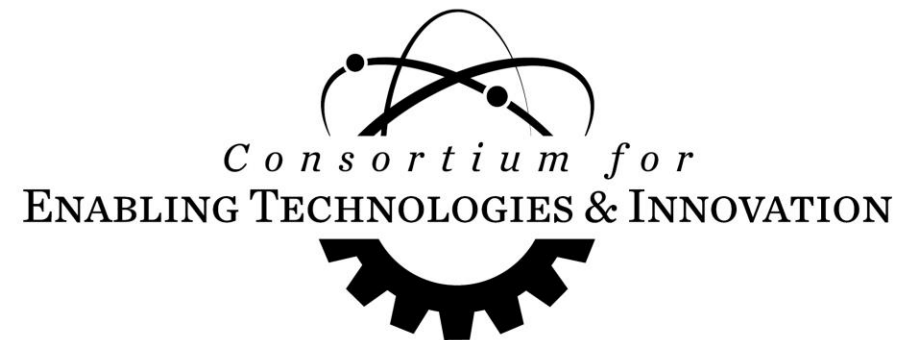


Explosion Source Localization Using Smartphones

Samuel Kei Takazawa¹, Sarah Popenhagen¹, Milton Garces¹,
Luis Ocampo Giraldo², Jay Hix²

¹University of Hawai'i at Mānoa, ²Idaho National Laboratory

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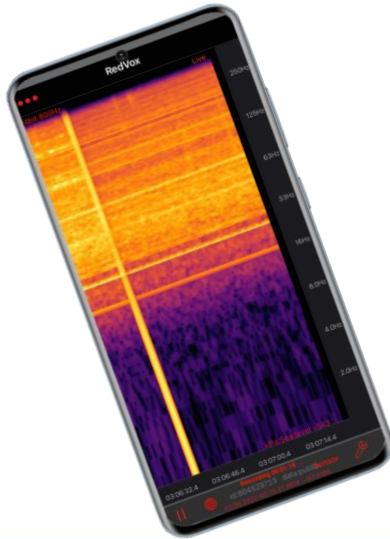


»» Introduction and Motivation

- Big picture, what are the underlying reasons for the work?
 - Estimate the location of explosions
 - Utilizing a smartphone sensor network
- 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

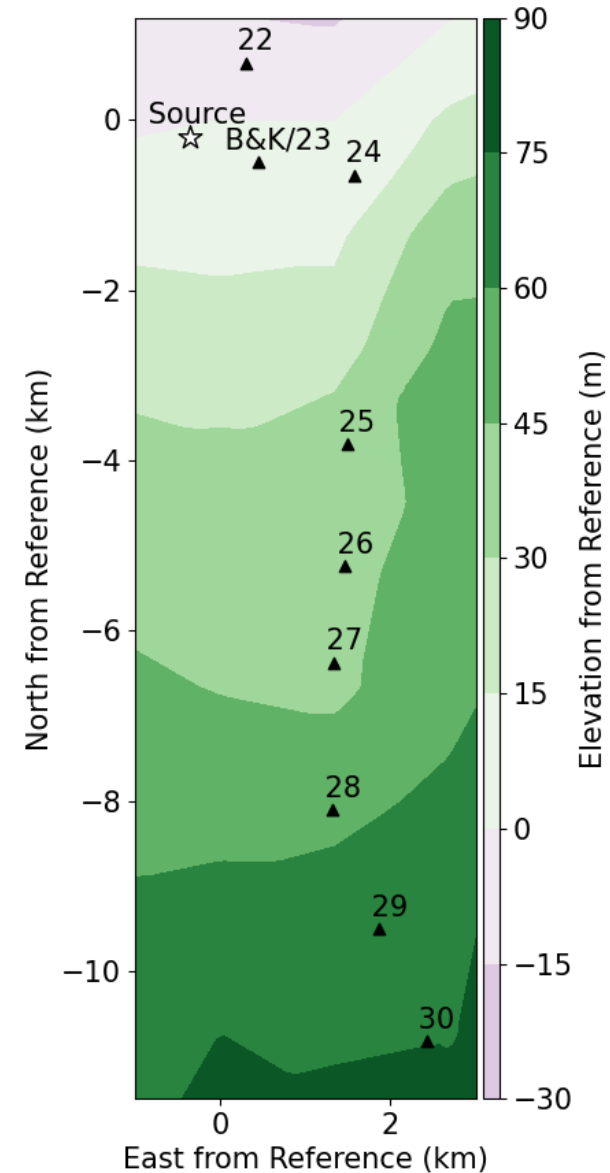
»» Mission Relevance

- 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.



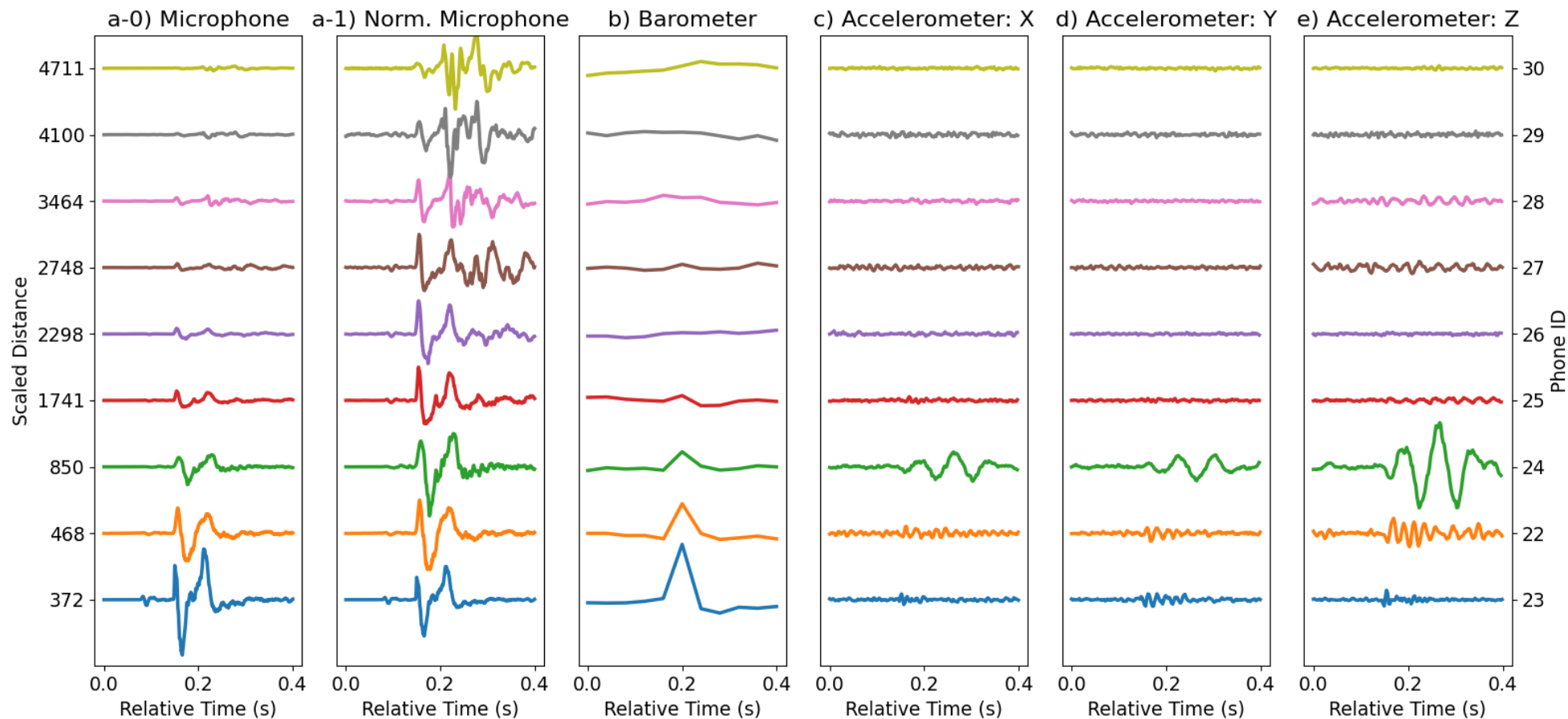
»» The Explosions and Sensors

- 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



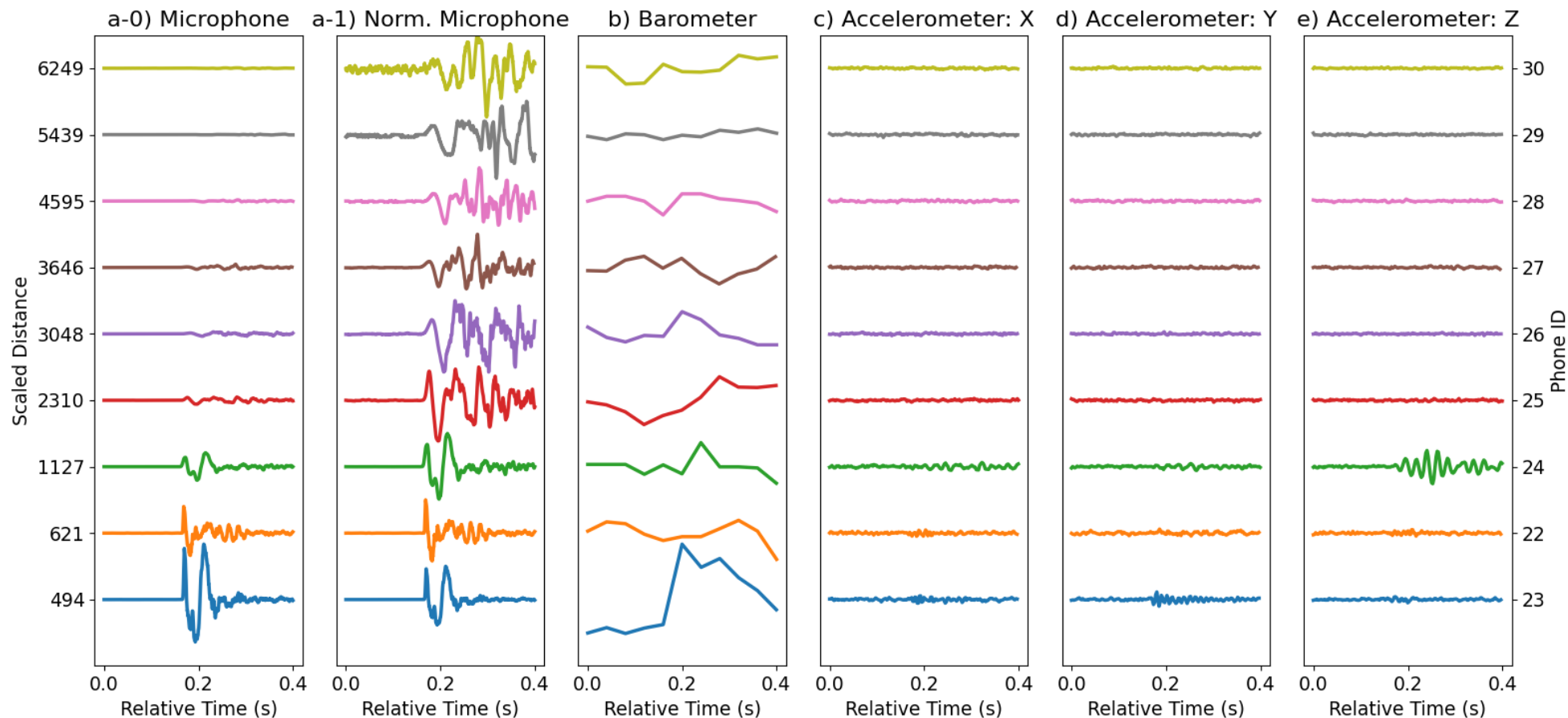


The waveforms – FAE



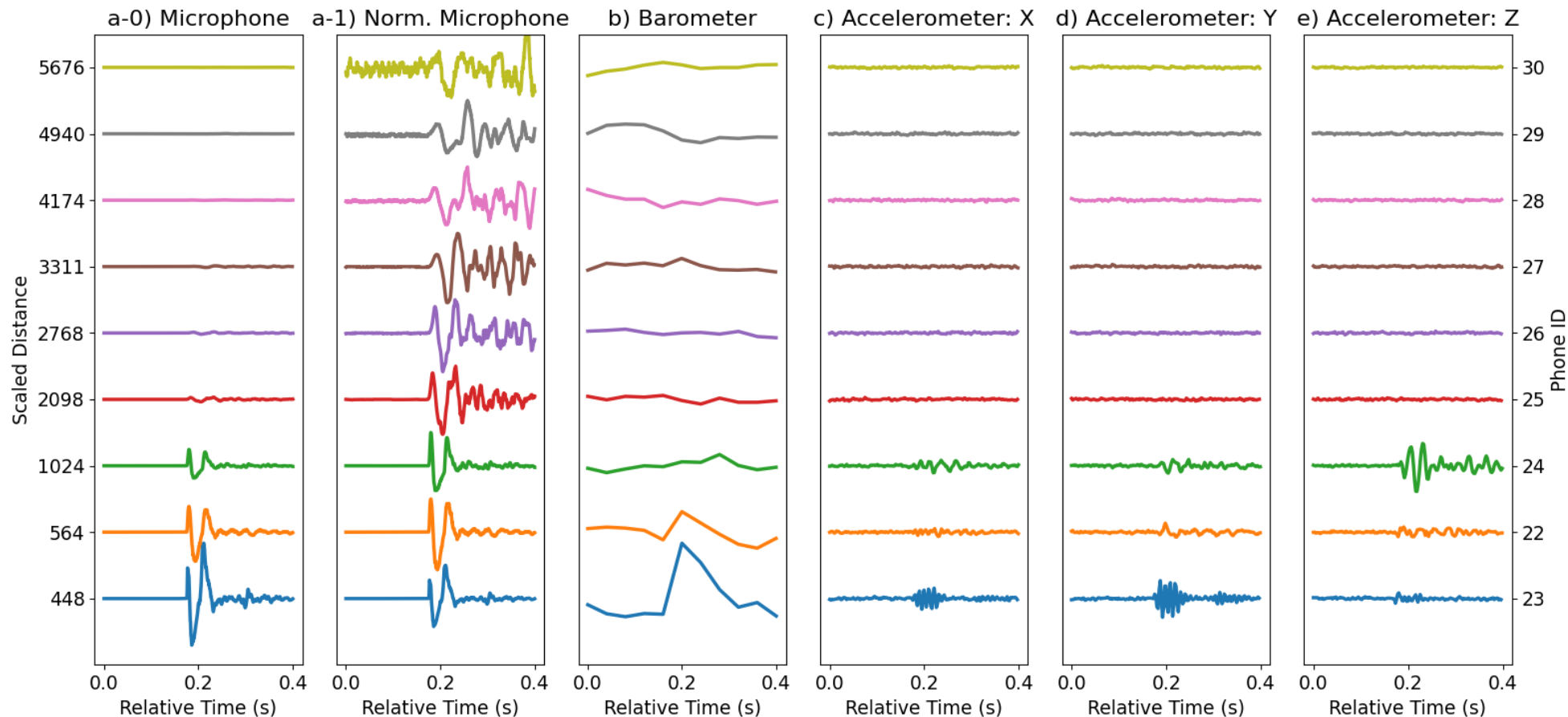


The waveforms – 3 detonations



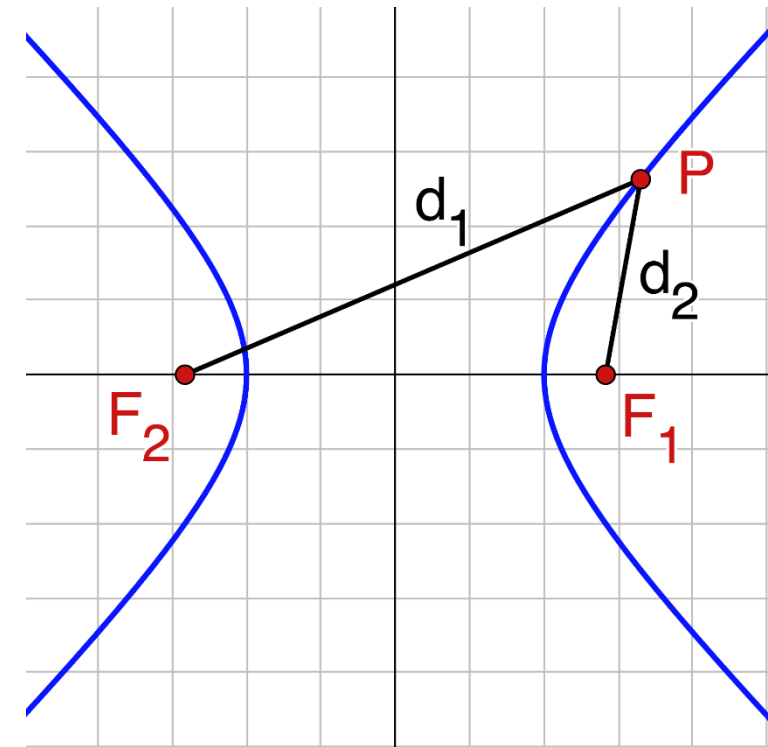


The waveforms – 1 detonation



» Multilateration (Hyperbolic Positioning)

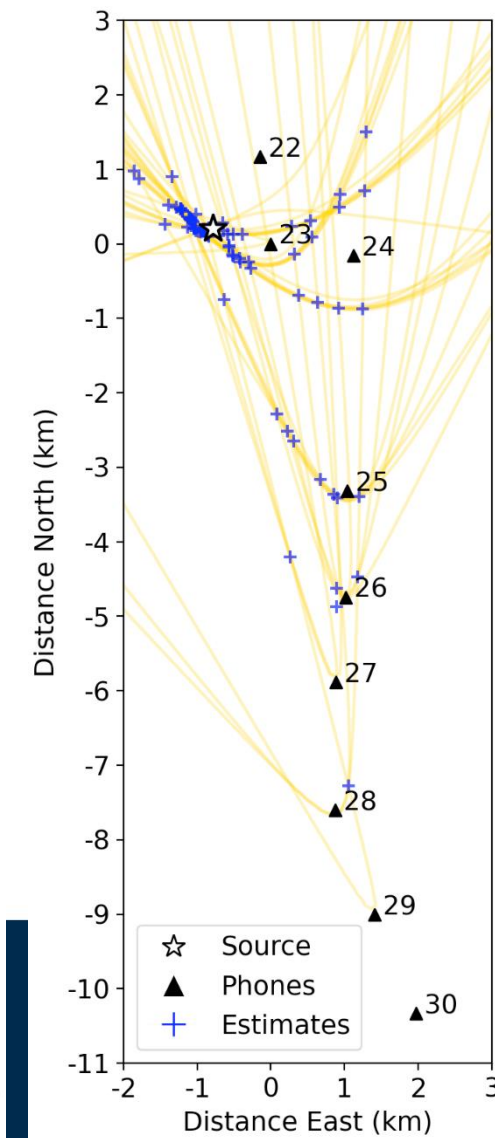
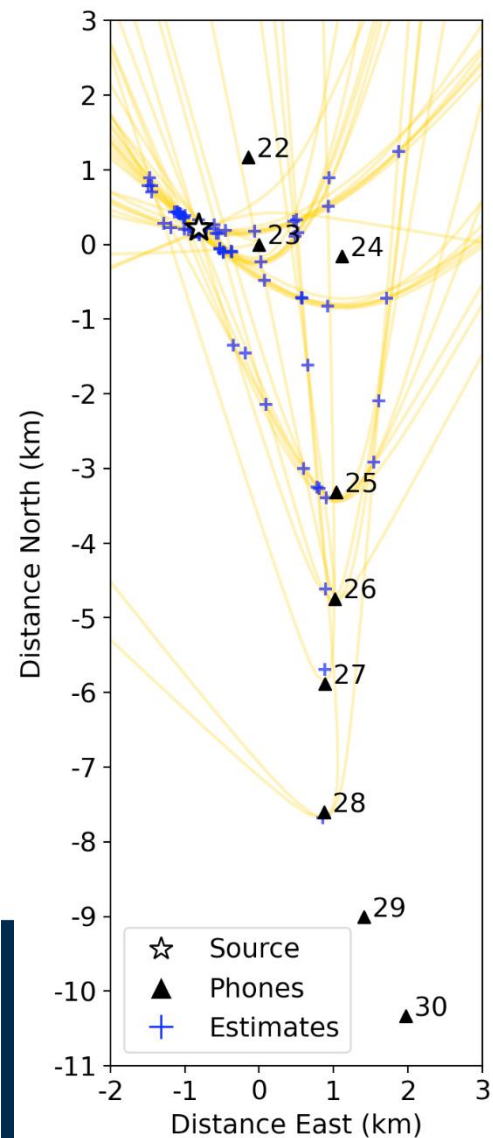
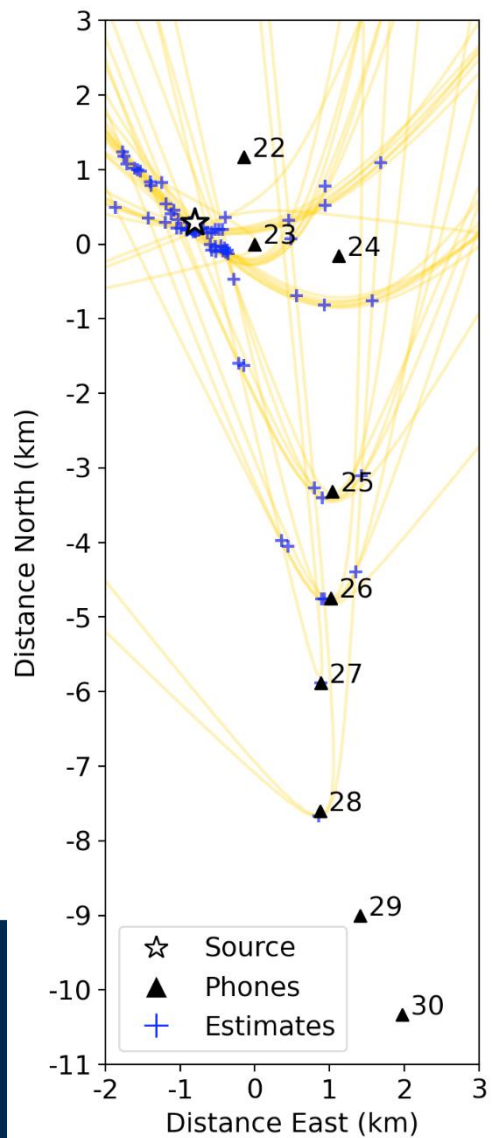
- Method of determining the location of a source
 - Utilizes the Time Difference of Arrival (TDoA)
 - Uses systems of hyperbolas between sensors
 - Minimum of 3 necessary for 2D multilateration
 - Chose point where hyperbolas overlap
- Calculate for each 3 sensor pairs
 - 9 smartphones = 84 combinations



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

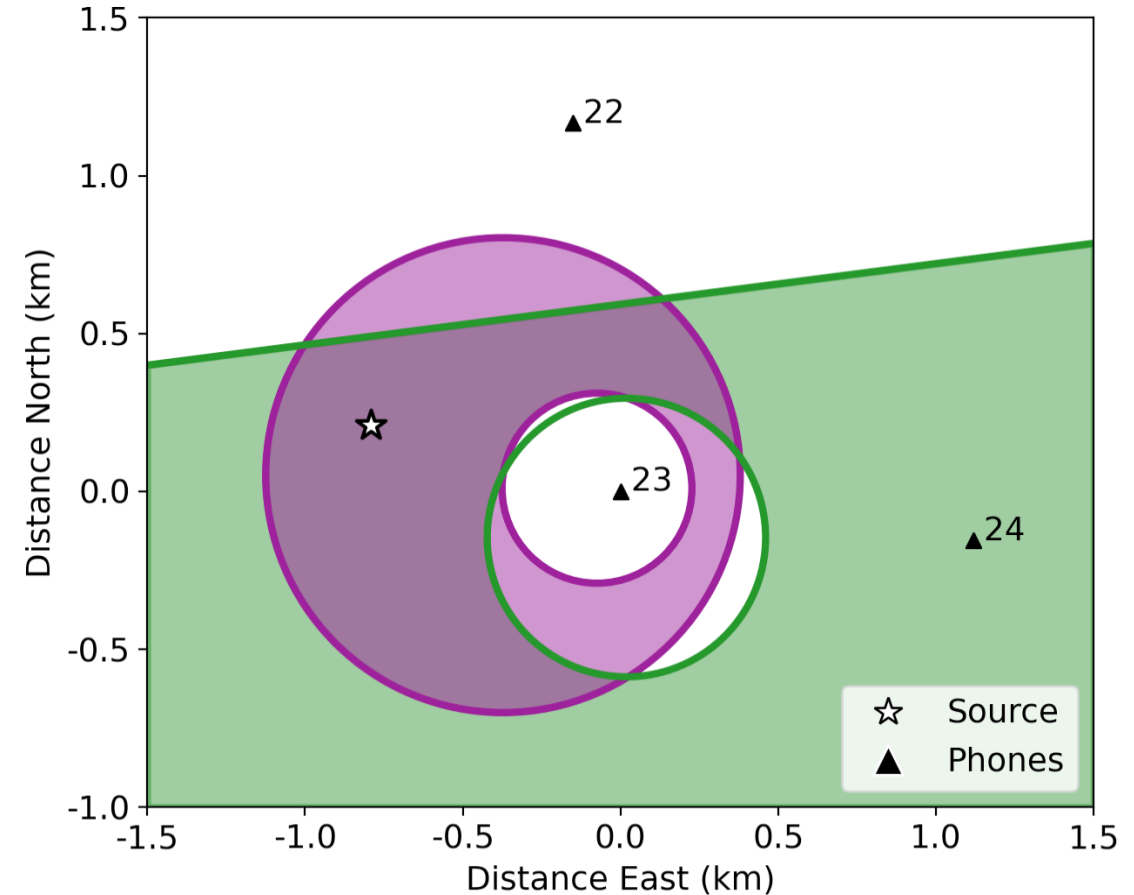


Multilateration Plots



» 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 23 / Phone 24
 - 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

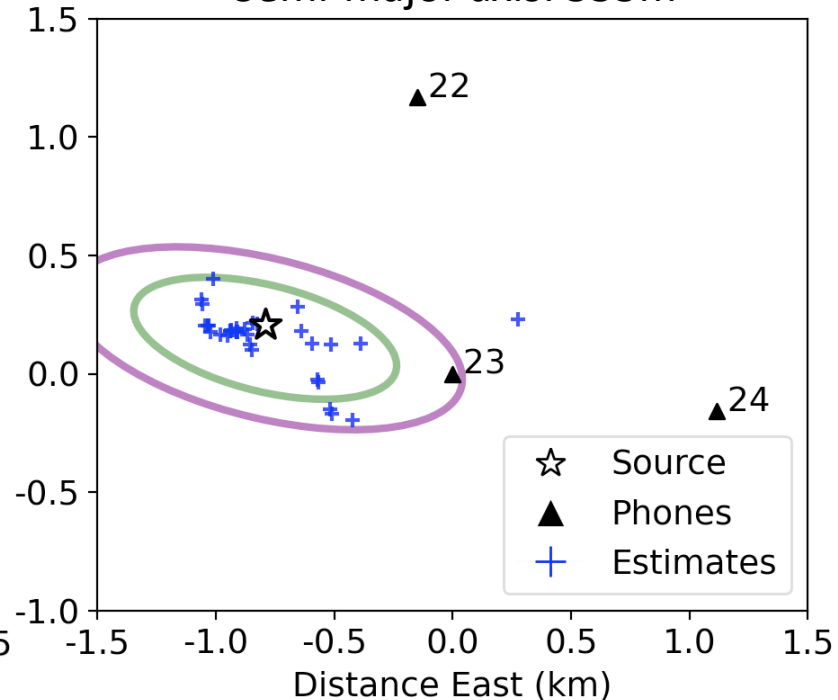
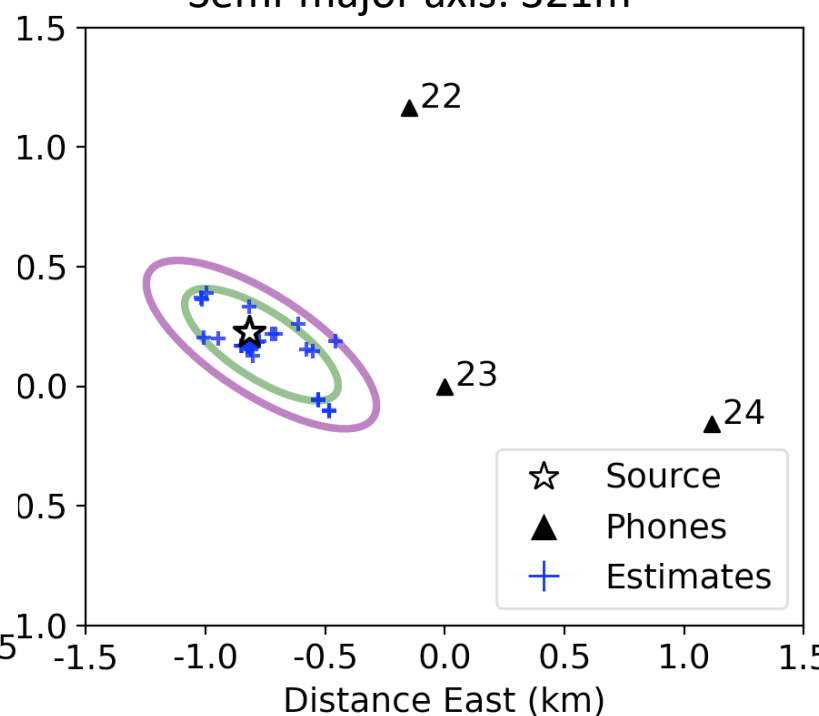
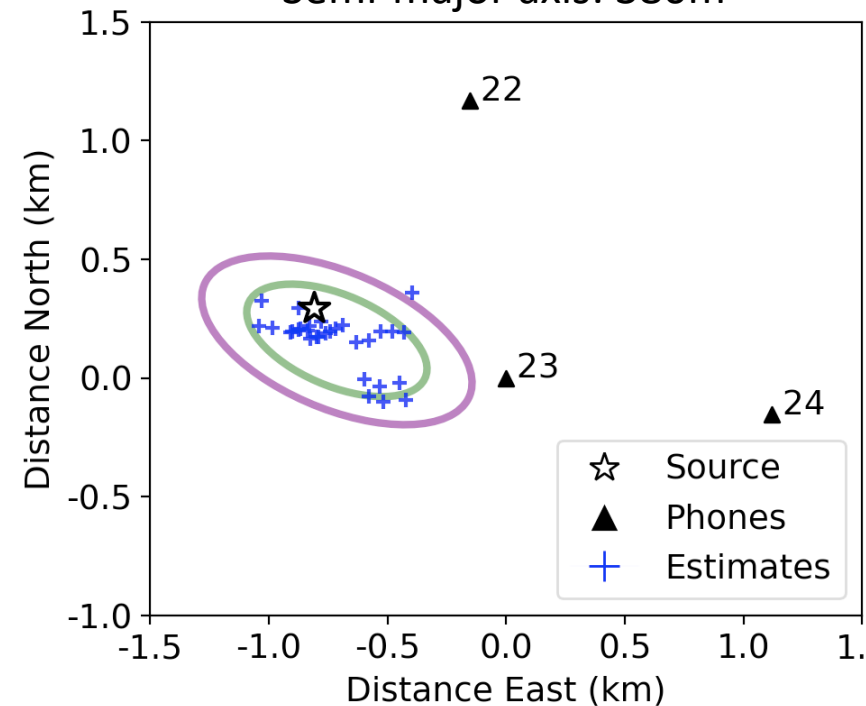


Final Estimates

Fuel Air Explosive
Semi-minor axis: 237m
Semi-major axis: 380m

3 detonations
Semi-minor axis: 235m
Semi-major axis: 321m

1 detonations
Semi-minor axis: 257m
Semi-major axis: 555m



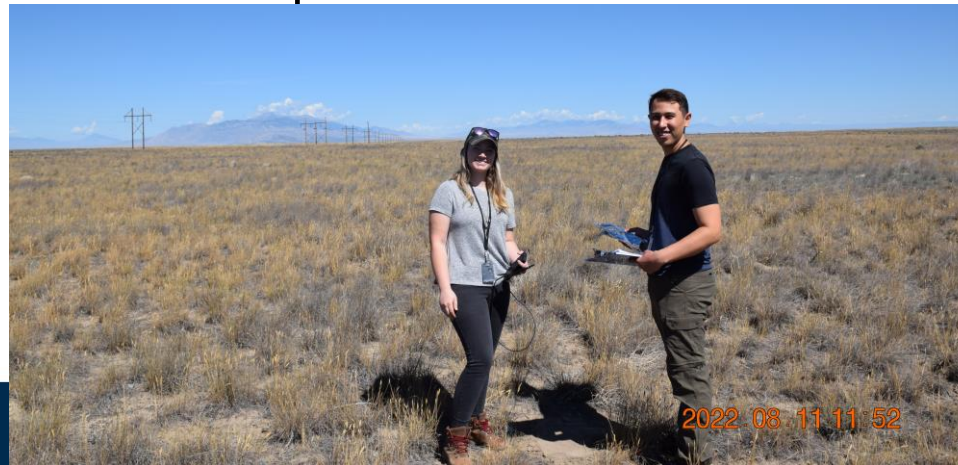
»» ETI Impact

- 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



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