PMT response studies in photosensor test facility (PTF)

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1 Introduction

Studies of the response of a 20 inch PMT (Superkamiokande detector's PMT) in the Photosensor Test Facility (PTF) located at TRIUMF in Vancouver have been done. These studies include normal incidence scanning of the PMT and analyzing the response in different radial position of PMT. The Cherencov light produced in Superkamiokande (SK) detector, however, are incident on the surface of detector from many angles. Measurement of the PMT gain, transit time, transit time spread and quantum efficiency at different locations and incidence angles is the goal of this work. To measure the absolute detection efficiency of the PMT, it will be scanned, radially and axially. The light source for the scans is a Hamamatsu laser at 400 nm(Cherencove light wavelength) with stability of... . , so that the results will be applicable for PMTs of Superkamiokande(SK) water Cherencov detector in Japan.

2 Objective

3 Methodology

The pulses produced by laser in PTF are sent to the optical box and divided into two equal parts. One part is counted by a monitor PMT inside the optical box and another part used to scan the PMT.Therefore, one can calculate the detection efficiency and response parameters of PMT of detector. The light produced by laser will be directed at different angles on PMT, as well as from various radial and axial situations of the source(Figure 1) and the response of PMT for different configuration will be analyzed.

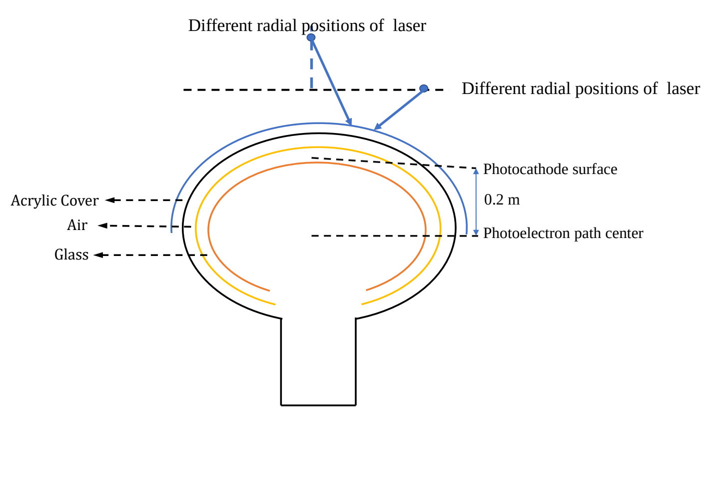

Figure 1: Differet radial and axial positions of laser which irradiate the surface of PMT from different angles

3.1 Vertical scanning of the PMT

In vertical scanning method, the laser pulse hitting the PMT is perpendicular to xy plane. In this case, there are two factors which are different for photons coming from different angles: 1. The length of acrylic cover that photon passes through. 2. The angle of incidence of every single photon. Figure 2 shows the different path length of acrylic cover before touching the photocathode.

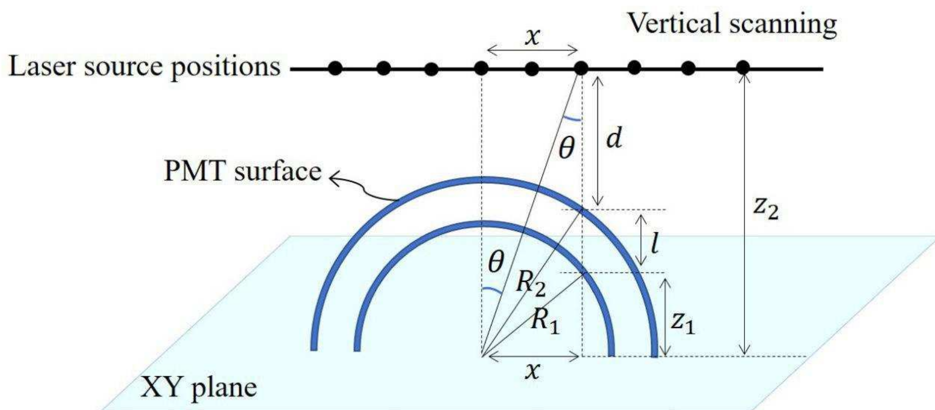

Figure 2: Vertical scanning of PMT

Considering the figure 2, the relation between the radial position of the source and the path length of the photon is given as below:

$$l = \sqrt{{R_2}^2 - x^2} - \sqrt{{R_1}^2 - x^2} \tag{1}$$

Figure 3 shows the path length of photon inside the acrylic cover in terms of laser source position for vertical scanning of the PMT.

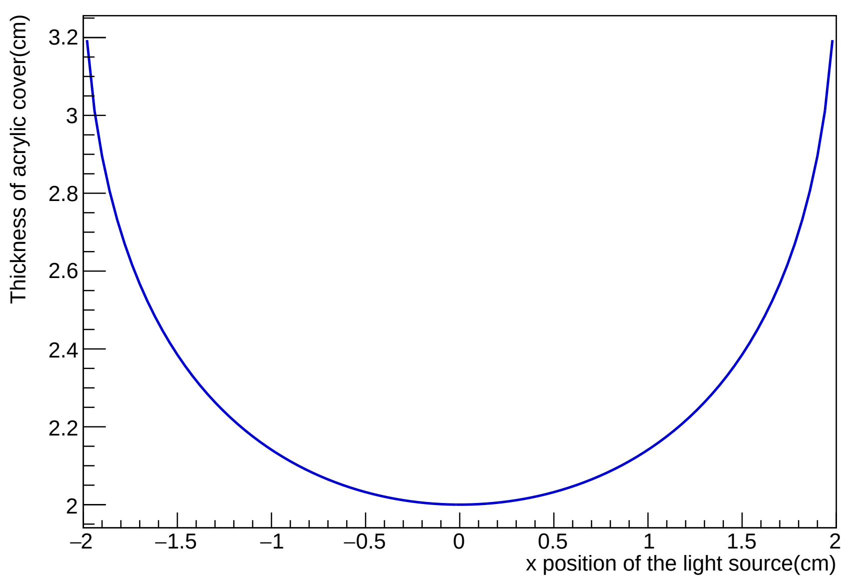

Figure 3: The length of acrylic cover that photon faces in vertical scanning of PMT terms of radial position of the laser source

3.2 Normal scanning of the PMT

Normal scanning of the PMT refers to the targeting the center of PMT, so that the photon coming from the laser is normal to the surface of the PMT. Figure 3 indicates the normal scanning of the PMT. In this kind of scanning the path length of the photon inside the acrylic cover as well as the incident angles are the same for all laser photons. Figure 5 shows the path length of photon inside the acrylic cover in terms of laser source position for normal scanning of the PMT.

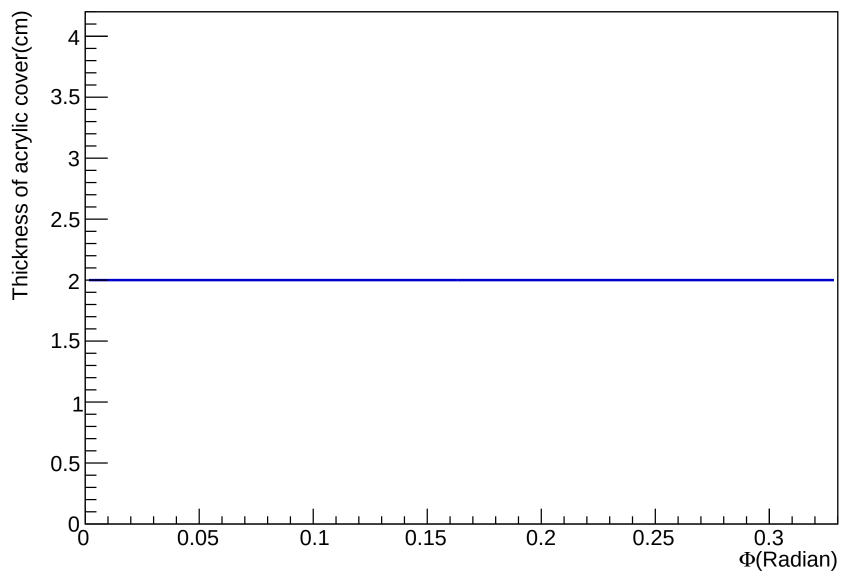

Figure 4: The length of acrylic cover that photon faces in normal scanning of PMT(This length is equal to the thickness of PMT)

3.3 angle scanning of the PMT

In this kind of scanning the PMT is scanned by different incident angles of photons for each position of the laser. Therefore, there are different lenths of path and incident angle for any single position of the laser source. Since in this method of scanning the incident angles of photons vary for each position of laser source, it is the most applicable scanning to simulate the PMT response of the Superkamiokande detector. Figure 4 shows the schematic of angle

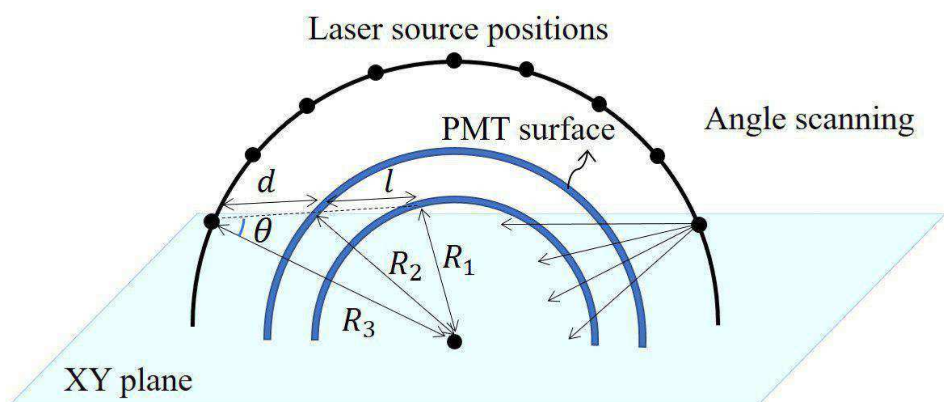

Figure 5: Angle scanning of PMT

scanning of the PMT. In angle scanning of PMT,the path length between the outer surface of acrylic cover and photocathode is given by equation 2.

$$l = \sqrt{{R_3}^2 \cos^2\theta - ({R_3}^2 - {R_2}^2)} - \sqrt{{R_3}^2 \cos^2\theta - ({R_3}^2 - {R_1}^2)} \tag{2}$$

Figure 7 shows the path length of photon inside the acrylic cover in terms of laser source position for angle scanning of the PMT.

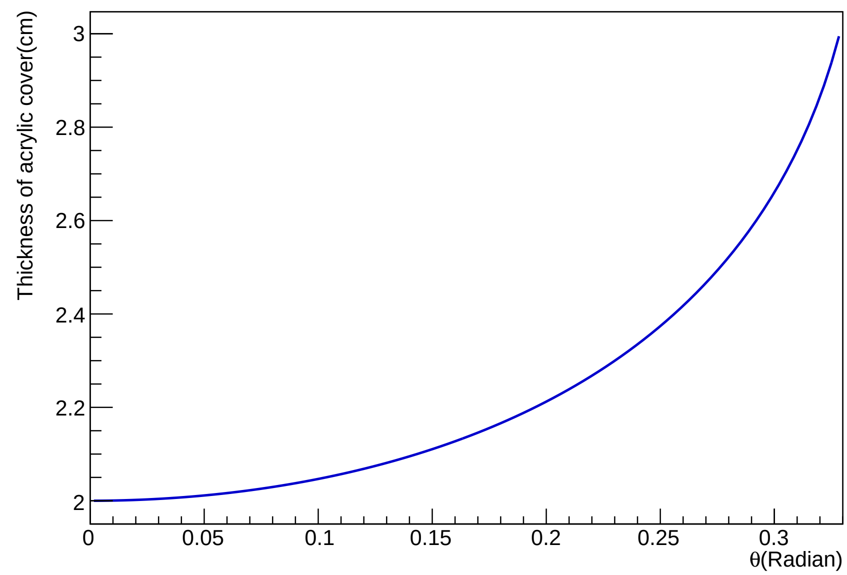

Figure 6: Length of acrylic cover that photon faces in vertical scanning of PMT in terms of the radial position of the laser source

4 Measurements and results

The pulse produced in PMT can be shown as a waveforms using waveform digitizer analysis. Considering the frequency of scan and the stop time of laser in each position , which are 1600 Hz and 3 seconds, respectively, the number of waveformes in each point is around 4800. Figure 2 shows typical noises produced by 34 sample length (correspond to the time during that 34 pulse sent from the power to the laser) .

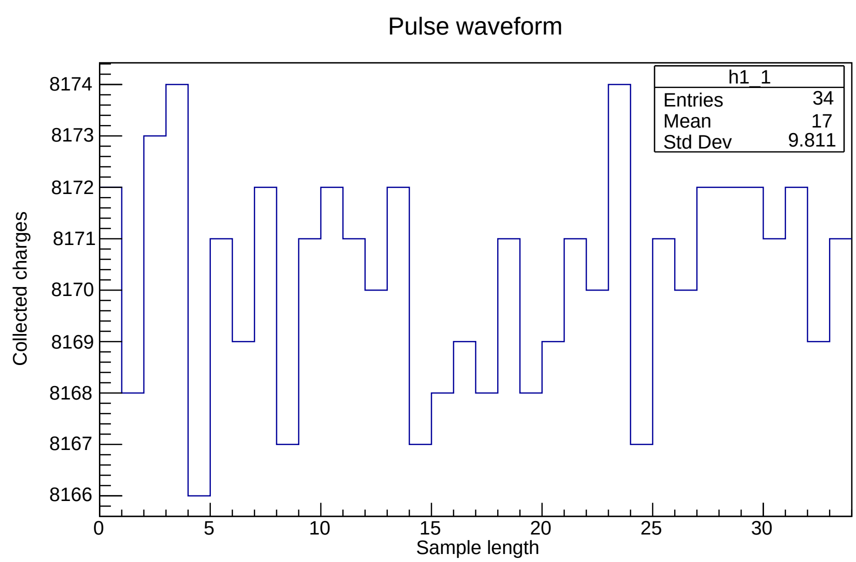

Figure 7: Different radial and axial positions of laser which irradiate the surface of PMT from different angles