ChargedVeto Summary

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1 Introduction

This report summarises the study on ChargedVeto during the engineering run in 2002. ChargedVeto consists of 36 scintillator counters. There are two type of ChargedVeto called Inner and Outer. Four Inner counters(32-35) are set parallel to the beamline. Outer counters cover the front face of the CsI, and they are numbered from 0 to 31 as shown in Figure 1.

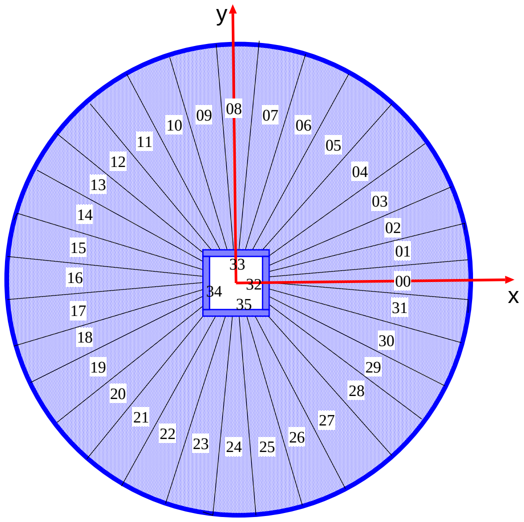

Figure 1: ChargedVeto numbering viewed from down stream.

2 HV setting

First, we decided the HV for each ChargedVeto's PMT. The model fo PMT is H1161. We adjusted the signal charge for muon to be 20pC. For Outer, we used μ-beam and required only one SUM signal from CsI. For Inner, we used cosmic ray muons. Figure 2 shows the setup used to calibrate the Inner. The trigger was a coincidence of SUM1 · SUM3 or SUM2 · SUM4 Outer

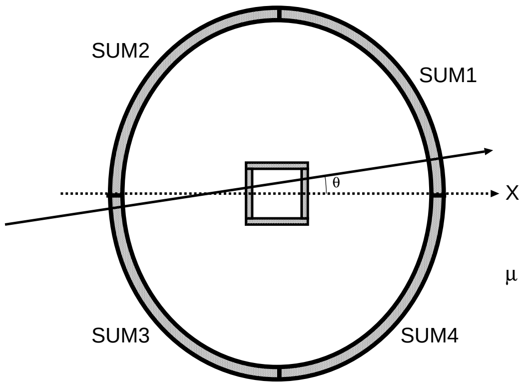

Figure 2: InnerChargedVeto calibration setup

ChargedVeto signals. We then selected muons which passed through two Outer counters which are exactly on the opposite sides. Figure 3 shows the signal charge for MIP after adjusting the HV. Table 1 shows each ChargedVeto's HV. The outer counters are gain matched to within ±12%.

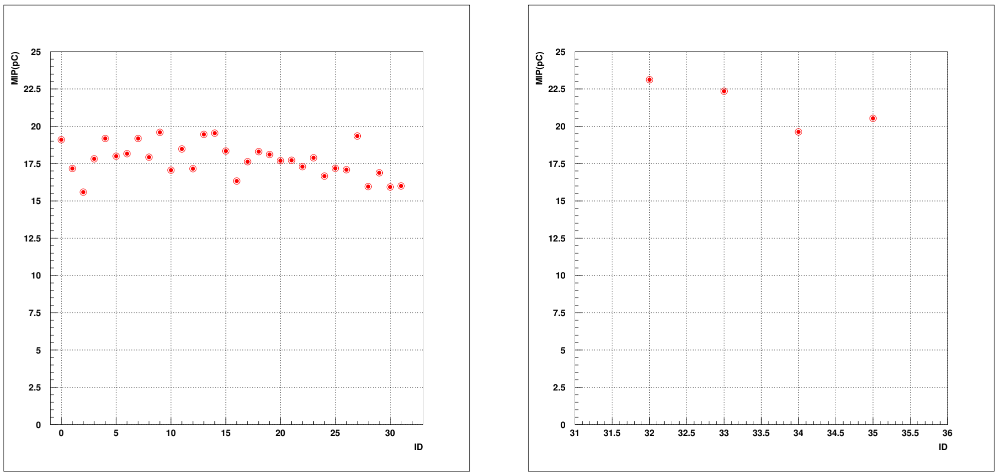

Figure 3: The signal charge for MIP is shown for Outer(left) and Inner(right).

PMT	HV[V]	PMT	HV[V]
00	1670.00	18	1610.00
01	1430.00	19	1480.00
02	1730.00	20	1620.00
03	1560.00	21	1760.00
04	1650.00	22	1500.00
05	1750.00	23	1580.00
06	1710.00	24	1230.00
07	1630.00	25	1640.00
08	1360.00	26	1540.00
09	1640.00	27	1680.00
10	1760.00	28	1780.00
11	1560.00	29	1680.00
12	1440.00	30	1450.00
13	1740.00	31	1650.00
14	1600.00	32	1330.00
15	1760.00	33	1590.00
16	1770.00	34	1550.00
17	1810.00	35	1280.00

Table 1: HV for each ChargedVeto.

3 Position Dependence

We checked the light output of the Outer ChargedVeto with two methods. First, we used $Ru^{106}\beta$-source. Figure 4 shows the setup for the source-test. The light output was measured for 8 source positions.

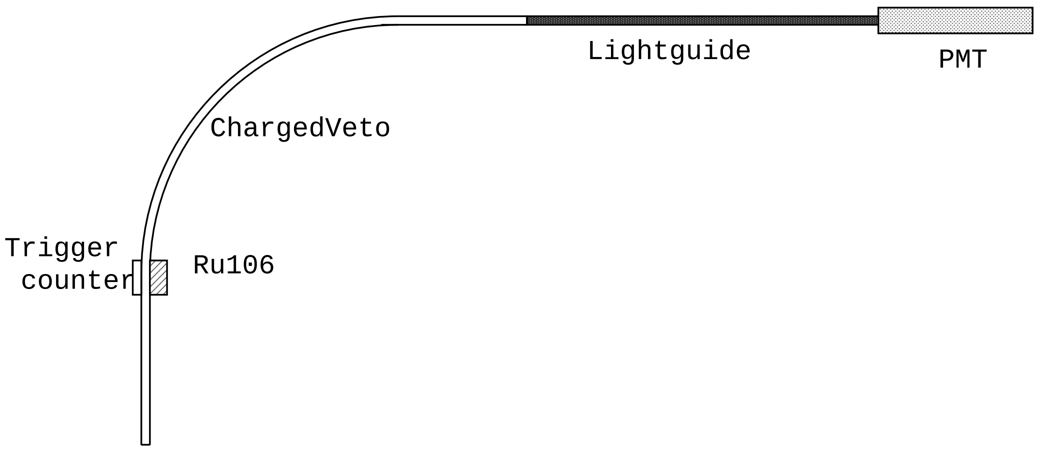

Figure 4: source-test's setup

Second, we measured the light output with μ beam after the counters were installed and the HV were adjusted. ChargedVeto's hit position was found from CsI. Figure 5 and 6 show the number of photoelectrons, as a function of the distance from the lightguide. Red points show β-source test and blue points show the μ-beam test results.

All ChargedVeto counters except for CV08 and CV20 have more then 10 photoelectrons. The data for CV20 is missing because we could not observe the single photoelectron peak. The number of photoelectrons starts increasing beyond 100cm. This is because the light collection efficiency increases due to the scintillator shape near the end. There is a large difference between β-source test and μ-beam measurment the number of photoelectrons. We suspect a coupling between the lightguide and PMT.

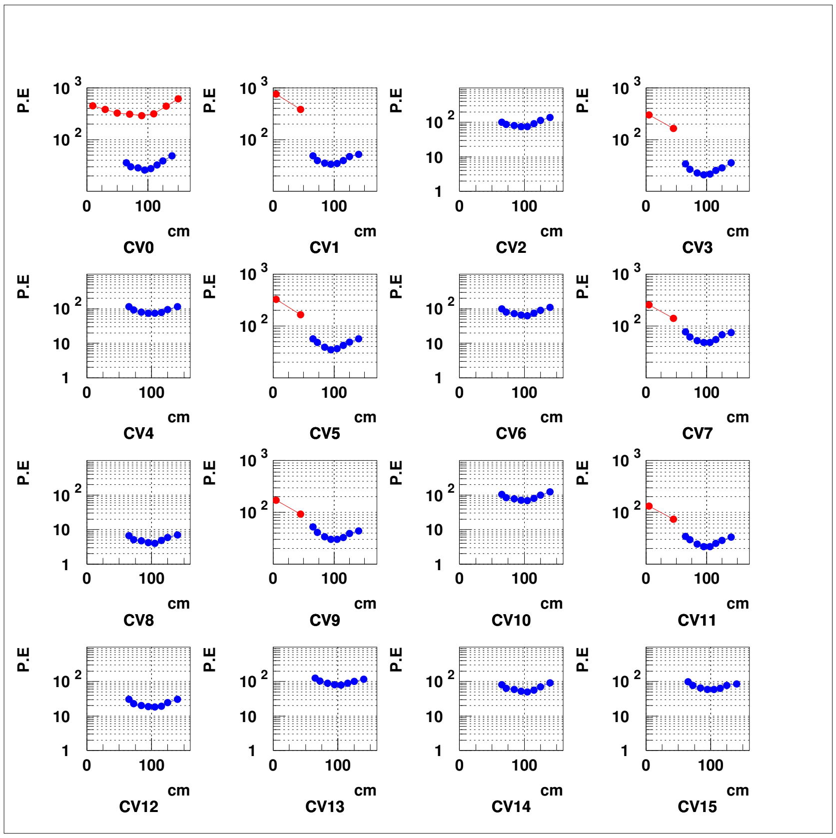

Figure 5: These plots show the number of photoelectrons as a function of the distance from lightguide, for CV00 to 15. Red points show β-source test results, blue points show the μ-beam measurements.

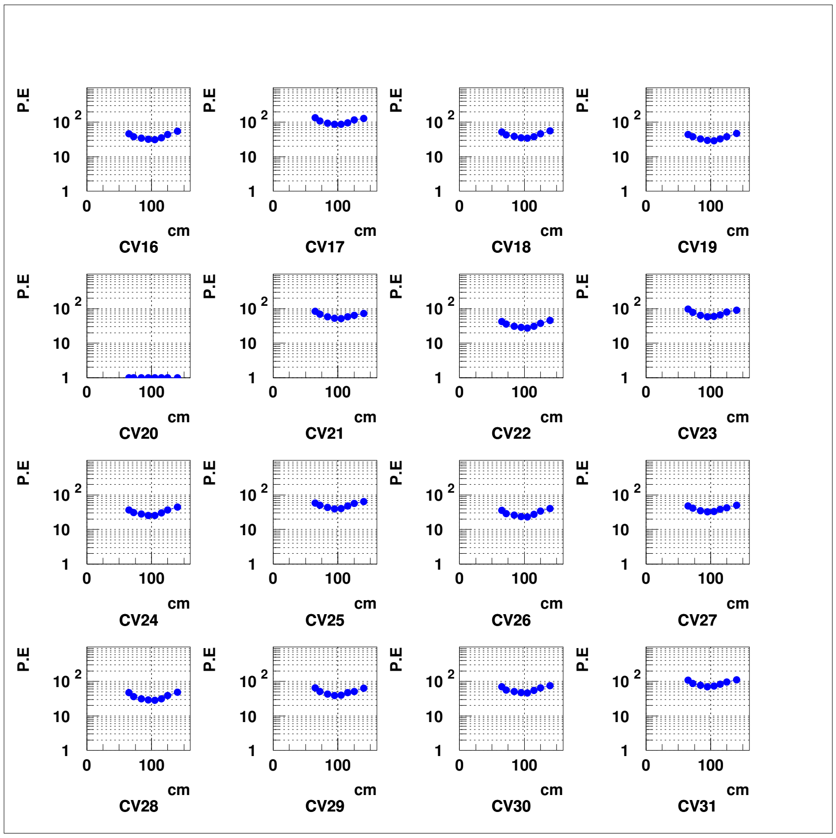

Figure 6: These plots show the number of photoelectrons as a function of the distance from lightguide, for CV16 to 31. Blue points show the μ-beam measurements.

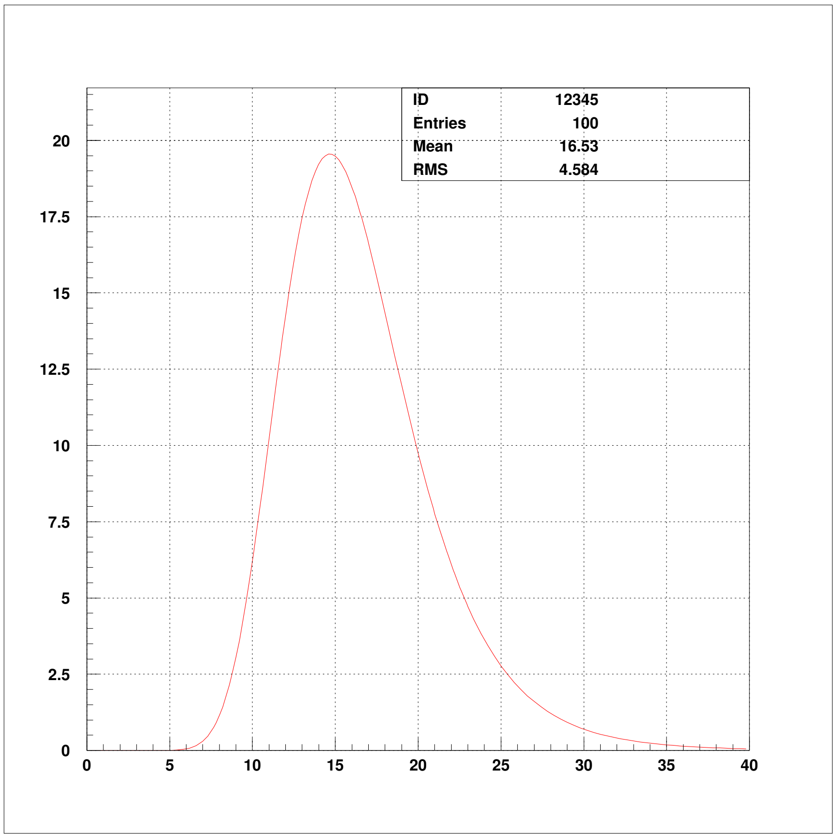

Figure 7: Asymmetric Gaussian's distribution is this.

Next we calculated the threshold to satisfy 10^{-5} inefficiency. The pulse height distribution was fit for an asymmetric Gaussian, as shown Figure 7. We found a threshold where the integration of the asymmetric Gaussian from 0 to the threshold is 10^{-5}. Table 2 shows the threshold required to satisfy 10^{-5} inefficiency and the number of photoelectrons at the threshold.

The threshold is about 4pC. All ChargedVeto counters except for CV8 have more then 4 photoelectrons.

ID	threshold[pC]	#P.E	ID	threshold[pC]	#P.E
00	3.20	5.9	16	3.00	7.3
01	3.95	9.6	17	4.75	27.9
02	3.35	20.9	18	4.20	9.7
03	3.25	4.8	19	4.10	8.3
04	4.95	23.5	20	3.75	—
05	3.80	9.5	21	4.40	15.7
06	4.45	19.3	22	4.30	8.4
07	4.40	13.3	23	4.05	16.8
08	3.15	0.9	24	3.70	7.1
09	4.20	8.0	25	3.90	11.4
10	4.50	22.5	26	4.10	7.3
11	3.85	5.5	27	4.45	9.6
12	3.60	4.8	28	3.65	8.2
13	3.80	18.0	29	3.90	11.4
14	3.75	11.3	30	4.35	15.5
15	4.35	16.7	31	3.85	21.3

Table 2: "threshold"shows value to satisfy inefficiency 10^{-5}. #P.E is the number of photoelectrons.

4 Timing Check

We checked the timing of Outer ChargedVeto with two methods.

4.1 Method 1

Method 1 measures the time difference of adjacent counters by using muons passing through an overlapping region. Figure 8 shows the setup.

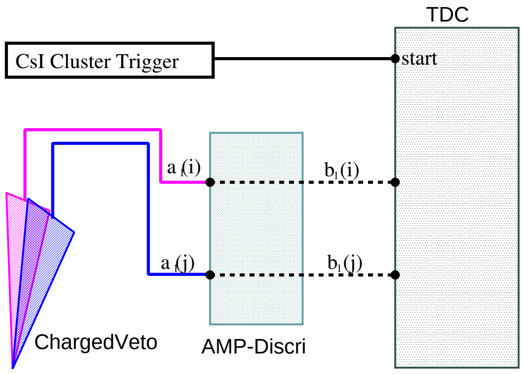

Figure 8: method1 setup

The time difference between CV-i and CV-j measured by TDC is

$$\begin{aligned} T_1(i,j) &= [a_1(i) + b_1(i)] - [a_1(j) + b_1(j)] \\ &= [a_1(i) - a_1(j)] + [b_1(i) - b_1(j)], \end{aligned} \tag{1}$$

where a_1 is a propagation time between CV's PMT and AMP-Discri, and b_1 is a propagation time between AMP-Discri and TDC. The timing difference from CV0 is then

$$\begin{aligned} T_1(0,1) &= [a_1(0) - a_1(1)] - [b_1(0) - b_1(1)] \\ T_1(0,2) &= [a_1(0) - a_1(2)] - [b_1(0) - b_1(2)] \\ &\vdots \\ T_1(0,i) &= [a_1(0) - a_1(i)] - [b_1(0) - b_1(i)]. \end{aligned} \tag{2}$$

Next, we measured the difference of propagation time between AMP-Discri and TDC. With a setup shown in Figure 9, we injected a pulses from a pulser to the input of AMP-Discri with the same timing. The measured time difference is

$$T_2(i,j) = b_2(i) - b_2(j) = b_1(i) - b_1(j). \tag{3}$$

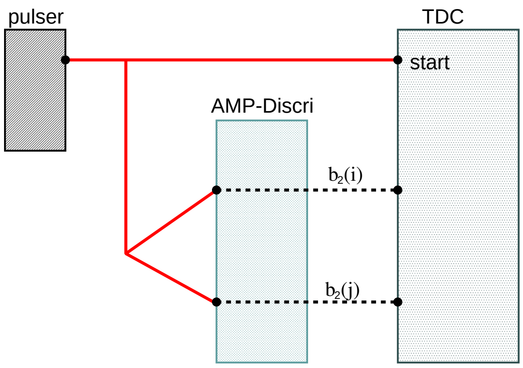

Figure 9: pulsar setup

The time difference between ChargedVeto and AMP-Discri is then

$$a_1(i) - a_1(j) = T_1(i,j) - T_2(i,j). \tag{4}$$

The time difference from CV0 is

$$\begin{aligned}
[a_1(0) - a_1(1)] &= T_1(0,1) - T_2(0,1) \\
[a_1(0) - a_1(2)] &= T_1(0,2) - T_2(0,2) \\
&\vdots \\
[a_1(0) - a_1(i)] &= T_1(0,i) - T_2(0,i).
\end{aligned} \tag{5}$$

4.2 Method 2

Method 2 measured a time difference between each counter and a trigger counter. The size of the trigger counter was 22cm×22cm. Trigger Counter was placed 4cm upstream of ChargedVeto centered on the beam line. Figure 10 shows method 2's setup.

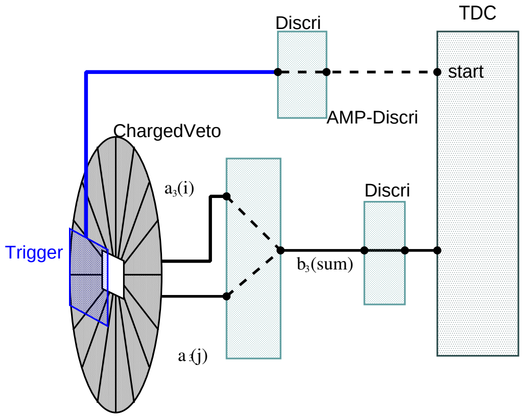

Figure 10: method 2 setup

In this method, we measured the timing of ChargedVeto SUM signal. To obtain CV-i's signal, we required one hit in the ChargedVeto, and required that the timing of i-th counter is within 1σ of its peak in the timing distribution. The timing difference between CV-i and CV-0 is

$$\begin{aligned}
T_3(0,0) &= [a_3(0) + b_3(sum)] - [a_3(0) + b_3(sum)] = 0 \\
T_3(0,i) &= [a_3(0) + b_3(sum)] - [a_3(i) + b_3(sum)] \\
&= a_3(0) - a_3(i). \qquad (6)
\end{aligned}$$

4.3 Result

Figure 11 shows measurement results. The two methods give consistent results. The counters are cross-timed to within ±3ns, as measured by Method 2.

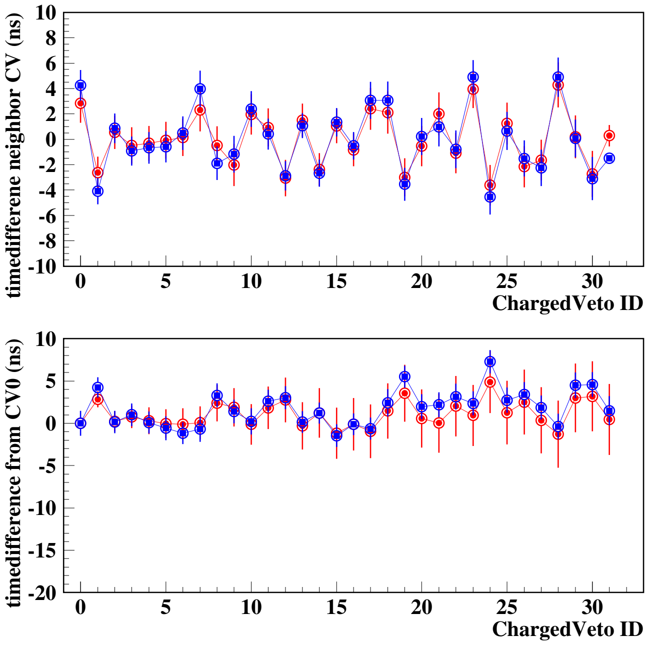

Figure 11: time difference result. The upper plot shows the timing difference between adjacent counters. The bottom plot shows the timing difference from CV0. Red points show method1, blue points show method 2.