HYGAIN TH3JR: An ANALYSIS and

PERFORMANCE IMPROVMEMENT ON 20 METRES

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PURPOSE OF THIS ARTICLE

This Part 1 is the first of a series of articles showing analysis of the Hygain TH3JR showing initial gain on 20 metres is only -13.9 dBi. Subsequent articles show how the NEC model was further developed and the antenna altered to provide a theoretical gain of 11.8 dBi on 20 metres. The purpose of the article is to request feedback from amateurs who have used and modified the TH3JR to gain their knowledge of how well the antenna worked installed to the factory manual and any experiences they may have of modification and performance improvement.

The next version of this post will show how the antenna was modified.

WHAT IS THE REAL PERFORMANCE?

I have had a TH3JR for some time. I had not got to putting it up because I was unconvinced by the Hygain Specification which says:

Specifications	
Electrical	
Forward Gain	Up to 8 dBi
Front-To-Back Ratio	25 dB
VSWR at Resonance	Less than 1.5:1
Nominal Impedance	50 ohms
Power Capability (Transmitter Output)	600 Watt PEP, 300 Watt AM

The questions I had were:

What does up to 8 dBbi mean? One would assume obviously this would be a simple statement for the best band so that was likely to be the performance on 10 meters. So the question I had was "what was the gain on 20 meters and 15 meters?"

10 meters is never open so it is of little interest to a DXer.

Really the performance on 20 meters is really what matters. so what was the gain 20 metres ????

Well this should be easy to answer in theory. All I need is the NEC model and I can run this through 4NEC.

I have searched the internet for years but could I find an NEC model? No. In fact here are very few NEC models or commercially made beams form the per NEC era.

So eventually in 2019 I decided to dedicate considerable time (4 weeks) to creating an NEC model and finding out what the beam really did put out.

BUILDING THE MODEL

Finding in the dimensions from the HighGain was little challenging because the copies on the internet are illegible. Obviously a quality control issue with MFJ who put out the current manuals.

However eventually by recalculating the imperial feet and inches I was able to get all the dimensions.

TRAPS

Information on the TRAPS was non existent except for some values of dip frequencies using a dip meter.

I was able to measure length form the traps I held

To find resonant frequencies I connected a Rig Expert AA-54 antenna analyzer across the trap with short lengths of insulated wire. Traps have to be kept at least 400 mm away from other metal objects to get a repeatable reading. To identify the resonant frequency scan from 0 to 30MHZ and using the R+Ji series or parallel view indentify the region where inductance changes to capacitance. This is shown in figure 4.67 from the 2007 ARRL Handbook. The theory of on resonance is explained in detail in Chapter 4 and so if you want to understand the basis of these calculations read Chapter 4 on L / C parallel circuits at resonance.

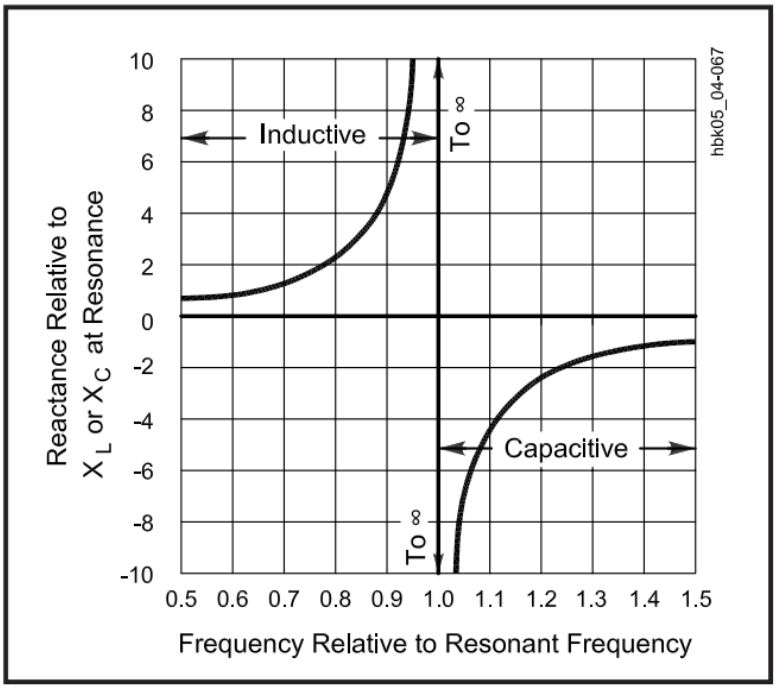


Fig 4.67 — The transition from inductive to capacitive reactance in a parallel-resonant circuit as the frequency passes resonance.

The measured values of resonant frequency are very different to the trap dip figures Hygain published in the 1970s.

To measure the inductance of coils I took the outer capacitor tube off the trap and measured the coil inductance **in the region where the value was low (say between 0.08 to 2.0 as shown in the above figure 4.67)** well before the inductance values rapidly increase at resonance. The rapidly increasing values are not typical of trap operation and should be ignored.

CALCULATE CAPACTANCE

From page 6.35 of 2004 ARRL handbook equation 92 at resonance says

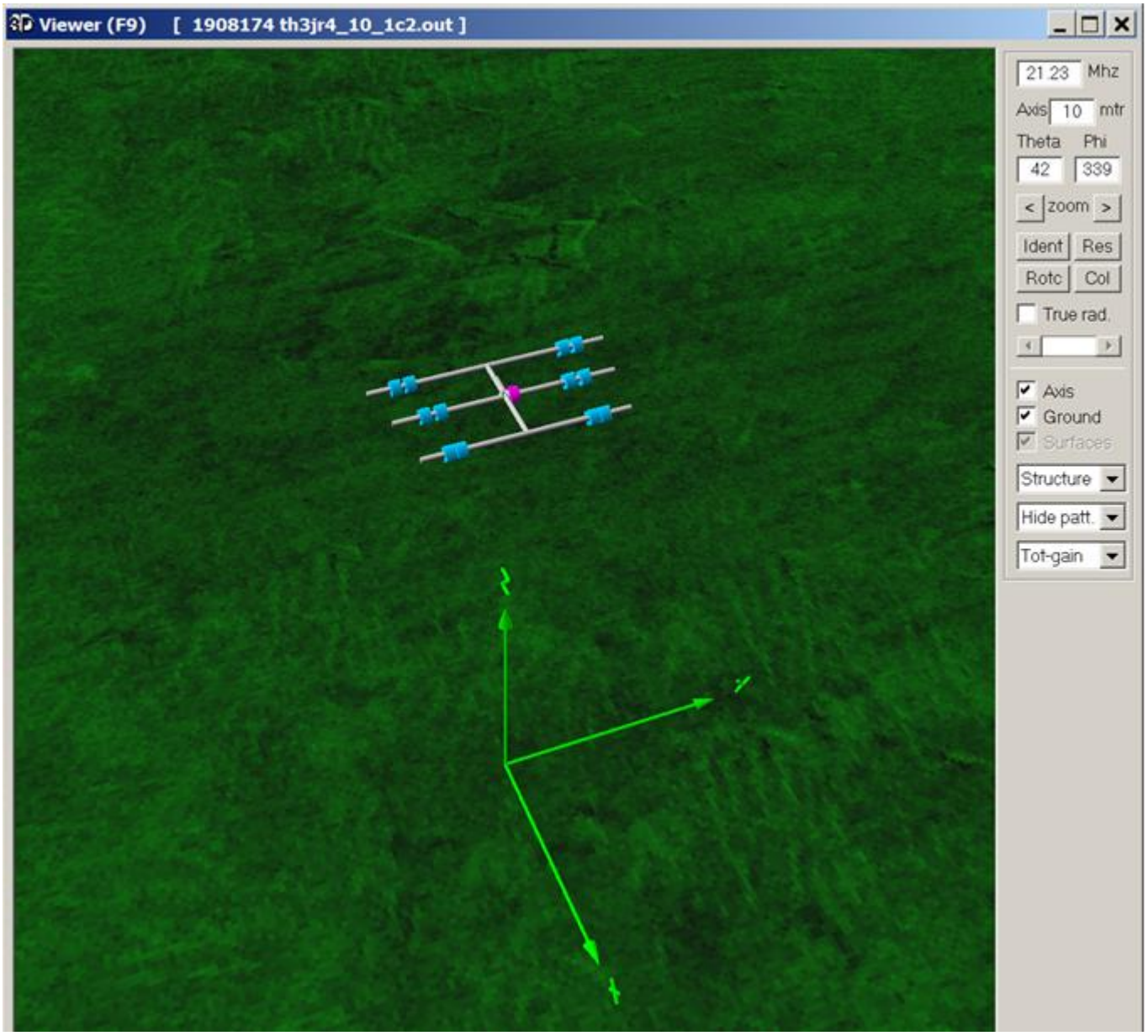
C = 25,330 / ((F^2) . L)

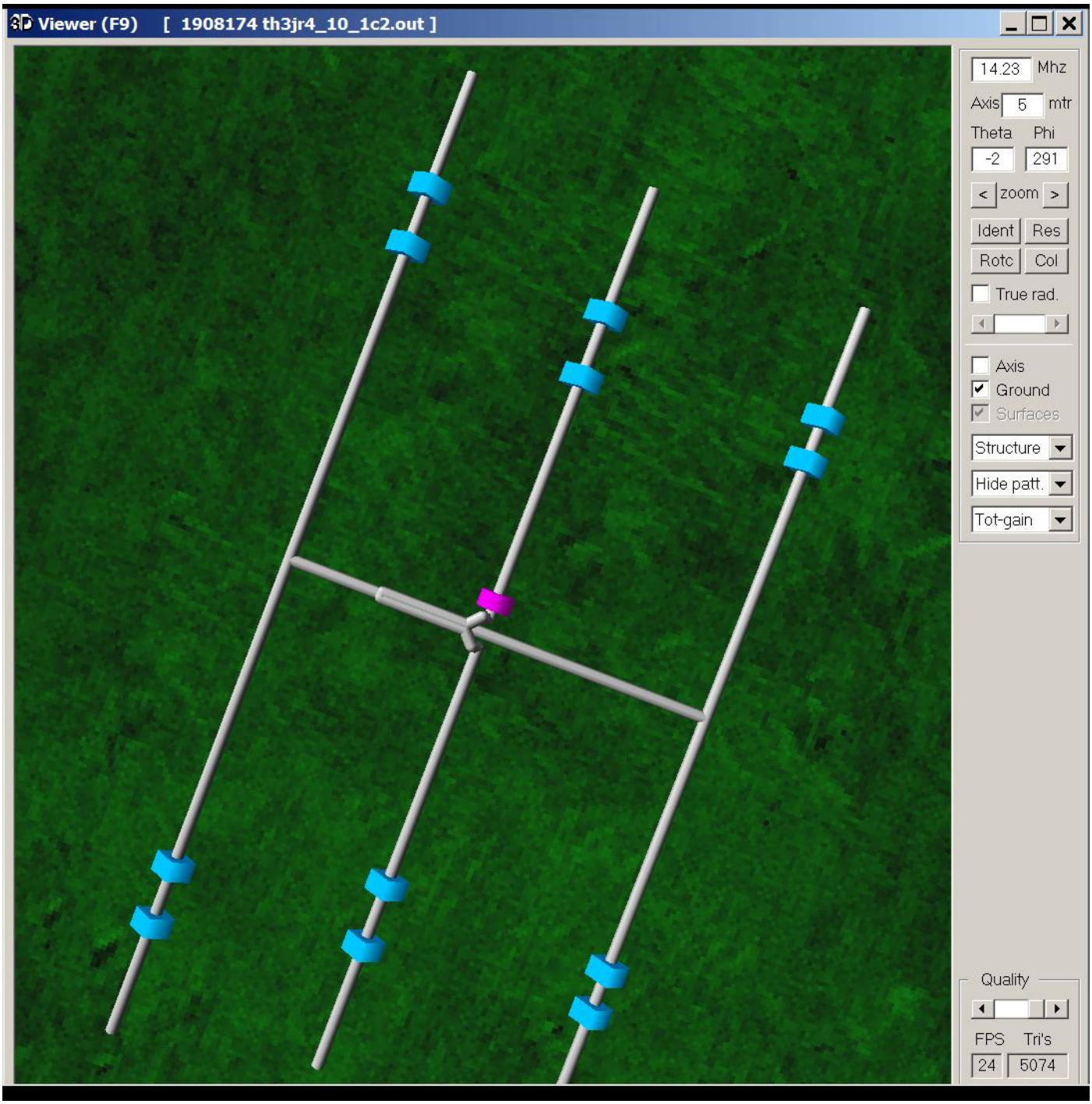
Res F	L		Calculate C
MHz	uH		pF
21.1	2.0		28.45

Alternatively you can measure trap capacitance using an oscilloscope to establish the time for charging to 5/8 height of square pulse wave. Many examples of how to measure this way are available on Youtube.com.

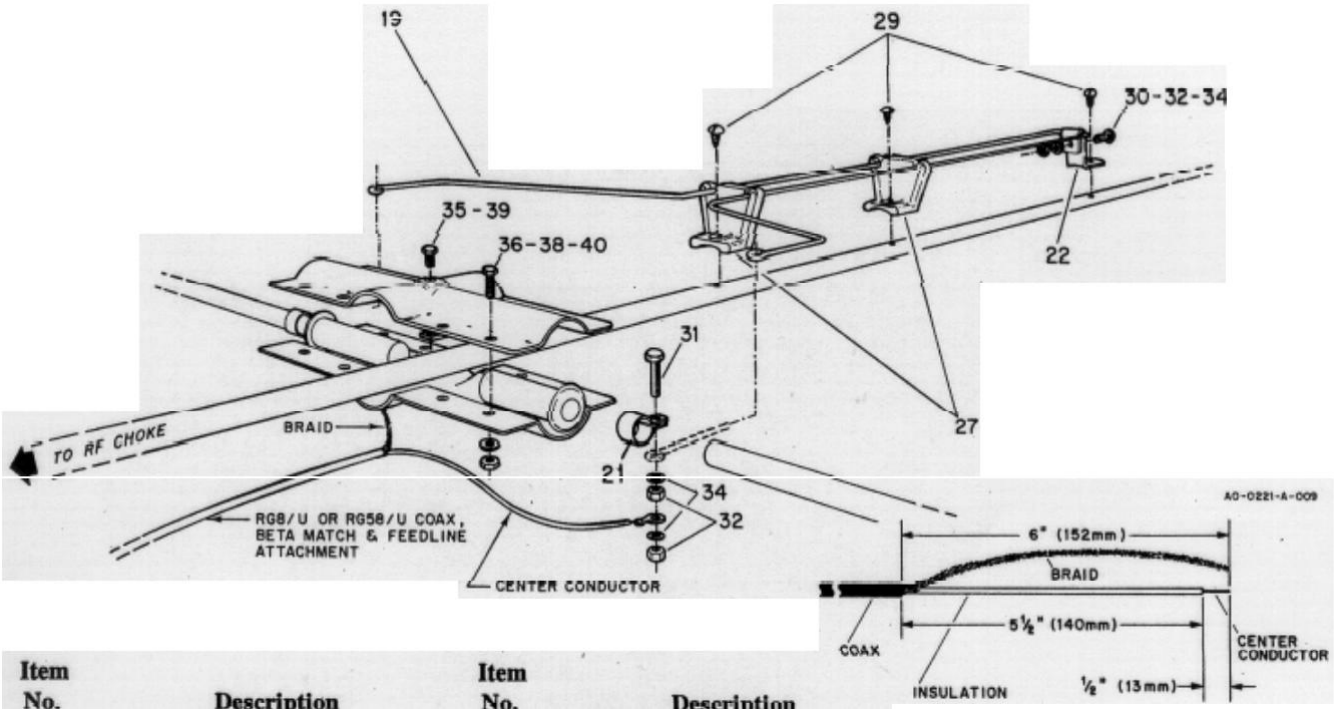
CALCULATE PERFORMANCE THROUGH SEVERAL STEPS

1. **Stage 1: Analysis of the original Hygain TH3JR complete antenna model**



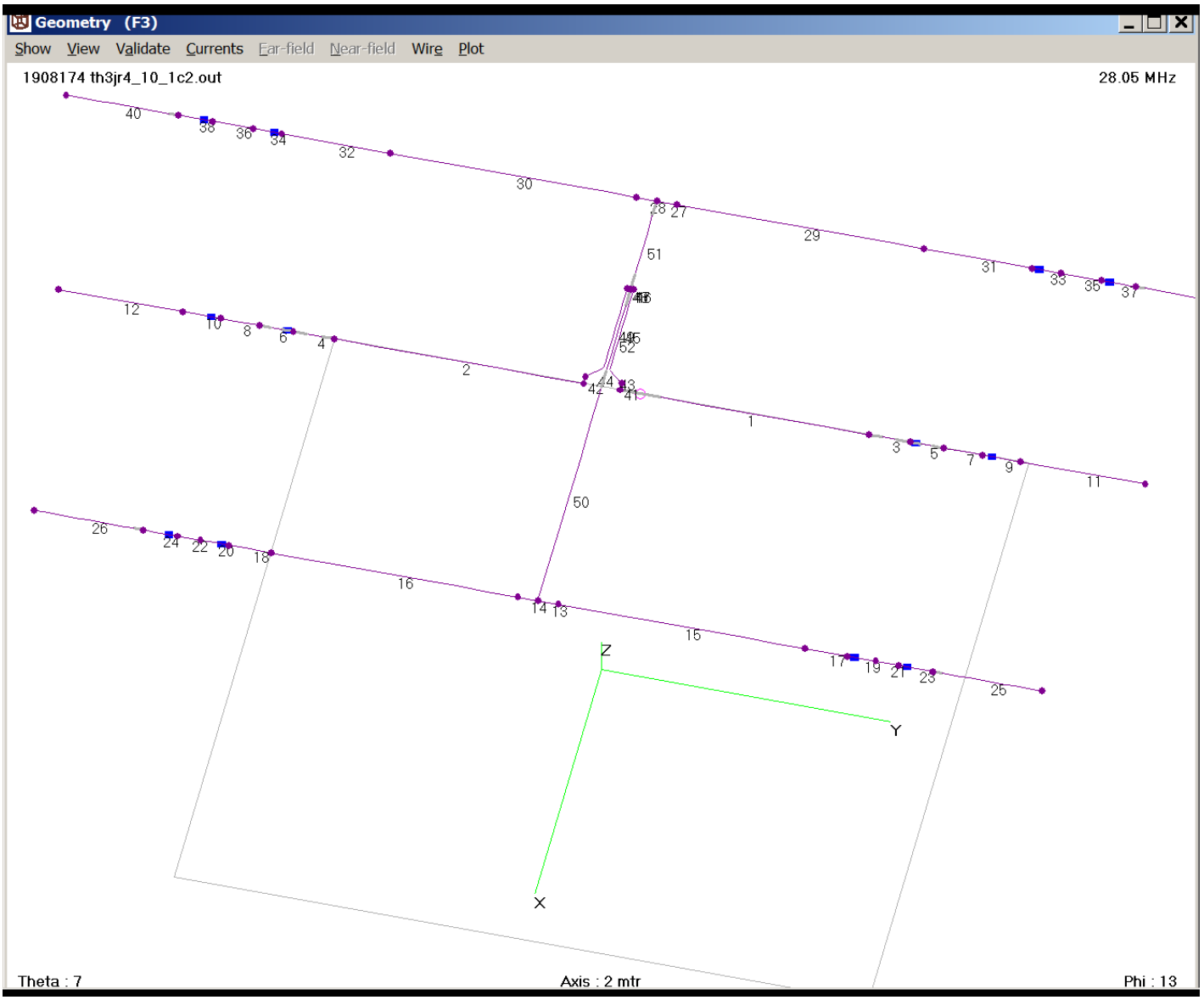


The TH3JR is a complex electrical structure: where the boom is electrically connected to the Director and Reflector: The matching is via a hairpin which extends towards the reflector and connects electrically in the centre to the boom at point Hygain say is neutral.

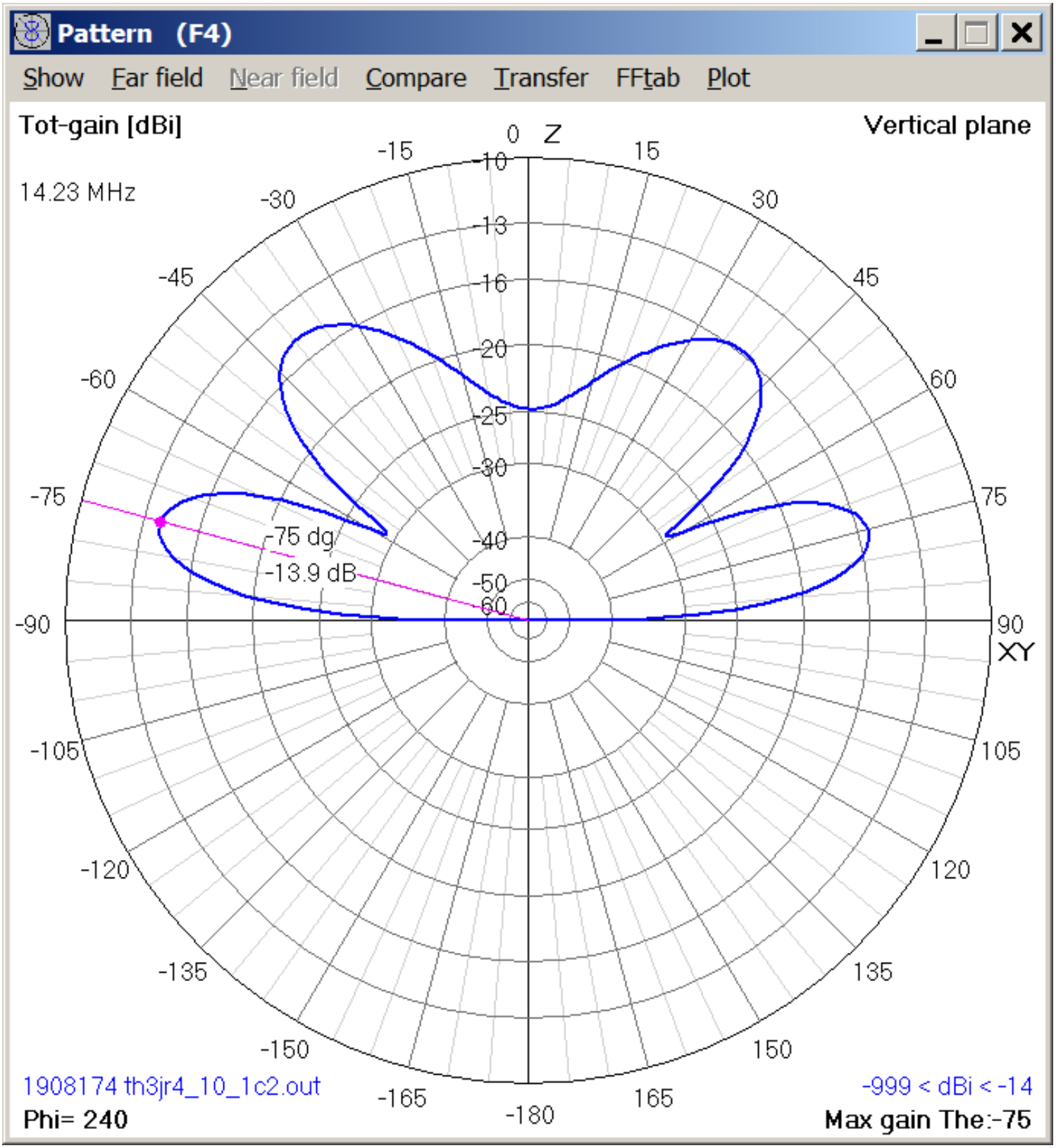


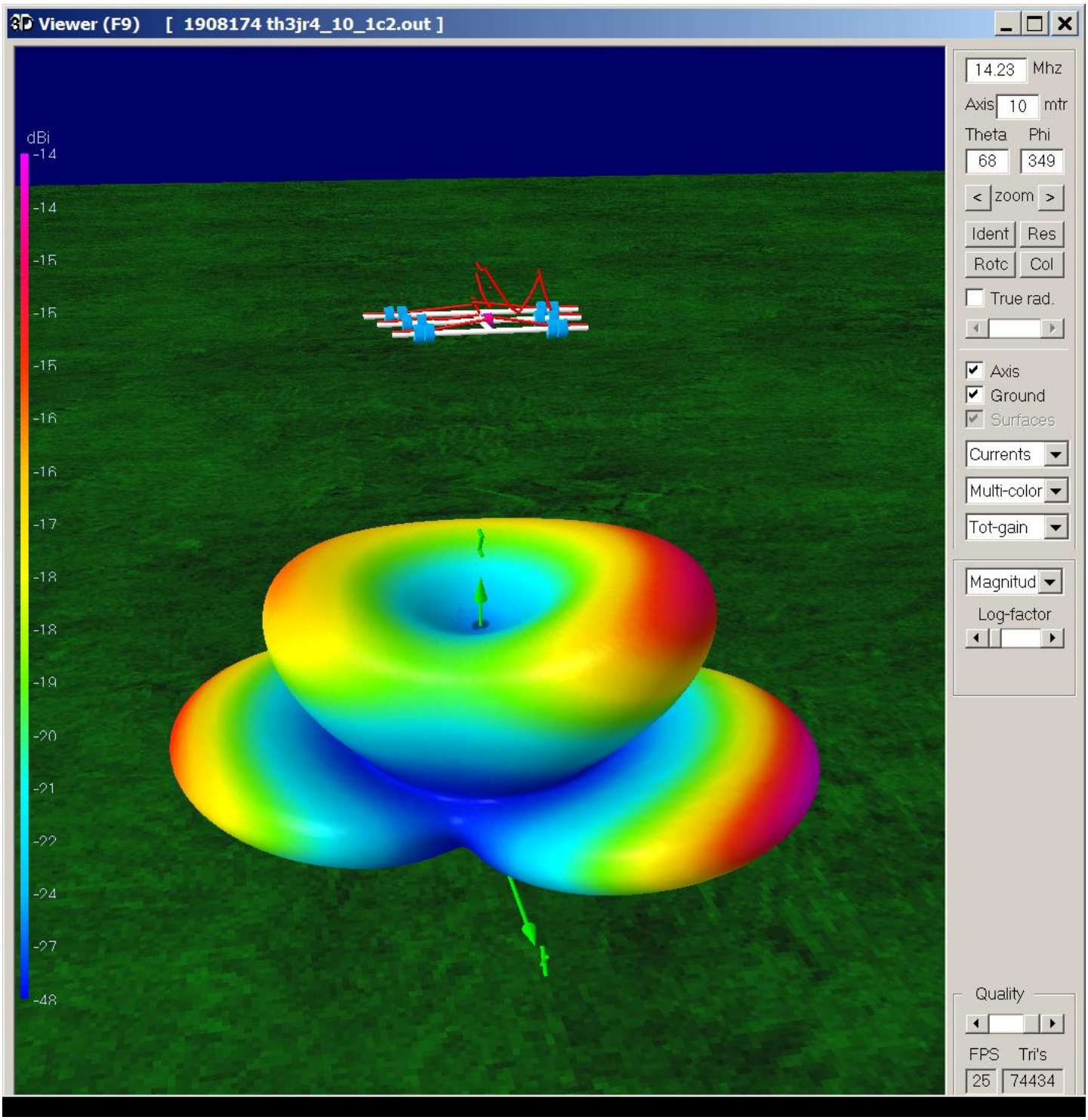
Item No.	Description	Item No.	Description

The Model analyzed is below.



On **14.225 MHZ** showed a very unimpressive -13.9 dBi off the back of the beam and current was formed on only half the elements: Essentially a very low performance of rotatable dipole.


Pattern (F4)
Show
Far field
Near field
Compare
Transfer
FFtab
Plot
Tot-gain [dBi]
Vertical plane
14.23 MHz
0
Z
15
30
45
60
75
90
XY
105
120
135
150
165
-180
-165
-150
-135
-120
-105
-90
-75
-60
-45
-30
-15
-10
-13
-16
-20
-25
-30
-40
-50
-60
-75 dg
-13.9 dB
1908174 th3jr4_10_1c2.out
Phi= 240
-999 < dBi < -14
Max gain The:-75

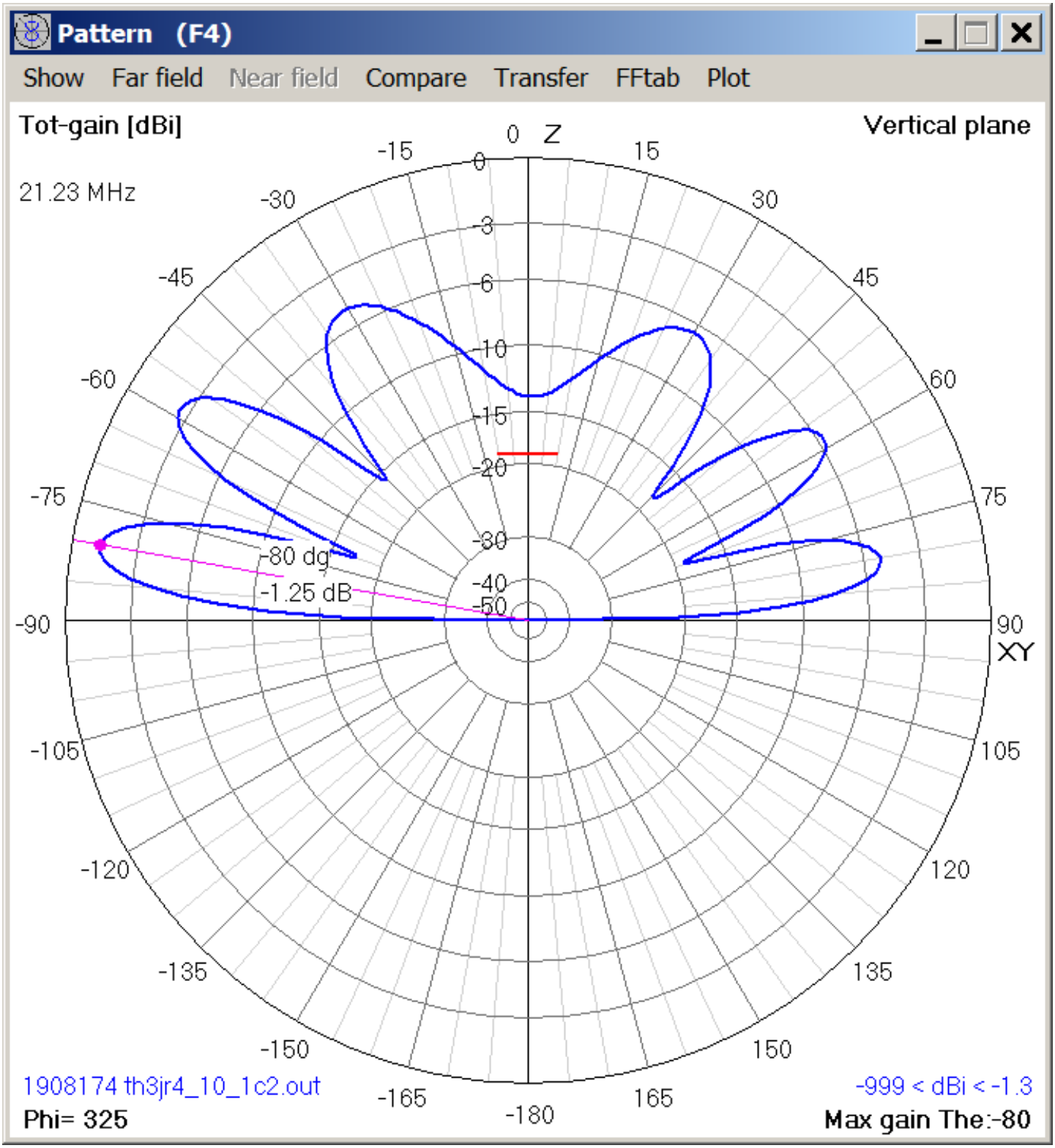


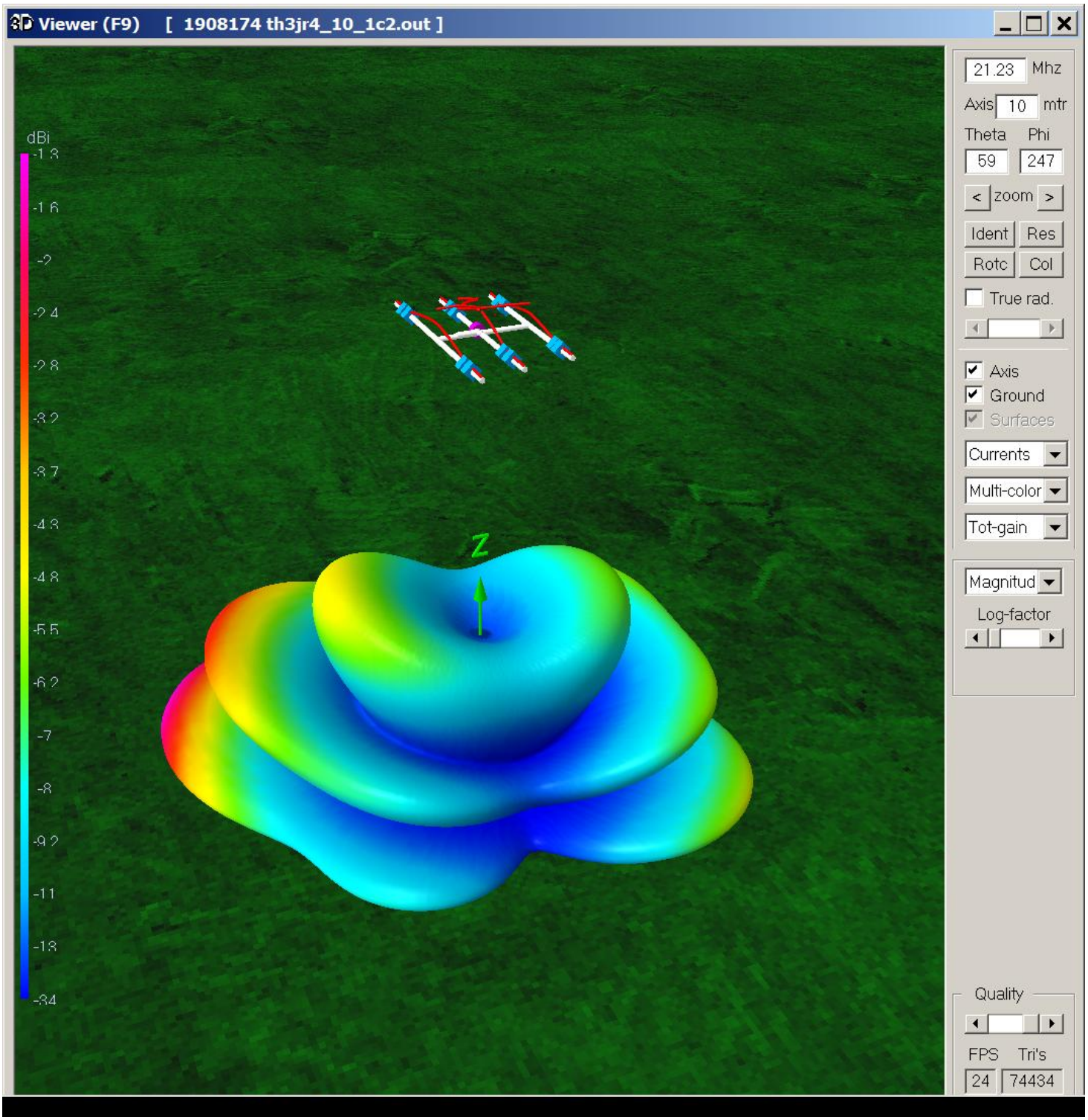
Look above at those currents in red. Distorted due to the input matching system of due to a hairpin attached to the boom.

This matching causes:

- currents along currents along the boom. process and
- the current drops signficantly on the right hand side Driven Element (when viewed indirection Reflector to Director).

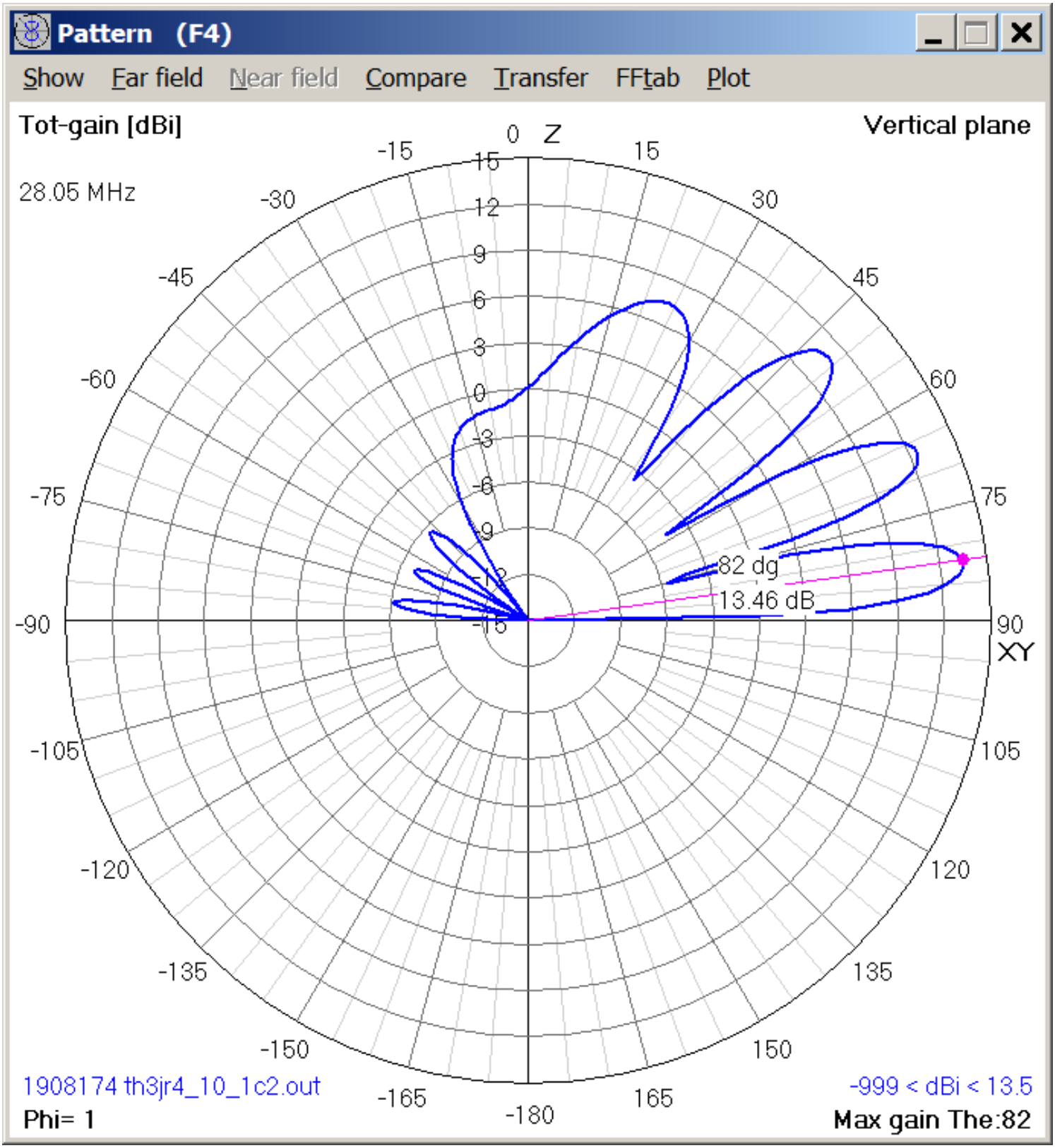
On **21.225 MHZ** showed a very **un**impressive -1.3Bi off the back of the beam

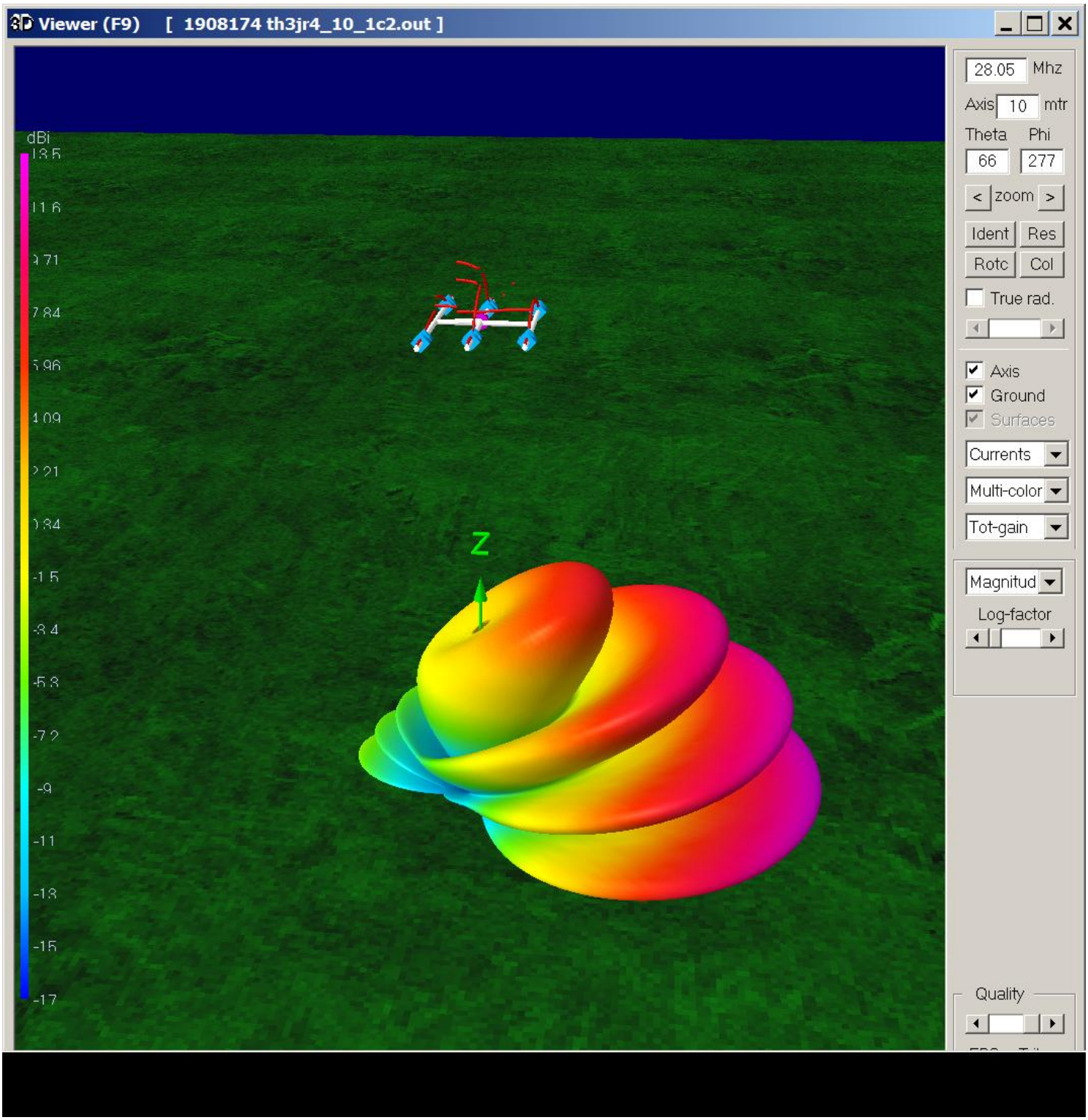


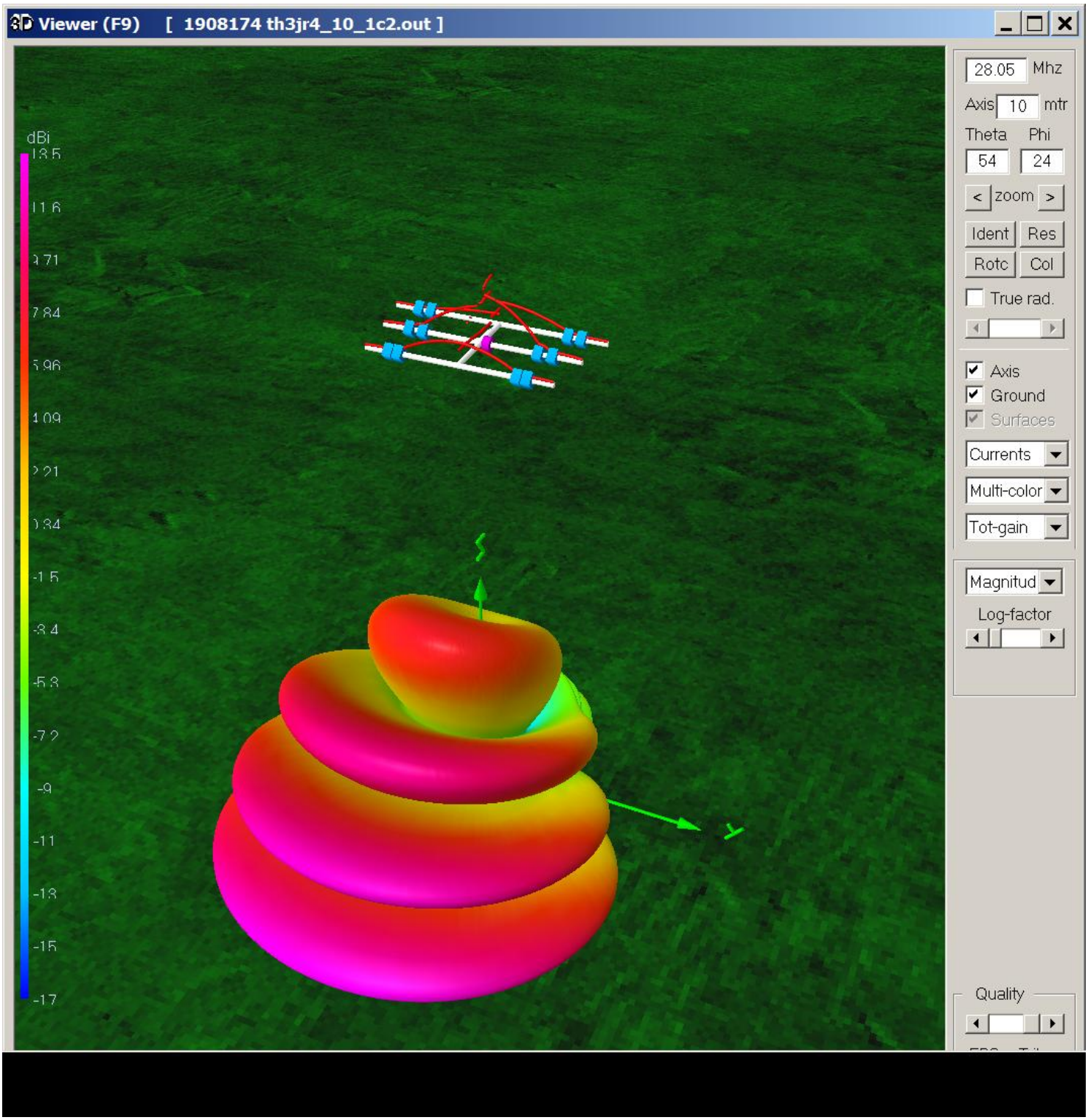


on 15 MHZ had currents formed only partly across the DE DIR and REF elements to 10m traps: Is better currents but these should extend at least out to the 15M trap.

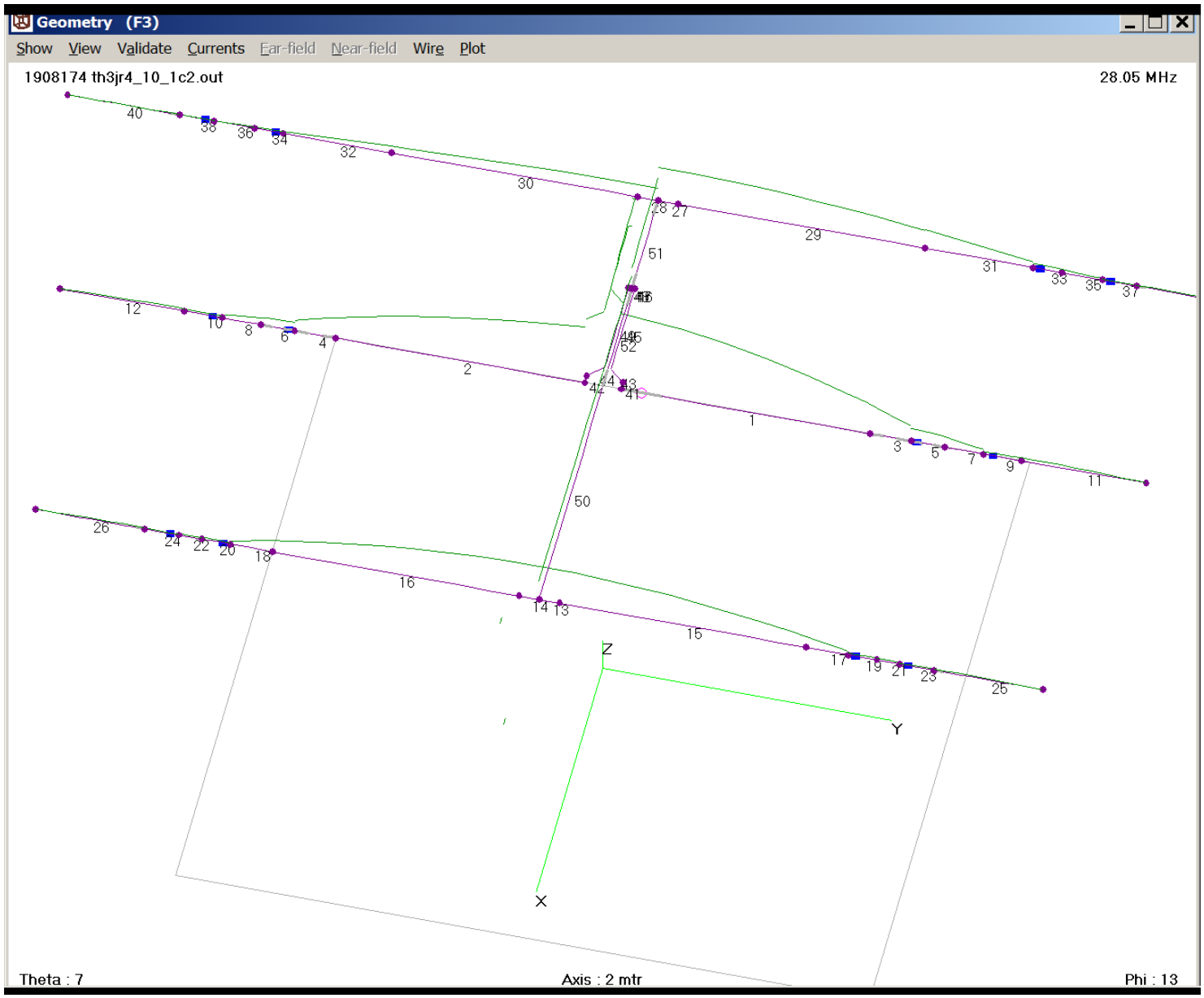
On **28.050** MHZ showed a **very impressive 13.46 dBi** off the front of the beam


Pattern (F4)
Show
Far field
Near field
Compare
Transfer
FFtab
Plot
Tot-gain [dBi]
Vertical plane
28.05 MHz
0
Z
15
30
45
60
75
90
XY
105
120
135
150
165
-180
-165
-150
-135
-120
-105
-90
-75
-60
-45
-30
-15
15
12
9
6
3
0
-3
-6
-9
-12
-15
82 dg
13.46 dB
1908174 th3jr4_10_1c2.out
Phi= 1
-999 < dBi < 13.5
Max gain The:82


3D Viewer (F9) [1908174 th3jr4_10_1c2.out]
dBi
13.5
11.6
9.71
7.84
5.96
4.09
2.21
0.34
-1.5
-3.4
-5.3
-7.2
-9
-11
-13
-15
-17
Z
28.05 Mhz
Axis 10 mtr
Theta Phi
66 277
< zoom >
Ident Res
Rotc Col
True rad.
Axis
Ground
Surfaces
Currents
Multi-color
Tot-gain
Magnitud
Log-factor
Quality



10 MHZ had high currents formed across the 10m sections of elements: shown above and below.



Conclusion: This antenna is of little or no use to me as it has no gain or performance on 20 meters.

Next Part of this article will tell you how the antenna model was analyzed and altered in the model to raise the 20m dBi peak off the front of the beam to 11.8dBi. Plots of the 10m and 20m band will also be supplied.

NEC File for TH3JR analyzed in Part 1.

```
CM Multi Band TH3JR (20m,15m,10m)
CM This is the full antenna with actual trap measurements
CM Lengths optimized for 20 meter above average ground
CE
SY delen = 0.737        'Director end length
SY DIRfifc = 2.46pF  '15m trap capacitance DIR&REF Actual measure  2.46pF
SY DIRfifi = 47.87uH                '15m trap inductance  DIR&REF  Actual measure 47.87uH
SY DEfii=46.08uH     '15MTRAP DE inductance Actual measure = 46.08uH
SY DEfic=2.34pF      '15MTRAP DE capacitance Actual measure =2.34pF
SY DEtei=7.56uH      '10MTRAP DE inductance       Actual measure  =7.56uH
SY DEtec=10.32pF     '10MTRAP DE capacitance   Actual measure  =10.32pF
SY REFteni= 11.09uH                '10M TRAP REF Actual measure = 11.09uH
SY REFtenc= 9.00pF '10M TRAP REF Actual measure = 9.00 pF
```

SY DIRteni=39.243uH '10M TRAP DIR Acutal measure =39.24uH
SY DIRtenc=2.11pF '10M TRAP DIR Acutal measure =2.11pF
SY REFfifc = 2.46pF '15m trap capacitance DIR&REF Actual measure 2.46pF
SY REFfifi = 47.87uH '15m trap inductance DIR&REF Actual measure 47.87uH
CM CM DRIVEN element

GW	3	6	0	0.125	20	0	1.845	20	2.20E-02
GW	4	6	0	-0.125	20	0	-1.845	20	2.20E-02
GW	5	3	0	1.845	20	0	2.131	20	1.60E-02
GW	6	3	0	-1.845	20	0	-2.131	20	1.60E-02
GW	11	3	0	2.131	20	0	2.366	20	1.60E-02
GW	12	3	0	-2.131	20	0	-2.366	20	1.60E-02
GW	7	2	0	2.366	20	0	2.633	20	1.90E-02
GW	8	2	0	-2.366	20	0	-2.633	20	1.90E-02
GW	21	2	0	2.633	20	0	2.892	20	1.90E-02
GW	31	2	0	-2.633	20	0	-2.892	20	1.90E-02
GW	9	8	0	2.892	20	0	3.756	20	1.10E-02
GW	10	8	0	-2.892	20	0	-3.756	20	1.10E-02

CM REFLECTOR

GW	51	1	1.905	0.14	20	1.905	0	20	2.20E-02
GW	59	1	1.905	0	20	1.905	-0.14	20	2.20E-02
GW	53	8	1.905	0.14	20	1.905	1.845	20	2.20E-02
GW	54	8	1.905	-0.14	20	1.905	-1.845	20	2.20E-02
GW	55	2	1.905	1.845	20	1.905	2.137	20	1.60E-02
GW	56	2	1.905	-1.845	20	1.905	-2.137	20	1.60E-02
GW	61	2	1.905	2.137	20	1.905	2.333	20	1.60E-02
GW	62	2	1.905	-2.137	20	1.905	-2.333	20	1.60E-02
GW	57	1	1.905	2.333	20	1.905	2.492	20	1.90E-02
GW	58	1	1.905	-2.333	20	1.905	-2.492	20	1.90E-02
GW	71	2	1.905	2.492	20	1.905	2.729	20	1.90E-02
GW	81	2	1.905	-2.492	20	1.905	-2.729	20	1.90E-02
GW	59	12	1.905	2.729	20	1.905	3.481	20	1.10E-02
GW	60	12	1.905	-2.729	20	1.905	-3.481	20	1.10E-02

CM DIRECTOR element

GW	101	1	-1.654	0.14	20	-1.654	0	20	2.20E-02
GW	102	1	-1.654	0	20	-1.654	-0.14	20	2.20E-02
GW	103	8	-1.654	0.14	20	-1.654	1.845	20	2.20E-02
GW	104	8	-1.654	-0.14	20	-1.654	-1.845	20	2.20E-02
GW	105	2	-1.654	1.845	20	-1.654	2.594	20	1.60E-02
GW	106	2	-1.654	-1.845	20	-1.654	-2.594	20	1.60E-02
GW	111	2	-1.654	2.594	20	-1.654	2.791	20	1.60E-02
GW	112	2	-1.654	-2.594	20	-1.654	-2.791	20	1.60E-02
GW	107	2	-1.654	2.791	20	-1.654	3.070	20	1.90E-02
GW	108	2	-1.654	-2.791	20	-1.654	-3.070	20	1.90E-02
GW	121	2	-1.654	3.070	20	-1.654	3.307	20	1.90E-02
GW	131	2	-1.654	-3.070	20	-1.654	-3.307	20	1.90E-02
GW	109	12	-1.654	3.307	20	-1.654	4.082	20	1.10E-02
GW	110	12	-1.654	-3.307	20	-1.654	-4.082	20	1.10E-02

cM
CM HAIR PIN included

GW	204	1	0	0.125	20	-0.055	0.125	20.046	0.008
GW	205	1	0	-0.125	20	-0.055	-0.125	20.046	0.008
GW	206	1	-0.055	0.125	20.046	-0.150	0.022	20.046	0.005
GW	207	1	-0.055	-0.125	20.046	-0.150	-0.022	20.046	0.005
GW	208	10	-0.866	0.022	20.046	-0.150	0.022	20.046	0.005
GW	209	1	-0.866	0.022	20.046	-0.866	0	20.046	0.003
GW	210	1	-0.866	0	20	-0.866	0	20.046	0.008
GW	211	1	-0.866	0	20.046	-0.866	-0.022	20.046	0.003
GW	212	10	-0.866	-0.022	20.046	-0.150	-0.022	20.046	0.005
CM BOOM				X1	Y1	Z1	X2	Y2	Z2
GW	201	6	1.905	0	20	0	0	20	3.20E-02
GW	202	6	-1.654	0	20	-0.866	0	20	3.20E-02
GW	203	6	-0.866	0	20	0	0	20	3.20E-02
GE	-1								
LD	6	11	1	1	100	DEtei	DEtec		
LD	6	12	1	1	100	DEtei	DEtec		
LD	6	21	1	1	100	DEfii	DEfic		
LD	6	31	1	1	100	DEfii	DEfic		
LD	6	61	1	1	100	DIRteni	DIRtenc		
LD	6	62	1	1	100	DIRteni	DIRtenc		
LD	6	71	1	1	100	DIRfifi	DIRfifc		
LD	6	81	1	1	100	DIRfifi	DIRfifc		
LD	6	111	1	1	100	REFteni	REFtenc		

LD	6	112	1	1	100	REFteni	REFtenc
LD	6	121	1	1	100	REFfifi	REFfifc
LD	6	131	1	1	100	REFfifi	REFfifc
LD	5	3	0	0	24900000	'Alum. 6061-T6	
LD	5	4	0	0	24900000	'Alum. 6061-T6	
LD	5	5	0	0	24900000	'Alum. 6061-T6	
LD	5	6	0	0	24900000	'Alum. 6061-T6	
LD	5	11	0	0	24900000	'Alum. 6061-T6	
LD	5	12	0	0	24900000	'Alum. 6061-T6	
LD	5	7	0	0	24900000	'Alum. 6061-T6	
LD	5	8	0	0	24900000	'Alum. 6061-T6	
LD	5	21	0	0	24900000	'Alum. 6061-T6	
LD	5	31	0	0	24900000	'Alum. 6061-T6	
LD	5	9	0	0	24900000	'Alum. 6061-T6	
LD	5	10	0	0	24900000	'Alum. 6061-T6	
LD	5	51	0	0	24900000	'Alum. 6061-T6	
LD	5	53	0	0	24900000	'Alum. 6061-T6	
LD	5	54	0	0	24900000	'Alum. 6061-T6	
LD	5	55	0	0	24900000	'Alum. 6061-T6	
LD	5	56	0	0	24900000	'Alum. 6061-T6	
LD	5	61	0	0	24900000	'Alum. 6061-T6	
LD	5	62	0	0	24900000	'Alum. 6061-T6	
LD	5	57	0	0	24900000	'Alum. 6061-T6	
LD	5	58	0	0	24900000	'Alum. 6061-T6	
LD	5	71	0	0	24900000	'Alum. 6061-T6	
LD	5	81	0	0	24900000	'Alum. 6061-T6	
LD	5	59	0	0	24900000	'Alum. 6061-T6	
LD	5	60	0	0	24900000		
LD	5	101	0	0	24900000	'Alum. 6061-T6	
LD	5	103	0	0	24900000	'Alum. 6061-T6	
LD	5	104	0	0	24900000	'Alum. 6061-T6	
LD	5	105	0	0	24900000	'Alum. 6061-T6	
LD	5	106	0	0	24900000	'Alum. 6061-T6	
LD	5	111	0	0	24900000	'Alum. 6061-T6	
LD	5	112	0	0	24900000	'Alum. 6061-T6	
LD	5	107	0	0	24900000	'Alum. 6061-T6	
LD	5	108	0	0	24900000	'Alum. 6061-T6	
LD	5	121	0	0	24900000	'Alum. 6061-T6	
LD	5	131	0	0	24900000	'Alum. 6061-T6	
LD	5	109	0	0	24900000	'Alum. 6061-T6	
LD	5	110	0	0	24900000		
LD	5	201	0	0	24900000	'Alum. 6061-T6	
LD	5	202	0	0	24900000	'Alum. 6061-T6	
LD	5	203	0	0	24900000	'Alum. 6061-T6	
LD	5	204	0	0	24900000	'Alum. 6061-T6	
LD	5	205	0	0	24900000	'Alum. 6061-T6	
LD	5	206	0	0	24900000	'Alum. 6061-T6	
LD	5	207	0	0	24900000	'Alum. 6061-T6	
LD	5	208	0	0	24900000	'Alum. 6061-T6	
LD	5	209	0	0	24900000	'Alum. 6061-T6	
LD	5	210	0	0	24900000	'Alum. 6061-T6	
LD	5	211	0	0	24900000	'Alum. 6061-T6	
LD	5	212	0	0	24900000	'Alum. 6061-T6	
GN	2	0	0	0	13	0.005	
EK							
EX	0	3	1	0	1	0	0
FR	0	0	0	0	14.225	0	
EN							

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