Tomographic Imaging of nuclear contraband using a cubic foot muon-tomography station

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Overview

- **Reconstruction**
- **Design**
- **Physics of a Gaseous Electron Multiplying Detector**
- **Purpose**
- **Visual Representation of Muon Scattering**
  - Presenting Multiple Images on the Discrimination of Materials with Different Atomic Numbers (Z) and Density
- **Current plans for Improvement**
- **The near future**

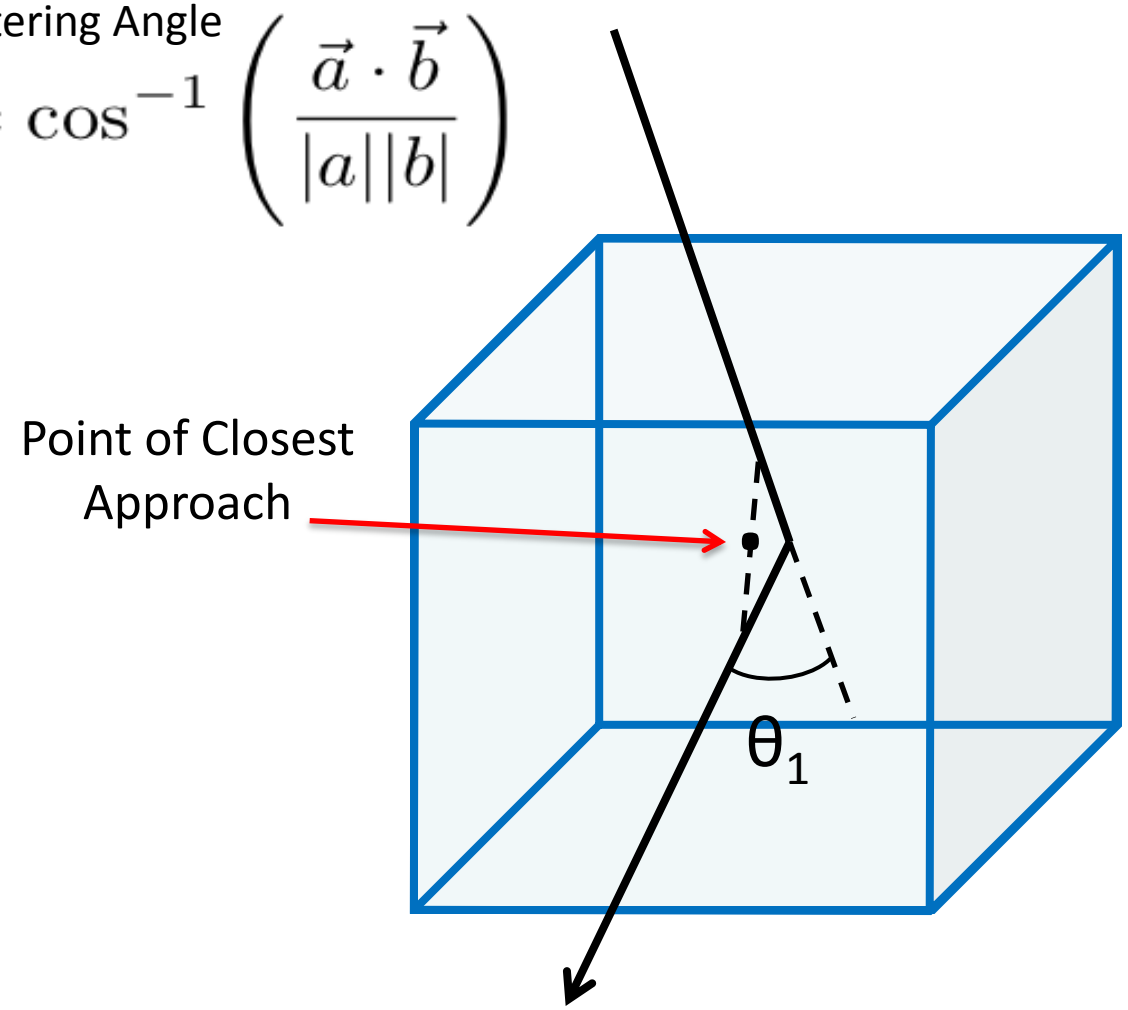
Reconstruction

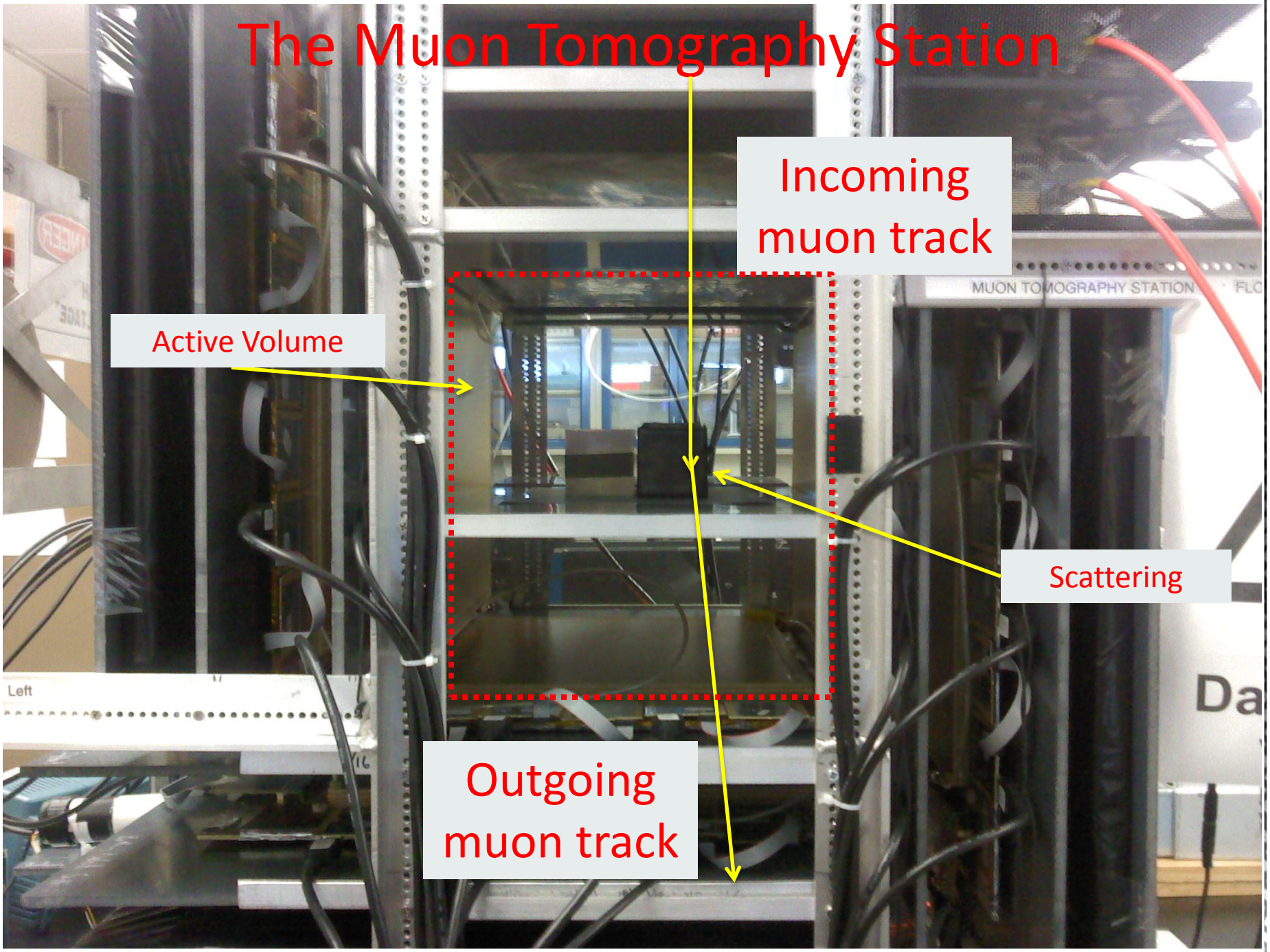
- The ultimate goal of reconstruction is to find the Point of Closest Approach (POCA) and corresponding scattering angle.
- Using an incoming and outgoing track we are able to calculate the amount of scattering a muon experiences while travelling through dense materials.
- This scattering is small, requiring extremely accurate spatial resolution from the detectors.

POCA Reconstruction

Scattering Angle

$$\theta = \cos^{-1}\left(\frac{\vec{a}\cdot\vec{b}}{|a||b|}\right)$$

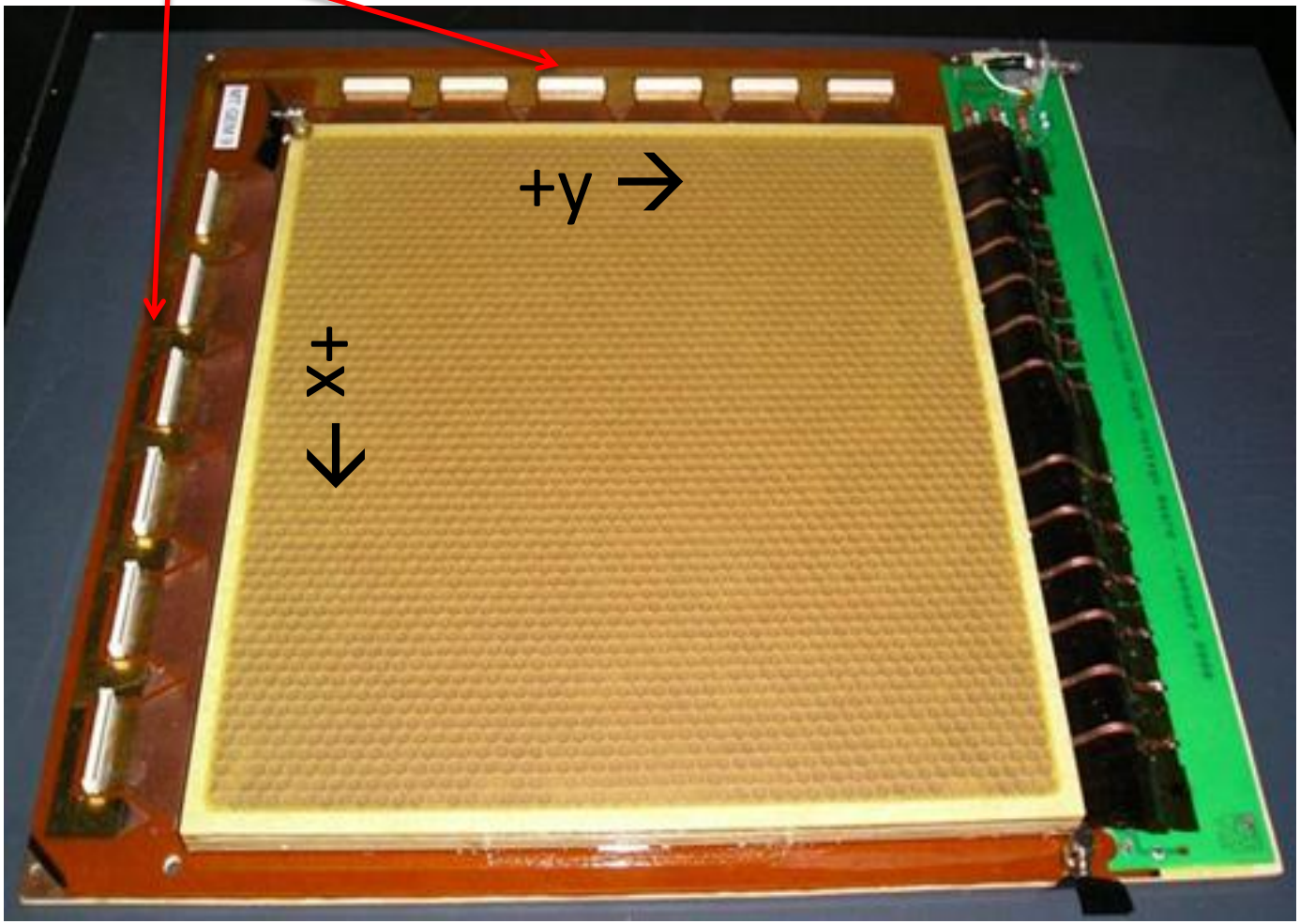



The Muon Tomography Station
Incoming muon track
Active Volume
Scattering
Outgoing muon track
MUON TOMOGRAPHY STATION
Left

A View from the Outside

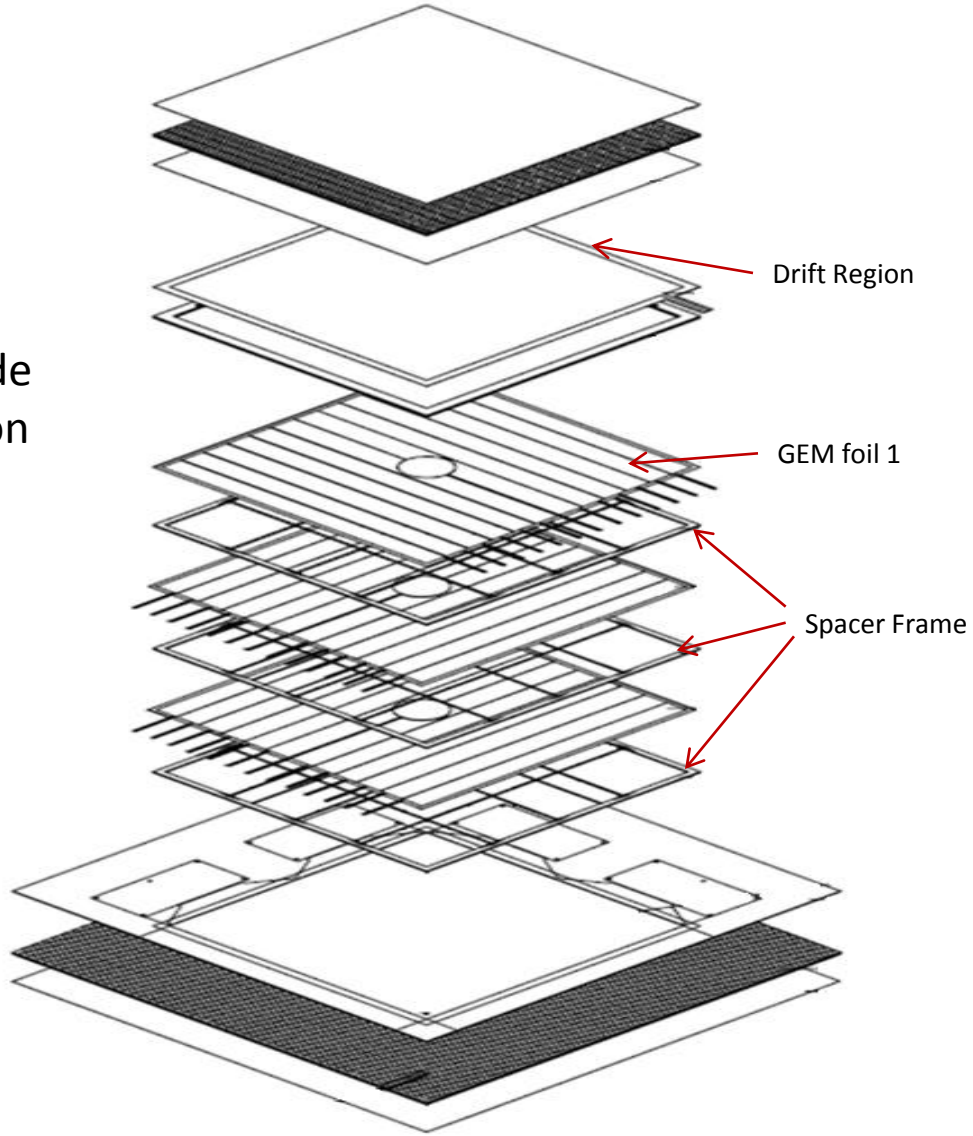
Each readout panel contains 768 readout strips in X and Y plane

30 cm x 30 cm triple-GEM detectors

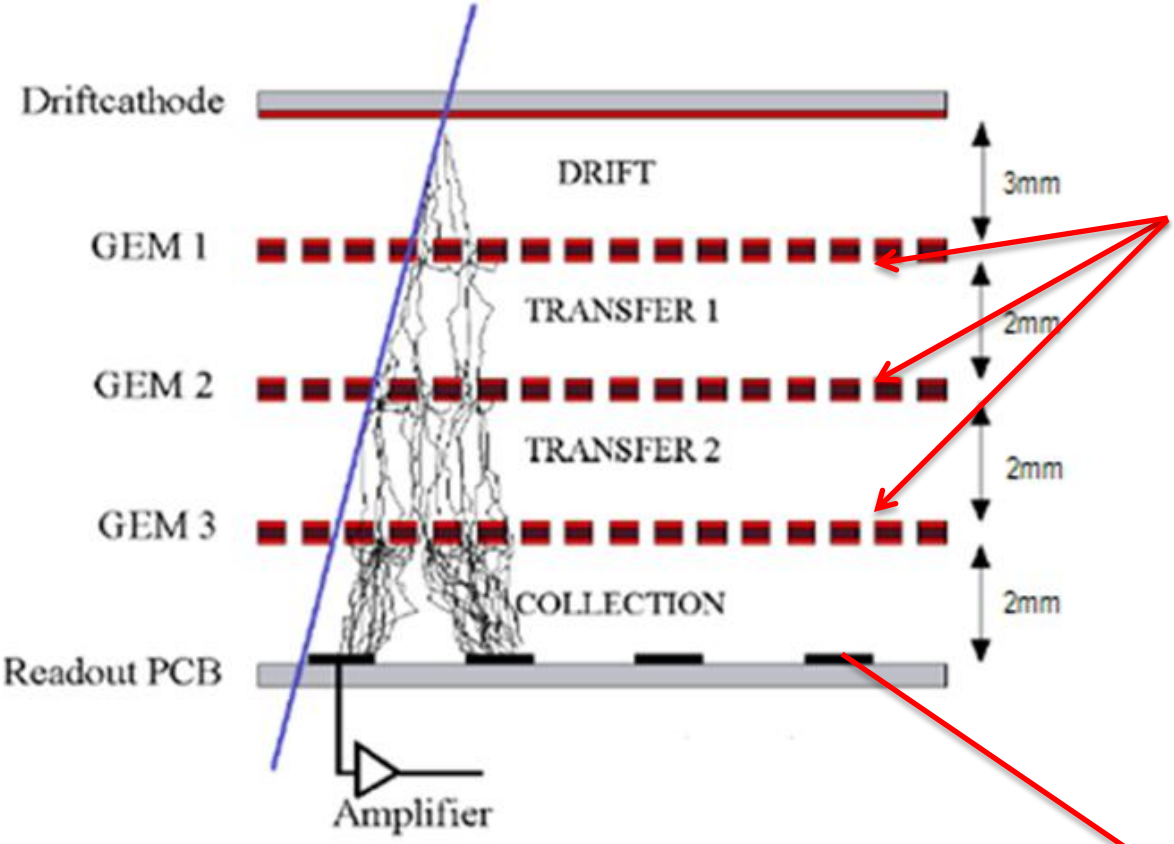


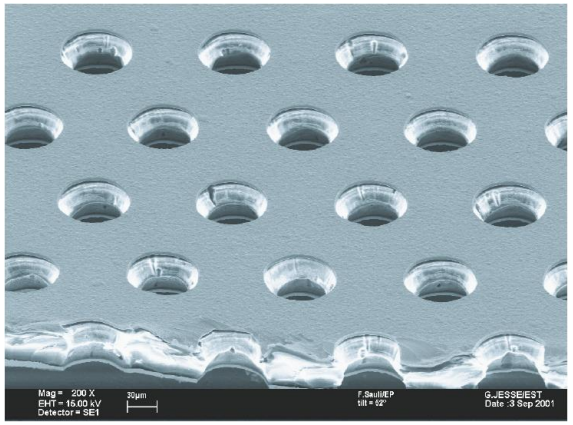
Exploded View of the GEM Detector

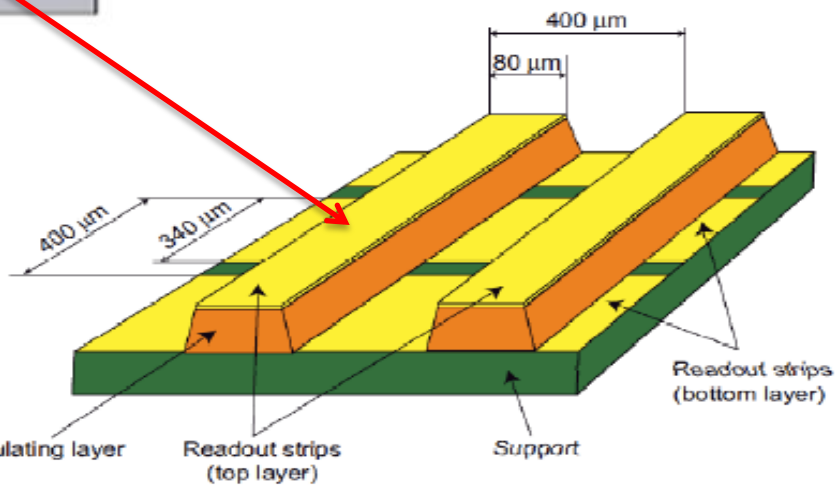
Each GEM is filled with an Argon/Carbon Dioxide mixture during operation



The Inner Workings

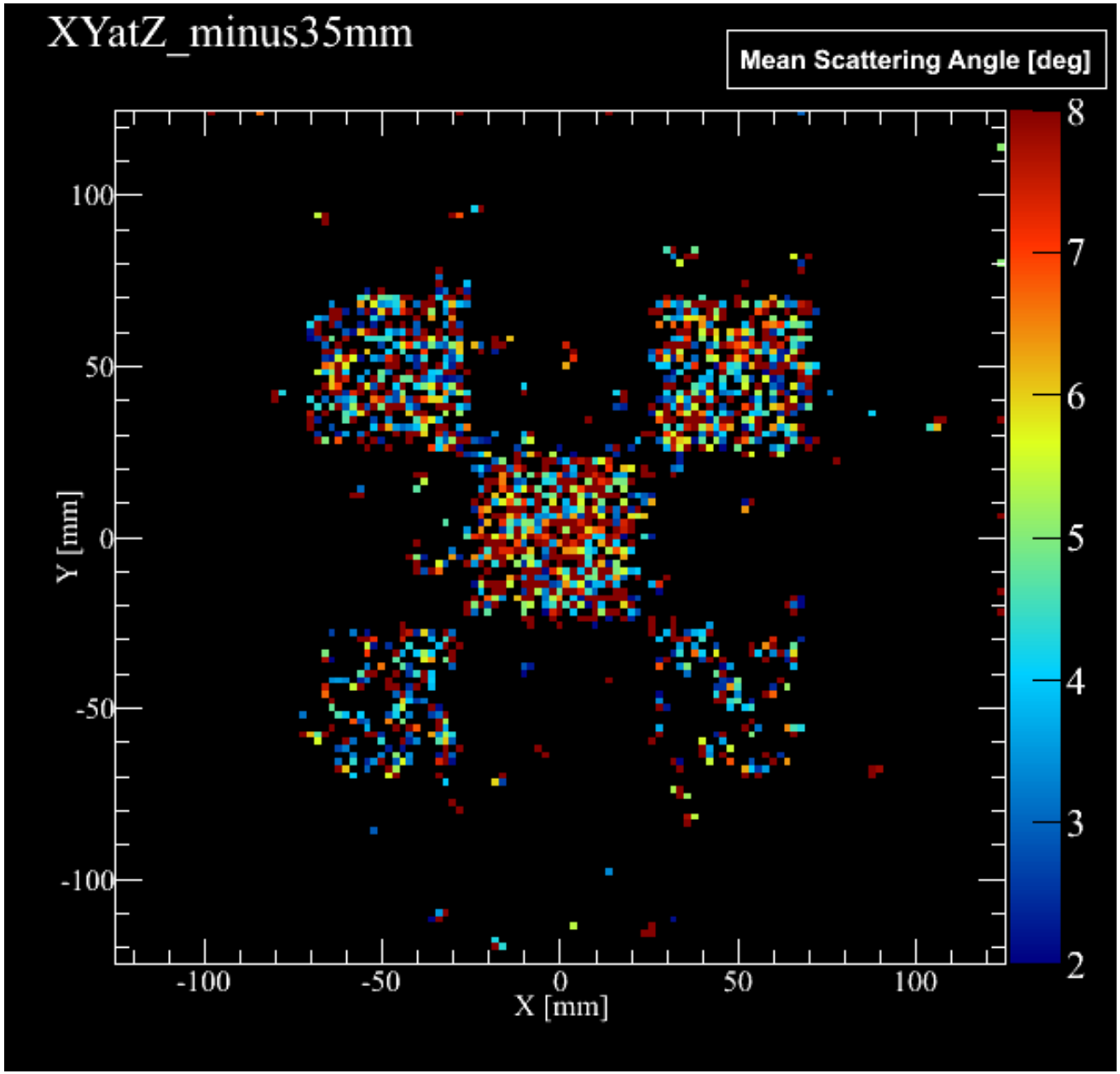




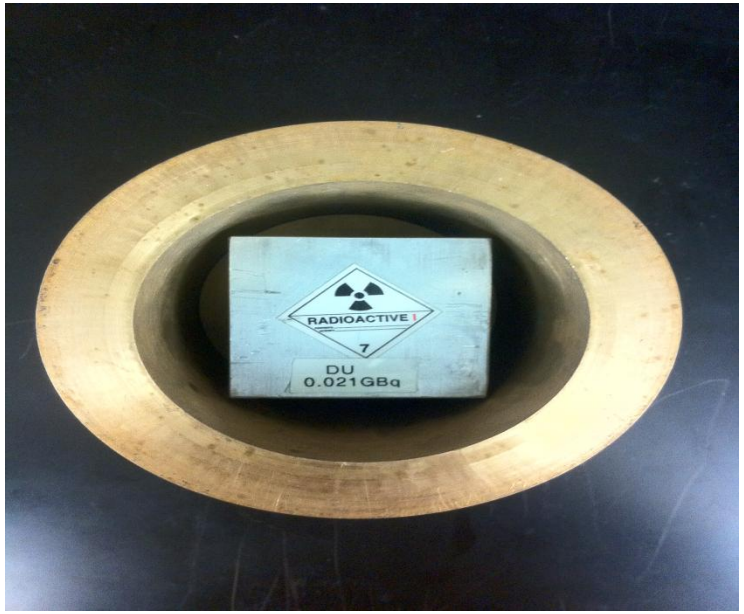


Differentiating Materials

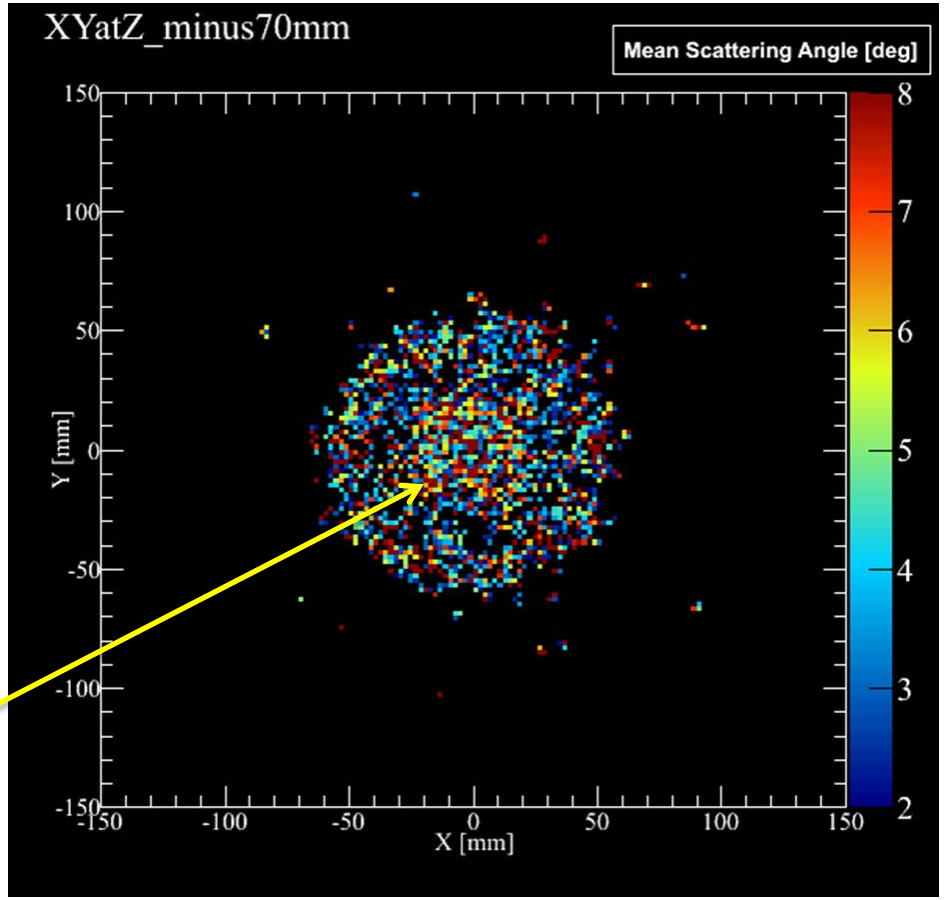
Five Target Reconstructed Images



Discrimination and Shielding

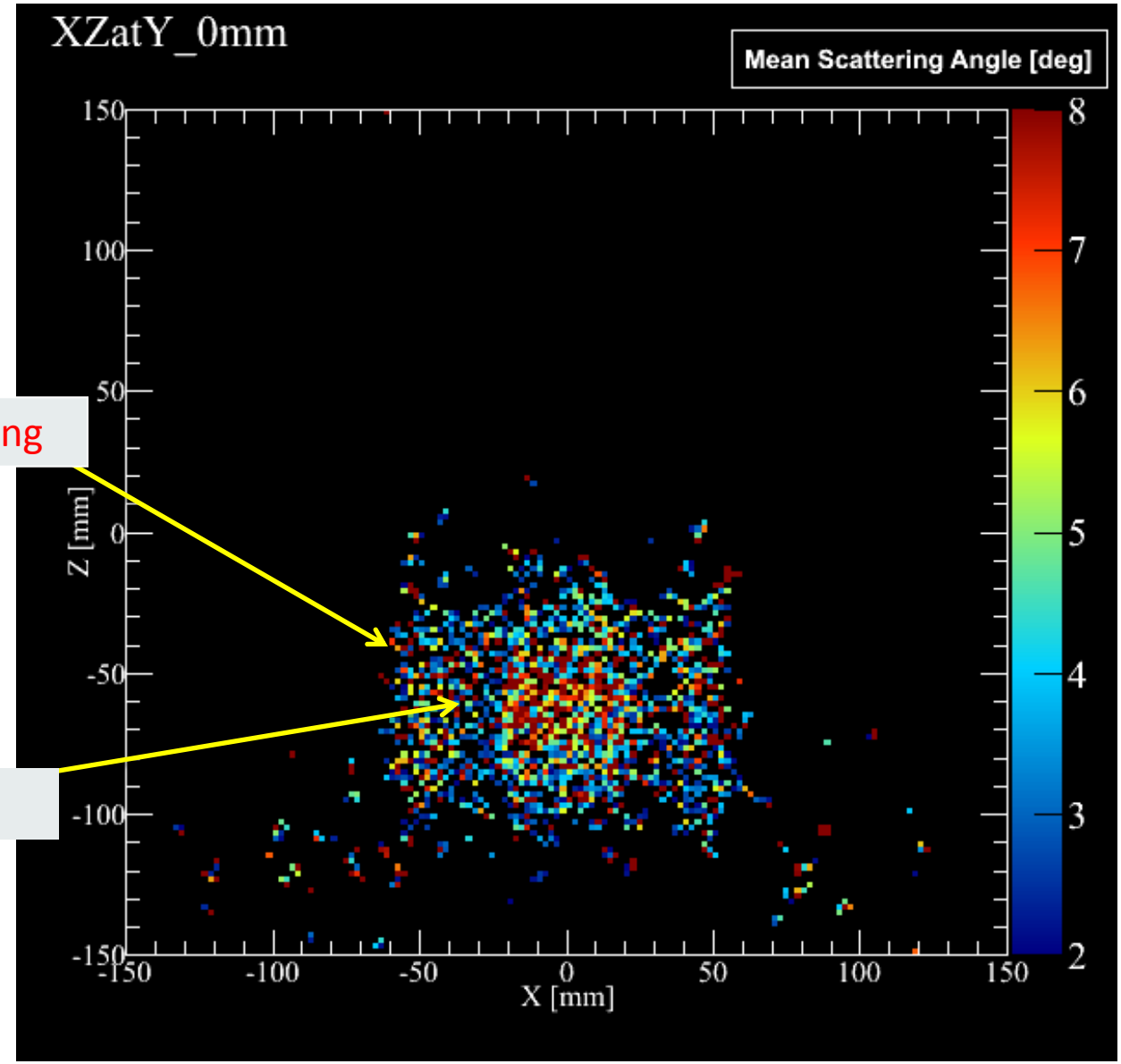


The Brass Shield
Top-View



Uranium Target at the Middle

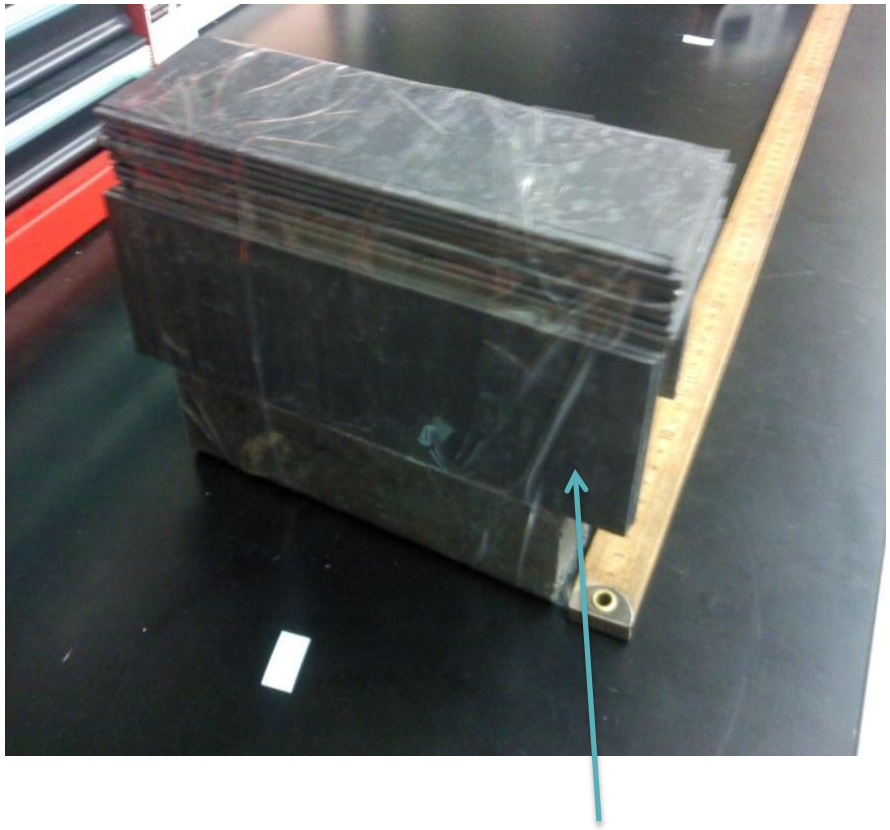
Identifiable Shielding

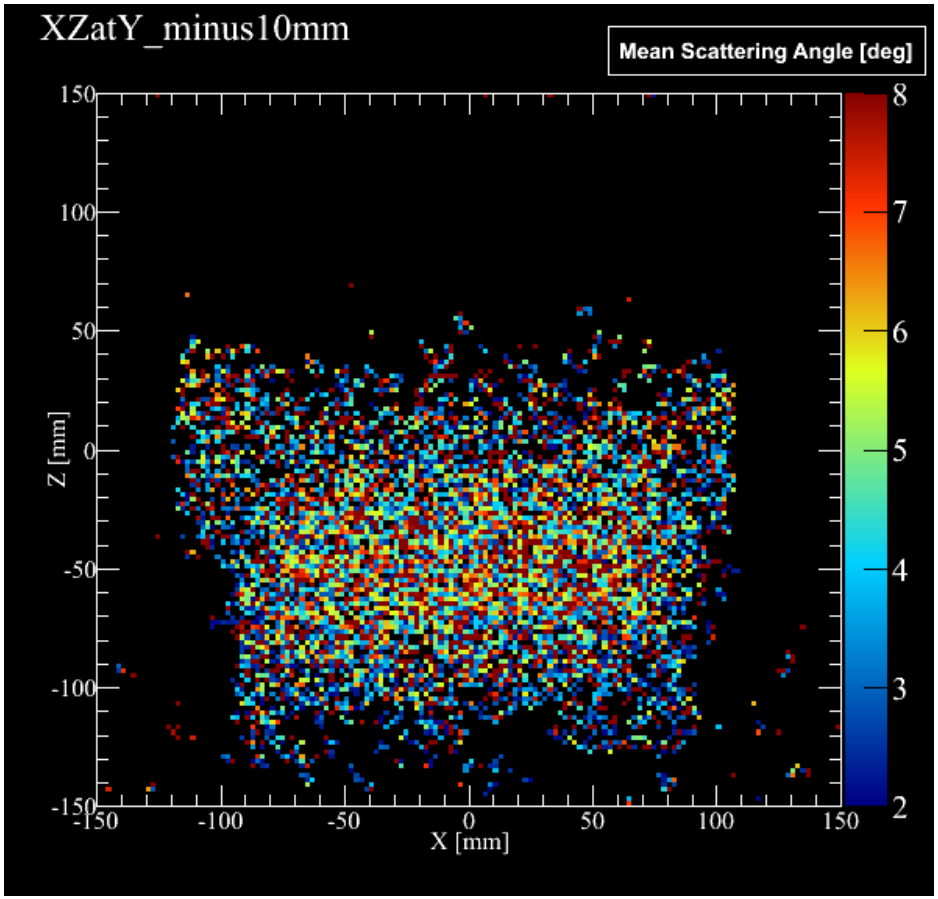


Outer Shielding

Small Gap

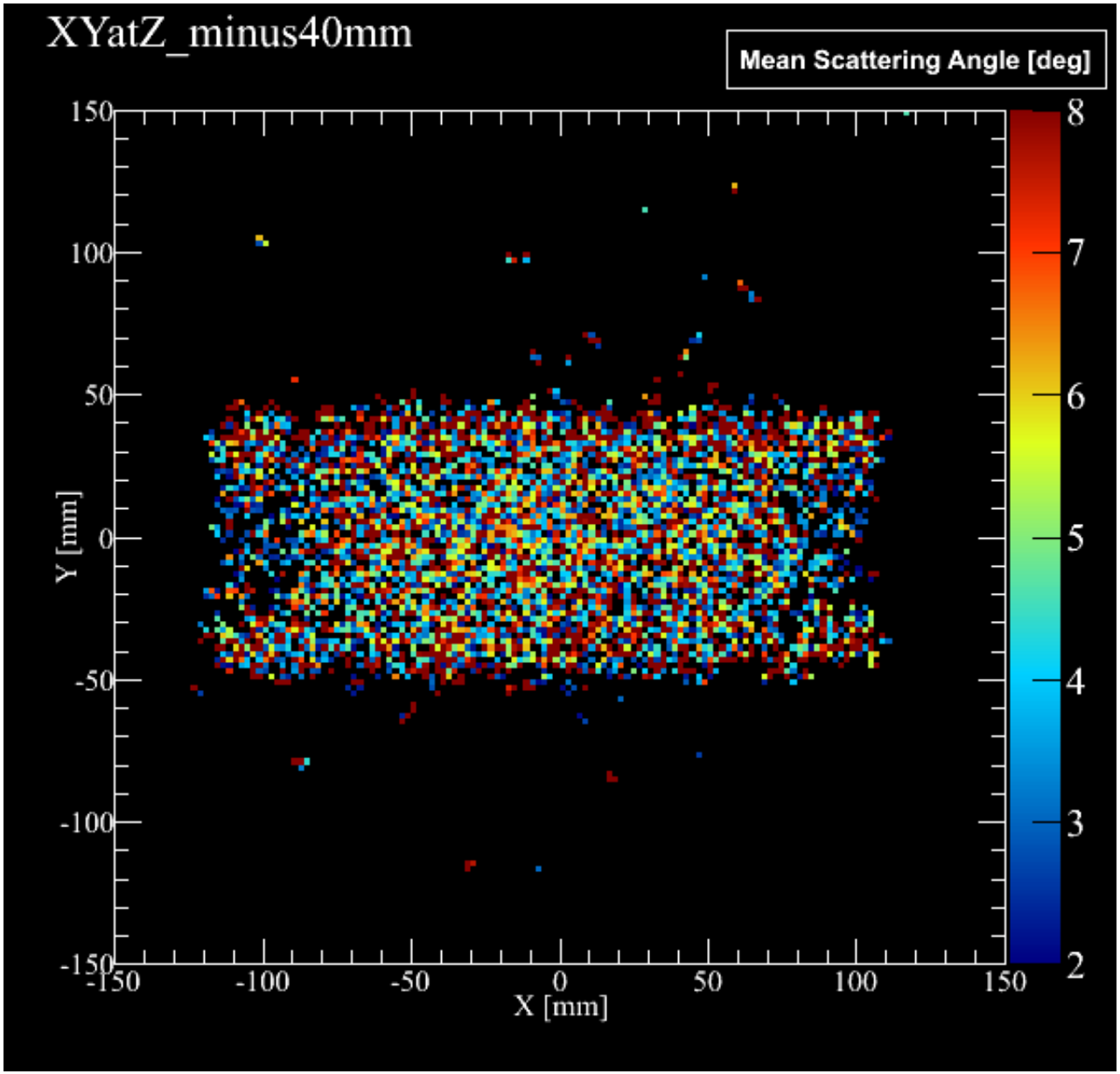
The Lead Shielded Target





Inside sit four different blocks, including a large cube of depleted uranium.

Looking down on a Lead Brick



In Summary

- The amount of scattering is proportional to the atomic number and density of the material. Allowing for the imaging of material that is surrounded by commonly used metals like Iron or Steel.
- The ability to image such dense materials as uranium will provide a more effective way of detecting illegal nuclear material.

The Near Future

- Experimenting with new Detector Geometries and Designs
- Live Display of targets in the MTS Station
- Experimenting with new readout structures on the miniature GEM detectors