T2DM2 muography project

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1. Objectives of T2DM2 project

✓ **Development of a non-destructive system using muon particles for imaging and monitoring large volumes of matter**

- Reconstruction of muon tracks using only one detection plane
- Design, fine characterization and industrialization of a very compact detector

2. Context of the project

- ✓Initiated in 2010 at the Low Background Noise Laboratory (LSBB) operated by CNRS (National French Research Center).
- ✓Member of CERN's RD51 collaboration, which aims at facilitating the technological development and application of Micropattern Gas Detectors.
- ✓Since 2015, BRGM (French Geological Survey) and IRIS Instruments (geophysical equipment manufacturer) joined the partnership.
- ✓Currently the team is composed by 8 people; including PhDs, engineers, a PhD student and post doctoral fellow.

3. Complementarity of partnership

1) LSBB

- Low background noise environment
- Layout of the galleries allowing to deploy the detectors easily between 0 and 518m deep

2) BRGM

- National geological survey aiming to respond to Geosciences issues
- Skills in a large array of applications (Geological investigation, Natural Hazards, Natural Resources…)

3) IRIS Instruments

- Private company providing geophysical equipment's all over the world
- Shared by BRGM and OYO company

T2DM2's initiator

Leader in Geosciences

Skilled in sensors development

4. From Academic Science to Industrial sector

✓ The project started at low step of the technological readiness level (TRL) in Academic sector.

✓The partnership evolved including two others members (BRGM and Iris Instruments).

✓ If the partnership succeeds in all technical issues, IRIS Instruments will insure the new detector commercialization.

5. Targeted applications

6. Applications and constraints

Detector located at the surface

- Landslide and volcanoes monitoring
- Cultural heritage investigation
- Civil infrastructure inspection

Detector located underground

- Natural resources exploration
- Underground reservoir monitoring

Main constraints

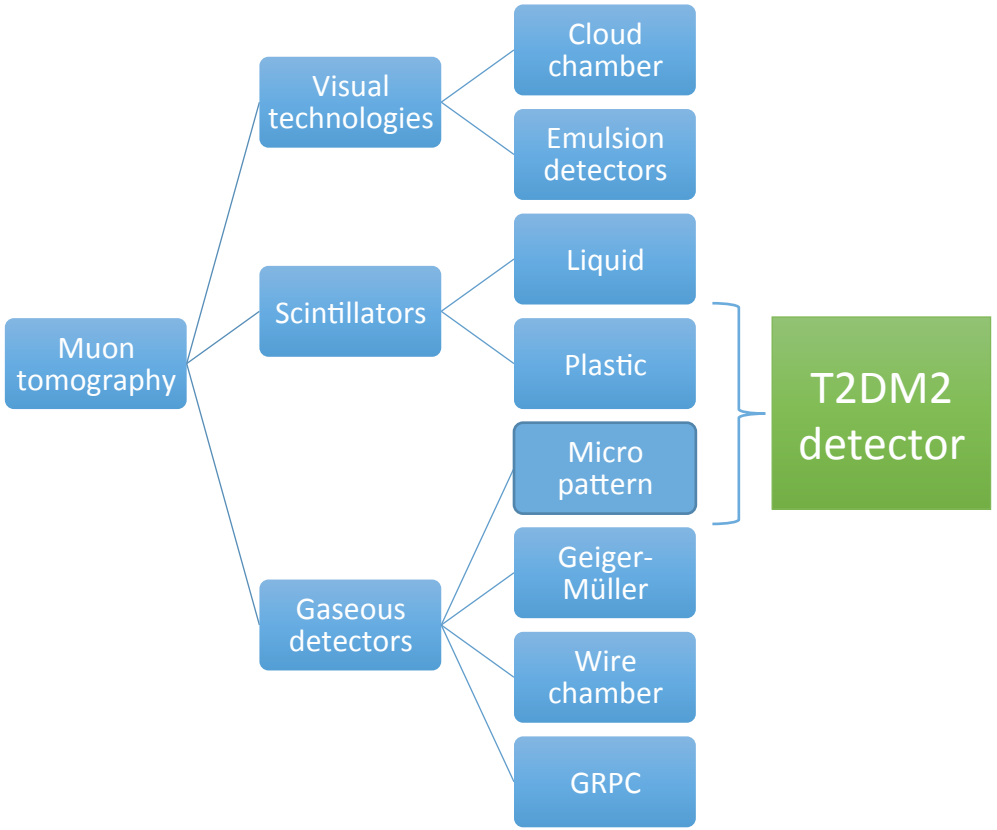
- Influence of other cosmic particles
- Atmospheric conditions

- Limited power supply
- Environmental parameters variations
- Deployment of materials

- Narrow space for detector location
- Natural radioactivity
- Gas evacuation

6. Technologies

Main Muon detection technologies

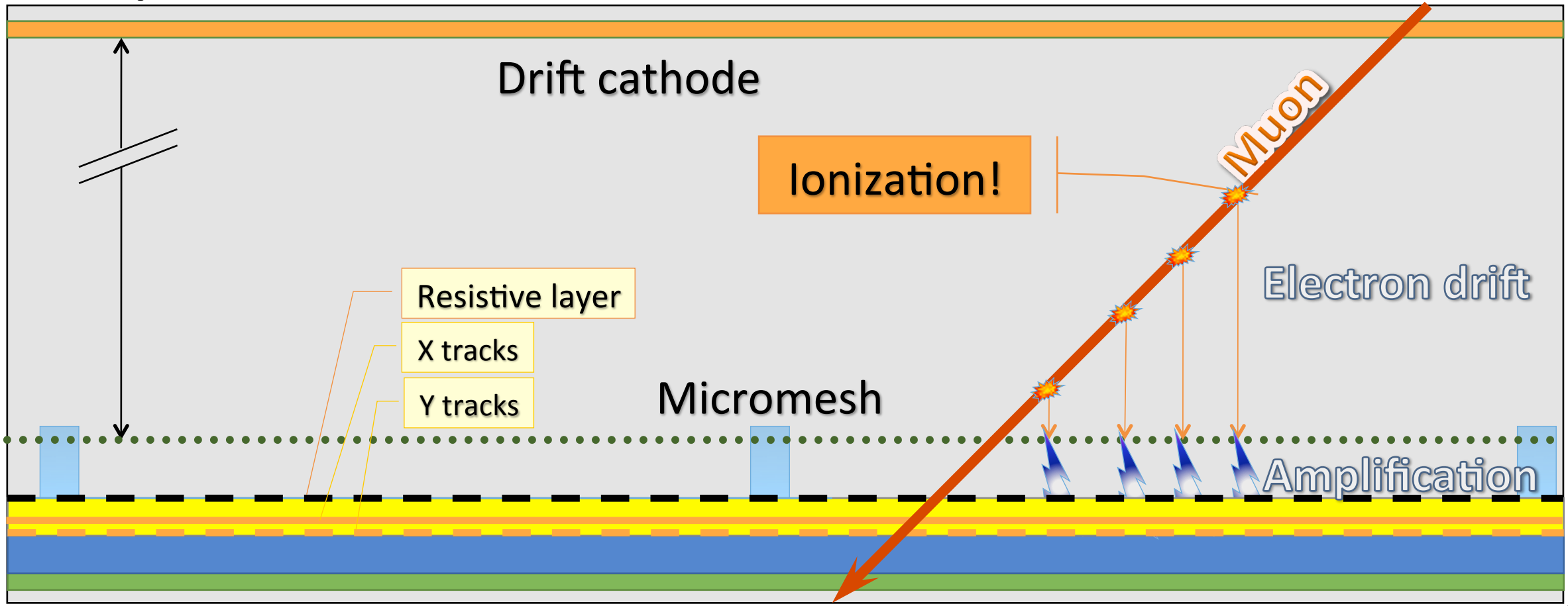


T2DM2 detector

- ✓ External trigger provided by scintillator
- ✓ Compact and light
- ✓ Only one detection plane allows reconstructing the particle track
- ✓ Performance:
  - Temporal resolution, few ns
  - Angular resolution, better than 1° for reconstructed tracks

7. New Detector of T2DM2

Principles

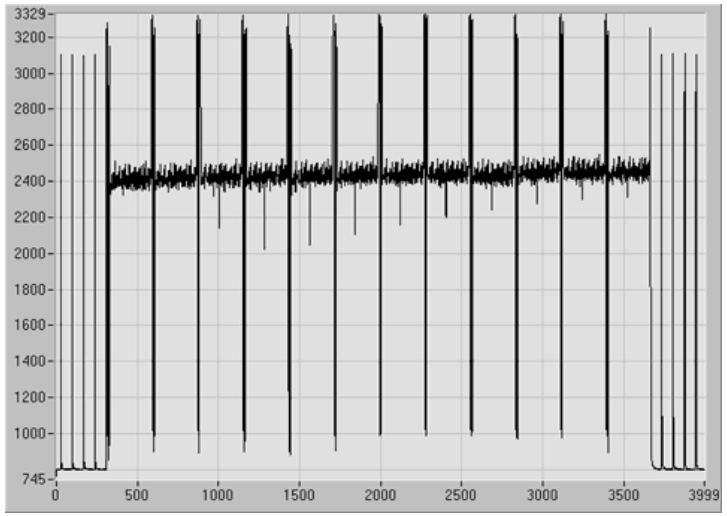


8. Track reconstruction

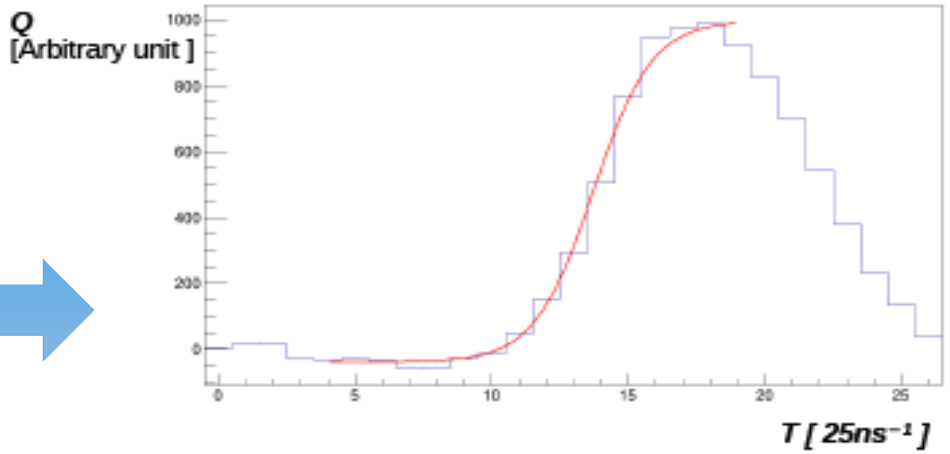
Raw data

Points

Tracks



- Measurement of the voltage on each channel with precise time information
- The rise time provides an accurate origin in time of the event, essential for the TPC performance

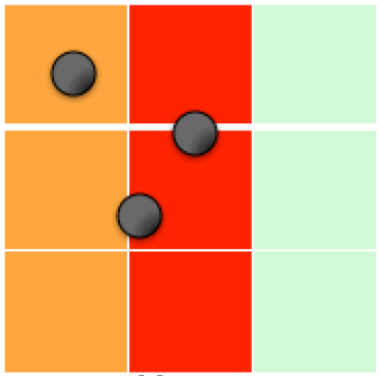


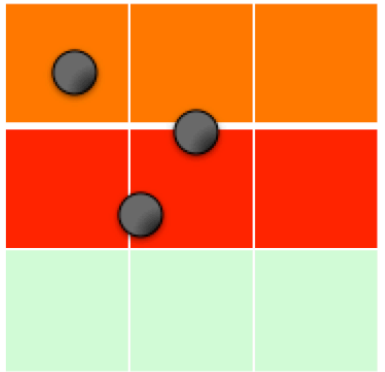
8. Track reconstruction

Raw data

Points (2D)

Tracks



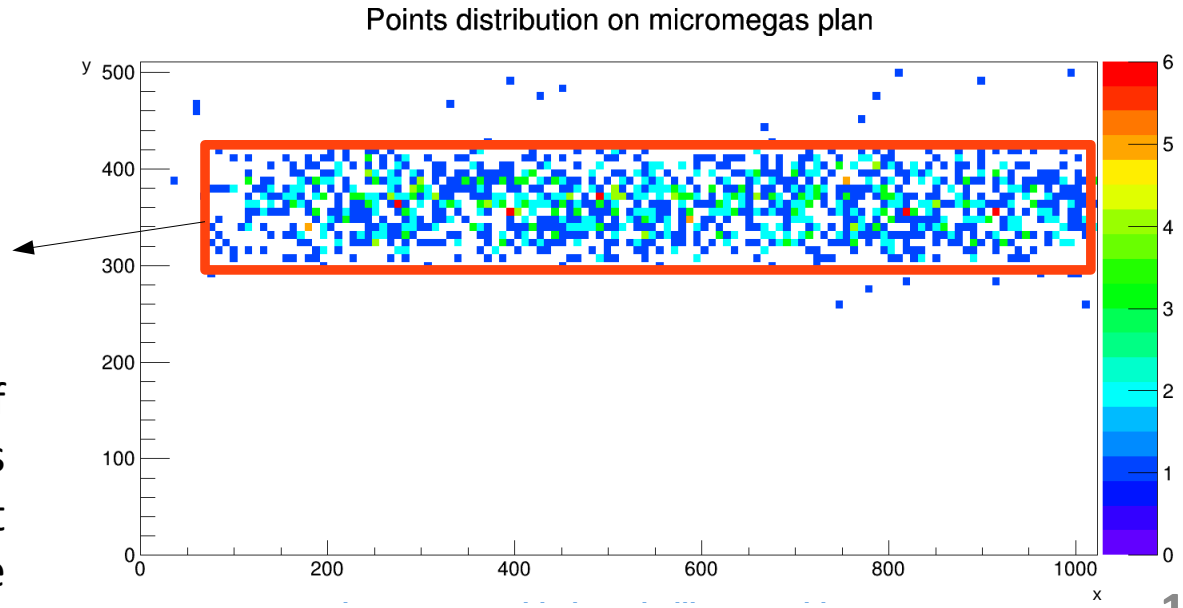


Cluster: Association of neighboring hit channels within a time window

- muon projection in chamber hit 10 channels typically
- it helps to minimize the false positives (less noise and artifacts)

Scintillator used for triggering

Association of simultaneous clusters on X and Y axis to get the position on the detection plane

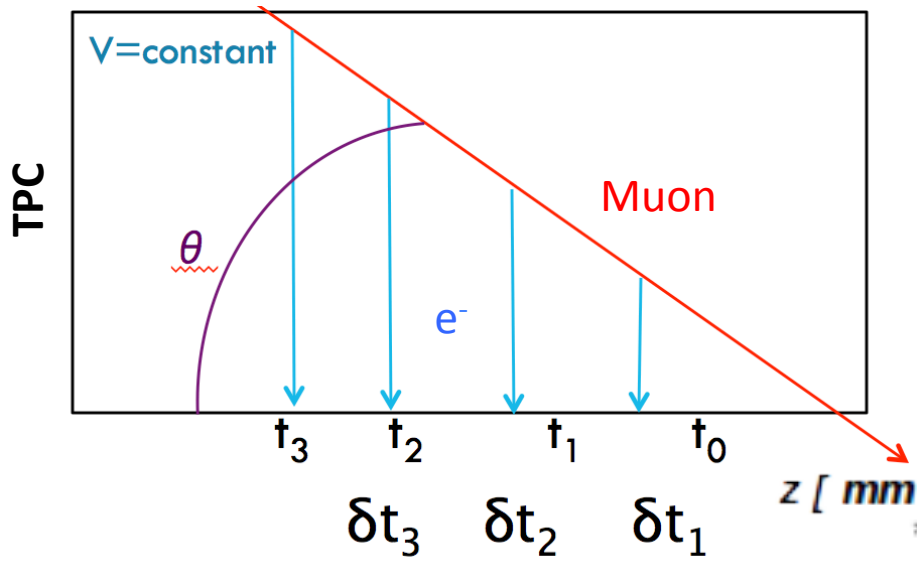


8. Track reconstruction

Raw data

Points

Tracks (3D)

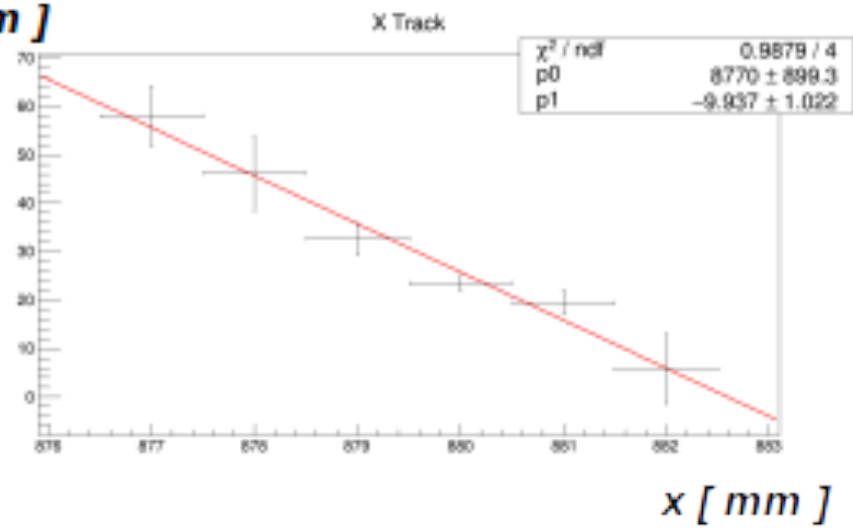


By knowing:

- the electron drift speed in the TPC
- time of arrival of primary electrons

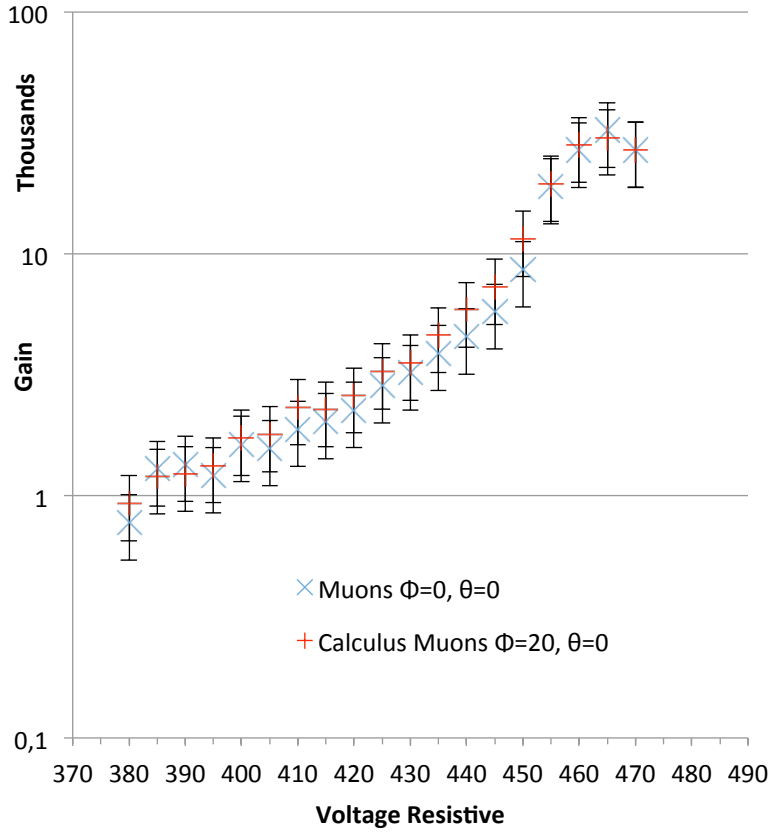
↓

Reconstruction of the particle's track



9. Controlled source

At CERN facilities



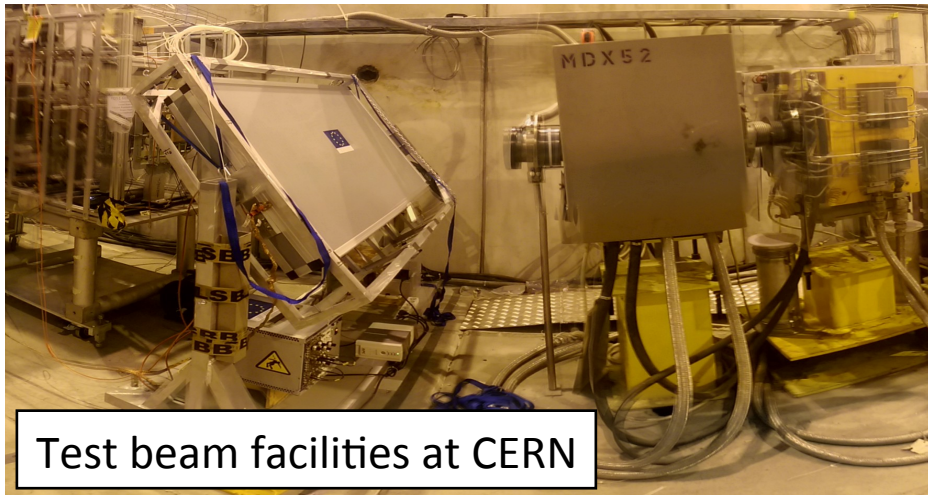
Gain measurements

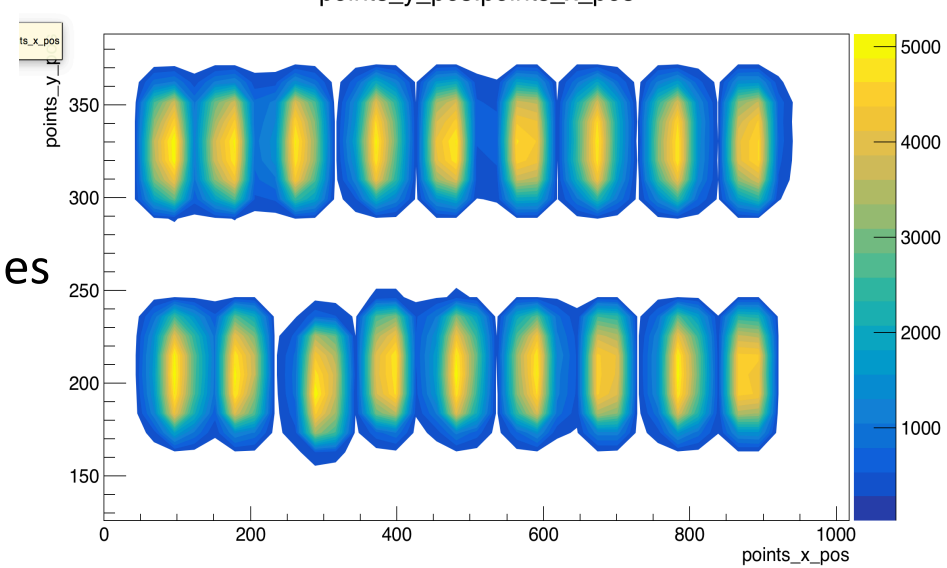
Tests performed:

- Detection efficiency
- Influence of the trigger
- Sensitivity to other particles

(π and e^-)

- Electronic latency
- Track reconstruction



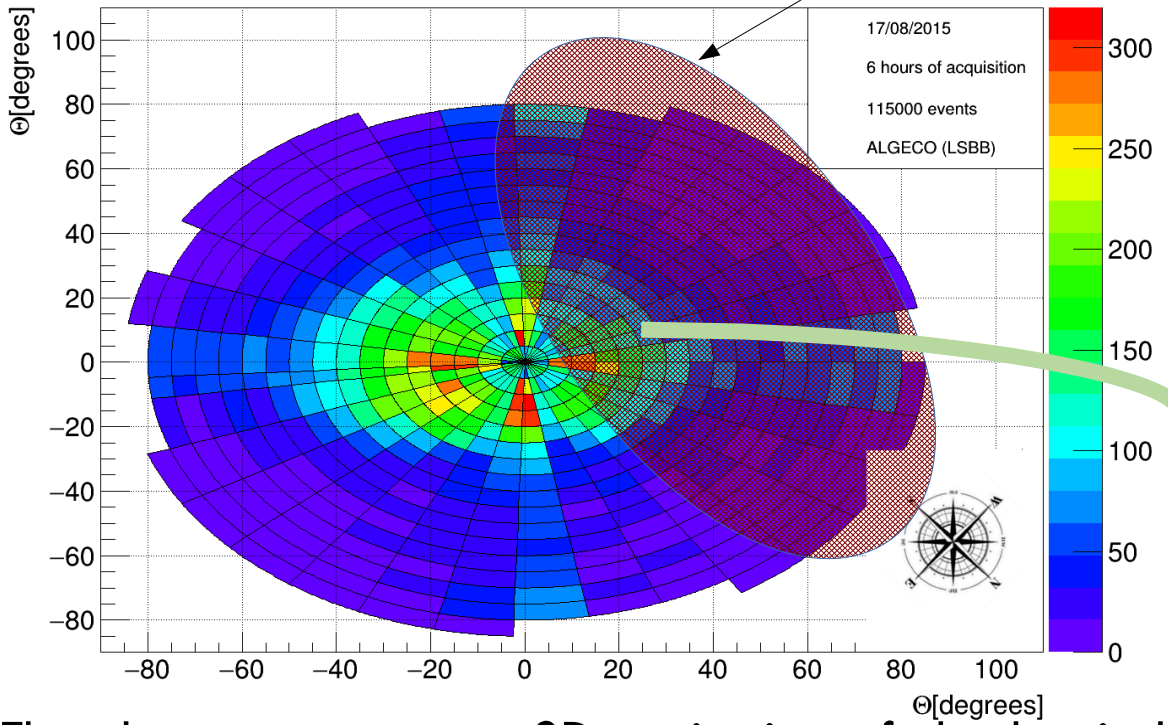


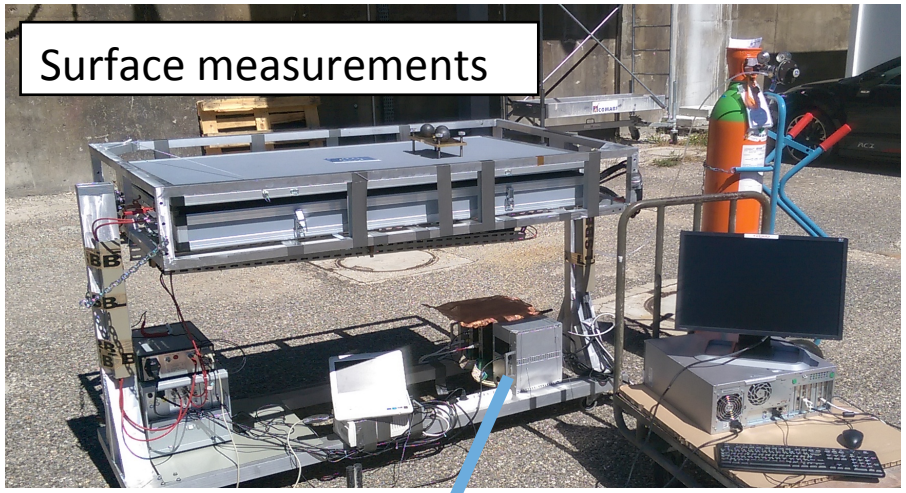
Surface homogeneity and particle positioning

10. Cosmic recordings

At LSBB facilities

The highlighted area corresponds to the "shadow" of the mountain





The chart represents a 2D projection of the hemisphere above the detector in polar coordinates

Histogram with the number of muon detected coming from a given origin

11. Conclusion

✓ The development of a compact detector based on Micromegas technology is still running

✓ Results of first tested key performance indicators are encouraging

✓ Need of complementary experimental tests to validate the design

Acknowledgements

PhD leading institutions:

Collaborators:

Sponsors: