Antenna Beam Pattern Calculations using Range Measurements
Update #1

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March 29, 2001

This memo provides an update to the results presented in my memo of March 25, 2001. Since that time I have made the following changes to the Igor algorithms to calculate the antenna pattern:

(1) I have corrected a bug that caused unequal weighting on different sides of the antenna. This was the main cause of the observed large phase variations.

(2) I have corrected Eq. (3) from my previous memo. That equation for calculating the complex feed pattern from chamber measurements to the aperture field was

$$I = 10^{(A/10)}\, e^{i\Delta\varphi} \tag{Old 3}$$

where A was the observed amplitude in dB and φ the residual phase. The corrected equation, based on information from Brian Corey, is

$$I = 10^{(A/20)}\, e^{i\Delta\varphi} \cos^2\left(\frac{\psi}{2}\right) \tag{New 3}$$

where ψ is the axis angle. The cosine factor accounts for the increasing distance between the feed and reflector with axis angle.

(3) I updated the integration scheme to use Simpson's rule. This has a negligible effect on the small axis angles ($\psi \leq 10°$), but I can now obtain the "theoretical" result out to $\psi = 70°$.

(4) Phases for $\psi \leq 67.4°$ (the angular width of the AMCS dish as seen from the position of the feed) are now used to fit the phase model. The RMS residual increases from 1.6° to 1.7°.

The new results are shown in Figure 1. The beamwidth is 5.5°, somewhat larger than calculated before, but the sidelobes are smaller. This result is more consistent with what we would expect. The beamwidth (defined to be the FWHM) notwithstanding, the main lobe extends out rather far, and does not reach -40 dB until $\psi \simeq 12°$. The phase variations are quite small out to the first null, where there is a 180° phase shift.

The small non-zero phase for $\psi = 0$ is simply an artifact of the average phase being zero from the least-squares solution. If, in this solution, I weighted the ith phase by an amount $|I_i|\Delta A_i$, where I_i is calculated from (3) and ΔA_i is the areal weighting

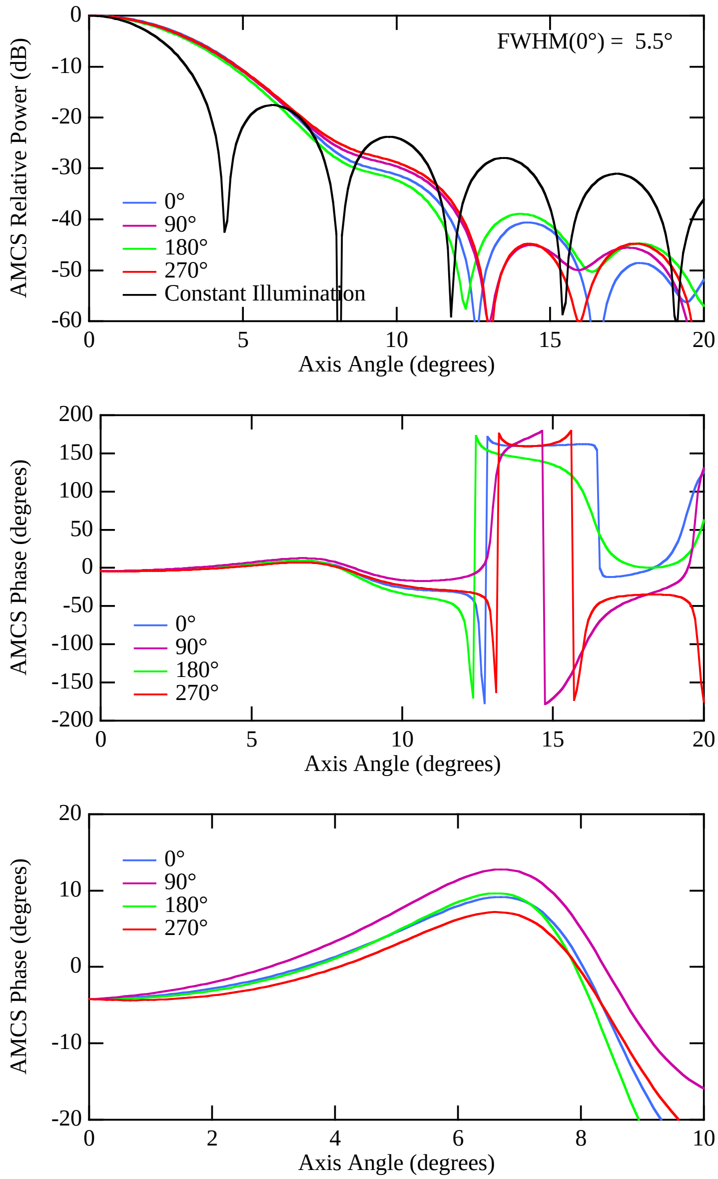

Figure 1. Top: Calculated power. Middle: Calculated phase. Bottom: Close-up on phase near $\psi = 0$.

in the numerical integration, the AMCS phases would have been offset such that the AMCS phase for $\psi = 0$ is zero.

The calculated L1 phase variation in Figure 1 is acceptable, if our pointing accuracy is really 0.5°. The maximum L1 phase variation over that angular error is $\sim$0.2 mm. BY $\psi = 1°$, however, the error increases to $\sim$0.4 mm, and by $\psi = 1.5°$ the error is $\sim$0.8 mm.

Referring to Figure 2 of the March 25 memo, I was fairly suspicious of the small "jumps" in phase that can be observed in the close-up. Although these are small,

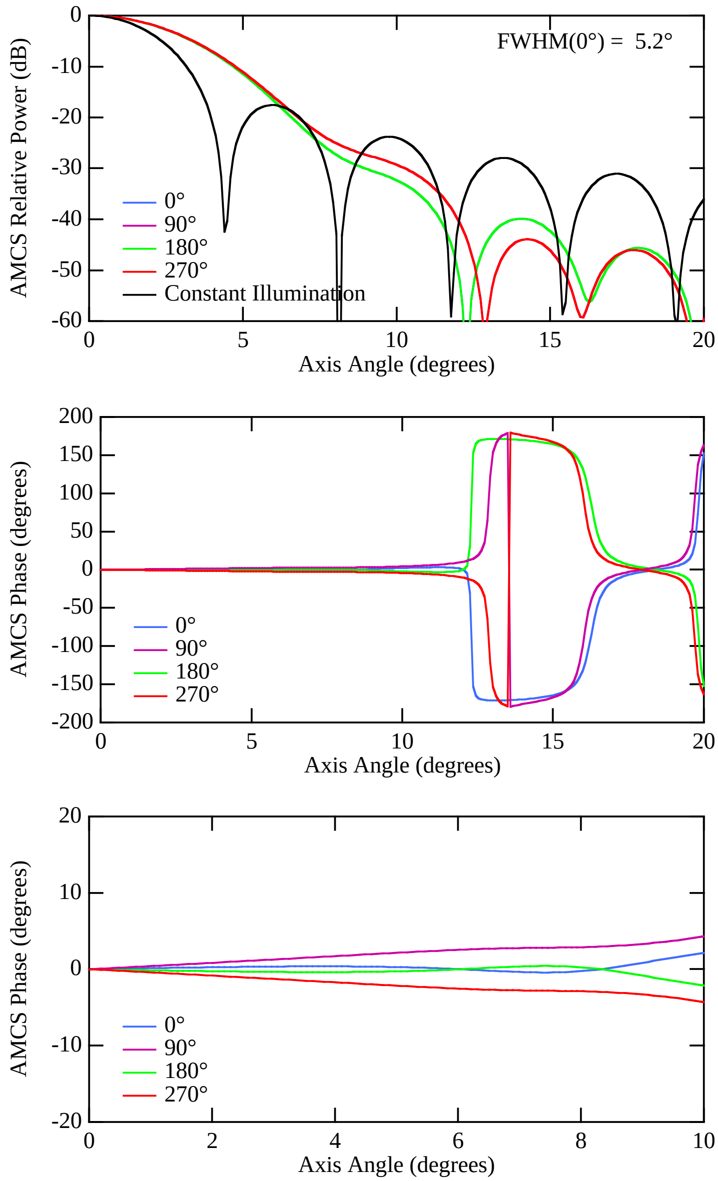

Figure 2. Calculations performed assuming observed phases of zero. Top: Calculated power. Middle: Calculated phase. Bottom: Close-up on phase near $\psi = 0$.

typically $\pm 0.8°$, they are fairly systematic, and if "reconstructed" the phases can change by several degrees. I therefore also performed the calculations in which the observed phase information was discarded, i.e., φ was taken to be zero in (new and old) Eq. (3) These results are shown in Figure 2.

The overall result when the phase information is discarded does not change significantly. The phase variation is slightly less in absolute value, but the phase is antisymmetric as one expects for a real I. Thus the phase variation across $\pm 0.5°$ is also $\sim$0.2 mm. The beamwidth decreases slightly, from 5.5° to 5.2°, probably within the true error of the calculations.

In conclusion, for L1 the phase error across the main beam is tolerable, 0.2 mm or less, is the pointing error is 0.5° or less. Next, I'll perform the L2 calculations.