INL/MIS-23-70947-Revision-0

2023 ETI Workshop - Explosion Source Localization Using Smartphones

February 2023

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Changing the World's Energy Future

Idaho National Laboratory

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National Nuclear Security Administration

Explosion Source Localization Using Smartphones

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Consortium for Enabling Technologies & Innovation

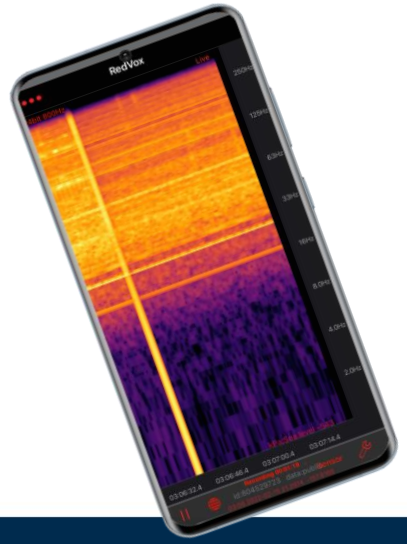
Introduction and Motivation

- Big picture, what are the underlying reasons for the work?
  - Apply Multilateration techniques to determine the source of an explosion

- What is the fundamental problem you are trying to solve?
  - Can a smartphone sensor array be used to estimate the location of an explosion?
    - Timing and Location Accuracy
    - Detection of Explosions

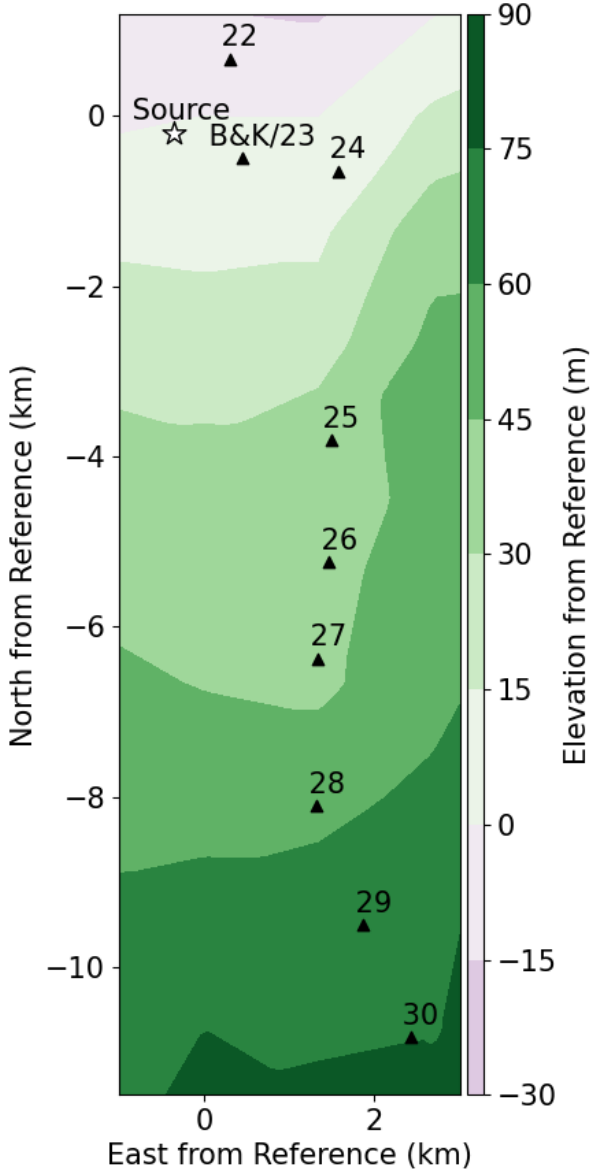
Mission Relevance

- How does this work, and the problem you are trying to solve, relate to the NNSA mission?
  - Explosion detection and source localization is a vital part of non-proliferation monitoring.
  - Utilizing smartphones as a ubiquitous sensors network.

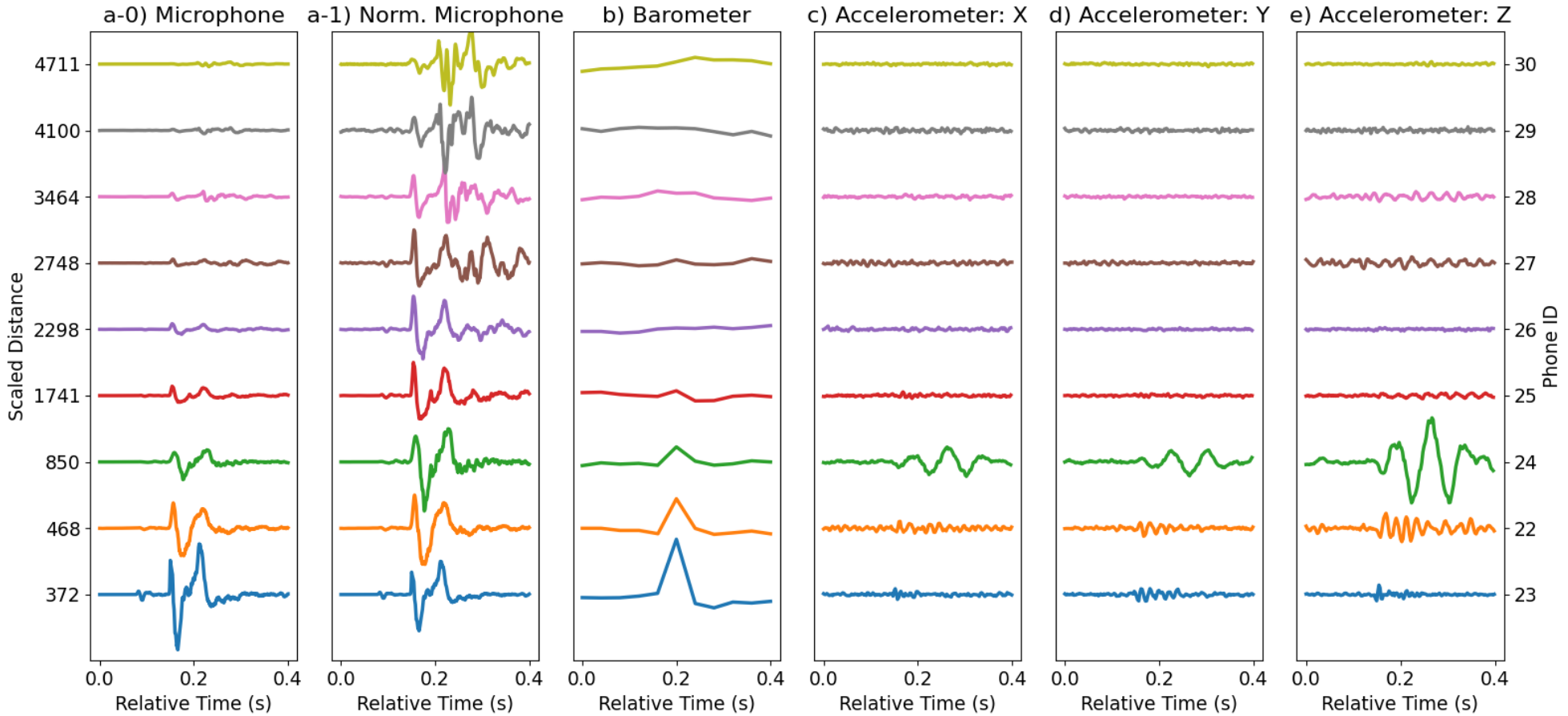


The Explosions and Sensors

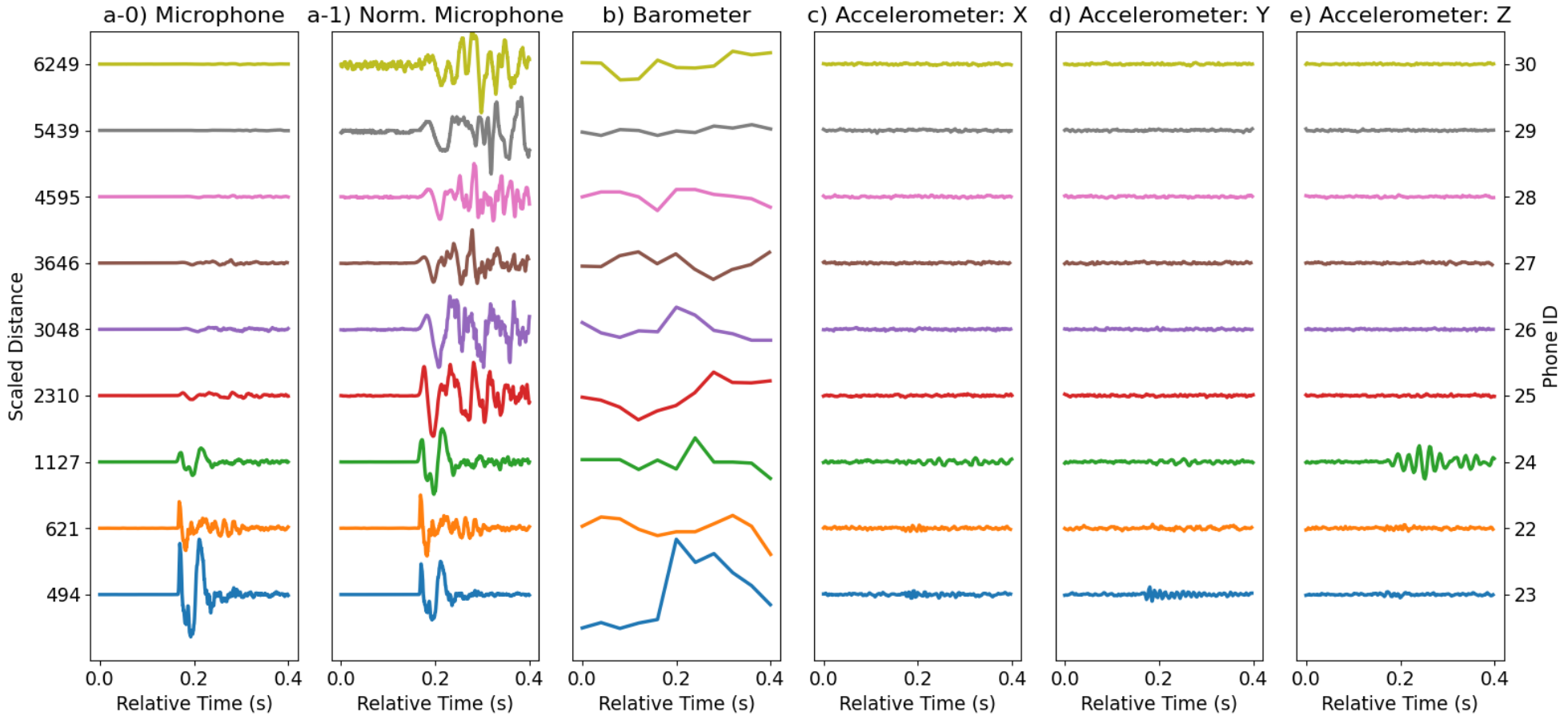
- 3 explosion events
  - Fuel Air Explosive (6.35 kg)
  - Three Simultaneous Detonations (2.72 kg)
  - One Detonation (3.63 kg)
- Source within 100 meters of all events



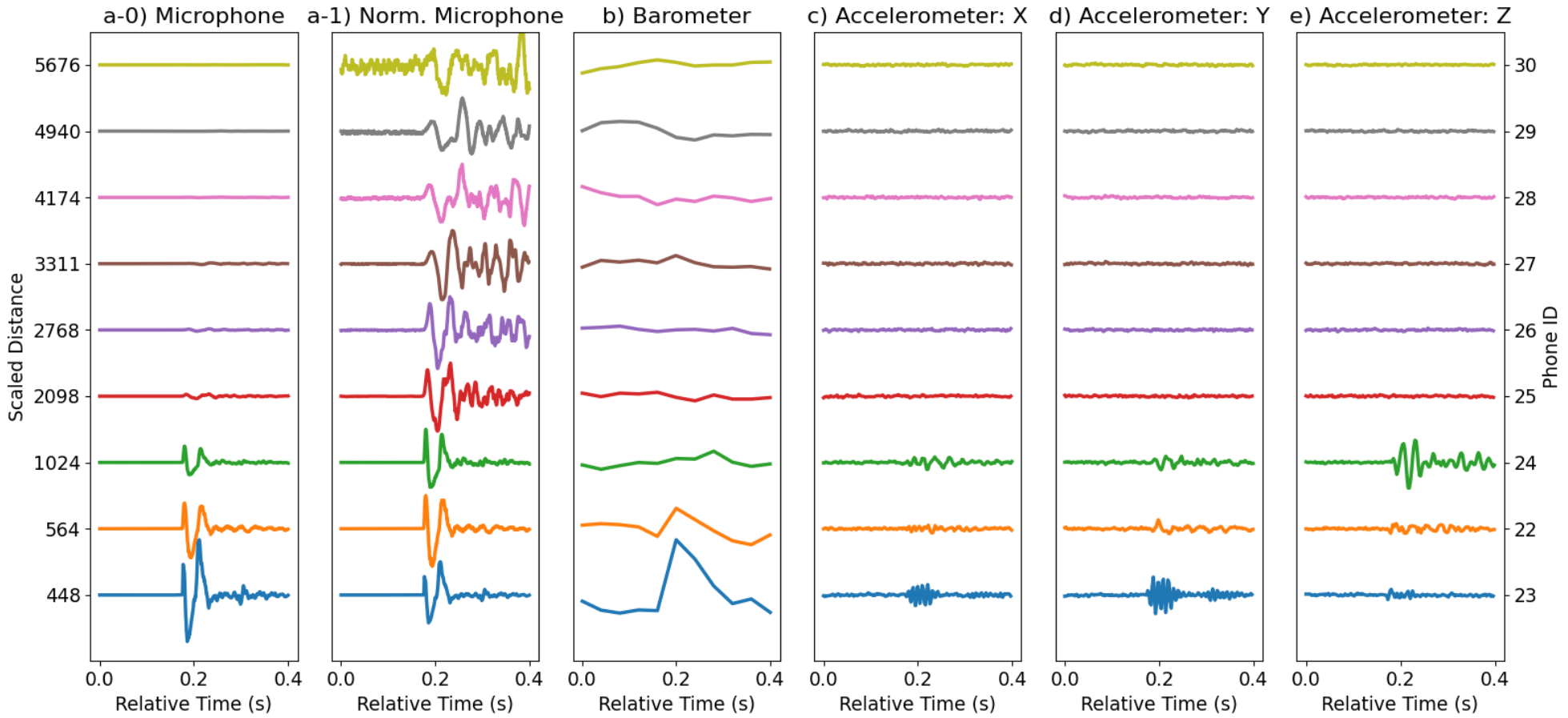
The waveforms – FAE



The waveforms – 3 detonations

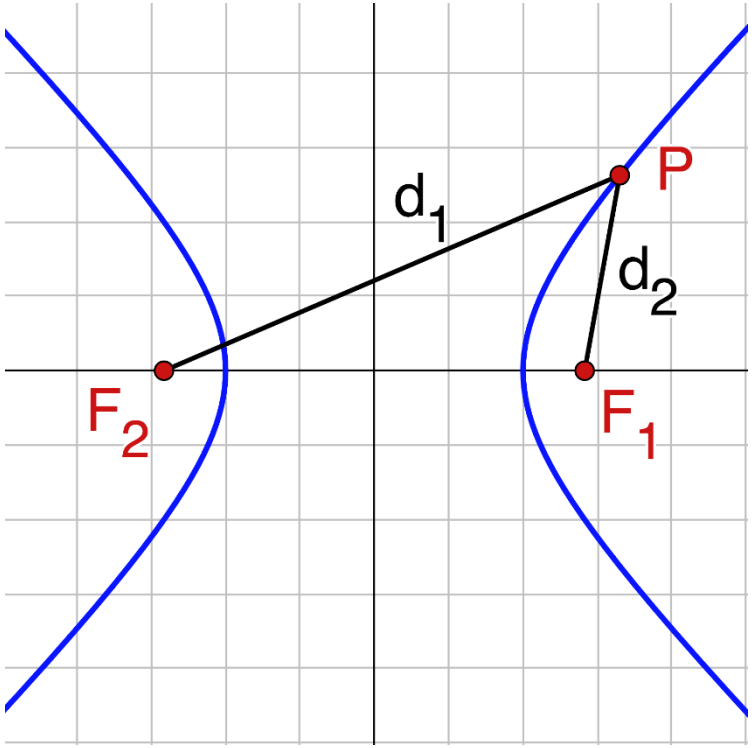


The waveforms – 1 detonation



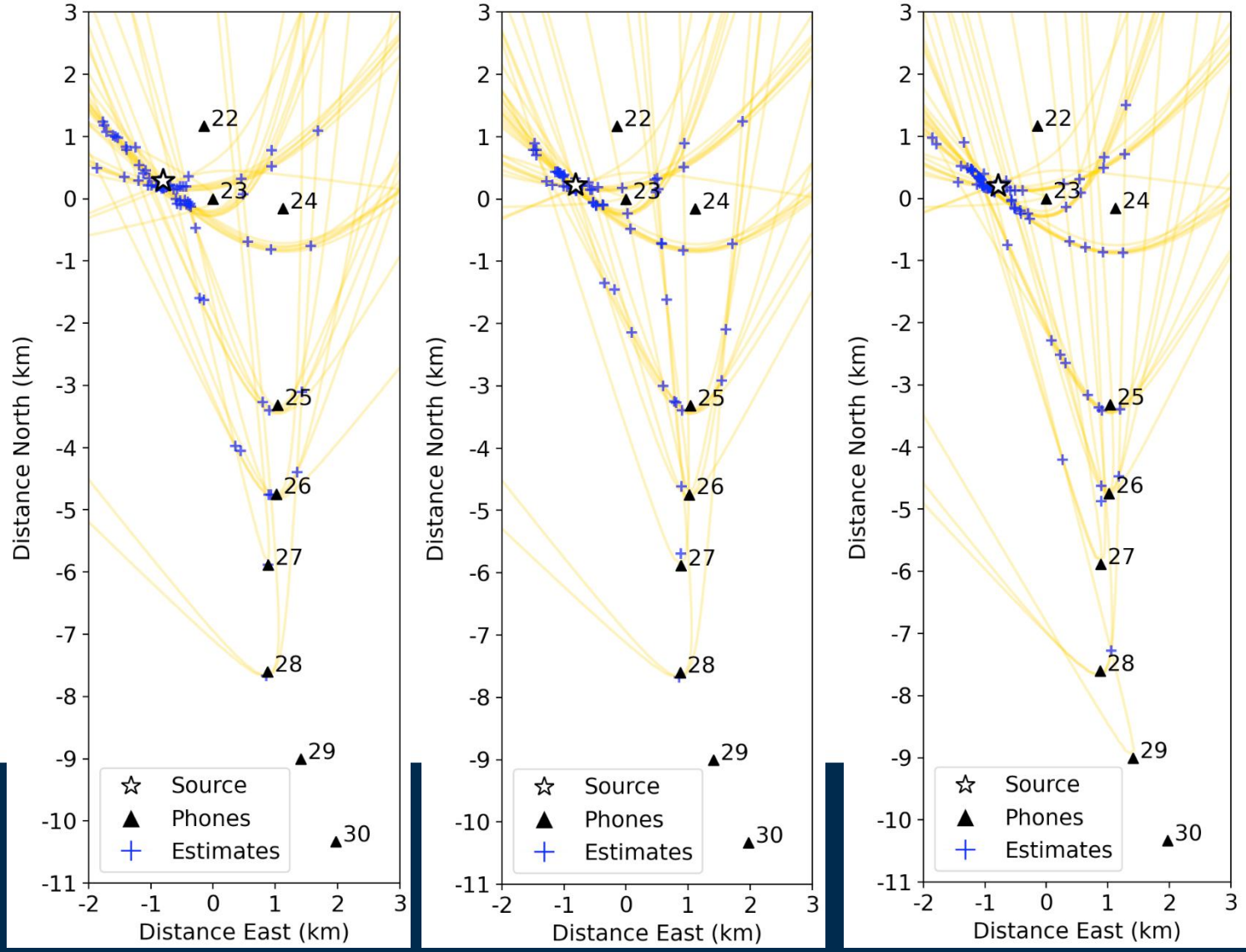
Multilateration (Hyperbolic Positioning)

- Method of determining the location of a source
  - Utilizes the Time Difference of Arrival (TDoA)
  - Uses systems of hyperbolas between sensors
  - Minimum of 3 necessary for 2D multilateration
  - Chose point where hyperbolas overlap
- Calculate for each 3 sensor pairs
  - 9 smartphones = 84 combinations



https://www.andrews.edu/~rwright/Precalculus-RLW/Text/07-04.html

Multilateration Plots



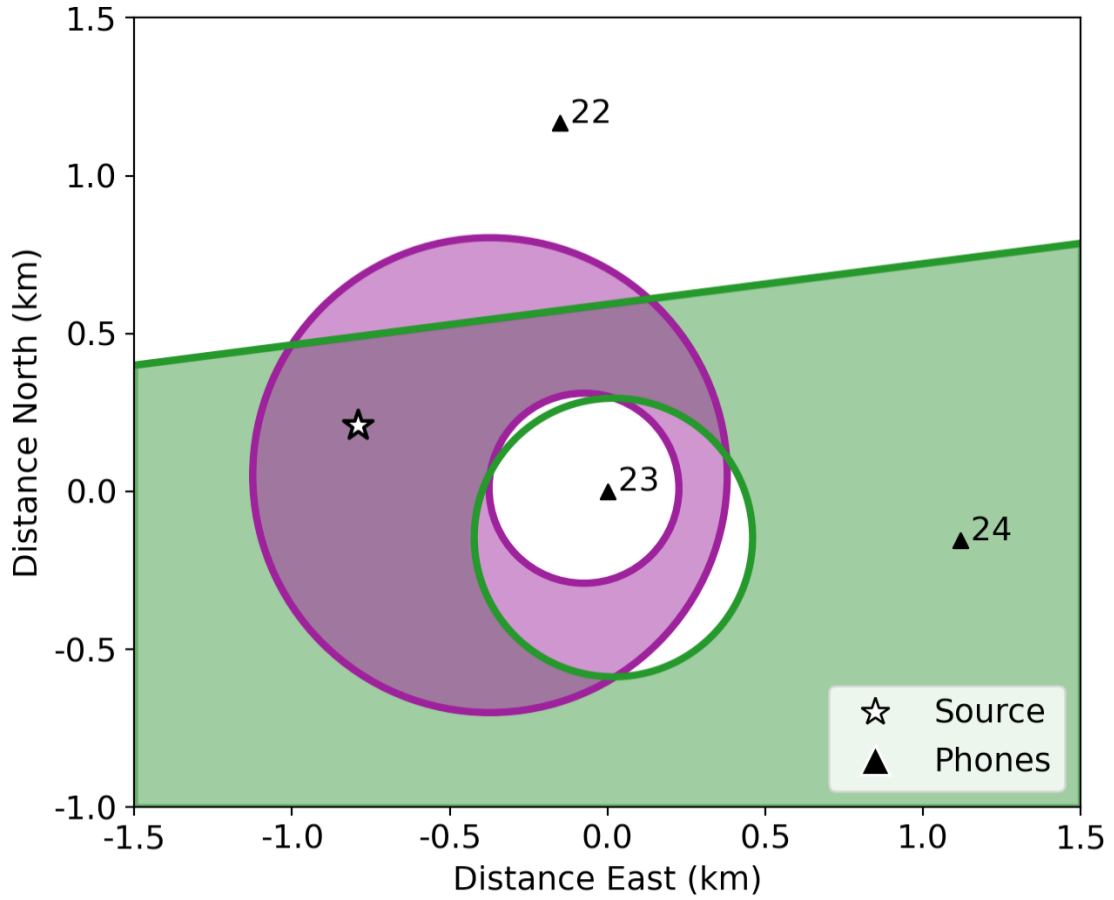
National Nuclear Security Administration

ETI

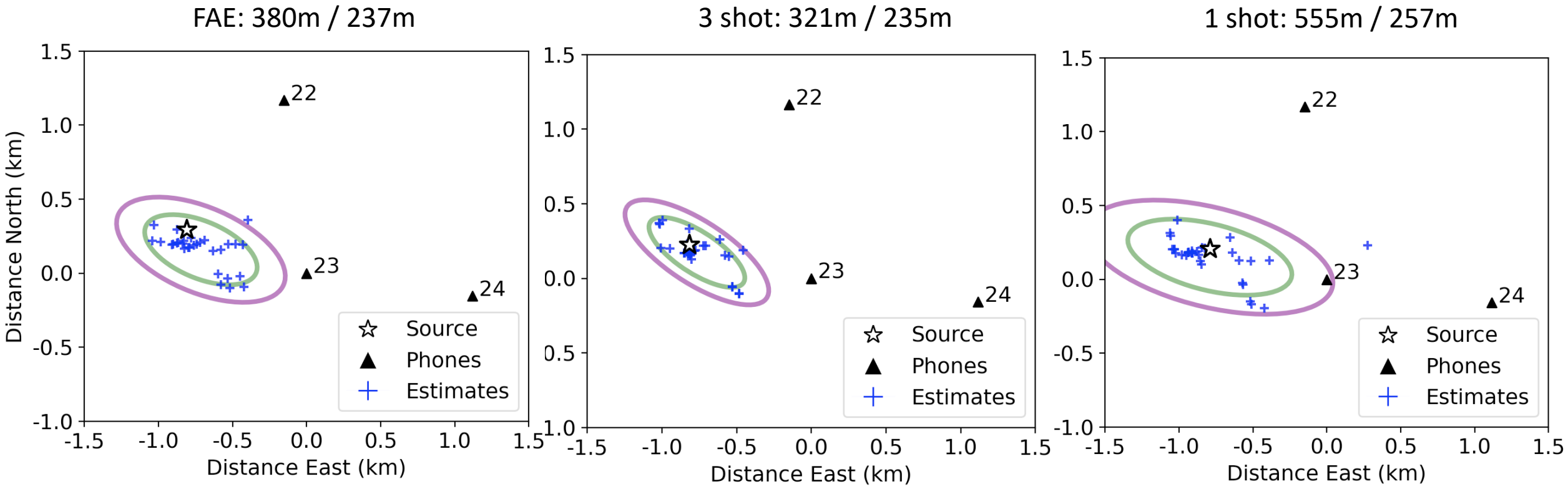
Vetting of the Estimates

- Inverse Distance Law
  - Check 3 closest smartphones' sensor magnitudes
  - Phone 23 / Phone 22
    - Microphone (2.00, 2.08, 2.14)
    - Barometer (2.18, 1.36, 2.54)
  - Phone 24 / Phone 22
    - Microphone (4.20, 3.96, 3.39)
    - Barometer (2.97, 1.71, 2.85)

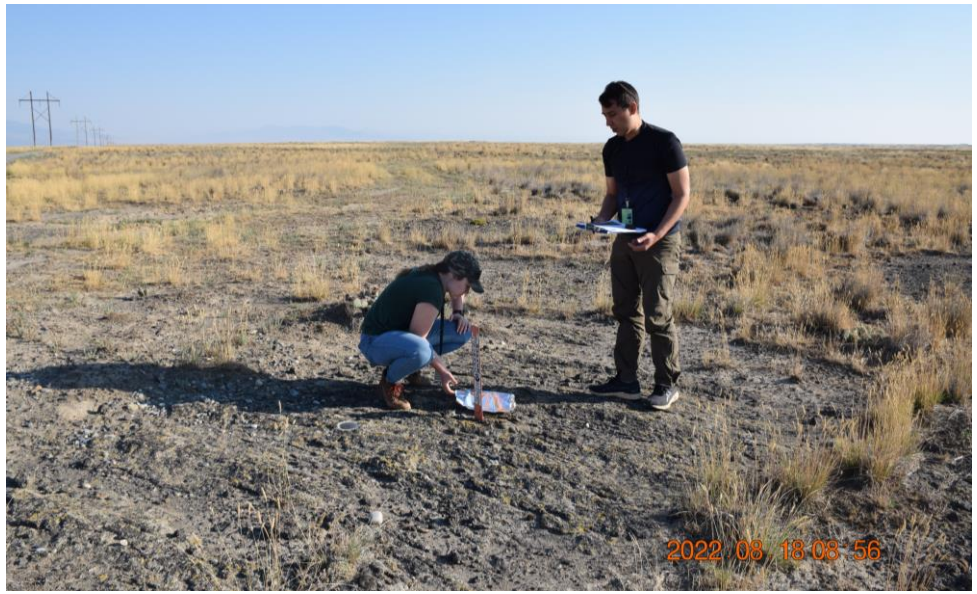
- Apollonius' definition of a circle
  - Constant distance ratio between two points
  - When ration is greater or less than 1



Final Estimates



ETI Impact



- What is the impact of the ETI on your development?
  - Internship with Idaho National Laboratory
    - Data Collection of Explosions
    - Designs of the techniques for sensor deployments
- Personnel transitions: Plans for future relationship with national labs
  - Continued relation for Data Collections
    - Idaho National Laboratory
    - Nevada National Security Site
- Technology transitions
  - Applying Multilateration Methods to other sets of explosion data

Conclusion and Future Work

- Quantitatively summarize the main results
  - ➢ Multilateration with Smartphone Sensor Networks to determine location of explosions.
  - ➢ 95% confidence ellipses of 200~400 meters
  - ➢ Majority of estimates within 100 meters of source

- Provide concluding statements that interpret what the data mean in context of the NNSA mission
  - ➢ Smartphone Sensor Networks can be used as part of the arsenal of monitoring techniques for non-proliferation.

- Paper in Progress

ACKNOWLEDGEMENTS

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