

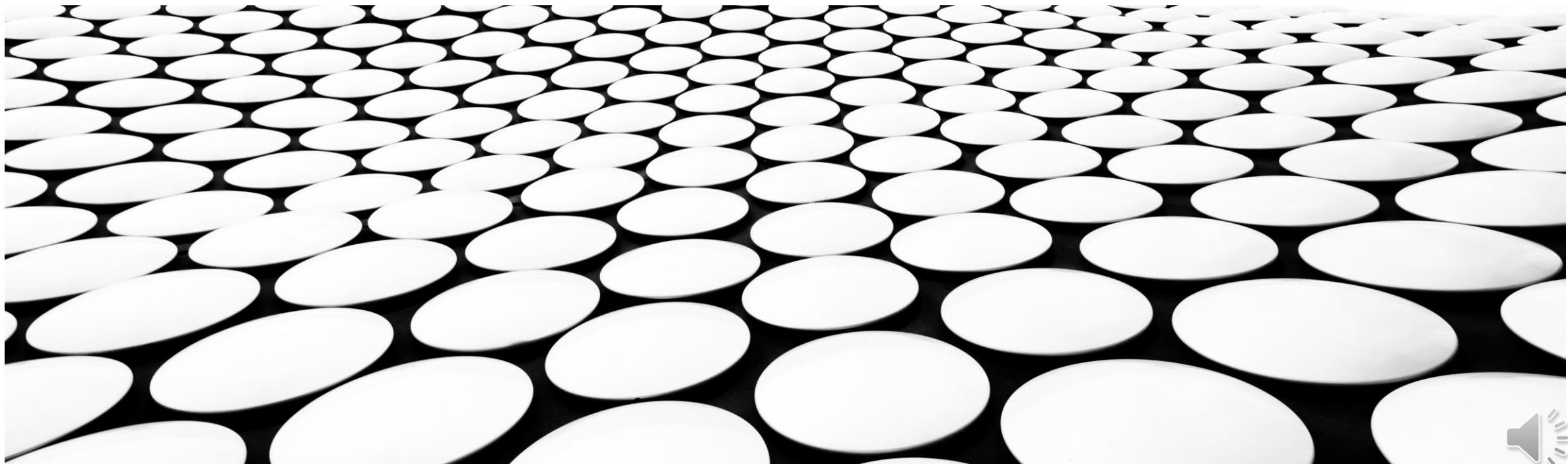
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# **GROUND STATION TEST TRANSCEIVER**

**By Ray, WA1CYB**

**SDR GROUND STATION TEST TRANSCEIVER WITH USB, LSB, AM, NBFM, WBFM & PACKET TELEMETRY**



# Ground Station Test Transceiver - Agenda

- What is this Ground Station Test Transceiver ?
- Architecture – Three Sections
  - Receiver flowgraph
  - Transmitter flowgraph
  - Telemetry flowgraph
- GUI displayed with a ADALM Pluto SDR
- Over the Air results as received on a ETTUS B205mini on SDR-Console software
- Discussion on finer points of Packet telemetry
- Same flowgraph modified for UHD, Ettus B205mini and why you need to modify it
- QT display , GRC 3.8.2 / 3.8.0 minor issues noted
- Discussion



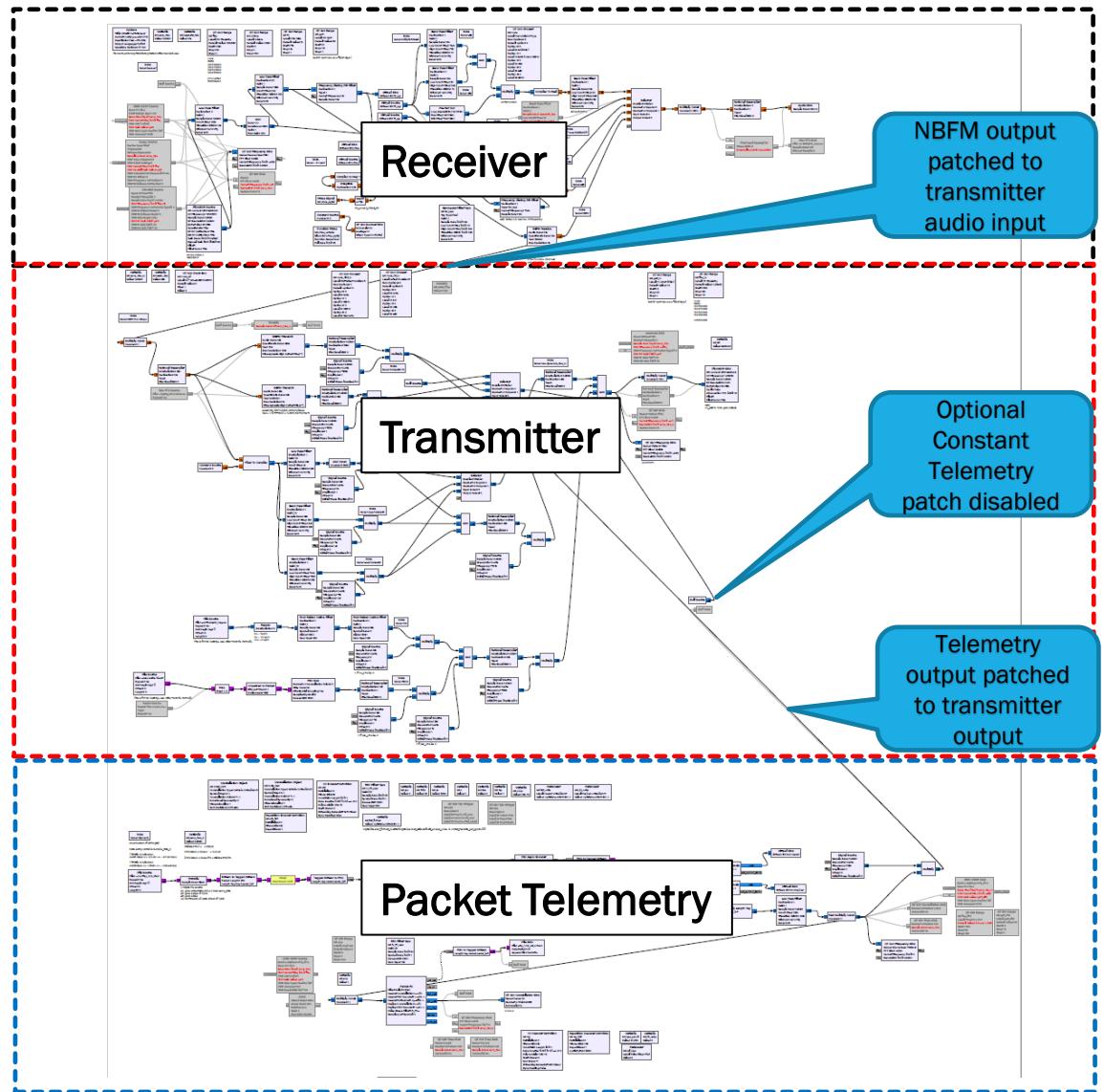
## DISCLAIMER, etc

- 1. This Flowgraph is used to test AMSAT GOLF Series Satellites currently under design**
  - 1. Modulation separation and bandwidths are arbitrary for this configuration**
- 2. Based on other peoples fine open source work.. THANKS !**
- 3. Easily modified for other uses**
- 4. It is architected to test external system operation of other hardware. GUI not set up for typical Ham transceiver operation. Hopefully this can provide a working starting point for those so inclined**
- 5. Set up with new ubuntu 20.04 install and pybombs GNU radio 3.8.2**
- 6. Several OOT's installed but were not used except for the particular SDR used. In this case the gr-iio**
- 7. My edited history file may help to see how to reconstruct the running system including resources added to monitor performance and connections**
- 8. I'm not a software person**



# Ground Station Transceiver Divided into 3 sections

- Each Section Developed Separately
- Receiver then Transmitter then Telemetry
- This Configuration Uses a single ADALM Pluto for both receiving and transmitting
- Maximum Packet Telemetry Rate determined after the receiver and transmitter were developed
- ADALM Pluto limited by USB-2 connection
  - note USB is 5% faster than using the ip context
  - *usbttop* used to determine max rate
  - ~16.555 MBps with 4.608 Msps sample rate
- More Bandwidth available if a 2<sup>nd</sup> SDR is used....
  - Examine disabled blocks... left to students



# Ground Station Transceiver Divided into 3 sections

Receiver →

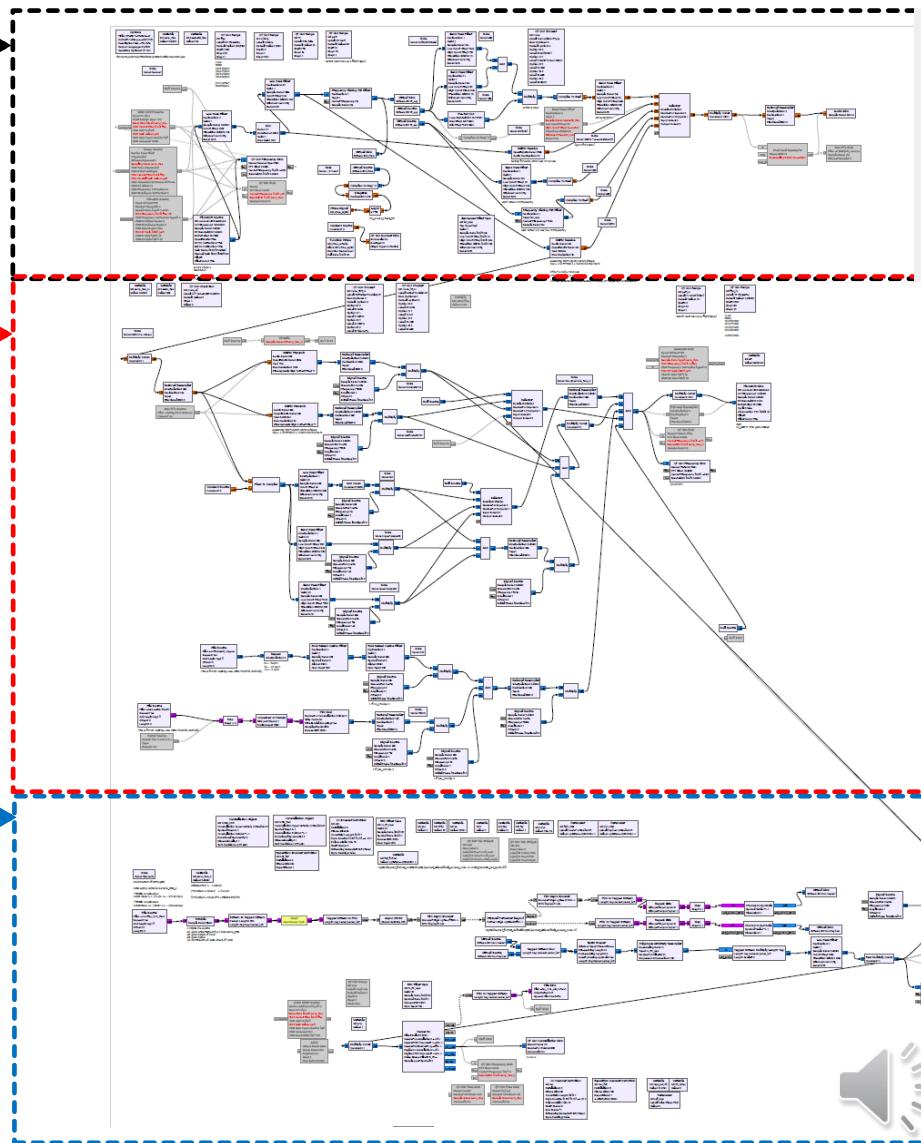
- LSB/USB/AM/NBFM/WBFM
- NBFM wired to Transmitter for testing convenience (NWS)

Transmitter →

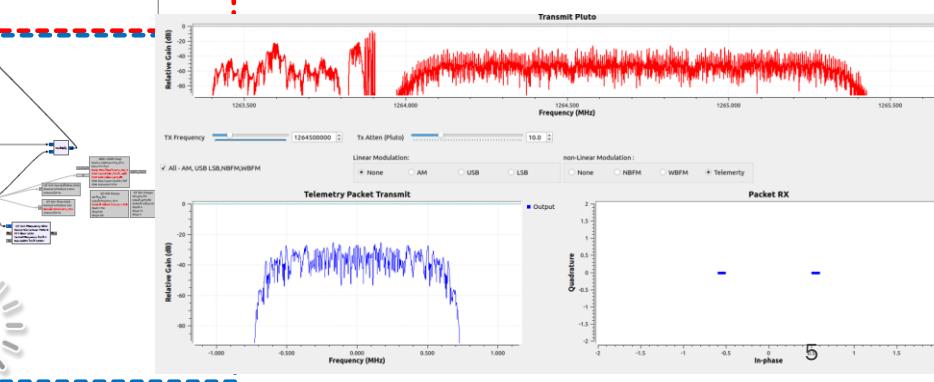
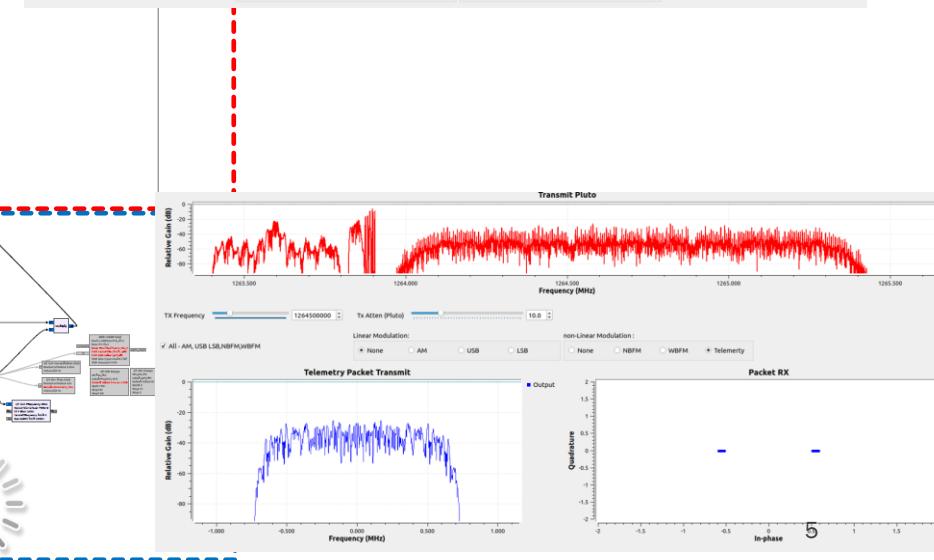
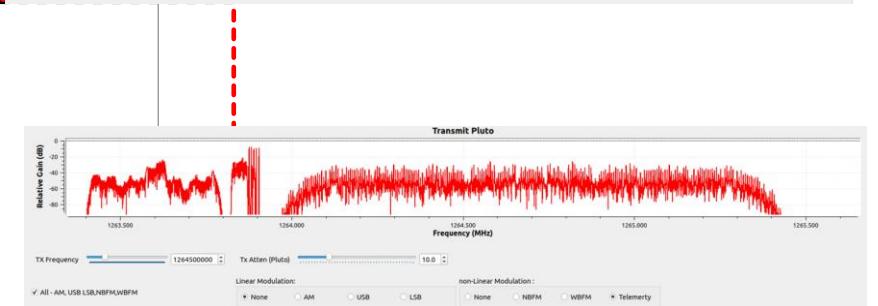
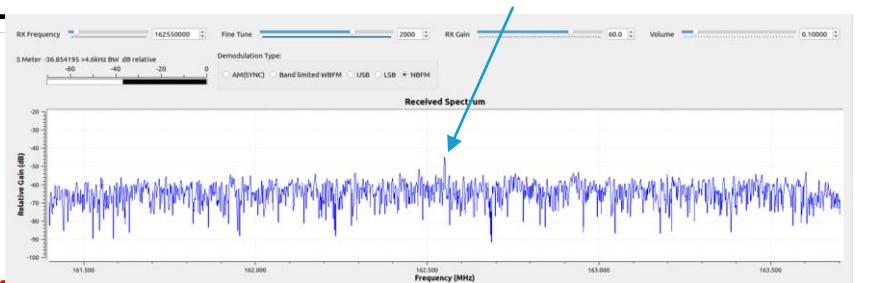
- Non Linear: WBFM, NBFM
- Linear: AM/LSB/USB
- CW-ID signal, PSK31 signal
- Constant tone (for freq. locking)
- NBFM wired to Transmitter for testing convenience (NWS)

Packet Telemetry →

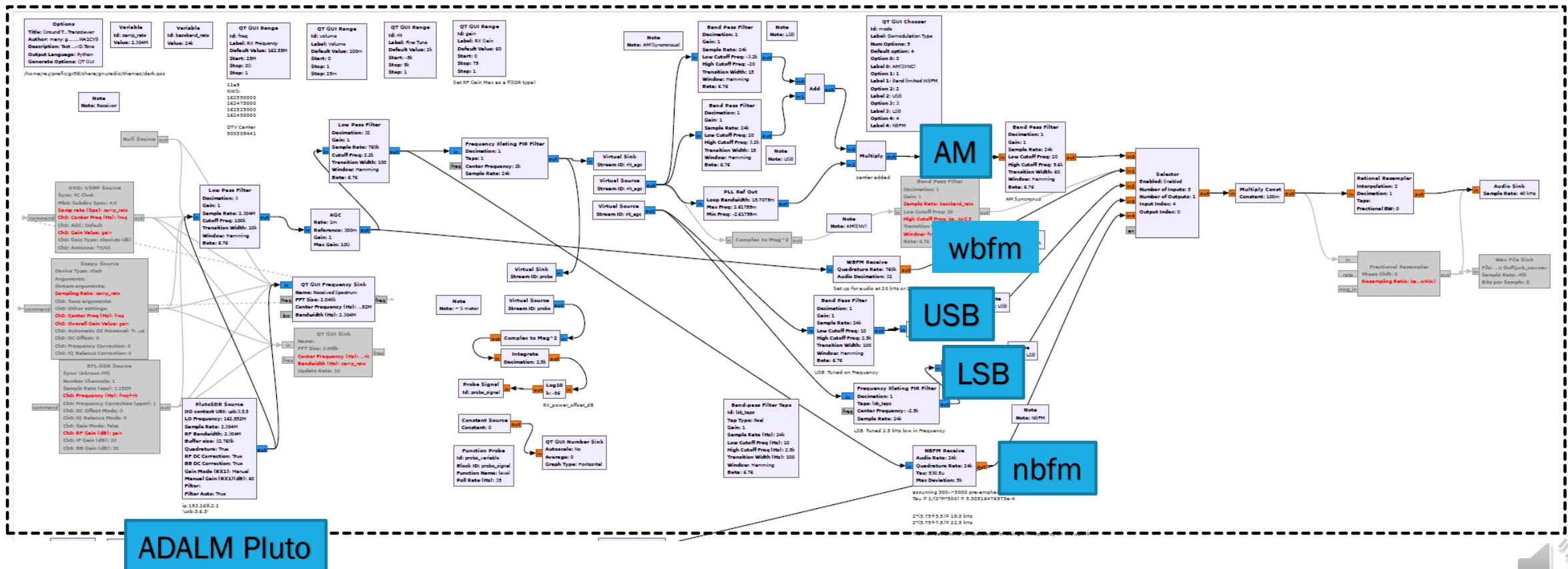
- Based on gr-digital
  - BPSK Header and Data
  - Set for ADALM PLUTO Maximum
    - ~68.4kBps
- $0.95 * [(\text{sample rate})/8] * (1/\text{sps})(1/\text{rate})$
- 0.95 determined empirically



national weather service signal from 12" wire antenna



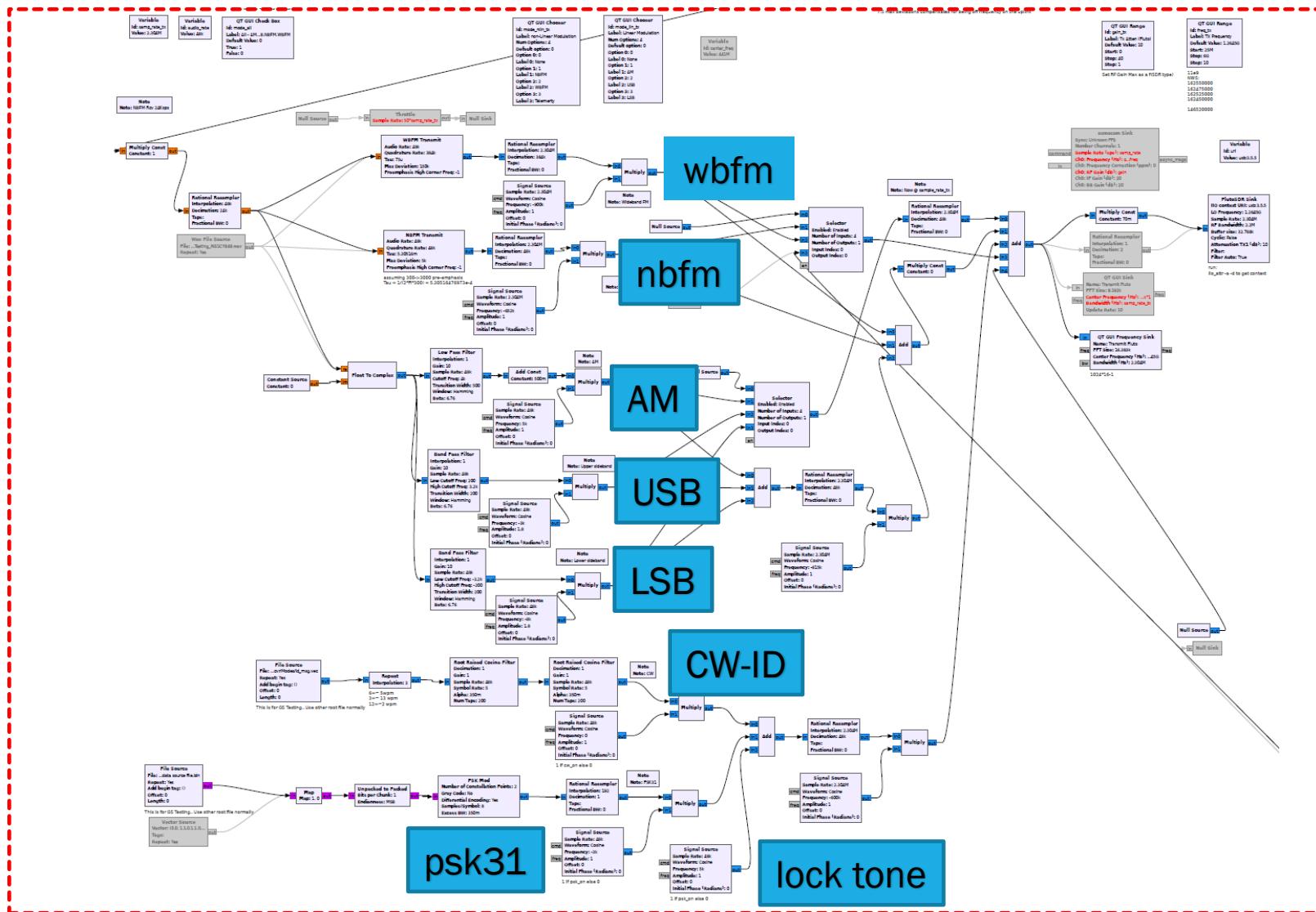
# Ground\_Station\_Xcvr\_RevB.grc .... Upper Receiver Section



# Ground\_Station\_Xcvr\_RevB.grc .... Middle Transmitter Section

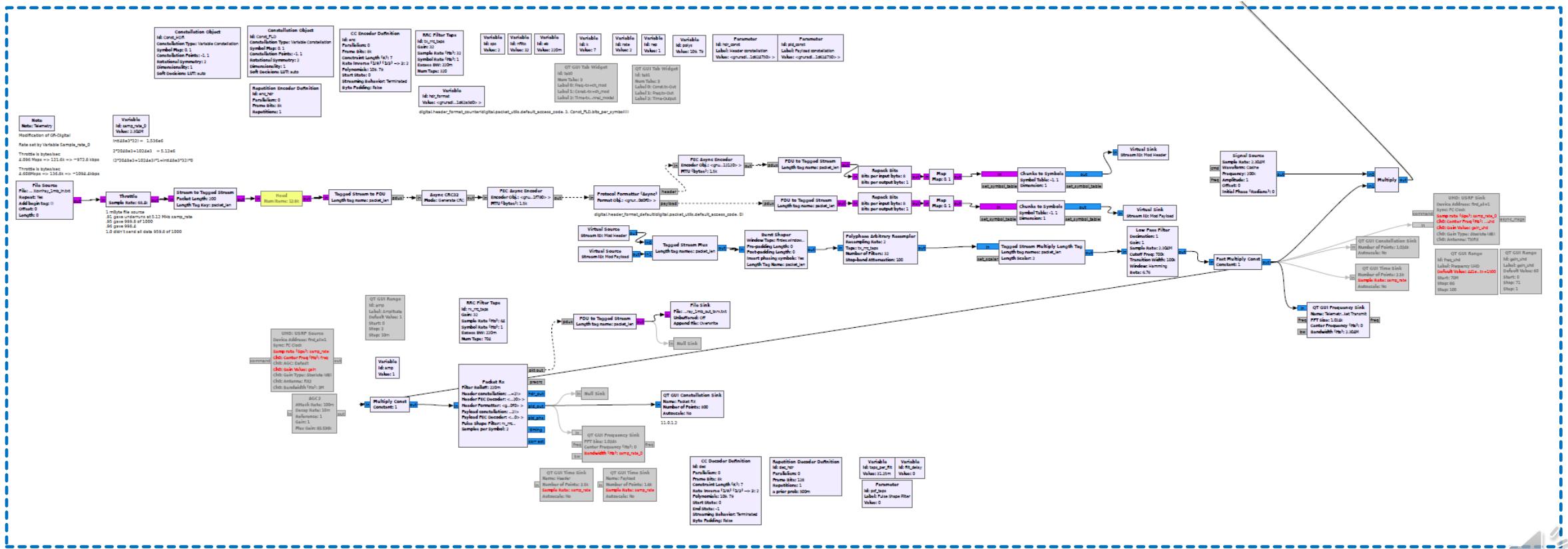
Frequency Offsets relative to freq\_tx  
(1.2645GHz for this setup)

- wbfm -900 kHz
- nbfm -652 kHz
- am -610 or +5 kHz
- usb -618 or -3 kHz
- lsb -623 or -8 kHz
- cw-id -600 kHz
- psk31 -603 kHz
- tele +200 kHz

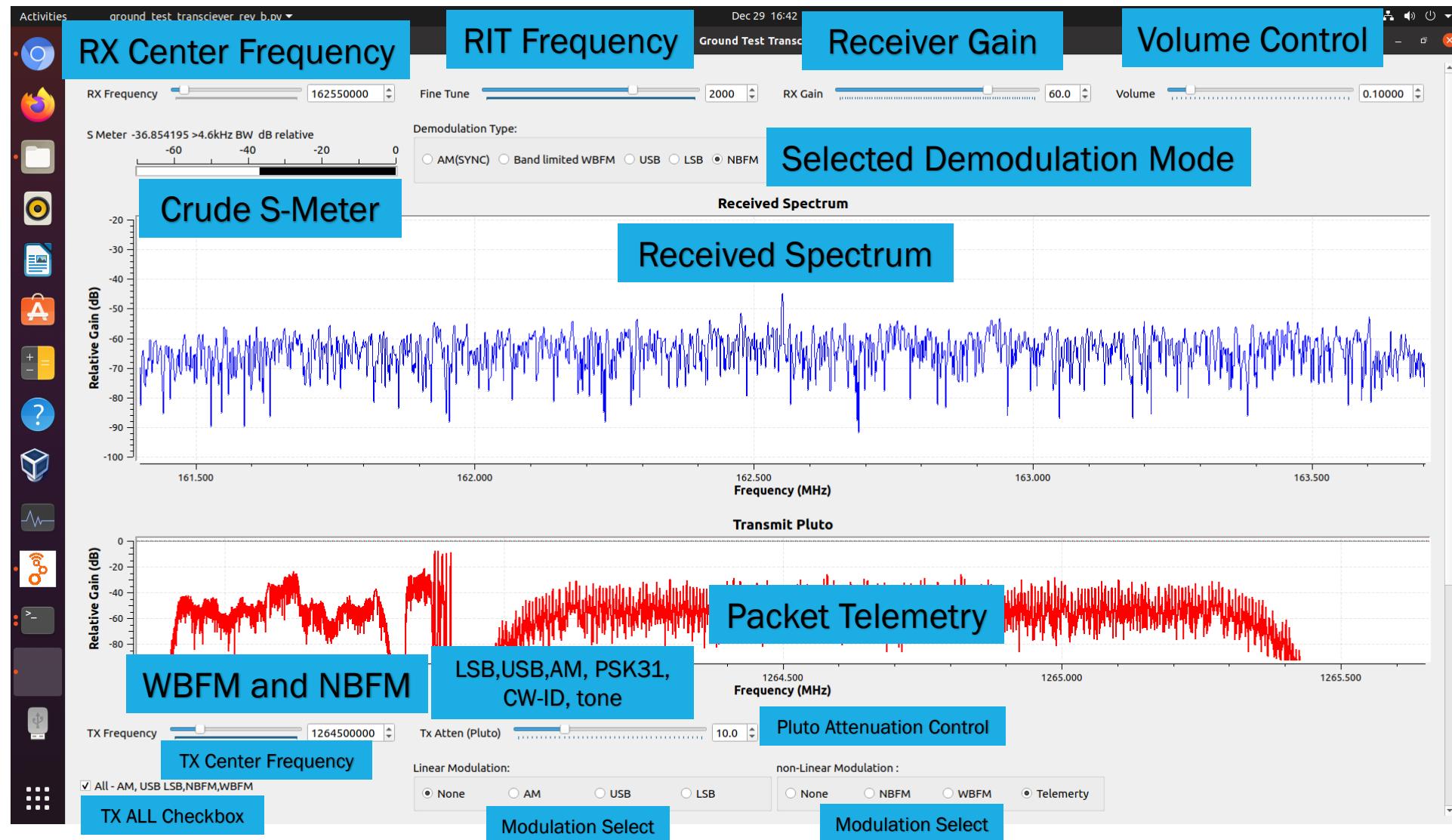


# Ground\_Station\_Xcvr\_RevB.grc .... Lower Packet Telemetry Section

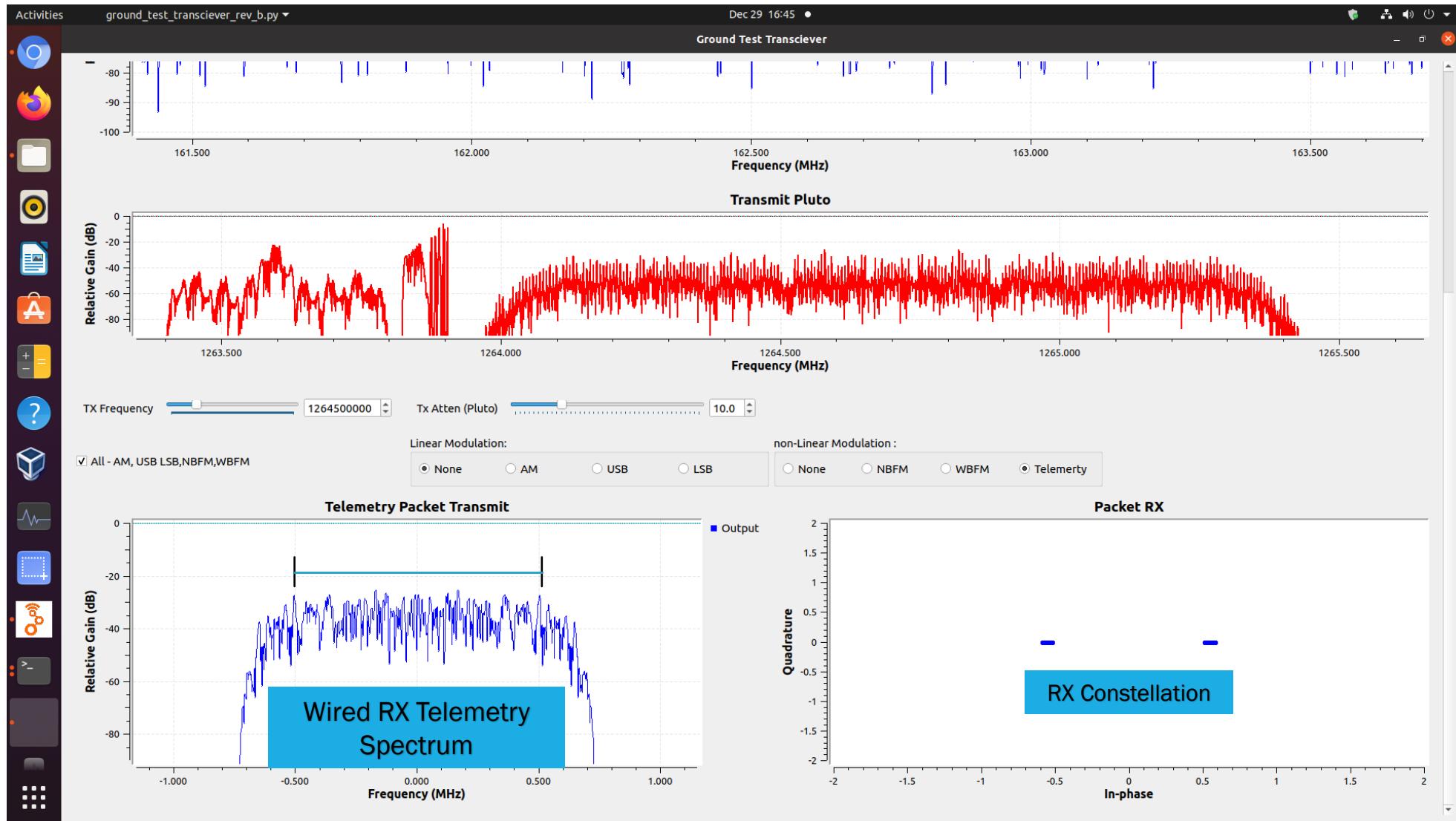
Look at gr-digital under gnu radio installed packet examples (95% identical)  
 Transmit section not HEIR because of performance reduction when using Heir block



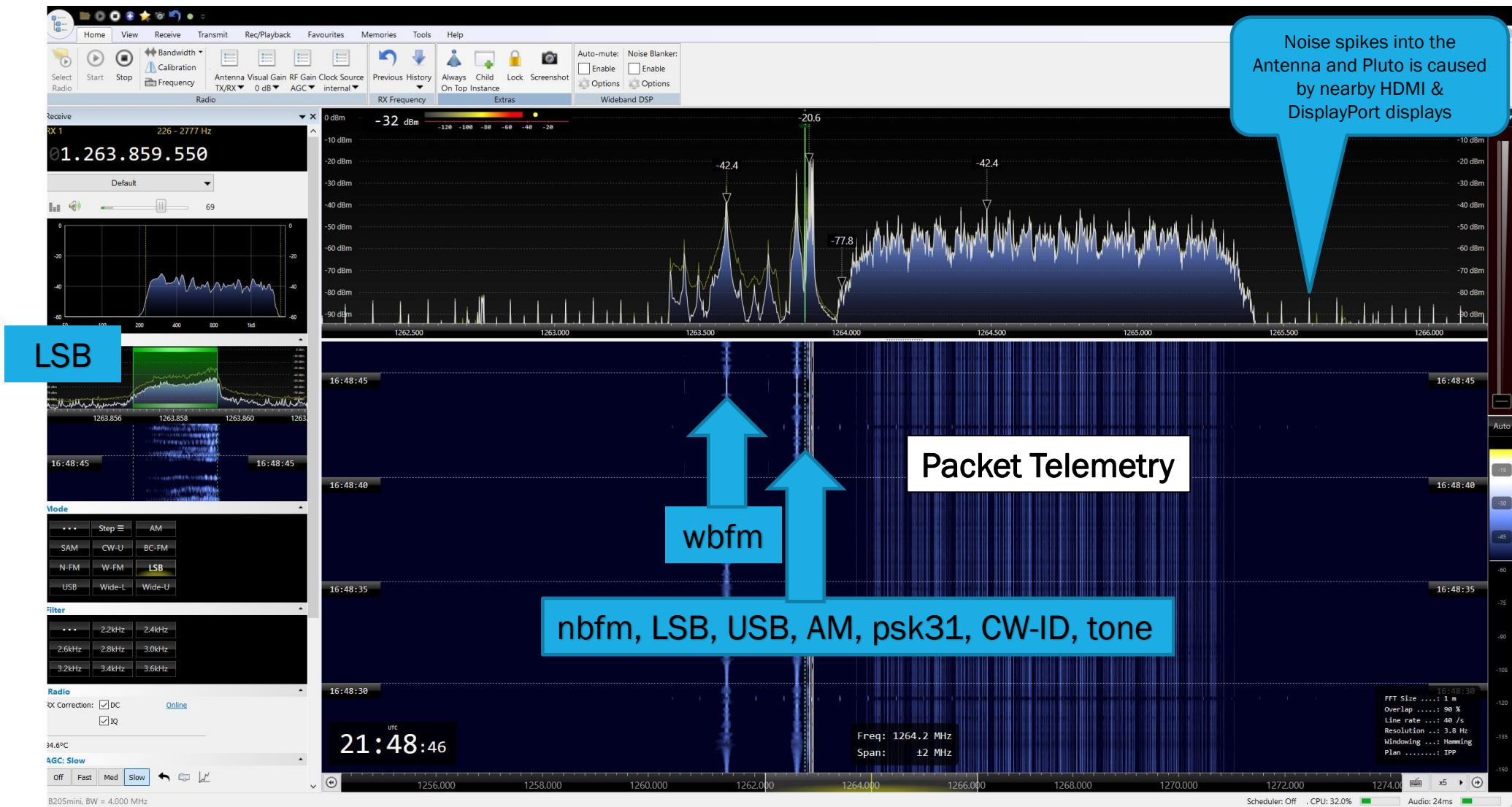
# Upper Part Of GUI Display



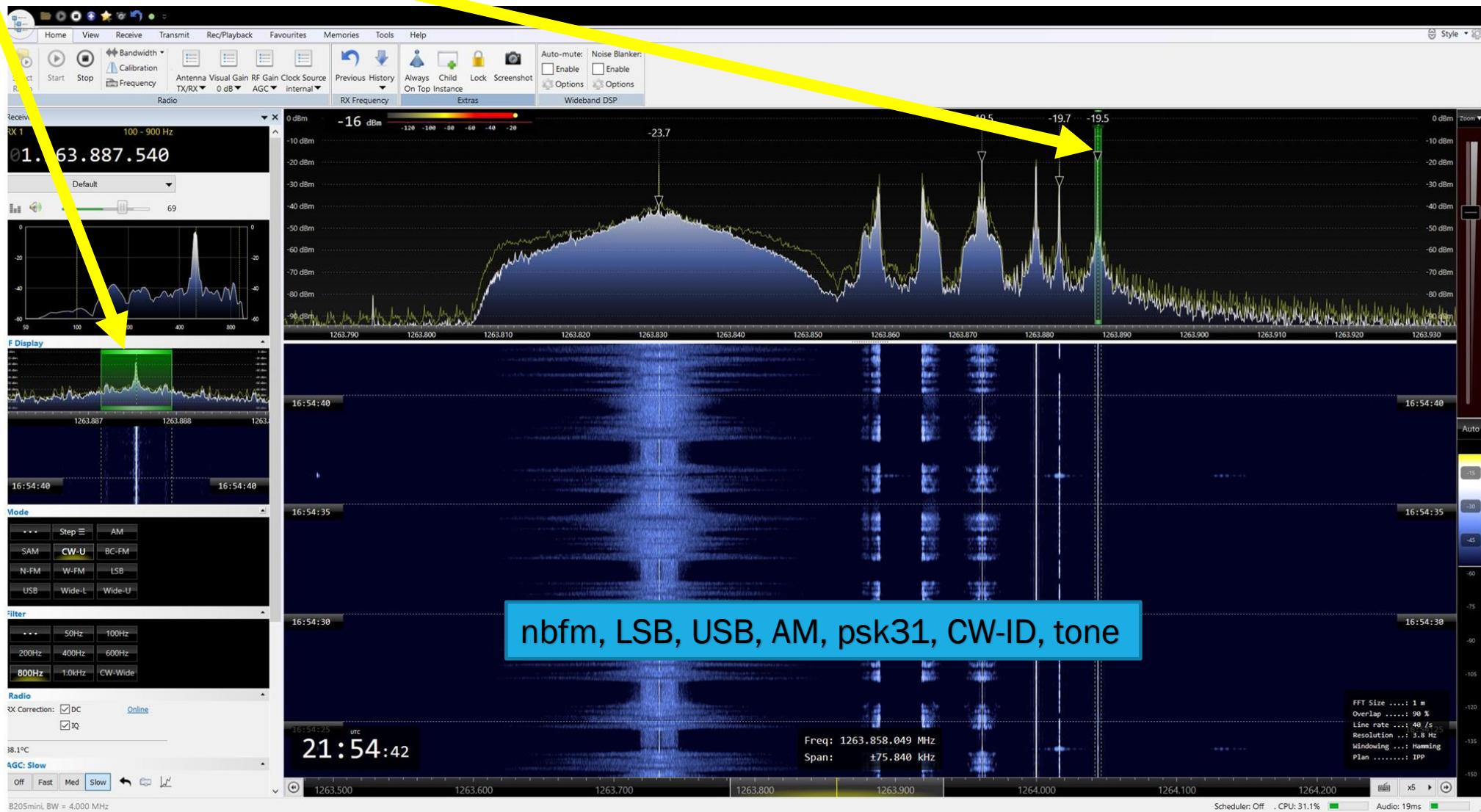
# Lower Part Of GUI Display



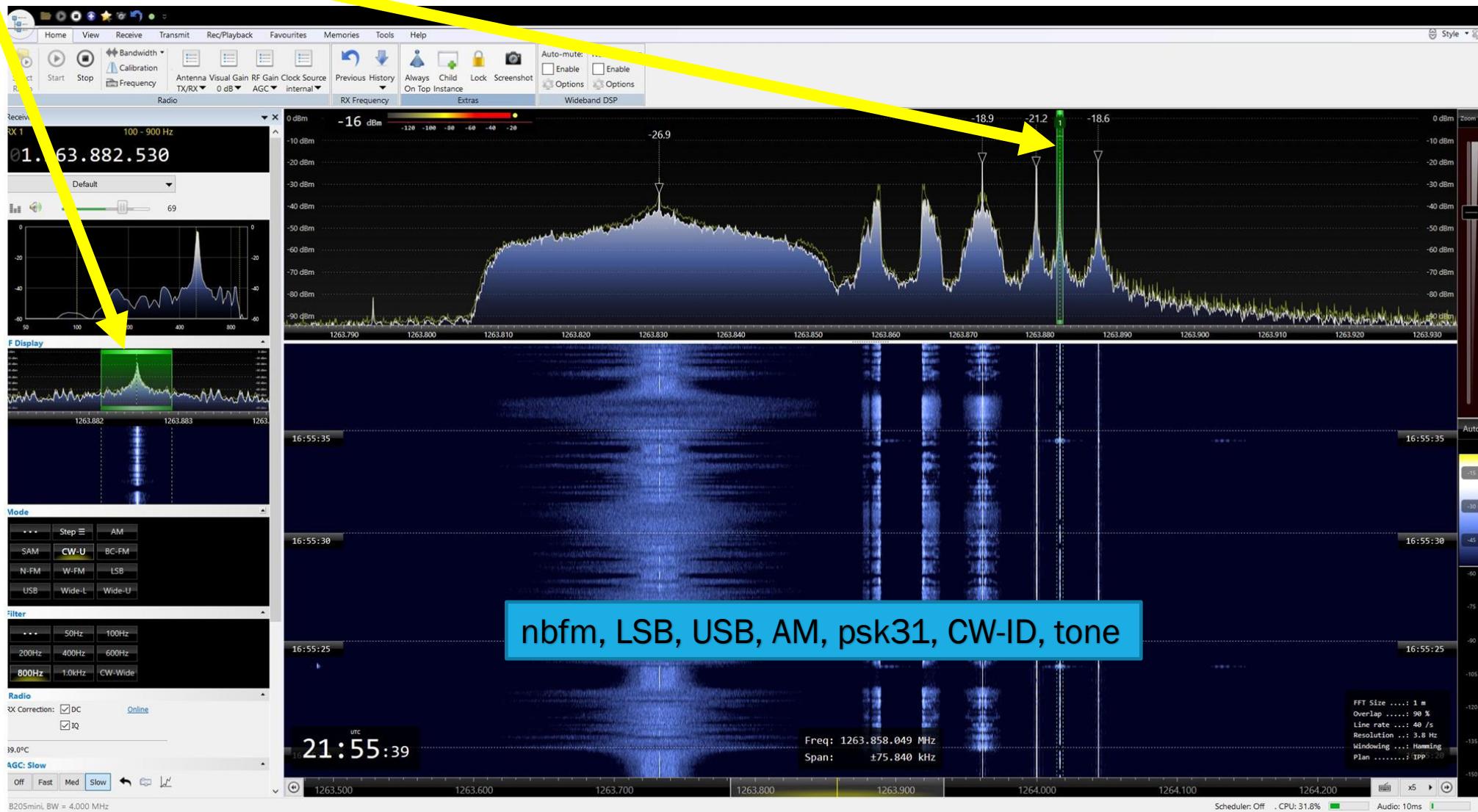
# As seen by SDR-Console Receiver (Ettus B205 mini)



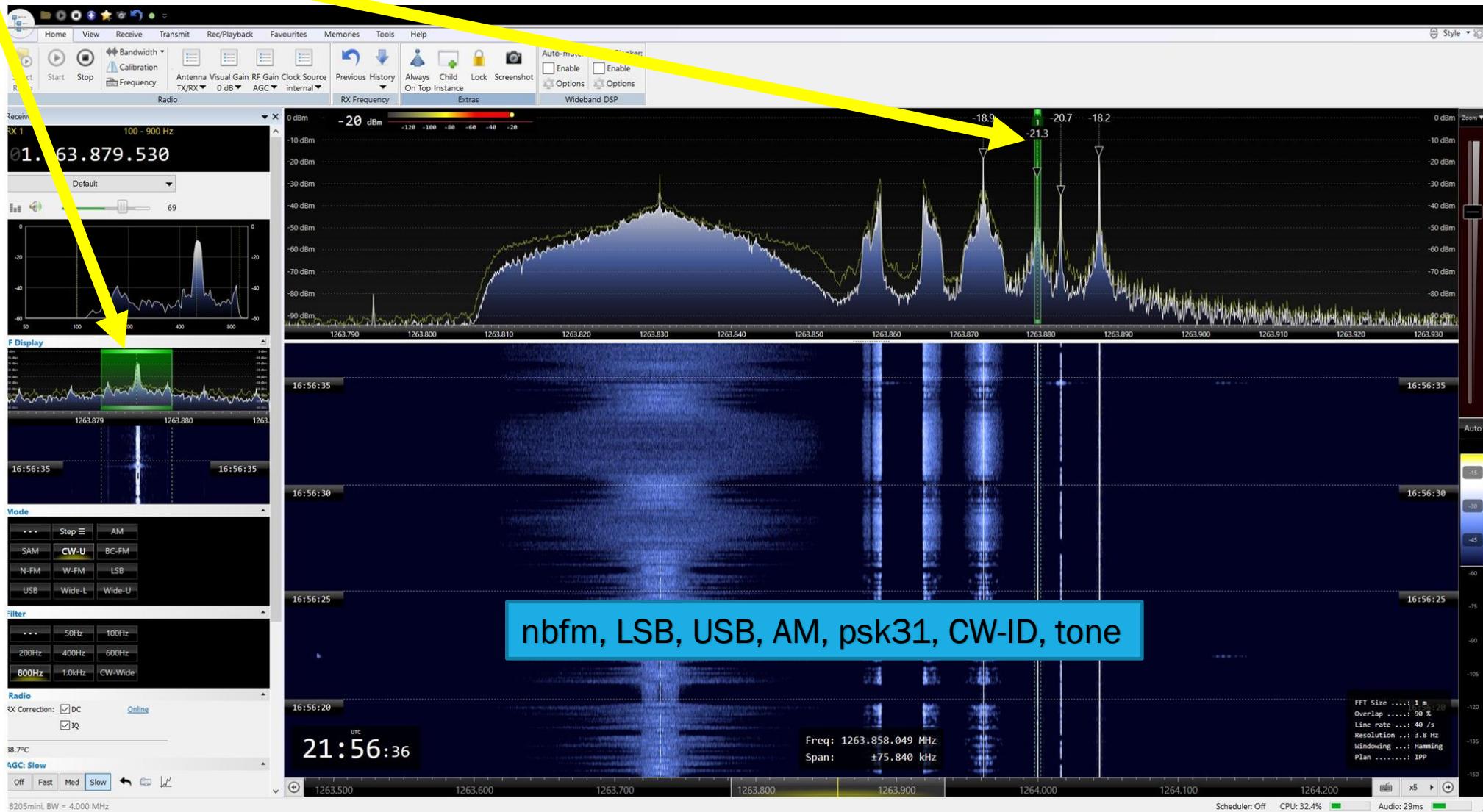
# LOCK TONE



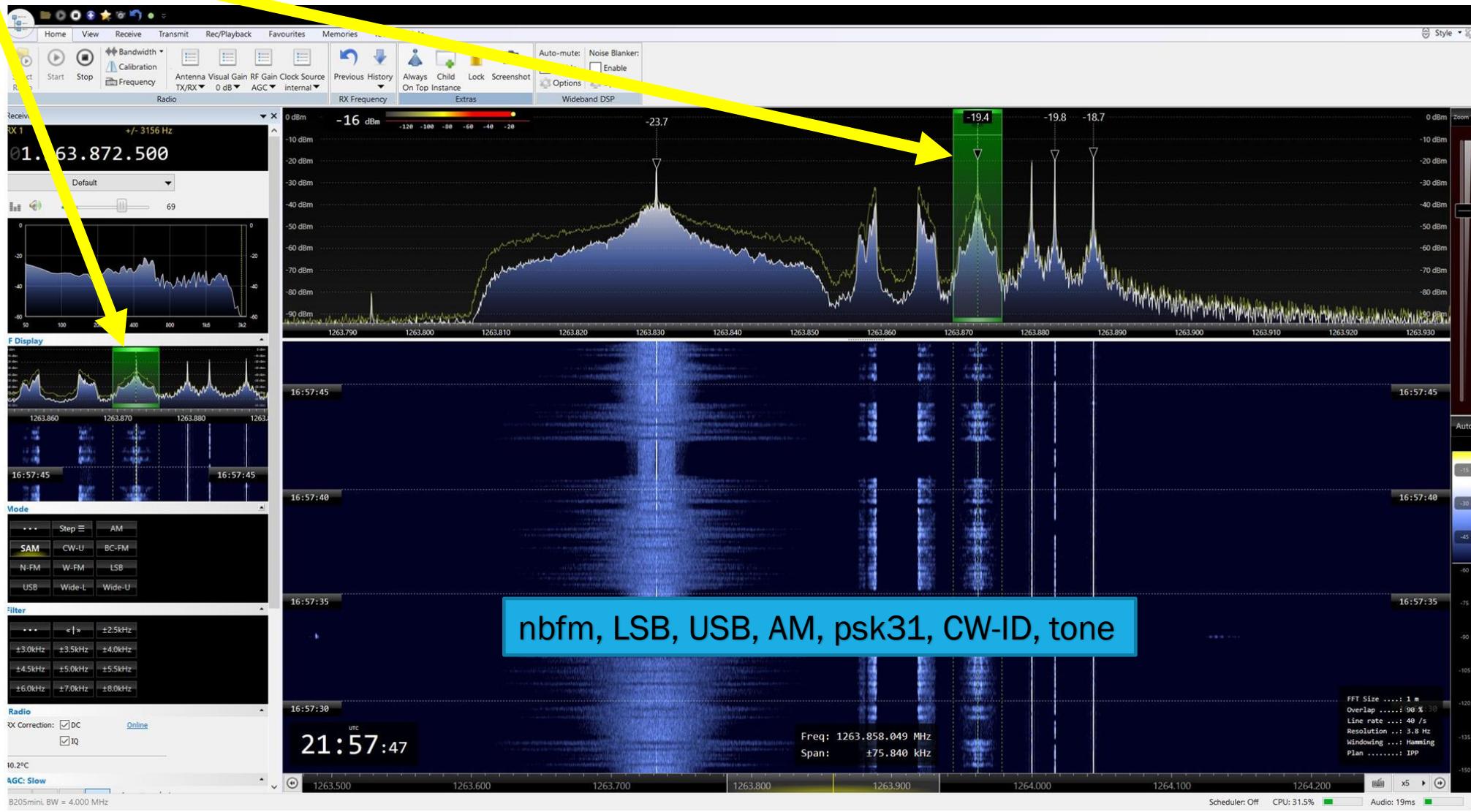
# CW-ID



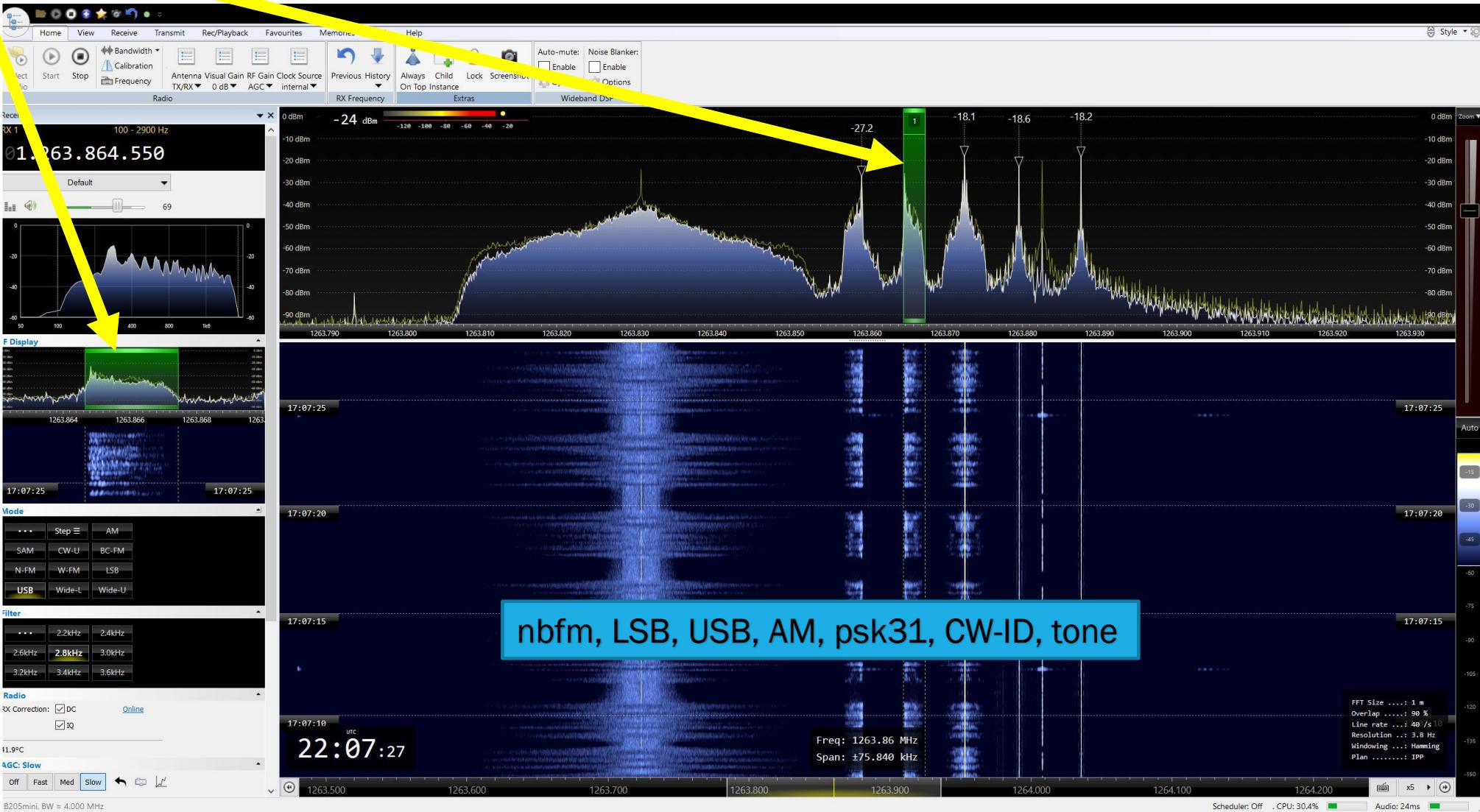
# PSK31



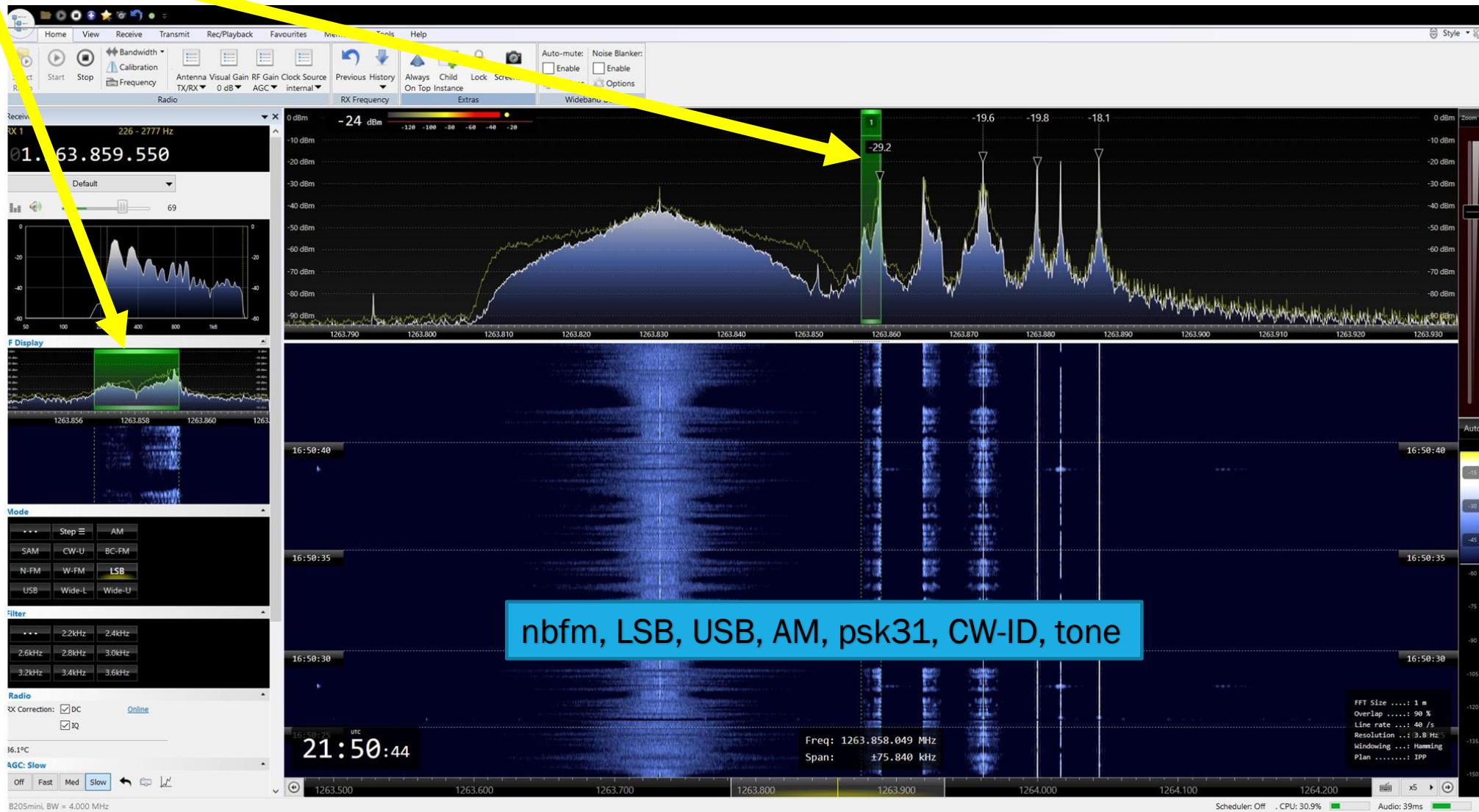
AM



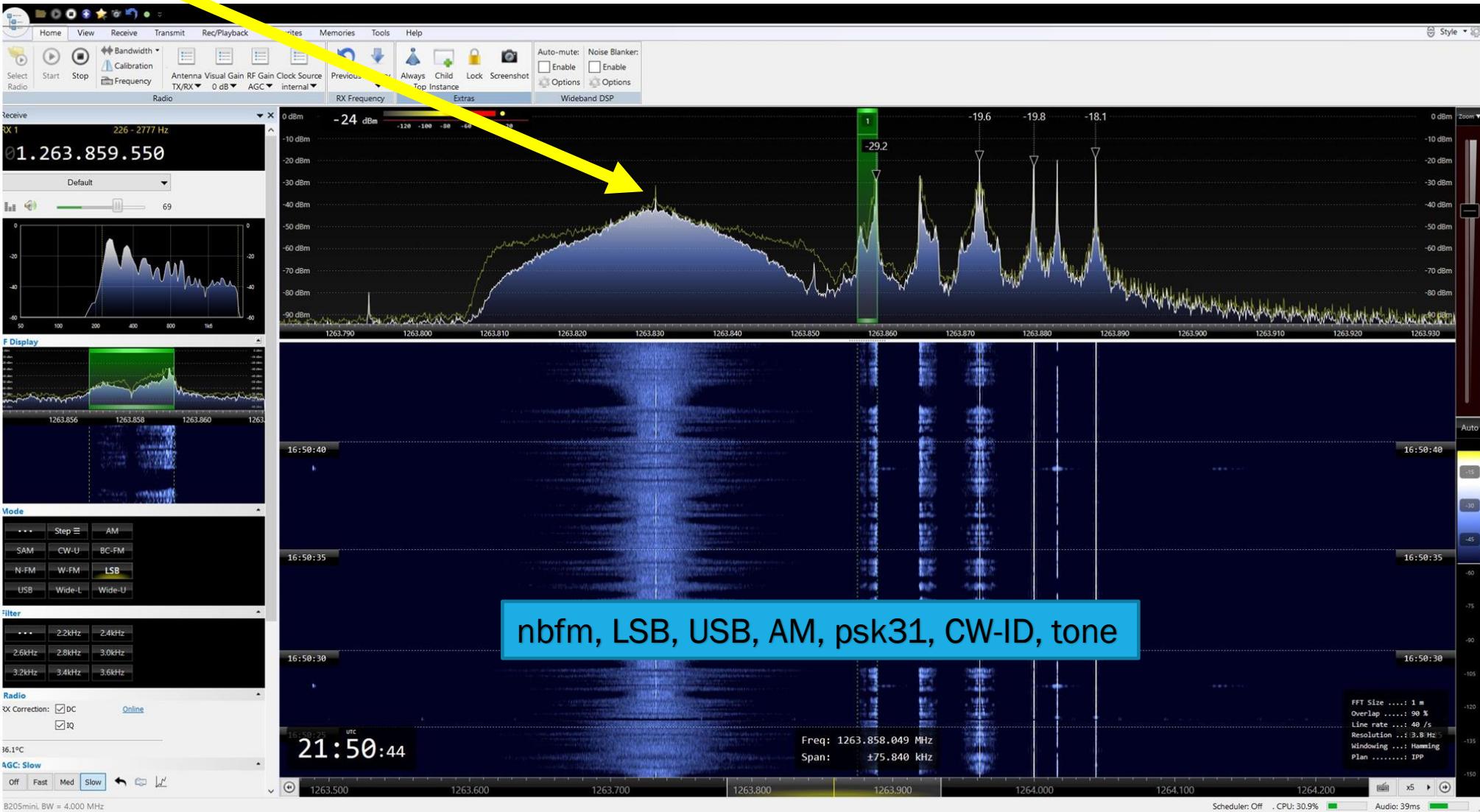
# USB



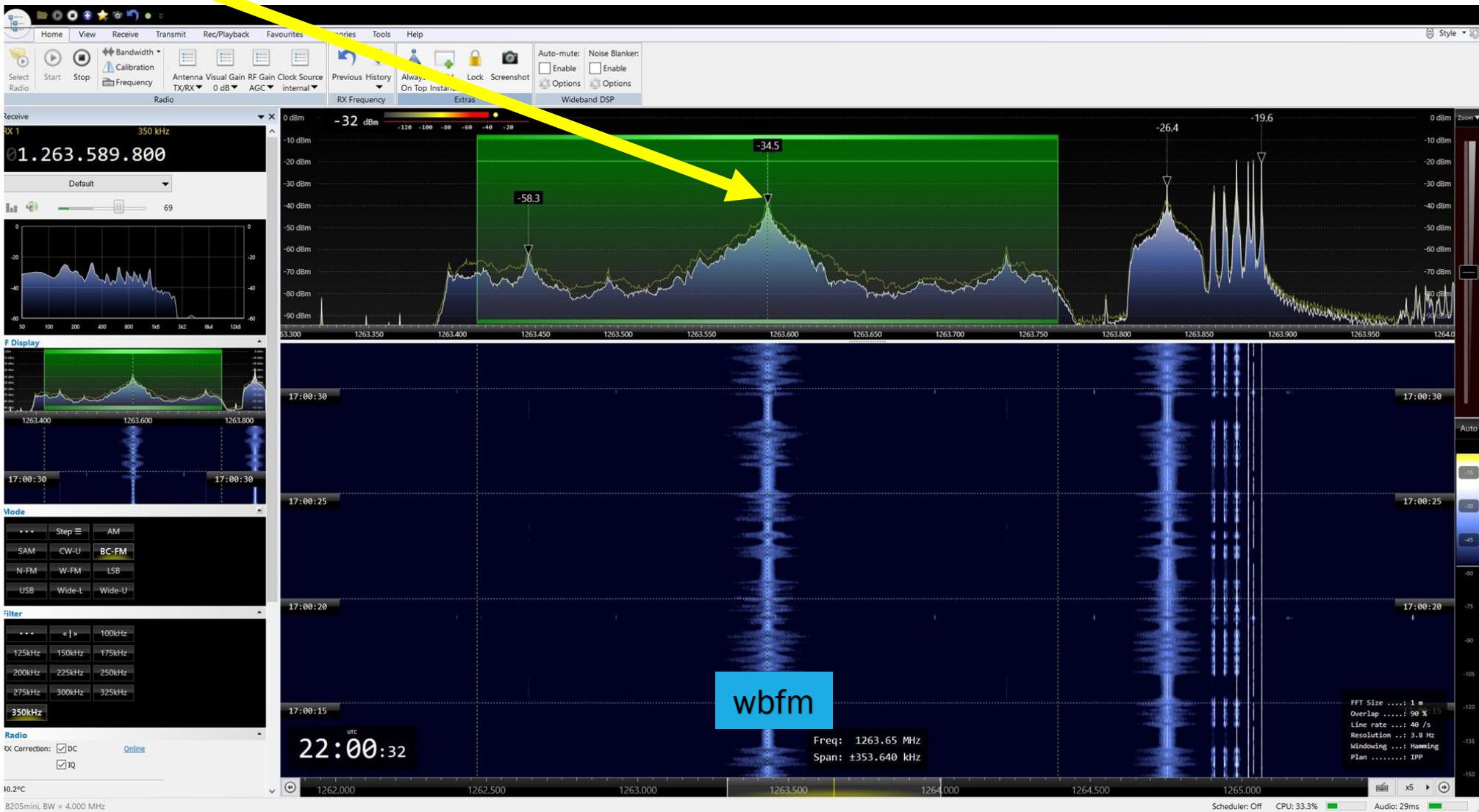
LSB



# NBFM

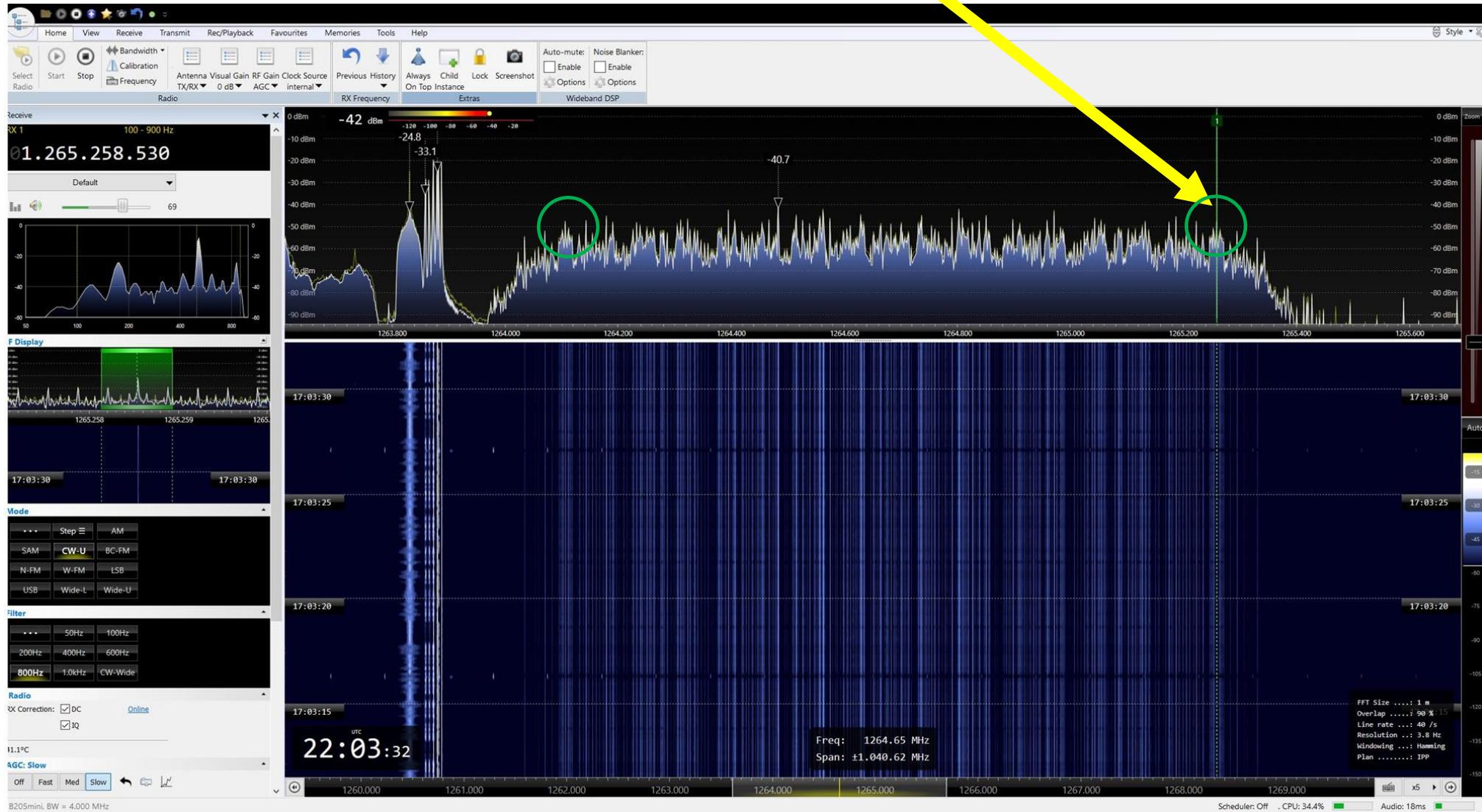


# WBFM



# DATA –

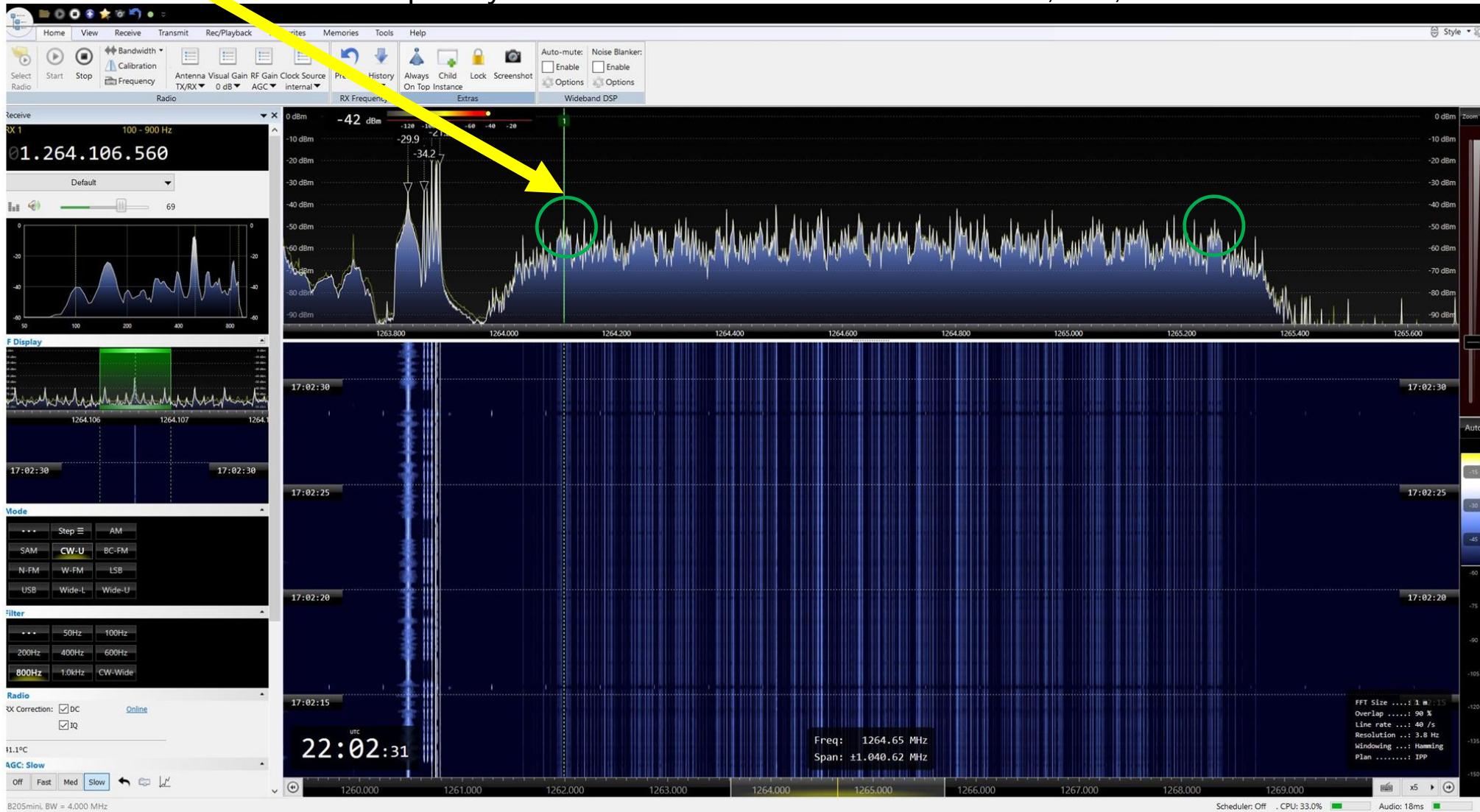
## Upper Tone 1265258530 Hz



Delta F = 1151970 Hz, rate = 2: 575985 bps expected , 575985 bps /8 = 71,998.125 Bps . GRC throttle set to 0.95\*72,000 Bps

# DATA – Lower Tone 1264106560 Hz

Delta Frequency = 1265258530 - 1264106560 = 1,151,970 Hz



# Packet Telemetry

- Set for ADALM PLUTO Maximum without dropping sync for > 10 seconds\*
  - ~68.4kBps
  - Lower system sample rate if better performance (with less thruput) is desired

$0.95 * [(\text{sample rate})/8] * (1/\text{sps}) * (1/\text{rate})$

- 0.95 determined empirically

Delta Freq Measured = 1151970 Hz, rate = 2: 1151970 Hz / 2 = 575985 Hz therefore, 575985 bps expected,  
575985 bps /8 = 71,998.125 Bytes per second expected max packet rate.

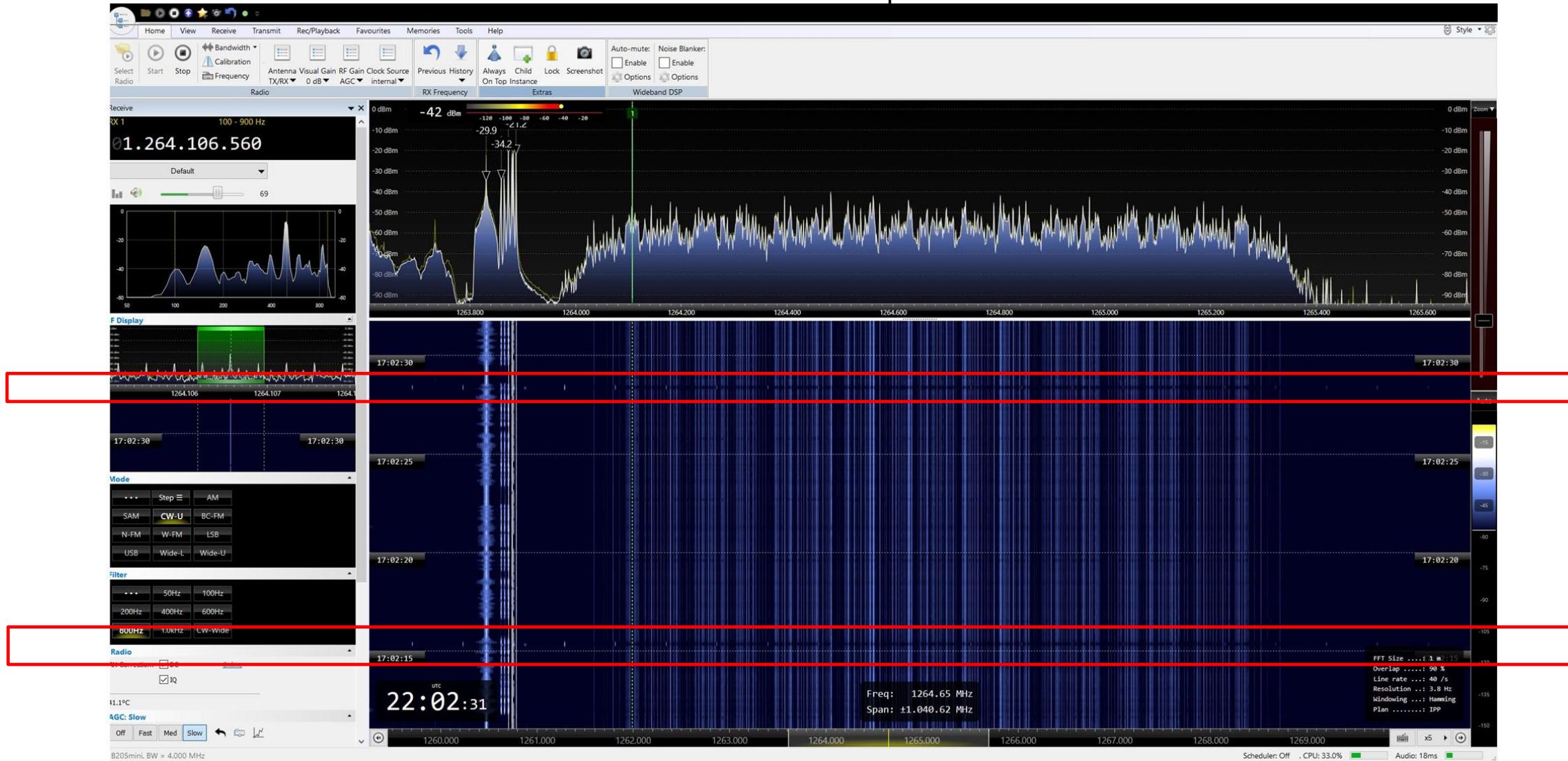
GRC throttle set to  $0.95 * 72,000 \text{ Bps} = 68.4 \text{ Bps}$

\* Analog Device chip with a hardware memory buffer appears to “reset” parts of the chip every 12 seconds. Appears as a glitch in the RF spectrum (a peak at “dc” with no other modulation). This is observed with the ADALM Pluto and the Ettus B205 mini and other Ettus hardware. You can change the timing of this in the Pluto by changing the buffer size in the Pluto GRC sink block.



# Note the Two Dropout Lines in the Waterfall Display

12 to 14 seconds separation

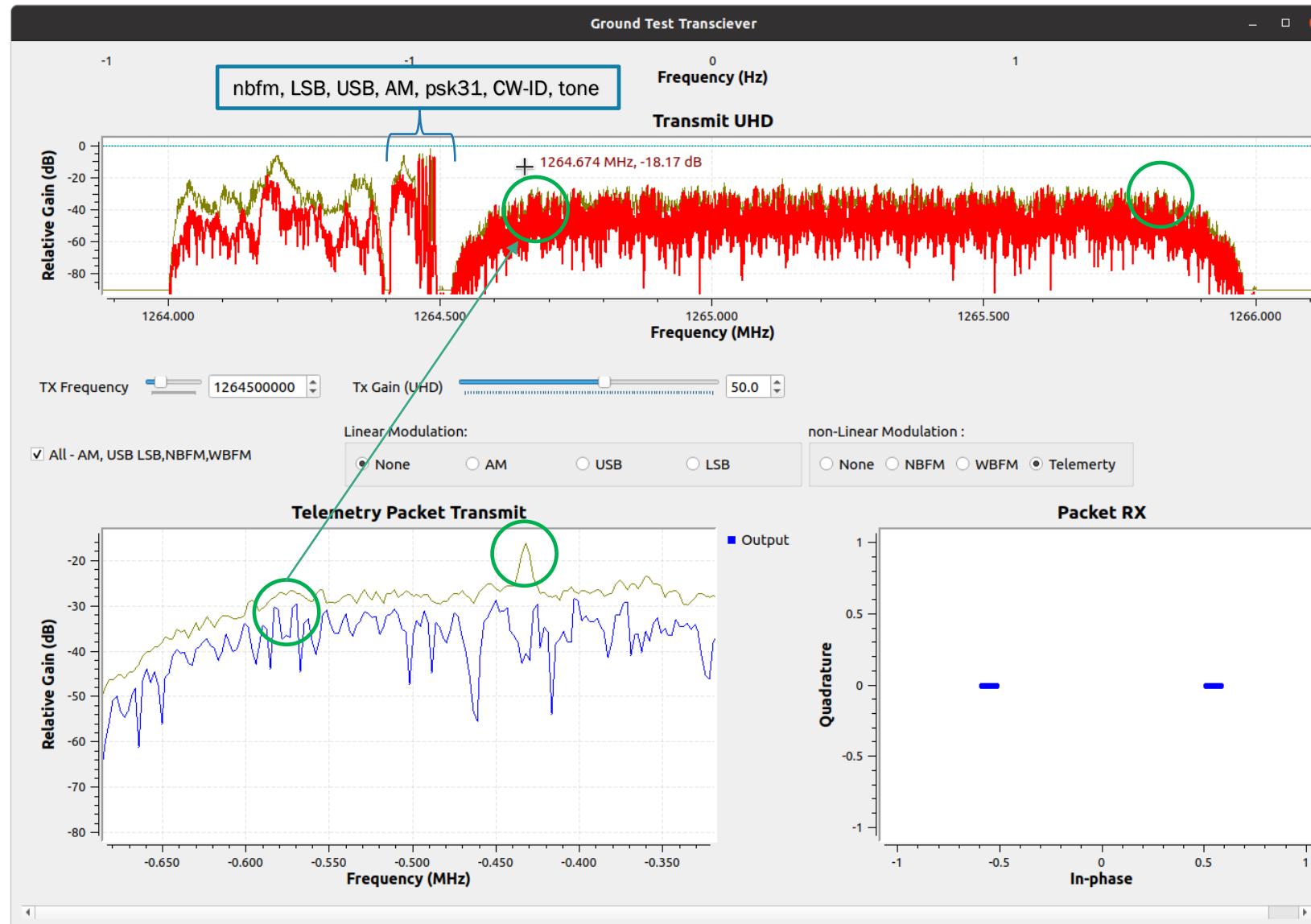


## UHD Variation – Ettus B205 mini

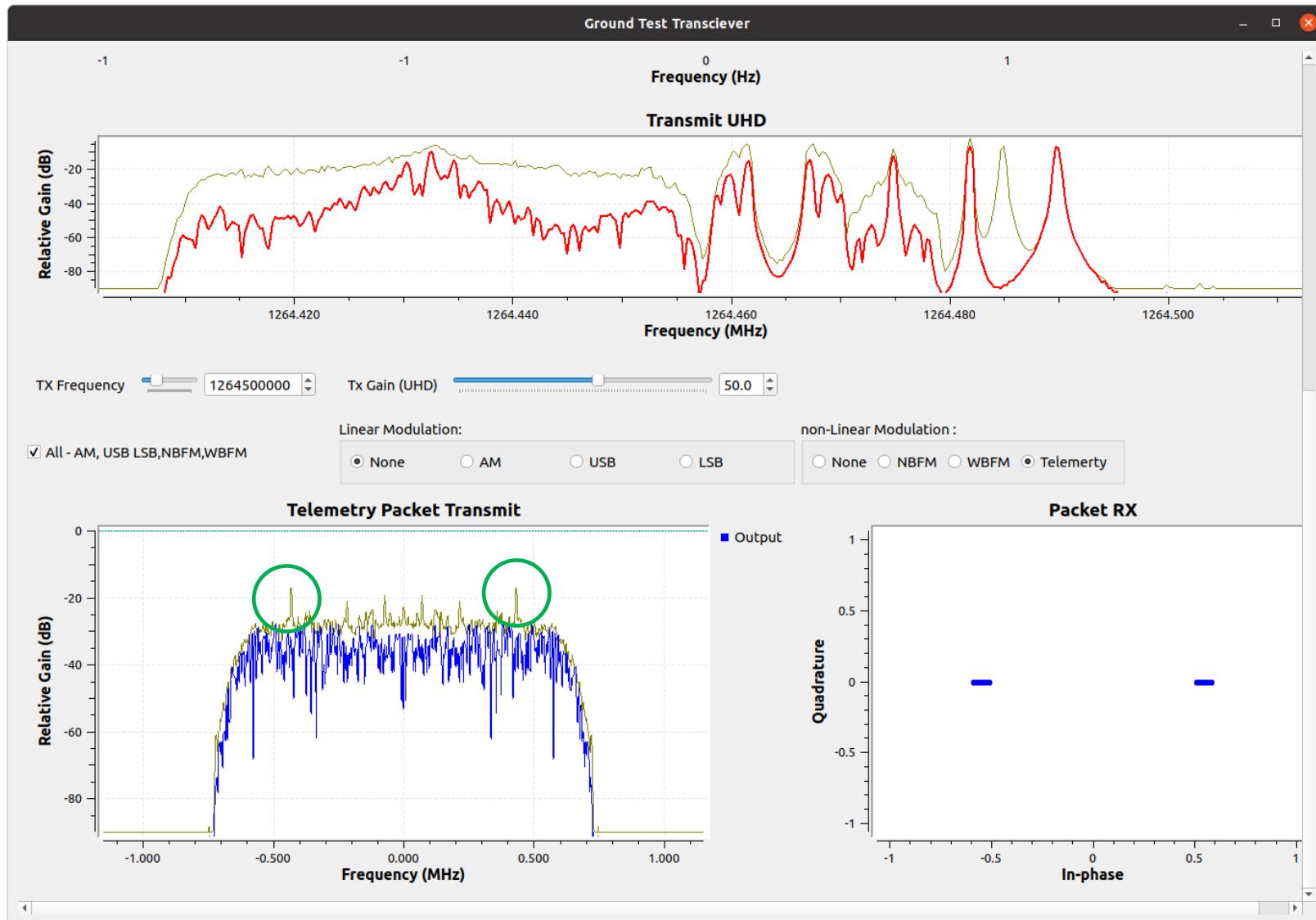
- Simply replacing the Pluto with a UHD Block doesn't work
- DC spike quite large initially. Appeared in the telemetry data spectrum
- Increased sample rate to place spike out of the way (4,608kHz sample rate)
  - Rate determined by **usbtop**
- Put a DC Block (32 or 1024 tap) just before the UHD sink block and it **Oscillated** after a couple of seconds ! I won't be doing that again.
- I had the Bandwidth in the sink block set to 3e6 Hz. When I changed the value to 0 or to the transmitter sample rate (samp\_rate\_tx), the dc spur decreased by 22 dB (tx gain = 50) and by 25.1 dB with tx gain = 60 dB.
  - Still high but probably will work OK for the telemetry (especially if you place the carrier in a null in the spectrum)
  - Changing the rate appears to be the safer option



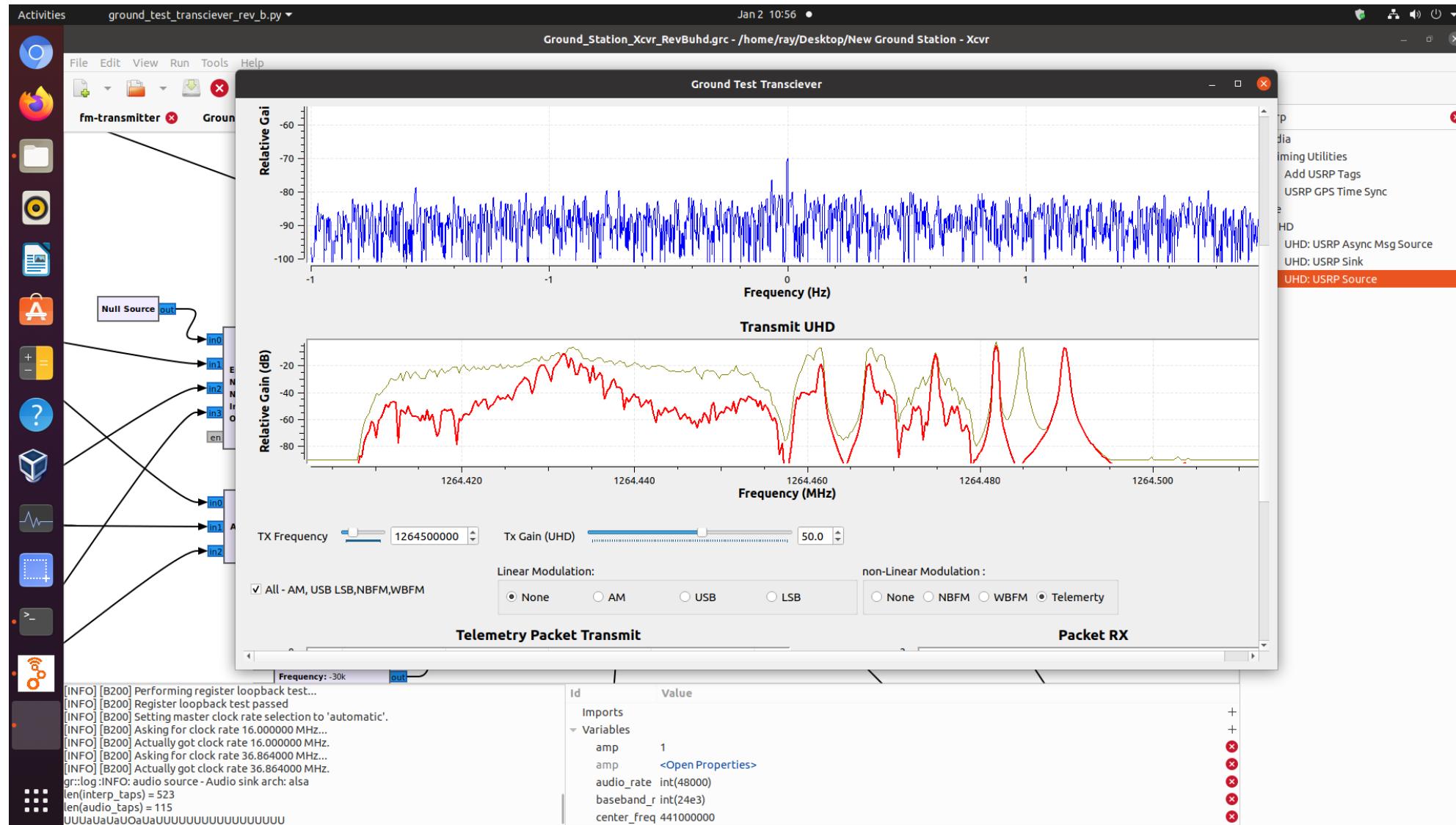
# Packet Telemetry UHD\_Tele\_lower\_point.png



# Packet Telemetry UHD\_audio+tele-mon\_peak\_hold.png



# audio\_uhd\_peak\_hold\_16k.png



## QT Display 20.4 Issues : GRC 3.8.2 vs 3.8.0 Noted

Doesn't happen with 18.04

- Frequency plot disappears after the 12 second “spike” caused by the hardware
  - If you left click on it and change the fft size the display will come back
  - If the sync is set to free instead of anything else it holds on longer
  - If the window function is changed to Hann versus Blackman Harris it also holds on longer
- In order to get higher resolution than 4096 points one would think simply multiplying it by factors of 2 would work, ie: 8192 and 16,384
  - It turns out 16,384 -1 or 16,383 works. 16,384 throws an error
- Running the flowgraph under 18.04 and GRC 3.8 the selector does not display the correct selection, but still works



# Discussion

