Muography Optimization

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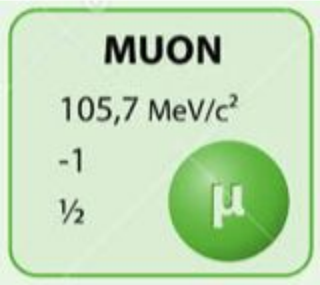
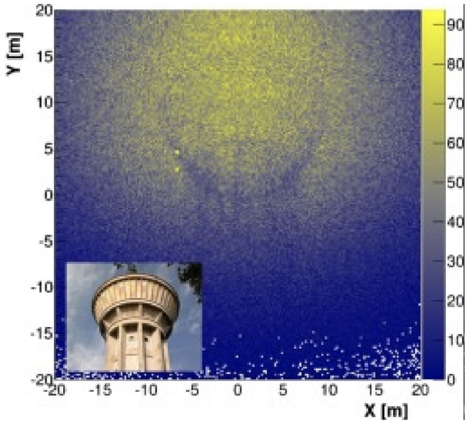
Muons

- The Muon is a fundamental subatomic particle belonging to the Standard Model of particle physics.
- The high mass of this particle allows it go through most matter with little interaction, which allows it to travel great distances in a straight line. This is the reason that allows it to be used in muography.



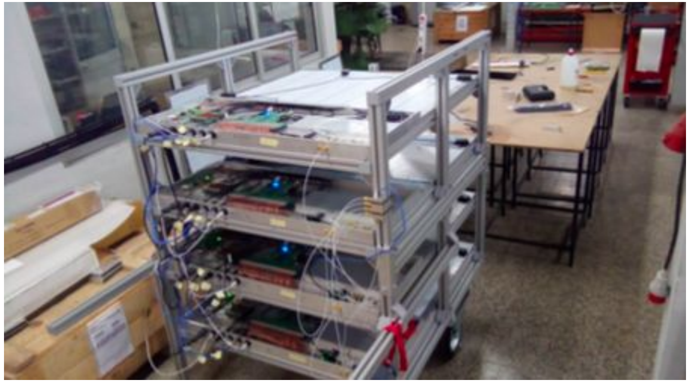
Muography

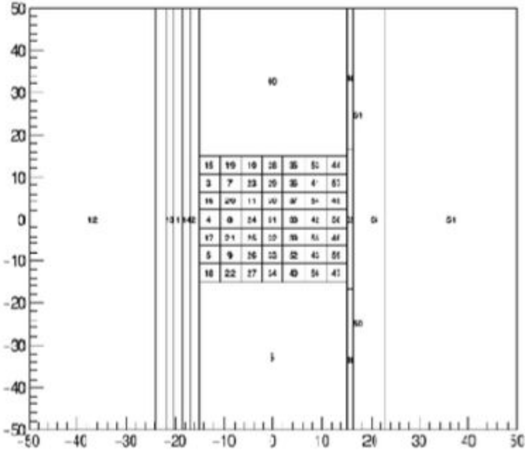
- Muography is a imaging method using natural cosmic-ray derived muons for characterising and monitoring variation in average material density in a diverse range of objects that cannot be imaged by conventional imaging techniques.



Muon detector

- At LIP there are currently two detectors, one of them being a prototype placed in Lousal Mine and the final version is in development in Coimbra.
- It consists in 4 planes, the first has a particular geometry (not being relevant in our work) while the other 3 have identical geometry (as shown in the image below).





Muon detector

- The detection is made possible by the fact that every plane consists of a layer of gas that when crossed by a muon emits an electrical charge that the pad in which this muon passed picks up. In each plane, the pad which detected the highest value of charge is assumed to be, in principle, the pad which the muon crossed in that plane, as long as that value of charge is above a certain minimum value. In this context, that pad is stated to have detected the muon.
- The data collected from the detector is relative to several events. Each event corresponds to the detection of one muon, by the detector. For each event, there is information, for each plane of the detector, about which one of its pads detected the muon and which column and line correspond to that pad.

Efficiency study of the detector

- As said before, the development of the detector is still being made, part of this process implies calculating multiple efficiencies, which is necessary for future improvement and final development of the machine.
- In particular, we have studied the efficiency of plane 2 of the detector.

$$efficiency\ of\ plane\ i = \frac{number\ of\ events\ in\ which\ plane\ i\ correctly\ detected\ a\ muon}{number\ of\ events\ in\ which\ a\ muon\ crossed\ plane\ i}$$

- Importante notes:
  - For each event, it is assumed that the pads which detected a muon in planes 1 and 3 were, in fact, the pads which the muon crossed in those two planes.
  - Only the events in which the corresponding muon crossed the bottom three planes of the detector in the respective corepixes were taken into account.

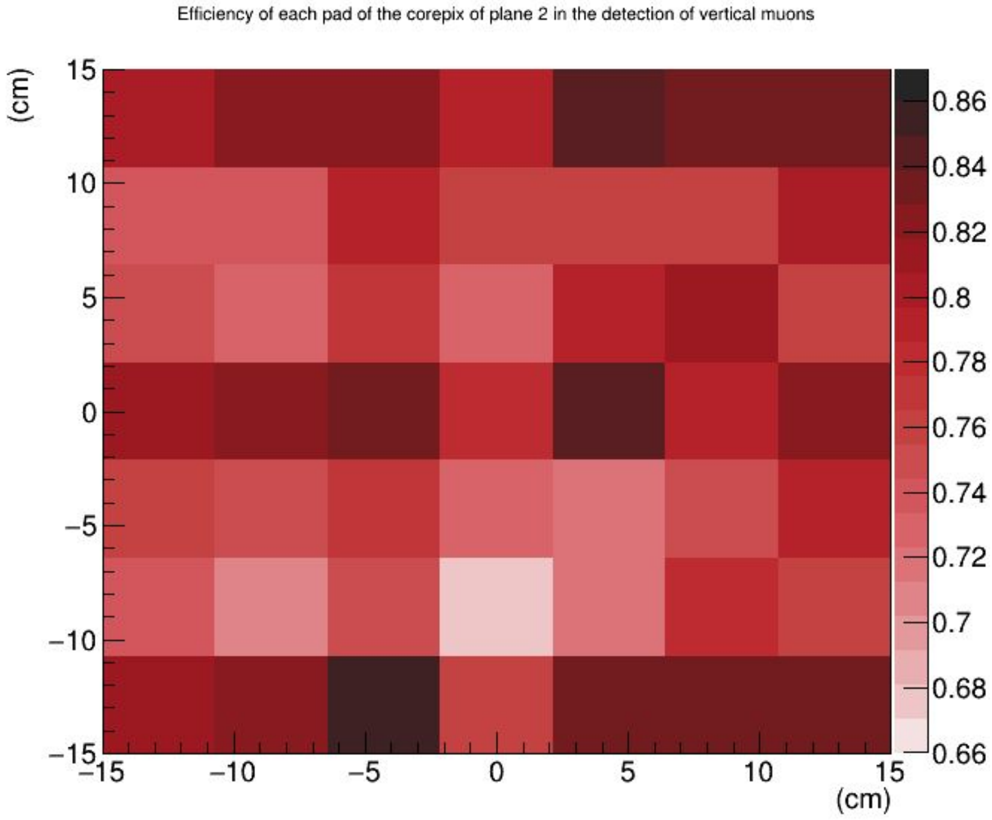
Efficiency in the detection of vertical muons

- A muon is considered vertical if the pad which detected it in plane 1 is the same pad which detected it in plane 3.

$$general\ efficiency\ of\ plane\ 2\ (vertical\ muons) = \frac{number\ of\ events\ in\ which\ planes\ 1,\ 2\ and\ 3\ detected\ a\ muon\ in\ the\ same\ pad}{number\ of\ events\ in\ which\ planes\ 1\ and\ 3\ detected\ a\ muon\ in\ the\ same\ pad}$$

$$= 0,78$$

Efficiency in the detection of vertical muons



Efficiency in the detection of muons with any trajectory

➜ Determine, for each event, whether plane 2 correctly detected the muon or not.

- Expected line, l_T = line which the muon must have crossed in plane 2
- Expected column, c_T = column which the muon must have crossed in plane 2

$$l_T = \frac{l_1 + l_3}{2} \qquad c_T = \frac{c_1 + c_3}{2}$$

$c_i = column\ where\ the\ muon\ was\ detected\ in\ the\ corepix\ of\ plane\ i$

$l_i = line\ where\ the\ muon\ was\ detected\ in\ the\ corepix\ of\ plane\ i$

$i = 1, 3$

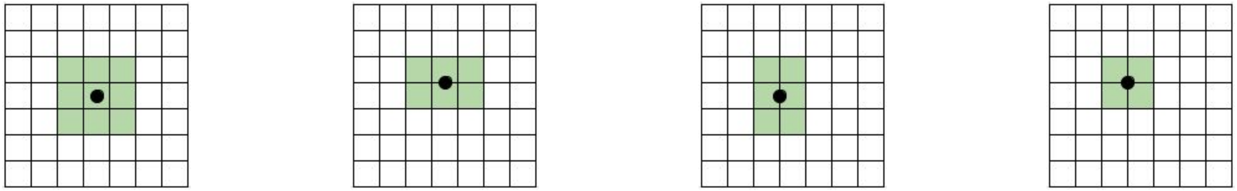
Expected line and column

- Assuming the muon crossed planes 1 and 3 in the centre of pads:

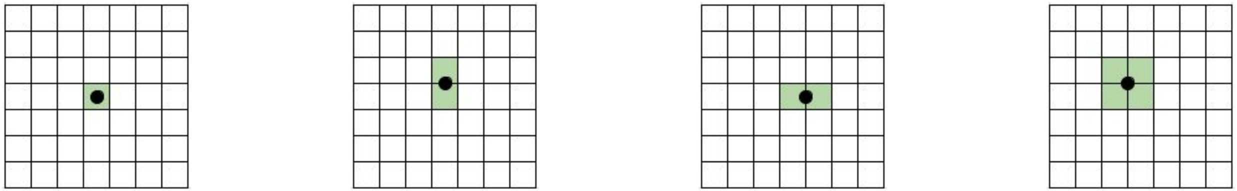
	Theoretical place of passage of the muon in plane 2
l_T and c_T integers	Centre of a pad
l_T non-integer	Border between two lines
c_T non-integer	Border between two columns
l_T and c_T non-integers	Border between two lines and two columns

Criteria used to assess the detection made by plane 2

- Criterion 1 (less selective): maximum difference between the line in which the muon was detected and the expected line = maximum difference between the column in which the muon was detected and the expected column = 1.



- Criterion 2 (more selective): these maximum differences depend on whether the muon was expected to cross plane 2 in a border between different columns or lines, or not.



General Efficiency of plane 2

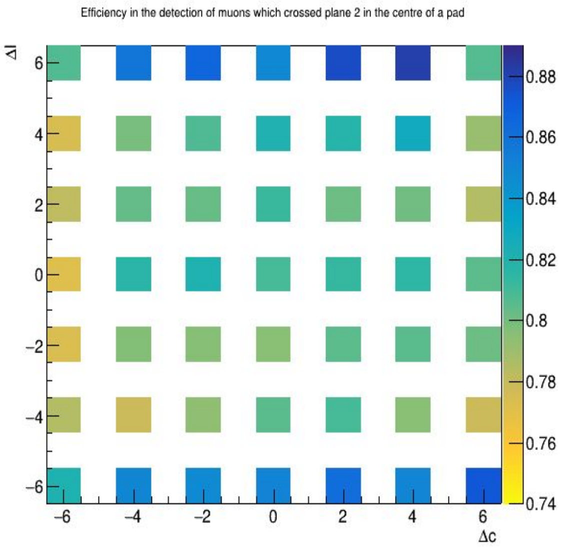
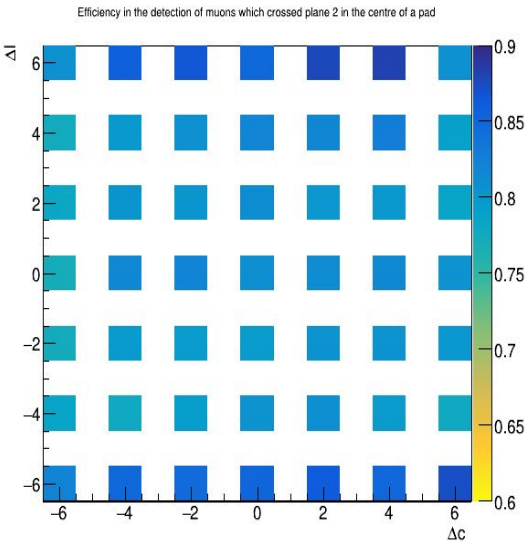
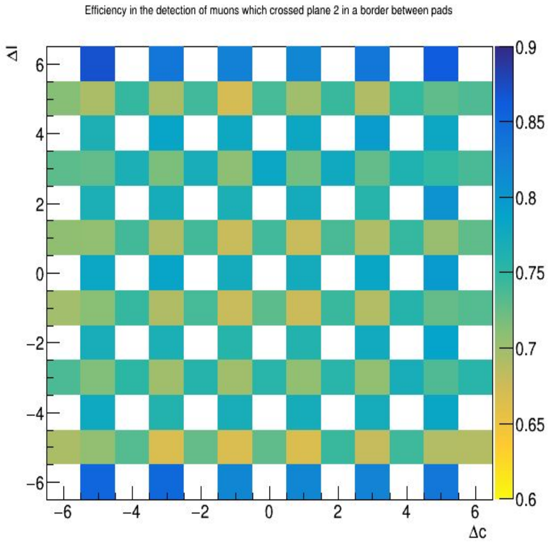
$$general\ efficiency\ of\ plane\ 2 = \frac{number\ of\ events\ in\ which\ plane\ 2\ correctly\ detected\ a\ muon}{number\ of\ events\ in\ which\ a\ muon\ crossed\ plane\ 2}$$

Criterion 1	0,76
Criterion 2	0,74

Efficiency dependence on place of passage of the muons (border vs centre of pad) and on muons inclination

- Criterion 1

General Efficiency of Plane 2 in the detection of muons which crossed plane 2 in a:

Centre of a pad		Border between pads
		

Δl= Line[3] - Line[1]　　　Δc= Column[3] - Column[1]

Line[i]/Column[i]= line/column where the muon was detected in plane i

Efficiency dependence on place of passage of the muon (border vs centre of pad)

- General efficiency of plane 2 in the detection of muons which (theoretically) crossed it in the centre of a pad VS in the detection of muons which (theoretically) crossed it in a border between pads

	Border between pads	Centre of a pad
Criterion 1	0,74	0,81
Criterion 2	0,73	0,77

Thank you for your attention!