**Description of Calibration Offsets in EVPA Between IFs on the VLBA**

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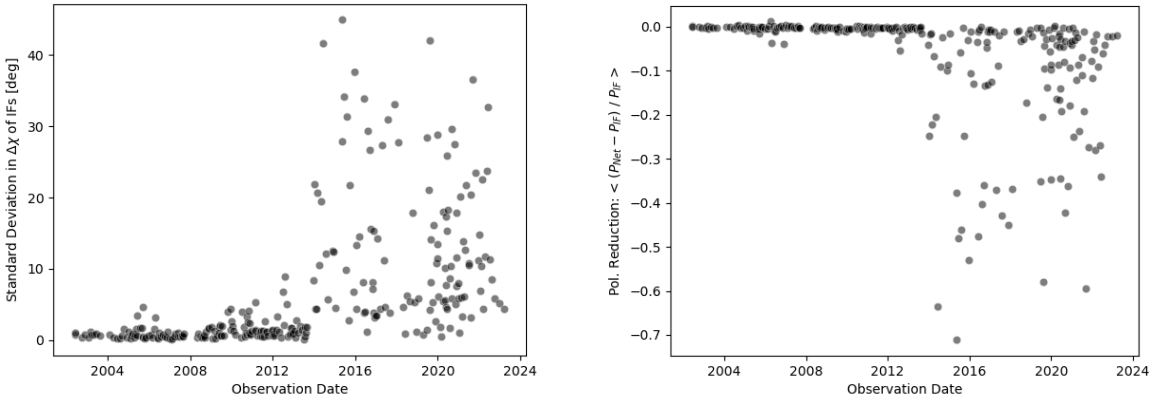
In early August, we reported a wide-band polarization calibration issue that we've discovered in MOJAVE data at U, K, and Q bands to the NRAO help desk. The issue is still under investigation, but we believe this issue could be a general one beyond MOJAVE and may have affected many polarization sensitive experiments on the VLBA since the switch from 8 MHz IF widths to wider IFs approximately a decade ago. Whether the origin is due to the IF width directly (as we initially speculated) or some other change that happened at about the same time (software, correlator, etc.) is unclear.

To summarize, we have found that the VLBACPOL / RLDLY calibration that is designed to line up the RL and LR IFs in phase often leaves significant EVPA offsets, $\Delta\chi$, between the IFs in our experiments with > 8 MHz wide IFs. These offsets lead to degradation of the net polarization, in the worst cases reducing the net polarization by several 10s of percent. We have observed this effect at U, K, and even to a small degree at Q-band, but most of our results are at U-band with only recent experiments (2019-2021) at K and Q band (see our plot at the end of the report).

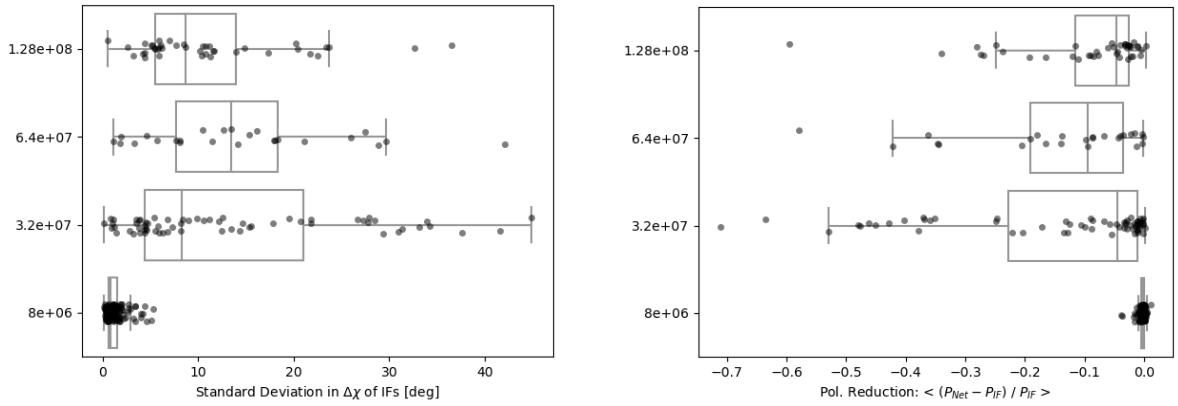
Unfortunately this issue can be difficult to diagnose, particularly if one doesn't know to look for it. Even rotations of 10-20 degrees between IFs can have significant effects on the net polarized images. We have now run a simple analysis on all 273 reduced MOJAVE U-band epochs starting in 2002 through very early 2023, and we include a summary of our results below.

We fit the polarization of each source using a single Gaussian at the phase center and removed sources that were particularly poorly fit by this simple model. Fortunately, many sources survived this process in each epoch and produced consistent results for the polarization rotation of each IF and the net polarization reduction. The plots below show the standard deviation of the EVPA offsets of the IFs (Right) and the polarization loss due to averaging over IFs (Left) for experiment as a function of observing date.

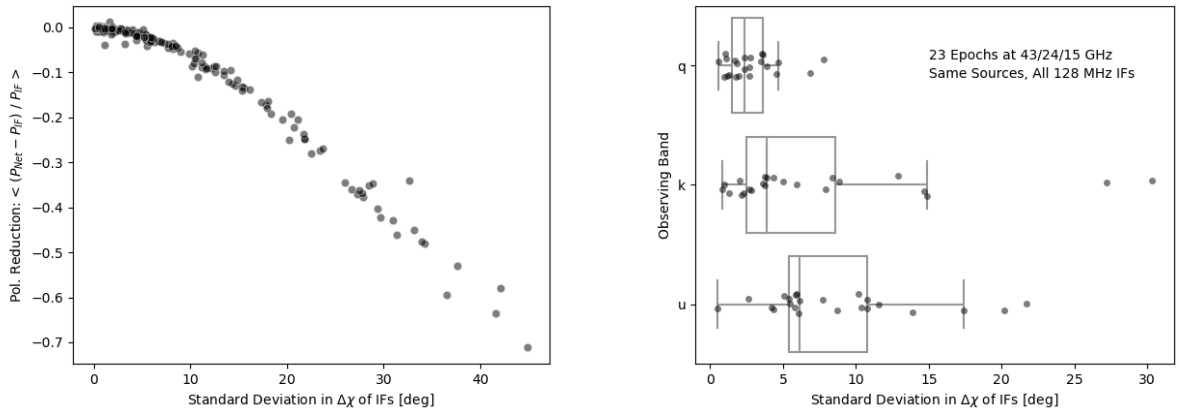



The next plots show the same quantities, now on the x-axis, with the IF width used in each experiment plotted on the y-axis. The box plots show the 25%, median, and 75% points of each

distribution along with whiskers that are 1.5 x the interquartile range. Here you can see that while there is a sharp jump in polarization calibration problems when the IF width goes from 8 to 32 MHz, the magnitude of the issues do not increase with bandwidth beyond that point.




As you might expect, the standard deviation in EVPA offsets for each IF in an experiment correlates directly with the amount of polarization reduction observed when the IFs are averaged together (Right Panel). Note that we also see the issue at other bands than just 15 GHz, the left panel below shows the results for 23 recent experiments at 15/24/43 GHz.




As you know, in AIPS the D-term solutions come after the RLDLY / VLBACPOL step when the IFs have already been channel averaged, so Dterms are still present in the data when one of these tasks is run to remove the RL and LR offsets and delays across the band. We therefore originally wondered if this issue might be due to D-terms that are changing across these larger bandwidths, but the lack of larger deviations as the IF width increased further with later experiments may argue against this possibility. Alternatively, perhaps there is something else that changed either in AIPS or another part of the system with the switch to > 8 MHz IFs.

Fortunately, we have kept our IFs separate in our database and do not average across them in our final .uvf files, so we were able to run the above analysis and detect the problem. We should be able to resolve it to first order by simply using CLCOR to rotate the IFs in each of the

affected experiments to agree with one another and re-imaging; however, if there are also Dterm changes across the band (prior to channel averaging in each IF) there may be additional polarization loss in some individual IFs, particularly for sources with strong Stokes I.

We have devoted significant time and resources over the summer to detect and characterize this issue, and we are now working on implementing the fix described above.

We wanted to include this addendum to our VLBA Large Proposal Report to make you aware of this issue that may not only affect MOJAVE but possibly many other polarization sensitive experiments observed on the VLBA since the switch to > 8 MHz IF widths.