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SUBJECT: Some thoughts on the calibration of broadband geodetic VLBI

In order to be able to coherently integrate over several centimeter wavelength bands the phases of each band need to be calibrated. One possible scheme under study is to radiate pulses from the vertex of a prime focus dish into the broadband multi wavelength feed at the prime focus. For a small dish the distance from the vertex to the prime focus should be constant or at least a repeatable function of elevation to within a millimeter.

If a picosecond pulse is coupled into an antenna which approximates a half-wave droopy dipole at the shortest wavelength then a fairly good match can be obtained down to the longest wavelength by terminating each ends of the dipole in 25 ohms to the ground plane. Using EZNEC I found the following antenna gain and path loss to a 10 dBi prime focus feed vs frequency

Frequency (GHz)	Gain (dBi)	Path loss to prime focus (dB)
2	-20	62
4	-11	59
6	-6	56
10	0	56

Table 1. Path loss from pulse calibration feed to prime focus

The low efficiency of the transmitting feed at low frequencies is largely compensated by the increased collecting area of the receiving feed at low frequencies.

If we assume that the picosecond pulse has a peak voltage of 50 mV into 50 ohms at the transmitting antenna the peak power received by the feed is -73 dBm assuming a 60 dB path loss. This peak power is equivalent to about 400K in a 10 GHz bandwidth and should be in no danger of saturating the receiver. If a 10 MHz pulse repetition rate is used the average power for a 30 ps pulse duration is 0.12 K which is less than 0.2% of the system noise. On the other hand the power in each 10 MHz rail is about -138 dBm or an SNR of about 14 dB in a 1 kHz bandwidth for a 50 K system. This is strong enough to permit the old tradition of looking at

phase calibration tones on a scope with a filter or a spectrum analyzer. Processing of a phase calibration tone in 1 bit/sample data with the current correlator would result in an rms of about 0.5 deg in 1 second integration. Gated pulse processing at each station is another possibility for future enhancement. Injection via the vertex is likely to be corrupted by multipath mainly due to reflections from the feed back to the vertex and back to the feed. The phase calibration tone phases from a DBE will be proportional to the delay. Multipath will result in an added ripple with period of about 31 MHz for an added path to the vertex and back to the feed on a 12 m dish with $f/D \sim 0.4$.