Memorandum

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cc: J. Webber

From: J. Effland

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Subject: Noise Temperatures Measured Manually and with Chopper Wheel

Summary

This memo compares receiver noise temperatures measured under computer control using a chopper wheel with manual measurements using the SIS Lab's "standard" loads. Also included here are measurements of the cold load's relative noise power as a function of distance from the Dewar window. All measurements use the new lens designed by Geoff Ediss, and comparison to data obtained with the old lens is included.

Receiver noise temperatures measured with the chopper wheel using the previous lens system, which had largely unknown characteristics, differed by as much as ± 8K (±5.6%) from manual measurements using the lab standard loads assuming an effective temperature for the chopper's cold load. The new lens system has reduced this discrepancy to about ±3K (±4%) and the effective temperature of the chopper wheel's cold load has also decreased from 97.1K to 94.9K. (Different mixers were used in testing the old and new lenses so the receiver noise temperatures were not identical. This means that the same absolute discrepancy values in Kelvin yield different percentages.)

With the new lens, the variation of cold load noise power with distance from the Dewar is much more similar at 230 GHz and 270 GHz. This means that the effective temperature of the chopper wheel's cold should be more constant with frequency, which is supported by the measured data. The data also show that wide-angle scattering and/or beam spillover still exists with the new lens system.

Measurement Setup

The laboratory standard loads are fabricated from sheets of Eccosorb AN72 absorber formed to the shape of a cone. The absorber is 9 cm in diameter inside the base of the cone and the internal height of the cone is 15 cm. The outside of the cold load' cone is enclosed in a copper case and the entire assembly is dipped in a bath of liquid nitrogen to cool it. The ambient load is a section of AN72 absorber without the copper casing and the base of its cone and is 9 cm with a height of 17 cm.

The chopper wheel is 35.6 cm in diameter and reflects the beam from the Dewar window into either a hot load, consisting of approx. 12 x 12 cm of Eccosorb CV-3 absorber, or through a 44 cm square aluminum reflector to a cold load. The cold load is also Eccosorb CV-3 absorber enclosed in a Styrofoam cylinder of dimensions 8 cm high and 14 cm in diameter. Liquid nitrogen was added to the bowl to cover the absorber tips.

Measurement samples from each technique were obtained in groups at each frequency. That is, three measurements were made with the manual loads, then three with the chopper wheel.

Receiver Noise Temperature Measurements

Figure 1 compares receiver noise temperatures over a band of frequencies measured manually using the lab's standard conical loads and automatically using the chopper wheel. The discrepancy results primarily from an increase in the effective temperature of the chopper wheel's cold load. This temperature can by determined from a least squares analysis of receiver noise temperatures, where the chopper wheel's cold load temperature is adjusted to minimize the discrepancy over the frequencies measured with the receiver noise temperatures obtained using the lab standard loads. This analysis shows that the minimum discrepancy occurs when the effective temperature of the chopper wheel's cold load is 94.9K. Using this cold load temperature to calculate receiver noise temperature, shown as X's in Figure 1, discrepancies between the two measurement techniques is less than 3K, which close to the overall measurement uncertainty.

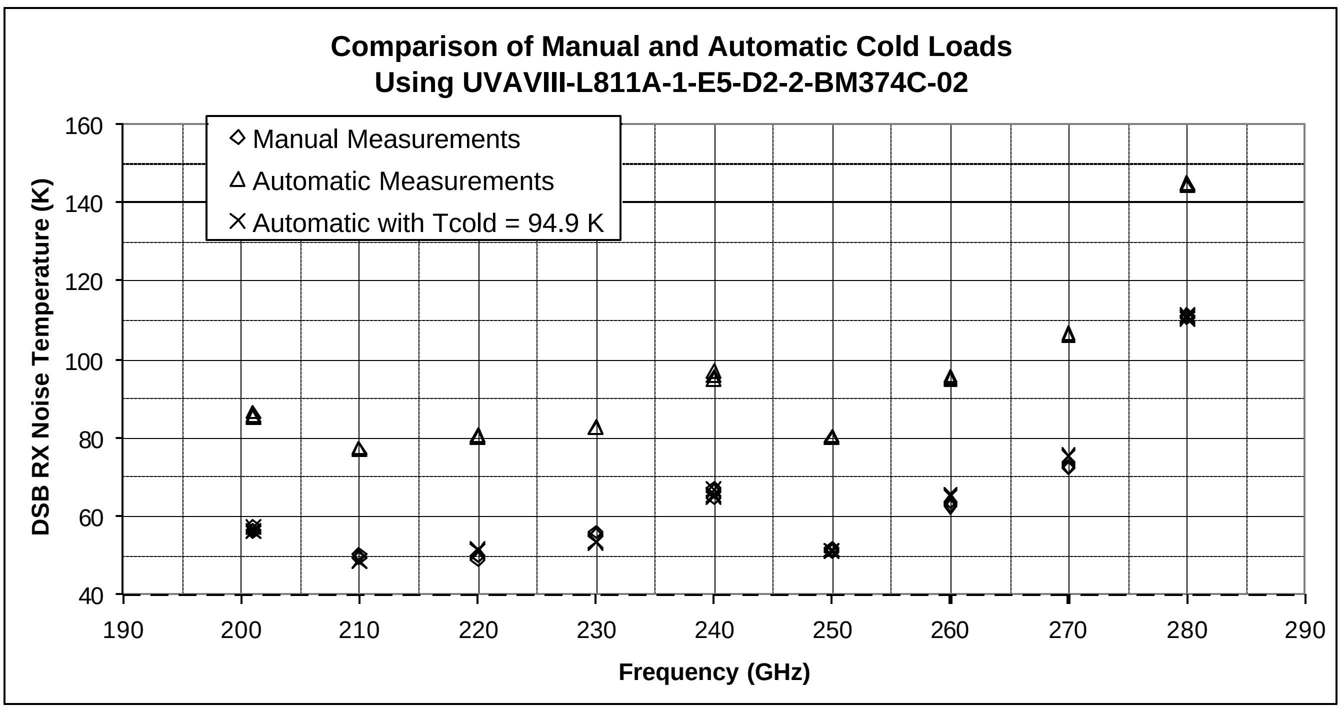

Figure 1: Comparison of Noise Temperatures Measured with Lab Standard and Chopper Wheel Loads

Figure 2 shows the residual discrepancies for receiver noise temperatures measured with both techniques. No attempt was made to order or average the measurement samples. That is, for a particular frequency, the first measurement obtained with the manual load was compared to the first measurement acquired with the chopper wheel.

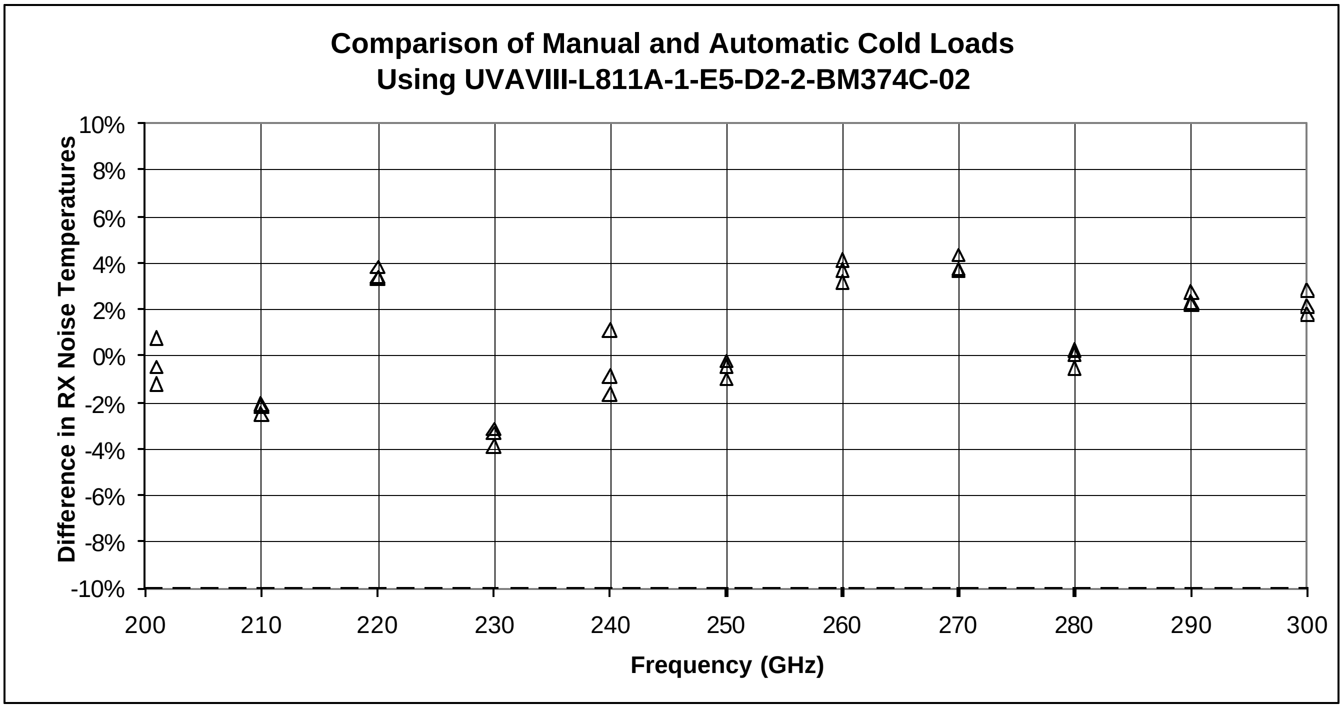

Figure 2: Percent Discrepancy between Automatic and Manual Cold Loads

Cold Load Noise Power vs. Distance

Cold load noise power changes as a function of its distance from the Dewar were measured using Geoff Ediss' new lens and compared to similar data measured with the old lens. The data were measured by referencing the HP436 power meter to 0 dB while holding the Lab's standard conical cold load against the Dewar window, then recording the relative noise power after moving the cold load a certain distance from the window. The load was dipped again in liquid nitrogen after measuring noise power in groups of three distances, and the results were repeated three times. The lowest two readings are shown plotted in the graphs

Figure 3 is the relative cold load noise power measured at 230 GHz, and it suggests that wide-angle scattering and/or beam spillover still occurs with the new lens design, because the noise power from the cold load changes immediately after the load is moved away from the Dewar window. The solid curve is the subtended half angle from the Dewar wall *vs*. distance for the conical load, which has an opening of 9 cm.

Figure 4 is the relative cold load noise power measured at 270 GHz and plotted with the same scale as Figure 3. The important feature to note is that the beam size is much more constant with frequency than the beams created from the original lens. This implies that the effective cold load temperature should remain more constant with frequency with the new lens.

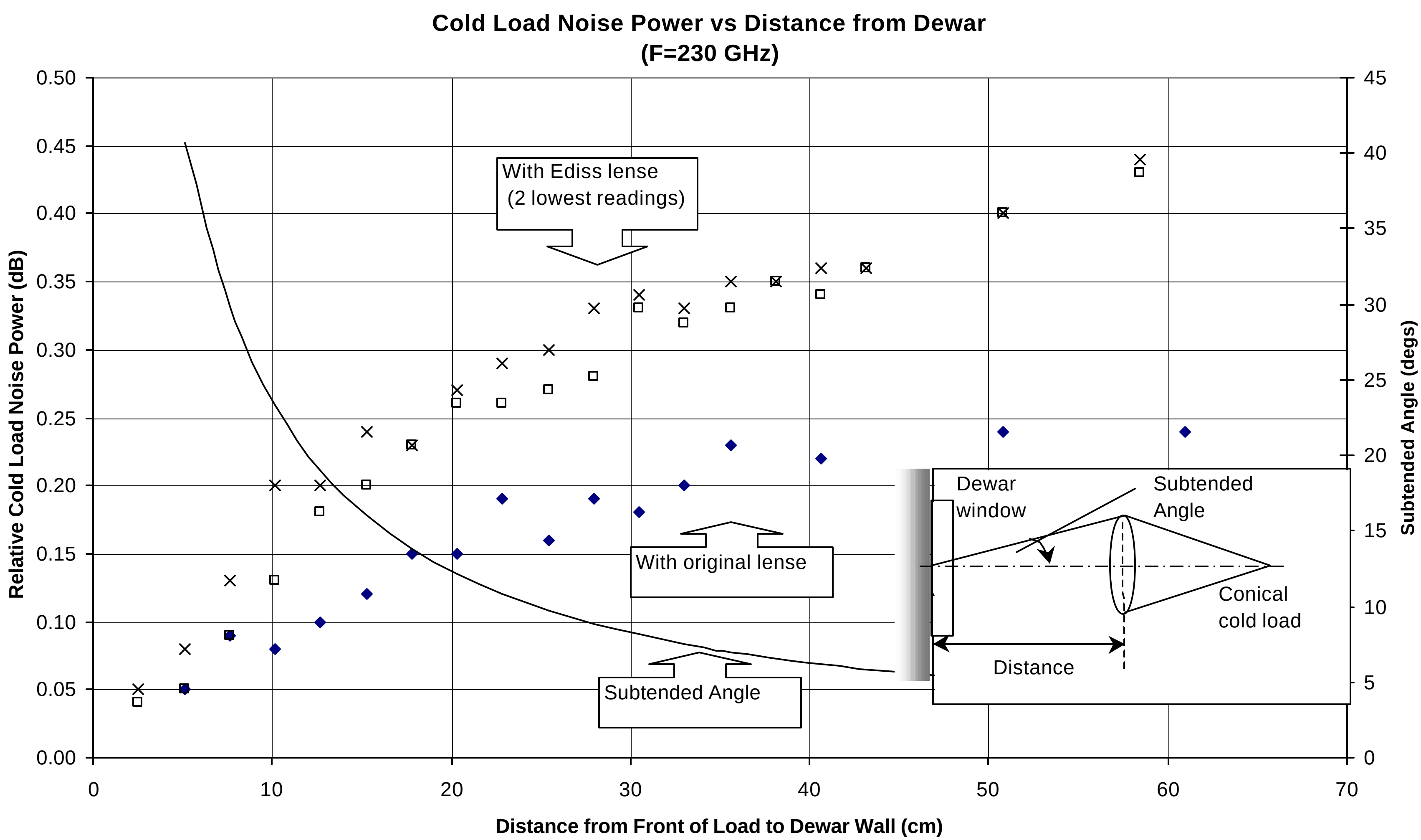

Figure 3: Cold Load Noise Power vs. Distance 230 GHz

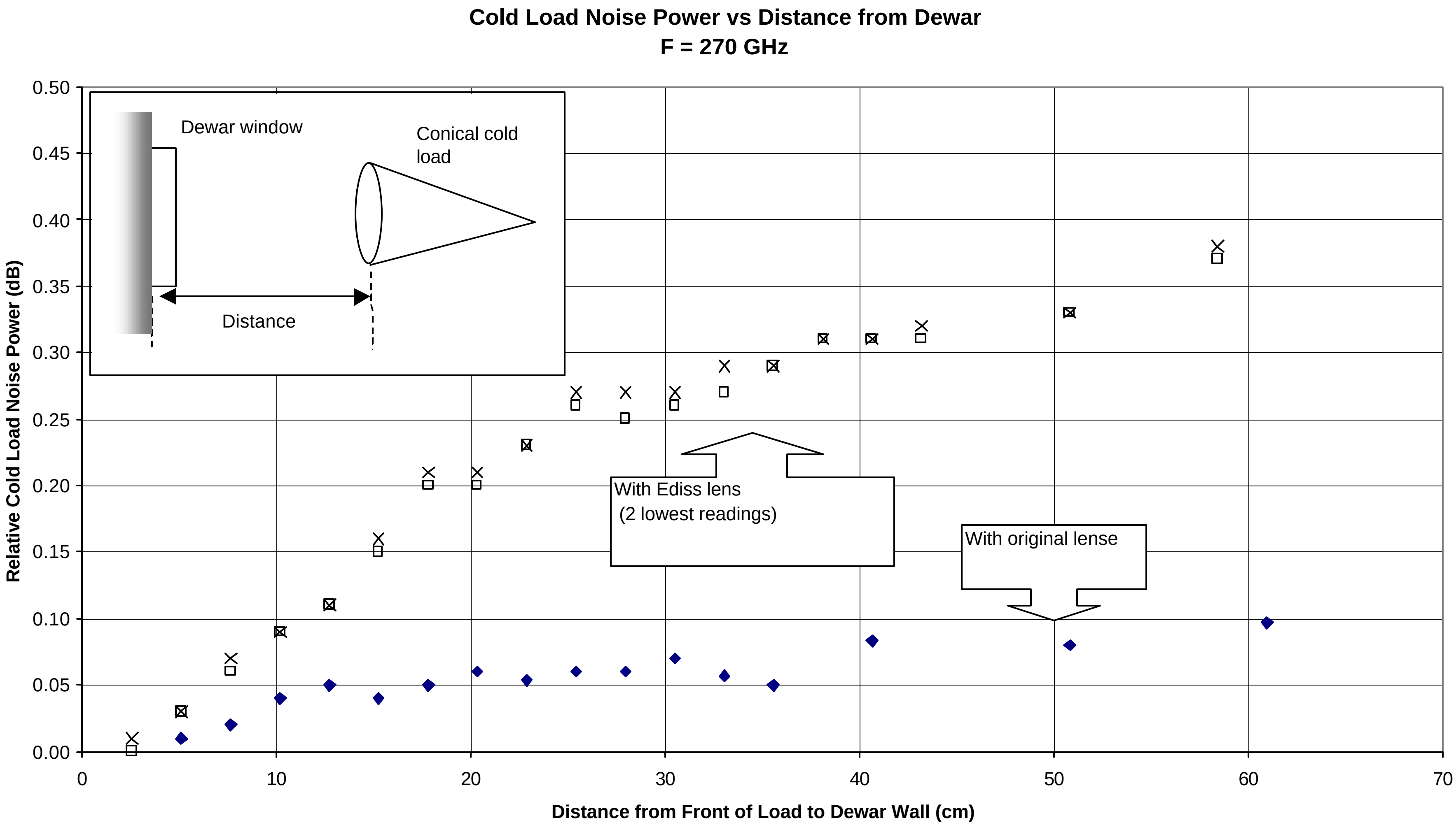

Figure 4: Cold Load Noise Power vs. Distance 270 GHz