

Muographying the City

LIP 2023 summer internships

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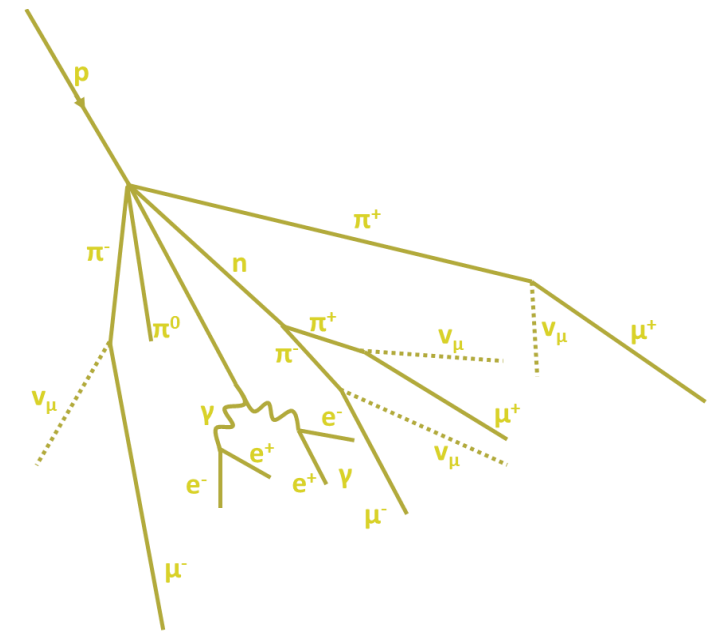
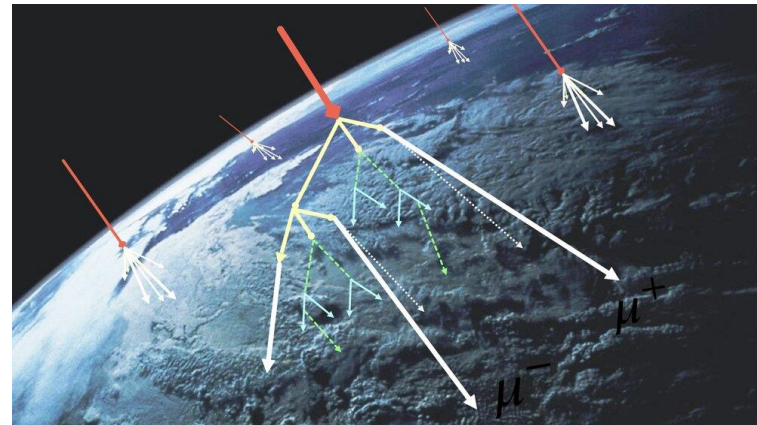


LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS



Universidade do Minho

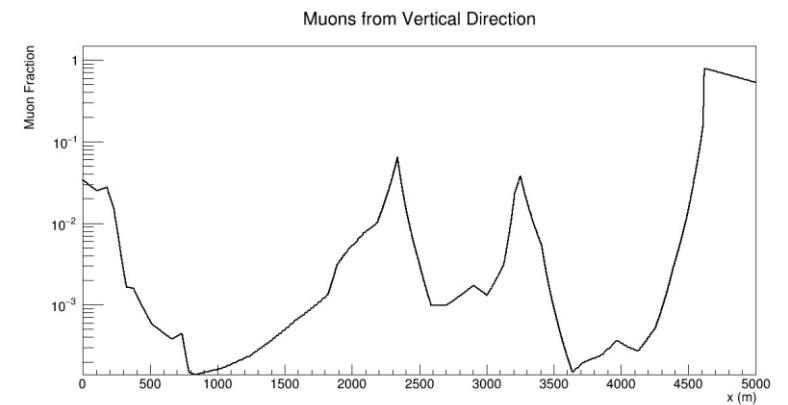
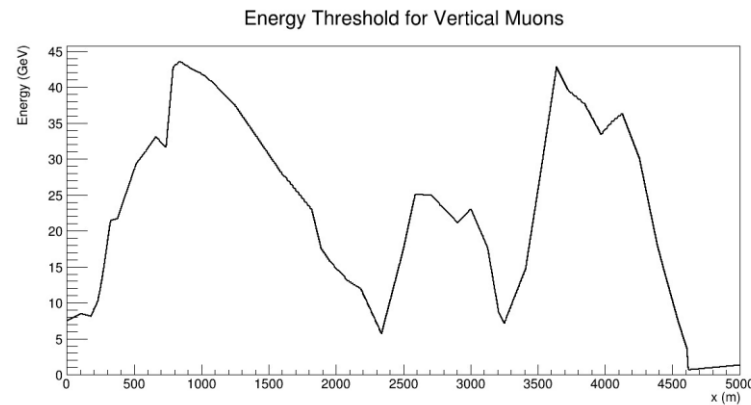
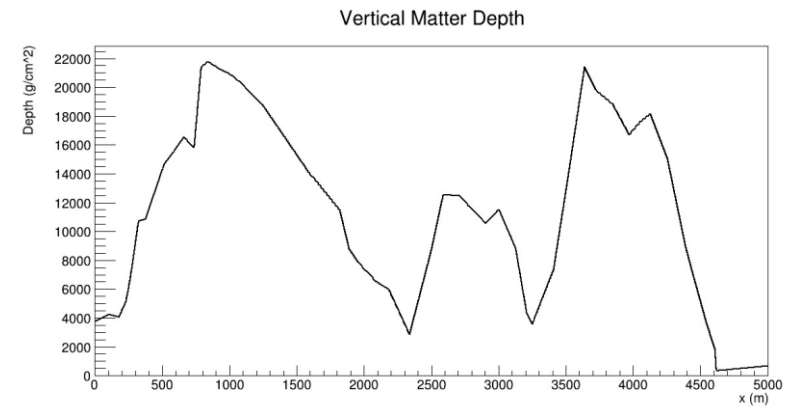
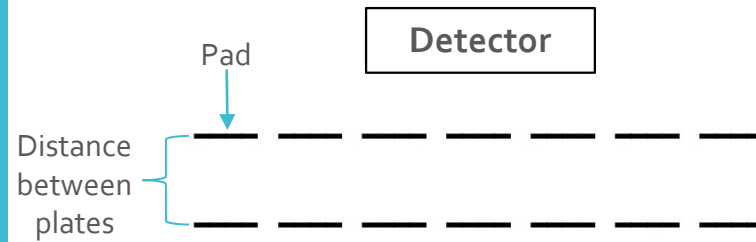
Our Project and Muography



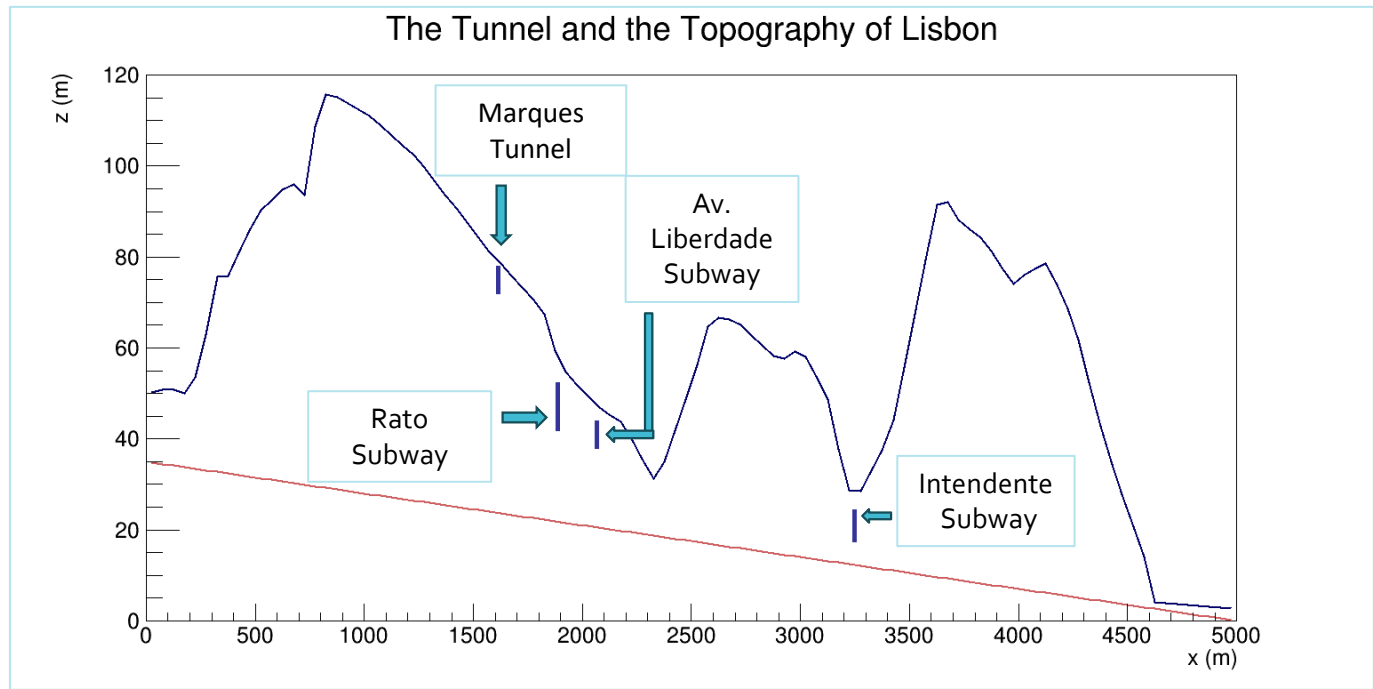
Initial data and the detector

Fundamental physical properties of muons:

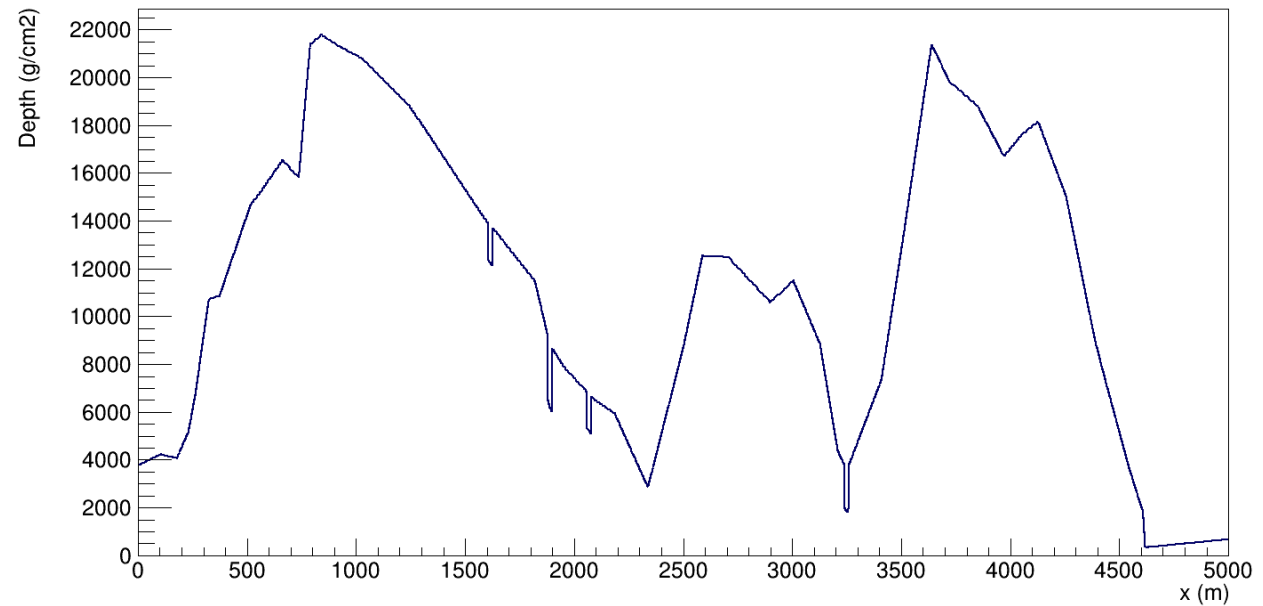
- Energy distribution of atmospheric muons is stable;
- Muons lose energy as they pass through matter at a constant rate.



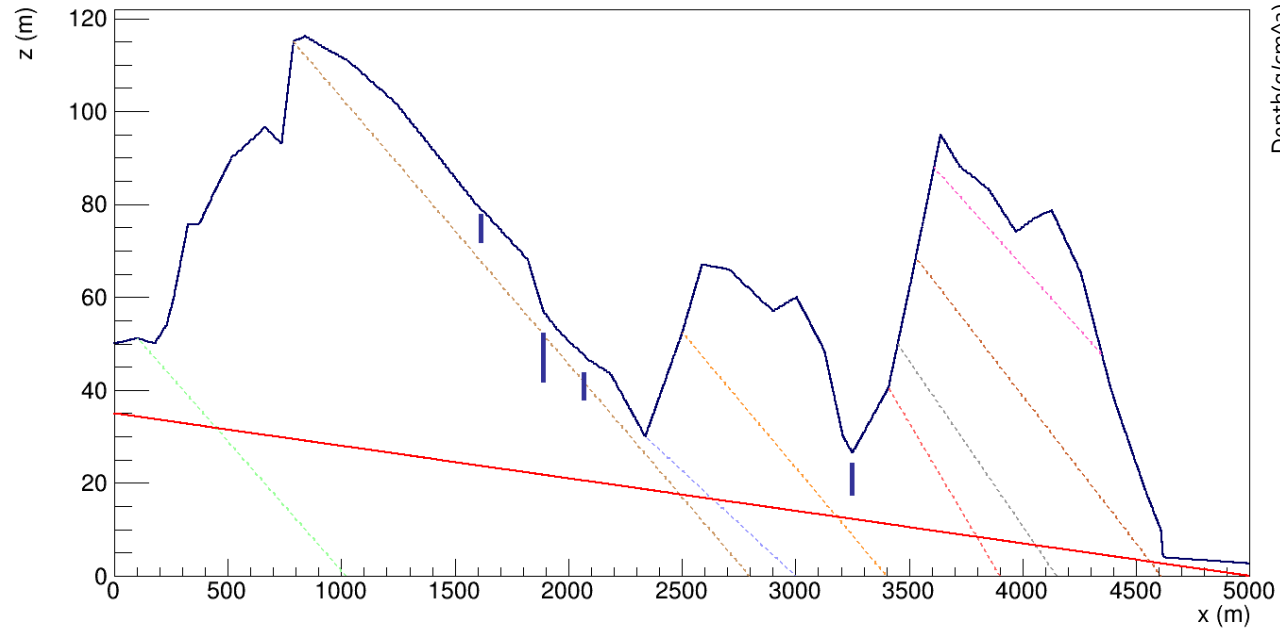
Matter Depth in the Tunnels



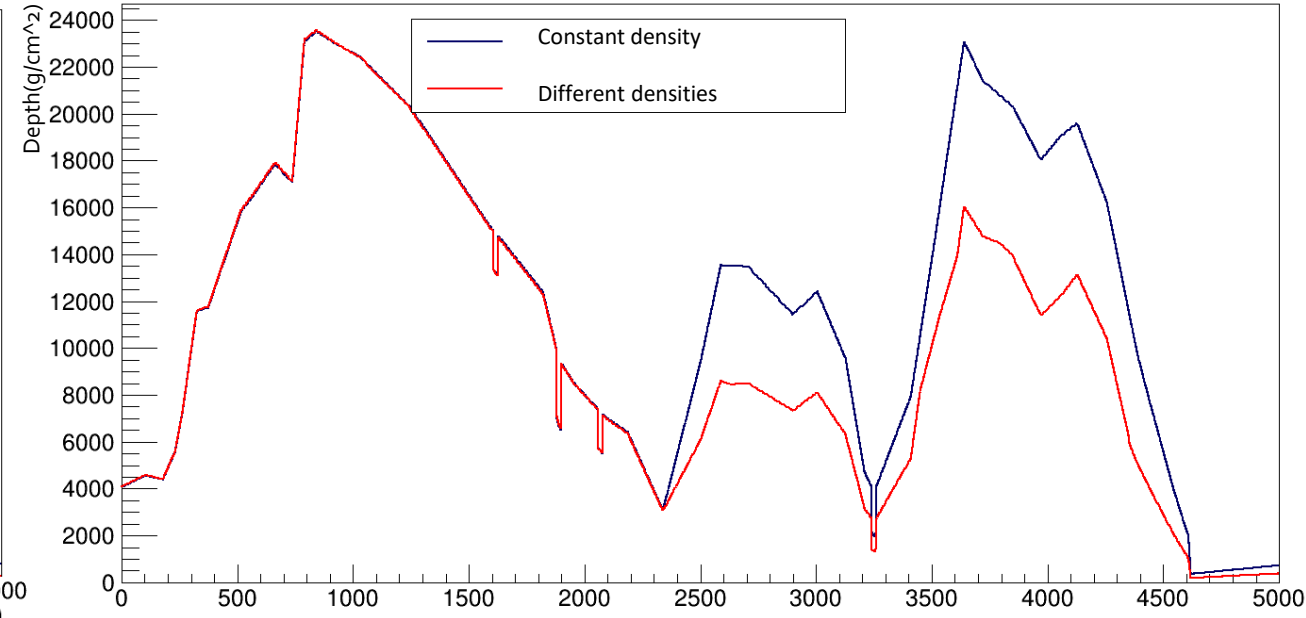
Vertical Matter Depth



Schematic Geological Profile of Lisbon

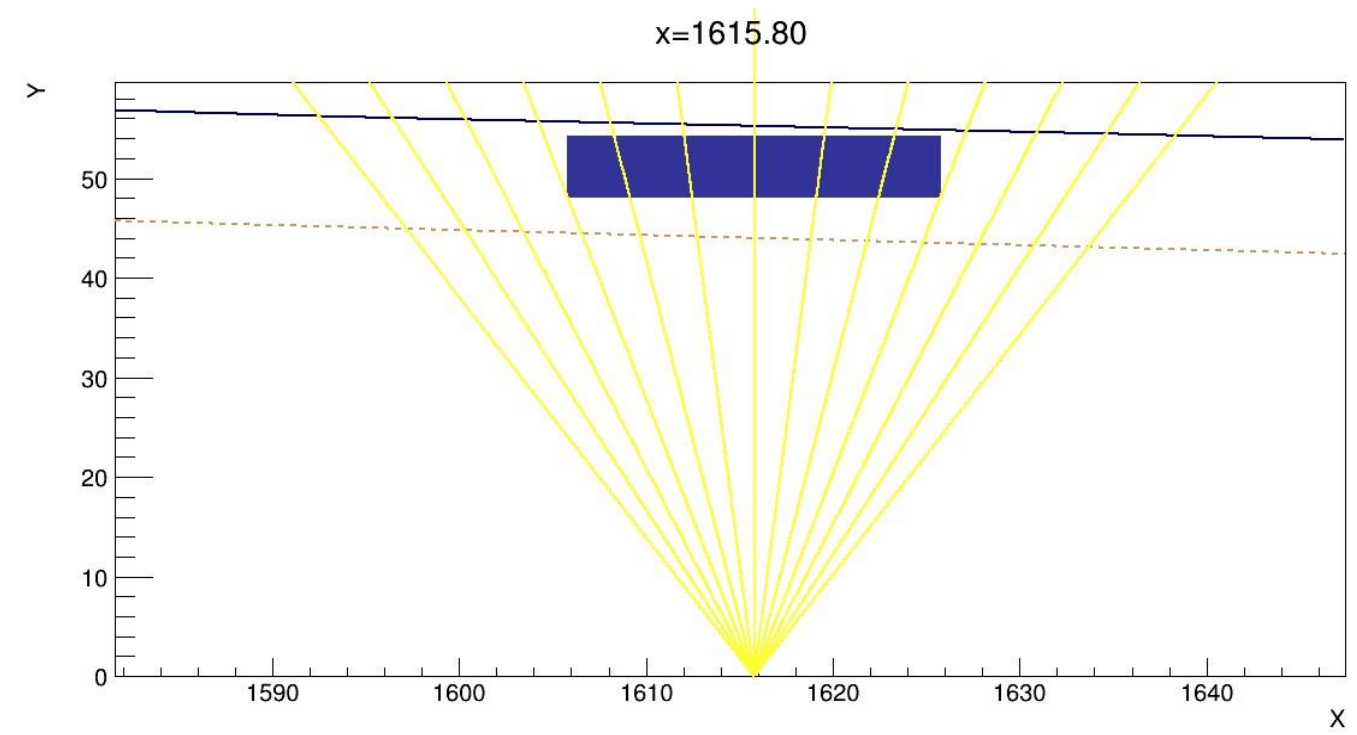
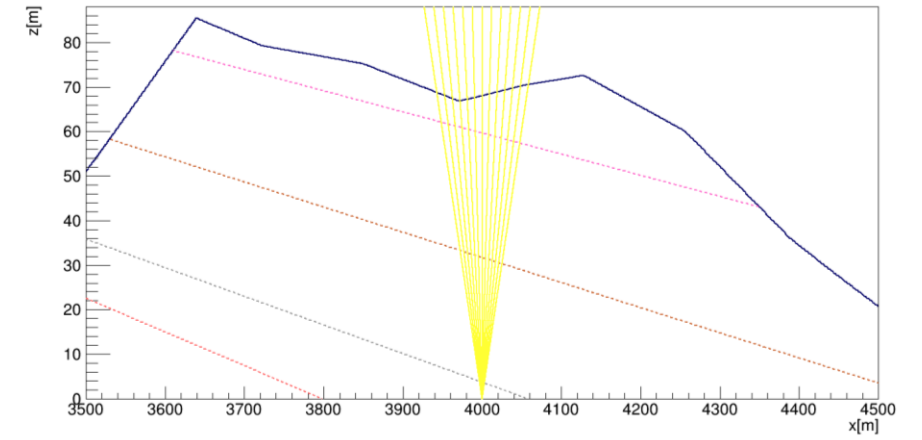
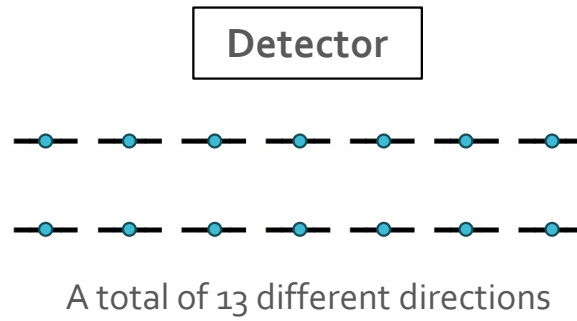


Vertical Matter Depth

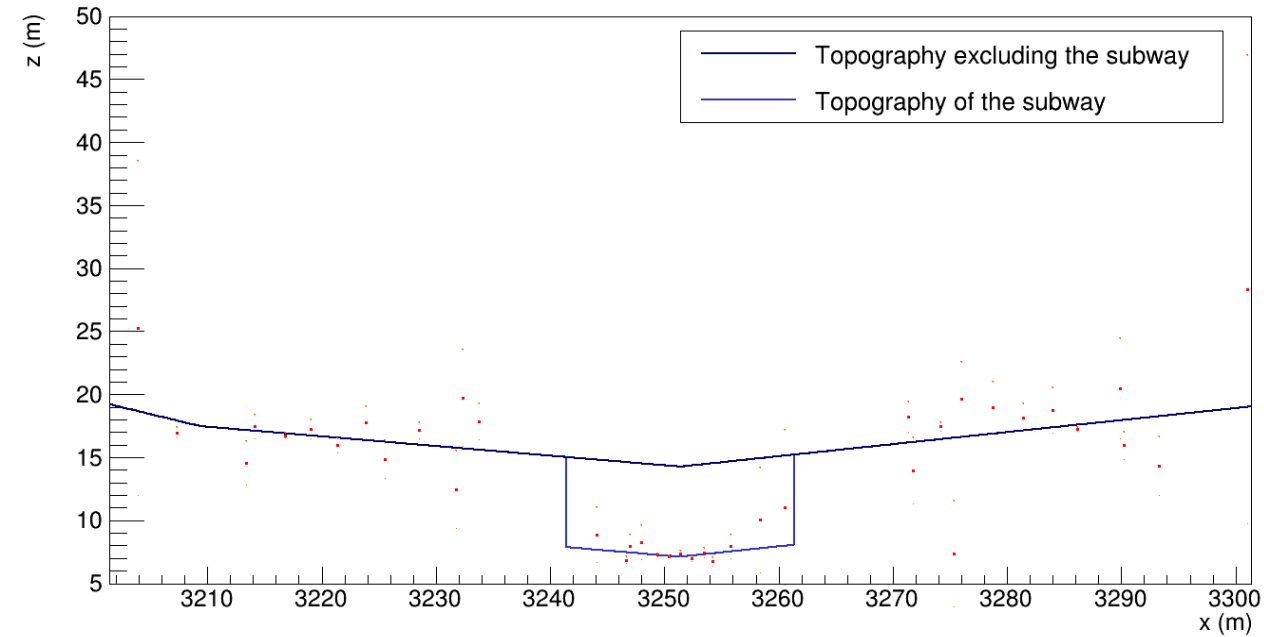


The Influence of Incorporating Layers with Diverse Densities

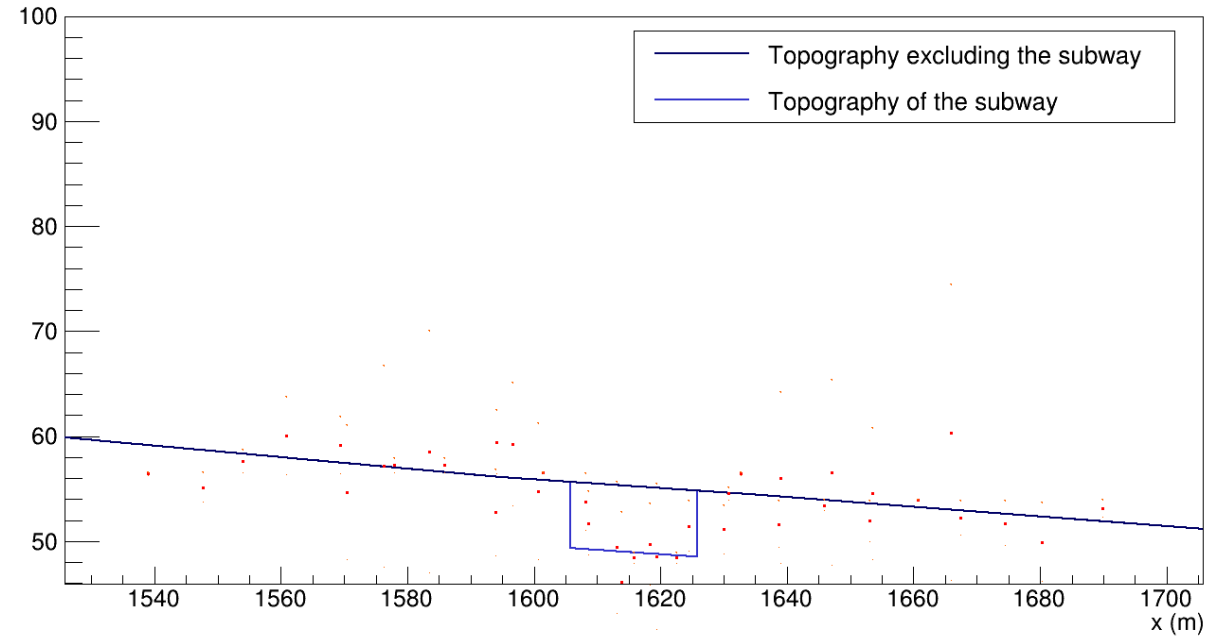
Muons from generalized directions



Topography of Intendente Subway Over a 12-Hour Study

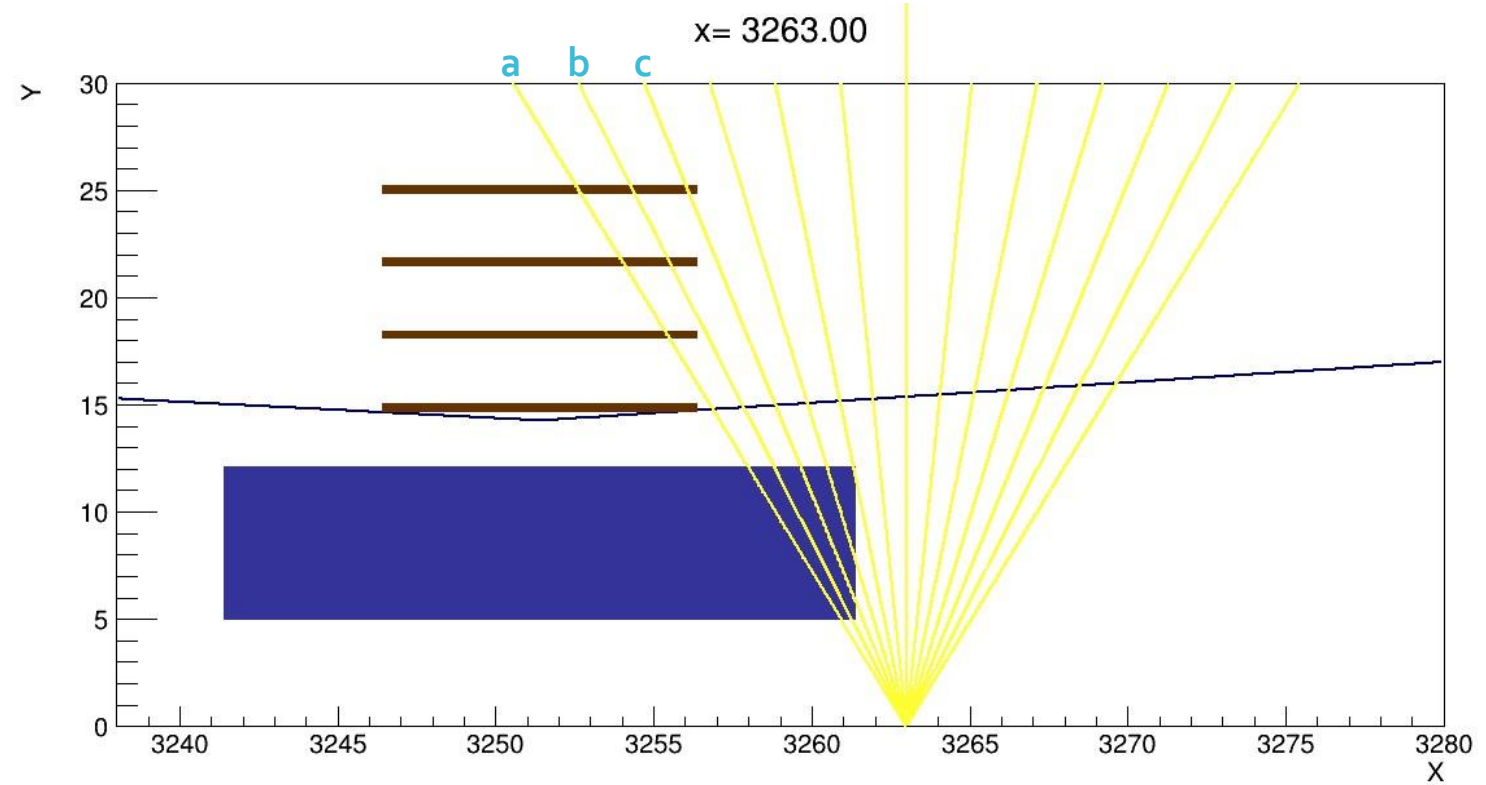


Topography of Marques Tunnel Over a 30-Day Study



The detector on Subways

Buildings



Without building

Angle: -22.5236
Matter depth: 2237.88
Angle: -19.0641
Matter depth: 2212.9
Angle: -15.4542
Matter depth: 2409.52
Angle: -11.7142
Matter depth: 2928.34
Angle: -7.87023
Matter depth: 3971.23
Angle: -3.95376
Matter depth: 4135.08

With building

Angle: -22.5236
Matter depth: 2588.19
Angle: -19.0641
Matter depth: 2440.22
Angle: -15.4542
Matter depth: 2520.98
Angle: -11.7142
Matter depth: 2928.34
Angle: -7.87023
Matter depth: 3971.23
Angle: -3.95376
Matter depth: 4135.08

a
b
c

Without building

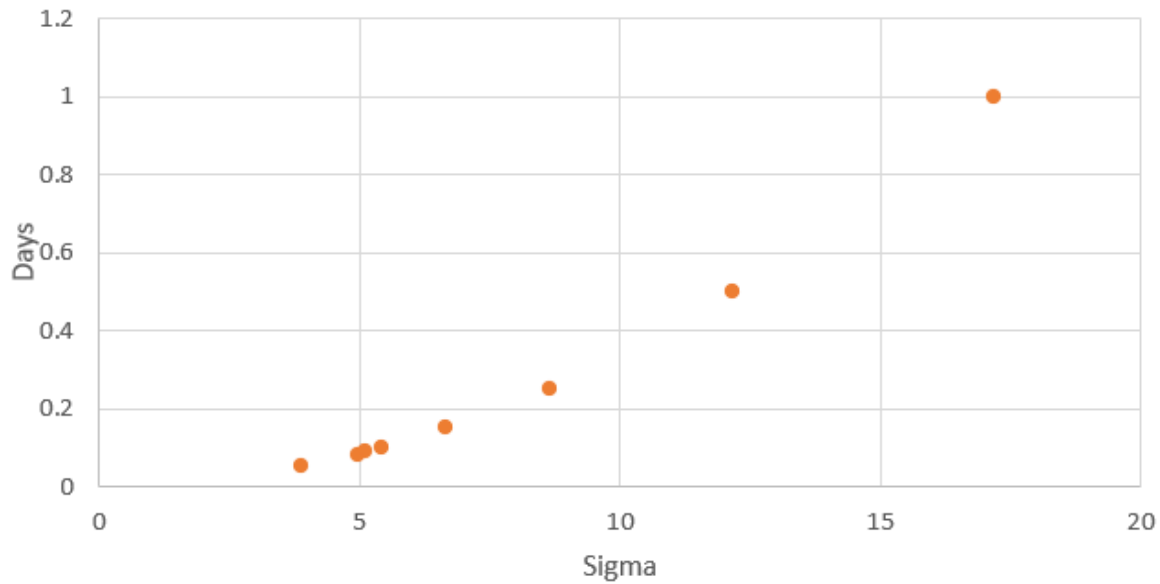
Threshold energy: 4.47576
Threshold energy: 4.4258
Threshold energy: 4.81904
Threshold energy: 5.85669
Threshold energy: 7.94246
Threshold energy: 8.27017

With building

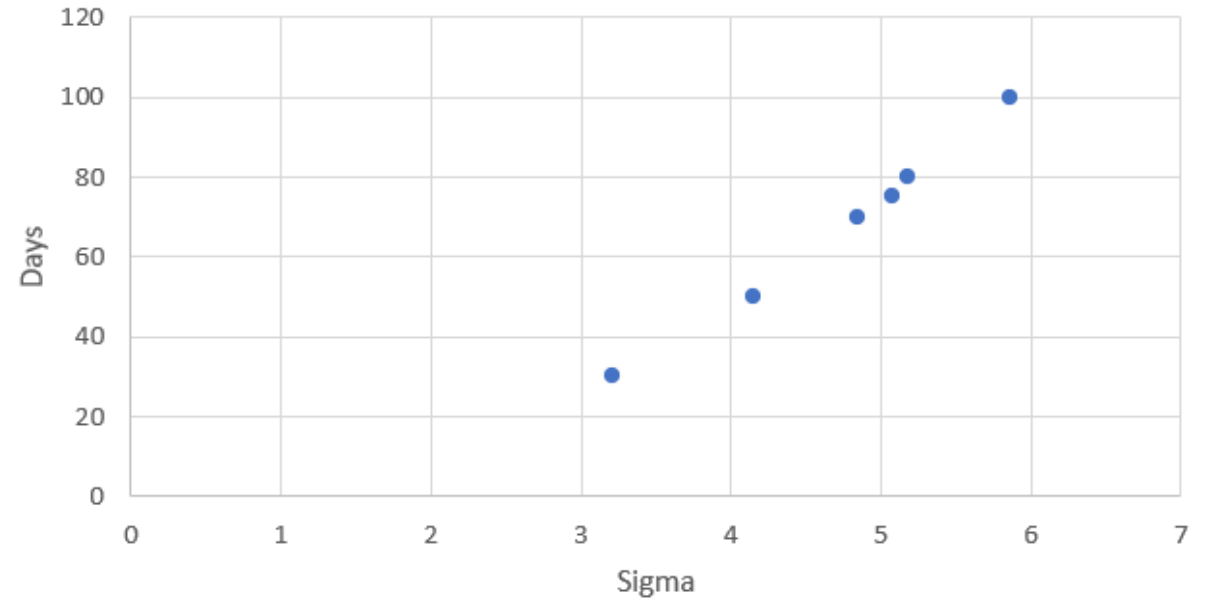
Threshold energy: 5.17637
Threshold energy: 4.88044
Threshold energy: 5.04196
Threshold energy: 5.85669
Threshold energy: 7.94246
Threshold energy: 8.27017

a
b
c

Sigma for Intendente's Subway , z =7.11



Sigma for Marques' Subway , z = 48.9m



Sensitivity for subways

$$\sqrt{\sigma^2} = \frac{\mu(z) - \mu(z - dz)}{\sqrt{\mu(z)}}$$

Muographying a City

But why muography a city?

- This technique does not damage the city neither the people;
- It can prevent disasters;
- Let us know more about the city in many branches of study that can have valued implications to society.

Thank you
for your
time!