LAD track multiplicity simulation

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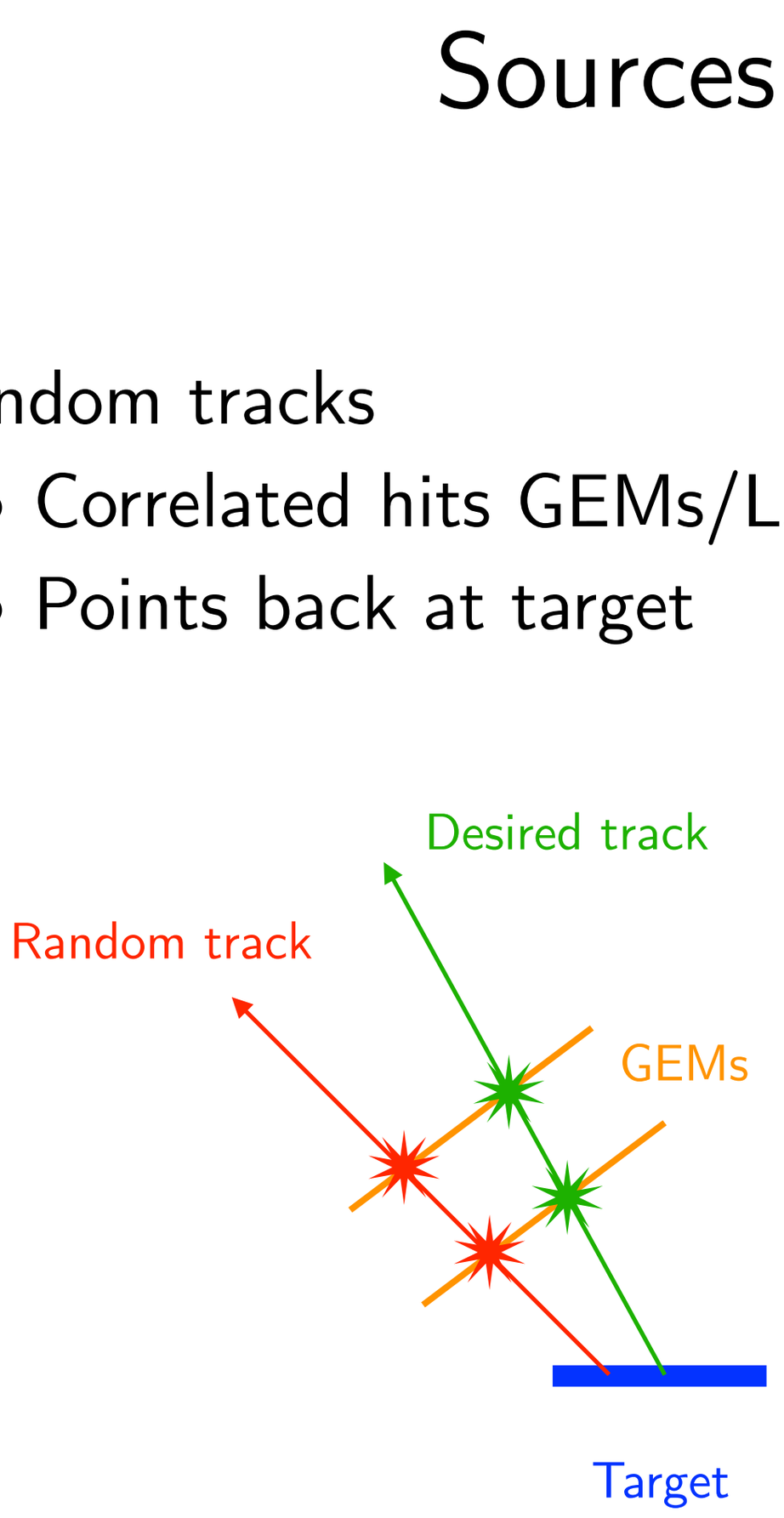
Sources of background

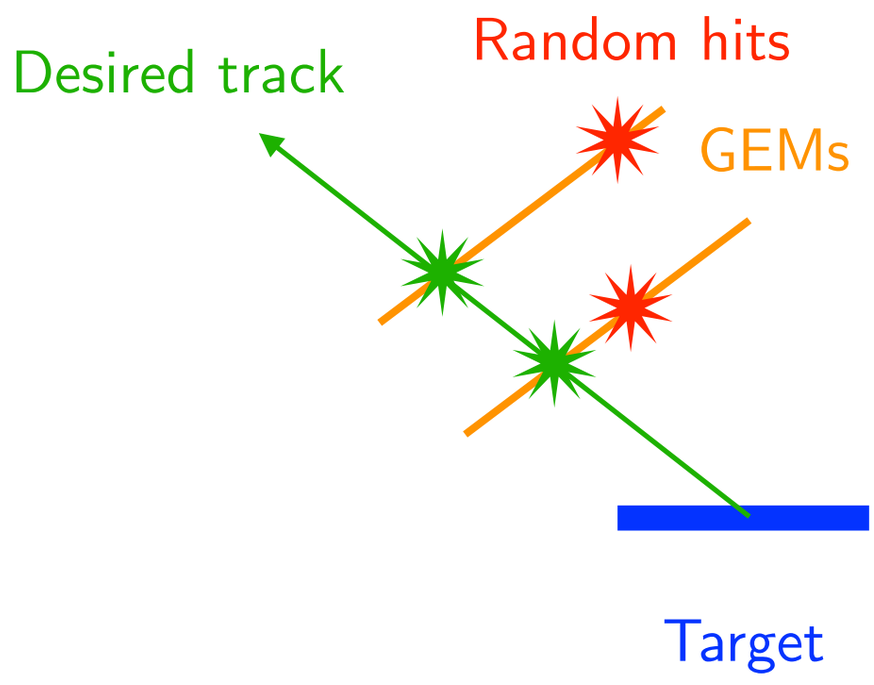
Random tracks

- Correlated hits GEMs/LAD
- Points back at target

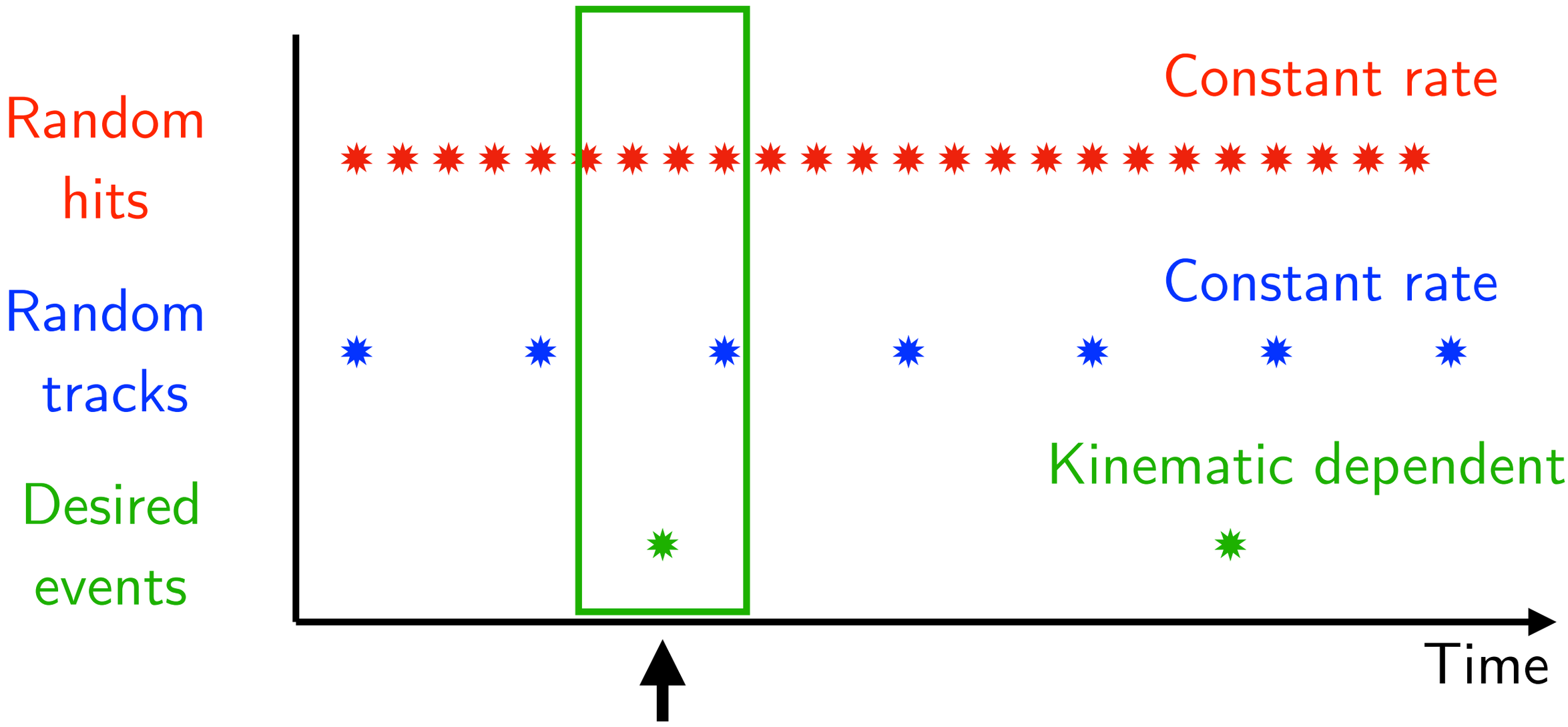


Random GEM hits

- Uncorrelated between GEM layers



Estimating background



Need to account for all background occurring around event trigger

Estimate number of *random tracks*

- Expect LAD/GEM proton rate of approximately 20 MHz (estimate from proposal for 1.2 x 10^{37} cm^{-2} s^{-1} luminosity)
- GEM time resolution is 15 ns (assume 30 ns)

20 MHz x 30 ns = 0.6 random tracks

Round up to *1 random track/event*

Estimate number of *random hits*

GMn numbers:

- GEMs 1.5 m from target at 40°
- Luminosity 1.2 x 10^{38} cm^{-2} s^{-1}
- GEM random hit rate of 100 kHz cm^{-2}

For LAD...

- Scale rate down x10 for luminosity (1.2 x 10^{37} cm^{-2} s^{-1})
- Scale rate up x4 for shorter distance to target (0.7 m)
- Scale rate down x2 for large backward angle (127°)
- Average GEM area approximately 0.6 m^2

(20 kHz/cm^2) x (0.6 m^2) x (30 ns) = 3.6 random hits

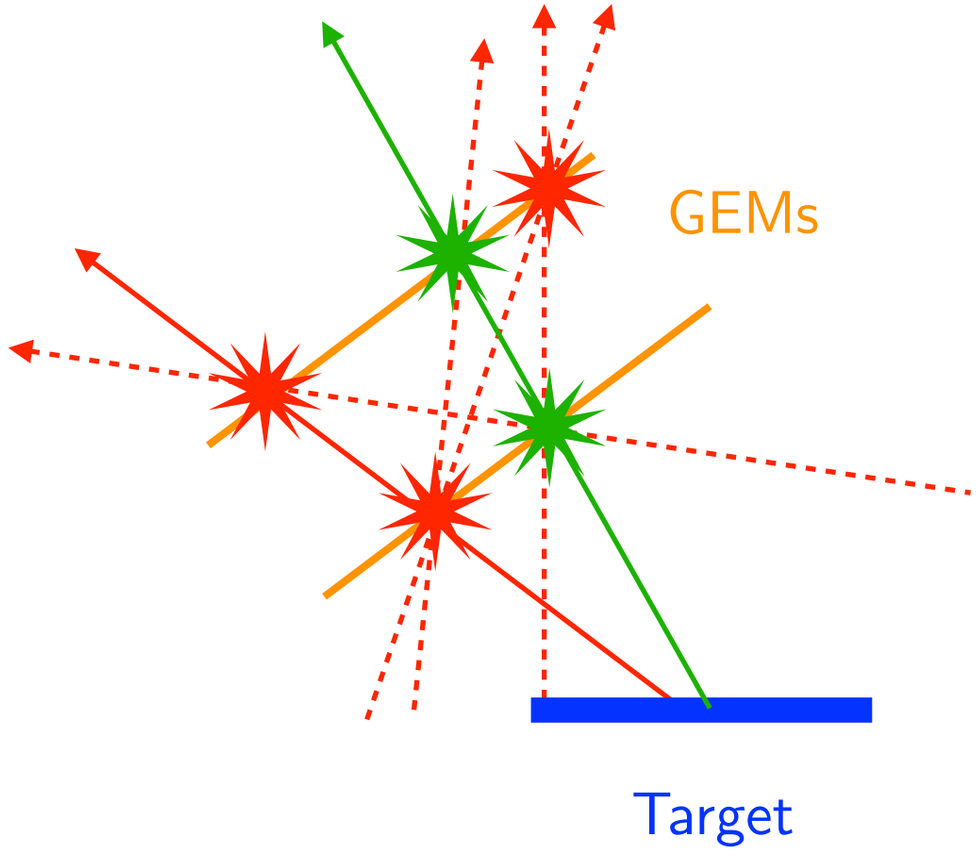
Round up to *5 random hits/event*

Track multiplicity for a single event

For each *desired event*, add...

- Poisson($\lambda = 1$) random tracks
- Poisson($\lambda = 5$) random hits in each GEM plane

Form tracks from *all* pairs of GEM hits



y-dimension (vertical) not pictured, but is included in simulation

Simulation

- Hall C deuterium DIS generator from proposal (W. Cosyn)
- GEM planes are at 70 cm and 90 cm from the target, perpendicular to 127°
- Generate 20e6 events
- Additional events generated for random tracks
- Assume that resolutions are included in background suppression cuts (events are not smeared)

Kinematic cuts

Use the *true* scattering kinematics to calculate Q^2, W^2, and x'.

For *all* events, require:

$$Q^2 > 2 \text{ GeV}^2$$

$$W^2 > 4 \text{ GeV}^2$$

Additionally, require:

$0.25 < x' < 0.35$
For low-x' kinematics

$0.45 < x' < 0.6$
For high-x' kinematics

Cuts to suppress background

For each event, we have:

- True target vertex position z_{vertex}, known from [S]HMS
- Hit positions at LAD

For every possible track...

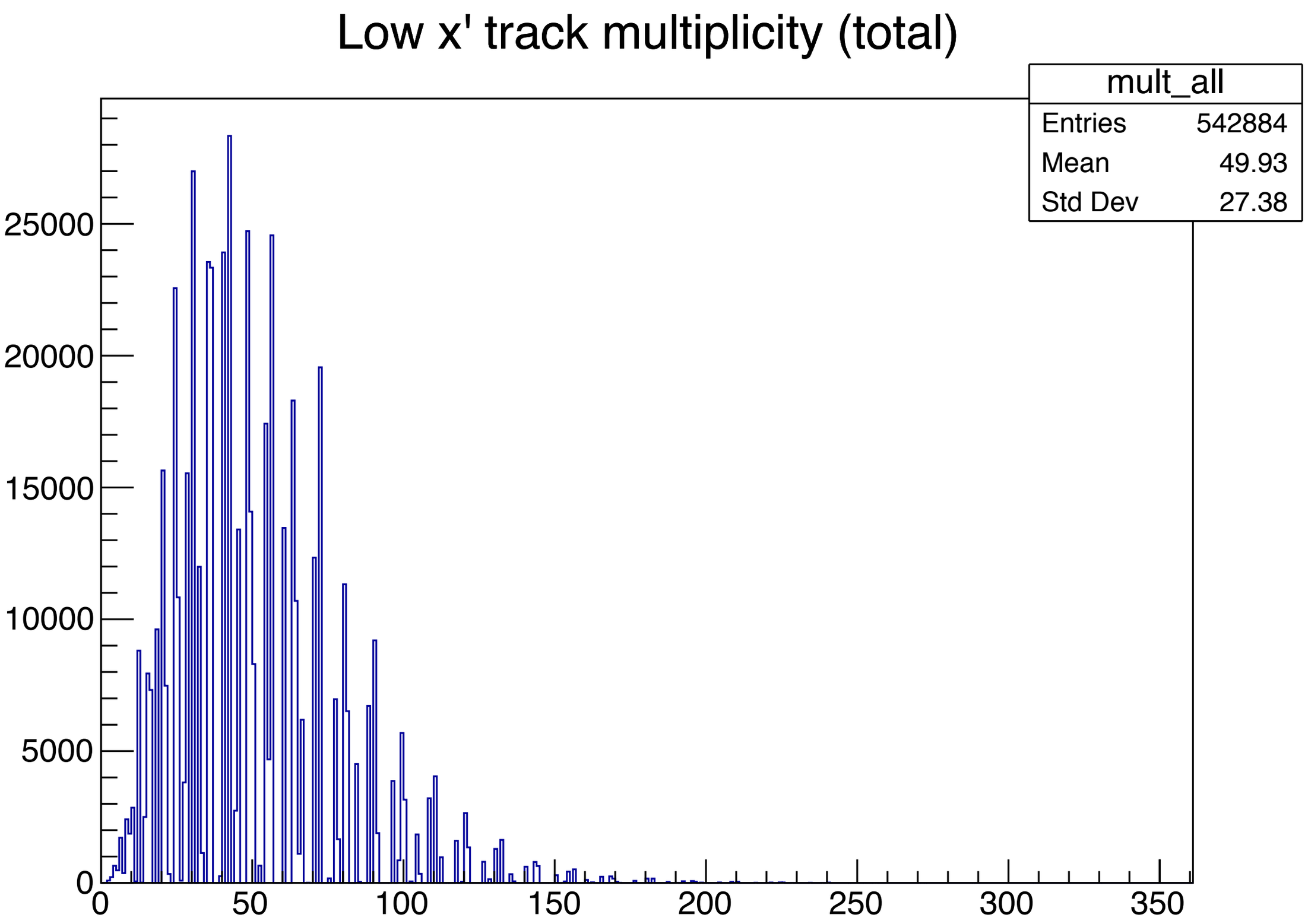
- ...project to LAD
- ...project to target (get z_{track}, $r_{track} = min\left(\sqrt{x_{track}^2 + y_{track}^2}\right)$)

Cuts to suppress background

Reject tracks that don't meet cuts:

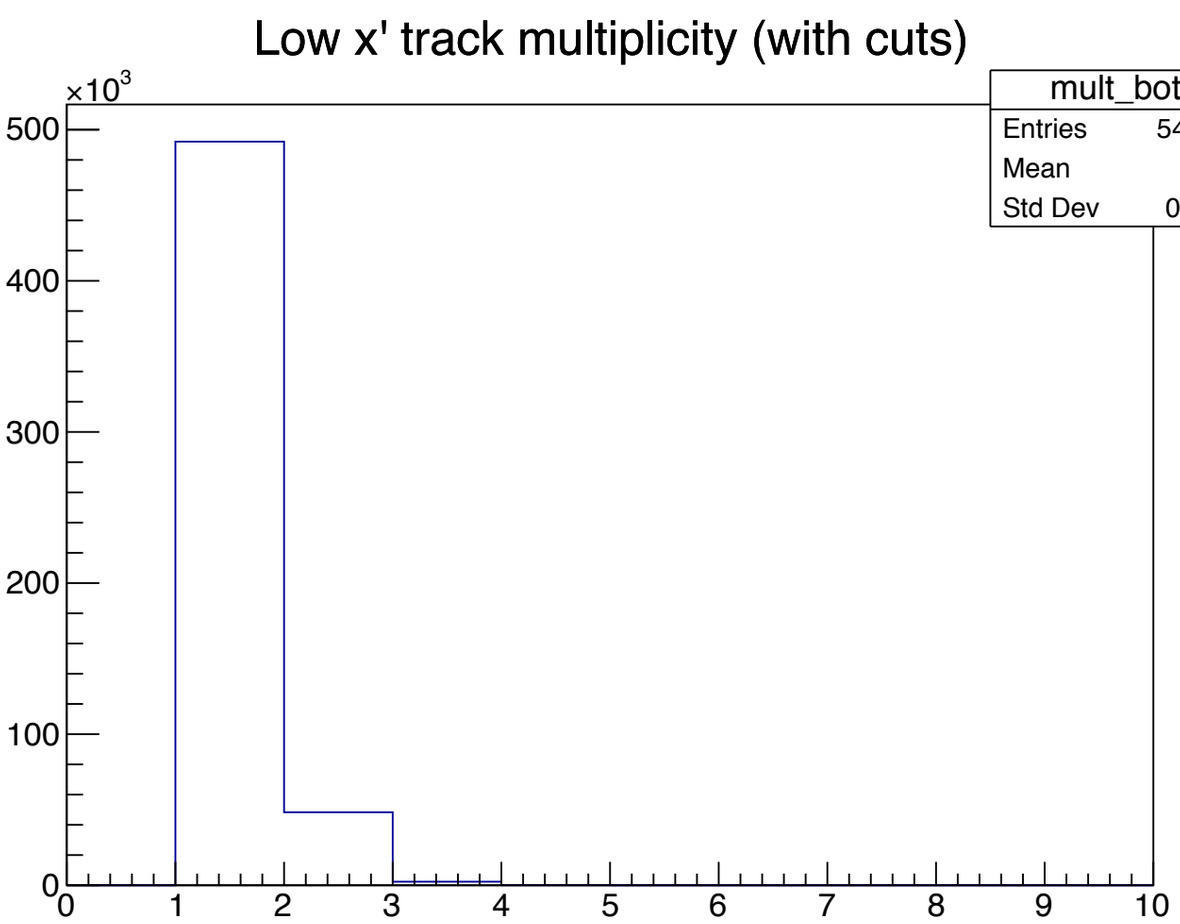
- $|\Delta z_{targ}| = |z_{track} - z_{vertex}| < 1$ cm
- $r_{track} < 1$ cm
- Projection to LAD intersects same plane and bar as LAD hit
- $|\Delta y_{LAD}| = |y_{track} - y_{LAD}| < 10$ cm

Many tracks can be formed with all GEM hits...



...but these are suppressed with GEM tracking cuts.

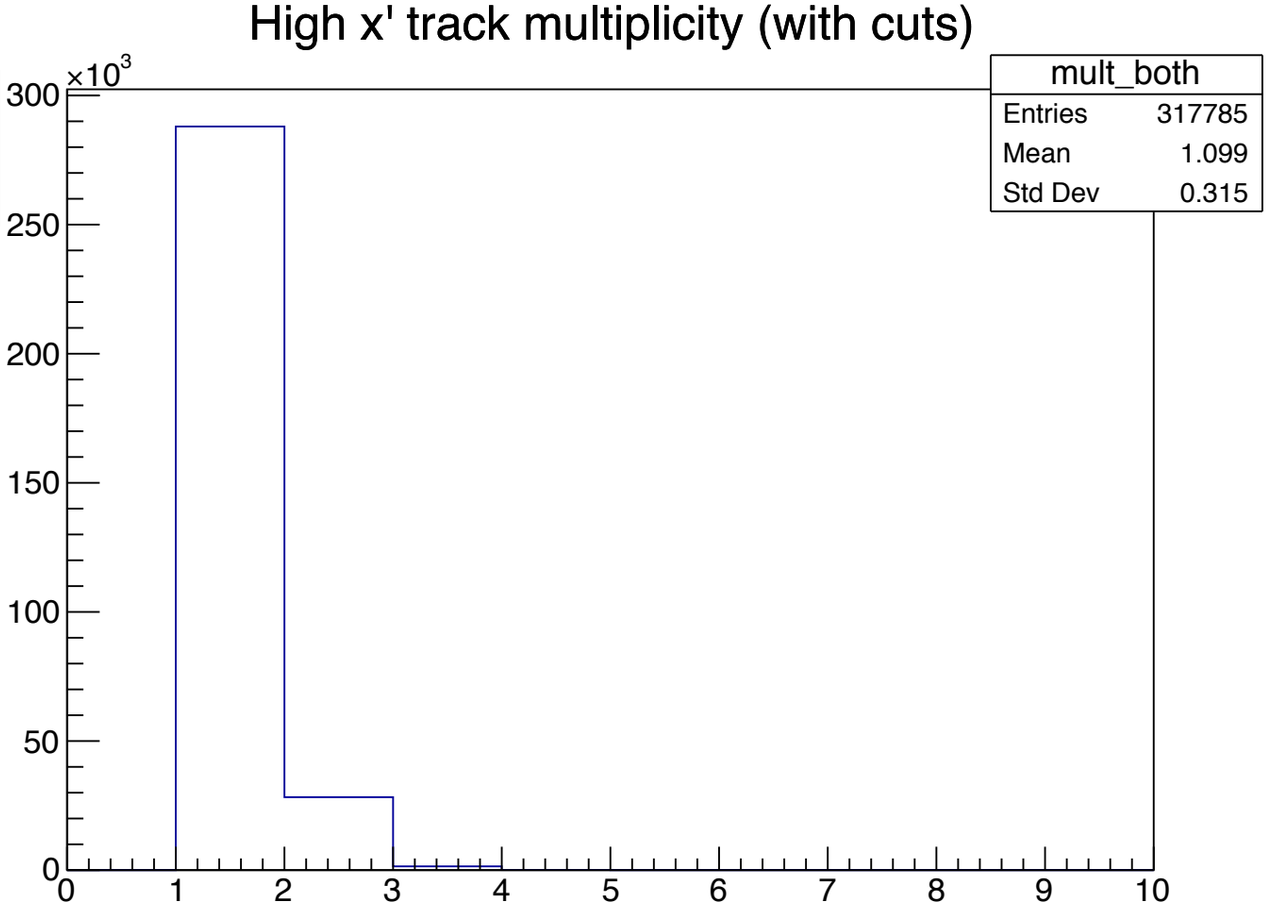
Low x' results



~90% of events have 1 track

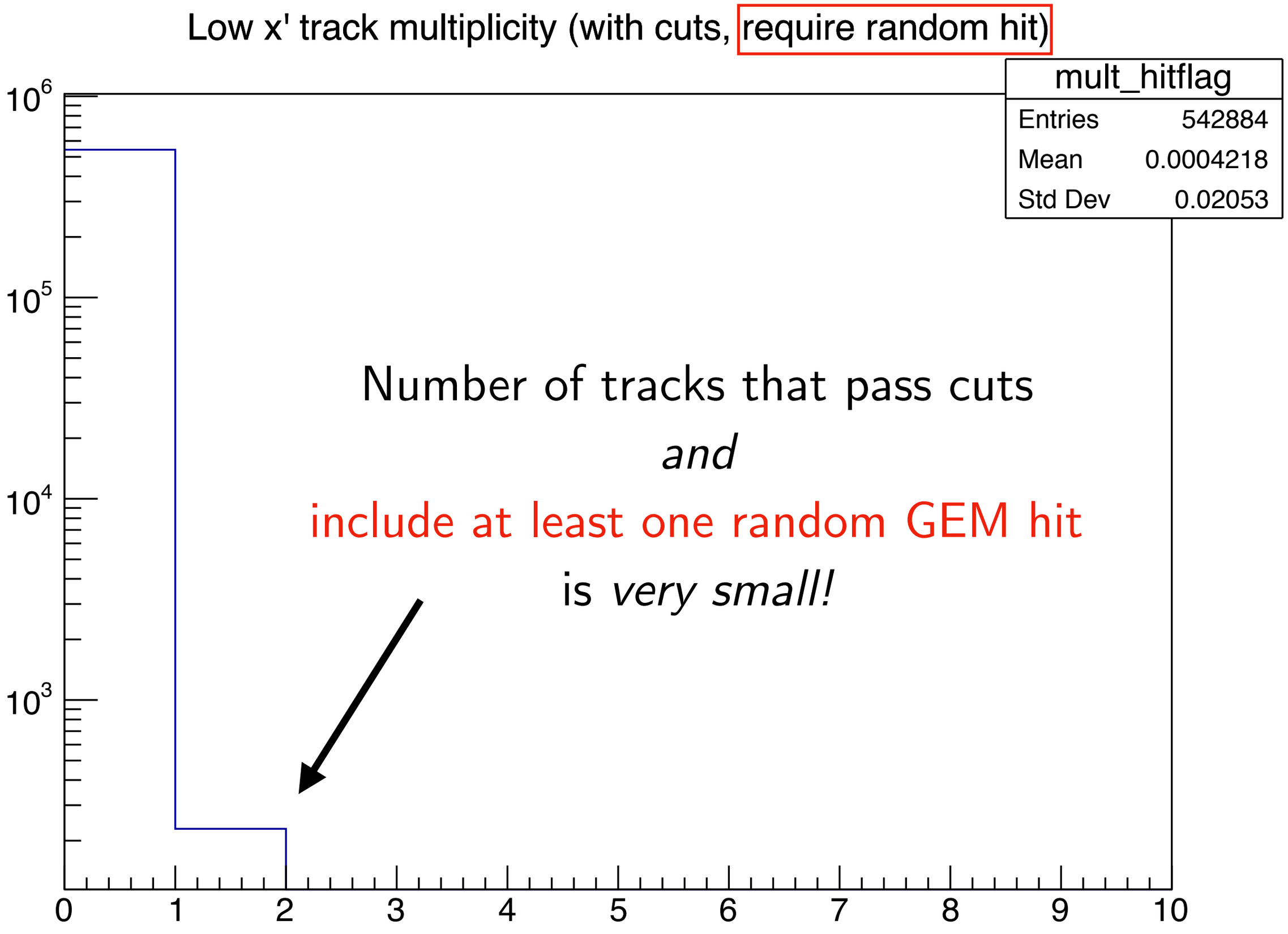
~10% of events have 2+ tracks

High x' results



~90% of events have 1 track

~10% of events have 2+ tracks



Random GEM hits contribute very little

Summary

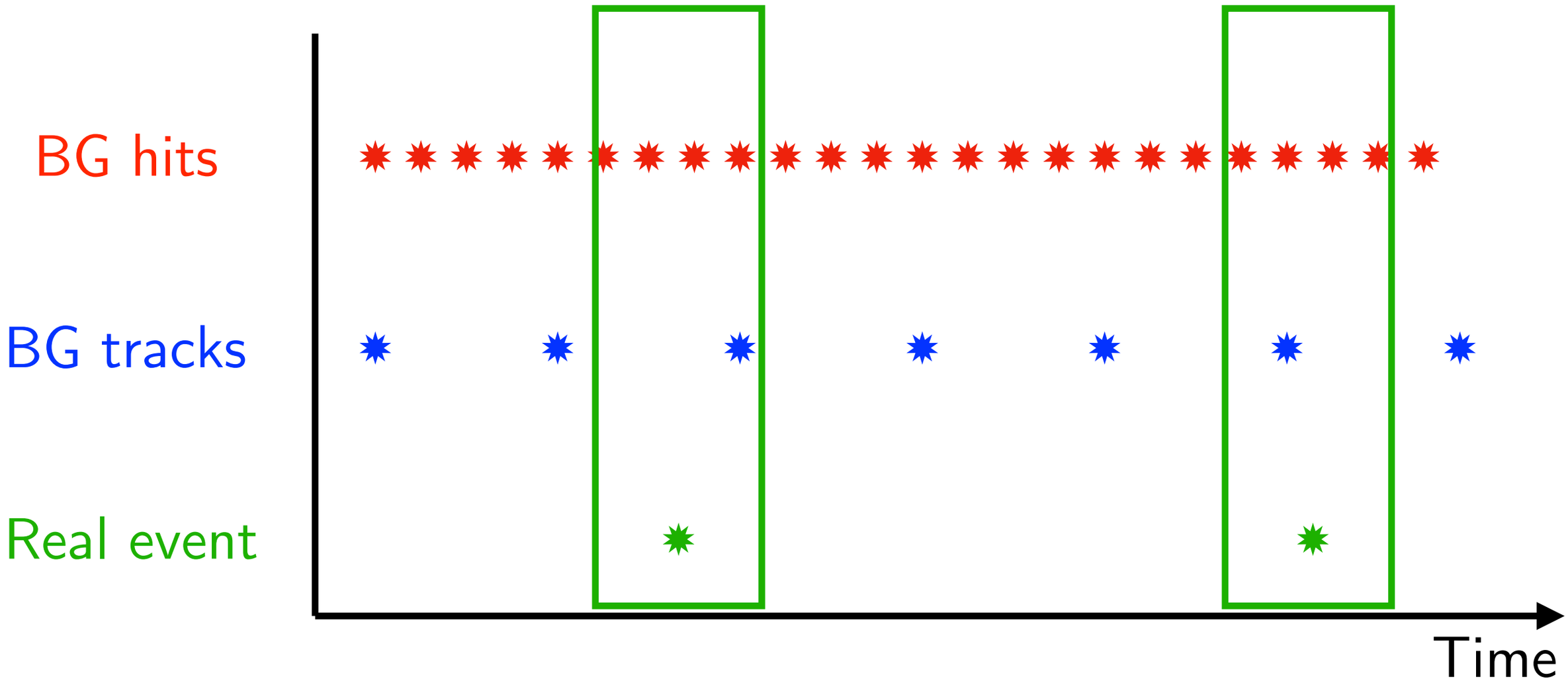
- Conservative estimates on background rates give 1 random track and 5 random GEM hits per event

- Simulation shows that background at these rates is suppressed to the 10% level with GEM tracking cuts

- With constant background rate, relative background is independent of event rate → similar background for low and high x'

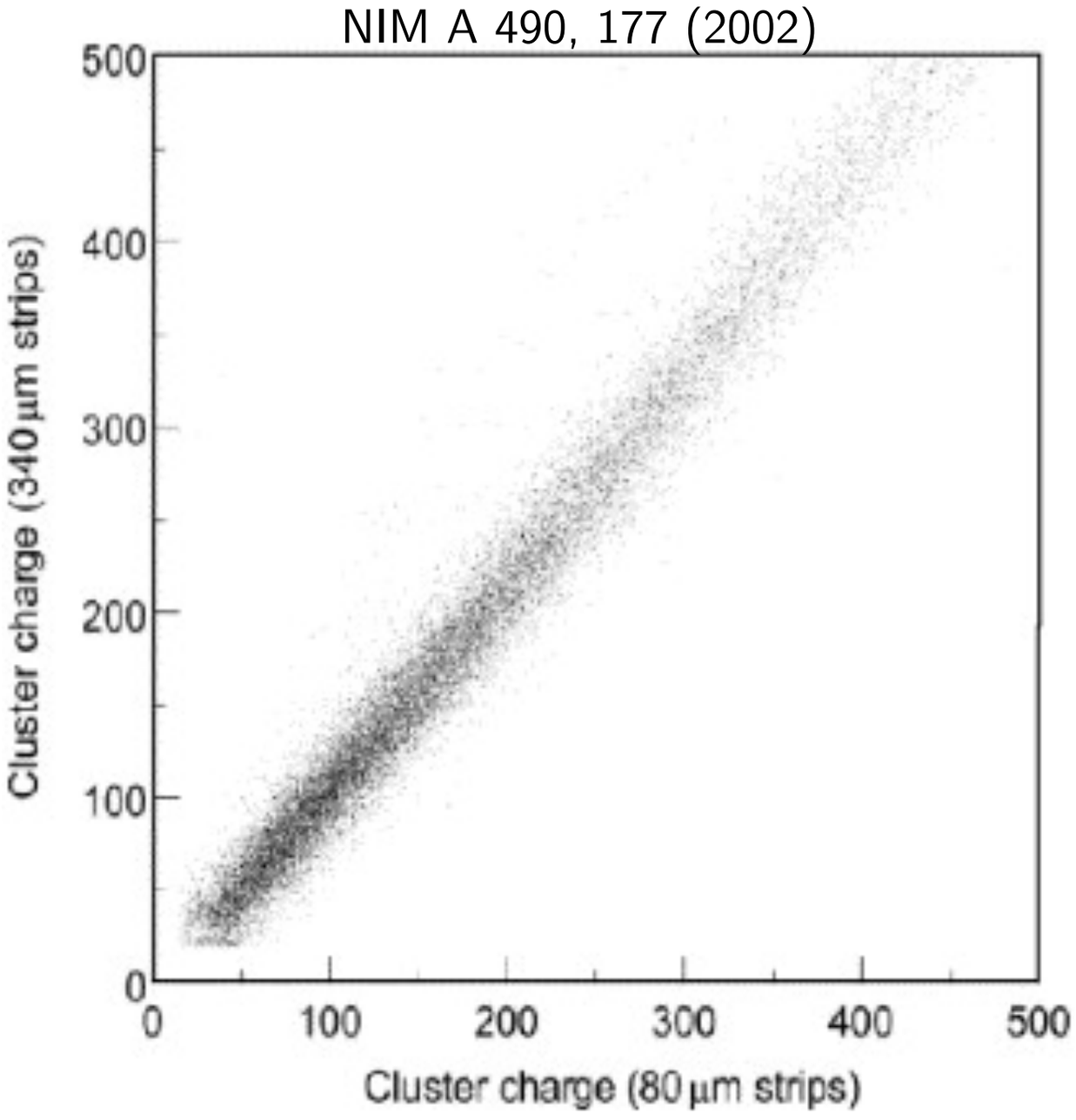
Backup

Estimating background



Constant background rate → relative background the same at high- and low-event-rate kinematics (i.e., low and high x')

Forming 2D GEM hit



- Two layers of orthogonal readout strips to obtain x, y positions
- Strong correlation in cluster charge deposited in each readout layer
- This can be used to resolve ambiguity from multi-track events

Treat all GEM hits as fully-defined 2D points