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Development of Multipurpose Aerogel Cherenkov Counter

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Abstract

We have been developing a multipurpose aerogel Cherenkov counter which is able to identify charged particles at any environments such as a limited space and high magnetic field [1,2]. The device is composed of an aerogel radiator [3], light guide made of 4 kinds of wavelength shifting (WLS) fibers and small photo-device (PMTs or SiPMs). Cherenkov light emitted from the aerogel radiator is collected by the fiber light guide, and transferred to the both ends of the fiber by a total reflection condition. Therefore, this counter enables to identify particles on a large effective area and arbitrary shape with a small photo-devices.

Light Guide using WLS fibers

WLS fibers made by Kuraray Co., Ltd. have the following properties; 4 kinds of absorption and emission wavelengths (B-3, Y-11, O-2, and R-3), trapping efficiency of 5.4% by double cladding, attenuation length of about 3 m and 0.2 mm minimal diameter [4]. Cherenkov light emitted from the aerogel radiator is transferred the both ends of the fiber by the total reflection condition. Since the light has continuous spectrum depending on the wavelength, collection efficiency would be improved. Furthermore, the light leaked from a fiber layer would get a chance to be absorbed by another fiber layer.

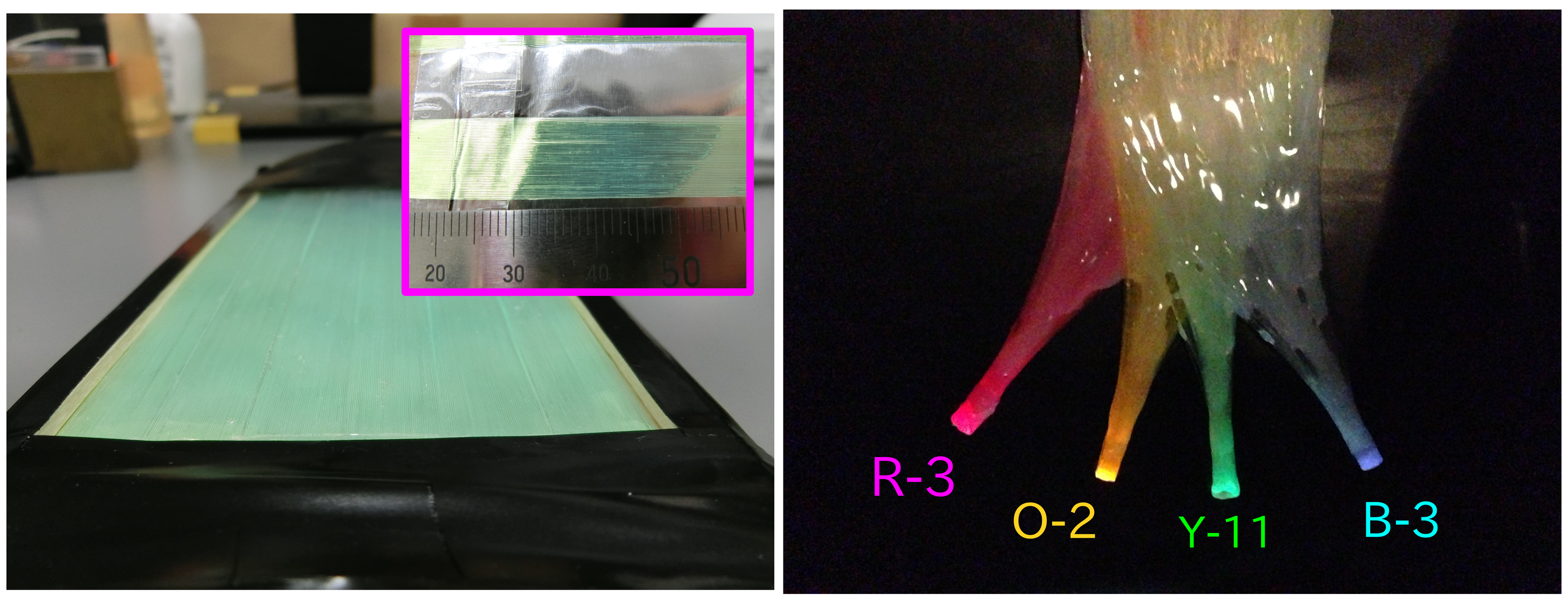

Fig. 1: This light guide made of 4 kinds of wavelength shifting (WLS) fibers has 0.2 mm diameter fibers and effective area of 60 mm x 100 mm (left). The fiber made by Kuraray Co., Ltd. has 4 kinds of wavelengths (right).

Production of Prototype

A prototype counter has an effective area of 120 mm x 100 mm read by the WLS fibers and PMTs. The aerogel radiator have a refractive index of 1.05 and a total thickness of 60 mm. We observed a collection efficiency of about 8%, the mean number of detected photoelectrons of 1.3 p.e., an uniformity of 90% or more, and a timing resolution of 140 ps.

Cherenkov light emitted from the aerogel enters the fiber light guide by being reflected by a V-shaped reflector, and is transferred to 4 ends of the fibers. A cross section of each end of the light guide is 7 mm in diameter, and the connected PMTs have a small photo-cathode of 8 mm in diameter.

Fig. 2: The light guide has two sensitive faces with the fibers (left) and two side faces are covered with it (top right). A box has a V-shaped reflector and internal. Total aerogel size is (120 mm x 90 mm) x 60 mm (bottom right).

Performance Measurement

We performed a performance measurement of the prototypes with a test beam line, where a positron produced from gamma ray of a few GeV/*c*. Two scintillation trigger counters were used at the upstream and downstream ends of the aerogel counter. Cherenkov light emitted from the radiator enter the fiber light guide reflected by the reflector placed at 45 degrees. The efficiency and number of detected photoelectrons were decided from "or" logic with detection events of 4 PMTs. The result and schematic of the setup are shown in figures below.

Fiber Light Guide	effective area[mm^2]	p.e.	error	collection eff.
BYOR	60 x 100	**1.43**	0.03	**8.1%**
BBYY	60 x 100	**1.14**	0.03	**6.4%**
BY	60 x 100	**1.19**	0.03	**6.7%**
BBYY+coating	60 x 100	**1.42**	0.03	**8.0%**
BYOR	120 x 100	**1.31**	0.03	**7.4%**
PMT direct	60 x 100	**17.71**	0.06	

Table. 1. The result of prototype counter's performance.

Summary

We have performed production and performance measurements of the prototype counter. The device did not obtain sufficient number of detected photoelectrons; however, it would be increased by using SiPMs, improving the collection efficiency of WLS fibers, and changing combination with the fibers. Furthermore, we have an idea of covering all of the side face on the radiator. Nobody has been performed it; however, the idea is possible by using the device.

References

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[3] M. Tabata *et al.*, Nucl. Instrum. Methods A 668 (2012) 64.
[4] Kuraray Co. Ltd., Kuraray's Scintillation Materials. Product Catalog. Available: http://kuraraypsf.jp/