

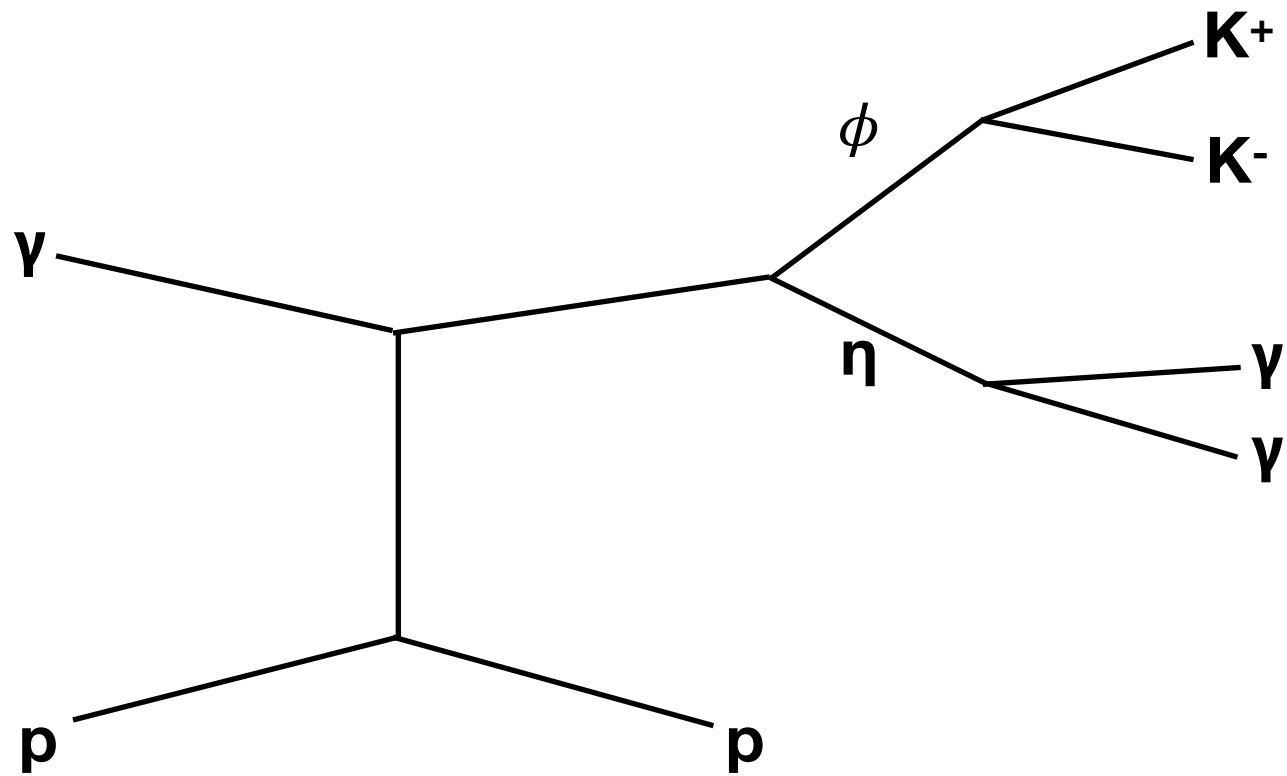
$\gamma p \longrightarrow p \phi \eta$  Update

Bradford Cannon  
Florida State University  
02/21/2019

# Outline

- Motivation
- Cuts
- Selecting  $\phi\eta$  Events
- Preliminary Results

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



- Spring 2017 Data Set
- 21,822 total events after selection cuts

# Data Selection for $\gamma p \rightarrow p K^+ K^- \gamma \gamma$

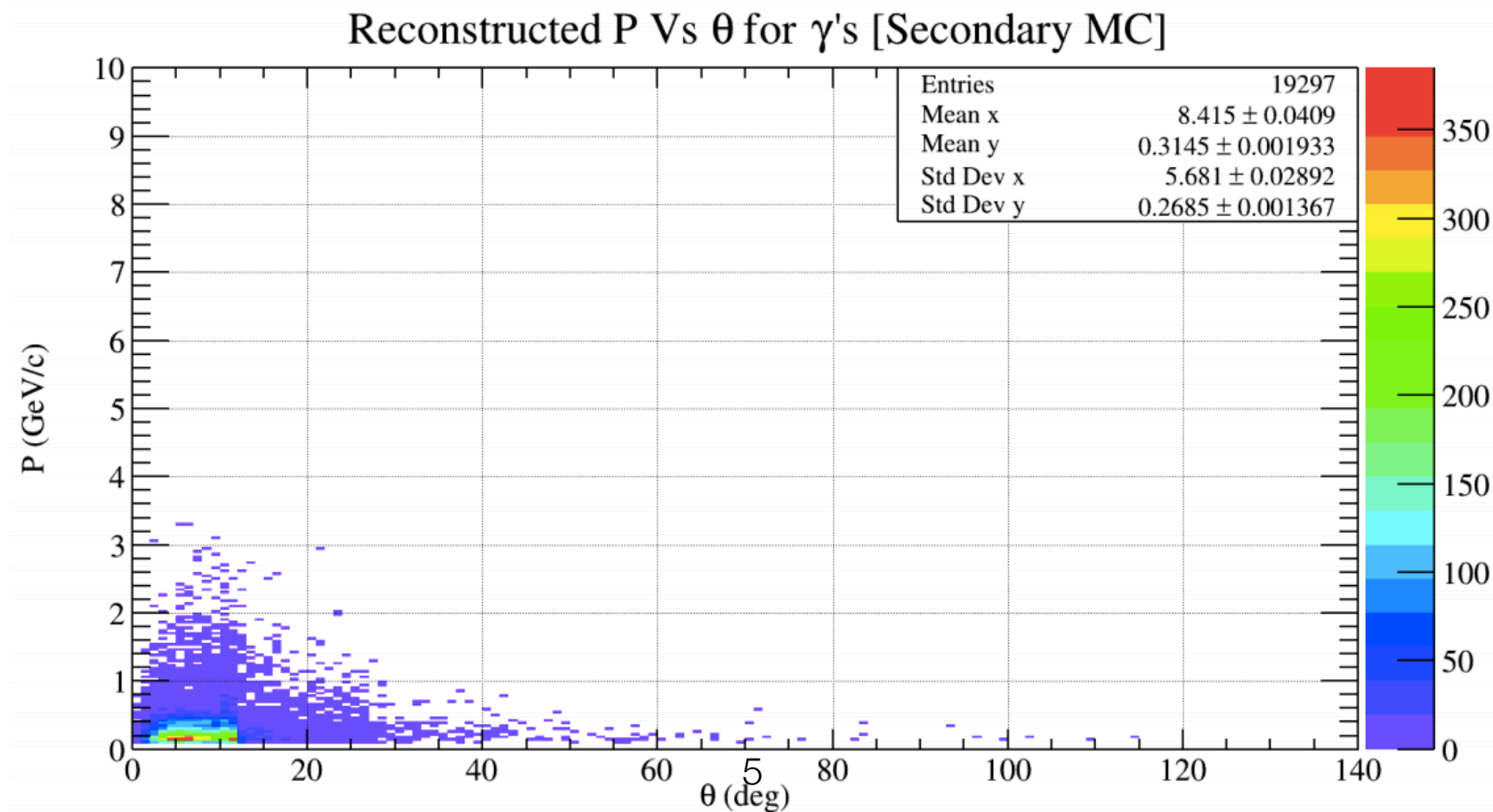
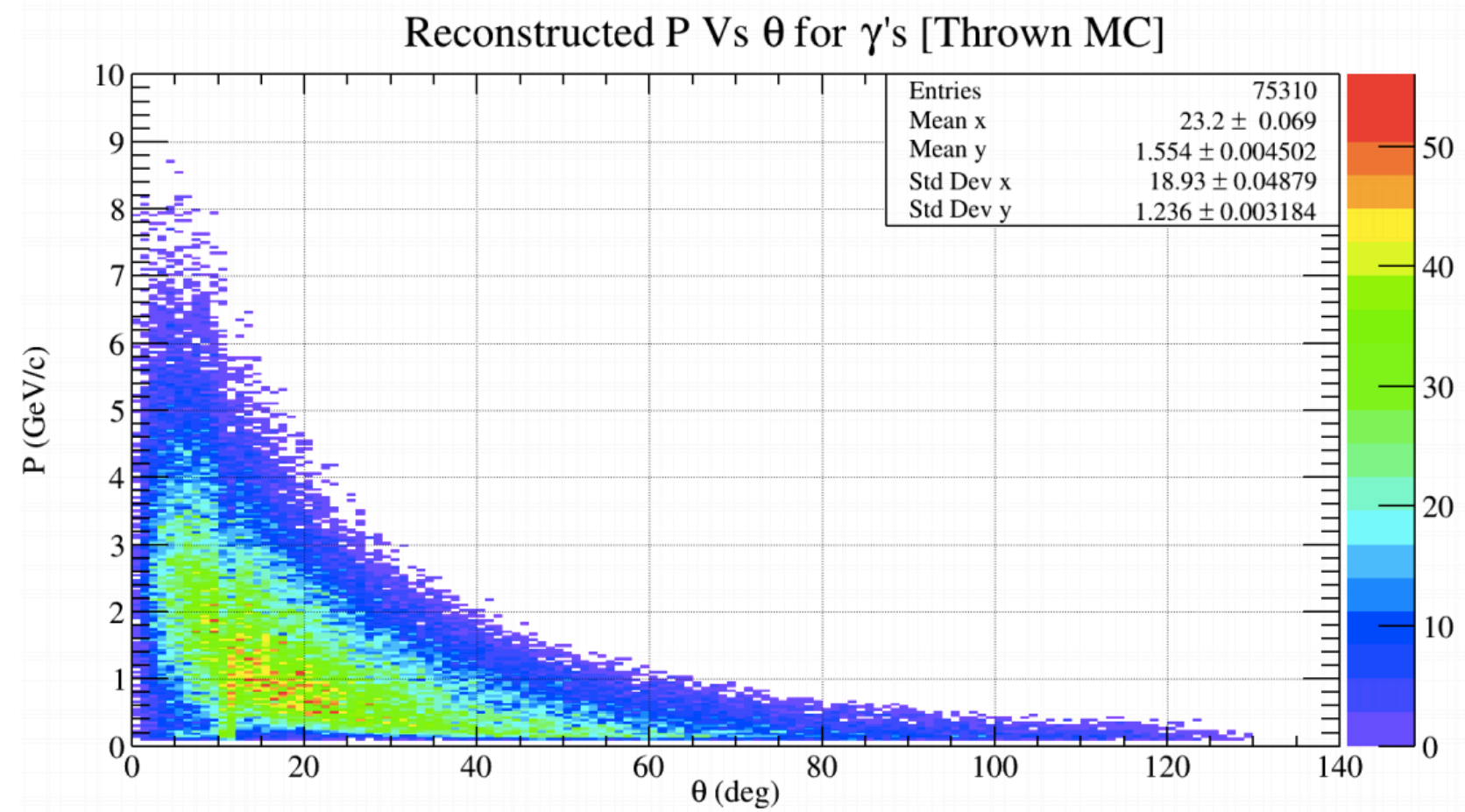
## Standard GlueX Cuts:

- RF Timing (3 beam bunches)
- $51 \text{ cm} < \text{Vertex } Z < 79 \text{ cm}$
- Vertex  $R \leq 1 \text{ cm}$
- $dE/dX$  in CDC for proton
- PID Timing Cuts
- $|MM^2| < 0.02$
- Unused Shower Energy  $< 50 \text{ MeV}$

## Cuts Specifically for $\phi\eta$ :

- $K^+ K^-$  Invariant Mass  $< 1.055$
- $0.3 < \gamma\gamma$  Invariant Mass  $< 0.8$
- Beam Photon With Best  $MM^2$
- FCAL Photon  $E < 500 \text{ MeV}$
- At least 1 Kaon I.D. from TOF
- Kaon Timing from TOF Only

# FCAL Photon $E < 500$ MeV

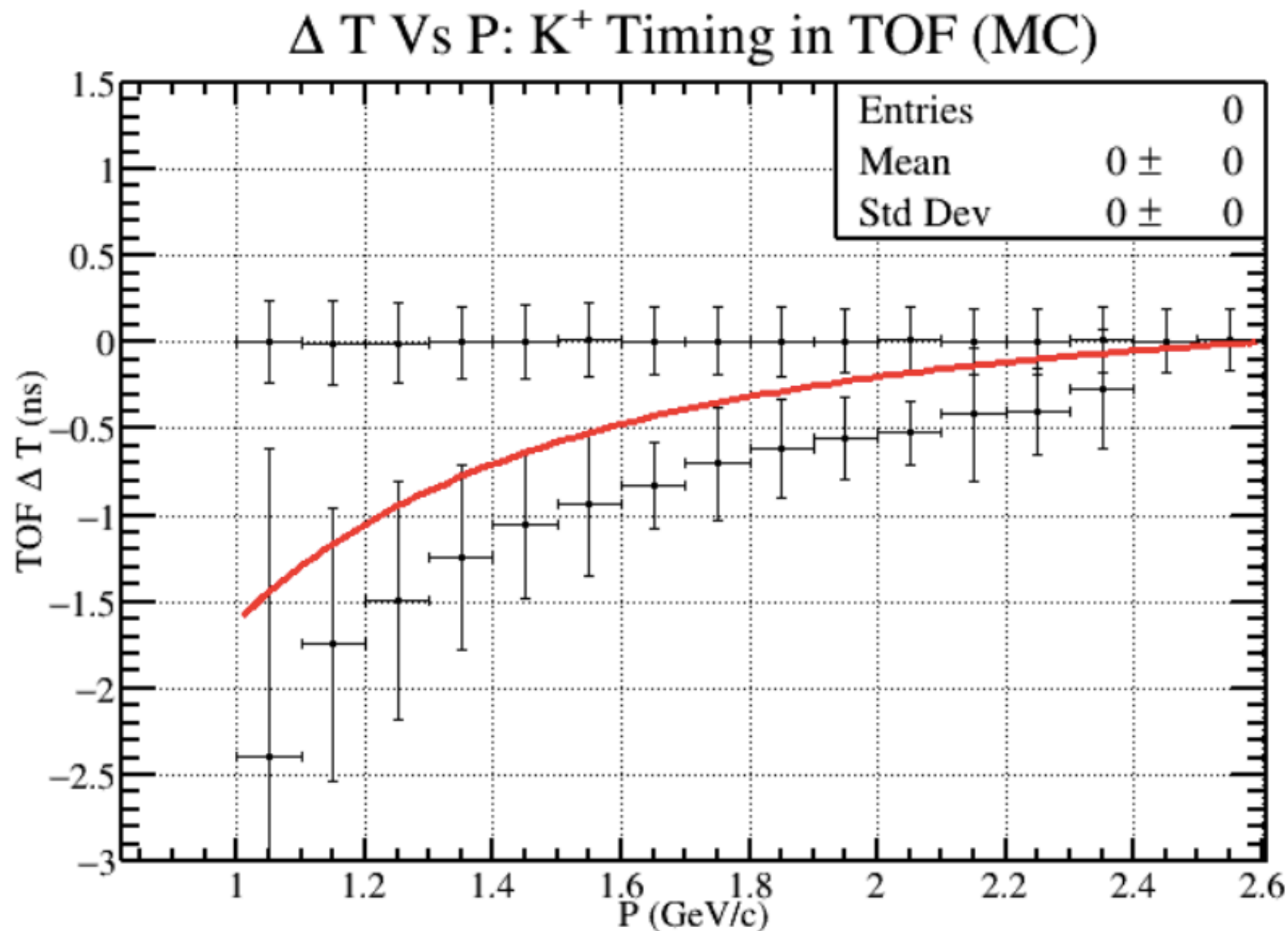


# Kaon Selection & Pion Rejection from TOF

$$t = \frac{\delta X}{V} = \frac{\delta X}{\beta c}$$

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

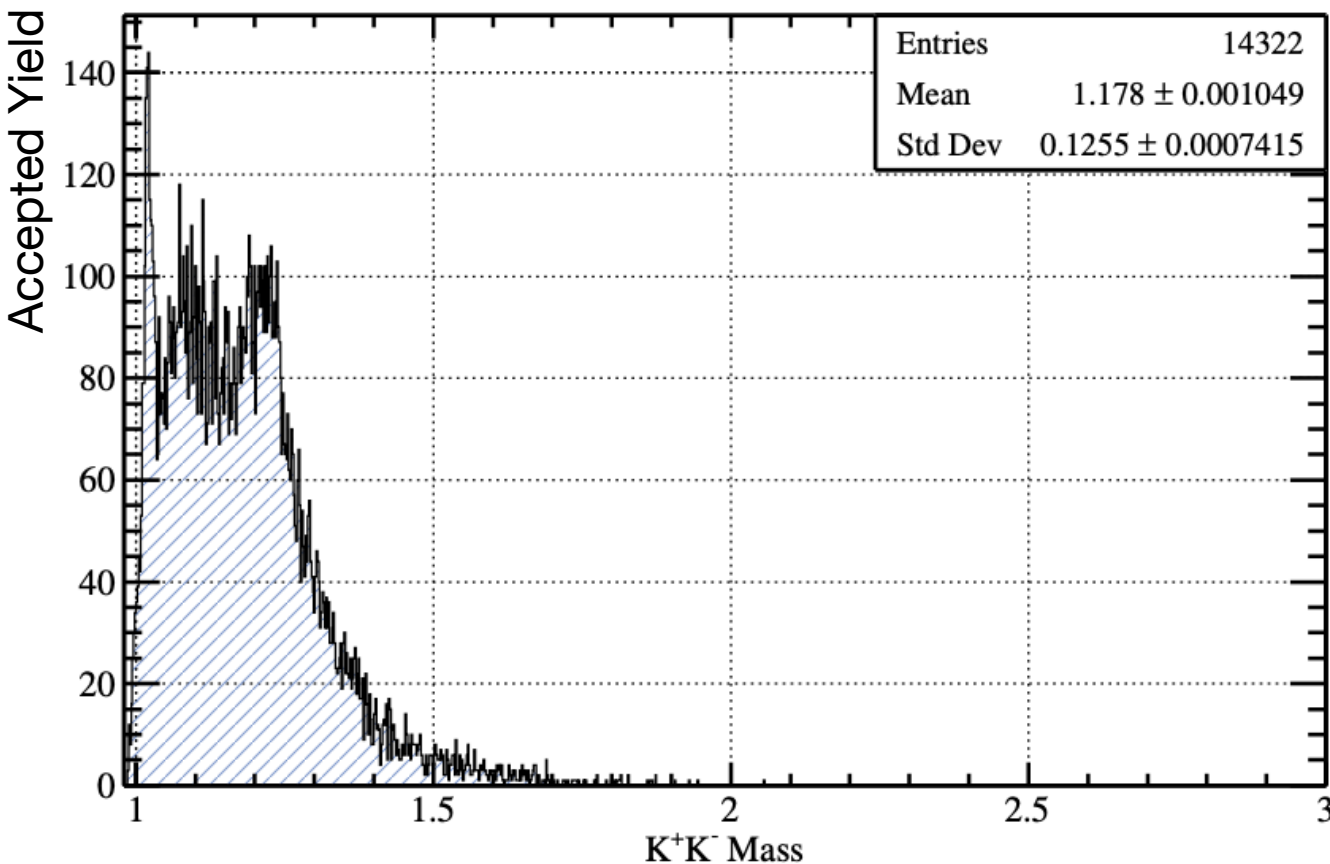
$$\delta t = \frac{\delta X}{c} \frac{\sqrt{m_\pi^2 + P^2} - \sqrt{m_K^2 + P^2}}{P}$$



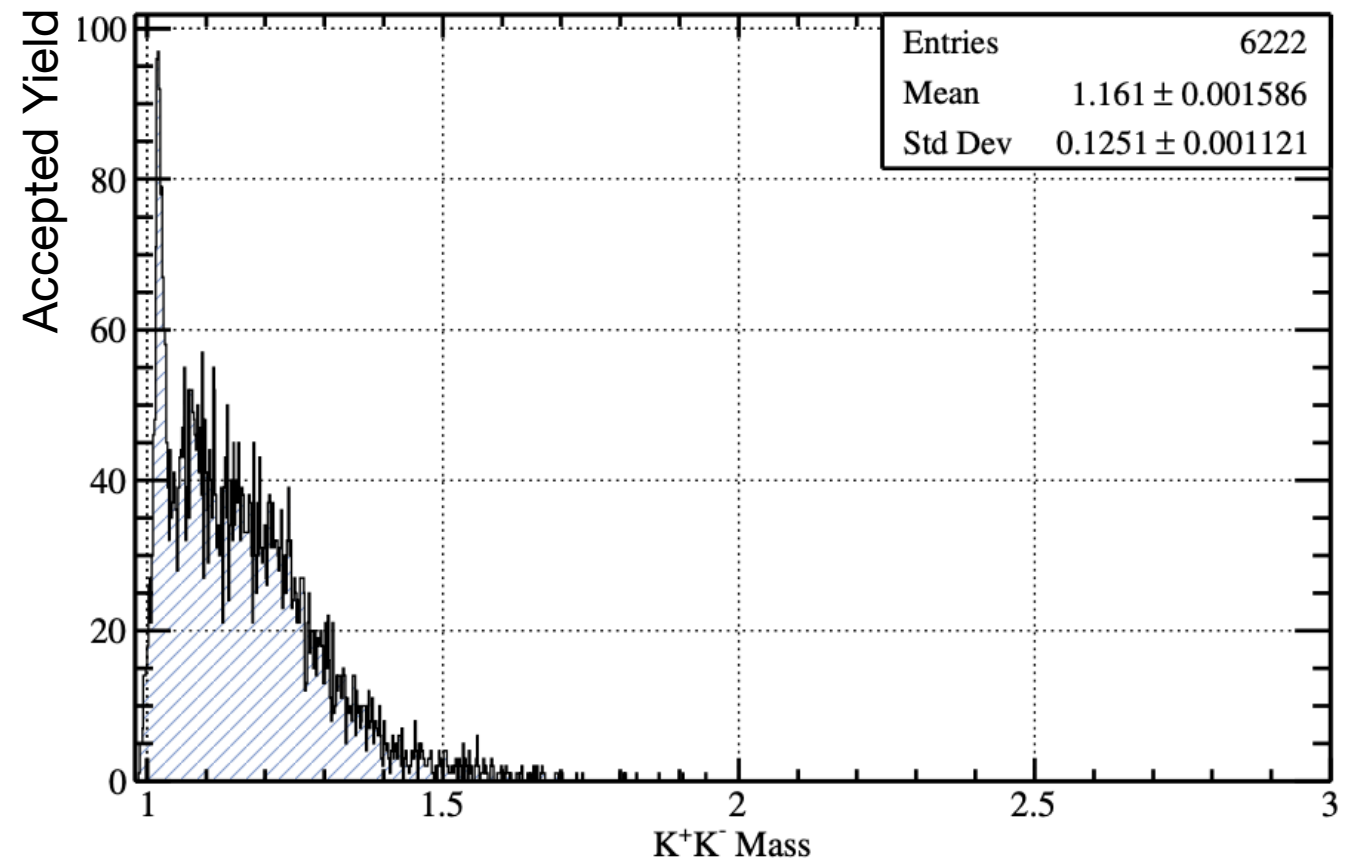
- Each event must have at least 1 Kaon ID from TOF
- A Kaon ID is any Kaon above the red line

# Effects of Kaon Selection and Pion Rejection

Before TOF Kaon ID



After TOF Kaon ID Selection

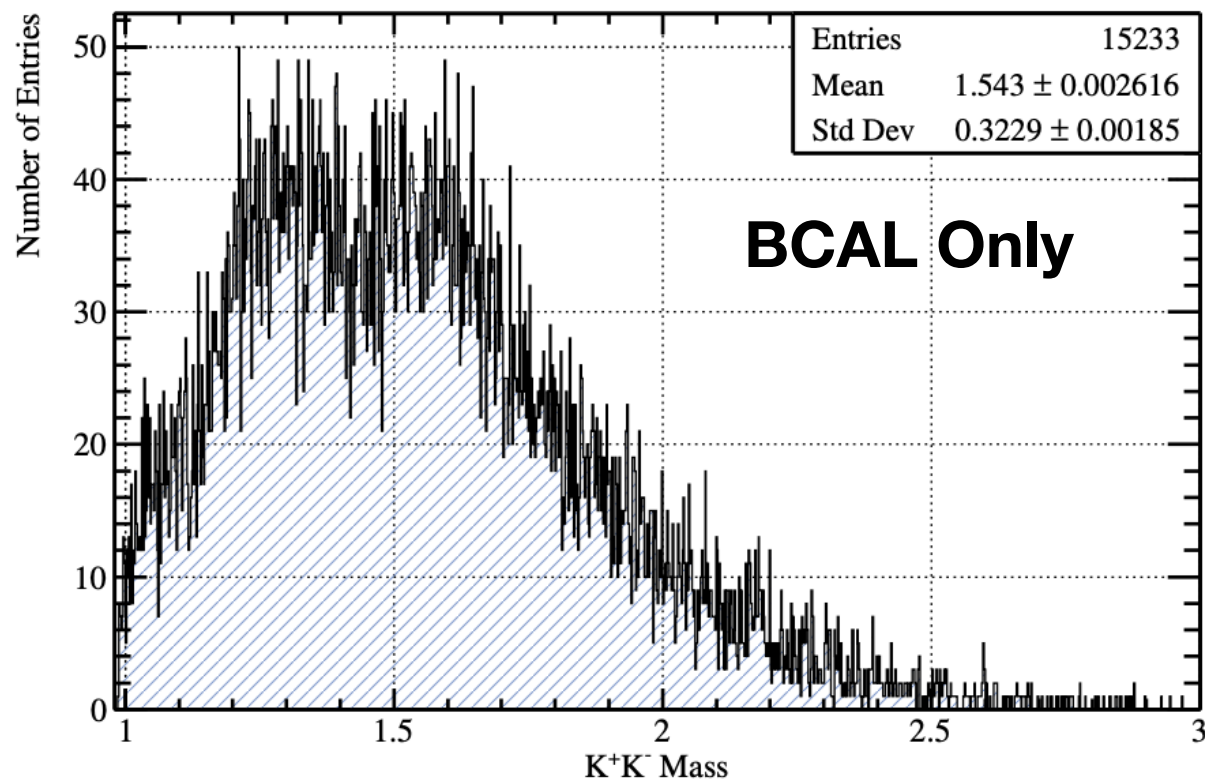


- Misidentified Pions are removed
- Negligible effect to  $\phi$  yield

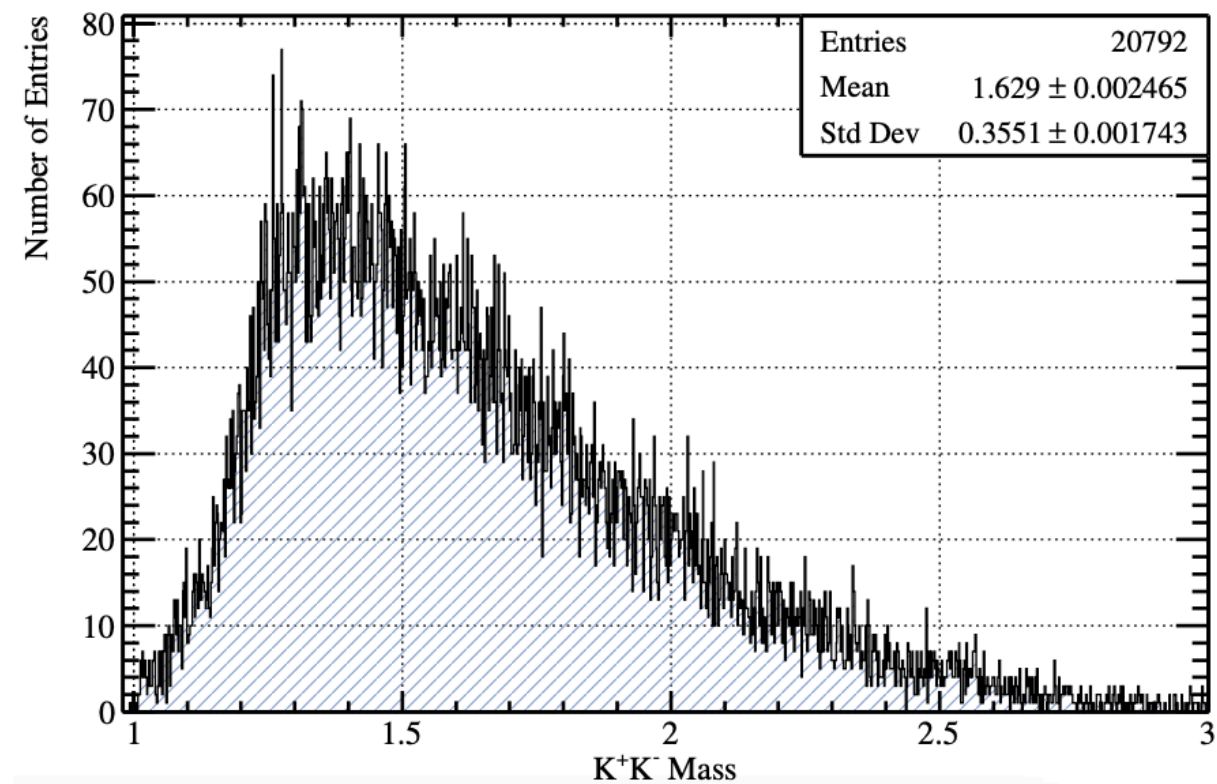


# $\phi$ Only Seen in TOF

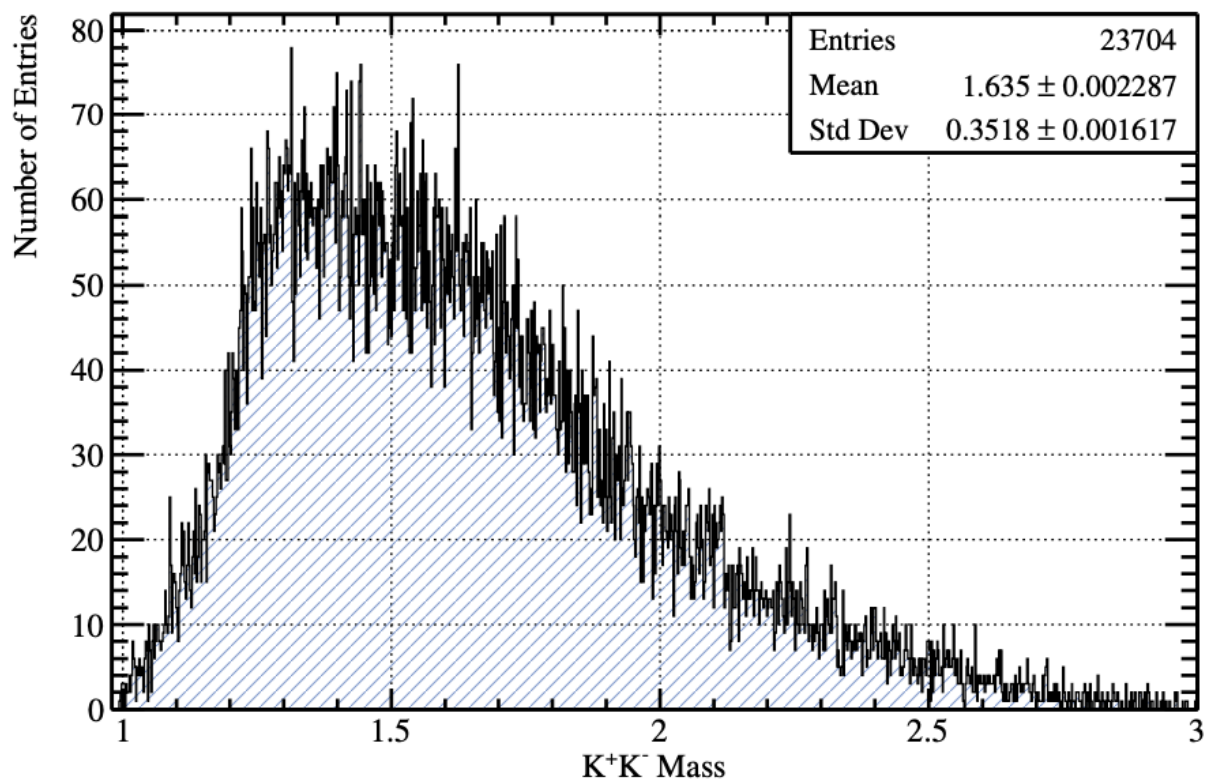
ProjectionY of binx=1 [x=-0.5..0.5] [ $K_{\text{BCAL}}^+ K_{\text{BCAL}}^-$ ]



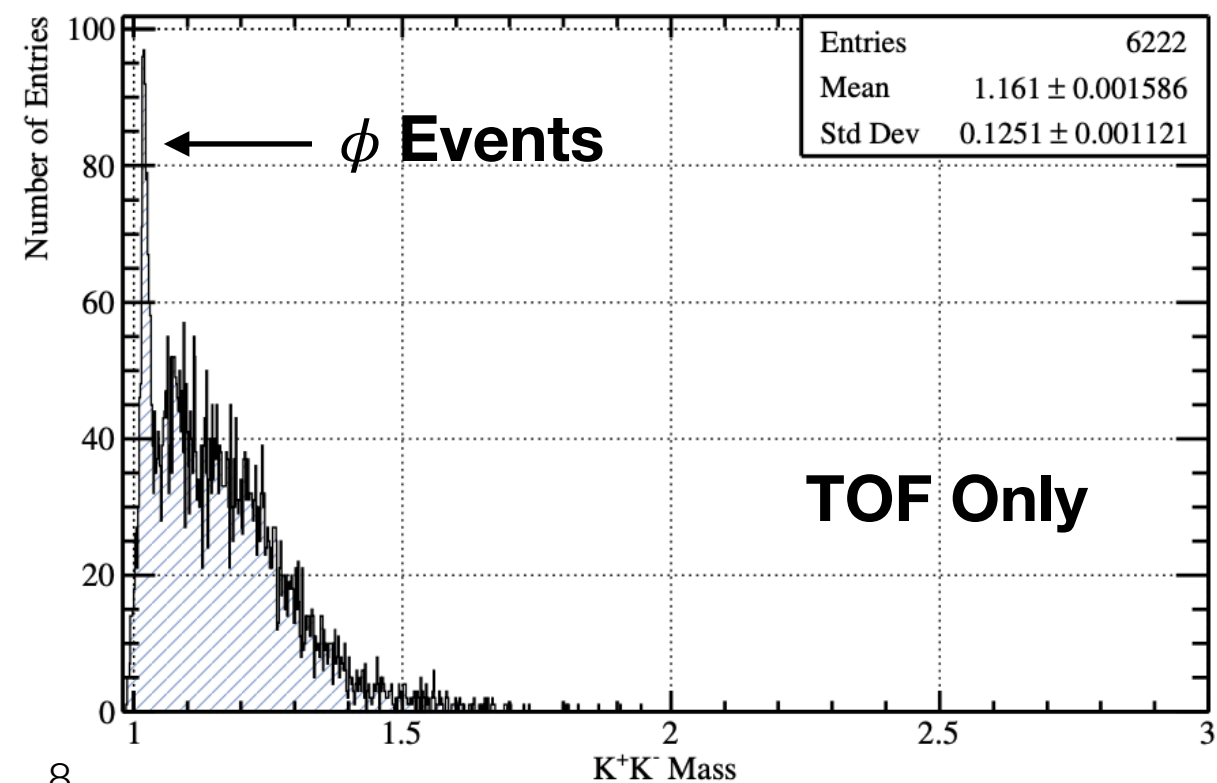
ProjectionY of binx=3 [x=1.5..2.5] [ $K_{\text{BCAL}}^+ K_{\text{TOF}}^-$ ]



ProjectionY of binx=7 [x=5.5..6.5] [ $K_{\text{TOF}}^+ K_{\text{BCAL}}^-$ ]

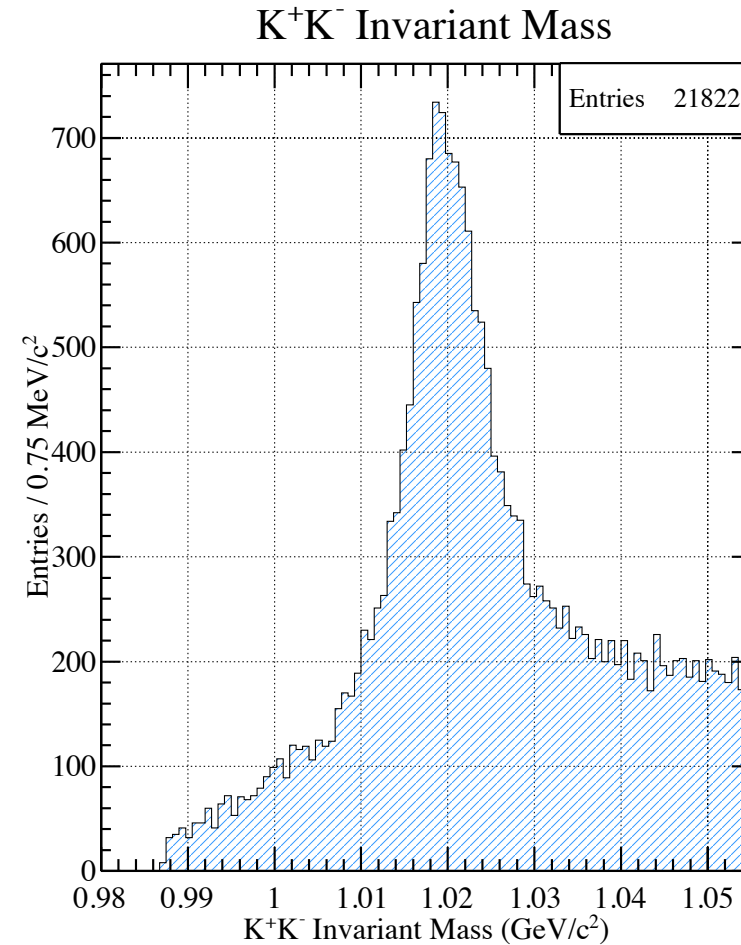
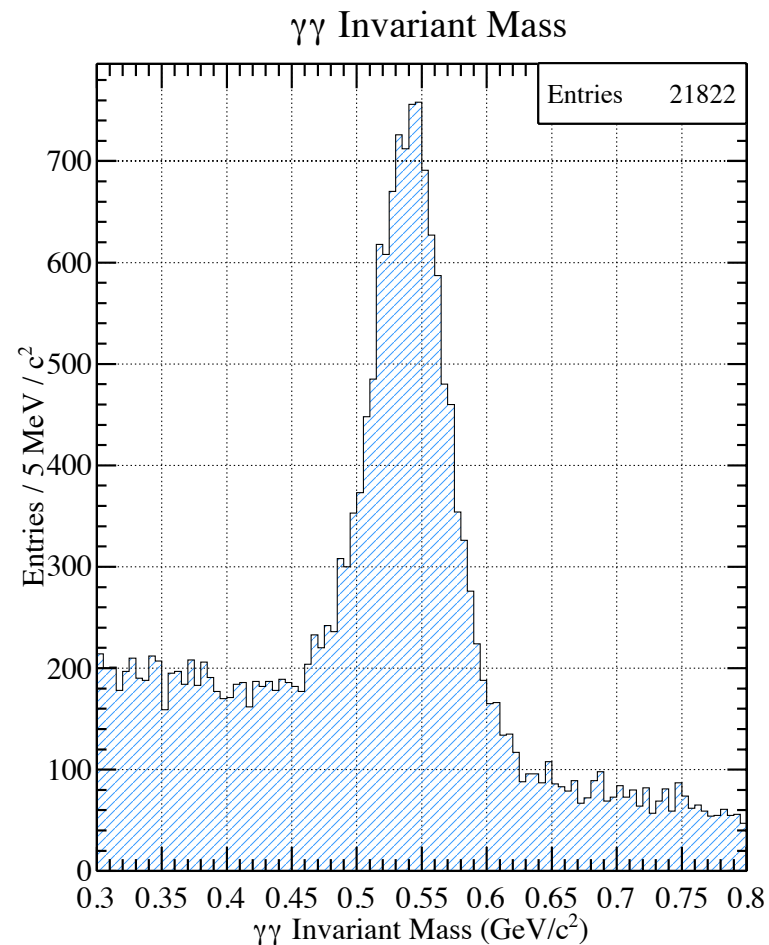


ProjectionY of binx=9 [x=7.5..8.5] [ $K_{\text{TOF}}^+ K_{\text{TOF}}^-$ ]





# Selecting $\phi\eta$ Events



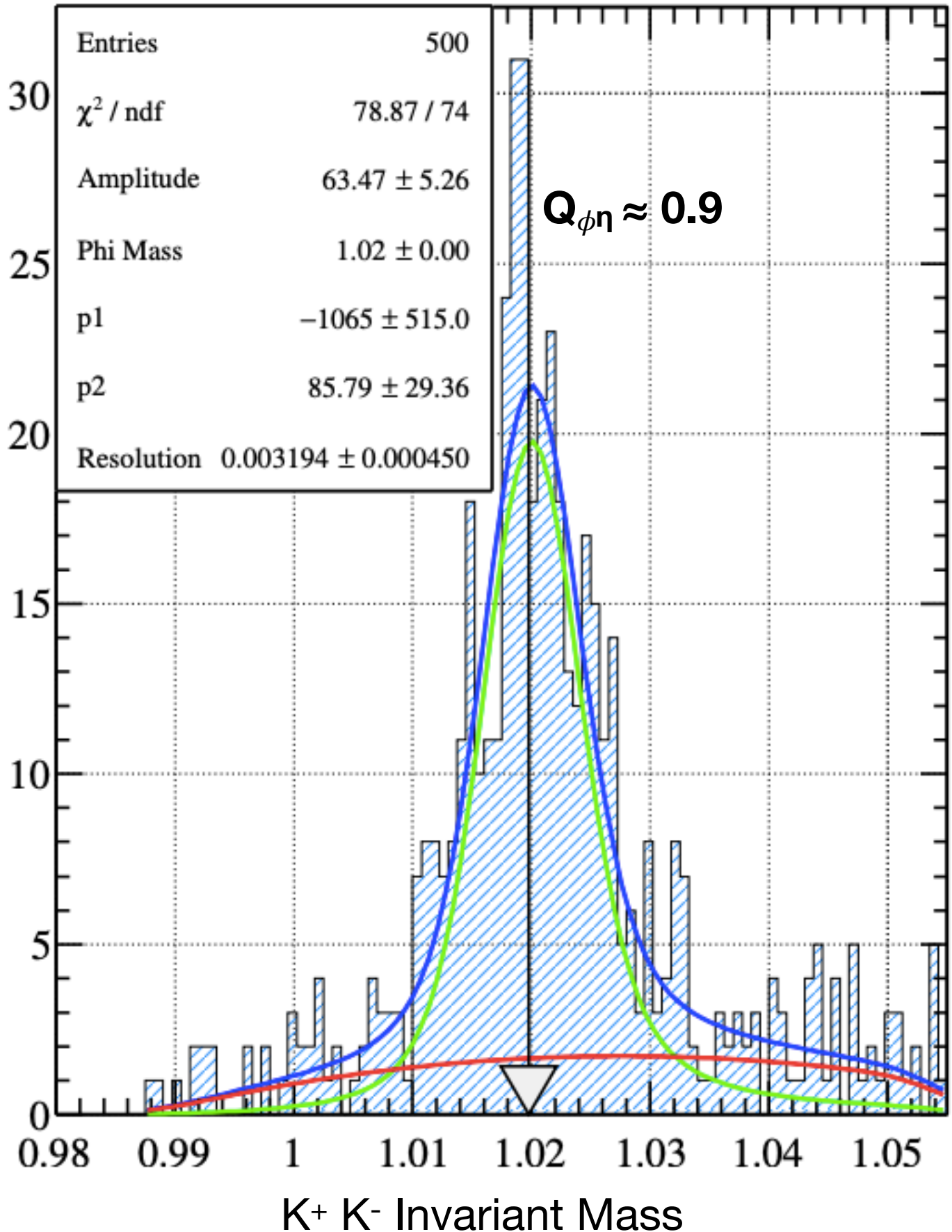
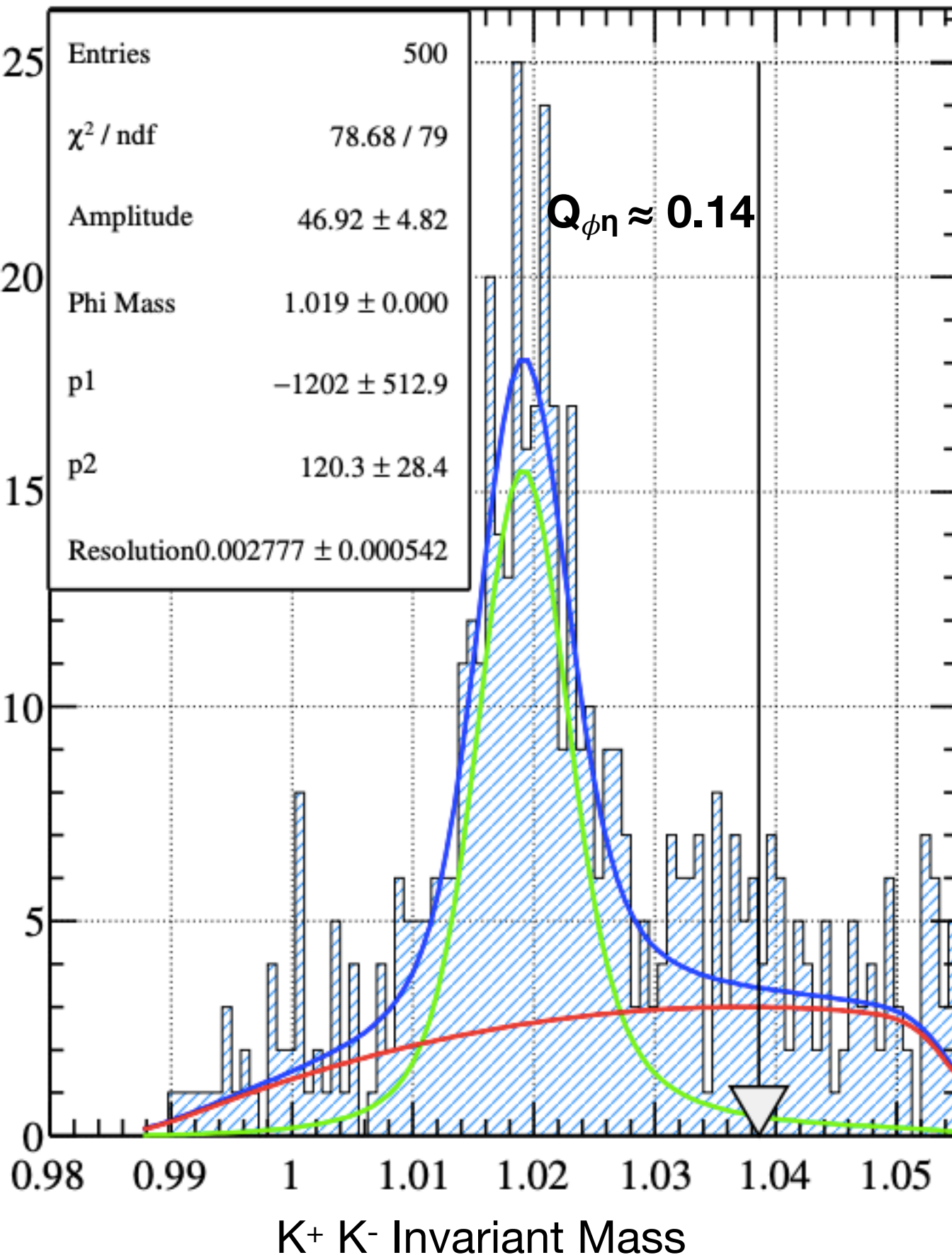
## Studied Various Selection Methods

- Elliptical/Sideband Subtraction

- Quality Factor Approaches

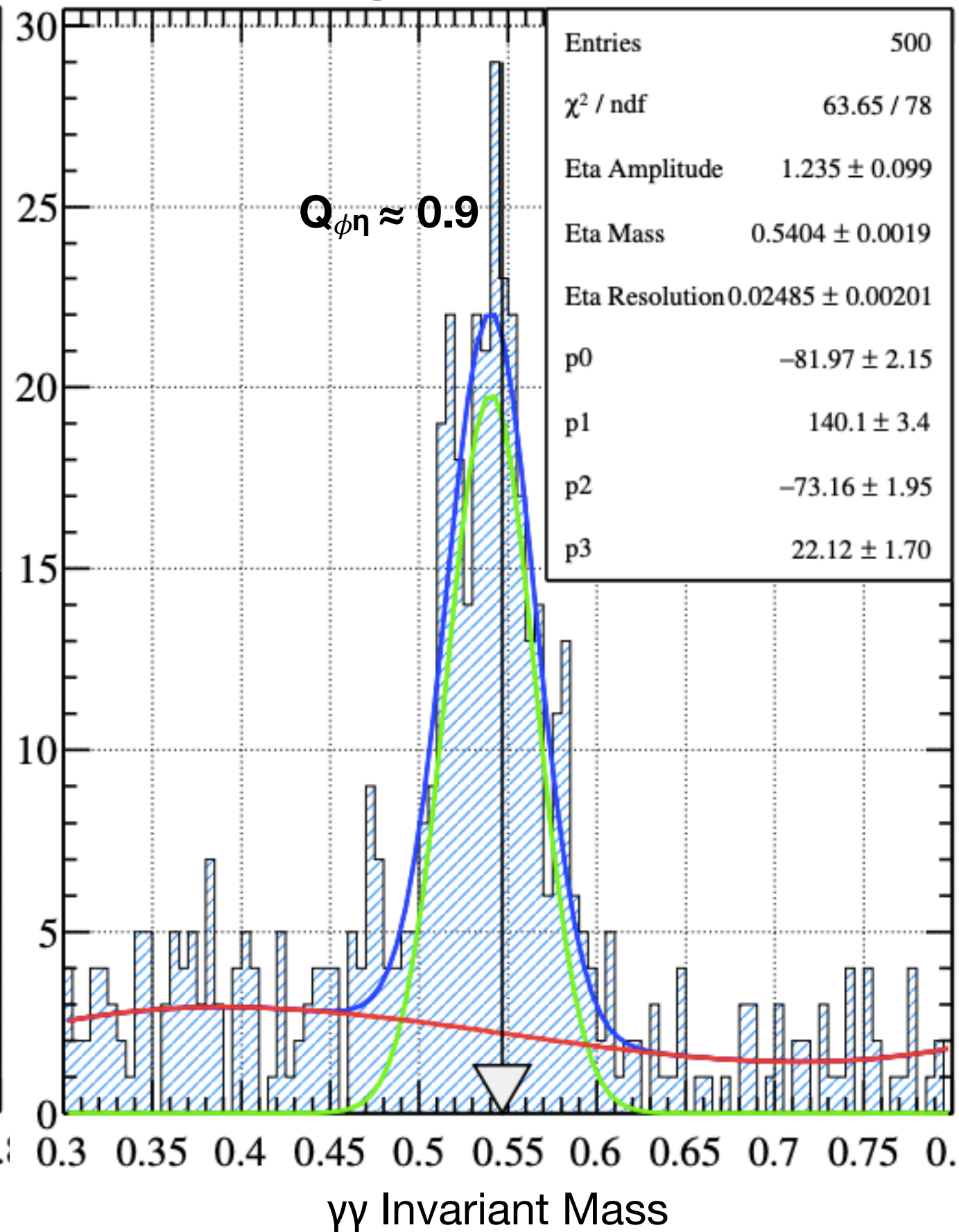
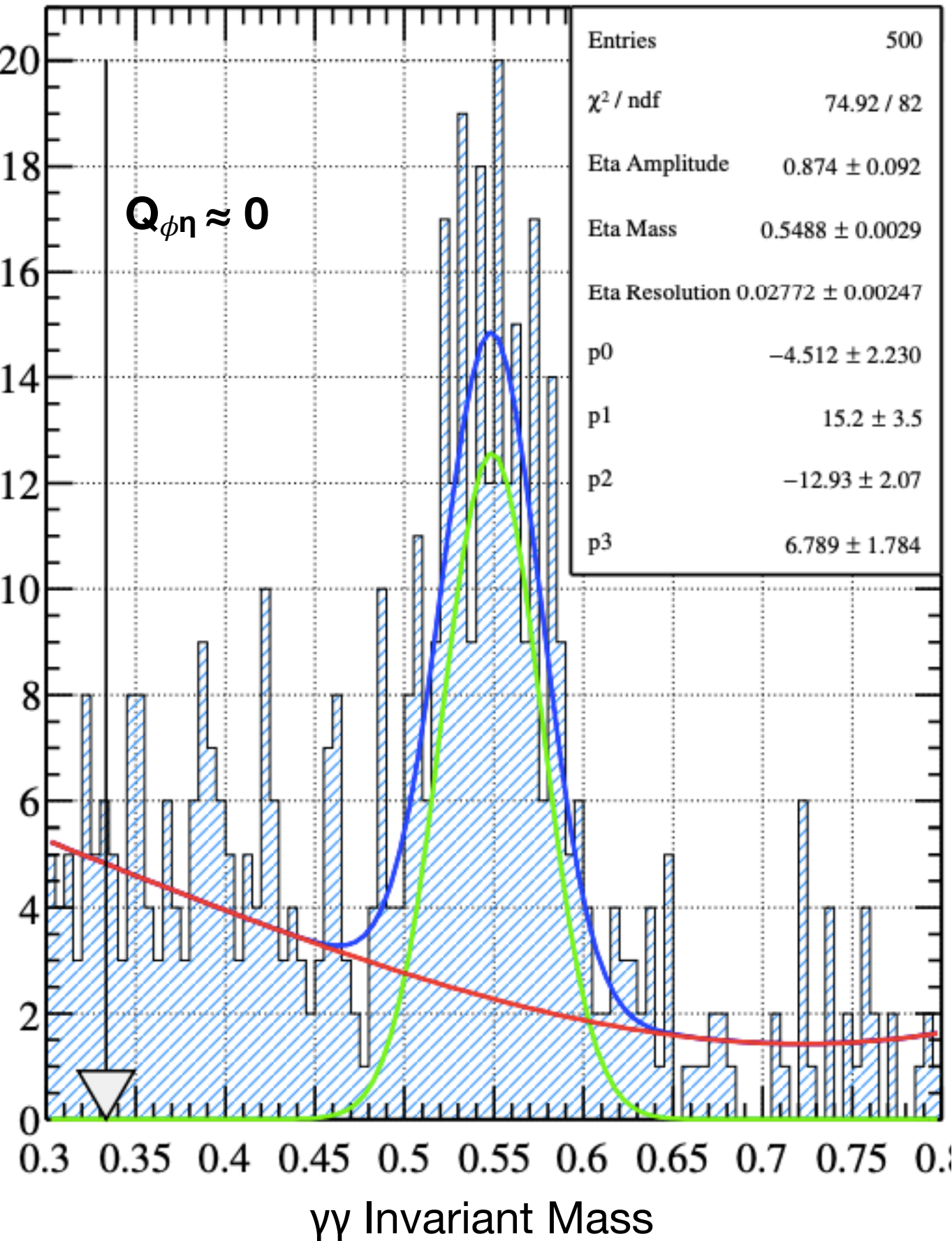
- $Q_{\phi\eta}$
- $Q_{\phi}$  w/  $\eta$  Selection
- $Q_{\phi} \times Q_{\eta}$
- $Q_{\eta}$  w/  $\phi$  Selection

# Example of Nearest Neighbors Fit

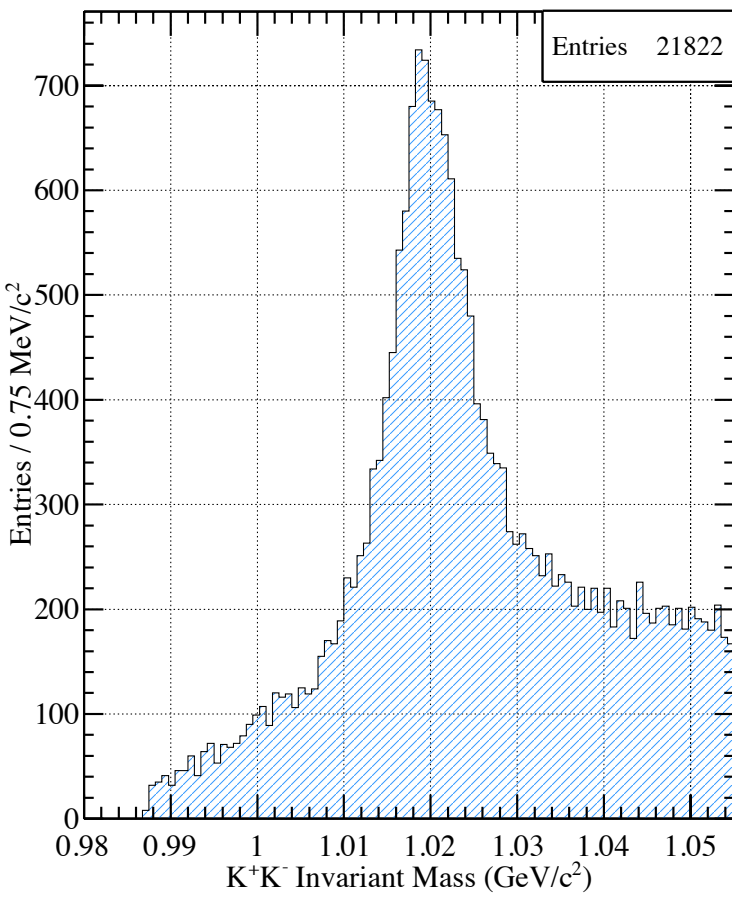




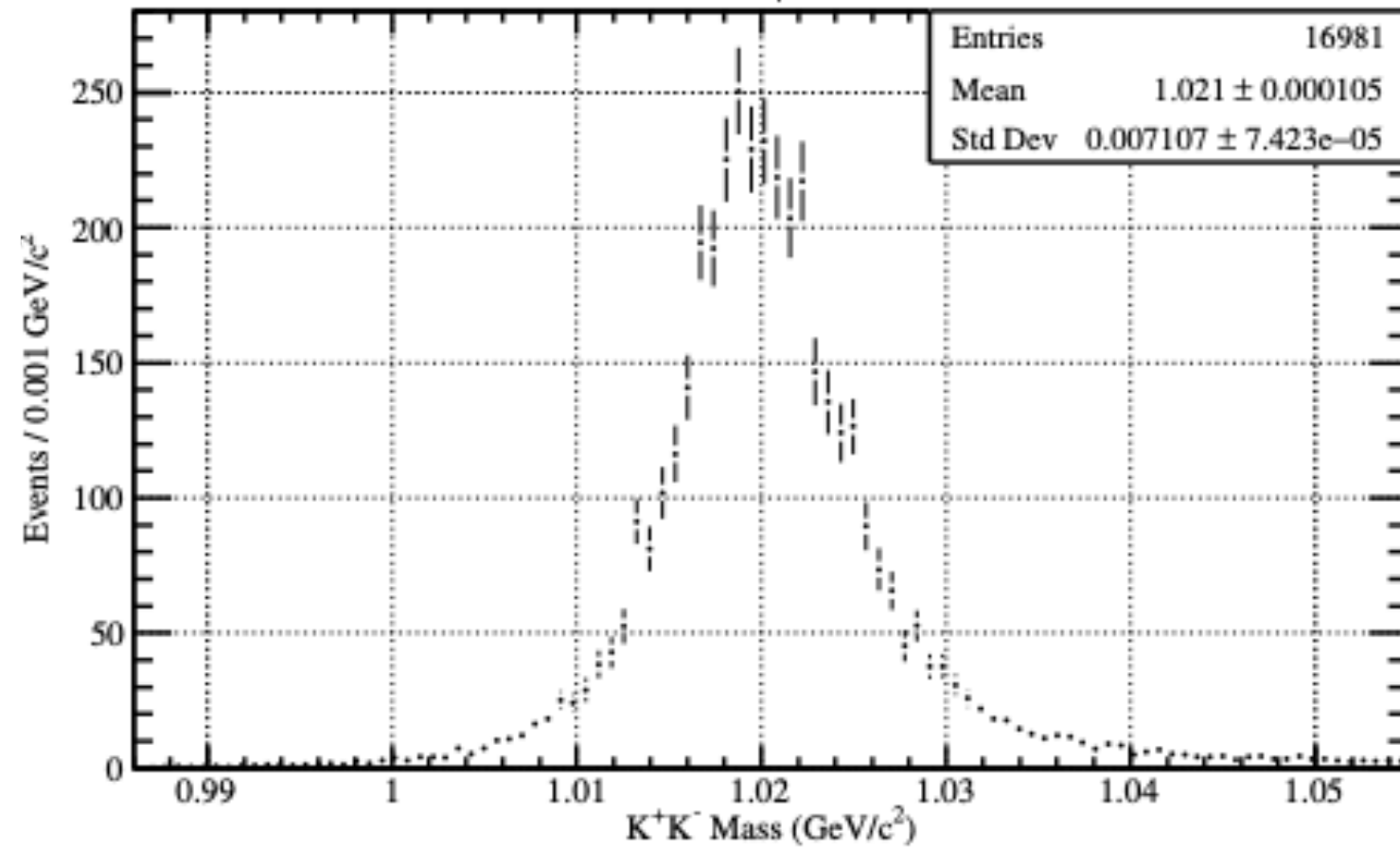
# Example of Nearest Neighbors Fit



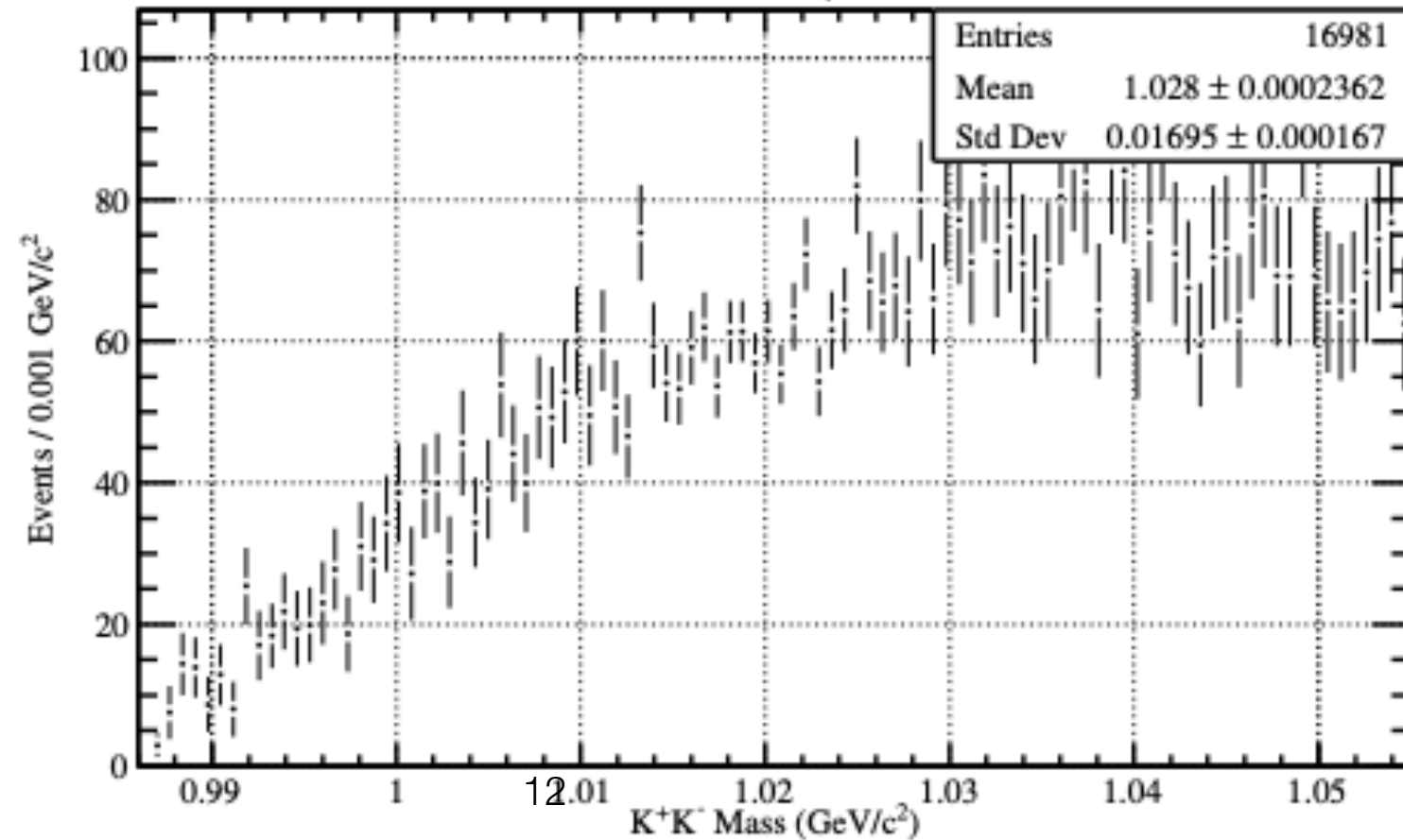
$K^+K^-$  Invariant Mass

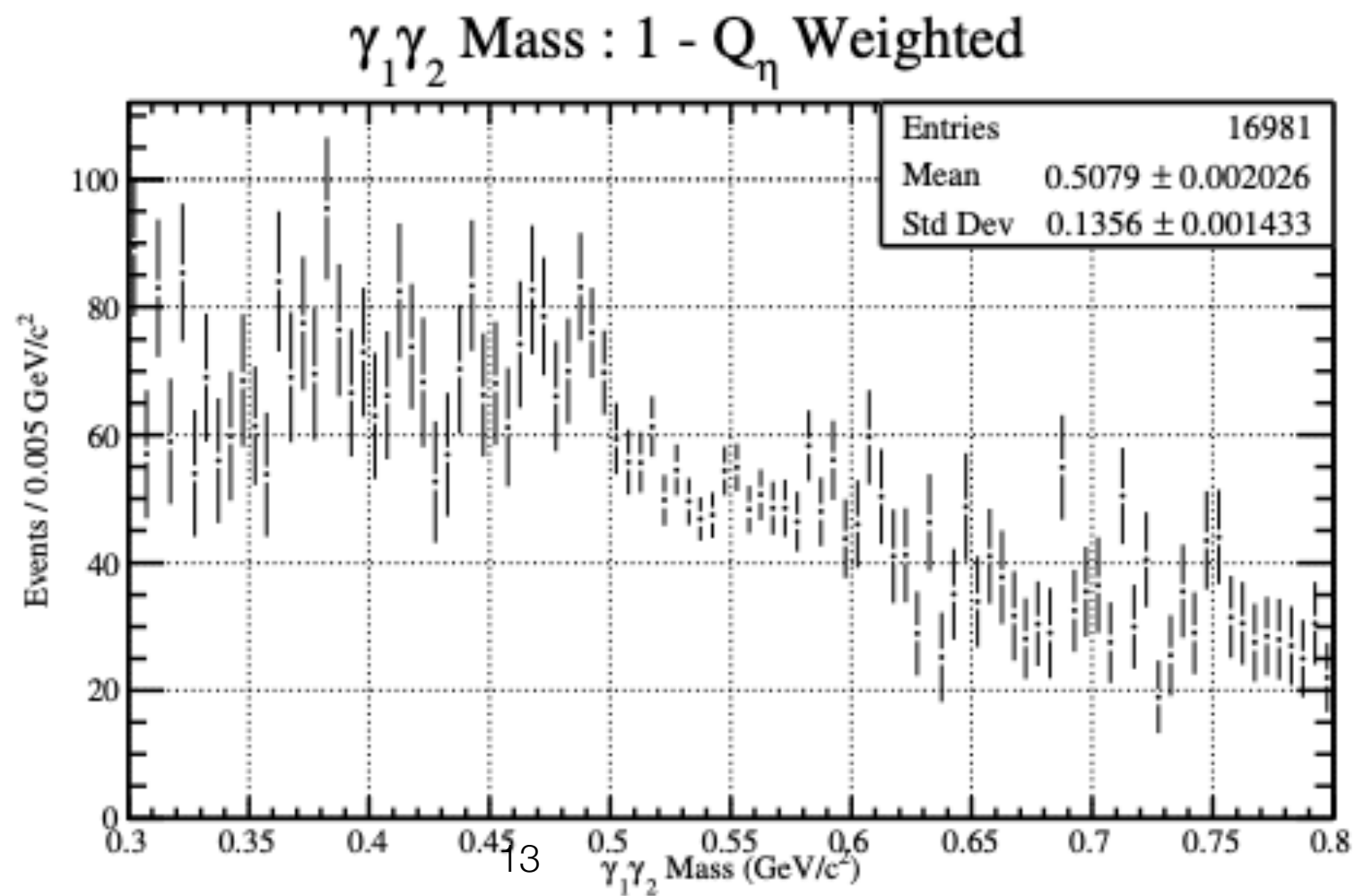
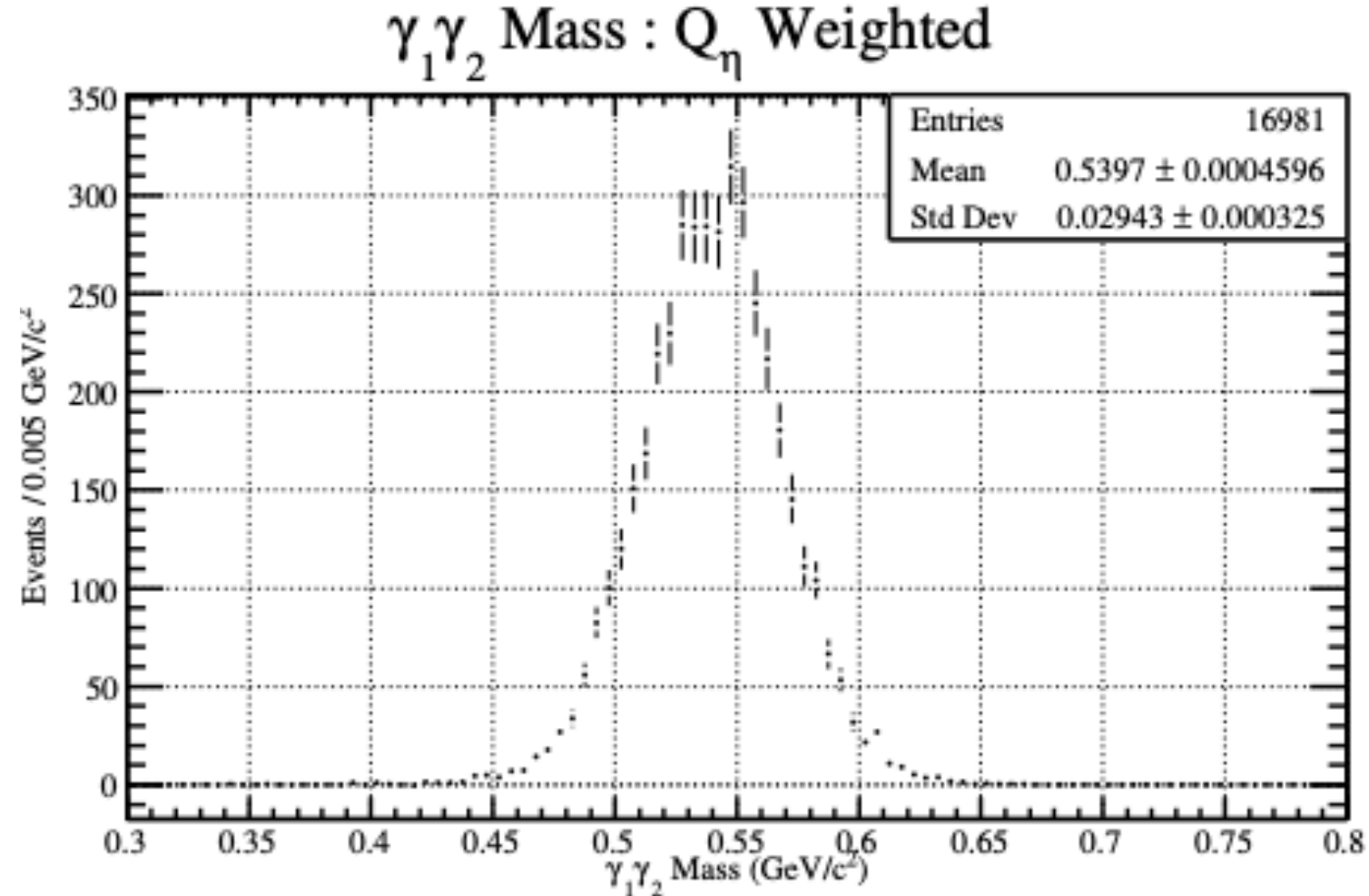
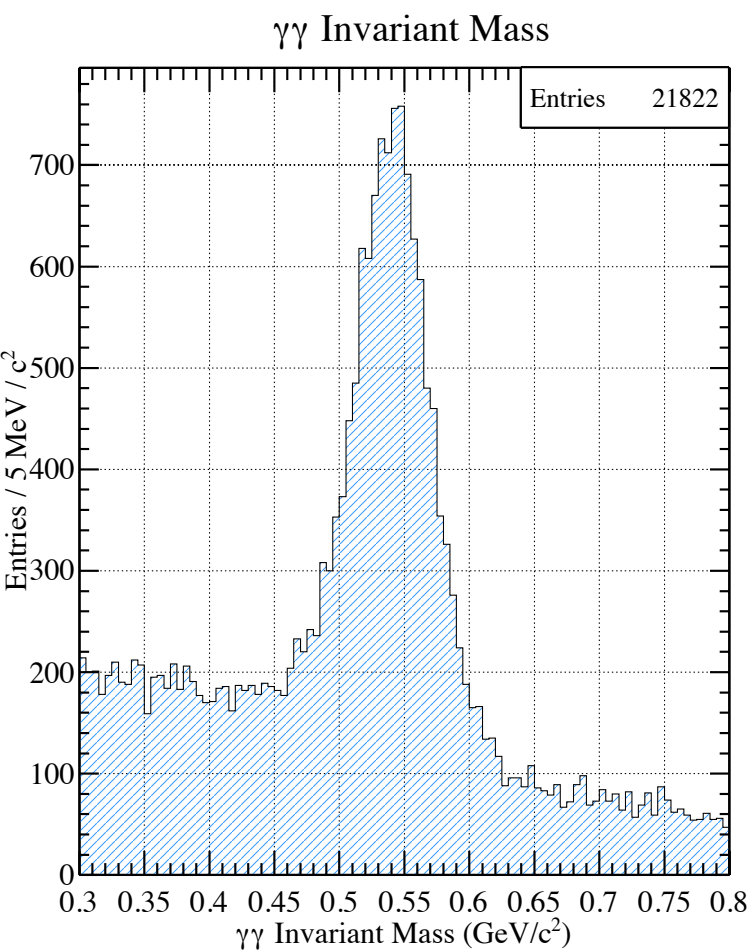


$K^+K^-$  Mass :  $Q_\phi$  Weighted



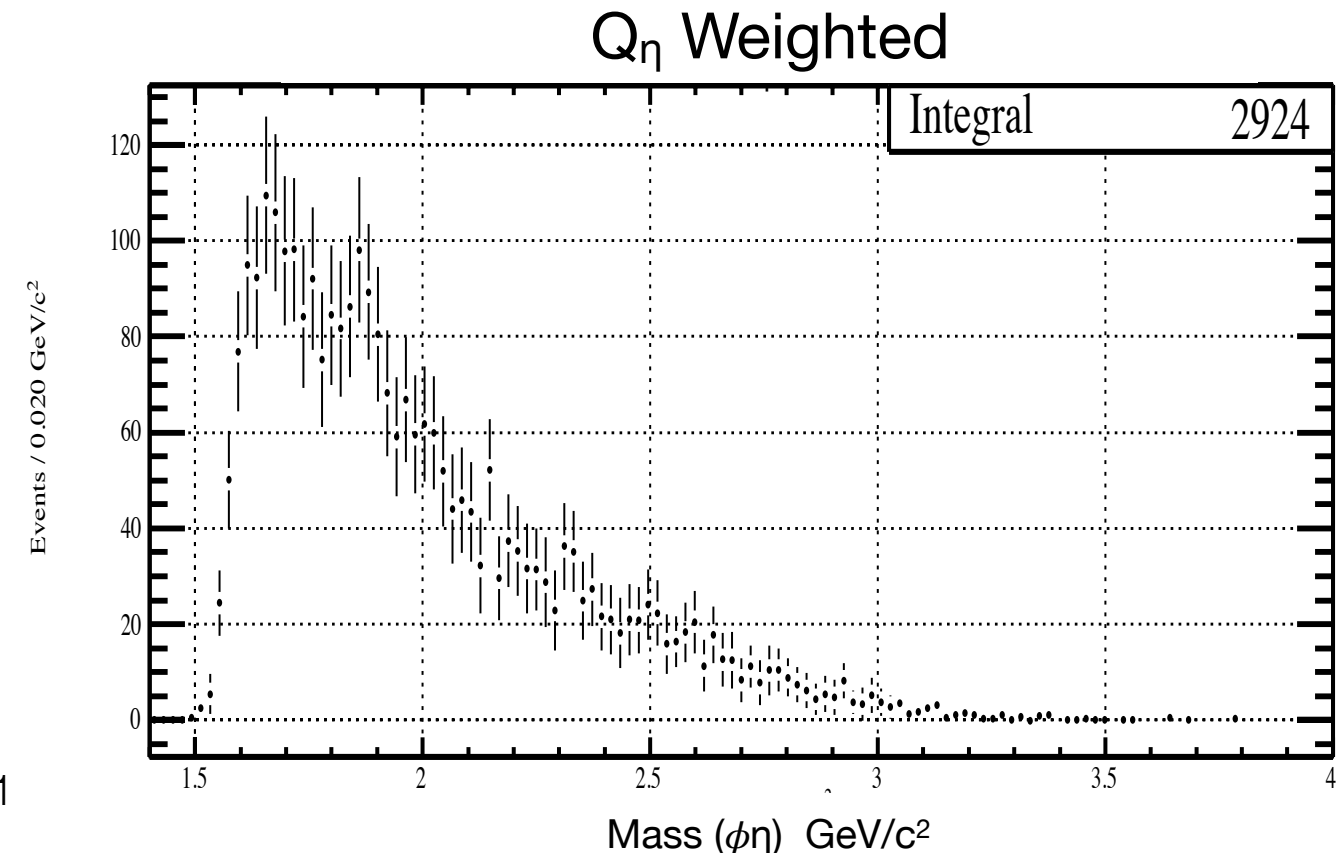
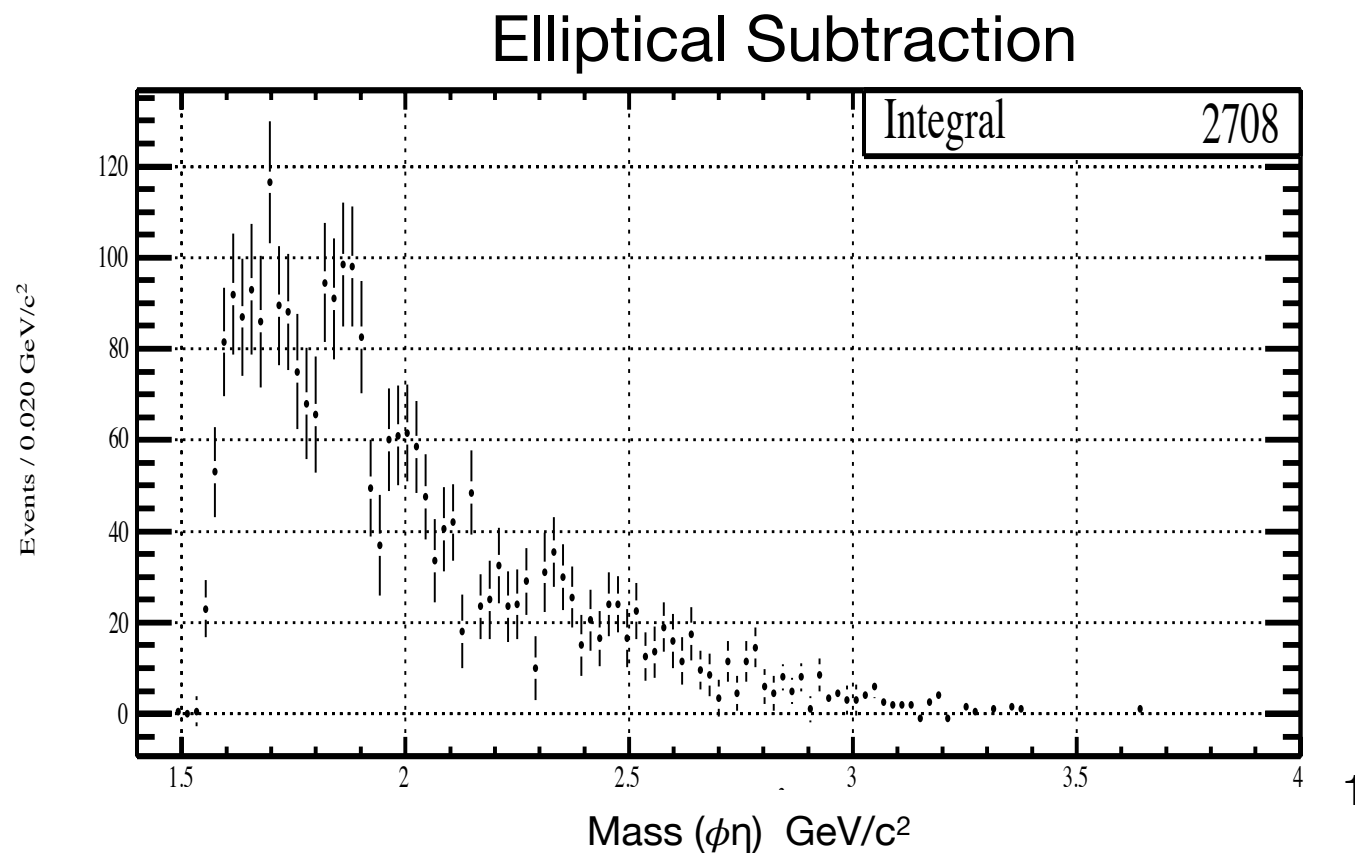
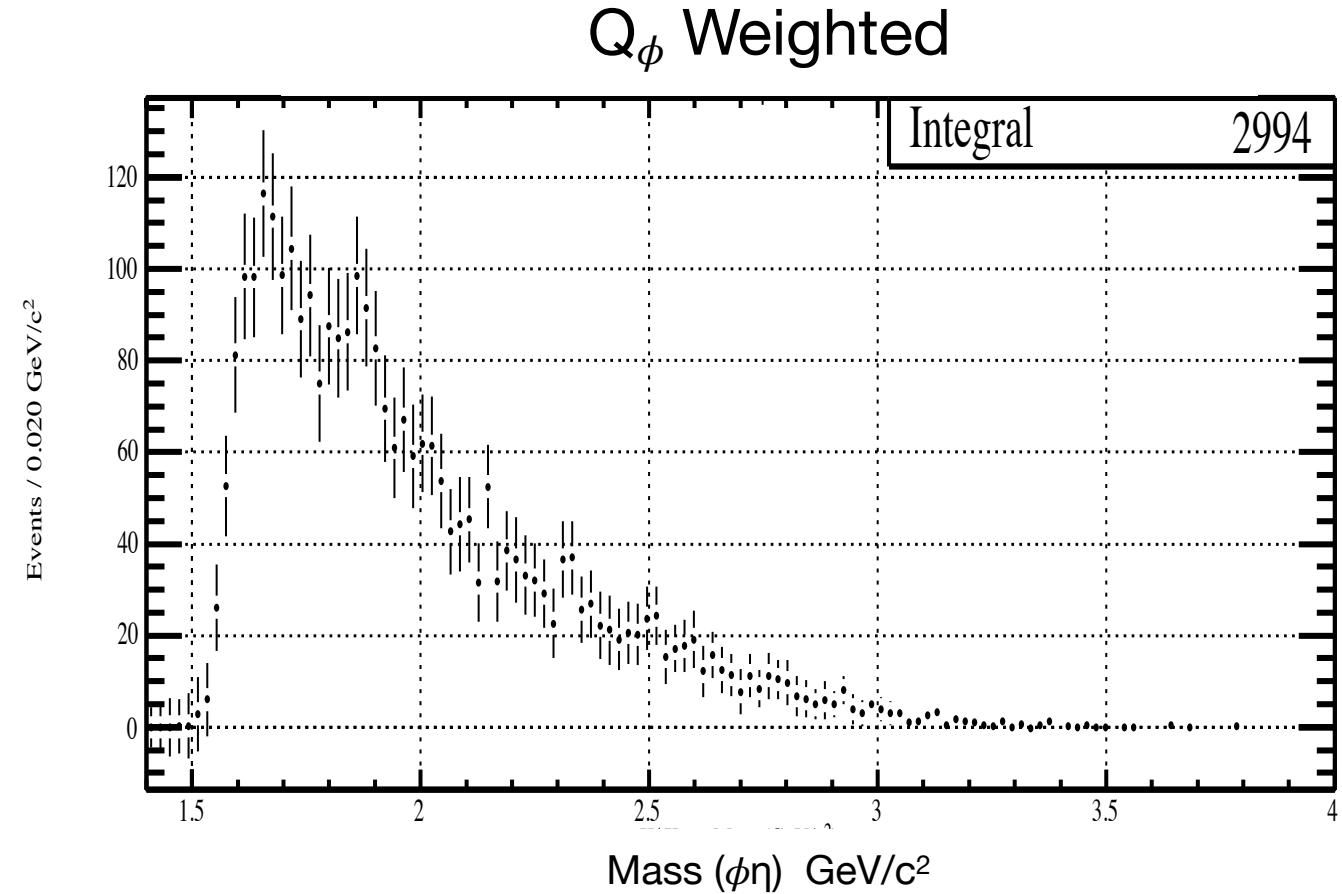
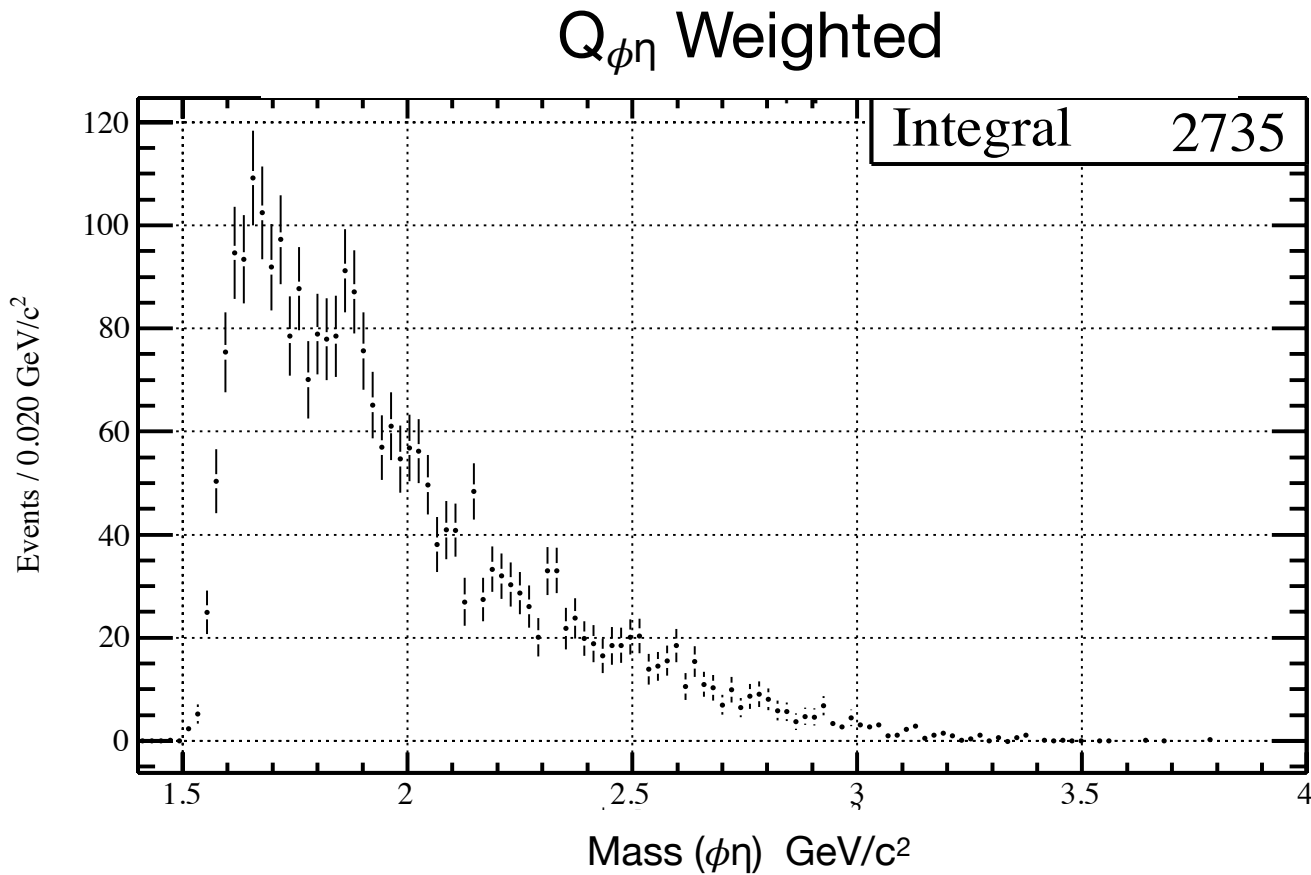
$K^+K^-$  Mass :  $1 - Q_\phi$  Weighted





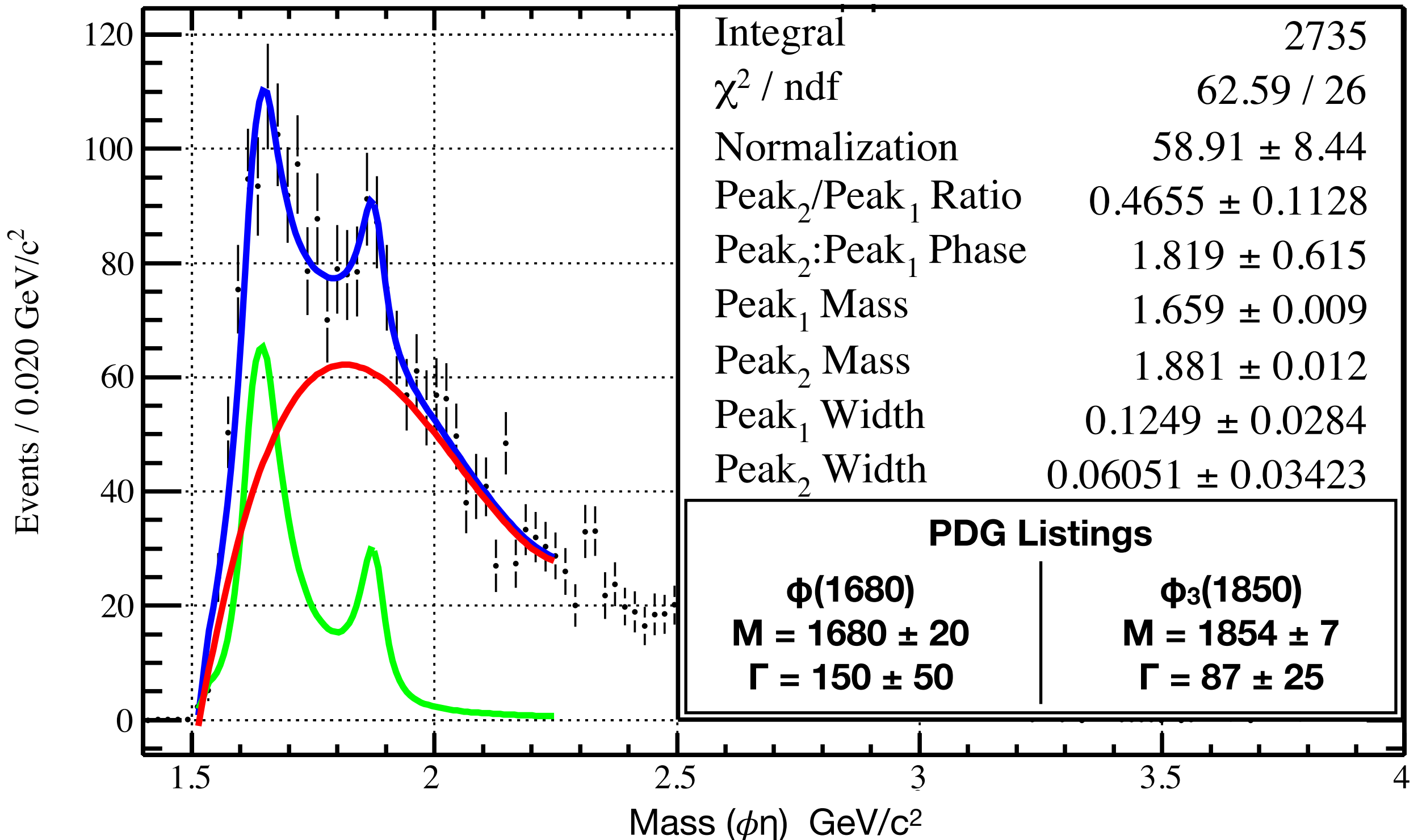


# $\phi\eta$ Invariant Mass for Different Selections



# Mass Dependent Breit-Wigner Fit

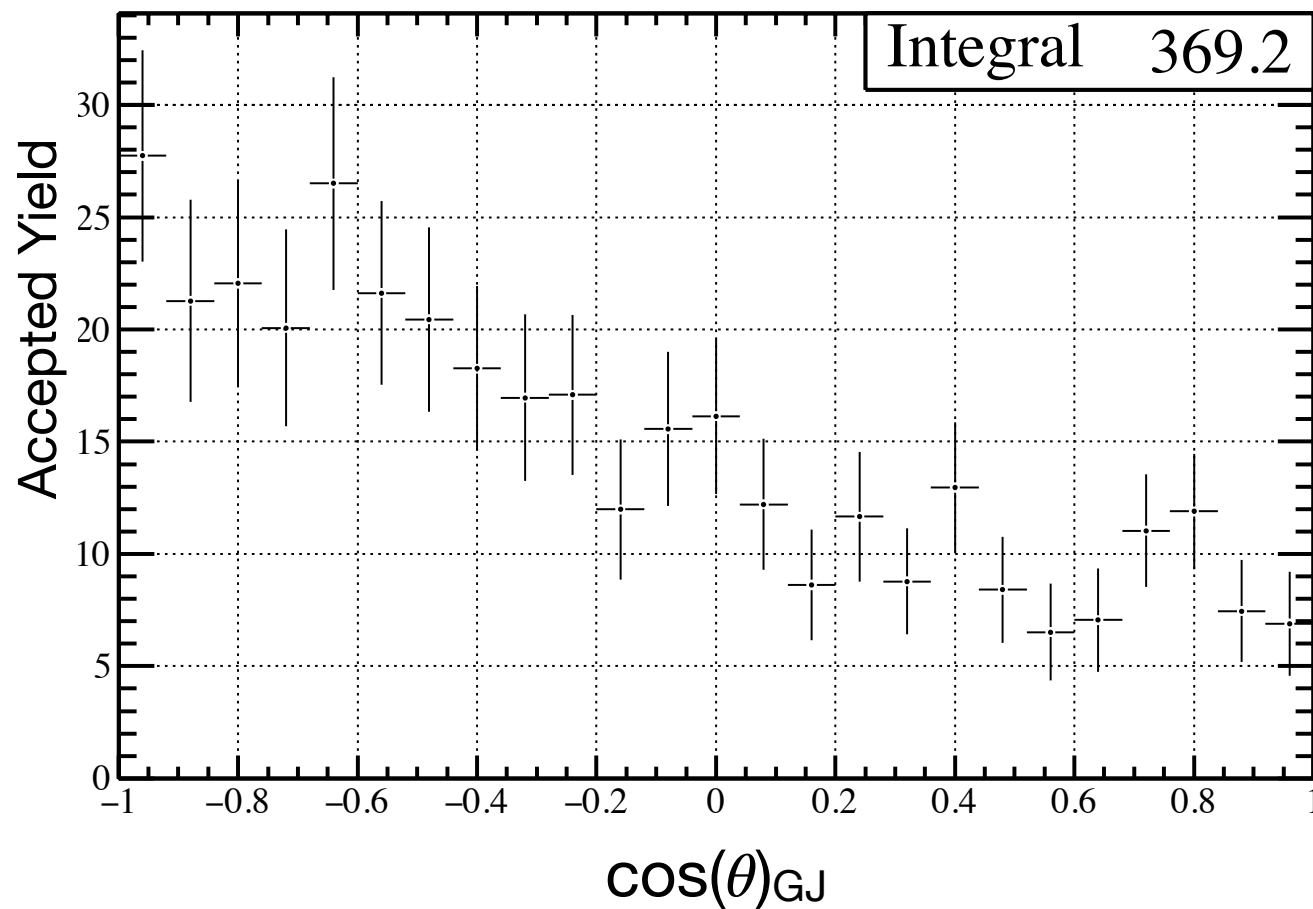
$Q_{\phi\eta}$  Weighted



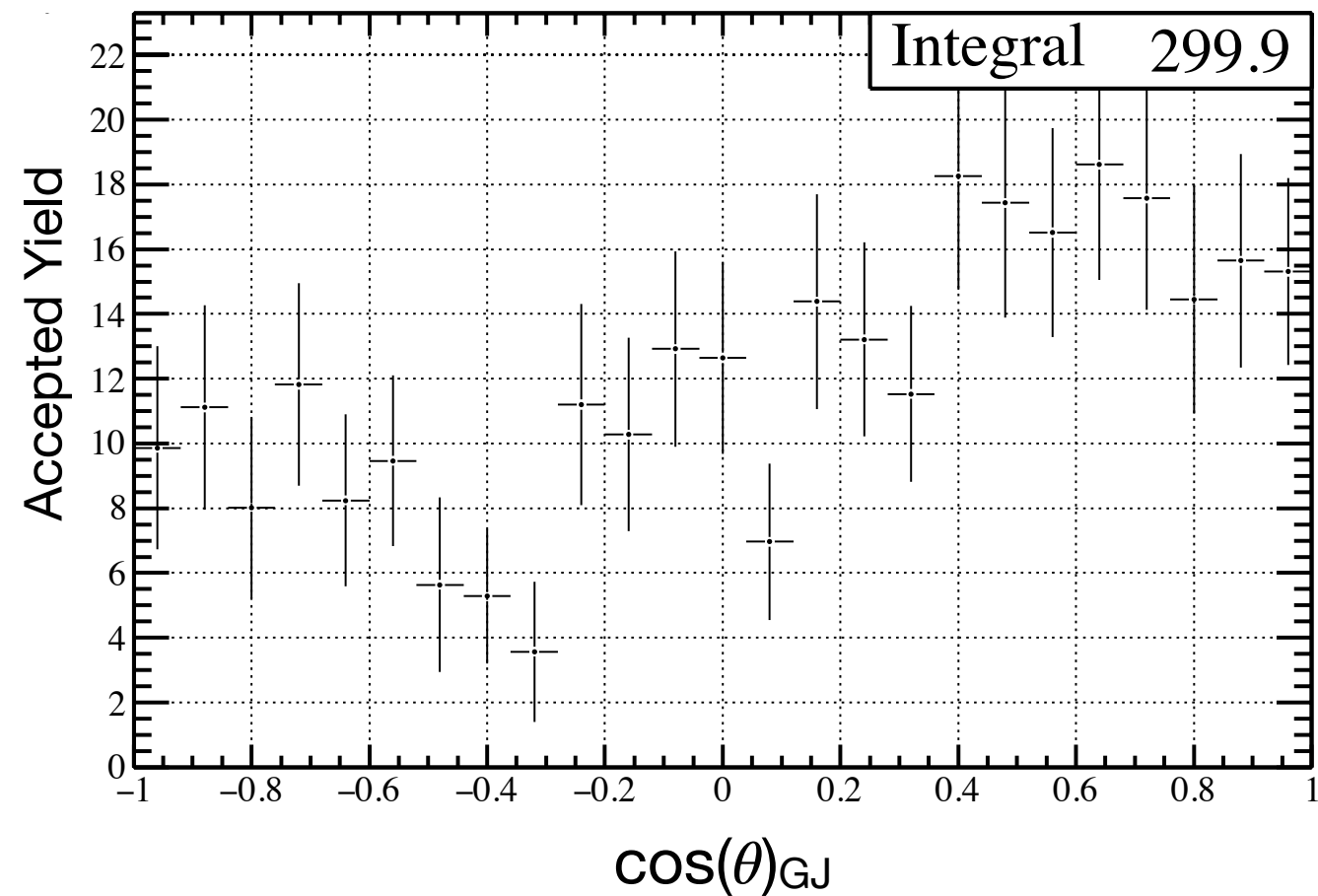
# Accepted Decay Angles

$\cos(\theta)$  in the  $\phi\eta$  Gottfried-Jackson Frame

$\phi(1680)$  Mass Region



$\phi_3(1850)$  Mass Region

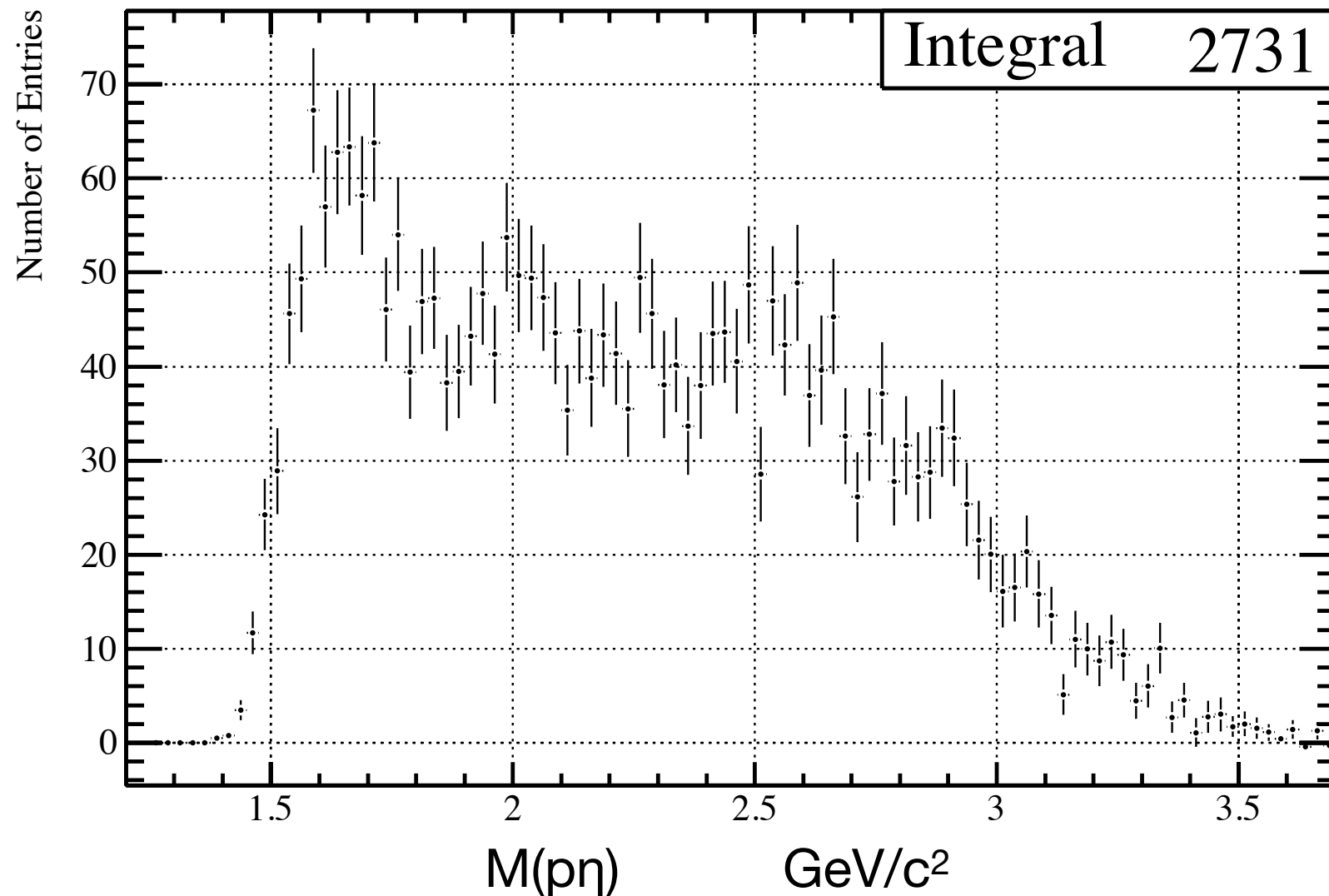




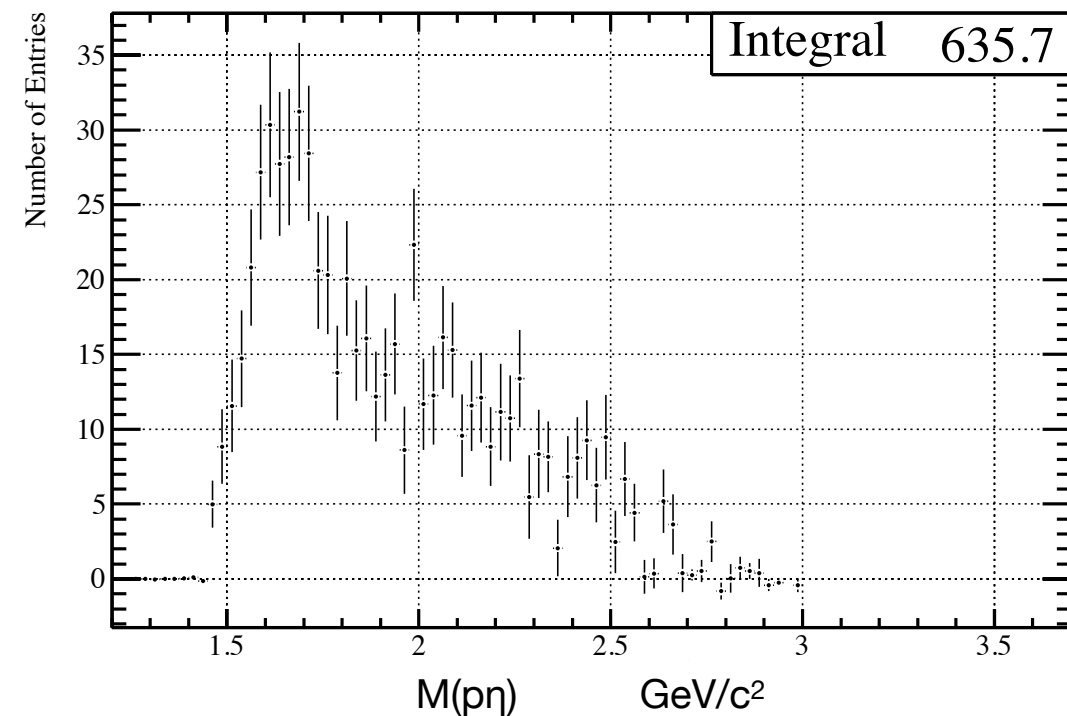
# $\gamma p \longrightarrow N^* \phi$ Background

$$N^* \longrightarrow p \eta$$

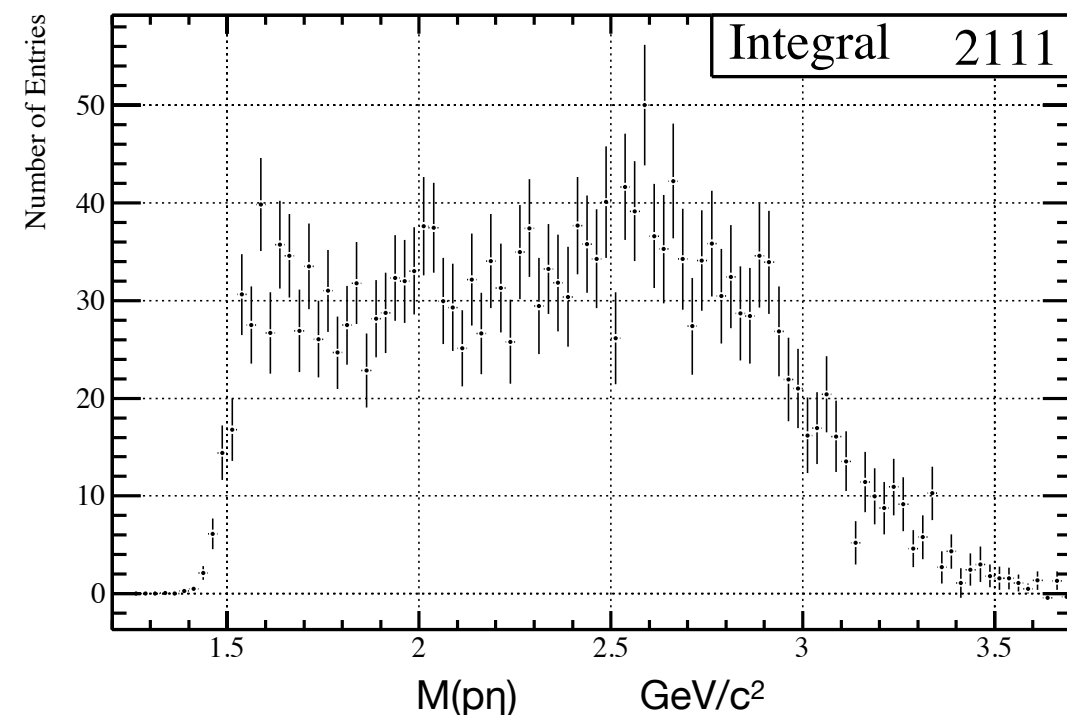
**All Beam Energies**



**Beam Energy < 7.5 GeV**

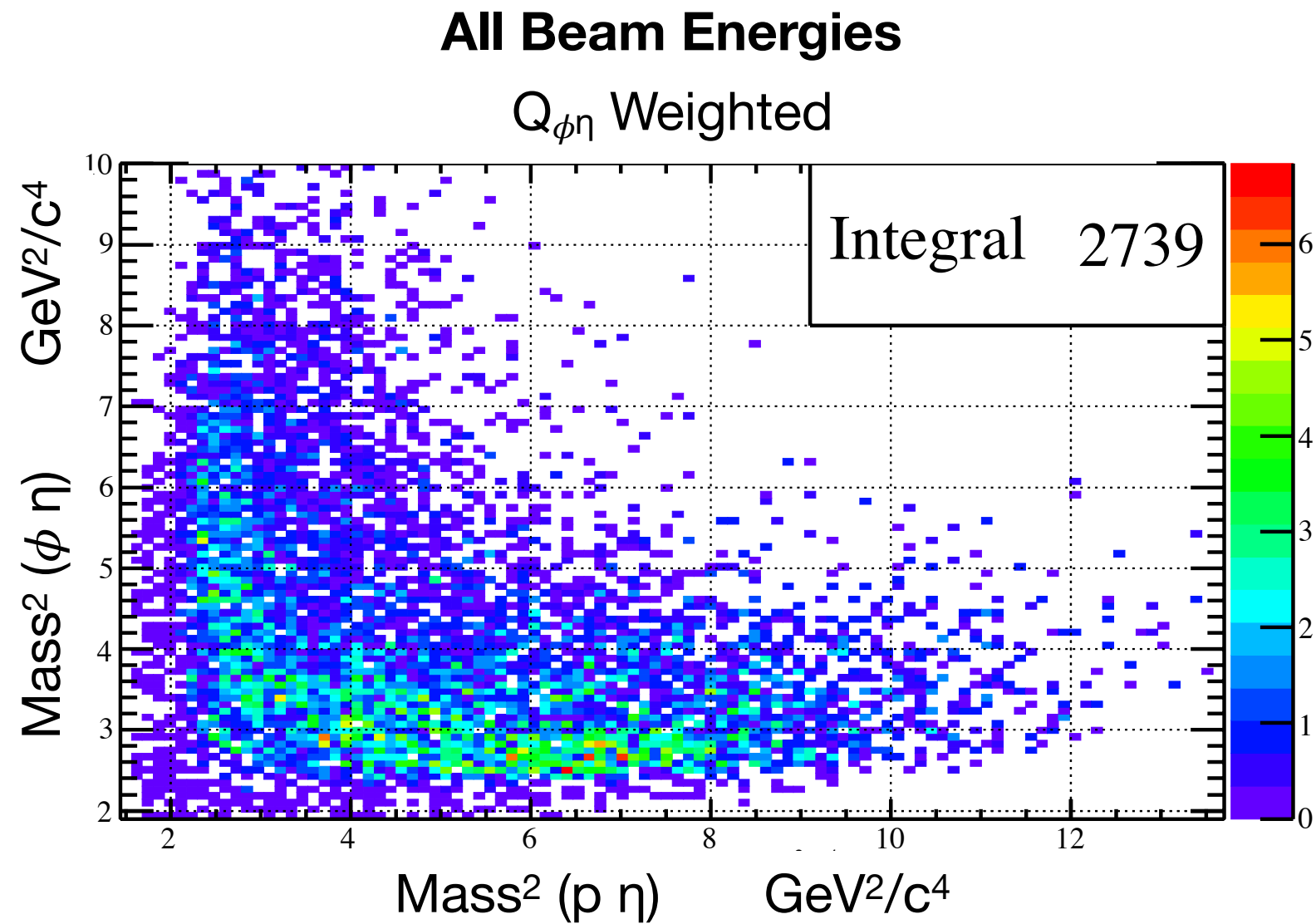


**Beam Energy > 7.5 GeV**

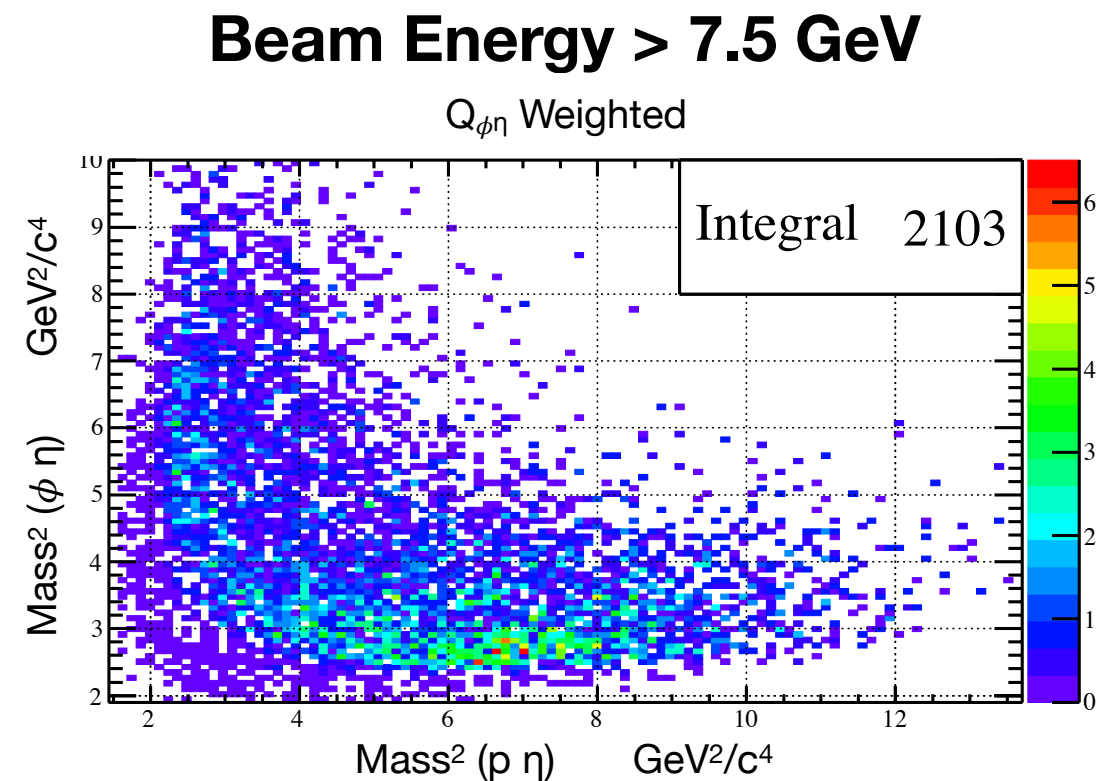
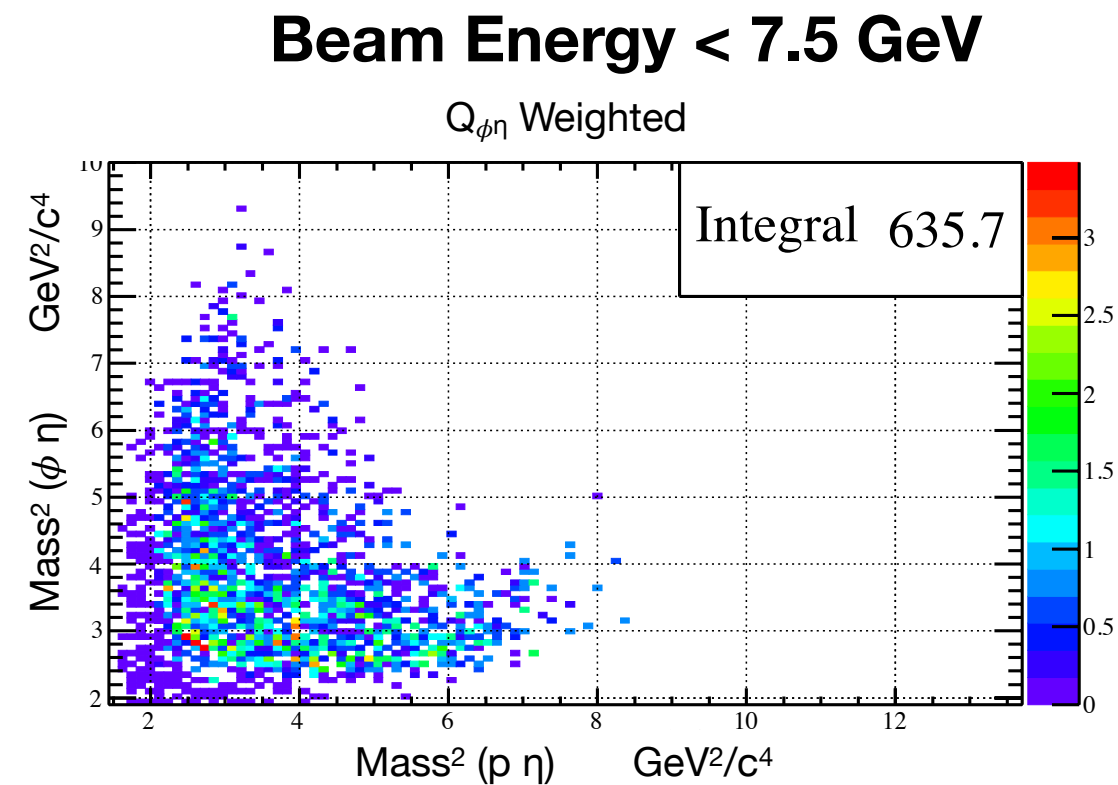


- **Using All photon energies to study effectiveness of  $N^*$  background cuts**

# $p\phi\eta$ Dalitz Plots



- Currently studying  $p\eta$  mass and angular cuts



# Summary

Two structures are observed in the  $\phi\eta$  Invariant Mass

- The first structure is consistent with the  $\phi(1680)$ 
  - Observed in  $e^+e^-$  and in photoproduction of  $KK$
- The second structure is consistent with the  $\phi_3(1850)$ .
  - Only observed in  $K^-p \rightarrow K\bar{K}\Lambda$ ,  $K\bar{K}^*\Lambda$  experiments
  - Assumed an  $s\bar{s}$  candidate due to non-observation of signal to  $2\pi$
  - Observation in  $\phi\eta$  is confirmation of  $s\bar{s}$  state

Work in progress:

- $N^*$  Background Studies
- Monte Carlo Acceptance Studies
- Development of Analysis Note (100+ pages exist)