A 408 MHz Quagi Receiving Antenna for Radio Astronomy

By Hal Braschwitz and Jim Carroll

One tangible result of the 1996 conference of the Society of Amateur Radio Astronomers (SARA) was the organization of a program to produce a number of 408 MHz receivers of the design Jim Carroll has been developing for several years.

One purpose of this endeavor was to achieve a long time SARA goal of operating more than two observatories in concert.

This article presents an antenna design suitable for use with the SARA receiver. Jim Carroll demonstrated a prototype of this antenna at the 1990 SARA Conference. It was a version of an antenna Wayne Overbeck described in the April, 1977 issue of QST Magazine and was called a "Quagi Antenna."

A companion article by Chuck Forster covers the construction of the 408 Mhz Quagi.

The Quagi is a hybrid combination of loop and cylindrical elements in a Yagi array. It consists of loop reflector and a loop driven element along with a number of cylindrical director elements. The loop driven element was chosen as it presented fewer problems in matching and feeding a transmission line.

Jim Carroll scaled the Overbeck design from 432 MHz to 408 MHz. This antenna has functioned very well for Jim Carroll in his radio astronomy efforts.

Tom Crowley and Chuck Forster, present and immediate past SARA Presidents of SARA, asked us to look into the Overbeck design with current computer modeling programs to see if further improvements in the design could be made.

Figure 1 shows the antenna geometry.

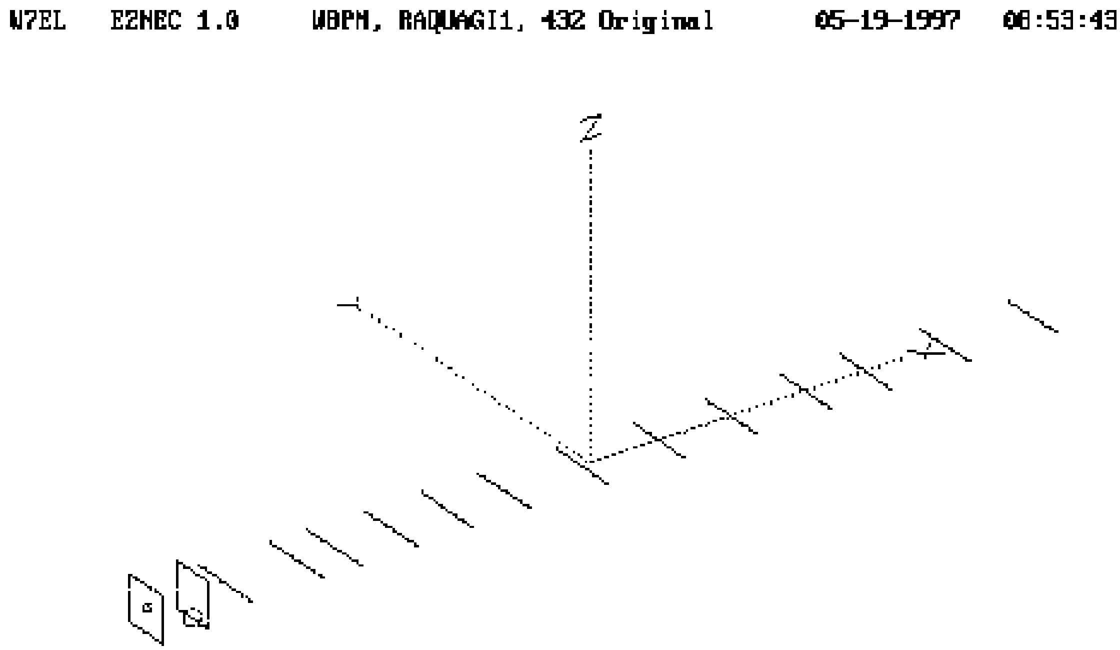

Figure 1 - View of antenna as shown by the analysis program.

Figures 2 and 3 show the free space elevation and azimuth patterns of the original 432 MHz Quagi antenna array. The driving point impedance at 432 MHz is 54.4 + J 10.18 ohms.

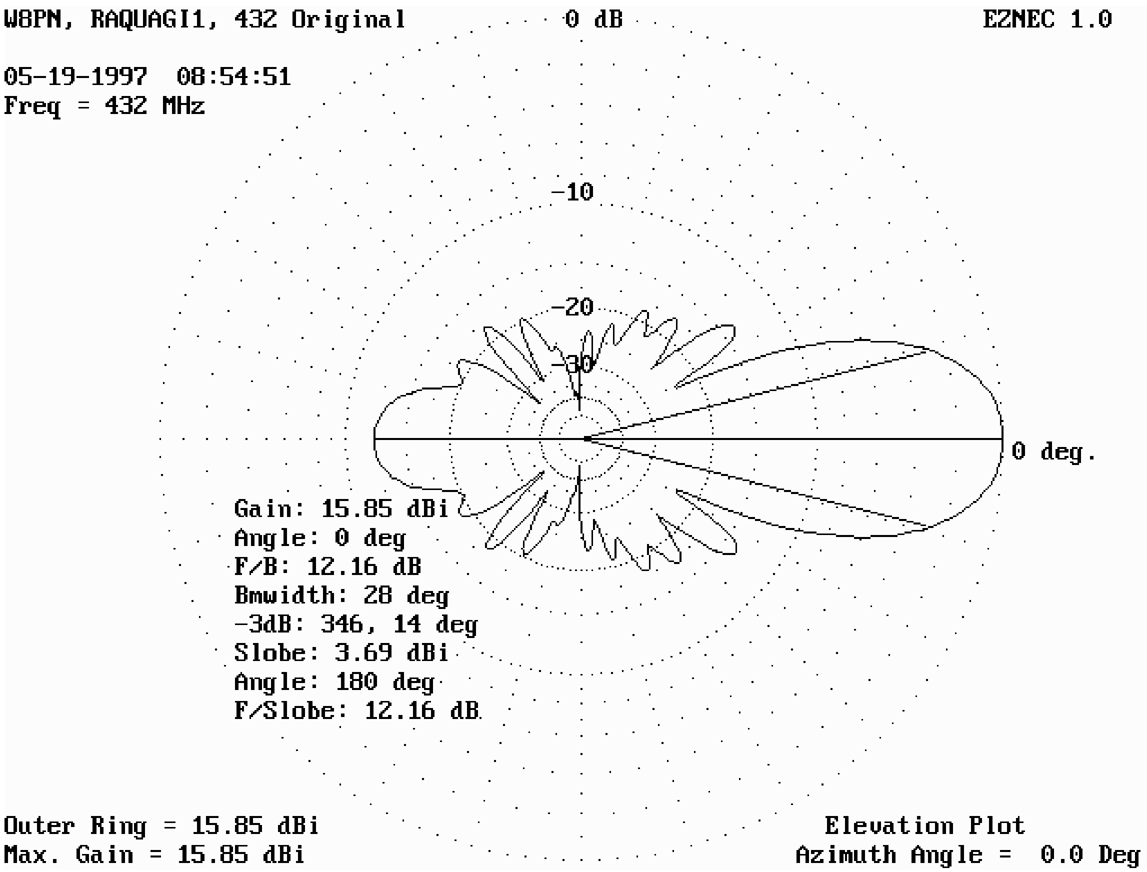

Figure 2 - An elevation pattern plot of the 432 Mhz design.

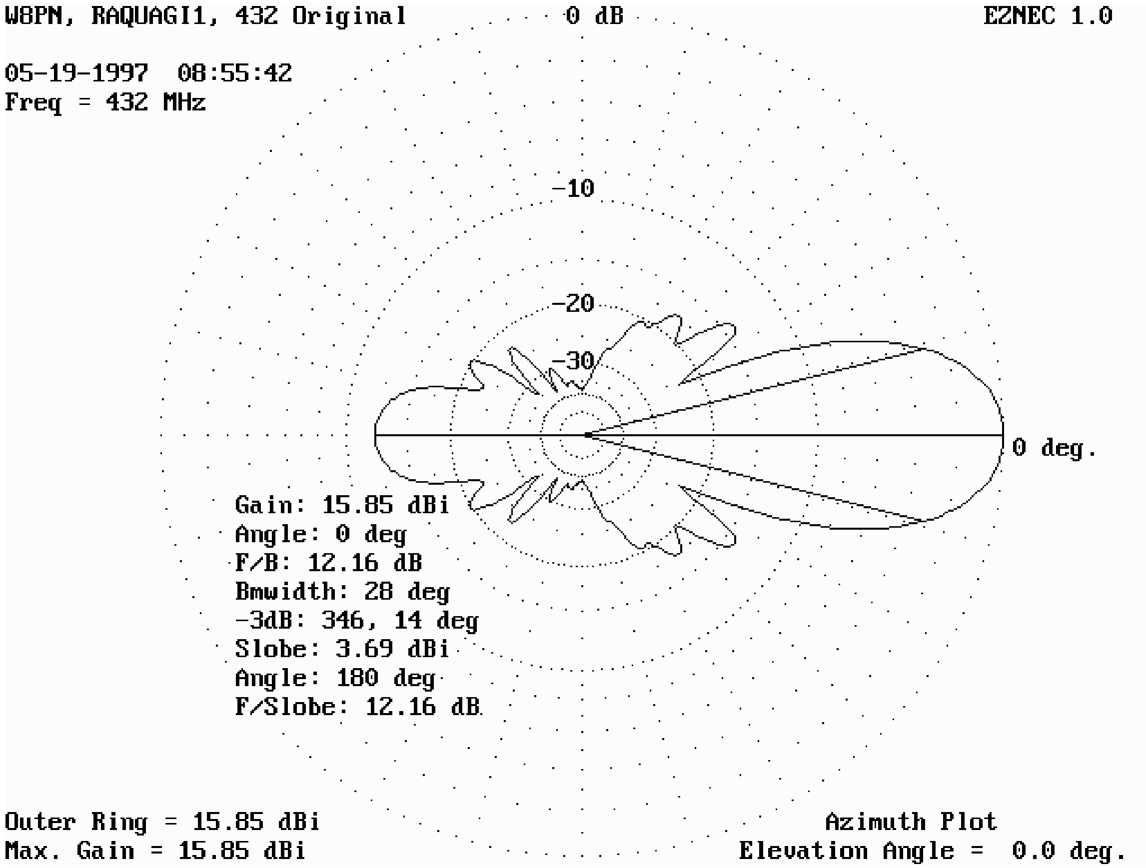

Figure 3 - An amimuth pattern plot of the 432 Mhz design.

This quagi antenna consists of a loop reflector and loop driven element along with 13 straight wire type director elements. The W7EL EZNEC computer program was used to model the antenna described in this article. EZNEC is a version of the NEC2 antenna modeling program.

The W7EL EZNEC computer program shows the 432 MHz array to have a free space gain of 15.85 dBi (decibels gain compared to an isotropic radiator). It has a horizontal and vertical beamwidth of 28 degrees and a front to back ratio of 12.16 dB along with a number of lesser side lobes. See figures 2 and 3 above.

The modified antenna array version shown below for our application exhibits about the same forward gain, improved front to back ratio and similar side-lobe patterns.

Mechanically, most of the director elements are of constant length rather than being of varying lengths and therefore yields simpler assembly. The free space elevation and azimuth patterns are shown in Figures 4 and 5.

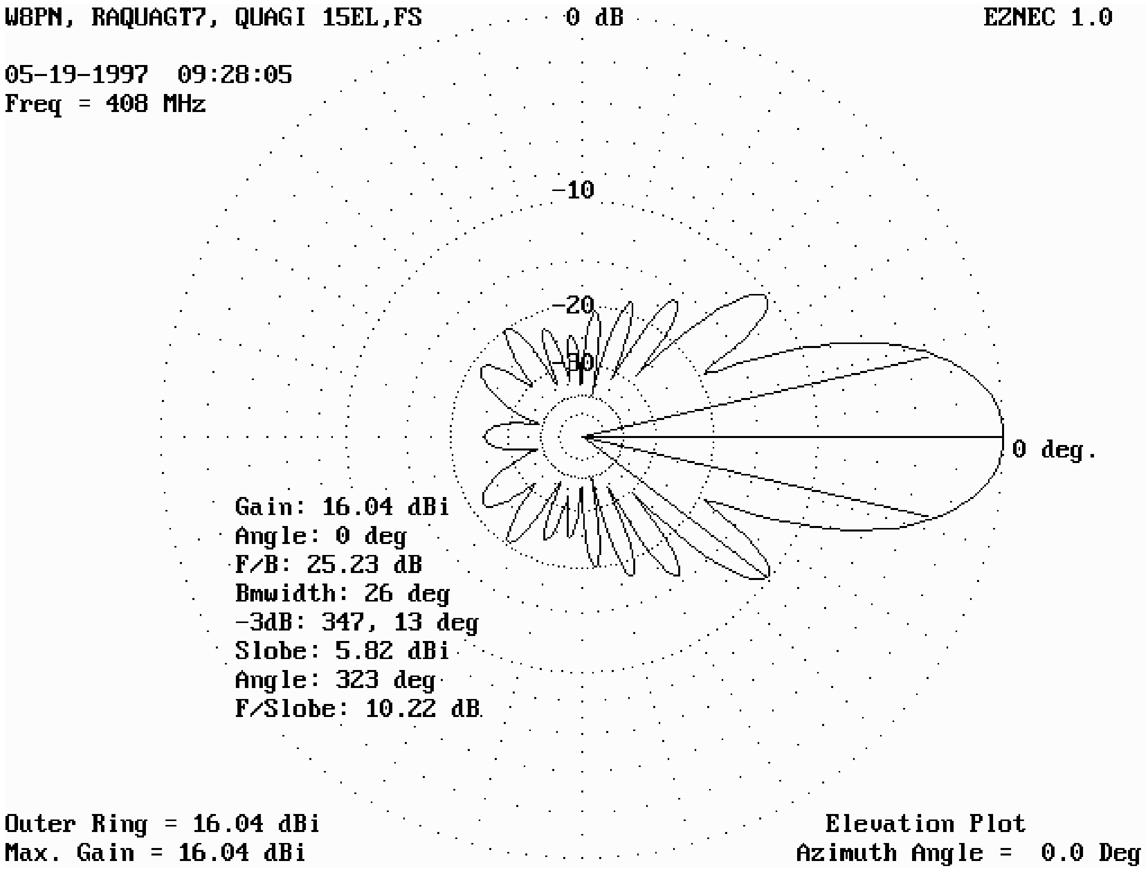

Figure 4 - An **amimuth** pattern plot of the 408 Mhz design.

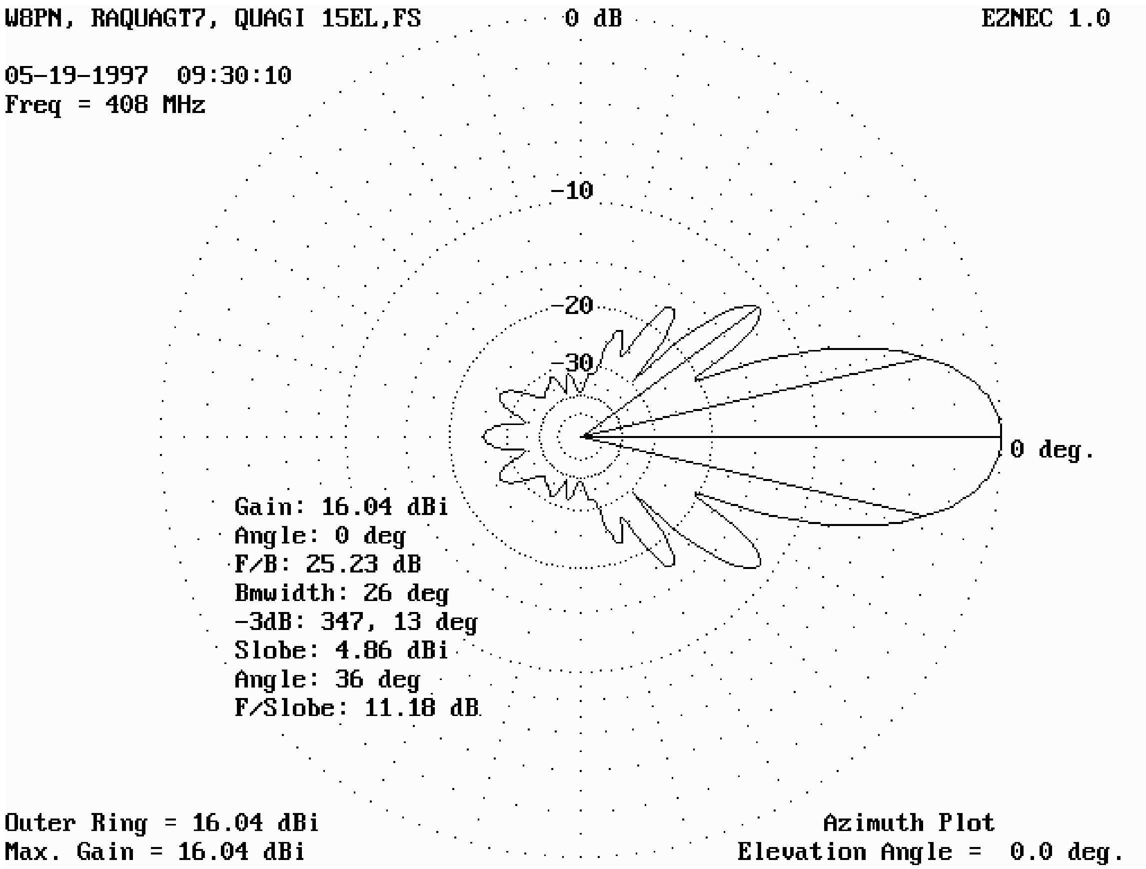

Figure 5 - An **elevation** pattern plot of the 408 Mhz design.

The driving point impedance at 408 MHz is 45.51 +j 3.36 ohms.

Next we modeled this version of the Quagi over average ground while pointed at the zenith. The lowest element, the loop reflector was located at a height of 61.5 inches above ground. Patterns for this arrangement are shown in Figures 6 and 7.

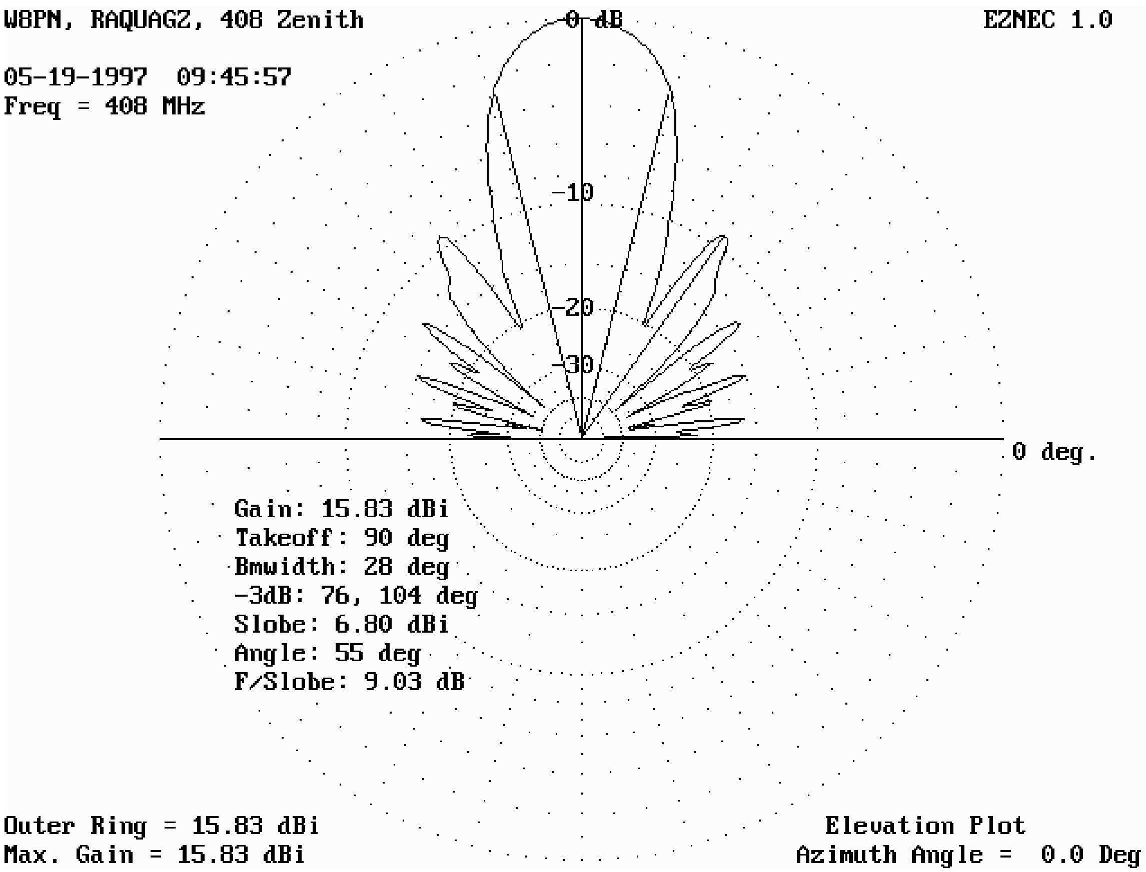

Figure 6 - An elevation pattern plot of the **408 Mhz** design **when aimed straight up!**

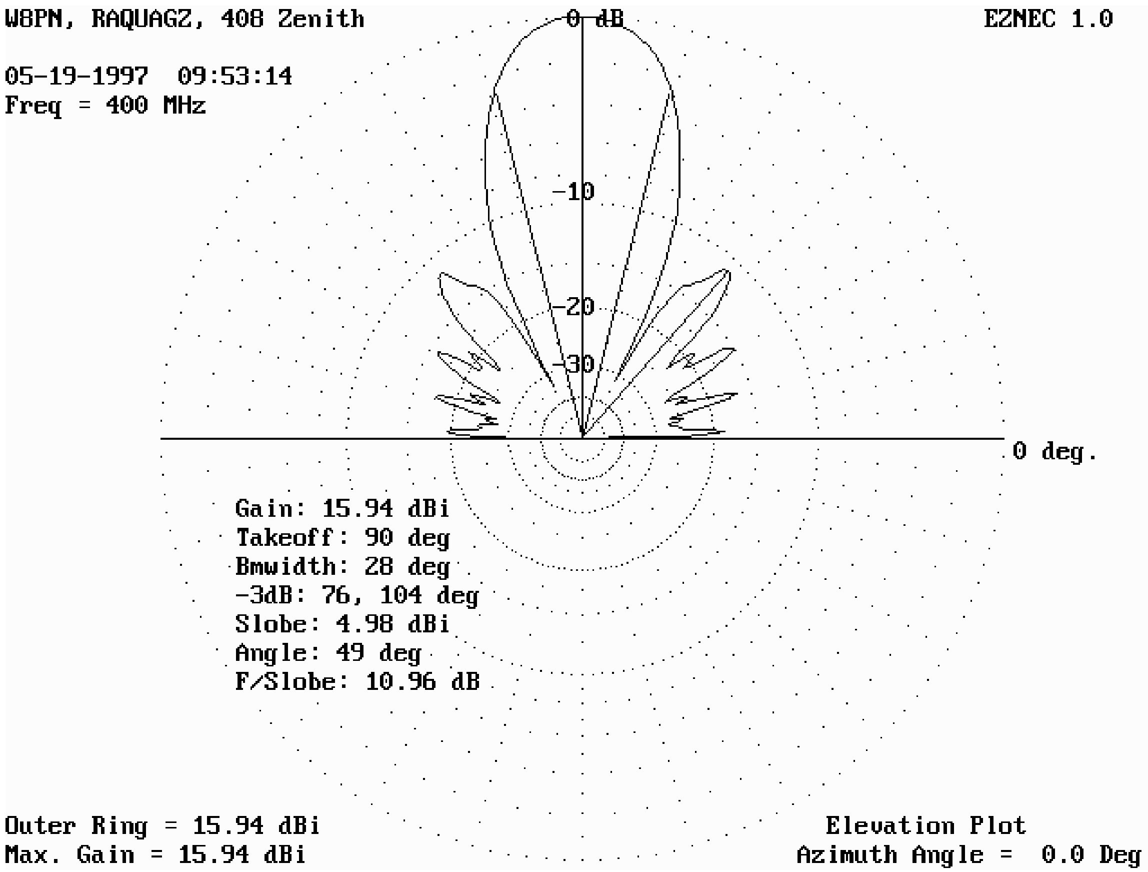

Figure 7 - An elevation pattern plot of the antenna at **400 Mhz when aimed straight up!**

The antenna driving point impedance is almost the same as that shown for the free space model.

Next this antenna was modeled at increasing angles from the zenith, up to 90 degrees, and the patterns were evaluated. The main pencil like beam was observed for angles up to 60 degrees from the zenith or up to 30 degrees from the horizontal. At angles of more than 60 degrees from the zenith the main antenna pattern beam starts deteriorating and is probably unusable for radio astronomy work.

The input impedance at 400 MHz is 64.15 - j 31.96 ohms. The input VSWR in a 50 ohm system is 1.836. Further, the input impedance at 410 MHz is 39.12 +j 21.48 ohms with a corresponding VSWR of 1.712.

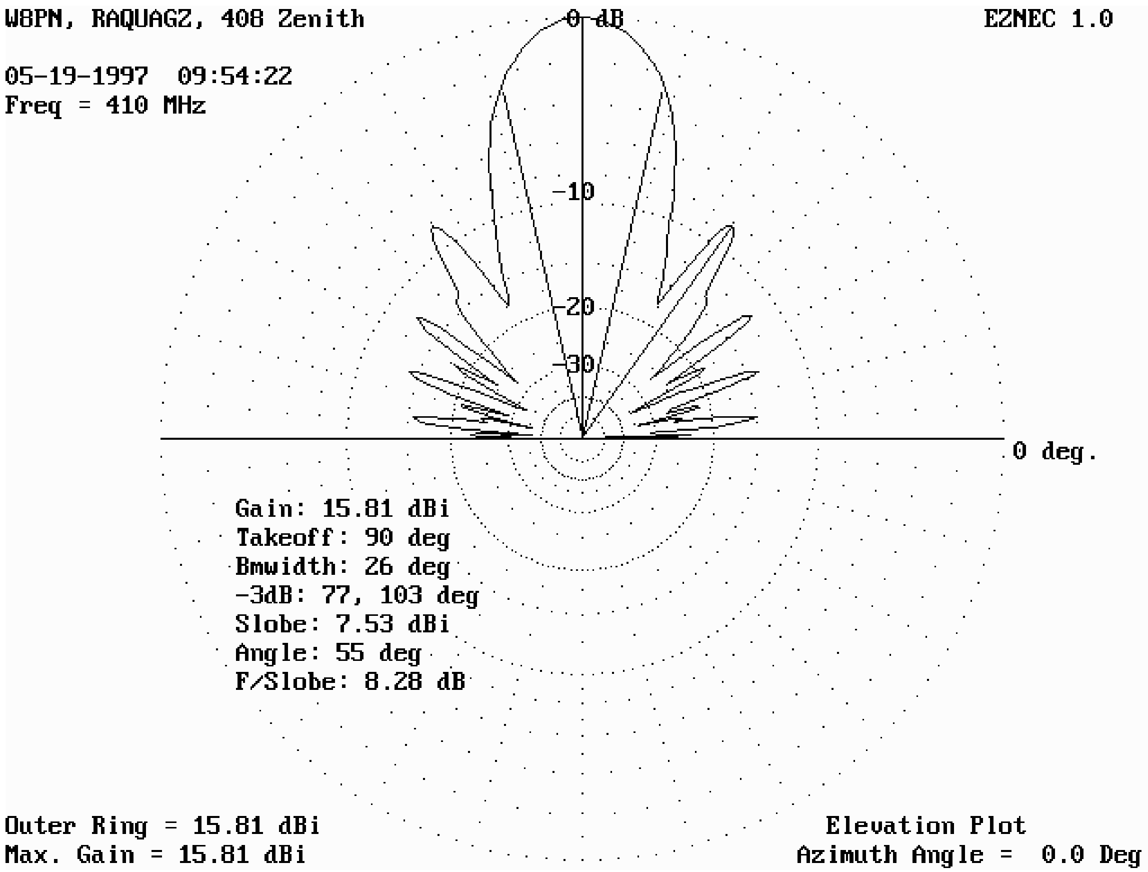

Figure 8 - An elevation pattern plot of the antenna at **410 Mhz when aimed straight up!**

We have also modeled designs with larger diameter elements for increased bandwidth and have studied stacking the basic array both horizontally and vertically for decreased beam widths and increased gain. These results will be presented in subsequent articles.

Hal Braschwitz

Editors note: I would like to thank Hal and Jim for the fine job of developing a simple antenna for our members. I evaluated all design data by using the EZNEC program and believe the design to be quite accurate. Jim Carroll has produced working units that have been used successfully with the SARA 408 MHz receiver. I have prepared a construction article to show you how to construct the antenna.

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