PRACTICAL RADIO ASTRONOMY PROJECTS

Sean Johnston
Supervisor: Jose Sabater Montes

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- Undertaking small, easily reproduceable radio astronomy projects and providing (if successful):
  - Proof of concept
  - Documentation/Instruction
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- Chosen two in the available time:
  - Meteor Radio Scatter
  - Milky Way HI Emission

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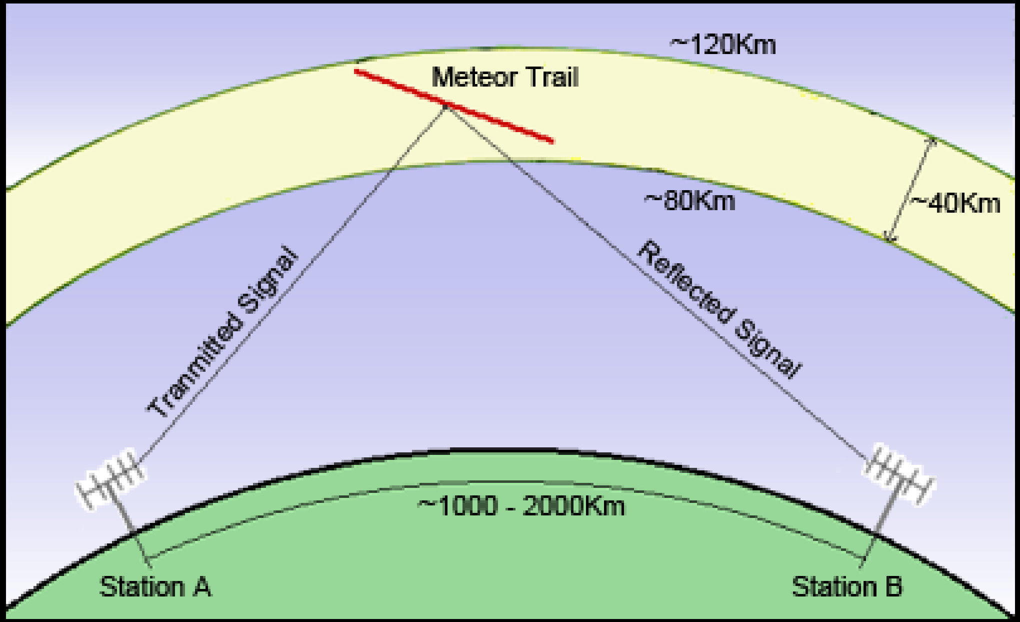
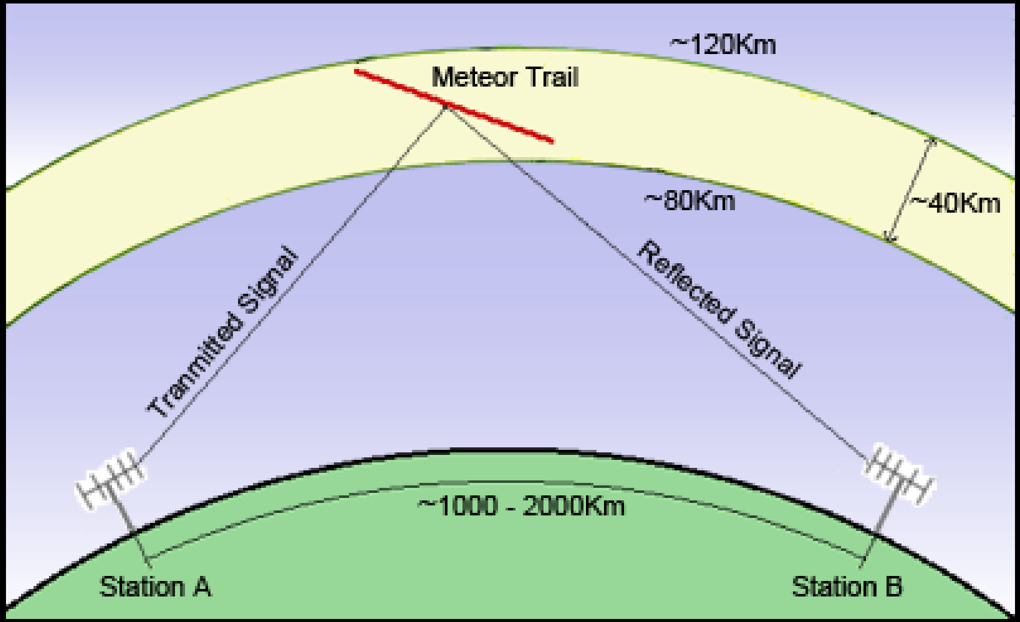


METEOR RADIO SCATTER

- Meteors can create dense trails of ionised gas between 80 - 120 km above the ground

- Useful for brief long range communications:
  - Can reflect radio waves in the VHF band
  - They can last for up to a few seconds
  - Typical distances of 1000 – 2000 km



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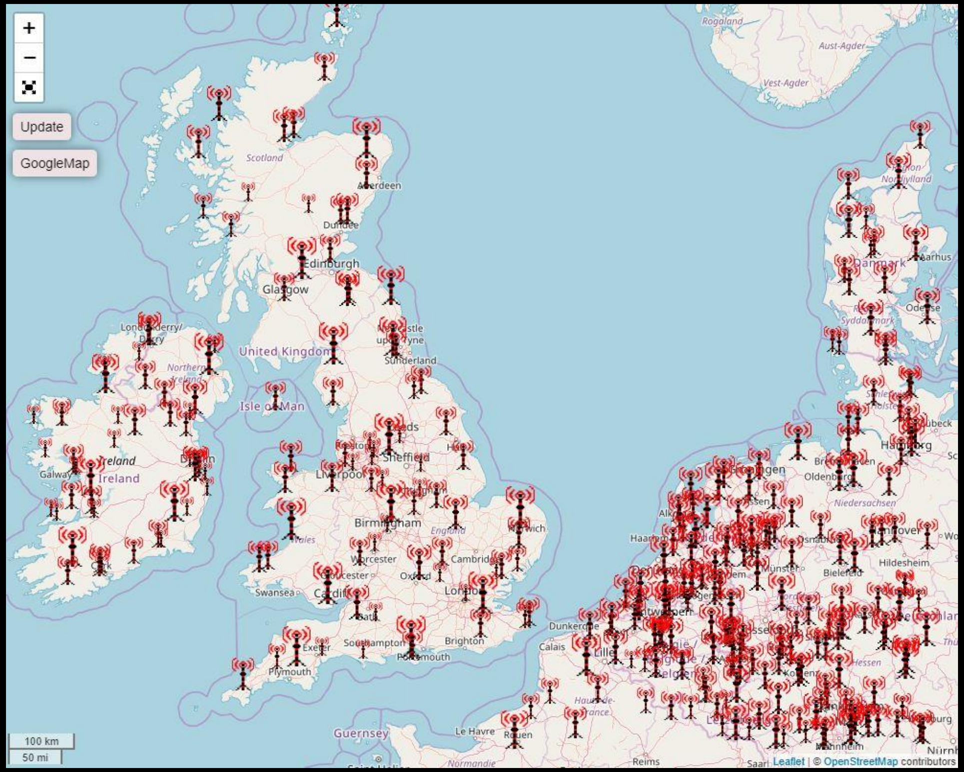

Example FM transmitter map search from fmscan.org

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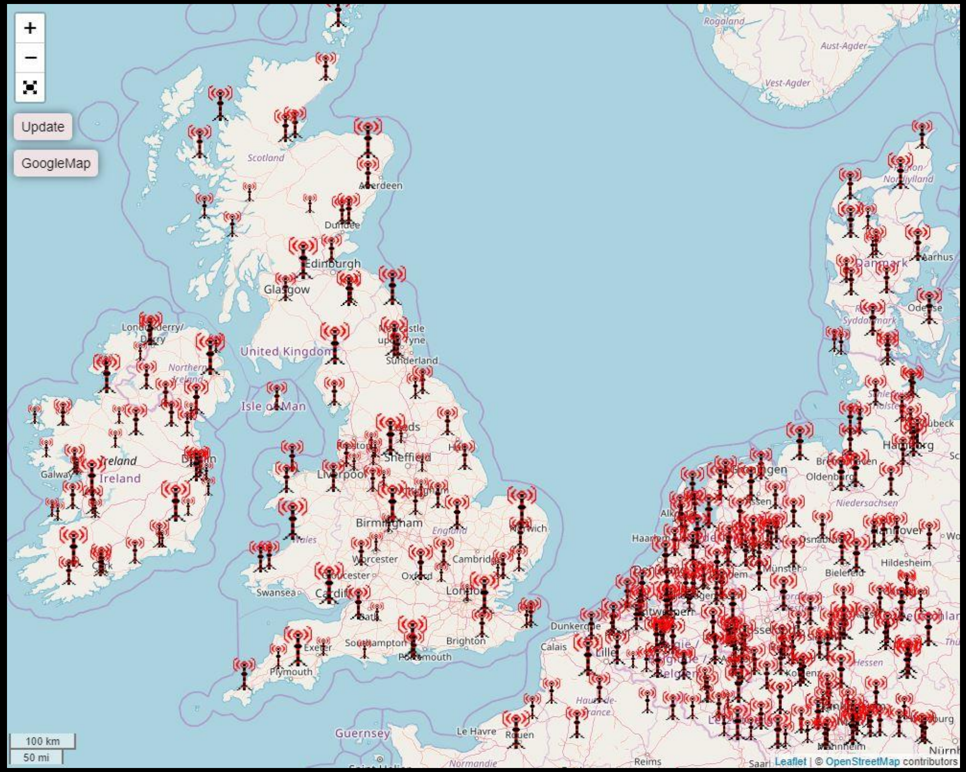
- Utilised useful information from *The Radio Sky and How to Observe It* by Jeff Lashley



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HARDWARE

- RTLSDR receiver dongle
- SDRPlay receiver
- Directional Yagi antenna
- Enough cable to rig a small ship
- Laptop
- Antenna mast
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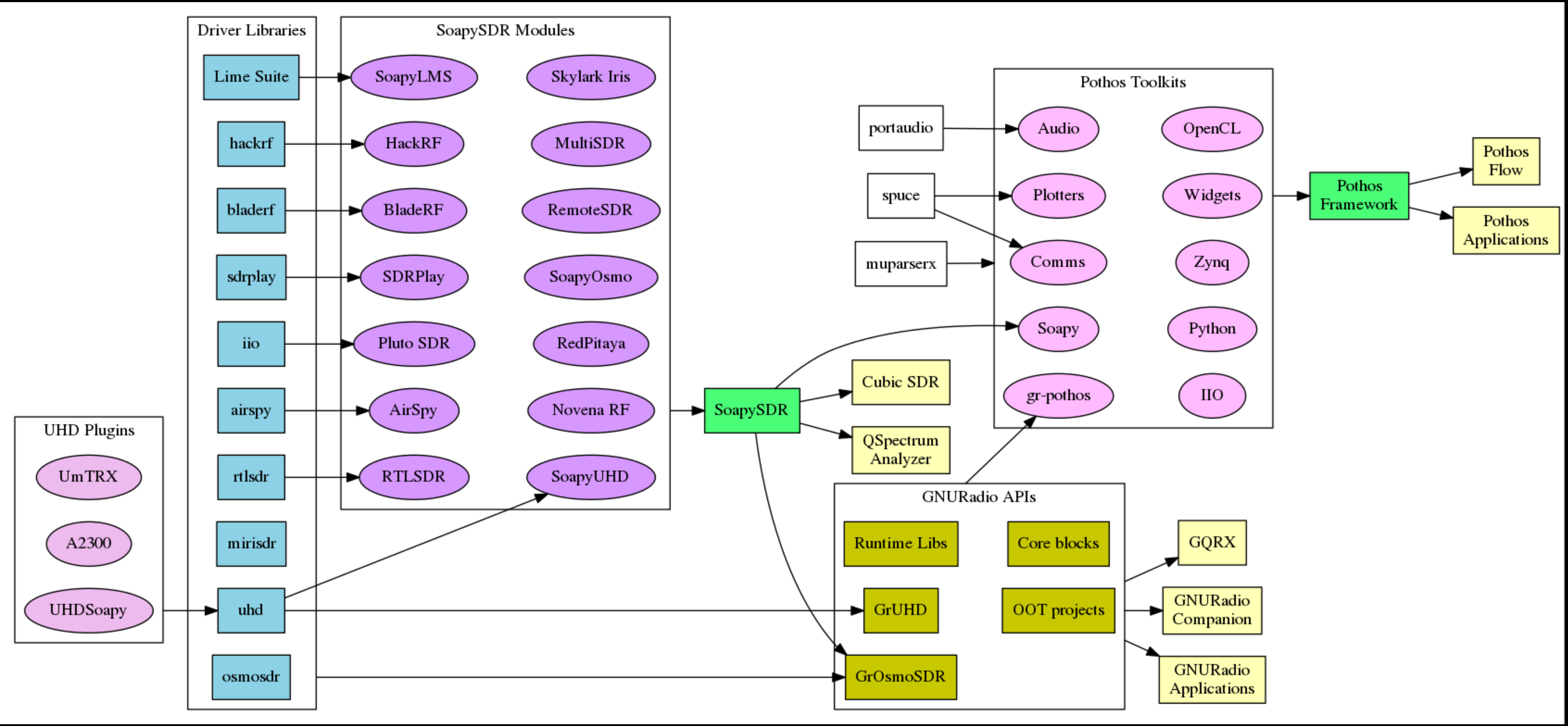
  - Open-source, vendor neutral, platform independent C/C++ API and runtime library
  - General – can interface with most SDR device types/environments
  - soapy_power terminal command available to obtain power spectrum
  - SoapySDR Python bindings available

SOAPYSDR ECOSYSTEM



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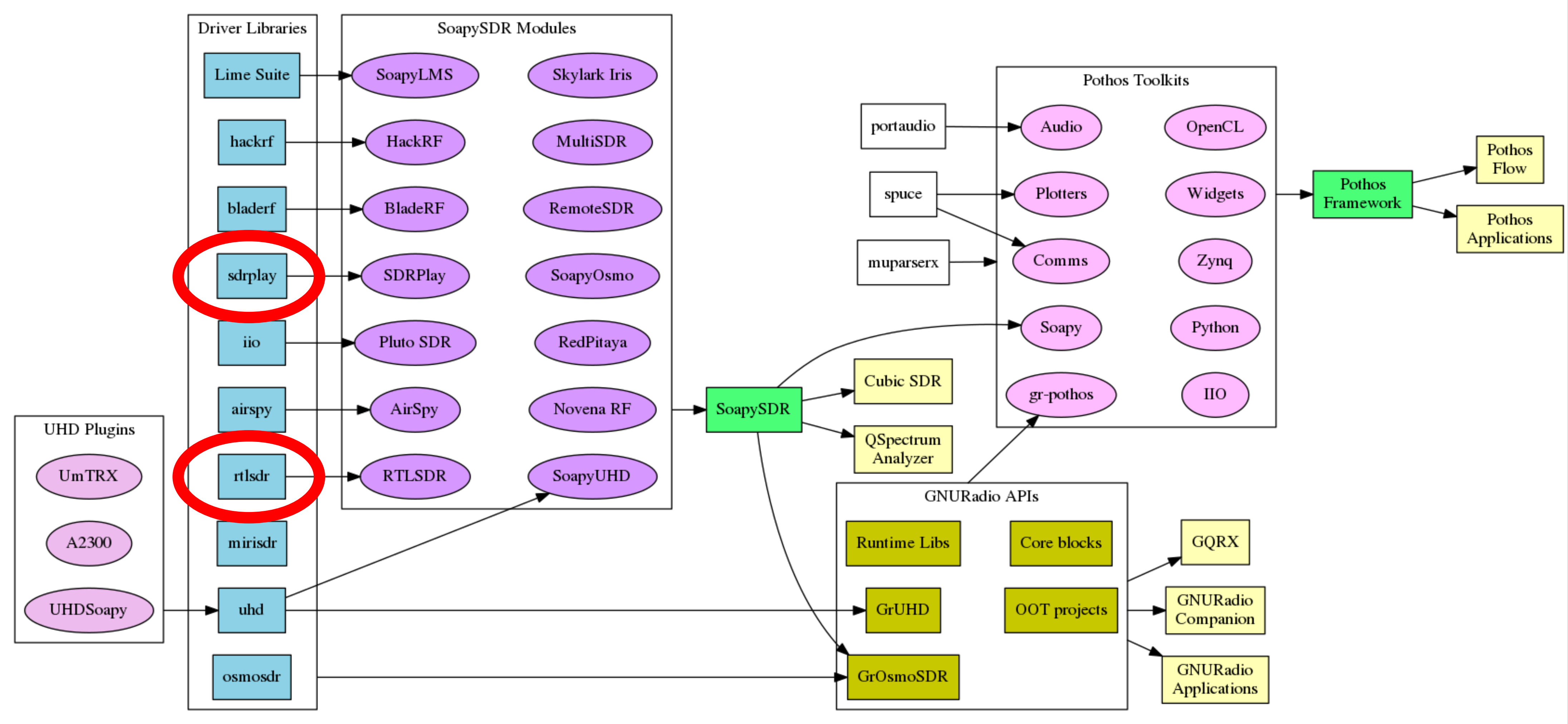

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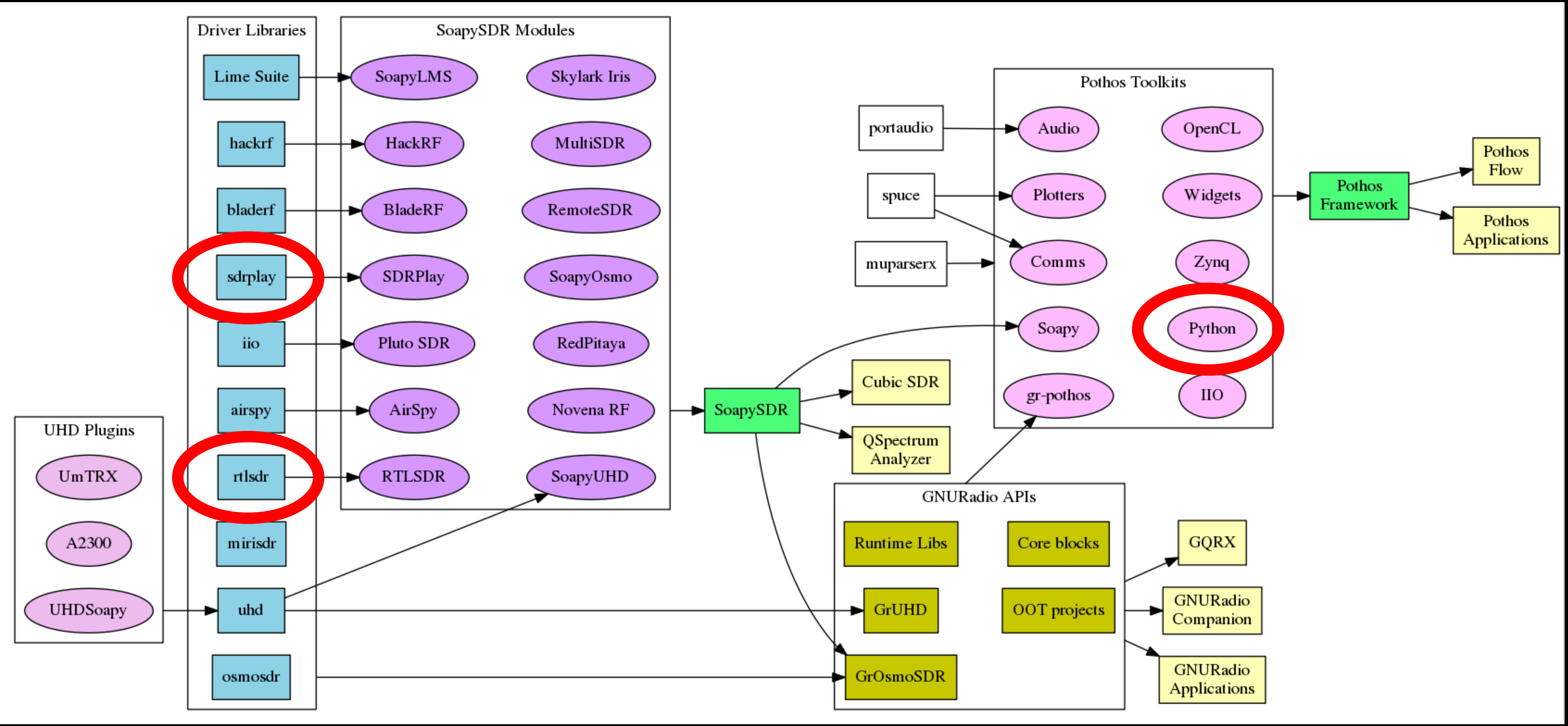

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- Ran into many issues attempting to install software and then getting it to work with the hardware…

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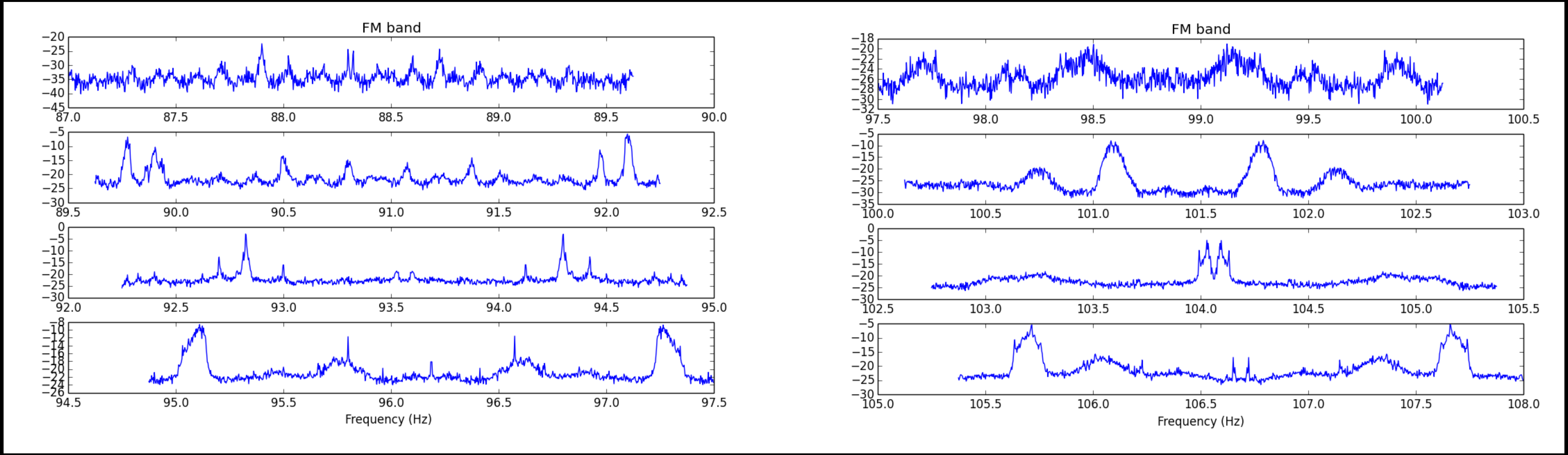

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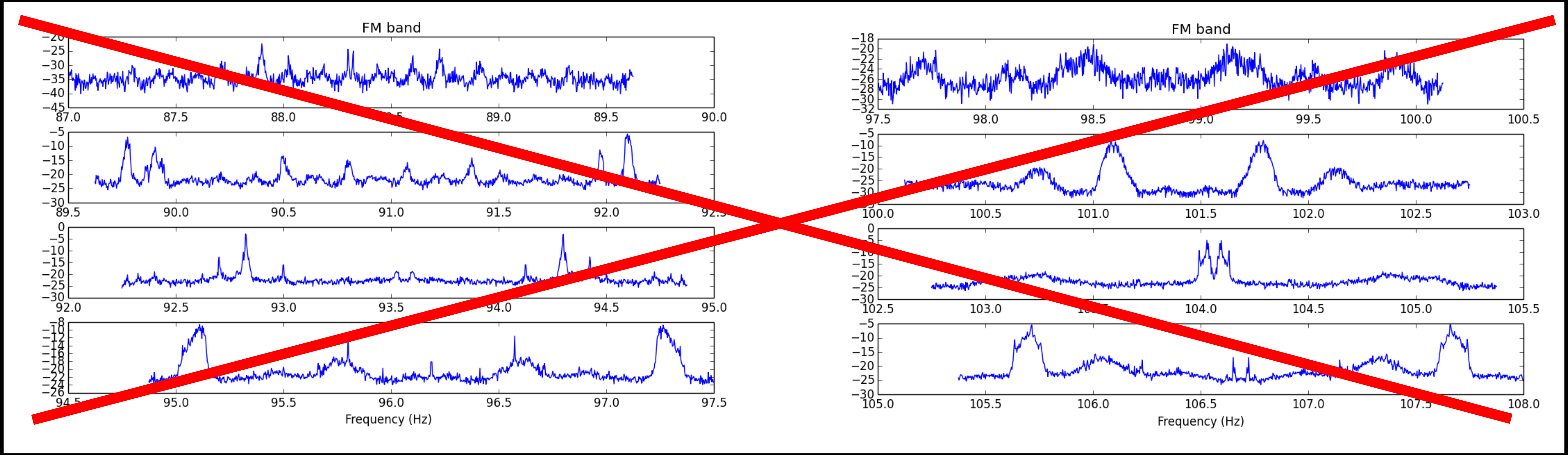

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  - Managed to install SoapySDR Python bindings
    - Wrote Python script to run receivers
  - Also got soapy_power power spectrum terminal command working

  - Python script and soapy_power provide two methods for gathering data

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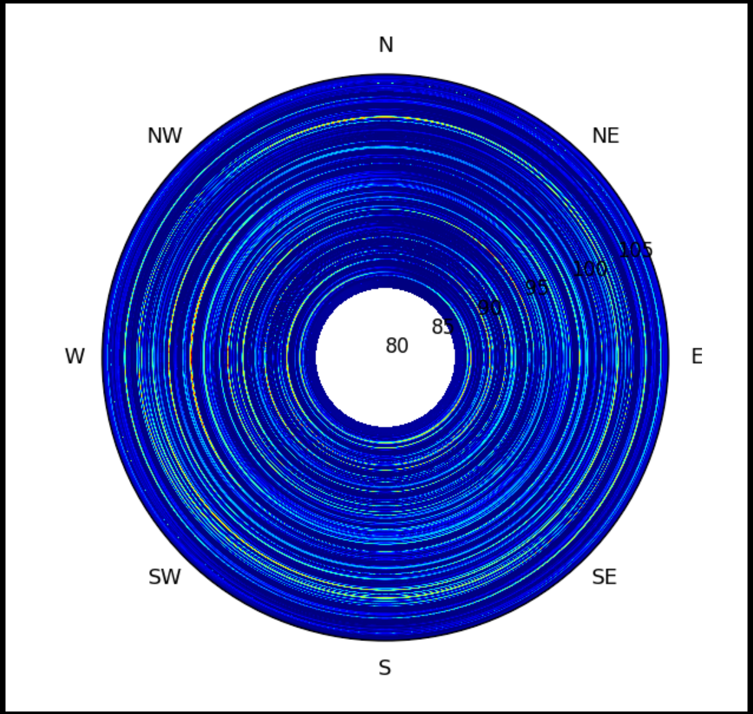

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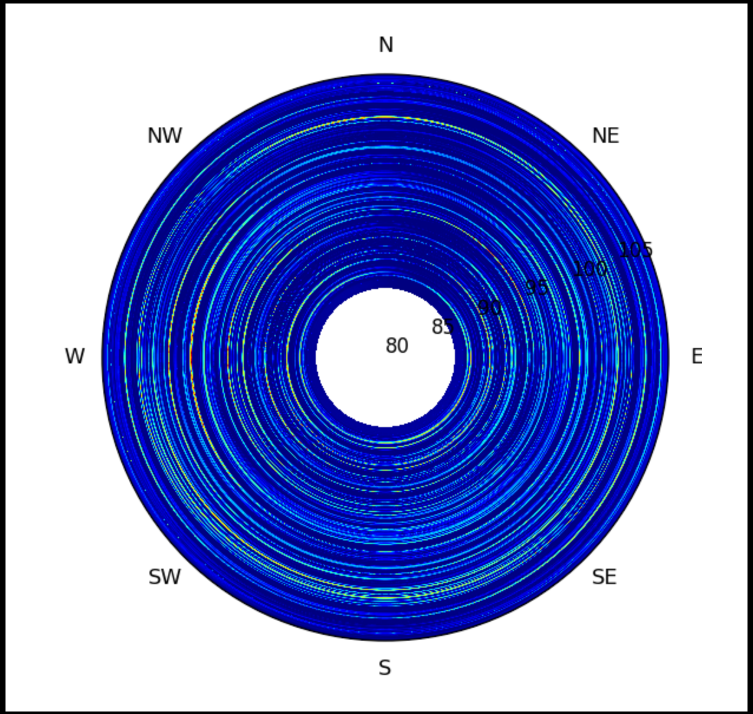

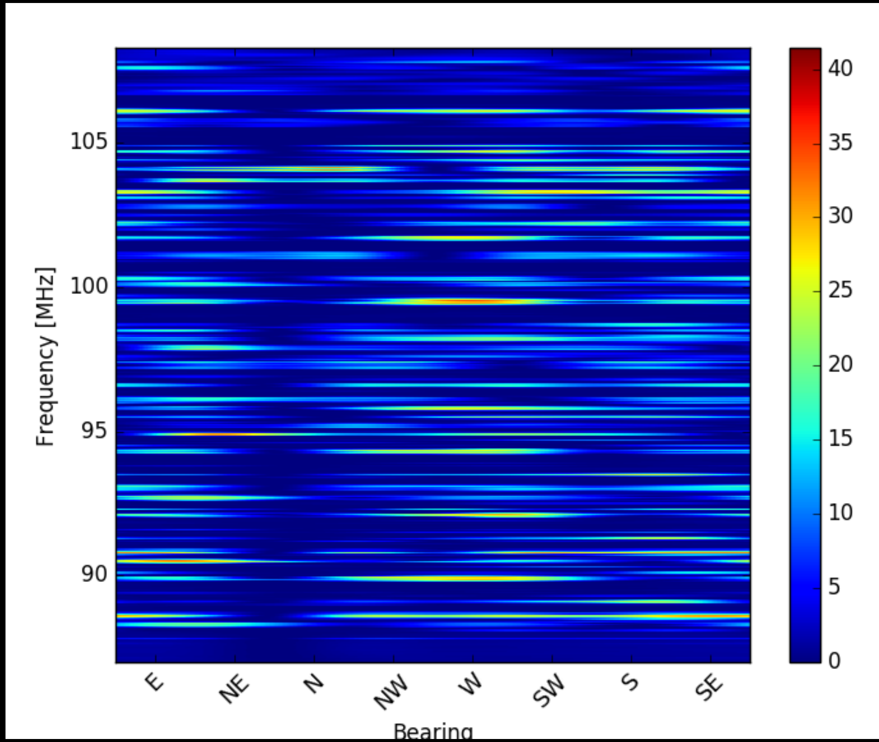

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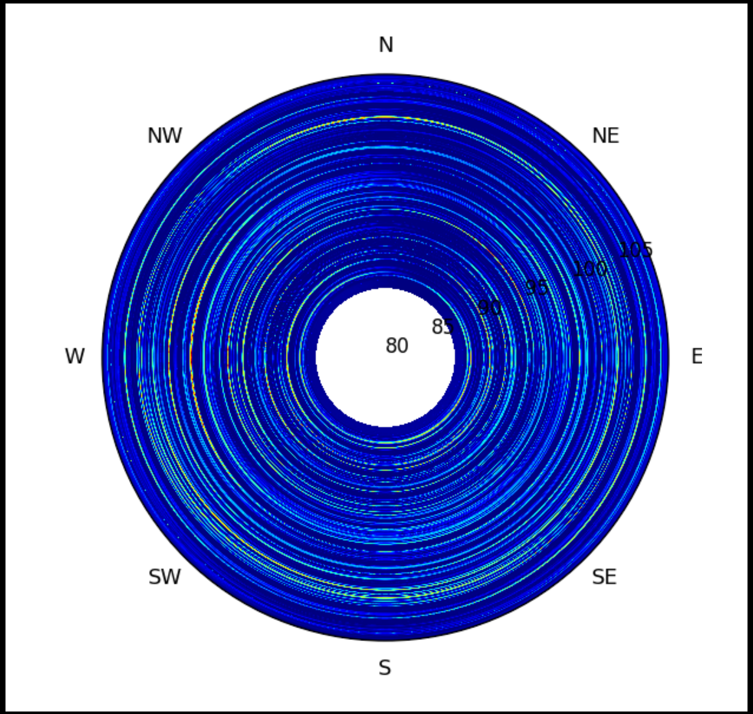

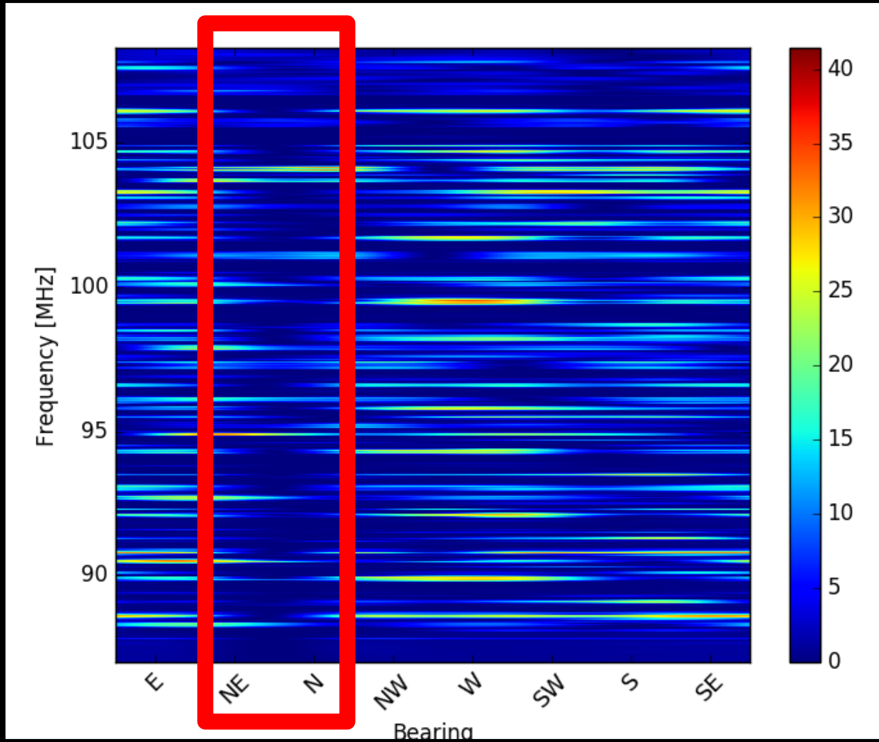

FIRST DETECTION!

- Then made test run using CubicSDR
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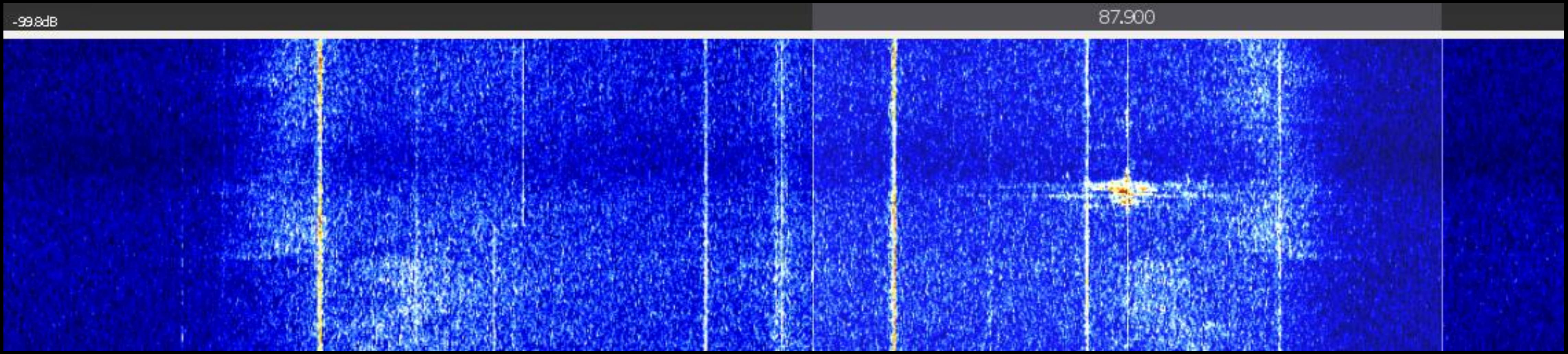

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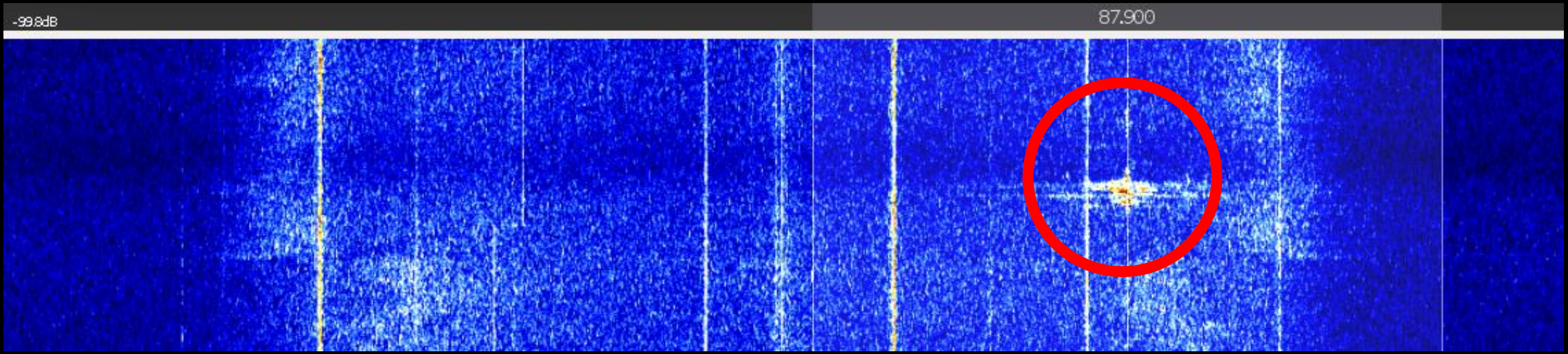

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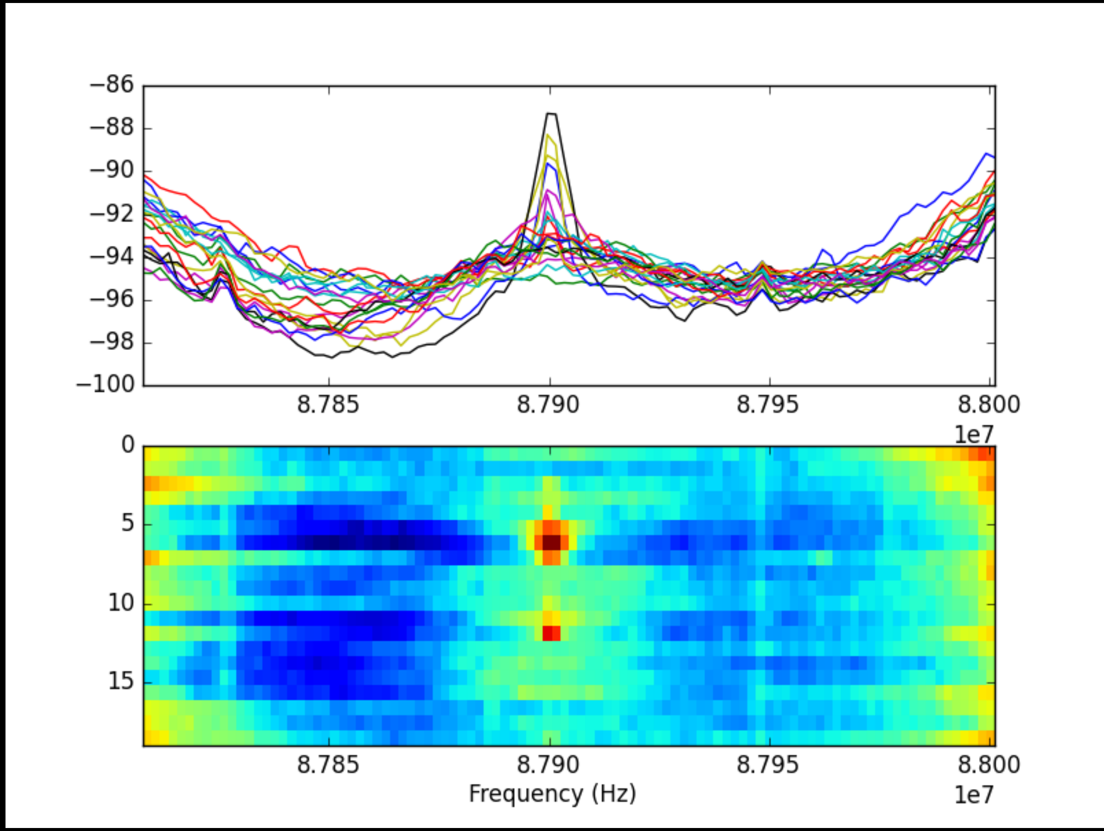

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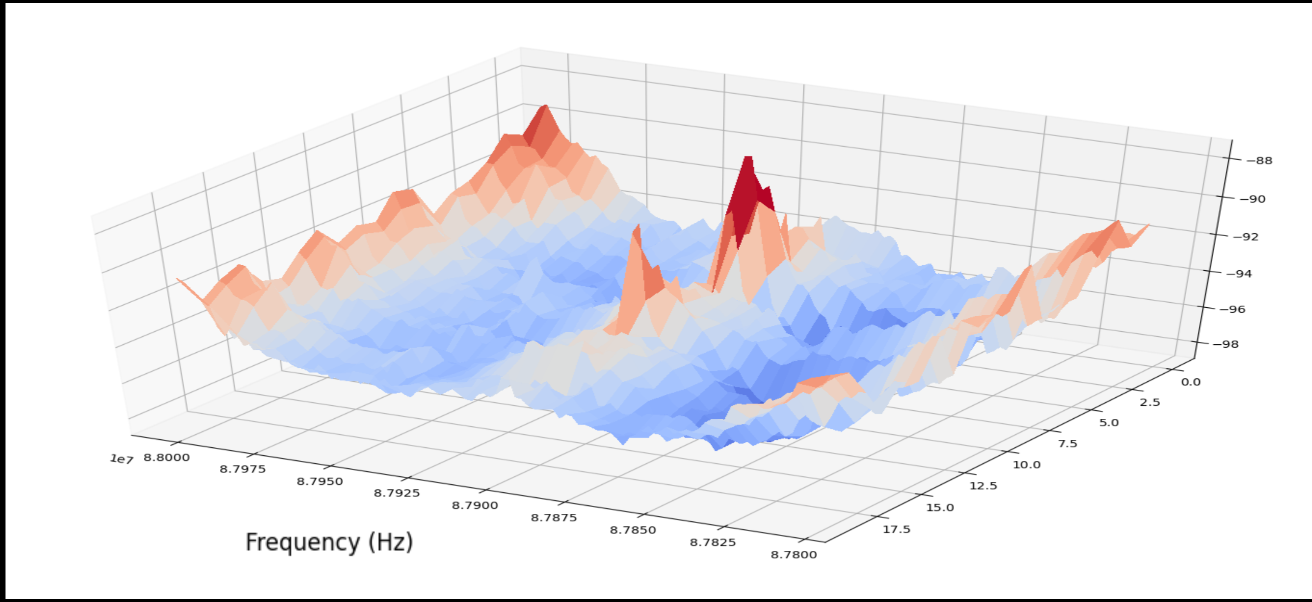

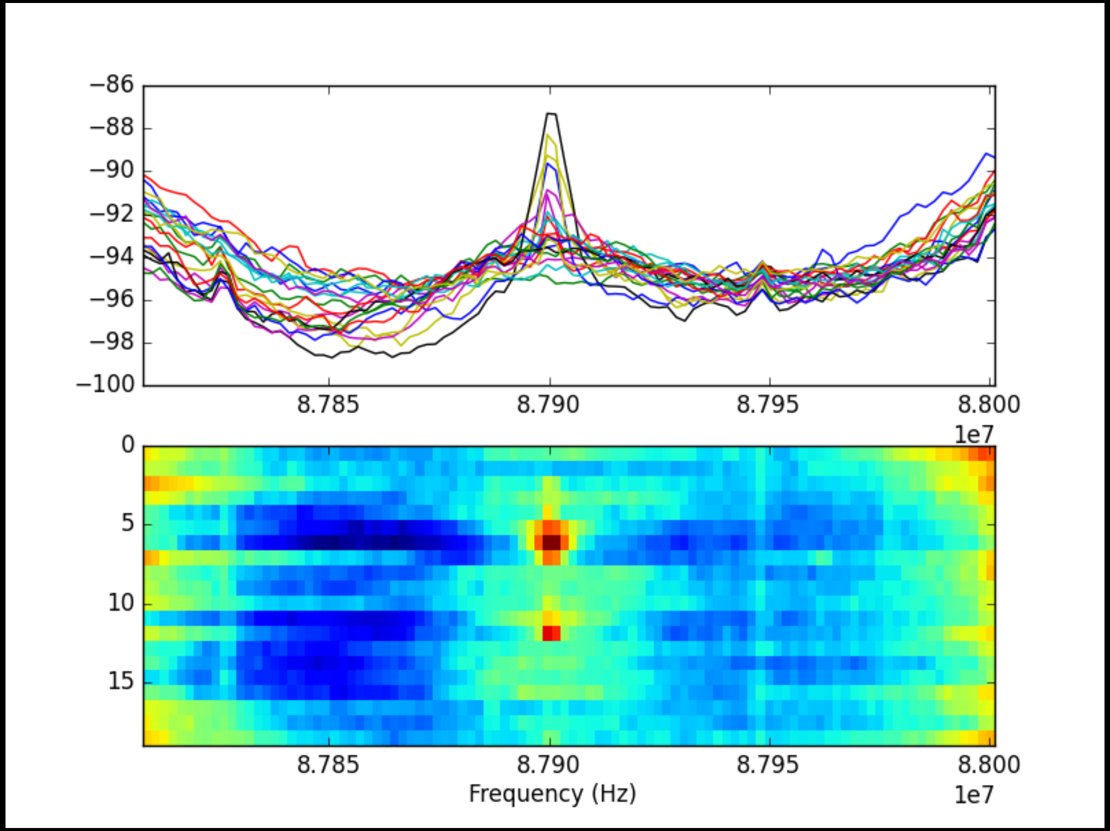

PHASE 4: SOME PROPER ANALYSIS

- Then wrote an event detection script
  - Calculates a moving median and standard deviation of past integrations (around 50 or so)
  - Compares next integration to these statistics
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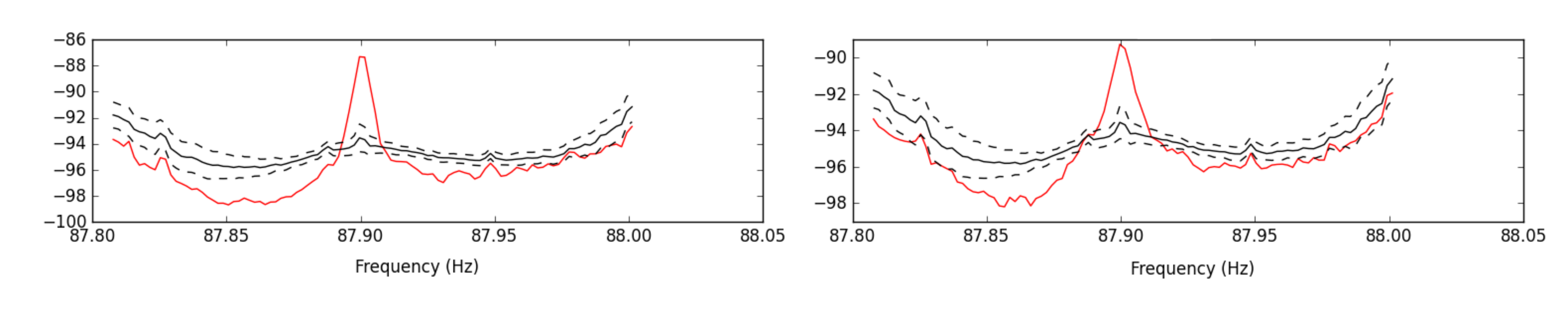

PHASE 5: AUTOMATION?

- Combined event detection code and receiver driver code to allow for on-the-fly event detection
  - After each integration is taken, compares with statistics etc.

- By this point, time dictated we move on to our second project

MILKY WAY HI EMISSION

- Neutral Hydrogen atoms are distributed throughout the Milky Way galaxy
- These atoms have two energy states determined by the relative spins of the proton and electron:
  - State with spins aligned has higher energy
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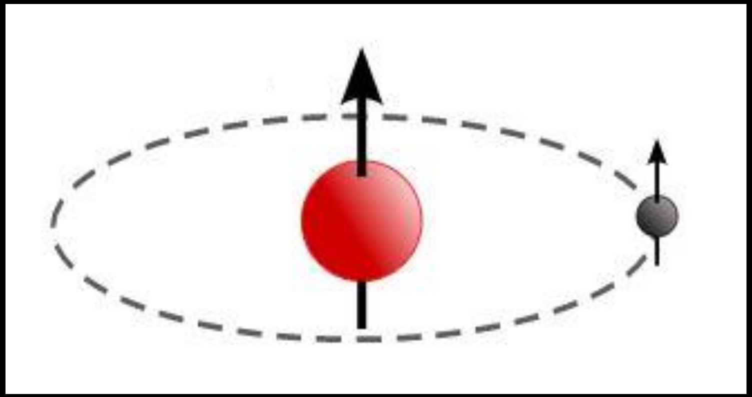

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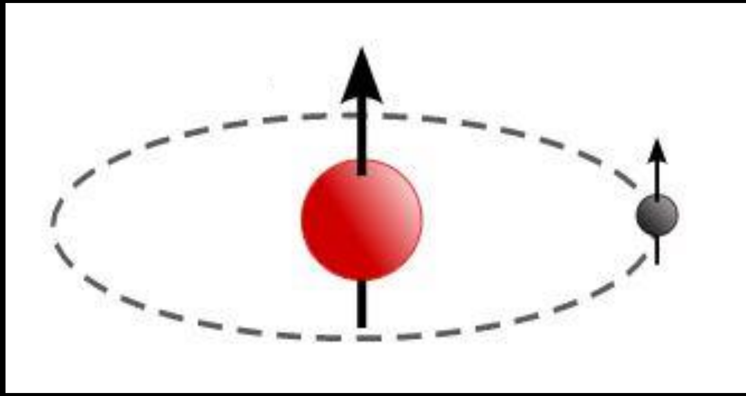

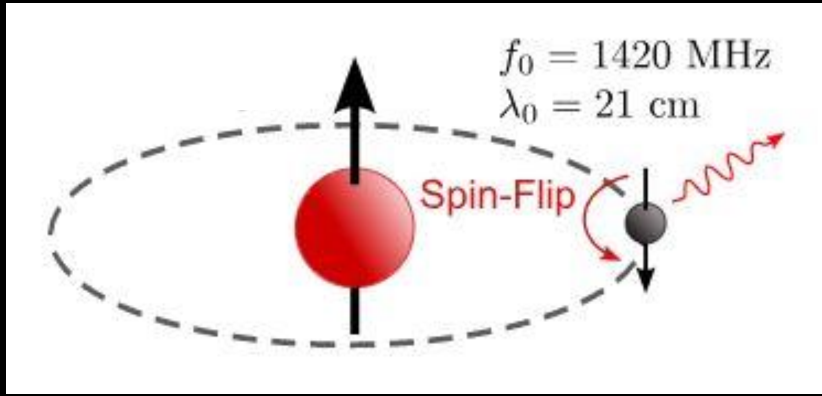

MILKY WAY HI EMISSION

- This emission will be stronger in directions that contain more of the galaxy
  - i.e. looking toward the centre as opposed to looking out from the plane
- As Earth rotates through one day, different parts of the galaxy will be overhead
  - Can leave a detector pointed in a fixed direction over one day to measure this changing HI intensity

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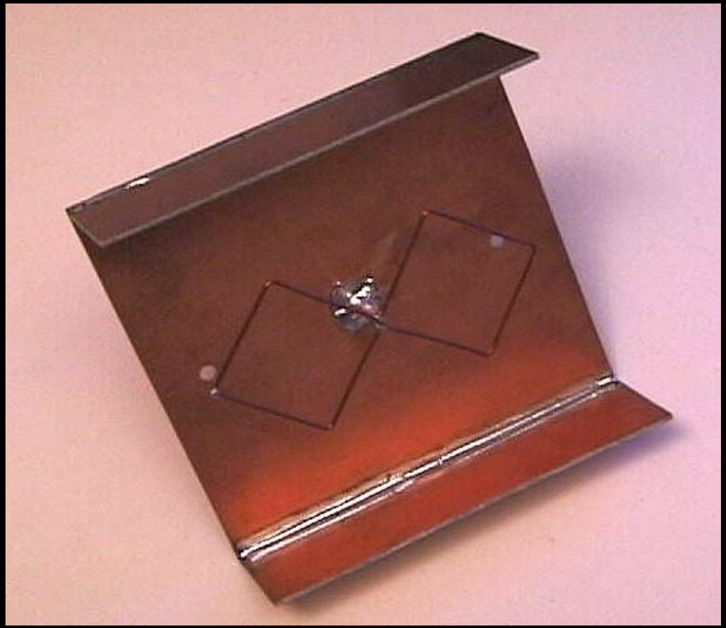

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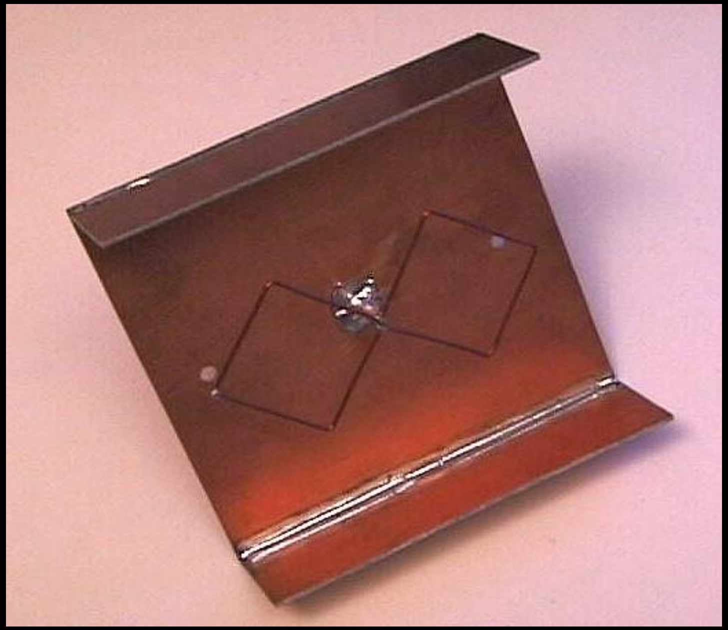

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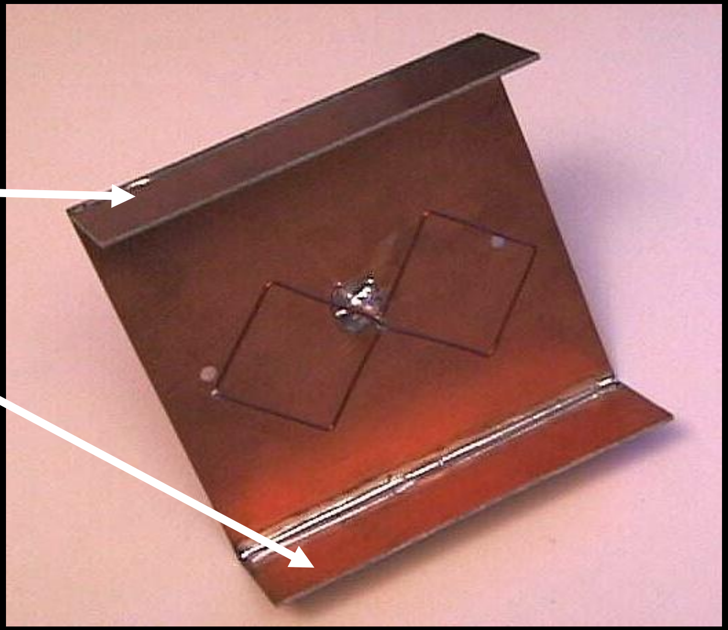

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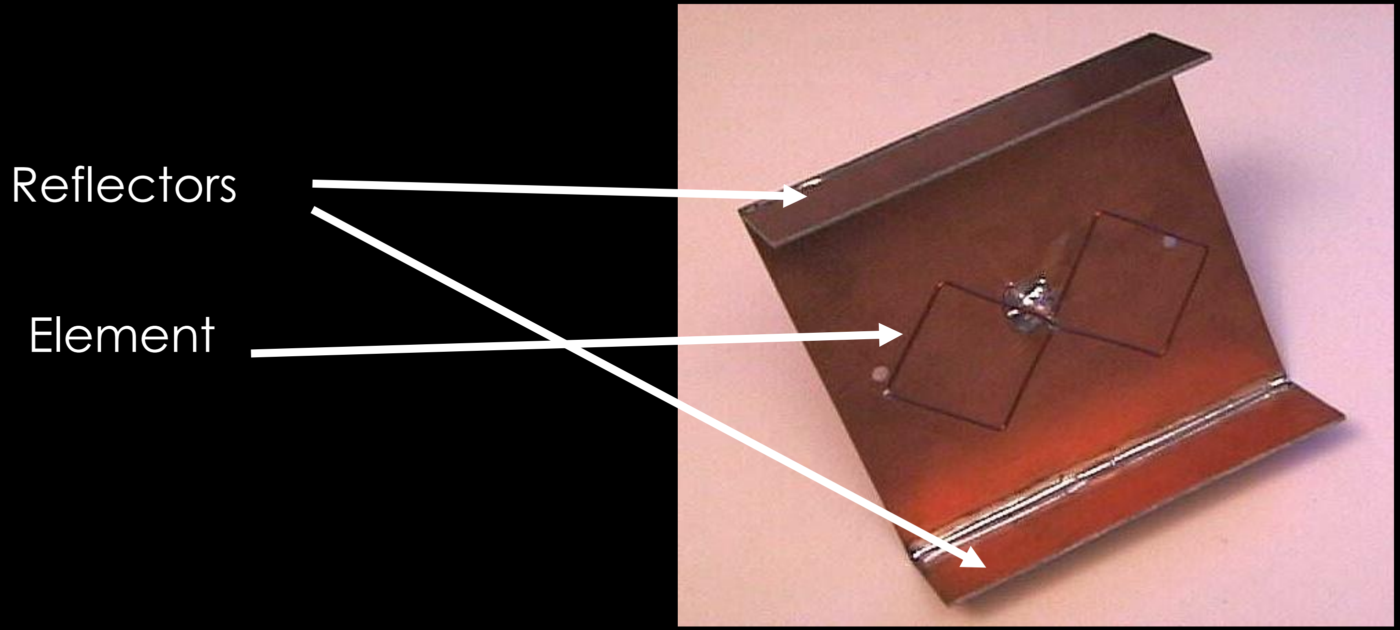

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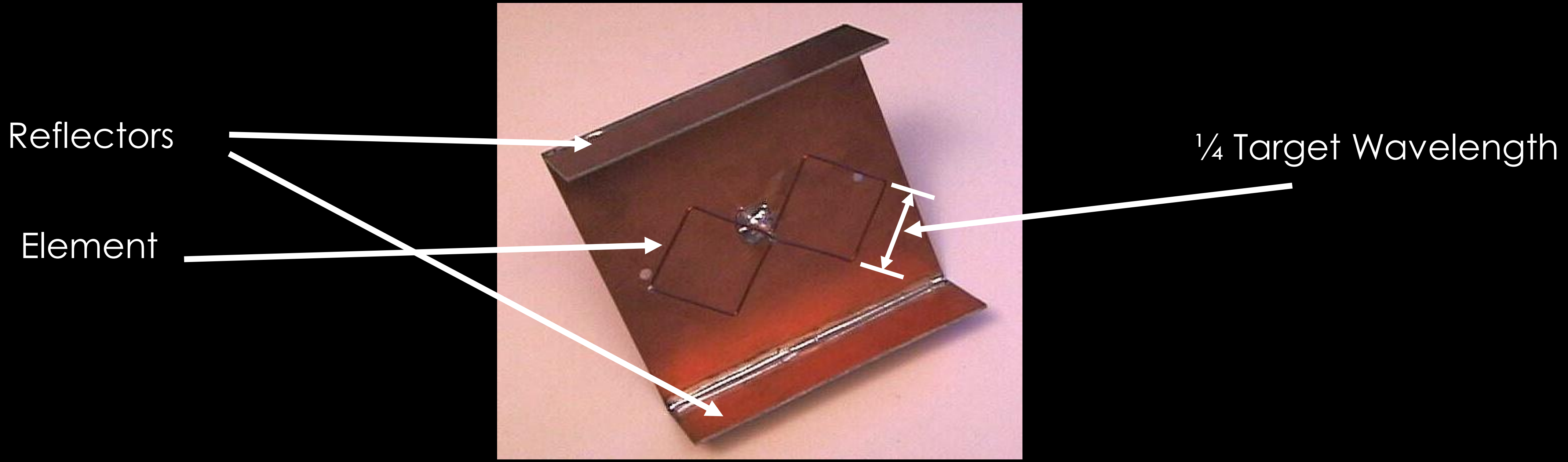

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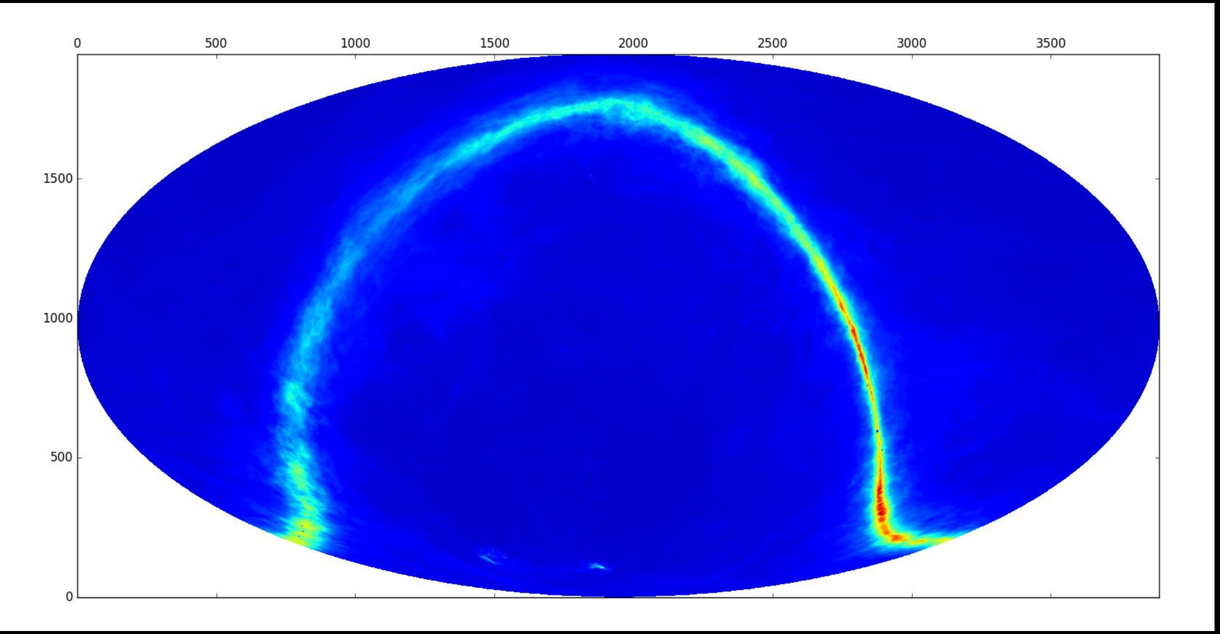

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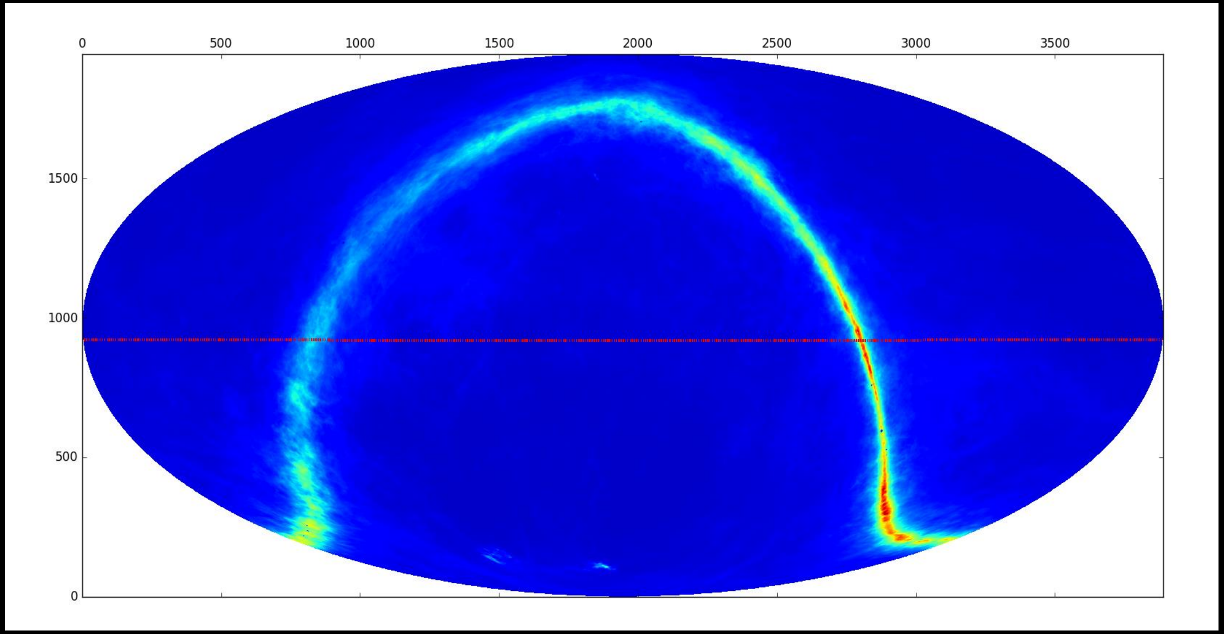

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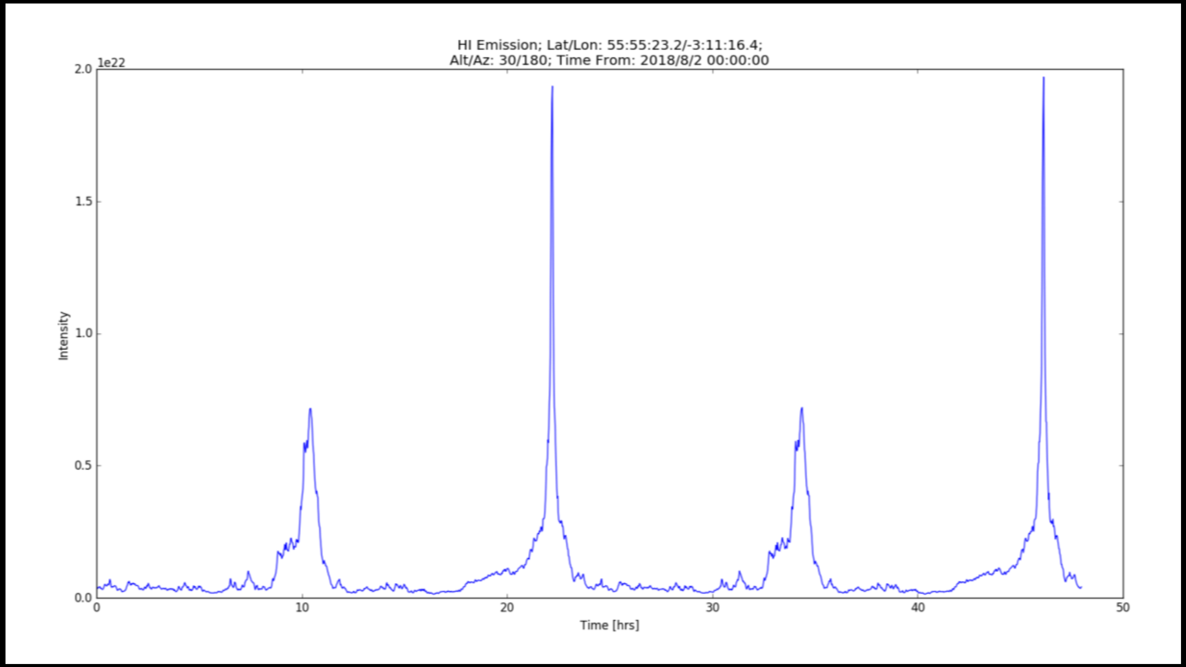

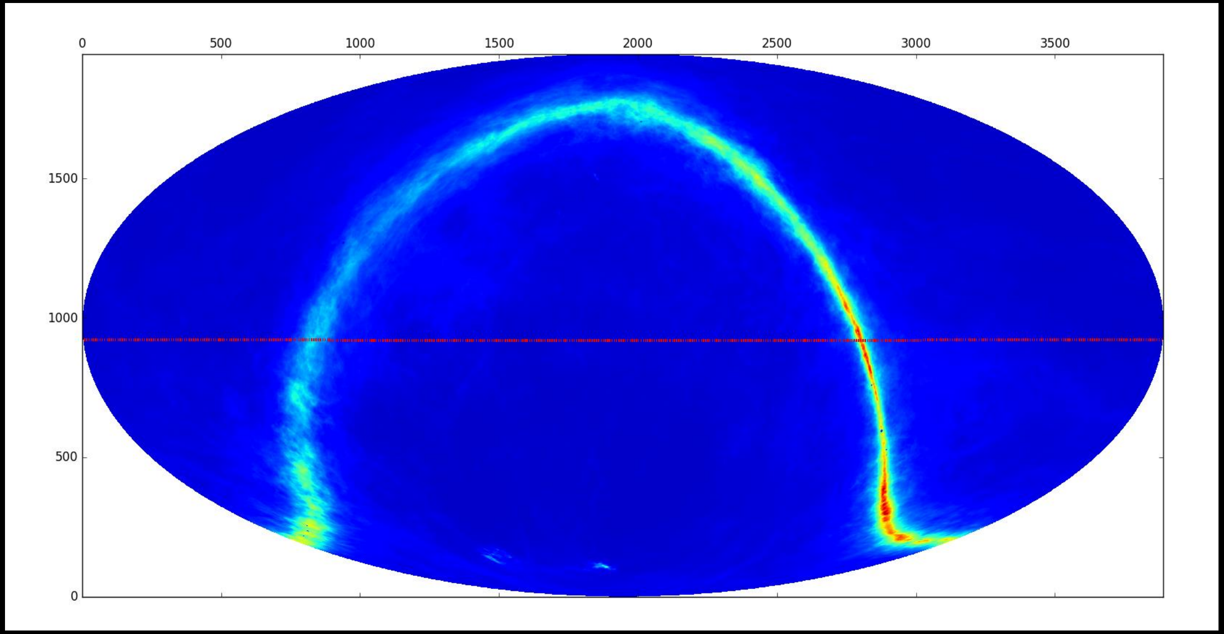

PHASE 2+: EVERYTHING ELSE

- Hope to have antenna built soon and will commence taking data
- Experiment with different observation altitudes
- Compare to simulated data
- Possible solar interference during daytime?

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- Hope to have antenna built soon and will commence taking data
- Experiment with different observation altitudes and possible solar interference during daytime

- Possible permanent installation of equipment if successful

QUESTIONS?