Large W2IMU Feeds for Improved G/T on Offset Dishes

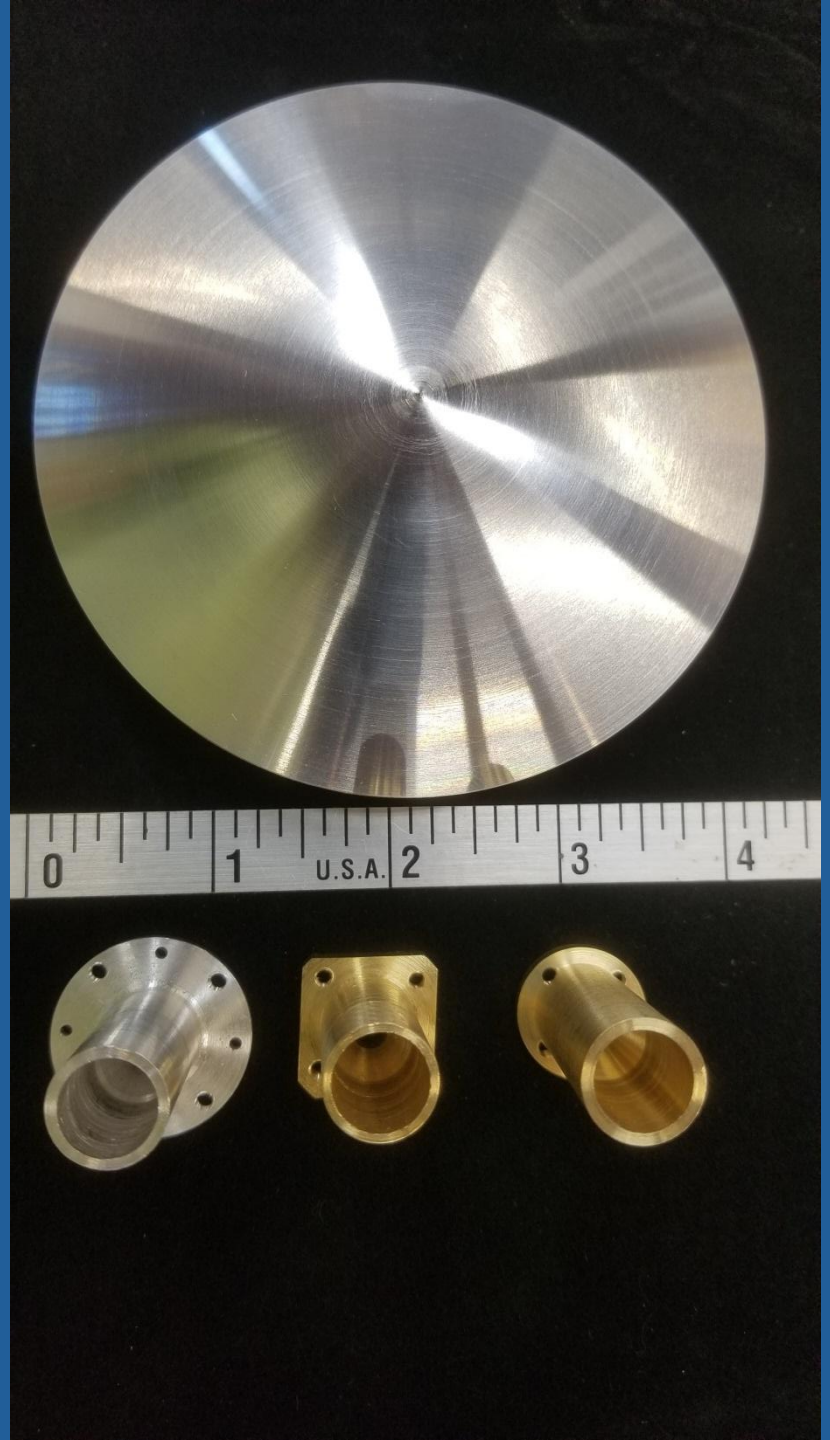
PAUL WADE W1GHZ

EME 2026

Also good for Cassegrain Feed

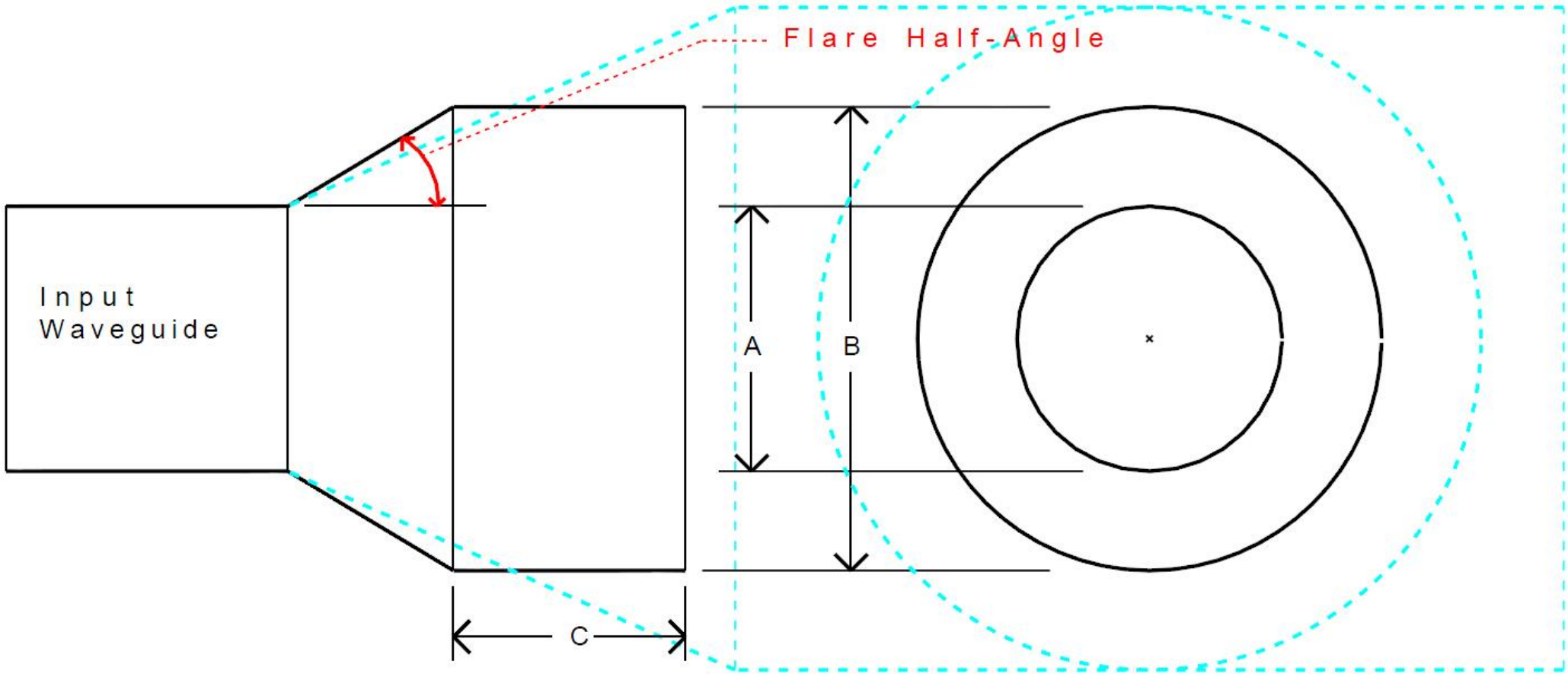
47 GHz Cassegrain

VE2UG dish

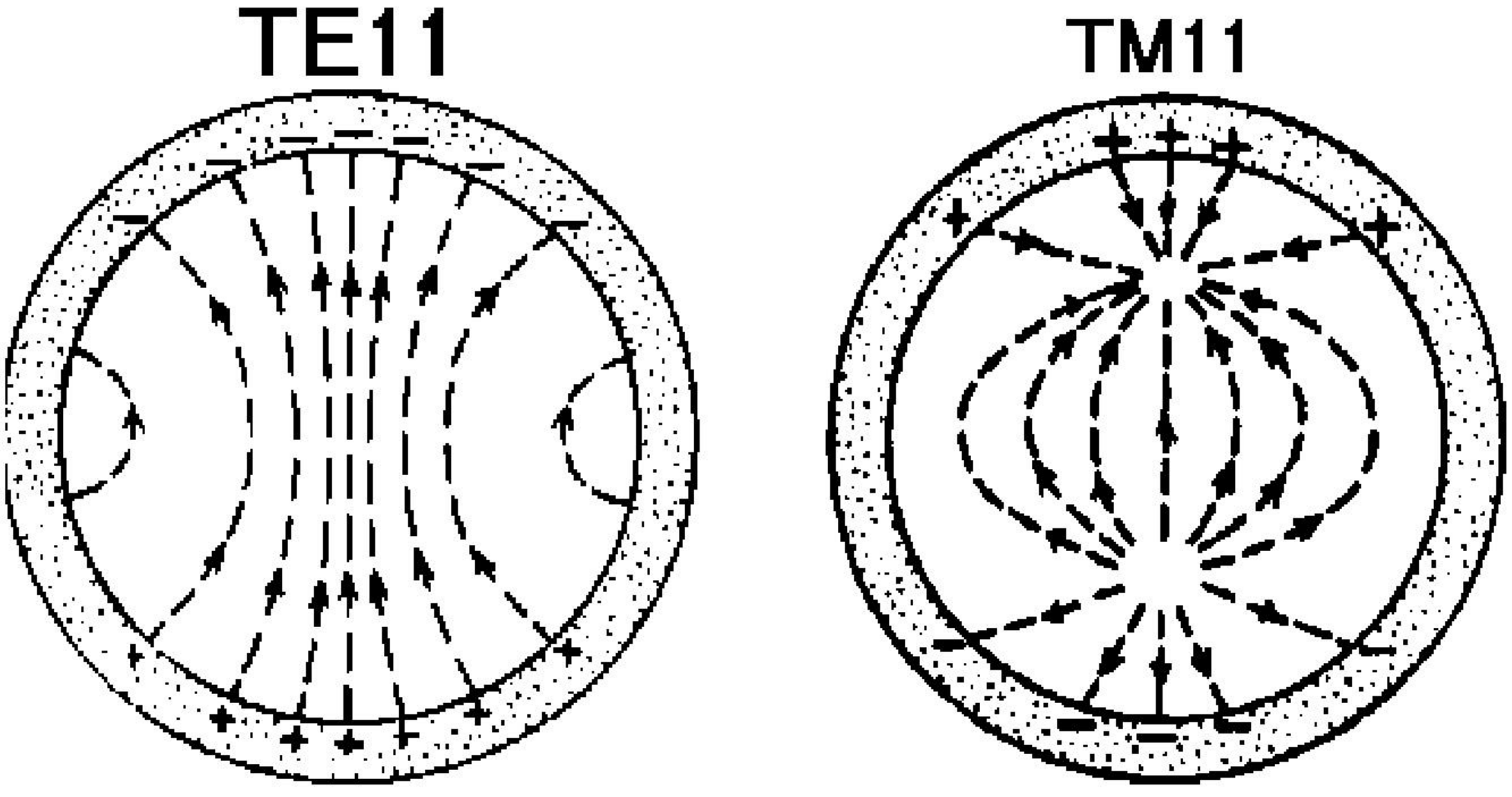


W2IMU Dual-Mode Feedhorn

- **Invented by Dick Turrin, W2IMU & patented**



Dual-mode Horn



Dual-mode Horn

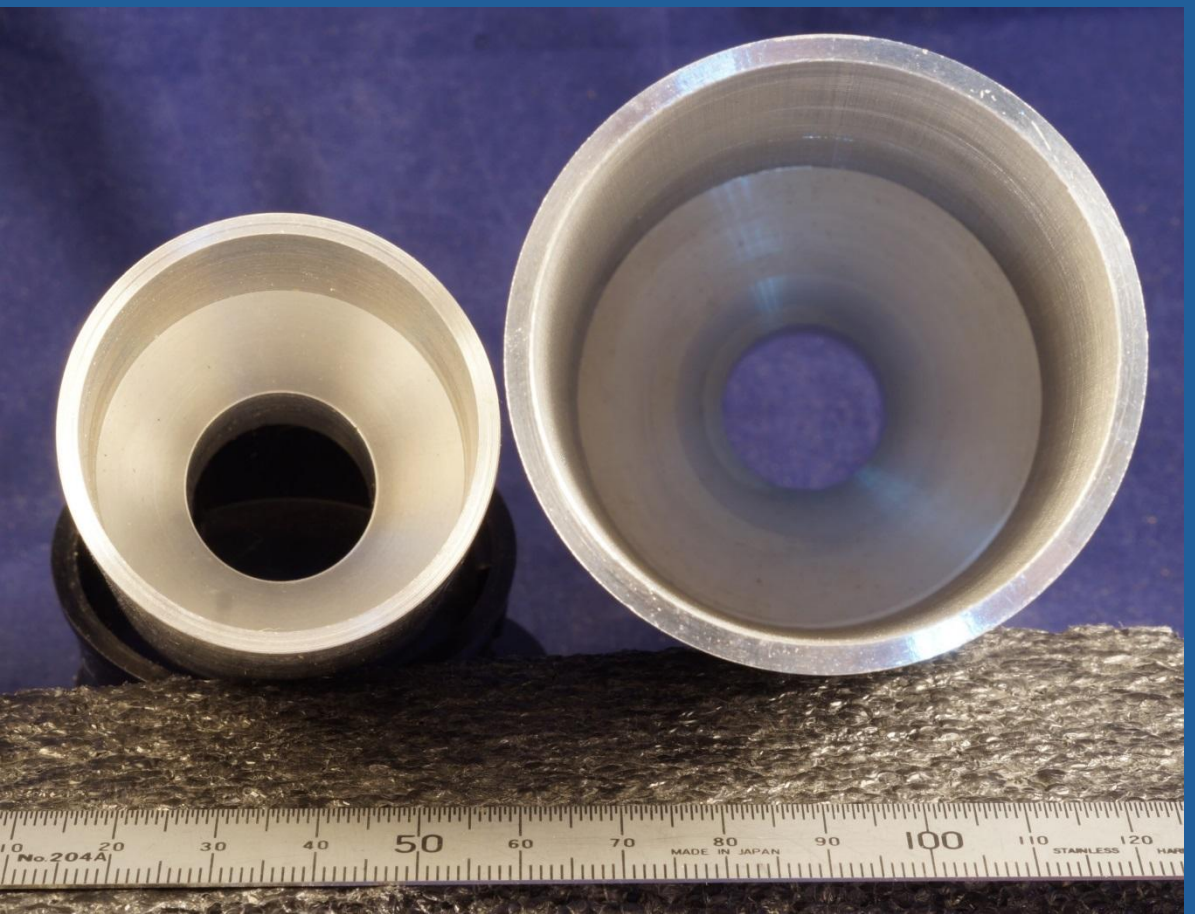
- Input Waveguide only propagates TE11 mode
- Flare generates TM11 mode
- Modes travel at different velocities in horn
- Horn length chosen so modes cancel at rim
- No currents in rim → Reduced sidelobes
  - More power on dish
  - Less ground noise

W2IMU Dual-mode Horn

- Original 1.31λ horn diameter
- W2IMU also described 1.86 λ horn diameter
- Diameters from 1.22 λ to ~2 λ diameter work
- Horn length increases with larger diameter
- Flare angle decreases with larger diameter

Copper Feeds for 10 GHz

Machined Aluminum Feeds for 10 GHz



Measurement

- Good measurement is hard at higher frequencies
- Easier at 10 GHz
- Machine accurately at 10 GHz
- Several aluminum pipe sizes available for 10 GHz
- Simulate horn lengths for 30 degree flare
- Machine with range of feed diameters
- Measure Sun Noise

Machining Aluminum Feeds

- Horns are around 50 mm diameter, 100 mm long
- Boring from solid stock difficult and wasteful
- CNC machine flare section with input waveguide
- Turn down to almost fit inside pipe (~0.1 mm over)
  - *Measure after cooling off – machining heats material*
- Heat pipe to > 100 C - expands ~22 ppm/degree
- Slip over flare section
- Permanently attached after cooling (in seconds!)

W2IMU feedhorns

Original and three larger sizes

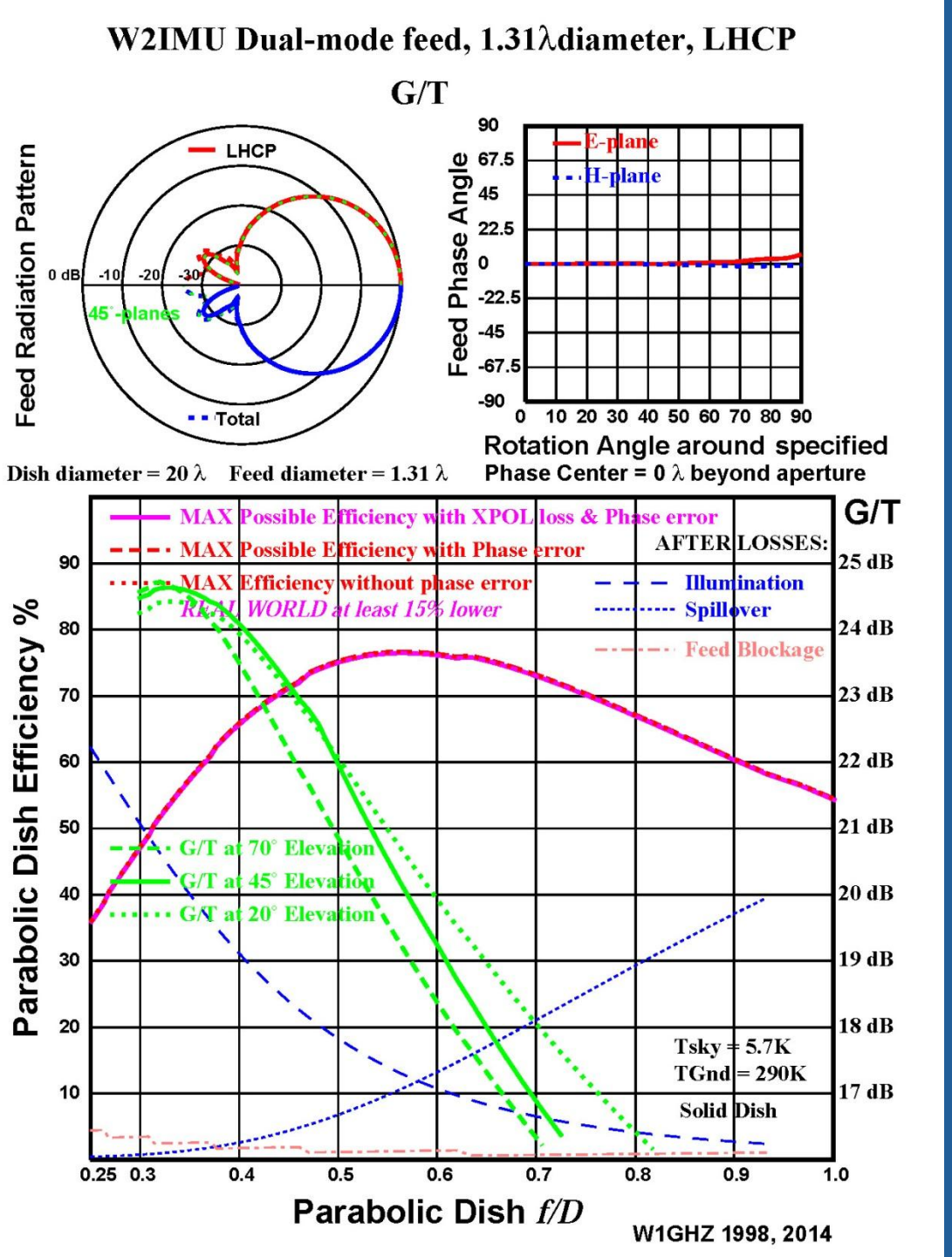
Matching Plate – WA6KBL design

G/T

- **Gain/Tsystem is what counts for EME**
- **Gain/noise → S/N (*hearing signals*)**
- **Small Dish:**
- $\frac{30\ dB\ gain}{1\ dB\ Tsys}\ g = \frac{1000}{75K}\ G = 13.3 = 11.3\ dB$
- $\frac{30\ dB\ gain}{2\ dB\ Tsys}\ g = \frac{1000}{170K}\ G = 5.9 = 7.7\ dB$
- $\frac{30\ dB\ gain}{3\ dB\ Tsys}\ g = \frac{1000}{290K}\ G = 3.4 = 5.3\ dB$
- **2 meters:**
- $\frac{16\ dB\ gain}{Tsky}\ g = \frac{40}{600K}\ G = .07 = -11\ dB$

Original W2IMU feed

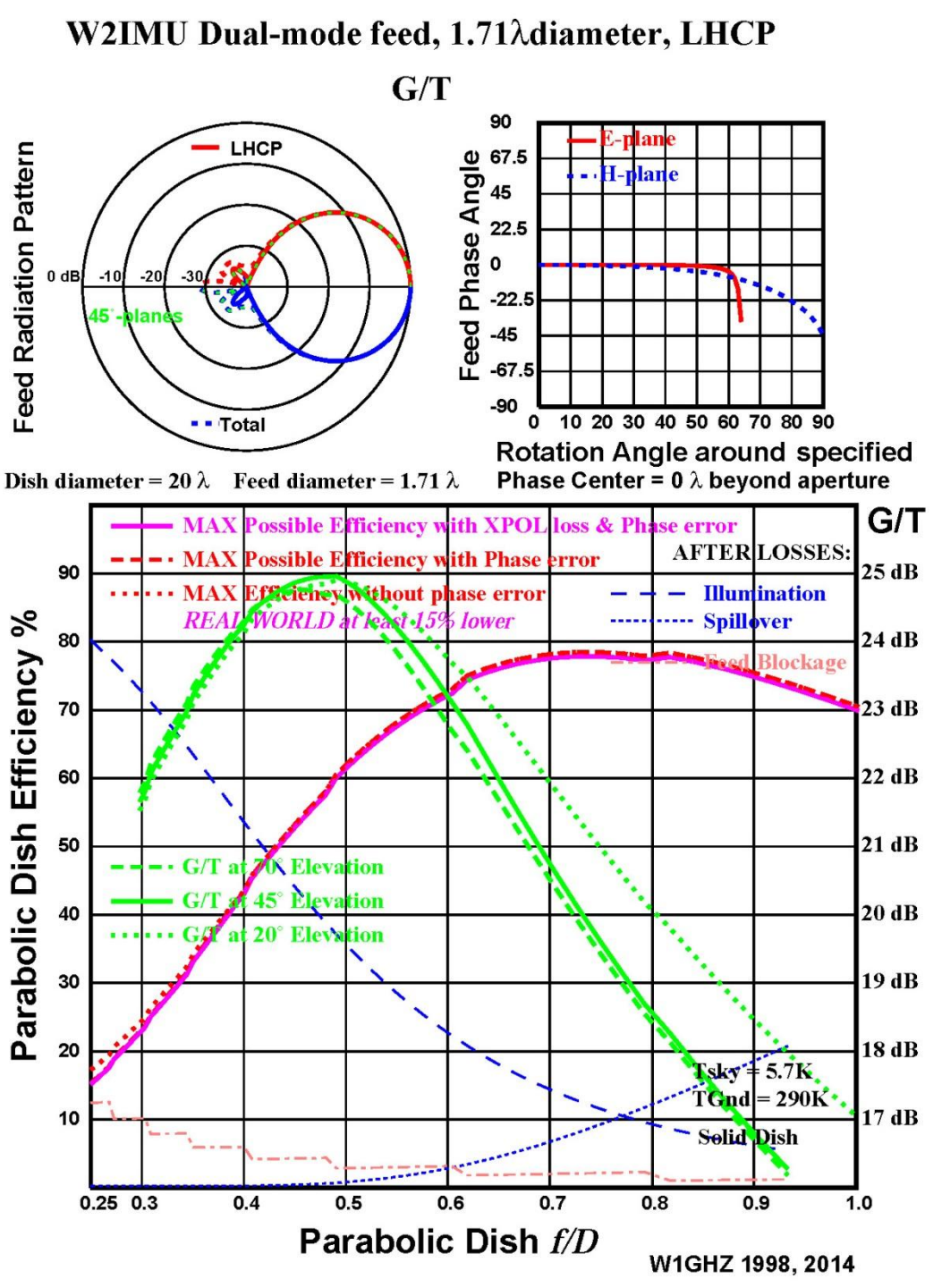
Best G/T at lower f/D (antenna only)



Large W2IMU feed 1.71λ diameter

Best G/T at lower f/D (antenna only)

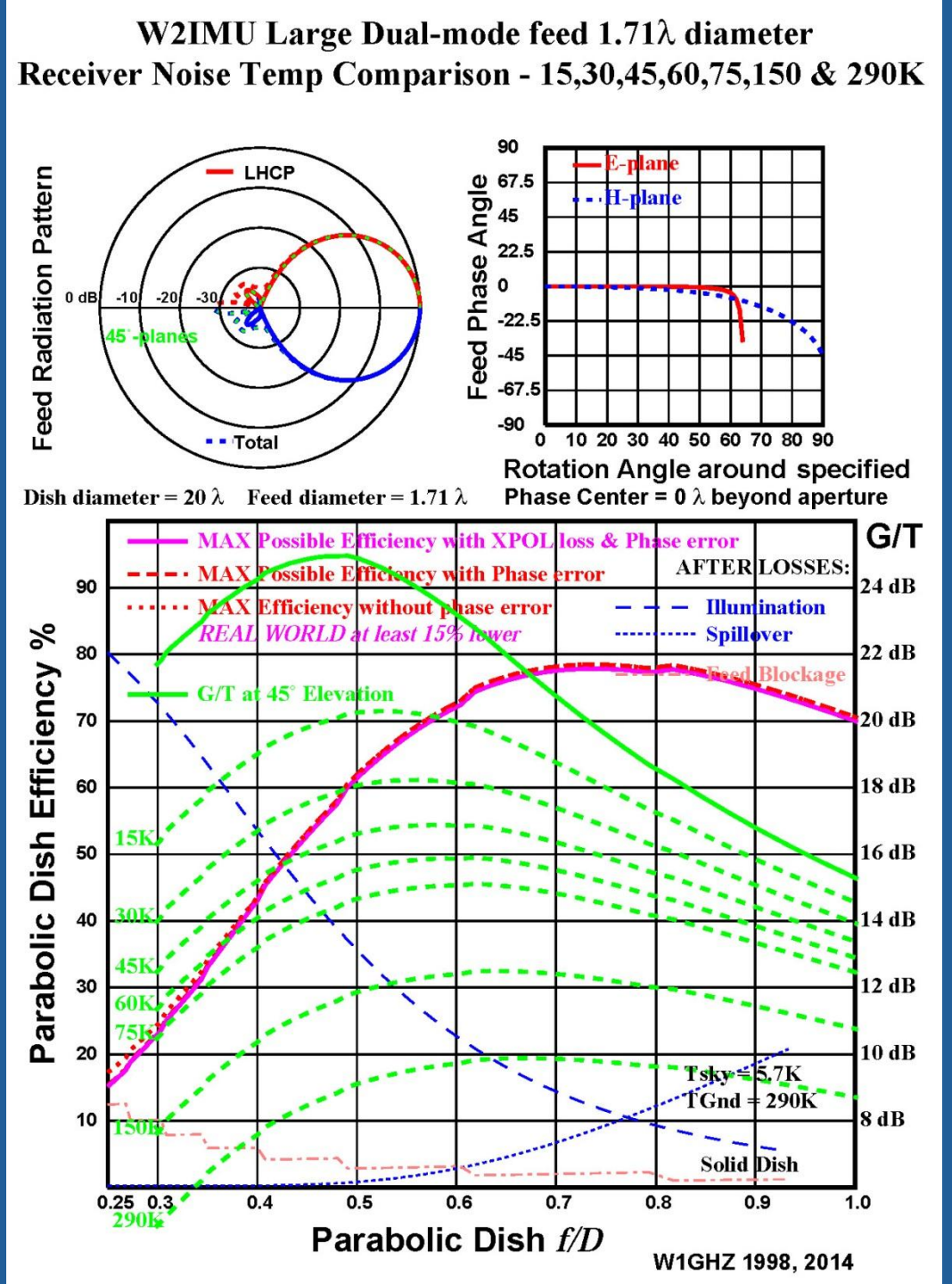
But closer to offset dish



Large W2IMU feed 1.71λ diameter Tsys effect

G/T drops rapidly as Tsys increases

f/D for Best G/T goes up as Tsys increases



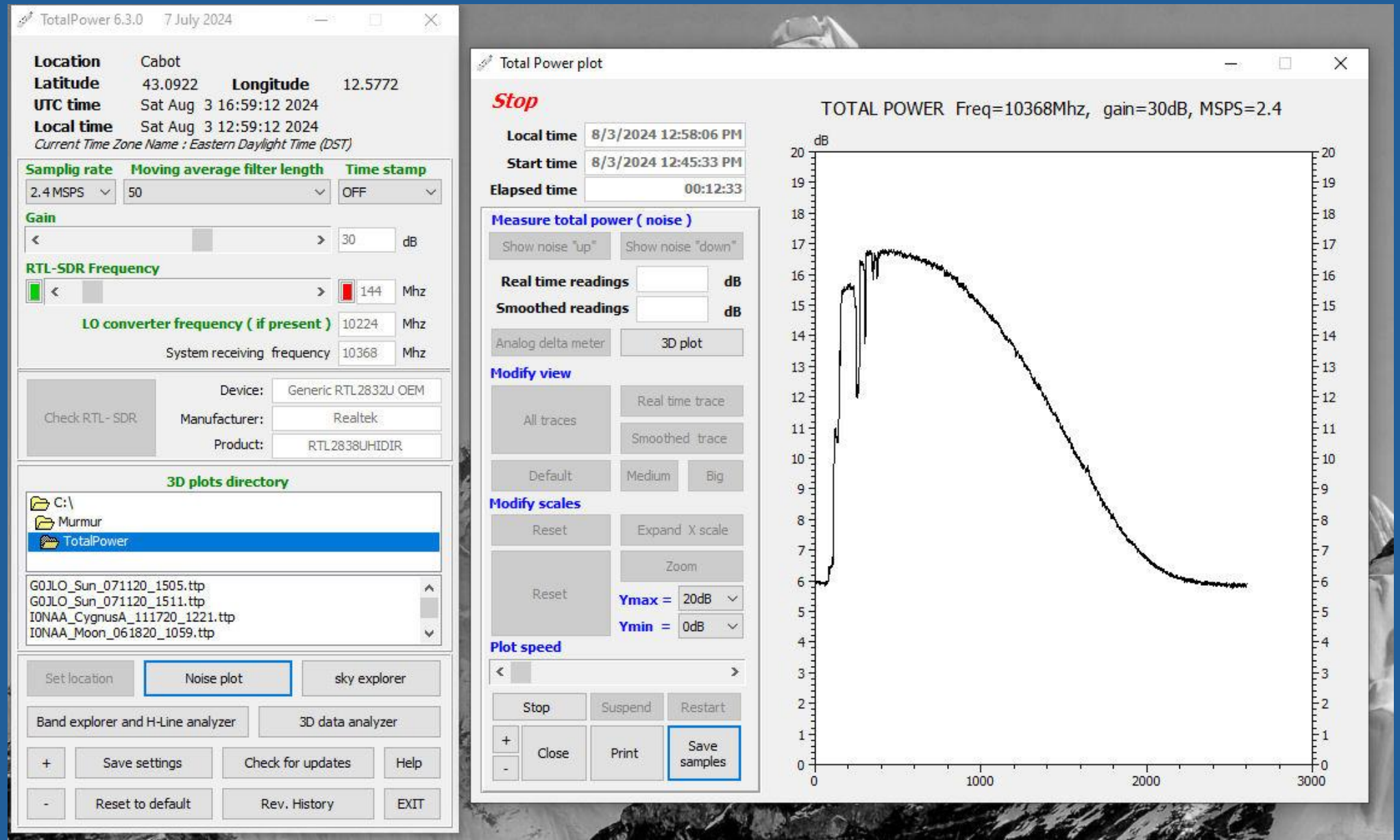
Sun Noise (& Ground Noise)

- Sun compared to Cold Sky
  - Indicator for G/T
- Ground noise compared to cold sky
  - Indicator for Tsys
  - Measure on preamp directly for Noise Figure

Measure Sun Noise with TotalPower by I0NAA

- Uses RTL-SDR Dongle
- Connect to IF output
- Modest Laptop adequate

TotalPower by I0NAA



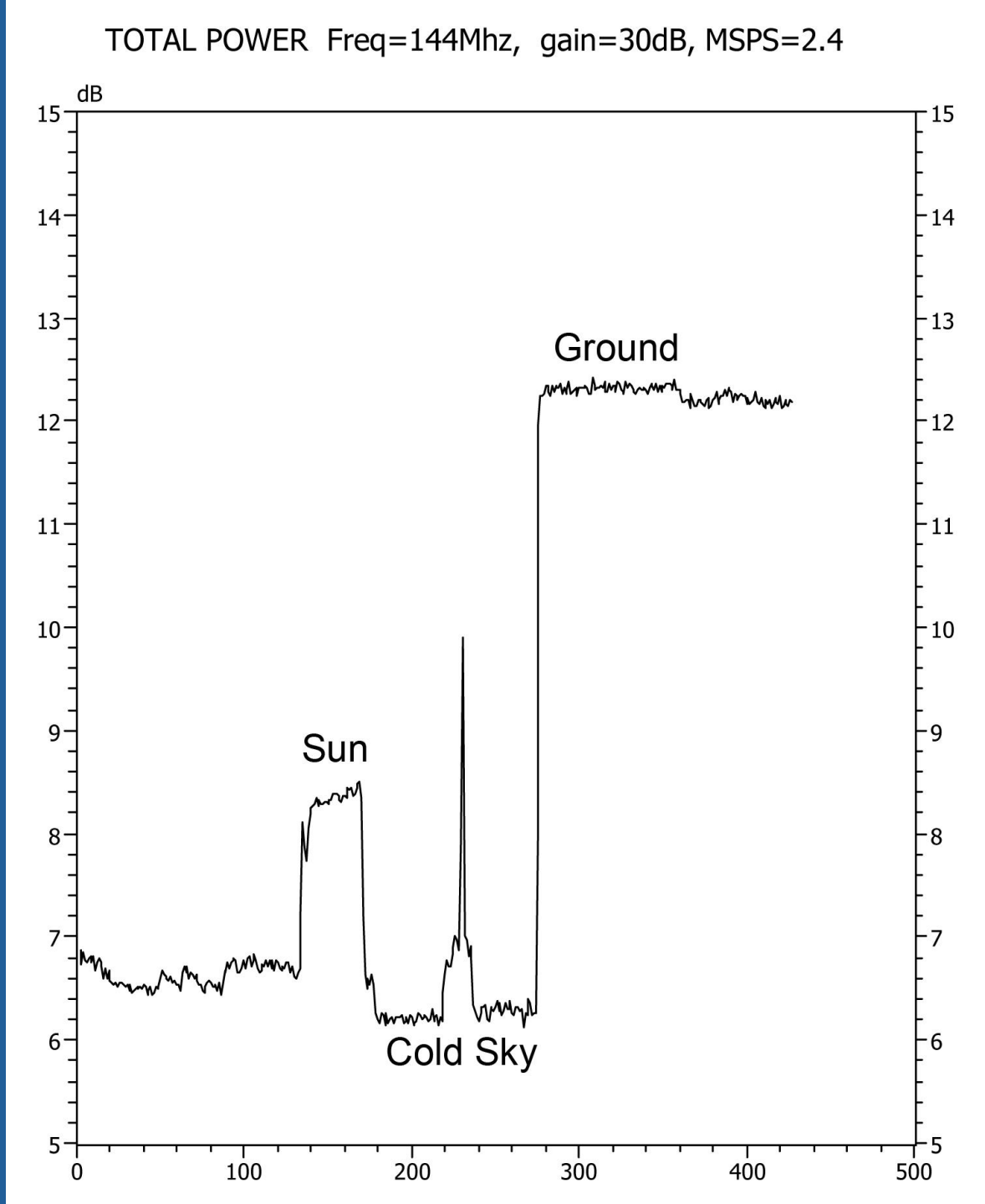
Noise Figure Preamp and Feedhorn

CS/G

Dish behind shields from Ground noise

TotalPower plot of Preamp and Feedhorn

6.1 dB CS/G
→ 0.75 dB NF



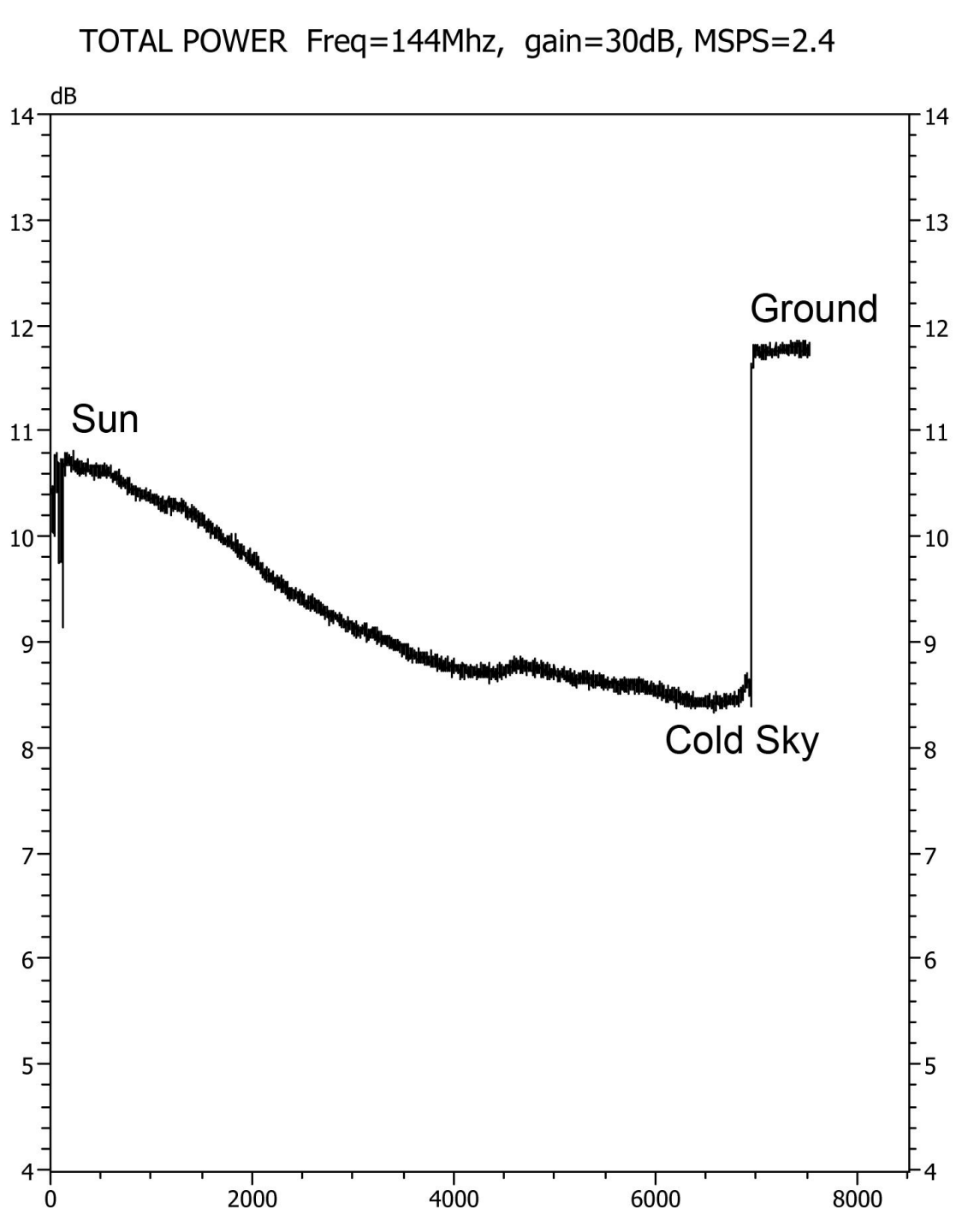
Measure Rover System

Sun to Cold Sky
and
Cold Sky to Ground

10GHz Rover System

Drift Plot –
Point at Sun,
earth rotation moves sun out of beam.

Then point at Ground



Troubleshooting

Use similar feed with

Power Meter

or

Noise Source & NF meter

or

Spectrum Analyzer

- ***Typical loss ~ 1 dB***

Dish Feed Comparison

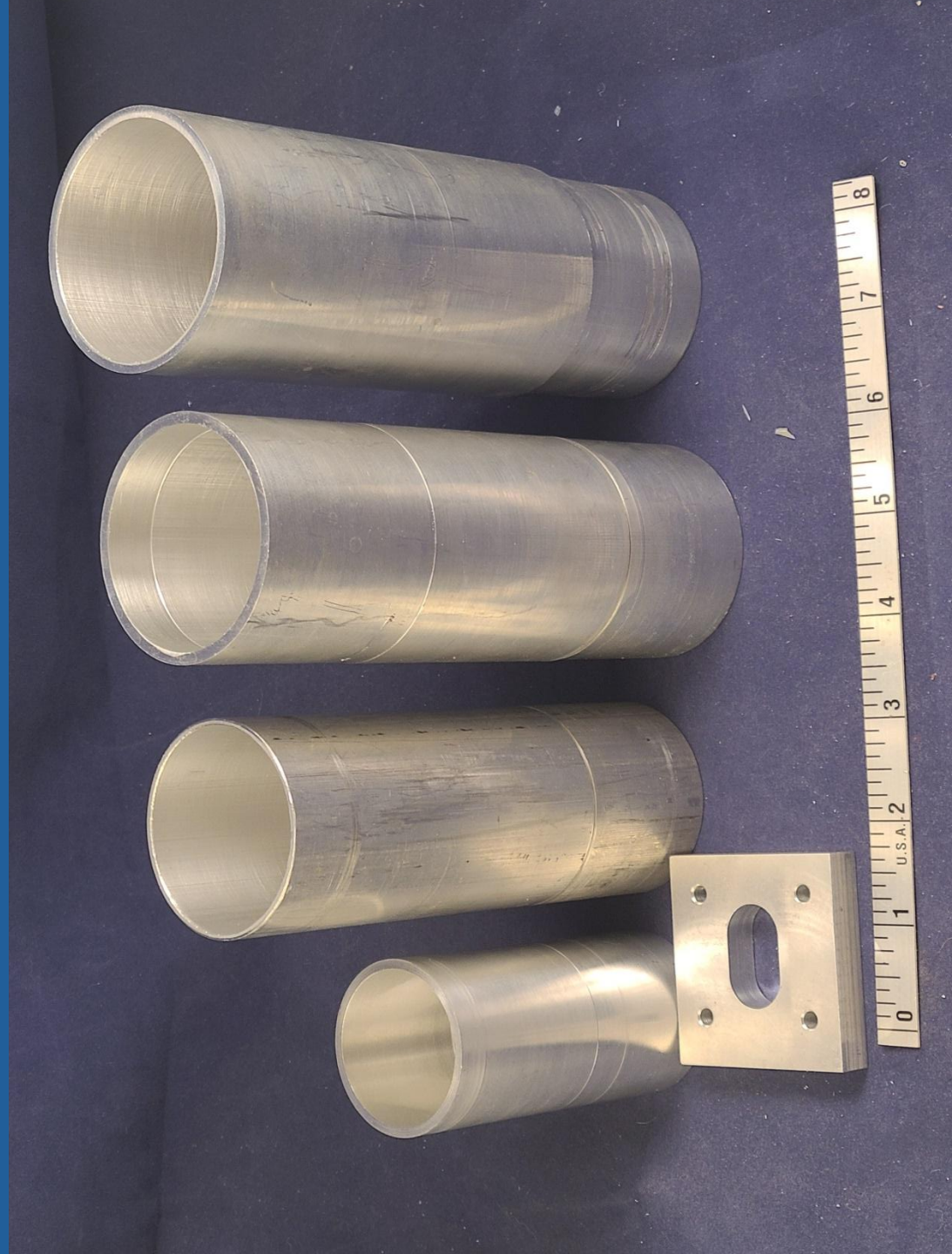
Larger Dish (1.2 Meter)
Low-noise Preamp
at feed
(short waveguide)

1.88 λ Diameter

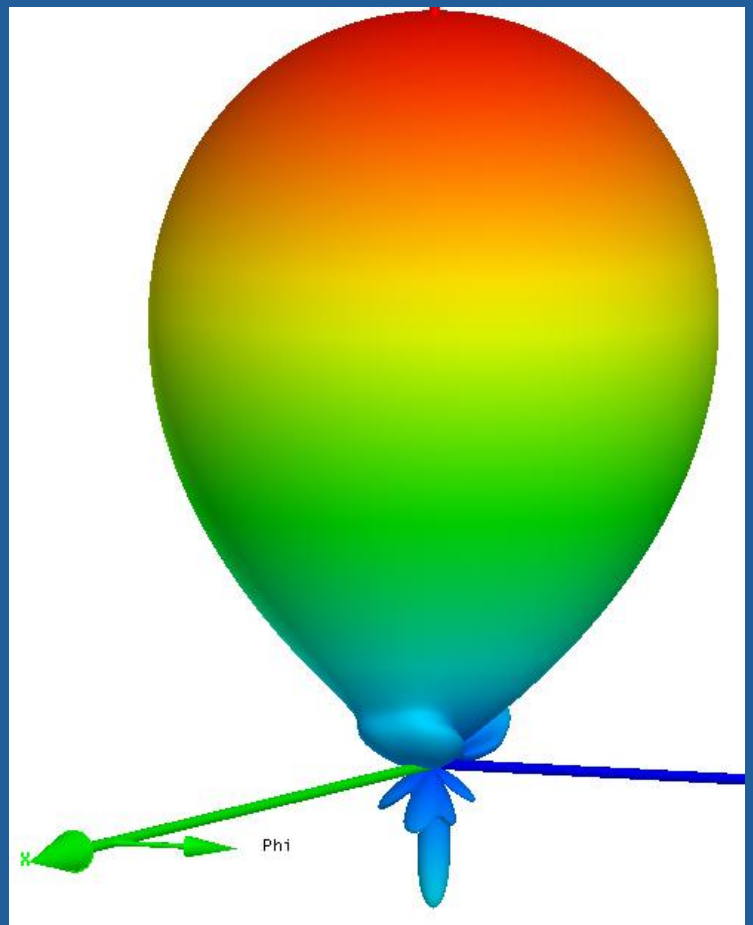
1.75 λ Diameter

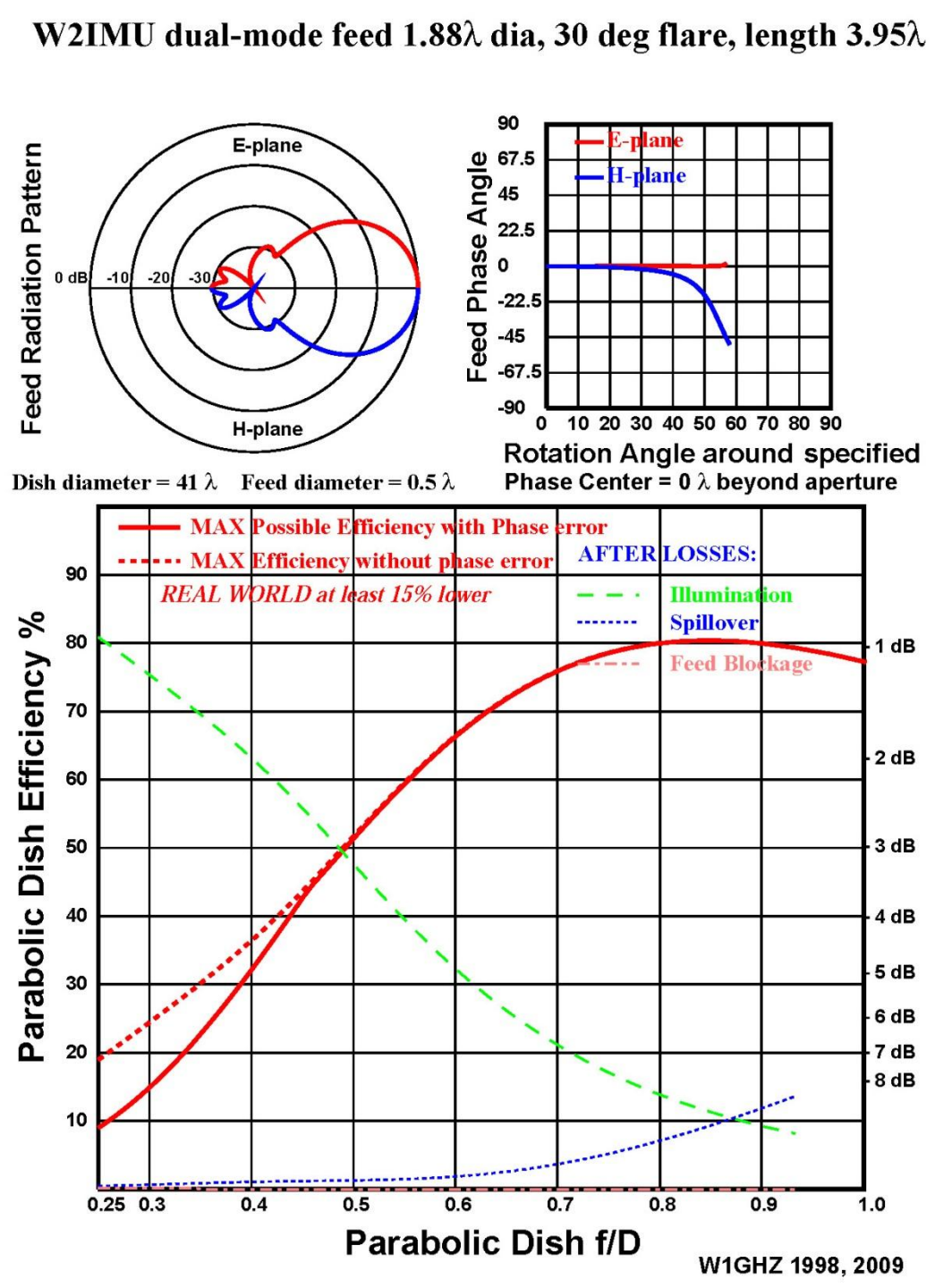
1.62 λ Diameter

1.31 λ Diameter



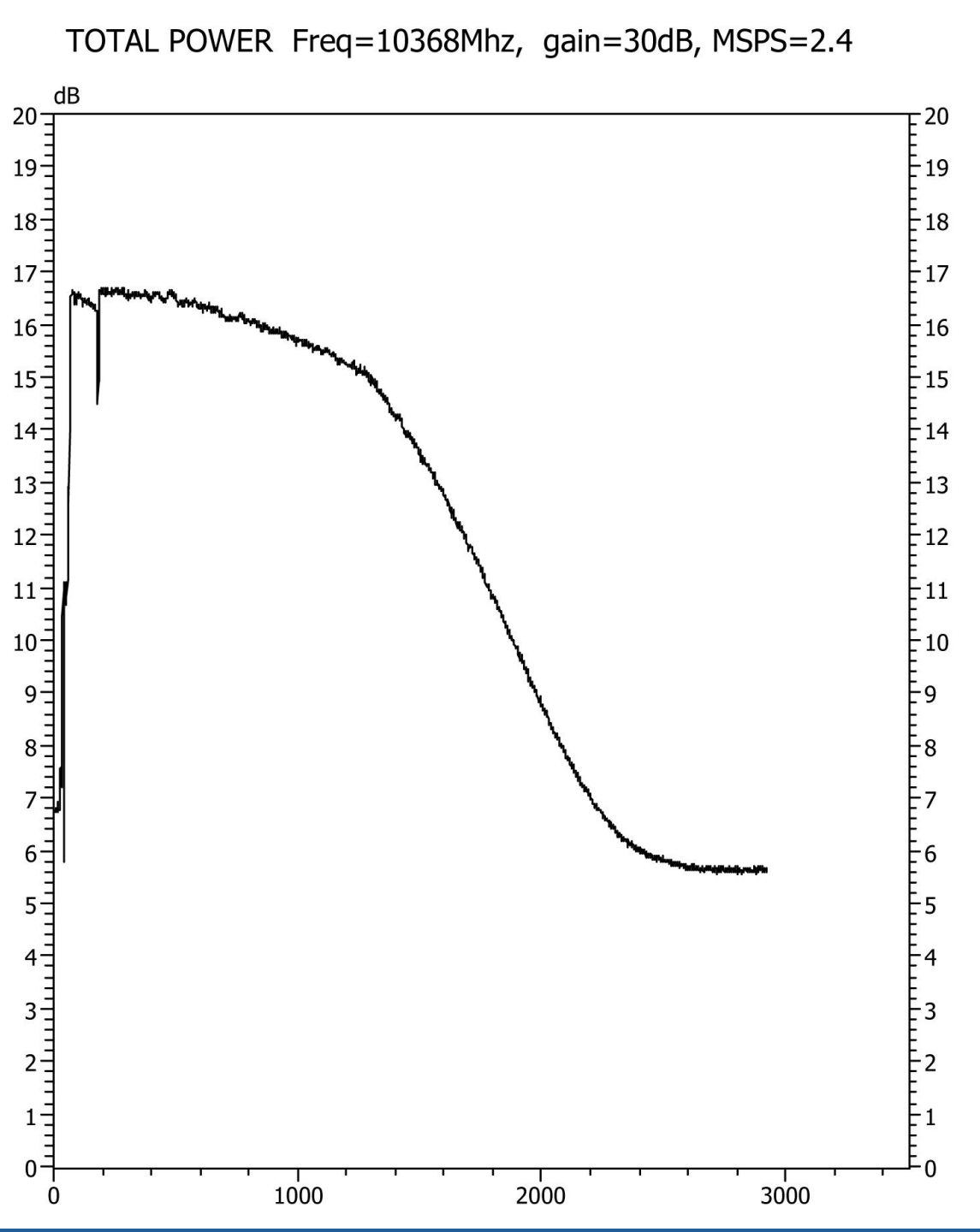
Large W2IMU Feed
1.88 λ Diameter
1.2 meter dish



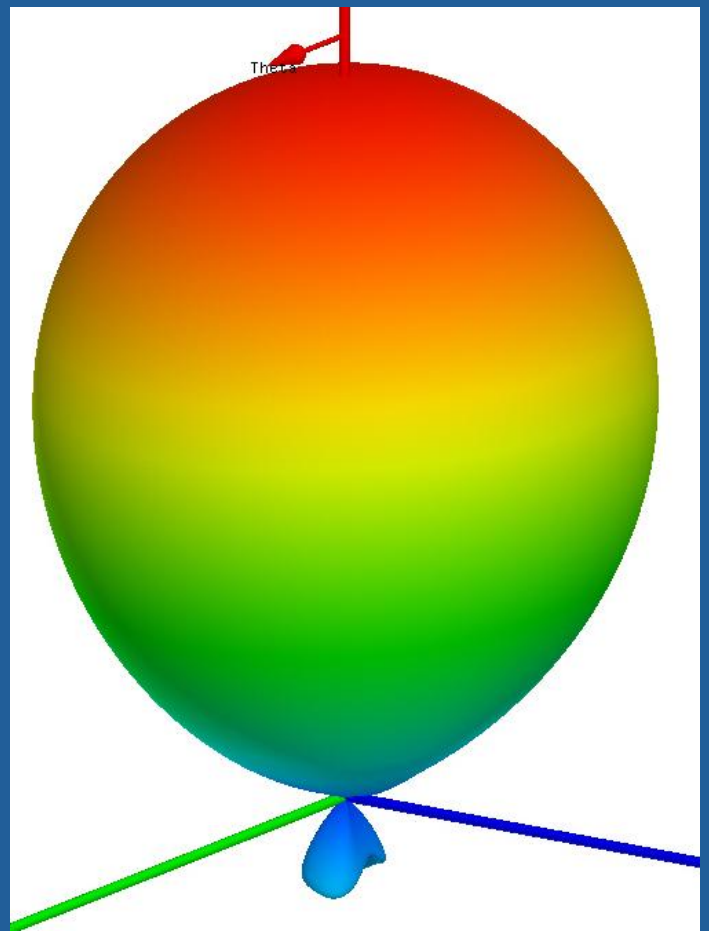


Large W2IMU Feed
1.88 λ Diameter
1.2 meter dish

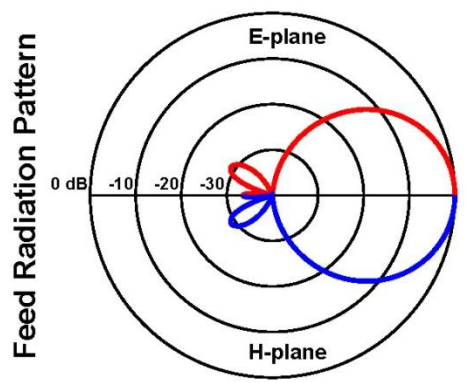
11 dB Sun Noise

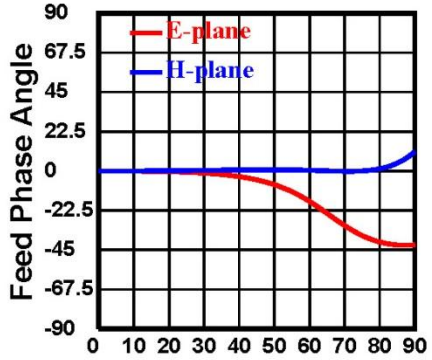


Large W2IMU Feed
1.75 λ Diameter
1.2 meter dish

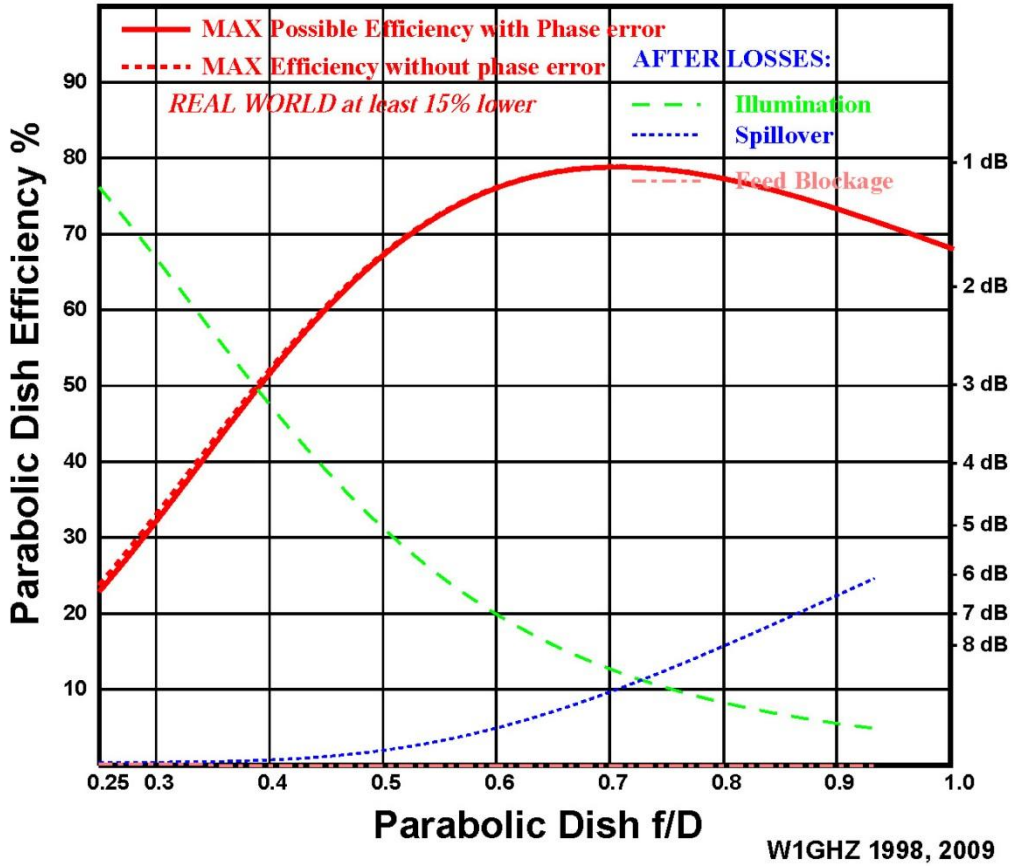


Large W2IMU feed 1.75λ dia, 30 deg flare, length 3.66λ





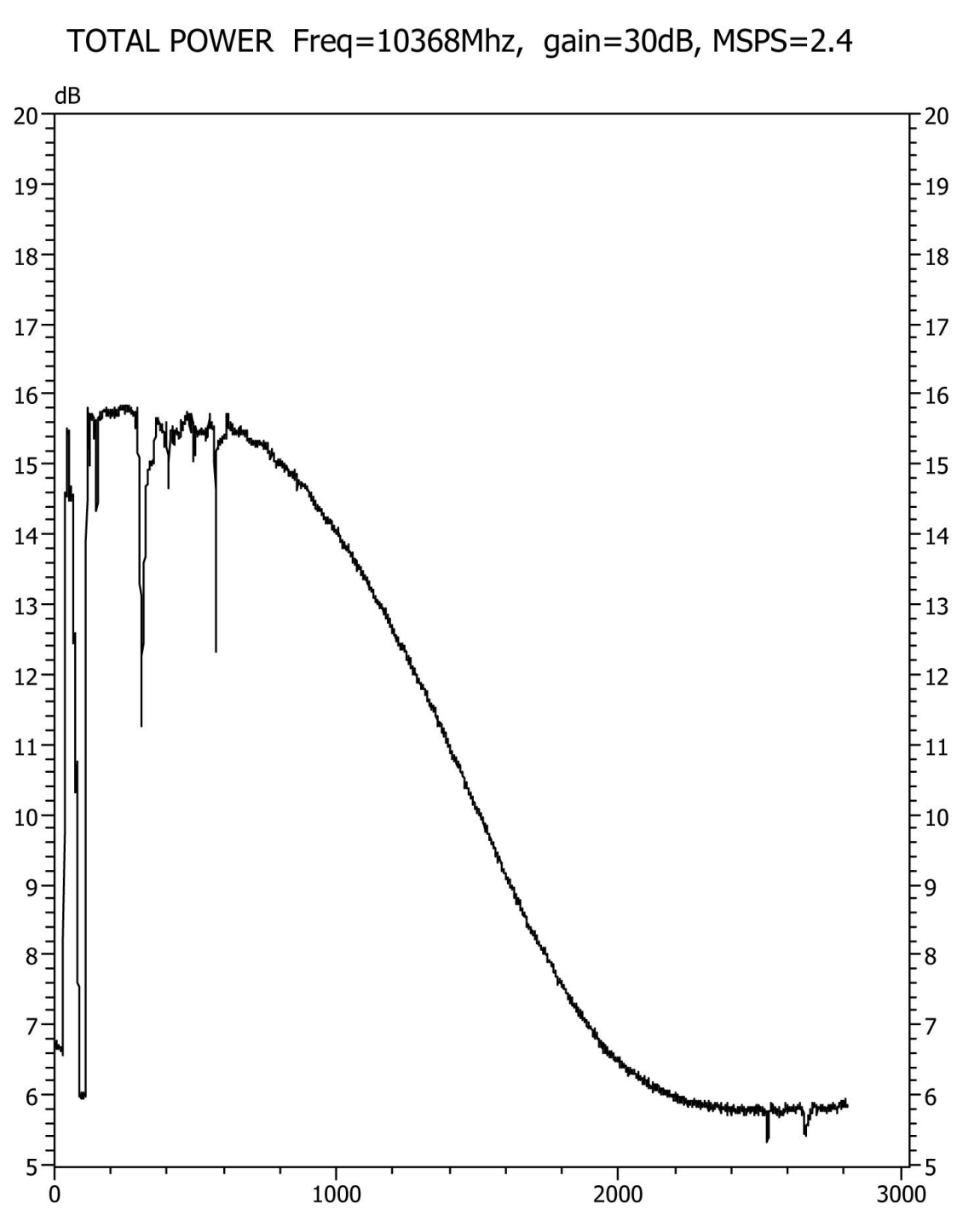
Dish diameter = 41 λ Feed diameter = 0.5 λ



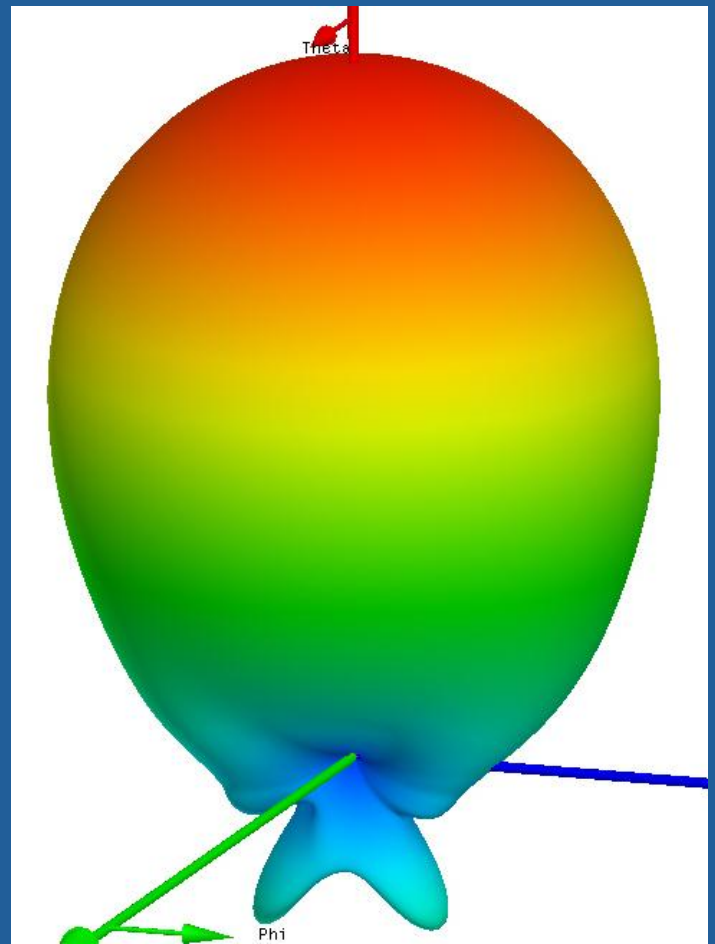
W1GHZ 1998, 2009

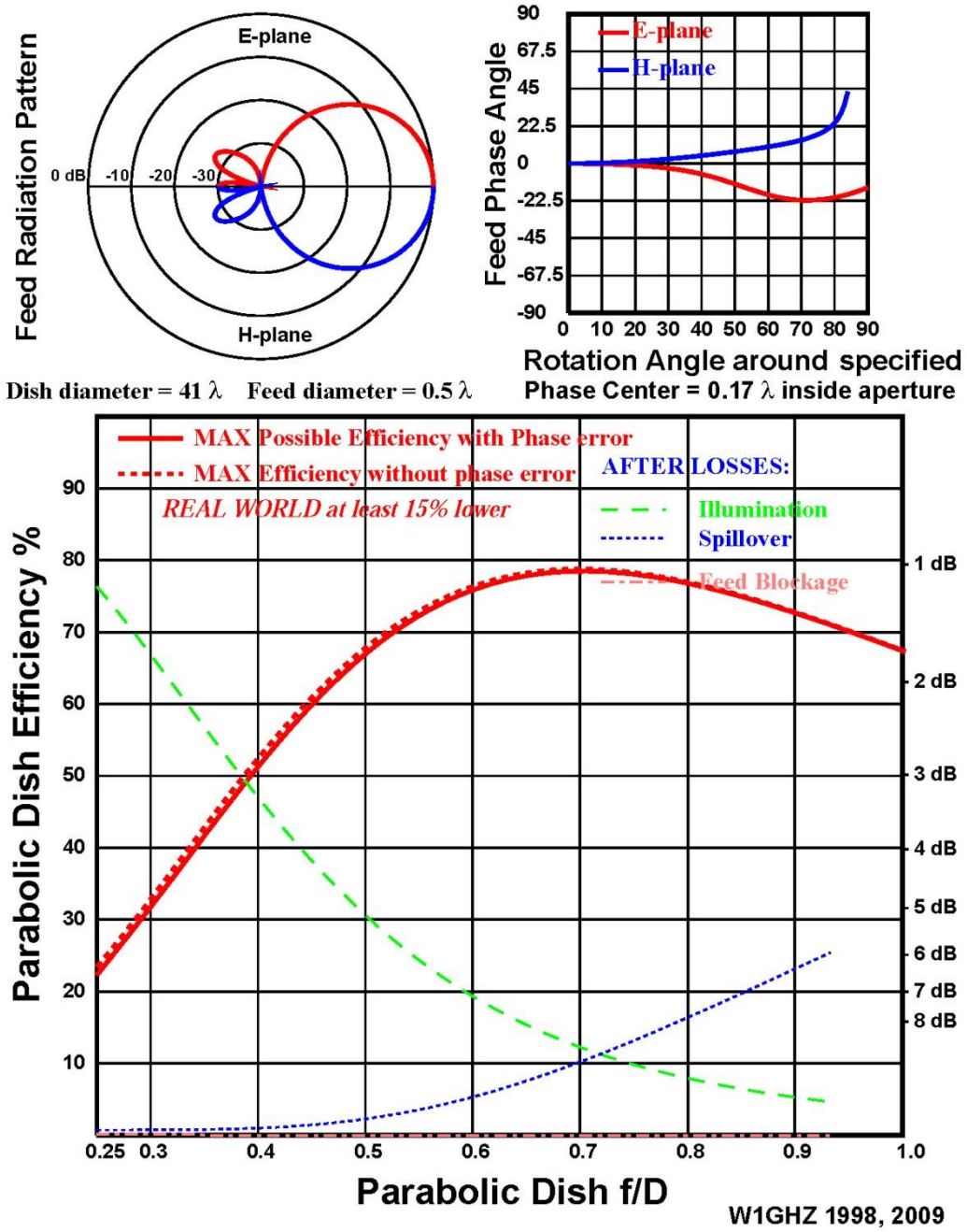
Large W2IMU Feed
1.75 λ Diameter
1.2 meter dish

10 dB Sun Noise



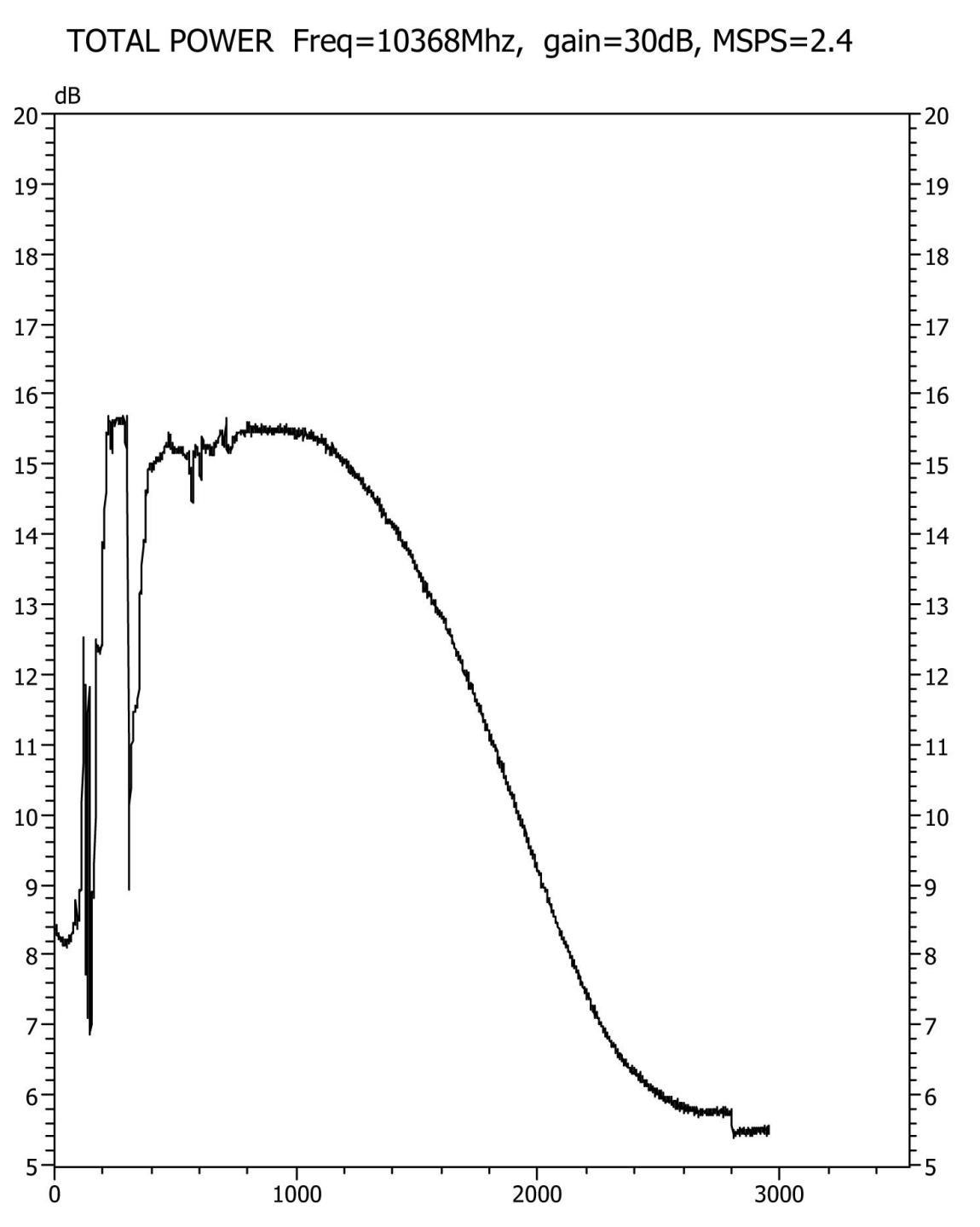
Large W2IMU Feed
1.62 λ Diameter
1.2 meter dish





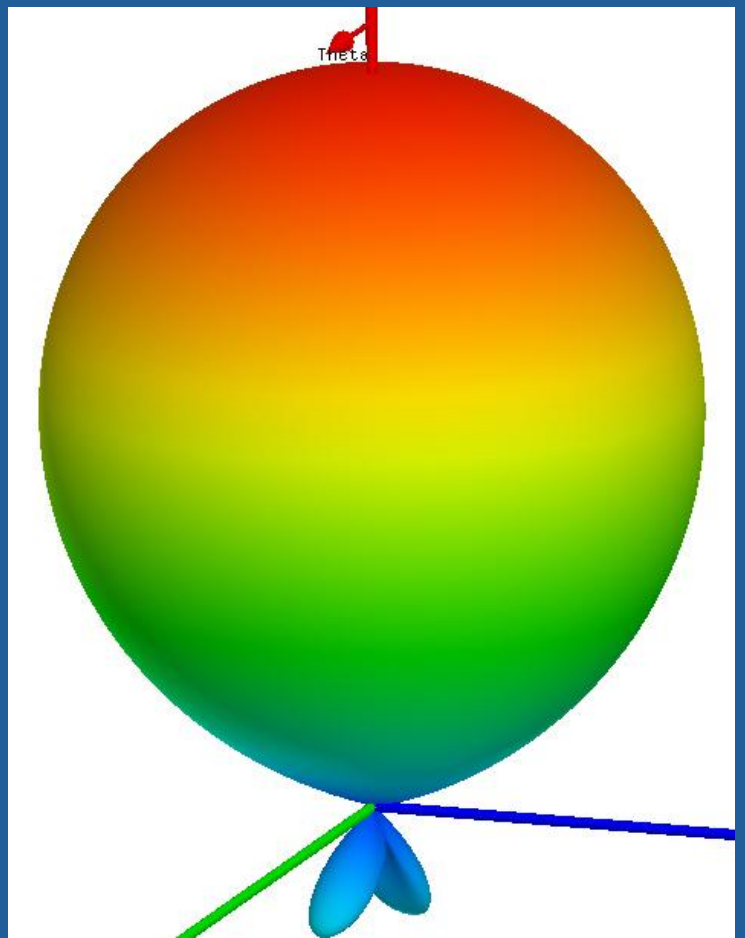
Large W2IMU Feed
1.62 λ Diameter
1.2 meter dish

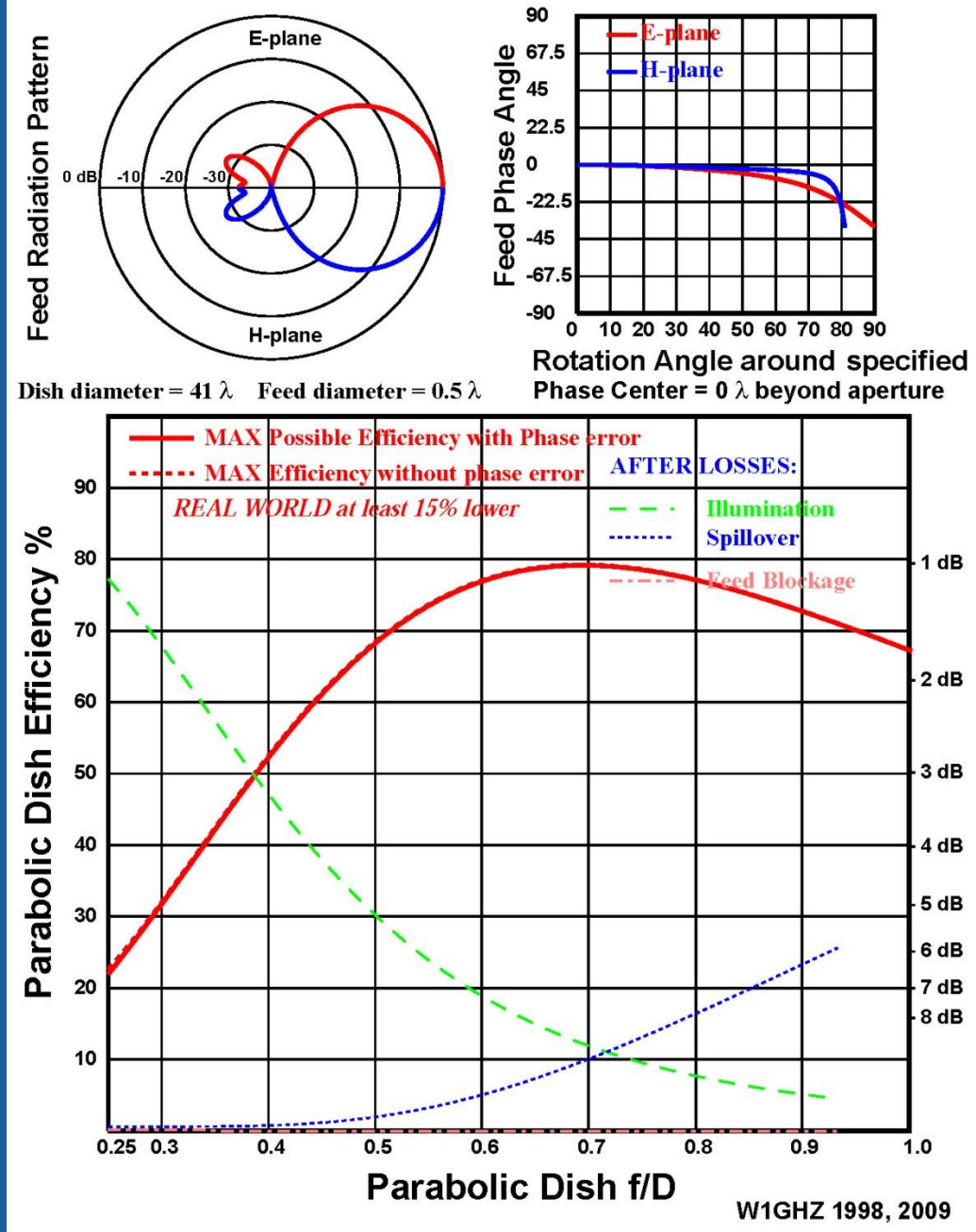
10.9 dB Sun Noise



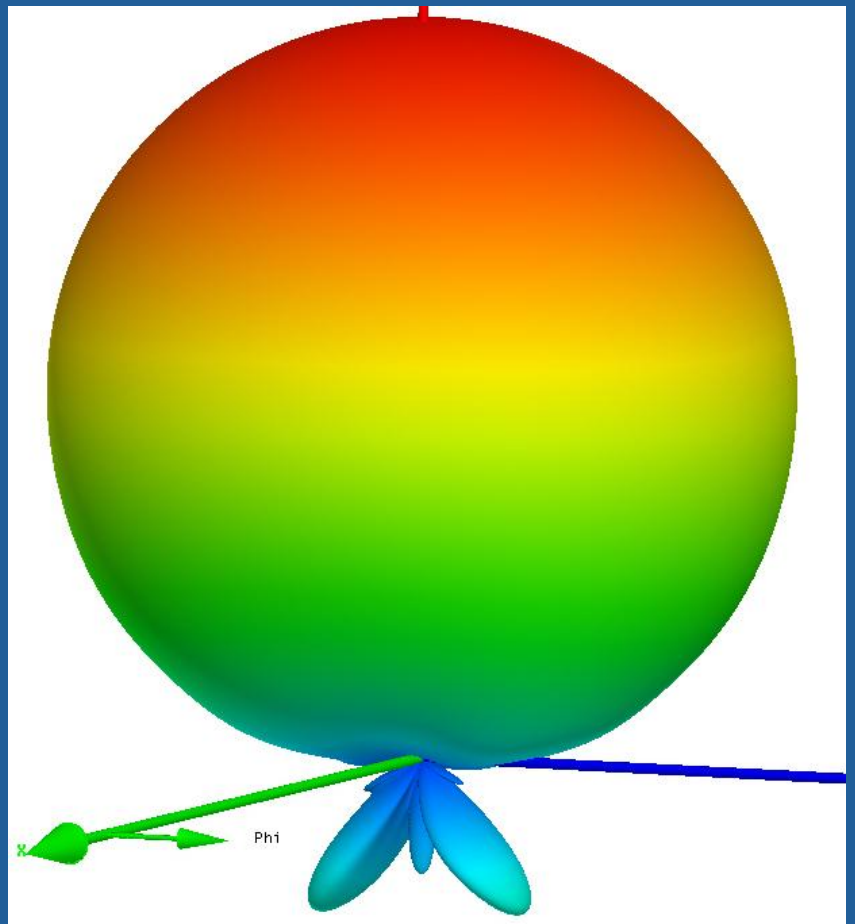
Large W2IMU Feed
1.62 λ Diameter
1.2 meter dish

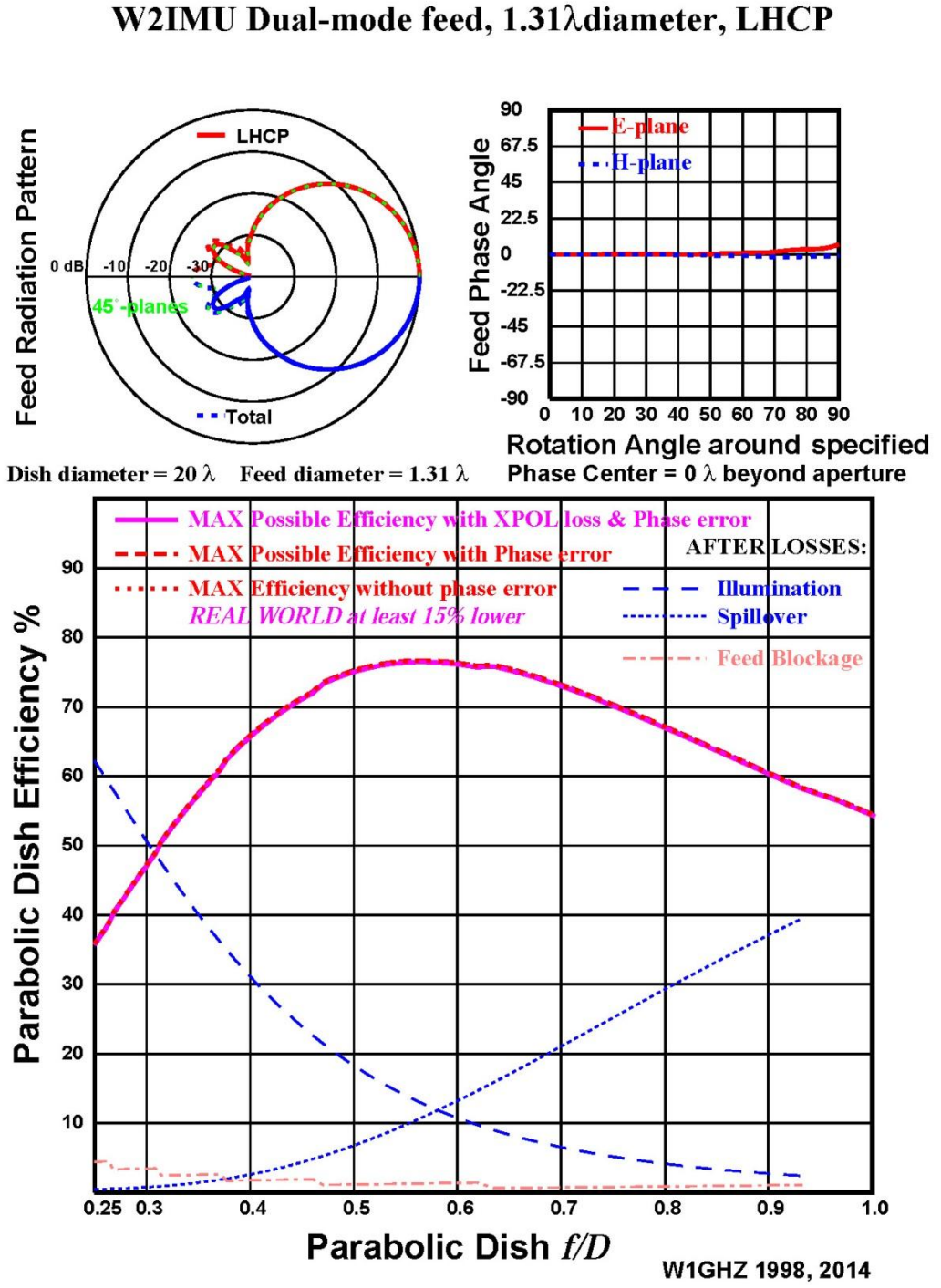
- Looks better
- Not built or tested yet





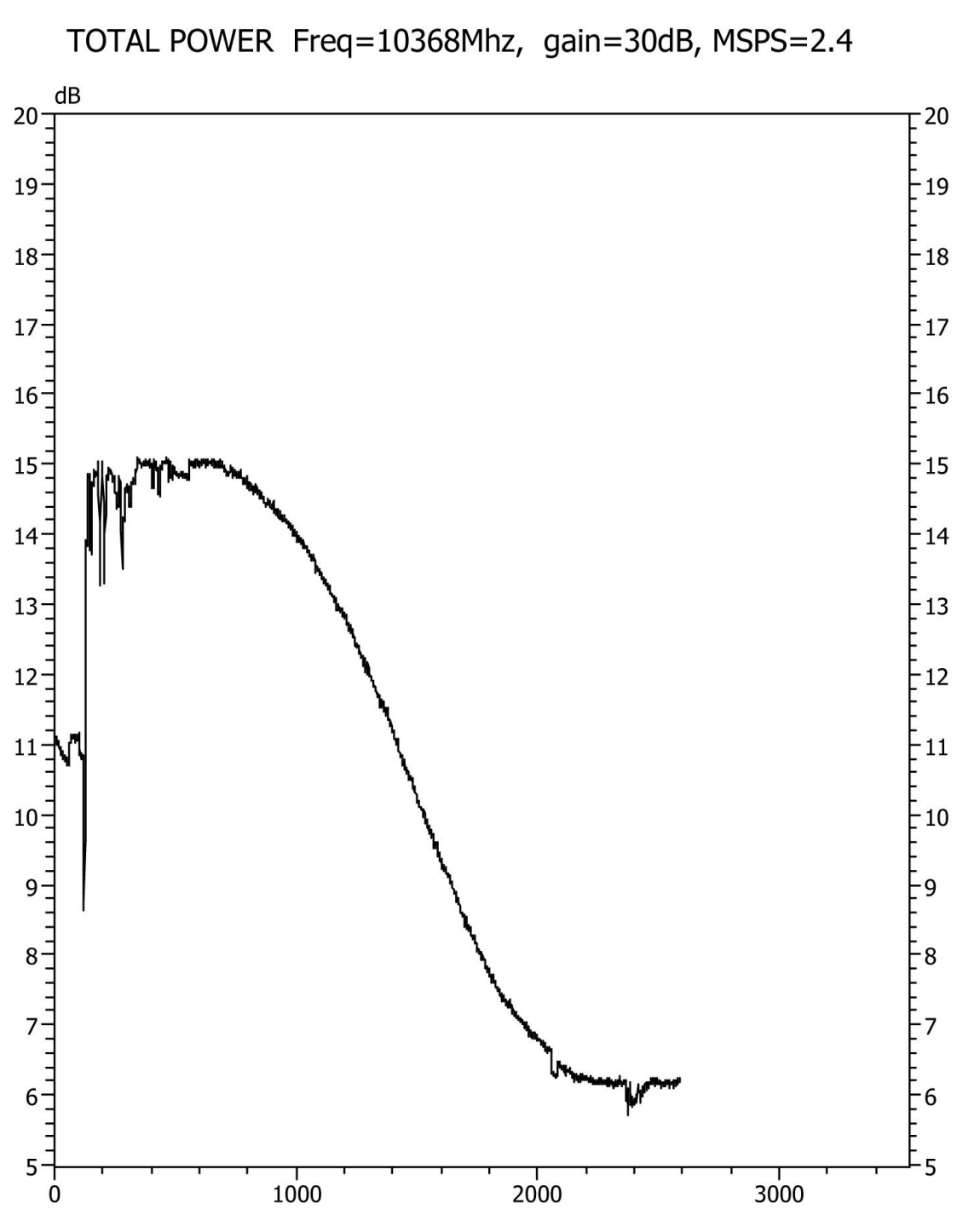
Large W2IMU Feed
1.31 λ Diameter
1.2 meter dish





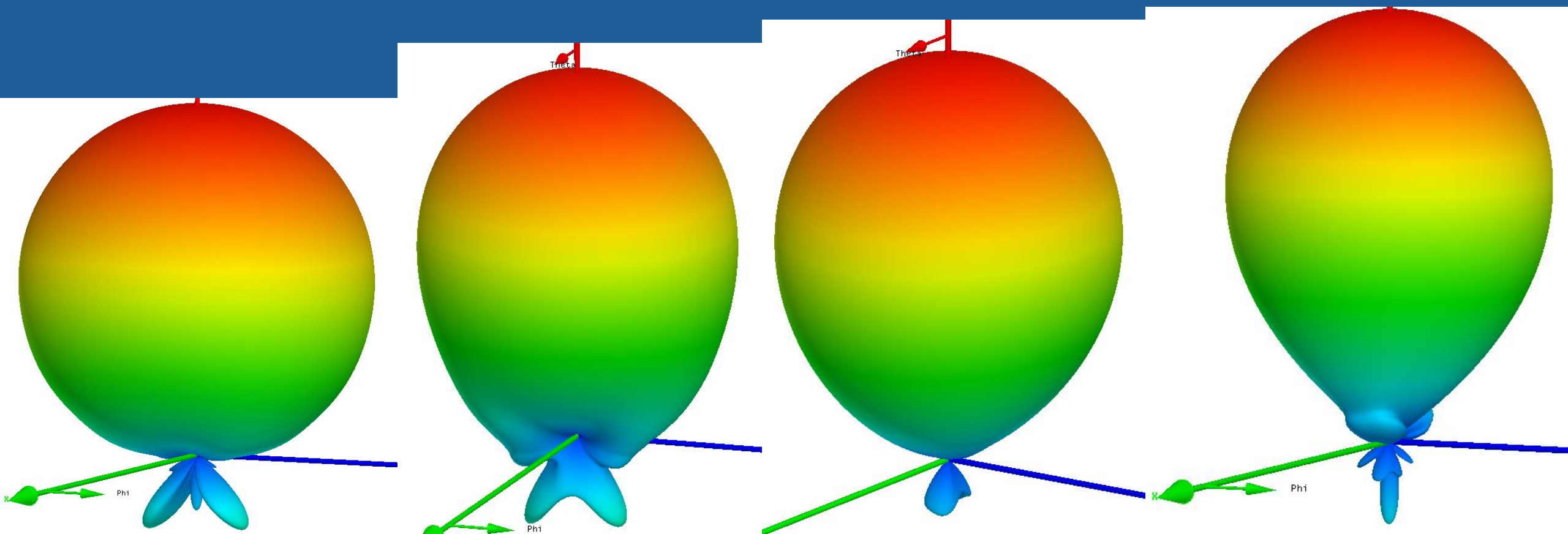
Large W2IMU Feed
1.31 λ Diameter
1.2 meter dish

8.7 dB Sun Noise



W2IMU Dual-Mode Feed Patterns

1.31 λ 1.62 λ 1.75 λ 1.88 λ



Try to do comparisons in short time
Solar Flux varies day to day

- 1.88 λ 10.8 to 11.6 dB Sun Noise
- 1.75 λ 0.2 to 0.4 dB less (best 3.66 λ long)
- 1.62 λ 0.4 to 0.6 dB less
- 1.31 λ ~1.6 dB less

VE4MA 10 GHz Evaluation

- 1.88λ Diameter Large W2IMU
- 0.5 dB better Sun Noise than best EME feed

24 GHz VE4MA

- [18 Nov] On my feed I was getting an honest 2.5 dB of moon noise. On your feed I was getting an honest 2.7 dB of moon noise ! I know that is a small number but it is a very significant increase! I expect you can extrapolate the difference into what the sun noise change might be. The Sun noise was about 12.5 dB....but that may have been down from the bushes?

24 GHz W5LUA

- [22 Nov] This morning with the sun up about 30 degrees, I was measuring 15.7 dB sun noise with my old handmade W2IMU. Both my feed and Paul's feed were about the same opening size. When I went over to your feed Paul, I was seeing 16 dB sun noise. I was also seeing 4.8 dB termination over cold sky with your feed Paul compared to 4.5 dB with my old IMU.
- [24 Nov] I looked at moon noise today on 24 GHz. I measured 2.4 dB. The best I have ever seen before was 2.2 dB and most times under 2 dB due to humidity.
- Even today not the greatest. 55F, 53 dew point and 92% humidity. The feedhorn is a top performer!

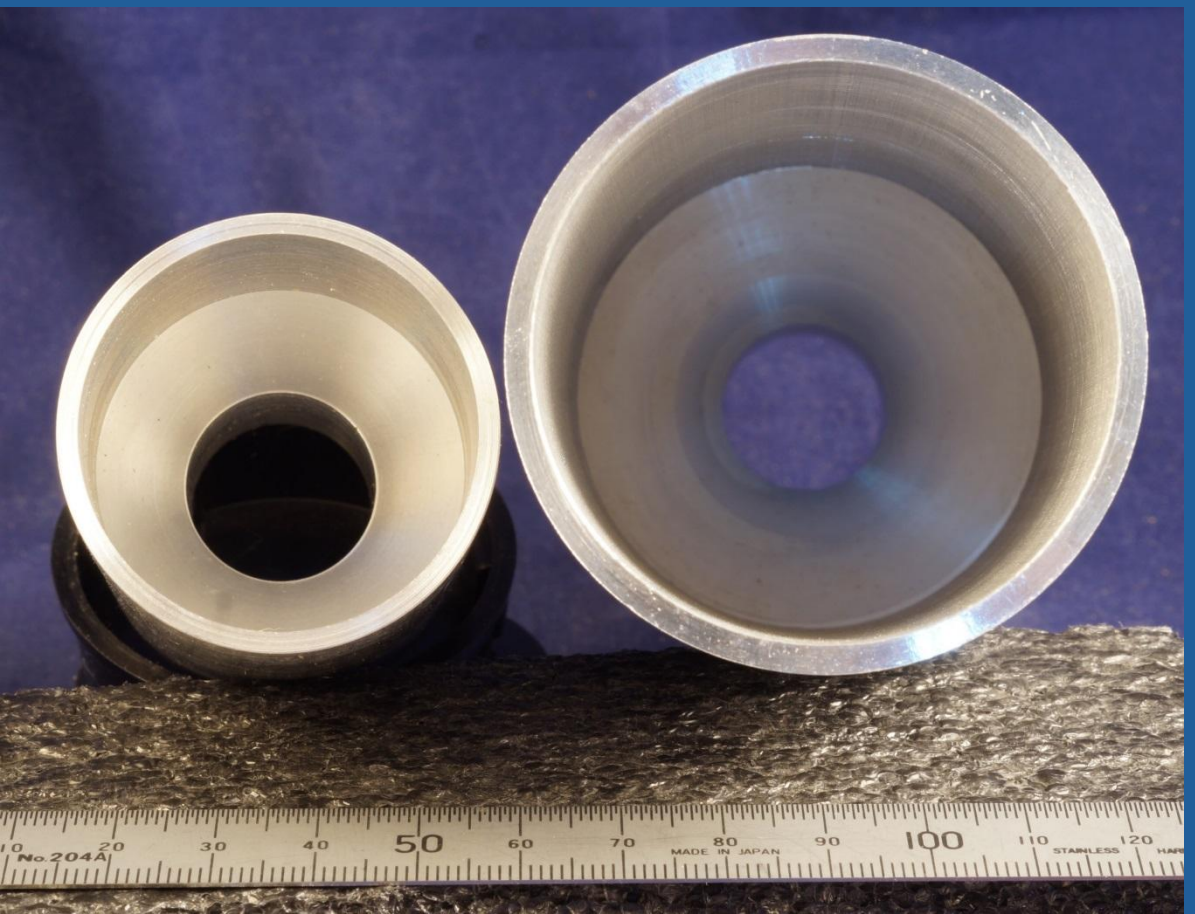
Summary – Offset Dish Feeds

- EME
  - Large W2IMU 1.88 λ Diameter best G/T
- Terrestrial
  - Any Large W2IMU good
  - Dual-band 10 & 24 GHz good for two bands
- Whatever gets you on the air is best

Feed construction

- Machine on CNC Lathe – long boring bar
- Long cylinder difficult to machine with good finish
- Two piece
  - Machine flare and input waveguide
  - Output horn is aluminum tubing
  - Heat horn to fit over flare, shrinks on permanently
  - Very tight tolerance < 0.1mm
  - Tubing has poor circularity

Machined Aluminum Feeds for 10 GHz



Affordable Feedhorns

- Long cylinder difficult to machine with good finish
- Two piece feed requires tight tolerances
- Solid aluminum is expensive

- How about 3D printing?

No Machining

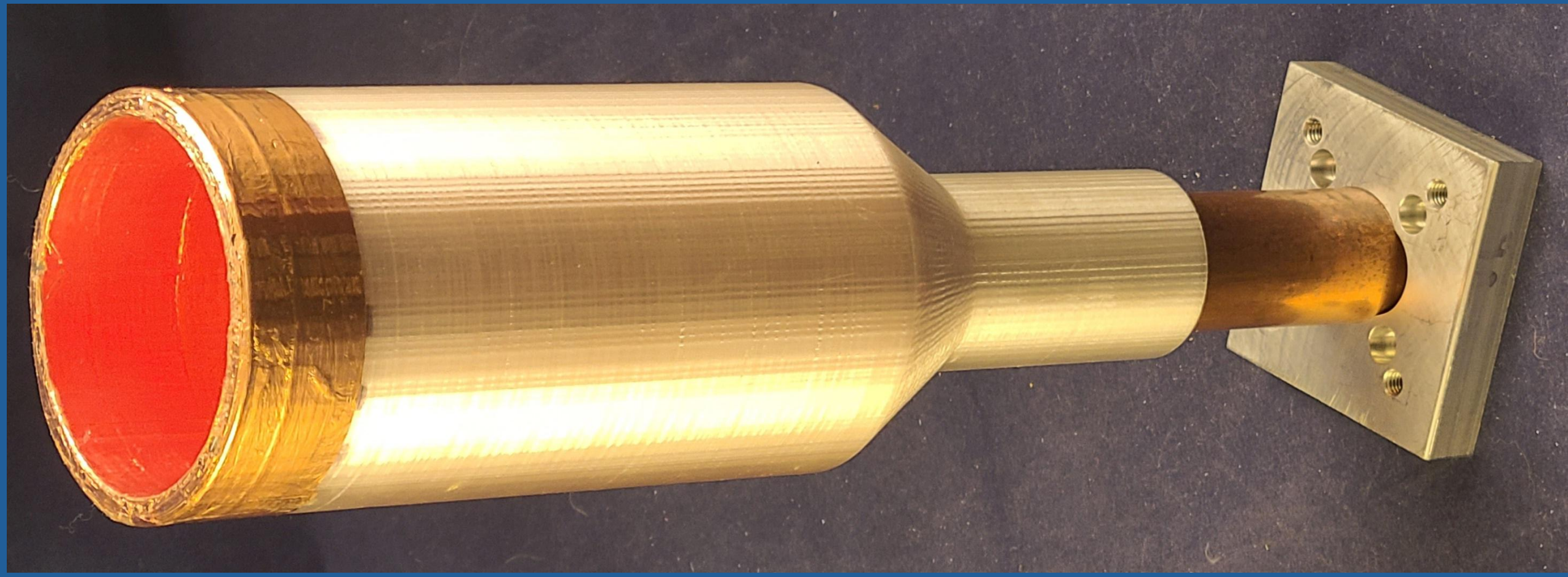
- KN0WS
3D printed
- (EME2024)

- Copper
Guitar tape
(Adhesive)

- ~ 0.6 dB below metal

3D printed horn

Copper tape and waveguide pipe



Copper Tape

Inside horn
(-0.6 dB)
or
Outside
(-2.8 dB)

W1FKF - Hybrid construction

- Difficult to print long cylinder
- Plastic horn is printed in sections and glued

- Alternative:
- 3D print Flare section
- Metal tube for input waveguide and horn
- Finish with copper guitar tape (adhesive)

Hybrid – 3D print flare, metal waveguide and horn, copper tape inside

Better metal tubing

- Copper is expensive and heavy
- Water pipe has poor circularity
- Structural aluminum tubing has poor circularity

- Intercooler intake tubing – race cars?
- Aluminum with good finish and circularity
- Reasonable price

Two inch tubing = 10 GHz Horn

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10 GHz Horn

Aluminum

3.5 inch Tubing = 5760 MHz Horn

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Last purchased Feb 3, 2026
Size: **OD: 3.5" (89mm)** | Color: **Straight - 1PC** | View order

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3.5 Inch 89mm OD Aluminum Intercooler Pipe Piping Air Intake Tube Straight 11.8" 300mm Long, Brushed Finish

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Size: **OD: 3.5" (89mm)**

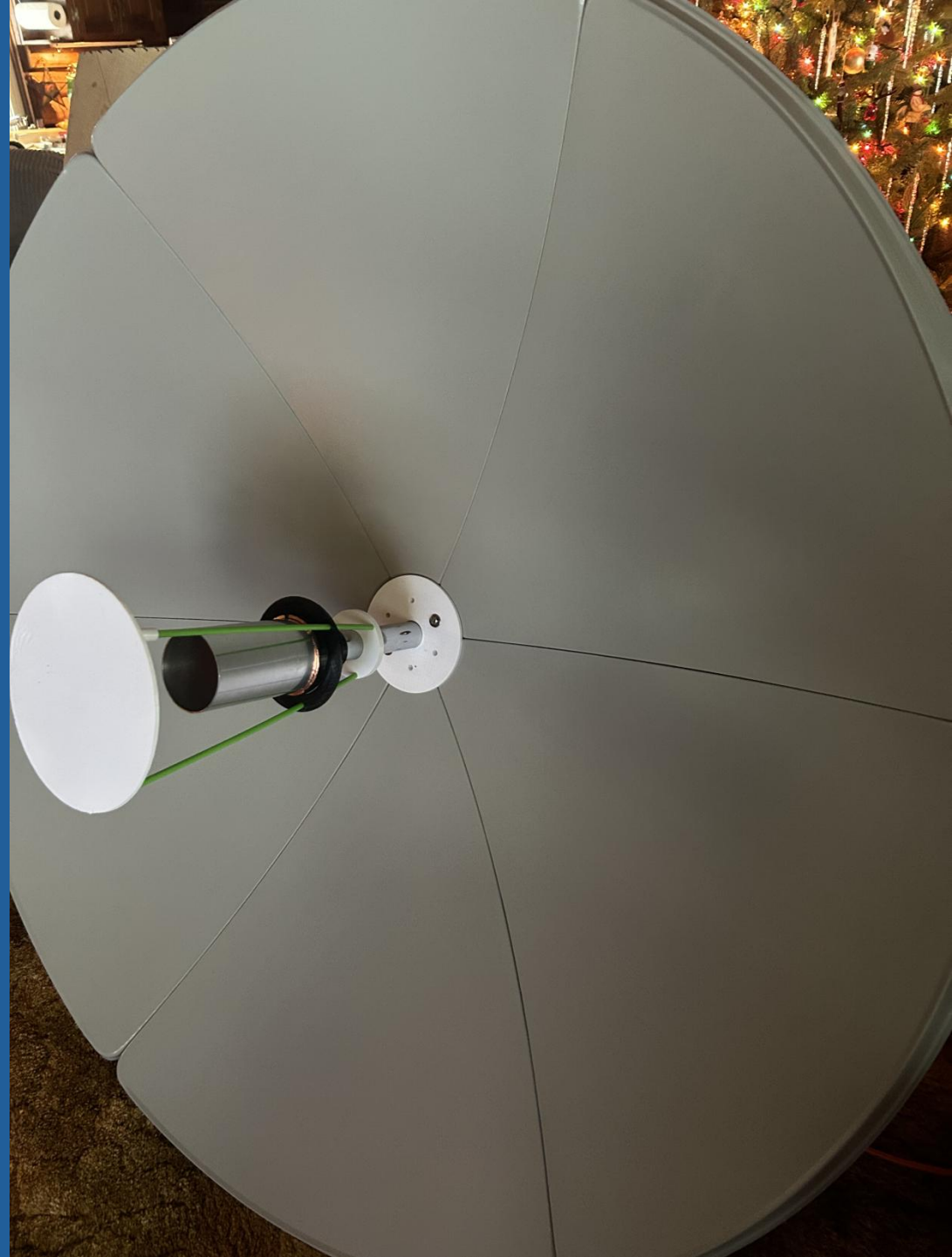
OD: 1.5" (38mm) | OD: 1.75" (45mm) | OD: 2" (51mm) | Od: 2" (51mm)
OD: 2.25" (57mm) | OD: 2.5" (63mm) | OD: 3" (76mm) | OD: 3.5" (89mm)
Od: 3.5" (89mm) | OD: 4" (102mm)

Color: **Straight - 1PC**

5760 MHz Horn – Aluminum

Waveguide could be 2 inch aluminum

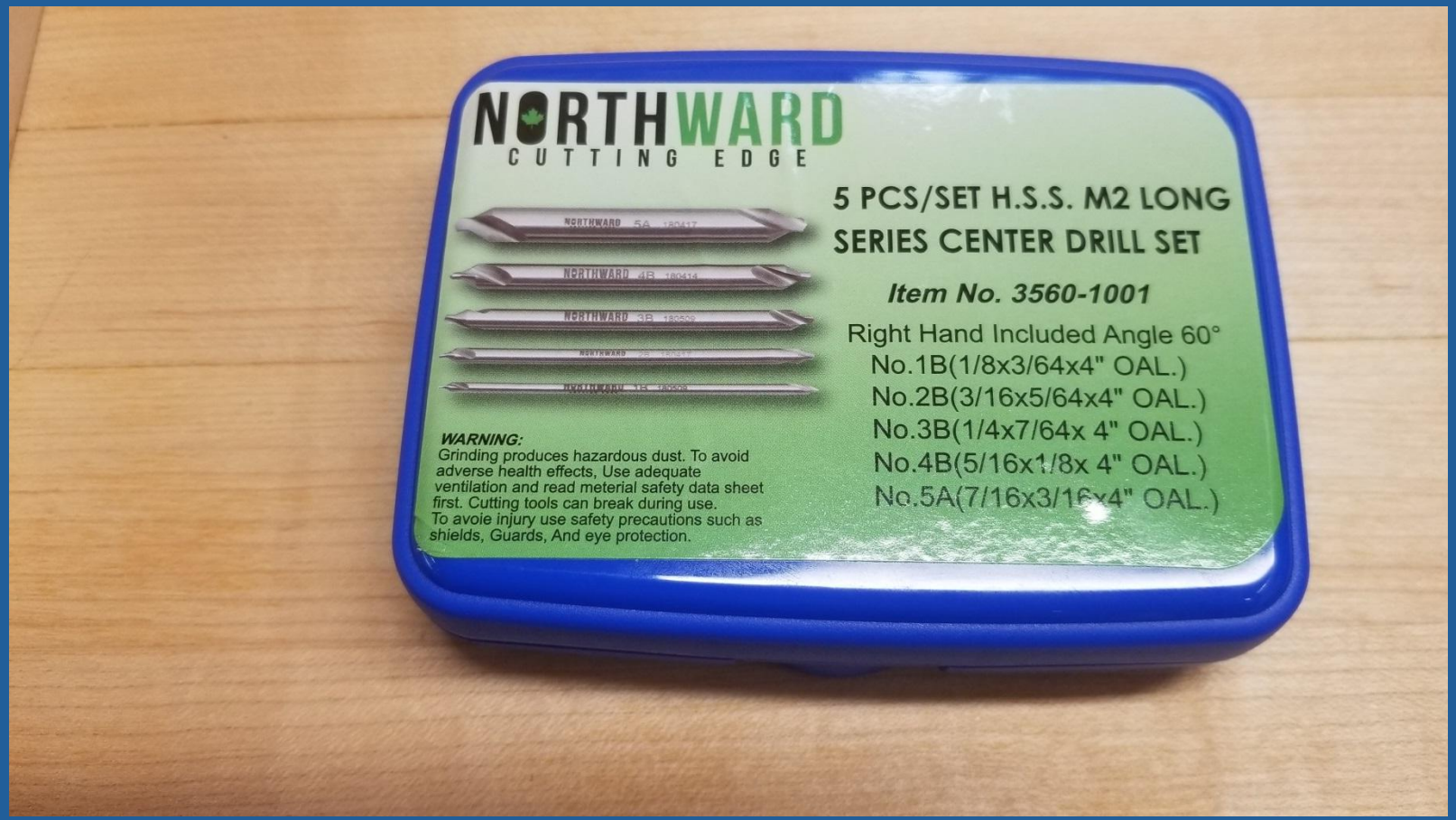
W1FKF
Solar Cooker Cassegrain Antenna



Large W2IMU Feeds for Higher Bands

- Feeds for offset and Cassegrain
- Machining requires boring small deep holes
- Micro boring bars are expensive and VERY fragile
- Calculated Flare Angle is ~25 degrees
- Long Center drills can make horn with 30 degree flare
- Simulation suggests 30 degree flare can work with adjusted horn length

Long Center Drills

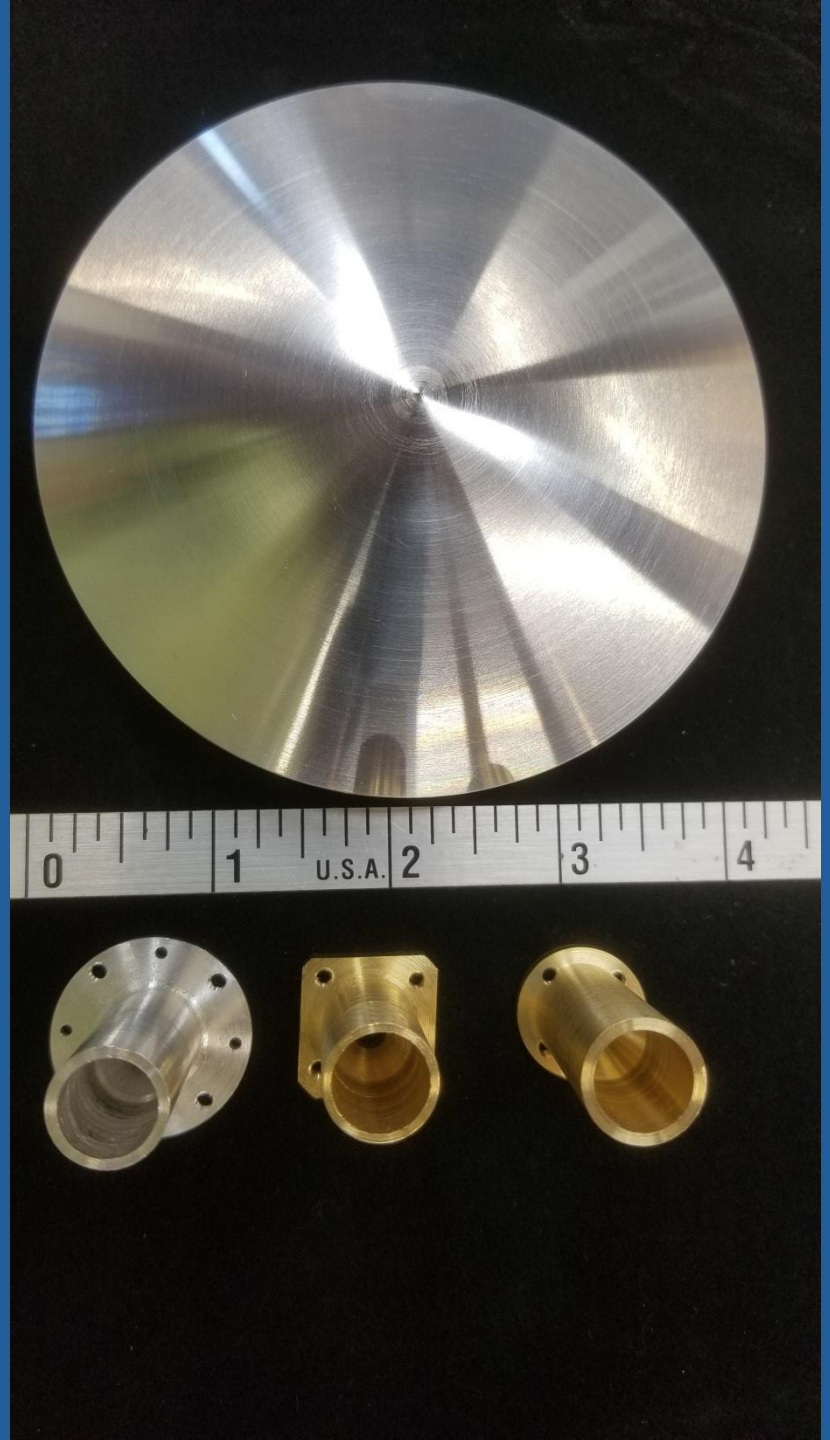


Center Drill Table

Frequency	Flare	Tool	Horn diameter		Horn Length		Gain	BW - 10
	degrees		inches	λ	inches	λ	dB	degrees
10.368	30		2.00	1.78	4.215	3.7	13.9	35
	30		2.15	1.88	4.5	3.95	14.6	32.5
24.192	30	#9	0.875	1.79	1.806	3.7	13.9	35
47.088	30	#5	0.4375	1.74	0.928	3.7	13.9	35
76	30	#3	0.250		0.439		13.9	39
78	30	#3	0.250	1.65	0.439	2.9	13.1	39
122	30	#2	0.1875	1.94	0.415	4.3	14.6	32
122	30	4mm	0.157	1.63	0.281	2.9	13.1	39
241	30	2mm	0.079	1.66	0.142	2.9	13.1	39
HDL_ANT	25			1.78		3.5		
small IMU	30			1.31		1.37	11.6	47

47 GHz Cassegrain

VE2UG dish



78 GHz - W1FKF

122 GHz – W1FKF