EME
Earth-Moon-Earth

"You may think it's a long way down the road to the chemist's but that's just peanuts to space!"
-Douglas Adams

Sam - WB6RJH
SLV ARC - 4 February 2022

"It was dusk when he returned to the little room. A hundred miles above his head, tenuous and invisible, the Heaviside Layer would be expanding outward toward the stars as the sun went down. So it had done every evening for millions of years, and for half a century only, Man had used it for his own purposes, to reflect around the world his messages of hate or peace, to echo with trivialities or to sound with music once called immortal."

–Arthur C Clarke, "The Forgotten Enemy", 1949

"An ambassador is shot by a would-be assassin. To remove the bullet, a surgeon needs to consult a colleague on a cruise ship in the Pacific. Scientists bounce a TV signal off the moon to the ship so he can watch and direct the operation."

Science Fiction Theatre, "Signals from the Moon", S2-E29, 1956
IMDB: In this science-fiction anthology series host Truman Bradley introduces stories extrapolated from actual scientific data available in the 1950s, concentrating on such concepts as space flight, UFO's and mental telepathy.
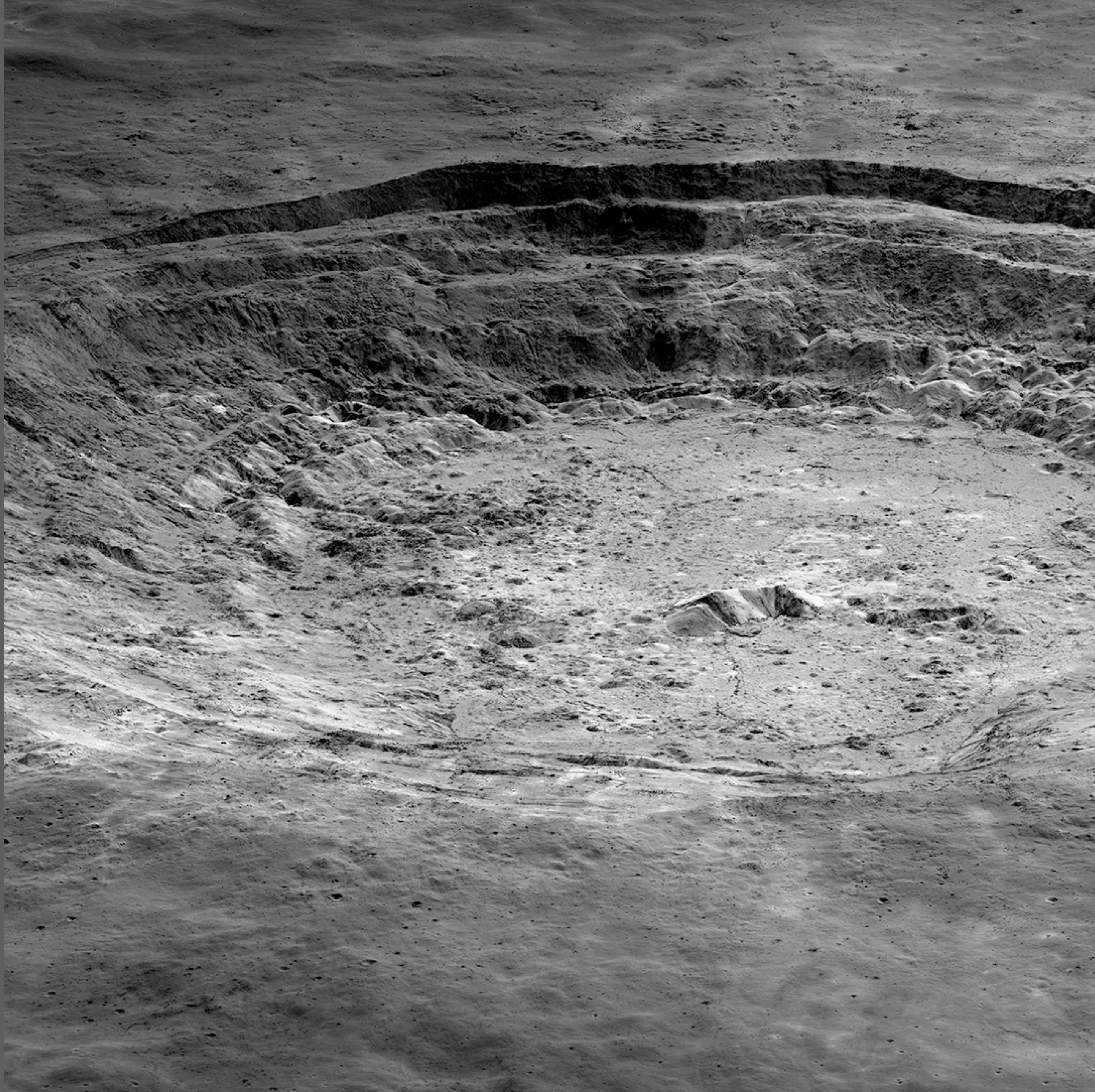
EME is hard

- Massive path loss - order of 250dB, this practically defines "weak signal work"

- Doppler shift - Moon-Earth as well as Earth's rotation

- Polarization - atmospheric "Faraday rotation", geometry

- Radio astronomy - "degradation" from background sources, Milky Way especially

- Contest - of course there are EME contests! But it's helpful to beginners, too.

- Amateur protocols - mainly JT65, Q65, in WSJT-X and others

- Challenge for its own sake - education and engineering challenge, "everything I know"

- Foretold by my 4Runner's license plate assigned in 2003 having "EME" in it

Bands

- 6m, 2m, 1.25m, 70cm, 23cm, and up-up-up

- I'm only doing 2m — for now!

- 6m EME can take some very serious antenna construction - see W6UC's page on QRZ

- 2m seems most popular, especially at the entry level

- once you get to 23cm you're getting into the territory of dishes and waveguides, but yagis are still viable

Power restrictions on 70cm

- California has geographical restrictions - Pave PAWS military radar

- Beale AFB and Pt Mugu installations

- Waivers required to exceed 50W in certain areas, including most of SLV

- But if you're directing most all your power up…well, it still matters

- See the ARRL website for more info

Equipment

- Every tenth of a dB matters! Don't use so-called "UHF" connectors above 6m

- Good weak signal rig desirable - but older equipment can be made to work

- As much power as you can muster, long TX cycles derate amplifier output

- LNA - Low Noise Amplifier, the best pre-amp(s) you can get/afford

- Low loss transmission lines - LMR-400 a bare minimum, Heliax preferred

- May have multiple runs of coax, e.g., one for TX plus two for H and V receive, with relays

- May have LNAs and even power amp out at the antennae

- Array of antennae with phasing harness and power splitter

- Az-El rotator system and tracking software (optional, at least initially)

- More optional gear than you can imagine, especially for dealing with polarization

If you start out small, look for the big dogs
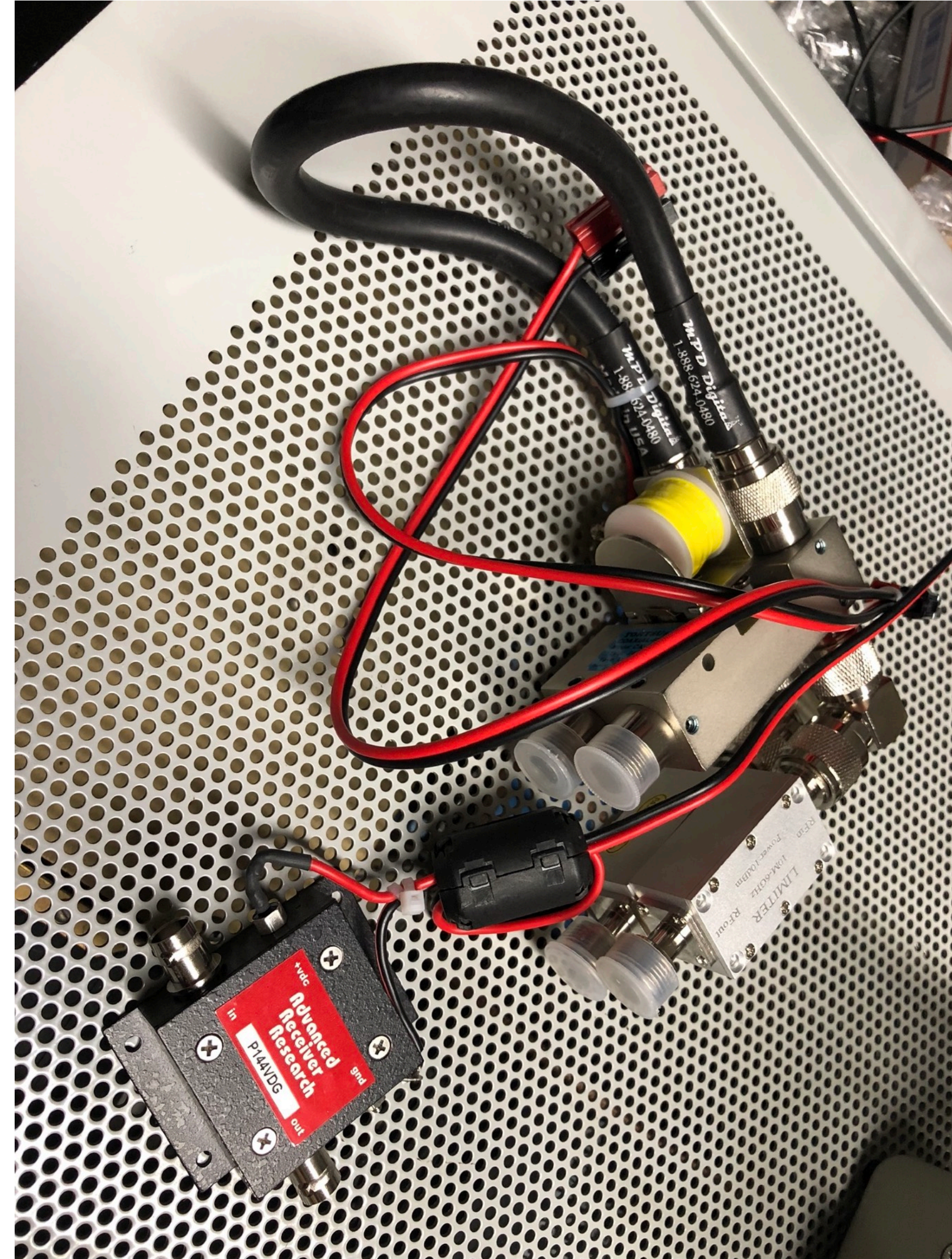
My little puppy "array"

Cross-boom, phasing harness, power splitter, LNA

Making a phasing harness

- Match the cables to a couple degrees (e.g., 1-2 cm on 2m)

- Must be electrically matched, not just physically

- Build or buy

- Use something like a NanoVNA

- See "how to" pages on the net, see Resources at end; it's a bit tricky and takes some trial and error

# LNAs, pre-amps, lumps of coal

2m QRO, you betcha! Upgrade on order

The rig

- My primary: IC-9700 (built-in sequencer and bias-tee)

- My backup: TS-2000 (needs a bunch of help, but usable)

- An external sequencer may be needed depending on the complexity of your setup, for control of antenna relays, pre-amp, linear, transmitter

- "Sidecar" SDRs commonly used, even for primary receiver, but also for simultaneous reception of H and V polarization

Sequencing example - W6PQL
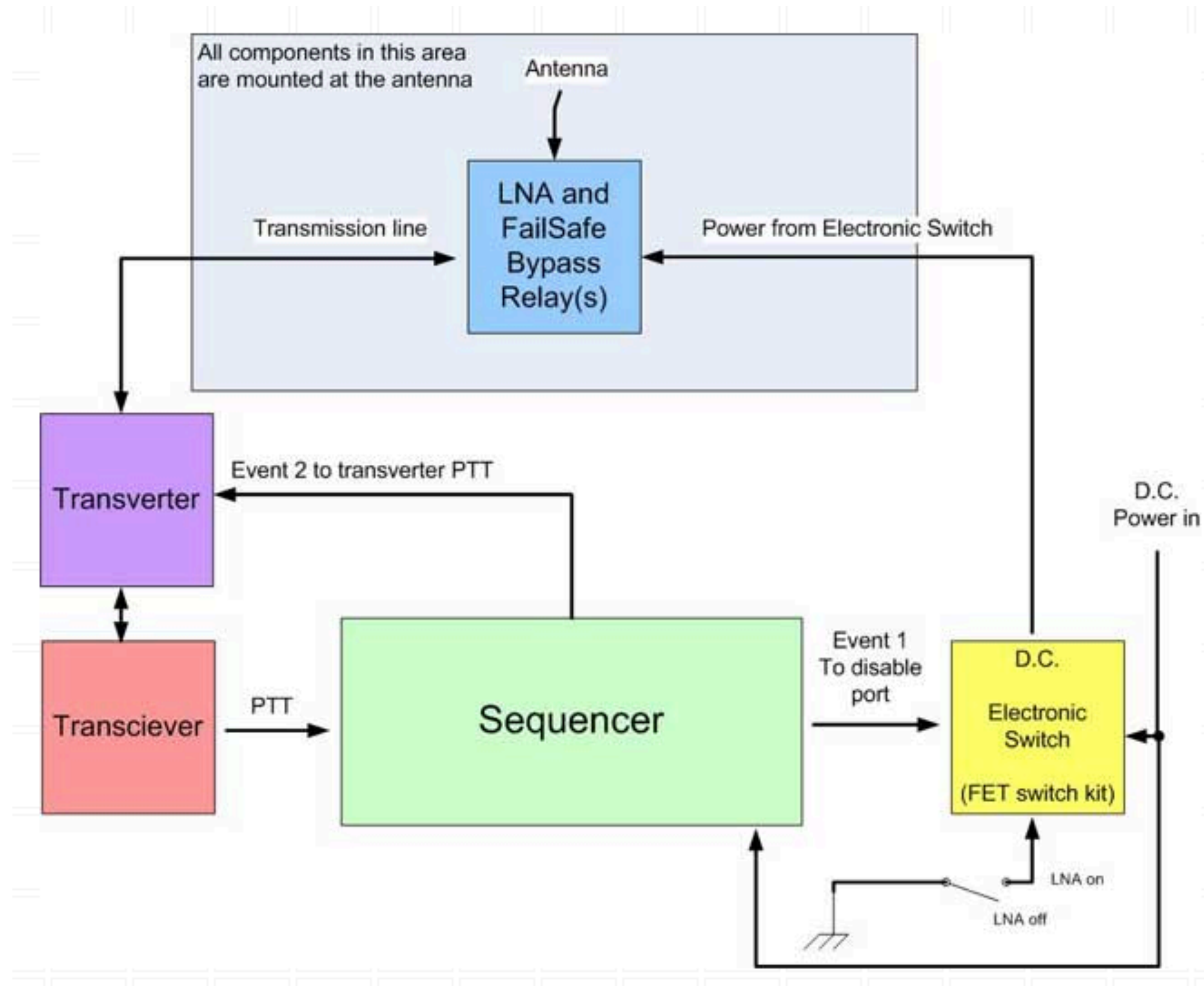
Accuracy vs Stability

- Absolute time accuracy similar to FT8

- Note specific DT for EME vs terrestrial - about 2.5 vs 0.5

- Frequency accuracy nice, stability a bigger issue - GPSDO can help both

- Long transmissions challenge rig's thermal stability

- Everyone has to deal with Doppler drift

- Doppler computations included in various software packages

- Settings and usage of software very important

Methods of Coordination

- The Internet, of course!

- It's fairly unlikely to make random EME contacts, unless you've got a big signal and call CQ a lot on the most common frequencies

- Even with coordination, it may take a while for you to get decoded, due to polarization rotation, software averaging, etc.

- If someone knows you're calling CQ, they can get better decoding by entering your callsign in the DX field to give the software some help

- Practically everyone announces on EME-1 (see the Resources page), including during contests

What it looks like in WSJT-X
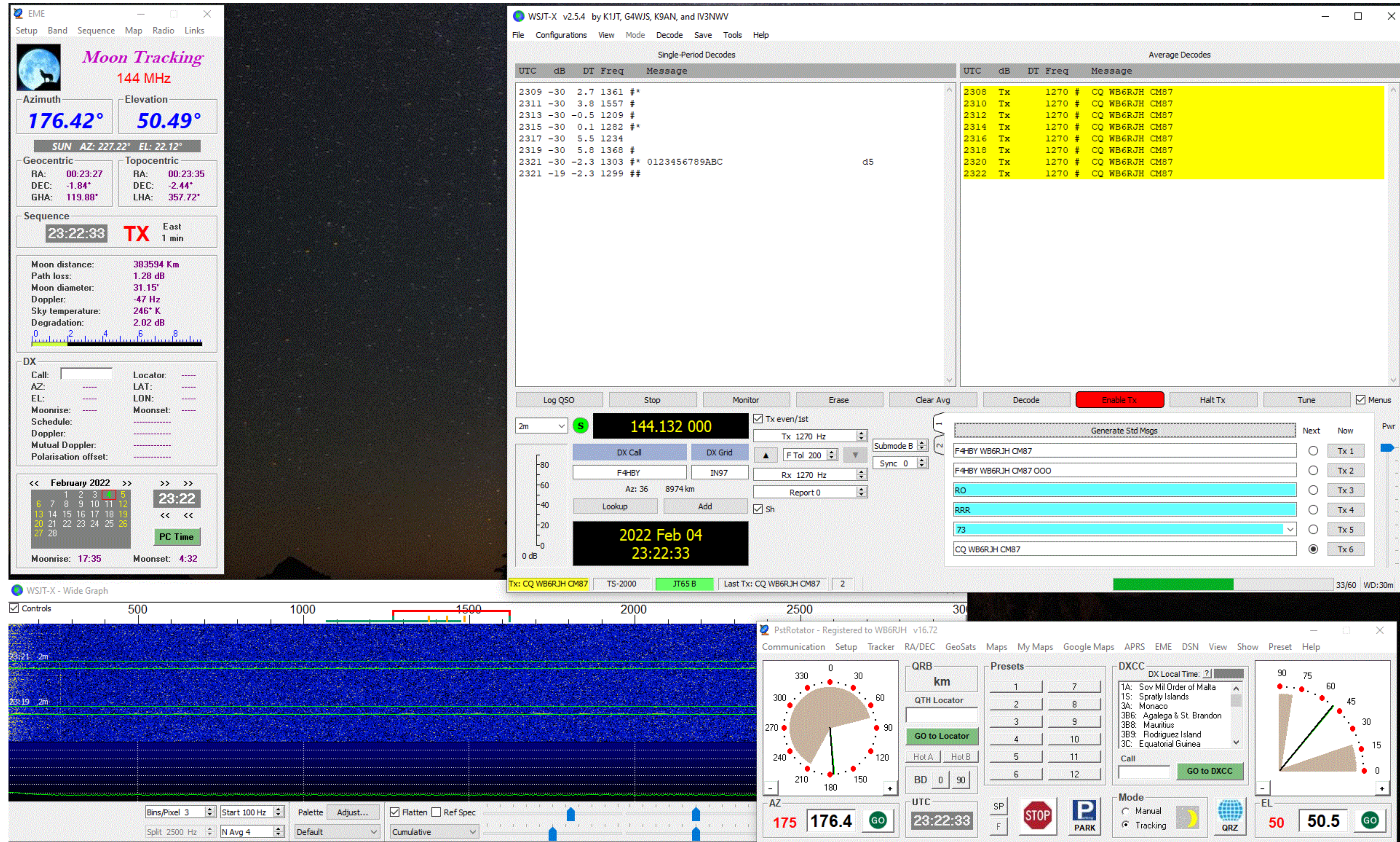
```
UTC   dB   DT  Freq    Message
0812 -30 -3.3 1106  #*
0814 -27 -2.4 1120  #*
0816 -23  2.6 1117  #*  WB6RJH EB5EEO IM98                    f
0816 -21  2.6 1114  ##
0818 -23  2.6 1115  #*  WB6RJH EB5EEO IM98                    f
0818 -18  2.6 1118  ##
0820 -24  2.6 1114  #*  WB6RJH EB5EEO IM98                    f
0820 -20  2.6 1111  ##
0822 -26  2.6 1112  #*  WB6RJH EB5EEO IM98                    d*
0822 -20  2.6 1115  ##
0824 -25  2.5 1111  #*  WB6RJH EB5EEO IM98                    f
0824 -18  2.5 1110  ##
0826 -23  2.6 1109  #*  WB6RJH EB5EEO IM98                    f
0826 -19  2.6 1108  ##
0828 -25  2.6 1108  #*  CQ EB5EEO IM98                        f
0828 -22  2.5 1110  ##
0830 -30 -0.3 1395  #*
0832 -30  3.0 1397  #*
0834 -30  4.9 1170  #*
0836 -30  5.7 1194  #
0838 -30 -0.7 1025  ##
0840 -25  2.7 1121  #*  WB6RJH DL8II JN49                     f
0840 -27  2.6 1121  ##
0842 -22 -0.8 1116  #   RO
0844 -22  5.9 1110  #   73
0846 -30  4.8 1141
```

```
UTC   dB   DT  Freq    Message
0802 -23  2.6 1122  #*  CQ EB5EEO IM98                        f
0803 Tx       1270  #   EB5EEO WB6RJH CM87
0805 Tx       1270  #   EB5EEO WB6RJH CM87
0807 Tx       1270  #   EB5EEO WB6RJH CM87
0809 Tx       1270  #   EB5EEO WB6RJH CM87
0811 Tx       1270  #   EB5EEO WB6RJH CM87
0813 Tx       1270  #   EB5EEO WB6RJH CM87
0815 Tx       1270  #   EB5EEO WB6RJH CM87
0817 Tx       1270  #   EB5EEO WB6RJH CM87 OOO
0819 Tx       1270  #   EB5EEO WB6RJH CM87 OOO
0821 Tx       1270  #   EB5EEO WB6RJH CM87 OOO
0823 Tx       1270  #   EB5EEO WB6RJH CM87 OOO
0825 Tx       1270  #   EB5EEO WB6RJH CM87 OOO
0827 Tx       1270  #   EB5EEO WB6RJH CM87 OOO
0829 Tx       1270  #   CQ WB6RJH CM87
0831 Tx       1270  #   CQ WB6RJH CM87
0833 Tx       1270  #   CQ WB6RJH CM87
0835 Tx       1270  #   CQ WB6RJH CM87
0837 Tx       1270  #   CQ WB6RJH CM87
0839 Tx       1270  #   CQ WB6RJH CM87
0840 -27  2.6 1121  ##  0123456789ABC OOO                   d*7
0841 Tx       1270  #   DL8II WB6RJH CM87 OOO
0843 Tx       1270  #   RRR
0845 Tx       1270  #   CQ WB6RJH CM87
0847 Tx       1270  #   CQ WB6RJH CM87
```

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

2m

144.132 000

☐ Tx even/1st

Tx 1270 Hz
▲ F Tol 50 ▼
Rx 1110 Hz
Report -25

Submode B
Sync 0

DX Call | DX Grid

DL8II | JN49

Az: 29   9285 km

Lookup | Add

☑ Sh

2022 Jan 22
08:47:56

Generate Std Msgs | Next | Now

DL8II WB6RJH CM87 | ○ | Tx 1
DL8II WB6RJH CM87 OOO | ○ | Tx 2
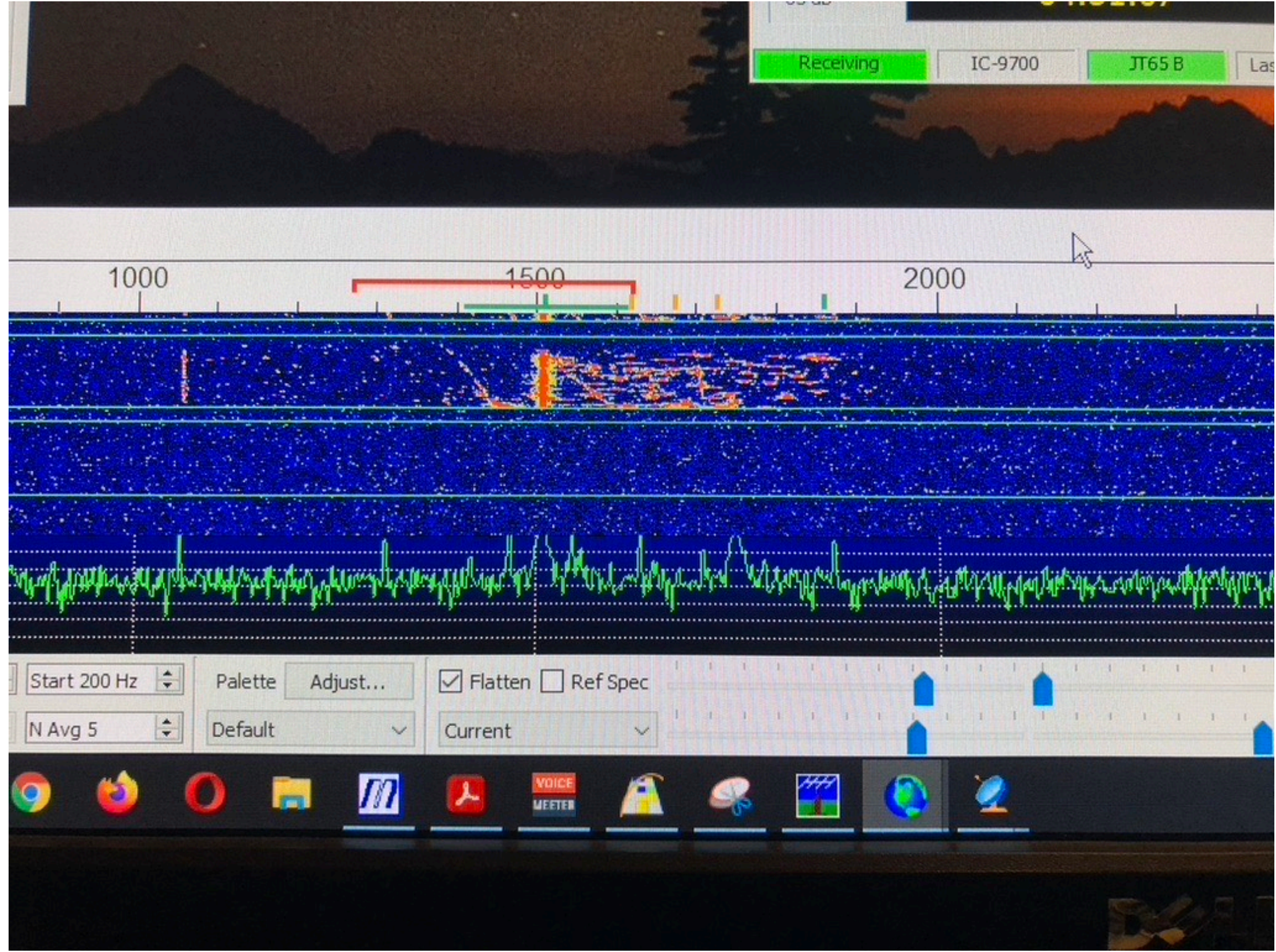RO | ○ | Tx 3
RRR | ○ | Tx 4
73 | ○ | Tx 5
CQ WB6RJH CM87 | ◉ | Tx 6

-80 -60 -40 -20 0

Just a beginner, but…

- Started a few months ago

- Initially was just able to copy a station with one beam

- Then got the amp, hooked up the second antenna and LNA

- High point was working about 15 stations in one contest evening

- How else do you work 2m grids in Europe?

- Looking forward to much more success and VUCC 2m

Any Questions?

Resources

- WSJT-X download: https://physics.princeton.edu/pulsar/k1jt/wsjtx.html

- EME with JT65: https://physics.princeton.edu/pulsar/K1JT/WA50_June05.pdf (especially note the photo at the end)

- EME-1 chat: https://www.chris.org/cgi-bin/jt65emeA

- Channel 5-eme on VHF-Chat group in Slack: vhf-chat.slack.com

- Great gear and info: http://www.w6pql.com/ especially on sequencing: http://www.w6pql.com/lna_sequencing_and_protection.htm

- Phase matching with NanoVNA: https://nuclearrambo.com/wordpress/make-your-own-phased-matched-cables-with-nanovna/

- ARRL, 70cm power limitation info: http://www.arrl.org/us270