TO:	Phil Perillat (Arecibo Observatory)
	... plus interested parties...
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SUBJECT:	New idea for near-term RFI tests at Arecibo

Some RFI cancellation experiments that correct two astronomy data channels, using a single reference antenna in combination with the existing Arecibo correlator capacity, could be implemented for a class of astronomical sources – those that are intrinsically unpolarized (or weakly polarized), such as normal galaxies being observed in the 21cm line. The RFI subtraction scheme is a variation on that of Briggs, Bell & Kesteven (BBK, astro-ph/0006222), requiring computation of autocorrelation and cross power spectra for combinations of astronomical signals and RFI reference signals. These schemes rely on the scattering paths for the RFI signal remaining constant over an integration time during which the spectra are constructed and recorded. The actual cancelation is performed off-line by combining the cross power spectra to take advantage of closure relations obeyed by the RFI signal. A further requirement is that the RFI not be so strong as to drive either the analog or digital stages of the receiving system into saturation.

The existing instrumentation at Arecibo prevents an immediate application of the BBK scheme, since there is only a single polarization reference antenna, while the ideal BBK system would have two reference antennas that are physically separated to prevent cross correlated power due sources other than the RFI, such as leakage between polarizations of a dual polarized horn or stray radiation. Even if there were two reference antennas, the existing correlator would be capable of forming a number of cross power spectra between data channels that would allow for correction of only one astronomical data channel.

It is worth considering experiments with a scheme that take advantage of the fact that the RFI signal entering the dual polarized astronomical horn is highly correlated in the two channels. Then, using the mathematical definitions of BBK (signals $s_1(t)$ and $s_2(t)$ come from the two polarizations of the telescope, and $i_3(t)$ comes from the reference atnenna), a variation on the BBK scheme can be implemented as follows:

The correction to be subtracted from the total power spectrum $< |S_1(f)|^2 >$ of astronomical data channel 1 is

$$|g_1|^2 < |I(f)|^2 >= \frac{g_1 g_2^* g_1^* g_3}{g_2^* g_3} < |I|^2 >= \frac{C_{12}(f) C_{13}^*(f)}{C_{23}^*(f)} \approx \frac{C_{12} C_{13}^* C_{23}}{\psi(f) + |C_{23}|^2}$$

where C_{ij} is a cross power spectrum between data channels i and j integrated on time scales short enough that the complex voltage gains $g_i(f)$ are essentially constant, and $\psi(f)$ depends on the noise spectrum and is invoked here to prevent divergences at frequencies where $C_{23}(f)$ is weak.

A similar correction spectrum can be computed for astronomical data channel 2:

$$|g_2|^2 < |I(f)|^2 >= \frac{g_1 g_2^* g_1 g_3^*}{g_1 g_3^*} < |I|^2 >= \frac{C_{12}(f) C_{23}(f)}{C_{13}(f)} \approx \frac{C_{12} C_{13}^* C_{23}}{\psi(f) + |C_{13}|^2}.$$

This scheme for deriving the correction should be fine, provided the $C_{12}(f)$ cross power spectrum for the two Arecibo feeds is weak compared to the celestial signals obtained in the data channels 1 and 2; this means that the polarized flux and noise crosstalk between the channels must be low.

This scheme requires only three cross correlations to implement in order to cancel RFI in both polarizations. A scheme involving two RFI sensors (such as two polarizations of a reference horn) works in the more general case of polarized celestial signals and cross-polarized noise in the C_{12} power spectrum, but the general scheme requires 5 cross power spectrum to implement to clean up both $|S_1(f)|^2$ and $|S_2(f)|^2$, plus a sixth cross correlation if the celestial polarized spectrum is desired.

Since the present Arecibo correlator can produce four cross power spectra, the simplified method proposed here would allow tests – and perhaps astronomical observations – to be performed in the near term on specific test cases, rather than waiting for the construction of new instrumentation.