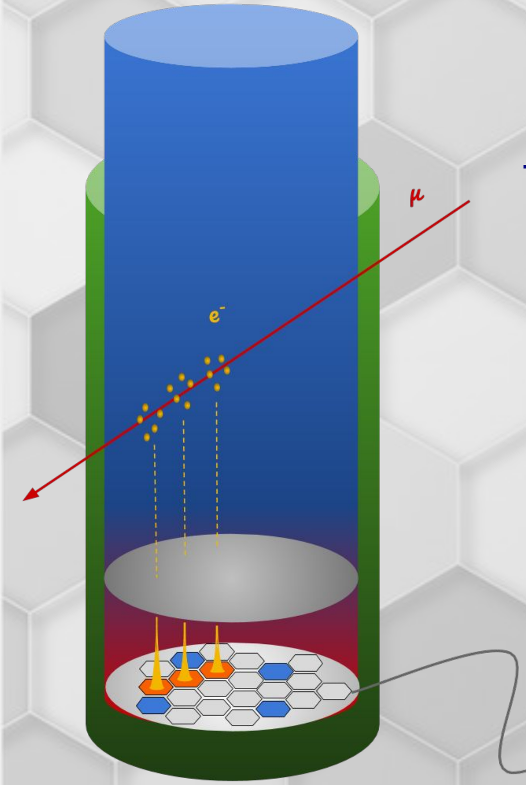
D3DT: an innovative TPC for muon tomography



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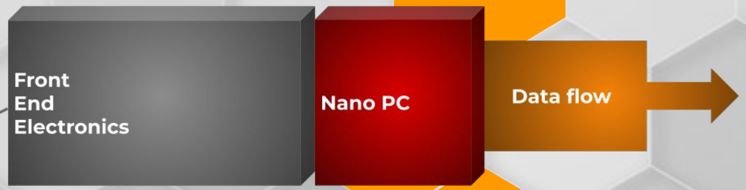

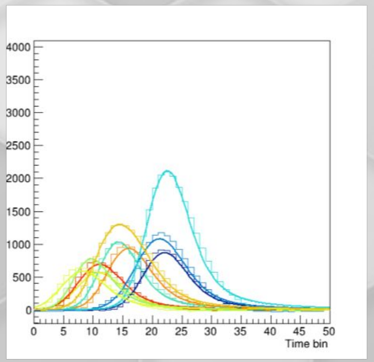

Outline

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- First tracks
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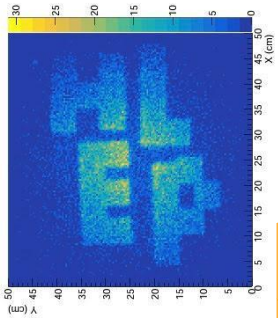
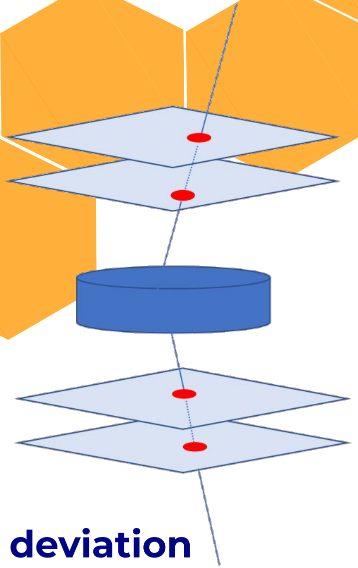
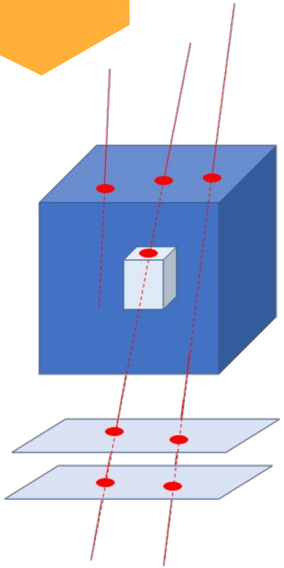
Muon tomography

Use of atmospheric muons to probe in a non-invasive and non-destructive way the structure of an object.



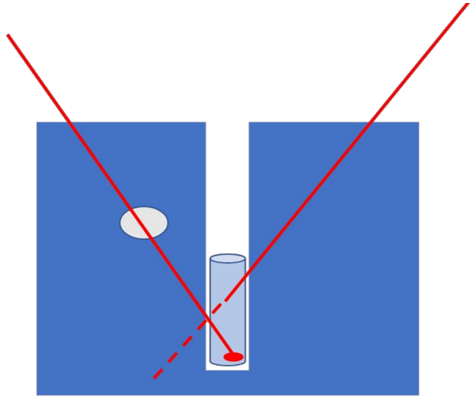


By deviation
*(sensitive to the **deviation angle** induced by **Coulomb scattering**).*



By transmission
*(sensitive to the **flux variations**, image of the **opacity variations**)*

New with D3DT



By transmission *with an improved angular acceptance up to* 2π

Motivations

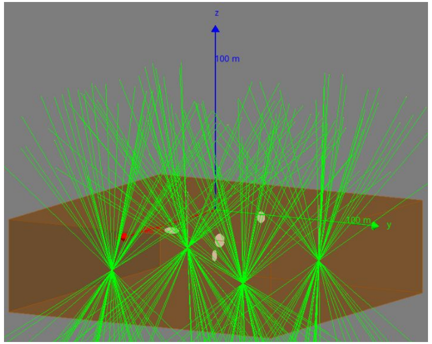
Develop a new instrument for muon tomography that meets specific requirements for new applications.

Characteristics of the new detector : a compact gaseous TPC

- 3D muon tracking
- 2π angular acceptance
- Geometry adapted to reduced spaces *(such as drilling holes)*
- Possibility to be installed in network

Fields of application

- Studies of drilling holes and its surroundings
- Mining exploration
- Geothermal fields sounding
- Civil engineering (prospecting & monitoring)

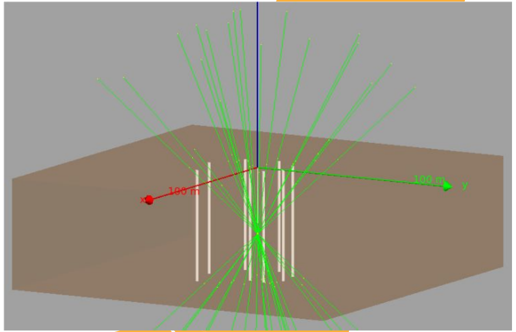


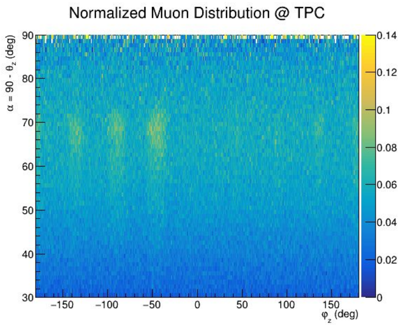
First simulations results

Simulations were conducted using G4TomoMu *(developed by Dr. Héctor Gómez and based on GEANT4 simulation framework).*

Conditions of simulation :

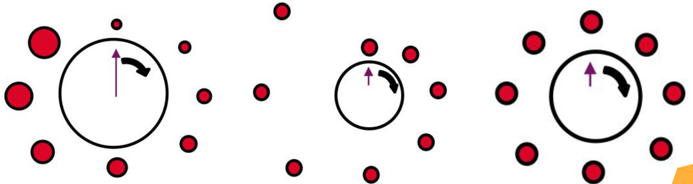
- Detector at 30 m depth
- 2.2 g/cm uniform soil
- Network of cavities to test different parameters in one simulation

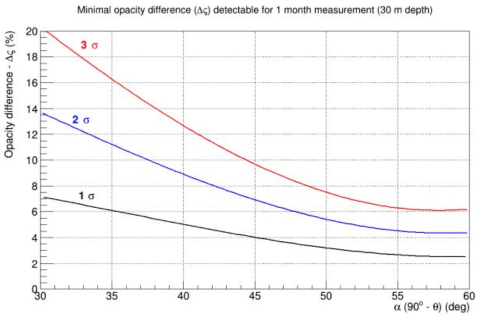


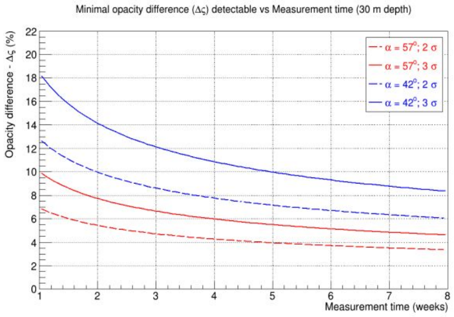


Parameters studied :

1. Diameter of the cavities
2. Distance of the cavities
3. Density of filling material

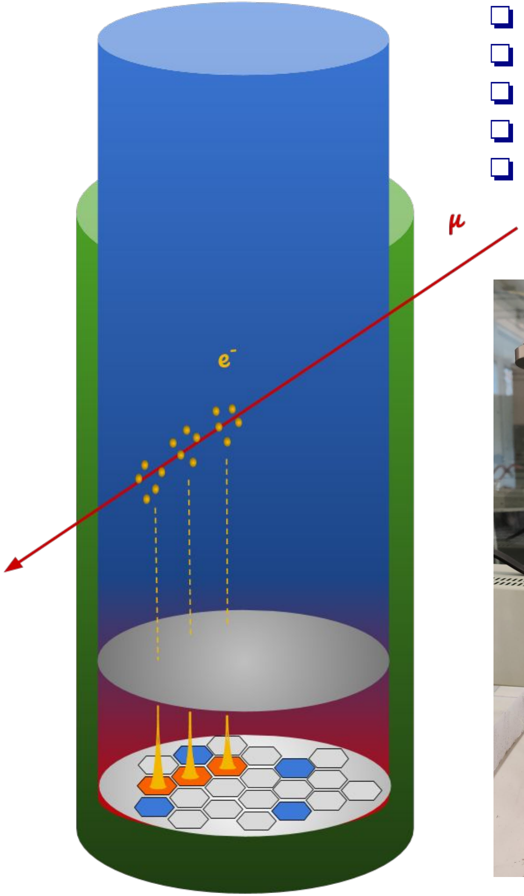






Conclusion : The relevant parameter to determine whether or not a cavity would be detected is actually the opacity difference induced by the cavity.

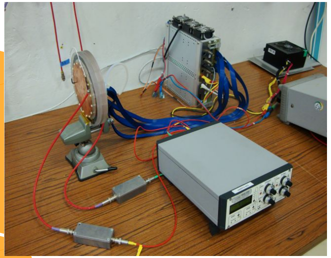
Description



A compact Time Projection Chamber

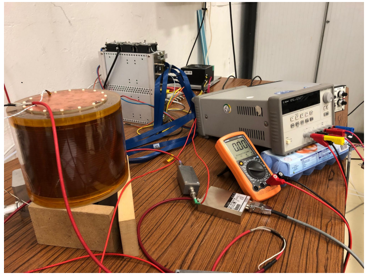
- 40 cm drift space
- 13 cm ⌀ readout plane
- 18 cm ⌀ (with shielding)
- 10 kV on the cathode
- Double clad field cage

Prototypes



First prototype
Only 3 cm drift space to test the Micromegas detector

Second prototype
20 cm drift space. Currently used for data taking.

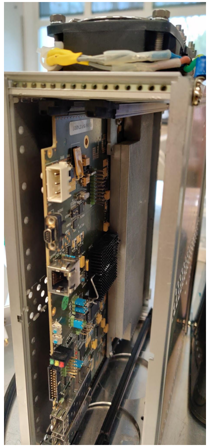


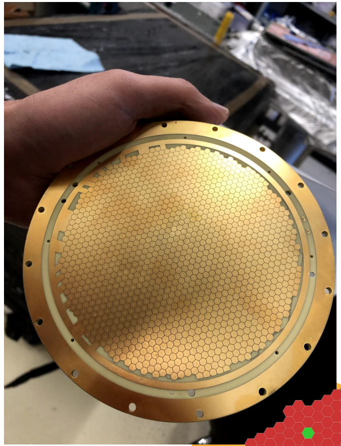
Experimental setup and data-taking conditions :

- Gas : Ar-iC_4H_{10}-CF_4 (95:2:3)
- V_{mesh} = -440 V
- V_{drift} = -3800 V
- Peaking time = 283 ns
- Sampling frequency = 125/6 MHz ie. 48 ns/sample

Electronics & readout

In order to minimize the volume occupied by the electronics, the readout plane is 2D-multiplexed allowing to read 1344 pixels using only 192 channels.



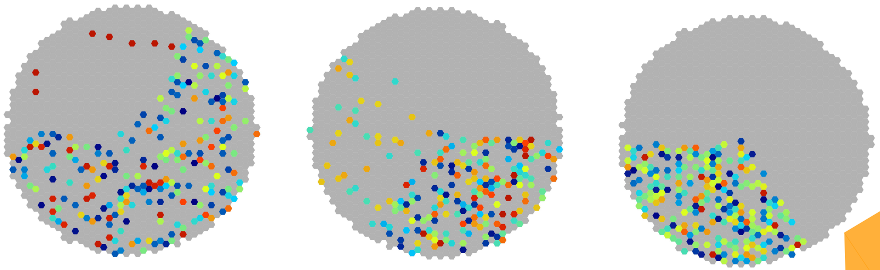


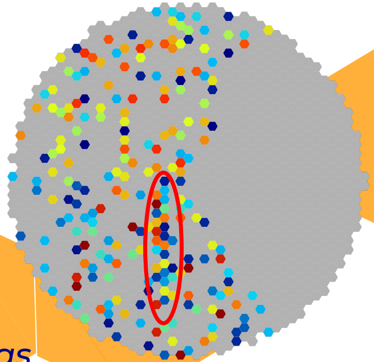
Readout plane characteristics :

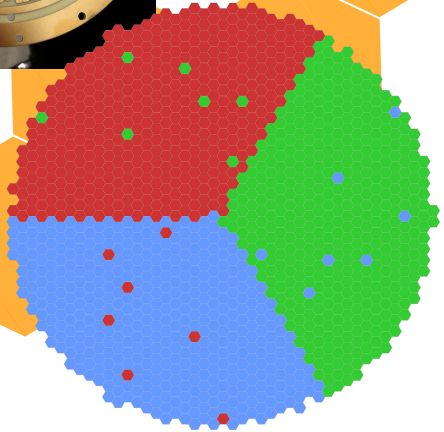
- Read by a FEU* electronic card
- Mapping of each sector obtained by rotation
- Each sector is read by an asic DREAM**
- Each asic is connected to 64 channels
- Each channel is connected to 6 to 9 pixels

Difficulty for the post processing :

How to reconstruct tracks if 9 pixels light up when only one received charge ?







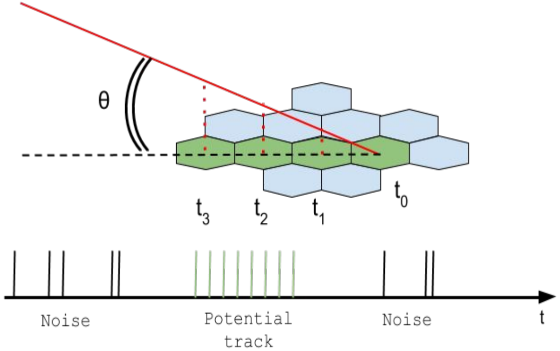
Channel 16 on each sector

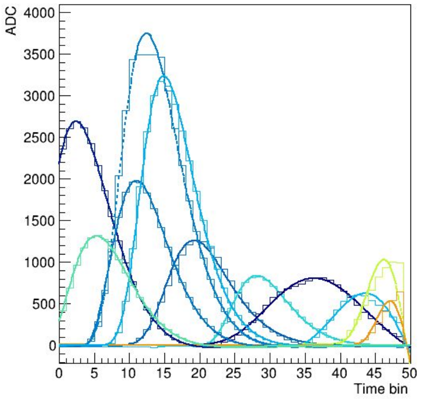
*FEU : Front End Unit

**DREAM : Dead timeless Readout Electronics Asic for Micromegas

Post-processing and reconstruction algorithms
(work in progress)

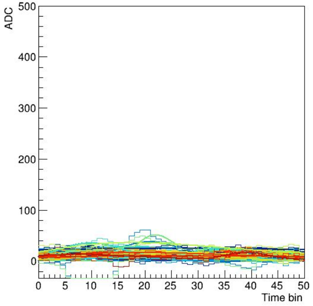
Algorithm based on time :

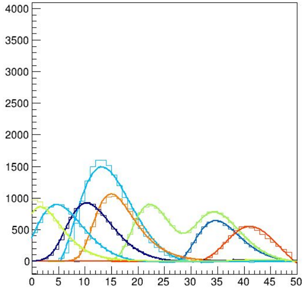




Algorithm based on amplitude :

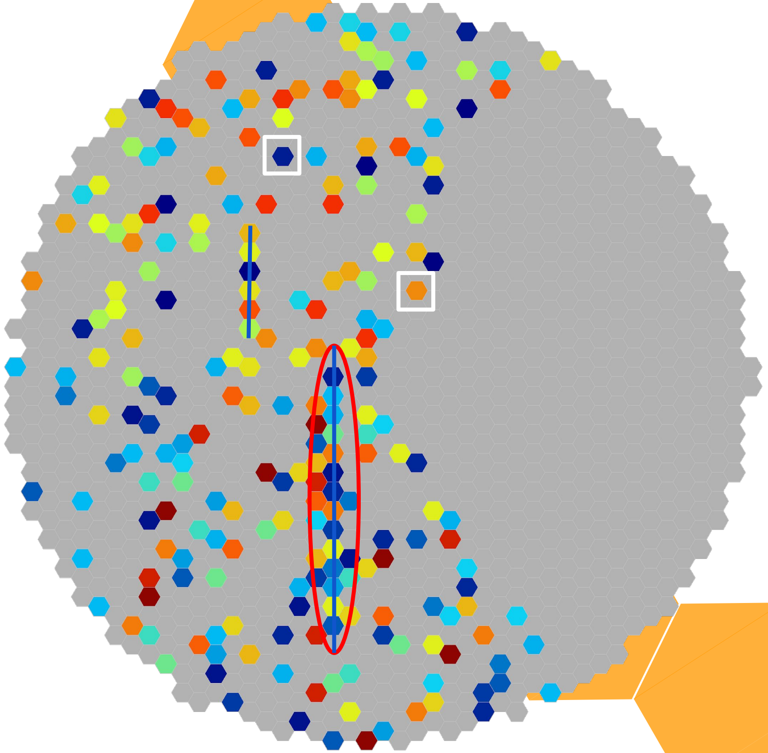
- ❑ Cut to remove electronic low amplitude noise
- ❑ Selections on the amplitude to integral ratio





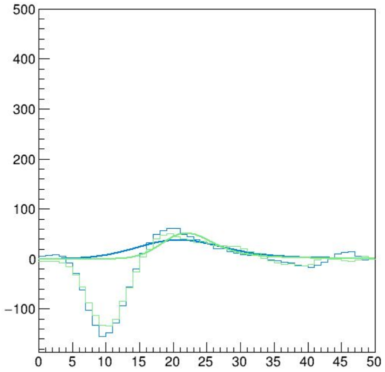
Algorithm based on geometry :

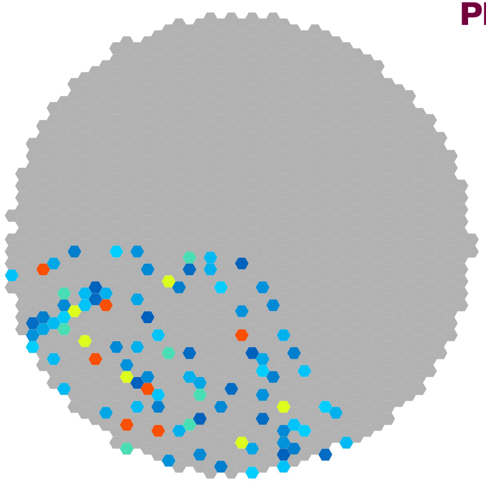
- ❑ "Lonely" pixel
- ❑ RANSAC



Perspectives & Conclusion

- ❑ Still a lot of work to do for the reconstruction
- ❑ Lots of difficulties due to the 2D-multiplexage
- ❑ 3 noisy channels to investigate
- ❑ Track reconstruction *(Kalman filter, Hough transform…)*
- ❑ Monitoring & online processing for muography





Simulated track

- ❑ **D3DT is the first 2D-multiplexed TPC**
- ❑ Prototype with final dimensions to be expected early next year
- ❑ Possibility to take data in drilling holes