Office of Counterterrorism and Counterproliferation
Nuclear Incident Policy and Cooperation

Workshop on the Implementation of the International Radiation Monitoring Information System

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IAEA IEC Incident and Emergency Centre

Networked radiation detection system for rapid tactical response

Sanjoy Mukhopadhyay, Richard J. Maurer, Mark Biery
Nevada National Security Site
US DOE/NNSA Nuclear Incident Policy and Cooperation (NIPC)

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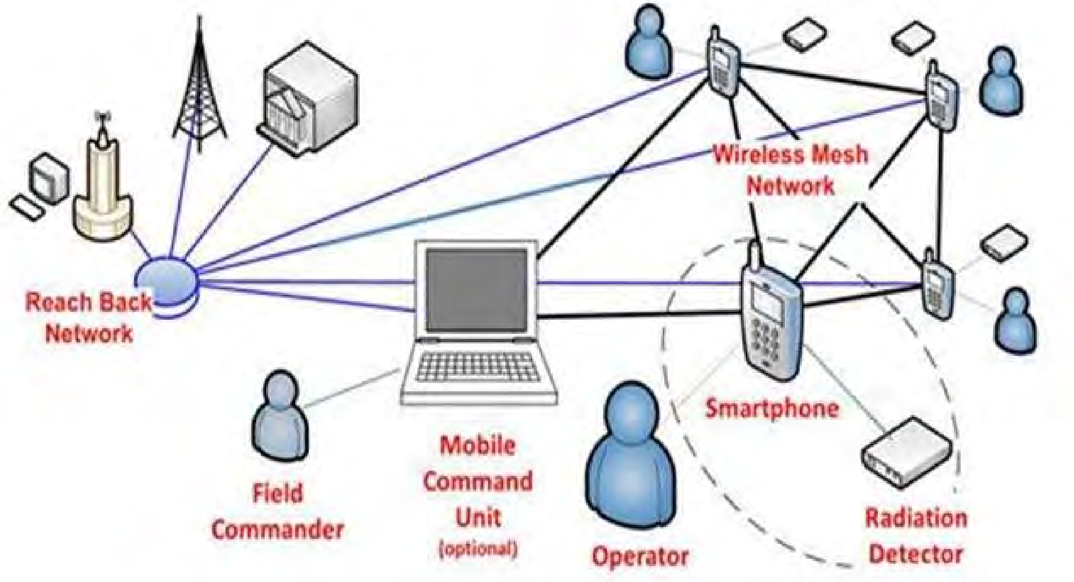
What is tactical response?

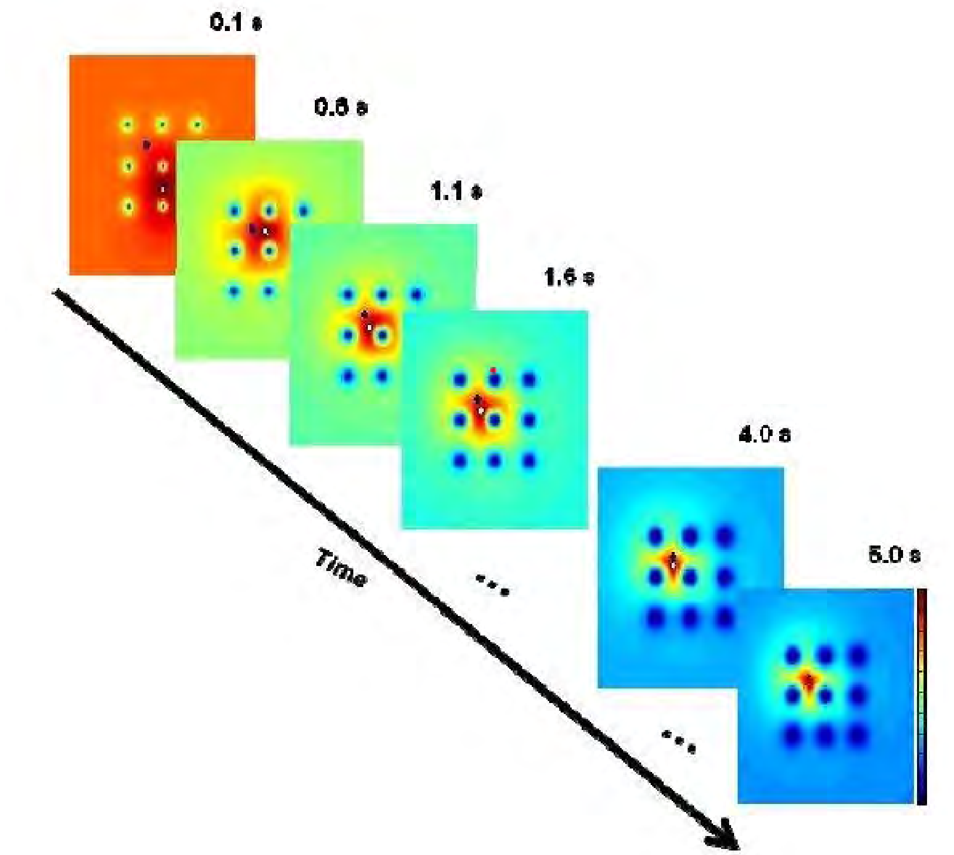
Tactical response covers

- Pre-event operations to detect, deter, defeat to save human lives, valuable infrastructures and properties from the adverse effect of radiological and nuclear release/detonation
- Search, surveillance, monitoring including unattended safeguard, in situ preliminary forensic leads
- Creation of Complete Operational Picture (COP) of the “scene” by providing relevant contextual meta data to shorten the time for any Decision Support Tool to decide GO/NO GO under severe time constraints
- Remote Sensing Laboratory (RSL) supports federal law enforcement mission partners in tactical responses to WMD threats (e.g., investigate, detect, interdict, diagnose, stabilize, and render safe threat items).



Why sensors need networking?

- Multiple sensors (often multimodal—radiation data, still images, video images) have the advantage of being able to predict with certainty the probability of finding a radiological source (called Heat Map).
- Decision support tools and processes that depend on tactical field data are constantly seeking more situational meta data from the field operations in real time.
- With increased numbers of deployed networkable individual sensors collecting multimodal data during search, surveillance, or safeguard/monitoring operations, there is constant demand for higher data exchange speed.
- A larger number of connected users demanding data and persistency of the network capability minimizing data loss and latency



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Outline of project

1. This project uses a small number of sensors that are integrated over the network, constantly exchanging data, creating a common operating picture, and using a probability distribution function, determining where the radiological HOT SPOT is.
2. Current detector systems do not exchange data among themselves; the Search Management Center is more of a reporting, adjudicating, and accounting platform. It does not “lead” the search process.
3. The proposed network system directs itself to the source of radiation. It actively finds the source. Current system depends on CONOPs (thoroughness of search pattern, grids, or prior intelligence) to find a source.
4. We have worked at incorporating sub-second GPS and data acquisition times, which directly improves the quality of collected data particularly in aerial measurements.
5. By using an ad hoc mesh networking system, we have cut down the network latency time (data do not have to go through any central or deployed servers).

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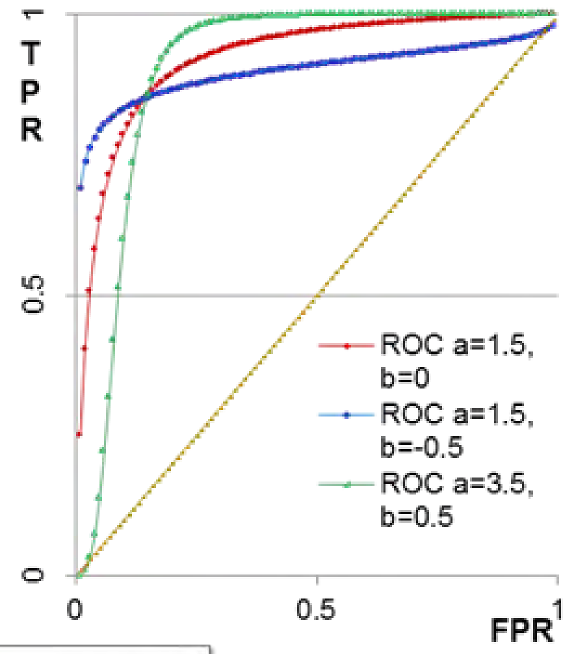
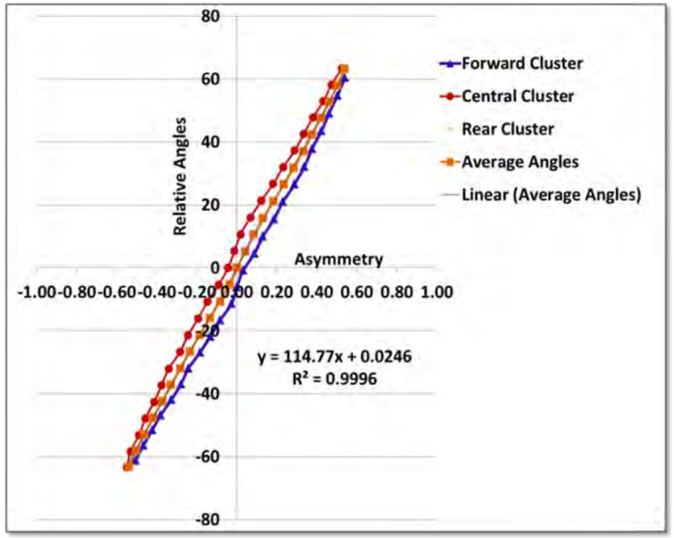
Technical elements of the scope

1. Fast, accurate response, hence a low false alarm rate
2. False alarm rate is dependent on spectral resolution when identifying isotopes; FAR ~R(FWHM)$^{3.54}$
3. Faster response time from the equipment—faster electronics, reduction of latency, faster scintillator
4. The sharper ROC (Receiver Operating Characteristics) the better. An ROC plot should look like as shown by the green curve.
5. Use of multiple verifiable confirmation sources
6. Rapid identification algorithm
7. Possible multiple search algorithms running in parallel to handle the background terrestrial radiation
8. Eliminating real but benign source alarms (NORM, medical isotopes, TENORM, etc.)
9. Angular sensitivity





Integrated system performance characteristics

- Sensors work at a faster rate of 0.5 s.
- System provides alerts, location, and trajectory of any nuclear or radiological material to each node and communications unit in the network.
- System automatically maps radiation in the operational area, sharing with other network nodes, and continuously keeping track of background profiles.
- Sensors operate completely autonomously and are suitable for first responders (police, firefighters, coast guard, military, and security personnel).
- System provides complete situational awareness for the entire network.
- System analyzes networked data independently for greater sensitivity and robustness.

Communication infrastructure

The mobile vehicle maintains its own ad hoc mesh networking with other deployed vehicles. A cradle point using three (AT&T, Verizon, and Sprint) air cards provides seamless cell-net service for data telemetry and networking.

The data communication design consists of portable spectroscopic radiation detectors designed to improve the detection, localization, tracking, and identification of potential radiological threats.

The system design is targeted to situations where it is not feasible to direct all traffic through portal radiation detection systems, e.g., large events, search team objectives.

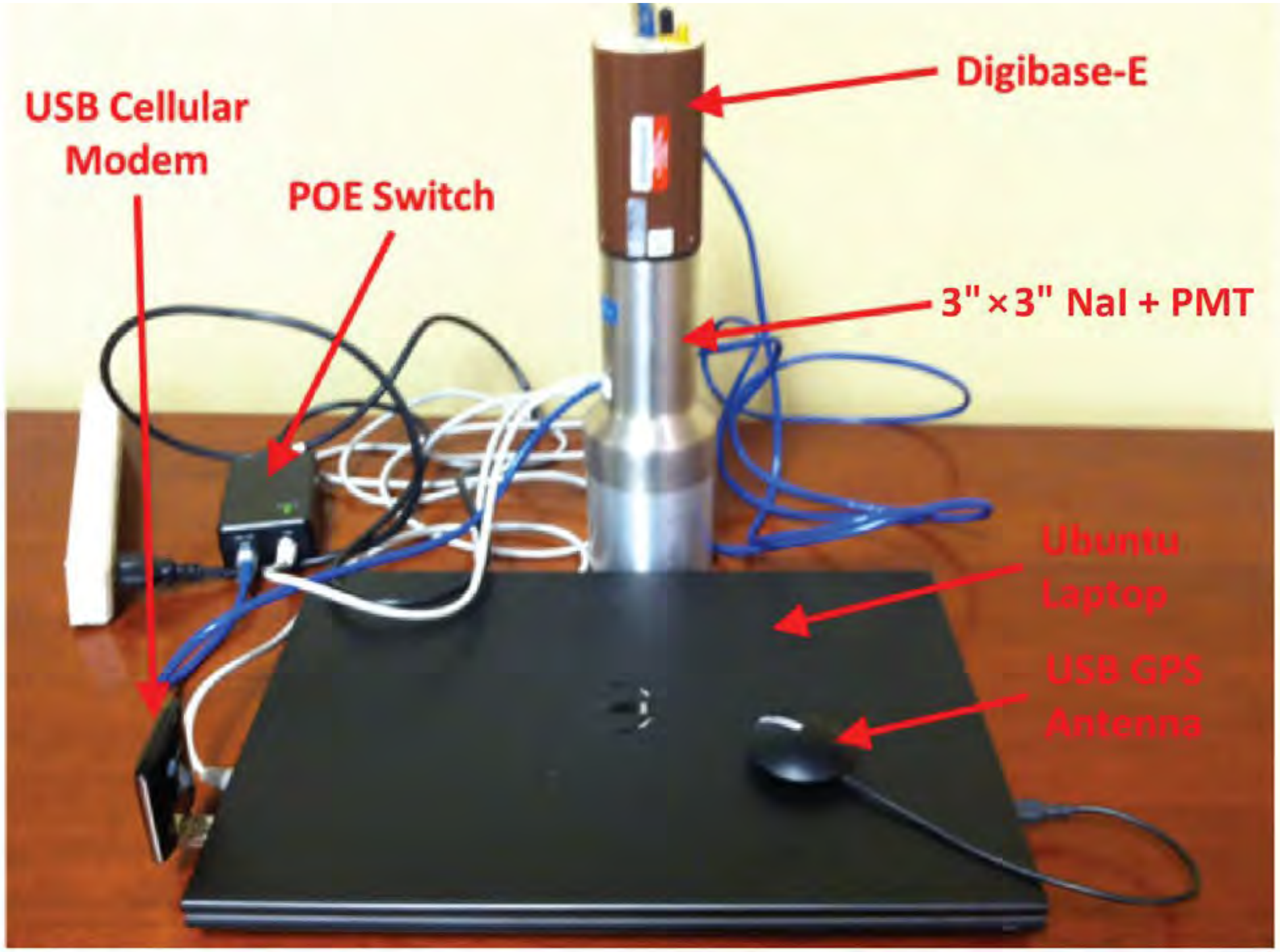
The fully customizable system may consist of any number of portable and/or fixed detectors.

The capability to network individual portable detectors and fuse their data using advanced algorithms and COTS hardware significantly increases their performance in a variety of NORM backgrounds.

System parameters

- Defined the detection requirement (minimum detectable activity for SNM should be sub-kilo materials detected at 12 m in 3 s). Made use of MCNPX-based Rad-Detect software package developed at RSL.
- Defined the parameter metrics for data fusion, display, and visualization requirement using legacy and recent data residing in the cloud for change detection purposes.
- Determined the sensor set optimum for the mission has spares and substitutes to be carried in the deployed support. Defined the electronics required for fast acquisition: use cyclic 4 elements FIFO buffers for microchannel analyzer data for each cluster (3 s in each buffer so that a sample local background reference spectrum is always available for comparison).

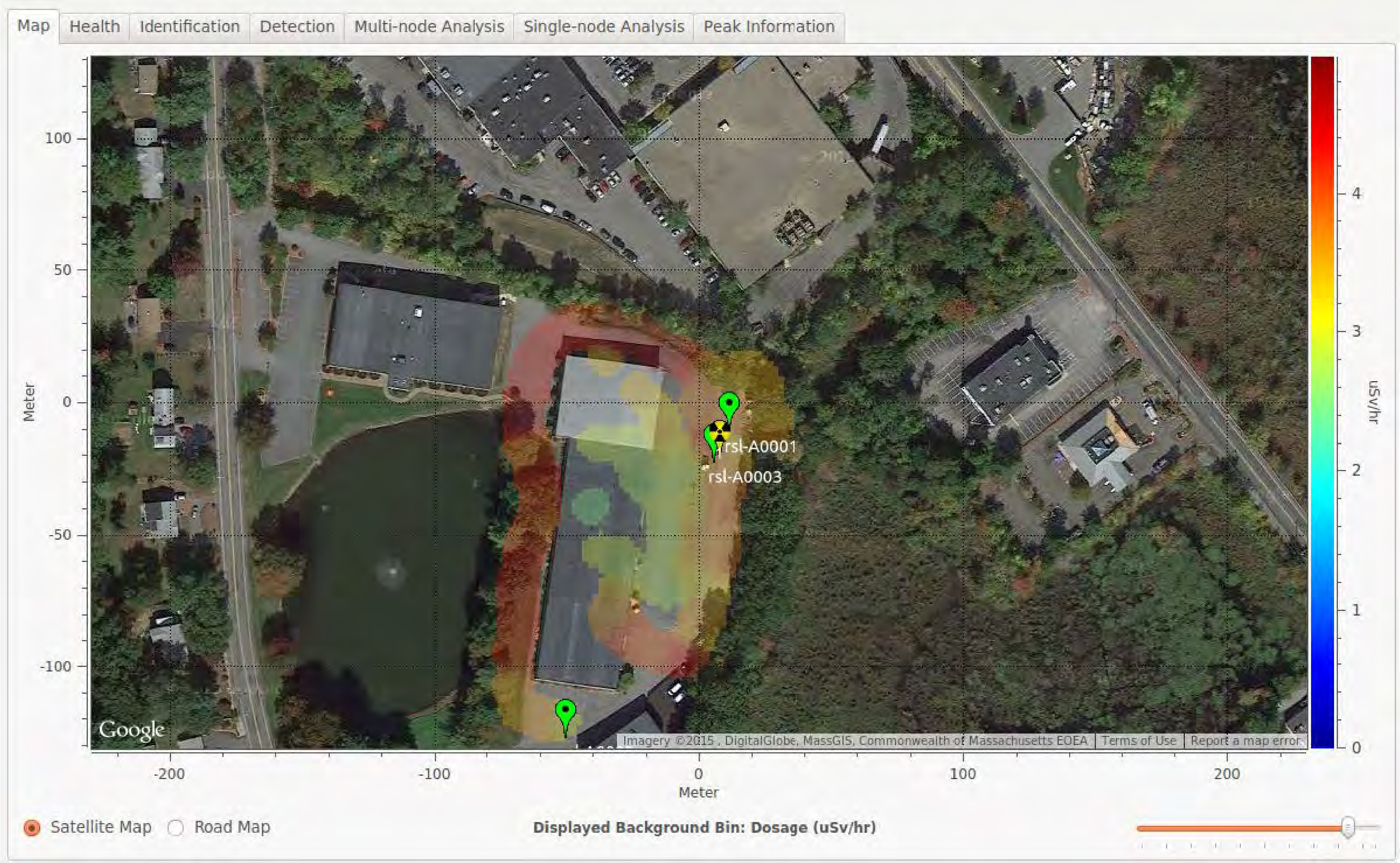
Prototyped hardware



System Component Details

- Ubuntu 14.04 laptop running on a battery
- Cellular USB device for network connectivity
- GPS USB device to provide positional information
- 3" × 3" NaI:Tl scintillator crystal with integrated 2" PMT
- DigiBASE-E base readout electronics (LAN cable plugged into POE switch)
- POE switch (LAN cable from laptop to POE switch)
- DC/AC converter plugged into vehicle, supplying AC power for the POE switch. Note that power for this test was supplied from a vehicle battery. As prototypes are assembled, a dedicated battery will provide power to the POE switch.

Background map with three mobile detectors



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Confidence level of detecting ^{137}Cs as a function of time

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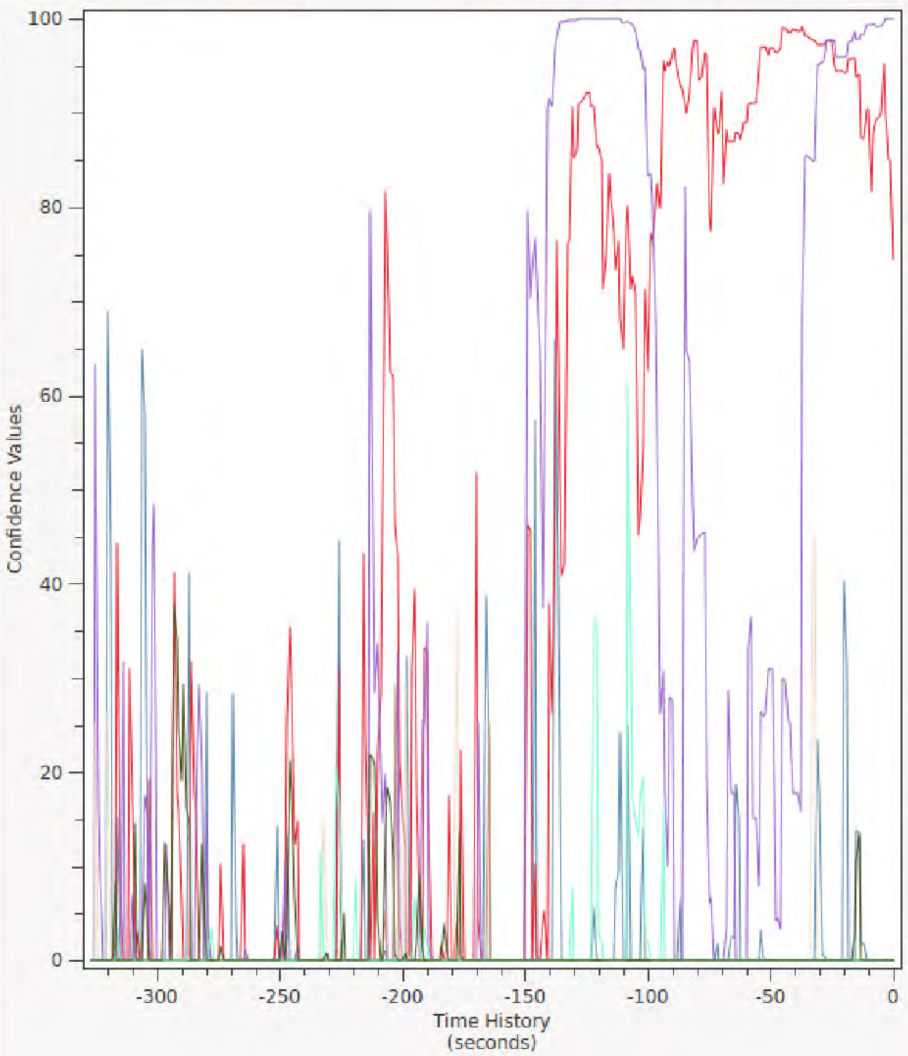
Map | Health | Identification | Detection | Multi-node Analysis | Single-node Analysis | Peak Information



	Isotope	Confidence %
14	235U	0.0
15	201Tl	0.0
16	235U_67Ga	0.0
17	57Co_239Pu_99Tc_235U	0.0
18	201Tl_67Ga_235U	0.0
19	NORM_C1	0.0
20	226Ra_67Ga_133Ba	0.0
21	226Ra_133Ba_131I	0.0
22	239Pu 1	0.0
23	NORM_C2	0.0
24	18F_22Na	0.0
25	232U_226Ra	74.4
26	137Cs	100.0
27	NORM_C3	0.0
28	238U	0.0
29	NORM_C4	0.0
30	60Co_22Na	0.0
31	NORM_40K	0.0
32	NORM_C5	0.0
33	232Tl_NORM	0.0

☐ Show Alarming Detections Only

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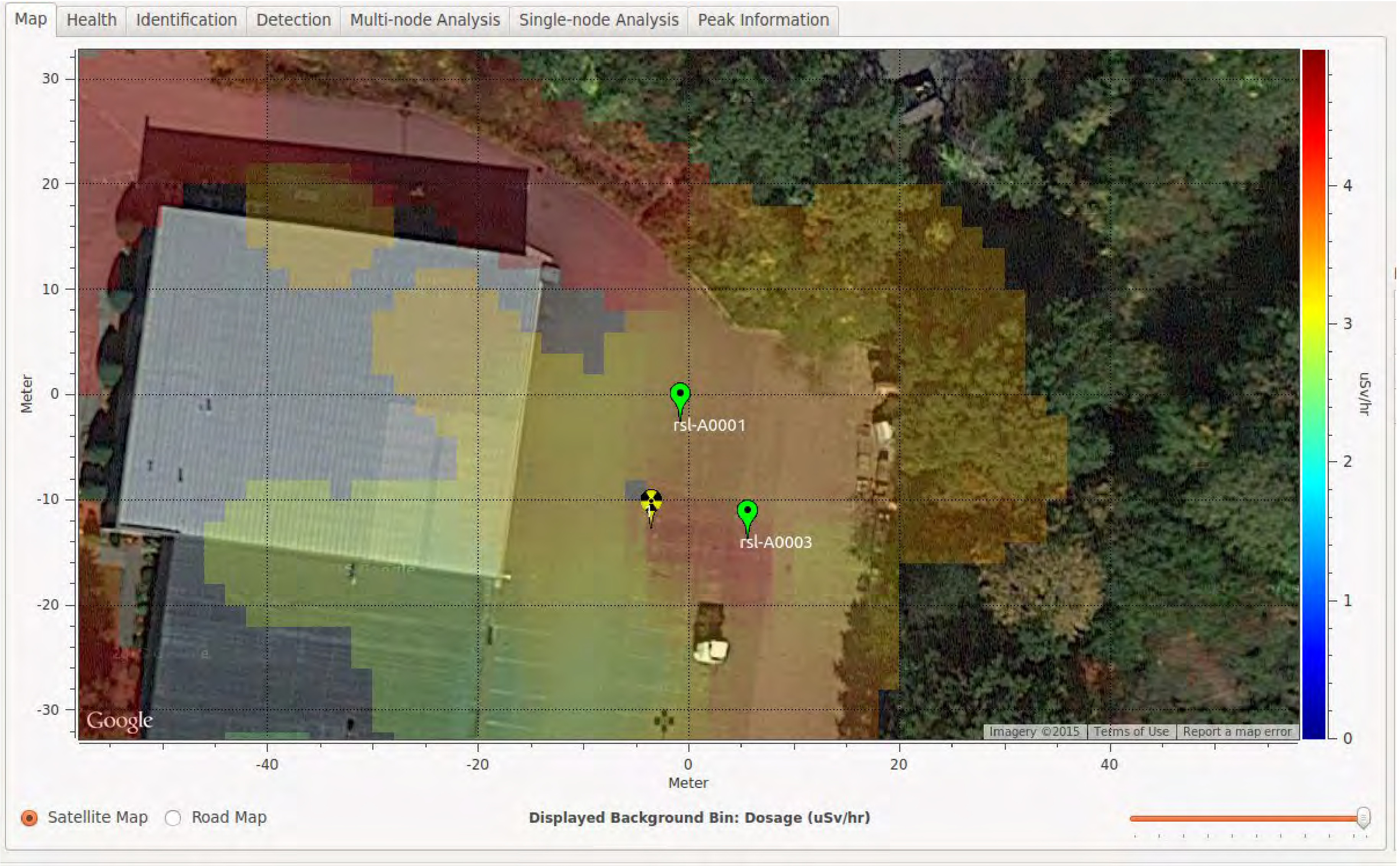
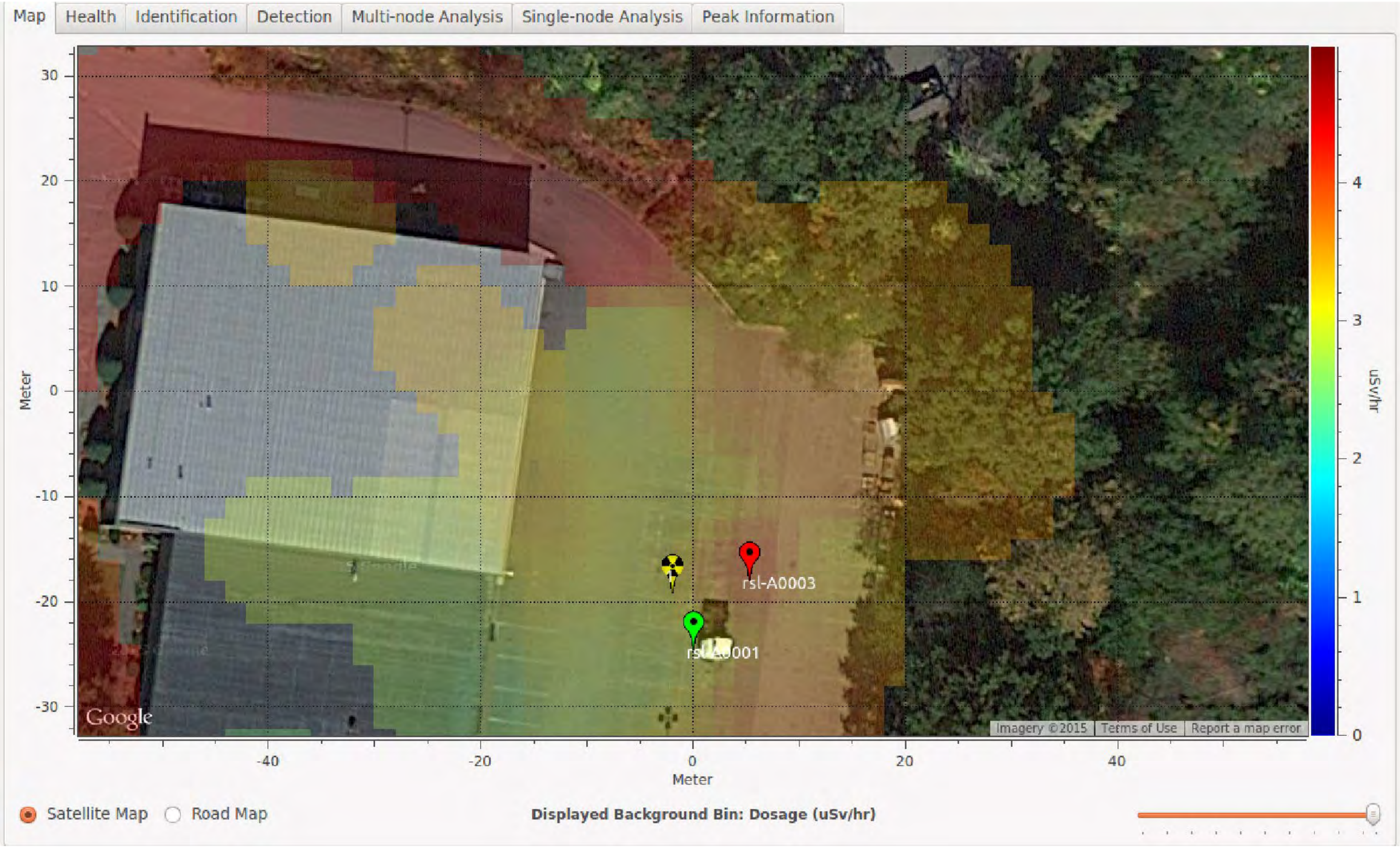
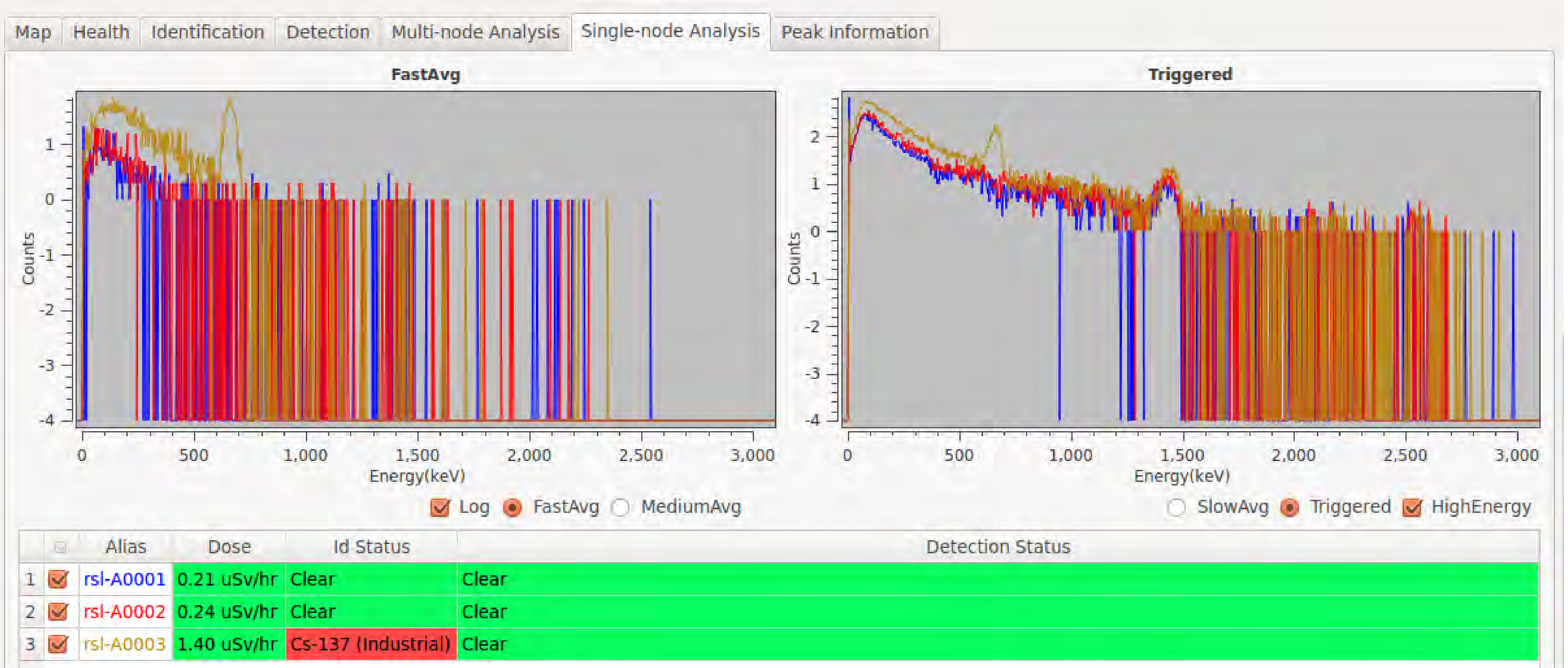
Location estimate when the source is first detected



Identification of the source as ^{137}Cs



Spectral data after identification

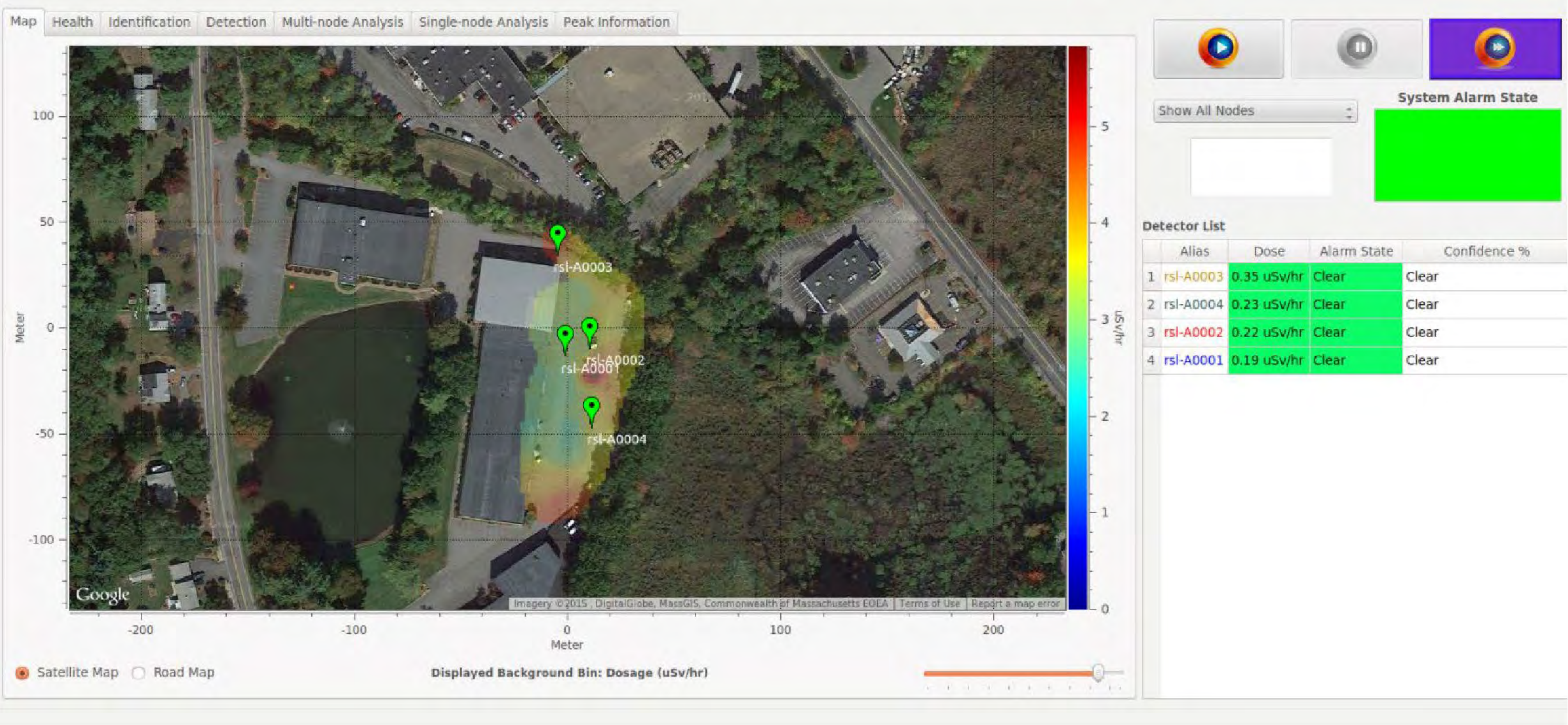


Spectra when the identification occurs. Two time buffers are displayed:

(1) the fast time buffer, which is approximately 4 seconds of data, and

(2) the triggered time buffer, which starts after a detection occurs.

Background map just before ^{60}Co detection (with four sensors)



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Background map with ^{60}Co energy bin – lot cleaner as expected

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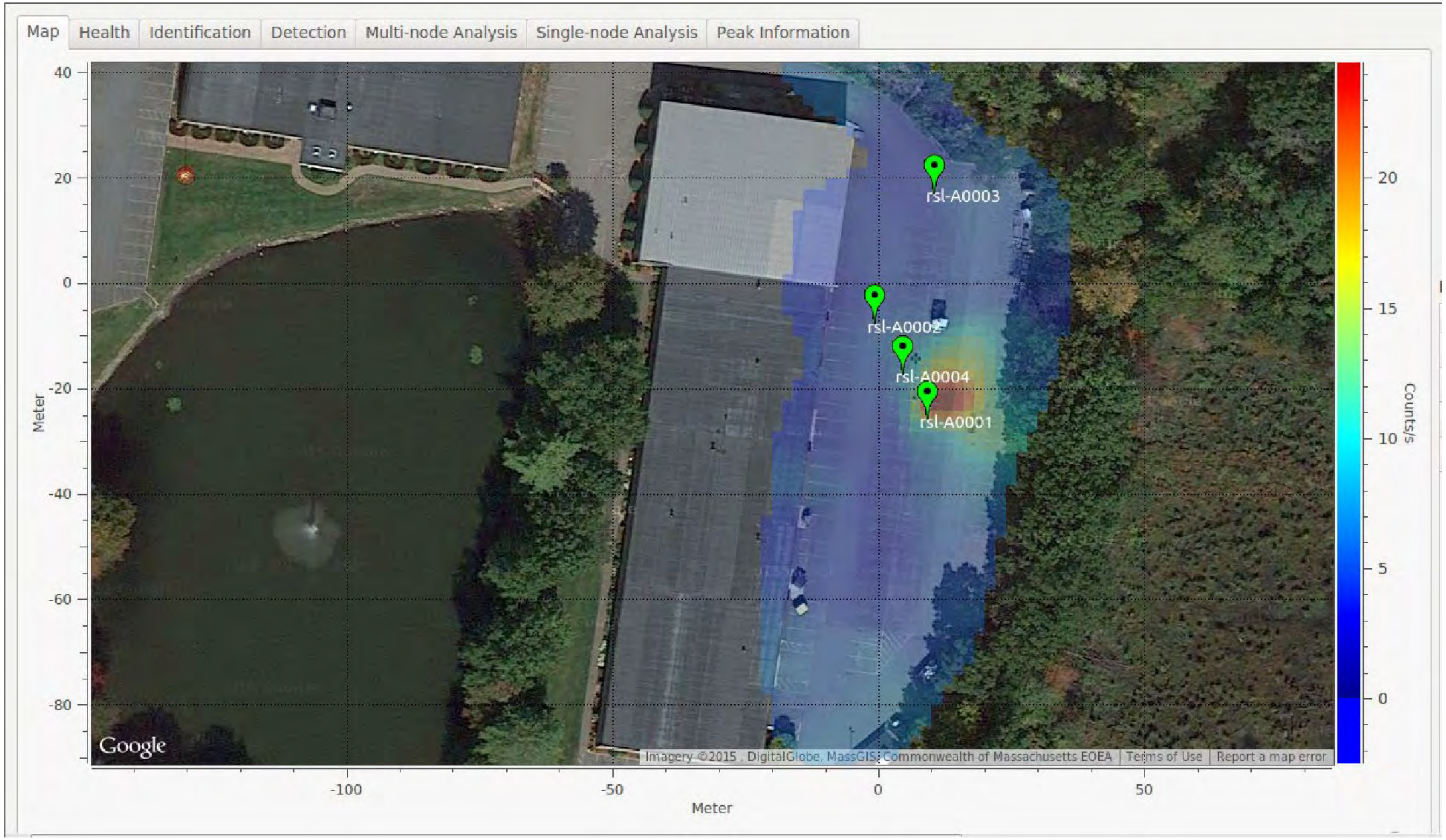

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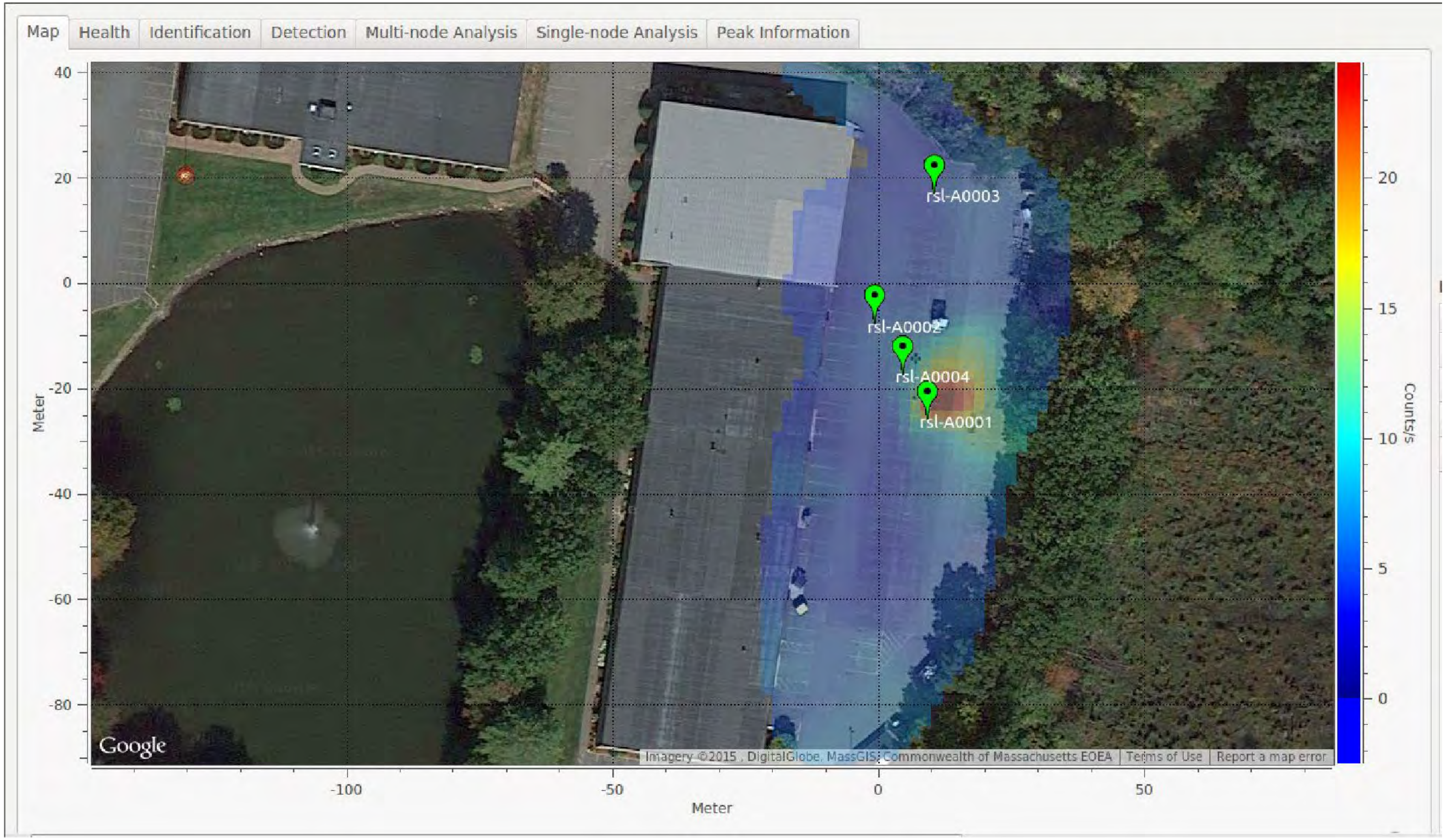
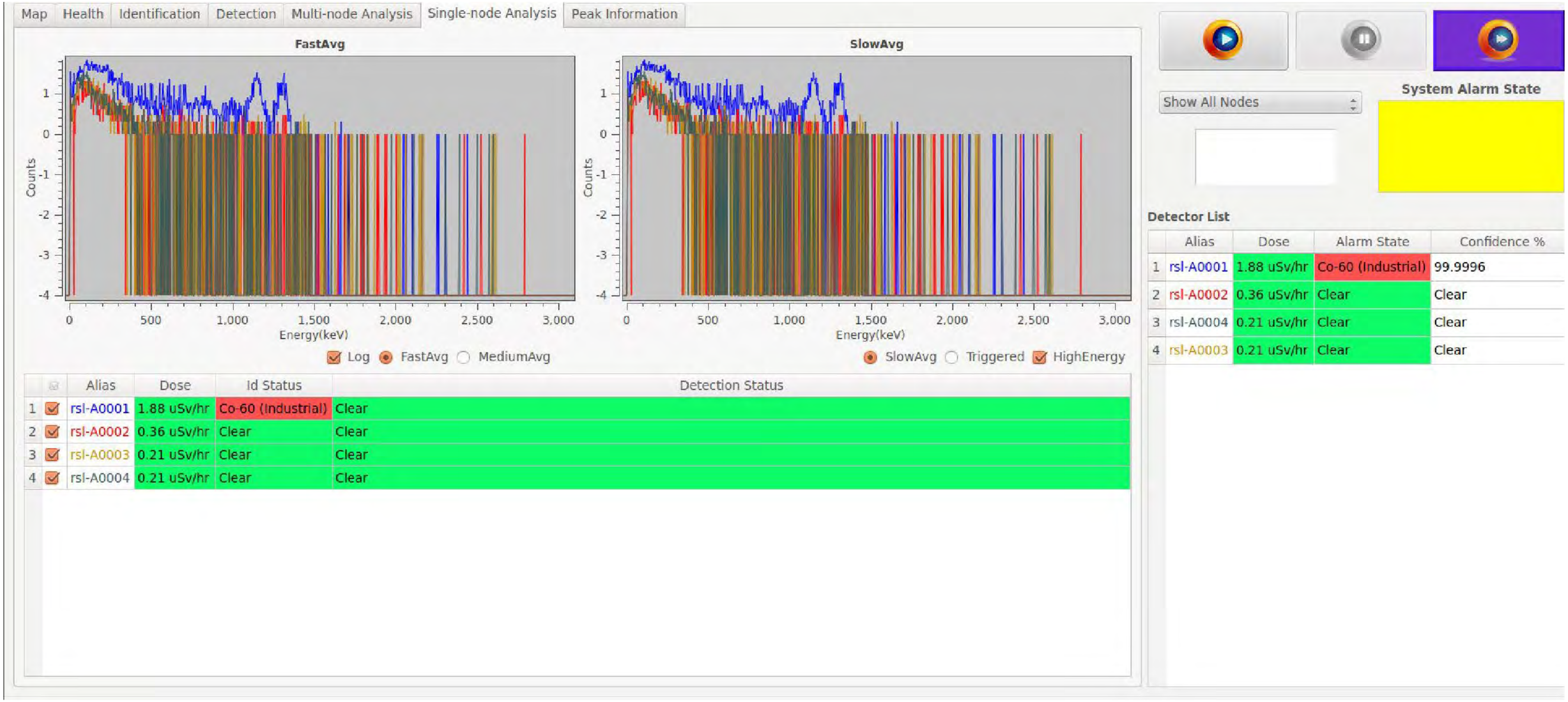
Map showing localization of the source (^{60}Co)



Spectral display

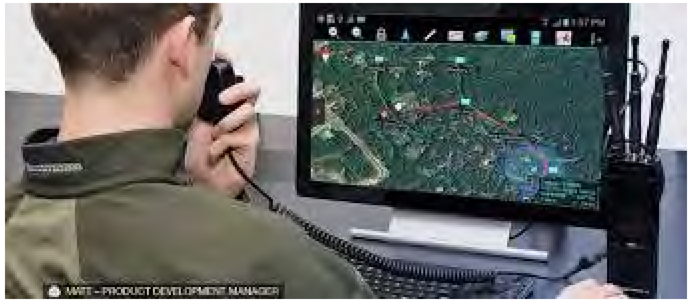


Summary of accomplishments

- The present networked system directs itself to the source of radiation; like a Bayesian-predictive search system, it actively finds the source.
- Currently deployed systems depend on CONOPS (thoroughness of search pattern, grids, or prior intelligence) to find a source. This system is CONOPS agnostic.
- We have incorporated sub-second GPS and data acquisition times, which directly improves the quality of localization, particularly in aerial measurements.
- By using an ad hoc mesh networking system, we have cut down the network latency time (data do not have to go through central servers).

Future plans

- Multiple Input, Multiple Output (MIMO) radios to provide Mobile Ad hoc Network (MANET) connectivity for integration of distributed radiation sensor network
- Will utilize software-defined radio technology to provide a persistent MANET environment to enhance maritime domain awareness
- Surveillance posture
- Routine maintenance and status of health checks
- Radiation alerts and alarm monitoring
- Constant two-way communications using Microsoft Outlook webmail app and other Microsoft Office 365 tools including Microsoft Teams



Future plans (continued)

- To integrate **pedestrian mapper** that works in GPS-denied environment using inertial measurement units (IMUs) and provides mapping capabilities. RSL has developed the pedestrian mapping techniques using man-portable backpacks and generic floor plan. A LIDAR-based self-mapping pedestrian mapping is being contemplated, the development of which will be part of this project.
- Integrate **full-motion video** for use with deployed sensors.

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Thank You
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For more information, contact

Sanjoy Mukhopadhyay mukhops@nv.doe.gov

Remote Sensing Laboratory, Joint Base Andrews
Nevada National Security Site

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