

## *Haystack Observatory - - Small Radio Telescope*

### Measure Aperture Efficiency

#### Introduction:

Aperture efficiency  $\eta$ , is the ratio of the effective aperture of a radio telescope divided by the true aperture. True aperture  $A$ , is defined as the collecting area of the telescope surface. Effective aperture  $A_e$ , can be defined as the losses from a perfect reflector due to such things as blockage of the surface by the feed and feed supports, over/under-illumination of the surface by the feed and other factors such as surface irregularities. Typically, total losses amount to 35%-50% of the theoretical limit. That is, 50%-65% of the power from the observed source reaches the receiver.

$$h = Ae/A$$

For the purposes of the use of the SRT, the aperture efficiency ( $\eta$ ) is expressed by the following equation:

$$h = 2k T_A / FA$$

where,  $T_A$  = the antenna temperature in degrees K,  $k$  = Boltzman's constant ( $1.38 \times 10^{-23}$  w Hz<sup>-1</sup> K<sup>-1</sup>),  $F$  = the radio source flux density in Janskys ( $10^{-26}$  w m<sup>-2</sup>) and  $A$  = the area of the reflector in m<sup>2</sup>

Measurement of the aperture efficiency of the SRT can be carried out on several sources: Cygnus-X, Cas-A, the Moon and even the Sun. The procedure below will use Cas-A.

#### Procedure:

The user should first move the telescope to an area of the sky near the source to be observed. The calibration should typically be done at the same elevation as the source but offset in azimuth by at least two beamwidths (10 degrees for a 3m dish). Since this is a "continuum" measurement, the frequency setting for the receiver should be away from the 1420.4 MHz hydrogen line.

The observing mode will be beamswitching. Beamswitching involves alternate on-source/off-source observations with each off-source observation alternating in a plus/minus azimuth direction. A typical command file for a five-minute, beamswitched run on CasA might look like this:

LST 18:00:00	(select a time when CasA is at higher elevation)
: record <i>filename</i>	(Start recording, filename is optional)
: azel 80 45	(Calibration position)
: freq 1419 20 0	(Set frequency, number of samples and sample spacing)
: calibrate	
: CasA	(Move to CasA)
:300 b	(300 seconds observing, b=beamswitch mode)
: roff	(recording off)

### **Discussion of Data Reduction:**

The resulting data output file will be a succession of on-source then off-source samples. The statistical reduction to arrive at an average Antenna Temperature  $T_{ant}$  to use in the above Aperture Efficiency equation is as follows:

$$P_k = P_{on} - P_{off}$$

Where, k = the cycle number. (On/Off pair)

$$\begin{aligned} \text{For, } k = 0,2,4 & \quad -P_{off} + \text{previous } P_{on} \\ \text{For, } k = 1,3,5 & \quad P_{on} - \text{previous } P_{off} \end{aligned}$$

For N cycles

$$P_{ave} = \Sigma P_k / N$$

Where,  $P_{ave}$  = average of N on/off pairs

$$P_{SD} = (\Sigma P_k^2 - N P_{ave}^2)^{1/2} (N - 1)^{-1/2} \quad \text{For } N > 1$$

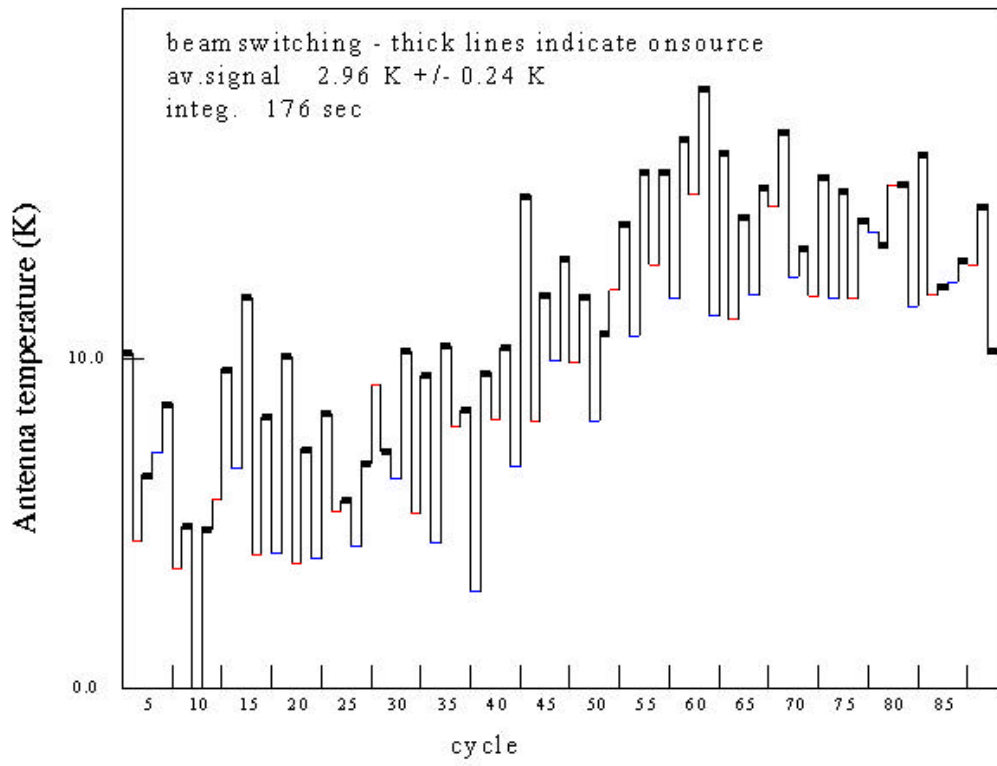
The plot of the reduced output data was generated from a program written by Alan Rogers for SRT Beam-Switched Data reduction. The program is written in JAVA and when compiled will read the output data file from the SRT beamswitched run. The syntax of the compile and run steps are listed as follows:

C:\ **javac bplot.java**

C:\ **java bplot filename.rad**

The output data plot is in Postscript form with the default name:

C:\ **srt.pos**



SRT

D:srtjawascratchcasbeam2.rad