# The Mobile Antineutrino Demonstrator Project

## Goal: Develop & construct a readily mobile aboveground ton-scale antineutrino detector system to advance neutrino applications


Nathaniel Bowden, *Lawrence Livermore National Laboratory*

*on behalf of the Mobile Antineutrino Demonstrator Project*

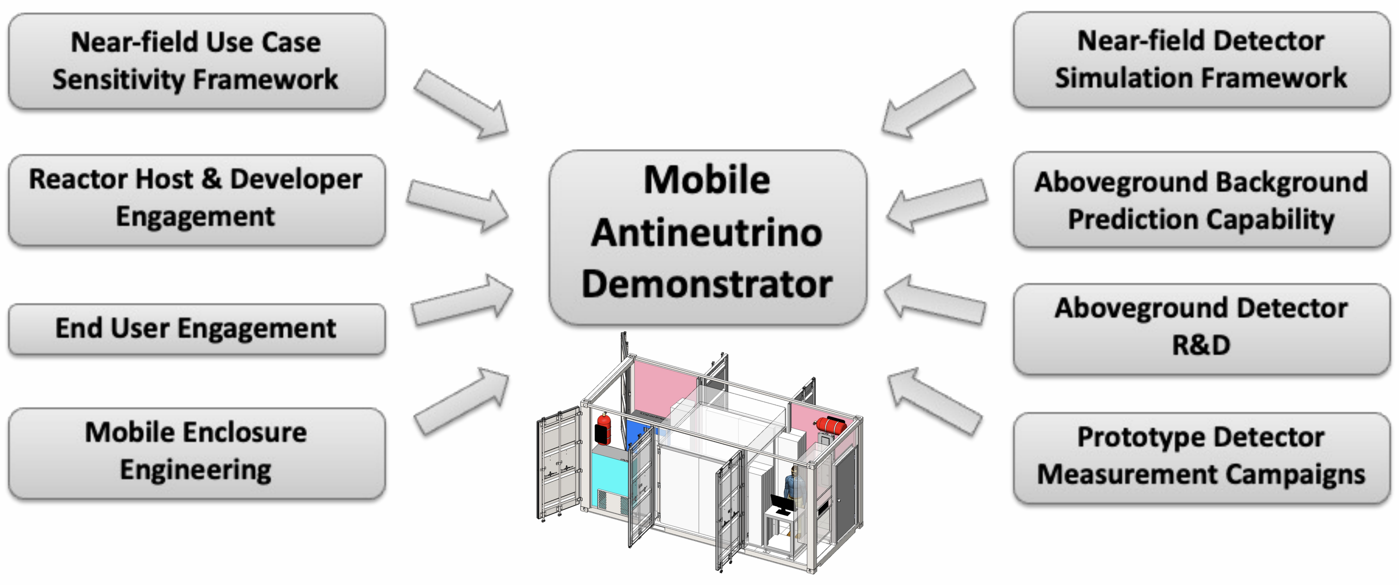

## Introduction

The Mobile Antineutrino Demonstrator will:

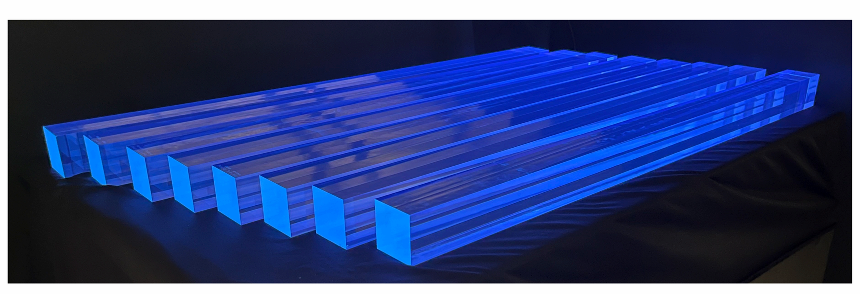
- require no infrastructure beyond power & deployment footprint
- operate aboveground without significant shielding
- incorporate potential end-user input
- advance "Technical Readiness" of neutrino applications by performing capability demonstrations in operationally relevant environments

Timeline:

- 2022-2023: Detector concept R&D, potential host and end-user engagement
- 2023-2024: Technology selection, system design, construction & commissioning



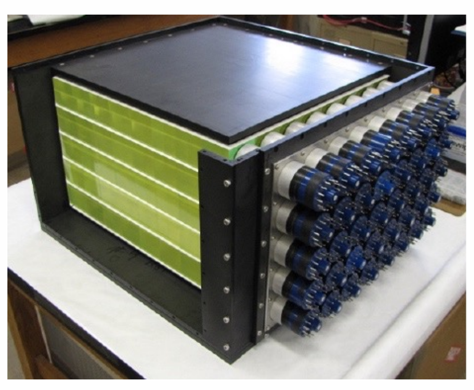

## Advancing Two Solid-State Detection Technologies



*2D segmentation using*
*$^6$Li-doped PSD plastic scintillator*

- *Novel material*
- *IBD analysis based on PROSPECT*

arxiv:2405.19573



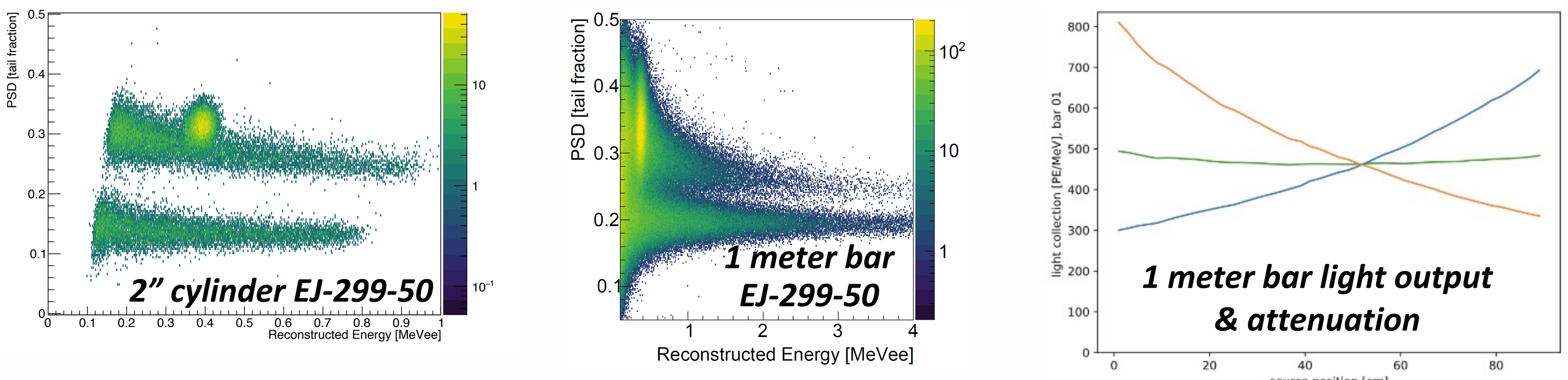
*3D segmentation using*
*$^6$LiZnS & WLS plastic (CHANDLER)*

- *Mature COTS materials*
- *Novel 3D reco & topological analysis*

https://doi.org/10.1103/PhysRevApplied.13.034028

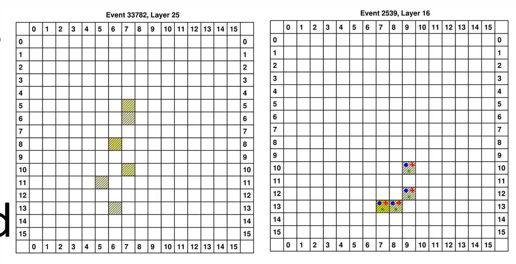
## 2D Concept R&D Focus:
## Large-scale EJ-299-50 $^6$Li-doped PSD Plastic *(See Poster 471)*

- Light output (~65% of EJ-200), PSD, meter-scale attenuation length
- No significant performance degradation over 6-12 month time-scales
- Mechanical properties suitable for ton-scale detector construction
- Some precipitation of primary dye observed; address via packaging

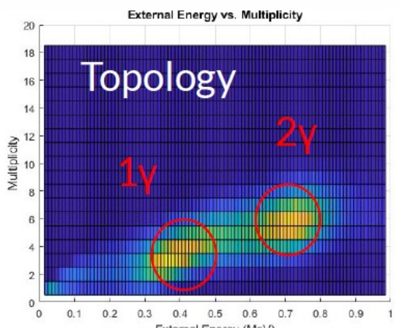



## 3D Concept R&D Focus:
## 3D Reconstruction & Topological Event Selection

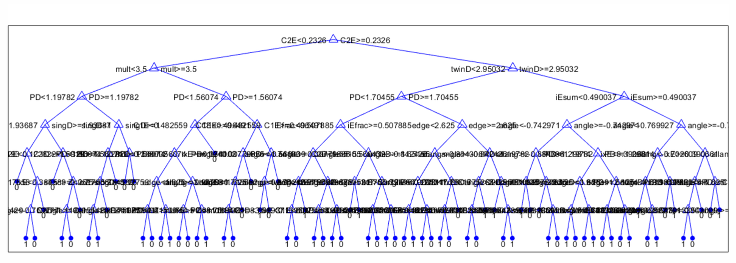
- 3D reco uses light profiles measured using vertical muons
- Best-fit hit pattern found via superposition of measured responses and minimization of weighting factors
- Multiple observables for identifying IBD events developed using topology, energy, and pulse shape
- Classification and Regression Trees (CART) algorithm used to explore event selection in complex multivariate space

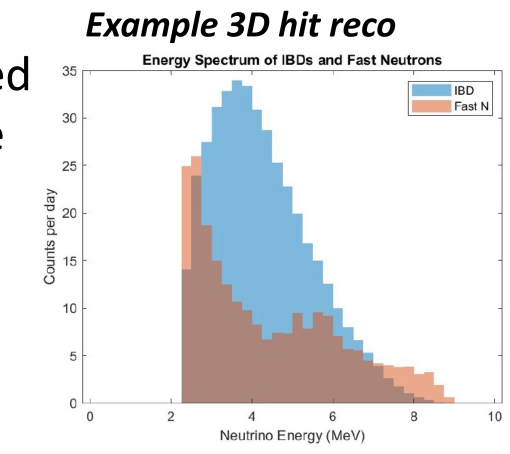


*Example 3D hit reco*




*Example topology based observable*






*Predicted 3D subsystem signal/background*

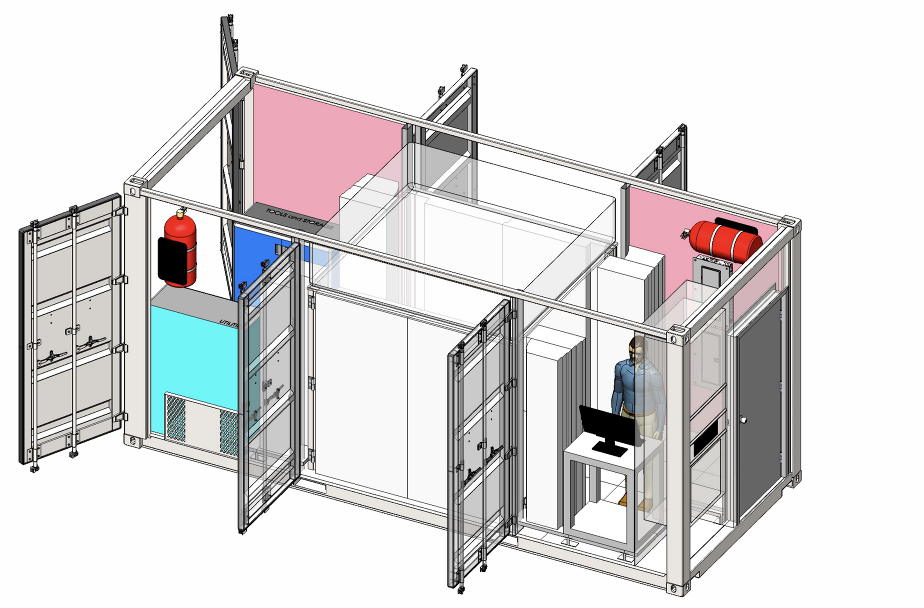
## Engagement with Potential End-Users, Reactor Sites, & Other Mobile Projects

Important Utility and Logistical Topics:

- Reliability
- Demonstration fidelity
- Security inspection for PA access
- Fire Suppression
- Environmental Control
- Safety & Mechanical Assessment
- Physical Site & System Access

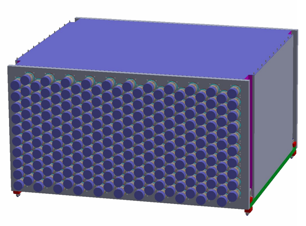

## Mobile Enclosure

- compliance with host requirements for safety, security, and inspections
- environmental control, power distribution, and connectivity
- modest detector shielding
- safe detector transport

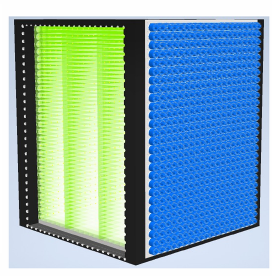


## R&D Phase established two concepts with good performance

Predicted sensitivity comparable for systems within project budget envelope

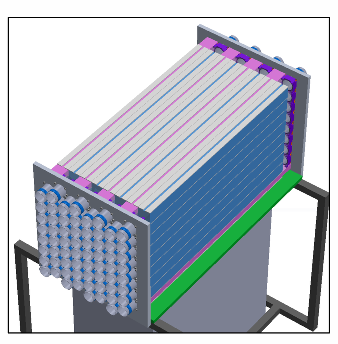


| Concept | $x$ | $y$ | $z$ | Volume | Elements | PMTs | "Eff. Counts" |
|---|---|---|---|---|---|---|---|
| 2D | 14 bars<br>84.0 cm | 14 bars<br>84.0 cm | -<br>100 cm | 0.71 $m^3$ | 196 | 392 | 130 $day^{-1}$ |
| 3D | 16 cubes<br>92.8 cm | 16 cubes<br>92.8 cm | 41 ½-cubes<br>116.9 cm | 1.01 $m^3$ | 10,496 | 1,344 | 131 $day^{-1}$ |

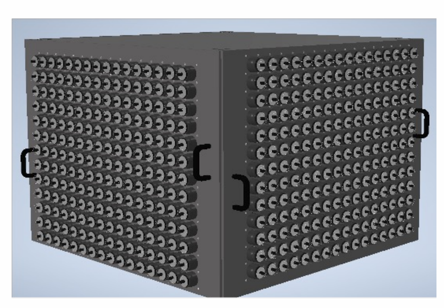


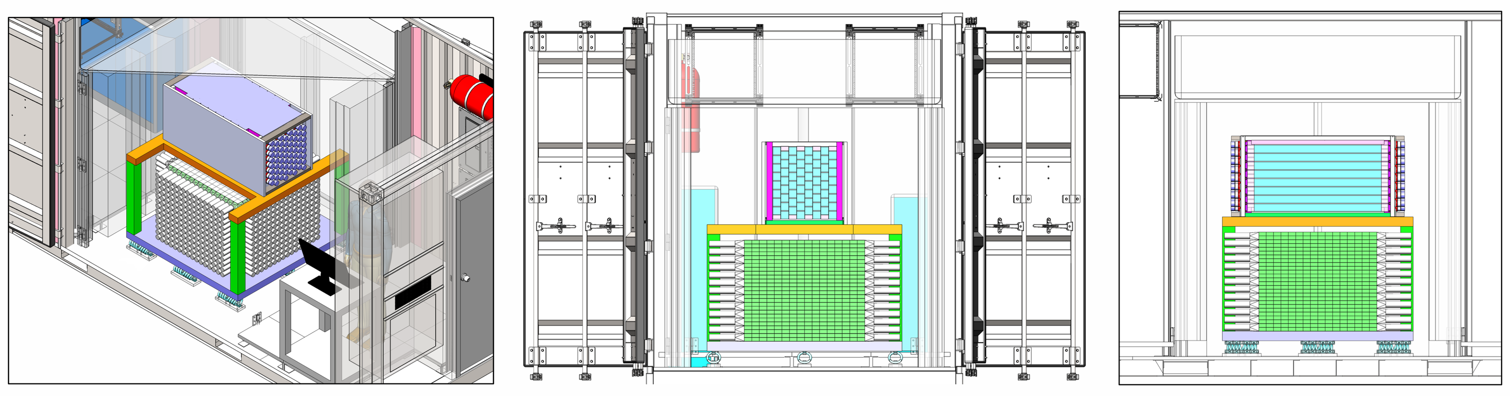
- Residual technical risks for both concepts most effectively resolved through build out at larger scale
- Neither relative performance nor technical considerations provided a strong preference for either concept

MAD will be equipped with two detector subsystems



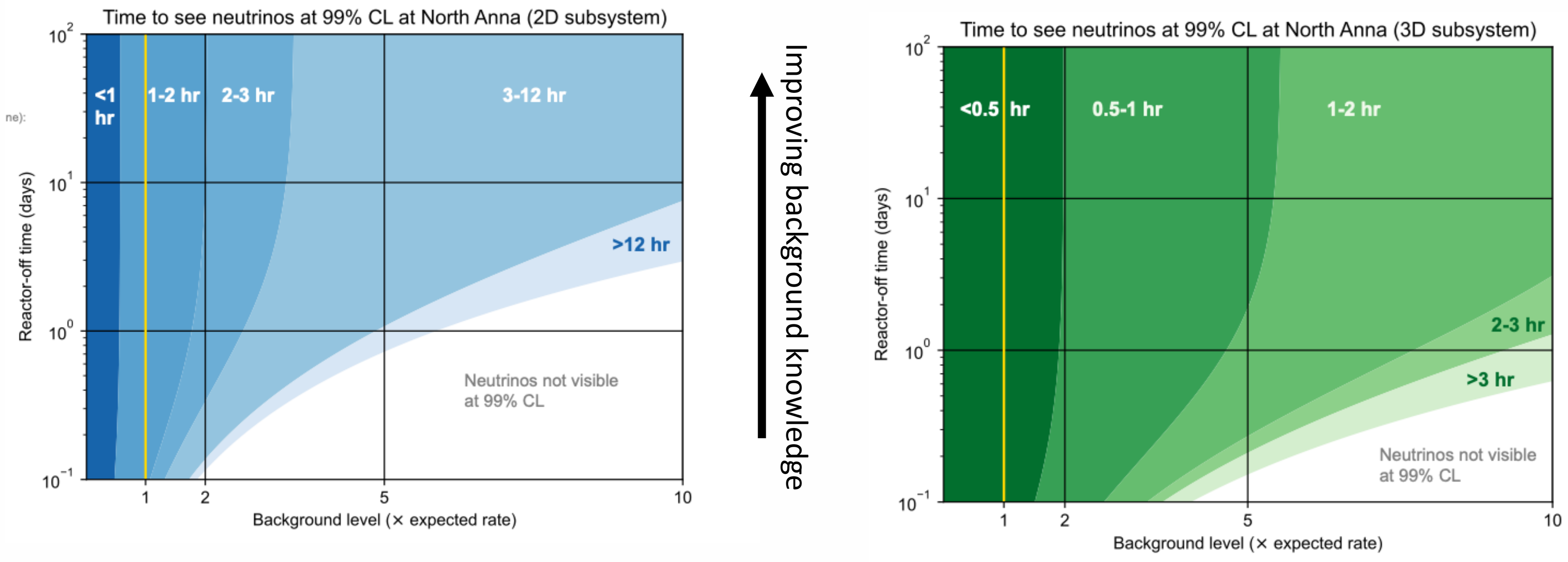
| Concept | $x$ | $y$ | $z$ | Volume | PMTs |
|---|---|---|---|---|---|
| 2D | 8 bars<br>48.0 cm | 8 bars<br>48.0 cm | -<br>100 cm | 0.23 $m^3$ | 128 |
| 3D | 16 cubes<br>92.8 cm | 16 cubes<br>92.8 cm | 25 ½-cubes<br>73 cm | 0.61 $m^3$ | 832 |





## Example Performance Prediction

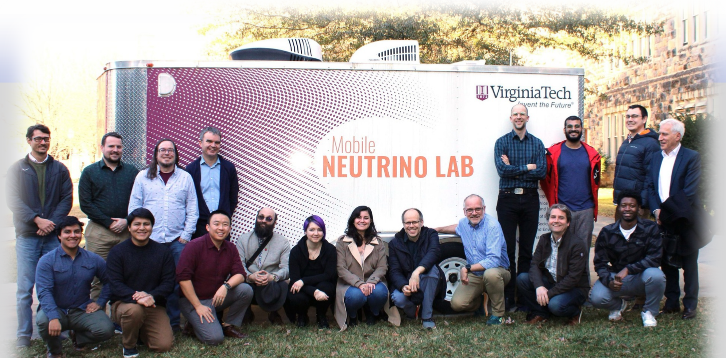
During an aboveground deployment 25m from a 3GW reactor, On-Off observation expected within hours even if backgrounds higher than predicted




Both subsystems will be able to reactor antineutrino detection capability demonstrations and advance the technology concepts

## PARTICIAPTING INSTITUTIONS

Georgia Tech · Illinois Institute of Technology · Lawrence Livermore National Laboratory · Oak Ridge National Laboratory · NIST · USNA · Virginia Tech · Yale




LLNL-POST-865244 This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.