August 3, 2005

Status Report for the Global 3 mm VLBI Array

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Introduction:
Based on a Memorandum of Understanding of the directors of the participating observatories, the Global mm-VLBI Array (GMVA) was founded in 2003 as successor of the former Coordinated mm-VLBI Array (GMVA). The main aim of the GMVA is to facilitate global 3mm-VLBI imaging with higher angular resolution and better sensitivity than the stand-alone VLBA. The GMVA is also considered as an environment to further improve and develop the capabilities of mm-VLBI for future application. A detailed description of the GMVA is available on the web at http://www.mpifr-bonn.mpg.de/div/vlbi/globalmm.

At present, two global observing sessions are performed per year, in spring and autumn. The GMVA is open to the astronomical community and offers support in all aspects relevant for successful 3mm-VLBI observations. As end-product, the GMVA delivers to the P.I. correlated VLBI data in FITS format ready for imaging. The correlation of the data is done with the VLBI correlator of the MPIfR at Bonn, Germany. The two proposal deadlines, 6 month in advance of each observing session, are synchronized with the usual VLBI proposal deadlines of the NRAO and the EVN. The refereeing process uses the established review systems at the NRAO and at the individual observatories (i.e. program committee at Bonn). After review at each observatory, the proposals are scheduled jointly by a two person scheduling committee (R. Porcas - MPIfR, B. Clark - NRAO) on the basis of the combined review results.

The following observatories regularly participate in Global 3mm-VLBI: Pico Veleta (PV) (30m, IRAM, Spain), Plateau de Bure (PdB) (6x15m, IRAM, France), Effelsberg (EFF) (100m, MPIfR, Germany), Onsala (20m, OSO, Sweden), Metsähovi (14m, MRO, Finland) and the VLBA (NRAO, USA). The VLBA presently has 8 of its 25 m antennas equipped with 3 mm receivers. It is hoped that in the (near) future, other observatories join the GMVA (i.e. CARMA, GBT, Noto, Yebes (40 m), LMT, ALMA).

Observations :
So far, 3 observing sessions were performed, in April 2004, October 2004, and April 2005. The observations of October 2005 are now being prepared. Including the proposals for October 2005, the GMVA received so far 21 proposals with P.Is from 6 different countries (Germany, Italy, Spain, USA, Finland, China). From the 21 proposed experiments, 6 projects were rejected by the referees. Between April 2004 and April 2005, 12 projects were successfully observed, some of them in more than one session as part of proposed multiple epoch observing. Most of the proposed projects requested continuum imaging of AGN. Some spectral line VLBI on SiO-maser sources was also requested and got scheduled.

In Table 1 we show some typical signal-noise-ratios seen on the individual VLBI baselines for two specific experiments in October 2004 (3C345) and April 2005 (NRAO150). We note that in April 2005, the addition of VLBA_BR led to fringe detections with an SNR of more than 100, even across the Atlantic (see Table 1 and Fig. 1, bottom).

At millimeter wavelengths it is unavoidable that the VLBI experiments are affected by non-optimal weather conditions at some sites. In each of the observing sessions, however, never more than one station was completely weathered out. Typically, periods of bad weather last no longer than 1-2 days and affect only 1-2 stations simultaneously, which is – in view of the 4-6 days duration of a typical observing

session with 13 telescopes – still acceptable. Of particular interest are the weather conditions at the sites of the large European telescopes (PV, PdB, EFF). In none of the experiments performed so far more than one of the three large antennas was lost due to bad weather (or technical problems). This is important in view of the high angular resolution and sensitivity, which is obtained through the combination of these telescopes with the VLBA. However, it should be also noted that in the past 3 sessions, the periods where all 3 large European antennas observed at the same time were somewhat limited. At Plateau de Bure in the French Alpes, the observations in April seem to be frequently affected by harsh winter conditions (snow, ice, wind), which in the past sessions led to data loss (up to 50%). In order to optimize the mutual observing time between PV and PdB, a shift of the observing date from April to May is discussed.

In 2003/2004 and for PdB, the observations were affected by residual phase noise in the local oscillator chain. This reduced the fringe amplitudes by at least a factor of two in all sessions. Therefore the SNR of the fringe amplitudes seen between PV and PdB was limited to a few hundred (typically $< 300 - 400$, see also Table 1). A maser borrowed from the Geodesists (Wettzell) and temporarily replacing the broken French maser, did not really improved the situation. In April 2005 it was found that an unstable local oscillator (Racal Dana) was responsible for the main phase instability seen on timescales of minutes. After this problem was fixed, an SNR of 3355 was obtained in a fringe test on 3C454.3 on the PV-PdB baseline (see Fig. 1, top). Another less pronounced but more rapid instability, responsible for some 45° phase noise on the 30 sec timescale, is under investigation and hopefully will be removed before the October 2005 session. To further improve the performance of PdB, IRAM has ordered a new maser, which should arrive in September 2006. It is hoped that after this date, Plateau de Bure can operate at its maximum sensitivity.

For 2005, the standard continuum observing mode was changed from a recording rate of 256 Mbit/s to 512 Mbit/s. This resulted in a factor of 1.4 higher baseline sensitivity. While most of the recording in 2004 was done with tapes, in October 2004 some stations, and in April 2005 all stations were able to record their data on the new MKV hard disks. The hard disk recording also led to considerable relaxation in the constraints for scheduling and media logistics (limited rate of tape changes at the VLBA). Furthermore it made the correlation of the data much easier, allowing much faster throughput, and yielding a significant improvement of the quality of the correlated data (no tape read errors).

Summary and Outlook:
So far, the GMVA performed well and provides good quality data. It yields 3mm VLBI images with a dynamic range of several hundred and an angular resolution of up to 40 micro-arcseconds. With the transition from tape to disk recording and the increased recording rates, the sensitivity of the array and its performance has further increased.

Unfortunately the number of received proposals still is not yet very high. One possible reason why P.I.'s might hesitate to submit proposals are the limited capabilities of the GMVA with regard to structural monitoring with only two observing sessions per year. Future observations with one more session per year would help, also with regard to relatively fast variations seen in some sources. In the meantime, P.I.'s are be encouraged to propose for the GMVA and VLBA in parallel, where the high sensitivity/high resolution GMVA observations scheduled at 6 months intervals would complement and bracket more frequently scheduled observations with the stand-alone VLBA.

The GMVA has limited polarization capabilities at 3 mm. At present, Effelsberg, Metsähovi and the VLBA offer dual polarization. Pico Veleta also records dual po-

larization, however, it is not yet possible to analyze polarization data from Nasmyth mounted telescopes in AIPS. It is also planned to test dual polarization observations with the Plateau de Bure interferometer. On PdB, the antennas either can record RCP or LCP (quarter-wave plates in front of linear feeds). A first attempt to split the array in two polarized sub-arrays (3x LCP, 3x RCP) was not successful and more work has to be invested here. Interested scientists are encouraged to participate in this development and also help with the necessary soft-ware modifications in AIPS (need Nasmyth mount-type in AIPS for tasks LPCAL, IMAGR, etc.).

The efficiency of the global 3mm-VLBI observations will improve further, when more MKV hard disk space becomes available. In April 2005, MPIfR and IRAM provided 4-5 Tbyte of disk space for each of the 13 participating stations (including VLBA(8)). With this and the higher recording rate of 512 Mbit/s, the observations can be performed with a duty cycle (ratio of observing time over total time) of $\leq 30\,\%$. For October 2005, about 2 times more disk space will become available. A duty cycle of at least 43 % is envisaged for Oct. 2005.

In order to facilitate better and more sensitive observations of low declination sources, including some of the brightest and most interesting objects (i.e. the Galactic Centre Source Sgr A*, but also M 87, 3C 279, 3C 446, etc.), 3mm-VLBI would profit very much from the addition of other sensitive millimeter antennas, particular if they are located at lower geographic latitudes and/or on the southern hemisphere.

Table 1: Maximum Signal-to-Noise Ratios for different interferometer baselines.

Baseline	Apr.05	Oct.04
Pico - PdBure:	-	300
Pico - Bonn:	200	400
Pico - Onsa/Metsa:	50	40
VLBA - PdBure:	-	10-30
VLBA - Pico:	40-100	20-60
VLBA - Bonn:	14-45	20-40
VLBA - Onsa/Metsa:	7-15	<7
VLBA - VLBA:	15-60	10-70
particularly good:		
Pico - BR :	103	
MK - BR :	58	

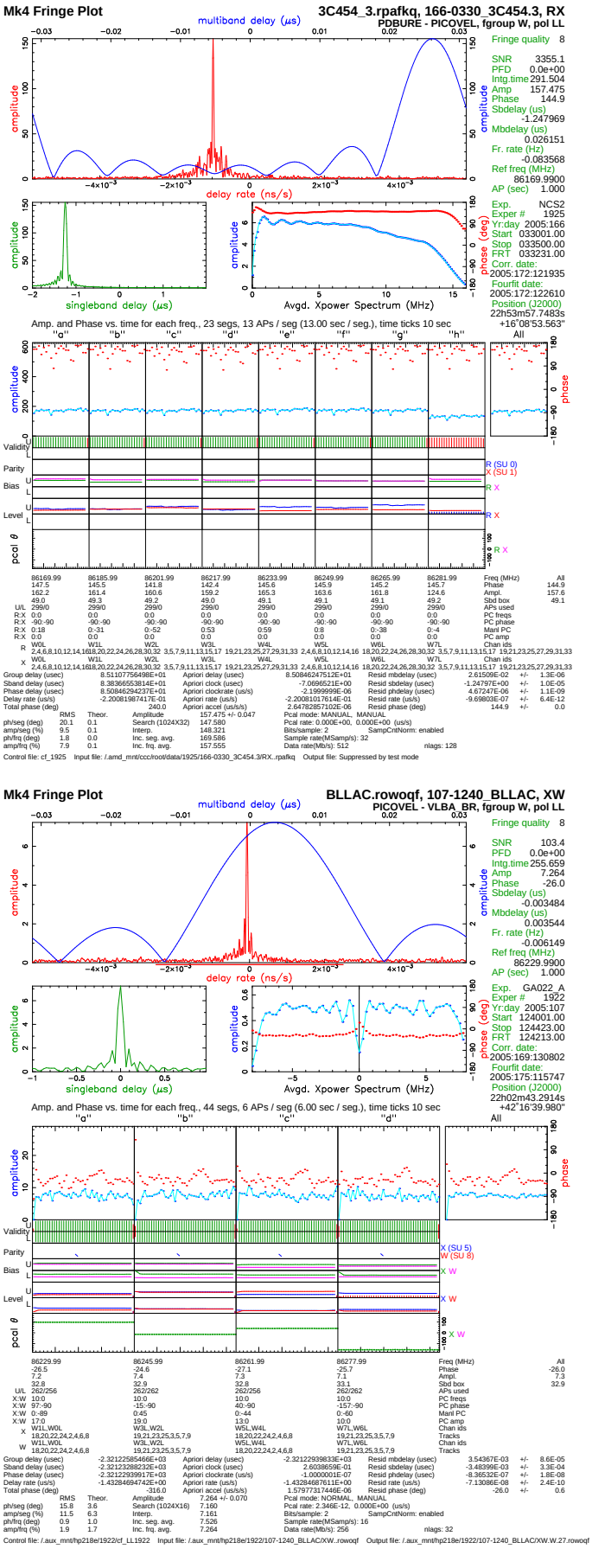

Figure 1: Left: Correlator fringe plot of a VLBI scan on 3C 454.3 on the baseline Pico Veleta to Plateau de Bure in May 2005. The SNR of the fringe detection is 3355 ! Right: After installation of a new receiver on the VLBA antenna in Brewster, the source BL Lac was detected with an SNR of 103 on the transatlantic baseline to Pico Veleta.