



# Progress of Tripwire: Multi-Modal Distributed Sensing for Repository Verification

July 2022

*Changing the World's Energy Future*

Luis A Ocampo Giraldo, Scott J Thompson, Jay D Hix, James T Johnson,  
David L Chichester



**DISCLAIMER**

This information was prepared as an account of work sponsored by an agency of the U.S. Government. Neither the U.S. Government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness, of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. References herein to any specific commercial product, process, or service by trade name, trade mark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Government or any agency thereof.

# **Progress of Tripwire: Multi-Modal Distributed Sensing for Repository Verification**

**Luis A Ocampo Giraldo, Scott J Thompson, Jay D Hix, James T Johnson, David L  
Chichester**

**July 2022**

**Idaho National Laboratory  
Idaho Falls, Idaho 83415**

**<http://www.inl.gov>**

**Prepared for the  
U.S. Department of Energy  
Under DOE Idaho Operations Office  
Contract DE-AC07-05ID14517**

63rd INMM Annual Meeting

July 25, 2022

# Progress of Tripwire: Multi-modal Distributed Sensing for Repository Verification

Luis Ocampo Giraldo

David Chichester

Scott Thompson

James Johnson

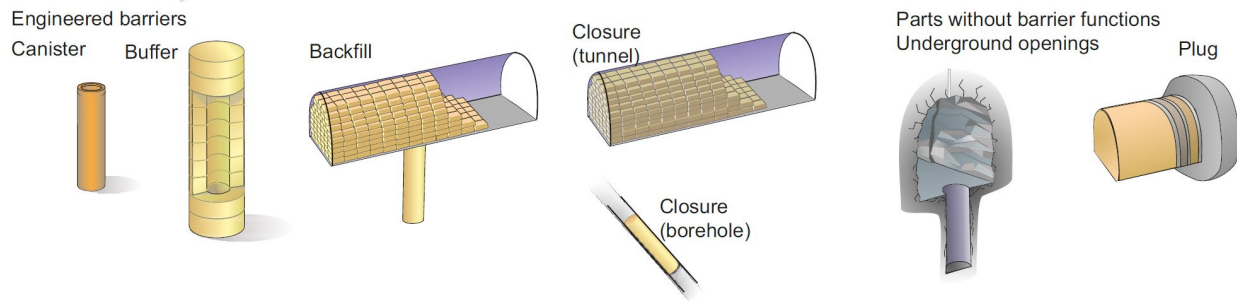
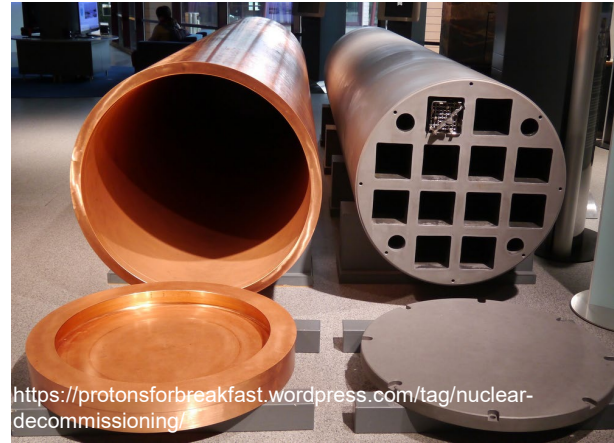
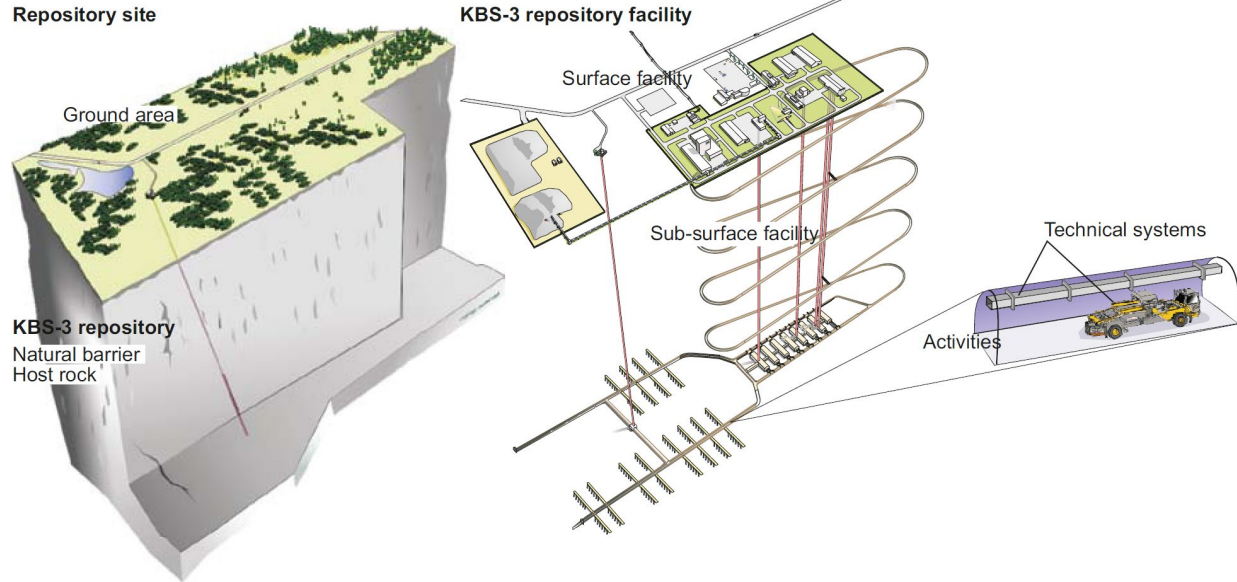
Jay Hix

INL is managed by Battelle Energy Alliance  
for the US Department of Energy



Idaho National Laboratory

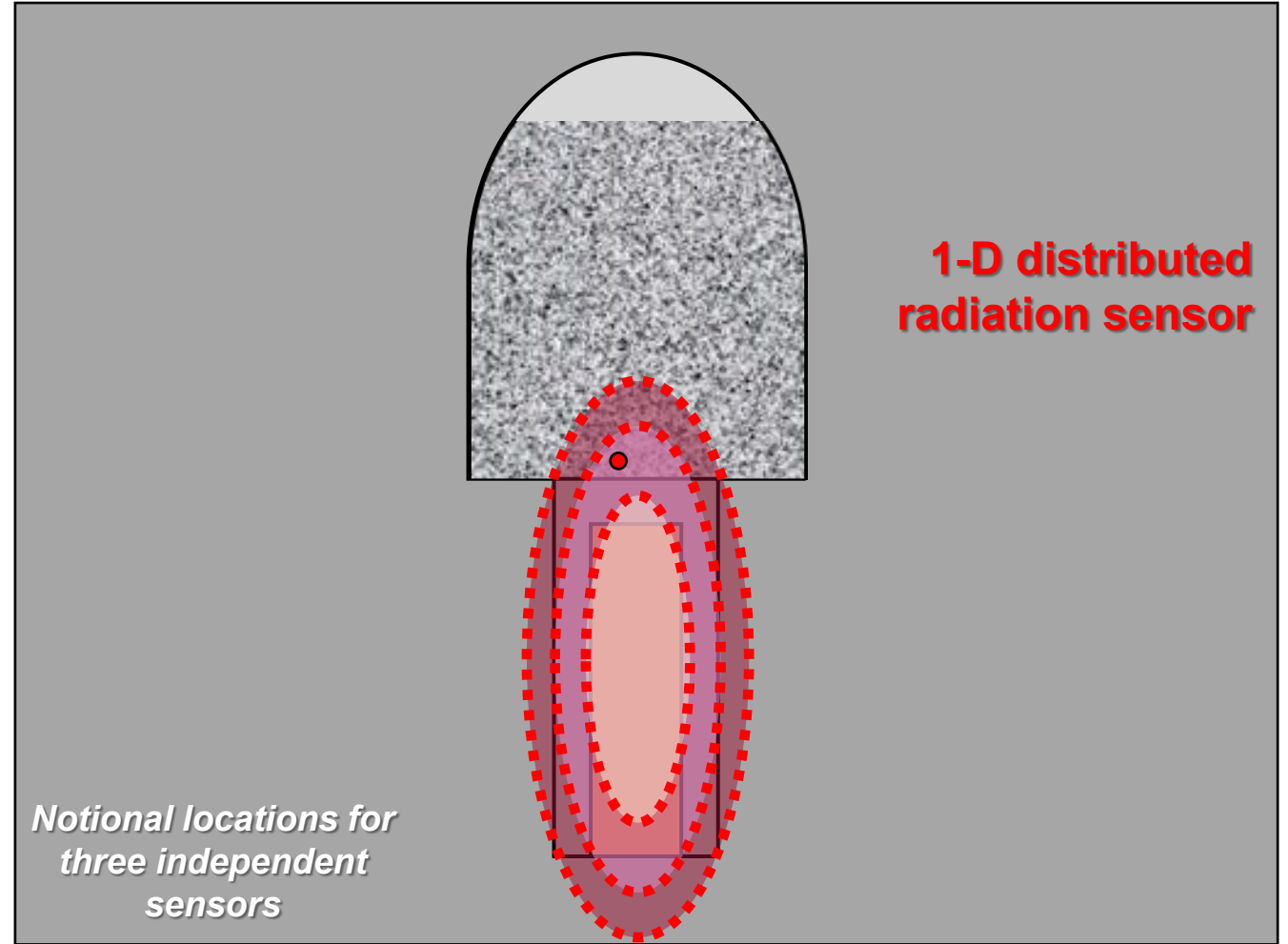
# One Proposed Repository Approach



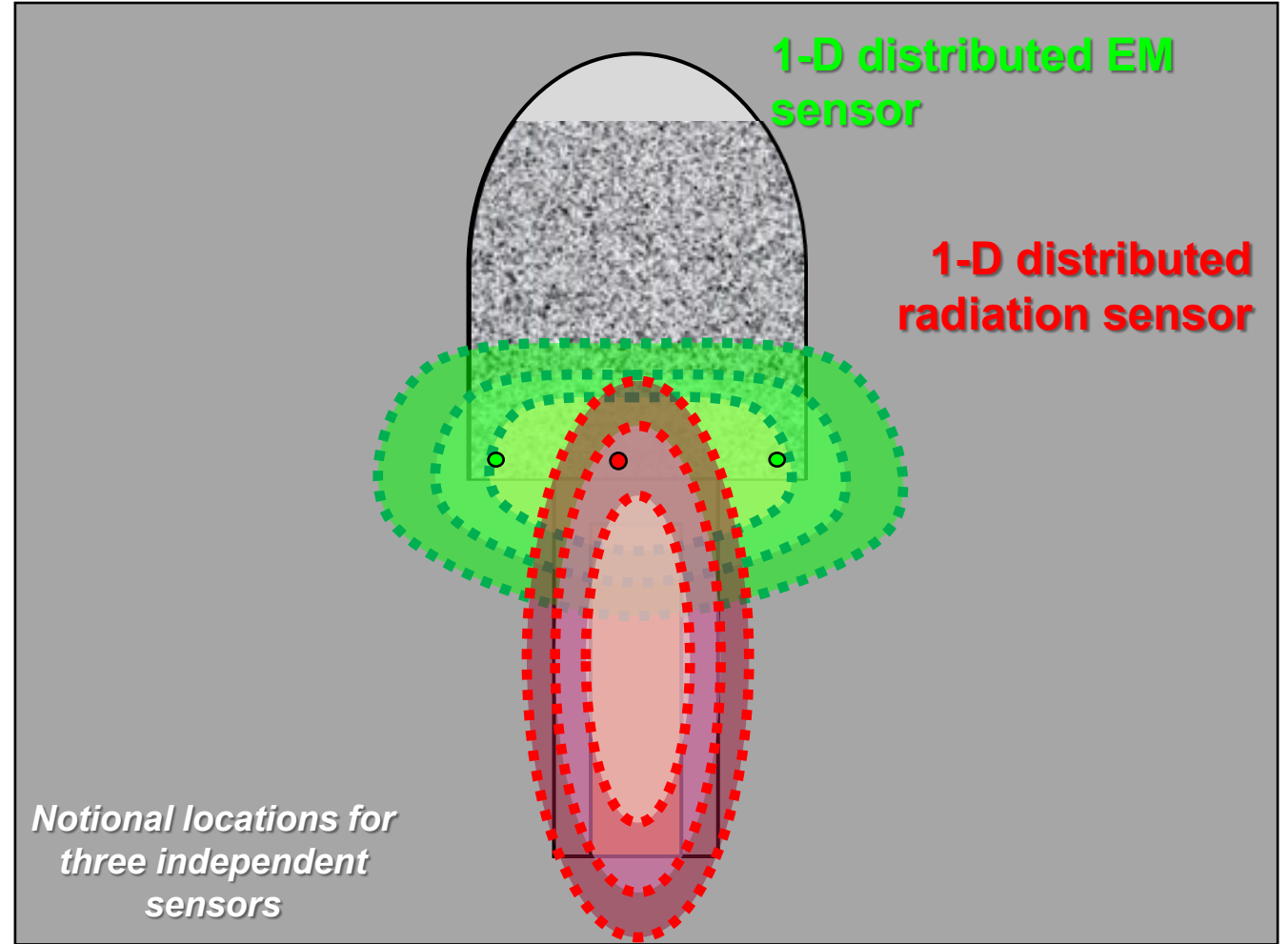
KBS-3 repository by the Swedish Nuclear Fuel and Waste Management Company



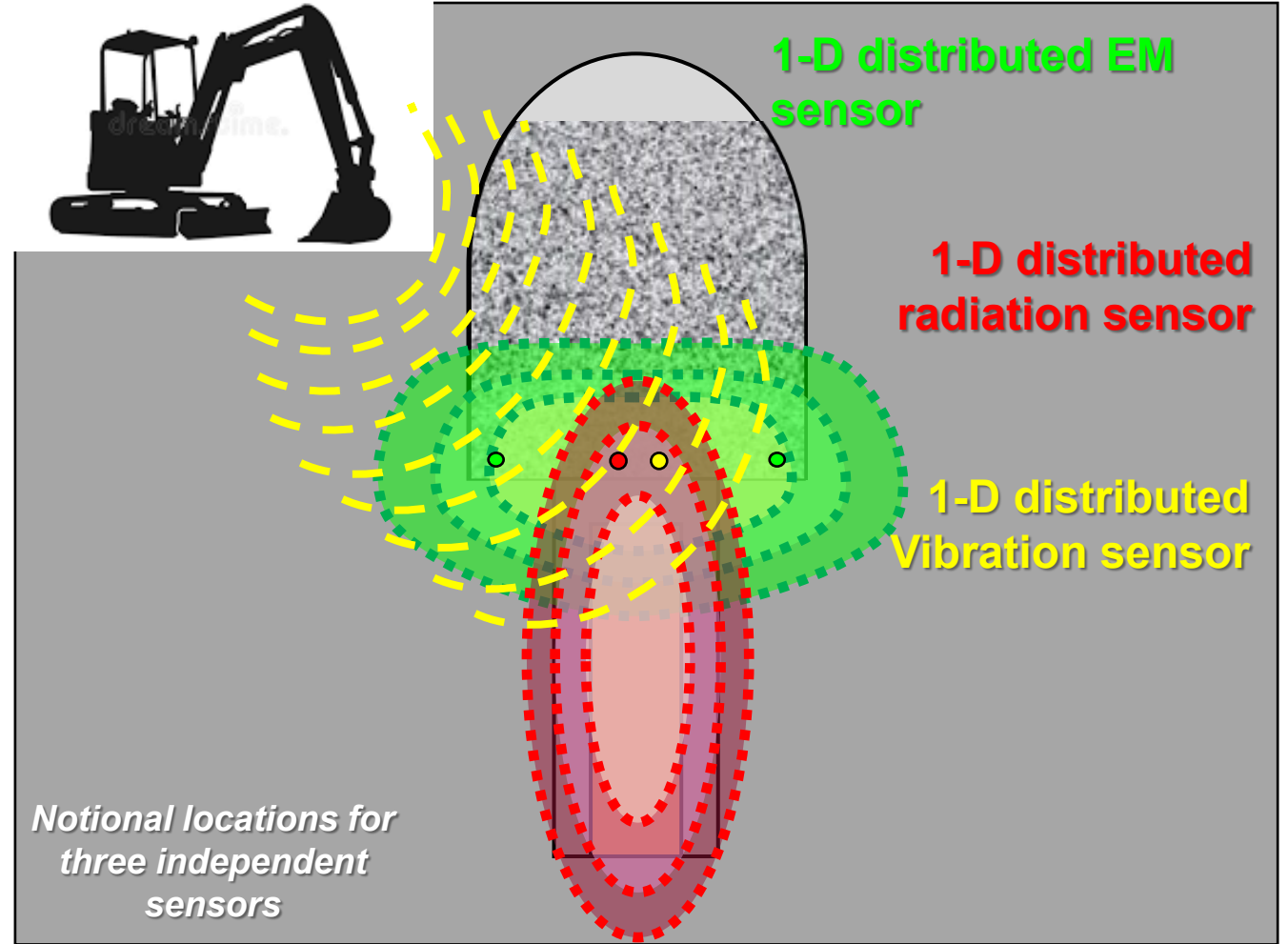
# TRIPWIRE Sensor Deployment Concept



# TRIPWIRE Sensor Deployment Concept



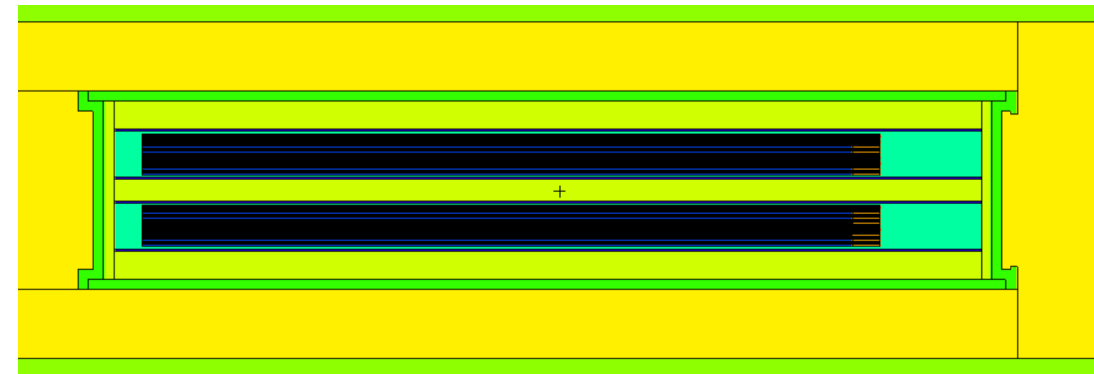
# TRIPWIRE Sensor Deployment Concept



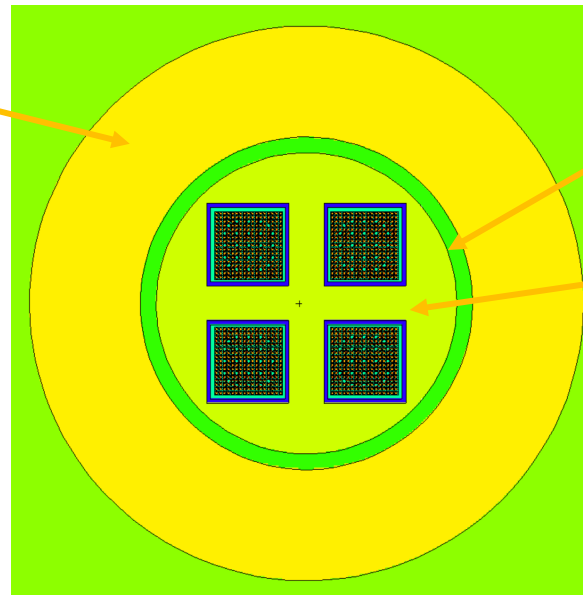
# MCNP6 Simulations

The spent filled cannister has been modeled using the spent fuel library from the Next Generation Safeguards Initiative burnup calculations

- A single assembly was chosen and inserted into all 4 cavities in the cassette
  - 17x17 PWR assembly
  - 5% Initial Enrichment
  - 60 GWD Burnup
  - 80-year Cool
  - Removed water surrounding pins before insertion



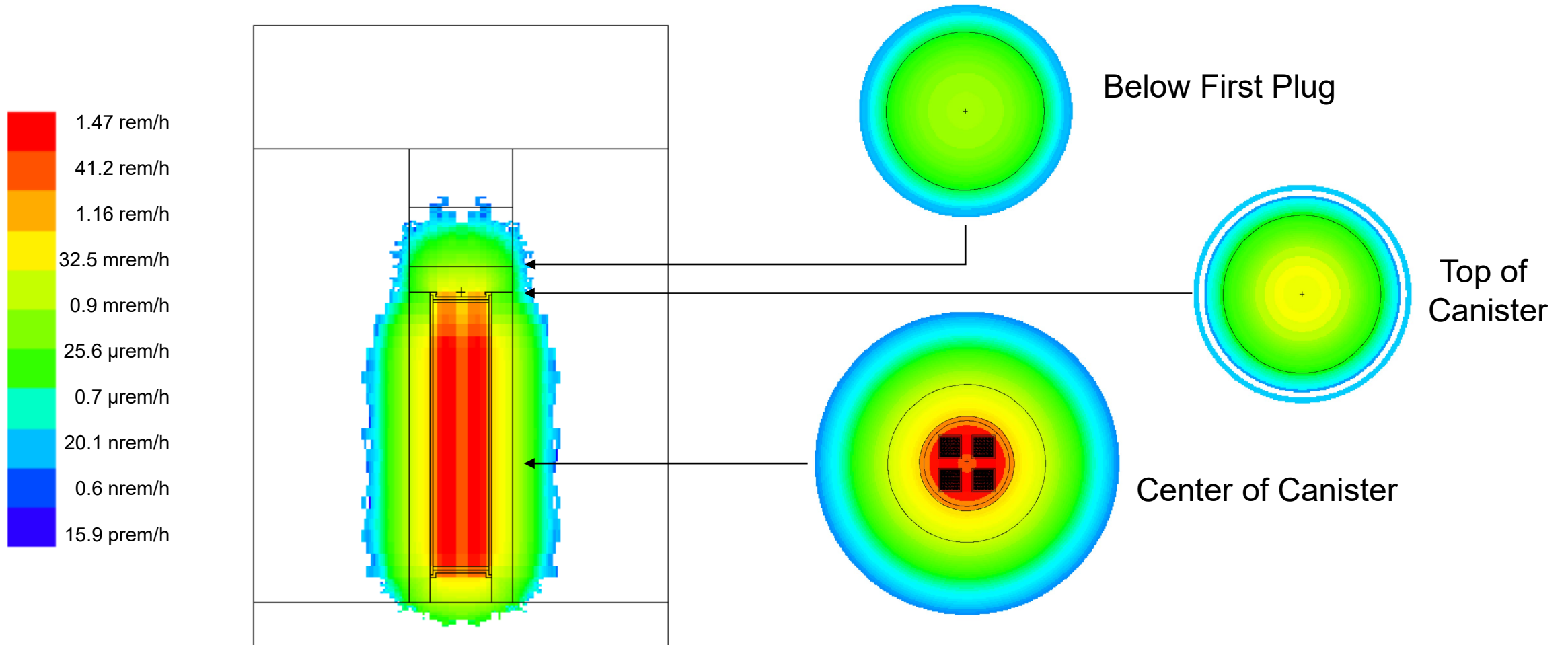
Wyoming MX-80 Bentonite



Copper Canister

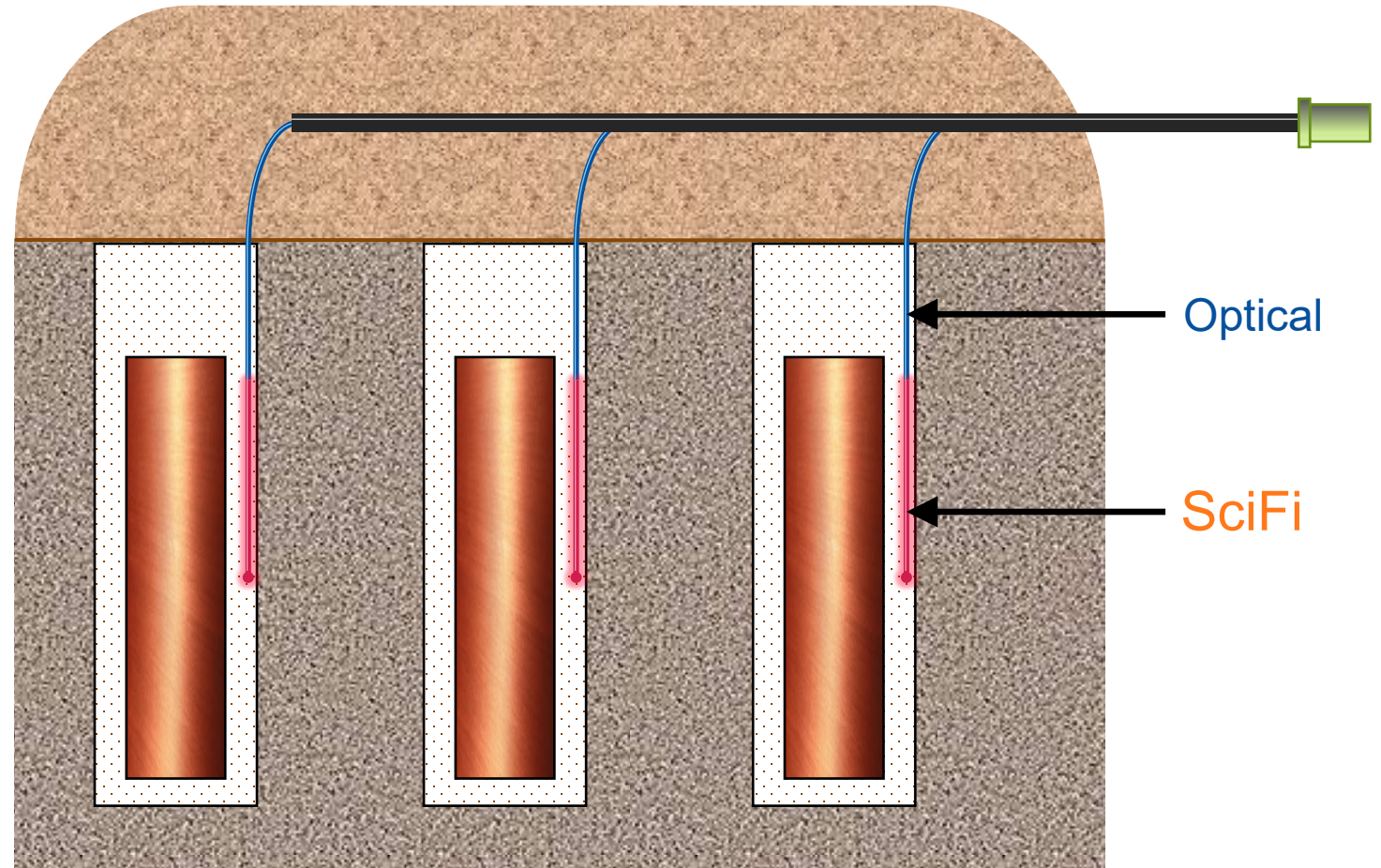
Cast Iron Cassette

# MCNP6 Simulation Results



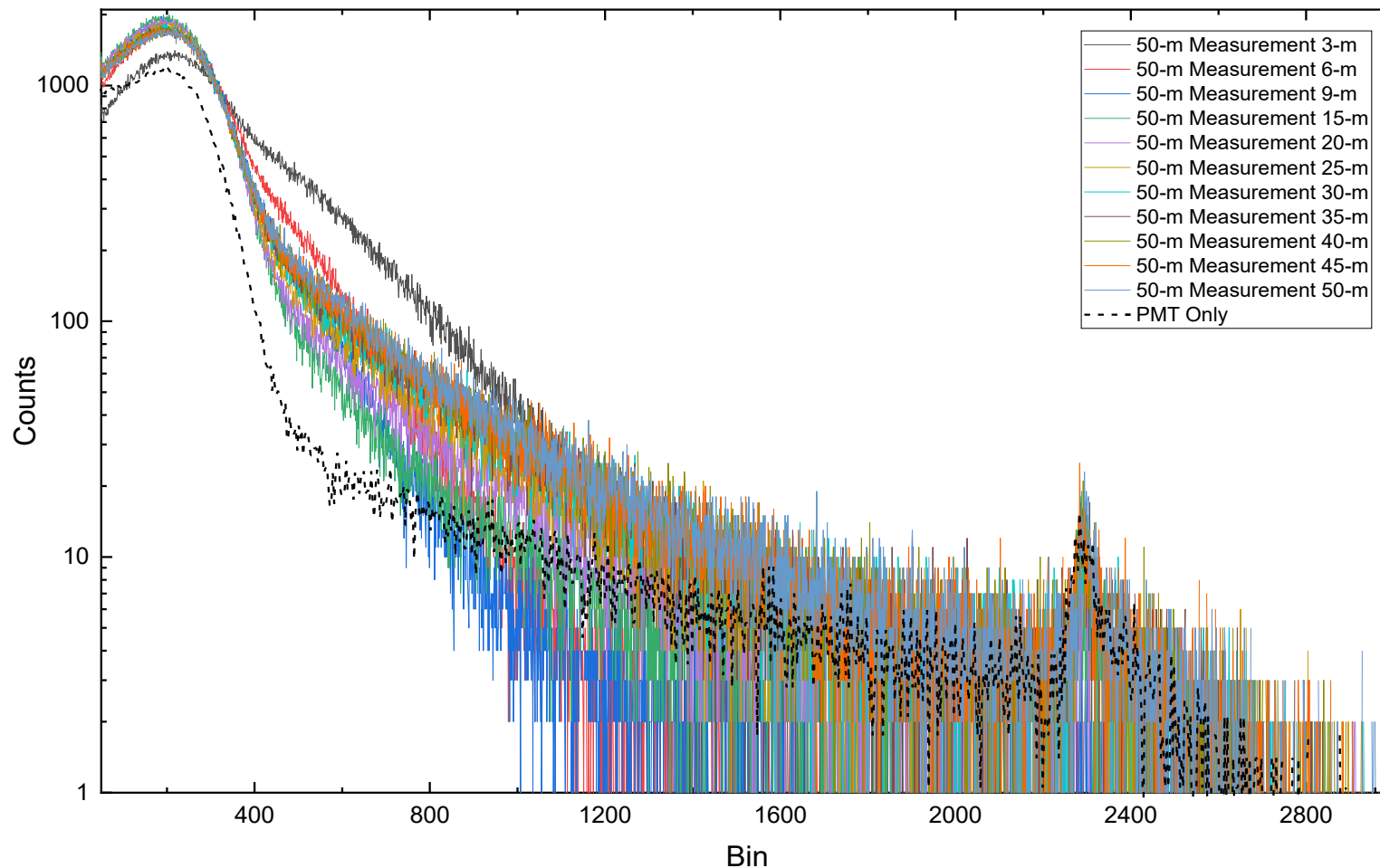
# Alternative CONOPS

- Shorter SciFi Segments coupled to the end of long optical fiber
- Sensitive end can be dropped down the buffer cavity surrounding each canister
- SciFi portion of TRIPWIRE at Onkalo becomes a bundle of 30 fibers that connect to a single PMT



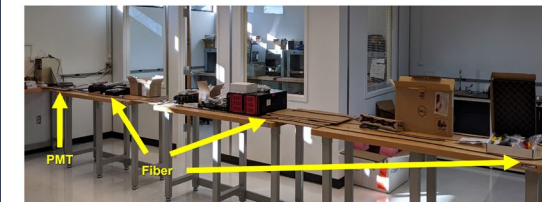
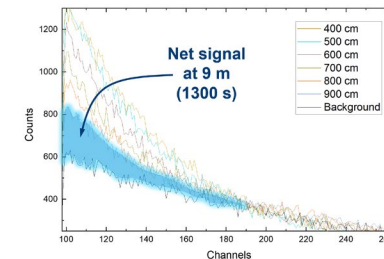
# Long-length Fiber Testing - 50-m Fiber

Testing the 50-m fiber to further understand the distance limitations of the updated laboratory set-up

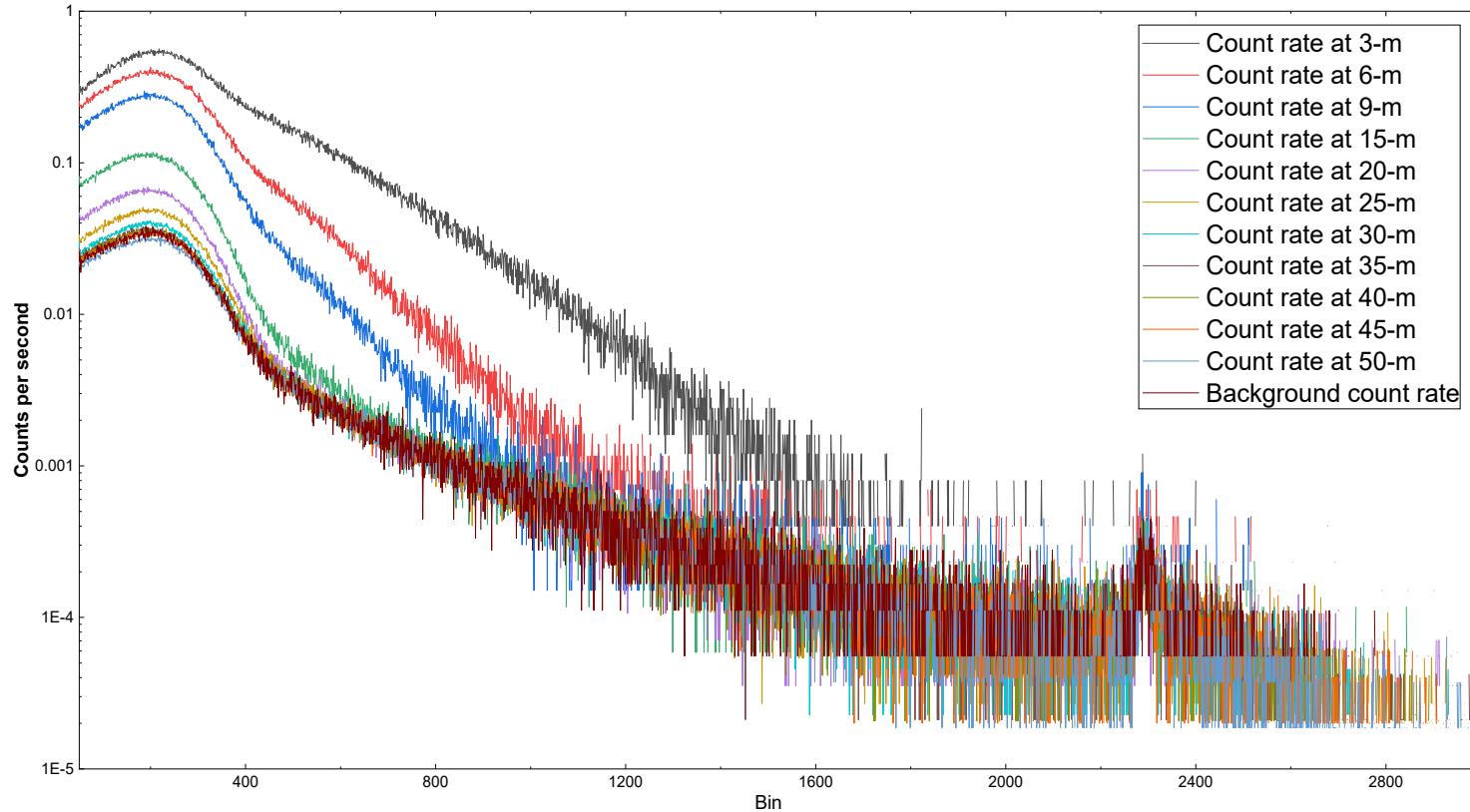


## Test Results – 10 m

- Studying light attenuation and signal strength at distances beyond 3 m
- Measurements were conducted in 100-cm increments along the length of the fiber
- Measurement time: 1300 s

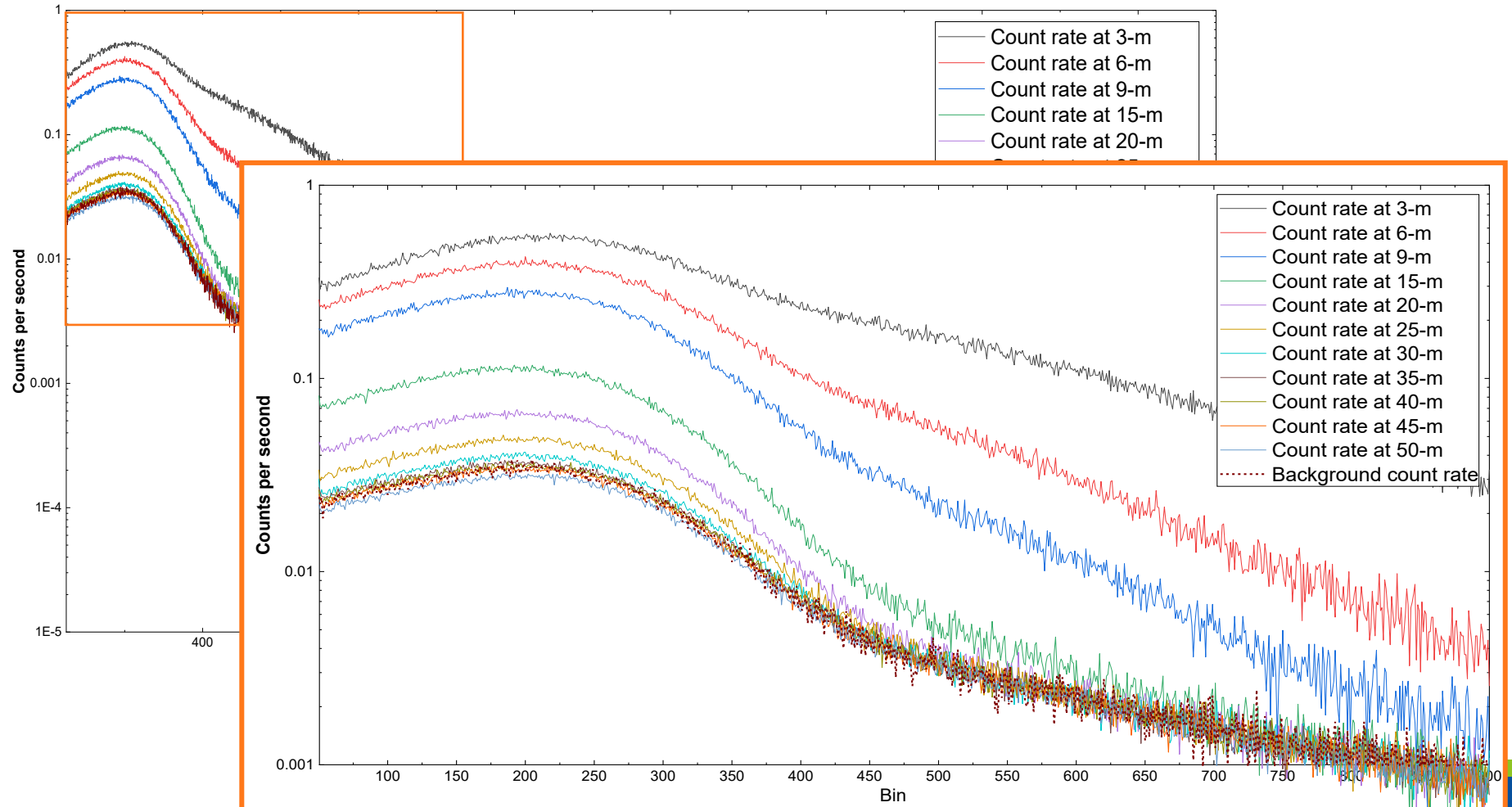


# Long-length Fiber Testing - 50-m Fiber

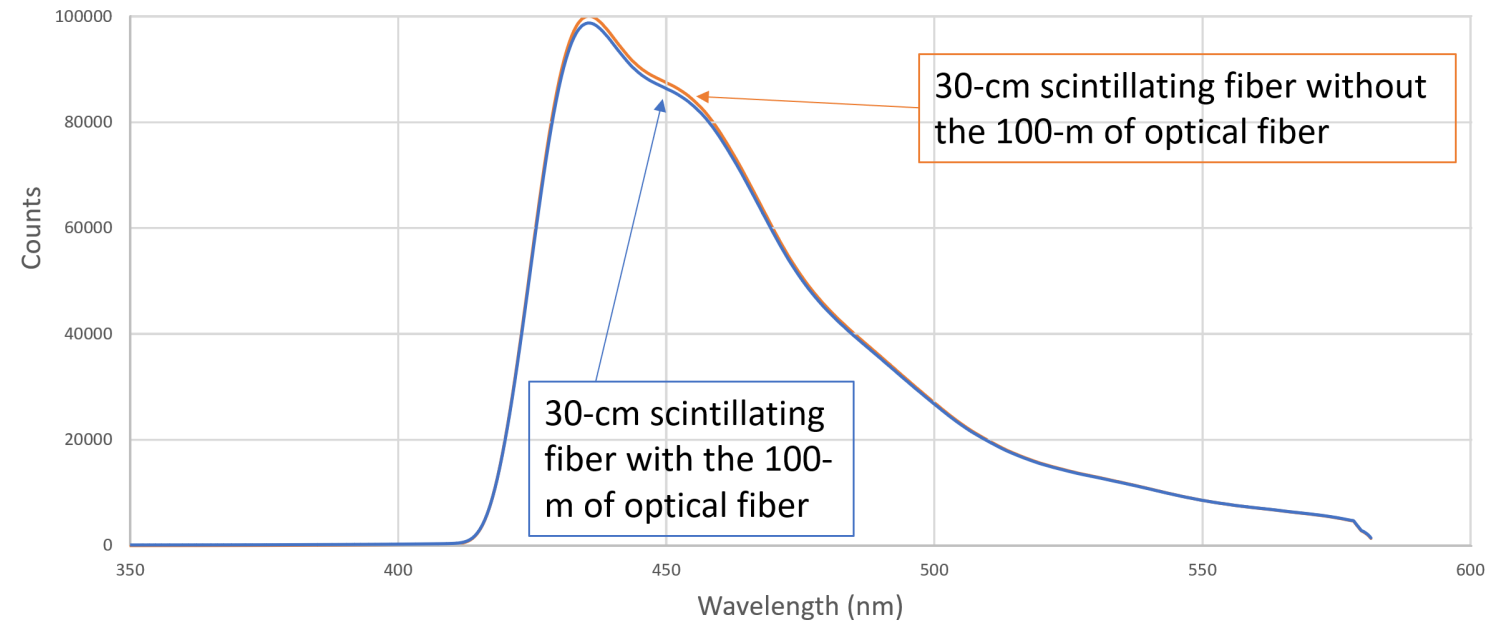
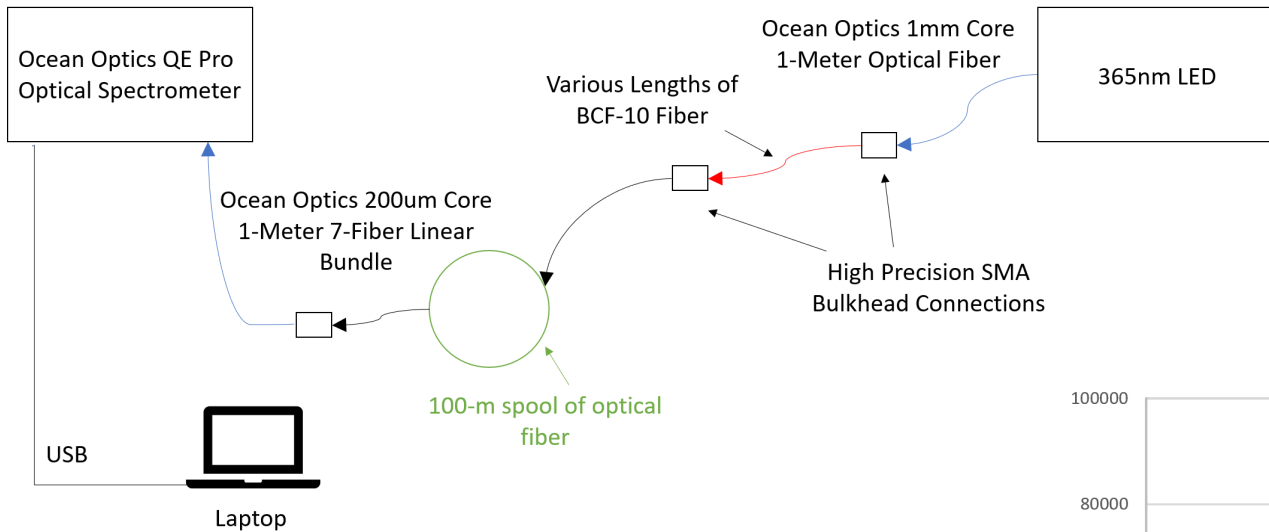


Distance (m)	Live time to record 500,000 in the region of interest
3	2495 seconds
6	72 minutes
9	1.9 hours
15	4.7 hours
20	7.8 hours
25	10.3 hours
30	12.2 hours

# Long-length Fiber Testing - 50-m Fiber

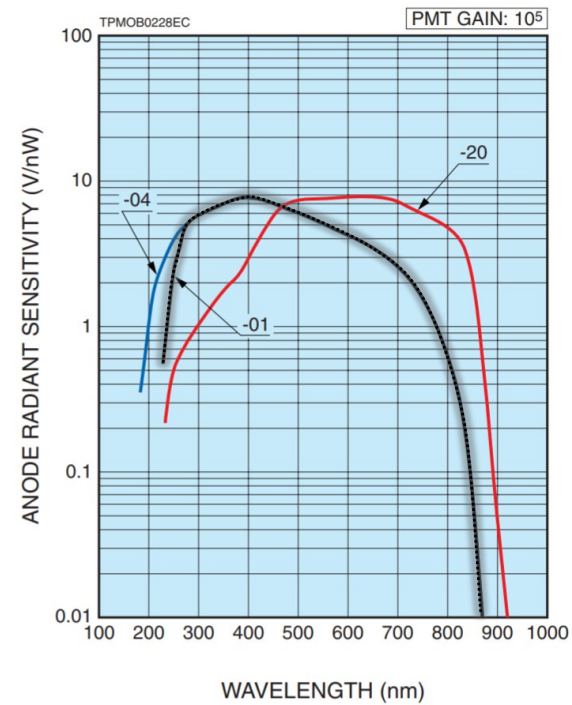


# Loss Due to Optical Fiber



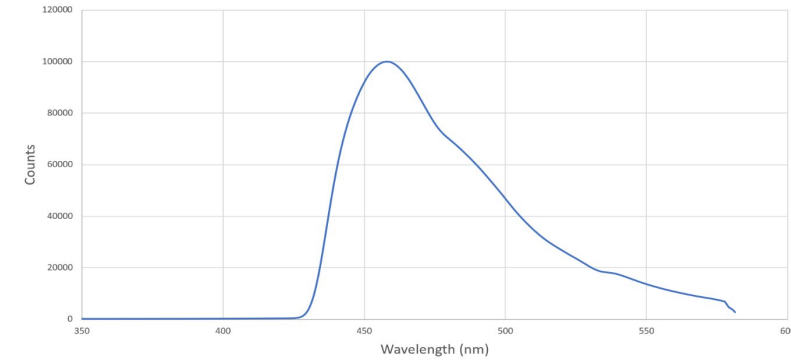
# Attenuation of Fiber Signal

Scintillating Fiber Length (BCF-10)	Measured Peak Emission
30 cm	435 nm
2 meters	463 nm
5 meters	458 nm
10 meters	463 nm
20 meters	493 nm
50 meters	519 nm/550 nm

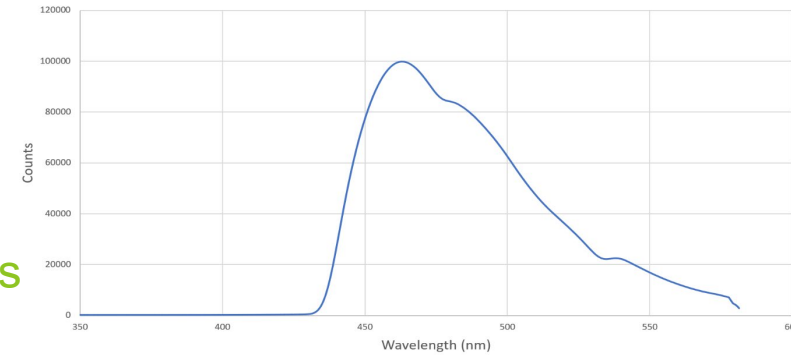


www.hamamatsu.com

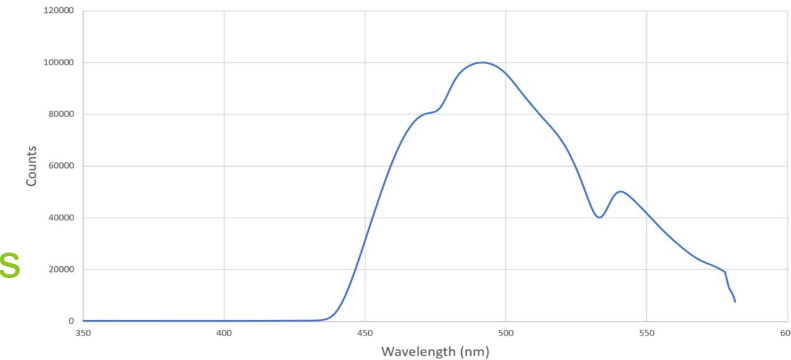
5 meters



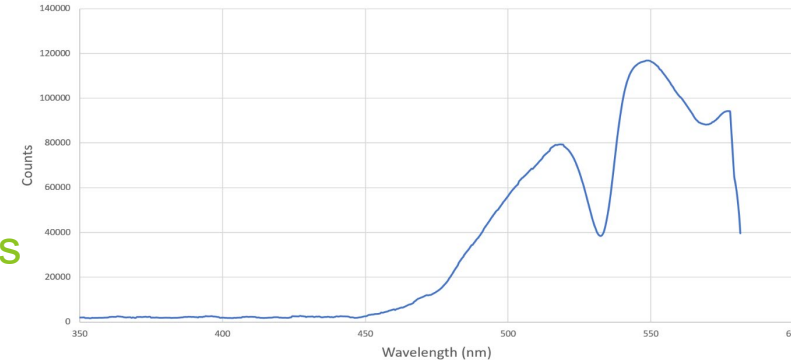
10 meters



20 meters



50 meters



# COTS Equipment and Alarm Station Concept



Current Events History ■ Stop

### System Events

Date & Time (UTC)	Event
20211118 21:34:00	SF Counting Started 10.0
20211118 21:34:00	SF Data Saved: TW-211118_213400.SPE
20211118 21:33:59	Low CPS 0.00
20211118 21:33:49	SF Counting Started 10.0
20211118 21:33:49	SF Data Saved: TW-211118_213349.SPE
20211118 21:33:38	SF Counting Started 10.0
20211118 21:33:38	SF Data Saved: TW-211118_213338.SPE
20211118 21:33:28	SF Counting Started 10.0
20211118 21:33:28	SF Data Saved: TW-211118_213328.SPE
20211118 21:33:17	SF Counting Started 10.0
20211118 21:33:17	SF Data Saved: TW-211118_213317.SPE

### PCC Alarms

**Alarm A**

OK

Reset

**Alarm B**

OK

Reset

**Tamper Alarm**

OK

Reset

**Fail Alarm**

OK

Reset

**Radiation Alarms**

**Temperature Alarm**

21.7

Reset

**LOW CPS**

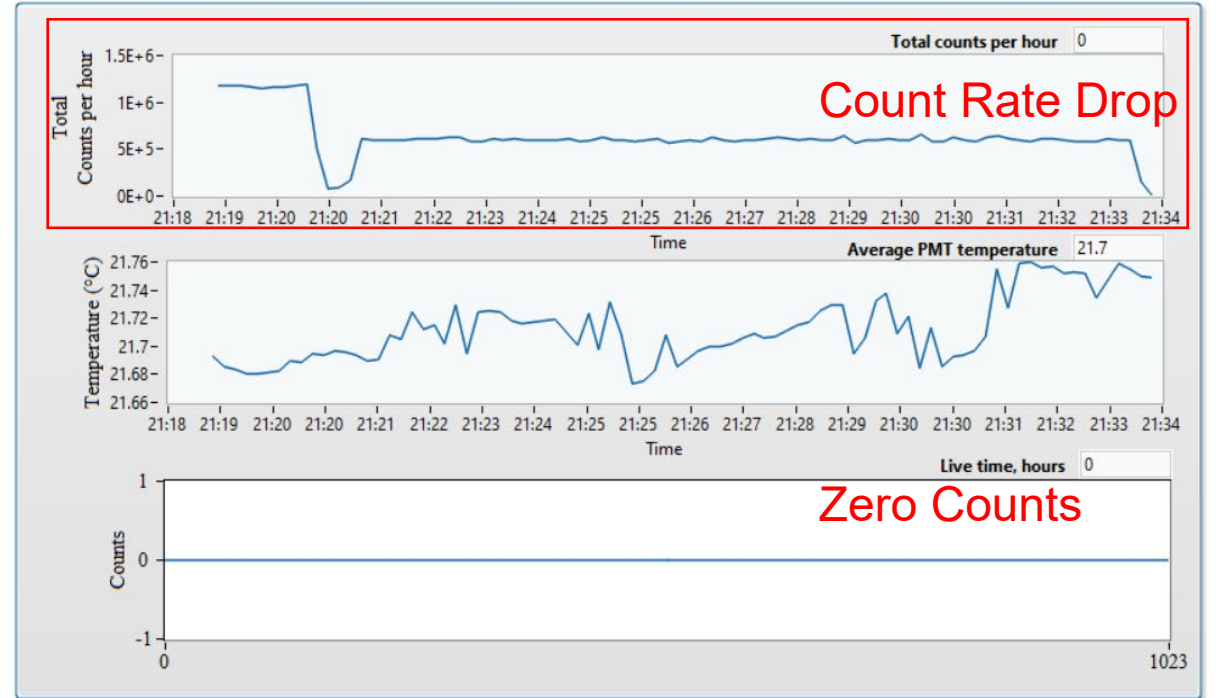
Alarm!

Reset

**MCA Comm Error**

OK

Reset



# Field Testing

- Currently performing field testing and demonstration with SciFi sensors to assess response to true, large-area distributed sources.
- First of a series of field tests at INL Radioactive Scrap Waste Facility





# Idaho National Laboratory

*Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy. INL is the nation's center for nuclear energy research and development, and also performs research in each of DOE's strategic goal areas: energy, national security, science and the environment.*