The Consortium for Enabling Technologies and Innovation

Virtual Summer Meeting for Young Researchers

BERKELEY LAB
Lawrence Berkeley National Laboratory

Applying advanced analysis and robotics tools to nuclear security challenges

Tenzing Joshi and Brian Quiter

Applied Nuclear Physics Program

Nuclear Sciences Division

July 8, 2020

ETI

National Nuclear Security Administration

Tenzing Joshi – thjoshi@lbl.gov

Academic trajectory

B.S. Nuclear Engineering – 2008
Purdue University

Ph.D. Nuclear Engineering – 2014
University of California, Berkeley

Lawrence Scholar
Lawrence Livermore National Laboratory

Postdoctoral Physicist – 2014 - 2017
Lawrence Berkeley National Laboratory

Staff Applied Physicist – 2017 - present
Lawrence Berkeley National Laboratory

(The pre-Covid look)

Shifting interests

Fusion and fission reactor dynamics

Mathematical modeling

NRF & mono-energetic gamma-ray sources

Neutrino and dark matter detection

Exotic radiation detection concepts

~~Semiconductor detector fabrication~~

Modern analysis methods, ML

Data fusion and robotics tools, CV

Quantitative data fusion methods

Demonstration and validation of new concepts in nuclear security

Learning opportunities

LLNL AX-division summer intern

Public Policy and Nuclear Threats at UCSD

International Nuclear Safeguards Policy and Information Analysi at MIIS

Topics on Astroparticle and Underground Physics

- Summer course and conference

Parenthood

Online courses, literature reviews, books, colleagues

Brian Quiter – bjquiter@lbl.gov

Academic trajectory

B.S. Bio-nuclear Engineering – 2003
University of California, Berkeley

M.S. Nuclear Engineering – 2005
University of California, Berkeley

Environmental Engineering– 2005-2006
Blasland, Bouck & Lee Inc.

Beer Industry – 2007
Pyramid Breweries Inc.

Ph.D. Nuclear Engineering – 2010
University of California, Berkeley

Project Scientist – 2010-2014

Staff Applied Physicist – 2014 - present
Lawrence Berkeley National Laboratory

Deputy Program Head 2019 - present
Applied Nuclear Physics Program,
Lawrence Berkeley National Laboratory

NNSA Lab Internships

LLNL 2001-2003

Radiation detectors, quantifying thermal neutron backgrounds

LBNL 2003-2005

Cosmogenic activation of neutrino-less double beta decay detector material

INL 2007

Digital acquisition electronics and active interrogation techniques

LANL 2008-2009

MCNP code improvements for nuclear safeguards and Nuclear Resonance Fluorescence applications.

Interests/Accomplishments

NRF as NDA for safeguards

Added NRF phenomena to MCNPX/6

Radiation detection & contextual sensor fusion

Making applied physics data availability to researchers:

www.grdc.nersc.gov

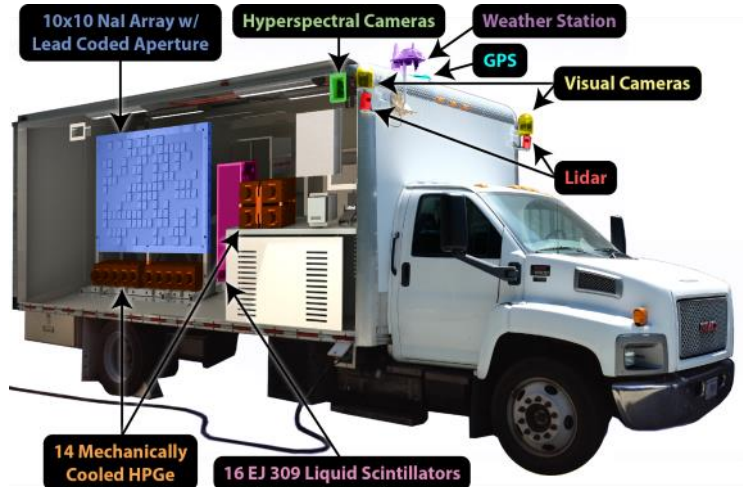
www.bdc.lbl.gov

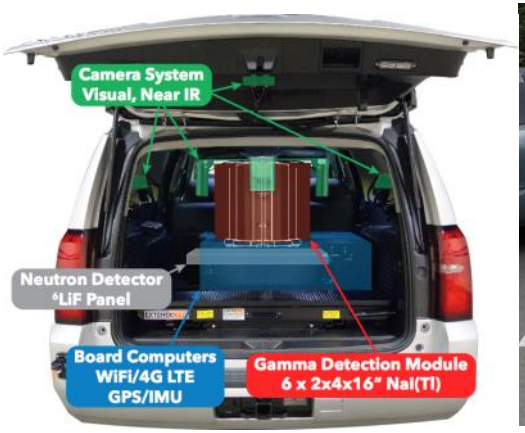
www.minos.lbl.gov

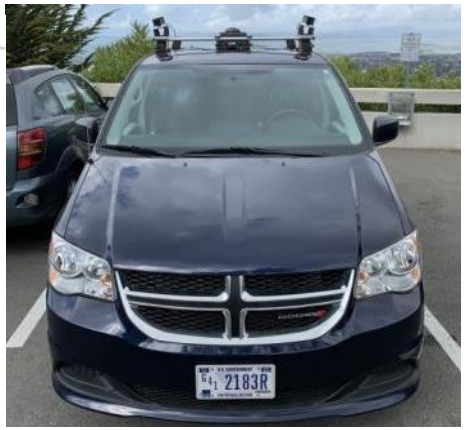
(The pre-Covid look)

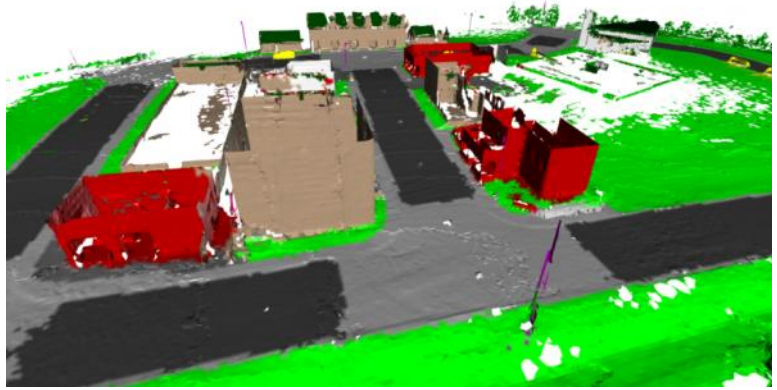
Vehicle-scale detector Systems

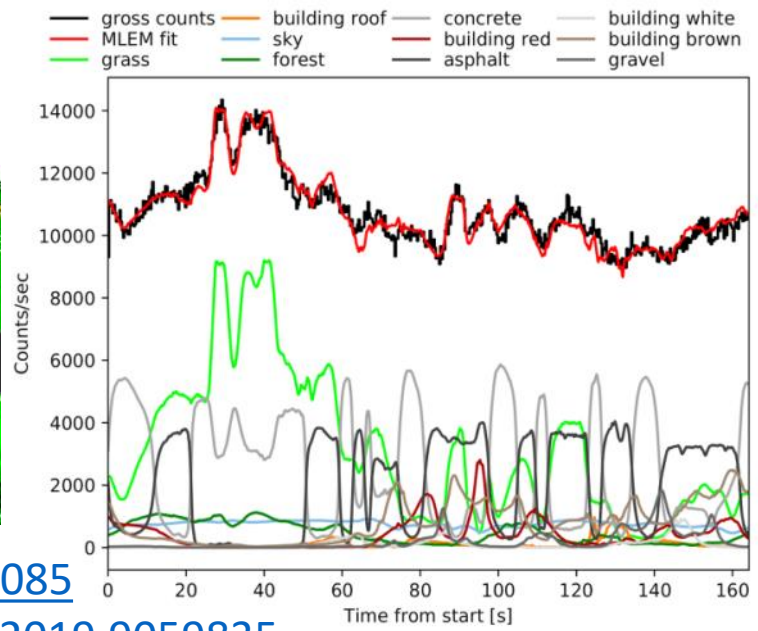
- Collected and disseminated large, contextually-informed radiological datasets
  - www.grdc.nersc.gov
- Attribute background gamma-ray spectra to surroundings
  - Semantic segmentation
- Develop contextually-informed radiation detection algorithms and methods
- Commercial and R&D systems









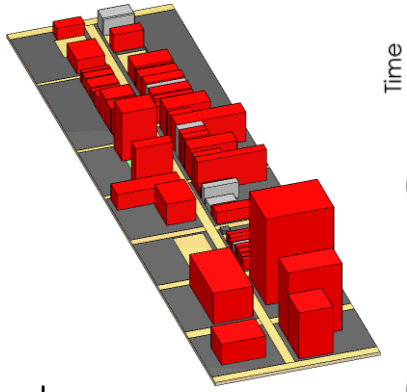


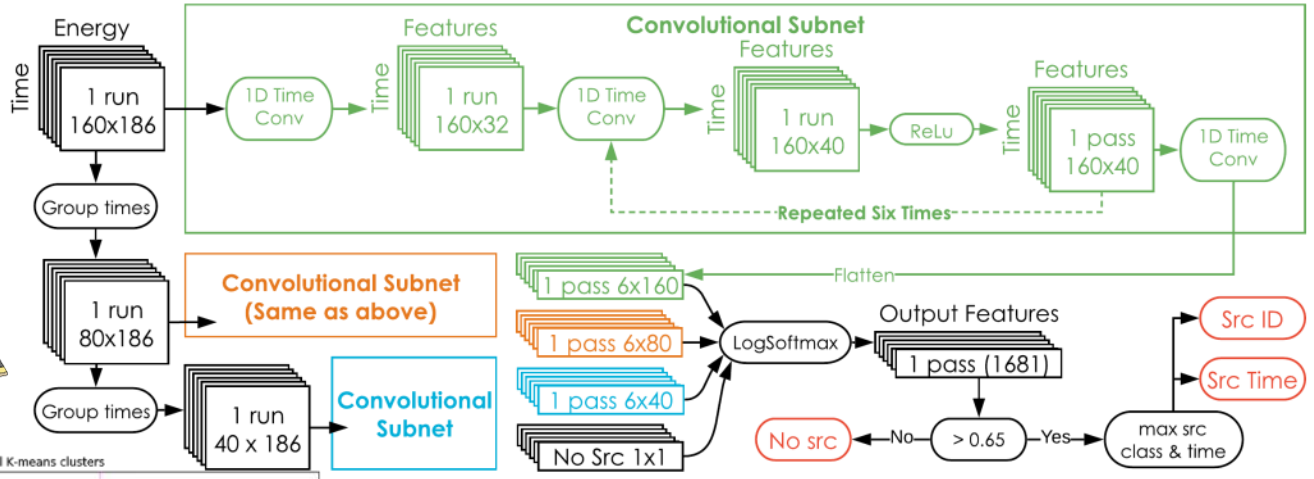
MURS:10.1016/j.nima.2018.08.087 Background Attribution:10.1109/NSS/MIC42101.2019.9059835 10.1016/j.nima.2018.08.085

Data competition for spectroscopic analysis

A challenging, open dataset

- **DOI: 10.13139/ornlnccs/159741**
- **DOI: 10.1109/TNS.2020.3001754**
- Training and Test sets, split into ~100sec runs.
- Test set: 43% public, 57% private.
- Variable background, 6 source classes



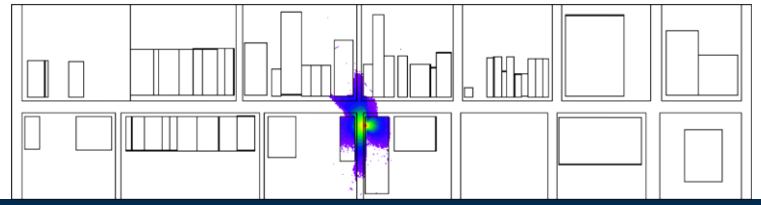


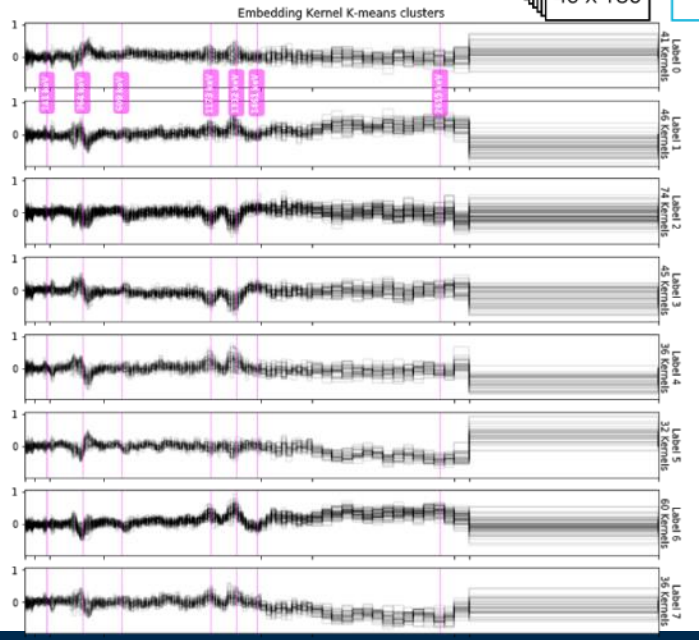
For each run in the test set, competitors must

- **Detect** whether there is an anomalous source.
- **Identify** the type of source.
- **Locate** when the detector is closest to it.

Competitions held via LBNL, then Top Coder

- Winning approaches submitted for cash prizes
- Currently evaluating winning algorithms





First place approach:

- Ensemble of 1D Conv nets
- 3 integration times
- 6 layers

Clustering on 1st layer weights across the ensemble

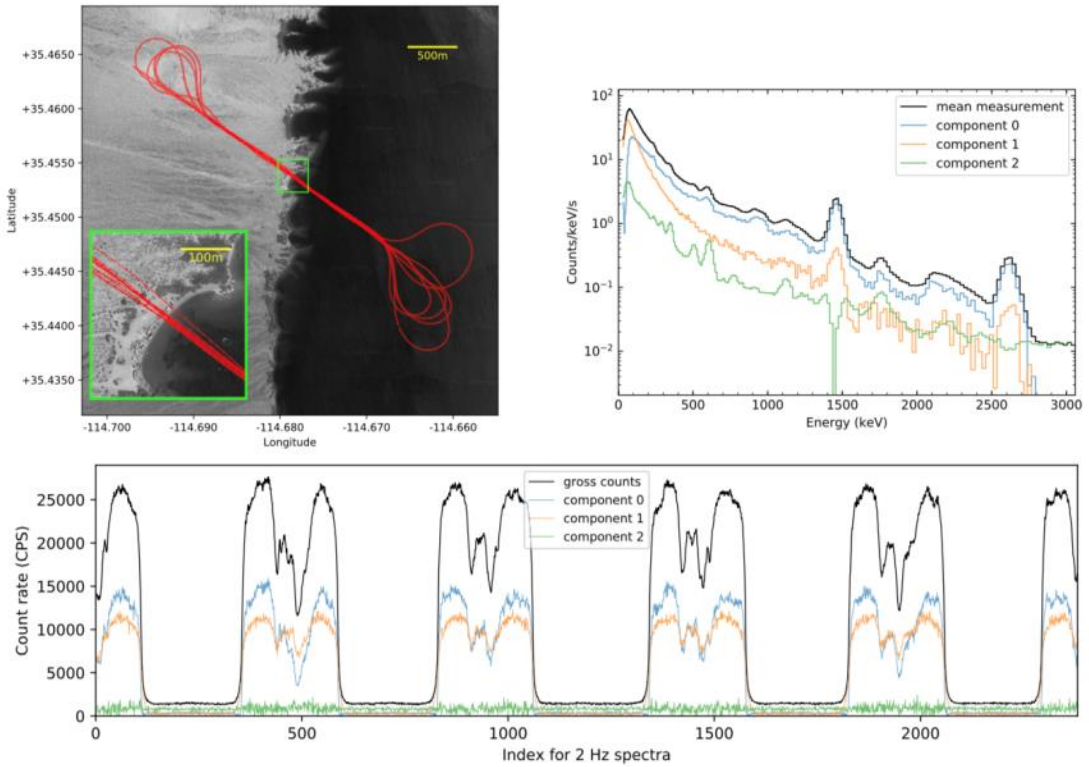
- Common features within the networks
- Have found through hyperpar opt that ensemble was in fact too large

Non-negative Matrix Factorization for Spectral Analysis

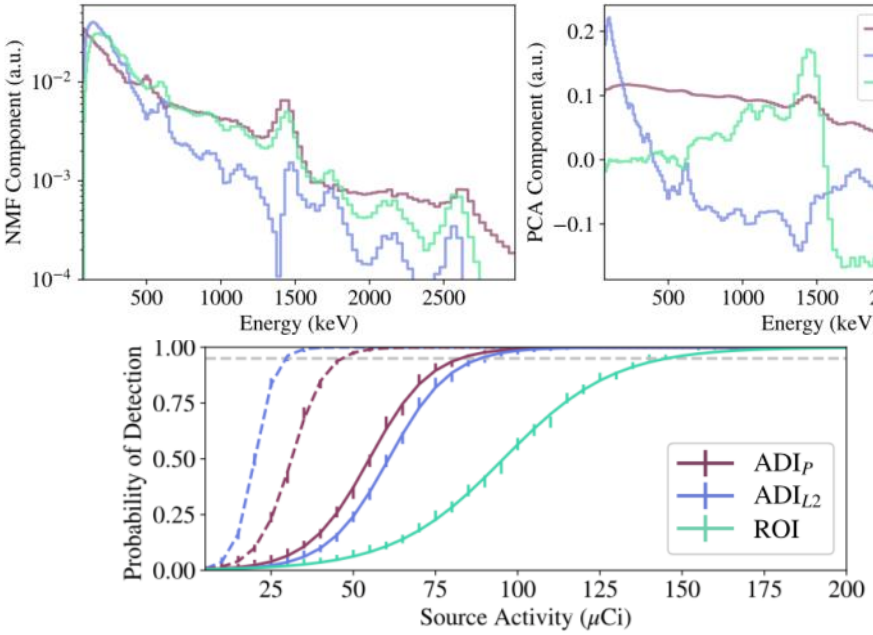
NMF is a principled approach to gamma-ray spectral analysis

- Low-rank model (limited variation in the environment)
- Non-negative (additive nature of flux field)
- Poisson loss function (matches counting statistics)
- Non-convex, solved via alternating ML-EM

Aerial background decomposition



Anomaly detection and identification



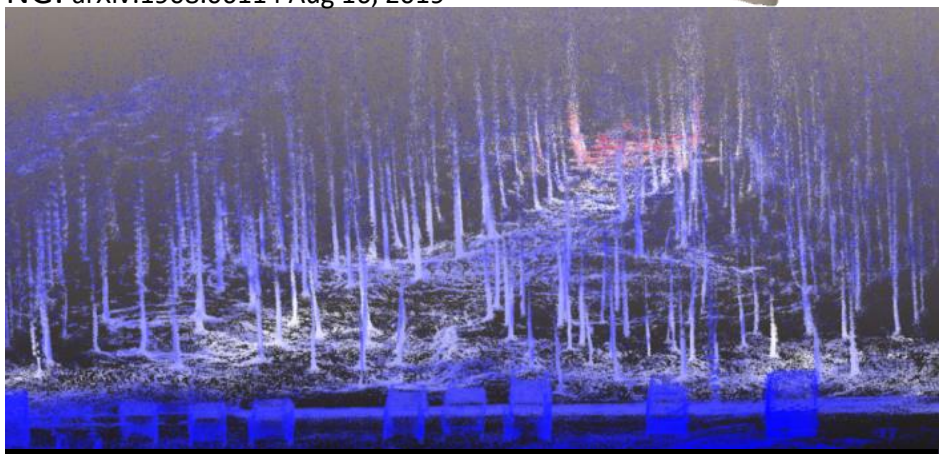
Aerial NMF: 10.1109/TNS.2020.2978798
Correlation of Bkg w/ Imagery: 10.1109/NSS/MIC42101.2019.9059803
Anomaly Detection and Identification: 10.1109/TNS.2019.2907267

3D Scene Data Fusion

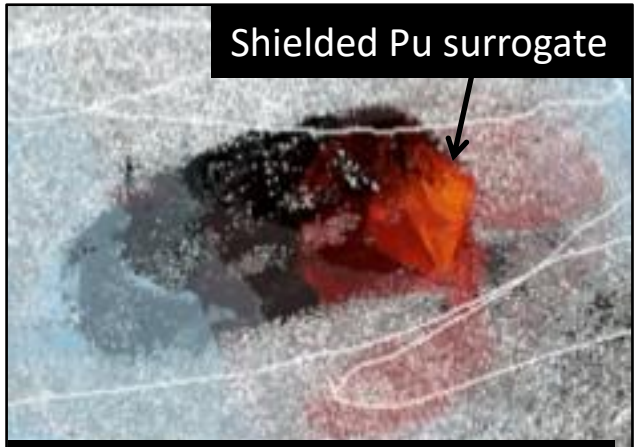
Fuse radiological and contextual data to localize and map radiological material in 3D in real-time

SDF Concept:, doi:10.1016/j.nima.2015.08.016.
doi.org/10.3390/s19112541

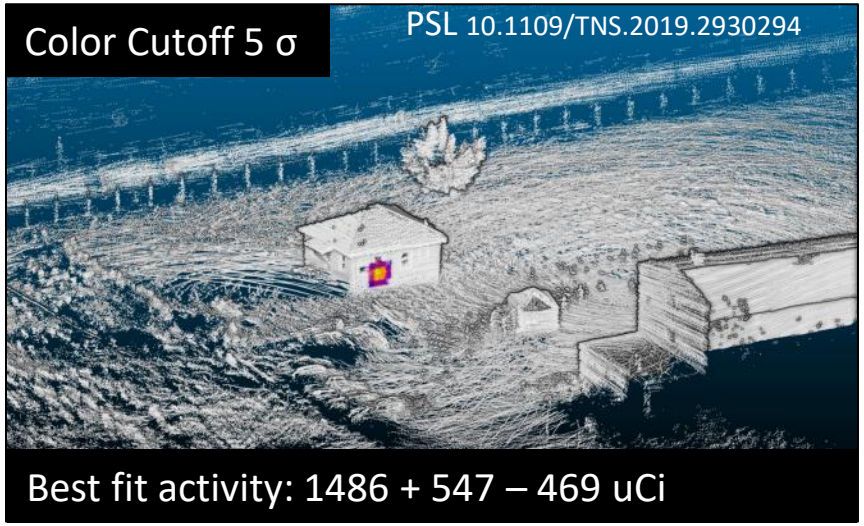
NG: arXiv:1908.06114 Aug 16, 2019



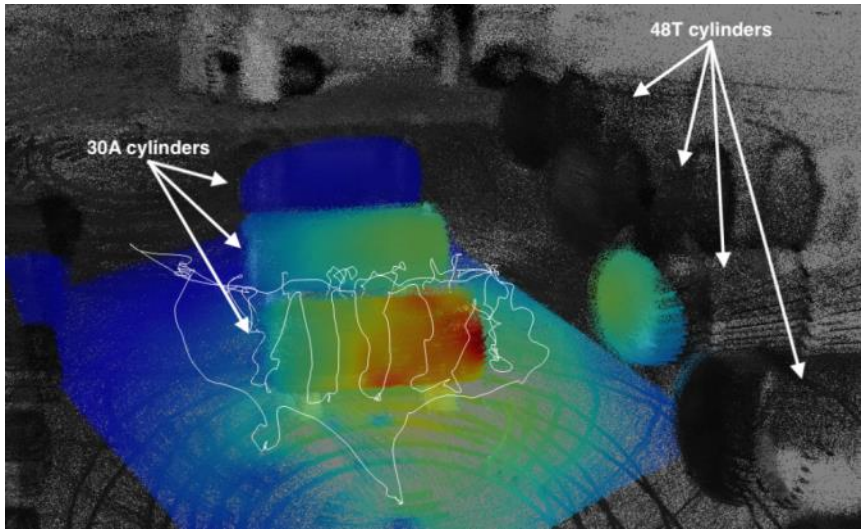
Mapping fallout in contaminated Fukushima forest



Concurrent neutron/γ sensitivity



Best fit activity: 1486 + 547 – 469 uCi



MiniPRISM: R. T. Pavlovsky, IEEE Nuclear Science Symposium, Manchester, UK, #R-11-01, 26 October - 2 November, 2019.

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Thank you!

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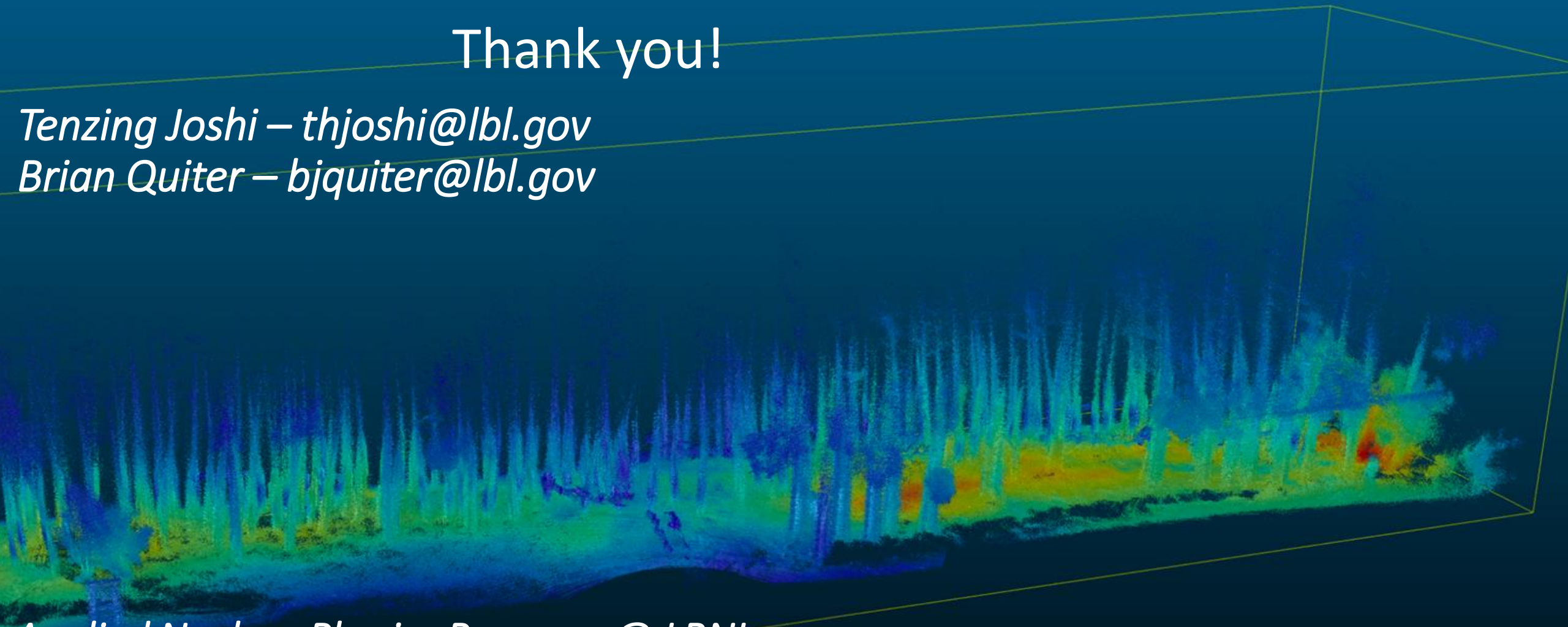

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