TRIUMF Experiment E614
Technical Note #34

Test results of (Chamber ′98 +Front-end Electronics) with ^{55}Fe source

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Chamber

All below measurements have been done with a chamber prototype manufactured in 1998. Distances between sense wires are 4mm, diameter of the wires is 12.7µm. 16 sense wires were stretched in central area of the chamber. High voltage capacitor 100pF has been used for " + " H.V. case. Resistors of 300Ω were soldered parallel with input of VTX for both cases of the H.V. polarity.

Figs.1-3 show signals from wire on scope. Fig.2 and Fig.3 demonstrate a different form of signal because a various nature of γ interaction with DME gas. The accumulated charge equals to each other roughly, but the amplitudes are different. It means that a cross talk value will be different for the two cases because it depends on signal amplitude only.

Fig.4 shows dependence of absolute gain of the chamber from H.V. Maximal amplitude of ^{55}Fe signal has been measured by VTX. Two curves have been recorded. First one (from 1.4kV to 1.84kV) was measured by VTX itself. Amplitude of VTX signal is close to saturation value (400mV) near 1.85kV. Therefore a second curve was measured from 1.7kV to 2.6kV with a 10Ω resistor soldered parallel with VTX input. Absolute gain value was calculated suggesting that ^{55}Fe produces 200 initial electrons in DME gas, and that gain of VTX is 1mV/fC [1].

VTX and Chamber

Fig.5 shows dependence of input resistance of VTX from input current. The measurement has been done with a pulser signal. Input current and pulse amplitude on input of VTX have been measured. Saturation input current value corresponds to 25µA of input current roughly. Input resistance is constant (about 150Ω) till 150µA of input current. No idea about an explanation this behavior. Fig.6 shows cross talk value from input current. It is constant also till about 150µA.

Figs.7-9 show signals from VTX. An accumulated charge equals to each other roughly for cases showed on Fig.8 and Fig.9, but it is obviously that one needs a few hundreds nanosecond in order to provide a correct collection of the charge.

Figs.10-11 show examples of cross talk for different sign of H.V. on the chamber. The cross talk value (maximal signal amplitude on channel #2 over amplitude on channel #1) changes event by event. The distribution of cross talk values for both H.V. signs is showed on Fig.12. Average value of the cross talk equals to 1% and 2.9% for "–" and "+" of H.V. correspondingly. The larger cross talk value for case of "+" H.V. is explained probably by a larger capacitance between channels (additional resistor and high voltage capacitor).

Some speculations appear therefore about selection of threshold value for E614 detector. A relativistic positron produces 64 initial electrons (in average) inside of 4mm gap of DME gas [2]. It corresponds to 3keV of deposit energy [3]. A surface muon produces about 320 electrons (15keV of deposit energy). Muon near stopping target produces about 2100 electrons (100keV of deposit energy [4]). A threshold value must be about 2e or less in order to reach a high efficiency of positron registration. One can estimate a minimum threshold value in order to register of a positron without cross talk. It is 2e/60e≈3% obviously. It is not so correct because, first of all deposit energy distribution of a relativistic positron has Landau long tail, second one the 64 ionization electrons spread through 4mm gap of DME gas. One can estimate from drift line contours [5, Fig.1] that maximal density of the electrons appears in area around a sense wire. About 26 electrons are inside contour with 20ns of drift time if a positron goes through sense wire at 0° angle. One can estimate maximal amplitude of the signal means that VTX has output rise time 5ns and output fall time 16ns. It is about 16e. It means that we would not have a cross talk if the cross talk value is ≤ 2e/16e≈12.5% at positron registration, ≤2e/80e≈ 2.5% at surface muon registration, and ≤2e/530e≈ 0.38% at muon registration near stopping target.

Postamplifier/discriminator, VTX and chamber

Fig.17 shows circuit diagram of postamplifier/discriminator (PD). Gain of postamplifier is 2 for each output. Total gain is 4. Cross talk value between nearest channels of the PD is less than 0.5% in accordance with John Schaapman measurements. Threshold value of 40mV has been placed and measured for 160 channels of PD. Results are shown on Fig18. Average value of the threshold is 41.5mV with spread ±1mV in accordance with input offset voltage of the comparator AD96687 (equals to 1-3mV (Analog Devices specification)). Figs.19-20 show a long tail part of chamber signal on negative input of the comparator with different value of capacitors C_{184} , C_{117} , and C_{133} . The capacitors of 100nF remove completely a positive overpeak. Fig.21 illustrates small VTX output signals from chamber. Figs.22-23 show discriminator output signals with different value of capacitor C_{17} . Figs.24-25 show cross talk signals from discriminator with different value of capacitor C_{17} . It seems that a cross talk contribution could be decreased with the value $C_{17} = 0$ because the cross talk signals (Fig.24) have width less than 10ns. So short pulses will not register by TDC LeCroy 1877.

References:

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Figure captions:

Fig.1. Signals from wire on scope. Loading is 50Ω, H.V.=–1750V, ^{55}Fe, DME.
Fig.2. Example of wire signal on scope. Loading is 50Ω, H.V.=–1900V, ^{55}Fe, DME.
Fig.3. Example of wire signal on scope. Loading is 50Ω, H.V.=–1900V, ^{55}Fe, DME.
Fig.4. Gain of chamber from H.V. DME gas. Maximal amplitude of ^{55}Fe signal has been measured.
Fig.5. Input resistance of VTX from input current. The measurement has been done with a pulser signal.
Fig.6. Cross talk between nearest channels of VTX from input current. The measurement has been done with a pulser signal.
Fig.7. Signals from VTX. DME, ^{55}Fe, H.V.=–1460V.
Fig.8. Example of VTX signal. DME gas, ^{55}Fe, H.V.=–1460V.
Fig.9. Example of VTX signal. DME gas, ^{55}Fe, H.V.=–1460V.
Fig.10. Example of cross talk between nearest channels. DME gas, H.V.=–1810V, ^{55}Fe, VTX outputs.
Fig.11. Example of cross talk between nearest channels. DME gas, H.V.=+1810V, ^{55}Fe, VTX outputs.
Fig.12. Cross talk amplitude distributions (%%) for "–" and "+" H.V. on chamber. DME gas, ^{55}Fe, VTX outputs.
Fig.13. VTX output signals from nearest wires. DME gas, H.V.=–1900V, ^{55}Fe, 1000pF soldered between cathodes and ground.
Fig.14.VTX output signals from nearest wires. DME gas, H.V.=–1900V, ^{55}Fe, 1000pF and 43Ω soldered consequently between cathodes and ground.
Fig.15. VTX output signals from nearest wires. DME gas, H.V.=+1900V, ^{55}Fe, cathodes grounded.
Fig.16. VTX output signals from nearest wires. DME gas, H.V.=+1900V, ^{55}Fe, 43Ω soldered between cathodes and ground.
Fig.17. Circuit diagram of two channels of postamplifier/discriminator.
Fig.18. Threshold value distribution for 160 channels of postamplifier/ discriminator. DME gas, ^{55}Fe.
Fig.19. Long tail of signal on invert input of discriminator. Real vertical scale is 20mV/cm. C_{184}= C_{117} = C_{133} =10nF (Fig.17), DME, ^{55}Fe.
Fig.20. Long tail of signal on invert input of discriminator. Real vertical scale is 20mV/cm. C_{184}= C_{117} = C_{133} =100nF (Fig.17), DME, ^{55}Fe.
Fig.21. VTX output signals from ^{55}Fe. DME gas, H.V.=–1380V.
Fig.22. Discriminator output signals. Real vertical scale is 500mV/cm. DME gas, H.V.=–1400V, ^{55}Fe, C_{17}=0 (Fig.17).
Fig.23. Discriminator output signals. Real vertical scale is 500mV/cm. DME gas, H.V.=–1400V, ^{55}Fe, C_{17}=50pF (Fig.17).
Fig.24. Discriminator output signals from nearest wires. Real vertical scales are 500mV/cm. DME gas, H.V.=–1900V, ^{55}Fe, C_{17}=0 (Fig.17).
Fig.25. Discriminator output signals from nearest wires. Real vertical scales are 500mV/cm. DME gas, H.V.=–1900V, ^{55}Fe, C_{17}=50pF (Fig.17).