The Compact Muon Solenoid Experiment

CMS Draft Note

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The Effect of Space Between the Wrapper and the Scintillator Body on the Efficiency of the Scintillator.

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Abstract

Extending Alan Horst's work with improving upon the efficiency of Scintillator particle detection, we plan to run GEANT4 simulations utilizing the scintillator design from Alan's work that tests the effect of the gap between the wrapping material and scintillator body on the photon production. As we have yet to methodically test this, as a proof of concept we manipulated a GEANT4 example to produce a modified Hadronic Calorimeter that exhibits the type of changes we hope to make in the future.

1 Introduction

Within the Hadron Collider the role of the scintillator is to allow researchers to see when and what particles are released from a collision due to the property that when a particle passes through the scintillator it release light which can change in luminosity dependent on the intensity of the particles radiation.

As suggested by Dr.Eno for further research, for this project we will be looking at how the efficiency of photon production changes if the scintillator is either wrapped or painted. The painted wrapping produces no gap between the body and the wrapping material, while wrapping with any fabric-like material is guaranteed to produce some gap between the body and wrapper material.

1.1 Motivation, previous work, etc...

We chose this topic because it sounded interesting and it is an extension of a simulation done by Alan Horst, on how responsive a dimple tile is to a muon source. The reason we are referencing this paper is because it mentions a majority of the experiments and formulas that we will either need to use or tweak to t our purposes for what we want to do with our research topic. A main component of the paper that we will reference is how Horst and Eno conducted the simulations to best represent and acquire results needed for comparison between the materials being experimented with. The way that Horst and Eno test their simulated devices and primarily the scintillator was through the use of two sources. One simulates the scintillators response to a beam of muons travelling through a trigger and onto a random point within said trigger on the tile. The second source went to a single location on the tile. Both sources only utilized photons released in the scintillator are simulated which were created along the path of the muon and shot through in an isotropic distribution.

We used the GEANT4 with CMSSW.10.5.0 to get a mapping of the scintillator and its associated dimple. We will be going forward using the GEANT4 program to test various gaps between the reflective wrapper and the scintillator body, using both Alan Horsts previous data as well as our own original work. Below is a plot of the scintillator design well be working with, one that Alan Horst generated.

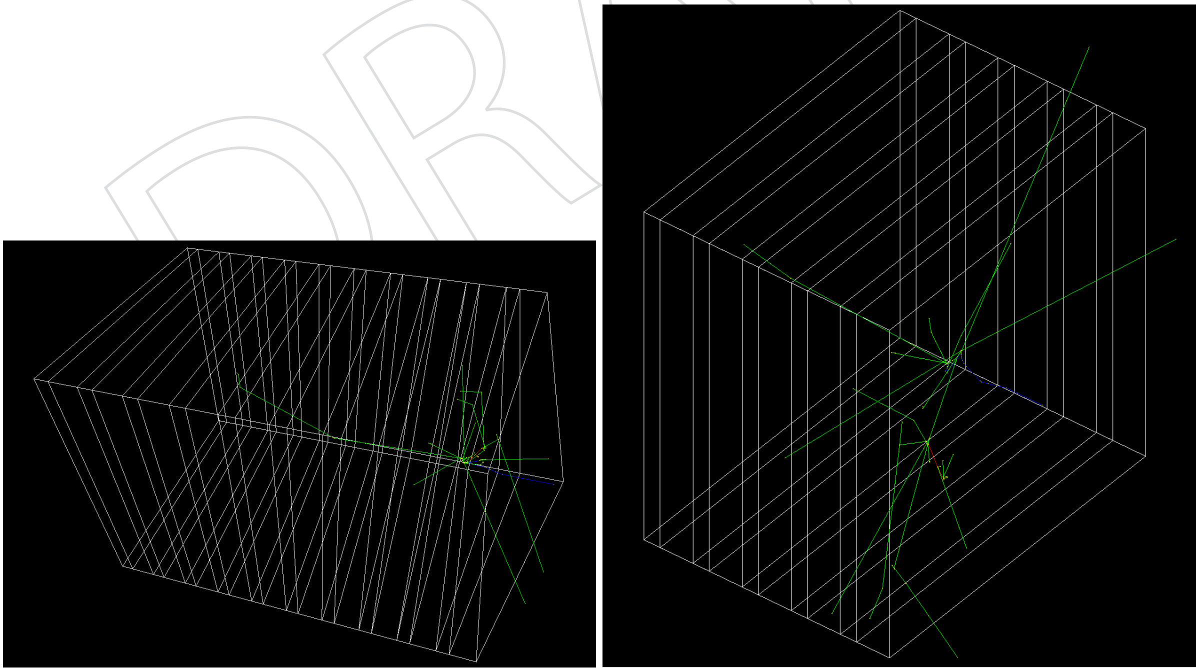
Due to limitations within our work environment, a full test of of the wrapping material was not possible in a timely manner; therefore, that motivated us to provide a proof of concept. This allowed us to gain a better understanding of the CMS software and GEANT4, while still being relevant to our primary objective.

2 Methods

In order to construct pour proof of concept we needed a pre-coded detector, so we used an example from the GEANT4 GitHub library and manipulated it's structure. To accomplish this we modified the parameter for the size of detector, paralleling the modifications we hope to make in the parameter of the gap in the wrapping. It is similar to Alan's and Sarah's work where they modified the radius and overall size of the dimple to see the change in data. We are going to keep the dimple on the scintillator because of the following reason. The minimum ionizing particle (MIP) produces the same amount of light independently of the impact position, when crossing the flat tile. The light which is emitted in front of the SiPM has twice higher probability to reach the photo-dector. To improve the uniformity, one can reduce the mean light emission from MIP in the tile center by reducing the scintillator thickness there by making a dimple in the scintillator in front of the SiPM.Keeping the dimple will help us get better results.

3 Results

Our success in reducing the amount of scintillators within the detector shows that other parameters like gap can be modified with relative ease. On the left is the original calorimeter and the right displays the modified one. The particle showering present in both charts is to confirm different functionality between them.



4 Discussion

The information required for us to conduct our research will include the simulation code required for us to run our experiments and collect data to then compare. We will also need to know the reective properties of the materials we wish to experiment with and the properties of the scintillator which will be needed during simulation to best represent how the materials will respond in a real context or experiment. We will also need to know formulas required to conduct the calculations to be able to compare which material has the best result and has the greatest reective potential out of the four selected materials.

In the coming semester we plan to conduct the simulations by changing the parameters in Alan's code to simulate having the different changes of either using wrappers or painting and how that in turn affects the detection of the scintillators. We also plan to use the GEANT4 GitHub library to fully utilize and properly simulate the detectors structure. In FIRE 276 we plan to conduct the bulk of these experiments and simulations to determine which form is best to improve the detection ability of the scintillators currently in use on the Hadron Collider.

For the future we plan to work with our assigned PM who will hopefully help guide us and answer any questions that may come up along the way during our simulations and experiments. We also plan to narrow the parameters of the material we will be using when the scintillators are wrapped or painted; presently the material we will be using and it characteristics have not been considered. After we determine the specifications of the material, we will use a modified version of Alan's code to stimulate data that will help us predict experimental data.

References

[1] J.Anderson "Uprage of the CMS Hadron Calorimeter with sipms", Physics Procedia, 77 pp 72-78, 2012

[2] J.K A H et al, "Large-area sipms for the CMS hadron outer calorimeter",

A Appendix 1: Analysis Code Documentation

Please either place a link to GitHub repository for your code (well-documented) or the code itself here in this section. (amended by MK)