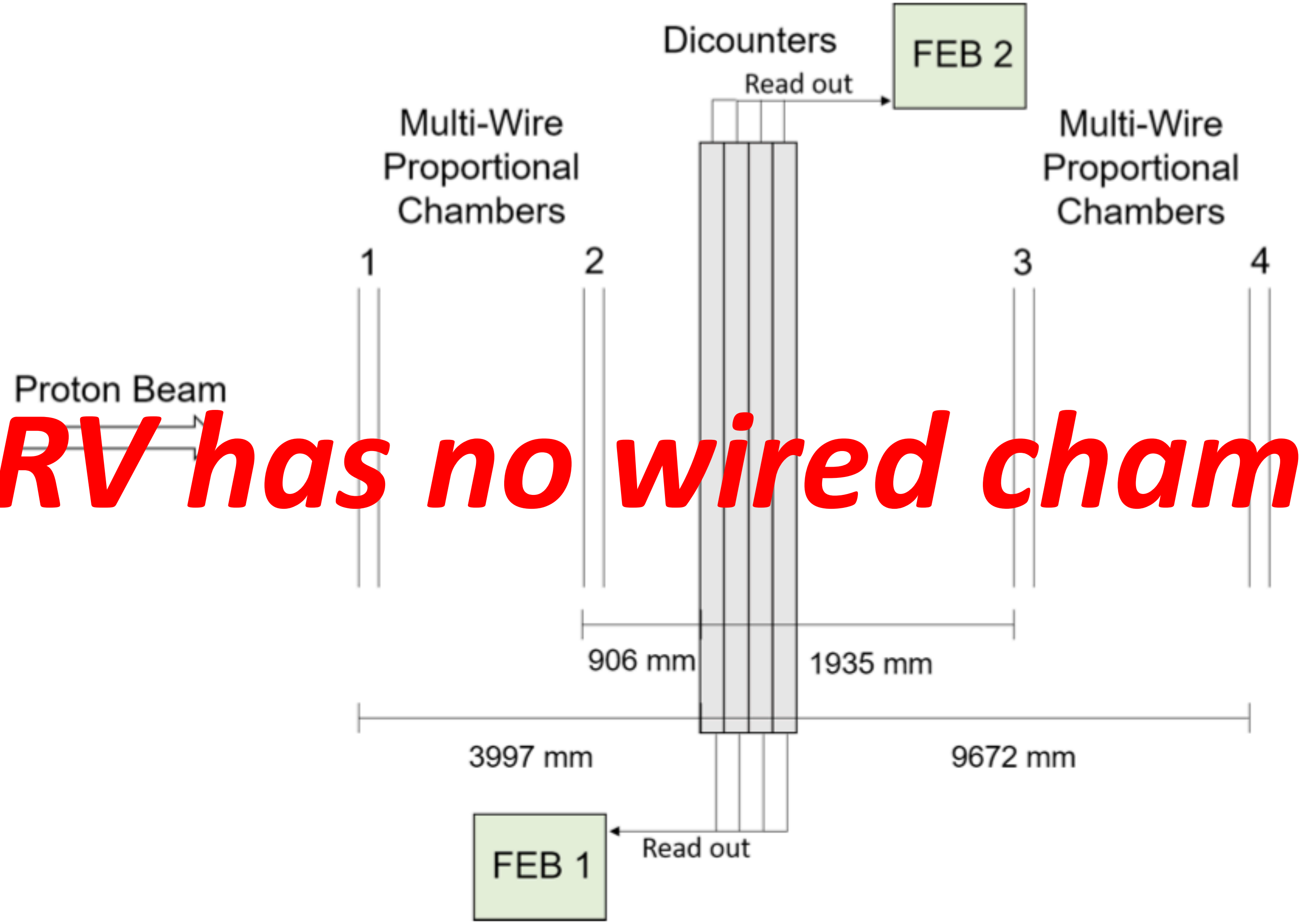
Position Measurements with CRV

Using Arrival Time and Light Yield Differences

Test runs 1002,1005-1018 from June 2017

Go Figure (Test Beam Run Setup)



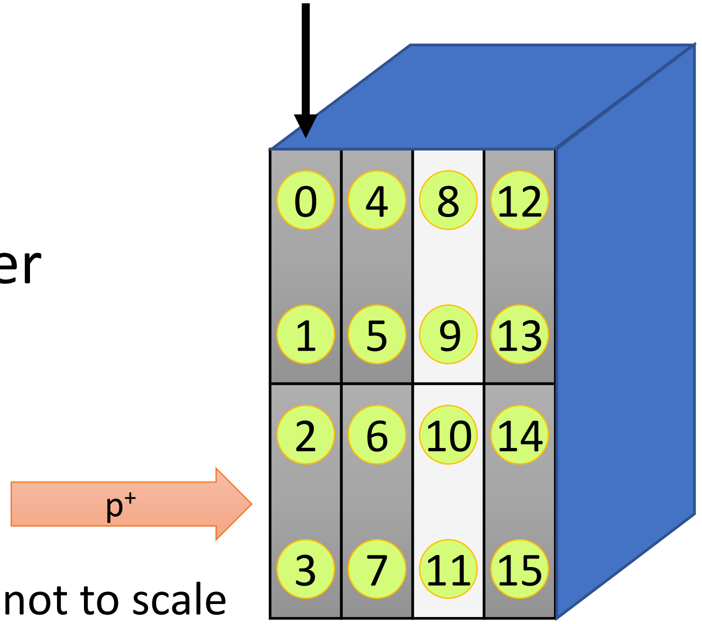
CRV has no wired chambers...

Motivation

- Estimate position of muons using time and light yield differences

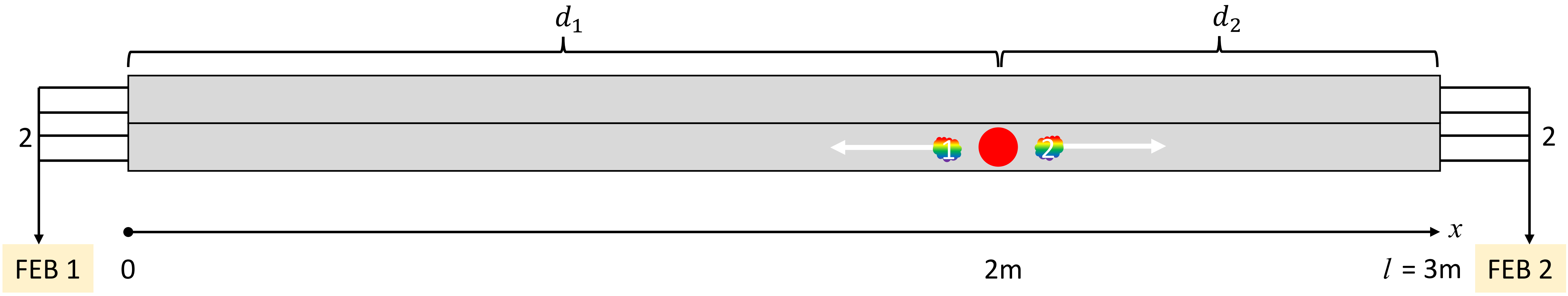
Method

- Test runs 1002,1005-1018 from June 2017
  - beam position varied from 5 to 2250mm from FEB1 end
- Used channels 2,3
- Plotted Wire-chamber measured x-position
- Plotted calculated x-position with formulae
  - using arrival time difference on opposite ends of fiber
  - using light yield difference on opposite ends of fiber



*not to scale

Time Difference Method (Using One Fiber, Channel 2)



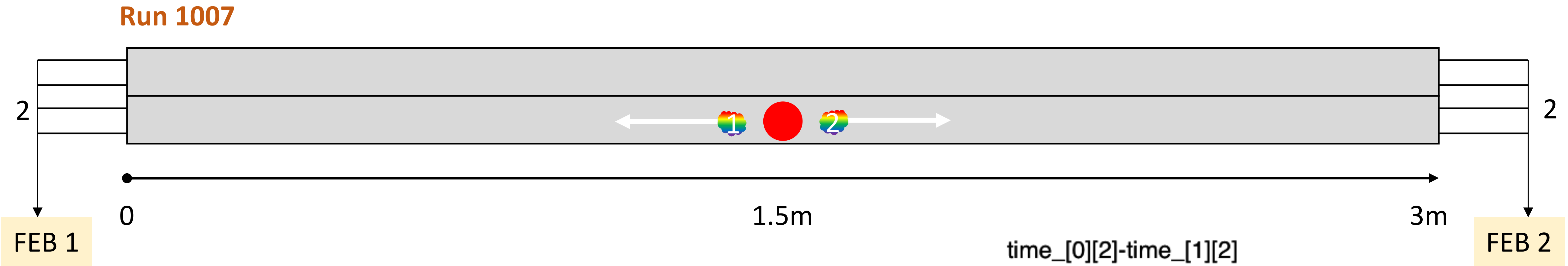
$$(t_1 - t_2) \cdot v = \Delta d$$

$$\Downarrow$$

$$(t_1 - t_2 - t_c) \cdot v = \Delta d$$

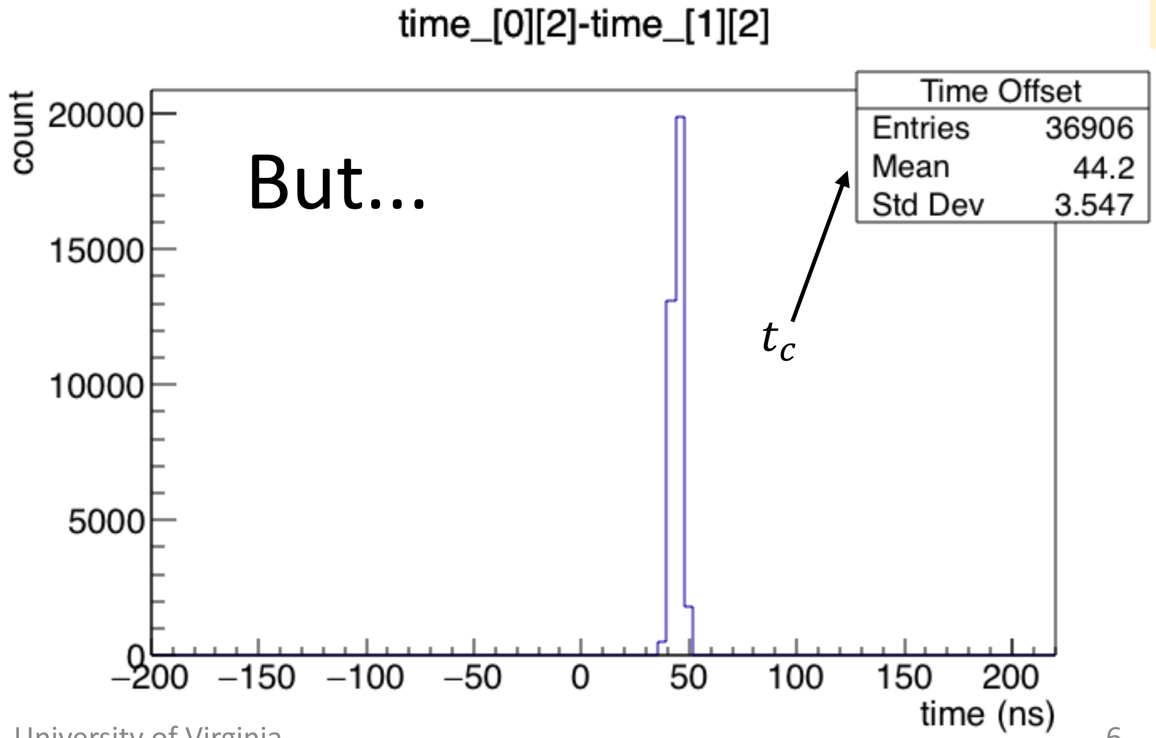
$$x = \frac{(l + \Delta d\,)}{2}$$

t_c: Time Offset Correction



Ideally:

$$\frac{1}{N}\sum(t_1 - t_2) = 0$$



Time Difference Method (Using Both Fibers, Channels 2 &3)

One Fiber

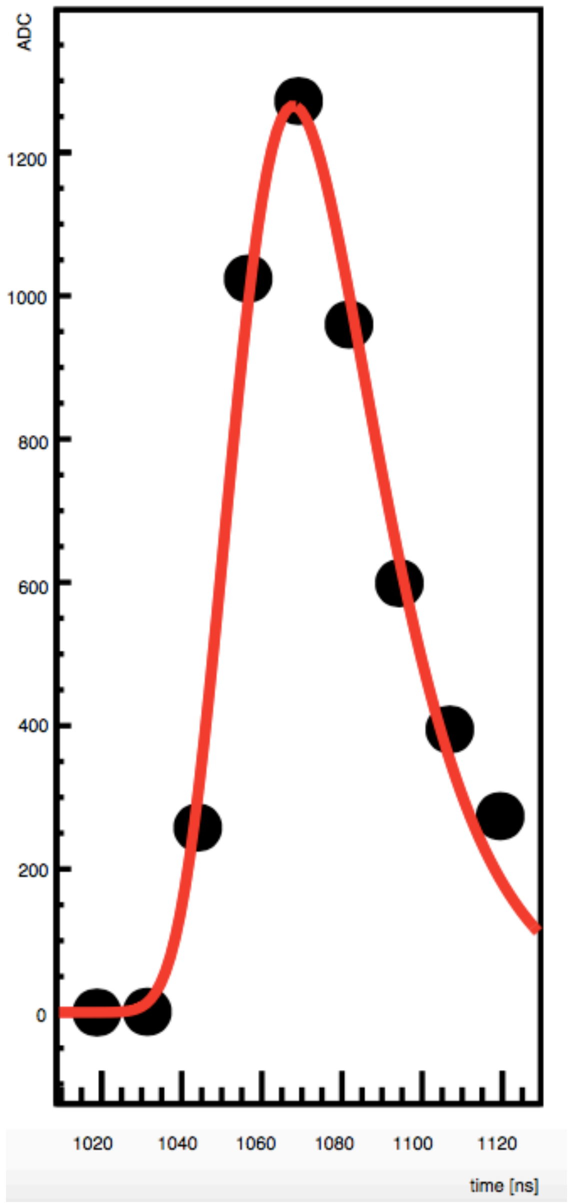
$$(t_1 - t_2 - t_c) \cdot v = \Delta d$$

Two Fibers

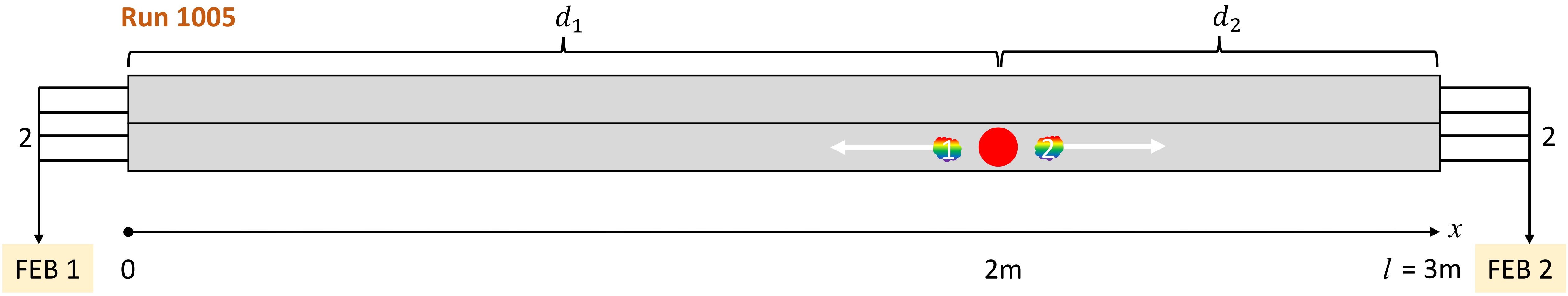
$$\left(\frac{t_{1,2} + t_{1,3}}{2} - \frac{t_{2,2} + t_{2,3}}{2} - t_c\right) \cdot v = \Delta d$$

Leading Edge Time vs. Peak Time

- Two types of arrival times recorded by FEBs
  - Leading edge (LE) time
  - Peak time (or simply, time)

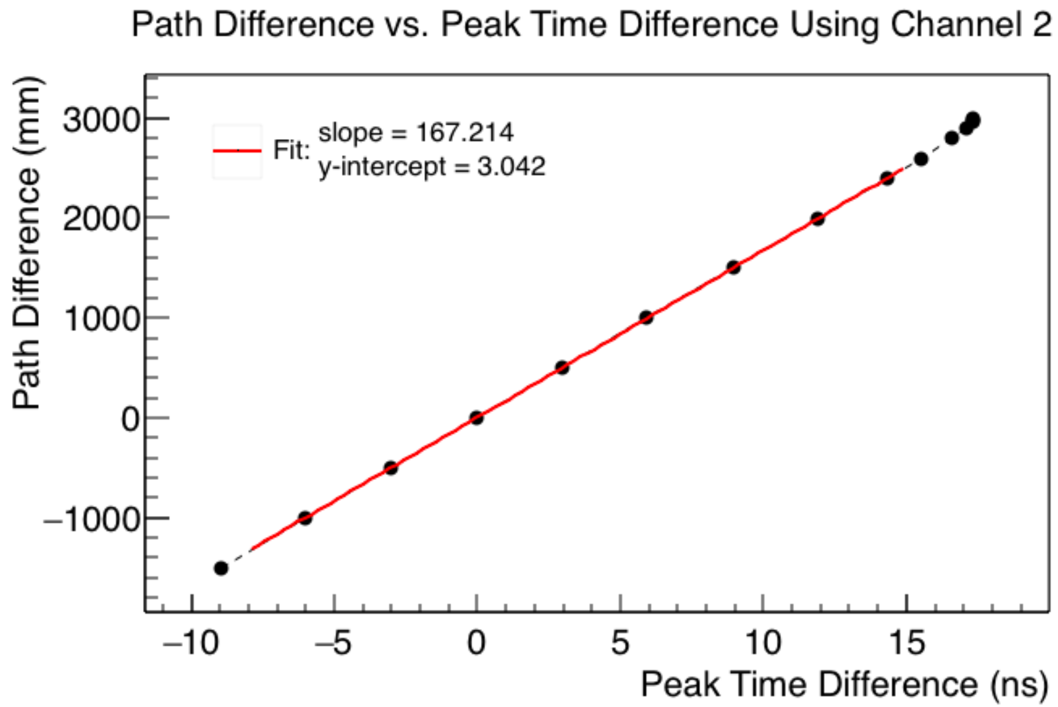


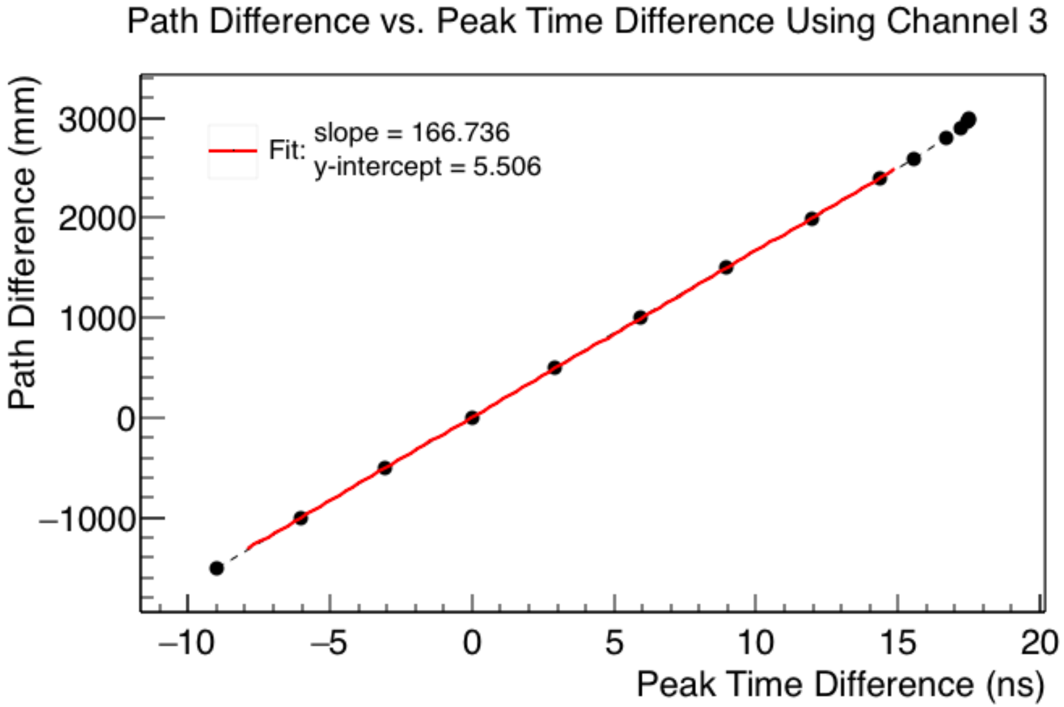
Speed of Light Calculation



$$\Delta d = v \cdot (t_1 - t_2 - t_c)$$

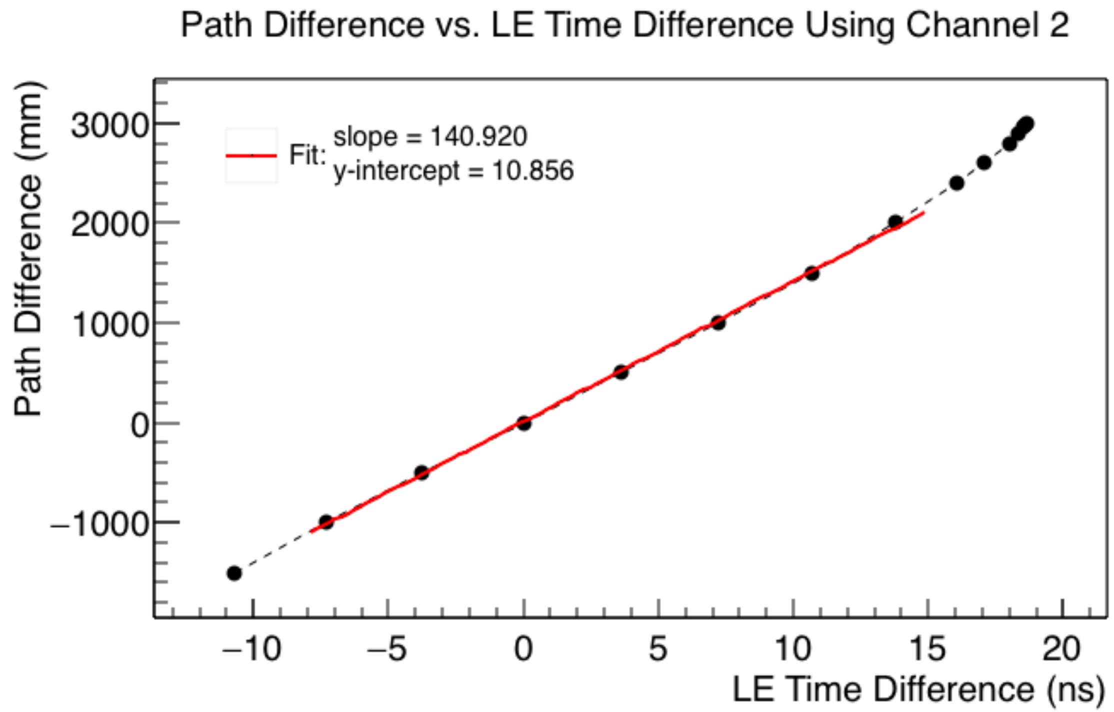
Using Peak Time

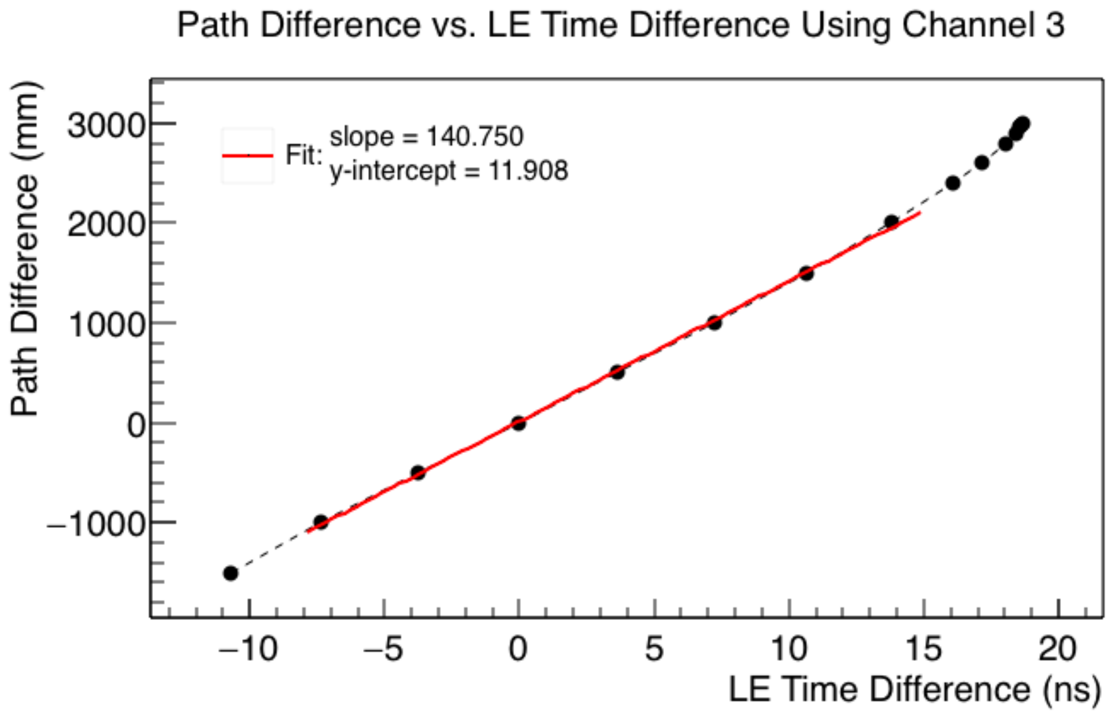




$$v_{\text{using peak time}} \approx 166.975\text{mm/ns}$$

Using LE Time



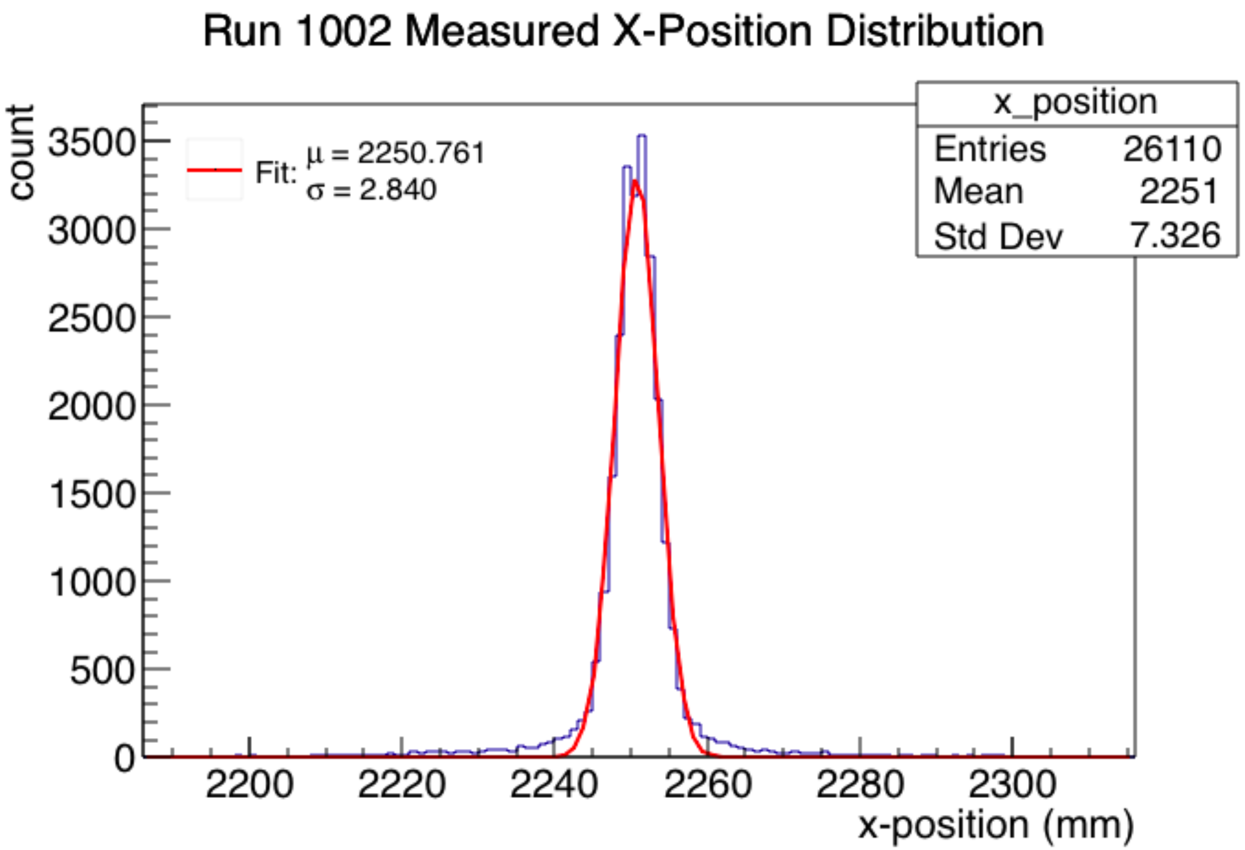


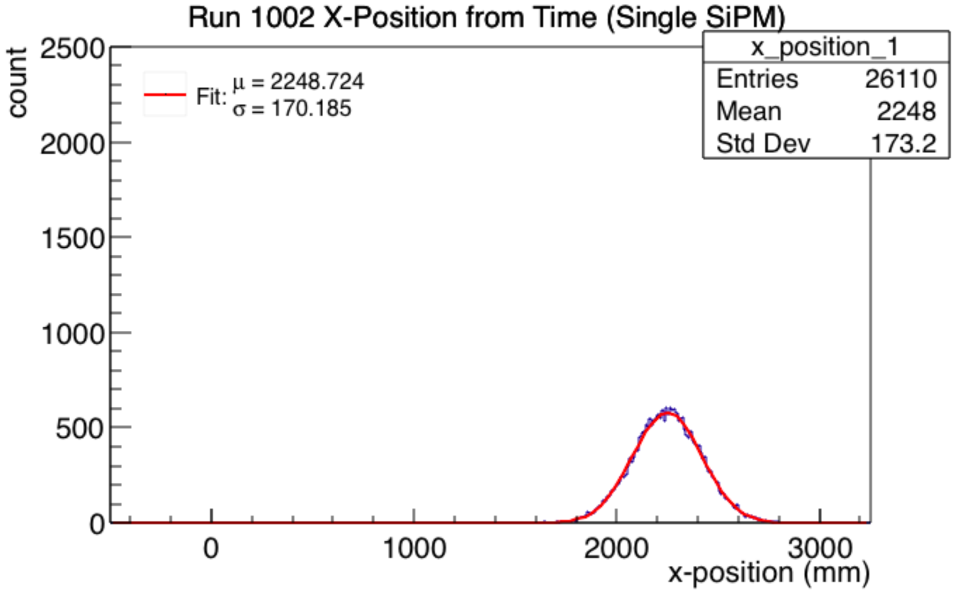
$$v_{\text{using LE time}} \approx 140.835\text{mm/ns}$$

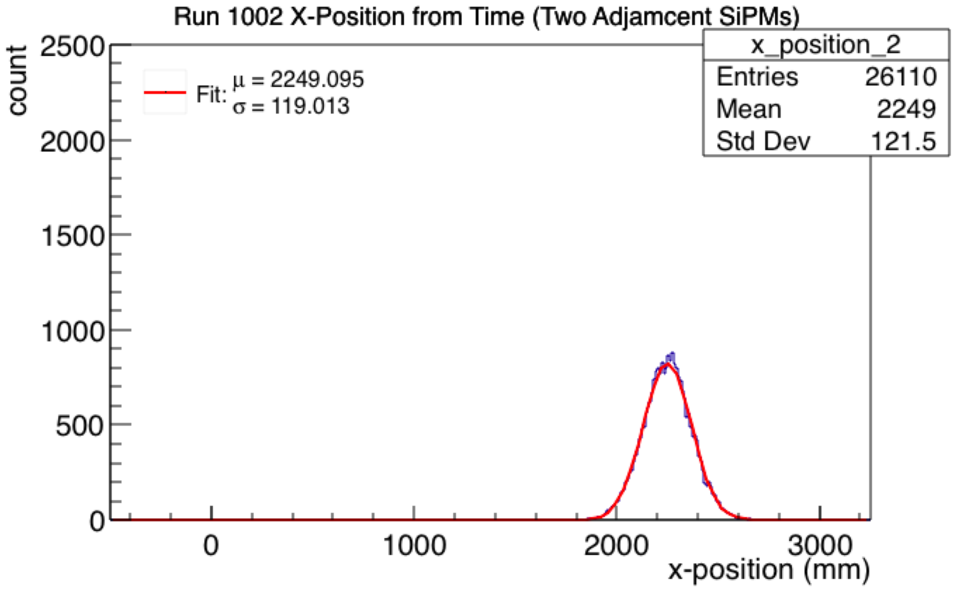
Position Plots

Run 1002

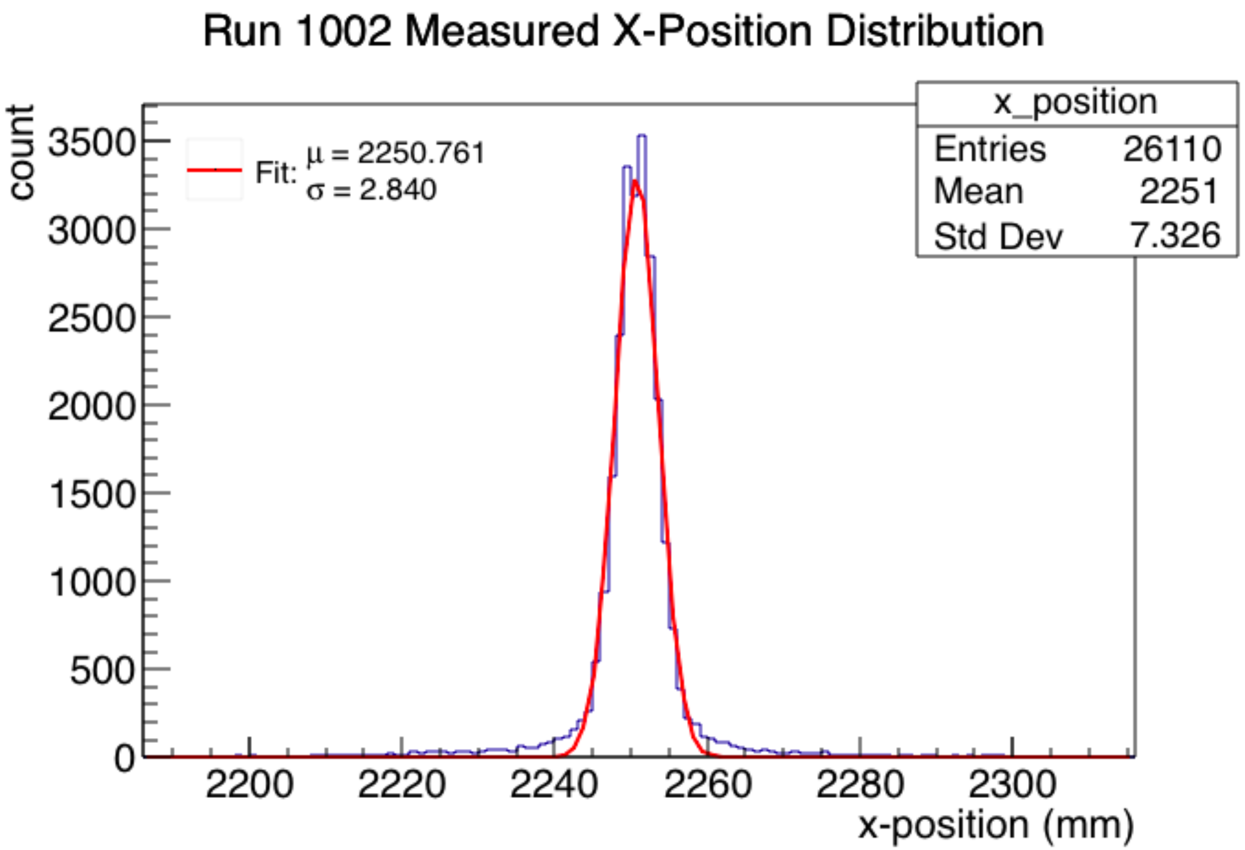
Using Peak Time

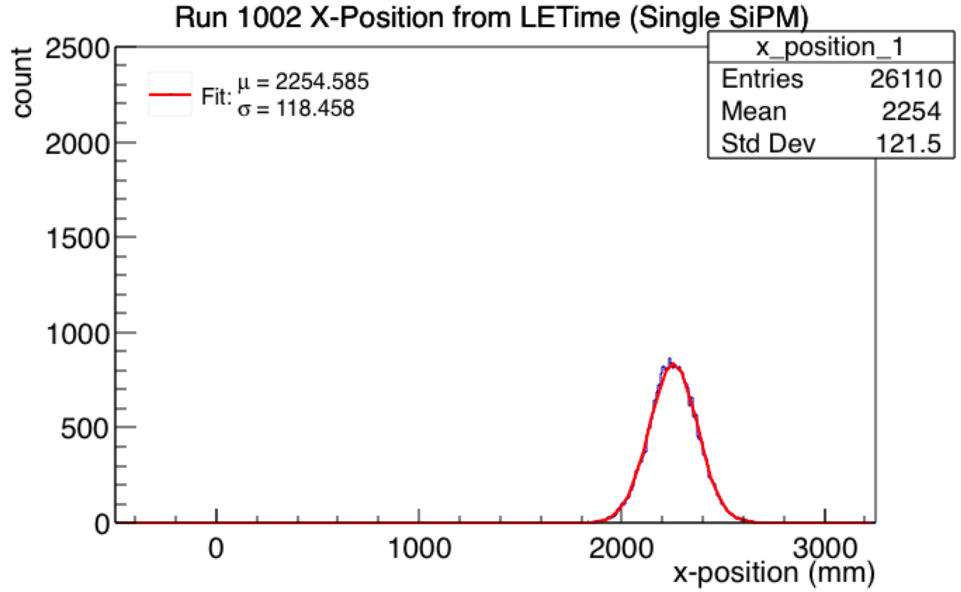


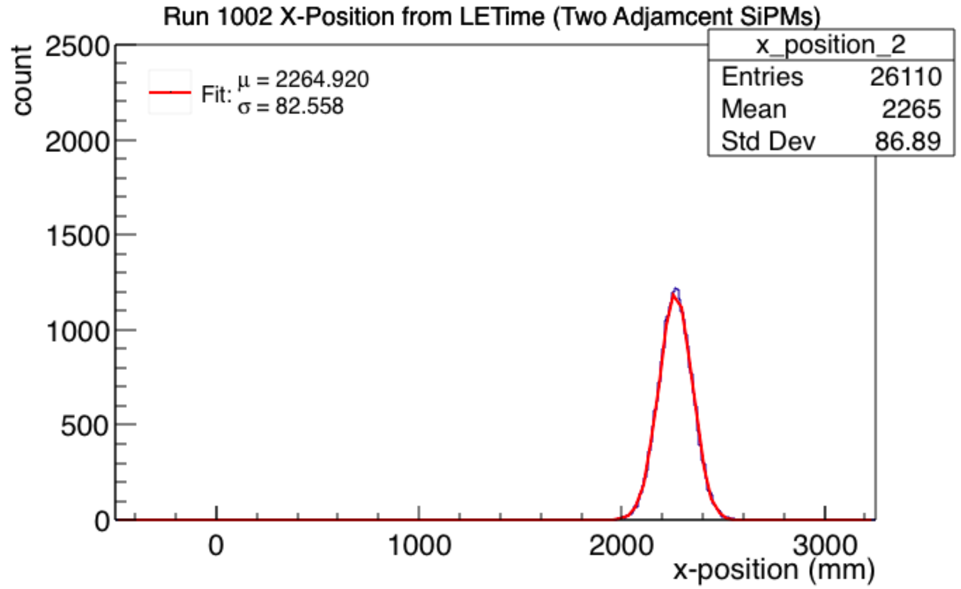




Using LE Time



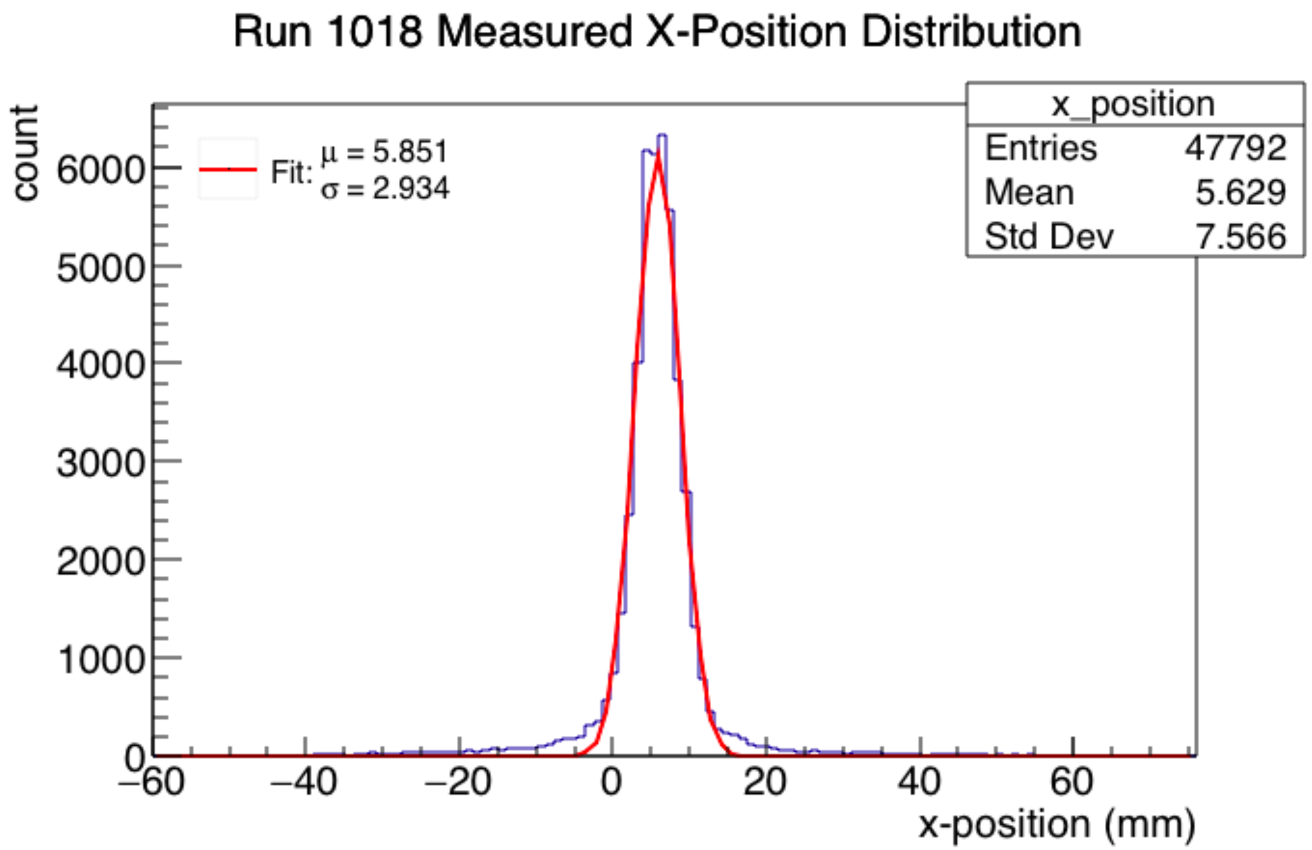


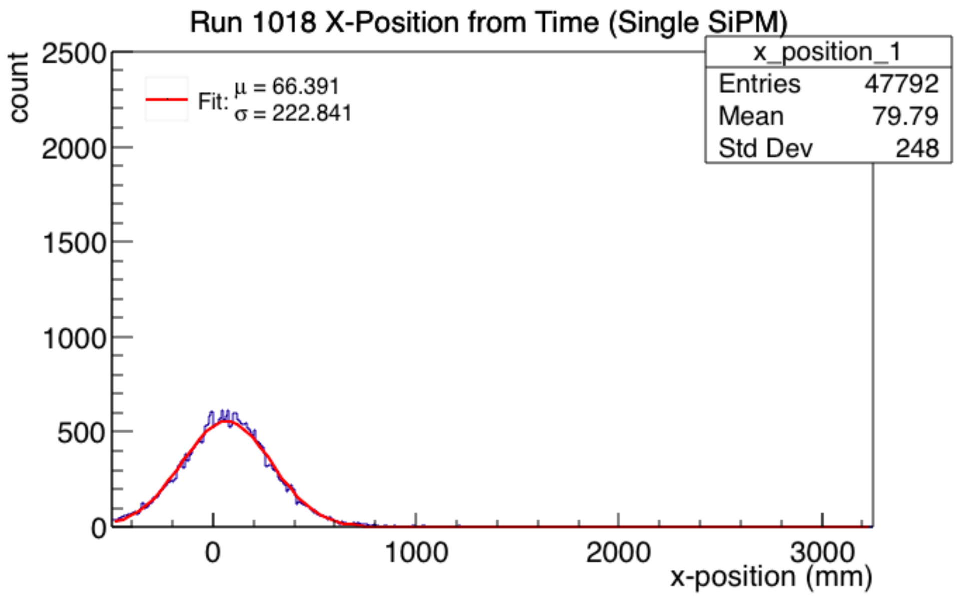


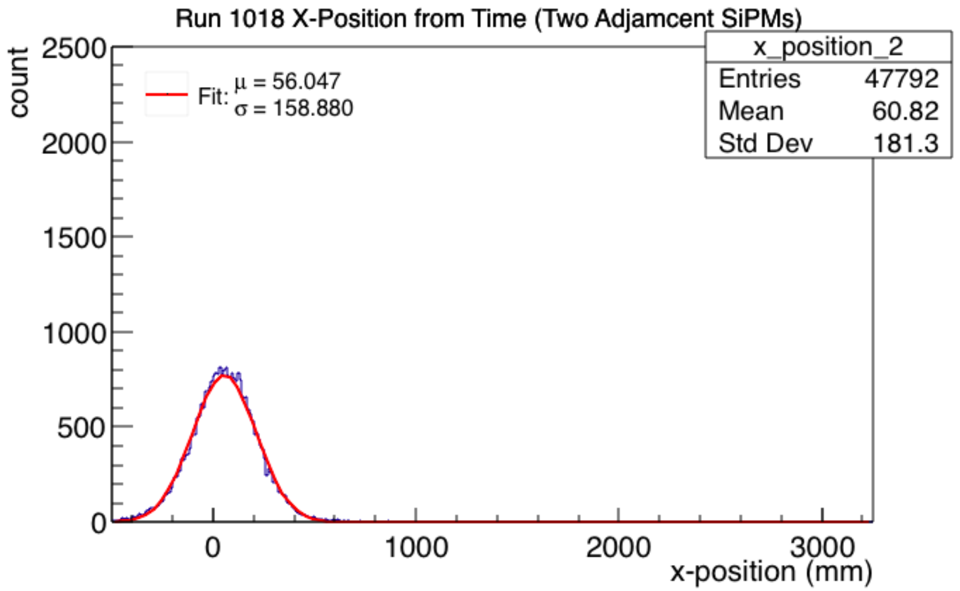
Position Plots

Run 1018

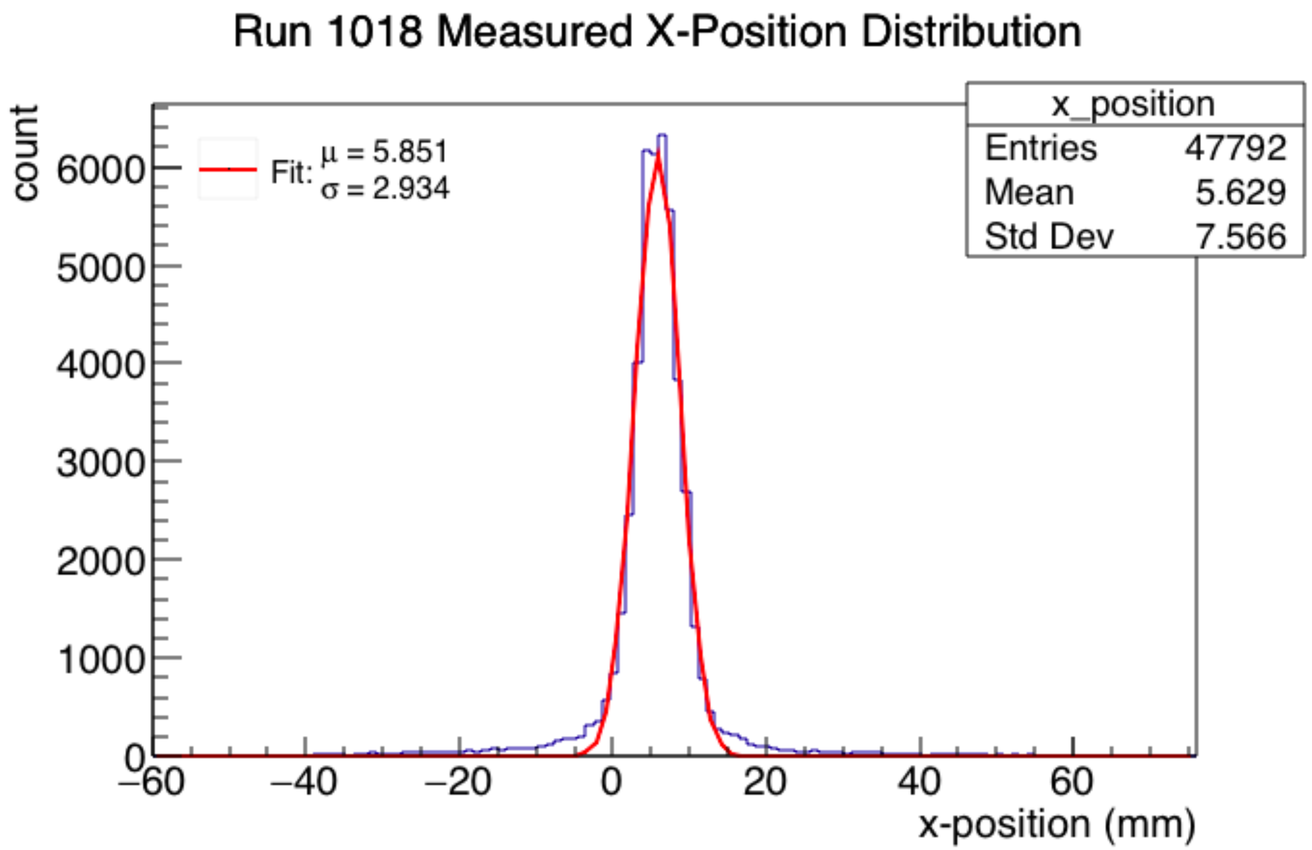
Using Peak Time

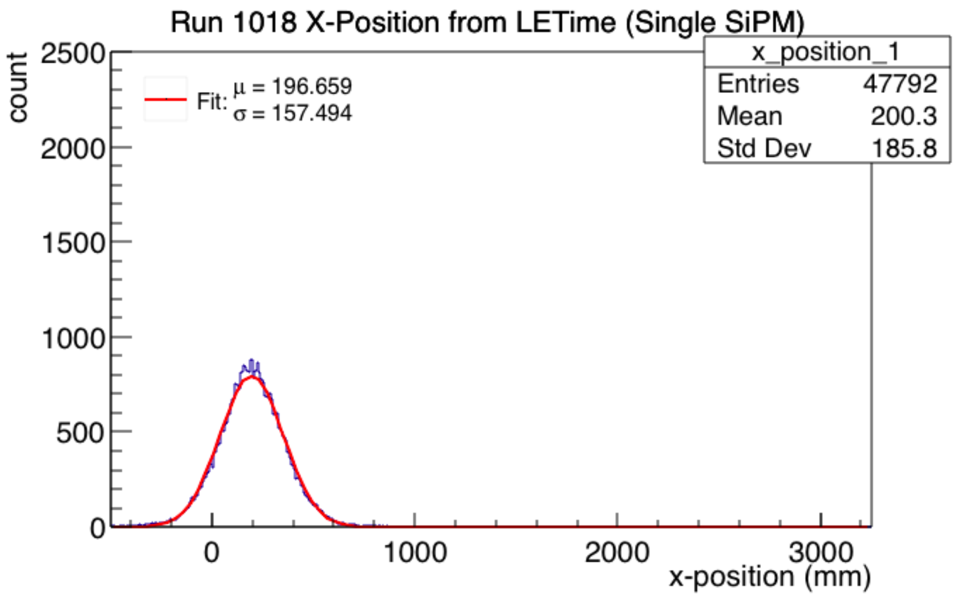


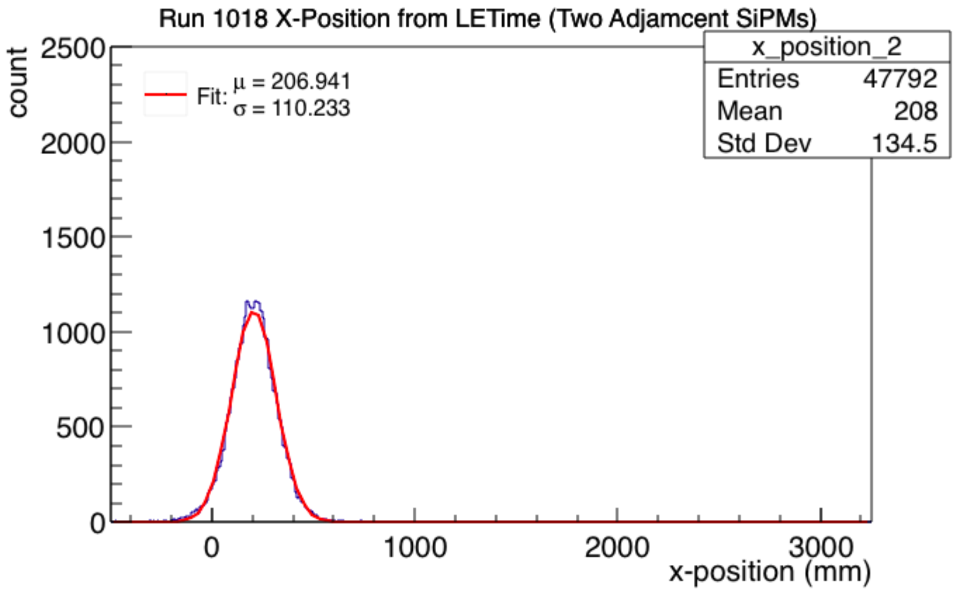




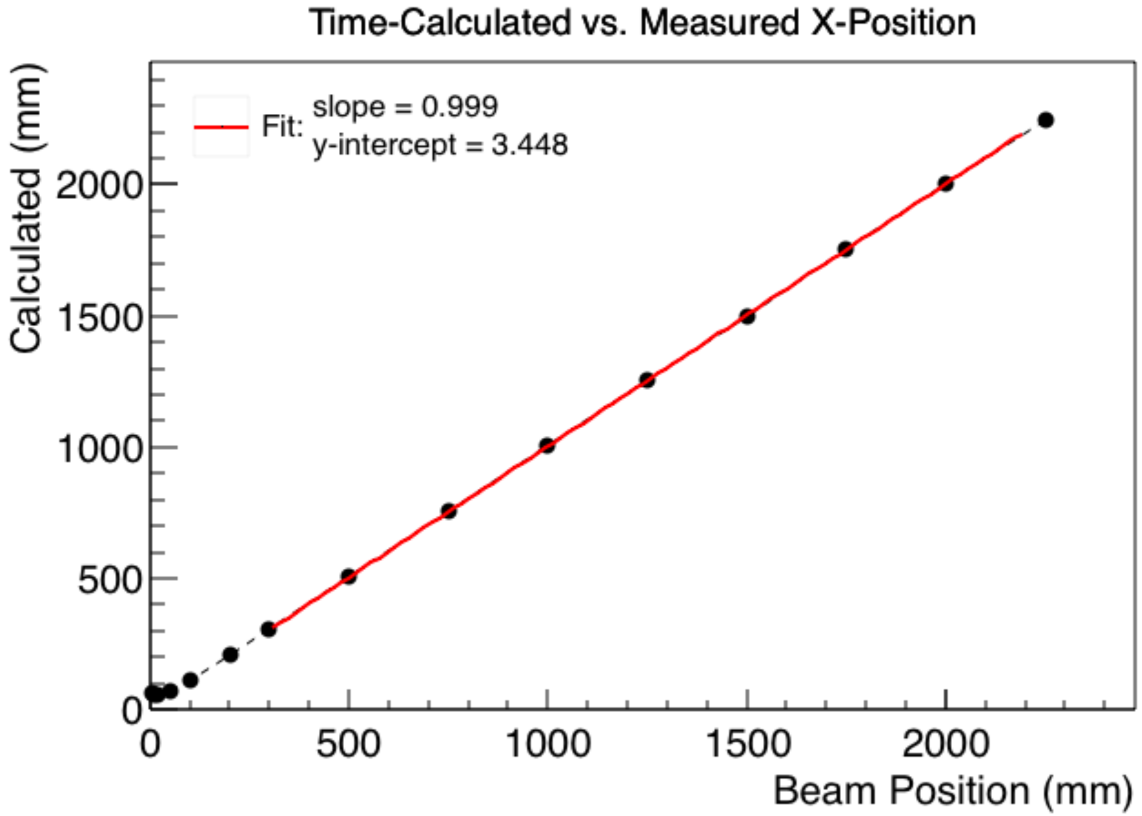
Using LE Time

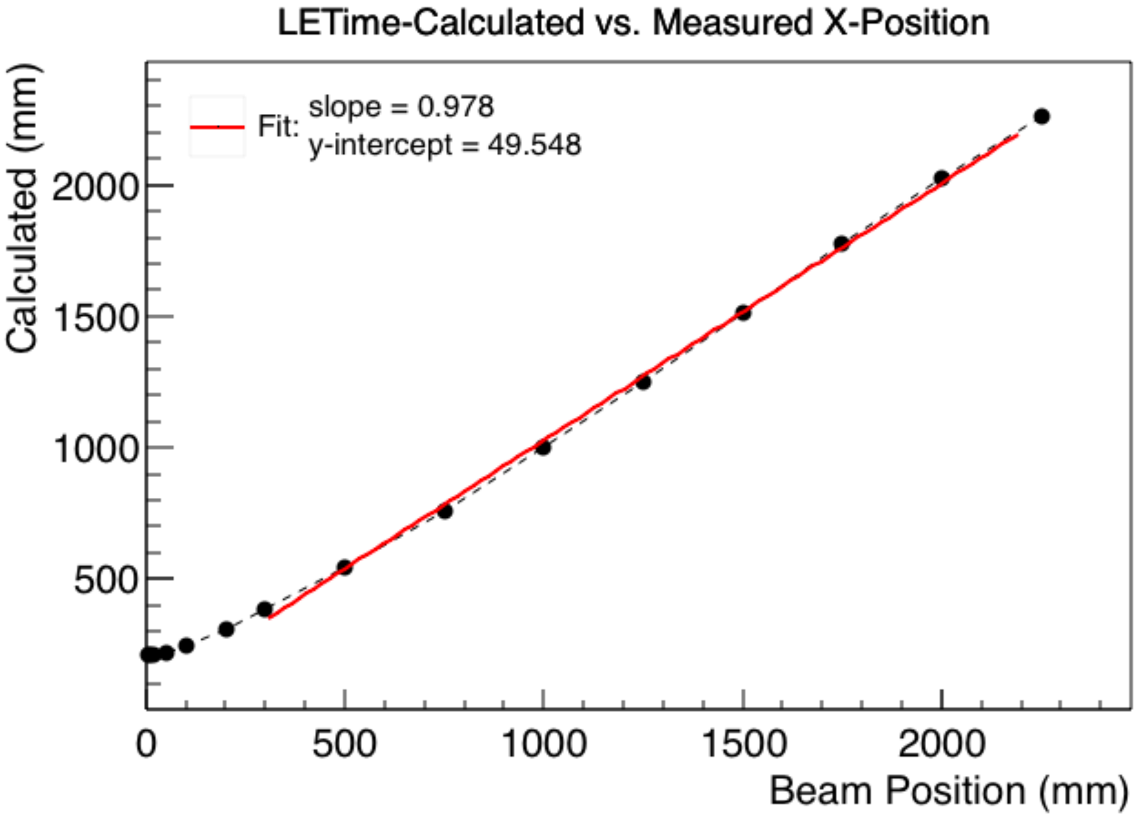






Correlation Plots





Statistics

- When both fibers are used, for both peak and LE time methods...
  - standard deviation becomes smaller
  - average position becomes less accurate

Light Yield Difference Method

$$R = \frac{S_1 - S_2}{S_1 + S_2}$$

$$S \approx e^{-x/\lambda} \approx 1 - \frac{x}{\lambda}$$

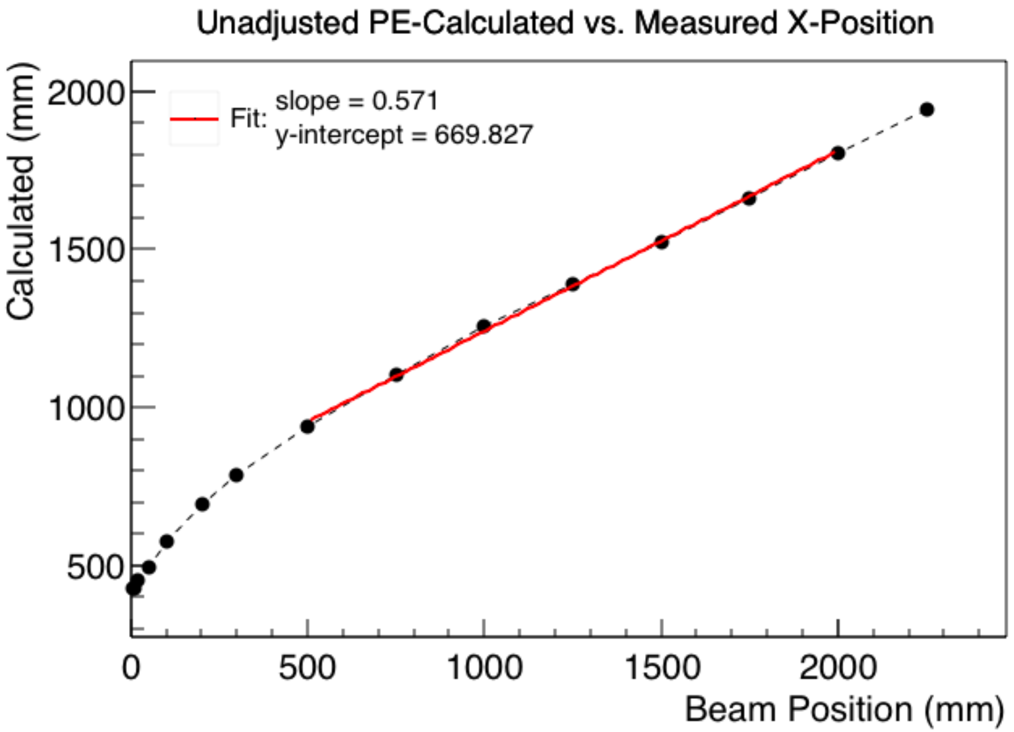
$$x = \frac{l}{2} - R\left(\lambda ? \frac{l}{2}\right)$$

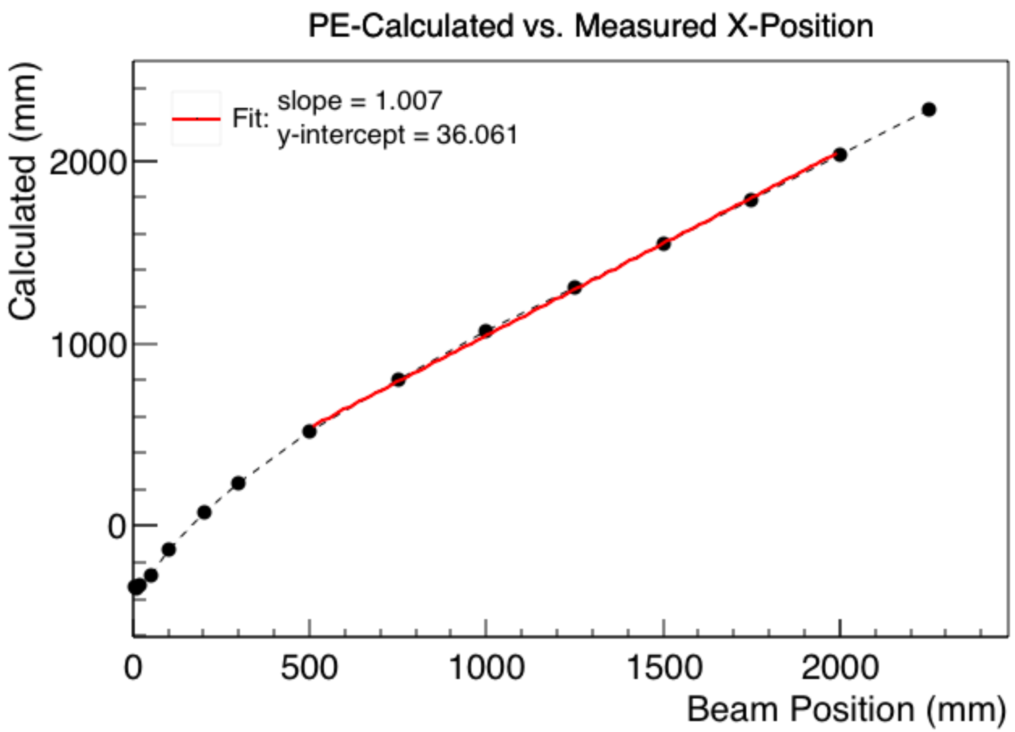
Approximating Unknown Attenuation Length (λ)

$$x = \frac{l}{2} - R\left(\lambda - \frac{l}{2}\right)$$

$$\lambda - \frac{l}{2} = 3000 = l$$

$$\lambda - \frac{l}{2} = \frac{3000}{0.571}$$



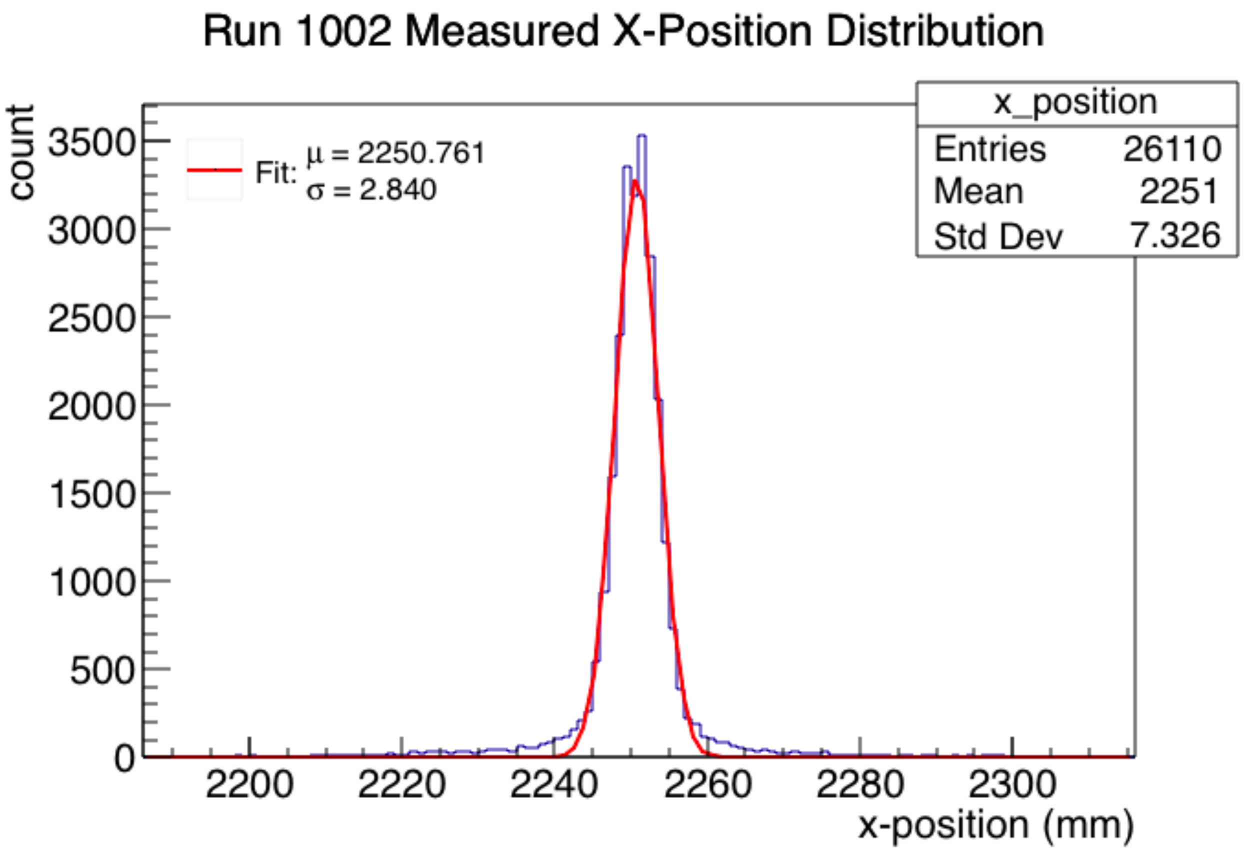


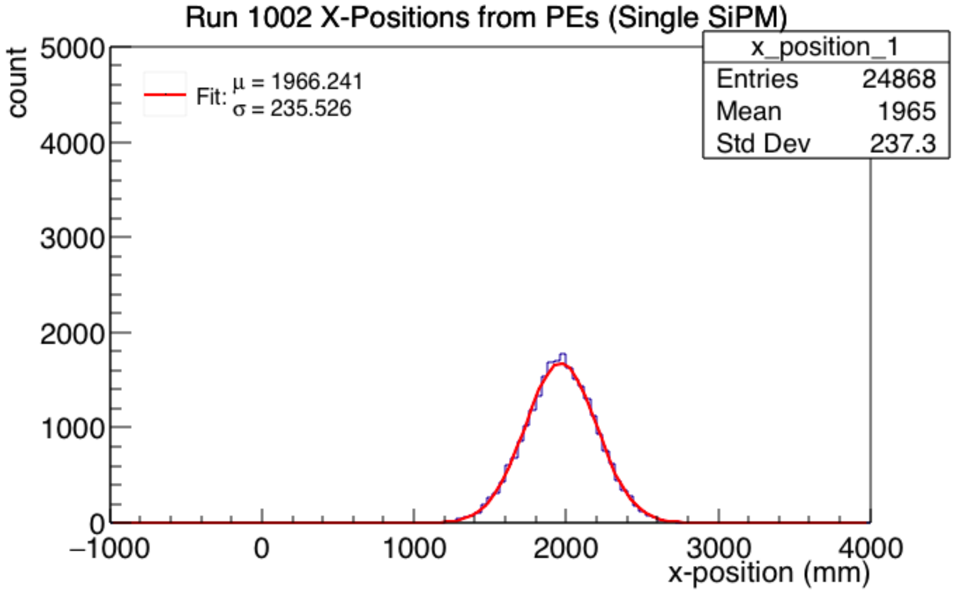
Position Plots

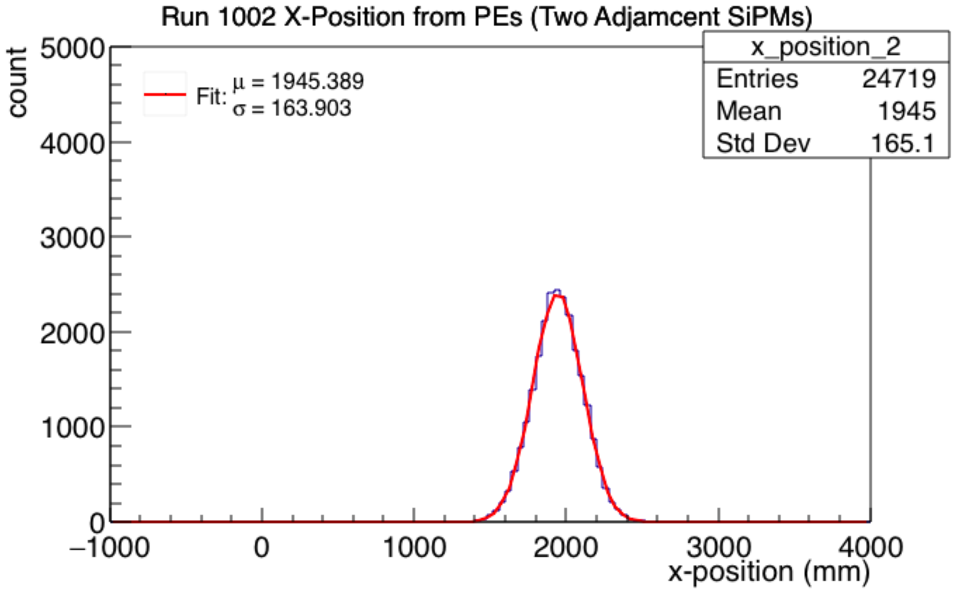
Run 1002

Using $\lambda - \frac{l}{2} = 3000$ mm

λ = 4,500 mm

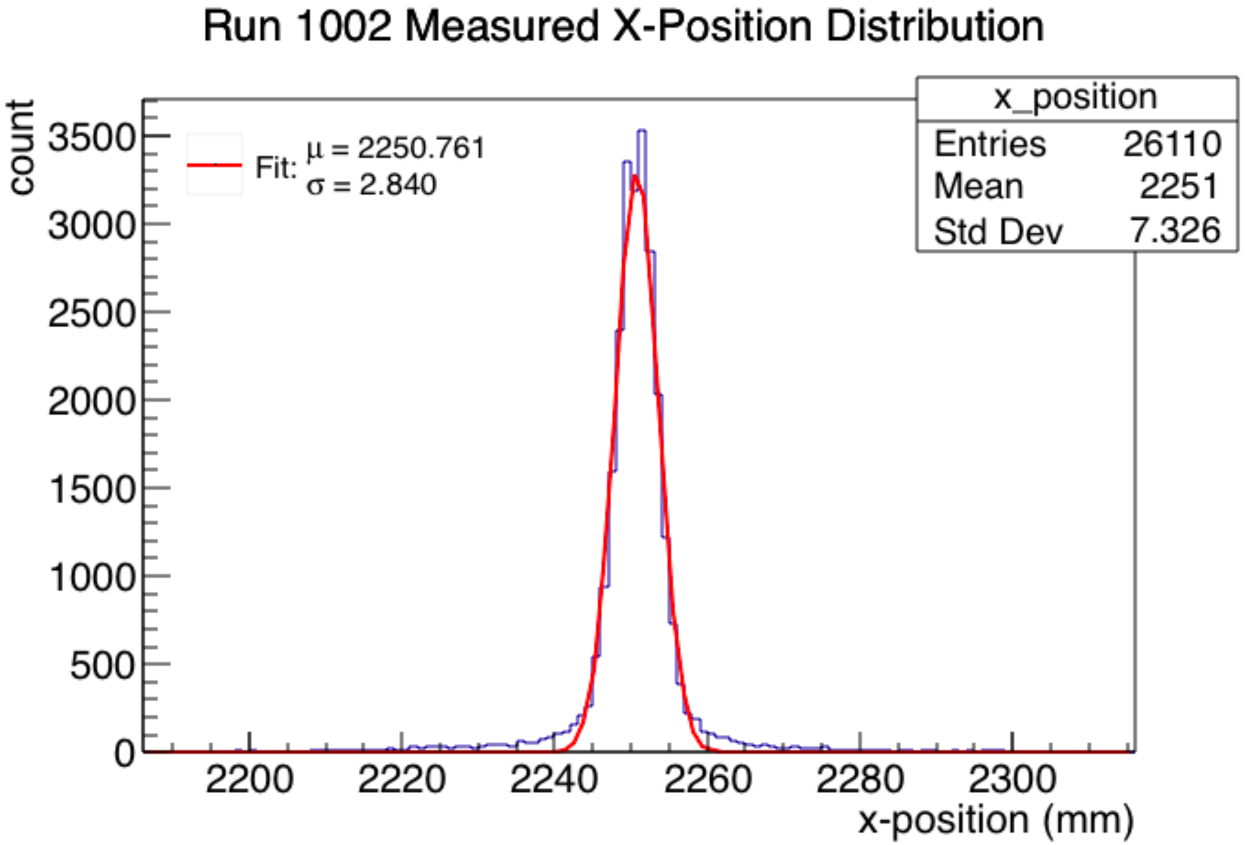


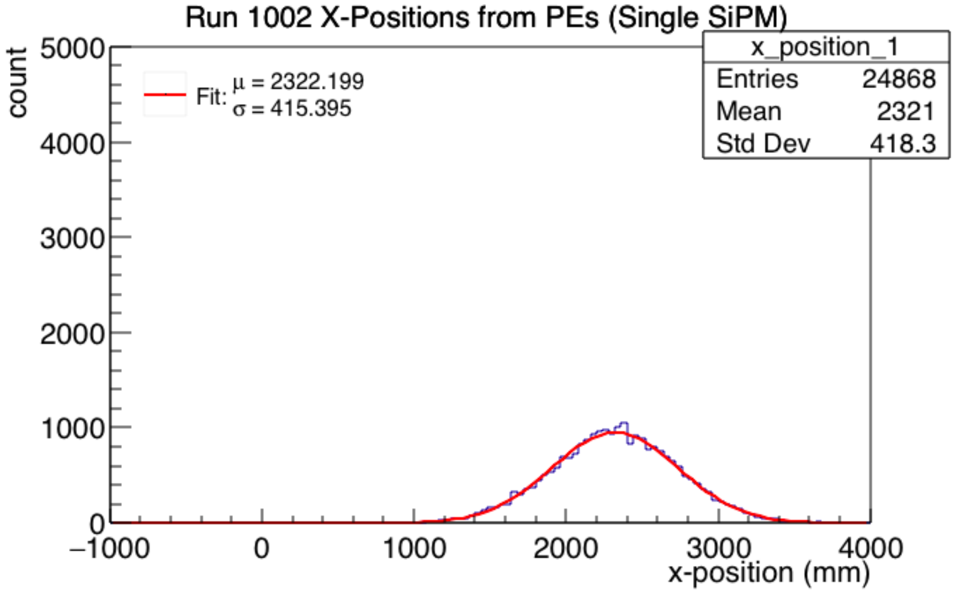


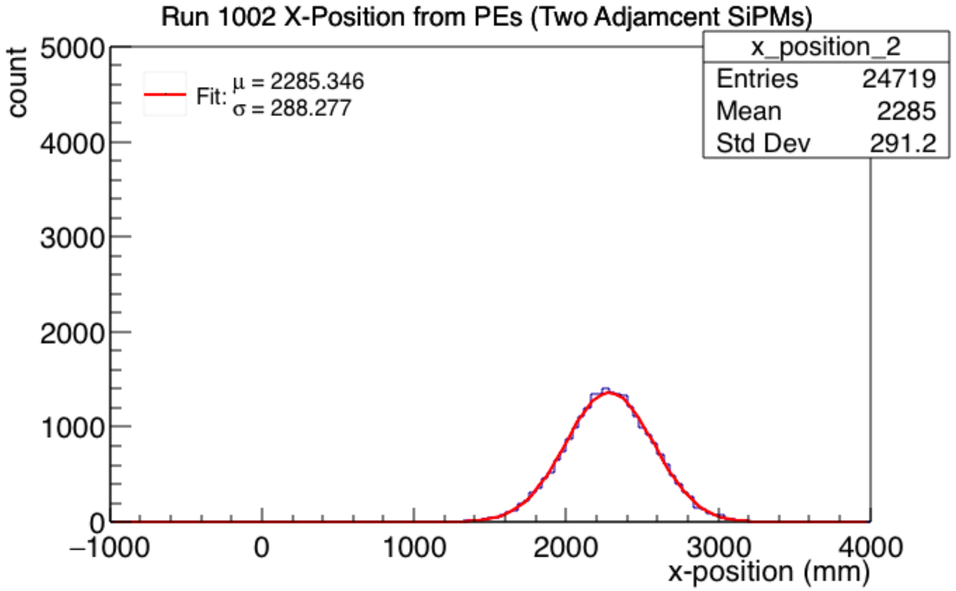


Using $\lambda - \frac{l}{2} = \frac{3000}{0.571}$ mm

λ = 6,754 mm





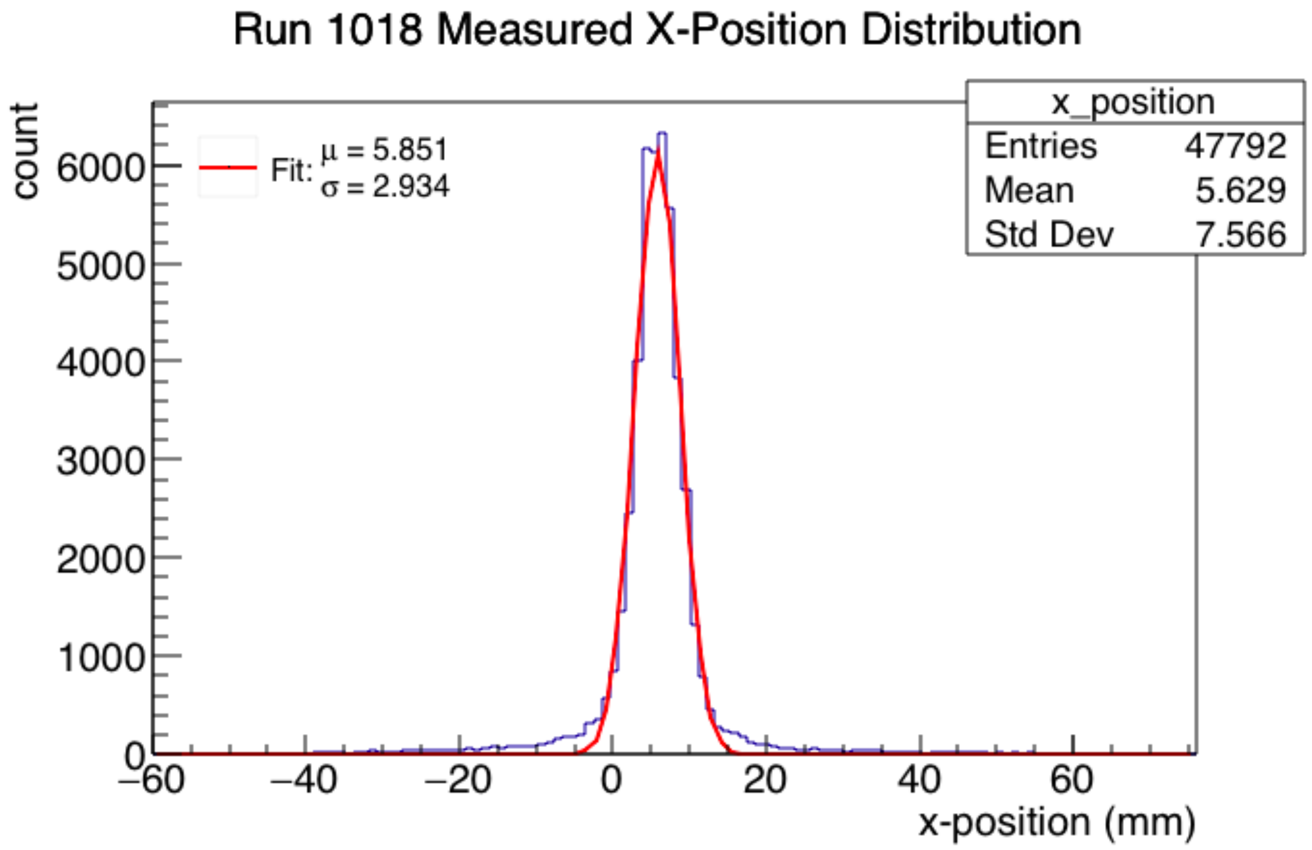


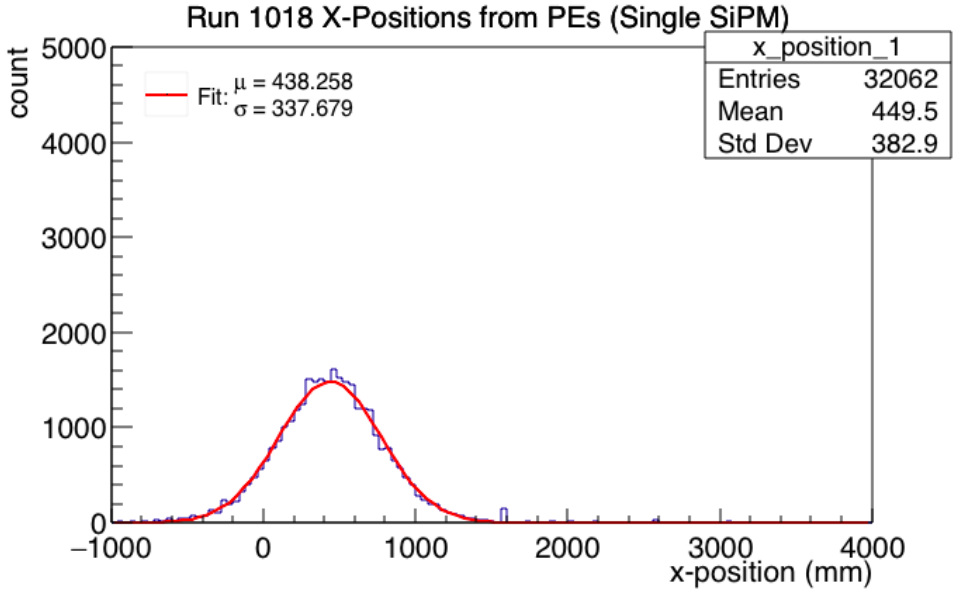
Position Plots

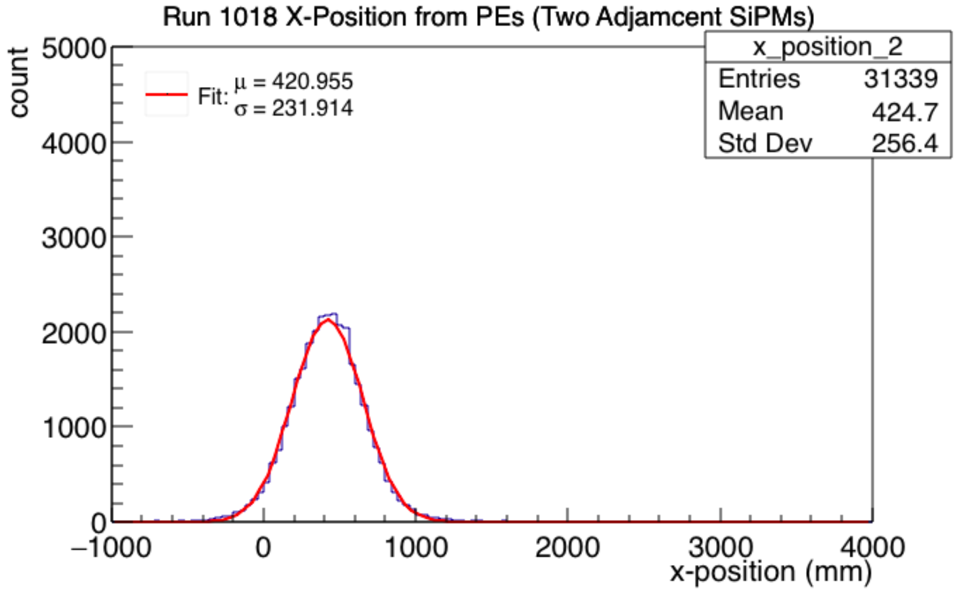
Run 1018

Using $\lambda - \frac{l}{2} = 3000$ mm

λ = 4,500 mm







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