



Receiving and Spotting WSPR and FT8 on “all” bands at once, using GNU Radio and RTL SDRs

By Mark Smith, N6MTS

With *TONS* of advice from
Derek Kozel, MW0LNA



Introduction: Who am I?

- Mark Smith
 - N6MTS as of February 2021, formerly KR6ZY
 - Licensed in high school, 1991. Extra in 2001.
-
- SmittyHalibut on Twitter, YouTube, and GitHub
 - Recurring guest on the Ham Radio Workbench podcast



What are we talking about today?

- The “What” and “Why”
- Overview of solution
- GNU Radio blocks
 - Top Block
 - Dual SSB Demodulator
 - SSB Demodulator
- Demonstration
- Q&A



What are we talking about today?

- The “What” and “Why”
- Overview of solution.
- GNU Radio blocks.
 - Top Block
 - Dual SSB Demodulator
 - SSB Demodulator
- Demonstration
- Q&A



WSPR and PSKReporter Networks

- Digital modes provide a unique opportunity to collect real time propagation information:
 - Tx location and power
 - Rx location and SNR
- Requires transmitting and receiving stations.



WSPR and PSKReporter Networks: Transmitters

- Inexpensive WSPR beacons:
 - Ultimate 3S, QRP Labs
 - Can beacon on several bands (one at a time)
- Ubiquitous FT8 transmitters:
 - Everyone's operating FT8!



WSPR and PSKReporter Networks: Receivers

- Receivers require more computation than a Microcontroller
- Conventional receivers, sound interfaces, and computers
 - Ties up whole radio and computer for one band, one mode, at a time.
- Full Spectrum SDRs and FPGAs:
 - Red Pitaya: Can receive and spot WSPR on 8 bands concurrently. No FT8.
 - <http://pavel-demin.github.io/red-pitaya-notes/sdr-transceiver-wspr/>



WSPR and PSKReporter Networks: Receivers

- Receivers require more computation than a Microcontroller
- Conventional receivers, sound interfaces, and computers
 - Ties up whole radio and computer for one band, one mode, at a time.
- Full Spectrum SDRs and FPGAs:
 - Red Pitaya: Can receive and spot WSPR on 8 bands concurrently. No FT8.
 - <http://pavel-demin.github.io/red-pitaya-notes/sdr-transceiver-wspr/>
- Can we do this better and/or cheaper?



What are we talking about today?

- The “What” and “Why”
- Overview of solution.
- GNU Radio blocks.
 - Top Block
 - Dual SSB Demodulator
 - SSB Demodulator
- Demonstration
- Q&A

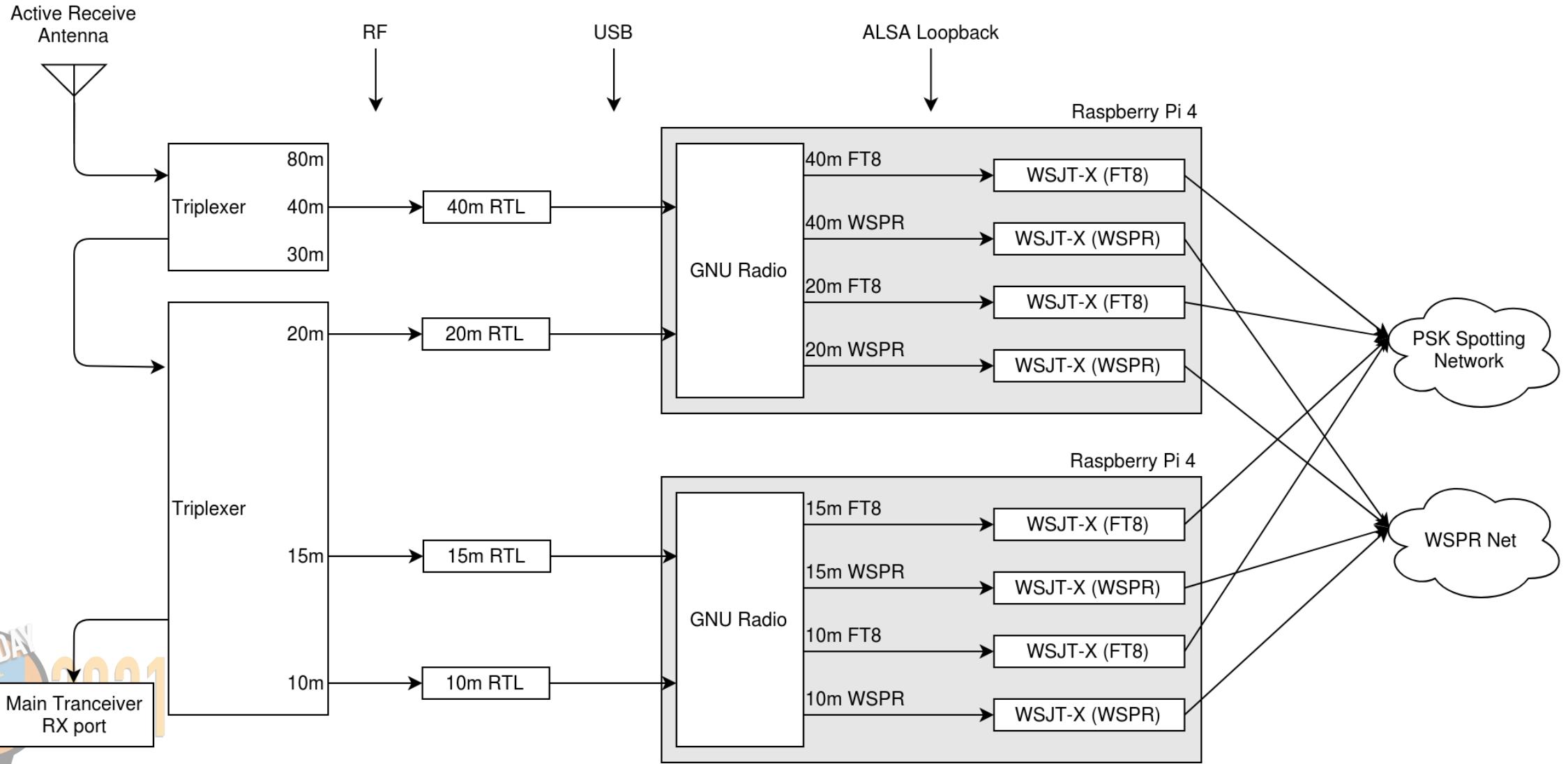


What are we talking about today?

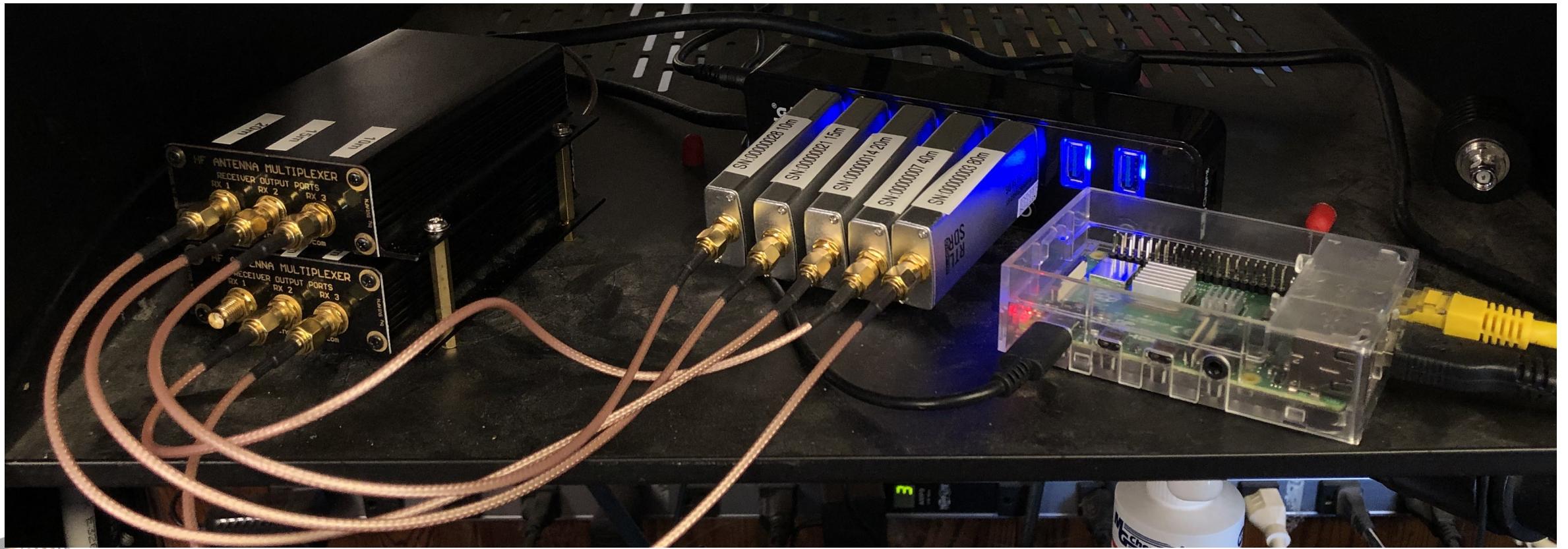
- The “What” and “Why”
- Overview of solution.
- GNU Radio blocks.
 - Top Block
 - Dual SSB Demodulator
 - SSB Demodulator
- Demonstration
- Q&A



Architecture

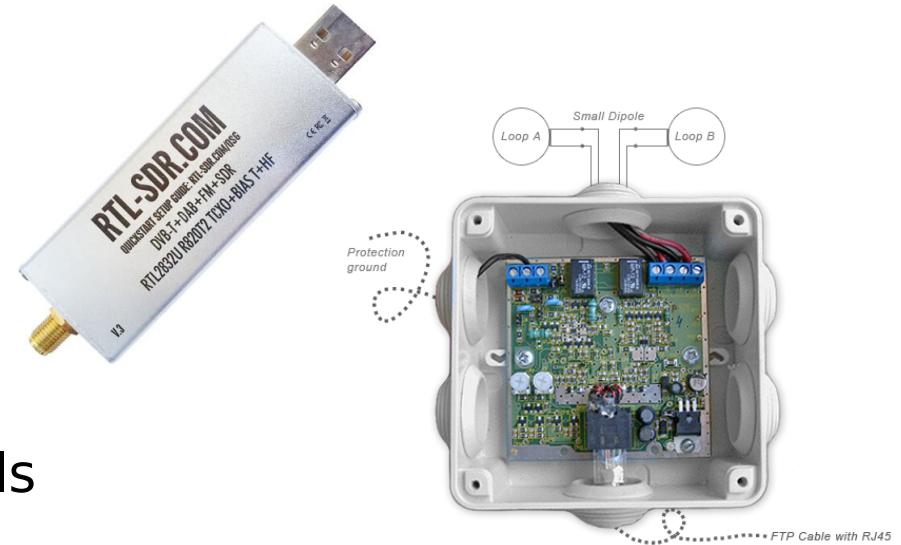


My Setup

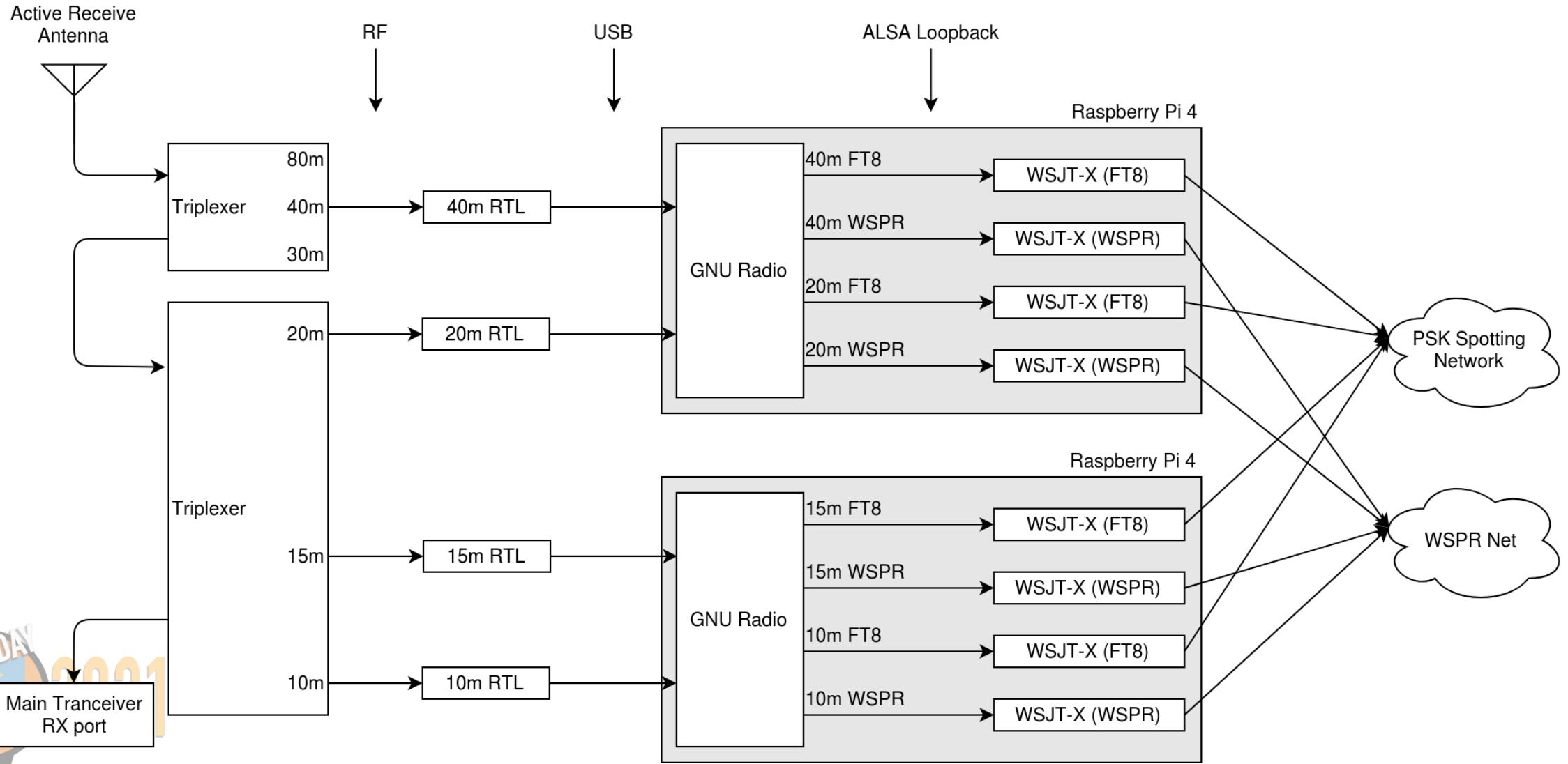


Parts

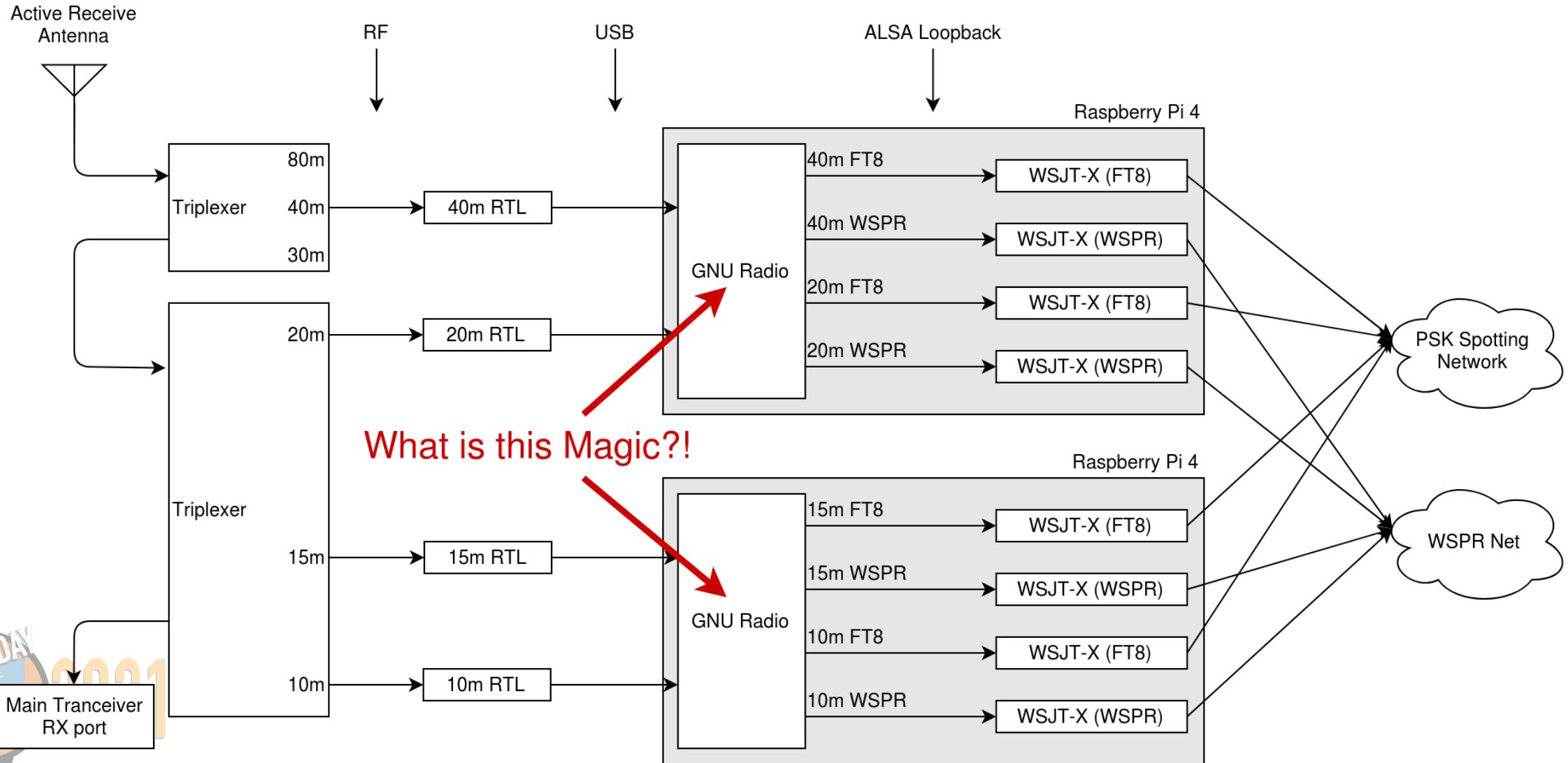
- RTL-SDR receivers:
 - Inexpensive, \$25 each for rtl-sdr.com V3.
 - Receives 1 entire HF band, no up-converter.
- Wideband active receive antennas:
 - active-antenna.eu by LZ1AQ, €105 plus materials
 - One antenna for all bands, good sensitivity
- HF Bandpass Filters / Triplexer
 - sv1afn.com: €95 for 3 bands, two for 6 bands.
 - Bonus: Triplexer provides pre-selection on RTL-SDR!



Architecture



Architecture



What are we talking about today?

- The “What” and “Why”
- Overview of solution.
- GNU Radio blocks.
 - Top Block
 - Dual SSB Demodulator
 - SSB Demodulator
- Demonstration
- Q&A



What are we talking about today?

- The “What” and “Why”
- Overview of solution.
- **GNU Radio blocks.**
 - Top Block
 - Dual SSB Demodulator
 - SSB Demodulator
- Demonstration
- Q&A



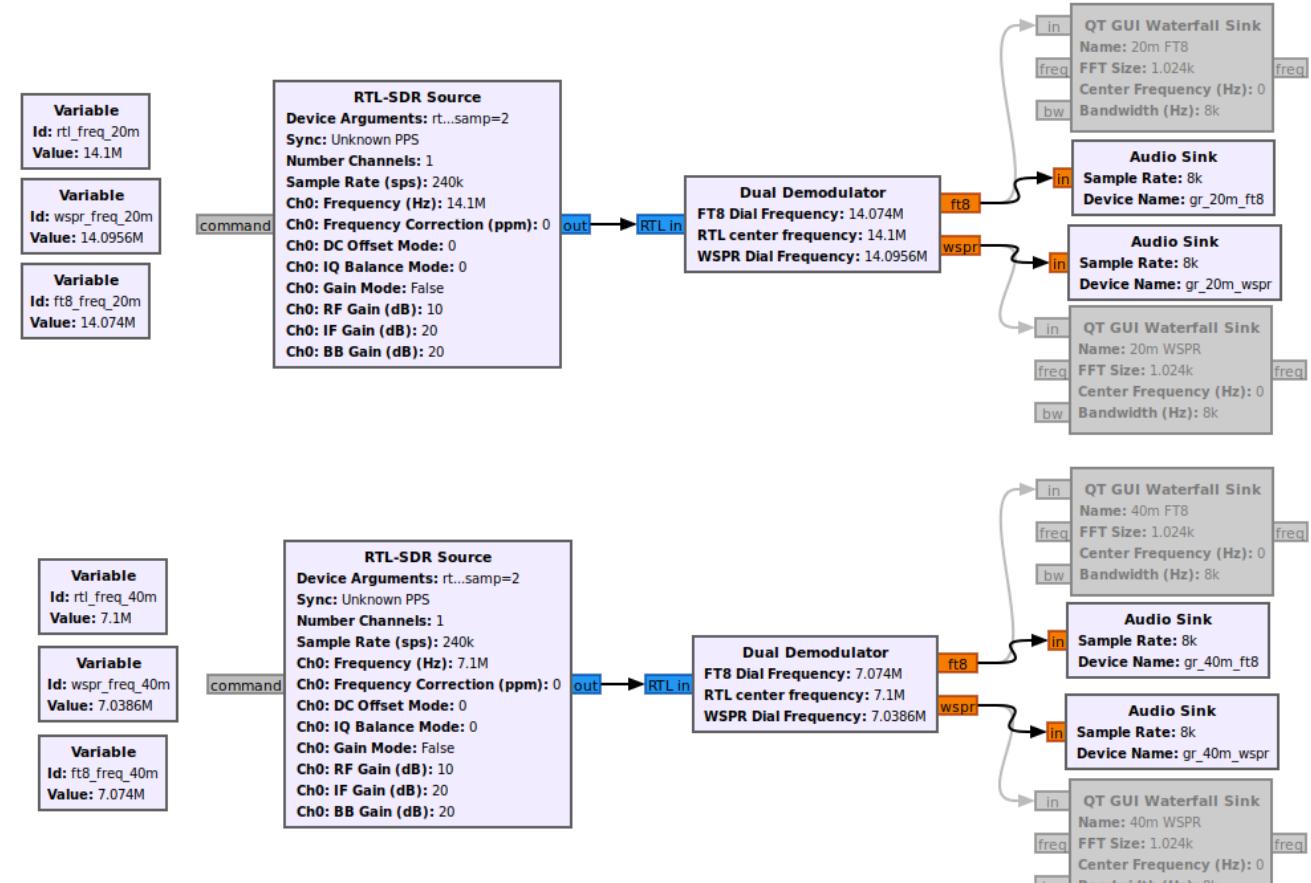
What are we talking about today?

- The “What” and “Why”
- Overview of solution.
- **GNU Radio blocks.**
 - Top Block
 - Dual SSB Demodulator
 - SSB Demodulator
- Demonstration
- Q&A



GNU Radio: The “Top Block”

- Two paths: RTL to Audio
 - One for each: 20m and 40m
- RTL-SDR Source
 - Receives 240kHz of spectrum
- Dual Demodulator:
 - Demods FT8 and WSPR subbands
- Audio Sinks:
 - Sends demodulated audio to ALSA loopback interfaces
- Waterfalls for debugging
 - Disabled for normal operations



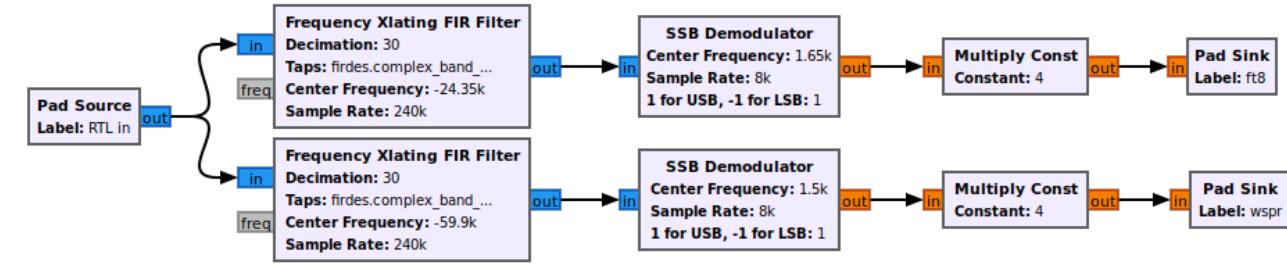
What are we talking about today?

- The “What” and “Why”
- Overview of solution.
- **GNU Radio blocks.**
 - Top Block
 - Dual SSB Demodulator
 - SSB Demodulator
- Demonstration
- Q&A



GNU Radio: Dual SSB Demodulator

- Frequency Translating FIR Filter selects sub-bands:
 - Wide band RF input
 - Bandpass filter to just the signal of interest
 - Translates signal to center, 0Hz
 - Decimates to lower sample rate
 - Filtered baseband RF output
- Passes sub-band to SSB Demodulator (up next!)
- Made into a Hierarchical Block, used in Top Block



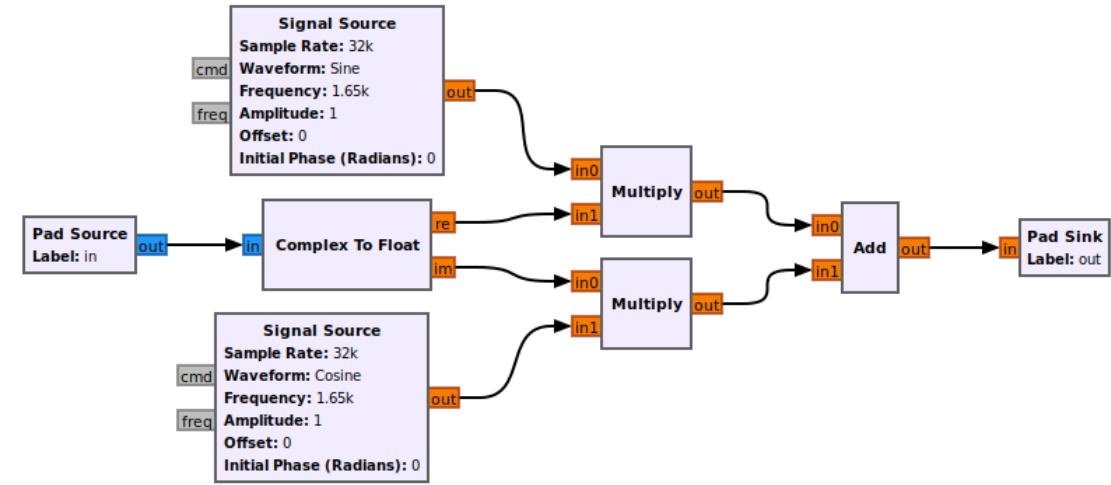
What are we talking about today?

- The “What” and “Why”
- Overview of solution.
- **GNU Radio blocks.**
 - Top Block
 - Dual SSB Demodulator
 - SSB Demodulator
- Demonstration
- Q&A



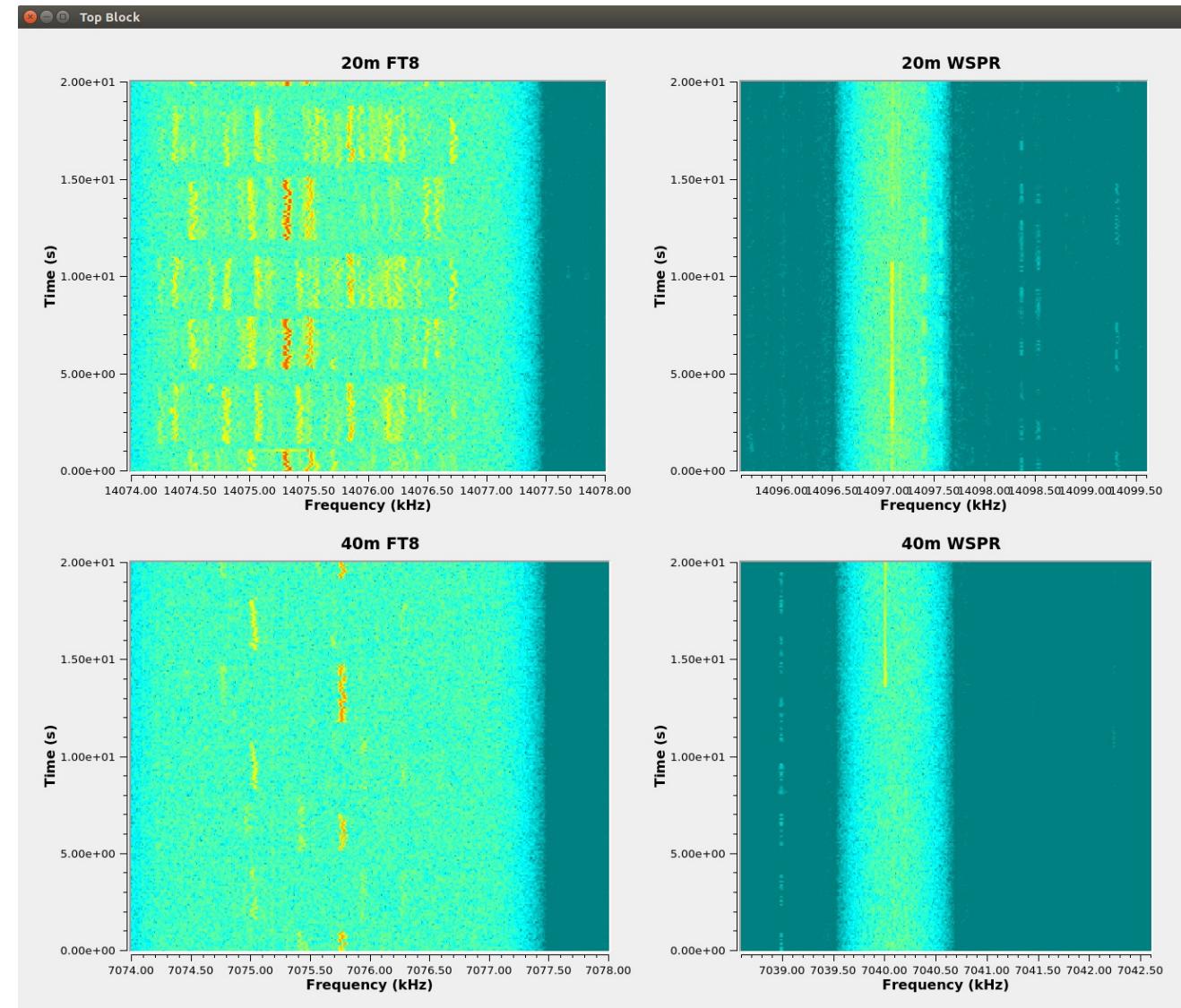
GNU Radio: SSB Demodulator

- An almost direct copy of the SSB Demodulator example on the GNU Radio wiki:
 - Baseband RF in, “dial frequency” at 0Hz
 - Weaver Method SSB demodulator
 - USB or LSB audio out
- Made into a GNU Radio Hierarchical Block, used in Dual SSB Demodulator



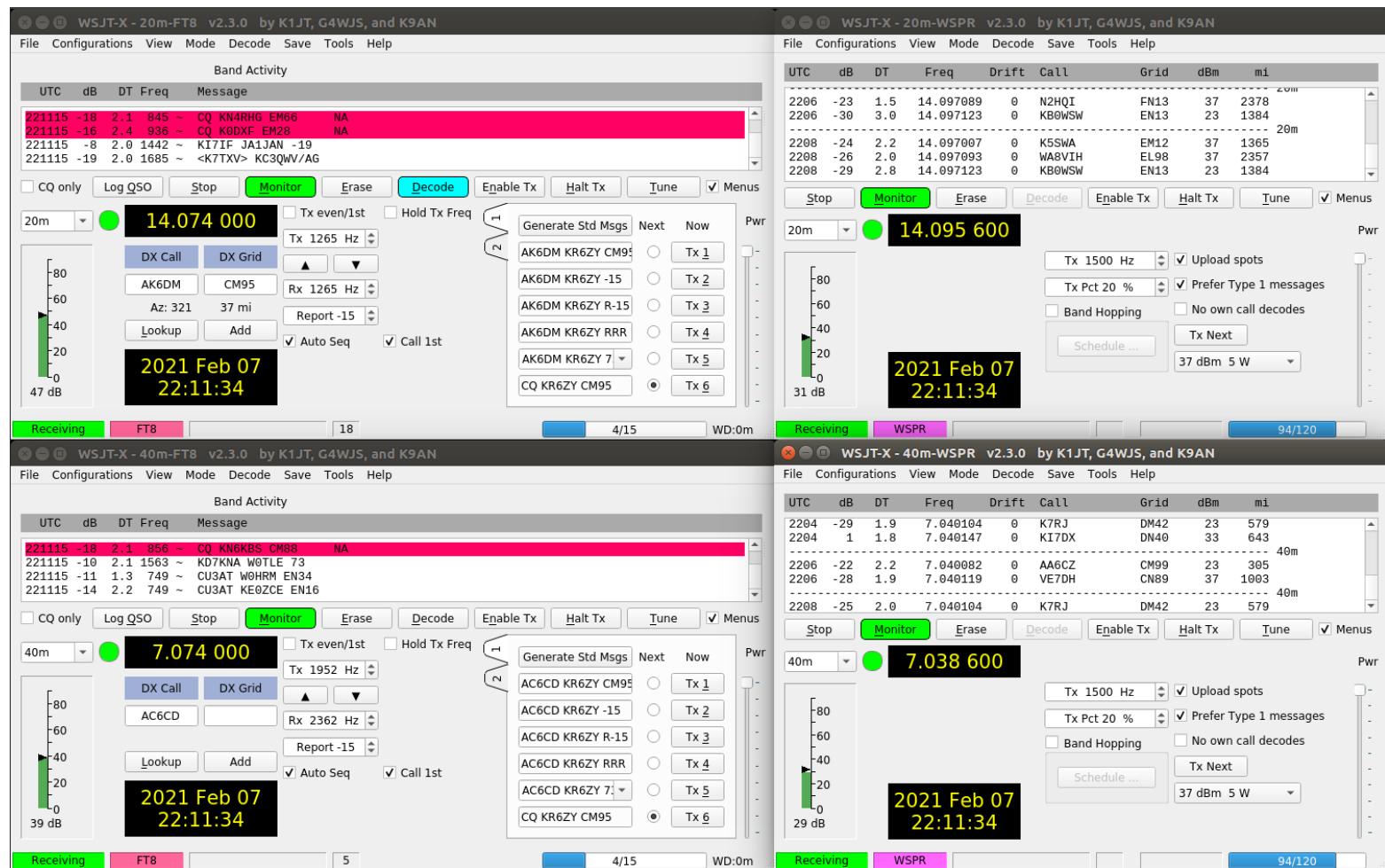
GNU Radio: What does it look like?

- Waterfalls enabled
- Notice:
 - The Filtered sub-bands
 - The 15 second period in the FT8 waterfalls
 - The beginning of a 20m WSPR, and end of a 40m WSPR
 - There were a lot more WSPR decodes than just the lines you can see!



WSJT-X: What does it look like?

- Waterfalls disabled
- Rows are bands
 - Top: 20m, Bottom: 40m
- Columns are mode
 - Left: FT8, Right: WSPR



What are we talking about today?

- The “What” and “Why”
- Overview of solution.
- **GNU Radio blocks.**
 - SSB Demodulator
 - Dual SSB Demodulator
 - Top Block
- Demonstration
- Q&A



What are we talking about today?

- The “What” and “Why”
- Overview of solution.
- GNU Radio blocks.
 - SSB Demodulator
 - Dual SSB Demodulator
 - Top Block
- Demonstration
- Q&A



Live Demonstration!

...I see no way this will end poorly...



What are the problems with this?

- CPU Intensive:
 - Raspberry Pi 4 is able to keep up with two modes, two bands, but it still slips behind some.
 - My laptop (2017 Dell XPS 15) does two modes, two bands, about 50% CPU.
 - Disable waterfalls in GR and WSJT-X, setting to “Normal” decode, helps.
- Latency:
 - Even when it’s not behind, it still adds 1 to 2 seconds of latency.
 - Enable “Decode after EME delay” to compensate.
- It’s not truly “headless”:
 - WSJT-X requires a GUI. I was hoping to do it all at the command line, or in a start-up script.





Q&A

<https://github.com/SmittyHalibut/GR-MultipleReceivers>

<https://twitter.com/SmittyHalibut>

<https://youtube.com/SmittyHalibut>



Foo Bar



Foo Bar

