PRELIMINARY RESULTS WITH **MUST²** DETECTOR

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T2DM2 Project

Ignacio's presentation : https://indico.cern.ch/event/365380/session/10/contribution/23/material/slides/0.pdf

→ **Temporal Tomography of rock mass Density by the Measure of Muons**

- Goal is to develop a non-destructive imagery technic for unreachable sites

- Measure of temporal and spatial evolution, mostly for geological applications :
  - water saturation in rock
  - aquifer resource
  - underground vacuum and mass instabilities

- Based on cosmic muons

→ **Measurement constraints**

- Underground measurements <=> low flux
  Requires high efficiency detector

- Local density variation measurements
  Requires an high angular resolution

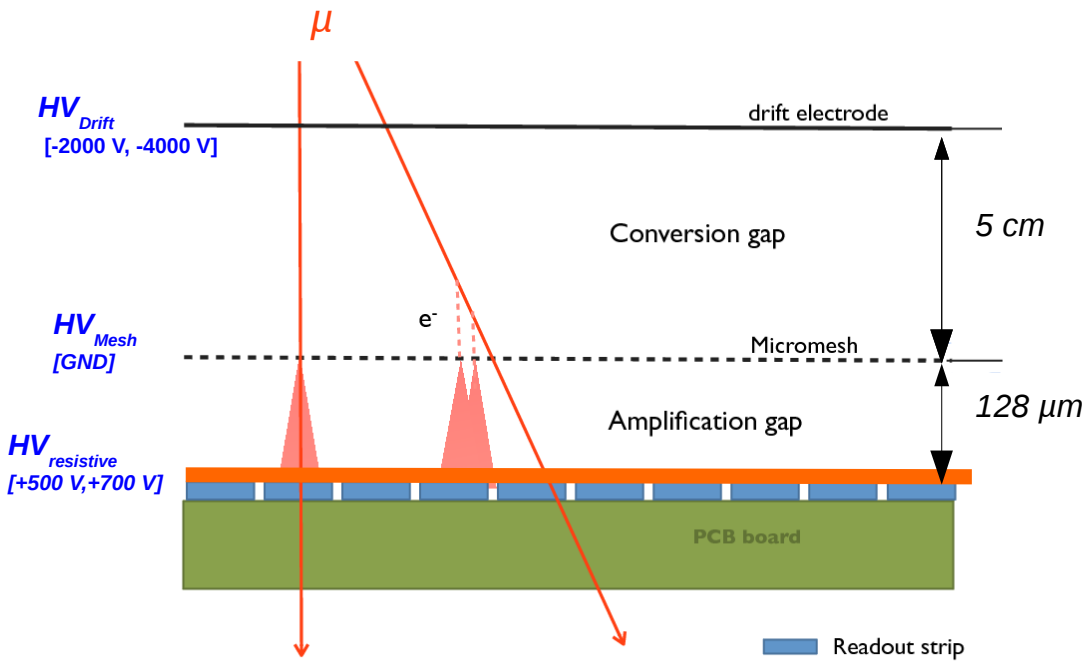
- Ambiant radioactivity in underground sites
  Requires good rejection of background

Development of a new detector = MUST²

MUST²

→ Micromegas coupled to TPC

- gas is Ar : CO2 (93 % : 7 %)
- plan TPC of 100cm x 50cm x 5cm
- amplification gap of 128 µm, ~40 kV/cm
- 1024 readout strips on x axis (0,5 m long)
  512 readout strips on y axis (1,0 m long)



→ Expected performances

- efficiency > 98 %
- spatial resolution ~ 0,1 mm
- angular resolution << 1°
- time resolution ~ 10 ns

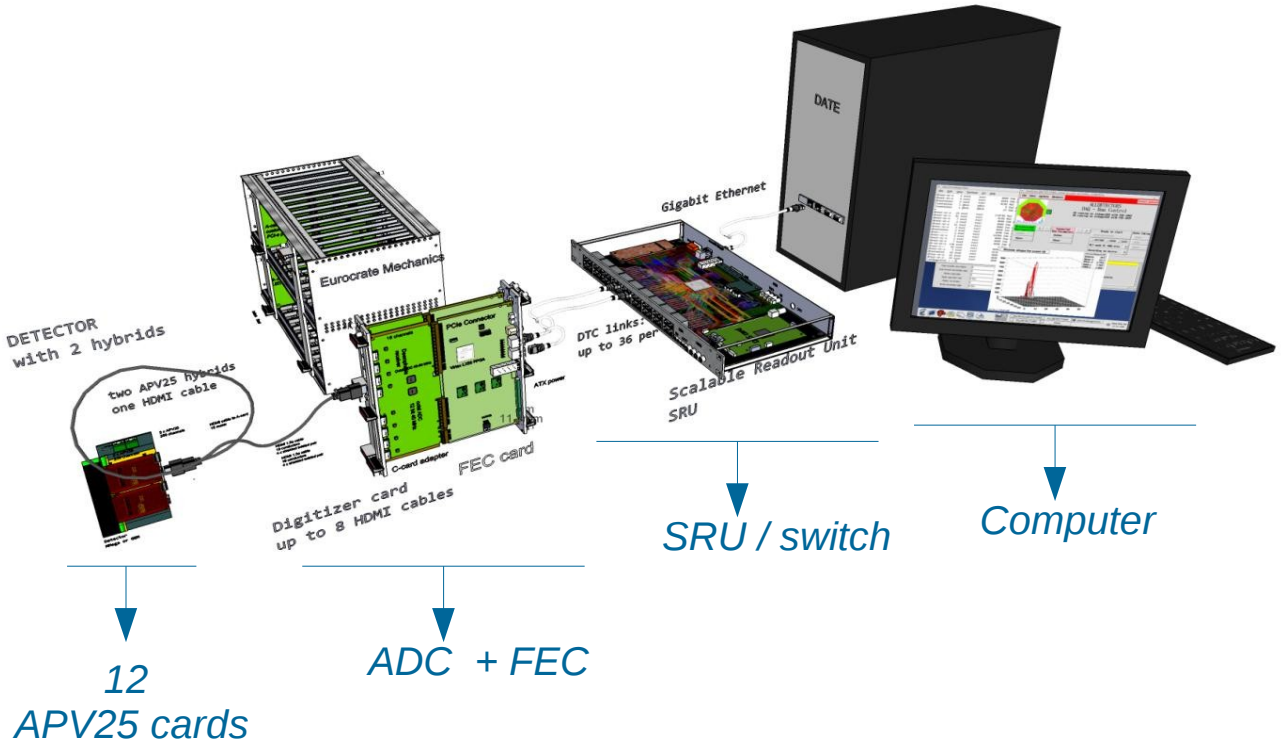
Derived from simulation
and from ATLAS MAMMA results

NIM A 617 (2010) 161–165

MicroMegas TPC perfect for our goal reach

Data acquisition

→ **SRS system**



→ **Software**

DATE
- acquisition

AMORE SRS
- Convert raw data in root format
- Pedestal
- Monitoring / analysis capabilities

Private Code
- Tuning of hits, clusters and tracks reconstruction

Huge thanks to Kondo and Eraldo for their help

Cosmic bench

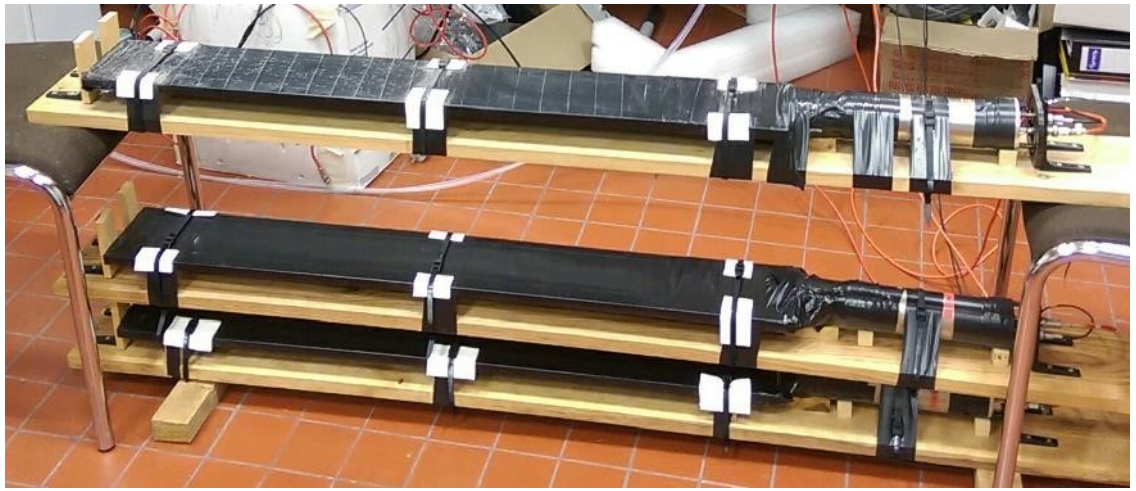
→ Setup

- For now, no inner trigger in our detector

- Use 3 plastic scintillators of 1m x 0.2m

- Triple coincidences as trigger

- 1 position tested = Scintillators aligned with X axis, at y ~ 1 quarter of the detector



→ Motivations

- Preliminary efficiency measurements

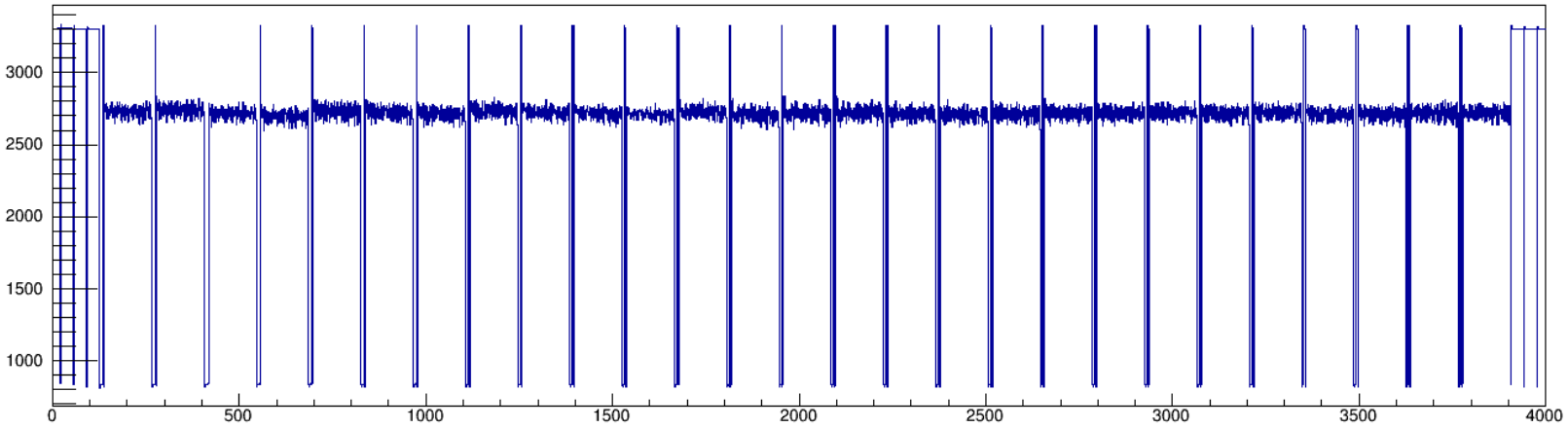
- First tests on hit, cluster and track algorithms

APV25 setup

→ APV card data

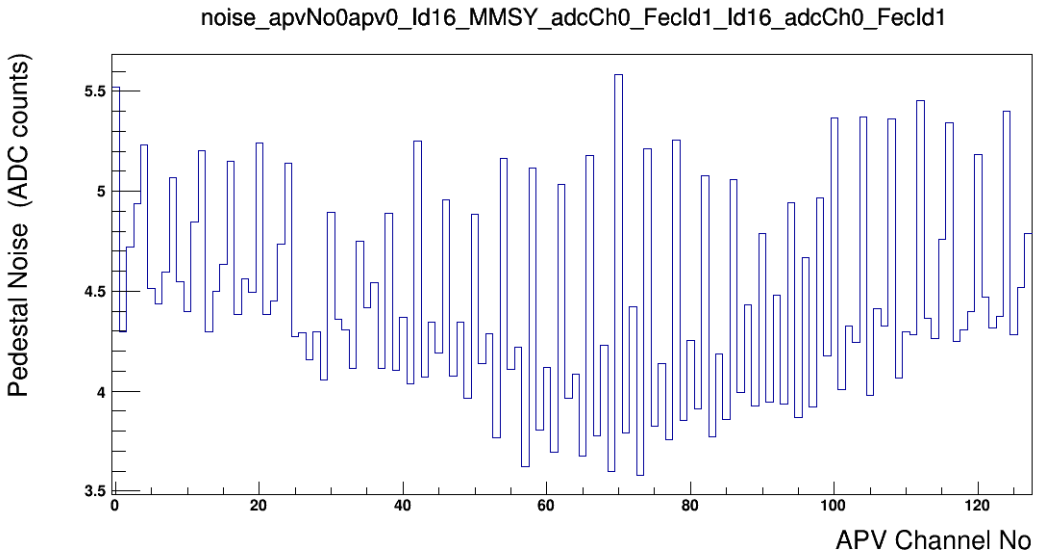
- 128 channels per APV
- TPC <=> max time window
- 27 time samples, 675 ns

Raw APV data with no signal

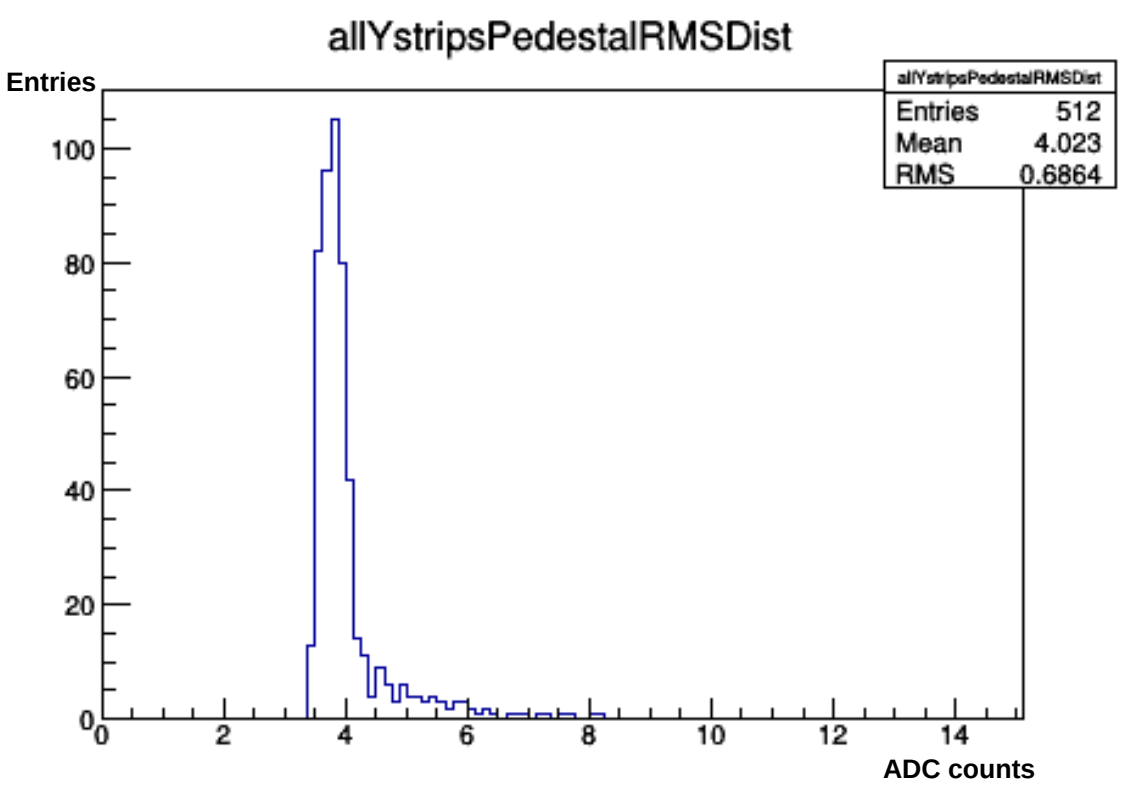


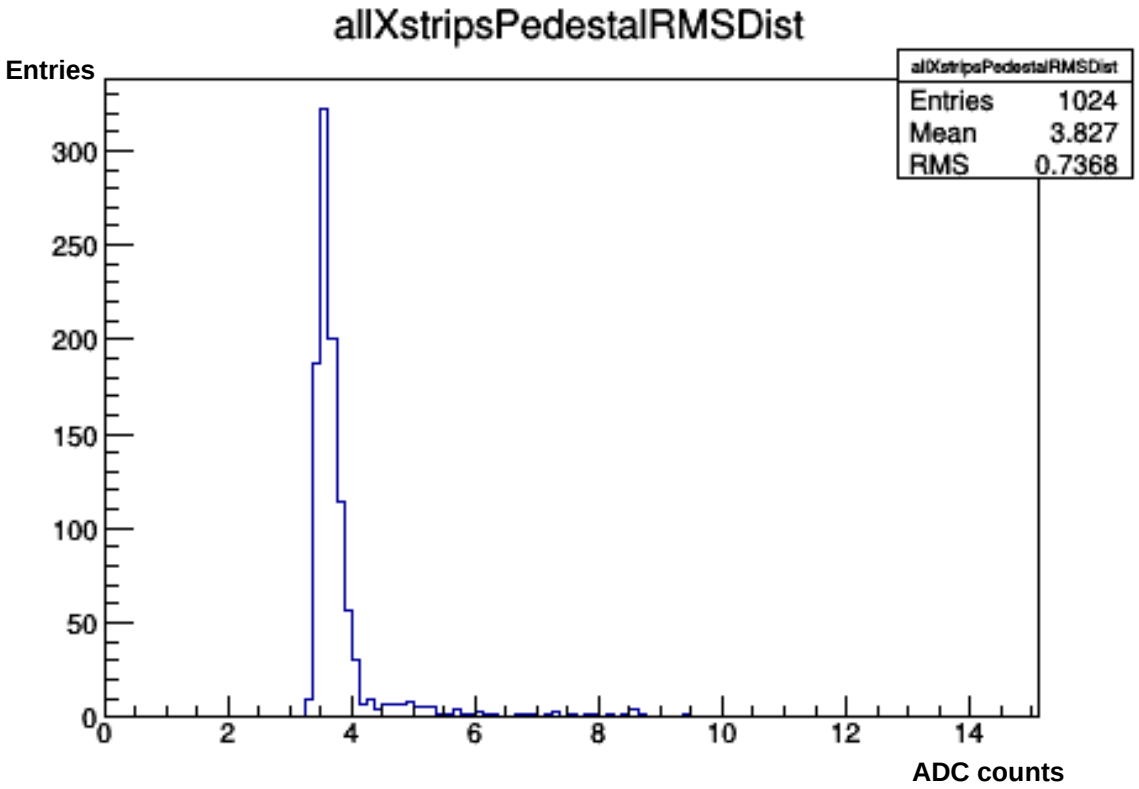
→ APV Noise

- obtain with amore SRS
- Classic noise distribution on APV channels
- Due to channel configuration on the card



APV25 pedestal





- Measured with detector HV on

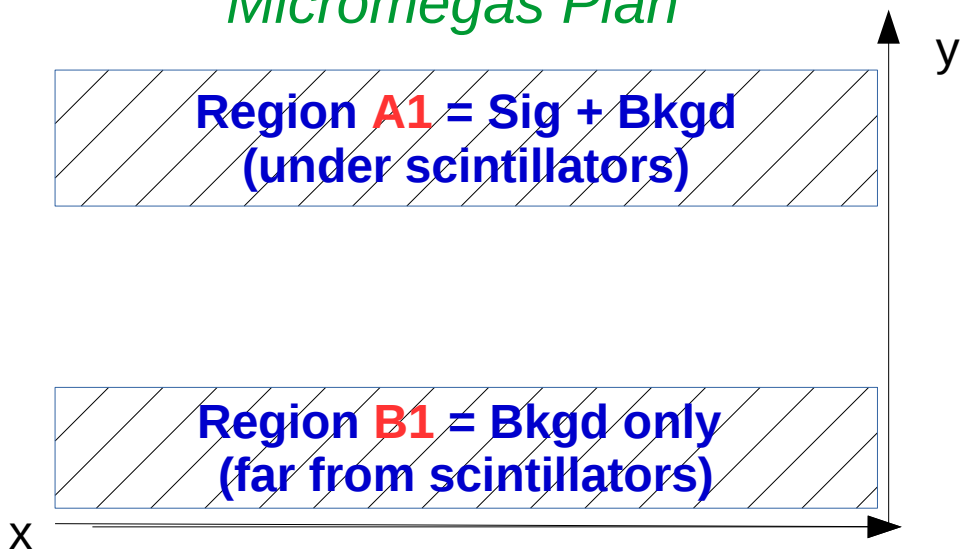
- Mean noise is about 4 ADC counts, ~ 1000 electrons

- Slightly higher for y cards, consistent with longer strips

Low electronical noise

Optimisation of pedestal cut

Micromegas Plan



→ S / B definition

- B = mean number of hits in region B1

- S = mean number of hits in region A1 – k.B

- k, normalisation factor = ratio of area

→ Efficiency

- 1 hit = 1 strip i with mean ADC > σ . $pedestal_i$

- Check how many events triggered with scintillators gives at least 1 hit on x and one on y

$$\epsilon = \frac{N_{events}\left(\geq 1\, hit\ on\ x/\,y/\,x \wedge y\ axis\right)}{N_{events}}$$

Optimisation of pedestal cut (2)

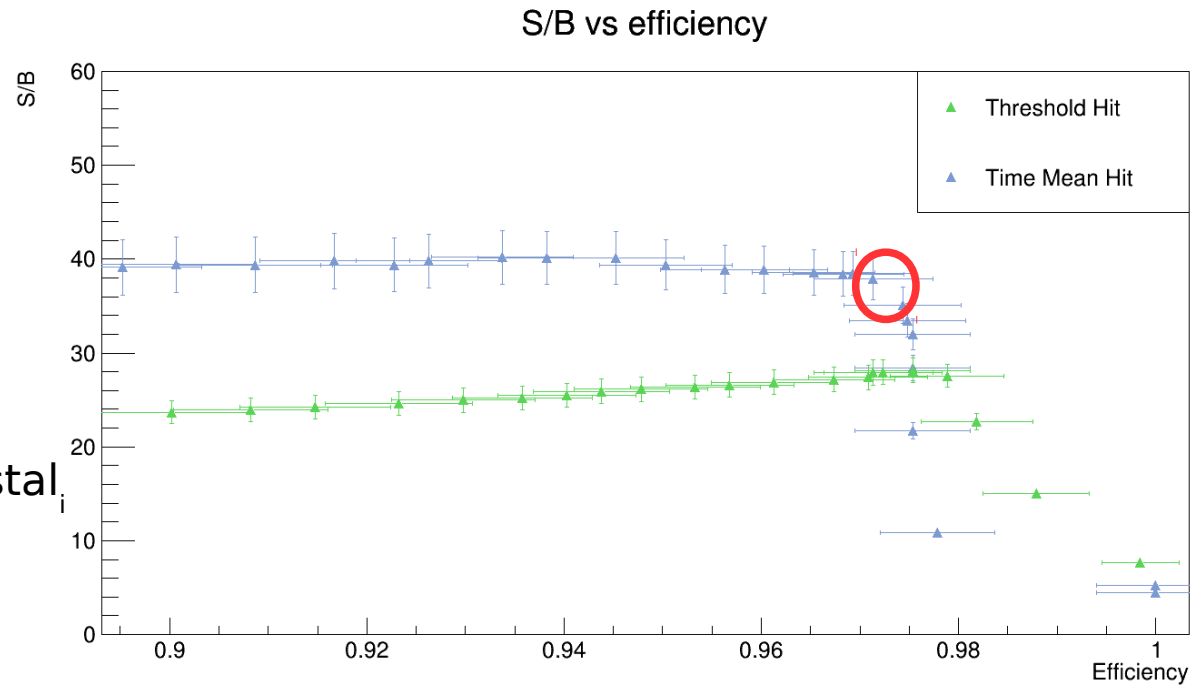
→ S / B versus efficiency

- σ constant to be fixed

- Comparing 2 hit definitions :

Threshold hit :1 time sample > σ.pedestal$_i$

Mean hit : mean(27 time samples) > σ.pedestal$_i$
(default on amoreSRS)



For σ = 20, S/B plateau and ε ~ 97-98 %

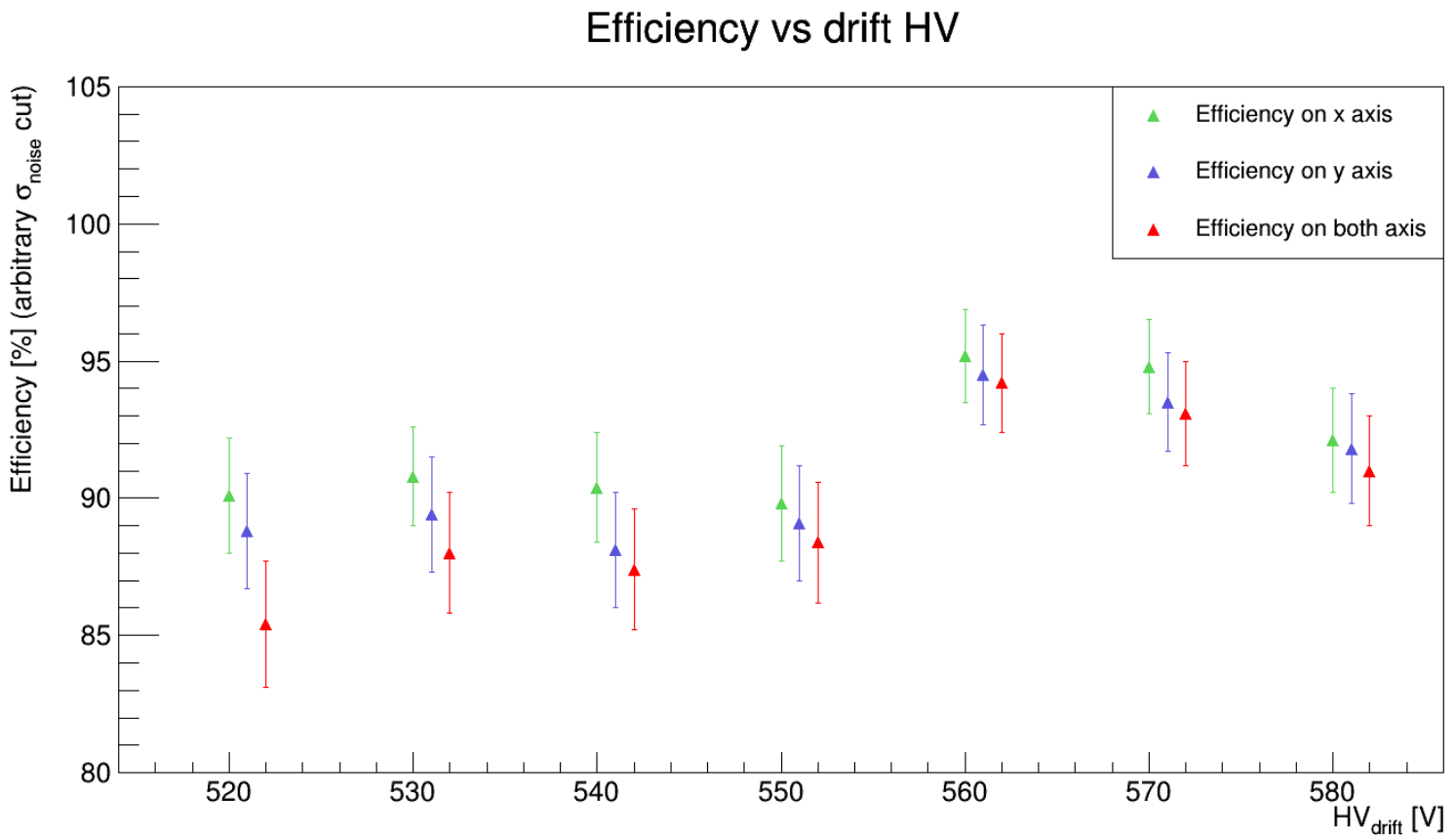
Choice of HV Resistive

- No gain measurement made for now

- HV optimized on ε

- Pedestal recomputed for each HV

- Fixed arbitraty σ cut



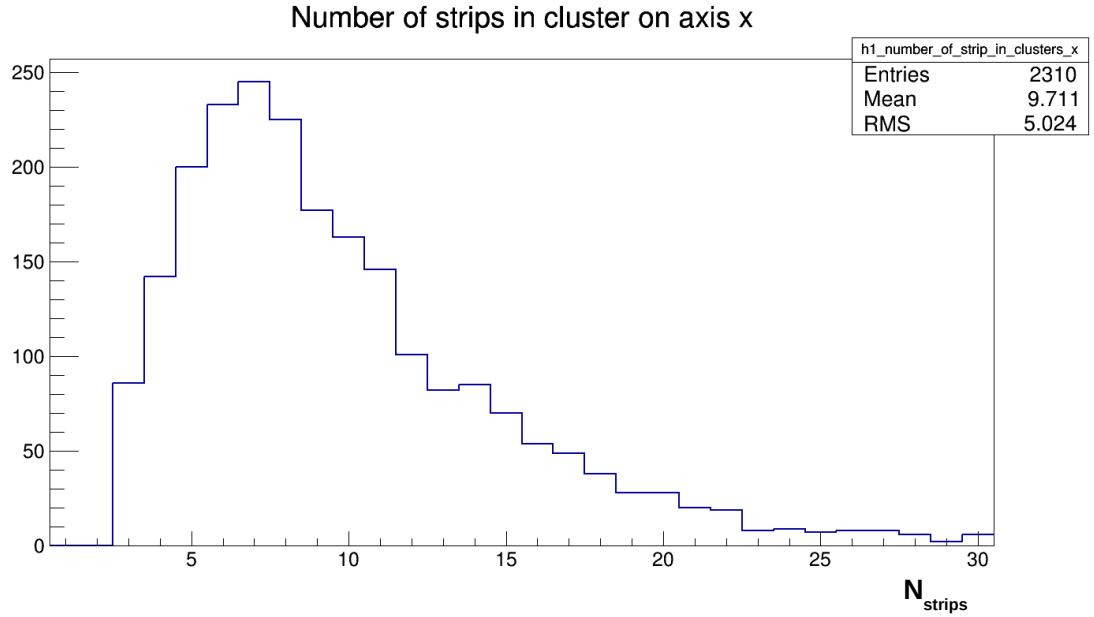
HV set at 560 V (44 kV / cm)

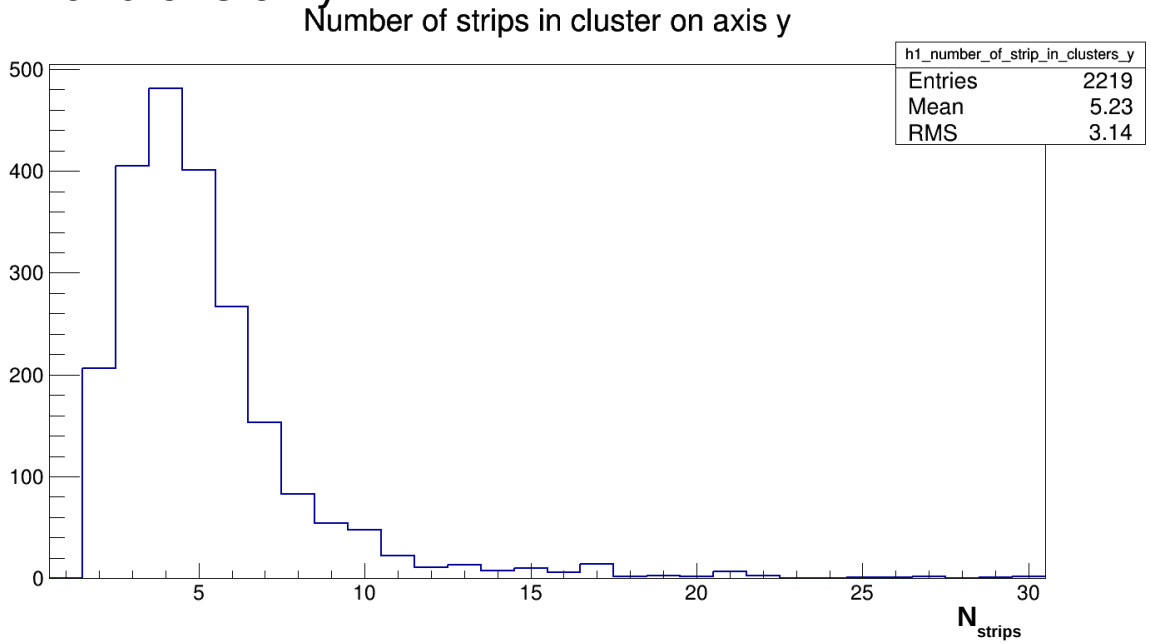
Cluster

- Cluster = group of neighbouring strips hitted

- Clusters of 1 hit ignored

- Measuring cosmic muons => exactly one cluster on x and one on y



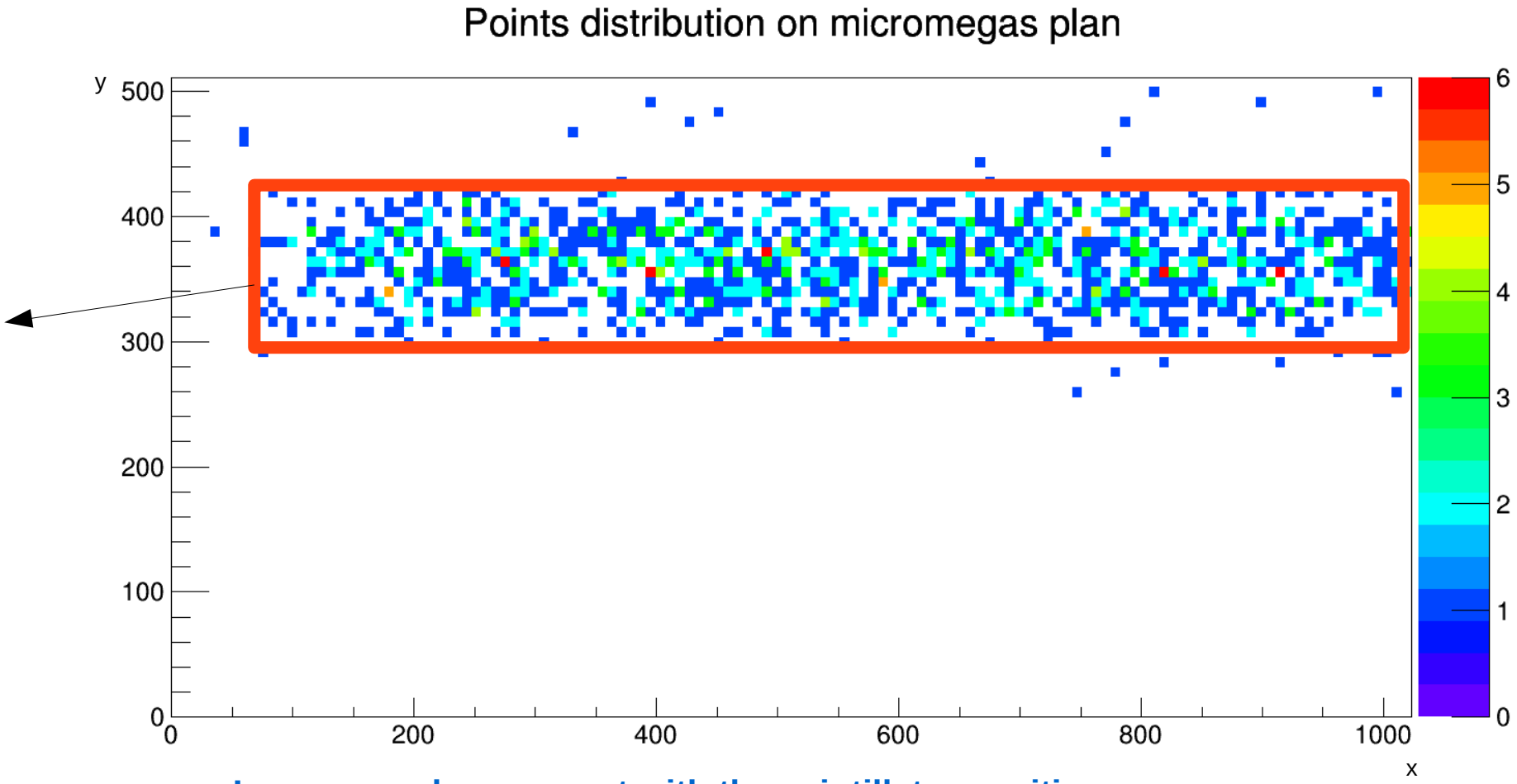


- More hits on x axis because of the scintillator configuration
- Need a special treatment of events with more than one cluster

More than 80 % of events with one cluster on x and one on y

Distribution on micromegas plan

- Points built as the center of ADC counts of x and y cluster



Scintillator position

In very good agreement with the scintillator position

Track

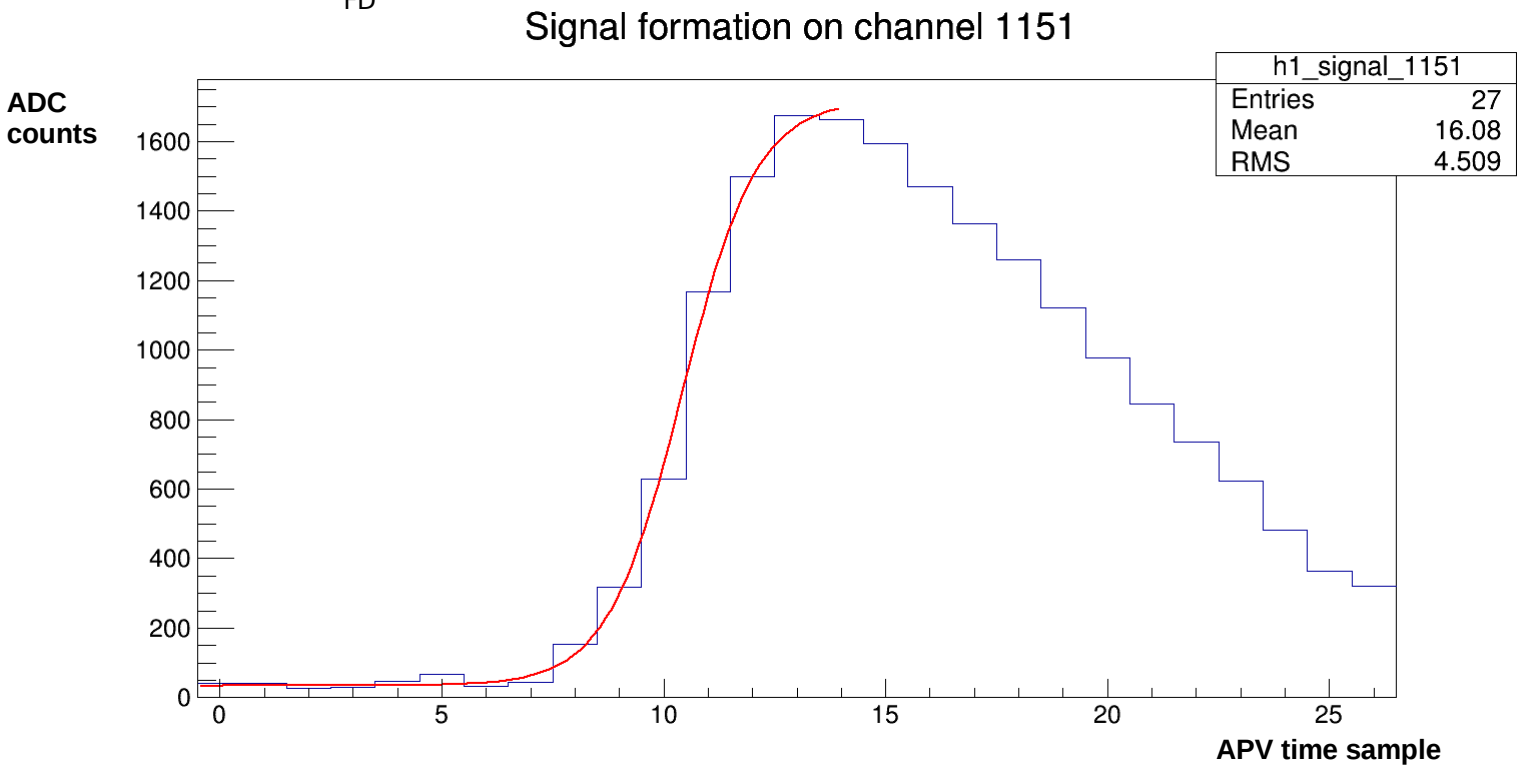
→ Track reconstruction strategy

- Clusters are seeds

- Loop on each strip hitted and fit with Fermi-Dirac

$$FD(t) = K\frac{1}{1+e^{-(t-t_{FD})/\sigma_{FD}}} + B$$

- Get the mean rise time t_{FD} for track reco.

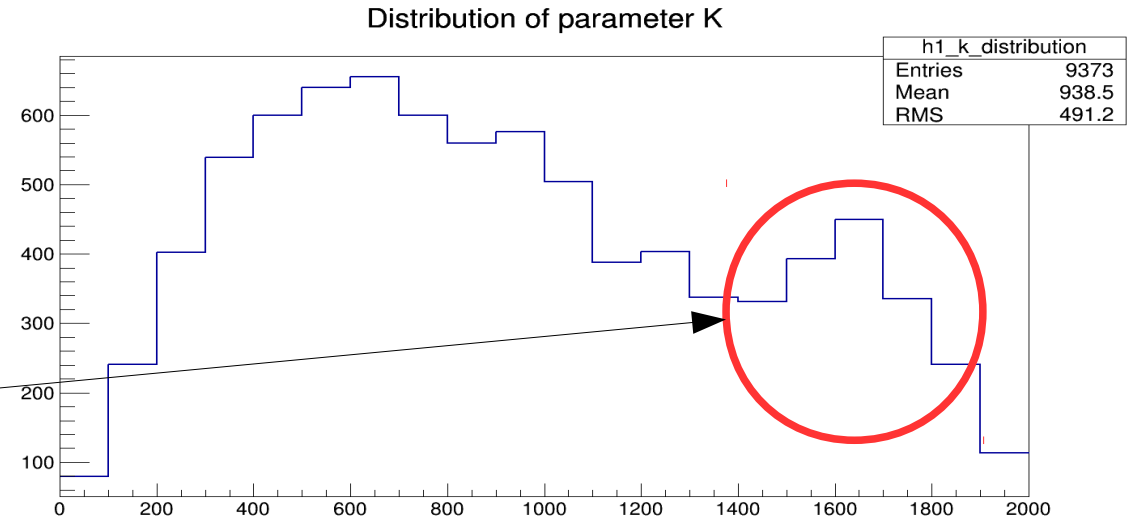


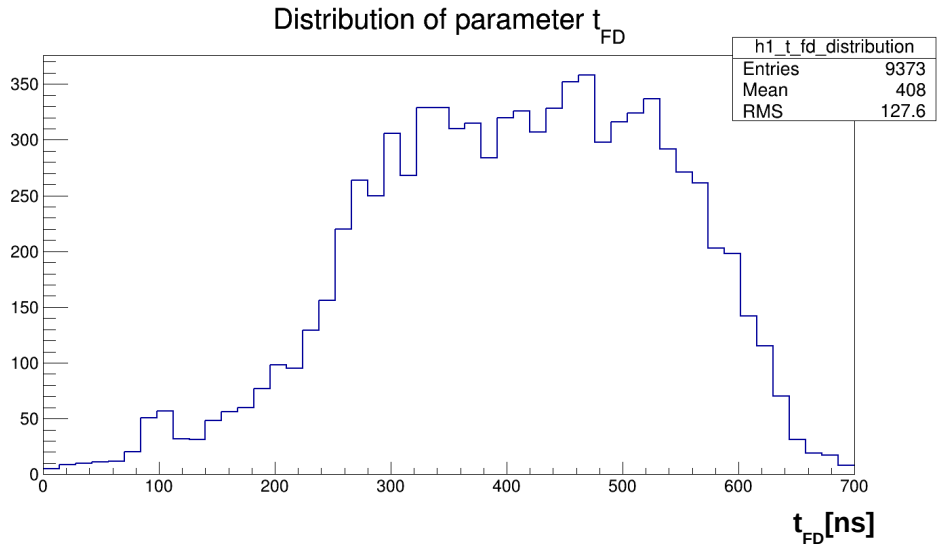
Track fit parameters

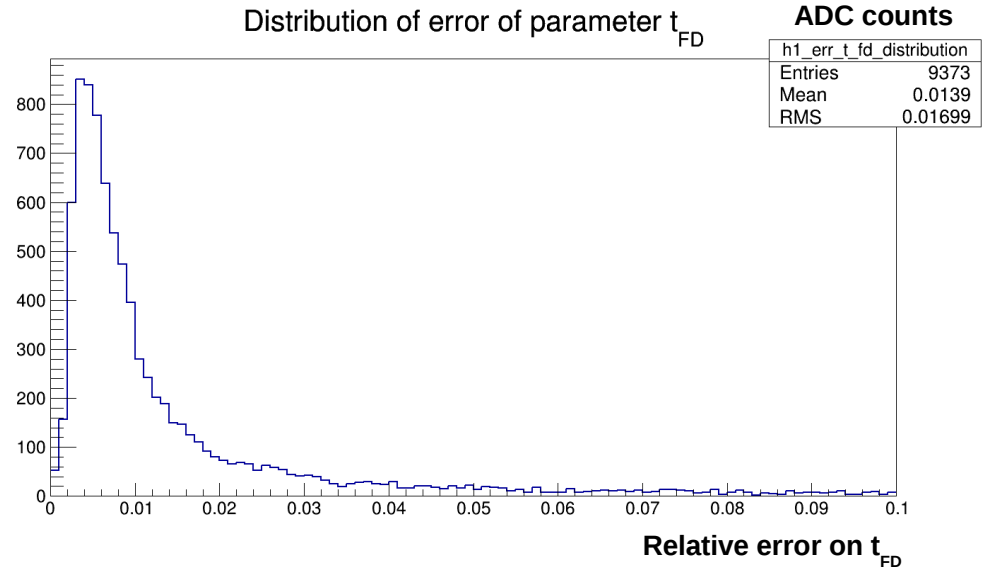
$$FD(t) = K \frac{1}{1 + e^{-(t - t_{FD})/\sigma_{FD}}} + B$$

- K equivalent to max ADC counts in event

- 10 % of hits with saturation

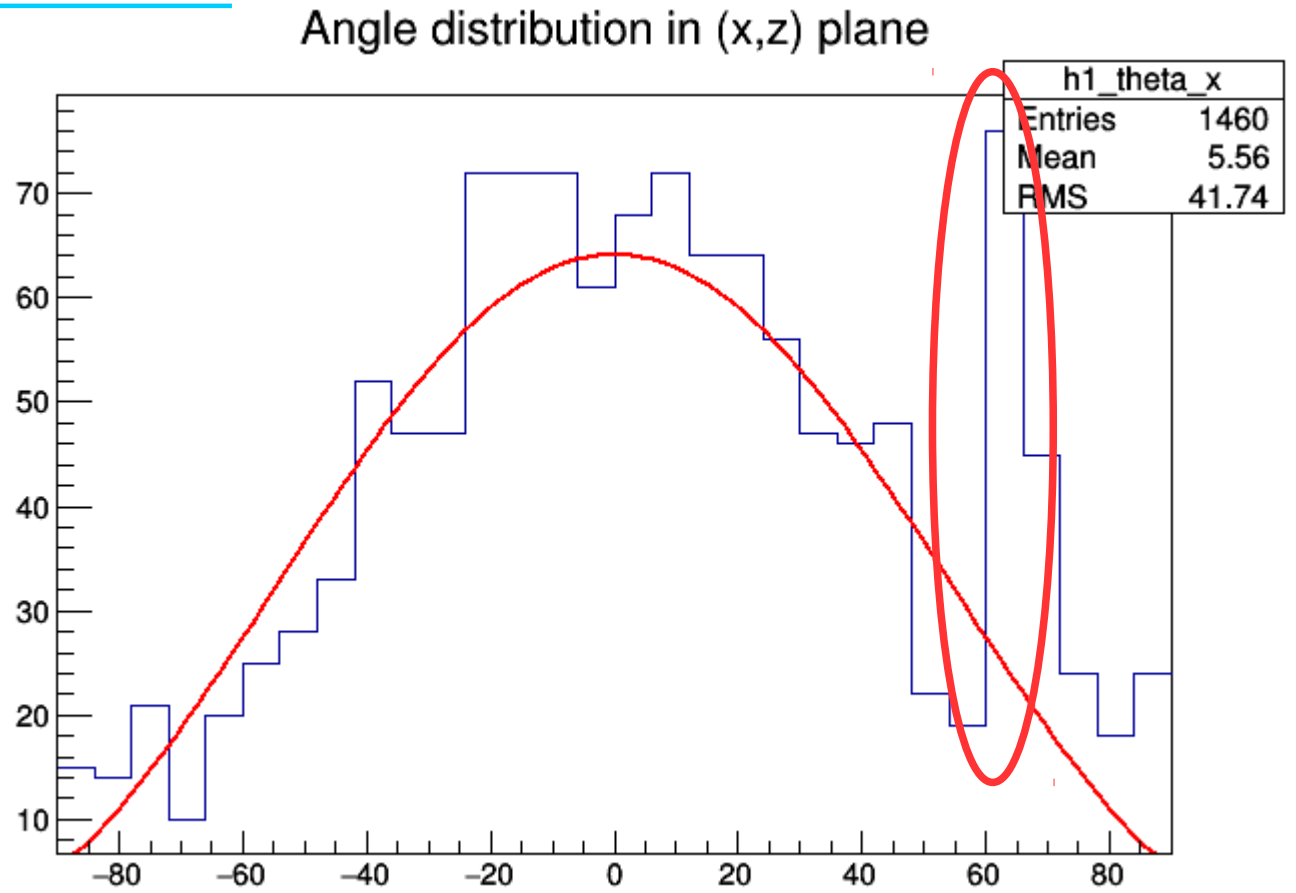






Fit uncertainty on t_{FD} is ~5 ns

Angle distribution



- Fitted with a $\cos^2$
- Weird peak around 65°, looks like software problem

Not so bad for 1st cosmic tests

Conclusion

→ **MUST² detector**

- MUST² = TPC + micromegas for muon tomography
- First working detectors, ready for industrialisation
- Specific analysis code developed
- Preliminary results show encouraging performances

→ **Next steps**

- Develop an inner trigger by mesh signal measurement (See Ignacio presentation, Tuesday, 10.30)
- Get 6 working detectors
- Full characterization of the detectors

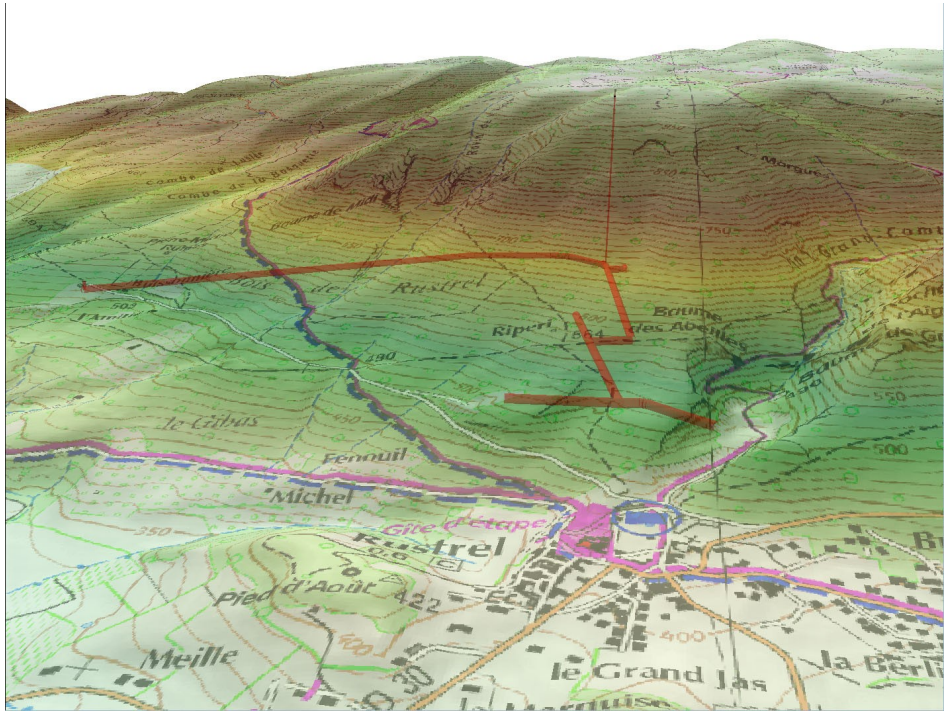
Project demonstrator

→ Detector network

- network to increase active area <=> modularity
- 6 detectors to be deployed
- Status : 2 in fabrication, 1 preassembled , 3 ready to work

→ LSBB site

- low background noise inter-disciplinary URL
- Offers 3 km of galleries fully equipped
- depth varies from 0 to 550 M
- Under a zone of karst aquifer
  → *Water saturation monitoring*



LSBB perfect site for our demonstrator

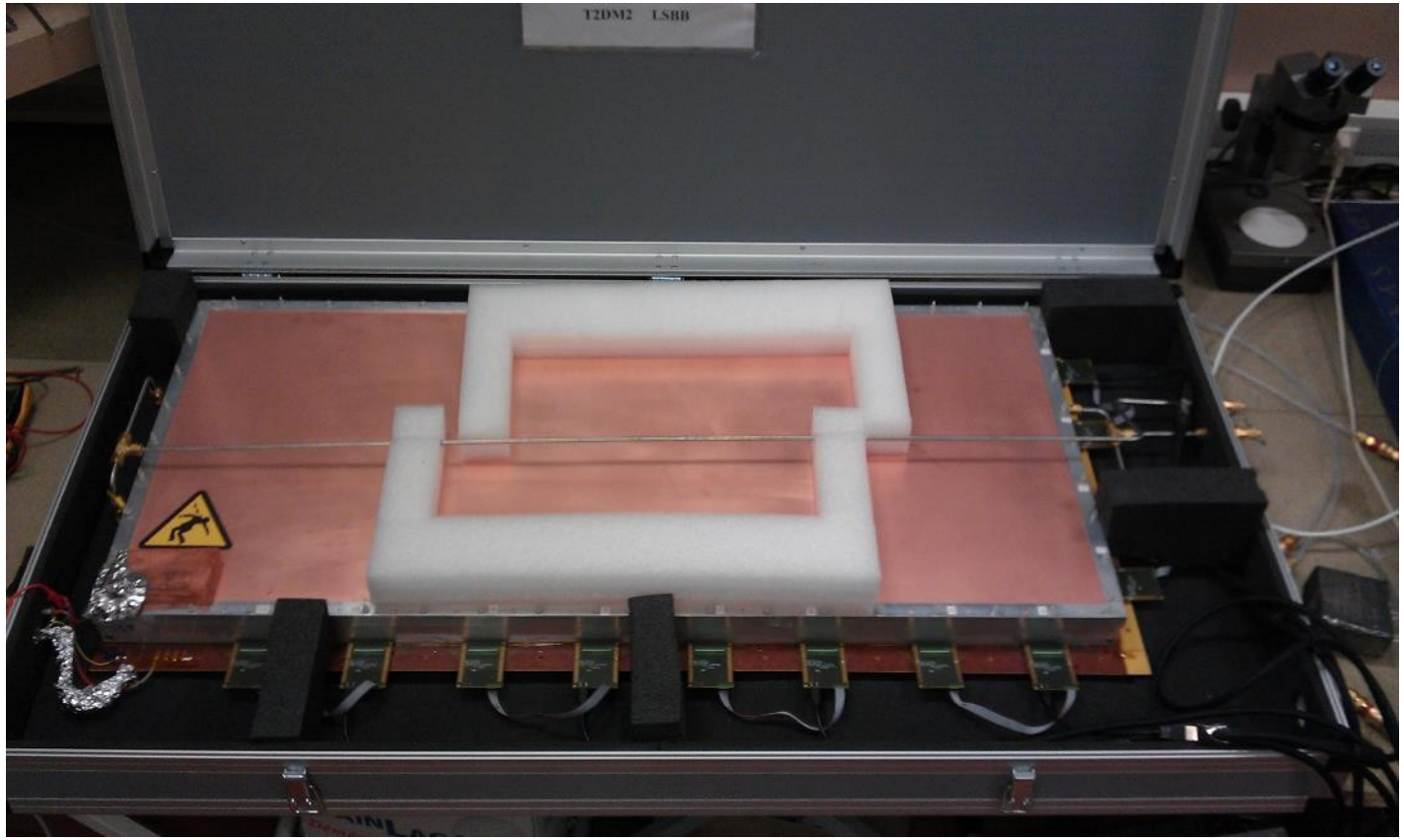
MUST² (2)

→ **Production**

- See Ignacio presentation on last Tuesday, 10.30

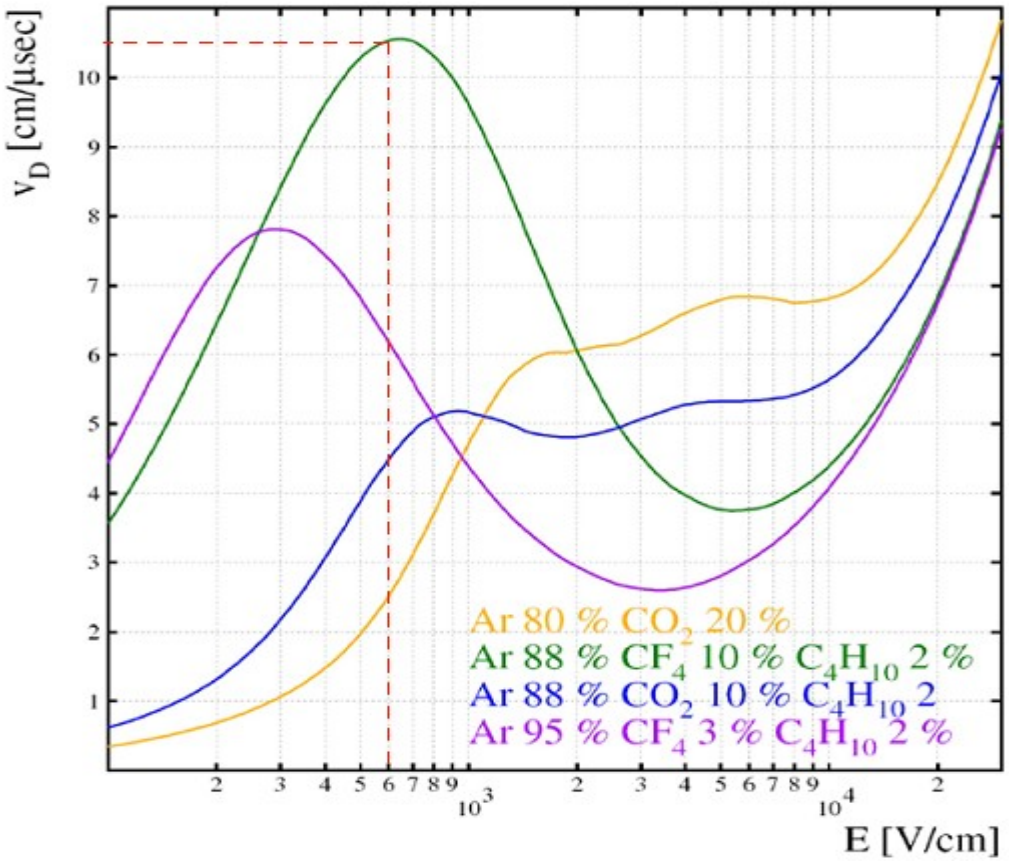
→ **Working version of MUST²**

- Enclosed in a solid case
- < 30 kg
- Easily plug / unplug
- Can be pile up



Transportable and modular

MUST² (2)


v_D [cm/µsec]
E [V/cm]
Ar 80 % CO_2 20 %
Ar 88 % CF_4 10 % C_4H_{10} 2 %
Ar 88 % CO_2 10 % C_4H_{10} 2
Ar 95 % CF_4 3 % C_4H_{10} 2 %

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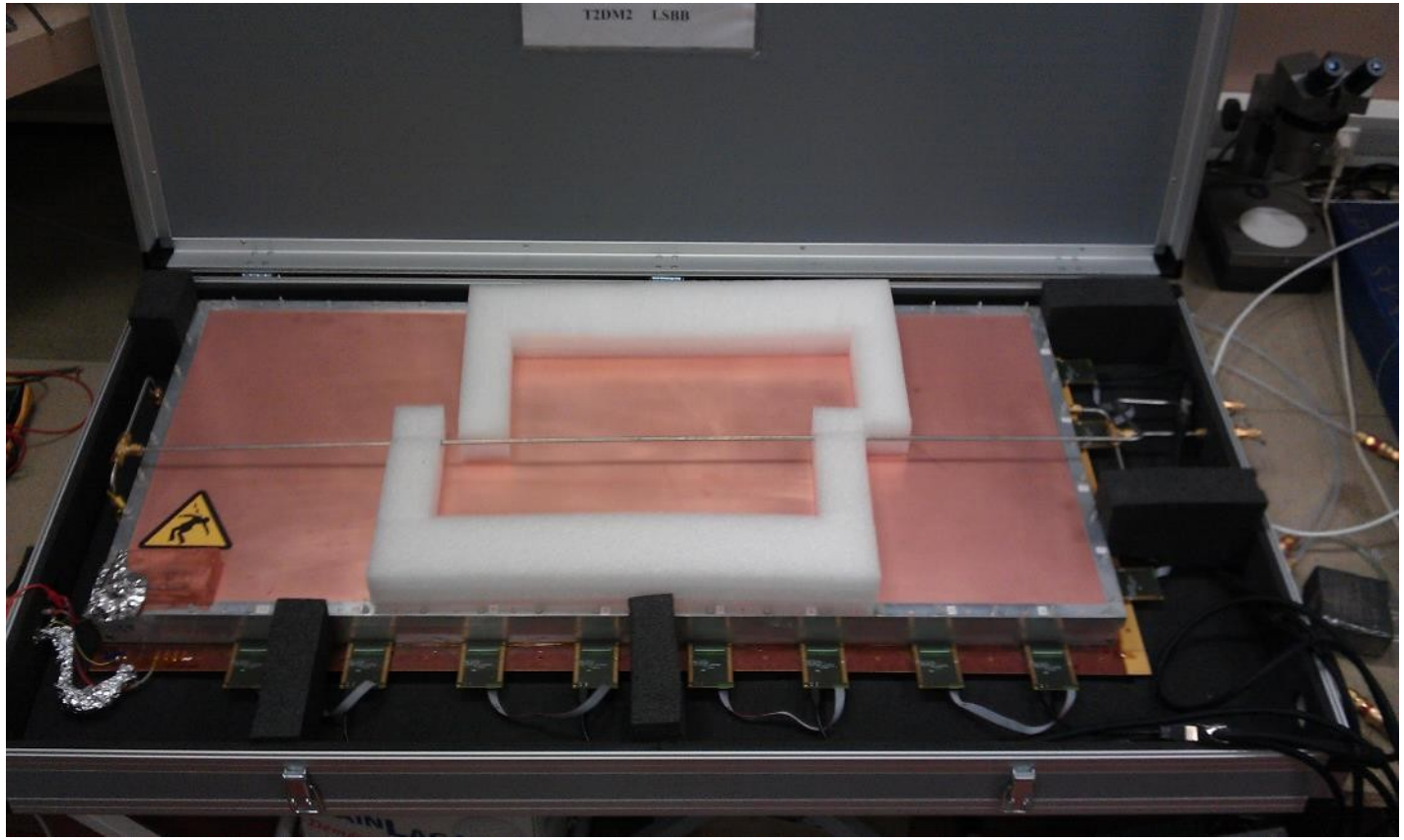

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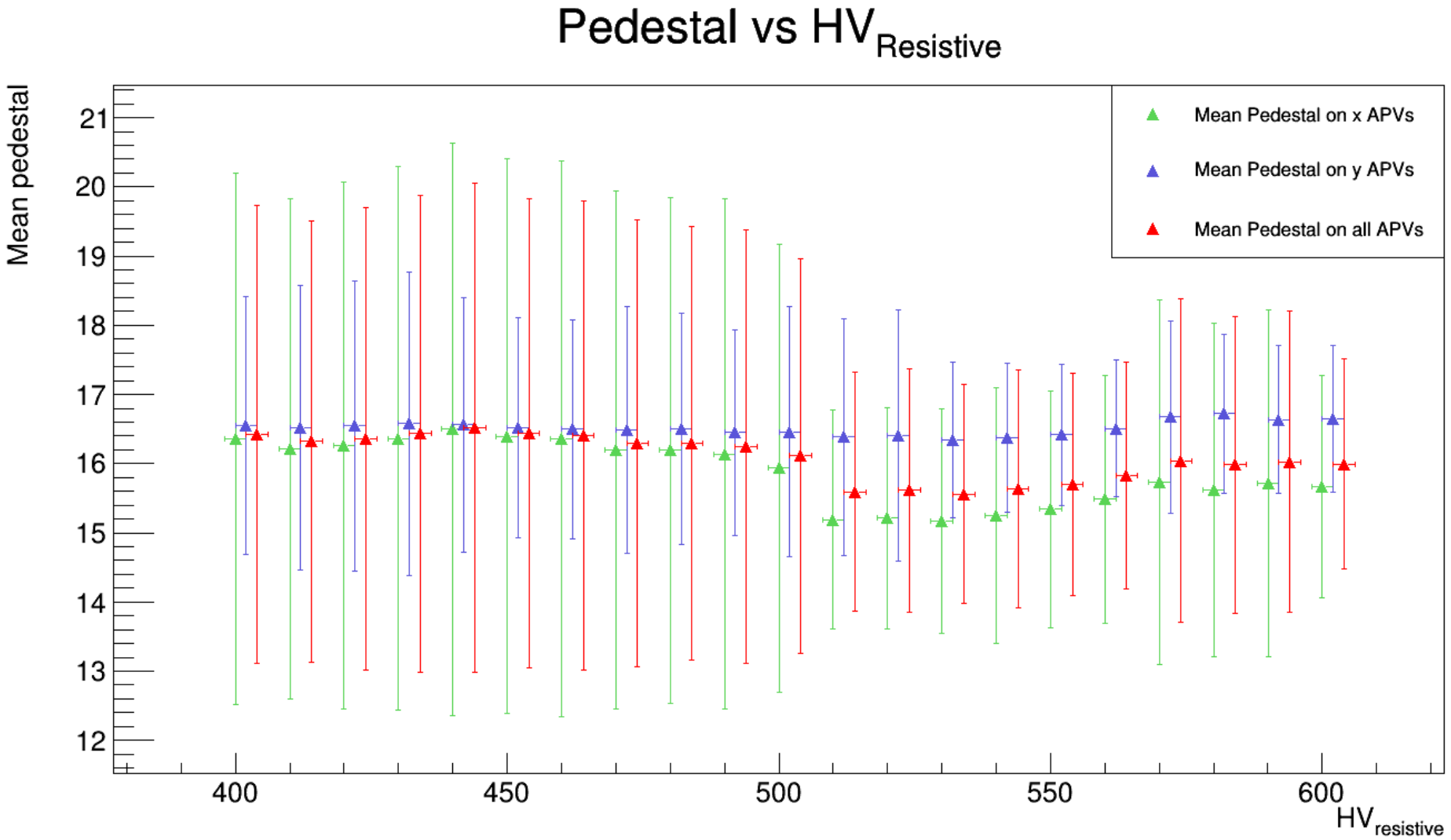
Pedestal vs HV Resistive
Mean pedestal
21
20
19
18
17
16
15
14
13
12
400
450
500
550
600
HV resistive
Mean Pedestal on x APVs
Mean Pedestal on y APVs
Mean Pedestal on all APVs