Large Area GEM Detectors for Muon Tomography:
Application to Nuclear Material Contraband Detection

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Principle of Muon Tomography using cosmic ray muons

Incoming muons ($\mu$)

Regular material (low/medium Z):
Small scattering angles

High-Z material:
Big scattering angles!

Note: angles are exaggerated!

$\theta_0 = \frac{13.6 \text{ MeV}}{\beta cp} \sqrt{\frac{x}{X_0}} \left[1 + 0.038 \ln \left(\frac{x}{X_0}\right)\right]$ with $\frac{1}{X_0} \propto (Z(Z + 1))$

Nearly Gaussian distribution of the scattering angle $\theta$ with the width $\theta_0$ proportional to $Z$
Muon Tomography with Drift Tubes

Original idea:
- L. Schultz et al. (Los Alamos 2003)

Other Groups:
- CMS muon chambers (INFN Padova)
- ATLAS Muon Chambers (IHEP, Protvino)

Commercial approach: Decision Science Corp. in collaboration with Los Alamos National Lab.
Large GEM vs. Drift Tubes for MT

DS/LANL DT Station

FIT, GEM station

Muon acceptance of the MTS volume

Better spatial resolution

140 cm

~10 to 20 cm

Z (cm)
X (cm)
Y (cm)
Simulation of a GEM-based MT station

The reconstruction:

- Point Of Closest Approach (POCA) algorithm for the 3D interaction point
- Scattering density $\lambda$ using the scattering angle information and the muon

$\lambda$ (a.u.)

The GEANT4 scenario

Closest approach of two lines in 3-D space
First MT prototype: Proof of Concept

Production of 10 GEM detectors:

- Based on the upgrade of COMPASS design by TERA (F. Sauli)
- Assembly of the detectors currently ongoing
- Help from CERN GDD group (L. Ropelewski) and CERN PCB workshop (R. de Oliveira)

Front End Electronics and readout system:

- Different options under investigation
- Any help and suggestions are welcome
Large area GEM detectors for the next generation MT station prototype

- Typically ~1 m² size GEM detectors needed.
- These large chamber => base unit for a full size MT station.
- We are willing to participate on the R&D's effort
  - We want to be one of the first applications testing large area GEM chambers

For more, come and take a look at the poster!

Thank you