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Study of Hadron Calorimeter Active Elements

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Abstract

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Several configurations of the active elements (scintillator and WLS fibres) for hadron calorimeter with scintillators parallel to beam have been considered. Uniformity of light collection and the number of photoelectrons have been measured.

Аннотация

Горин А.М., Кораблев А.В., Крышкин В.И. Исследование активных элементов адронного калориметра: Препринт ИФВЭ 97-82. – Протвино, 1997. – 5 с., 5 рис., библиогр.: 3.

Рассмотрено несколько конфигураций активных элементов (сцинтилляторов и оптическое волокно со смесителем спектра) адронного калориметра со сцинтиллятором, расположенным параллельно пучку падающих частиц. Измерены однородность светосбора и число фотоэлектронов.

Introduction

A novel hadron calorimeter design was proposed in [1] and several versions of an active element were considered. In all cases WLS fibres (or part of their length) were inserted in grooves. Machining of such grooves in a thin scintillator becomes difficult. Tendency for the maximum density of a calorimeter requires the decrease of the scintillator thickness. The hadron calorimeter with a scintillator 2 mm thick was studied in [2]. In this paper different active elements without grooves for WLS fibres are considered to optimise the uniformity of light collection and light yield.

1. Measurements

There were used BSF-92 (Bicron) WLS fibres 1 mm in diameter with a wavelength of maximum emission ~500 nm. The measured value of fibre attunuation length was equal to 2 m.

An active element consisted of two plates of scintillator with dimensions 500 mm × 200 mm (Fig.1). The scintillator was 5 mm thick and it was made by block polymerization method at Kharkov NPO "Monokristall-Reaktiv". Short edges of these plates were polished. Corners of the active element had a radial shape with a radius of 30 mm. Transparency of the scintillator wrapped up in Tyvek was 400 mm.

A uniformity of light collection was obtained by measuring of the PMT anode current scanning of the scintillator with the radioactive source ^{106}Ru placed in a collimator with the 10 mm diameter hole. The measurements error was ~5%. The number of photoelectrons was obtained from the efficiency of triple coincidence rate when two scintillation counters were placed at different sides of the active element that was the third one. FEU – 85 PMT with 10% quantum efficiency for green light was used.

Three configurations of the active element shown in Fig.1 were measured.

Version (1). Two fibres 3 m long each were placed along the scintillator perimeter. The ends of the fibres were polished and connected to PMT with air contact.

Version (2). The previous scintillator was cut in the middle along the axis. Two fibres 1.5 m long each were inserted in the gap. The opposite to PMT ends of fibres were covered with white paint.

Version (3). In this case in contrast to the previous one, the fibres aslo covered short edges of scintillators at the opposite to PMT end of the active element.

Besides, the characteristics of the active element assembled in configuration of version (1) with 3 mm thick extruded scintillator were studied. This scintillator was made by NPO "Polymersintez", Vladimir.

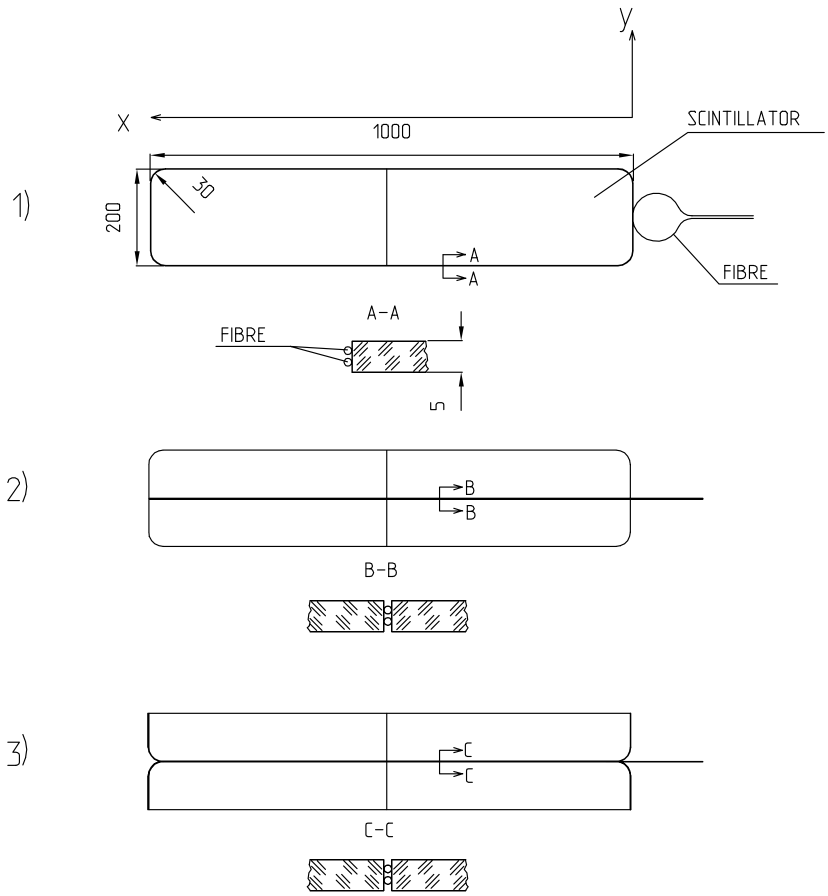

Fig. 1. Three versions of active element.

2. Results

Figs.2-5 show the uniformity of light collection for all studied active elements. Table contains quantitative characteristics for the uniformity of light collection (RMS) and the number of photoelectrons which was measured in the middle of scintillator for version (1) and at the quarter of active element width for versions (2) and (3), 20 cm from the nearest to PMT edge of scintillator.

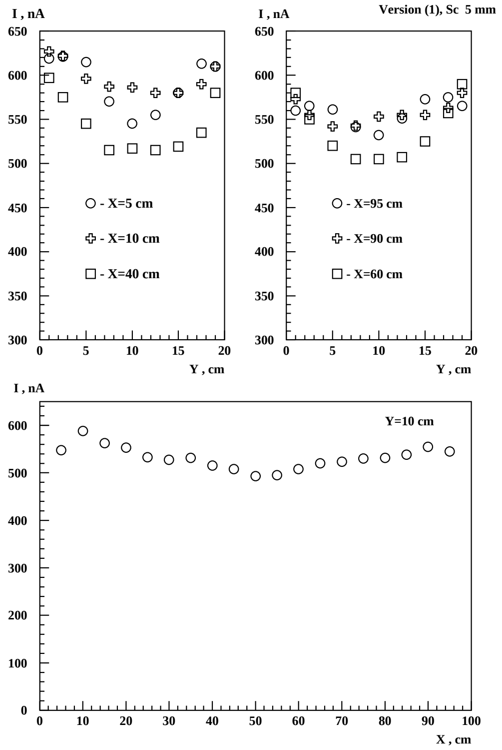

Fig. 2. Uniformity of light collection for version (1).

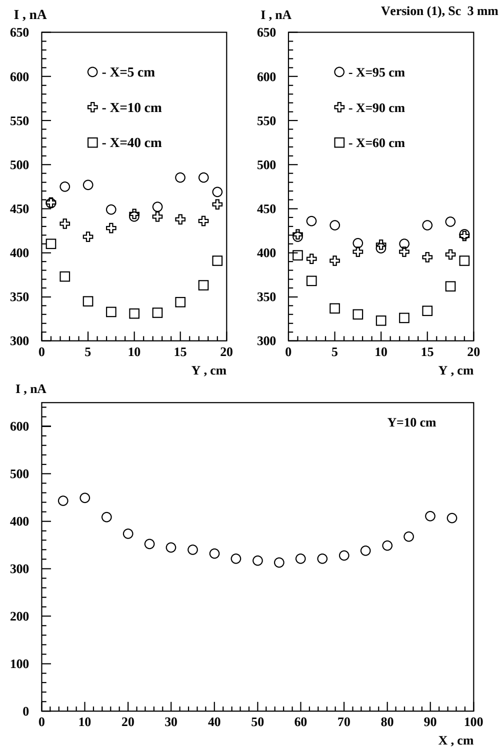

Fig. 3. Uniformity of light collection for version (1) and the scintillator of 3 mm thick.

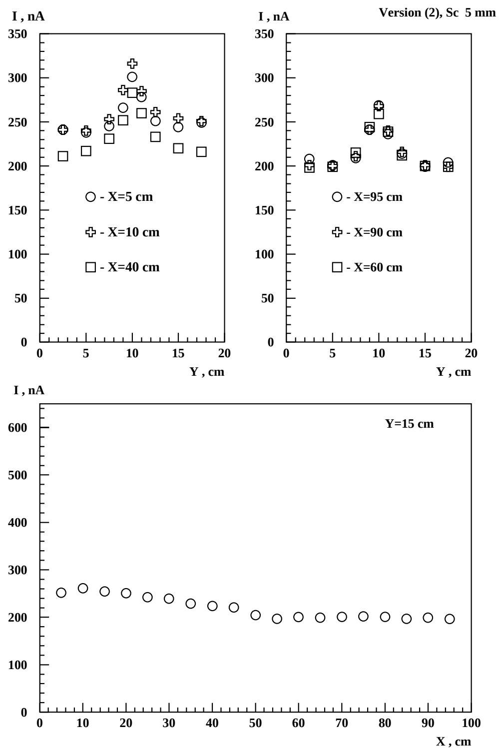

Fig. 4. Uniformity of light collection for version (2).

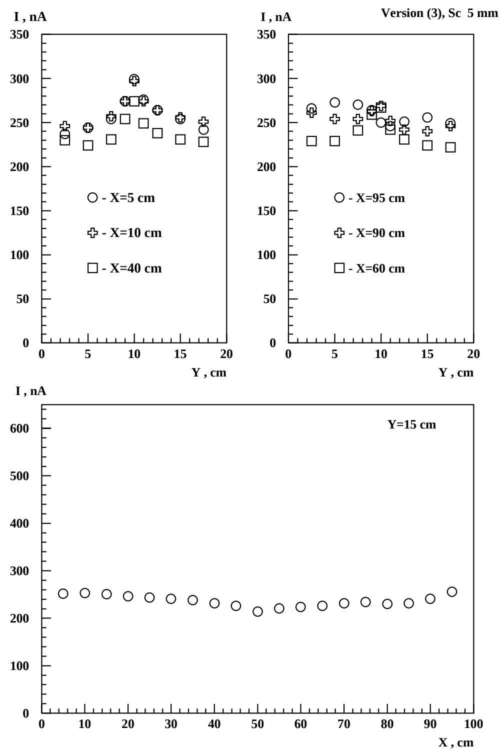

Fig. 5. Uniformity of light collection for version (3).

Table 1. Light yield (number of photoelectrons) and uniformity of light collection for three versions of active element geometry shown in Fig.1.

Version (Fig.1)	Scintillator thickness, mm	Uniformity of light collection, (RMS, %)		Number of photoelectrons, N_{pe}
		Longitudinal	Transversal*	
1	5	4.3	3.8	3.8
	3	11.8	4.8	2.6
2	5	10.4	9.6	1.8
3	5	4.9	6.1	1.9

* – these data were obtained with the scanning of the active element at the distance of $X = 60$ cm from the nearest to PMT edge of scintillator with a step of 2.5 cm (7 points).

Conclusions

As was expected, version (1) gave the best uniformity of light collection and a maximum number of photoelectrons. As is shown in Fig.2, the light yield does not depend on radioactive source position along the active element at the border of two scintillators. For a calorimeter with large active elements one can use plates of scintillator with smaller dimensions and if necessary divide it in depth.

Drawbacks of this version are the following:

1. There is a double layer of fibres (about 2 mm thick) between scintillators of neighbouring towers. It may lead to the variation of signal amplitude in this region. In [3] such effect, in case of electromagnetic calorimeter, was not observed.

2. The amount of scintillator along the particle track is a little bit smaller in 6 cm stripe ($\pm$ 3 cm) near neighbouring towers border than in the center of a tower (due to the radial shape of active element corners). But the influence of this factor on characteristics of detector must not be profound because most of the energy losses in the process of hadron shower development don't take place in the regions of front or back sides of the calorimeter.

Version (2) has the worst uniformity of light collection and it can be used for projective calorimeters with a wedge shaped absorber, when the change of light collection must be inversely proportional to the absorber thickness. For this version it is possible to get better longitudinal uniformity of light collection by using WLS fibre with better transparency and better reflectivity of the fibres ends.

Version (3) has better uniformity of light collection than version (2).

Acknowledgement

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