An Aerogel RICH Detector for CLAS

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In this note I will briefly outline progress on the design of a ring imaging Cerenkov detector (RICH) utilizing a silica aerogel radiator for integration into the CLAS detector. This detector will be used to augment particle identification in the CLAS detector when operating with higher energy electron beams.

At increased JLAB energy there is a need for additional particle identification beyond the current CLAS capability. In particular, the separation of kaons from pions using ordinary time of flight becomes less useful for momenta much greater than 2 GeV/c, whereas for an incident energy of 10 GeV the momentum of produced kaons within the CLAS acceptance will be greater than 6 GeV/c. In order to achieve this separation two types of Cerenkov techniques, threshold and ring imaging (RICH), have been commonly applied. Recently, there have been technological developments which have simplified the technology of RICH detectors and opened up the potential for their more common use.

First, the quality of silica aerogel has been improved in the light transparancy and index of refraction (n) variability so that they have been shown to be useful Cerenkov Radiators. Second, techniques for detecting the rings of Cerenkov light with good resolution are being developed.

Figure 1. shows a possible scheme for such a detector placed as the first element in the upgraded CLAS. The detector, as drawn, consists of aerogel radiators of thickness 5 cm, and spherical mirrors to reflect the Cerenkov light outside the maximum acceptance angle of the CLAS.

Aerogel: The new generation of aerogel has been developed for manufacture by the Matsushitu Electric Works in Japan and can be obtained in large quantities, and with variable n upward of about 1.01. This material can be used for kaon/pion separation, and indeed has been installed in a Cerenkov detector at HERMES [3], and it is planned for use at LHC [4]. One of the main disadvantages of aerogel is that the transmission of light T, due to Rayleigh becomes worse according to the equation $T = Aexp(-Ct/\lambda^4)$, where C is a *clarity factor*, and t is the thickness. One can see that T is very non-linear as a function of λ and t. Figure 2a. shows T vs λ for several thicknesses of aerogel with $n = 1.03$ measured in ref. [2]. It is apparent that only visible light is transmitted, whereas the Cerenkov light intensity increases in the UV according to $1/\nu$, where $\nu = 1/\lambda$.

Figure 2b. shows the threshold and opening angles for Cerenkov light for pions and kaons, as a function of momentum, for various n radiators in the momentum range of interest at CLAS.

It is seen that for $n = 1.02$ the detector can operate in a threshold mode for momenta almost up to 3 GeV/c. For $n = 1.01$ the threshold is about 0.5 GeV/c higher. For momenta greater than about 2.5 GeV one would have to

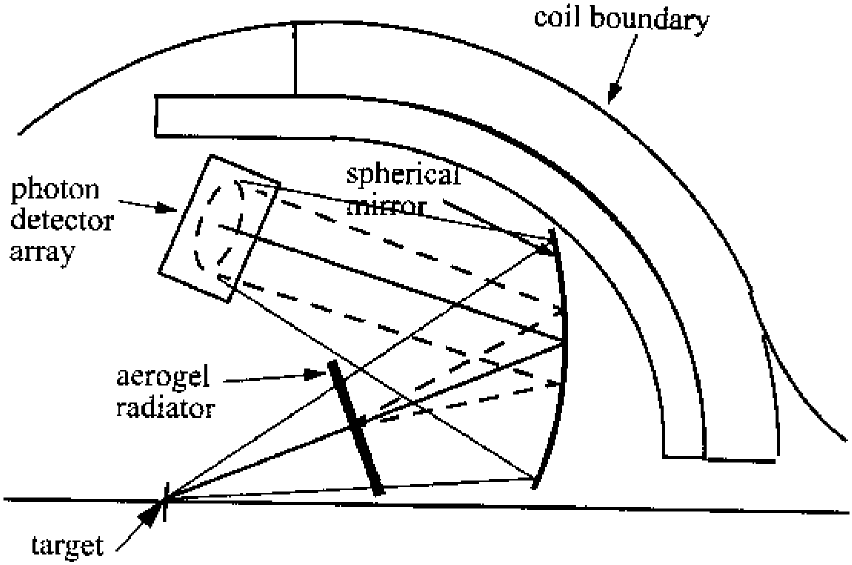

Figure 1: Possible design of aerogel RICH detector to be installed in the upgraded CLAS. One of the six elements is shown. The detectors upstream of the RICH detector are the calorimeter and tracking detectors which lie within the boundries of the the solenoid coils. The dashed lines represent the Cerenkov light ring.

operate in the RICH mode. Some of the criteria which must be considered for the aerogel are as follows. The higher n the greater the number of photons and the larger the Cerenkov light cone radius. However, the smaller n the greater the relative angles between pions and kaons and the larger the range of momentum it can usefully operate. The thicker the radiator, the greater number of photons, but the greater the thickness of the ring, which reduces pion-kaon separation ability. Also, the thicker the radiator the greater the Rayleigh scattering of the Cerenkov light, so that the increase in the number of photons is not linear.

Mirrors: In order to minimize multiple scattering upstream of the particle tracking drift chambers the mirror structure must present the minimum density material to the particle trajectories. Although the structural design of the present outer gas Cerenkov detectors is very light, due to the relatively smaller size of the mirrors in the RICH proposed detector we anticipate developing an even less intrusive structural design.

Light detection: Several methods have been considered to deteect the Cerenkov light with enough resolution to resolve the rings. The most straightforward solution is to construct a "honeycomb" of small (1/2″) photomultiplier tubes, covering the entire focal surface. This has been shown to work well [1],

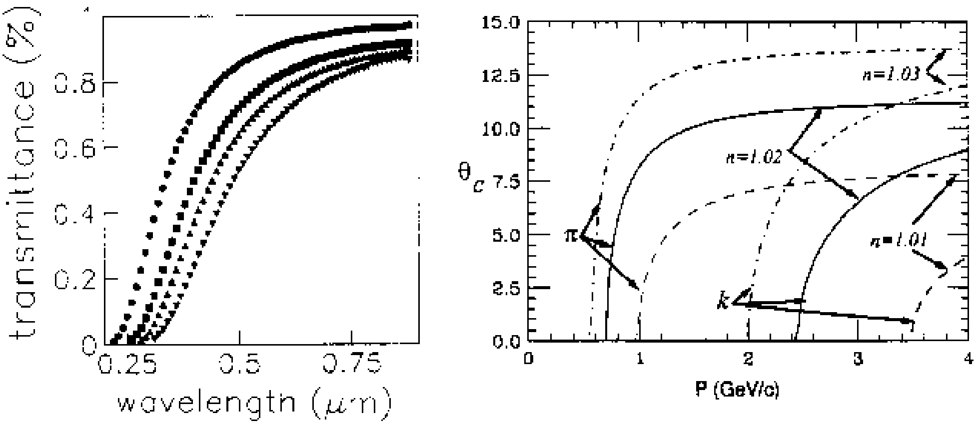

Figure 2: a) Transmission T vs λ for several thicknesses of aerogel with $n = 1.03$ measured in ref. [2]. Upper curve: $t = 1$ cm. Lowest curve $t = 4$ cm. (b) The threshold and opening angles for Cerenkov light for pions and kaons, as a function of momentum, for various index of refraction radiators in the momentum range of interest at CLAS.

and has been chosen for HERMES [3]. However, for the several thousand required the costs would be prohibitive. A possibly attractive solution is *hybrid photon detectors* (HPD's) which are currently under development at CERN [5]. These are essentially very high gain tubes which have been tested to have a spacial resolution of $\sigma \sim 0.7$ mm over a surface diameter of about 11 cm. The single photon resolution is also far better than any photomultiplier tube. Figure 3. shows a cross section of the HPD and the silicon pixel detector layout. It is planned to manufacture a large number of these for LHCb. This is one of the options which we will be under study for this application at JLAB.

References

[1] R. De Leo et al, Nucl. Inst. Meth. A **401** , 187 (1997)

[2] E. Nappi, private communication; R. De Leo et al, preliminary CERN report (1998).

[3] E. Cisbani et al, HERMES proposal, March 1997;

[4] Y.Ypsilantis and J. Seguinot, Nucl. Inst. Meth. A **368** , 229 (1995), P. Weilhammer, these proceedings. H. Jackson, private communication, B. Filippone, private communication.

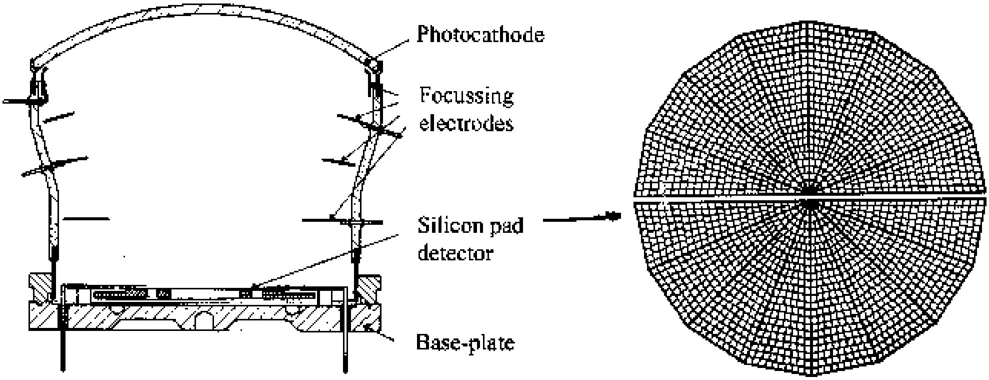

Figure 3: Left: cross section of newly developed HPD detector for CERN LHC-b. Right: the layout of the silicon pixel array. The operating potential between the photocathode and the silicon pixel array is about 20 kV.

[5] E. Chesi et al., CERN-PPE/96-202 (1996), also to be published; J. Seguinot, E. Chesi, private communication.