

Liquid scintillator tiles for high radiation environments

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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,

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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 constructure.

3. Tile Simulation

25 We use the GEANT4 package

4. Test beam results

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

6. Radiation hardness tests

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

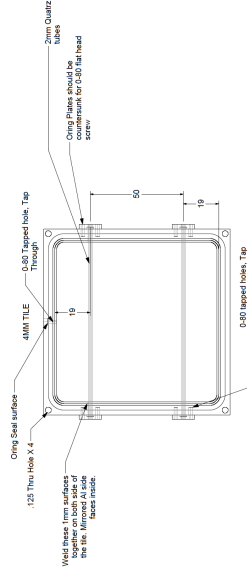


Figure 1: Mechanical design of a liquid scintillator tile.

7. Conclusions

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References

- [1] U. Holm, K. Wick, Radiation stability of plastic scintillators and wave-length
 40 shifters, Nuclear Science, IEEE Transactions on 36 (1) (1989) 579–583. doi:
 10.1109/23.34504.
- [2] K. Wick, D. Paul, P. Schrder, V. Stieber, B. Bicken, Recovery and dose
 rate dependence of radiation damage in scintillators, wavelength shifters
 and light guides, Nuclear Instruments and Methods in Physics Research

- 45 Section B: Beam Interactions with Materials and Atoms 61 (4) (1991) 472
 – 486. [http://dx.doi.org/http://dx.doi.org/10.1016/0168-583X\(91\)95325-8](http://dx.doi.org/http://dx.doi.org/10.1016/0168-583X(91)95325-8)
 doi:[http://dx.doi.org/10.1016/0168-583X\(91\)95325-8](http://dx.doi.org/10.1016/0168-583X(91)95325-8).
 URL <http://www.sciencedirect.com/science/article/pii/0168583X91953258>
- 50 [3] B. Bicken, U. Holm, T. Marckmann, K. Wick, M. Rohde, Recovery and
 permanent radiation damage of plastic scintillators at different dose rates,
 Nuclear Science, IEEE Transactions on 38 (2) (1991) 188–193. doi:10.
 1109/23.289295.
- 55 [4] B. Bicken, A. Dannemann, U. Holm, T. Neumann, K. Wick, Influence of
 temperature treatment on radiation stability of plastic scintillator and wave-
 length shifter, Nuclear Science, IEEE Transactions on 39 (5) (1992) 1212–
 1216. doi:10.1109/23.173180.
- 60 [5] G. Buss, A. Dannemann, U. Holm, K. Wick, Radiation damage by neutrons
 to plastic scintillators, Nuclear Science, IEEE Transactions on 42 (4) (1995)
 315–319. doi:10.1109/23.467829.
- 65 [6] B. Wulkop, K. Wick, W. Busjan, A. Dannemann, U. Holm, Evidence
 for the creation of short-lived absorption centers in irradiated scintil-
 lators, Nuclear Instruments and Methods in Physics Research Section
 B: Beam Interactions with Materials and Atoms 95 (1) (1995) 141 –
 143. [http://dx.doi.org/http://dx.doi.org/10.1016/0168-583X\(94\)00435-8](http://dx.doi.org/http://dx.doi.org/10.1016/0168-583X(94)00435-8)
 doi:[http://dx.doi.org/10.1016/0168-583X\(94\)00435-8](http://dx.doi.org/10.1016/0168-583X(94)00435-8).
 URL <http://www.sciencedirect.com/science/article/pii/0168583X94004358>
- 70 [7] A. Bross, A. Pla-Dalmau, Radiation damage of plastic scintillators, Nuclear
 Science, IEEE Transactions on 39 (5) (1992) 1199–1204. doi:10.1109/23.
 173178.
- 8 [8] V. Hagopian, I. Daly, Radiation damage of fibers, AIP Conference Proceed-
 ings 450 (1) (1998) 53–61. doi:<http://dx.doi.org/10.1063/1.56958>.

URL <http://scitation.aip.org/content/aip/proceeding/aipcp/10.1063/1.56958>

75