3D Printed 47 GHz Cassegrain Antenna

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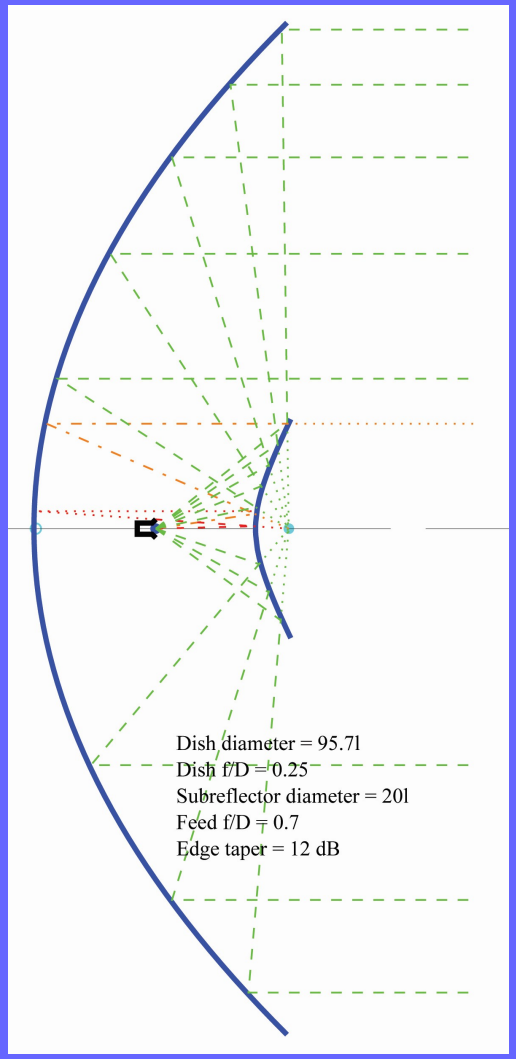
Need for gain

- 1FT antennas are common, 2FT rare and expensive.
- VA3ELE uses 2FT with great success.
- We asked Paul W1GHZ if he can come up with a design for 47 GHz.
- 2FT Edmund Optics reflectors are available and inexpensive.
- We had good success with 1FT at 122 GHz, let's try 47!

Paul Wade W1GHZ design

- Cassegrain feed and subreflector.
- Signal from back, K&S #8129 brass tube feed (3/16, 0.014 wall).
- Large aperture W2IMU, can be bored with #5 center drill.
- Matched to either 4 or 5 inch subreflector.
- Settled to 4 inch, easier to print.

Paul Wade W1GHZ design



Dish diameter = 95.7l
Dish f/D = 0.25
Subreflector diameter = 20l
Feed f/D = 0.7
Edge taper = 12 dB

Vertex to feed phase center = 89mm.
Vertex to subreflector = 135.9mm.

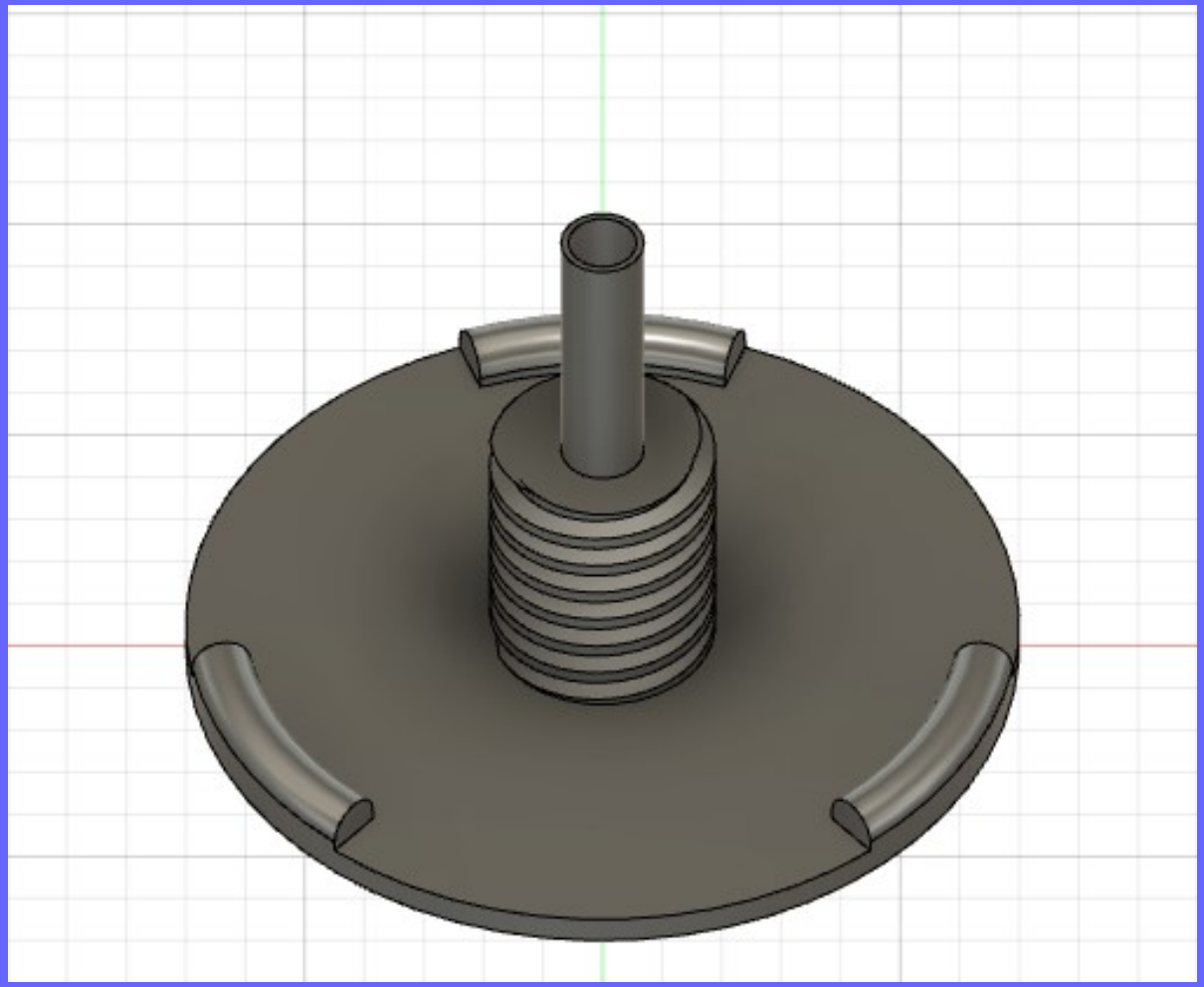
Metal vs Plastic

- Paul built a metal feed and CNC subreflector.
- I do the same with 3D printing.
- Reflective part covered with aluminum duct tape. Feed interior with conductive paint.
- Will be compared on antenna range.

3D Print Design

- Done on Fusion360.
- Steep learning curve. I know maybe 1% of it. Enough for simple parts.
- Material is PETG for heat resistance.
- PLA will melt in a hot car. True.
- 3 parts:
  - Reflector mount/feed.
  - Subreflector.
  - Lock nut.

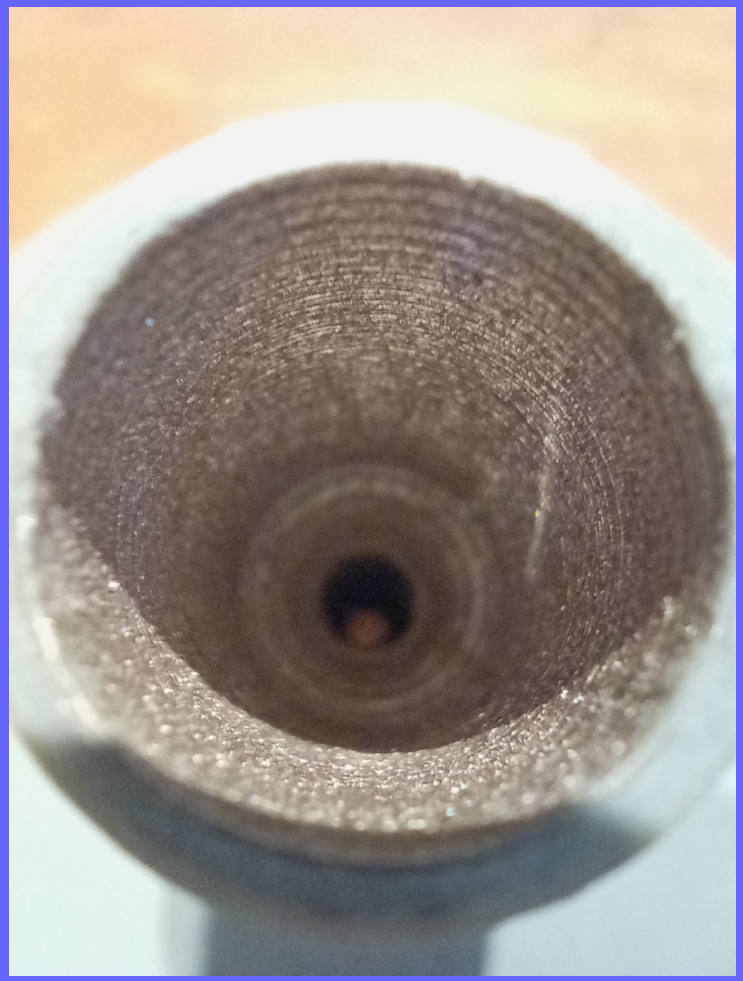
Reflector mount and feed



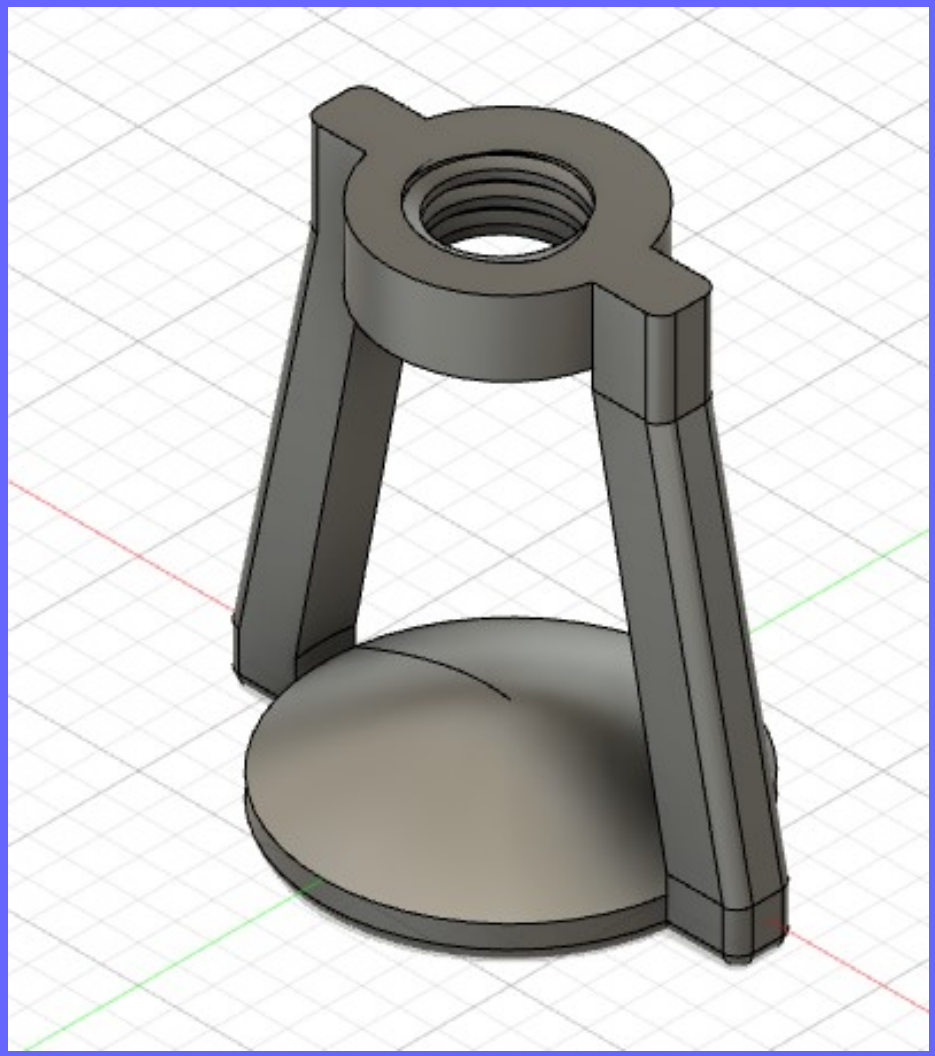
Reflector mount and feed

- 3 points support.
- Acme thread.
- Shoulder on thread to align reflector.
- W2IMU design. Large diameter length 3.7λ.
- Feed distance adjusted from design.
- Feed interior painted with 3 coats of MG Chemicals 843WB Super Shield Conductive Paint.

Inside of feed, paint



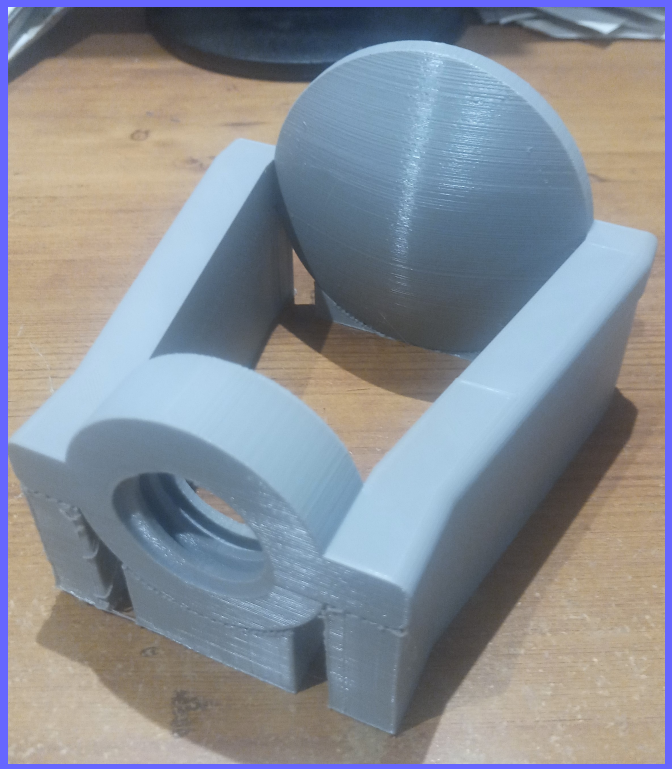
Subreflector



Subreflector

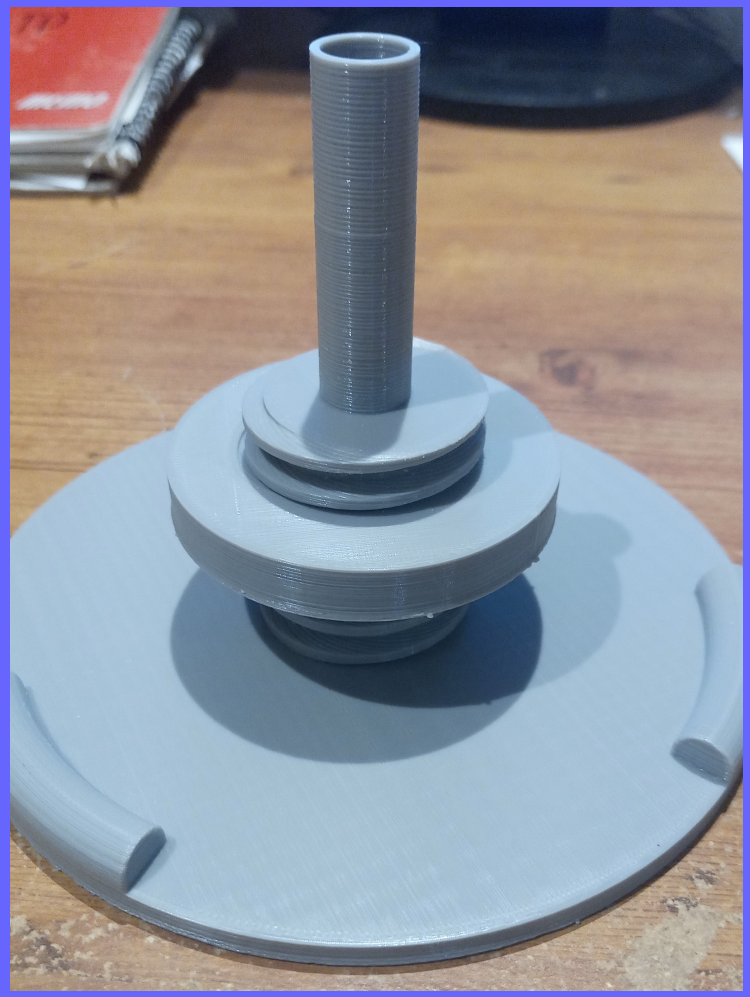
- Simulated hyperboloid.
- Close to CNC dimension (fraction of mm).
- Printed with arms horizontal, for strength.
- Thread size scaled +4% X-Y for fit.
- Necessary to account for filament spread during print.
- Covered with aluminum duct foil.

Subreflector, metal and plastic



Lock Nut

- Straightfoward design.
- X-Y scaled +4%.
- 15mm thick for tests. Final 18mm.
- Subreflector is screwed over it. No adjustment.



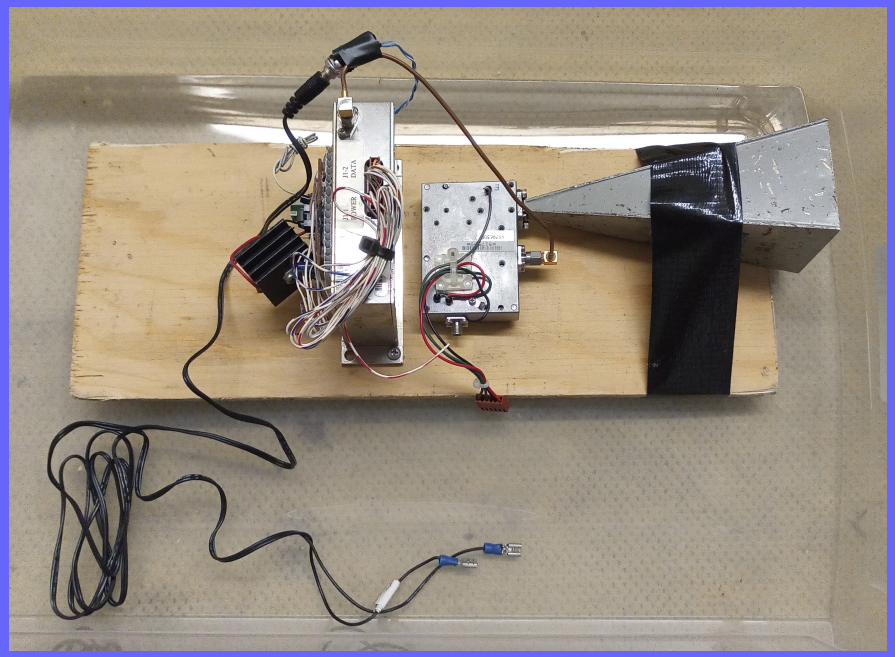
Antenna range

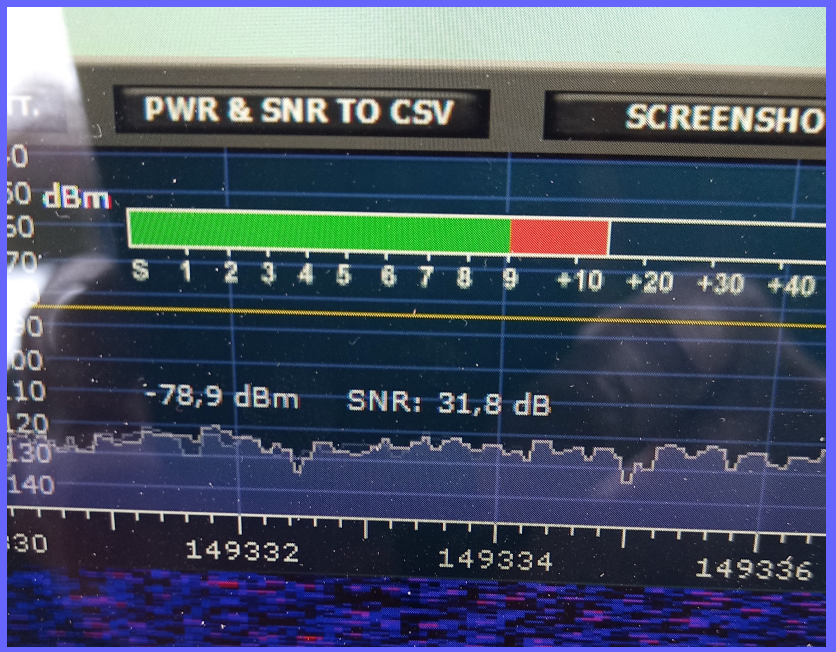
- Rayleigh distance for 2FT dish is 106M.
- I found a site with 120M, not trivial in winter.
- Barely into far field.
- I plan to redo the test at longer range in summer.

Source and receiver

- Weak signal source from Elcom synth, PCOM RX converter and horn.
- Receiver is Khune transverter + RSPdx and SDRuno.
- Tried SDR Console but RSL is too unstable +-0.5 dB.
- SDRuno stay within +-0.1 dB, and track my HP generator within 0.1 dB.

Weak source and SDRuno





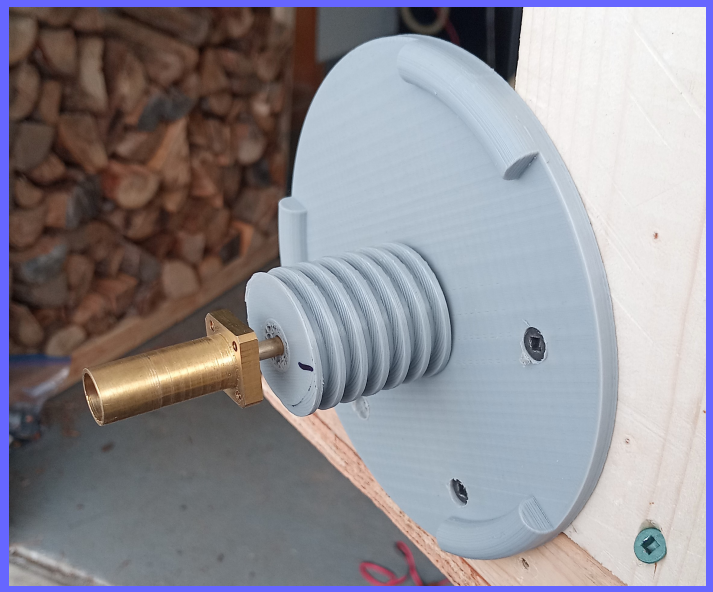
Test Method

- Measure signal with feed only.
- Then add subreflector and measure difference.
- Feed gain alone is around 14 dBi.

Antenna gain = 14 + signal increase.

Plastic vs Metal

- We can compare bare feeds.
- Also signal increase between subreflectors, for each type of feed.



Test results, bare feeds

- Metal feed = -92.6 dBm.
- 3D feed = -94.5 dBm.
- Plastic is -1.9 dB less than metal.
- Could be the paint conductivity and/or surface roughness.

Metal vs 3D subreflectors

Test results, subreflectors

- Baseline is -92.6 dBm.
- Metal feed + CNC sub. = -60.9 dBm (+31.9 dBr).
- Metal feed + 3D sub. = -60.9 dBm (+31.9 dBr).

- Baseline is -94.5 dBm.
- 3D feed + CNC sub. = -62.6 dBm (+31.9 dBr).
- 3D feed + 3D sub. = -62.3 dBm (+32.2 dBr).

Test results, whole antennas

- Base feed estimated at 14 dBi.
- Metal feed + CNC sub. = 45.9 dBi.
- Metal feed + 3D sub. = 45.9 dBi.

- Plastic feed + CNC sub. = 45.9 dBi.
- Plastic feed + 3D sub. = 46.2 dBi.
- NOTE: Resistive, surface loss will lower your RSL.

Antenna efficiency

- Calculated with antenna diameter of 58cm.
- Metal feed + CNC sub. = 47%
- Metal feed + 3D sub. = 47%

- Plastic feed + CNC sub. = 47%
- Plastic feed + 3D sub. = 51%
- Resistive/surface loss ommited.

- 47 - 51 % efficiency at 47 GHz is pretty good!

Source of loss, plastic feed

- More coats of paint? Maybe.
- Better paint? MB Chemicals have other products.
- Surface roughness? Feed internal diameter could be printed smaller and finished with a #5 center drill.

Conclusions

- CNC and metal subreflector are the same.
- While I find a solution for 3D plastic feed loss you can use a metal feed.
- Print the mount and snap the plastic feed off. You will have to adjust the feed to subreflector distance.
- Still, only 1.4 dB difference in RSL between metal and plastic. Worth the effort?

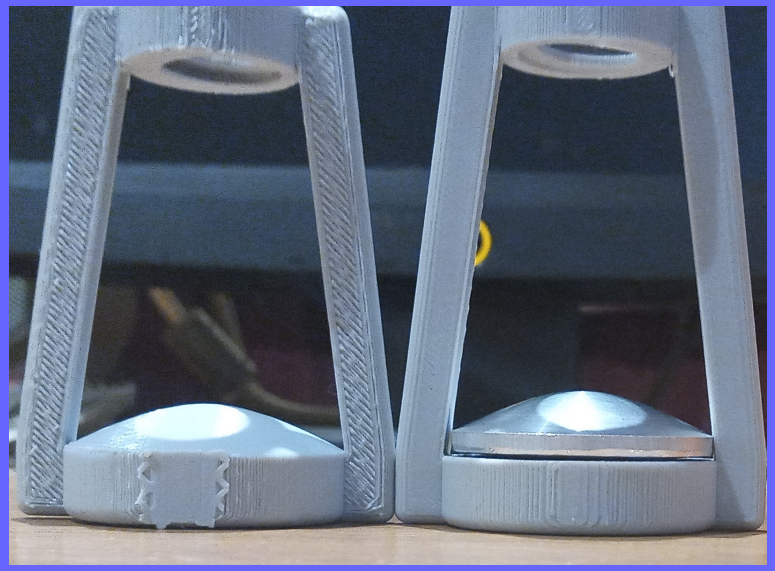
Wait, 122 GHz?

- Yes, it can be done!
- Subreflector.
- Box.
- PCB tray.
- Scope mount.

122 GHz Gain and Efficiency

- Bare feed = 14.9 dBi.
- With CNC subreflector = 45.3 dBi.
- With plastic subreflector = 45.1 dBi.
- Efficiency = 24%

Plastic and CNC



Box and Scope Mount

And 78 GHz?

- No design yet.
- But have Loea commercial antenna as baseline.
- 71-76 / 81-86 GHz.
- Gain is 49.9/51.2 dBi.
- Efficiency 46-48%
- The design at 47 GHz compare well to it.

Special Thanks

- Thanks to Paul Wade W1GHZ, who took the time and effort to design the feeds and subreflectors.

- To my wife, who was wondering why I stayed hours in the cold ☺