**Summer Internship Project**
Report

# Detection of Cosmic Muons Using Gas Detectors

Submitted by

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# Acknowledgements

I would like to express my sincere gratitude to Dr. Sanjib Muhuri, my guide and mentor, for his invaluable support, guidance, and expertise throughout my internship on the simulation and experimental detection of cosmic muons using the ALICE detector. His vast knowledge and constant encouragement have been instrumental in shaping my understanding of this complex field of study. I am also grateful to the High Energy Group at VECC (Variable Energy Cyclotron Centre) for providing me with the necessary resources, infrastructure, and access to the ALICE detector. Their assistance and cooperation have been vital in carrying out the experimental phase of this internship. I extend my heartfelt appreciation to the Department of School of Physical Sciences at NISER (National Institute of Science Education and Research) for providing me with the opportunity to pursue this internship. The conducive academic environment and the support of the faculty have greatly contributed to my overall learning experience. I would like to acknowledge the collective efforts of the researchers, technicians, and staff members who have been associated with the project. Their contributions, suggestions, and collaboration have significantly enriched my internship journey. Lastly, I express my gratitude to my fellow interns and friends for their camaraderie, stimulating discussions, and continuous encouragement. Their presence has made this internship an enjoyable and enriching experience. In conclusion, I am immensely thankful to all individuals and institutions mentioned above for their unwavering support, guidance, and contributions, which have been instrumental in the successful completion of this internship.

# Variable Energy Cyclotron Centre, Kolkata

## *Certificate*

This is to certify that Mr. Anantha Padmanabhan M Nair, a student of the National Institute of Science Education and Research (NISER), has successfully completed a summer internship in the field of Cosmic Muons and its Detection by ALICE Detectors. The internship was conducted from 5/6/2023 to 29/7/2023, under the guidance and supervision of Dr. Sanjib Muhuri.

During the internship, Mr. M Nair demonstrated exceptional dedication, enthusiasm, and competence in conducting simulations, experimental data collection, and analysis related to cosmic muons and their detection using the ALICE detector. Through their hard work and perseverance, they contributed significantly to the understanding of cosmic muons' behavior and their energy deposition within the detector setup.

We commend Mr. M Nair for their exemplary performance, commitment to scientific inquiry, and collaborative spirit. Their active participation and insightful contributions have been instrumental in the success of the internship project.

We extend our best wishes to Mr. M Nair for a bright and successful future, both in their personal life and professional career. May they continue to excel in their academic pursuits and make significant contributions to the field of research.

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Sanjib Muhuri
(Project Guide)

Date:

**Abstract**

This report focuses on the simulation and experimental detection of cosmic muons using the ALICE (A Large Ion Collider Experiment) detector, employing the Geant4 simulation framework. The study aims to understand the behavior of cosmic muons and their energy deposition within the detector setup, consisting of a honeycomb gas detector filled with Argon and $CO_2$. The simulation phase involved utilizing Geant4 to replicate the laboratory setup and simulate the interaction of cosmic muons with the detector. By accurately modeling the trajectory and behavior of cosmic muons, the simulation facilitated the calculation of their energy deposition within the ALICE detector. This process provided valuable insights into the expected behavior of cosmic muons within the simulated environment. Subsequently, the actual experimental phase involved collecting data from the ALICE detector in the laboratory. The detector, filled with Argon and CO2 gases, accurately captured cosmic muons as they traversed through it. The collected data allowed for a comparison between the simulated and experimental results, validating the accuracy of the Geant4 simulation model and providing further insights into the behavior of cosmic muons. The internship report outlines the methodology employed during both the Geant4 simulation and the experimental data collection phases, including the parameters and variables considered. It discusses the data analysis techniques used to evaluate the energy deposition of cosmic muons and presents a comprehensive comparison between the simulated and experimental results.

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# 1 Introduction

The detection and study of cosmic muons hold great significance in the field of particle physics and high-energy physics. Cosmic muons, which are highly energetic charged particles originating from cosmic rays, provide valuable insights into the properties of elementary particles and the fundamental forces governing our universe. To explore the behavior of cosmic muons and their interaction with matter, sophisticated detector systems such as the ALICE (A Large Ion Collider Experiment) detector are employed.

This internship report focuses on the investigation of cosmic muons and their detection using the ALICE detector. The objective of this study is to simulate the behavior of cosmic muons within the detector setup and to experimentally collect data to validate the simulation results. The ALICE detector, known for its capabilities in tracking and identifying particles, serves as a crucial tool in understanding the characteristics and energy deposition of cosmic muons.

The internship comprises two main phases: simulation and experimentation. In the simulation phase, the Geant4 framework is utilized to model the laboratory setup and replicate the interaction of cosmic muons with the ALICE detector. Geant4, a widely used toolkit in high-energy physics, provides a comprehensive platform for simulating the passage of particles through matter, accurately capturing their interactions and energy deposition.

Following the simulation phase, the experimental phase involves collecting real data from the ALICE detector in the laboratory. The detector, filled with Argon and CO2 gases, is capable of precisely tracking and measuring the energy deposited by cosmic muons as they pass through it. By comparing the simulated results with the experimental data, a comprehensive analysis of the accuracy and effectiveness of the simulation model can be performed.

The findings of this internship contribute to our understanding of cosmic muons and their detection using the ALICE detector. By examining the energy deposition of cosmic muons, valuable information can be obtained regarding their origin, behavior, and potential interactions with various materials. Such insights are crucial for advancing our knowledge of fundamental particle physics and may have implications in astrophysics and cosmology.

In this report, we will outline the methodology employed during the simulation and experimental phases, discuss the data analysis techniques used to evaluate the energy deposition of cosmic muons, present the comparison between simulated and experimental results, and provide a comprehensive analysis of the overall internship experience.

By delving into the study of cosmic muons and their detection using the ALICE detector, we aim to contribute to the ongoing advancements in particle physics research and pave the way for future investigations in this fascinating field.

# References