Ham Radio SDR Configuration and Data Flows

Effects of the 2017 Solar Eclipse on HF Radio Propagation and the D-Region Ionosphere: Citizen Science Investigation

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Presentation for the Osher Lifelong Learning Institute

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Who am I?

- Retired NASA (37 years – whoosh!) - Computer Engineer, oversaw tasks to develop, test new computer loads and updates for general purpose computers and infrastructure at Marshall. Also, science satellite operations, computer network development, science web development, science computer support, throw in a little programming and what-nots
- Long time Huntsville resident
- Married, two sons – married one off last week!
- Hobbies – music, reading, biking, travel, scuba...

How did I get involved as a Citizen Scientist?

Mitzi Adams – Primo Science Outreach Coordinator, Scientist and Teacher extraordinaire, old friend and former colleague

Me: “Mitzi, Can I hand out eclipse glasses for you?”

Mitzi: “I know just the person to introduce you to…”

I didn’t hand out any glasses. Instead, through Dr. Fry, I was exposed to a brand new hobby and learned a lot of cool stuff.

Moral of the Story: You are lucky if you don’t get what you ask for!

Technical Stuff

Experiment Objectives

- Collect specific Morse Code-based calls (“CQ”) on a useful Radio band from Ham transmitters before, during, and after the eclipse.
  - “CQ” is Ham shorthand for initiating a general call. Hams must identify themselves by their licensed callsign. A typical sequence of general call initiation using Morse code is “CQ CQ CQ DE K9GB K9GB K9GB K”
- Report received CQ calls and callsigns live to the Reverse Beacon Network
- Record raw transmissions for later upload and study by the ham radio community

($c = \lambda\nu$) Ham Frequency Bands

Wavelength (λ)	Frequency (ν)	Wavelength (λ)	Frequency (ν)
2200m	135.7-137.8 kHz	12m	24.890-24.990 MHz
630m	472-479 kHz	10m	28.000-28.500 MHz
160m	1.800-2.000MHz	6m	50.0-54.0 MHz
80m	3.525-4.000 MHz	2m	144.0-148.0 MHz
60m	5 distinct channels between 5.332-5405 MHz	1.25m	219-220 MHz (a number of restrictions on use)
40m	7.025-7.300 MHz	70cm	42.0-450.0 MHz
30m	10.100-10.150 MHz	33cm	902.0-928.0 MHz
20m	14.025-14.350 MHz	23cm	1270-1300 MHz
17m	18.068-18.168 MHz	various	various bands between 2300 MHz - 250GHz
15m	21.025-21.450 MHz	all	above 300GHz

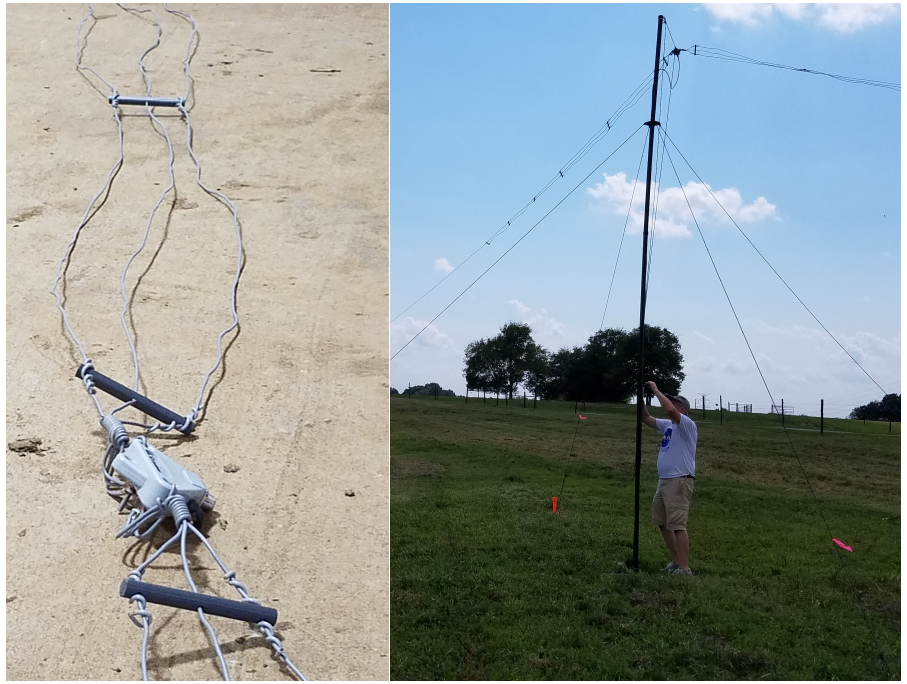
source: http://www.arrl.org/frequency-allocations

Ham Band Choice

- Frequencies less than 10MHz propagate further at night due to Ionospheric D-layer extinction after sunset. An eclipse is presumably like a very short night
- Listened to both 3.5 and 7 MHz ranges leading up to eclipse day. Although the 3.5 MHz range had some traffic, we chose the 7 MHz range to collect data due to its greater use. (40m = 7 MHz radio band)

Basic equipment

1. Dipole Antenna (attached scientist mandatory)

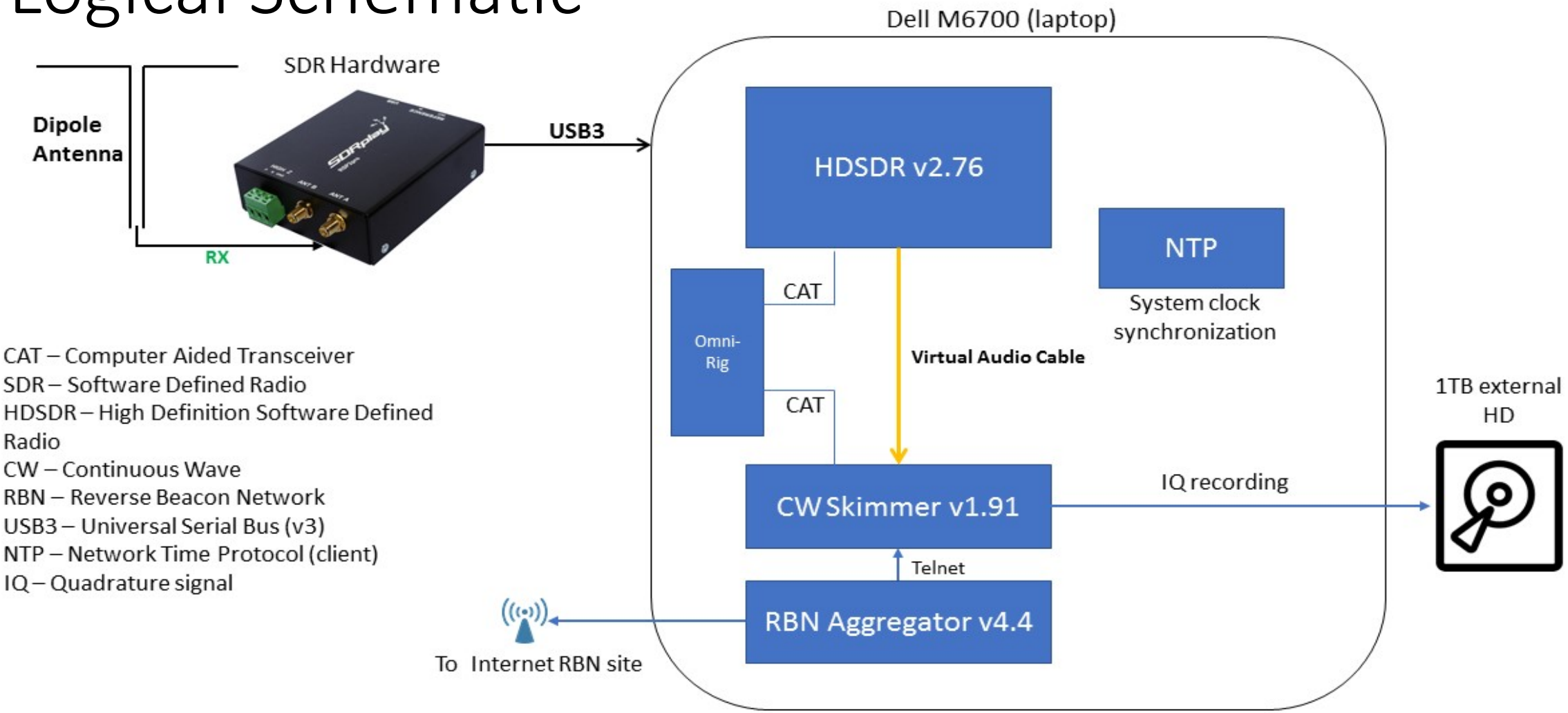


2. Ham Radio

3. Laptop computer and software

4. Cables

Logical Schematic



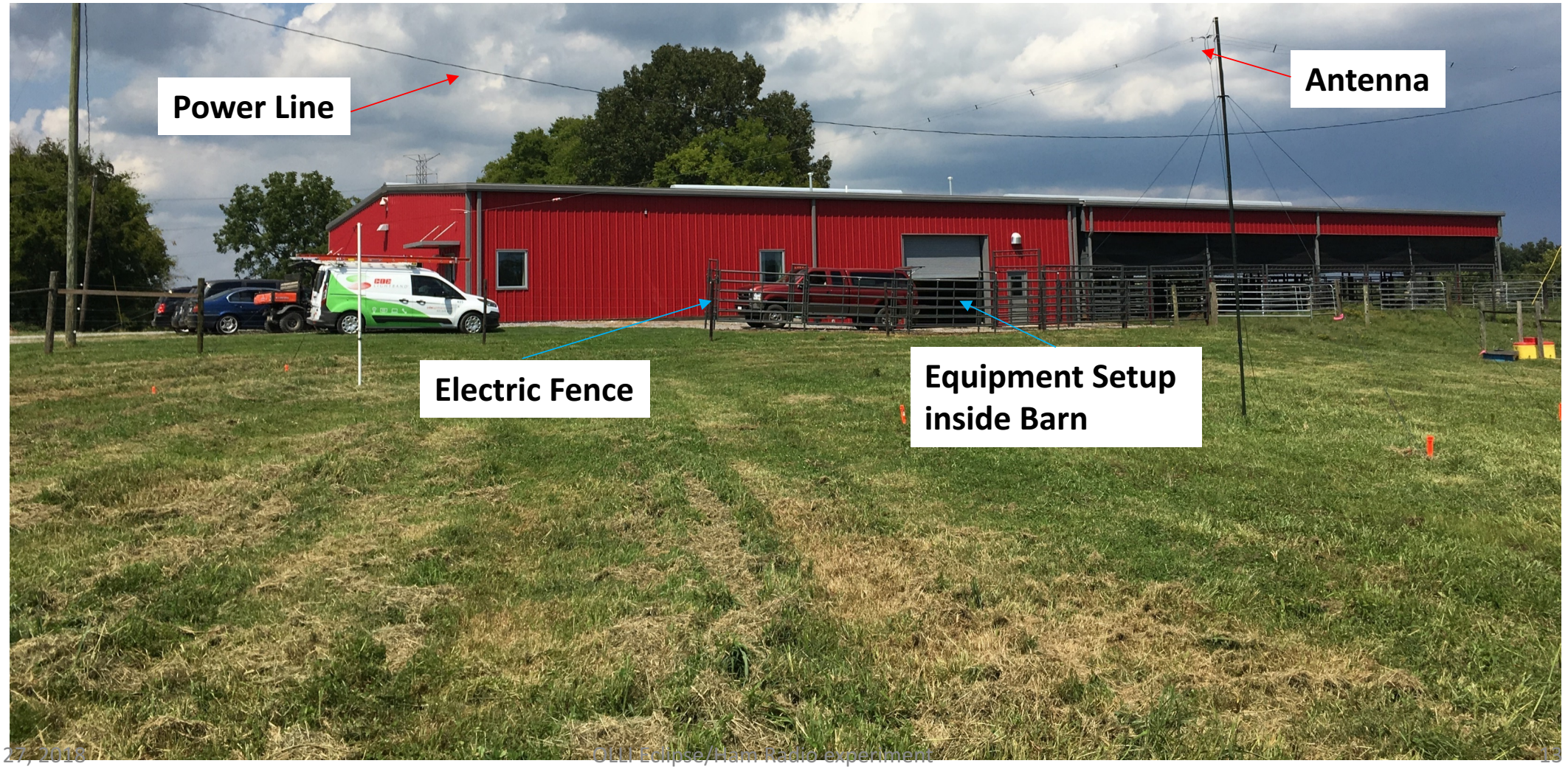
CAT – Computer Aided Transceiver
SDR – Software Defined Radio
HDSDR – High Definition Software Defined Radio
CW – Continuous Wave
RBN – Reverse Beacon Network
USB3 – Universal Serial Bus (v3)
NTP – Network Time Protocol (client)
IQ – Quadrature signal

What does the core software do?

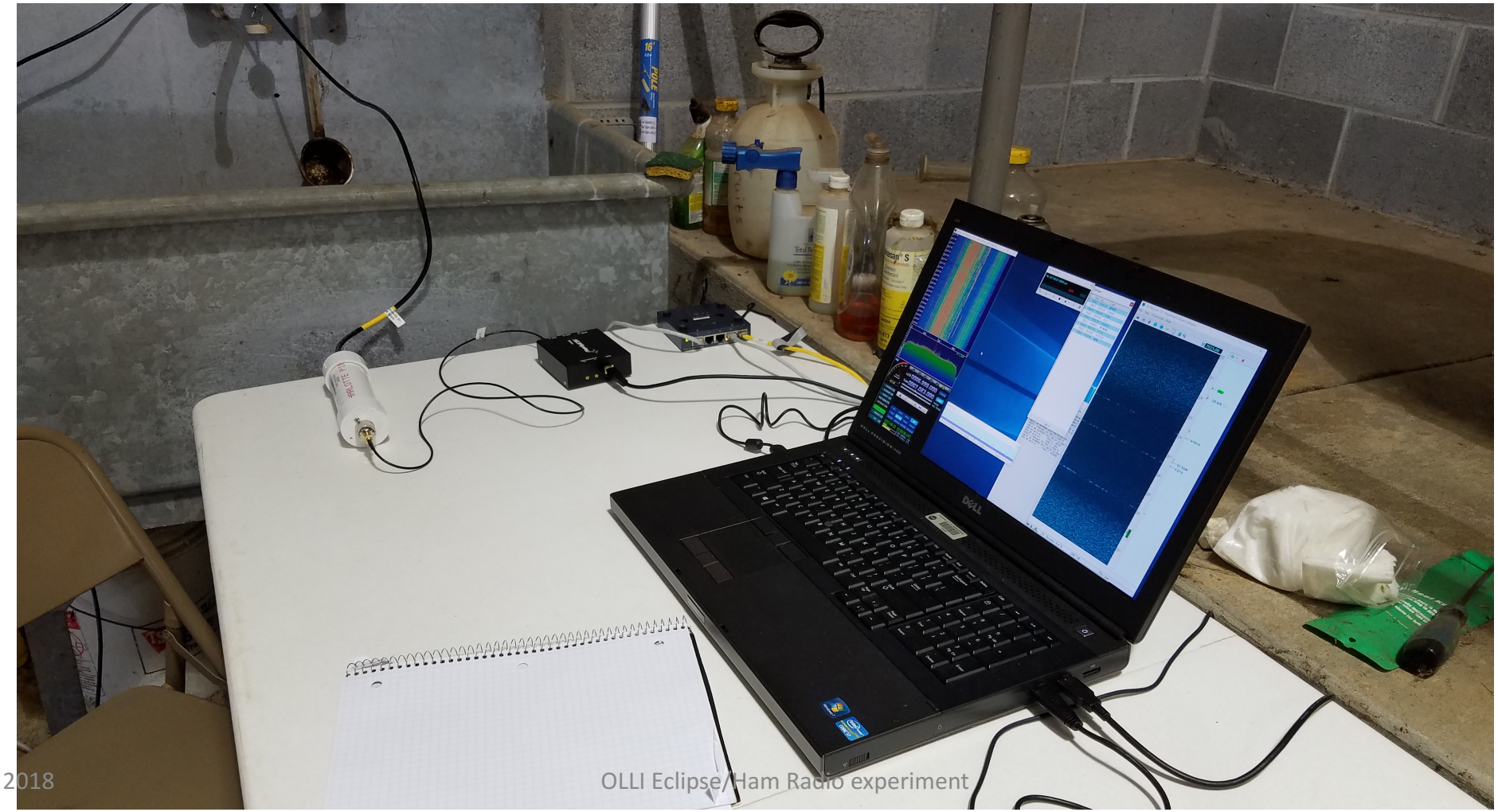
- **HDSDR** – primary program used to control the Software Defined Radio. It provides tuning, filtering, various demodulator modes (e.g. AM/FM, CW, Digital). For the purpose of this experiment, WL7C acted only as a collector and performed no transmission
- **CW Skimmer** – program which takes tuned output from HDSDR, analyses all signals in the band received, and decodes Morse code to detect "CQ" calls. A successful detection is called a "Spot". CW Skimmer also records raw audio data in a weird 24bit audio ".wav" file
- **RBN Aggregator** – program that collects all spots from CW Skimmer and uploads spots in real time to the Reverse Beacon Network

Experimental Conditions

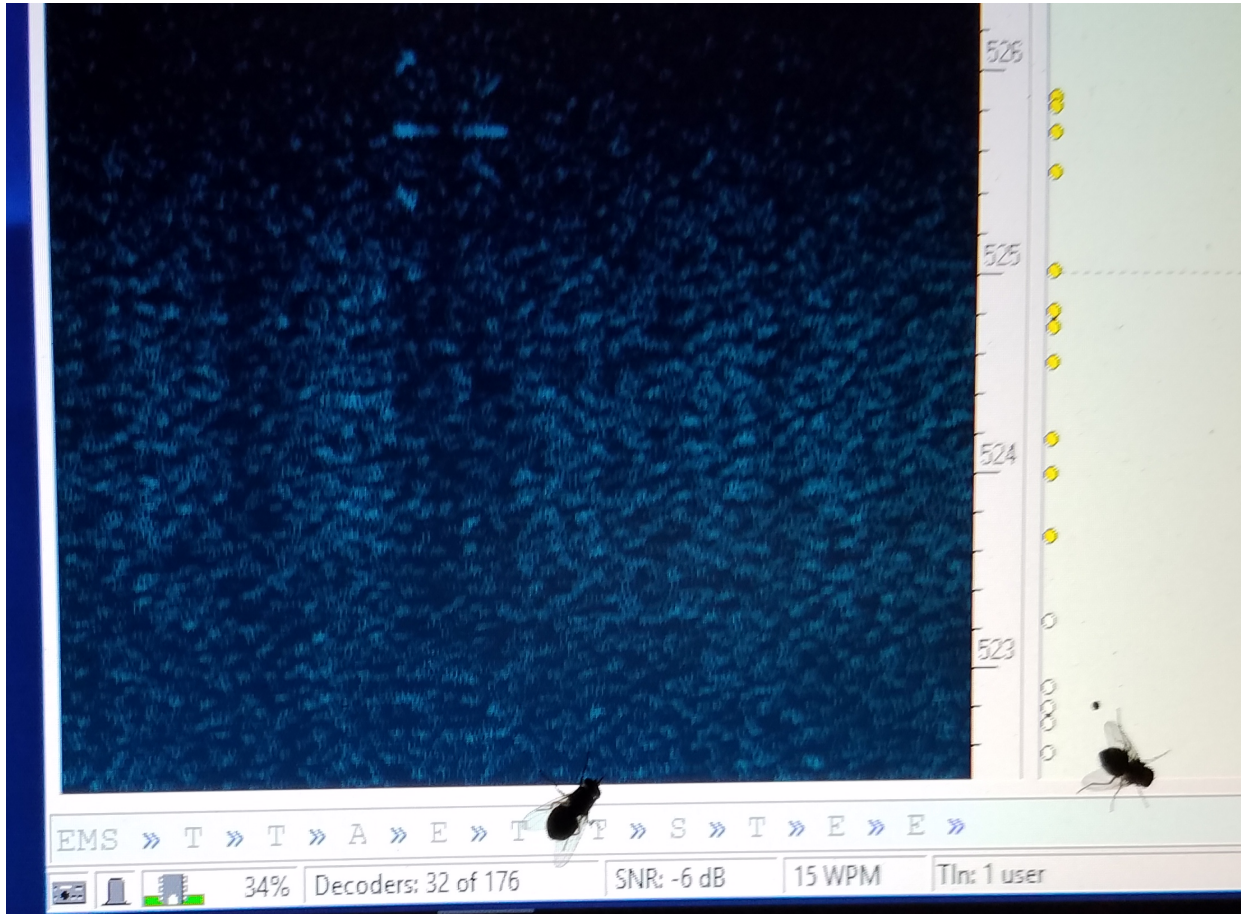
The Barn and Bull Paddock



In the Barn



Office Mates



Embed screen capture with CWSkimmer A/V output;
max 2 minutes worth, include close-up of decoded Morse code;

Challenges

- Ham Radio software is written by Hams and for Hams. Finding enough documentation to integrate the software effectively was slow going
- Ham software writers generally don’t worry much about computer security, and tell you so
- Data: CQ calls do not require geographic information in the call. Some Hams did include their location in Morse code, but most did not, and location was not part of the Spot data uploaded live to the RBN network.
- Knowledge of location of transmitter relied on where the Call Sign is registered (usually Ham’s home address), and was pulled from the internet a few weeks after the eclipse

Successes

- The rig worked! Data were reported and collected/uploaded to the Ham community
- The data indicated several interesting scenarios with respect to eclipse progression, DX (transmitter) distance and direction and ionospheric impacts (leaving the hard explanations for Dr. Fry!)
- The eclipse was magnificent, and any effort was vastly rewarded by the end-to-end experience
- Thank you!

Questions?