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CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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Development of a continuous field xenon detection system

Christine Johnson, Jacob Inman, James Knox, Justin Lowrey, Michael Mayer, Rose Perea, Franco Spadoni

Pacific Northwest National Laboratory, Richland, WA USA

Pacific Northwest NATIONAL LABORATORY

INTRODUCTION

PNNL is developing in-field detectors to analyze ^{133}Xe concentration in whole air to support gas transport experiments.

These detectors will be incorporated into an automated subsurface sampling system to continuously monitor the ^{133}Xe concentration.

METHODS/DATA

Detector materials and geometries were modeled using GEANT4 to estimate ^{133}Xe detection limits.

Detector prototypes have been tested with ^{133}Xe and in outdoor settings to estimate temperature effects and natural background mitigations.

START

RESULTS

Modeling suggested design improvements that have been implemented:

- Gas filtering to reduce or remove radon daughters
- Use of a carbon fiber gas cell to minimize attenuation
- Thin shielding inside detector cases to reduce natural background

CONCLUSION

We have developed a system to continuously flow subsurface gas through whole air xenon detectors.

Detector design has been optimized to reduce attenuation and radon background to provide a theoretical ^{133}Xe MDC of 2 kBq/m^3 over a 15 min count.

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Introduction

- Underground nuclear explosions (UNEs) produce signatures in the surrounding environment (seismic, hydroacoustic, radionuclide, and infrasound)
- Radioactive noble gases are direct evidence of nuclear event
- Field experiments provide real-world data on the transport of radioxenon in the subsurface
- Samples are typically collected as whole-air samples and shipped to a lab for analysis of xenon
- Recent experiments have pushed towards the ability to sample and analyze continuously in the field
  - Allows use of shorter half-life tracers
  - Provides significantly higher time resolution

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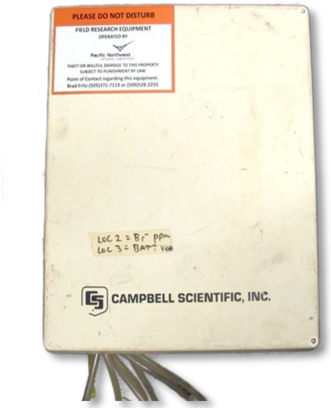
Objectives

The Past…

Marinelli beaker surrounding 3x3 NaI(TI)

- No continuous flow
- Xe memory in plastic
- Manual sample loading/unloading
- Laboratory grade electronics



The Goal…

1. Develop fieldable continuous flow whole-air detector systems utilizing NaI(TI)
2. Optimize detector design to maximize ^{133}Xe detectability
3. Develop a method for automated gas collection and switching between multiple sampling locations

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Methods/Data

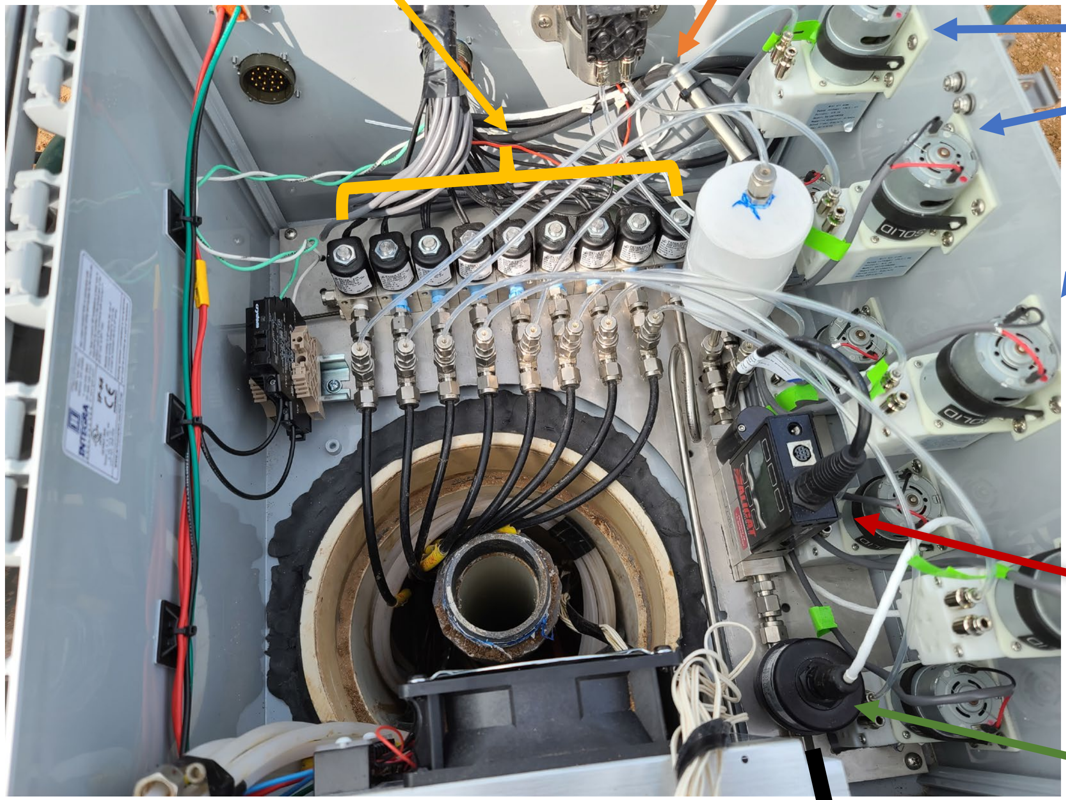
Collecting the gas

Pumps continuously circulate gas between box and sample point

Manifold remotely selects sample point for analysis

Gas flows through pressure and O_2 measurements

Mass flow controller remotely sets output flow rate



Methods/Data

Xenon Detection

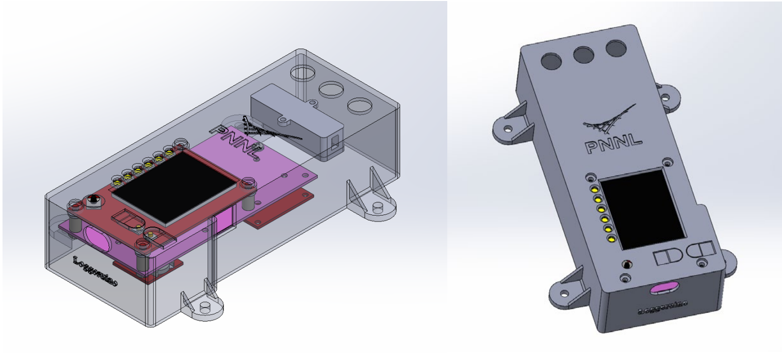
Detector system built around a 2 L Saint Gobain NaI(Tl) crystal

Gas cell constructed of carbon fiber to reduce memory effect and low-energy γ attenuation

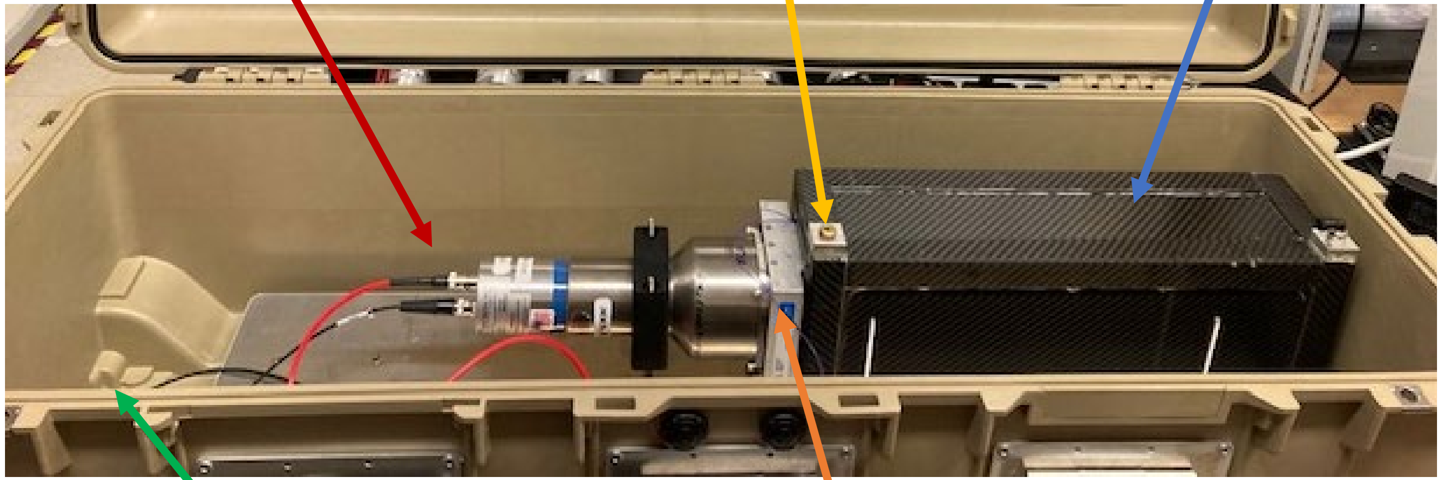
HEPA filter at gas inlet to remove radon progeny

Arduino based Loggeruino module records detector position and gas pressure and temperature

Ventilated external case to modulate temperature fluctuations and protect from environment



Loggeruino module records location, pressure, and temperature



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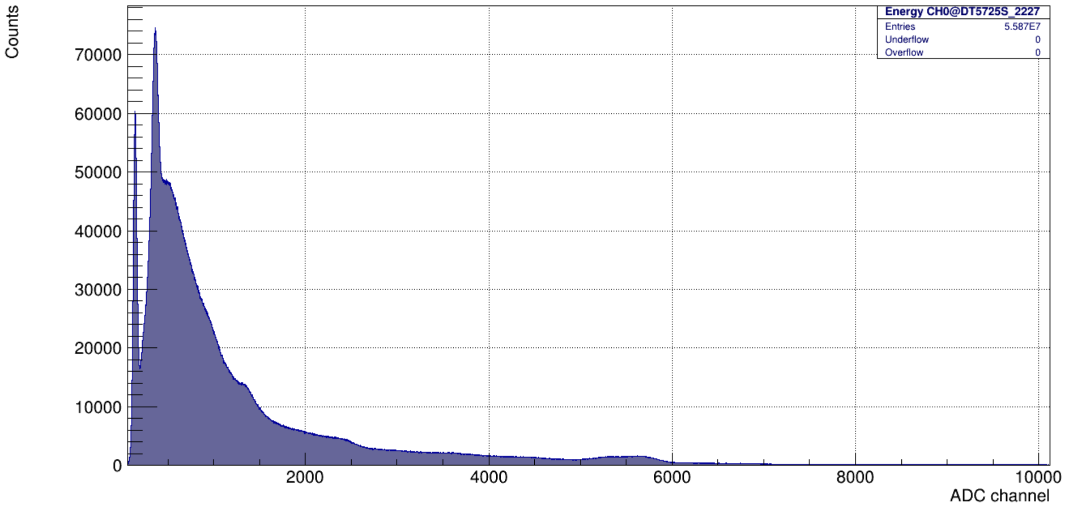
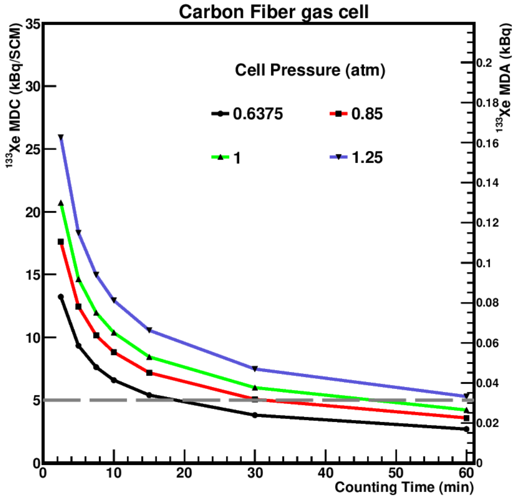
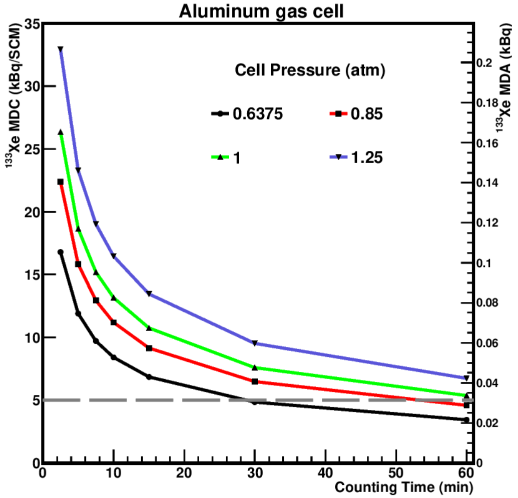
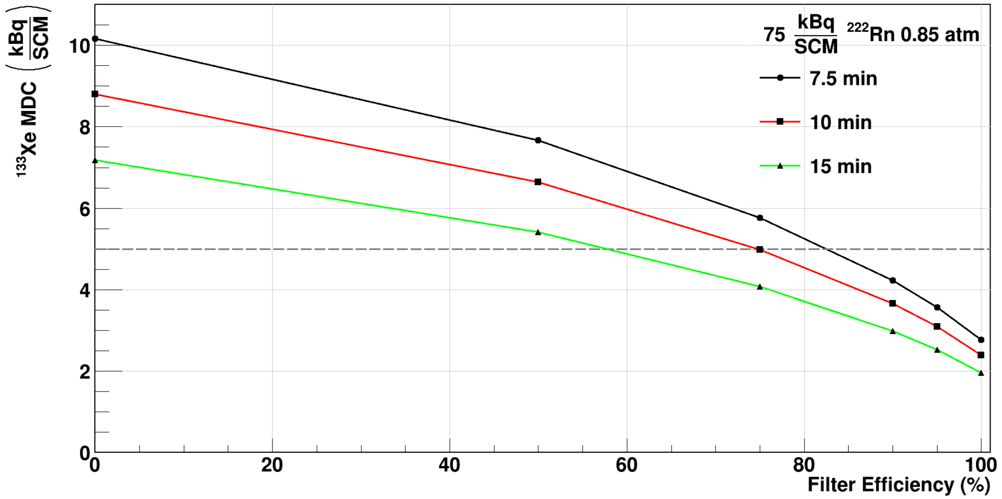
Results

1. With a 100% effective filter the detectors have a theoretical MDC of 2 kBq/SCM for ^{133}Xe
2. Addition of a gas filter to remove radon progeny can potentially reduce the ^{133}Xe MDC by >4x
3. Use of the carbon fiber gas cell allows detection of both the 30-keV and 80-keV peaks from a mixed ^{133m}Xe + ^{133}Xe source





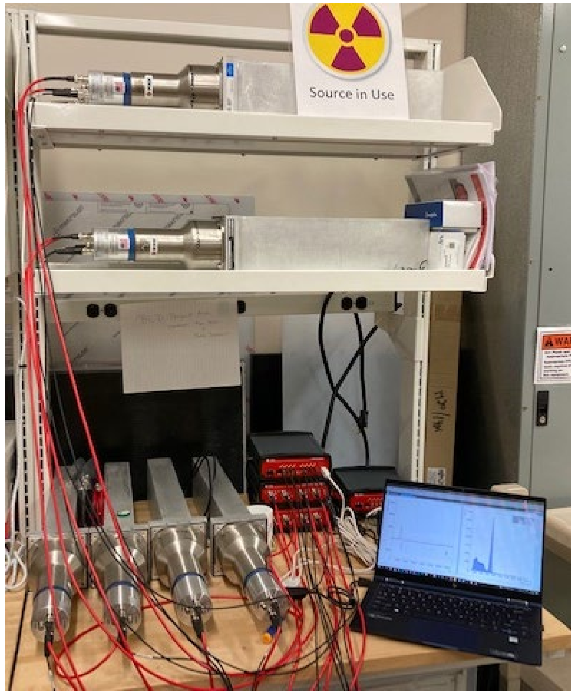


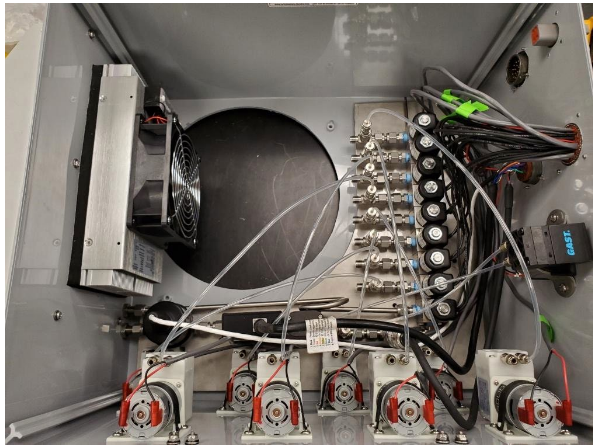


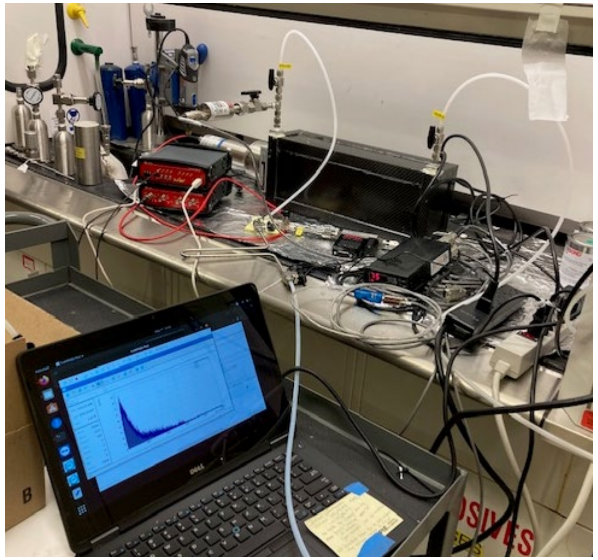
GEANT4 simulations of ^{133}Xe MDC with detector optimizations

Conclusion

- System developed for automated gas sampling and remote sample collection
- Fieldable detector prototypes built and tested
- Detectors optimized for ^{133}Xe detection
  - Radon progeny filtering to reduce background
  - Carbon fiber gas cell to reduce memory, γ attenuation
- Theoretical detector MDC's calculated at 2 kBq/SCM in whole air
- Arduino based module developed to monitor gas pressure & temperature







Acknowledgements

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