KLOE Facts

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As part of the CDR chapter section on BCAL, this subsection describes the KLOE calorimeter and performance.

Overview

As noted earlier, the solenoidal geometry of the GlueX exotic hybrid search experiment drives the need for a cylindrical (barrel-shaped) electromagnetic calorimeter to measure photons from π^0 and η decays. The GlueX geometry calls for this calorimeter to be approximately 4 m long with a thickness that will fit inside the bore of the solenoid while accommodating a tracking detector around the target. The electromagnetic detector used in the KLOE detector [1] at DAΦNE [2], the Frascati ϕ-factory, operates in a magnetic field and has similar requirements.

The KLOE calorimeter [3, 4, 5] consists of 24 lead-scintillating fiber (Pb/SciFi) modules that are 4.3 m long and 23 cm thick with a trapezoidal cross-section of bases 52.5 and 59.0 cm. The inner radius of the KLOE calorimeter is 2.0 m. The fibers run along the length of the module and are glued into grooved 0.5 mm thick lead foils. The fibers used are Kuraray SCSF-21 and PoliHiTech 0046. These fibers emit "blue" light. The glue is Bicron epoxy BC-600ML [4]. The attenuation lengths of the SCSF-81 and PoliHiTech fibers are 321 ± 5 cm and 284 ± 5 cm respectively [6]. The light propagation velocity in the fibers is $v_p = 16.9$ cm/ns independent of fiber type [6]. The fiber:lead:glue ratio is 48:42:10 and the matrix has an average density ρ of approximately 5 gm/cm^3 and a radiation length X_0 of approximately 1.5 cm. The sampling fraction is 12%.

There are 60 readout segments at each end of the 24 modules requiring a total of 2888 PMT's (Hamamatsu R5946/01 fine mesh 1.5-in diameter). Each segment is 4.4 cm wide and the first four layers (starting closest to the beam) are 4.4 cm thick and with the fifth layer being 5.2 cm thick. The five segments are aligned along the azimuthal angle ϕ. The segmentation for one end of a module is shown in Figure 1.

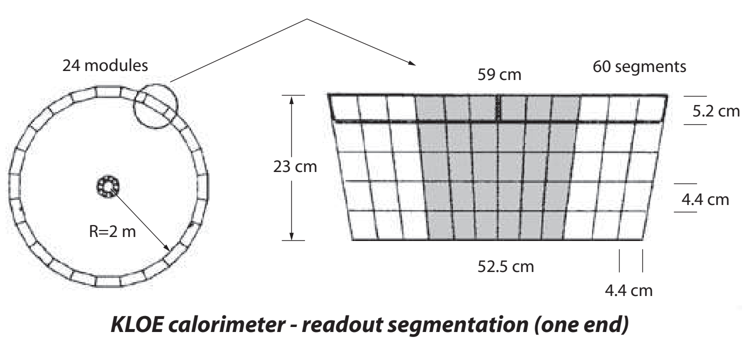

Figure 1: Taken from Figure 5 of reference [7].

Performance characteristics

The KLOE calorimeter performance characteristics [4] are summarized in Figure 2. The energy resolution is given by $\sigma(E)/E = 5.4\%/\sqrt{E(GeV)}$ where the resolution is dominated by sampling fluctuations, the contribution from photoelectron statistics being about 2.7%. This latter number was determined by looking at the fluctuation in the ratio of the response from one end relative to the other leading to a estimate of about 700 photoelectrons per side for a 1 GeV photon at the center of the module [8]. From cosmic ray tests, the photoelectron yield for 1 mm of crossed scintillator for a minimum ionizing particle at 2 m from a "standard" bialkali photocathode PMT is $N_{p.e.} = 2.4 \pm 0.2$ for the SCSF-81 fiber and $N_{p.e.} = 1.8 \pm 0.2$ for the PoliHiTech fiber [6].

The resolution in the time difference between the two ends of a module is given by $\sigma_t = 56/\sqrt{E(GeV)} \oplus 133$ ps [8]. This resolution determines the position (z) resolution along the length of the module since $\sigma_z = v_p \cdot \sigma_t/2$. The error in the transverse coordinate ($\delta(R\phi)$, where R is the inner radius) is 4.4 cm$/\sqrt{12}$. The photon detection efficiency is $> 99\%$ for $E_\gamma > 80$ MeV and the linearity is within approximately 1 to 2% for $E_\gamma > 50$ MeV [4]. The mass resolutions for the π^0 and η are completely dominated by the photon energy resolution [8]. The sigma of the diphoton mass distribution for $\pi^0 \to \gamma\gamma$ events is 14.7 ± 0.1 MeV$/c^2$ and for $\eta \to \gamma\gamma$ events is 41.8 ± 0.5 MeV$/c^2$ [9].

As part of the KLOE physics program, the KLOE calorimeter has measured a number of decays, such as $\phi \to \pi^0\pi^0\gamma$ [10] and $\phi \to \eta\pi^0\gamma$ [11]. It is important to point out differences in the GlueX and KLOE applications of the barrel calorimetry. In KLOE, the intersection region is placed symmetrically about the calorimeter which is symmetrically illuminated by photons. In GlueX the 30-cm target is placed near one end of the calorimeter and the majority of photons illuminate the section near the opposite end. In KLOE the photon energies are quite low, the average less than 250 MeV, whereas for GlueX the average photon energy in the barrel calorimeter is more like 1 GeV.

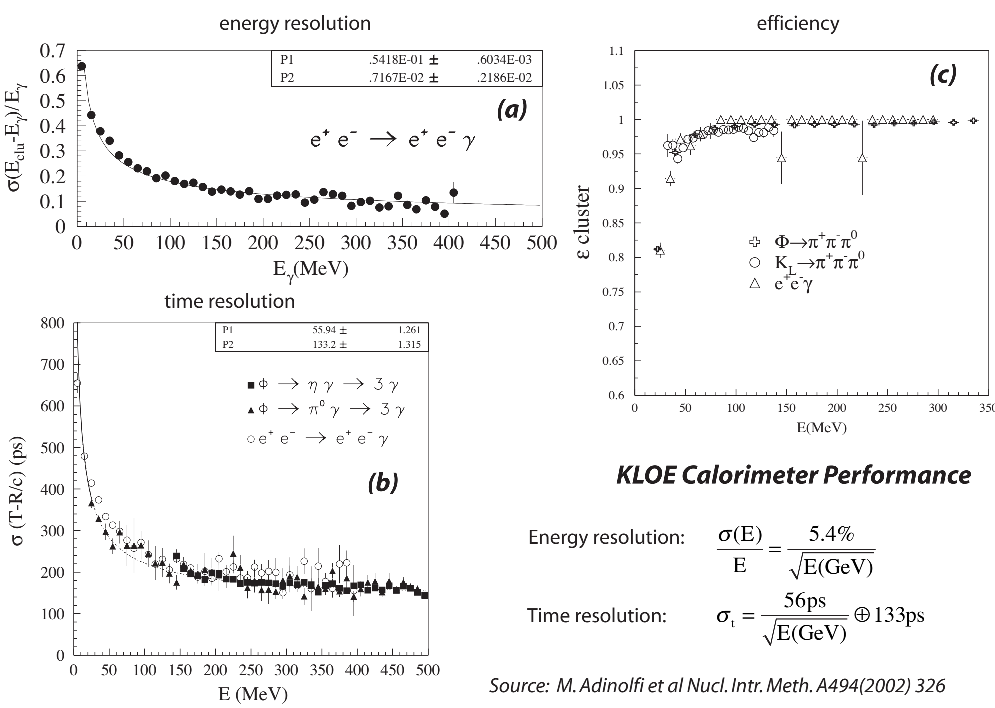

Figure 2: Figures from reference [4]. (a) energy resolution as a function of energy; (b) time resolution as a function of energy; and (c) photon detection efficiency as a function of energy.

References

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