

Liquid scintillator tiles for high radiation environments

Alberto Belloni^{a,*}, Mahnegar Amouzegar^a, Jeff Calderon^a, Sarah C. Eno^a,
Kenichi Hatakeyama^f, Kevin Pedro^e, Geng Yuan Jeng^a, Joshua Samuel^a,
Elmer Sharp^d, Young Ho Shin^a, Zishuo Yang^a, Yao Yao^a, Sung Woo Youn^c

^a*Dept. Physics, U. Maryland, College Park MD 30742 USA*

^b*Eljen Technology, 1300 W. Broadway, Sweetwater, Tx 79556 USA*

^c*Institute for Basic Science, Center for Axion and Precision Physics Research, IBS Center
for Axion and Precision Physics Research Room 4315, Department of Physics, Natural
Science Building (E6-2), KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 305-701, South
Korea*

^d*Elmer Sharp Engineering, 7007 Leesville Blvd. Springfield, VA 22151*

^e*Fermi National Accelerator Laboratory, Batavia, IL, USA*

^f*Baylor University, Waco, Texas, USA*

Abstract

Future experiments in high energy and nuclear physics may require large, inexpensive calorimetry 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 ⁶⁰Co 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
5 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,

*Corresponding author

Email address: abelloni@umd.edu (Alberto Belloni)

the light output decreases with exponentially with dose, with an decay constant
10 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

15 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°C. It's low flash point is important for its
suitability for a collider environment.

20 The design of tile to hold the liquid needs to consider light collection effi-
ciency, light collection uniformity, and cost. The container should not leak and
there should not be interactions between the container and its contents that de-
grade the light output over time. Figure 1 shows the mechanical construction.
The case is aluminum. Two transparent support tubes with outer diameter of
25 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.

30 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 [9] package to simulate the optics of our tile.

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