Update on GDA studies with $p\,\bar{p} \to \gamma\gamma$ and $p\,\bar{p} \to \pi^0\gamma$ Channel

Faiza Khalid

Justus Liebig University Giessen

May 31, 2022

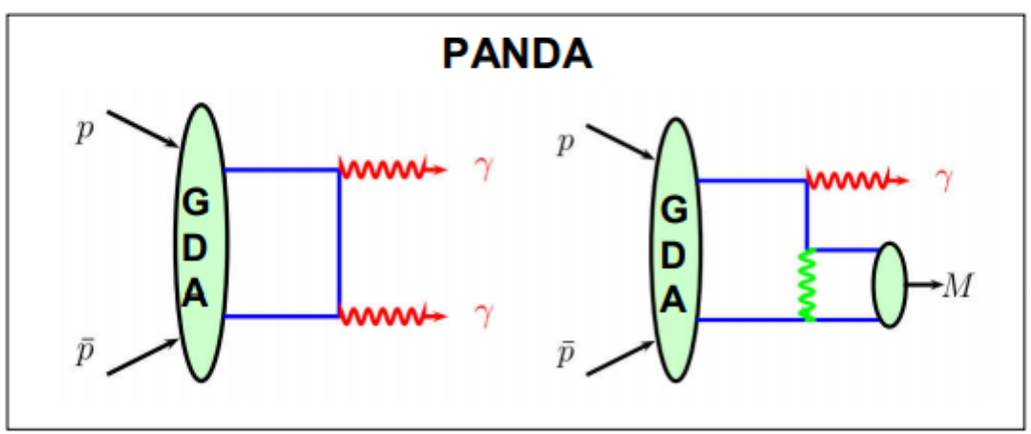
Introduction

$$p\bar{p} \rightarrow \gamma M$$ at large Mandelstam variables

process amplitudes factorizes:

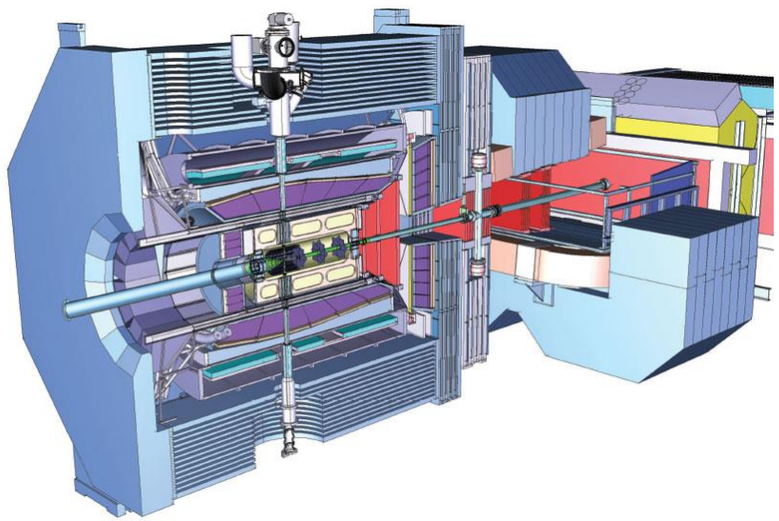
hard partonic subprocesses + annihilation form factors

represent moments of baryon-antibaryon **G**eneralized **D**istribution **A**mplitudes (GDAs)



Simulation and Event Selection

- Full MC simulation with PANDARoot Framework
- Signal $\boldsymbol{p\bar{p} \rightarrow \gamma\gamma}$
- background $\boldsymbol{p\bar{p} \rightarrow \pi^0\gamma}$ and $\boldsymbol{p\bar{p} \rightarrow \pi^0\pi^0}$
- 1M signal and 1M background events simulated at beam momenta of 2.5, 5 and 10 GeV
- Events with at least two photons were selected
- Two gammas were combined to form initial $\bar{p}p$ system
- 4C fit is applied to select exclusive events



Phase Space Distribution

Weighted with Cross-Section

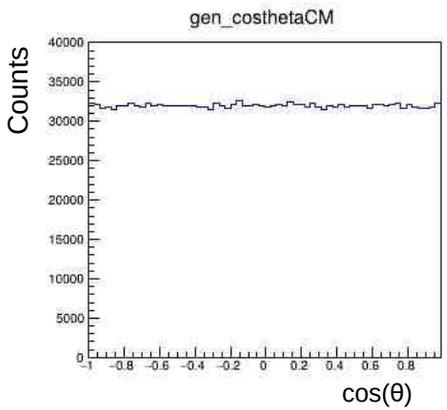
Generated

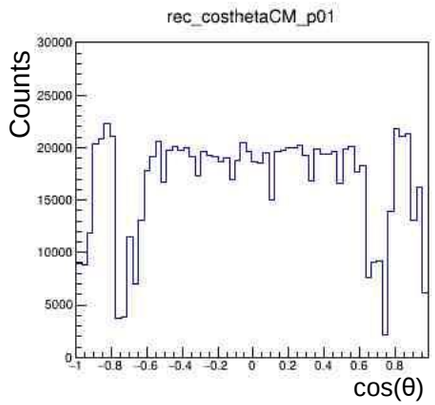
Reconstructed

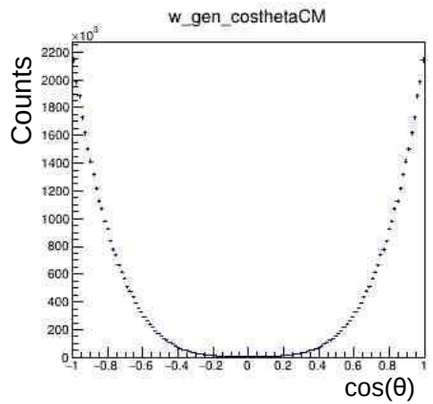
Generated

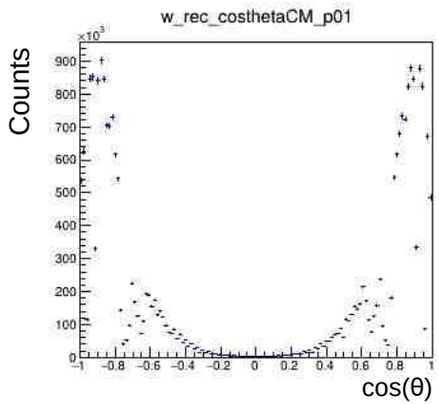
Reconstructed

2.5 GeV/c

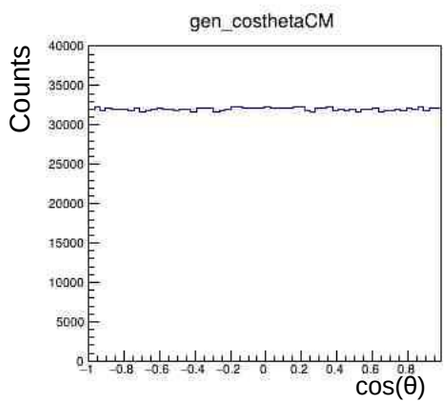


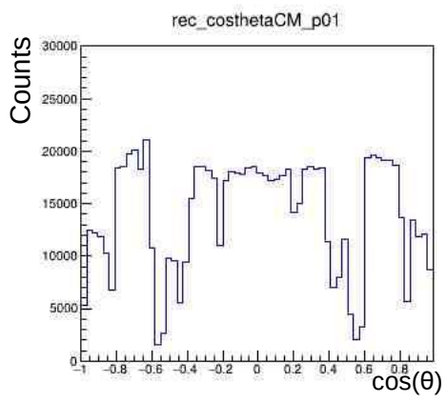


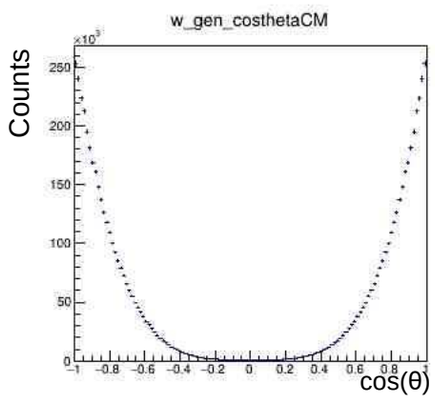


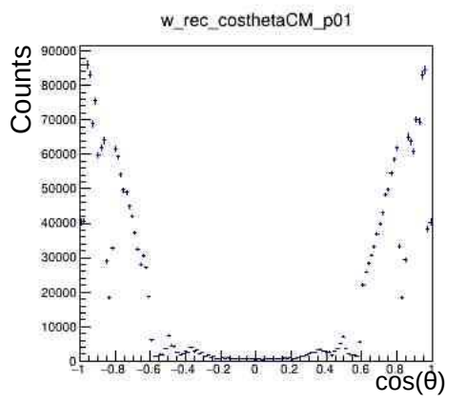


5 GeV/c

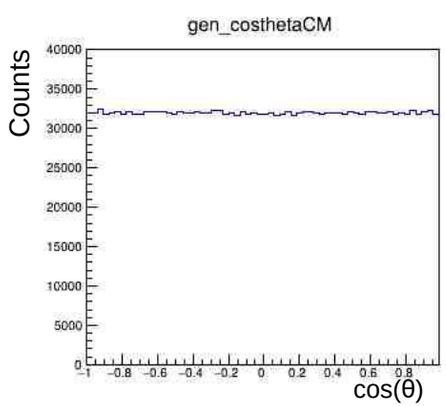


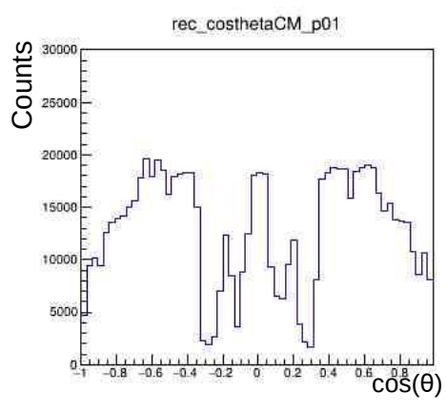


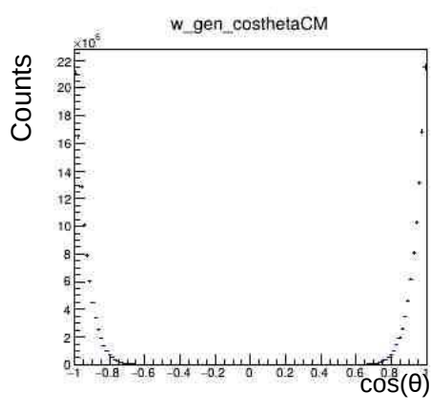


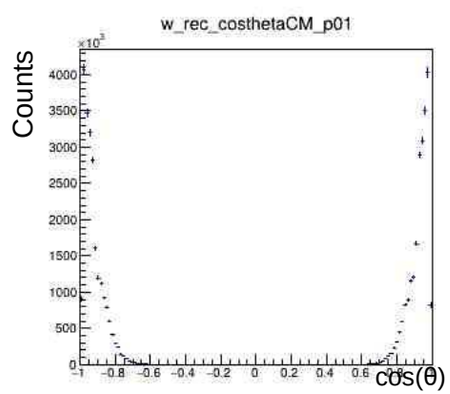


10 GeV/c



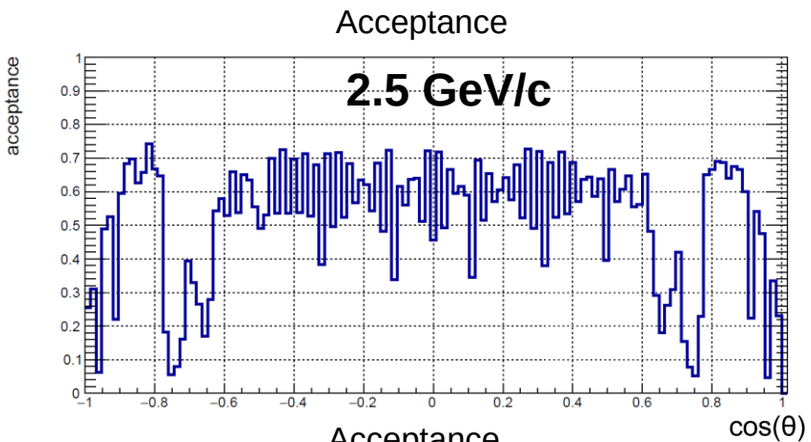


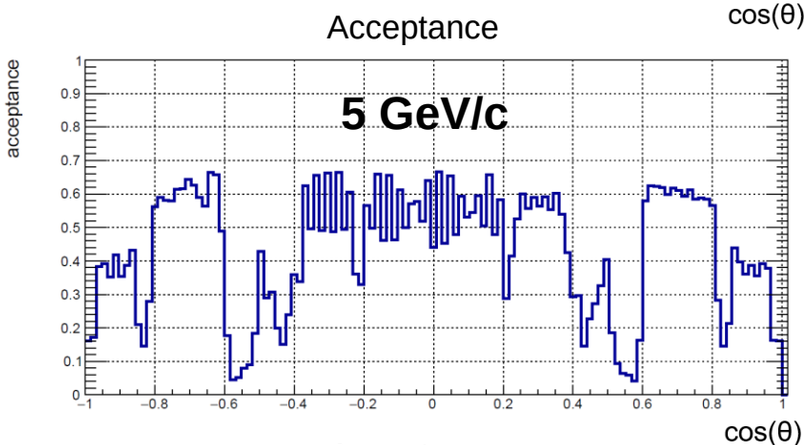


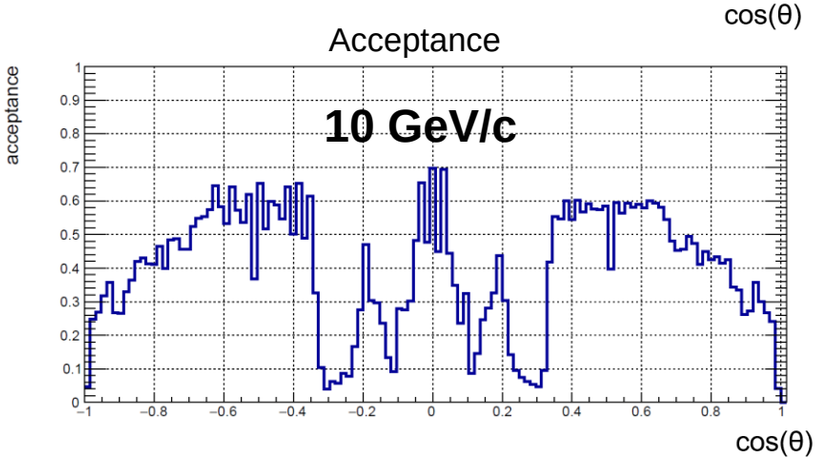


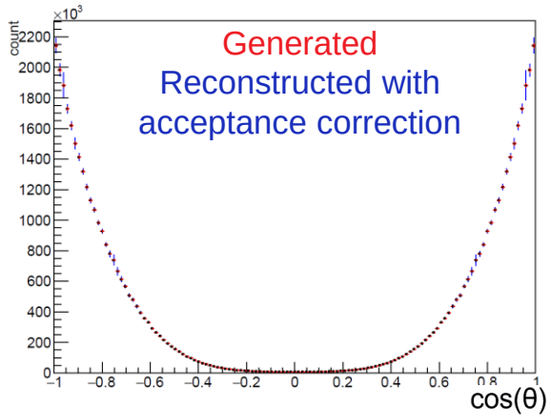
Acceptance for $p\bar{p} \rightarrow \gamma\gamma$

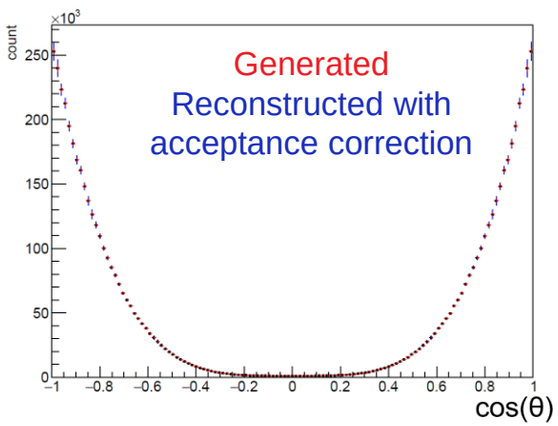
$$A = \frac{N_{rec}}{N_{gen}}$$

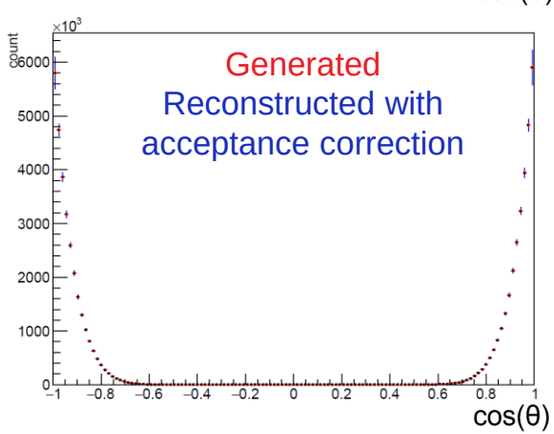








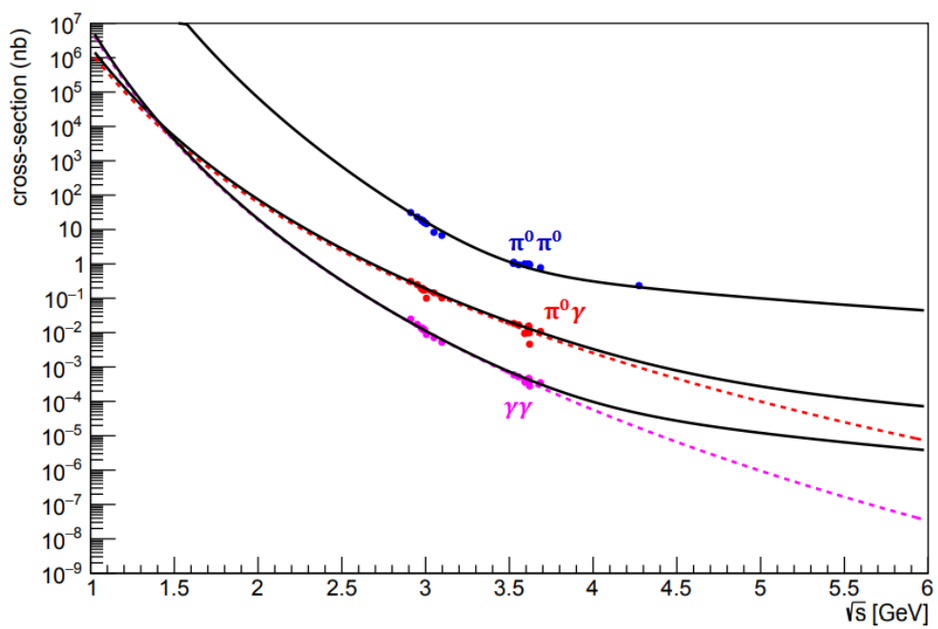




$$N_{corr} = \frac{N_{rec}}{A}$$

Cross-sections from E760 Data

- T. A. Armstrong*, Two-body neutral final states produced in antiproton-proton annihilations at $2.911 \leq \sqrt{s} \leq 3.686\ \mathrm{GeV}$
- Integrated the angular range for a fixed $\sqrt{s}$ to get the partially integrated cross section in the cos(θ) range which is available for all energies.

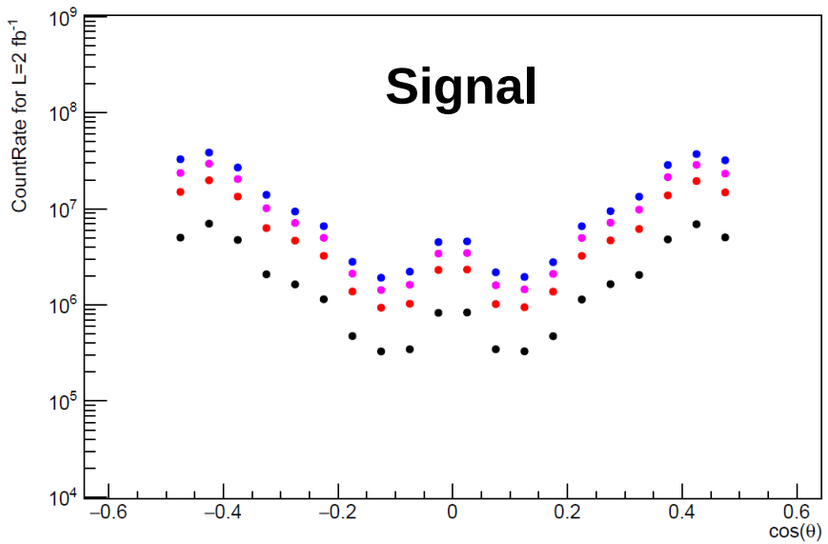


*https://doi.org/10.1103/PhysRevD.56.2509

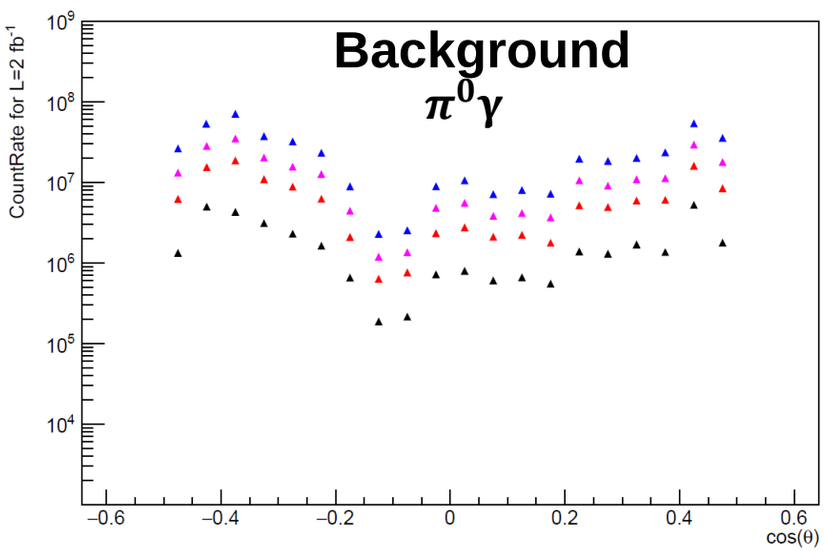
Count Rate

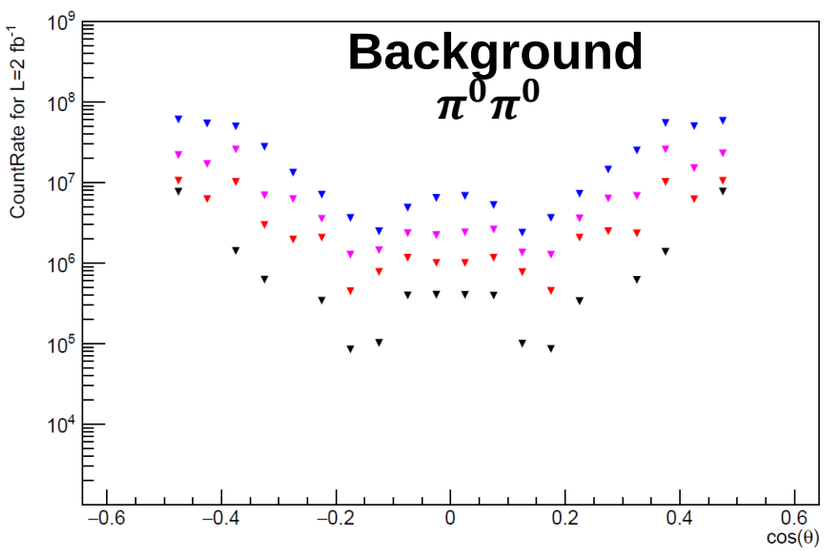
P_{beam} = 2.5 GeV

- Count rate = $\text{Cross section}_{\text{scaled}}$
  $*$ Acceptance $*$ Integrated Luminosity
- $\text{Cross section}_{\text{scaled}} = \text{cross section}_{\text{E760.}}$
  $*$ scaling factor



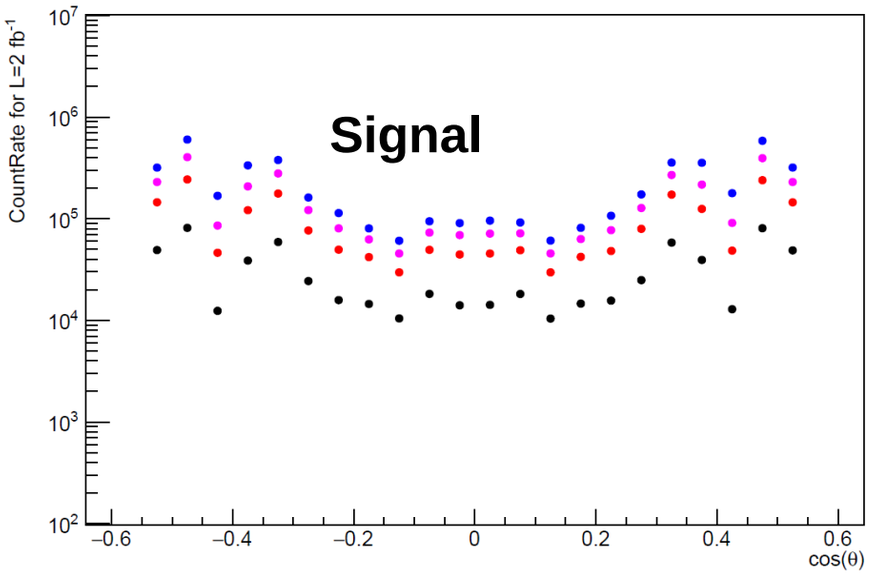
p>0.01
p>0.1
p>0.3
p>0.7



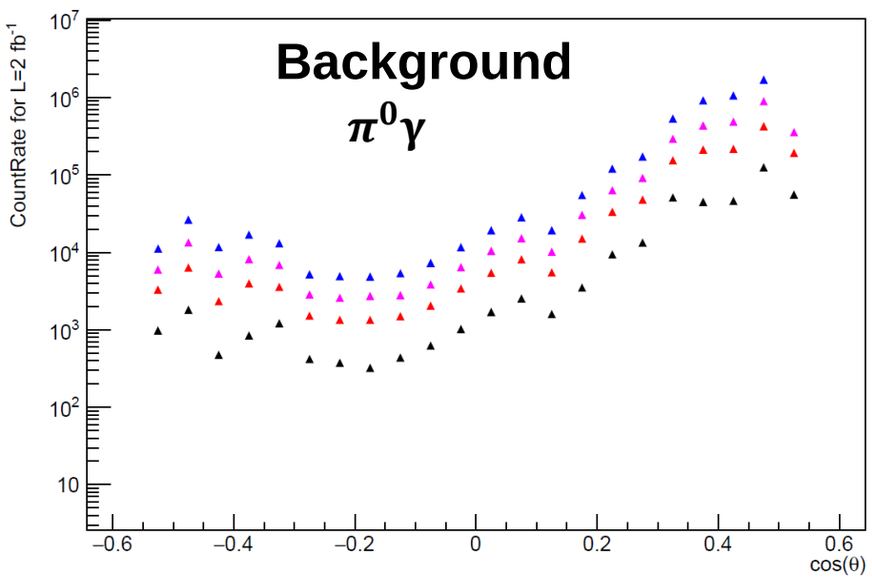


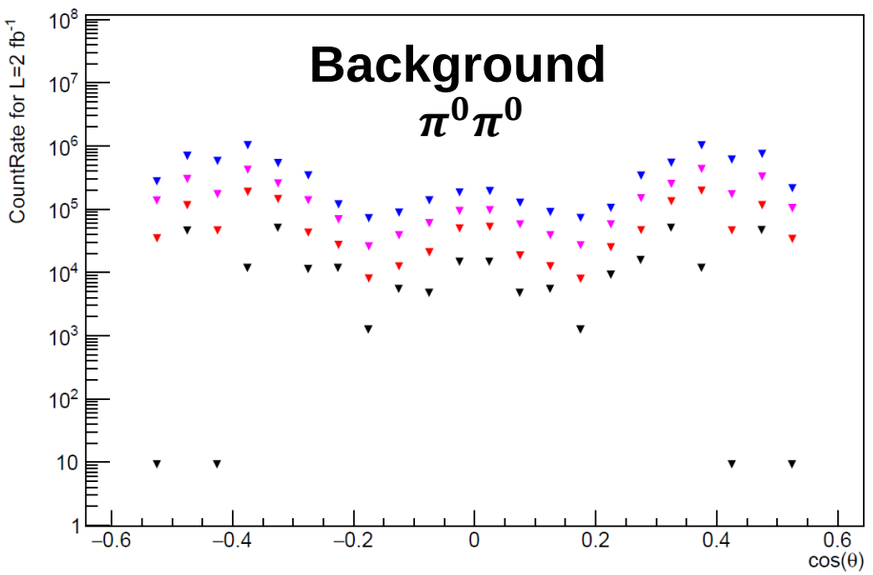
Count Rate

P_{beam} = 5 GeV



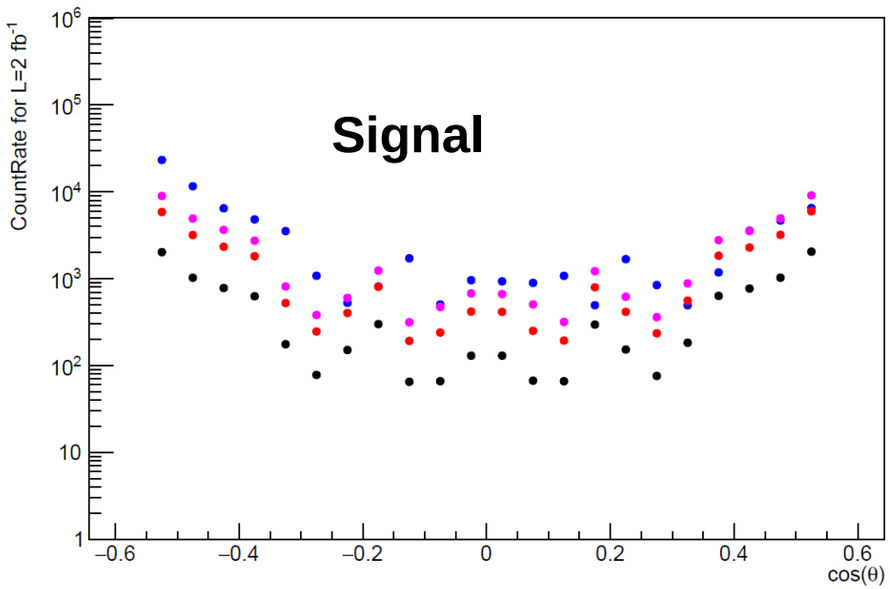
p>0.01
p>0.1
p>0.3
p>0.7



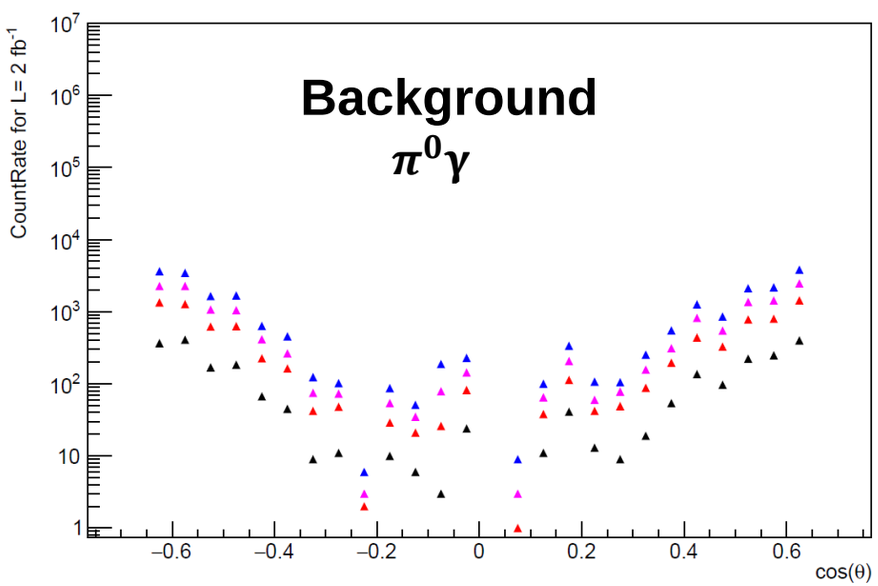


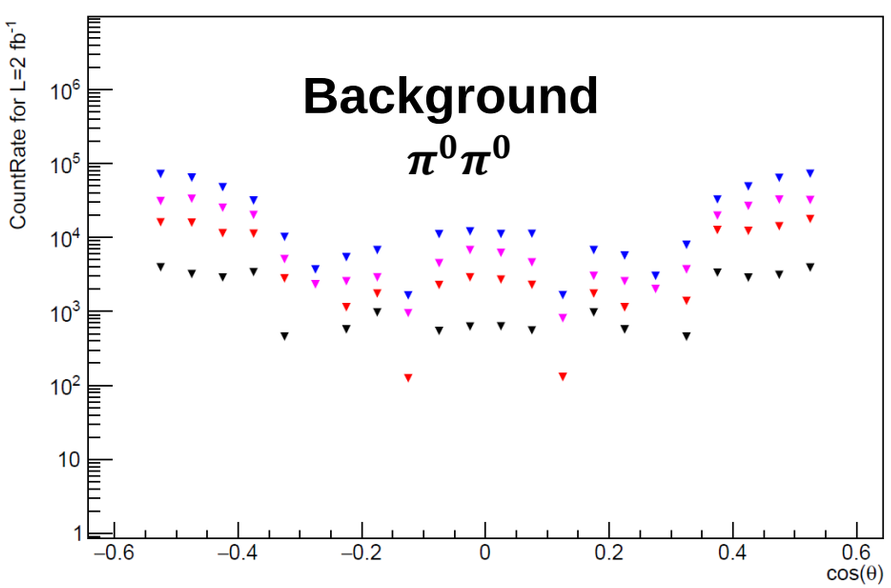
Count Rate

P_{beam}= 10 GeV



- p>0.01
- p>0.1
- p>0.3
- p>0.7

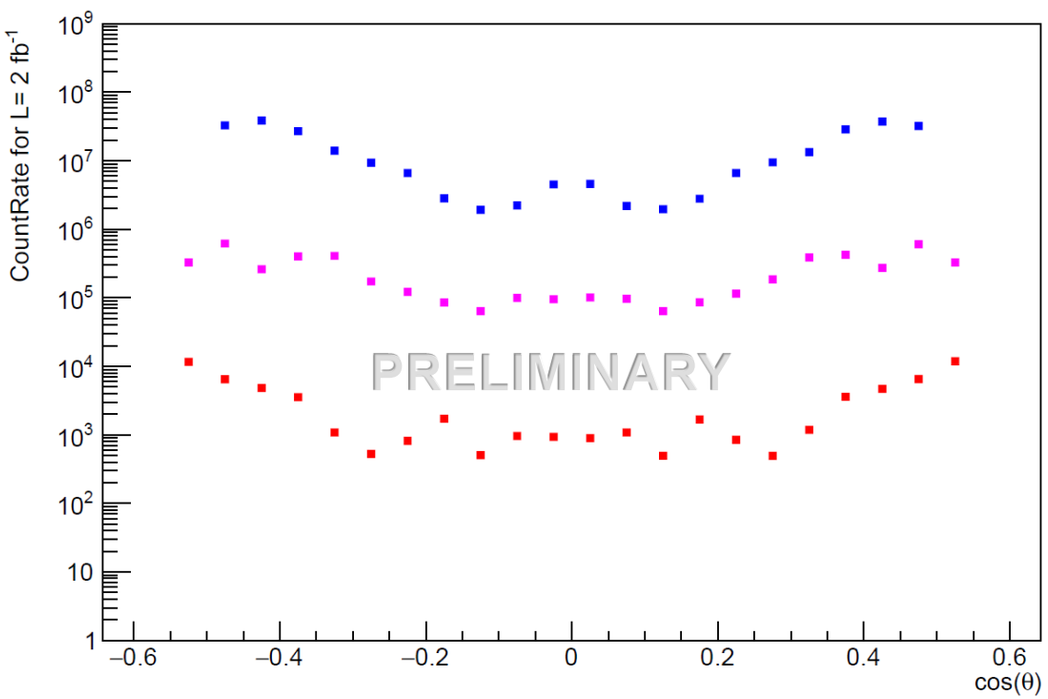




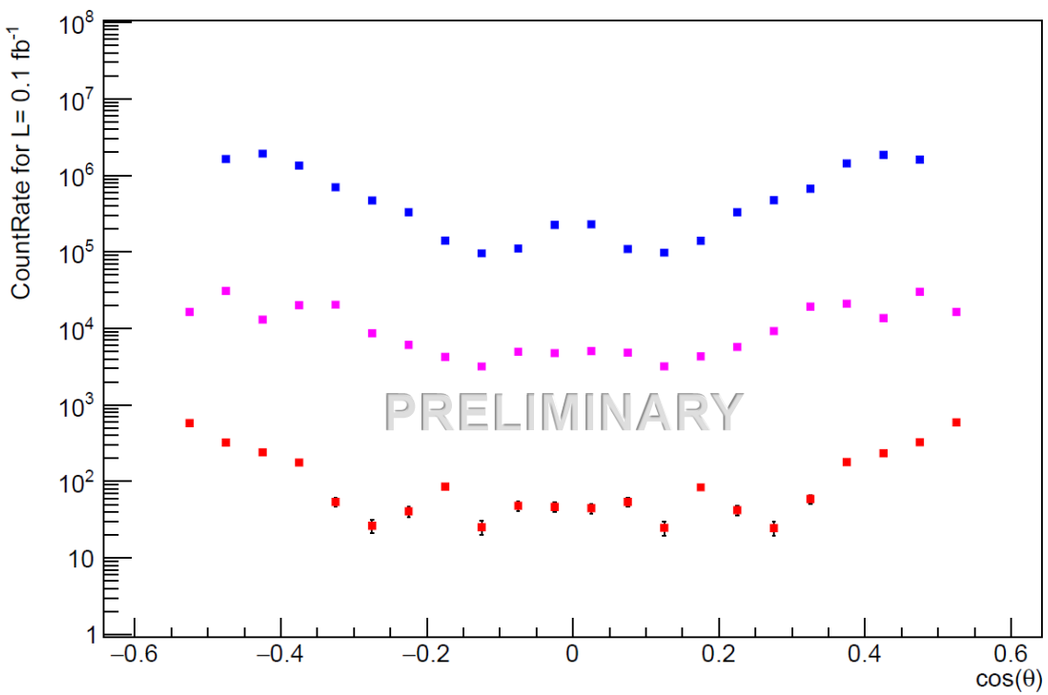
Count Rate for $\mathcal{L} = 2\ \mathrm{fb}^{-1}$ and $\mathcal{L} = 0.1\ \mathrm{fb}^{-1}$

- $\mathbf{p_{beam} = 2.5\ GeV/c}$
- $\mathbf{p_{beam} = 5\ GeV/c}$
- $\mathbf{p_{beam} = 10\ GeV/c}$

$\mathcal{L} = \mathbf{2\ fb^{-1}}$

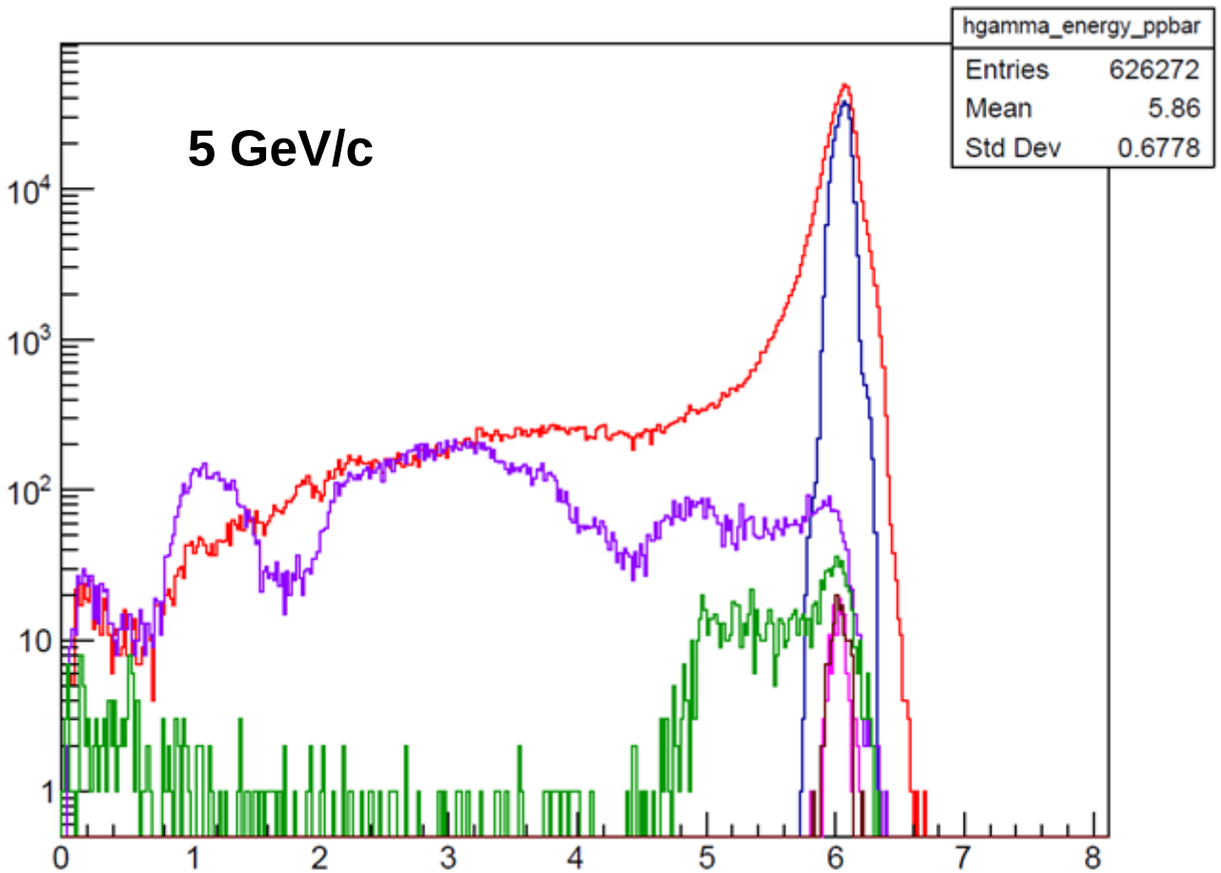


$\mathcal{L} = \mathbf{0.1\ fb^{-1}}$



Background Suppression

★ count gamma=2
★ Kinematic fit + energy > 5.7

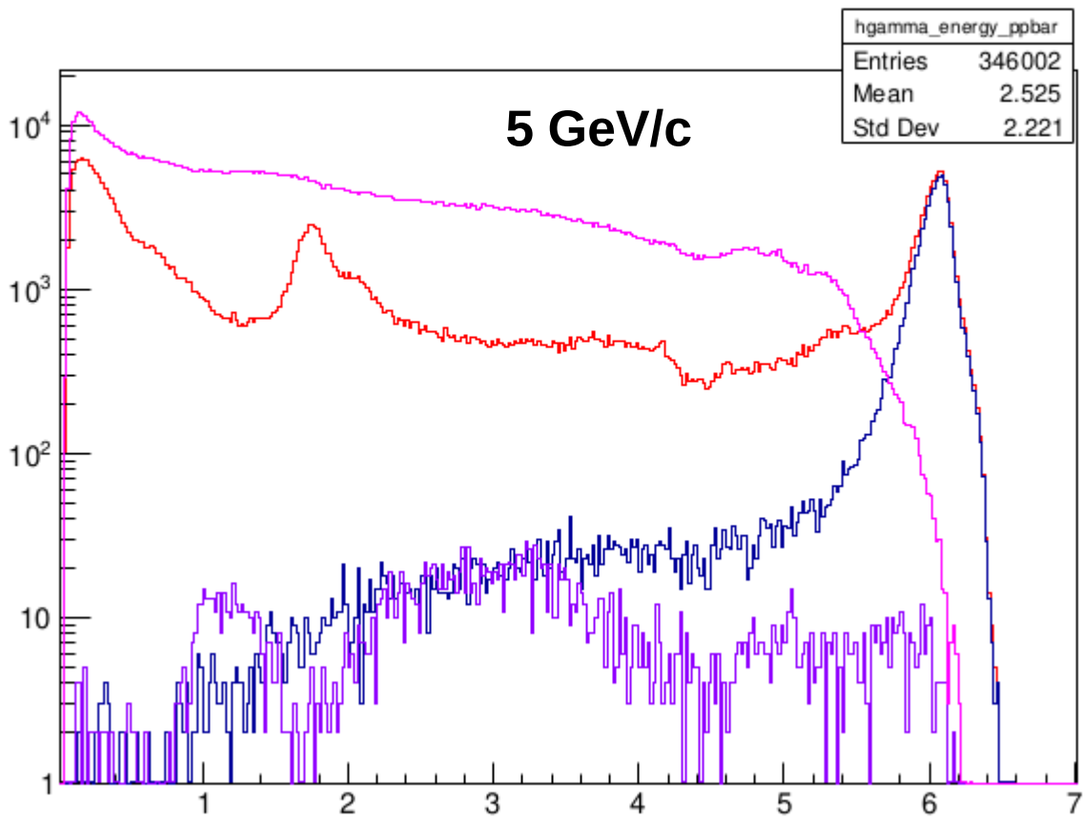


Signal:

Bkg $\pi^0\pi^0$:

Bkg $\pi^0\gamma$:

Background Suppression



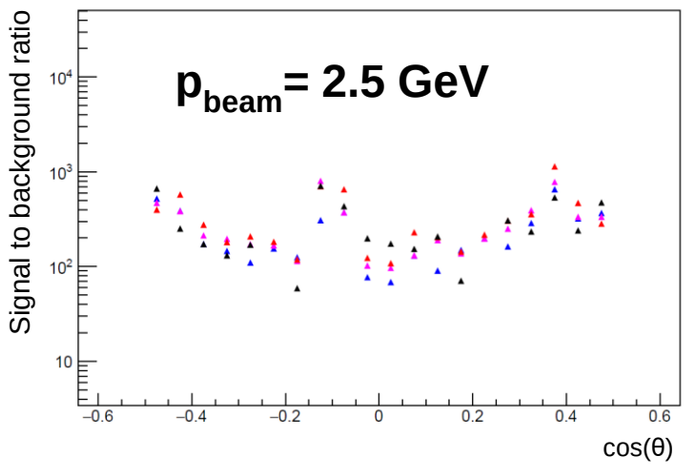
Signal $\gamma\gamma$:
count gamma>1
count gamma=2

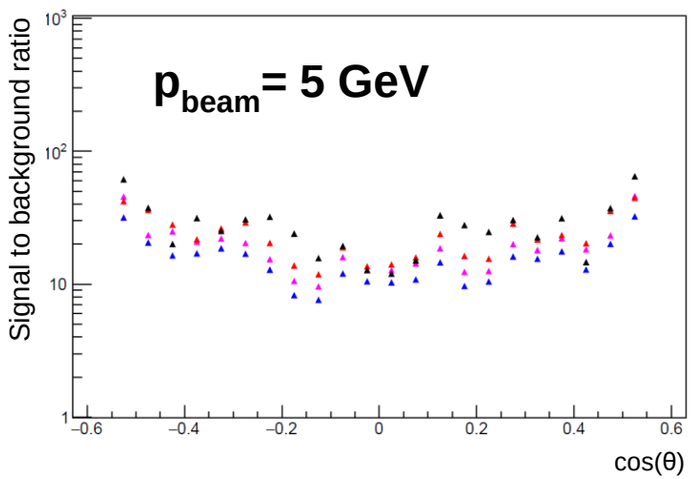
Bkg $\pi^0\pi^0$:
count gamma>1
count gamma=2

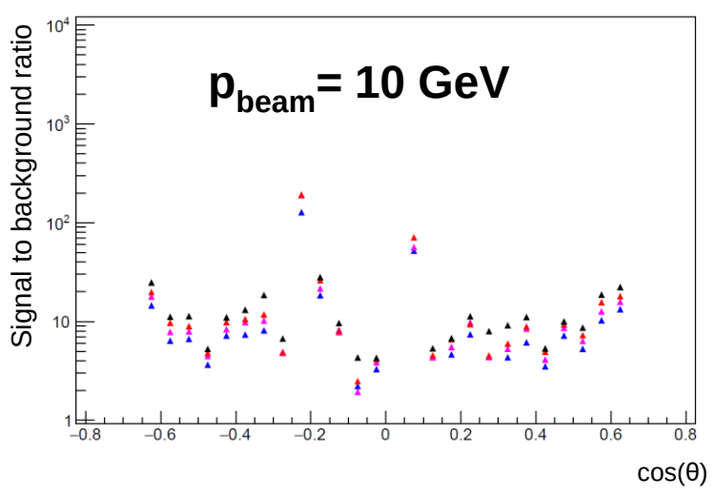
Signal to Background Ratio

p>0.01
p>0.1
p>0.3
p>0.7

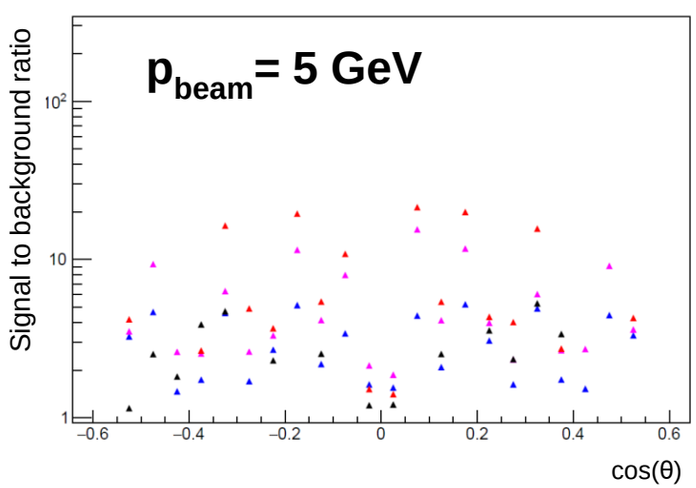
$\pi^0\gamma$

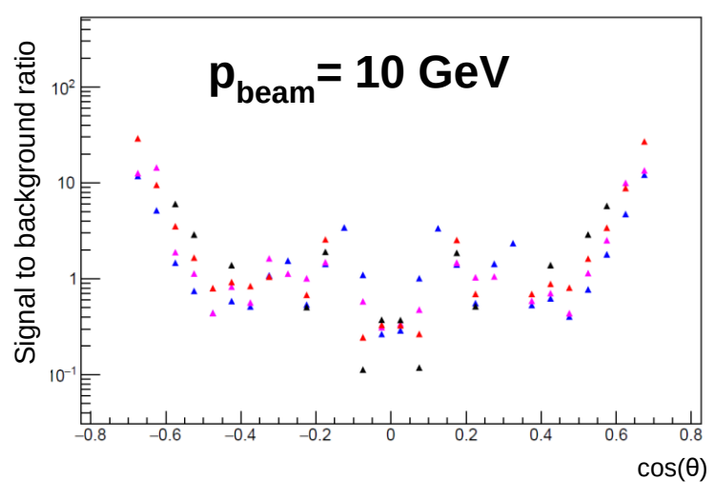






$\pi^0\pi^0$

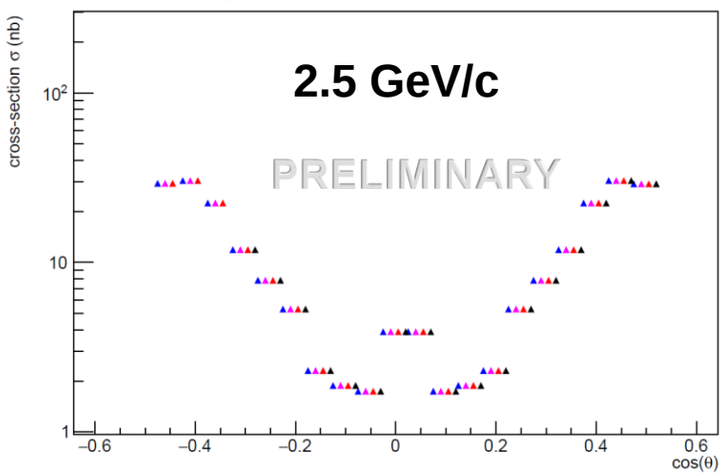


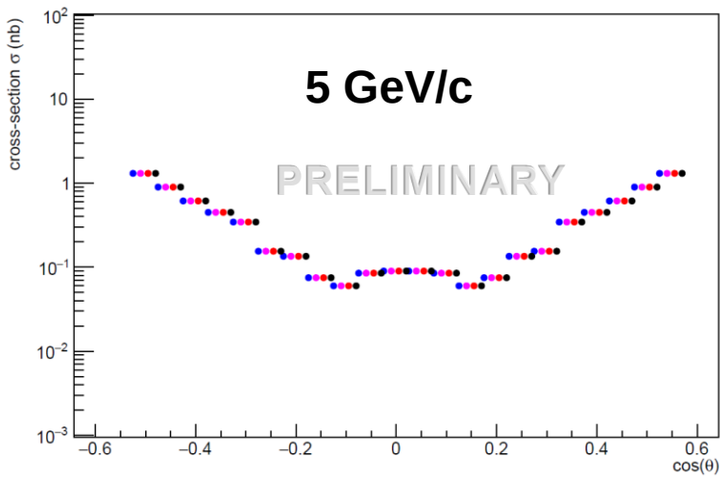


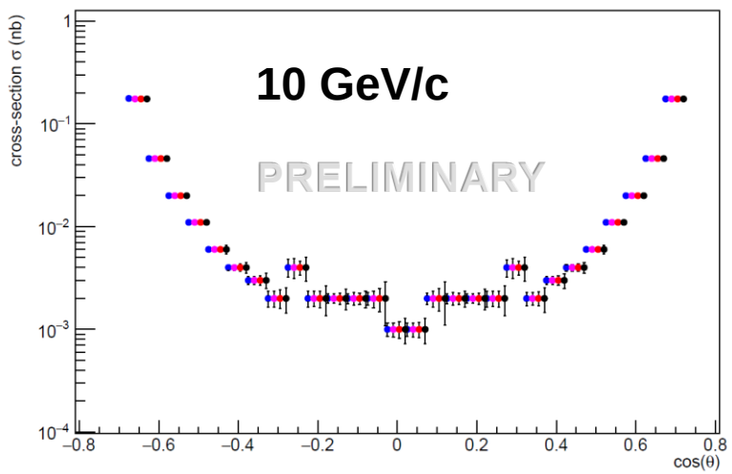
Cross-section with Statistical Uncertainties

p>0.01 p>0.1 p>0.3 p>0.7

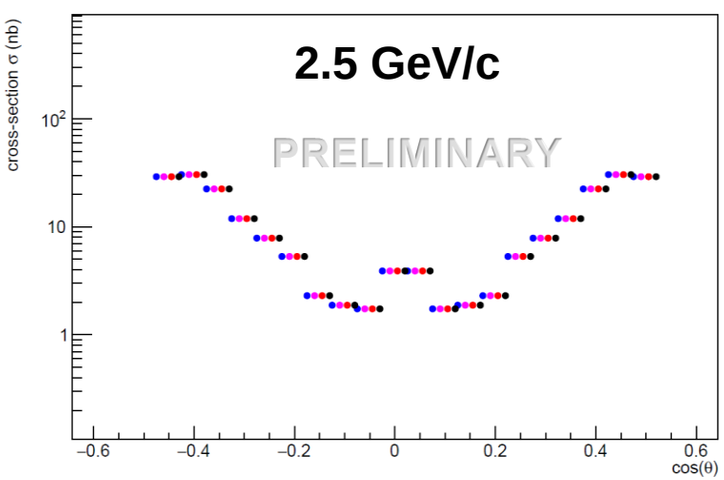
Luminosity = 2 fb^{-1}

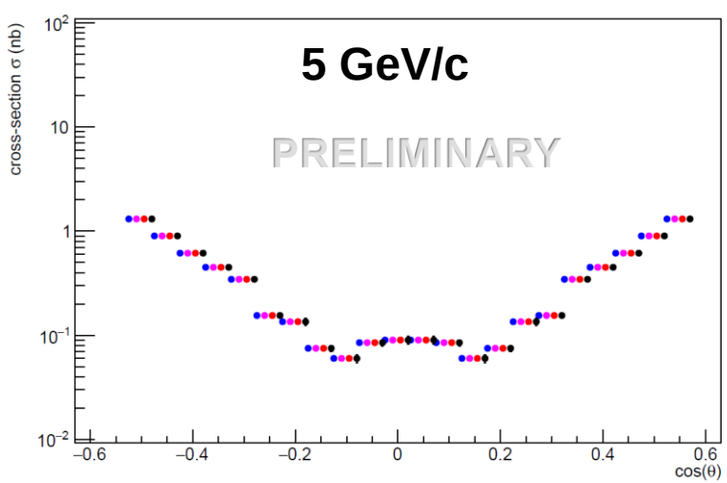


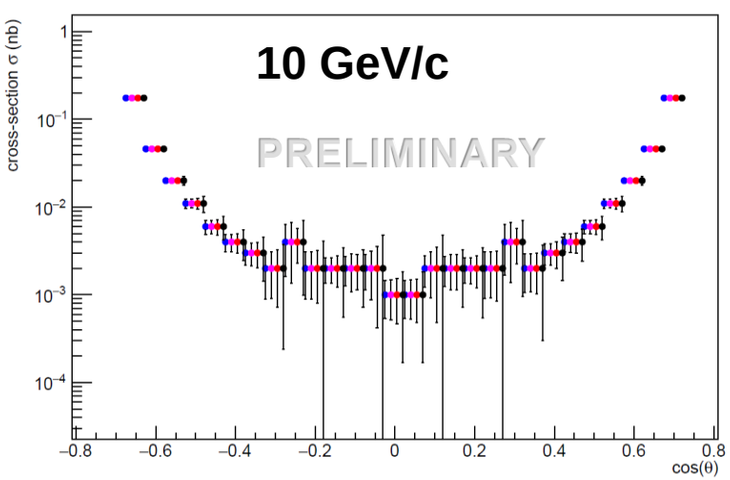




Luminosity = 0.1 fb^{-1}







Summary

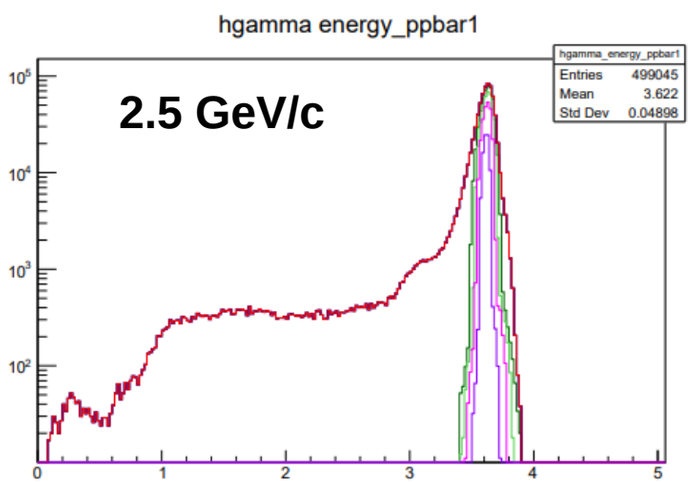
- Exclusive event selection with 4C kinematic fit was performed
- Acceptance in cos(θ) has been checked
- Acceptance corrections were done
- The cos(θ) dependence of the cross-section has been implemented and a reconstruction study has been performed at $\sqrt{s} = 2.6\ GeV$, $\sqrt{s} = 3.4\ GeV$ and $\sqrt{s} = 4.5\ GeV$
- Count rate estimates and estimates of the expected statistical uncertainty was performed.
- Signal to background ratio was determined.
- Selection cuts were investigated to optimize the signal to background ratio while keeping a reasonable reconstruction efficiency.
- The channel $\mathrm{p\bar{p}} \rightarrow \gamma\,\gamma$ can be well measured with $\overline{\mathrm{P}}\mathrm{ANDA}$ but background has to be considered as it was done in the E760 experiment.

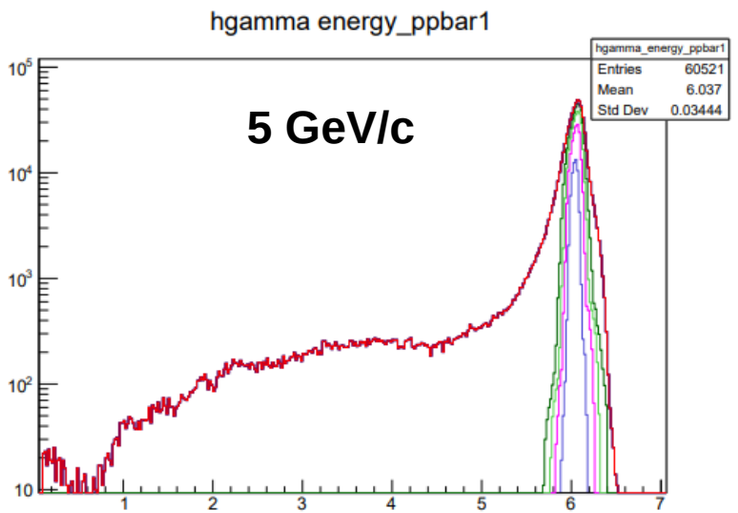
Thank You For Your Attention!

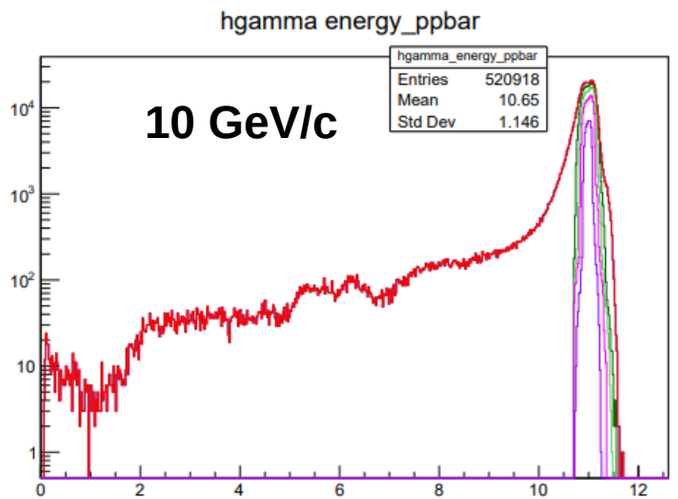
Suppressing the background

- p>0.01
- p>0.1
- p>0.3
- p>0.7

Effect on the sum of energies of the two gamma particles with increasing probability of Kinematic fit





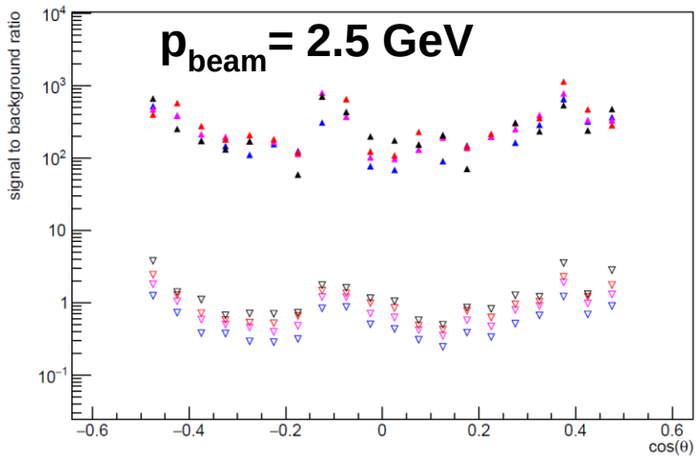


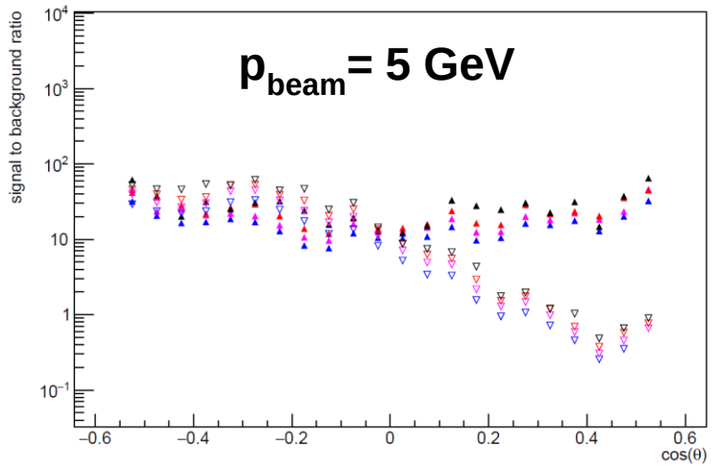
Signal to Background Ratio- a comparison

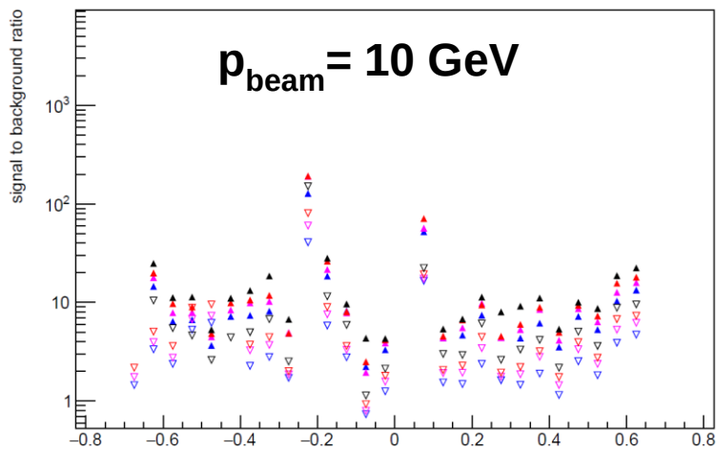
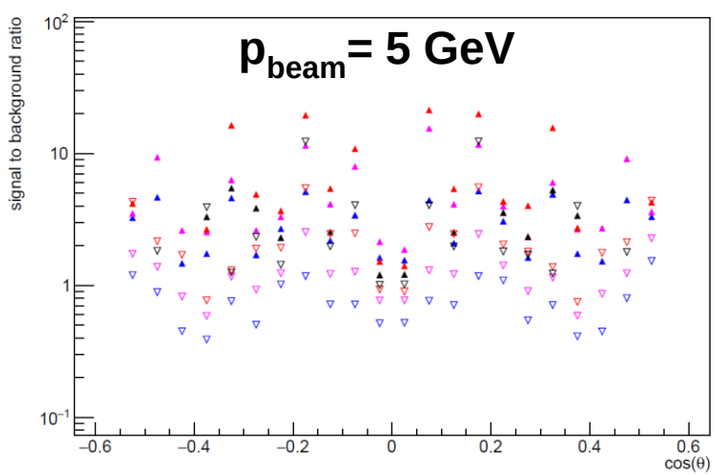
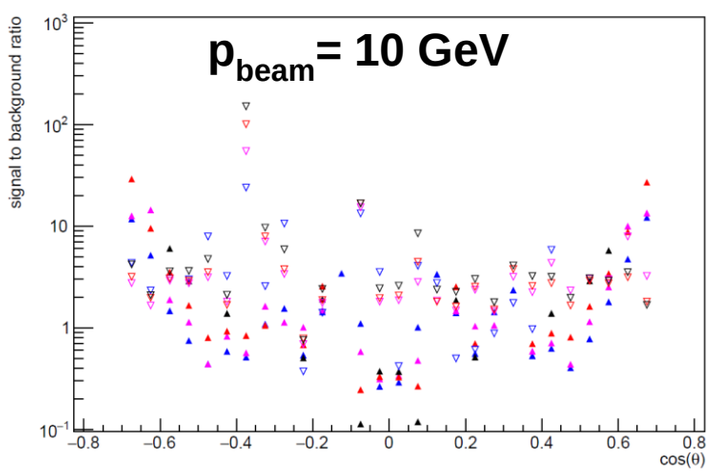
p>0.01
p>0.1
p>0.3
p>0.7

▲ gamma count = 2 △ gamma count > 1

$\pi^0\gamma$







$\pi^0\pi^0$