$\gamma p \longrightarrow p\phi\eta$ Update

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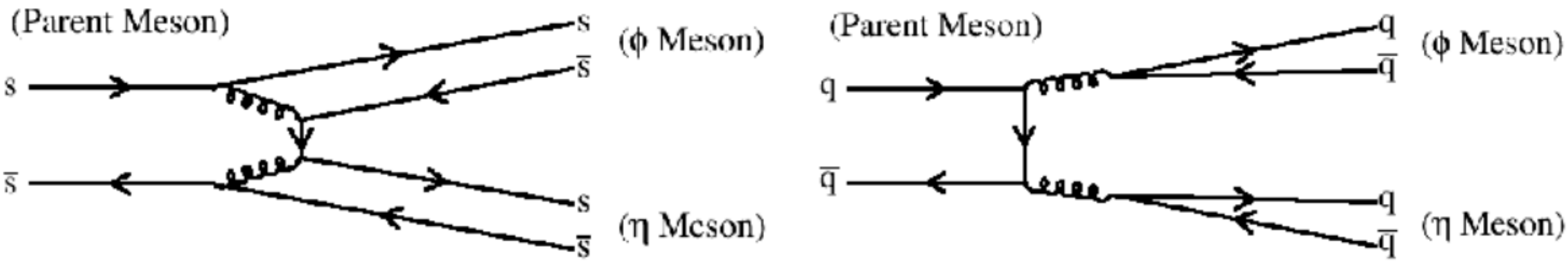
Outline

- Motivation
- Cuts
- Quality Factor Method
- Preliminary Results

Search for New and Unusual Strangeonia States Using $\gamma p \longrightarrow p\phi\eta$

- $\gamma p \longrightarrow p\phi\eta$ is expected to be dominated by an $s\bar{s}$ parent state

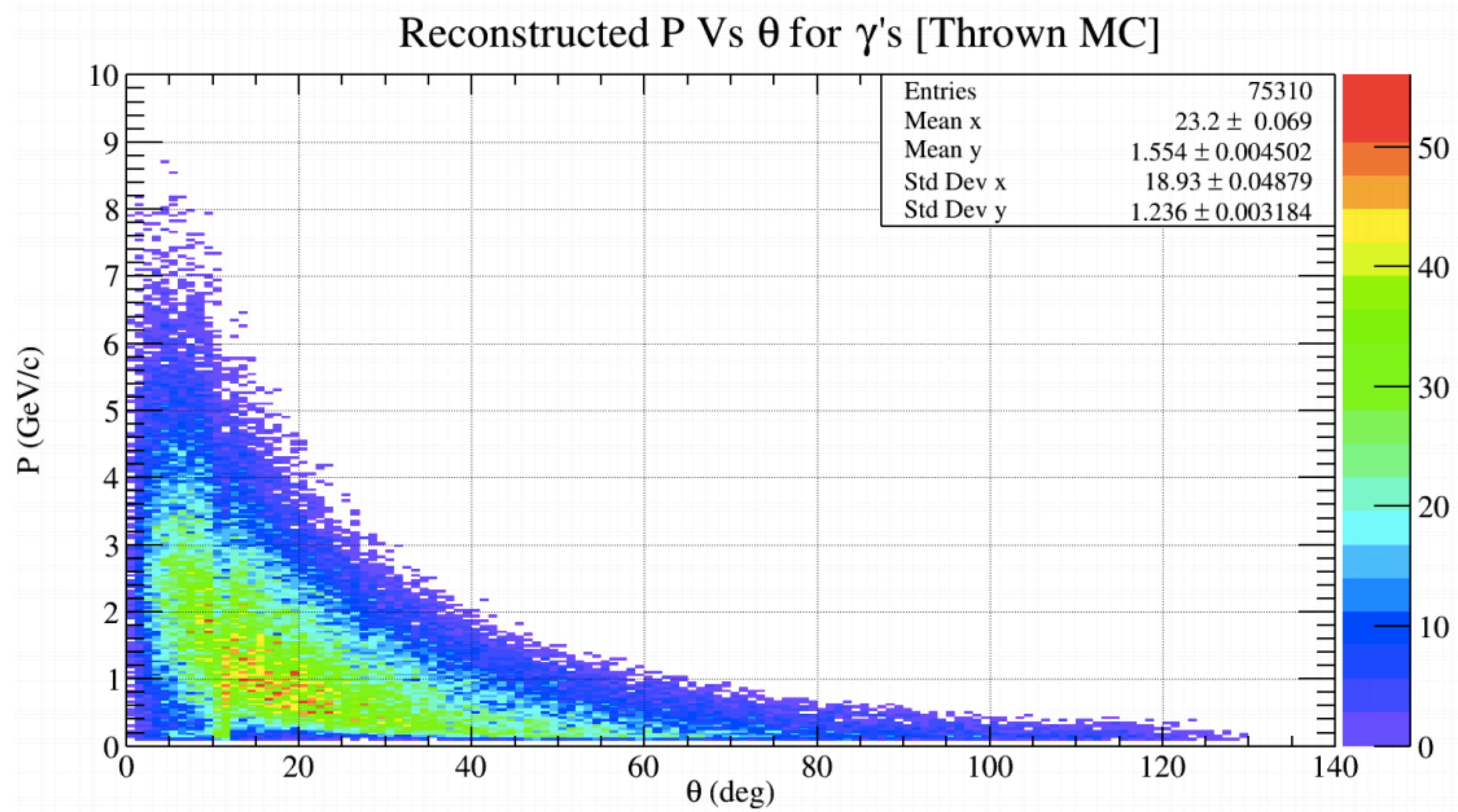


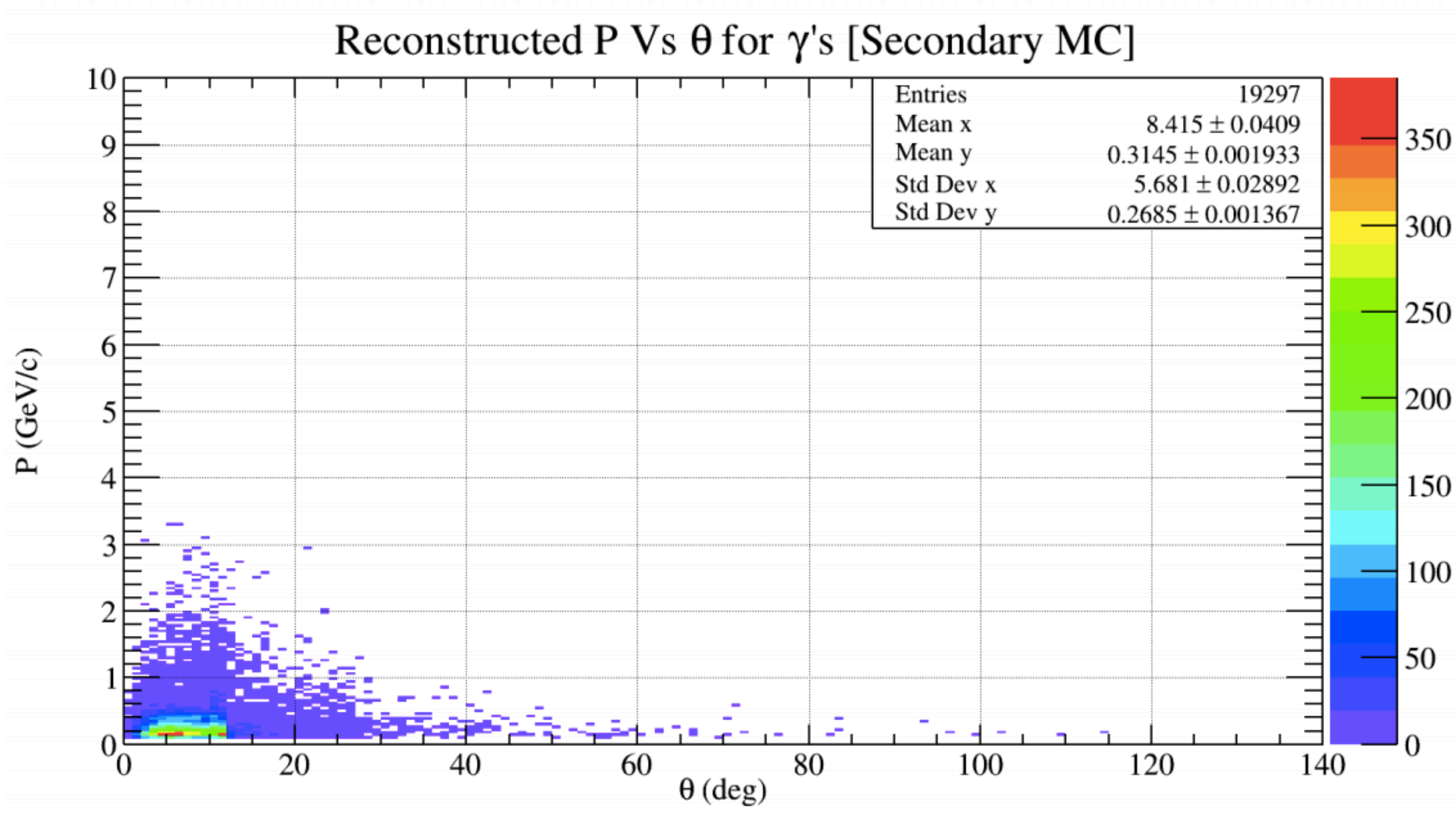
- Observation of a state with a large branching fraction to $\phi\eta$ and small branches to non strange final states would establish an $s\bar{s}$ state.

Cuts for $\gamma p \longrightarrow p \phi \eta$

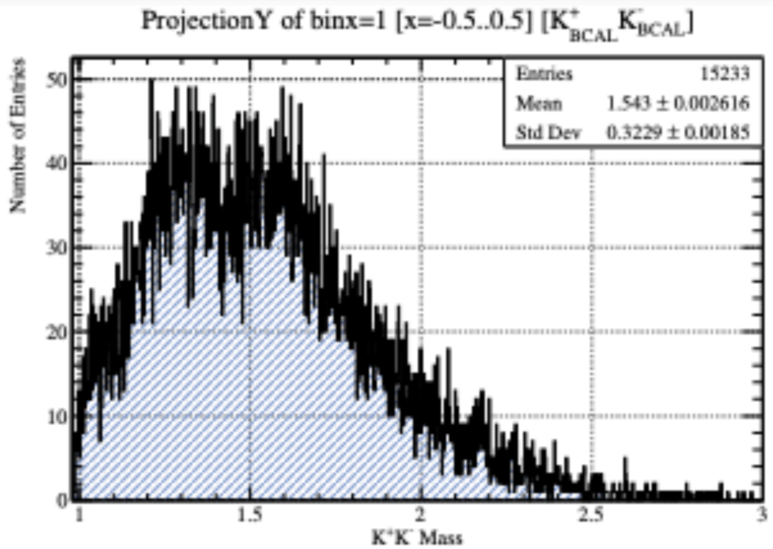
- dE/dX in CDC for proton
- PID Timing Cuts
- 51 cm < Vertex Z < 79 cm
- Vertex R <= 1 cm
- RF Timing (3 beam bunches)
- Unused Shower Energy < 50 MeV
- $|MM^2| < 0.02$
- <u>Fiducial Photon Cut (θ<12° and E < 500 MeV)</u>
- K^+K^- Invariant Mass < 1.055
- 0.3 < γγ Invariant Mass < 0.8
- <u>Kaon Timing from TOF Only</u>
- <u>Strangeness Conservation</u>
- Beam Photon With Best MM^2

Fiducial Photon Cut

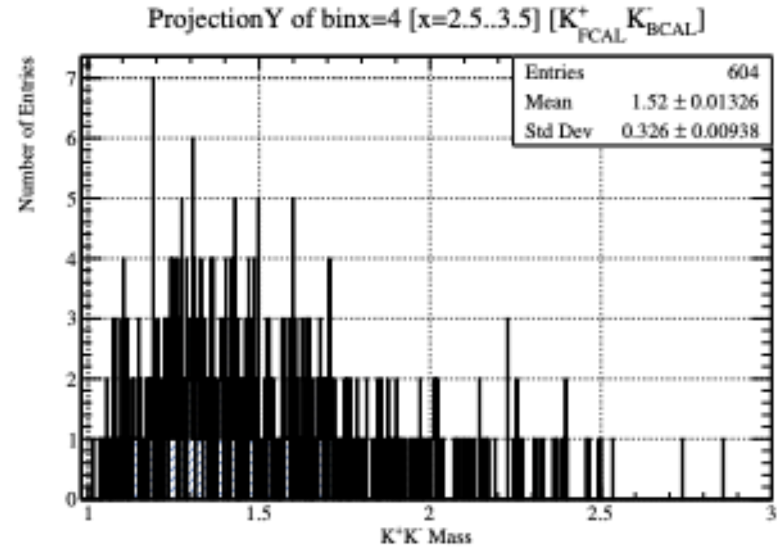




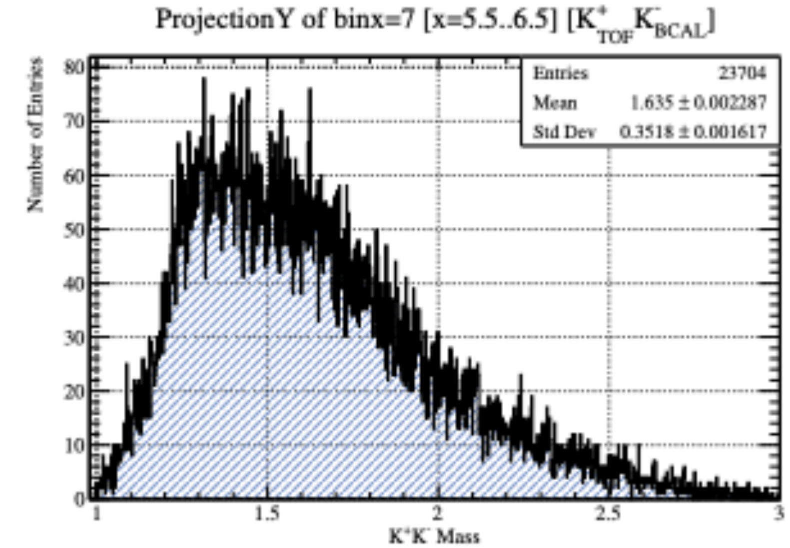
Kaon Timing From TOF Only



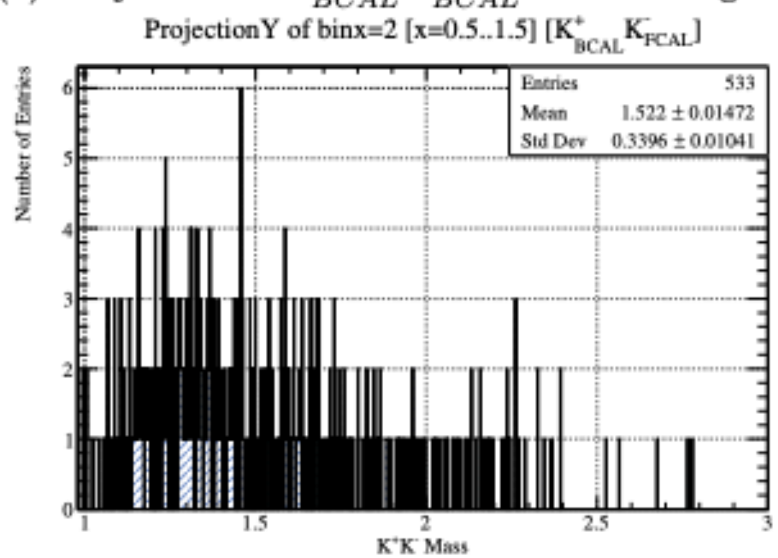
(a) Projection of $K^{+}_{BCAL}K^{-}_{BCAL}$ bin from Figure



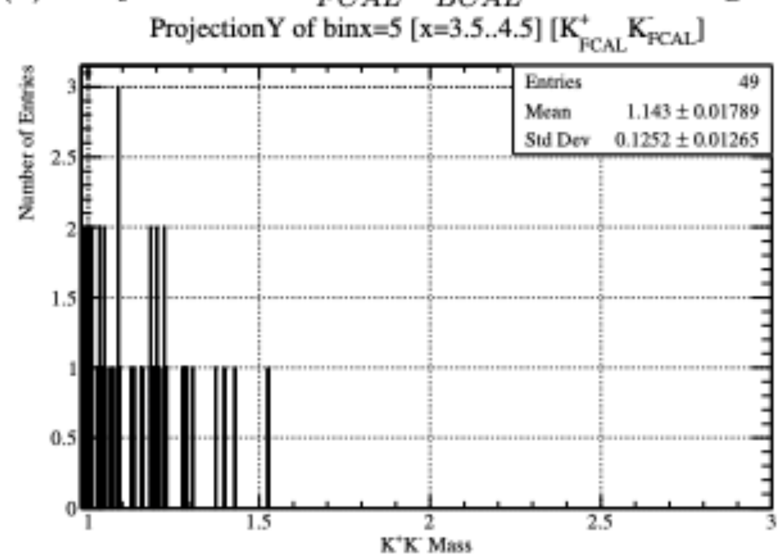
(a) Projection of $K^{+}_{FCAL}K^{-}_{BCAL}$ bin from Figure 3



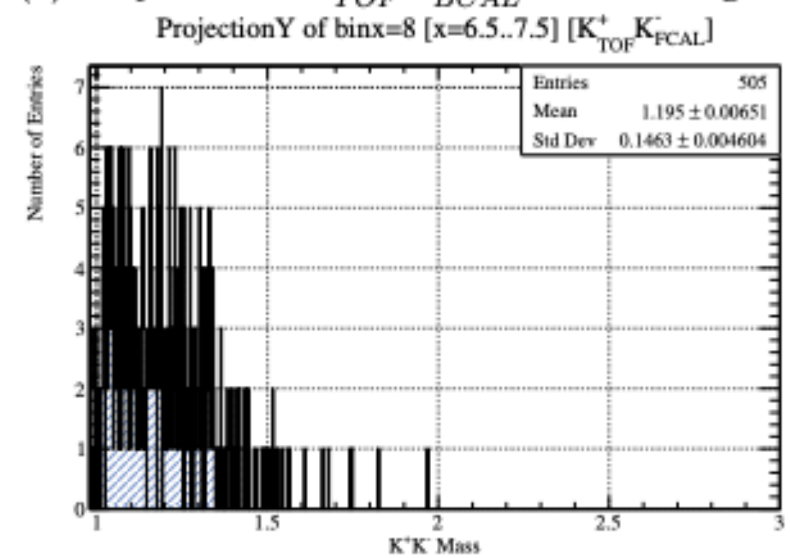
(a) Projection of $K^{+}_{TOF}K^{-}_{BCAL}$ bin from Figure 33.



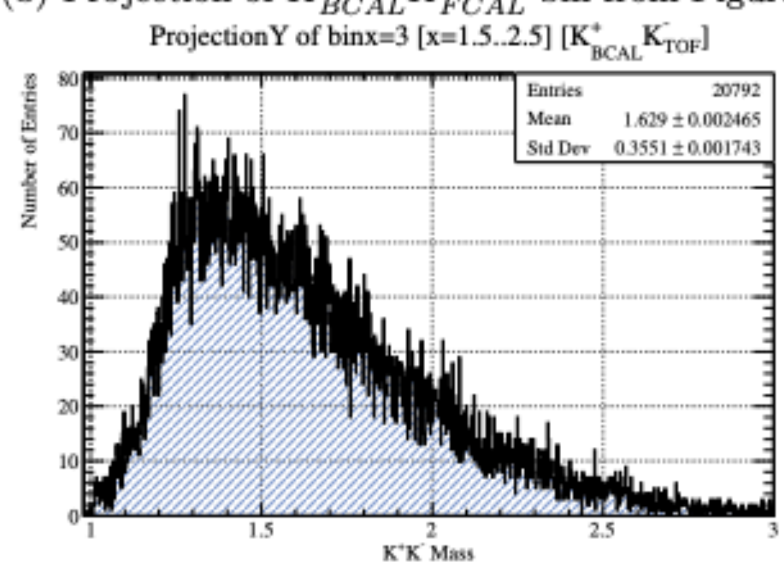
(b) Projection of $K^{+}_{BCAL}K^{-}_{FCAL}$ bin from Figure



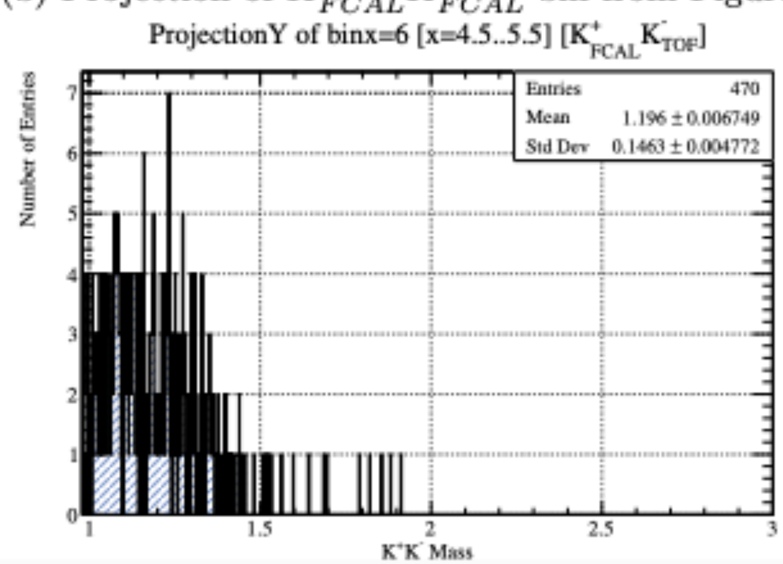
(b) Projection of $K^{+}_{FCAL}K^{-}_{FCAL}$ bin from Figure 3



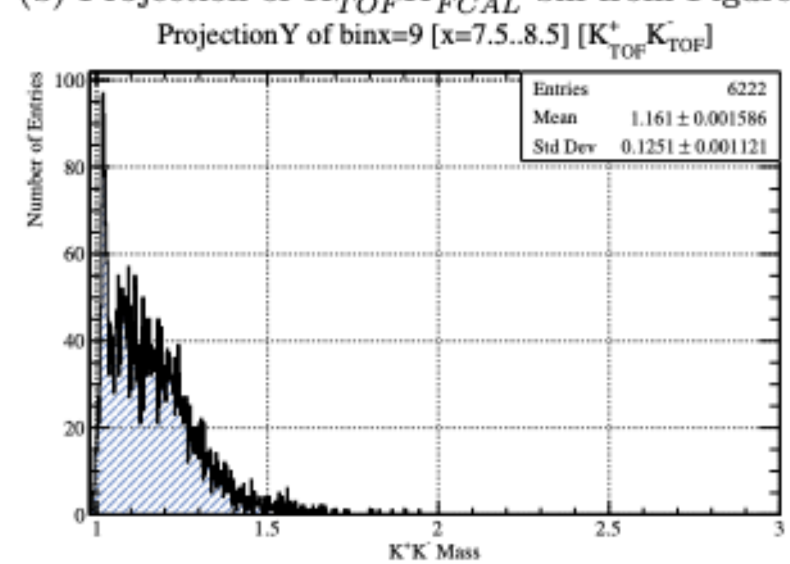
(b) Projection of $K^{+}_{TOF}K^{-}_{FCAL}$ bin from Figure 33.



(c) Projection of $K^{+}_{BCAL}K^{-}_{TOF}$ bin from Figure 3



(c) Projection of $K^{+}_{FCAL}K^{-}_{TOF}$ bin from Figure 33

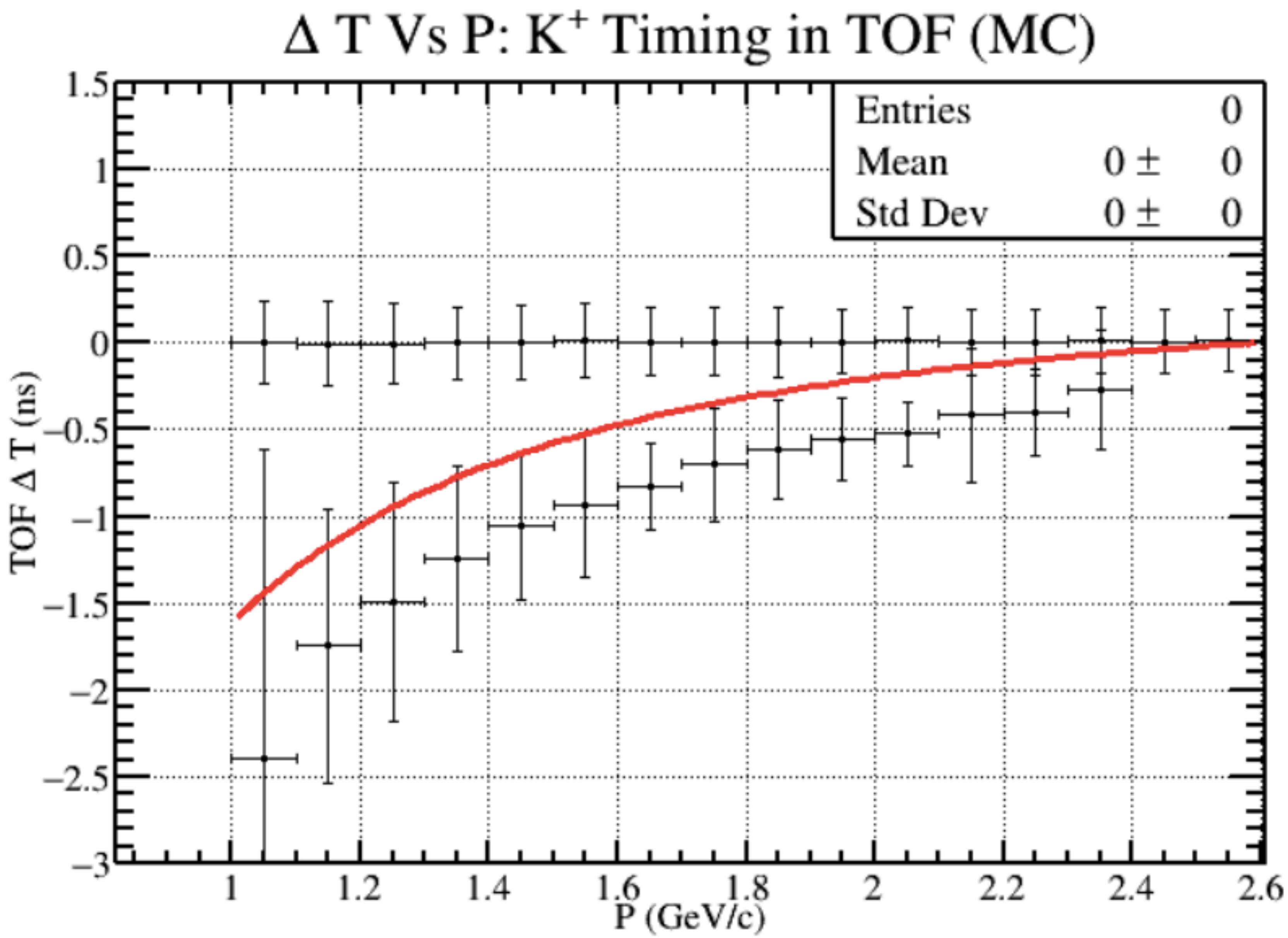


(c) Projection of $K^{+}_{TOF}K^{-}_{TOF}$ bin from Figure 33.

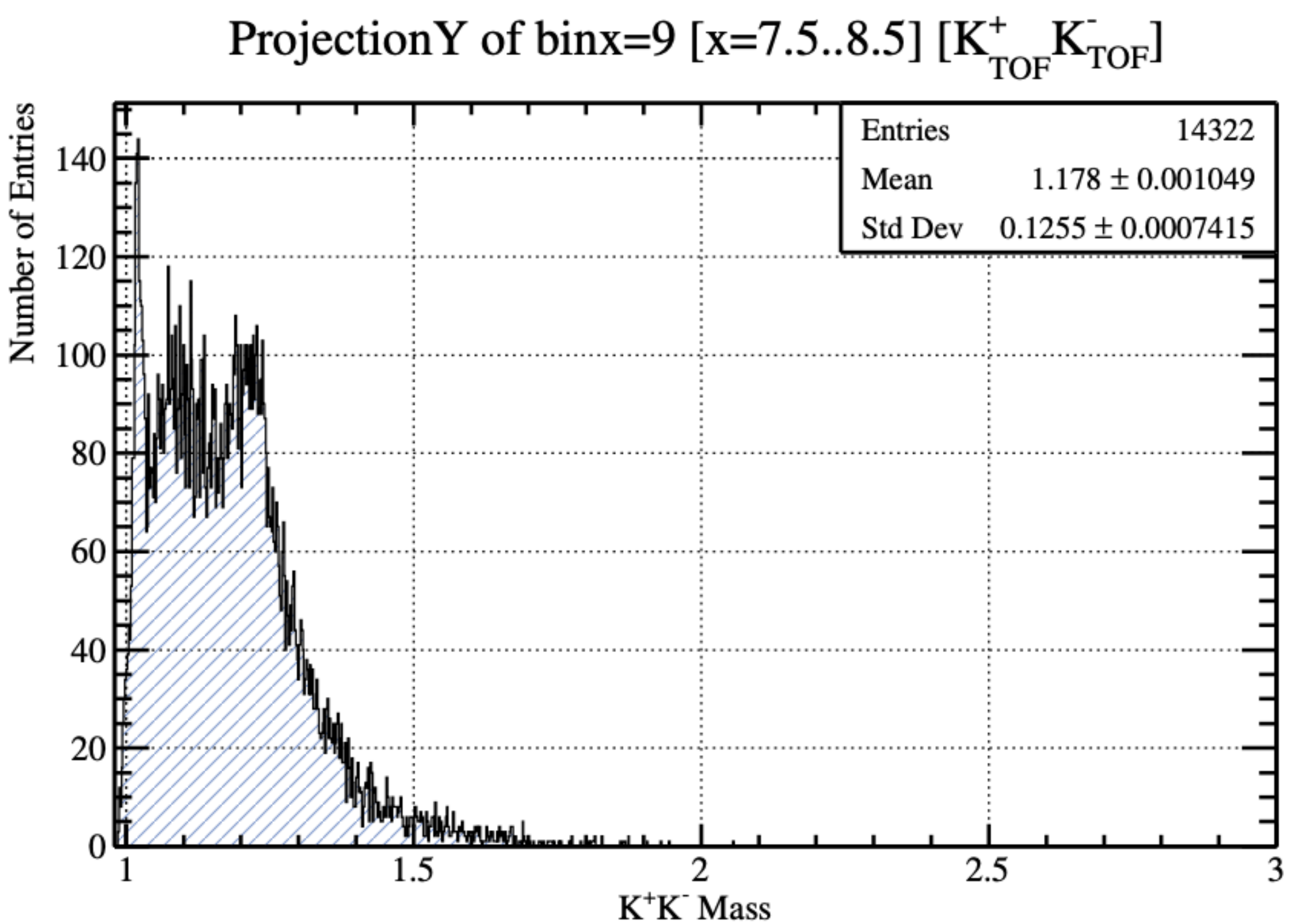
Strangeness Conservation

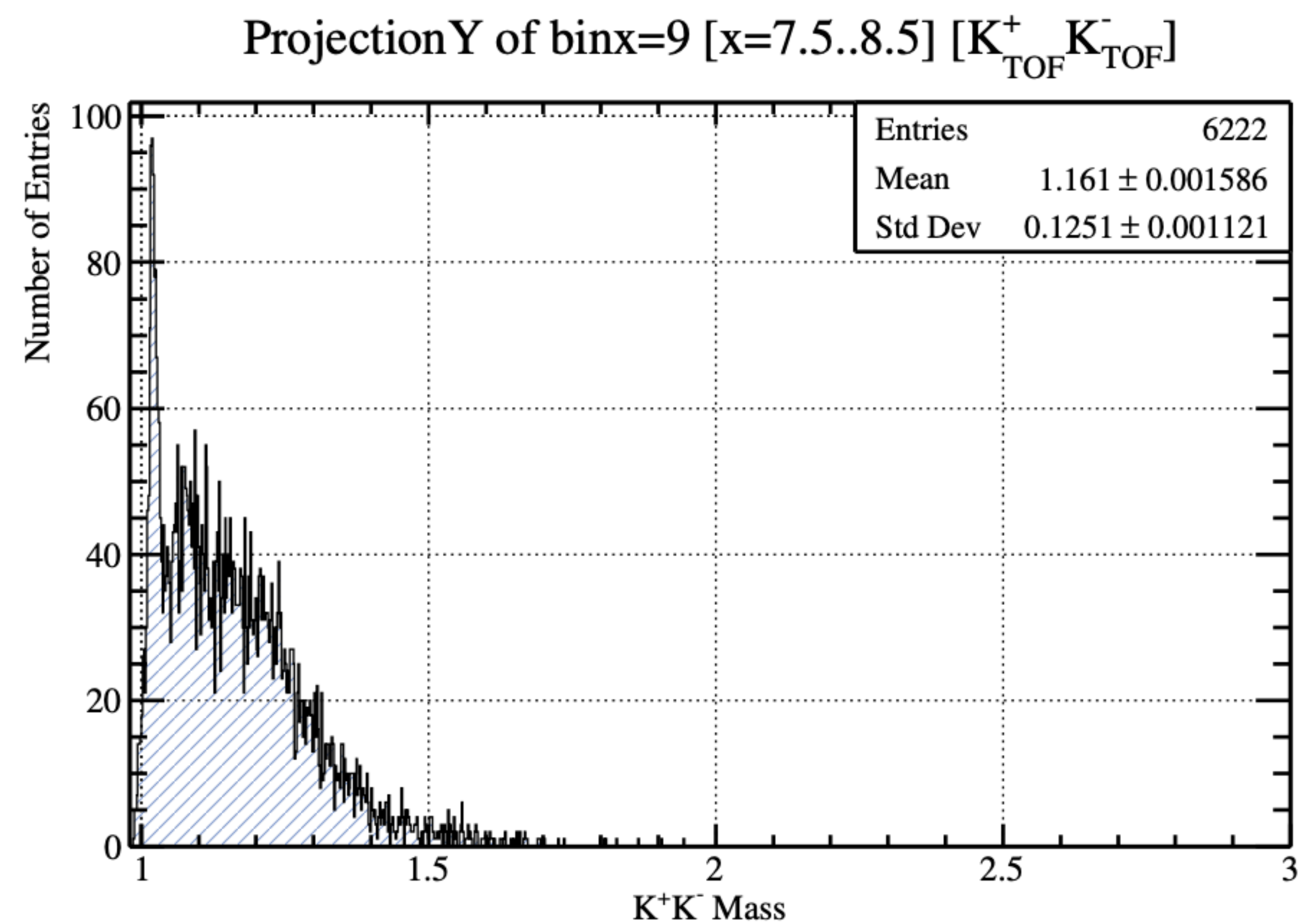
$$t = \frac{\delta X}{V} = \frac{\delta X}{\beta c} \qquad t = \frac{\delta X}{c} \frac{\sqrt{m_i^2 + P^2}}{P}$$

$$\delta t = \frac{\delta X}{c} \frac{\sqrt{m_\pi^2 + P^2} - \sqrt{m_K^2 + P^2}}{P}$$



Strangeness Conservation





Quality Factor Method

- A method for separating signal and background
- M. Williams, M. Bellis and C. A. Meyer “Separating Signals from Non-Interfering Backgrounds using Probabilistic Event Weightings.”

Assumption:

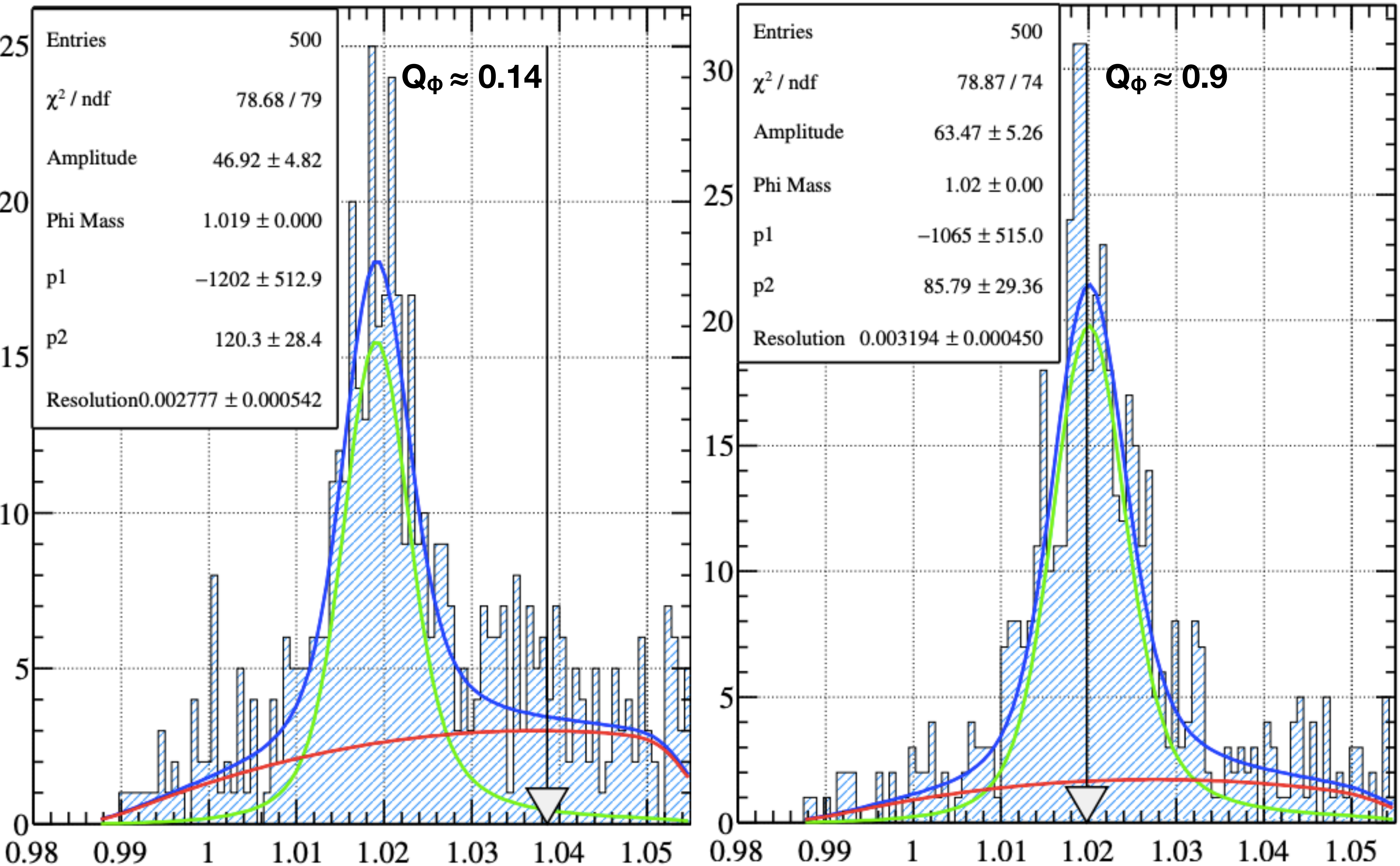
- A given event has a set of other events which it shares similar kinematic features with. These are called nearest neighbors
- Plotting the invariant mass of the event with its nearest neighbors provides insight into the “Quality Factor” or probability that the event is signal or background

Quality Factor Method

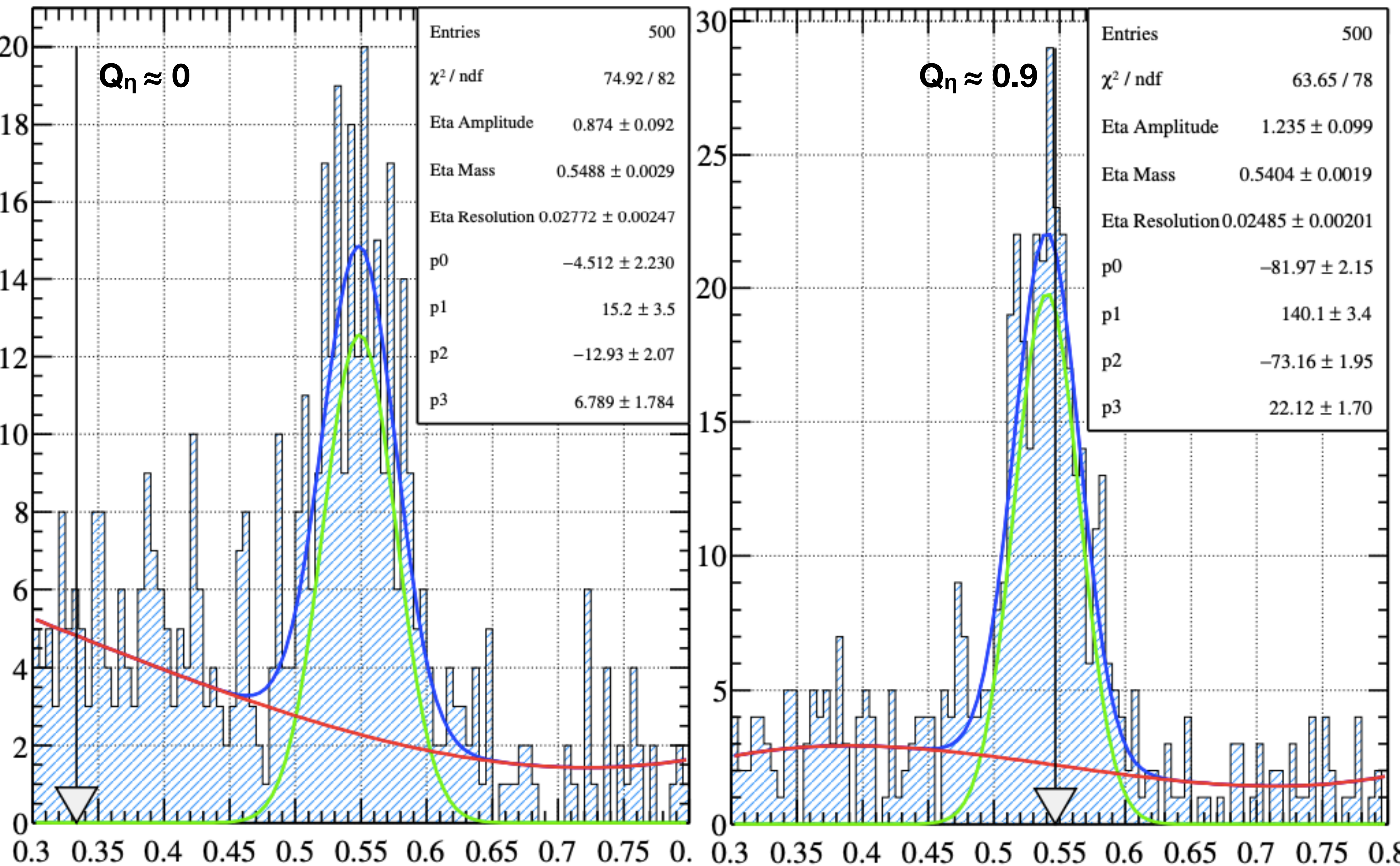
Algorithm:

- For a given event calculate a kinematic distance between that event and all other events
- Only accept the N nearest neighbors to that event
- Plot the K+K- and gg invariant mass for the N nearest neighbors
- Fit each invariant mass distribution with a signal function plus a background function
- Calculate the number of signal and background events at the mass value of the event using the fits
- Assign a Quality Factor to the event: Q = s / (s+bg)

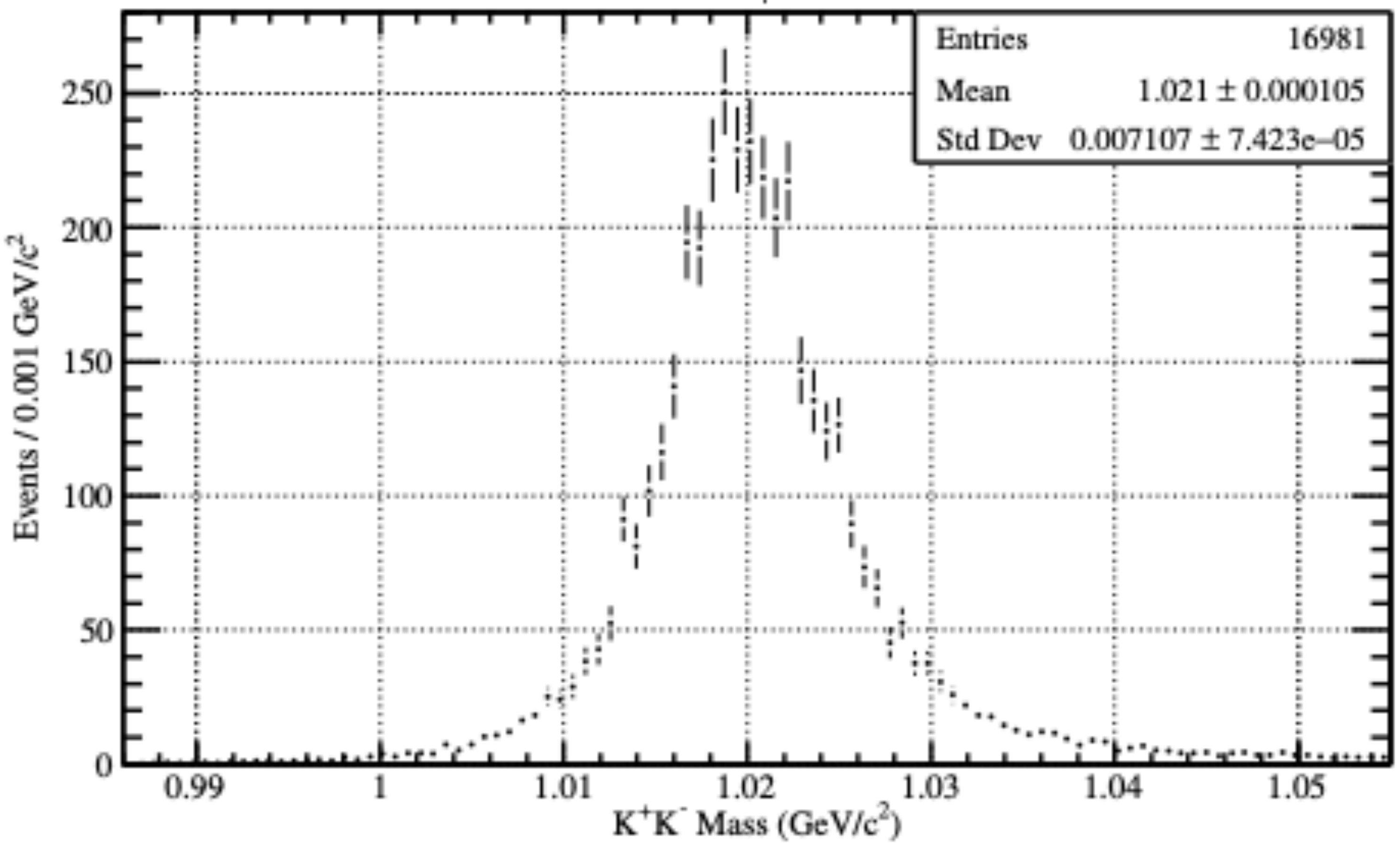
K+K- Invariant Mass



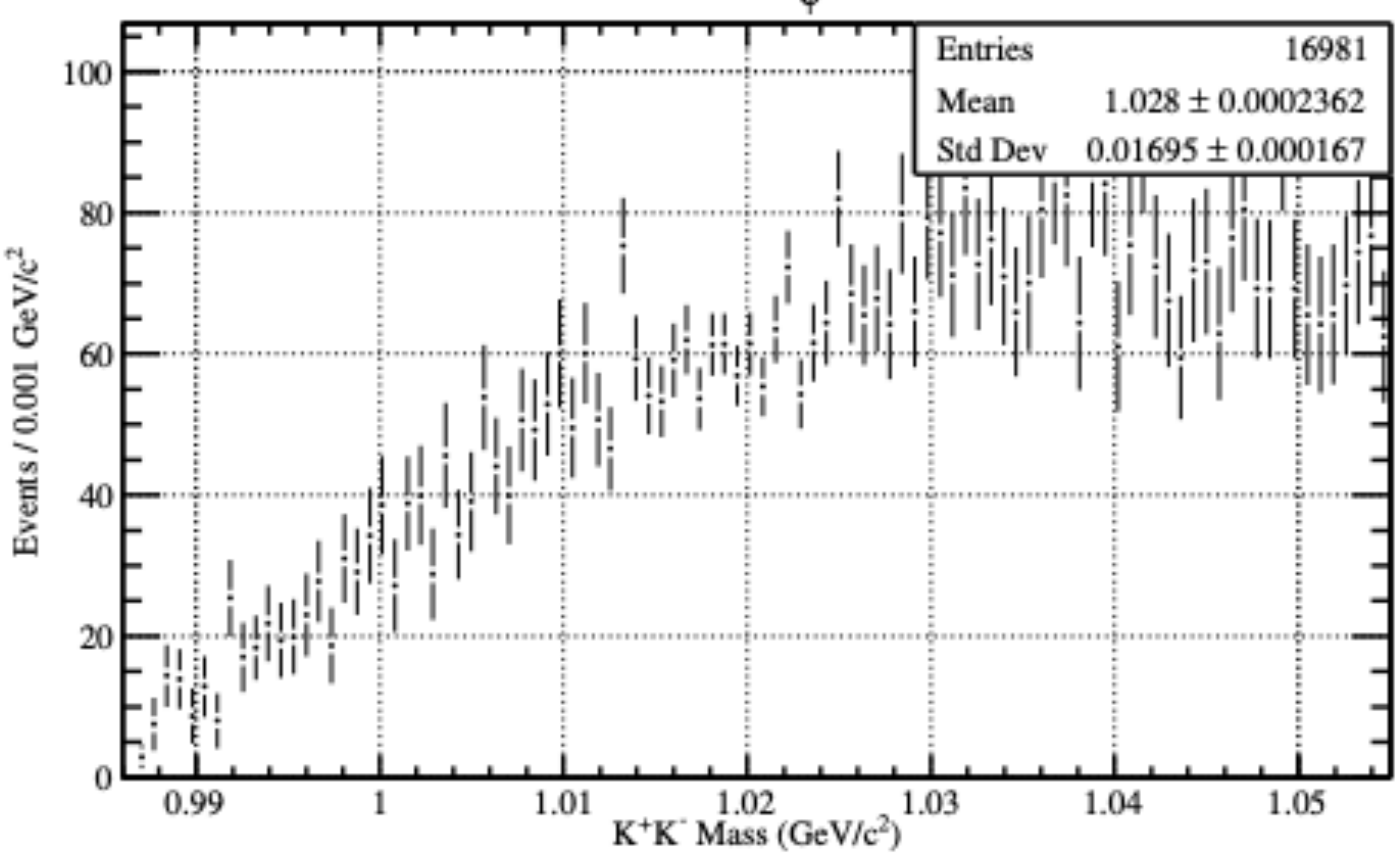
γγ Invariant Mass

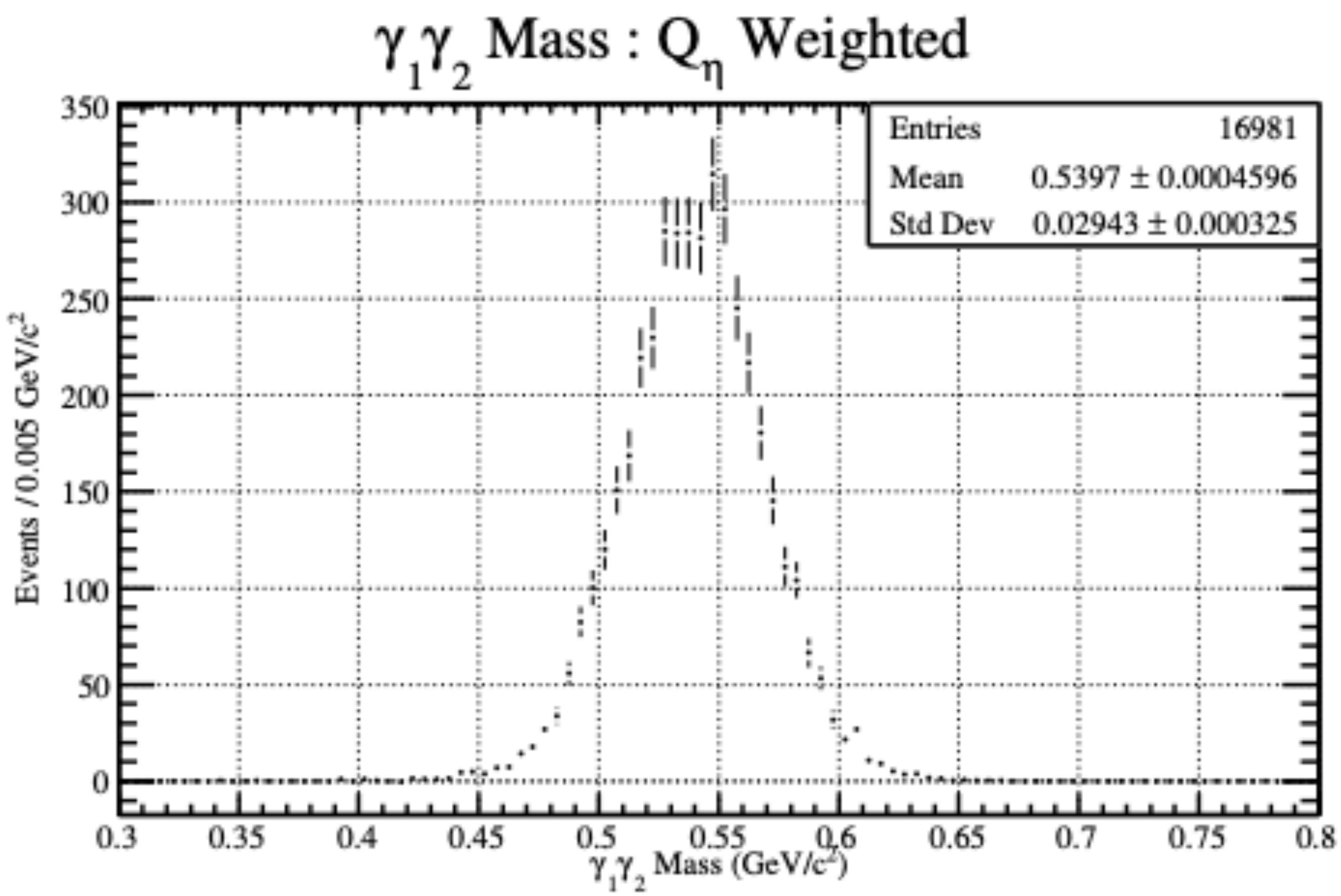


K^+K^- Mass : Q_ϕ Weighted

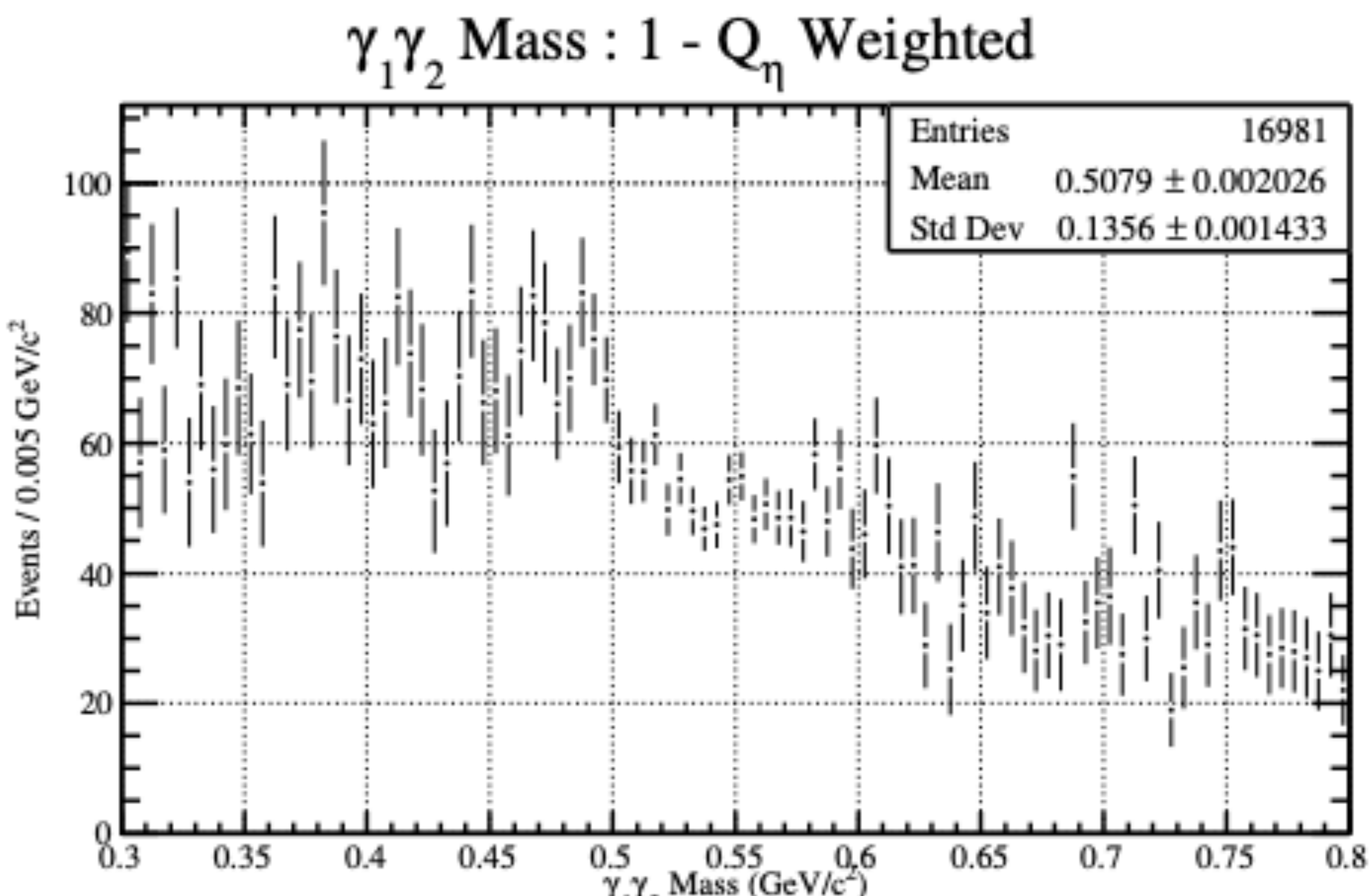


K^+K^- Mass : 1 - Q_ϕ Weighted



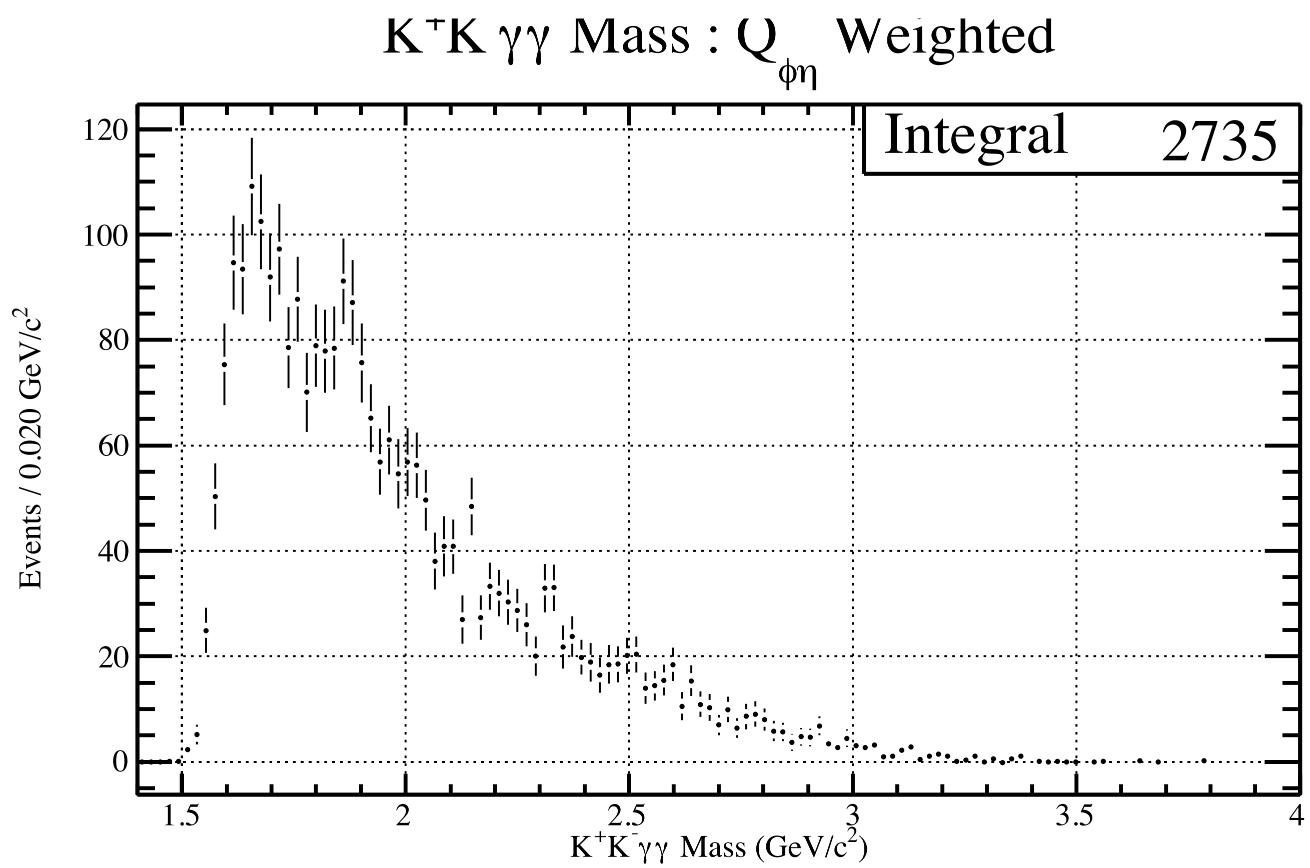


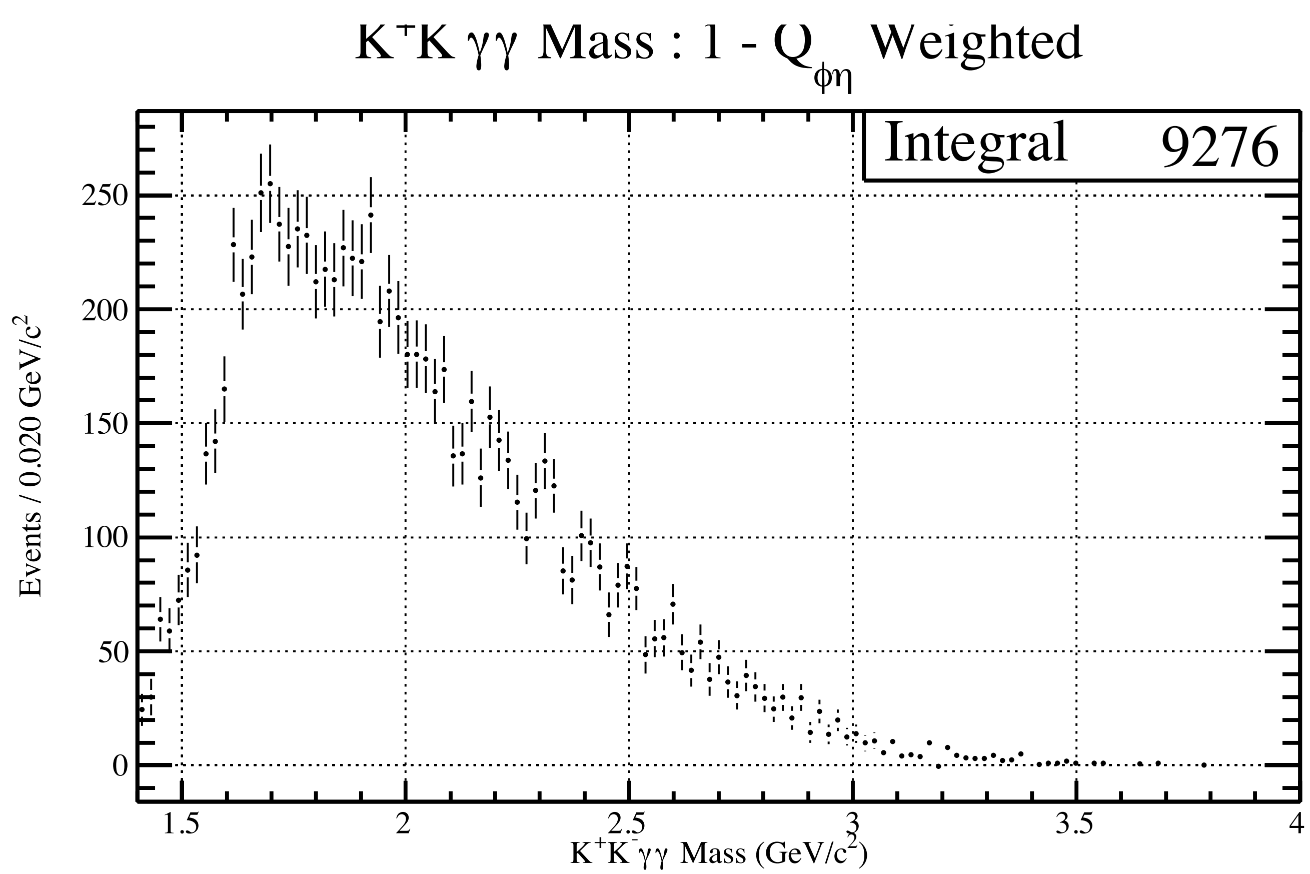
$\gamma_1\gamma_2$ Mass : Q_η Weighted
Entries 16981
Mean 0.5397 ± 0.0004596
Std Dev 0.02943 ± 0.000325
Events / 0.005 GeV/c^2
$\gamma_1\gamma_2$ Mass (GeV/c^2)



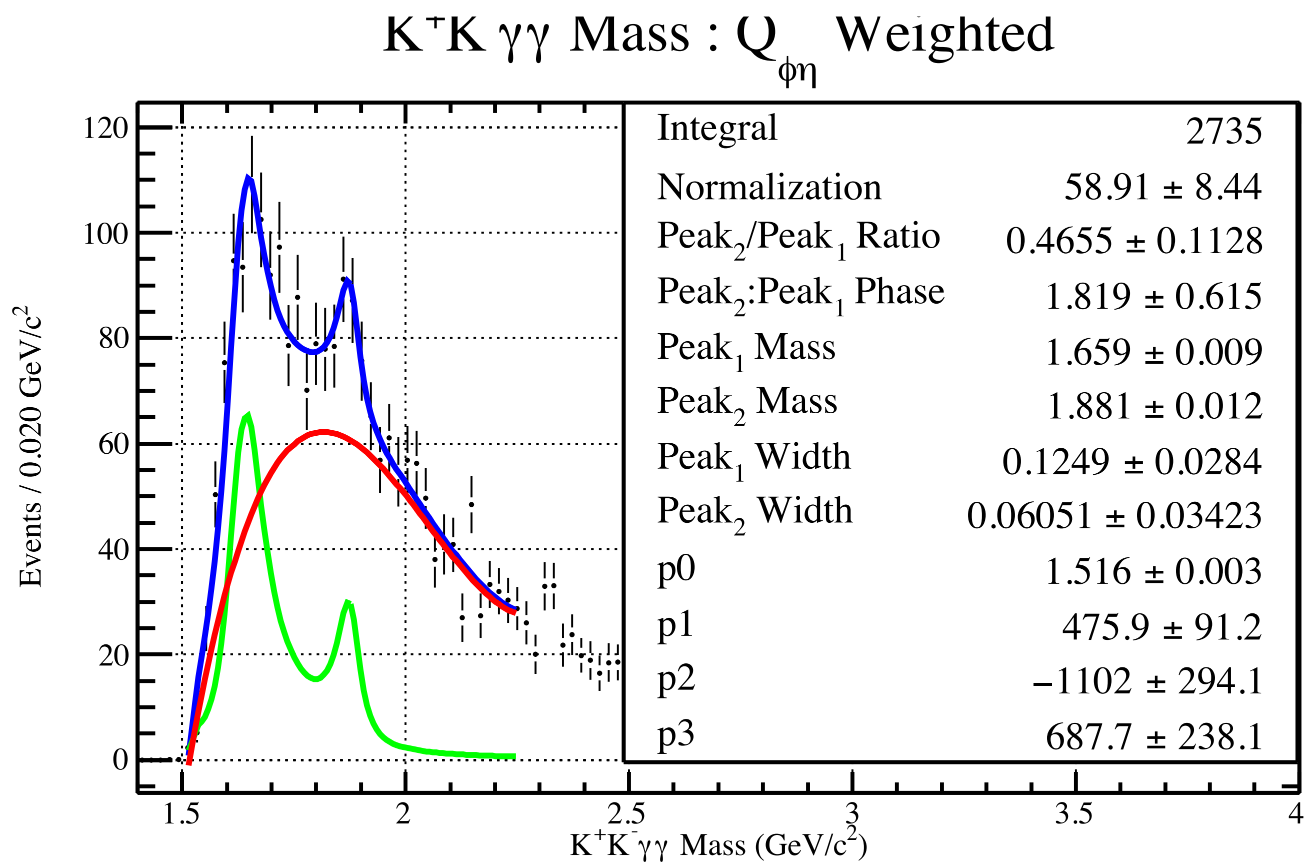
$\gamma_1\gamma_2$ Mass : 1 - Q_η Weighted
Entries 16981
Mean 0.5079 ± 0.002026
Std Dev 0.1356 ± 0.001433
Events / 0.005 GeV/c^2
$\gamma_1\gamma_2$ Mass (GeV/c^2)

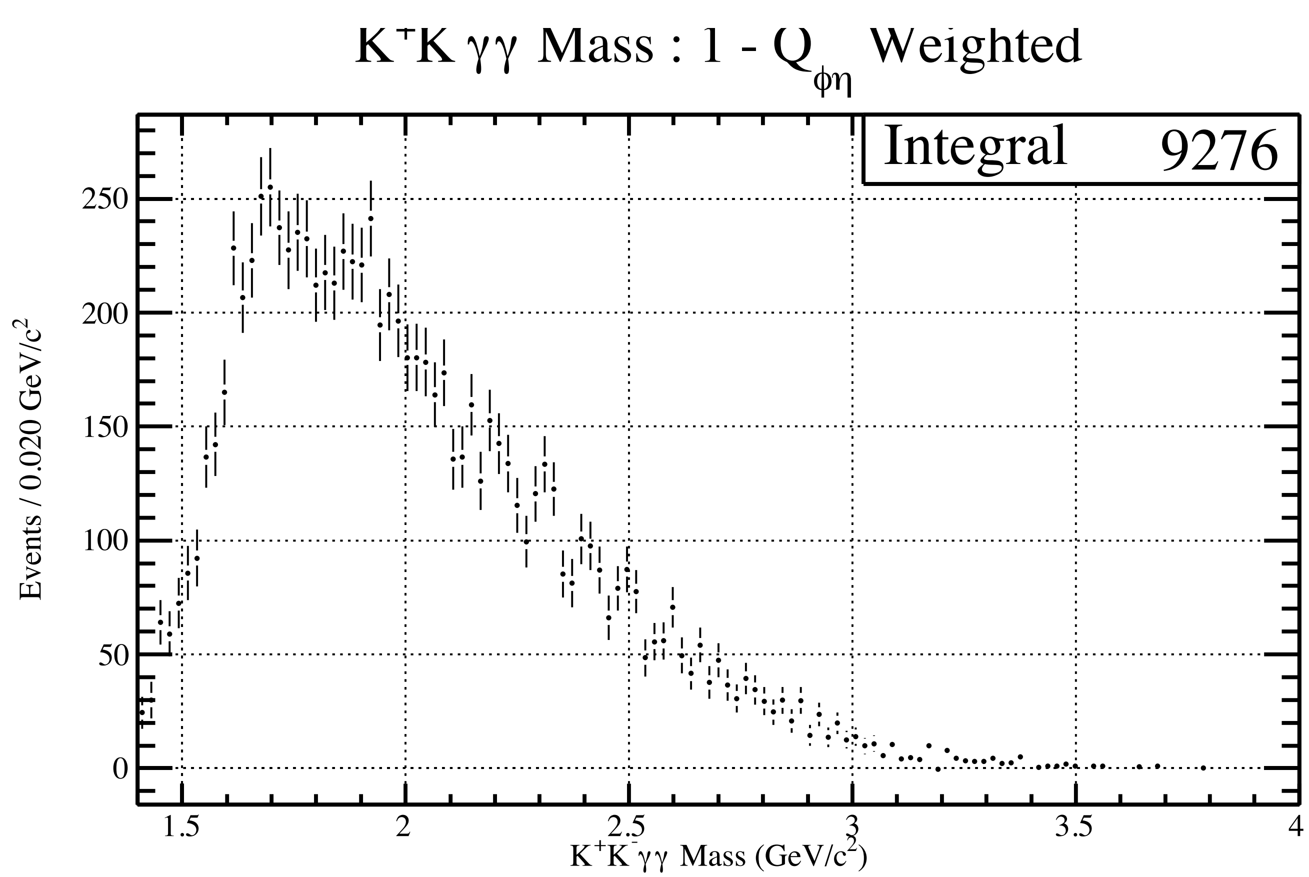
Preliminary Results: QFactor



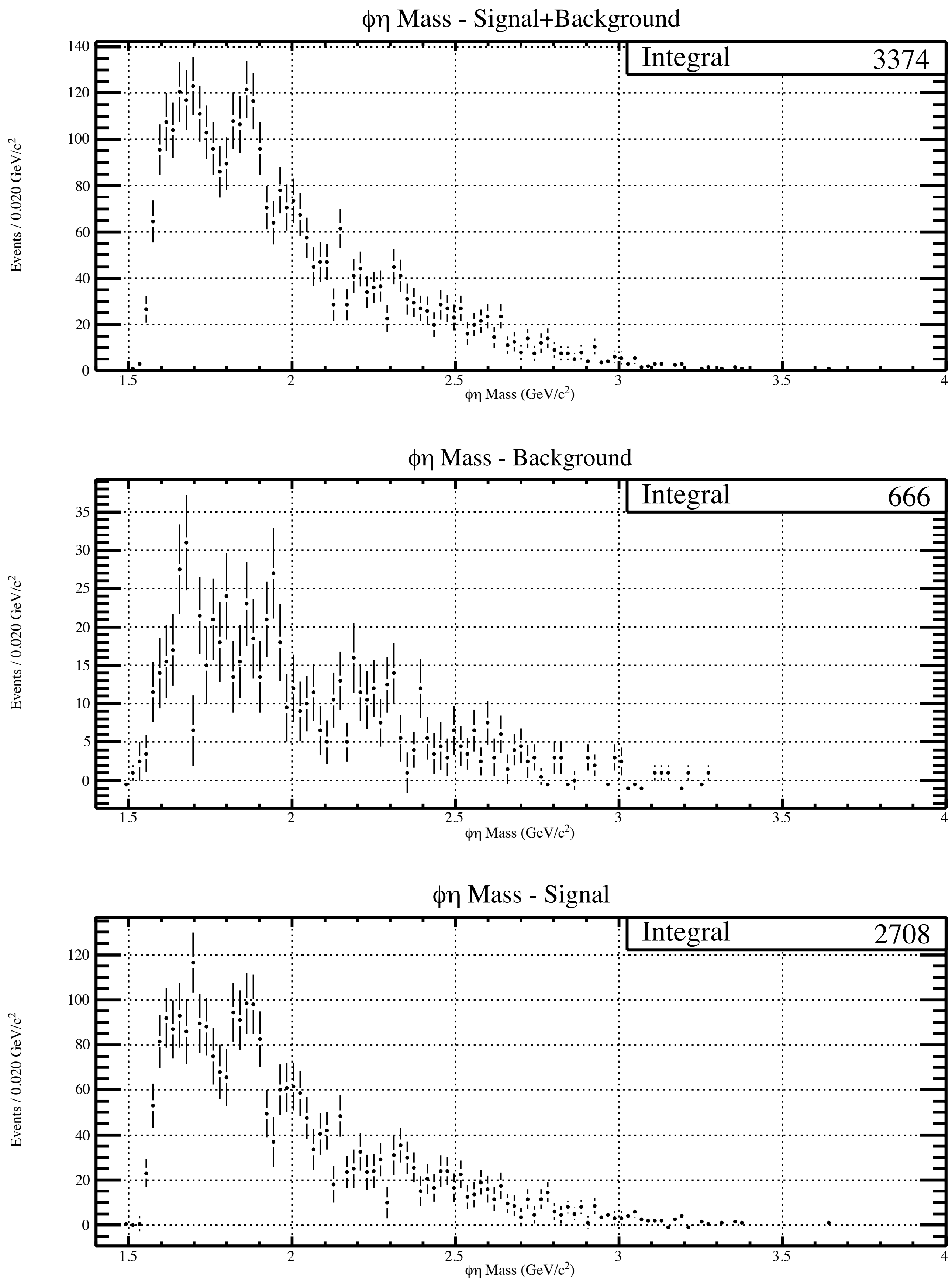


Preliminary Results: QFactor Fit

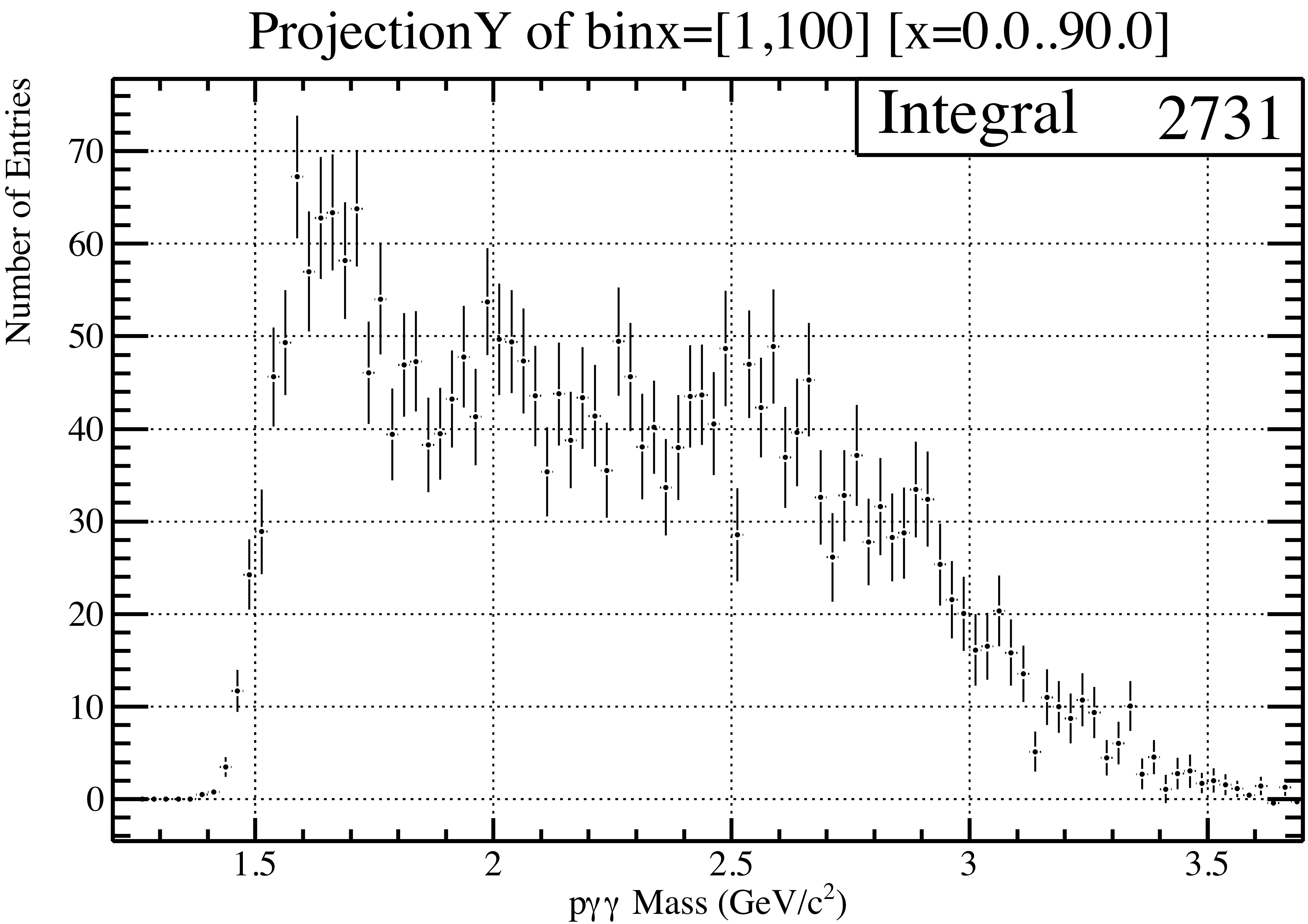




Preliminary Results: Elliptical Subtraction



Preliminary Results: N* Background



Summary

- We observe two structures in the $\phi\eta$ Invariant Mass
- The first structure is consistent with the $\phi(1680)$, or the radially excited ϕ. This has only been observed in e^-e^+ experiments
- The second structure is consistent with the $\phi_3(1850)$. This has only been observed in $K^-p \longrightarrow K\bar{K}$, $K\bar{K}^*$ experiments

			J^{PC}	**Name**	**Mass (MeV)**
n=2	L=0	S=0	0^{-+}	η_s	1415
		S=1	1^{--}	ϕ	1680
	L=1	S=0	1^{+-}	h_1	1850
		S=1	0^{++}	f_0	2000
			1^{++}	f_1	1950
			2^{++}	f_2	2000
n=3	L=0	S=0	0^{-+}	η_s	1950
		S=1	1^{--}	ϕ	2050

Table 2: Radial Excitations of (I=0,$s\bar{s}$) Mesons

			J^{PC}	**Name**	**Mass (MeV)**
n=1	L=0	S=0	0^{-+}	$\eta,\eta^{'}$	548,958
		S=1	1^{--}	ϕ	1020
	L=1	S=0	1^{+-}	$h_1^{'}$	1380
		S=1	0^{++}	$f_0^{'}$	1500
			1^{++}	$f_1^{'}$	1530
			2^{++}	$f_2^{'}$	1525
	L=2	S=0	2^{-+}	$\eta_2^{'}$	1850
		S=1	1^{--}	ϕ_1	1850
			2^{--}	ϕ_2	1850
			3^{--}	ϕ_3	1854

Table 3: Orbital Excitations of (I=0,$s\bar{s}$) Mesons