Subject: Gain losses from observing and focusing at different frequencies
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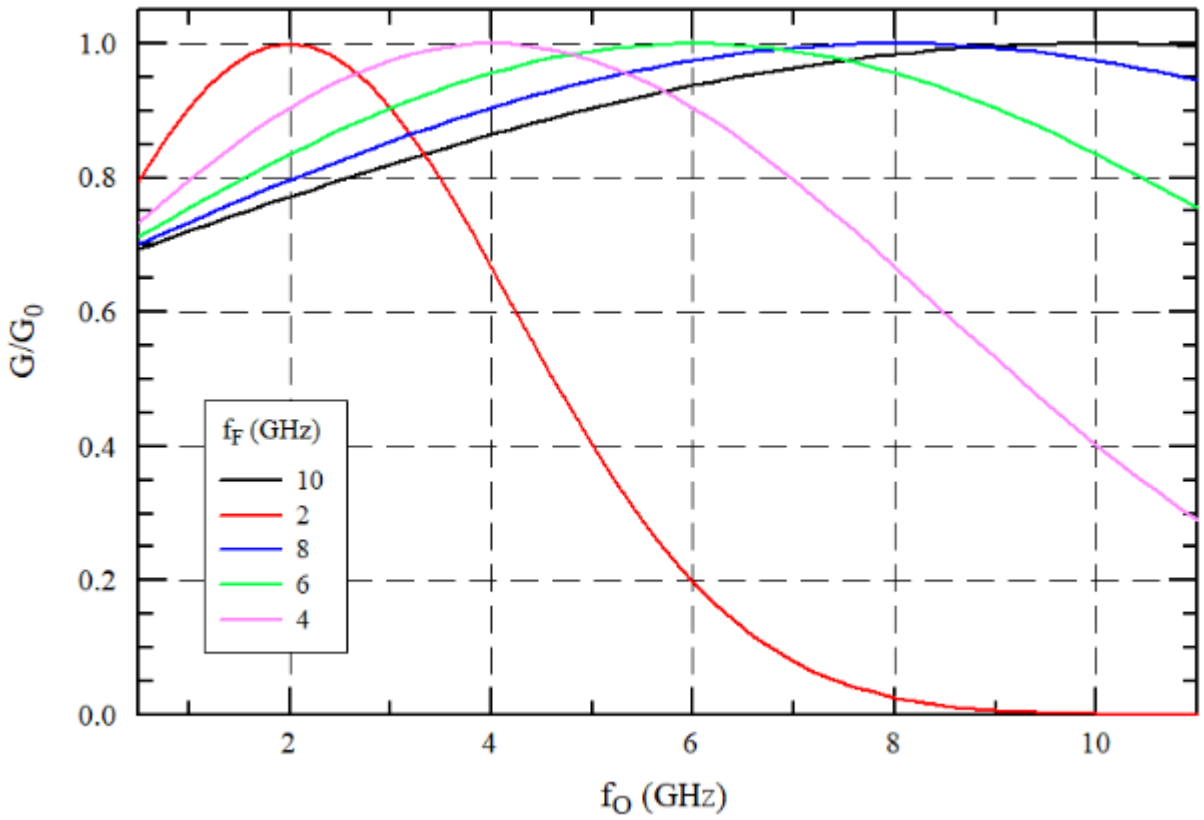
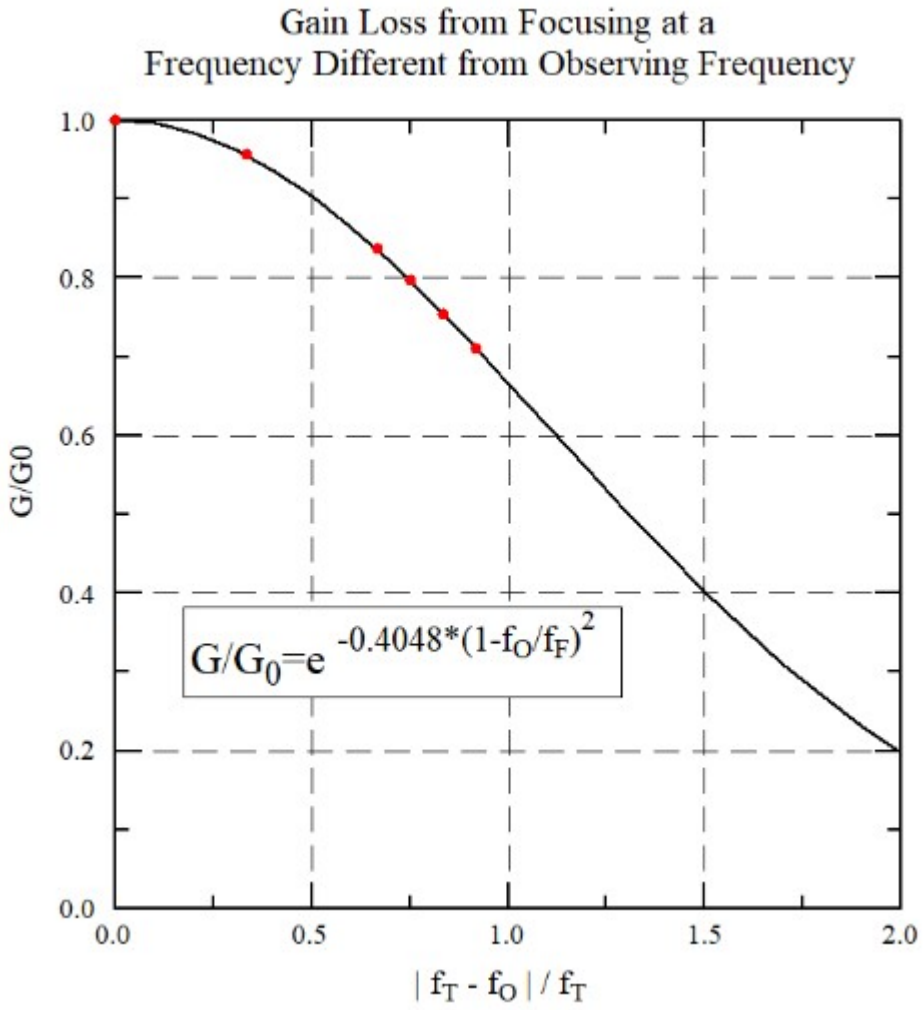
Here's a followup on today's discussion of Alex's measurements of observing at frequencies other then the one at which an ATA dish is using for its focus setting. The discussion spurred me to finish the analysis I started a few weeks ago.

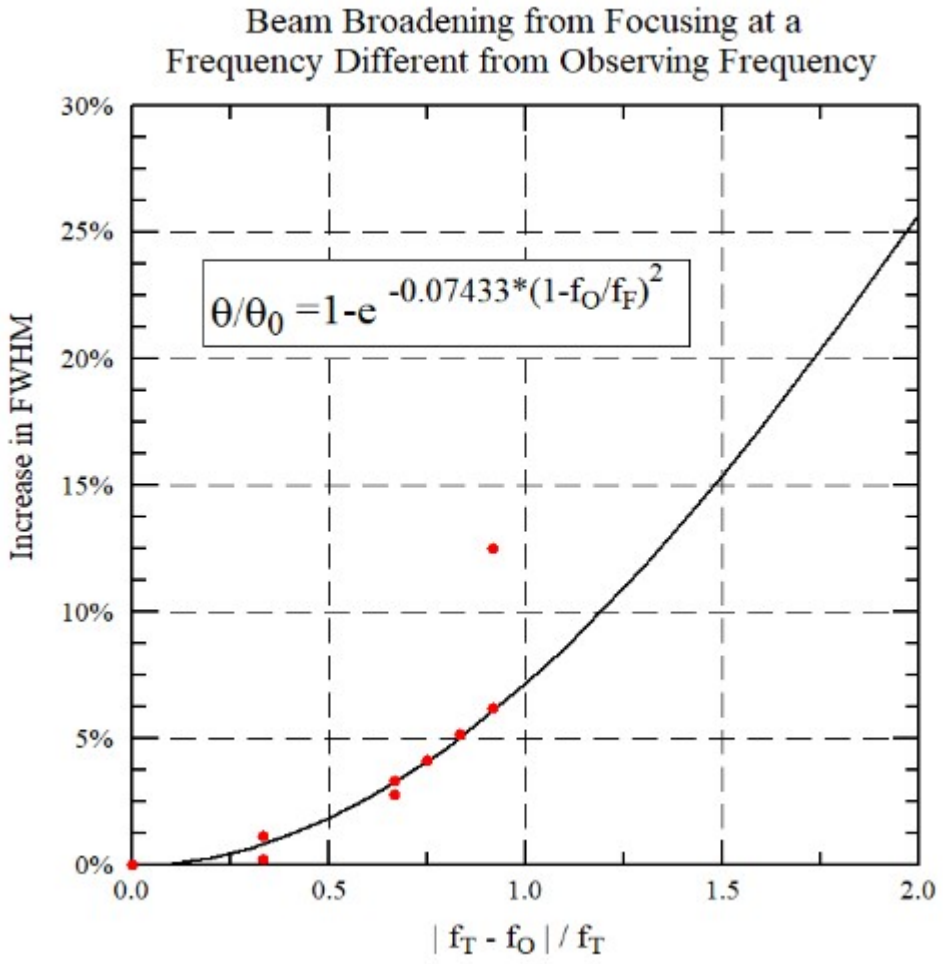
Jack Welch's ATA memo 78 (https://www.seti.org/sites/default/files/ATA-memo-series/memo78.pdf) considered the gain losses from setting the focus for 6 GHz but observing at other frequencies. The theory behind memo 78 is pretty rock solid when compared to actual observations. I've extended what Jack has done to the more generic case of setting the focus position that is appropriate for one frequency, f_F, while observing at any other frequency, f_O .

The first plot shows the theoretical loss in gain for a point source as a function of observing frequency, f_O, when the focus is set for f_F=2 GHz (which is the case for the data Alex showed tonight), and for 4, 6, 8, and 10 GHz. (Since the Moon is not a point source at the higher frequencies, the measured loss in gain for a Moon measurement at high frequencies won't be as drastic as in the plot.) This plot should help you decide what to use as a focus frequency when you start observing at multiple frequencies simultaneously.



The last two plots below are for any other case. These show the theoretical loss in gain and the increase in beam width as a function of abs(F_T-F_O)/F_T. The red dots are derived from the table in Jack's memo -- gain loss is column 6 / column 5 and the increase in FWHM is 1 - column 8 / column 7. (One mystery: according to theory and the mathematics, the value of FWHM(of) at 0.5 GHz in Jack's table should be ~7.5d, not the 7.99d in Jack's table. That odd entry in his table produces the discrepant point in the bottom plot).


Gain Loss from Focusing at a
Frequency Different from Observing Frequency
1.0
0.8
0.6
0.4
0.2
0.0
G/G0
0.0
0.5
1.0
1.5
2.0
| f_T - f_O | / f_T
G/G_0=e^-0.4048*(1-f_O/f_F)^2


Beam Broadening from Focusing at a
Frequency Different from Observing Frequency
30%
25%
20%
15%
10%
5%
0%
Increase in FWHM
θ/θ0 =1-e -0.07433*(1-fO/fF)2
0.0
0.5
1.0
1.5
2.0
| fT - fO | / fT