



## A Long-standing Streaming Application Brian J. Quiter STREAM2016 March 22, 2016 Tysons Corner, VA



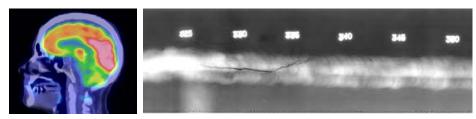
Some of this work has been supported by the US Department of Homeland Security, Domestic Nuclear Detection Office, under IAA HSHQDC-11-X-00380. This support does not constitute an express or implied endorsement on the part of the Government.



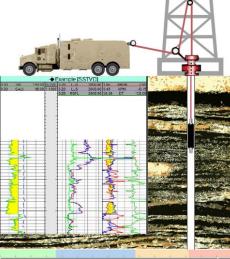
# **Radiological Search**

- Radiological and Nuclear (R/N) material is used in a variety of industrial, medical, and defense applications.
  - Nuclear energy
  - Nuclear weapons

- Construction (weld inspection)
- Oil exploration (well logging)
- Nuclear medicine (radiotherapy, medical imaging)
- 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)



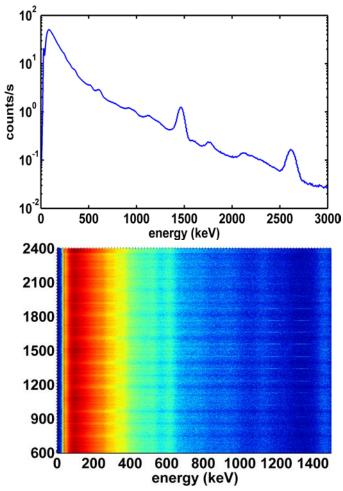








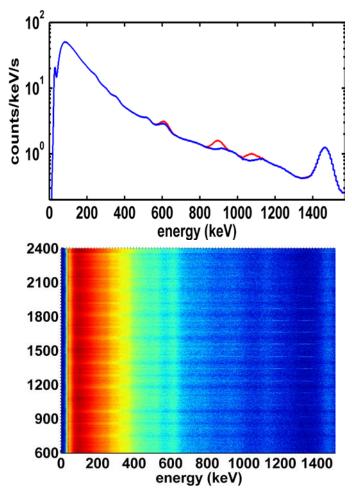
• Radiation detectors can measure the energy and (with less fidelity) incident direction of  $\gamma$  rays and neutrons.



• Benign radioactivity can obscure threat signals.



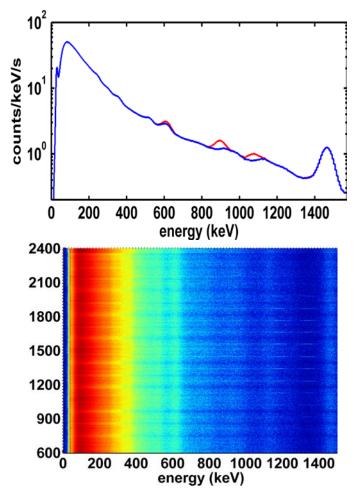
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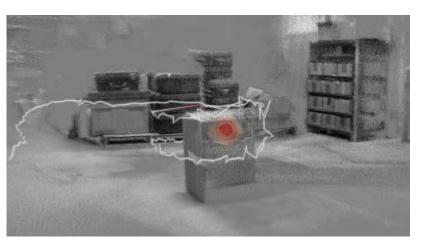
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- Algorithms have been developed to highlight spectral changes or matches to threat templates.



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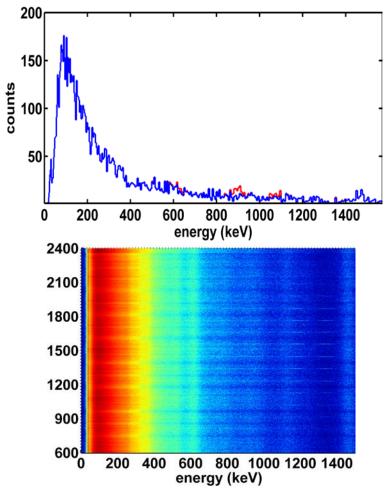


- Benign radioactivity can obscure threat signals.
- Algorithms have been developed to highlight spectral changes, or matches to threat templates, and localize an anomaly.

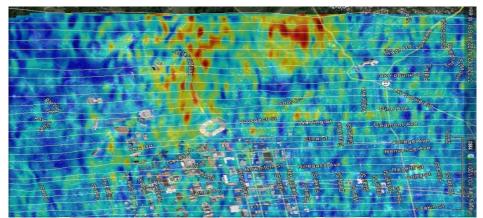




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- Algorithms have been developed to highlight spectral changes or matches to threat templates.
- Greatest challenges are low statistics and changing radiological environments.



## **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?



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

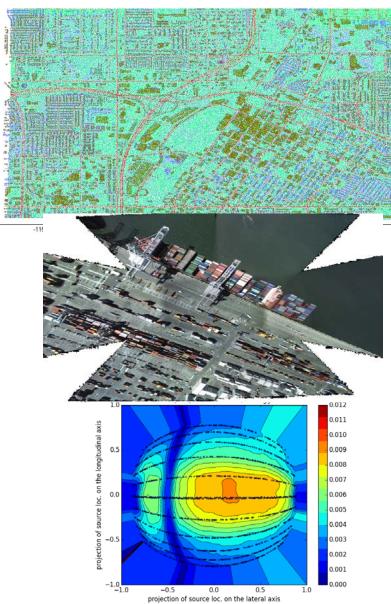




# LBNL's ARES Role



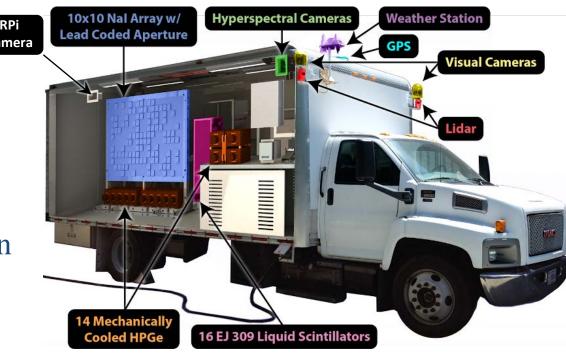
- Assess data quality
  - $-\gamma$ -ray detector system
  - contextual data
- Algorithm characterization through replay
  - Re-create streaming environment by providing measured and/or modified data to algorithms via API
- Assess and highlight
  - technological advances and
  - the potential of further performance improvements
  - that resulted or could result from the ARES program.



### RadMAP



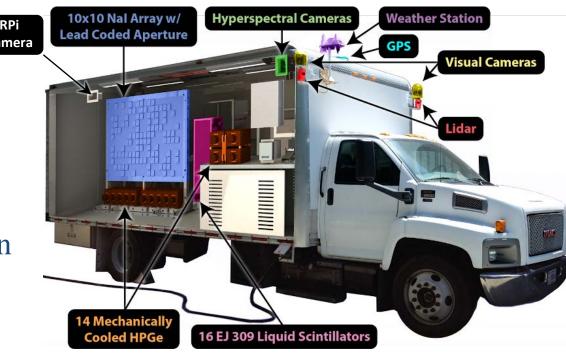
- Mobile detector and contextual sensor system
  - Operated around SF Bay Area (>300 hrs) and Singapore (50 hrs)
  - Produces synchronous data at 0.5TB/hr
    - Writing to three synchronized servers
- Data being used (to date) only in post-processing
  - Testing algorithms
  - Providing realistic
  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



### RadMAP

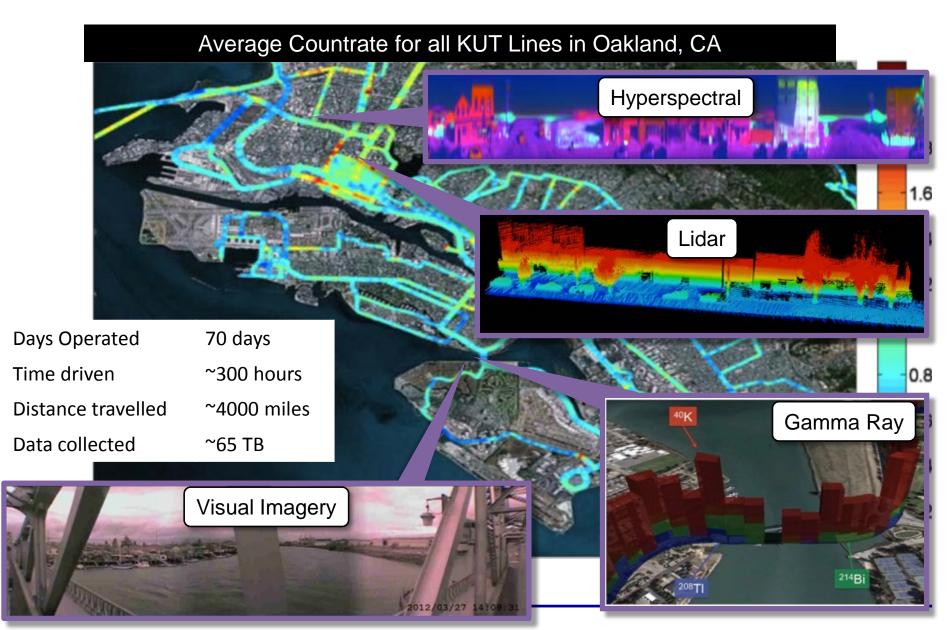


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### **RadMAP Data Collection – SF Bay**



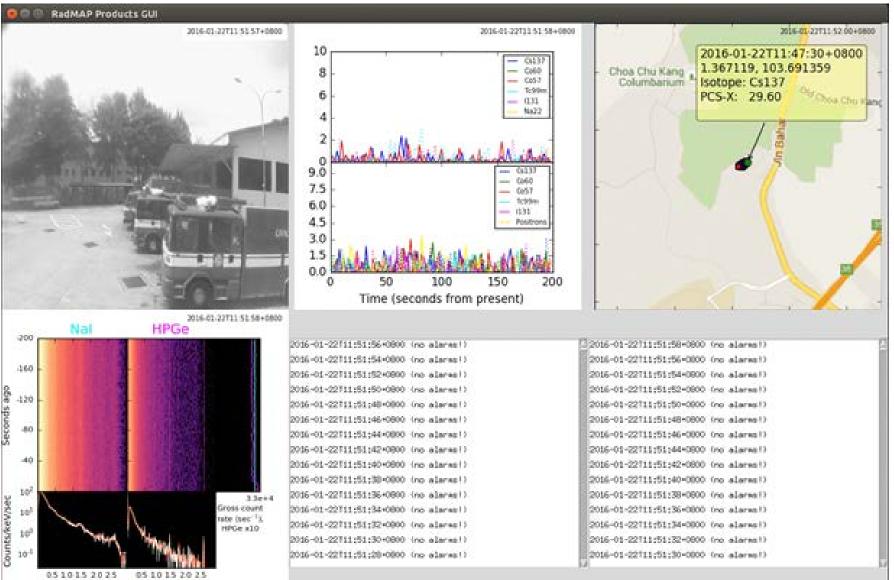


### **RadMAP Streaming**

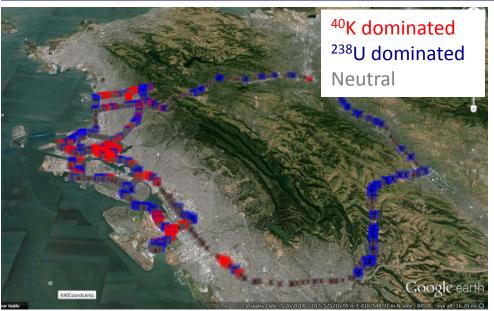
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### **Machine Learning and RadMAP**

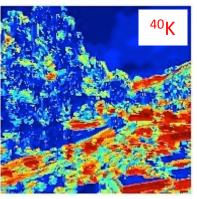


Significant performance improvements demonstrated using segmented images to inform environmental background model

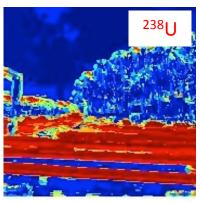
lsotope	PCS	PCS-X
<sup>137</sup> Cs	65 μCi	35 μCi
<sup>133</sup> Ba	37 μCi	20 μCi
<sup>60</sup> Co	25 μCi	17 μCi

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



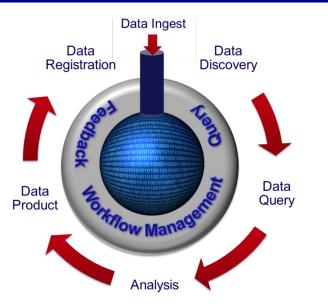






### **Berkeley Data Cloud (BDC)**





### Web-based interface for visualization and data access:

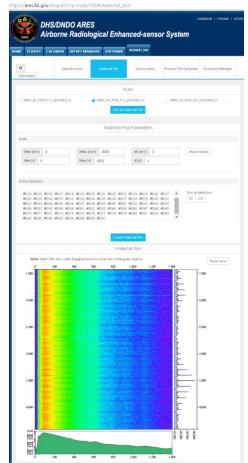
- Data browsing, visualization, analyses
- Radiological source injection tool
- 'Waterfall' radiological data visualization tool

## API interfaces provides data access for analyses

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

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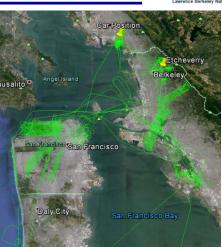
#### Web-based data visualization and retrieval



### 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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