MARK 5 MEMO #086

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

Telephone: 781-981-5400
Fax: 781-981-0590

5 February 2010

To: Mark 5 Development Group

From: Alan E.E. Rogers

Subject: Software correlator for station checks

"VLBI2" is a simple software correlation program written to aid in the testing of DBEs. Initially this program was only capable of performing a 1-bit correlation (using the "sign" bits in the Mark 5B data format). In addition the program lacked the geometrical calculations needed to get fringes on short baselines like those at the SMA and CARMA.

To make the program more useful it has been augmented with the following additional features:

1] Geometrical calculations done with sufficient accuracy for short (< few km) baselines.
2] Ability to handle specific sideband and L.O. offsets
3] An FX routine to handle 2-bits/sample and very large L.O. offsets.
4] An optional simple control file to input frequencies sideband, L.O. and clock offsets etc.

Control file example

```
* control file for vlbi0 correlator
* line which start with * or # are comments
*
XYZ2 – 2397433.121 -4882056.240 3843478.717
XYZ1 -2397431.3 -4482018.9 3843524.5
*LATLON1 37:00:00 – 118:00:00
*LATLON2 37:00:00 -118:00:00

NUMFRAMES 2400000
*NUMFRAMES 240000 // FOR 10 SECONDS
DELAYNS 466
FREQ 223.313
USB
*LSB
RA 12:30:49.4233 // M87
DEC 12:23:28.043

*FOFFSET
```

In addition some command line options are still supported which will override the control file:

Control file (vlbi0.cat):

-numframes	Set the number of Mk5B frames to be processes
-1bit	To use 1-bit correlation with Van Vleck correction
-delayns	Clock "delay" in nanoseconds
-freq	Frequency GHz
-toff	Time offset in seconds

The program (renamed vlbi0) is written in C with all the code in vlbi0.c and can be compiled with

gcc –W –Wall -03 -D_FILE_OFFSET_BITS = 64 vlbi0.c - ℓm

The program outputs to the screen and writes a single page postscript plot in vlbi0.pos

Examples:

Figure 1 shows weak fringes obtained on M87 between 2 CARMA dishes separated by about 50m using the control file example listed in this memo. The text at the top shows the coherent integration time, the sideband, the source coordinates, baseline, correlation and SNR. The text below the bottom plot shows the total delay, local oscillator offset, and residual rate. Below are the individual correlations for each channel (DBE channel 0 is shown but is not used). At the bottom are the 2-bit states which should all be close to unity if the levels are set correctly.

Figure 2 shows the autocorrelation of the second CARMA antenna in Figure 1 and Figure 3 is the same autocorrelation using only the sign bits (-1bit option) in which the Van Vleck 1-bit quantization correction has been applied.

[Contact Alan Rogers if you want a copy of this program.]

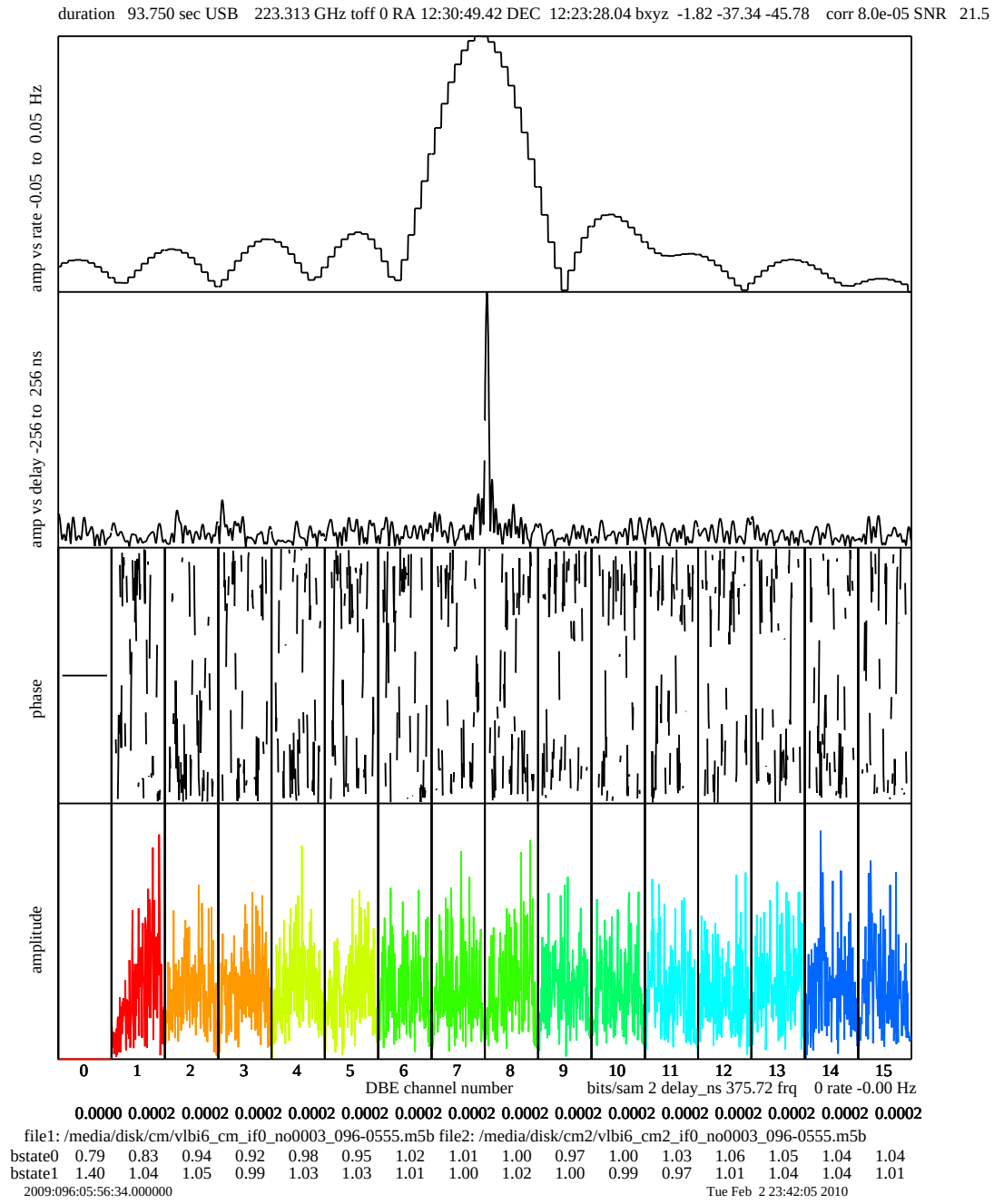
duration 93.750 sec USB 223.313 GHz toff 0 RA 12:30:49.42 DEC 12:23:28.04 bxyz -1.82 -37.34 -45.78 corr 8.0e-05 SNR 21.5
amp vs rate -0.05 to 0.05 Hz
amp vs delay -256 to 256 ns
phase
amplitude
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
DBE channel number
bits/sam 2 delay_ns 375.72 frq 0 rate -0.00 Hz
0.0000 0.0002 0.0002 0.0002 0.0002 0.0002 0.0002 0.0002 0.0002 0.0002 0.0002 0.0002 0.0002 0.0002 0.0002 0.0002
file1: /media/disk/cm/vlbi6_cm_if0_no0003_096-0555.m5b file2: /media/disk/cm2/vlbi6_cm2_if0_no0003_096-0555.m5b
bstate0 0.79 0.83 0.94 0.92 0.98 0.95 1.02 1.01 1.00 0.97 1.00 1.03 1.06 1.05 1.04 1.04
bstate1 1.40 1.04 1.05 0.99 1.03 1.03 1.01 1.00 1.02 1.00 0.99 0.97 1.01 1.04 1.04 1.01
2009:096:05:56:34.000000
Tue Feb 2 23:42:05 2010

Figure 1.

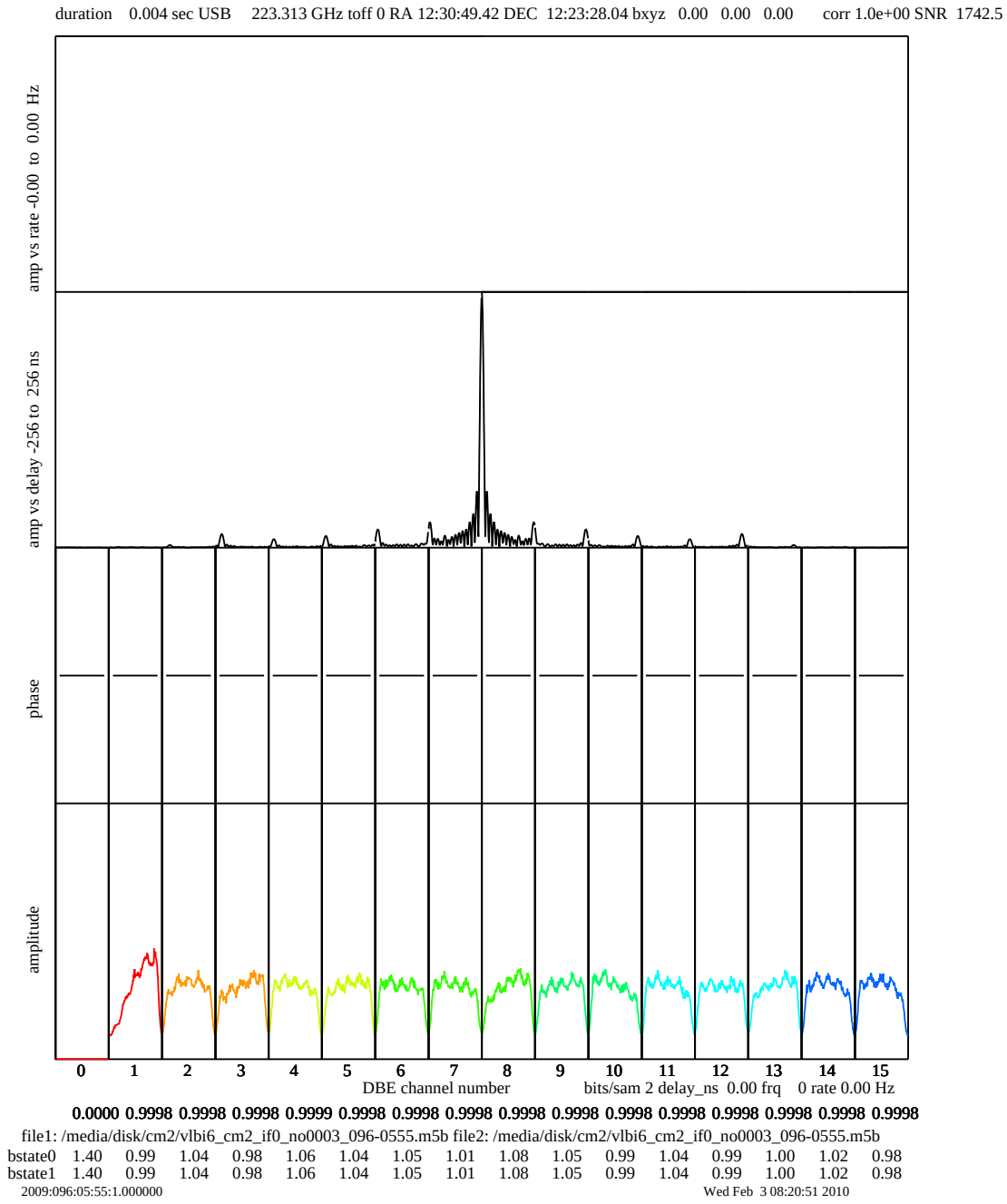
duration 0.004 sec USB 223.313 GHz toff 0 RA 12:30:49.42 DEC 12:23:28.04 bxyz 0.00 0.00 0.00 corr 1.0e+00 SNR 1742.5
amp vs rate -0.00 to 0.00 Hz
amp vs delay -256 to 256 ns
phase
amplitude
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
DBE channel number
bits/sam 2 delay_ns 0.00 frq 0 rate 0.00 Hz
0.0000 0.9998 0.9998 0.9998 0.9999 0.9998 0.9998 0.9998 0.9998 0.9998 0.9998 0.9998 0.9998 0.9998 0.9998 0.9998
file1: /media/disk/cm2/vlbi6_cm2_if0_no0003_096-0555.m5b file2: /media/disk/cm2/vlbi6_cm2_if0_no0003_096-0555.m5b
bstate0 1.40 0.99 1.04 0.98 1.06 1.04 1.05 1.01 1.08 1.05 0.99 1.04 0.99 1.00 1.02 0.98
bstate1 1.40 0.99 1.04 0.98 1.06 1.04 1.05 1.01 1.08 1.05 0.99 1.04 0.99 1.00 1.02 0.98
2009:096:05:55:1.000000
Wed Feb 3 08:20:51 2010

Figure 2.

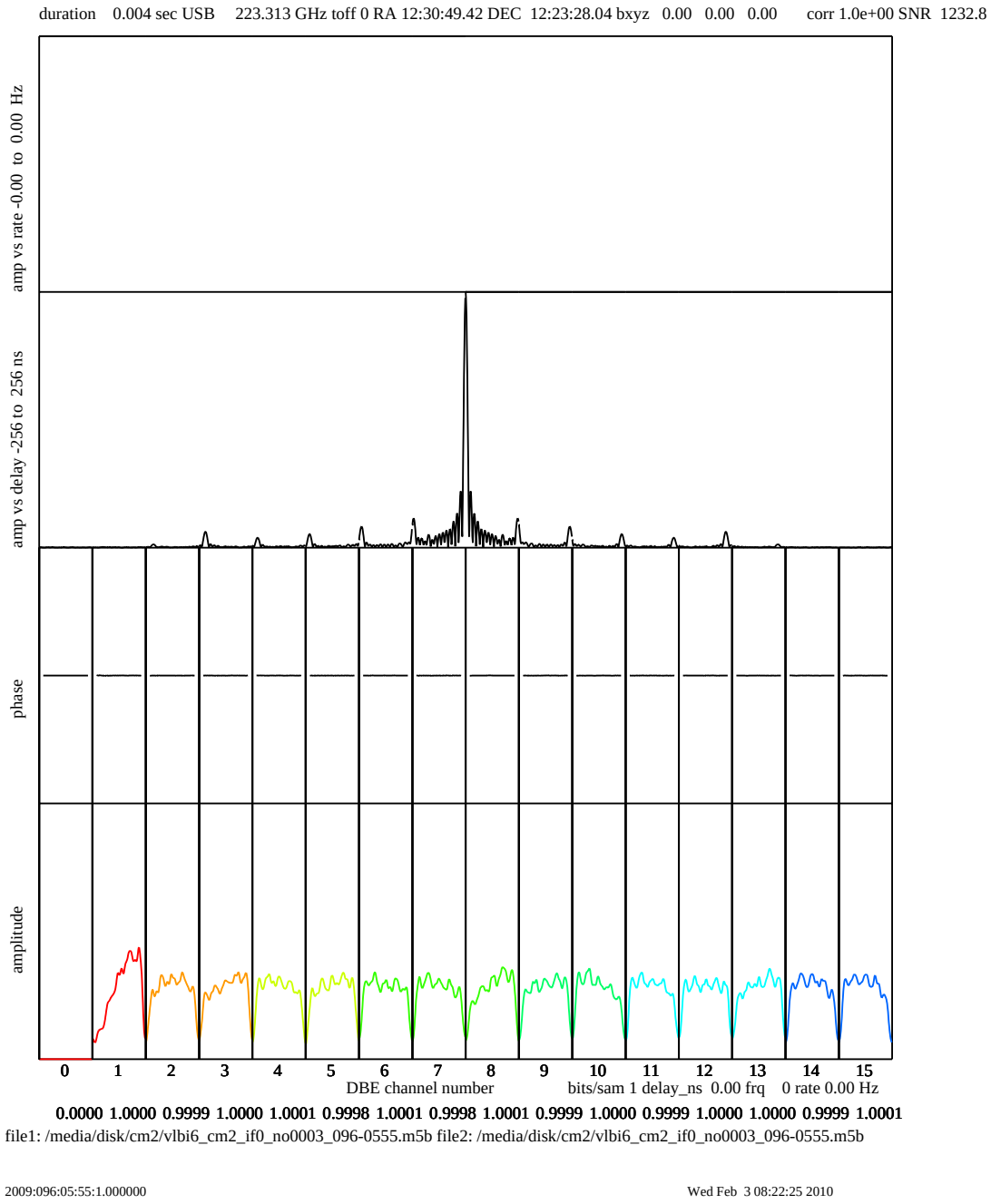
duration 0.004 sec USB 223.313 GHz toff 0 RA 12:30:49.42 DEC 12:23:28.04 bxyz 0.00 0.00 0.00 corr 1.0e+00 SNR 1232.8
amp vs rate -0.00 to 0.00 Hz
amp vs delay -256 to 256 ns
phase
amplitude
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
DBE channel number
bits/sam 1 delay_ns 0.00 frq 0 rate 0.00 Hz
0.0000 1.0000 0.9999 1.0000 1.0001 0.9998 1.0001 0.9998 1.0001 0.9999 1.0000 0.9999 1.0000 1.0000 0.9999 1.0001
file1: /media/disk/cm2/vlbi6_cm2_if0_no0003_096-0555.m5b file2: /media/disk/cm2/vlbi6_cm2_if0_no0003_096-0555.m5b
2009:096:05:55:1.000000
Wed Feb 3 08:22:25 2010

Figure 3.