Haystack Observatory - - Small Radio Telescope

Measure System Temperature using Vane Calibration:

Introduction:

The user should calibrate the telescope before making any observations. The SRT uses an ambient-temperature vane calibrator and/or a noise diode to obtain a measure of the system noise, background sky, atmosphere and spillover from the feed. The vane is a circular piece of absorber material attached to a motorized arm that can allow the absorber to completely cover the feed aperture during the calibration sequence. The noise diode is located at the dish apex and will directly illuminate the feed during the calibration. The calibration is the ratio of the power measurement by the receiver with the vane enabled and blocking the feed divided by the power measurement by the receiver when the vane is retracted and the signal is received from the sky (this includes contributions from spillover). The power ratio is seen in the equation below.

$$P_{vane}/P_{sky} = T_s + T_{vane} \ / \left(T_s + T_{spillover} + T_{sky}\right)$$

Where, $\boldsymbol{P_{vane}}$ = the power measurement with the vane deployed, $\boldsymbol{P_{sky}}$ = the power measurement with the vane retracted, $\boldsymbol{T_{vane}}$ = the ambient temperature of the vane, $\boldsymbol{T_{spillover}}$ = the feed spill-over $\boldsymbol{T_{sky}}$ = the combined temperature contributions from the sky and $\boldsymbol{T_s}$ = the system temperature

The power ratio for the noise diode calibrator is seen in the equation:

$$P_{on}/P_{sky} = T_s + T_{noisecal} + T_{spillover} + T_{sky} \Big/ \left(T_s + T_{spillover} + T_{sky}\right)$$

The value of $T_{noisecal}$ is determined from comparisons between the electronic noise calibrator and the vane calibrator.

The minimum signal power that can be distinguished from the random fluctuations in the output of a measuring system caused by noise inherent in the system is the sensitivity of the system. If the system noise has a power, P watts, then the equivalent system temperature or noise temperature can be described by

$$T = P/kB$$

Where, $\boldsymbol{k}$ = Boltzman's constant (1.38 x 10^{-23} w Hz^{-1} K^{-1}), $\boldsymbol{B}$ = the bandwidth and $\boldsymbol{P}$ = power in watts.

Procedure:

To calibrate the system, move the telescope to an area in the sky that is close in elevation and approximately two beamwidths (about 10 degrees) offset in azimuth from the source that is to be observed. If the sun is being observed, the azimuth offset should be larger, perhaps 40 degrees.

The SRT user can manually calibrate the system using a left mouse-button click on the **Cal** button on the command tool bar at the top of the SRT console window.

In a command file the syntax might look like this:

: record *filename*	/Start recording, output *filename* is optional
: azel 130 45	/calibration position
: 1415 5 0.0	/scan frequency, 5 bins (samples), no frequency step
: 1415.0	/center frequency with default 500MHz bandwidth
: calibrate	/calibration with Vane
: noisecal	/when using the noise diode calibrator
: Sun	/Source command

After the approximately 20 second calibration routine, the resulting calculated system-noise-temperature, $\mathbf{T_{sys}}$ will be printed in the information side bar. Approximately 20 degrees of the total system temperature reported will be accounted for as the receiver temperature $\mathbf{T_{rec}}$.

SRT Commands: (Manual Operation)

From a MSDos prompt change your directory to the sub-directory where your compiled **srt java** software is resident. Type the following command to start the SRT software:

C:\srtjava> **java srt 0**

With the SRT control panel operating the telescope will probably be in the normal stowed position. That is, at the physical position that represents the start positions of the motion counts of the two drive motors. For normal "north -south" orientation, this "**stow**" position will be approximately pointing east and parked at a 10-degree elevation angle from the horizon. This position will be marked with a red 4-point cross at the lower left-center of the sky-map.

Move the mouse pointer to the Command Toolbar at the top of the console and click on the button marked:

azel

Move the pointer to the text-input box at the bottom of the control panel and type:

120 60

This will move will move the telescope from the stow position to the commanded 120 azimuth and to the 60 degree elevation. The azimuth drive will move the entire command BEFORE the elevation drive moves. This is because there is only one motion counter and the position count of the first drive must be registered before the elevation count can begin. By enabling the keyword **COUNTPERSTEP *n***, in the **SRT.CAT** file (where ***n*** is the step size), the antenna will alternate motion from azimuth to elevation and display the intermediate position on the console. This allows the user to monitor the progress of the telescope when slewing to a new position. The step ***n*** can be any integer

When the command position has been reached, move the mouse pointer and click on the button labeled:

Vane

The mechanical vane of absorber material will move to cover the receiver feed to begin the calibration process. The system will take data for ten seconds with the vane in place and a comparison ten-second period after the vane is retracted. The new derived system temperature or "**Tsys**" will be reported in the information sidebar of the console.

Alternately, for systems equipped with a diode calibrator (most of the SRT systems produced in the future will have ONLY the noise diode calibrator). Move the mouse pointer to the button labeled:

Cal

The noise diode will inject a ten second signal into the feed horn and then compare to a ten-second "noise off" signal to produce the proper system temperature. **Be sure that the keyword "NOISECAL" is included in the SRT.CAT file.**

To proceed to the next position, (in this case the Sun) move the mouse pointer to the console map. Click on the spot labeled:

. Sun

Move the pointer to the Command Toolbar and click on the button labeled:

track

The antenna will now move to the Sun for the next observation sequence.