

76 GHz EME – The Next Frontier

First Ever two-way 76 GHz EME QSO by Amateur Radio

Sergei Zhutyaev RW3BP

Manfred Ploetz DL7YC

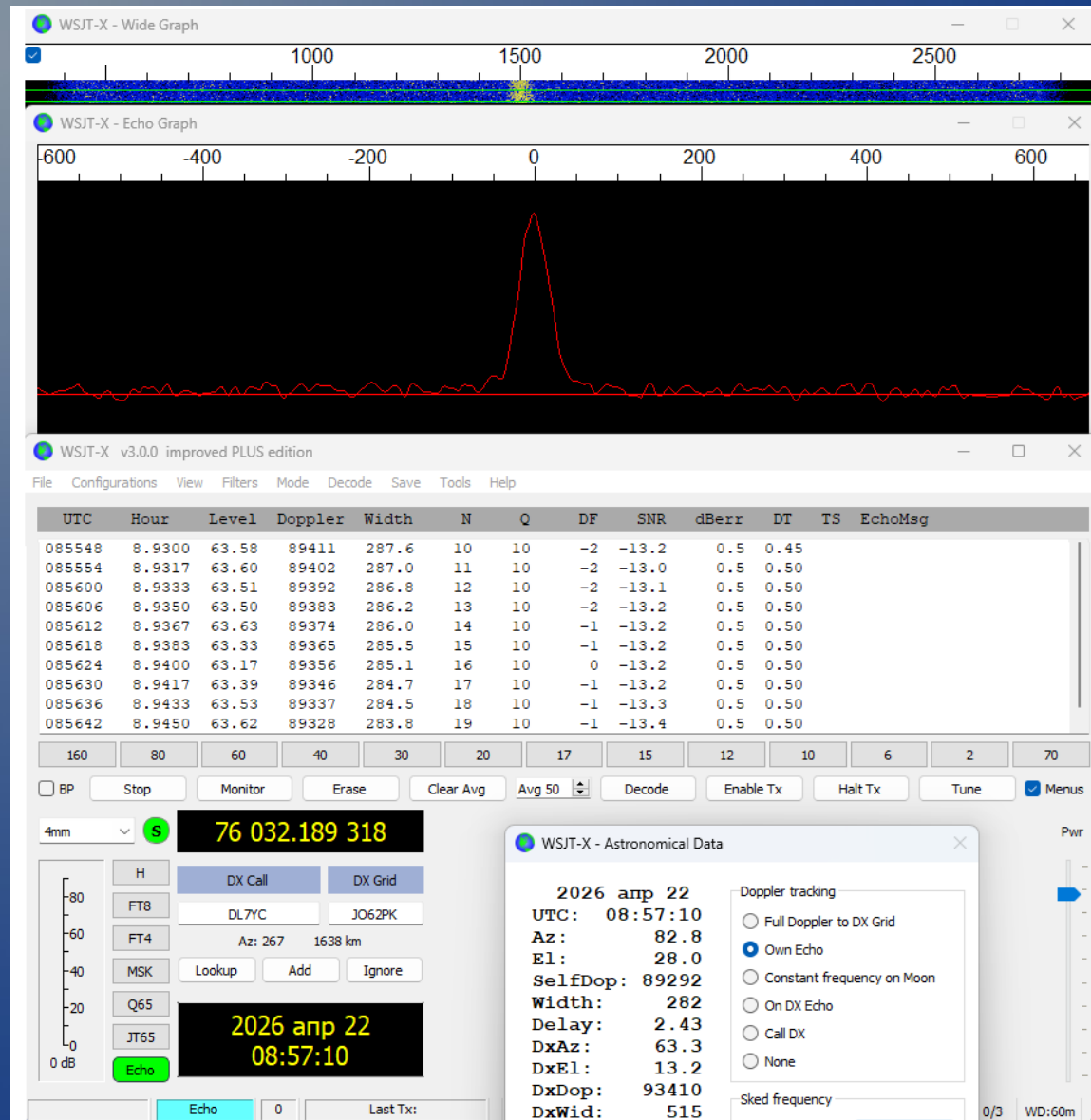
Introduction

- EME radio amateur communication becomes increasingly complicated the higher the QRG
- Above 40 GHz there is still much unknown territory to explore
- Tracking precision, Atmospheric losses, Spectral broadening due to Libration become more and more important

Medium Term Goals

- Improvement of the Noise-Figure (now 2.2-2.5dB)
- Better understanding of the weather influence
- Comparison and study of the predicted Libration versus the actual Libration using a 2.4m reflector which narrows the beam more

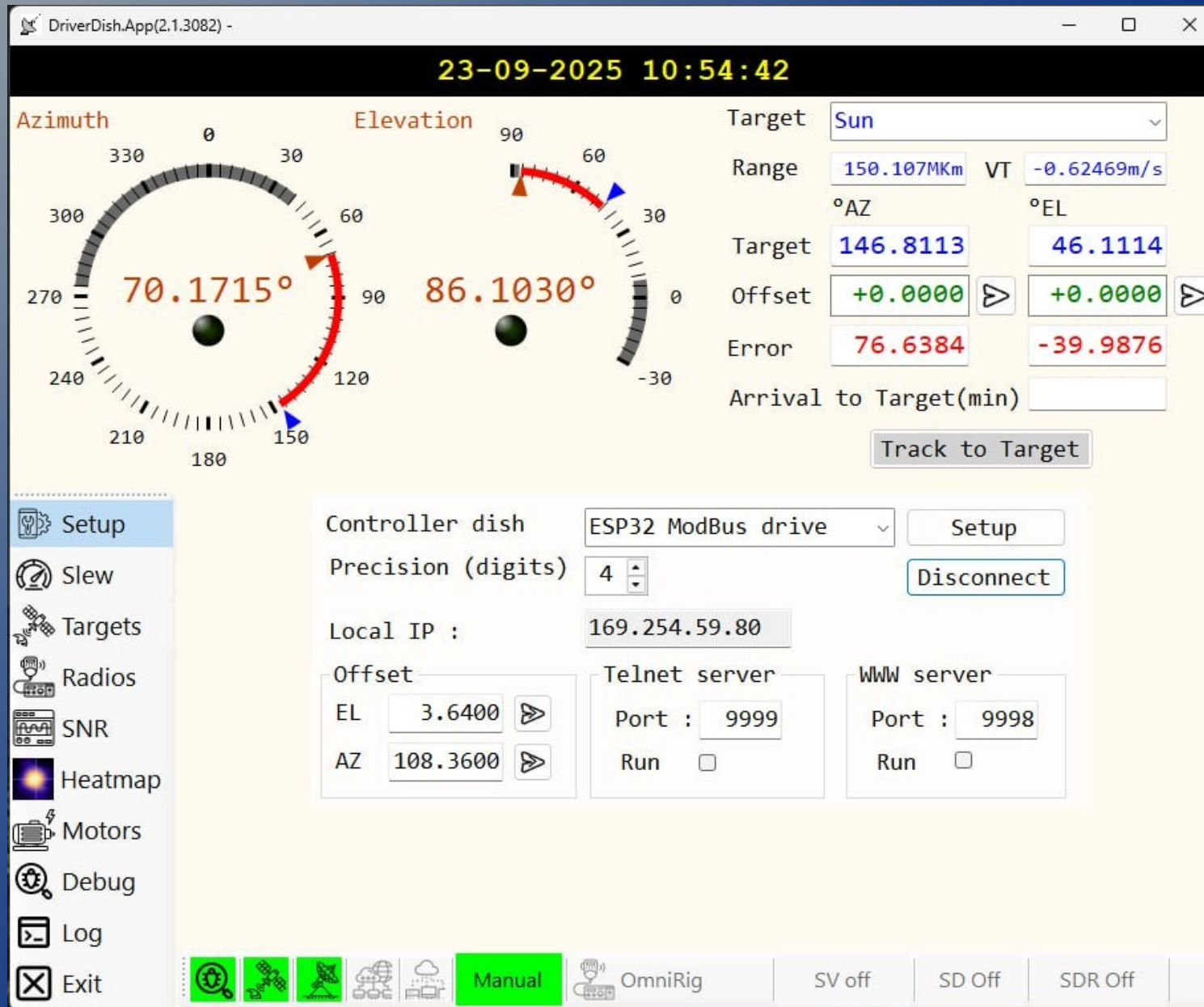
Echo Tests with 8.1W at RW3BP



How About the Current Situation?

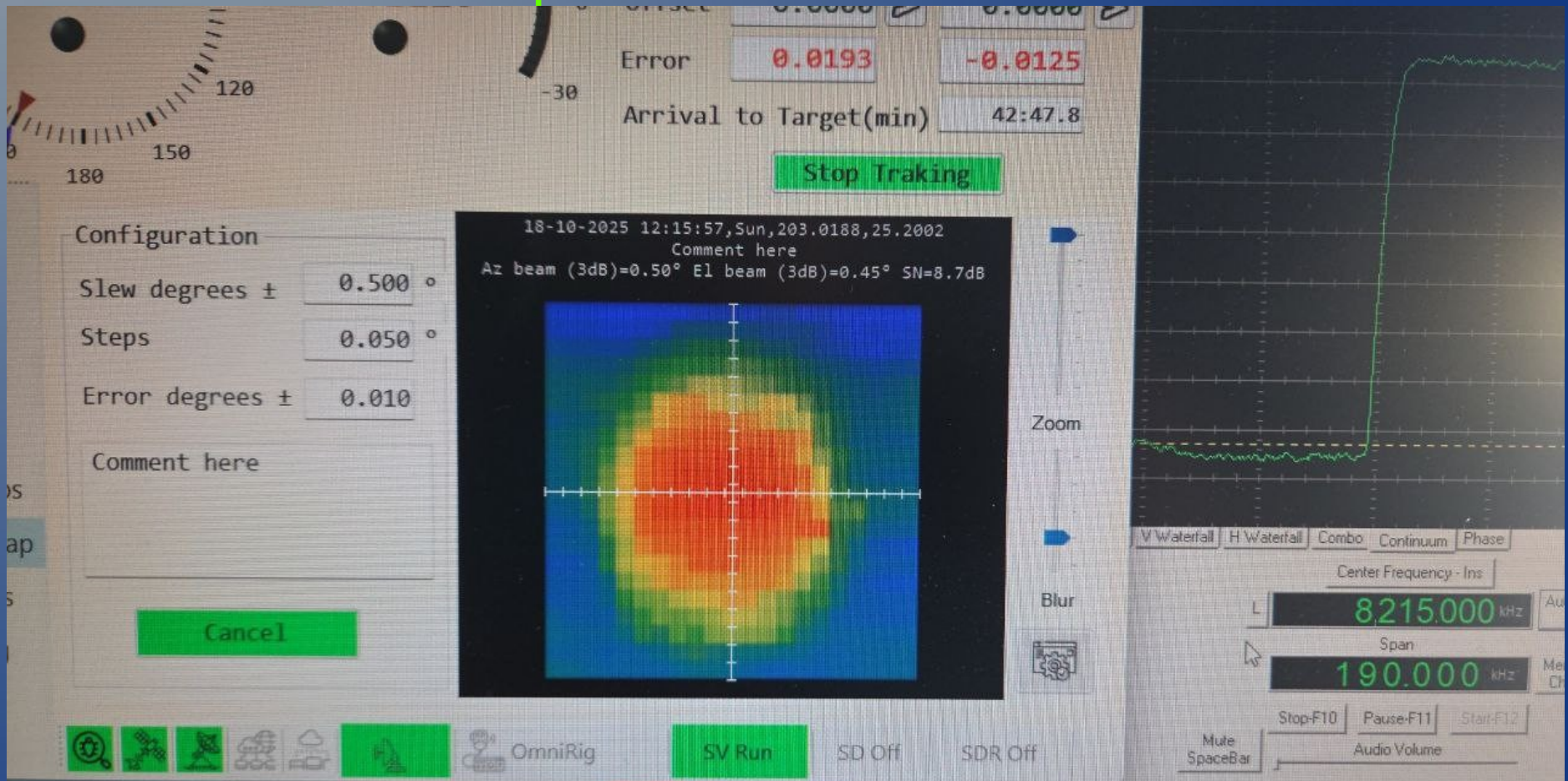
- The influence of the system noise figure is assumed to be known
- Likewise, the adherence to frequency accuracy through GPS locking is assumed to be understood
- The TRACKING ACCURACY is largely under control (± 0.005 deg) thanks to use of dual-drive precision gearboxes, 18-bit angle encoders, and EA3HMJ hardware & software

DriverDish App developed by EA3HML



Heatmap Feature Verifying Tracking

The noise in SpectraVue is measured from IF



Situation at **RW3BP** - K085vs

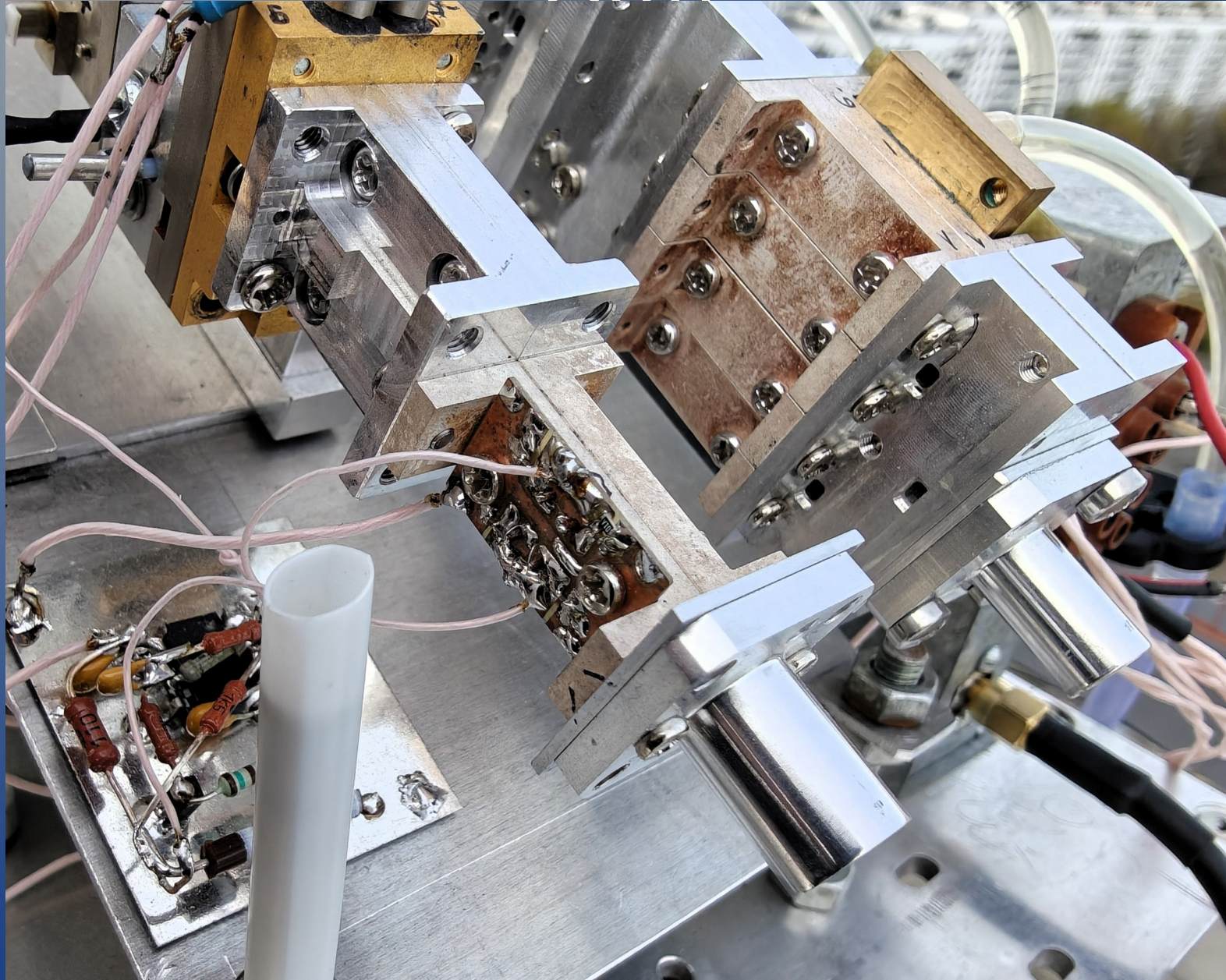


Gregorian 2.4m Offset Dish System

CNC milled sub-reflector. It's profile corrects antenna RMS parameter. Gain improvement of about 2 dB



Closeup of the RW3BP Outdoor Unit

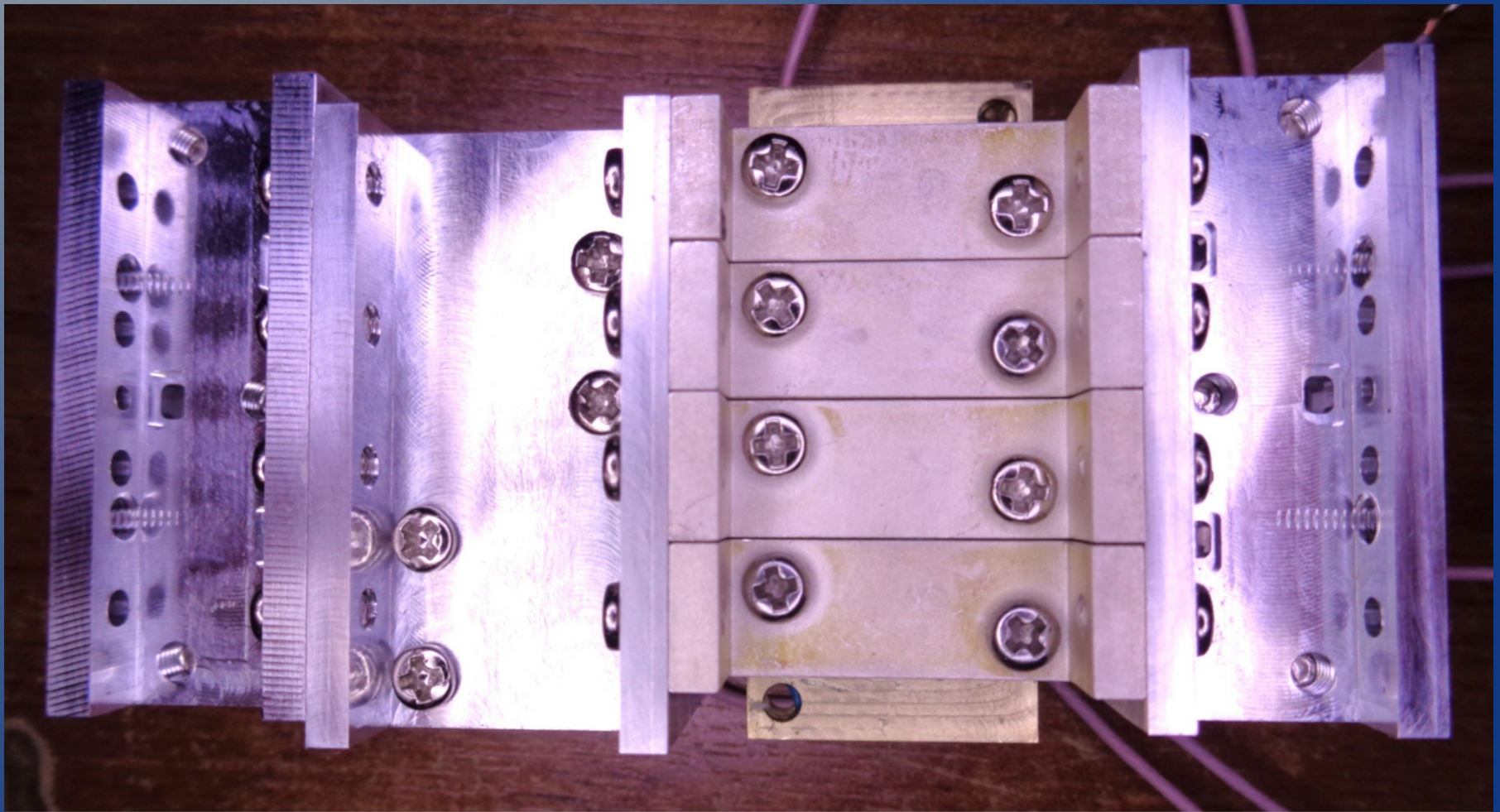


RX / TX exchange at RW3BP

- Insert the RW3BP feed moving video here
- File type not supported?

RW3BP 8.1W homebuild 76 GHz SSPA

- 4 x 2.2 W Amplifiers



DIVIDER

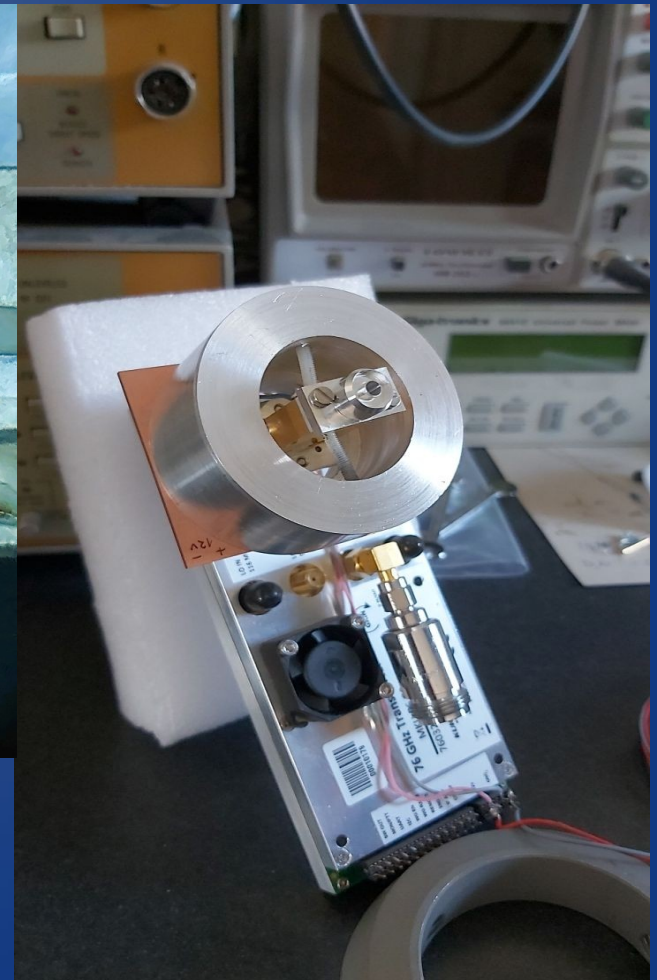
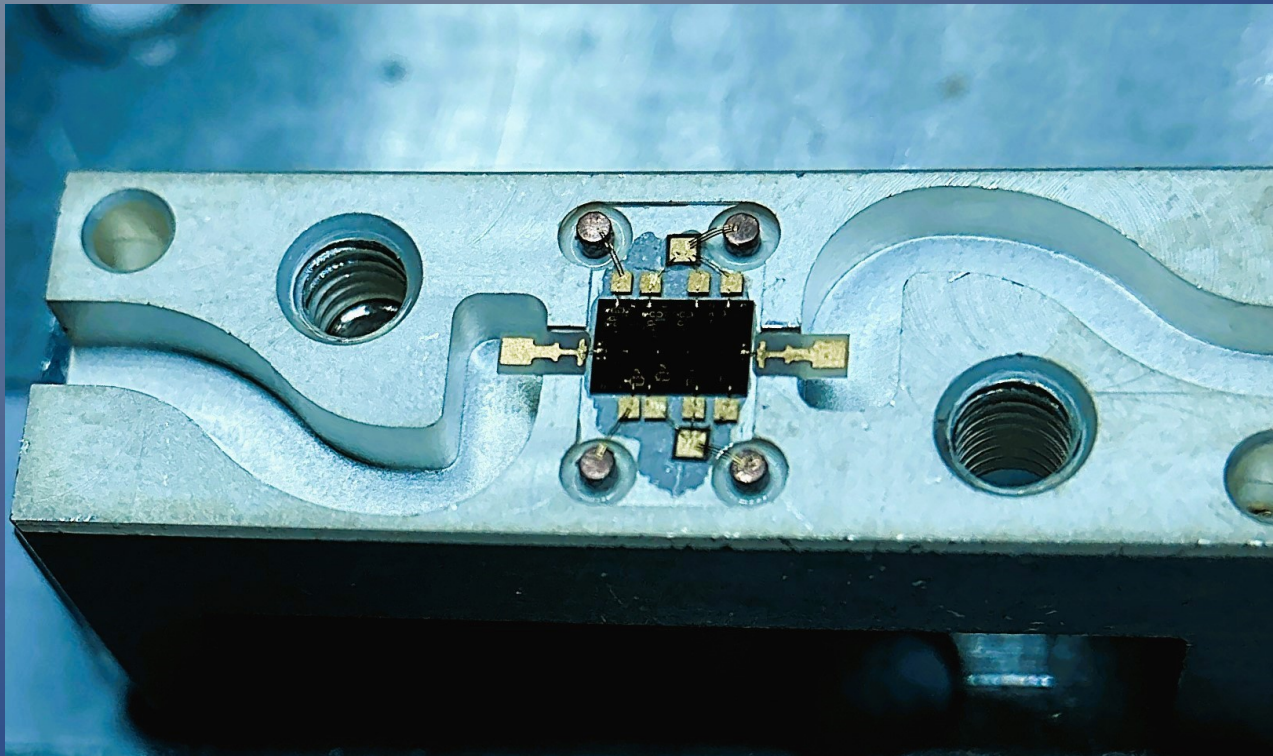
PHASE SHIFTER

4 x 2.2W AMPS

COMBINER

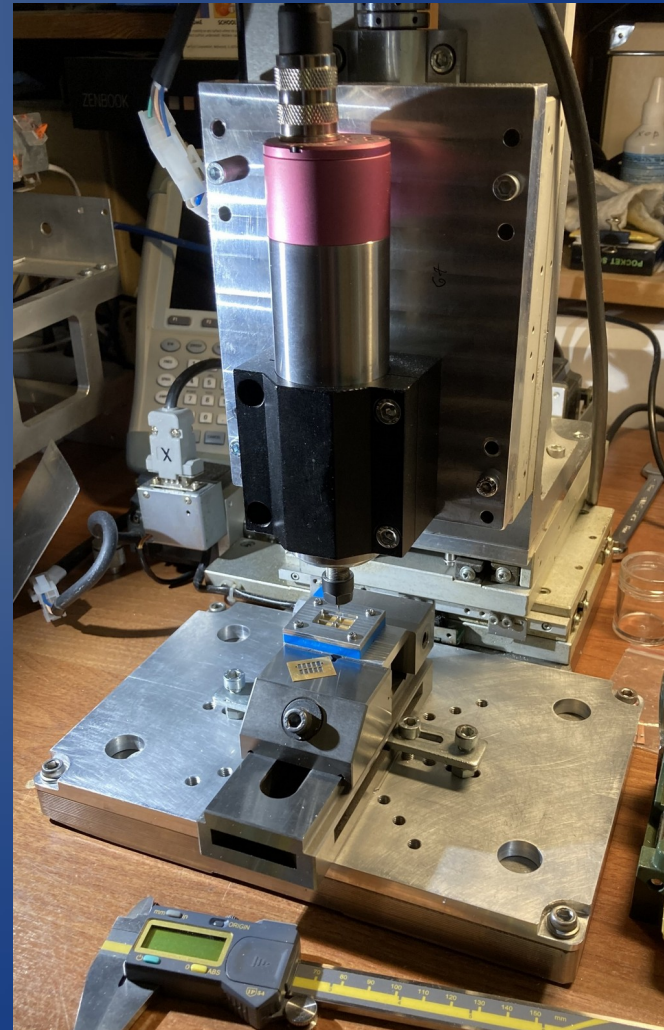
Uncooled LNA's - $NF < 2.5$ dB

- RW3BP 2.2 dB low noise 76GHz preamps
with CGY 2190UH/C2

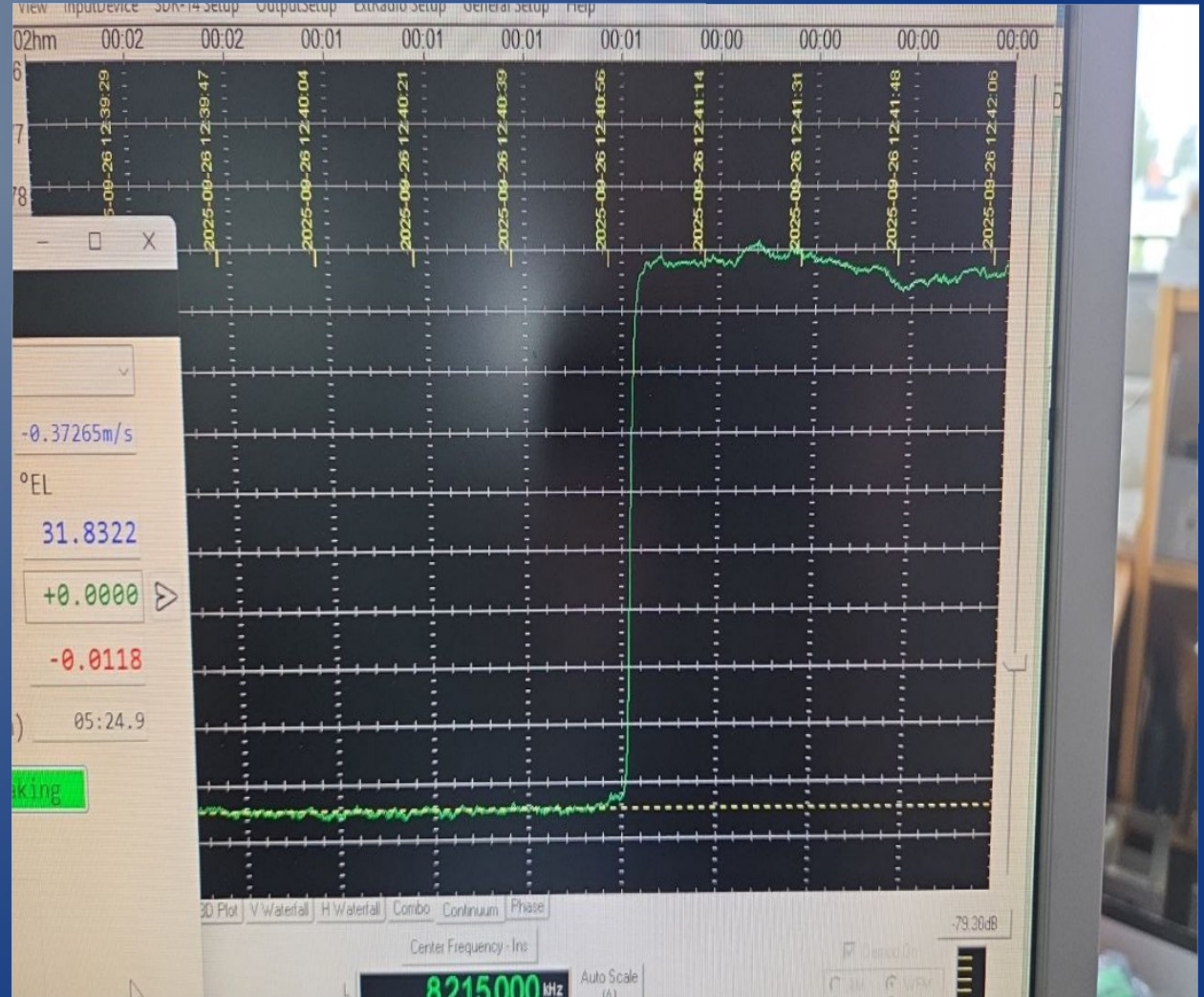


RW3BP In the Home Workshop

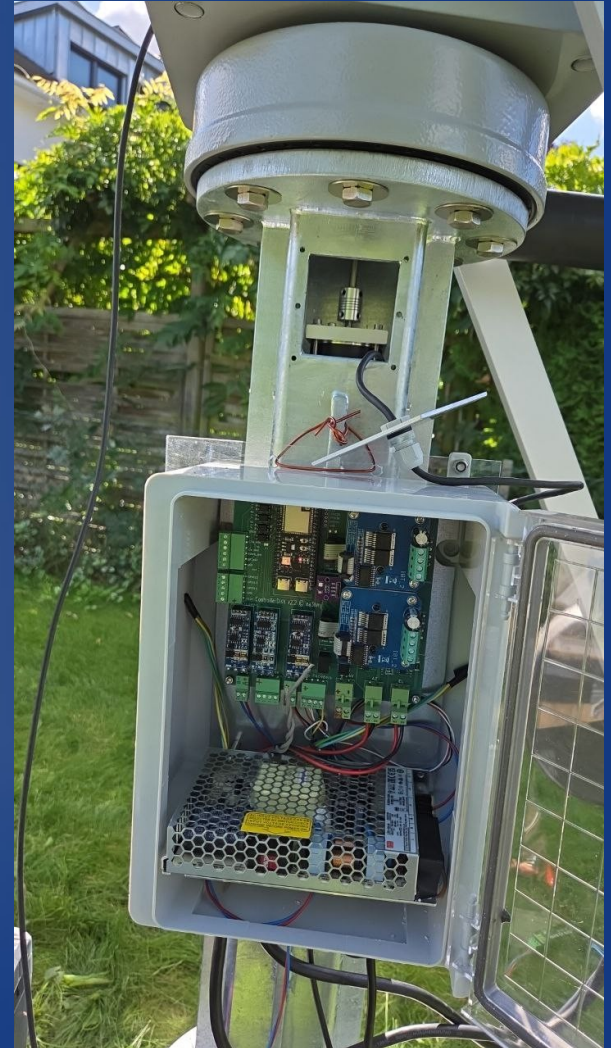
Wire bonding Microstrip milling



IF: 8.1MHz - Linearity controlled with R&S Video Noise Meter



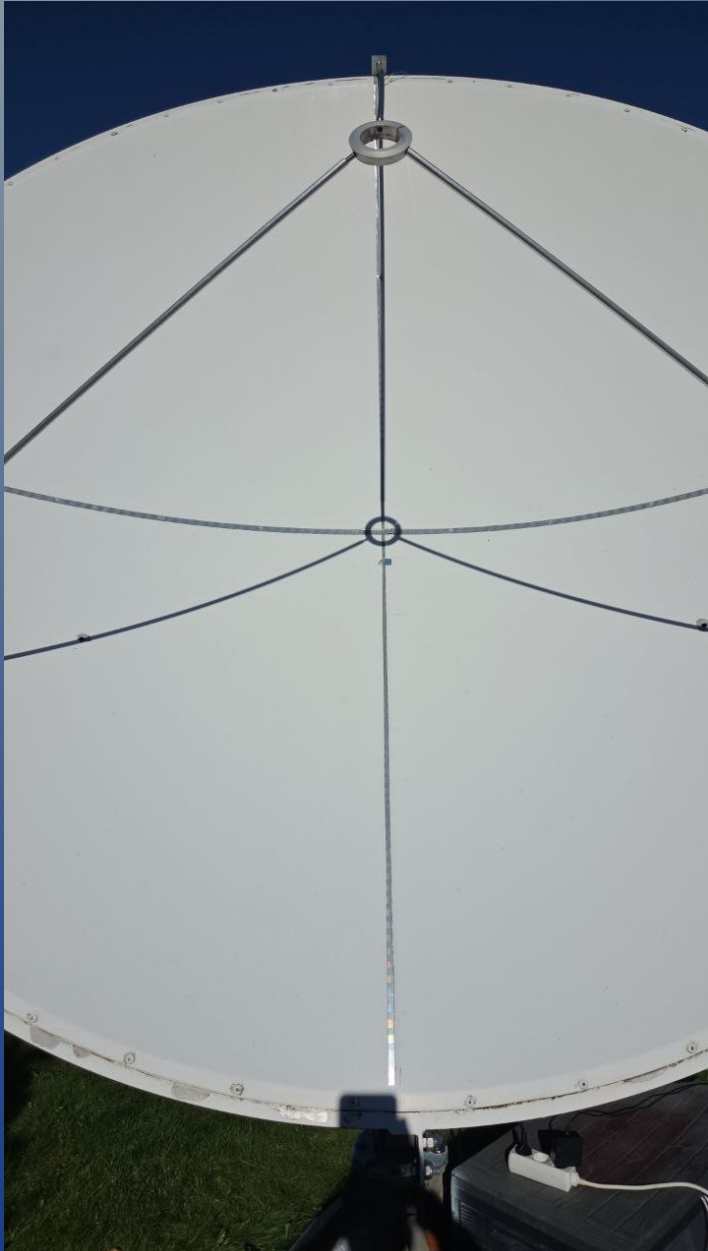
DL7YC Dual Slewing Drive with 18-Bit Encoders



Development So Far

- With this prior knowledge, extensive reception tests were undertaken in October 2025 between **RW3BP** (TX 8.1 Watts) and **DL7YC**
- The choice of test days and times was important (10.10.2025)
- The influence of the weather is far less critical than assumed (as was already the case with 47 GHz too)
- The required TX power was unknown and could now be verified for the first time !!

Reflector Adjustment Using the Sun

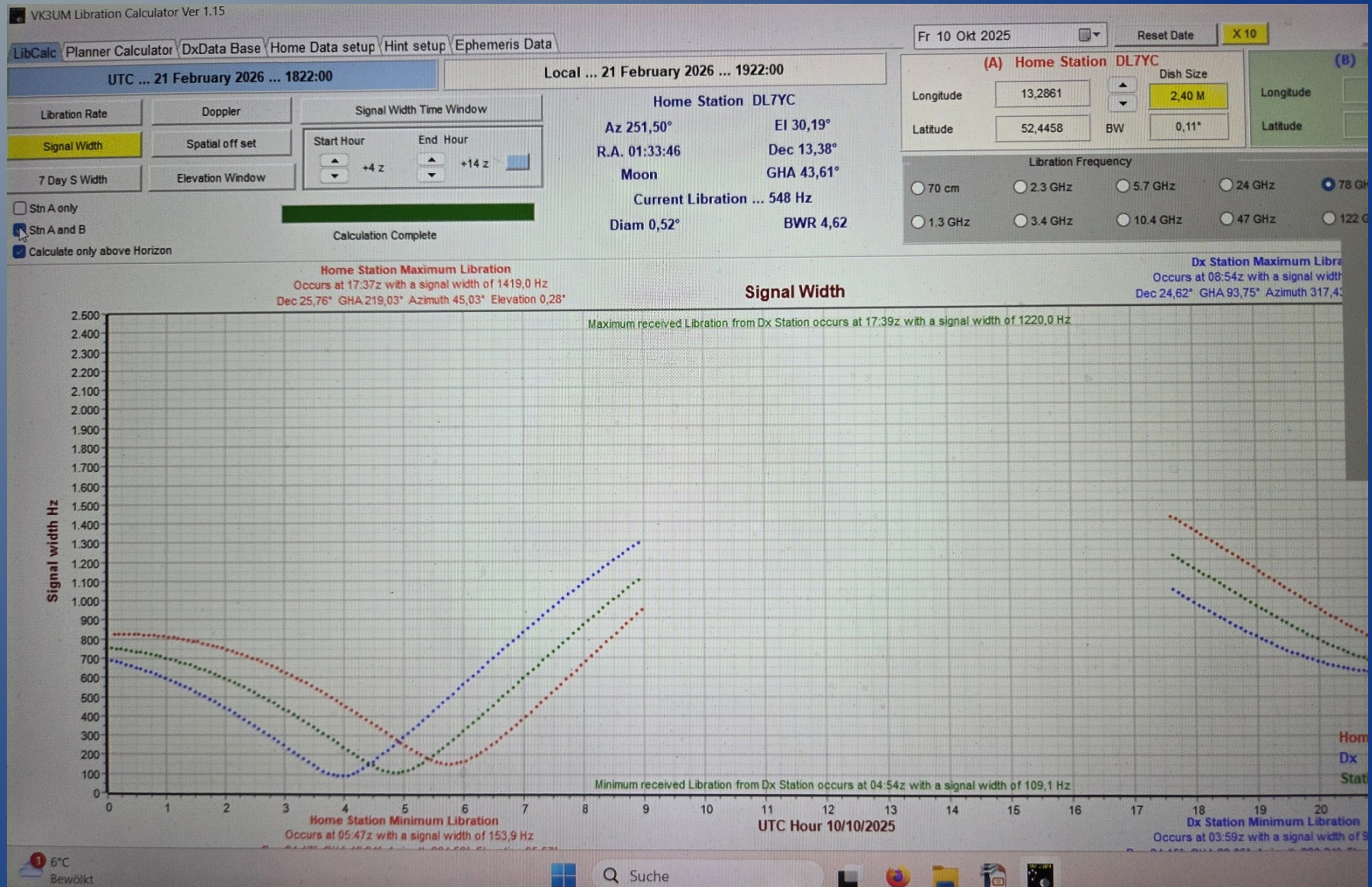


First EME QSO at 76 GHz

On October 10th and 11th, 2025 using WSJT-X (Q65-60E) a 1-Way QSO was achieved for the first time worldwide !

- Q65-120E and CW continuous wave transmissions were also successfully received
- Regardless of the S/N values displayed at the WSJT screen, subsequent offline decodings yielded S/N values of 1 – 4 dB

LibCalc at 10.10.2025



Important Insights Gained

- The files recorded by DL7YC were subsequently **decoded and verified** by several other amateurs, like DL3WDG and CT1BYM
- **CT1BYM** and others used a special function of WSJT-X (noise addition) to analyze all prior recorded data files

Past Decodes by CT1BYM

WSJT-X v3.0.0-rc1

File Configurations View Filters Mode Decode Save Tools Help

Single-Period Decodes

UTC	dB	DT	Freq	Message
0000	-18	2.5	639	: DL7YC RW3BP KO85 q3 [3808 km]
0000	-17	2.5	634	: DL7YC RW3BP KO85 q3 [3808 km]
0000	-16	2.5	629	: DL7YC RW3BP KO85 q3 [3808 km]
0000	-16	2.5	622	: DL7YC RW3BP KO85 q3 [3808 km]
0000	-16	2.5	625	: DL7YC RW3BP KO85 q3 [3808 km]
0000	-16	2.5	615	: DL7YC RW3BP KO85 q3 [3808 km]

Average Decodes

UTC	dB	DT	Freq	Message
0000	-18	2.5	639	: DL7YC RW3BP KO85 q3
0000	-17	2.5	634	: DL7YC RW3BP KO85 q3
0000	-16	2.5	629	: DL7YC RW3BP KO85 q3
0000	-16	2.5	622	: DL7YC RW3BP KO85 q3
0000	-16	2.5	625	: DL7YC RW3BP KO85 q3
0000	-16	2.5	615	: DL7YC RW3BP KO85 q3

160 80 60 40 30 20 17 15 12 10 6 2 70

☐ BP Log QSO Stop Monitor Erase Clear Avg Decode Enable Tx Halt Tx Tune Menus

4mm S 76 032.100 000

H DX Cal DX Grid

FT8 RW3BP KO85V

FT4 Az: 45 3860 km

MSK Lookup Add Ignore

Q65 2025 out 10 08:11:34

JT65

Echo

☐ Tx even/1st Tx 700 Hz F Tol 1000 Rx 615 Hz Report -16 T/R 60 s ☐ Sh ☒ Auto Seq CQ: First ☐ Tx6

15A 19C 30B 60C 60D 60E

Submode E Max Drift 0

Generate Std Msgs

Next Now

RW3BP DL7YC IM68

RW3BP DL7YC -16

RW3BP DL7YC R-16

RW3BP DL7YC RR73

RW3BP DL7YC 73

CQ DL7YC IM68

☐ Tx 1 ☒ Tx 2 ☐ Tx 3 ☐ Tx 4 ☐ Tx 5 ☐ Tx 6

Receiving IC910 Q65-60E 0.0 Last Tx: RW3BP DL7YC -16 34/60 WD-60m

WSJT-X v3.0.0-rc1

File Configurations View Filters Mode Decode Save Tools Help

Single-Period Decodes

UTC	dB	DT	Freq	Message
0522	-18	2.5	639	: DL7YC RW3BP KO85 q3 [3808 km]
0524	-17	2.5	634	: DL7YC RW3BP KO85 q3 [3808 km]
0526	-16	2.5	629	: DL7YC RW3BP KO85 q3 [3808 km]
0528	-16	2.5	622	: DL7YC RW3BP KO85 q3 [3808 km]
0530	-16	2.5	625	: DL7YC RW3BP KO85 q3 [3808 km]
0532	-16	2.5	615	: DL7YC RW3BP KO85 q3 [3808 km]

Average Decodes

UTC	dB	DT	Freq	Message
0522	-18	2.5	639	: DL7YC RW3BP KO85 q3
0524	-17	2.5	634	: DL7YC RW3BP KO85 q3
0526	-16	2.5	629	: DL7YC RW3BP KO85 q3
0528	-16	2.5	622	: DL7YC RW3BP KO85 q3
0530	-16	2.5	625	: DL7YC RW3BP KO85 q3
0532	-16	2.5	615	: DL7YC RW3BP KO85 q3

160 80 60 40 30 20 17 15 12 10 6 2 70

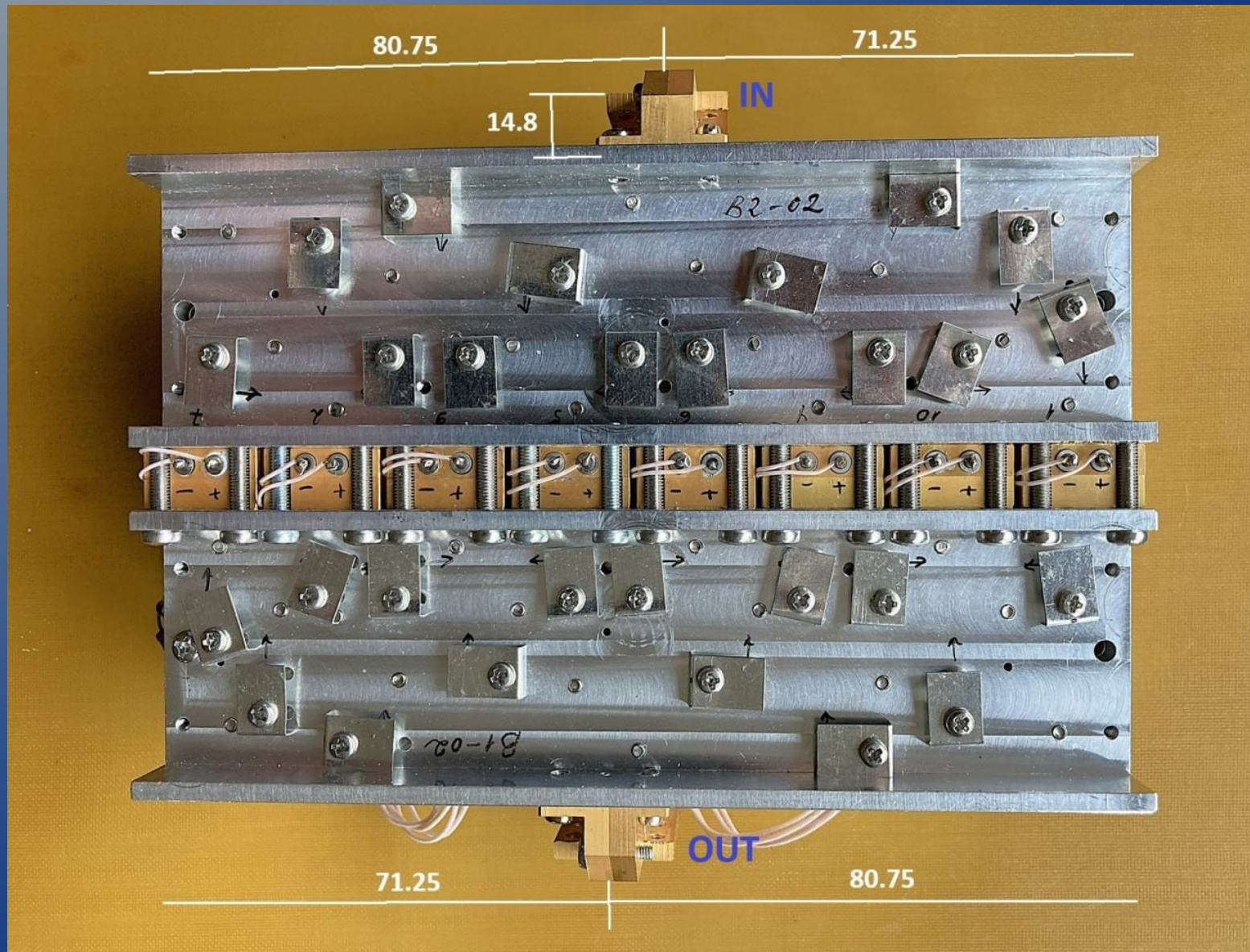
More Important Insights Gained

- **CT1BYM** was able to add up to **6dB of noise** to approximately 15% of the recorded files during decoding the 2025 files!
- **We remind you:** The transmit power used was 8.1- 8.2 Watts !
- **This means:** Even with **2.1 Watt** (- 6dB) TX power, successful decoding would have been possible under THESE conditions !

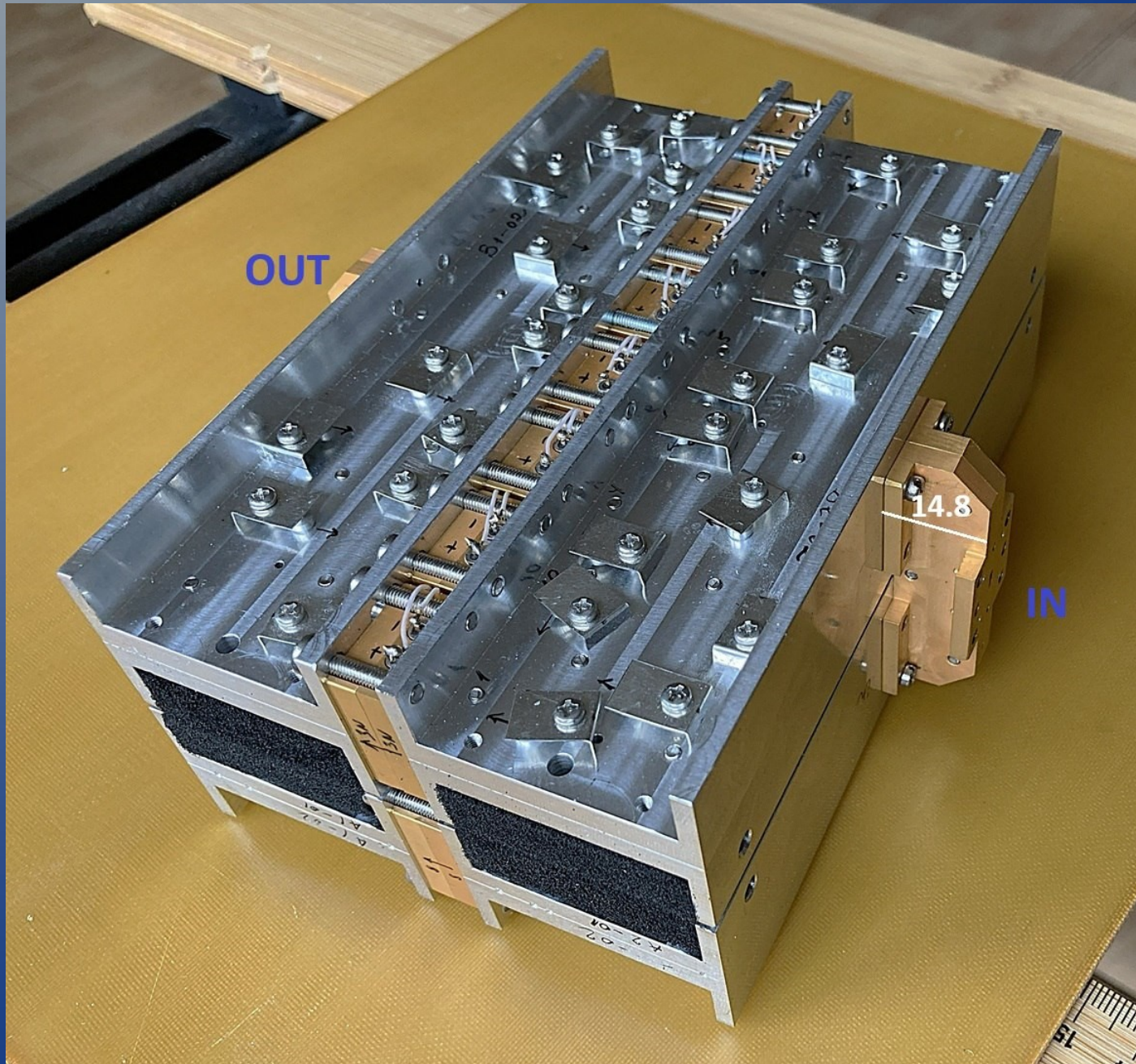
More Important Insights Gained

- This realization made continuing the experiments worthwhile
- Previously it was unknown what TX power was even necessary with 2.4m dishes and < 2.5 dB noise figure
- A second TX with 5.0 Watts (construction by RW3BP) was available, which DL7YC could integrate into his system

76 GHz / 5.0 Watt TX – Upper Side Phase Tuning Elements at Coupler



76 GHz / 5.0 Watt TX Complete



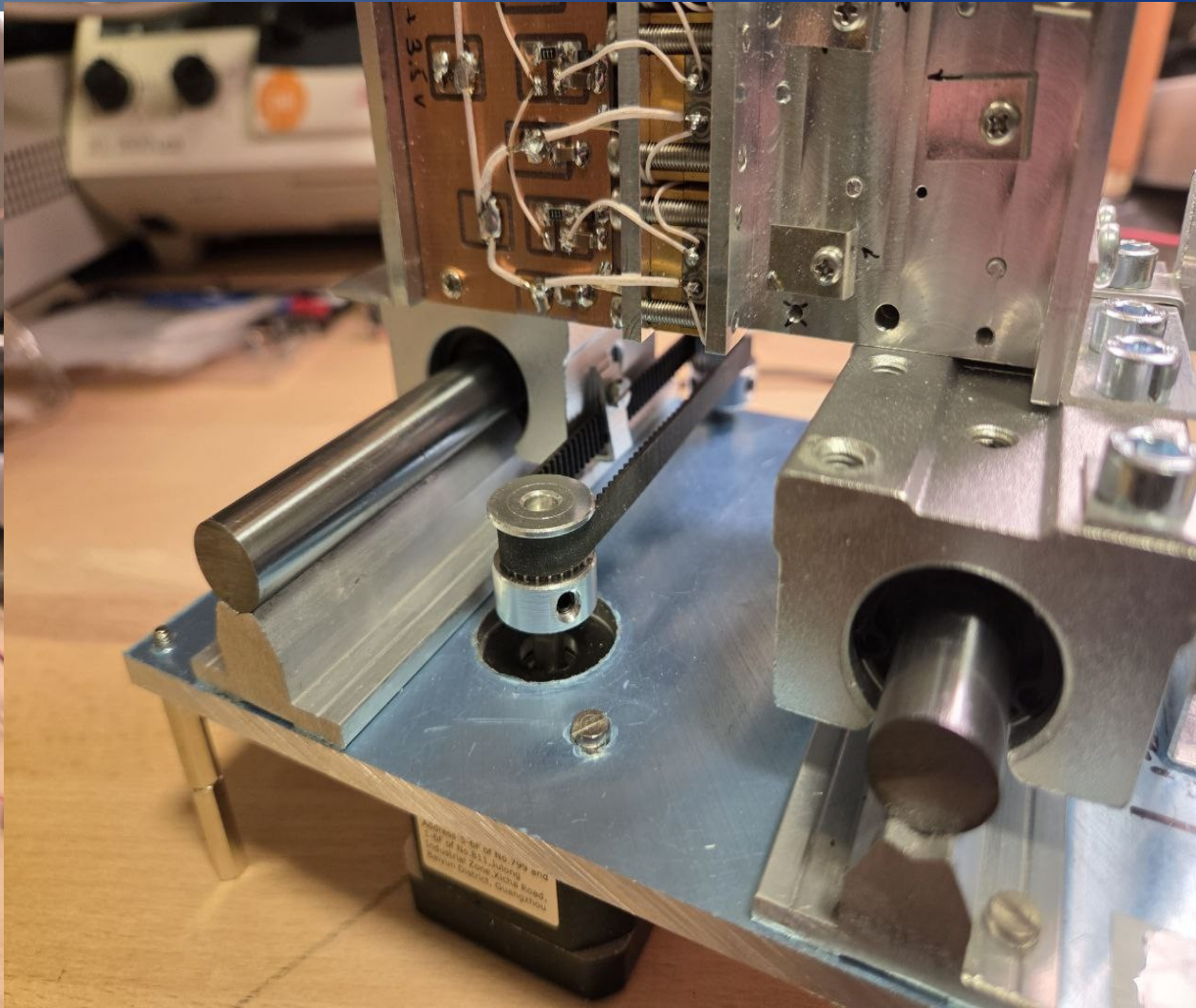
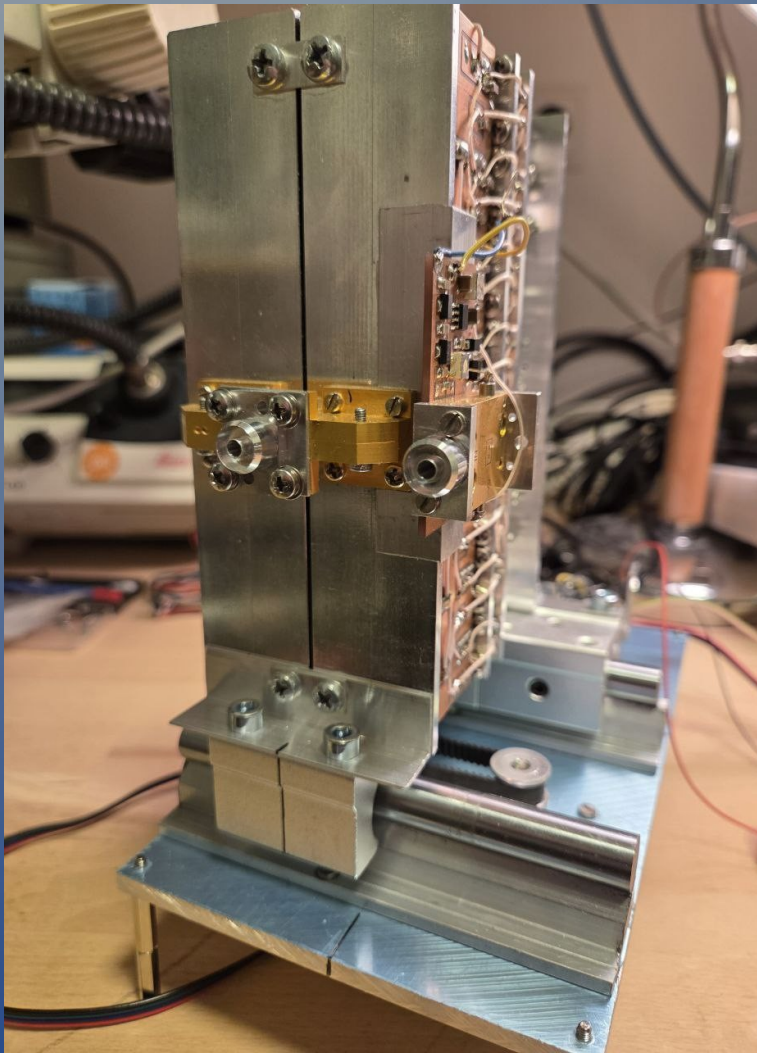
System Integration

- The transmit power of 5.0 Watts is apparently sufficient to be decodable as well
- However there is Little or No room for additional losses on either TX or RX
- This means:
- No waveguides AFTER the TX output
- No antenna relay possible

System Integration at DL7YC

- How can this be achieved in a PF dish ???
- The RX preamplifier is located directly behind the RX feedhorn
- A second feedhorn (TX only) is located on the Output of the last WG coupler from the 16 individual medium power amplifiers
- The RX to TX switch is achieved by horizontal moving both units using a stepper motor to overcome the distance of 38mm.

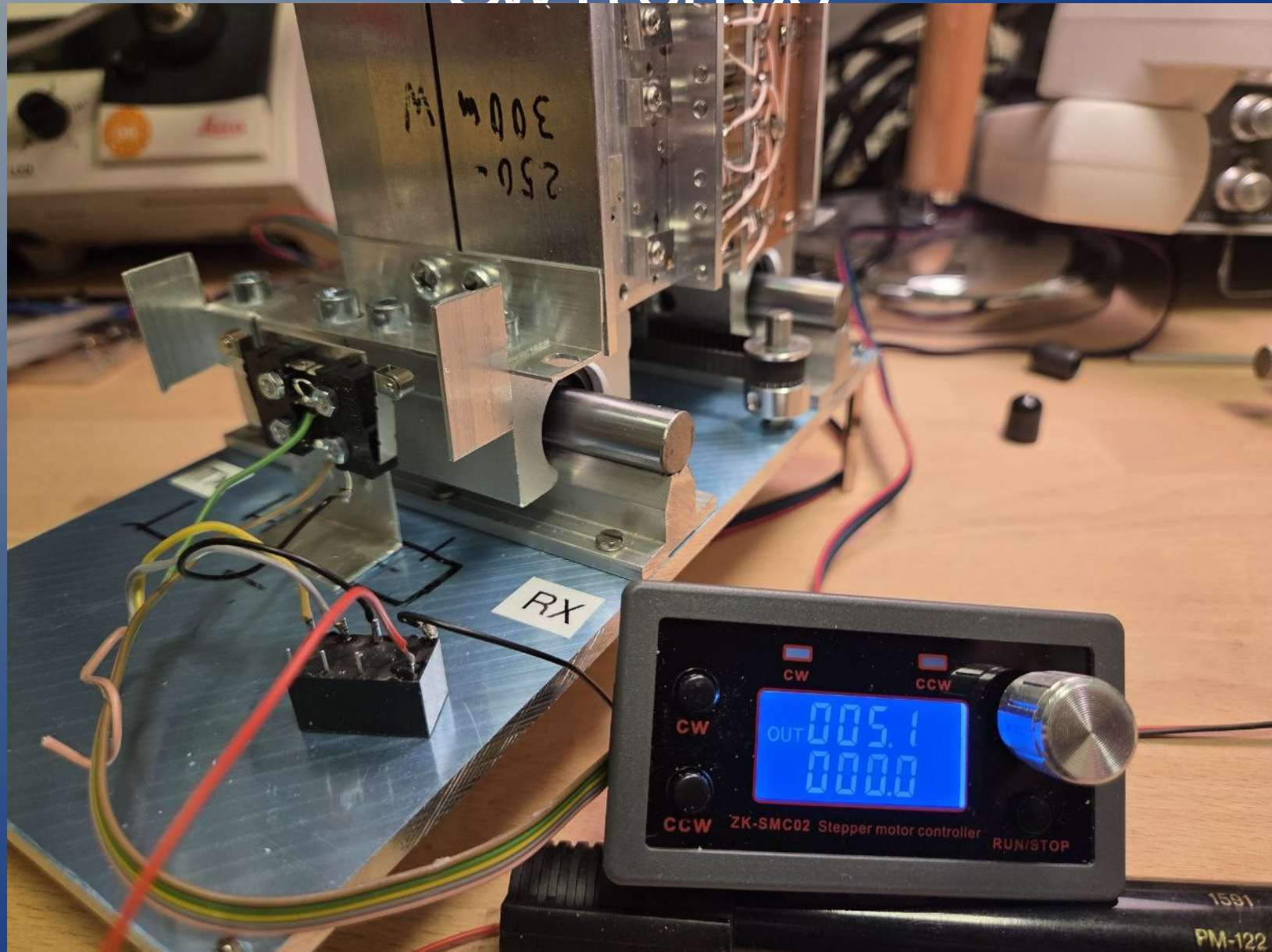
Tx and RX Ball Bearing Mounted



System Integration at DL7YC

- How is this mechanically achieved ???
- The entire TX/RX is moved horizontally with an accuracy of 0.1mm within 600 – 800 mS on linear bearings using a toothbelt and a stepper motor unit
- Built into a lightweight cage, the complete 76 GHz station (including the TRV and the oscillator chain) is thus located in the focus of the PF parabolic dish

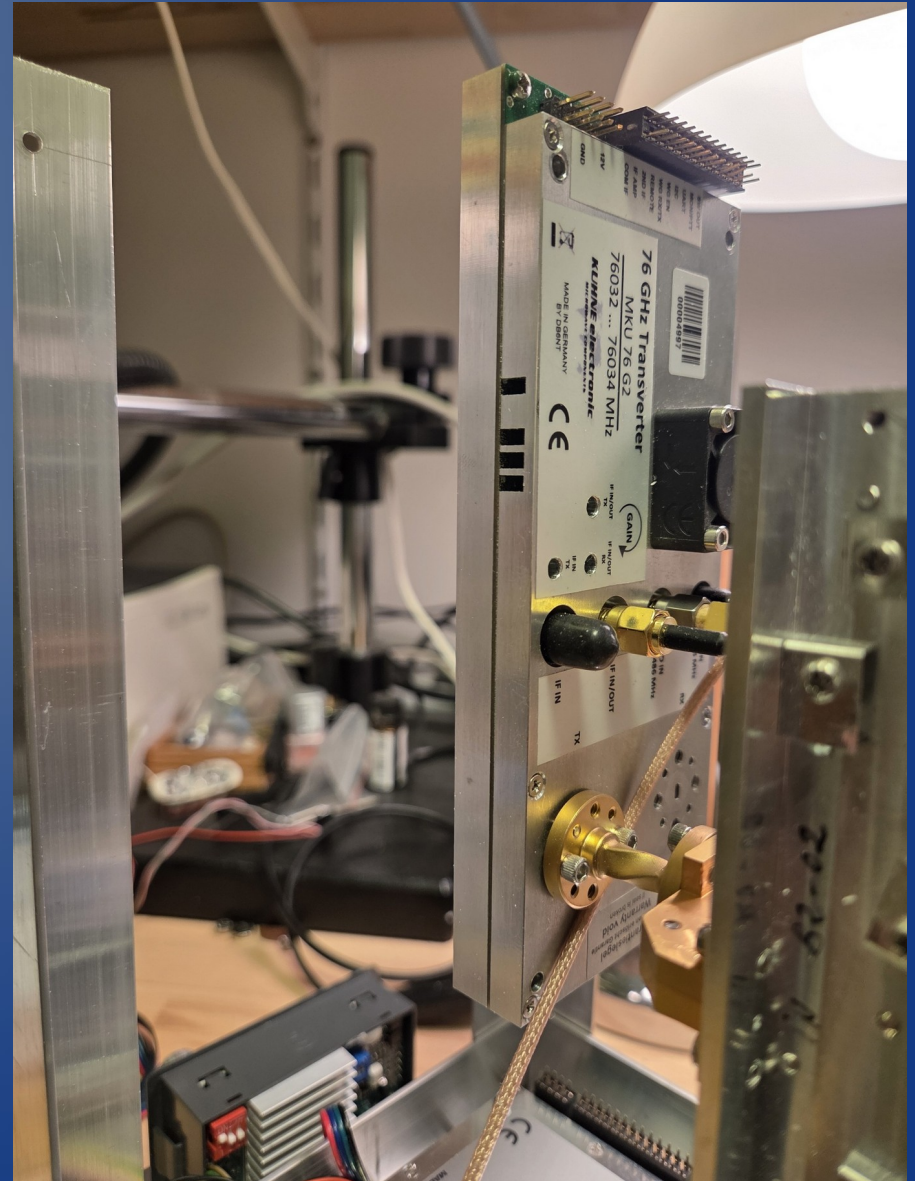
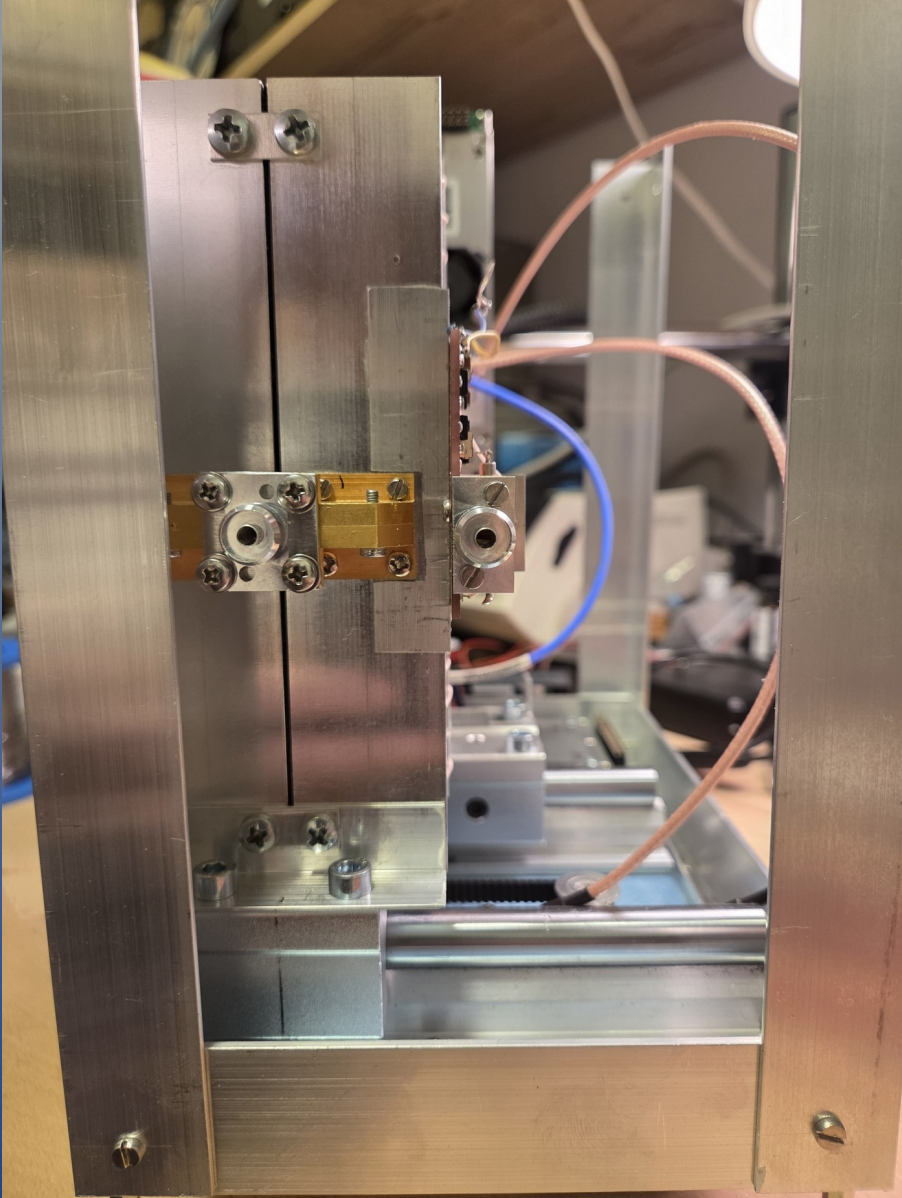
Motordriver Unit using End Switches



Precision“Move” in $< 800\text{mS}$

- Insert the DL7YC video here

Details of the 76 GHz Feedbox



System Integration at DL7YC

- The system integration into the final feedbox took place in March 2026
- Unlike the integration at RW3BP, at DL7YC the feedbox had to be mounted centrally (at boresight) of the 2.4m PF dish

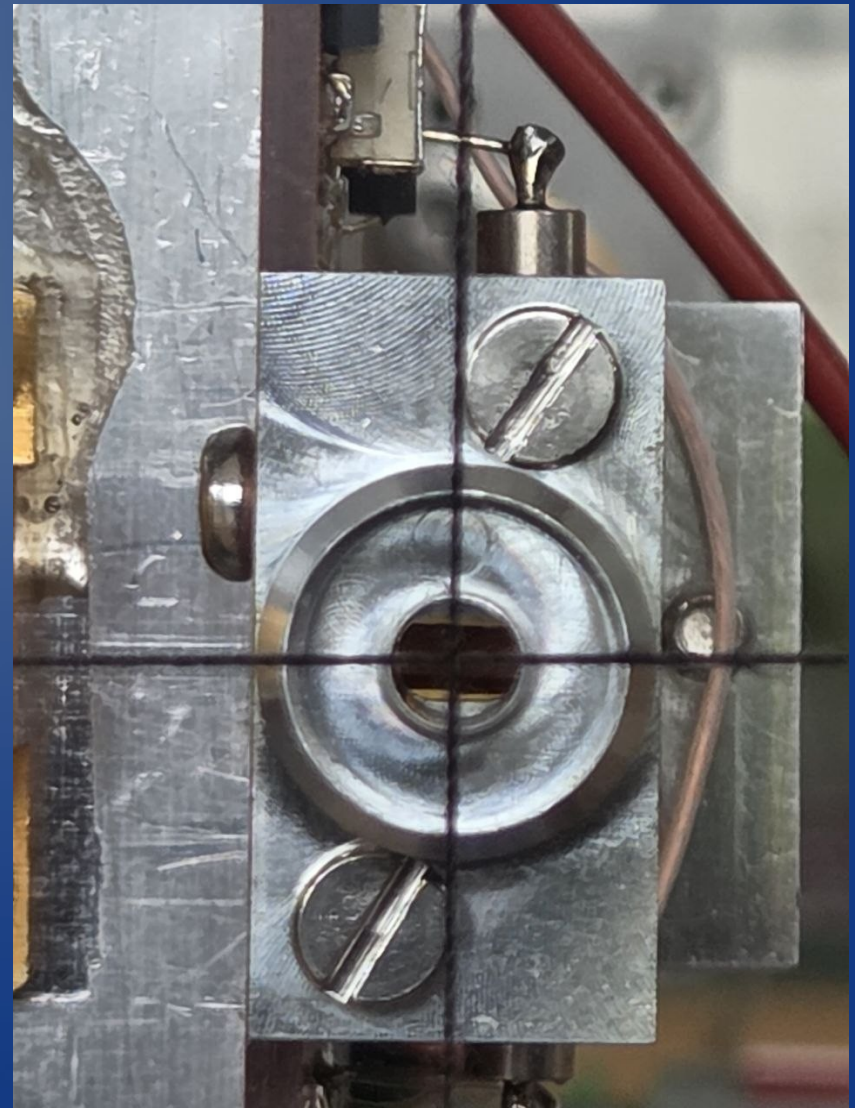
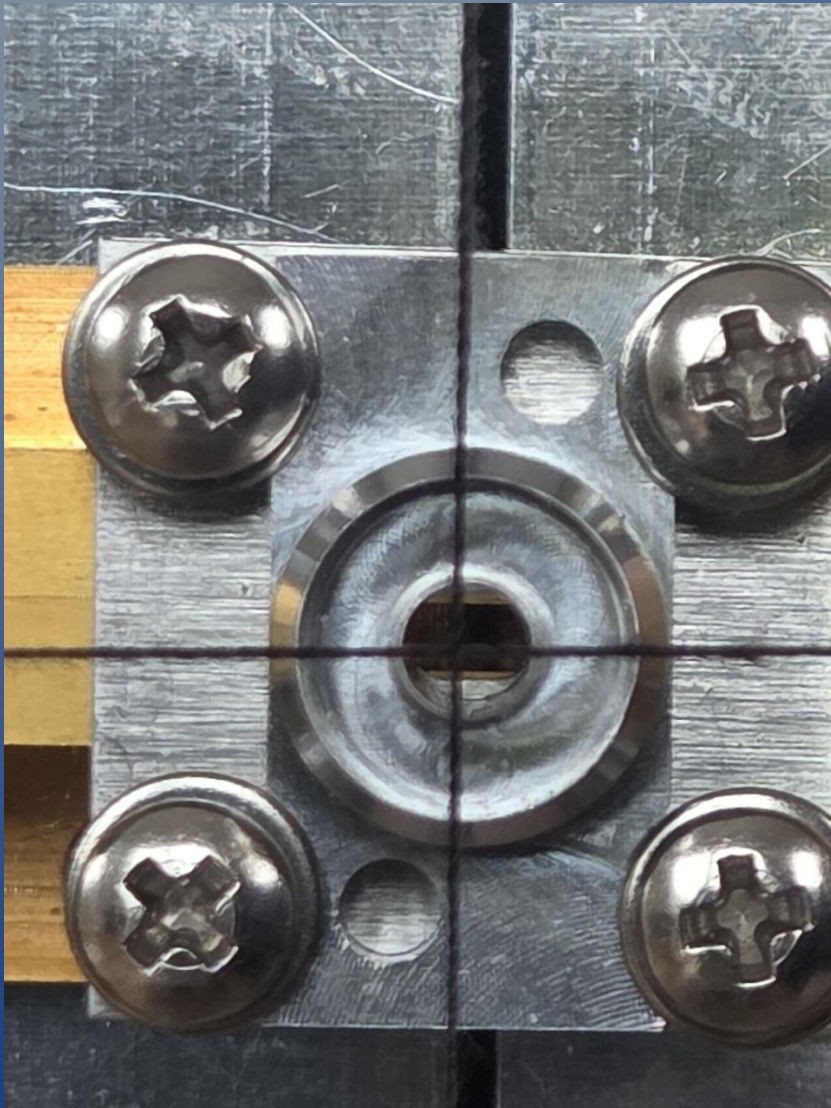
System Integration at DL7YC

During the integration and setup of the box, the following problems came to light:

- 1. Both feed horns must move on exactly the same horizontal plane (vertical deviation of feedholder from left to right $<0.2\text{mm}$)
 2. The travel distance has to be exactly the same ($<0.1\text{mm}$) as the boresight distance of the individual feeds.

System Integration at DL7YC

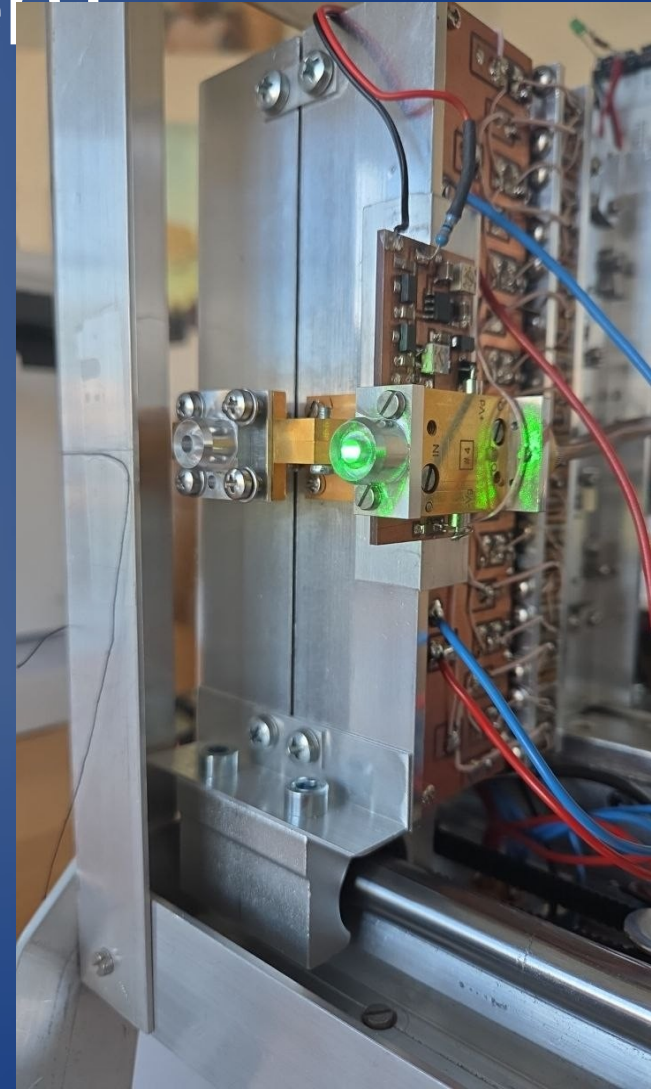
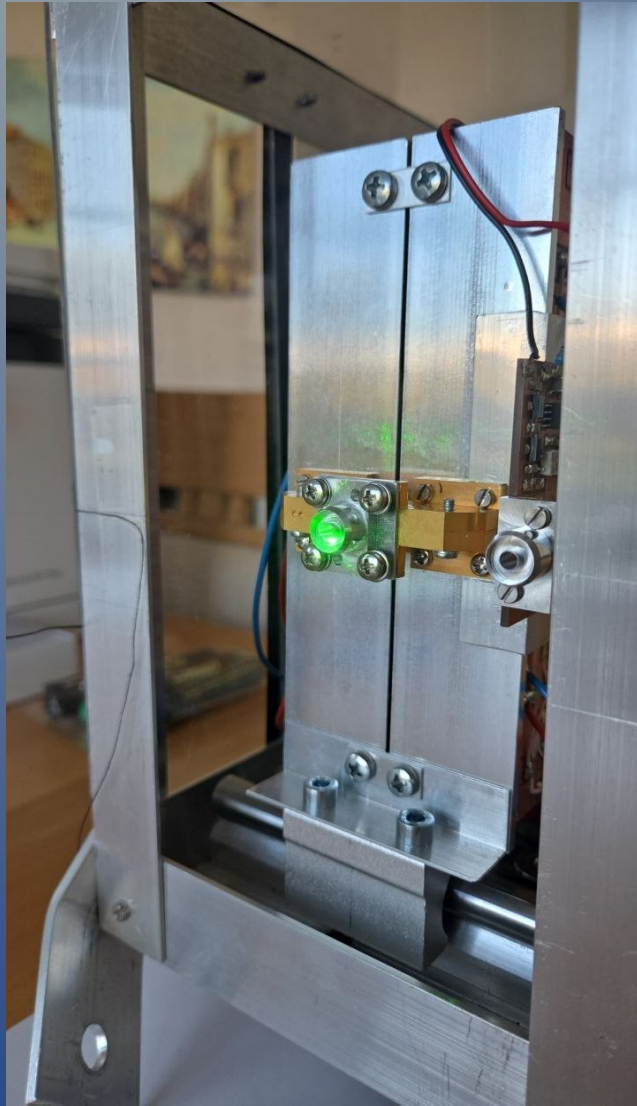
- Example of a slight **misalignment** of feeds



System Integration at DL7YC

- Additionally the feeds have to be oriented exactly in boresight direction (z-axis).
- And last but not least: Both feeds have to be in the focal plane, when they reached their end-travel-position!
- Any change to a single parameter usually and often unintentionally alters other values as well.

Laser Adjustment for Better Alignment



DL7YC trial to find the exact feed positions

EXTREME Low Tolerances Needed

- Calculation of tolerances – made by RW3BP

If we use the UA3AVR graph, we get the following figures:

Loss = 0.5 dB Angle θ = 0.010 degrees

Loss = 1.0 dB Angle θ = 0.017 degrees

Loss = 2.0 dB Angle θ = 0.029 degrees

Loss = 3.0 dB Angle θ = 0.038 degrees

The corresponding inaccuracy of the feed horn movement

$\Delta = \theta * F$. Here, θ is in radians.

For the DL7YC antenna, $F = 0.91$ m. Then we get:

Loss = 0.5 dB $\Delta = 0.16$ mm

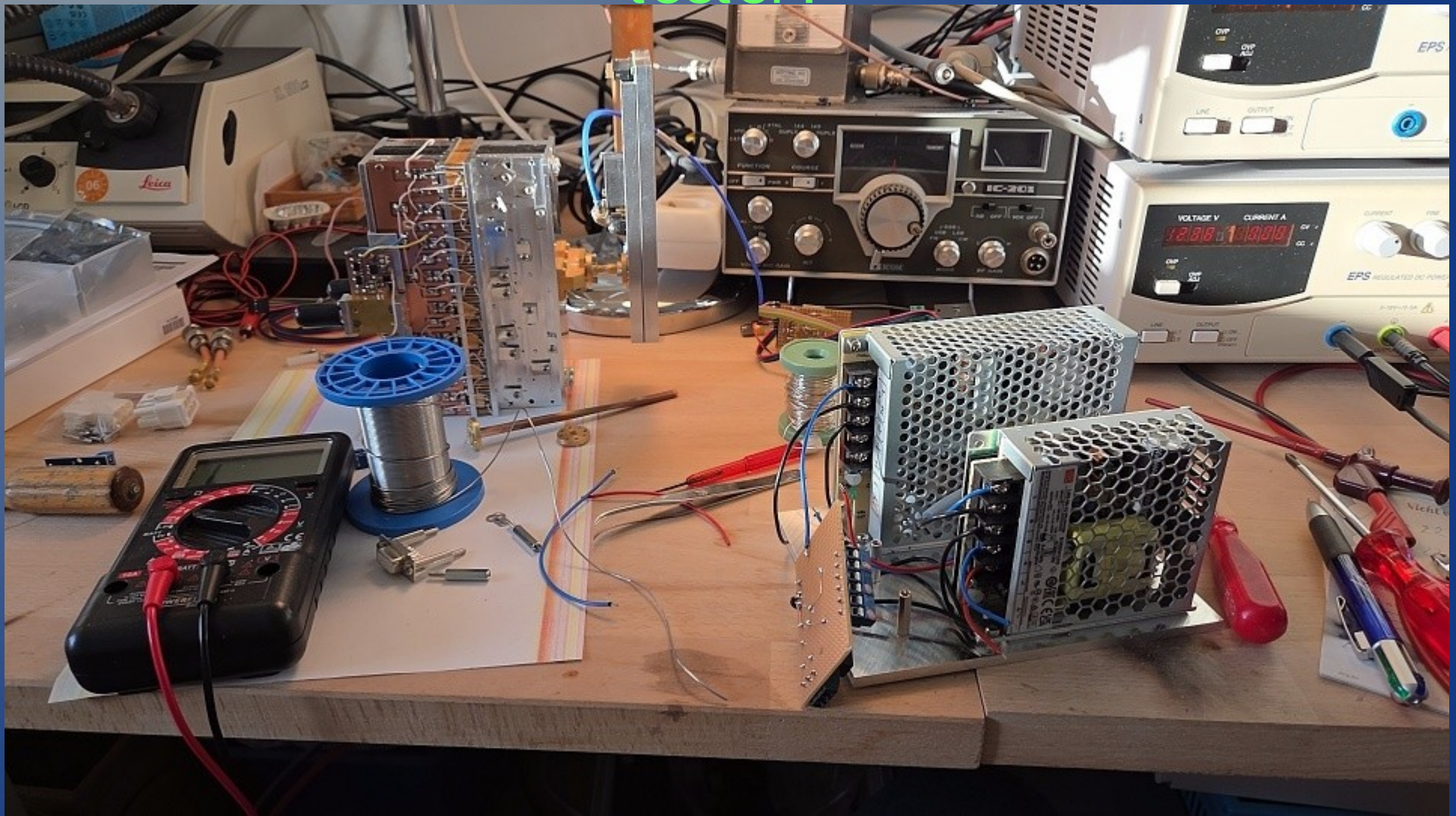
Loss = 1.0 dB $\Delta = 0.27$ mm

Special Power Supply at DL7YC

- The feedbox at DL7YC needed various voltages:
- +13.6V for the LOCAL oscillator, TRV, LNA and stepper motor supply
- - 5.0V as fixed bias supply for the SSPA
- +3.5V / 13A as Vdd supply for the SSPA. For security reasons, this power supply is switched on at the primary side to prevent transients.

Special 76GHz 3.5V Power Supply

In the background is a 50 year old 144MHz tester!



Special Power Supply at DL7YC

The +3.5V / 13A Vdd supply for the SSPA had to be VERY stiff.....**but** it is connected remotely by two 5m long 20 mm copper wires.

- A 1/10 volt reduction (from 3.5v) significantly reduces the output power of 5W **but a Vdd of 4.0 volt is dangerous for the expensive MMIC's.**
- All return wires must be routed separately to the SSPA to avoid current coupling !!!!

Waterproof Feedbox at DL7YC



Waterproof Feedbox at DL7YC

2.4 m Prime Focus
dish with 76 GHz
feedbox & Acrylic
cover



The Day of the QSO

April 22, 2026 * 10:05.....10:43 UTC

Libration minimum at 10:30 <180Hz nominal. The true Lib was lower due to the large dish size

At **RW3BP**: clear sky, 986 hPa, 26% rel. Hum, +12 deg C

At **DL7YC**: clear sky, 1022 hPa, 39% rel. Hum, +12 deg C

The Day of the QSO

- After automated echo testing some time before **RW3BP** started to transmit @ 10:04UTC
- **DL7YC** decoded his transmission 10:06 first time, and than ALL WSJT-X every 2 minutes until 10:42 UTC
- Sergei had **No decodes** of my signal, but after 14 min he started to move his antenna on RX (odd times) by 0.1 deg east. Nothing heard.....
- A second 0.1 deg move to the east (totally 0.2 deg) at RX had the same result.....

DL7YC Decoded RW3BP Every Time

WSJT-X v2.7.0 by K1JT et al.

File Configurations View Mode Decode Save Tools Help

Single-Period Decodes

UTC	dB	DT	Freq	Message
0830	-18	2.5	713	: DL7YC RW3BP KO85 q3
0832	-17	2.5	705	: DL7YC RW3BP KO85 q3
0834	-17	2.5	697	: DL7YC RW3BP KO85 q3
0836	-17	2.5	713	: DL7YC RW3BP KO85 q3
0838	-17	2.5	707	: DL7YC RW3BP KO85 q3
0840	-16	2.5	685	: DL7YC RW3BP KO85 q3
0842	-16	2.5	687	: DL7YC RW3BP KO85 q3
0844	-17	2.5	695	: DL7YC RW3BP KO85 q3
0846	-17	2.5	702	: DL7YC RW3BP KO85 q3
0848	-16	2.5	693	: DL7YC RW3BP KO85 q3
0854	-16	2.5	725	: DL7YC RW3BP KO85 q3
0856	-17	2.5	713	: DL7YC RW3BP KO85 q3
0900	-16	2.5	697	: DL7YC RW3BP KO85 q3
0902	-16	2.5	700	: DL7YC RW3BP KO85 q3
0904	-16	2.6	690	: DL7YC RW3BP KO85 q3

Average Decodes

UTC	dB	DT	Freq	Message
084300	Tx		700	: RW3BP DL7YC JO62
0844	-17	2.5	695	: DL7YC RW3BP KO85 q3
084500	Tx		700	: RW3BP DL7YC JO62
0846	-17	2.5	702	: DL7YC RW3BP KO85 q3
084700	Tx		700	: RW3BP DL7YC JO62
0848	-16	2.5	693	: DL7YC RW3BP KO85 q3
084900	Tx		700	: RW3BP DL7YC JO62
085100	Tx		700	: RW3BP DL7YC JO62
085300	Tx		700	: RW3BP DL7YC JO62
0854	-16	2.5	725	: DL7YC RW3BP KO85 q3
085500	Tx		700	: RW3BP DL7YC JO62
0856	-17	2.5	713	: DL7YC RW3BP KO85 q3
085700	Tx		700	: RW3BP DL7YC JO62
085900	Tx		700	: RW3BP DL7YC JO62
0900	-16	2.5	697	: DL7YC RW3BP KO85 q3
0902	-16	2.5	700	: DL7YC RW3BP KO85 q3
0904	-16	2.6	690	: DL7YC RW3BP KO85 q3

Log QSO Stop Monitor Erase Clear Avg Decode Enable Tx Halt Tx Tune

4m 76.032,152 680 Tx even/1st Tx 700 Hz F Tol 200 Submode E Rx 700 Hz Max Drift 0 Report -18 T/R 60 s Sh Auto Seq Tx6

H Dx Call Dx Grid RW3BP KO8SV5 Az: 67 1636 km Lookup Add

2026 Apr 21 09:05:17

Generate Std Msgs Next Now

RW3BP DL7YC JO62 Tx 1

RW3BP DL7YC -18 Tx 2

RW3BP DL7YC R-18 Tx 3

RW3BP DL7YC RR73 Tx 4

RW3BP DL7YC 73 Tx 5

CQ DL7YC JO62 Tx 6

Receiving Default - Copy Q65-40E Last Tx: RW3BP DL7YC JO62 0 4 17/60 WD:59m

The Day of the QSO

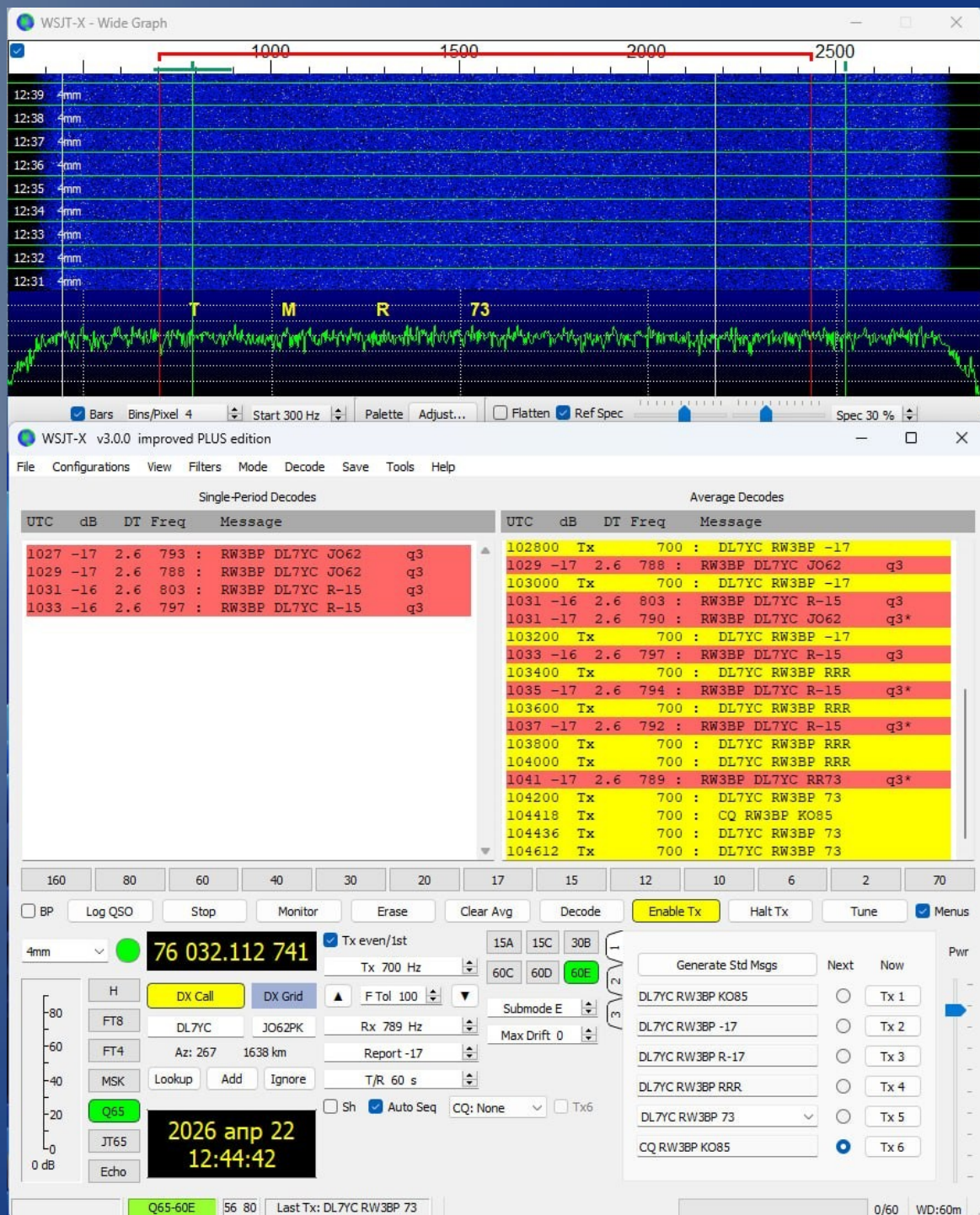
Third attempt was a 0.1 deg move to the West side at **RW3BP's** RX period with **Successful decoding DL7YC's report -17 !!!!**

What happened ?

DL7YC's antenna spot at TX was 0.1deg apart from his RX spot. This feed misalignment was further investigated and identified as a feed travel distance error.

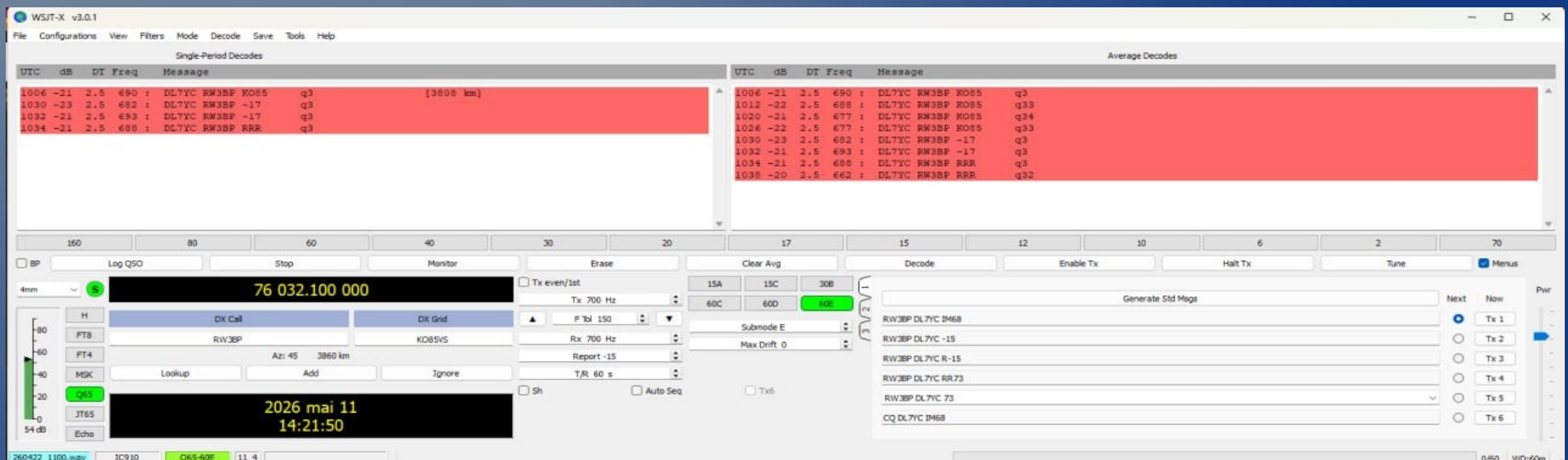
First 76 GHz EME QSO

- This is a completed screenshot of DL7YC's 5.0W signals
- The RW3BP signals were between -14/-16 dB



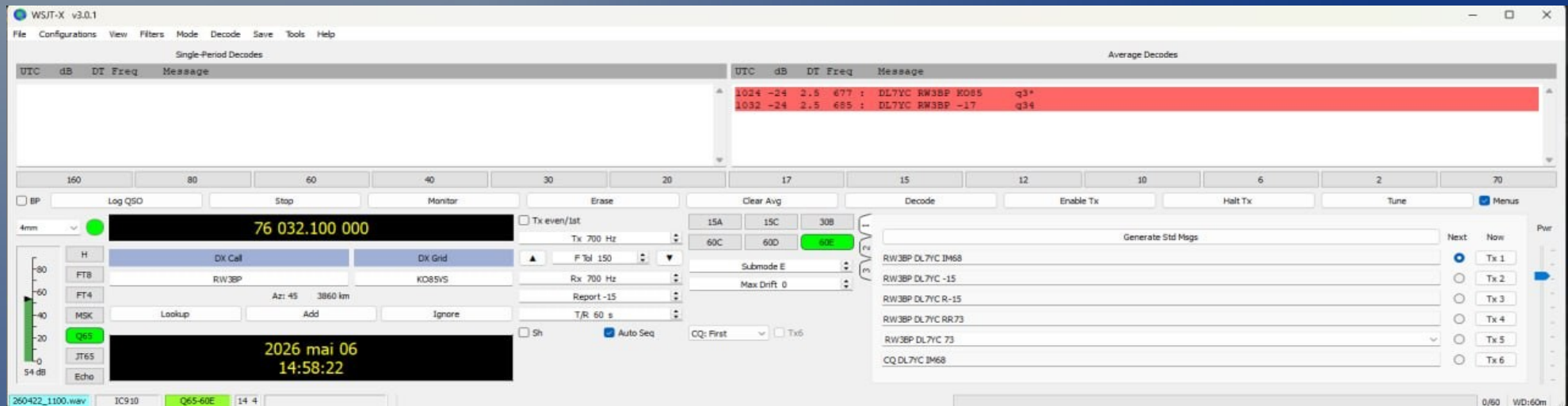
Post Processing of Decodings

- This is an example of 7.5dB added noise to WSJT decoded file – processed by **CT1BYM**



Final Results

9.2 dB Added Noise gave the following result!



This decode shows that 9.2dB less TX power (1.2 Watts) is probably sufficient to overcome all losses to and from the moon

This was the Short Story of the Worldwide FIRST 76 GHz EME QSO

Thank You for your
Attention

Are There Any Questions?