

Beamline Systematics

Jake Calcutt
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Introduction



The ProtoDUNE beamline provides for beam-related analyses:

- Momentum measurement
- Location at the face of the TPC
 - Cutting out wrongly-tagged beam particles
- PID of beam particles

Need to understand beamline performance and systematics (i.e. momentum resolution)

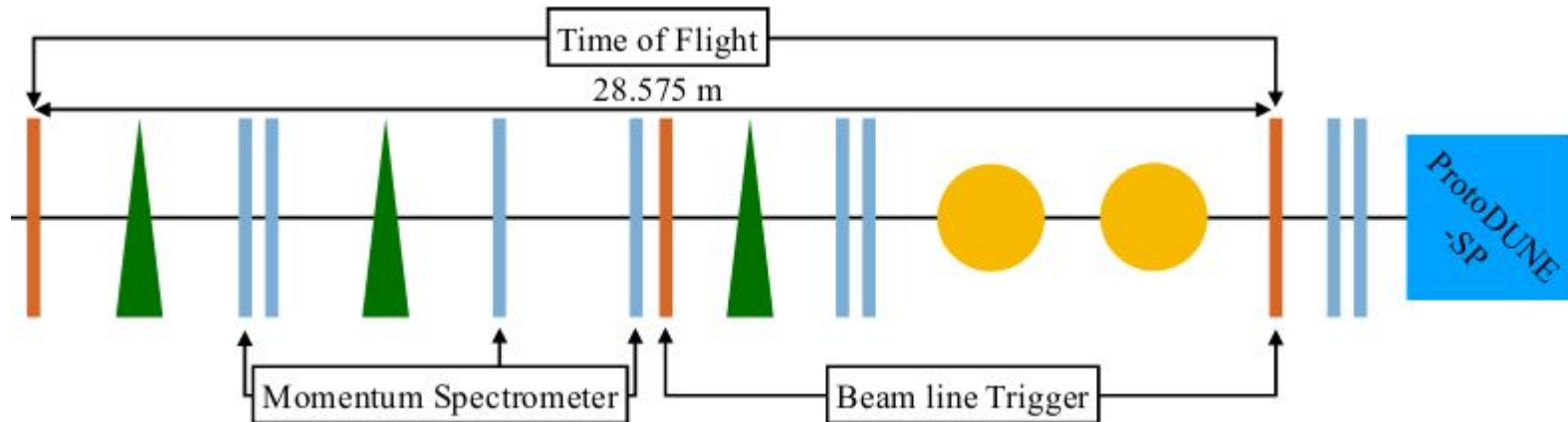
Beamline Layout

Bending Magnets

Scintillator Profile Monitors For Momentum/Tracking

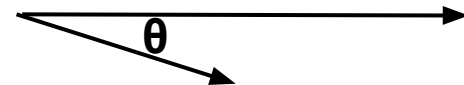
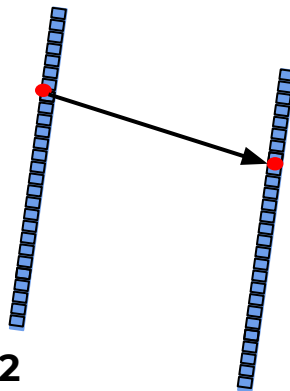
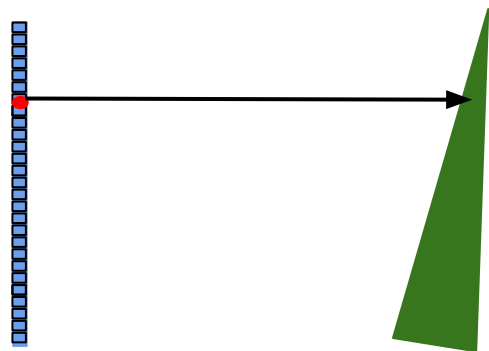
Scintillator Planes for TOF and Trigger

Cerenkov Devices for Particle ID (PID)



Momentum Calculation

- Project hit in Profiler 1 to magnet, connect hits in Profilers 2,3
 - Get θ between these trajectories
- Get current in magnet: I_B
- Momentum: $p \sim f(I_B) / \theta$



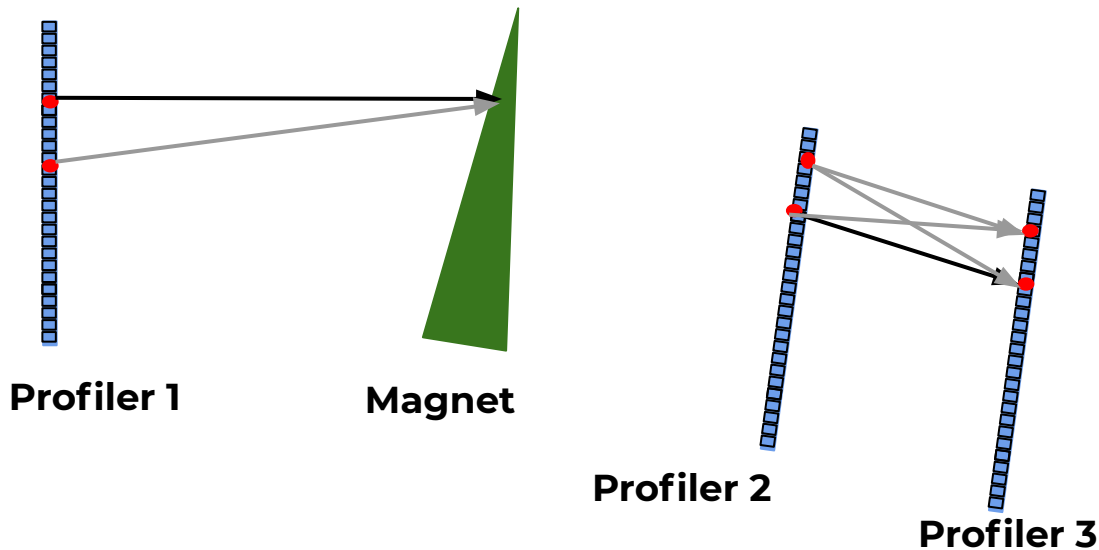
Profiler 2

Profiler 3

Momentum Errors

Multiple hits in profilers → multiple trajectories w/ different θ

- 1) Which θ to choose?
- 2) Sometimes drastically different momentum reconstructed (next page)

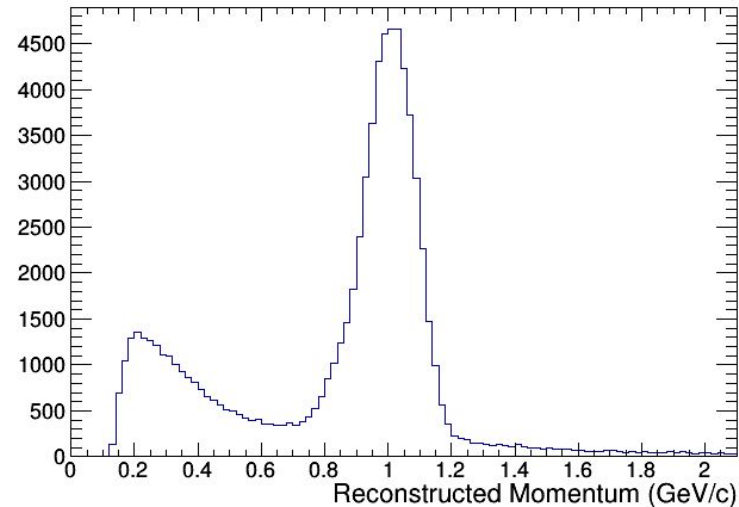
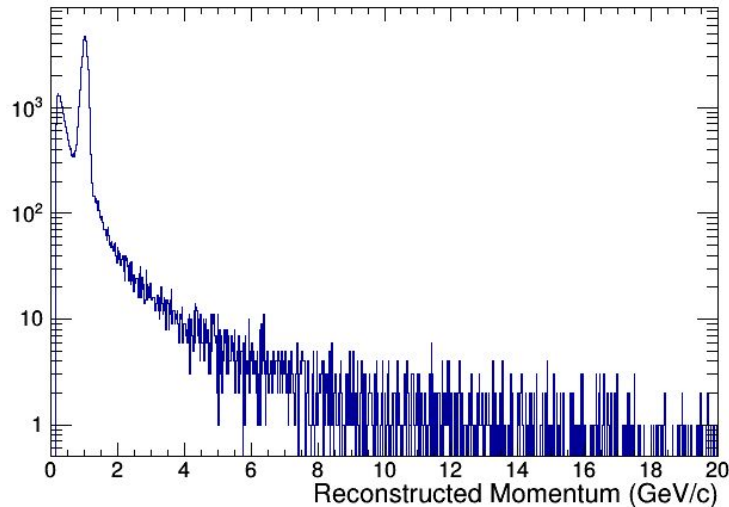


Momentum Errors

Without requiring singular reconstructed momentum:

Distribution can extend quite high

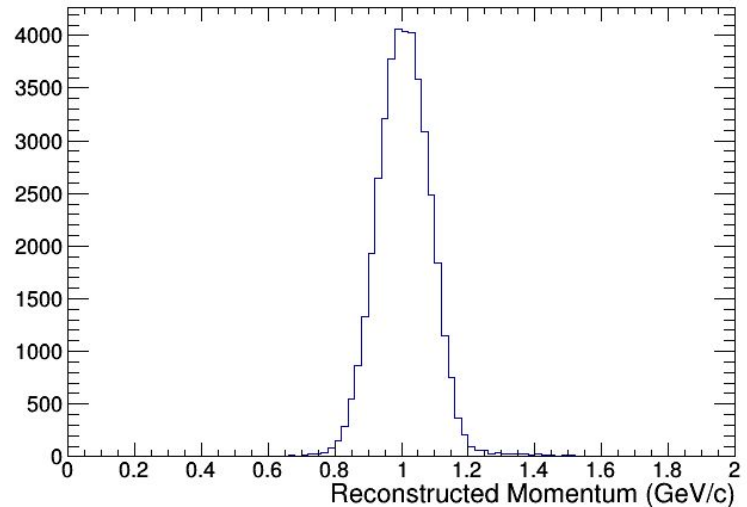
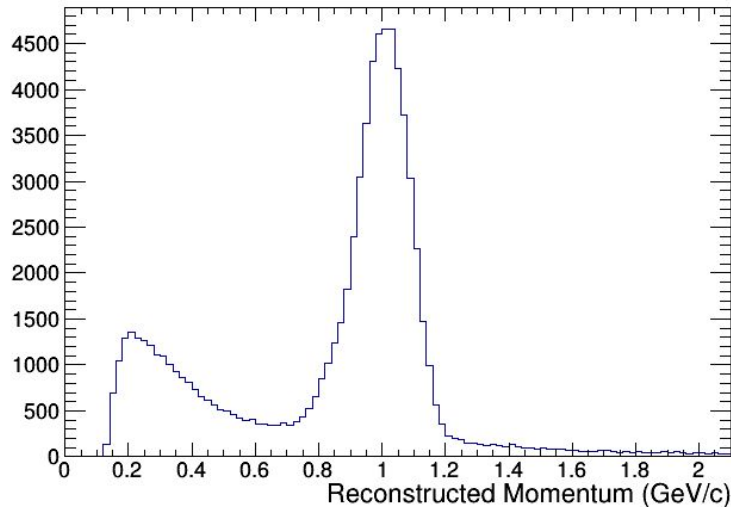
Has a strange peak in the lower end



Momentum Errors

Requiring 1 reconstructed momentum fixes the distribution

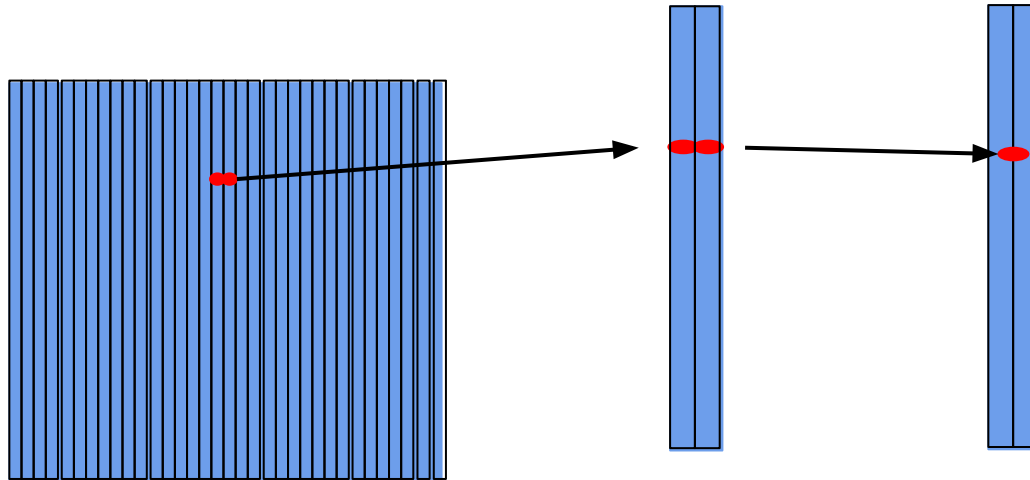
Need to determine the efficiency of this (later slides)



Neighboring Hits

Normally, position of hits in monitors are placed at center of fiber (1mm width). Neighboring hits → Condense to boundary between fibers.

Represents a $\pm 0.5\text{mm}$ shift in the position → How does this affect momentum reconstruction?



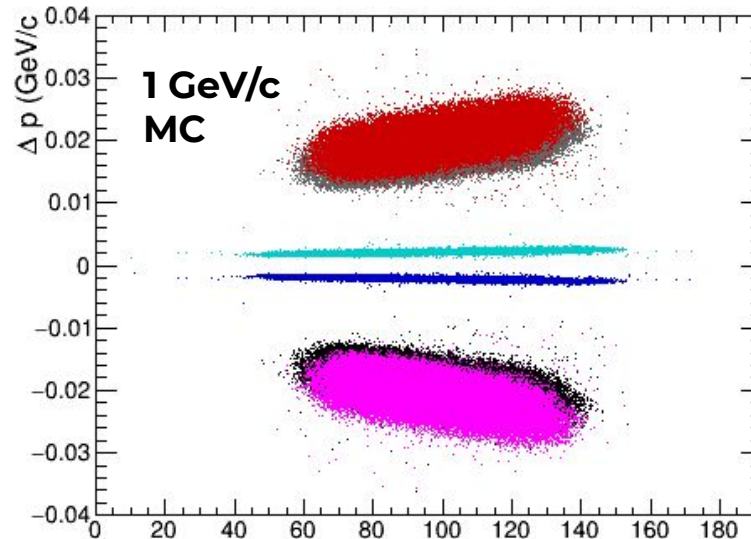
Neighboring Hits

For each fiber, shifted position by $\pm 0.5\text{mm}$ in the 3 different monitors (separately)

Blue/Teal: First

Red/Magenta: Second

Black/Grey: Third



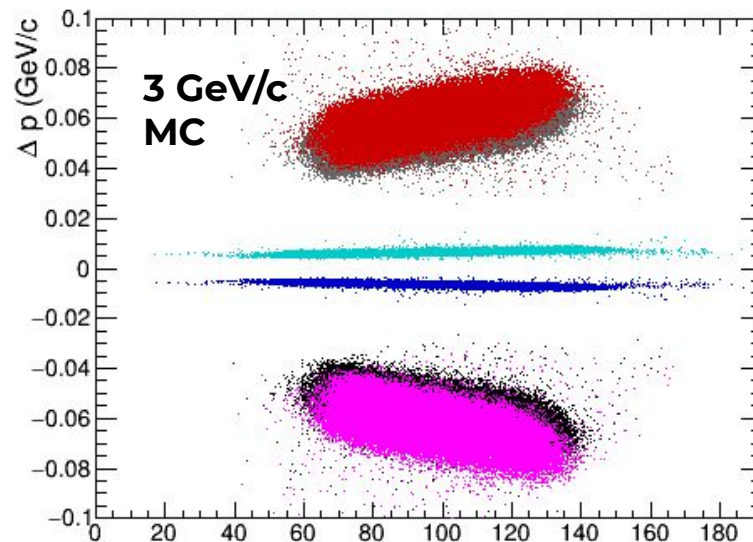
Neighboring Hits

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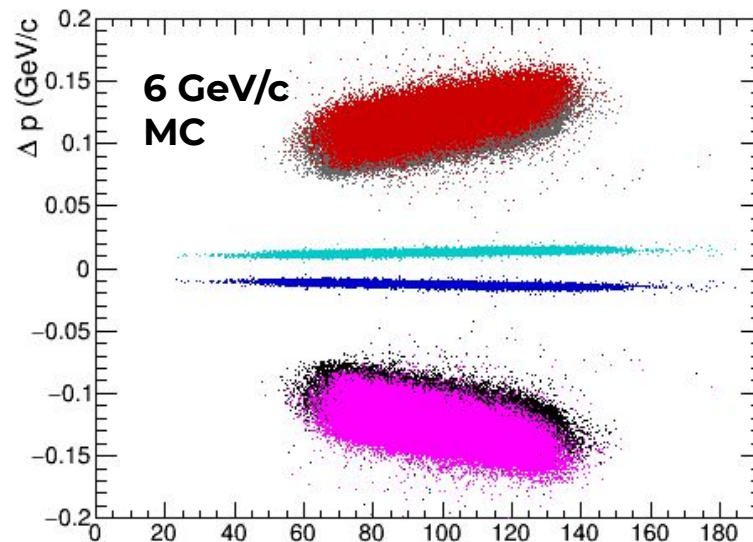
Neighboring Hits

For each fiber, shifted position by $\pm 0.5\text{mm}$ in the 3 different monitors (separately)

Blue/Teal: First

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Black/Grey: Third



Neighboring Hits



Shift amounts to:

~0.3% in Profiler 1

~2.5% in Profilers 2, 3

Can we just cut these all out? → Need to see how often neighboring hits occur (next slide)

Efficiency

Requiring “Perfect” pion-like events (1 fiber in each momentum spectrometer monitor -- 1 track from tracking monitors): **~60% efficient**

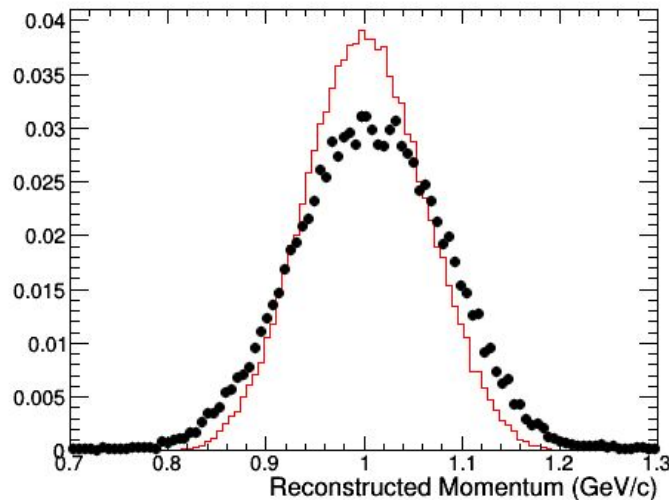
1 reco'd momentum \rightarrow no neighboring hits: **~3% change**

Momentum (GeV/c)					Total Percent
Run Number					
π -like	1	2	3	6	
	5387	5432	5786	5770	
	26594	33517	84602	88086	
	100	100	100	100	
1 Momentum	23567	30573	77938	79104	
	88.62	91.22	92.12	89.80	
1 Track	17569	24297	61086	60694	
	66.06	72.49	72.20	68.90	
1 Track, 1 Momentum	15704	22306	56637	55203	
	59.05	66.55	66.95	62.67	
1-Fiber in Spec.	14943	21265	54074	52680	
	56.19	63.44	63.92	59.81	

Comparison to MC

Compared run 5387 data to beam simulation files (used as input for our event generation)

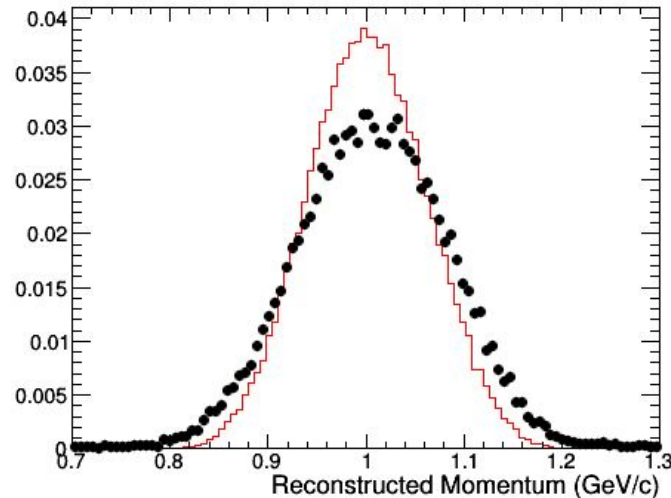
Data is slightly wider than MC (Agrees with what beam experts see)



Comparison to MC

Note: Even if these disagree, if the event-by-event resolution (predicted $\sim 2\text{-}2.5\%$) agrees, then we're "ok"

Need to understand why these disagree \rightarrow Could be coupled to event-by-event resolution

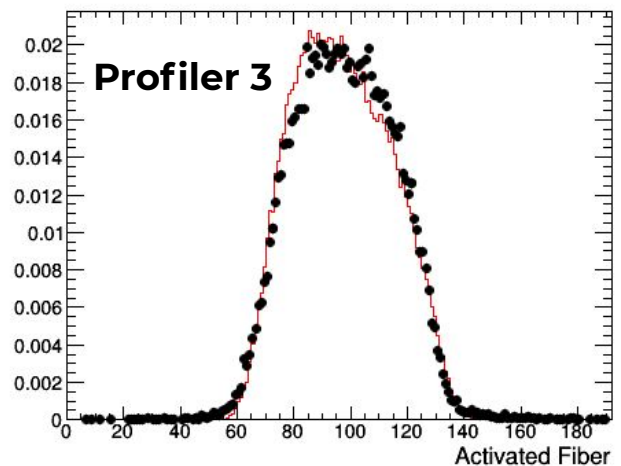
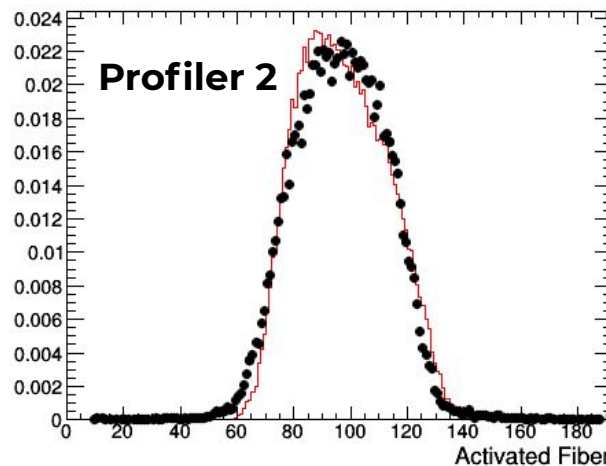
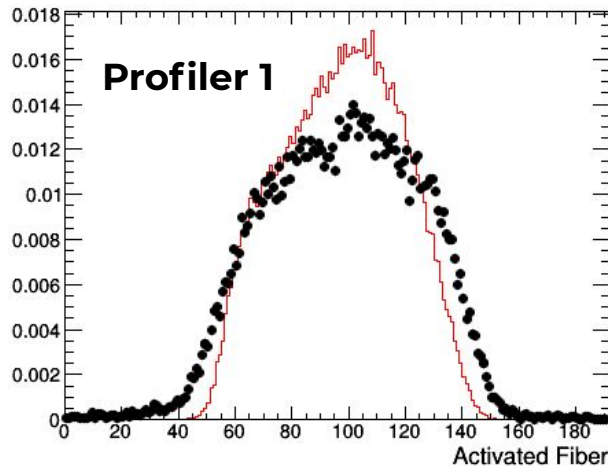


Comparison to MC

Tried digging into what was causing the spread

Looked at activated fibers in the 3 monitors

Required single reconstructed momentum

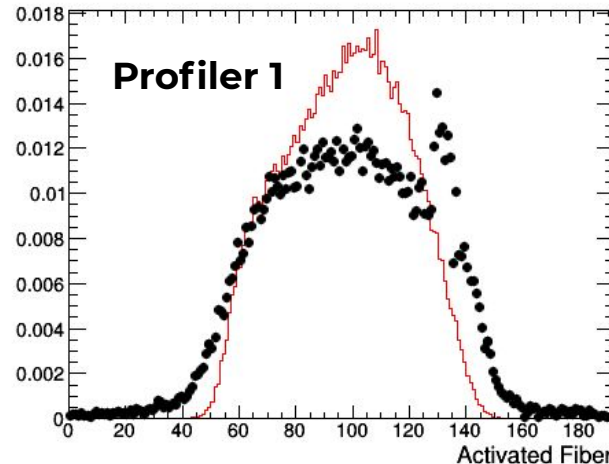
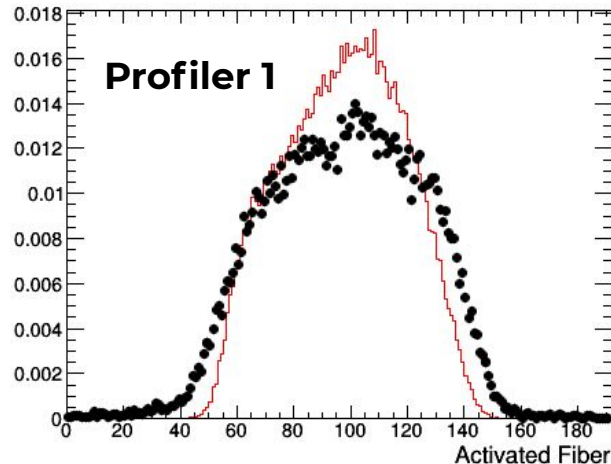


Comparison to MC

In addition to spread, noticed a few peculiarities

- 1) Gap at Fiber 96 (Left)
- 2) Bump present when including multiple hits (Right)

In talks with experts to determine cause/solution

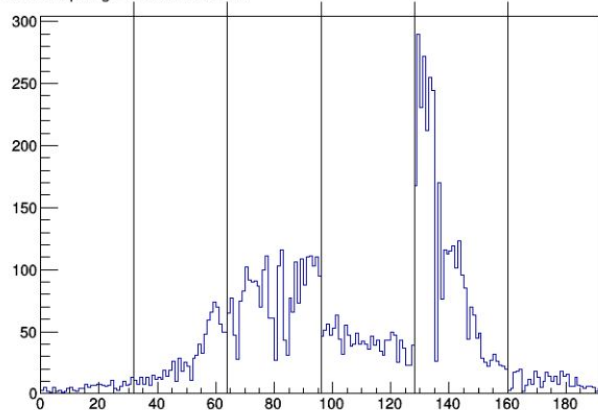


Profiler Issues

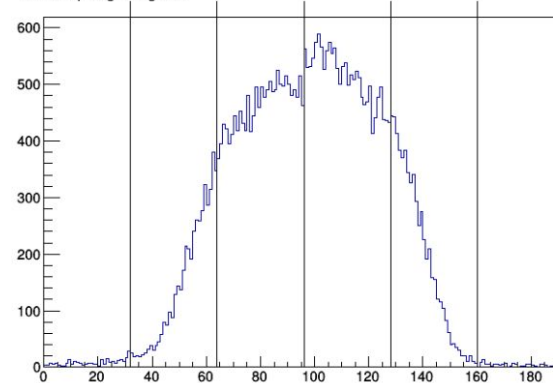
Beam experts informed us that there was an issue within software that affected how data collected by the profiler was packaged and saved.

The data from the fibers was collected into 6 sets of 32 bits, representing whether or not the fiber was activated at time of acquisition. The issue (waiting to hear what this was) seems to have affected 2 of the 6 sets as evident in the plots below (showing the rate of activated fibers)

This is requiring >1 hit in Monitor 697



This is requiring a single hit:



Conclusion



Can keep ~60% events while requiring “perfect” events

Noticed some issues with some instrumentation

In contact with experts to diagnose this

Thanks for listening