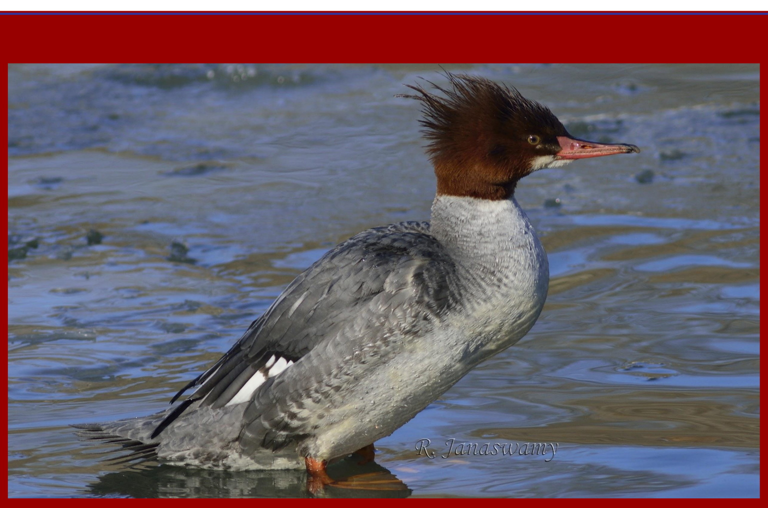
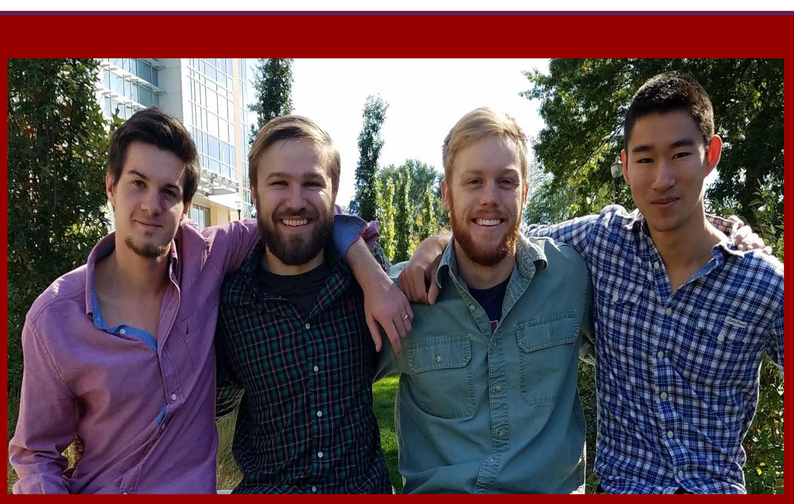


# SITTING DUCK



Jonathan Jamroga Jonathan Yam Michael Sheehan Sean Turner
Faculty Advisor: Professor Ramakrishna Janaswamy

## Abstract

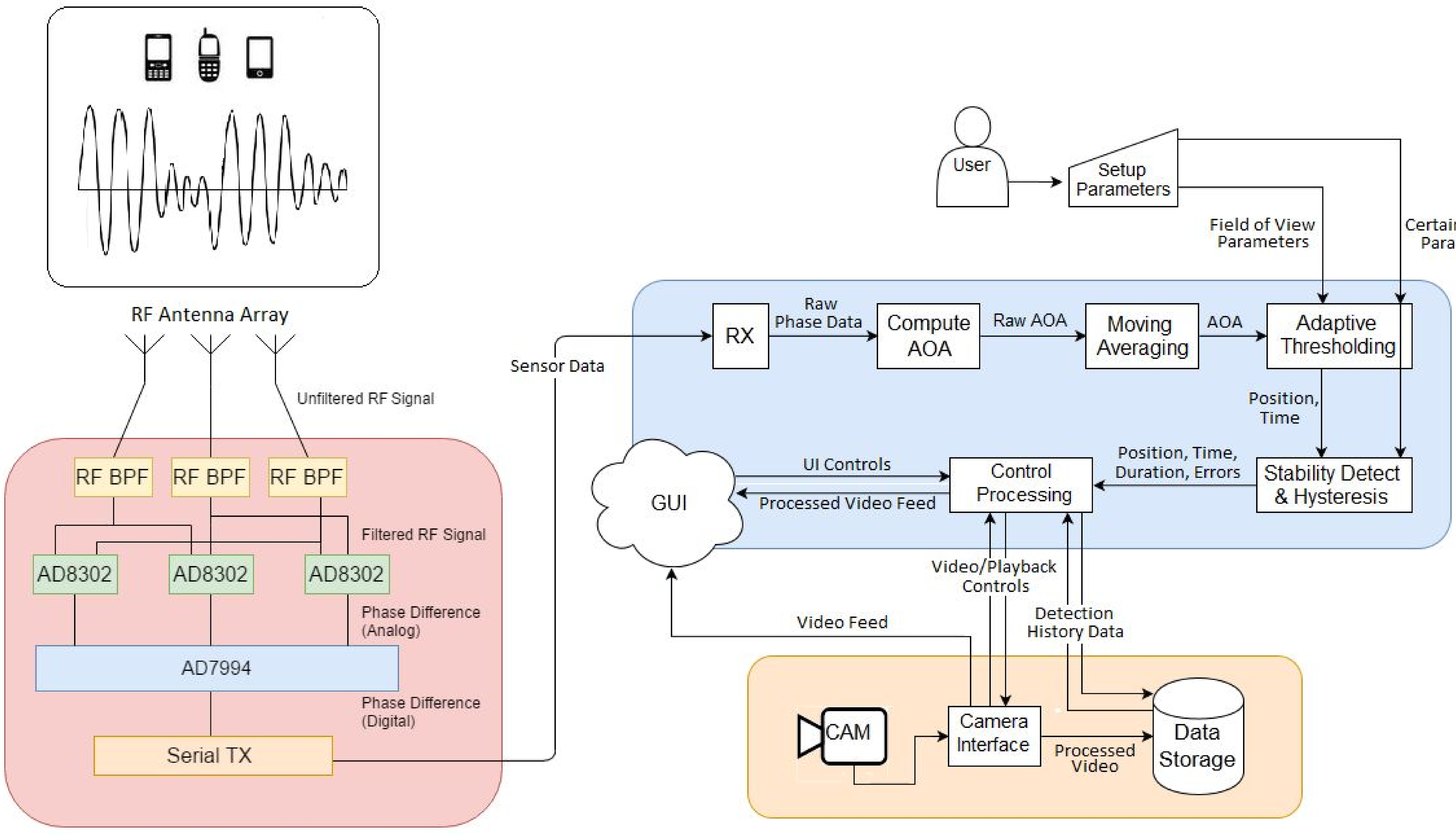
Modern cellular devices facilitate access to the internet from nearly everywhere. However, there are numerous settings in which cell phone use is prohibited. Ethically regulating the use of cell phones in these information sensitive settings is a difficult but important task.

Sitting Duck is a successful demonstration of a cell phone detection system that autonomously detects, locates, and documents useful video evidence of unauthorized cell phone use in an ethical manner. The tool is easily configurable to work in most environments of interest.

## System Overview

- The system employs an antenna sensor array that receives local RF signals which are filtered and evaluated for phase differences using logarithmic detector based hardware.
- Waveform properties are used to calculate the incoming signals' physical angles of arrival, which are processed by a variety of real-time digital signal processing algorithms.
- Efficient image processing methods provide useful video evidence of suspicious events, which are logged for later reference.

## System Block Diagram




## Specifications

| |
|---|
| Localizes detection at 30' range to within ±5° |
| Supports 30sec sensor-to-user presentation latency |
| Offers real-time video feed with 2D heatmap overlay |
| Facilitates user playback of stored detection events |
| Operates in a frequency band including 850MHz |
| Utilizes BPF to filter out extraneous frequency bands |

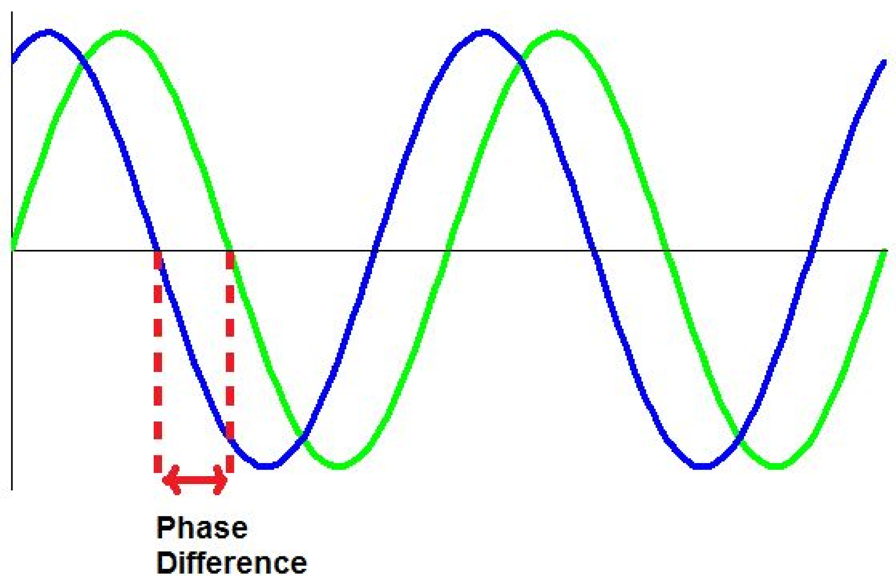
## Results

- Signals are effectively band-pass filtered and evaluated for phase difference.
- Angles of arrival are calculated in real-time.
- Real-time signal processing algorithms effectively distinguish signals of interest from other ambient or unstable signals with <1sec latency.
- Video evidence recorded and processed to graphically display signal source locations.
- Event log facilitates user playback of events.

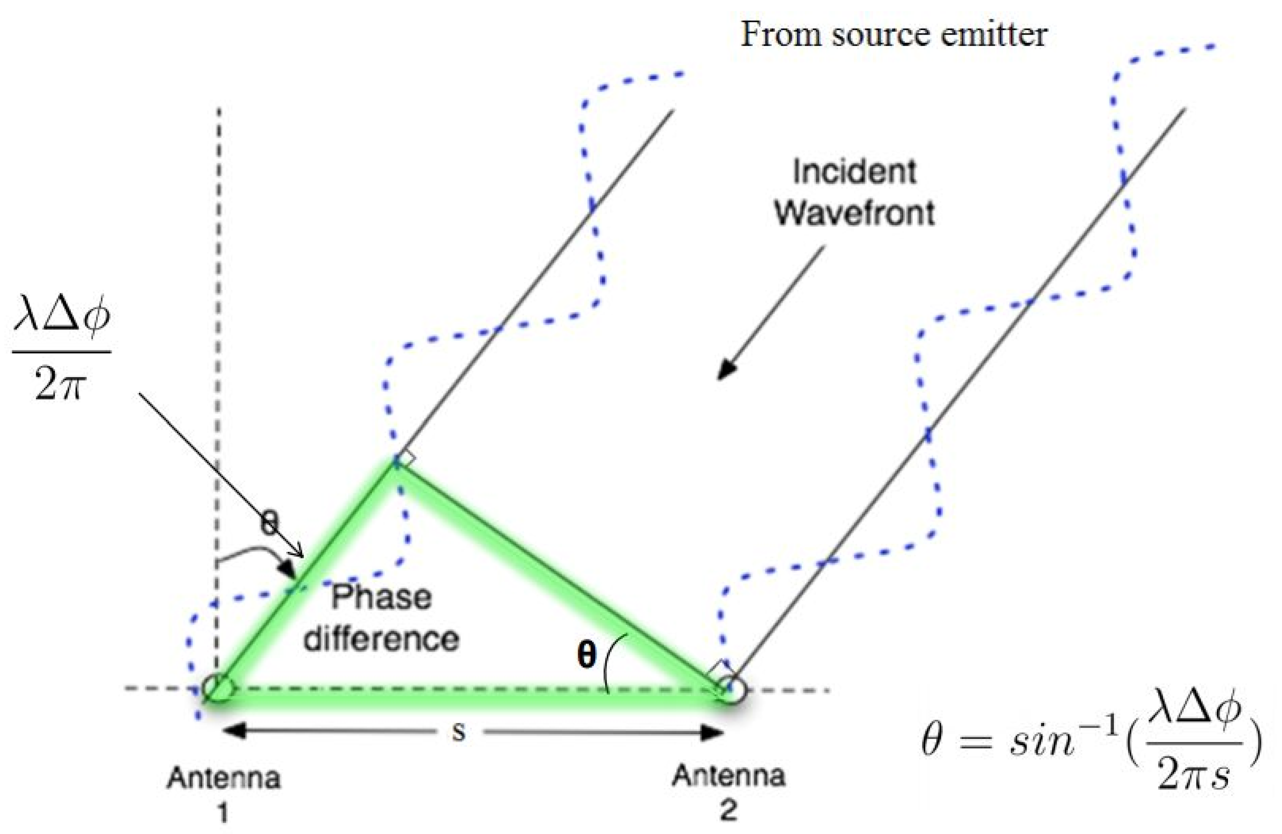
## Acknowledgements

We would like to thank our advisor, Professor Ramakrishna Janaswamy, for his sustained guidance and support. We would like to thank our evaluators, Professor Paul Siqueira and Professor C. Mani Krishna, for their feedback. Finally, we want to thank Tom Hartley for providing us valuable resources for the development of this project.

# Waveform Properties



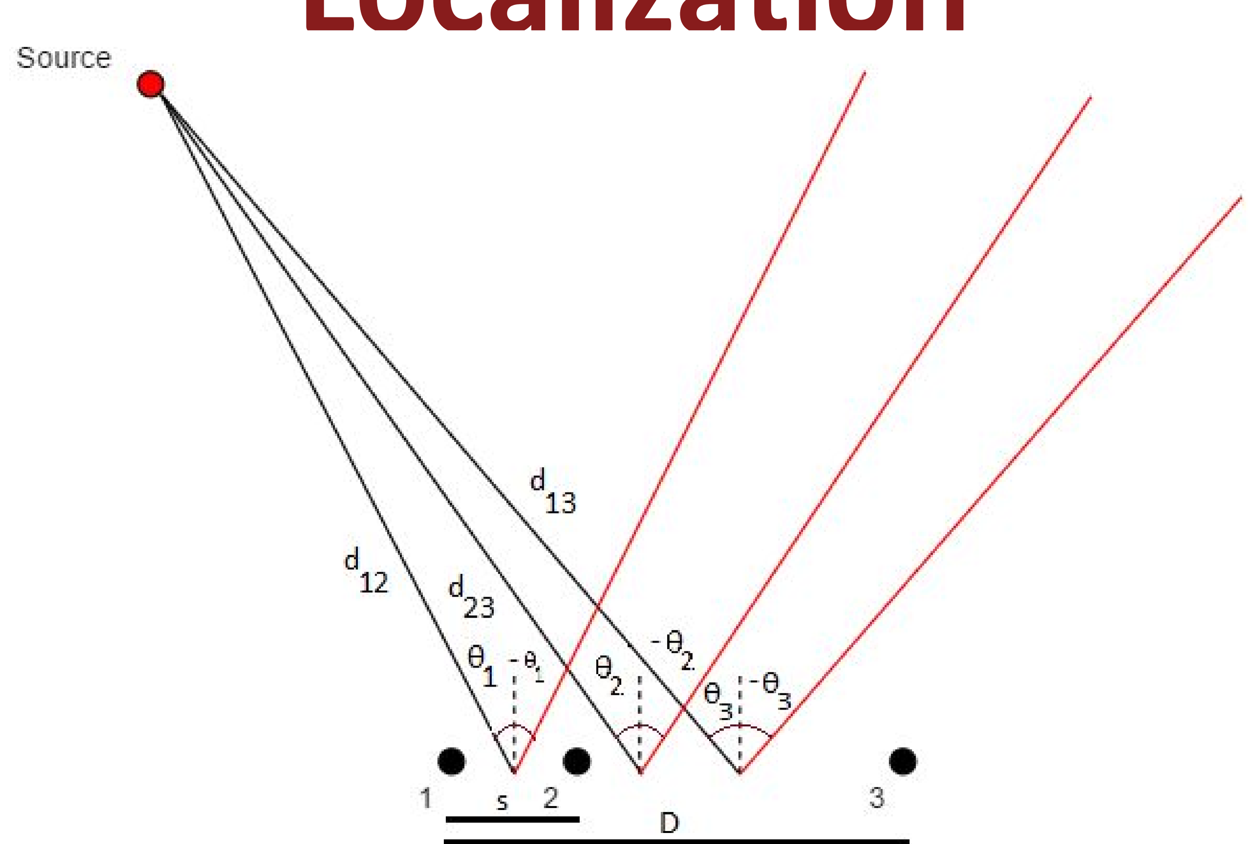

The difference in the signals' times of arrival corresponds to a unique phase difference between the two signals when received by the antennas




This phase difference translates into a physical difference in length between the paths of the two signals.

The different path lengths can be used to calculate an angle of arrival, which indicates the direction of the source transmitter with respect to the antenna array.

# Localization

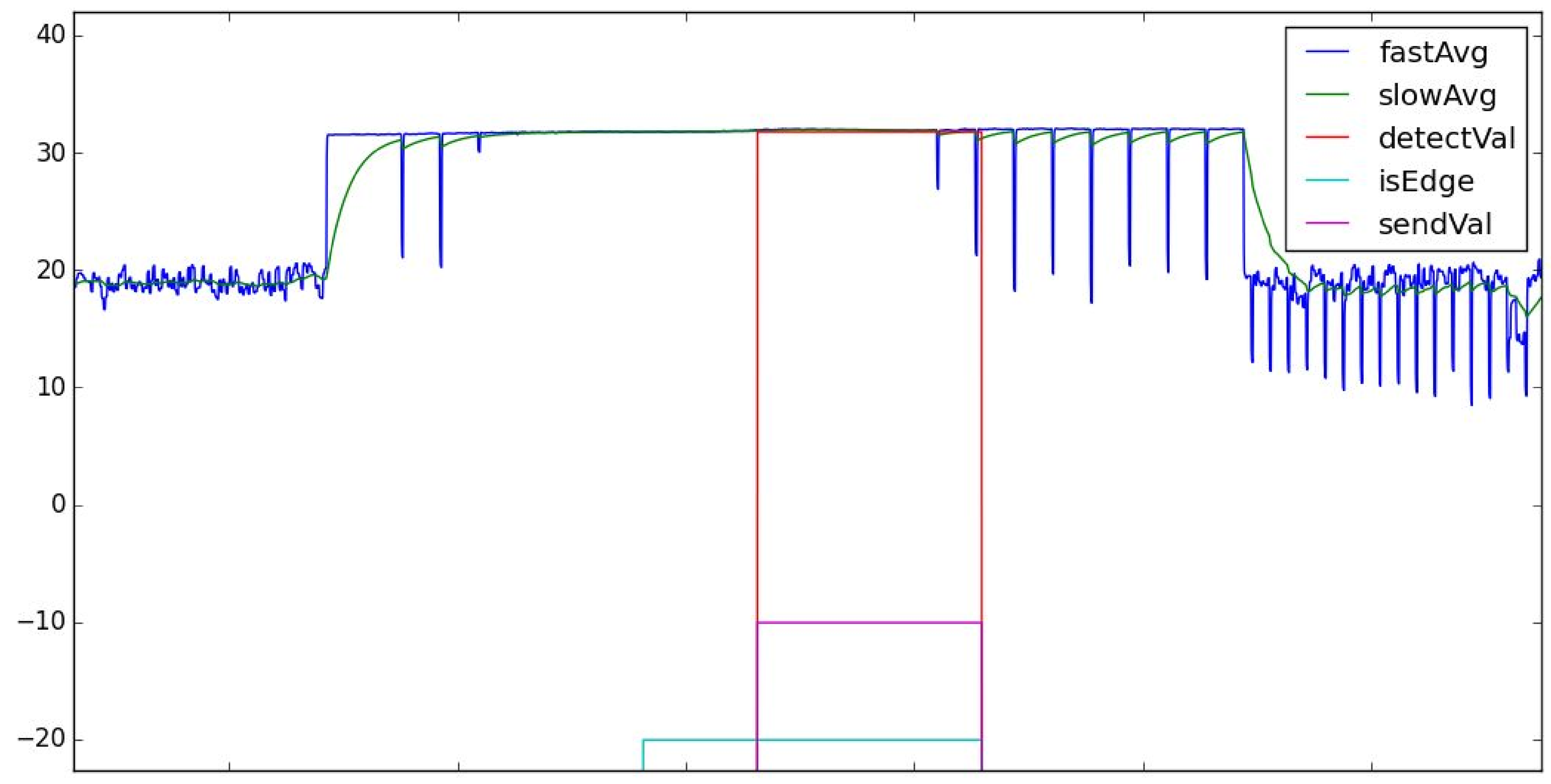



With three antennas, three angles of arrival can be calculated and used to triangulate the location of the source transmitting the signal.

# Cost

| Component | Development Cost | Cost (per thousand) |
|---|---|---|
| PCB's (x3) | $15.00 | $15.00 |
| 50Ω female SMA connector (x6) | $41.76 | $24.36 |
| 2-1200MHz broadband splitter (x3) | $45.00 | $29.97 |
| Raspberry Pi AD/DA expansion board | $25.10 | $25.10 |
| AD8302 phase detector module (x3) | $39.21 | $20.25 |
| 2.1mm DC Barrel Jack | $0.95 | $0.86 |
| 12VDC 1A power adapter | $8.95 | $3.68 |
| 78 nH SMD | $1.27 | $0.49 |
| 3G/4G/LTE DiPole Antenna (x3) | $59.97 | $29.97 |
| Adjustable Pi camera mount | $4.95 | $4.95 |
| 2-meter Pi camera flex cable | $5.95 | $5.95 |
| FTDI friend v1.0 | $14.75 | $14.75 |
| Arduino Pro mini 328 5V/16MHz | $9.95 | $9.95 |
| Ation mount camera polearm | $9.99 | $9.99 |
| Dual USB 2.0 female panel mount | $7.99 | $7.99 |
| Active VGA/HDMI MtoM, 15 pin video cable | $10.99 | $10.99 |
| HDMI extenson cable M/F | $5.59 | $5.09 |
| 250V 10A panel mount plug adapter | $7.23 | $5.78 |
| | | |
| Total Cost | $314.60 | $225.12 |

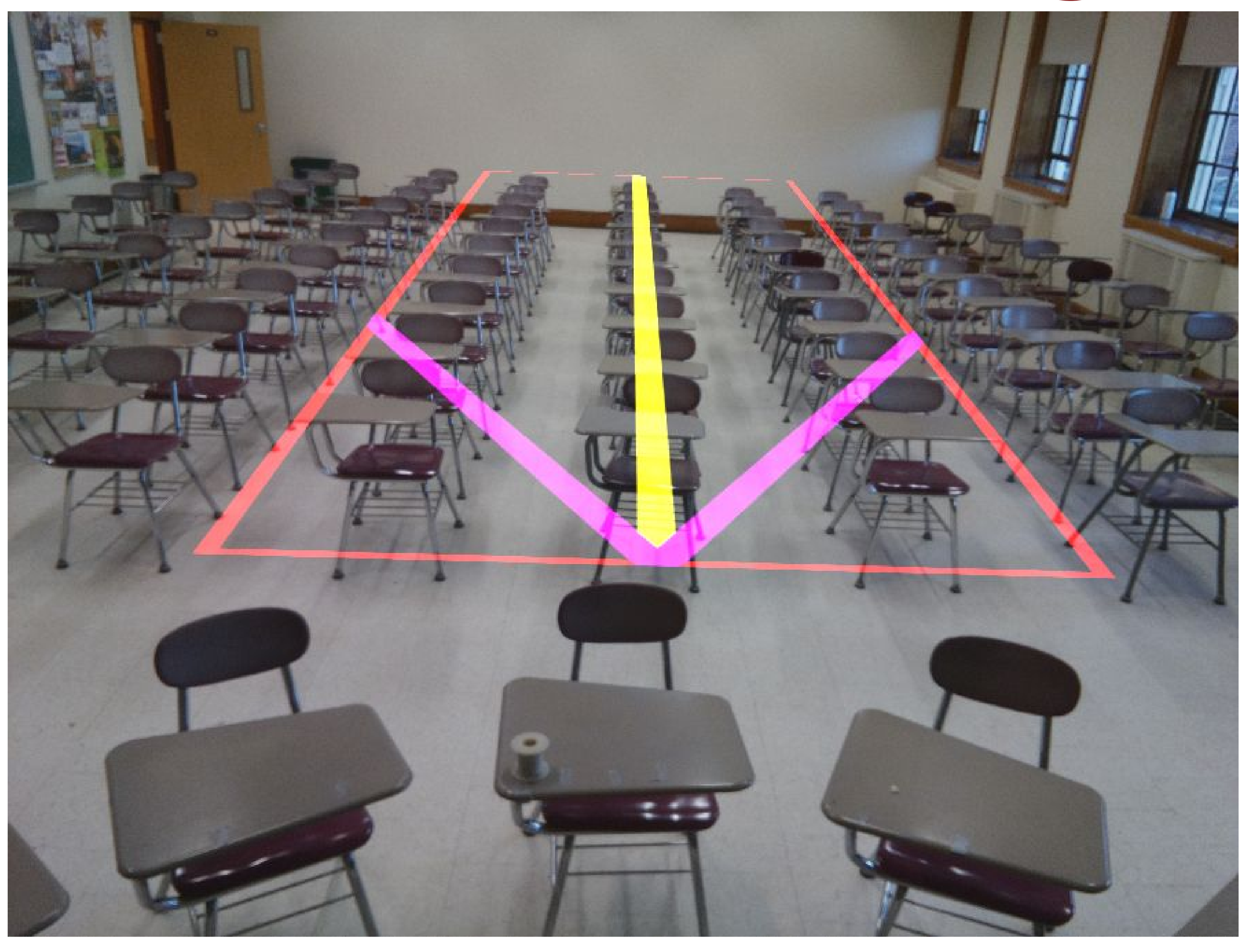
# Digital Signal Processing




Following hardware signal processing, the phase differences are calculated into angles. These angles are received by the digital processing subsystem at >4k samples per second, and are processed in real-time to distinguish stable signals of interest.

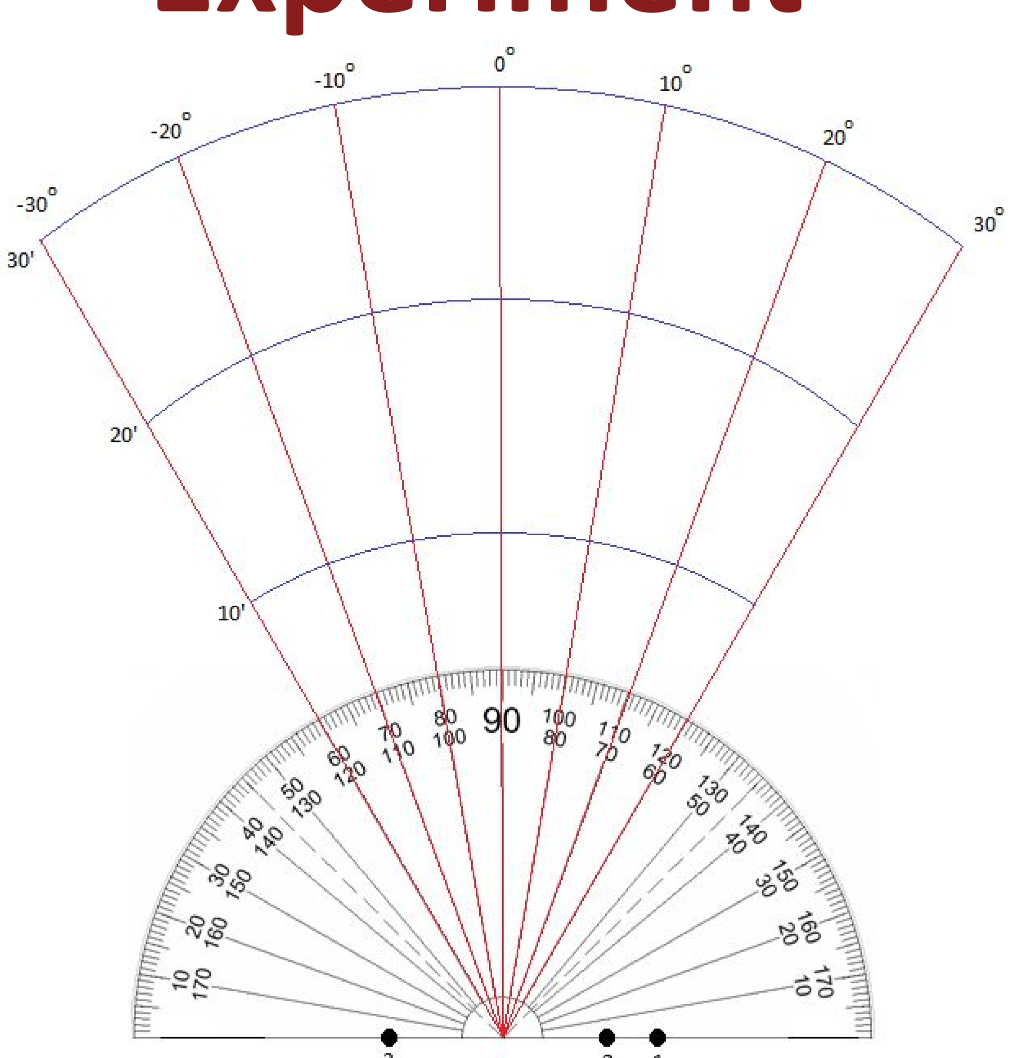
This is achieved with a number of real-time DSP algorithms including moving-exponential averaging, threshold stability detection, and hysteresis.

# Video Processing



During setup, the operator is prompted in a GUI to specify the region of interest on a live image of the camera view. This input parameter is used to find a homography between the grid plane of the room and the camera perspective, which is used to process video recording with a location specifying overlay. Processed video is stored with a corresponding data log.

# Experiment




Azimuths corresponding to angles of arrival ranging from (-30°,30°) were mapped in an arc in front of the antenna array. This was done for distances of 10,20, and 30 feet. Data gathered was compared to hand calculations and MATLAB simulations to evaluate correctness.