



LABORATÓRIO DE INSTRUMENTAÇÃO  
E FÍSICA EXPERIMENTAL DE PARTÍCULAS  
*partículas e tecnologia*

# MUON TOMOGRAPHY FROM COIMBRA TO LOUSAL

Authors:  
André Morais  
Yanhan Zhou

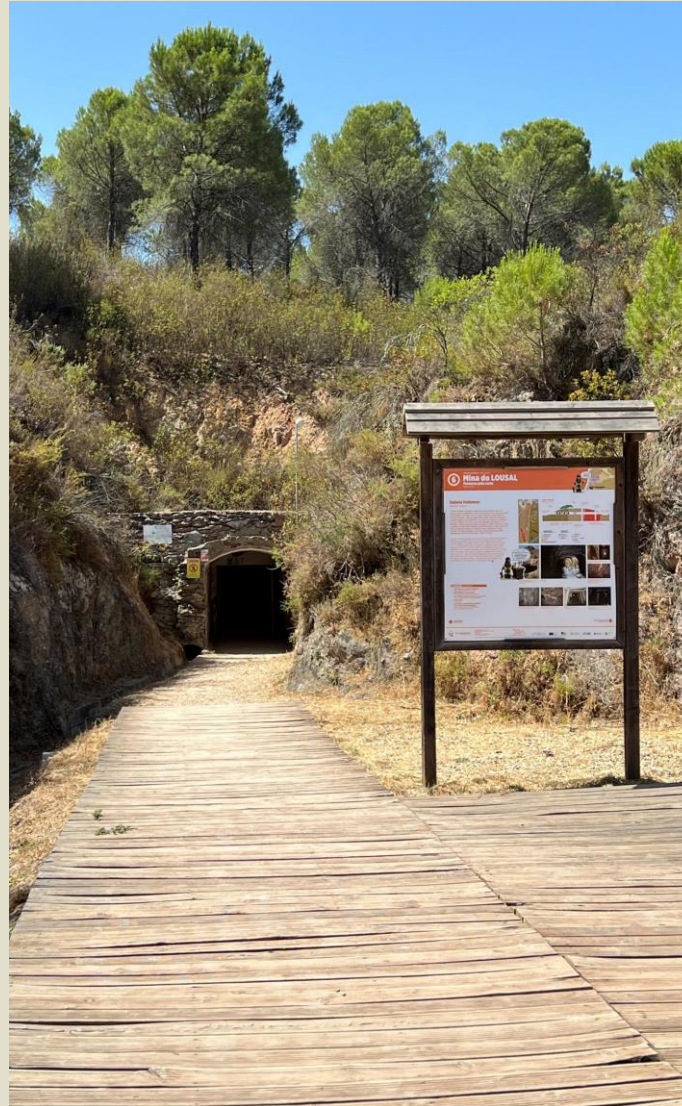
Supervisors:  
Sofia Andringa  
Raul Sarmiento

# Muon Tomography

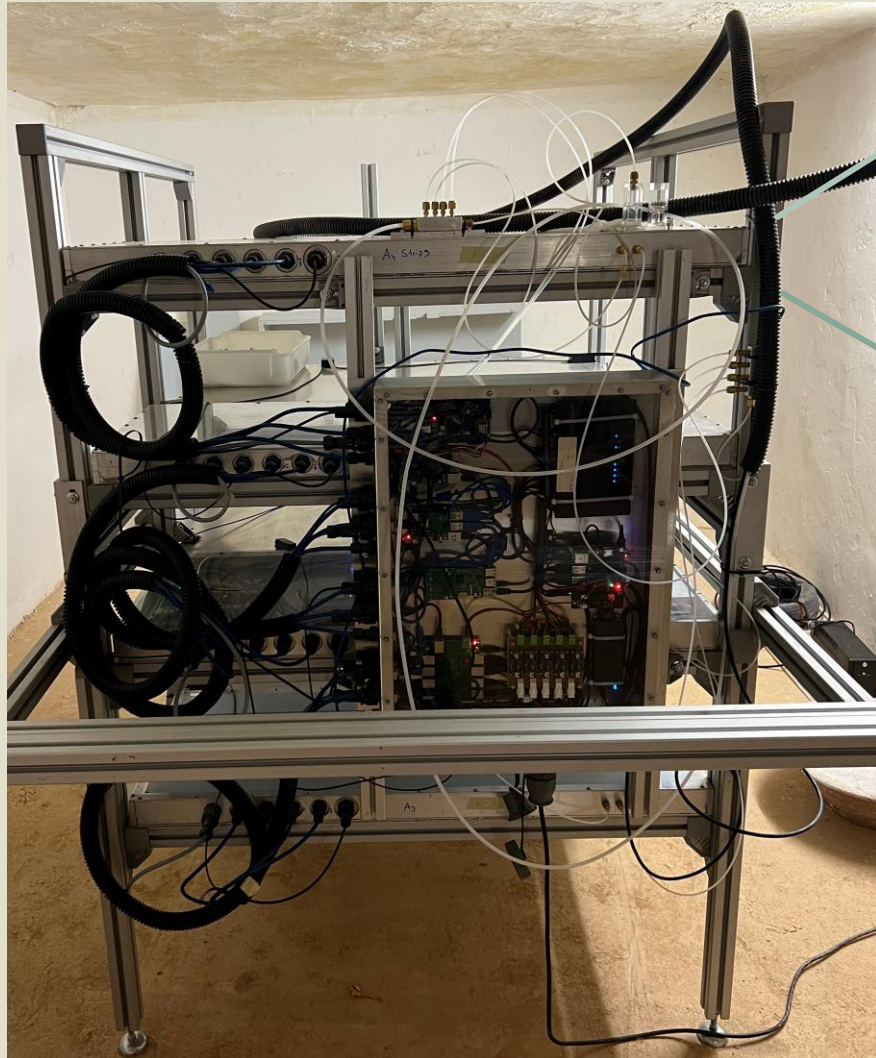
- Determines the relative number of muons arriving from each direction to infer the density of the materials traversed;
- A technique using cosmic muons to obtain images of large objects (e.g., buildings, geological structures);

# LouMu

- Application of mougraphy to geophysics;
- Detector is placed inside Lousal's mine to study the geological properties of the area;



# 4 Resistive Plate Chambers(RPC)



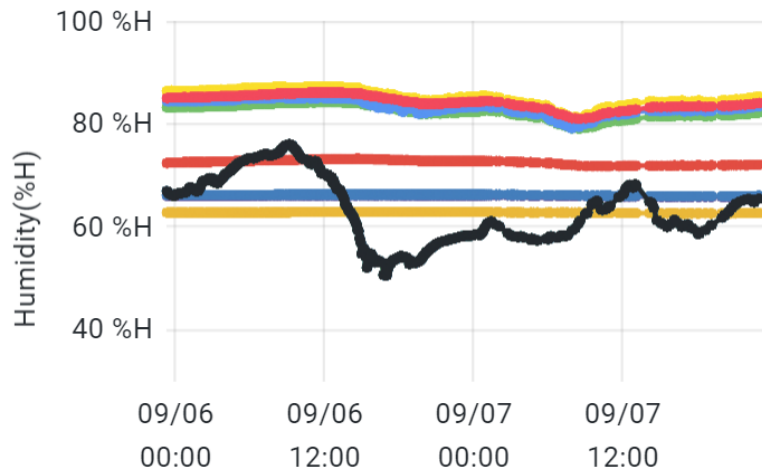
■ Glass

■ Gas gap

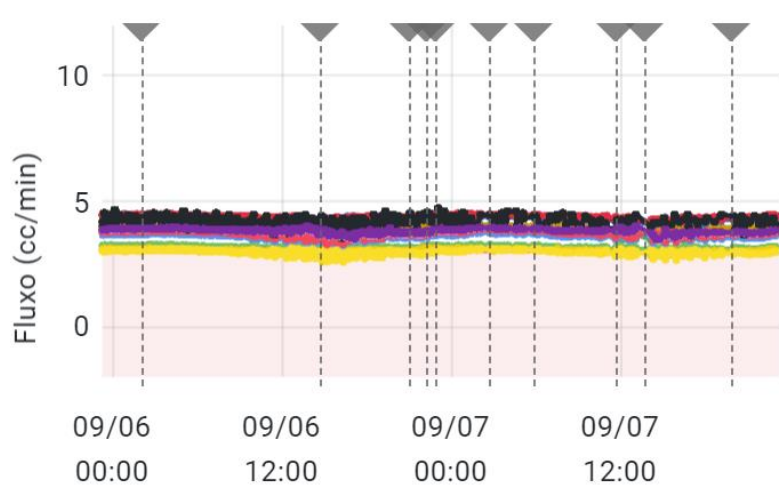
# Objectives

- Verify the operation of detector in Lousal;
- Study the impact of environmental variables on efficiency;
- Optimise the algorithm to obtaining better efficiency.

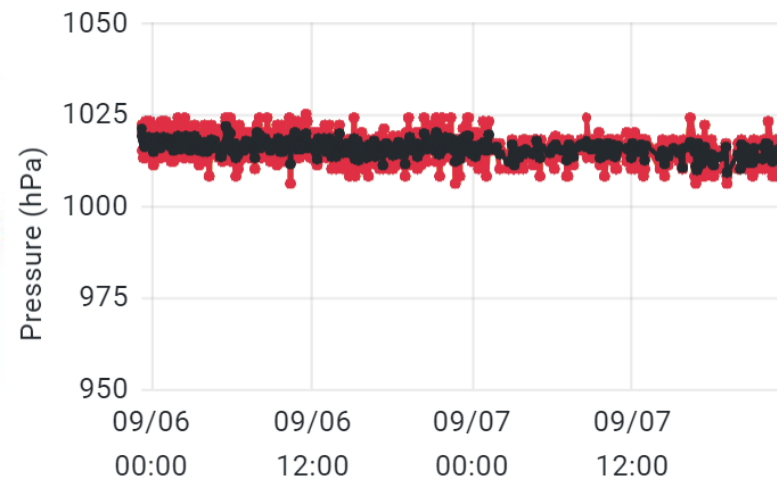
### Humidity (External & Internal)



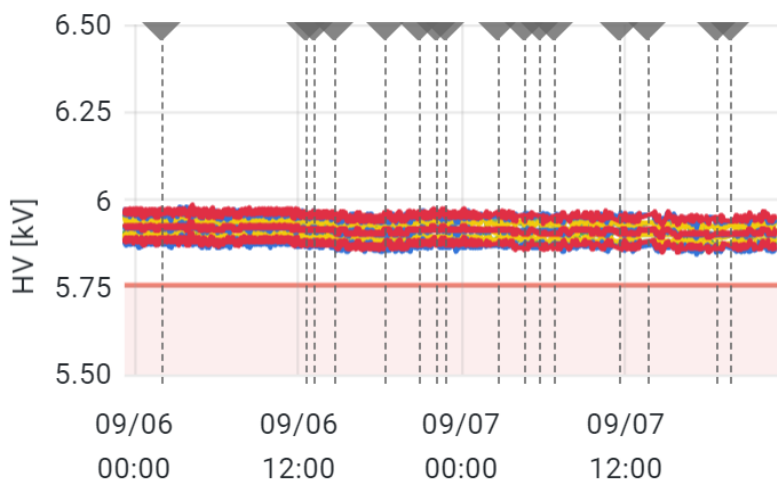
### ♥ All Gas Flow (& Gas Pressure)



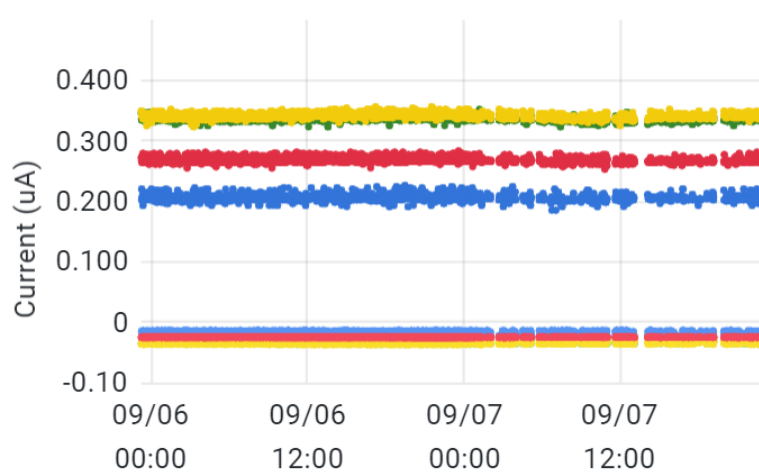
### Atmospheric Pressure (with mean)



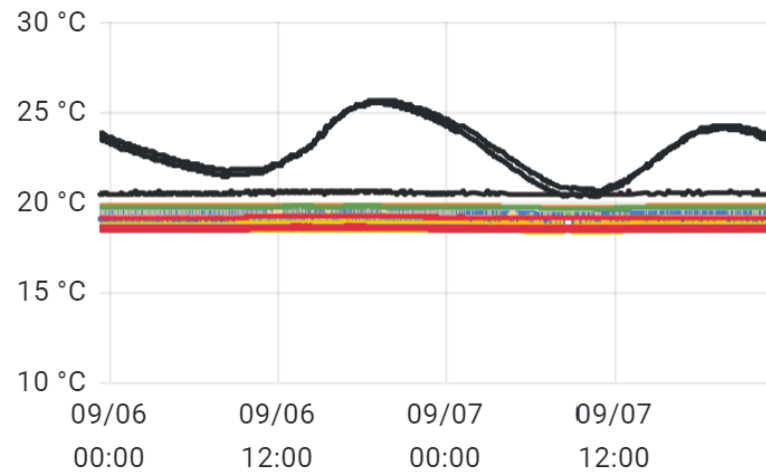
### ♥ All Voltages



### Currents (+/-)

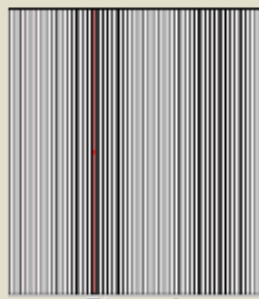


### All temperatures

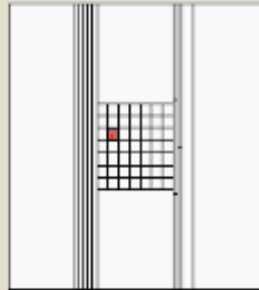


Data: 29/8/2022

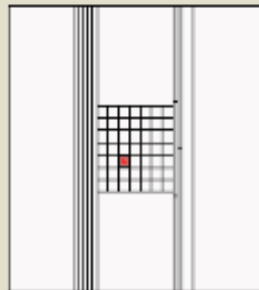
Hora: 7:35:59



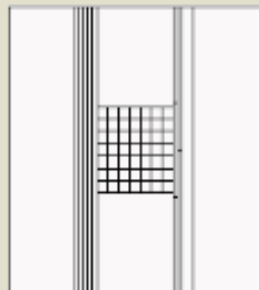
Plano 0



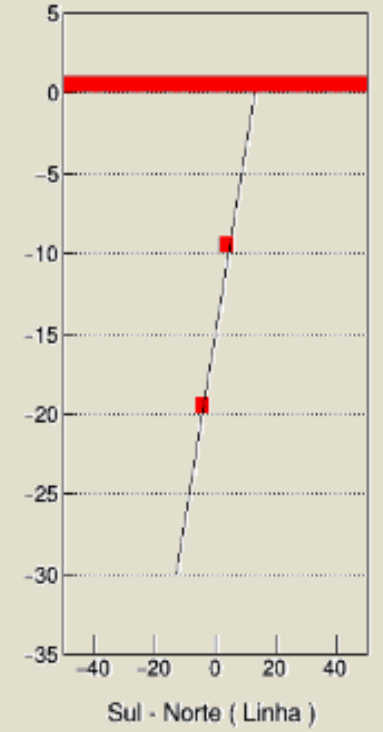
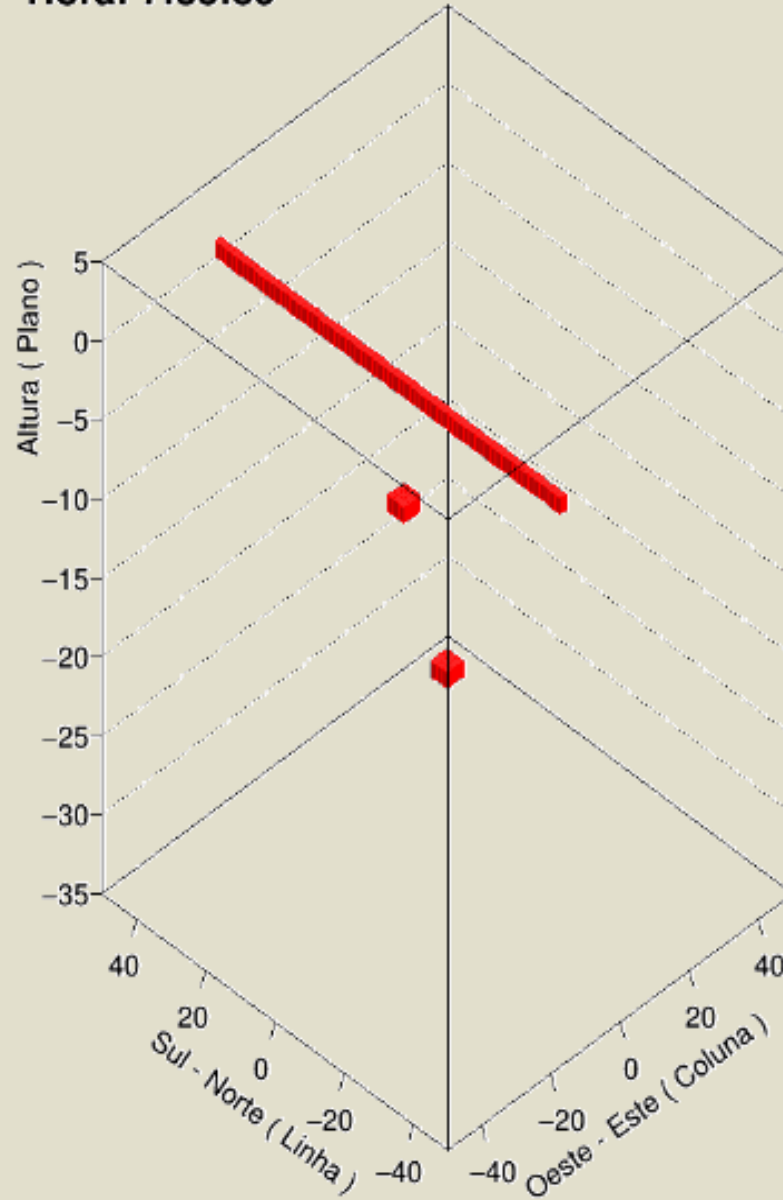
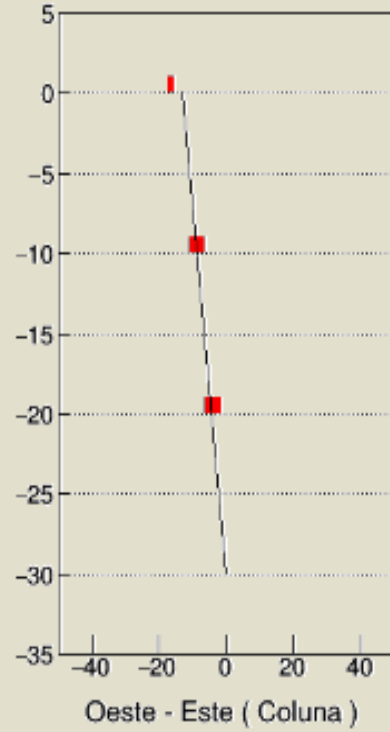
Plano -10



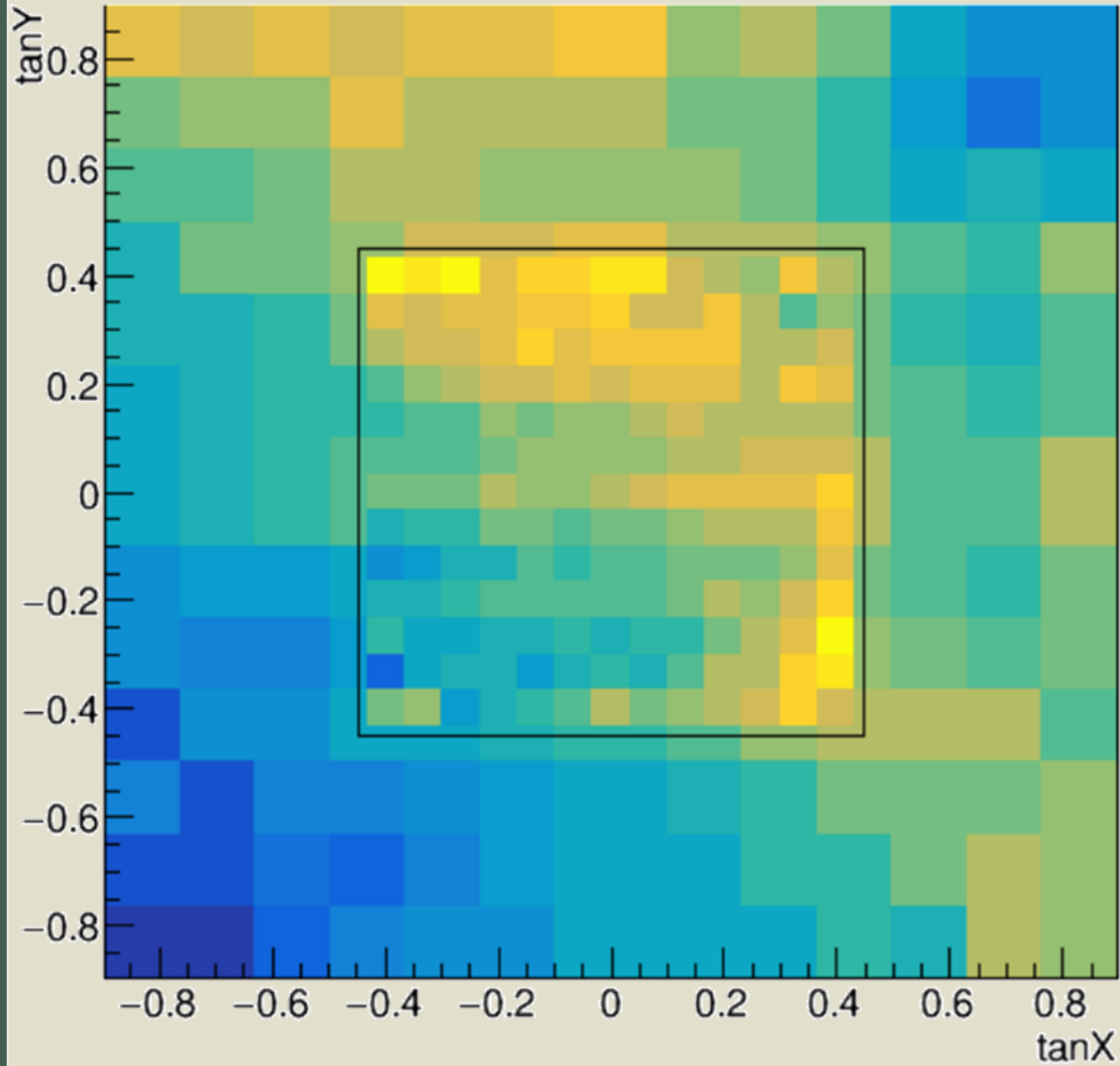
Plano -20



Plano -30



# Muografia/Muography



$$\tan X = \frac{\Delta x}{\Delta z}$$

$$\tan Y = \frac{\Delta y}{\Delta z}$$

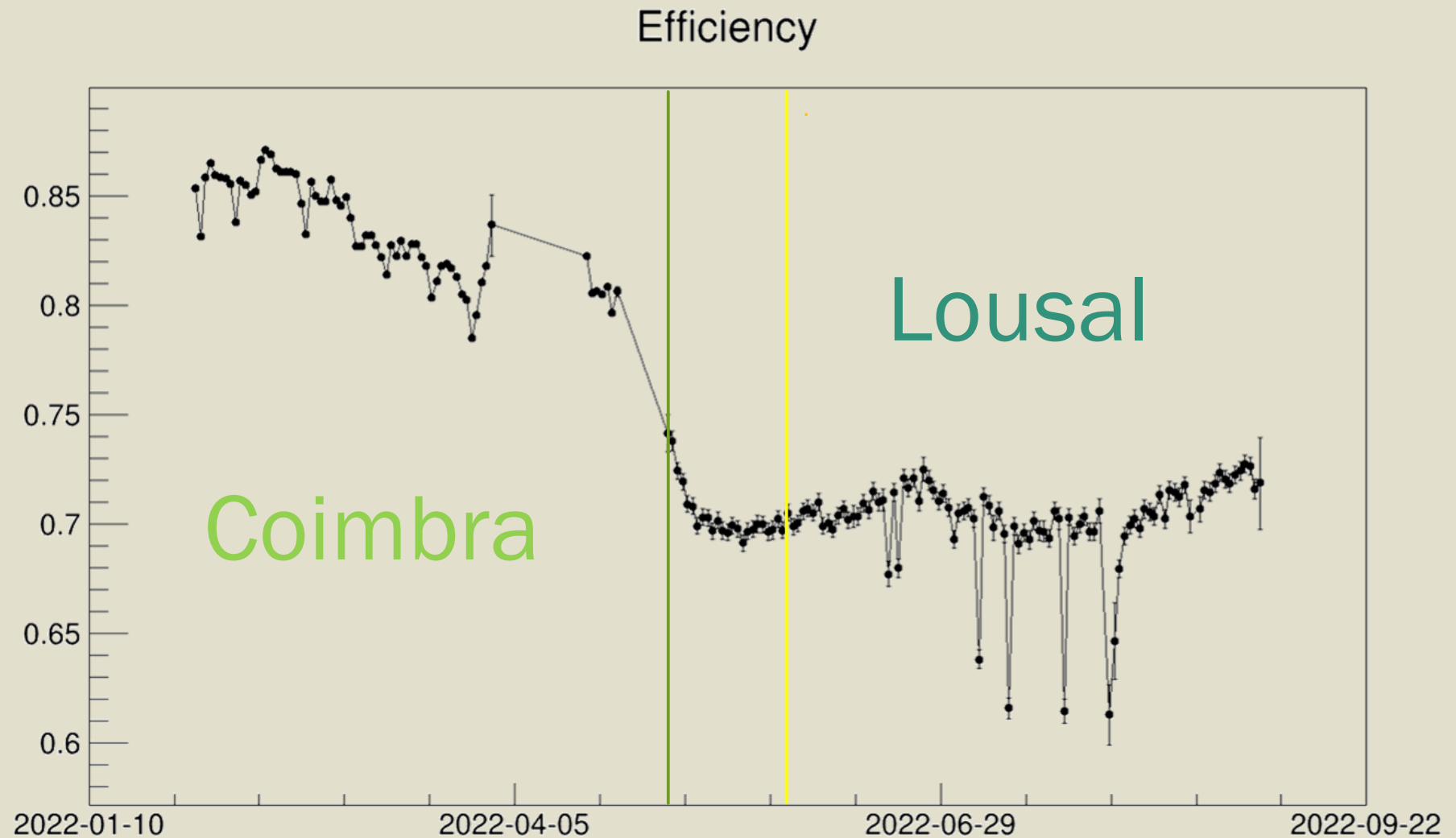
x: Column

y: Row

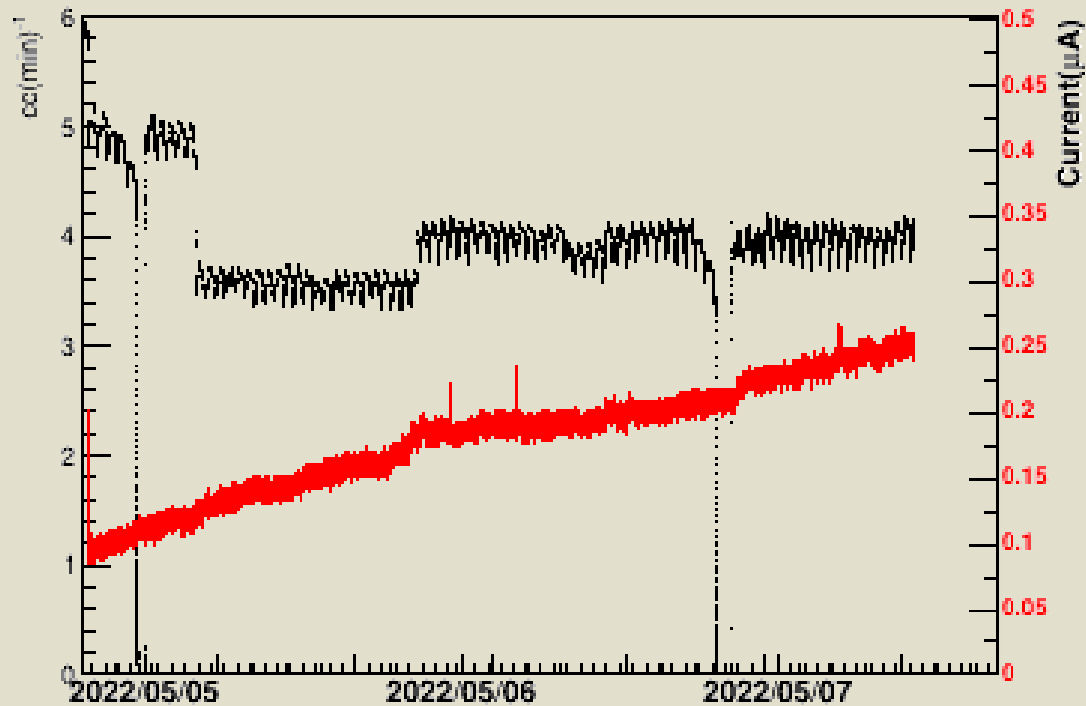
z: Height



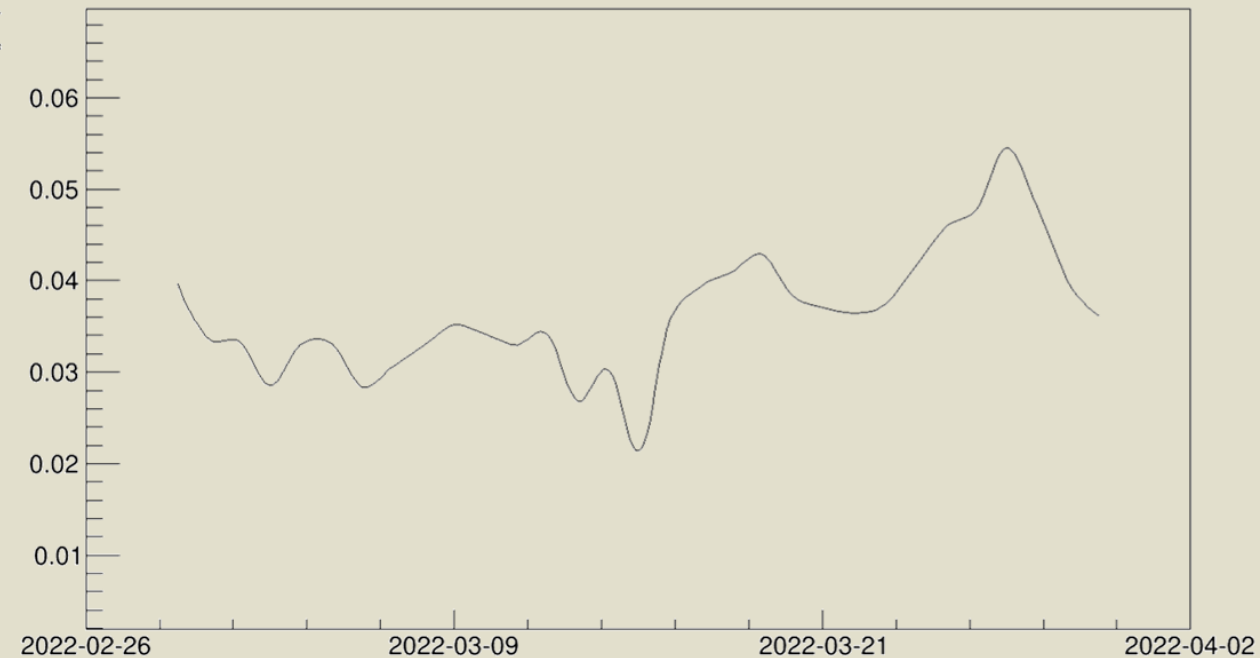
# Efficiency Changed from Coimbra to Lousal



# Adjustment of Detector in Lousal

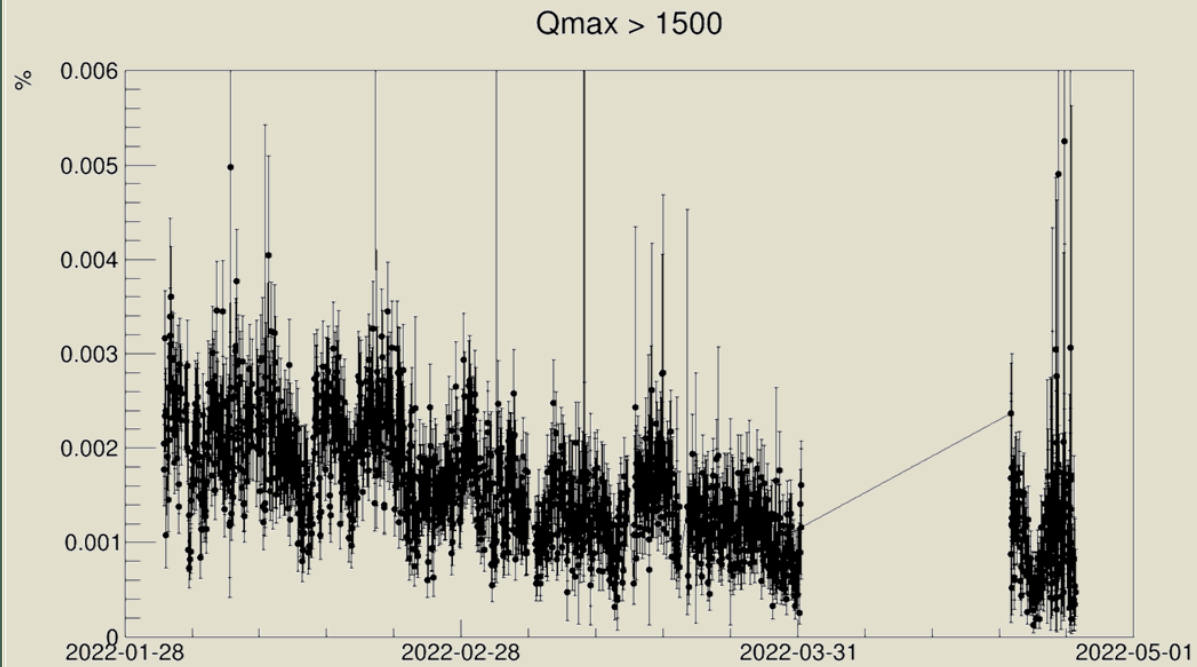


Lousal

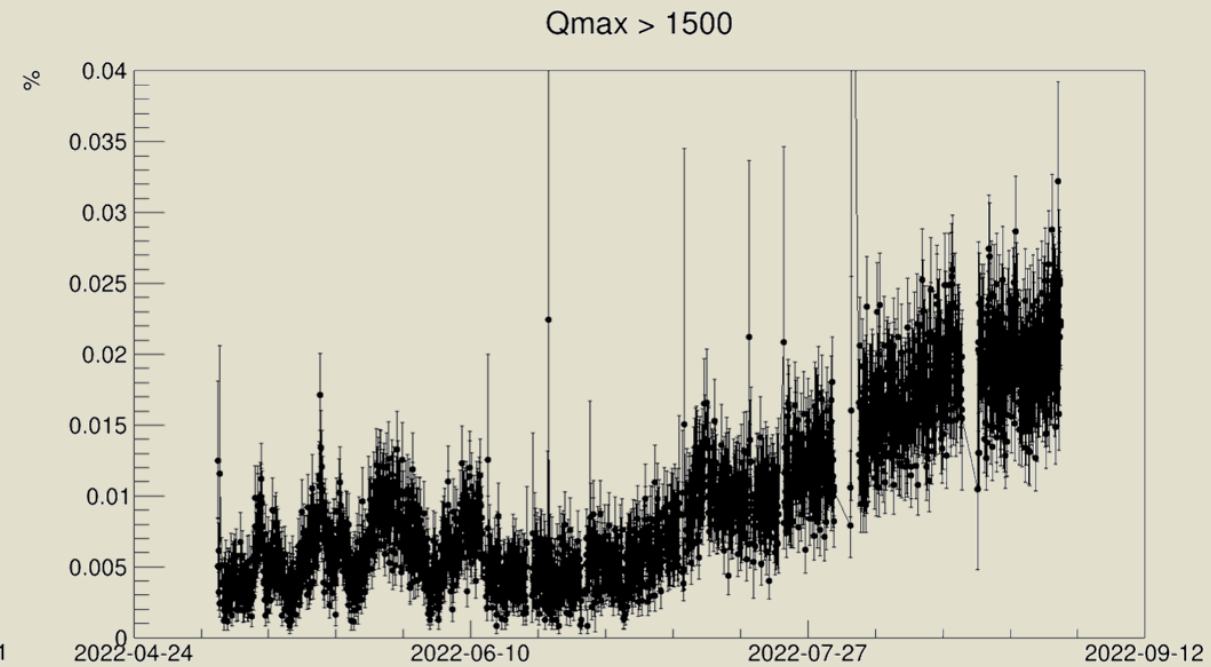


Coimbra

# First Sign



Coimbra



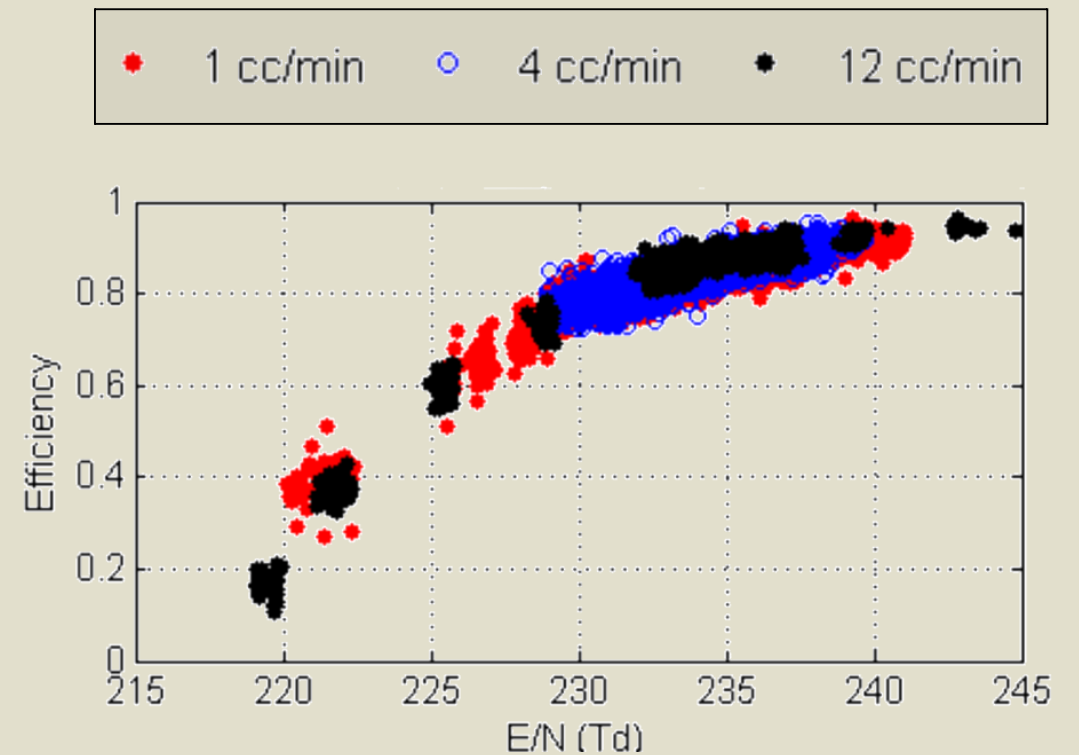
Lousal

# E/N and Efficiency

- E/N(reduced electric field) is the electric field applied over a gas divided by the atomic density of the gas;
- This quantity determines the rate of excitation and ionisation of a gas;

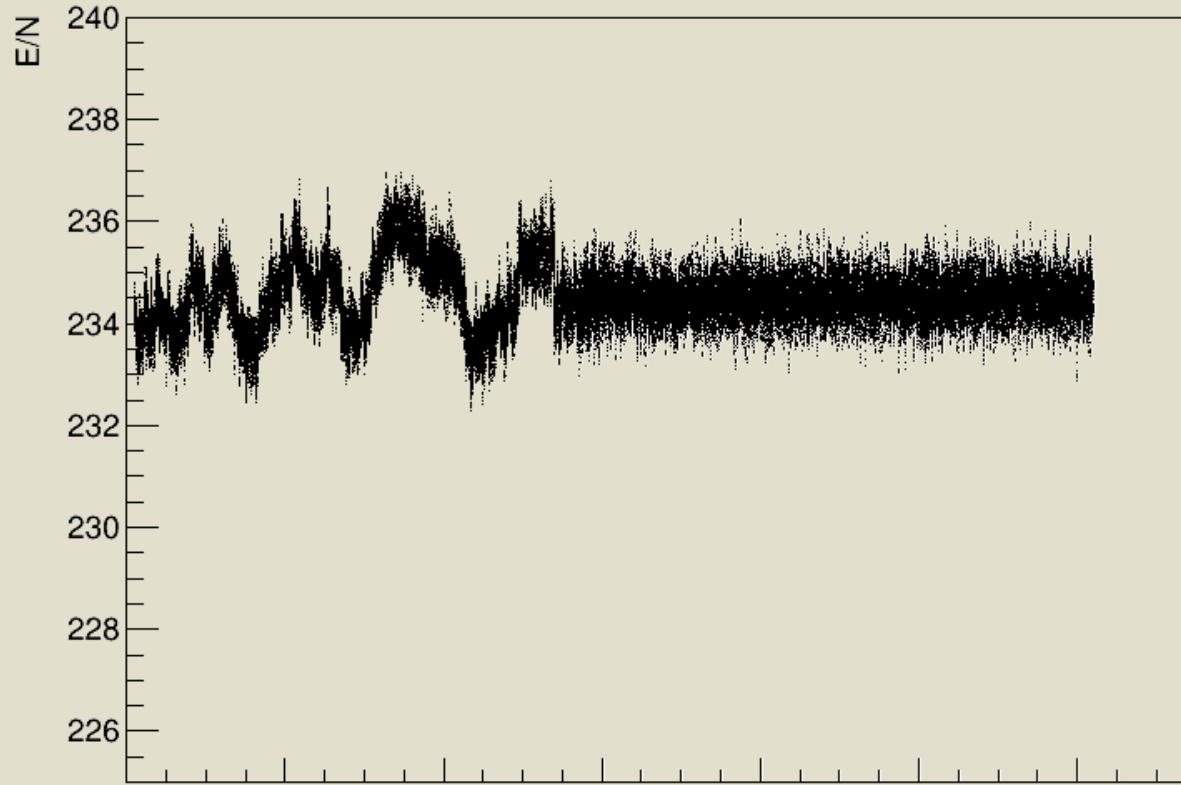
$$E/N = 0.0138068748 \frac{V_{eff}}{d} \frac{T + 273.15}{P} \text{ [Td]}$$

$$V_{eff} = V_{app} - R_{cm^2} I_{cm^2}$$



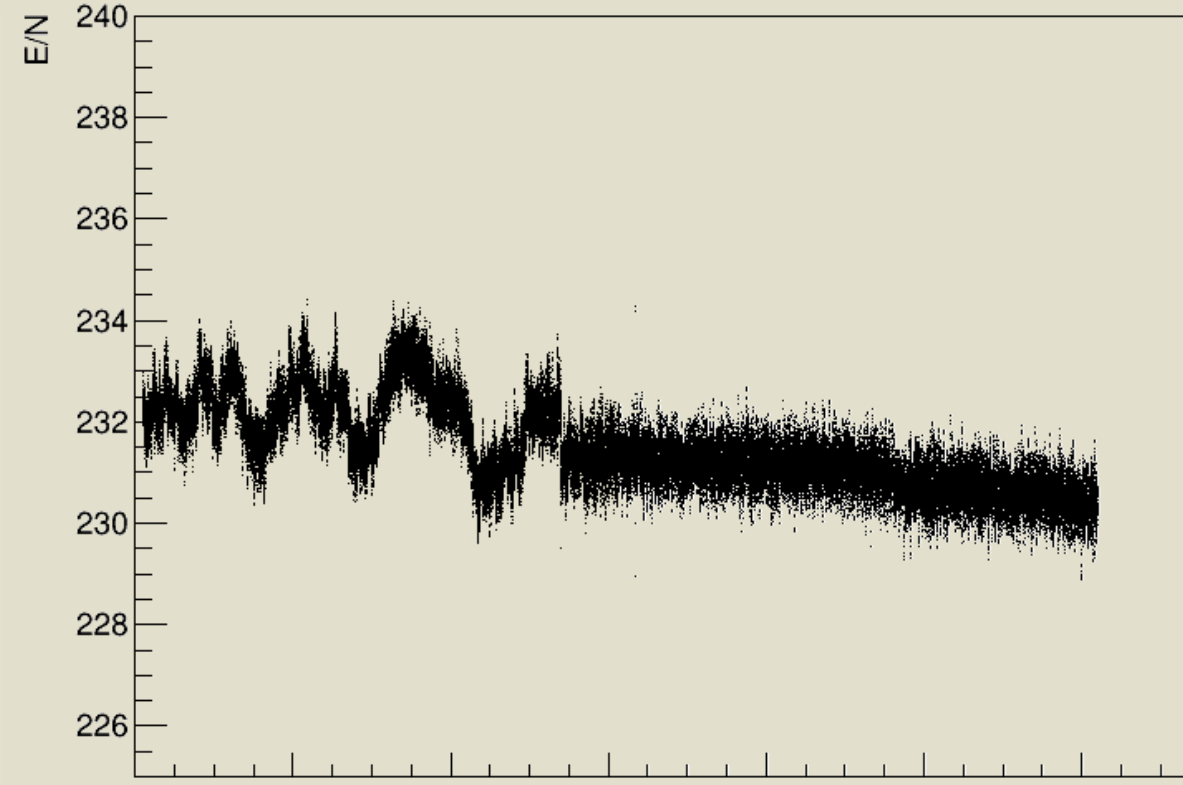
# Adjustment of E/N

Lousal



Time elapsed (min)

Lousal with current

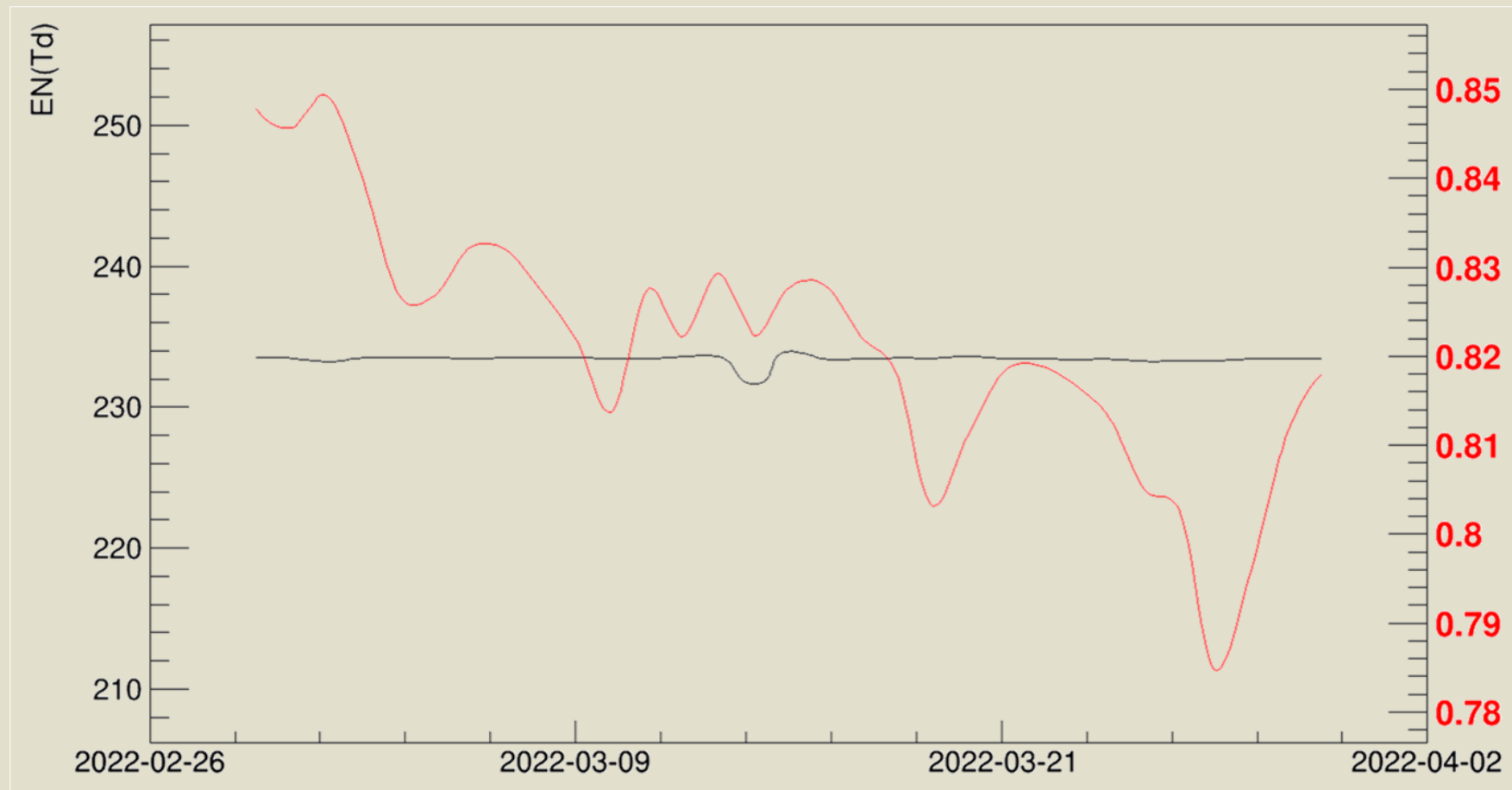


Time elapsed (min)

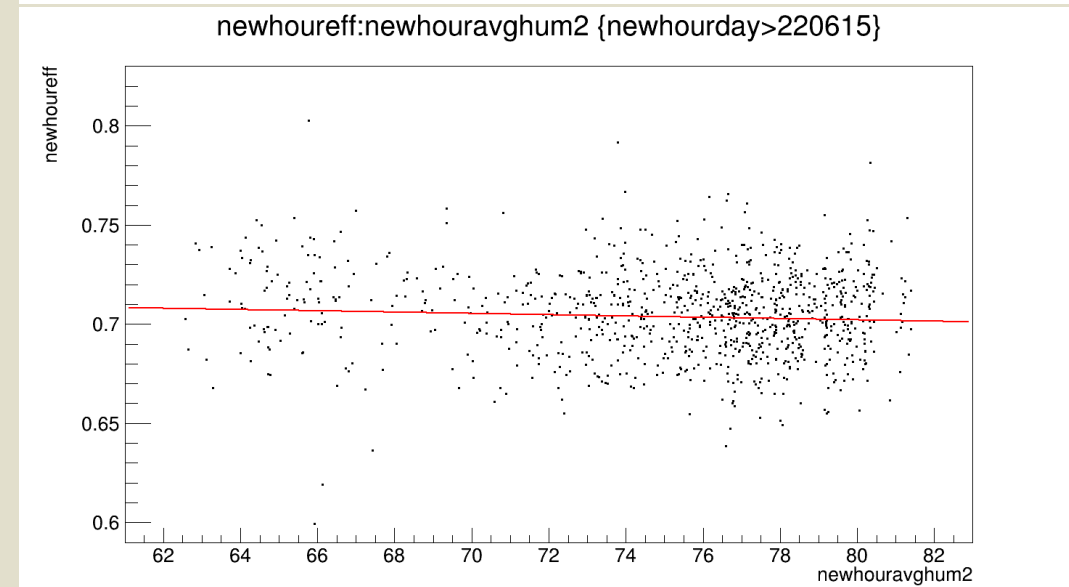
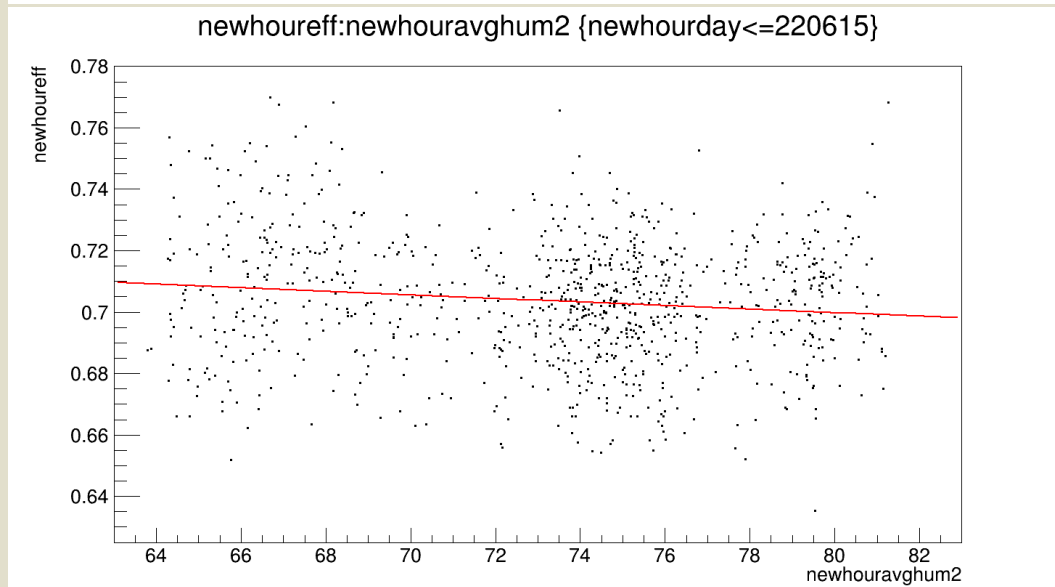
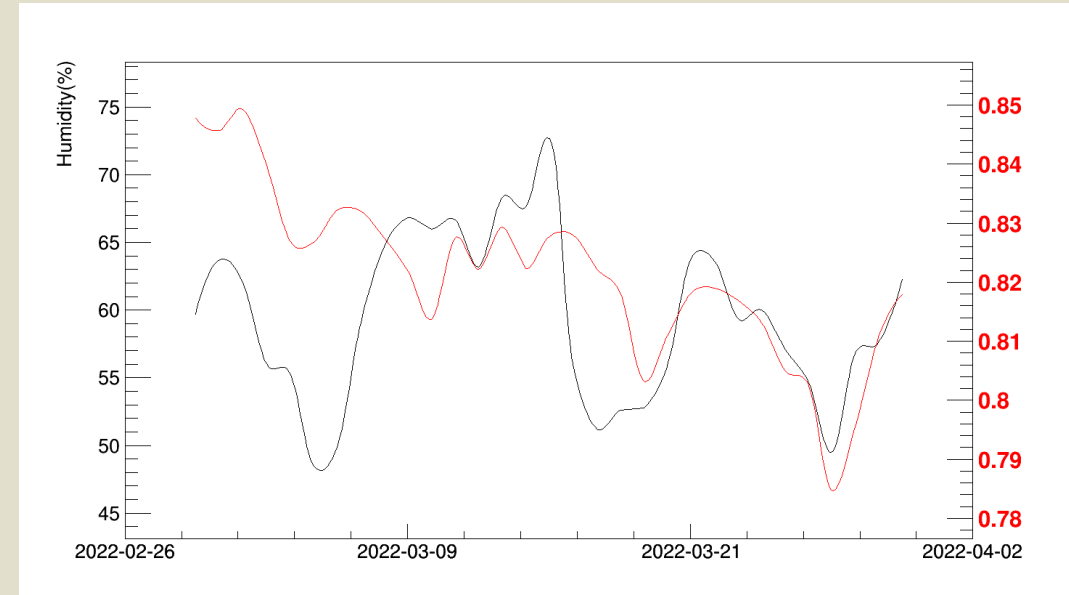
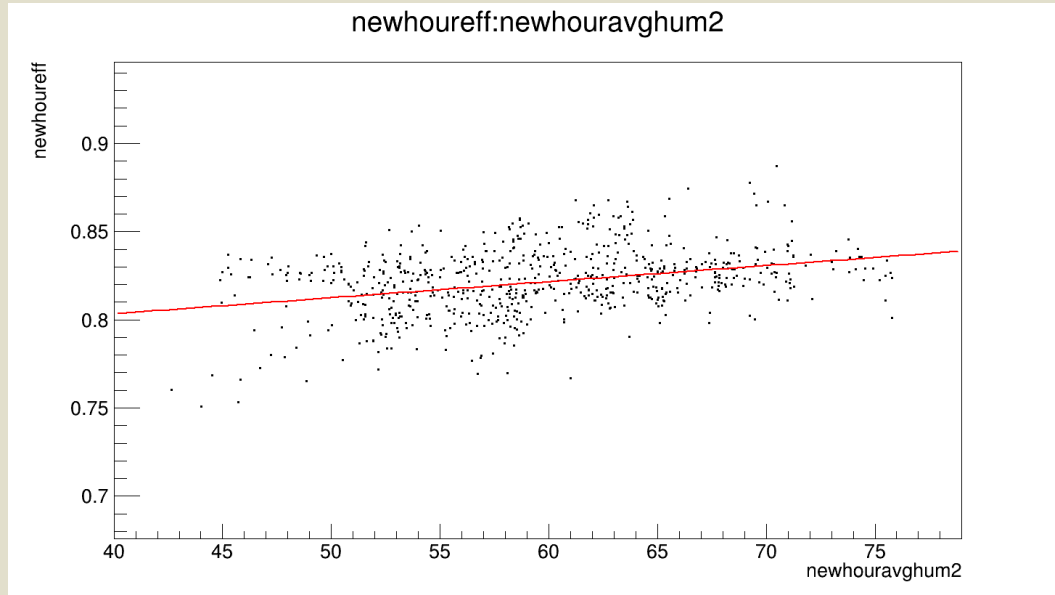
$$E/N = 0.0138068748 \frac{V_{eff} T + 273.15}{d P} [\text{Td}]$$

$$V_{eff} = V_{app} - R_{cm^2} I_{cm^2}$$

# Efficiency not totally depended on E/N



# Another Parameter: Humidity



# Outlook

- Increasing current in the Lousal setup: From the analysis of the slow-control data we detected a steady rate of deterioration of the detector's gas which was visible in the increasing values of measured current.
- Decreasing efficiency in Lousal: We saw fast drop in beginning but now is more stable, we are studying effect of the other variables.



# References

- LouMu Website - "[https://www.lip.pt/experiments/LouMu\\_/tablets/index4.html](https://www.lip.pt/experiments/LouMu_/tablets/index4.html)";
- R. Luz, *“Development of the instrumentation and readout schemes of MARTA, an upgrade to the Pierre Auger Observatory”*, defended these at IST in 2021;

# Thanks for the attention!

## Questions?