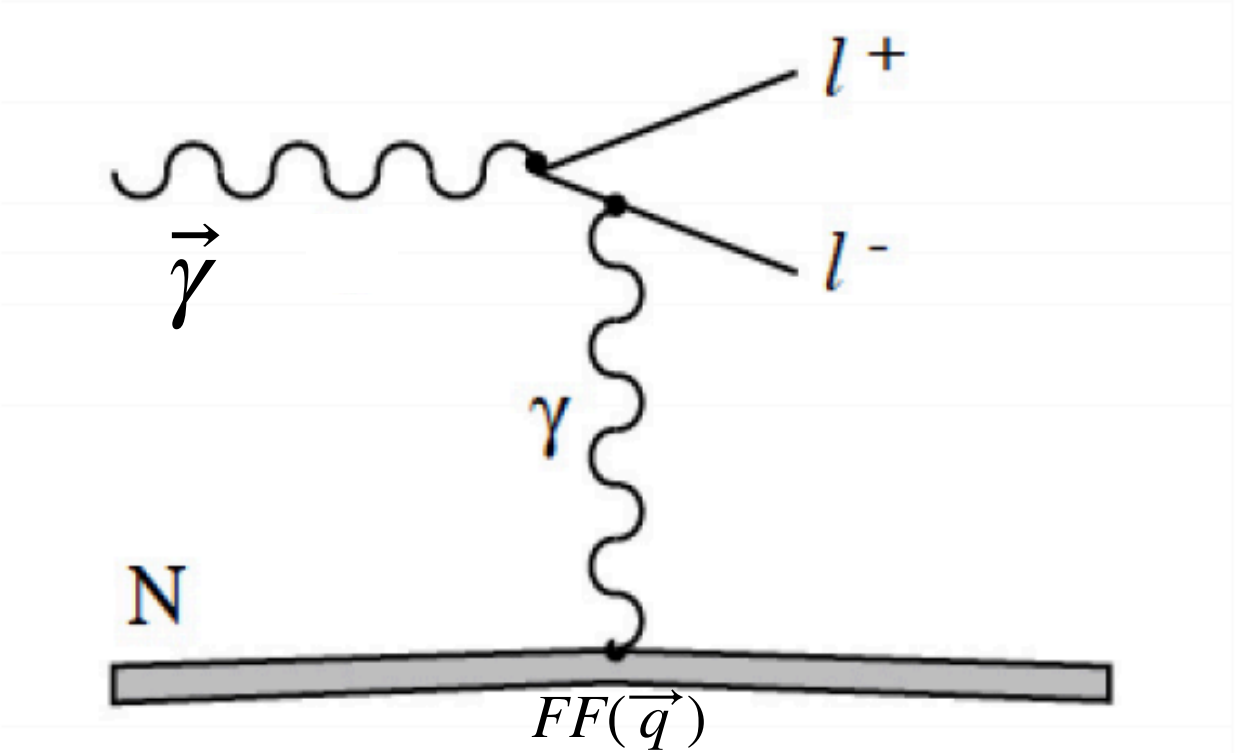
University of Massachusetts Amherst

MENP

2018-01 Run, Bethe-Heitler Study

$\gamma p \rightarrow e^+e^-(p)$



Andrew Schick

Wednesday, September 25 2019

Objectives of the BH Analysis:

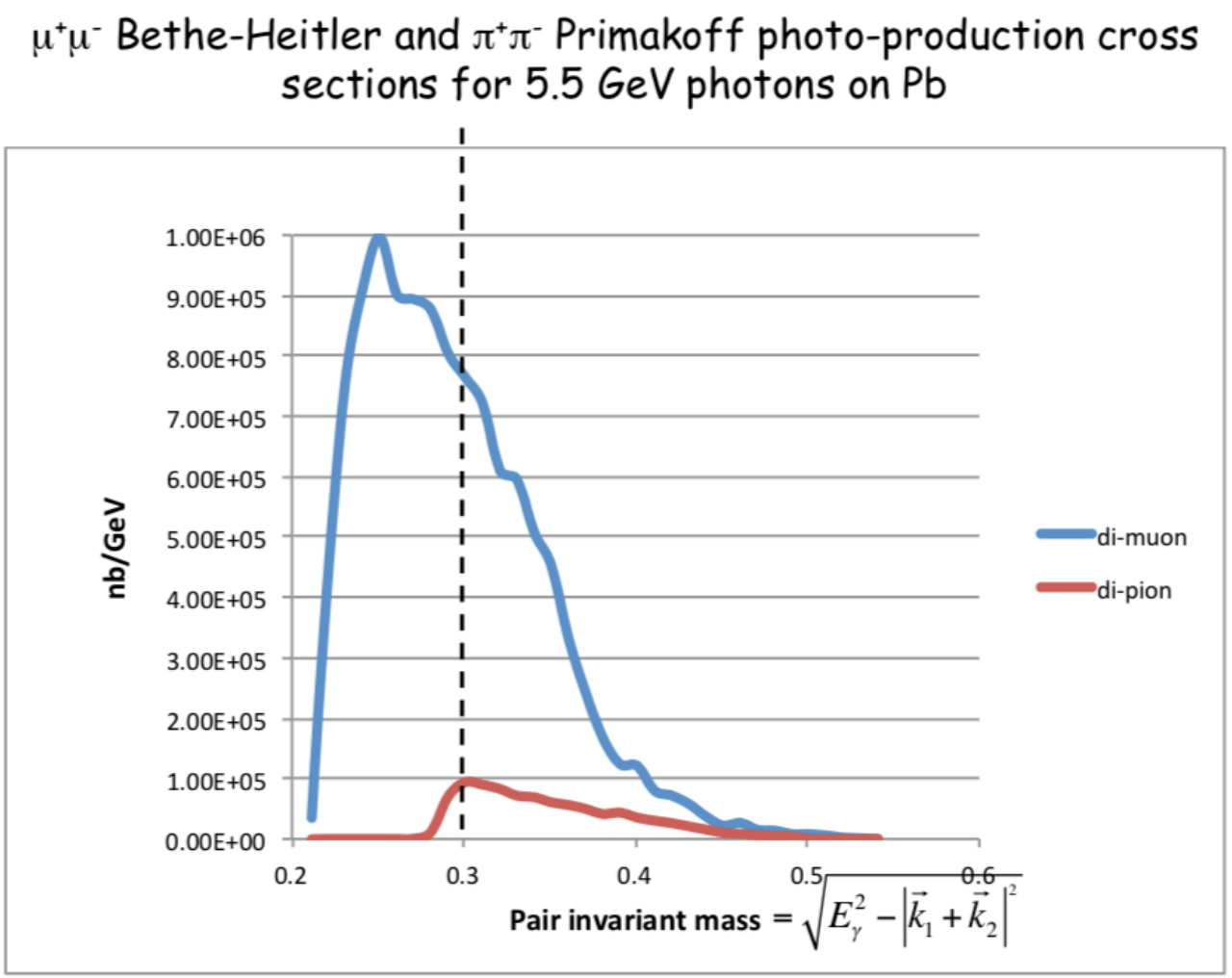
1. Use Bethe-Heitler pair production for normalization in the Charged Pion Polarizability experiment. Therefore, developing an analysis suite for BH pairs is necessary.

2. We would like to extract the polarization signal of the BH pairs.

3. Measure the form factor/charge radius of the proton.

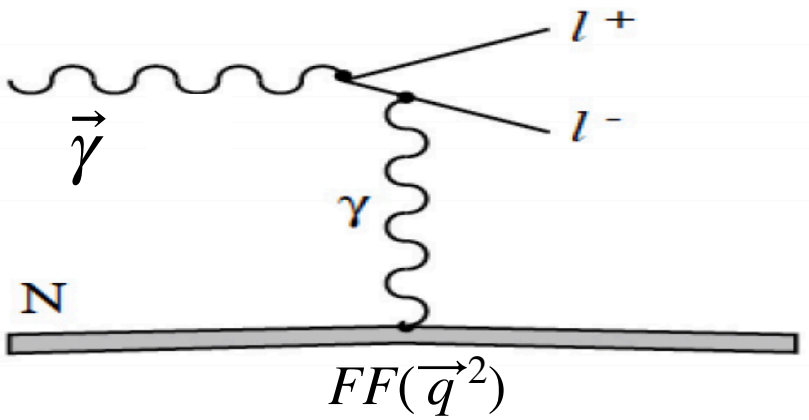
OBJECTIVES

1. Use Bethe-Heitler pair production for normalization in the Charged Pion Polarizability experiment.



OBJECTIVES

2. Use BH pairs as a polarimeter.



$$\frac{\mathrm{d}\sigma_B^c}{\mathrm{d}x\,\mathrm{d}^2\vec{p}_{t\,1}\,\mathrm{d}^2\vec{p}_{t\,2}} = \frac{2\alpha^3 Z^2\omega^4 x^2(1-x)^2}{\pi^2(\vec{q}^{\,2})^2} \times [W_{\mathrm{unp}} + P_\gamma W_{\mathrm{pol}}\cos(2\phi)] \times |F_{\mathrm{nuclear}}(\vec{q}^{\,2}) - F_{\mathrm{atomic}}(\vec{q}^{\,2})|^2$$

$$W_{\mathrm{unp}} = [x^2 + (1-x)^2]\,|\vec{J}_T|^2 + m^2|J_S|^2\,; \qquad W_{\mathrm{pol}} = -2x(1-x)\,|\vec{J}_T|^2$$

$P_\gamma =$ photon polarization; $\quad x =$ energy fraction carried by e^+

ϕ is angle between the polarization direction and $\vec{J}_T$

$$J_S = \frac{1}{\vec{p}_{t\,1}^{\,2} + m^2} - \frac{1}{\vec{p}_{t\,2}^{\,2} + m^2}; \qquad \vec{J}_T = \frac{\vec{p}_{t\,1}}{p_{t1}^2 + m^2} + \frac{\vec{p}_{t\,2}}{p_{t2}^2 + m^2}$$

$\vec{p}_{t\,1}$ and $\vec{p}_{t\,2}$ are the transverse momenta of the leptons.

OBJECTIVES

3. Measure the form factor/charge radius of the proton.

$$\frac{\mathrm{d}\sigma_B^c}{\mathrm{d}x\,\mathrm{d}^2\overrightarrow{p_t}_1\,\mathrm{d}^2\overrightarrow{p_t}_2} \propto |F_{\mathrm{nuclear}}(\overrightarrow{q}^2) - F_{\mathrm{atomic}}(\overrightarrow{q}^2)|^2$$

i.) Get t distribution for the data.

ii.) Do MC with standard dipole form factor and get t distribution.

iii.) Divide data by simulation and look for deviations from standard dipole at really low momentum transfer.

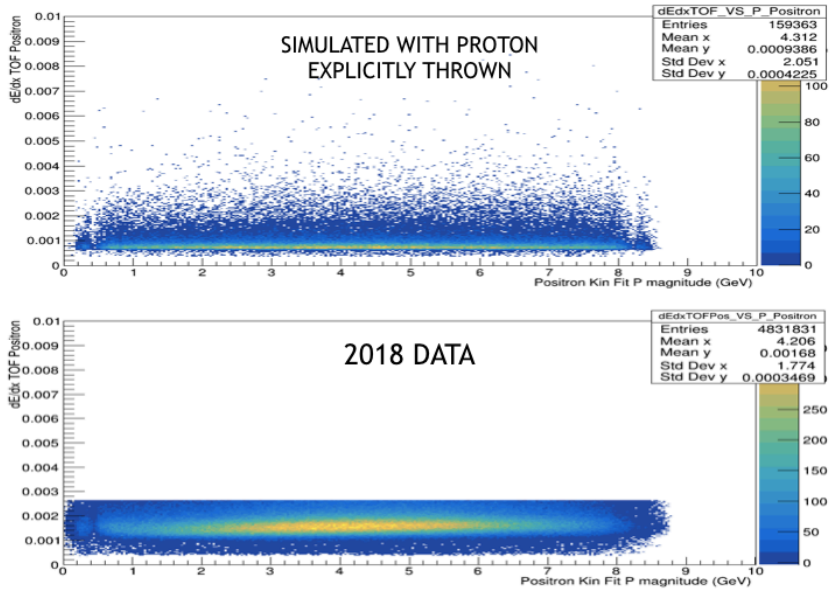
Last time we primarily discussed:

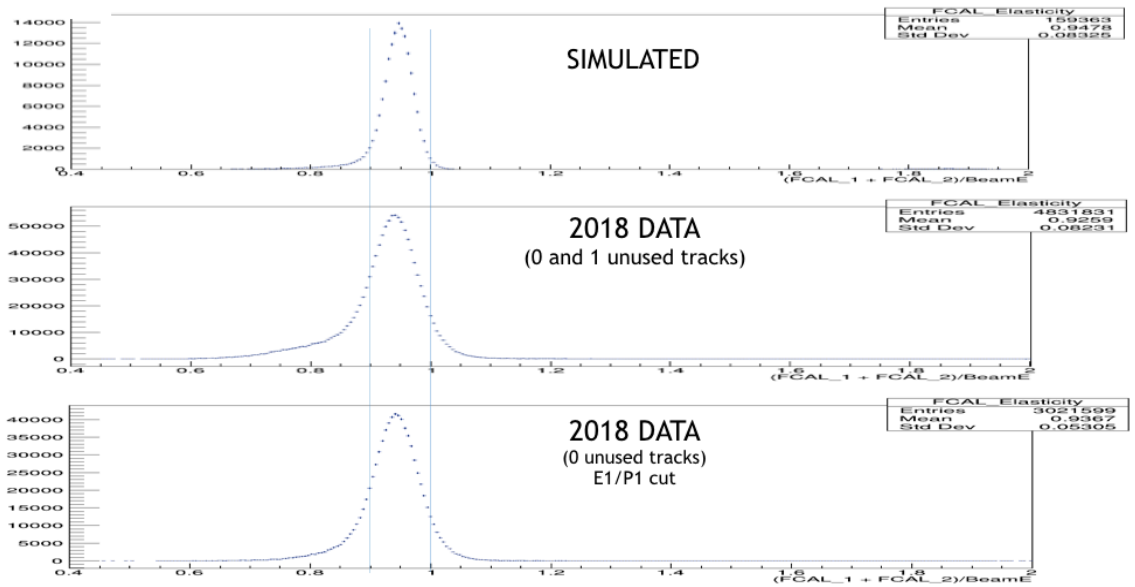
1.) Discrepancies between MC and data (distribution widths, dE/dx in TOF, W peak location)

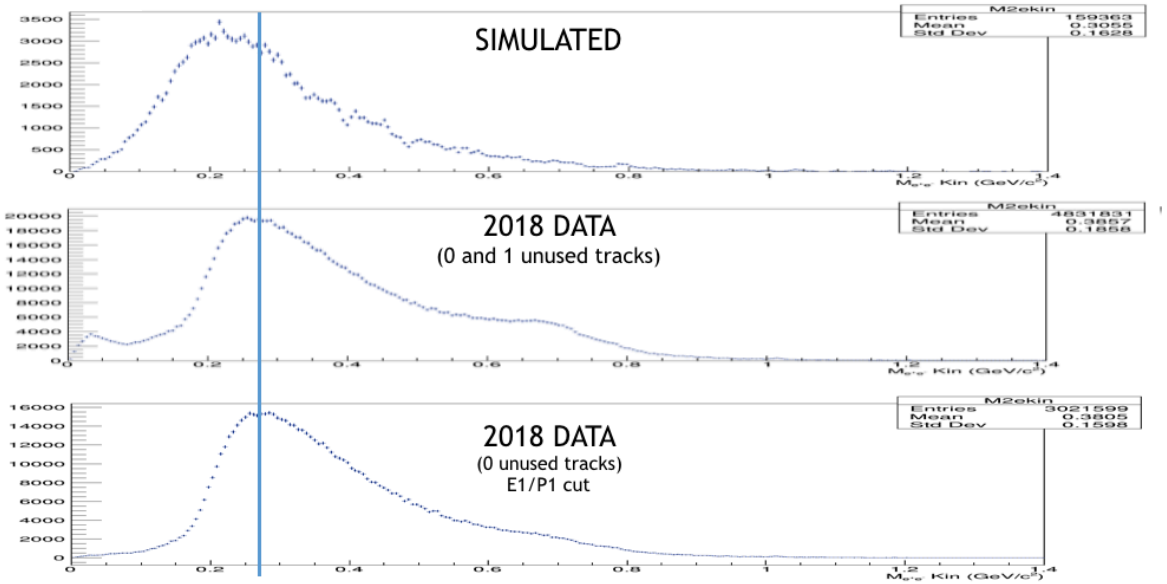
2.) Tracking down small W peak (next slide)

Proton Mis-ID?

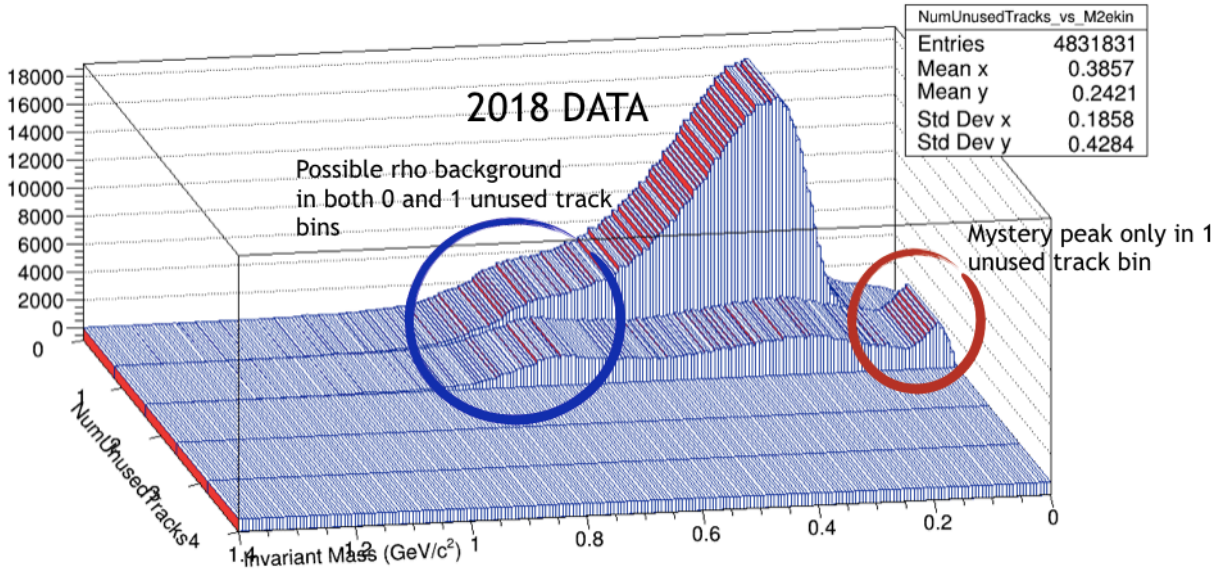
- Calibration is off between MC and DATA
- Otherwise, dE/dx for positron looks mostly independent of momentum

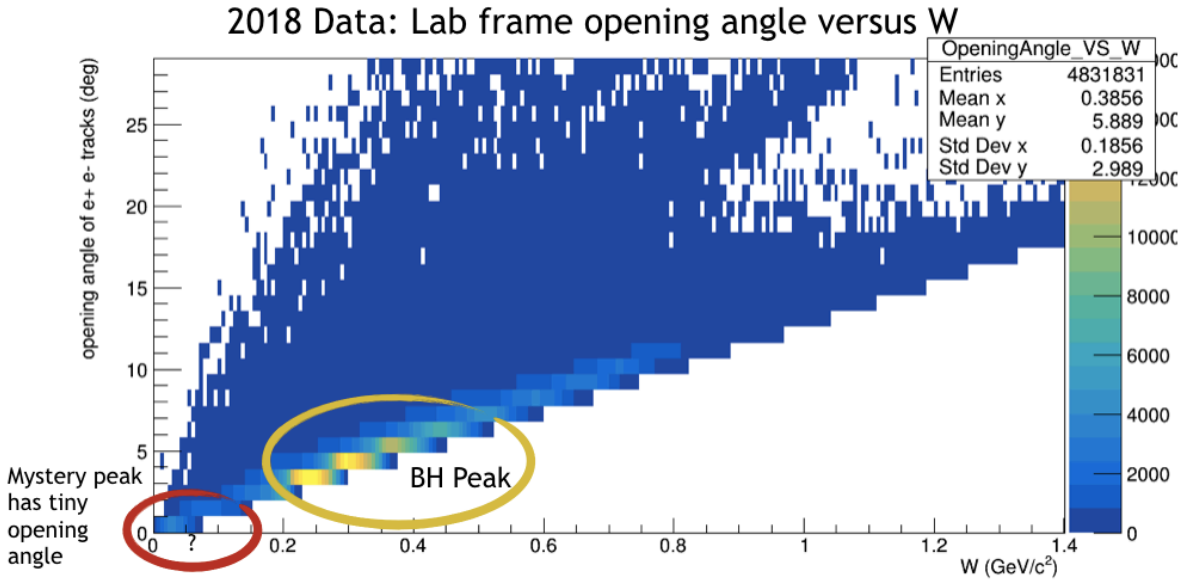


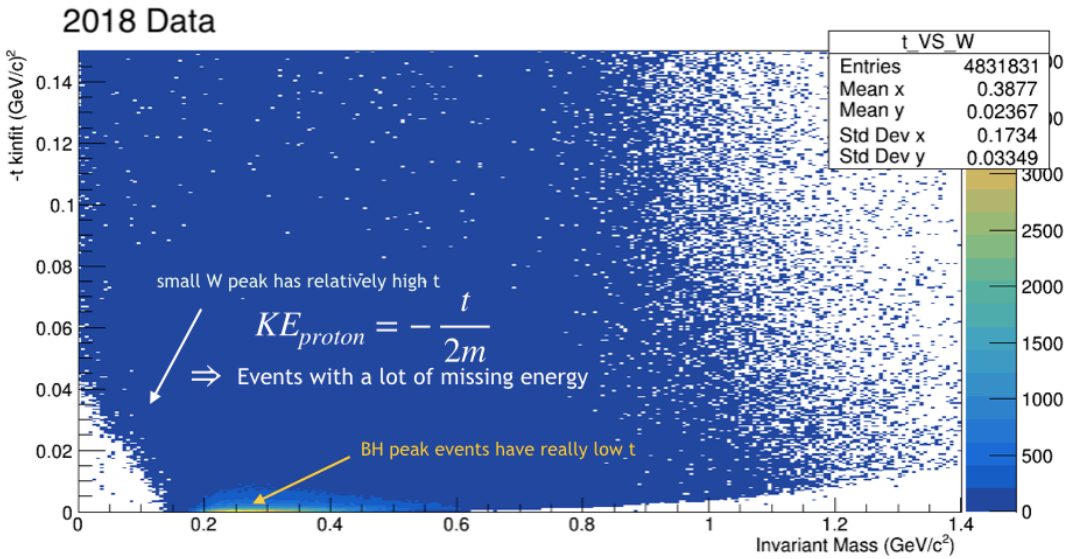




FROM LAST TIME: SMALL W PEAK

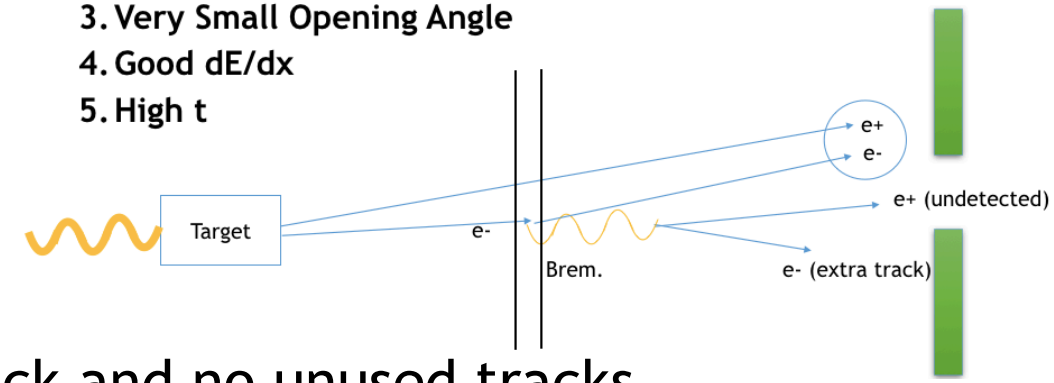






Need explanation that satisfies:

1. **Small Invariant Mass**
2. **One Extra (Unused) Track**
3. **Very Small Opening Angle**
4. **Good dE/dx**
5. **High t**



=> Split up data into 1 unused track and no unused tracks

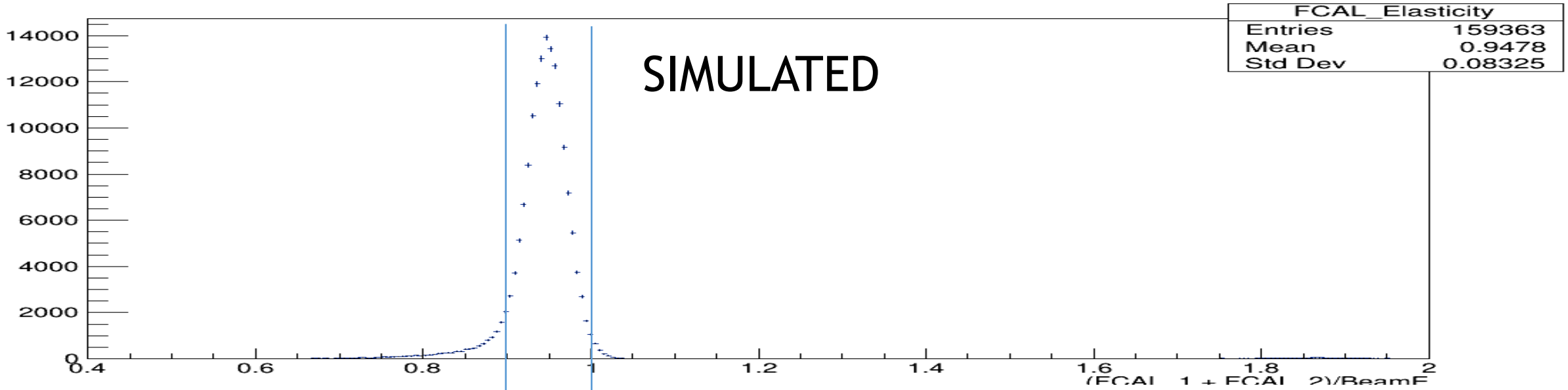
Cuts for $\gamma p \rightarrow e^+e^-(p)$

Preselection Cuts

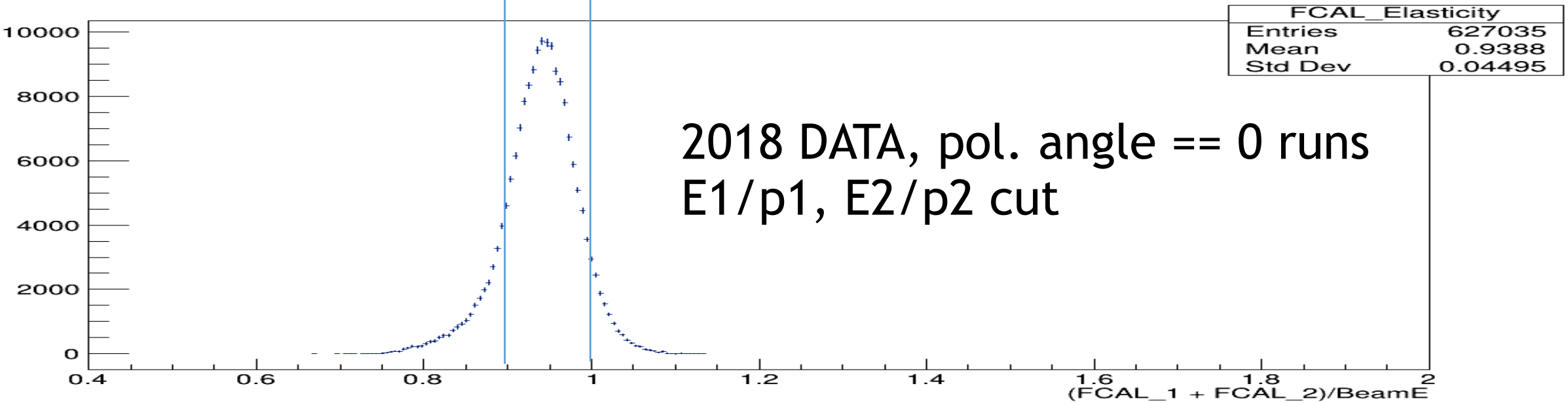
1. Default GlueX cuts: https://halldweb.jlab.org/wiki/index.php/Spring_2017_Analysis_Launch_Cuts
2. Require E/p > 0.7 for electron and positron tracks in FCAL and BCAL

DSelector Cuts

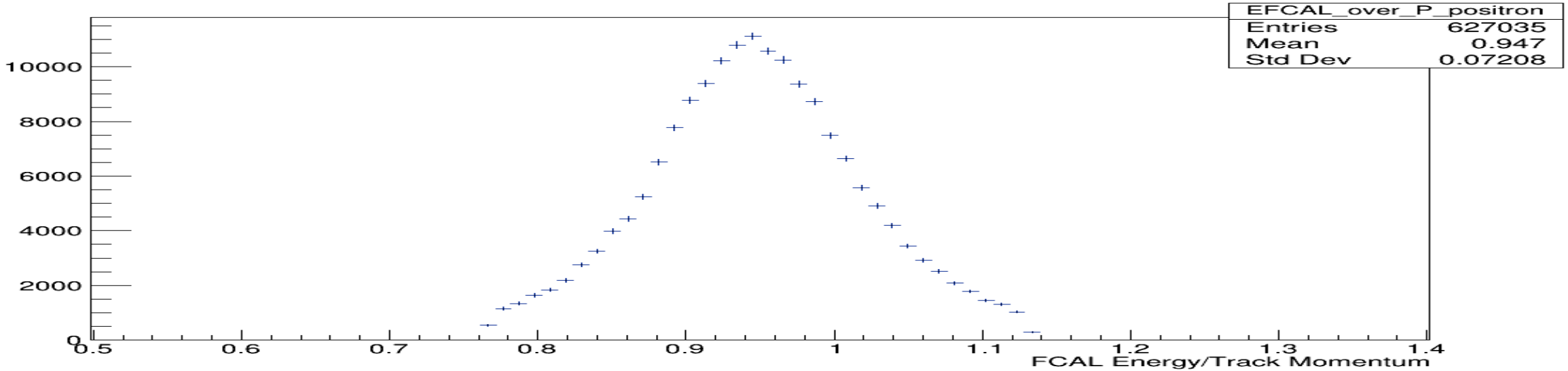
1. Cut on coherent peak: 8.12 < Eγ < 8.88
2. Require both electron and positron tracks have hit in FCAL
3. Require both electron and positron tracks have hit in TOF
4. Require dMinKinFitCL > 10E-6
5. Eliminate events with NumUnusedTracks ≥ 2, (Split up data into 1 unused and 0 unused.) Today we are only looking at **0 unused track events**.
6. Eliminate events with Energy_UnusedShowers > 0
7. TOF dE/dx cut for electron and positron tracks at 3σ
8. FCAL DOCA cut for e+ and e- tracks at 3σ
9. **Cut on** $\frac{E_1}{p_1}$ **and** $\frac{E_2}{P_2}$ **at** $\pm 3\sigma$



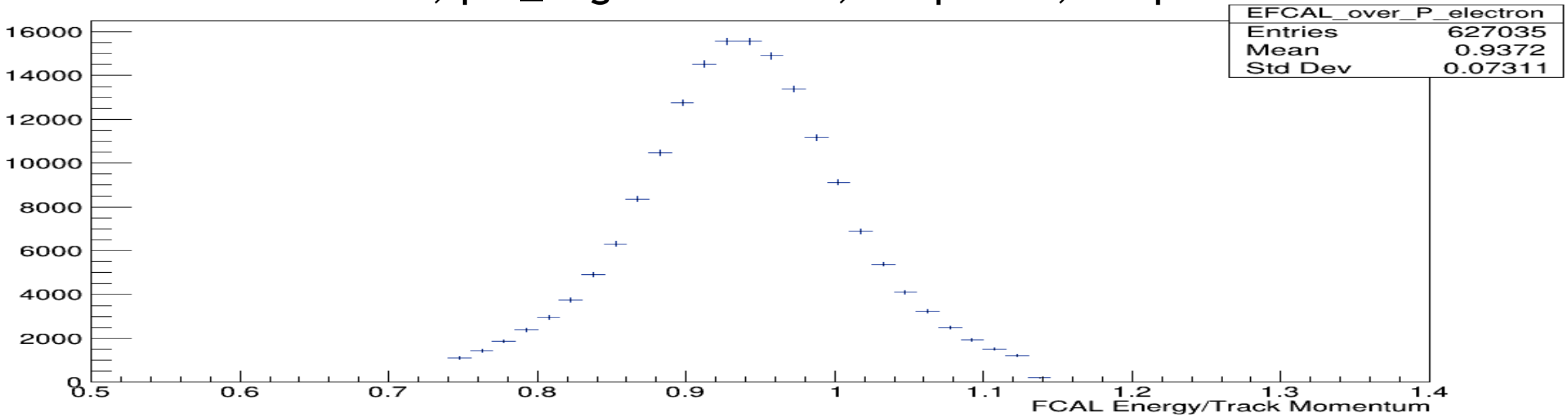
SIMULATED

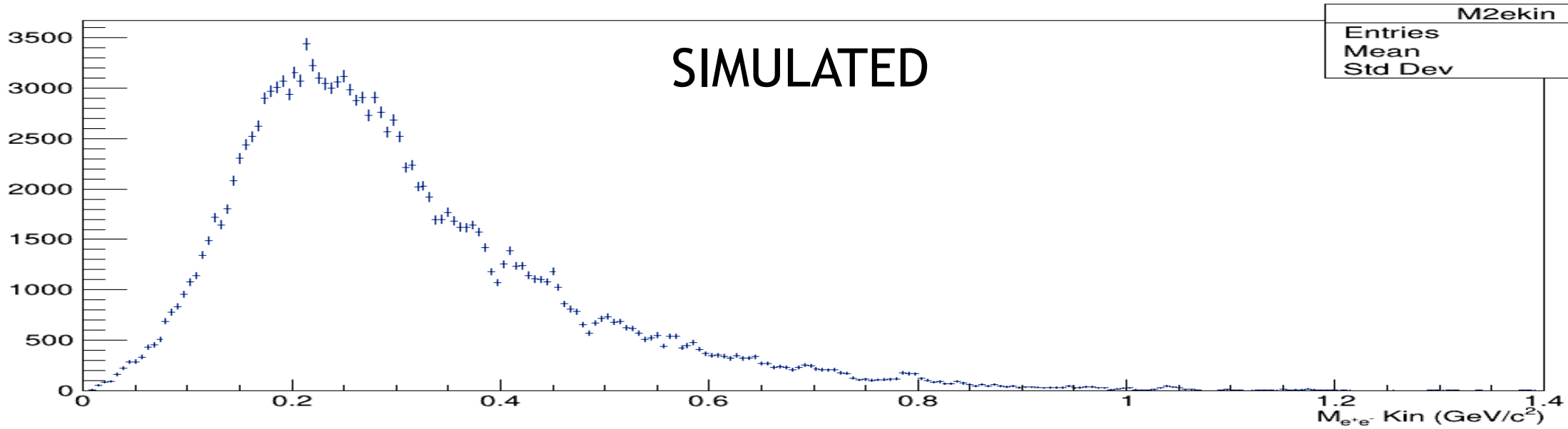


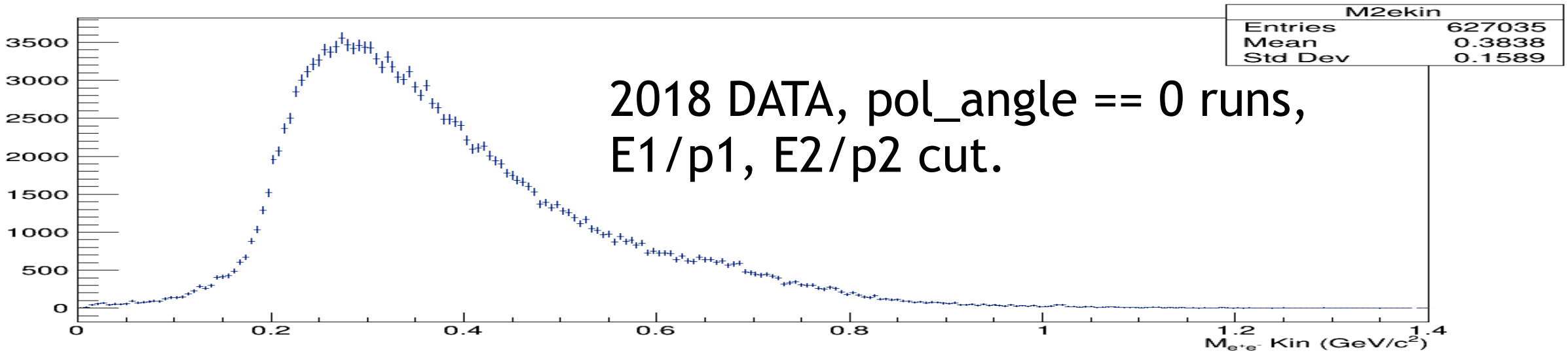
2018 DATA, pol. angle == 0 runs
E1/p1, E2/p2 cut

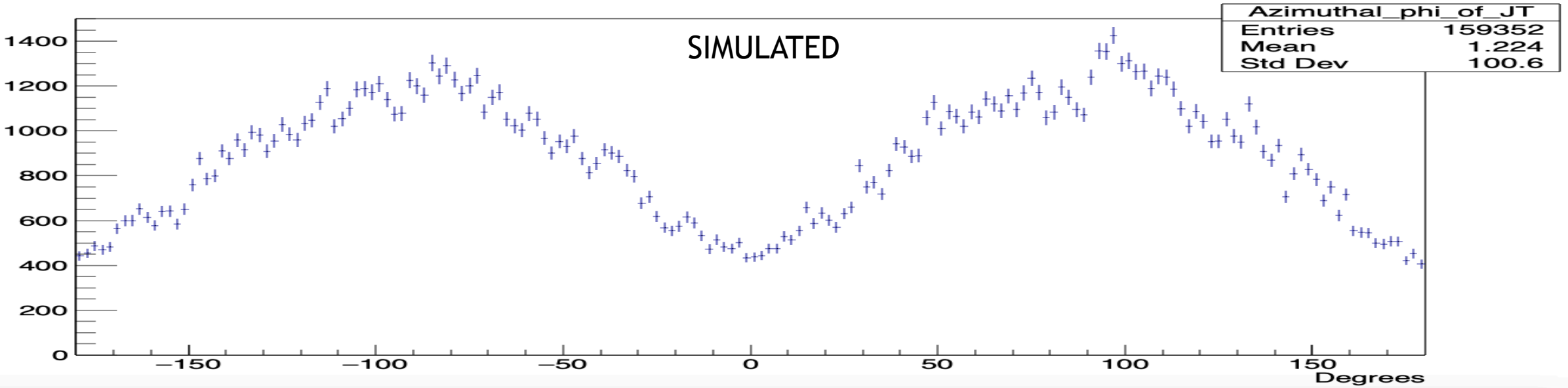


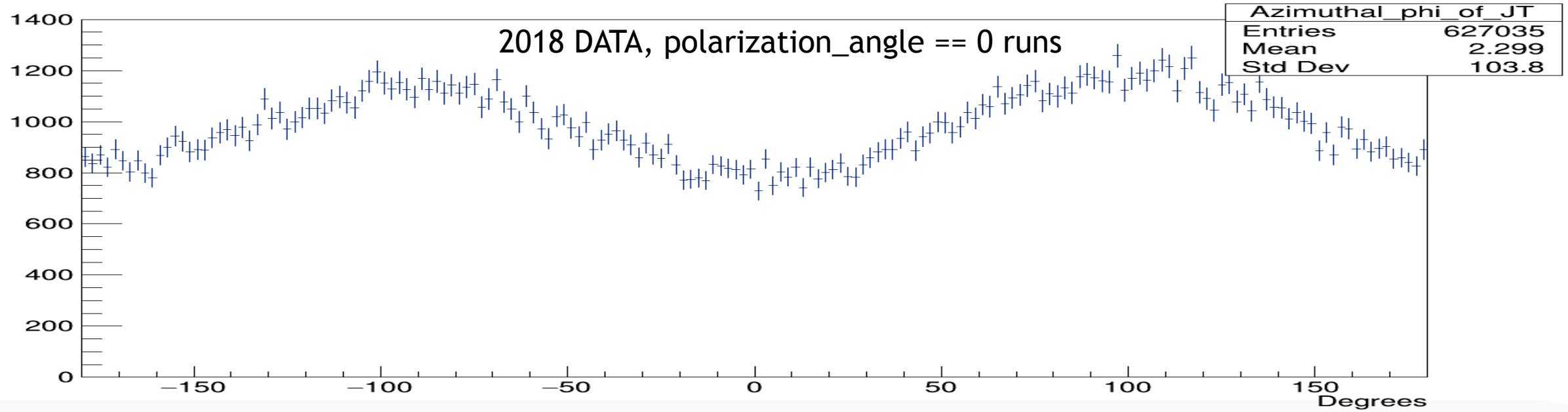
2018 DATA, pol_angle == 0 runs, E1/p1 cut, E2/p2 cut



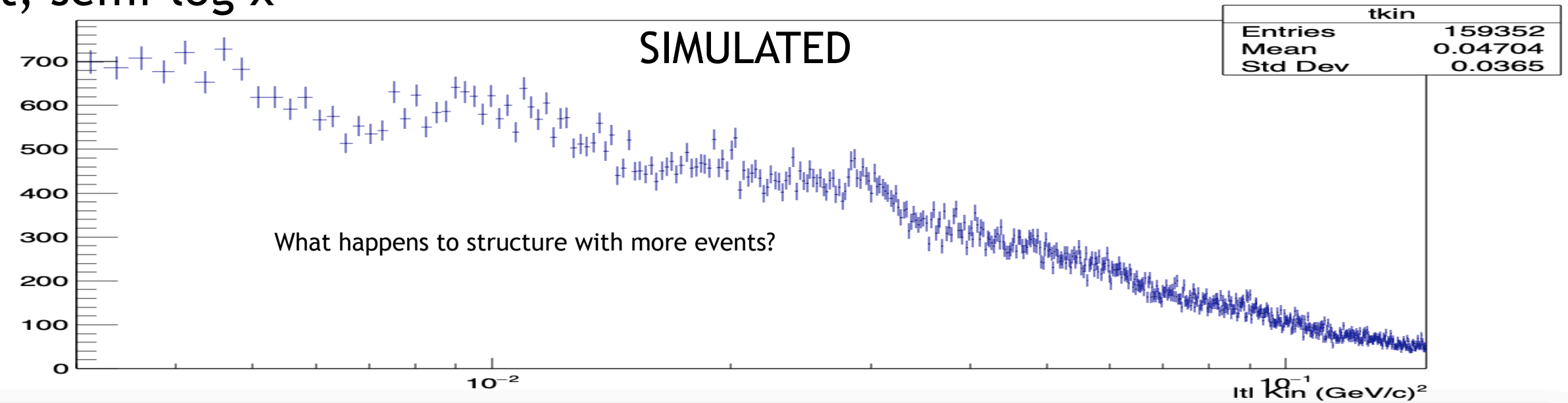

M2ekin
Entries 159363
Mean 0.3055
Std Dev 0.1628
SIMULATED
3500
3000
2500
2000
1500
1000
500
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
$M_{e^+e^-}$ Kin (GeV/c^2)

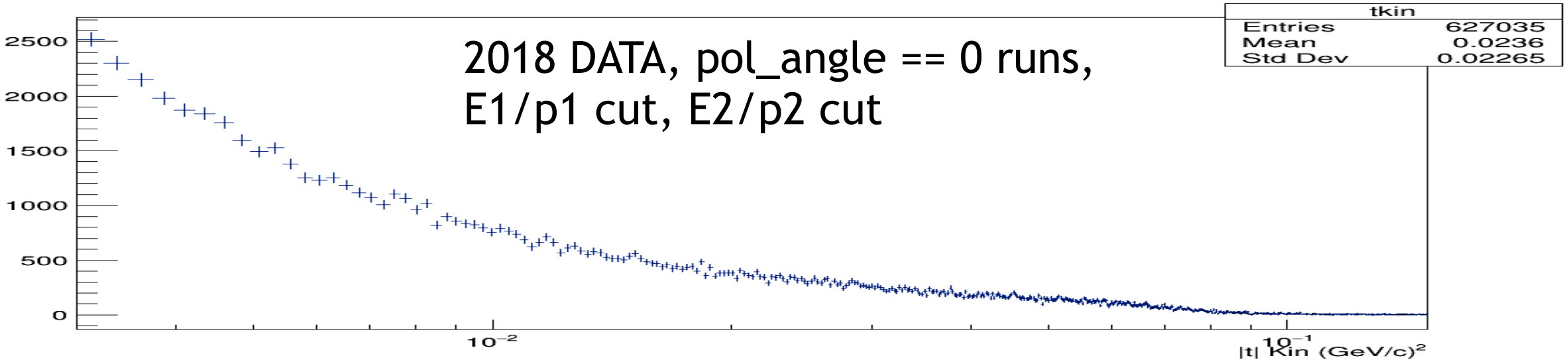

M2ekin
Entries 627035
Mean 0.3838
Std Dev 0.1589
2018 DATA, pol_angle == 0 runs,
E1/p1, E2/p2 cut.
3500
3000
2500
2000
1500
1000
500
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
$M_{e^+e^-}$ Kin (GeV/c^2)


SIMULATED
Azimuthal_phi_of_JT
Entries 159352
Mean 1.224
Std Dev 100.6
1400
1200
1000
800
600
400
200
0
−150
−100
−50
0
50
100
150
Degrees


2018 DATA, polarization_angle == 0 runs
Azimuthal_phi_of_JT
Entries 627035
Mean 2.299
Std Dev 103.8
1400
1200
1000
800
600
400
200
0
−150
−100
−50
0
50
100
150
Degrees

-t, semi-log x


SIMULATED
tkin
Entries 159352
Mean 0.04704
Std Dev 0.0365
What happens to structure with more events?
700
600
500
400
300
200
100
0
10^{-2}
10^{-1}
|t| Kin (GeV/c)²


2018 DATA, pol_angle == 0 runs,
E1/p1 cut, E2/p2 cut
tkin
Entries 627035
Mean 0.0236
Std Dev 0.02265
2500
2000
1500
1000
500
0
10^{-2}
10^{-1}
|t| Kin (GeV/c)²

Conclusions

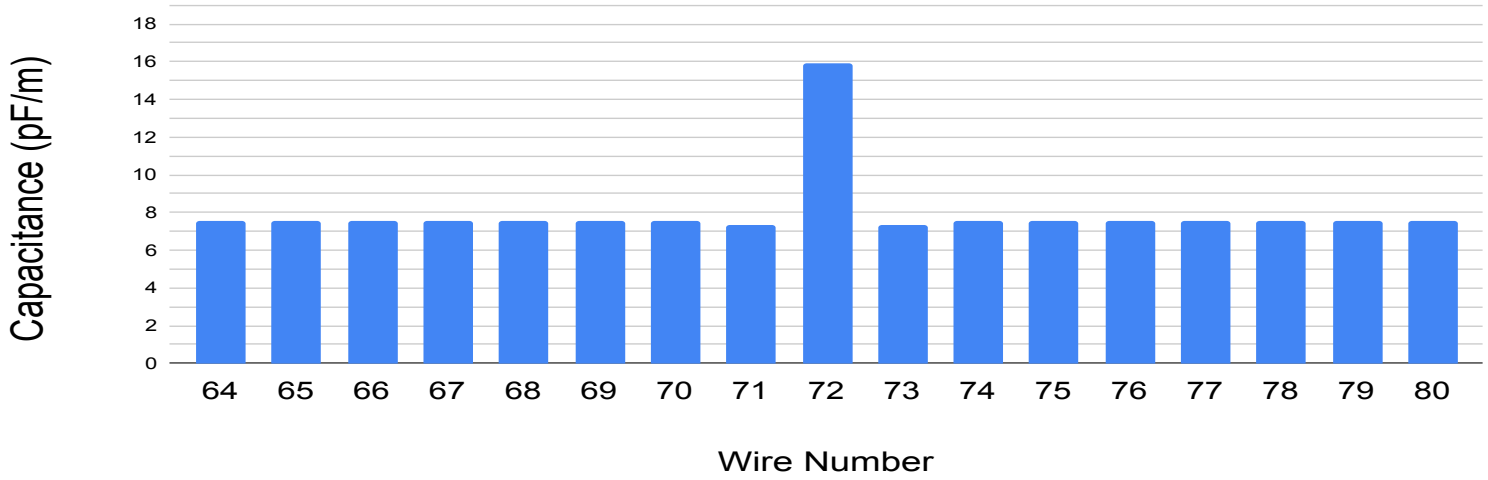
Have to return to MC to make it as robust as possible:

-> Really focus on finishing my event generator.

- Real bremsstrahlung photon distribution
- Tagger Accidentals
- Open up phase space in theta to have very low angle tracks along the beam line
- Many more events!

Capacitance vs Wire Number

1 Carbon Tube



Capacitance vs Wire Number

2 Carbon Tubes