Liquid scintillator tiles for high radiation environments

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Abstract

Future experiments in high energy and nuclear physics may require large, inexpensive calorimetery that can operate to doses of 50 Mrad or more. We present the results of a study of a scintillator tile based on EJ-309 liquid scintillator using cosmic rays, test beam, and ^{60}Co irradiations.

Keywords: organic scintillator, liquid scintillator,, radiation hardness, calorimetry

1. Introduction

Sampling calorimeters using plastic scintillator tiles with wave length shifting fibers, such as the CDF plug calorimeter [**?**], are popular due to their suitable performance at a reasonable cost. Plastic scintillator is available commercially from companies like Kuraray, St. Gobain, and Eljen. When irradiated, however, the performance of plastic scintillator deteriorates; light self-absorption (yellowing) increases and light output decreases. The resulting damage has been studied for most common plastics[1], [2], [3], [4],[5],[6],[7],[8]. Generally,

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the light output decreases with exponentially with dose, with an decay constant on order of a few Mrad. Future high energy and nuclear experiments, however, may have to operate in environments that will deliver doses of tens of Mrad. In this paper, we present the design and optimization of a liquid scintillator tile, based on EJ-309 liquid scintillator, that can operate in thie kind of environment.

2. Tile design

Our tile is based on EJ-309 scintillator, from Eljen Technology, and is based on naphthalene with wavelength shifting additives. It has a light output that is 75% of anthracene, a wavelength of maximum emisison of 424 nm, a refractive index of 1.57 and a flash point of 144^{o}C. It's low flash point is important for its suitability for a collider environment.

The design of tile to hold the liquid needs to consider light collection efficiency, light collection uniformity, and cost. The container should not leak and there should not be interactions between the container and its contents that degrade the light output over time. Figure 1 shows the mechanical construction. The case is aluminum. Two transparent support tubes with outer diameter of 2mm run through the liquid and can hold either wavelength shifting fiber or liquid wavelength shifter. The support tube is sealed to the case with a viton fluoroelastomer o-ring. The thickness of the top and bottom Aluminum plates is 0.1 mm. The inner surface can either be polished to increase reflectivity ("mirroring") or not.

Several variations on this design were constructed. For the default design, the thickness of the liquid is 4 mm and the support tubes were quartz with an inner diameter of 1.3 mm. Sapphire tubes were also tested.

3. Tile Simulation

We use the GEANT4 package

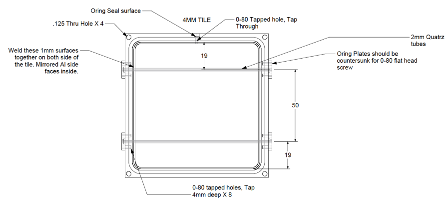

Figure 1: Mechanical design of a liquid scintillator tile. Units are mm.

4. Test beam results

5. Light yield dependence on tile parameters and comparison with simulation

6. Radiation hardness tests

Performance of the tile under irradiation in a proton-proton collision environment will be the subject of a future paper.

7. Conclusions

8. Acknowledgements

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