Coincidence Simulation of a Two-Channel CZT-based Radioxenon Detector

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INTRODUCTION

The Comprehensive Test Ban Treaty Organization makes use of radioxenon detection systems in the International Monitoring System stations to watch for signs of nuclear weapons testing and undeclared facilities. Systems using beta-gamma coincidence detection have been shown to have significantly reduced background counts, and are thus able to detect trace amounts of atmospheric radioxenon. A prototype of a multi-element coplanar CZT that uses two face-to-face coplanar CZT crystals to measure beta-gamma coincidence events from atmospheric radioxenon was developed at OSU.

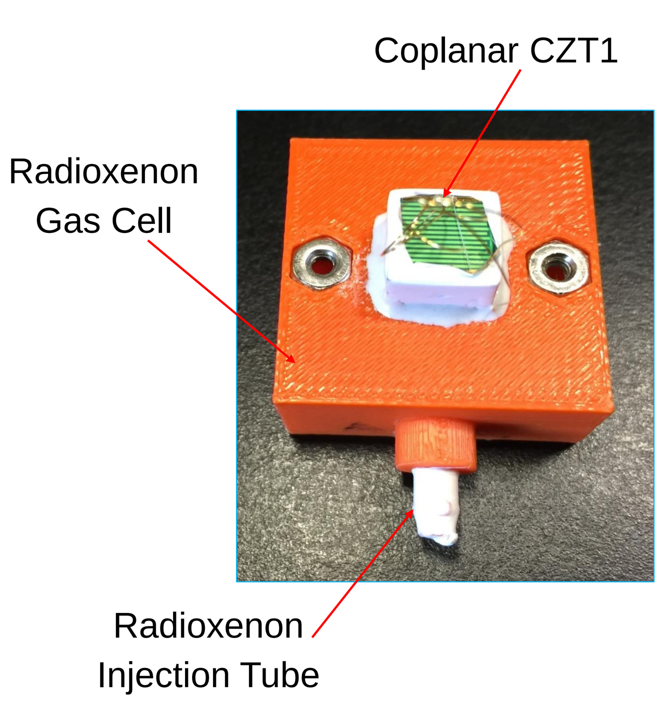
OBJECTIVES

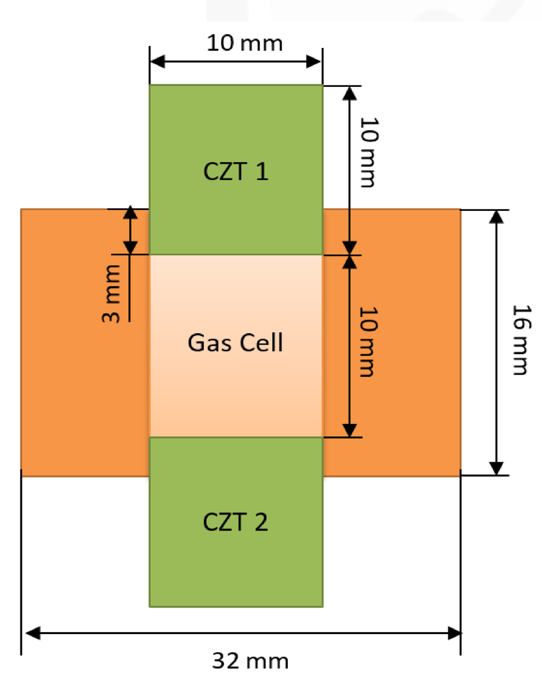
The CZT-based detection system was simulated using MCNP to find the response of the detector to the xenon radioisotopes of interest and also calculate the coincidence detection efficiency of the device for these radioisotopes. In this work, modeling results from ^{131m}Xe, ^{133m}Xe, and ^{135}Xe are reported.

Isotope	Half-life	Coincident Energies (keV)	Type	Intensity (%)
^{131m}Xe	11.9 d	30 129	K X-ray CE	54.1 60.7
^{133m}Xe	2.19 d	30 199	K X-ray CE	56.3 63.1
^{133}Xe	5.245 d	31 81 45 346	K X-ray Gamma CE Beta (endpoint)	48.9 37 54.1 99
^{135}Xe	9.1 h	250 910	Gamma Beta (endpoint)	99 97

MCNP MODELING

1. DETECTOR GEOMETRY





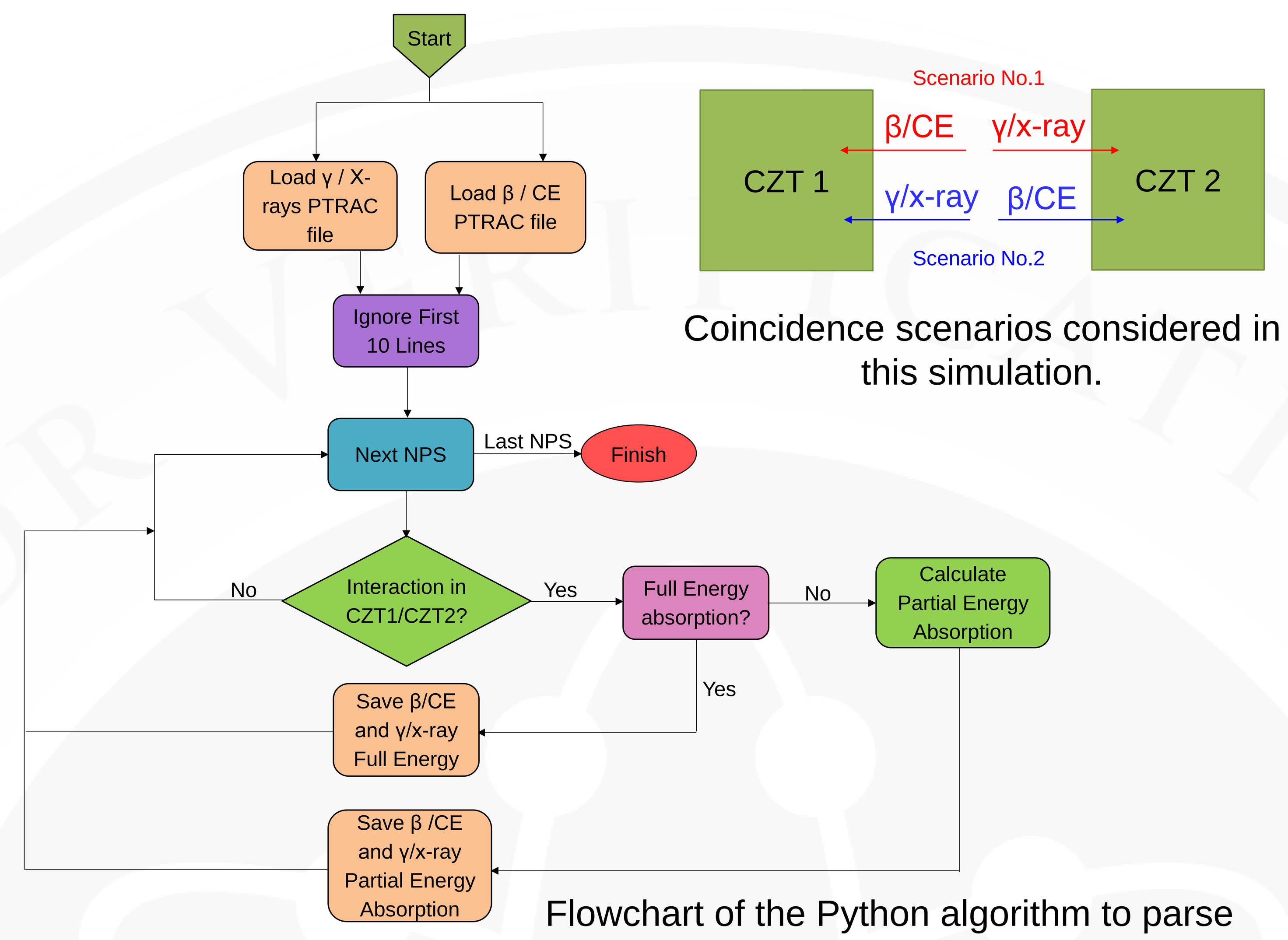
Geometry of the CZT-based radioxenon detection system simulated in MCNP.

2. PTRAC CARD

To model β-γ coincidence events in the CZT crystals, the PTRAC card was used. PTRAC follows each particle individually and writes an output file containing the entire history of that particle including position of interaction, energy of the particle, and the history number. A Python code was developed to parse the PTRAC files and extract the position of interaction, energy released in each CZT crystal, and the history number of each event from the PTRAC files. β-γ coincidence events were then extracted for events with the same history number (NPS number).

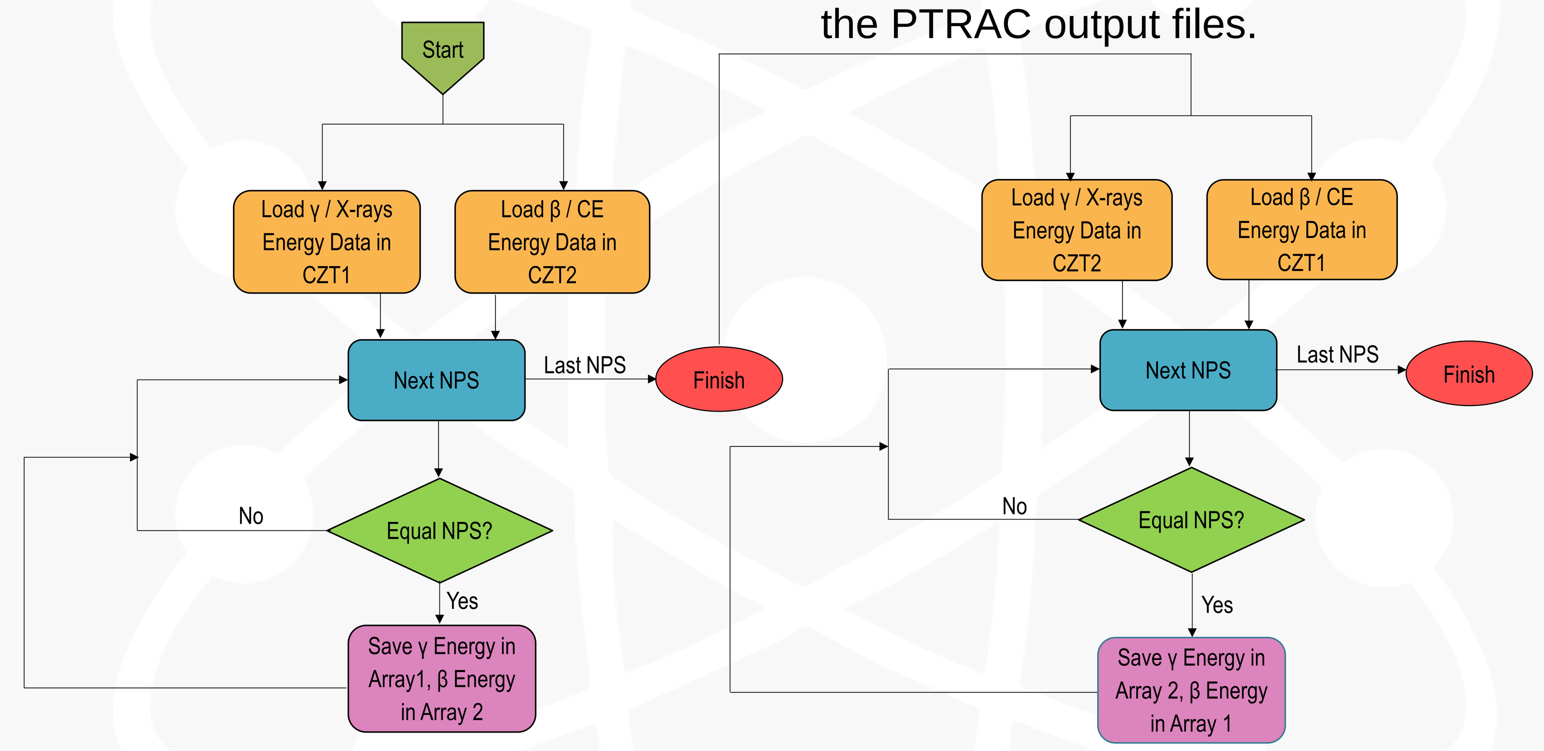
COINCIDENCE DETECTION

PYTHON ALGORITHMS



Coincidence scenarios considered in this simulation.

Flowchart of the Python algorithm to parse the PTRAC output files.

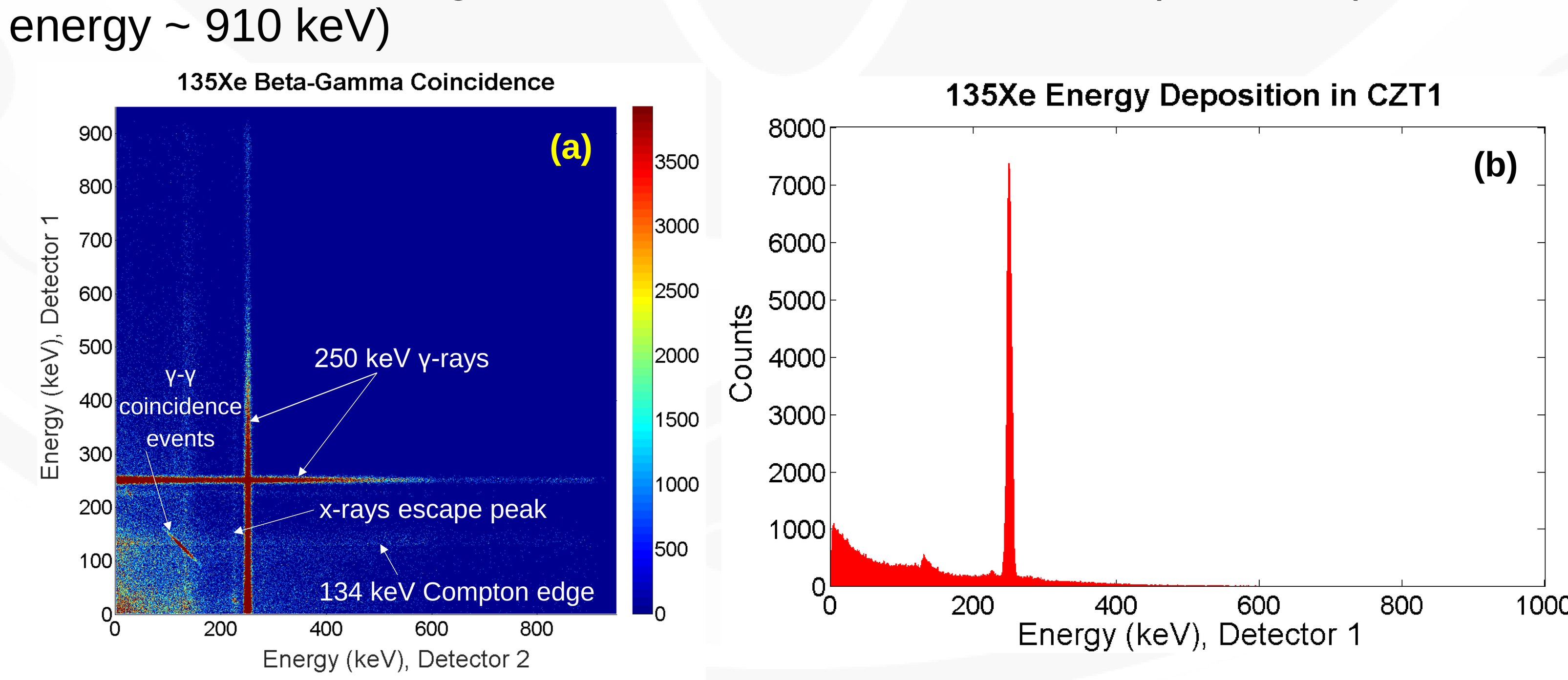


Flowchart of the Python algorithm to extract coincident events.

RESULTS

^{135}Xe

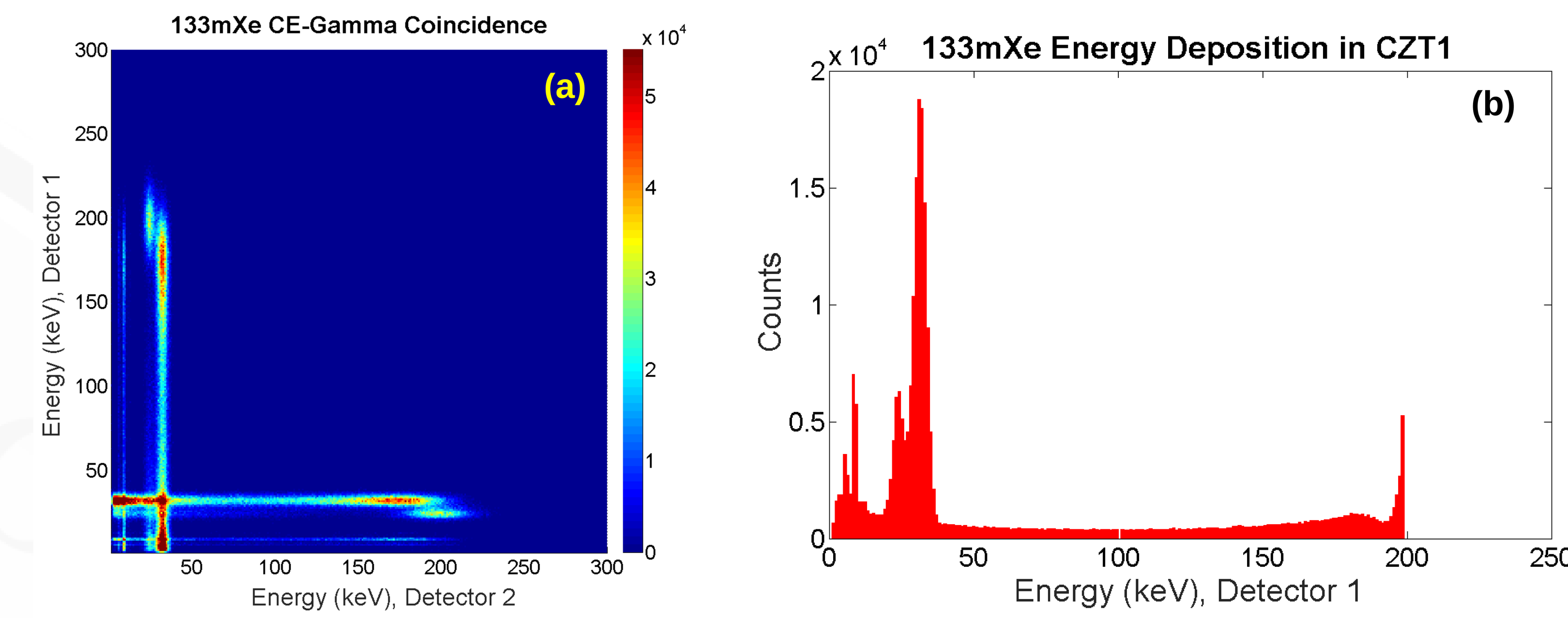
^{135}Xe emits 250 keV gammas in coincidence with beta particles (maximum energy ~ 910 keV)



(a) Simulated beta/gamma coincidence spectrum of ^{135}Xe **(b)** energy deposited by ^{135}Xe coincident events in CZT1.

^{133m}Xe

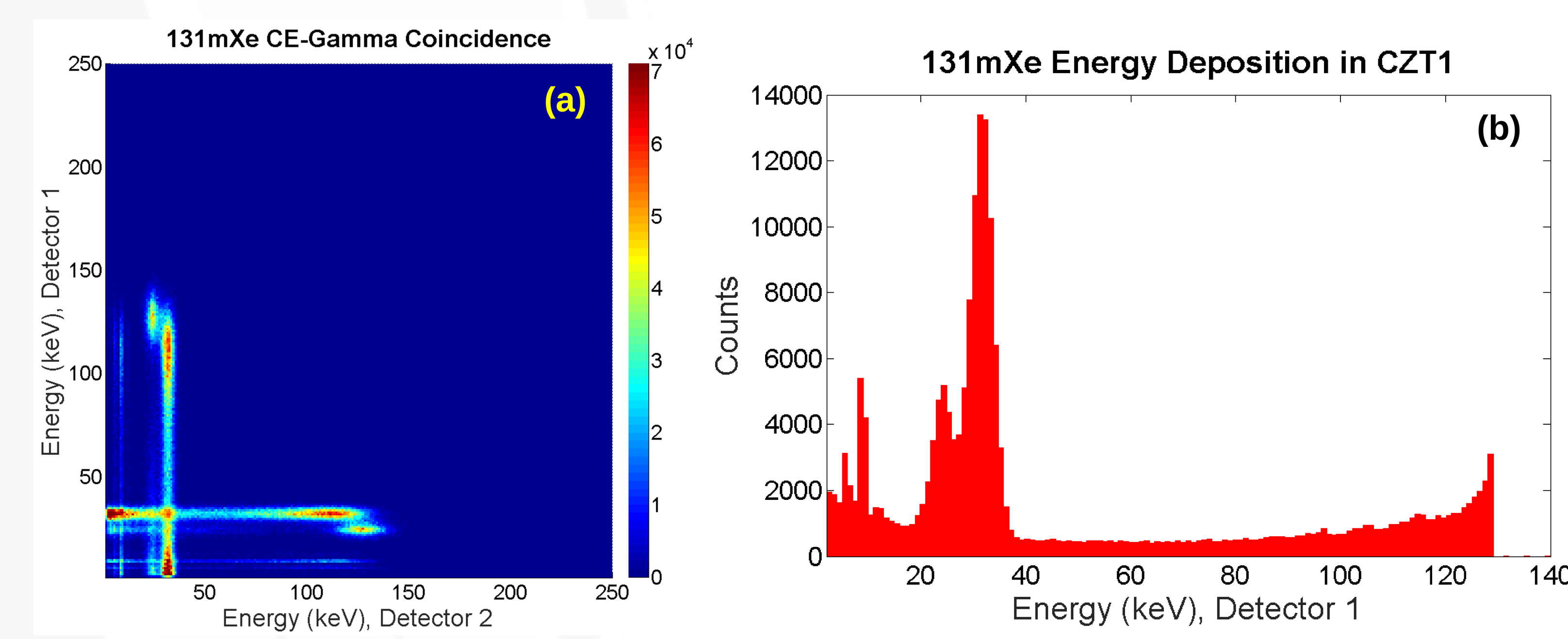
^{133m}Xe emits 30 keV x-rays in coincidence with 199 keV conversion electrons.



(a) Simulated beta/gamma coincidence spectrum of ^{133m}Xe **(b)** energy deposited by ^{133m}Xe coincident events in CZT1.

^{131m}Xe

^{131m}Xe emits 30 keV x-rays in coincidence with 129 keV conversion electrons.



(a) Simulated beta/gamma coincidence spectrum of ^{131m}Xe **(b)** energy deposited by ^{131m}Xe coincident events in CZT1.

Radioxenons coincidence detection efficiencies calculated using MCNP.

Radioxenon	Coincidence Efficiency (%)
^{131m}Xe	3.1
^{133m}Xe	2.7
^{135}Xe	1.7

Unclassified

This work was funded in-part by the Consortium for Verification Technology under Department of Energy National Nuclear Security Administration award number DE-NA0002534.