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February 28, 2013

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To: Holography Group

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Subject: System temperature above the atmosphere from a tip scan.

The system temperature outside the atmosphere can be estimated from a scan of the atmosphere in elevation. In this case the total power, P, is given by

$$P = g\left(T_{atmos}\left(1-e^{-\tau/\sin\theta}\right)L_R + T_{\rm lna} + T_{rad}\right) \qquad (1)$$

Where g = receiver gain

τ = zenith opacity

θ = antenna elevation

T_{atmos} = temperature of atmosphere

$T_{\rm lna}$ = temperature of LNA

T_{rad} = noise contribution from radome

L_R = radome loss factor

The power received from a radio source is

$$P_{source} = g\left(\frac{A_{eff}F}{2k}\right)\left(L_R e^{-\tau/\sin\theta}\right) \qquad (2)$$

Where A_{eff} = antenna effective aperture inside radome

F = source flux density outside atmosphere

k = Botzmann's constant

If we assume $T_{\rm lna}$, T_{rad} are constant, $L_R = 1$ and T_{atmos} = outside temperature we can solve for g and τ from the elevation dependence. Further we can convert from power to the kelvin temperature scale and obtain the system temperature above the atmosphere

The quantity known as the system temperature above the atmosphere is

$$T_s = T_{atmos}\left(P_g / P_{elev} - 1\right)^{-1}$$

Where P_g / P_{elev} is the ratio of total power looking at the ground (or an absorbing vane) and the total power looking off the source in azimuth at the elevation of the source. This ratio is also known as a "Y" factor. The "vane" calibrated temperature of the radio source is

$$T_{source} = \left[\left(P_{on} - P_{off}\right) / P_{off}\right] T_s$$

Where $P_{on} - P_{off}$ is the difference in the power between being on and off the source. The T_s relationship to the source temperature can be derived for equation 1 and 2 assuming the opacity is infinite when P_g is measured.

Unfortunately we cannot estimate the radome loss by this method as it cannot be distinguished from losses in the feed which in turn raise the system temperature. Radome losses could only be estimated from a system temperature based on a hot/cold calibration done inside the radome.