Inter-Observational Delay Changes in the VLBA's RDBE PFB Personality

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Introduction

The preceding memo in this series (#47) presented current information about *inter-scan* delay "jumps" in data derived by the VLBA RDBE/DDC personality. To limit confusion, this memo describes the much more limited, *inter-observation* delay changes in data derived by the RDBE/PFB personality.

Overview of PFB Timing

The PFB personality of the RDBE produces output in 32 channels, each 32 MHz wide, spanning both of the 512-MHz wide bands available on its two IF inputs. Only 16 of these channels can be recorded, selected in a table generated by the control system from user input. The table can specify output channels from a single input IF, or dual-polarization (or other multi-IF) channels selected from both IF inputs.

Timing of the samplers for each IF input is initialized upon loading of the PFB firmware, separately for each of the IF inputs, and continues without change throughout the observation, even when the channel-selection table is modified.

Unfortunately, the RDBE does not have access to a sufficiently precise clock for absolutely simultaneous initialization of its two samplers. Delay offsets often occur between the samplers. These only have a significant effect on observational results when data from the two IFs are correlated against each other, as in the case of cross-polarization processing. However, these delay offsets do remain constant for the duration of an observation, even when observing frequencies and/or the polarization states are changed within the schedule.

Subsequent *observations,* however, will likely start and observe with different sampler timing offsets, and the observed delay and phase of the *cross-polarized* visibility data will differ from one observation to another. As is also the case with the DDC personality, an interruption in the scheduled observation can allow changes in cross-polarized delay and phase to occur upon restarting.

Impact on Users

The effect described above is unavoidable in the VLBA's current dual-personality scheme, which supports a broad range of observing styles with the RDBE. Although the legacy sampler/BBC system was carefully designed to maintain sample timing continuity over long periods, this was necessarily lost in the transition to the wider-bandwidth, more flexible and versatile RDBE system.

We learned about this effect from Matthew Lister during the USNC-URSI meeting in January 2018, and subsequently noted a paper published by his group (Lister et al. 2018, ApJS, 234, 12) that referred to the phase becoming "unstable with time". While this statement is quite accurate on the multiple-observation timescale to which it applied, we emphasize here that we believe instrumental delays and phases remain completely stable *within* a single PFB observation.

We trust that the four-fold increase in observable bandwidth and the uniform bandpass profiles that the RDBE/PFB made available in 2011 are worthwhile improvements in return for this loss.