BBDev Memo 030.1

Results for 2009/049 polarization session – 1: First look at amps, phase differences, and delays

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1. Introduction

On 2009 Feb 18 five hours of observations were made with Westford and MV3 on the source 4C39.25 to measure the VLBI polarization characteristics for four bands from 3.5 GHz to 8.5 GHz.

The amplitudes varied with parallactic angle as expected.

The residual singleband, multiband, and phase delays have been aligned by adding 15.625 nanosec ambiguities to the multiband delays where needed to make them agree with the singleband delays, and by adding cycles of RF to the phase delays to make them agree with the adjusted multiband delays.

Investigation of the anomalous phase cal phase with time using independent software suggests that the correlator was not processing phase cal correctly (as of 090303). This has been confirmed and corrected by Roger Cappallo.

2. Measurements

The four bands were set to the sparse frequencies centered on approximately 8.0, 7.5, 5.5, and 3.5 GHz. The focus settings were +1.5 inches at Westford and ?? at MV3.

The source 4C39.25 was chosen in order to observe a rotation of parallactic angle of almost 360° as it passed between the two antennas. The session ran from 049-0200 to 049-0700 during which time the parallactic angle changed from +6° through 180° to +351°. The parallactic angle is shown on the phase figures.

Scans were begun every ten minutes with 30 seconds between scans. Phase cal was on but appears to have been stronger than desired since the amplitudes were as large as 150 on the *fourfit* plots.

3. Results

3.1 Amplitudes

The cross-correlation amplitudes for all polarization combinations are shown in Figure 1. The dip in the amplitudes at 0330 UT corresponds to when Westford was off-source to change to the other cable wrap and the dip at 0435 UT to when MV-3 was attempting to track very near zenith as the source transited. The parallel-hands amplitudes should be proportional to cos(difference of parallactic angles) and the cross-hands to sin(difference of parallactic angles). The LL and RL amplitudes for the 3.5 GHz band are shown in Figure 2 along with the expected temporal variation. The amplitudes chosen for the model are estimated from the data. The scan length of 10 minutes does not allow the rapid variation near minimum and at the time of the rapid change in parallactic angle to be tracked. Higher time resolution is possible by segmenting the correlator output using *fringex*.

3.1 Multiband delays

The residual multi-band delays over the full pass are shown in Figure 3 for all polarization combinations for the 8.0GHz band. The common ambiguity has been selected. The other bands are quite similar. The means and standard deviations of the differences between the LL and RR multi-band delays for each of the bands (3.5, 5.5, 7.5, and 8.0 GHz) are given in the following table. The spread is 355 psec (~118 mm in vacuum). This seems fortuitous in view of the possible differences in cable lengths among components of the four bands. (Cables should be measured to find expected differences.)

LL-RR	3.5 GHz	5.5 GHz	7.5 GHz	8.0 GHz
mean (psec)[1]	-9916	-9735	-10090	-9916
std dev (psec)	67	19	27	34

[1] ambiguity is 15625 psec

3.1 Phases

The differences in phase relative to LL and for RL-LR are shown in Figure 4. The parallactic angle at each antenna and the differences (DPA) are shown as lines without symbols. The vertical dashed lines bound the time when the parallactic angle difference between the two antennas is in the range 90° to 270°.

For pure L and R polarization, the phase differences between polarizations should not change as the differential parallactic angle changes except for variations in cable lengths or changes in component delays due to e.g. temperature. Except in the ten minute scans that include a change in DPA of 180°, this is a good description for RR-LL and for RL-LR. However, for RL–LL and LR-LL there is a change of about 180° during the transition from both antennas looking east to both antennas looking west, i.e. the period from 04:24 to 04:44 UT.

3.1 Combining SBD, MBD, and phases to resolve phase delay

If the uncertainties are small enough, the multiband delays can be adjusted by integer number of ambiguities to agree with the singleband delay to less than half an ambiguity. For these observations, the ambiguity is 1/64MHz or 15.625 nanosec. The phases, converted to a delay at each frequency, can then be made to align with the fixed multiband delays. The results are shown in Figure 5 for 049-0500. This scan was chosen as a compromise to obtain the largest SNRs in both the parallel hands and cross hands correlations.

The four bands cannot be lined up yet because the phasecal phases were processed incorrectly in the correlator. This occurred primarily because the tones were too strong at record time for the 5 second length of the accumulation period (AP). The AP has been reduced to 3 seconds by Roger Cappallo and, after testing, all scans will be re-correlated. With the correct phasecal phases, the delay offsets between bands can be calculated and removed.

The 8 GHz LR delays are expanded in Figure 6, and the phase ambiguities are shown.

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Figures

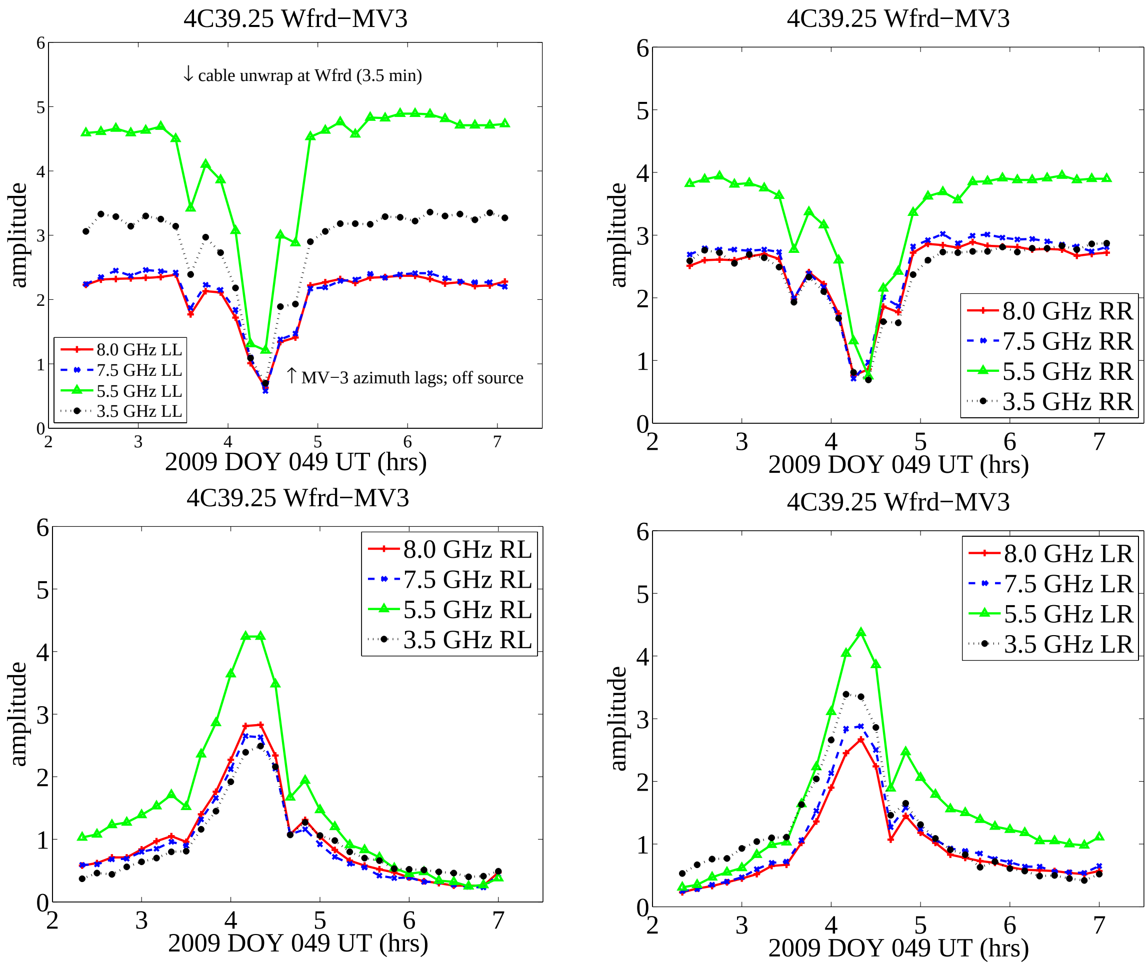


Figure 1. Amplitude for all bands and polarization

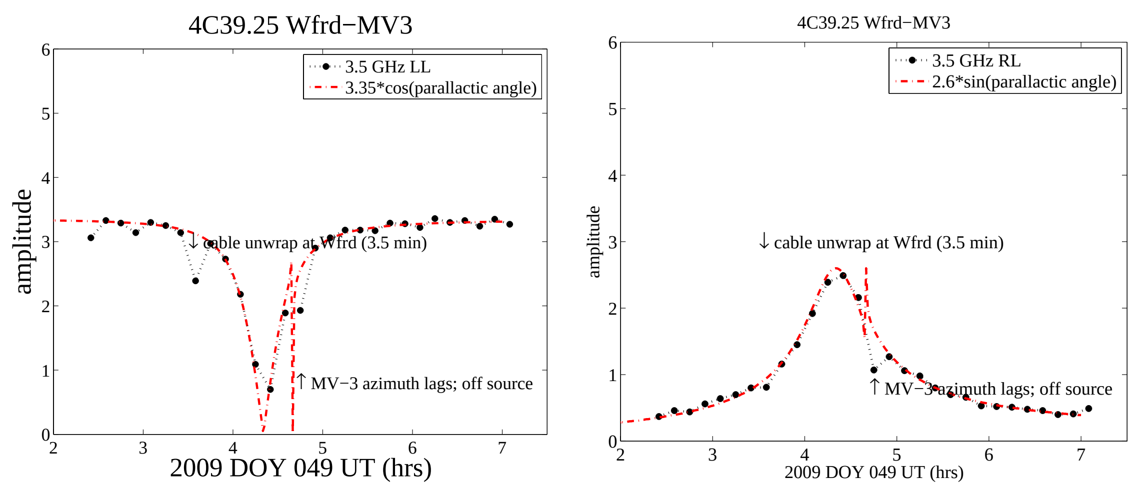


Figure 2. Amplitudes for LL and RL polarizations for 3.5 GHz band.

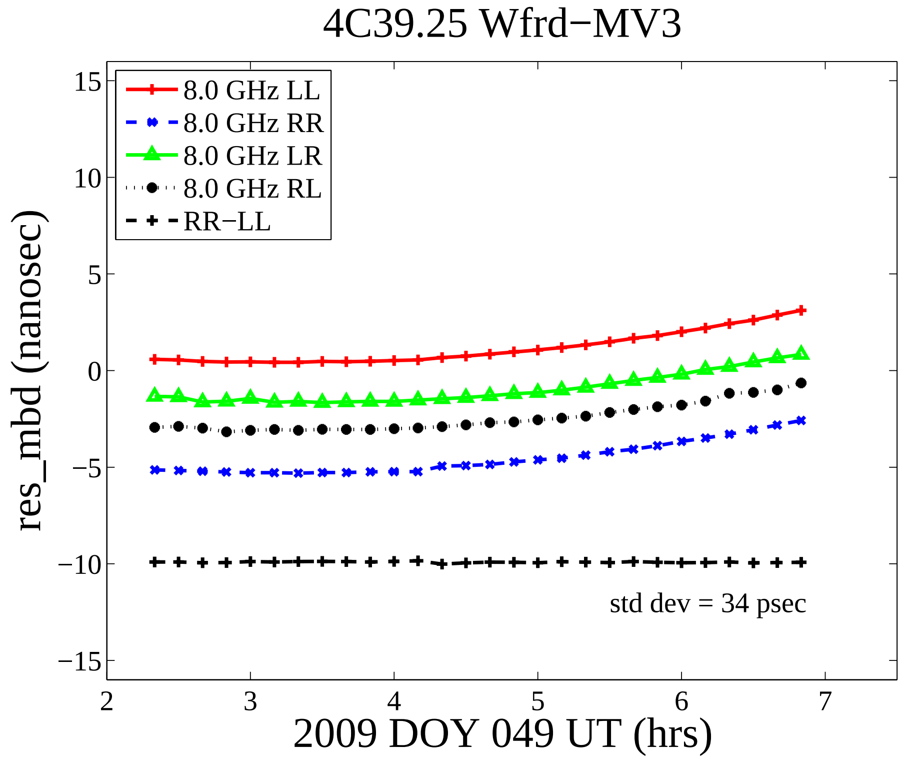
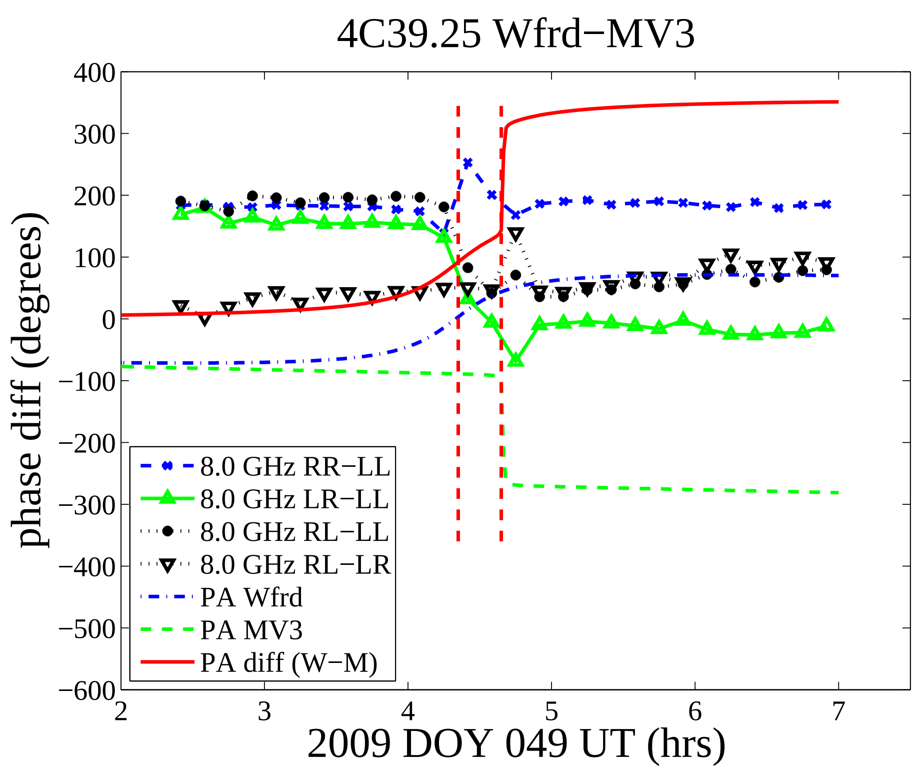
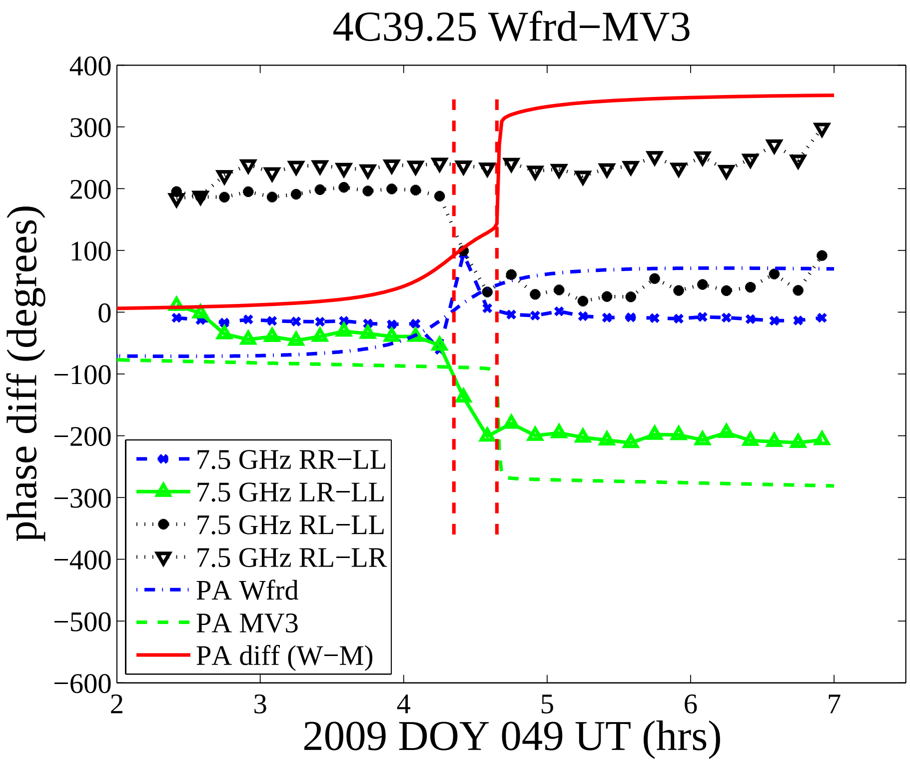
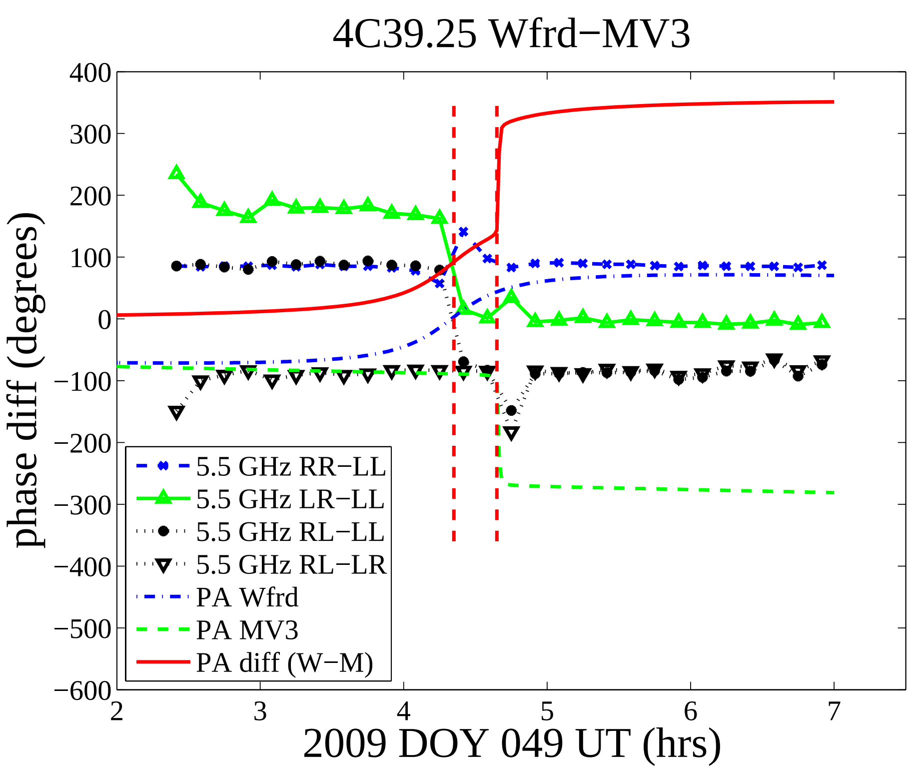


Figure 3. Residual multiband delays for all polarization combinations for the 8.0 GHz band.





4C39.25 Wfrd−MV3
phase diff (degrees)
2009 DOY 049 UT (hrs)
7.5 GHz RR−LL
7.5 GHz LR−LL
7.5 GHz RL−LL
7.5 GHz RL−LR
PA Wfrd
PA MV3
PA diff (W−M)



4C39.25 Wfrd−MV3
phase diff (degrees)
2009 DOY 049 UT (hrs)
5.5 GHz RR−LL
5.5 GHz LR−LL
5.5 GHz RL−LL
5.5 GHz RL−LR
PA Wfrd
PA MV3
PA diff (W−M)

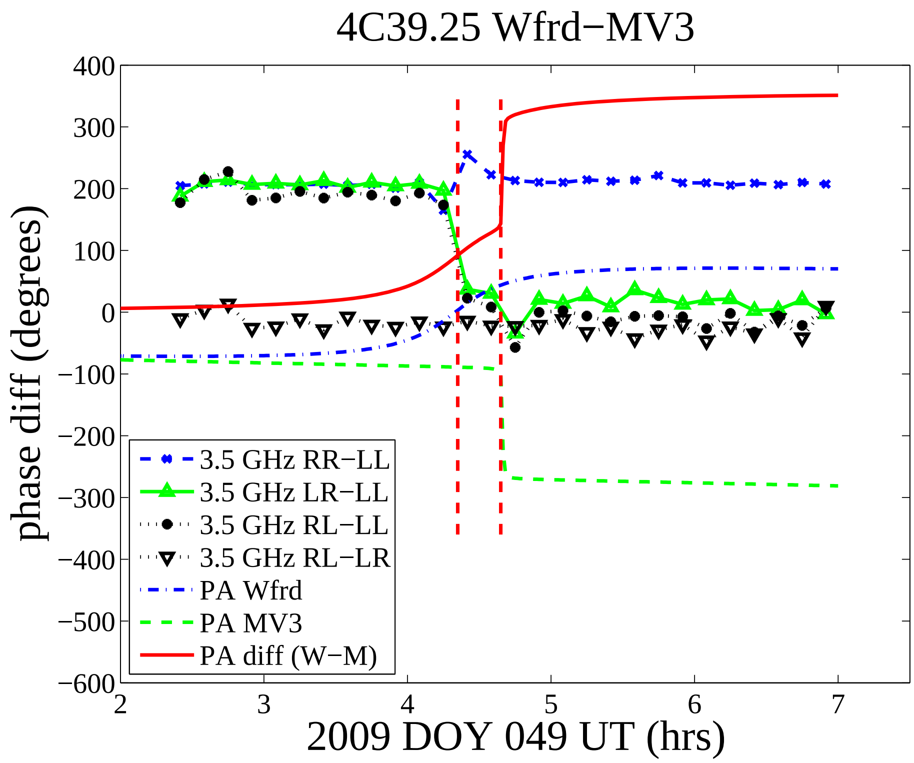
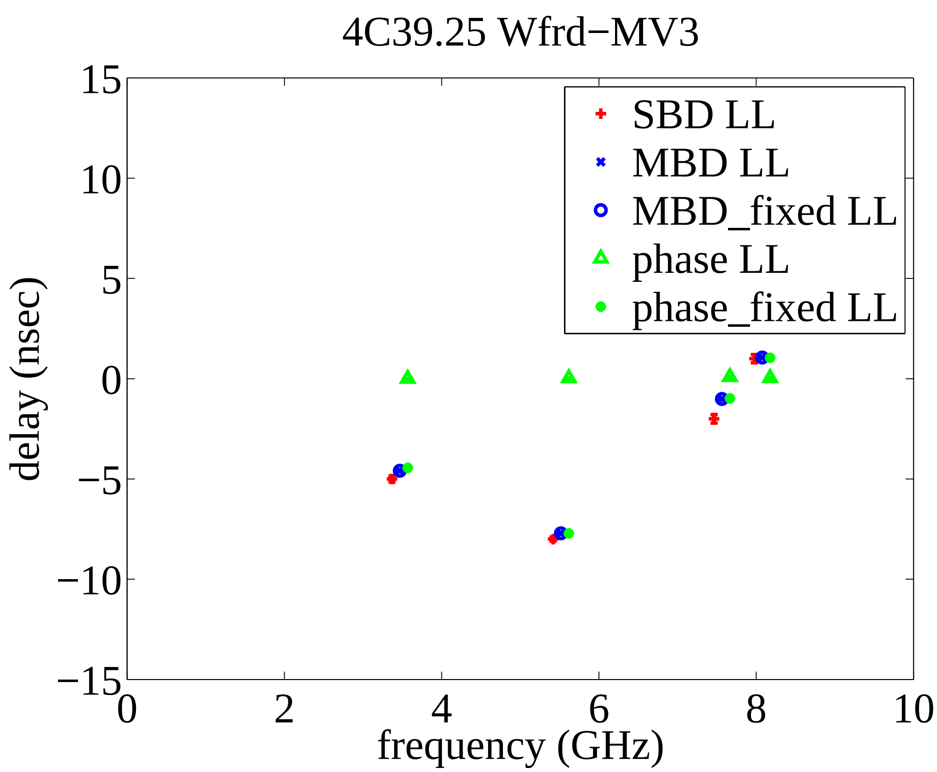
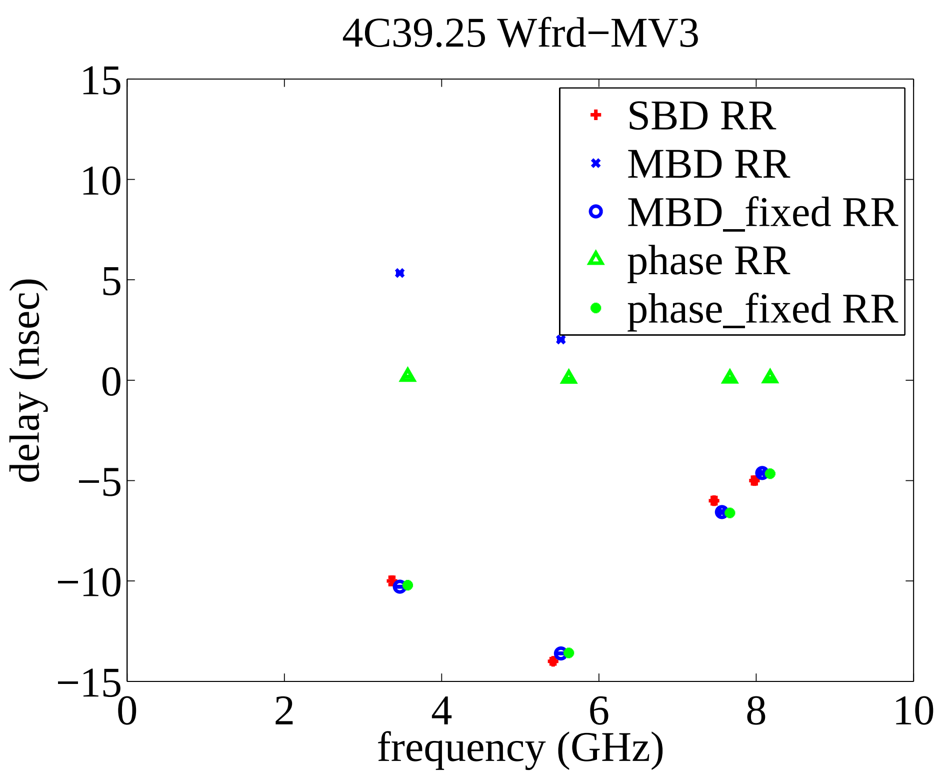
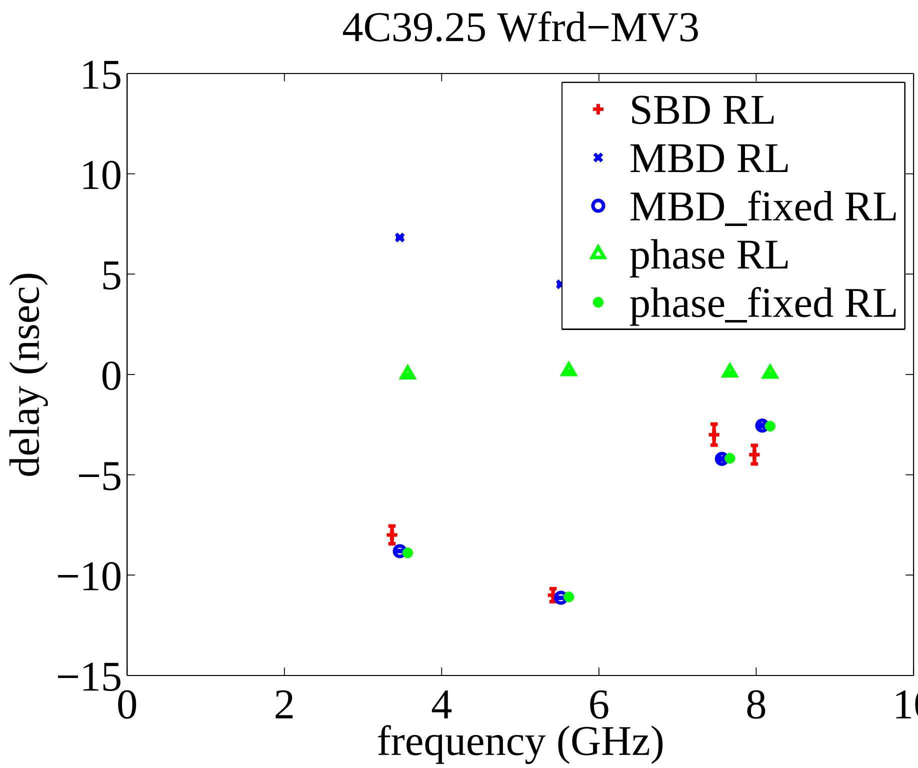


Figure 4. Differences in residual phase between RR, RL, and LR polarizationsand LL as the reference, plus the difference RL –LR. The parallactic angles for Westford and MV-3 and the difference are shown.


4C39.25 Wfrd−MV3
SBD LL
MBD LL
MBD_fixed LL
phase LL
phase_fixed LL
delay (nsec)
frequency (GHz)
15
10
5
0
−5
−10
−15
0
2
4
6
8
10


4C39.25 Wfrd−MV3
SBD RR
MBD RR
MBD_fixed RR
phase RR
phase_fixed RR
delay (nsec)
frequency (GHz)
15
10
5
0
−5
−10
−15
0
2
4
6
8
10



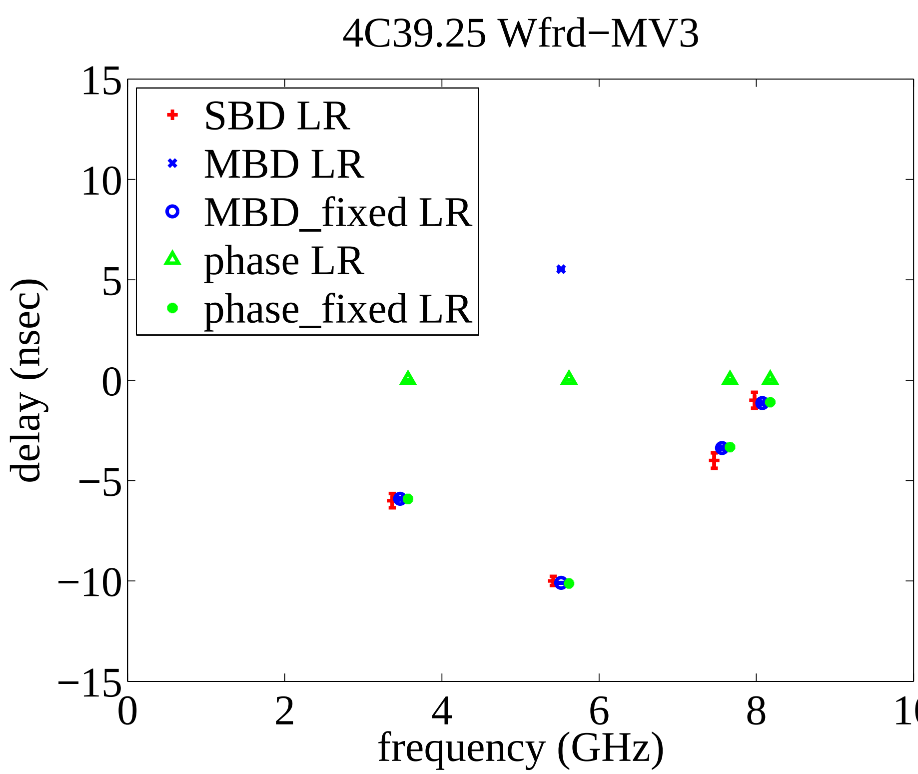


Figure 5. SBD, MBD, and phase delays. MBD are offset by 0.1 GHz and phase delays are offset by 0.2 GHz. The green triangles are the phases output from *fourfit*. The green circles have been adjusted (fixed) by integer cycles to agree with the MBDs that have been adjusted (fixed) by multiples of 15.625 nanosec to agree with the SBDs.

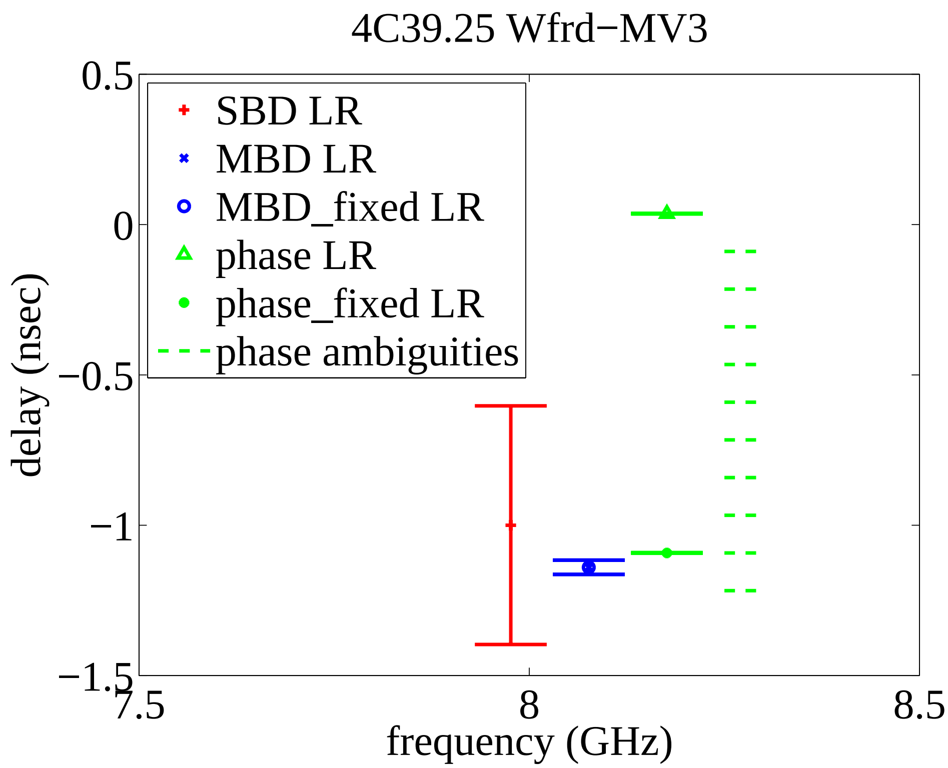


Figure 6. The 8 GHz LR delays showing phase ambiguities.