VLBA Correlator Memo No. 67

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To: VLBA Correlator Group

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Subject: FX Correlator and O'Sullivan Zero Padding

Based upon simulations and some simple theory, I conclude that the FX needs a complex FFT of size 4N* where N is the number of independent spectral channels to achieve the resolution of a cross-correlator with 2N complex lags.

Without O'Sullivan's padding the FX cross spectral channels which have sinc^2 response overlap at the $(2/\pi)^2$ points (41% of full response) producing an SNR loss of 43% for an unresolved line that falls midway between two spectral channels. With the O'Sullivan fix (doubling FFT size and padding half FFT with zeroes) the overlap point is 91% in amplitude and the SNR loss is negligible. In any event, the cross-spectral function is now sampled with sufficient density that there is no fold-over and Fourier interpolation can be performed, if desired, by transforming to the cross-correlation domain, reweighting or further zero padding and transforming back. The XF with uniform weighting yields a sinc response which has very high sidelobes (-22%). Cosine weighting can be used to improve the sidelobe level (to -7%) but triangular weighting is needed to yield the sinc^2 function - but now with half the resolution. Thus if spectral line observers are willing to give up resolution to obtain lower sidelobe level it might be fair to compare a 4N FFT FX with a 4N complex correlator utilizing triangular weighting. The 4N complex correlator with triangular weighting having about the same performance as the 4N FFT FX. When uniform weighting is used the complex correlator has twice the resolution at the expense of a degradation in sidelobe level. The attached computer simulations illustrate these points. More complete simulations are clearly highly desirable.

*A factor of 2 because negative frequencies contain no useful information and another factor of 2 for zero padding.

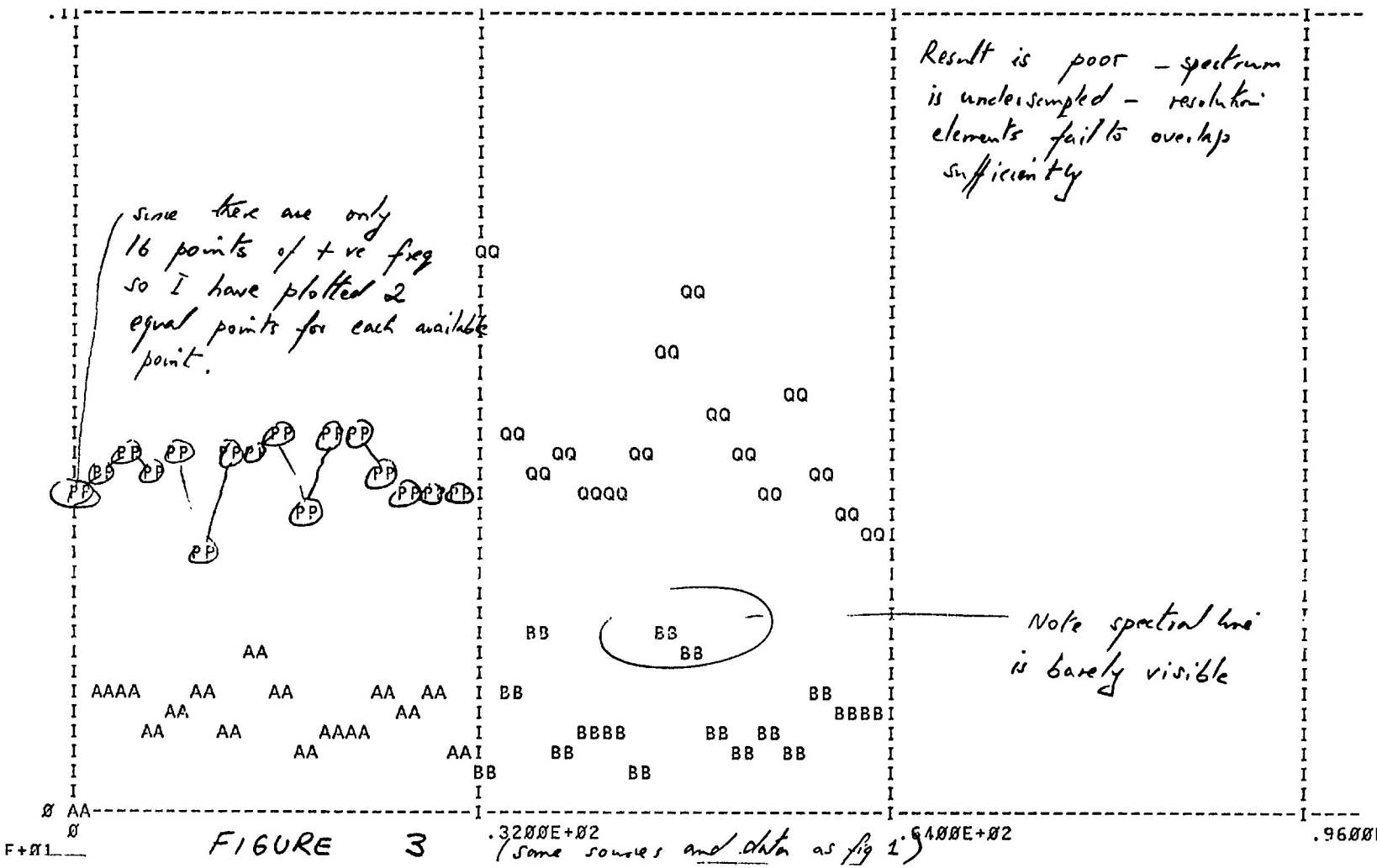

FIGURE 3 (same source and data as fig 1)

Fx

no zero padding

i.e. 32 complex points
32 data points

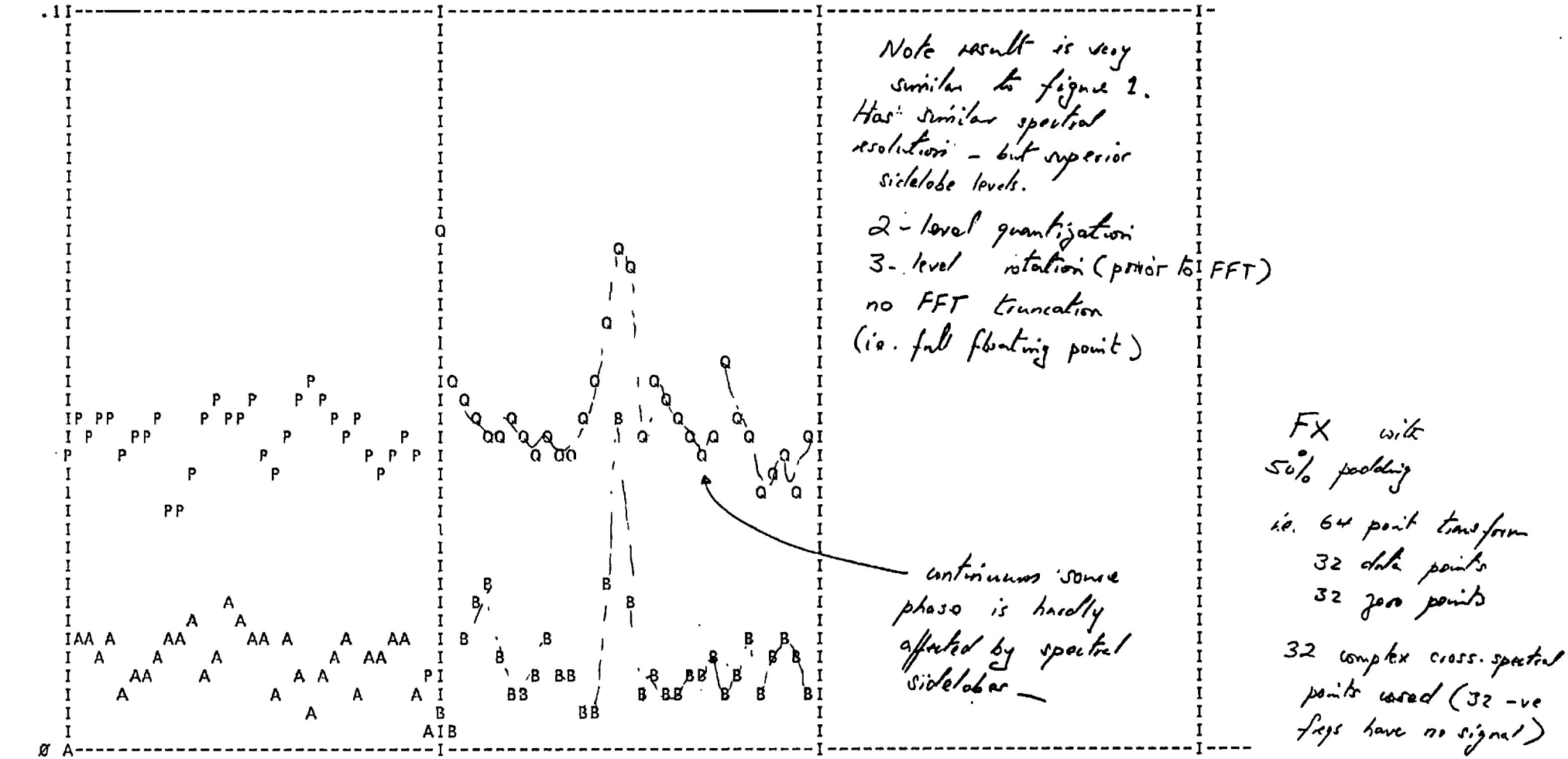

FIGURE 4 (same sources as fig 1) and data

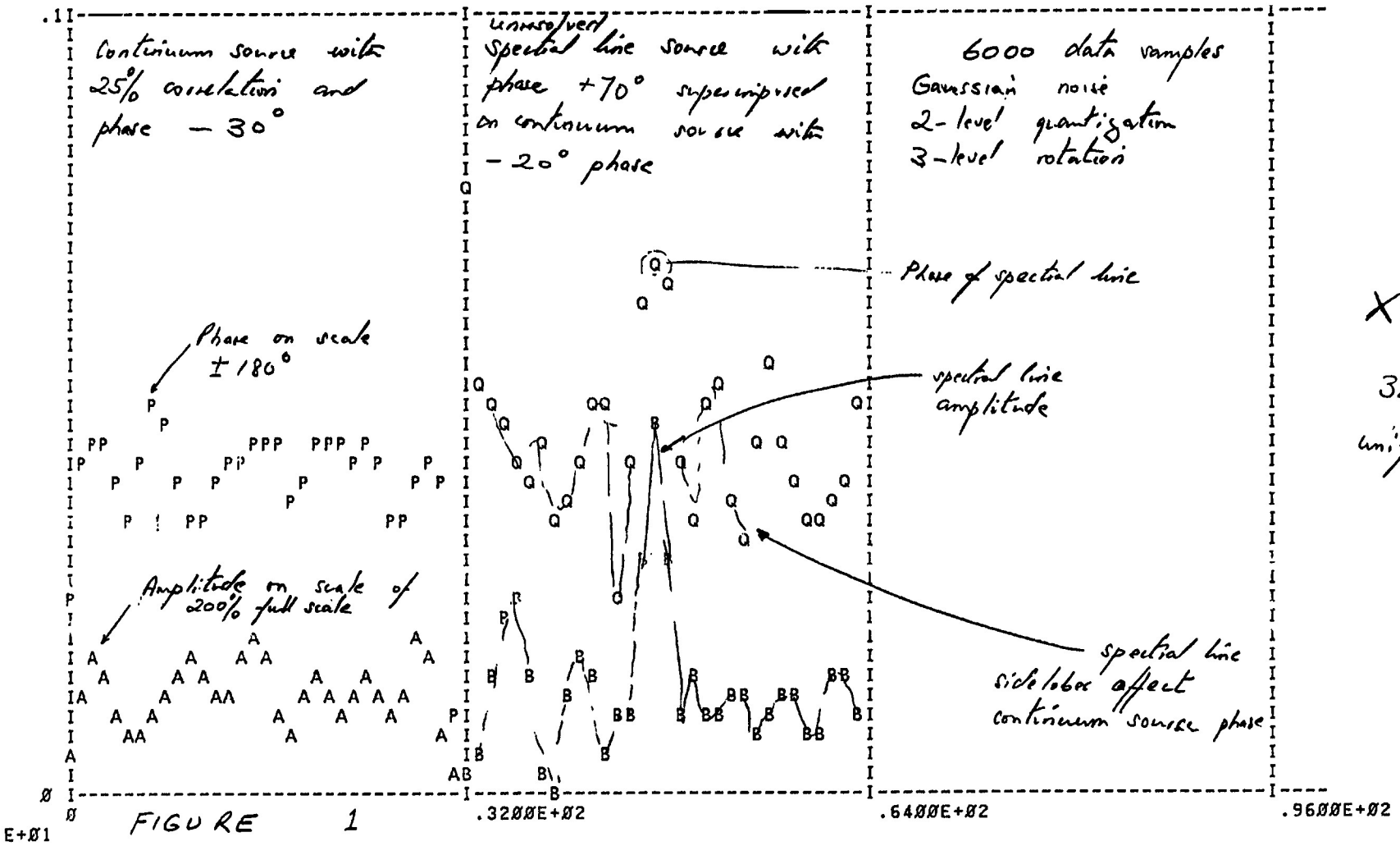

FIGURE 1

XF (Mark II/III version)
complex
32 lags
uniform wt

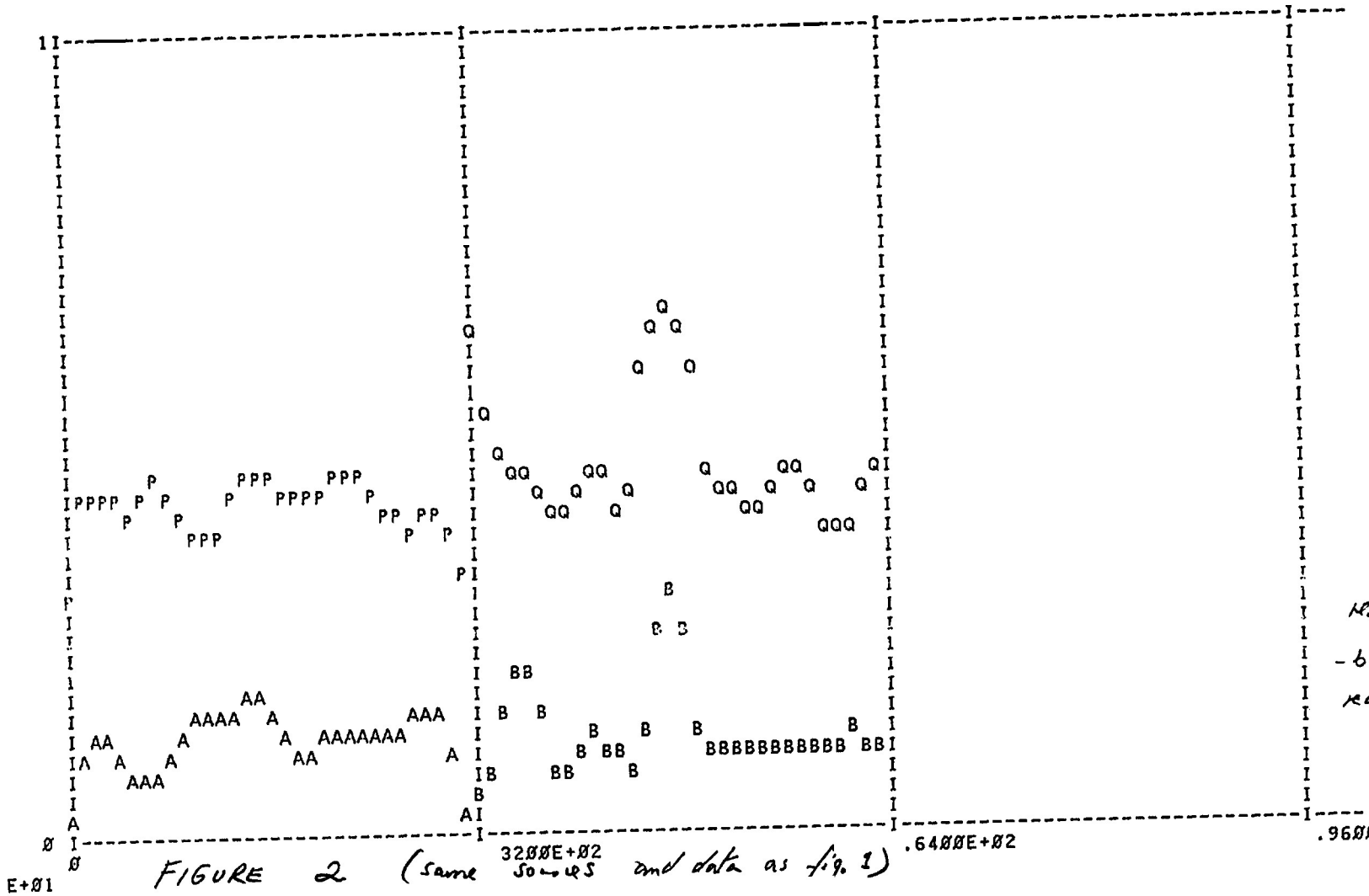

FIGURE 2 (same sources and data as fig. 1)

XF

32 lags

cosine wt - (-7% sidelobe)

resolution is degraded - but sidelobes are reduced.