Test of the Burle 85011 micro-channel plate PMT as the detector of Cherenkov photons

status report - all numbers are preliminary!

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***Abstract*— Using aerogel as radiator and the Burle 85011 multianode micro-channel plate PMT for photon detection, a proximity focusing Cherenkov ring imaging detector has been constructed and tested in the KEK $\pi 2$ beam. The aim is to experimentally study the performance of the novel type of photon detector, in particular its ability to efficiently detect single photons.**

***Index Terms*— micro-channel plate PMT, Cherenkov counters, aerogel, multianode PMTs, Belle spectrometer.**

I. Introduction

The present paper reports on experimental investigation of a novel type of photon detector, the Burle 85011 multianode micro-channel plate PMT, in an aerogel based RICH detector of the proximity focusing type. Such a detector is being considered in connection with a possible upgrade of the BELLE particle identification system at KEK.

II. The experimental set-up

Beam test studies of a similar device, with flat pannel PMT Hamamatsu 8500 as photon detectors, were reported recently [1]. The present paper describes measurements and results obtained with the new photon detector in the same π 2 beam at KEK. A beam particle - pion, muon or electron - traversing the apparatus is signaled by two 5×5 cm^2 scintillation counters which determine the time of arrival. Two CO_2 gas Cherenkov counters produce signals only upon the passage of electrons so these signals could be used either to select or to exclude electrons.

The aerogel radiator and the position sensitive, single photon detector are contained in a light tight box (Fig. 1), of which the entrance and exit sides each have a multiwire proportional chamber for measuring the track of the incident particle. These 5×5 cm^2 MWPC's, with 10 μm diameter, gold-plated tungsten anode wires at 2 mm pitch and with 90% Ar + 10% CH_4 gas flow, are read out by delay lines on the x and y cathode wires.

After passing through the entrance MWPC, the charged particle hits the aerogel radiator in which it emits Cherenkov photons. The position sensitive detector of Cherenkov photons is situated 20 cm downstream of the aerogel. The photon detector is a multichannel device with 8x8 channels, an active area size of 48 mm $\times$ 48 mm, and with 5 mm $\times$ 5 mm large pads, separated from each other by a 1 mm gap.

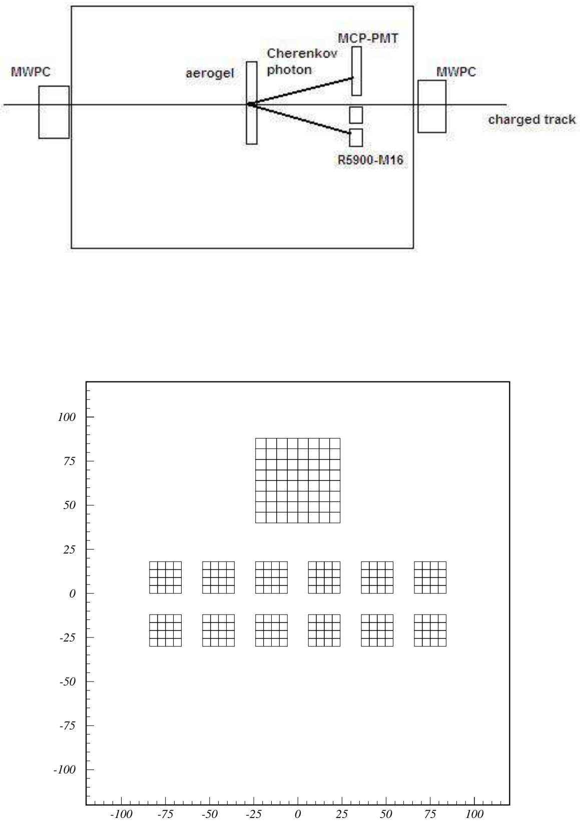

Fig. 1. The experimental set-up: side view (top), photon detector plane (bottom).

In addition to the detector under study, and array of 6×2 16 channel multianode photomultiplier tubes (Hamamatsu PMTs type R5900-00-M16 with borosilicate window [2]) at 30 mm pitch is used as a reference detector, covering parts of the same Cherenkov ring (Fig. 1). The photon detection system and the aerogel radiator tile may be rotated around an axis perpendicular to the beam direction, enabling measurements of the number of detected Cherenkov photons and the Cherenkov angle resolution as a function of the charged particle incident

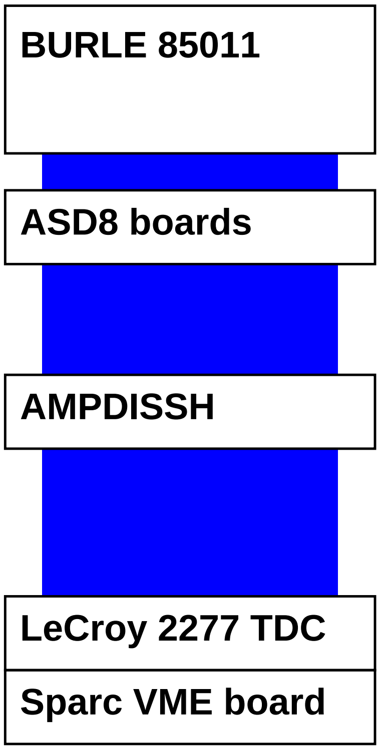

Fig. 2. Read-out system.

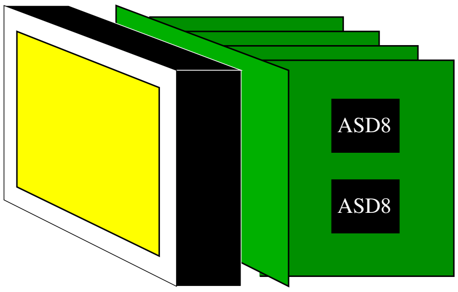

Fig. 3. Read-out system: the first stage in the light tight box.

angle.

The photon detector under study is plugged into a signal routing board inside the light tight box with signals passing through connectors to the readout system (Fig. 2). The first stage of the read-out is inside the light tight box. In this stage the PMT anode signals are first amplified, shaped and discriminated in the ASD08 chips [3]. This first read-out step is very much the same as for the HERA-B RICH counter [4]. The discriminator output, digital output realized as a current source, are led out of the light tight box to the AMPDISSH boards. There they are converted to the standard ECL logic signals. The ECL outputs are then recorded by CAMAC multihit, multichannel TDCs, for which the common STOP is provided by the scintillation counter signals. The TDC information is stored for later analysis.

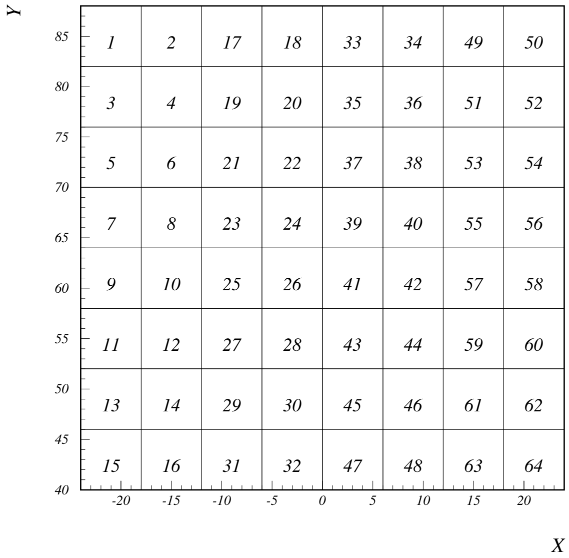

Fig. 4. Read-out system: the mapping of anode channels to the read-out channels.

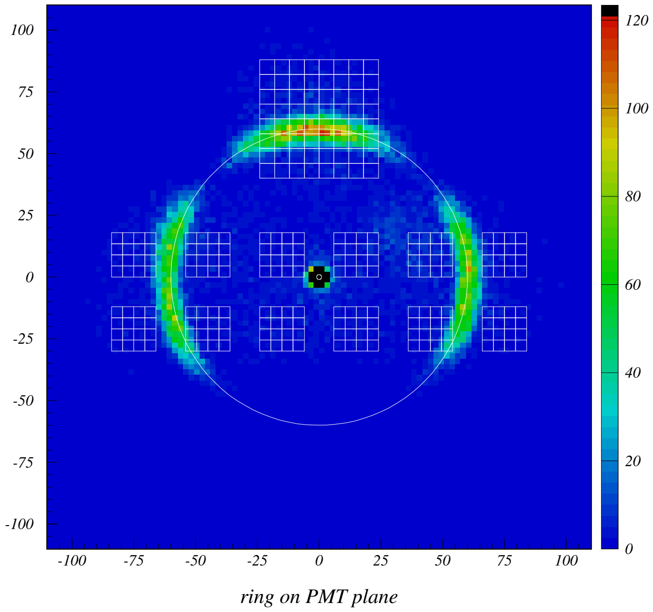

Fig. 5. Accumulated hits corresponding to Cherenkov rings, as recorded with the photon detector under study (top part) and the reference counter (bottom).

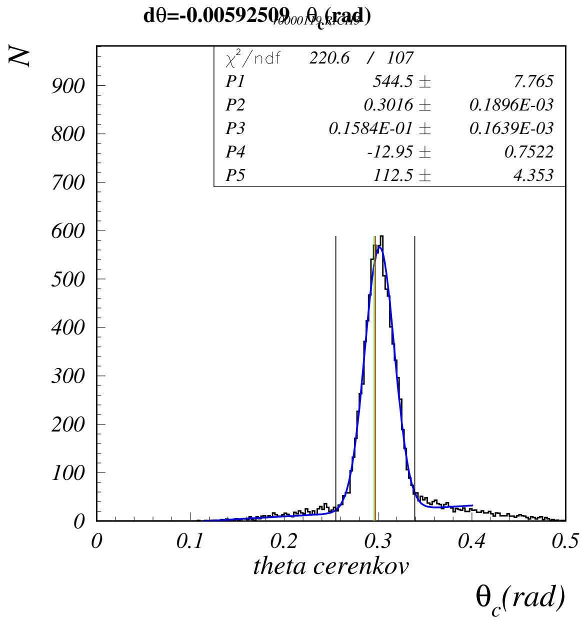

Fig. 6. The distribution of Cherenkov angles measured for 3 GeV/c pions, radiating in an $n = 1.046$ aerogel radiator.

III. Measurement and Results

Accumulated hit distribution, corrected for the track position and direction, is displayed in Fig. 5. From the photon hit position and the measured direction of the incident charged particle, the Cherenkov angle is calculated. Accumulated distributions of hits, depending on their Cherenkov angle, is plotted in Fig. 6. The peak, corresponding to pions, is clearly visible. Fitting this distribution with a Gaussian function and a linear background yields the average value and standard deviation of the measured Cherenkov angle, as well as the number of photons per ring section, covered by the counter.

The number of detected Cherenkov photons per incident charged particle was extracted from the integral of the Gaussian function in Fig. 6. For this specific case (run 119) $N_{phot} = 1.29$ was detected per section of the ring covered by the active area of the photon detector. If $N_{phot} = 1.29$ is extrapolated to the full ring (and full active area is assumed), the number of detected photons would be 9.7. Taking into account the active area fraction of the MCP PMT, the number of photons per ring would amount to about 4.9 if the photon detector surface were covered by this type of counter. The reference photon detector registered 2.19 photons; the corresponding extrapolated values are 16.2 (full active area) and 5.8 (densely packed tubes).

The photon yield was also studied as a function of the high voltage applied to the photon detector. As can be seen from Fig. 7, the saturation was reached below the standard operating voltage of 2350 V.

The main contributions to the resolution in Cherenkov angle as determined from a single photon (standard deviations of the peaks in the distribution of Fig. 6) come from pixel size and

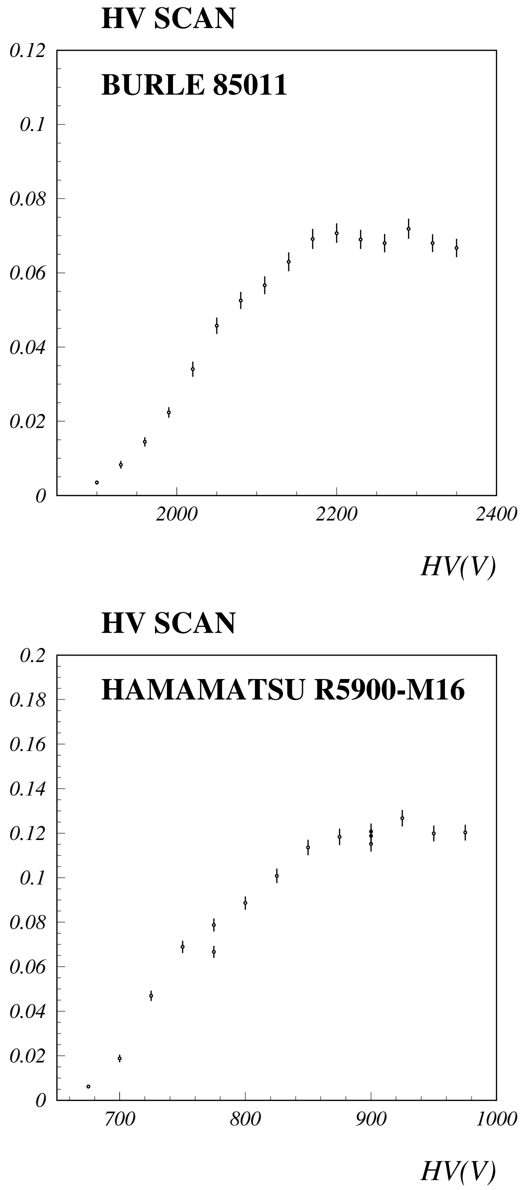

Fig. 7. Photon yield (arbitrary units) as a function of high voltage applied to the photon detector: Burle 85011 MCP PMT (top), Hamamatsu R5900-M16 (bottom).

from uncertainty in the emission point. The measured value, $\sigma = 15.8$ mrad, corresponding to the parameter $P3$ of the fit in Fig. 6, is in reasonable agreement with the expectation. Note that on the reference photon detector with slightly smaller pads (4.5 mm instead of 5 mm) a resolution of 14.3 mrad was observed.

Finally, in Fig. 8, the variation is shown of the single photon Cherenkov angle resolution with high voltage applied to the photon detector. The slight increase at highest values might indicate an onset of cross-talk, however no corresponding effect can be seen in the saturation of yield (Fig. 7). This issue is still under study.

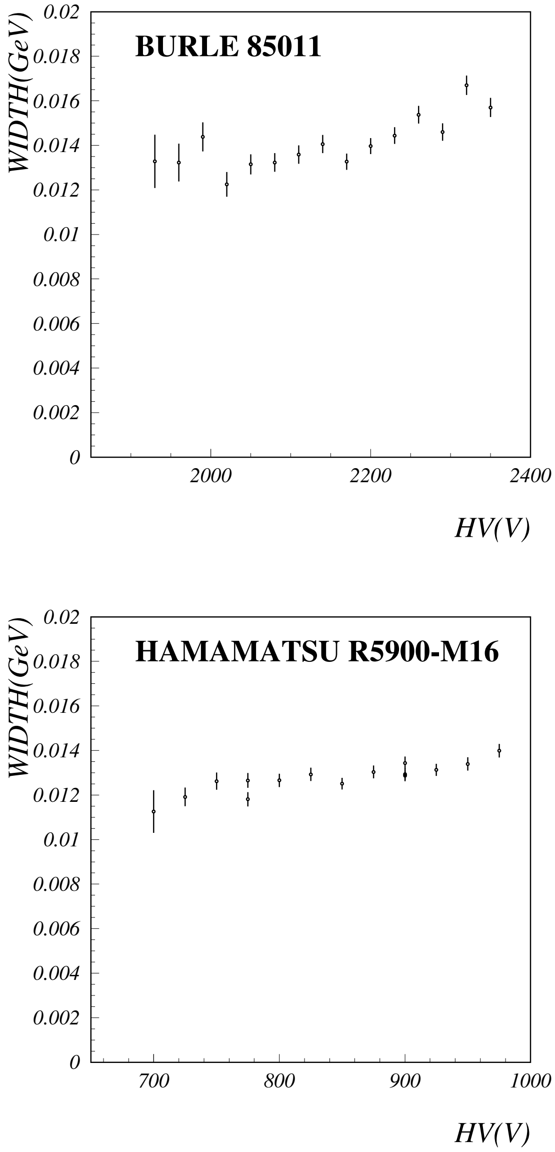

Fig. 8. Single photon Cherenkov angle resolution as a function of high voltage applied to the photon detector: Burle 85011 MCP PMT (top), Hamamatsu R5900-M16 (bottom).

IV. CONCLUSIONS

We have constructed and tested a proximity focusing RICH detector module with aerogel as radiator and multianode microchannel plate PMT Burle 85011 as position sensitive detectors of individual Cherenkov photons....

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