Inexpensive Lightweight High-Performance Small Yagi Antennas for VHF-UHF Portable Operation

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But why? We already have:

"Inexpensive Lightweight Small Yagi Antennas for VHF-UHF Portable Operation," by Kent Brittain, WA5VJB

Kent has never claimed these were anything but cheap and easy to build. They are very popular, and have made scores of contest points for a generation of VHF-UHF operators.

They have two problems, one **serious**:

> The gain and pattern are not as good as one can obtain from the same elements and boom length
>
> **The hairpin half-folded dipole feed couples antenna currents onto the feedline**

Why are antenna currents on the feedline a serious problem?

A hot feedline means the transmission line, you, and your radio are all parts of the antenna. Feedline routing will change the pattern, gain may be low, the pattern will be ugly, reflected power is squirrely and a function of where you stand, RF in the shack and your neighbor’s stereo...

The hairpin driven element was tried and published in the 1960s, see for example page 293 of “Understanding Amateur Radio,” by George Grammer, ARRL, 1963.

...it seems to work OK, until you compare it with anything else. It was abandoned, and used as a “bad example” for classes taught by professor Donald K. Reynolds K7DBA, late 1970s.

Kent reinvented it later, after D. K. Reynolds passed away.

So we will use a different feed, something symmetrical

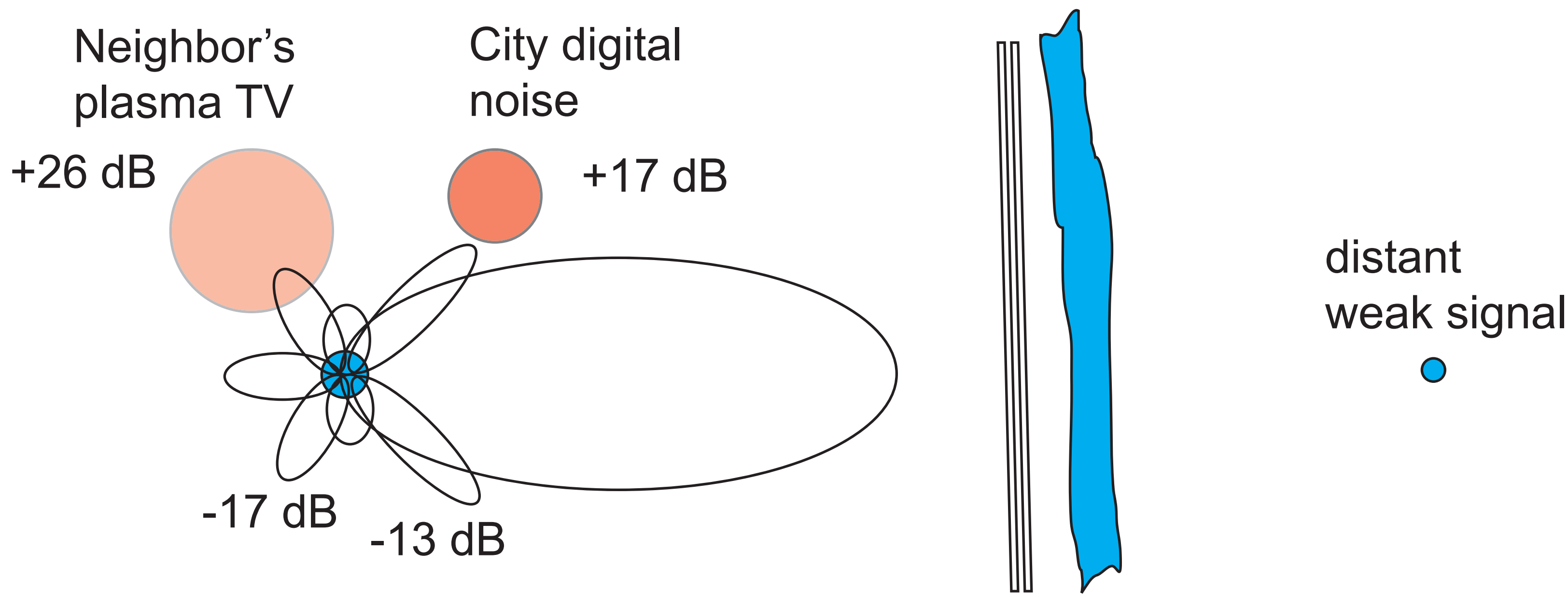
Several good choices, but with EZNEC, the folded dipole feed is increasingly attractive. We use the software to design for 50 ohm match at the folded dipole.

Next: design for optimum use of boom length, elements, size, weight and cost.

In ancient, quiet times, the only antenna parameter was gain. Now that “digital devices per cubic meter” is a thing, we find that it is often more important to not hear in some directions than to design for maximum gain.

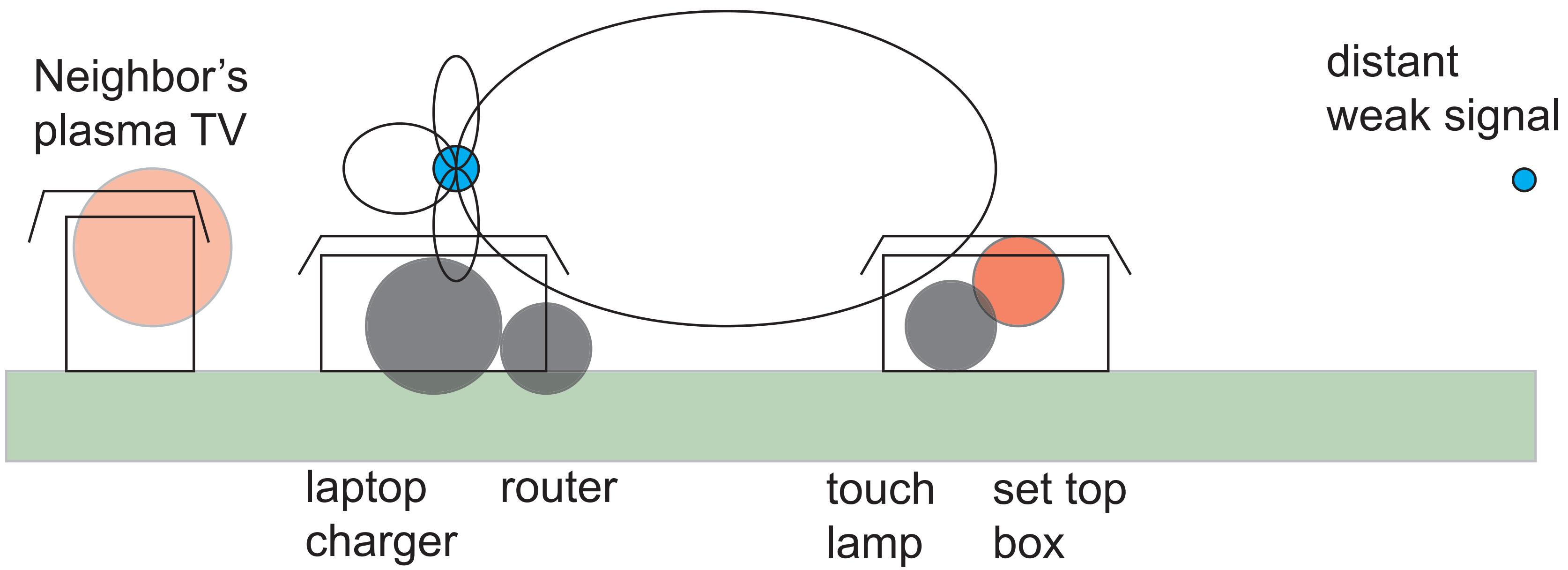
Modern design tools allow us to design for gain, clean patterns, and match. EZNEC5+ was used for these designs.

Why Clean Pattern in horizontal E plane?



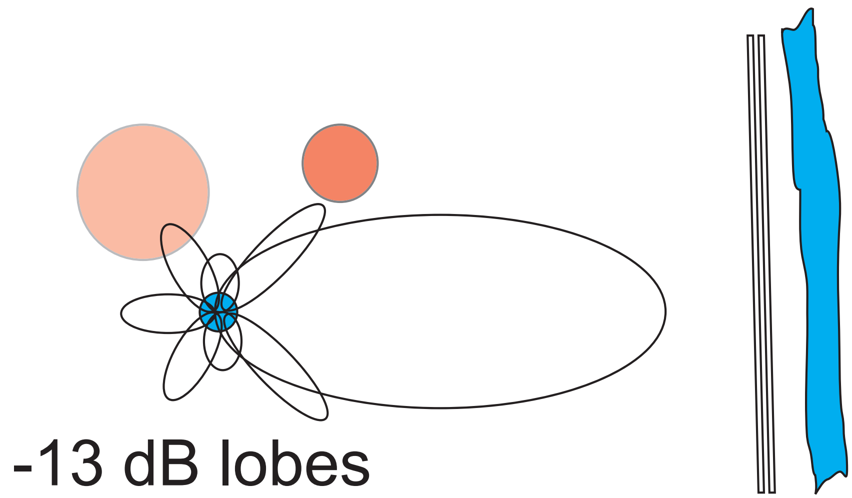
Adding up all the noise contributions in your sidelobes, your noise floor has increased by 13 dB. Easy experiment: disconnect your 2m antenna and listen.

Why Clean Pattern in vertical H plane?

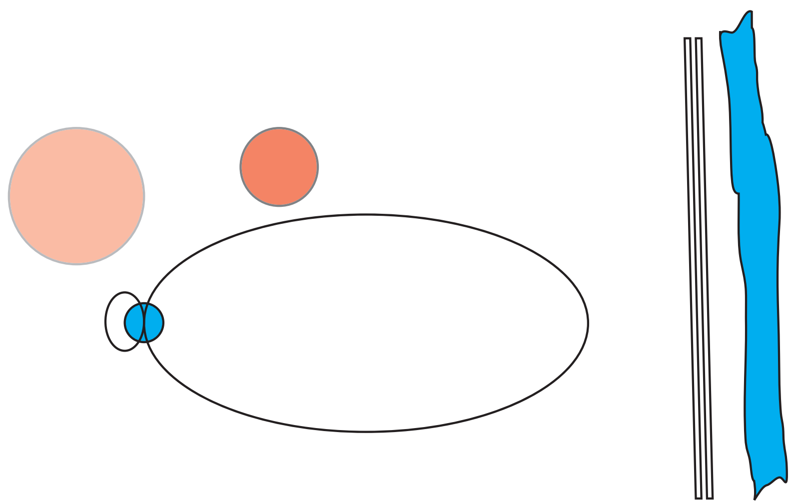


The worst offenders are often in your own home. Clean vertical pattern may reduce your noise floor by >10 dB.

Some Experiments: how much forward gain do we sacrifice for really clean E and H patterns?



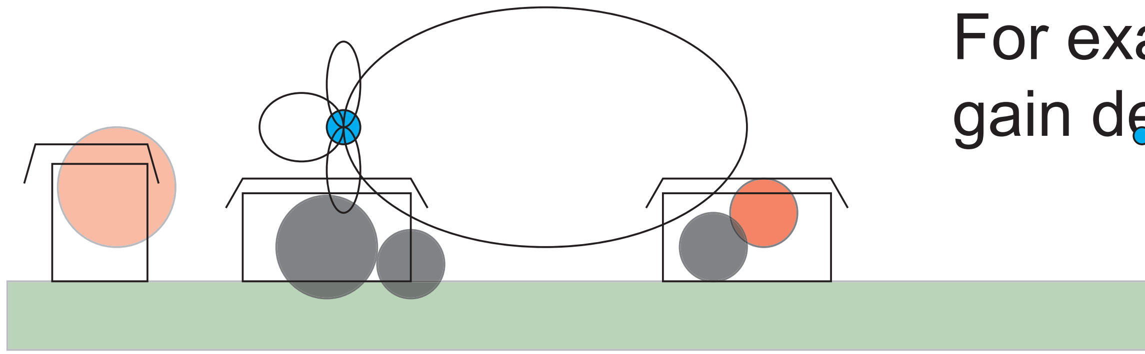
For example, maximum gain design 12.1 dBi



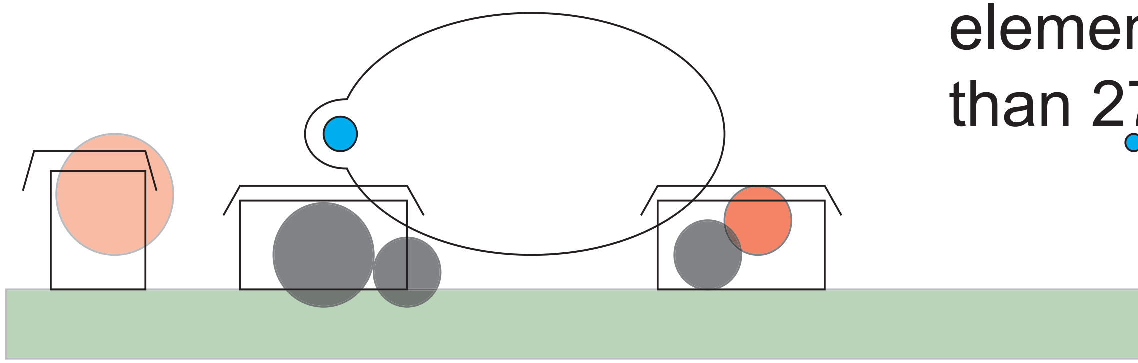
Same boom and number of elements, all lobes more than 21 dB down, 11.6 dBi

About half dB

Some Experiments: how much forward gain do we have to sacrifice for really clean E and H patterns?



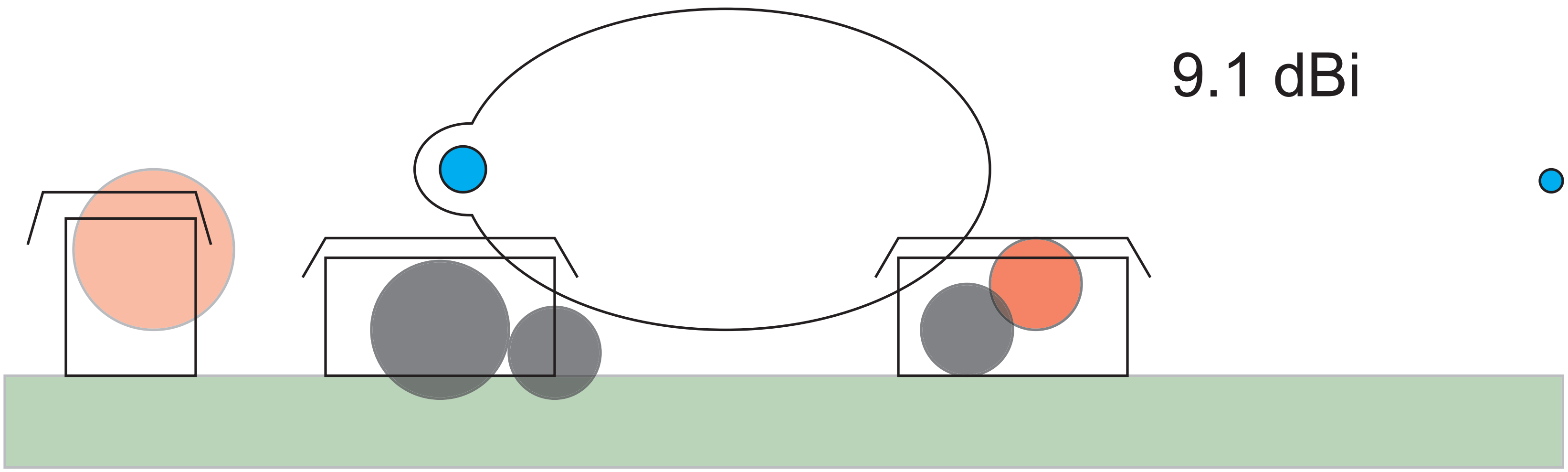
For example, maximum gain design 9.7 dBi

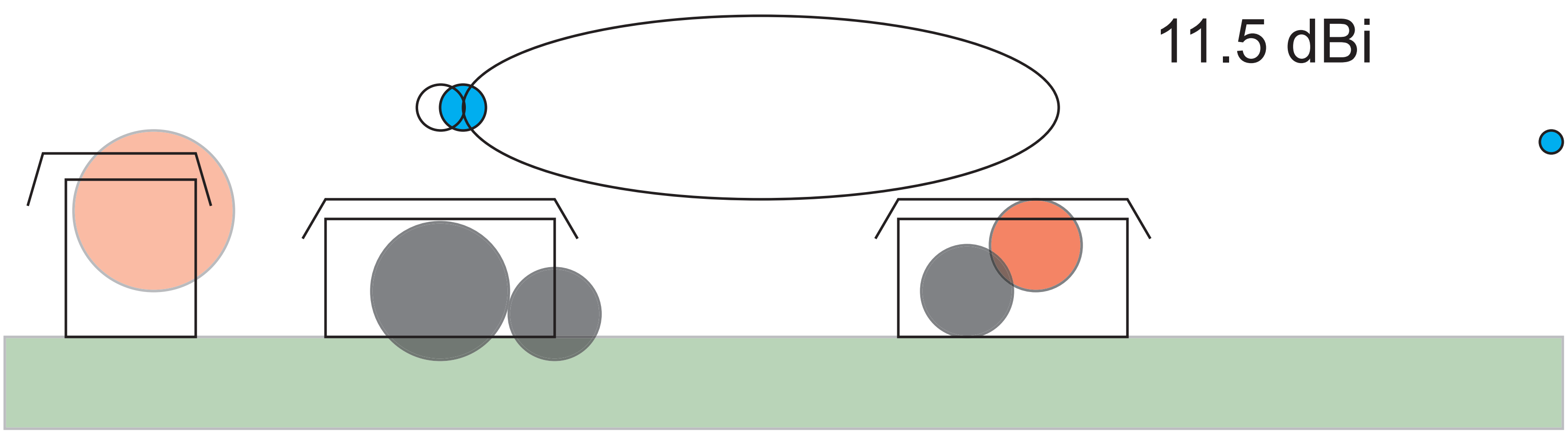


Same boom and number of elements, one lobe, more than 27 dB down, 9.1 dBi

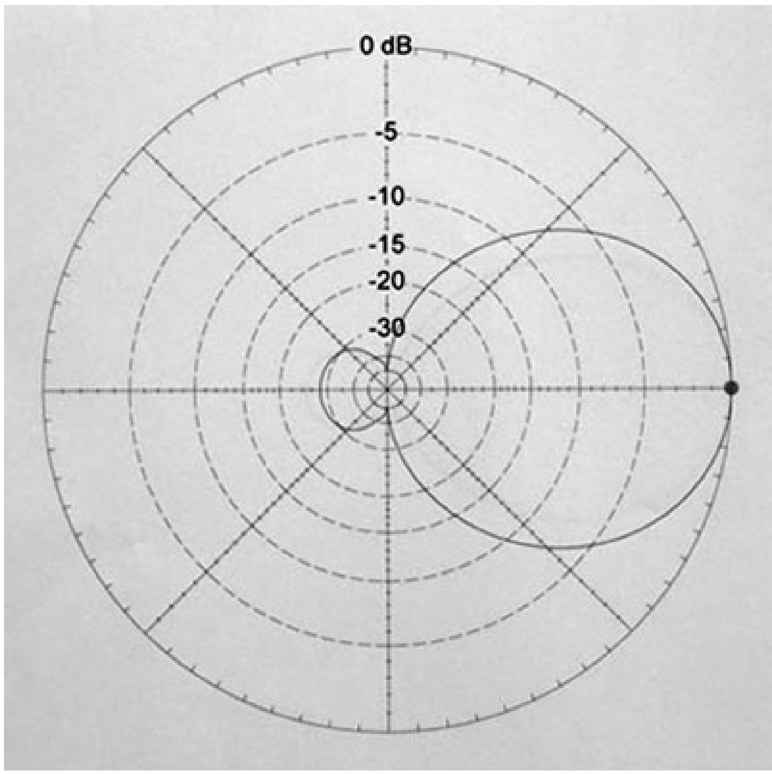
About half dB

Clean little yagis make ideal elements for arrays. If you want more gain and an even cleaner vertical pattern, stack two:

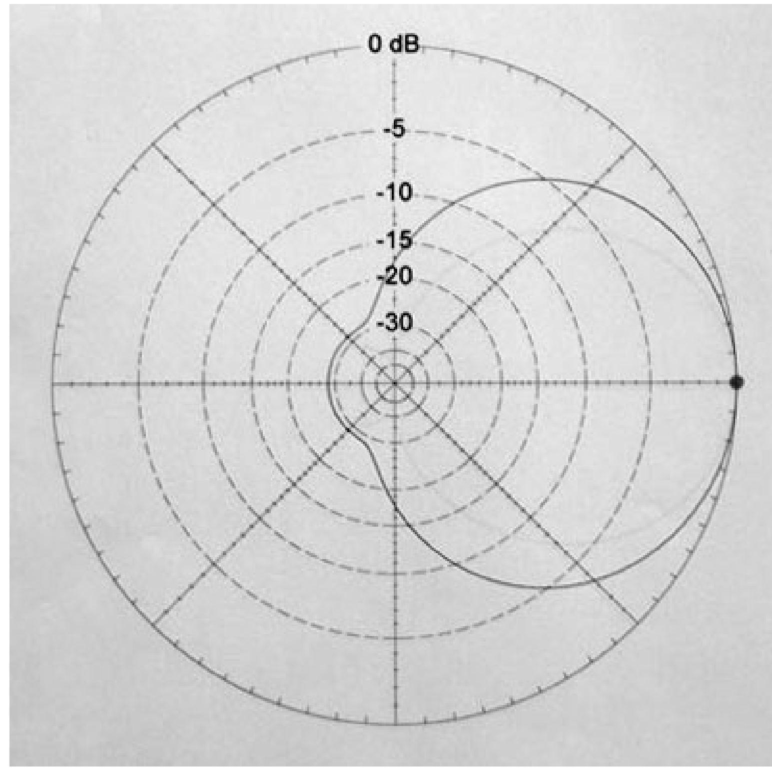




Enough background. Some actual designs. “Square Yagi” for 144.2 and 222.1 MHz. 4 elements on a boom the same length as the reflector (hence “square”). 9.1 dBi gain.



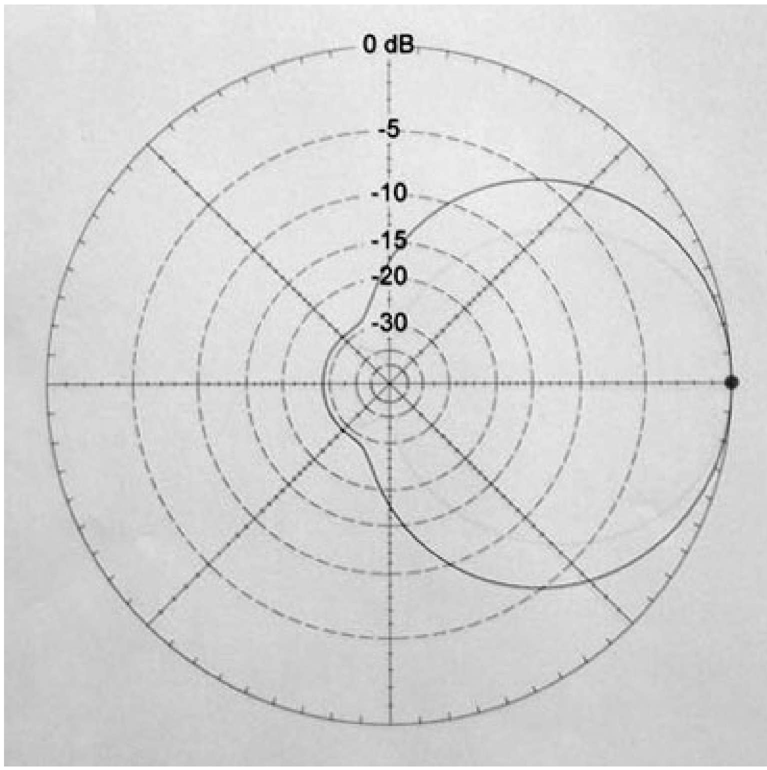
Horizontal E Plane 9.1 dBi
28.1 dB back lobe



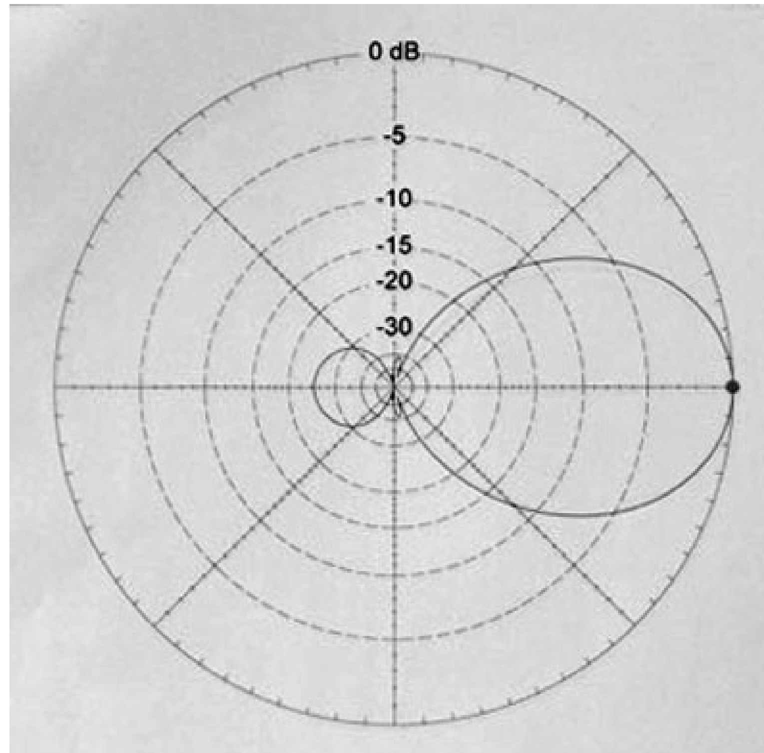
Vertical H Plane 9.1 dBi
28.1 dB back lobe

Interesting...these patterns look like an audio engineer’s dream microphone

Stacking a pair of clean, small yagi antennas for more gain and cleaner vertical pattern. Simulation at 222.1 MHz.

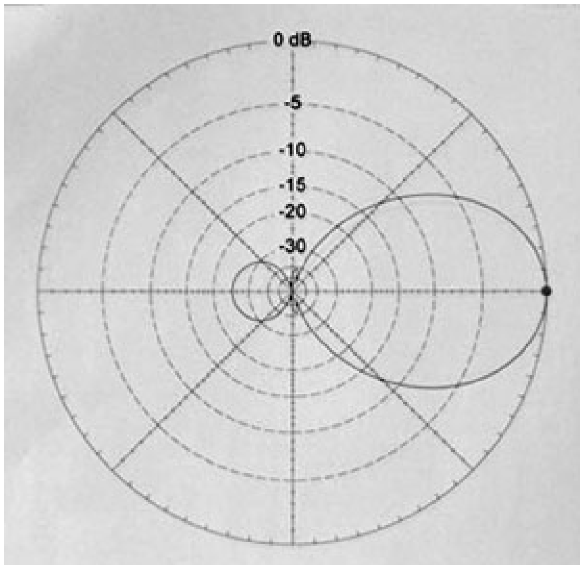


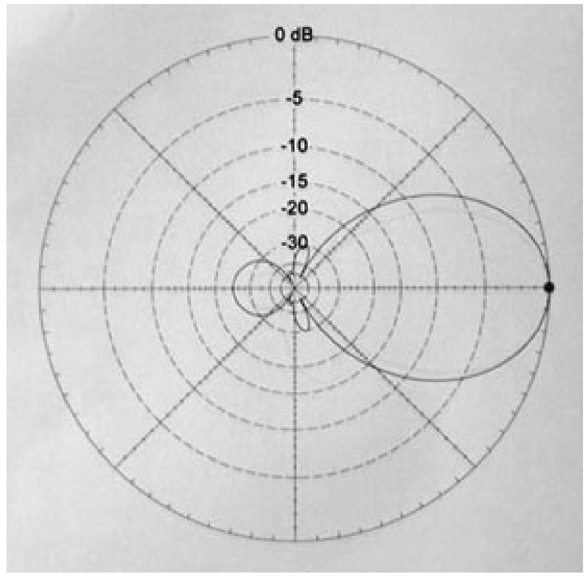
Single yagi H plane
28.1 dB back lobe
9.1 dBi gain

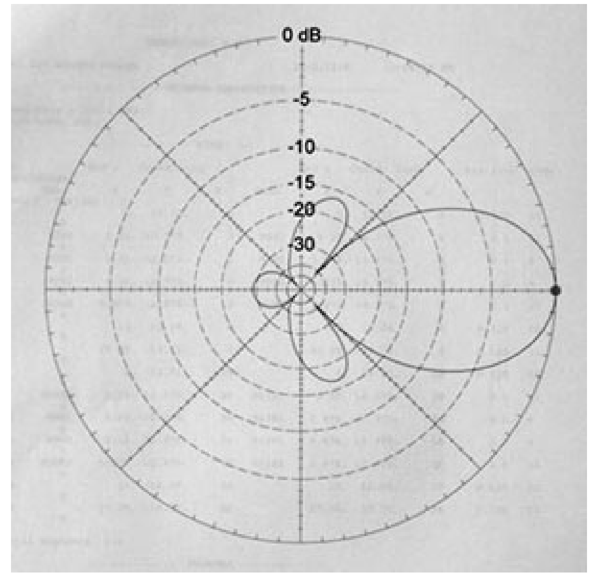


28” vertical stack pair
24.7 dB back lobe
11.5 dBi gain

Stacking distance affects gain and sidelobes. Simulation at 222.1 MHz. Boom length is 28"







Stacking distance 28"

Gain 11.53 dBi
Back lobe 24.69 dB

sidelobes > 40 dB down

Stacking distance 30"

Gain 11.69 dBi
Back lobe 24.36 dB

sidelobes 30 dB down

Stacking distance 36"

Gain 12.1 dBi
Back lobe 28.69 dB

sidelobes 16.42 dB

again, about a half dB from super clean to maximum gain

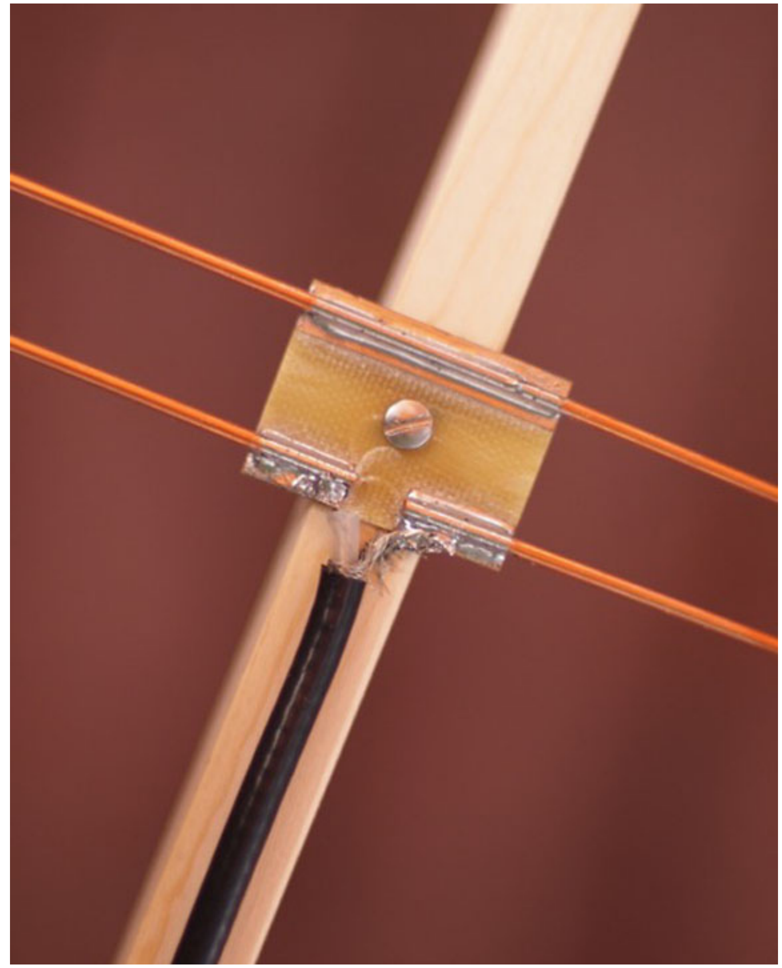
222.1 and 144.2 MHz 4 element Square Yagi dimensions

		Reflector	Driven Element	First Director	Second Director
222.1 MHz	Distance Along Boom	0.000″	5.250″ 5.875″	13.000″	27.250″
	Length	26.625″	24.875″	24.5625″	21.500″
144.2 MHz	Distance Along Boom	0.000″	8.000″ 9.000″	20.000″	42.000″
	Length	41.000″	38.750″	38.125″	33.50″

Reflector and directors 0.125” diameter 6061 Aluminum rod from MSC Direct. Folded Dipole driven elements #14 bare house wire. 0.625” spacing on 222 folded dipole, 1.000” spacing on 144 folded dipole, round ends. Reflector and director lengths are to nearest 1/64” inch, taken from EZNEC simulations. Folded dipole lengths measured from built antennas after trimming for minimum reflected power at calling frequency.

222 MHz square yagi, 4 elements on 28” boom

Square Yagi for 222.1 MHz
4 elements on 3/4” x 5/8” wood
boom. 9.1 dBi gain, clean pattern



Detail of folded dipole feed. No
balun, symmetry and low EH
fields behind antenna keep
antenna currents off feedline.

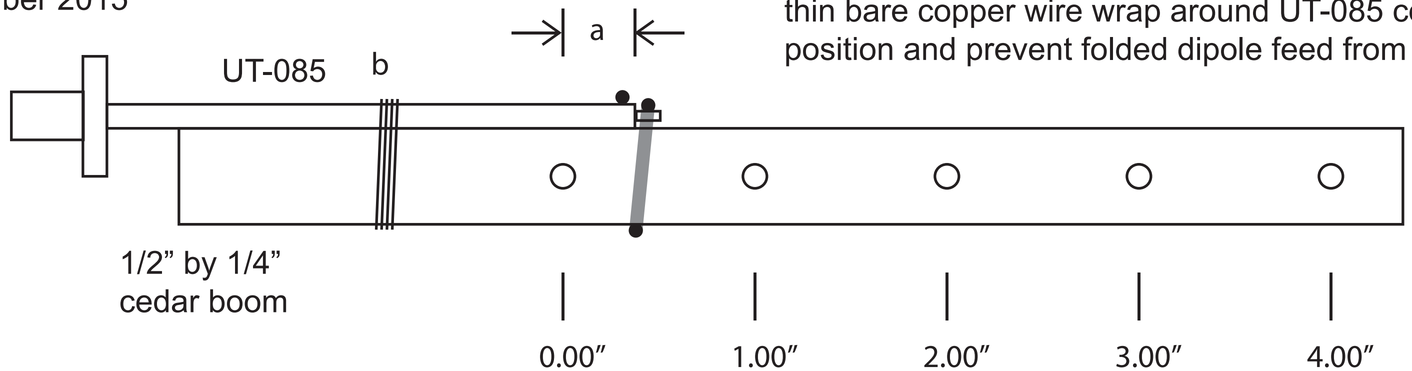
144 MHz yagi feed, showing ferrite sleeve balun

The balun presents a balanced 50 ohm feed to the folded dipole. It is optional but good practice, and there is no evidence of any antenna current on the outside of the feedline in this antenna. A clean pattern and cold feedline mean that all the transmit power is radiated off into space in the desired direction. Note how the folded dipole was cut, lengthened, and resoldered to the center support to trim.

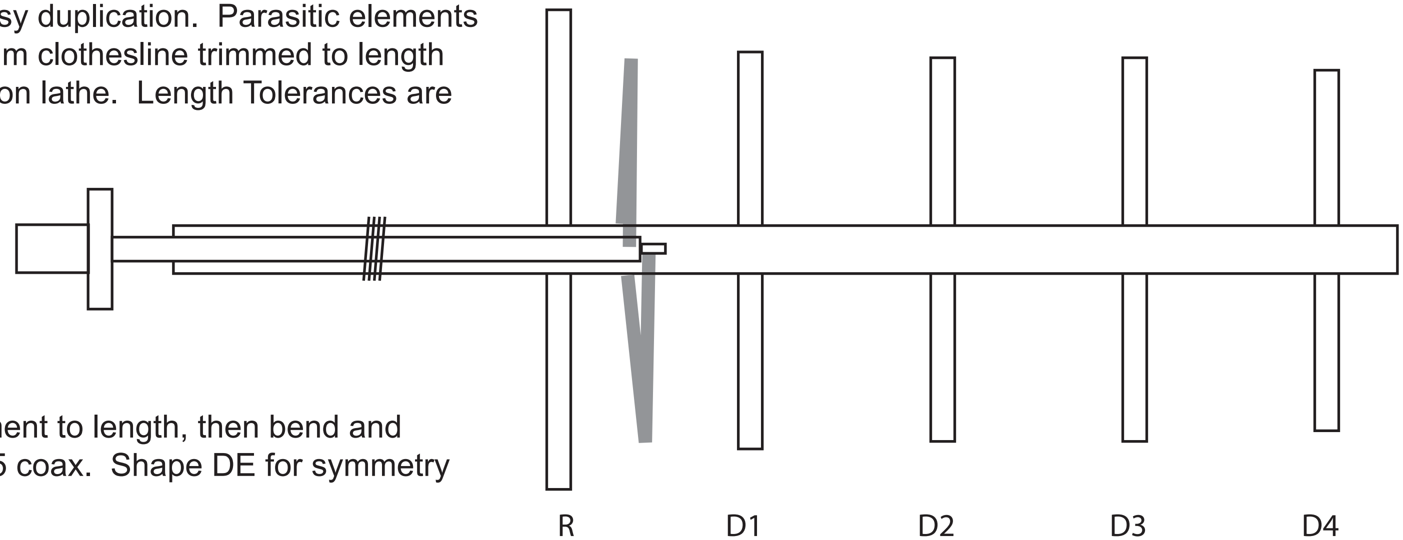
They work on 1296...and are cute.

2304 Christmas Yagi
KK7B 25 December 2015

adjust a after construction for 20 dB return loss, then solder thin bare copper wire wrap around UT-085 coax at b to hold position and prevent folded dipole feed from rotating.

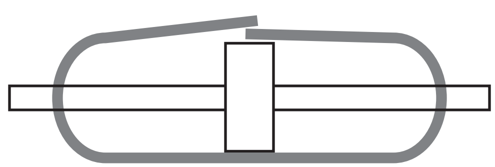


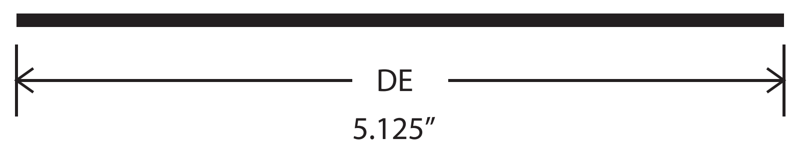
Dimensions from basic antenna theory after design study of similar antennas using EZNEC. Designed for easy duplication. Parasitic elements are 1/8” aluminum clothesline trimmed to length and finished off on lathe. Length Tolerances are roughly 10 mils.



Cut Driven Element to length, then bend and solder to UT-085 coax. Shape DE for symmetry and fit.

R	D1	D2	D3	D4	
2.679”	2.147”	2.022”	2.007”	1.873”	measured lengths





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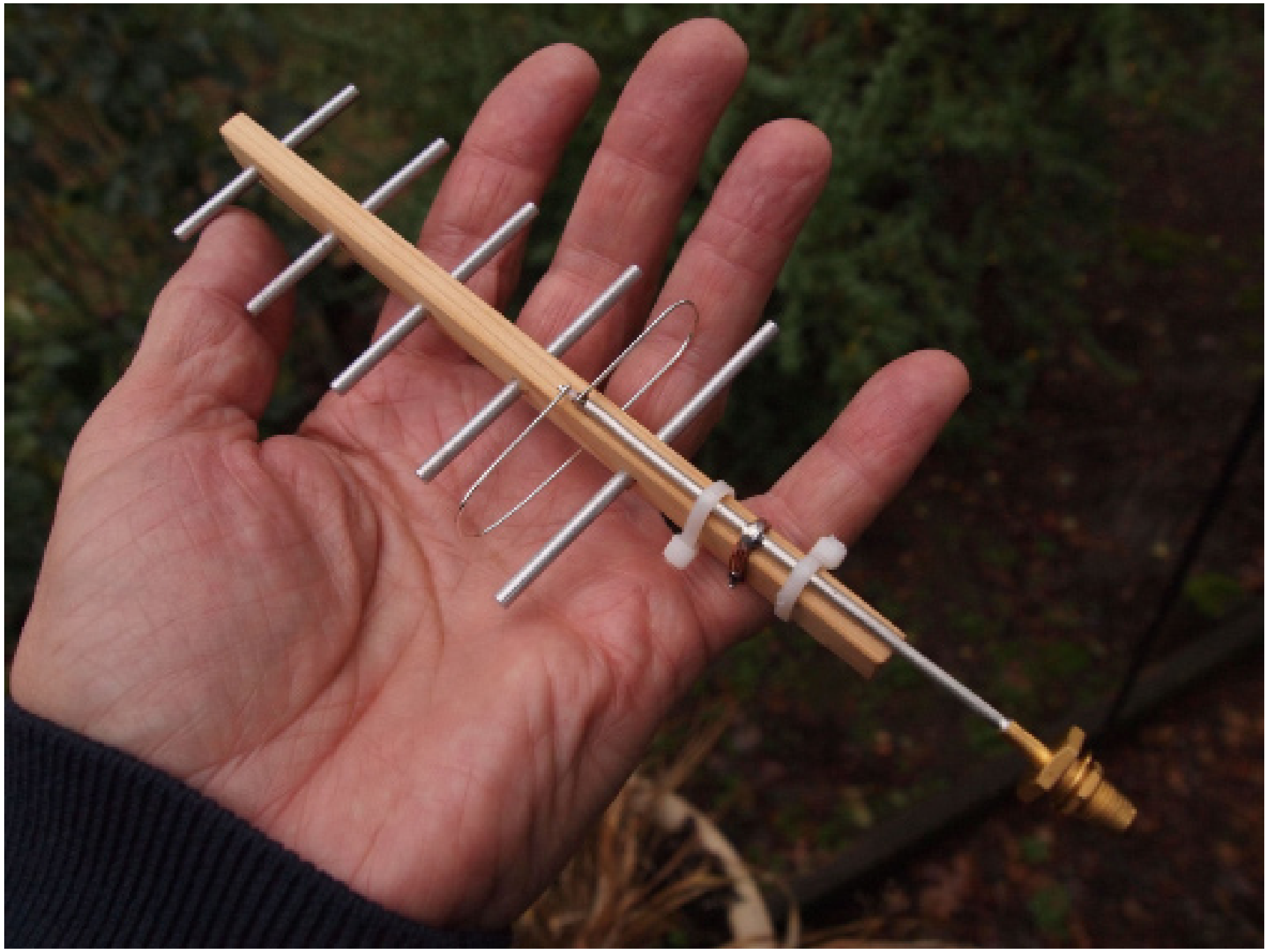

EZNEC simulations after construction indicate 10.7 dBi gain, all E plane sidelobes -20 dB, H plane sidelobes at + and - 90 degrees -12.3 dB. E plane beamwidth 52 H plane beamwidth 65 . Backlobe increases with reduced a and greater DE width.

Thank you, more to come.

Thanks to Kent Brittain, WA5VJB for publishing a family of cheap, simple yagi antennas we have all used.

Thanks to Roy Lewallen for EZNEC, the tool I use to design antennas with clean patterns.

Thanks to everyone I've worked on the air since 1979 with experimental yagi antennas of my own design.

Thanks to the late Donald K Reynolds, my friend and antenna professor at UW.

Thanks to my dad, for teaching me by example, to build things than had never been built before, with the materials at hand.