CORRELATOR REPORT, EVN Correlator at JIVE
EVN TOG MEETING, May 2017, Ventsplils
(a complete recycling of the May 2017 EVN CBD Meeting report)

27 April 2017 (statistics cover 17 October 2016 − 23 April 2017)
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SCIENCE OPERATIONS

  Sessions and their Experiments

  The table below summarizes projects correlated, distributed, and released from 17 October 2016 to 23 April 2017. The table lists the number of experiments as well as the network hours and correlator hours for both user and test/NME experiments. The definitions of network and correlator hours remain the same as in previous reports. Multiple correlator passes for SFXC typically occur only for phase−referenced spectral−line experiments (separate "continuum" and "line" passes) and for pulsar observations wanting multiple gating/binning configurations.

	User Experiments			Test & Network Monitoring		
	N	Ntwk_hr	Corr_hr	N	Ntwk_hr	Corr_hr
Correlated	44	349	381	9	28	28
Distributed	52	423	559	14	43	46
Released	55	457.5	571.5	18	57.5	63.5

The following table summarizes the sessions with any activity in their user experiments since the previous report (entries = remaining to do / total).

	N_to.corr	Corr.hrs	N_to.dist	notes
Jul−Nov OoS+RadAst	4/4	59/59 hr	4/4	GA037A,B; EG089A,B
session 1/2016	0/19	0/231 hr	0/19	
Jan−Apr OoS+RadAst	6/6	56/56 hr	6/6	EG89C,D; EG97A−D (corr.only)
session 2/2016	0/18	0/279 hr	0/18	
session 3/2016	2/22	10/198 hr	8/22	
Sep−Nov OoS+RadAst	3/3	28/28 hr	3/3	EG094A,B; GA038
Nov−Jan e−VLBI	0/10	0/62	1/10	
session 1/2017	22	148	prognosis	
Feb−Apr e−VLBI	0/10	0/75	4/10	3 ToOs, 2 triggers

(3 of the 4 remaining e−EVN experiments to distribute from April were distributed on 24 April, the day after the period covered by this report)

Some landmarks since the previous CBD report:

Session 1/2016
- *) Distribution of user experiments concluded on 28 October (the final one was EG078E, the second 12−hour part of the second 24−hour epoch of the 699−target multiple phase−center experiment on the Hubble Deep Field).

Session 2/2016
- *) Correlation of user experiments finished by 3 March; distribution by 10 April. The final experiment in each case was the EVN+LBA observation EG088. Issues included:
  - −) Mopra data needed re−translating from LBA to Mark5B
  - −) ATCA had two separate recorders to cover the Gbps bit−rate (2x 64MHz subbands), and the two recorders had significantly different clock offsets (4.7 us). The current vex files permit a linear clock model per station, so each half of the total frequency range was correlated in a separate pass, and later VBGLUed together in AIPS.
  - −) Sub−netted schedule unraveled into two non−overlapping correlation control vex files.
- *) Bug found/fixed in the KVN control system for observations with 8MHz BBCs (recorded only first half of bit−streams); solved by the KVN after the session.
- *) SFXC buffering adapted to allow 2s integrations to be used with 64MHz channels, as required for NRAO RDBE/DDC stations in 2Gbps globals.

*) SFXC permits "uncovered" subbands, as required for L-band globals in which the EVN stations cover 128 MHz and NRAO stations 256 (1Gbps and 2Gbps, respectively): 16 dual-pol 16MHz subbands cover the entire 256 MHz range, even in scans having only EVNs with 8 such subbands.

Session 3/2016

*) First time trying phased-JVLA at P-band: proved impossible in the A-configuration; the option of dropping to 3-4 antennas per arm waived by PI, and the P-band block was canceled for now).
*) Kunming included in 6cm, 5cm, and 3.6cm NMEs, with fringes in all 3 band -- a first for 6cm and 5cm.
*) Irbene inserted into all possible NMEs, and various user experiments that fit within 48TB of packs. Fringes in all bands (18, 6, 5, 3.6 cm).
*) Operational e-shipping to FlexBuffs at JIVE from Effelsberg, Onsala, and Yebes.
*) The new version of the DVP back-end at Robledo, which can record fewer than 32 channels did not produce useful data (apparently a problem with the complex-sampling to real LSB/USB sampling conversion).
*) Three or four e-MERLIN out-stations (Cambridge, Darnhall, Knockin, sometimes Tabley/Pickmere) included in 5cm, 6cm, and 18cm NMEs, and scheduled in four user experiments up to 1Gbps each. There were no fringes from the NMEs via the data transferred in the ftp fringe-tests, and the full data from the user experiments have not arrived yet.
*) The two experiments yet to correlate are
    -) EK036B: waiting on PI to see whether there are in-beam calibrators to use from the wide-field correlation in EK036A [2.5TB])
    -) EM122B: the chronologically last user experiment with e-MERLIN out-stations, for which Jodrell Bank thinks the likelihood of fringes is highest.

Session 1/2017

*) 5 frequency blocks (18/21, 6, 90, 1.3, 0.7 cm), no spectral line. The JVLA was in D-configuration, for which phasing tests were successful.
*) Hartebeesthoek began operational e-shipping to FlexBuffs at JIVE, bringing the total number of such stations to four.
*) A few other non-FlexBuff stations used e-shipping to compensate for disk-pack problems during the session. There were also some instances in which experiments for both JIVE and Bonn correlators were recorded on a single pack, which also led to subsequent e-shipping and use of FlexBuff space. Some of these were for NRAO stations, for whom it may be inevitable if the schedule calls for switching destination correlators on sub-daily time-scales. Altogether, this "unbudgeted" e-shipping occupies about 71 TB of FlexBuff space, which will affect the available room going into session 2/2017.
*) Robledo reverted to the original version of the DVP back-end.
*) e-MERLIN out-stations include only Cambridge in the 18cm and 6cm NMEs and an 18cm user experiment.
*) Correlation of the 1/2017 session has not yet begun.

e-EVN:

*) 4 target-of-opportunity observations, from 3 different proposals, in this period. 2016 had the second-most e-EVN ToO network hours (121 hr), trailing 2010 which had 138 hr; 2017 has 41 e-EVN ToO hours already.
*) C-band e-EVN observations have been run at 2Gbps throughout this period; stations that can participate at the full 2Gbps rate include Effelsberg, Onsala, Yebes, Medicina, Noto, Hartebeesthoek, and Irbene (the first Irbene 2Gbps fringes came in November 2016).
*) The current record for total Gbps in an e-EVN user experiment is 18.5 Gbps (i.e., rate summed over all the individual stations).
*) EO014: simultaneous e-VLBI correlation and recording onto FlexBuffs at JIVE (a spectral-line observation needing continuum and line passes). Effelsberg used a linear 5cm receiver; liaison with Ivan Marti-Vidal resulted in casa code (operating on FITS files) to convert Effelsberg data to circular polarization.
*) EM128A: the first pulsar-gating e-EVN. Seven PSR scans were recorded during the clock-search period, from which no clear profile was seen in the gate-fitting (20-40 bins over a full-period gate; target PSR about 180 uJy). Production went ahead with 40 bins across the whole period rather than a single bin over the pulse. This is the remaining Oct-Jan e-EVN experiment "to distribute" in the above table, as work

with the PI to craft a set of output FITS files that would be the most convenient to use continues.

*) RP027: the first 2Gbps e-EVN observation including Arecibo, who were limited to 16MHz subbands (mark4). Centering 16MHz USB BBCs in each 2Gbps stations' 32MHz subbands avoided the copying implicit in standard mixed-BW correlation (two 16MHz subbands packed into a 32MHz subband), which might not have been able to keep up with real-time correlation with the 12-station array. This worked, but it turned out that Arecibo needed an Arecibo-only vex file to set themselves up properly (as yet not understood).

TECHNICAL DEVELOPMENTS

The total FlexBuff storage capacity at JIVE continued to increase, helped by funding from INAF. Two FlexBuffs were purchased, for Noto and Medicina, however only one of these was (partly) populated with 8TB hard disks. As soon as more funding becomes available the remaining slots will be filled as well. Westerbork and Jodrell Bank will soon follow suit.

In order to facilitate the increased use of e-shipping, decisions had to be made about the way to store data. This led to a system that automatically balances the load on the available FlexBuffs during the observing sessions, while limiting the number of individual station recordings per experiment to two per FlexBuff. More than two stations per unit might adversely influence the playback speed during correlation.

Two Gbps is rapidly becoming the de facto standard way of operations in the EVN, both recorded and in real time, and 4 Gbps is being actively tested. This, combined with the ever increasing number of FlexBuffs at the correlator, has prompted an analysis of the current and future needs of JIVE in terms of hardware and connectivity and how these could be accommodated. A design document is nearly completed, and based on this document new equipment will be purchased that will double the current number of cores of the SFXC, hook up all four UniBoards at full capacity and upgrade the entire internal JIVE network.

The in-house developed jive5ab program, which is used throughout the EVN (and beyond) for both recorded and real-data transfer, continued to be improved. It is now capable of handling data rates up to 256 Gbps, which should be sufficient for the foreseeable future. Many small and large improvements were implemented, increasing its ease of use of the fully transparent handling of both Mark6 and FlexBuff formats.

Work on the CASA fringe fitter continued, now funded by RadioNet after the BlackHoleCam project money ran out. The existing Python prototype was fine-tuned, and a C++ implementation within the CASA framework begun. Extensive comparisons were made among the result from CASA, AIPS, and HOPS, to which MeqTrees simulations to study the impact of the troposphere on fringe fitting were added. Besides the actual fringe fitter, a lot of additional code had to be written to make fringe fitting in CASA at all possible: the translation of AIPS calibration tables into CASA calibration code, the application of the solutions, handling of VLBI amplitude calibration and importing Tsys and weather information from FITS-IDI files.

Work in the Asterics project continued, with JIVE participating in several tasks and leading one work package. The mid-term review in Brussels in March this year went very well with very positive feedback from the reviewer.

In the SKA-NL Roadmap project, through which JIVE funds the Synchronization and Timing (SAT) architect, all effort went towards completing the CDR of the SaDT consortium.

Unfortunately the NWO-Dome project, which eventually should lead to global VLBI with the MeerKat array via a demonstration with KAT7, was held up by not-yet understood problems with the data of the phased-up KAT7. The KAT7/MeerKat VLBI working group however did produce a draft white paper, positioning VLBI in the current development of MeerKat and eventually SKA.

The Jumping JIVE project kicked off, and as part of one of its work packages

the time-honored sched program will be re-factored. As a first step, a forum was set up, consisting of specialists and demanding users, and a conference call was held. A plan is now being made to determine how to modernise what parts of sched, so as to make it easier to maintain and modify.

The JIVE UniBoard Correlator (JUC)

After the first attempt to use the JUC for real-time correlation it became clear that the corner-turning mode in the Fila10G, with fan-out to different JUC nodes, would not become available any time soon. Instead it was decided to implement this fan-out locally. This however made it necessary to re-write large parts of the control code. A second recent attempt managed to get data flowing through the correlator, and after the latest simulations and fixes the JUC should be ready for its first real-time fringes.

In recorded mode, a very detailed comparison was made between the results of SFXC and the JUC, leading to images that are virtually indistinguishable (and a JIVE-Astron picture of the day).

EVN Software Correlator at JIVE (SFXC)

SFXC continues to be used for all correlation at JIVE, both traditional disk-based VLBI and e-VLBI. Improvements continue to be made based on feedback from users, correlator operators and support scientists.

To allow correlation of more stations at 2 Gbps the connection between the SFXC cluster and the e-VLBI network has been improved. A typical e-EVN observation now includes 6-7 stations at 2 Gbps and 3-4 stations at 1 Gbps using data directly streamed from the Fila10G at the 2 Gbps stations.

SFXC now supports the XY-EW mount of the Hobart 26m telescope. This has been used to correlate the joint EVN+LBA observations from last June. Work has started to support multiple input sources per station (to be used for 4 Gbps e-VLBI and to support including KVN stations at 2 Gbps) and to improve support for sub-netting.

Experimental filter-bank support now exists for SFXC, which improves the spectral resolution of the correlator output. This offers an opportunity to reduce the number of spectral channels in the output data (and therefore reduce the total data size) while still meeting the science goals of spectral line experiments.

USER SUPPORT

There was 1 EVN data-reduction visit to JIVE in this period. JIVE continued to provide PIs with experiment-specific template "setini" blocks and station catalogs, as well as the new procedure for depositing schedules in which PIs send their key files to JIVE rather than posting sched output directly to the VLBEER server themselves. There were three first-time PIs in session 1/2017. JIVE also provided assistance with scheduling mm-VLBI (GMVA) experiments, so that they would reflect the field-system preferences for DBBC/PFB modes developed during the PFB testing over the past year.

Three work-stations in the JIVE Visitors' Room are in the process of being replaced or upgraded, to benefit the larger data sets being delivered by the enhanced wide-field capabilities of SFXC (e.g., greater disk capacity, partly in SSDs; larger screens).

The EVN Data Reduction Guide on the EVN Users' Guide web page is being revised, with a more extensive spectral-line section and a roll-out test in conjunction with a visitor in May to be completed before becoming operational. Links to the VLBI tutorials from the 2015 European Radio Interferometry School were added to the "analysis" section under the Users' Guide page. A more general review of the EVN web pages is also underway.

Initial modifications to the EVN Archive at JIVE and supporting utilities have been made in order to host FITS files resulting from EVN observations

correlated at Bonn. The FITS file from the first such experiment has been retrieved from Bonn and successfully archived here using the standard procedures. The fitsfinder utility (databases information from the archived FITS files to permit searching the Archive across a variety of query parameters) does not seem to be registering this new FITS file, which is currently being investigated. Initial design discussions have begun to be able to link (or host) proposal abstracts on the EVN Archive, pending decisions on the desired scope to be taken at this CBD meeting.

NETWORK SUPPORT

Nkutunse (Ghana) participated in the 6cm NME from session 1/2017 (N17C1), but with no immediate fringes from the ftp fringe-test transfers. There was no 5cm block in the session, with which to include a methanol-maser source (as a check on the frequency set-up). Their data has been e-shipped to FlexBuffs at JIVE to purse in more detail. The Jumping JIVE support scientist visited Ghana 18-27 April in conjunction with a DARA-related training event.

There was a series of three Q-band tests for Yebes prior to session 1/2017 (Yebes had ftp fringe-test fringes in both F17Q1 and N17Q1), another 4 Gbps DBBC/PFB test, and a test of the UniBoard correlator in e-VLBI using both 16 and 32 MHz channels.