Electrical Engineering
Capstone Design
2016-2017

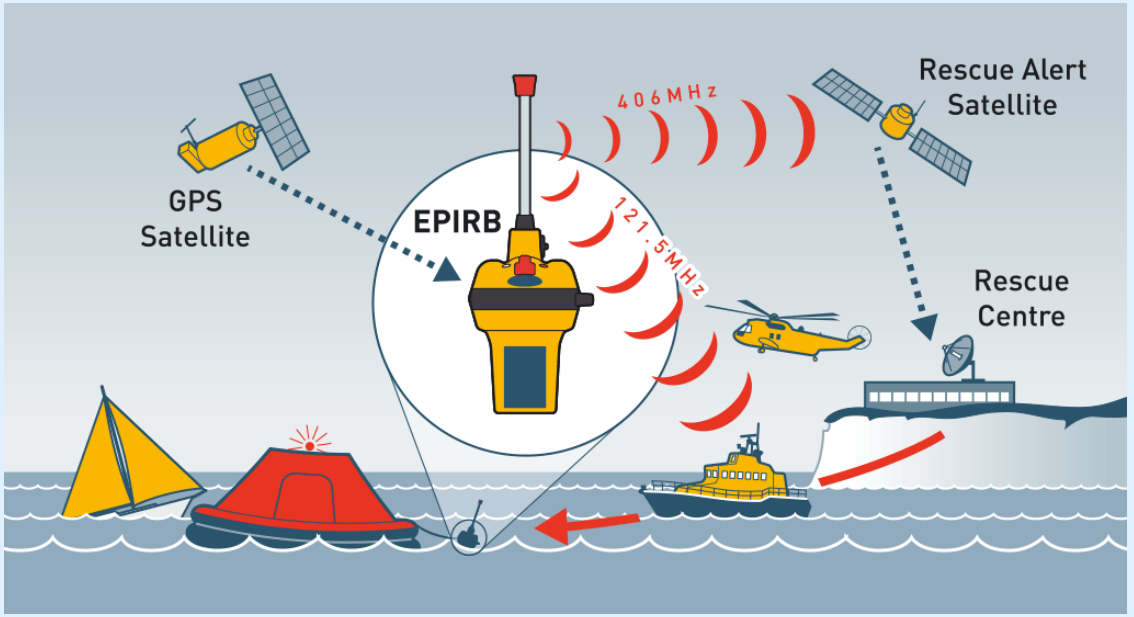
Direction Finding on Spread Spectrum Signals (DFSSS)

1/c Shane Corbett and 1/c Kirsten Logan

Project Advisors:
Dr. Paul Crilly
Dr. Ali Reza
Dr. Richard Hartnett
Sponsor:
CG-761 – Mr. Ed Thiedeman

Introduction

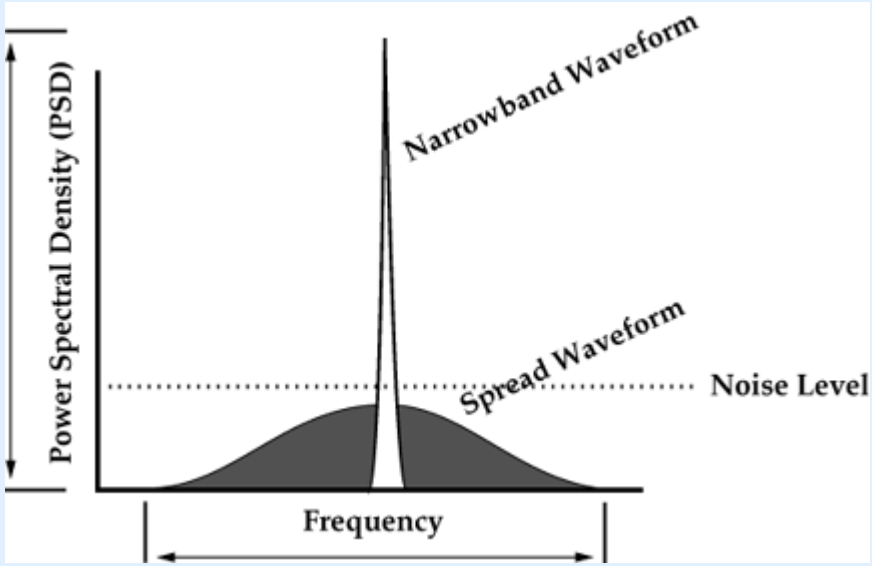
- Emergency Position Indicating Radio Beacon (EPIRB)
- EPIRB has aided the CG in saving 39,000 lives



Needs and Objectives

- Problem: Coast Guard assets will not be able to DF on EPIRBS emitting the new Direct Sequence Spread Spectrum (DSSS) signal

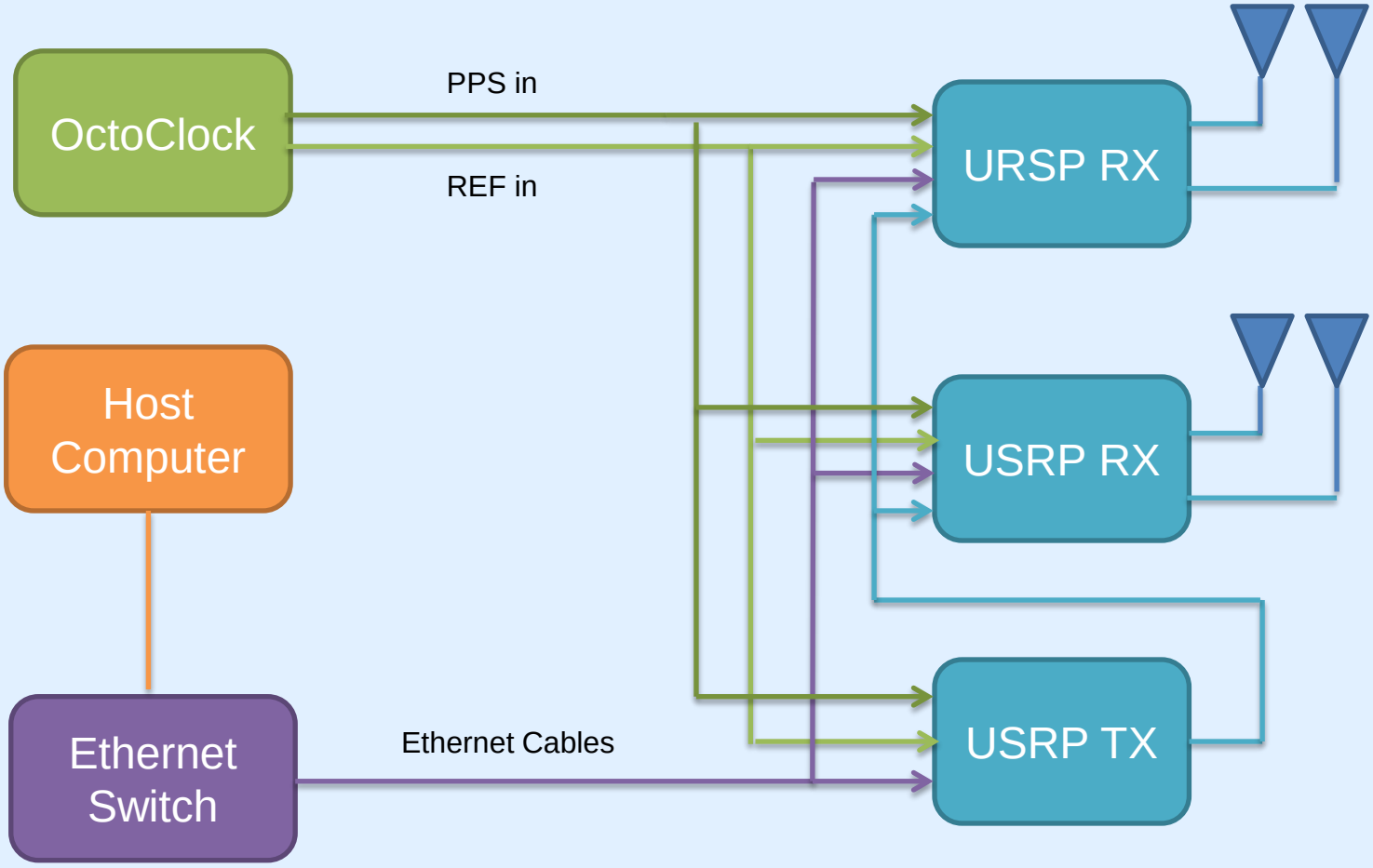
- Goal: Create a continuous and user friendly system to home in on the new generation EPIRB signal



Requirements

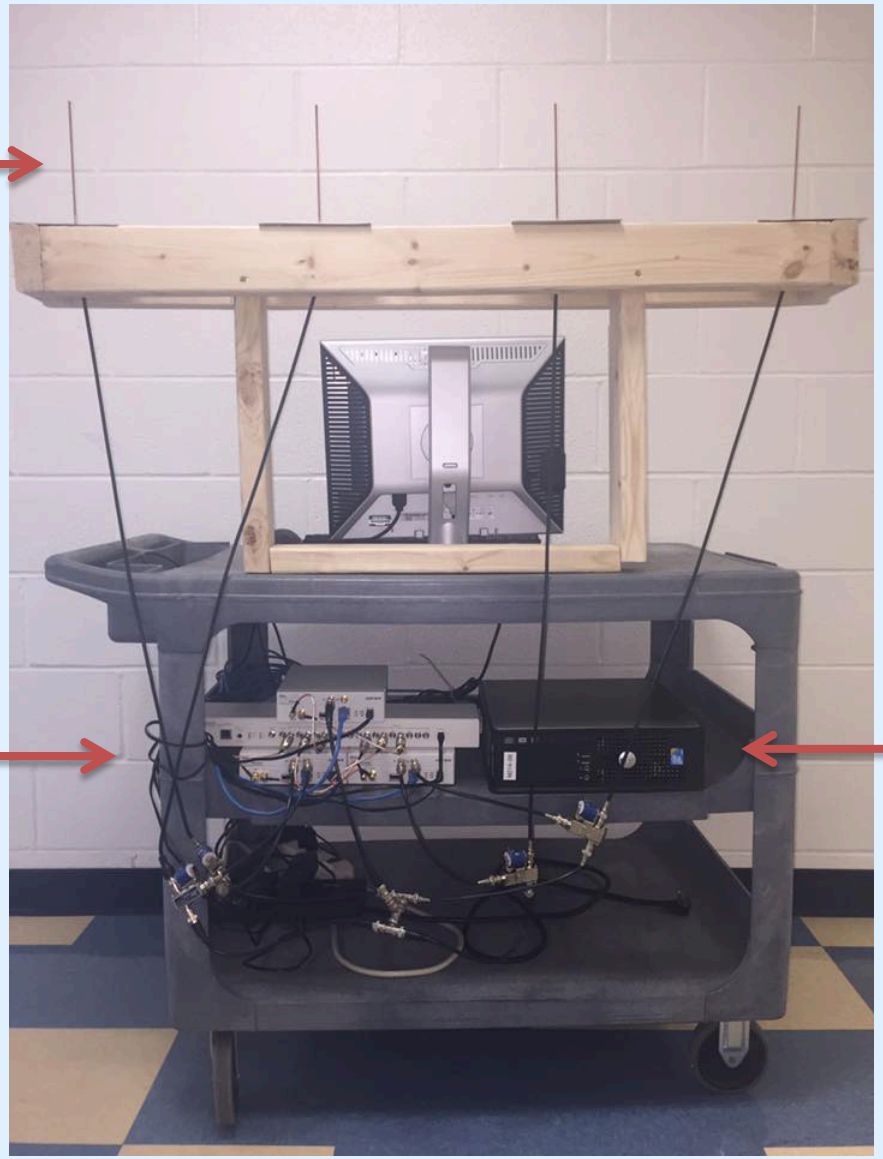
- Make a continuous system
- Make a user friendly system
- Optimize efficiency of the system
  - Antenna construction
  - Cost of hardware

System Overview



System Overview

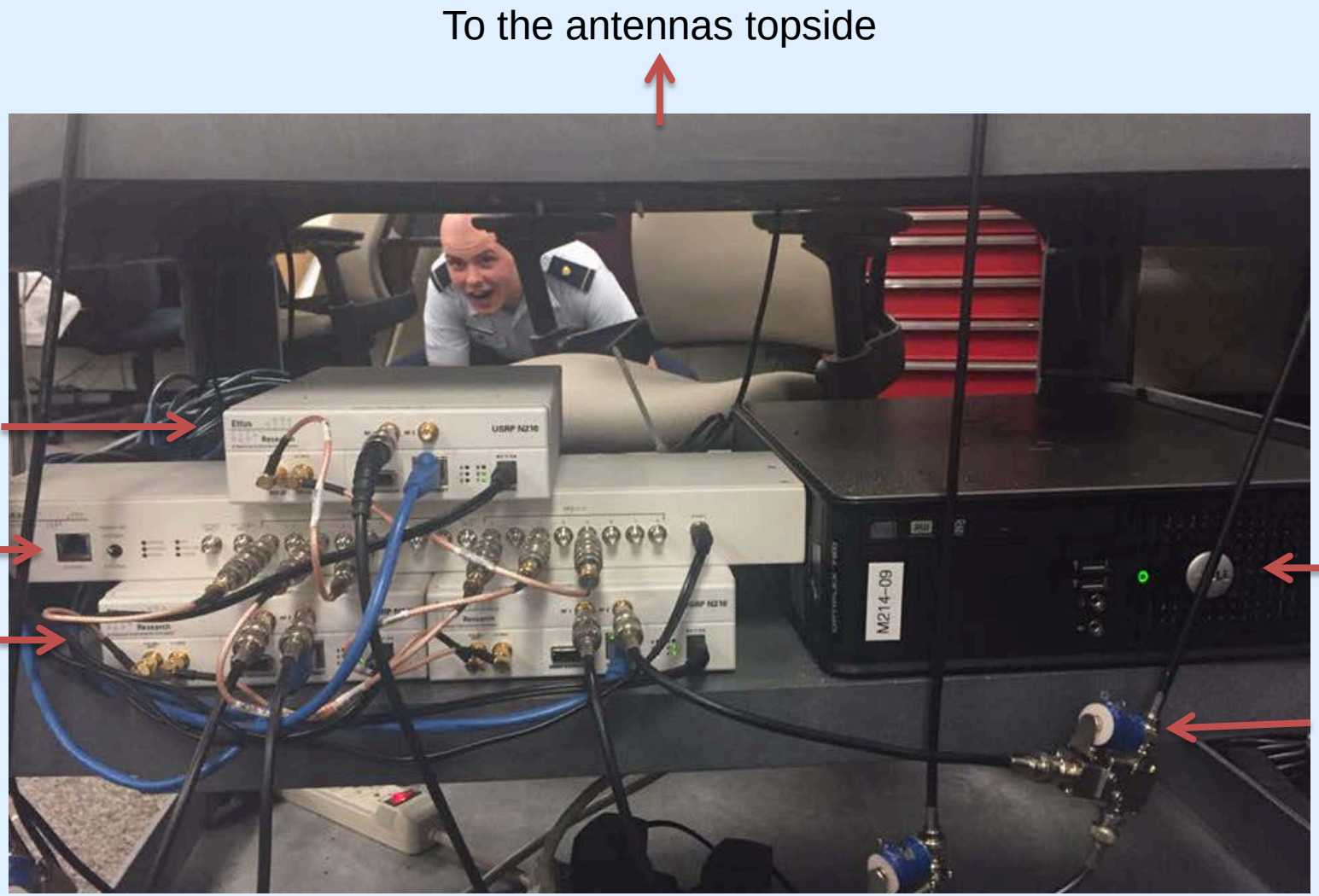
Antenna array: half-wave monopoles



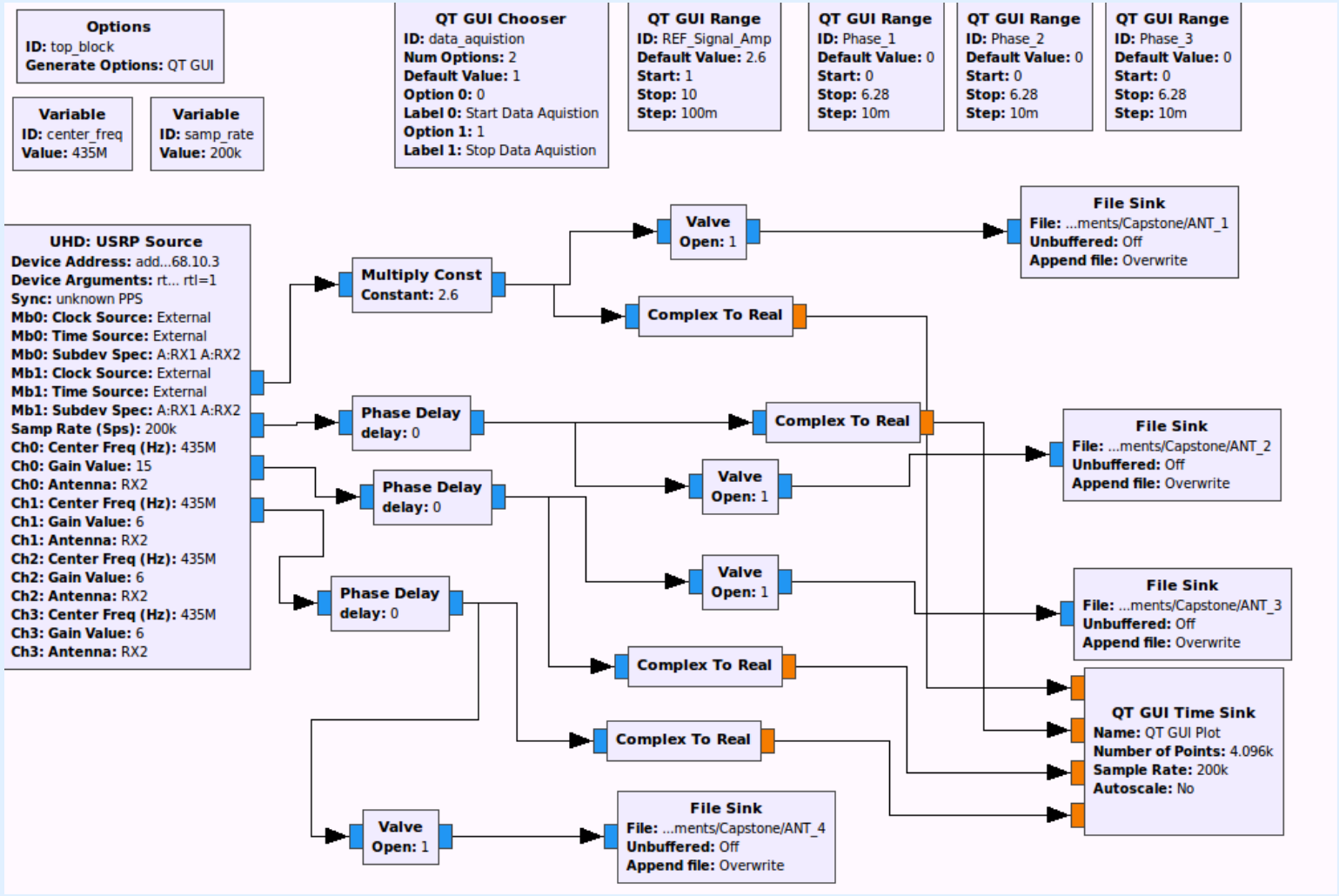
USRPs and Clock equipment rack

New tower for increased processing

System Overview (rack view)



GNU Radio Companion (GRC)



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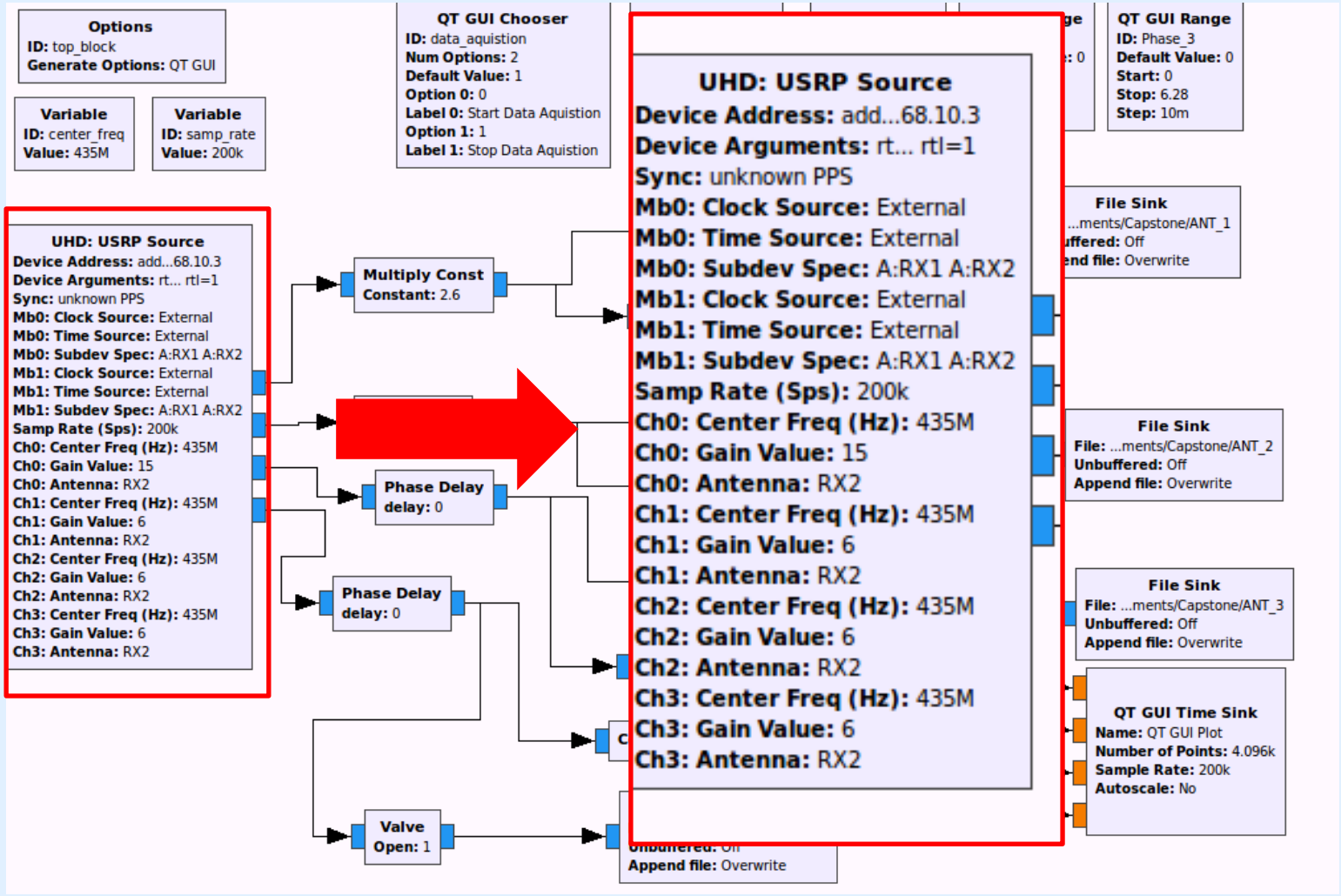

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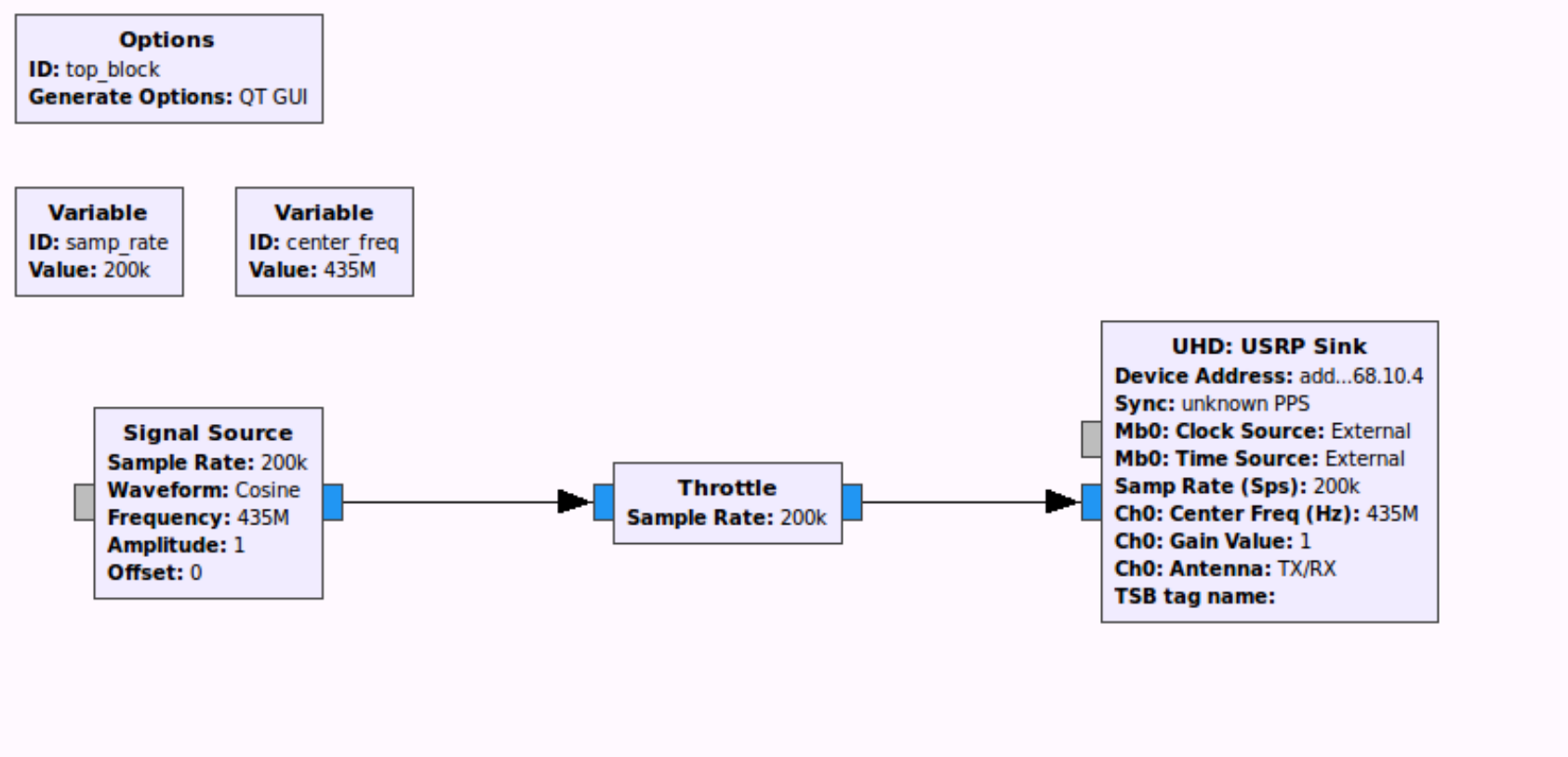

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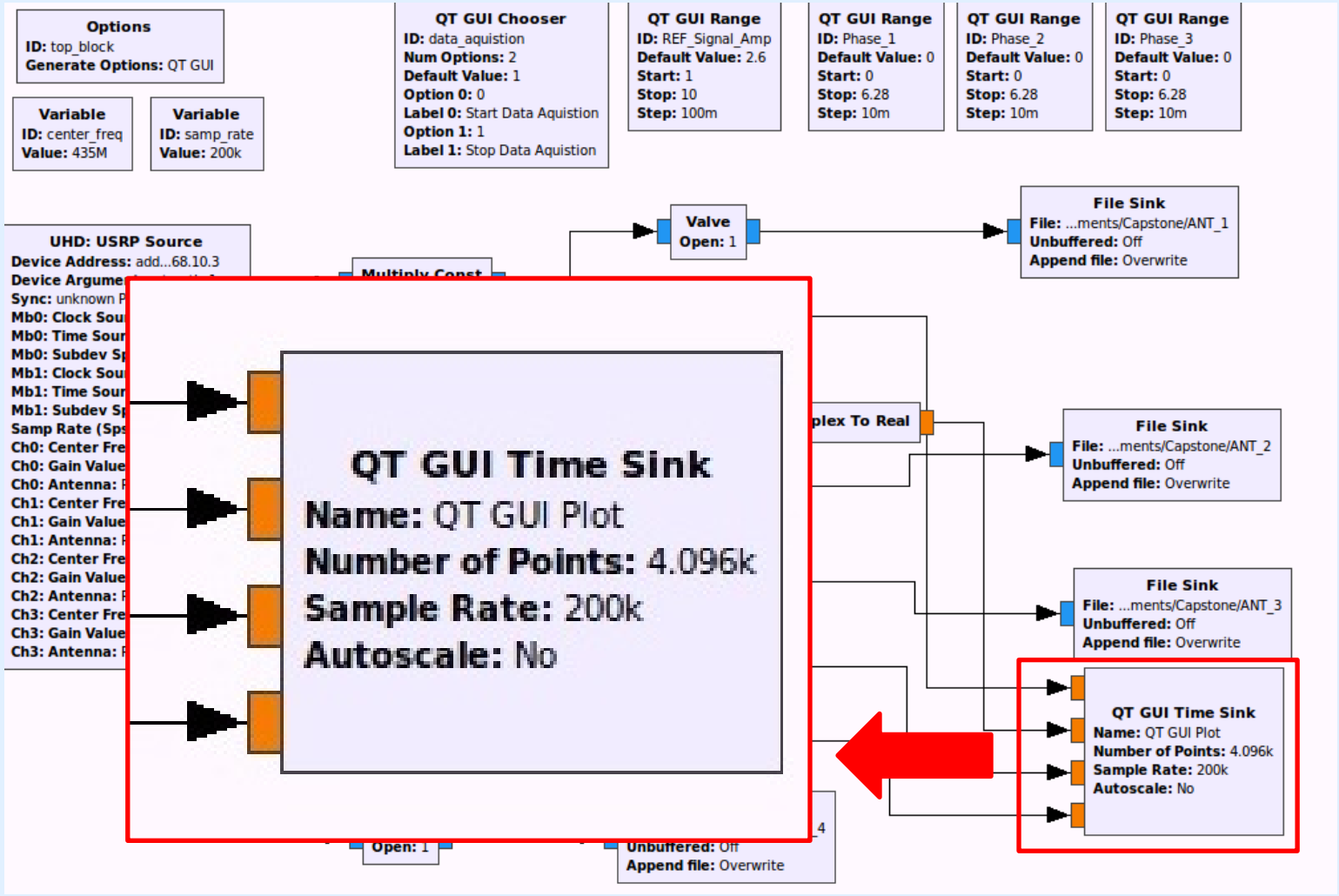
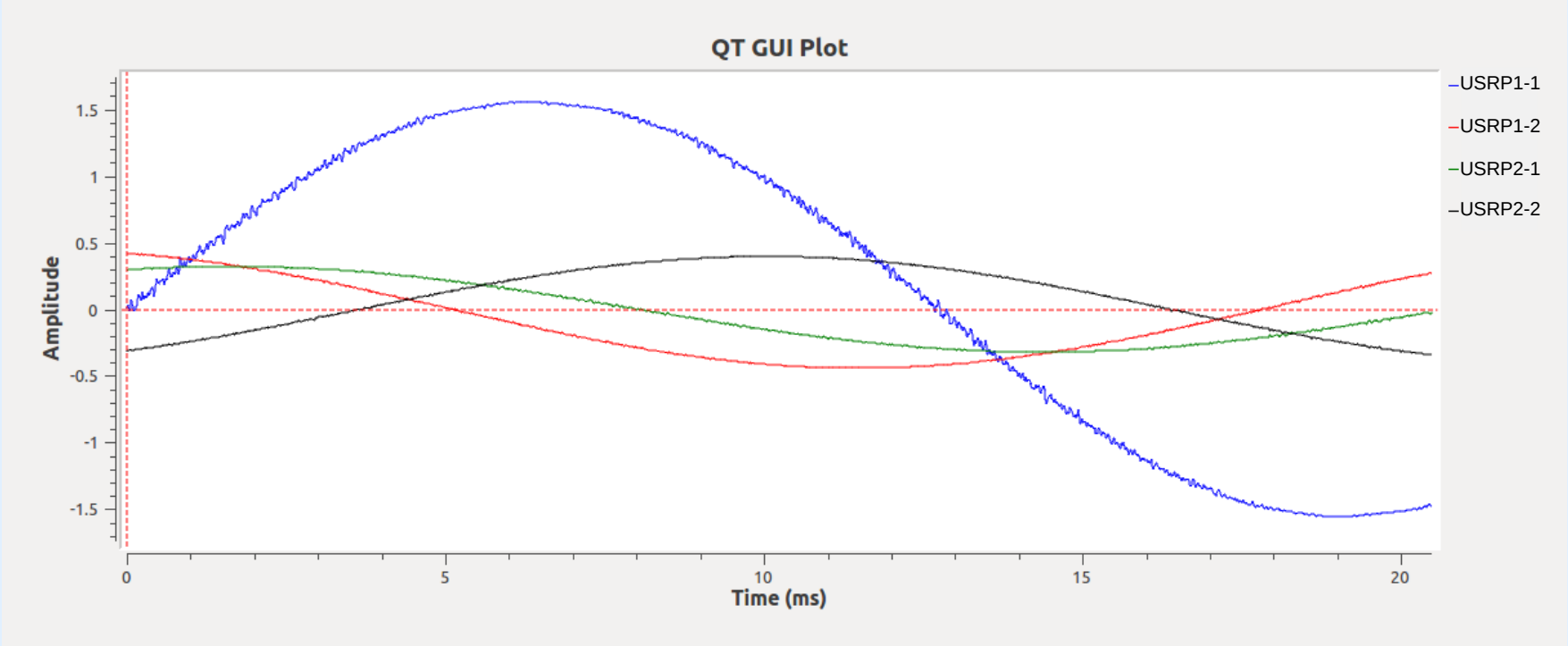


Incoming Calibration Signal



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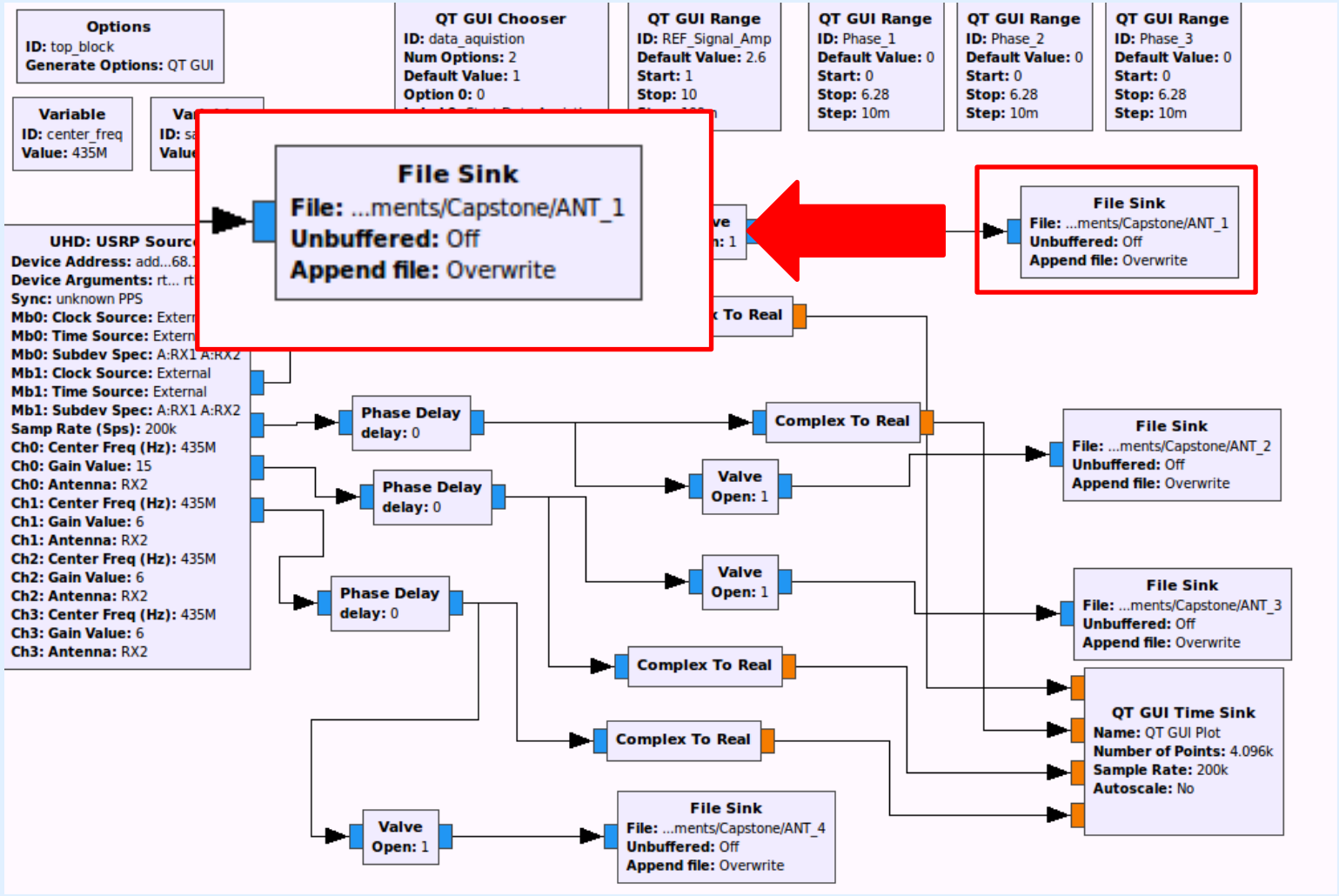
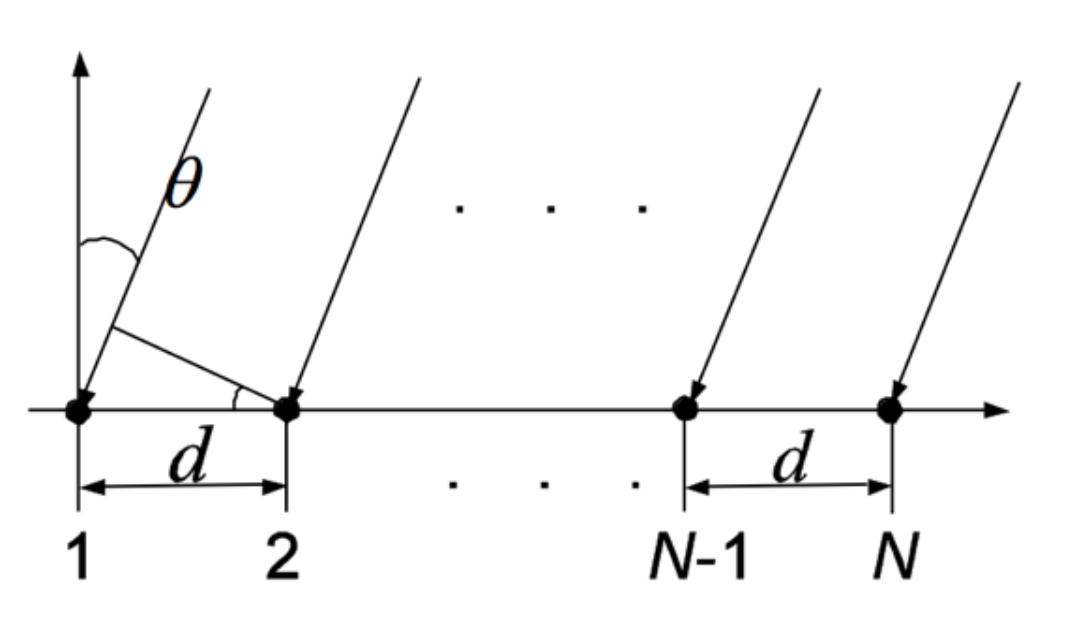


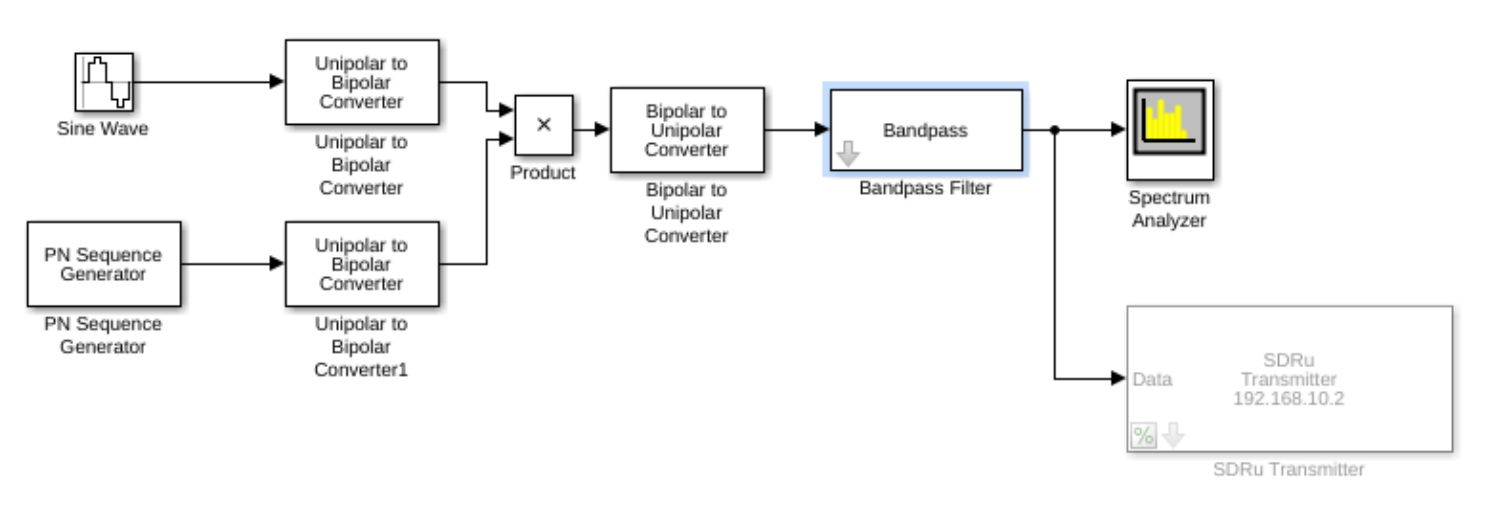
Multiple Signal Classification (MUSIC) Algorithm

- $R = ASA^H + Q$
  Eigen Decomposition of incoming data
- $J(\theta) = (\sum_{m=M+1}^{N} |\bar{a}^H(\theta) \cdot \bar{u}_m|)^{-1}$
  Peak estimator function



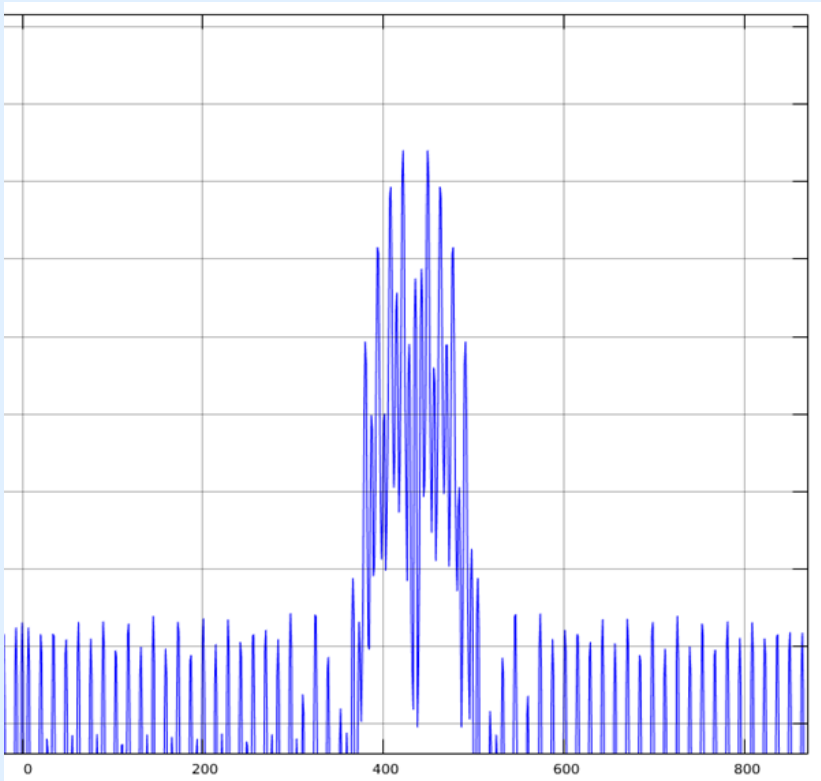
GRC Transmitter

- Need to emulate new Direct Sequence Spread Spectrum Signal
- Consists of pseudo random binary data to spread signal around a center frequency



GRC Transmitter

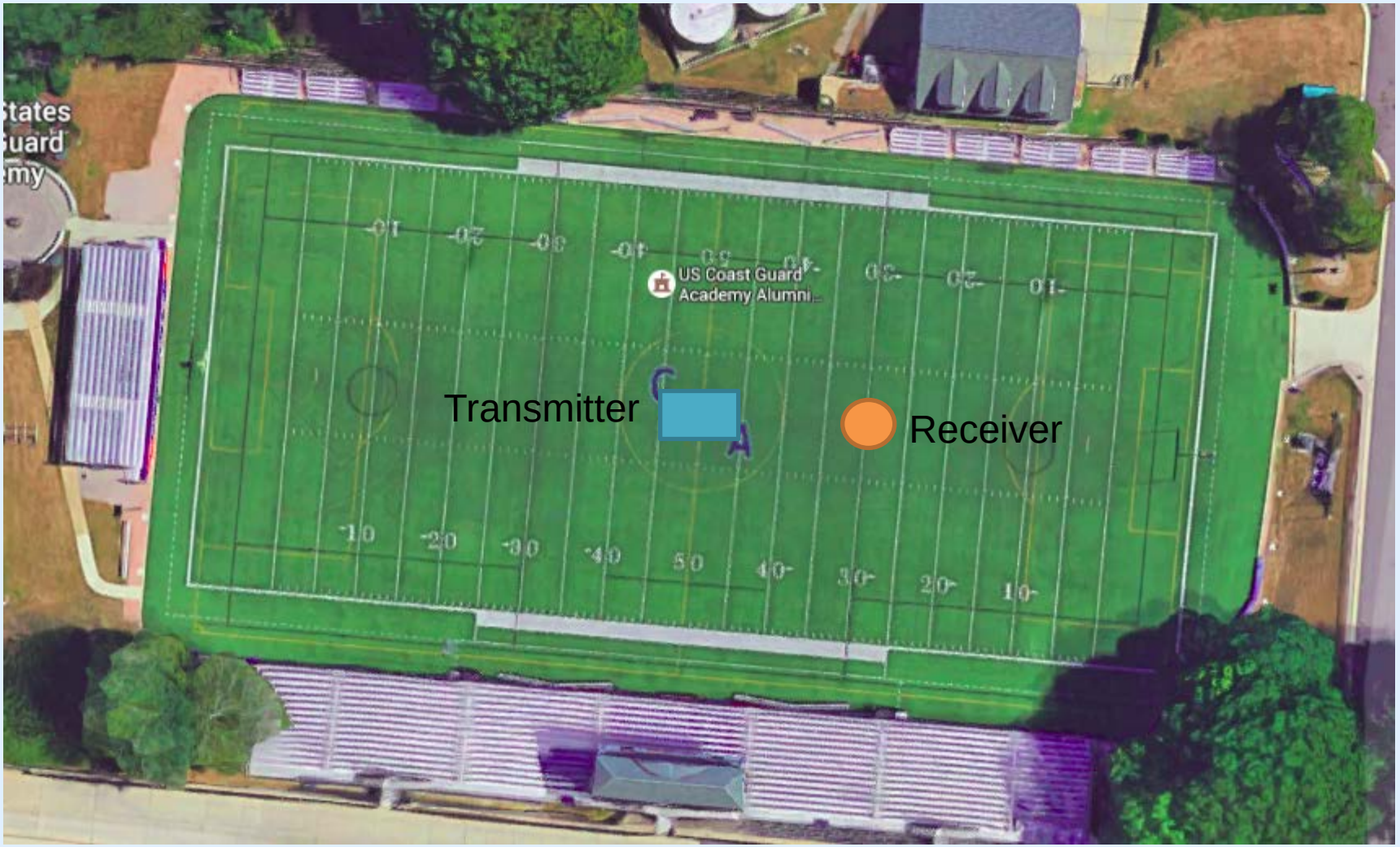
- EPIRB specs: GMSK: 1bit/symbol, 38,400 chips/sec
- Center Frequency: 406.05MHz, null to null 76.8kHz.



Testing Procedure

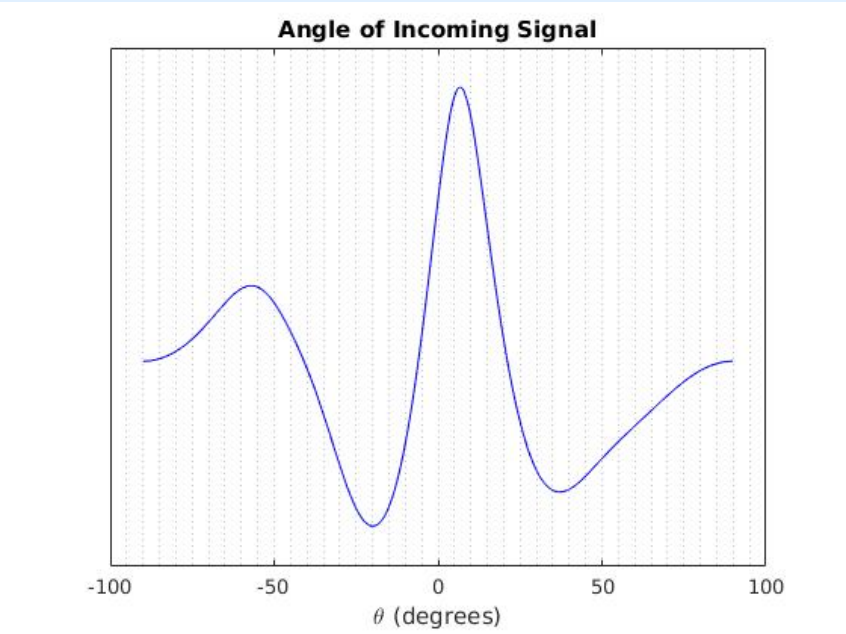
- Test signal centered at 435MHz, λ=.6892m
- Far field pattern assumed at 6.892m
- Test at 15 yards = 13.716 or approximately 2 times the far field
- Calibrate and then data collect

Testing Procedure

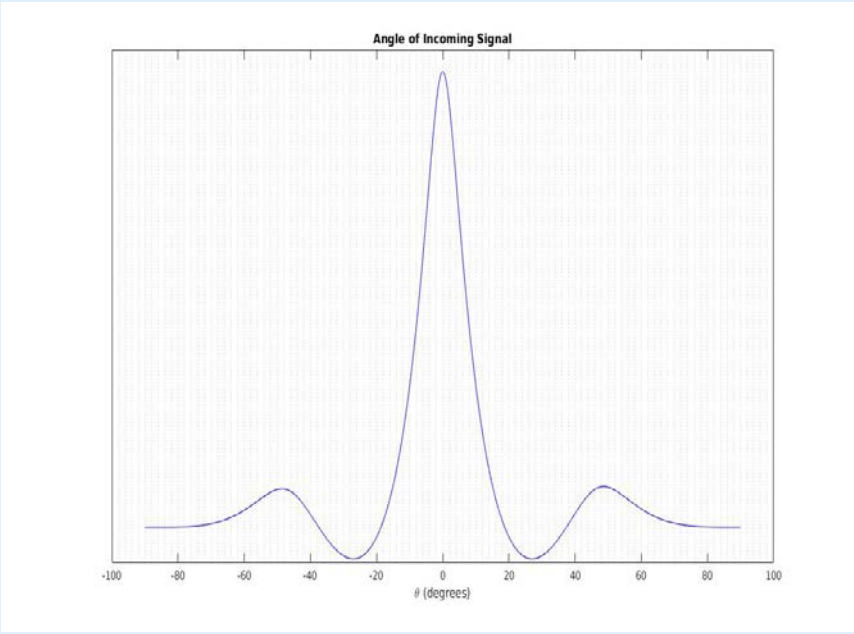


Initial Problems Encountered

- Trouble understanding how to test the system
- Error due to multipath

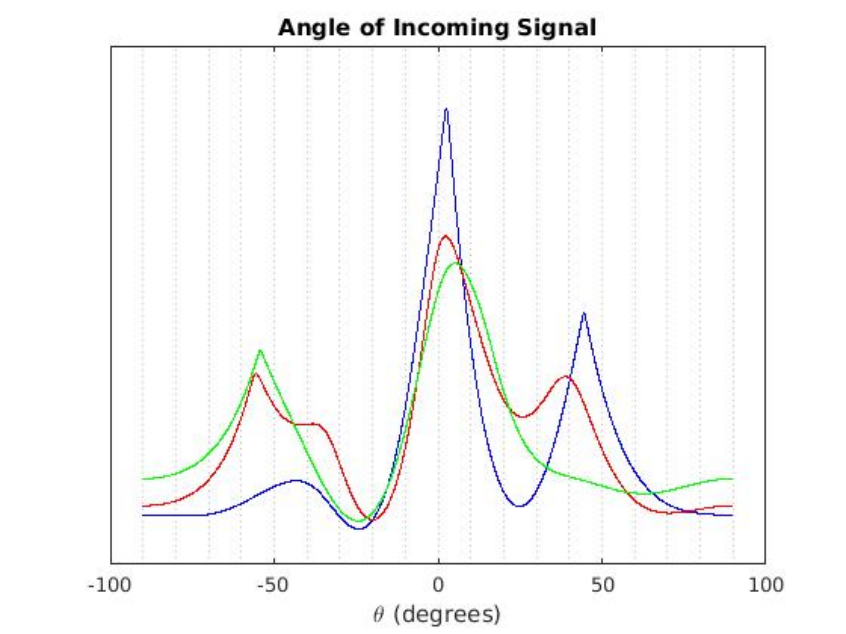


Narrow Band, angle 6 degrees



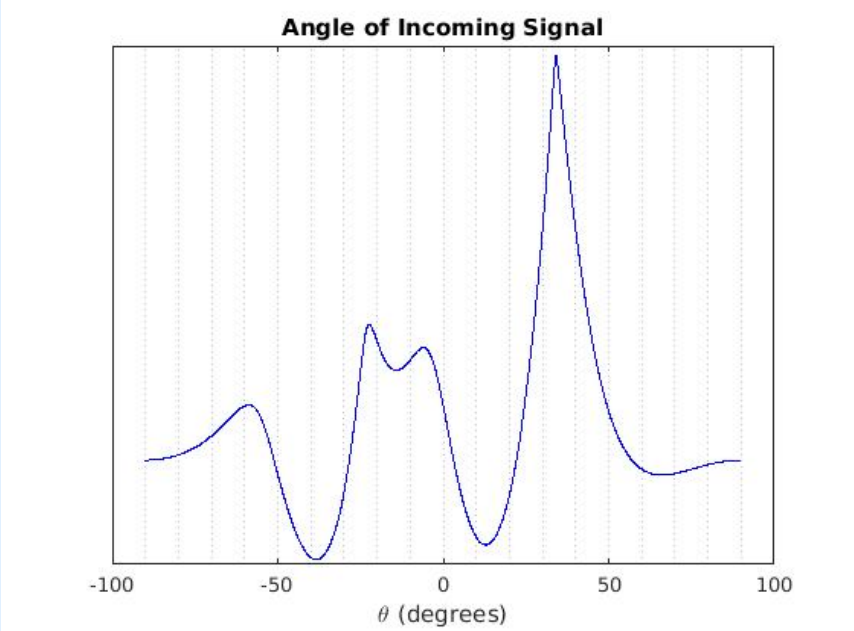
Wide Band, angle 0 degrees

Narrow Band Data



Angle 0°

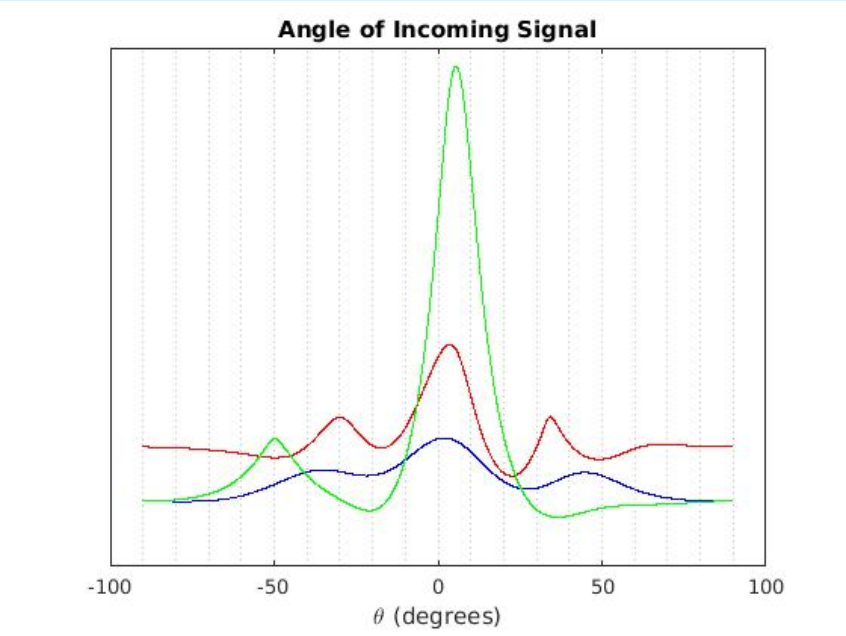
Test 1 (blue)	2.5
Test 2 (red)	2.3
Test 3 (green)	5.1
Average	3.3

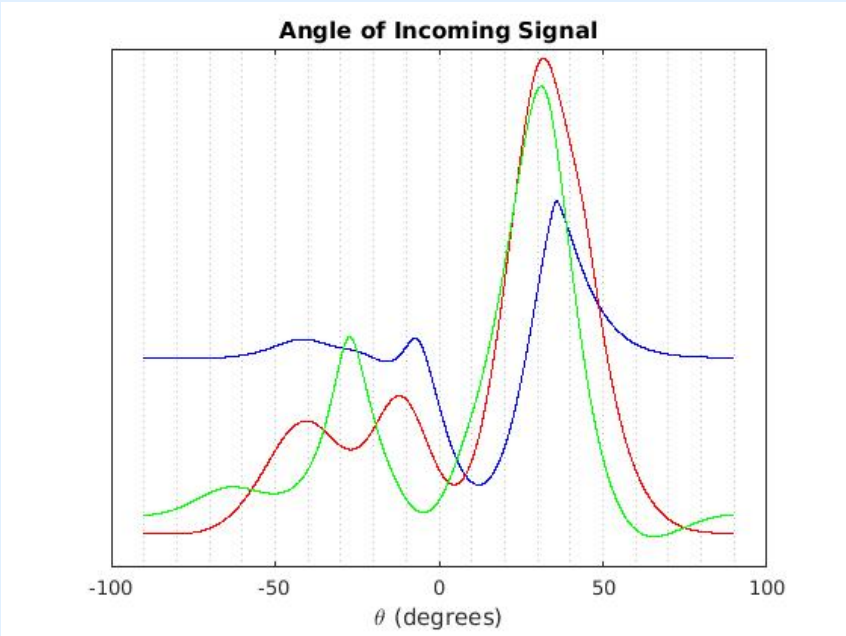


Angle 30°

Test 1	34

Wide Band Data





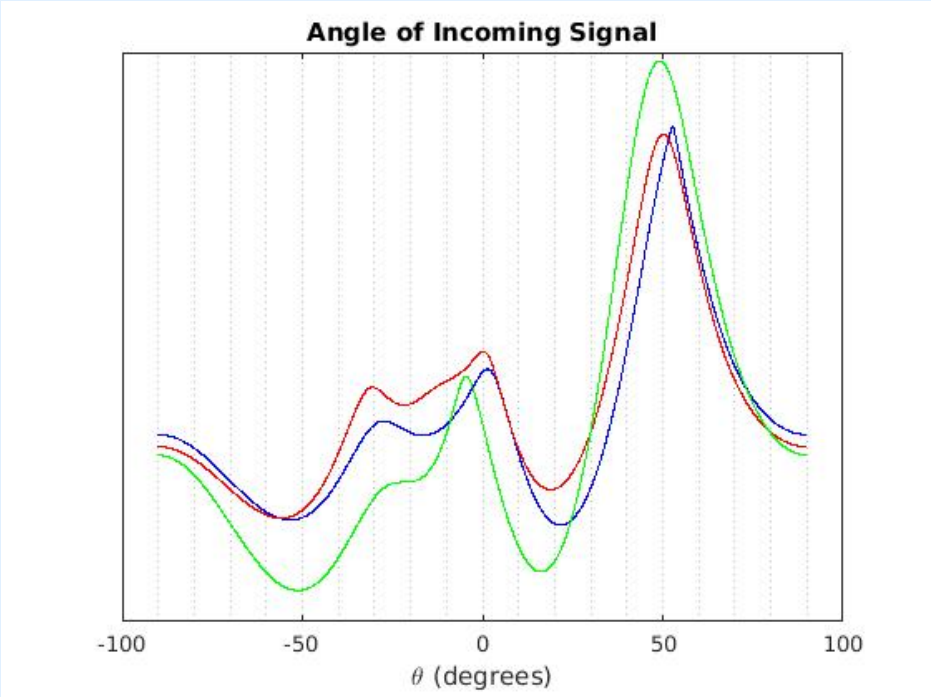
Angle 0°

Test 1 (blue)	1.8
Test 2 (red)	3.6
Test 3 (green)	5.5
Average	3.6

Angle 30°

Test 1 (blue)	35.9
Test 2 (red)	31.8
Test 3 (green)	31.1
Average	32.9

Wide Band Data



Angle 45°

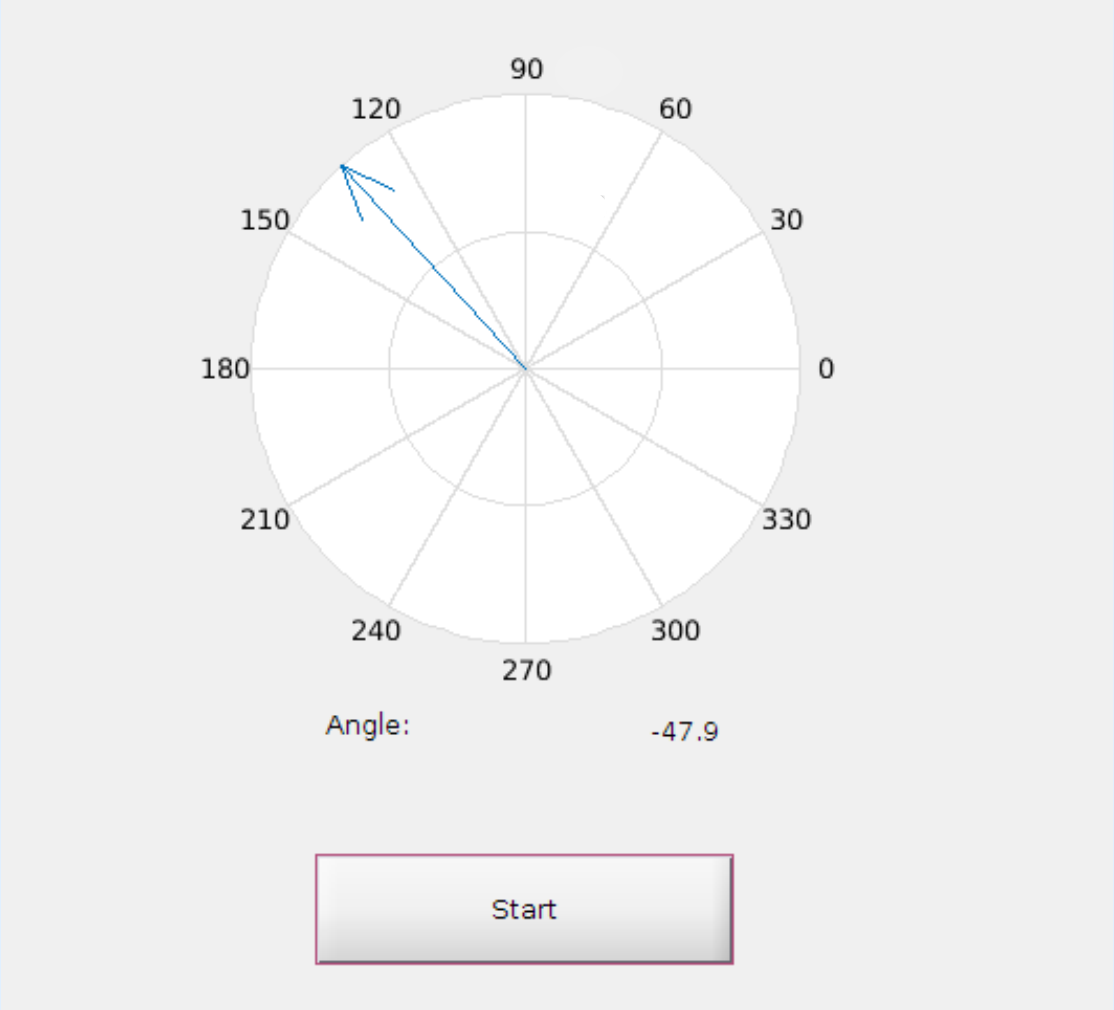
Test 1 (blue)	52.8
Test 2 (red)	50.1
Test 3 (green)	49.1
Average	50.6

Continuous System

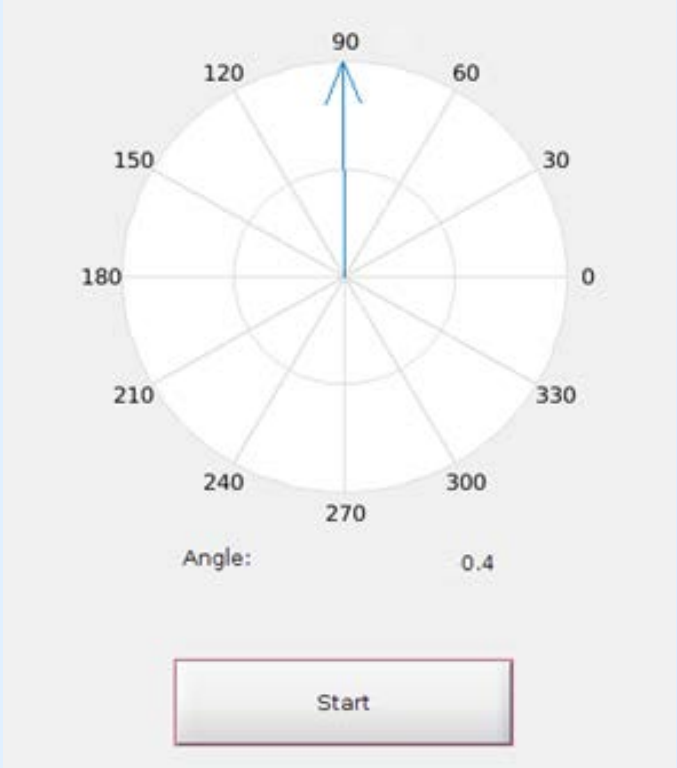
- Road to completion
  - MUSIC Block
  - User Datagram Protocol (UDP)
  - MySQL

- Achieved through MatLab© and LibreOffice Base

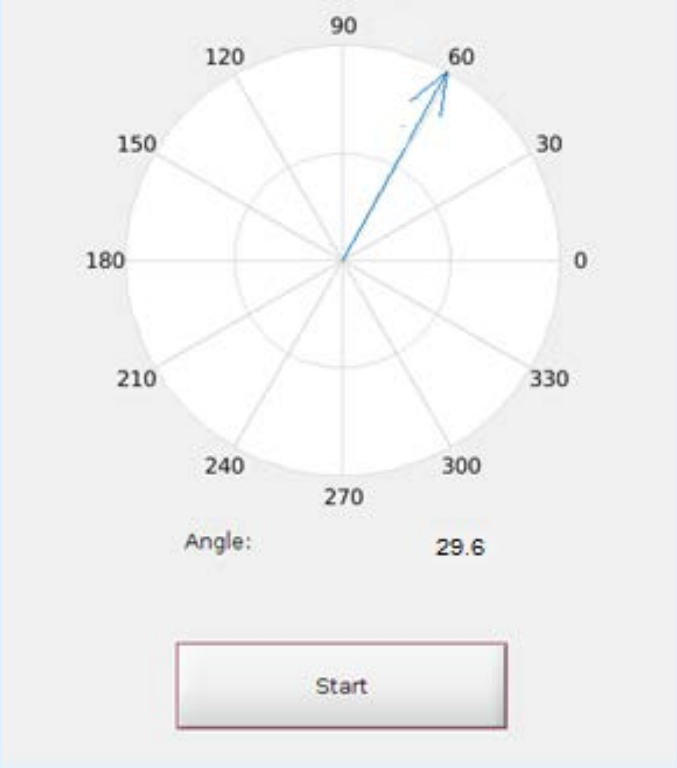
Continuous System



Wide Band Data



Angle 0º

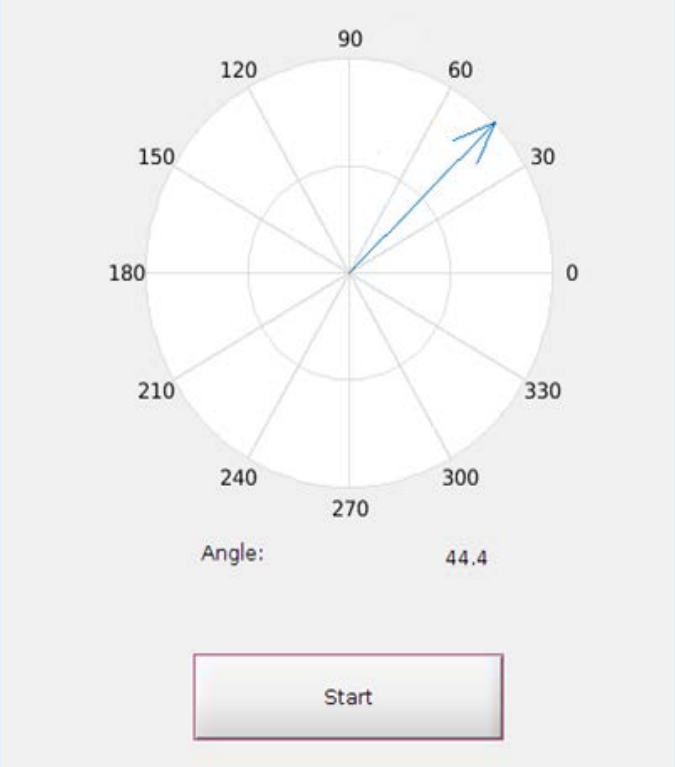


Angle 30º

Average	3.6
Std. Dev.	1.85

Average	32.9
Std. Dev.	2.59

Wide Band Data



Angle 45^{o}

Average	50.6
Std. Dev.	1.91

Future Work

- Expand to multidimensional array
- Explore optimization
- Create EPIRB message

Acknowledgements

- Dr. Paul Crilly
- Dr. Richard Hartnett
- Dr. Ali Reza
- CDR Armstrong
- Class of 2017 EEs

Questions?