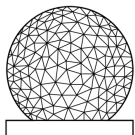


# Radio Frequency Interference: Mitigation and Monitoring

**John Swoboda  
MIT HO**

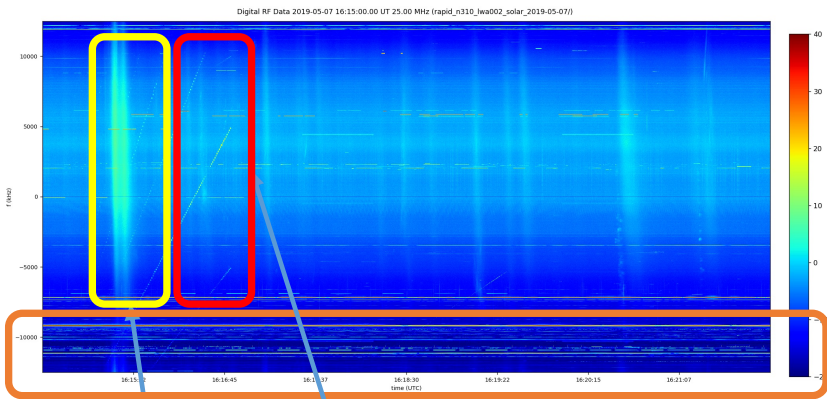
**Thanks to Dr. Frank Lind (MIT HO)  
for many Figures**



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# RFI in Geospace Sensors

## RAPID Recording of Solar Radio Burst



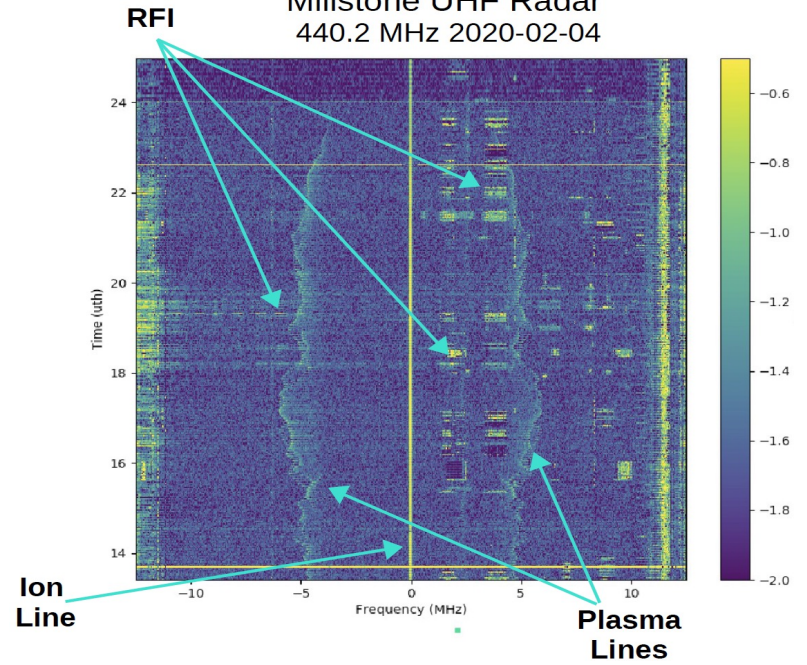
Solar Radio Burst

RFI: Power Regulators

RFI: Radar



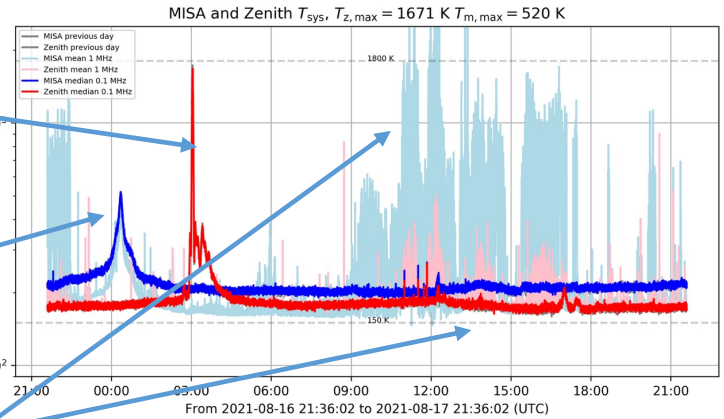
Millstone UHF Radar  
440.2 MHz 2020-02-04



Cygnus A

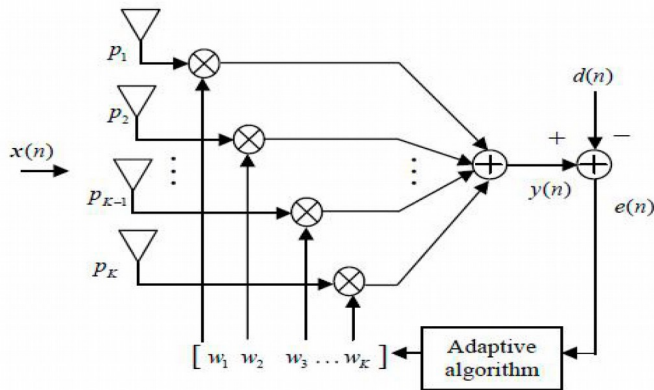
Sagittarius

RFI

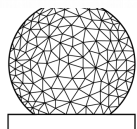


# Adaptive Beam Forming

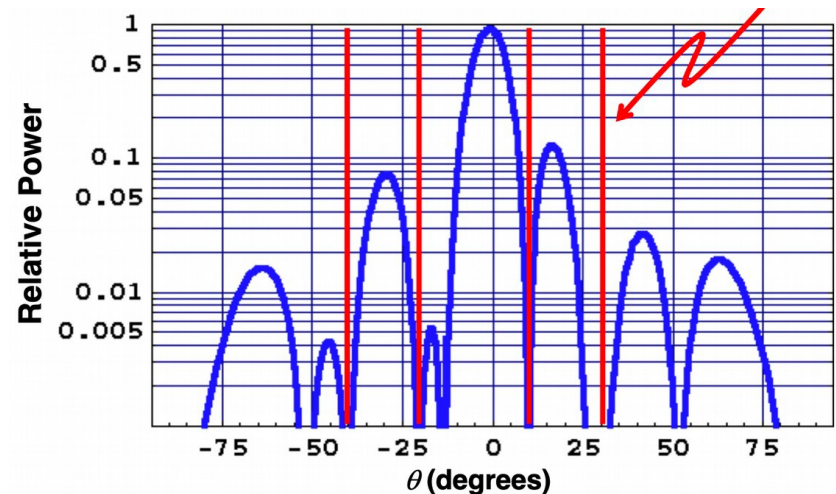
- Working on developing distortion less adaptive technics
- Most theory is geared toward SINR optimization
- How do these algorithms impact statistics?
- Still need receivers in linear mode, no saturation



Typical Adaptive Beamformer  
(Das & Sarma 2012)



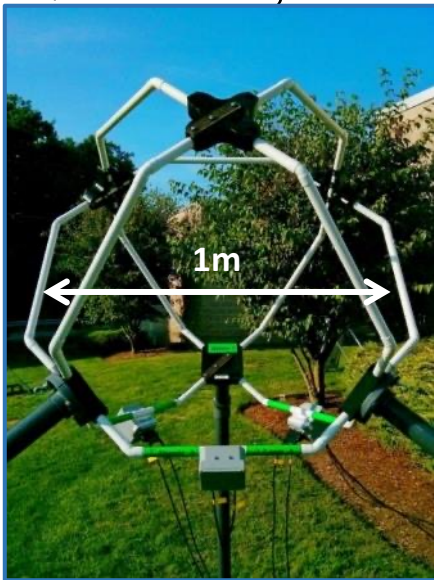
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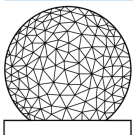
Resultant beam pattern nulling interference  
(Bliss 2006)

# EM-VS Background

- Measures all six components of the electromagnetic field at a single phase center
- Components come from 3 dipoles/monopoles and 3 loops that are balanced, no mutual coupling

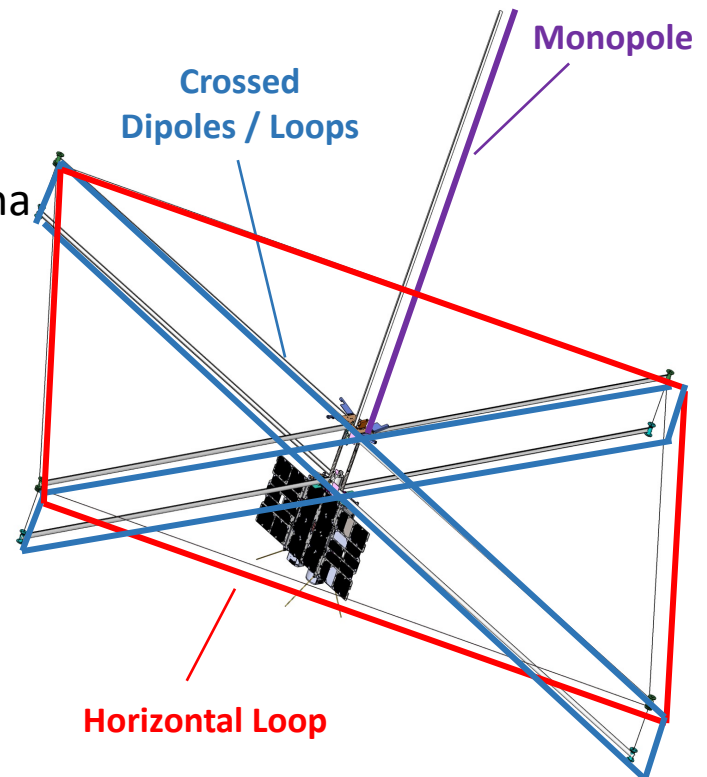


Atom  
Antenna



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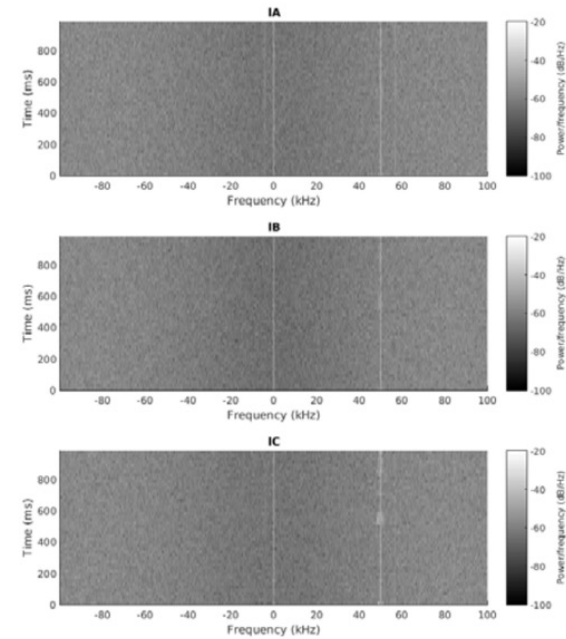
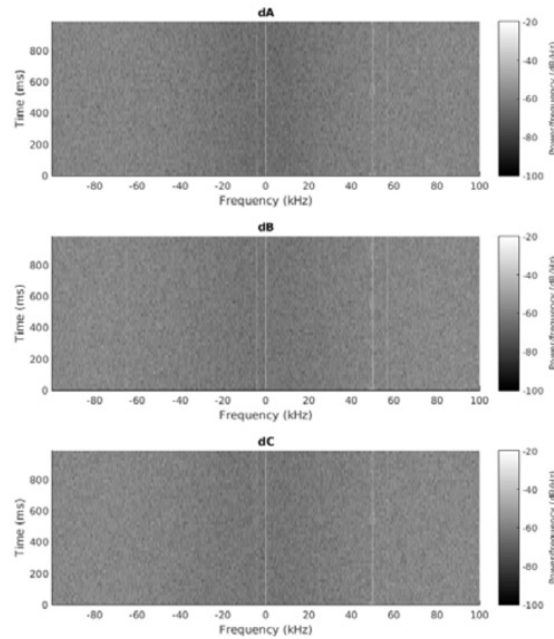
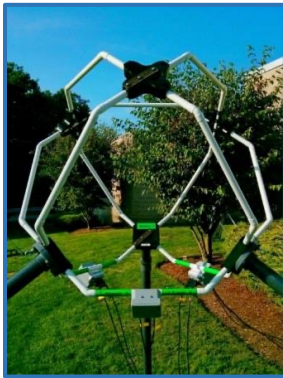
AERO-VISTA  
Deployed Antenna



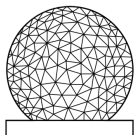
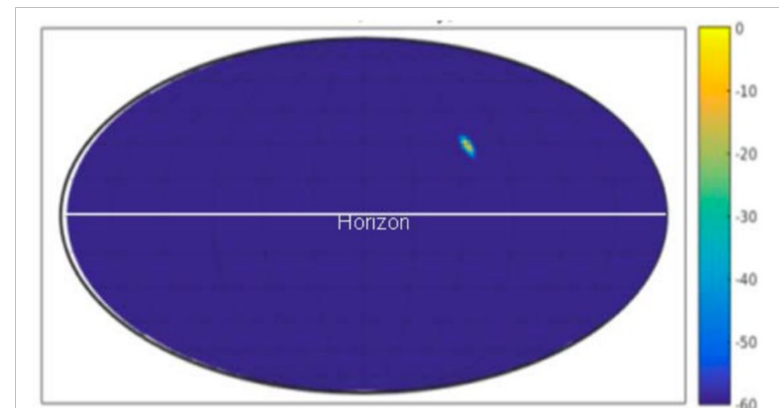


# DOA of EM-VS

- Example using Atom antenna
- Estimate DOA of AM radio station WWV



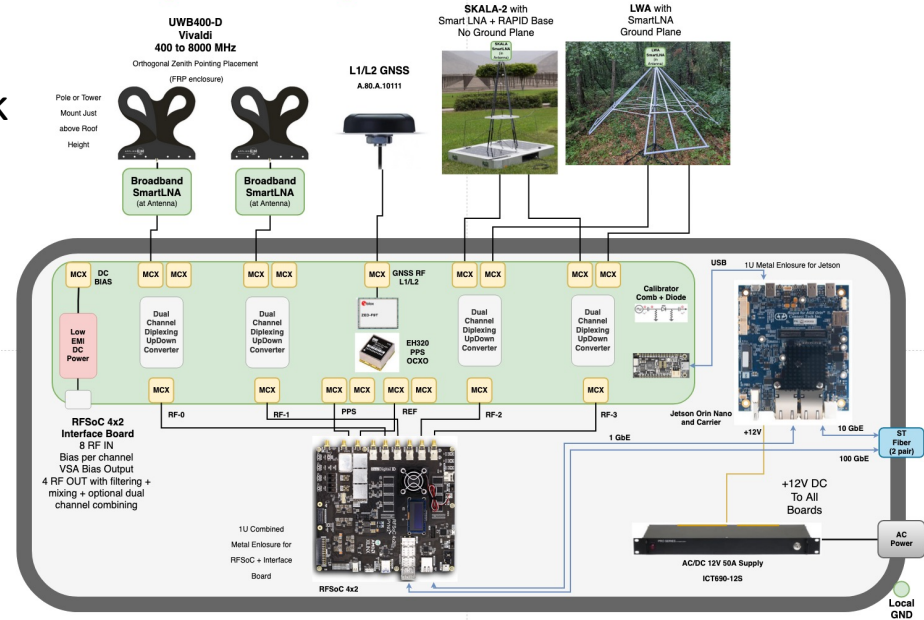
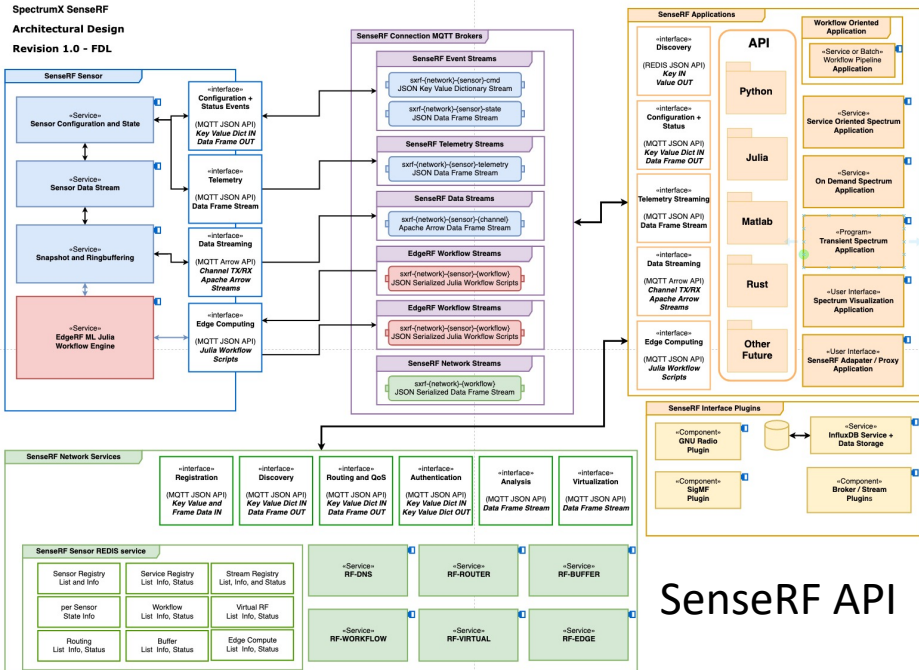
*Robey et al. 2016*



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# RFI Monitoring

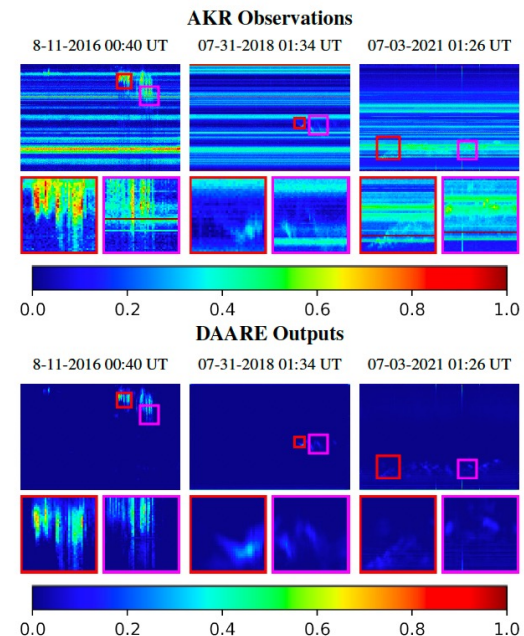
## RFI Monitoring Network



- Next Gen RFI Monitoring system
  - Software
    - SenseRF API allows for streaming and ML applications to improve Sensor robustness to RFI
  - Hardware
    - Utilize RFSoc architecture with GPU accelerated Nvidia Jetsons

# ML for RFI Monitoring

- Various machine learning techniques have been used for RFI identification
- Some companies are doing signal identification
- ML techniques can also be used to discriminate between "natural" signals vs noise



Cheng 2023

# RFI Monitoring COTS

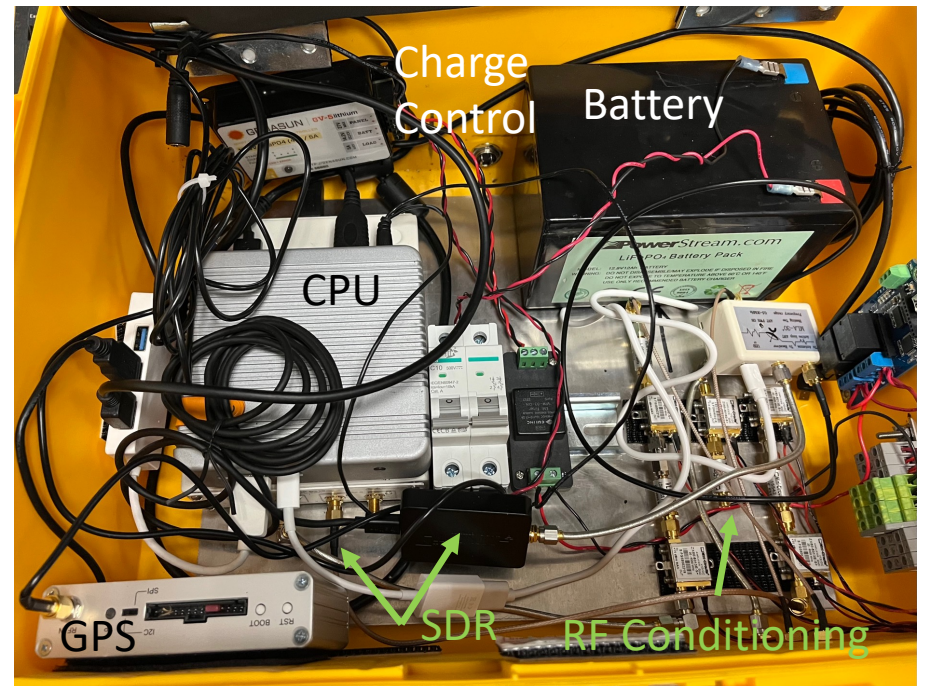
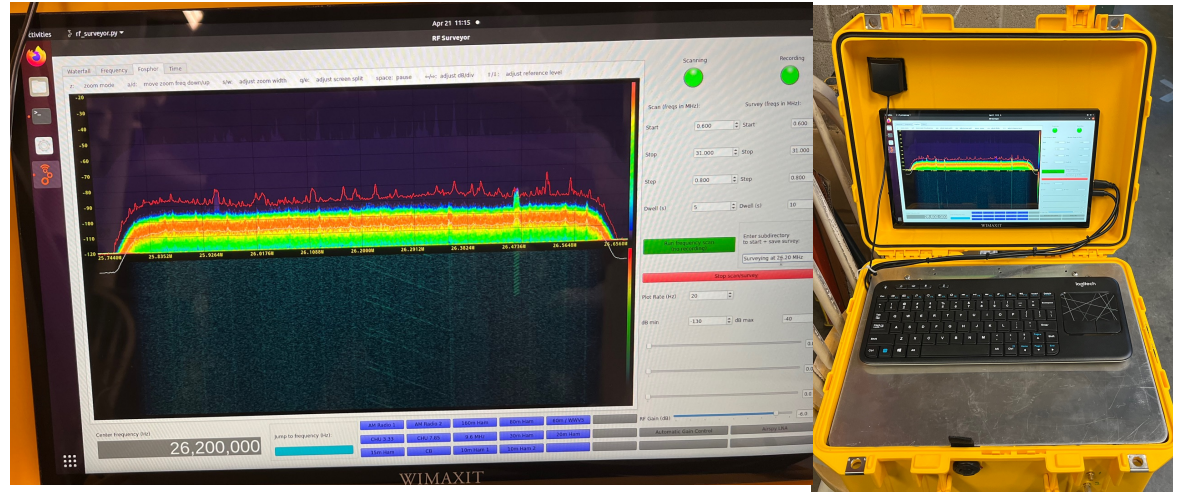
- Many monitoring solutions exist
- Signal hound has a full set of software and equipment to 12.4 GHz
- Field Fox devices can be used
  - Export data





# RFI Survey Box

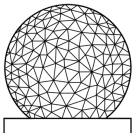
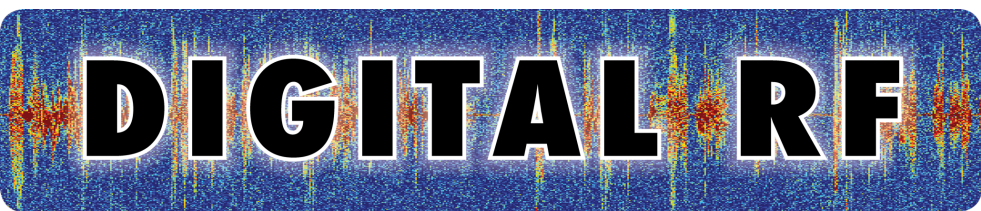
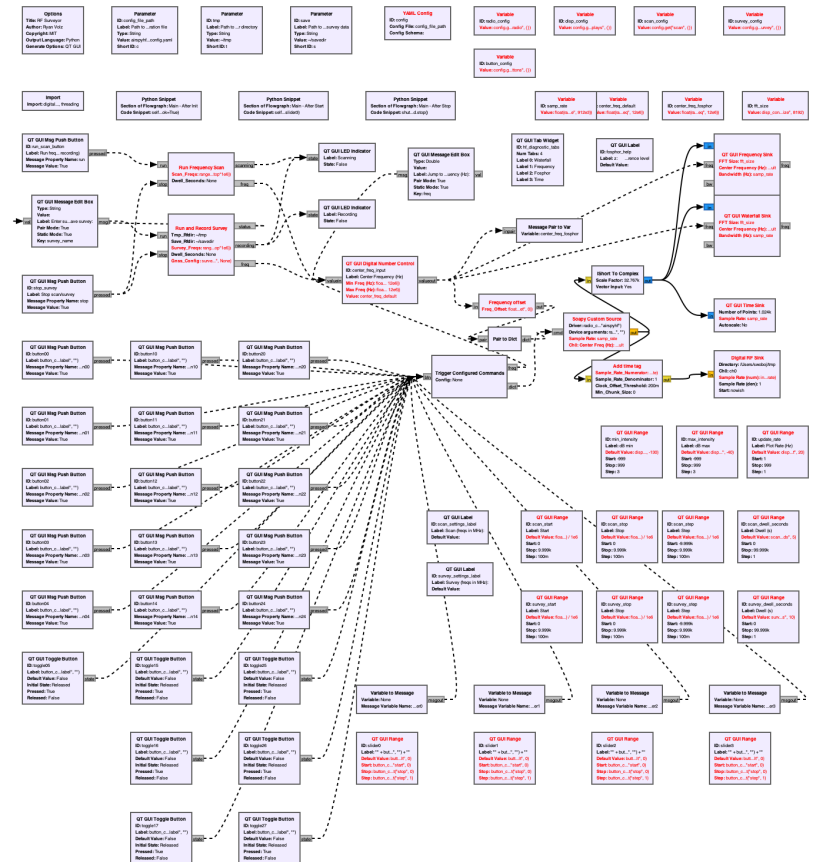
- Custom made device
  - COTS SDR
    - Ettus B210
    - AirSpy HF
  - GPS Receiver
  - Power system
    - Battery
    - Voltage Regulation
  - Linux PC
  - Software
    - GNURadio
    - Digital RF





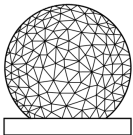
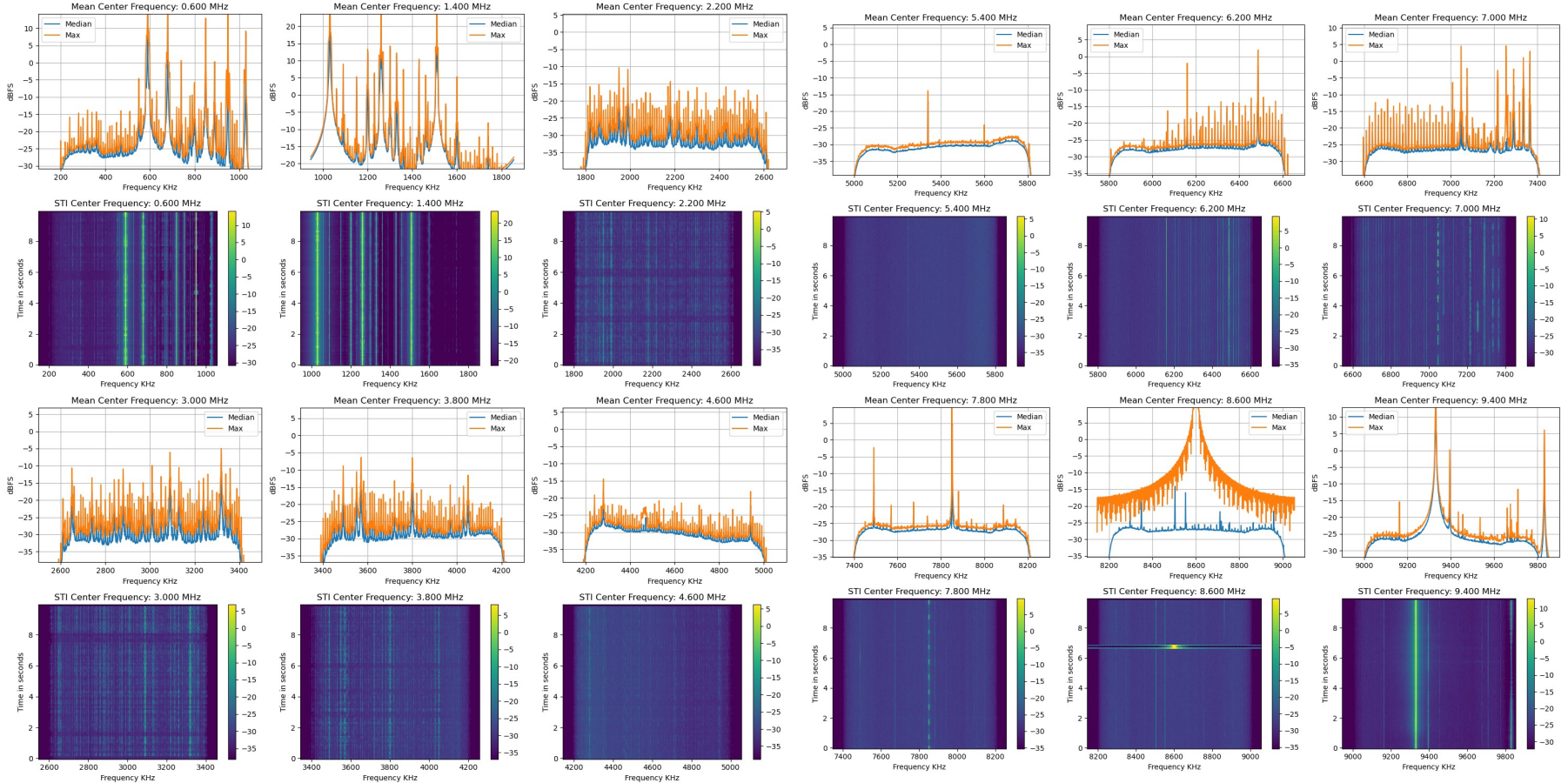
# RFI Survey Box Software

- Using COTS SDRs, software is developed using GNURadio
- Raw voltage level data is saved using Digital RF
- Low level data saved along with metadata (GPS position)



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# RFI Survey Example Data



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# Future Systems

- RFI monitoring using UAS
- Work on triangulation of RFI sources
- Originally developed system for antenna pattern measurement

