

INCOMING RADIO SIGNAL DIRECTION FINDING USING AN ANTENNA ARRAY

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OBJECTIVE

Design a stationary antenna array system that accurately detects the angle of arrival of incoming signals at line-of-sight distances in a field environment with the provided budget.

VALUE PROPOSITION

Current livestock tracking methods are costly, time-consuming, and high-maintenance for cattle ranchers. Our project offers a low-cost, low-maintenance solution that supports safer and more efficient herd management practices.

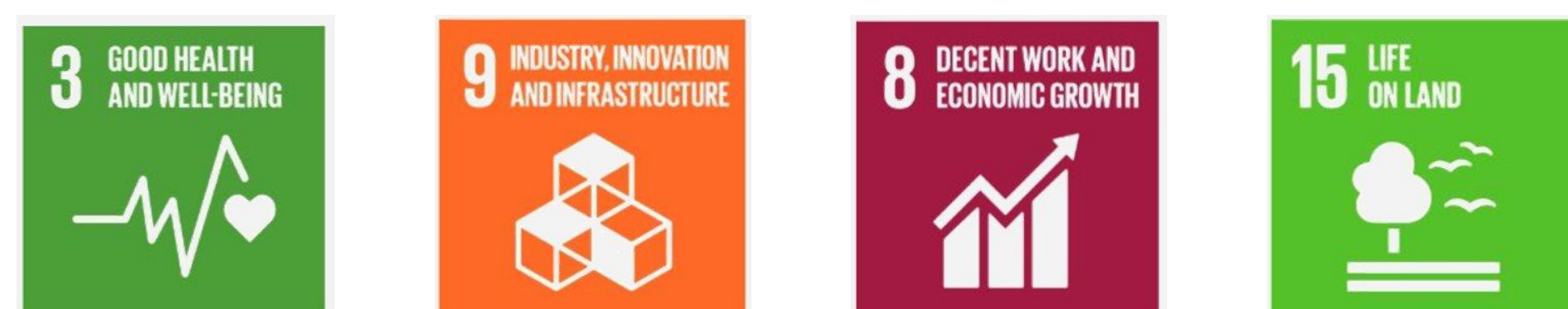
KEY REQUIREMENTS

- Angle measurement approaches 1 degree of control accuracy
- Angle measurement is consistent within 100 ft of signal propagation



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CONCEPT DEVELOPMENT

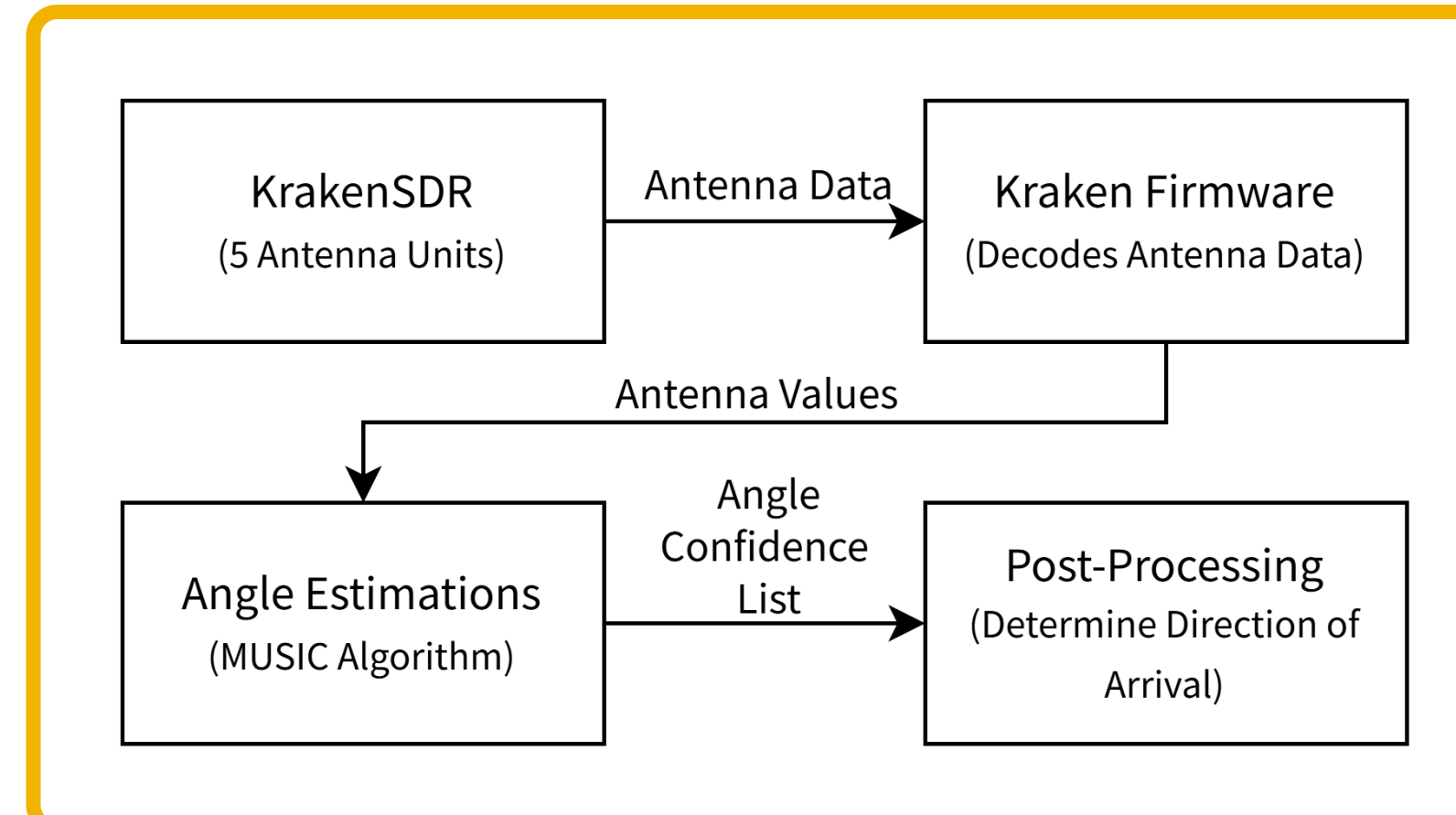


Figure 1: System Block Flow Diagram

GNURadio:

- Antenna data extraction and processing through GNURadio.
- Angle Estimation with MUSIC Algorithm
- Rapid Prototyping and Intuitive Visualization.

Hardware:

- KrakenSDR with 5 Antennas
- Raspberry Pi 5

Software:

- GNURadio – Development and Testing
- Python – Final Design

Algorithm:

- Multiple Signal Classification – MUSIC

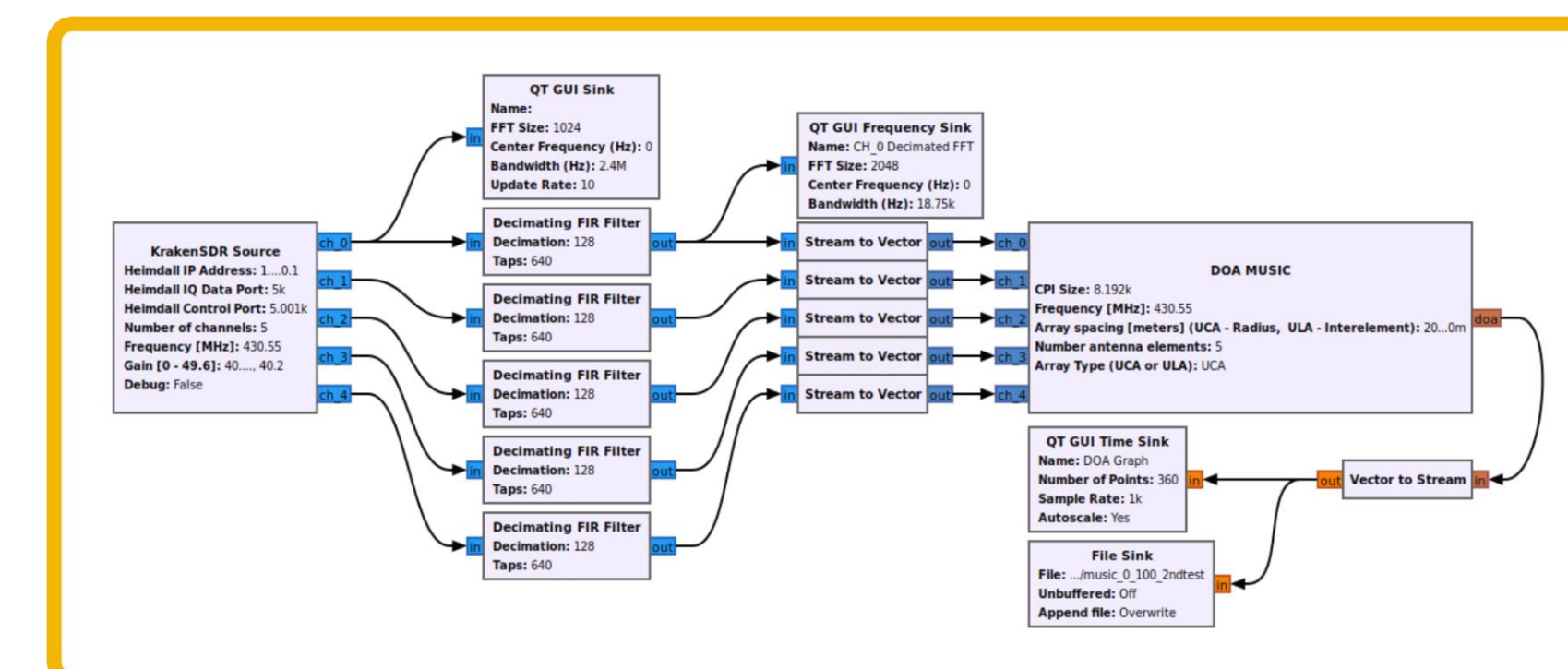


Figure 2: Data Flow Diagram in GNURadio

FINAL RESULTS

Analysis Methods

- Music algorithm to process incoming radio signal
- Post processing used to pick a single angle over many measurements

Post Processing

1. Convert angle strengths to probabilities over each measurement
2. Eliminate angles under 3% likelihood
3. Sum pool of each angle across time and neighboring angles
4. Pick highest scoring angle for each measurement
5. Select most frequent angle chosen across time
6. Format using a 3x7 pool window

Radial axis: Accuracy of angle measurement

Angular axis: Angle of incoming signal

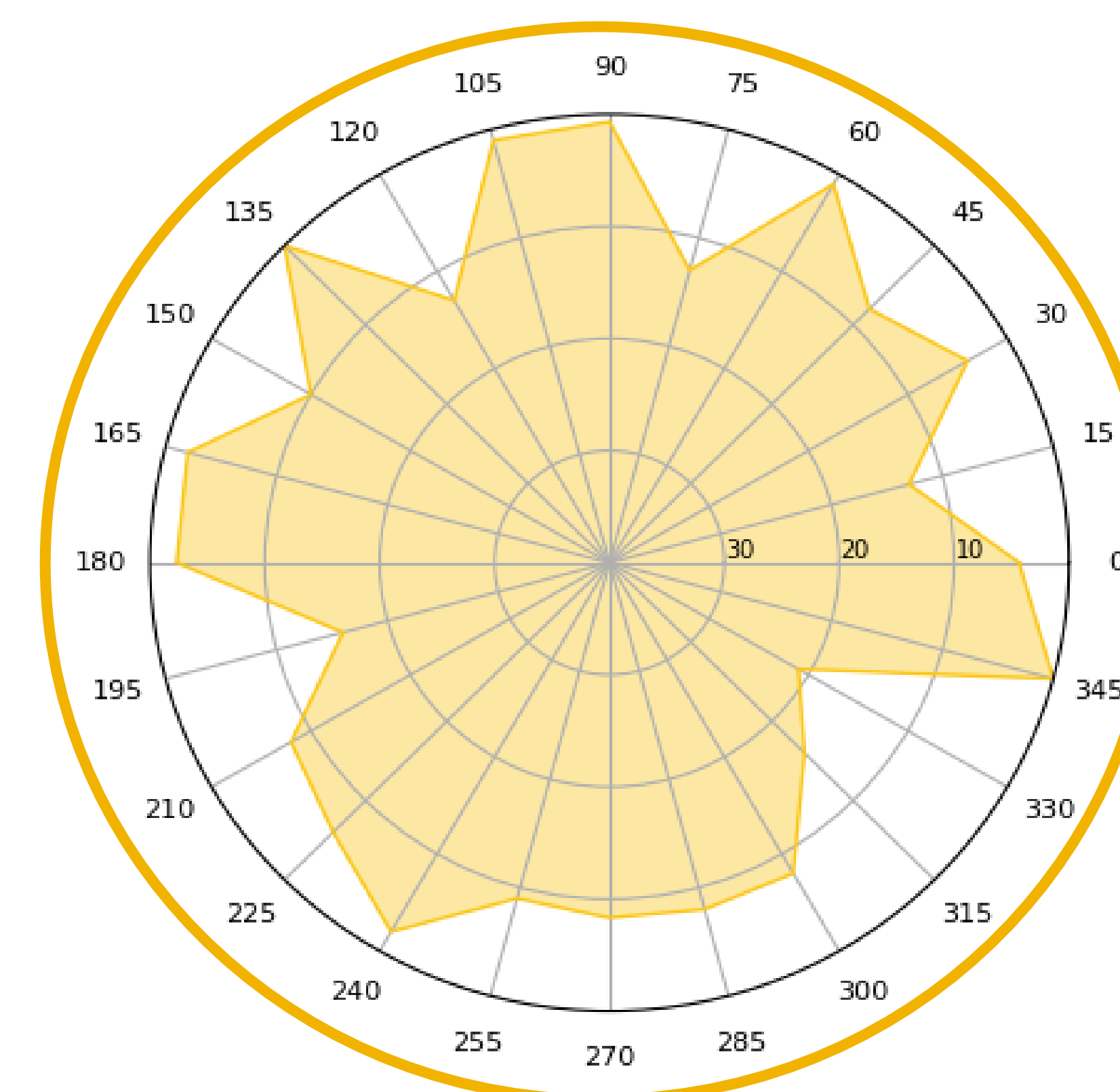


Figure 4: Radar chart of final accuracies for each angle tested

TESTING AND VALIDATION

1. HAM Radio transmits constant signal
2. KrakenSDR receives signal and passes raw data to computer
3. Computer calculates angle of arrival
4. Angle is compared to physical measurement

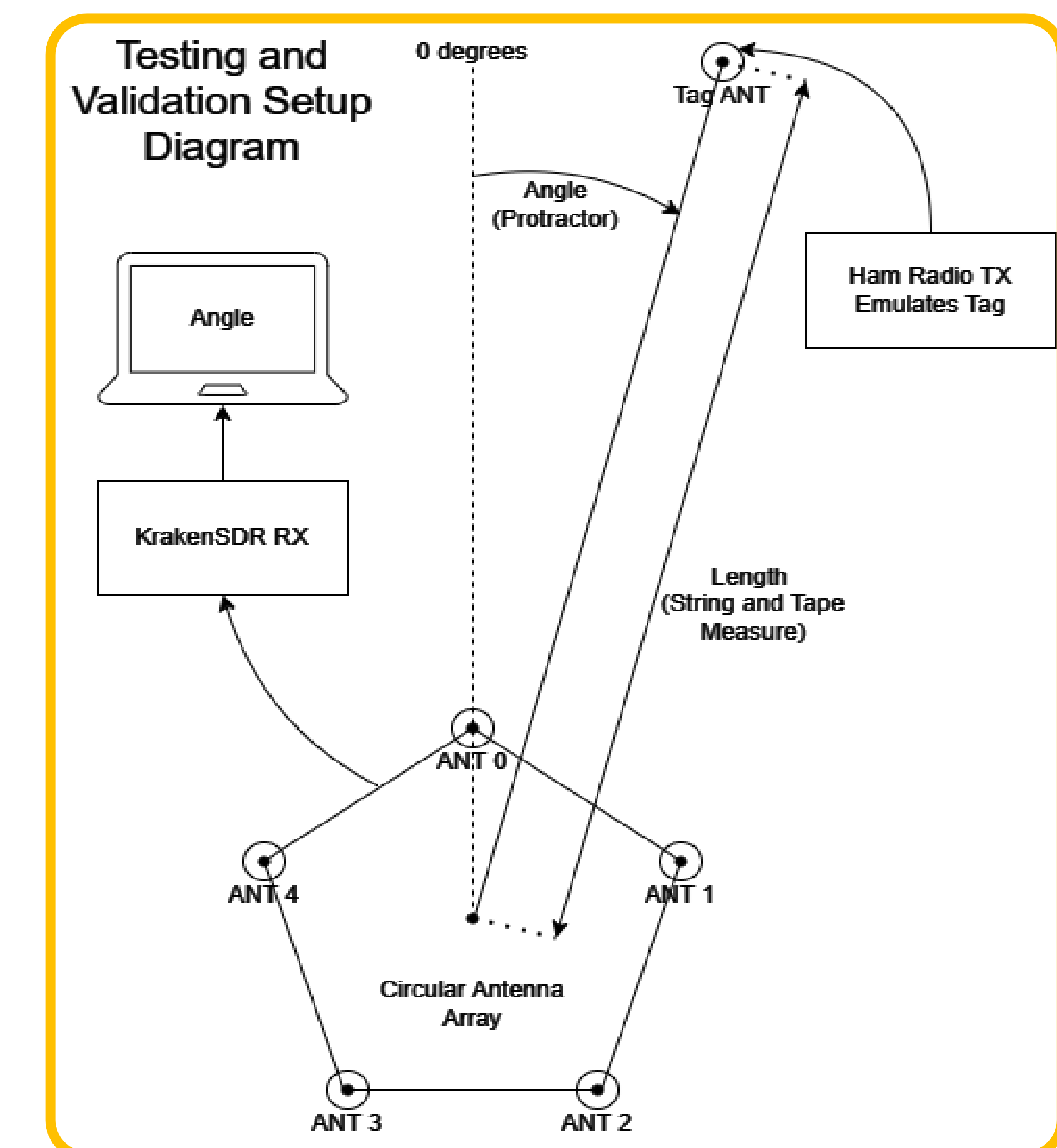


Figure 3: System Block Diagram

CONCLUSION

- Successfully demonstrated angle of arrival calculation for radio signals
- Achieved an average accuracy of ± 7 degrees using MUSIC algorithm
- Custom hardware required for compatibility with 2.4 GHz system