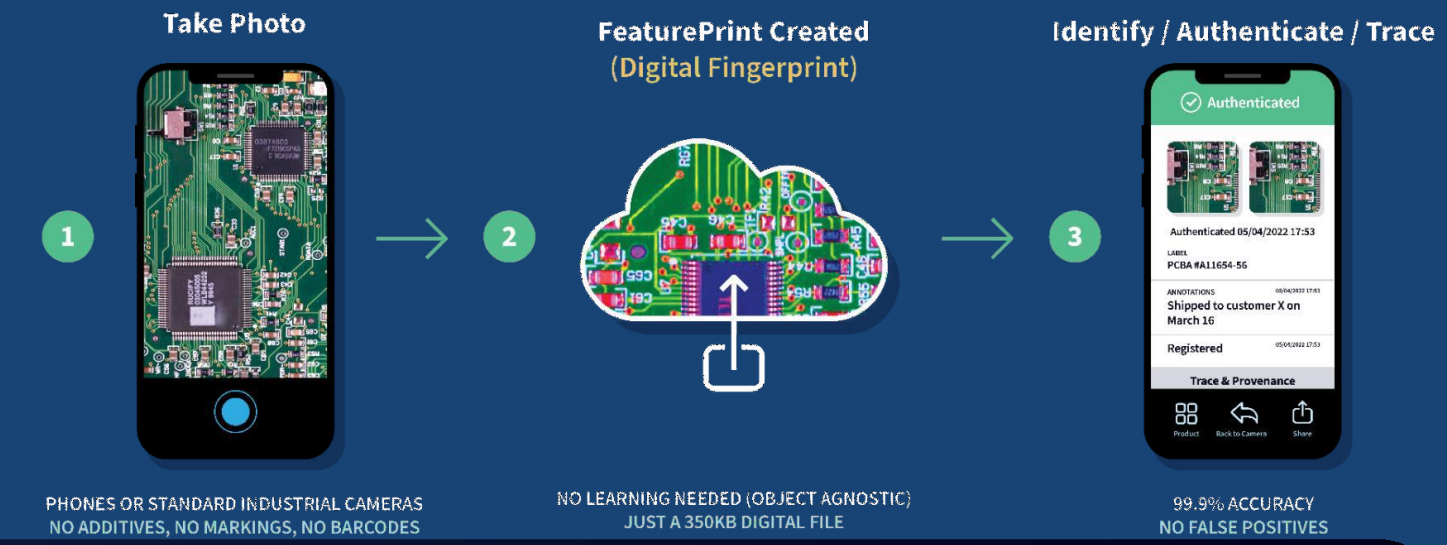
# FeaturePrint® for Supply Chains and High Consequence Items

- Provides for items, what fingerprints are for people – *a unique and persistent identifier*.
- *No-touch serialization* with just a photo from a standard industrial camera or even mobile phone.
- *No additives* (etchings, tags, stickers, QRs, or other proxies) that can be damaged, removed, moved, or faked.
- Enables you to *trace products, eliminate counterfeits and gray markets, and reduce human error*.
- Successful DoE Phase I programs with reactor pebbles, electronics, hardware, and more.
- Use case examples:
  - Trace pebbles at an individual level
  - Secure and ensure reactor supply chains





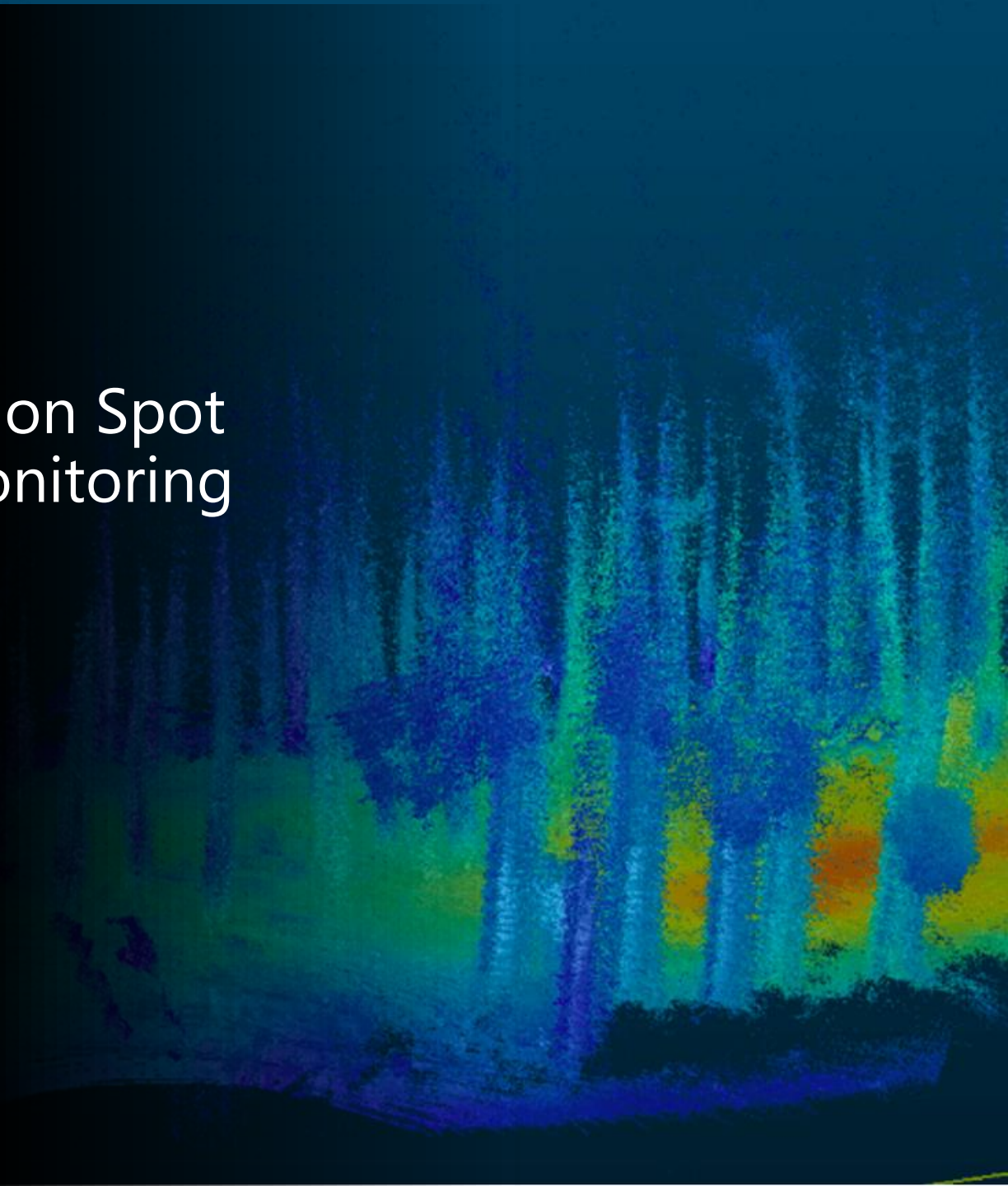

**OIG Special Inquiry finds fraudulent, counterfeit parts in US reactors**
Feb 2022

# Automated 3D Data Fusion Surveys on Spot Robot for Next Generation Plant Monitoring (DOE SBIR Phase II)

Andy Haefner, PhD
CEO - Principal Investigator
Gamma Reality, Inc. (GRI)

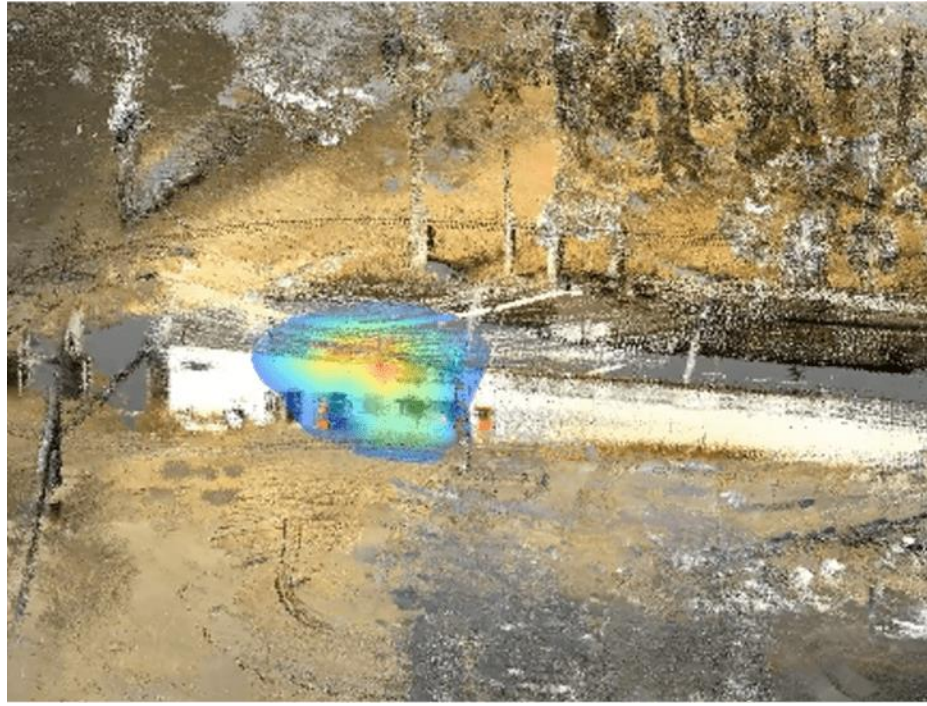
DOE NE-5 National Reactor Innovation Center
Program Review

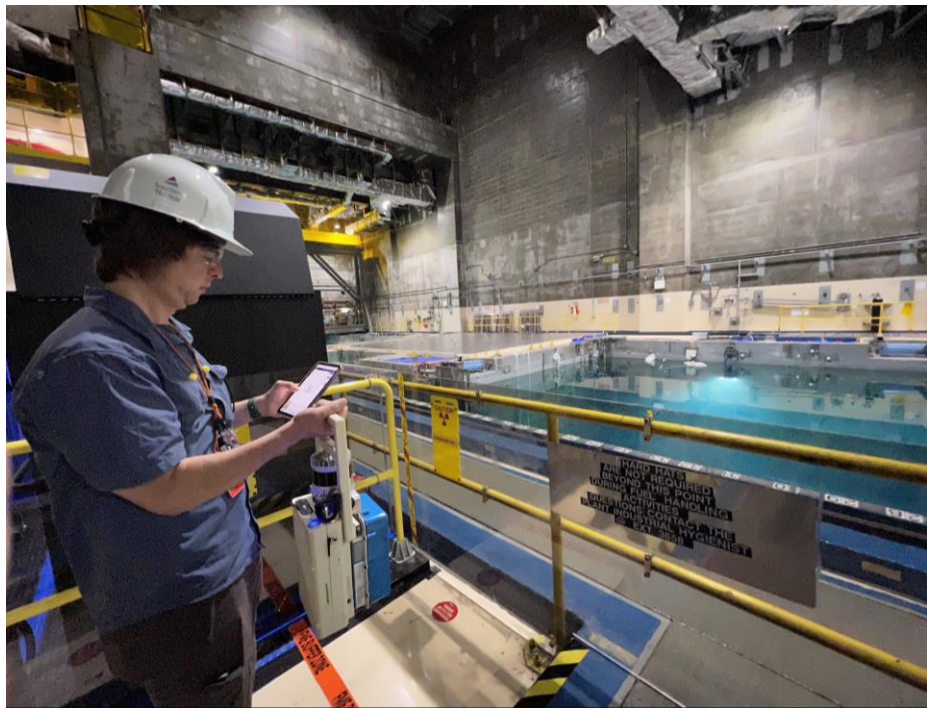
April 23-25, 2024

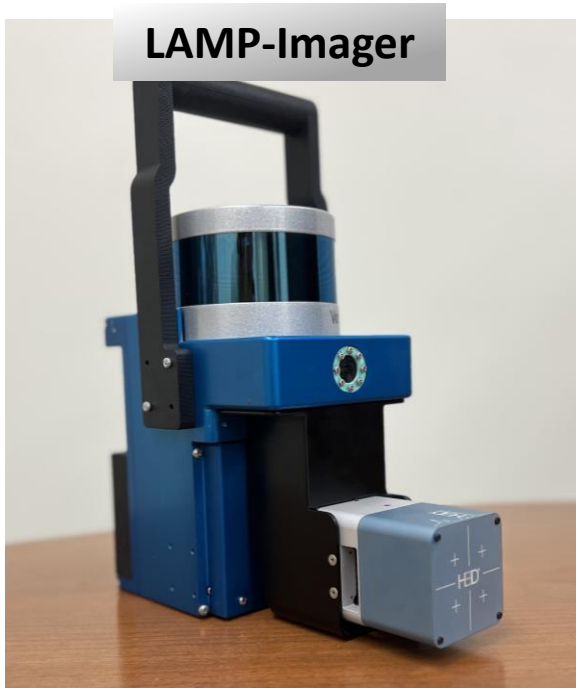


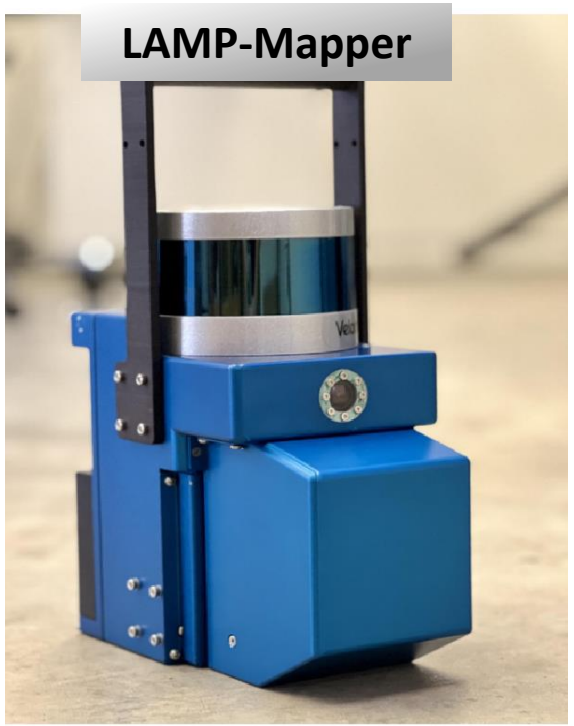
# Gamma Reality Inc.

- Lawrence Berkeley National Laboratory spinoff
- Commercialized Scene Data Fusion and LAMP 3D radiation mapping, data fusion, and visualization technologies
- Expertise in multi-sensor data fusion, radiation detection, 3D mapping, gamma-ray imaging, computer vision, robotic sensor integration, and readout electronics








# GRI-LAMP 3D Radiation Mapping

**Real-time 3D map and radiation data** streamed to control tablet

- High resolution LiDAR maps
- Source term maps
- Radiation data: spectroscopy, dose rate, isotope ID
- Augmented reality camera overlay
- *Available versions*:
  - LAMP-Imager:
    - 10x better mapping resolution than LAMP-Mapper
    - CZT semiconductor from H3D
    - GRI 3D Compton imaging
  - LAMP-Mapper:
    - Dual gamma-ray and neutron mapping
    - CLLBC scintillator
    - GRI 3D proximity mapping

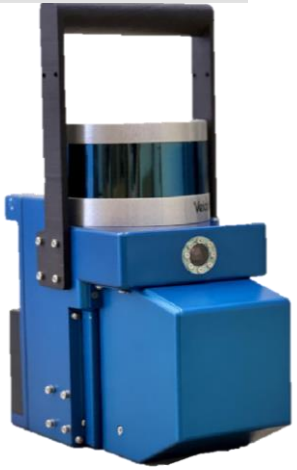
**Data processed and stored onboard system**

**Weight**: 10lb

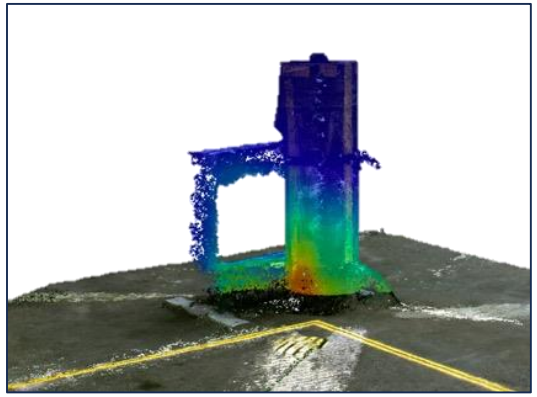
**Battery life**: ~2.5 hour active data collection (swappable)

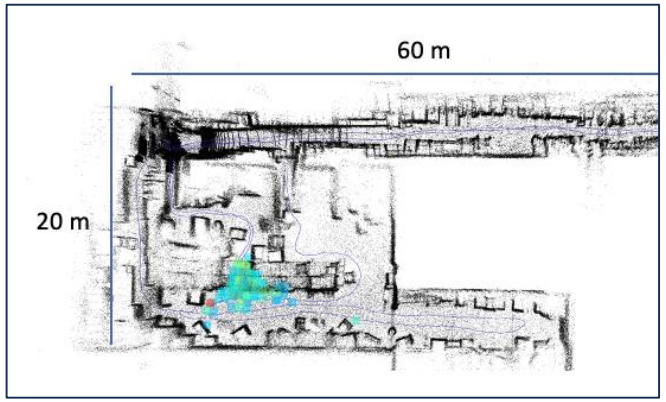
# LAMP: Commercial multi-sensor mapping system
## with 3D mapping, data fusion, and visualization software

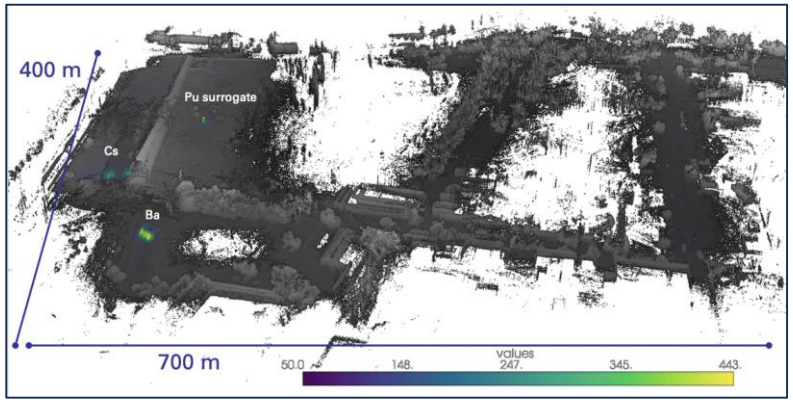
**LAMP**



LAMP can be used to map and localize radiation in single objects, buildings, or entire facilities and outdoor environments, such as forests or fields.





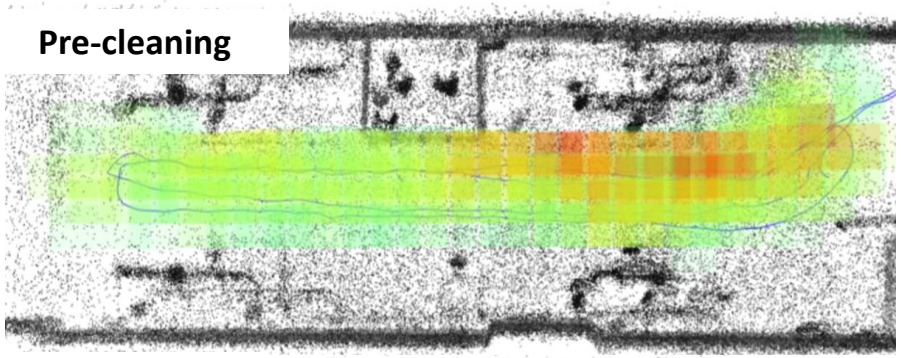




*Dynamic deployment for dynamic missions*

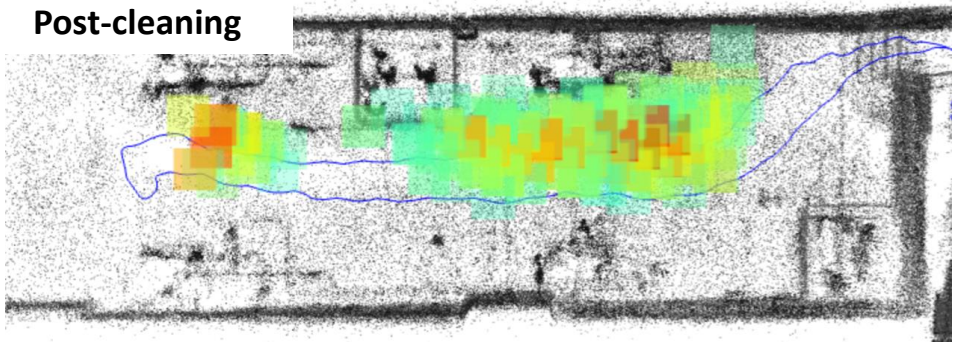
LAMP can be deployed in handheld mode, on unmanned aerial or ground robots, and on manned vehicles.

## Cleaning Verification

Pre-cleaning

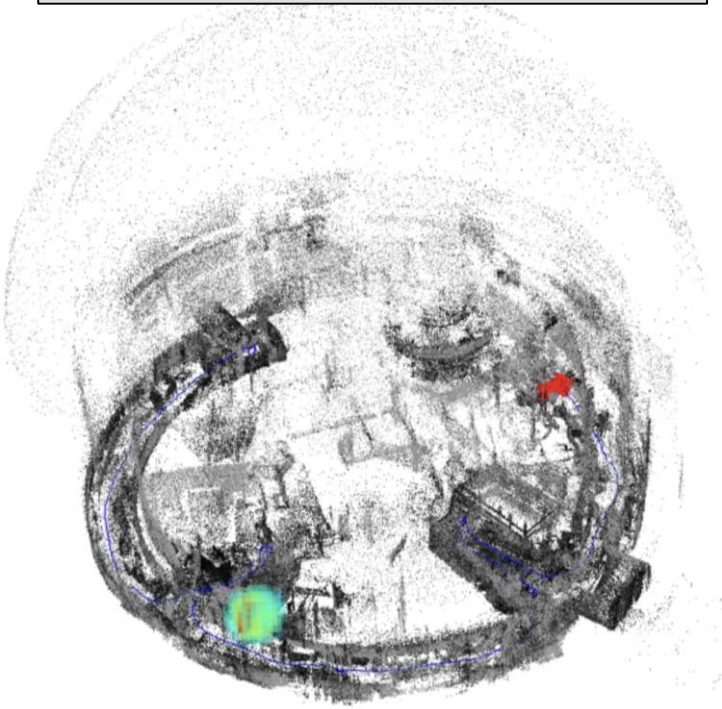


Post-cleaning

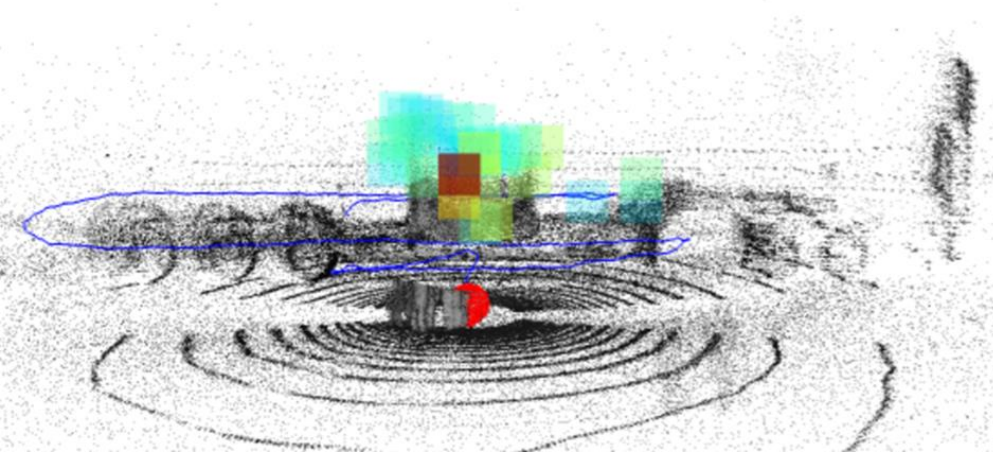


## Deploying LAMP on Spot in Locked High Rad Areas

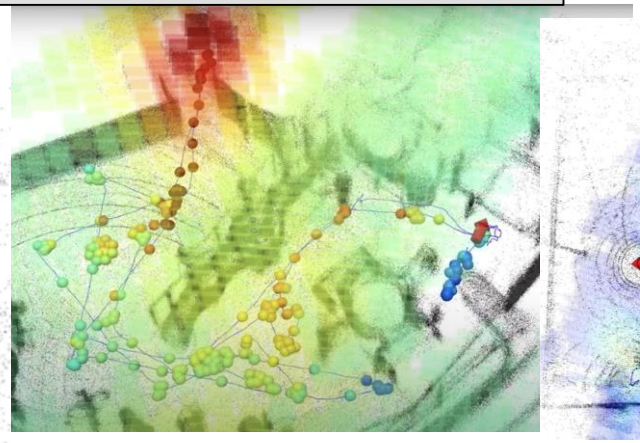

## Outage Surveys



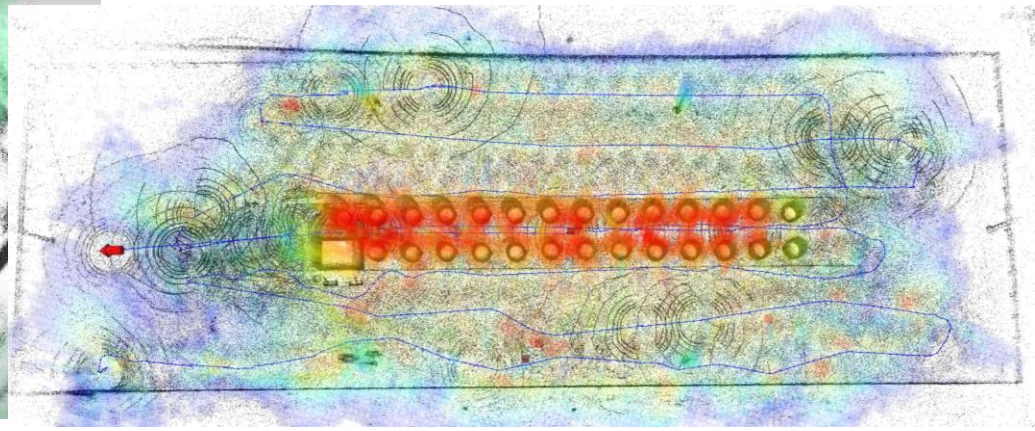
## Radwaste Shipment Survey

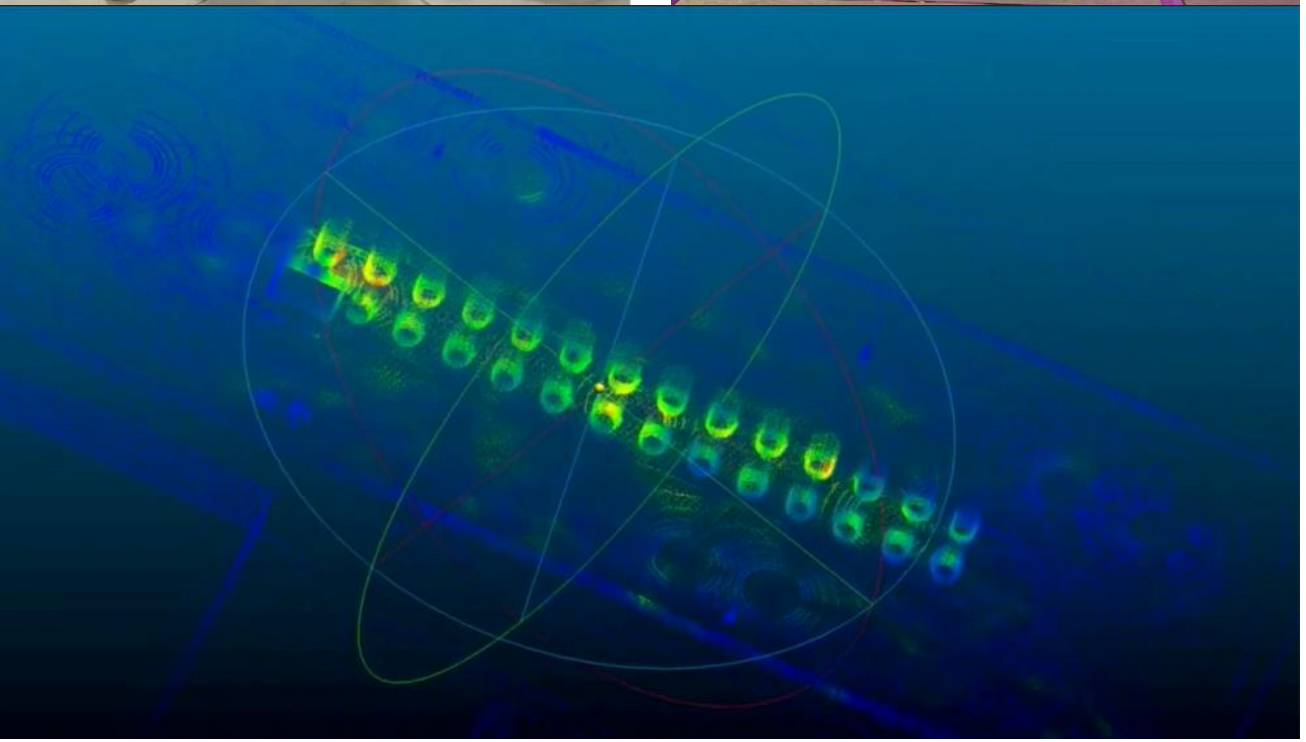


## Shielding verification



## Mapping ISFSI

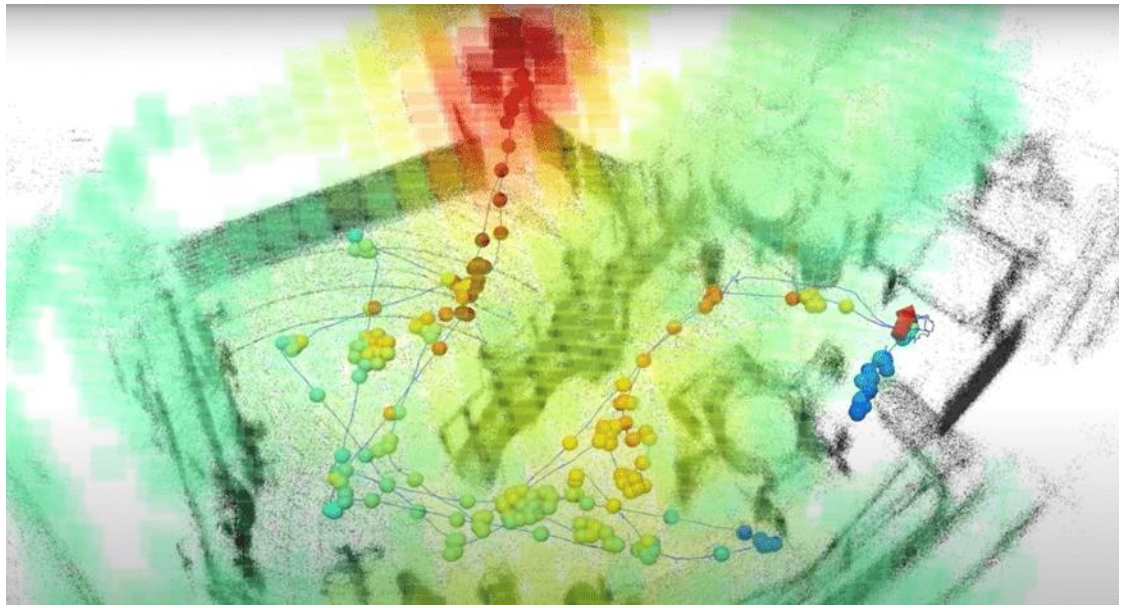


# 2023 Nuclear Energy Institute Top Innovative Practice Award and Best of the Best Dominion Energy Surry

*Radiation Monitoring with Quadruped Robotics and 3D Radiation Mapping*

Awarded to Dominion Energy Surry at 2023 Nuclear Energy Assembly hosted by Nuclear Energy Institute



# DOE SBIR Overview

Next Generation Intelligent Radiation Monitoring Capabilities

# Problem Statement

**Current nuclear plant fleet:**

- Radiation protection processes time consuming and labor intensive
- Often survey data communication still relies on old blueprints and pen and paper in the field

**Next generation reactors**

- Will require robust radiation protection and monitoring technologies to enable safe, economical/cost-effective, and broad deployment
- Next gen reactors may also need remote monitoring for low staffed sites

## Solution:

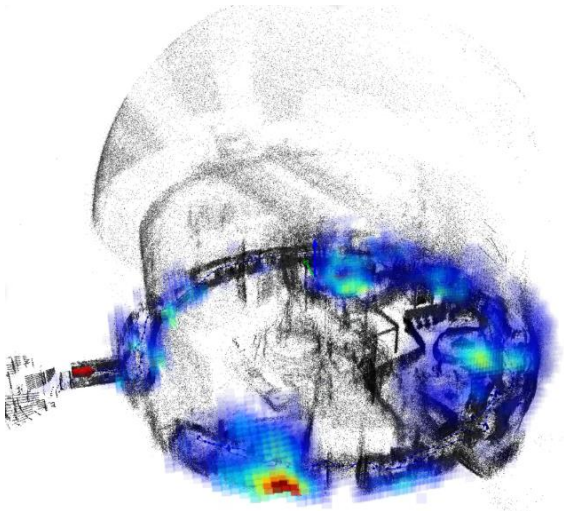
1) LAMP+Spot will conduct automated, routine radiation surveys, reducing the need for a technician simply to collect data and ensuring consistent data sets.

2) GRI's trend analysis and data fusion software will automatically track changes and notify operators of anomalies, reducing the need for active monitoring and enabling data-driven action

# Vision: Next Generation Radiation Protection and Intelligent Monitoring

LAMP+Spot live inside nuclear power plant on the Spot Dock (Doghouse) and conduct routine RP surveys.

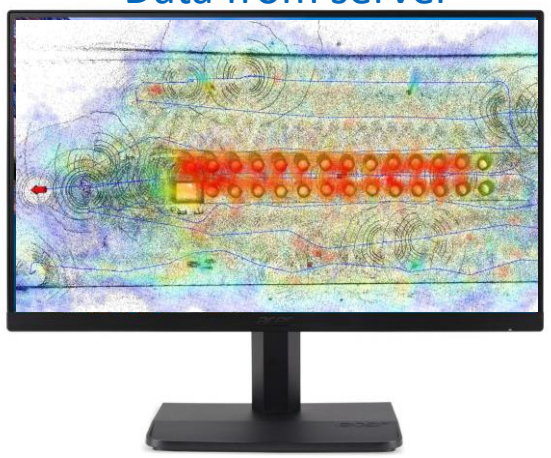




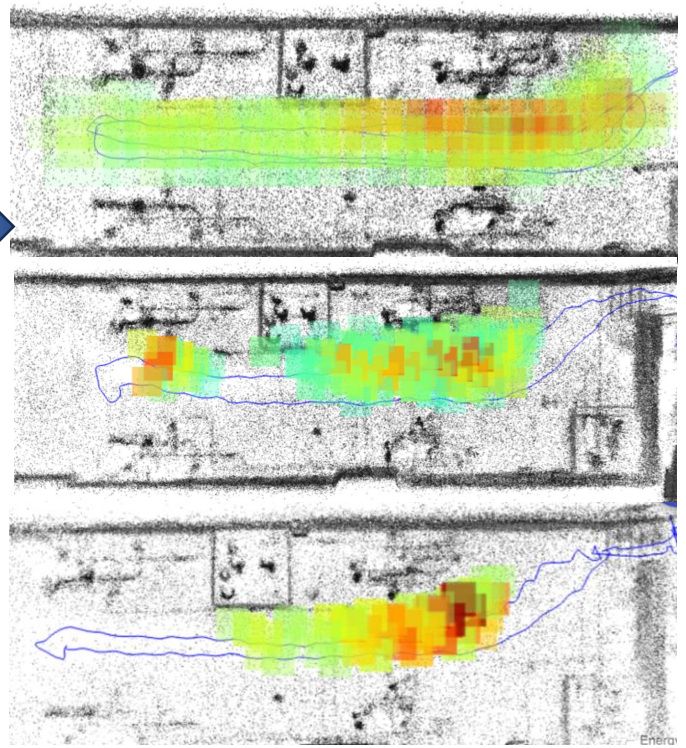
When LAMP+Spot return home to the Dock, survey data is uploaded to a server where GRI Trend Analysis software ingests data.

servers

Data from server



Over time, the trends can inform predictive maintenance and alert operators to anomalies to further investigate.



# Impact & Benefits

- Reduce operator burden through automated multi-sensor data collection & analysis, and intuitive visualization of hazards

- Reduce dose by deploying LAMP+Spot to conduct recurring surveys and inspections, enabling operators to focus on more complex tasks while minimizing dose exposure

- Improve operational efficiency and reduce operating/maintenance costs
  - Potential to use the data to inform risk-based surveys and predictive maintenance

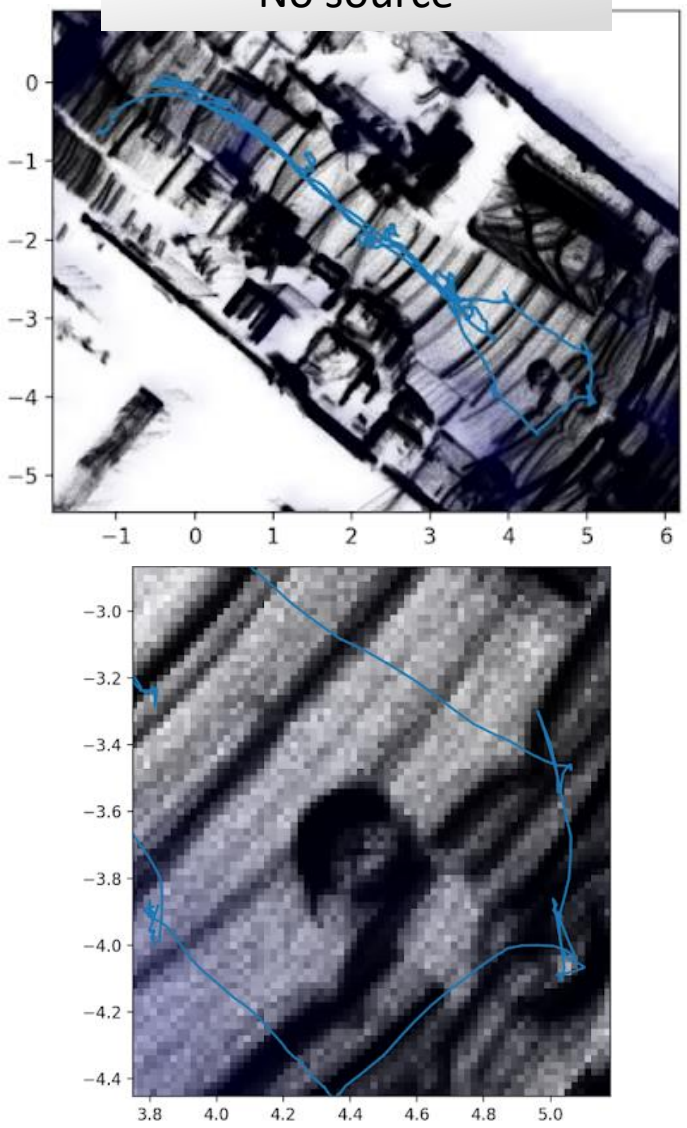
  - Track physical changes in the plant (in addition to radiological) with continuous 3D LiDAR scanning and object recognition

  - Integrate other sensor data into LAMP 3D representation of the plant (i.e. thermal imaging) to provide holistic view of equipment health

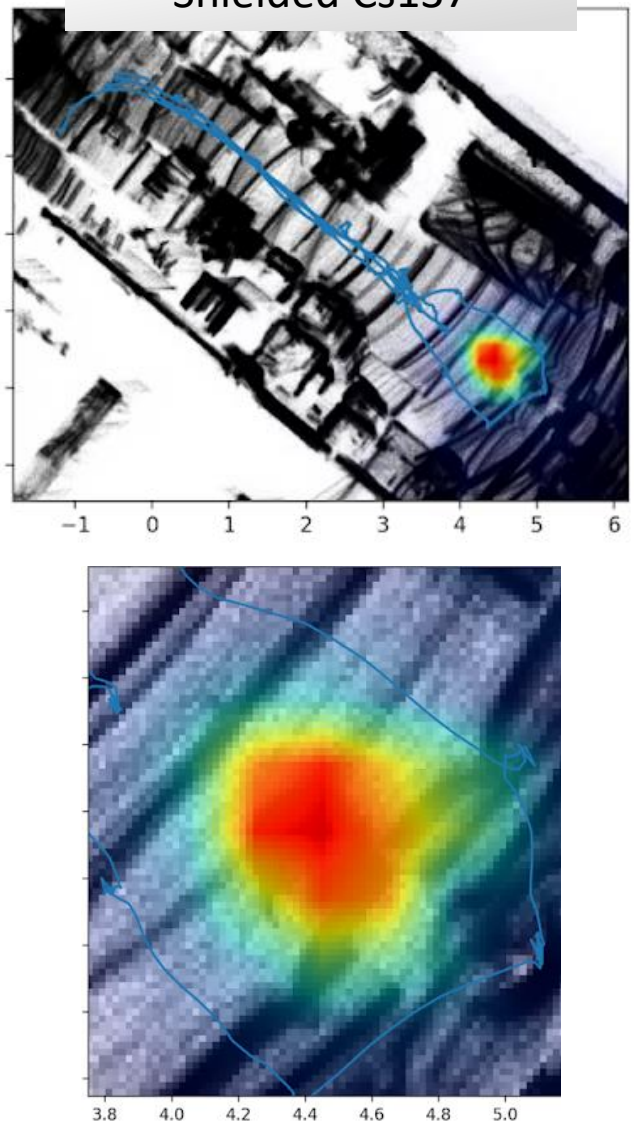
- Enable economical & cost-effective plant monitoring operations in support of our clean energy future

# Change Detection: LAMP+Spot Autowalk Test

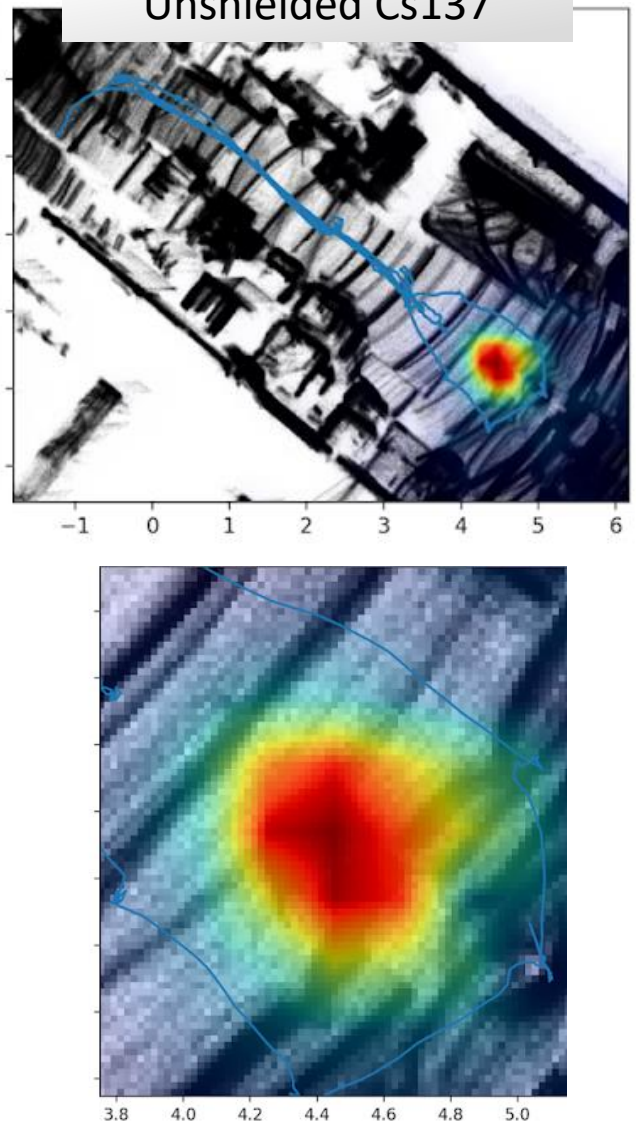
No source




Shielded Cs137




Unshielded Cs137



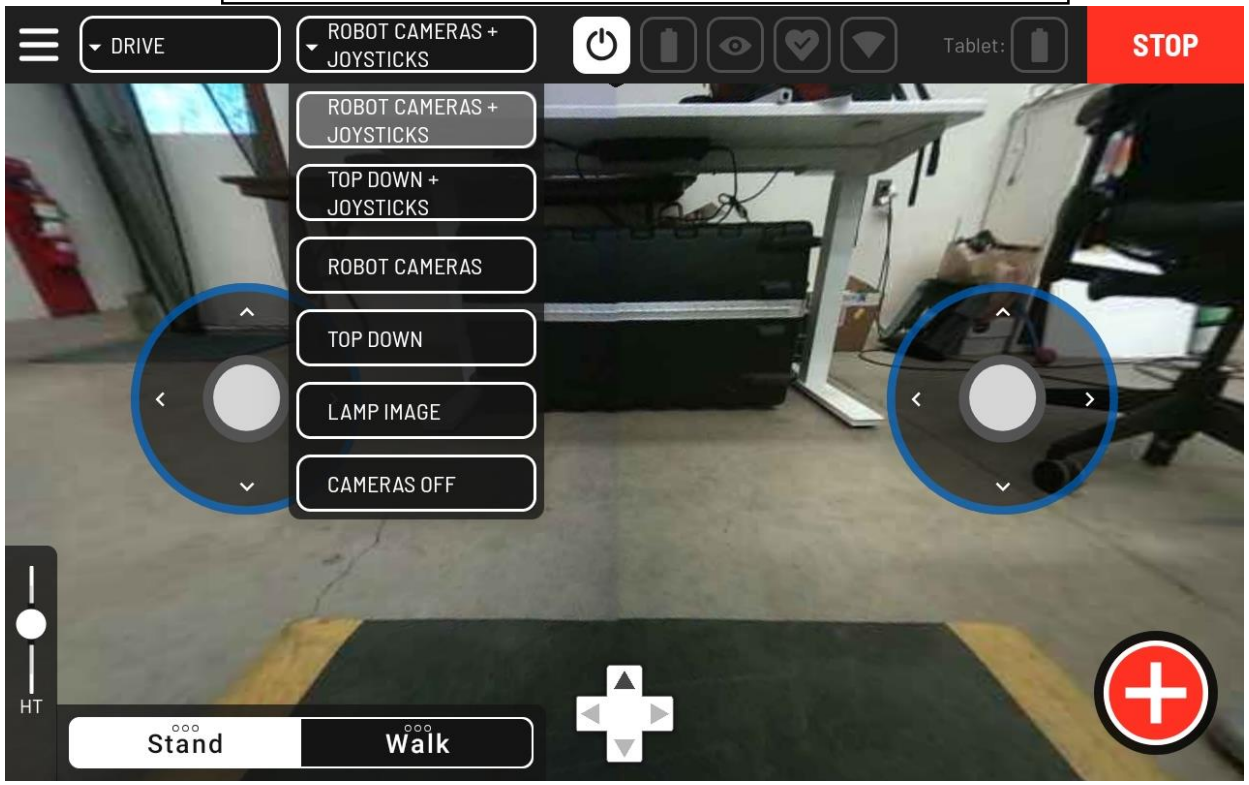
# Initial Commercialization: Software Package

Base LAMP+Spot Software Package is now commercially available

Software Package features:

- LAMP camera shown on Spot's controller
- Start/Stop LAMP runs
- Autowalk: Integrate LAMP control (start/stop) and save snapshots into a Spot Autowalk
- Automatic payload registration and bounding box

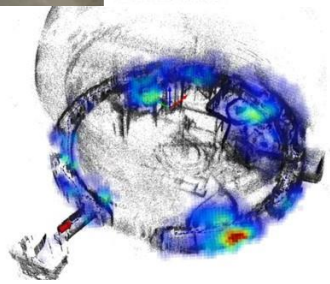
LAMP's camera shown on Spot controller



# Utility Partnerships – pilot programs

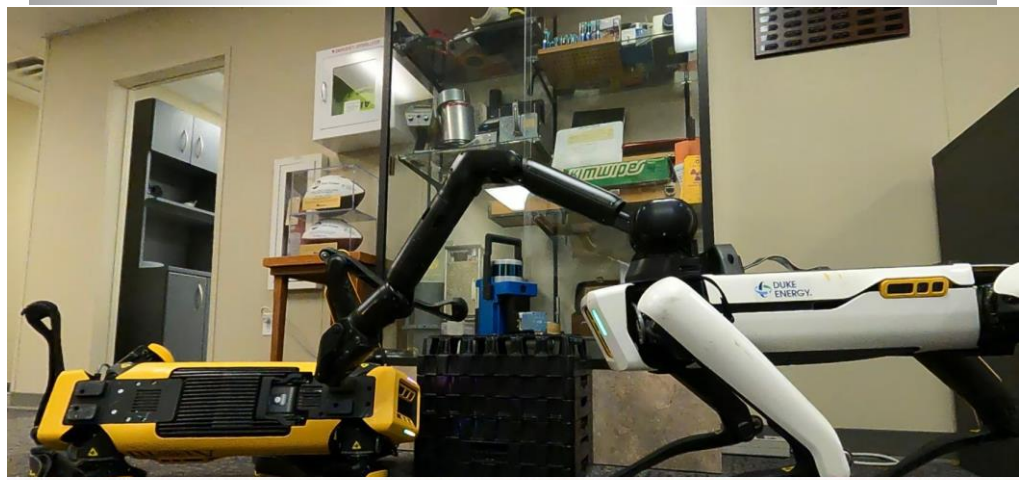
## Dominion Energy Plant Surry

**Robot dog fetches radiation data:**
*Surry's award winner makes new strides*
By Joshua Bell

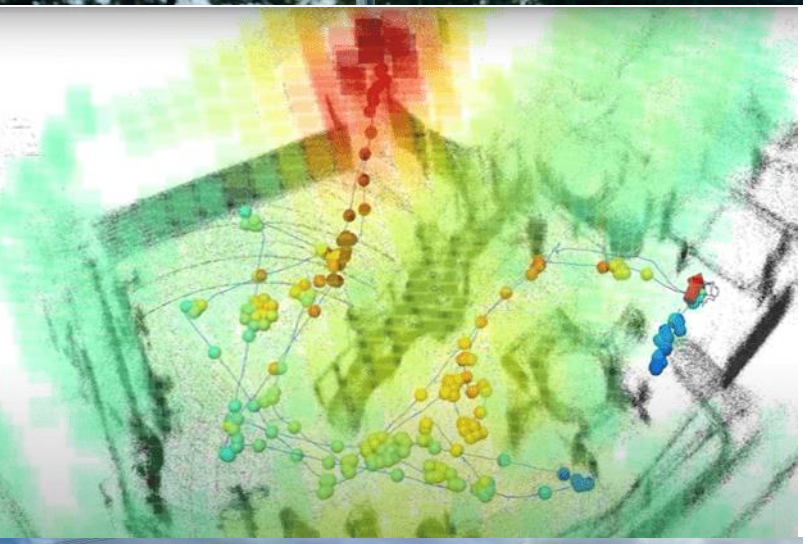

Images credit: Joshua Bell, Dominion Energy

## Duke Energy Oconee Station




Images credit: Bobby Leigh, Duke Energy

***Looking for Next Gen Reactor partners for initial pilot studies**

# Conclusions

- DOE SBIR effort is developing new capabilities to support existing fleet and next generation reactors
  - Automated 3D radiation mapping surveys and change detection and analysis
  - Active pilot programs with partner nuclear plants
- Commercial LAMP currently used in existing nuclear plant fleet to improve RP processes with Spot as an ALARA tool
- Looking for next gen reactor companies to partner with on piloting automated surveys and robotic deployment

Andy Haefner: ahaefner@gammareality.com
https://www.gammareality.com

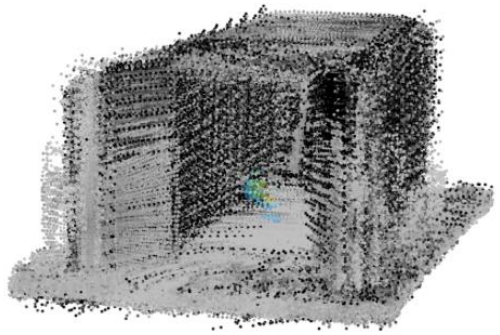
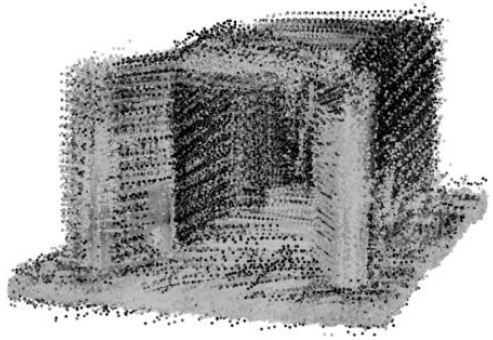
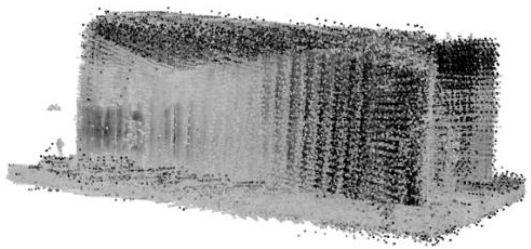
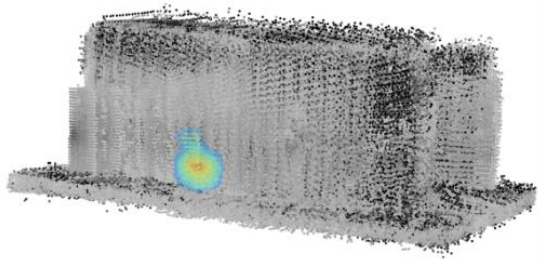
# Acknowledgements & Disclaimer

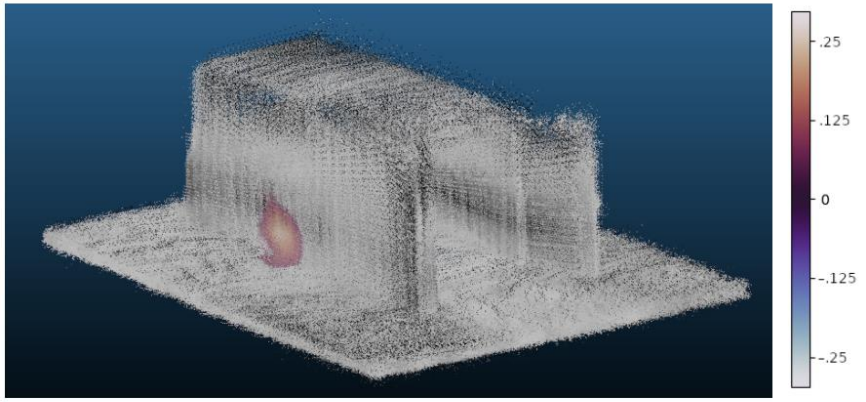
This material is based upon work supported by the Department of Energy Office of Science under Contract No. DE-SC0022705

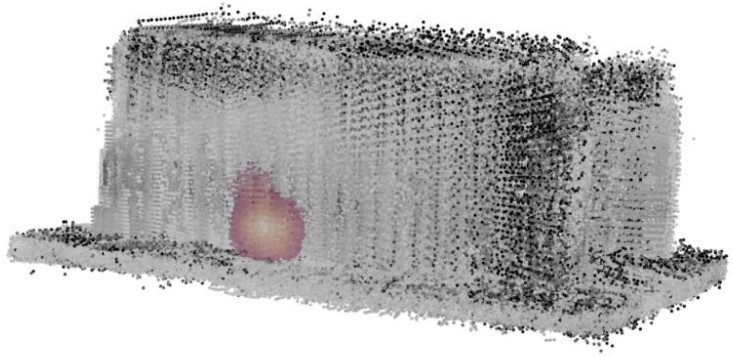
Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of Energy.

# Backup

# Phase I Initial Results

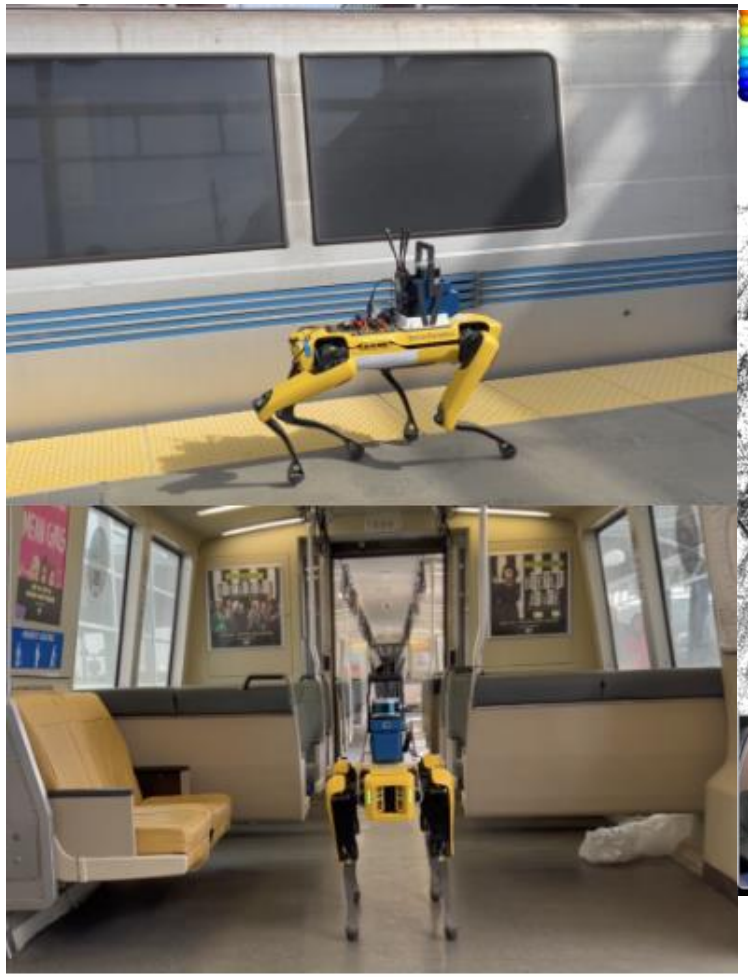
| Run 2 | Run 4 |
| --- | --- |
|  |  |
|  |  |

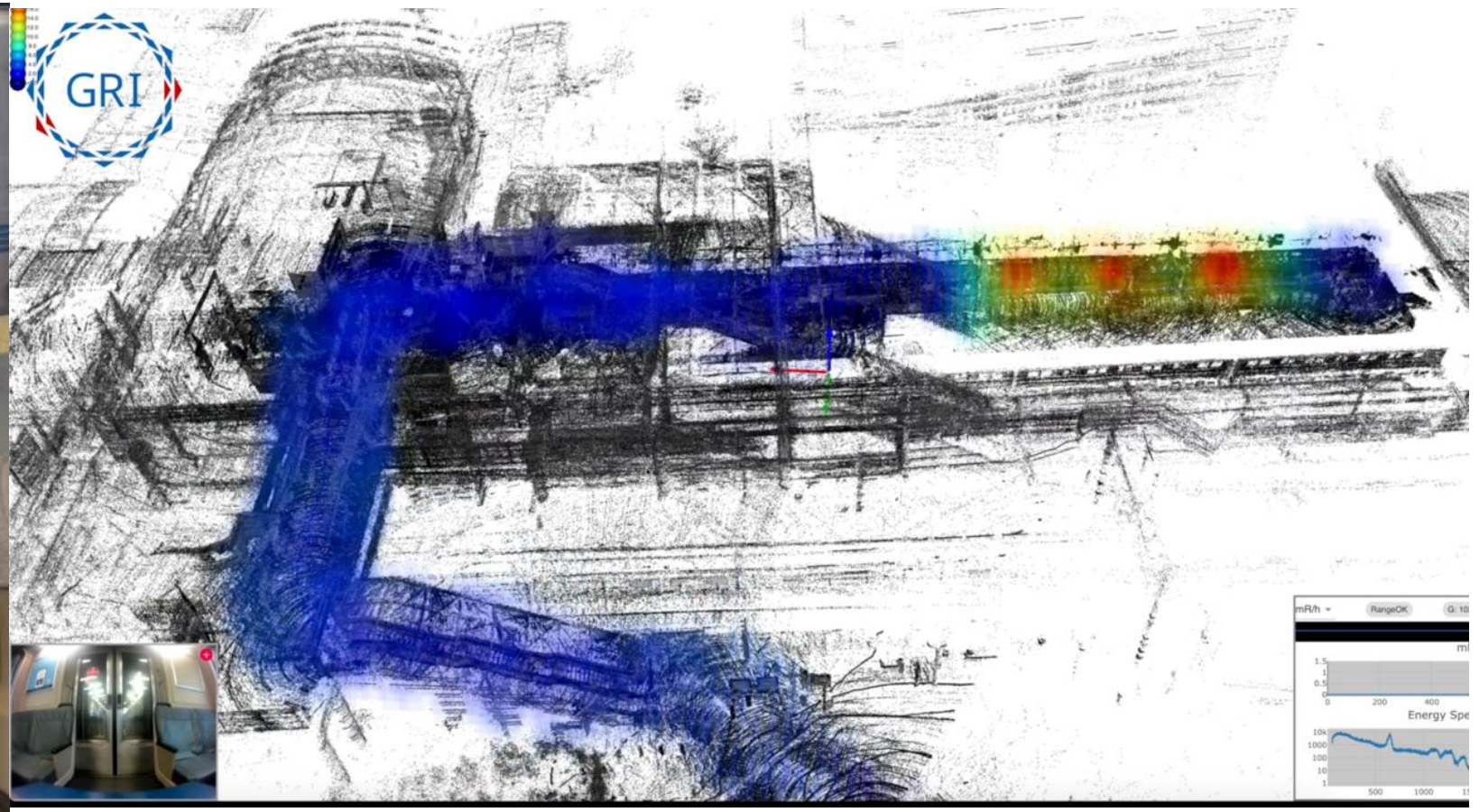


# Deploying LAMP+SPOT for Emergency Response

- LAMP+SPOT remotely deployed for regional emergency response exercise
- Simulated RDD incident on a train at a transit hub with multiple sources
- Real-time 3D map streamed back to command center







19

# Modular Radiation Shielding for Transportation and Use of Microreactors

## Contract DE-SC0023875

CPS Technologies Corp.
April 24th, 2024

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# Introduction - CPS

CPS Technologies

## WHO IS CPS?

We develop advanced composite materials for the transportation, energy, aerospace, and defense industries. Our **metal matrix composites (MMCs)** offer superior properties for thermal management and other high-stress applications improving performance and reliability. We bring together theory and practice to deliver products unlike any other on the market.

- Formed in 1984 as an MIT spin-off
- Located in Norton, MA
- ~40,000 $ft^2$ production facility
- Approximately 110 total employees (35 salaried/exempt, 75 nonexempt)
- Publicly traded (NASDAQ: CPSH)
- Four key product lines
  - MMC
  - Hermetic Packaging
  - HybridTech Armor
  - Contract R&D

Massachusetts Institute of Technology

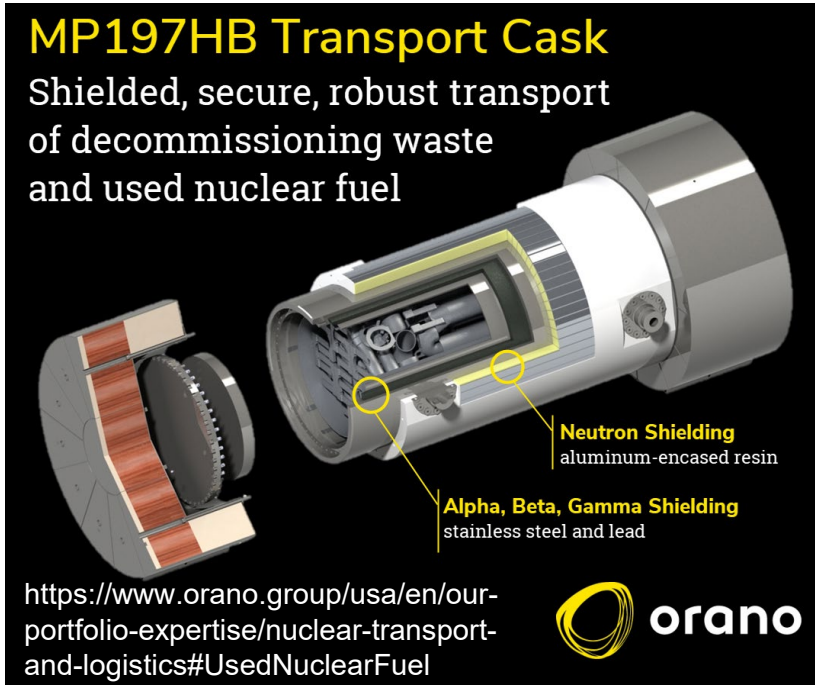
MOTOROLA

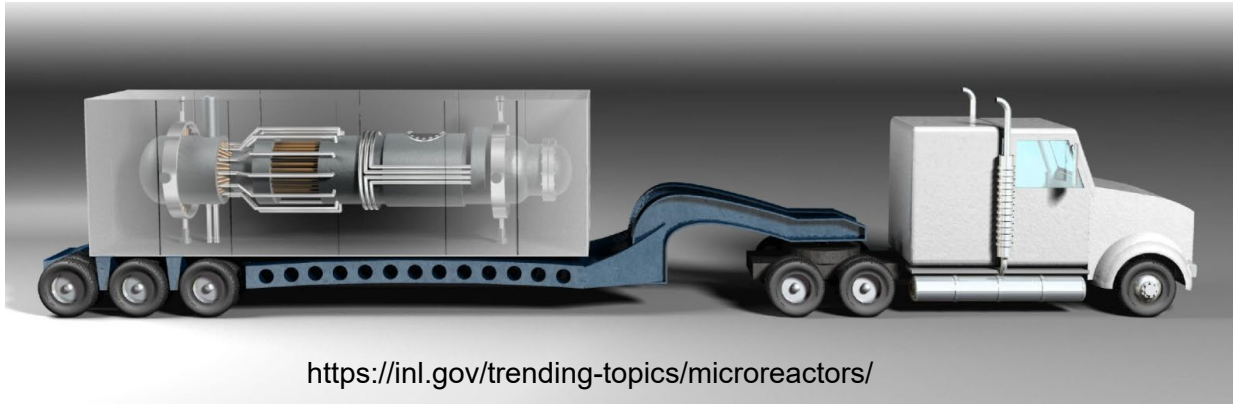
1993 First High-Volume Production Customer


# Problem Statement

***"…. developing and demonstrating fueling/defueling systems, modular shielding, and transport options for microreactors…."***

- Current reactor shielding technologies frequently rely on large volumes of cement and water, which is not feasible for mobile solutions.
- For mobile systems, shielding should be:
  - Light weight
  - Easy to install, maintain, and replace regardless of design.
- Combining multiple functional layers into a single, robust, shielding material reduces complexity of installation and transport



https://inl.gov/trending-topics/microreactors/

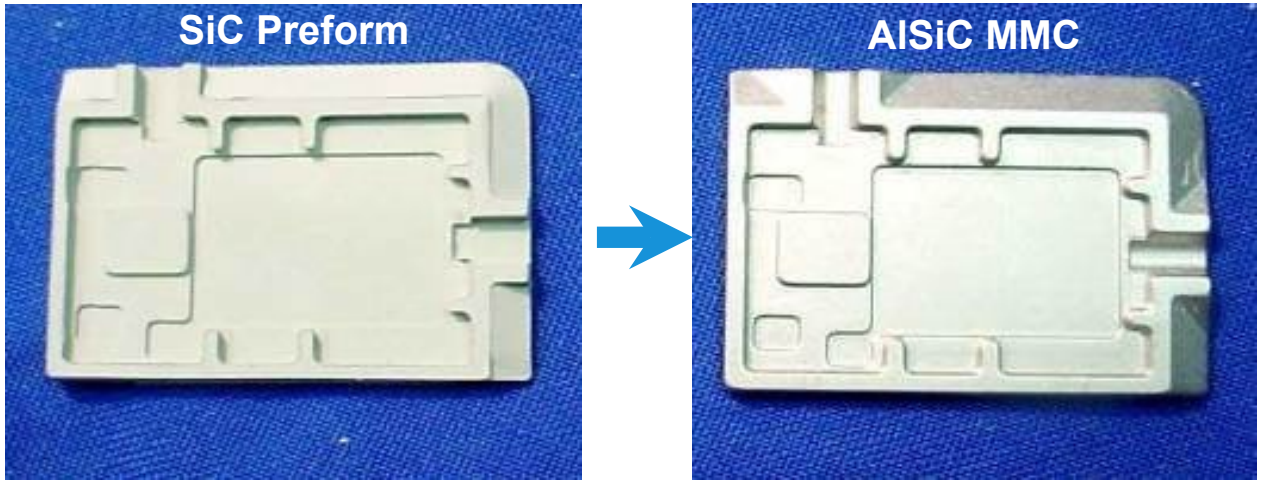
# Proposed Solution

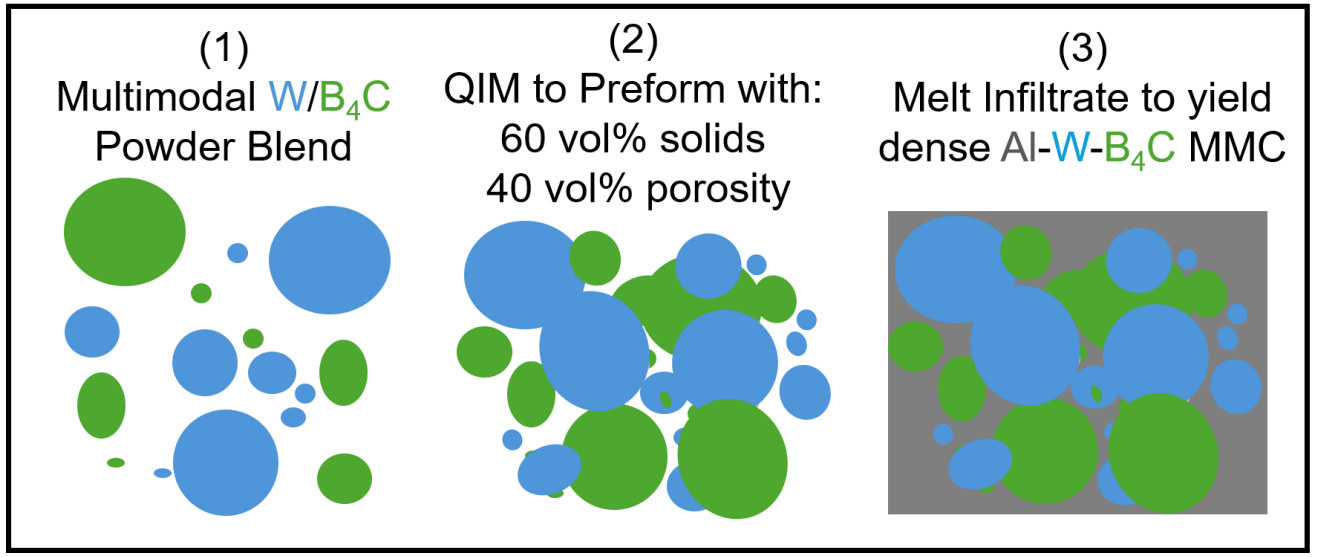
CPS Technologies

***Integrate W and $B_4C$ in a single Al-matrix composite for unified neutron/gamma shielding***

- CPS MMCs are highly loaded with reinforcement (60 vol%)
- Two-step approach for net-shape MMC fabrication
- Compatible with any individual metal/ceramic (Examples: SiC, W, $B_4C$, AlN, Ti, Steels, Inconel, $Si_3N_4$, $Al_2O_3$)
- Multi material blends have not been demonstrated prior to Phase I

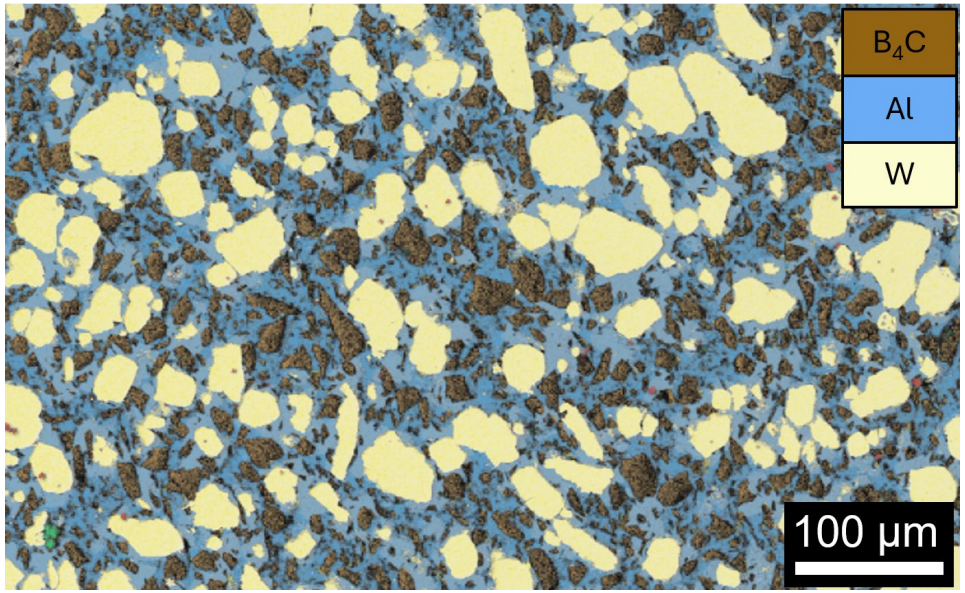
***Transition to W/$B_4C$ blends for Al-W-B4C MMC***



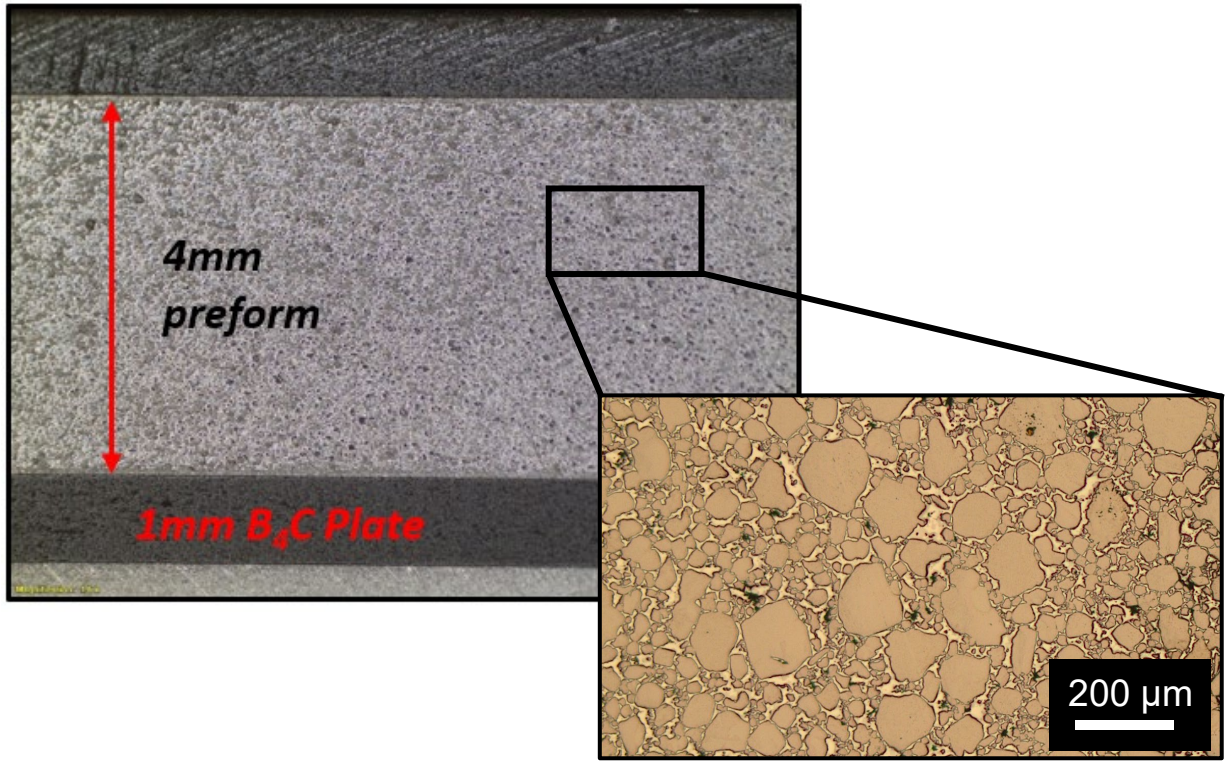



# Sample Fabrication

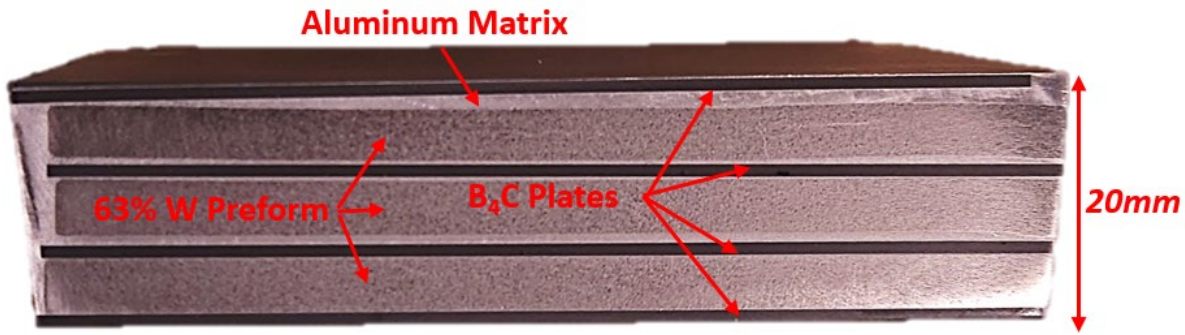
- Samples easily infiltrated to full density
- Three example MMCs shown
- Final dimensions 80 x 100 mm, 7 or 20 mm thick




**Al-30 vol%W-30 vol% $B_4C$ composite**




**Al-60 vol% W sandwiched between $B_4C$ plates**

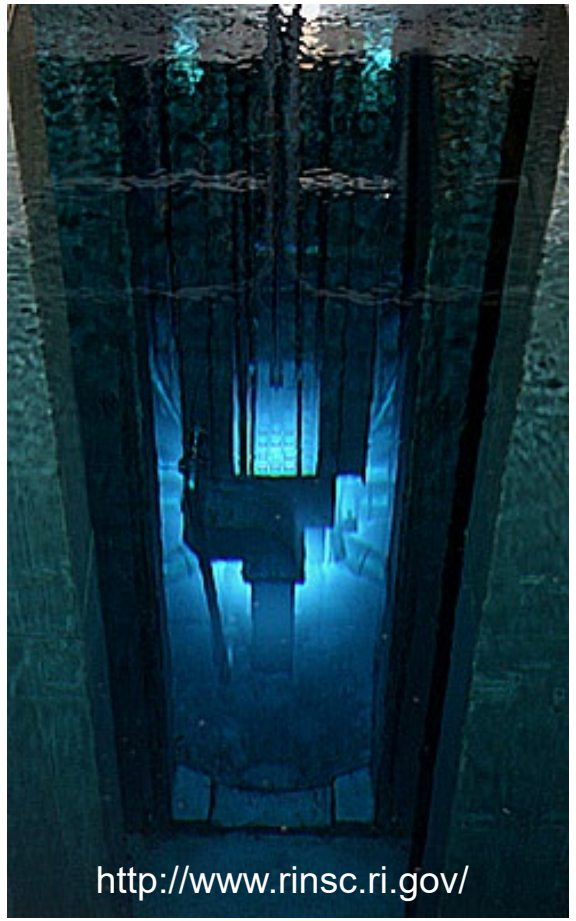



**Al-60 vol% W layered between four $B_4C$ plates**

# Radiation Testing

Performed at Rhode Island Nuclear Science Center (RINSC) reactor:

- 8” Beam Port, 2MW, light water cooled, pool type
- $10^{12}$ Thermal Flux [n/cm$^2$]
- $10^{11}$ Epithermal Flux [n/cm$^2$]
- Sample stack exposed for 1 hour. Large samples in front of stack, wood separators between each sample




Al-W-$B_4C$ composites showed low gamma transmission and HVL, similar to lead and tungsten, ***but at less than 50% of the mass***

Neutron absorption results pending, contact for details

| *Material* | *Co60 HVL (mm)* | *Density (g/cc)* | *Half-Value Mass (g)* |
|---|---|---|---|
| Concrete | 60.5 | 2.5 | 15.125 |
| Lead | 12.5 | 11.34 | 14.175 |
| Tungsten | 7.9 | 19.3 | 15.247 |
| **Al-W-$B_4C$ Blend 1** | **15** | **4.1** | **6.15** |
| **Al-W-$B_4C$ Blend 2** | **9** | **6.7** | **6.03** |

**> 50% reduction**



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