Haystack Observatory VLBI Correlator

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Abstract

This report summarizes the activities of the Haystack Correlator during 2010. Highlights include processing of the very large astrometry session IYA2009, more VLBI2010 experiments, a new tarball release, DiFX software correlator development, RDBE and Mark 5C testing, and more u-VLBI SgrA* observations. Non-real-time e-VLBI transfers and engineering support of other correlators continued.

1. Introduction

The Mark IV VLBI correlator of the MIT Haystack Observatory, located in Westford, Massachusetts, is supported by the NASA Space Geodesy Program and the National Science Foundation. The available correlator time is dedicated mainly to the pursuits of the IVS, with a smaller fraction of time allocated to processing radio astronomy observations for the Ultra High Sensitivity VLBI (u-VLBI) project. The Haystack Correlator serves as a development system for testing new correlation modes, for e-VLBI, for hardware improvements such as the Mark 5C system, and for diagnosing correlator problems encountered at Haystack, at the identical correlator at the U.S. Naval Observatory, and, until late 2010, also at the Max Planck Institute for Radioastronomy. This flexibility is made possible by the presence on-site of the team that designed the correlator hardware and software.

2. Summary of Activities

2.1. IYA2009 Session

IYA2009 production processing dominated the entire first half of the year, essentially until June when the final data set was exported to Goddard. In total, twenty-two passes were needed to process all baselines of the thirty-three stations which participated, and roughly 560 hours of correlator time were used. This experiment tested all aspects of the processing chain. Many limitations of the real-time system, other supporting software, and the HOPS software suite were found and fixed. Examples include total number of files, total number of stations in the real-time software, and plotting limits within the aedit post-processing software. All these limits were raised in order to shepherd the experiment through to export.

2.2. Broadband Delay Experiments

Four broadband-delay development experiments using prototype VLBI2010 systems were conducted and correlated in a variety of configurations, including different frequency placements of the RF bands and different LO frequency offsets. These experiments were designed to explore the capabilities and potential limitations of the evolving VLBI2010 hardware. All were interferometric observations between the Westford 18-m and the GGAO 5-m antennas, with the post-receiver hardware at each site including four digital back ends (DBEs) and Mark 5B+ units. Although there were fewer broadband experiments this year, each was conducted more effectively due to lessons learned from previous years' work. All were re-observations of previous experiment types

such as one overlapping bands test, a 3C273B/3C279 source swapping test, and a 4C39.25 transit. These tests were facilitated by changes to the post-processing software to allow a fit of 64 channels across four bands, extracting phase cal information from all tones within the bands, and by correcting the phases for ionospheric effects.

2.3. New Tarball Release

A new tarball was released after extensive development and testing. This involved significant revision to the run-time software system which now incorporates techniques like compilation from source code on each individual platform in order to improve stability and to maintain compliance with the growing number of operating systems involved in the hardware correlator system. This tarball was installed in Bonn and is pending installation at WACO.

2.4. DiFX Software Correlator Development

Extensive DiFX correlator testing is underway, with the intent of transitioning to the new system by mid-2011. The *difx2mark4* application was developed in order to convert the output of the DiFX correlator into Mark IV format for reading into the HOPS package for post-processing. Extensive effort was expended on getting the DiFX correlator to handle phase cal tones properly. In December 2010 the Bonn correlator switched to DiFX for production, a transition made possible by these developments.

2.5. Independent HOPS Package

An independent HOPS release package was developed so that this package can be made generally available to the geodesy and astronomy communities. Thus, recipients of raw correlator output can do their own post-correlation analysis.

2.6. Digital Backend Testing

Testing was done on some next generation digital backend systems such as the RDBE and recording systems such as the Mark 5C. The Conduant SDK9 software package was also tested on two Mark 5B DOMs.

2.7. WACO Support

In addition to the usual support work, a significant amount of correlator time was used for testing equipment, such as four Mark 5Bs and several CIBs, prior to their shipment to WACO. There was also testing of a suspect control board when WACO was having top-crate syncing problems.

2.8. Bonn Support

Help was provided in converting K5 e-VLBI-transferred data to Mark 5B format; this was an augmentation of the ability to convert K5 to Mark 5A format. Various disk and correlator software related processing problems were addressed. Additionally, Haystack re-established the programmer for FIFO chips in order to replenish stock and provide spares to Bonn and WACO.

2.9. Galactic Center Polarization Project

Another u-VLBI project involving observations of the galactic center (SgrA*) was conducted, this time with dual polarization. This also was an engineering test of a phased-array processor system to combine the collecting area of interferometer elements on Mauna Kea. This system will increase the sensitivity of the u-VLBI array and will be adopted at other sites once fully operational.

2.10. Frequency Standard Test

There was an experiment to compare the stability and performance of a crystal sapphire oscillator to a hydrogen maser and rubidium clock as a frequency standard for the u-VLBI project.

2.11. e-VLBI

Non-real-time transfers have continued. Data from ten experiments were transferred to Haystack this year from six stations, all in Japan: Kashima, Tsukuba, Chichijima, Ishigakijima, Aira, and Mizusawa. In addition, this year the Westford station participated in twenty-six Intensive sessions which were e-transferred to the GSI correlator.

2.12. Experiments Correlated

In 2010, twenty-seven geodetic VLBI experiments were processed at the Haystack Correlator, consisting of the previously mentioned IYA2009, two R&Ds, four T2s, and twenty test experiments. The test experiments included broadband development and a wide assortment of other projects, some of which were touched on in the summary above. As usual, there was also a large number of smaller tests that are not included in the above count because they were too small to warrant individual experiment numbers.

2.13. Current/Future Hardware and Capabilities

As of the end of 2010, functioning hardware installed at the correlator included two tape units, seven Mark 5A units, seven station units, seven Mark 5B units (DOMs) with their associated correlator interface boards (CIBs), sixteen operational correlator boards, two crates, and miscellaneous other support hardware. We have the capacity to process all baselines for eleven stations simultaneously in the standard geodetic modes, provided the aggregate recordings match the above hardware matrix. This configuration reflects the addition of three new 5B units, for a grand total of fourteen playback units on the Mark IV correlator. This gives us the capability to run larger experiments in one pass.

In mid-2011, we hope to transition to the software correlator, only keeping the hardware correlator alive in support of USNO until their transition, expected in 2012.

3. Staff

Staff who participated in aspects of Mark IV, DiFX, Mark 5, and e-VLBI development and operations include:

3.1. Software Development Team

- John Ball - Mark 5A/5B; e-VLBI
- Roger Cappallo - real-time correlator software and troubleshooting; system integration; post-processing; Mark 5B/5C; Linux conversion; e-VLBI; DiFX correlator development
- Geoff Crew - DiFX correlator development, post-processing software
- Kevin Dudevoir - correlation; maintenance/support; Mark 5A/5B/5C; e-VLBI; Linux conversion; correlator software and build system development; computer system support/development
- Jason SooHoo - e-VLBI; Mark 5A/5B/5C
- Chester Ruszczyk - e-VLBI; Mark 5A/5B/5C
- Alan Whitney - system architecture; Mark 5A/5B/5C; e-VLBI

3.2. Operations Team:

- Peter Bolis - correlator maintenance
- Brian Corey - experiment correlation oversight; station evaluation; technique development
- Dave Fields - playback drive maintenance; Mark 5 installation and maintenance; general technical support
- Glenn Millson - correlator operator
- Arthur Niell - technique development
- Don Sousa - correlator operator; experiment setup; tape library and shipping
- Mike Titus - correlator operations oversight; experiment setup; computer services; software and hardware testing
- Ken Wilson - correlator maintenance; playback drive maintenance; general technical support

4. Conclusion/Outlook

A full transition to the DiFX software correlator is expected by mid-2011. Testing of a complete VLBI2010 system is expected to start in early 2011. Testing and implementation of new digital back end and recording systems will continue.