Arno Müskens: group leader. Scheduling of T2, OHIG, EURO, INT3, and e-VLBI supervisor.

Simone Bernhart: experiment setup and evaluation of correlated data and media shipping. (successor of A. Höfer)

Alessandra Bertarini: experiment setup and evaluation of correlated data, software correlator development, e-VLBI commissioning tests and media shipping. Digital baseband converter (DBBC) testing. PhD student at IGGB since early 2007 to reduce the effect of polarization leakage on geodetic measurables.

Christian Dulfer: e-VLBI development and operations.

Bertalan Feher: setup and trial correlation of INT3.

Frédéric Jaron: e-VLBI support, software support and Web page maintainance.

Four student operators for night shifts and weekends.

The people in the astronomy group of MPIfR at the Bonn correlator, who support IVS correlation, are:

Walter Alef: head of the VLBI technical department, correlator software maintenance and upgrades, computer system administration and friend of the correlator.

David Graham: technical development, consultant, software correlator development and DBBC development and testing.

Alan Roy: deputy group leader, water vapor radiometer (WVR), technical assistance, FPGA firmware for DBBC for linear to circular polarization conversion.

Heinz Fuchs: correlator operator, responsible for the correlator operator schedule, daily operations and media shipping.

Hermann Sturm: correlator operator, correlator support software, media shipping and Web page development.

Michael Wunderlich: engineer maintaining correlator, playback drives, Mark 5 and development of the DBBC.

Rolf Märtens: technician maintaining correlator hardware, playback drives and Mark 5 playbacks.

One student operator for night shifts and weekends and help with VLBI data export.

4. Status

Experiment Status: in 2007 the Bonn group correlated 48 R1, five EURO, one T2, three OHIG, 18 intensive, one R&D and about 30 astronomical projects.

e-VLBI: near-real-time e-VLBI transfers from Tsukuba, Onsala, Metsähovi, Ny-Ålesund, Wettzell, and Kashima have become regular at the correlator. This reduced the time between observation and correlation since no shipment is required. The data rates achieved ranged from 100 Mb/s with Ny-Ålesund (limited by radio link) to 400 Mb/s with peak up to 800 Mb/s. The transfers are done using the UDP-based Tsunami protocol.

INT3: a third intensive series was introduced in mid-2007 and is scheduled and correlated in Bonn. Thanks to near-real-time e-VLBI transfer, the turnaround between observation and database submission to the analysis center is about seven hours.

Mark 5B: three Mark 5B units are installed at Bonn and are in regular use since Westford, Badary and Parkes antennas are equipped with Mark 5B.

Correlator Status: during 2007 the correlator control software has been partly ported from HP to Linux by the Haystack group. Bonn correlator installed the Linux version of the components that have been released at an early stage. Six tape drives were decommissioned at the end of 2007 to make space for the software correlator cluster, so the number of usable tape drives is now reduced to one unit.

Software Correlator: Validation tests of the DiFX software correlator are being conducted with the support of the Australian group at Melbourne and Perth. First results are very promising and a small publication is being prepared. A new Linux cluster (Fig: 2) was installed in late December.

21 nodes
2 nodes for user interaction
1 I/O node with 20 TB of disk space
1 service node
8 cores per node
20 Gbps InfiniBand interconnections
12 1 GBit inputs for Mark 5 units

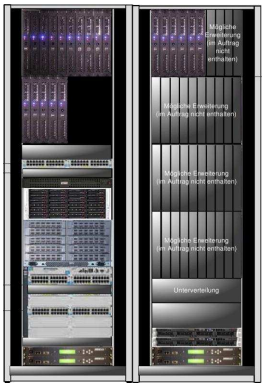

Figure 2. Scheme of the Linux cluster. The left rack contains top to bottom: part of the nodes, the service node (with keyboard and monitor), the 20 TB disk RAID, the switches and the panel control. The right rack contains top to bottom: part of the nodes, empty slots for future nodes an the panel control.

DBBC: the Bonn group is involved in the development of a DBBC for the European VLBI Network (EVN). This unit is designed as a full replacement for the existing analogue BBCs. Version 1 is in production; the first unit was delivered to Wettzell in November 2007. Two more units have been integrated and tested in December 2007.

5. Outlook for 2008

Correlator: the tape drive will be maintained in 2008 until the last session with tapes has been correlated. There will be a gradual changeover to Mark 5B, which will further simplify the correlation process since the station units will no longer be needed.

Software Correlator: the software correlator will be installed on the new Linux cluster and first astronomical correlation is awaited by the end of January 2008. The Mark IV hardware correlator and the new software correlator will coexist for some time.

e-VLBI: stream correlation using e-VLBI transfer will continue and e-VLBI tests with other antennas are envisaged. A K-band experiment will be transferred via e-VLBI from Australia to Bonn and copied directly to Mark 5B disks. The net protocol to be used for this transfer is still under discussion.

Personnel Changes: a new post-doc will dedicate 50% of her/his time for the future development for the software correlator.

DBBC: version 2 is under developement to provide broader bandwidth by using a new analogue-to-digital converter (ADC) and more powerful FPGA cores. This will lower costs by implementing four BBCs on a single FPGA. The ADC card prototype is ready for testing. The new card, the FiLa-10G board, provides outputs on optical fiber and testing will begin in the first half of 2008.