

DL6WU Yagis for 23cm

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Introduction

Yagi antennas are a good alternative to dishes on 23cm for tropo work. Günter Hoch, DL6WU, was the first, who proved the feasibility of long Yagis on 23cm in his pioneering article ([1]) in 1982. Today also several commercial Yagis are available. Tonna was the first company to discover Yagi antenna design on 23cm. After several years delay some American companies (KLM, AEA and M^2) followed this line recently by 'rediscovering' the Yagi for 23cm.

For the home constructor, the design by DL6WU is a premium choice. These Yagis are unequalled in terms of gain, pattern, match and broad band performance. If properly built, they outperform any commercial counterpart and also those ubiquitous loop Yagis. They are cheap (Cost is less than DM 50,- per antenna) and made from easily available material.

Einführung

Yagis eignen sich als gute Alternative zu Spiegeln für Tropo auf 23cm. Es gibt inzwischen auch einige kommerzielle Produkte. Die erste Firma, die Yagis herausbrachte, war TONNA. Inzwischen sind auch andere Firmen wie KLM, AEA, HAG und M^2 auf den Zug aufgesprungen.

Wenn man selbst bauen kann, eignet sich das bereits vor 12 Jahren veröffentlichte DL6WU Design hervorragend. Diese Antennen sind unerreicht in den Eigenschaften Gewinn, Diagrammgüte und Breitbandigkeit. Sie sind bei geeigneter Konstruktion jeder kommerziellen Yagi und vor allen Dingen Loop-Yagis überlegen.

Design

To construct a Yagi on 23cm on a 15mm boom with 4mm diameter elements and non insulated element mount you need a robust and dimension tolerant basic design. Element lengths are very critical on 1296 and shortening factor is 67% of boom diameter, i.e. 10mm for a 15mm boom. Elements have a thickness of 0.017 wavelengths and the boom diameter is 0.065 wavelengths. This corresponds to a 135mm diameter boom with 36mm thick elements for an equivalent 144MHz Yagi! This is the reason why TONNA didn't tackle this problem but instead mounted the elements of their 23cm Yagis on those somewhat curious plastic holders.

The DL6WU design has all the necessary features to guarantee a successful construction: By virtue of its logarithmic element profile it's broad band with built in safety factor for mechanical tolerances and bad weather, it provides high gain, low sidelobe pattern and good match to 50 ohms. Gain

Table 1: Yagi Electrical Performance Data @ 1296MHz

Length [mm]	Length [λ]	Gain [dBD]	3dB Angle ϕ_E	3dB Angle ϕ_H	Stack-Hori [mm]	Stack-Verti [mm]
1945	8.4	16.6	21.2	21.6	625	615
2497	11	17.5	20.5	20.8	650	640
2957	13	18.1	19.3	19.6	690	680
4061	17	19.1	17.0	17.3	780	770
5993	26	20.3	14.7	14.9	900	890

Gain-Bandwidth (-1dB): 1265-1355MHz, Gain peak at 1315 MHz
 VSWR: < 1.2:1 (1.1:1 typ. @ 1296MHz)

Mechanical Data of 1296MHz³ Yagis

Element	Position ¹ [mm]	Length ² [mm] for 4mm El. & 15mm Boom
R	0	120
DE	50	120
D1	68	106
D2	110	104.5
D3	160	103
D4	218	101.5
D5	283	100
D6	353	99
D7	426	98
D8	502	97
D9-10	582, 665	96
D11-12	751, 841	95
D13-15	933, 1025, 1117	94
D16-18	1209, 1301, 1393	93
D19-21	1485, 1577, 1669	92
D22-24	1761, 1853, 1945 (8.4λ)	91
D25-28	2037, 2129, 2221, 2313	90
D29-32	2405, 2497 (11λ) , 2589, 2681	89
D33-37	2773, 2865, 2957 (13λ) , 3049, 3141	88
D38-43	3233, 3325, 3417, 3509, 3601, 3693	87
D44-50	3785, 3877, 3969, 4061 (17λ) , 4153, 4245, 4337	86
D51-D58	4429, 4521, 4613, 4705, 4797, 4889, 4981, 5073	85
D59-D68	5165, 5257, 5349, 5441, 5533, 5625, 5717, 5809, 5901, 5993	84

¹ Positions must be accurate to ± 0.5 mm

² Length must be accurate to ± 0.3 mm

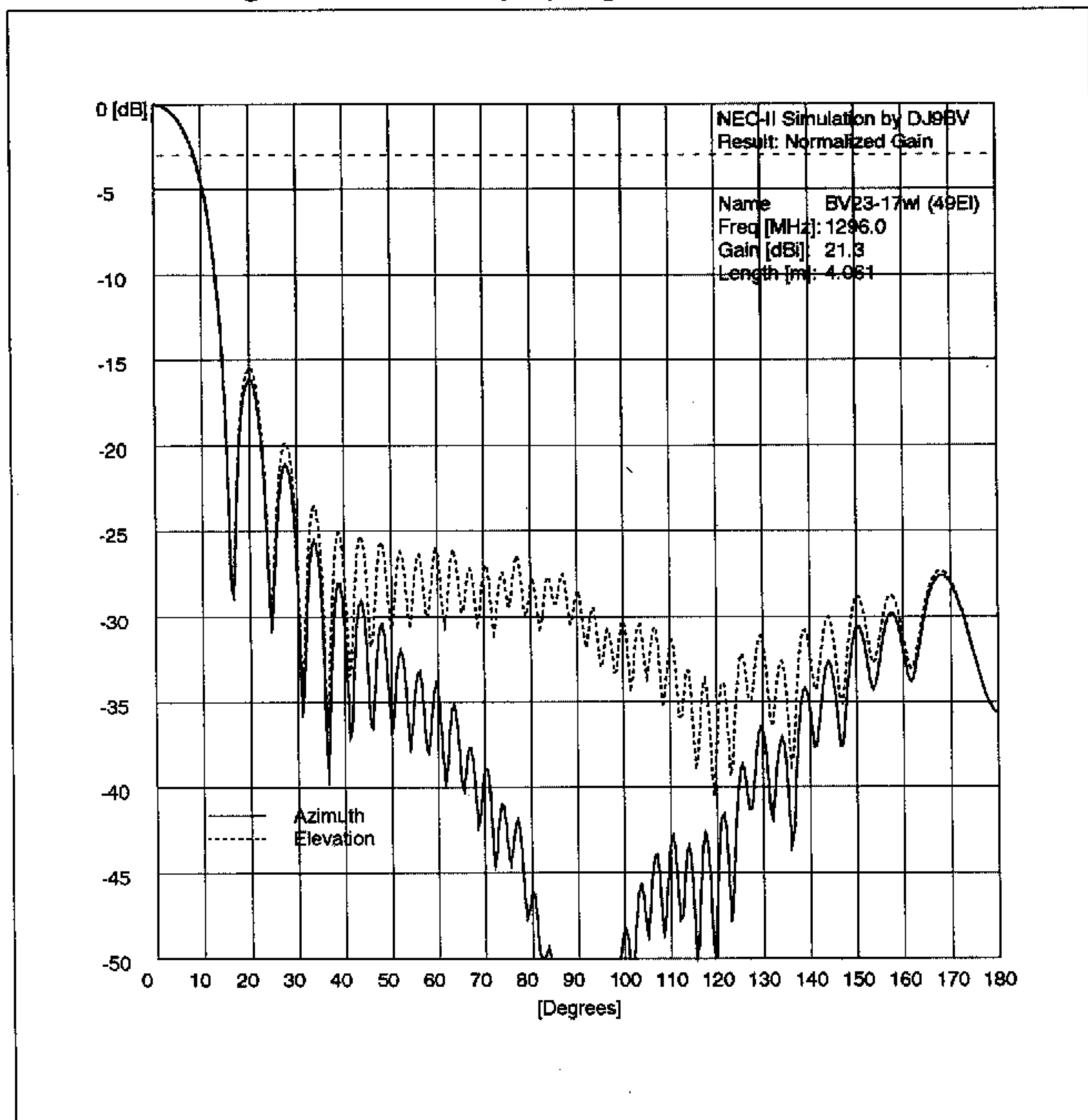
³ To lower operating frequency to the 1240...1280MHz Band (Satellite, ATV, Packet), all elements have to be lengthened by 2mm. See Fig. 5 for gain characteristic.

peak for 1296MHz design is at 1315 MHz. The antenna works very well from 1270 to 1310 MHz. Because this antenna is a modular design it can be cut to any length from 0.5m to >6m. Electrical data for boom lengths ranging from 2m to 6m with associated gains of 16.6 to 20.3 dBD are given in Table 1.

Computer optimisation was not applied to the basic design. First, at the time of first construction (1983) no computer simulation for Yagis had been

available. Today a redesign with the aid of CAD-software makes no sense, because the variety of amateur programs like MININEC, ELNEC, YAGIMAX, YO etc. cannot simulate this type of 'thick' element Yagis satisfactorily. This has been shown in ([2]). The only program, which can simulate this type of antenna with sufficient accuracy is NEC-II and its direct descendants. But even then an improvement is questionable, because optimisation means trading gain for bandwidth. But bandwidth is urgently needed for a 23cm Yagi to

Figure/Abb. 1: 17w1 (4m) Yagi/NEC-II Simulation



function under all environmental conditions. Conclusion: Even in its 12th year the DL6WU Yagi design is still going strong.

Design

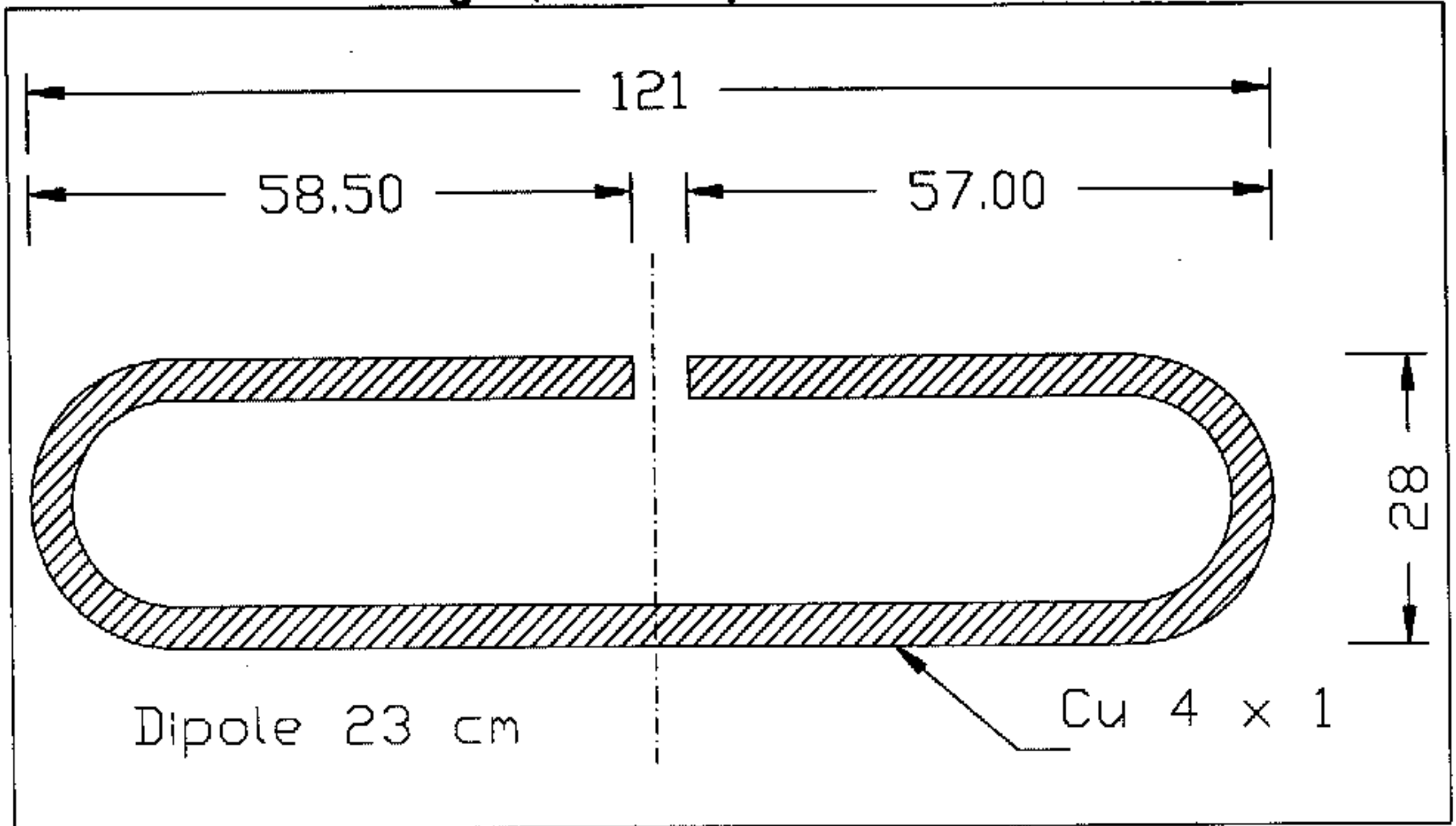
Die ersten Yagis wurden schon 1983 gebaut. Sie wurden direkt nach der Beschreibung von DL6WU konstruiert ([1]). Nur der Boombdurchmesser und die Konstruktion des Faltdipols wurden geändert. Seitdem sind Hunderte von diesen Antennen erfolgreich nachgebaut worden.

Die Antennen sind für Längen von 2m bis 6m spezifiziert. Dabei sind die Gewinne zwischen 16,6 und 20,3 dBD möglich. Ansonsten kann die Yagi an jeder Stelle abgeschnitten werden. Das modulare Design läßt dieses zu.

Construction

The antennas described below were first built in 1983 following the DL6WU design ([1]). Only the boom diameter has been changed to 15mm and a special folded dipole with a semirigid balun has been constructed. Since then hundreds of these antennas have been built by amateurs all with

Figure/Abb. 2: Dipole Dimensions



excellent results. Because of not ending inquiries about the constructional data a publication seems to make sense.

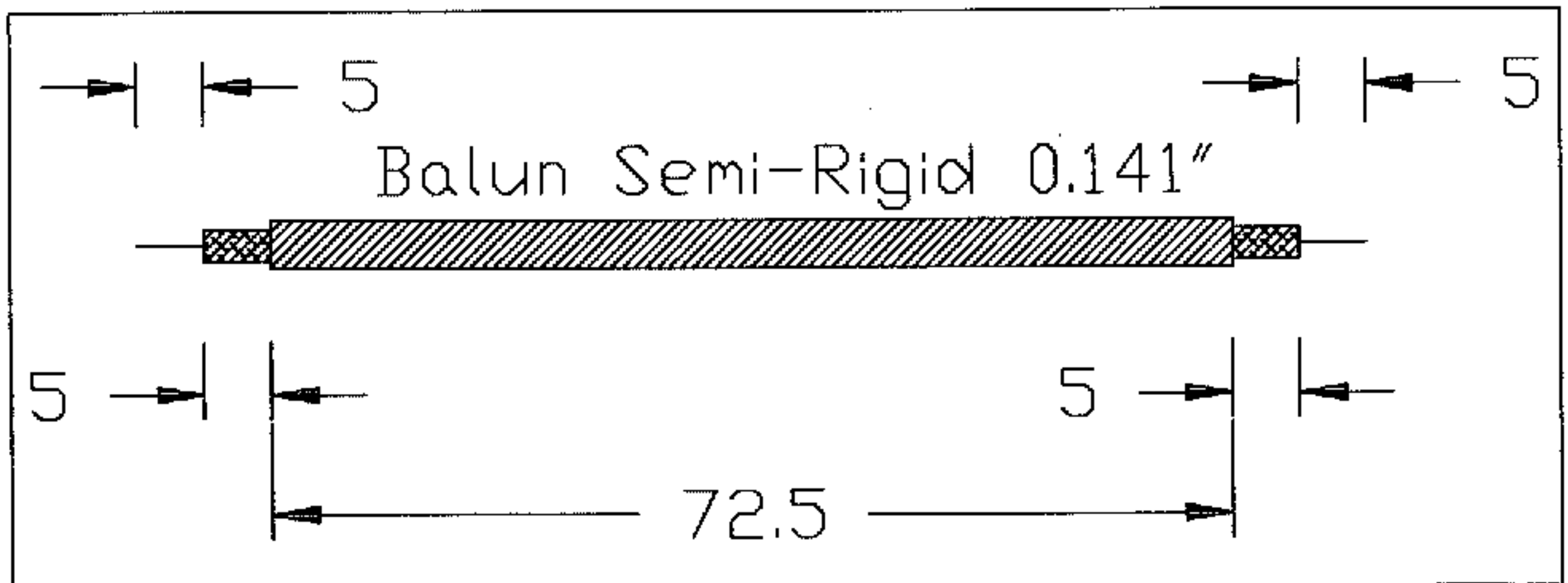
Non insulated element mounting requires protection against corrosion. If the element loses contact to boom severe detuning will be the consequence. Two component paint for aluminium (i.e. BRILLUX 853 epoxy paint) should be used.

Mechanical Data

- Boom-Length: 2-6m (8.4λ - 26λ)
- Boom-Diameter: 15mm
- Element lengths include correction of 11mm for indicated boom diameter

- Element-Diameter: 4mm, made from AlMgSi1 standard aluminium rods
- Dipole: 4mm Diameter, 121mm long (See Figures 2,3,4,7)
- Element-Mounting: Non insulated through boom: Drill a hole of 3.9mm diameter and hit element through the boom to achieve a tight fit.
- Anti-Corrosion Coating with two component Paint: For example Brillux 853 two component paint for aluminium

The first antenna with a normal folded dipole had a VSWR of 1.4:1. Together with DC3XY we de-



Figure/Abb. 3: Semirigid Balun

veloped a dipole construction by experiments which gives a VSWR of less than 1.1:1 on 1296. The main departure from theory was to lengthen the dipole and to shorten the balun in semirigid UT-141. A wise decision is to use a hermetic N-connector, which does not allow water getting into the inner line.

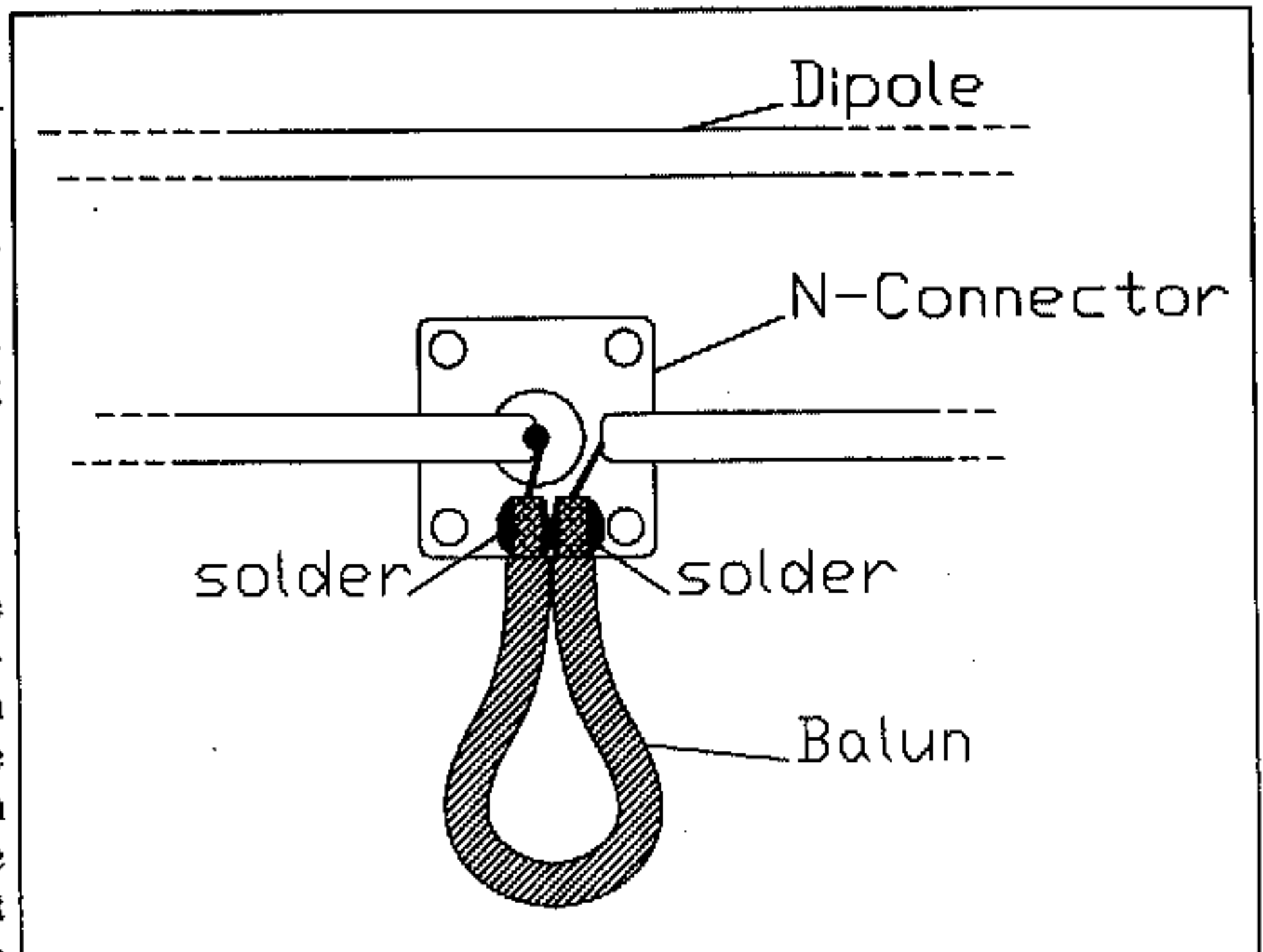
Konstruktion

Die Montage der Elemente mit 4mm Durchmesser erfolgt galvanisch leitend durch den Boom. Daher muß die Antenne durch einen Anstrich mit Zweikomponenten Farbe gegen Korrosion geschützt werden. Für die N-Buchse wird eine hermetische Ausführung empfohlen. Damit ist das Problem der Abdichtung zuverlässig gelöst.

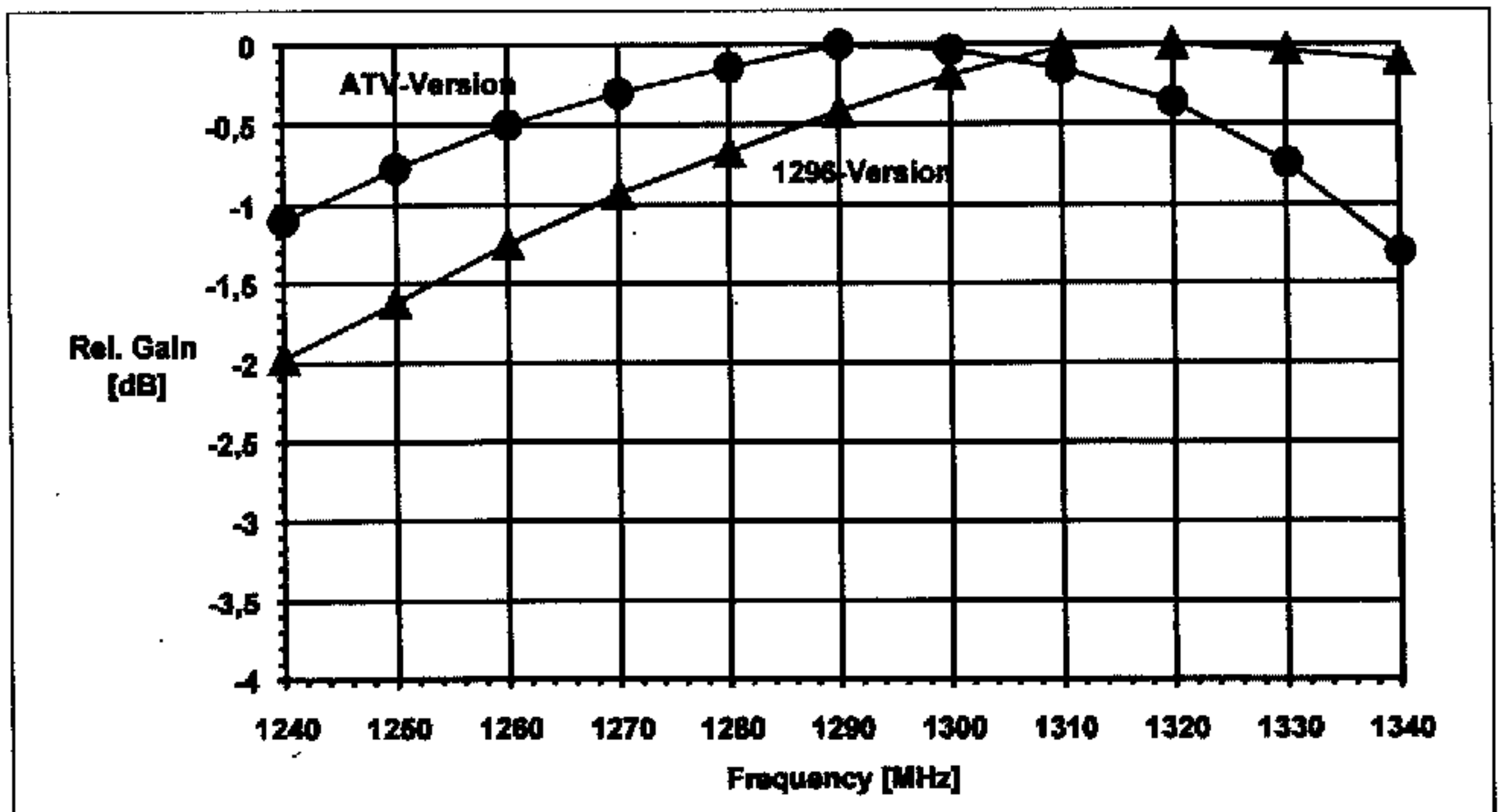
Mechanische Daten:

- Boom-Länge: 2-6m ($8,4\lambda$ - 26λ)
- Boom-Durchmesser: 15mm
- Element Längen schließen Boom-Korrektur ein.

Figure/Abb. 4: Balun Assembly

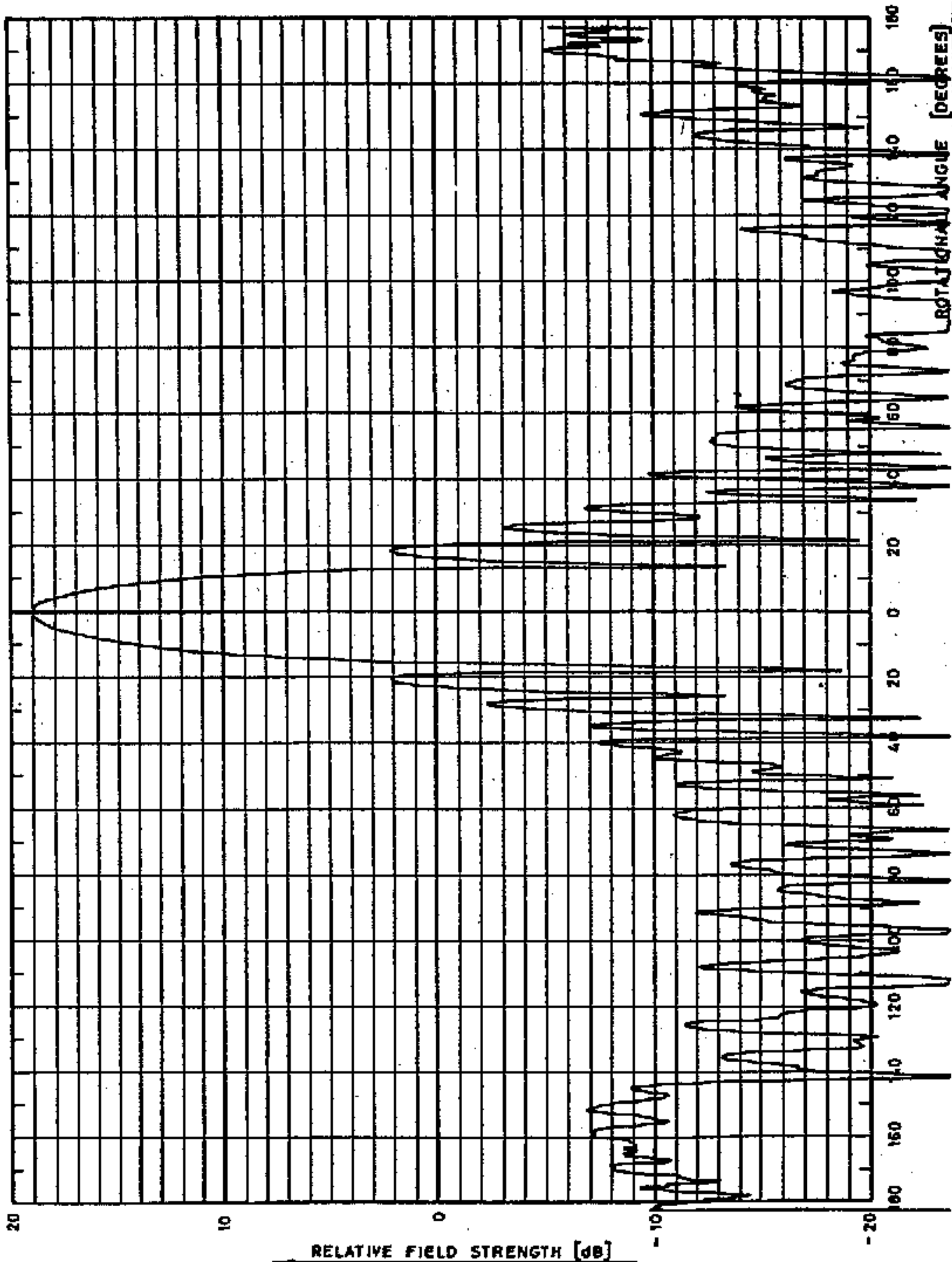


- Element-Durchmesser: 4mm, aus AlMgSi1 Aluminium Stangen
- Dipol: 4mm Durchmesser, 121mm lang (Siehe Abb. 2,3,4,7)
- Element-Montage: Nichtisoliert durch den Boom: Loch mit 3,9mm Bohrer bohren und die Elemente mittels Schlaghülse und Hammer durchschlagen.



Figure/Abb. 5: Gain versus Frequency

RADIATION PATTERN MEASUREMENT		
ANTENNA TYPE :	4E Yagi	17λ 4m DL6WU
FREQUENCY :		
MANUFACTURER :		
OWNER :	DJ9BV	
STATED SPECIFICATIONS BY MANUFACTURER :		
GAIN (dBd):	3 dB-BEAMWIDTH:	
F/B RATIO:	MAX. SWR:	
MEASUREMENT RESULTS		
MEASUREMENT PLANE : E		
MEASUREMENT FREQ : 1296		
GAIN (dBd) : 19.0		
3 dB - BEAMWIDTH :		
F/B RATIO :		
SWR AT MEAS. FREQ. :		



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Figure/Abb. 6: 17wl (4m) Yagi/Measurement

- Korrosionsschutz mit Zweikomponentenfarbe: Brillux 853 Epoxy Farbe für Aluminium

Measurements

During the Scandinavian VHF/UHF meeting in Haslev/Denmark in 1985 pattern and gain were measured with good results: 18.3 dBD for the 3m version and 19.1 dBD for the 4m version. Patterns are excellent with low sidelobes and extremely high F/B ratio (see Figure 6). Four of 4m long Yagis provide marginal EME performance on 23cm in spite of the 3dB polarisation loss. This has been demonstrated by DL3YEE and others.

Electrical performance data can be seen from table 1. Data is calculated by NEC-II software and is in very good agreement with the measurement data. For good bad weather performance the gain maximum is designed for 1315 MHz for a dry antenna (Fig. 5). During rain the gain peak may go down to 1300 MHz. In either case the antenna will function in tenths of a dB of the optimum gain. For low band work (Satellite, ATV, Packet) longer elements (See Box Mechanical Data and Fig. 5) provide optimum performance.

Meßwerte

1985 wurden während des Skandinavischen VHF/UHF Meetings in Haslev/Dänemark die Antennen vermessen. Der gemessene Gewinn beträgt 18,3 dBD für die 3m lange Version und 19,1 dBD für die 4m lange Version. Außerdem konnte das ausgezeichnete Diagramm gemessen werden (Abb. 6). Mit vier von 4m langen Yagis ist man bedingt EME-tauglich, obwohl man 3dB Polarisationsverlust hat. Das wurde von DL3YEE und anderen gezeigt.

Die elektrischen Eigenschaften sind aus Tabelle 1 ersichtlich. Die

Daten wurden mittels NEC-II simuliert und stimmen im Fall der 3m und 4m Version ausgezeichnet mit den gemessenen Daten überein. Zur Sicherheit gegen Nässe auf den Elementen sind die Antennen für ein Gewinnmaximum bei 1315 MHz dimensioniert (Abb. 5). Auf 1296 MHz fällt der Gewinn bei trockener Antenne nur wenige Zehntel ab. Ist die Antenne naß, rutscht das Gewinnmaximum auf 1300 MHz, so daß eine große Unempfindlichkeit gegen schlechtes Wetter gewährleistet ist. Um 2mm längere Elemente erlauben optimalen Betrieb von 1240-1280MHz für Packet etc. (Siehe Box Mechanical Data und Abb. 5).

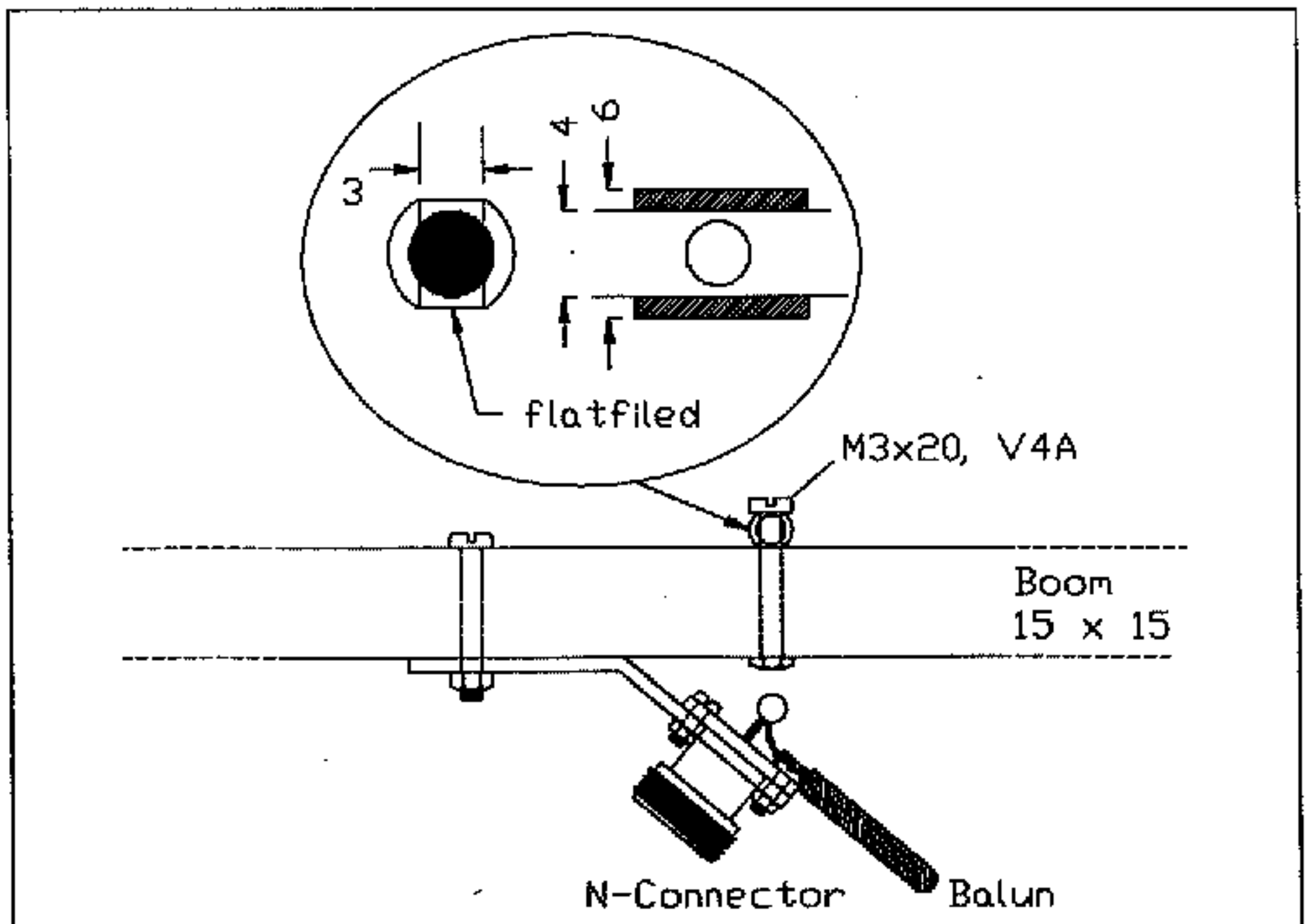
Parts/Teile

Special Parts, dipole assemblies and ready made Yagis are available from Rainer Jäger, DC3XY, Breslauer Str.4, D-25479 Ellerau. Phone: ++49 (0)4106-73430.

Teile, fertige Dipole und komplette Antennen sind bei obiger Adresse erhältlich.

References

- [1] Günter Hoch, DL6WU, "Extrem Lange Yagi-Antennen", UKW-Berichte 1/1982, pp.3-11
- [2] R. Bertelsmeier, DJ9BV, G. Hoch, DL6WU, "Yagi Simulation: CAD-Software for Evaluation and Development", DUBUS 3/1992, pp.42-66.



Figure/Abb. 7: Dipole Assembly