

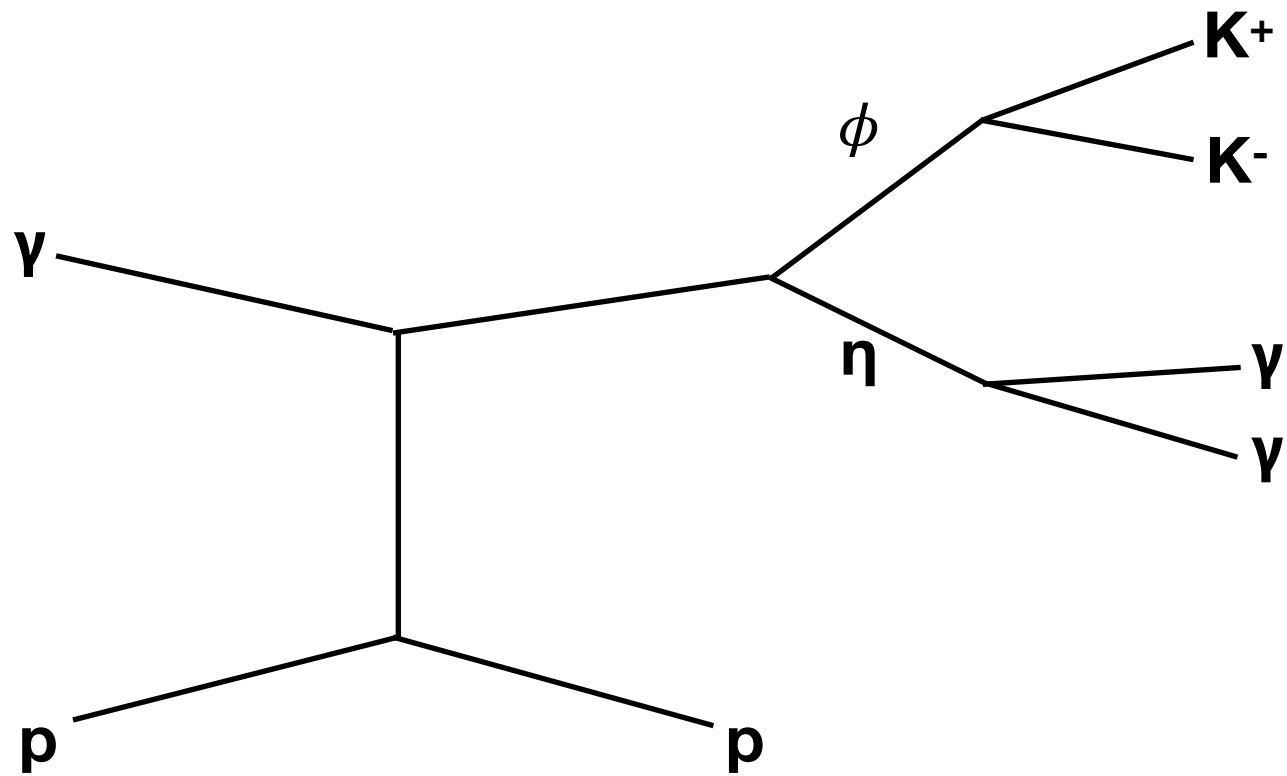
$\gamma p \longrightarrow p \phi \eta$ Update

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 $\gamma p \rightarrow p K^+ K^- \gamma \gamma$

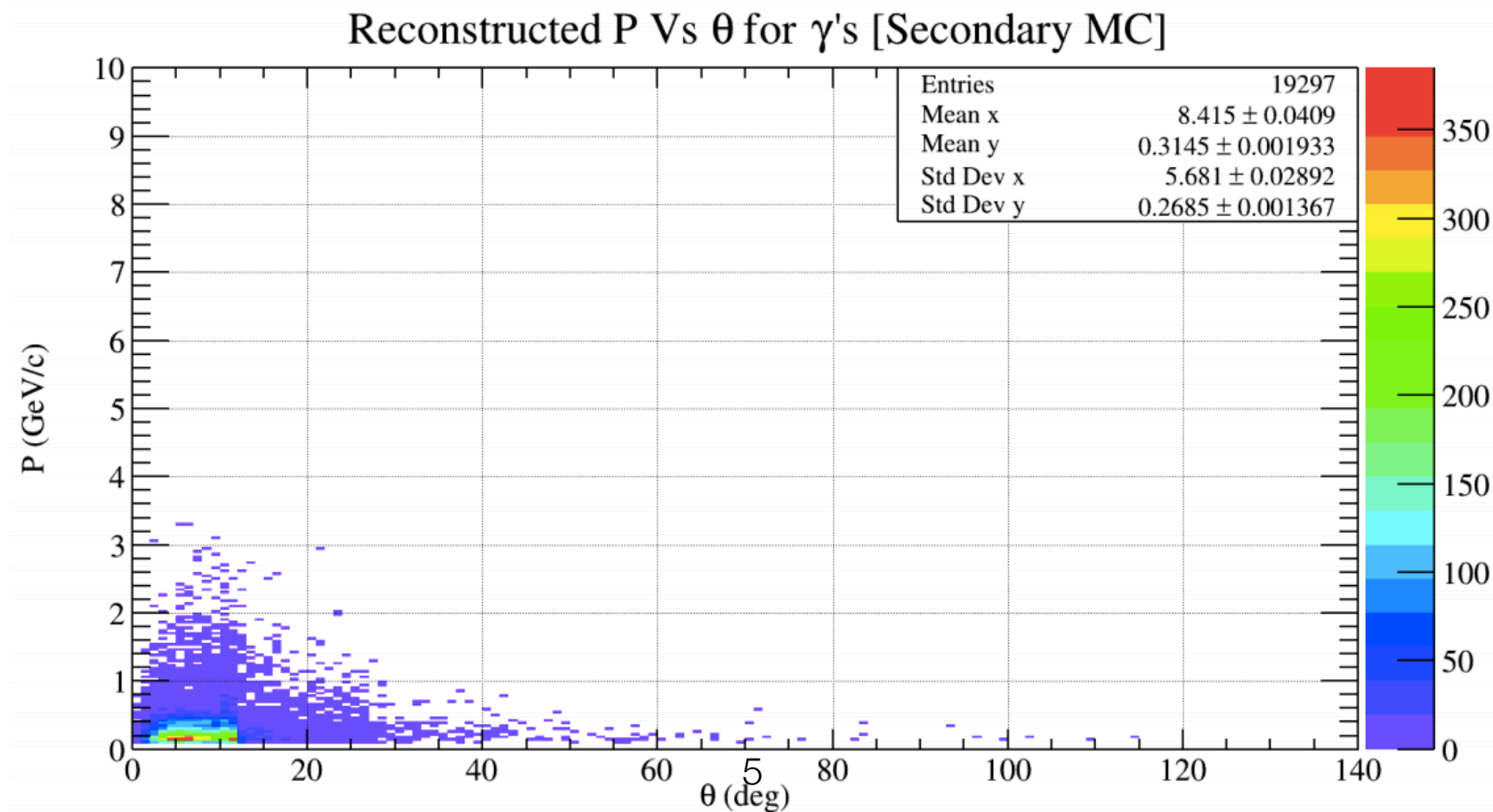
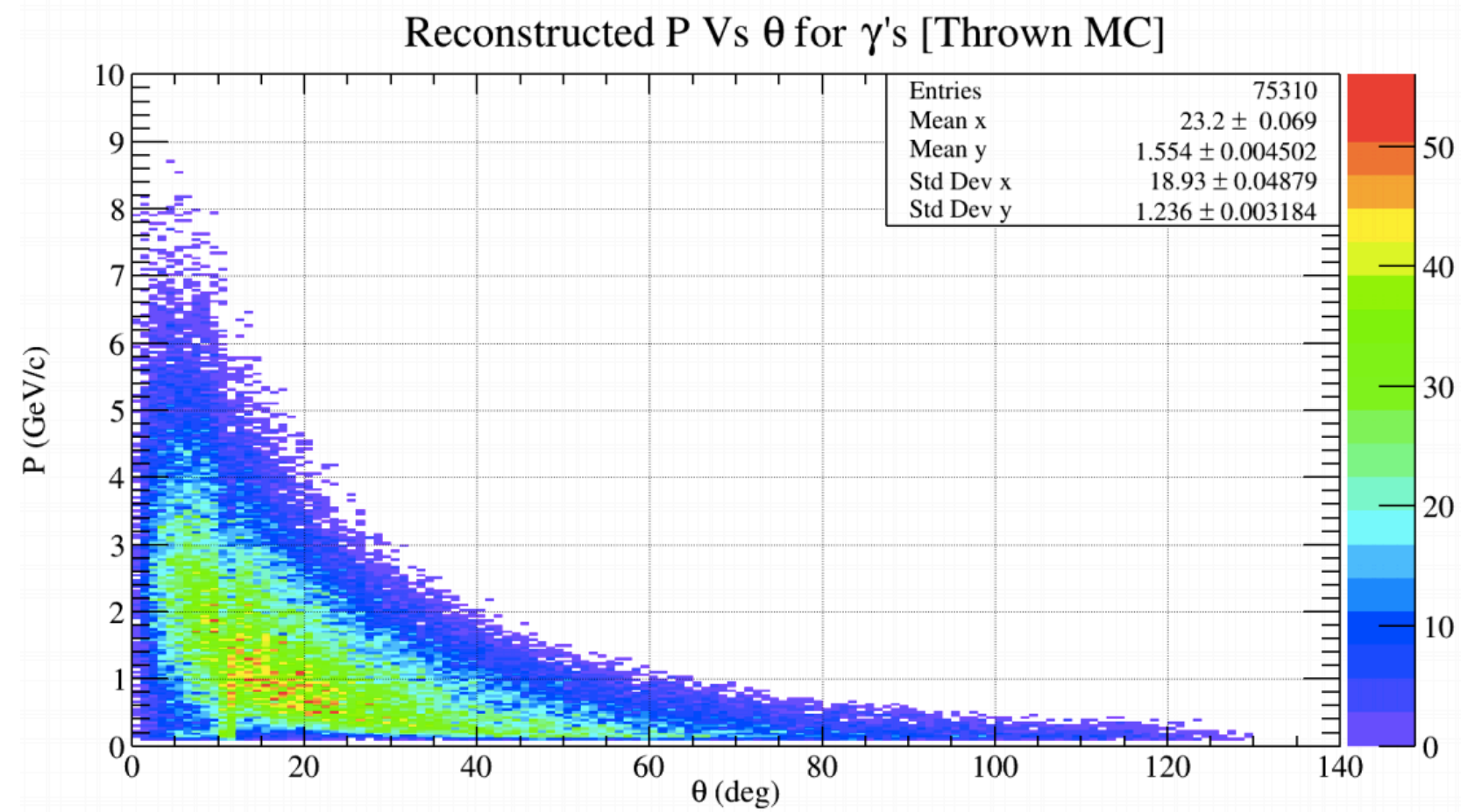
Standard GlueX Cuts:

- 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

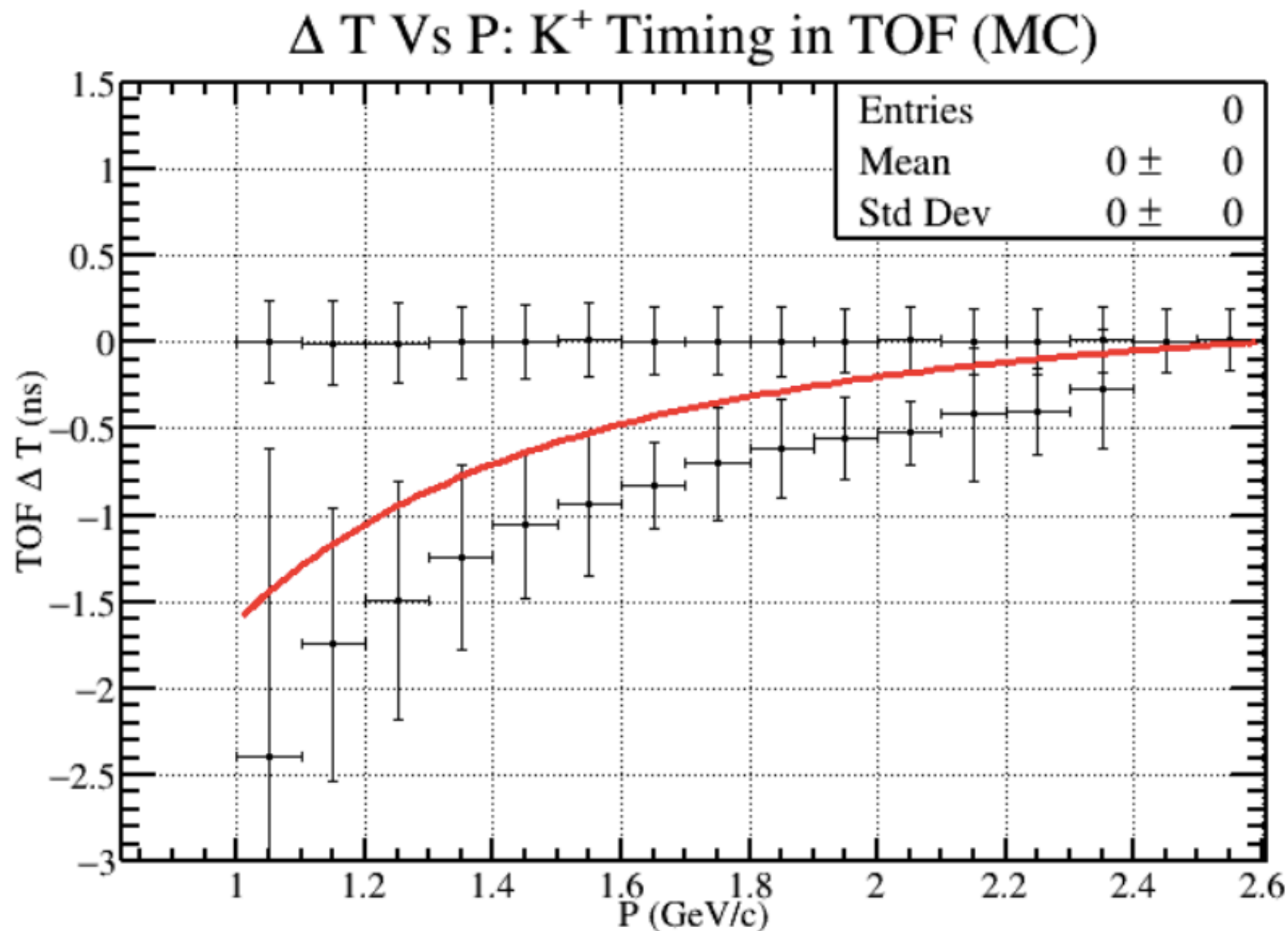


Kaon Selection & Pion Rejection from TOF

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

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

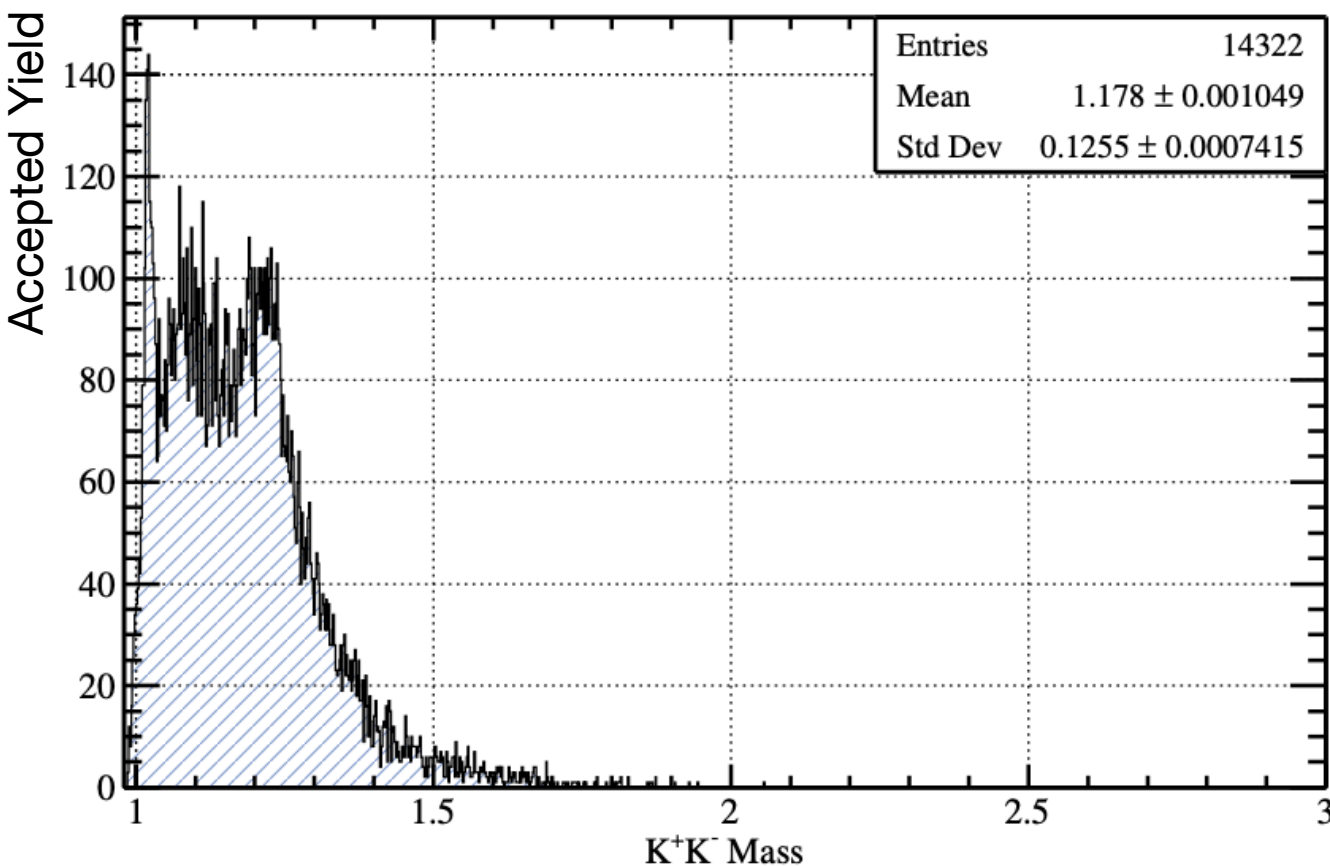
$$\delta t = \frac{\delta X}{c} \frac{\sqrt{m_\pi^2 + P^2} - \sqrt{m_K^2 + P^2}}{P}$$



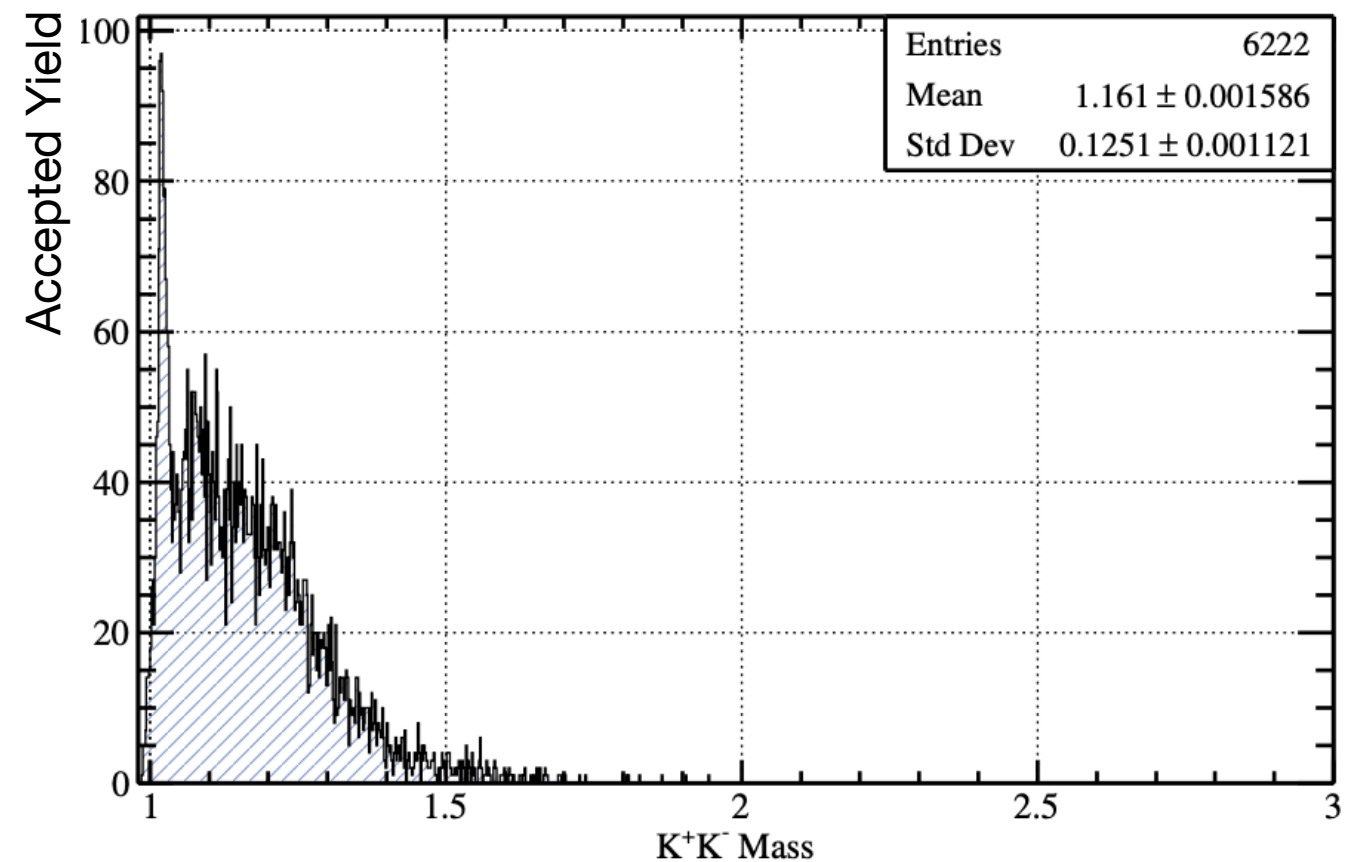
- Each event must have at least 1 Kaon ID from TOF
- A Kaon ID is any Kaon above the red line

Effects of Kaon Selection and Pion Rejection

Before TOF Kaon ID



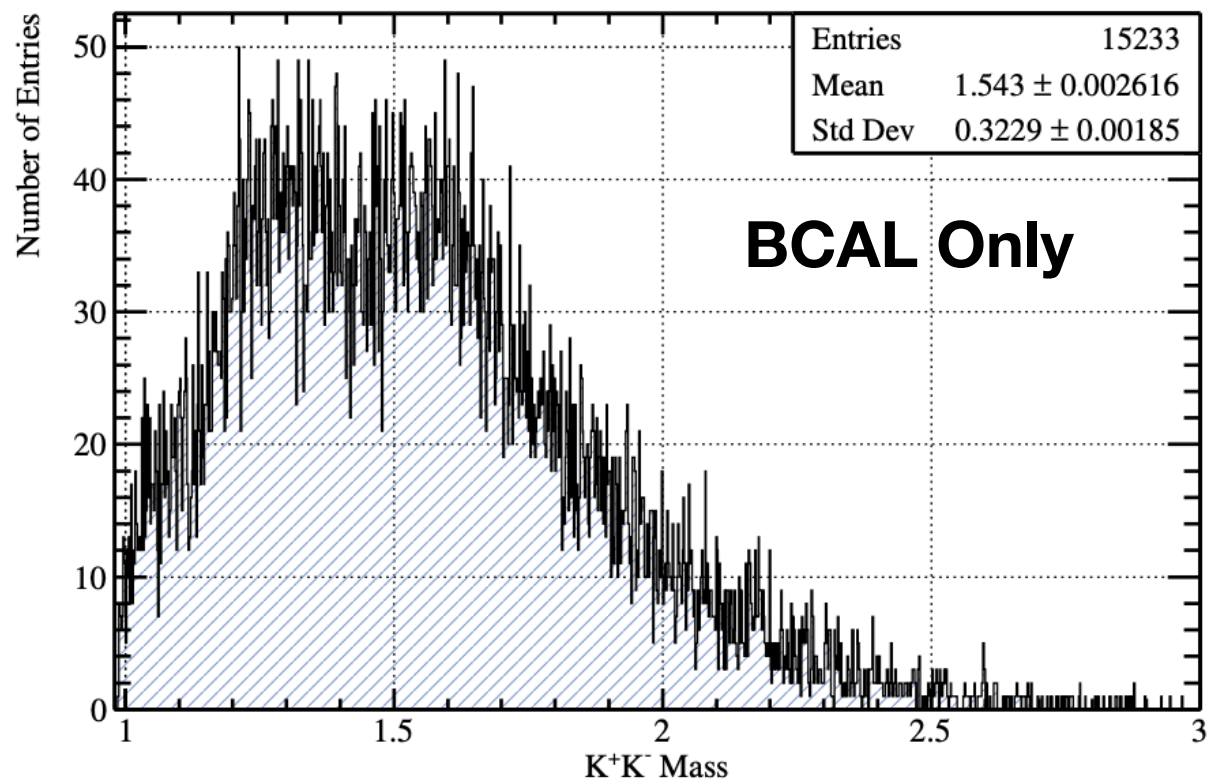
After TOF Kaon ID Selection



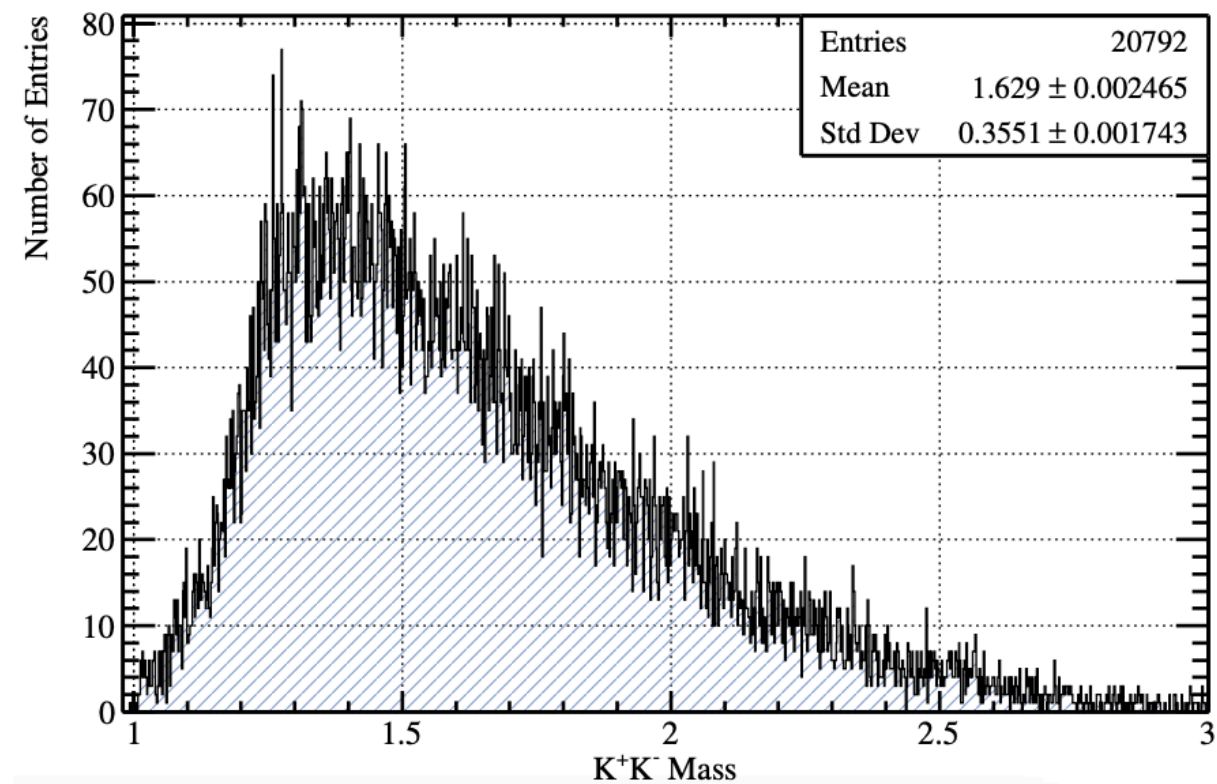
- **Misidentified Pions are removed**
- **Negligible effect to ϕ yield**

ϕ Only Seen in TOF

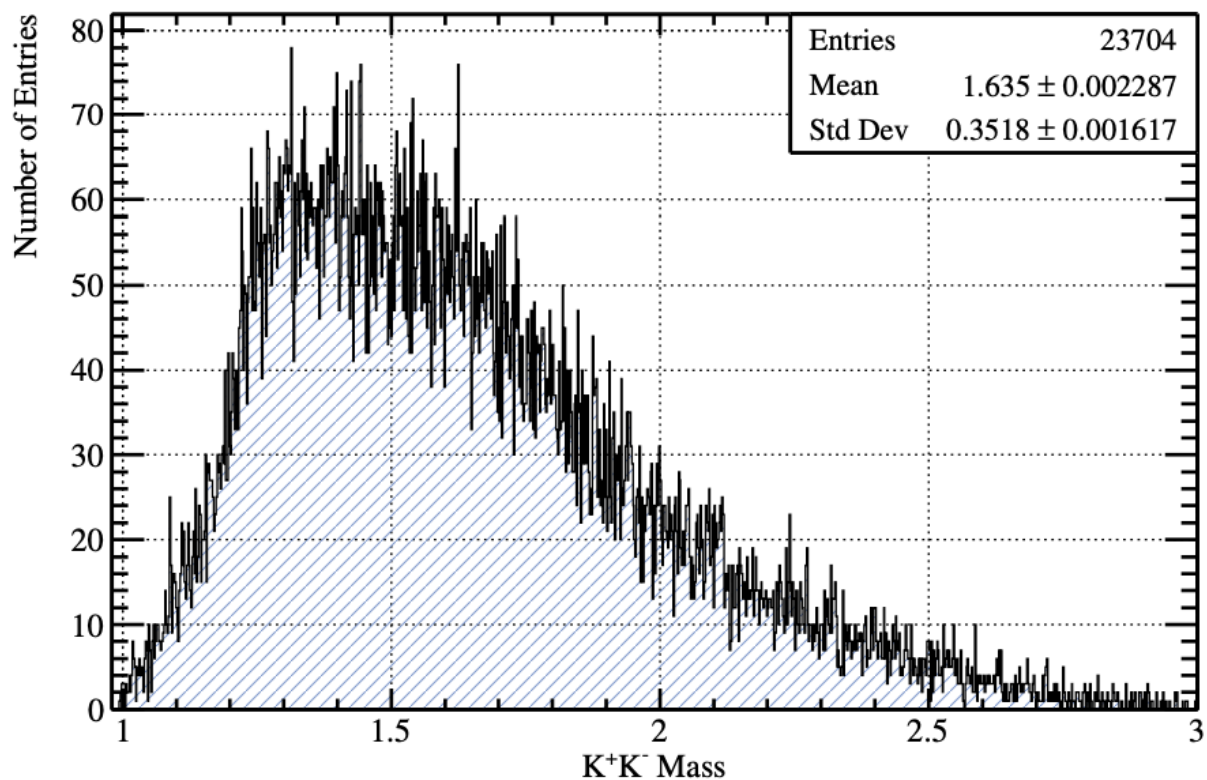
ProjectionY of binx=1 [x=-0.5..0.5] [$K_{\text{BCAL}}^+ K_{\text{BCAL}}^-$]



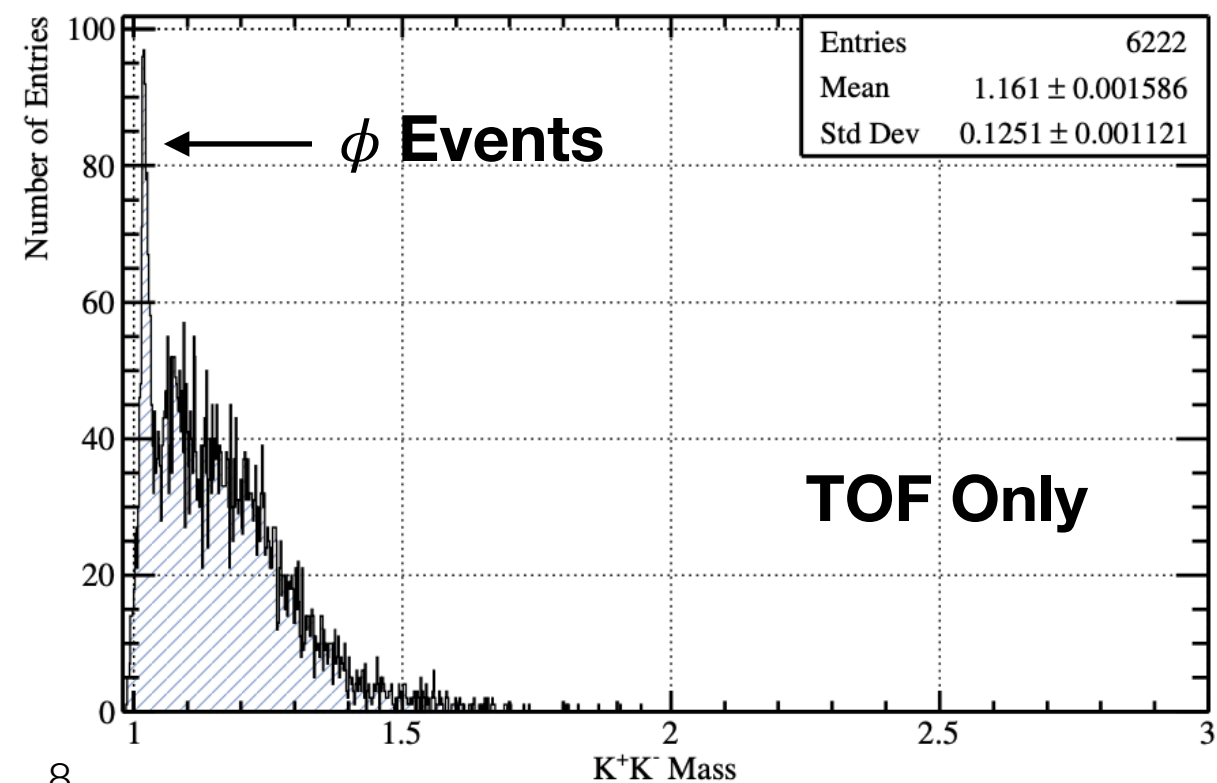
ProjectionY of binx=3 [x=1.5..2.5] [$K_{\text{BCAL}}^+ K_{\text{TOF}}^-$]



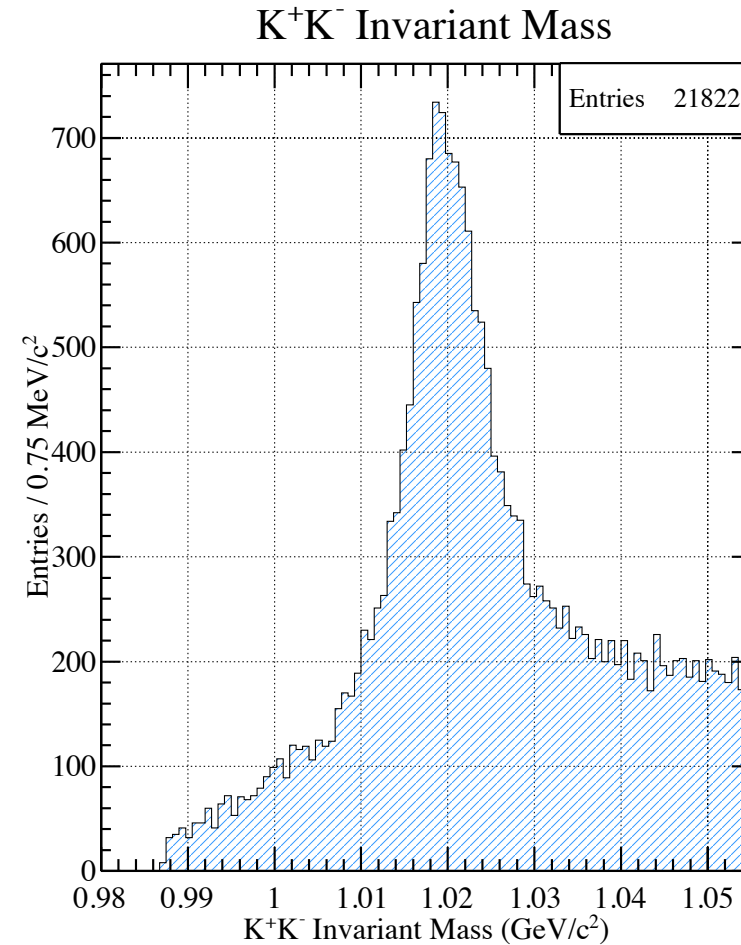
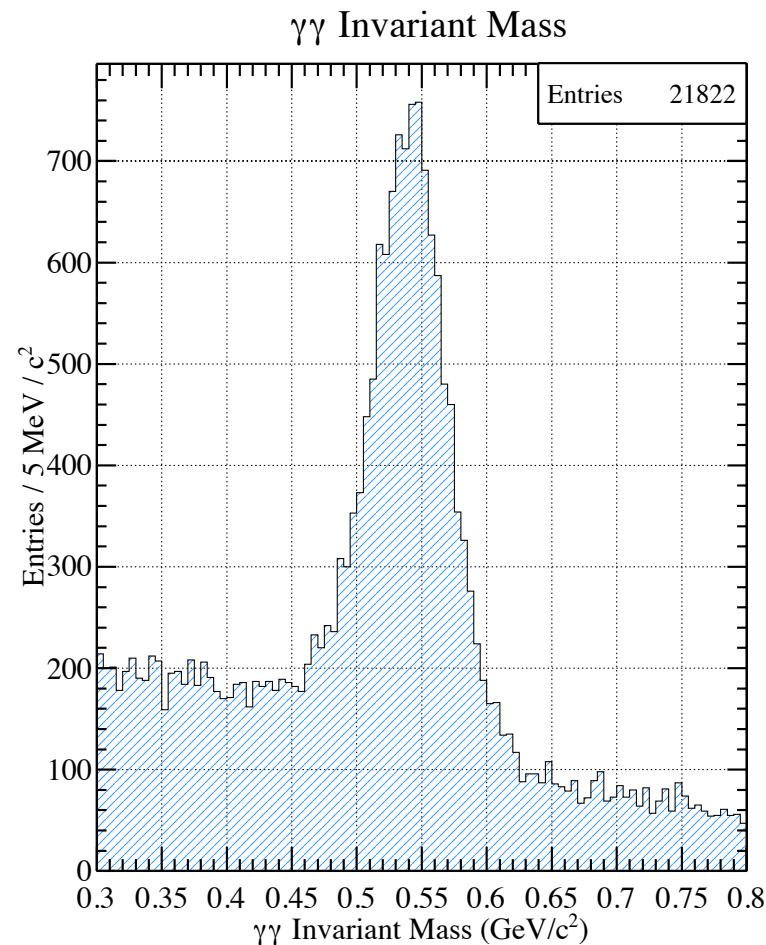
ProjectionY of binx=7 [x=5.5..6.5] [$K_{\text{TOF}}^+ K_{\text{BCAL}}^-$]



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



Selecting $\phi\eta$ Events



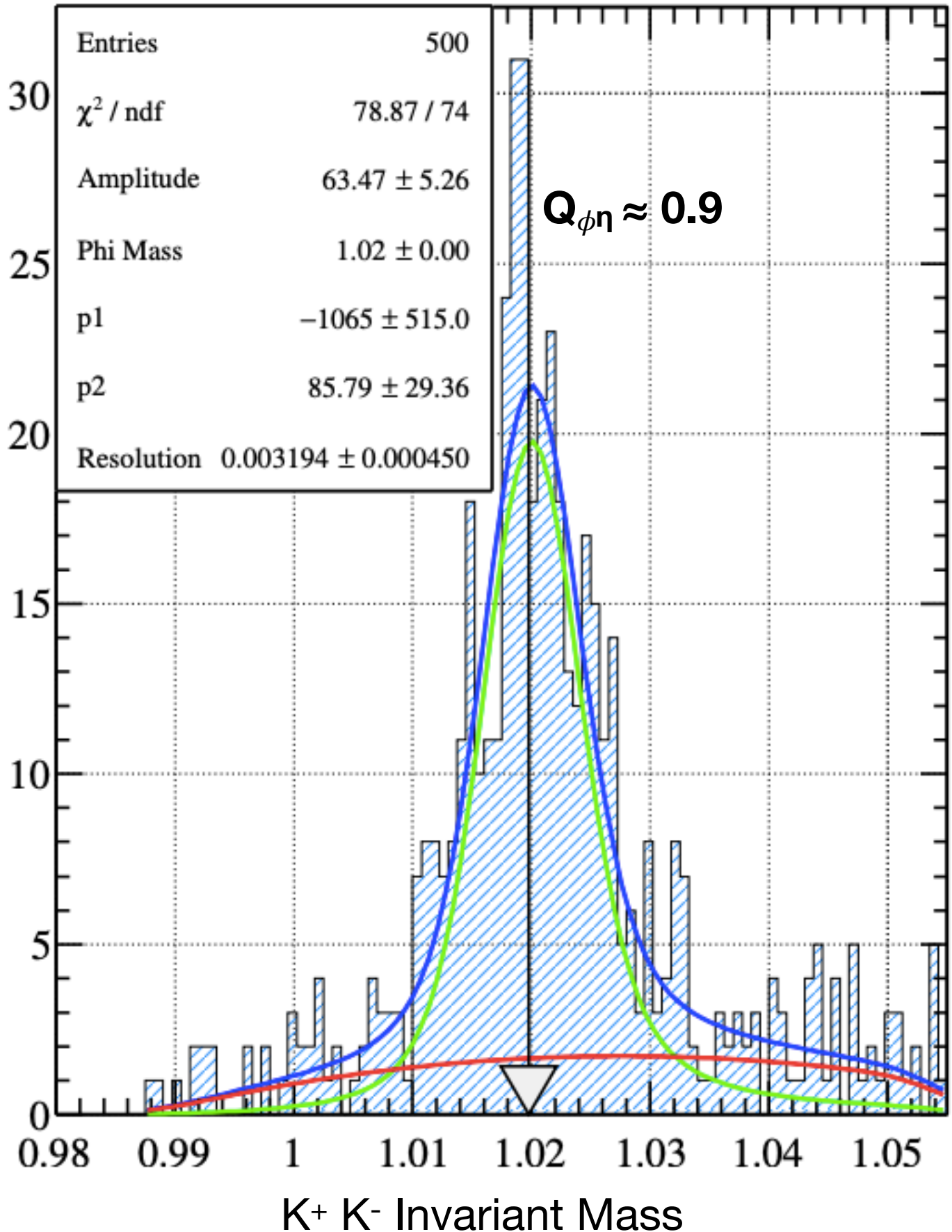
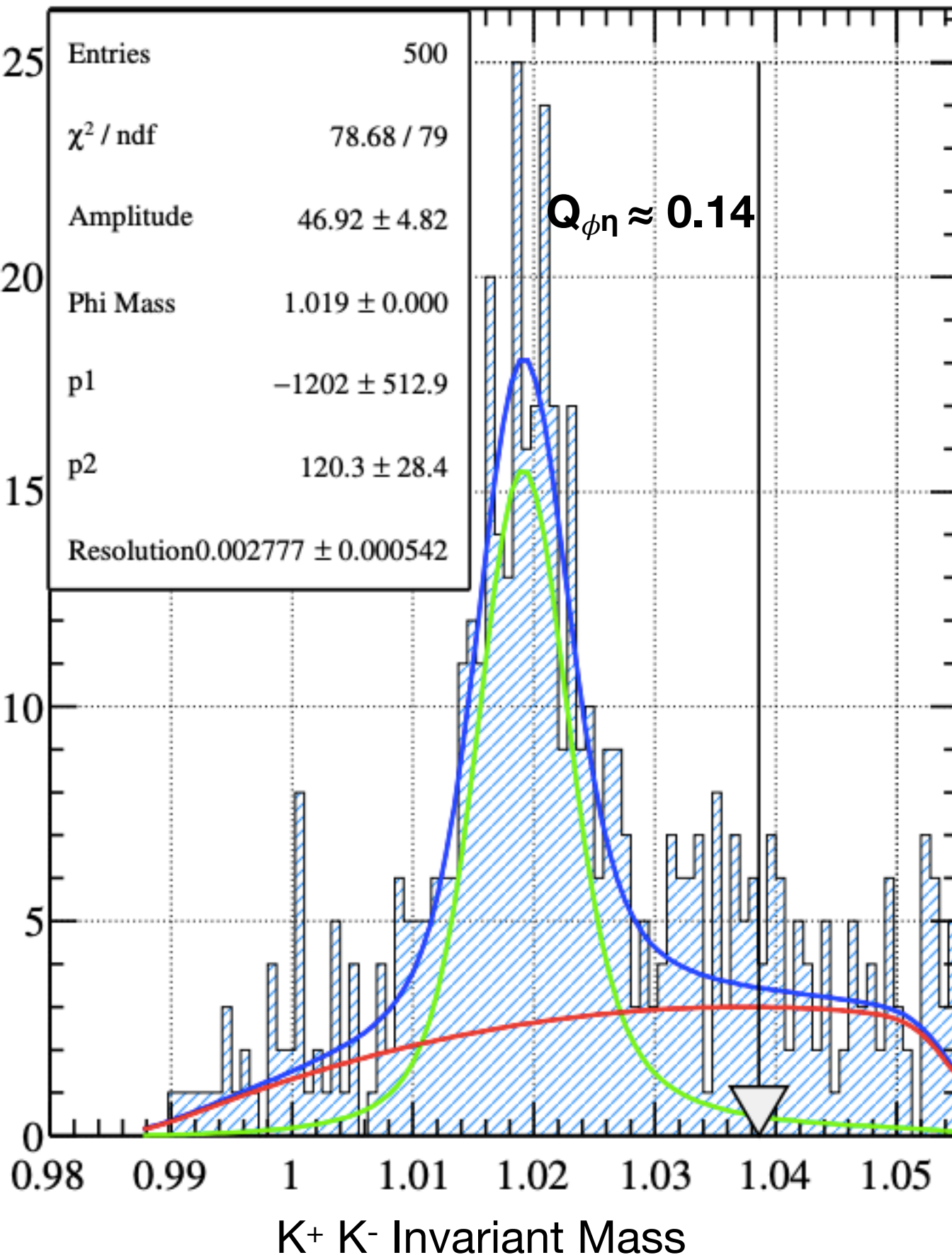
Studied Various Selection Methods

- Elliptical/Sideband Subtraction

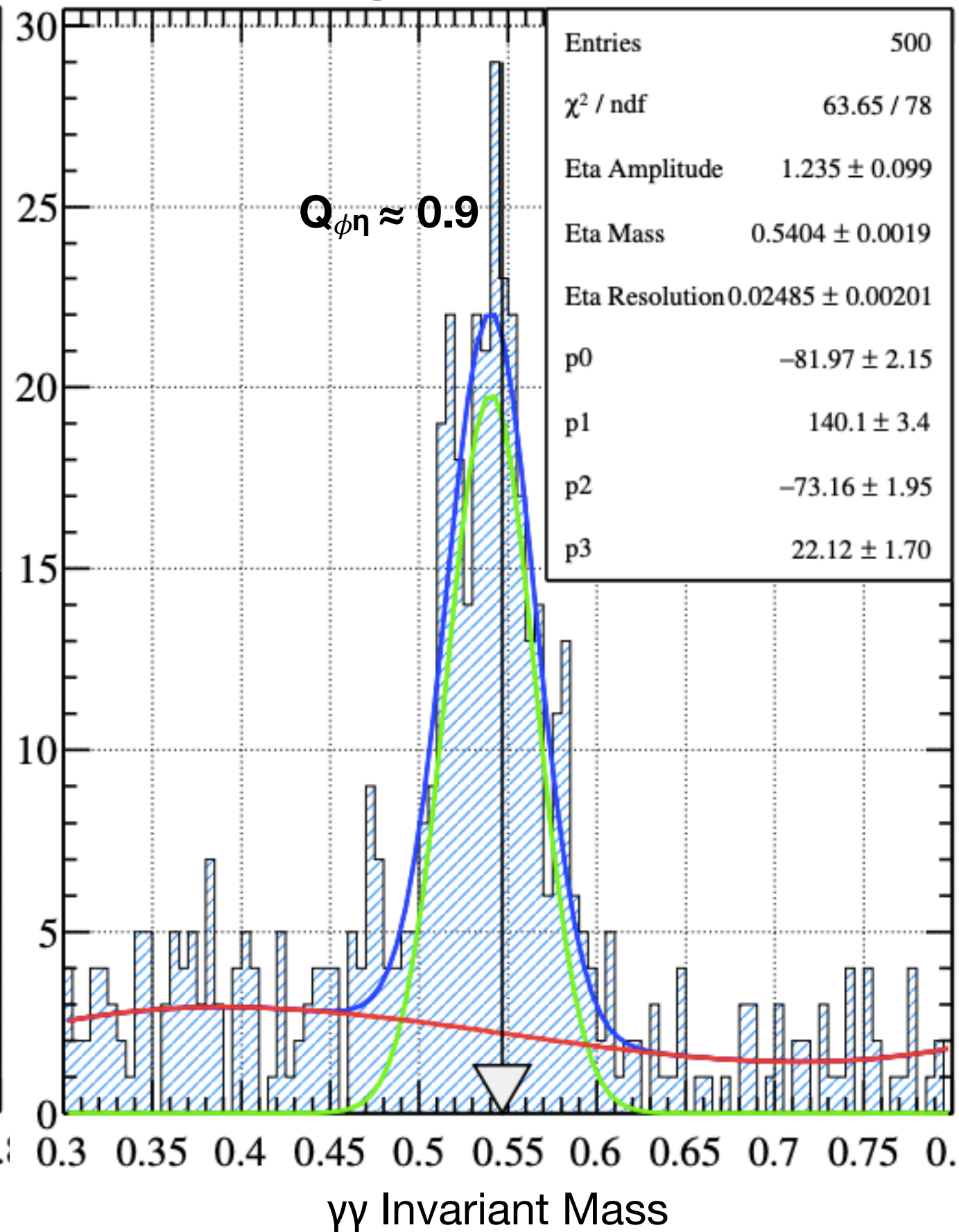
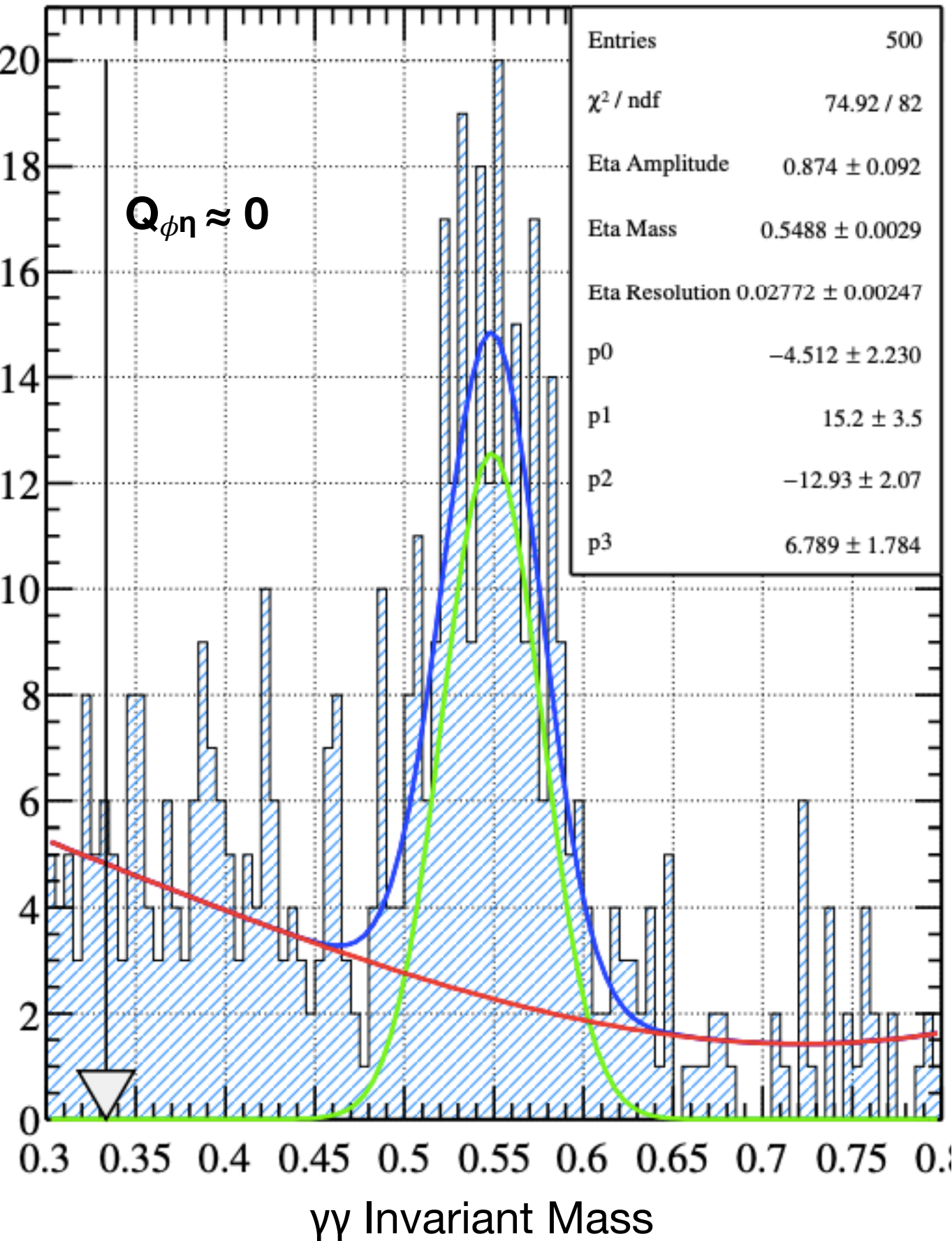
- Quality Factor Approaches

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

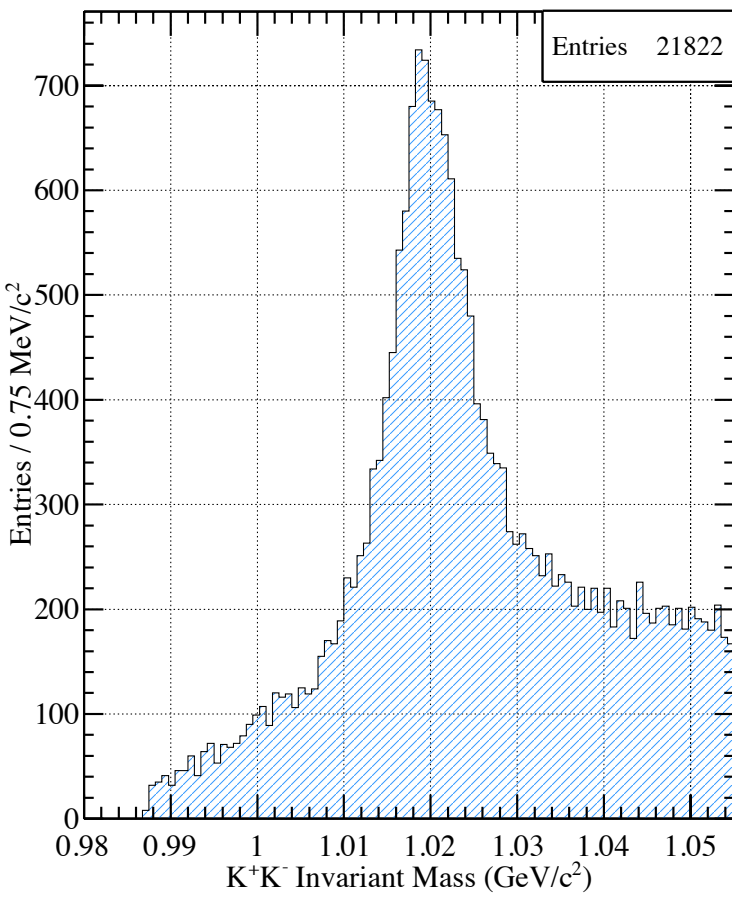
Example of Nearest Neighbors Fit



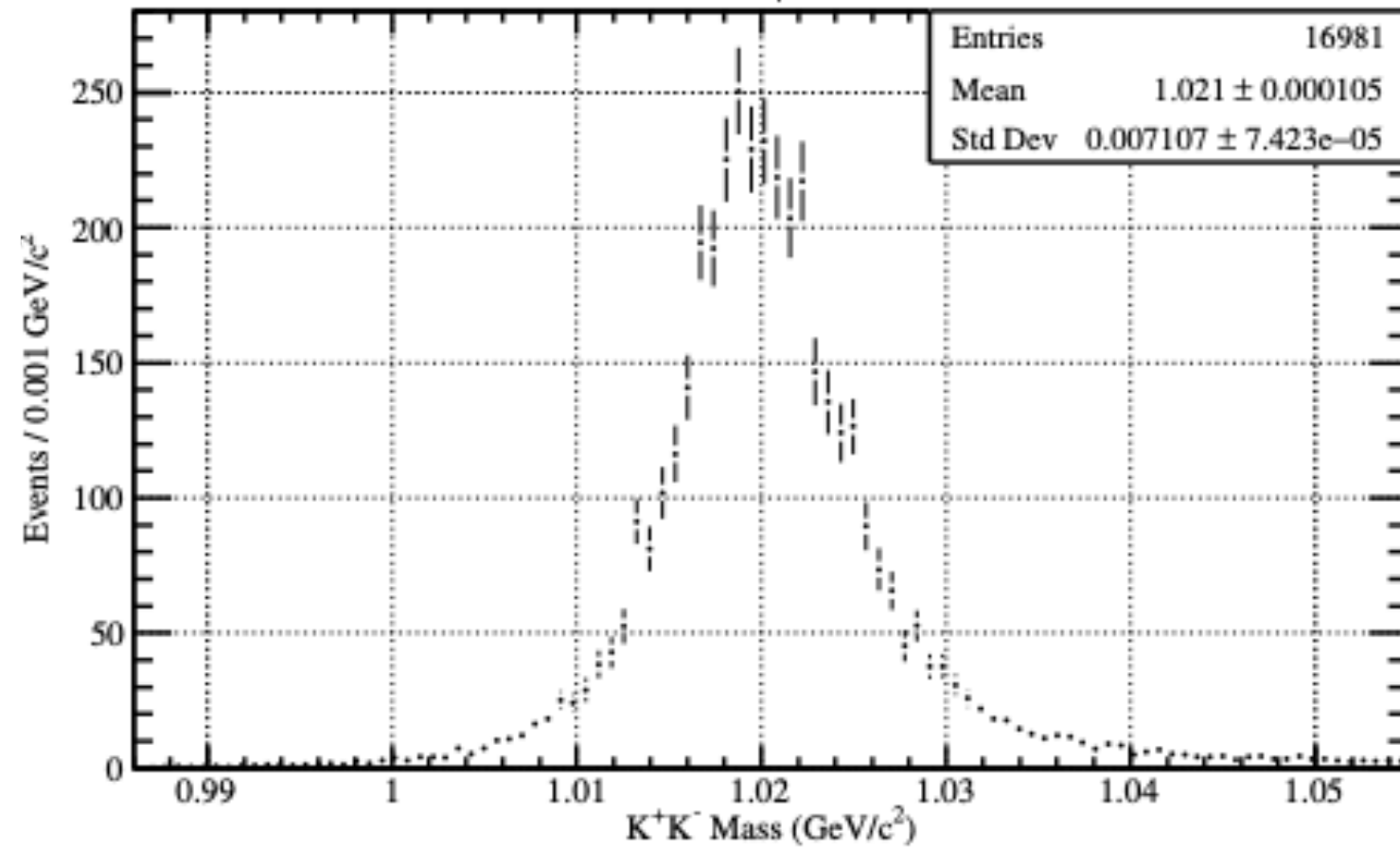
Example of Nearest Neighbors Fit



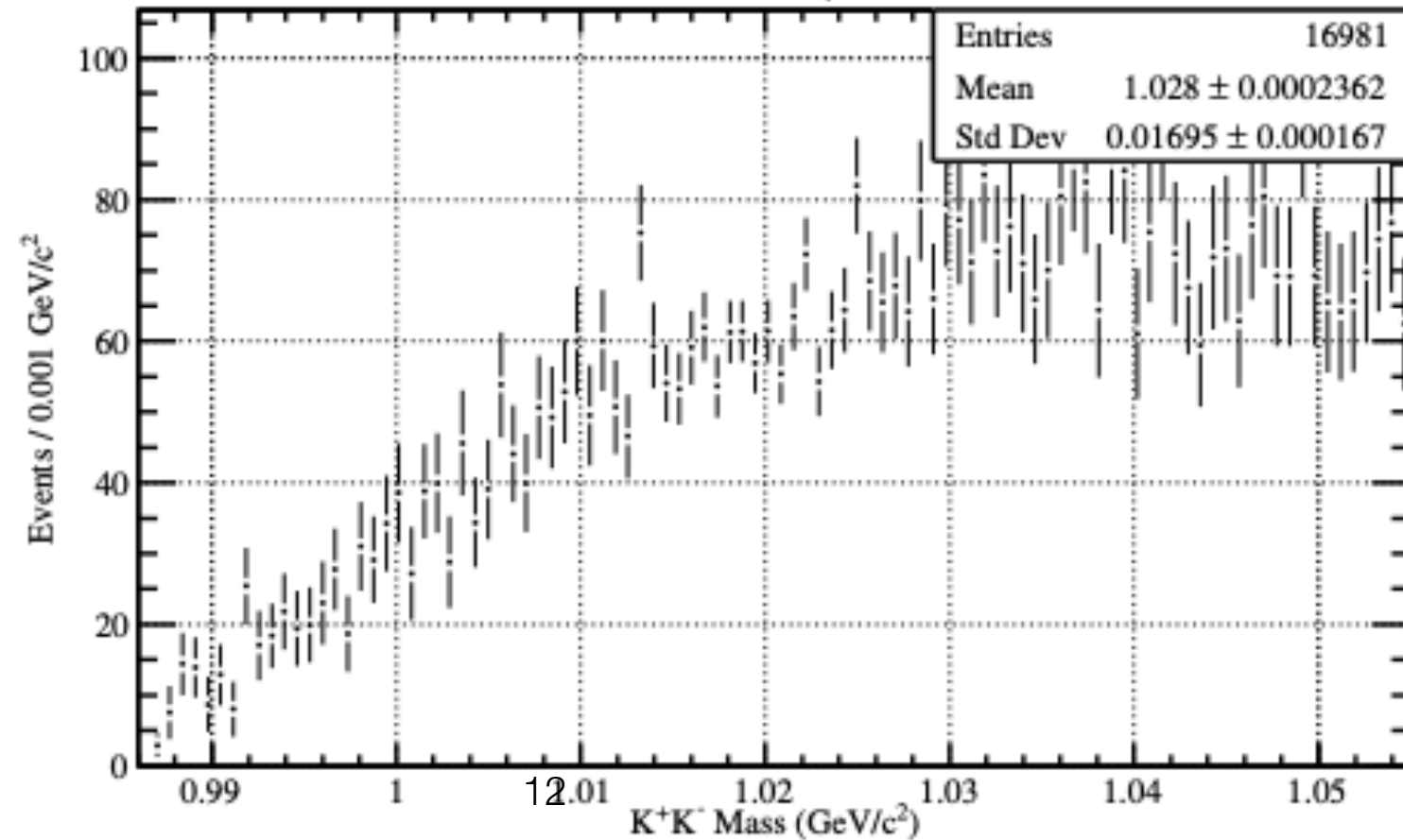
K^+K^- Invariant Mass

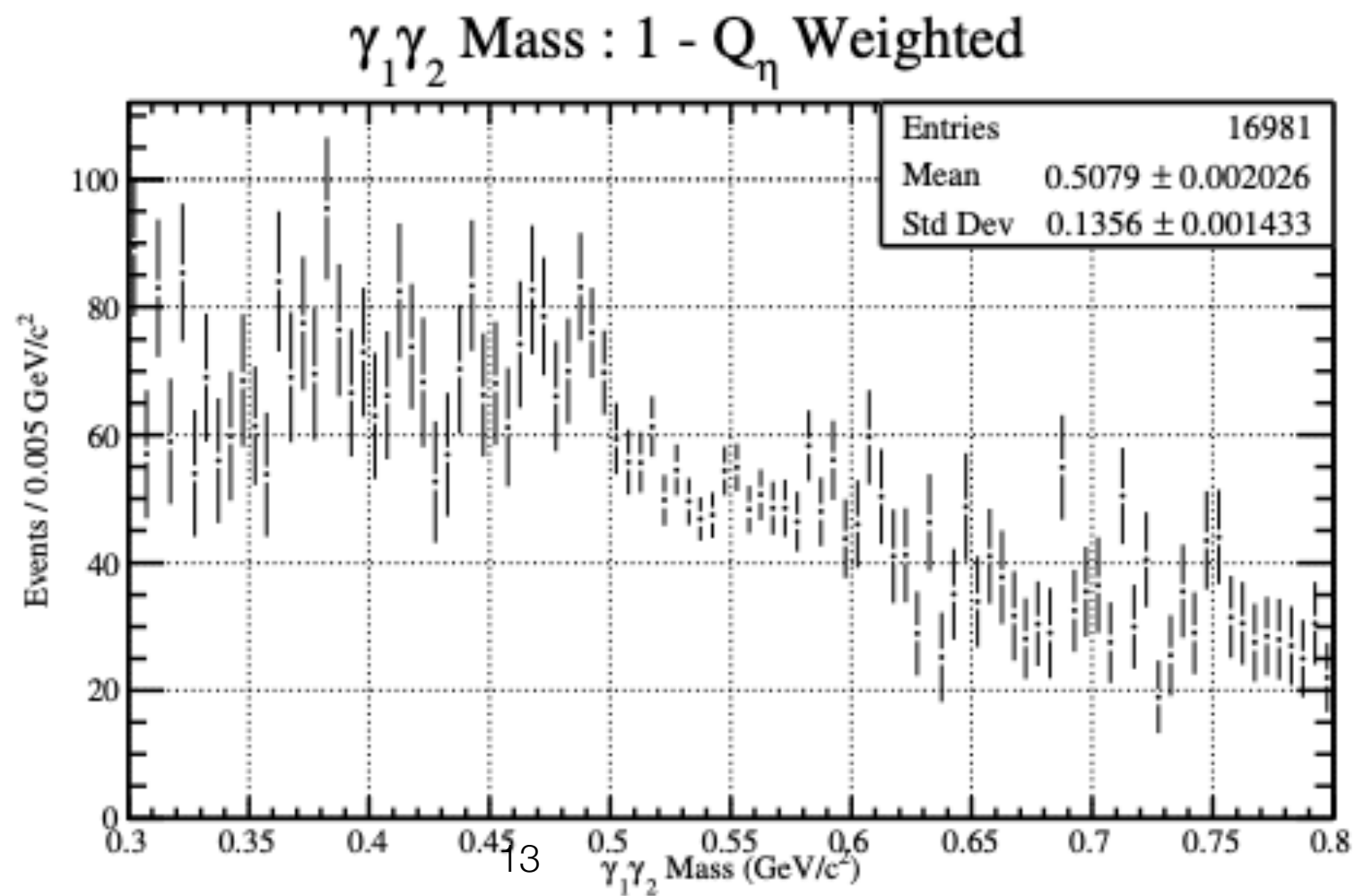
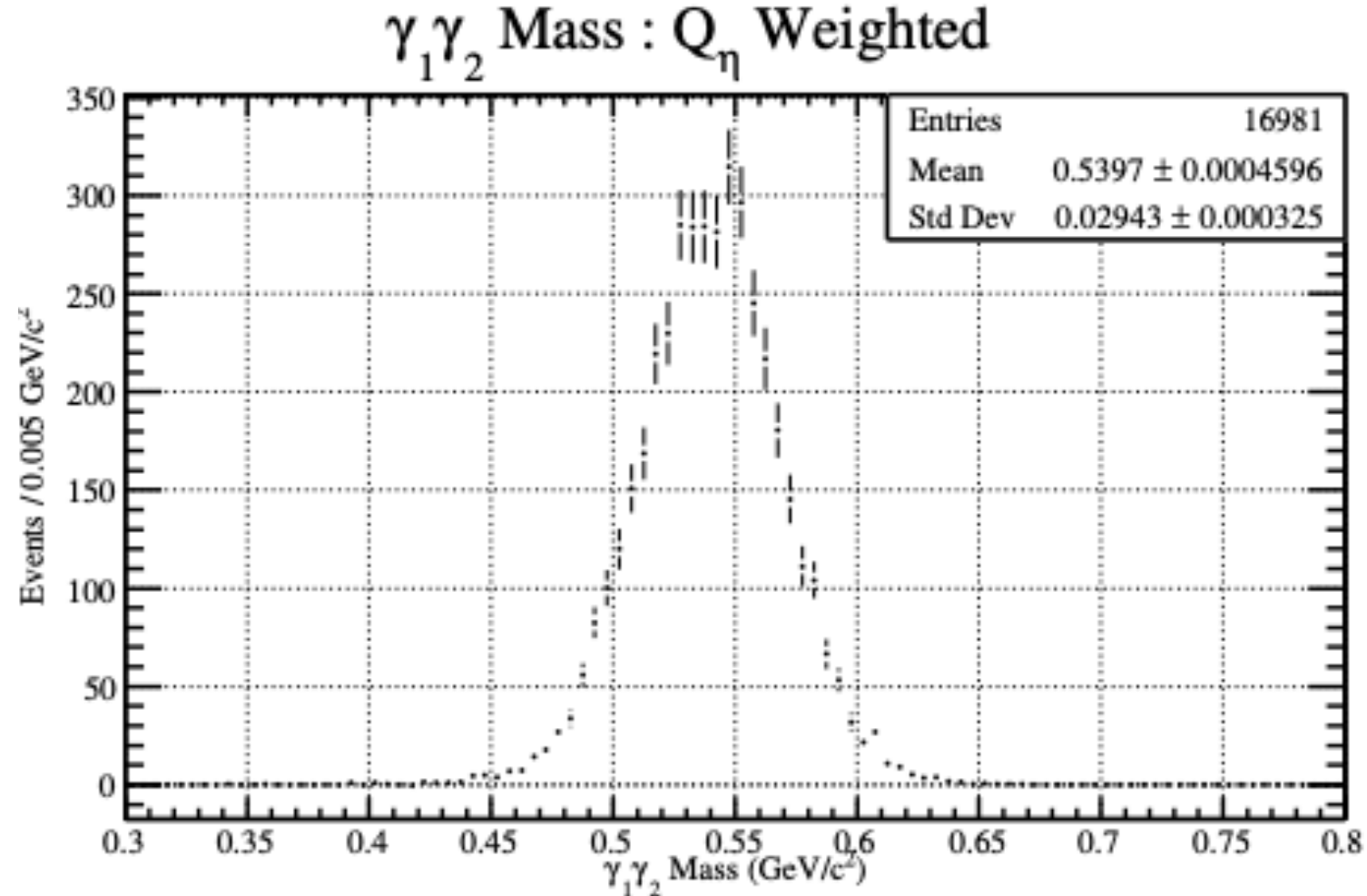
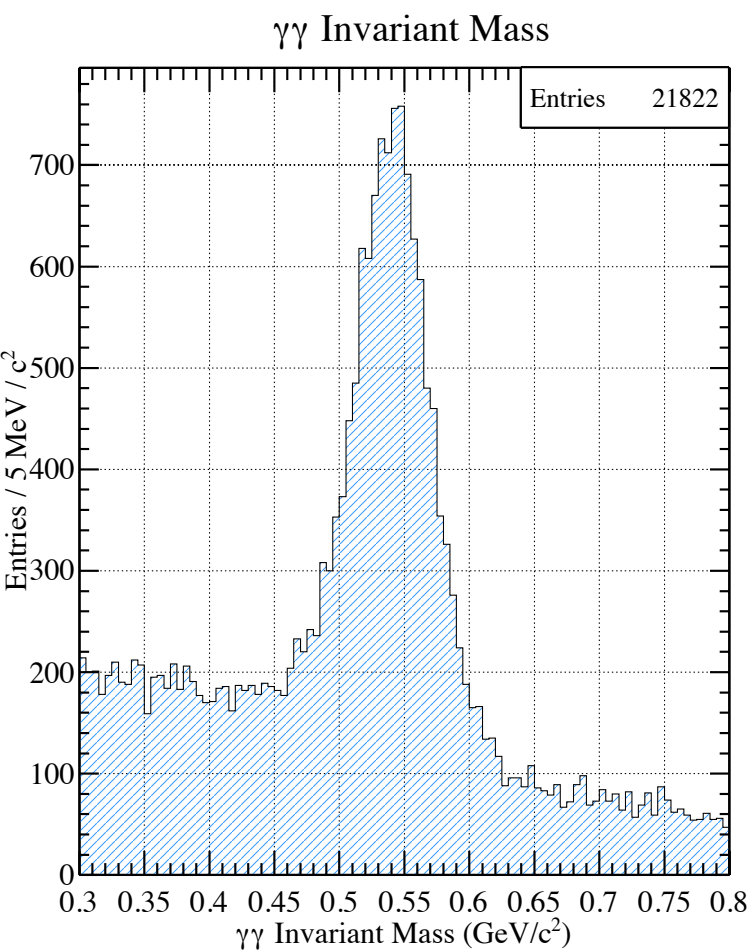


K^+K^- Mass : Q_ϕ Weighted

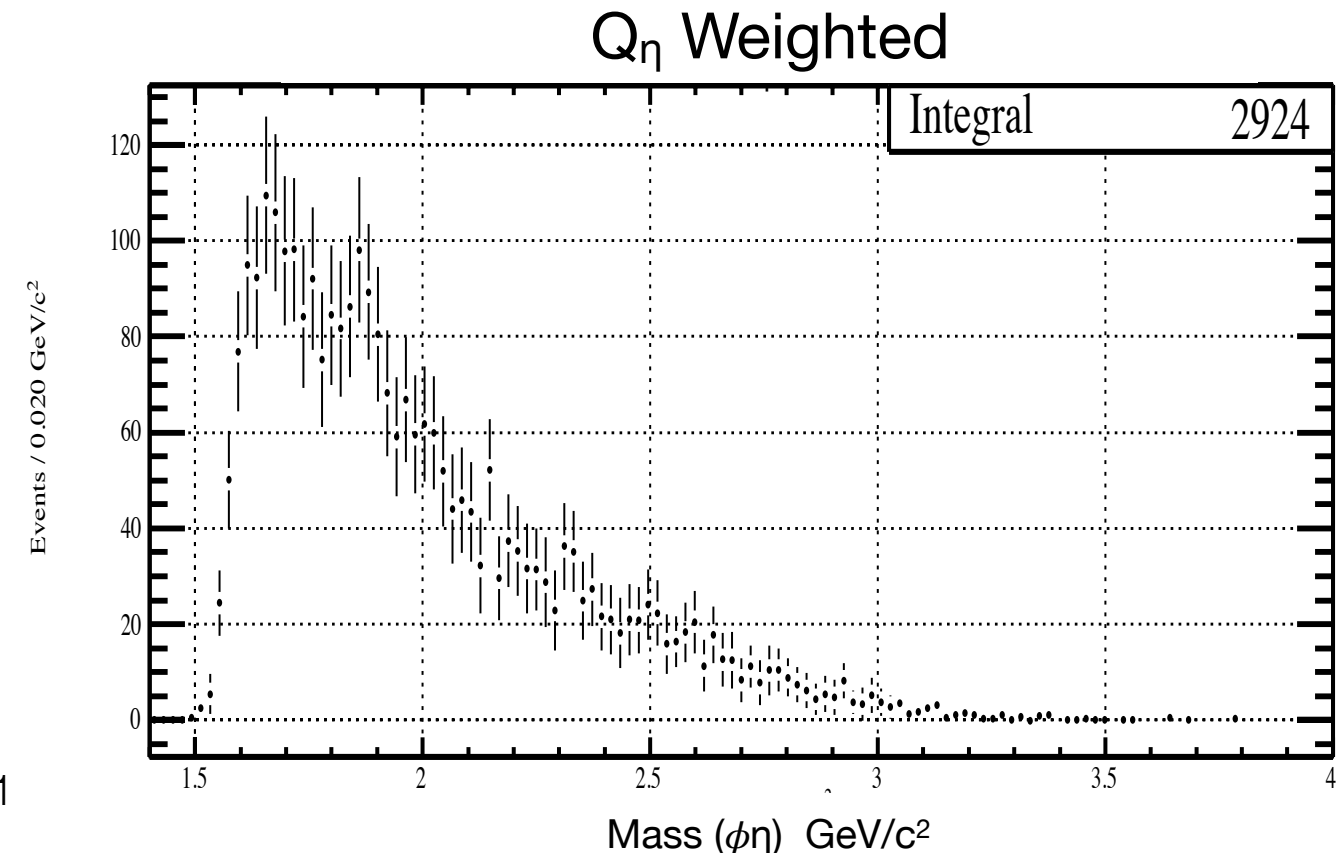
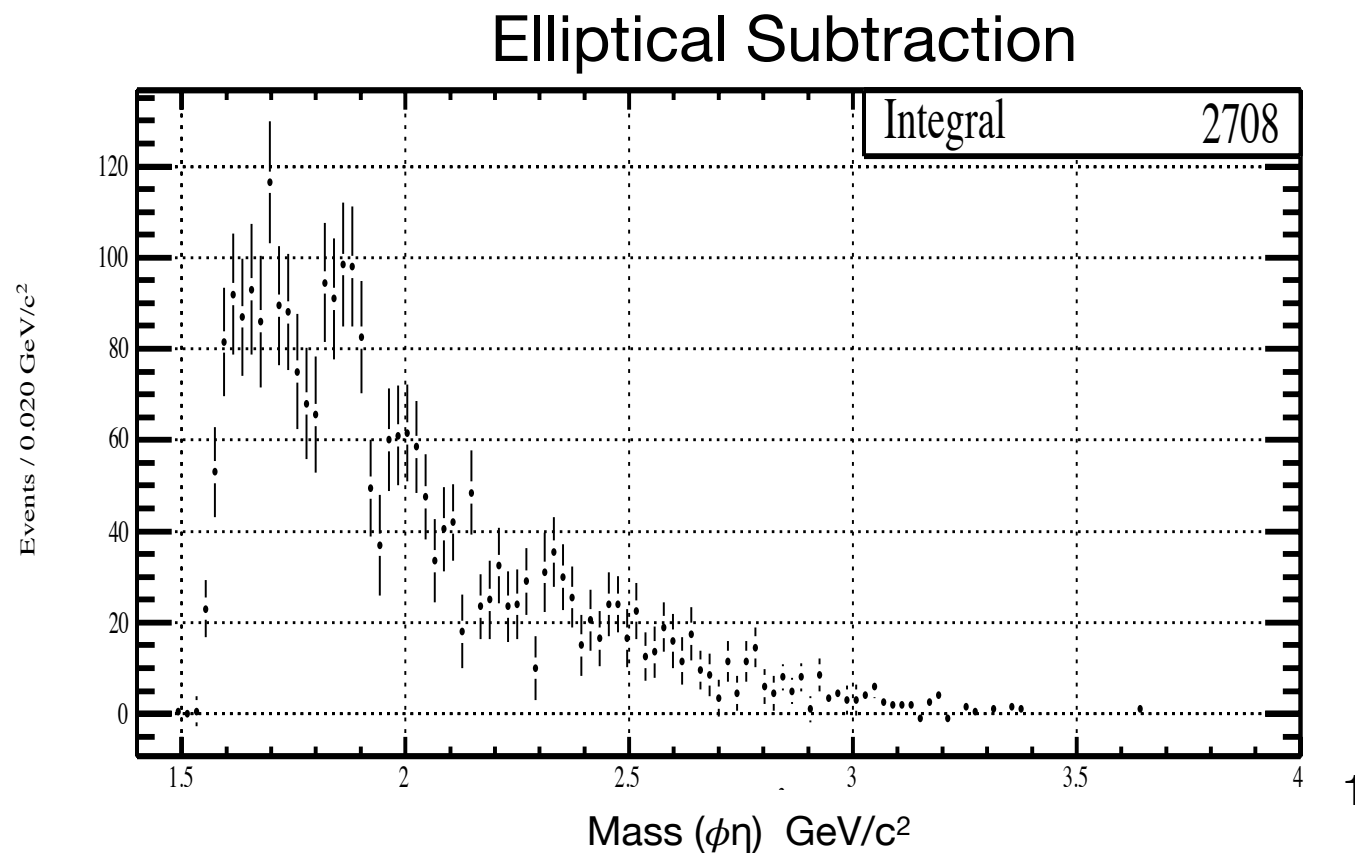
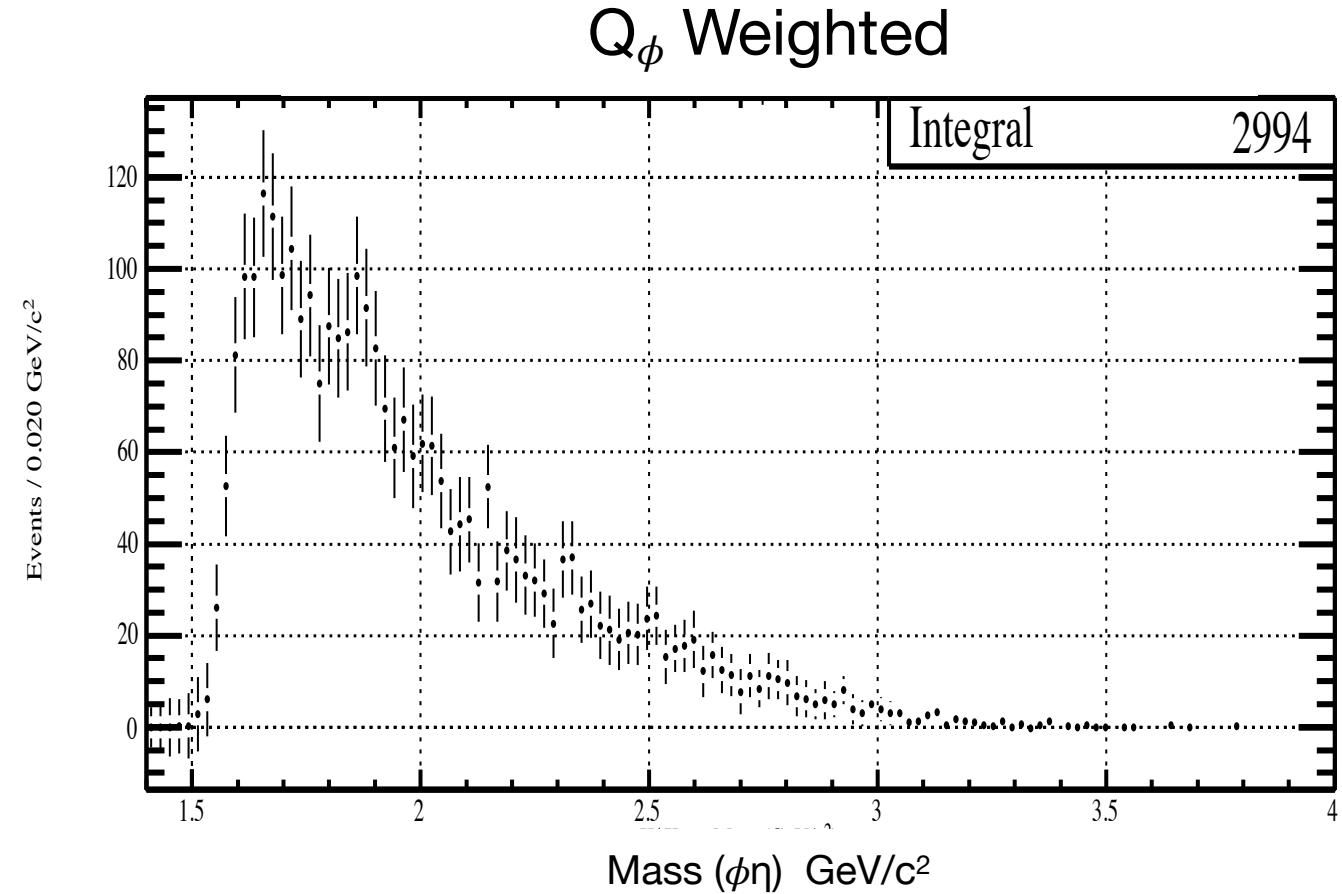
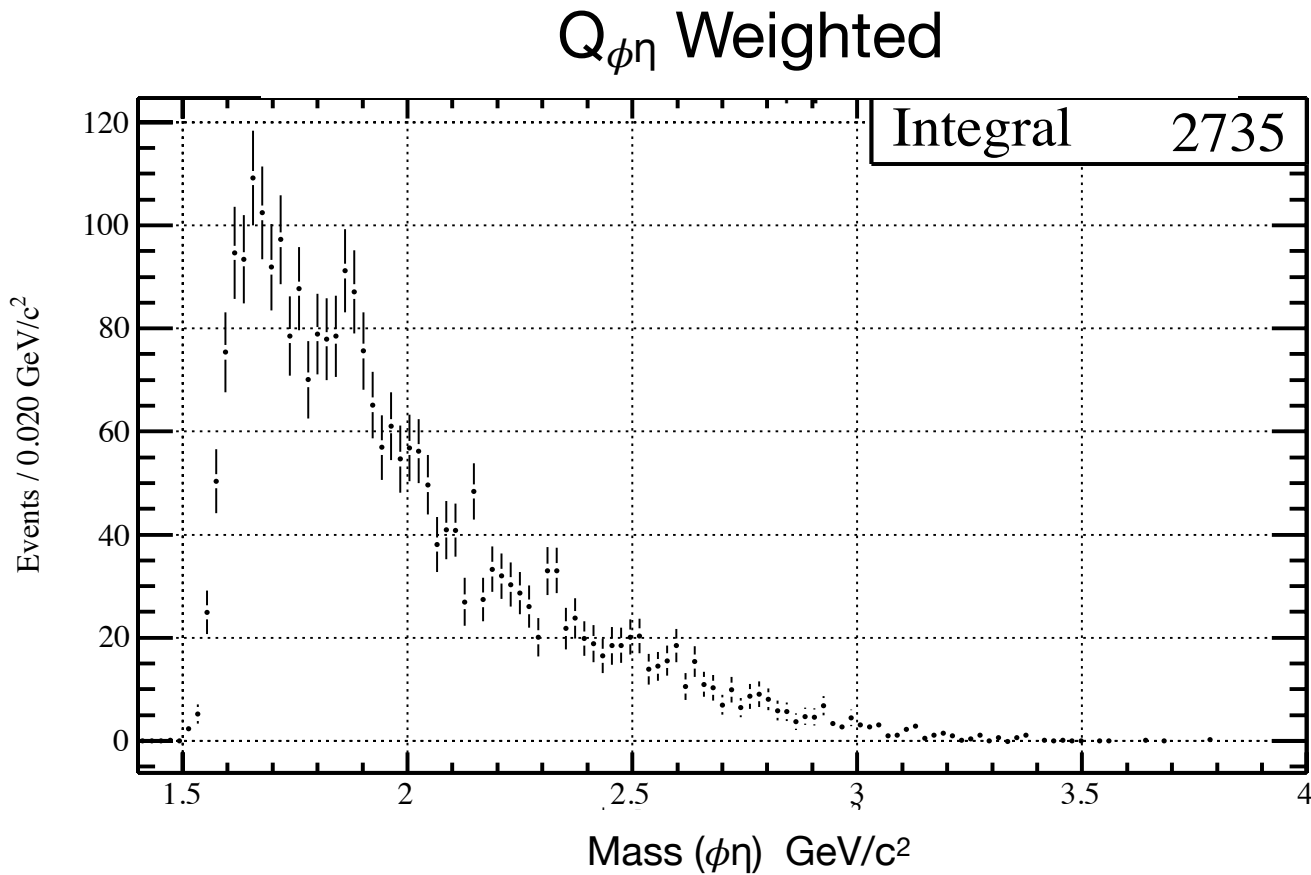


K^+K^- Mass : $1 - Q_\phi$ Weighted



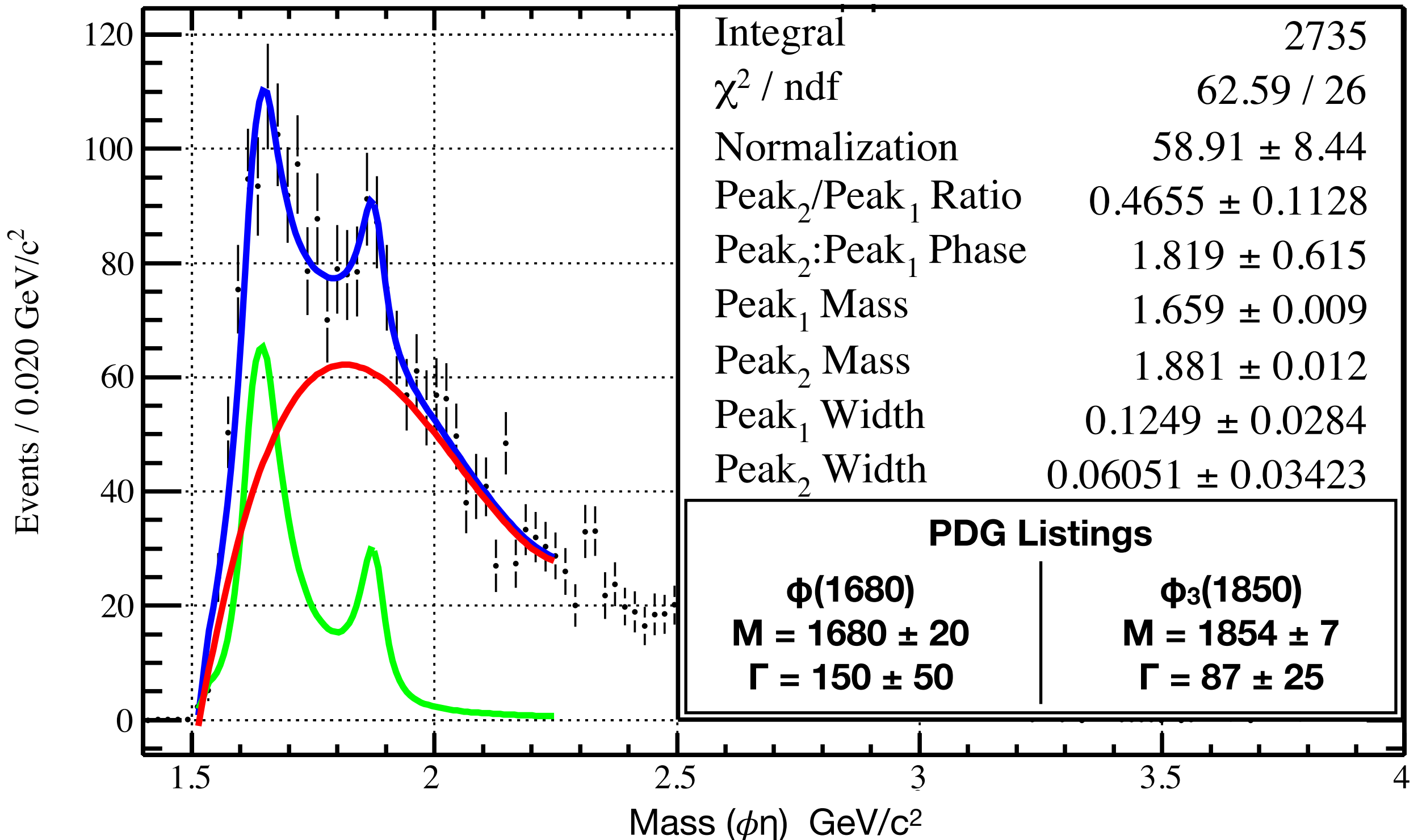


$\phi\eta$ Invariant Mass for Different Selections



Mass Dependent Breit-Wigner Fit

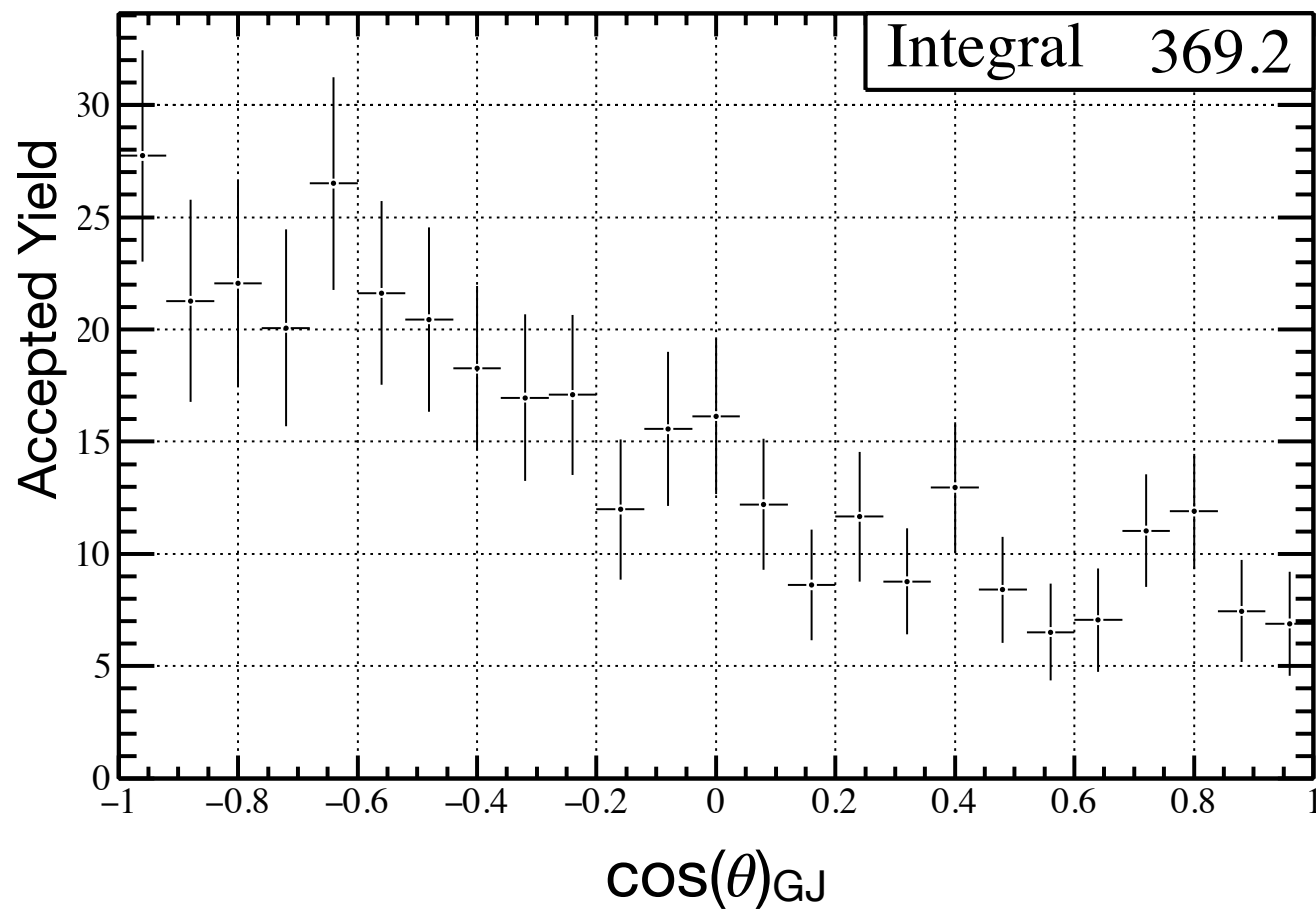
$Q_{\phi\eta}$ Weighted



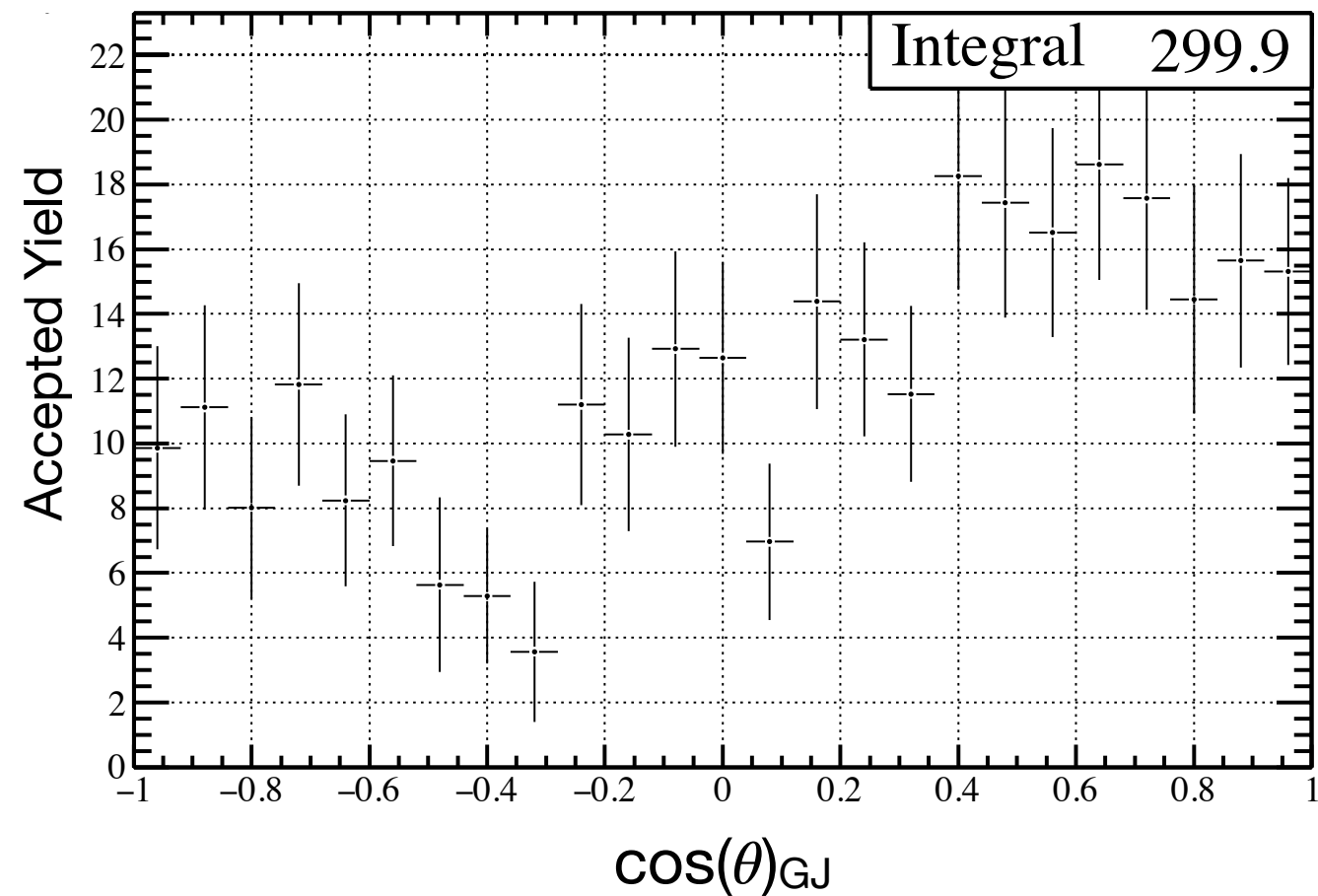
Accepted Decay Angles

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

$\phi(1680)$ Mass Region



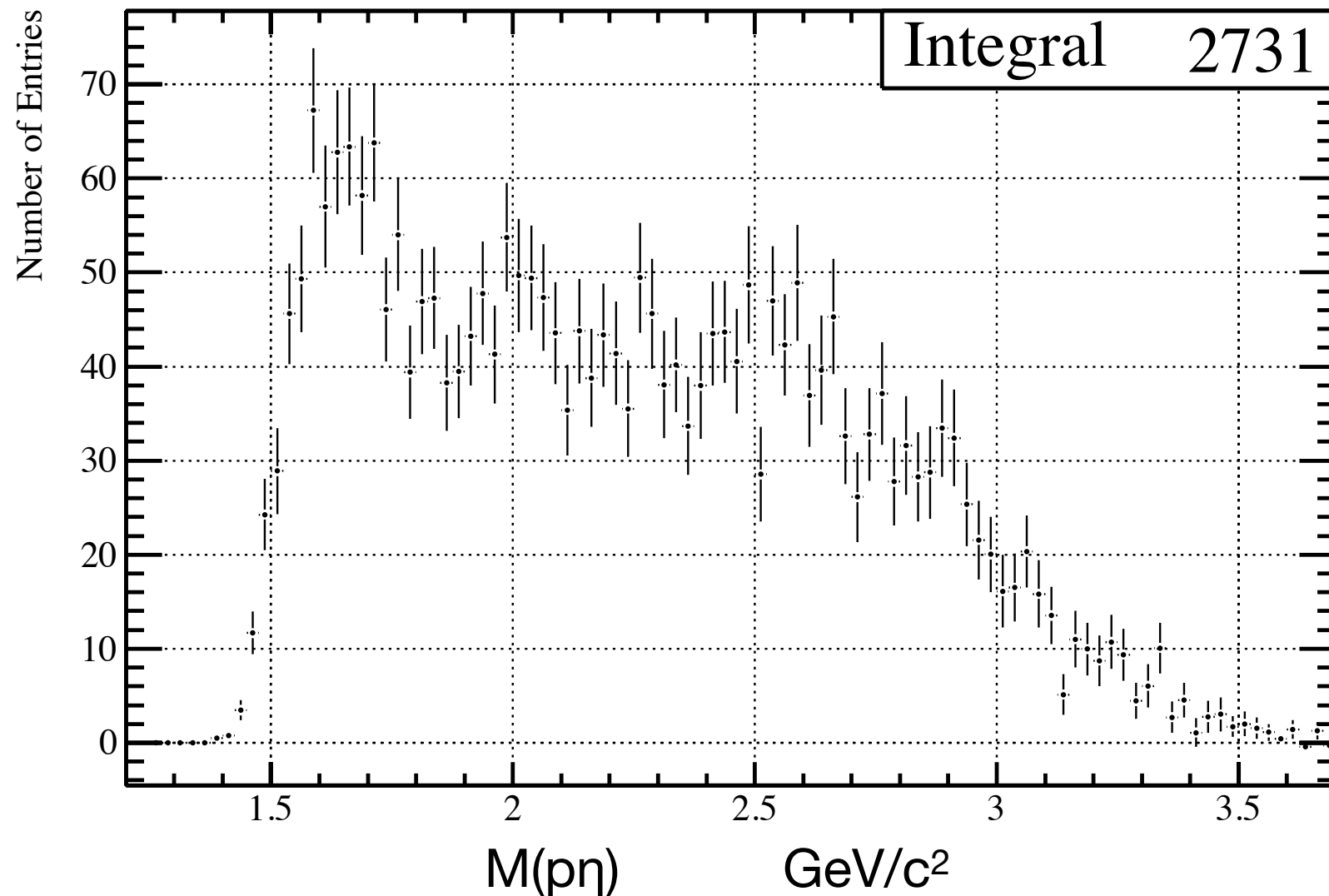
$\phi_3(1850)$ Mass Region



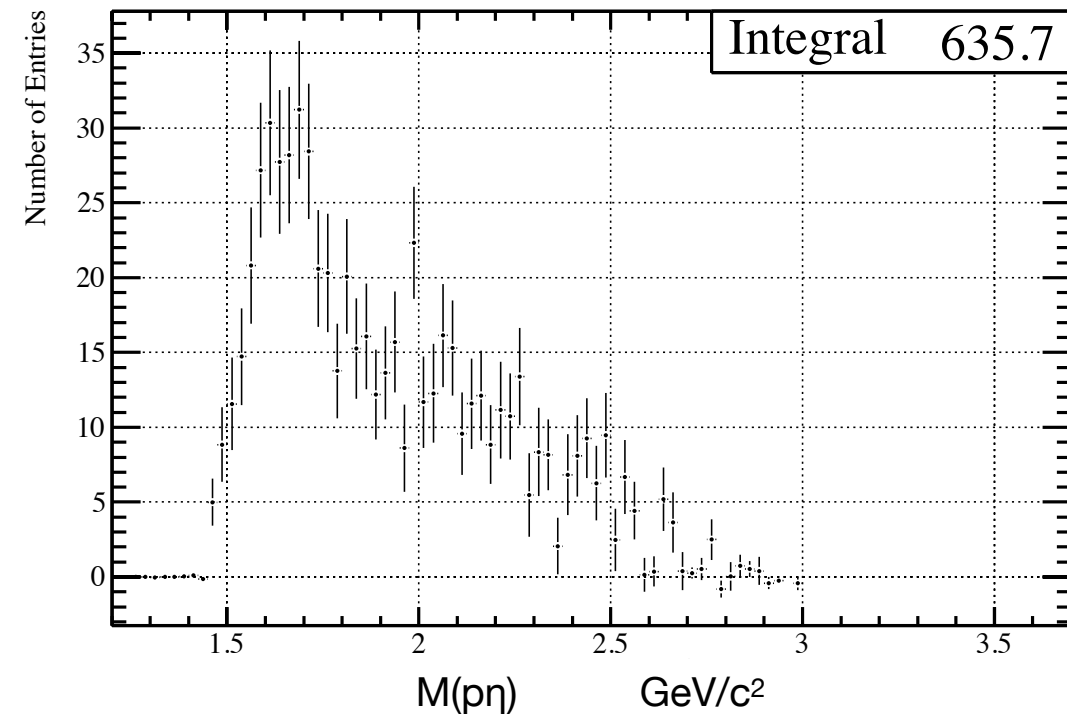
$\gamma p \rightarrow N^* \phi$ Background

$$N^* \rightarrow p \eta$$

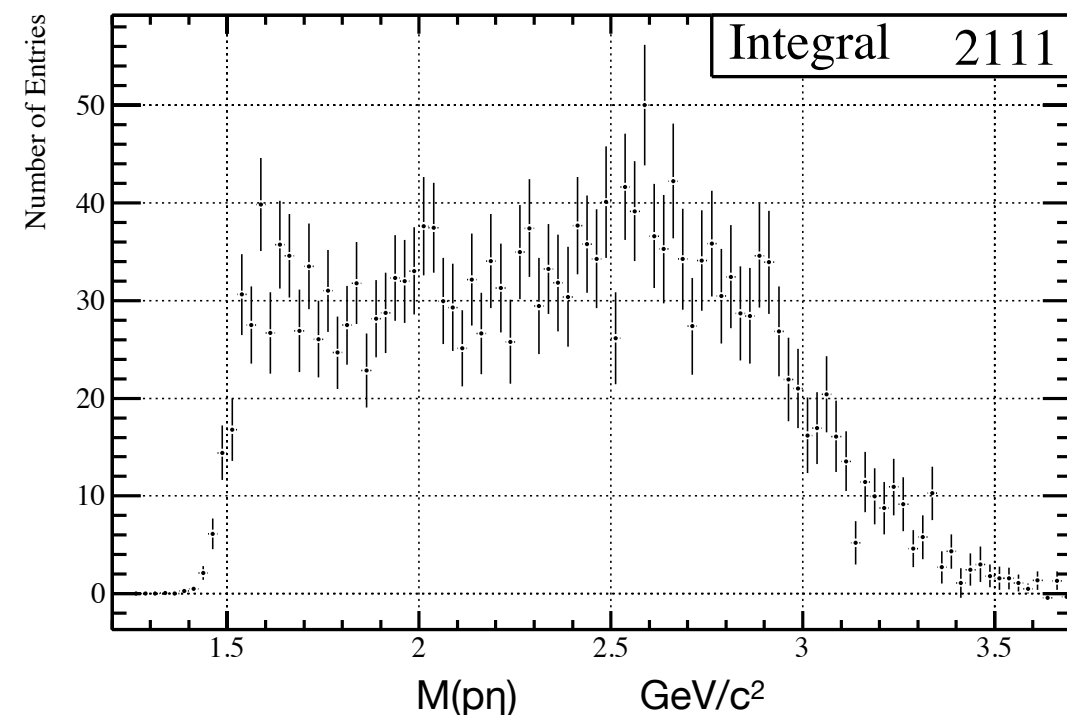
All Beam Energies



Beam Energy < 7.5 GeV

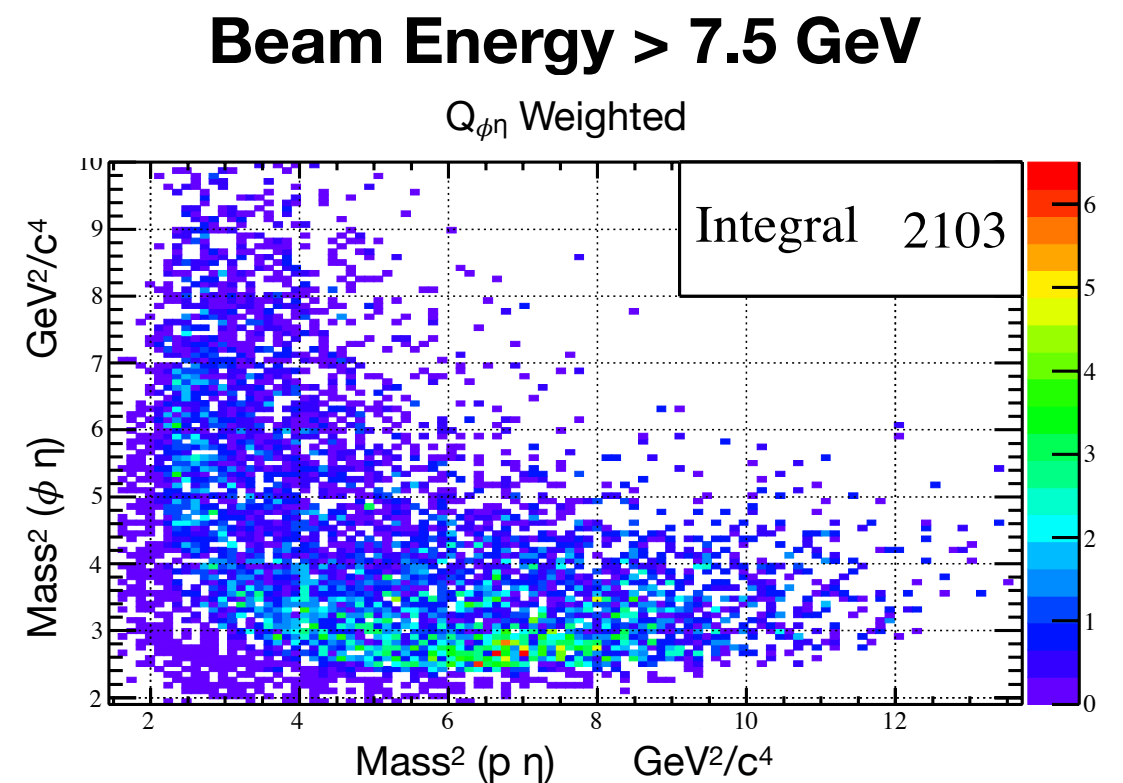
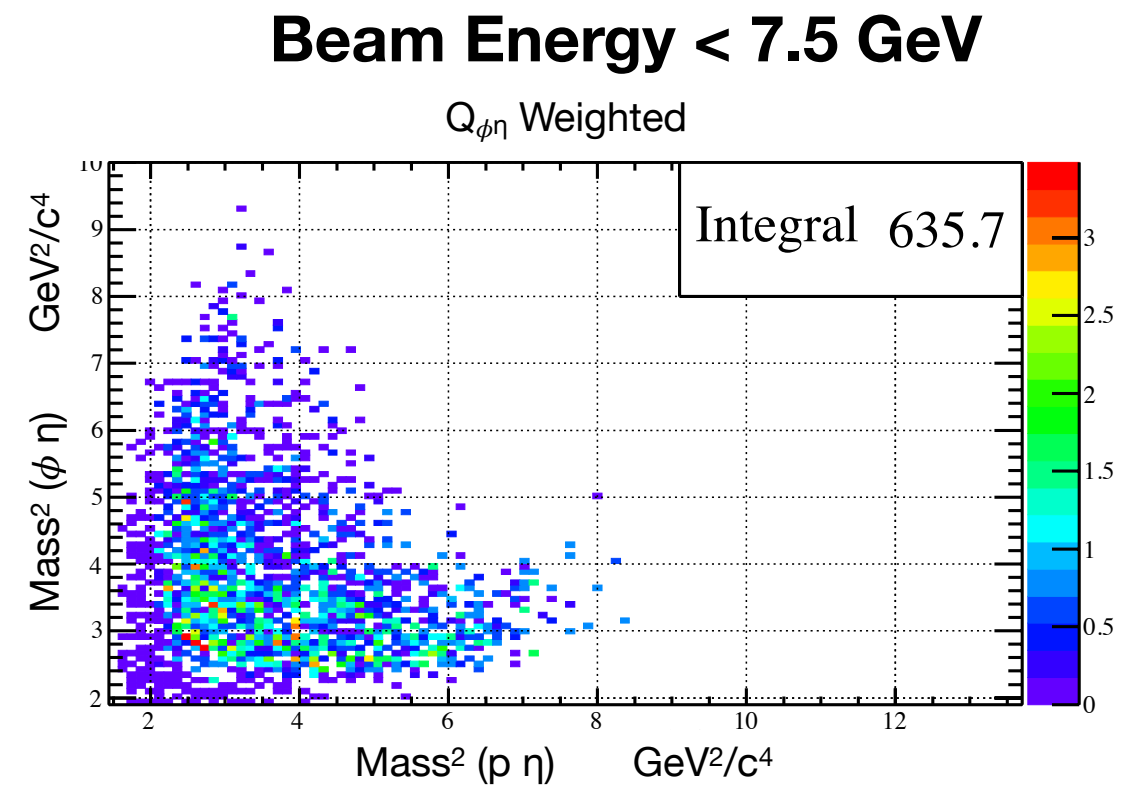
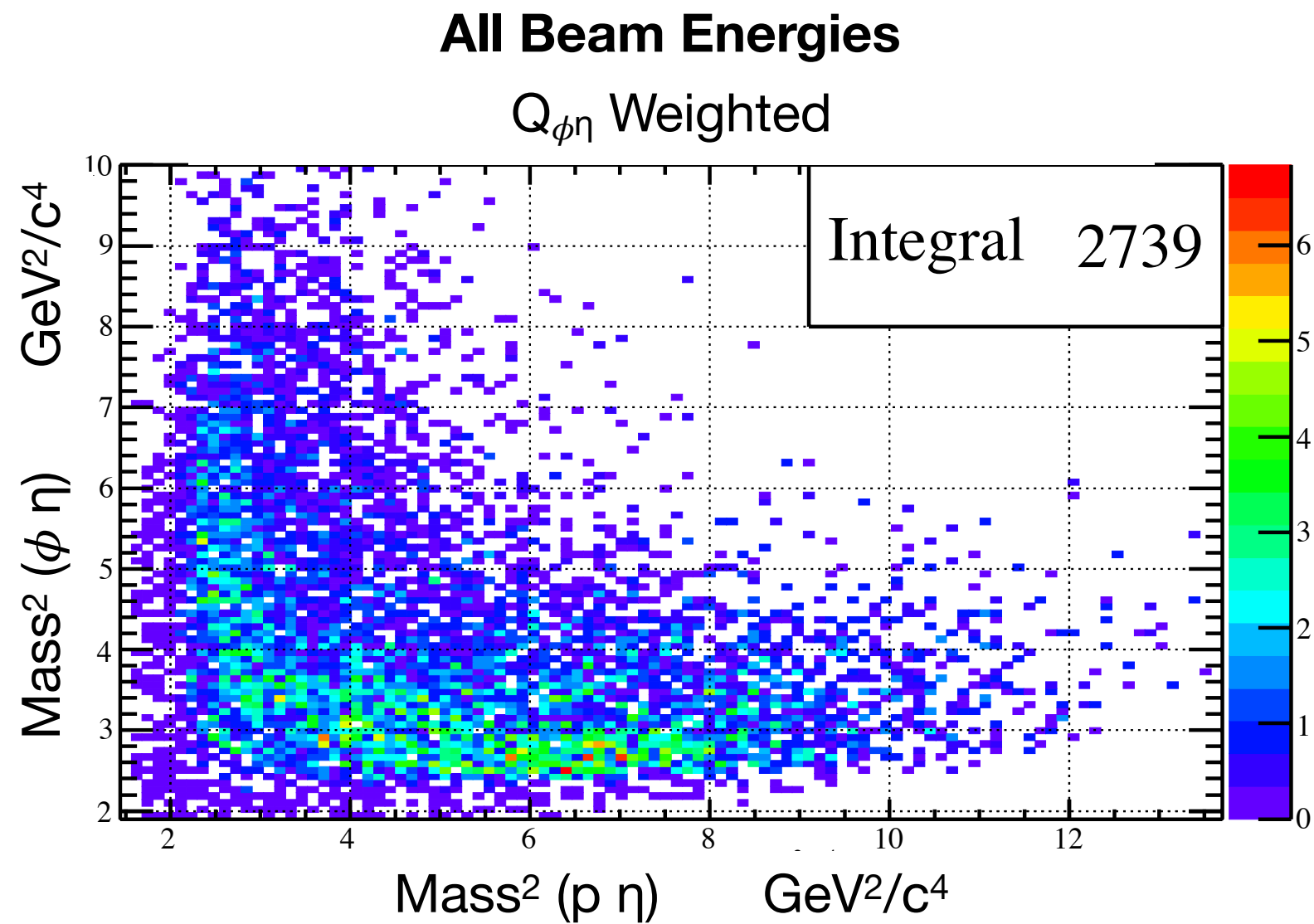


Beam Energy > 7.5 GeV



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

$p\phi\eta$ Dalitz Plots



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 2π
 - 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)