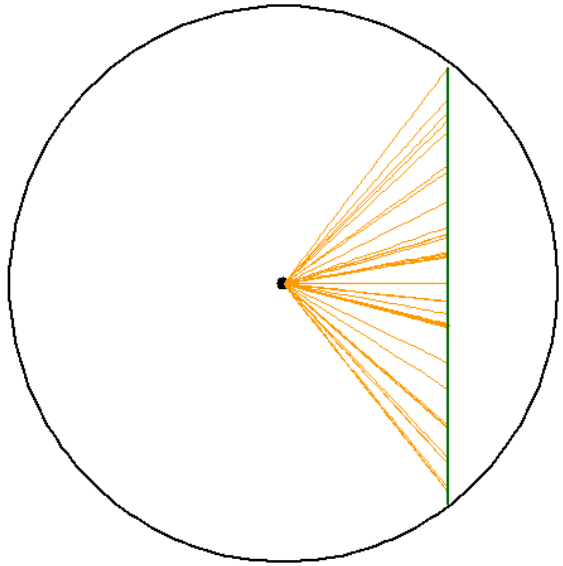
Simulation parameters (SPD setup)

1. Straw diameter: 10 mm
2. Anode diameter: 30 mkm
3. HV: 1750 V
4. Gas mixture: Ar+CO2 / 70:30 [%]
5. Gas mixture temperature: 20 celsius
6. Gas mixture Pressure: 1 atmosphere
7. Ionization particle: muon 1 GeV
8. Track angle α: 90°.
9. Magnetic field: 0 T
10. Gas Gain is fixed $= 4.5 \cdot 10^4$ (Penning coefficient is 0)



A track of 1 GeV muon crossing the straw tube shown together with electron drift lines.

Threshold crossing time

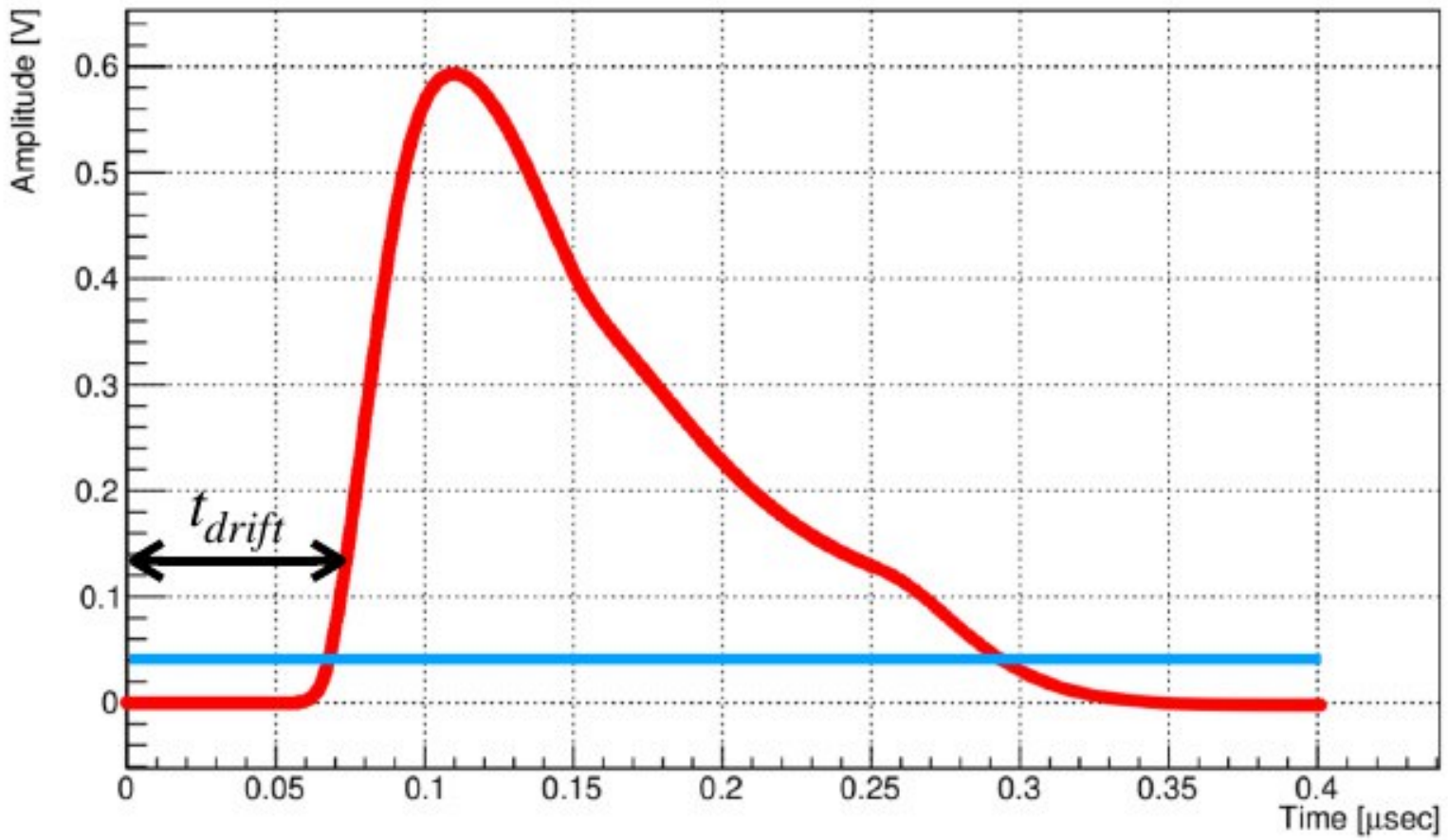
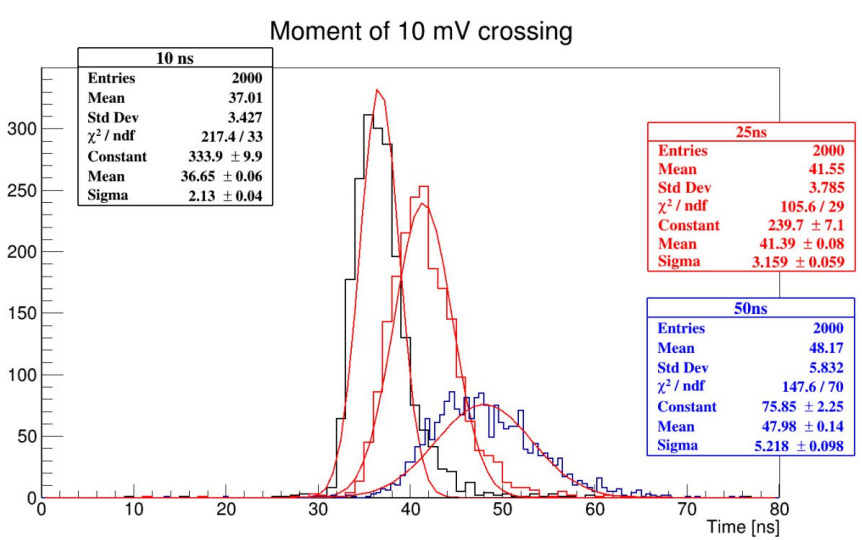
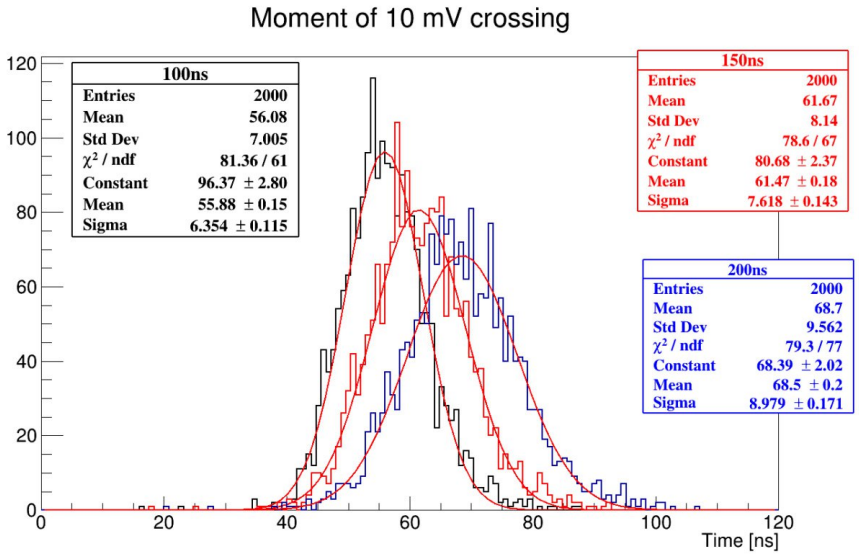


Figure 1: Ordinary Garfield++ and LTSpice signal output (red) with threshold (blue)

Threshold crossing time for 10 mV



a)



b)

Figure 2: Threshold crossing time for 2 mm distance. (a) Peaking time 10, 25 and 50 ns (b) Peaking time 100, 150, 200 ns
Electronics parameters: signal amplification 3 mV/fC, noise implemented here is 1500e, threshold 10 mV. VMM-based model

σ due to peaking time

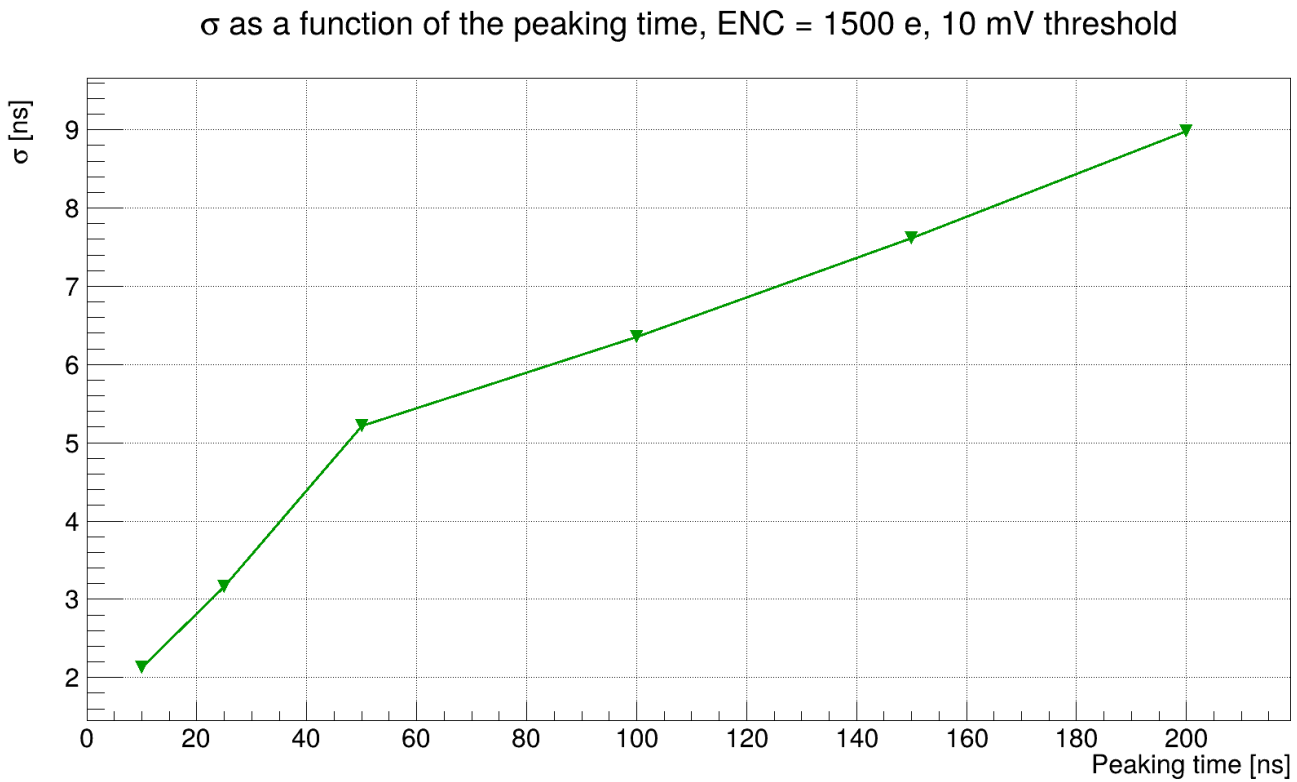
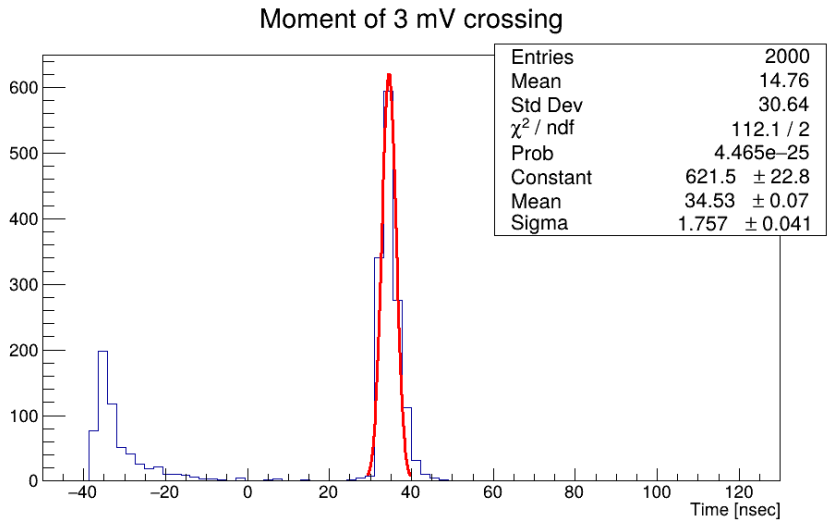
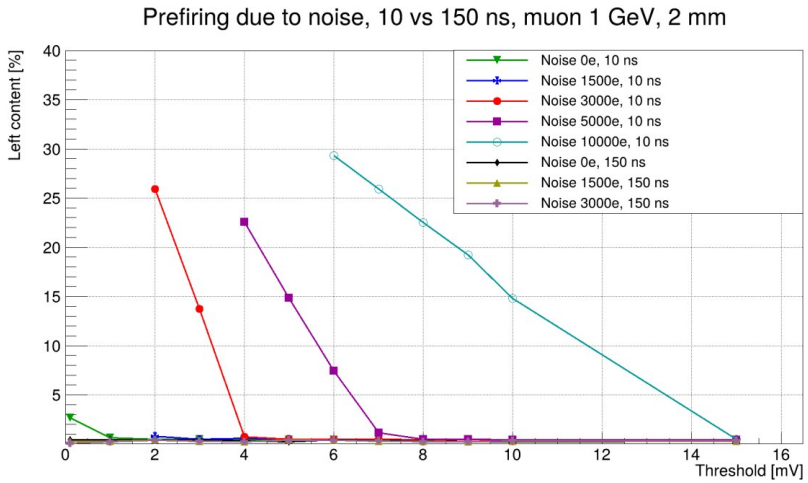


Figure 3: σ as a function of peaking time.

Prefiring due to noise



a)



b)

Figure 4: (a) 3 mV threshold crossing time for 2 mm distance. Peaking time 10 ns, 5000e noise. (b) Prefiling due to noise from 0e to 10000e, Peaking time 10 ns and 150 ns

σ due to threshold crossing time

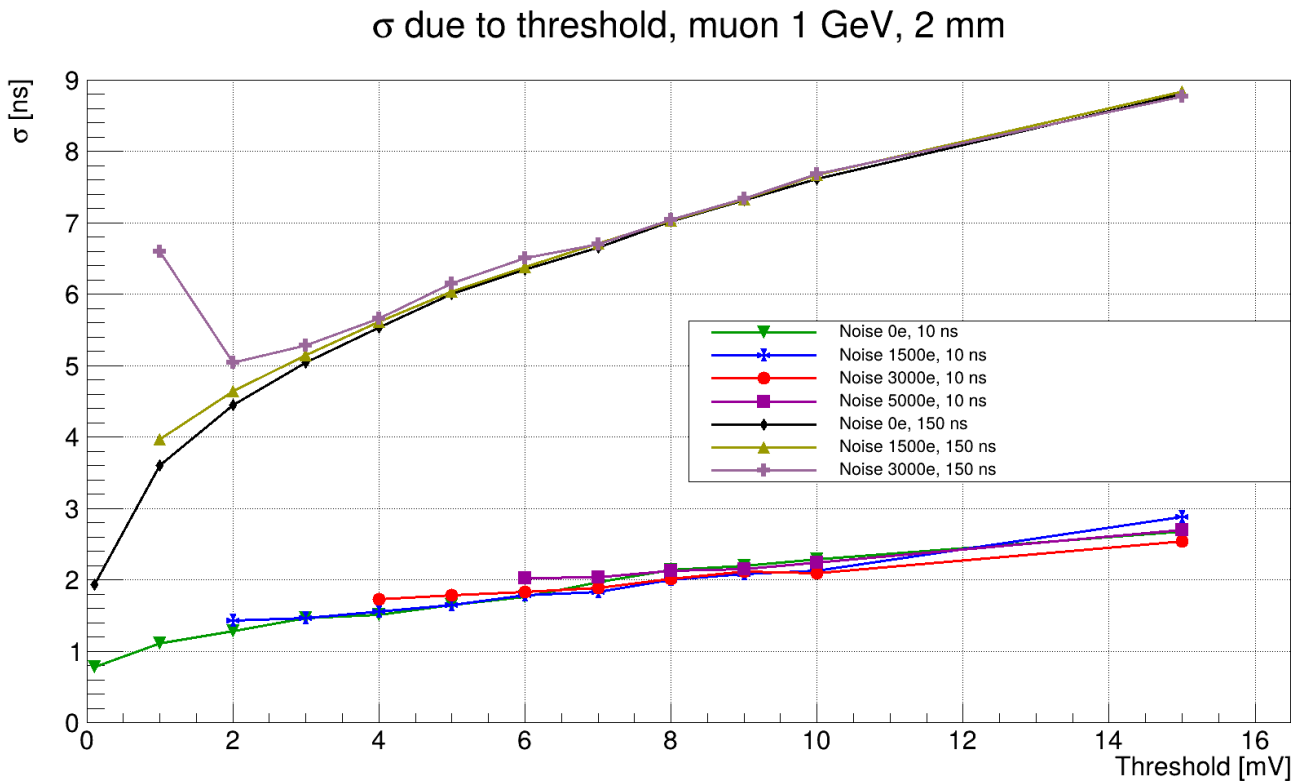


Figure 5: σ of threshold crossing time due to threshold [mV] for 10 ns and 150 ns peaking time.

σ due to threshold crossing time

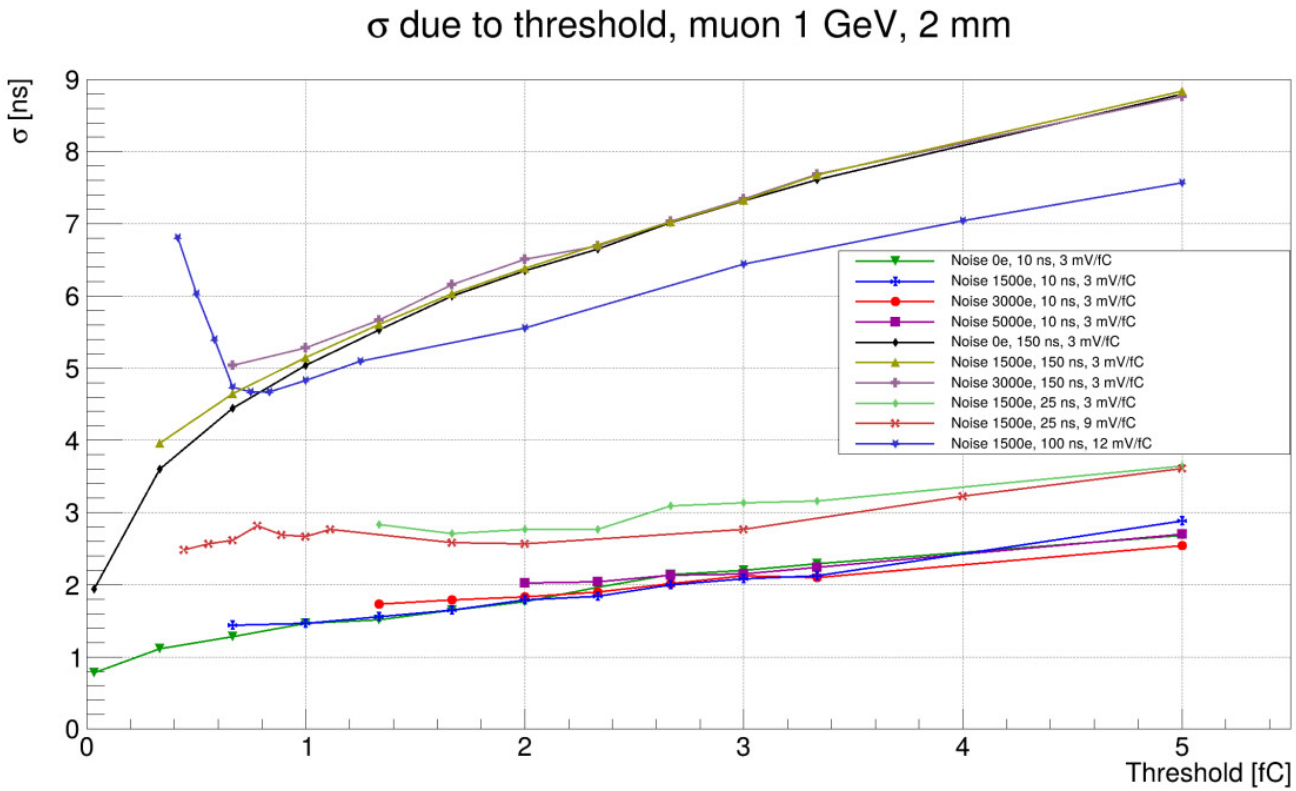


Figure 6: σ of threshold crossing time due to threshold [fC] for 10 ns, 25 ns and 150 ns peaking time. Added 9 mV/fC and 12 mV/fC amplifications

σ due to threshold crossing time

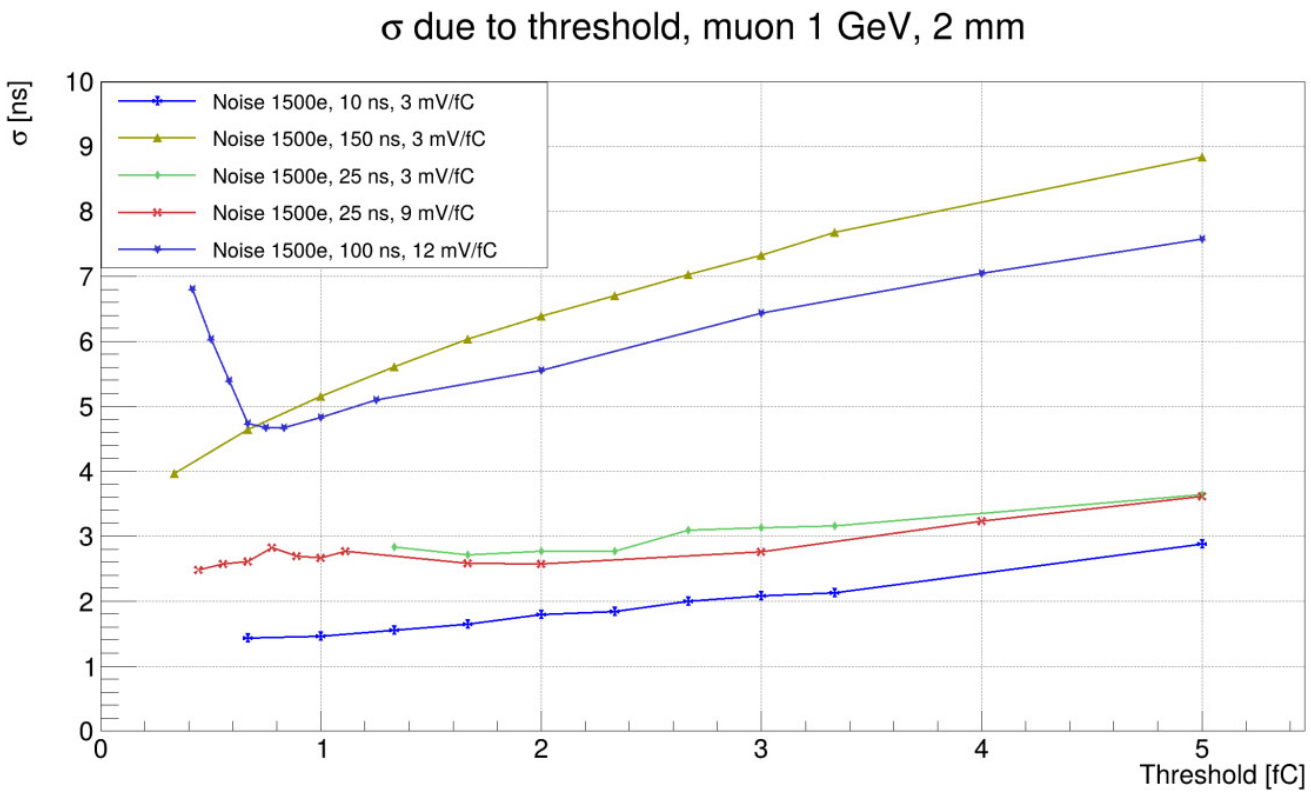


Figure 7: σ of threshold crossing time due to threshold [fC] for 10 ns, 25 ns and 150 ns peaking time. Added 9 mV/fC and 12 mV/fC amplifications. Only 1500e noise

σ due to threshold crossing time

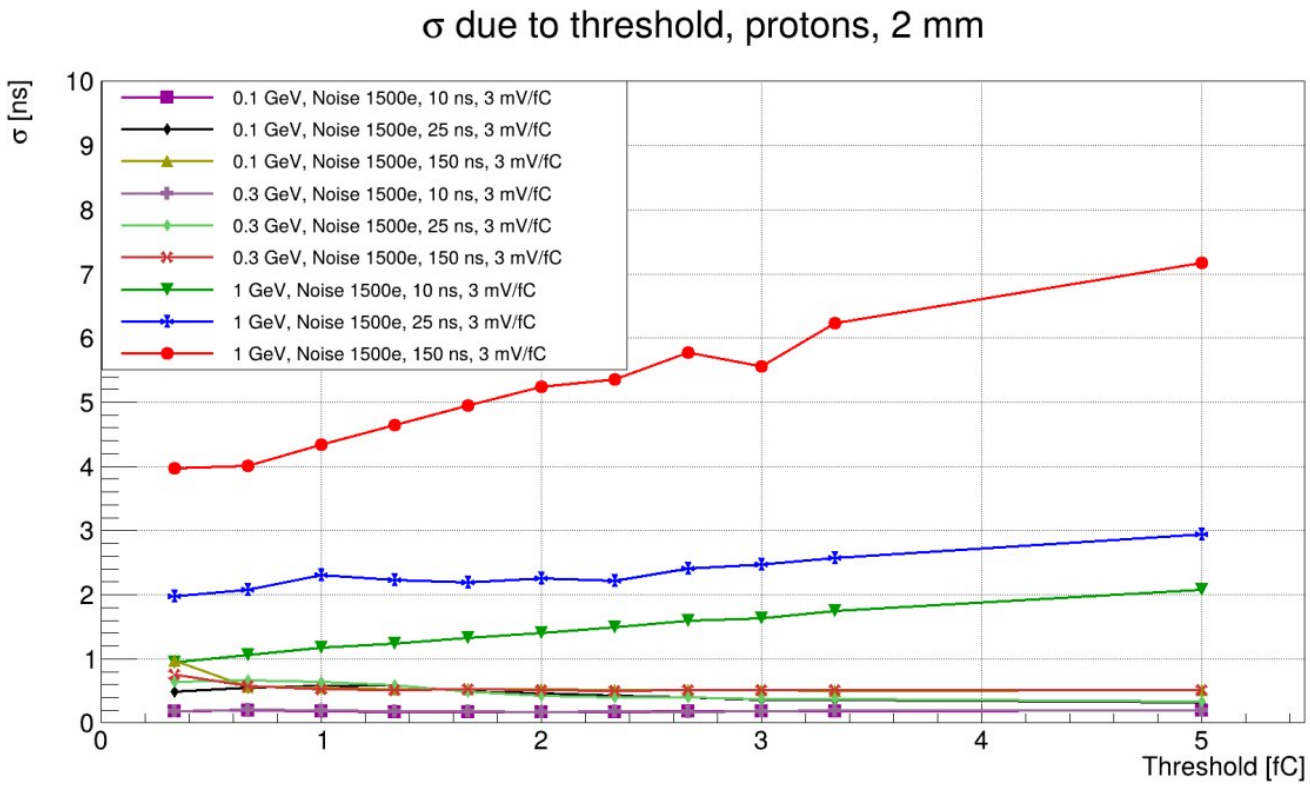


Figure 8: σ of threshold crossing time due to threshold [fC] for 10 ns, 25 ns and 150 ns peaking time. Only protons, 1500e noise

σ due to threshold crossing time

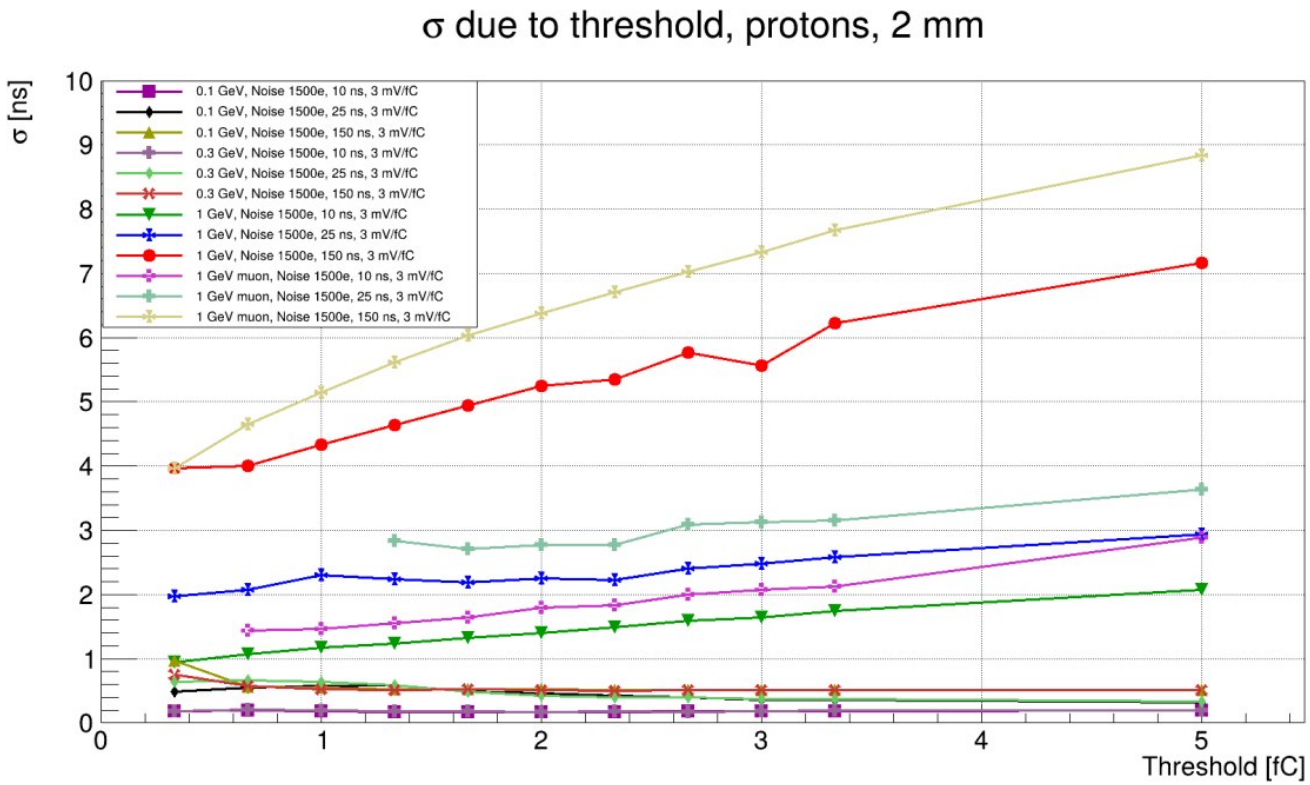


Figure 9: σ of threshold crossing time due to threshold [fC] for 10 ns, 25 ns and 150 ns peaking time. Muon and proton, 1500e noise

σ due to threshold crossing time

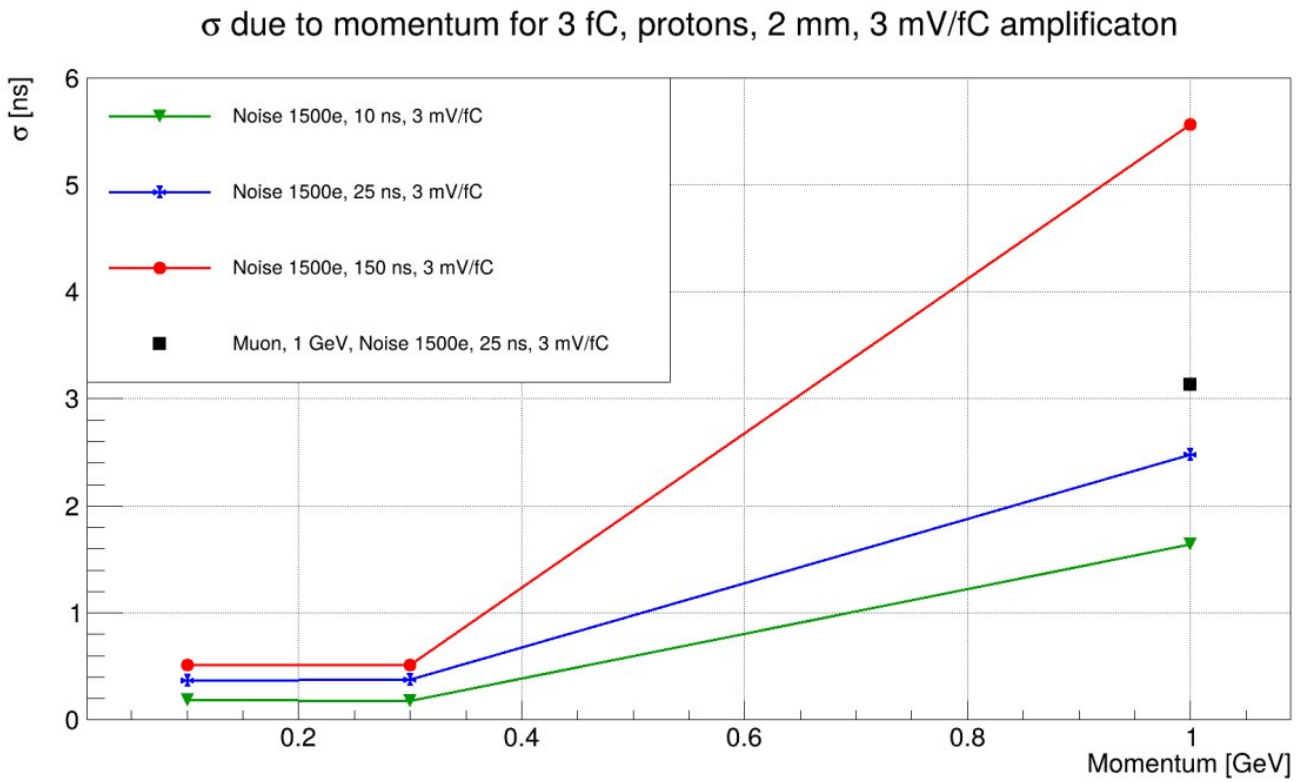


Figure 10: σ of threshold crossing time due to particle momentum [GeV] for 10 ns, 25 ns and 150 ns peaking time. Muon and proton, 1500e noise

Total charge vs voltage amplitude

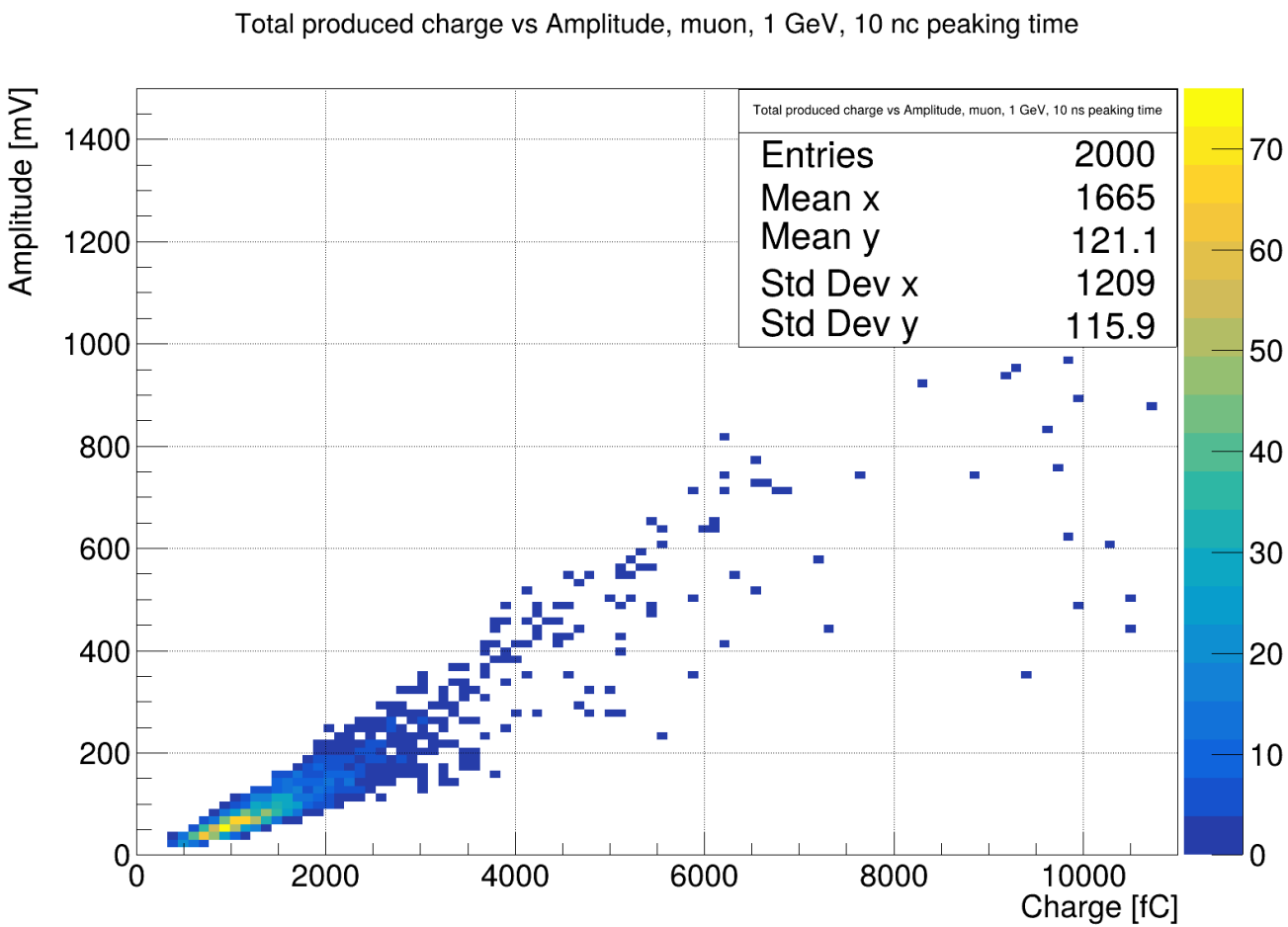


Figure 11: Total charge [fC] vs voltage amplitude [mV]. Muon, 1 GeV, 10 ns peaking time

Total charge vs voltage amplitude

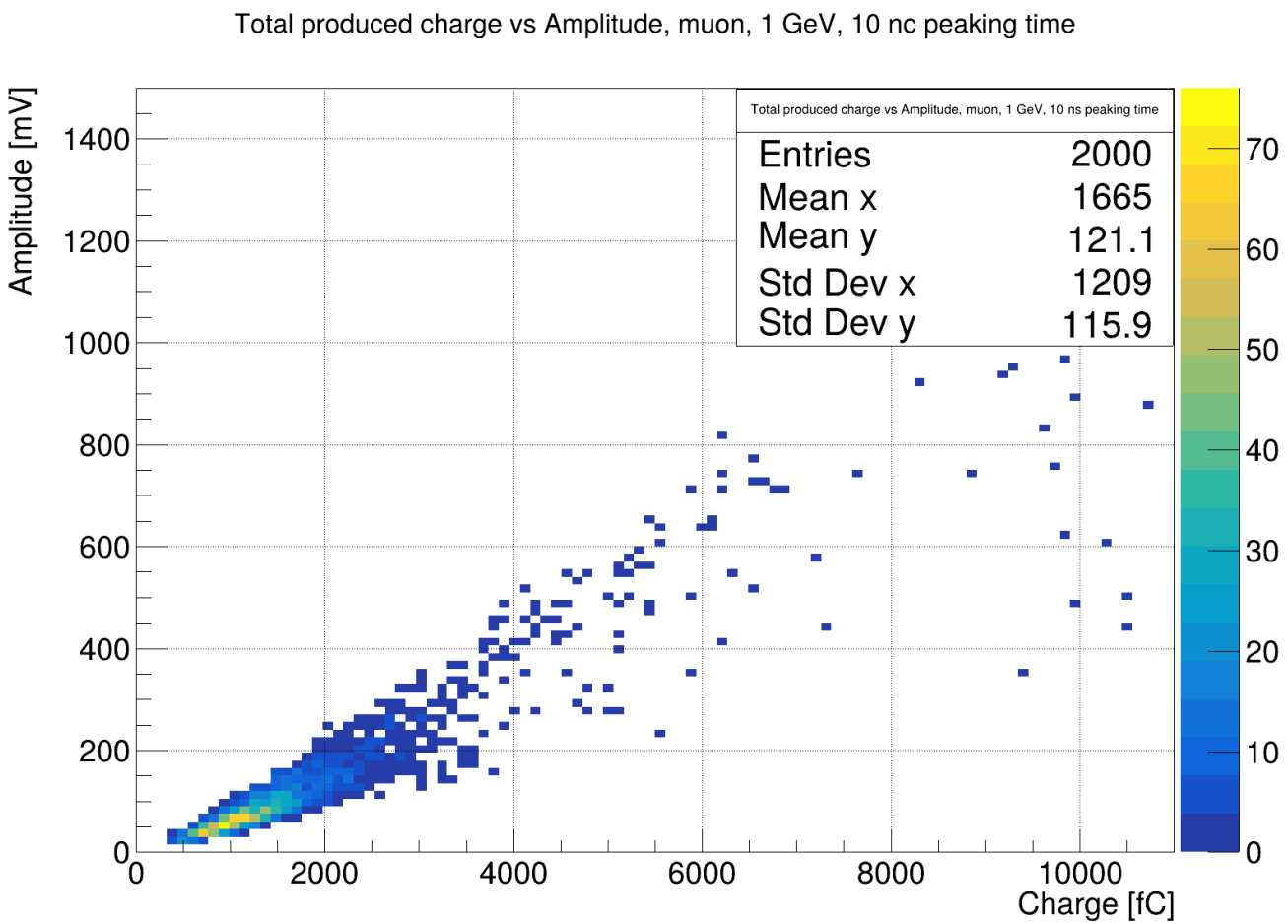


Figure 12: Total charge [fC] vs voltage amplitude [mV]. Muon, 1 GeV, 10 ns peaking time

Total charge vs voltage amplitude

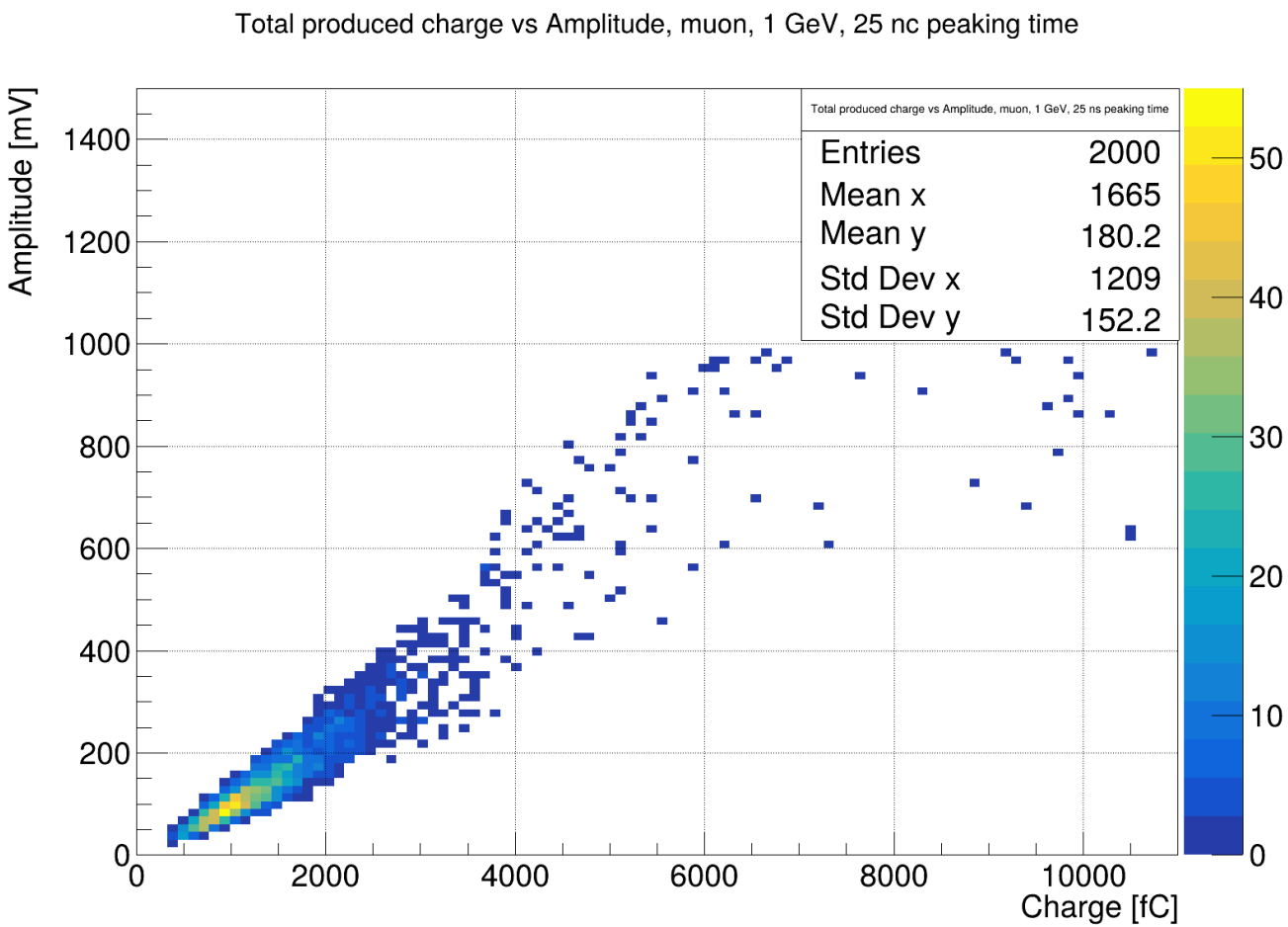


Figure 13: Total charge [fC] vs voltage amplitude [mV]. Muon, 1 GeV, 25 ns peaking time

Total charge vs voltage amplitude

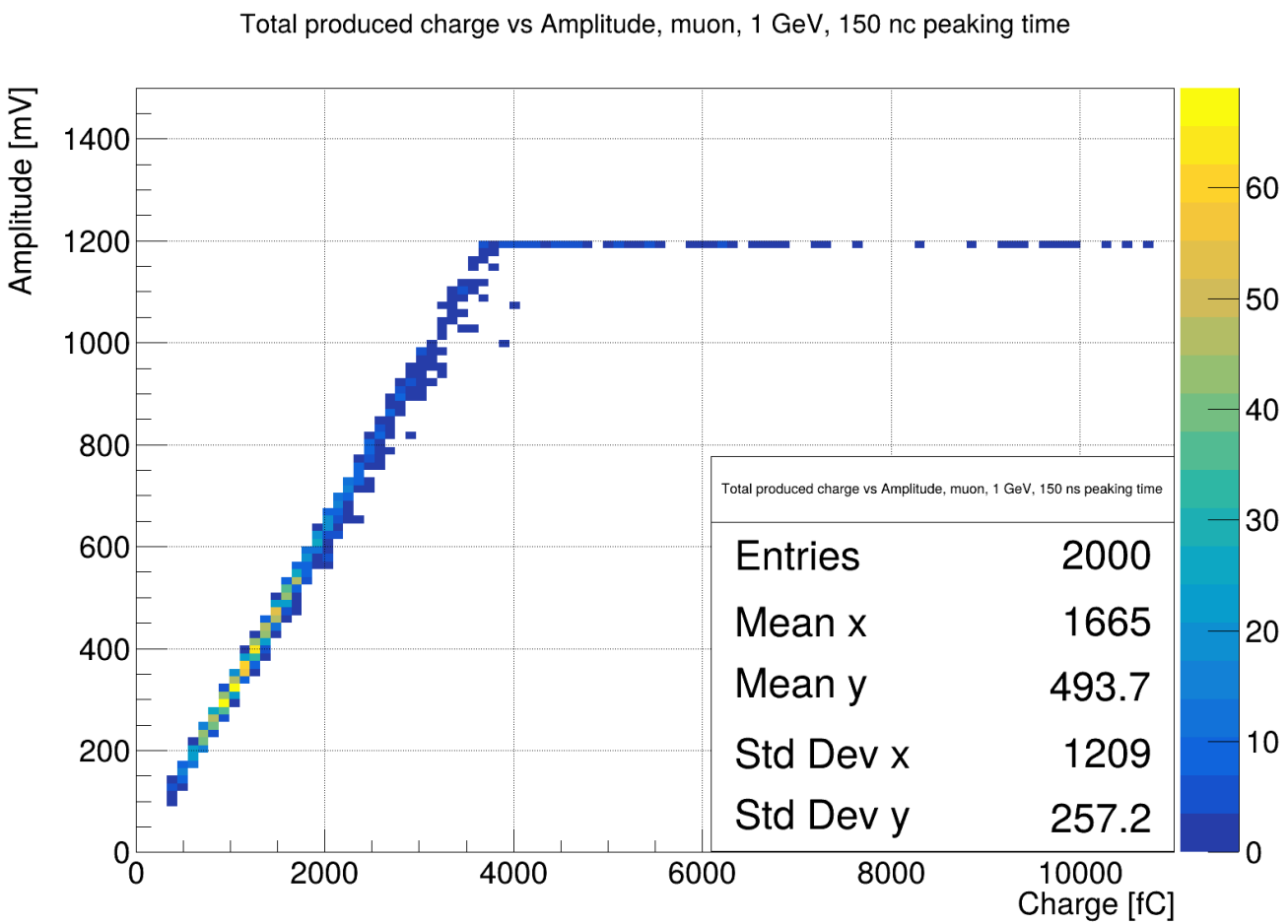


Figure 14: Total charge [fC] vs voltage amplitude [mV]. Muon, 1 GeV, 150 ns peaking time

Total charge vs voltage amplitude

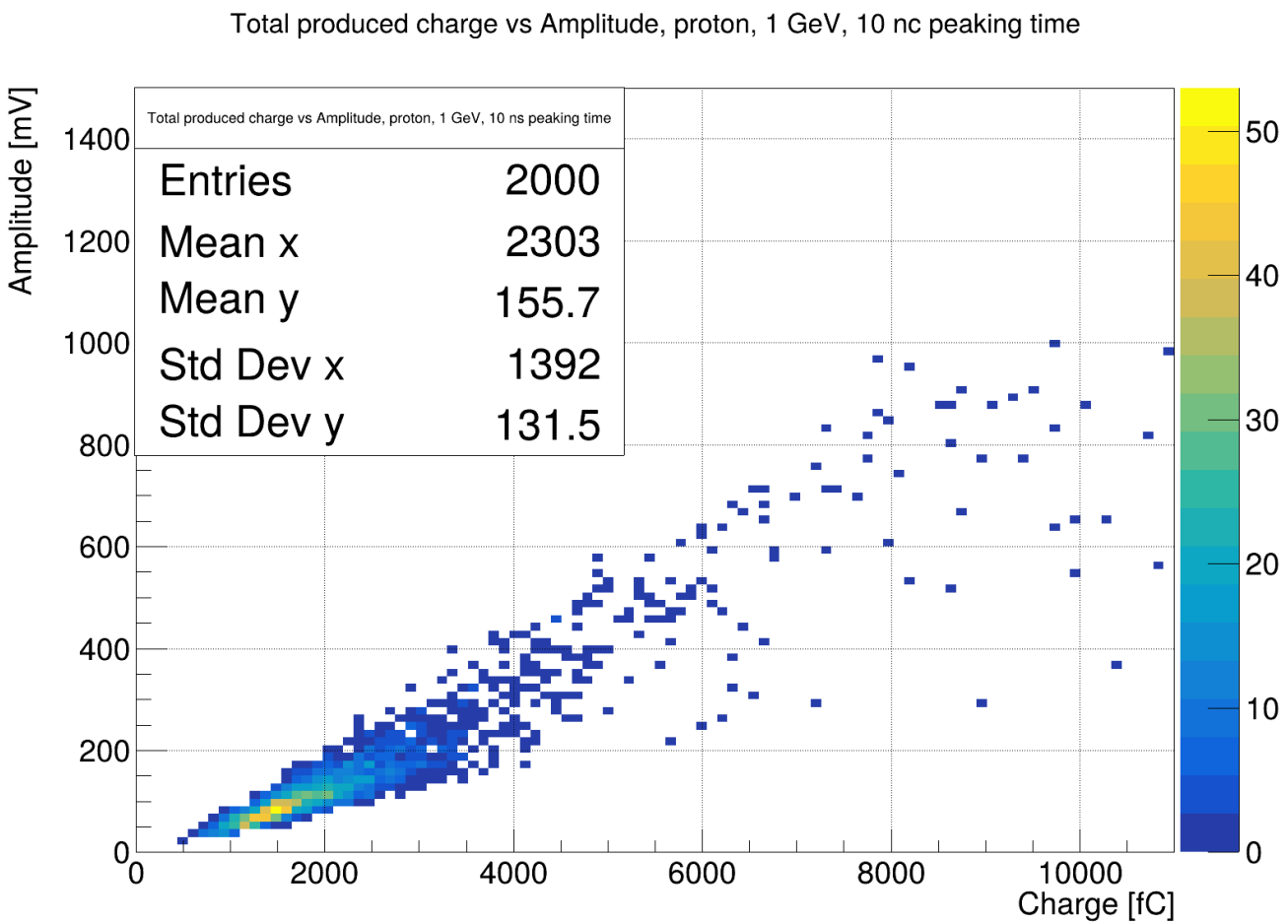


Figure 15: Total charge [fC] vs voltage amplitude [mV]. Proton, 1 GeV, 10 ns peak time

Total charge vs voltage amplitude

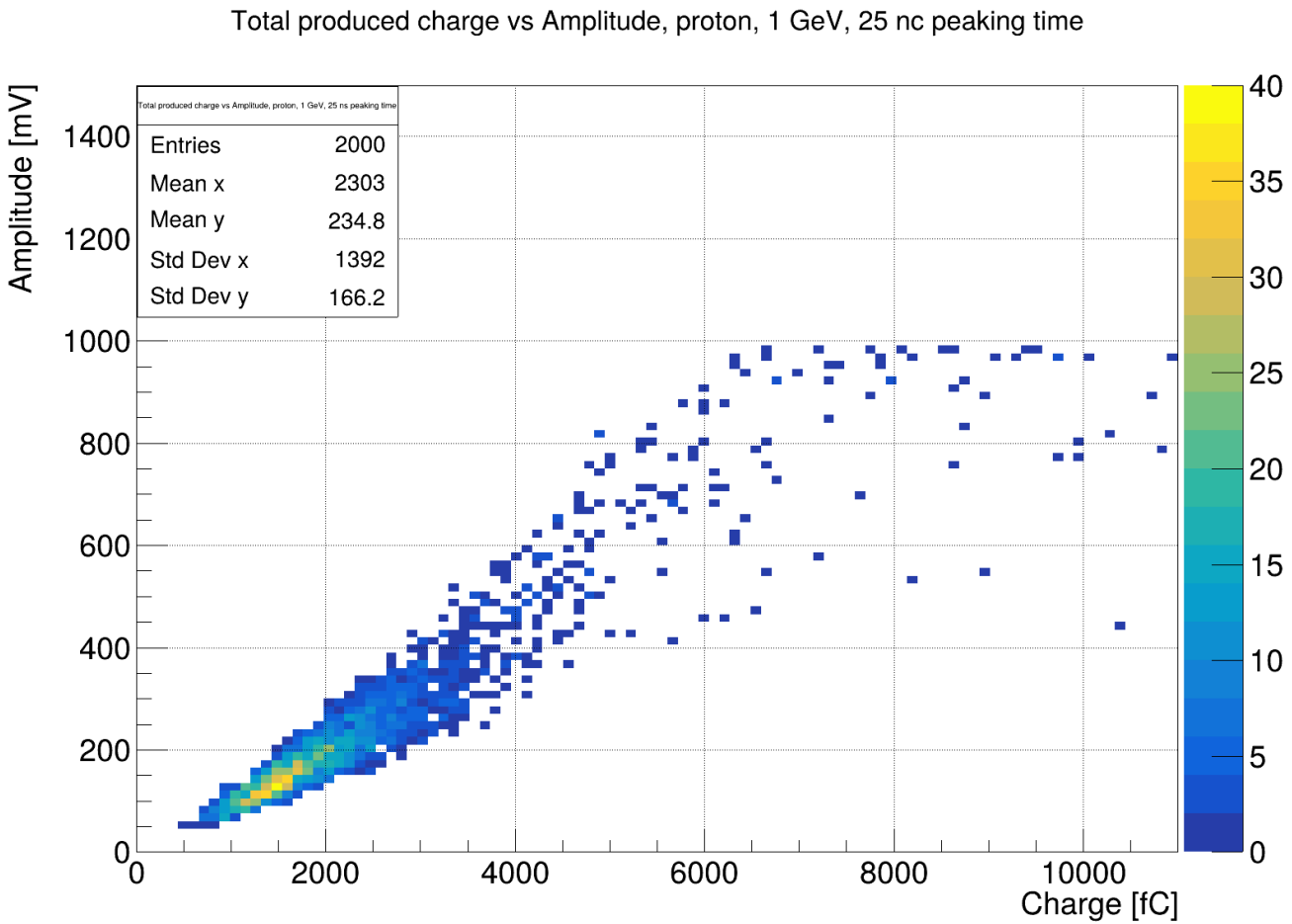


Figure 16: Total charge [fC] vs voltage amplitude [mV]. Proton, 1 GeV, 25 ns peak time

Total charge vs voltage amplitude

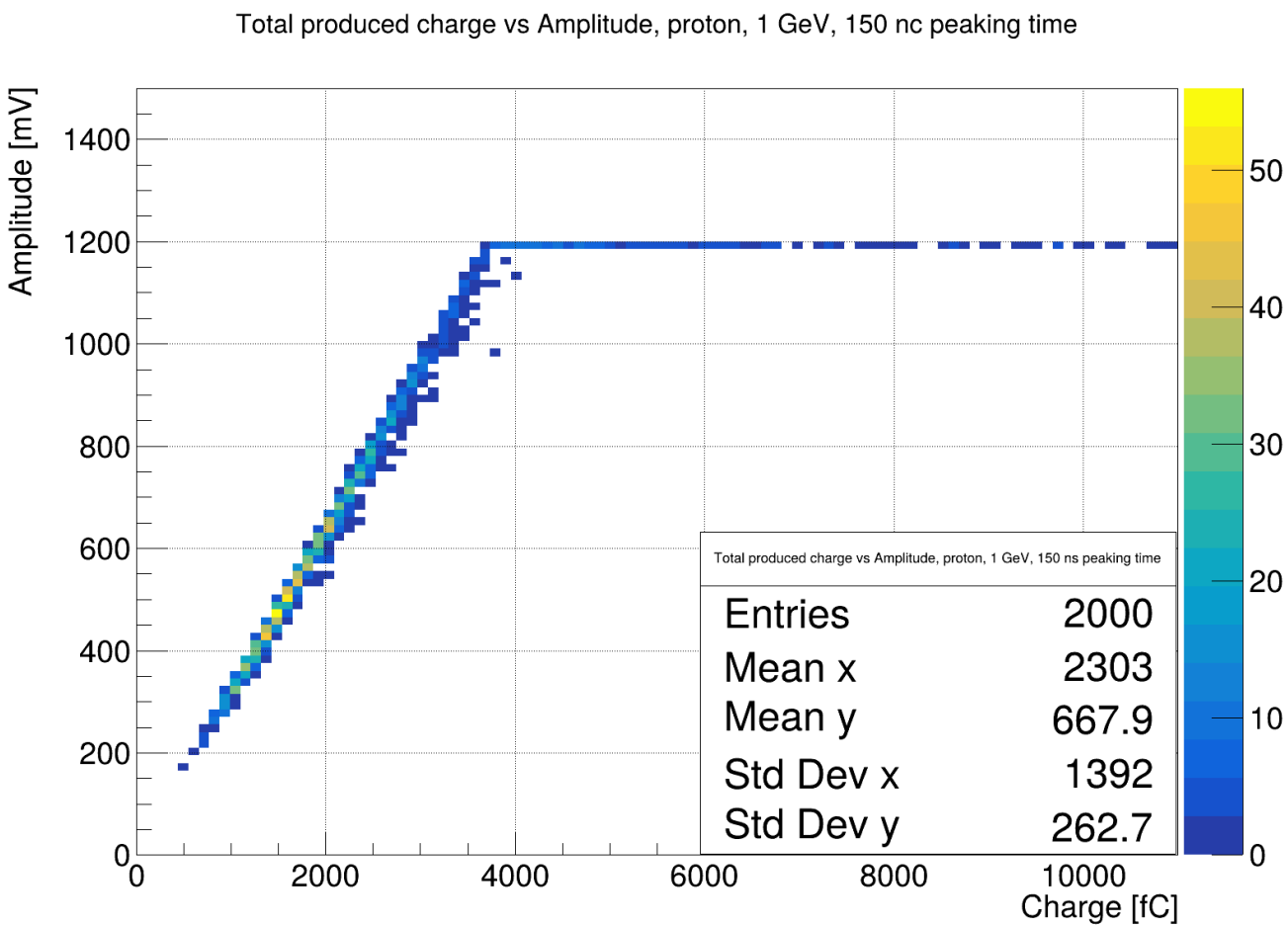


Figure 17: Total charge [fC] vs voltage amplitude [mV]. Proton, 1 GeV, 150 ns peak time