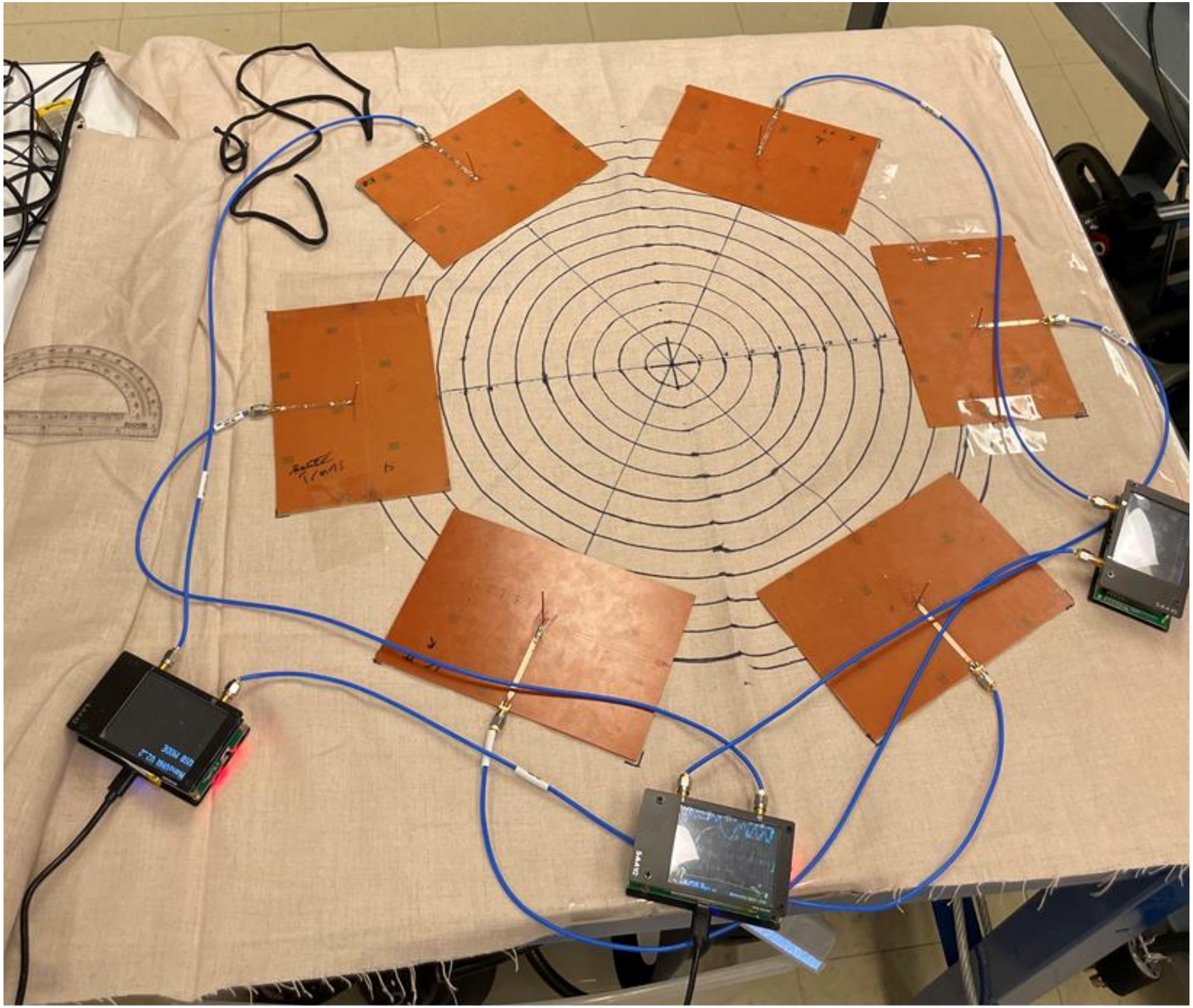
6.013 Radiolocalization Project

Conducted by Leif Clark, Abigail Shull, and John Paris

Presented by Leif Clark

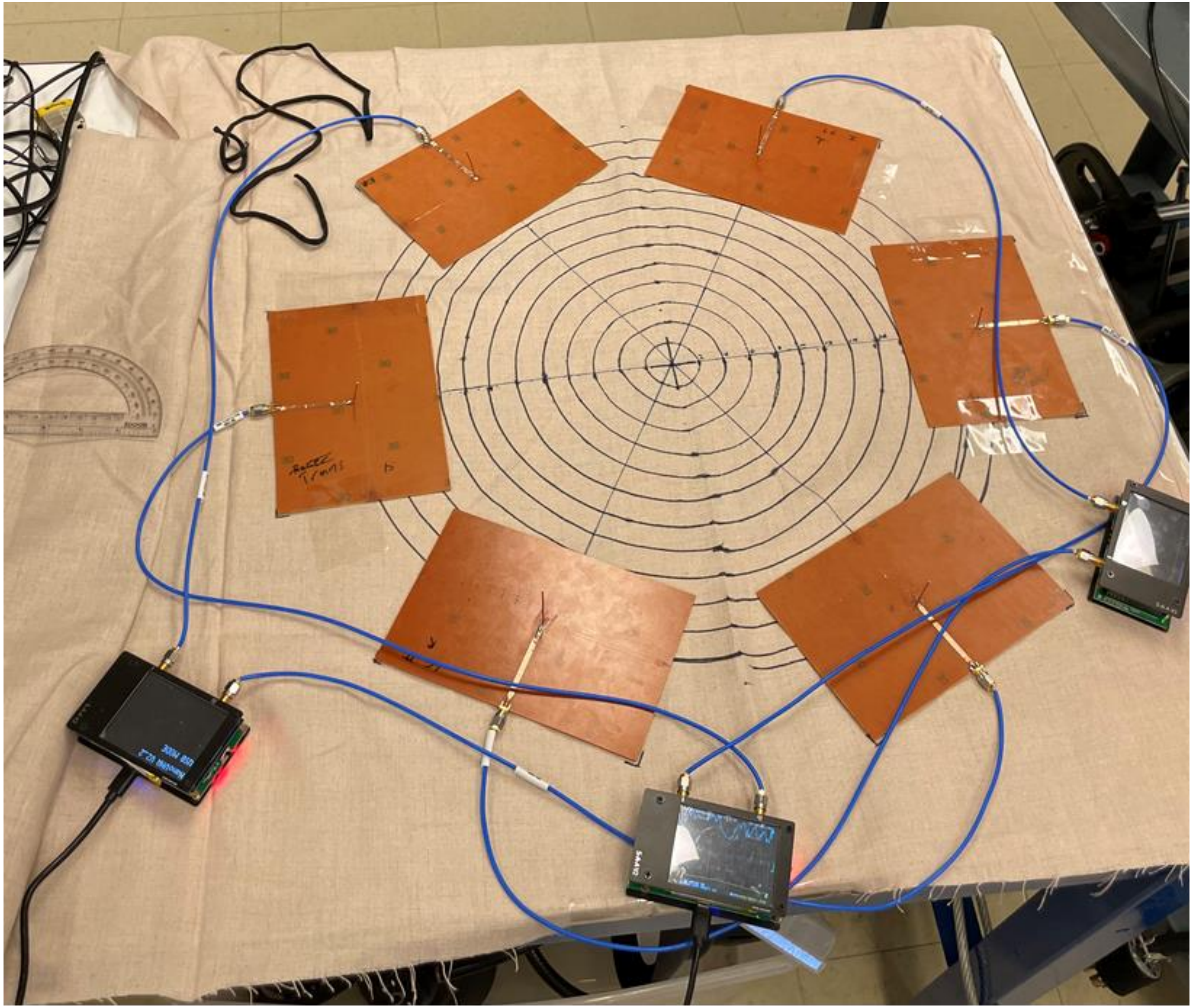
Fundamental Idea

- A conductive object between a transmitting and receiving antenna should divert, reflect, deflect, and obstruct the transmitted signal
- The size and location of this conductive object impact the power received over a range of frequencies in a consistent manner
- How is this different than radar?
  - Radar relies on detecting radio waves reflected from the object back to a receiving antenna, often at/near the transmit point, and considers timing
  - “passive” location relies on detecting how a signal is disrupted between two points at a distance from each other, and relies heavily on considering signals that are *missing* at the receive point
  - “passive” location is time agnostic



Data Collected

- At three distinct frequencies:
  - S11 – ratio of signal transmitted by antenna 1 to signal received by antenna 1 – how much was reflected
  - S21 – ratio of signal transmitted by antenna 1 to signal received by antenna 2 – how much of the signal made it across the circle
- This information as collected for approximately 40 different known locations of the can at different radii and angles
- Dataset forms a set of 6 values that the VNA's should read if the can is at one of those locations



An Ideal Approach

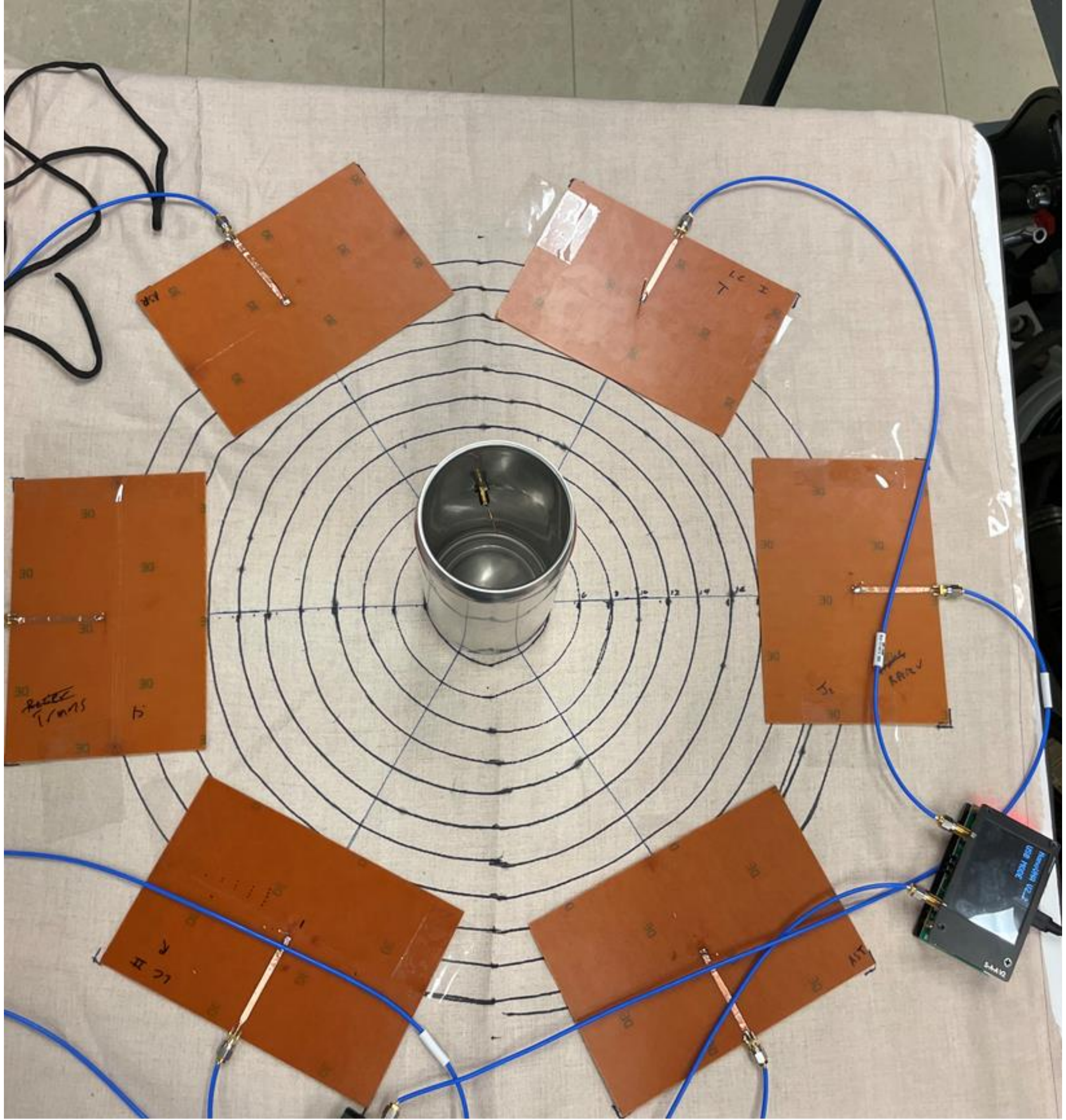
- Define 6 continuous 2-D functions over the area of the circle to fit the data points and create smooth contours between them
- Upon receiving 6 new datapoints for an unknown location, identify the location where each datapoint best fits the contours of the 2-D functions
- *Ideally*, with perfect data, the S11 and S21 readings from each VNA should predict two points, and one point should be common to all three VNA readings

In practice

- Data far from ideal
  - Sensitivity to environmental variables
  - Measurement resolution
  - Antenna construction
- Matlab AI toolbox returned highly inconsistent, very incorrect results

Approach Used

- Discrete approximation of the 6 continuous functions
- All 6 readings for each known point were summed
- When 6 readings are received from an unknown point, the sum of those measurements is compared to the list of sums of measurements associated with a known point, and a deviation is calculated
    - Yields an ordered list of known locations that the can is most likely near
    - Guessed location is an average of the top three nearest known locations, weighted by their deviation
- Best of top three predictions typically accurate to about 5 cm – half the radius of the can



Extended approaches

- The same system, split into three components to consider values from each antenna separately
  - Eschews the noise resistance of summing all 6 measurements
  - When noise is controlled, offers far more powerful
- Addition of phase data
  - Relationship much harder to predictively model, but likely quite interesting
- Weighting importance of known datapoints
  - i.e. taking data that matches a location directly between a transmit/receive pair to be more valuable than data corresponding to the periphery of transmit/receive pair