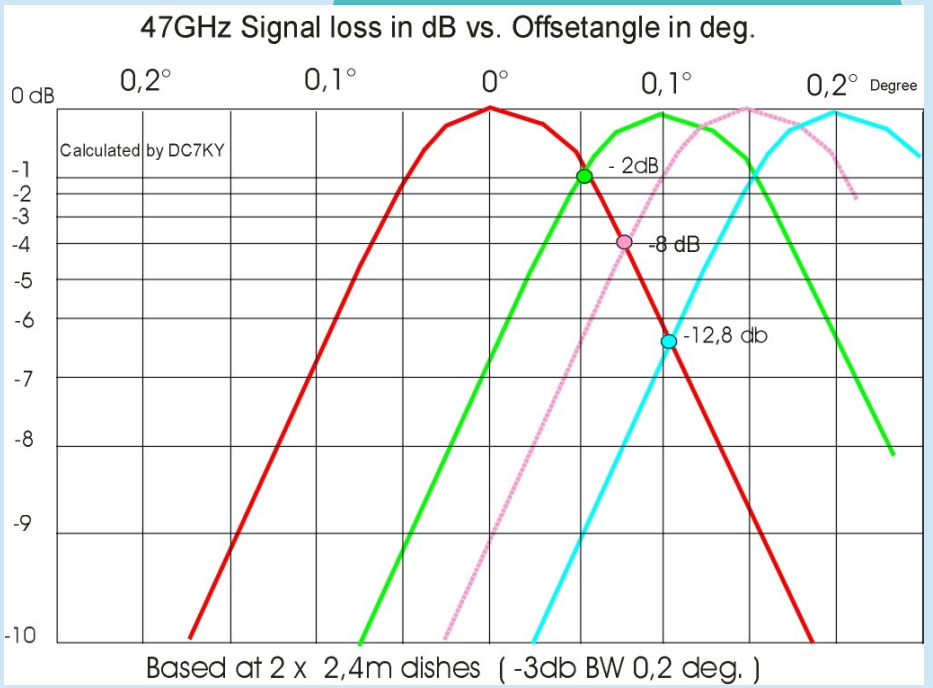
47 GHz EME

a joint report by
OK1DFC
and
DL7YC

Manfred Ploetz
DL7YC



The first echo in the 47 GHz band was heard by Sergey RW3BP in July 2004 (100W RF).

The attempt was also heard by AD6FP, W5LUA, VE4MA and VE7CLD in August 2004.

First CW! QSOs were made in the 47 GHz band:
RW3BP and AD6FP, W5LUA and VE4MA

RW3BP configuration

RW3BP

Offset dish 2.4 m
100 W output power
50 MW ERP
CS/MN 1 dB

VE4MA configuration

VE4MA

Offset dish 2.4 m
9 W output power
CS/MN 1 dB

W5LUA configuration

W5LUA

2.4 m offset antenna
30 W output power
C/S-M/N - 1dB

Ex AD6FP - K6MG configuration

AD6FP (now K6MG)

1.8 m offset antenna
30 W output power
New 140W TWT ??
1 dB moon noise

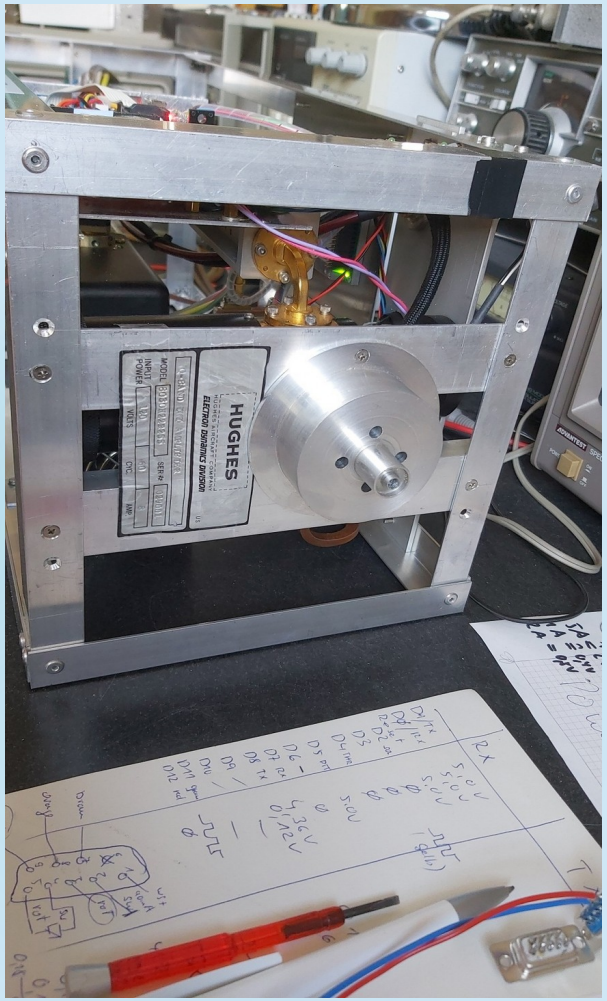
47 GHz - DL7YC configuration

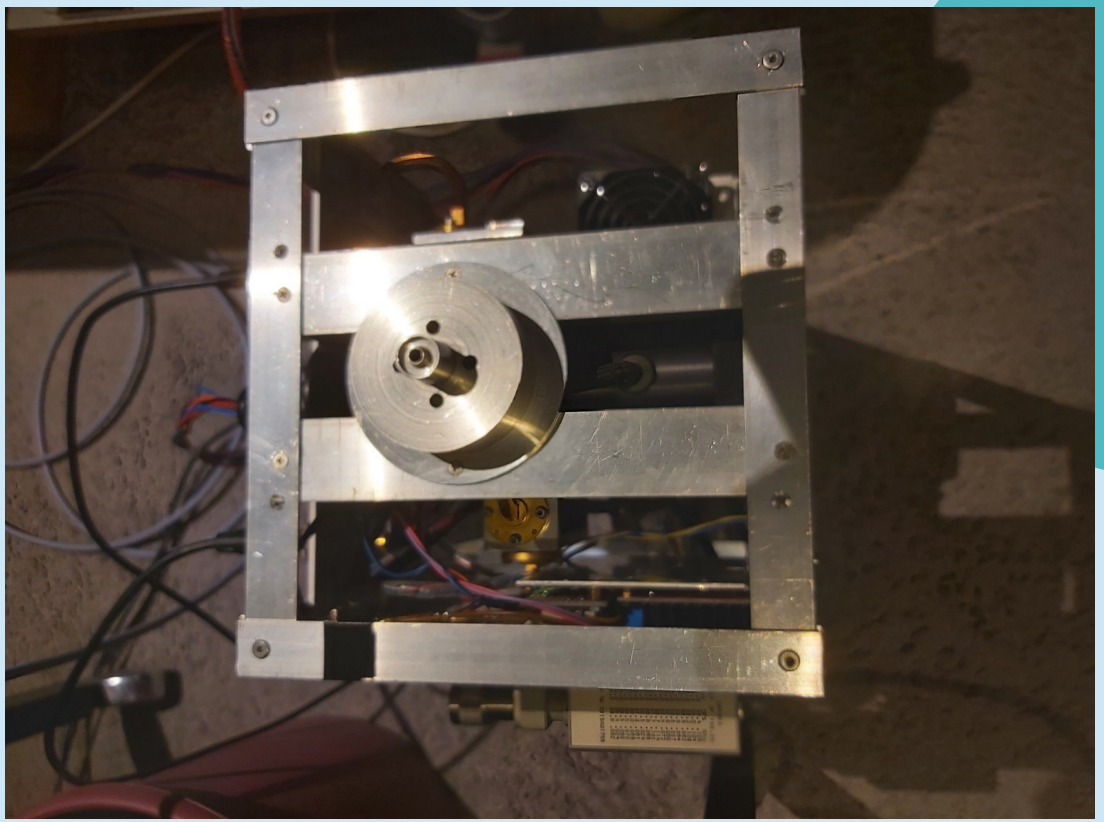
- 2.4 m prime focus alu antenna
- VE4MA f/D 0.4 “Super-Feed”
- Dish for 10-12 GHz; worked up to 76 GHz with good results
- VLNA 2.0dB N/F - 24dB gain JA8CMY
- HUGHES TWTA 42W RF out
- TRV DB6NT
- G3RUH low drift GPS / LO DB6NT

- SN/CS = 12.0 dB max
- MN/CS = 1.2 dB max

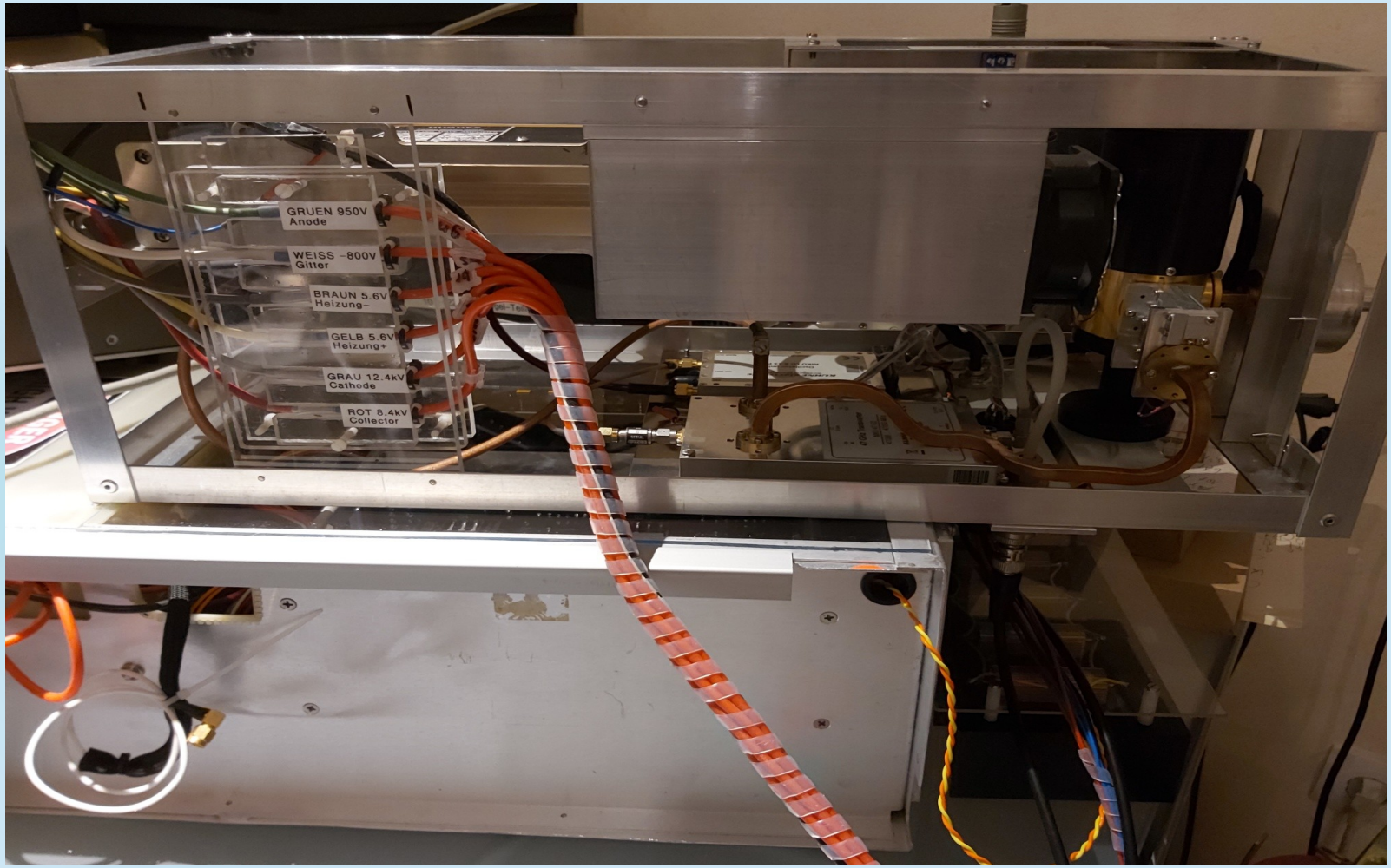
DL7YC – 47GHz 2.4m antenna
Feedbox mount

DL7YC - 47 GHz Feed in front



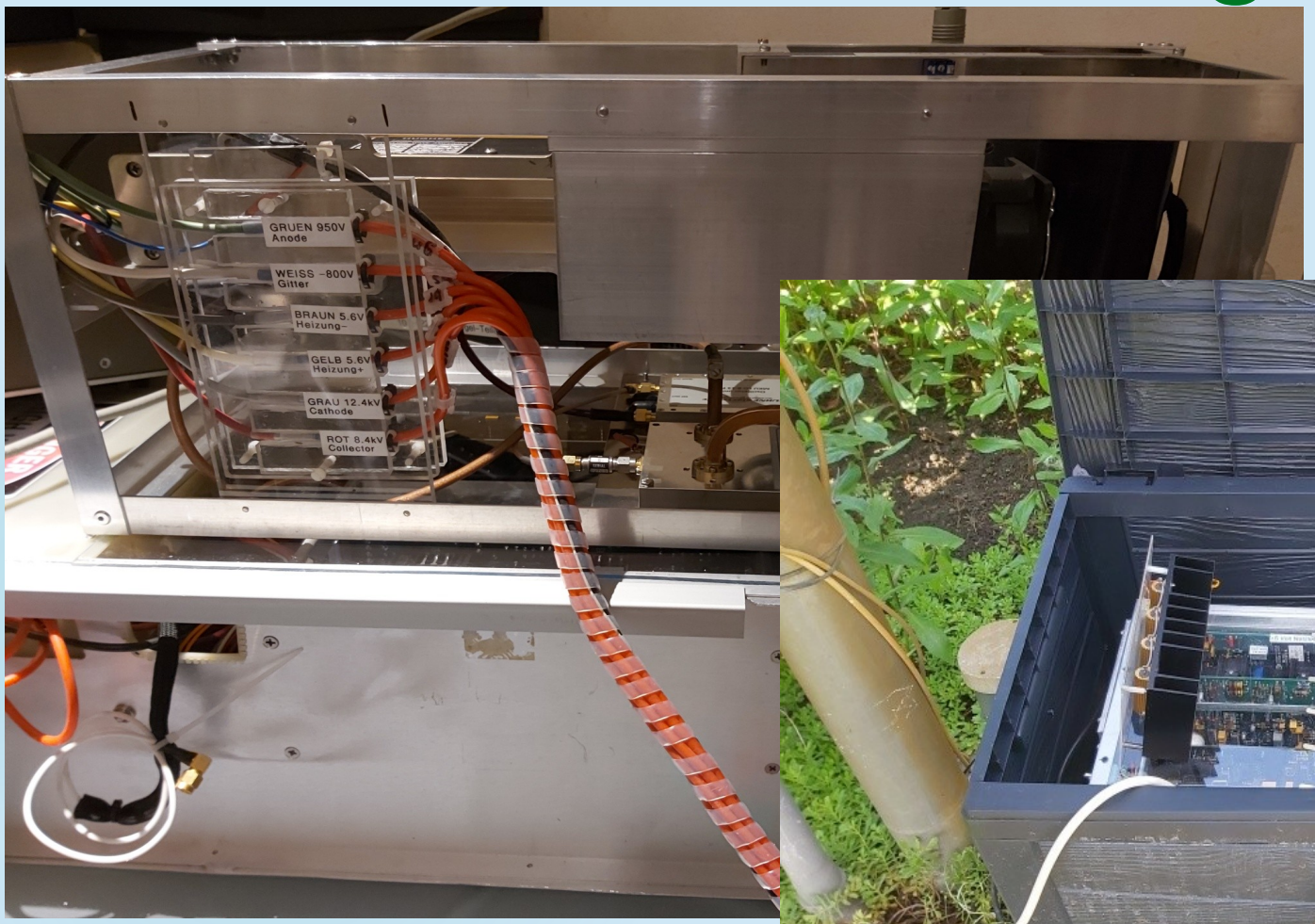


DL7YC - 47 GHz HV Connector



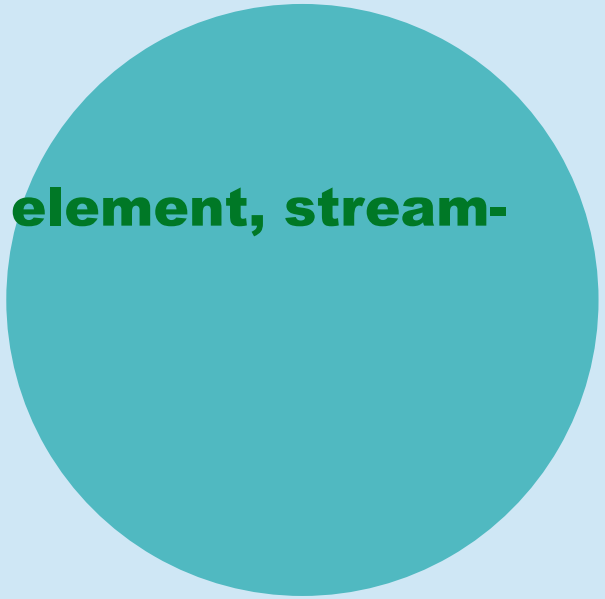
DL7YC - 47 GHz High Voltage Power Supply

47GHz HV PS & cabeling @ DL7YC



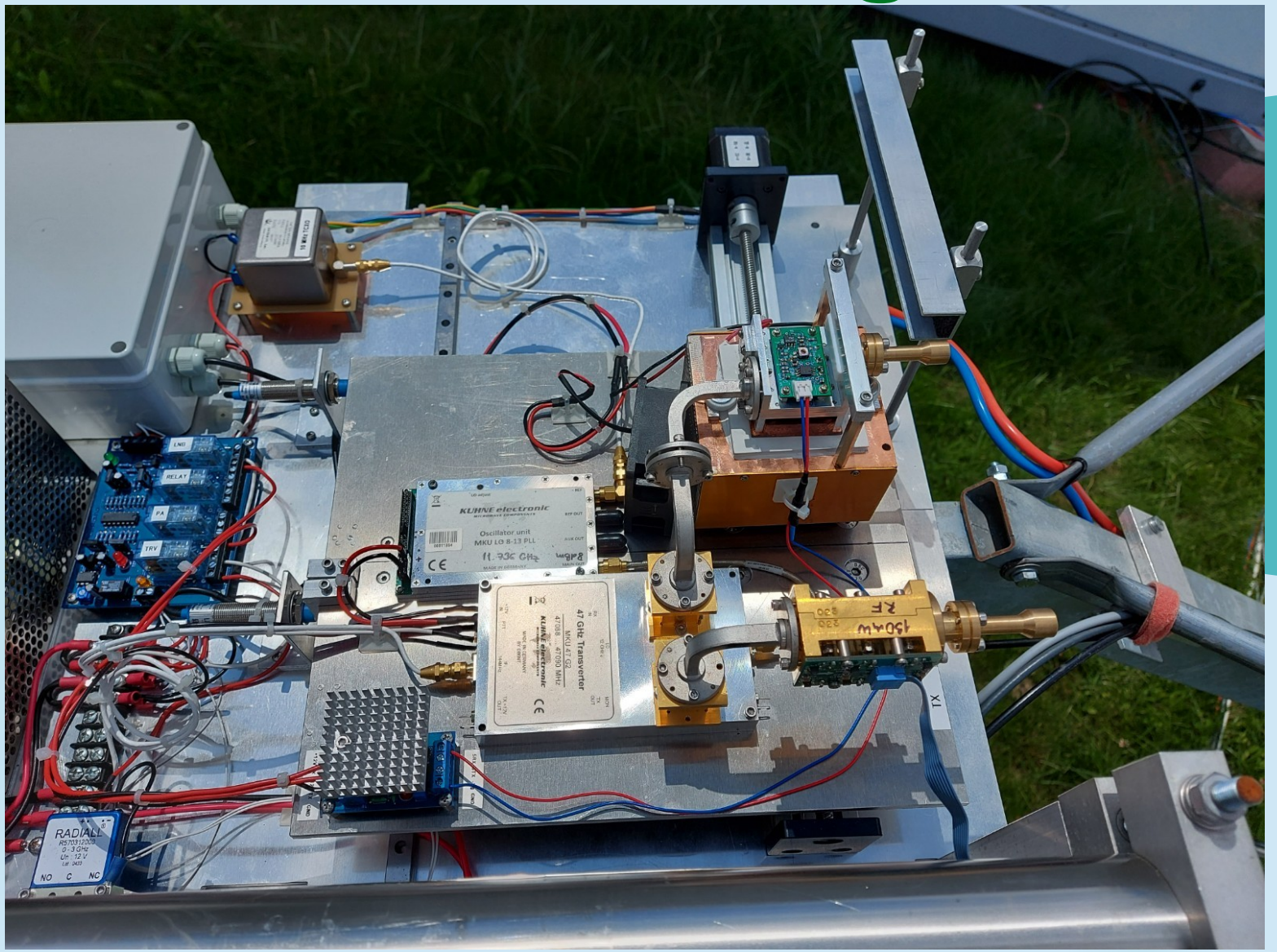
47 GHz - OK1DFC configuration

- 2.6 m offset antenna
- W2IMU F/D 0.6 feedhorn
- Dish calibrated to 36 GHz, one 5 mm thick AlSiMg element, stream-formed
- VLNA 2.4dB N/F - 24dB gain JA8CMY
- **SSPA 2W RF out**
- TRV DB6NT
- GPS LO DB6NT



- SN/CS = 8.6 dB
- MN/CS = 0.85 dB

47 GHz - OK1DFC configuration



47 GHz – OK1DFC parabolic antenna 1

- First test with Prodelin offset 2.4m
- Glass laminate with integrated grid 1.5x1.5 m
- 4 pieces of mirrors
- Adjustment accuracy of 0.1°.

  - SN/CS = **7.5 dB**
  - MN/CS = **0.7 dB**

47 GHz – OK1DFC parabolic antenna 2

- Second version offset 260cm
- AlSiMg dural 5mm
- 1 piece mirror
- AZ/EL adjustment accuracy 0.01°

  - SN/CS = **8.6 dB**
  - MN/CS = **0.85 dB**

47 GHz: problems multiply

	10 GHz	24 GHz	47 GHz
Frequency stability		2.5 x	5 x + phase noise
Doppler spread	~ 200 Hz	400+ Hz	900+ Hz
Doppler shift	up to 20 kHz	~ 60 kHz	~120 kHz
Round trip attenuation	289 dB	297 dB	~ 303 dB
ATT O2	-	0.02 dB/km	0.4 dB/km
ATT H2O	-	0.3 dB/km	0.15 dB/km

What are the „barriers“ at 47 GHz ?

* Accuracy of dish surface - „Ruze`s equation“

* Tracking accuracy better 0.05 deg for center pointing

* Self-Doppler shift up to 120 kHz – managed by CFOM

* **Atmospheric loss up to 4 dB (both ways)**

*** Signal spread up to 1000 Hz !! (spread vs. loss)**

Station equipment today

* Offset or Primefocus parabolic dish (1.2m – 2.4m)

* Optimized feedhorn for more rectangular surface layer

* Preamplifier / Transverter < 2.5dB NF

* **TWTA or SSPA > 10 watts**

* Waveguide switch s21 < 0.2 dB (better 0.1dB preferred)

47 GHz - parabolic antenna

	10 GHz	24 GHz	47 GHz
Radiation diagram with 2.6 m	0,77°	0,33°	0,17°
Aiming accuracy	+/-0,2°	+/-0,05°	Continuous monitoring + CCD optical inspection
Gain	47.54 dBi	54.85 dBi	**60.69 dBi** **10W RF = 10MW ERP**
Surface accuracy of 0.1λ	(λ=28.9 mm) 3 mm	(λ=12.4 mm) 1.2 mm	**(λ=6.24 mm) 0.6 mm !!!**

See Ruze`s equation

And what are the REAL „barriers“ at 47 GHz ??

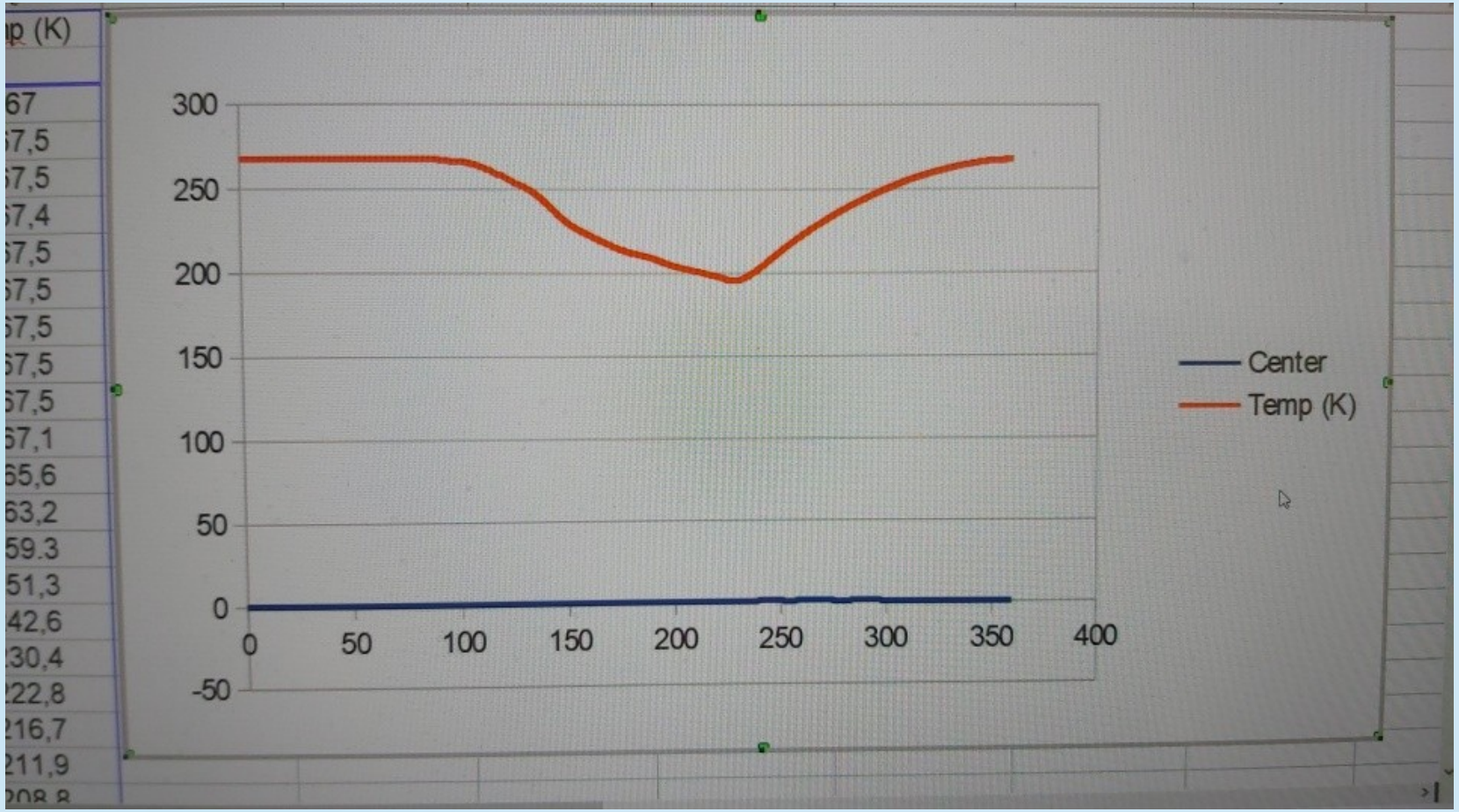
* Moon center not identical with Moon Noise maximum

* Radio „HOTSPOT“ several days delayed behind visual moon

* Additional „moon center“ doppler shift with 2.4m antennas (0.1deg / 50Hz ??) due to Doppler Calc referenced to Moon Center

* **Pointing must be calculated or camera controlled !!**

Moon Temperature vs. Moon Phase



„Hot Spot“ vs. Moon Phase

Example of „HOTSPOT“ calculation

(Source: Köppen @ Kiel / Germany)

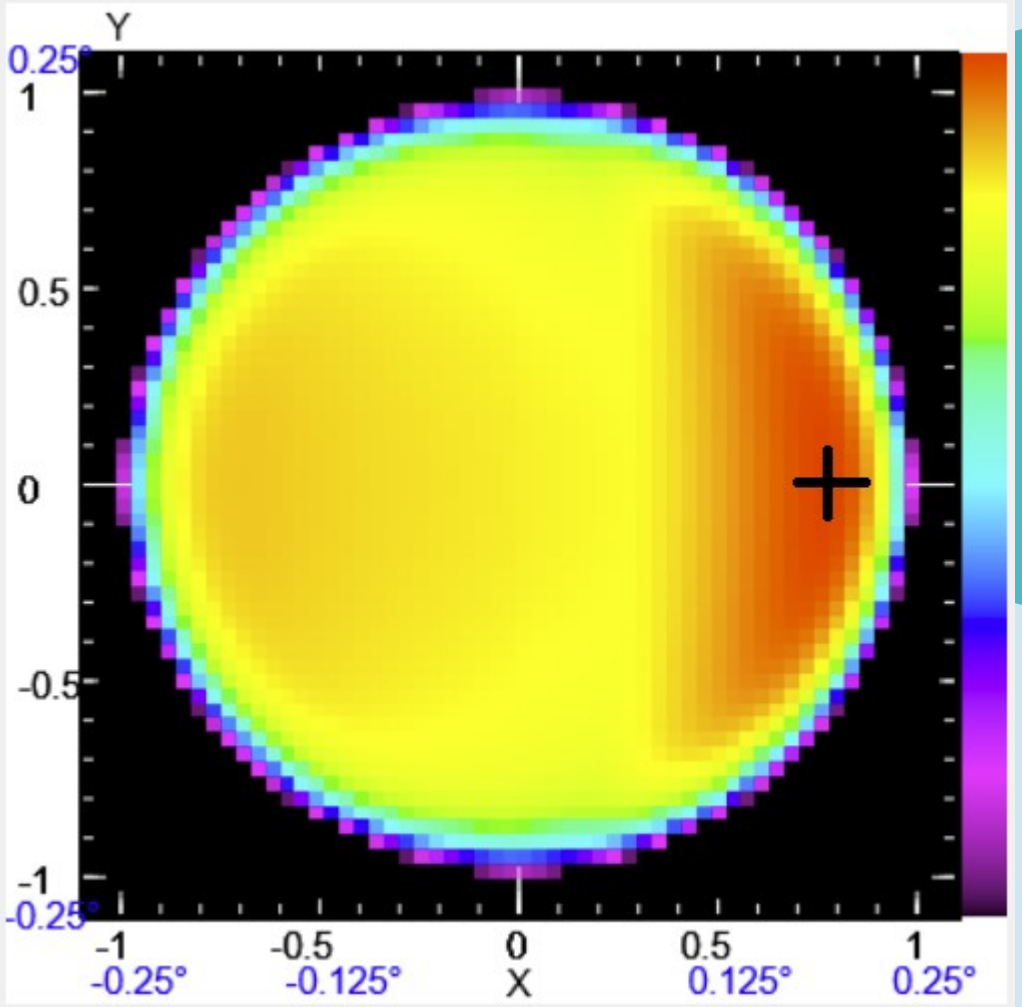
frequency [GHz]	47
phase [Full Moon = 0°]	252
no.bins	60

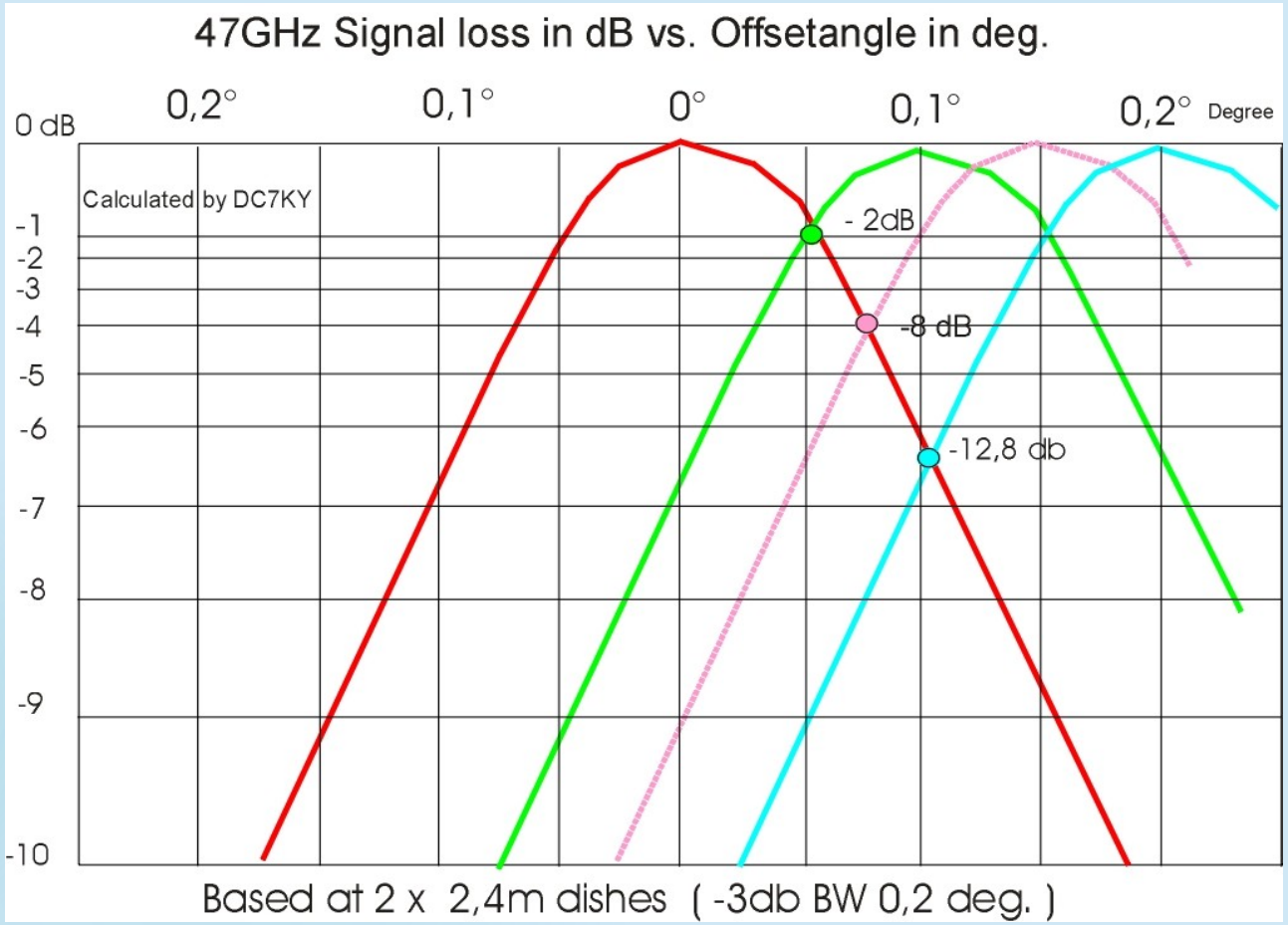
image

contour start [K]	200
contour step [K]	10

average temperature [K] 167.4
temperature at disc centre [K] 182.3
antenna beam HPBW [°] 0.2
temperature in beam [K] 182.2

Mouse position:
X 0.76 Rmoon = 0.19°
Y 0.012 Rmoon = 0.0031°
brightness temperature [K] 214.2



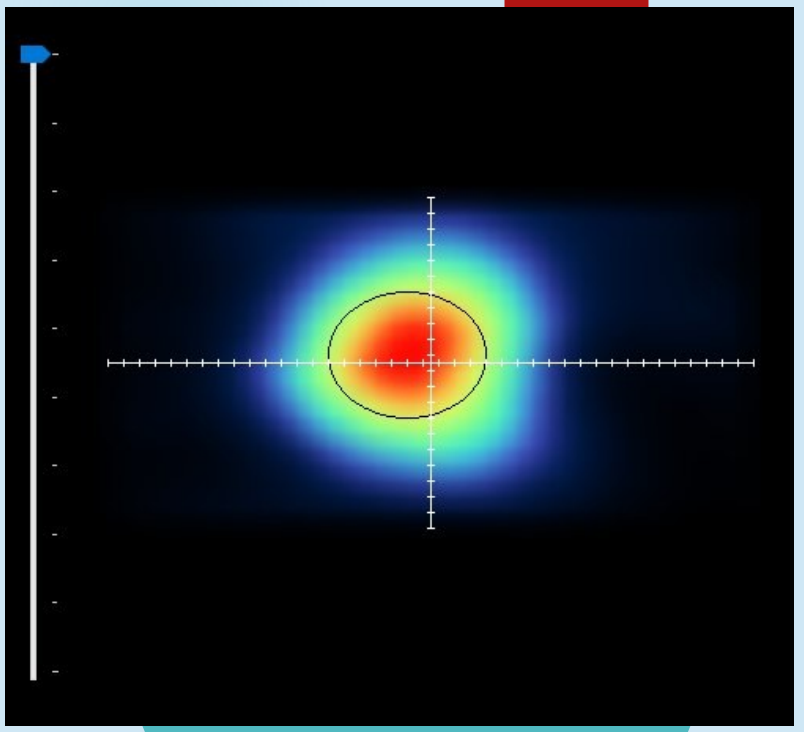


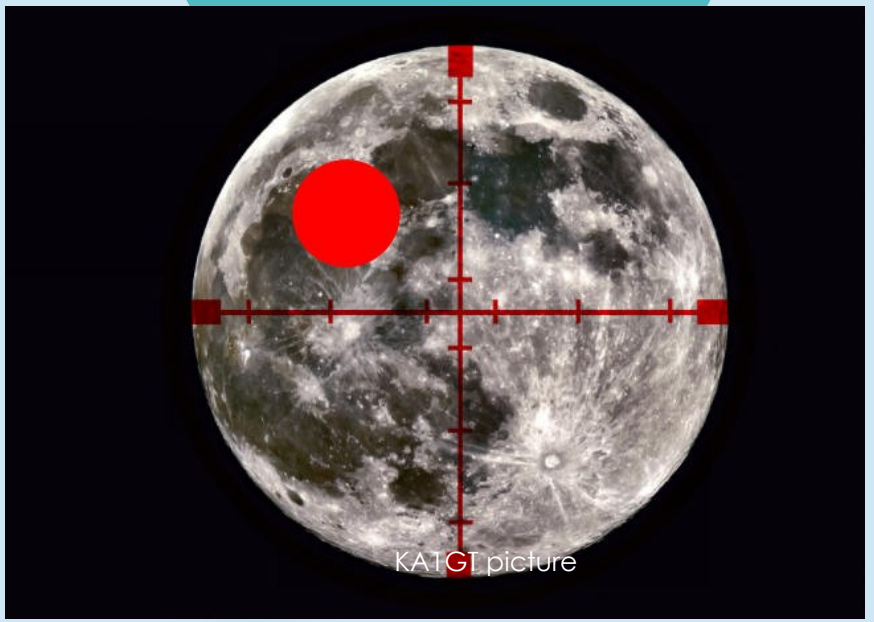
47 GHz 2 x 2.4m dish pointing error

47 GHz - pointing

- **The angular diameter of the Sun** in the sky is 31´ 59.2 ´´ = about **0.5°.**

- **The angular diameter of the Moon** varies according to its distance from Earth and ranges from 29.4′ to 34.1′, or **0.5°** again.





- **OK1DFC dish 0.16°**
  - F1EHN SW - Resolution 0.01° US Digital Encoders
  - Threshold-free gearboxes
  - DC motor speed control - smooth operation
  - Camera

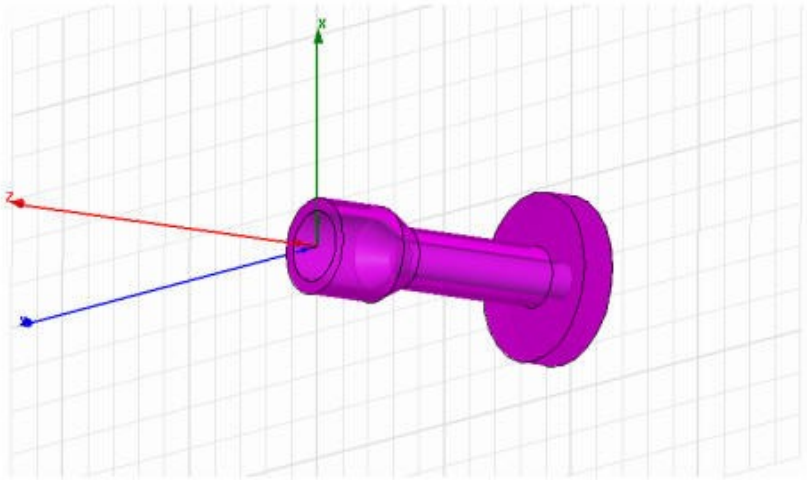
47 GHz - the cuckold of the W2IMU band.

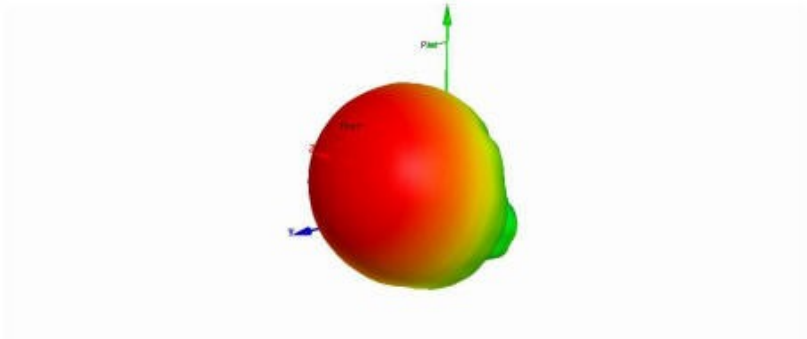
- F/D 0.8 & 0.6
- Model TNX OK2AQ

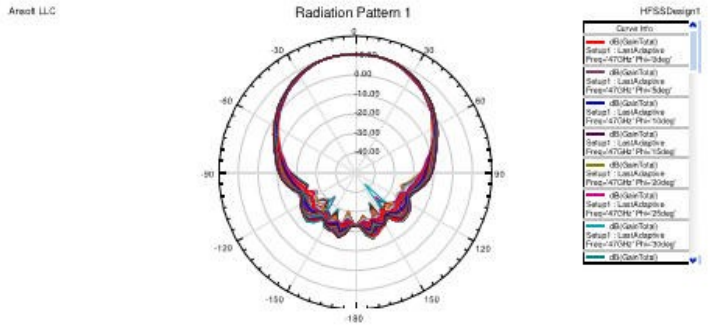
Dual mode feed W2IMU

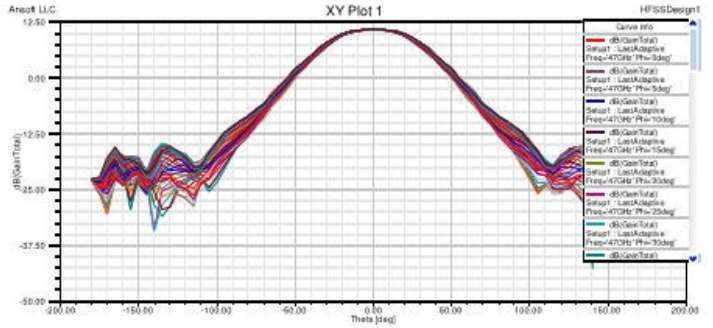
for offset dish f/d = 0,6 OK1DFC on frequency 47 GHz

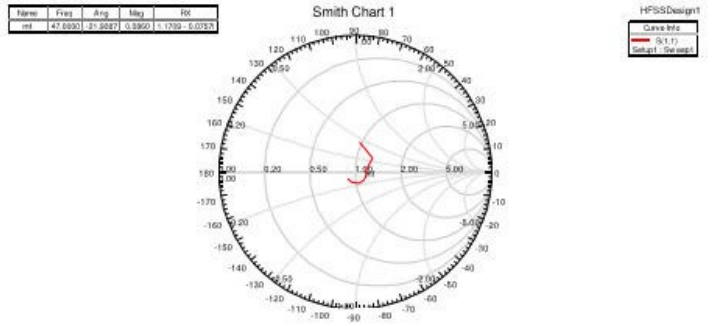
analyzed by Mirek Kasal OK2AQ





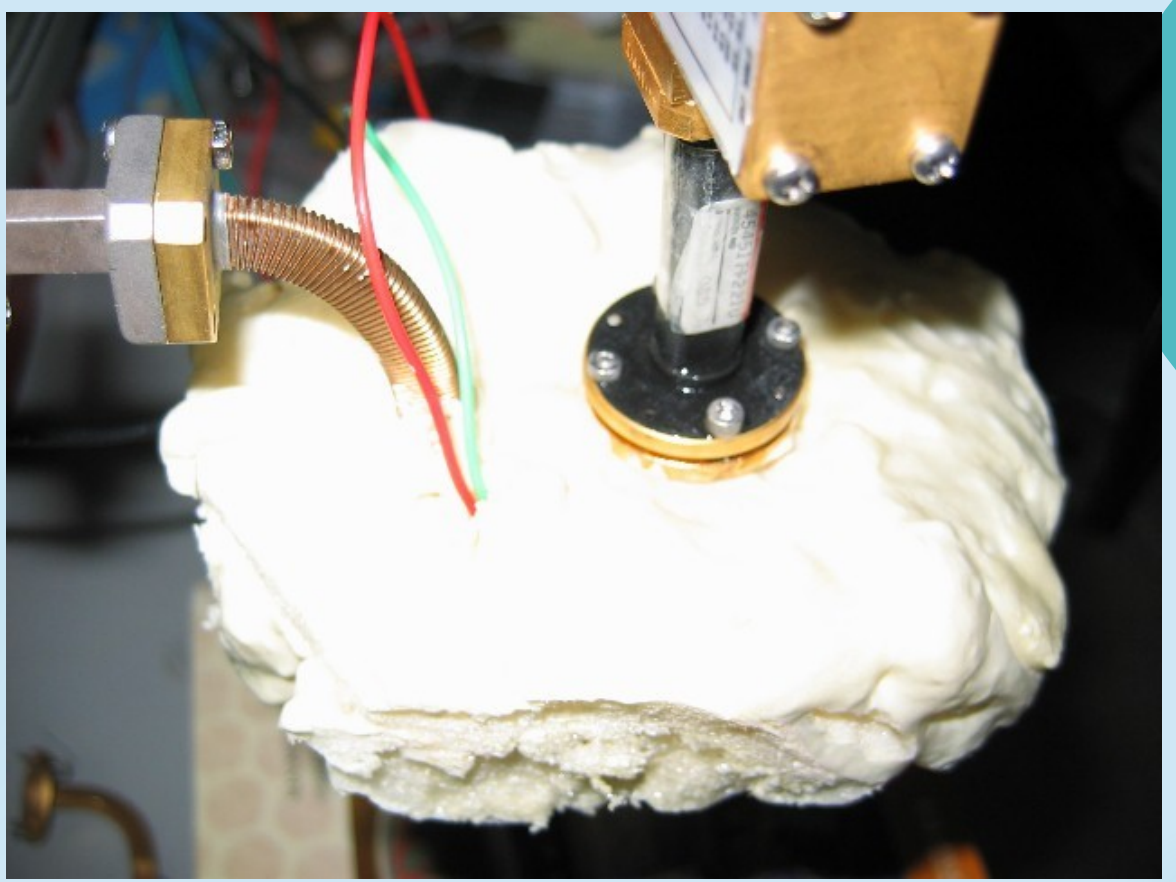




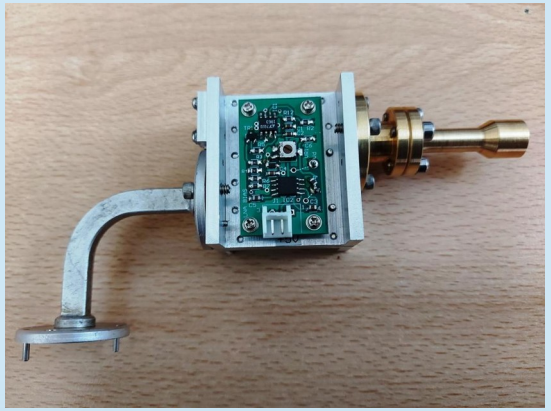


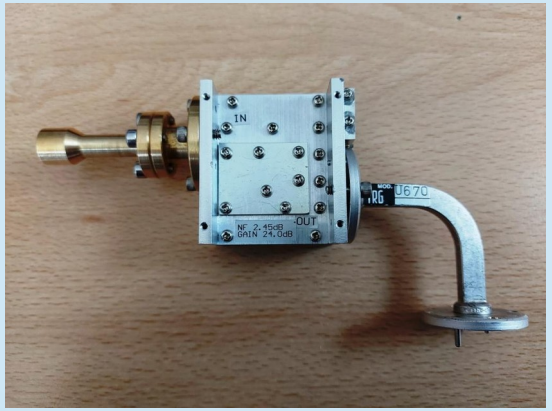
Nitrogen-cooled VLNA K6MG

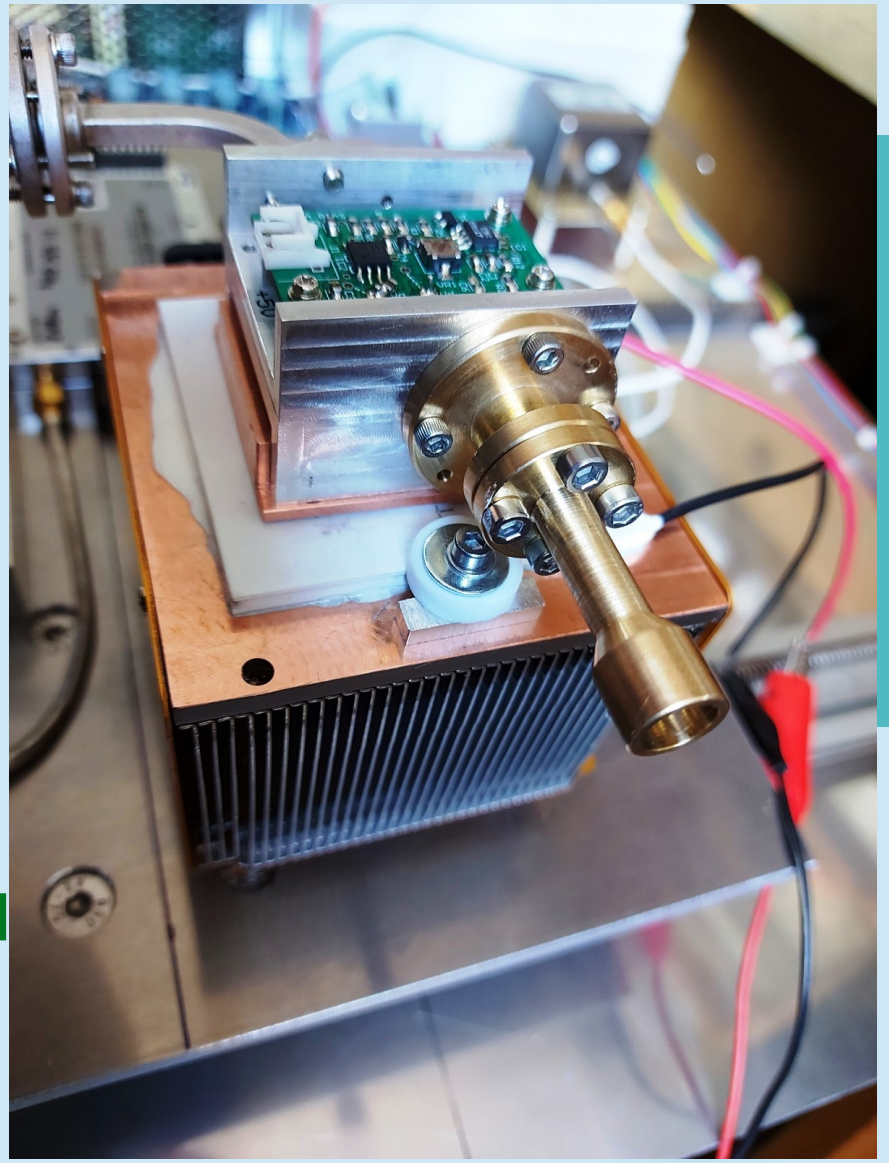
1.5 dB NF @ 77° K (4 dB @ 290 K).



47 GHz – VLNA Peltier cell cooling

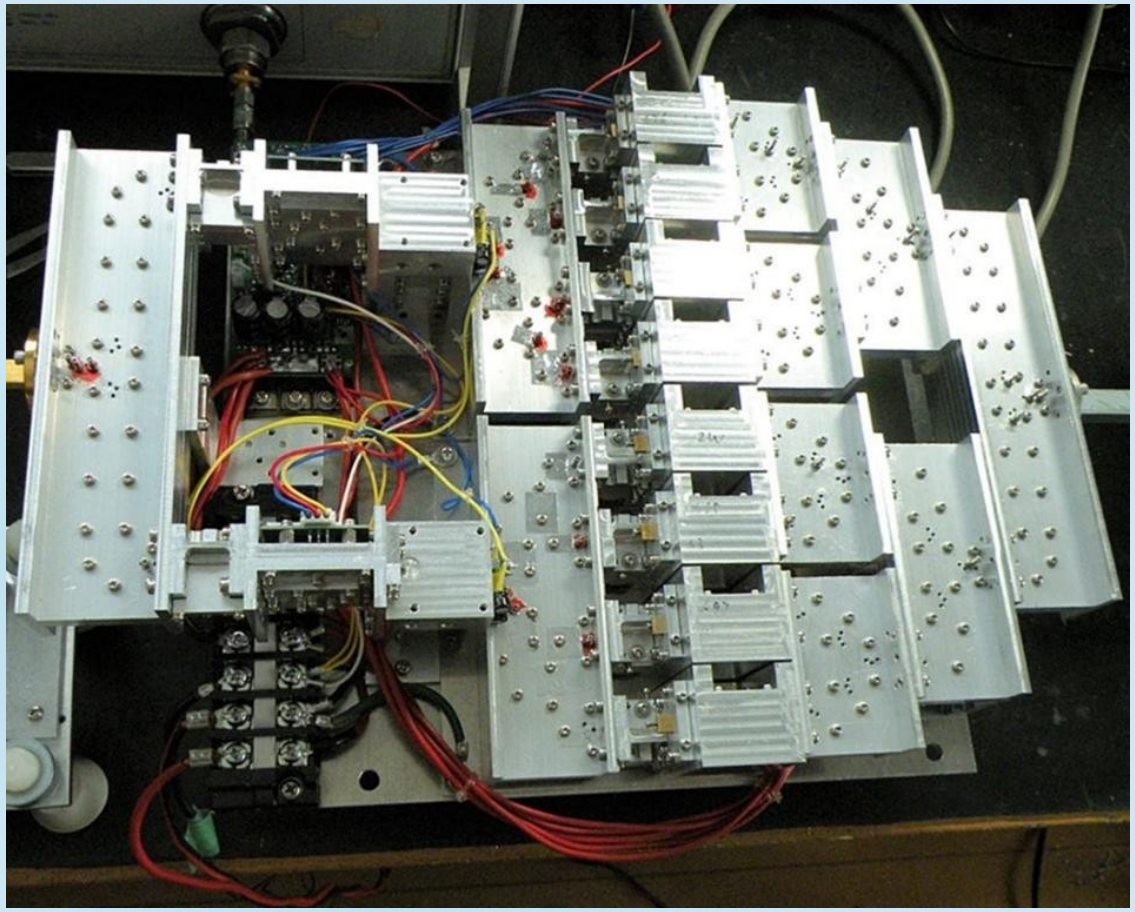


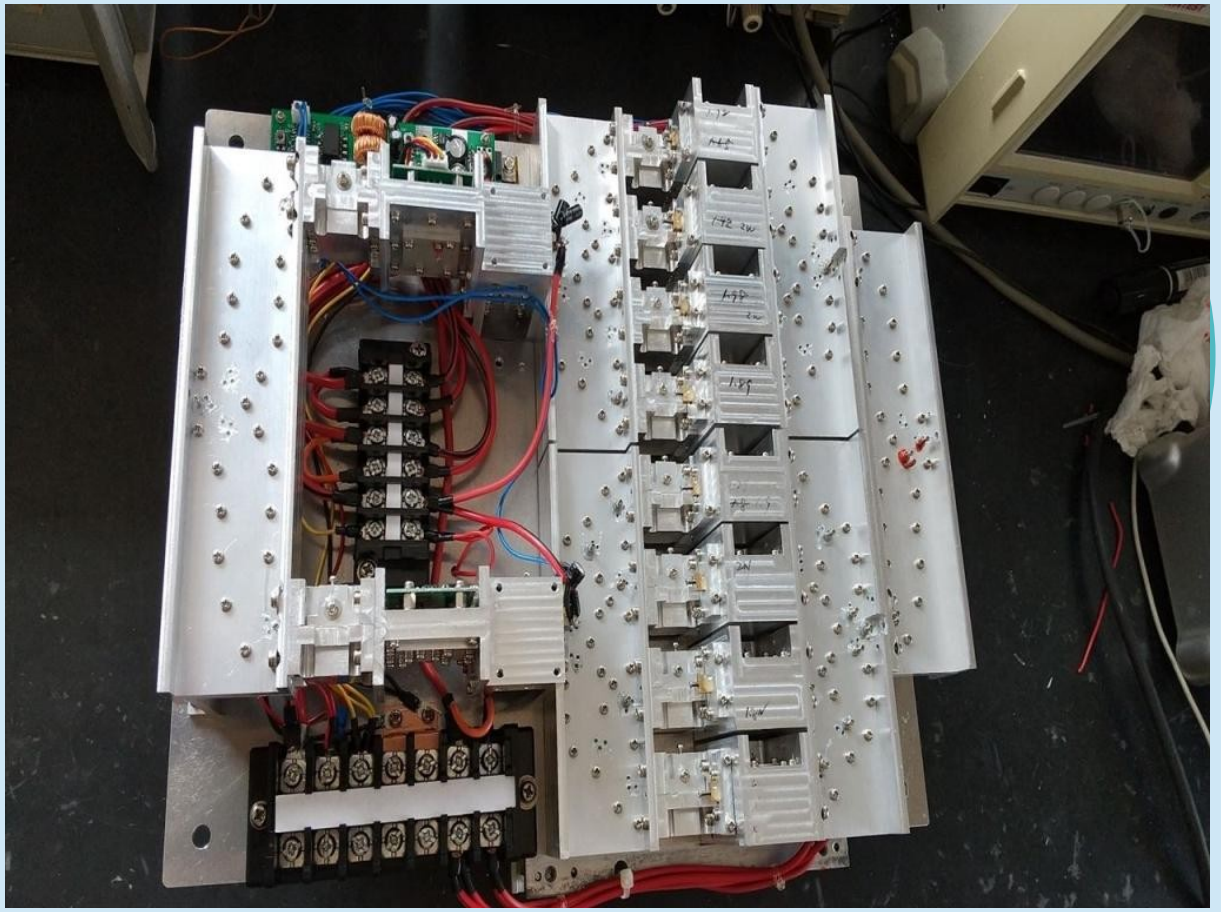




- WR19 or WR22 waveguide systems
- 2.0 - 2.4dB N/F
- Gain 24dB
- Peltier cell as cooling down to -20°C
- **Condensation problem – automated dew point control needed !!**

47 GHz – JA1WQF SSPA 11W RF



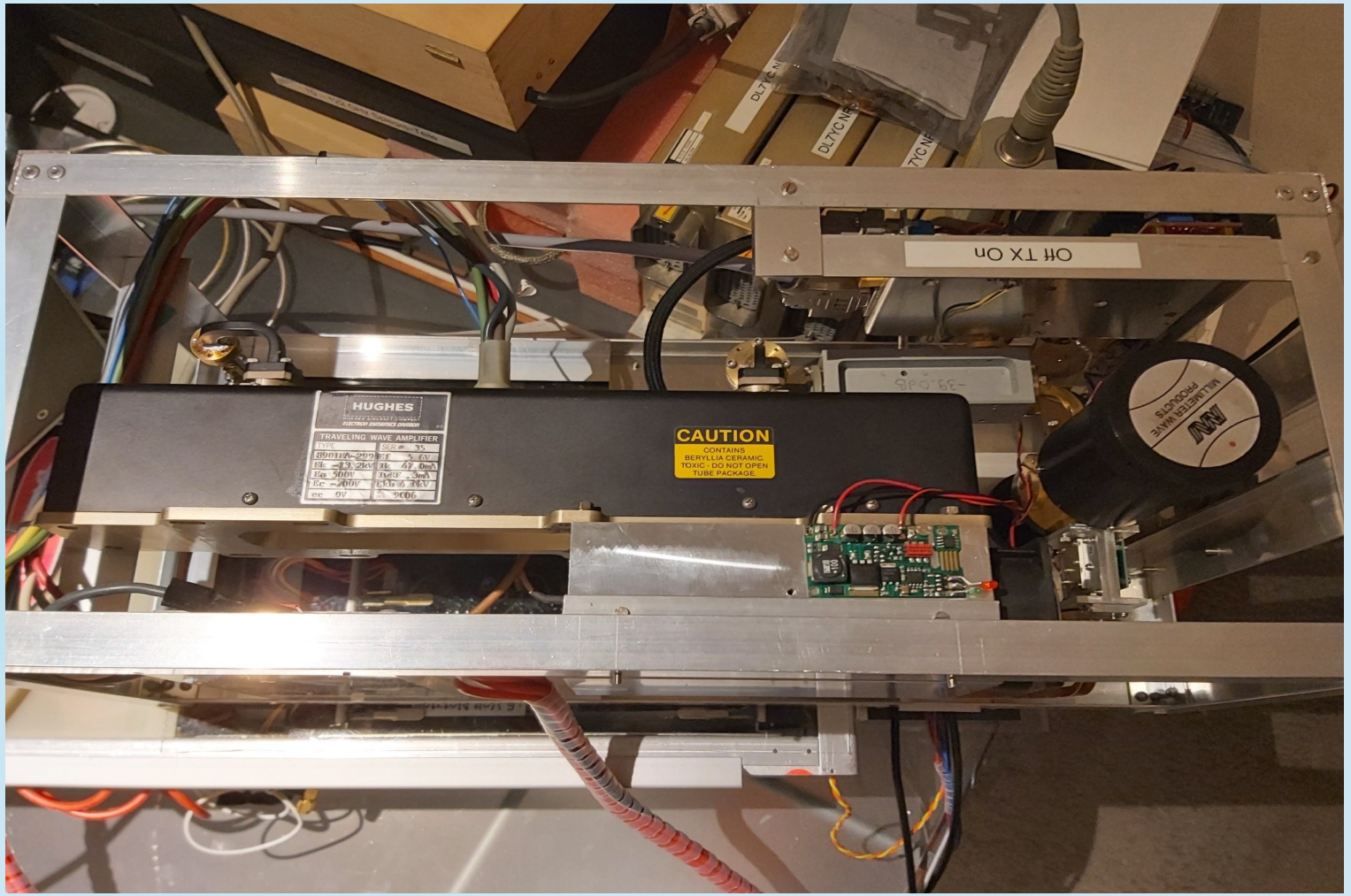


JA1WQF - 10W RF

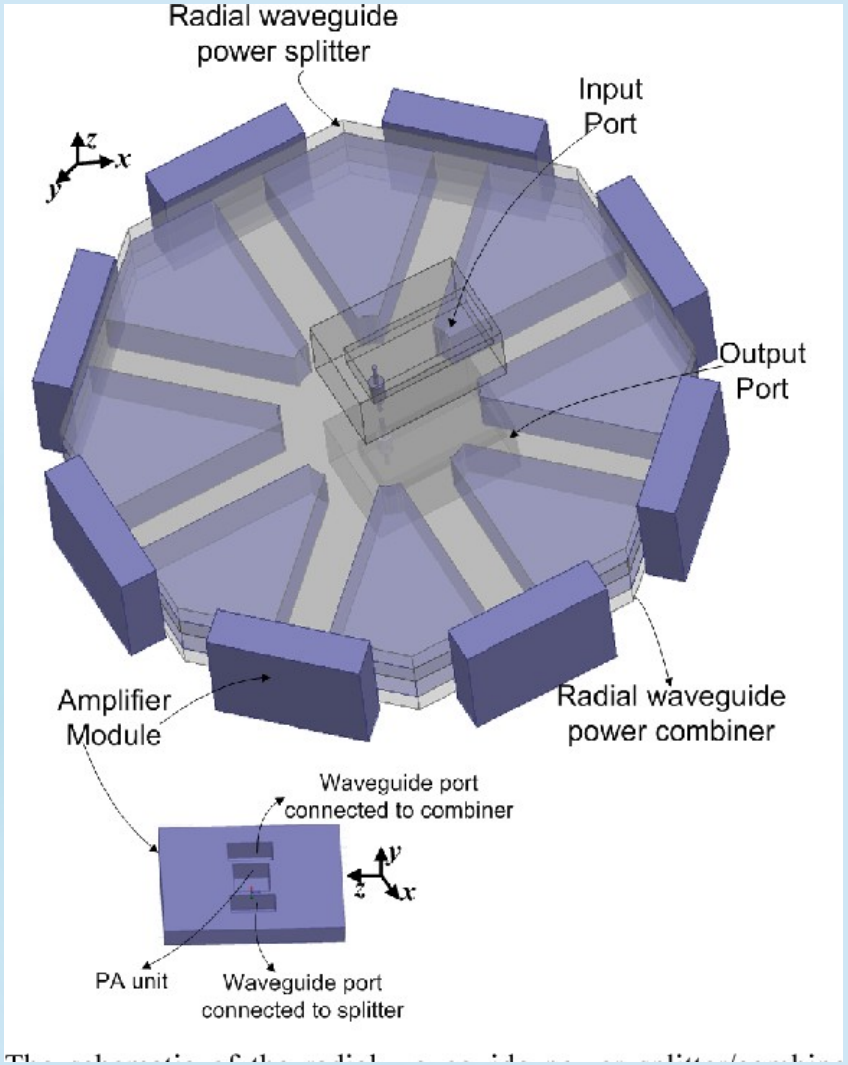
8xTGA4046

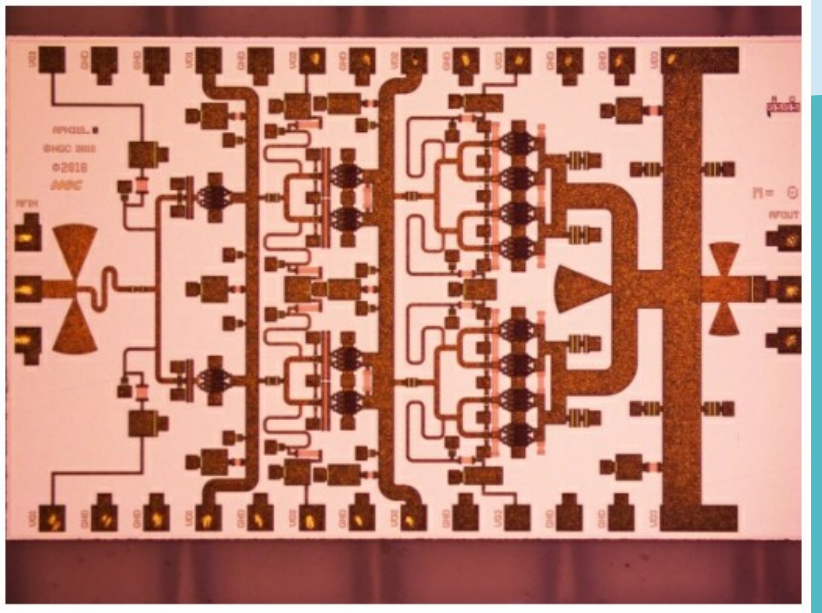
JA1WQF - 12W RF

47 GHz TWTA / 42 watts @ DL7YC



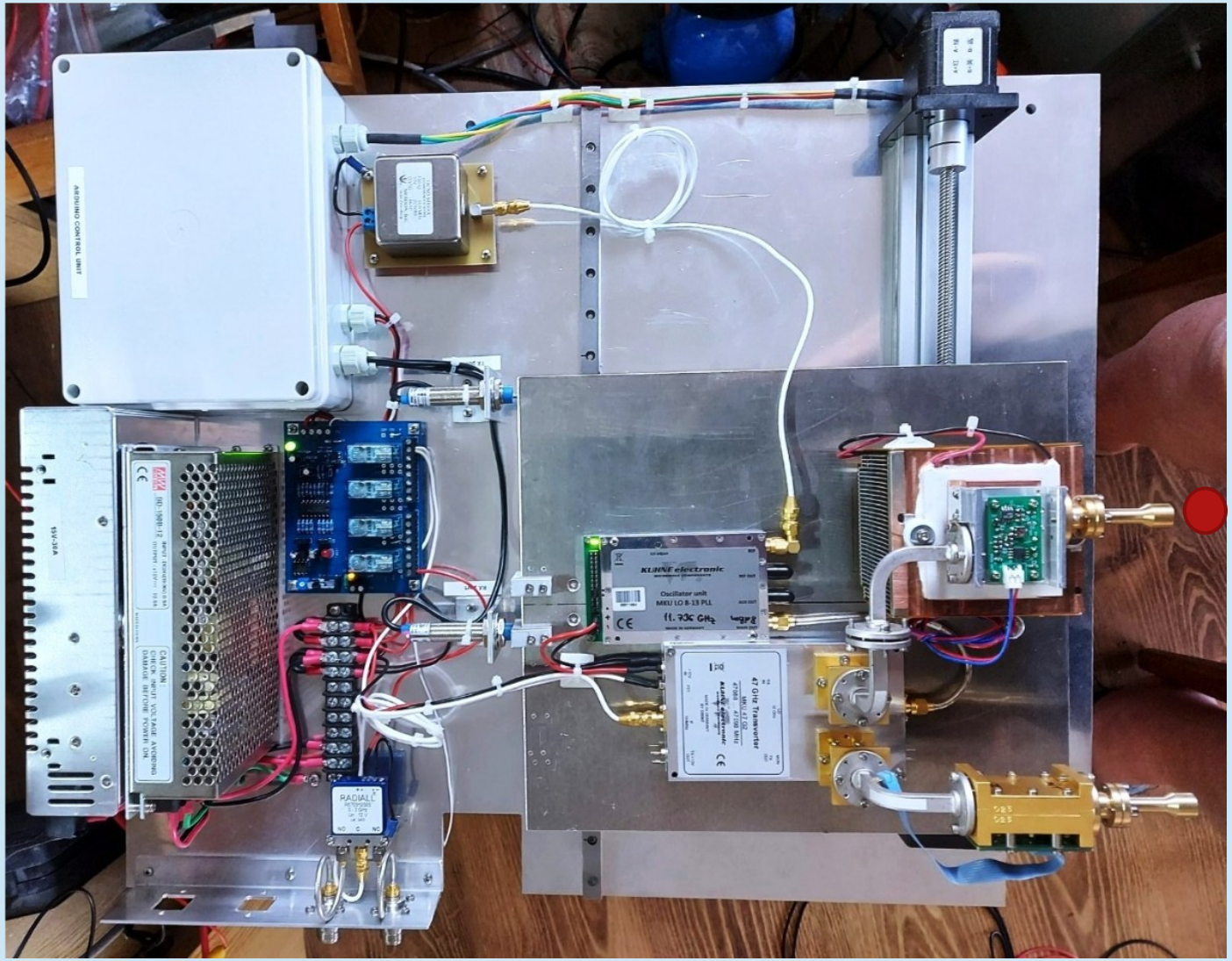
47 GHz - SSPA 32W 8 x APN318



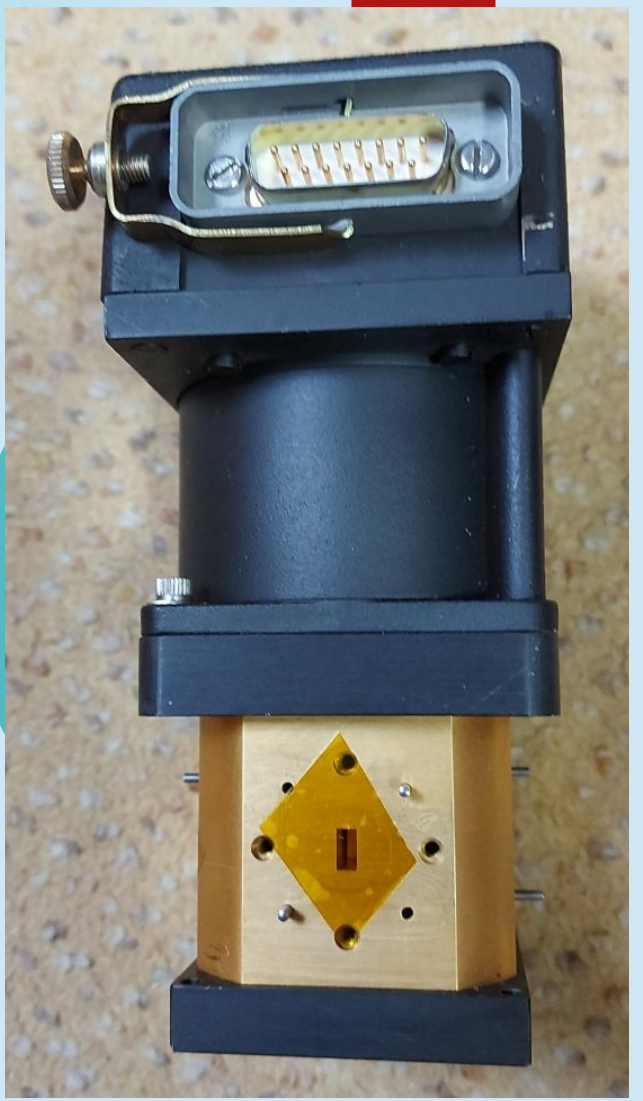


- **NORTHROP GRUMMAN APN318** $380 USD …..3.2 x 2.2 mm
- 47-51 GHz
- **> 4.6 W – CW !!!!**
- Pulsed up to 10 W ??
- 16dB gain
- 28V DC/1.62A

47 GHz RX/TX switch

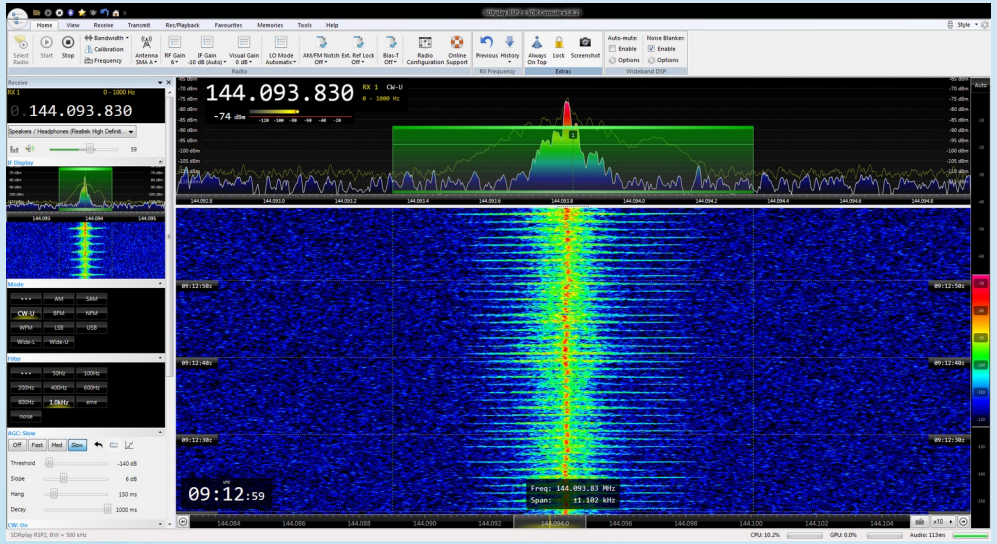


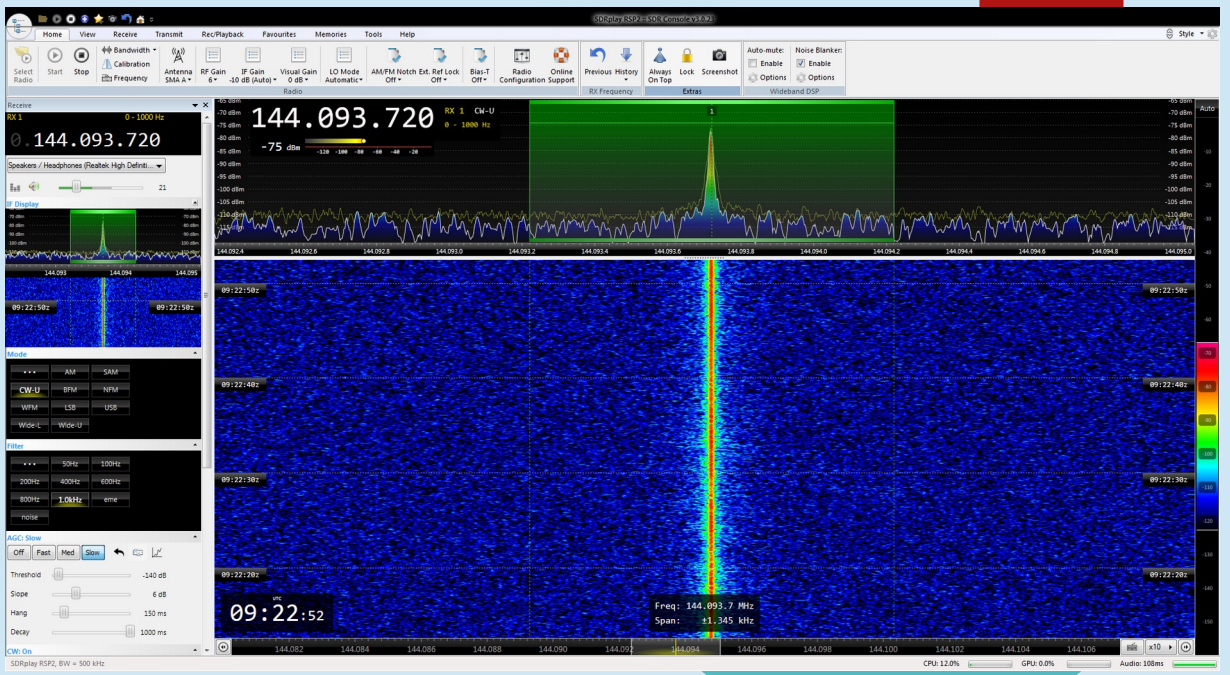
F point

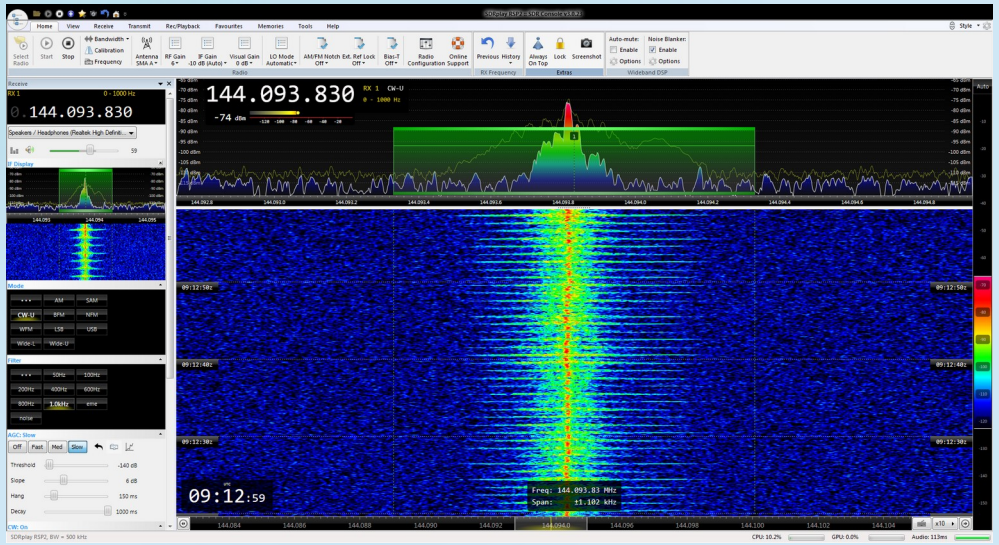


Profi Militech waveguide switch - < 0.2dB Att and price ??????? Expensive !!

47 GHz - LO stability





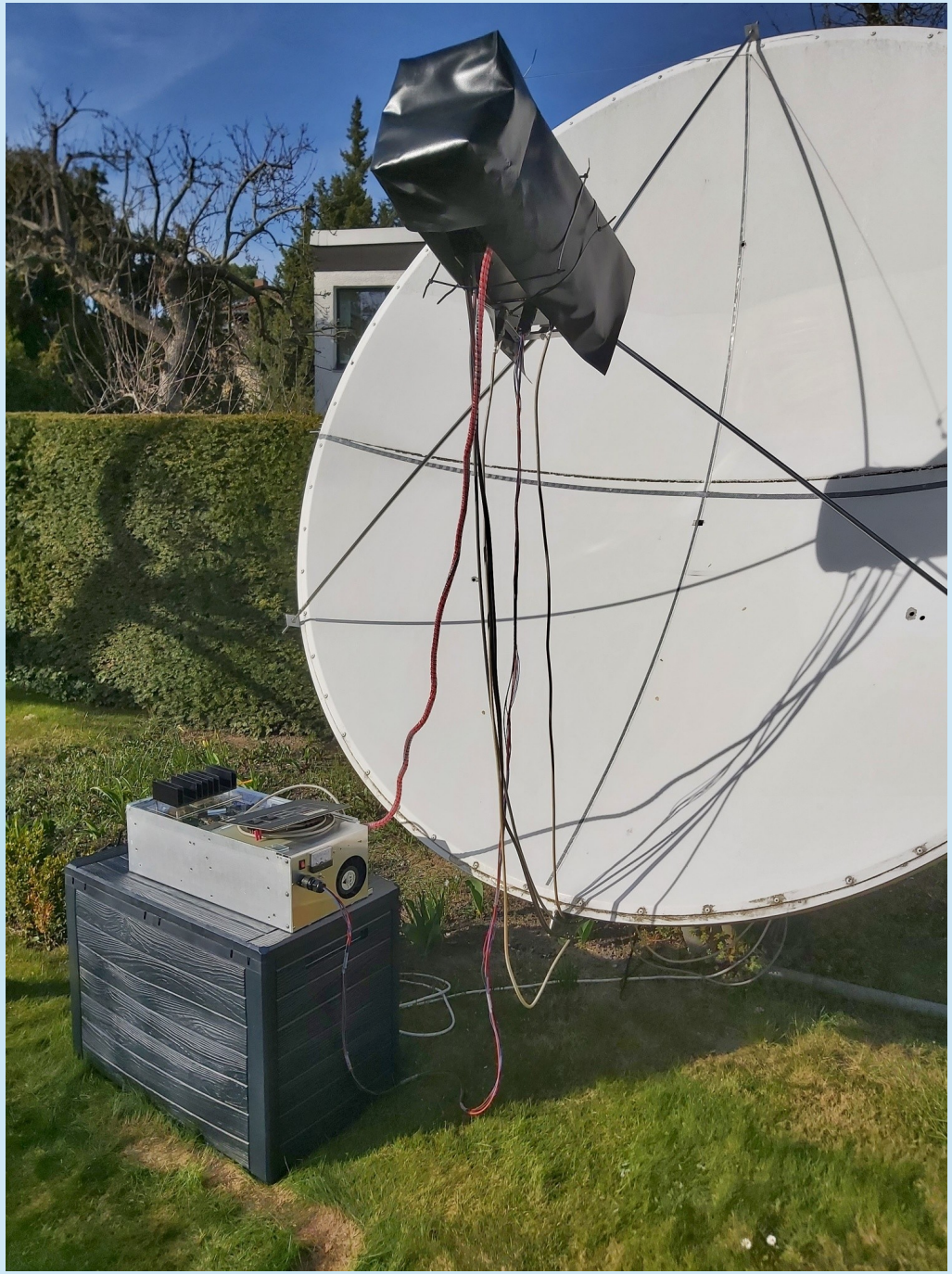


- GPS LO BG7TGL disciplined oscillator
- GPS disciplined oscillator LO Bodnar
- MORION - double stabilized TCXO oscillator

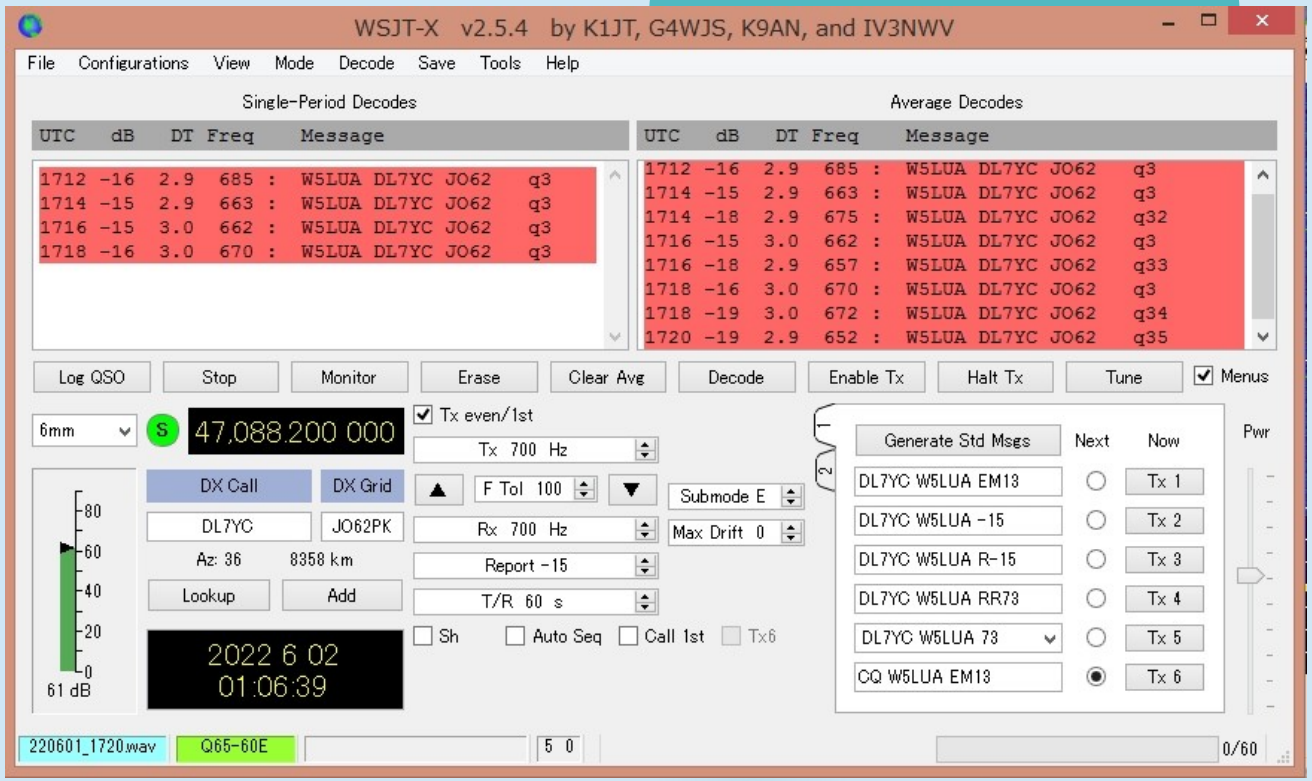
47 GHz stations today

Station	Antenna	Nf	Pwr	Sunnoise	Altitude /temp	Moonnoise	altitude/temp/humid	CS/G	date of measurement	with the WG switch	Moon temperature	Comments
AD6FP	1.8 mtr shift	1.5 dB cooled	140 ?	9.2 dB								QRV infuture
DC7KY	2.4 mtr shift	2.2 @17C	14	9.5 dB	15 ?	0.69 dB				yes		Copied W5LUA - QSO with DL/YC
DL7YC	2.4 mtr 0.4 PF	2.0 dB	42	11.5 dB	50 degrees	1.15 dB	60 degrees			yes		Copied W5LUA – QSO with DC7KY
EA3HMJ	1.2 mtr shift	2.6 dB	2	7.7 dB	43 degree	0.6 dB	64deg/11C/94%		6-10-2020	z	274 K	New LNA EB3FRN – copied DL7YC
JA1WQF	2.4 mtr cassegrain	1.65 dB	11	9.3 dB	>27 degrees	1 dB	>27 degrees	2.8 dB	12-11-2020	yes		New LNA JA8CMY - Copied W5LUA
LX1DB	3.0 mtr 0.3 pf	2.2dB Spacek	?	7.1 dB	19C 63%	0.45 dB		0.8 dB				
OK1DFC	2.4 mtr shift	2.4 dB	0,1	7.7 dB	25 degrees/14C	0.77 dB	25 degrees/8C/46%				253 K	New LNA
DL/PA0EHG	1.8 mtr 0.4 pf	2.5 dB	4	8.1 dB	22deg/13C	tbd		1.5 dB	28-10-2020	z	K	
RW3BP	2.4 mtr shift	8 dB DSB		4.9 dB		0.6 dB						Copied DL7YC MWCW
VE4MA	2 feet shift	4 dB	?	5.5 dB		0.3 dB						
W5LUA	2.4 mtr shift	2.85	30	8.2	45 degrees/28C	0.72 dB	60 degrees/28C/75%				228 K	new LNA JA8CMY

47 GHz station - Feedbox @ DL7YC



DL7YC tx ed to W5LUA – decoded by DC7KY



JA1WQF received and decoded W5LUA.

WSJT-X v2.1.2 by K1JT

File Configurations View Mode Decode Save Tools Help

Single-Period Decodes

UTC	dB	DT	Freq	Message
1143	-23	2.2	1059	:
1144	-22	2.7	1089	:*
1145	-22	4.4	900	:*
1146	-23	2.7	994	:* JA1WQF W5LUA EM13
1147	-23	2.6	1040	:
1148	-23	0.7	927	:
1149	-24	-0.3	1081	:

Average Decodes

UTC	dB	DT	Freq	Message
1146	-23	2.7	994	:* JA1WQF W5LUA EM13

Log QSO | Stop | Monitor | Erase | Decode | Enable Tx | Halt Tx | Tune | Menus

6mm | 47,088.150 629 | Tx even/1st | Tx 1000 Hz | Hold Tx Freq | F Tol 100 | Rx 1000 Hz | Report -15 | Submode D | Sync 1 | Sh | Tx6

DX Call: W5LUA | DX Grid: EM13QC | Az: 44 | 10365 km | Lookup | Add

2020 2 10
11:49:57

40 dB

Generate Std Msgs | Next | Now | Pwr

W5LUA JA1WQF QM05		Tx 1
W5LUA JA1WQF -15		Tx 2
W5LUA JA1WQF R-15		Tx 3
W5LUA JA1WQF RR73		Tx 4
W5LUA JA1WQF 73		Tx 5
CQ JA1WQF QM05	●	Tx 6

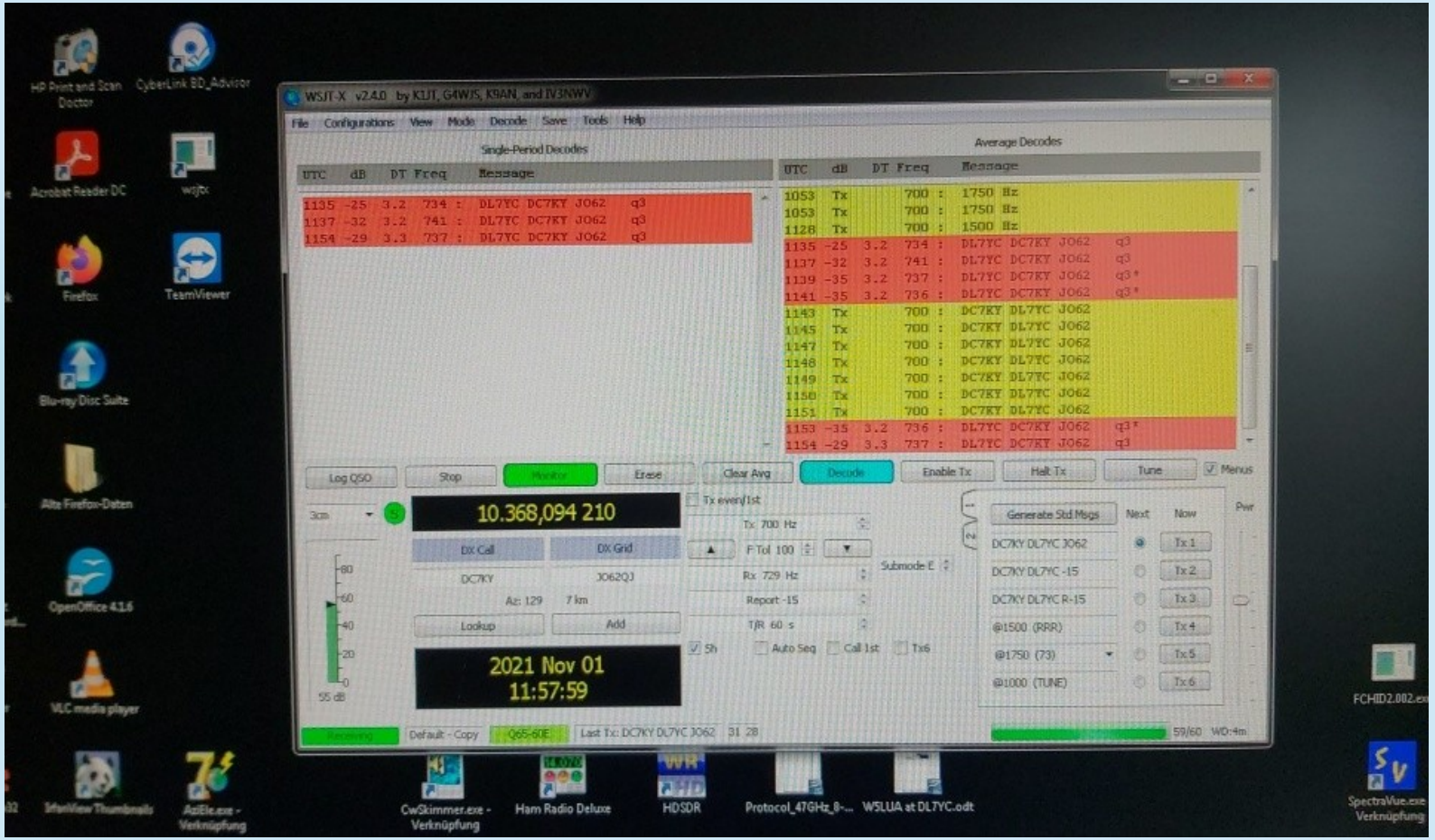
Receiving | QRA64 D | 57/60

WSJT-X settings to be successful fast

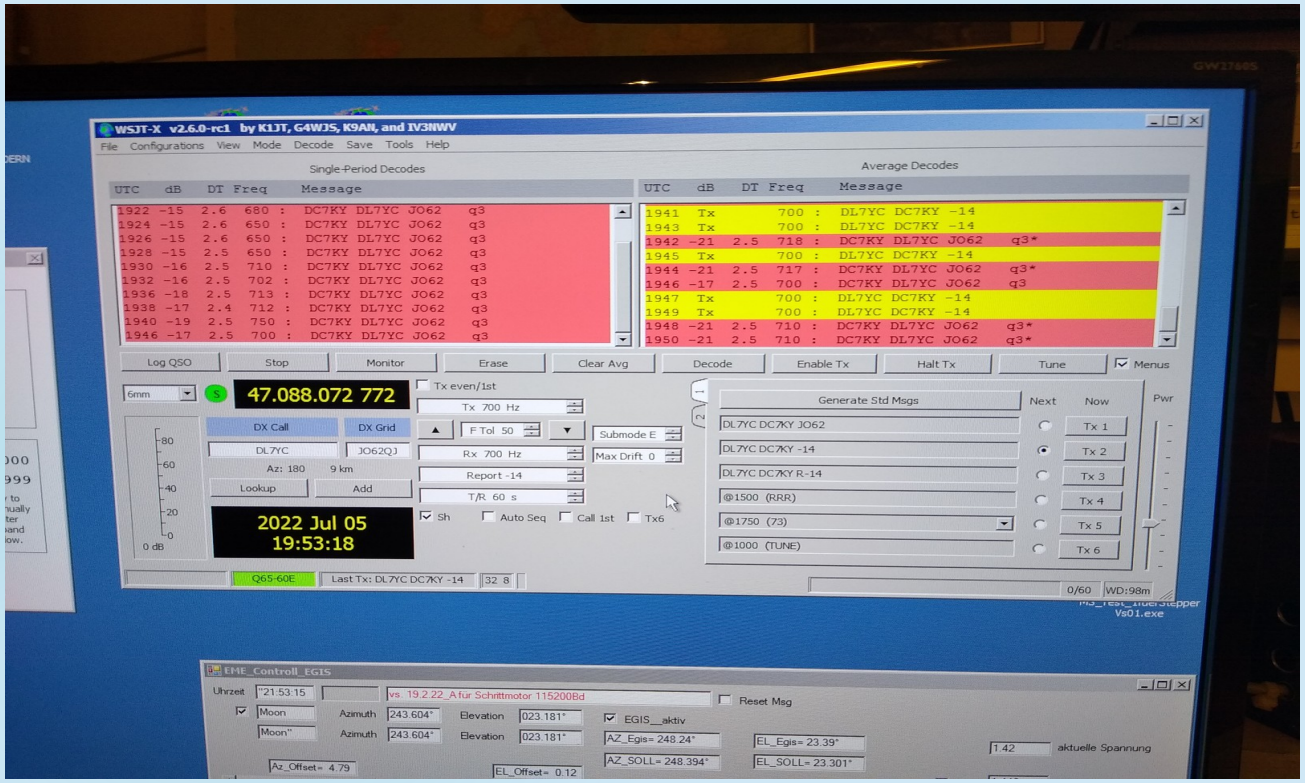
* Q65-60E ... CFOM … 700Hz Tx
* Ftol 20Hz / 50Hz
* Drift 0 Hz
* Deep search
* Enable Averaging / Auto Clear after Decode

* „Jump“ with mouse pointer from the 700Hz Rx setting
    Up and/or Down +/-50Hz /100Hz in the widescreen waterfall to find the sync tone for a decode

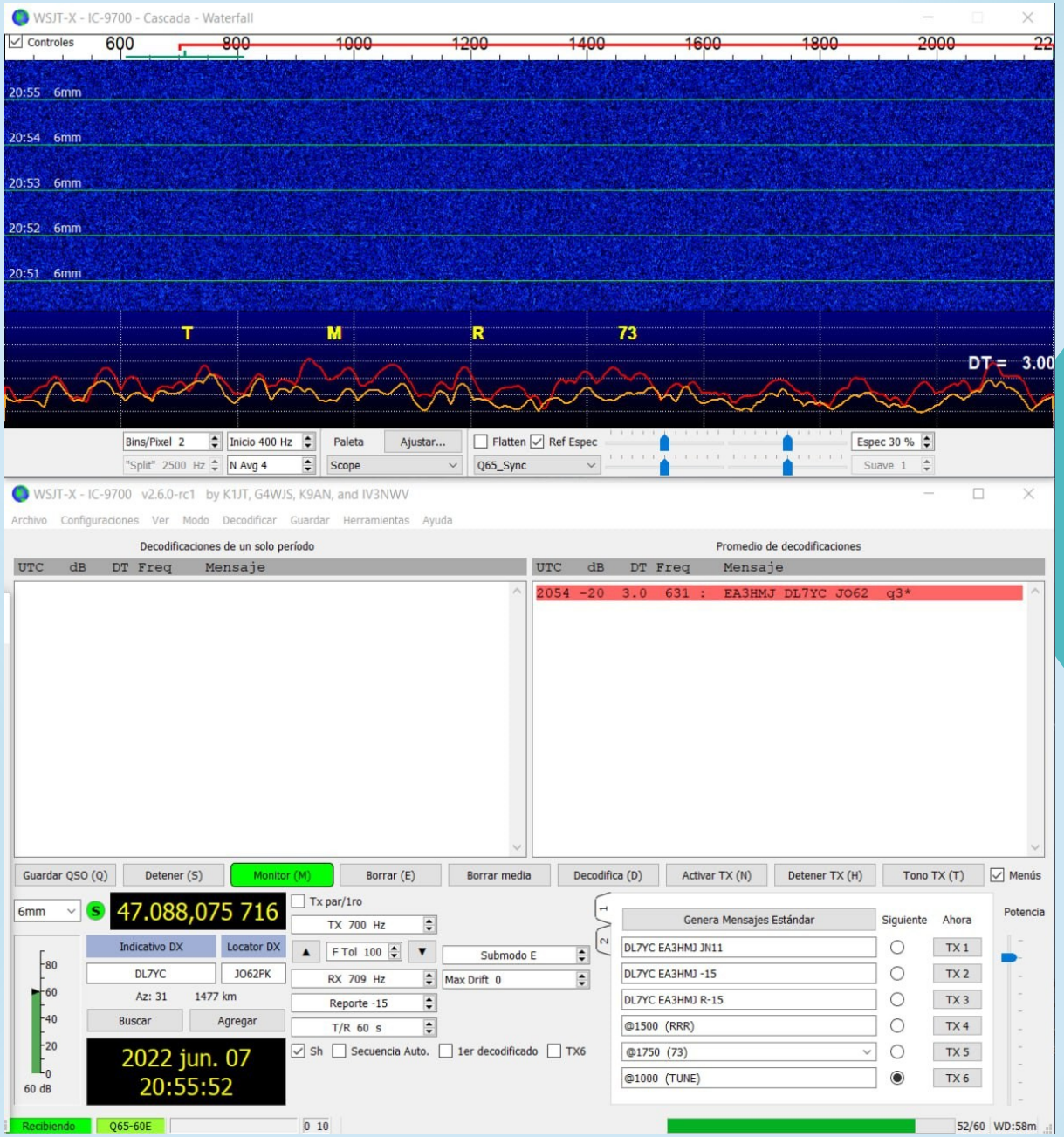
DL7YC decoded successful live EME @ 14 watt RF from DC7KY´s 2.4m dish



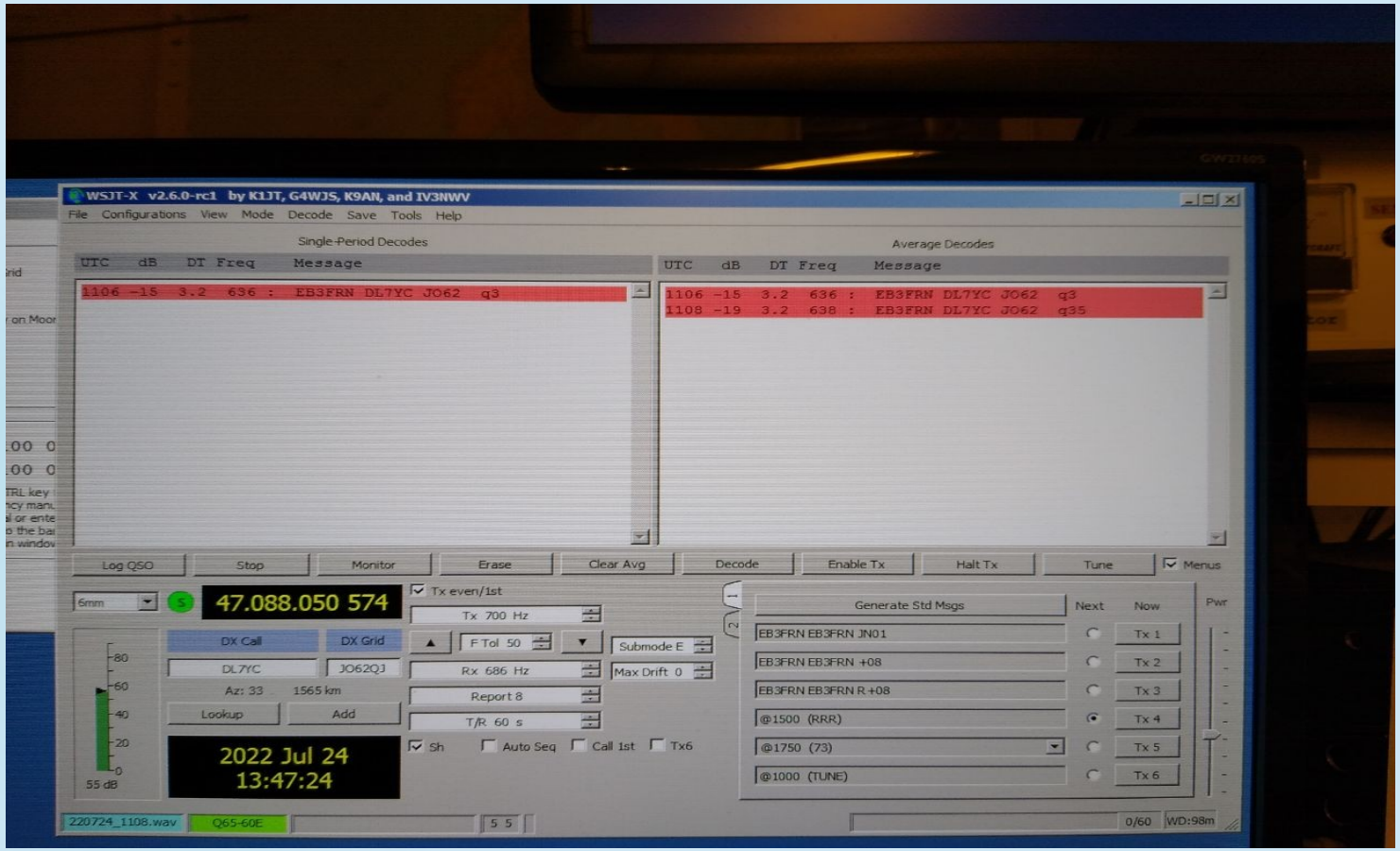
DC7KY received and decoded DL7YC.



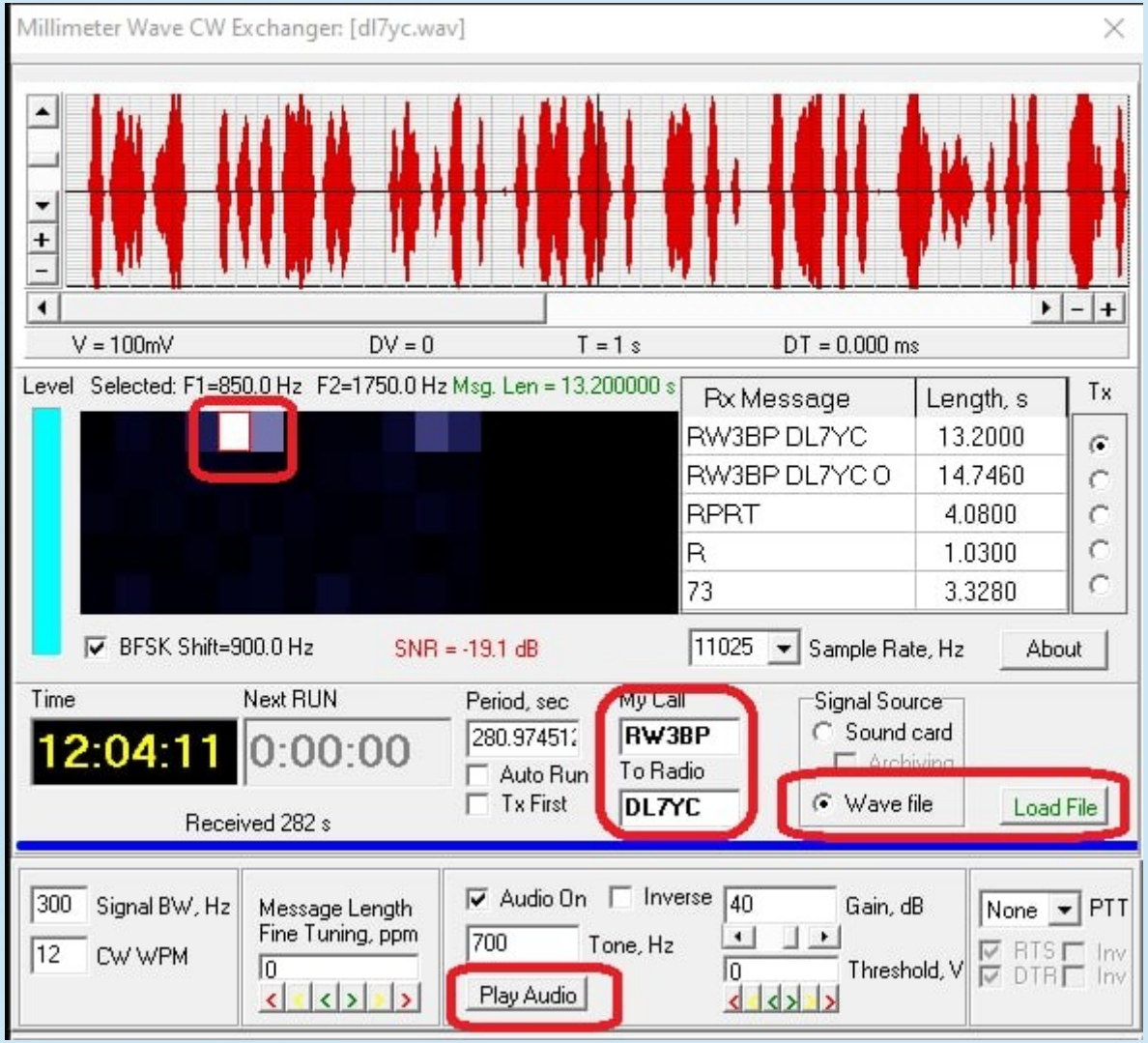
EA3HMJ received with a 120cm dish and decoded DL7YC.



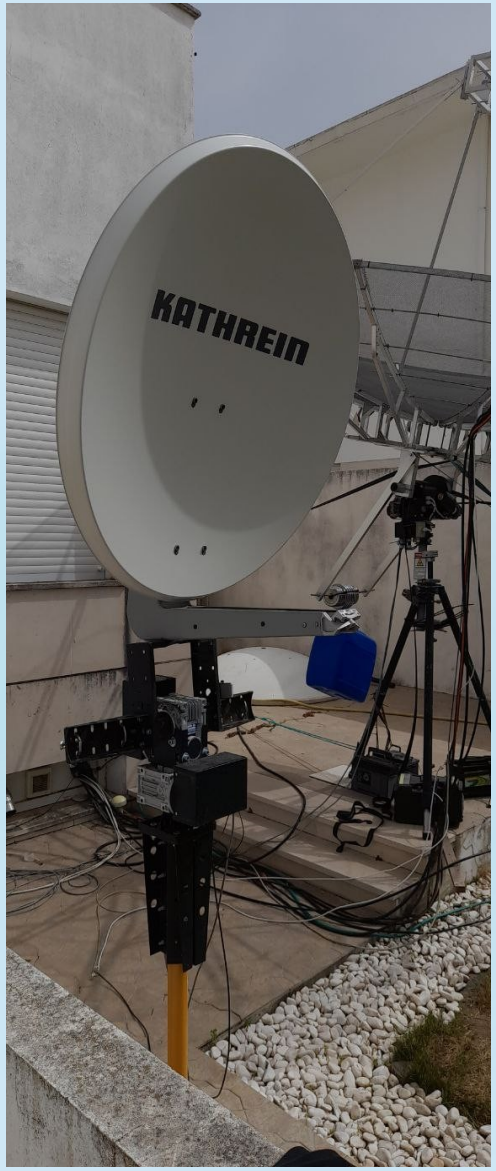
EB3FRN received with a 150cm dish and decoded DL7YC.

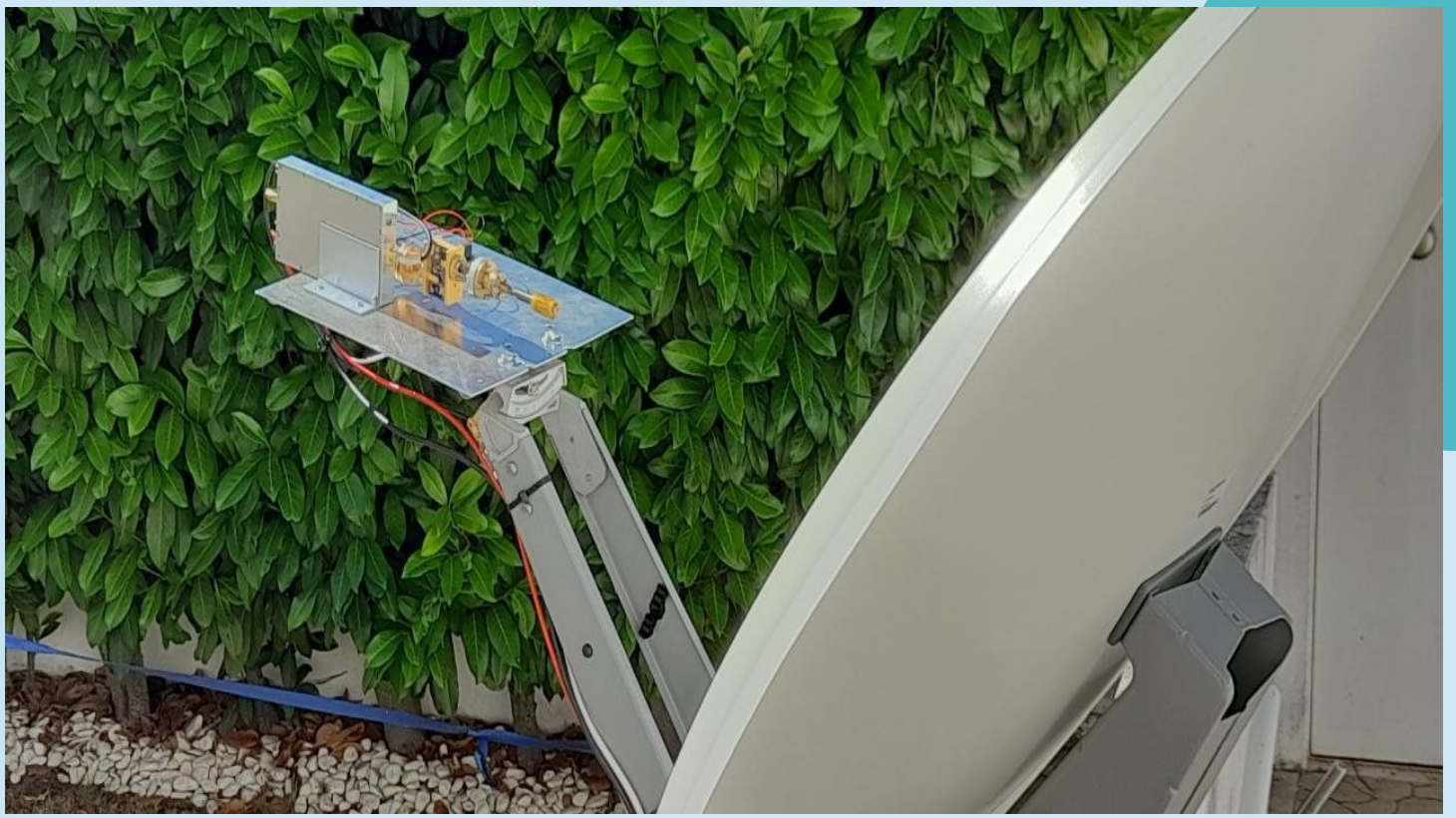


DL7YC received by RW3BP in MWCW (12WPM)

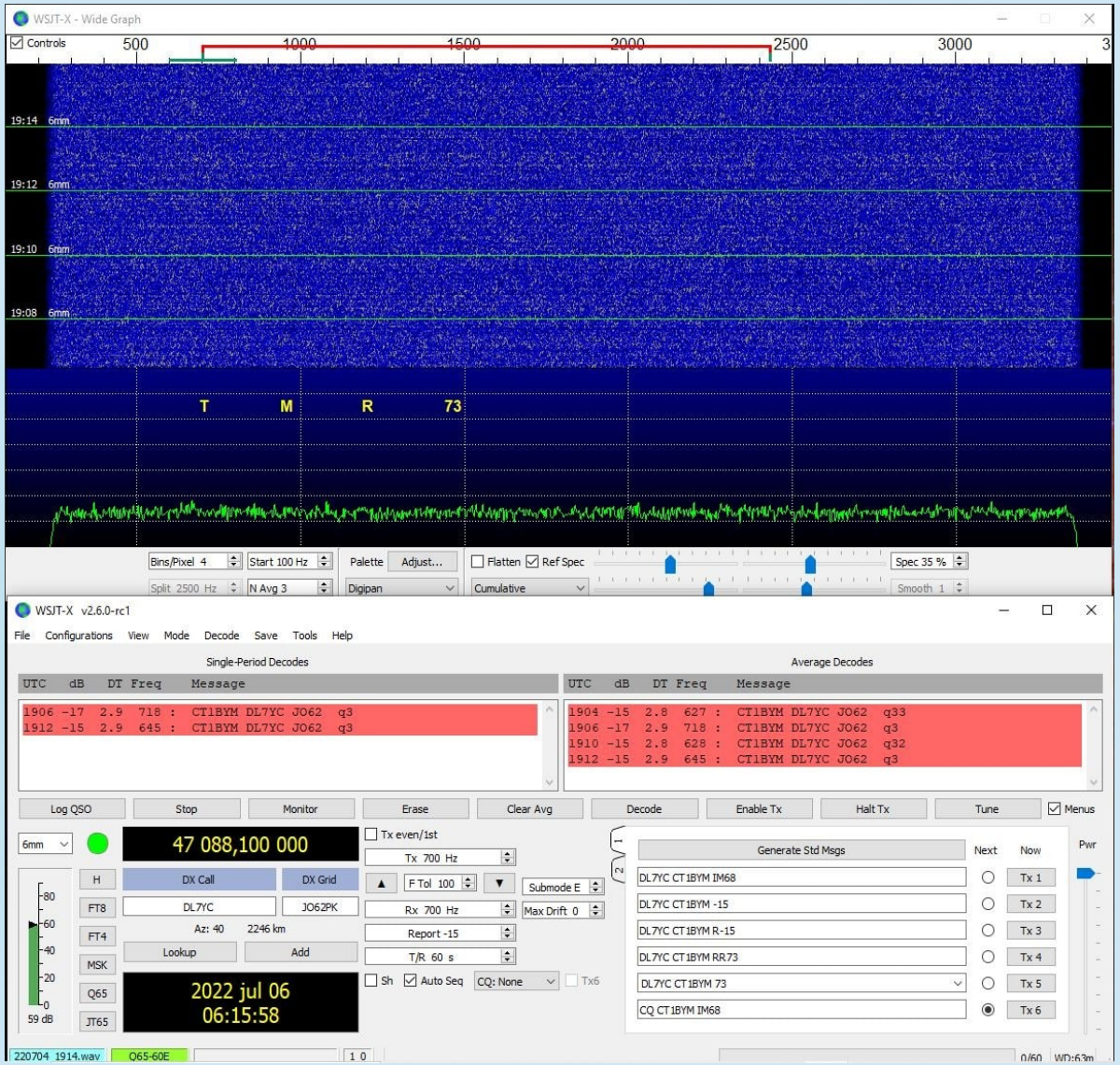


CT1BYM - 47GHz using 90cm !! dish

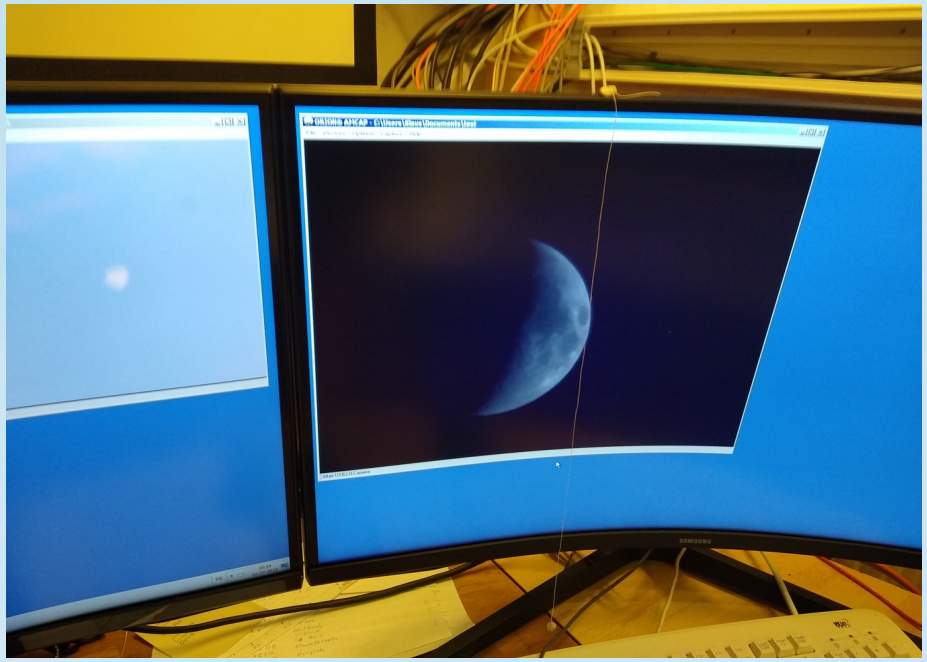




CT1BYM received 47GHz using his 90cm dish



Thank you for your attention



Questions????