Haystack Observatory VLBI Correlator

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Abstract

This report summarizes the activities of the Haystack Correlator during 2011. Highlights include acquisition of new hardware for a DiFX cluster, development and improvement of tools to facilitate DiFX production, more u-VLBI Galactic Center observations, Mark 6 recording system testing, and various other continuing projects. Non-real-time e-VLBI transfers and engineering support of other correlators continued.

1. Introduction

The Mark IV and DiFX VLBI correlators of the MIT Haystack Observatory, located in Westford, Massachusetts, are supported by the NASA Space Geodesy Program and the National Science Foundation. They are 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 correlators serve as a development system for testing new correlation modes, for hardware improvements such as the Mark 6 system, and in the case of the Mark IV, for diagnosing correlator problems encountered at Haystack and at the identical correlator at the U.S. Naval Observatory. This flexibility is made possible by the presence on-site of the team that designed the Mark IV correlator hardware and software. Some software support is provided to the Max Planck Institute for Radioastronomy (MPI) in Bonn, Germany for DiFX processing of IVS experiments.

2. Summary of Activities

2.1. DiFX Cluster Acquisition

Commissioning of the DiFX correlator has accelerated. Acquisition of cluster hardware began in mid-2011. This included the purchase of six Supermicro server machines with 12-core Intel CPUs, an infiniband switch, and infiniband cards for each server and some of the capable Mark 5 units. Configuration and testing of the cluster and new hardware are in progress. The transition to all-DiFX correlation is expected in the first half of 2012 but will be coupled with hardware correlator comparison tests. Some comparison tests of many experiment types have already been done with the existing setup. The annual DiFX developers' meeting, which was held at Haystack in 2011, resulted in much progress adapting some of the other sites' tools, such as the database system developed at MPI and a GUI developed at USNO. Other tools will be adapted by mid-2012.

2.2. DiFX Software Support

Meanwhile, the development of the tools to support conversion of DiFX output to Mark IV format has continued, such as the difx2mark4 utility for converting DIFX correlator output and an export package of HOPS tools to facilitate post-processing data analysis at other institutions. Some of these tools have been installed at Goddard and used to process geodetic experiments.

2.3. Broadband Delay

Although Broadband Delay "production" observing has been light this year, one major milestone was reached in seeing first fringes to the Patriot 12-meter antenna which was recently completed at the GGAO site. Two fringe tests were conducted over the last year, one in March and another in June.

2.4. Galactic Center Observations

Further u-VLBI observations of the Galactic Center were conducted and correlated. The lessons from 2010's engineering test of a phased-array processor system to combine the collecting area of interferometer elements on Mauna Kea were applied to the interferometer elements at the CARMA site.

2.5. WACO Support

Similar to 2009, the Haystack correlator was used during the Technical Operations Workshop (TOW) held at Haystack in May to process Kokee-Wettzell Intensive sessions, with the data then being sent down to WACO for cleanup and export. This demonstrated that Haystack can serve as a backup correlation site in the event of down time at WACO. Another experiment, an APSG, was correlated at Haystack to reduce WACO's processing backlog. The raw correlator output was fourfited and exported by WACO. This correlation was also done to fulfill contractual requirements to USNO.

2.6. Bonn Support

A significant amount of support for difx2mark4 and HOPS issues was provided to the Bonn DiFX correlator to facilitate geodetic operations. Also, the Haystack Correlator gave support related to the SgrA* Galactic Center observations conducted in April to facilitate fringe searches for two newly participating MPI-sponsored antennas.

2.7. Special IYA Export

A special export of the IYA-2009 data was made for Arnaud Collioud of Bordeaux Observatory to allow imaging of sources in the AIPS software package (one of the goals of the IYA session). Assistance was also provided for the HOPS software package so that the data could be prepped for reading into AIPS through the MPI-developed mk4in method.

2.8. RDV Fourfiting

With NRAO converted to DiFX correlation, the option of processing RDV experiments through the HOPS/Mark IV data path, as opposed to the AIPS path, has opened. In order to test the viability of this path, RDV85 through RDV89 were converted to the Mark IV data structure with difx2mark4 and then fourfited. It was concluded that the Mark IV data path is preferable, so we are developing a procedure to turn Mark IV conversion and fringing into the default method.

2.9. Mark 6 Testing

A live demonstration of 16 Gb/sec recording with RDBEs and Mark 6 data recorders was performed at the TOW meeting in May. Another test was conducted in October between GGAO and Westford, where fringes were obtained using RDBE digital back ends and Mark 6 data recorders. A description of the Mark 6 system and those demonstrations can be found at:
http://www.haystack.mit.edu/tech/vlbi/mark6/mark6_memo/04-2011.12.05_Mark6_data_system -DiFX_mtg-Haystack.pdf

2.10. e-VLBI

Non-real-time transfers have continued. Data from thirty-two experiments were transferred to Haystack this year from nine stations (eight in Japan, and one in Sweden): Kashima34, Kashima11, Koganei, Tsukuba, Chichijima, Ishigaki, Aira, Mizusawa, and Onsala. e-VLBI transfers will significantly increase this coming year due to an upgrade of Haystack's connectivity to the Internet, which enables higher data transfer rates.

2.11. Experiments Correlated

Production processing using the Mark IV correlator continues amidst all the DiFX development. In 2011, twenty-nine geodetic VLBI experiments were processed, at least in part, on the Haystack Mark IV correlator, consisting of six R&Ds, six T2s, an AUST experiment, an APSG, and the Intensives during the TOW for USNO as mentioned before. The remainder were various tests. The R&Ds were especially important this year as they were preparatory tests for the CONT campaign which ran in September. This pre-testing was designed to ensure that the CONT campaign collected the highest quality data possible. The other test experiments included the broadband fringe tests and an assortment of other projects, some of which were touched on in the summary above. As usual, there were smaller tests that are not included in the above count because they were too small to warrant individual experiment numbers.

3. Current/Future Hardware and Capabilities

As of the end of 2011, the Mark IV correlator was comprised of seven Mark 5A units, seven station units, seven Mark 5B units (DOMs) with their associated correlator interface boards (CIBs), 16 operational correlator boards, two crates, and miscellaneous other support hardware. We have the capacity to process all baselines for 11 stations simultaneously in the standard geodetic modes, provided the aggregate recordings match the above hardware matrix. Note that all experiments up to 15 stations have been done in one pass due to the ability to share playback units between stations which do not co-observe. A subset of the playback units is accessible to the DiFX cluster.

In 2012 we hope to transition to the software correlator, only keeping the hardware correlator alive in support of USNO until their transition to a software correlator, which is expected in late 2012.

4. Staff

Staff who participated in aspects of Mark IV, DiFX, Mark 5/6, and e-VLBI development and operations include:

4.1. 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/6; Linux conversion; e-VLBI; DiFX correlator development
- Geoff Crew - DiFX correlator development, post-processing software; Mark 6
- Kevin Dudevoir - correlation; maintenance/support; Mark 5A/5B/5C; e-VLBI; Linux conversion; correlator software and build system development; computer system support/development; DiFX correlator development
- Jason SooHoo - e-VLBI; Mark 5A/5B/5C/6; computer system support
- Chester Ruszczyk - e-VLBI; Mark 5A/5B/5C
- Alan Whitney - system architecture; Mark 5A/5B/5C/6; e-VLBI

4.2. 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

5. Conclusion/Outlook

A full transition to the DiFX software correlator is expected by mid-2012. Testing of a complete VLBI2010 system comprised of new front and back end hardware at a station is expected to start in early 2012. Testing and implementation of new digital back ends and recording systems will continue.