Revisiting the reaction $\gamma p \to \eta \pi^0 \pi^0 p$

University of Athens

January 29, 2018

Outlook:

Updated Cut Flow

Study of the M_η Sidebands

Invariant Mass Histograms

Dataset:

Full Sping 2017 Dataset

The reaction $\gamma p \to \eta \pi^0 \pi^0 p$:

- The reaction $\gamma p \to \eta \pi^0 \pi^0 p$ is very promising in the search for exotics
- The exotic η_1 state (if it exists) can couple to $f_2(1270)\eta$ as well as to $\alpha_2(1320)\pi$, leading to $\eta \pi^0 \pi^0$ in the final state
- We are particularly interested in the process $\eta_1 \to f_2(1270)\eta \to \eta \pi^0 \pi^0$ (the Branching Ratio for $\alpha_2(1320) \to \eta \pi^0$ is much smaller)
- The exotic η_1 state is one of the "early-reach" exotics that GlueX searches for

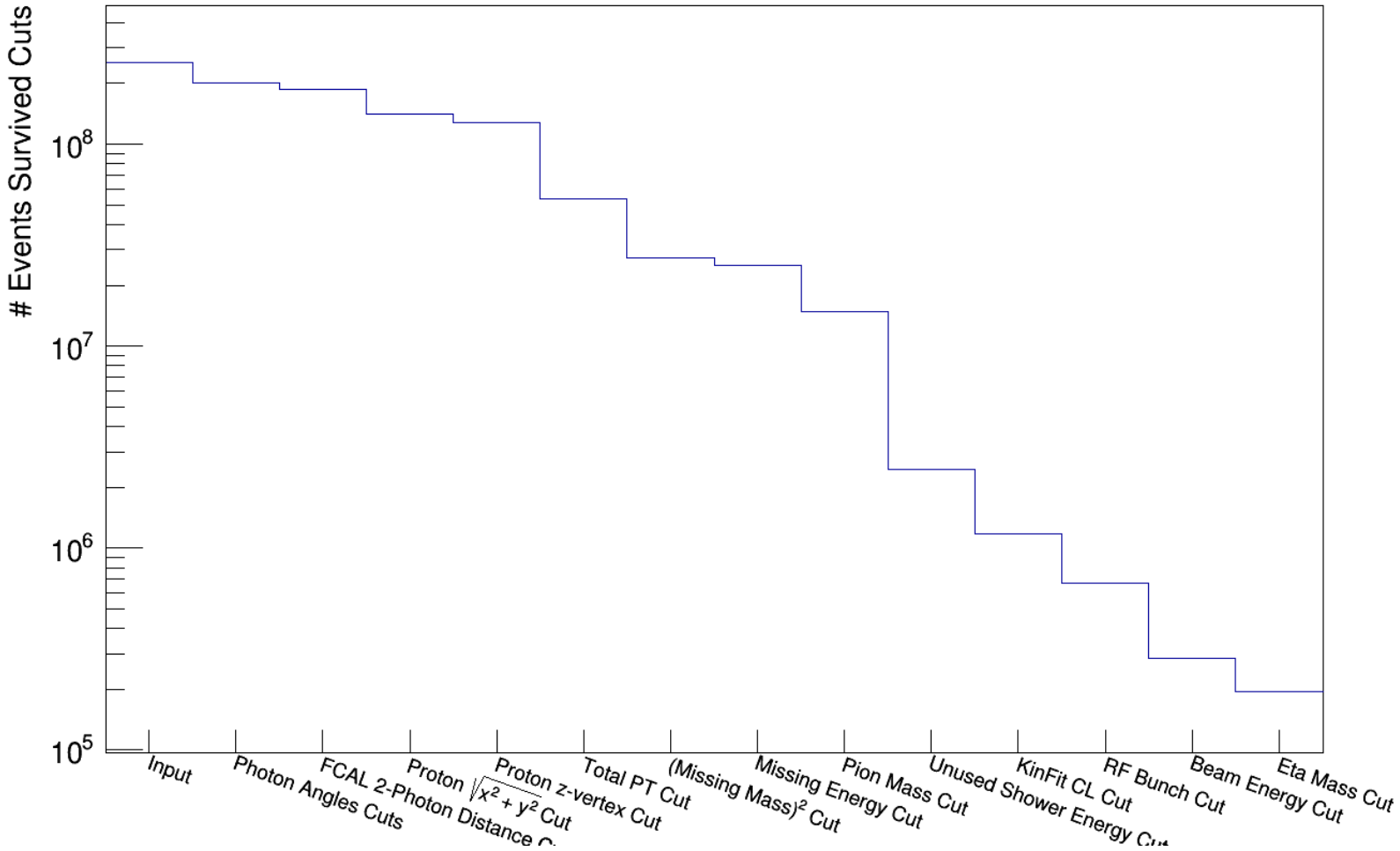
The Cut Flow

$\eta\pi^0\pi^0$ Updated Cut Flow:

- Analysis Launch Cuts
- $2^\circ < \theta_\gamma < 10.5^\circ, \theta_\gamma > 11.5^\circ$
- Distance($\gamma\gamma$) in FCAL > 18 cm
- Proton $\sqrt{x_{vertex}^2 + y_{vertex}^2} > 1$ cm
- 50 < Proton z_{vertex} < 80 cm
- Total PT < 200 MeV
- -0.02 < $(Missing\ Mass)^2 < 0.02\ (GeV/c^2)^2$
- -0.6 < Missing Energy < 0.6 GeV
- $0.11 < M_{\pi^0} < 0.16\ GeV/c^2$
- Unused E_{shower} < 100 MeV
- P4 + Vertex Fit
- KinFit FOM = 1E-4
- $|\Delta t_{Beam-RF}| < 2$ ns
- Beam Energy > 7 GeV
- $0.5 < M_\eta < 0.6\ GeV/c^2$ ‘

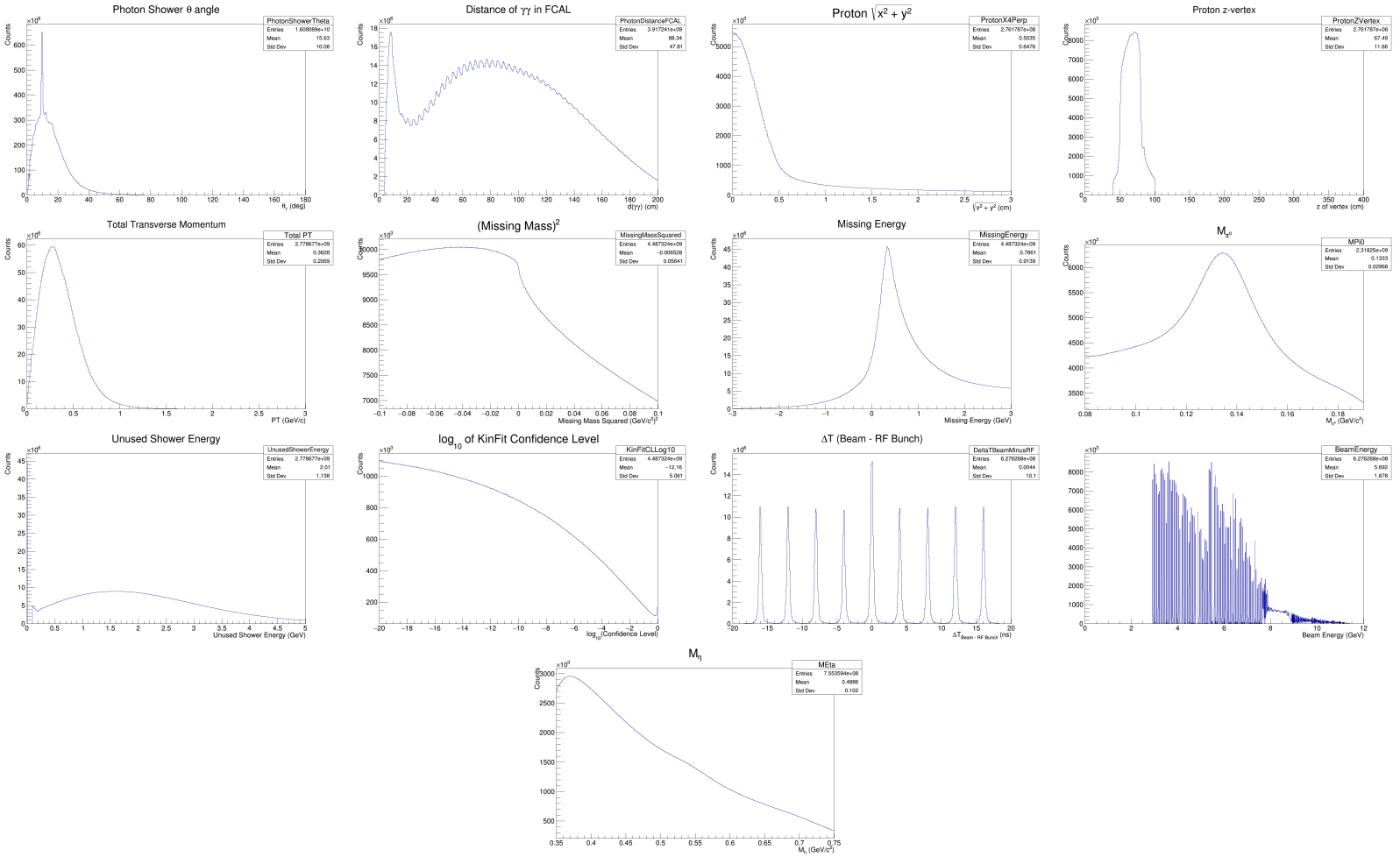
(See Backup Slides for histograms of each cut)

Number of events that survived the cuts:



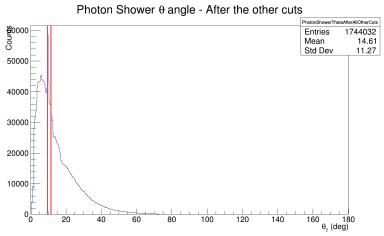
Cut-quantities before the application of the cuts:

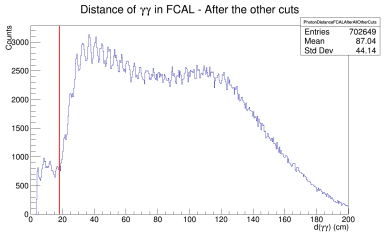
(See Backup Slides for details)

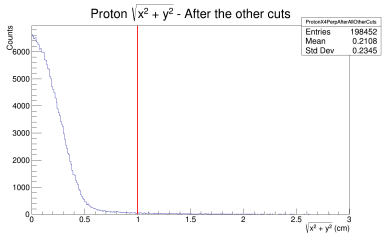


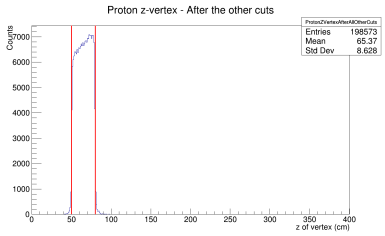
Cut-quantities after the application of the cuts:

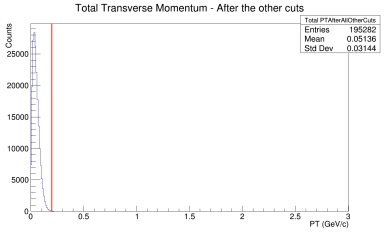
(See Backup Slides for details)

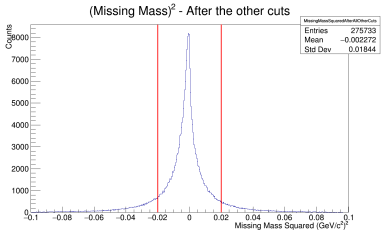


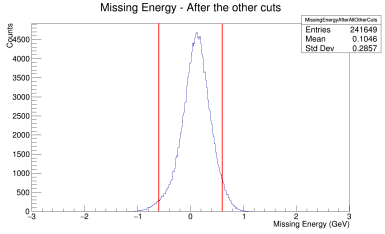


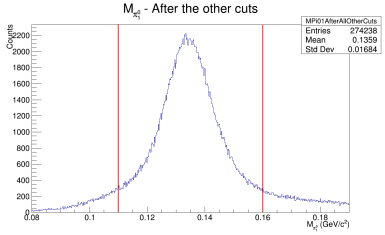


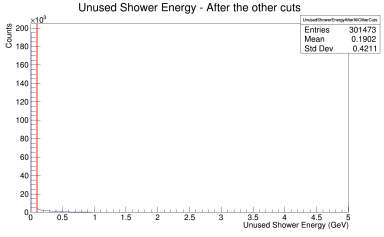


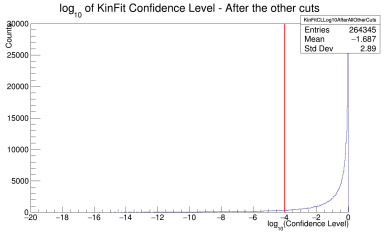


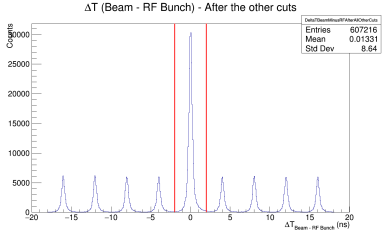


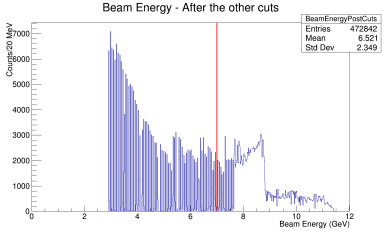


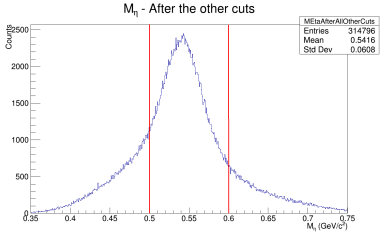










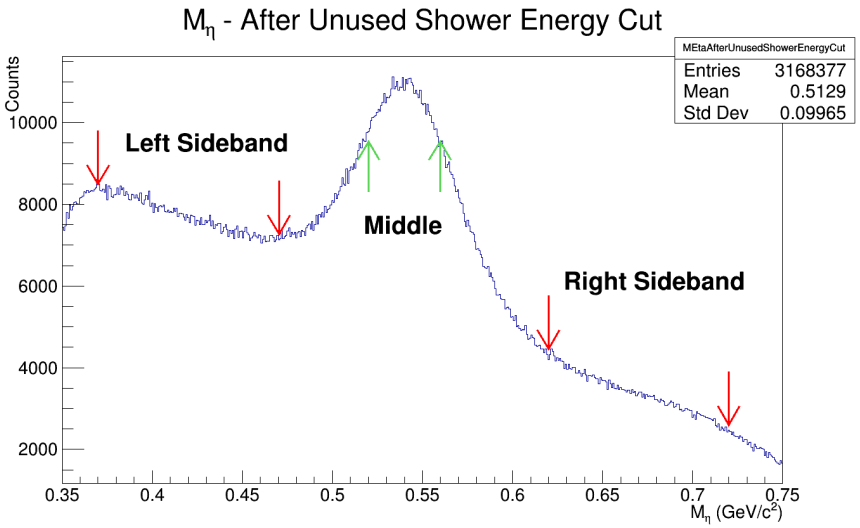


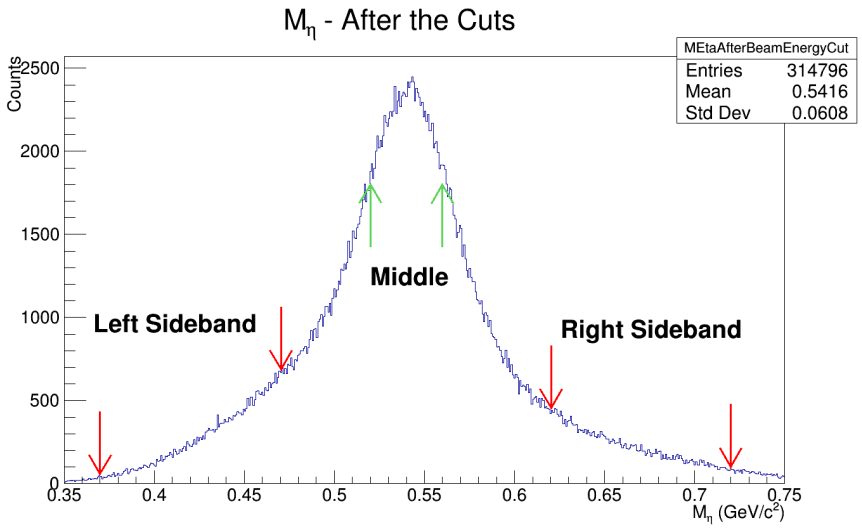
The M_η Sidebands

The M_η Sidebands:

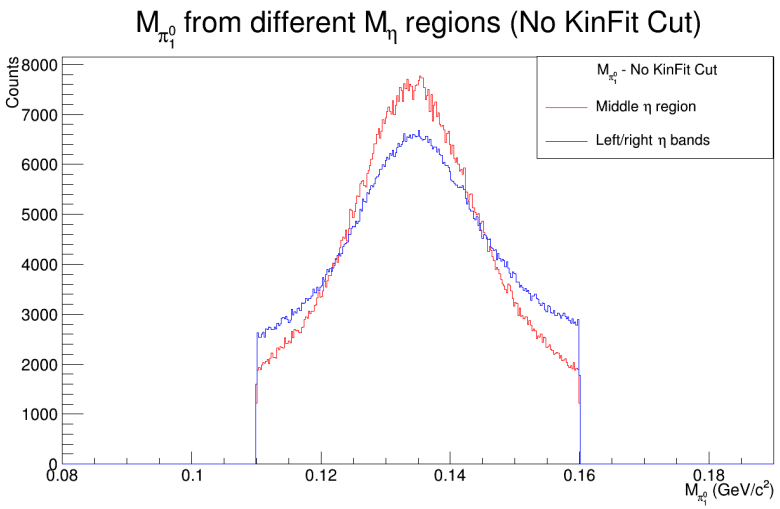
- During the first presentation of the $\eta\pi^0\pi^0$ results, questions were raised about the combinatoric background, especially in the M_η histogram
- The main suggestion was to widen the M_η cut and take a look at the sidebands
- We took events from the η sidebands as well as from the η signal region and plotted invariant mass histograms for different meson combinations
- We worked with two different versions of the η-mass histogram: a) the one after the Unused Shower Energy cut, where the sideband structure is prominent, and b) the one after all the cuts
- In what follows, the sidebands and the signal region plots have been normalized and superimposed for each different combination

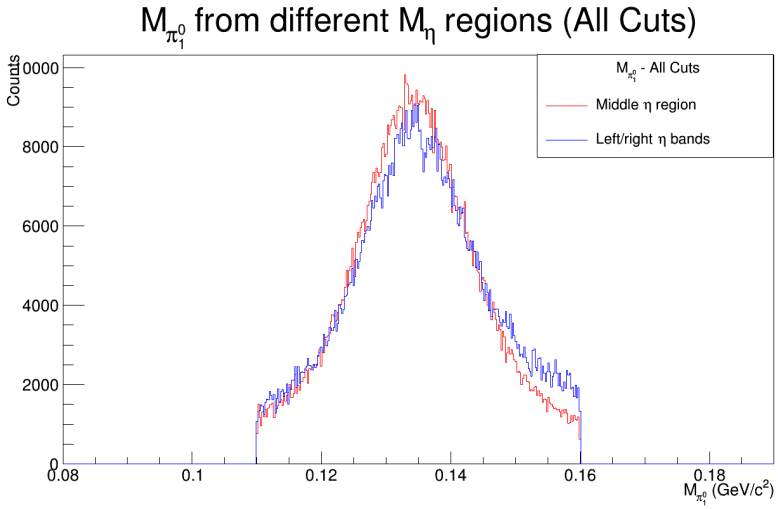
M_η - the ranges that were used:



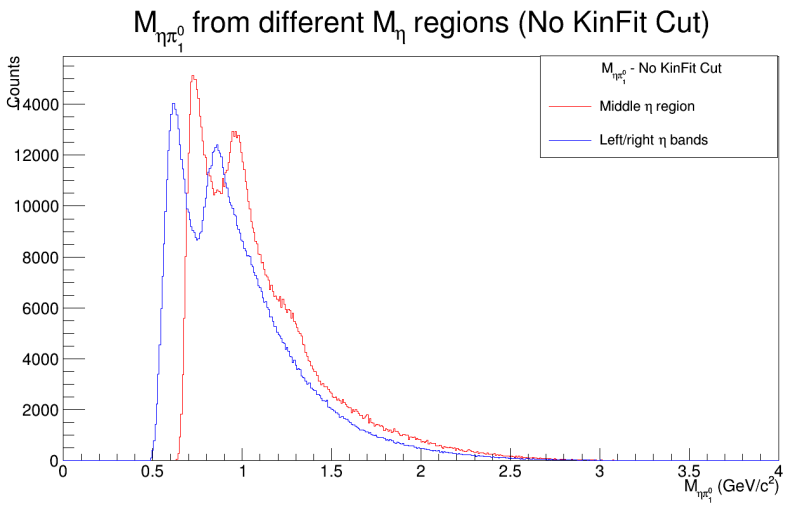


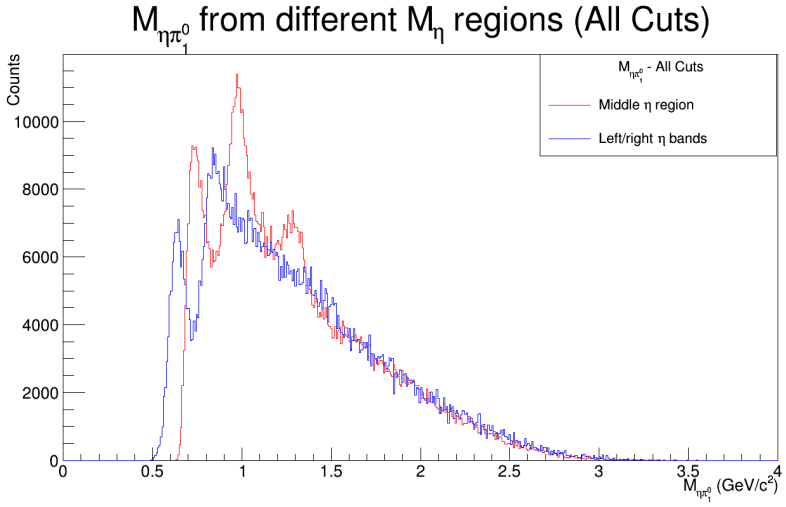
$M_{\pi 0}$:


$M_{\pi_1^0}$ from different M_η regions (No KinFit Cut)
Counts
$M_{\pi_1^0}$ - No KinFit Cut
Middle η region
Left/right η bands
$M_{\pi_1^0}$ (GeV/c^2)


$M_{\pi_1^0}$ from different M_η regions (All Cuts)
Counts
$M_{\pi_1^0}$ - All Cuts
Middle η region
Left/right η bands
$M_{\pi_1^0}$ (GeV/c^2)

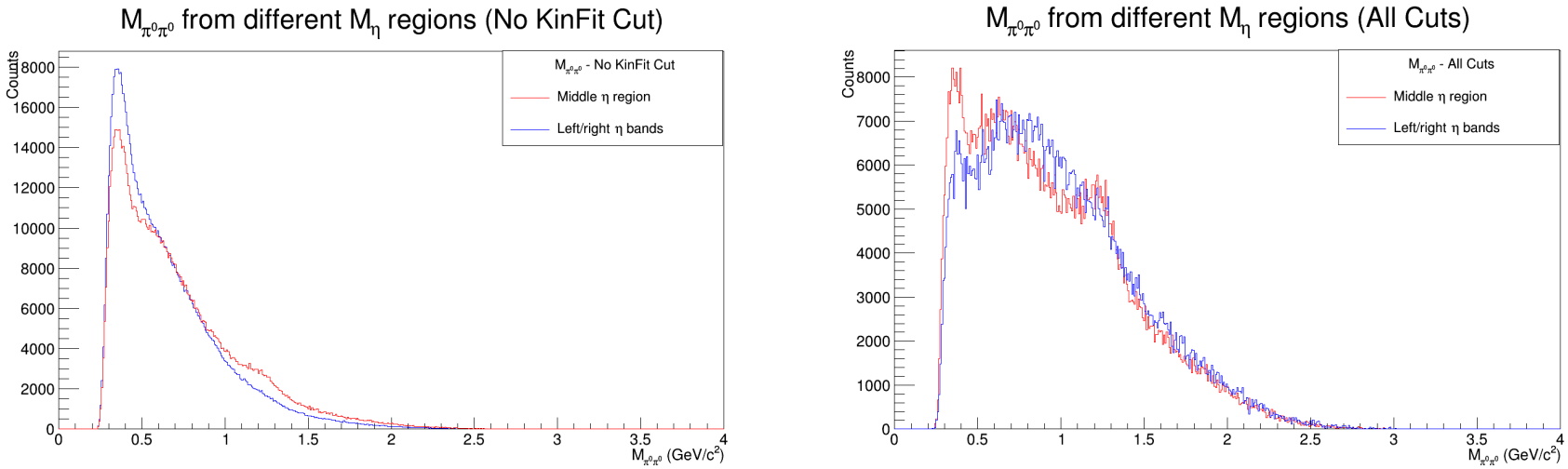
$M_{\eta\pi^0}$:





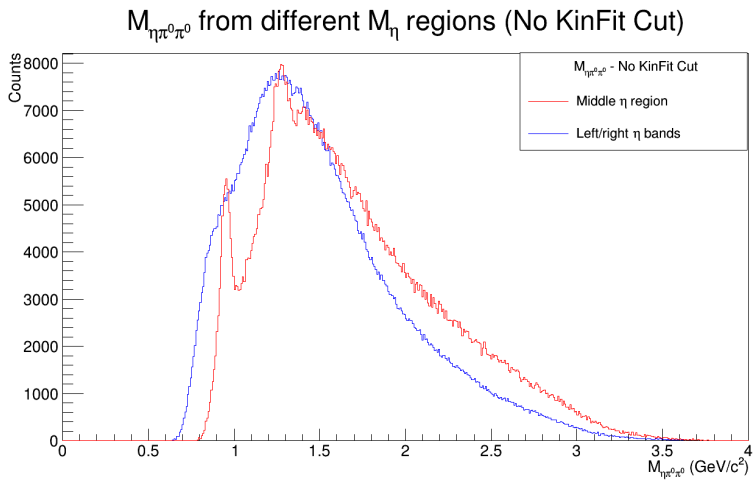
The bumps in the sidebands histogram (blue color) are probably phase space events. The two bumps are ”merged” when we look at events from the η-signal region (red color), giving a low-mass bump around 0.75 GeV/c^2

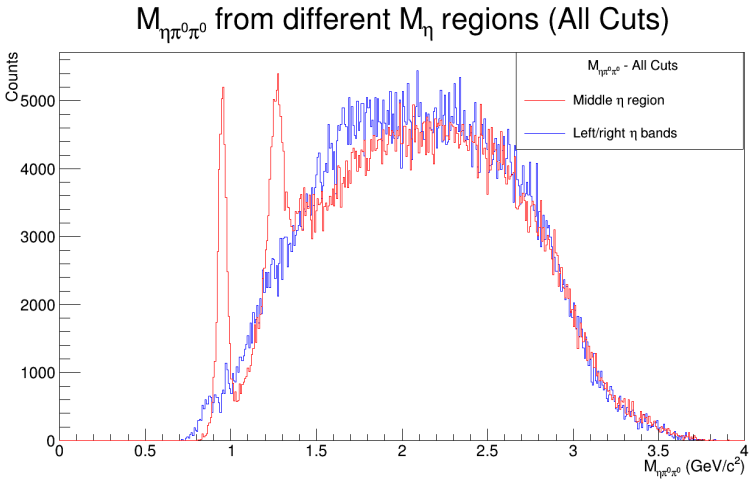
$M_{\pi^0\pi^0}$:

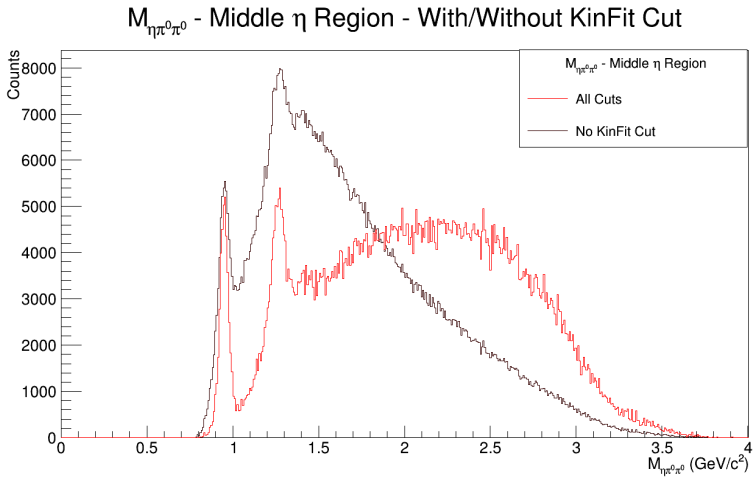


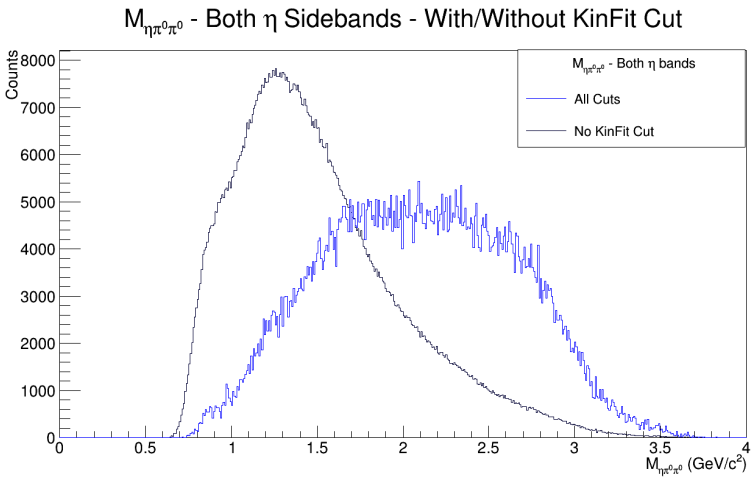
The $f_2(1270)$ is slightly visible in the histogram that was generated using events from the η-signal region (red color)

$M_{\eta\pi^0\pi^0}$:





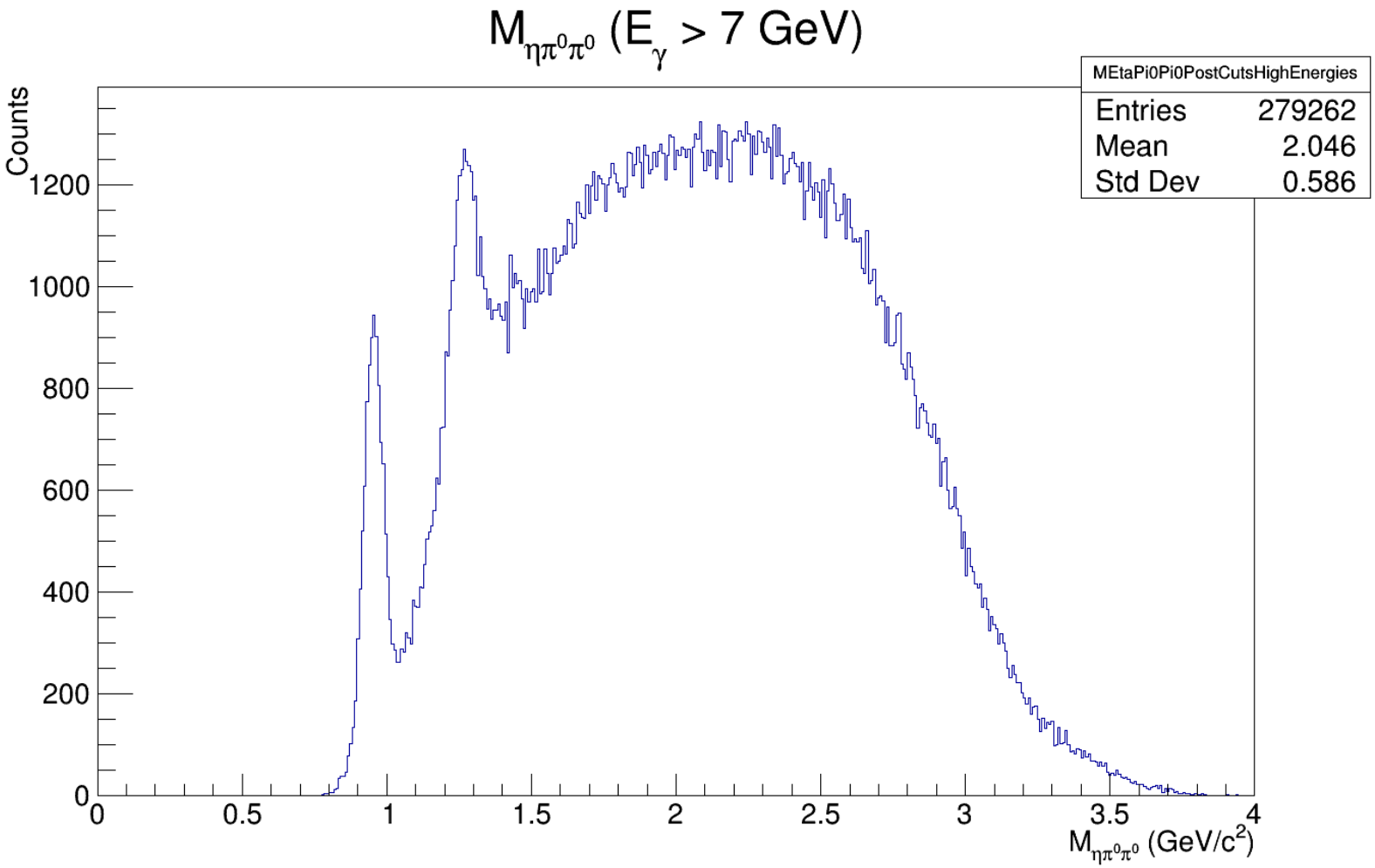




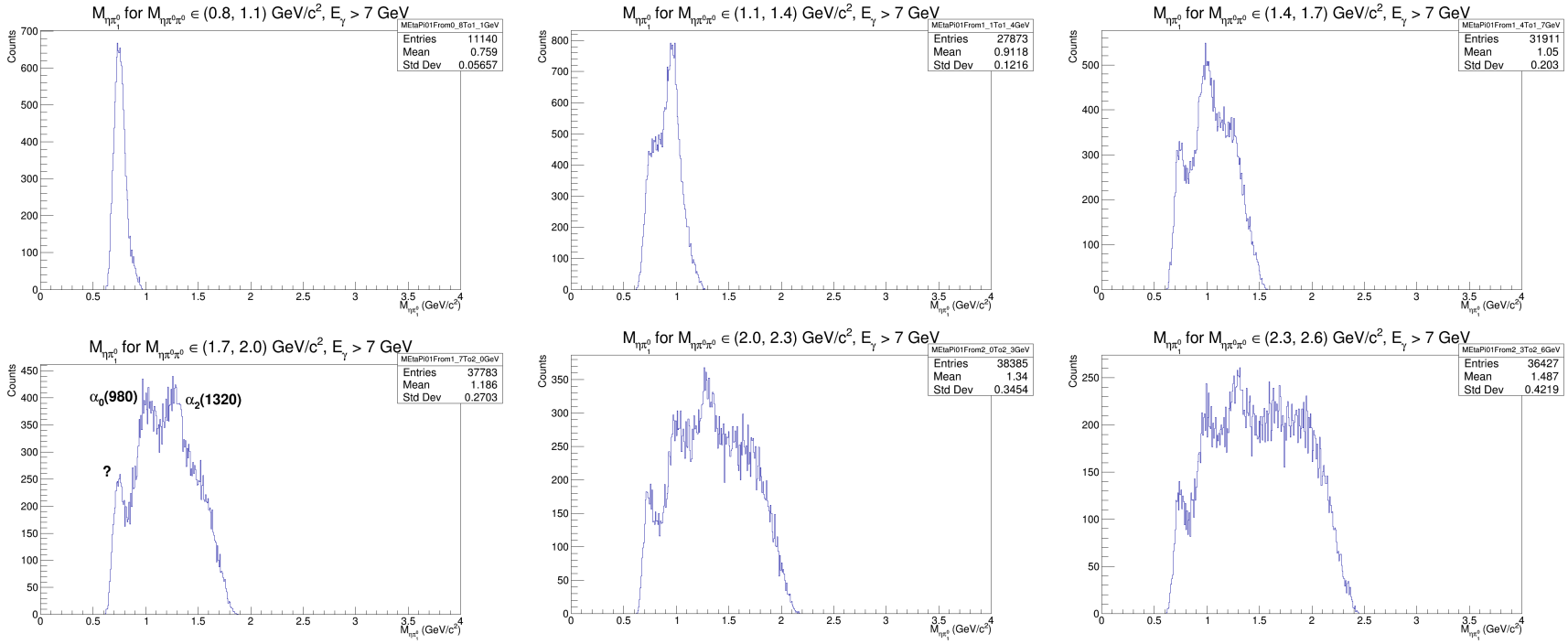
No visible structure in the ”sidebands histogram” (blue color)

Invariant Mass Histograms

$M_{\eta\pi^0\pi^0}$ after the cuts:

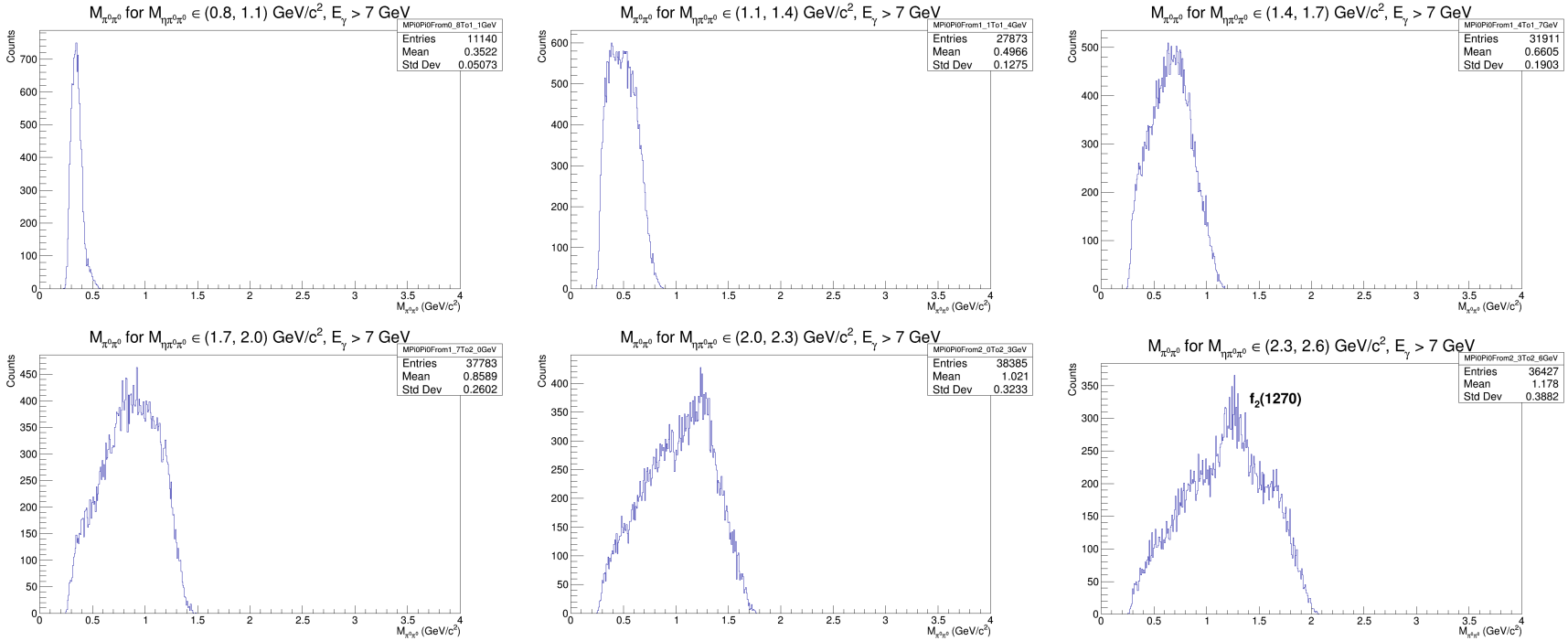


$M_{\eta\pi^0}$ for $E_\gamma > 7\ GeV$ and different $M_{\eta\pi^0\pi^0}$ intervals:



The presence of $\alpha_2(1320)$ in these plots is encouraging since we are searching for the exotic reaction $\eta_1 \to \alpha_2\pi \to \eta\pi^0\pi^0$

$M_{\pi^0\pi^0}$ for $E_\gamma > 7\ GeV$ and different $M_{\eta\pi^0\pi^0}$ intervals:



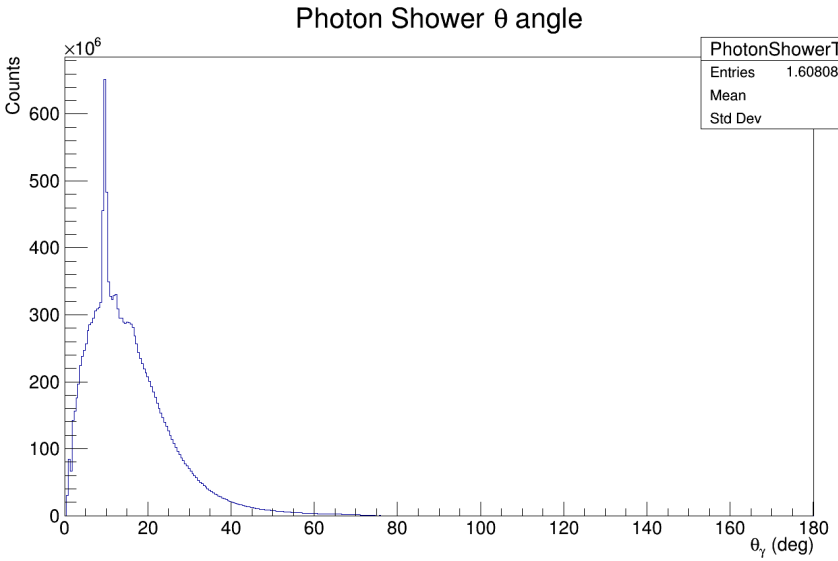
The bottom right plot is the only one that shows a glimpse of $f_2(1270)$. The exotic reaction of interest here is $\eta_1 \to f_2\eta \to \eta\pi^0\pi^0$

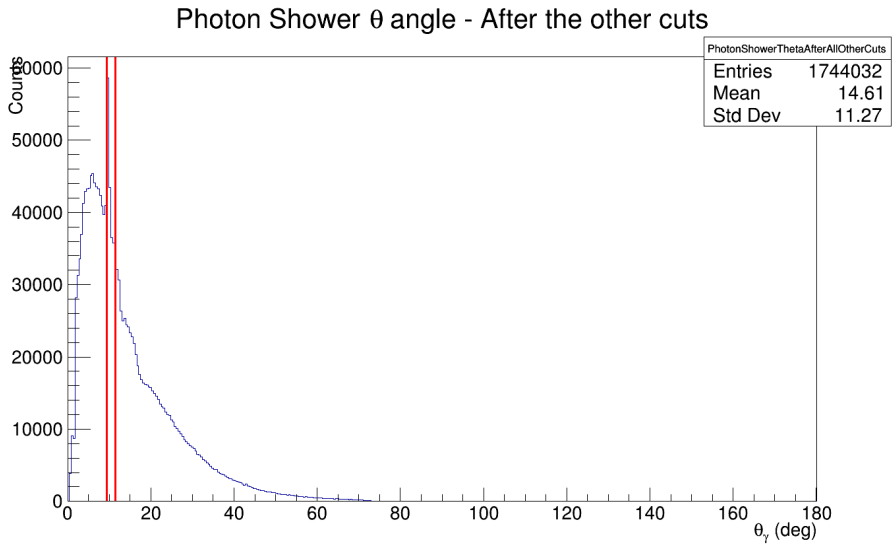
Summary:

- Repeated the $\eta\pi^0\pi^0$ analysis using the full Spring 2017 dataset, an updated set of cuts and the latest REST/Analysis files (REST ver02, Analysis ver08)
- Looking at different meson combinations using events from the M_η side-bands, we don't see any interesting structure, compared to the relevant plots that we get using events from the M_η signal region
- The situation regarding the presence of $f_2(1270)$ and $\alpha_2(1320)$ mesons in the $\pi^0\pi^0$ and $\eta\pi^0$ mass plots hasn't changed, despite the improved statistics
- The work for the combinatoric background determination/elimination is ongoing (ideas are welcome!)

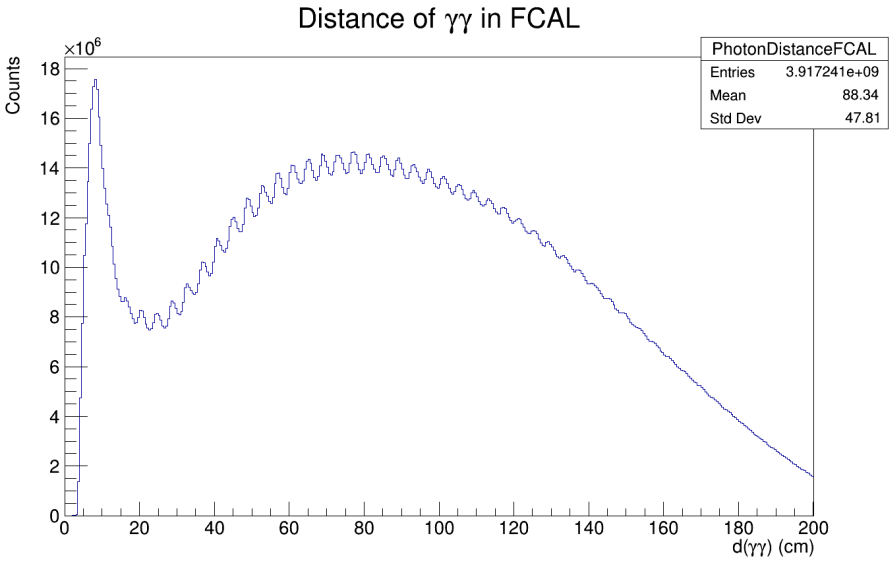
Backup Slides

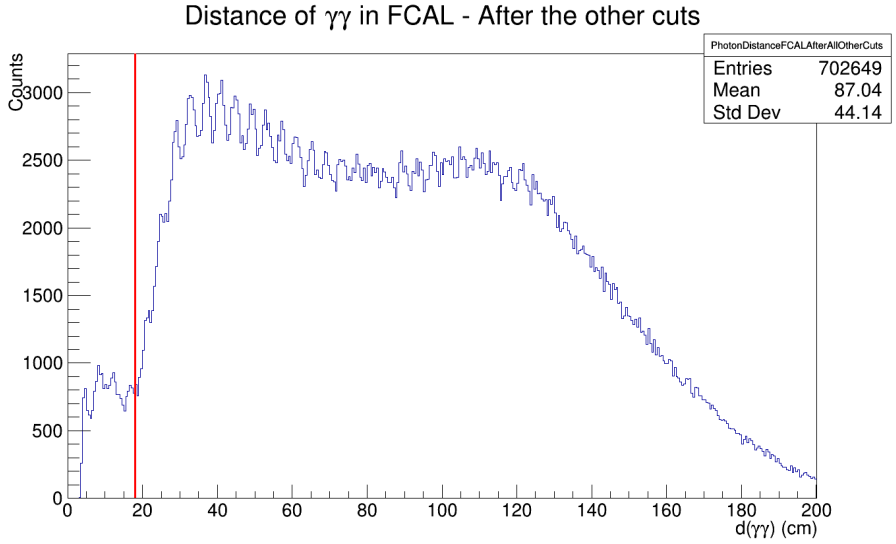
$$2^\circ < \theta_\gamma < 10.5^\circ, \theta_\gamma > 11.5^\circ$$



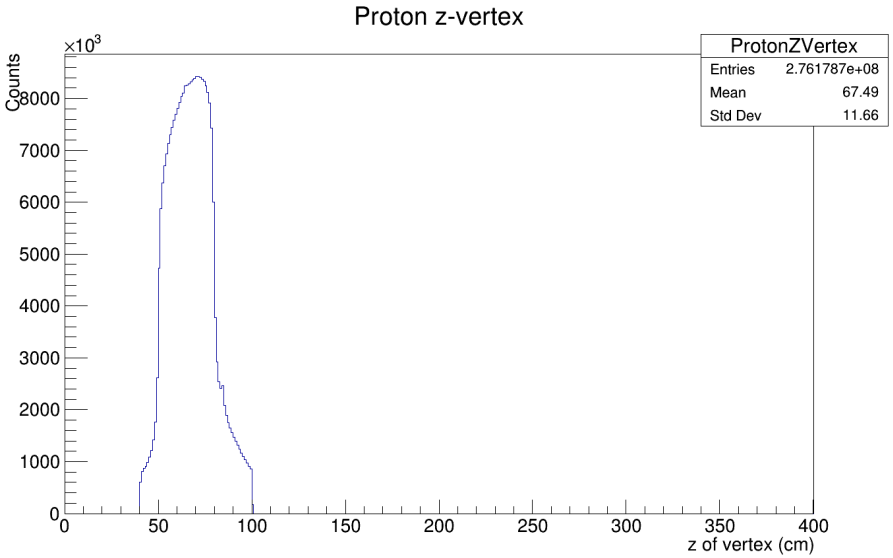


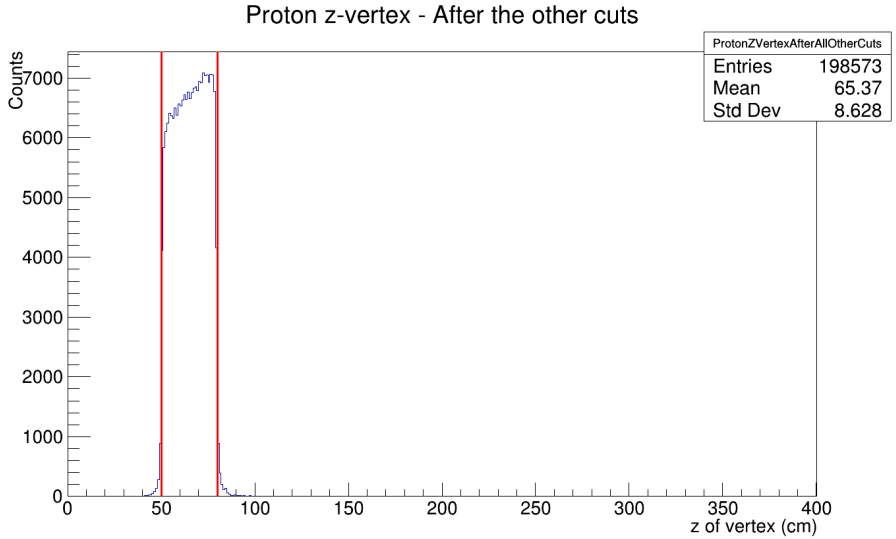
Distance($\gamma\gamma$) in FCAL > 18 cm



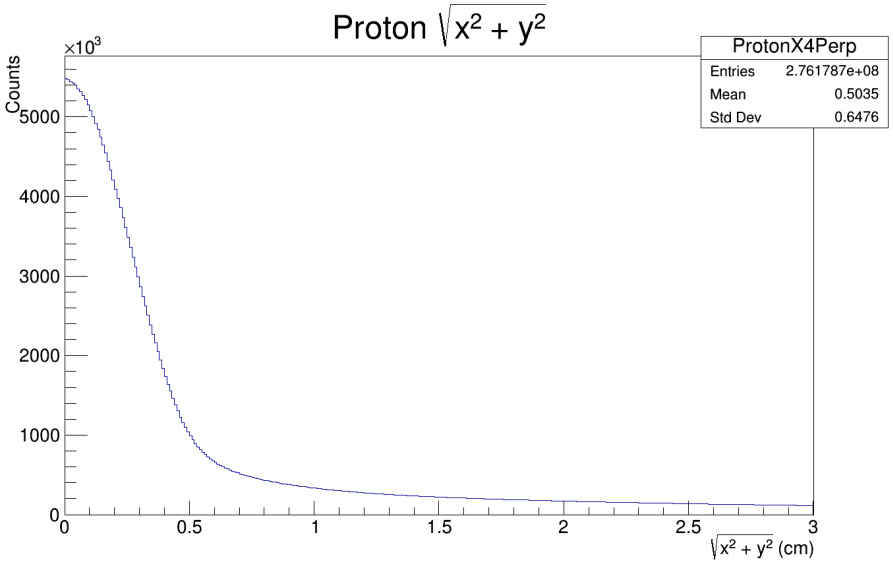


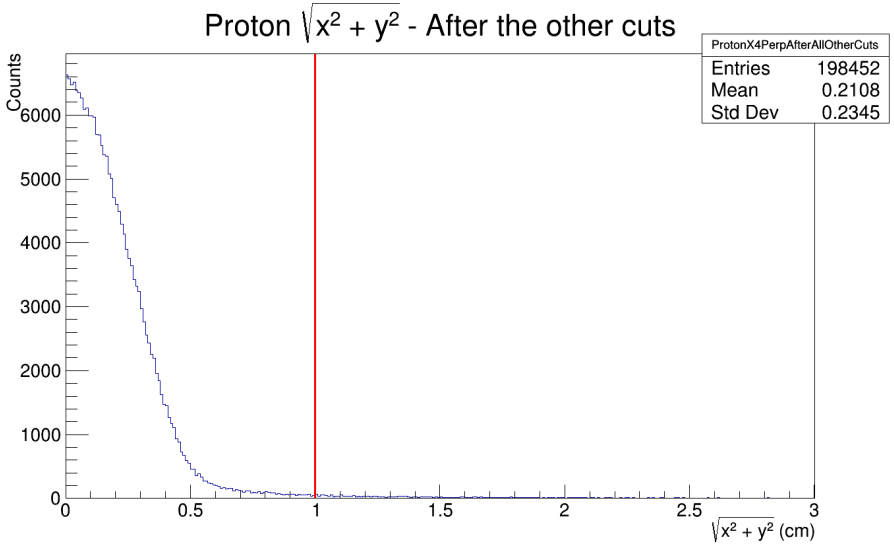
50 < Proton z_{vertex} < 80 cm



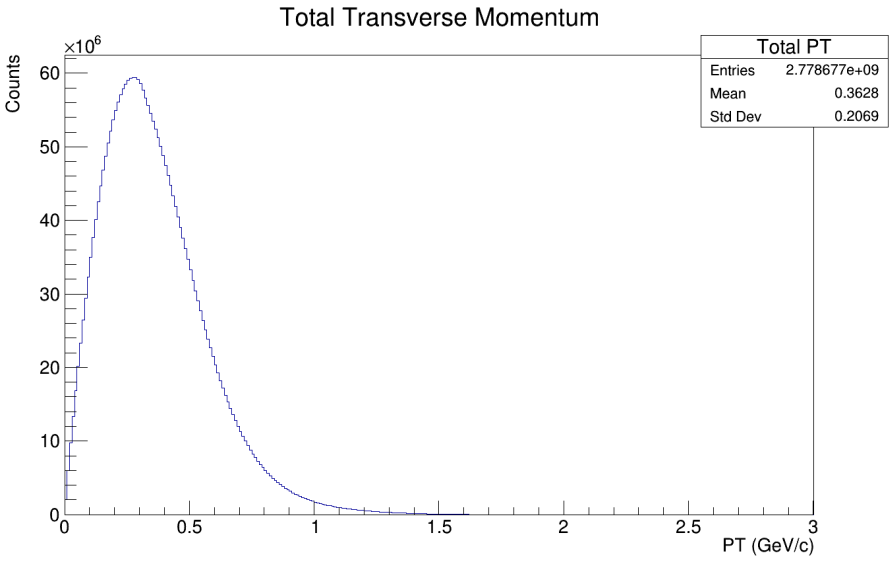


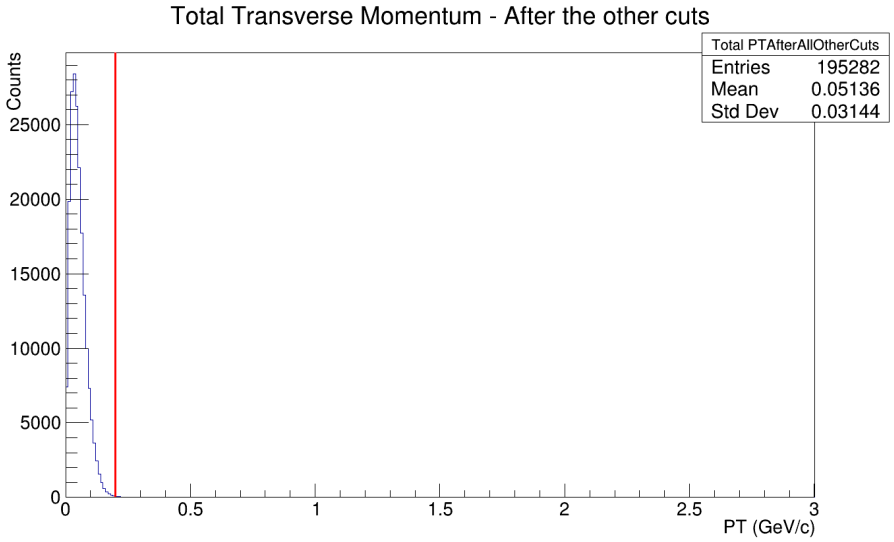
Proton $\sqrt{x_{vertex}^2 + y_{vertex}^2} > 1$ cm



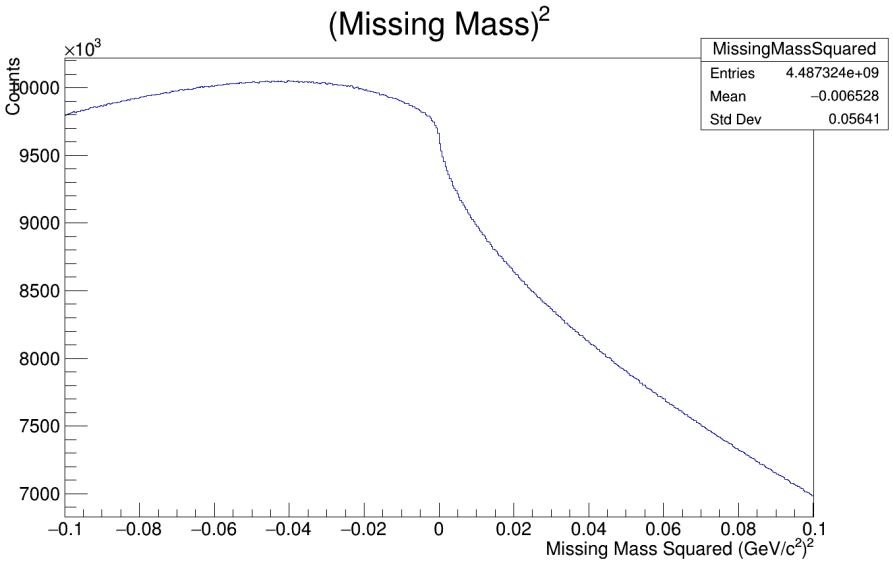


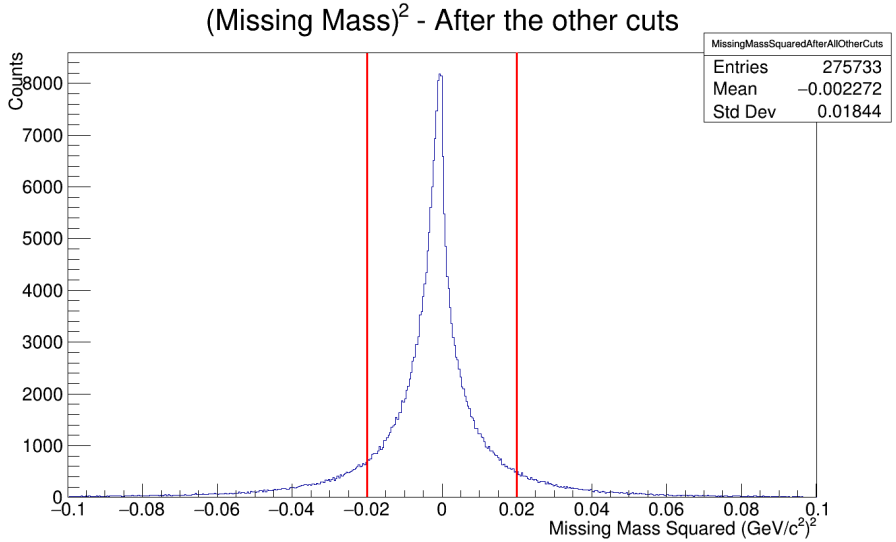
Total PT < 200 MeV



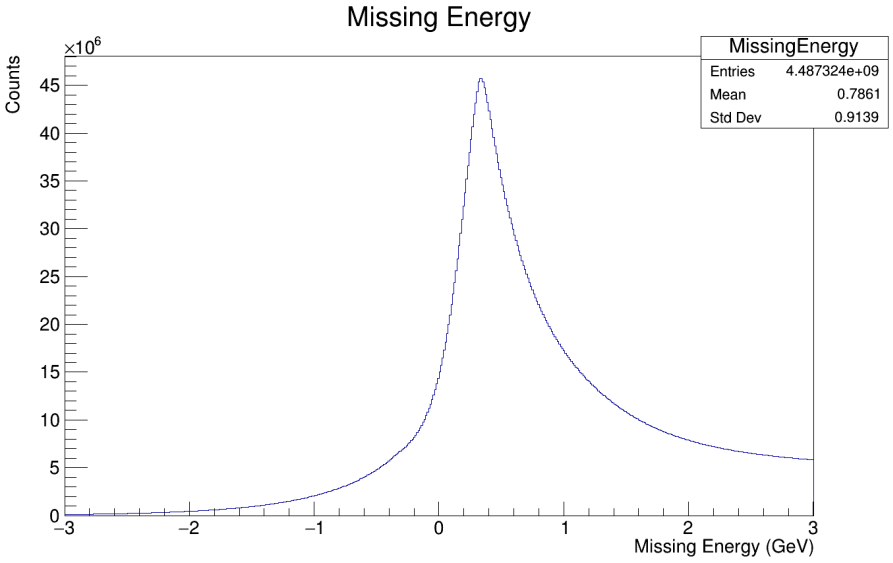


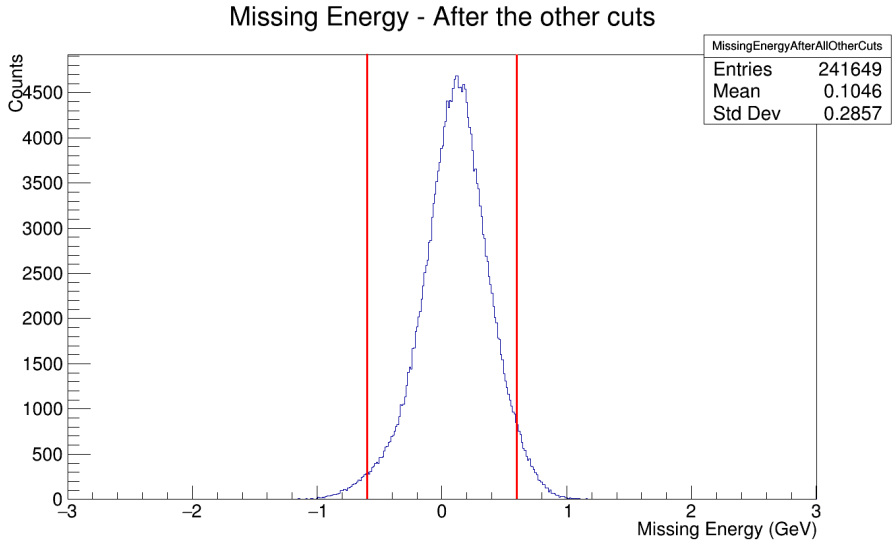
$$-0.02 < (Missing\ Mass)^2 < 0.02\ (GeV/c^2)^2$$



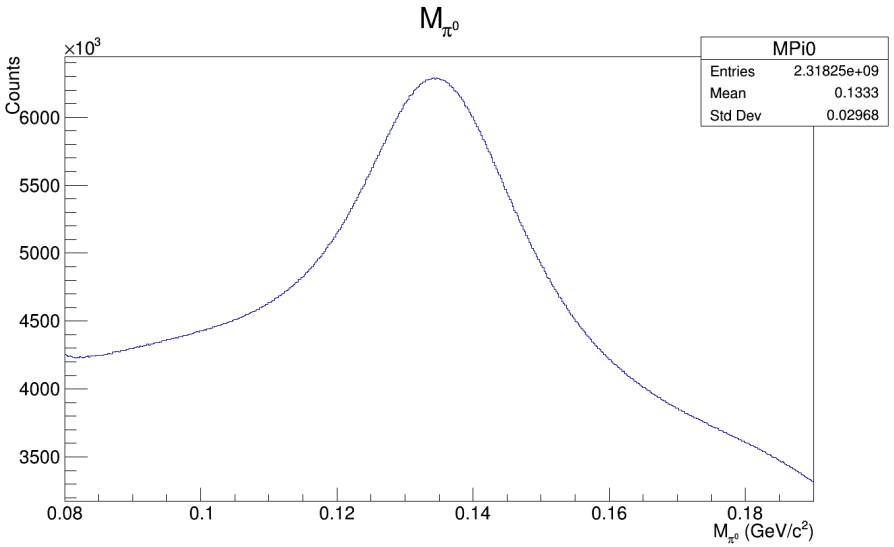


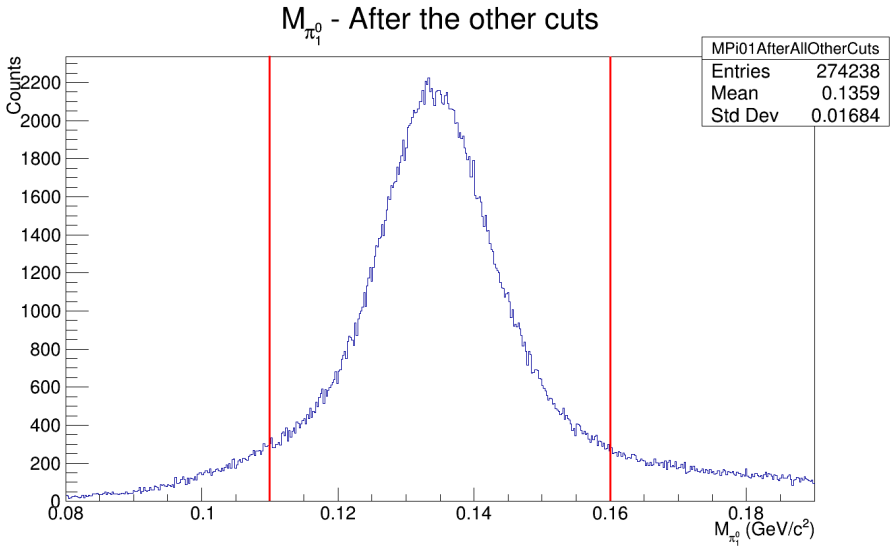
-1 < Missing Energy < 1 GeV



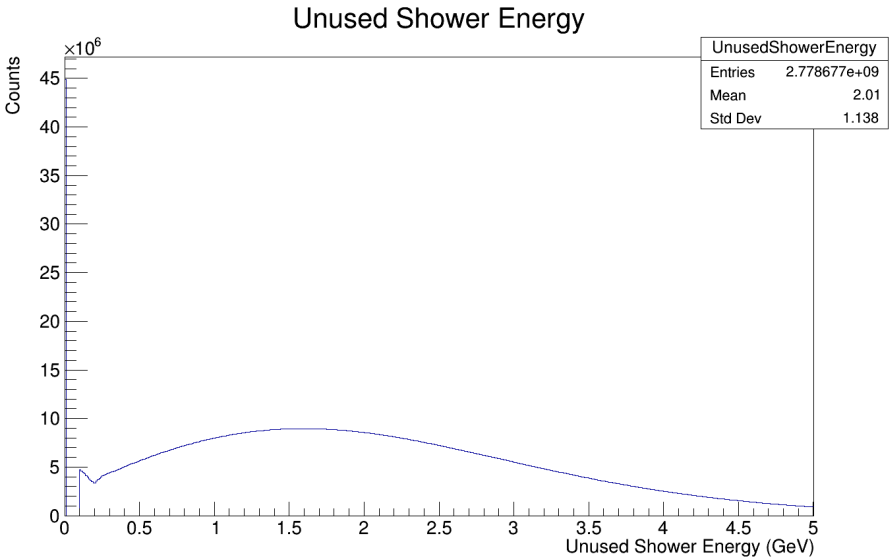


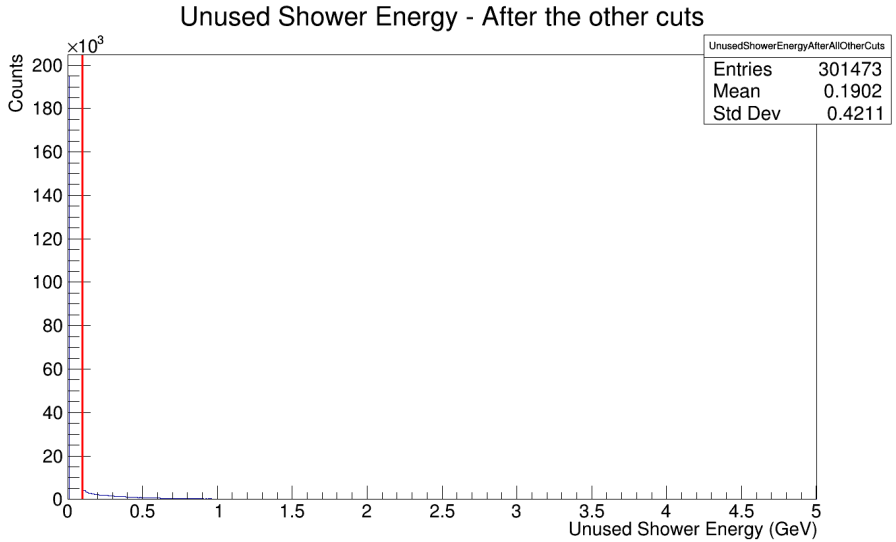
$$0.11 < M_{\pi 0} < 0.16\ GeV/c^2$$



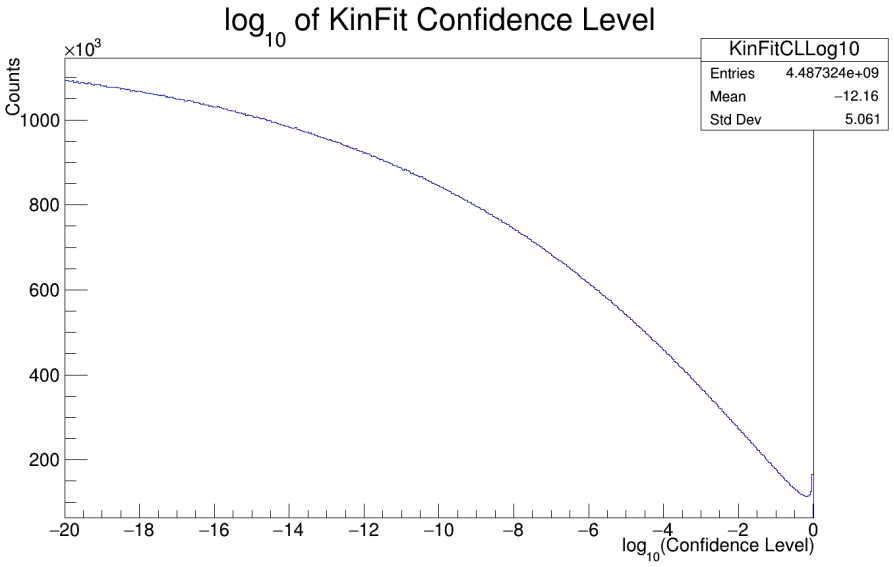


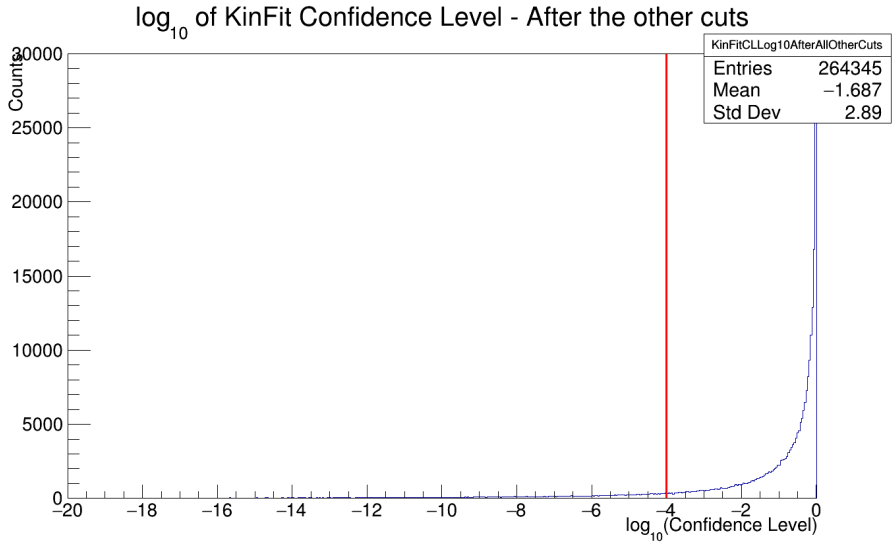
Unused E_{shower} < 100 MeV



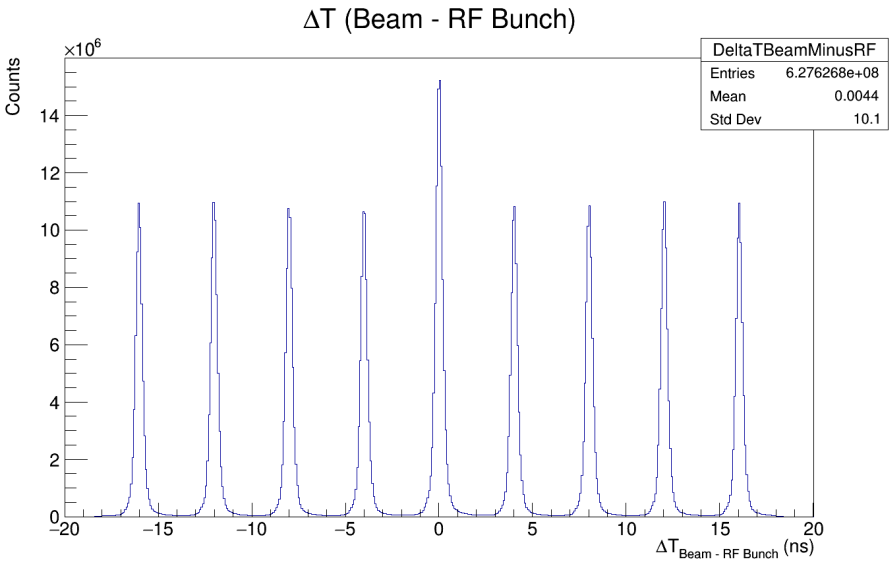


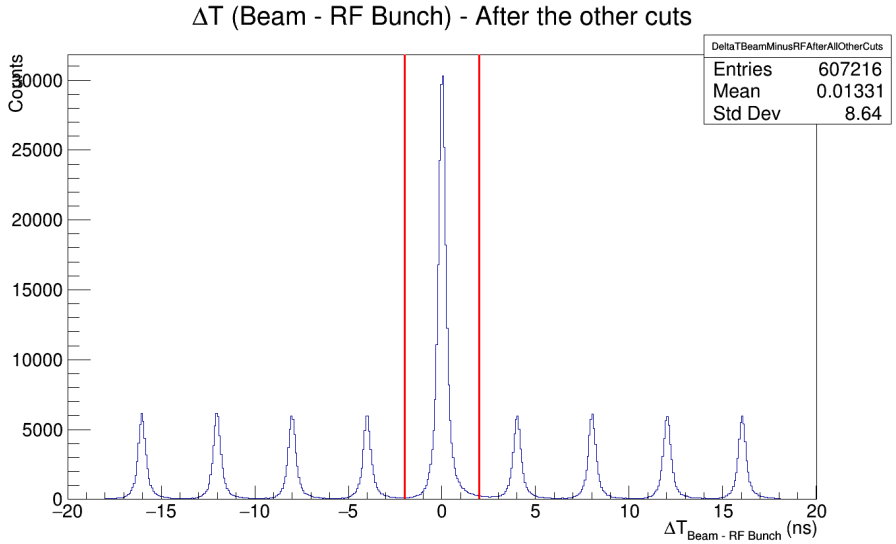
KinFit FOM = 1E-4



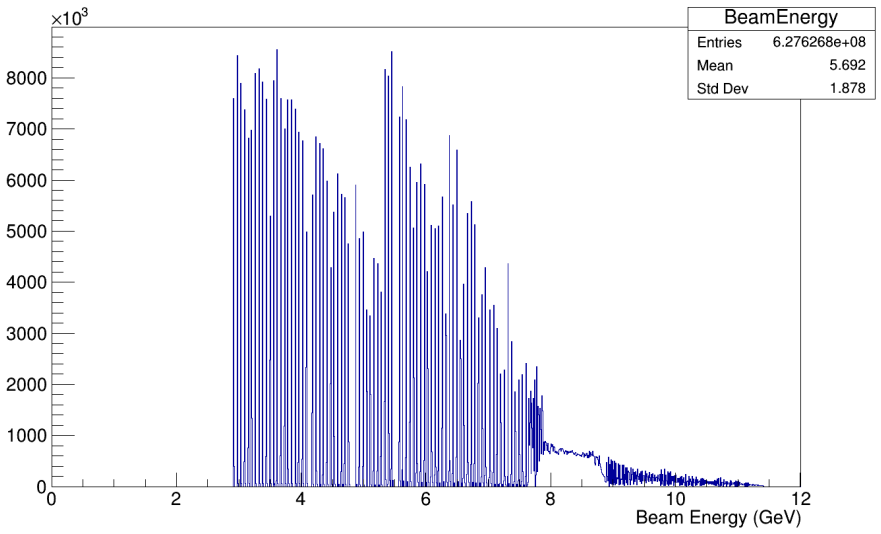


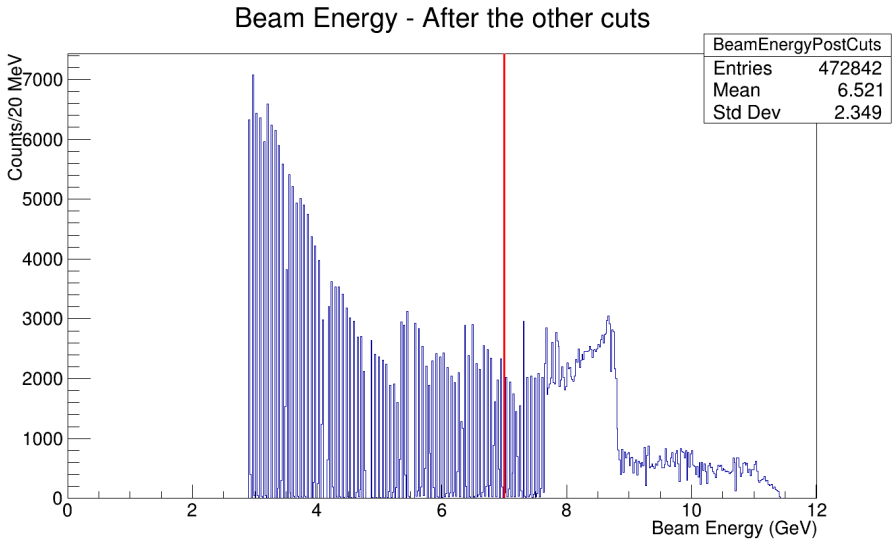
$$\left|\Delta t_{Beam-RF}\right| < 2 \text{ ns}$$





Beam Energy > 7 GeV





$$0.5 < M_{\eta} < 0.6\ GeV/c^2$$