

76 GHz EME – The Next Frontier

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

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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

The screenshot displays the WSJT-X software interface. At the top, there are two graphs: 'Wide Graph' and 'Echo Graph'. The 'Wide Graph' shows a spectrum with a prominent signal at approximately 1400 Hz. The 'Echo Graph' shows a red line plot with a sharp peak at 0 Hz, indicating an echo. Below the graphs is a menu bar and a table of test results.

UTC	Hour	Level	Doppler	Width	N	Q	DF	SNR	dBerr	DT	TS	EchoMsg
085548	8.9300	63.58	89411	287.6	10	10	-2	-13.2	0.5	0.45		
085554	8.9317	63.60	89402	287.0	11	10	-2	-13.0	0.5	0.50		
085600	8.9333	63.51	89392	286.8	12	10	-2	-13.1	0.5	0.50		
085606	8.9350	63.50	89383	286.2	13	10	-2	-13.2	0.5	0.50		
085612	8.9367	63.63	89374	286.0	14	10	-1	-13.2	0.5	0.50		
085618	8.9383	63.33	89365	285.5	15	10	-1	-13.2	0.5	0.50		
085624	8.9400	63.17	89356	285.1	16	10	0	-13.2	0.5	0.50		
085630	8.9417	63.39	89346	284.7	17	10	-1	-13.2	0.5	0.50		
085636	8.9433	63.53	89337	284.5	18	10	-1	-13.3	0.5	0.50		
085642	8.9450	63.62	89328	283.8	19	10	-1	-13.4	0.5	0.50		

Below the table are various controls including a 'BP' checkbox, 'Stop', 'Monitor', 'Erase', 'Clear Avg', 'Avg 50', 'Decode', 'Enable Tx', 'Halt Tx', 'Tune', and 'Menus' checkboxes. A call sign '76 032.189 318' is displayed in a large yellow font. To the right, an 'Astronomical Data' window shows the following information:

2026 apr 22
 UTC: 08:57:10
 Az: 82.8
 El: 28.0
 SelfDop: 89292
 Width: 282
 Delay: 2.43
 DxAz: 63.3
 DxEl: 13.2
 DxDop: 93410
 DxWid: 515

The 'Doppler tracking' section has 'Own Echo' selected. The 'Echo' button is highlighted in green.

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

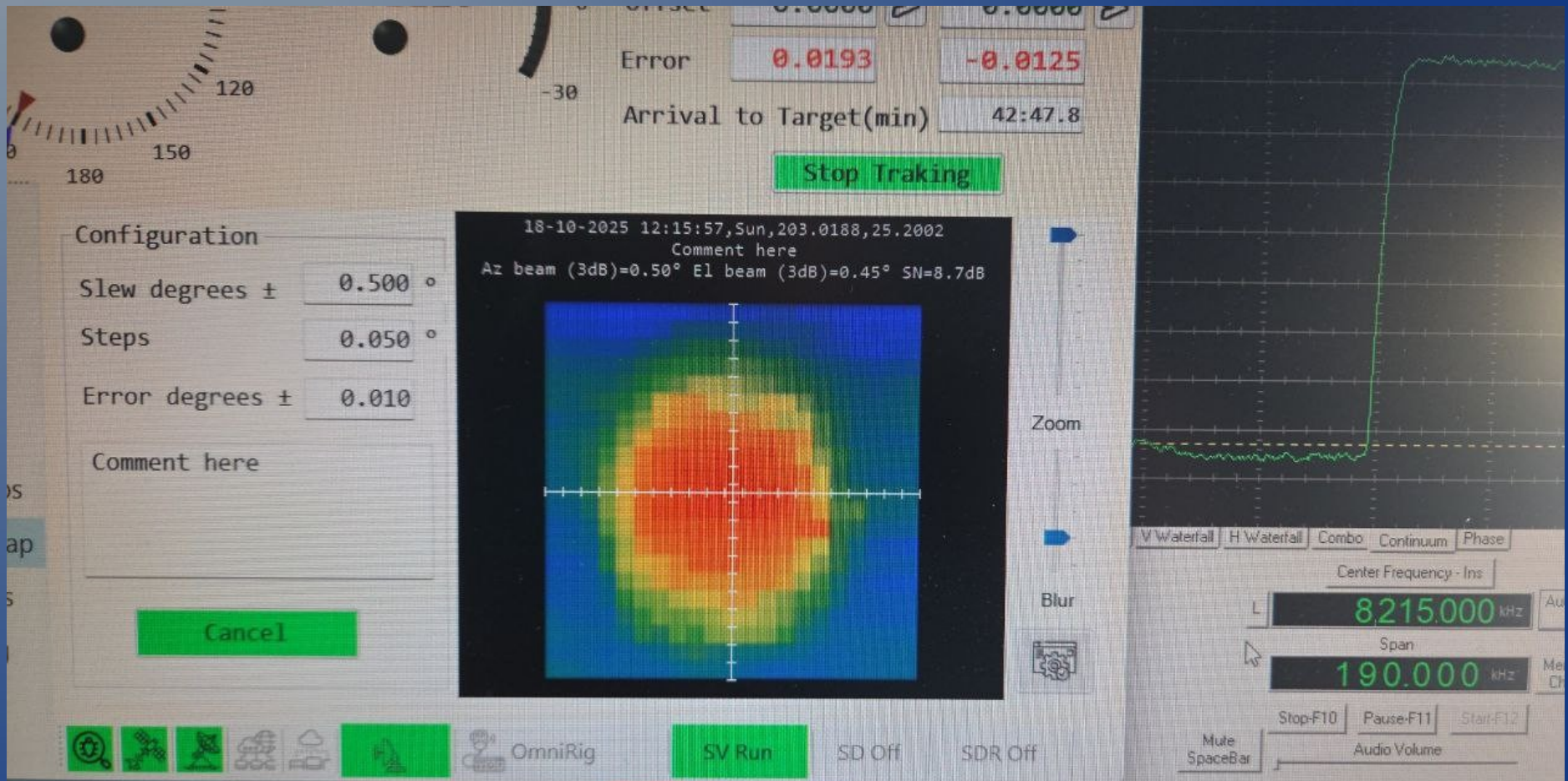
DriverDish App developed by EA3HMJ

The screenshot displays the DriverDish App interface with the following components:

- Header:** DriverDish.App(2.1.3082) - 23-09-2025 10:54:42
- Position Gauges:**
 - Azimuth:** A circular gauge showing a current value of 70.1715° .
 - Elevation:** A circular gauge showing a current value of 86.1030° .
- Target Settings:**
 - Target: Sun
 - Range: 150.107MKm
 - VT: -0.62469m/s
 - Target $^\circ\text{AZ}$: 146.8113
 - Target $^\circ\text{EL}$: 46.1114
 - Offset: $+0.0000$ (for both AZ and EL)
 - Error: 76.6384 (AZ), -39.9876 (EL)
 - Arrival to Target(min): [Empty field]
- Control Panel:**
 - Controller dish: ESP32 ModBus drive
 - Precision (digits): 4
 - Local IP: 169.254.59.80
 - Offset: EL 3.6400, AZ 108.3600
 - Telnet server: Port 9999, Run []
 - WWW server: Port 9998, Run []
- Navigation Menu:** Setup, Slew, Targets, Radios, SNR, Heatmap, Motors, Debug, Log, Exit
- Bottom Bar:** Manual, OmniRig, SV off, SD Off, SDR Off

Heatmap Feature Verifying Tracking

The noise in SpectraVue is measured from IF



Situation at RW3BP - K085vs

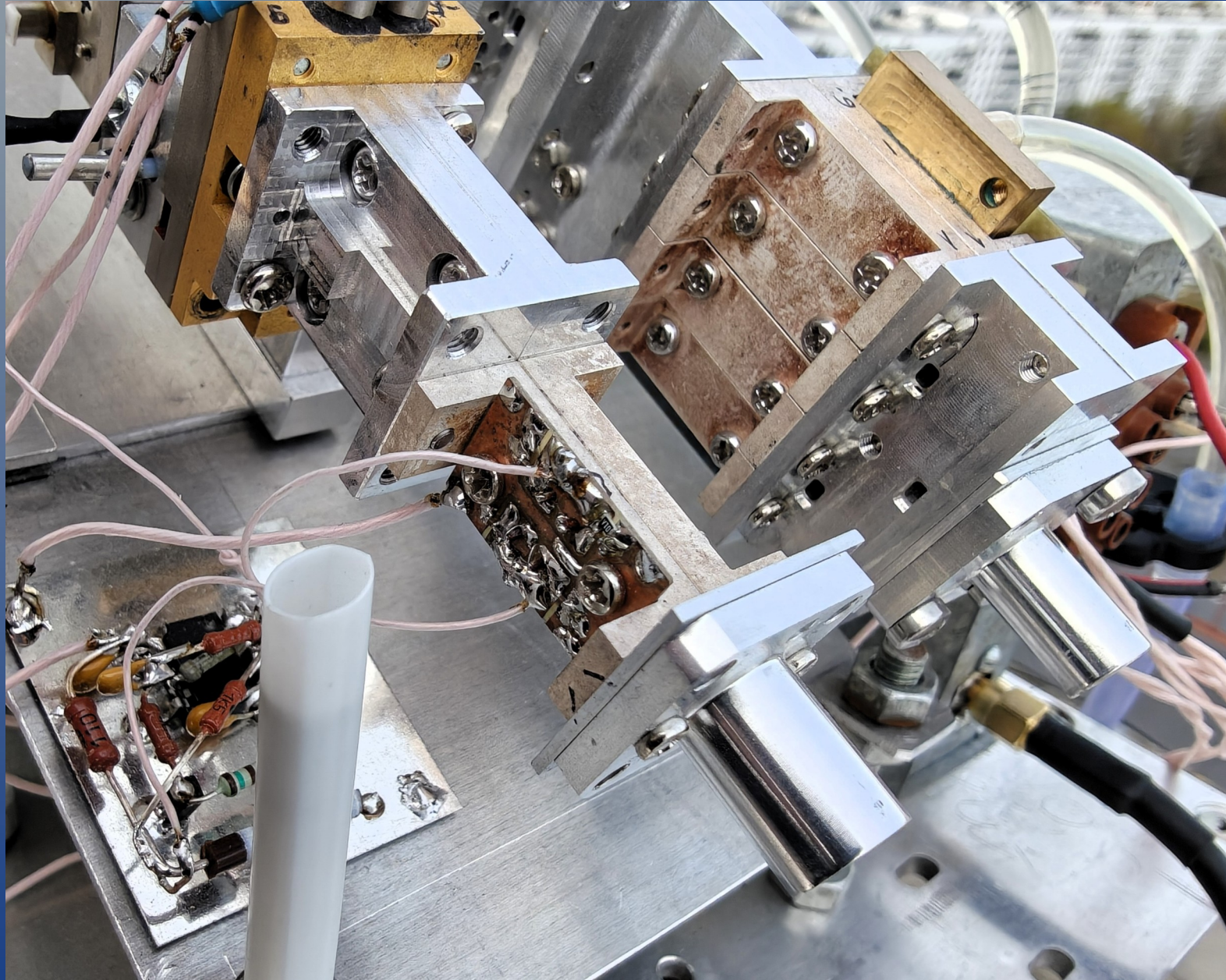


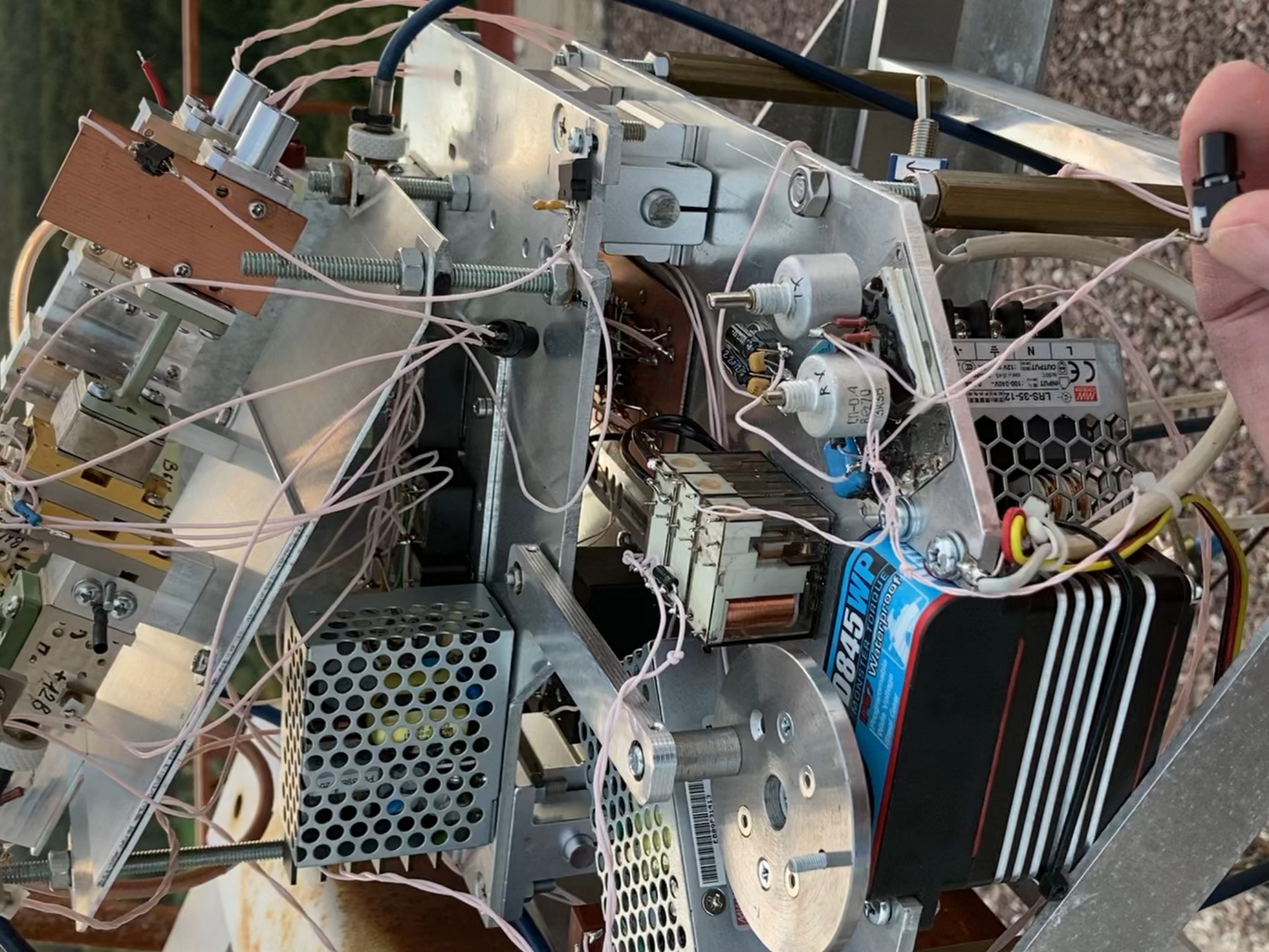
Gregorian 2.4m Offset Dish System

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



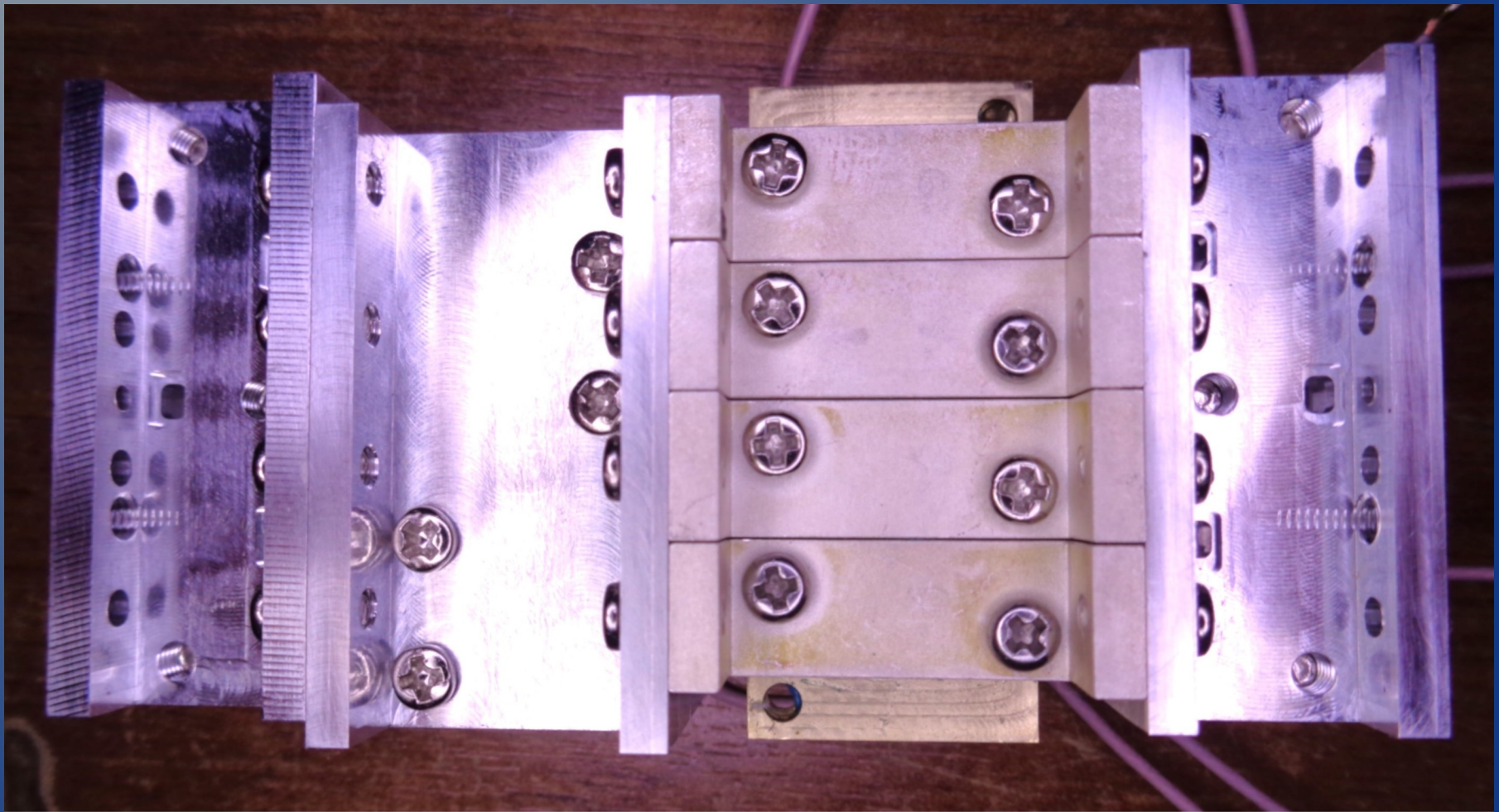
Closeup of the RW3BP Outdoor Unit





RW3BP 8.1W homebuild 76 GHz SSPA

- 4 x 2.2 W Amplifiers



DIVIDER

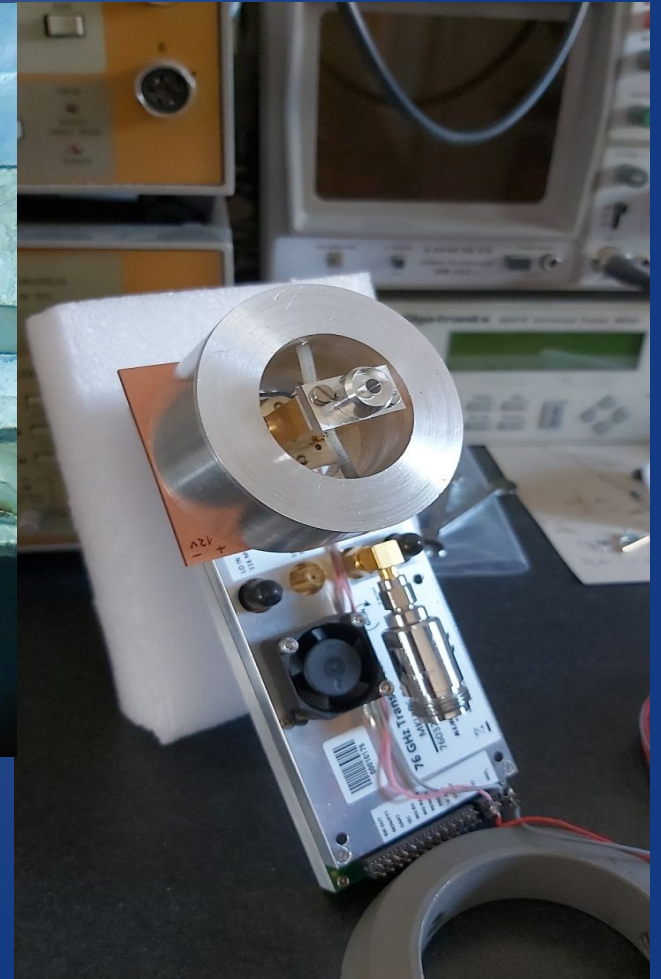
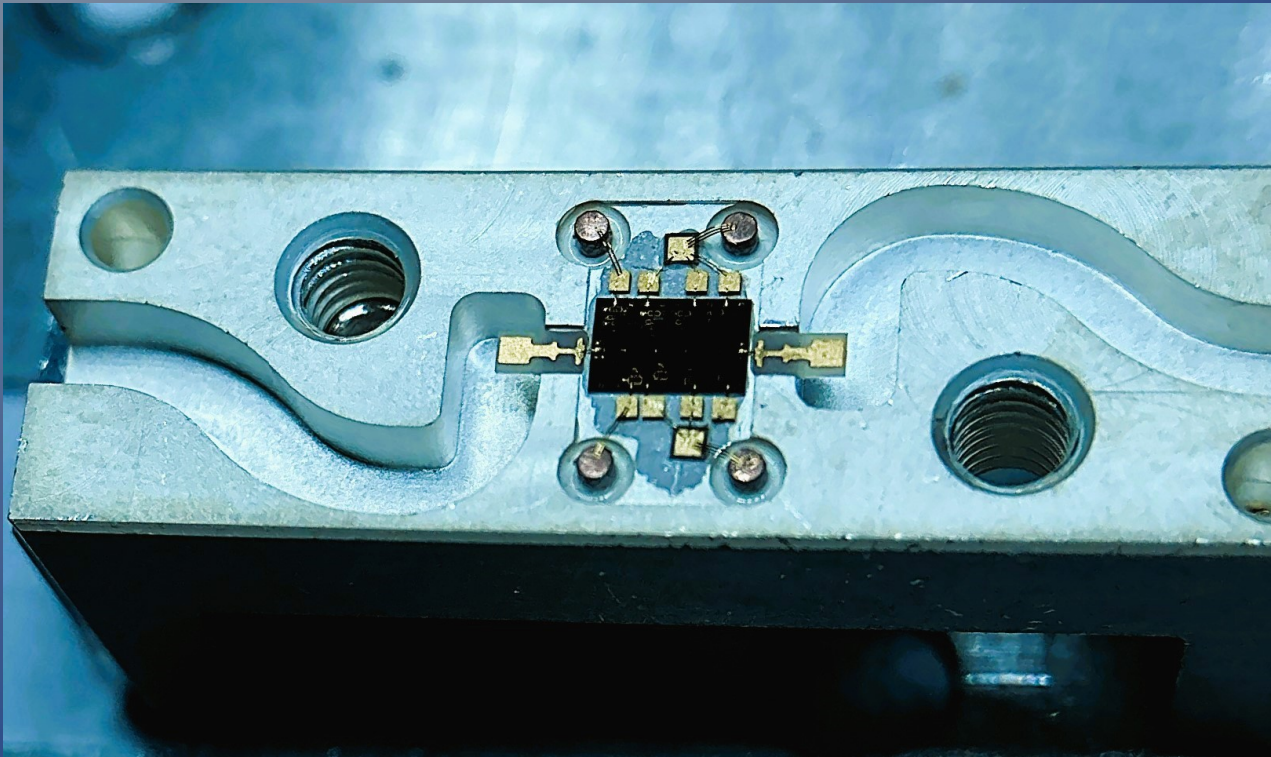
PHASE SHIFTER

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

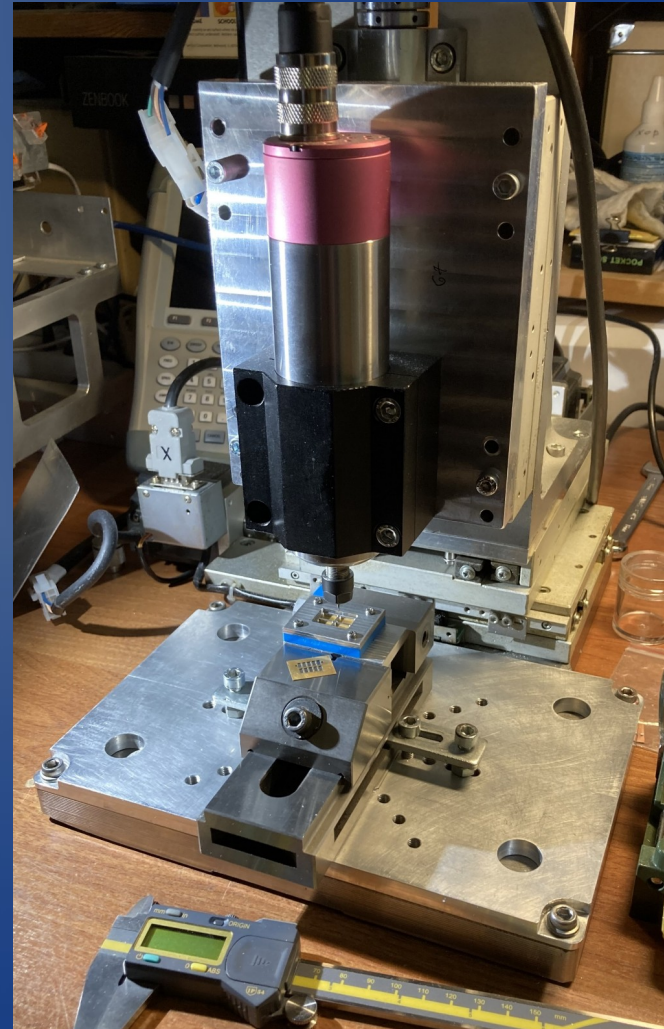


RW3BP In the Home Workshop

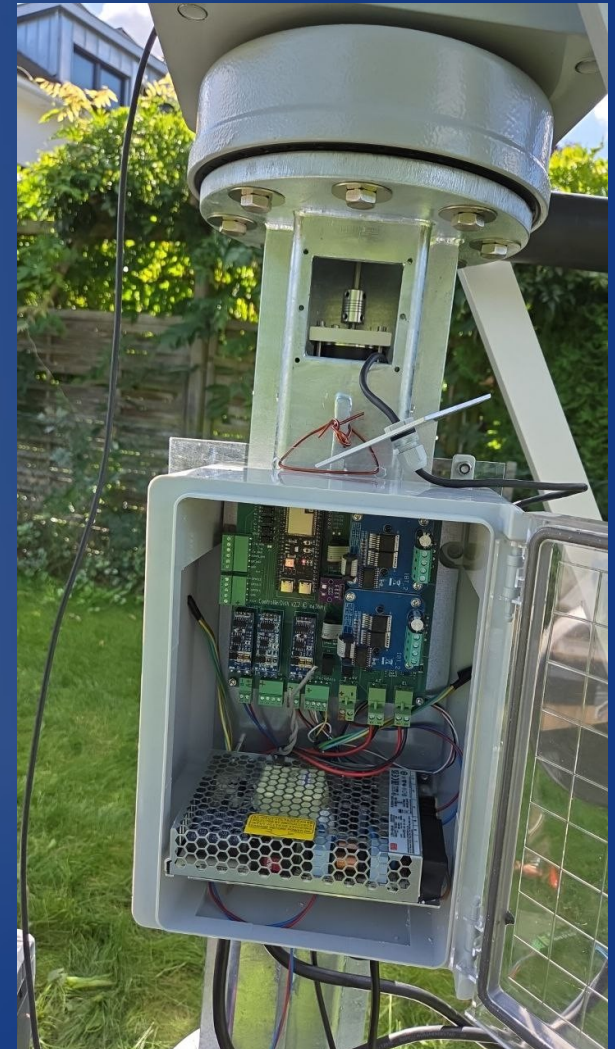
Wire bonding



Microstrip milling



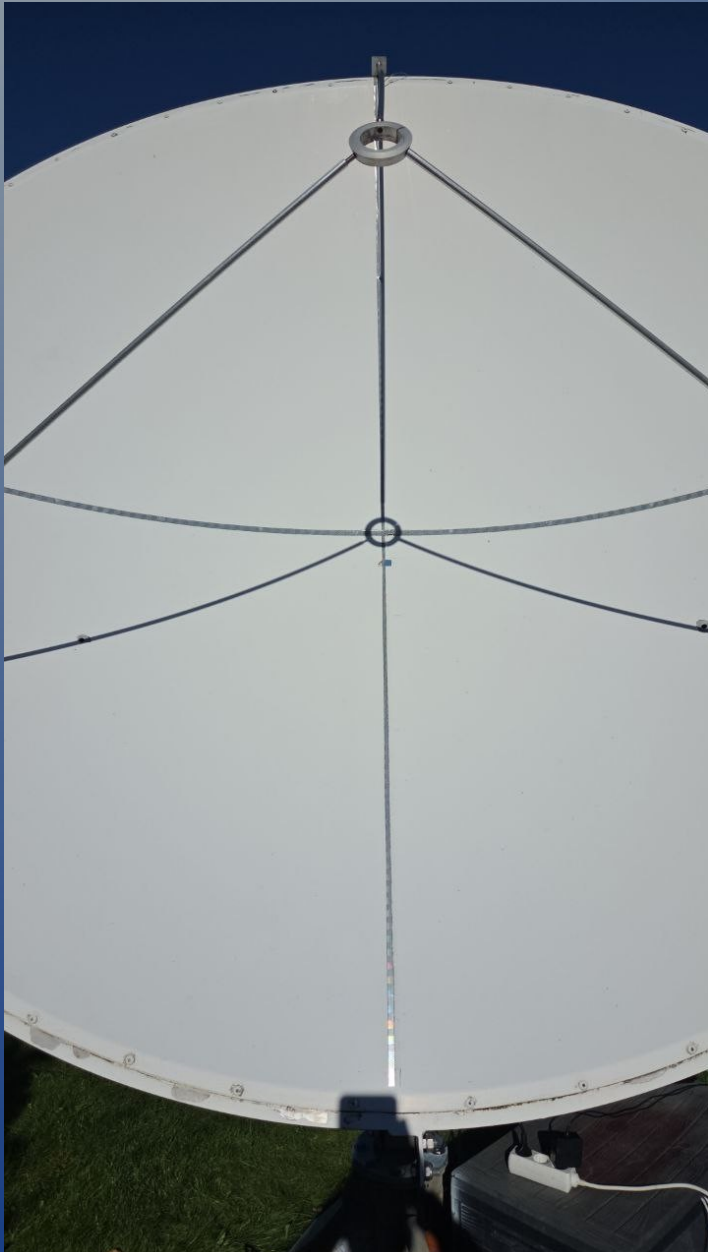
DL7YC Dual Slewing Drive with 18-Bit Encoders



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

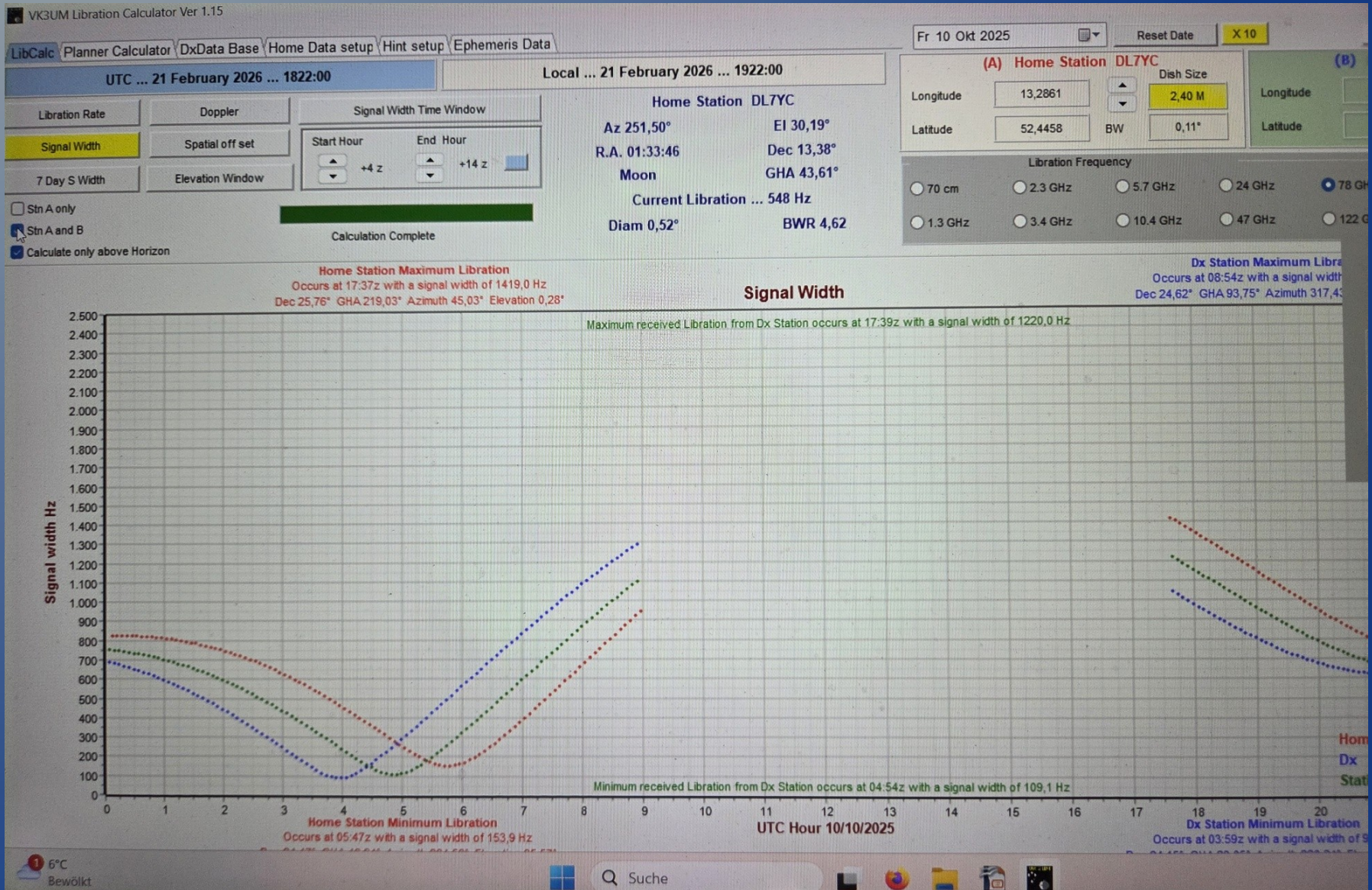


First EME QSO at 76 GHz

On October 10th and 11th, 2025 using WSJT-X (Q65-60E) a 2 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

The screenshot shows the WSJT-X v3.0.0-rc1 interface. The top section displays 'Single-Period Decodes' and 'Average Decodes' tables. The 'Single-Period Decodes' table has columns for UTC, dB, DT, Freq, and Message. It shows several entries for DL7YC RW3BP KO85 q3 with a distance of [3808 km]. The 'Average Decodes' table shows similar entries. Below the tables are various controls including 'Log QSO', 'Monitor', 'Erase', 'Clear Avg', 'Decode', 'Enable Tx', 'Halt Tx', 'Tune', and 'Menus'. A central display shows '76 032.100 000' and '2025 out 10 08:11:34'. The bottom status bar shows 'Receiving IC910 Q65-60E 0.0 Last Tx: RW3BP DL7YC -16'.

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]

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

The screenshot shows the WSJT-X v3.0.0-rc1 interface. The top section displays 'Single-Period Decodes' and 'Average Decodes' tables. The 'Single-Period Decodes' table has columns for UTC, dB, DT, Freq, and Message. It shows several entries for DL7YC RW3BP KO85 q3 with a distance of [3808 km]. The 'Average Decodes' table shows similar entries. Below the tables are various controls including 'Log QSO', 'Monitor', 'Erase', 'Clear Avg', 'Decode', 'Enable Tx', 'Halt Tx', 'Tune', and 'Menus'. A central display shows '76 032.100 000' and '2025 out 10 08:11:34'. The bottom status bar shows 'Receiving IC910 Q65-60E 0.0 Last Tx: RW3BP DL7YC -16'.

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]

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

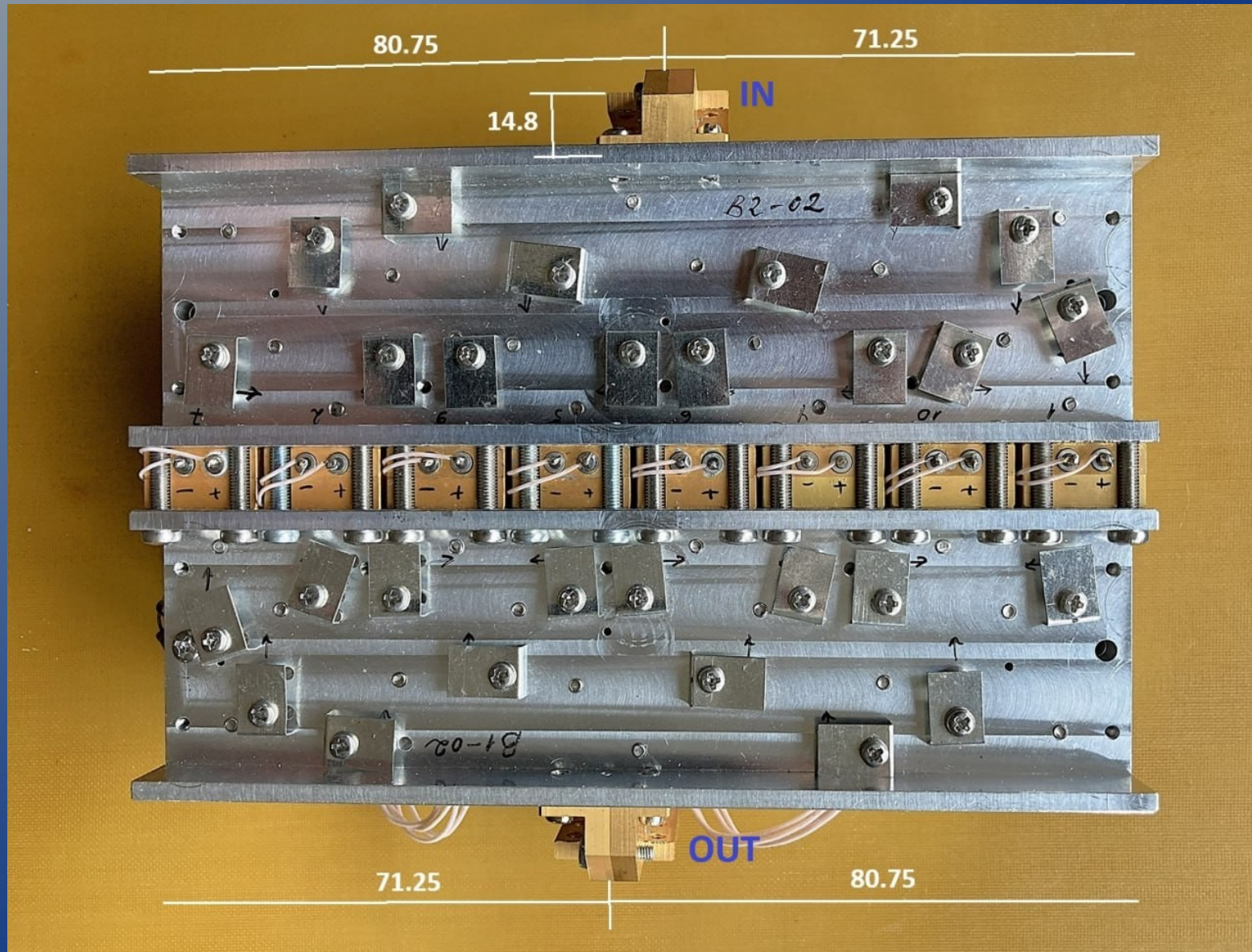
More Important Insights Gained

- **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



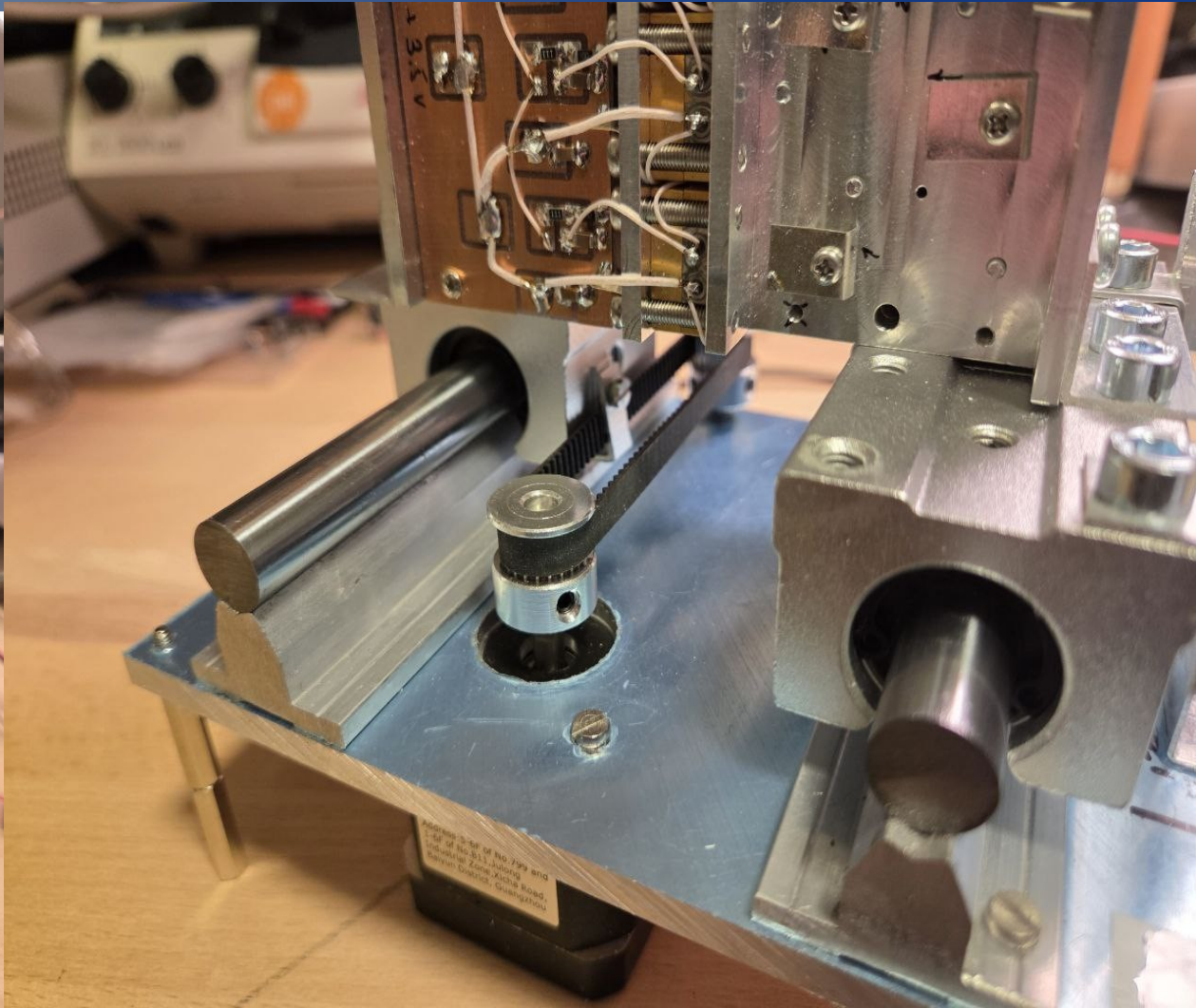
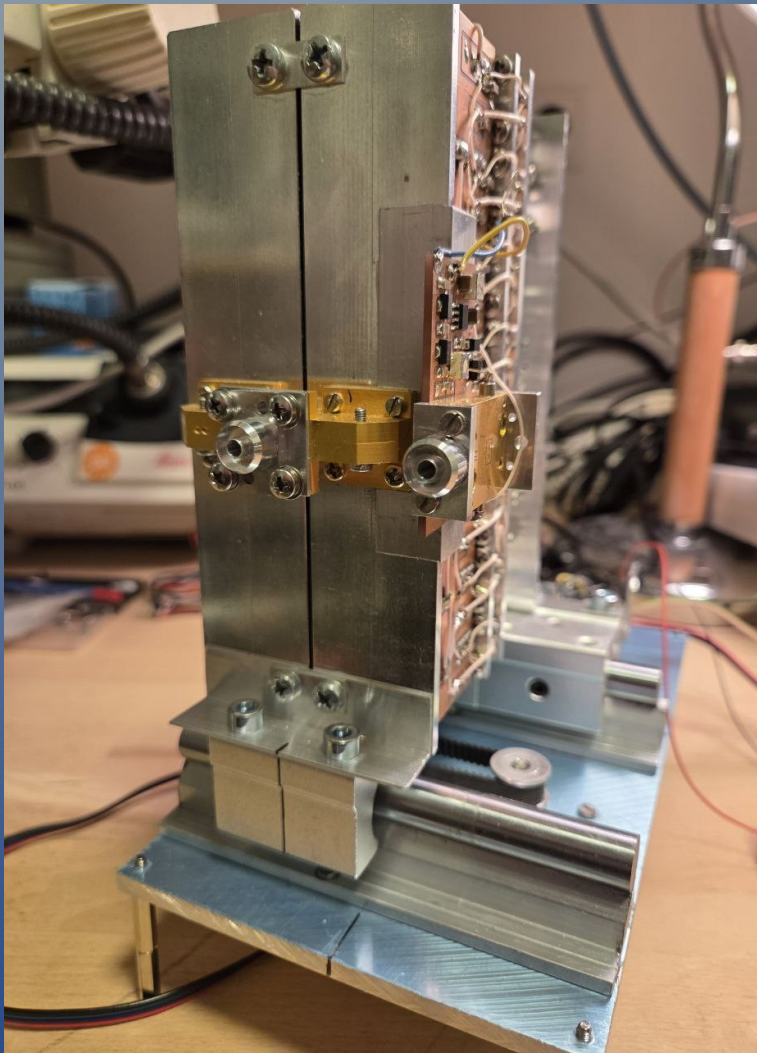
System Integration

- 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.

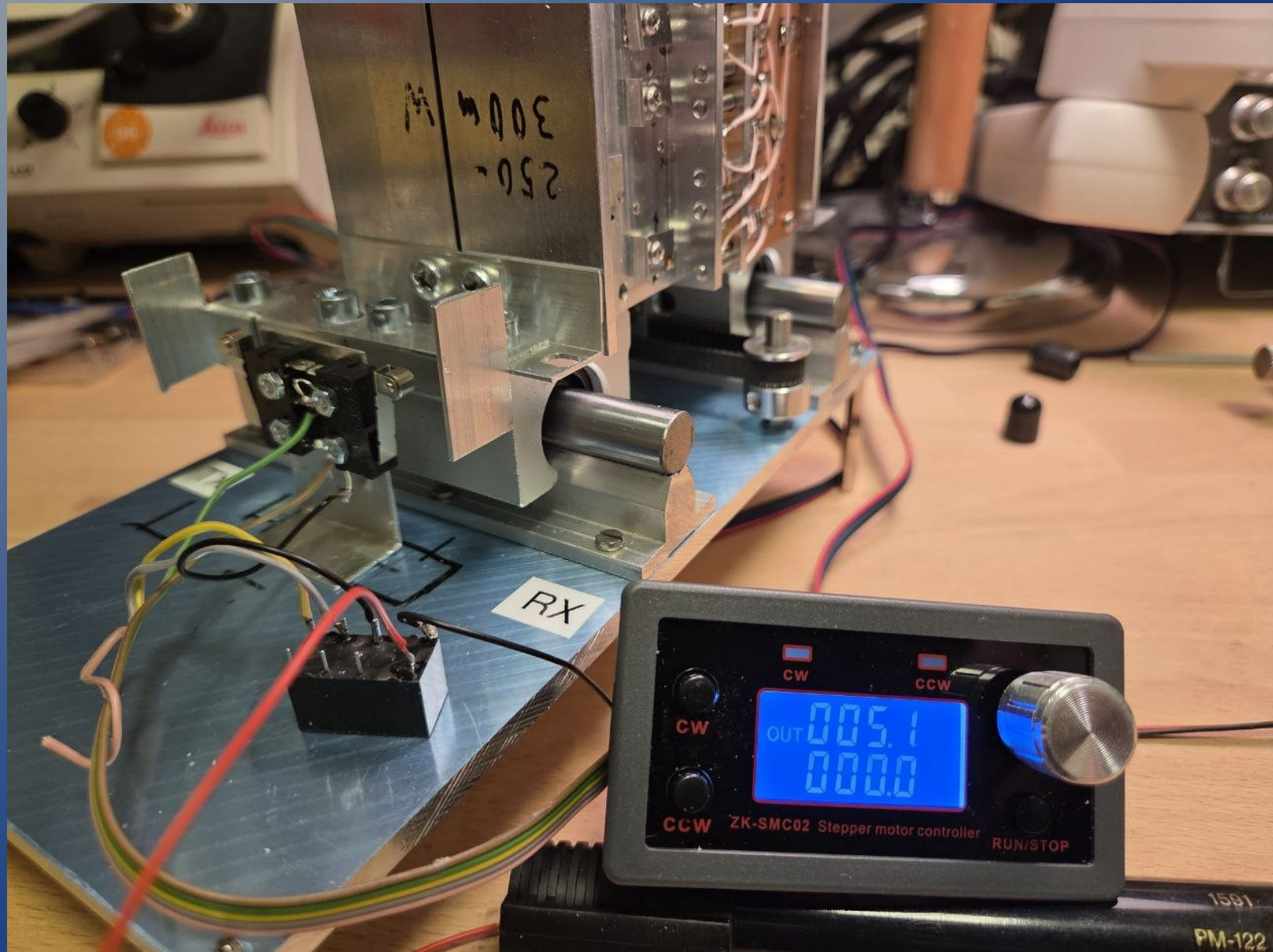
Tx and RX Ball Bearing Mounted



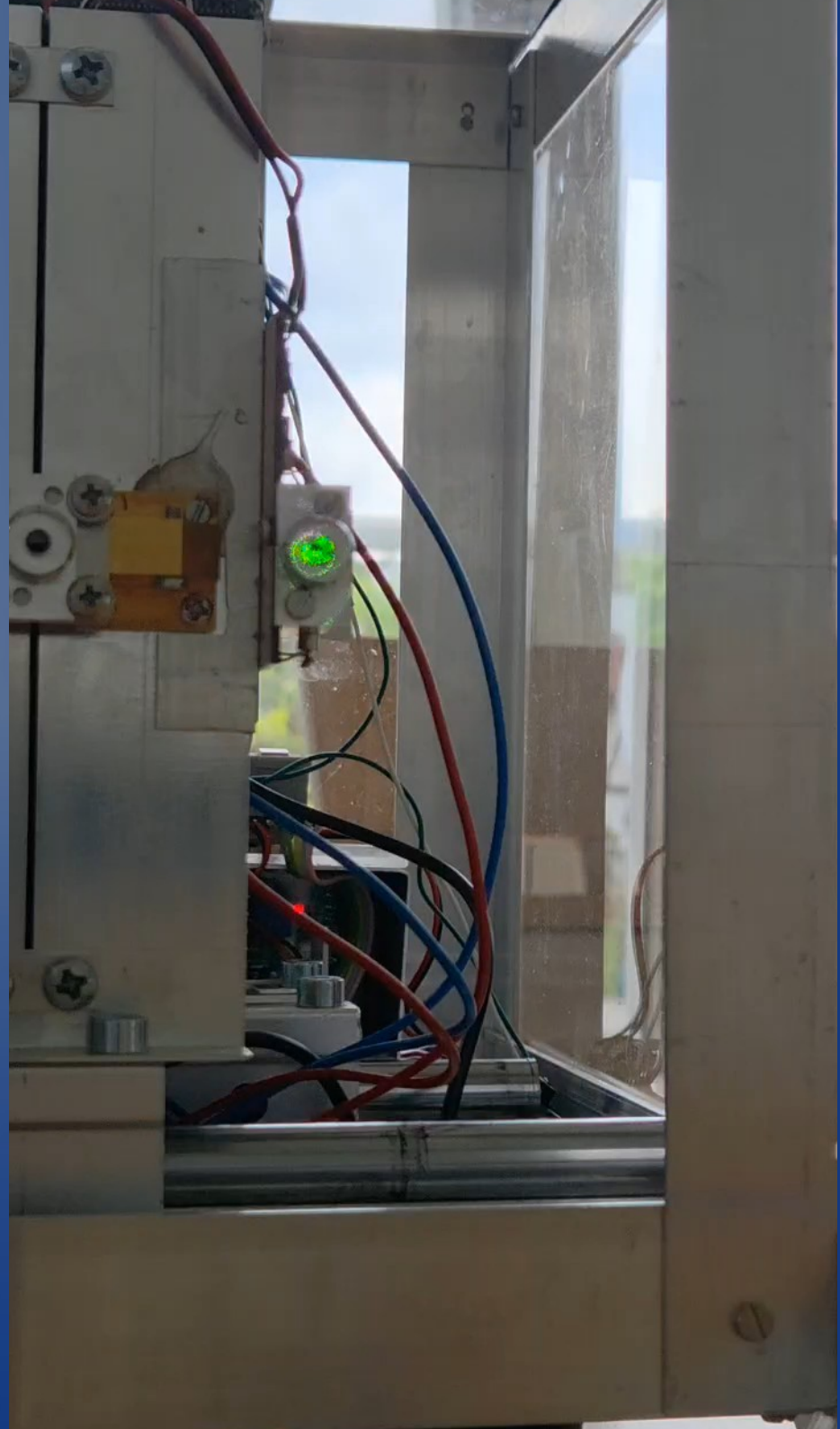
System Integration at DL7YC

- 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

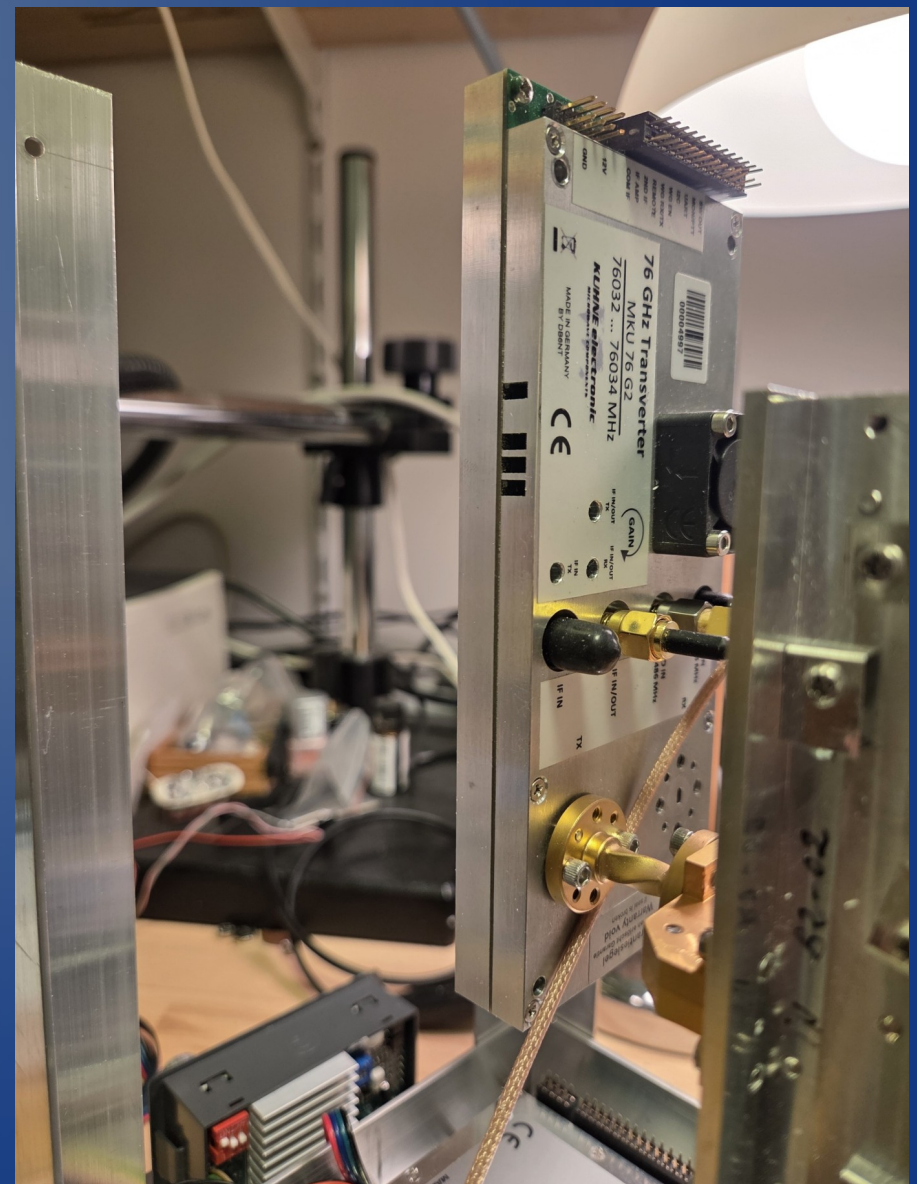
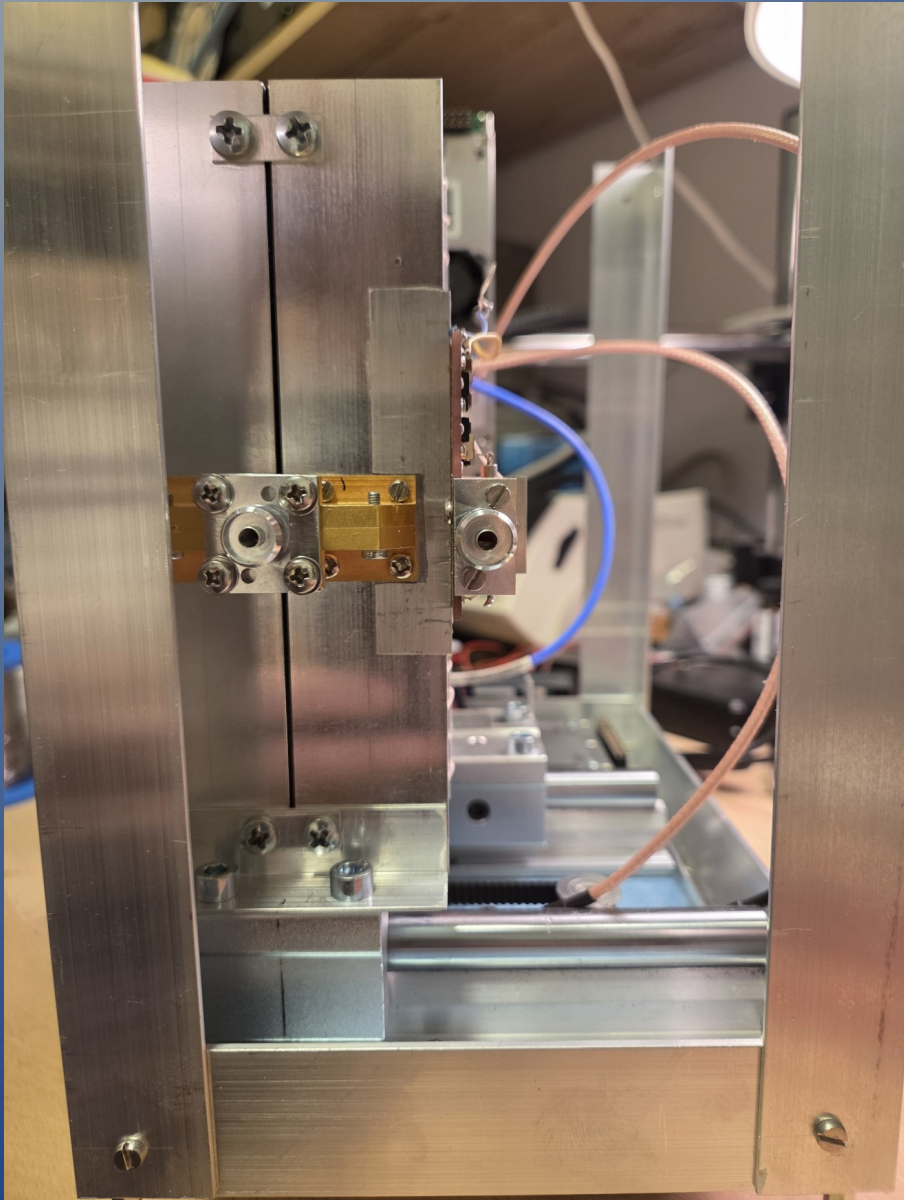
Motordriver Unit using End Switches



Precision TX/ RX
Move in $<800\text{mS}$
at DL7YC



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

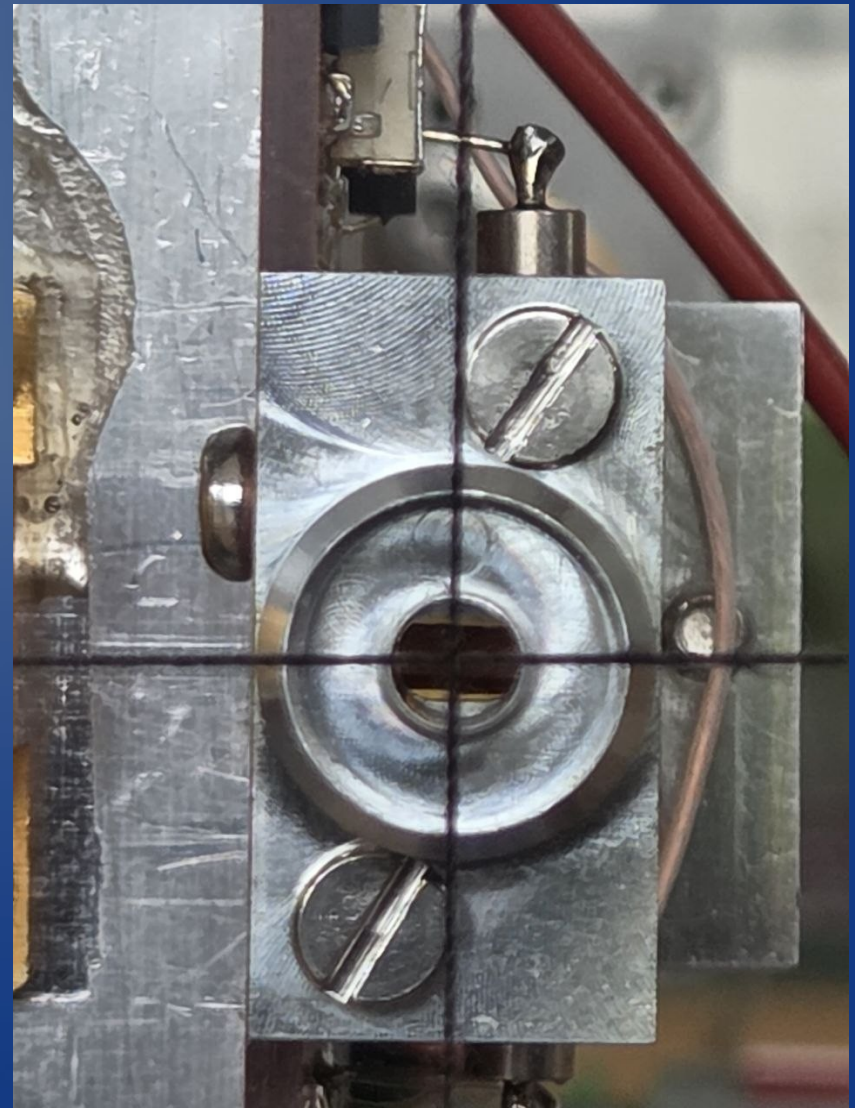
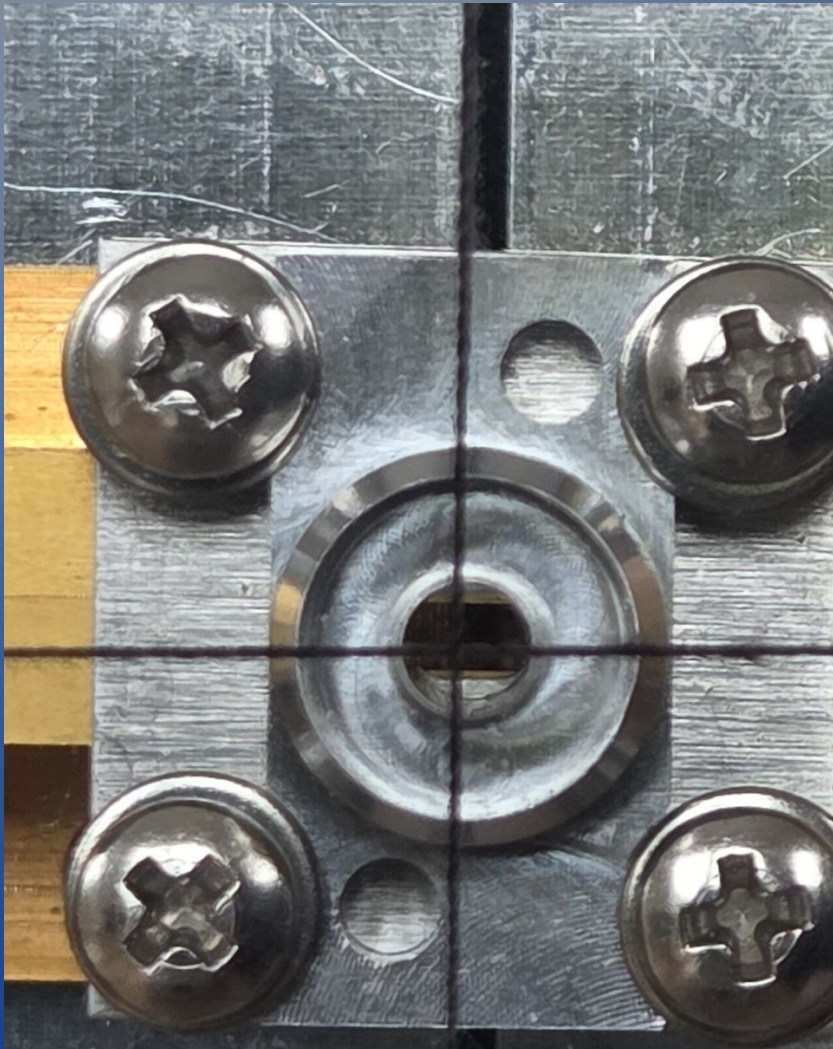
System Integration at DL7YC

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

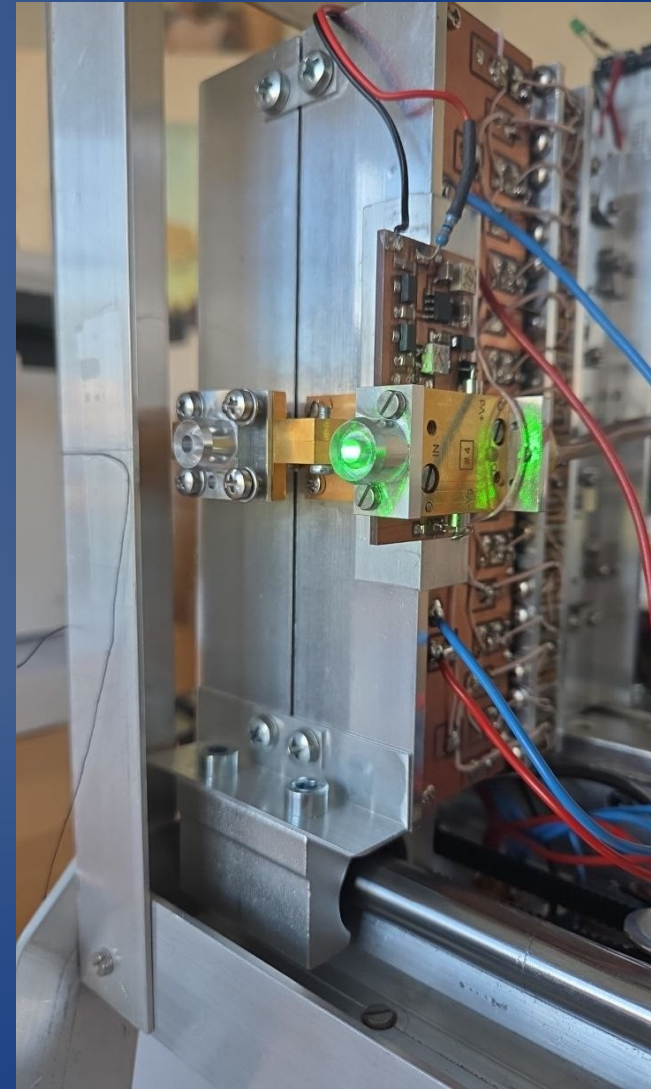
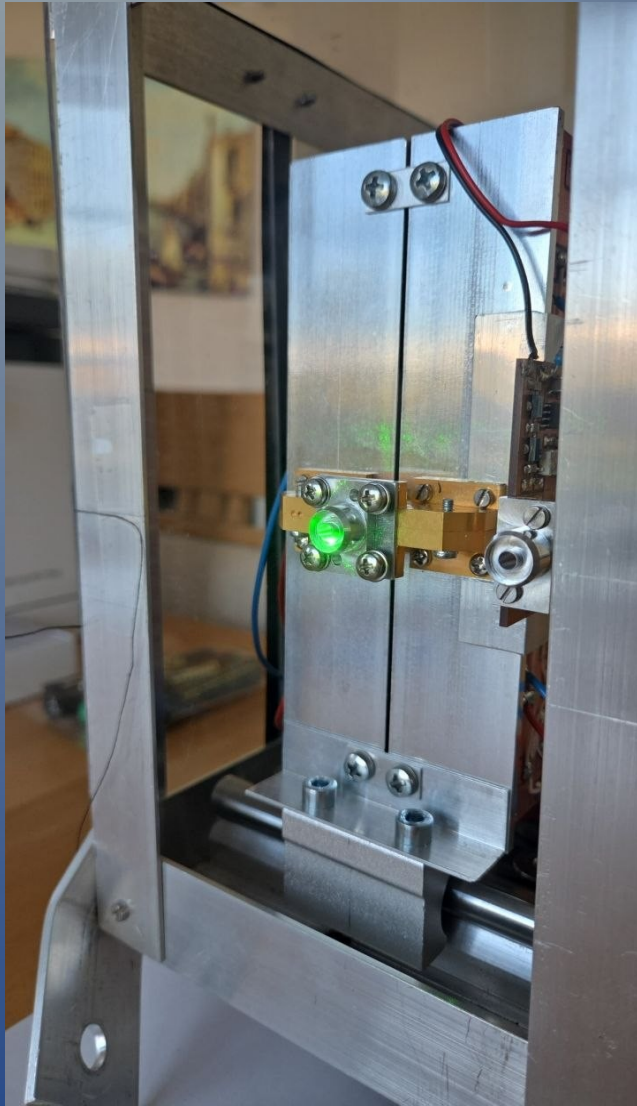
- Example of a slight **misalignment** of feeds



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:

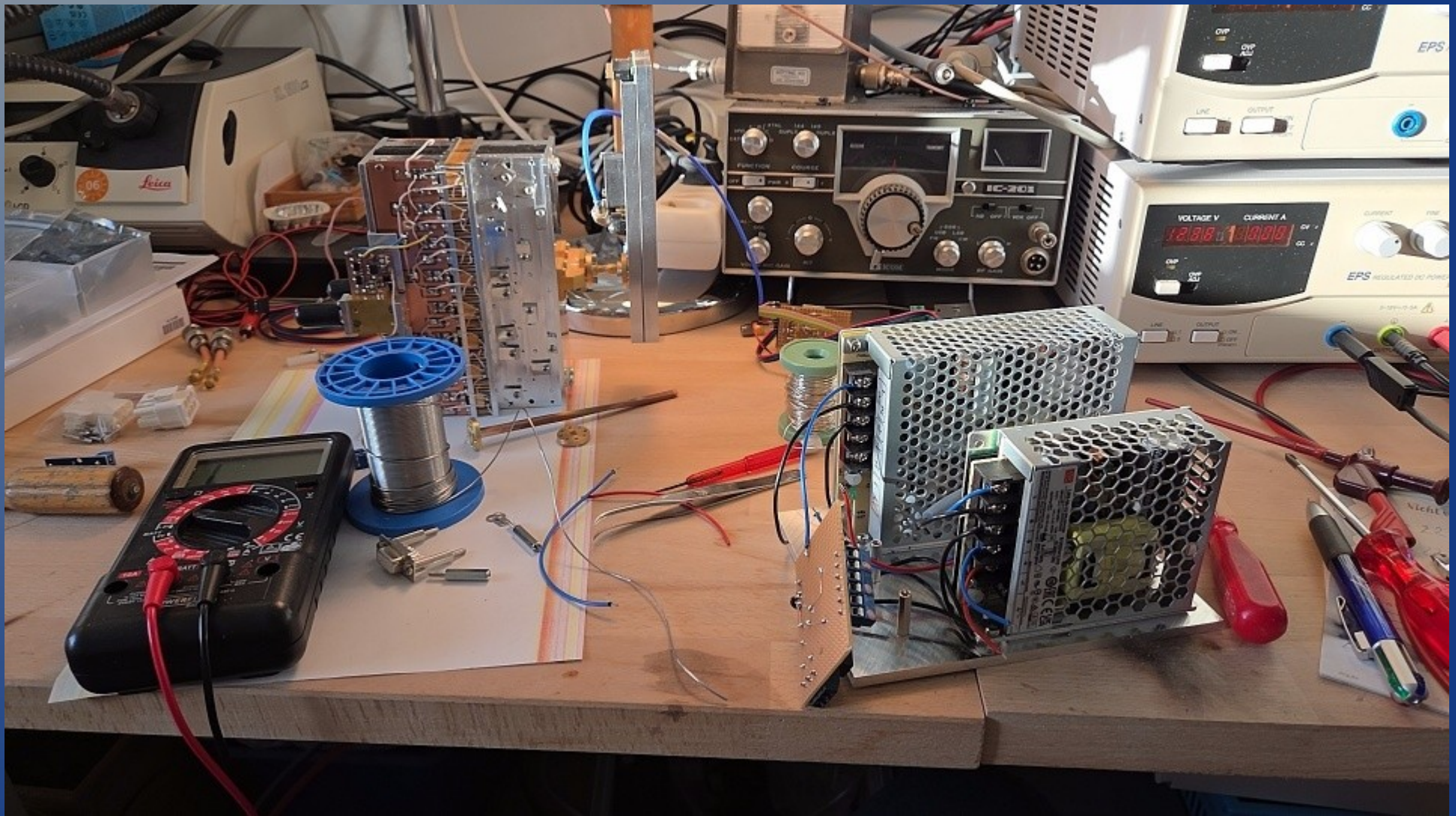
Loss = 0.5 dB	$\Delta = 0.16$ mm
Loss = 1.0 dB	$\Delta = 0.27$ mm
Loss = 2.0 dB	$\Delta = 0.45$ mm
Loss = 3.0 dB	$\Delta = 0.60$ mm

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

The screenshot displays the WSJT-X v2.7.0 interface. The top section is divided into two tables: 'Single-Period Decodes' and 'Average Decodes'. Both tables list decoded messages with columns for UTC, dB, DT, Freq, and Message. The 'Single-Period Decodes' table shows a list of messages from DL7YC RW3BP K085 q3, with a red background. The 'Average Decodes' table shows a list of messages from RW3BP DL7YC JO62, with a yellow background. Below the tables are control buttons: Log QSO, Stop, Monitor (highlighted in green), Erase, Clear Avg, Decode, Enable Tx, Halt Tx, and Tune. The bottom section features a frequency display showing 76.032,152 680, a signal strength indicator, and various control options like Tx even/1st, Tx 700 Hz, F Tol 200, Rx 700 Hz, Report -18, T/R: 60 s, Sh, Auto Seq, and Tx6. A 'Generate Std Msgs' panel is also visible, listing messages like RW3BP DL7YC JO62, RW3BP DL7YC -18, RW3BP DL7YC R-18, RW3BP DL7YC RR.73, RW3BP DL7YC 73, and CQ DL7YC JO62. The bottom status bar shows 'Receiving', 'Default - Copy', 'Q65-40E', 'Last Tx: RW3BP DL7YC JO62', '0 4', and '17/60 WD-59m'.

UTC	dB	DT	Freq	Message
0830	-18	2.5	713	: DL7YC RW3BP K085 q3
0832	-17	2.5	705	: DL7YC RW3BP K085 q3
0834	-17	2.5	697	: DL7YC RW3BP K085 q3
0836	-17	2.5	713	: DL7YC RW3BP K085 q3
0838	-17	2.5	707	: DL7YC RW3BP K085 q3
0840	-16	2.5	685	: DL7YC RW3BP K085 q3
0842	-16	2.5	687	: DL7YC RW3BP K085 q3
0844	-17	2.5	695	: DL7YC RW3BP K085 q3
0846	-17	2.5	702	: DL7YC RW3BP K085 q3
0848	-16	2.5	693	: DL7YC RW3BP K085 q3
0854	-16	2.5	725	: DL7YC RW3BP K085 q3
0856	-17	2.5	713	: DL7YC RW3BP K085 q3
0900	-16	2.5	697	: DL7YC RW3BP K085 q3
0902	-16	2.5	700	: DL7YC RW3BP K085 q3
0904	-16	2.6	690	: DL7YC RW3BP K085 q3

UTC	dB	DT	Freq	Message
084300	Tx		700	: RW3BP DL7YC JO62
0844	-17	2.5	695	: DL7YC RW3BP K085 q3
084500	Tx		700	: RW3BP DL7YC JO62
0846	-17	2.5	702	: DL7YC RW3BP K085 q3
084700	Tx		700	: RW3BP DL7YC JO62
0848	-16	2.5	693	: DL7YC RW3BP K085 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 K085 q3
085500	Tx		700	: RW3BP DL7YC JO62
0856	-17	2.5	713	: DL7YC RW3BP K085 q3
085700	Tx		700	: RW3BP DL7YC JO62
085900	Tx		700	: RW3BP DL7YC JO62
0900	-16	2.5	697	: DL7YC RW3BP K085 q3
0902	-16	2.5	700	: DL7YC RW3BP K085 q3
0904	-16	2.6	690	: DL7YC RW3BP K085 q3

The Day of the QSO

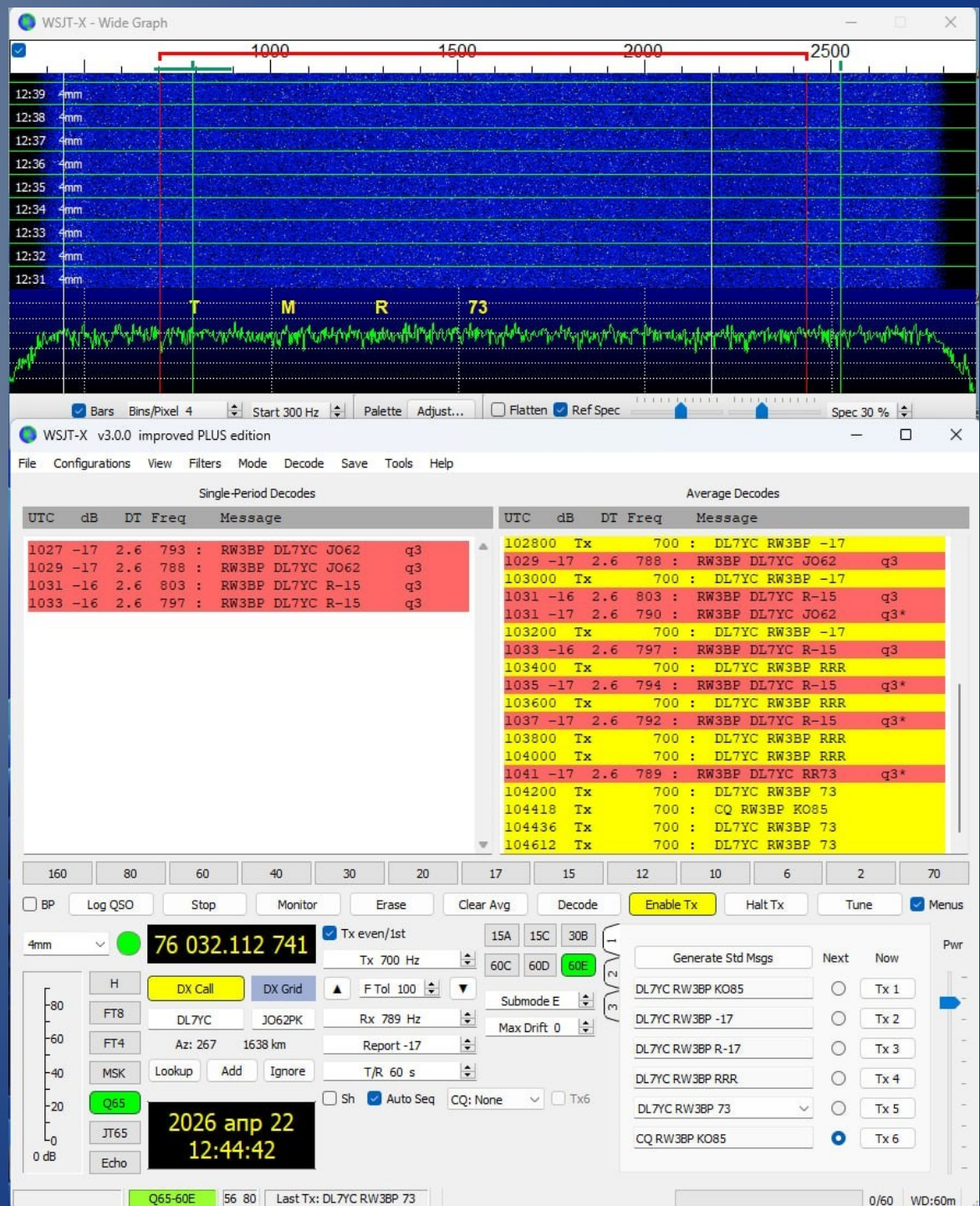
Third attempt was a 0.1 deg move to the West side at **RW3BP`s** RX period with **Sucessful decoding DL7YC`s report -17 !!!!**

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 completed !

- This is a 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**

The screenshot displays the WSJT-X v3.0.1 interface. The main window is divided into two panes: 'Single-Period Decodes' on the left and 'Average Decodes' on the right. Both panes show a list of decoded messages with columns for UTC, dB, DT, Freq, and Message. The messages are highlighted in red. Below the panes is a control panel with various buttons and settings. The 'Decode' button is highlighted in green. The 'Generate Std Msgs' section is also visible, showing a list of message templates. The status bar at the bottom indicates the current file is '260422_1100.wav' and the frequency is 'Q65-60E 11.4'.

UTC	dB	DT	Freq	Message
1006	-21	2.5	690	DL7YC RW3BP K085 q3 [3808 km]
1030	-23	2.5	682	DL7YC RW3BP -17 q3
1032	-21	2.5	693	DL7YC RW3BP -17 q3
1034	-21	2.5	688	DL7YC RW3BP RRR q3

UTC	dB	DT	Freq	Message
1006	-21	2.5	690	DL7YC RW3BP K085 q3
1012	-22	2.5	688	DL7YC RW3BP K085 q33
1020	-21	2.5	677	DL7YC RW3BP K085 q34
1026	-22	2.5	677	DL7YC RW3BP K085 q33
1030	-23	2.5	682	DL7YC RW3BP -17 q3
1032	-21	2.5	693	DL7YC RW3BP -17 q3
1034	-21	2.5	688	DL7YC RW3BP RRR q3
1038	-20	2.5	662	DL7YC RW3BP RRR q32

Final Results

9.2 dB Added Noise gave the following result!

The screenshot shows the WSJT-X v3.0.1 interface. The 'Average Decodes' window displays two entries:

UTC	dB	DT	Freq	Message
1024	-24	2.5	677	DL7YC RW3BP K085 q3*
1032	-24	2.5	685	DL7YC RW3BP -17 q3#

The interface also shows a frequency display of 76 032.100 000, a signal strength of -90 dB, and various control buttons like 'Decode', 'Enable Tx', and 'Halt Tx'. The status bar at the bottom indicates '260422_1100.wav', 'IC910', 'Q65-60E', '14.4', and '0/60 VID:60m'.

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?