CORRELATOR REPORT, EVN Correlators at JIVE
EVN TOG MEETING, April 2013, Bonn

4 April 2013 (statistics cover 29 Oct 2012 − 2 Apr 2013)
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SCIENCE OPERATIONS

  Sessions and their Experiments

  The table below summarizes projects correlated, distributed, and released from 29 October 2012 to 2 April 2013. The table lists the number of experiments as well as the network hours and correlator hours for both user and test/NME experiments. Here, correlator hours are the network hours multiplied by any multiple correlation passes required. This definition is carried over to the EVN software correlator at JIVE (SFXC), even though it can run faster or slower than real time depending on characteristics of the experiment. Because of its enhanced capabilities (e.g., larger spectral capacity, more than 16 station input, multiple phase centers), using SFXC leads to significantly fewer correlator passes −− essentially only for phase−referenced spectral−line observations when the PI wants a smaller "continuum" pass having all subbands with low spectral resolution, in addition to the high spectral−resolution "line" pass.

	User Experiments			Test & Network Monitoring		
	N	Ntwk_hr	Corr_hr	N	Ntwk_hr	Corr_hr
Correlated	47	327	354	7	26	26
Distributed	47	327	354	7	26	26
Released	53	396	437	14	50	50

One user experiment was abandoned prior to correlation (the target coordinates were off by 30s of RA in the observing schedule, which at DEC = −2 and at a frequency of 6.7 GHz fell well outside the main beam of the larger antennas).

  The following table summarizes by session the user experiments with activity since the previous report (entries = remaining to do / total). The "(e)" and "(d)" refer to e−VLBI or disk experiments within a traditional EVN session.

	N_to.corr	Corr.hrs	N_to.dist	
session 3/2012	0/31	0/252.5hr	0/31	2 ToO’s
Nov−Feb e−VLBI	0/10	0/64.5hr	0/10	incl. 1 ToO in November
session 1/2013 (e)	0/2	0/18.5hr	0/2	e−VLBI in disk session
session 1/2013 (d)	24/24	estim. 233hr		incl. 1 ToO after session
March e−VLBI	0/4	0/14.5hr	0/4	

Some landmarks since the previous CBD report:

  Session 2/2012 was the first disk−based session to correlate entirely on SFXC. All subsequent disk experiments have correlated on SFXC.

  From session 3/2012:
    A 23−station global (JIVE record for number of stations correlated at once)
    Irbene fringes in regular NME’s
    First Torun fringes at K−band
    First KVN_Ulsan fringes at JIVE

  First operational use of SFXC for e−VLBI production correlation in the December e−EVN day (Gbps with 8 stations with cross−pols). SFXC has been used for all subsequent e−EVN user experiments.
  SFXC e−VLBI correlation for Gbps with 10 stations, with cross−pols, in the January e−EVN day.
  First successful e−VLBI correlation of Shanghai using 5B data in the February e−EVN day. They observed a "normal" 2−bit sampled Gbps schedule, and we limited the transmission to the available 512 Mbps by pulling over only the sign bits and treating it as a 1−bit sampled station.
  First e−VLBI fringes to Irbene in the clock−search portion of the March e−EVN day. We stayed within the approximately 700 Mbps available link capacity by also pulling over only the sign bits, as was done for Shanghai.

  SFXC has now correlated many user experiments that would have been impossible or at best much less efficient on the MkIV:

4 spectral−line experiments having more than 2048 frequency points per subband/polarization (record so far = 8192)
17 spectral−line experiments with cross−polarizations
7 pulsar gating experiments (record minimum period so far = 16.45ms)
15 experiments with multiple phase centers (spanned fields range from 25" to 10’; record number of multiple phase centers so far = 50)
4 experiments having more than 16 stations (record so far = 23)

This list is valid through session 3/2012. There is some overlap among the above categories (e.g., an experiment used pulsar gating and multiple phase centers). There have been 22 user experiments that SFXC was able to correlate in a single pass, but would have been too big to fit in a single MkIV pass, even though they exceeded no individual MkIV limitation in number of stations or frequency points.

TECHNICAL DEVELOPMENTS

We obtained RadioAstron fringes using SFXC and the near−field model developed at JIVE for the RadioAstron spacecraft as a station. These fringes were from the observation RE03FU (Nov.2012), in which RadioAstron observed in a standard mode combining one dual−sideband "BBC" at C−band (RCP) and one dual−sideband BBC at K−band (LCP). Ground stations observed either at C− or K−band, or switched between the two bands during the observation. During this observation, the project baseline to RadioAstron was about 2.5 Earth diameters. The residual phase versus time on RadioAstron−ground baselines hang together well on time−scales of tens of minutes at both frequencies.

At the second−year NEXPReS review last autumn, the review panel, EC project officer and the project management agreed that a 4Gbps real−time correlation, obtaining closure phases with three telescopes, would be an achievement worthy of the adjective "excellent". It was also decided that the final review featuring the live demo would be held in Dwingeloo, in the autumn of 2013.

A number of 4G tests took place, and most problems encountered during the June 2012 attempt were solved. One timing problem remains however, which is most likely related to the firmware on the Fila10G boards. While this is certainly fixable, this has not been done yet. Another issue may be the availability of the Fila10G boards themselves.

Tests were set up to investigate the possibility of mixing 32MHz and 16MHz subbands, which would be needed for combinations of 2Gbps observing with DBBC or RDBE and 1Gbps on legacy systems. These tests have used the poly−phase filter bank personality of the digital back−ends, which raise the issue of finding compatible LO’s across the stations, given the tuning inflexibility of the PFB subbands. The most recent test also included correlating not only mixed bandwidths, but also mixed side−bands, on SFXC. These tests have been quite successful, and discussions are underway about how to advertise this capability to the community. Tests with higher bit−rate modes of the digital down−converter personality of the digital back ends are also being investigated, which would enable more control over subband tuning relative to the first LO’s.

A large amount of effort during the last period was spent on implementing the complete Mark5A/B command set in Jive5AB, the JIVE−developed Mark5 control code. Extensive testing in the field, on both B and A−units, revealed relatively few bugs, and we are now ready to ask all EVN stations to use Jive5AB exclusively from now on, for both real−time and recorded VLBI. One of the many nice and useful features that will become available is automated fringe testing. At the moment, ftp fringe tests are done only a few times per EVN session, as they involve quite a bit of effort and gaps have to included in the observing schedule to allow time for the data transfer. Using Jive5AB will make it possible to transfer data in real−time without interfering with the schedule. The complete pipeline includes a search for bright calibrators in the schedule, saving a few seconds of data to local disk, transferring the data to JIVE and running a correlation job when all data have arrived, all without human intervention. This could be done once per experiment, but could be nearly trivially extended to simultaneous recording/real−time streaming, one of the stated goals of NEXPReS. The Automated Fringe Test (AFT) pipeline has been tested and is nearly ready for production use.

Switching to SDK9.2 has been a long−standing wish of the EVN, as it will make

the use of large disk packs possible (16TB and above). As a first step, all (but one) playback units at JIVE were upgraded to the newest Linux Debian version and SDK9.2. SDK9 can handle disk packs written under SDK8, the opposite however does not hold, which is why this upgrade is coordinated with the correlators at USNO and Shanghai Observatory. Unfortunately it was then found that this particular combination of Linux kernel and SDK basically breaks e-VLBI at the stations. At this moment, engineers at JIVE, Haystack and Conduant are investigating the issue. Very likely we will advice the stations to upgrade to SDK9.2 but stick to a less recent kernel, until the problem is resolved.

At the end of March, a NEXPReS-related test took place, deploying FlexBuffs at Jodrell Bank, Metsahovi, Onsala, Medicina and JIVE, during which pre-recorded data were streamed to JIVE. To stress test the systems, high-bandwidth data streams were recorded on the FlexBuffs at the stations during the transfers, and at JIVE correlation started while up to 8Gbps was still being recorded. The test was a great success, and demonstrated the feasibility of EVN operations without shipping magnetic media.

Archive

Ongoing (and seemingly endless) problems with the mirror backup system of the EVN data archive were finally resolved by the installation of new backplanes. The archive is now backed up on tapes locally, and in addition, via the network, on a mirror machine located at Westerbork.

FPGA-based correlator development

The UniBoard^2 project kicked of in July 2012. The time-line of the project straddles two FPGA technologies, with 28nm available right now but 20nm just about to be released. As a consequence, the decision was made to defer the actual choice of device as long as possible. By the end of March 2013 however information on the roll-out of 20nm Altera devices will become available, with the technical information following after summer 2013. At that point, the design will start in earnest.

But, although the UniBoard^2 project has been treading water, correlator development has moved at a rapid pace. A successful design review was held in early 2013, not revealing any show-stoppers. All elements are in place, including a control and data capture system, and data is being fed into the correlator and correlated. At this point, one still realistically should speak of bug fixing, but proper commissioning will start soon.

EVN Software Correlator at JIVE (SFXC)

After having used SFXC for all disk-based correlation for a while now, we've started using SFXC for e-VLBI. This has been fairly smooth sailing and so far all e-VLBI sessions since December 2012 have been correlated with SFXC. Despite some minor glitches, reliability of the software correlator already seems to be better than that of the hardware correlator. And over the last couple of months, most of these glitches have been fixed. To improve flexibility, a couple of new features have been implemented. SFXC now allows for array changes within a correlation job. This removes the need to restart the correlator in the middle of an observation, which could lead to data loss if there was no gap of sufficient length in the schedule. It is also possible now to have stations that observe different sets of subbands in a single schedule. This provides more flexibility for stations for which the available network bandwidth is limited.

With real-time e-VLBI as the main driver, the cluster at JIVE has been extended with another 8 nodes, adding 128 CPU cores. With these new nodes it is now possible to do real-time correlation of 13 stations at 1024 Mbps each, including cross-pols. Work is underway to squeeze a little bit more performance out of the cluster to raise this to 14 stations.

Another important new feature is the capability to correlate mixed bandwidth experiments. This allows correlation of data recorded with legacy VLBI systems that provide 16 MHz subbands with data from the wider-band modes of the new digital back-ends that can provide 32 MHz or wider subbands. The wider bands will be split up into smaller "virtual" subbands such that the PI will get a uniform data set. The new code will also flip the sideband

of the a subband (e.g., turn a lower sideband into an upper sideband) if necessary. This feature has been successfully tested in a test observation in December (with data from an analog VLBA terminal, DBBC and RDBE) and in an FTP fringe test in session 1/2013 (analog Mark4, DBBC, Chinese CDAS, and Russian R1002). A more detailed analysis of the result will follow once the disk packs with data from the session arrive at JIVE.

USER SUPPORT

There was one EVN TNA-supported data-reduction visit to JIVE in this period.

We continue to contact all PI's once the block schedule is made public, and to check over schedules posted to VLBEER prior to stations down-loading them. This occupies a great deal of time in the month prior to the start of the session (late schedules are becoming more prevalent...), but this helps to prevent avoidable errors in the observations themselves and thus makes the available observing time more productive. We did not, however, catch the wrong target coordinates in the session 3/2012 experiment that wound up being abandoned prior to correlation. For observations in session 1/2013, we provided PI's with experiment-specific template "setini" blocks and station catalogs for sched v10.2. Only 3 observations reverted back to v10.1 (all from PI's at IRA), and these were all continuing epochs of experiments begun previously. Session 1/2013 seems to confirm that we have converged to two preferences for different sub-sets of stations using the DBBC, so we can begin making code for sched to handle these directly, as we had done for the KVAZAR station R1002 digital back-ends in v10.2.

Following on the merger between the EVN+MERLIN and e-EVN classes in the EVN NorthStar Proposal Tool accomplished prior to the October 2012 proposal cycle, we also added the possibility of e-EVN "Observations" to global proposals prior to the February 2013 cycle. Thus now any single proposal can request both e-EVN and disk-based observations in a standardized way.

NETWORK SUPPORT

Parallel DBBC recordings in some NME's included Onsala, Hartebeesthoek, and Noto in session 1/2013. Metsahovi shifted to their DBBC as their primary back-end for the session.

The problem at Medicina with data-throttling at Gbps remains since session 3/2012, but since this was known beforehand, we were able to account for this in the "setini" blocks we provided to PI's for scheduling their observations.

One incoming pack from Arecibo in session 3/2012 was accidentally conditioned prior to correlating. This was the result of a new vulnerability in the disk-database to the condition of packs arriving before the associated field-system log from the station. Any pack appearing to have no experiment associated with it is protected as a safety feature to allow investigation, but here specifically, experiments that were on that pack from the previous time it had been at JIVE for correlation were still associated with it, so that the absence of a new field-system log to link the pack to current experiments left it appearing to contain only released experiments. Three observations required (partial) re-queuing as a result (and were re-observed in session 1/2013). Additional tests based on the ordering of experiment observation date and most recent pack departure-date from JIVE have been added to guard against this condition recurring.

In session 1/2013, there were problems getting disk packs to the KVAZAR stations, such that each of them had to miss some user experiments and NME's in the middle part of the session due to lack of packs:

Svetloe:	2 user,	2 NME
Zelenchukskaya:	7 user,	3 NME
Badary:	5 user,	2 NME

It's not entirely clear what was different from our end that time. After talking with the station, we will try to avoid sending all packs in one shipment, but break them up into sub-shipment of no more than six packs each (the session 1/2013 shipment was 8 packs each for Svetloe and Badary, and 9 packs for Zelenchukskaya for a total of 25 -- the total shipment for session 1/2012 was bigger, at 33).