Surface sensitivity of multianode photomultiplier tubes

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Abstract

The sensitivity of three different multianode photomultiplier tubes (Hamamatsu R5900, type M4, M16 and L16) has been measured by scanning a 30 μm diameter light spot across the photocathode surface. For the M16 photomultiplier, the scan has been performed with three different color light sources (blue, green and red LEDs). Also the response at different incident angles of the light beam has been measured.

1 Introduction

For detection of Cherenkov rings in the HERA-B detector, 2300 multianode photomultiplier tubes (M4 and M16 Hamamatsu R5900) are being used [1]. Prior to installation they have all been tested with respect to gain and high voltage behavior [2,3]. In order to investigate the uniformity of response across the photocathode surface, as well as the dependence of the response on the photon wavelength and incident angle, we have constructed a computer controlled experimental set-up described below. Previous measurements of EMI 9956QB and EMI 9956QQB photomultiplier tubes by Veloso and Conde [4] have shown a dependence of the uniformity on both the wavelength and the angle of incident light. These parameters could be especially important in cases where multianode photomultipliers are used for read-out in combination with light concentrators [5].

2 Experimental set-up

The multianode photomultiplier tube and the light source are both enclosed in a light tight dark box (Fig. 1). For the light source, three different color light emitting diodes (LEDs) have been used (Fig. 2). With the eyepiece of a microscope, a light spot of about 30 μm diameter on the photocathode surface has been obtained. The light spot has been scanned across the surface of the PM window in steps of 125 μm, using a computer controlled 2D displacement system. The computer also adjusts the PM high voltage (via the CAEN-NET card), as well as sets the discrimination levels (Philips Scientific Mod.7106 CAMAC 16 channel discriminator) and reads out the count number for a preset measuring time (CAEN 16 ch. scaler C257) through the GPIB interface (LeCroy 8900A) (Fig. 3).

3 Results

The images obtained by scanning the three different types PMT's: M4 (s/n: LEA0055), M16 (s/n: KA0349) and L16 (s/n: LMU102) at normal incidence of light are shown in Fig. 4. Besides the metal foil dynode structure, which is clearly visible, one may also notice a sensitivity at the edges of the PMT glass window, outside of the channel geometrical acceptance. This is explained as refraction and reflection of light in the glass walls of the PMT vacuum vessel. Fig. 5. shows the count rate distribution across the M16 PMT surface (in the direction perpendicular to the metal foil channels) for the three different colors of LED light sources used. A gradual reduction of structure with decreasing wavelength is presumably due to the higher transverse velocity of the photoelectrons. Although the cross talk between neighboring anode channels of the M16 PMT is quite low [3], we notice a very slight increase at lower wavelengths (??).

An interesting effect is observed when photons are incident at an angle with respect to the normal on the photocathode (Fig. 6). In that case, a given anode channel is generating pulses although the beam is hitting the photocathode at relatively large distances from the channel in question. This particular kind of cross-talk (??) is however limited to the direction of the light beam inclination. The structure seen in the rate position dependence (Fig. 7) suggests that the transmitted light could be producing photoelectrons in the dynode system or could be reflected from the first metal foil back to the photocathode. A small contribution could also be expected from multiple reflections within the PMT window. For a more quantitative estimate of these effects, we show in Fig. 8 the count rate of one anode channel as a function of position in the direction of beam inclination for four angles of the light beam with respect to the normal. It is seen that the count rate increases on the side towards which the beam is inclined and decreases on the opposite side, with the effect being more pronounced at larger angles.

4 Conclusions

By scanning a 30 μm light beam across the photocathode surface of M4, M16 and L16 Hamamatsu R5900 multianode photomultiplier tubes, we have measured the variation of sensitivity, which mainly reflects the structure of the metal foil dynode system. There seems to be some smearing of this structure at lower wavelengths of the incident light. Also a dependence of the sensitivity on the photon incident angle has been measured. In this case we find that a particular anode channel may give signals although the light spot is quite distant from the corresponding photocathode surface. This effect is attributed to transmitted light producing photoelectrons either on the metal foil dynode system or being reflected back to the photocathode.

References

[1] J.L. Rosen, Nucl. Instr. Meth. **A408**(1998)191-198

[2] S. Korpar et al.,Nucl. Instr. Meth. **A442**(2000)316-321

[3] P. Križan et al.,Nucl. Instr. Meth. **A394**(1997)27-34

[4] J.F.C.A. Veloso, C.A.N. Conde, 1992 IEEE Nuclear Science Symposium and Medical Imaging Conference, October 25-31, 1992, Orlando, Florida, USA. Conference Records, p.21-23.

[5] P.J. Dervan, Characterisation of Multi-pixel PMTs, 2000 IEEE Nuclear Science Symposium and Medical Imaging Conference, October 15-20, 2000, Lyon, France.

Figure captions

Fig. 1 The experimental set-up.

Fig. 2 Typical quantum efficiency of the multianode PMT's and spectra of the light emitting diodes used in these measurements.

Fig. 3 Block diagram of the computer controlled measuring system.

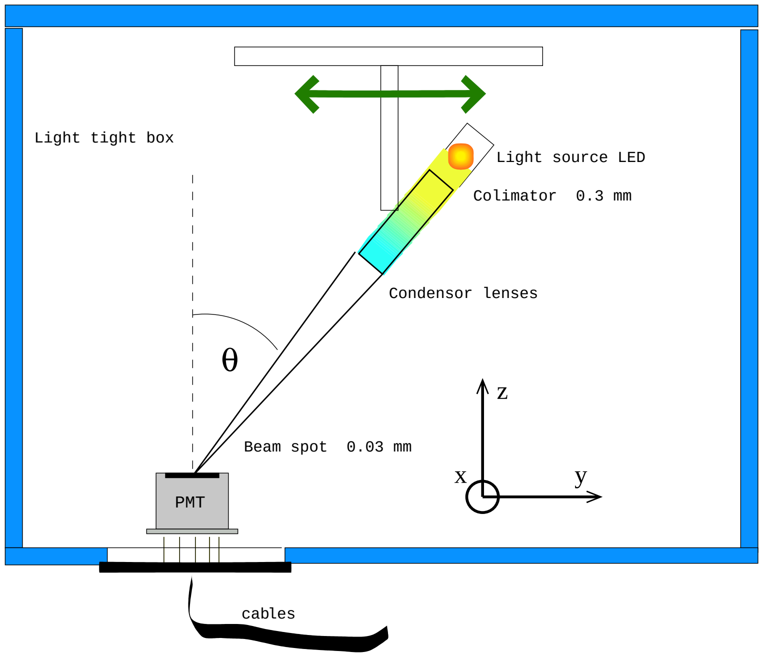
Fig. 4 Surface sensitivity (relative count rates) of the M4, M16 and L16 (from left to right) Hamamatsu R5900 multianode photomultiplier tubes.

Fig. 5 Position dependence of the relative count rate through a cross section of the M16 PMT (see Fig. 4) for the blue (top), green (middle) and red (bottom) light emitting diode.

Fig. 6 The relative count rate for one anode channel of the M16 PMT at normal incidence of photons (left) and at 50^0 incident angle with respect to the normal (right).

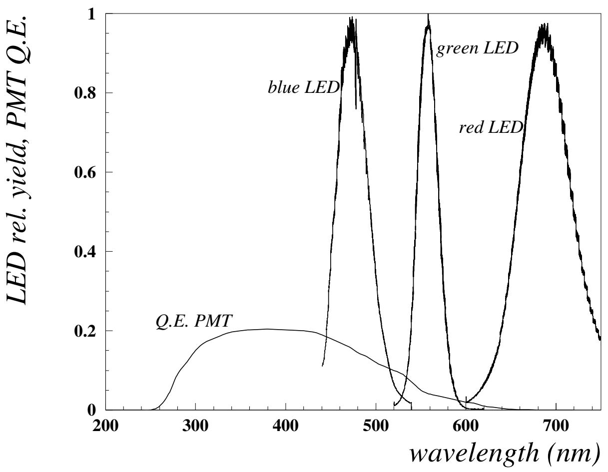
Fig. 7 Different cross sections through the distribution of Fig. 6 at 50^0 incident angles. The cross sections are in a direction orthogonal to the direction of inclination of the light beam at y=11 mm, 14 mm, 16.5 mm and 18.5 mm.

Fig. 8 Count rates of one M16 anode channel for different incident angles. The distributions are in the direction of inclination of the light beam.



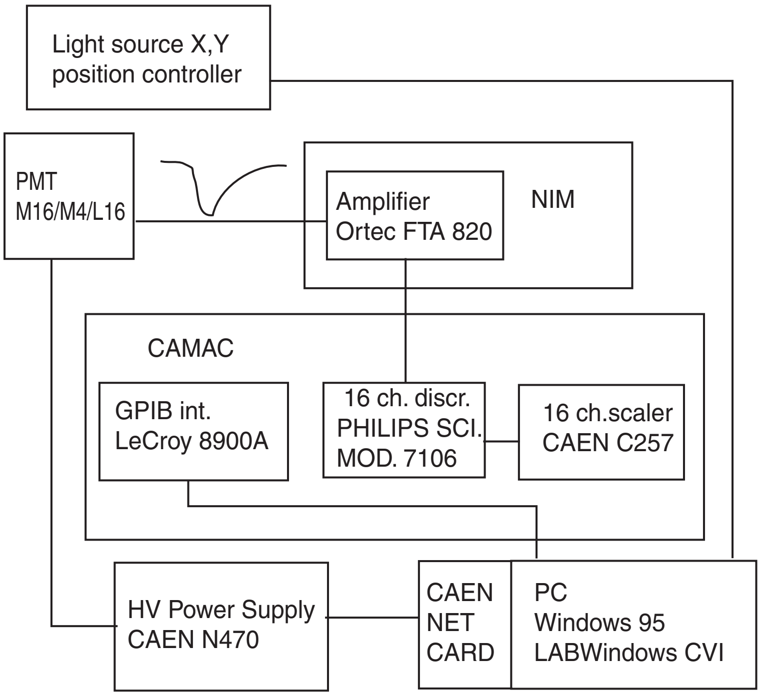
Light tight box
Light source LED
Colimator 0.3 mm
Condensor lenses
θ
Beam spot 0.03 mm
PMT
z
x
y
cables

Fig. 1.



LED rel. yield, PMT Q.E.
blue LED
green LED
red LED
Q.E. PMT
wavelength (nm)
0
0.2
0.4
0.6
0.8
1
200
300
400
500
600
700

Fig. 2.



Light source X,Y
position controller
PMT
M16/M4/L16
Amplifier
Ortec FTA 820
NIM
CAMAC
GPIB int.
LeCroy 8900A
16 ch. discr.
PHILIPS SCI.
MOD. 7106
16 ch.scaler
CAEN C257
HV Power Supply
CAEN N470
CAEN
NET
CARD
PC
Windows 95
LABWindows CVI

Fig. 3.

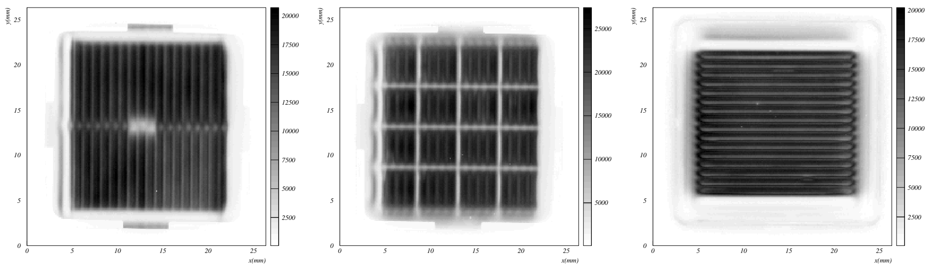


Fig. 4.

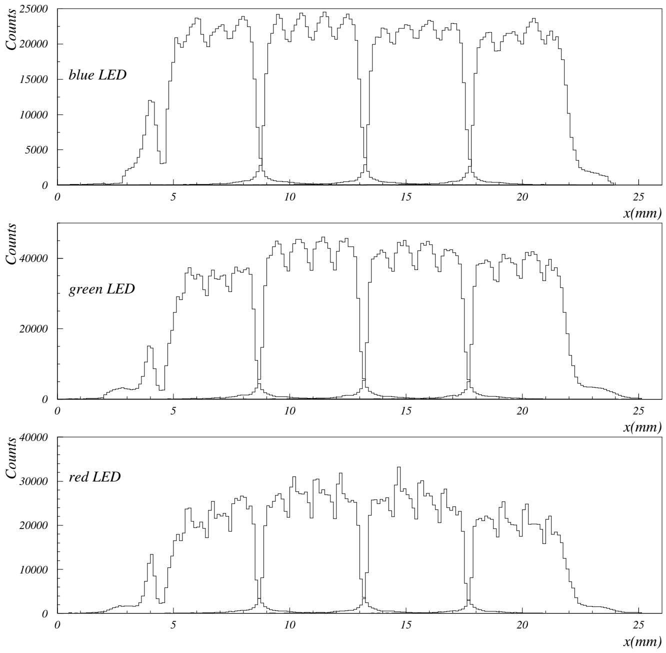

Counts
blue LED
x(mm)
Counts
green LED
x(mm)
Counts
red LED
x(mm)

Fig. 5.

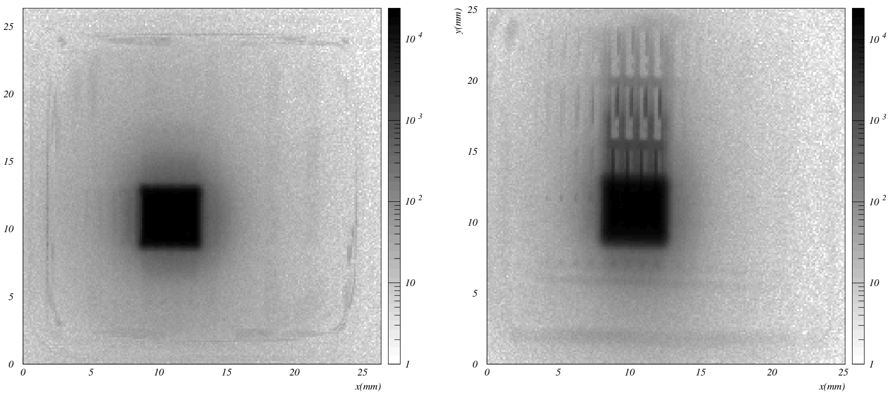

y(mm)
x(mm)
y(mm)
x(mm)

Fig. 6.

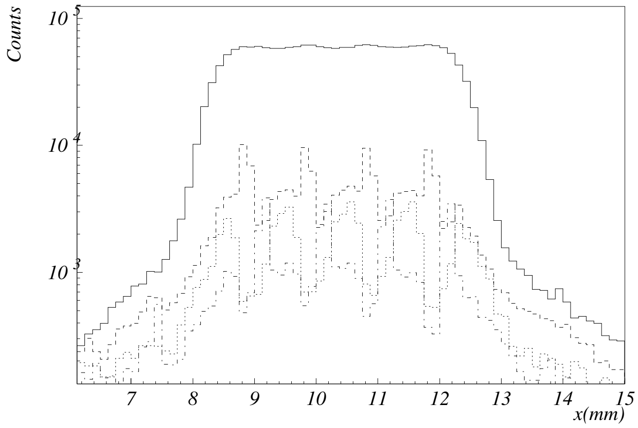

Counts
10^5
10^4
10^3
7
8
9
10
11
12
13
14
15
x(mm)

Fig. 7.

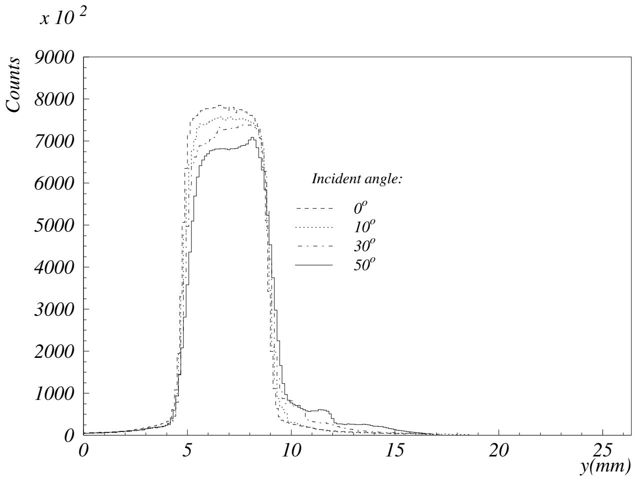

x 10^2
Counts
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Incident angle:
0°
10°
30°
50°
0
5
10
15
20
25
y(mm)

Fig. 8.