VLB ARRAY MEMO No. 518

(851216)

BANDWIDTH SYNTHESIS VS. CHANNELIZATION

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VLBA Memo No. 513 by Rogers and Robertson purports to show that dual-band delay measurements by bandwidth synthesis are degraded by the recent decision to increase the bandwidth of the baseband channels and reduce the number of channels proportionally. They claim that having eight separately tunable channels is "marginal" and that fewer channels would "pose serious problems." I show here, however, that these conclusions arise from an inefficient scheme for allocating the available bandwidth, and that fewer channels would be not only adequate, but better.

If the total RF bandwidth is fixed by the receiver, and the total recordable bandwidth is fixed at a smaller value, then for sufficiently high SNR the most accurate delay measurement is obtained by allocating half of the recordable bandwidth to each of two channels, placed at the ends of the RF band. That is because this gives the largest rms spanned bandwidth in the formulas of Rogers and Robertson. By "sufficiently high SNR" I mean high enough that the single band delay is able to resolve the ambiguity in the measurement over the RF band. If weaker sources must be observed, then some bandwidth must be allocated to mid-band channels for ambiguity resolution. (Incidentally, in this case the additional channels would be better allocated so that their frequency spacings follow a geometric progression, rather than the arithmetic progression suggested in Memo 513.) Thus, the proper view of the effect of having a limited number of channels is that it implies a minimum usable flux density for ambiguity resolution. According to Clark et al. (cited in Memo 513), radio sources used for geodesy are all stronger than 1 Jy at both 2.3 and 8.4 GHz. It is easy to show that the minimum usable flux for the VLBA will be much less than this, even if only two channels per band are used.

The VLBA will have 25 m diameter antennas with aperture efficiencies of 0.71 at each band, and system temperatures estimated at 40 K and 80 K for 2.3 GHz and 8.4 GHz, respectively. The total continuously recordable bandwidth is 64 MHz (with 2-level quantization and Nyquist sampling). Allocating 32 MHz to each RF band, assuming 200 sec integration time (cited as typical by Clark et al.), and taking the correlation efficiency to be 0.5, this gives SNRs of 227/Jy and 114/Jy for the two bands. Suppose now that we allocate two 16-MHz channels per band, placed on the band edges. From the formulas in Memo 513, the single band delay errors will be 0.152 and 0.304 nsec*Jy, respectively. Then even if we use the full RF bandwidths of the VLBA receivers (200 MHz and 800 MHz), rather than the 90 MHz and 360 MHz suggested in Memo 513, the ambiguities will be 5 nsec and 1.25 nsec apart. This gives minimum usable fluxes of 33 mJy and 243 mJy, respectively. In practice, fluxes several times these minima should be required in order to keep the probability of ambiguity error reasonably low.

I conclude that no valid technical arguments against the use of fewer channels of wider bandwidth for delay measurements have yet been presented. Only the non-technical issue of compatability, mentioned in Memo 513, remains valid, although its significance on the time scale of VLBA construction is arguable.