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To: Holography Group

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Subject: Using Sun limb scans to check antenna efficiency and astigmatism

At 3mm wavelength the Sun is close to a uniform disk of 7000 K brightness. While most solar activity is at frequencies below 20 GHz there are occasional hot spots at 100 GHz but these events are short, rare and are limited to localized areas on the solar disk

The limb of the Sun forms a step function of brightness and since the Sun's angular diameter of 530 mdeg is much larger than the haystack antenna beam of 5.7 mdeg plus its sidelobes the observed antenna temperature when pointed at the Sun should be 7000 K times the loss in the radome and atmosphere regardless of the surface errors on dish. The effect over surface errors which lead to a reduction of the aperture efficiency only become evident when the details of a limb scan are examined. A perfect dish with 10 dB aperture taper produces a response to the step from which the antenna half power full width beamwidth can be approximately determined from the scan angle between the 10 and 90% points. [Costa et al[1], 2002 show how a complete beampattern can be determined from radial scans.] Given the measured beamwidth in 2 orthogonal directions the aperture efficiency is approximately given by efficiency ~ $b^2/(b_x b_y)$ where b is the theoretical beamwidth and b_x and b_y are measurements of beamwidth in the 2 orthogonal directions respectively.

In the case that the antenna has astigmatism orthogonal beamscans will show differences between b_x and b_y which show up as a focus is changed. The Figures show the surface deviation, antenna beam and orthogonal beamscan from simulations for 3 cases:

1] Perfect antenna

2] Astigmatism of 560 microns peak at edge of dish

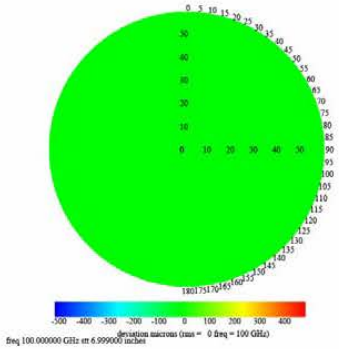
3] Astigmatism plus focus error

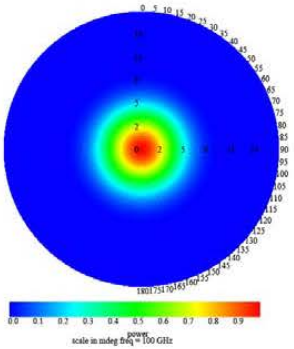
Cases 2 and 3 result in an aperture efficiency of about 50% (from the Sun scans and the Ruze formula) at 100 GHz (excluding attenuation of radome and atmosphere).

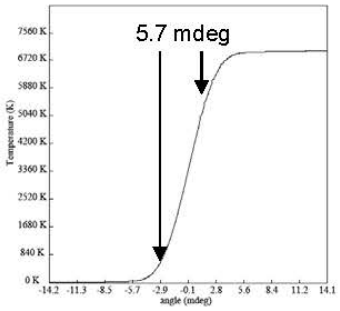
It should also be pointed out that the antenna surface deviations can be measured using phase-retrieval holography (see Morris, Davis and Mayer, "Experimental assessment of phase retrieval holography of a radio telescope," IEEE proceedings-H, 138, 3, June 1991). In this method the beampattern is measured on a strong source at 2 different focus positions and then transformed using the Misell method. While the method is not very good for individual panels it should work well for large scale distortions like astigmatism.

[1] Costa et al, "Beam Profile Determination by Tomography of Solar Scans," A&A 387, 1153-1160 (2002)

Perfect antenna



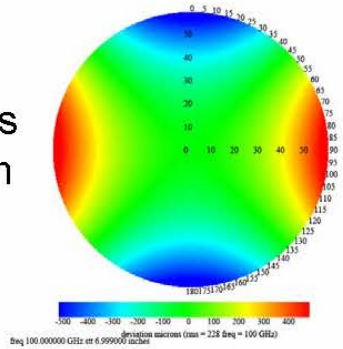


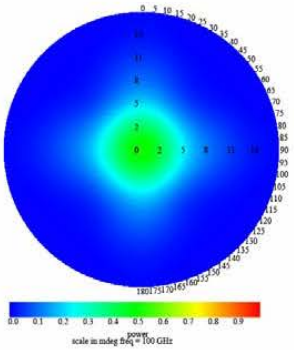


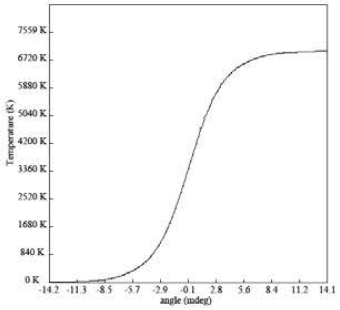
Angle between 10% and 90% ~ beamwidth

560 microns astigmatism

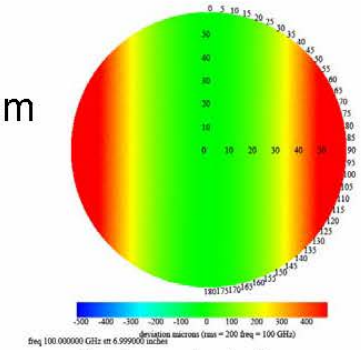
efficiency ~ 50%

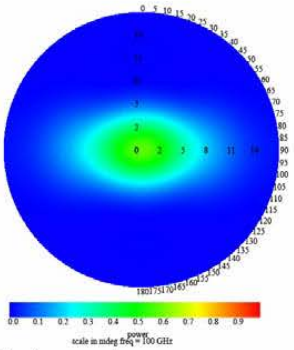


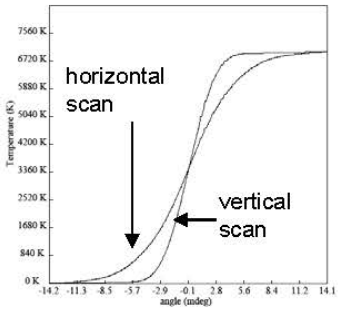




Astigmatism plus focus







Surface deviation **Antenna beam** **Sun scan**

Simulations of scans on the Sun for 37m at 3 mm

Figure 1.