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. Collaboration members

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

LSBB Laboratoire Souterrain à Bas Bruit
Low Noise Inter-Disciplinary Underground Science & Technology

T2DM2's initiator

brgm Geoscience for a sustainable Earth

Leader in Geosciences

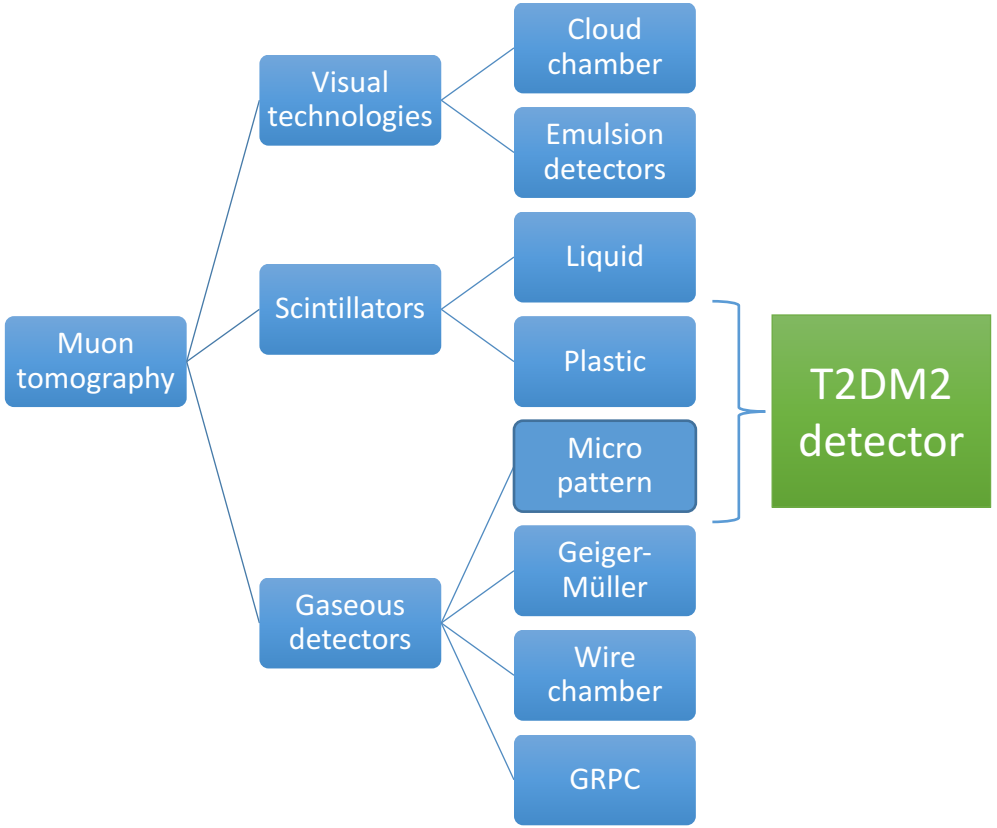
IRIS instruments

Skilled in sensors development

3. Targeted applications

4. Technology

Main Muon detection technologies

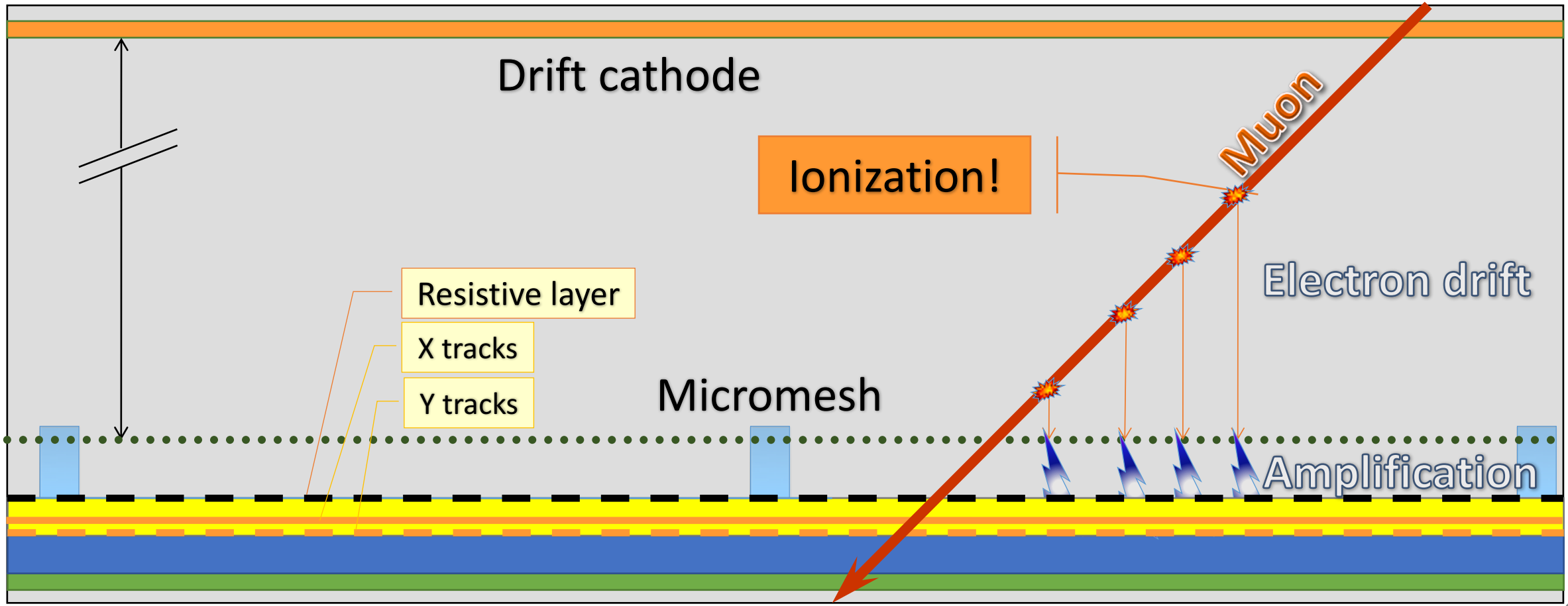


T2DM2 detector

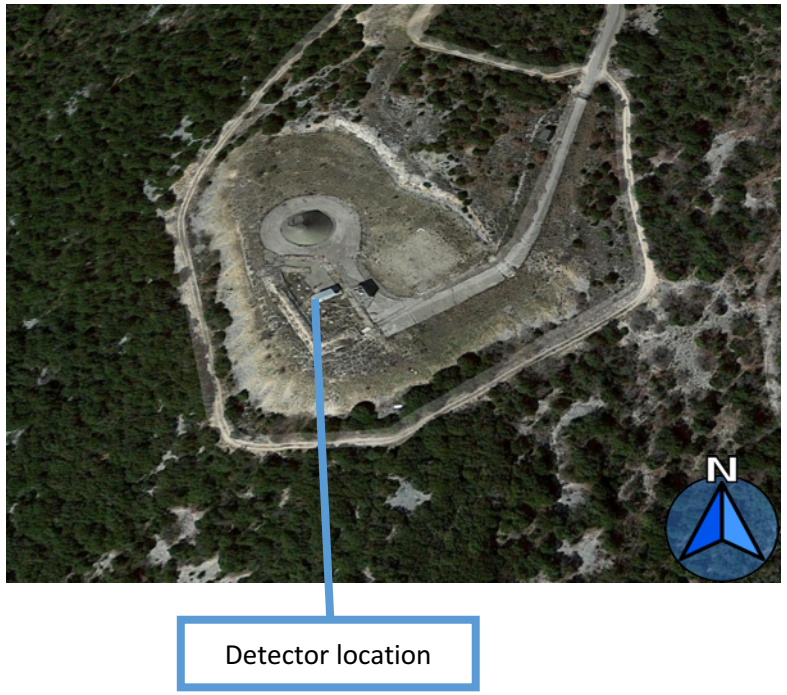
- ✓ External trigger provided by scintillator
- ✓ Compact and light
- ✓ Only one detection plane allows reconstructing the particle track
- ✓ Performance:
  - Temporal resolution, few ns
  - Angular resolution, better than 1° for reconstructed tracks
  - 2D resolution, better than 1mm

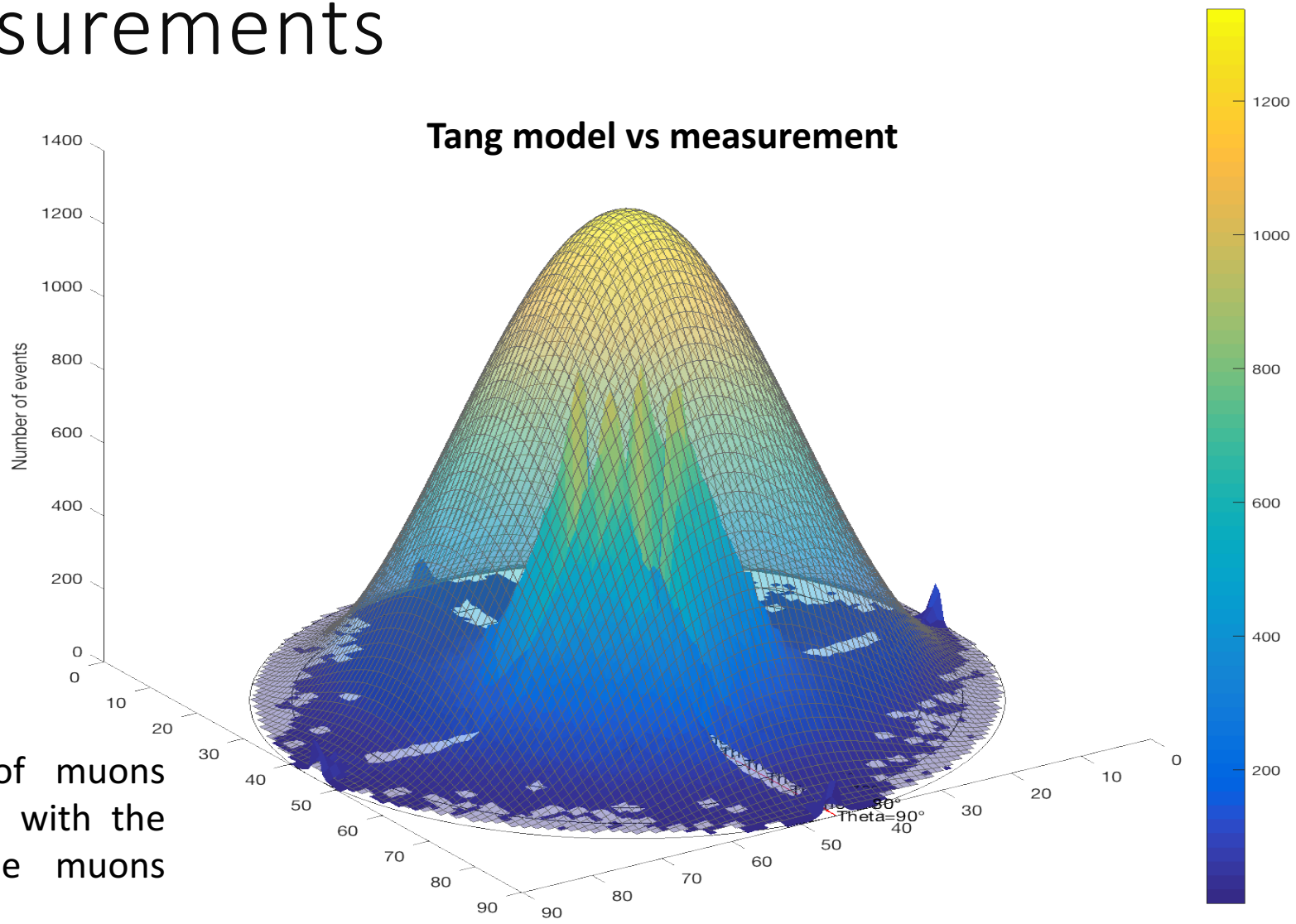
4. Technology

Principles



5. Open sky measurements



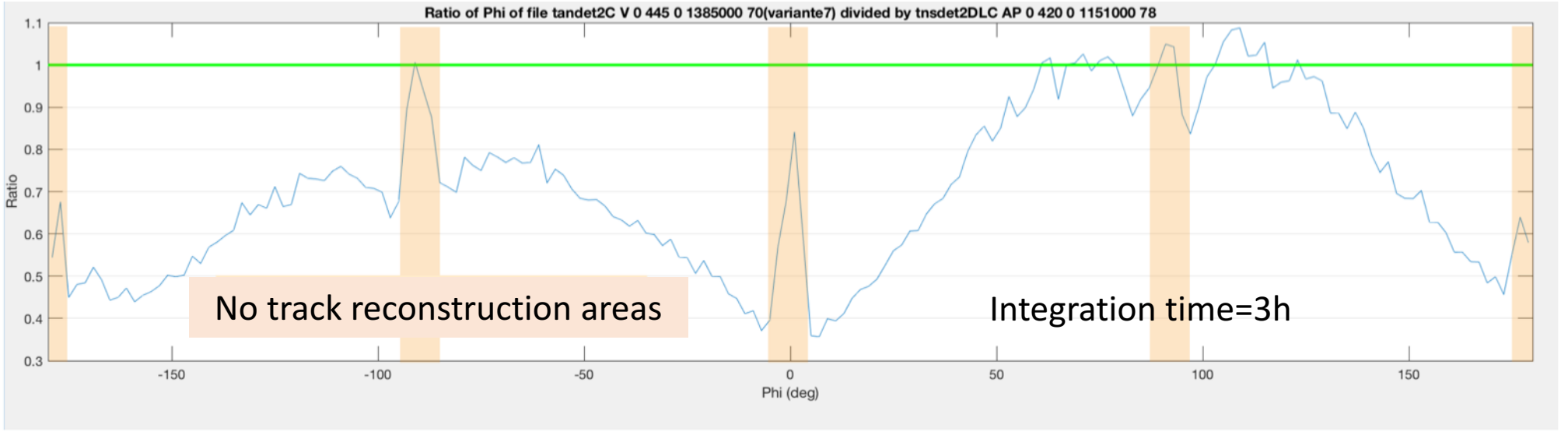


Comparison between the number of muons expected (according to Gaisser model with the parameters from A. Tang) and the muons measured.

REFERENCE MEASUREMENT

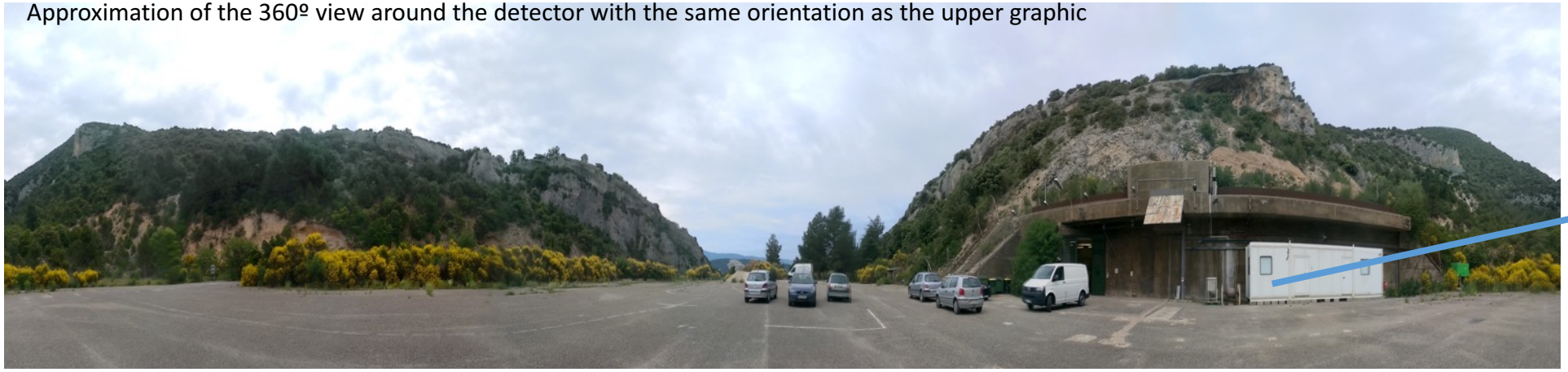
6. Outdoor measurements

$$Ratio = \frac{Muons\ per\ bin\ at\ \boldsymbol{Open\ sky\ measure}}{Muons\ per\ bin\ at\ \boldsymbol{Valley\ measure}}$$



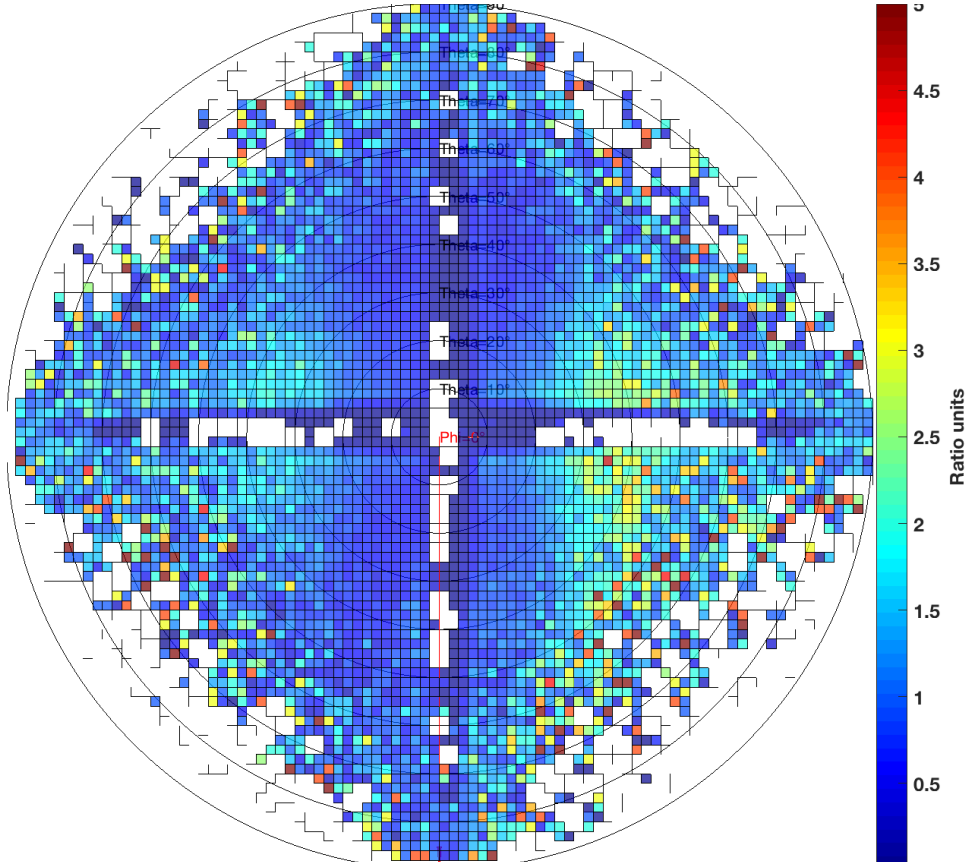
Higher values means bigger attenuation

Approximation of the 360º view around the detector with the same orientation as the upper graphic



6. Outdoor measurements

Same dataset as previous slide
Integration time=3h



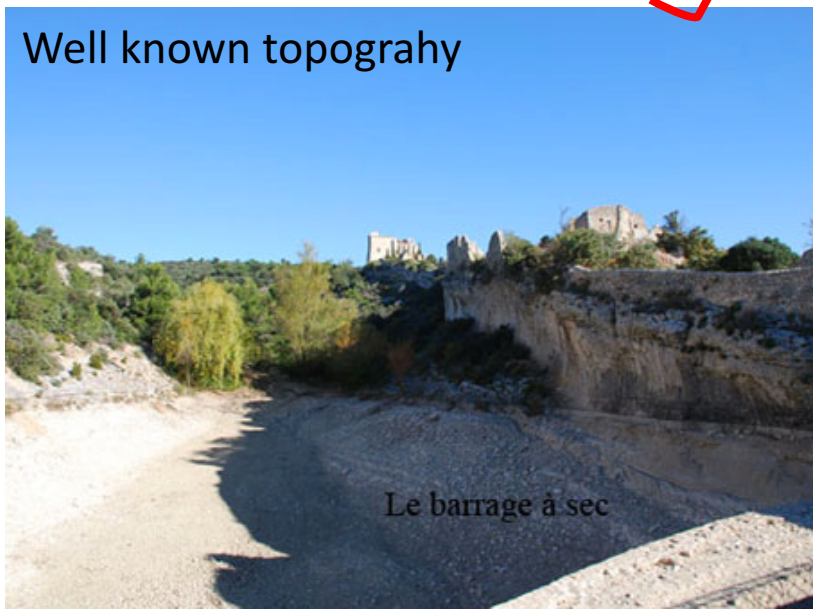
$$Ratio = \frac{Muons\ per\ bin\ at\ \boldsymbol{Open\ sky\ measure}}{Muons\ per\ bin\ at\ \boldsymbol{Valley\ measure}}$$

7. Study site

Narrow hill with a castle on the top and crossing tunnels underneath

- The detector is located at the base of the dam, inside the valve cabin.
- Monitoring:
  - Cabin temperature, atmospheric pressure and humidity.
  - Water level, temperature and conductivity.
  - Local rain and wind.
  - High atmosphere pressure

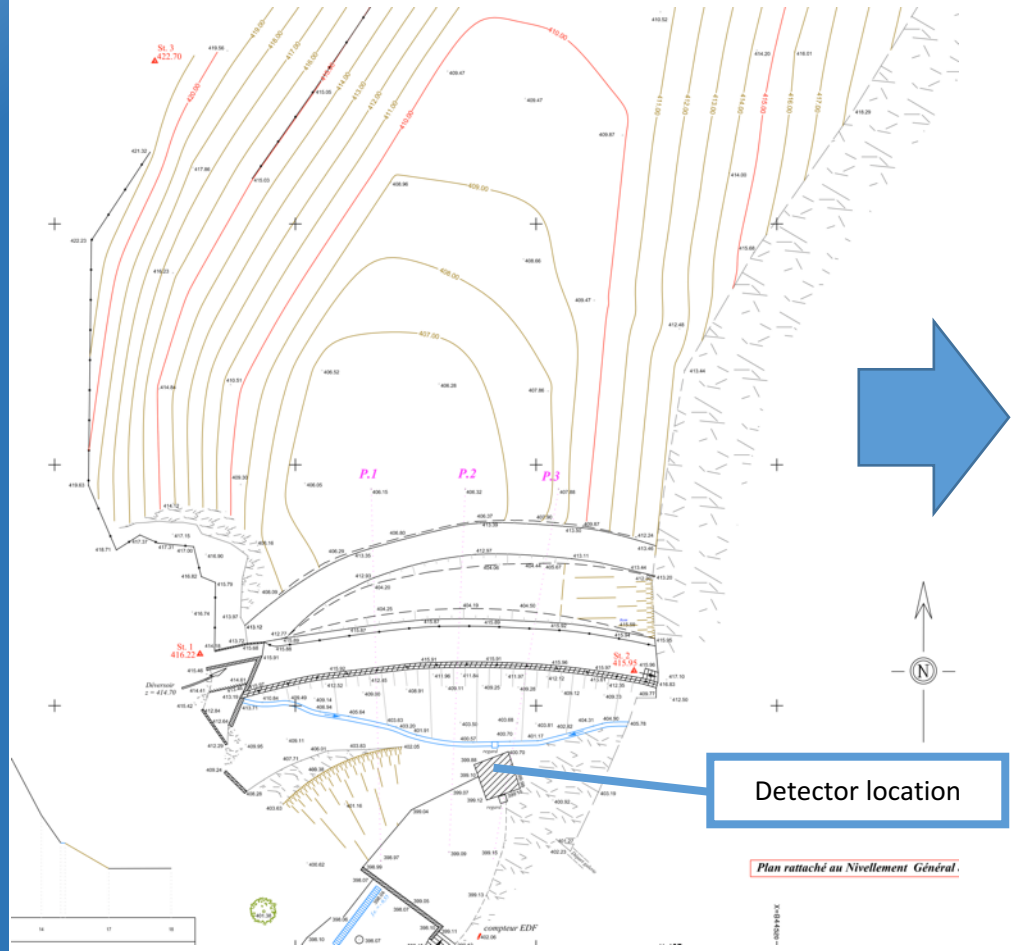
Well known topograhy



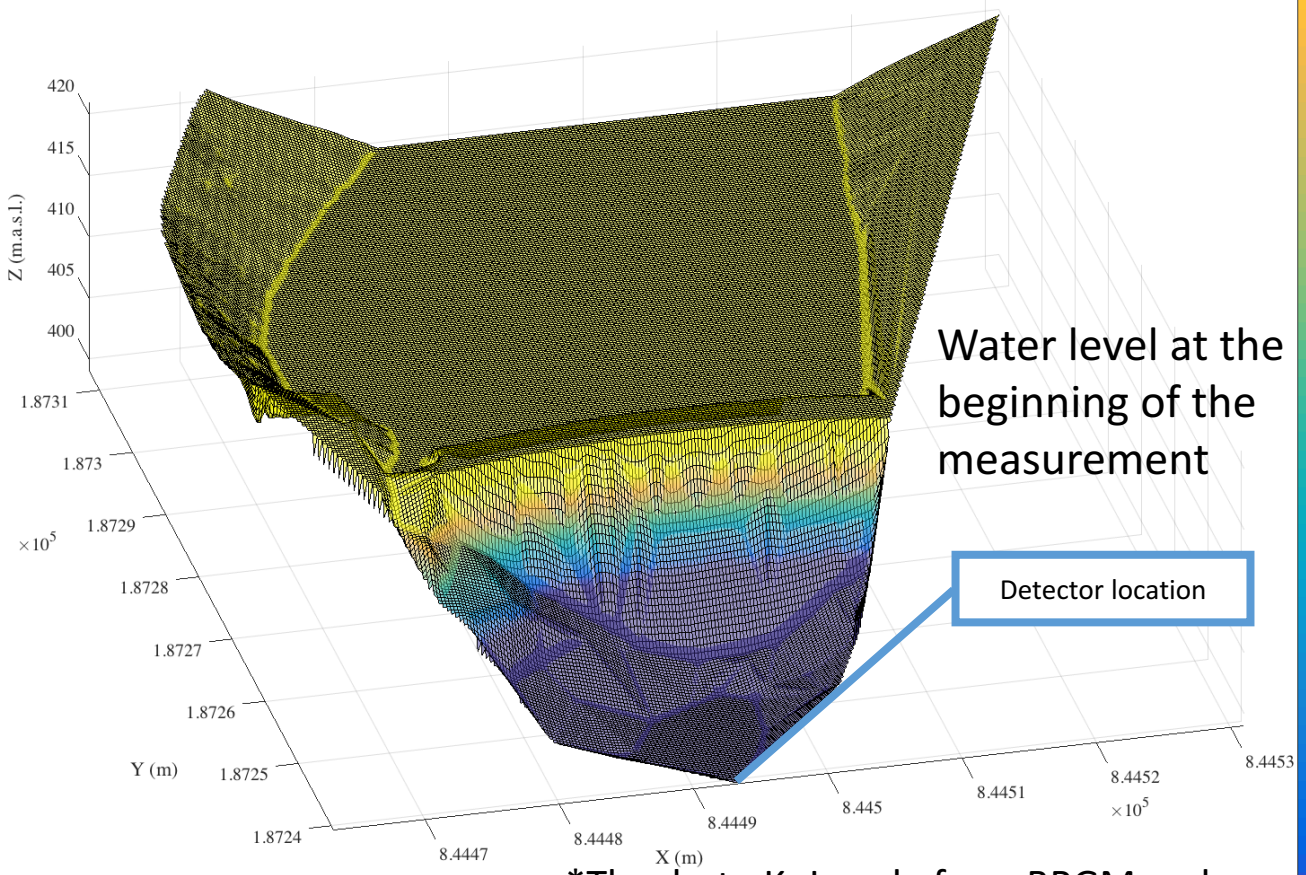
Risk surveillance

7. Study site - modelisation

Topographic data



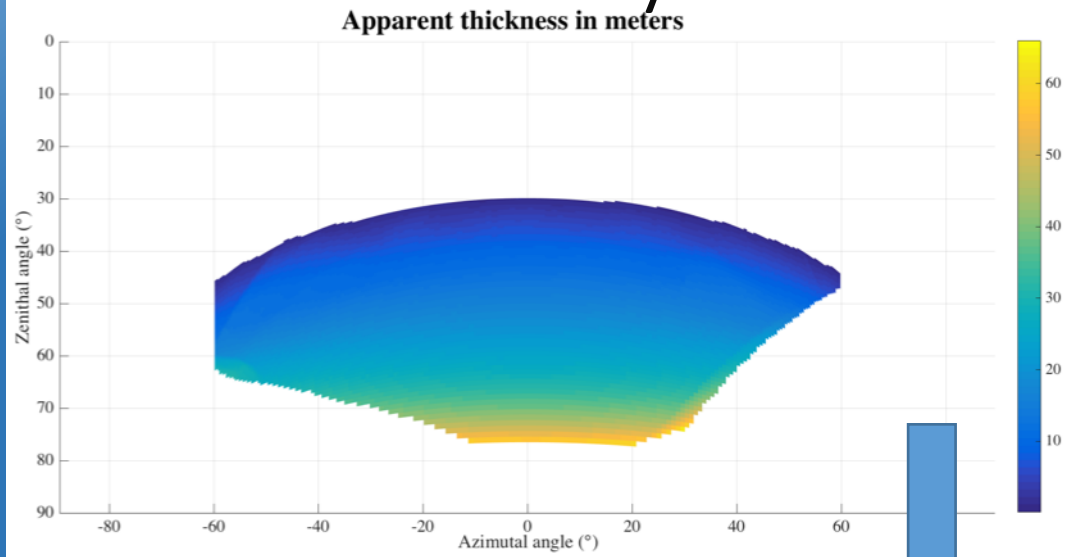
Digital model for simulation*

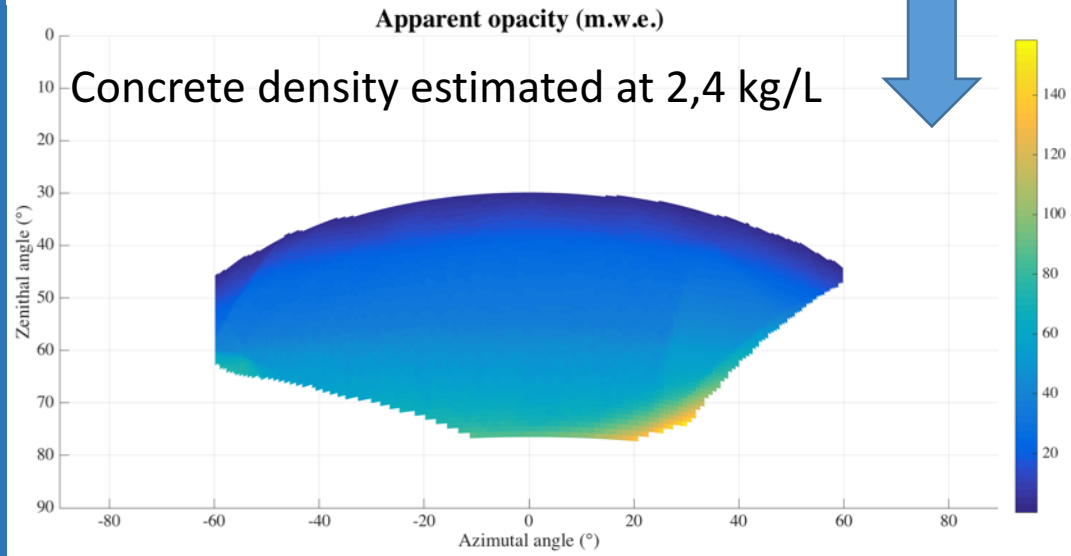


Water level at the beginning of the measurement

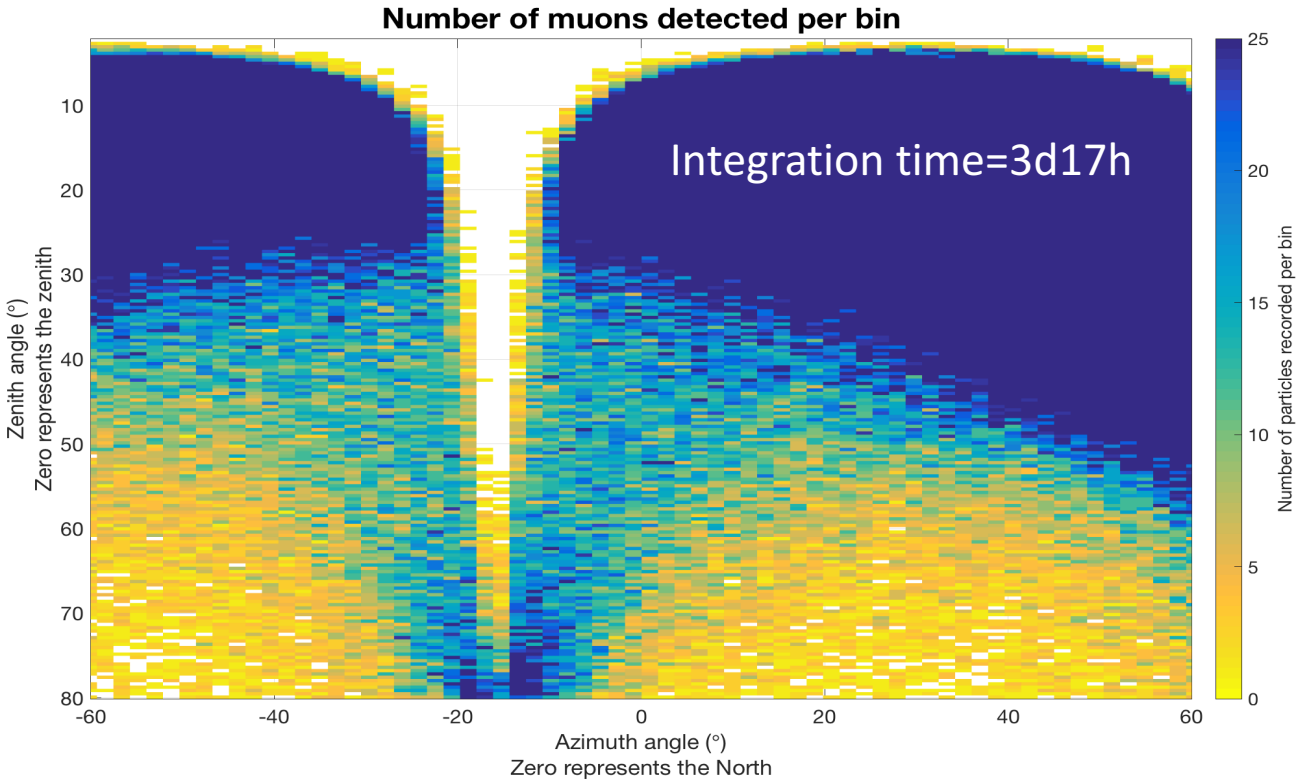
*Thanks to K. Jourde from BRGM and member of T2DM2 collaboration

8. Preliminary results





Concrete density estimated at 2,4 kg/L



9. Short term goals

- ✓ Continue acquiring data by the dam:
  - to improve the data analysis algorithms (P & T dependence, track reconstruction algorithm…)
  - to assess the variations of the water level (approx. 1cm per day)

- ✓ Work in the inverse problem to convert muon flux into density

- ✓ Build a new set-up in the galleries of an out-of-service mine in collaboration with the CEA.
  - Two different MicroMegas based detectors measuring in parallel.

10. Conclusion

- ✓Recently acquired capability to perform long-term measurements
- ✓First campaign of measures out of the lab accomplished, field transportability demonstrated
- ✓Currently working in the inversion to compare the prediction from the model against the acquired data
- ✓The data analysis shows that the trajectory reconstruction algorithm works well…
- ✓BUT, still room for improving the efficiency and reduce instrumental noise.

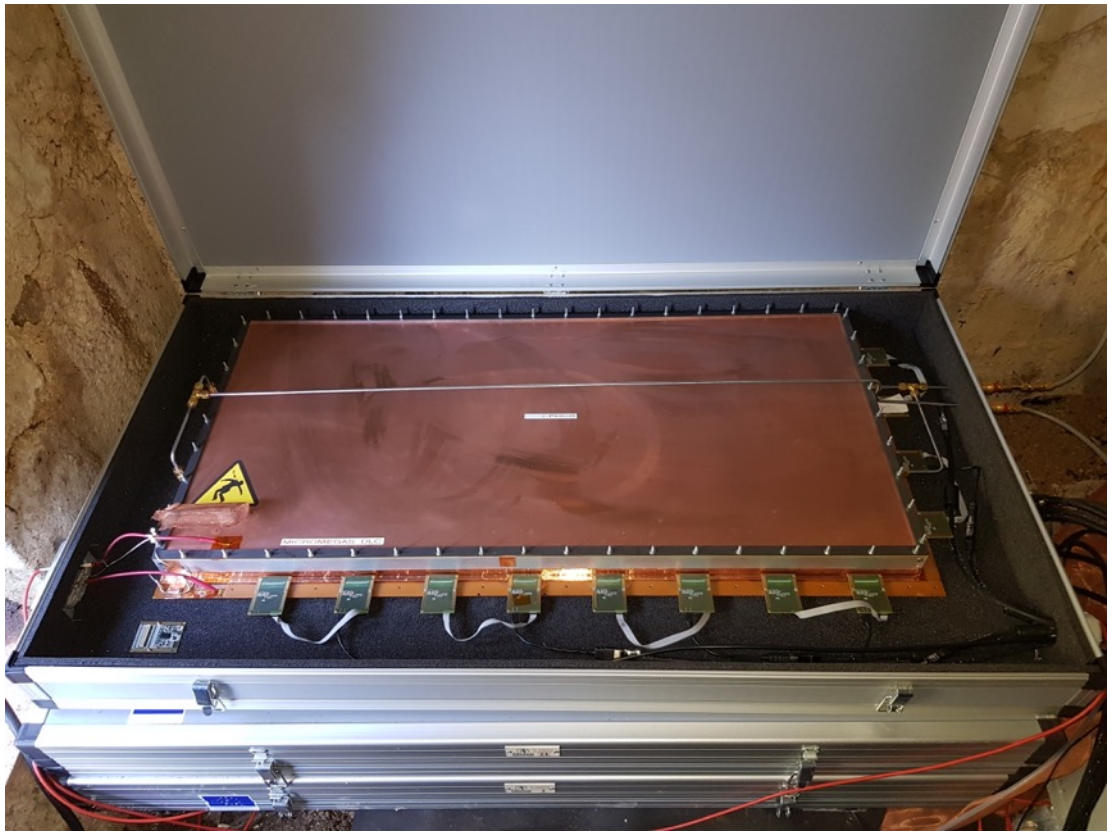
Acknowledgements

PhD leading institutions:

Collaborators:

Sponsors:

Spare slides



Spare slides