I.M.Panagiotopoulos School

Pallini

Muontrackers

Trajectories of muons in a cloud chamber: Testing alcohols' vapour trails

Proposal for "Beamline for Schools competition 2017"

Abstract

The experiment we would like to conduct at CERN's Proton Synchrotron concerns the muons trajectories which are formed in a cloud chamber. More specifically, we would like to test the muons trajectories which are produced by the ionisation of three alcohols - isopropanol, methanol and ethanol - inside the chamber when the cocmic muons travel through them. The results of the experiment could help us select the appropriate alcohol for our cloud chamber at I.M.Panagiotopoulos School.

Preface

We are students of the I.M.Panagiotopoulos School and after a series of discussions we ended up talking about muons and their orbits. At that point, we thought that it would be great if we could construct our own cloud chamber in our lab and test its accuracy concerning the orbits of muons in CERN.

Theoretical background

With a flux of about 1 muon per cm^2 per min, cosmic muons arrive at sea level (1). Cloud chambers are among the devices that are used for detecting this kind of particles that cannot be seen with the naked eye. These chambers create vapour trails because of the trajectories of various particles (2), such as muons we intend to use in our experiment.

At I.M.Panagiotopoulos School there is a cloud chamber under construction (see Appendix) by causing vapour of alcohol to supersaturate inside it (3), (4). We have chosen to achieve the supersaturation by creating temperature gradient in the chamber. When cosmic muons enter the vessel of the chamber, they travel through the supersaturated alcohol ionising its molecules which will then form a trail. The trail of the condensed alcohol vapour gives us information about the path that muons took. According to literature review, the trails of the muons are segments of lines. To obtain a better temperature gradient in our cloud chamber a choice should be made regarding the vapour that will be used for condensation. Three alcohols - isopropanol, methanol and ethanol (see Figure 1) - which have been compared in an experimental procedure (5) showed that isopropanol is the vapour that leads to better temperature distributions.

Figure 1. The three alcohols of the experiment

However, if the temperature gradient is not strong enough -as it happens in our school's cloud chamber- the supersaturation is rather small and a lower critical supersaturation from ethanol or methanol is preferable (5). The usage of T9 beam is helpful to test the three alcohols regarding the formation of the muons trajectories. The results of the experiment that could take place in the experimental area of T9 will help us locate the possible differences between the trajectories of muons from the three alcohols' vapour[1]. In this way we will be able to select the appropriate alcohol for our school's cloud chamber. Although testing the methanol throughout our experiment, it is not possible to conduct an experiment with it in school lab conditions. However, it is an interesting research question that we would be willing to explore.

Experimental setup

In order our experiment to be successful, we will need a 4GeV beam (see Figure 2). When the beam hits the target pions, kaons and electrons will be created. Then, with the aid of a collimator we will strike out all the particles that obtain energy level below or above 4GeV. After that, two magnets are needed so that we can make the beam smaller and as similar as possible with the flux of cosmic ray at sea level. In the meantime, a filter will be placed after the magnets to strike out all particles except for muons. At this point, the beam will have taken its final form and it will be ready to enter the cloud chamber. As mentioned above, the cloud chamber will be placed after the filter so that we can observe the orbit of the muons.

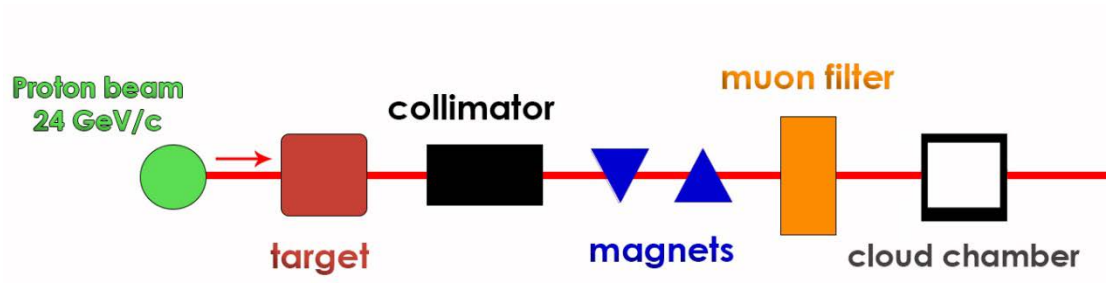

Figure 2. The experimental setup for the formation of muons' trajectories

[1] The mean number of ions produced per unit of length in cloud chambers by a passing particle is related to the density of the ionised gas as described by the Bethe equation (5), (6).

To successfully conduct the experiment and obtain videos and photos of the procedure, we will use a GoPro session 4 while shooting in 1080p 60fps. To observe the muon trajectories, we will use the GoPro capture application of an iPhone 5s (on iOS 10). After the experiment has been completed, we will be able to process the data by taking the micro-SD from the GoPro connecting it to a MacBook Pro early-2015 and using the iMovie application on the Mac (see Figure 3).

Figure 3. Collection of the cloud chamber's data by using a camera and a smartphone

Acknowledgements

We gratefully acknowledge Dr M. Tsiaganis for his constructive comments about the physicochemical approach to our proposal and Dr G. Daskalakis for his remarks about the final form of the written proposal and the video. We would also like to thank M. Grafanakis and A. Donis for their technical support as well as O. Haros for his contribution during the video production. Finally, we would like to thank E. Kaliskami for editing our proposal and the video as well.

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Appendix

Photos from the cloud chamber's construction