A Homebrew Yagi for 1296 MHz DX

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Many 23cm yagis from well known manufacturers are on the market. Anyway DXers want to know everything intimately. The author who works successfully via EME on this band wants to describe his own yagi design and give some of hints for the construction.
At the beginning there was the idea to enlarge the active surface of my 1296 MHz antenna. For this purpose the long lasting single Yagi should be substituted by a group of four yagis. In order to obtain real data for the gain I purchased yagis from different manufacturers and measured them several times under dry and wet conditions in free space and under conditions of little reflection. Table 1 shows the results.

Manufacturer Hersteller	model Typ	elements Elemente	length [m] Länge ca.	gain, dry [dBd] Gewinn, trocken	gain, wet [dBd] Gewinn, nass
M2	23CM35EZ	35	3	16,8	14,1
Tonna	20635	35	3	17,7	17,4
DJ9BV [1]	13WL	37	3	17,6	17,8
FlexaYagi	2317	48	4	17,8	15,4
SHF Design	2344	44	3	18,0	17,8
DJ9YW	4 m / 4 mm	47	4	18,7	18,6
DJ9YW	4 m / 3,2 mm	47	4	18,9	18,8
DJ9YW	5 m / 4 mm	59	5	19,7	19,6

Table/Tabelle 1: Far field measurements at 1296 MHz - Fernfeldvergleichsmessungen bei 1296 MHz

Interesting gain results

The cheap Tonna yagi worked unexpectedly well, but due to the lack of a balun there is no clean matching and for my purposes the antenna was to heavy. The mounting of the elements is electrically well solved. The solution from the Flexa yagi could not be really understood due to the labile contact of different kinds of metal. Due to the steel elements und their by comparison small diameter this antenna would need to be 1m longer to be equal with the others. Wetness caused a strong gain drop. The M2 was completely off-beat. I guess that despite the claim of 1296 MHz as operating frequency the real strength may be in the lower part of the 23cm band. The antenna from SHF Design (now WiMo) showed good gain but had quite a wind load due to the large reflector. Also critical is the lock of the elements. If the screws are not firmly tightened this could cause a loss in gain. The latter was probably solved best by the firm wrapping of the elements as done in the quite similar DUBUS yagi design from DL6WU/DJ9BV [1].

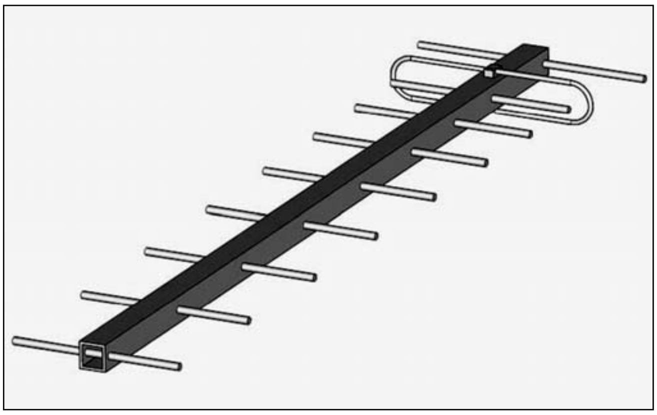

Fig. 1: Schema 10 element Yagi

Fig. 2: Parts for the dipole; bottom: a piece of UT141-CU for the balun

Months of work

As none of the versions satisfied me I could not find a fast solution and started my own design by building countless prototypes and making gain measurements in free space. At that time I had no antenna simulation software available. Unfortunately I did not know in advance how much time I had to spent for the development. But now the data for the design are determined and because of the large interest I want to share the possibility for building this yagi with other interested SHF friends.

I have started with the 10 element version shown in Fig. 1. For the boom an aluminium profile of 15 x 15 mm and 2mm thickness was used. For the elements rods of AlMg5 with 4mm diameter were used. These were cut accurately to a tenth of a millimetre by a lathe. For the drilling I have made a moulding tool and firstly drilled with 3mm followed by 3.9mm. Now the elements were driven in cleanly by a brass bush that was drilled to 4.1mm. A centric hub is most important. Building the dipole is more complex, see Fig. 2, 3 and 7. The inner conductor of 2.7mm diameter from Aircom Plus coaxial cable can be well used for this. The center of the dipole is grounded in order to prevent the expensive FETs of the RX and preamp, which are mostly coupled only by a 50 V SMD capacitor, from damage due to pulses.
The coat of a waterproof N norm jack [2] is fixed with a bracket and M3 V2A screws to the boom. At it also the balun from semi rigid cable UT141-CU alias SR3 [3] is soldered.
A cap from ABS [4] that is open downward provides protection from rain. Foaming in pack causes losses. An open mounting effects self drying. The dipole wire is bent over a roller on both sides to get 20 mm of internal distance. The outer distance should be 121mm. Afterwards one can protect the complete dipole against corrosion with urethane spray [4].

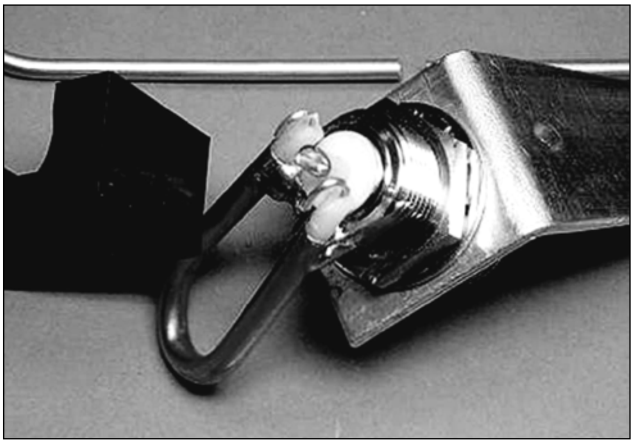

Fig. 3: Assembling the balun at the N jack - Montage des Baluns an der N-Buchse

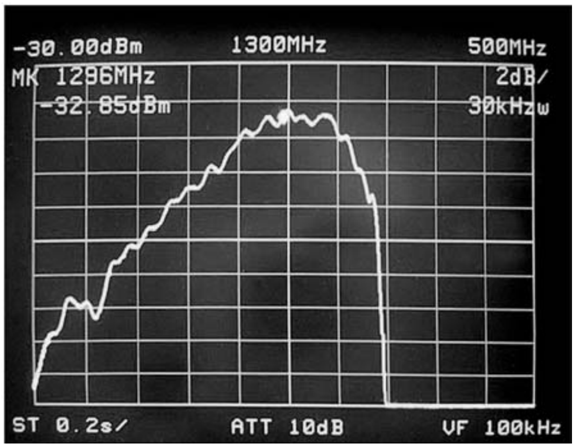

Fig. 4: Sweeping the 47 element yagi max. gain at 1299 MHz - Wobbelkurve der 47-Element-Yagi, Gewinnmaximum bei 1299 MHz

The free space sweeping curve brings all to light

After the 10 element yagi I started to design a 47 element yagi with a 4m boom of also 15 x 15 x 2mm. This one should be used for a stacked group of four yagis and also as a single yagi for portable operation from the car. But one can not, as one can often read, simply extend the short yagi. The new length causes a frequency shift. Thus a completely new design was necessary. I have set the gain maximum to about 1299 MHz as shown in Fig. 4. Then the unavoidable frequency shift down due to wetness effects only marginal drops at 1296 MHz. This is of great practical importance because often when there is wet fog there are good tropo conditions. Later on I have got antenna simulation software for checking the results. Anyway after often more than 3 hours of processing time no program could deliver reliable data in the optimisation mode. In part I have got total crazy dimensions for the elements unless the presettings were already close to my determined values according table 3. Personally I think the freely available program “MMAna” was the best [5].

Bodo, DL3OCH, got the possibility to simulate my data with the professional software „Microwave Studio“ and he provided the diagrams shown in Fig. 5 and Fig. 6. My measured results were widely confirmed. As the 4m version was working perfectly in practice and also the return loss was o.k. with more than 25 dB, I developed from this yagi another 5m long yagi with 59 elements and a clamp for elevation especially for EME work with WSJT [6] on 1296 MHz. See Fig. 8. The extension by 12 additional elements was not

critical at the equal boom profile. Anyway an extension of the support boom made sense because of mechanical reasons. The sagging of the boom should not exceed 3cm on both ends. This is the reason why the lightweight Aircom Plus cable was used as feedline. In the meantime several successful contacts took place via the moon with the 19.7 dBD yagi and 100 w at the dipole [7], [8].
For portable use a quadripartite pluggable version has proved to be appropriate. Details for the pluggable connection are shown in Fig. 9. Due to the higher strain when transporting by a car it is recommended to lock the elements through the boom additionally with sharp self-tapping V2A screws.

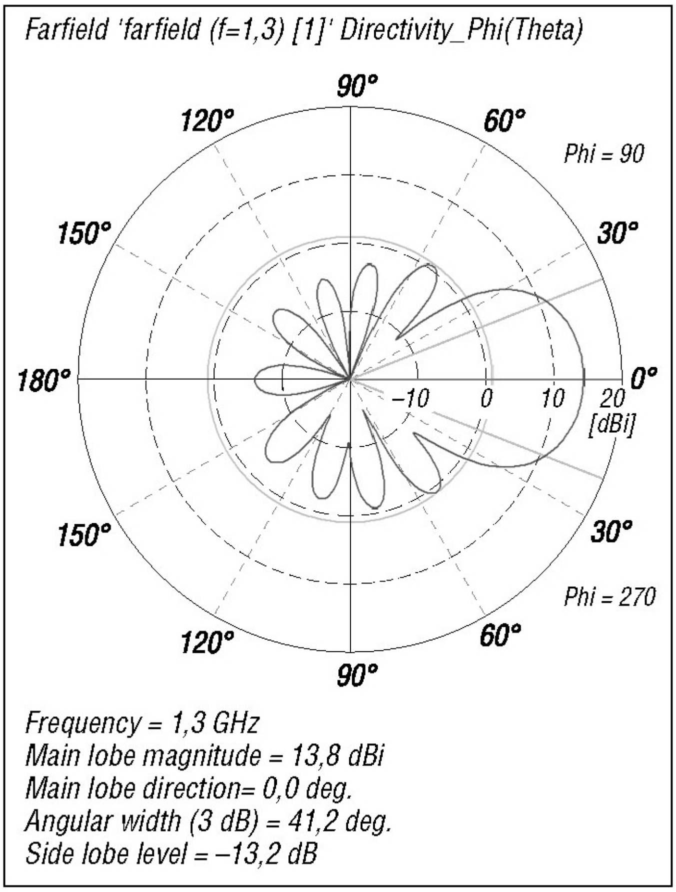

Fig. 5: Simulation of the 10 element yagi shows 13.8 dBi gain and 41,2° horiz. aperture - Die Simulation der 10-Element-Yagi weist 13,8 dBi Gewinn und 41,2° horizontalen Öffnungswinkel aus

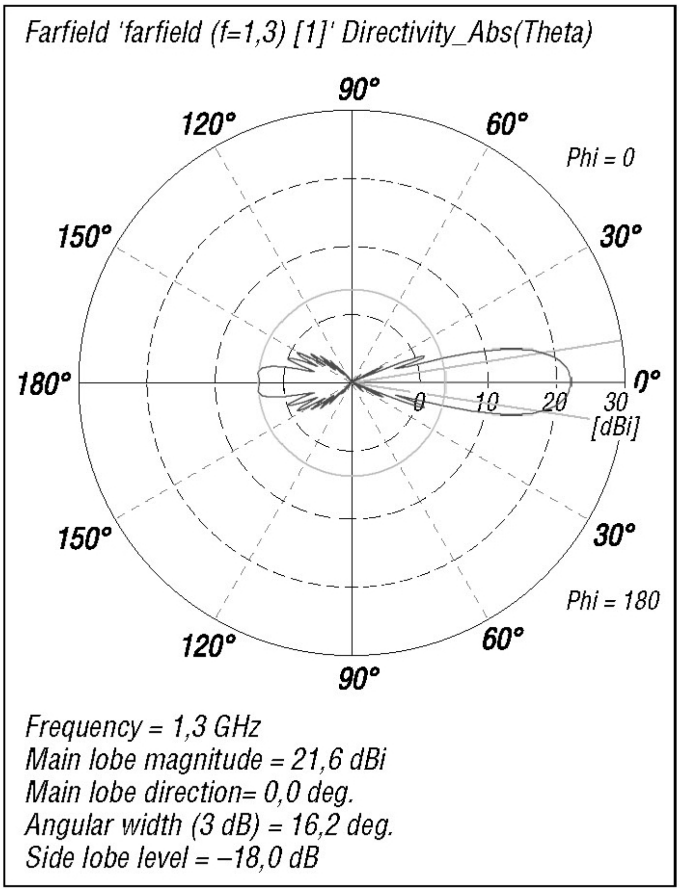

Fig. 6: Simulation of the 47 element yagi shows 21.6 dBi gain (19.5 dBD) and 16,2° horizontal aperture – Dito für die 47 Ele. Yagi 21.6 dBi (19.5 dBD) Gewinn und 16,2° horizontalen Öffnungswinkel

Lightweight construction

Another version was realized as lightweight construction with a boom profile of 15 x 15 x 1 mm and elements of 3.2mm diameter AlMg5 (drill to 3.1mm). Anyway for mechanical reasons here the length had to be limited to 4m. For a better current distribution I have used 4mm elements for the first director and the reflector. Overall considerable differences resulted for the lengths of the elements.
The measurement showed 0.2 dB more of gain, see table 2. A corresponding lightweight cross yagi showed not the hoped for gain, may be due to the too strong influence of the other plane in each case. Finally table 4 shows the dimensions of the only - including mast clamp - 67cm long original version with 10 elements.
I wish many success building your own 1296 MHz yagi!

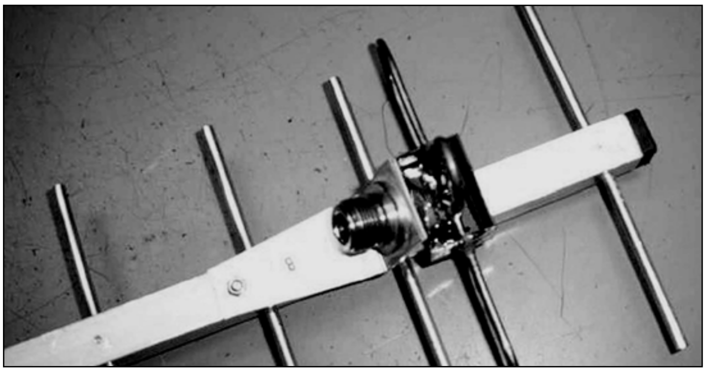

Fig. 7: Assembling the dipole to the 15 x 15 mm aluminium boom - Dipolmontage am Boom aus 15 mm × 15 mm Alu-Profil

Element	a [mm] zu Vorgänger	Pos. [mm]	l [mm]† für d = 4 mm	l [mm] für d = 3,2 mm
R	0	0	131	127,0*
S	50,0	50,0	121	121,0
D1	18,3	68,3	107,2	110,9*
D2	41,7	110,0	105,6	109,0
D3	49,3	159,3	104,1	107,5
D4	58,0	217,3	102,8	106,0
D5	66,6	283,9	101,6	104,8
D6	69,5	353,4	100,5	103,5
D7	73,6	427,0	99,5	102,4
D8	77,4	504,4	98,7	101,5
D9	81,1	585,5	98,0	100,8
D10	83,5	669,0	97,5	100,2
D11	86,6	755,6	97,0	99,7
D12	90,4	846,0	96,4	99,2
D13	91,2	937,2	96,0	98,7
D14	92,2	1029,4	95,6	98,3
D15	93,4	1122,8	95,2	97,9
D16	93,4	1216,2	94,8	97,6
D17	93,4	1309,6	94,5	97,3
D18	93,4	1403,0	94,2	97,0
D19	93,4	1496,4	93,9	96,7
D20	93,4	1589,8	93,6	96,4
D21	93,4	1683,2	93,3	96,1
D22	93,4	1776,6	93,0	95,8
D23	93,4	1870,0	92,7	95,5
D24	93,4	1963,4	92,5	95,2
D25	93,4	2056,8	92,2	95,0
D26	93,4	2150,2	92,0	94,8
D27	93,4	2243,6	91,7	94,6
D28	93,4	2337,0	91,5	94,4
D29	93,4	2430,4	91,3	94,2
D30	93,4	2523,8	91,1	94,0
D31	93,4	2617,2	90,9	93,8
D32	93,4	2710,6	90,7	93,6
D33	93,4	2804,0	90,5	93,4
D34	93,4	2897,4	90,3	93,2
D35	93,4	2990,8	90,1	93,0
D36	93,4	3084,2	89,9	92,8
D37	93,4	3177,6	89,7	92,6
D38	93,4	3271,0	89,5	92,5
D39	93,4	3364,4	89,3	92,4
D40	93,4	3457,8	89,1	92,3
D41	93,4	3551,2	88,9	92,2
D42	93,4	3644,6	88,7	92,1
D43	93,4	3738,0	88,5	92,0
D44	93,4	3831,4	88,3	91,9
D45	93,4	3924,8	88,1	91,8
D46	93,4	4018,2	87,9	–
D47	93,4	4111,6	87,7	–
D48	93,4	4205,0	87,5	–
D49	93,4	4298,4	87,3	–
D50	93,4	4391,8	87,1	–
D51	93,4	4485,2	86,9	–
D52	93,4	4578,6	86,7	–
D53	93,4	4672,0	86,5	–
D54	93,4	4765,4	86,4	–
D55	93,4	4858,8	86,3	–
D56	93,4	4952,2	86,2	–
D57	93,4	5045,6	86,1	–

Table 3: Positions and elemement`s lengths l for 1296 MHz - Tabelle 3: Position und Längen l der Elemente

Version	G [dBd]	Elements
4 m / 4 mm	18,7	47
5 m / 4 mm	19,7	59
4 m / 3,2 mm	18,9	47

Table 2: Gain of the 3 models
Tabelle 2: Gewinne der drei Varianten

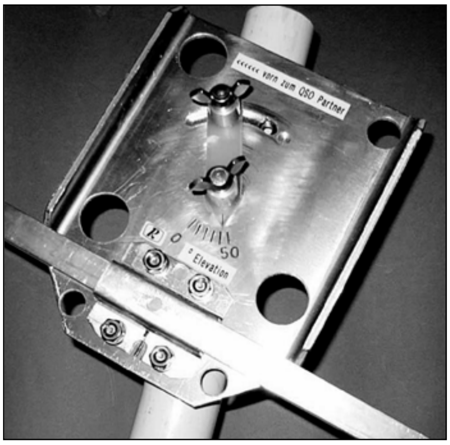

Fig. 8: DIY elevation clamp for EME - Eigenbau-Elevationsschelle für EME-Betrieb

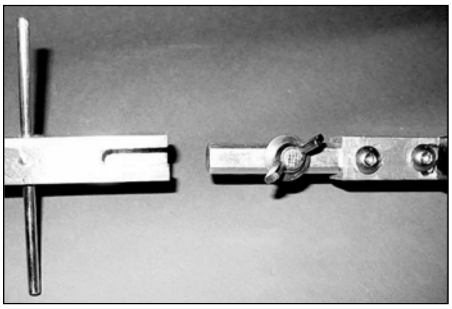

Fig. 9: Details of DJ9YW`s pluggable Yagi version - Einzelheiten des Boom-Stecksystems von DJ9YW, das ein zerlegen in vier Einzelstücke erlaubt

Element	a [mm] zu Vorgänger	Pos. [mm]	l [mm] für d = 4 mm
R	0	0	135
S	46,0	46,0	121
D1	14,3	60,3	105,6
D2	42,8	103,1	103,9
D3	50,4	153,5	102,3
D4	58,8	212,3	101,2
D5	66,0	278,3	100,0
D6	70,2	348,5	98,9
D7	73,1	421,6	97,8
D8	77,1	498,7	97,0

Table 4: Positions and element`s lengths for the 10 element yagi
Tabelle 4: Position und Längen l der Elemente bei der 10-Element-Yagi

***)** These elements have to be of 4mm diameter also for the 3.2mm yagi version. - Diese Elemente sind auch bei der 3,2-mm-Variante 4 mm dick auszuführen.

†) The 47 element yagi ends with the 45th director. - Die 47-Element-Yagi 4 m / 4 mm endet nach dem 45. Direktor.

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