Nuclear Contraband Detection Using Muon Tomography

Faculty/Staff: M. Hohlmann, K. Gnanvo
Graduate Students: L. Grasso, M. Staib
Undergraduates: W. Bittner, **J. Locke**,
M. Phipps, J. Alberto de Faria

High Energy Physics Lab A, OPS 341
Department of Physics and Space Sciences
Florida Institute of Technology

About the Presenter

- Senior undergraduate in physics.
- Worked in the **FIT HEP lab** since sophomore year.
- Primary responsibilities: simulation and data analysis (i.e. lots of code).
- Also researched at:
  - Drexel University (Summer 2009)
  - CERN (Summer 2010)
  - FIT Engineering Systems Dept. (Summer 2011-Present)

Motivation for Muon Tomography

Nuclear contraband is smuggled across borders.

Current radiation scanners use gamma and neutron emissions to detect nuclear contraband.

About 800 radiation portal monitors in the U.S.

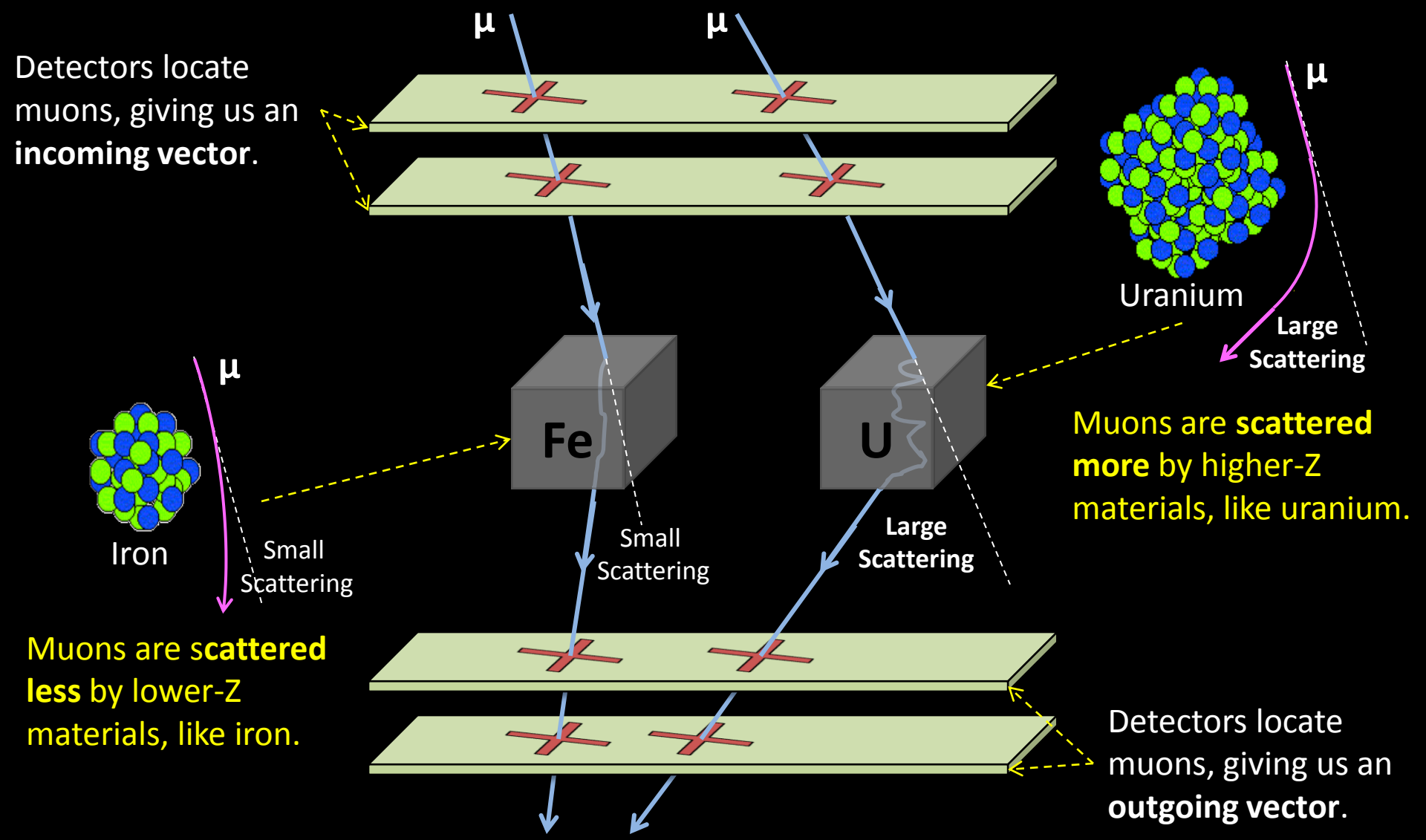
Only ***3.25 mm thick lead shielding*** needed to ***absorb 99% of gammas*** emitted by ^{235}U.

*Q: How can we detect **shielded** nuclear contraband?*

A: Muon tomography!

Muon Tomography Concept

Muons are subatomic particles that come from cosmic rays and pass through us all the time.



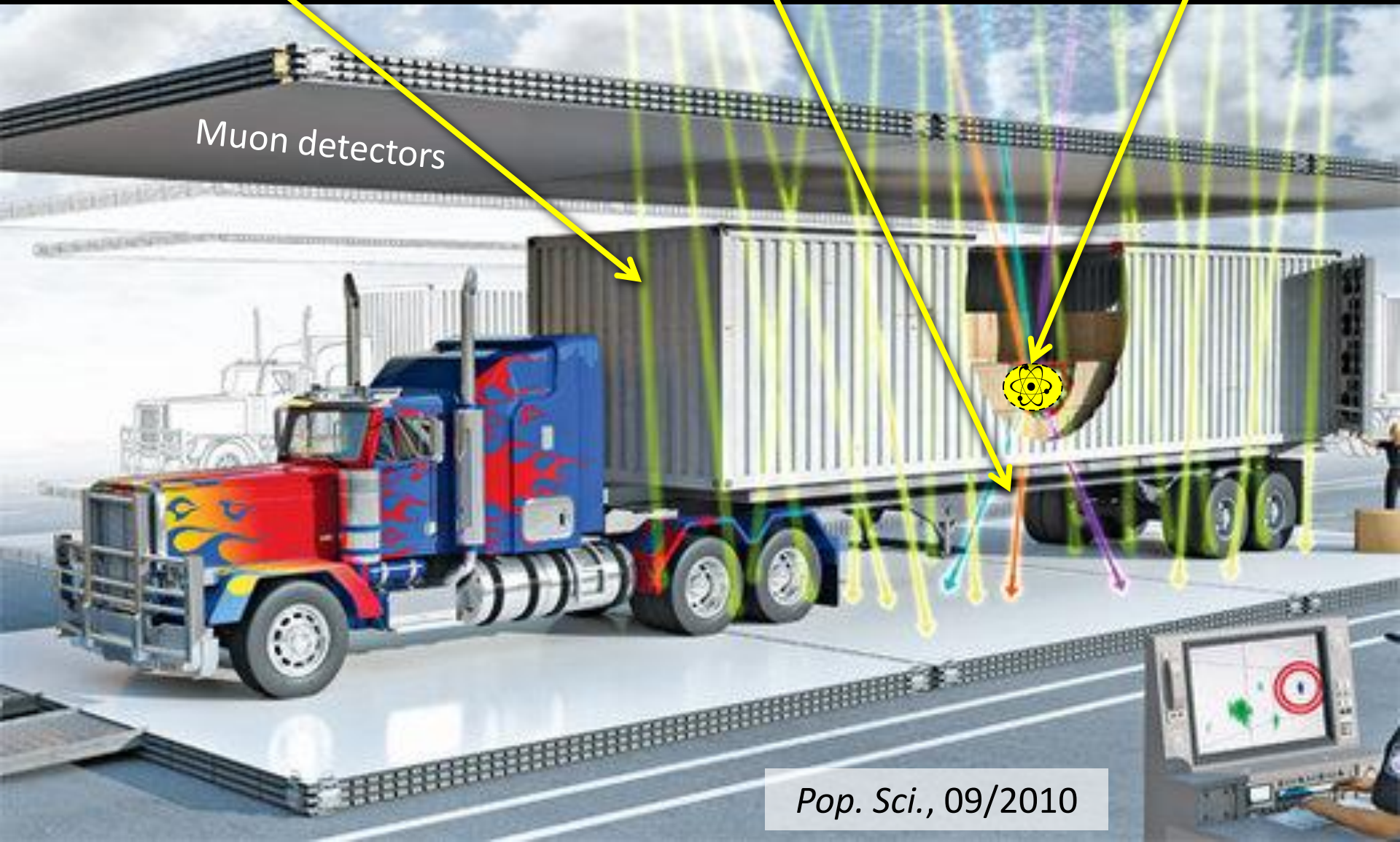
The location and angle of scattering are reconstructed using the incoming and outgoing vectors.

Muon Tomography Station Deployment

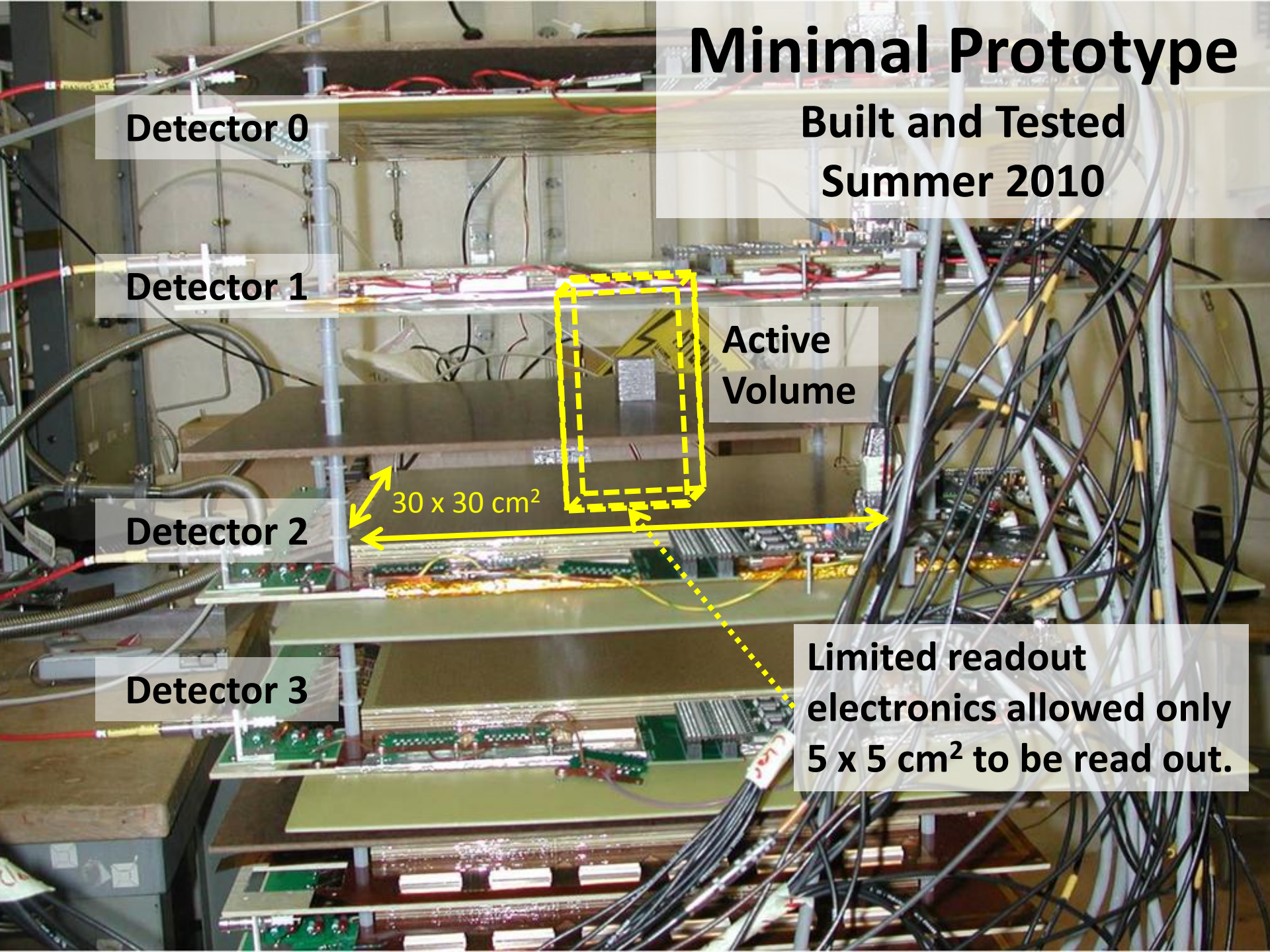
Low-scattering muons pass through cargo and container.

High-scattering muons Pass through high-Z material.

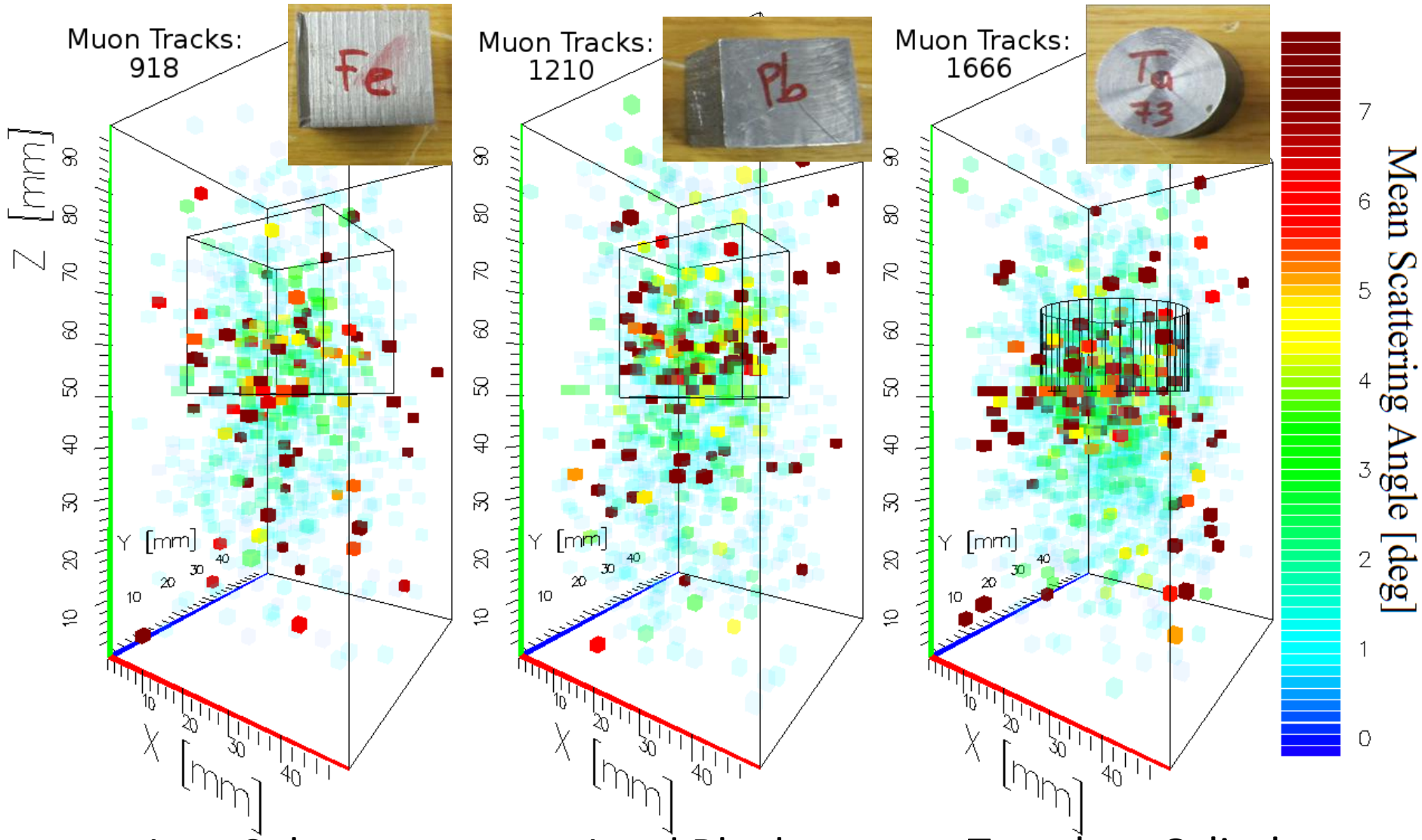
Hidden and shielded nuclear contraband.



Pop. Sci., 09/2010


Minimal Prototype
Built and Tested
Summer 2010
Detector 0
Detector 1
Active Volume
30 x 30 cm²
Detector 2
Detector 3
Limited readout electronics allowed only 5 x 5 cm² to be read out.

Minimal Prototype *Real Data* from Summer 2010



Iron Cube

3 x 3 x 3 cm^3

$Z = 26$, $\rho \approx 8$ g/cm^3

Lead Block

3 x 2.8 x 3 cm^3

$Z = 82$, $\rho \approx 11$ g/cm^3

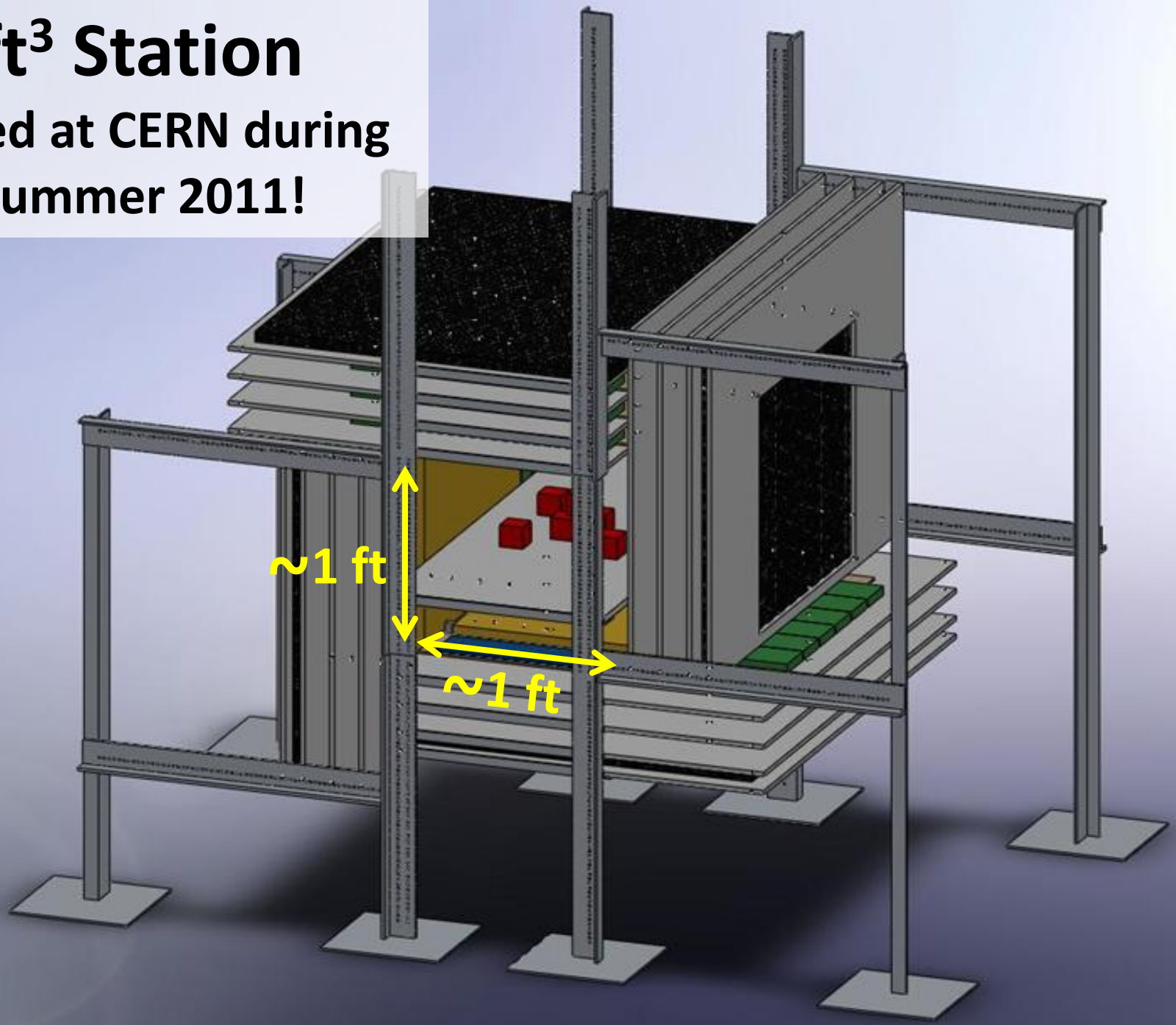
Tantalum Cylinder

$h = 1.6$ cm, $r = 1.5$ cm

$Z = 73$, $\rho \approx 17$ g/cm^3

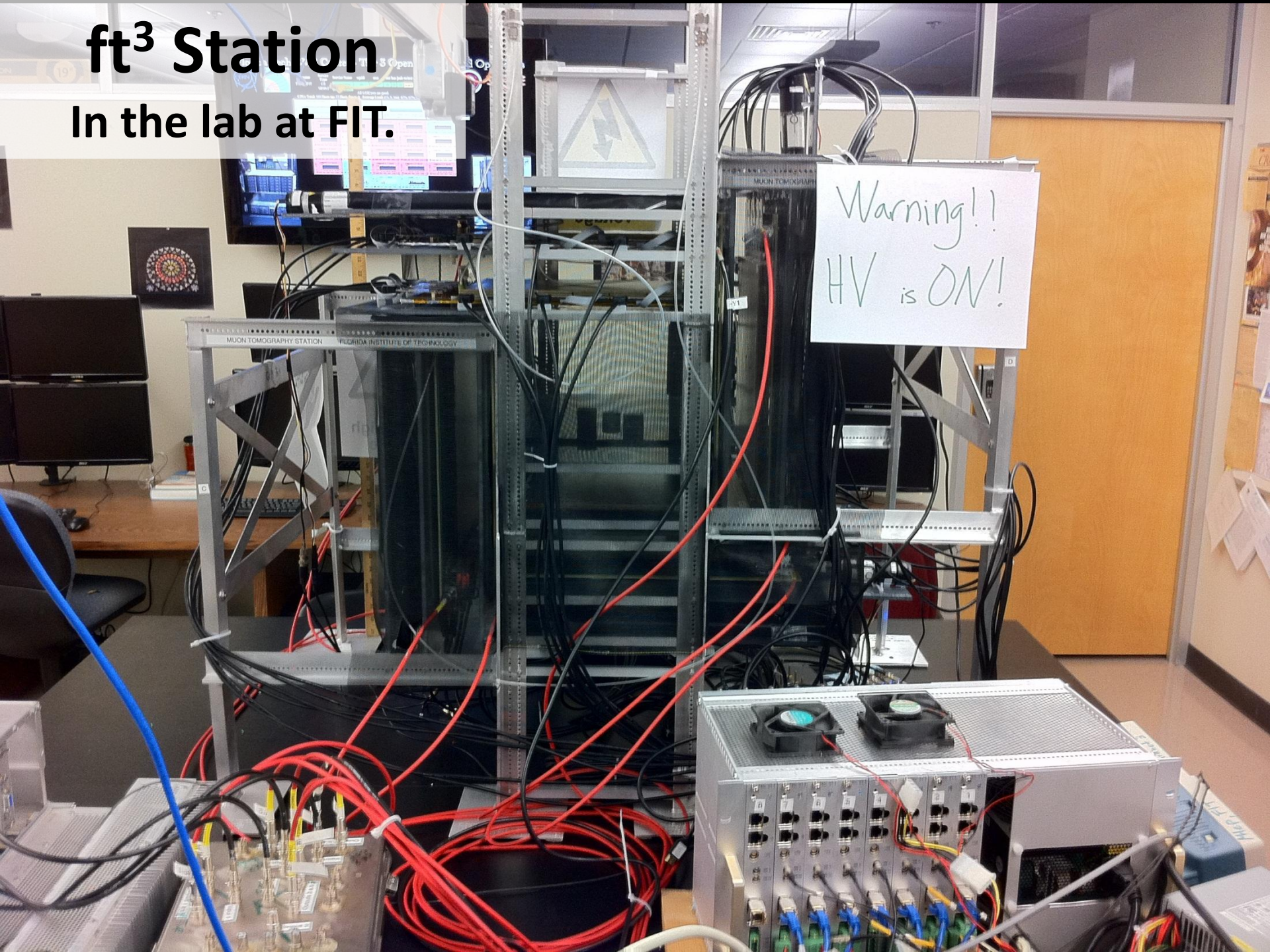
ft^3 Station

Tested at CERN during Summer 2011!



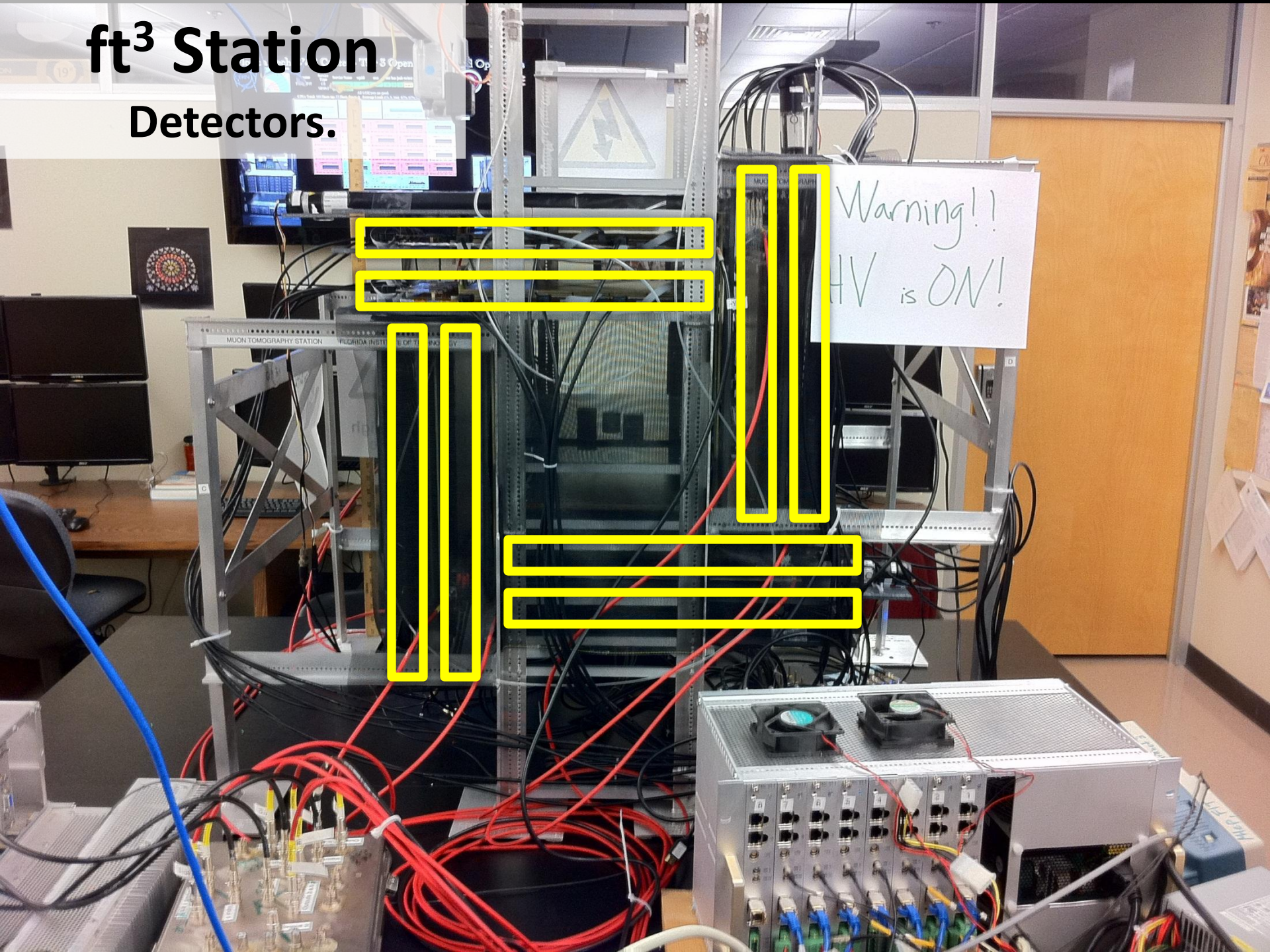
ft³ Station

In the lab at FIT.



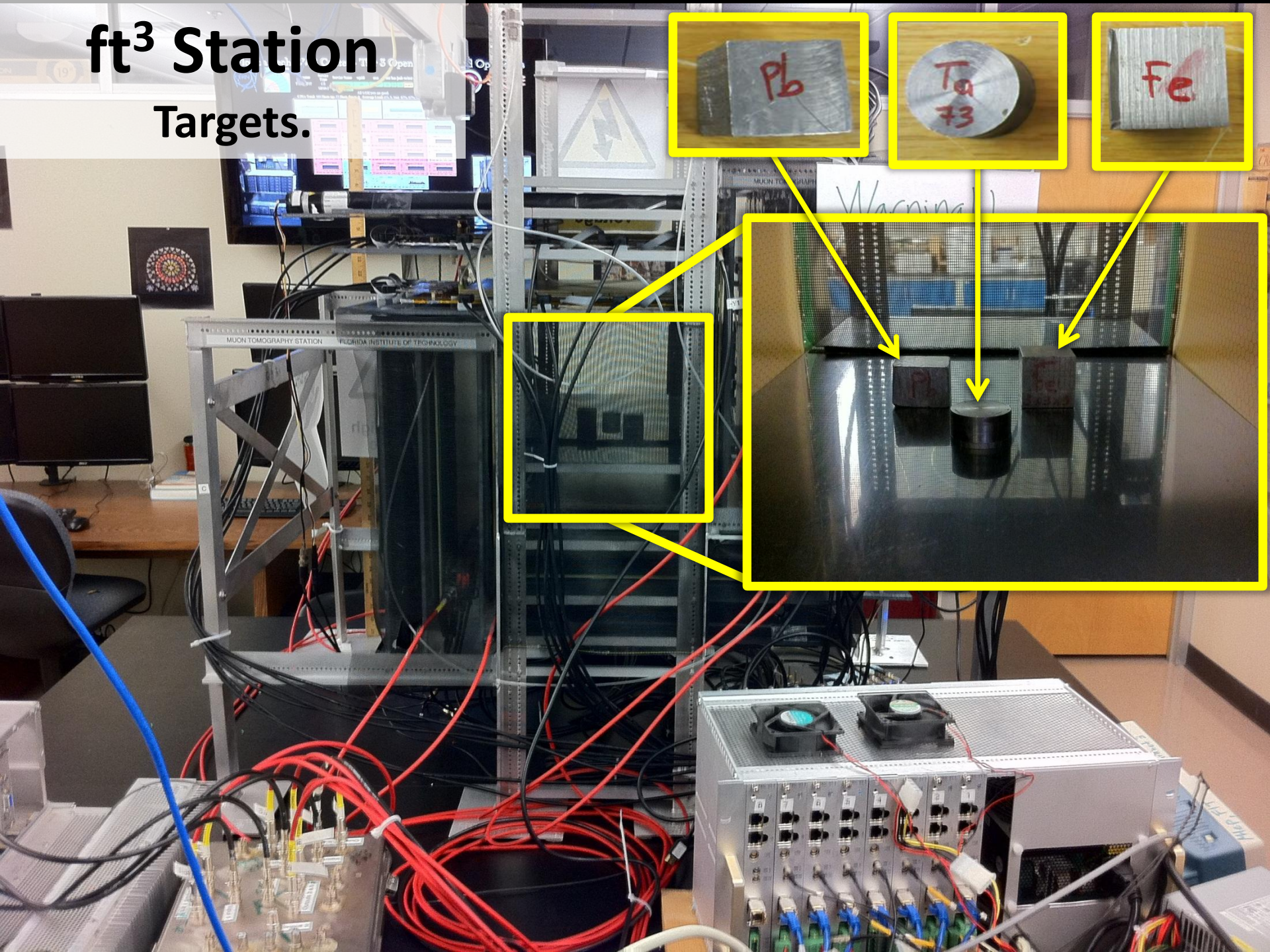
ft^3 Station

Detectors.



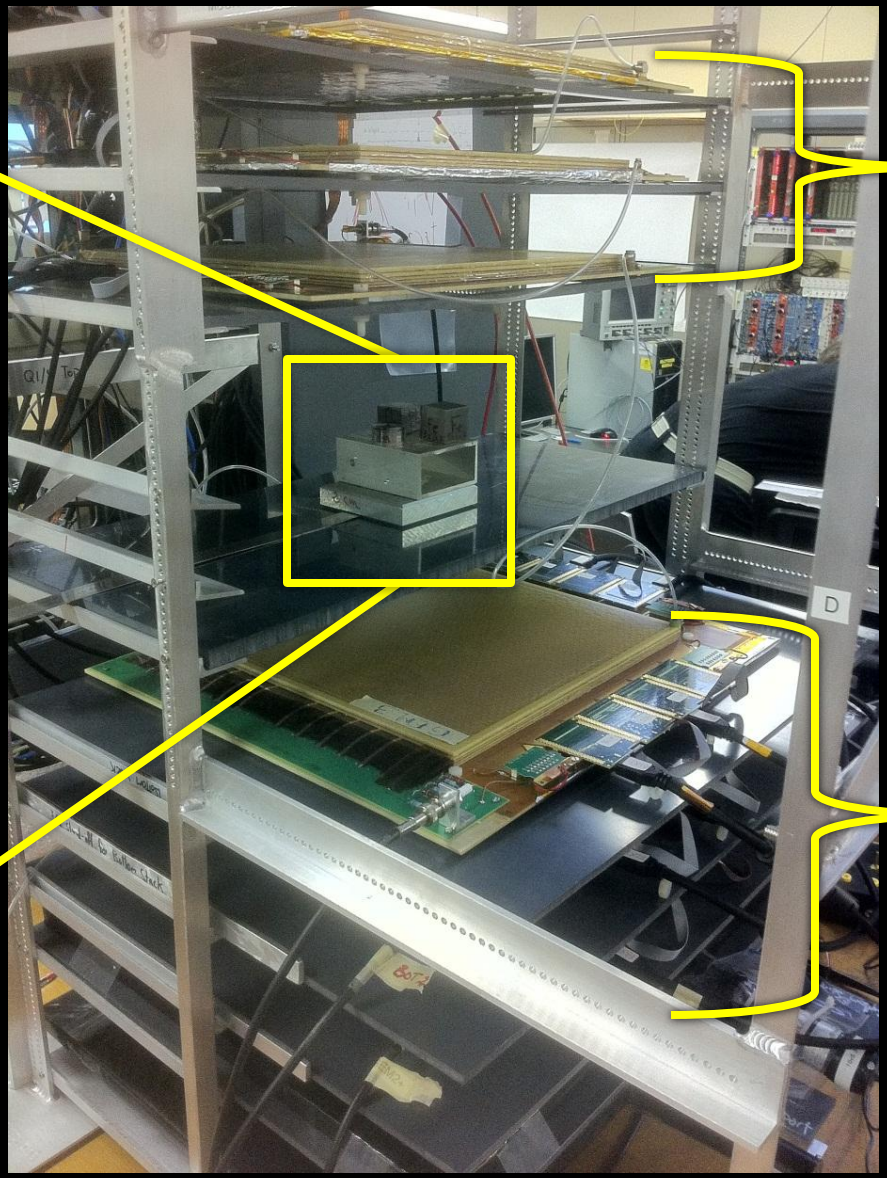
ft^3 Station

Targets.



3-Target Scenario (Summer 2011)

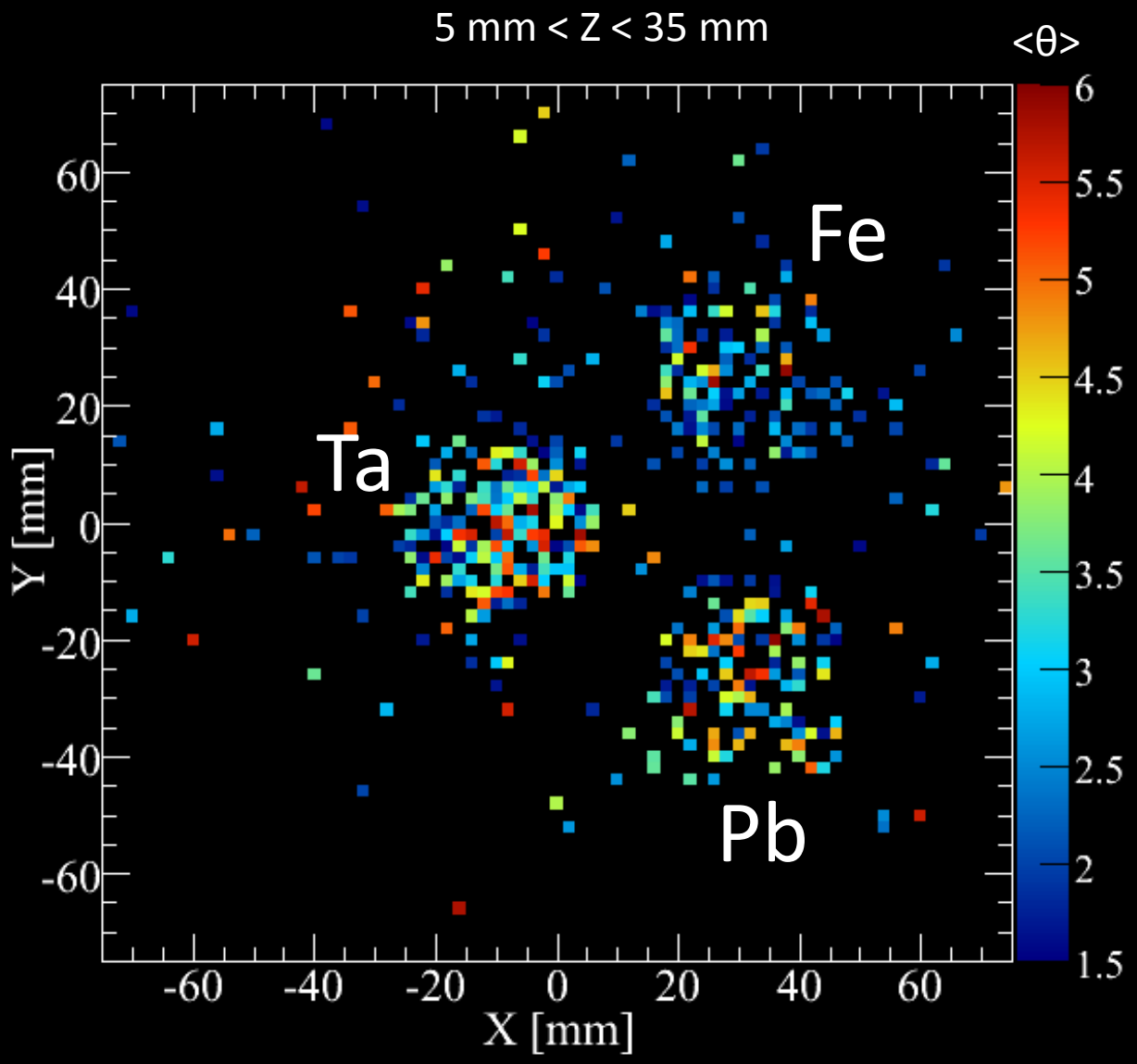
Target Scenario



3 Detectors on Top

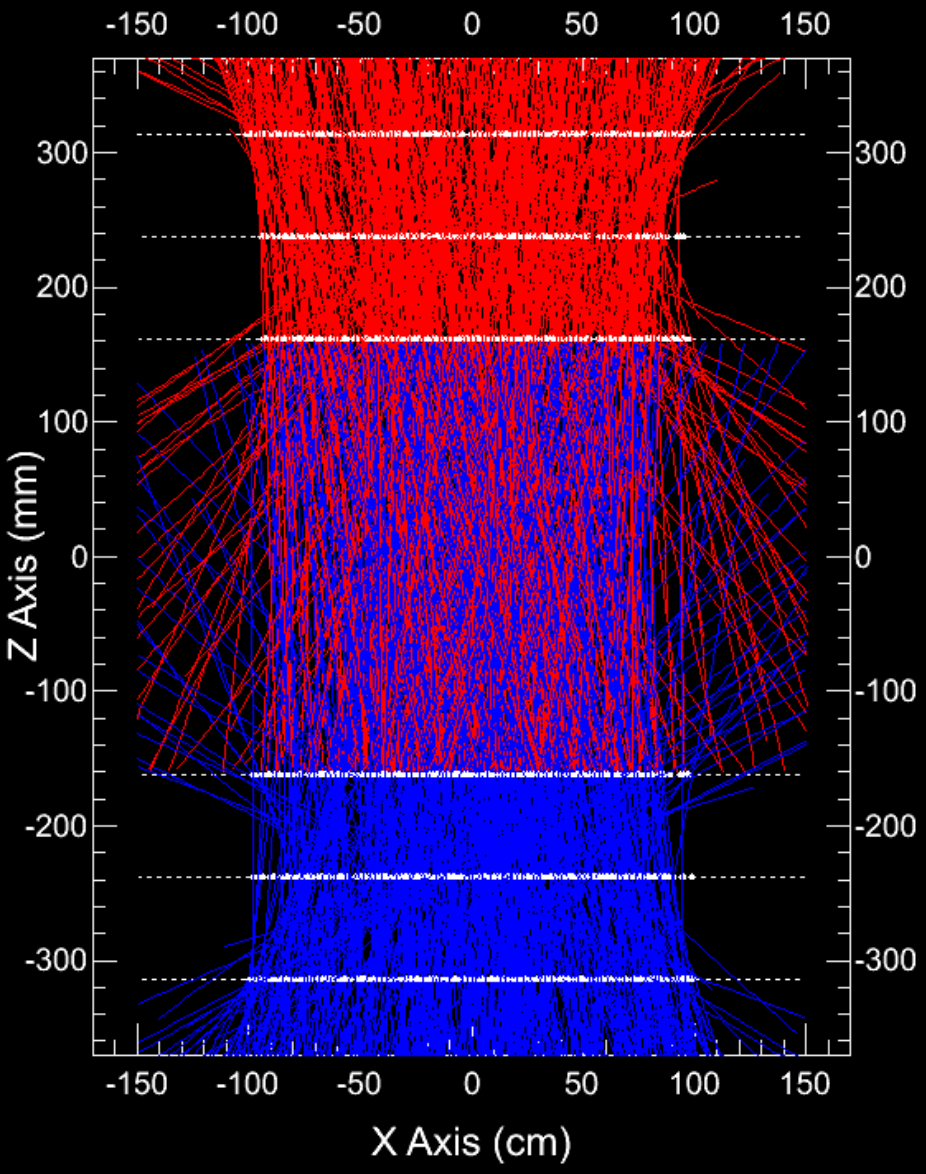
3 Detectors on Bottom

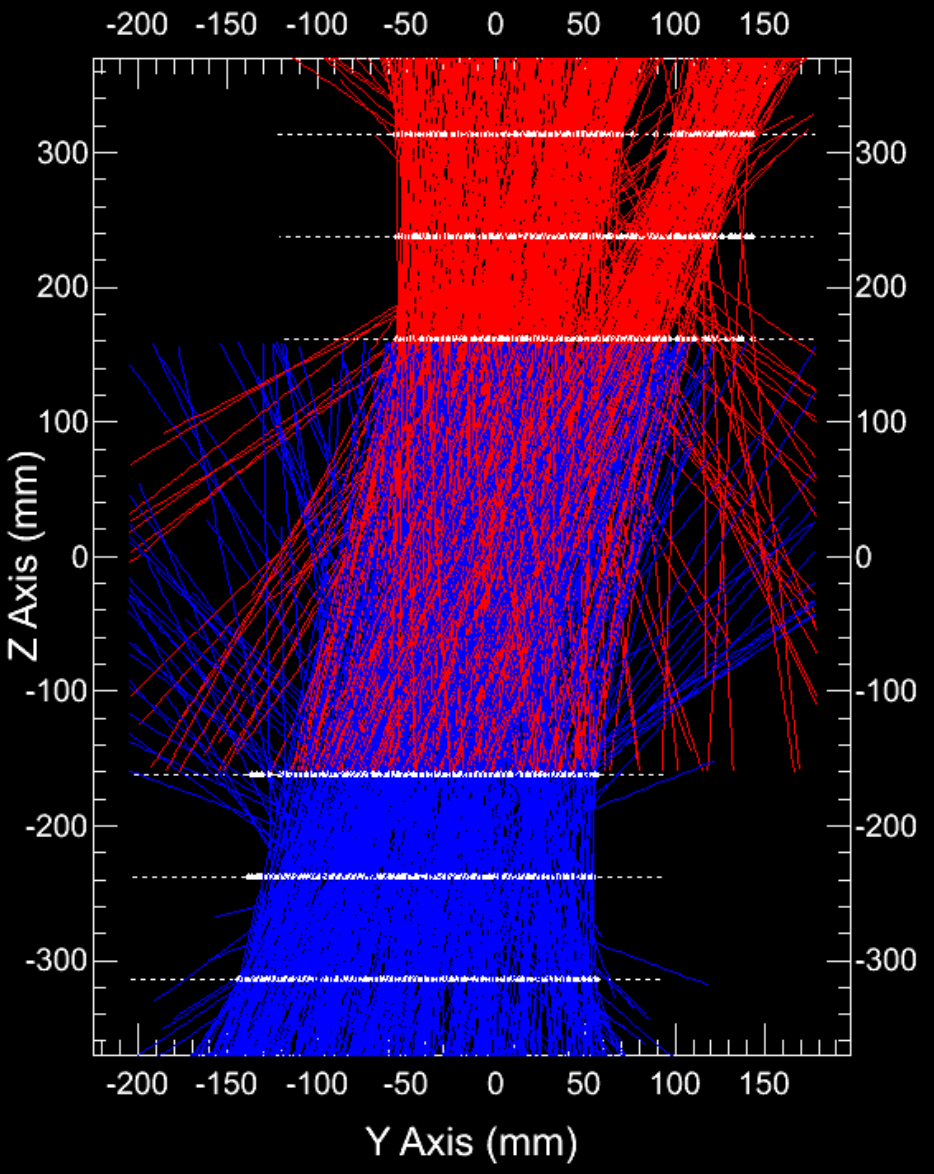
3-Target Scenario (Summer 2011)



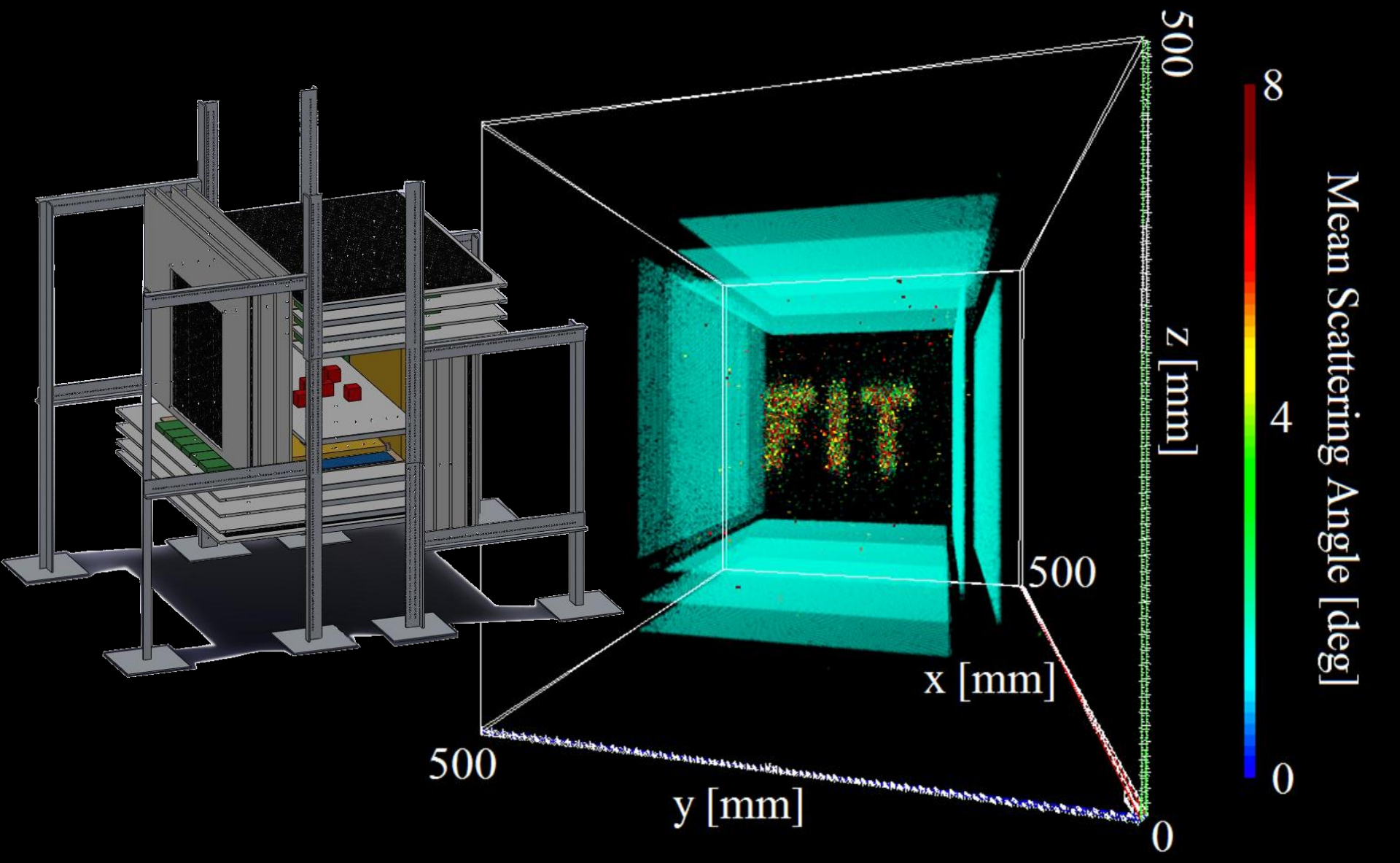
Experimental “Coverage”

500 muon tracks. Incoming = Red. Outgoing = Blue.





Simulation of “FIT” Made of Uranium

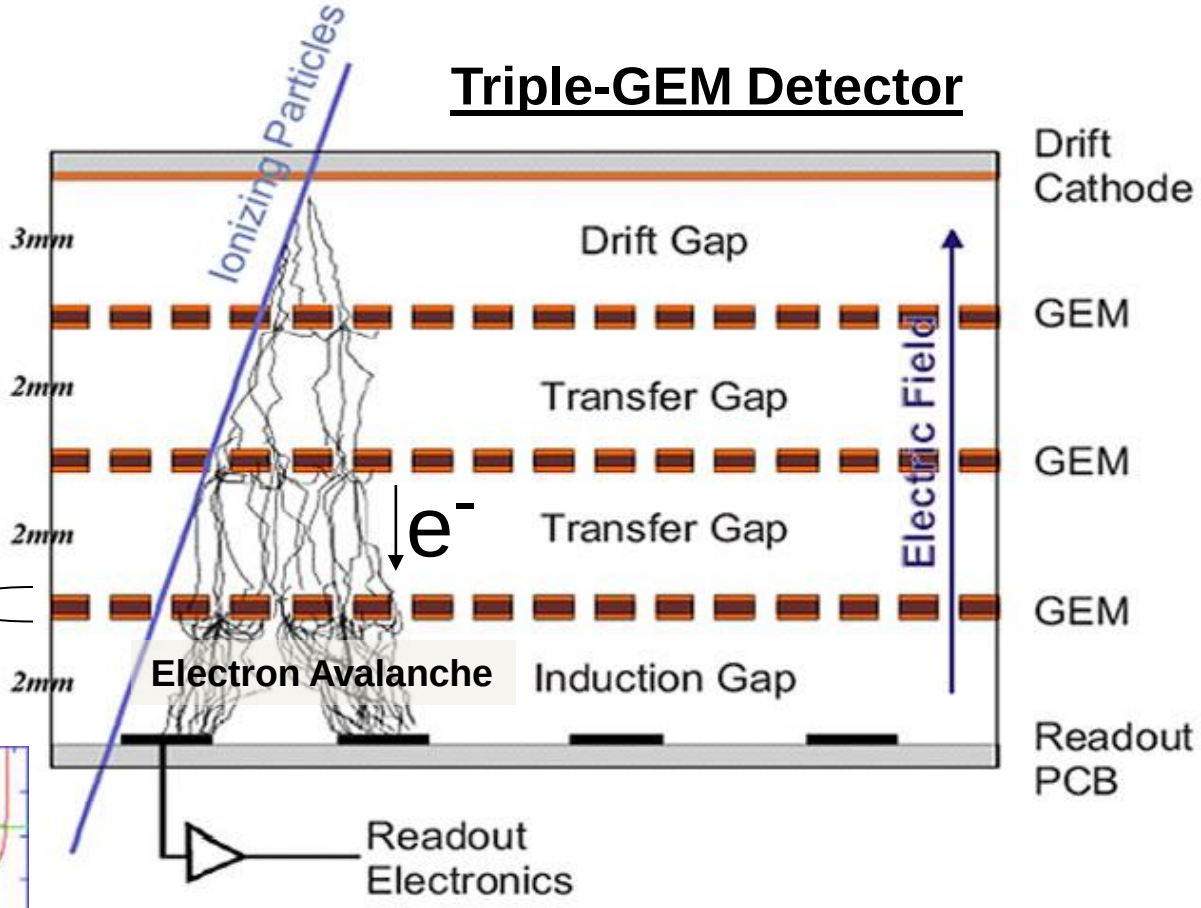


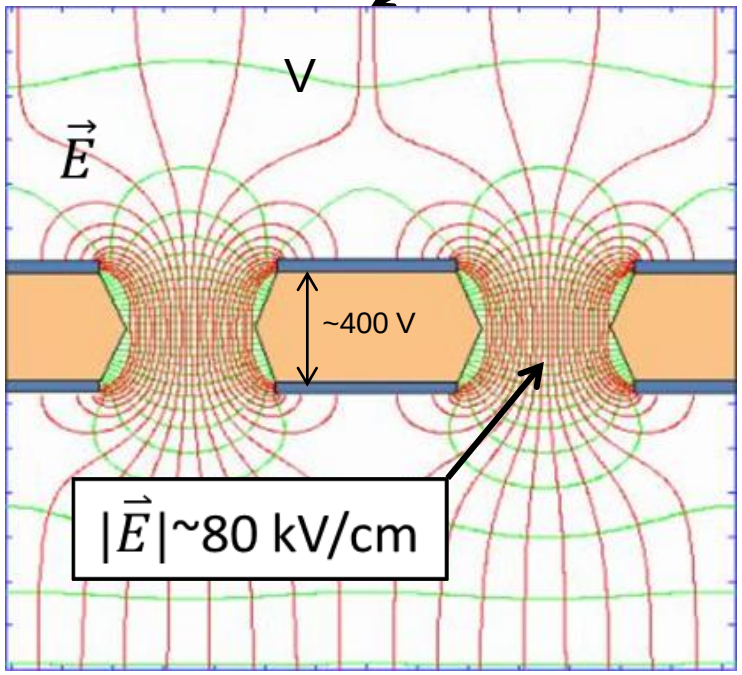
Summary

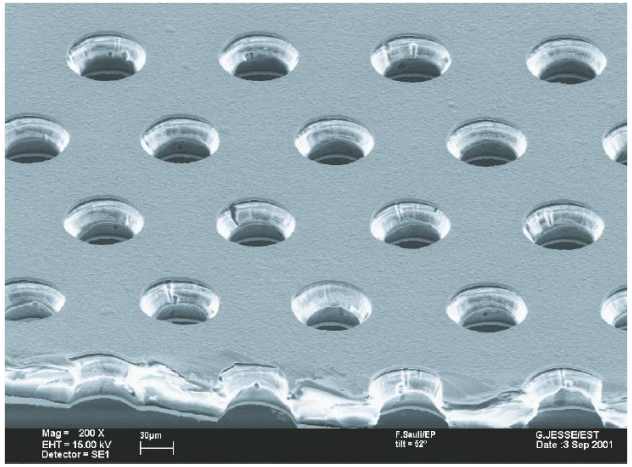
- Muon tomography uses technology developed for particle physics to detect hidden and shielded nuclear contraband.

- We have constructed two prototypes and successfully imaged several targets.

Triple-GEM Detector







$$D = 70\ \mu\text{m}$$
$$d = 60\ \mu\text{m}$$
$$p = 140\ \mu\text{m}$$