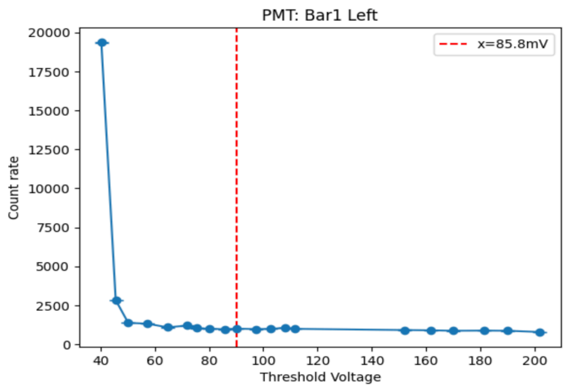
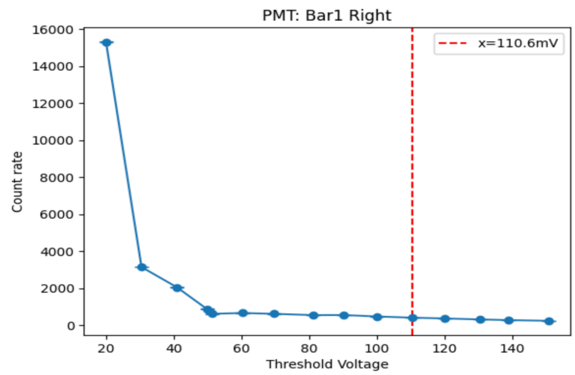
Data Analysis

October 16, 2024

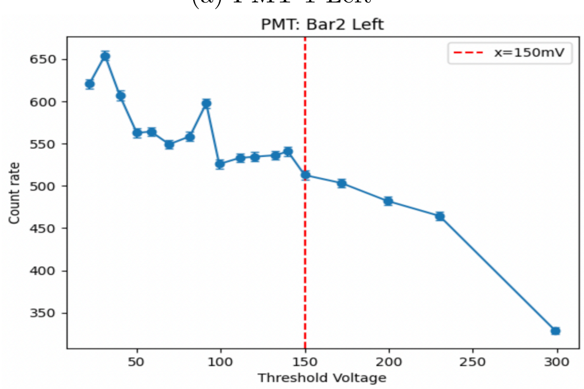
The first task was to determine the threshold voltage of the four PMTs by increasing and decreasing the voltage to obtain the corresponding counts. Threshold voltage can be seen when the plot has a plateau region. This is due to the fact that not all events that occurs in the scintillator are due to muons. Therefore it is important to identify the voltage that causes the events by the muons and filter out the rest. This voltage is recognized as the threshold voltage.



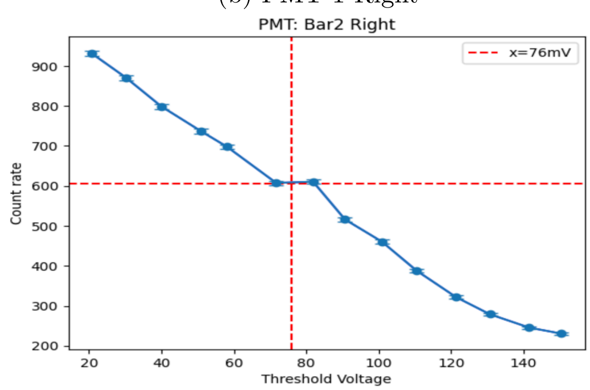
(a) PMT-1 Left



(b) PMT-1 Right



(c) PMT-2 Left



(d) PMT-2 Right

Figure 1: Bias voltage

Table 1 shows the obtained threshold voltage and the corresponding count rate for 30 second each. The error of the count rate was calculated using Poisson statistics, where the error is $\sqrt{N}$.

Table 1: Individual counts

PMT	Threshold voltage (mV)	counts	count rate (counts/sec)	Error (count rate)
Bar1 left	85.8	32440	1081.333	6.003
Bar1 right	110.6	9514	317.133	3.251
Bar2 left	150	14524	484.133	4.017
Bar 2 right	76	16704	556.800	4.308

Table 2: 2-fold count rate

PMT Tube	**Day 1**		**Day 2**			
	Trial 1	**Error**	**Trial 1**	**Error**	**Trial2**	**Error**
Coincidence 1	98.067	1.808	84.167	1.675	85.567	1.689
Coincidence 2	114.834	1.956	108.334	1.900	108.467	1.901

Table 3: 4-fold count rate

Day 1		**Day 2**							
Trial-1	Error	Trial-1	Error	Trial-2	Error	Trial-3	Error	Trial-4	Error
4.633	0.392	5.267	0.419	5.367	0.422	4.7	0.395	4.967	0.407

The angular distributions and the corresponding count rates were obtained with a step size of 10 deg. It can be seen that as the theta value decreases the count rate decreases too. The angle was obtained by moving the plum bob aligning it to the angle in the protector. Afterwards the two plots were made, Figure 2 and Figure 3.

Table 4: Angle distributions and the corresponding count rates

θ (deg)	θ (rad)	counts	count rate	Error (count rate)
90	1.5707	106	3.5333	0.3432
80	1.3962	135	4.5000	0.3873
70	1.2217	115	3.8333	0.3575
60	1.0471	87	2.9000	0.3109
50	0.8727	59	1.9667	0.2560
40	0.6981	53	1.7667	0.2427
30	0.5236	33	1.1000	0.1915
20	0.3941	17	0.5667	0.1374
10	0.1745	12	0.4000	0.1155
0	0.0000	11	0.3667	0.1105

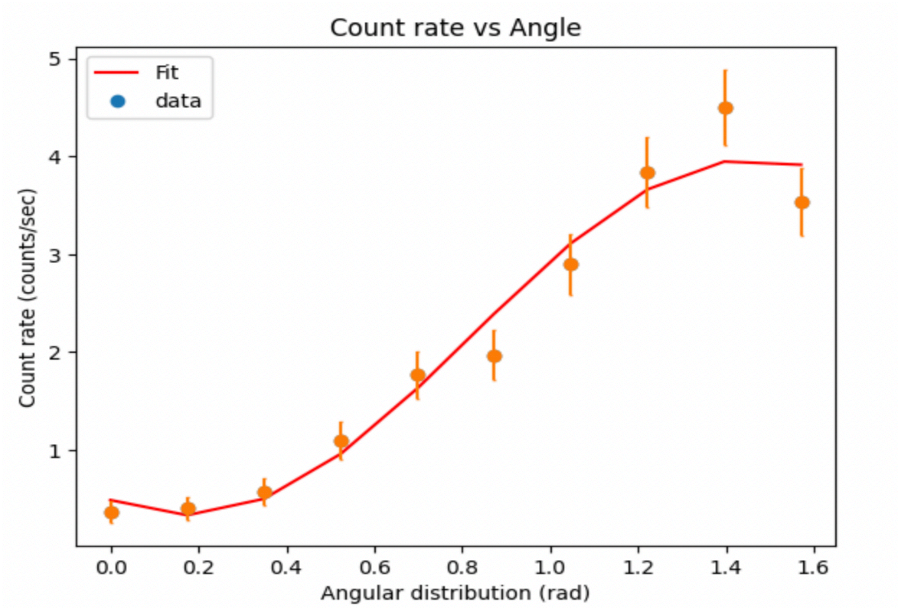


Figure 2: Square cosine dependence

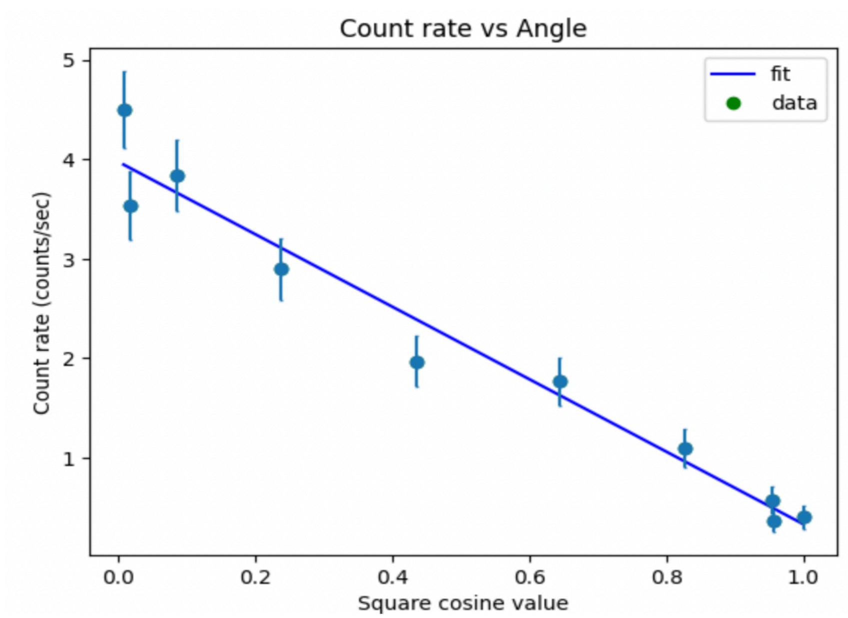


Figure 3: Linear relation

Figure 2 represents count rate vs angle. Expression for count rate vs angular distribution:

$$f = A * (cos(w\theta - \phi))^2 + B$$

A: -3.640, A-error: 0.298
w: 1.21, w-error: 0.174
ϕ: -0.207, ϕ-error: 0.145
B: 3.63, B-error: 0.225

Figure 2 has a linear relationship between the count rate and the square of the cosine angle. The expression can be written as,

$$f = m * (cos(w\theta + \phi))^2 + c$$

m: -3.640, m-error: 0.251
c: 3.973, c-error: 0.132

Table 5: Delayed timing events

Peak	**Time μs**	**Total count**	**Mean (bin)**	**RMS (bin)**	**Error**
1	1.46	240.00	1480.03	0.67	0.04
2	2.60	313.00	2645.00	2.18	0.12
3	3.82	263.00	3805.00	5.16	0.32
4	5.02	251.00	4959.00	7.44	0.47
5	6.16	251.00	6071.00	8.17	0.52
6	7.32	165.00	6244.00	8.37	0.65
7	8.00	309.00	6767.00	8.15	0.46

Table 5 shows the calibration of the TAC to ensure the accuracy of the measurements which are important when calculating the muon decay time. The setup was given a delayed pulse and then the time to amplitude converter gives the data as a voltage signal. This spectrum was graphed in DAQ that plots the counts vs the channel number as a histogram as seen in Figure 4.

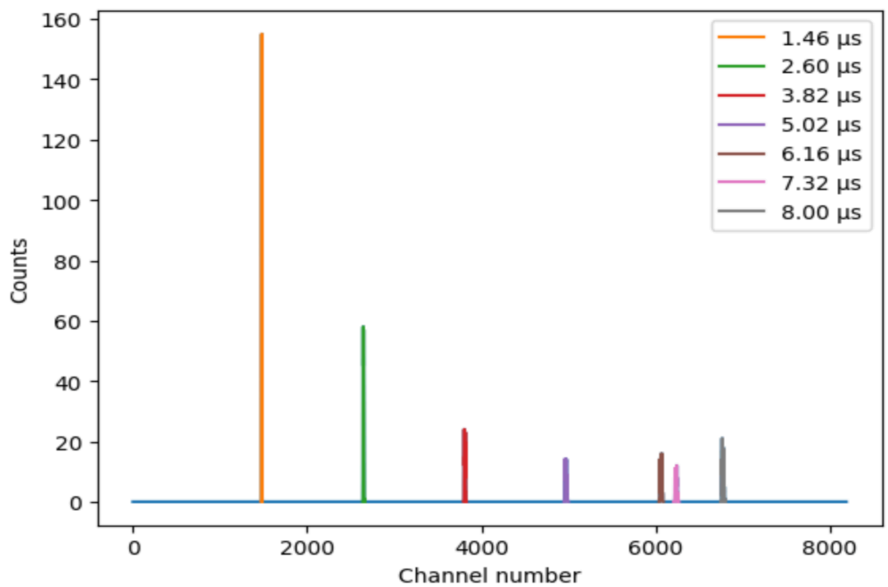


Figure 4: Delay time events

A linear regression fit can be obtained using the mean bin number calculated above to the corresponding delay time. The calibration line can then be using to obtain the time decay for other peaks whenever the particles are detected.

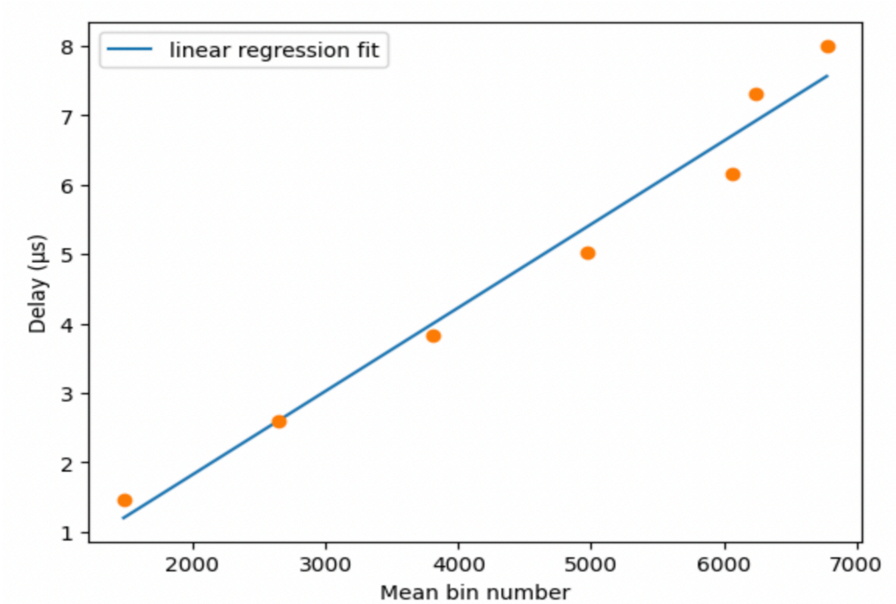


Figure 5: Linear regression fit