2010 Florida Academy of Sciences
Indian River State College, Fort Pierce, Florida

Monte Carlo simulations of a first prototype micropattern gas detector system used for muon tomography

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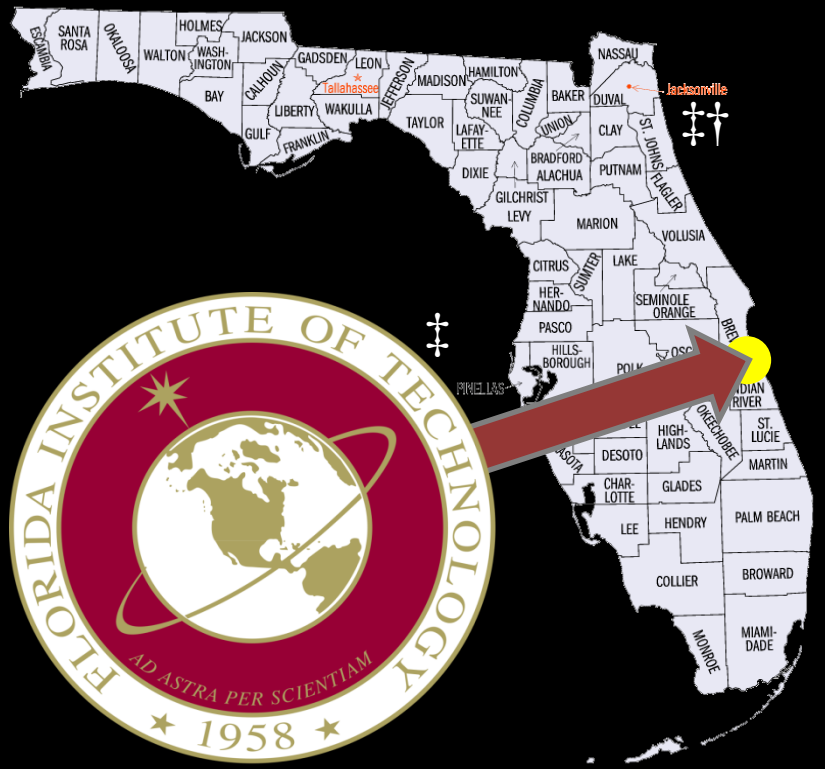


FIT High Energy Physics (FIT HEP) Research Group

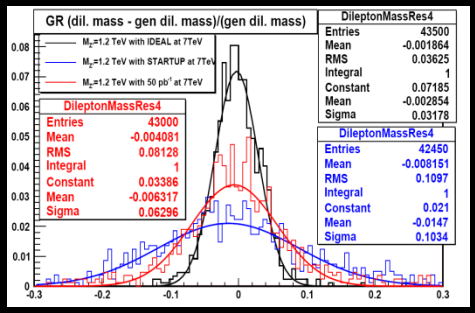
http://research.fit.edu/

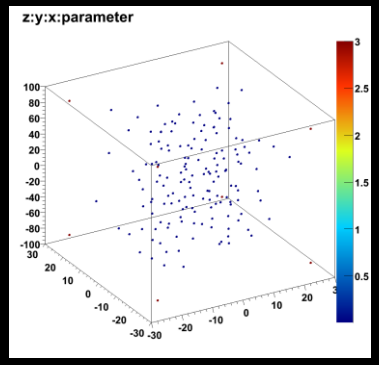
Pictures from the FIT HEP archives †, Florida Institute of Technology ‡, and the US Census Bureau ‡†.

High Energy Physics Research at FIT

CMS at LHC Experiment

Search for the Z' Boson





Muon Tomography Simulation

Quarknet

Particle Detector Construction

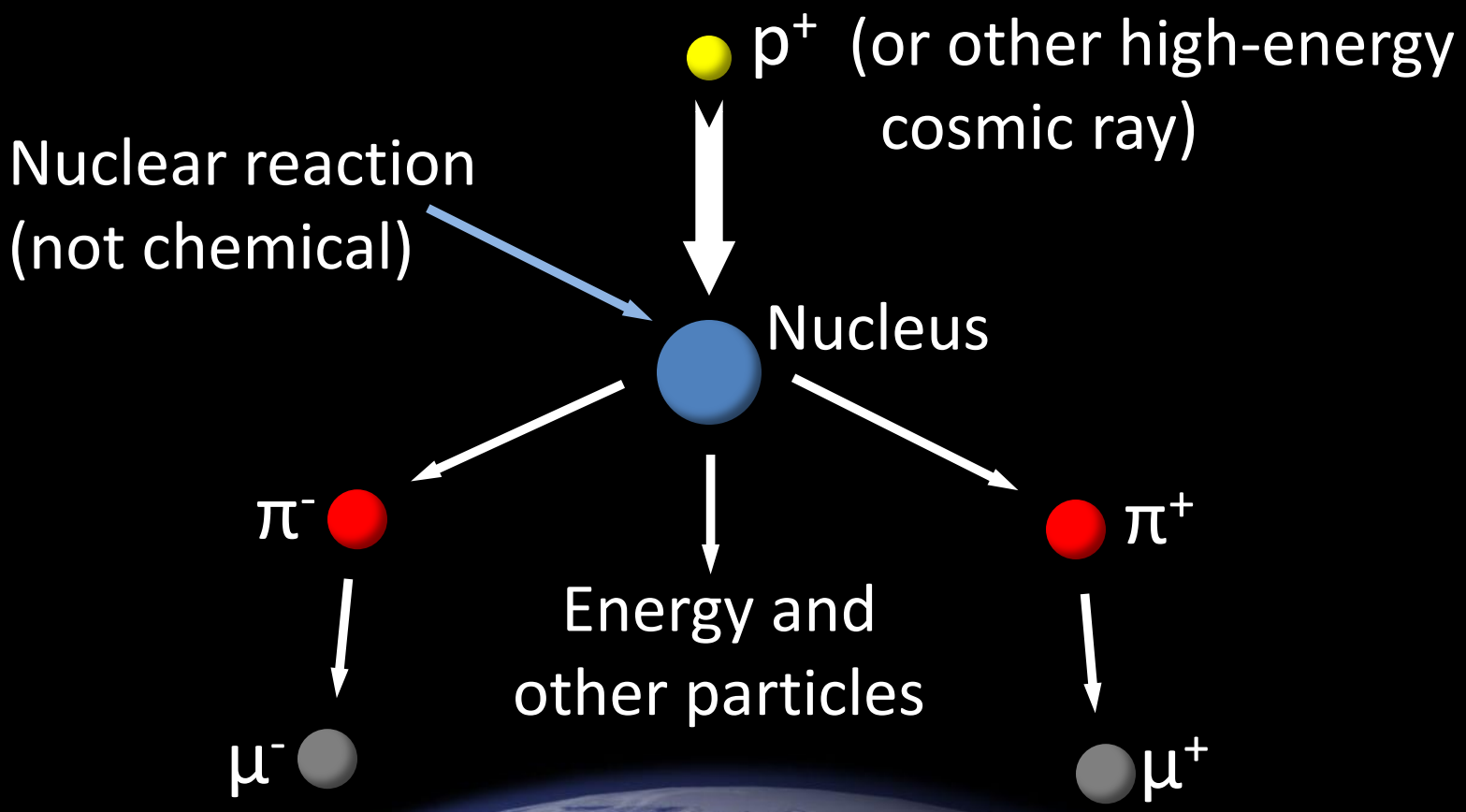
Open Science Grid Computing Cluster

Pictures from the FIT HEP archives.

What are Muons?

- Elementary particles, particularly leptons.
- Symbols:
  - Muon = μ^-
  - Antimuon = μ^+
- Similar to electrons, but 200 times more massive:
  - Muon mass = 0.106 GeV/c^2
  - Electron mass = 0.000501 GeV/c^2
  - Muon charge = -1 e
- Interact weakly electromagnetically with matter.

Where Do Muons Come From?

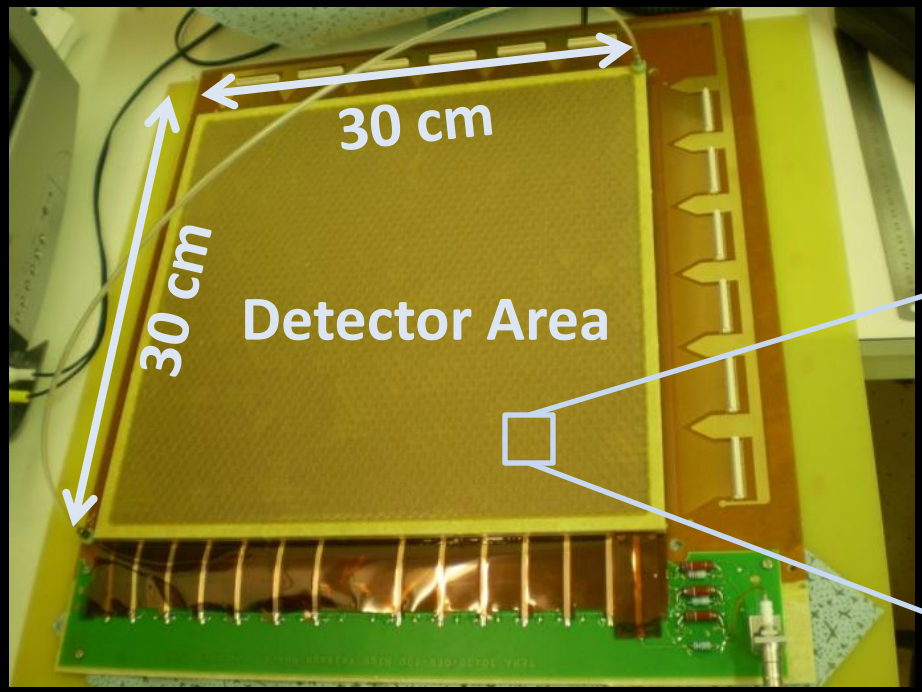


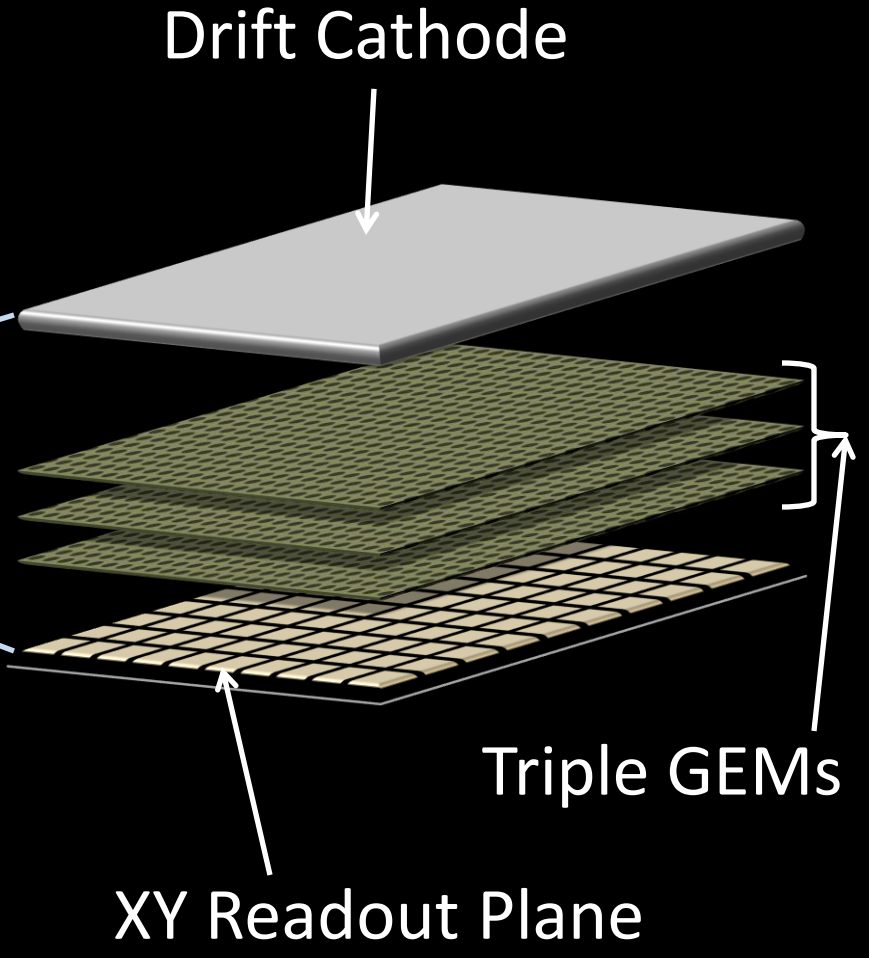
Picture of Earth from NASA Goddard Space Flight Center.

Important Numbers

- Average muon energy (sea level): 4 GeV
- Most probable muon energy (sea level): 1 GeV
- Muon flux at sea level: 10,000 muons/m^2/min

Micropattern Gas Electron Multiplier (GEM) Detector

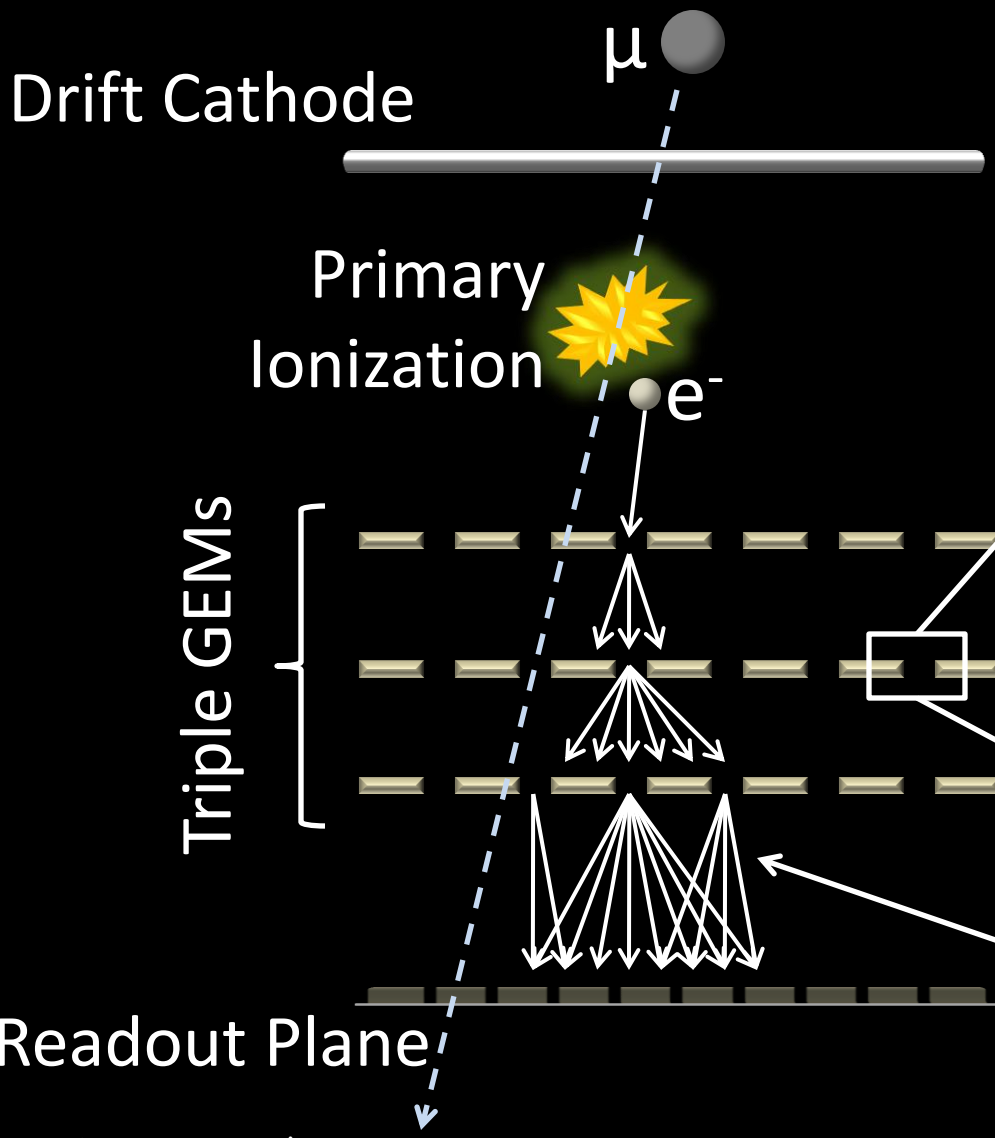


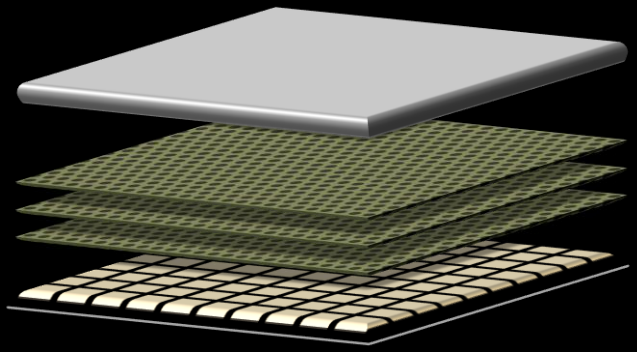


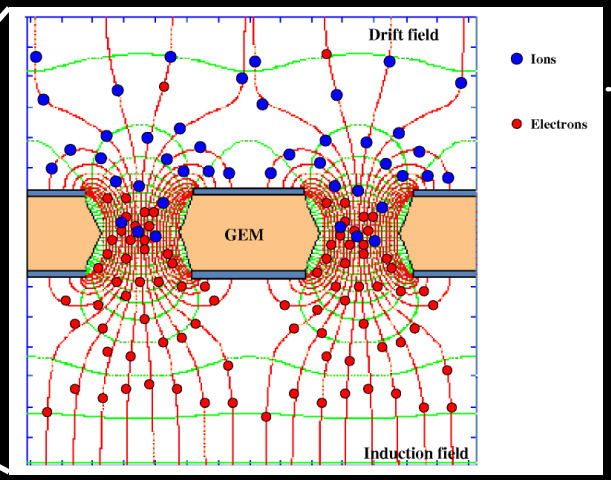
- Cost and space efficient.
- High resolution.

Picture from the FIT HEP archive .

GEM Detector Operation





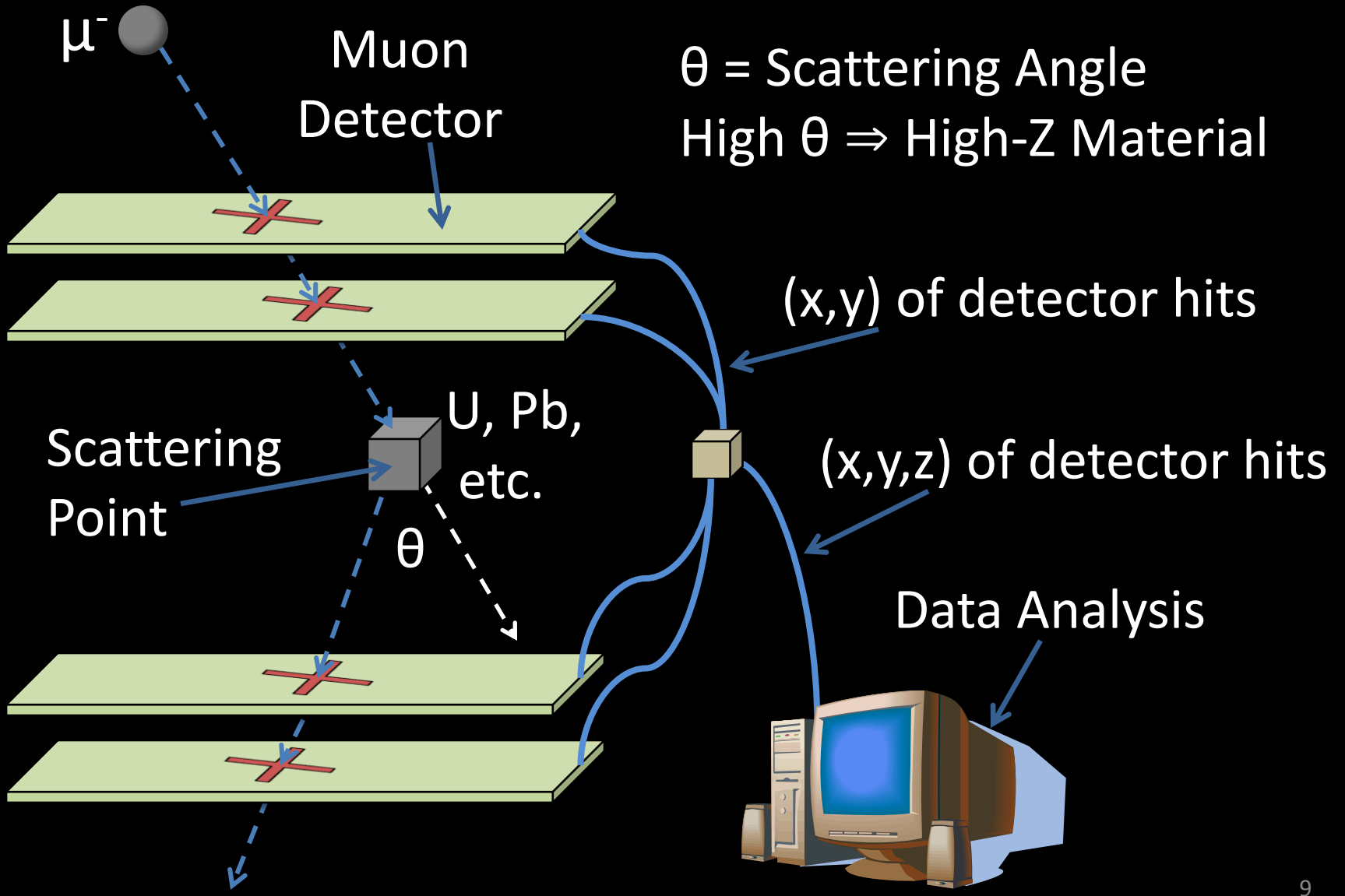


†

Electron Avalanche from Secondary Ionizations

Picture from DESY Labs †.

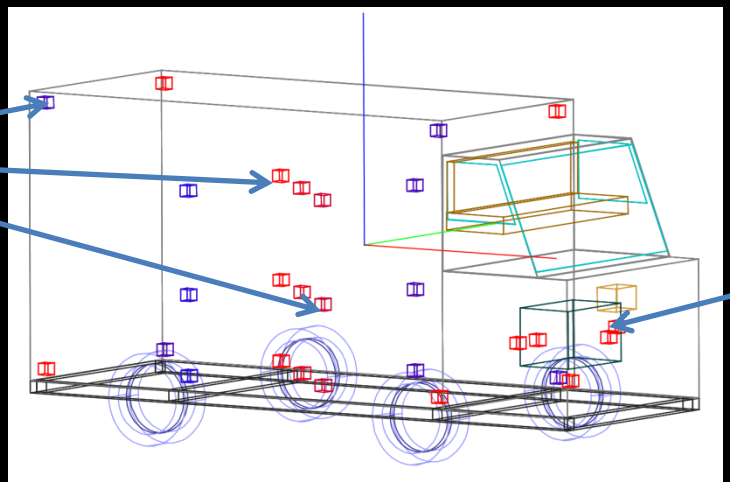
Muon Tomography Concept



Muon Tomography Applications

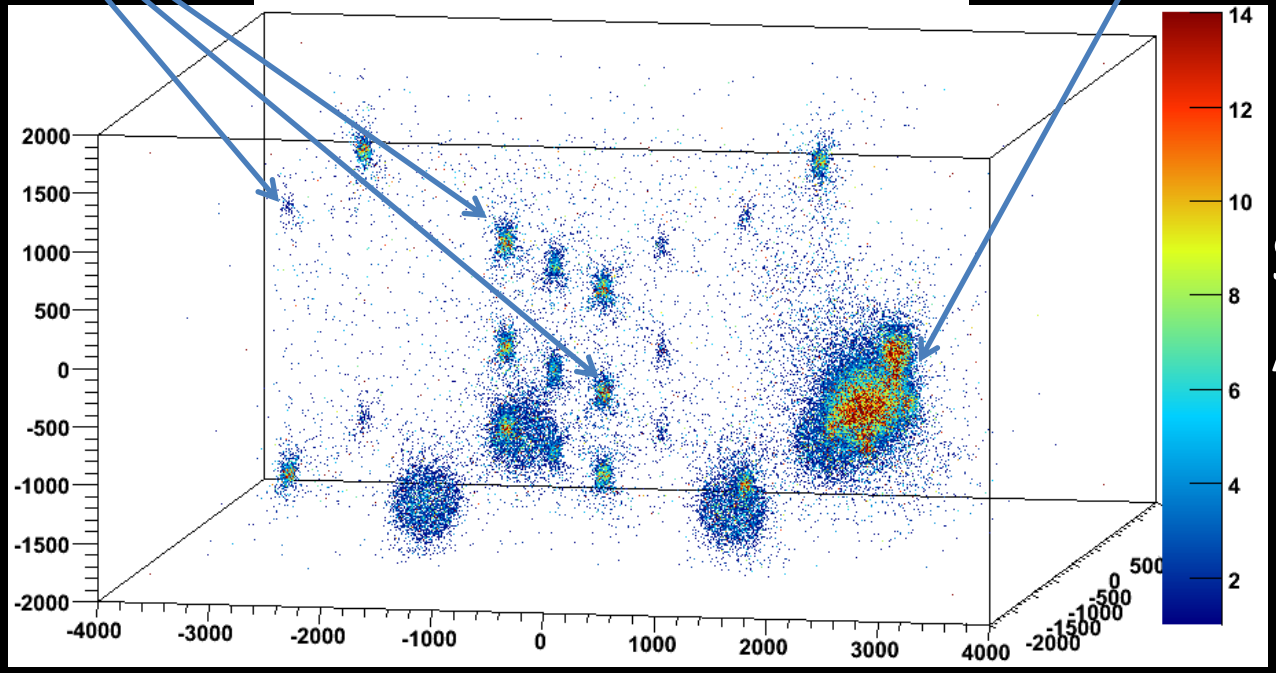
- Investigate trucks with the drivers inside.
- Locate high-Z contraband (Uranium, Plutonium, etc.), even if shielded.
- Possible medical applications when technology significantly improves.

GEANT4 Monte Carlo Simulations



Targets
(U, Pb, etc.)

Engine



Position
(x,y,z)
[mm]

Scattering
Angle
[degrees]

Pictures from the FIT HEP archives.

Prototype Muon Tomography System

30x30 cm^2
GEM Detectors
(Only 5x5 cm^2 Used)

3x3x2 cm^3
Pb Block

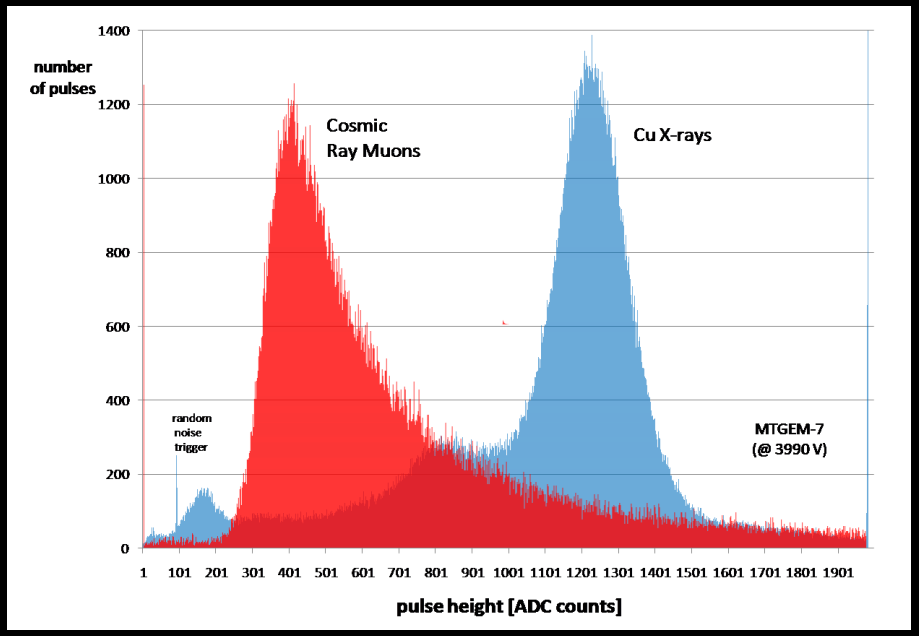
Target Support

GEM Detectors

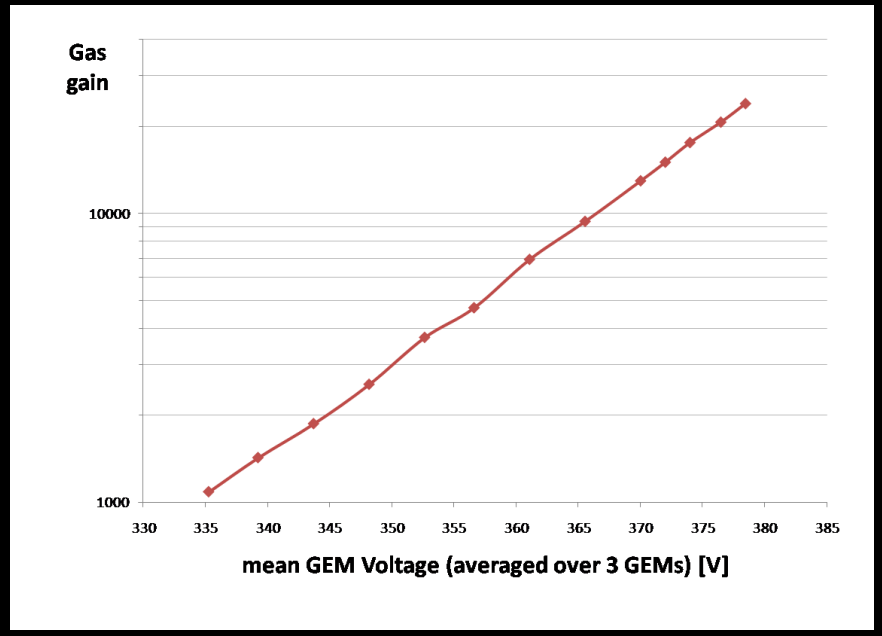
Picture from the FIT HEP archives.

First Results from the Prototype MTS

Muon and x-ray counts



Detector gain from x-ray source



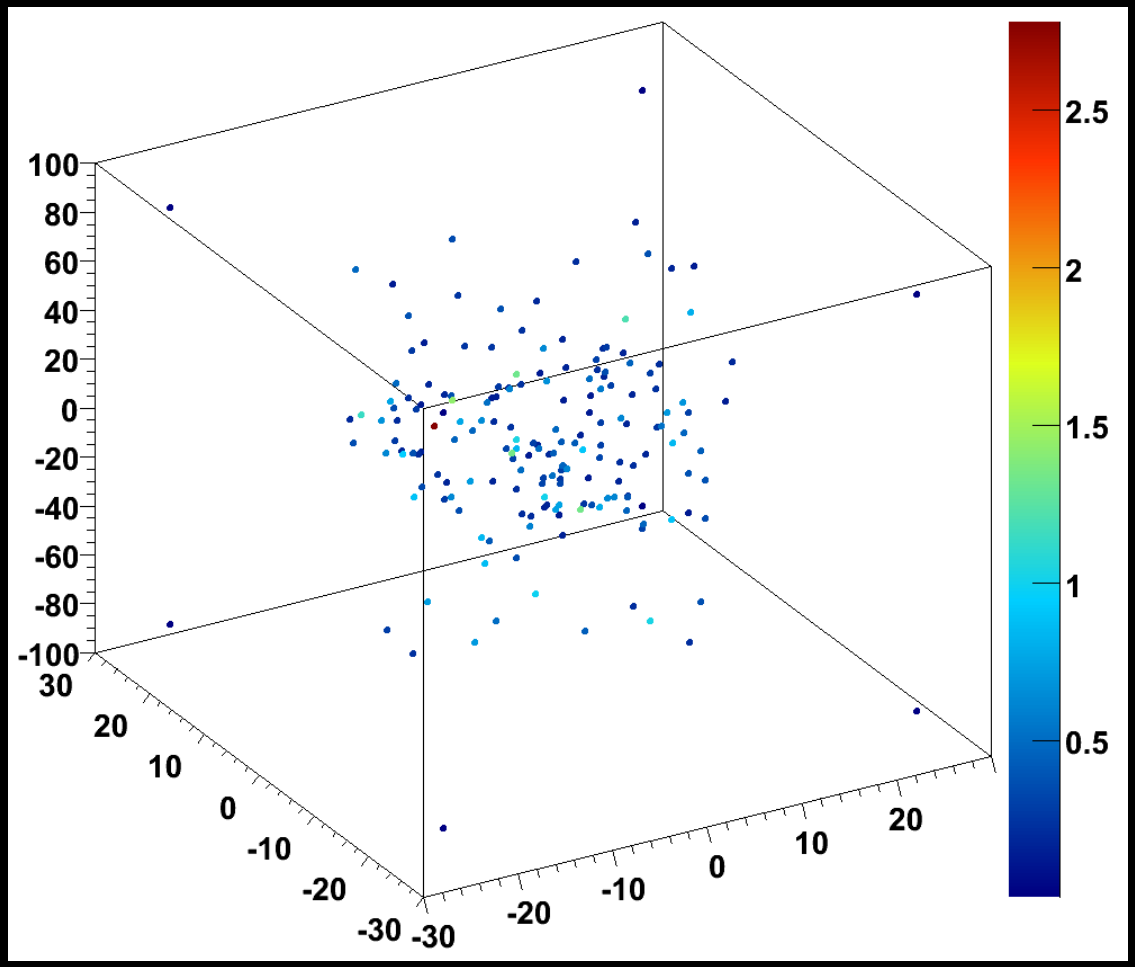
Tomography data still being analyzed.

Pictures from the FIT HEP archives.

Pb Box Target Simulation Results

24 hours exposure to natural muon flux.
Scattering angles less than 0.12° are cut from the data.

Position (x,y,z) [mm]

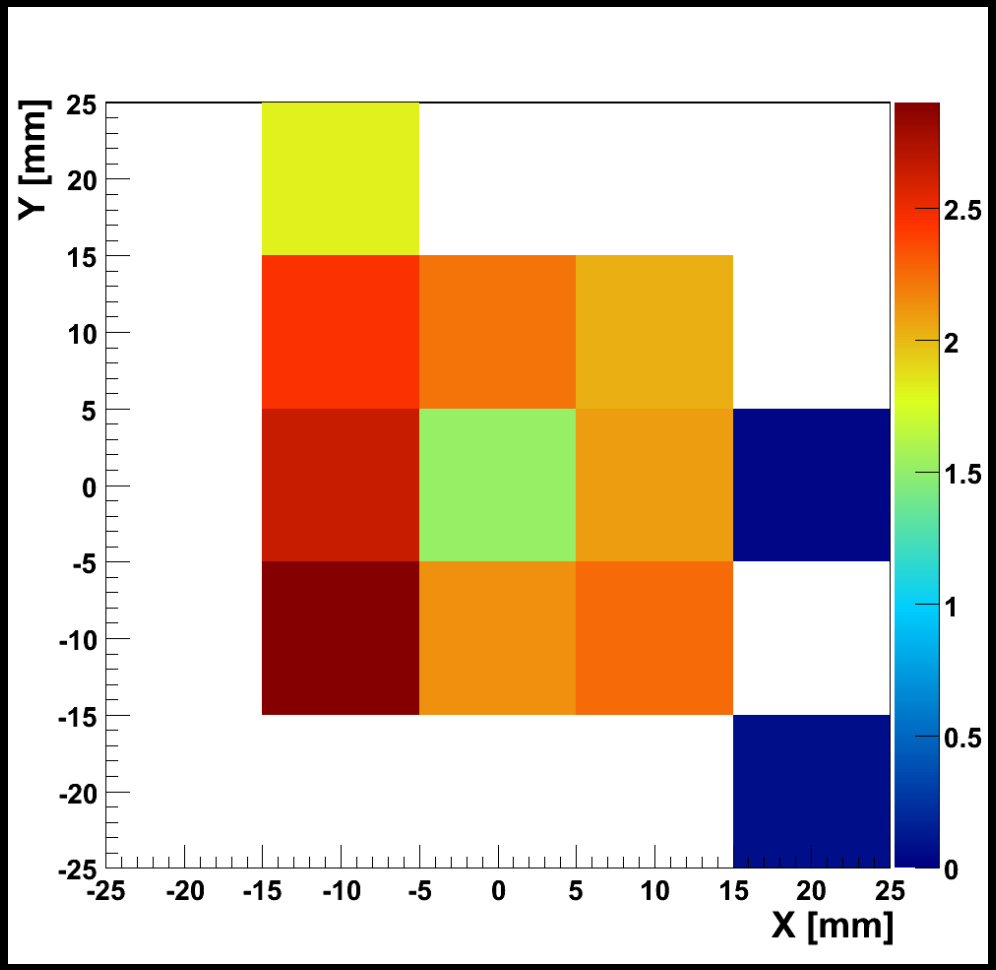


Scattering Angle [degrees]

Picture from the FIT HEP archives.

Pb Box Target Simulation Results

5 mm ≤ z ≤ 15 mm

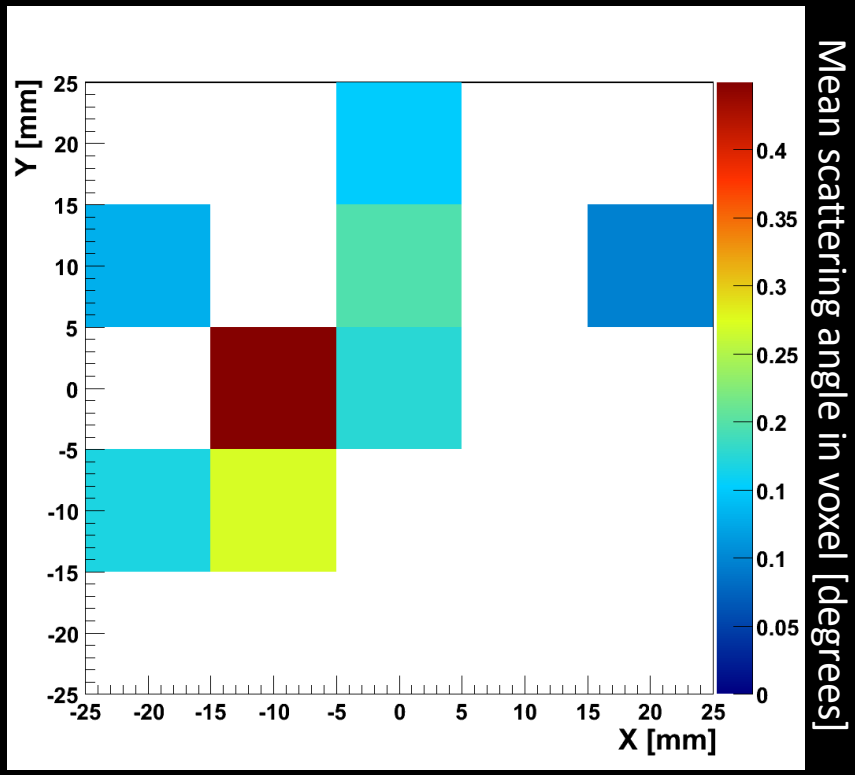


Mean Scattering Angle in Voxel [degrees]

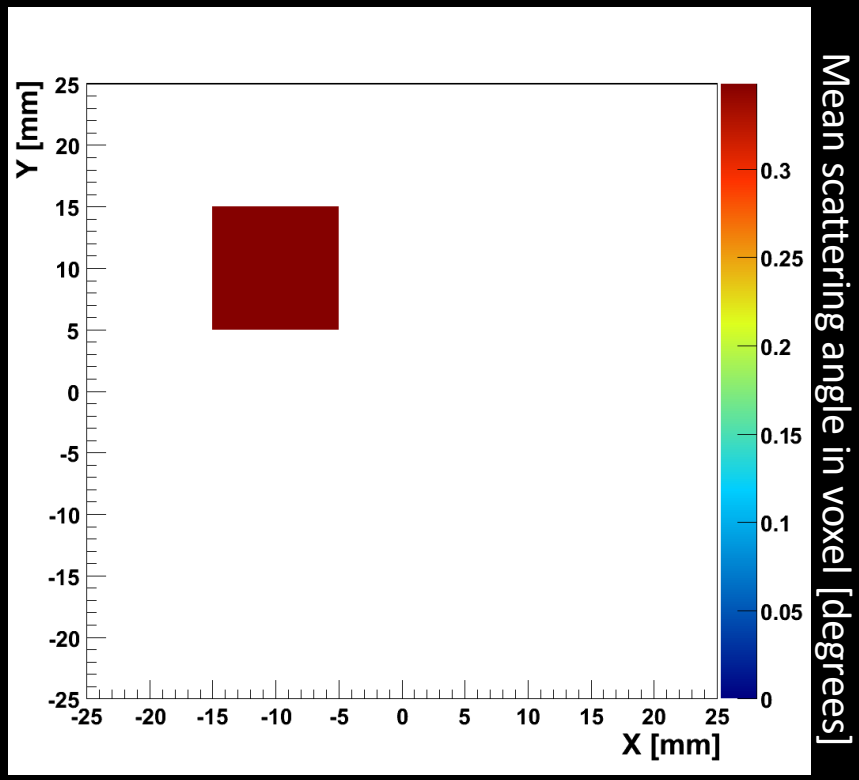
Picture from the FIT HEP archives.

Pb Box Target Simulation Results

75 mm ≤ z ≤ 85 mm
(far above target)



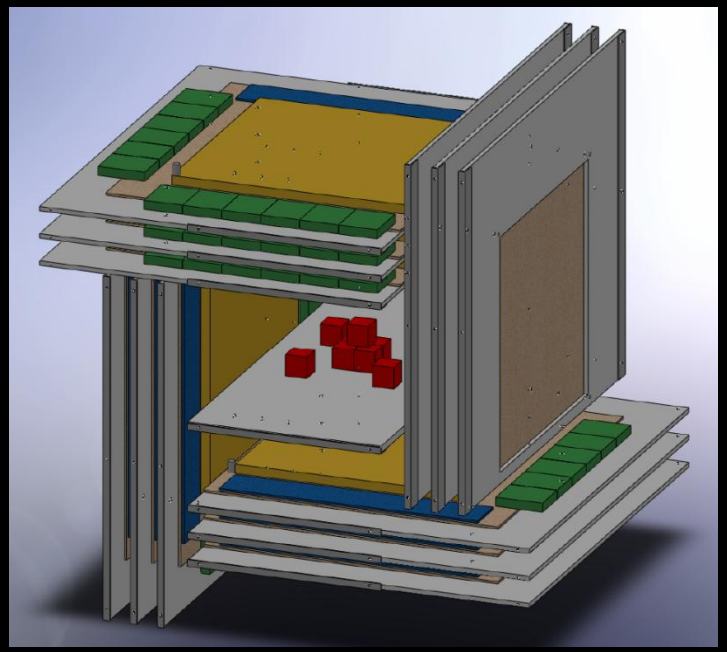
-85 mm ≤ z ≤ -75 mm
(far below target)



Pictures from the FIT HEP archives.

Current and Future Work

- Analyze data from the GEM detector system prototype.
- Construct a GEM detector system with a more efficient geometry and 8 to 12 detectors.
- Continue Monte Carlo simulations for various GEM detector system geometries.



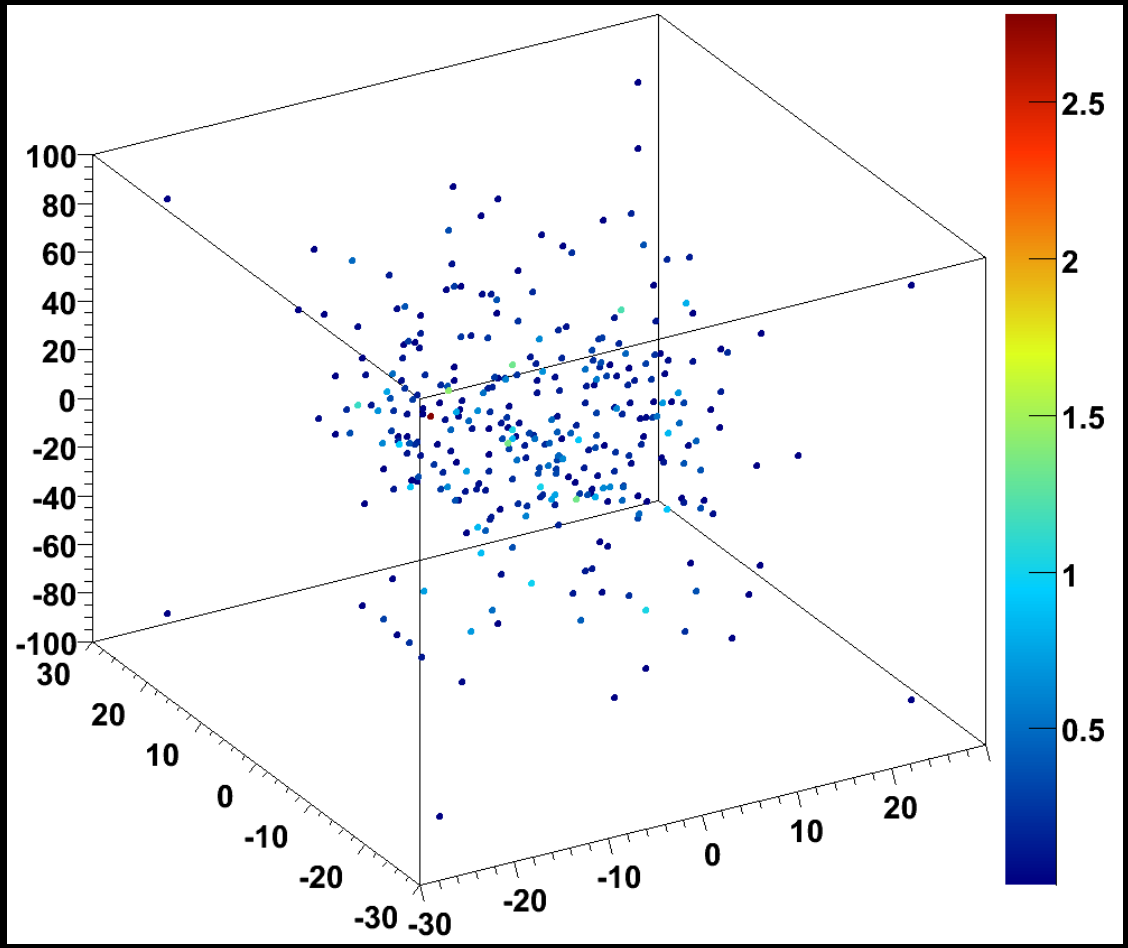
Picture from the FIT HEP archives.


FLORIDA INSTITUTE OF TECHNOLOGY
AD ASTRA PER SCIENTIAM
1958

Pb Box Simulation Results

24 hours exposure to natural muon flux.
No points are cut from the data.

Position (x,y,z) [mm]



Scattering Angle [degrees]

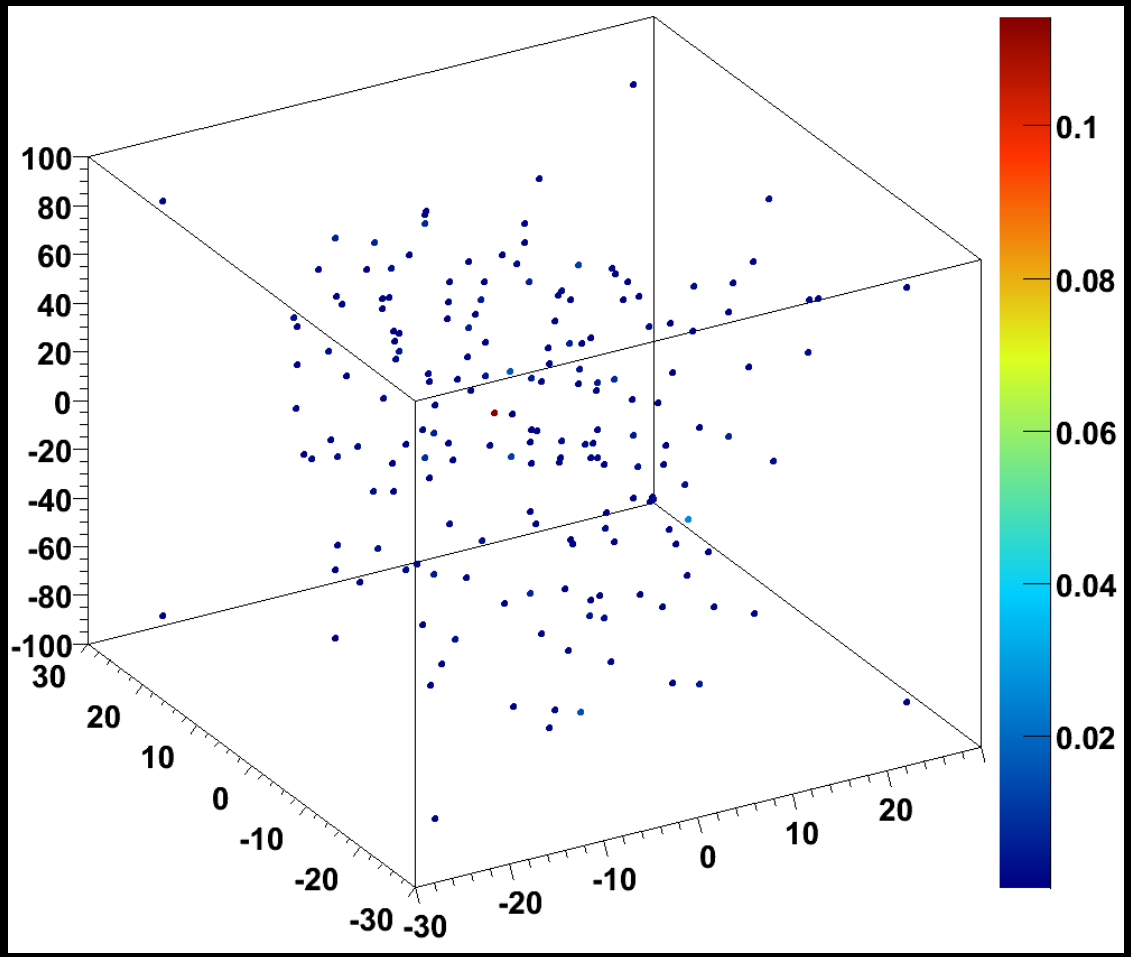
Picture from the FIT HEP archives.

“Empty” Detector Simulation Results

24 hours exposure to natural muon flux.

No points are cut from the data.

Position (x,y,z) [mm]

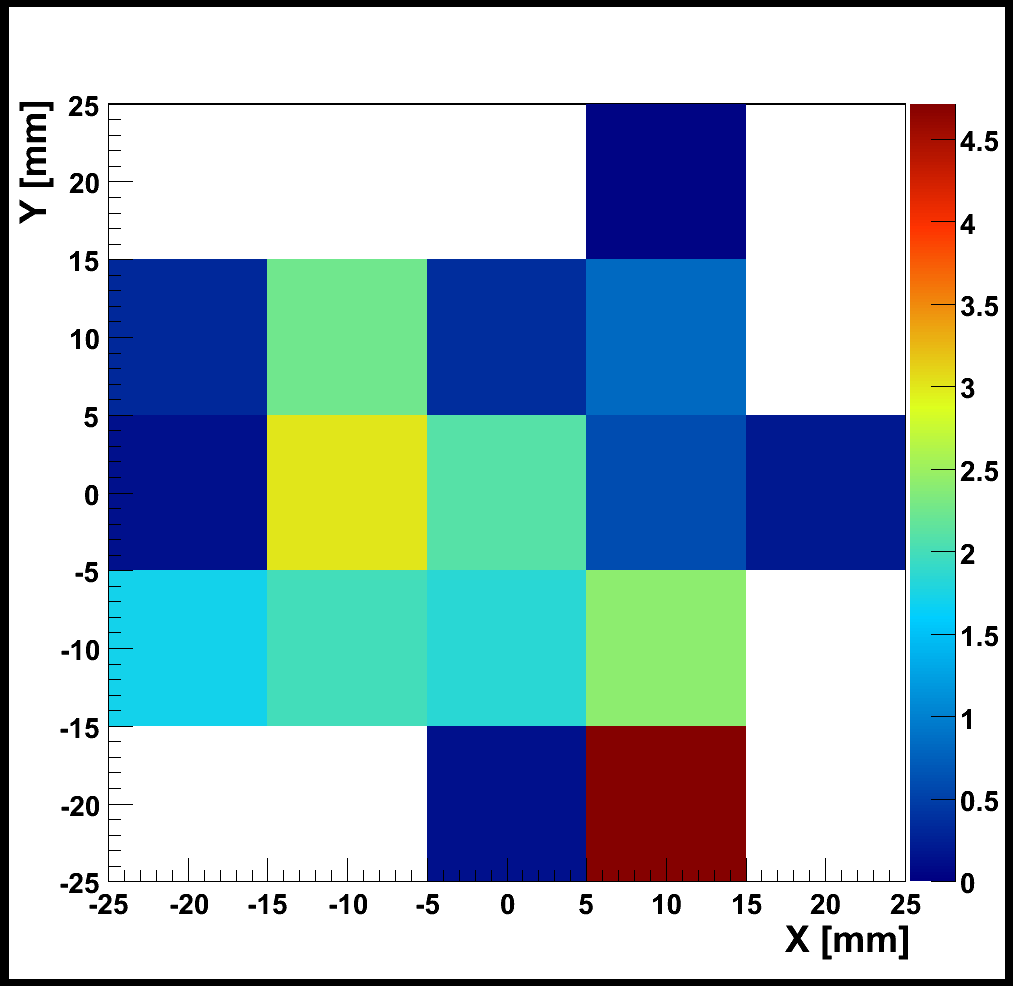


Scattering Angle [degrees]

Picture from the FIT HEP archives.

Pb Box Simulation Results

-5 mm ≤ z ≤ 5 mm



Mean Scattering Angle in Voxel [degrees]

Picture from the FIT HEP archives.