



The decay $\pi^0 \rightarrow e^+ e^- \gamma$ - Signal extraction



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Goals

- Isolate "clean" $\pi^0 \rightarrow e^+ e^- \gamma$ events from the exclusive reaction $\gamma p \rightarrow \pi^0 p$
- Use the bachelor photon from these events to determine the single-photon energy resolution of the detector

Dataset

- "Golden Runs", spring 2016
 - Monte Carlo events

Loose plugin cuts

The following cuts are the cuts placed at the plugin level, and they apply to all the slides that follow

- Type of Kinematic Fit performed: P4 and Vertex fit
 - $MaxPhotonRFDeltaT = \frac{BeamBunchPeriod}{2}$
 - $MaxExtraGoodTracks = 5$
 - π^0 Invariant Mass cut: [0.0, 0.3] GeV
 - $(MissingMass)^2$ cut: [-0.1, 0.1] $(\frac{GeV}{c^2})^2$
 - PID Δt , protons, TOF: $\pm 3ns$
 - PID Δt , protons, BCAL: $\pm 3ns$
 - PID Δt , protons, FCAL: $\pm 3ns$
 - PID Δt , positrons, TOF: $\pm 1ns$
 - PID Δt , positrons, BCAL: $\pm 2ns$
 - PID Δt , positrons, FCAL: $\pm 3ns$
 - PID Δt , electrons, TOF: $\pm 1ns$
 - PID Δt , electrons, BCAL: $\pm 2ns$
 - PID Δt , electrons, FCAL: $\pm 3ns$
 - PID Δt , photons, BCAL: $\pm 3ns$
 - PID Δt , photons, FCAL: $\pm 3ns$
 - dEdx cut in CDC

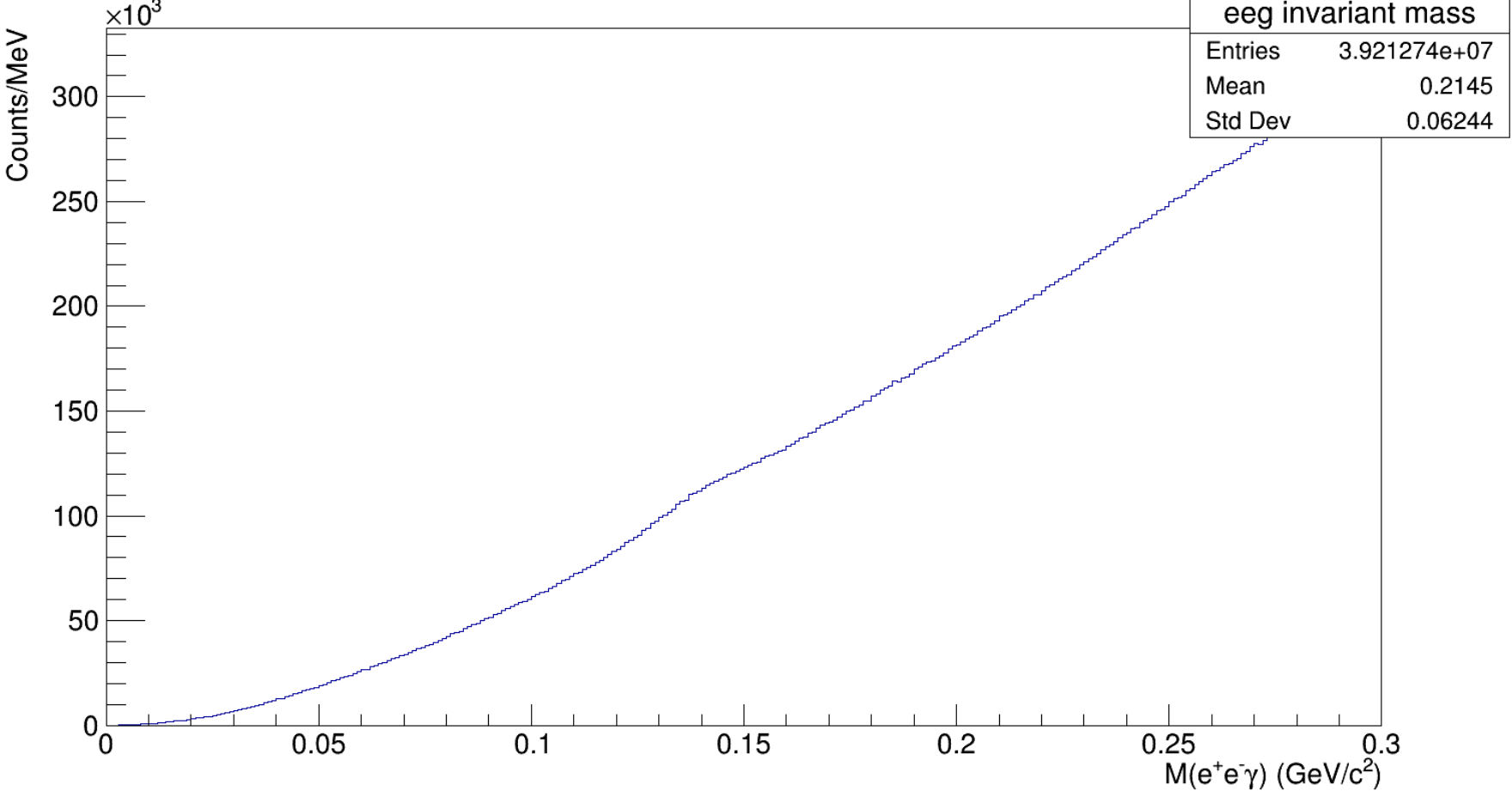
Steps:

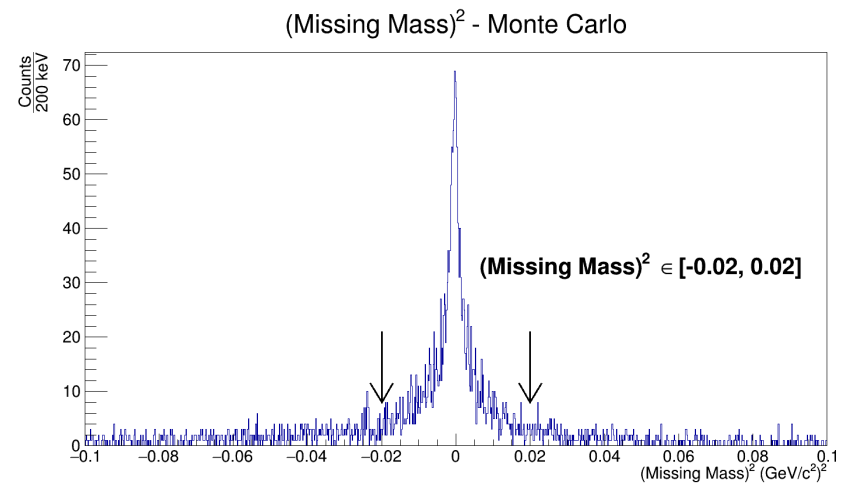
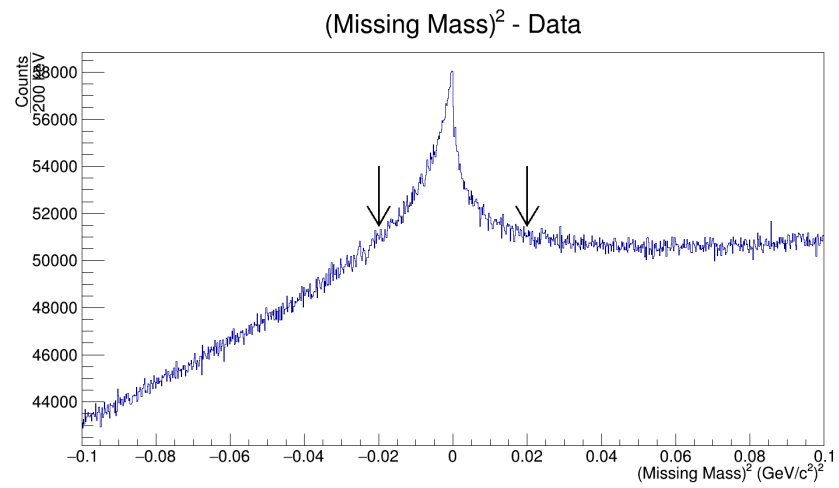
We tried various cut combinations. We ran Monte Carlo simulations for the $\pi^0 \rightarrow e^+ e^- \gamma$ reaction to determine the optimal cuts. In what follows we will see plots of the most powerful cuts (in purple) comparing Monte Carlo and Spring 2016 data and the effect they have on the invariant mass

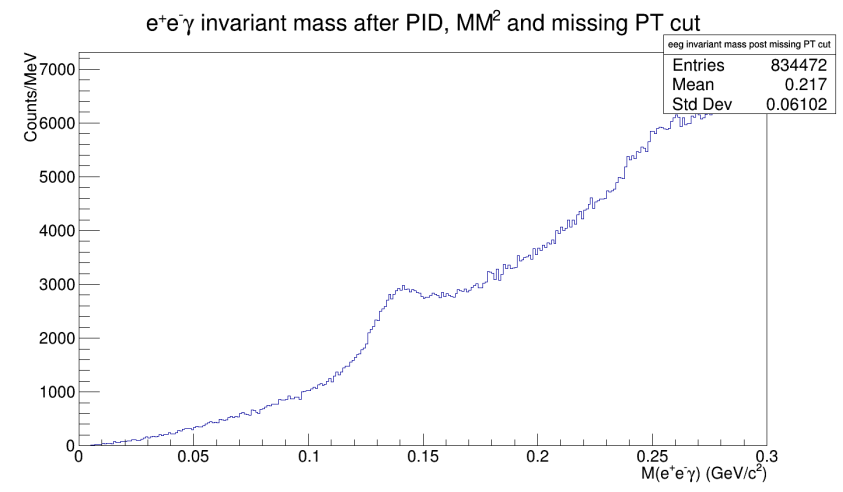
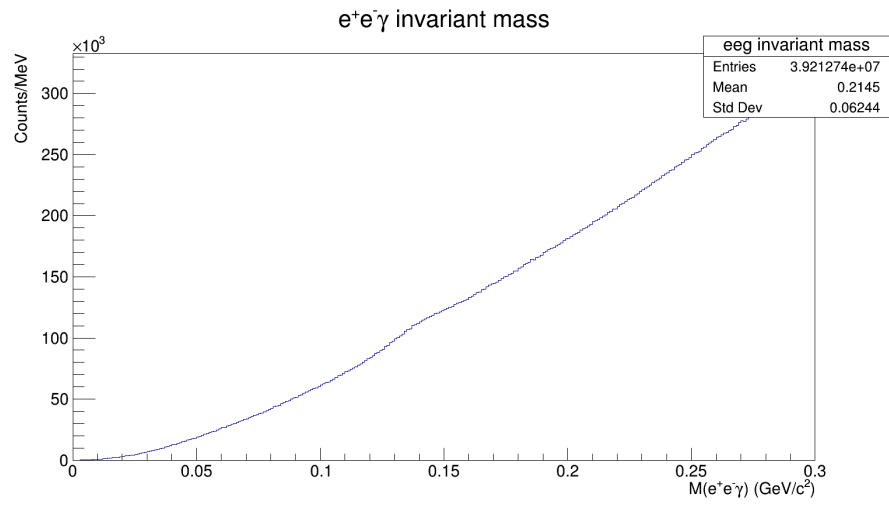
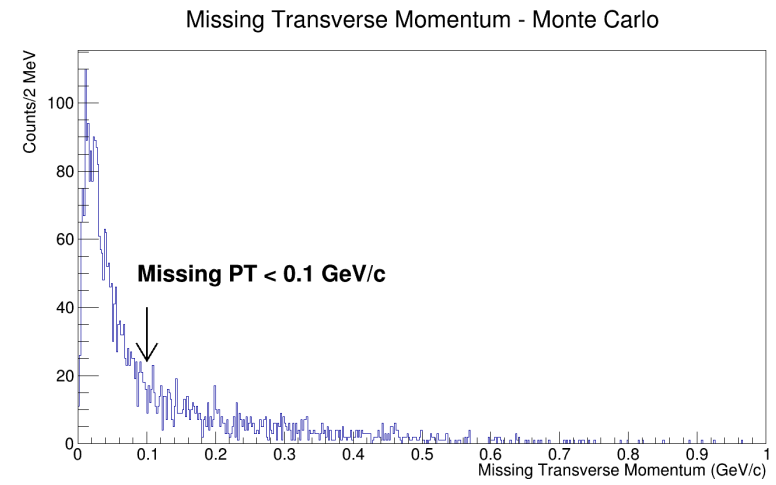
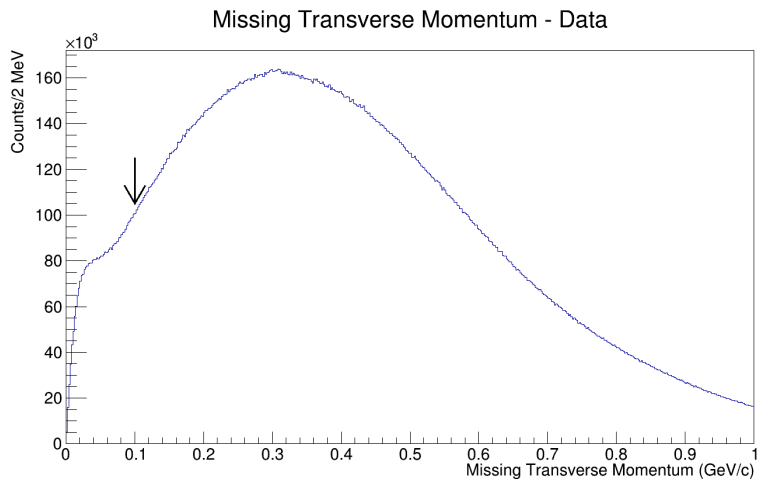
Full Cut Flow (in the order they were applied):

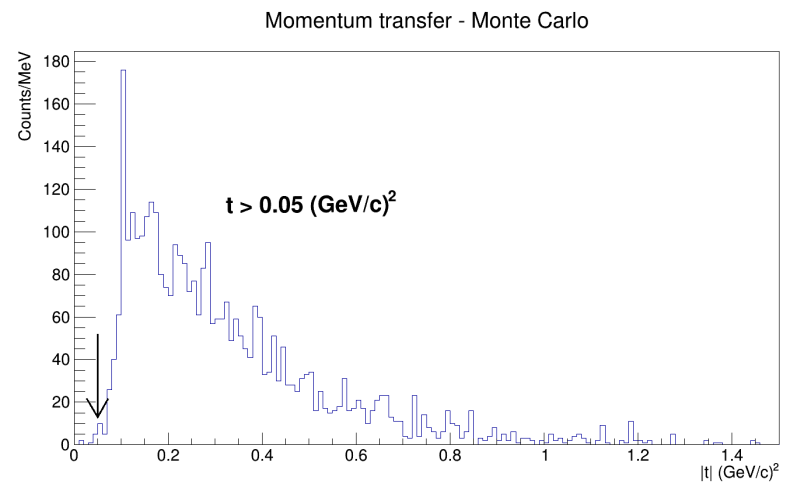
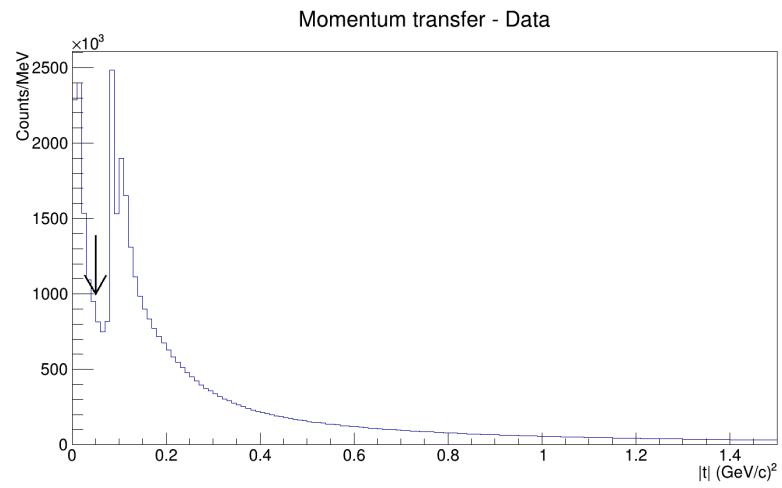
- Tighter PID cuts
- $(Missing\ Mass)^2 \in [-0.02, 0.02] (GeV/c^2)^2$
- **Missing Transverse Momentum $\in [0.0, 0.1] GeV/c$**
 - Momentum transfer $> 0.05 GeV/c$
 - **$E/p \in [0.85, 1.15]$ (FCAL only)**
 - **$M(e^+ e^-) < 100 MeV$**
 - **$\chi^2/NDF < 4$**
- **$\Delta z(p, e^+) < 3 cm, \Delta z(p, e^-) < 3 cm, \Delta z(e^+, e^-) < 3 cm$**

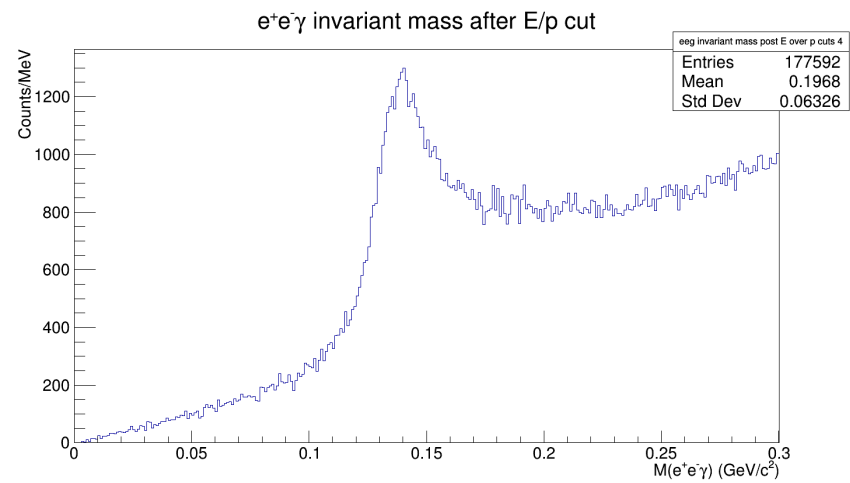
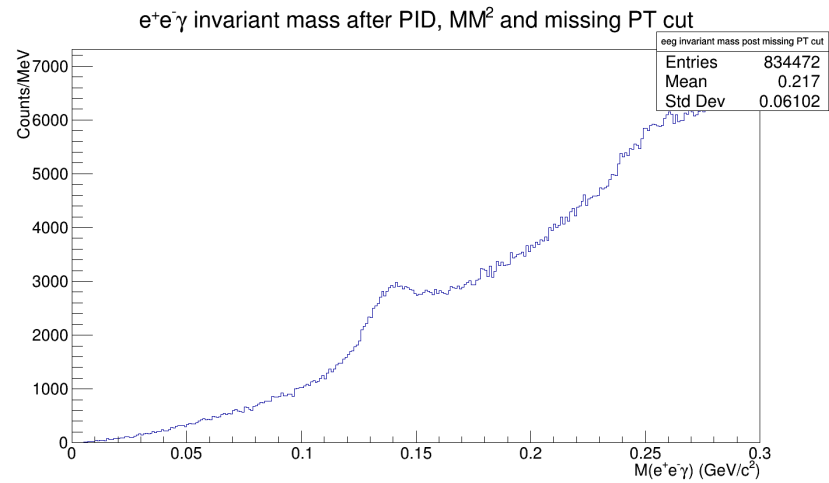
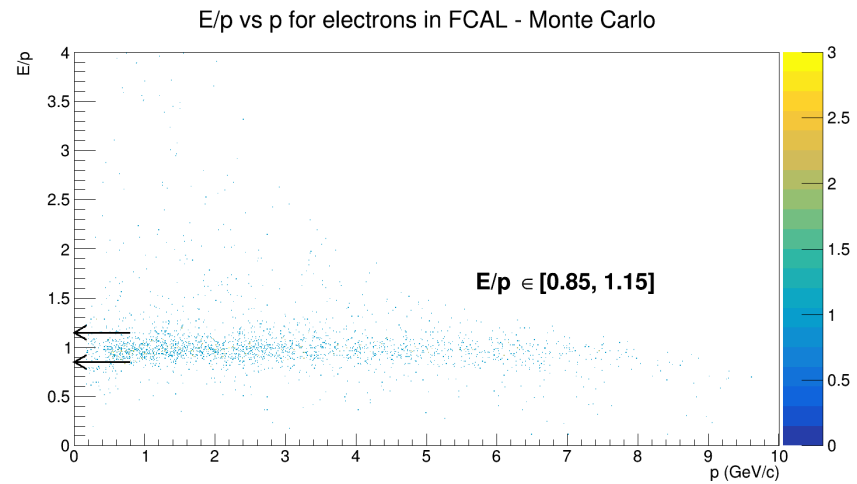
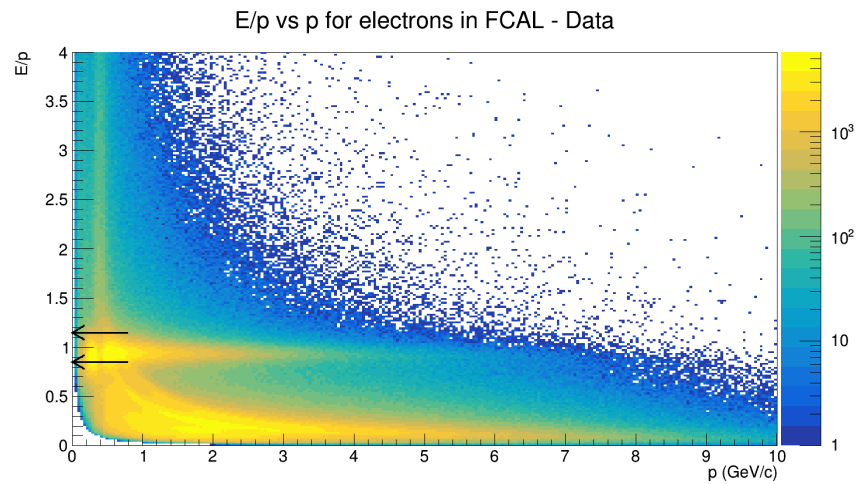
$e^+e^- \gamma$ invariant mass

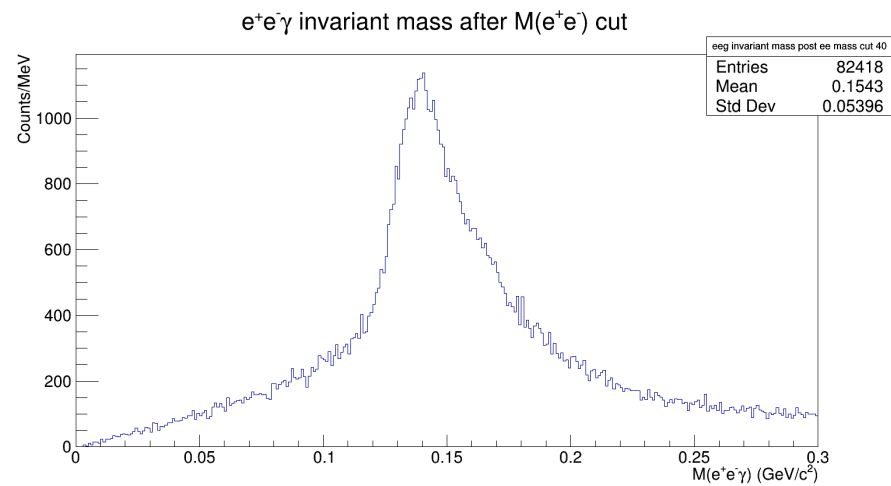
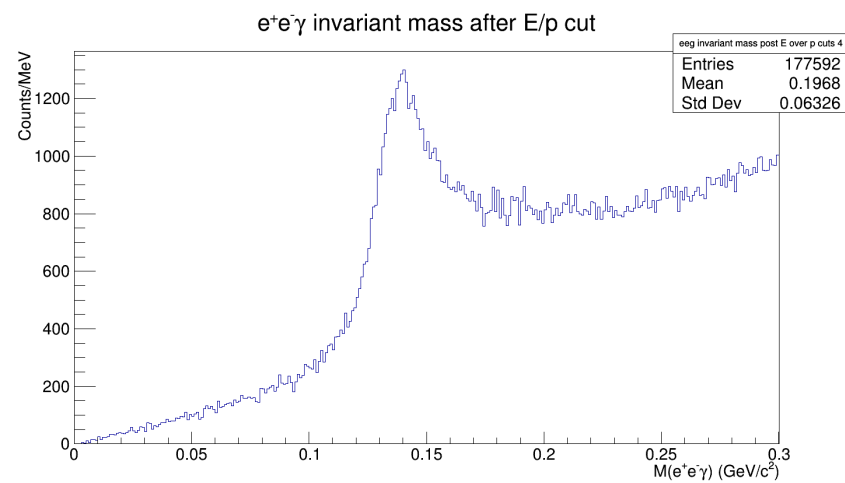
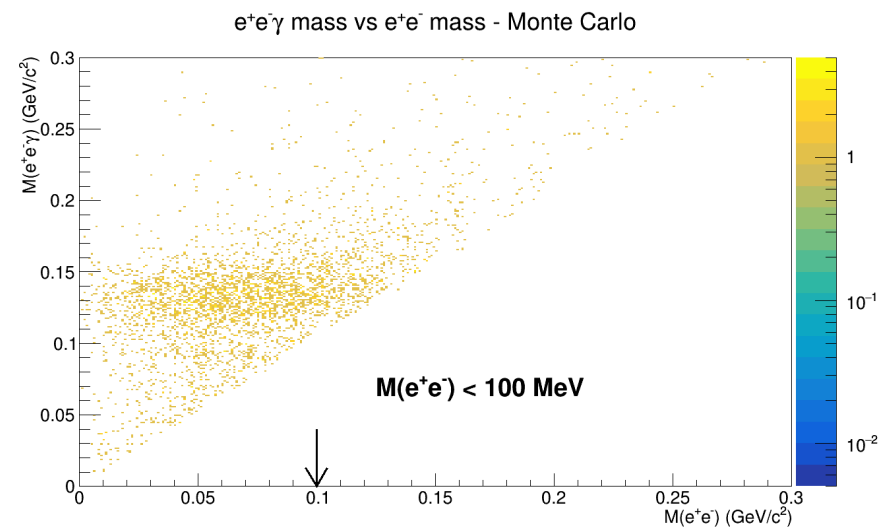
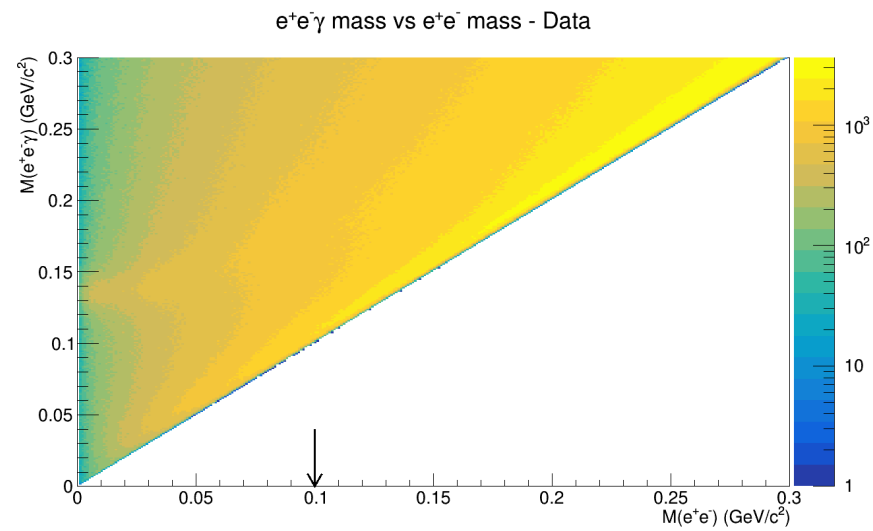




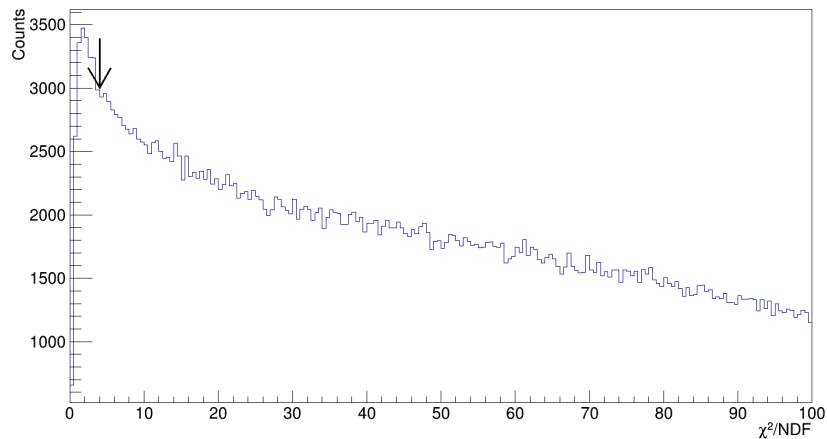




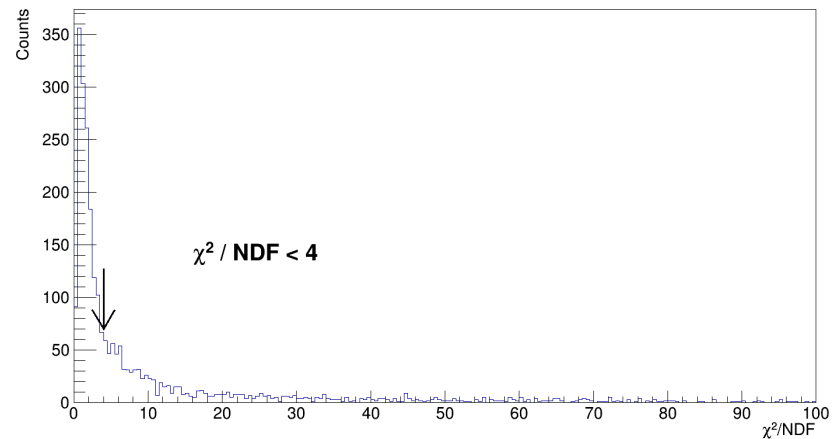




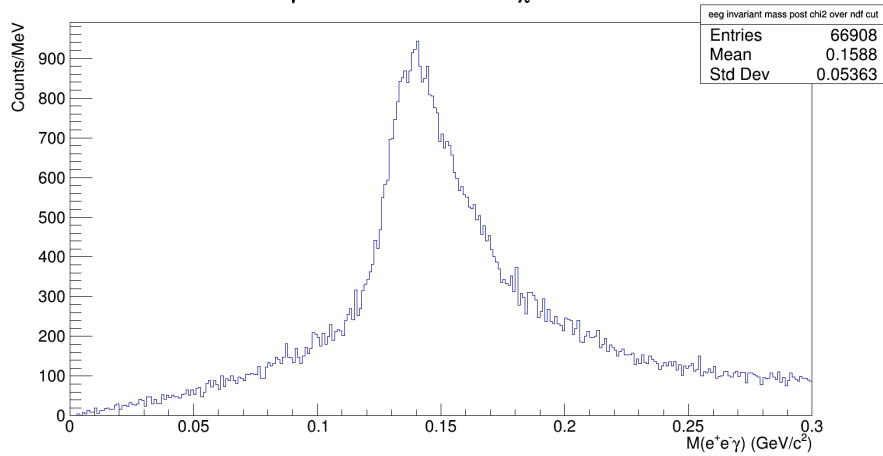
χ^2/NDF - Data



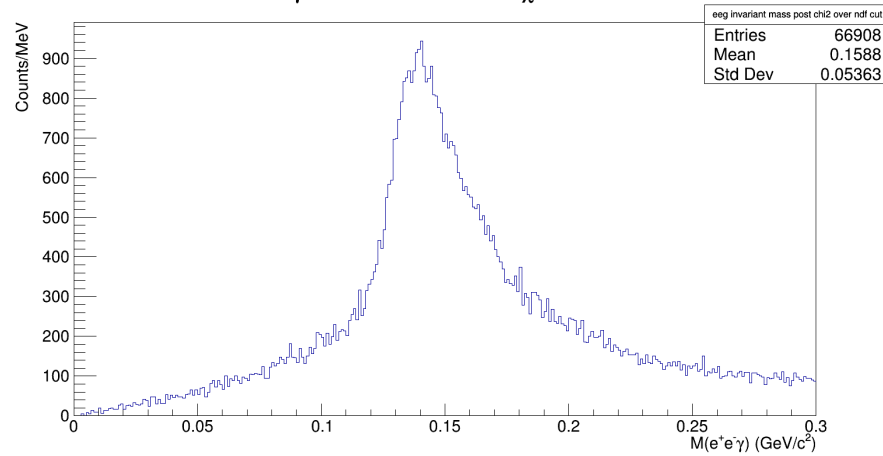
χ^2/NDF - Monte Carlo

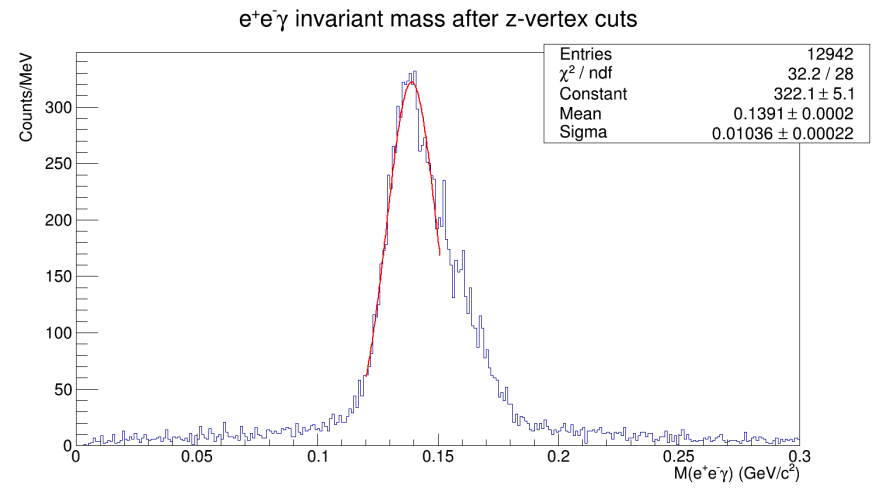
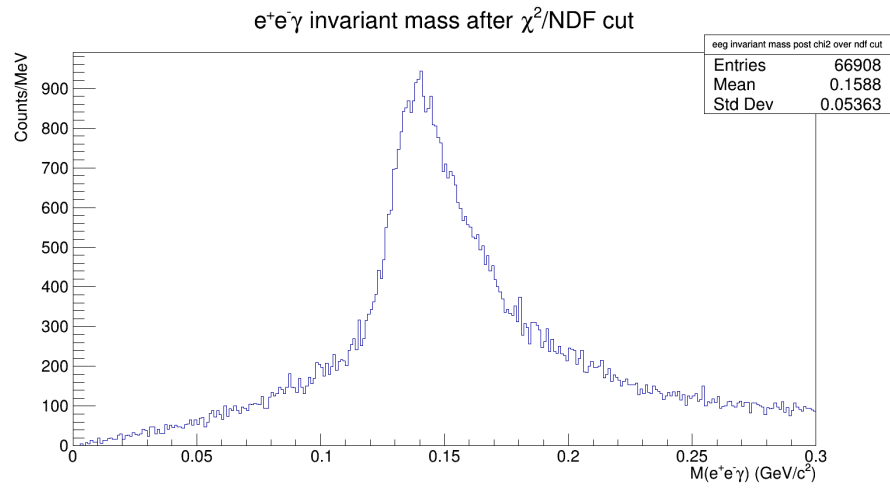
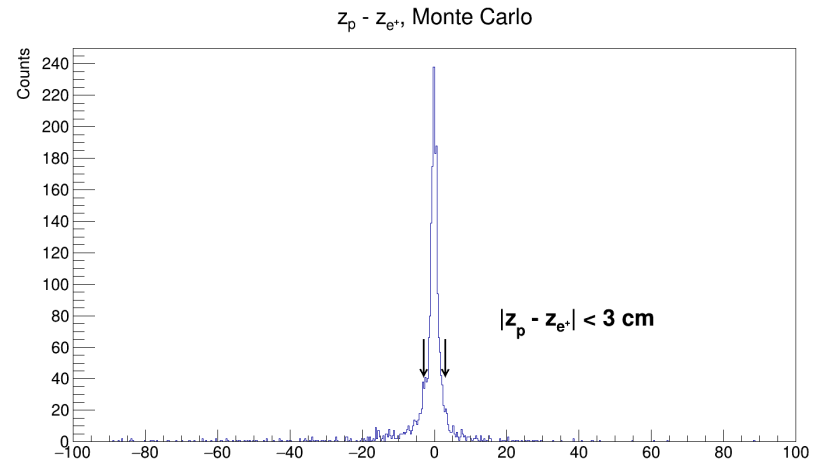
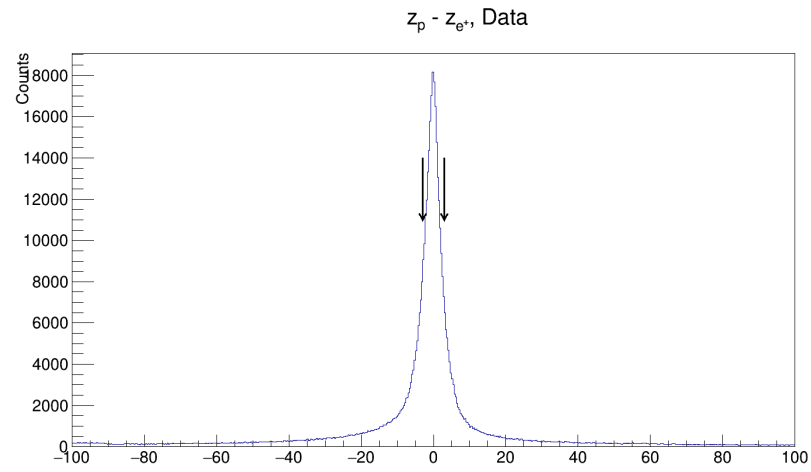


$e^+e^-\gamma$ invariant mass after χ^2/NDF cut

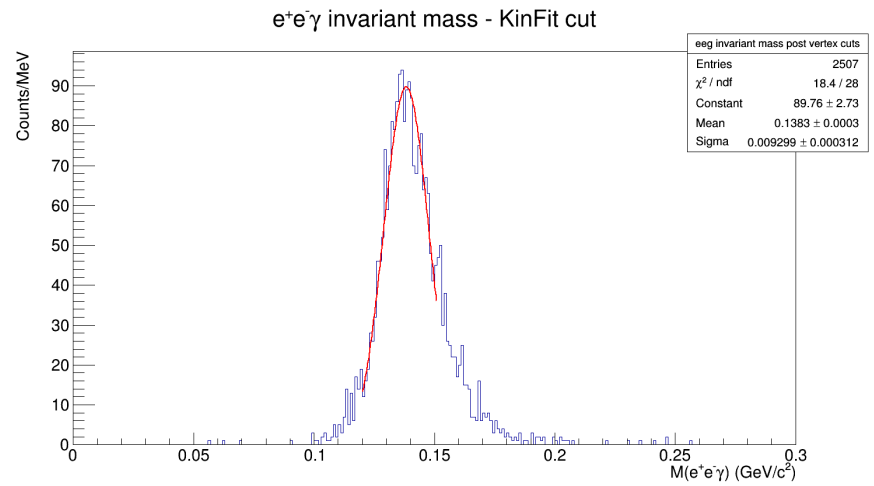
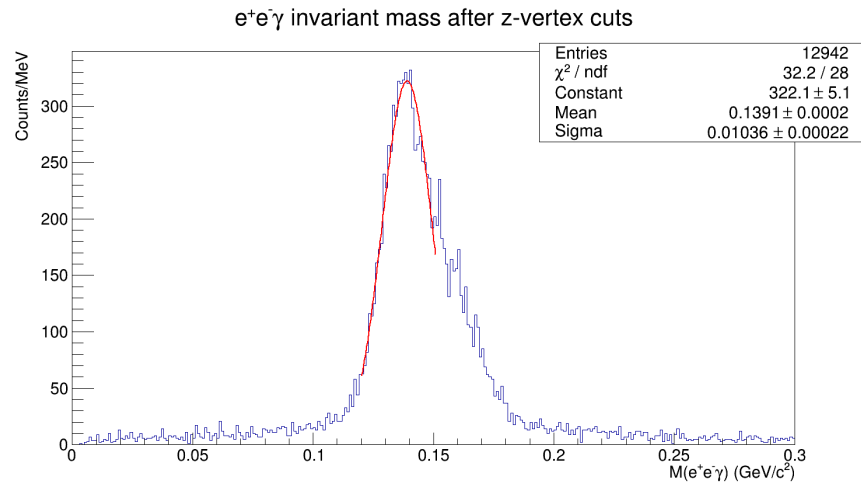


$e^+e^-\gamma$ invariant mass after χ^2/NDF cut





If a KinFitFOM cut is used:



Cut Efficiency		
Cut	% of events survived	
	Monte Carlo	Spring 2016 Data
PID cuts	97,33	84,19
$(Missing\ Mass)^2$	67,98	20,60
Missing PT	56,33	2,13
Momentum transfer	56,33	1,95
E/p	36,30	0,45
$M(e^+e^-)$	29,87	0,21
χ^2/NDF	25,12	0,17
z-vertex	14,74	0,03

