

# $\pi^0$ Background ID and Selection in fitQu $\ddot{n}$

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# Introduction

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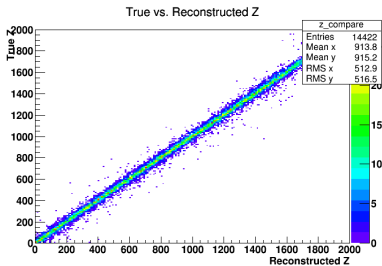
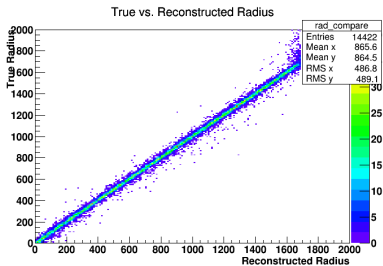
Events are generated with a particle gun of  $\pi^0$ s up to 1 GeV.

## Software aside: FiTQun Handling of $\pi^0$ s

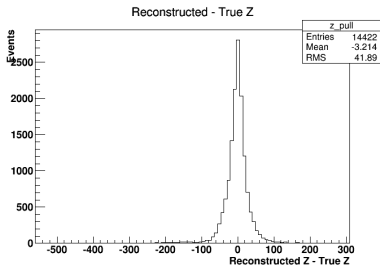
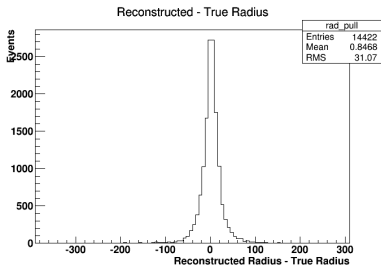
- $\pi^0$ s are reconstructed with both a constrained and non-constrained mass fit.
  - Constrained fit does not perform well at the moment; all plots shown are for non-constrained fit
- All  $\pi^0$  events are considered to have a single sub-event
- Output variables contained in the fqi0\* variables

- fqi0pctlg
- fqi0mom1
- fqi0mom2
- fqi0momtot
- fqi0dconv1
- fqi0dconv2
- fqi0t0
- fqi0totmu
- fqi0nll
- fqi0mass
- fqi0photangle
- fqi0pos
- fqi0dir1
- fqi0dir2
- fqi0dirtot

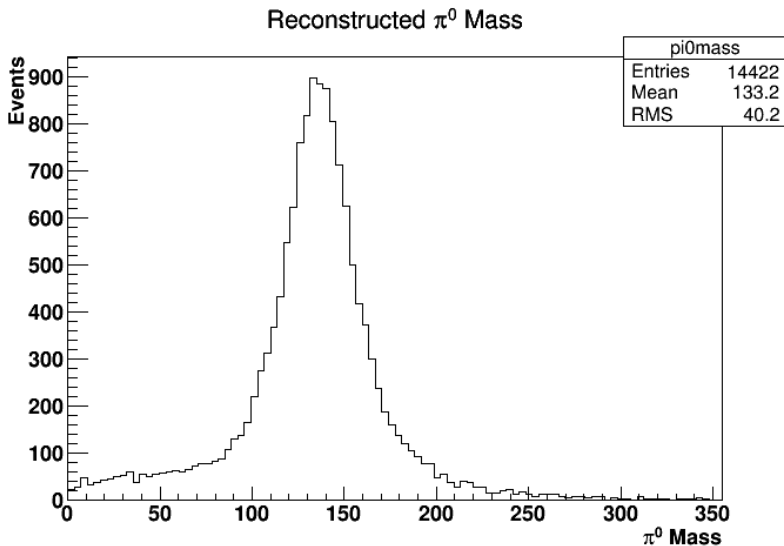
# Position Reconstruction



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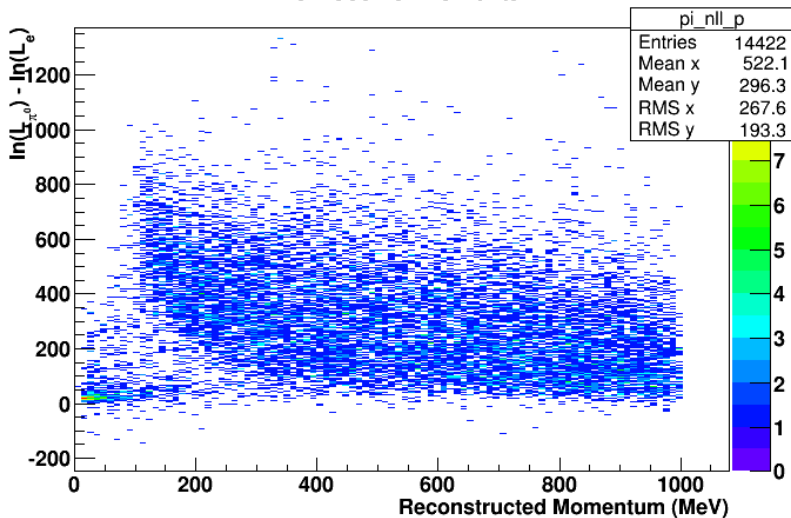
# Mass Reconstruction



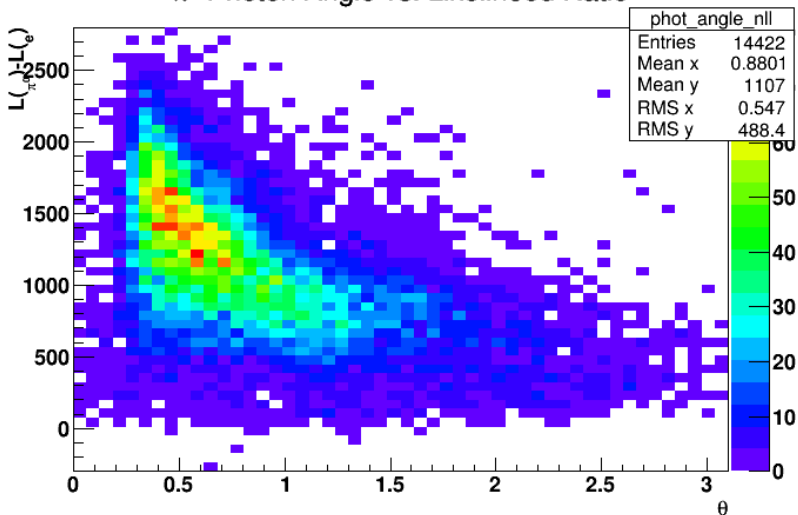


$-\log(\text{Likelihood})$ 

Likelihood vs. Momentum

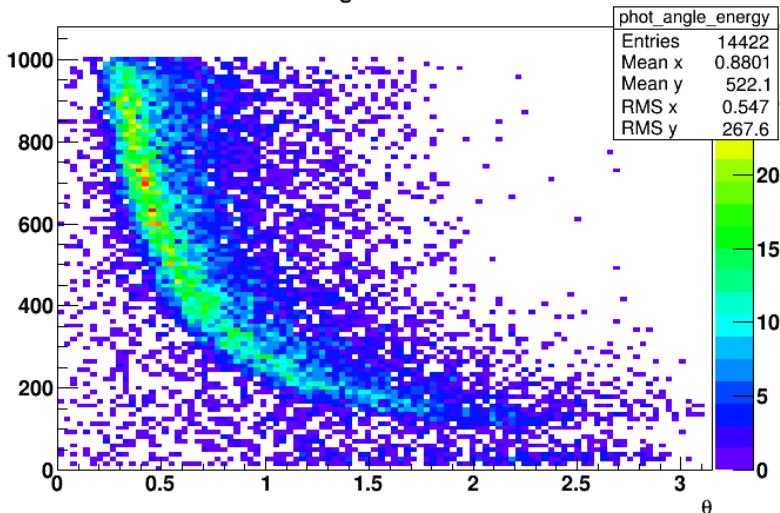


## Opening Angle

 $\pi^0$  Photon Angle vs. Likelihood Ratio

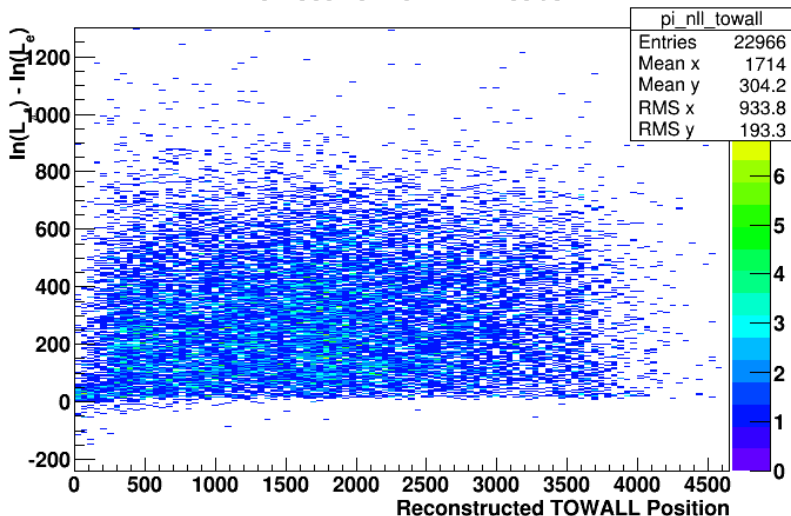
## Opening Angle

Photon Angle vs. Momentum



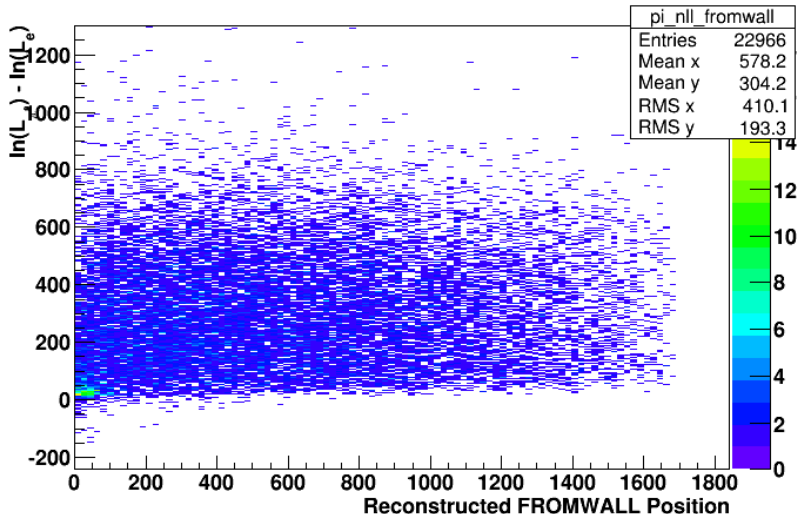
# Likelihood by towall

## Likelihood vs. TOWALL Position



# Likelihood by fromwall

## Likelihood vs. FROMWALL Position



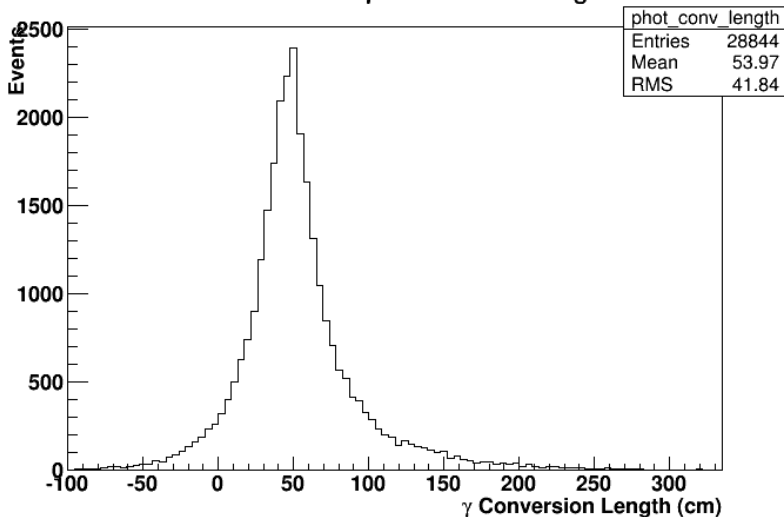
# Dead Region $\pi^0$ s

To investigate the possibility of photons from  $\pi^0$ s decaying in the deadregion converting in the ID, a sample of  $\pi^0$  events was generated entirely in the SK dead region.

Dead Region  $\pi^0$ s

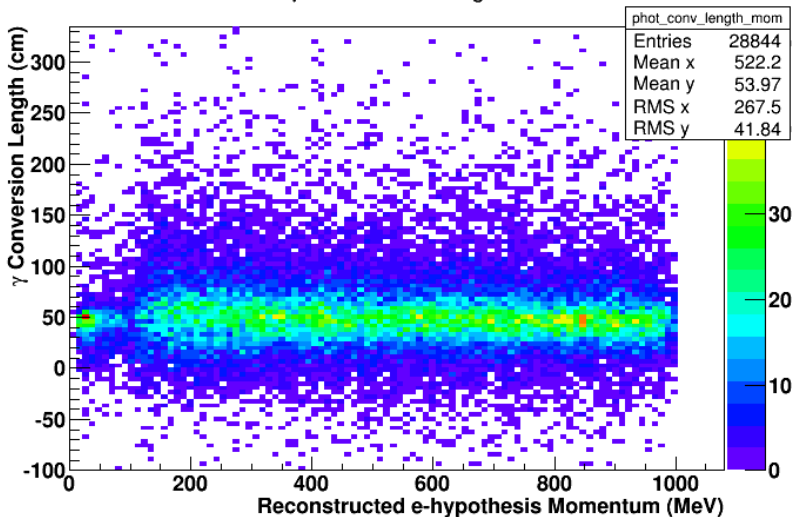
# Conversion Length

## Reconstructed $\gamma$ Conversion Length



Dead Region  $\pi^0$ s

## Conversion Length

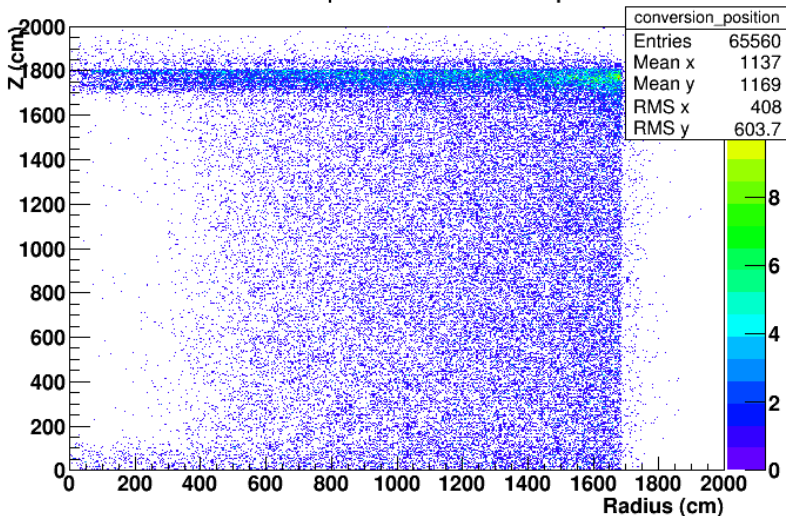
Reconstructed  $\gamma$  Conversion Length vs. Momentum



Dead Region  $\pi^0$ s

## Conversion Position (Contained Events)

Reconstructed photon conversion position



# Event Selection

The question of event selection remains to be addressed. Several possibilities exist:

- 1 Individual cuts on variables
- 2 Multivariate selection using fiTQun variables

Individual cuts have been performed in the past, but studies should be carried out to determine if the selection can be improved. Additionally, multiple analyses can be carried out as a secondary check on results.

# Event Selection

For multivariate processes, work has begun with TMVA to test several options, including Boosted Decision Trees (BDT) and k-Nearest Neighbor (kNN) techniques.

ROOT trees can be customized to relevant variables:



Dead Region  $\pi^0$ s

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This process is streamlined to allow for easy, streamlined use of FiTQun variables in TMVA.

# Conclusions

- fiTQun readily identifies  $\pi^0$ s over a wide range of momenta
- $\pi^0$  PID remains quite good even for low wall/towall values
- Event selection improvements may result from improved MVA or cut determination