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Recent developments in particle identification

Mehdi BENKEBIL

Laboratoire de L'Accélérateur Linéaire
IN2P3-CNRS et Université de Paris-Sud, F-91405 Orsay

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U.E.R
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Institut National
de Physique Nucléaire
et
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Bâtiment 200 - 91405 ORSAY Cedex

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Mehdi Benkebil
Laboratoire de l'Accélérateur Linéaire
IN2P3-CNRS et Université Paris-Sud, 91405 Orsay

Abstract

Two types of particle identification detectors will be described in the present article, the RICH and the DIRC. They will be installed in CLEO III at Cornell and in BaBar at PEP II, respectively.

1 Introduction

The construction of B meson factories led increased interest in particle identification detectors. Indeed, a new developments on the Ring Imaging Cerenkov counters (RICH) has been done during these last years. On the other hand, a new technique based on the total reflection of Cerenkov light in a radiator has been adopted for one of the B-factories detector, BaBar[2]. This type of device is called the DIRC, acronym for Detection of Internally Reflected light. In the RICH technique, used by CLEO III detector[1], the detected lights emerge from the radiator and expand in a cone. However, in the DIRC detector the emitted photons propagate in the radiator by total reflection and conserving the Cerenkov angle until the detector plane.

The physics requirement for both experiments CLEO III and BaBar are similar in the principle. They need to achieve a good K/π separation. In case of CLEO III, the separation should be performed in the momentum region up to $2.8GeV/c$. Due to the boost, the particle identification in BaBar must achieve this separation in a larger momentum range (1.5 to 4 GeV/c). Also, a kaon identification is required for the B mesons tagging in a 1 GeV/c momentum range. Finally, the CLEO III and BaBar should be capable to detect low energy photons. This requires that the detector in front of the electromagnetic calorimeter should be thin in the physical dimensions and radiation length.

2 The RICH of CLEO III experiment

The RICH of CLEO is aimed to achieve, with the dE/dx, a 4σ separation between kaons and pions. It also represents 13% of a radiation length for a track of normal incidence. Its design is based on the work done by the College de France and Strasbourg group [3]. It contains some modifications from the initial design: analog readout, a sawtooth shape for the radiator and some modification of the wire chamber parameters.

The detector (fig. 1) is composed of a LiF radiator medium where the photons are refracted. Then, an expansion zone filled with Nitrogen due to the fact that the emitted Cerenkov light is in the ultra-violet region. Finally, a photon detector which consists of a multi-wire chamber filled with a mixing of 93% CH_4 gas and 7% Triethylamine (TEA) vapor. The 230.000 cathode pads in the chamber will detect the induced charge from the avalanche.

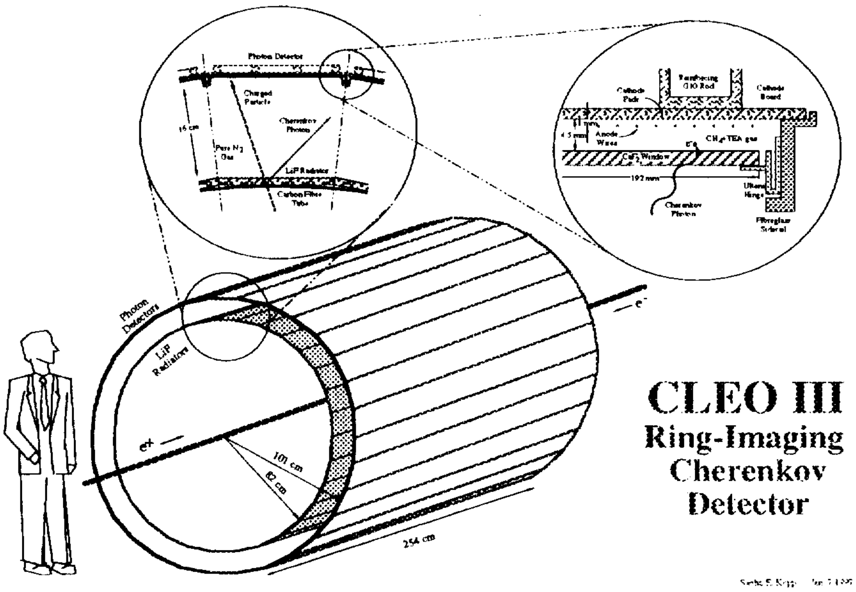

Figure 1: The mechanical elements of the RICH detector

2.1 The performance of the prototype in the beam test

A prototype composed of a 15×80 cm^2 chamber with its final gas mixture has been exposed to cosmic rays at Syracuse University. This test's goals are to study the mechanical feasibility such as corrosion of the materials to the TEA, the behavior of the wire chamber and the resolutions. For the chamber, no loss in the gain has been observed. The plateau has been reached with a gain of 2×10^4. At that gain, the number of reconstructed Cerenkov photons is 12 with a resolution per photon of 15.5 ± 0.5 *mrad*. By applying correction due to the limited acceptance, the resolution per Cerenkov photons will be 14 *mrad* with 13 photoelectrons detected per track of $\beta = 1$. These results are consistent with what it is expected from the Monte Carlo study. Thus, the CLEO III RICH could reach a 3.3σ separation between kaons and pions at 2.8 GeV/c.

For the prototype with the final geometry of the radiator, the beam test is underway at Fermilab. The initial results show that the chambers are stable and the lost of read-out channels is only 1%.

3 The DIRC detector for BaBar experiment

It is aimed to achieve more than 3σ separation up to 4.0 GeV/c with 20 to 50 detected photoelectrons. It is fast and tolerant to the background. Its radiation length and physical dimensions allow to the electromagnetic calorimeter to detect low energy photons. The device 2 is composed of 144 synthetic quartz bars in groups of 12 with the dimension $1.7 \times\ 3.5 \times 490$ cm^3. Each bar is obtained by gluing 4 bars of 122.5 cm length which is the longest bars of good quality commercially available. At the end of the bars, a mirror is placed in order to recover the forward going photons. When the Cerenkov photons leave the bar, they pass a wedge made of quartz which is used to reflect the photons coming from the upper side of the quartz. Then, these photons reach the expansion zone, called Standoff box, filled with a volume ≈ 6 m^3 of purified, de-ionized water. Finally, the detector plane is populated of 11000 photomultipliers placed on a toroidal surface.

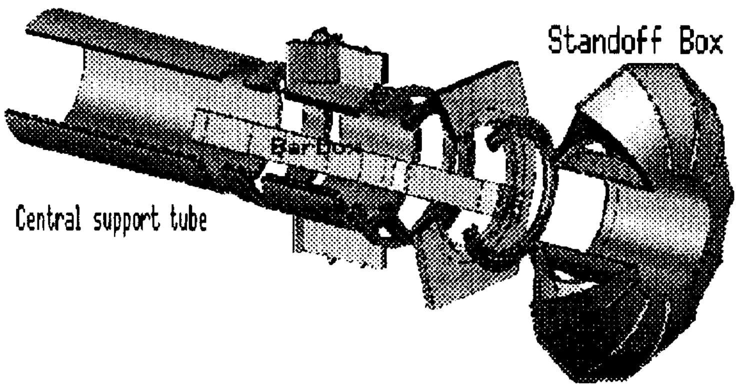

Figure 2: The mechanical elements of the DIRC detector

3.1 The performance of the prototype II in the beam test

The DIRC prototype II has a simple geometry compared to the final design. The standoff box has triangular cross section, and 500 PMTs were placed on a quartz windows in order to facilitate rearranging the coverage of Cerenkov ring. For the radiator, two quartz bars have been glued together to form a 2.4 m long bar.

The angular resolution per photon obtained during the beam test at CERN [4] is 10.2 $mrad$ which is in agreement with the Monte Carlo simulation. The measured separation between kaons and pions for 2.7 GeV/c momentum tracks is 3.6σ. This results corresponds to the detection of about 20 Cerenkov photons at track dip angle equal to 20^o which is the worst case in BaBar. Since the mean travel length of the photons in BaBar is about 5 m, the attenuation of the light in the quartz bar is an important parameter and has been found to be only $4.1\%/m$. Other results could be explored in the ref. [4]. Other tests on the final components of the DIRC have been successfully performed such as: the operation of PMTs in water, light catchers, background study.

4 Conclusion

We have reviewed two novel techniques of particle identification: RICH and DIRC. The detectors have the same goals but not at the same momentum range. The beam tests on the devices showed that both can meet the physics requirement needed for B physics at CLEO III and BaBar experiments.

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