Subject: *Horn 1 System Temperature Measurements*
Memo: 1, revision 1
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As a part of NSF Citizen Science-Outreach effort, Glen Langston has been developing a prototype horn system for astronomical observations of rapid radio transients. While initial tests were encouraging, repeated attempts at measuring the system temperature yielded inconsistent results. This note reports measurements made after securely refitting the feed port into the horn.

Measurements

The first measurements were carried out on June 8, 2015 under good weather conditions.

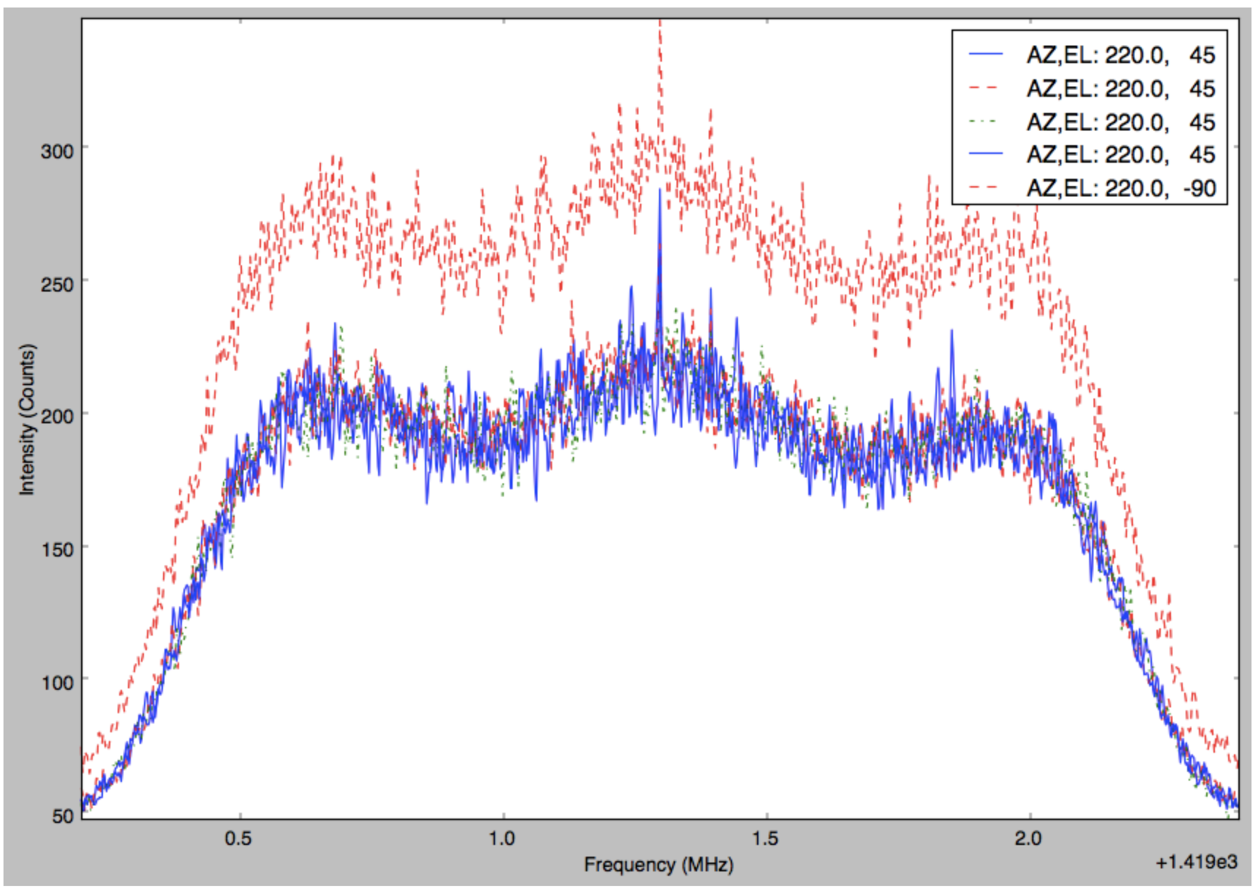

FIGURE 1: MEASUREMENT OF THE INTENSITY (COUNTS) WHILE THE FEED HORN WAS POINTED AT THE SKY (ELEVATION = 45) AND AT THE GROUND (ELEVATION = -90).

At frequency 1420 MHz, while pointing at the ground, the measured intensity is 265 counts and while pointing at the sky the intensity is 195. The difference, hot - cold counts, called DeltaC, is 70. At a frequency of approximately 1420.9 MHz the intensities were 262 and 190.

Assuming a ground temperature of 300K and the cold sky temperature of 10K, the System Temperature, Tsys, over the feed Gain, G, ratio may be calculated. In The Scale factor, S, corresponds to the amplification in the IF chain. The equations below work through an estimate of the system temperature gain ratio. Equations (1) and (2) present the formulas describing the relationship between the measured intensities, in counts, and system temperature and hot and cold loads.

S*Chot = (Tsys + G Thot) (1)
S*Ccold = (Tsys + G Tcold) (2)

Next solving for the scale factor S:

S * Delta C = G(Thot - Tcold) (3)
S = G(Thot-Tcold)/Delta C (4)

And finally solving for Tsys/G:

Chot * G *(Thot-Tcold)/DeltaC = Tsys + G Thot (5)

Tsys = Chot * G * (Thot-Tcold)/DeltaC - G Thot (6)
Tsys/G = (Chot * (Thot - Tcold)/Delta C) - Thot (7)

From the measurements at 1420 and 1420.9 MHz respectively values for Tsys/G are determined:

Tsys/G = (265 * 290K/70) - 300K = 1097 K - 300 K = 798 K (8)
Tsys/G = (262 * 290K/72) - 300K = 1055 K - 300 K = 755 K (9)

The consistency of the two measurements suggests that the T/G measurement is good and a representative estimate is 776+/-25.

Based the estimated noise figure of the first amplifier, 0.7dB, and 0.1 dB loss from each of the cable and from the feed horn waveguide port, the system temperature corresponding to the noise figure of 0.9dB loss from a 300 K device is 67K. From this it is deduced that the gain G is 67/776 or 0.086.

This 8.6% gain is much smaller than the anticipated 90 % efficiency expected for a horn. Alternatively some component of the radio frequency amplifier chain may have much greater than expected loss.

Conclusion

A horn feed has been constructed and connected with a pair of amplifiers to provide sufficient gain for a first measurement of the system gain of a small radio frequency transient detector.

Software has been created with is used to record average spectral line measurements. Additional software has been developed to reduce the observations.

The first system is capable of measurement of the system temperature to gain ratio. This value is found to be much larger than expected and further study is required.