LABORATÓRIO DE INSTRUMENTAÇÃO E FÍSICA EXPERIMENTAL DE PARTICULAS

LIP

MUOGRAPHY OF A WATER-CHERENKOV DETECTOR OF THE PIERRE AUGER OBSERVATORY

CATARINA FELGUEIRAS & DANIEL SOUSA

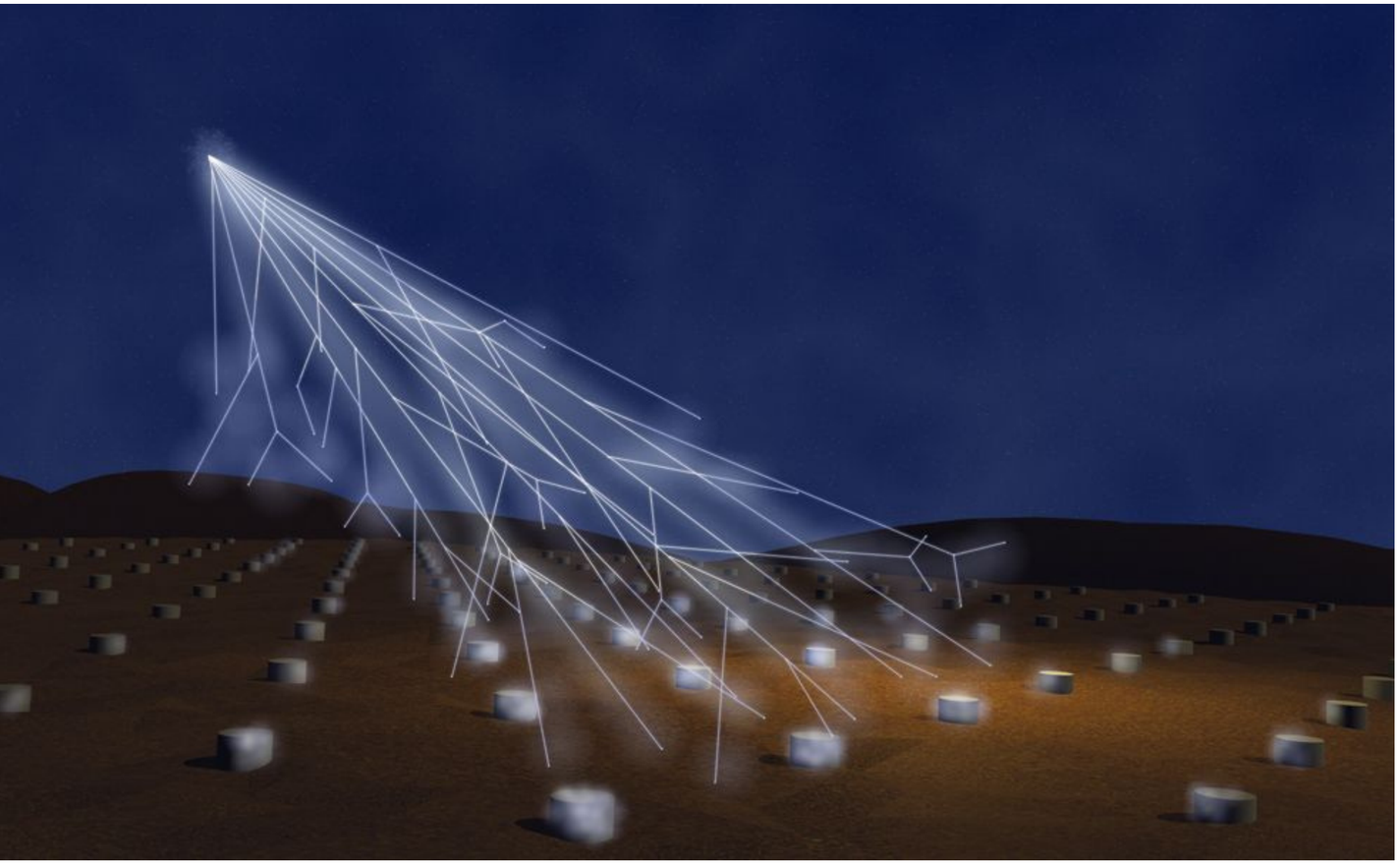
ADVISORS: RAUL SARMENTO & SOFIA ANDRINGA

Main Objectives

i. Muography Technique

ii. Energy Spectrum of the muons of the particle shower

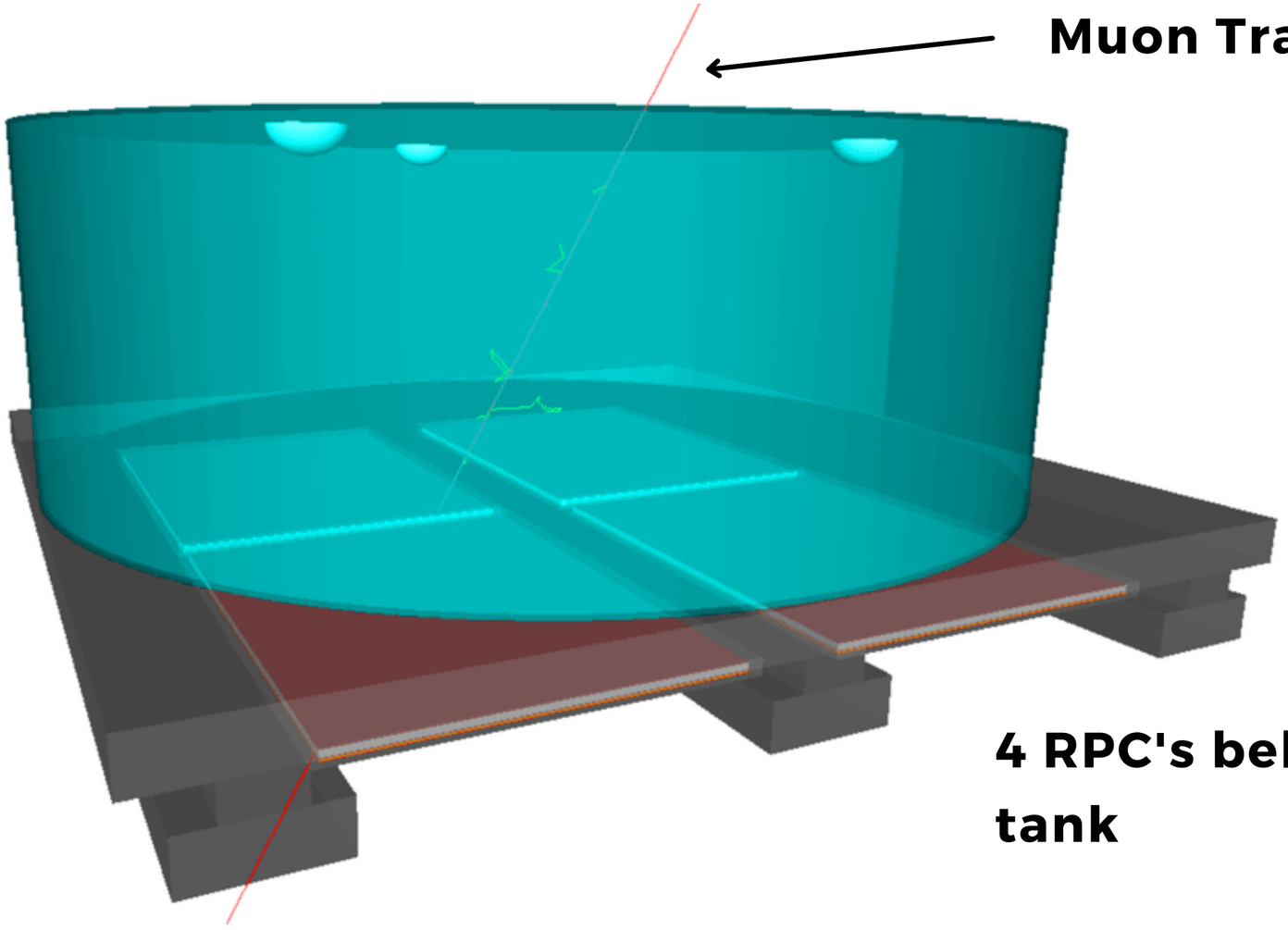
Pierre Auger Observatory



Structure Scheme

Muon Trajectory

Tank



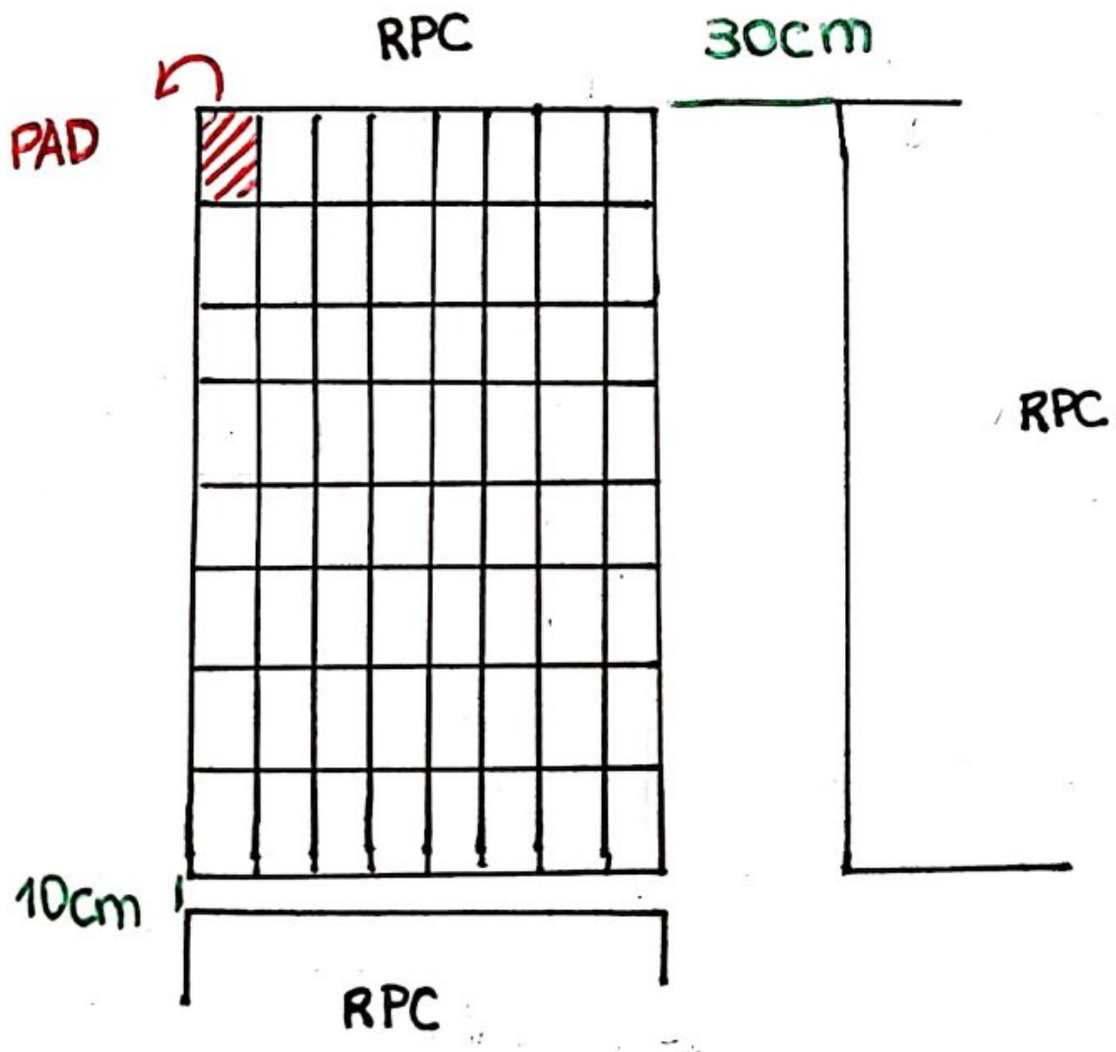
4 RPC's below the tank

RPC Scheme

Total:

4 RPC's

256 Pad's



First Steps

Information search: muons, muography, Pierre Auger Observatory, particle shower, detectors...

Analyse a file with simulation data of several atmospheric particles at an altitude of 1400 m, imitating the conditions of the Observatory.

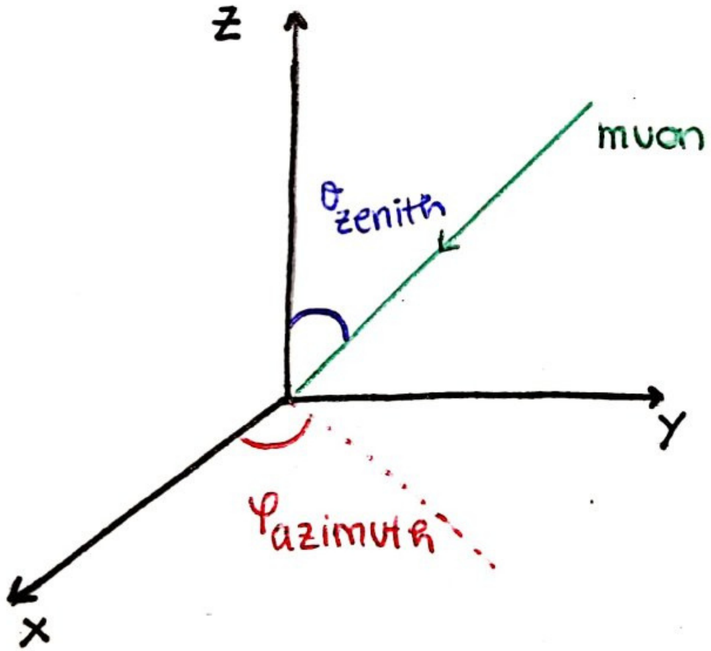
First Steps

Formulas:

$$E_k = \sqrt{m^2 + p^2} - m$$

$$\theta_{zenith} = \cos^{-1}\frac{p_z}{p}$$

$$\varphi_{azimuth} = tan^{-1}\frac{p_y}{p_x}$$



$E_k - Kinetic\ Energy$

$m - \text{Mass (105.66 GeV)}$

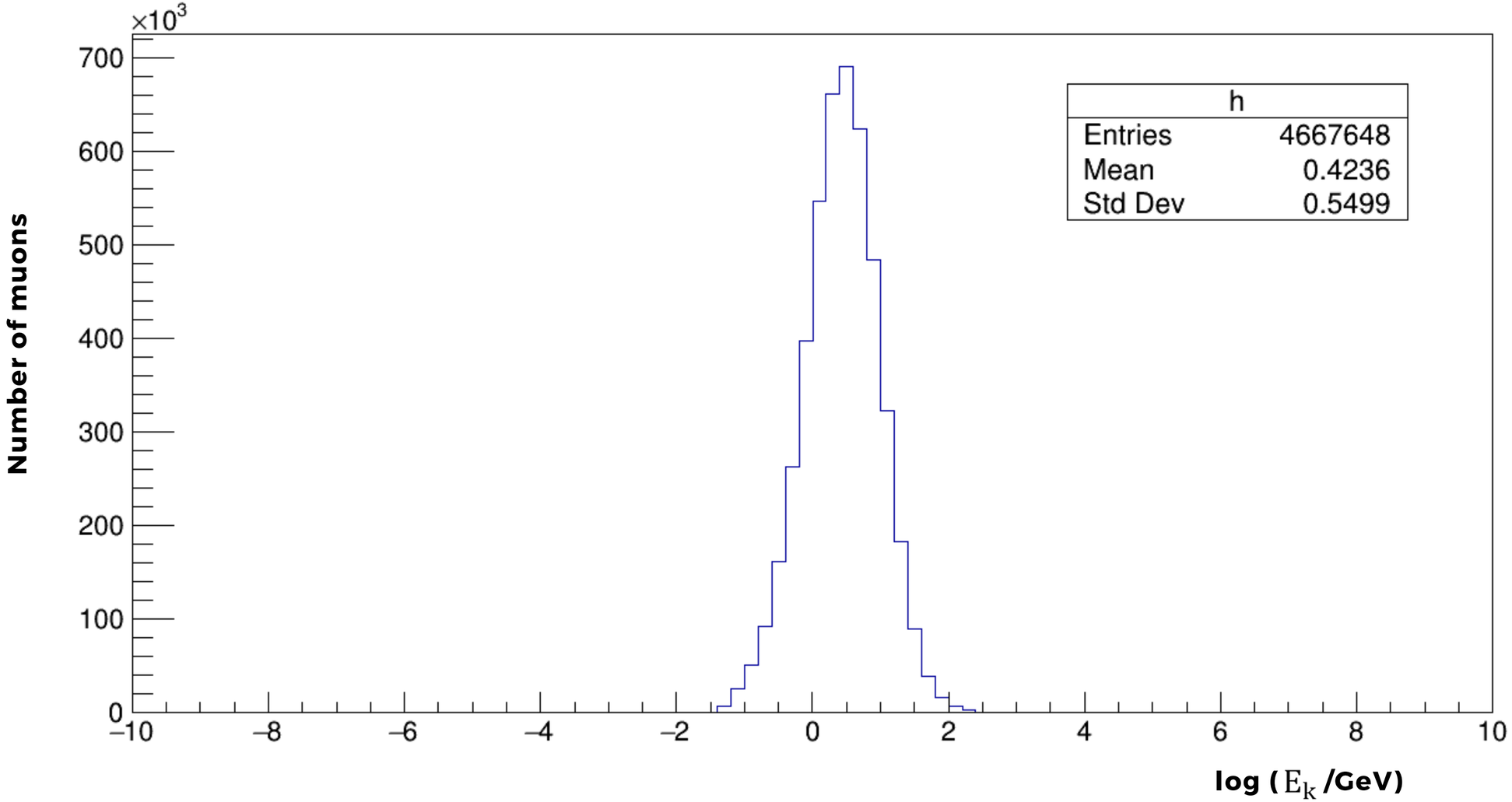
$\theta_{zenith} - Zenith\ Angle$

$\varphi_{azimuth} - Azimuth\ Angle$

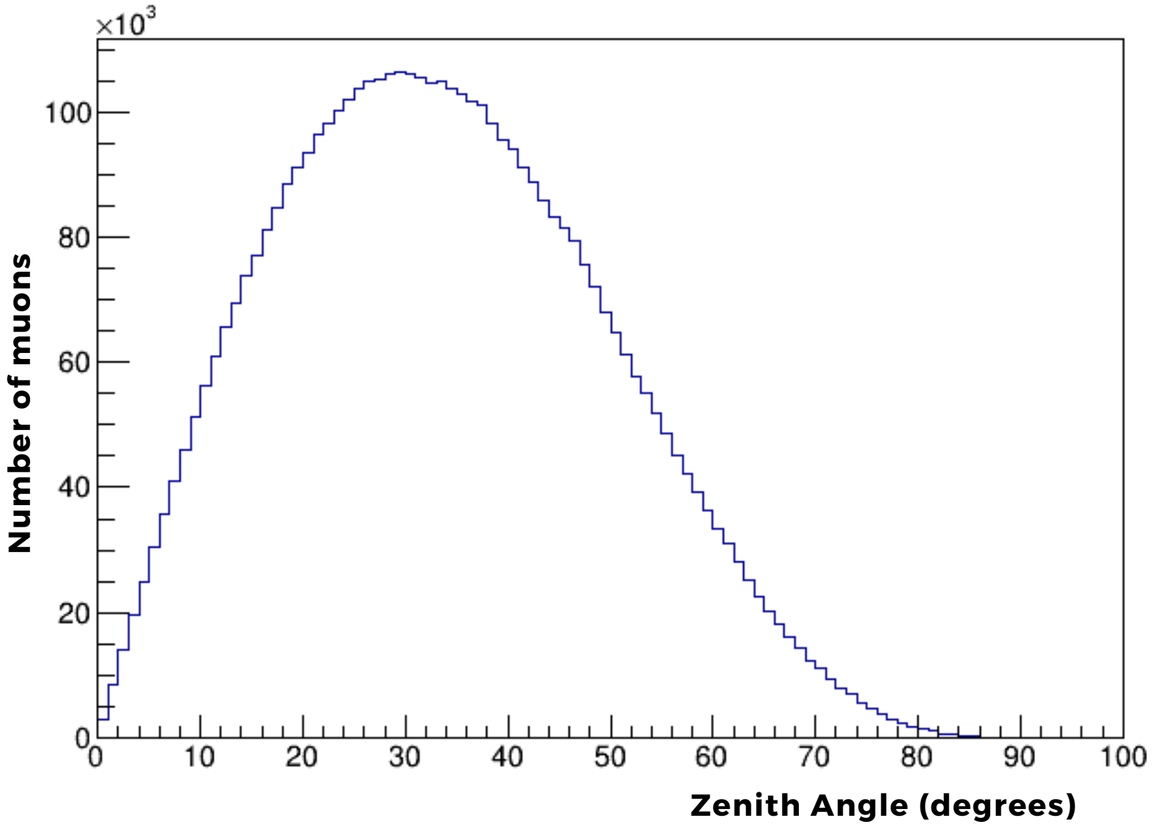
$p - Linear\ Momentum$

$p_x, p_y, p_z - \ Moment\ Components$

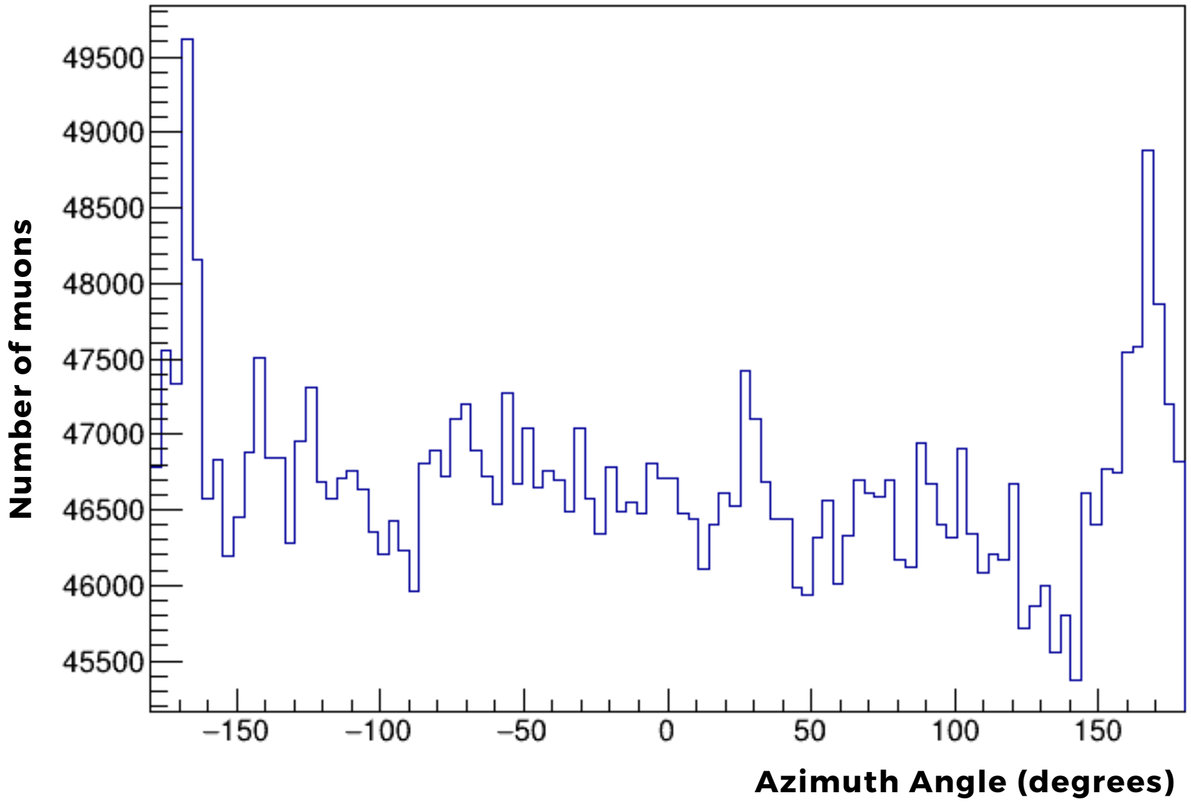
Kinetic Energy of muons



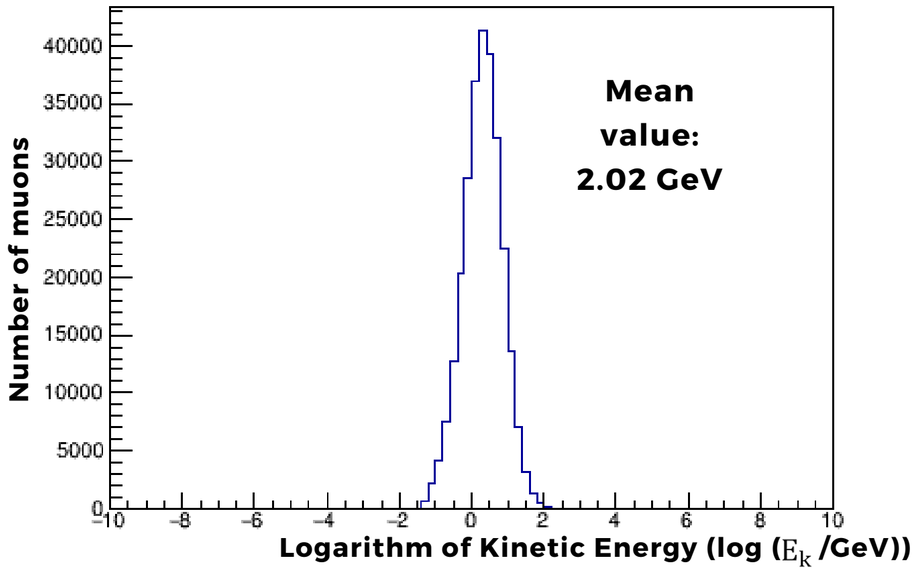
Zenith Angle of muons



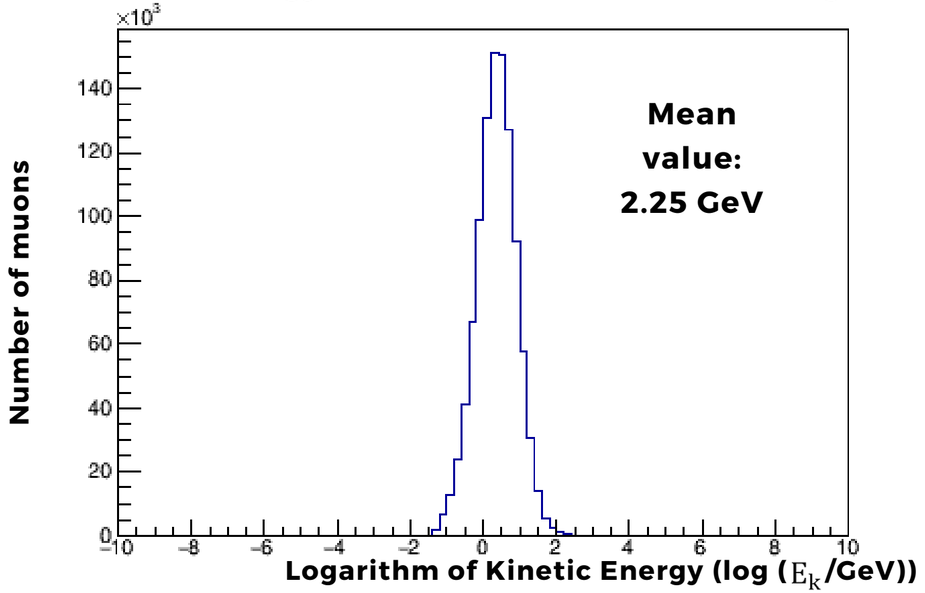
Azimuth Angle of muons



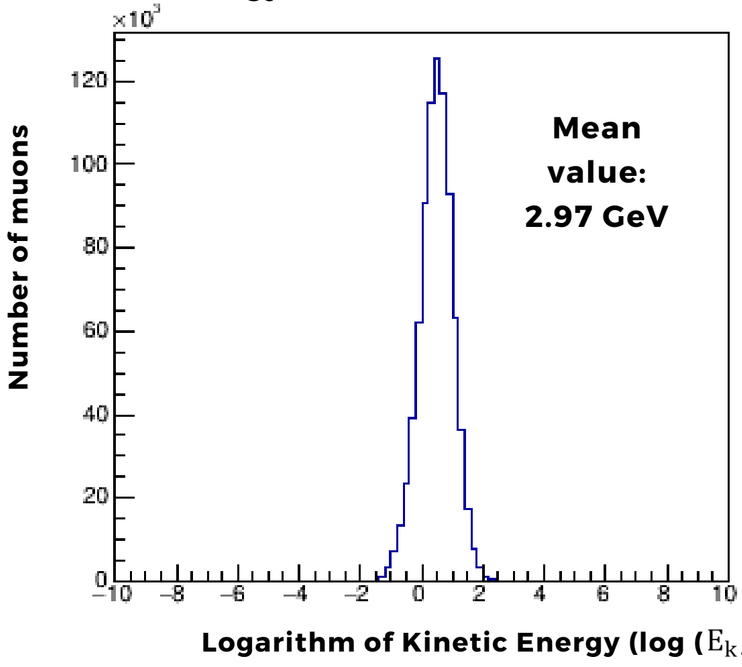
Kinetic Energy of muons for 0°-10° Zenith Angle



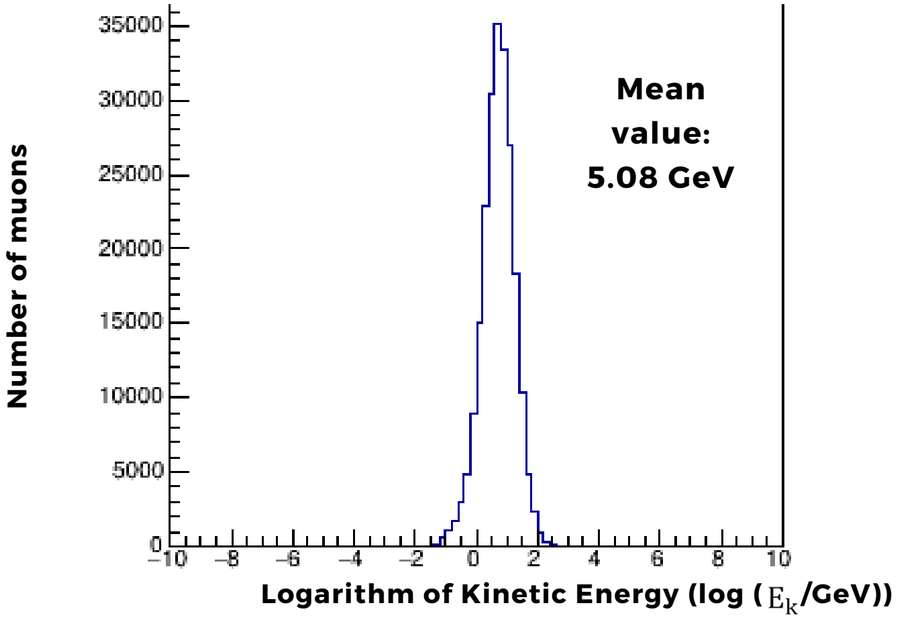
Kinetic Energy of muons for 20°-30° Zenith Angle



Kinetic Energy of muons for 40°-50° Zenith Angle



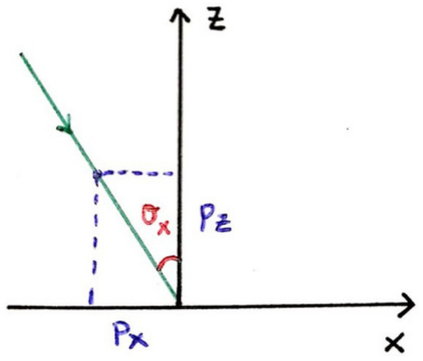
Kinetic Energy of muons for 60°-70° Zenith Angle

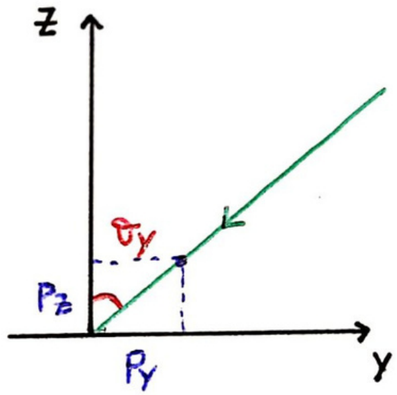


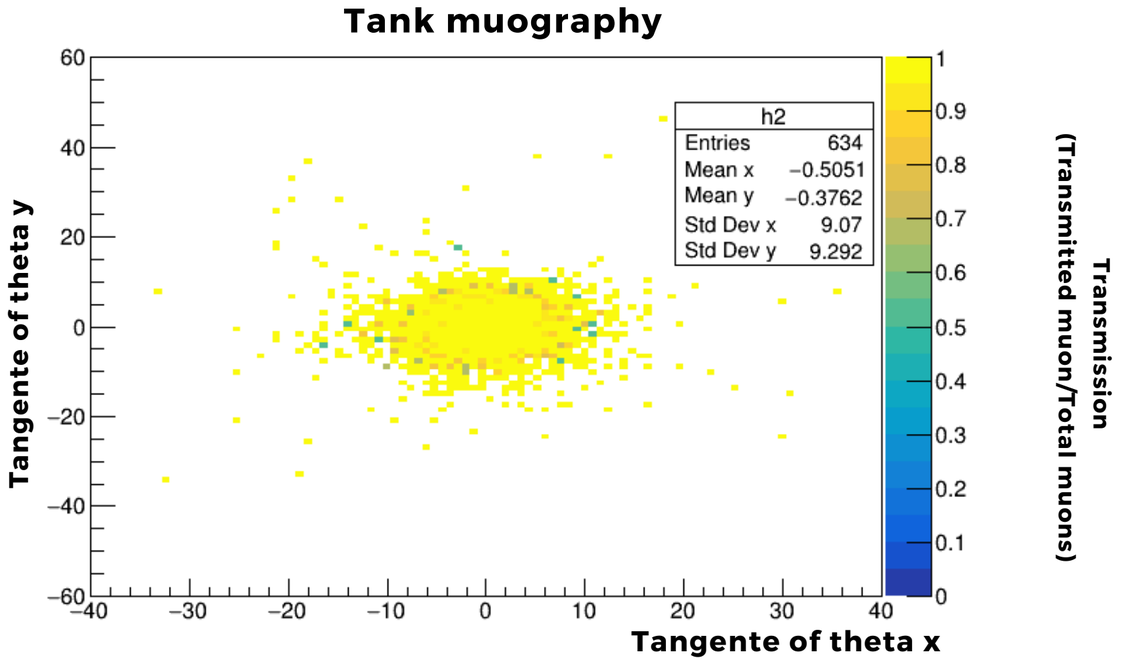
First Muography

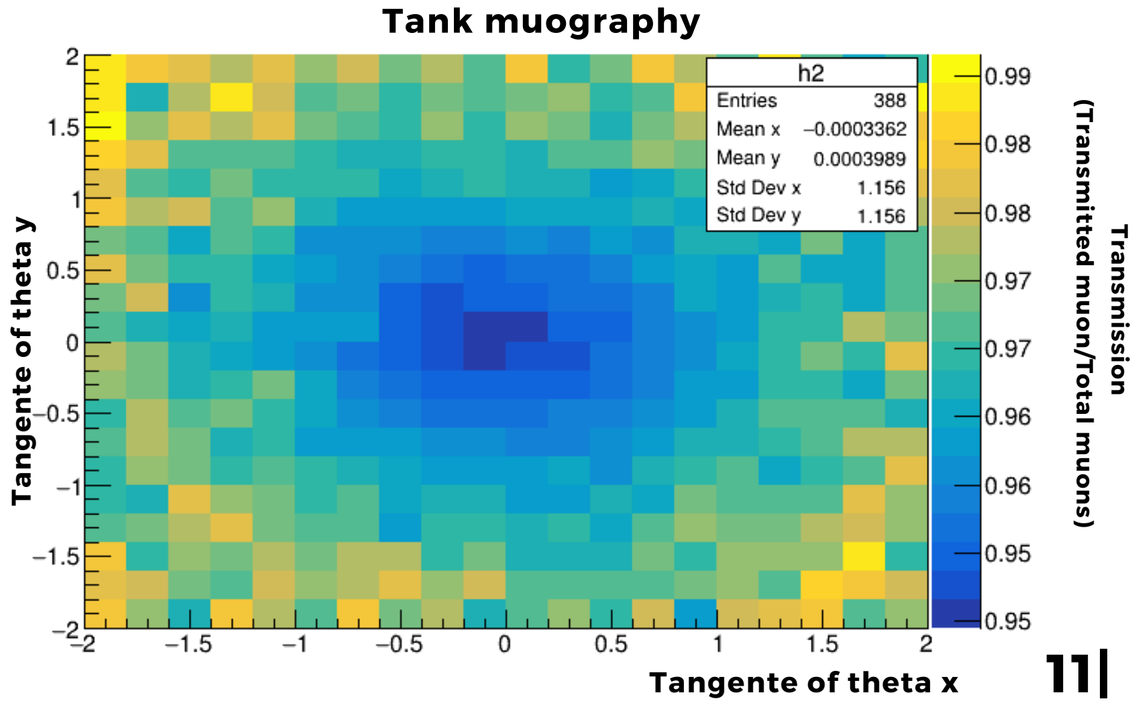
Formulas:

$$tan_{\theta_x} = \frac{p_x}{p_z} \qquad tan_{\theta_y} = \frac{p_y}{p_z}$$



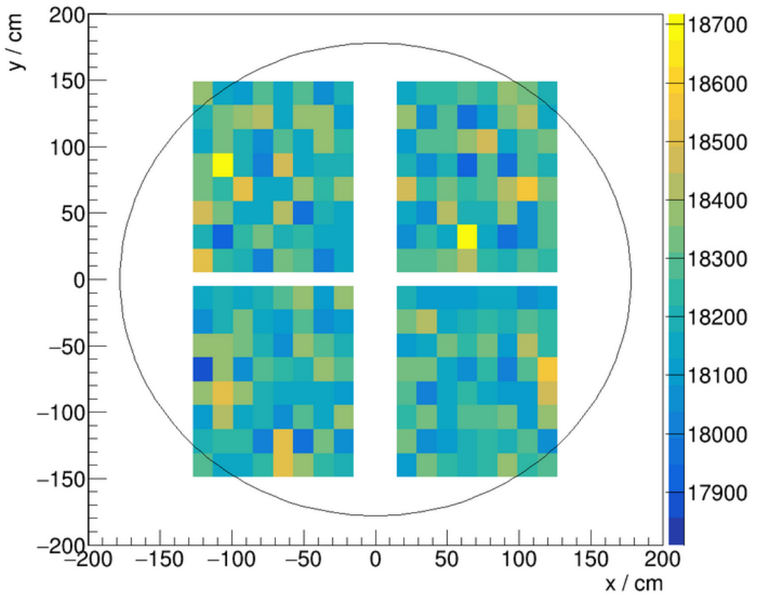




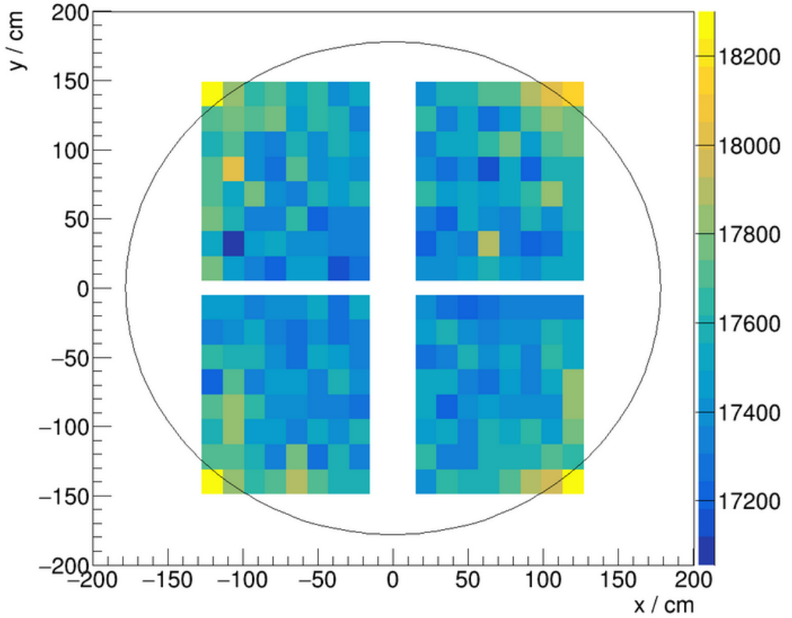


A Different Type of Muography

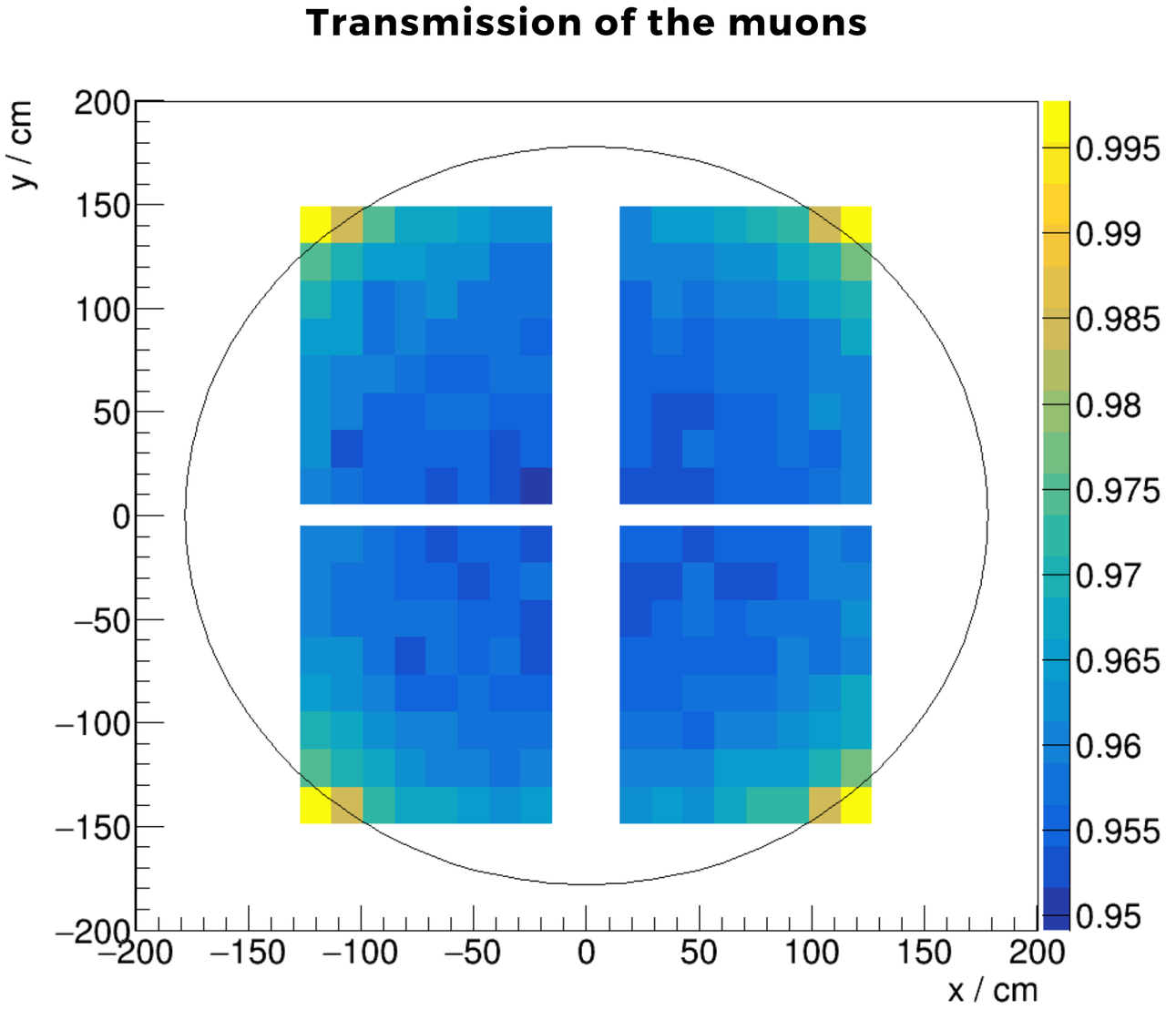
A total number of muons



A total number of muons transmitted

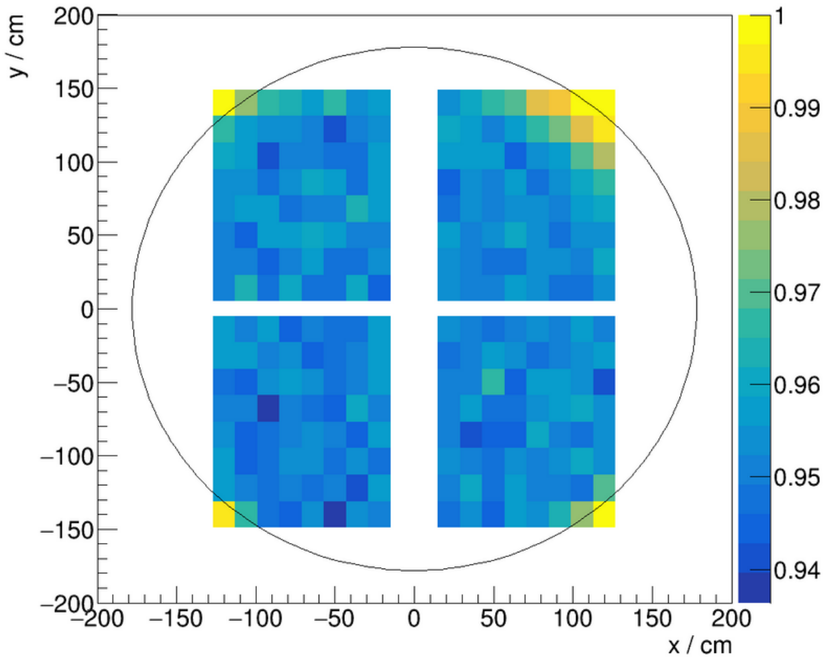


A Different Type of Muography

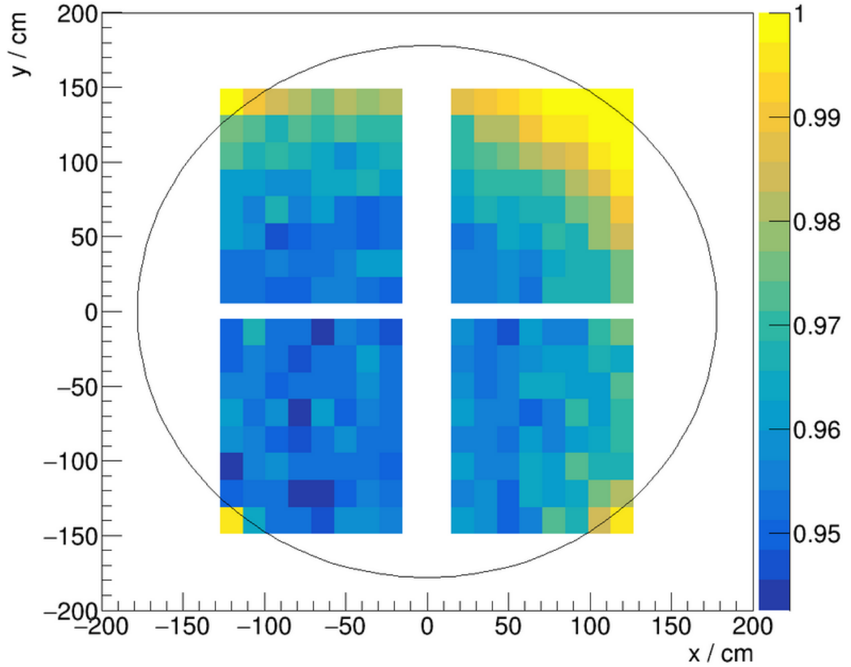


Some Graphics about Transmission with cuts in the Zenith and Azimuth Angles

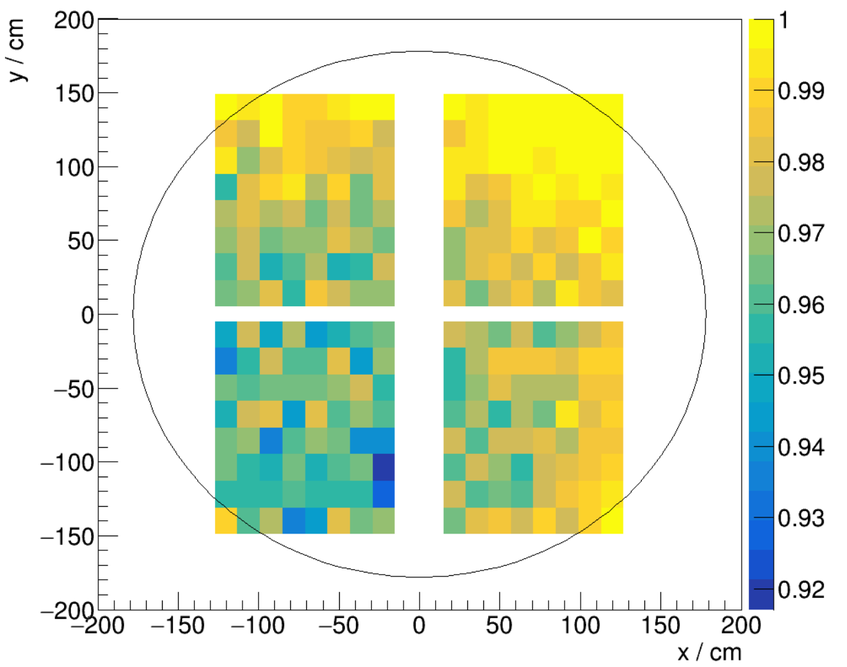
Θ : between 0° and 30°
φ : between 0° and 90°



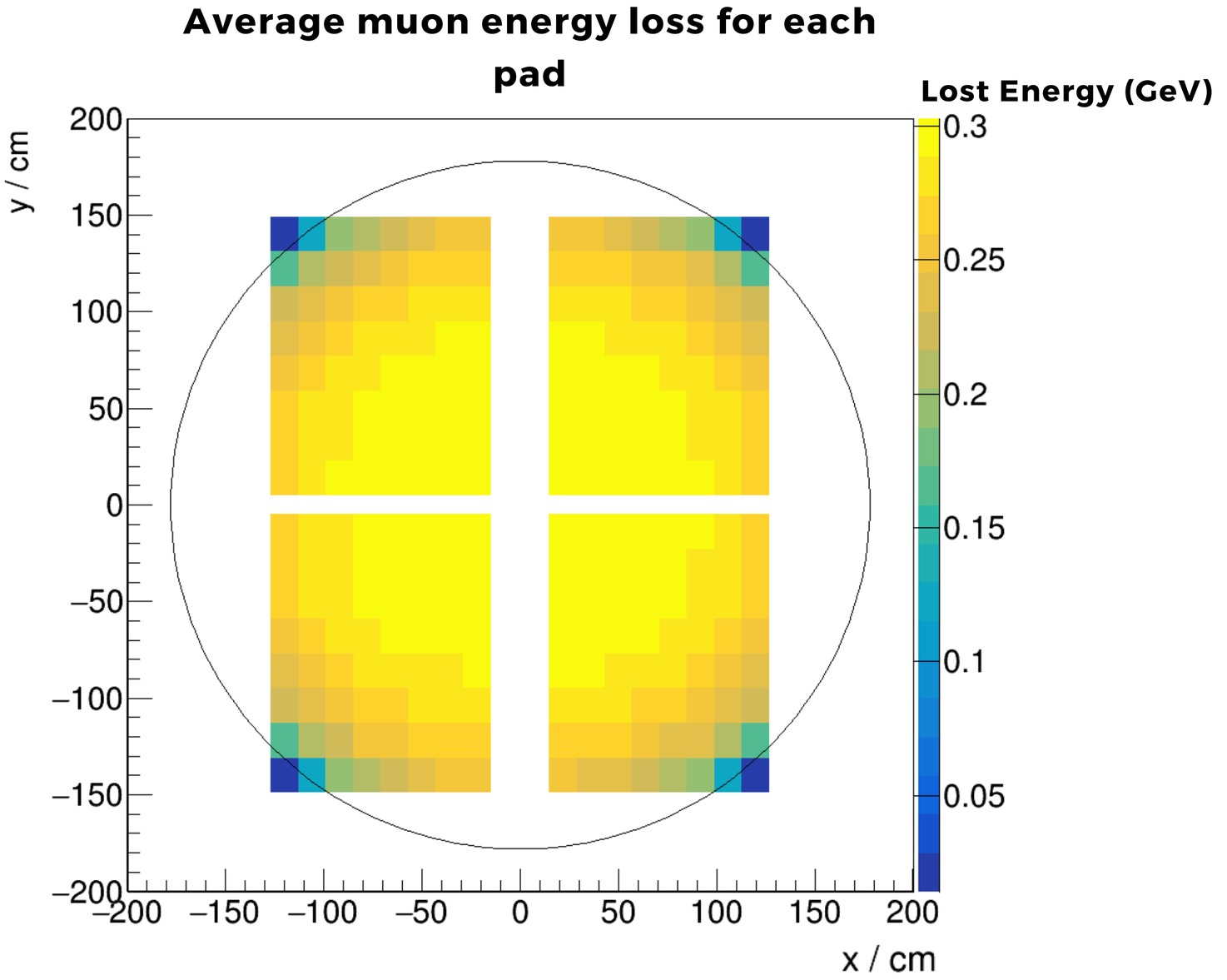
Θ : between 30° and 60°
φ : between 0° and 90°



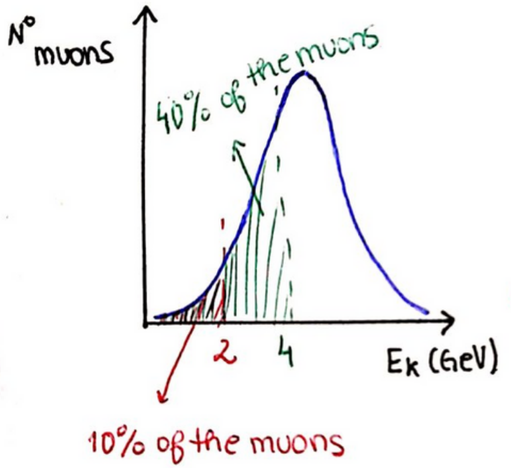
Θ : between 60° and 90°
φ : between 0° and 90°

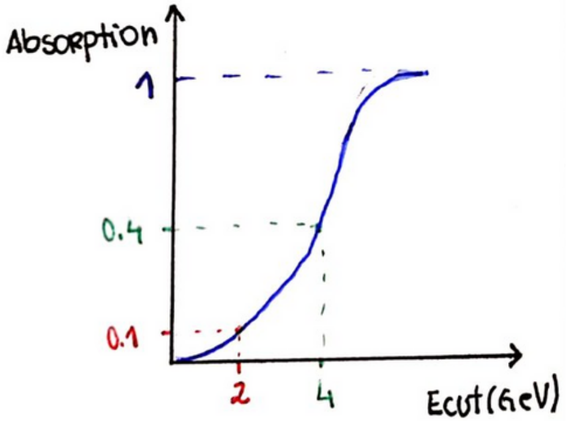


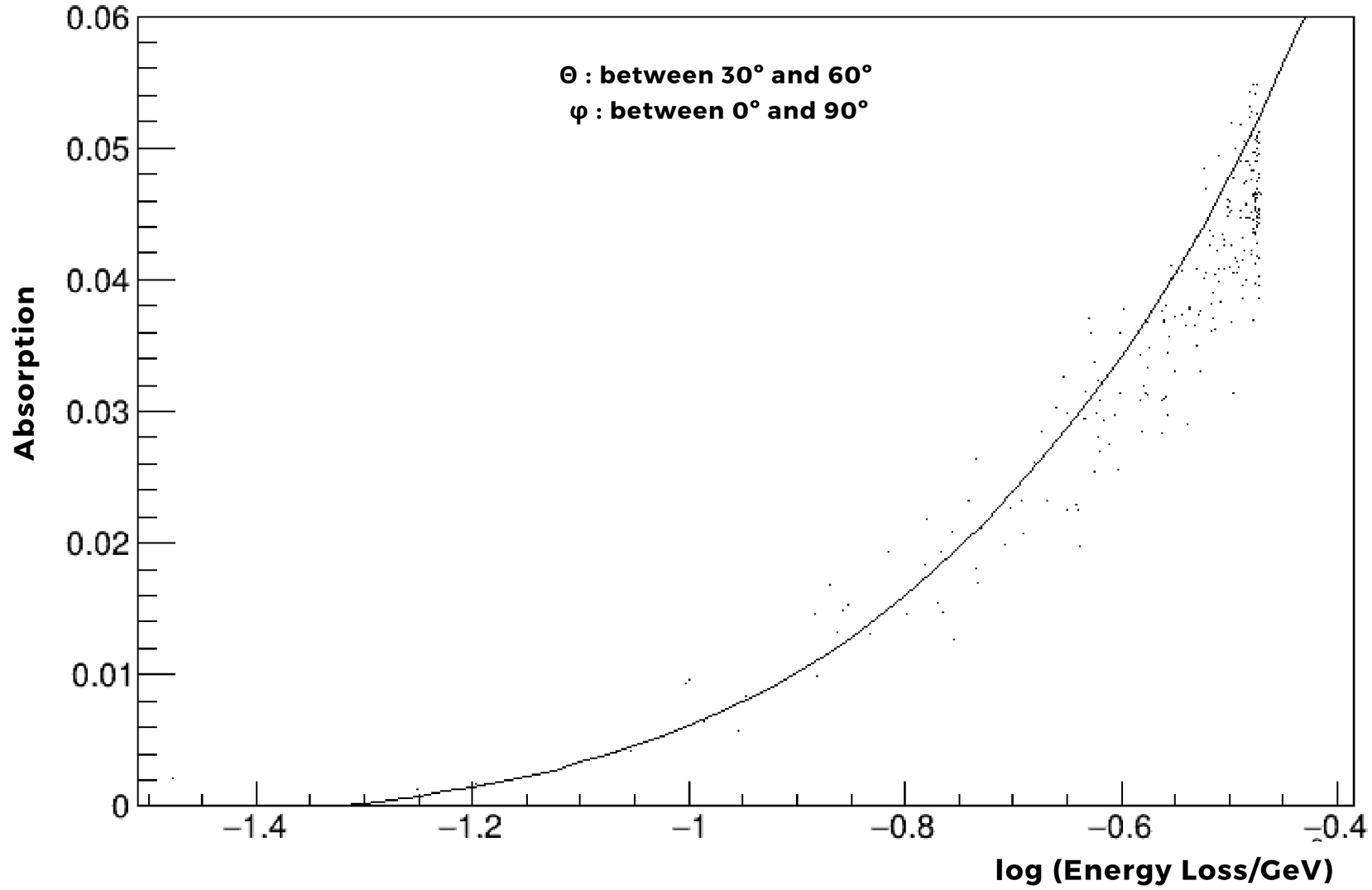
Towards of the muon Energy Spectrum



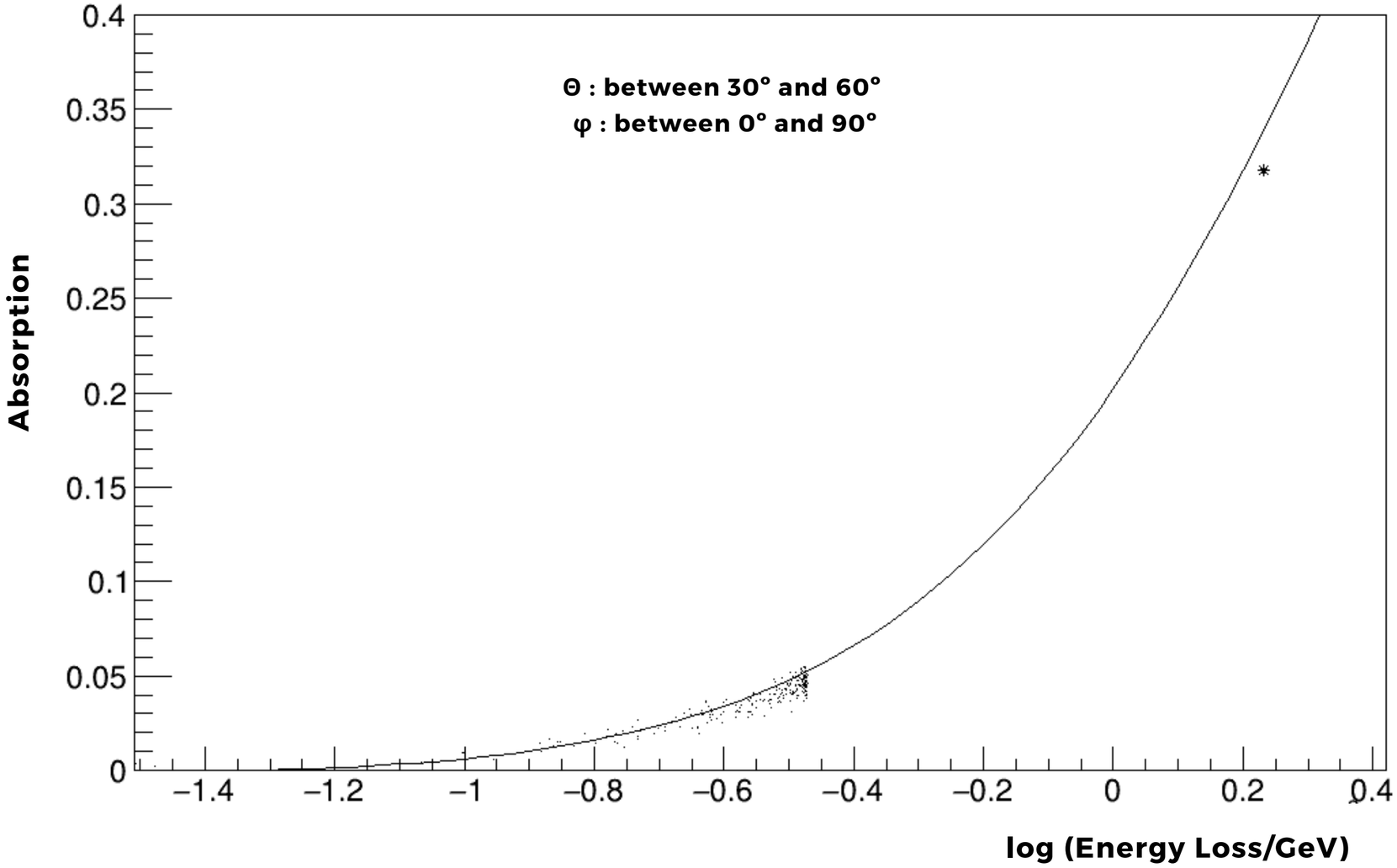
Absorption graphic in the function of the average energy loss in each pad with a cut in the Zenith and Azimuth Angles







Absorption graphic in the function of the average energy loss in each pad with a cut in the Zenith and Azimuth Angles



Conclusion

- **We managed to achieve results that may be considered to discover the energy spectrum of higher energy shower muons;**
- **In the future, a way to achieve different and more promising results may go through a reformulation of our setup.**

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LIP

THANK YOU!!

ANY QUESTIONS?

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