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U.S. DEPARTMENT OF ENERGY

Radiological Search

A Long-standing Streaming Application

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Tysons Corner, VA

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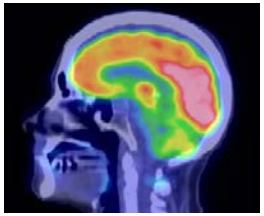
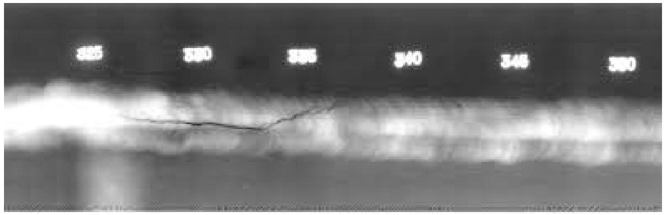
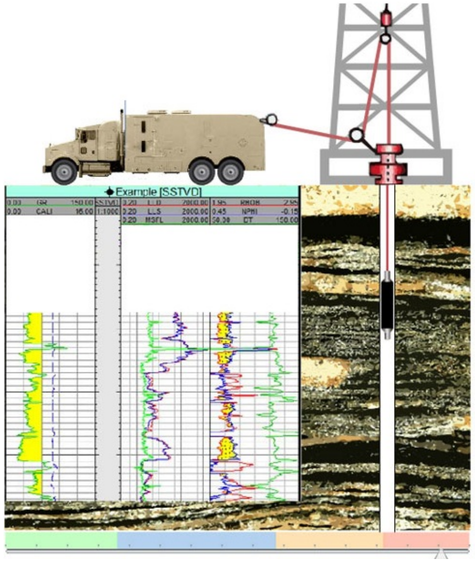
Applied Nuclear Physics

Radiological Search

- Radiological and Nuclear (R/N) material is used in a variety of industrial, medical, and defense applications.
  - Nuclear energy
  - Nuclear weapons
  - Nuclear medicine (radiotherapy, medical imaging)
  - Construction (weld inspection)
  - Oil exploration (well logging)

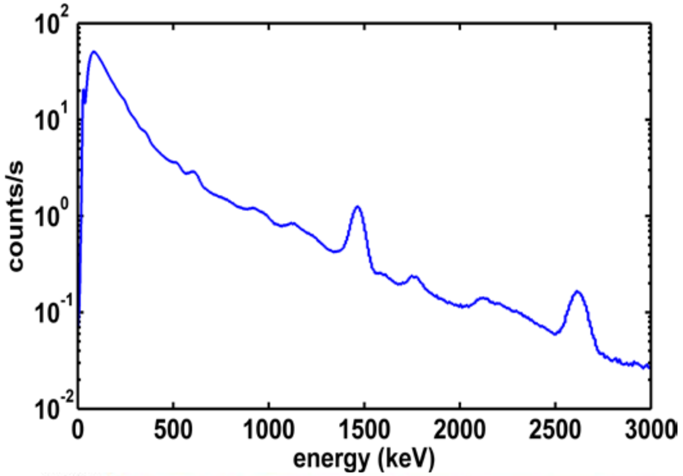
- Lost or stolen R/N material can be of great concern
  - ➔ R/N search important for recovering material.
- R/N search is complicated by the fact that **everything** is radioactive
  (even you)

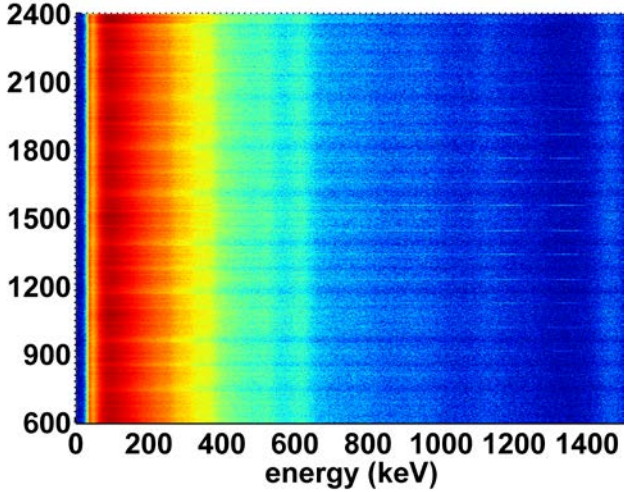



Detecting Radioactive Threats

- Radiation detectors can measure the energy and (with less fidelity) incident direction of γ rays and neutrons.





- Benign radioactivity can obscure threat signals.

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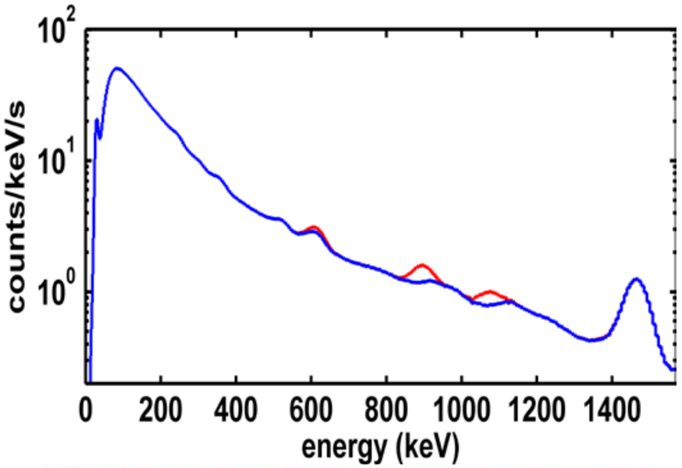

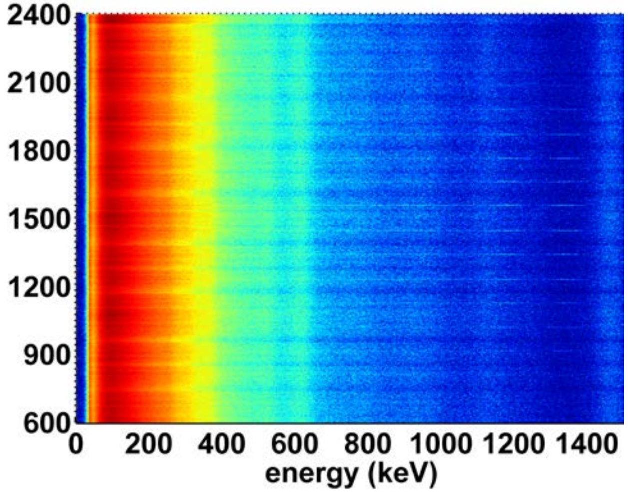

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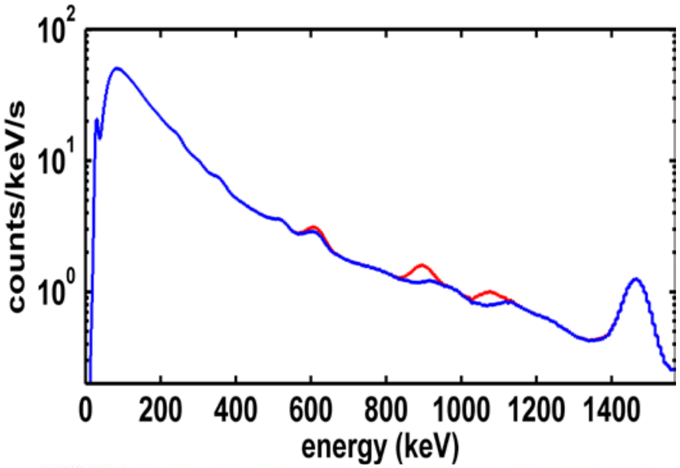
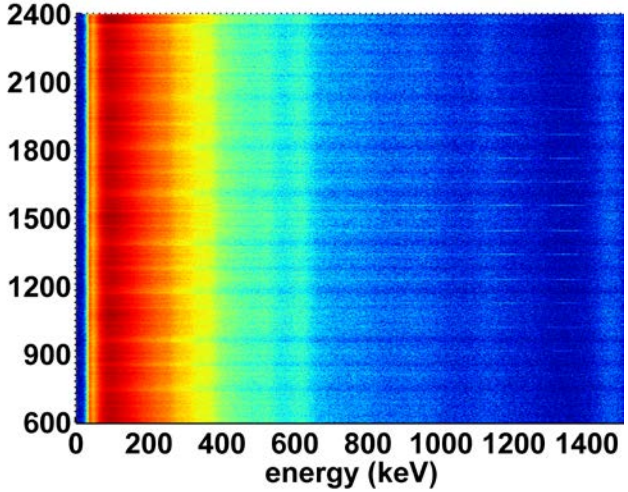
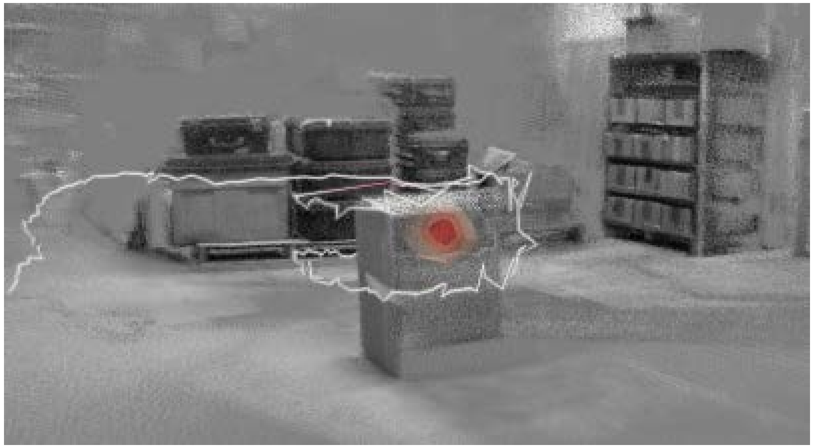




- Benign radioactivity can obscure threat signals.
- Algorithms have been developed to highlight spectral changes, or matches to threat templates, and localize an anomaly.



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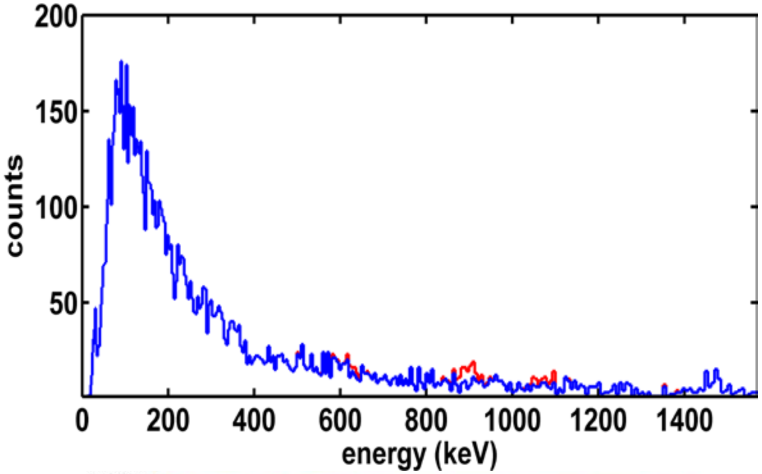
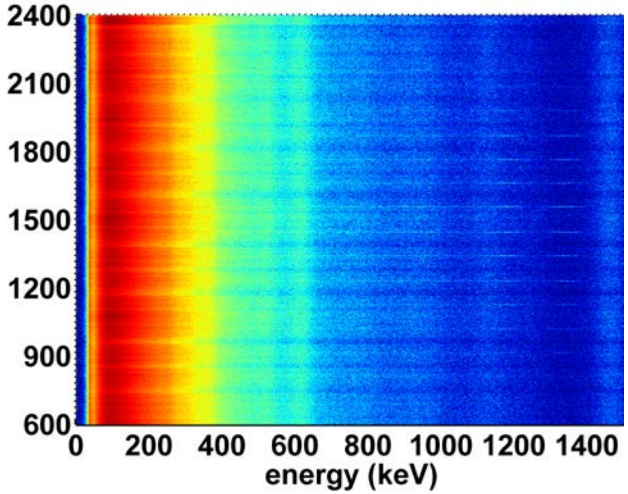
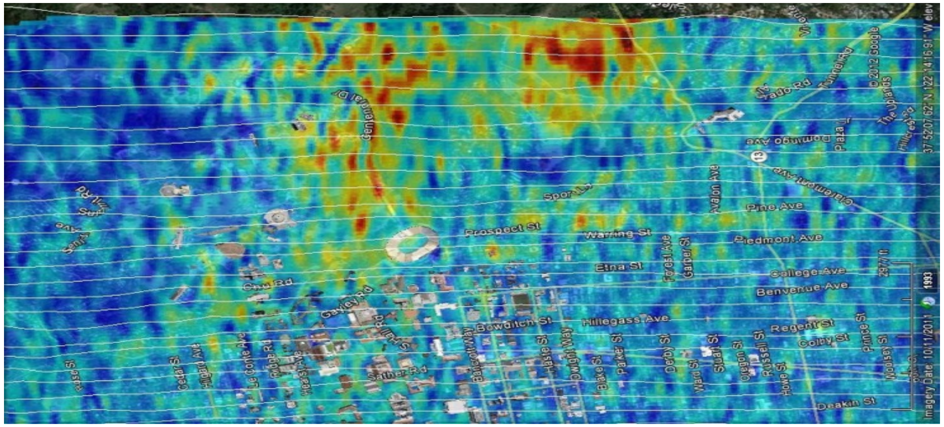




- Benign radioactivity can obscure threat signals.
- Algorithms have been developed to highlight spectral changes or matches to threat templates.
- Greatest challenges are low statistics and changing radiological environments.



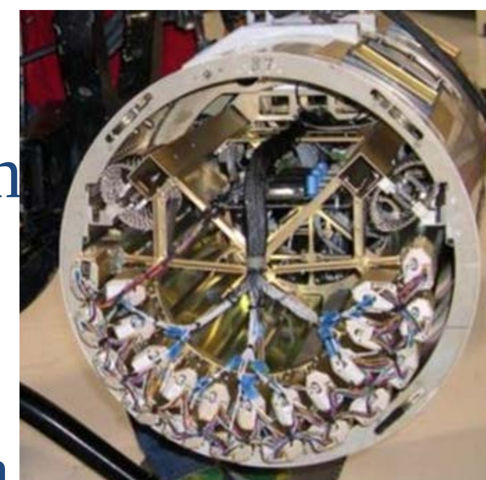
Outstanding Questions

- Can additional contextual information be used to improve radiological search performance?
  - We know the answer is ‘yes’. This is why radiation detection experts still outperform algorithms in most cases.
- Can algorithms be developed that leverage contextual information?
  - We also know the answer is ‘yes’, albeit only anecdotally.
- What contextual information is most valuable for improving search performance?
- How much impact can contextual information have on radiological search?

Airborne Radiological Enhanced-sensor System

ARES is a DNDO Advanced Technology Demonstration (ATD) with the goal to demonstrate improved ability to *detect, localize, and identify* static or moving R/N sources from an airborne platform.

- ARES uses:
  - Modern radiation sensors
    - 500GB/hr after online processing
  - Object tracking, INS stance and position
    - 7x HD Video Cameras – 2TB/hr
  - Terrain database
    - 1TB, interacts with positioning information



LBNL's ARES Role

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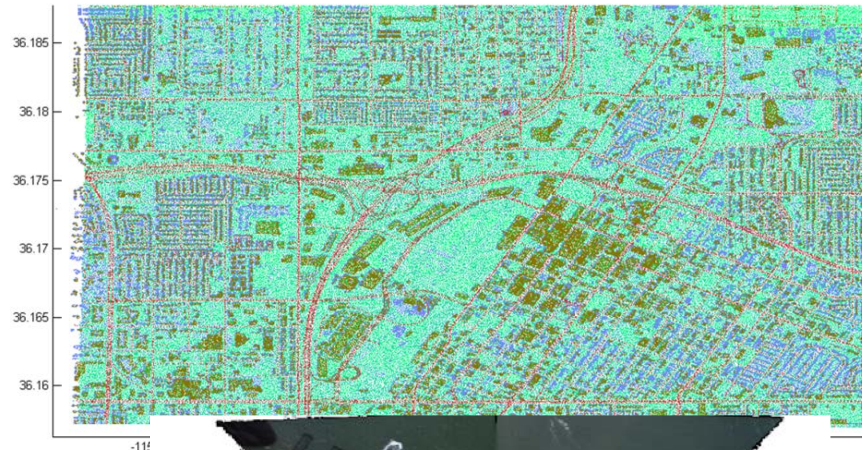
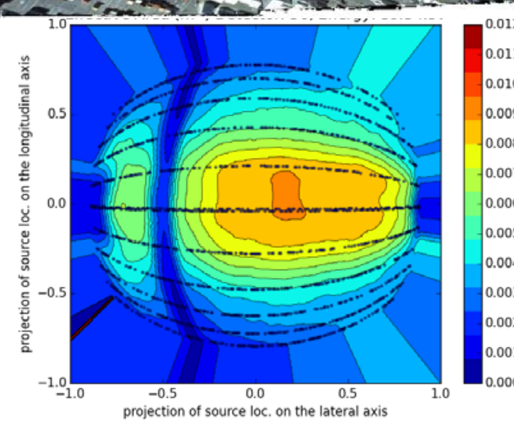
- Assess data quality
  - γ-ray detector system
  - contextual data
- Algorithm characterization through replay
  - Re-create streaming environment by providing measured and/or modified data to algorithms via API
- Assess and highlight
  - technological advances and
  - the potential of further performance improvements

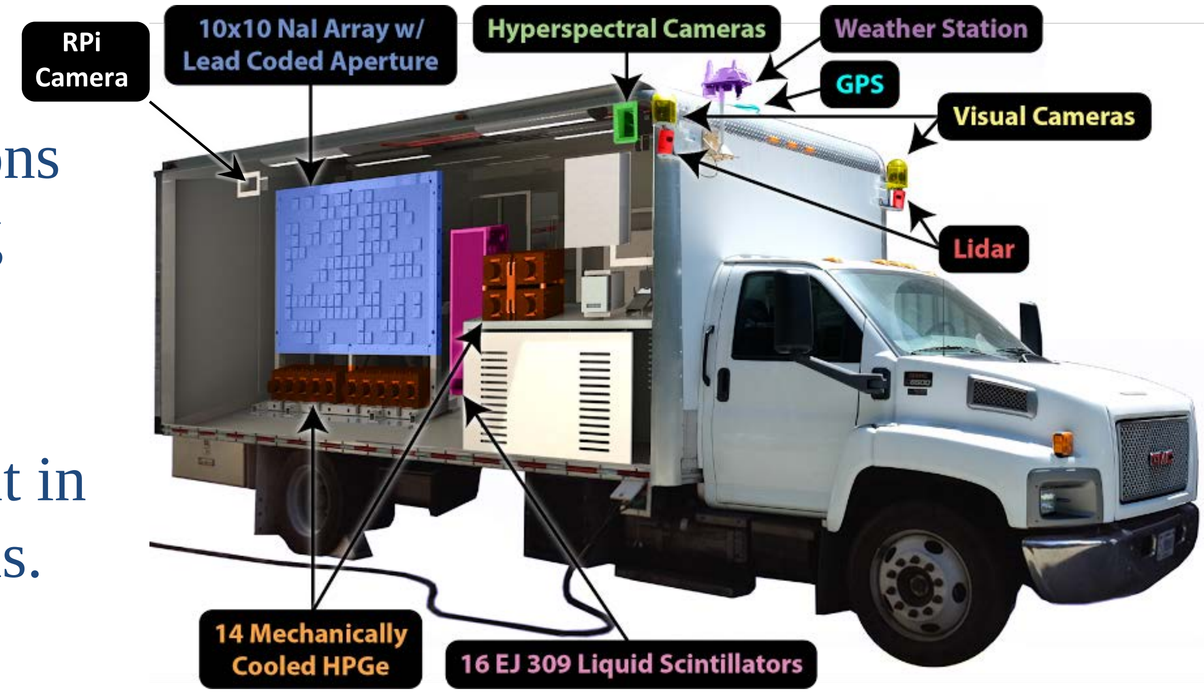
that resulted or could result from the ARES program.





RadMAP

- Mobile detector and contextual sensor system
  - Operated around SF Bay Area (>300 hrs) and Singapore (50 hrs)
  - Produces synchronous data at 0.5TB/hr
    - Writing to three synchronized servers
- Data being used (to date) only in post-processing
  - Testing algorithms
  - Providing realistic datasets for simulations and mission planning
  - Data can provide understanding of phenomena that result in background variations.



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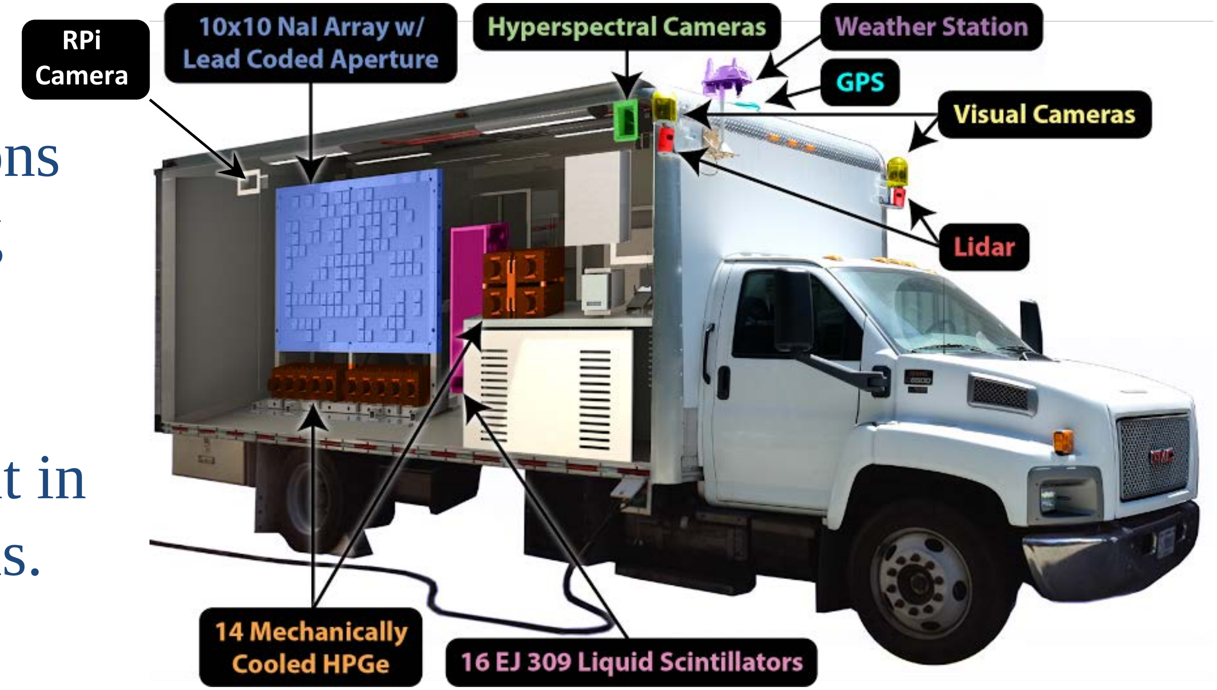
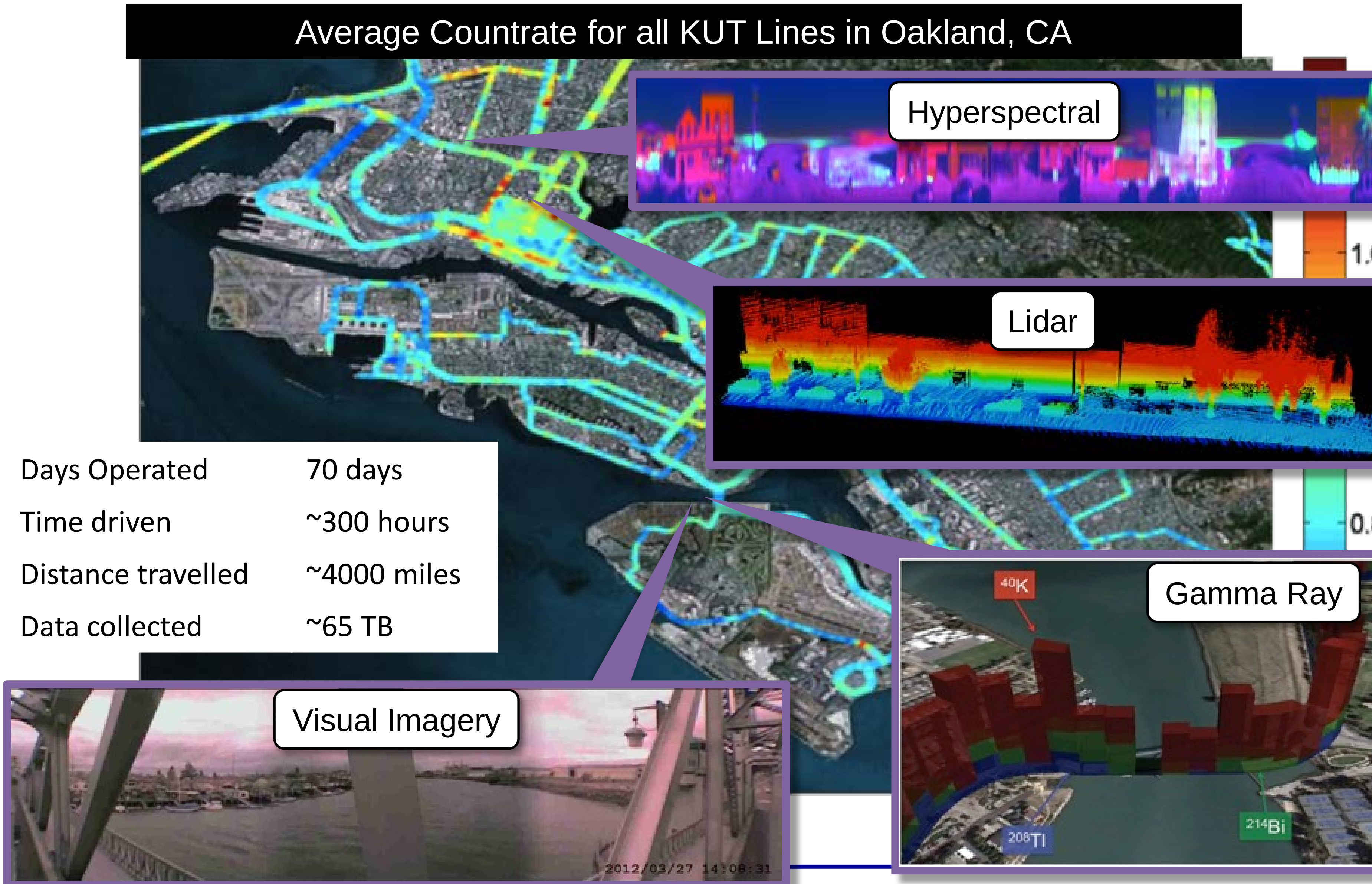
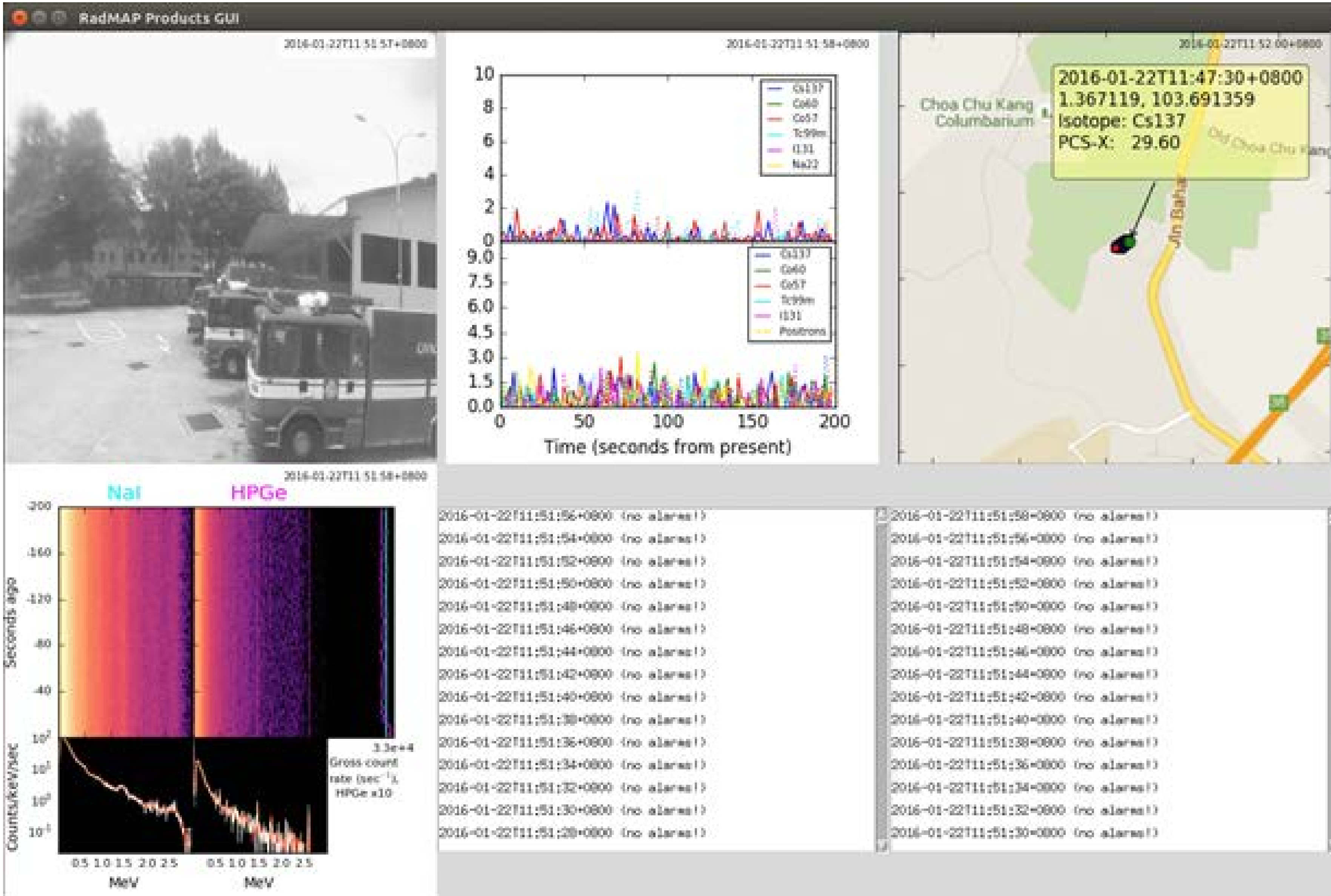


RadMAP Data Collection – SF Bay

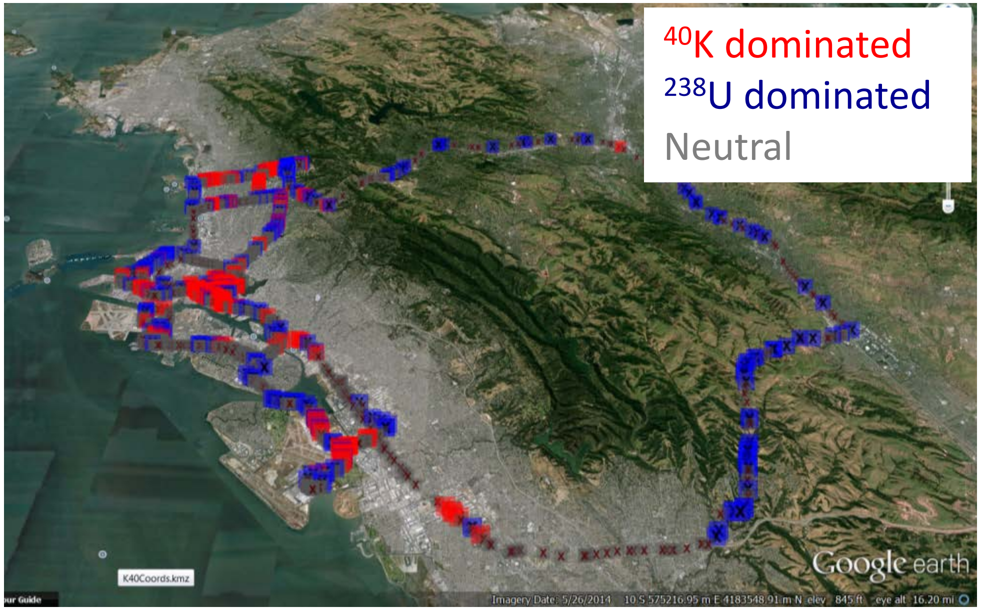


Days Operated	70 days
Time driven	~300 hours
Distance travelled	~4000 miles
Data collected	~65 TB

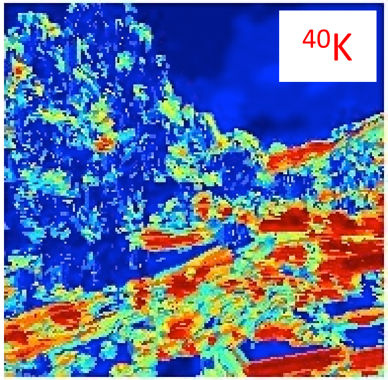
RadMAP Streaming



Machine Learning and RadMAP

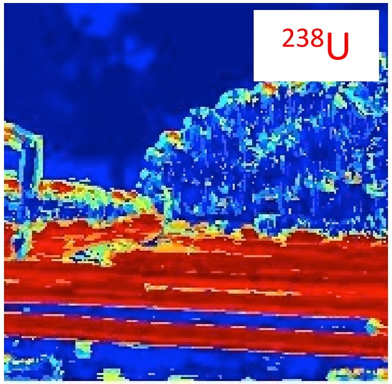


- Recent example where segmented visual imagery was used to train and test Support Vector Machine classifier to identify likely background characteristics.

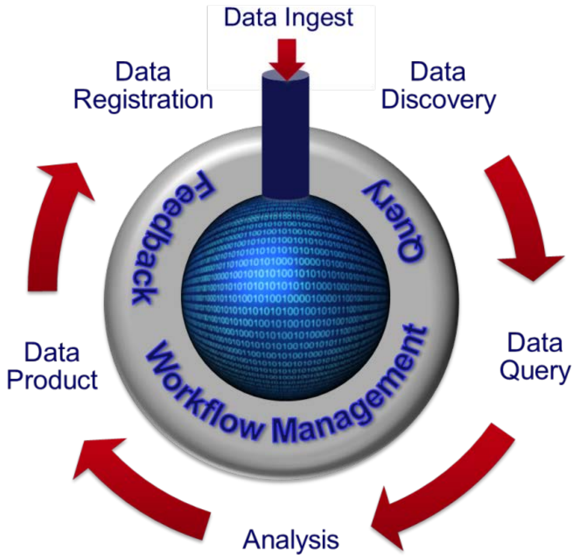


Significant performance improvements demonstrated using segmented images to inform environmental background model

Isotope	PCS	PCS-X
^{137}Cs	65 μCi	35 μCi
^{133}Ba	37 μCi	20 μCi
^{60}Co	25 μCi	17 μCi



Berkeley Data Cloud (BDC)

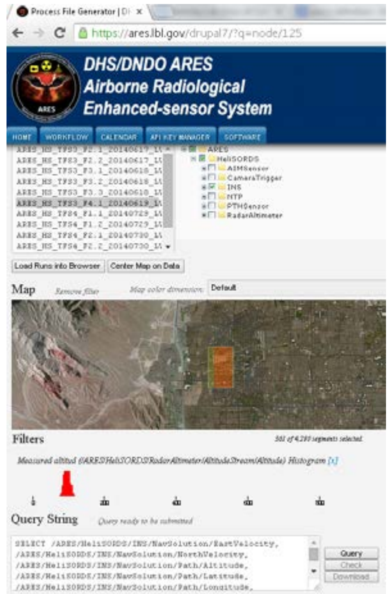


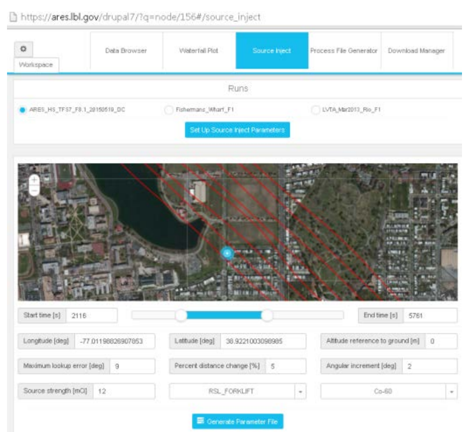
Web-based interface for visualization and data access:

- Data browsing, visualization, analyses
- Radiological source injection tool
- 'Waterfall' radiological data visualization tool

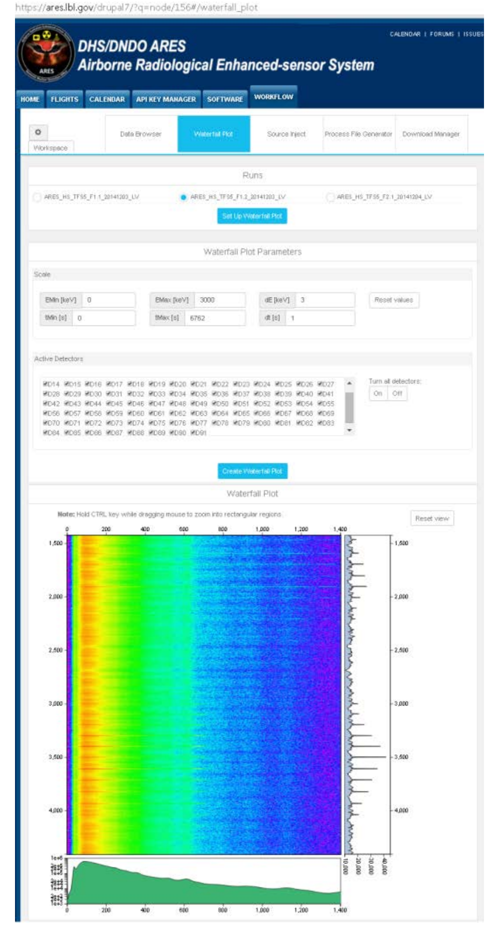
API interfaces provides data access for analyses

- C++, C#, Python, Java and Matlab
- Automated workflows





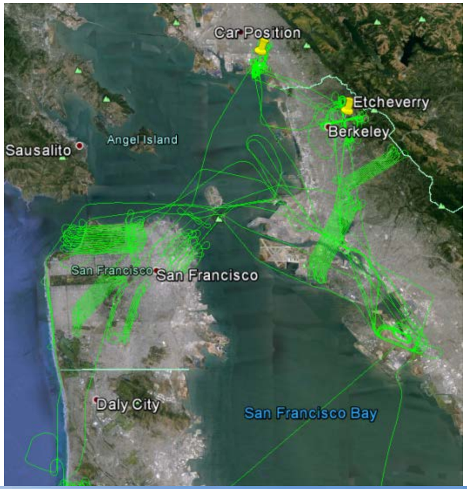
Web-based data visualization and retrieval

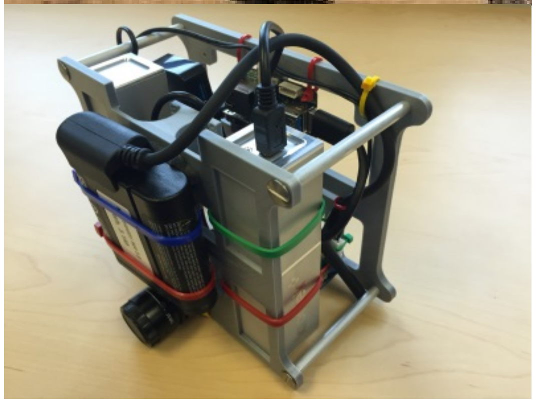


Manages ARES and RadMAP data and analysis products

Outlook

- Collecting, and storing streaming data at rates of 0.5-1TB/hr
- Developed means of managing and replaying large datasets
  - Demonstrating and quantifying value of different types of contextual data for search missions
  - Data is being made available online such that other researchers can build upon our findings
    - We don’t pretend to be experts in analyzing all the different contextual data types.
- Would like streaming data to enable improved steering, but must first demonstrate value in algorithmic steering.
- Smaller, cheaper platforms!





Thank you!!! Questions?

RadMAP: Mark Bandstra, Reynold Cooper, Ross Meyer Victor Negut, Joseph Curtis, Richard Zhang

ARES: Mark Bandstra, Tenzing Joshi, Jonathan Maltz, Andrew Haefner, Victor Negut, Sam Huh, Andreas Zoglauer,

BDC: Hamdy Elgammel, Krishna Muriki, Kai Song, Gunther Weber, Val Hendricks, Shreyas Cholia and Lavanya Ramakrishnan

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