High performance 1.9m station for 23cm EME

How a 1.9m mesh wire dish can outperform most current 3m+ system

August 9, 2024
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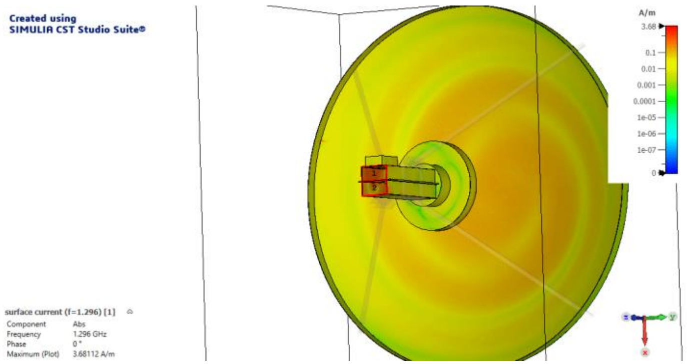
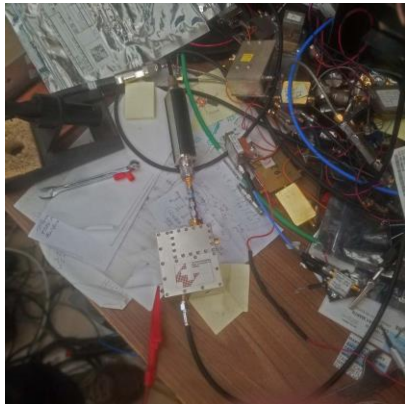
KB2SA

AGENDA

- Acknowledgements
- Why use a 1.9m dish?
- Hardware highlights
- Simulation highlights
- 1.9m feed on 4.88m dish
- Noteworthy 1.9m 23cm QSOs
- What's next?





ACKNOWLEDGEMENTS

WHO HELPED

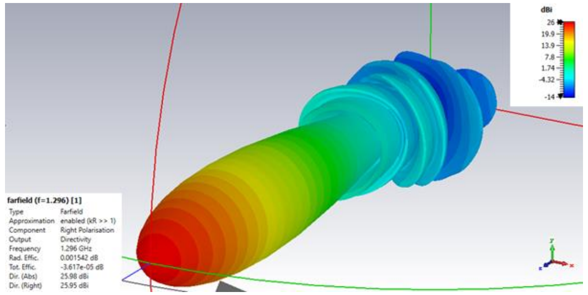
- Rastislav (Rasto) Galuscak (OM6AA) for hundreds of hours of simulation
- Rfspin s.r.o. for the use of SIMULIA CST Studio Suite® www.rfspin.com
- Bob Atkins (KA1GT) for his idea on using a square to round waveguide taper
- Paul Chominski (WA6PY) for expert advice, measurements and review
- Mats Bengtsson (KD5FZX) for building the optimized “KB2SA feed” and reporting excellent performance using a solid 4.88M, f/d = 0.39 dish.

WHY USE A 1.9M DISH?

WHY USE A 1.9M DISH?

LESS COULD BE MORE

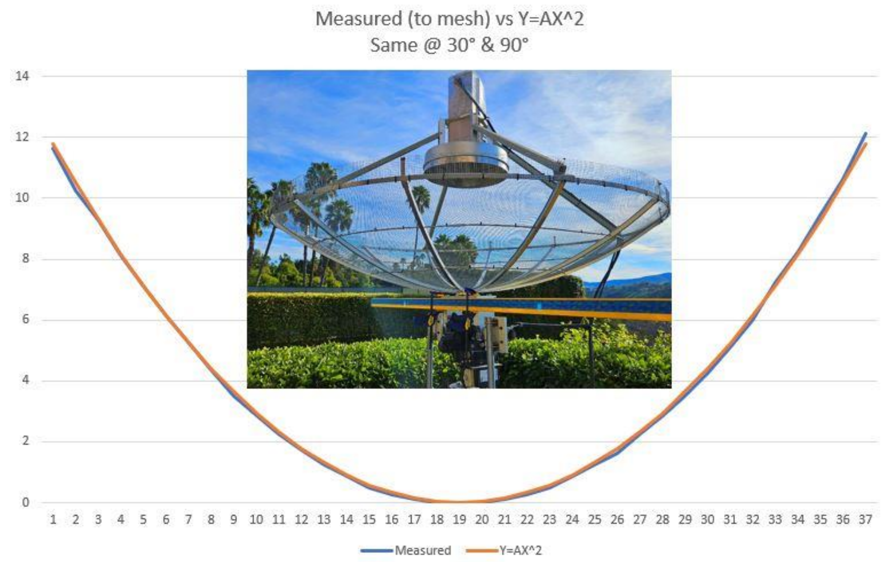
- Virtually invisible to weather
- Nearly invisible to guests
- Easy to tune & service
- Wide beamwidth hides tracking errors (-1 db when 2° off)
- Short Tx cable to feed (14’)

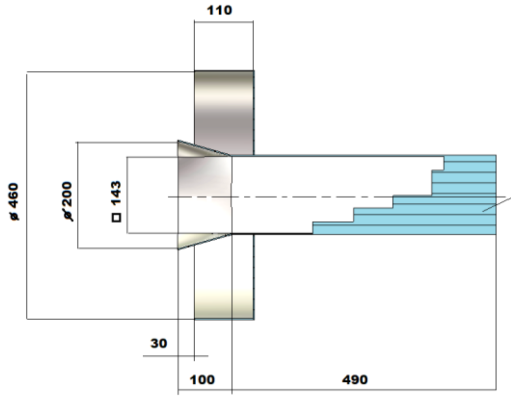


HARDWARE HIGHLIGHTS

HARDWARE HIGHLIGHTS

The devil's in the details





- ***Excellent parabolic surface***
- ***Low loss Rx probe to LNA input***
  Amphenol AD-SMAPSMAP-2
  RLC Electronics SR-2MIN-H
  HUBER+SUHNER 32_SMA-50-0-1/111_NE
- ***Precise feed construction and dimensions***
- Fiberglass struts
- S12 isolation disk
- Dish collar ring

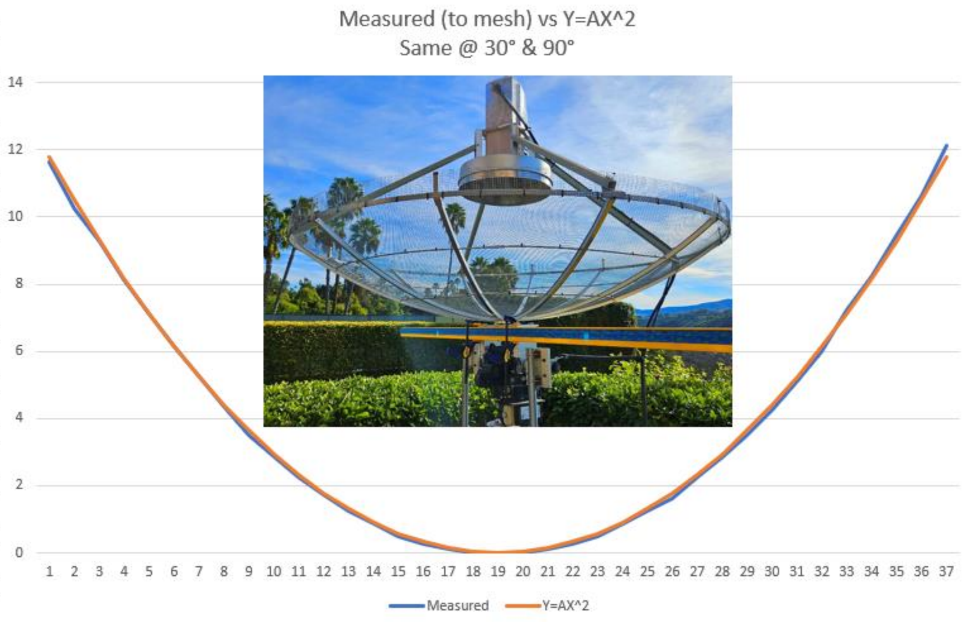
- D = Dish Diameter = 75.5” (1.92 M)
- Y = Measured every 2” along X
- Subtract Bias from Y to zero in center
- Y = A * X^2 (Select A for best fit)
- Actual Focus Point (f) = 1 / (4*A) = 27.47”
- Actual f/D = 27.47” / 75.5” = **0.364**

EXCELLENT PARABOLA

Measure It!

X	Y (90°)	Y-Bias (90°)	Y=AX^2 (90°)
-36	13.125	11.625	11.7936
-34	11.75	10.25	10.5196
-32	10.75	9.25	9.3184
-30	9.625	8.125	8.19
-28	8.625	7.125	7.1344
-26	7.625	6.125	6.1516
-24	6.75	5.25	5.2416
-22	5.875	4.375	4.4044
-20	5	3.5	3.64
-18	4.375	2.875	2.9484
-16	3.75	2.25	2.3296
-14	3.25	1.75	1.7836
-12	2.75	1.25	1.3104
-10	2.375	0.875	0.91
-8	2	0.5	0.5824
-6	1.75	0.25	0.3276
-4	1.625	0.125	0.1456
-2	1.5	0	0.0364
0	1.5	0	0
2	1.5	0	0.0364
4	1.625	0.125	0.1456
6	1.75	0.25	0.3276
8	2	0.5	0.5824
10	2.375	0.875	0.91
12	2.75	1.25	1.3104
14	3.125	1.625	1.7836
16	3.75	2.25	2.3296
18	4.375	2.875	2.9484
20	5	3.5	3.64
22	5.75	4.25	4.4044
24	6.625	5.125	5.2416
26	7.5	6	6.1516
28	8.75	7.25	7.1344
30	9.75	8.25	8.19
32	11	9.5	9.3184
34	12.125	10.625	10.5196
36	13.625	12.125	11.7936

Bias:	1.50	inches	
A:	0.0091	adjust for best fit	
D:	75.50	inches(measured)	1.92m
f/D (spec):	0.35		
f (calc):	26.43	inches	
f (actual):	27.47	inches	
f/D (actual):	0.364		



- Ruze’s equation (685.81 * (ε/λ)^2) estimates gain loss in db due to RMS surface errors (ε). If λ = 230 mm and ε = 5 mm, loss = 0.3 dB.
- The effort to estimate the gain loss is usually far more complex than the effort to fix it.
- Tweak “A” in ideal parabola to best fit measured parabola.
- Correct deformation throughout and calculate actual f and f/D.

RX PROBE TO LNA LOSS

1 dB for every 0.1 dB

ASSUME:

85° F ambient (300K)
LNA NF = 0.25 dB
No TX port noise (S12 is high)
Relay + connector loss = 0.1 dB

- Equivalent LNA noise = 300 * (10^((0.25+0.1)/10) – 1) = **25.18K**
- LNA noise = 300 * (10^((0.25)/10) – 1) = **17.78K**
- Antenna noise @ 30° elevation = **12K**

Rx performance loss = 10 * LOG[(25.18+12) / (17.78+12)] = **.96 dB**

- With typical 23cm LNA NF and antenna noise, a 0.1 dB loss between the RX probe and LNA input decrease RX sensitivity by almost 1 dB.
- ***6' of LMR-600 on 23cm is 0.3 dB. This would decrease RX sensitivity by 2.46 dB.***

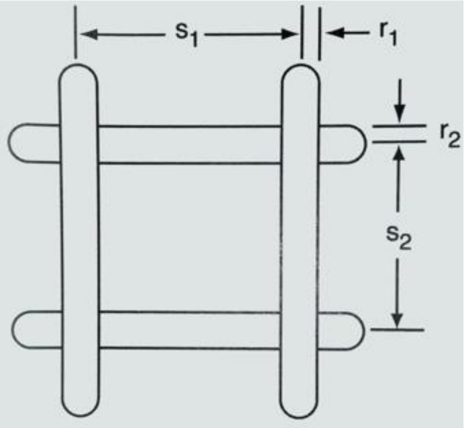
GAIN LOSS WITH MESH

<0.2 dB if holes < Lamba/10

- S, D specified for popular galvanized fence wire mesh
- Dish gain loss **.022 dB** @ 23 cm

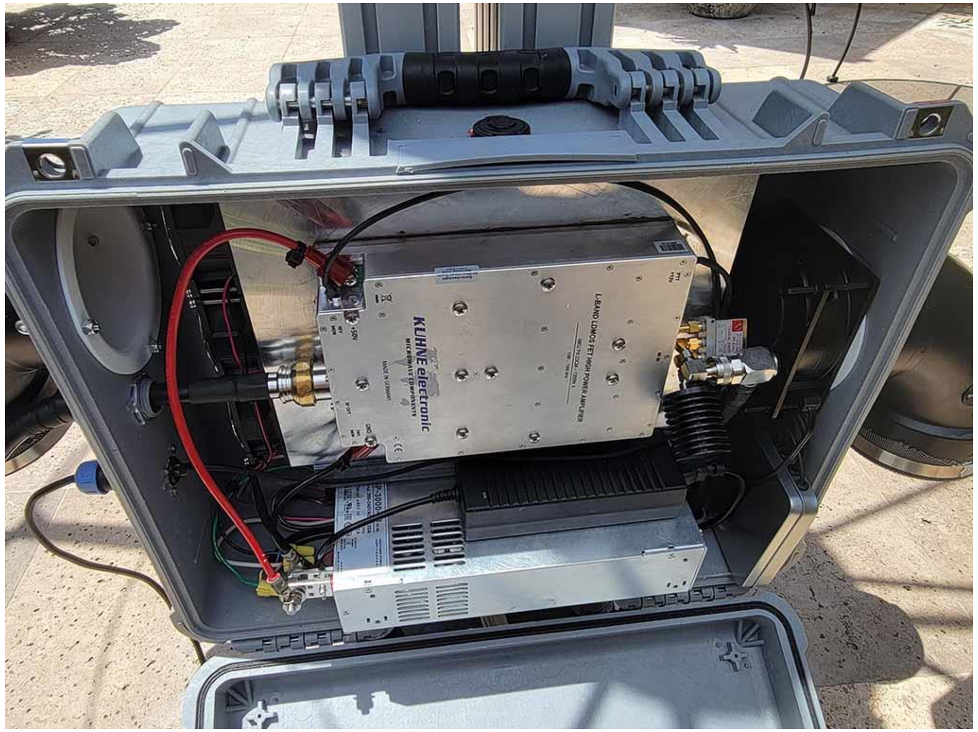
Define:

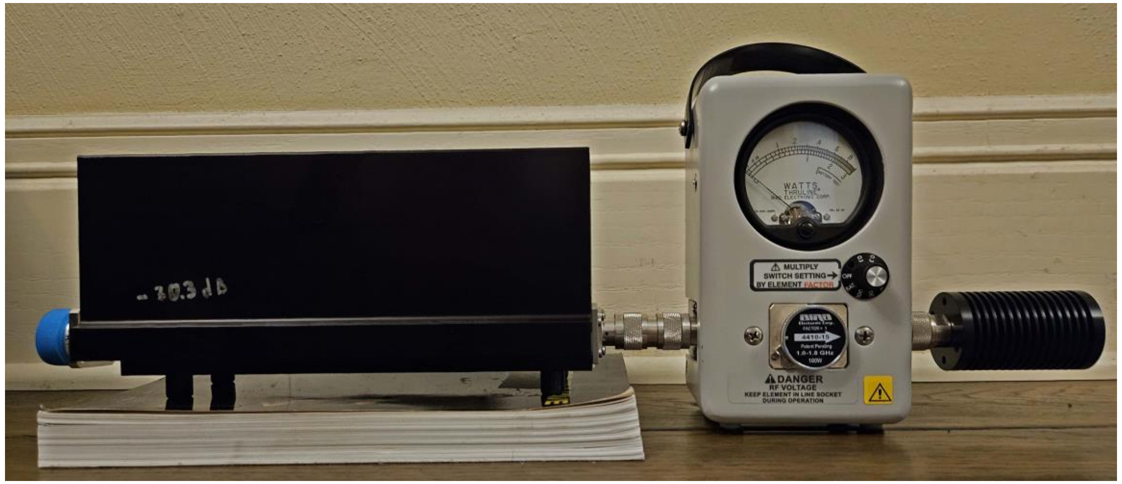
Dish Gain Loss (dB) = 10 * LOG (X / (X – 1))
X = 10 ^ (Mesh Loss (dB) / 10)
S = S1 = S2 = 6 mm
D = 2*R1 = 2*R2 = 0.55 mm
L = 230 mm (23 cm wavelength in mm)
V = LN (1 / (1 - EXP (-π*D/S))) = 1.38



Mesh Loss (dB) = 20 * LOG (L / (2 * S * V)) = 22.9 dB
X = 10 ^ (22.9 / 10) = 194.98

Dish Gain Loss (dB) = 10 * LOG (194.98 / (194.98 -1)) = .022 dB

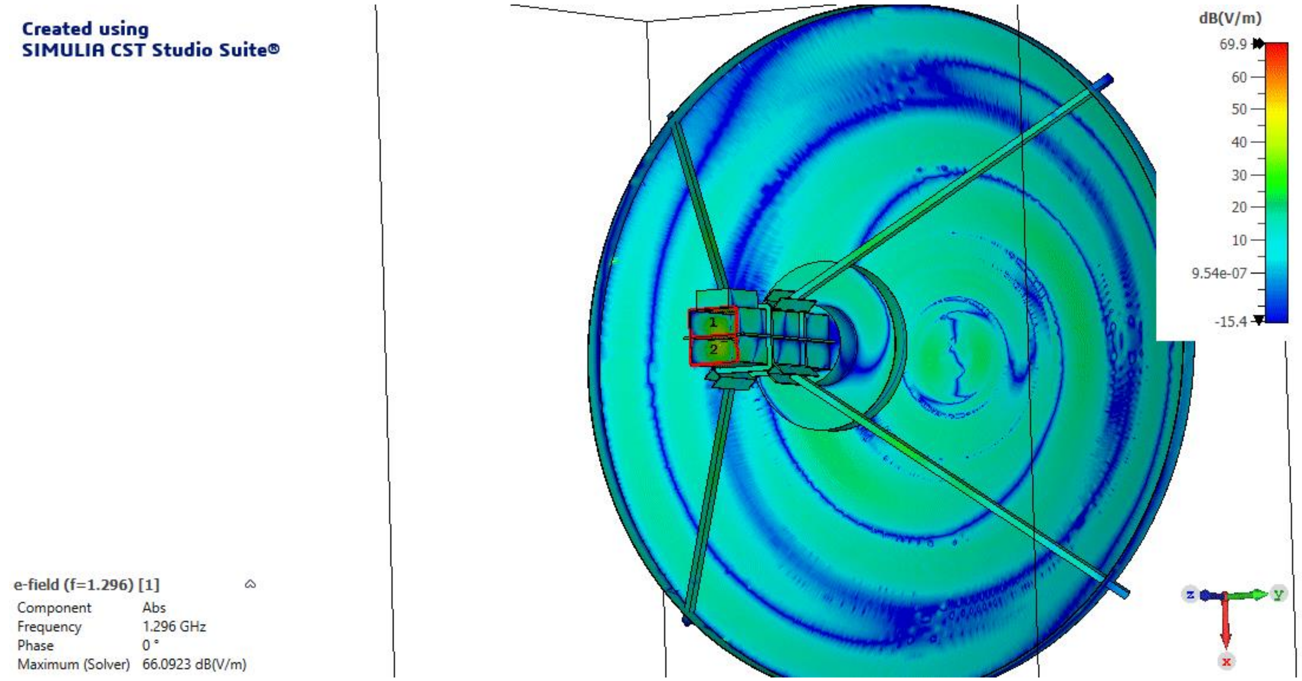




910W @ TX PORT

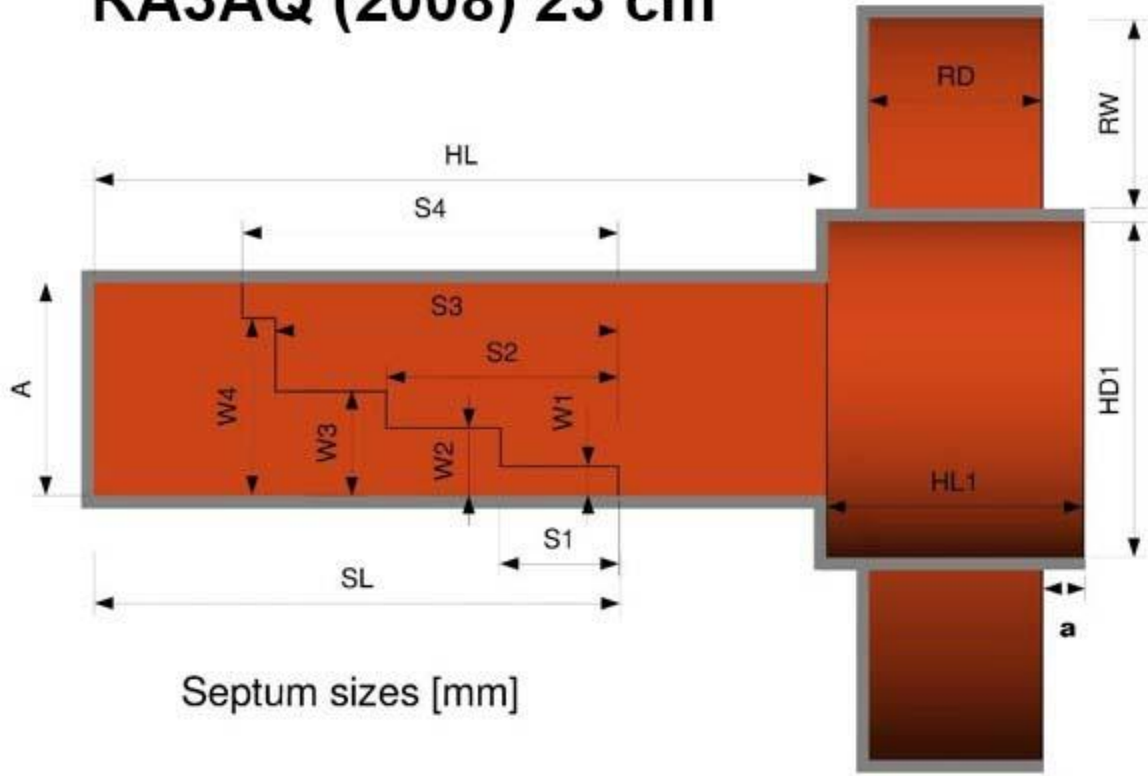
1200W PA Near Dish

- IC-9700 @ 35% → **3W**
- Q5 Signal 2330PA → **28W**
- 52’ LMR-600-DB → **20W**
- Kuhne 1200W → **1,020W**
- 14’ LMR-600-FR → **910W**
- All measured with calibrated Bird 4410A w/4410-15 slug and Bird 500-WA-MFN-30 attenuator.



SIMULATION HIGHLIGHTS

RA3AQ (2008) 23 cm



Septum sizes [mm]

F[MHz]	A	HL	SL	W1	W2	W3	W4	S1	S2	S3	S4
1296	143,0	475,0	340,0	22,2	46,9	70,9	117,7	75,6	148,6	220,5	242,3

Output section [mm]

F[MHz]	HD1	HL1	RW	RD
1296	214,0	173,0	118.0	81.0

SIMULATION HIGHLIGHTS

Starting Feed

- Simulations start with an RA3AQ-type feed tuned prior to simulations for maximum sun to cold sky with 1.9m mesh wire dish with f/d = 0.35
- Dish mesh S = 6 mm, D = 0.55 mm
- Updated to RW = 118 mm, RD = 60 mm and a = 30 mm based on highest sun to cold sky.
- Feed constructed from a modified RF HAMDESIGN feed.

No Choke | Choke

Absolute

Choke narrows beamwidth & lowers sidelobes

Left Polar

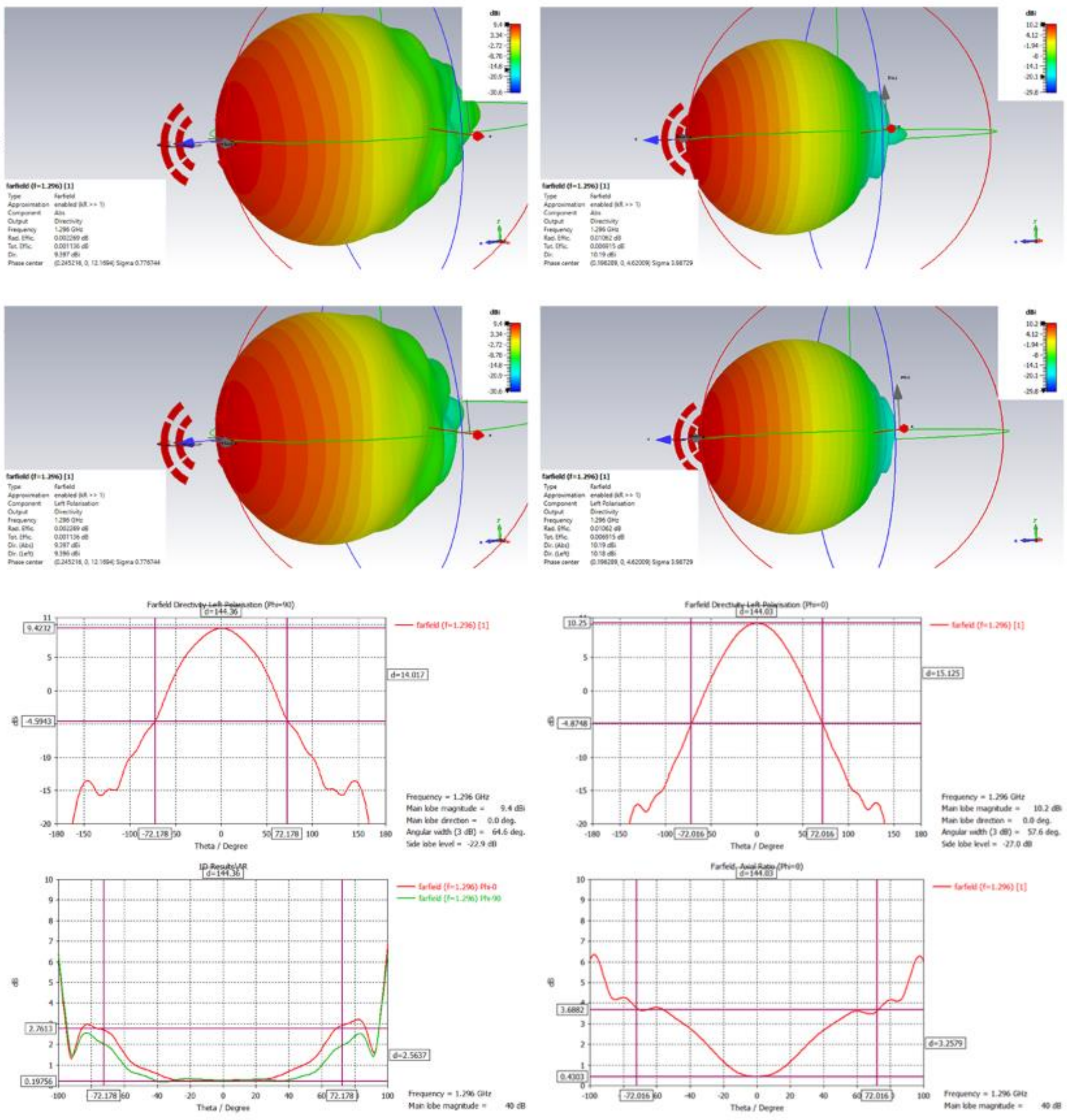
Same results with left polar

Left Polar

Choke 1 dB less power at dish perimeter with lower sidelobes

Axial Ratio

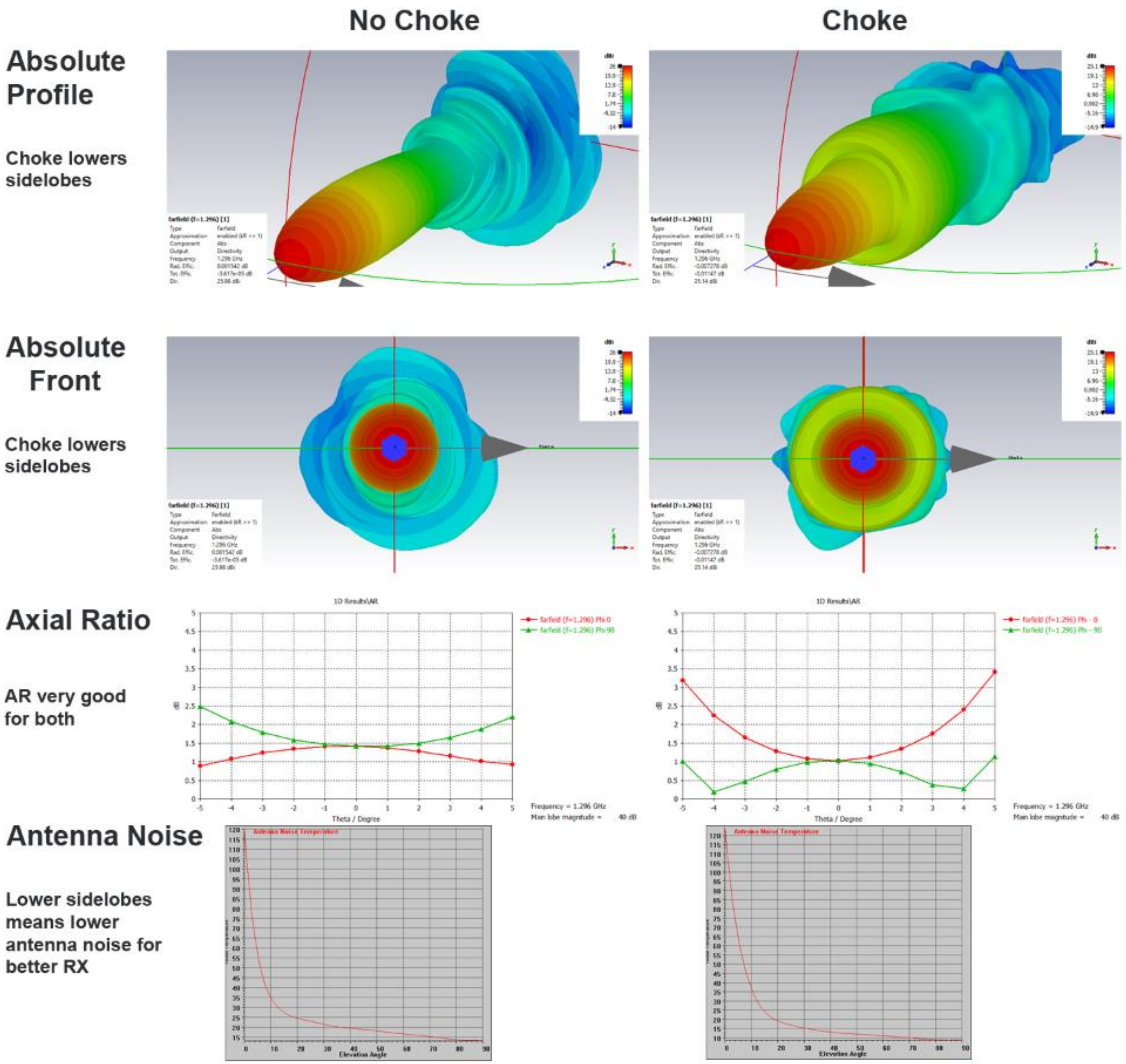
AR very good for both.



SIMULATION HIGHLIGHTS

Feed Only (no dish)
With/Without Choke

- Feed only (no dish) shows noticeable narrower beamwidth and lower sidelobes with choke
- 3 db beamwidth reduced from 64.6^{o} to 57.6^{o}
- Sidelobes reduced 4 dB
- Axial ratio good with/without choke

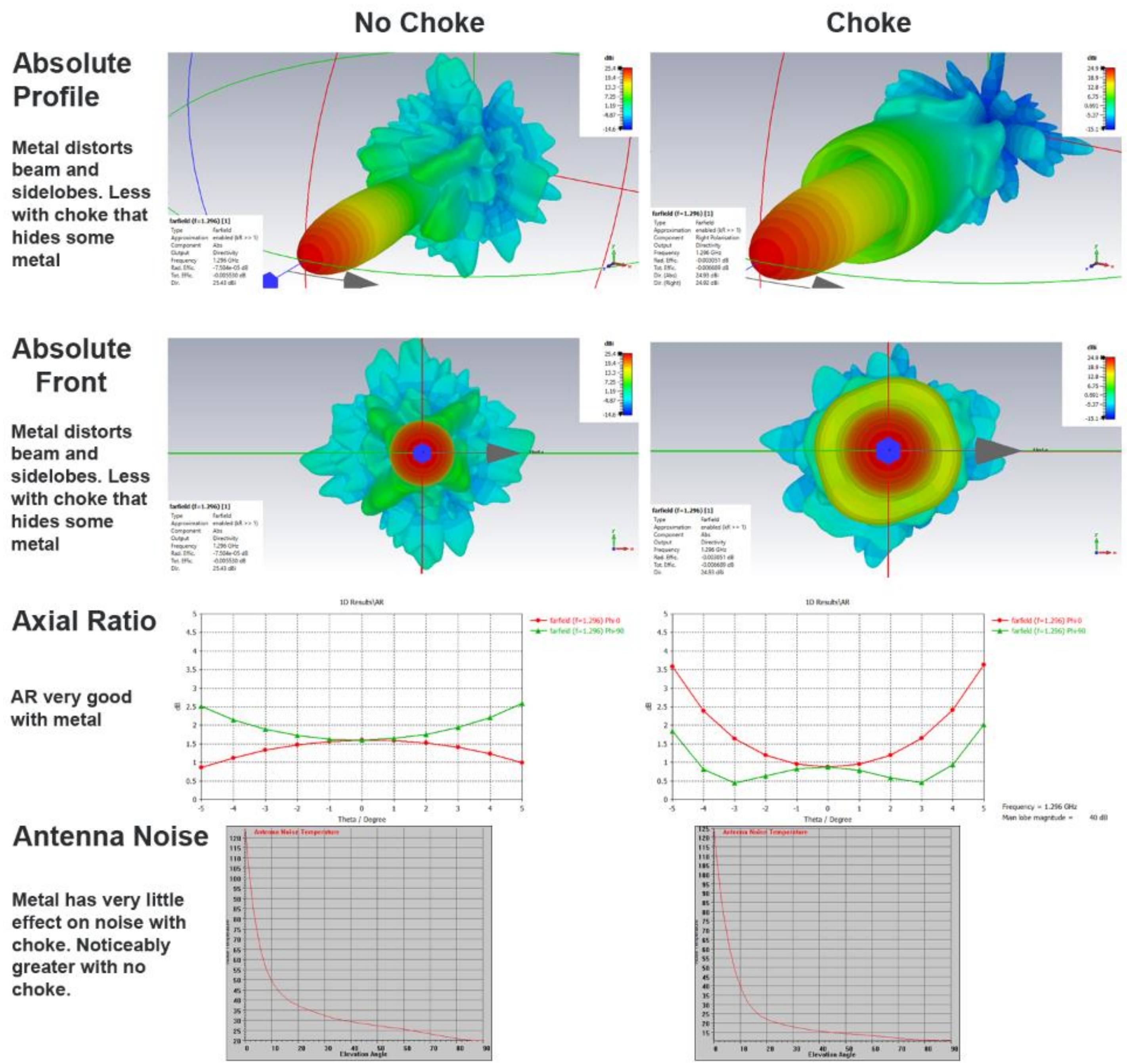


SIMULATION HIGHLIGHTS

Feed + Dish
Fiberglass Struts
With/Without Choke

- Choke lowers sidelobes (as expected from the feed-only behavior)
- Lower sidelobes result in lower antenna noise vs. dish elevation
- Antenna noise calculated with OM6AA Antenna Noise Temperature Calculator (ANTC) fed with simulated radiation patterns.
- $G/Ts_{\,dB} = 10*LOG\ [\ 10\text{^}(Gmax_{\,dBi}/10)\ /$

  $(LNA\ NF_{\,K} + Antenna\ Noise_{\,K})\ ]$



SIMULATION HIGHLIGHTS

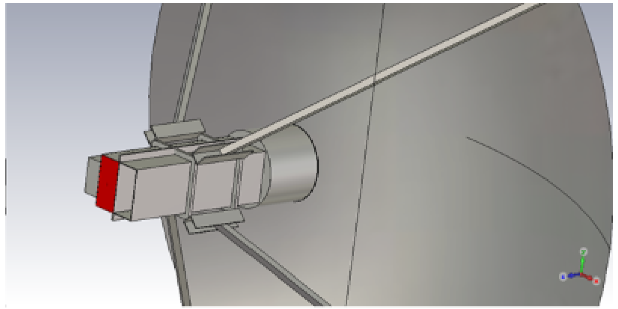
Feed + Dish
Aluminum Struts
With/Without Choke

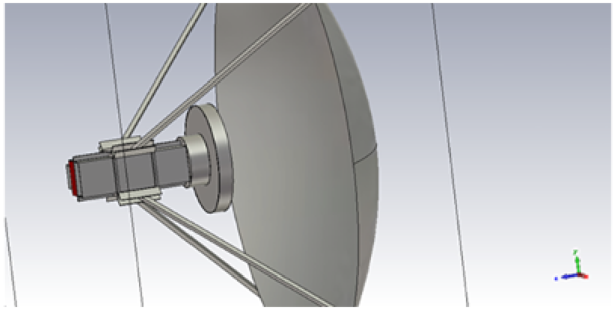
- Aluminum struts distort the beam and sidelobes
- Distortion is less noticeable with choke
- Noise temperature noticeably higher with Aluminum struts, even with choke (e.g., 3K @ 30°)

	No Choke	Choke

Simulator Model

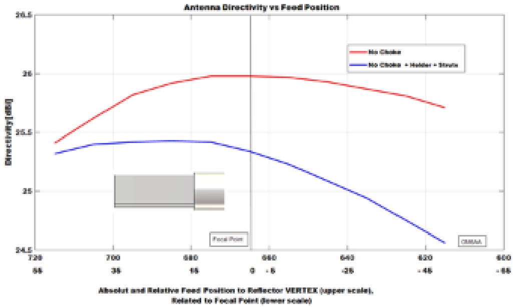
Simulia CST MW Studio. I-solver used for Dish+Feed T-solver for Feed only.

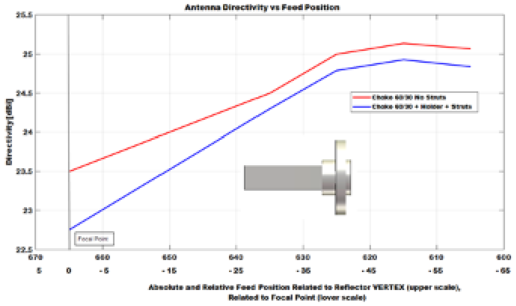




Feed Position

Choke much more sensitive to Feed Position





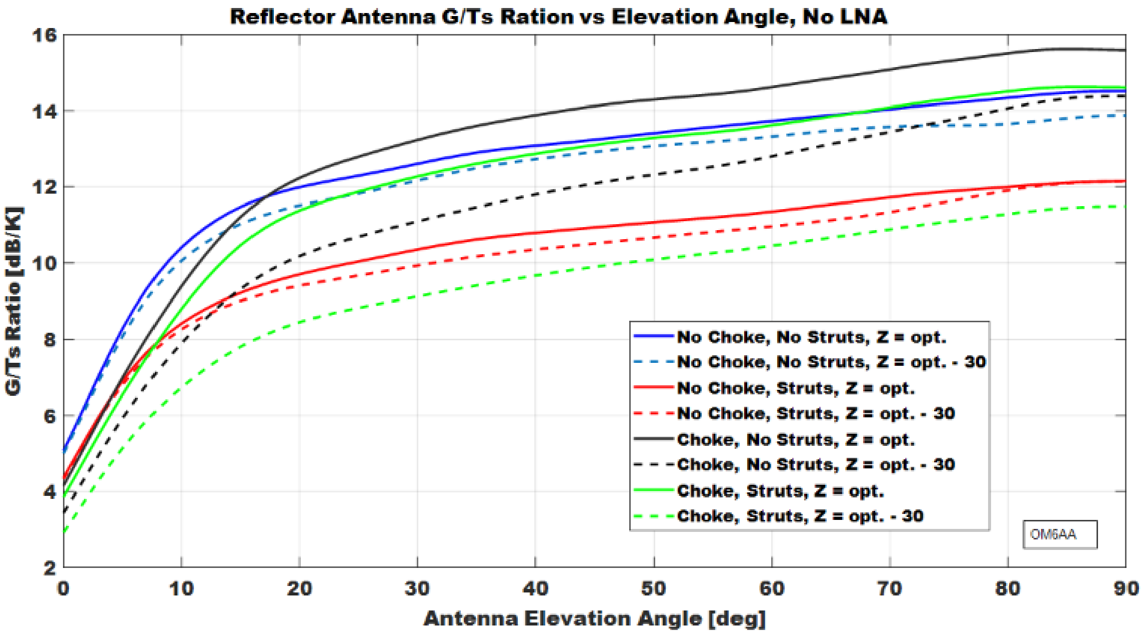
G/Ts, NF = 0dB

Choke is the winner with or without metal struts

No choke can get close, but requires no metal struts

Choke much more sensitive to Feed Position

Z opt = +10 mm no choke; -50 mm choke



SIMULATION HIGHLIGHTS

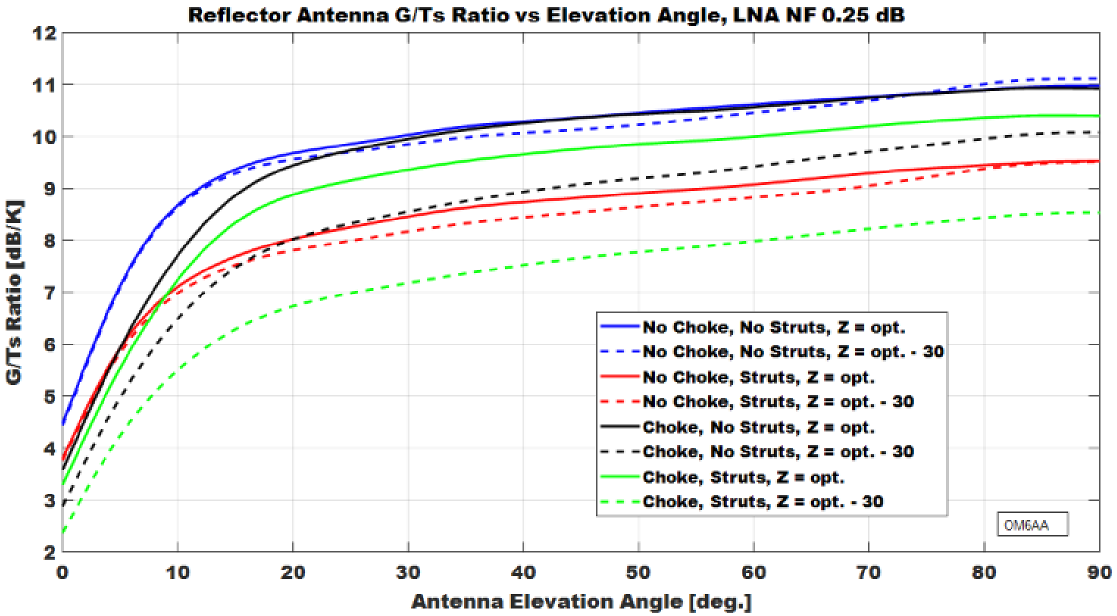
Feed + Dish
With/Without Choke
Summary 1 of 3

- Performance more sensitive to feed position with choke.
- Focus point +10 mm <u>outside</u> aperture without choke, -50 mm <u>inside</u> aperture with choke.
- With choke, -30 mm for best RX, -50 mm for best TX.
- Without choke, +10 mm for best RX, +10 mm for best TX.
- If invisible struts and holder, No Choke has about 1 dB more TX but 2 dB less RX.
- Struts and holder affect No Choke much more – nearly 2 dB on RX and 0.5 dB on Tx.

G/Ts, NF = 0.25dB

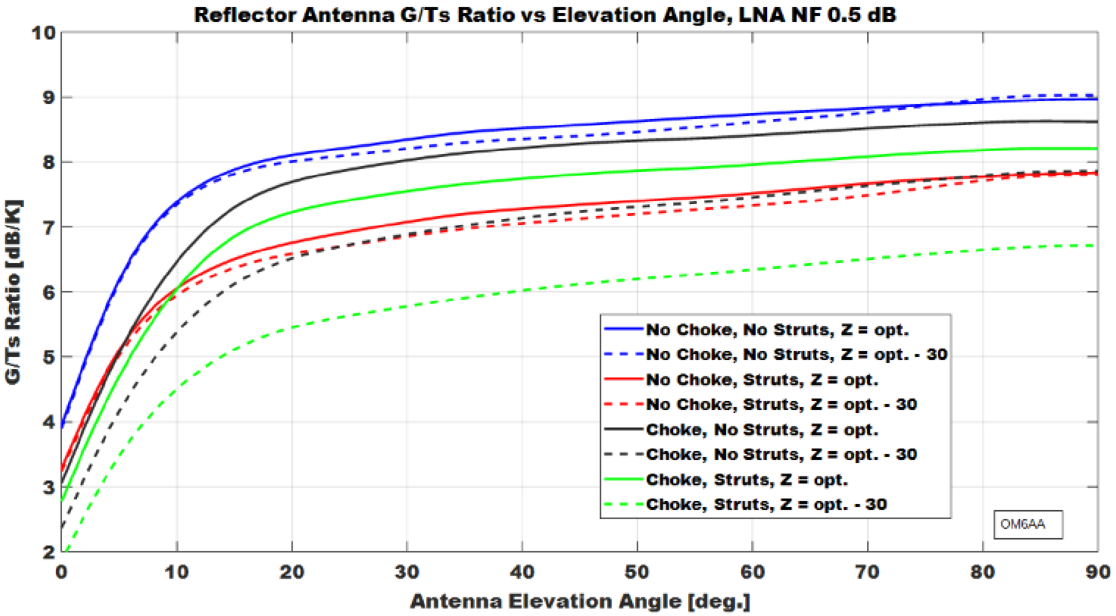
Added noise from a typical LNA @ 23 cm lowers the advantage of Choke vs No Choke

With metal struts, Choke still > 1 dB better than No Choke



G/Ts, NF = 0.50dB

Higher NF reduces Choke advantage to < 1 dB



SIMULATION HIGHLIGHTS

Feed + Dish
With/Without Choke
Summary 2 of 3

- Added LNA noise starts to mask advantage of choke and fiberglass struts.
- With LNA NF = 0.25 dB and fiberglass struts, No Choke can slightly outperform choke on RX.
- ***This indicates an RA3AQ-type feed with fiberglass struts may be best with no choke.***

SIMULATION HIGHLIGHTS

Feed + Dish
With/Without Choke
Summary 3 of 3

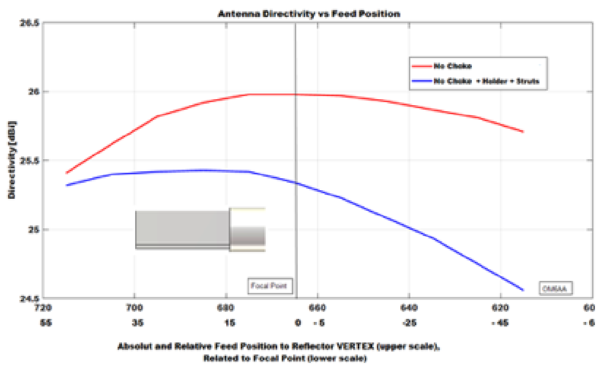
- RA3AQ-type feed without Choke also has better TX.

Gain (G)

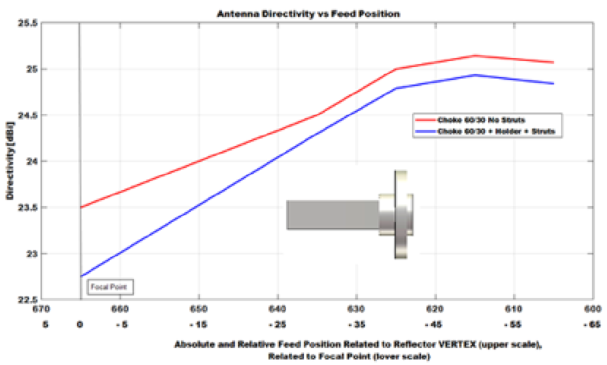
With no struts, No Choke has 0.8 dB higher gain

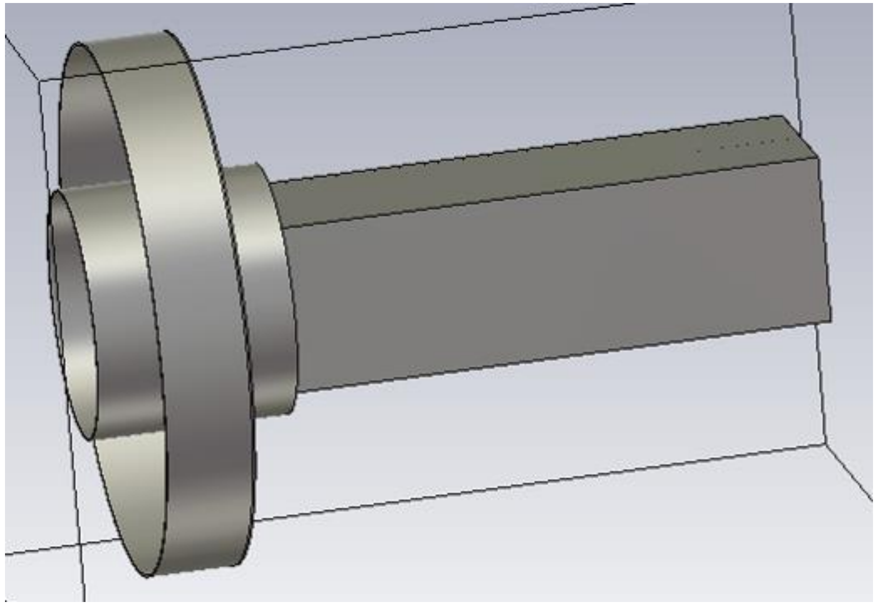
With struts, No Choke has 0.5 dB higher gain

No Choke

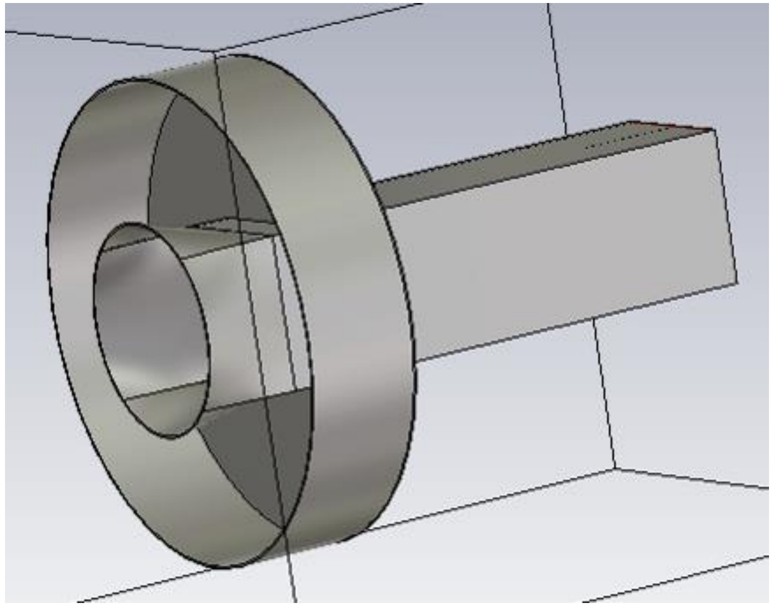


Choke



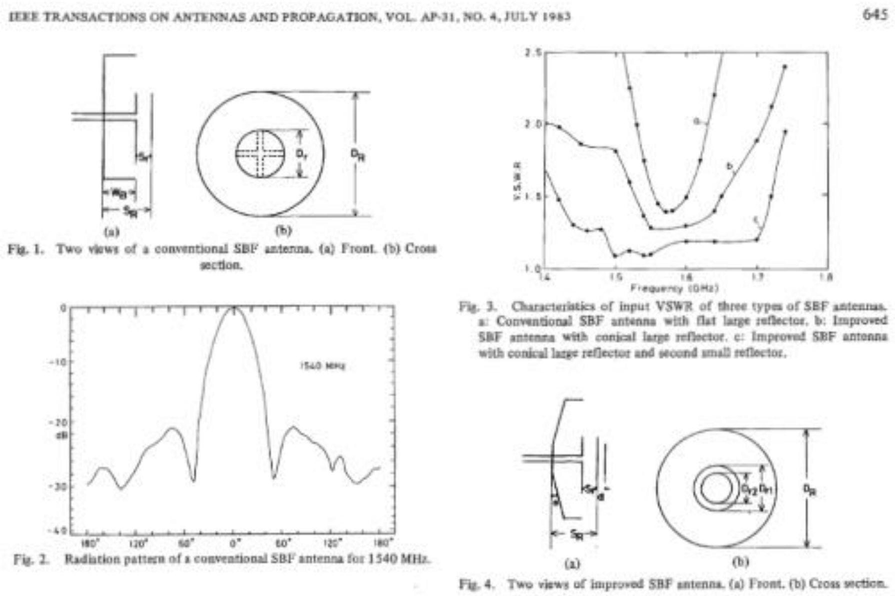


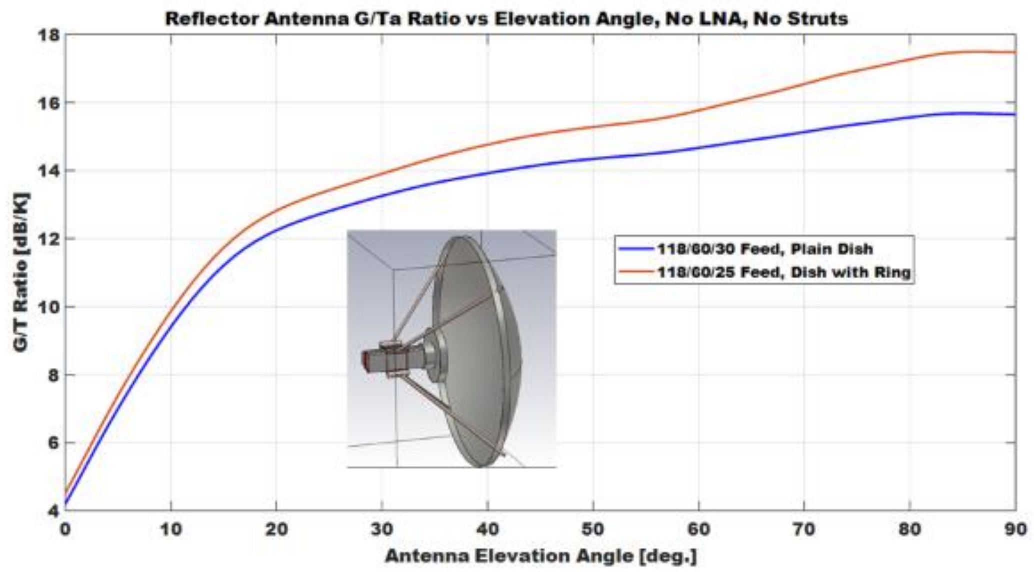
RA3AQ-type



Better?

CAN WE IMPROVE AN RA3AQ-TYPE FEED FOR A 1.9M F/D = 0.35 DISH?

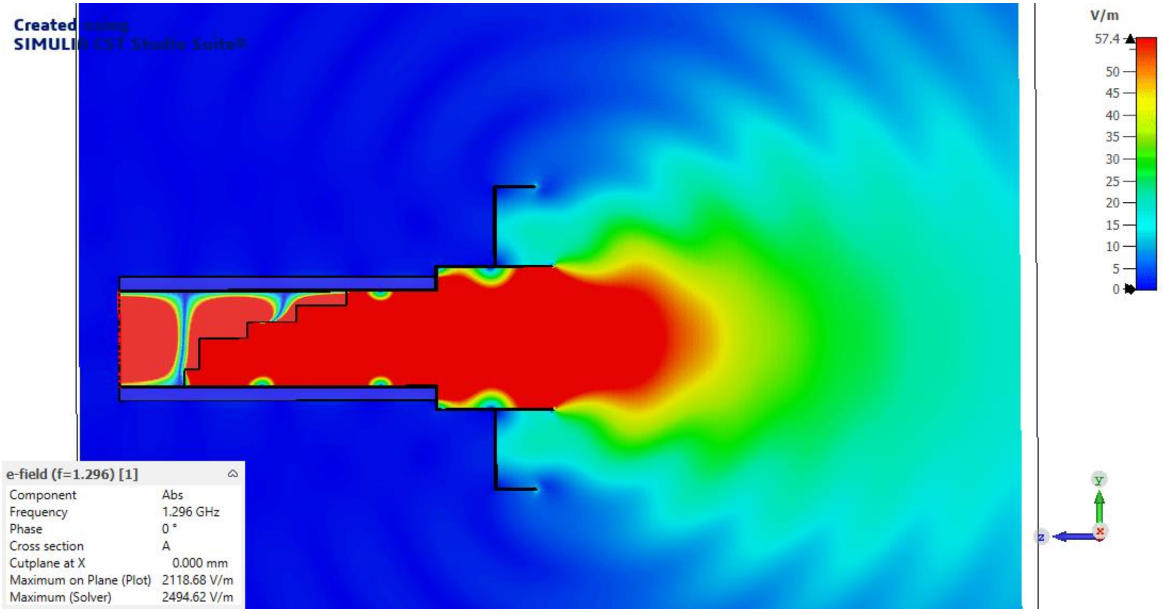


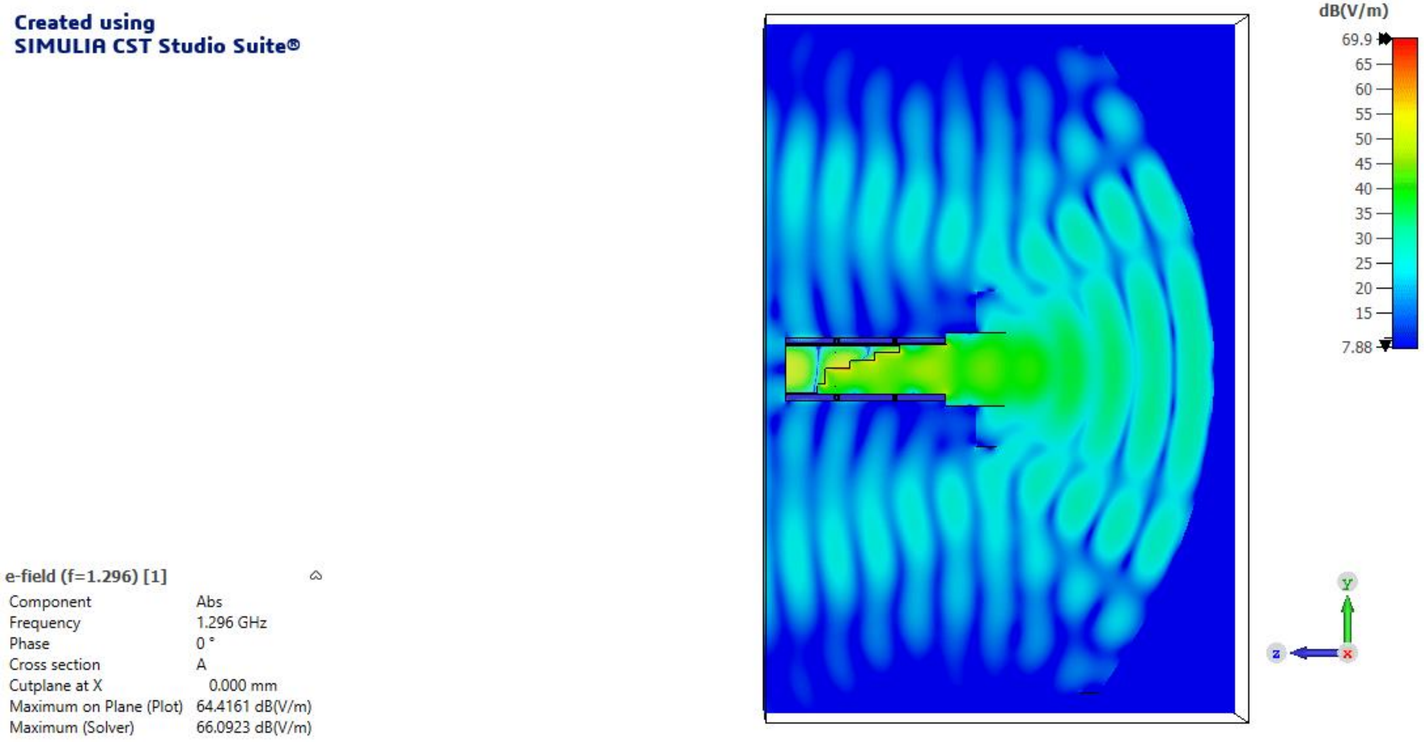


SHORT BACKFIRE BEHAVIOR

Feed + Dish
Add Dish Collar Ring
Improvement 1 of 16

- Simulations find the dish + feed combination provided two optimal focal points. This hints that the system may be operating as a Short Backfire Antenna (SBF).
- With a SBF, the choke + dish form a resonating cavity **with reduced sidelobes**. This helps negate the choke obstruction.
- Based on 1983 IEEE paper, an SBF antenna benefits with a Lamba/4 dish collar ring (58 mm).
- > 1 dB G/Ta simulated RX improvement with > 0.5 dB measured sun to cold sky improvement.





RESONANT WAVES

Feed + Dish
Add Dish Collar Ring
Improvement 2 of 16

- With feed alone, choke fills with the E field.
- When dish added, three partially stationary waves form between dish vertex and feed. These are resonant waves.
- Choke fills with the waves reflected off the dish. **Reversed waves folding on choke rim combine with reflected waves to help reduce sidelobes with collar ring.**
- Disadvantage is S12 reduced from 30 dB to only 14 dB due to dish reflection.

Square to Round Taper

The feed only pattern with a square to round taper (KA1GT) is nearly the same as that from the "perfect" round septum feed (VE4MA/OM6AA)

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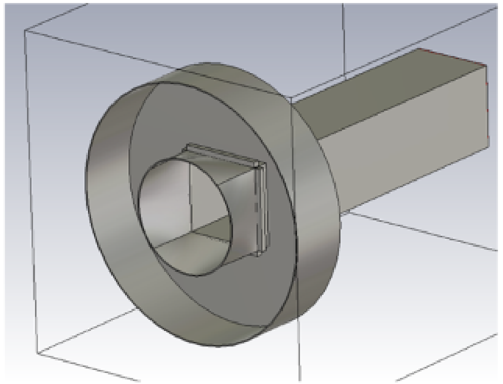
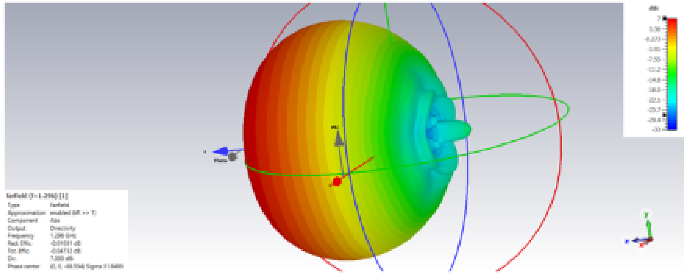


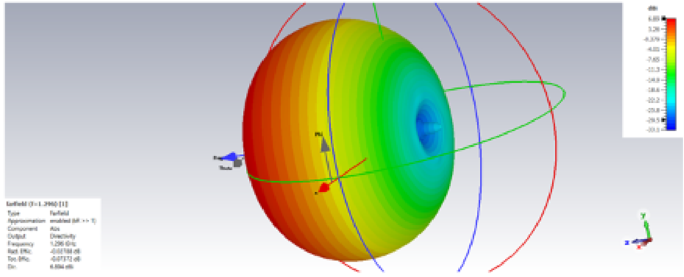
SQUARE TO ROUND TAPER

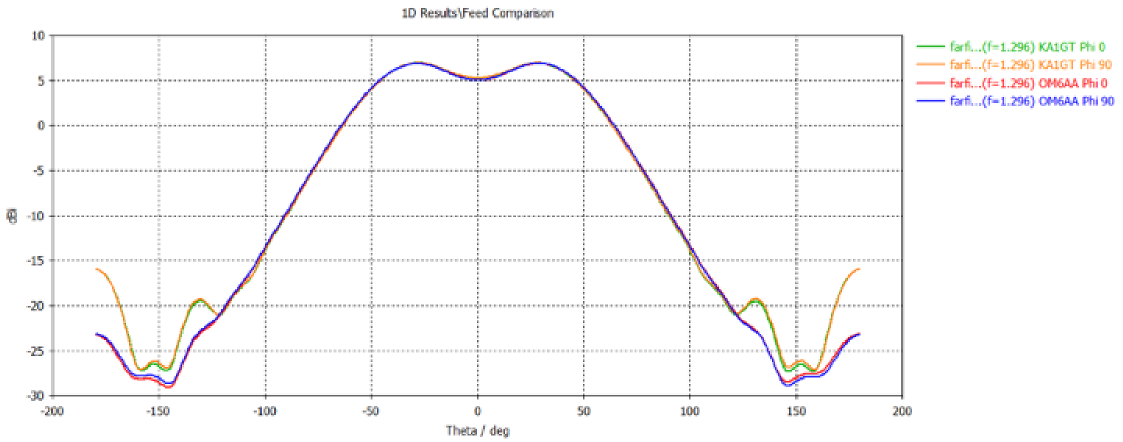
Feed only
Square to Round Taper
Improvement 3 of 16

Square to Round Feed-only Pattern



Round Feed-only Pattern



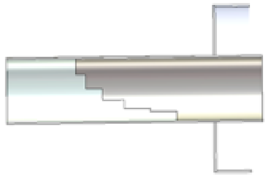


- Based on excellent RX performance observed by KA1GT, the abrupt square to round RA3AQ transition is replaced with a smooth square to round taper.
- ***Feed-only simulation indicates the pattern is nearly identical to a VE4MA/OM6AA round septum.***

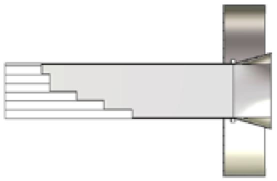
Comparing 3 “Best” Feeds

Extensive simulations at optimal focus and choke position yielded two feed competitors: OM6AA and KA1GT

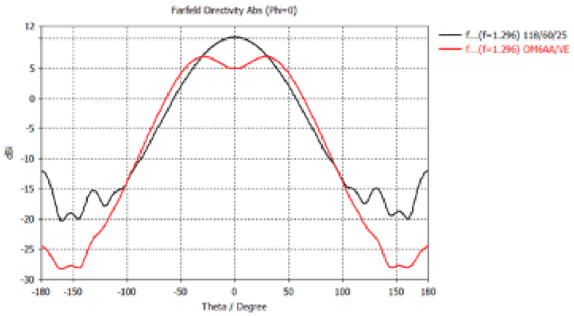
OM6AA Round Septum w/ Super VE4MA Choke

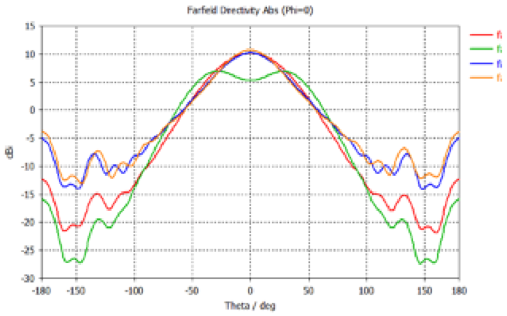


KA1GT Square to Round



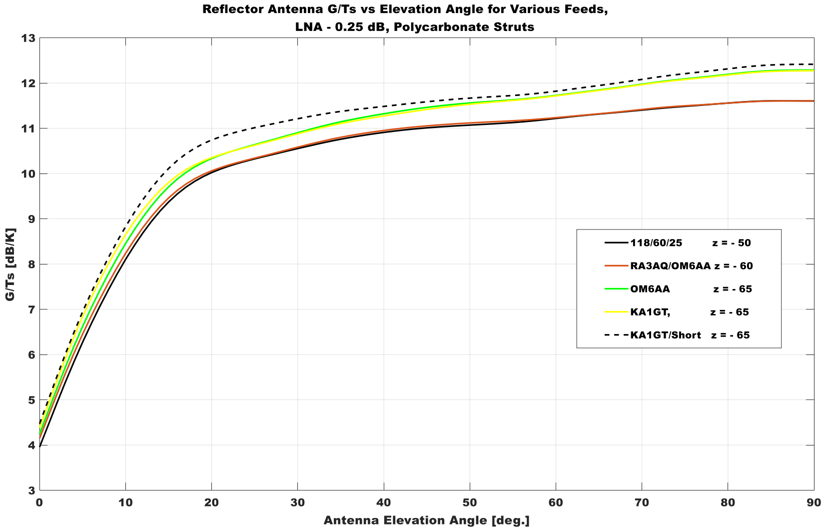
Both feeds have a “fatter” pattern (fill the dish better) with lower sidelobes





Both feeds @ optimal focus provide similar RX performance that exceeds the optimized RA3AQ feed.

At the optimal RX focus, KA1GT feed provides the best TX performance and is the least sensitive to changes in the focal point



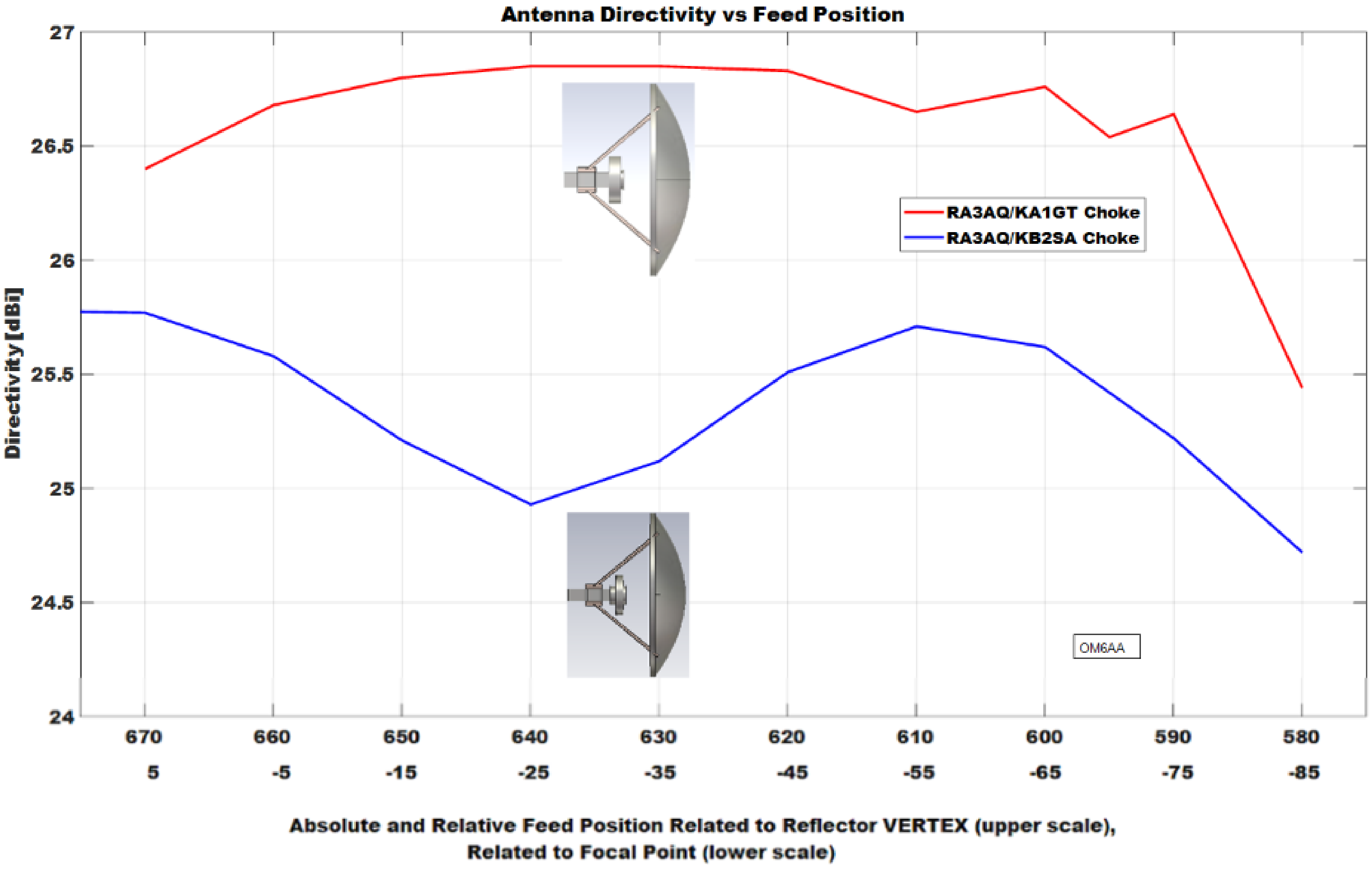
FATTER PATTERN

Feed only & Feed + Dish
Square to Round Taper
Improvement 4 of 16

- Both the round septum and square to round taper show > 1 dB RX performance increase over the RA3AQ feed.
- Both feeds have a “fatter” pattern that fills the dish better with significantly lower sidelobes.

Antenna Directivity

When comparing the KA1GT system to the 118_60_30 RA3AQ system, we find the KA1GT system has significantly higher TX gain that is less dependent on feed position.



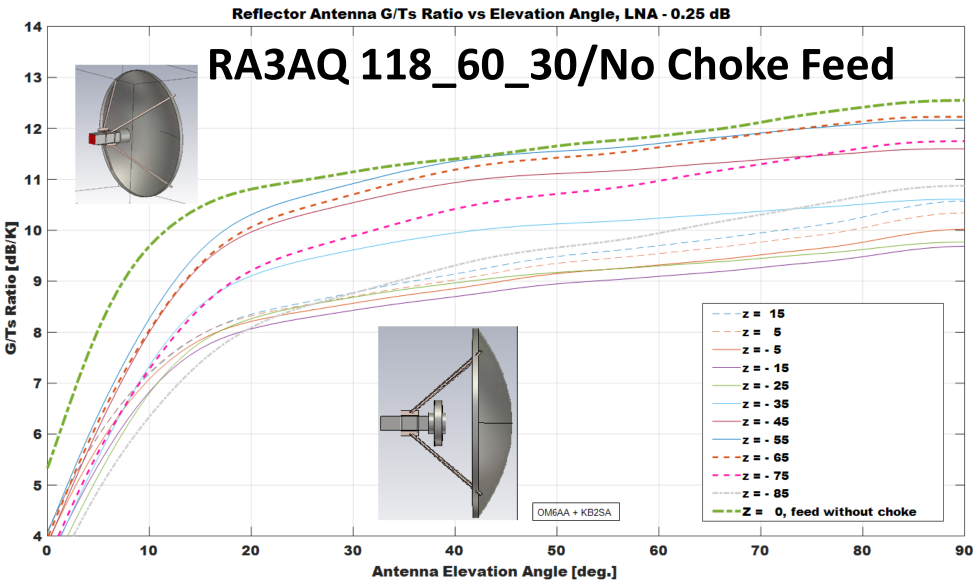
SAME TX AND RX POSITION

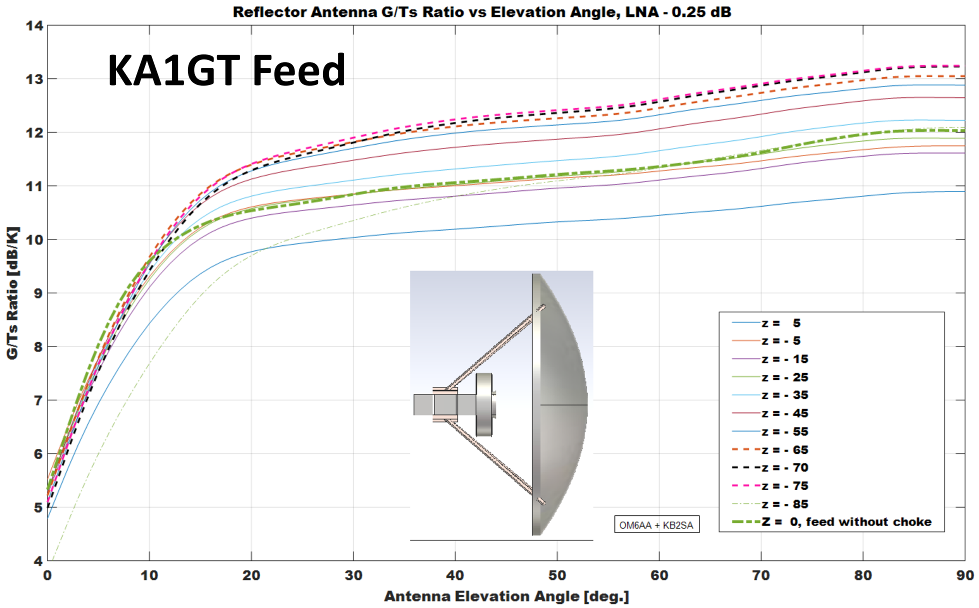
Feed + Dish
Square to Round Taper
Improvement 5 of 16

- The smooth square to round taper also shows a significant improvement over the abrupt square to round transition for TX gain.
- TX gain improved 1 dB and is less dependent on feed position.
- ***The optimal feed position is also nearly the same for both RX and TX.***

RX Performance

When comparing the KA1GT system to the 118_60_30 system, we find the KA1GT system has significantly higher RX performance at the optimal focal point. KA1GT also less susceptible to focal point changes.





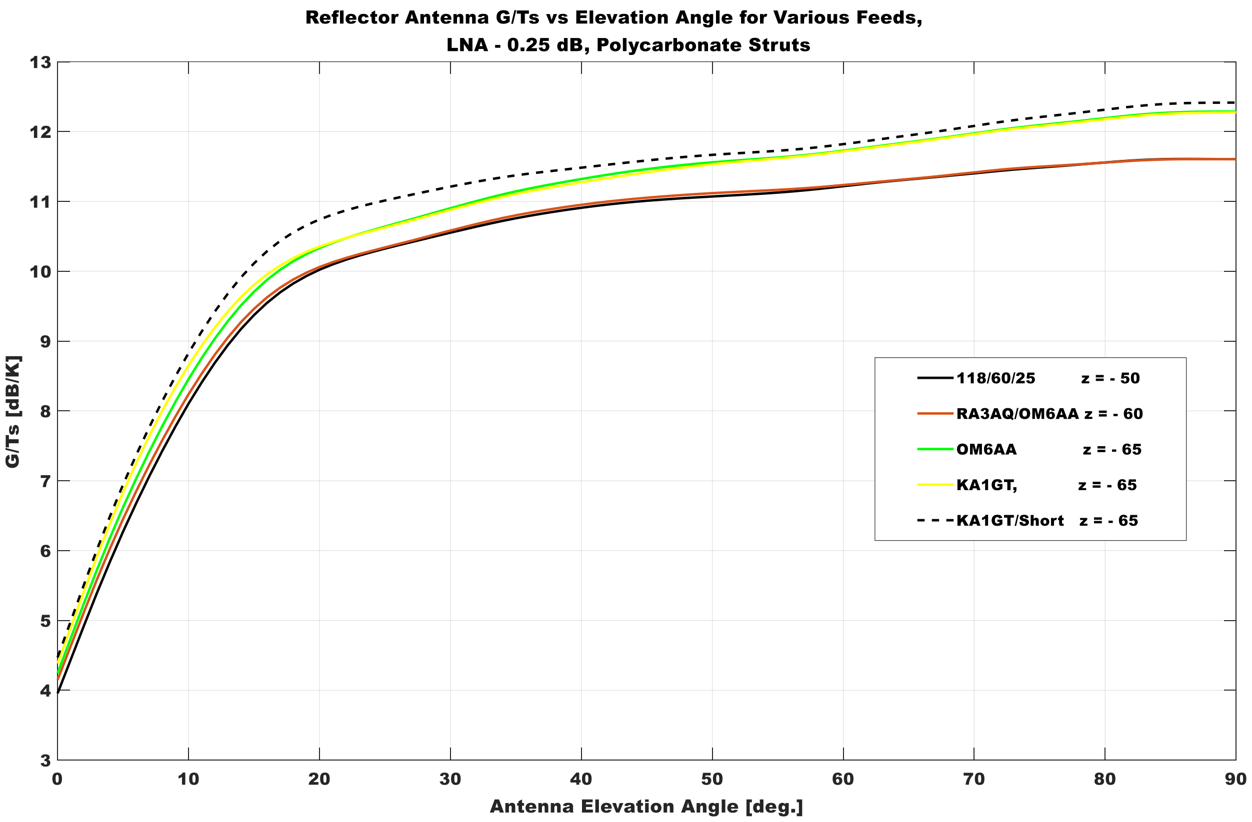
SQUARE TO ROUND TAPER!

Feed + Dish
Square to Round Taper
Improvement 6 of 16

- In summary, the smooth square to round taper has > 1 dB RX performance gain over the abrupt square to round transition.
- The RX performance is also less susceptible to feed position.
- ***RA3AQ feed with No Choke better than Choke.***

Can we shorten the KA1GT feed?

To help lower feed weight, simulations were performed on a shortened KA1GT feed. G/Ts performance is not degraded, but S12 decreased from 20 to 18 dB.



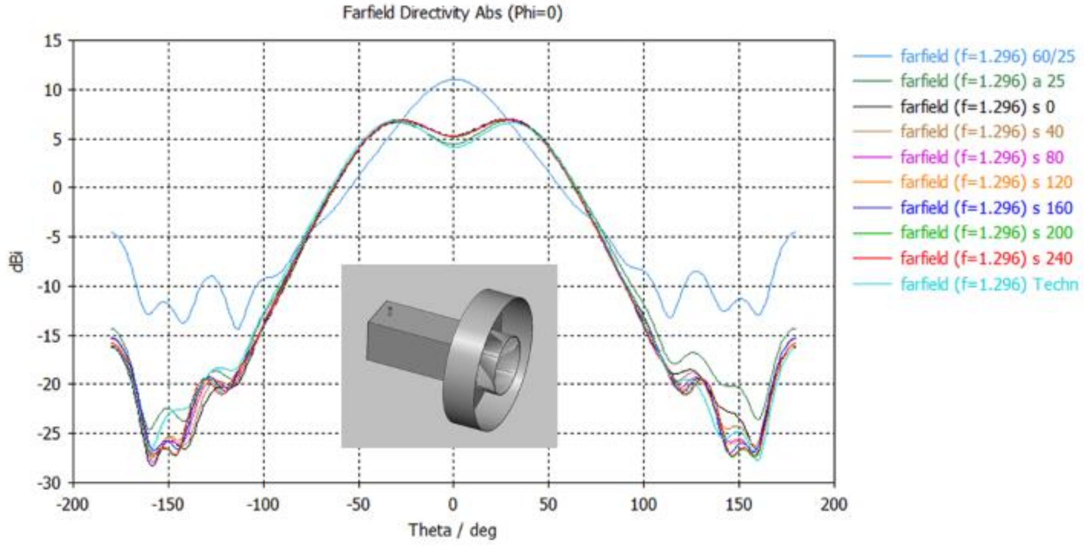
CAN WE SHORTEN FEED?

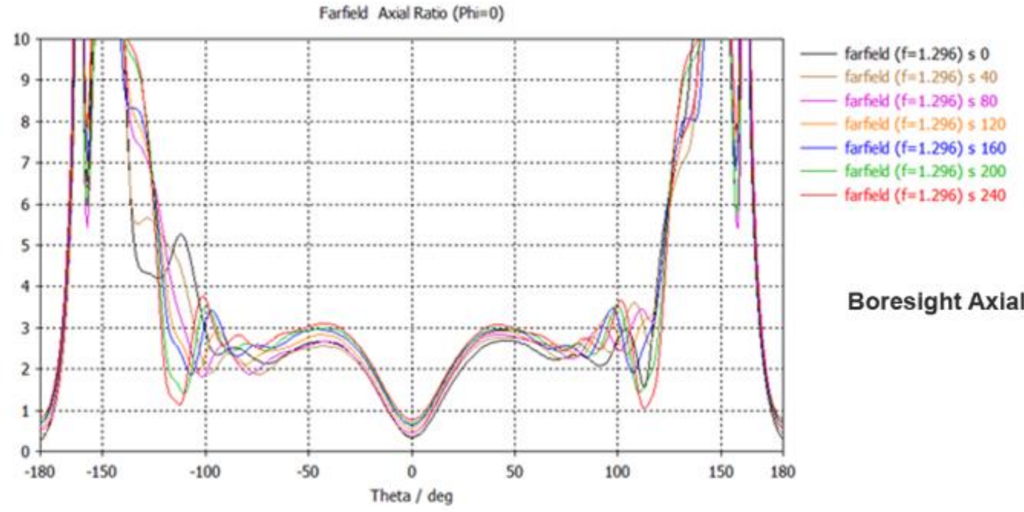
Feed + Dish
Square to Round Taper
Improvement 7 of 16

- There has been interest in a high-performance lightweight feed for portable operations.
- *An overall feed length of 470 mm <u>outperforms</u> 710 mm.*
- Shorter feed only looses 2 dB S12. We will fix this.

Feed length vs pattern

1. Plot “60/25” is a 60 mm deep choke 25 mm behind the aperture. This is not an optimal pattern.
2. Plot “a 25” is a 110 mm deep choke 25 mm behind the aperture.
3. Plots “s 0” to “s 240” are a 110 m deep choke 15 mm behind the aperture.
4. “s 240” = overall 710 mm feed length. “s 0” = 470 mm overall feed length. Note little effect on pattern.
5. A choke depth of lambda/2 widens the pattern by reversing the phase of the reflected field.





Boresight Axial ratio good for all lengths

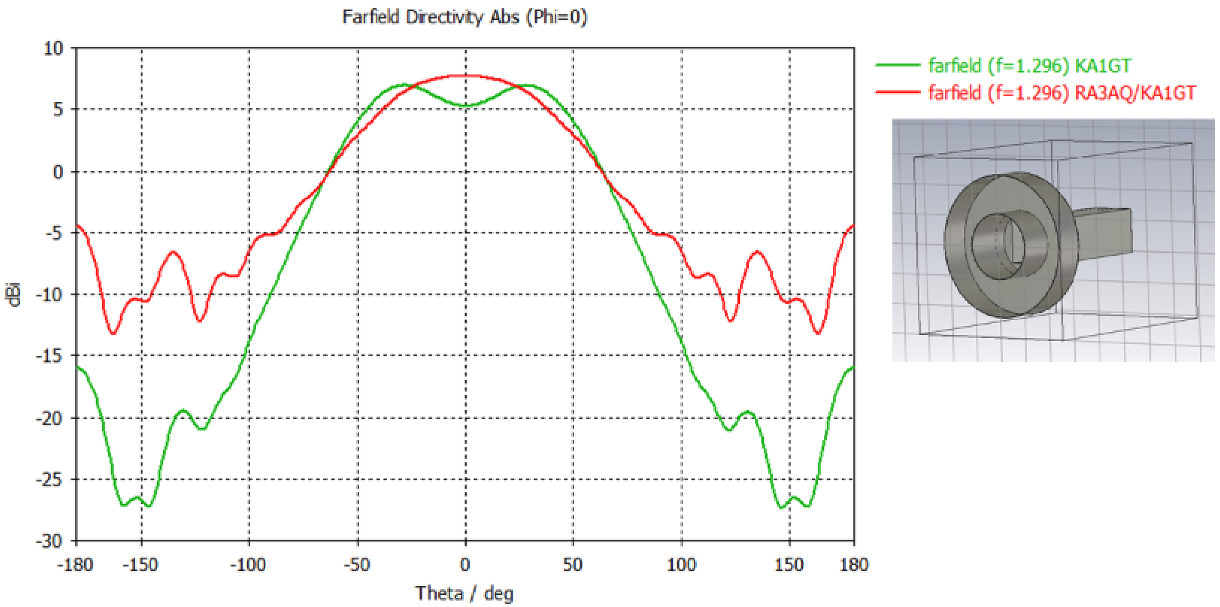
LENGTH & CHOKE DEPTH

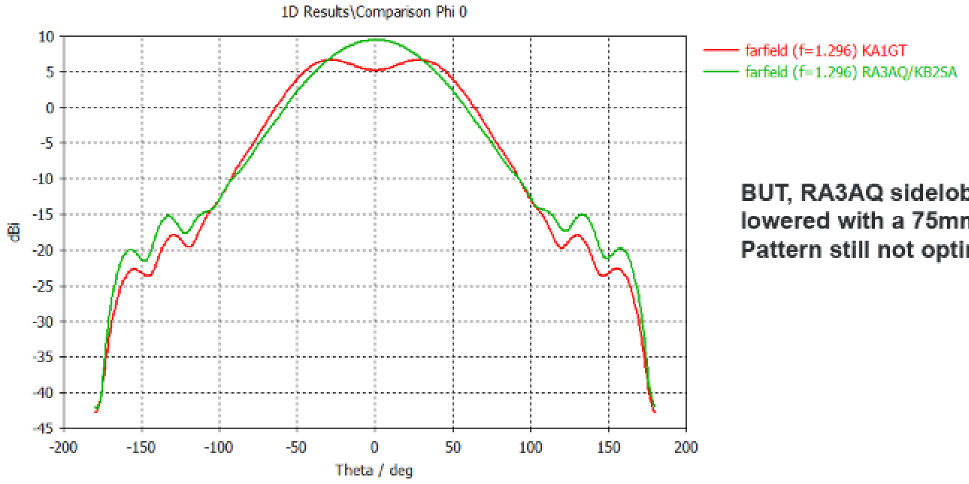
Feed only
Square to Round Taper
Improvement 8 of 16

- Extensive simulation confirms feed pattern is nearly identical for overall feed lengths between 710 mm and 470 mm.
- The more critical dimension is the choke depth.
- ***A choke depth near lambda/2 (110 mm) creates a desirable wide pattern due to resonating choke structure.***

Can a deep (110mm choke) improve the RA3AQ performance?

Adding a 110mm deep choke to the RA3AQ feed with an abrupt square to round transition does not improve the feed pattern. There is a waveguide discontinuity between the square and round sections that is not present with the smooth square to round transition.





BUT, RA3AQ sidelobes are lowered with a 75mm deep choke. Pattern still not optimal.

DEEP CHOKE ON RA3AQ?

Feed only
Abrupt Square to Round
Improvement 9 of 16

- Can a lambda/2 (110 mm) deep choke improve the RA3AQ feed performance?
- The “fat” pattern cannot be realized. A “waveguide discontinuity” occurs. This is not seen with the square to round taper.
- A 75 mm deep choke does lower sidelobes, but the pattern is still not optimal.

PATTERN VS CHOKE DEPTH

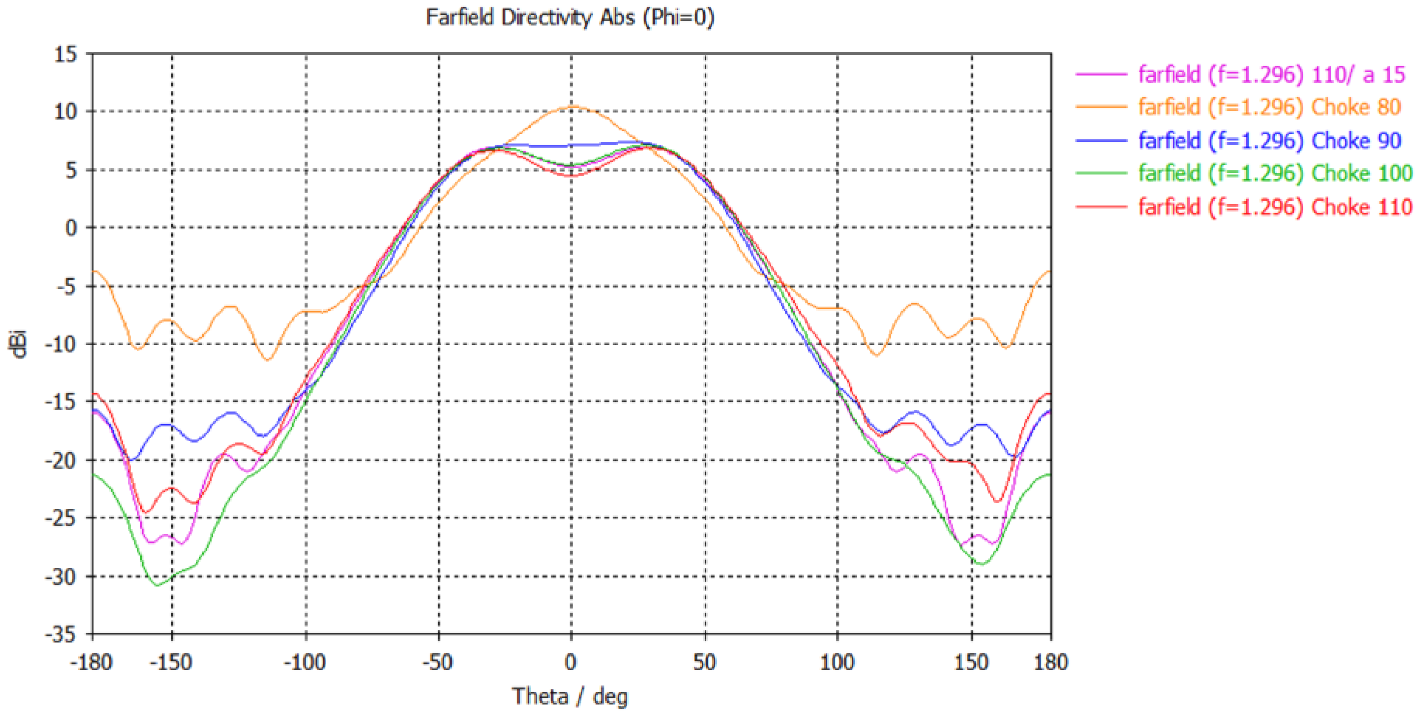
Feed only
Square to Round Taper
Improvement 10 of 16

How does the feed pattern vary with choke depth?

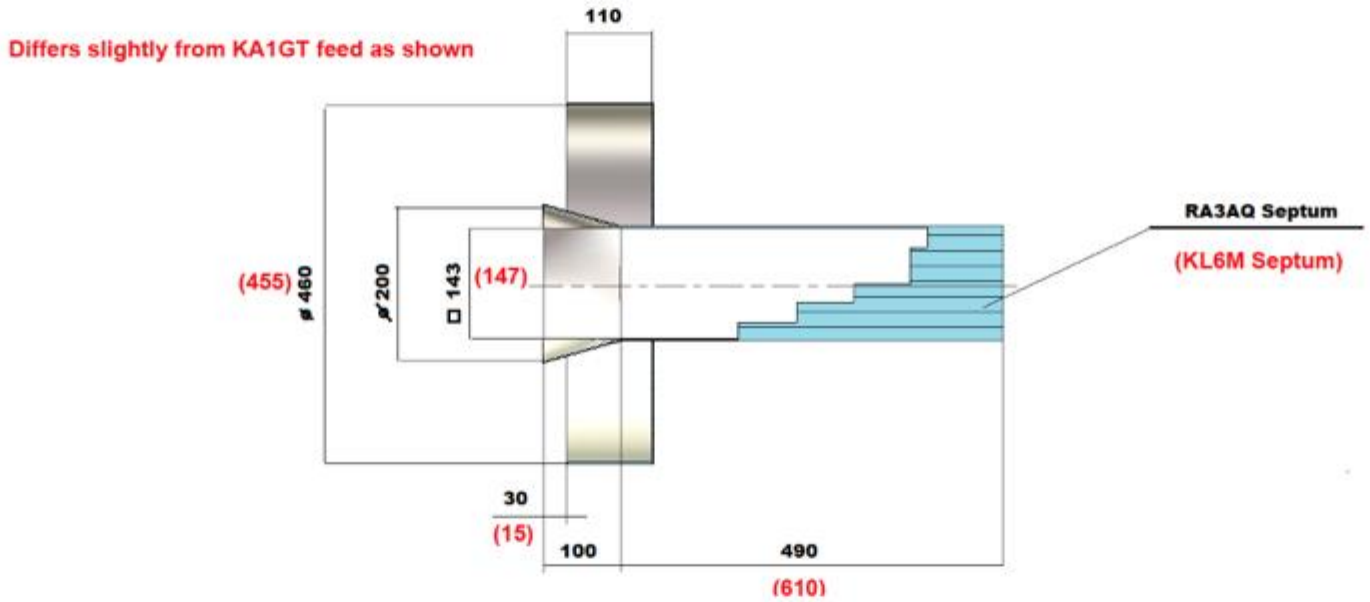
Here we show the feed pattern as we vary the choke depth on the KA1GT feed. Each example has the choke set back 25 mm compared with the original KA1GT feed with 110 mm choke set back 15 mm.

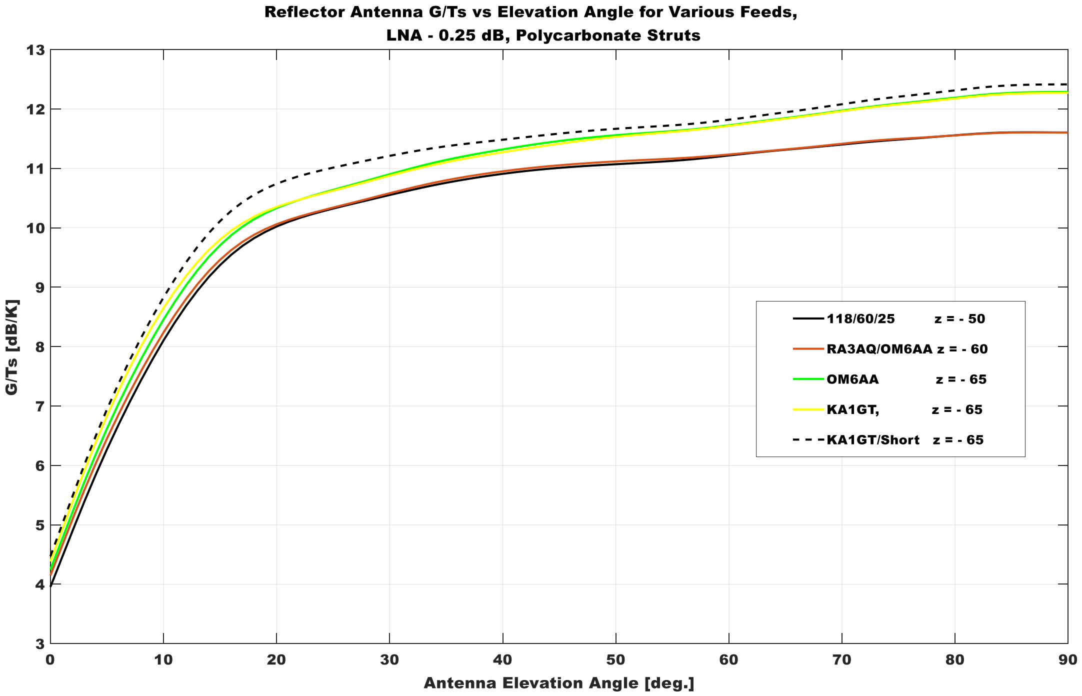
Note how a shallow choke depth (80 mm) creates an undesirable pattern. A 100 mm deep choke appears optimal.

This is with the short (470 mm) KA1GT feed variant.



- Feed shows the desirable “fat” pattern as choke depth increases.
- Pattern flattens noticeably @ 90 mm.
- As choke depth increases, pattern stays flat and sidelobes decrease and then start rising.





LET'S SUMMARIZE

Feed + Dish
Square to Round Taper
Improvement 11 of 16

- A very high-performance 23cm feed for a 1.9m f/d = 0.35 dish starts with an RA3AQ septum and adds a 110 mm deep choke and square to round taper.
- Optimal dimensions are very similar to that found experimentally by KA1GT (choke setback tuned to f/d).
- ***A total feed length of 470 mm is noticeably better than 710 mm*** *(590 mm shown in the figure).*
- Optimal focal point is approximately 65 mm inside the feed.

WHAT ABOUT S12?

Feed + Dish
Square to Round Taper
Improvement 12 of 16

- Earlier we saw that the isolation between the RX and TX port (S12) was significantly reduced when the dish is present with a square to round taper (14 dB measured).
- Assuming 85° F (300K) ambient and .25 dB LNA NF, RX sensitivity is reduced 1.2 dB due to 300K noise on the TX port from 50-ohm termination.

MEASURED:

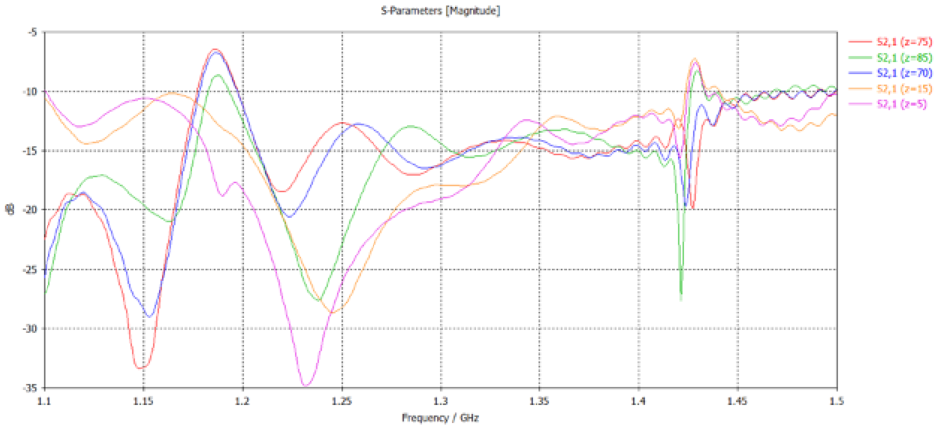
85° F ambient (300K)
LNA NF = 0.25 dB
S12 = 14 dB
Relay + connector loss = 0.1 dB

- RX noise from TX port = 300 / 10^(14/10) = **12K**
- Equivalent LNA noise = 300 * (10^((0.25+0.1)/10) – 1) = **25K**
- Antenna noise @ 30° elevation = **12K**

Total noise = **12K** + **25K** + **12K** = **49K**

If we can remove the **12K** noise from the TX port we can realize 10 * LOG [49/(49-12)] = **1.2 dB increased RX sensitivity.**

S12 is significantly degraded with the addition of the flare. -14 dB was measured. -15dB seen in simulation and varies with focal point.

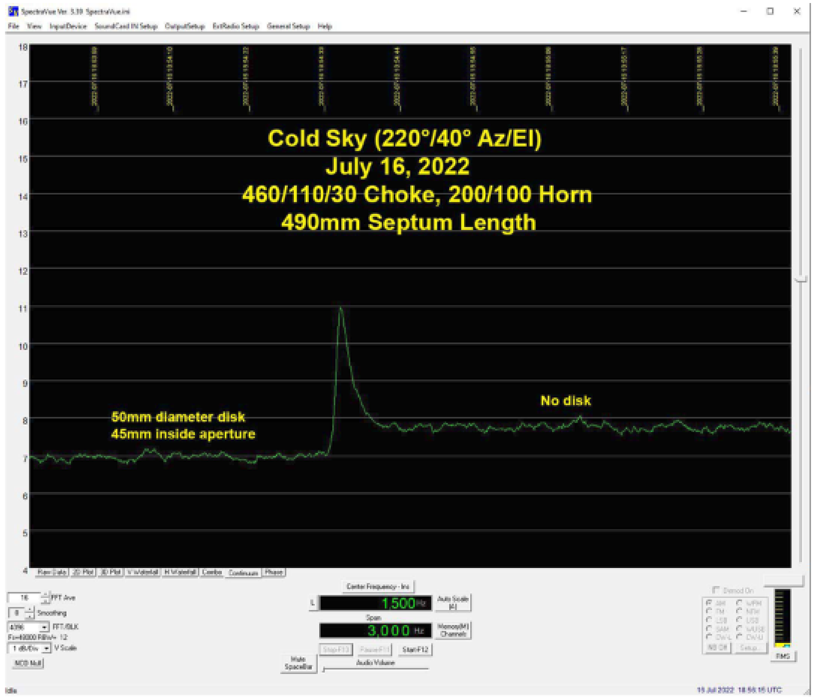


RECOVER S12 WITH DISK

Feed + Dish
Square to Round taper
Improvement 13 of 16

- A 50 mm metal disk centered 45 mm inside the taper increases S12 enough to eliminate the TX port noise on the RX port.
- RX sensitivity increased nearly 1 dB.

With degraded S12, noise on the TX port appears at the RX port. This increased the RX noise floor nearly 1 dB. A 50mm disk centered 45mm inside the flare lowered this TX noise. Dimensions selected by experimentation.



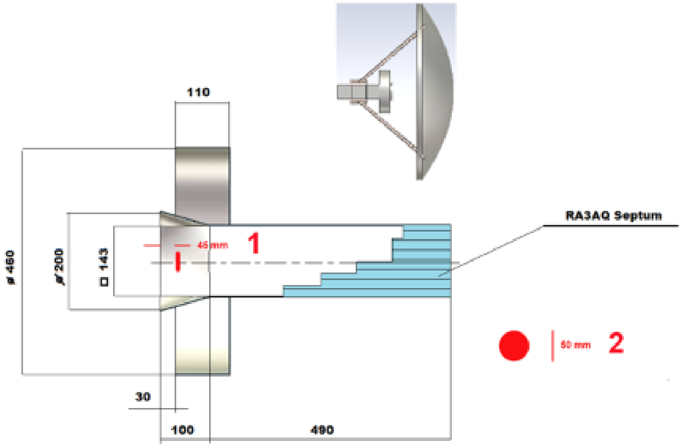
DISK NO EFFECT ON G/T

Feed + Dish
Square to Round taper
Improvement 14 of 16

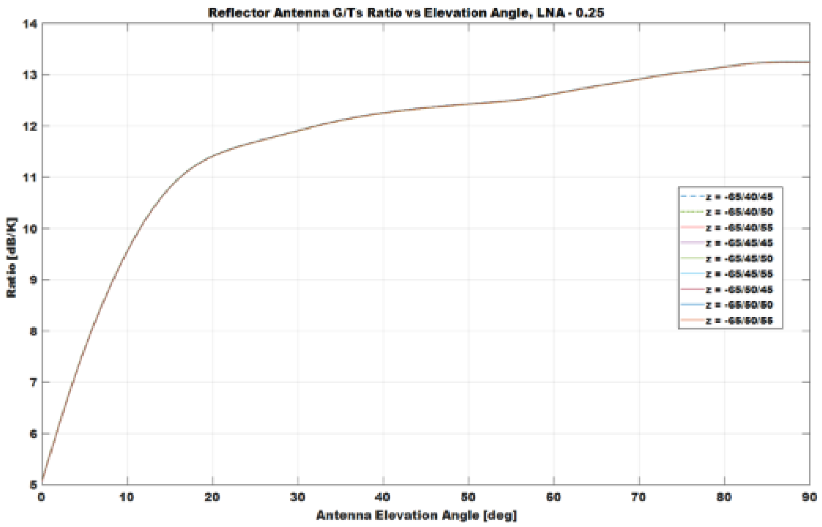
Simulations varied the disk diameter and placement to help characterize the behavior.

S12?

Z	1	2
65	45	50
65	45	45
65	45	55
65	40	45
65	40	50
65	40	55
65	50	45
65	50	50
65	50	55



Simulation found the disk placement and diameter did not change the overall G/Ts.

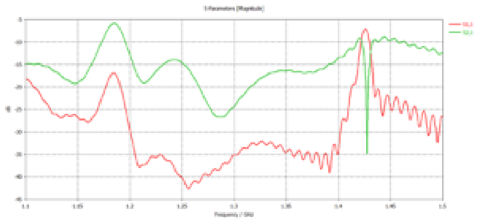


- Disk diameter between 45 and 55 mm placed 40 to 50 mm inside taper has no effect on G/Ts.

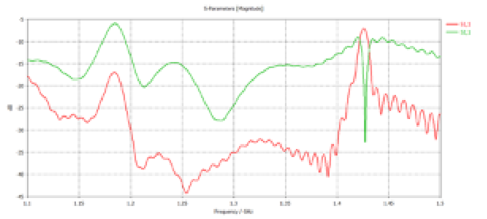
Simulations confirmed the 50mm disk 45mm inside the flare (45i/50d) is very good (-30dB), with 45i/45d and 50i/50d possibly being slightly better (-32dB)

S12 DISK SIZE & POSITION

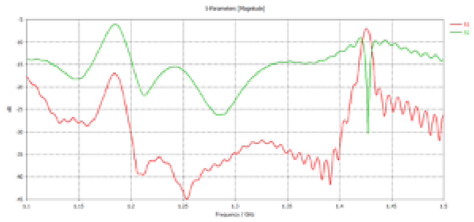
Feed + Dish
Square to Round taper
Improvement 15 of 16



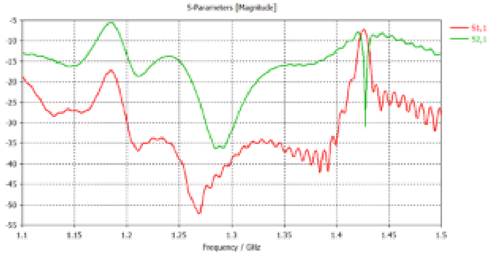
40i/45d



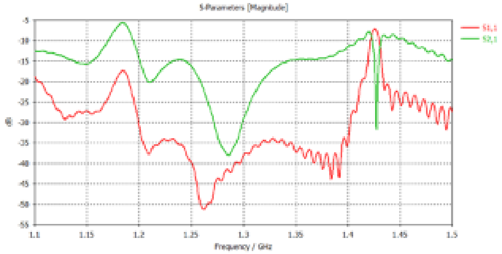
40i/50d



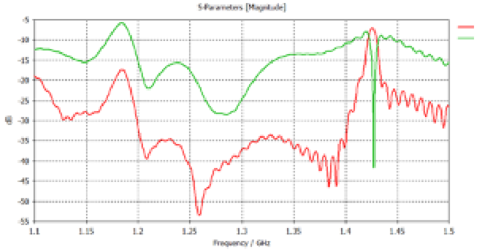
40i/55d



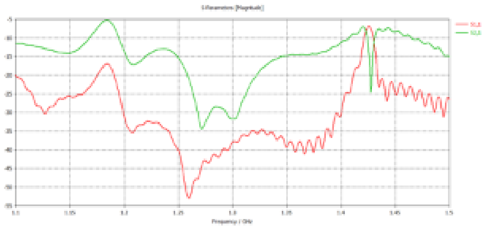
45i/45d



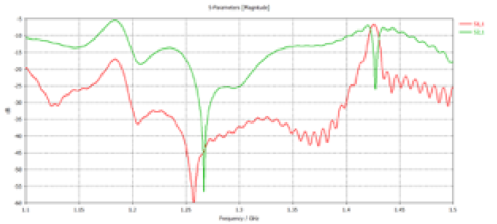
45i/50d



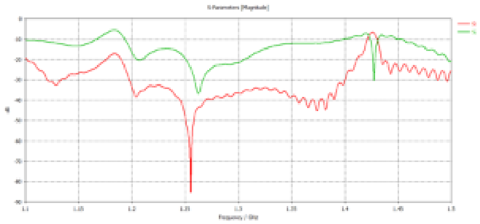
45i/55d



50i/45d

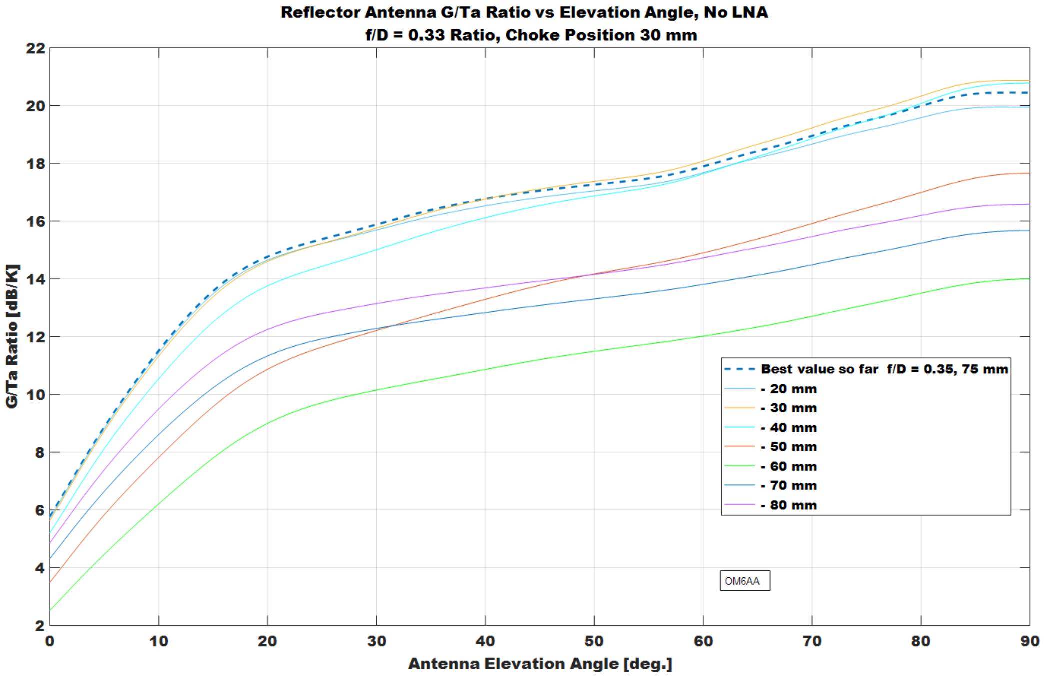


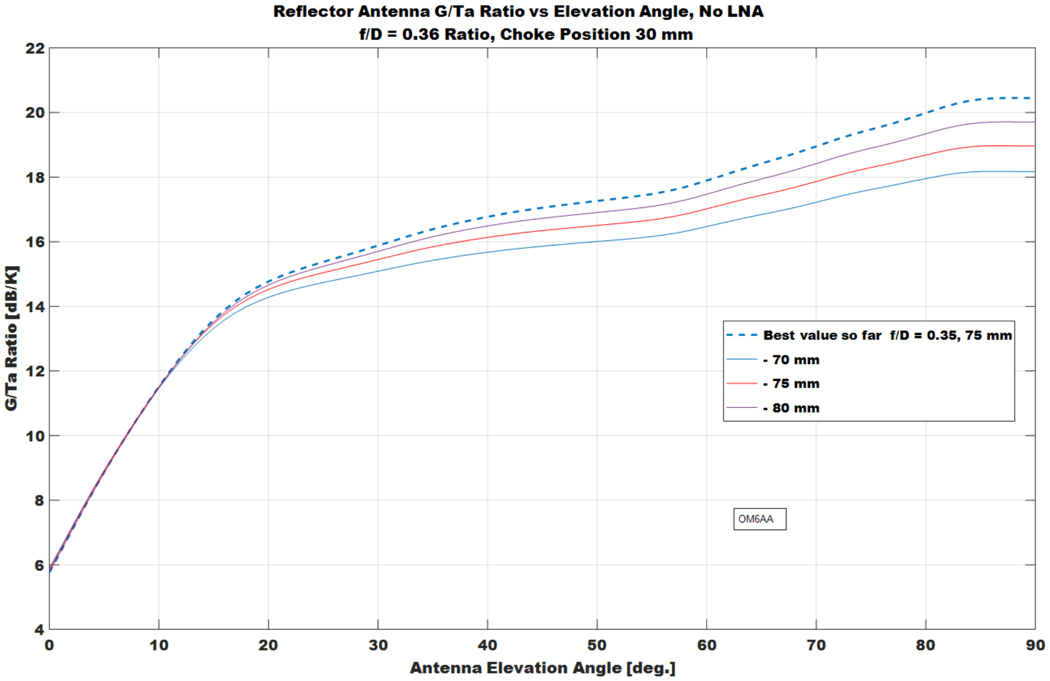
50i/50d



50i/55d

- S12 increased from 14 dB to > 30 dB with 45 – 50 mm diameter disk placed 45 – 50 mm inside flare.

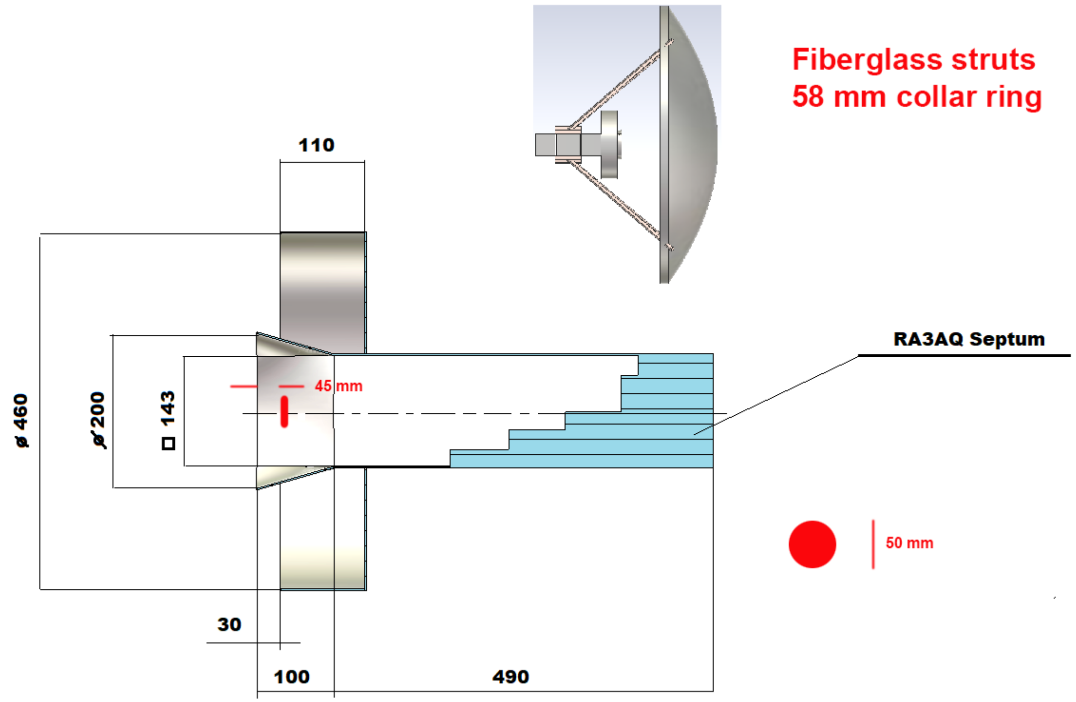




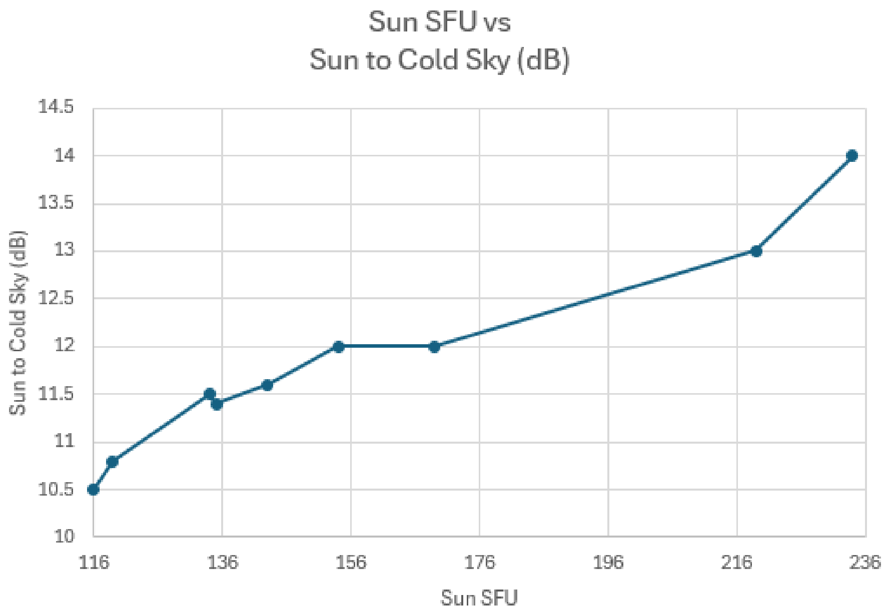
DIFFERENT F/D BETTER?

Feed + Dish
Square to Round taper
Improvement 16 of 16

- f/d = 0.35 works well with this feed type. Might a different f/d work better?
- A "deeper" f/d = 0.33 dish is slightly better. Shallower dishes (e.g., f/d > 0.36) are noticeably worse.
- Varied choke position and focus to confirm behavior.



Measured with SpectraVue



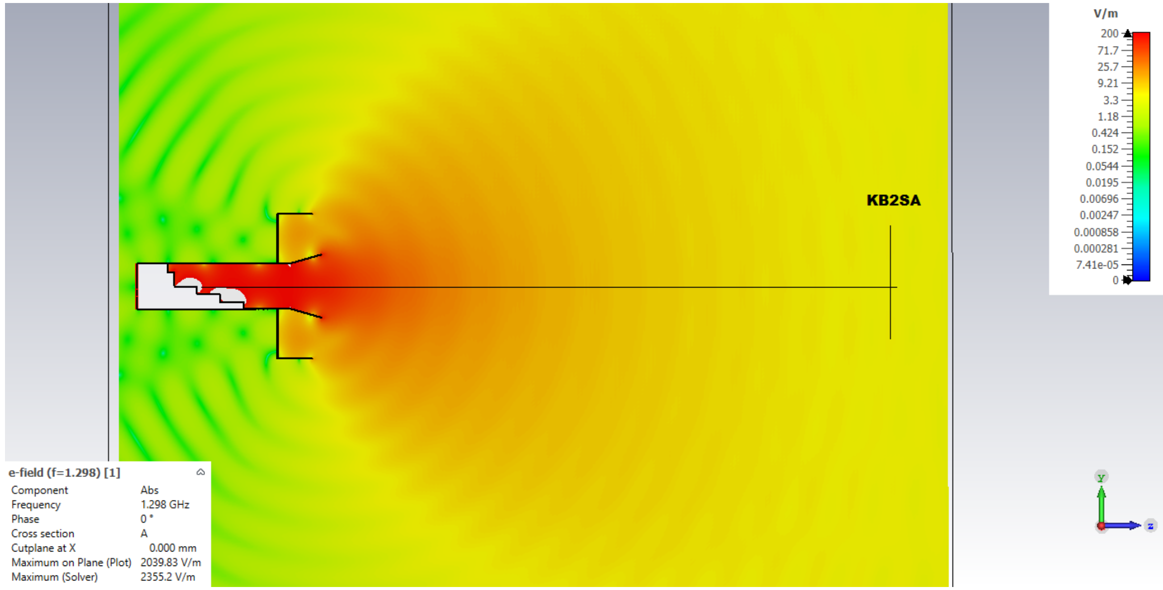
SUN TO COLD SKY

Feed + Dish + S12 Disk
Actual Feed (590mm length)

- Current KB2SA system (2023/2024).
- Sun to cold sky signal measured during 2023/2024 with 1.9m f/D = 0.35 mesh wire dish, collar ring, fiberglass struts, 0.25 dB NF LNA and S12 disk.
- *Adjust RF gain as needed so strongest and weakest signals are within the total RX system's linear response region (e.g., no sun saturation).*
- *AGC, Noise Reduction (NR) and Noise Blanking (NB) off. Sun > 40°.*

1.9M FEED ON 4.88M DISH

"KB2SA" feed radiation relatively uniform
in near, fresnel, and far field



1.9M FEED ON 4.88M DISH

Mats Bengtsson, KD5FZX
4.88M Solid, F/D = 0.39
"KB2SA" Feed

- Mats, KD5FZX, expertly constructed the "KB2SA" feed with choke offset tuned to his 4.88M f/d = 0.39 dish.
- The theoretical difference between 1.9m and 4.88m is about 8 dB.
- A 7-8 dB delta is confirmed on both TX and RX with hundreds of QSOs and echo tests.
- We suspect < 1dB loss due to non-optimal f/d = 0.39.

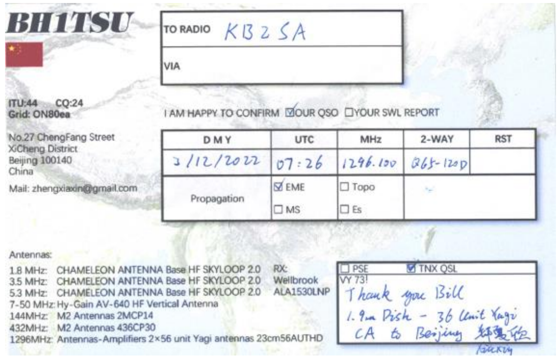
Mats made a polycarbonate cover for tunable S12 disk and birds/insects

NOTEWORTHY 1.9M 23CM QSOS

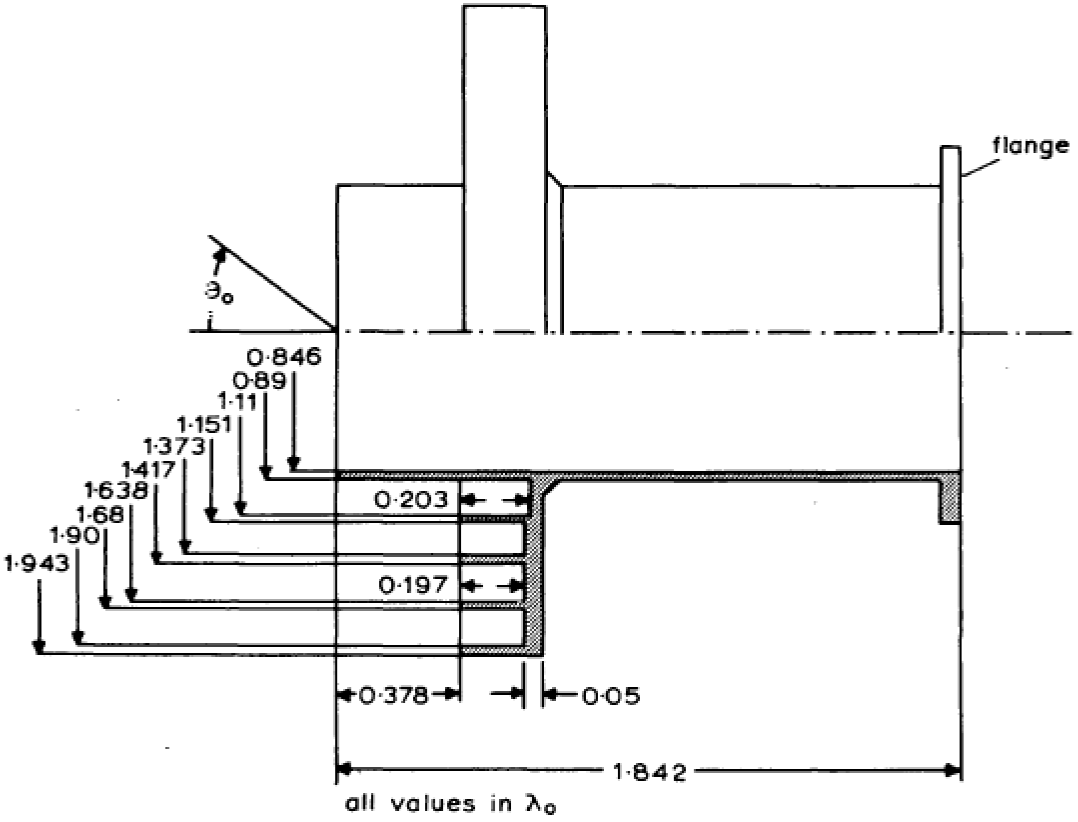
SSTV EME QSO (Scottie DX)
Martin 2 easily readable

NOTEWORTHY 1.9M 23CM QSOS

Timing is everything



- BH1TSU w/36-element yagi
- ZL1NJR w/1.8m folding dish through trees
- ZC4RH w/67-element yagi
- KA1GT w/3.1m dish ***and 5 watts***
- DK0TE w/70-element yagi (easy 60C and 30B QSOs)
- WAS #24. ***Thank you Peter, KA6U and Gene, KB7Q!***
- 2,895+ QSOs on LoTW
- ARRL International EME Contest, SO-1.2G
    - 2023: #**11**/60
    - 2022: #**13**/43
    - 2021: #**16**/51



R. WOHLLEBEN
H. MATTES
O. LOCHNER

Max-Planck-Institut für Radioastronomie
Argelanderstrasse 3
D-53 Bonn, W. Germany

30th August 1972

WHAT'S NEXT

LOOK BACK TO LOOK AHEAD

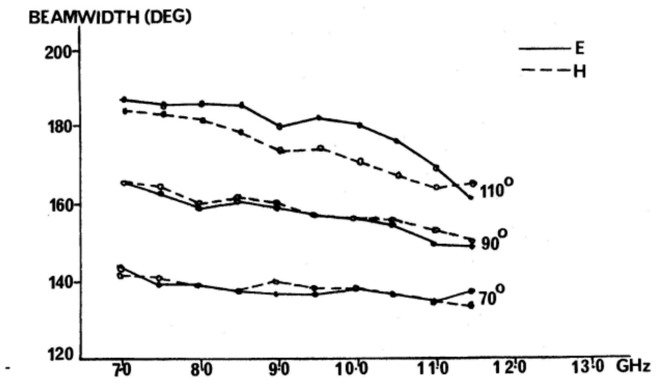


FIG. 2 20 dB BEAMWIDTHS

1971

1980

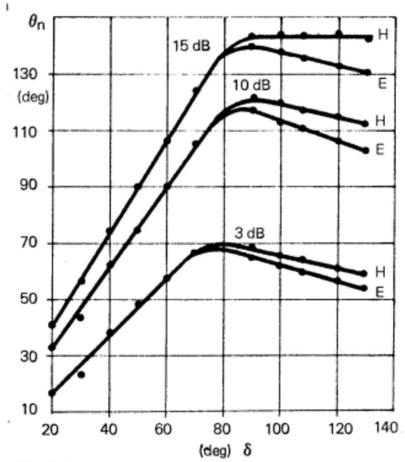
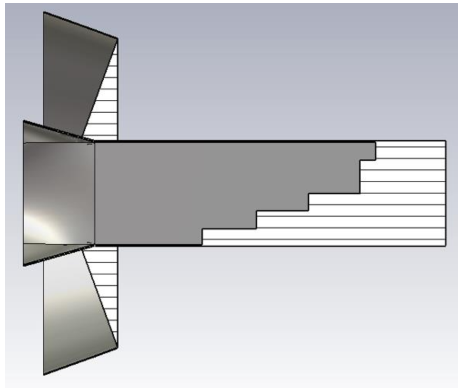
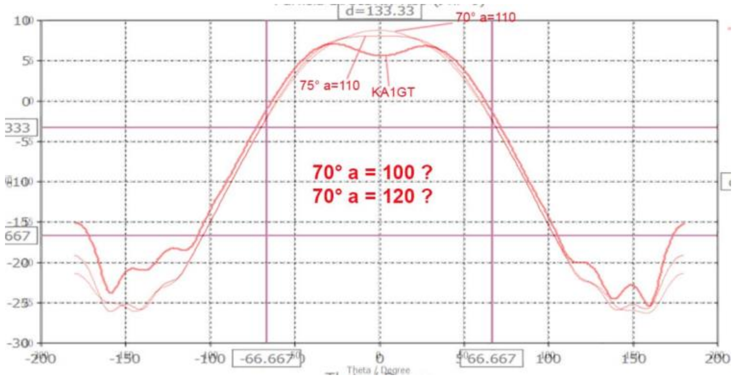


Fig. 4 - Beamwidths at relative power level -3 dB, -10 dB, -15 dB as function of half flare angle. α ≥ 3

2024

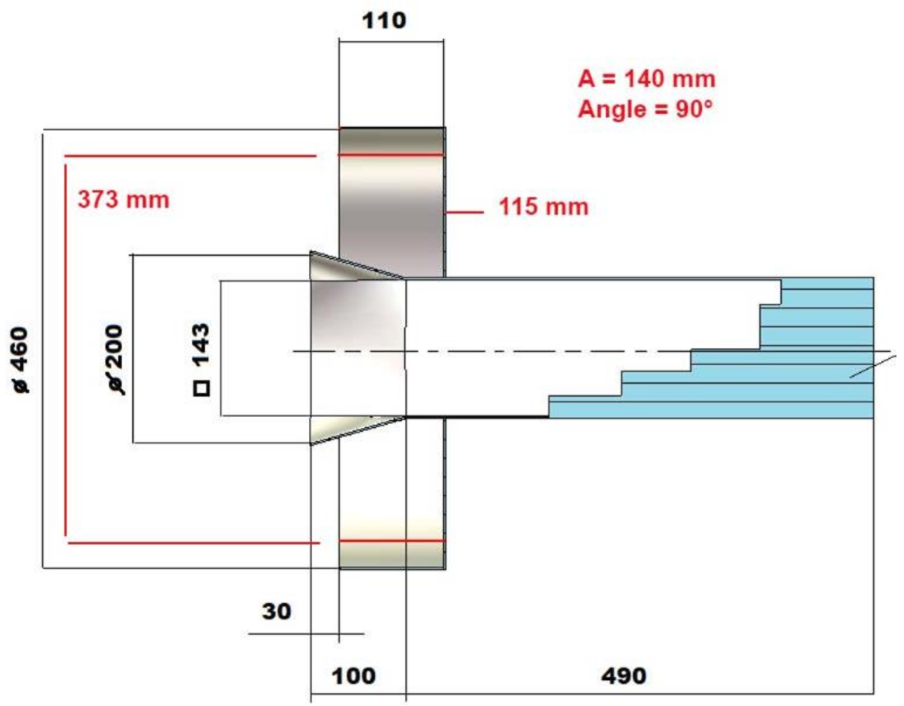


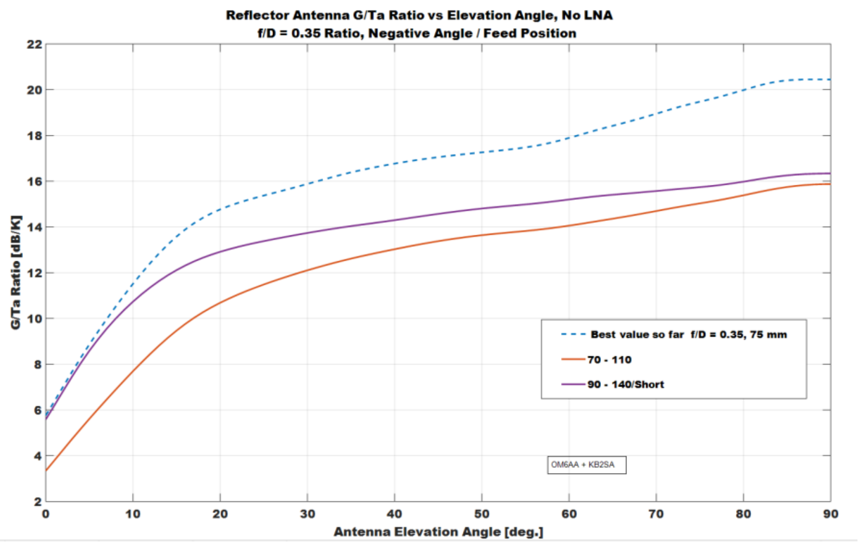


CONVEX CHOKE

Does it improve G/Ts ?

- Experiments by McInnes and Booker in 1971 indicate a 110° choke flare may provide a "fatter" beam.
- A revisit by Pagana and Massaglia in 1980 indicate flares > 90° do not widen beamwidth.
- Simulation in 2024 confirm the 1980 results using different flare angles and choke setbacks. 110° and 105° flare with 110 mm setback shown here. No improvement in G/Ts.





SMALLER CHOKE

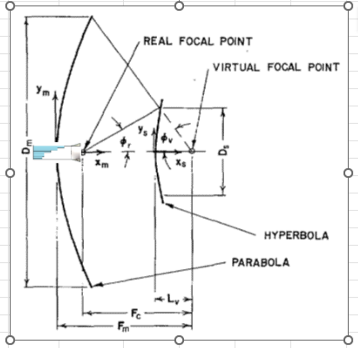
Does it improve G/Ts ?

- Might a smaller choke have less obstruction to overcome "non-resonant" losses?
- Preliminary results show no improvement. *More simulation is needed.*
- G/Ta shown here is best so far vs 110° flare with 110 mm setback and 90° flare with 140 mm setback and 373 mm diameter choke.

CASSEGRAIN ANTENNA

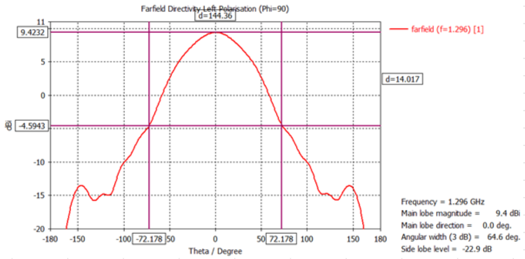
Can it work for 23cm ?

Φr	44.9	degrees	Pick for reasonable focal lengths, ideally down 10 dB at edge of sub dish.
Ds	690	mm	Pick for reasonable blockage
Dm	1900	mm	
Fm/Dm	0.35		
Fm	665	mm	
Φv	71.08	degrees	
Fc	464.49	mm	
Fm-Fc	200.51	mm	How much feed protrudes into dish
Φv - Φr	0.45685	radians	
Φv + Φr	2.02415	radians	
Lv	170.22	mm	
Fm-Lv	494.78	mm	Sub dish distance
e	3.7446		
a	62.0216		
b	223.811		
Fc-Lv	294.27	mm	Distance Real Focal Point to sub dish
Fc/Fm	0.69848		
Df	200	mm	Feed diameter
Df/Ds	0.28986		Want Fc/Fm about equal to Df/Ds for minimum blockage.



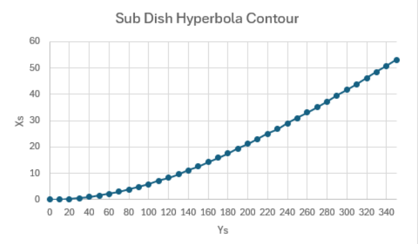
Standard dish to feed opening = 600 mm
Keep Real Focal Point above dish surface
"Reasonable" distance between feed and sub dish

Cassegrain Antenna

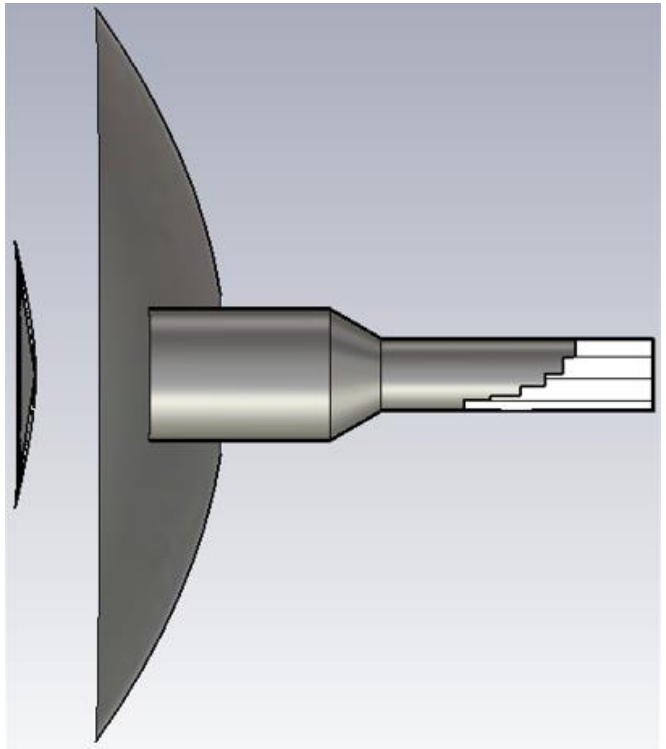


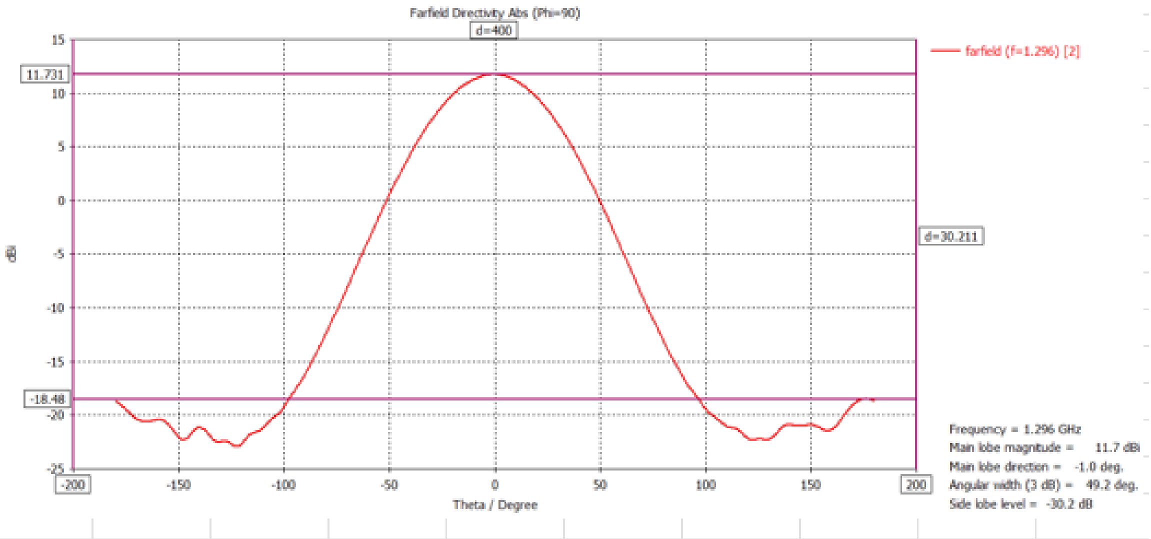
RA3AQ feed (no choke) down 14 dB @ +/- 72 °.
Down 7 dB @ +/- 50°.

Ys (mm)	Xs (mm)
0	0
10	0.061877
20	0.247141
30	0.554694
40	0.982746
50	1.528862
60	2.190031
70	2.962739
80	3.843063
90	4.826749
100	5.909309
110	7.086096
120	8.352383
130	9.703429
140	11.13454
150	12.64111
160	14.21867
170	15.8629



- Cassegrain antennas are used in high performance systems > 5 Ghz. Can it improve 23cm performance?
- Optical analysis indicates “reasonable” dimensions can be realized with a 1.9m dish.
- Simulation needed to determine if the improved sub dish illumination might overcome the excessive (forward) spillage from a septum feed.

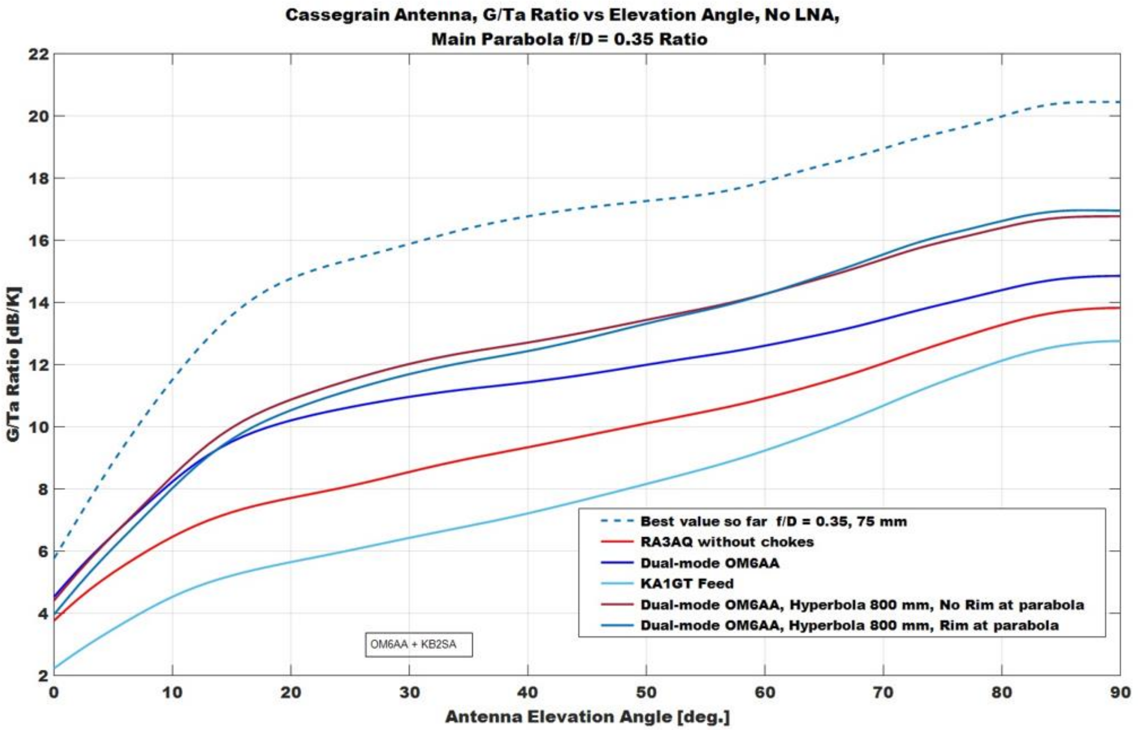


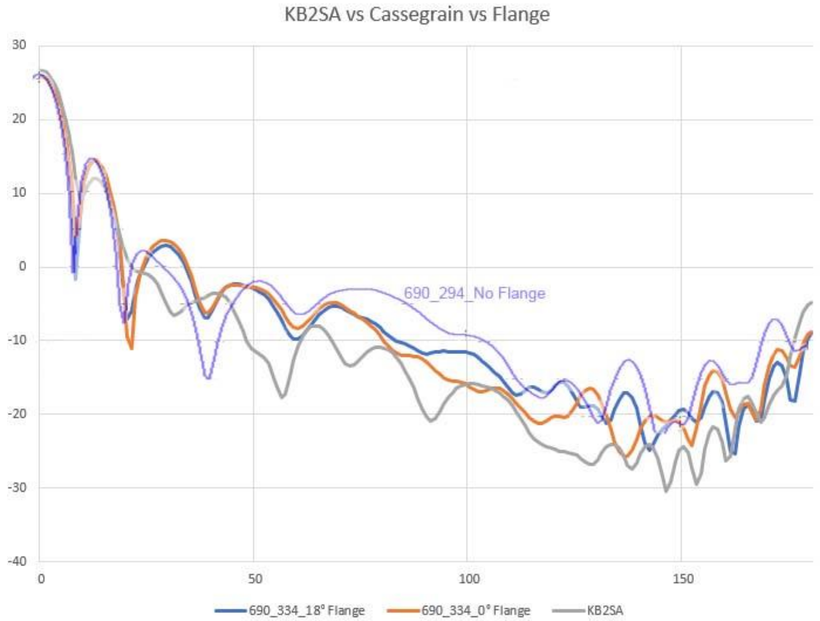


CASSEGRAIN ANTENNA

Sizing the subdish

- Existing "optical" analysis to date assumes dish sizes >> λ. This does not apply for 1.9m @ 23cm.
- We select a configuration that gets us close to -10 dB at the subdish edge with an available feed for the 1.9m f/d = 0.35 system. A 690 mm subdish results.
- An W2IMU-like feed (OM6AA used) provides the narrowest pattern.





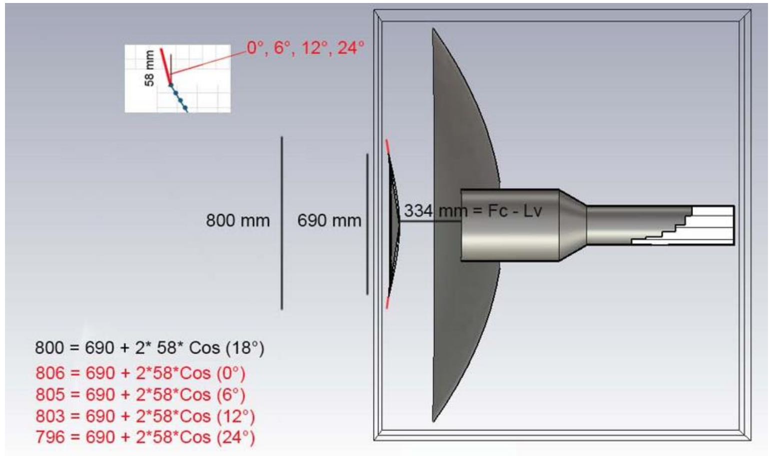
CASSEGRAIN ANTENNA

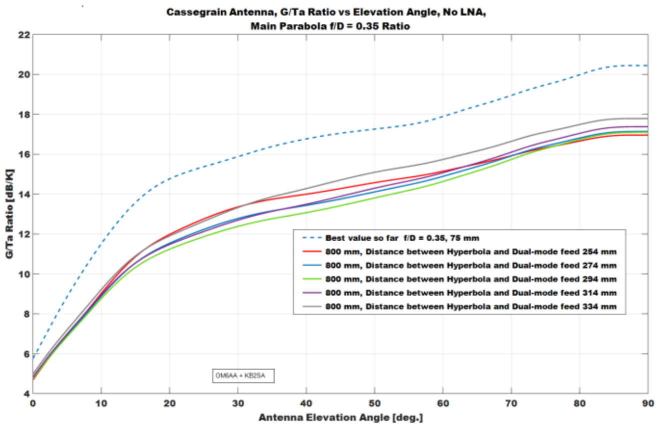
Initial Simulation Results

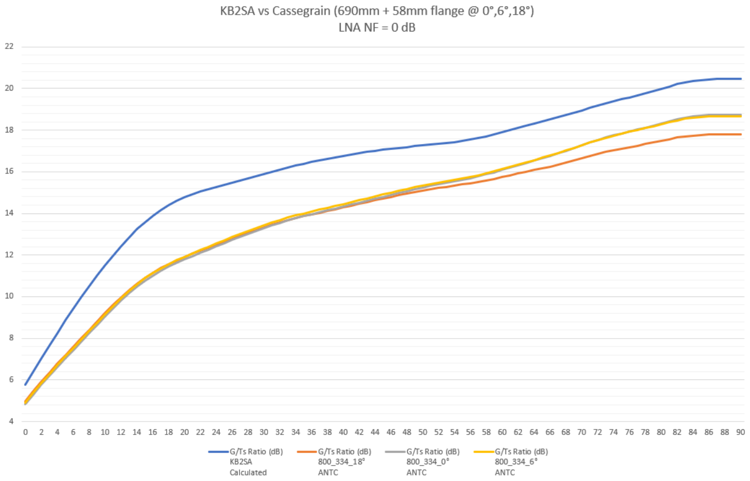
- First simulations with 690mm subdish indicate it works, but performance is not great compared to our best.
- A significant "breakthrough" occurs when we introduce a 58mm flange @ 18^{O} as suggested by Potter's Technical Report No. #32-214 (January 31, 1962).
- The flange reduces wide angle sidelobes with very little affect on small angle sidelobes. G/Ts jumps nearly 2 dB.

CASSEGRAIN ANTENNA

Tweaking 690mm + flange







- Tuning by varying the feed position and 58mm flange angle gets us to within 2 dB of our best system with a 0^{o} flange angle and 806mm obstruction (18% area obstruction).
- Increasing flange size or moving subdish position very quickly and dramatically reduced performance. This indicates “optical” analysis has some merit @ 23 cm (as expected from parabola tuning results).

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Minimum Blocking

	B	C	E	F	H	I	K	L	N
	25.31 dBi		26 dBi		20.8 dBi		?? dBi		
Φr	48	degrees	44.9	degrees	45.5	degrees	44.9	degrees	-10 dB down @ subdish edge
Ds	490	mm	690	mm	800	mm	581	mm	Subdish diameter
Dm	1900	mm	1900	mm	1900	mm	1900	mm	
Fm/Dm	0.35		0.35		0.35		0.35		
Fm	665	mm	665	mm	665	mm	665	mm	
Φv	71.08	degrees	71.08	degrees	71.08	degrees	71.08	degrees	
Fc	304.60	mm	464.49	mm	530.22	mm	391.12	mm	
Fm-Fc	360.40	mm	200.51	mm	134.78	mm	273.88	mm	How much feed protrudes into dish
Φv - Φr	0.4027	radians	0.45685	radians	0.44637	radians	0.45685	radians	
Φv + Φr	2.0783	radians	2.02415	radians	2.03462	radians	2.02415	radians	
Lv	116.96	mm	170.22	mm	196.13	mm	143.33	mm	
Fm-Lv	548.04	mm	494.78	mm	468.87	mm	521.67	mm	Sub dish distance
e	4.3095		3.7446		3.84342		3.7446		
a	35.34		62.0216		68.9778		52.224		
b	148.14		223.811		255.98		188.456		
Lr = Fc-Lv	187.64	mm	294.27	mm	334.09	mm	247.78	mm	Distance Real Focal Point to sub dish
Fc/Fm	0.458		0.69848		0.79733		0.58814		
Df	342	mm	342	mm	342	mm	342	mm	Feed diameter
Df/Ds	0.698	-0.239916	0.49565	0.20283	0.4275	0.36983	0.58864	-0.0005	Want Fc/Fm = Df/Ds for feed blockage = subdish blockage.
ATAN(Ds/2Fm)	0.353		0.47857		0.54152		0.41186		
ATAN(Df/2Fc)	0.5115	-0.158558	0.35275	0.12583	0.31198	0.22955	0.41217	-0.0003	Exact. Want ATAN(Ds/2Fm) = ATAN(Df/2Fc) for feed blockage = subdish blockage.
DfFm/Fc	746.65		489.632		428.934		581.49		Blockage due to feed (mm)
	746.65	mm	690	mm	800	mm	581.49	mm	Actual blockage = MAX(Ds, DfFm/Fc)

Ys (mm)	490mm	690mm	800mm	581mm
0	0	0	0	0
10	0.08042	0.06188	0.05261	0.07347
20	0.32061	0.24714	0.21022	0.29327
30	0.71735	0.55469	0.47209	0.65756
40	1.26558	0.98275	0.83707	1.1634
50	1.9586	1.52886	1.30353	1.80681
60	2.78853	2.19003	1.86949	2.58294
70	3.74663	2.96274	2.53258	3.48625
80	4.82375	3.84306	3.29011	4.51066
90	6.01058	4.82675	4.13917	5.64974
100	7.29796	5.90931	5.0766	6.89686
110	8.67707	7.0861	6.09908	8.24534
120	10.1396	8.35238	7.2032	9.68856
130	11.6777	9.70343	8.38546	11.22
140	13.2842	11.1345	9.64233	12.8336
150	14.9526	12.6411	10.9703	14.5232
160	16.6769	14.2187	12.3659	16.2833
170	18.4518	15.8629	13.8257	18.1085
180	20.2724	17.5697	15.3463	19.994
190	22.1343	19.3351	16.9246	21.9351
200	24.0337	21.1553	18.5574	23.9276
210	25.9671	23.0269	20.2417	25.9675
220	27.9314	24.9465	21.9746	28.0513
230	29.9237	26.9111	23.7535	30.1756
240	31.9416	28.9177	25.5757	32.3373
250		30.9636	27.4388	34.5337
260		33.0462	29.3405	36.7622
270		35.1632	31.2785	39.0205
280		37.3124	33.2508	41.3063
290		39.4918	35.2555	43.6177
300		41.6994	37.2907	
310		43.9335	39.3546	
320		46.1924	41.4458	
330		48.4747	43.5626	
340		50.7789	45.7037	
350		53.1036	47.8677	
360			50.0533	
370			52.2595	
380			54.485	
390			56.7289	
400			58.9902	

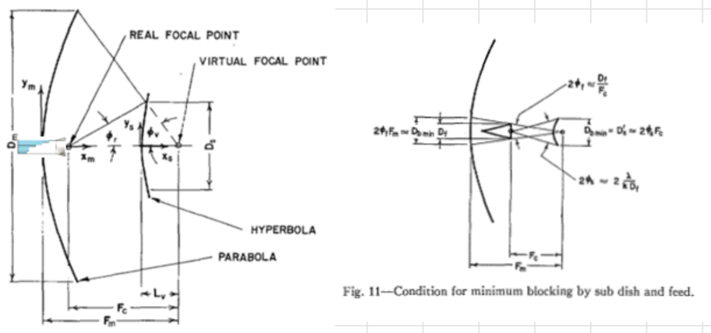
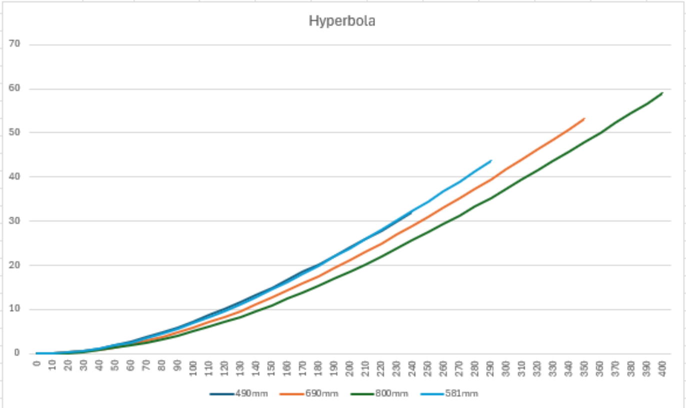


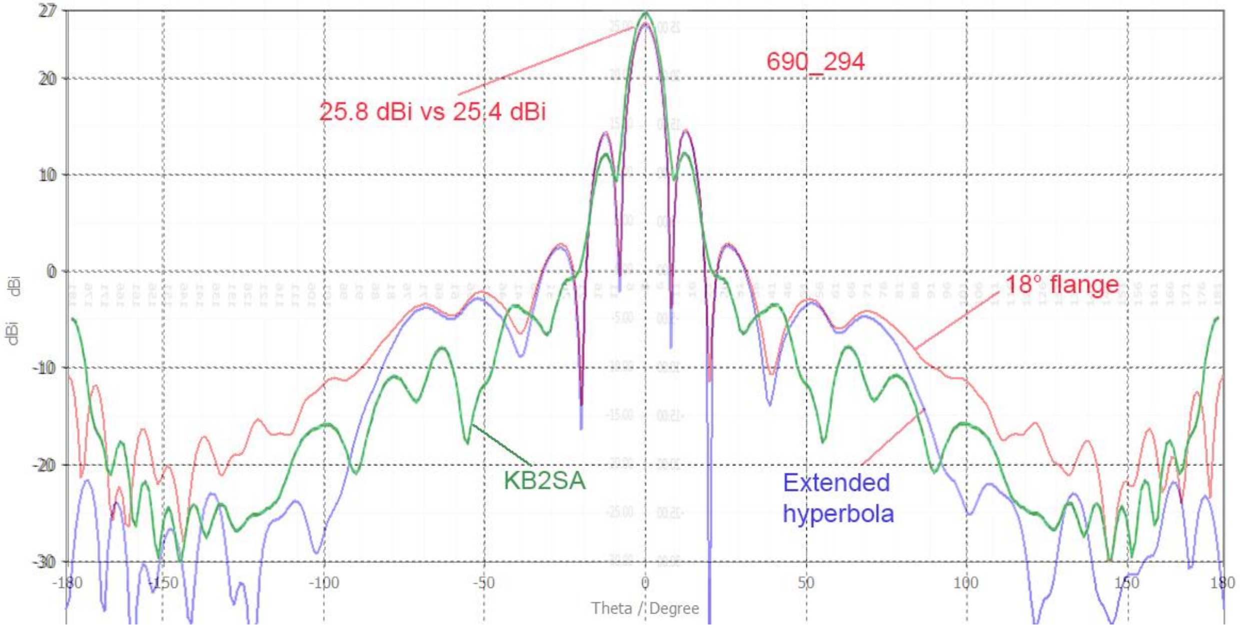
Fig. 11—Condition for minimum blocking by sub dish and feed.

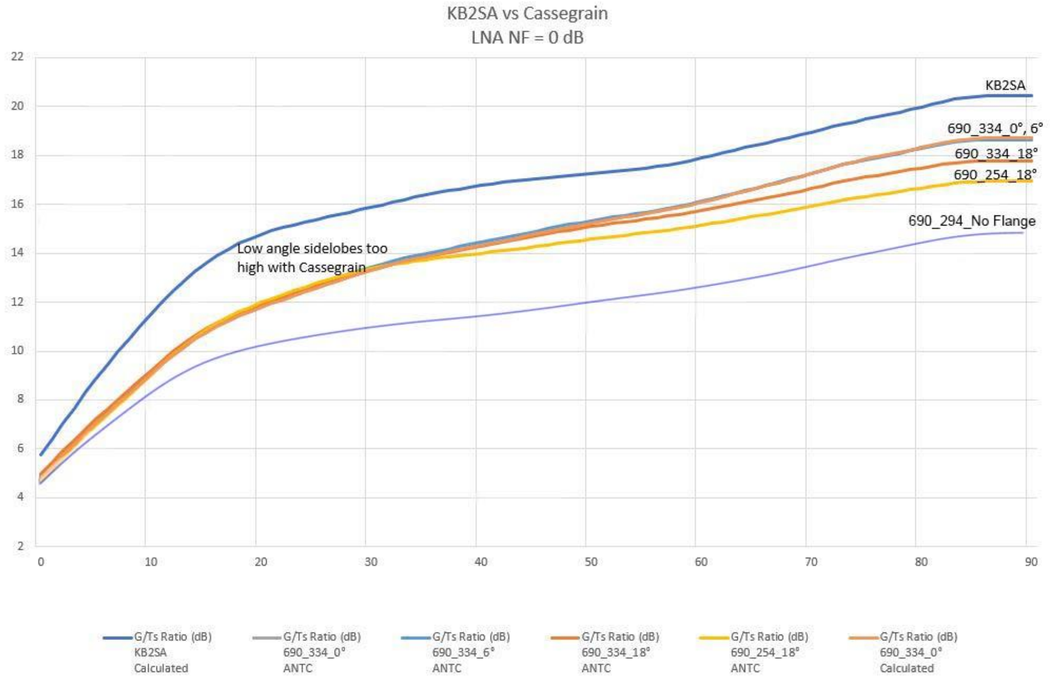
OPTIMIZE:

1. Optimize illumination of subdish (-10 dB at the edge)
2. Feed obstruction = subdish obstruction
3. Feed above dish surface
4. Maximize distance between feed and subdish (minimize S12)
5. Add flange to decrease large-angle sidelobes. Minimal effect on gain and small-angle sidelobes.



- Hannan's "Microwave Antennas Derived from the Cassegrain Telescope" (March 12, 1960) uses optical analysis to define a minimum blocking when the subdish blocking equals the feed blocking.
- Might this "sweet spot" optical analysis apply for 23 cm?
- It does NOT. The "oversized" subdish with 0^{o} flange provides the highest G/Ts.





CASSEGRAIN ANTENNA

Need a narrower feed

- Although we can reduce the sidelobes with a flange, the lower angle sidelobes are too high (i.e., OM6AA feed spillage past the subdish).
- A narrower (W2IMU-like) feed pattern may allow a Cassegrain to work well on 23cm with a flange and/or extended hyperbola (TBD).

THANK YOU!

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