Laboratori Nazionali di Frascati

LNF-92/005 (IR)
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A FLEXIBLE LIGHT GUIDE AS A SOLUTION FOR THE READ-OUT OF THE ENDCAPS IN KLOE ELECTROMAGNETIC CALORIMETER

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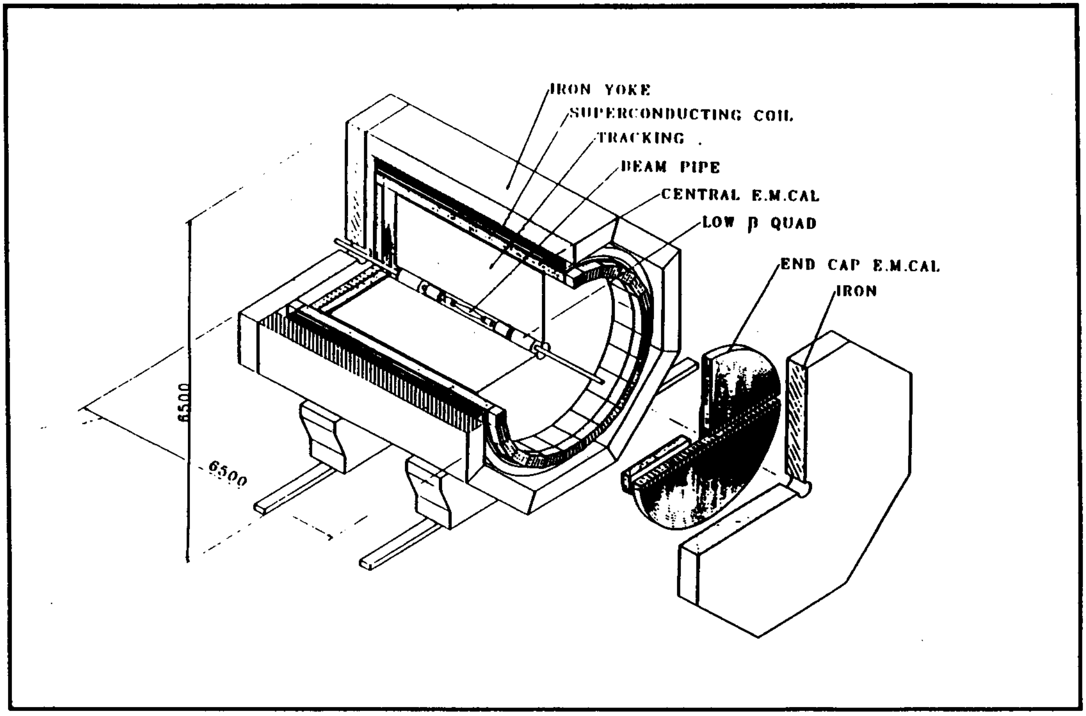
1 - INTRODUCTION AND MOTIVATION

Kloe is a general purpose detector to be used at DAΦNE, the LNF Φ–factory[1]. The detector[2] is optimized for the study of CP violation in K^0 decay. The KLOE electromagnetic calorimeter (EMC) will provide a measurement of energy and angles of photons from low energy neutral pions. In this way, decay length and momentum of the $K_{S,L}$ are determined; the photon energy spectra expected are in the range 20–300MeV.

The proposed EMC[3,4,5] is a fine sampling lead–scintillating–fiber calorimeter for both barrel and endcap region of the detector. The fibers to lead to glue volume ratio is 50:35:15 corresponding to a 10% sampling fraction and a radiation length X_0=1.6cm. The total thickness at normal incidence is 15 X_0 (24 cm).

In the endcap calorimeter fibers are arranged in half circular layers (Fig. 1) with a read–out granularity initially of 3x3cm^2 (for the first 10 X_0) and then of 5x5cm^2. Fibers are read out on both ends by photomultiplier tubes (PMT). Because of the magnetic field, the transport of the fiber signals in a region where high gain PMTs can safely operate is a major issue in the definition of endcap geometry. The design is presently based on two semicircles with an external radius of 2m and internal radius of 30cm, and a plug detector built with the same Pb–SCIFI technique that covers the space left empty to allow the extraction of optical signals (Fig. 2). Various techniques are under consideration to bend the light at 90°: clear fibers fused to the scintillating ones, prisms, Winston cones, alumized mirrors oriented to 45° or flexible light guides. This work presents a study on a flexible light guide, that can represent a suitable solution not only to bend the light but even to transport it outside the magnetic field, because the guide is a compact object that can be easily bent to bring the signals along the designed path.



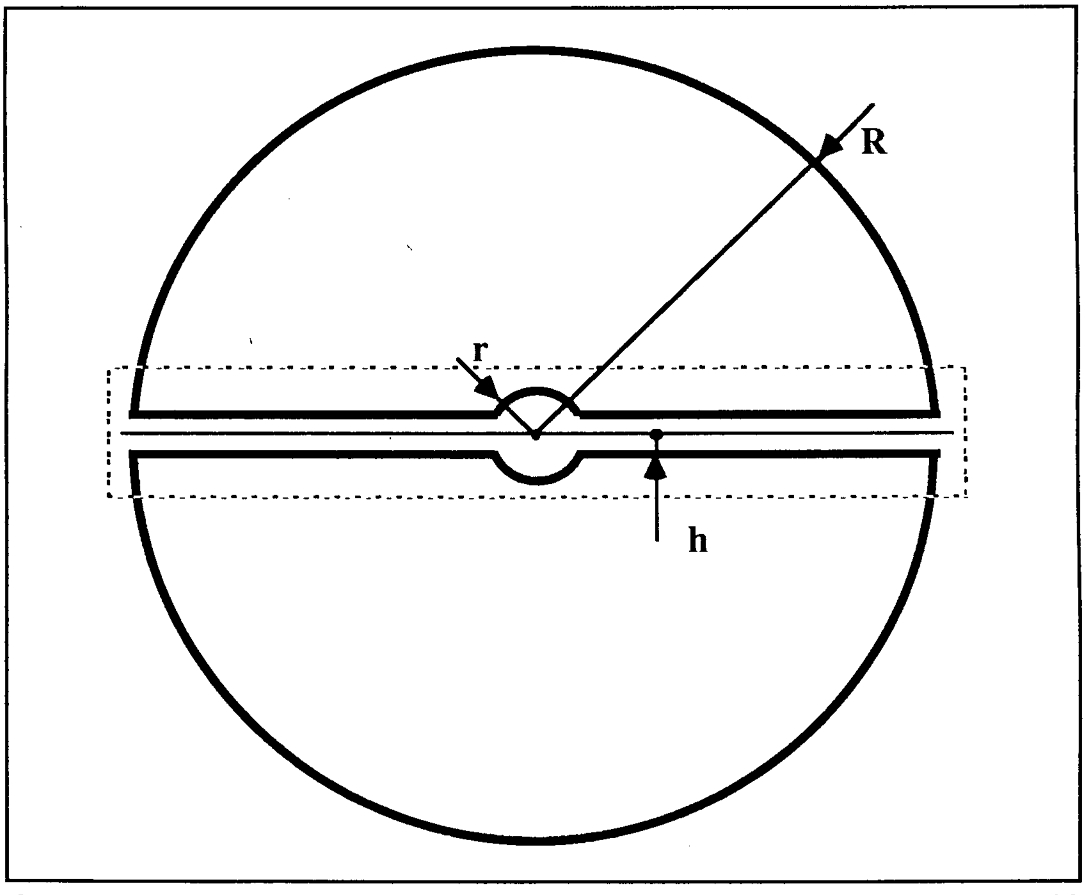


FIG. 2 – A sketch of the endcaps detector. R and r are respectively equal to 2m and 30cm, h represents the half width of the space dedicated to the extraction of the scintillating fibers signals. The dashed line represents the plug detector.

2 - EXPERIMENTAL SET-UP

The flexible light guide in study is a commercial one, produced by LUMATEC, 1m long with an internal diameter of 8mm. The core of this light guide is filled by a liquid with an index of refraction n_{core}=1.445 and it is covered by a plastic material (cladding) with n_{clad}=1.35. The plugs at both ends contains a quartz window.

In Fig. 3 the set–up is shown. We have used as light source a plastic scintillator bar exposed to a ß source (Sr^{90}); the dimensions of the bar ($4x4x40mm^3$) have been chosen to avoid edge effects. The scintillator bar is coupled with silicon grease to the flexible light guide. To improve the reproducibility of the measurement, a rigid aluminum support was used for the flexible light guide, the scintillator bar and the ß source in order to maintain their relative positions. The scintillation light propagates along the flexible light guide by a succession of total internal reflections at the core–cladding interface and is detected at the opposite end by an EMI9902 PMT. The quartz window of the light guide is coupled to the PMT using silicon grease.

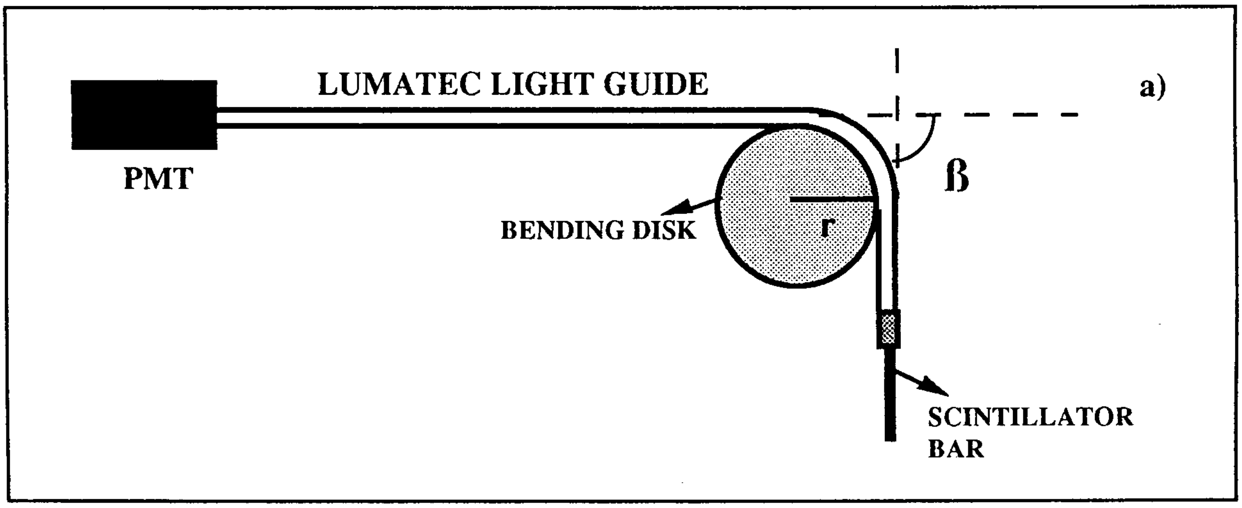


FIG. 3a – Top view of the set–up used for the transmission rate measurement (not to scale).

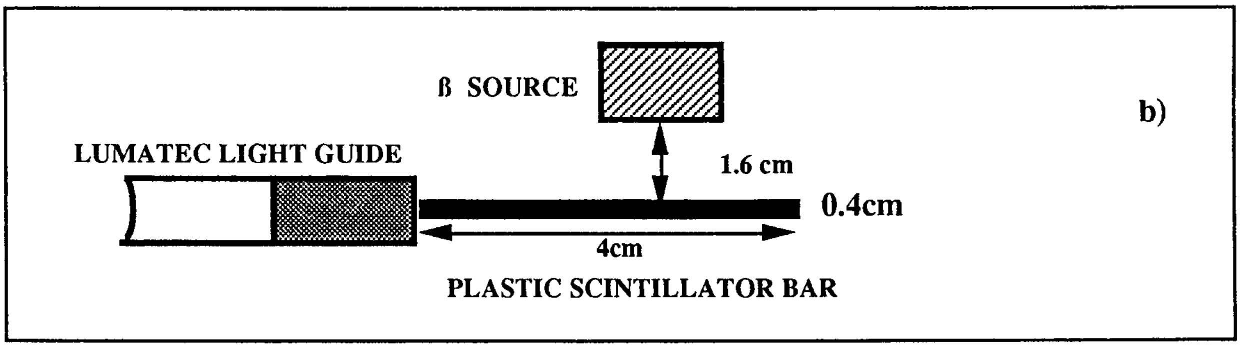


FIG. 3b – Side view of the end of the flexible light guide coupled to the scintillator bar (not to scale).

3 – TRANSMISSION RATE MEASUREMENTS

The purpose of these measurements is to evaluate the relative loss in the light transmitted by the guide as a function of its bending. We define the transmission rate as the ratio between the light transmitted when the flexible light guide is bent and without bending. The transmitted light is measured as the PMT mean anode current. When the flexible light guide is straight the mean anode current I_0 is 12.4μA with a 5% error.

The parameters that play a role when the flexible light guide is bent are essentially two: the bend radius r and the bend angle ß between the two ends (Fig. 3a). At first the transmission rate was measured as a function of the angle ß, keeping fixed the bend radius at two different values (r=7cm and r=11cm), (see Fig. 4). Then the measurement was repeated as a function of the bend radius with a fixed bend angle (ß=180°, value dictated by practical constraints), (see Fig. 5). Taking into account the present endcaps geometry, the half–width of the space allowed for the transport of the fiber signals will be anyway not larger than 20cm, then a possible path for the flexible light guide will have a bend radius of ~10cm and a ß angle of 90°. On the basis of our measurements in this working condition the transmission rate is about 87%.

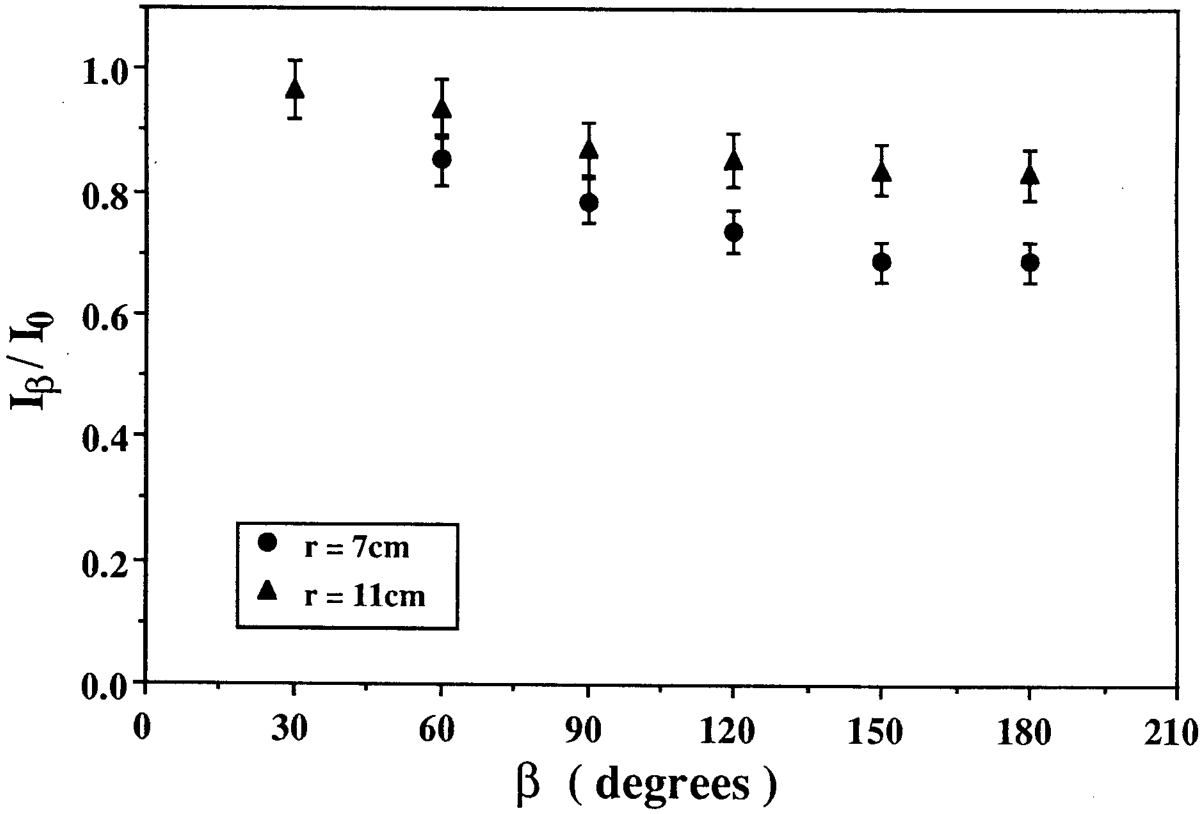


FIG. 4 – Trasmission rate measurement with bend radius fixed.

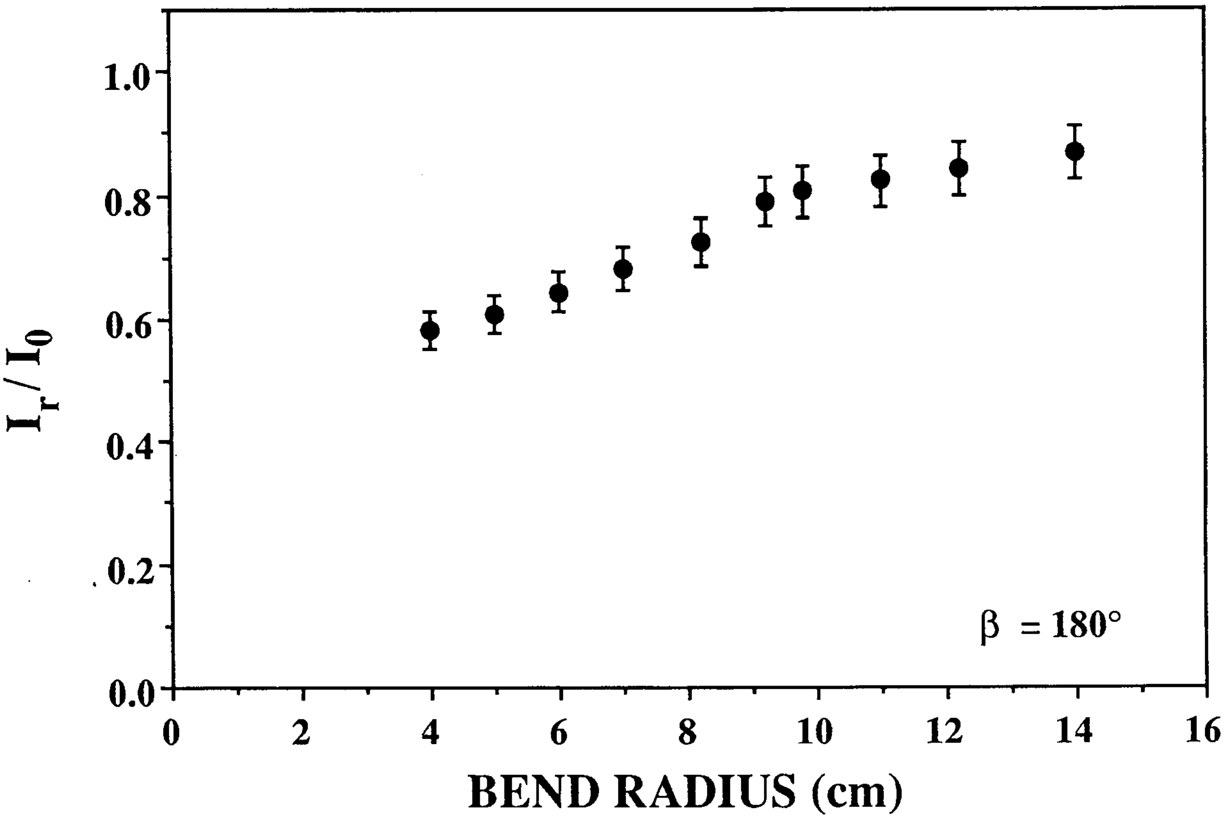


FIG. 5 – Trasmission rate measurement at fixed angle.

4 - CONCLUSIONS

We have measured the relative loss in the light transmitted by the Lumatec guide under few bending conditions. For the configuration foreseen in the present design of the endcap calorimeter, this kind of light guide shows a completely acceptable loss in the transmitted light, making this solution suitable to transport the scintillating fiber signals. We intend to study furtherly the behaviour of this guide, measuring the absolute efficiency of the scintillating fibers–PMT coupling via the Lumatec guide, both with direct scintillating fiber–quartz window coupling and with the scintillating fibers inserted directly inside the liquid of the guide.

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