

Introduction

Neutron tomography (NT) is a powerful imaging tool that lets us look inside objects without damaging them. It works especially well for materials that are hard to inspect with X-rays, such as plastics, water-based materials, and porous structures. However, traditional NT can be slow, blurry, and less accurate when dealing with optically thick or complex objects.

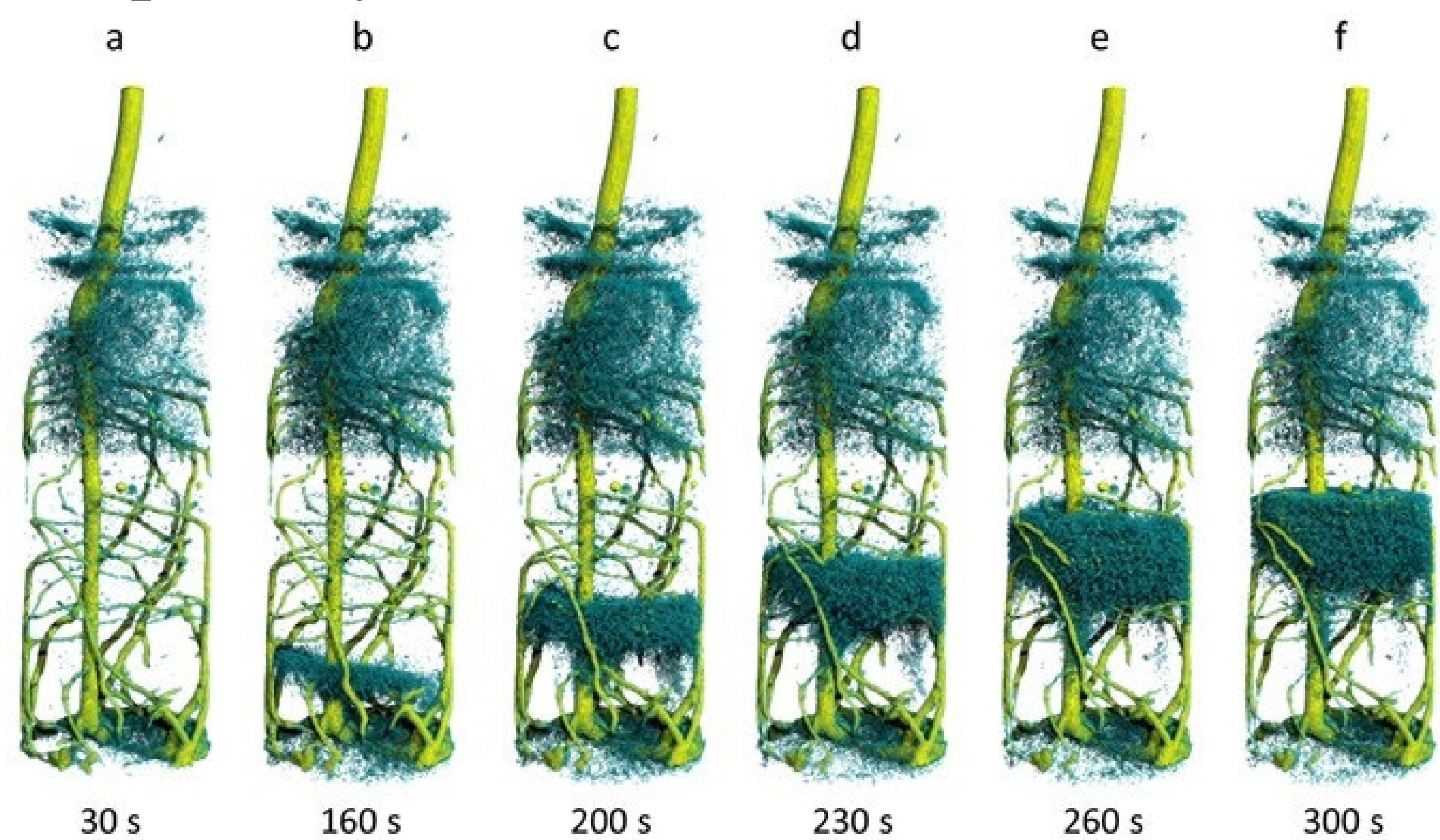


Figure 1. Time-resolved NT of a water injection through a lupine root system [1]

Objective:

We aim to use machine learning—specifically, artificial neural networks (ANNs)—to create faster, clearer, and more accurate neutron tomography images. This will help improve detection of hidden or shielded materials, which will benefit the mission of improved nuclear security.

**This material has been reviewed and released by the Department of Mechanical and Nuclear Engineering at Virginia Commonwealth University*

Methods

Our approach:

- Use Monte Carlo code to simulate neutron transmission through different materials
- Collected data from both simulations and real-world experiments
- Train an ANN to learn how neutron feedback correspond to different materials and locations
- Asses the ANN's ability to predict material types and create clearer images

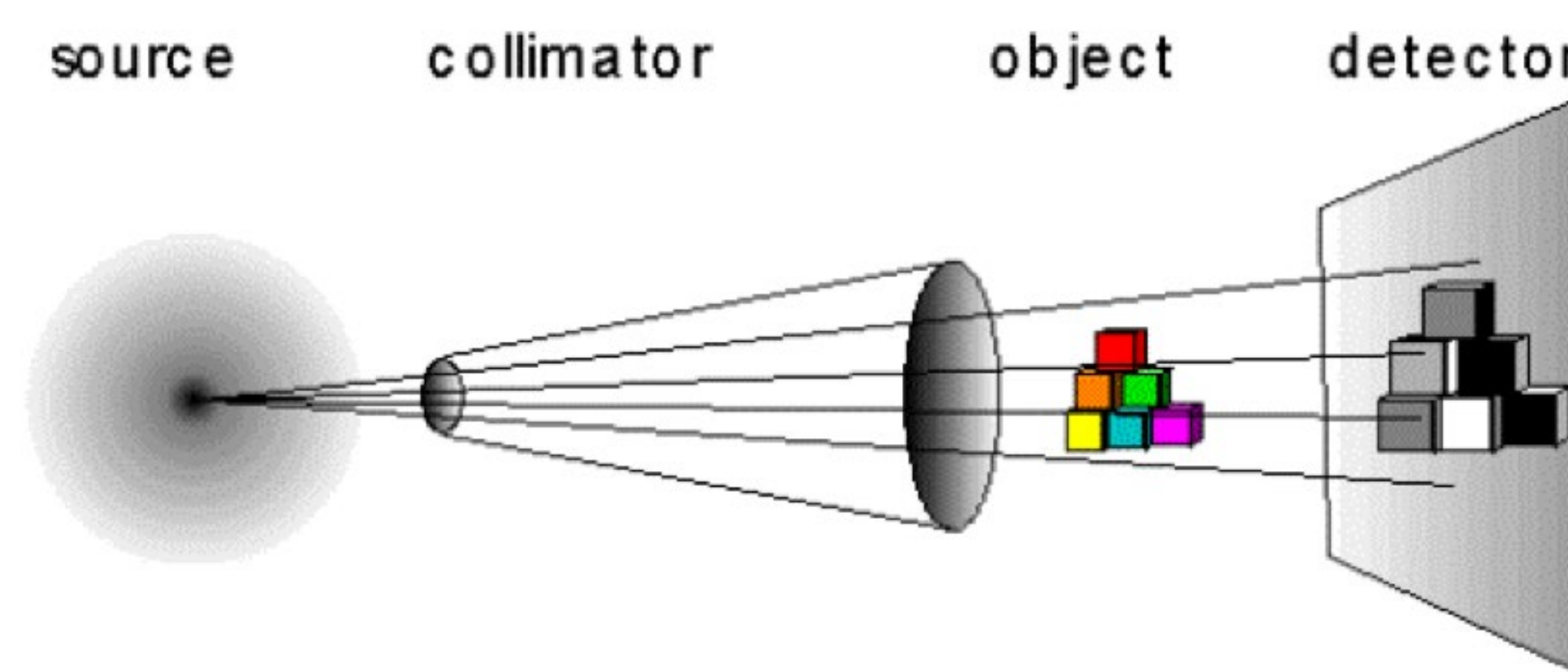


Figure 2. Basic configuration for radiographic imaging system [2]

Expected Results

Anticipated deliverables:

- A trained ANN that reconstructs images and identifies materials from neutron transmission data
- Datasets from both simulations and experiments
- Performance evaluations showing improvements in comparison to conventional methods
- A full technical report summarizing findings and recommendations

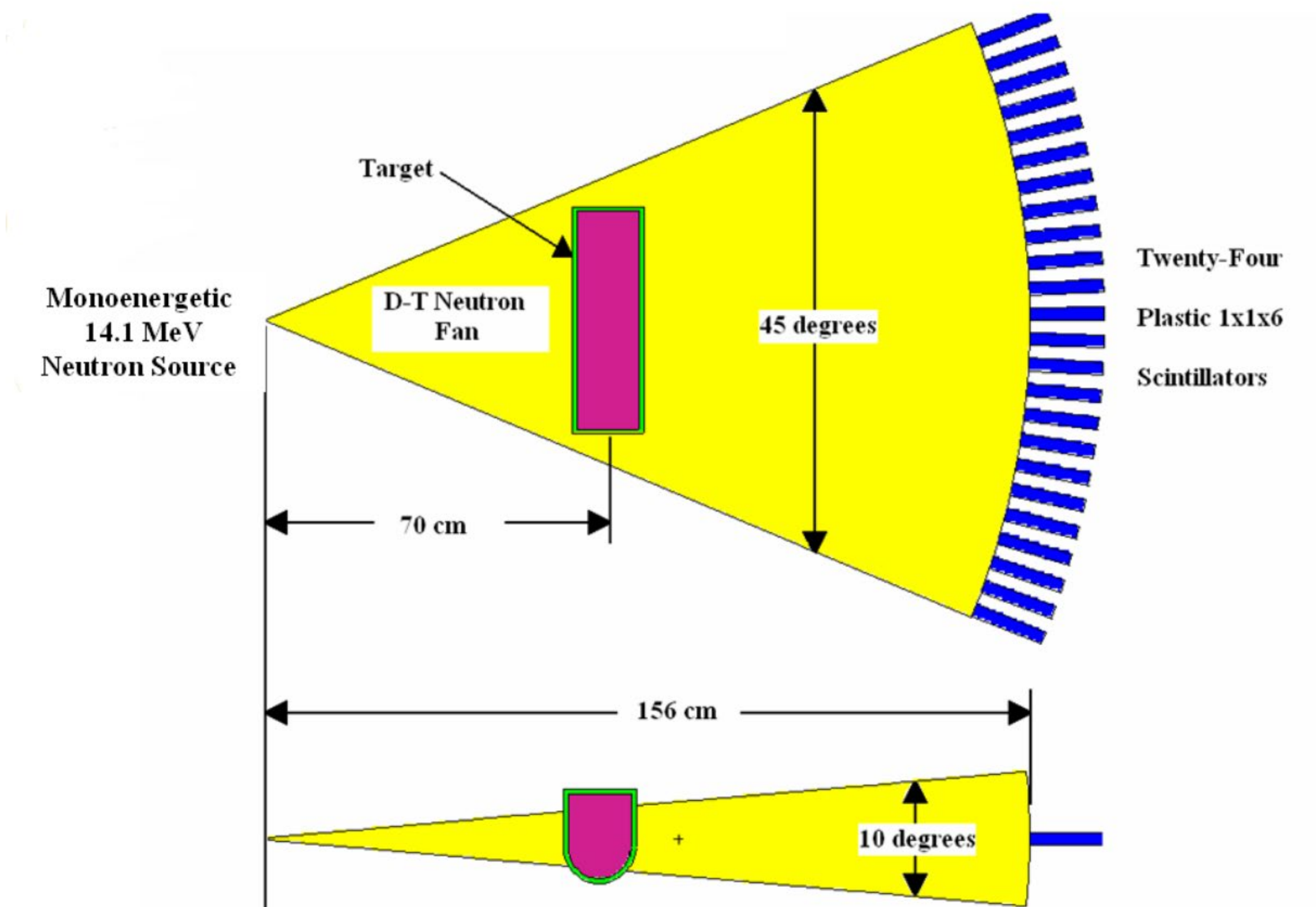


Figure 3. Geometric display of MCNP simulation used to determine mass of UO_3 powder in stainless-steel container [3]

Discussions and Relevance

Thus, this research would support the Office of Defense Nuclear Nonproliferation mission by:

- Improving methods for detecting and monitoring nuclear materials
- Enabling faster and more reliable inspections
- Developing of advanced technologies for nonproliferation and threat reduction

References

- [1] C. Tötze, N. Kardjilov, I. Manke, and S. E. Oswald, "Capturing 3D water flow in rooted soil by ultra-fast neutron tomography," *Scientific Reports*, vol. 7, no. 1, Jul. 2017. doi:10.1038/s41598-017-06046-w
- [2] "Nuclear analytical research and services," Nuclear and Radiation Engineering Program, <https://nuclear.engr.utexas.edu/about-the-program/experiment-facilities-and-services/nuclear-analytical-research-and-services> (accessed Apr. 22, 2025).
- [3] B. R. Grogan, *Estimating the mass of UO_3 powder in a container using MCNP-POLIMI simulations of NMIS measurements*, April 2008. doi:10.2172/931145

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