USING PULSECAL AMPLITUDES TO DETERMINE SYSTEM TEMPERATURE

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INTRODUCTION

System temperature is normally measured using modulated noise diode signal injected at the input of a receiver and synchroneously detecting the noise power at the backend in the BBCs. The injected noise diode signal is calibrated in the laboratory or in the field using hot and cold loads at the receiver input or at the feed input. Generally the injected noise power is about 5-10% of the receiver noise power and is assumed constant with time. Also it is assumed that the spectrum of the calibration noise is basically same as that of the system noise –which is normally assumed flat with frequency (over the passband of the receiver backend). The integration time constant for the total power and the synchroneous detectors is of the order of a few seconds. Thus for a bandwidth of 1 MHz at the backend of the receiver we expect the estimated system temperature to be accurate to within a few percent. The estimates are affected by linearity of the amplifiers and detectors used, offsets in the detectors, and quantization and such other errors in the monitoring system. The quantization errors for switched power (synchroneous detector output) becomes important because its effect on the system temperature estimation is amplified by the ratio of the total power to the switched power.

By increasing the injected noise power and/or integration time it may be possible to improve the estimation accuracy. For reasons of decreasing the system sensitivity it is not desirable to increase the injected noise power. Increasing the integration may help somewhat but has problems – e.g. at low elevations. Also it may be possible to measure the detector offsets etc. and apply appropriate corrections while calculating the system temperature values using total power and synchroneous detector values but it is somewhat cumbersome. Further the noise source should not vary from the time it is calibrated.

For the VLA the relative accuracy of the system temperature estimation of a few percent is considered adequate and several percent is probably acceptable. In most VLA observations absolute accuracy is not important as it is calibrated out using calibration sources. However in the VLBA it is somewhat different and it appears that it will be desirable to achieve an accuracy of 1-2% for the system temperature measurements. In view of the above it is desirable to examine whether amplitude of the pulse calibration detectors can be used for estimating the system temperature, and what are its merits and limitations in comperision with those of the noise calibration system presently used.

GENERATION

Pulse cal – uses tunnel diode driven by output pulses from two back to back connected Schottkey diodes, connected to the ground, and driven from output of an amplifier which is heavily saturated. Essentially the output pulse amplitude depends on the characteristics of the tunnel diode, and its rise/fall time depends on the diode bulk resistance and capacitances, and other stray capacitances in the circuit. We know that the delay/phase of the output comb frequency signal is very stable (needed for phase calibration) and one would expect that to be more sensitive to any circuit parameter variations. Therefore I would guess that amplitude of the output comb is very stable. For some narrow band operations comb frequency signal may not be available in backend (BBC) passband.

Noise cal – uses zenner diode in avalanche mode. Output noise power depends on the current through the diode. Other aspects like considerations for the noise spectrum dependence etc. should be similar to those for the pulsecal. The current through the diode depends on the drive circuit, and presently it is driven from a 28 Volt power supply switched through a transistor, which is a crude arrangement for this purpose. We should change this to a constant current source rather than a voltage source.

INJECTION

Both pulse cal and noise cal should have similar problems, except that noise cal is cheaper to build and therefore we have one for each receiver. Therefore its frequency ripples may be somewhat smaller than those of the pulse cal comb. But since pulse cal has been installed primarily for phase stability measurements, which are more sensitive to passband ripples and their variations, we have to ensure that passband ripples are not a problem. This distribution scheme has not been objected for the phase calibration purposes, and therefore for present I will consider that this is not a source of concern.

DETECTION

Pulse cal – uses coherent detection of narrow band signals from digitized data. The pulsecal amplitude is normalised using total power in the baseband signal. Non flat bandpass will therefore cause errors in the estimated pulsecal amplitude, and if the passband ripple around the pulsecal tone frequency changes, then the pulsecal amplitude will be affected even without the system temperature changing. Correction for this can be estimated by measuring the autocorrelation power in the frequency channels around the tone frequency, and therefore it is easier to account for it in a FX correlator. The pulsecal amplitude gives high signal/noise ratio for very small added signal. With limited spectral dynamic range of the correlator and limited linearity of the analog signal path, presence of narrow band signals like pulsecal tones may not be desirable during some spectral line observations.

Noise cal – uses syncroneous detection of broadband signal power level during two halves of the noise cal switching cycle. Change in power level during two halves of a cycle will affect the FFT of the FX correlator which will be reduced by fringe frequency but still may have some residual effects (due to common periodicity of 100 msec for FFT and cal switching). Linearity of amplifier and detectors, and offsets in the detectors etc. need to be accounted properly to estimate the system temperature value accurately.

CONCLUSION

I have used pulse cal amplitudes in conjuction with the noise cal and compared the two sets of data. Fig. 1 shows the pulse cal amplitudes for various BBC channels during a S/X phase stability test at Los Alamos with the antenna stowed. Fig. 2 shows system temperature values calculated using total power and synchroneous detectors from the monitor data. During this period the 4 cm receiver was cooling. The variations in the pulse calibration amplitudes (rather inverse of square of the amplitudes) seem to be tracking the system temperature values well. It seems that use of the pulse calibration amplitudes for estimating the system temperature is promising. It will have to be calibrated using hot and cold loads in the field (for present). It seems worthwhile to try this method out to learn its limitations and strengths.

4cm Rcvr Cooling

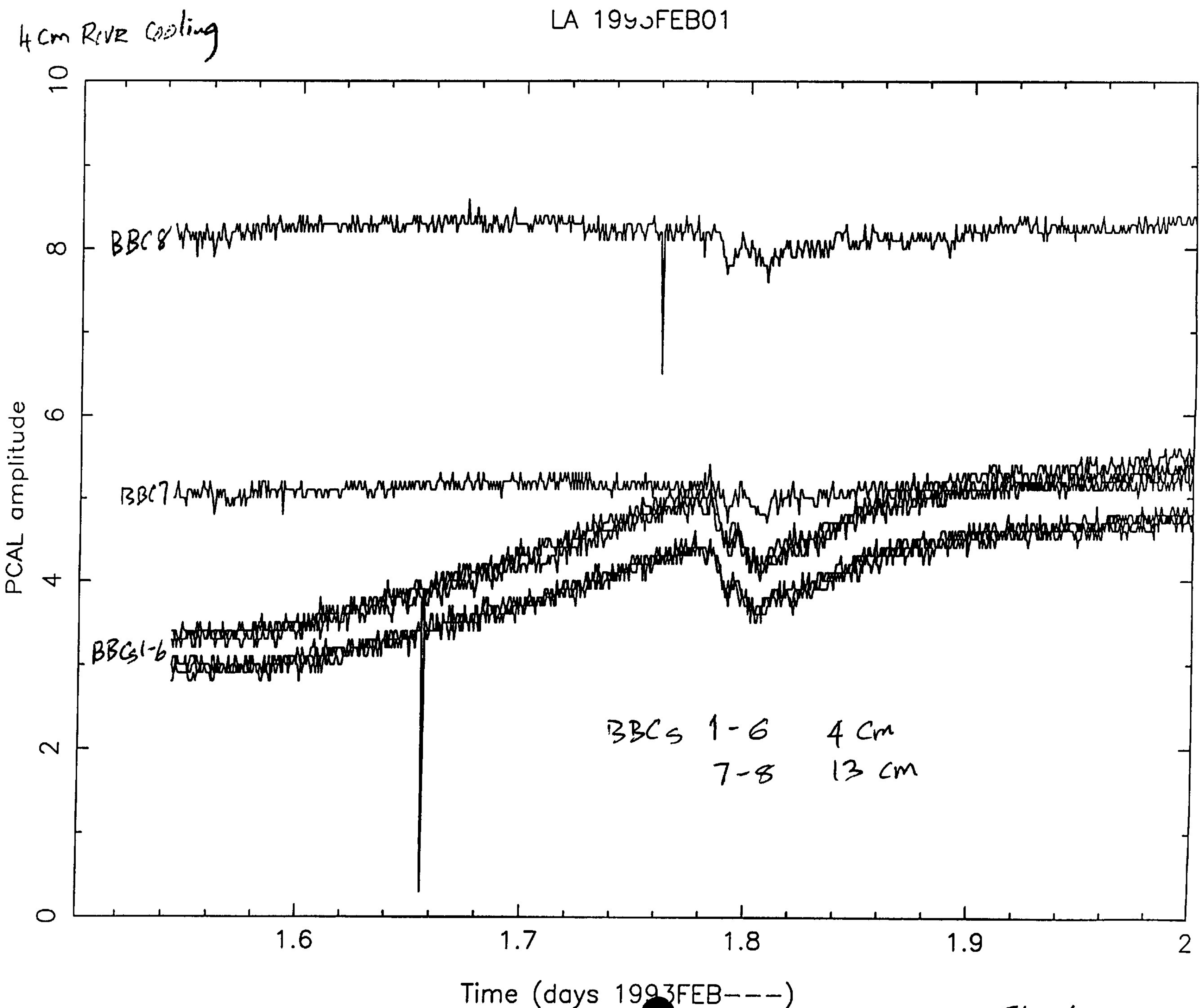

FIG. 1

4cm RCVR Cooling

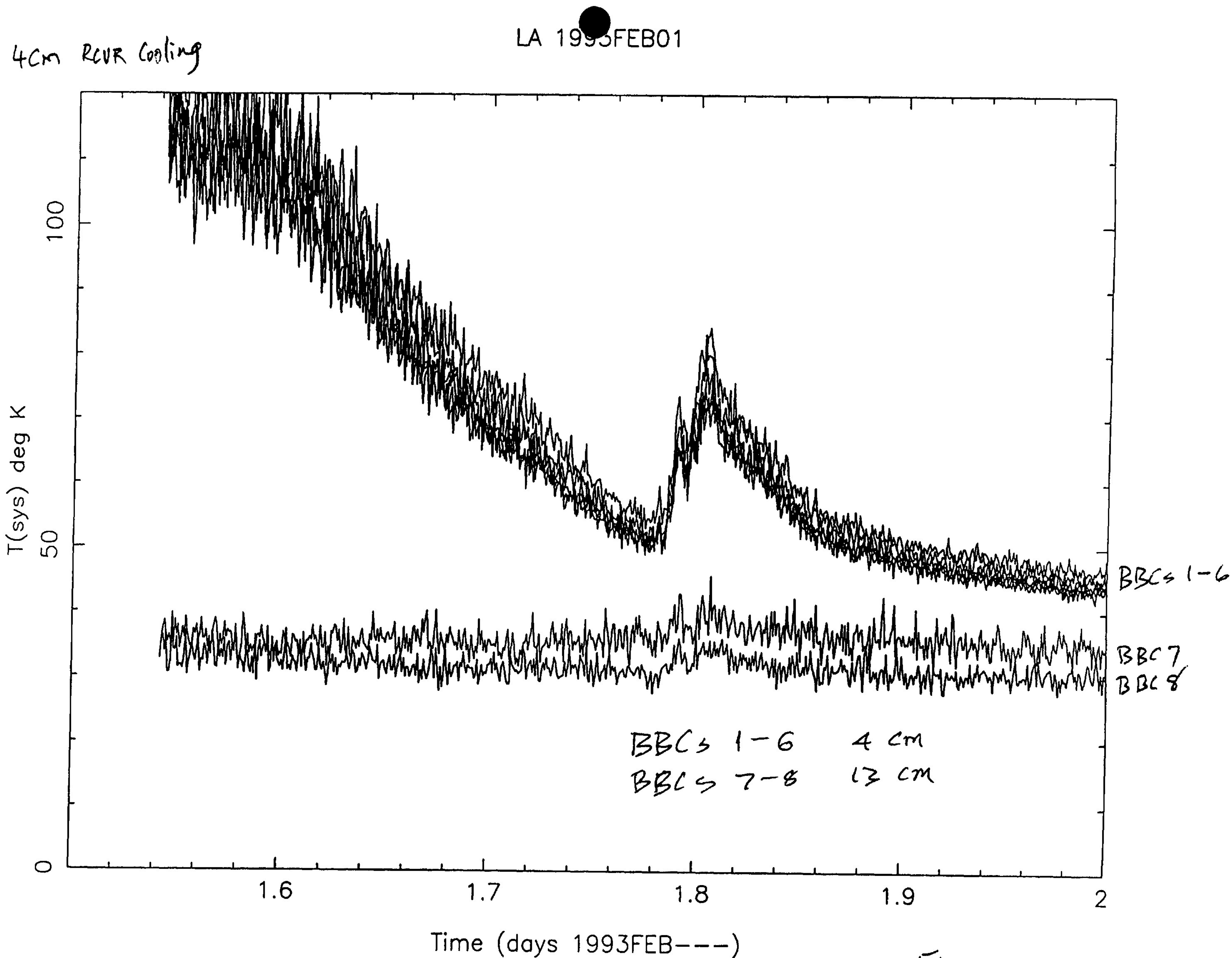

FiG. 2