MW EME with Small Offset Dish

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OK2AQ

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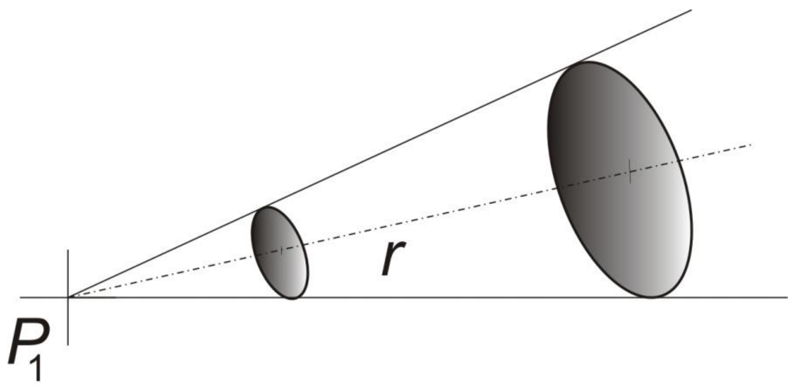
http://www.urel.feec.vutbr.cz/esl/files/EME/EME.htm

Outline

1. A bit of calculation
2. Small offset dish and right feed
3. Focused antenna
4. Sun, Moon and ground noise
5. 3 cm EME operation with small dish
6. 23 cm EME operation with small dish
7. 1.2 cm preparation

Why we can use smaller antennas for **MW** EME ?



$$L_0 = \left(\frac{4\pi \cdot r}{\lambda}\right)^2$$

$$\Pi_2 = \frac{P_1}{4\pi \cdot r^2} \qquad P_2 = \Pi_2 \cdot S_2 \qquad S_2 = \frac{\lambda^2}{4\pi}$$

The loss of direct elmag. wave propagation in free space is proportional to the square of the distance and inversely proportional to the square of the wavelength. This means that at 10 GHz we have 20 dB more attenuation than at 1 GHz

Are the microwaves therefore disqualified for longer distances?

We all know - no!

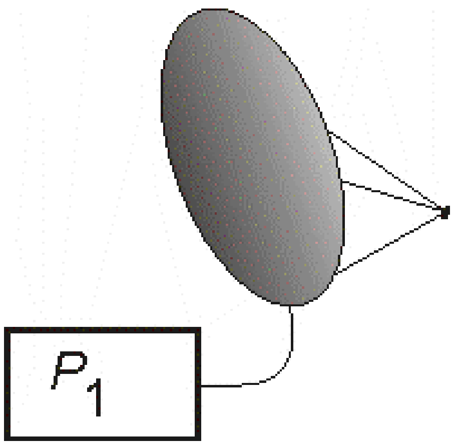
But why?

Including antenna gain, Link Budget at 10 GHz is 20 dB better than at 1 GHz.

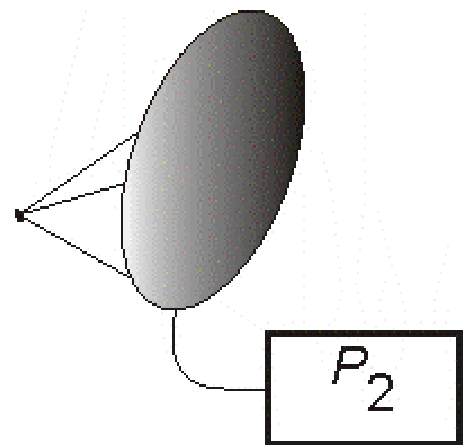
$$G_{\max} = \frac{S_{ef}}{S_i} = \frac{4\pi}{\lambda^2} S_{ef}$$

$$G_{\max} = \eta \left(\frac{\pi \cdot D}{\lambda} \right)^2$$

And that's why we can work on MW EME with smaller antennas.

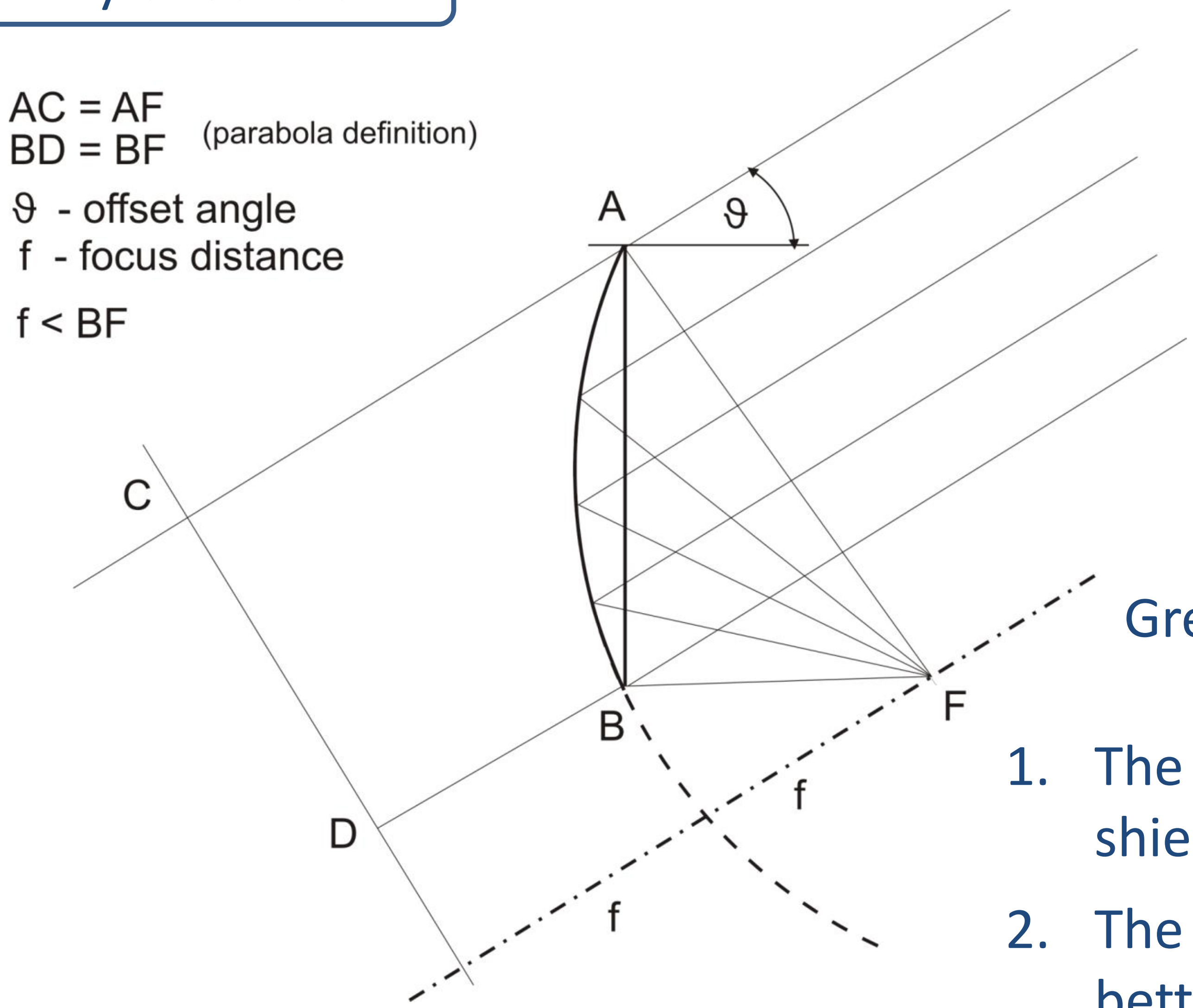


2 x



The dish with the same aperture has a gain of 20 dB greater at 10 GHz than at 1 GHz.

Why offset dish ?



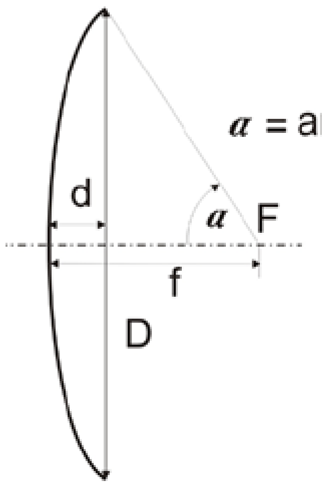
Greater G/T ratio

1. The aperture is not shielded by feed
2. The spill over is better eliminated at low elevation

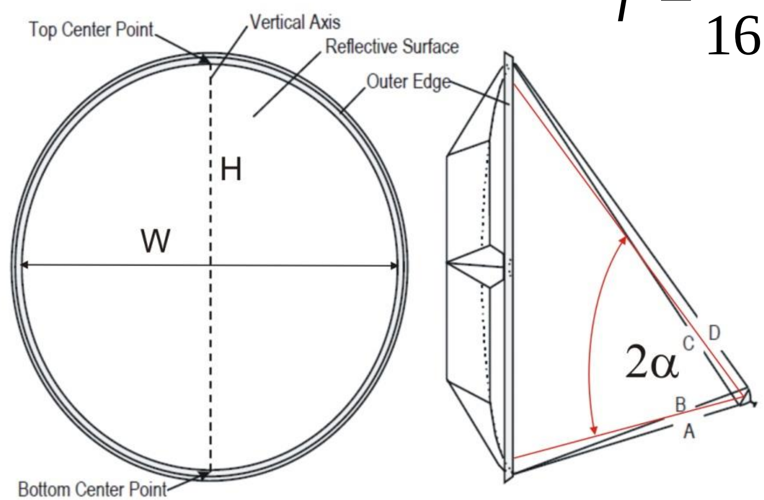
The Feed

$$f = \frac{D^2}{16 \cdot d}$$

$$f = \frac{W^3}{16 \cdot d \cdot H}$$



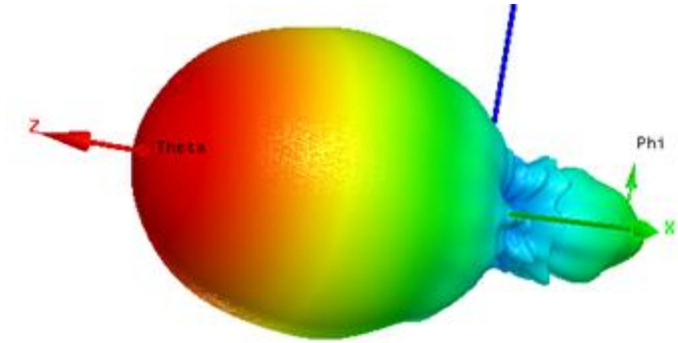
$$\alpha = \mathrm{arctg}\frac{8(f/D)}{16(f/D)^2 - 1}$$

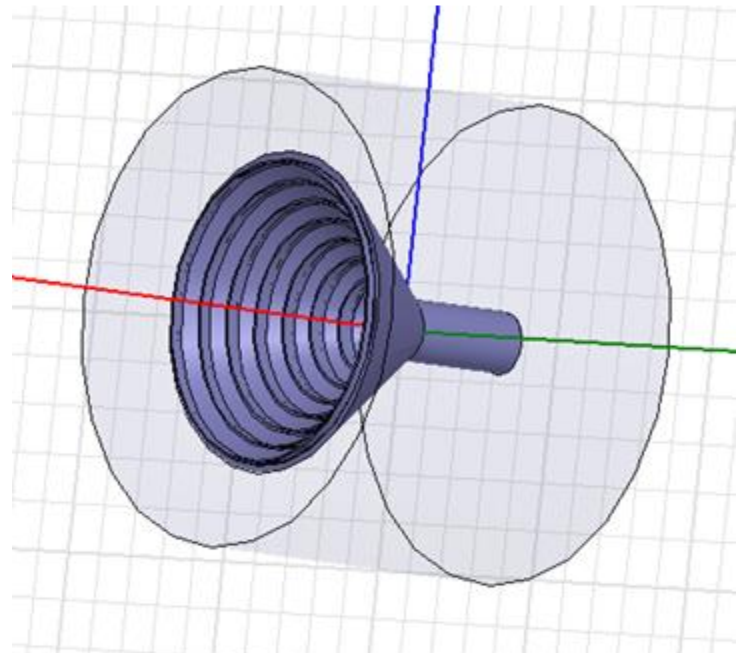


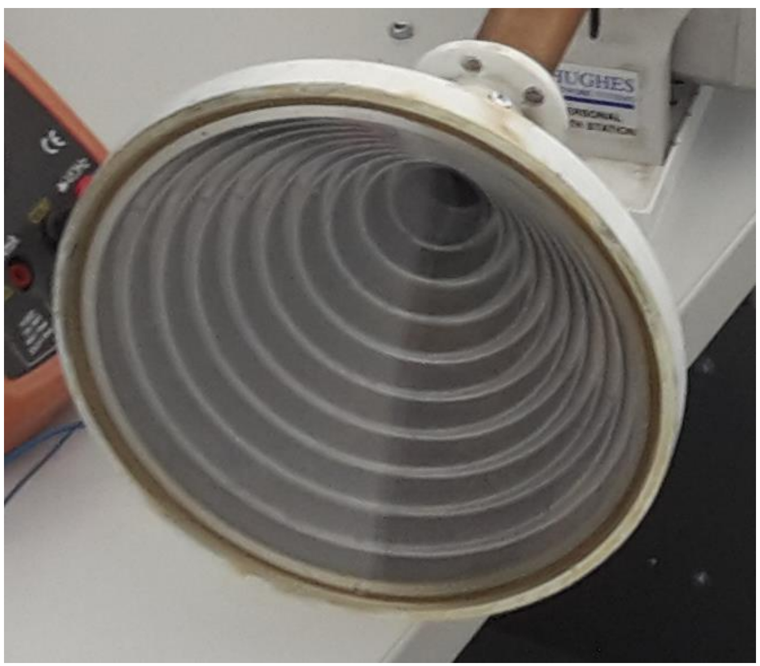
For small offset angle: W~D and then $\alpha = \arctan\frac{8(f/W)}{16(f/W)^2 - 1}$

f/D	alpha	2*alpha
0,4	64,01077	128,0215
0,6	45,23973	90,47946
0,8	34,70805	69,4161

10 GHz EME

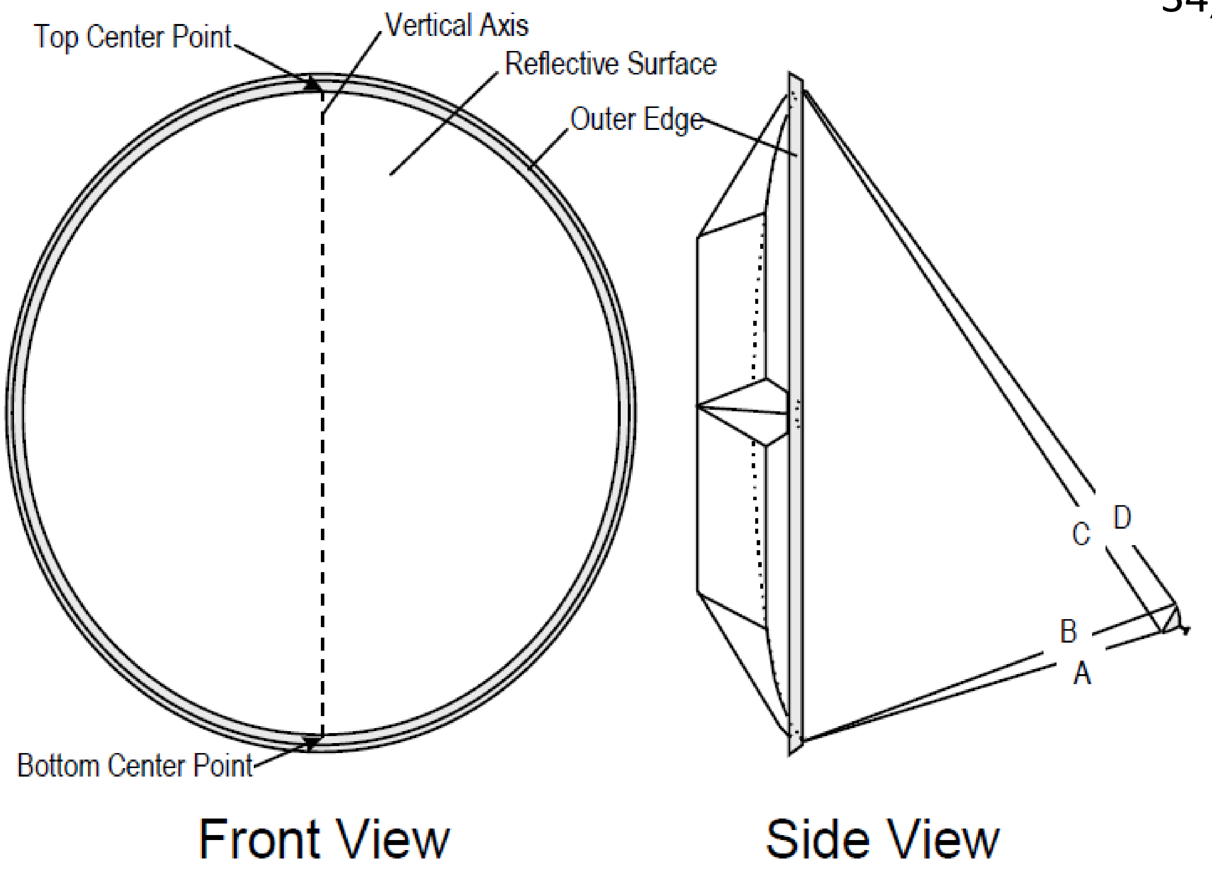






Feedhorn for the f/D = 0.8

Focused Antenna – Prodelin 1134 -1,2 m

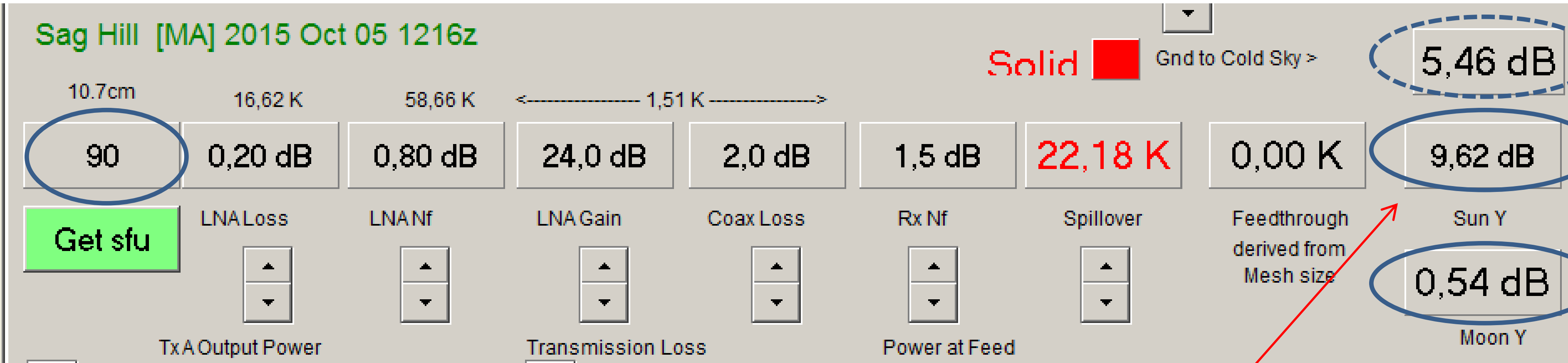


34,25 x 25,4 = 870 mm

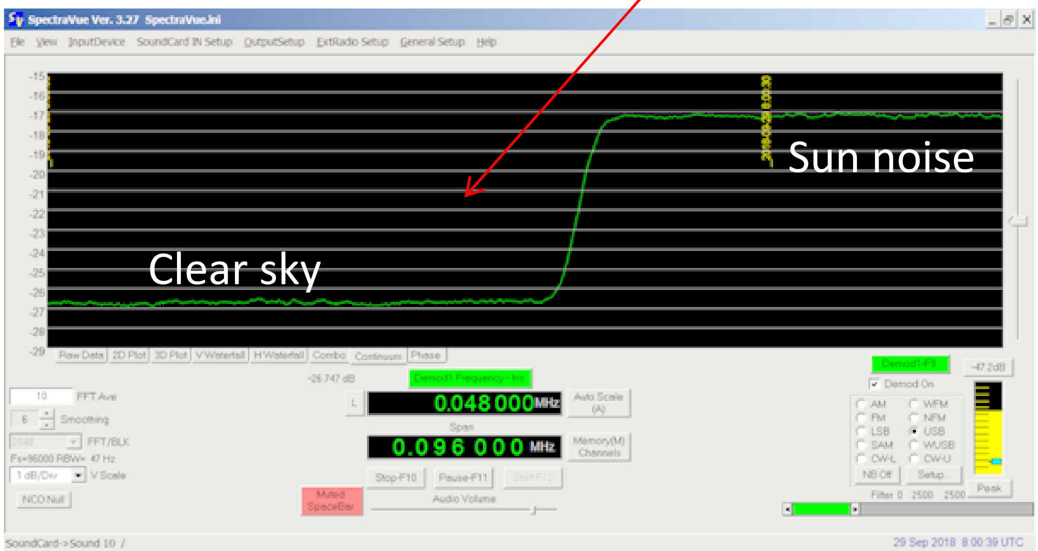
A	34.25 in. (34-1/4" or 820 mm)
B	37.08 in. (37-1/16" or 942 mm)
C	51.87 in. (51-7/8" or 1318 mm)
D	49.04 in. (49-1/16" or 1246 mm)

Sun Noise

Prodelin 1134 – 1,2 m



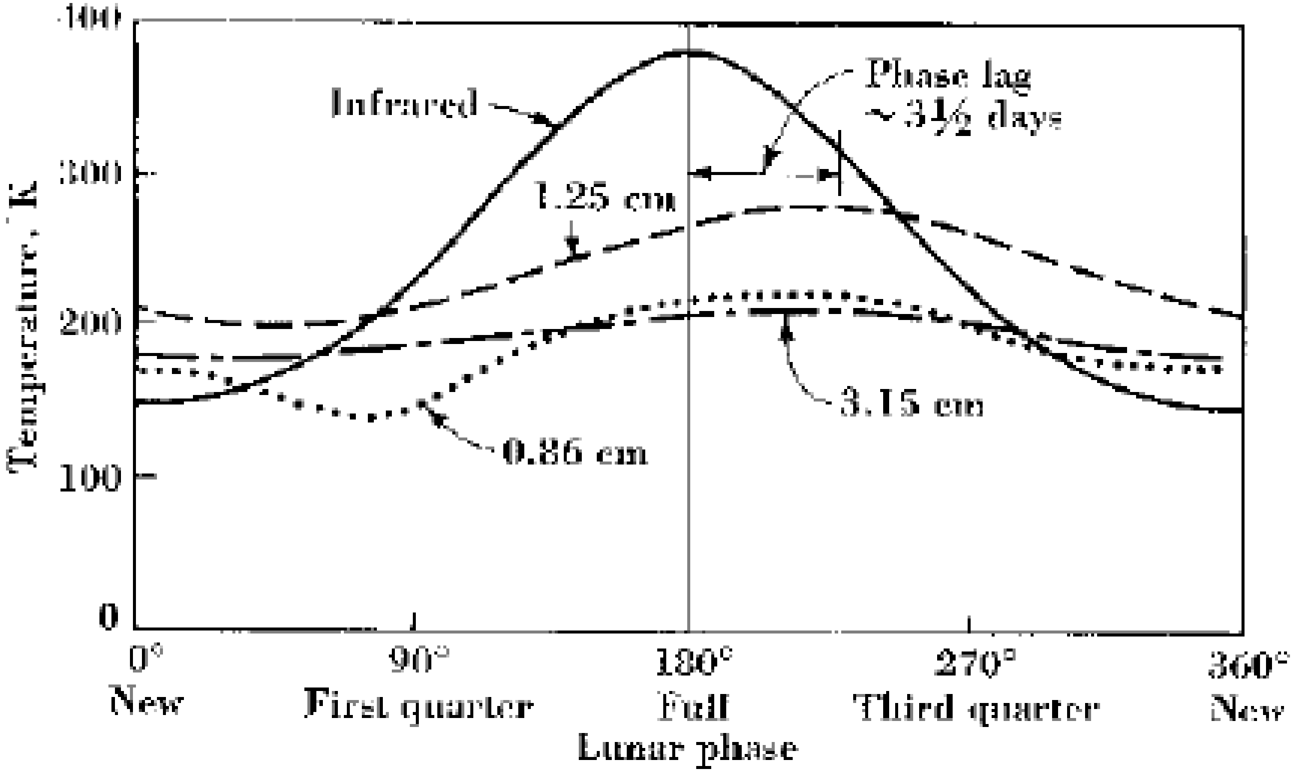
When focusing the antenna, it is necessary to record a wider range, say +/- 40 mm, and determine the correct focus position by interpolation.



Spectra Vue by RF Space

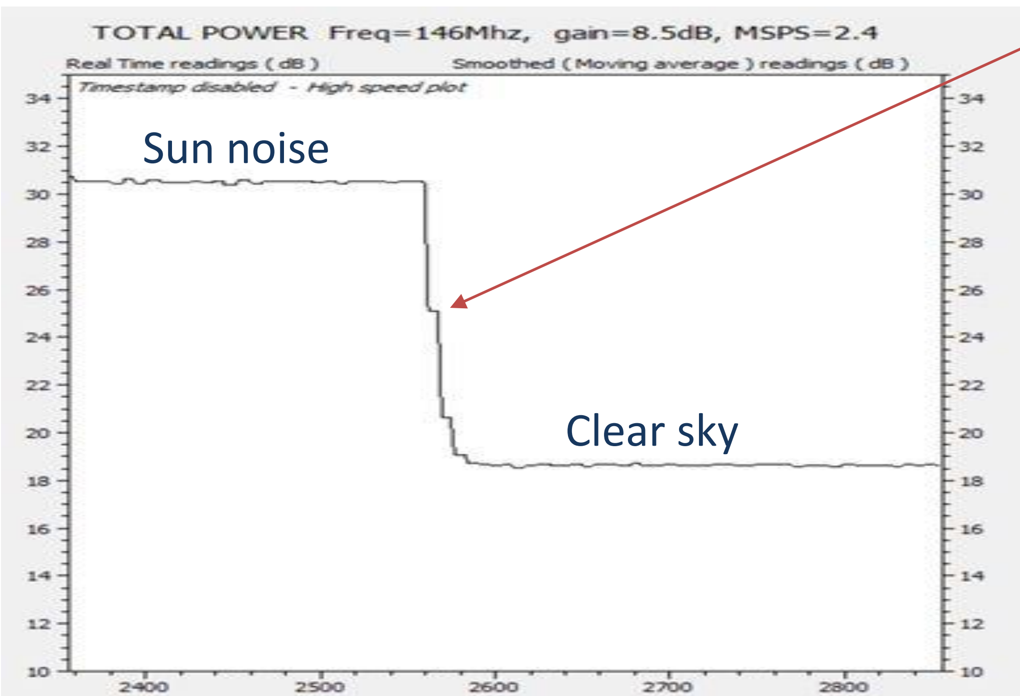
Moon noise and ground noise

Moon brightness temperature

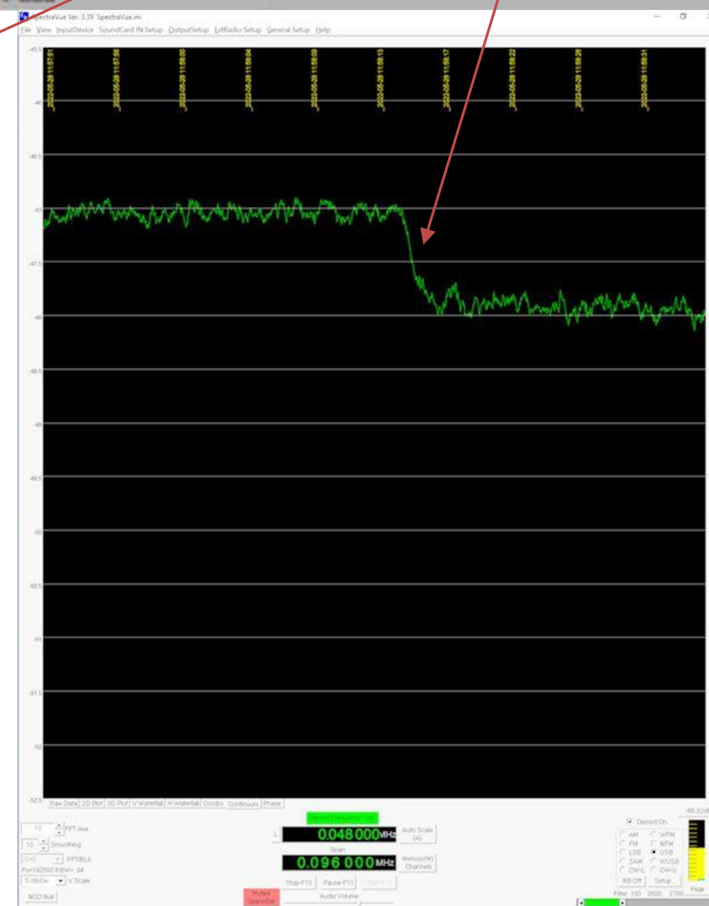


Ref: John D. Kraus, Radio Astronomy, McGraw-Hill,1966, pp 339

Sun & Moon Noise | Prodelin 1194 – **1,8 m**



Total Power by I0NAA



Ground Noise ?

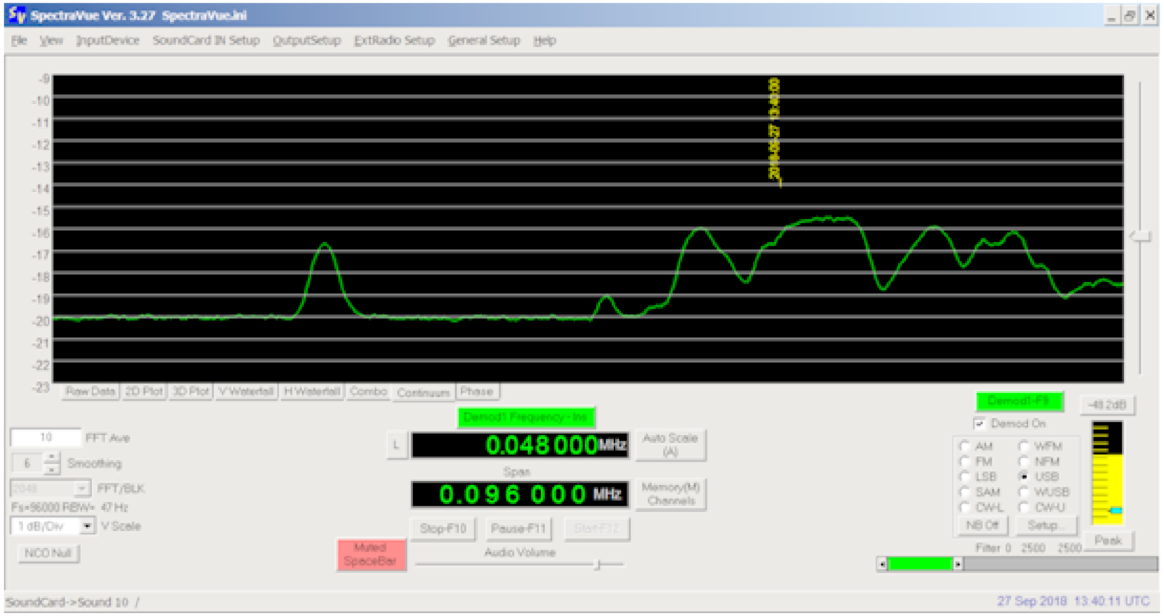
Far Field

For 1,8 m dish and

λ = 0,03 m

***FF* = 216 m**

Radiometric scan around at 10 deg elevation.



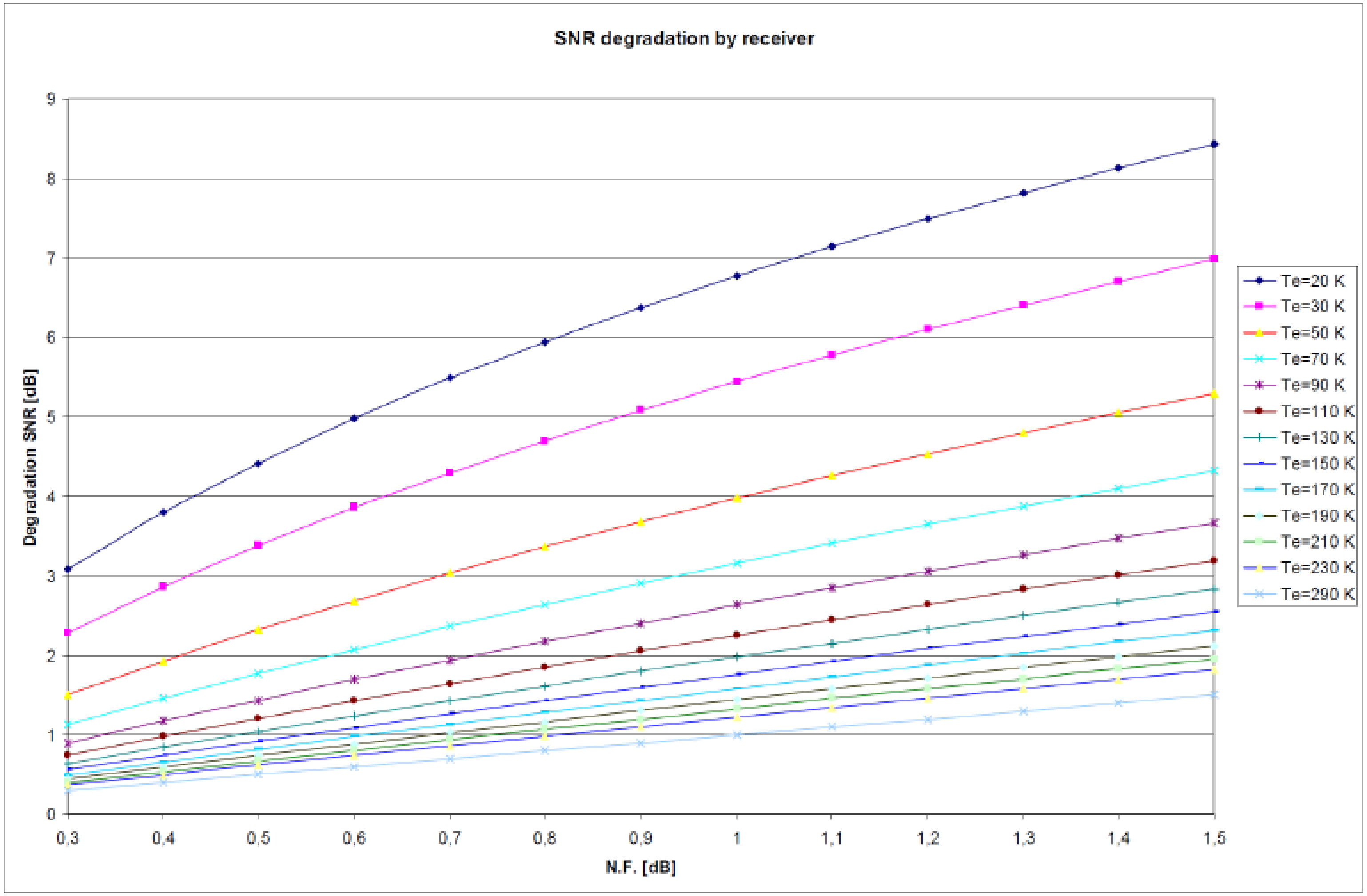
EME operation on MW with small dish

What we lack in the antenna we have to compensate otherwise - how?

1. G/T high as possible
2. Enough power
3. Frequency accuracy and stability including precise Doppler shift compensation ability
4. Precise automatic antenna pointing with continual monitoring of Moon noise and possibility to change plane of linear polarization
5. Advanced signal processing
6. Good planning

Ad 1) LNA plays a much bigger role than with large antennas

$$T_S = T_{SKY} + T_G + T_{bM} + T_{Rx} = T_e + T_{Rx}$$

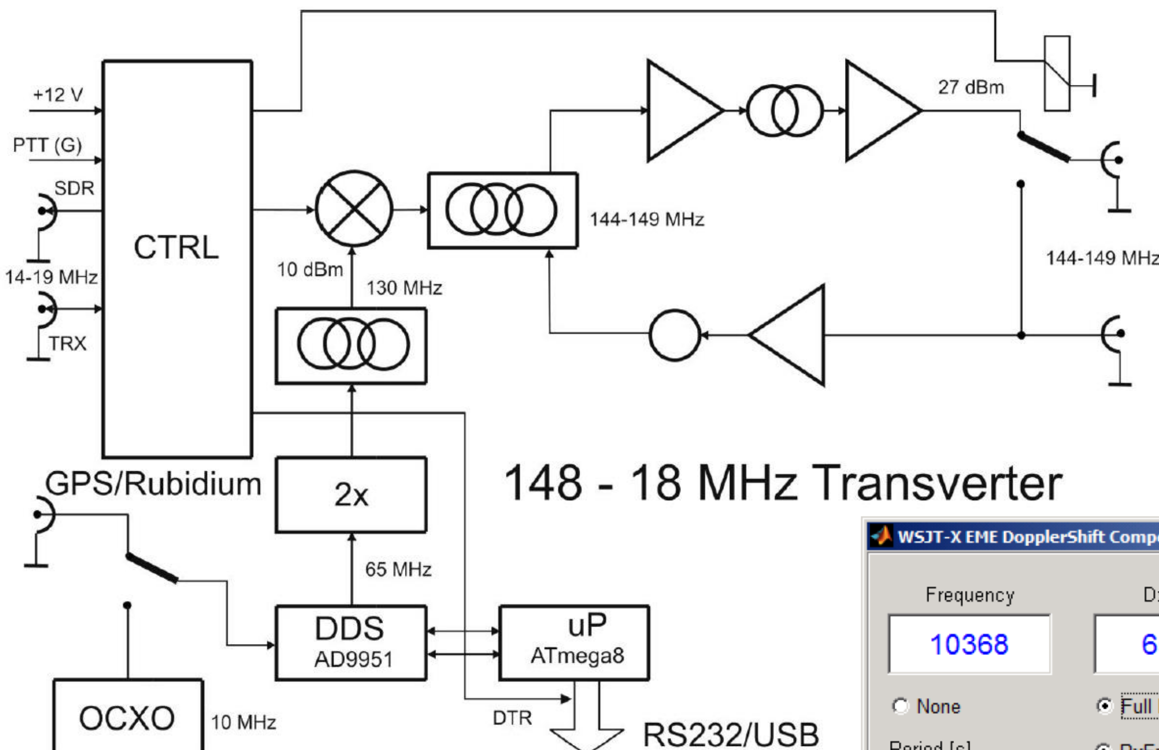


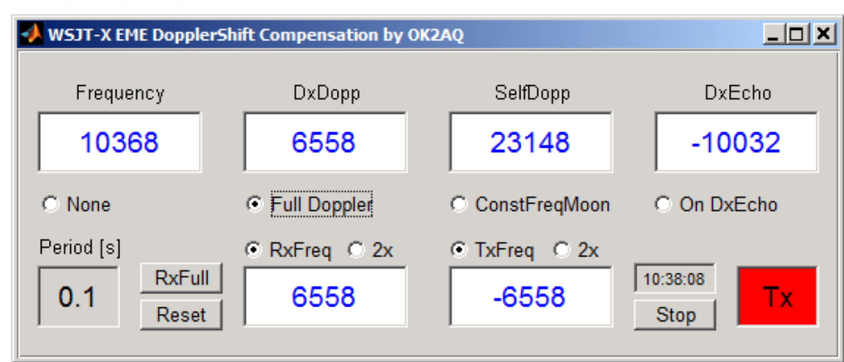
Ad 2) Enough power is - 20 W minimum, 50 W exactly right on 10 GHz

(one is enough)

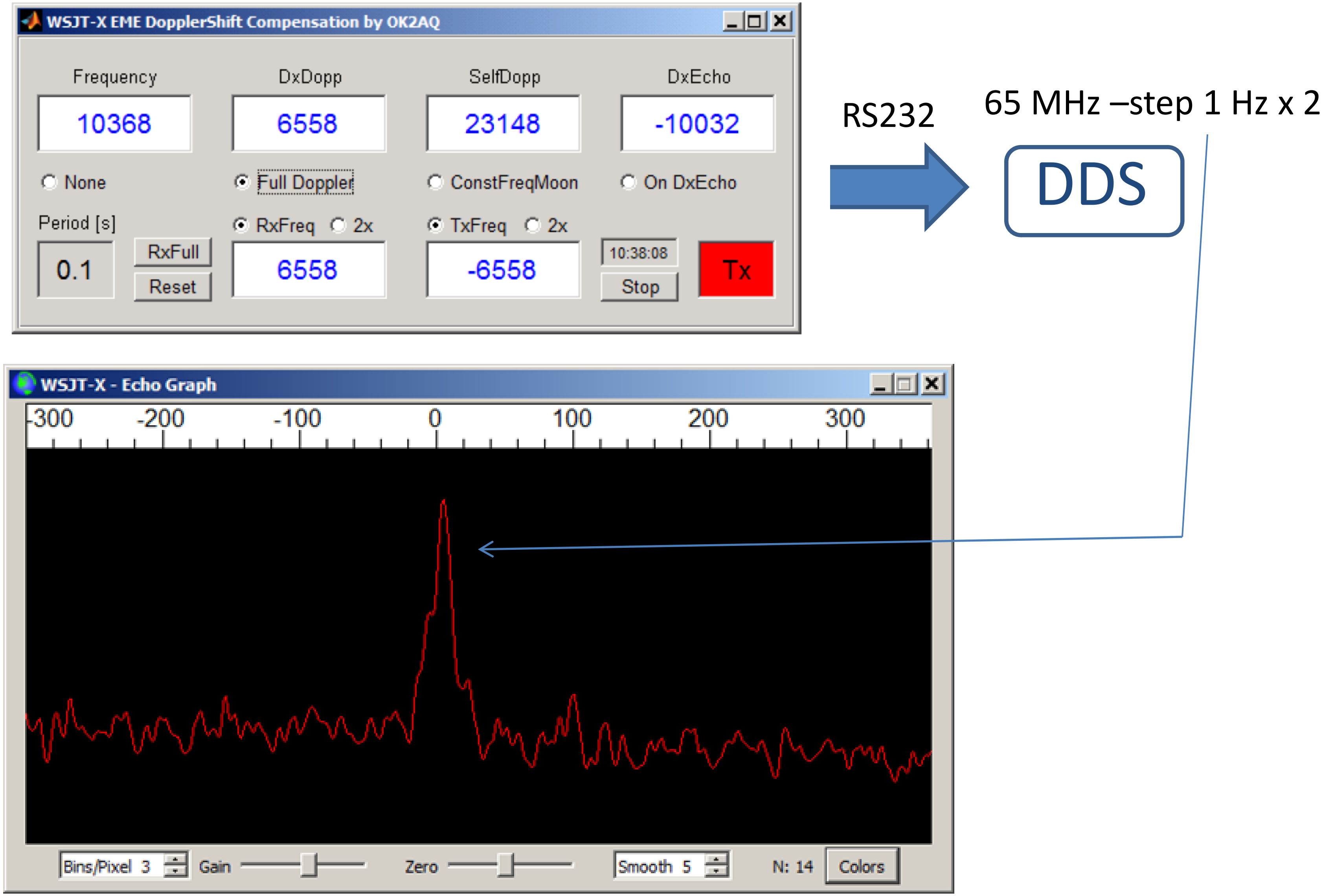
Ad 3) Frequency accuracy and stability including Doppler shift compensation ability

Because with a small antenna we will work along CW often DIGI modes
the frequency precision must be better than 100 Hz on 10 GHz. For this reason,
the frequencies of the microwave transverter but also VHF/UHF transceiver
need to be controlled by an atomic oscillator - cesium (GPS) or rubidium.

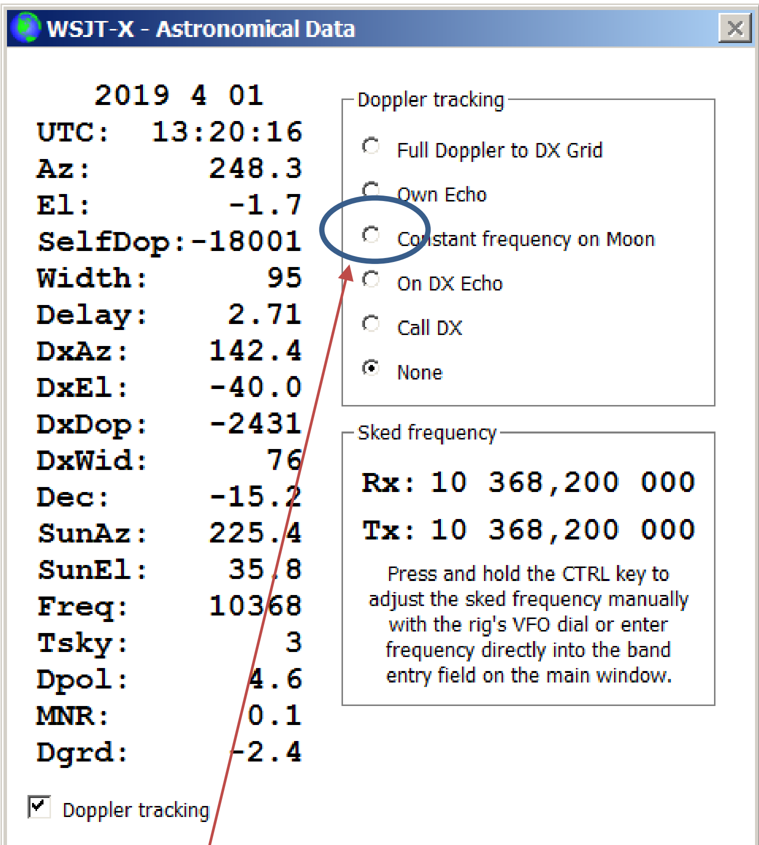




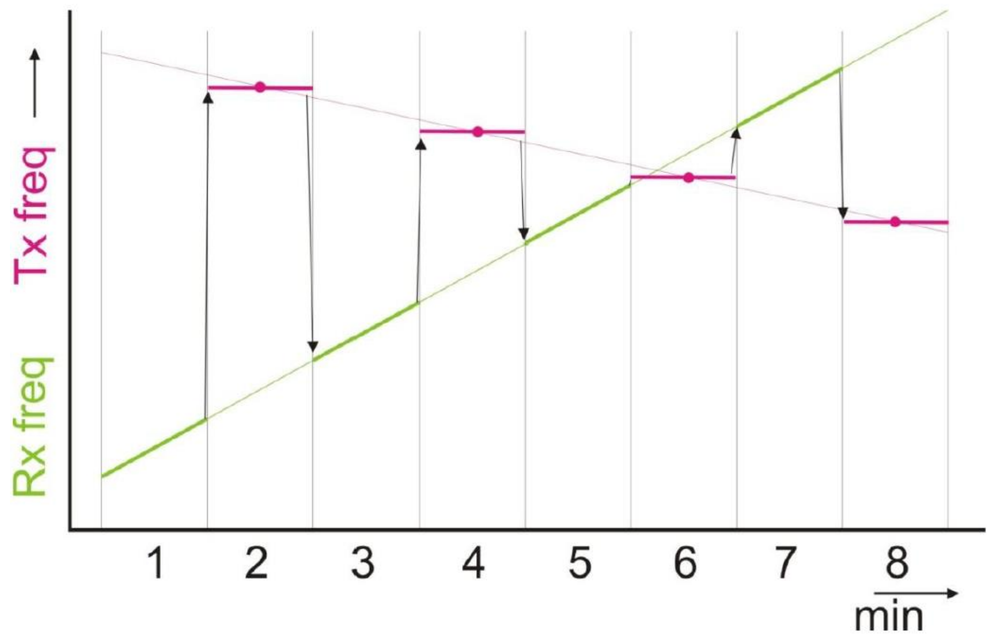
MATLAB program - source data are from WSJT-X



Doppler shift compensation



a) The problem is that most older transceivers cannot change the frequency by CAT during transmission.

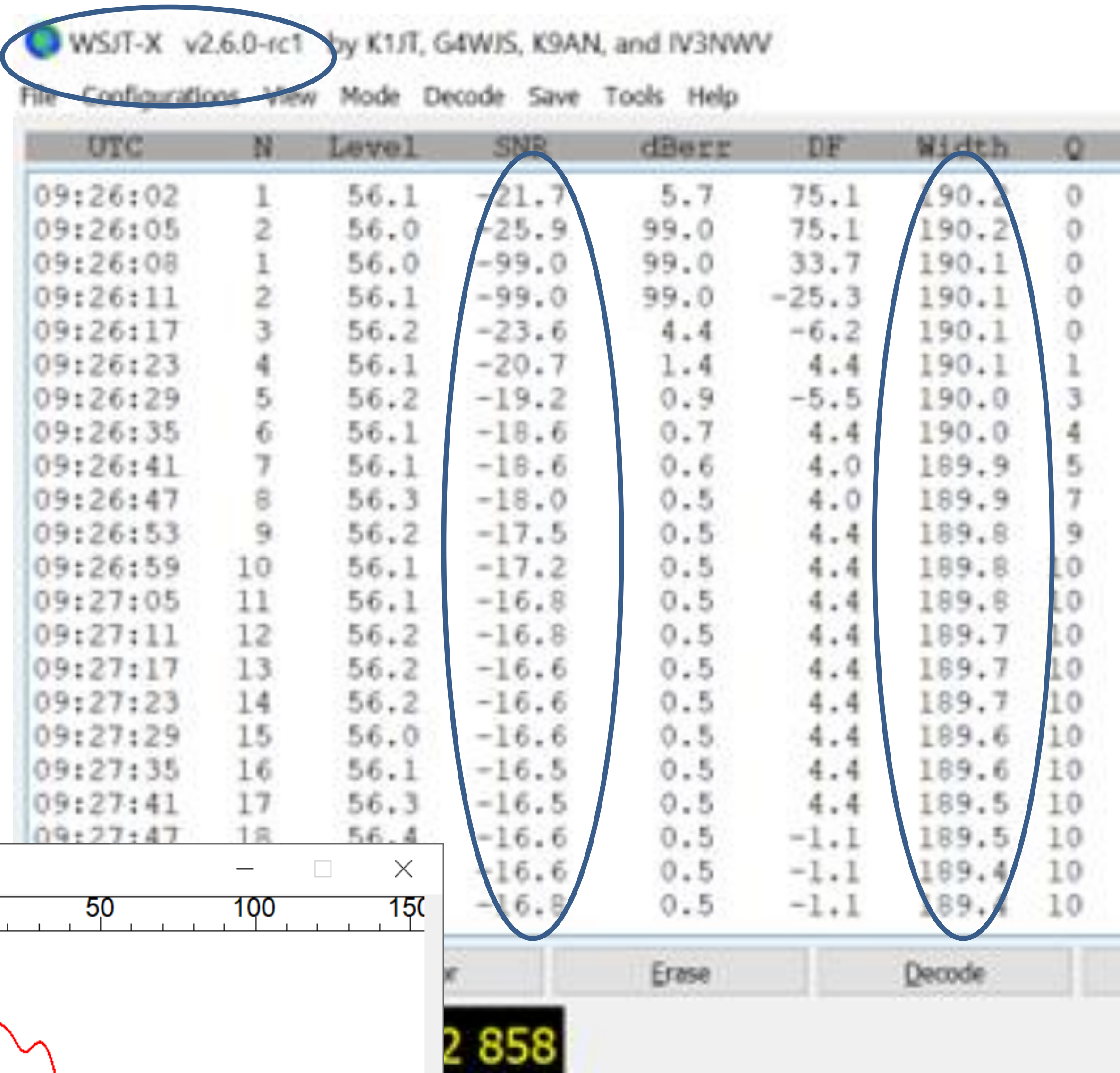


CFOM is preferred

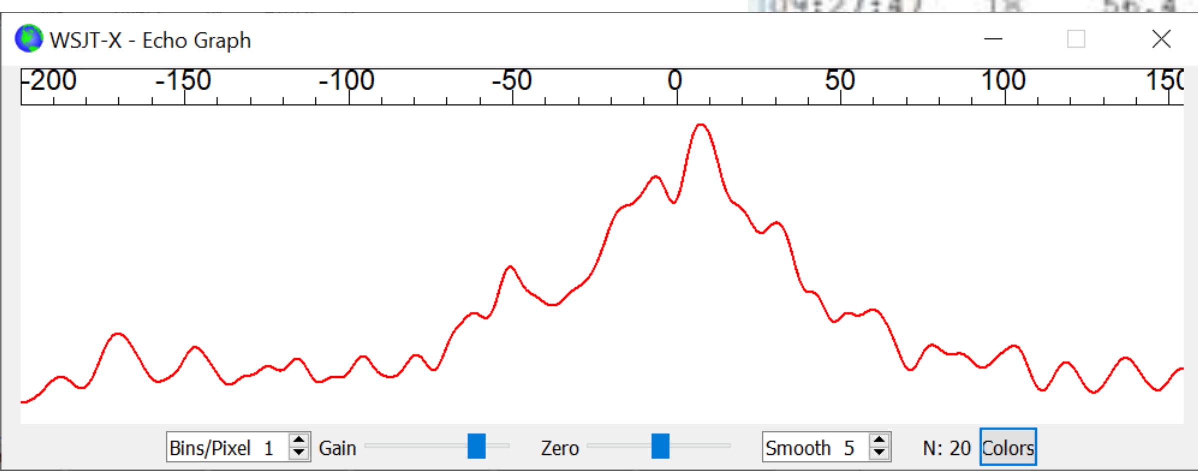
b) Most older transceivers have the lowest step 10 Hz at the CAT control.

Since WSJT-X v2.6.0-rc1

Echo SNR values are real also with very big spread.



UTC	N	Level	SNR	dBerr	DF	Width	Q
09:26:02	1	56.1	-21.7	5.7	75.1	190.2	0
09:26:05	2	56.0	-25.9	99.0	75.1	190.2	0
09:26:08	1	56.0	-99.0	99.0	33.7	190.1	0
09:26:11	2	56.1	-99.0	99.0	-25.3	190.1	0
09:26:17	3	56.2	-23.6	4.4	-6.2	190.1	0
09:26:23	4	56.1	-20.7	1.4	4.4	190.1	1
09:26:29	5	56.2	-19.2	0.9	-5.5	190.0	3
09:26:35	6	56.1	-18.6	0.7	4.4	190.0	4
09:26:41	7	56.1	-18.6	0.6	4.0	189.9	5
09:26:47	8	56.3	-18.0	0.5	4.0	189.9	7
09:26:53	9	56.2	-17.5	0.5	4.4	189.8	9
09:26:59	10	56.1	-17.2	0.5	4.4	189.8	10
09:27:05	11	56.1	-16.8	0.5	4.4	189.8	10
09:27:11	12	56.2	-16.8	0.5	4.4	189.7	10
09:27:17	13	56.2	-16.6	0.5	4.4	189.7	10
09:27:23	14	56.2	-16.6	0.5	4.4	189.7	10
09:27:29	15	56.0	-16.6	0.5	4.4	189.6	10
09:27:35	16	56.1	-16.5	0.5	4.4	189.6	10
09:27:41	17	56.3	-16.5	0.5	4.4	189.5	10
09:27:47	18	56.4	-16.6	0.5	-1.1	189.5	10
			-16.6	0.5	-1.1	189.4	10
			-16.8	0.5	-1.1	189.4	10



Ad 4) Precise automatic antenna pointing with continual monitoring of Moon noise and possibility to change polarization.

Ad 5) – WSJT-X

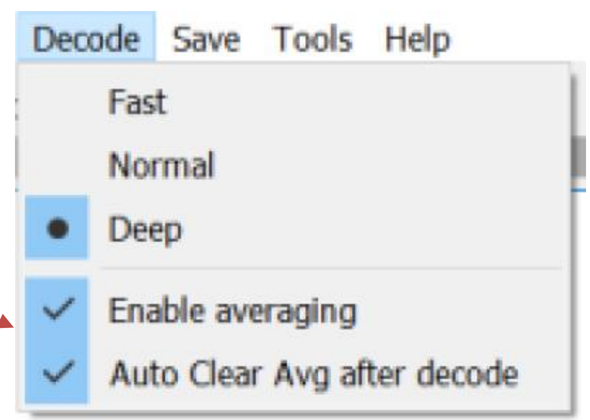
Q65

T/R Period (s)	B		C		D		E	
	Spacing (Hz)	Width	Spacing (Hz)	Width	Spacing (Hz)	Width	Spacing (Hz)	Width
15	13.33	867	26.67	1733				
30	6.67	433	13.33	867	26.67	1733		
60	3.33	217	6.67	433	13.33	867	26.67	1733
120	1.50	98	3.00	195	6.00	390	12.00	780
300	0.58	38	1.16	75	2.31	150	4.63	301

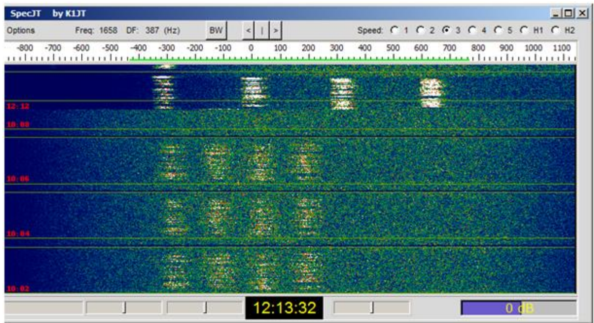
Ad 4a) – Longer T/R period at low SNR

Ad 4b) – Apriory Information - AP

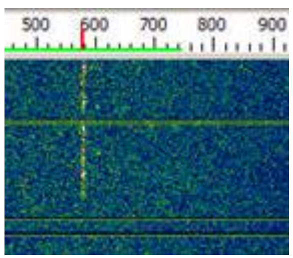
Ad 4c) – Averaging



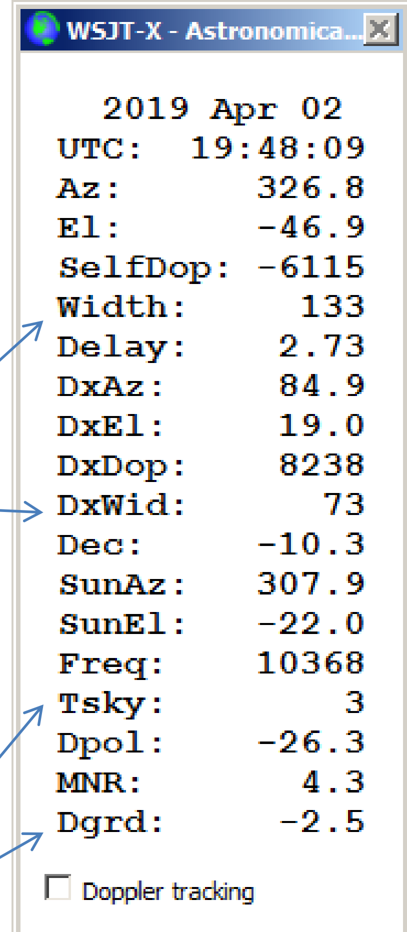
Ad 6) Good planning



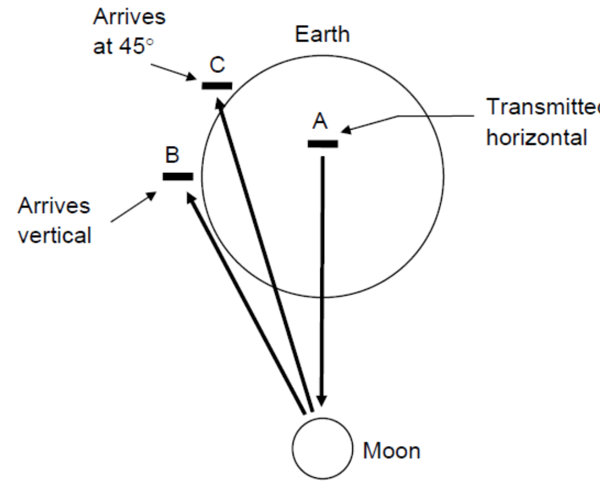
Spreaded spectrum



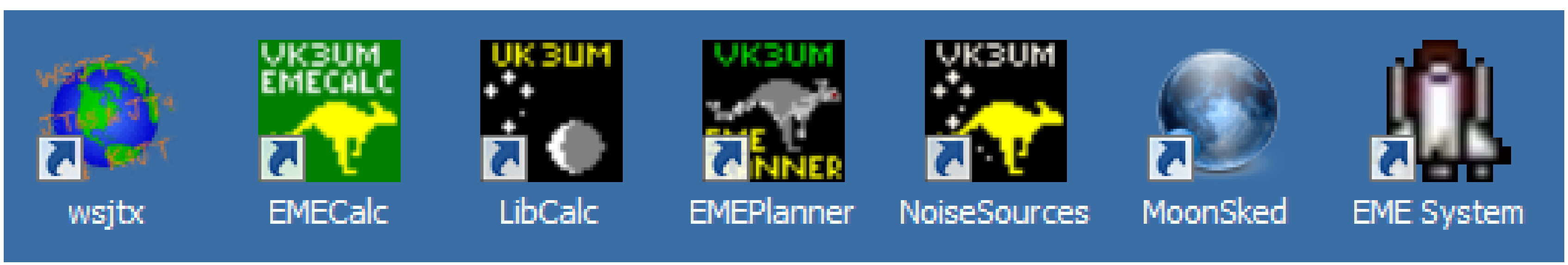
to Moon in perigee and cold sky



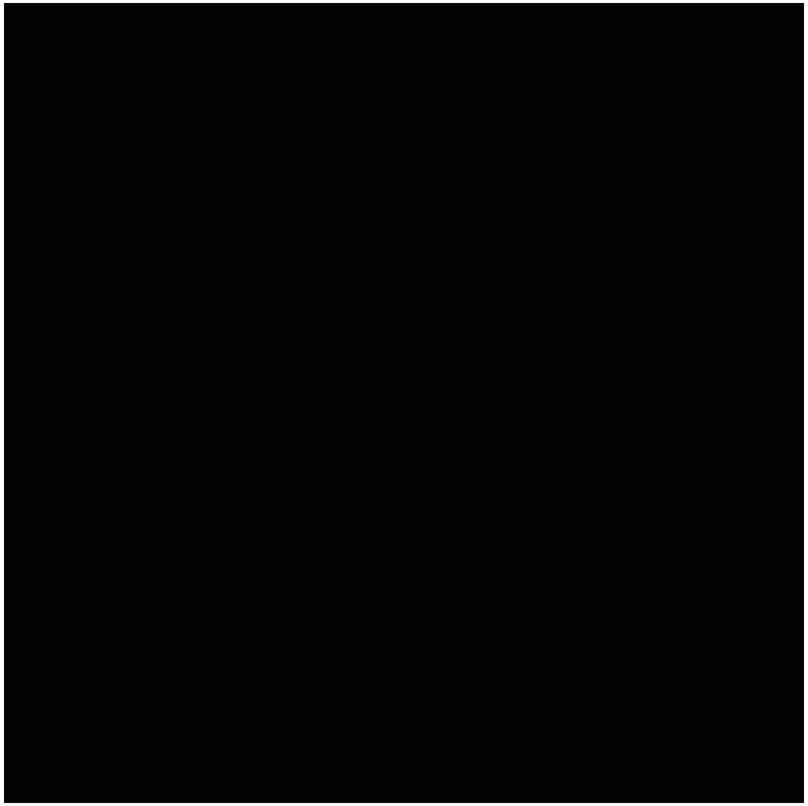
$$L_{Dpol} = 20.\log(\cos D_{pol}) \quad [\mathrm{dB}]$$

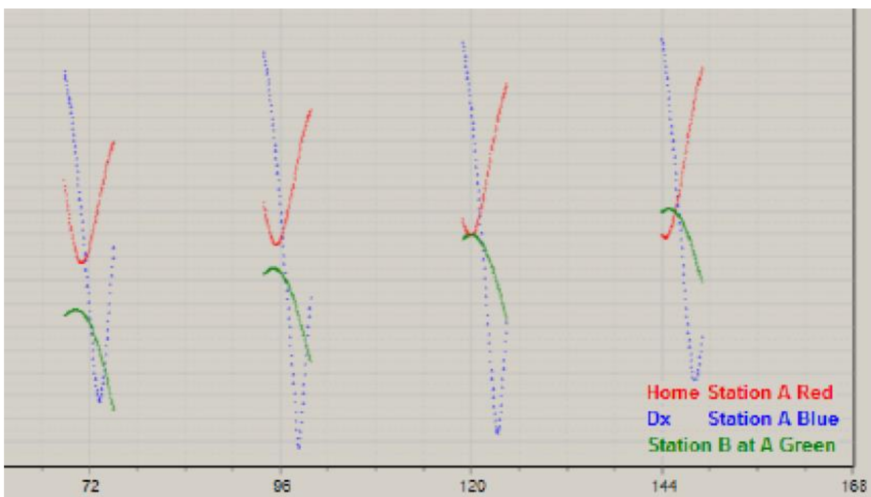


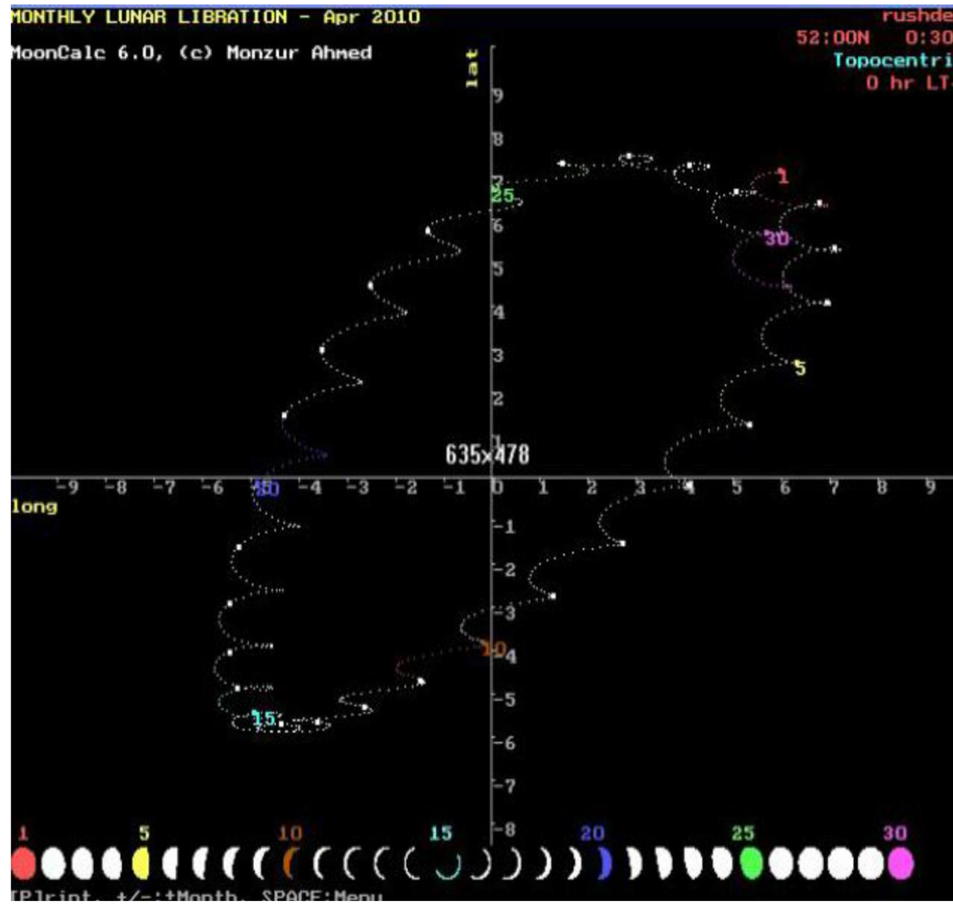
LP versus CP – LP is 1 – 1.6 dB better



Moon Libration – spreaded spectrum



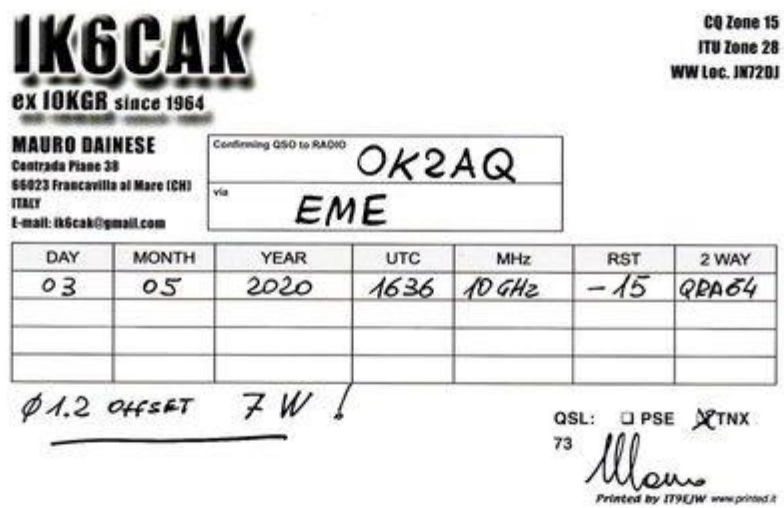




OK2AQ – 1.2 m offset dish

OK2AQ – 1.8 m offset dish

VK7MO – 0.77 m dish



IK6CAK
ex I0KGR since 1964

CQ Zone 15
ITU Zone 28
WW Loc. JN72DJ

MAURO DAINESE
Contrada Piane 38
66023 Francavilla al Mare (CH)
ITALY
E-mail: ik6cak@gmail.com

Confirming QSO to RADIO OK2AQ
via EME

DAY	MONTH	YEAR	UTC	MHz	RST	2 WAY
03	05	2020	1636	10 GHz	–15	QRA64

Ø1.2 OFFSET 7 W !

QSL: ☐ PSE ☒ TNX
73

Printed by IT9EJW www.printed.it

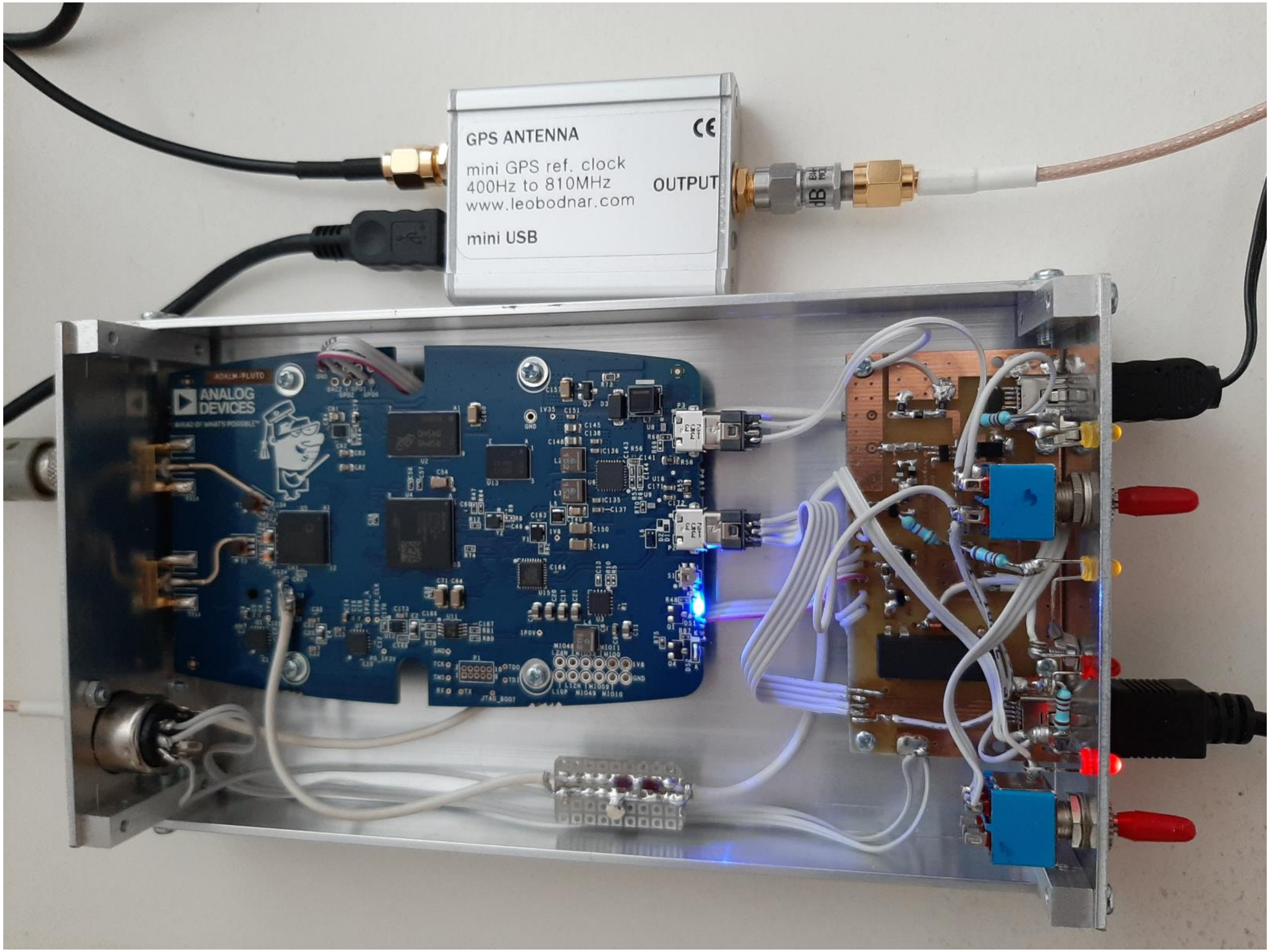
Smallest station worked – 1.2 m dish, 7W

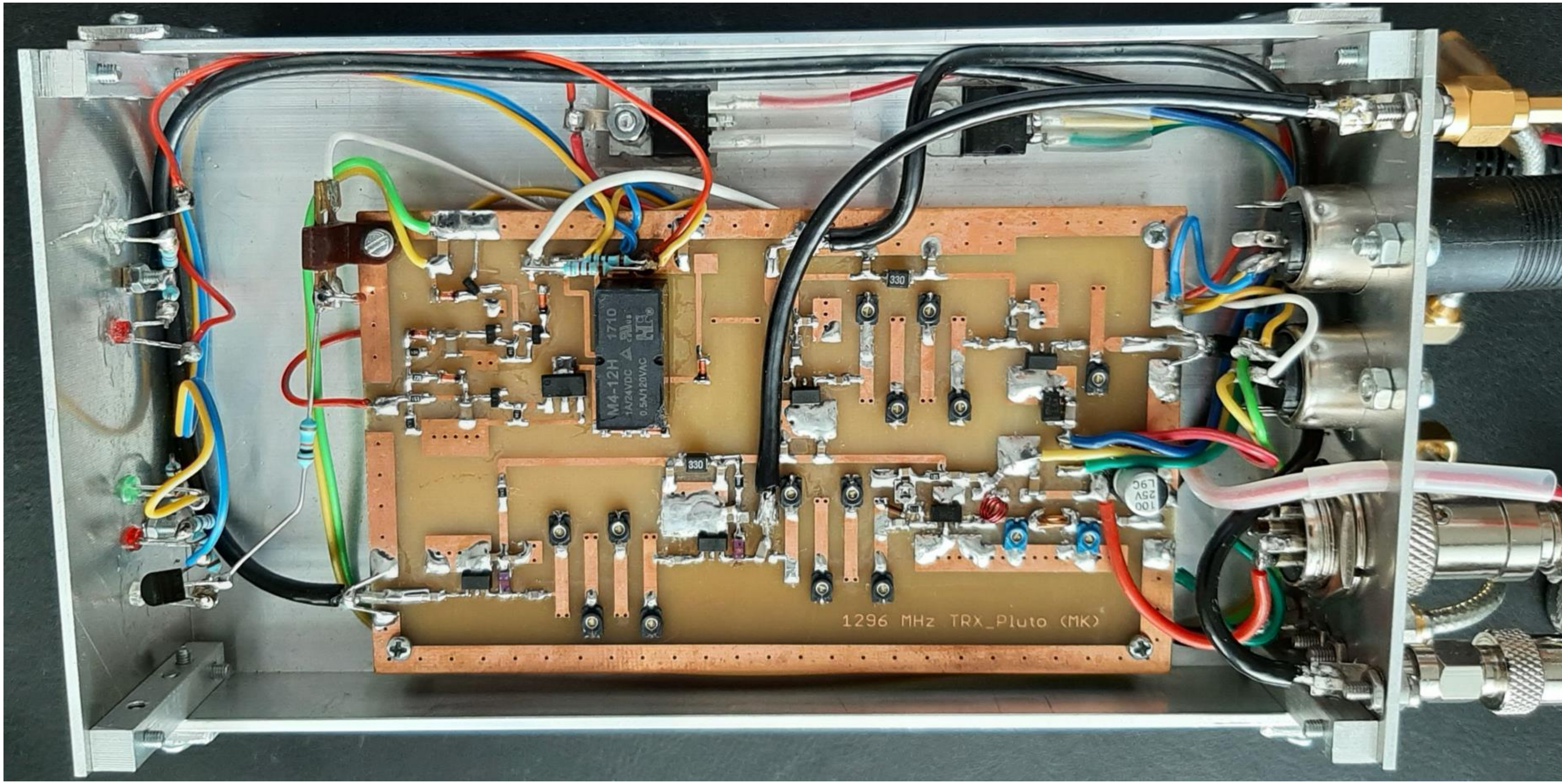
HB9Q as 3DA0MB, EA6/HB9COG and HB0/HB9DBM – 1.5 m dish

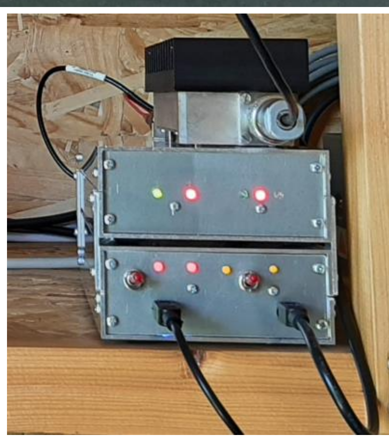
119 CW + Digi Initials
40 DXCC

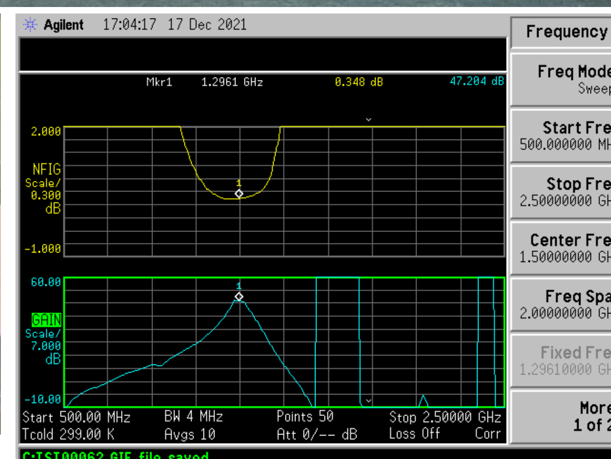
23 cm & 1.8 m offset dish & Adalm PLUTO
(my new toy)

Adalm PLUTO + new TCXO & external GPSDO

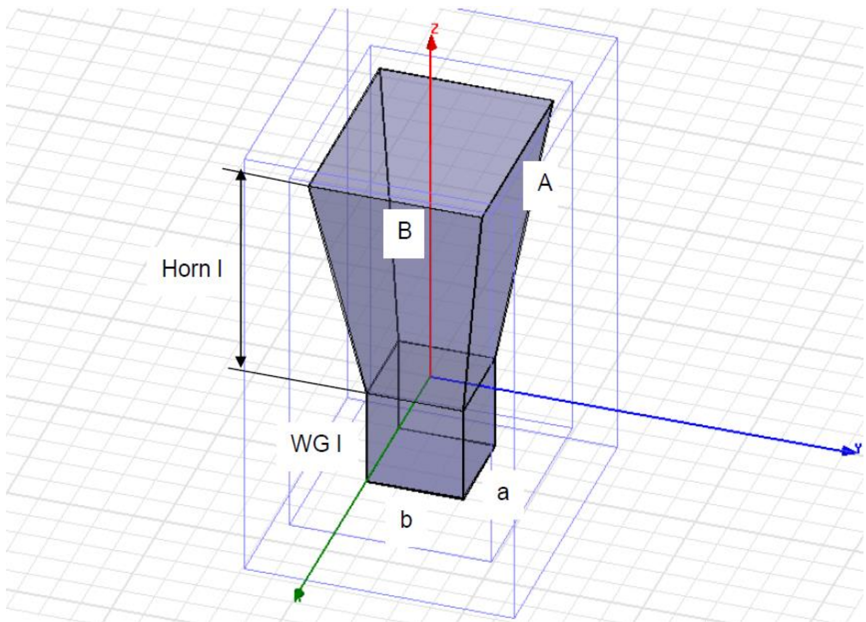


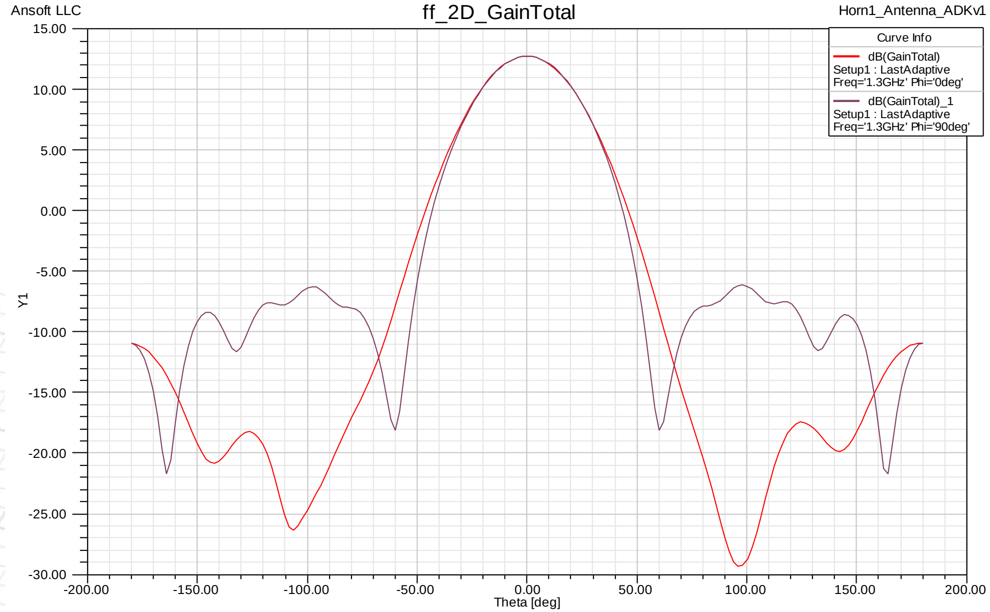

1296 MHz TRX_Pluto (MK)




Agilent 17:04:17 17 Dec 2021
Mkr1 1.2961 GHz 0.348 dB 47.204 dB
2.000
NFIG
Scale/
0.300
dB
-1.000
60.00
GAIN
Scale/
7.000
dB
-10.00
Start 500.00 MHz
Tcold 299.00 K
BW 4 MHz
Avgs 10
Points 50
Att 0/-- dB
Stop 2.50000 GHz
Loss Off
Corr
Frequency
Freq Mode
Sweep
Start Freq
500.000000 MHz
Stop Freq
2.50000000 GHz
Center Freq
1.50000000 GHz
Freq Span
2.00000000 GHz
Fixed Freq
1.29610000 GHz
More
1 of 2
C:TST00062.GIF file saved

SEPTUM + HORN





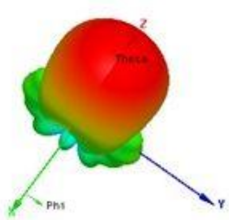
a = b = 150 mm

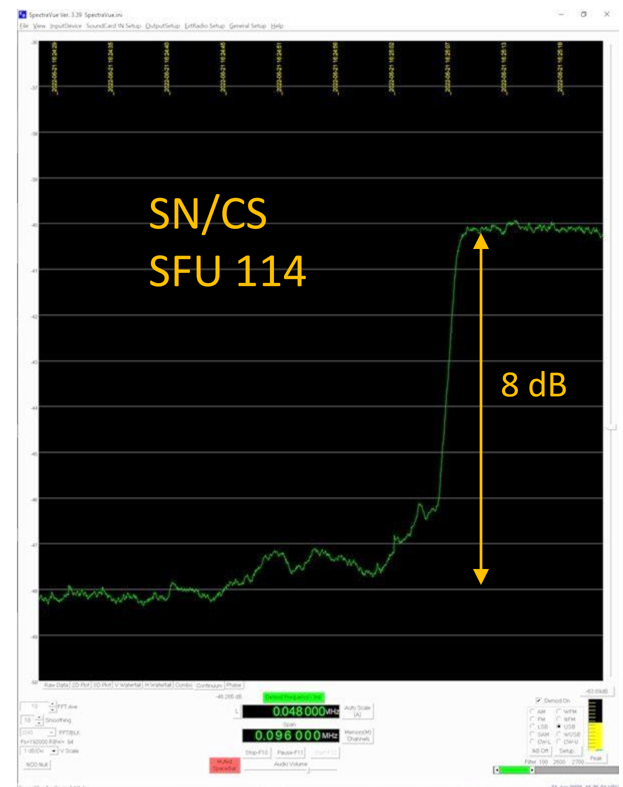
WG l = 150 mm

A = 335 mm

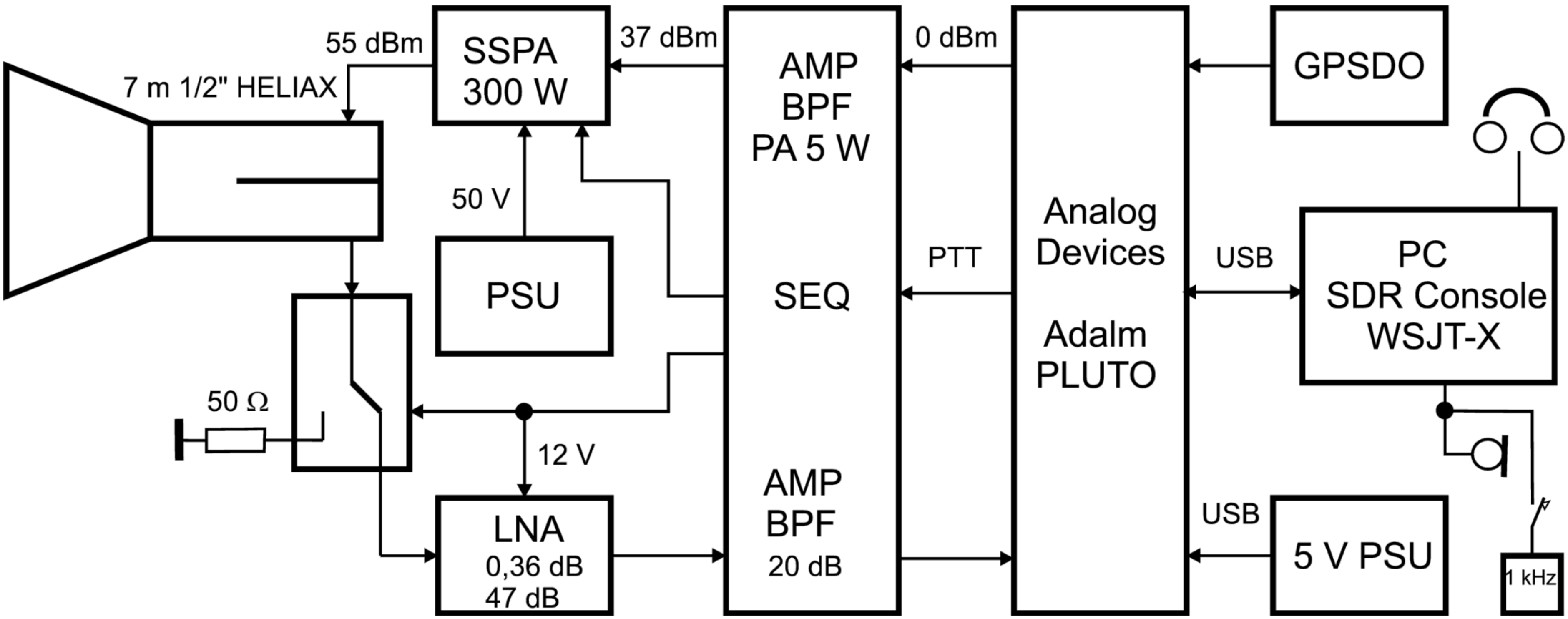
B = 270 mm

Horn l = 400 mm



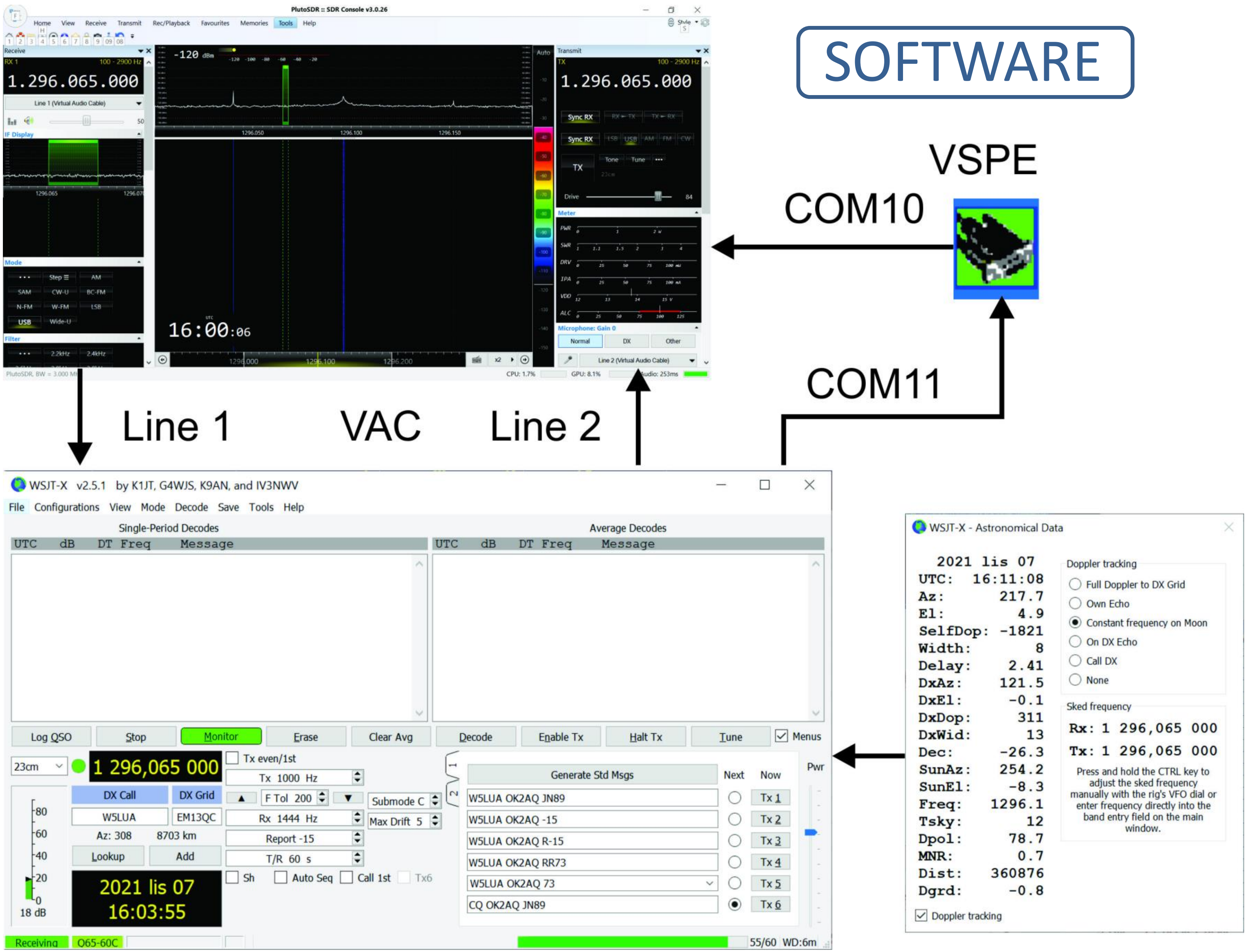


SETUP



55 dBm
7 m 1/2" HELIAX
SSPA
300 W
37 dBm
AMP
BPF
PA 5 W
0 dBm
GPSDO
50 V
PSU
PTT
Analog
Devices
SEQ
Adalm
PLUTO
USB
PC
SDR Console
WSJT-X
50 Ω
12 V
LNA
0,36 dB
47 dB
AMP
BPF
20 dB
USB
5 V PSU
1 kHz

SOFTWARE

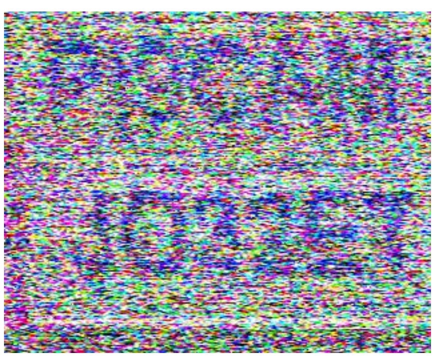

PlutoSDR :: SDR Console v3.0.26
Home View Receive Transmit Rec/Playback Favourites Memories Tools Help
Receive
1.296.065.000
Line 1 (Virtual Audio Cable)
-120
16:00:06
Transmit
1.296.065.000
Sync RX
TX
Drive
Meter
Microphone: Gain 0
Normal DX Other
Line 2 (Virtual Audio Cable)
VSPE
COM10
COM11
Line 1
VAC
Line 2
WSJT-X v2.5.1 by K1JT, G4WJS, K9AN, and IV3NWV
File Configurations View Mode Decode Save Tools Help
Single-Period Decodes
UTC dB DT Freq Message
Average Decodes
UTC dB DT Freq Message
Log QSO
Stop
Monitor
Erase
Clear Avg
Decode
Enable Tx
Halt Tx
Tune
Menus
23cm
1 296,065 000
Tx even/1st
Tx 1000 Hz
F Tol 200
Submode C
Rx 1444 Hz
Max Drift 5
Report -15
T/R 60 s
DX Call
DX Grid
W5LUA
EM13QC
Az: 308
8703 km
Lookup
Add
2021 lis 07
16:03:55
18 dB
Sh
Auto Seq
Call 1st
Tx6
Generate Std Msgs
Next
Now
Pwr
W5LUA OK2AQ JN89
Tx 1
W5LUA OK2AQ -15
Tx 2
W5LUA OK2AQ R-15
Tx 3
W5LUA OK2AQ RR73
Tx 4
W5LUA OK2AQ 73
Tx 5
CQ OK2AQ JN89
Tx 6
Receiving
Q65-60C
55/60 WD:6m
WSJT-X - Astronomical Data
2021 lis 07
UTC: 16:11:08
Az: 217.7
El: 4.9
SelfDop: -1821
Width: 8
Delay: 2.41
DxAz: 121.5
DxEl: -0.1
DxDop: 311
DxWid: 13
Dec: -26.3
SunAz: 254.2
SunEl: -8.3
Freq: 1296.1
Tsky: 12
Dpol: 78.7
MNR: 0.7
Dist: 360876
Dgrd: -0.8
Doppler tracking
Full Doppler to DX Grid
Own Echo
Constant frequency on Moon
On DX Echo
Call DX
None
Sked frequency
Rx: 1 296,065 000
Tx: 1 296,065 000
Press and hold the CTRL key to adjust the sked frequency manually with the rig's VFO dial or enter frequency directly into the band entry field on the main window.
Doppler tracking

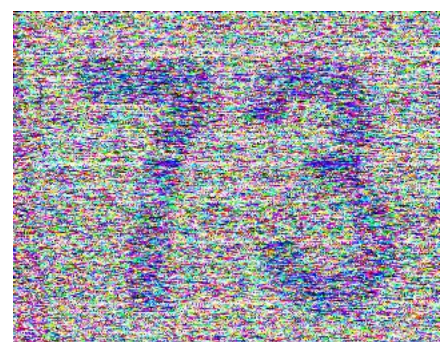
In June 2022 were established 64 QSOs with 44 {#]

QRPP Experiment

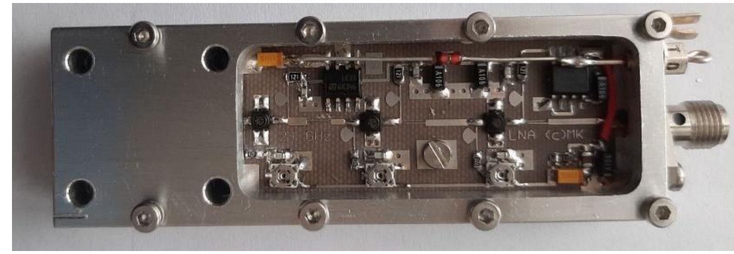
No	Date	UTC	Mode	Callsign	Sent	Rcvd	Locator	# CW	# JT	# MIX	DXCC	QSL	Remarks
75	27.07.2022	16:16	Q65-60C	G4CCH	-15	-23	IO93ql						/5.4 m dish, 500 W//1.8 m dish, 30 W
74	27.07.2022	15:32	Q65-120D	K5DOG	-20	-37	EM00wh						/4.4 m dish, 500 W//1.8 m dish, 30 W
73	26.07.2022	16:18	Q65-120D	KB2SA	-20	-35	DM13ja		not cfm				/1.9 m dish, 850 W//1.8 m dish, 30 W
72	24.07.2022	13:50	Q65-60C	YO2LAM	-16	-31	KN05ps		48	48	18		/4.5 m dish, 1 kW//1.8 m dish, 30 W
71	24.07.2022	11:16	Q65-60C	UA9FAD	-23	-26	LO88da						/3 m dish, 100 W//1.8 m dish, 30 W
70	23.07.2022	12:50	Q65-60C	OK2DL	-12	-21	JN79		47	47			/6 m dish, 1 kW//1.8 m dish, 30 W
69	23.07.2022	12:21	Q65-60C	SM5DGX	-8	-22	JO89nv						
68	23.07.2022	10:02	Q65-60C	I1NDP	-8	-19	JN45al		46	46			/10 m dish, 1 kW//1.8 m dish, 30 W
67	22.07.2022	10:15	Q65-60C	OK1DFC	-10	-15	JN79gw						
66	22.07.2022	9:53	Q65-60C	OK1DFC	-11	-15	JN79gw						on 1268 MHz
65	22.07.2022	9:25	Q65-60C	OK1DFC	-10	-19	JN79gw		45	45			/ 8 m dish, 1 kW//1.8 m dish, 30 W

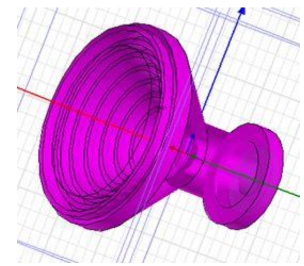
PI9CAM

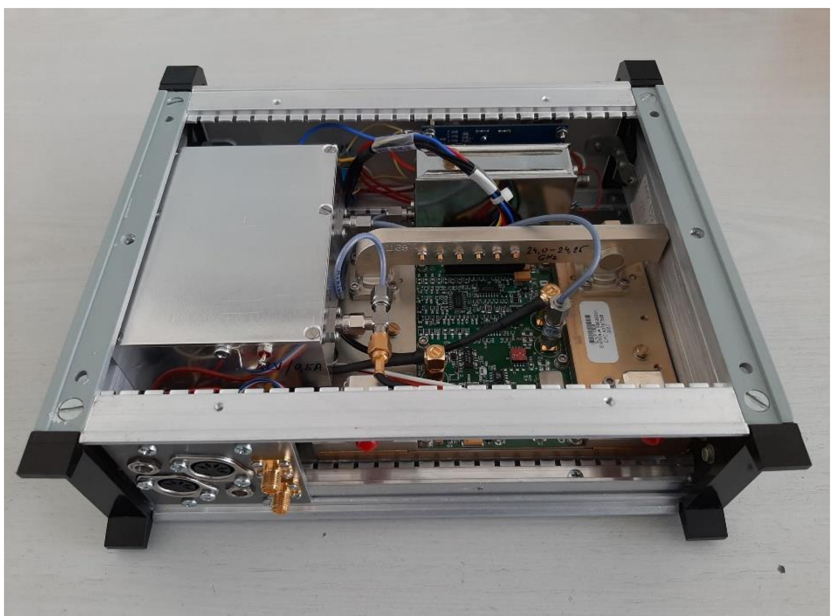




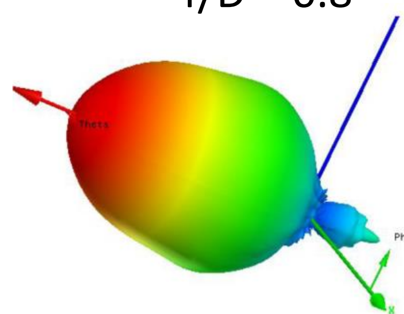
24 GHz is in the preparation phase

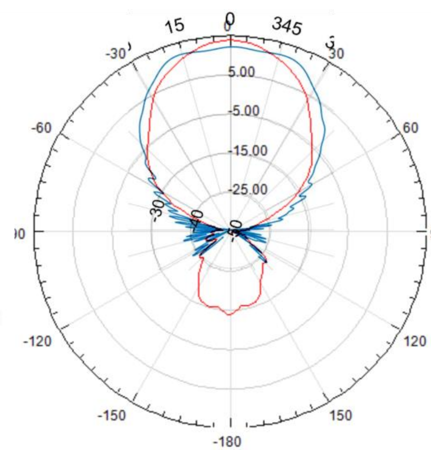






f/D = 0.8





Thank you for your attention

http://www.urel.feec.vutbr.cz/esl/files/EME/EME.htm