Central Tracker Benchmark: $\bar{p}p \longrightarrow n(\pi^+\pi^-)$ (n=1,2)

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Outline

- Kinematics of the reaction
- Data simulation
- Analysis
  - $\bar{p}p \longrightarrow \pi^+\pi^-$
  - $\bar{p}p \longrightarrow \pi^+\pi^-\pi^+\pi^-$
- Outlook

Kinematics of the reaction

In the $\bar{p}p$ annihilation process with charged pions are the most abbundant particles produced. In particular the interesting figures of merit are:

- Invariant mass resolution of $\pi^+\pi^-$ and $\pi^+\pi^-\pi^+\pi^-$
- Reconstruction efficiency of $\bar{p}p \rightarrow \pi^+\pi^-$ and $\bar{p}p \rightarrow \pi^+\pi^-\pi^+\pi^-$
- Single pion tracks resolution
- Vertex resolution

Energy in the center of mass system: 3.07 GeV; p_z=4.0 GeV

Cross section reference from: V. Flaminio, CERN-HERA 84-01:
- $\bar{p}p \rightarrow \pi^+\pi^-$: σ=0.007 mb at $E_{CM} = 3.07$ GeV
- $\bar{p}p \rightarrow \pi^+\pi^-\pi^+\pi^-$: σ=0.43 mb at $E_{CM} = 2.954$ GeV

Data simulation

- Event generation is performed with EvtGen event generator using PHSP decay model
- MonteCarlo simulation, digitization and reconstruction is performed within pandaroot framework
- PID is based on MonteCarlo Truth information
- Events were produced on the grid with and without event mixing.

Analysis

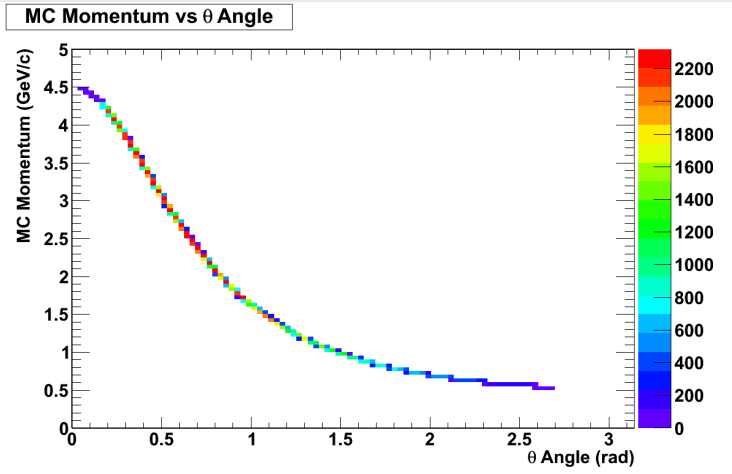
- Analysis is performed with rho package
- Events with 2.07 GeV $< m(\pi^+\pi^-) <$ 4.07 GeV are selected
- Events with 2.57 GeV $< m(\pi^+\pi^-\pi^+\pi^-) <$ 3.57 GeV are selected
- Vertex fit is performed and best candidate in each event is selected by minimal χ^2

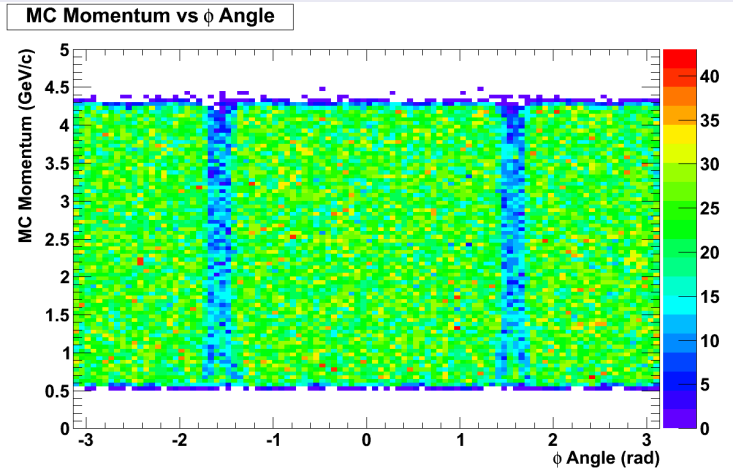
$\bar{p}p \longrightarrow \pi^+\pi^-$

No Event Mixing - Only Signal Events

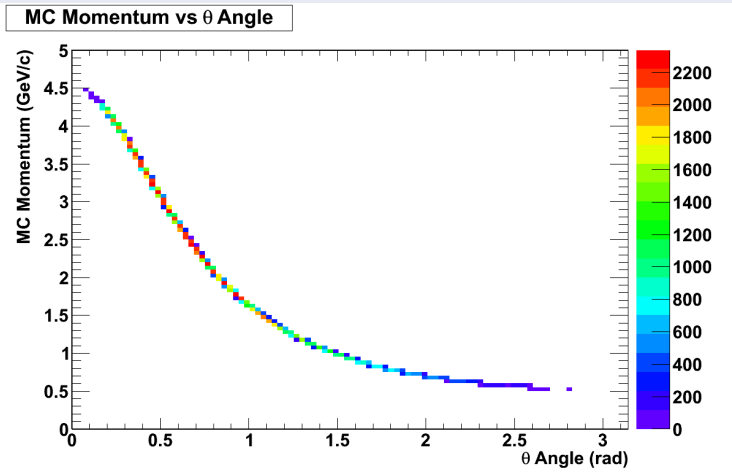
Single pion track reconstruction

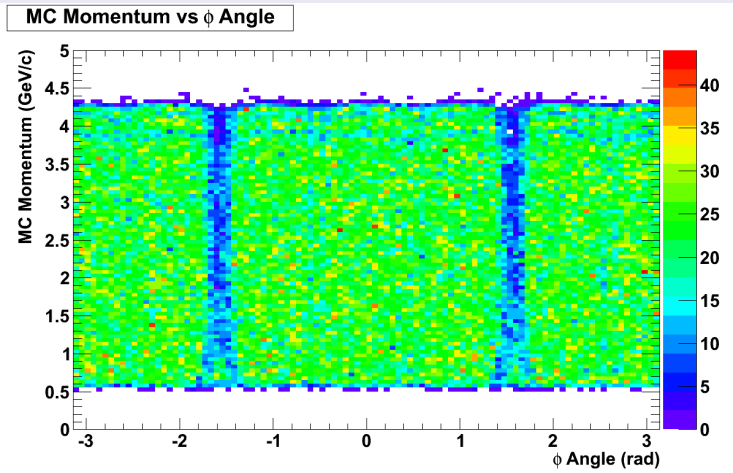
No clean up (Run906)





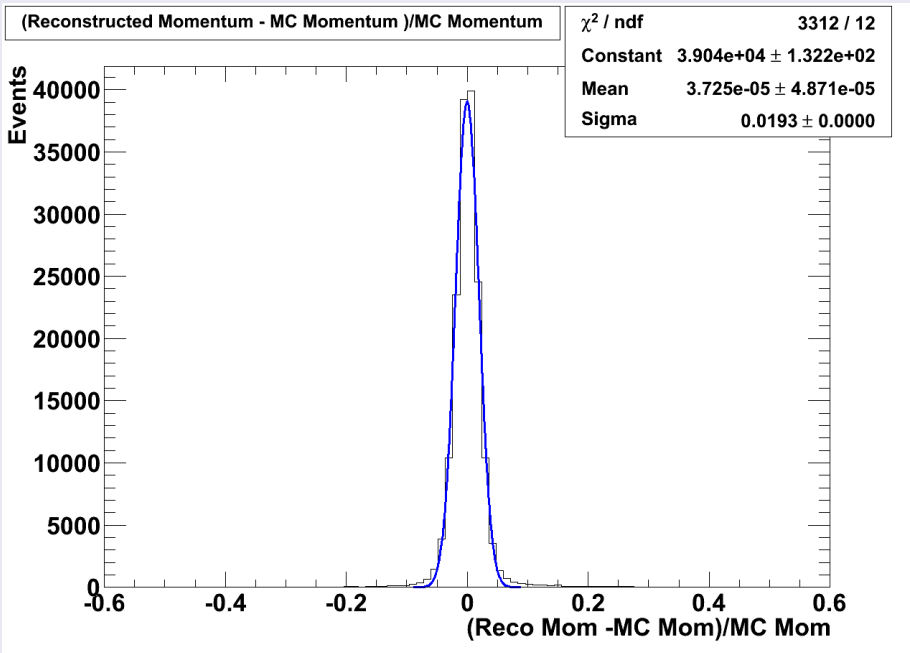
Clean up (Run906cu)





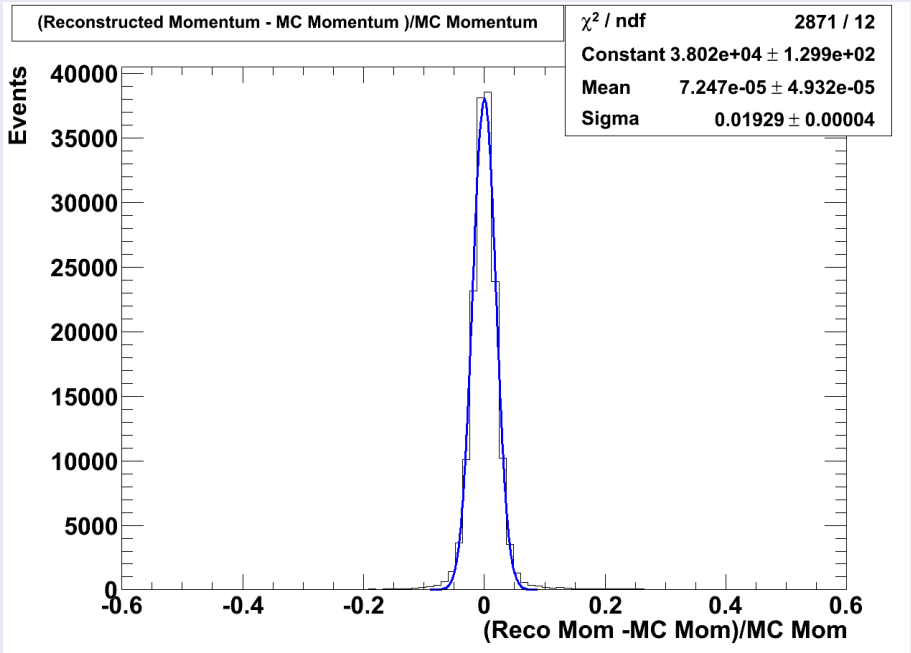
Single pion track reconstruction

No clean up (Run906)



Resolution: (1.93±0.01)%

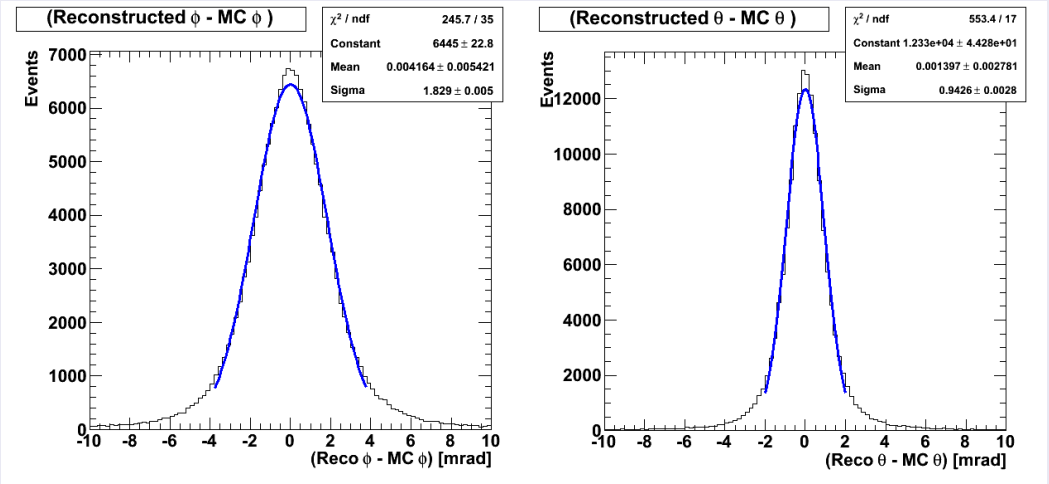
Clean up (Run906cu)



Resolution: (1.93±0.01)%

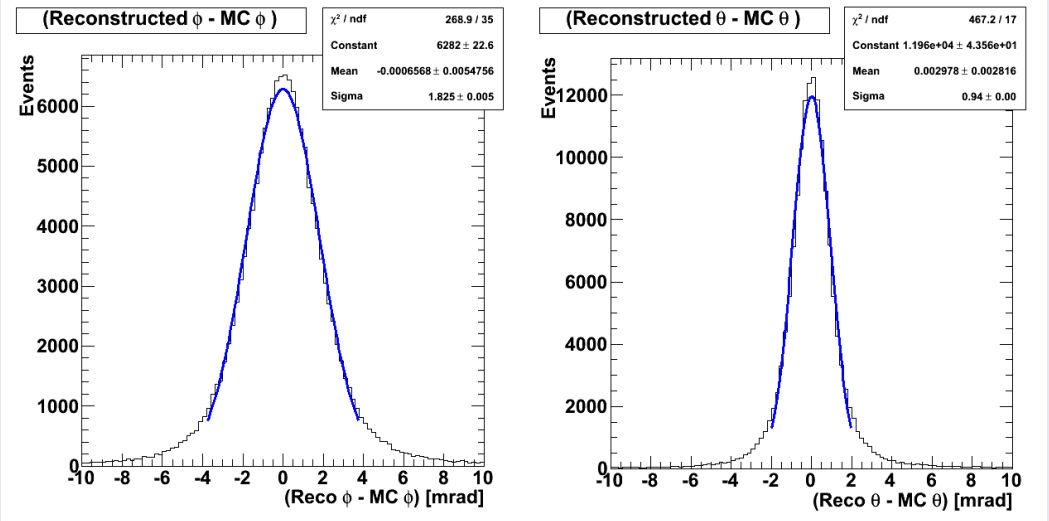
θ, ϕ resolution

No clean up (Run906)



$\sigma(\phi)$=(1.829±0.005) mrad
$\sigma(\theta)$=(0.943±0.003) mrad

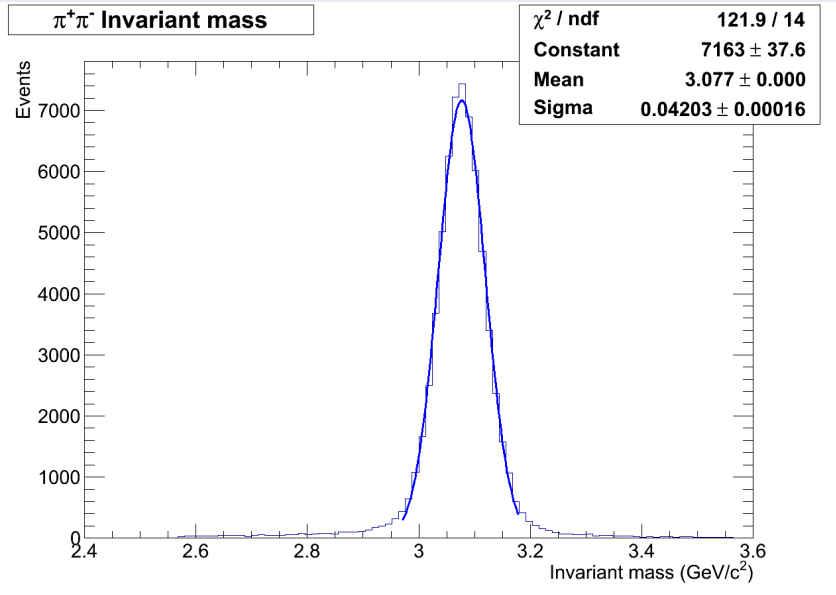
Clean up (Run906cu)



$\sigma(\phi)$=(1.825±0.005) mrad
$\sigma(\theta)$=(0.939±0.003) mrad

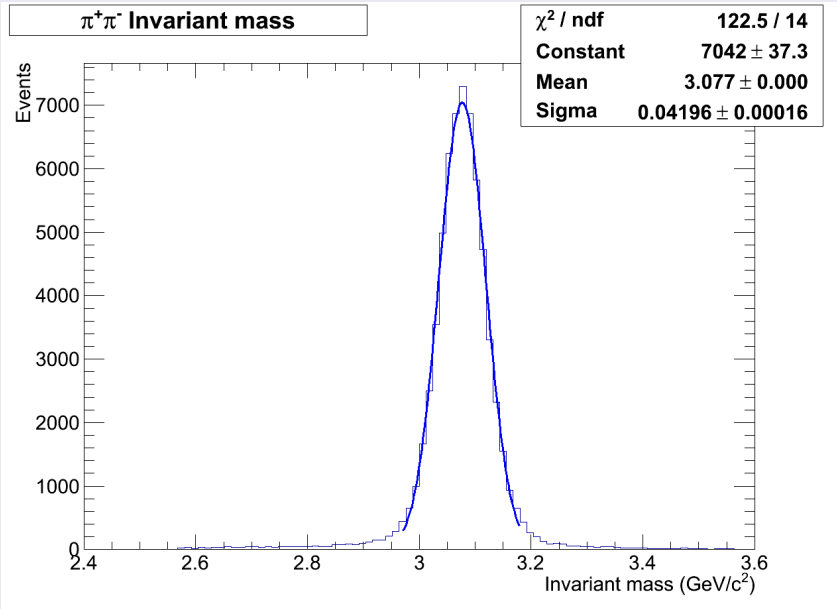
Invariant mass distribution

No clean up (Run906)



Resolution: 42.03±0.16 MeV/c^2
Efficiency (67.7±0.3)%

Clean up (Run906cu)

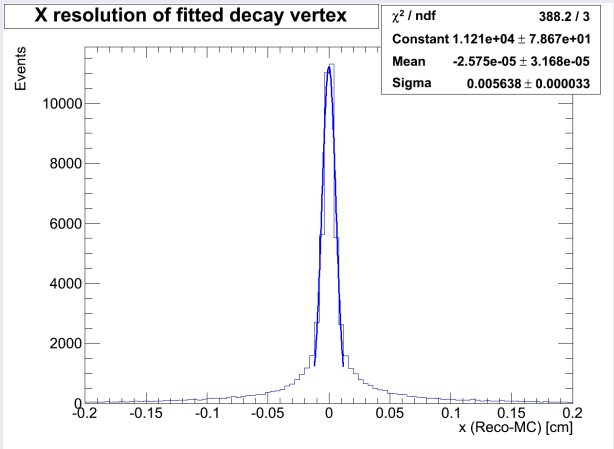


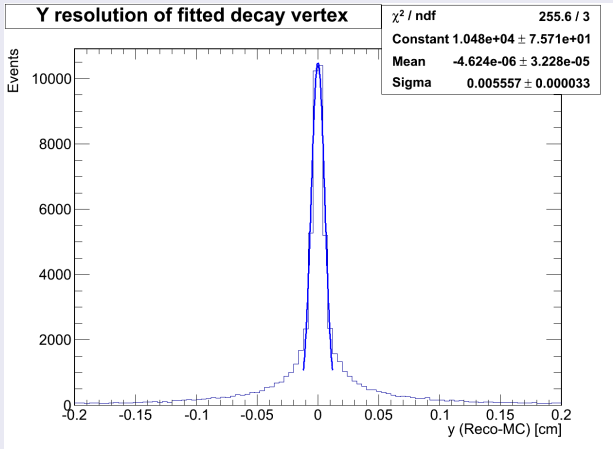
Resolution: 41.96±0.16 MeV/c^2
Efficiency (68.6±0.3)%

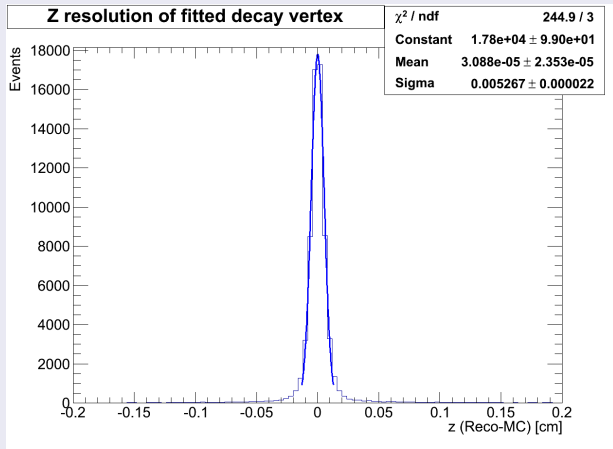
Efficiency=Number of reconstructed events/ number of generated events.
Run906: Number of generated events: 99500
Run906cu: Number of generated events: 95500

Vertex resolution

No clean up (Run906)

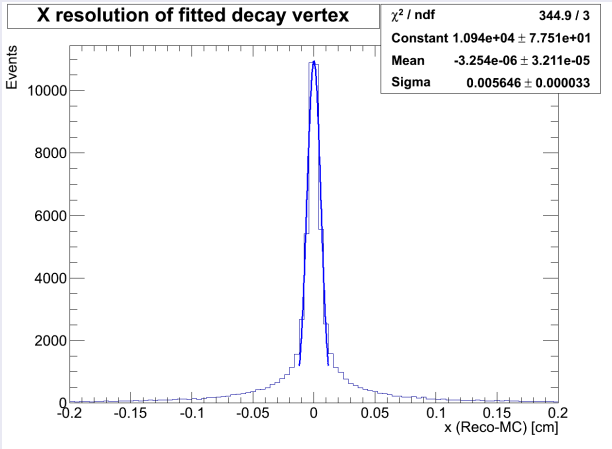


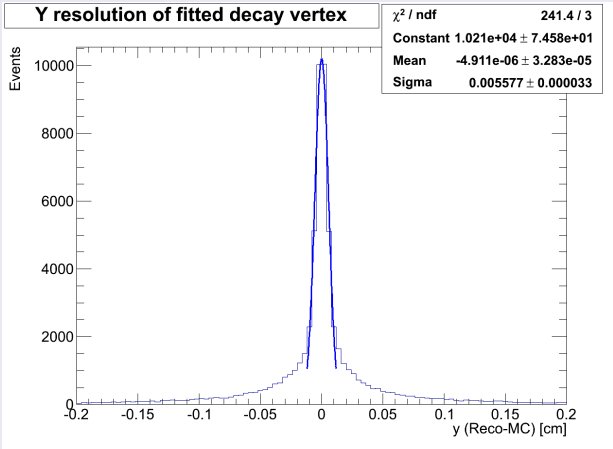


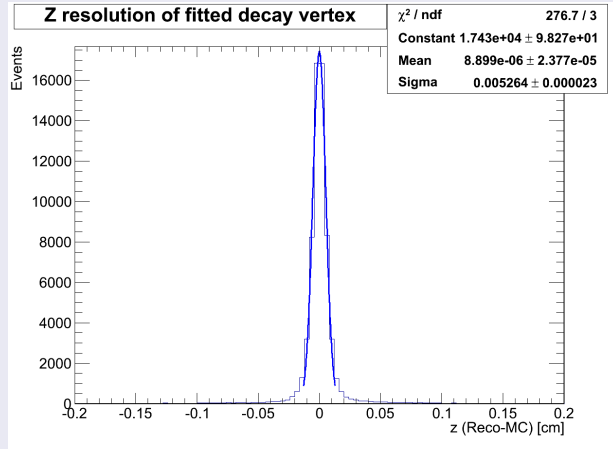


σ_x :(56.38±0.33) μm; σ_y :(55.57±0.33) μm; σ_z :(52.67±0.22) μm;

Clean up (Run906cu)





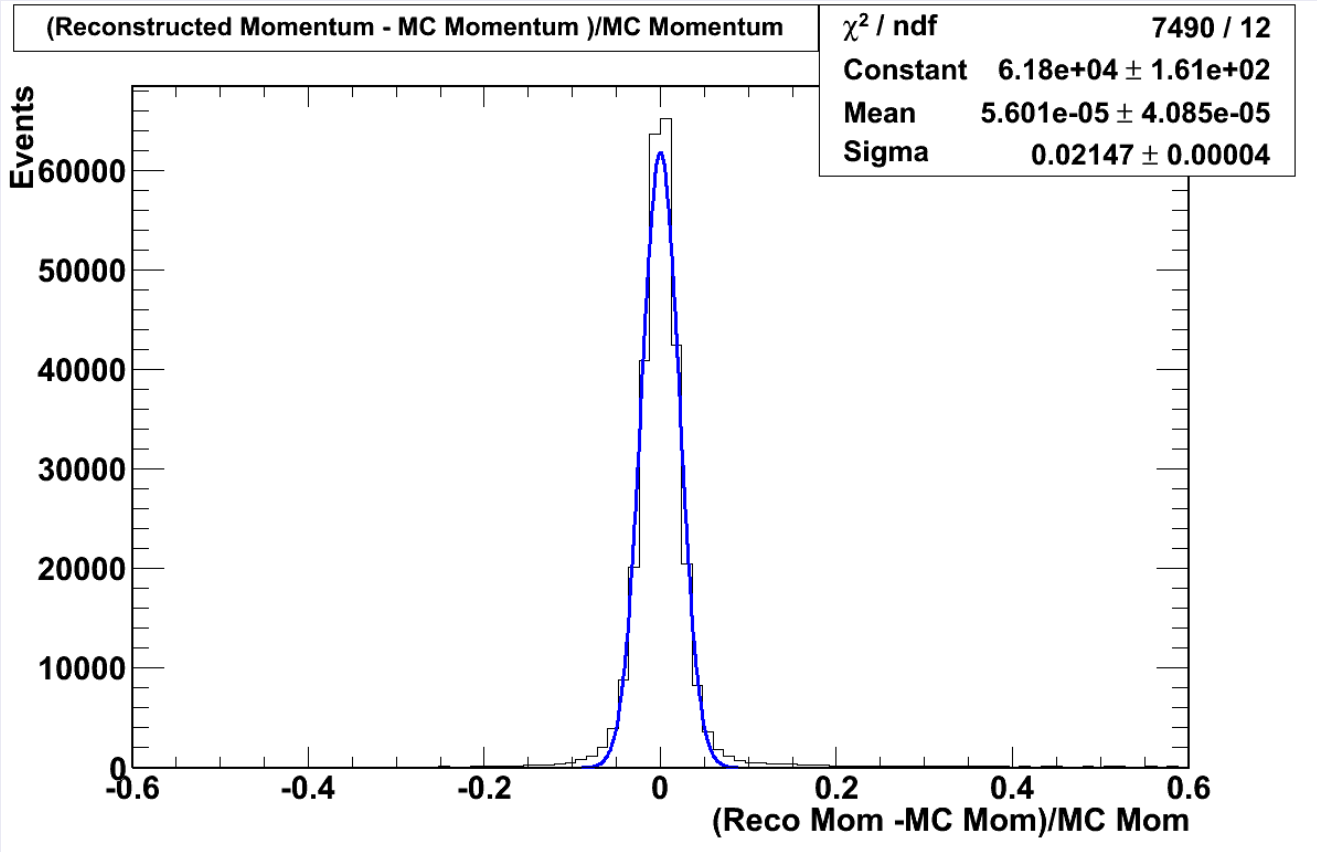


σ_x :(56.46±0.33) μm; σ_y :(55.77±0.33) μm; σ_z :(52.64±0.23) μm;

$\bar{p}p \longrightarrow \pi^+\pi^-$

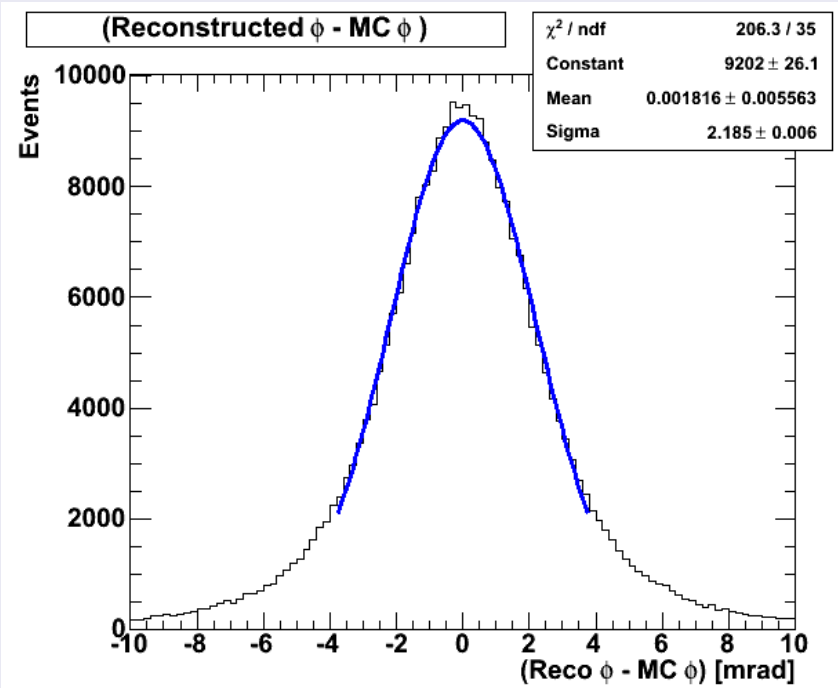
Event Mixing

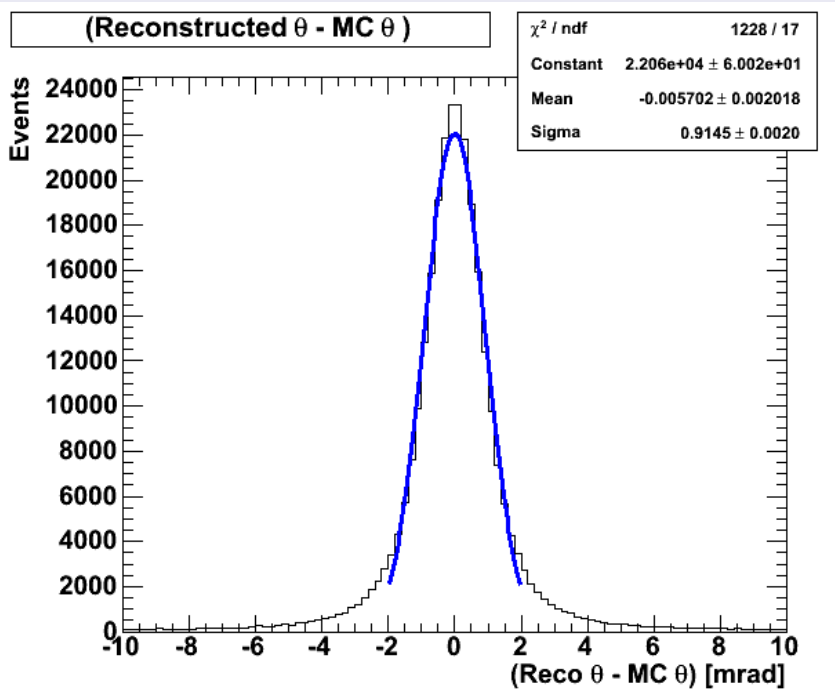
Single pion track reconstruction



Resolution: (2.15±0.01)%

θ, ϕ resolution



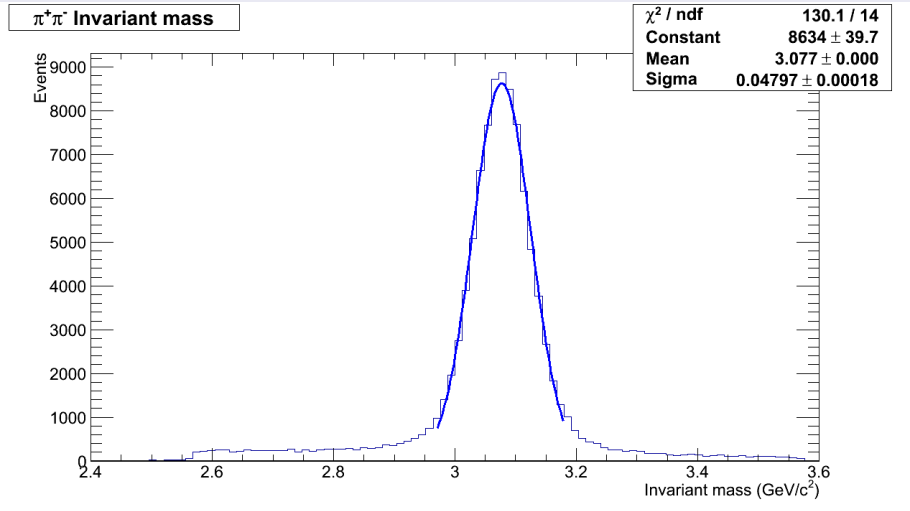


$\sigma(\phi)$=(2.185±0.006) mrad
$\sigma(\theta)$=(0.915±0.002) mrad

Invariant mass distribution

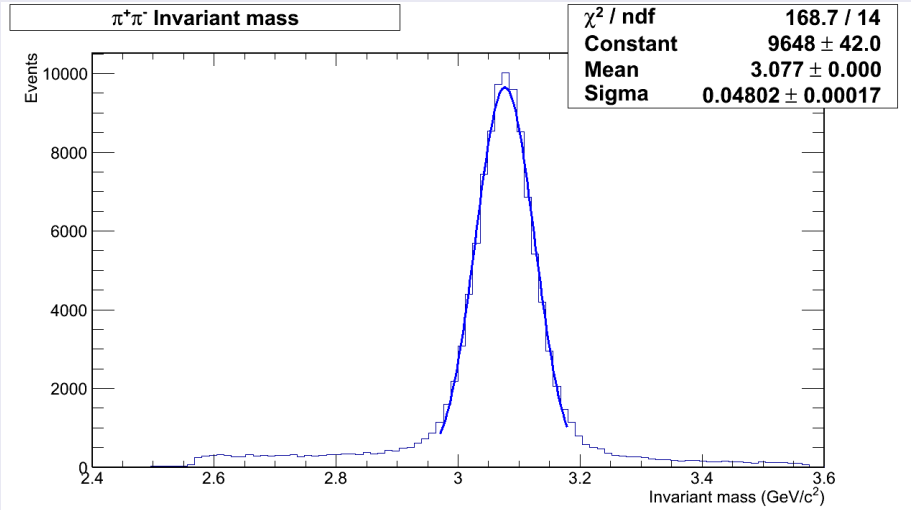
How results look like without MC PID and how PID is relevant for this study?

With PID



Resolution: 42.97±0.18 MeV/c^2
Efficiency (59.9±0.2)%

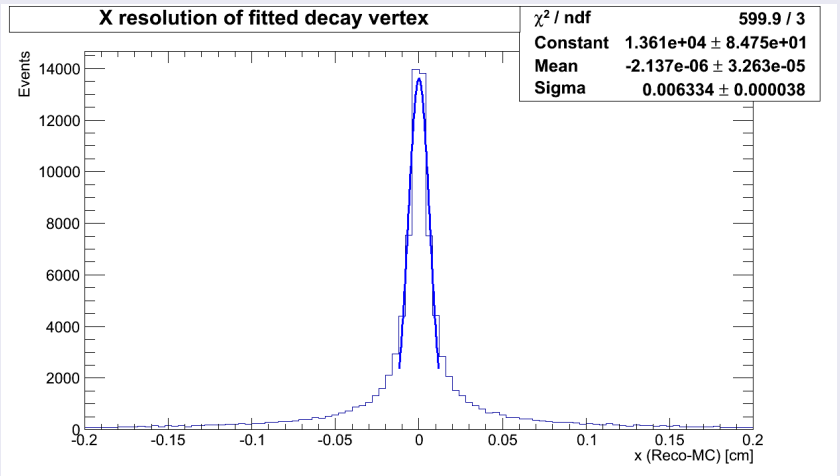
Without PID

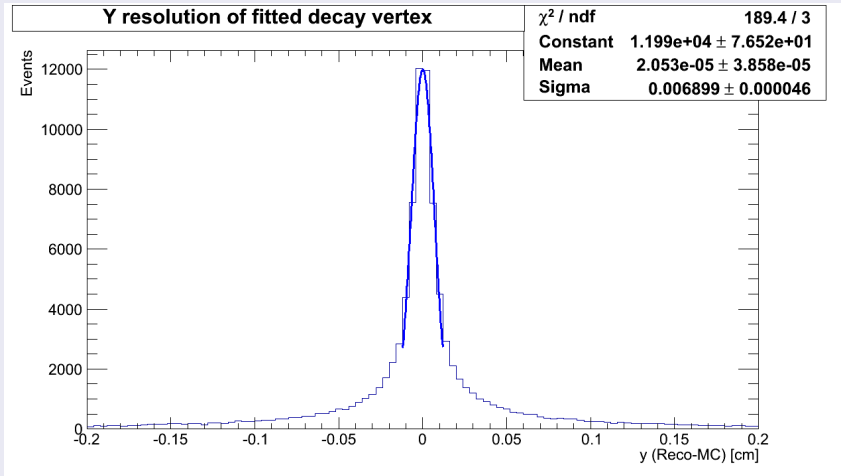


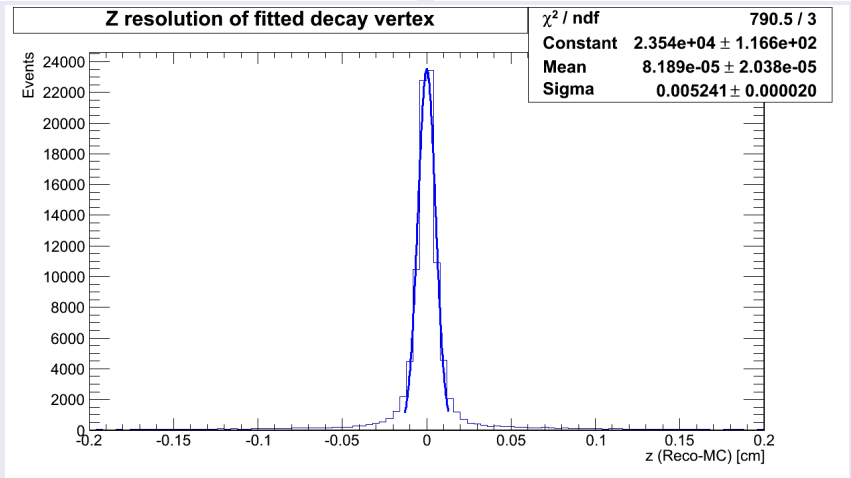
Resolution: 48.02±0.17 MeV/c^2
Efficiency (60.7±0.2)%

Efficiency=Number of reconstructed events/ number of generated events.

Vertex resolution







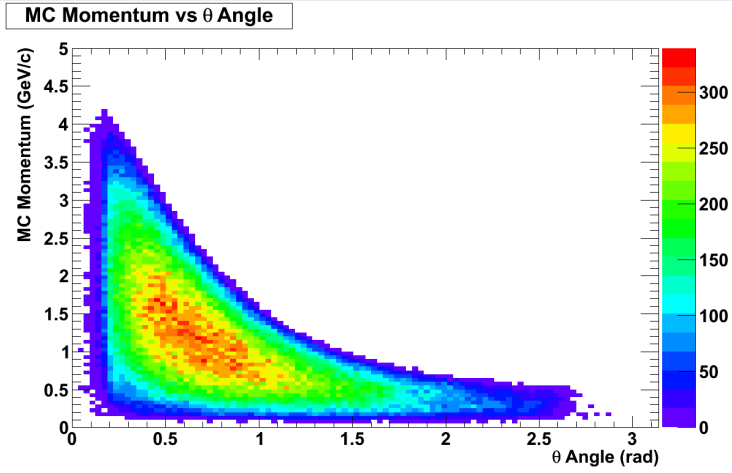
σ_x :(63.34±0.38) μm; σ_y :(68.99±0.46) μm; σ_z :(52.41±0.20) μm;

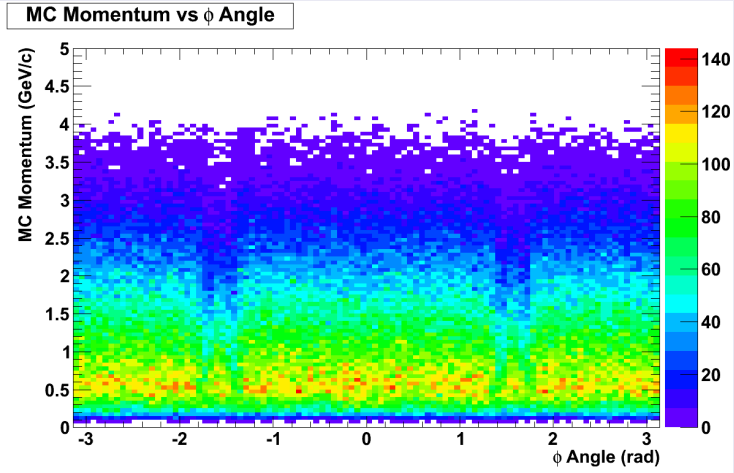
$$\bar{p}p \longrightarrow \pi^+\pi^-\pi^+\pi^-$$

No event mixing - Only signal events

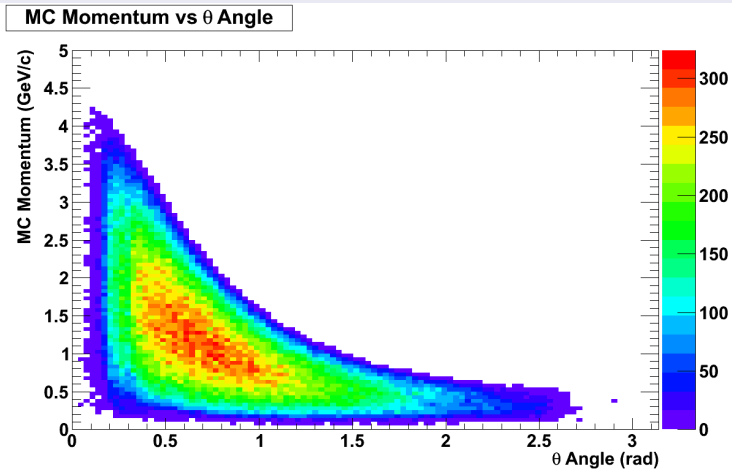
Single pion track reconstruction

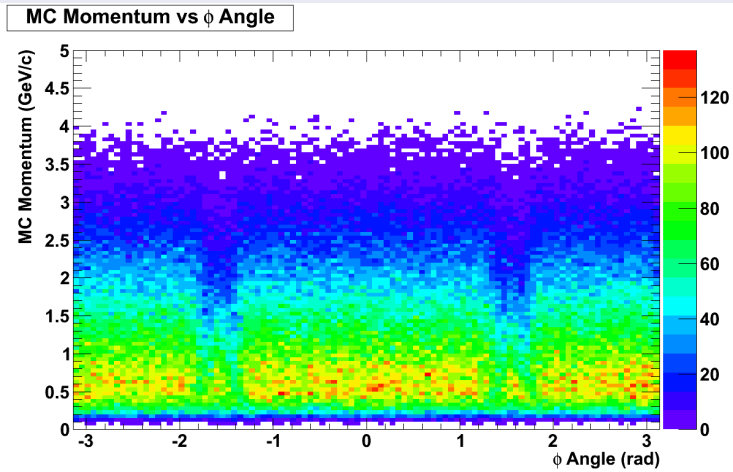
No clean up (Run916)





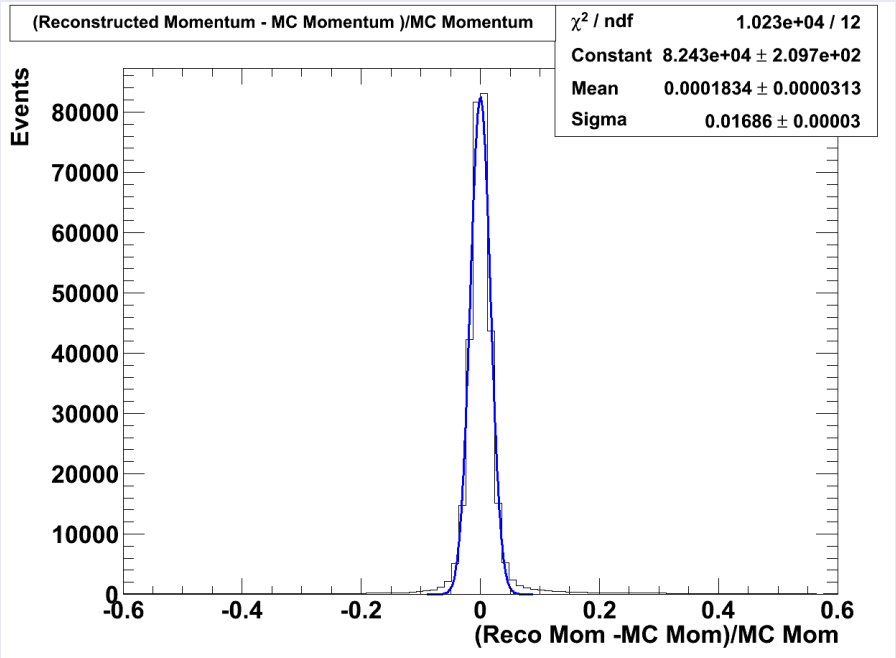
Clean up (Run916cu)





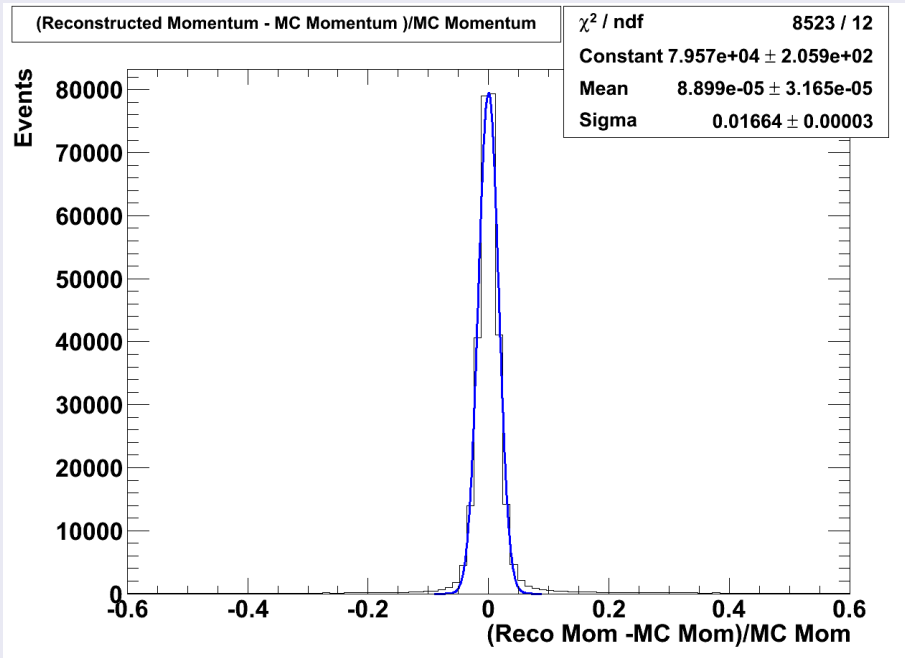
Single pion track reconstruction

No clean up (Run916)



Resolution: (1.70±0.01)%

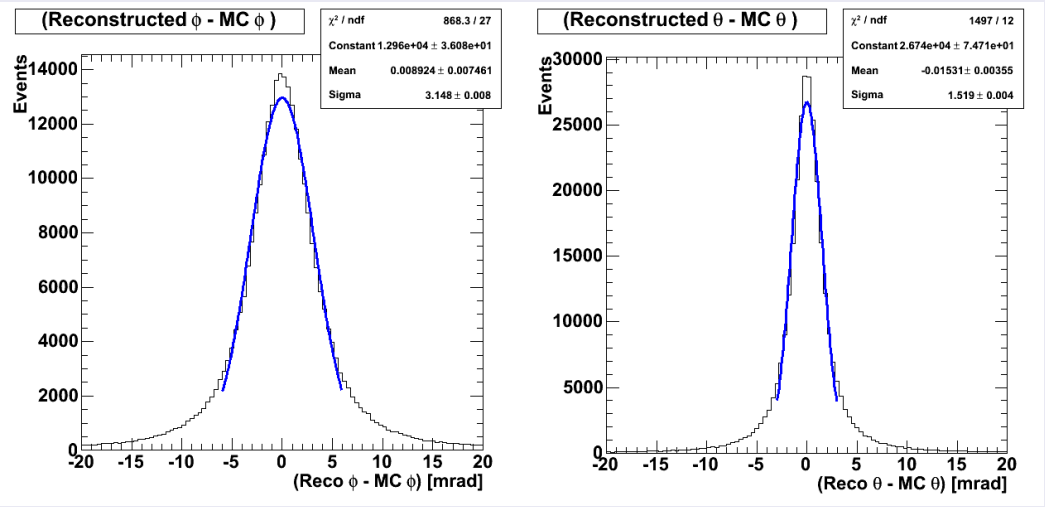
Clean up (Run916cu)



Resolution: (1.70±0.01)%

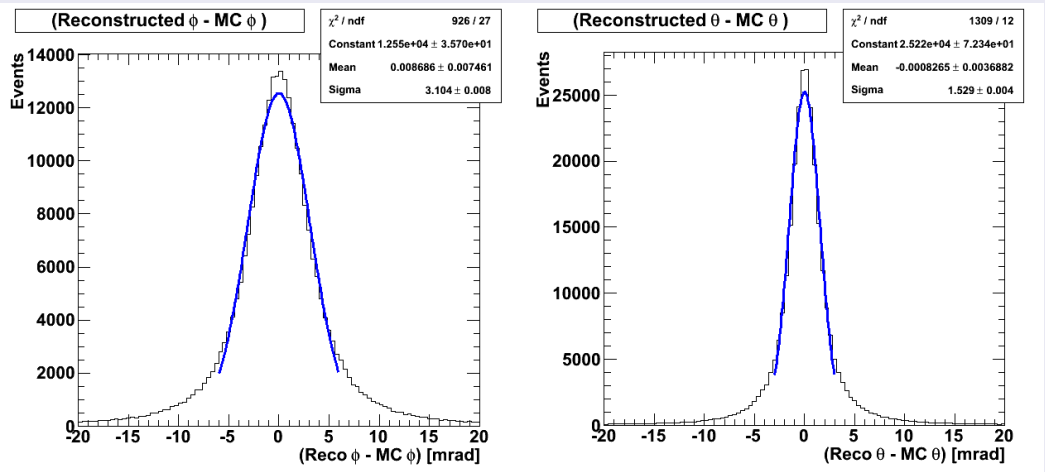
θ, ϕ resolution

No clean up (Run916)



$\sigma(\phi)$=(3.148±0.008) mrad
$\sigma(\theta)$=(1.519±0.004) mrad

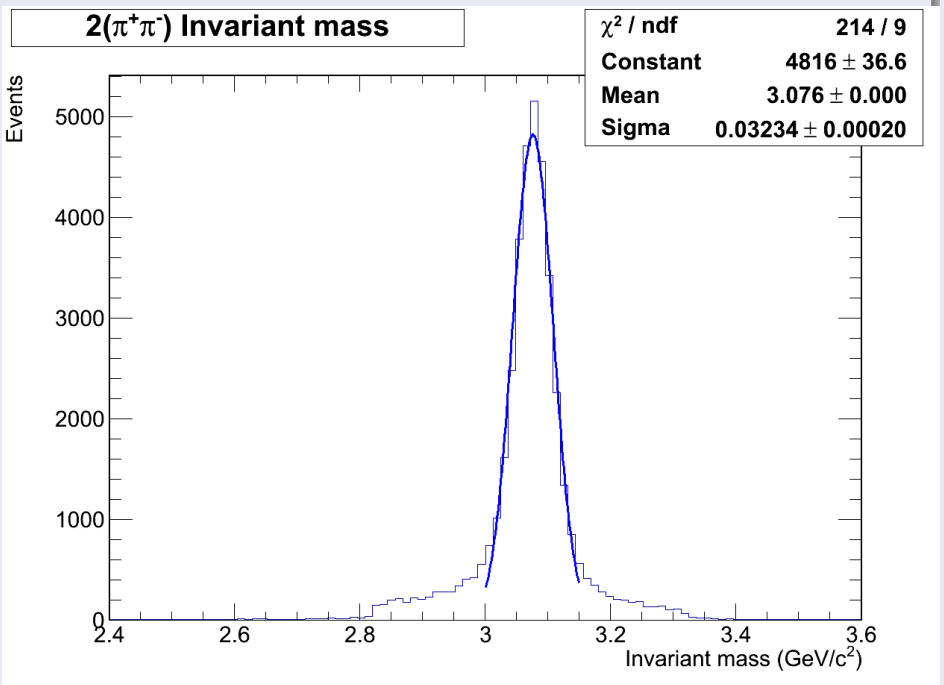
Clean up (Run916cu)



$\sigma(\phi)$=(3.104±0.008) mrad
$\sigma(\theta)$=(1.529±0.004) mrad

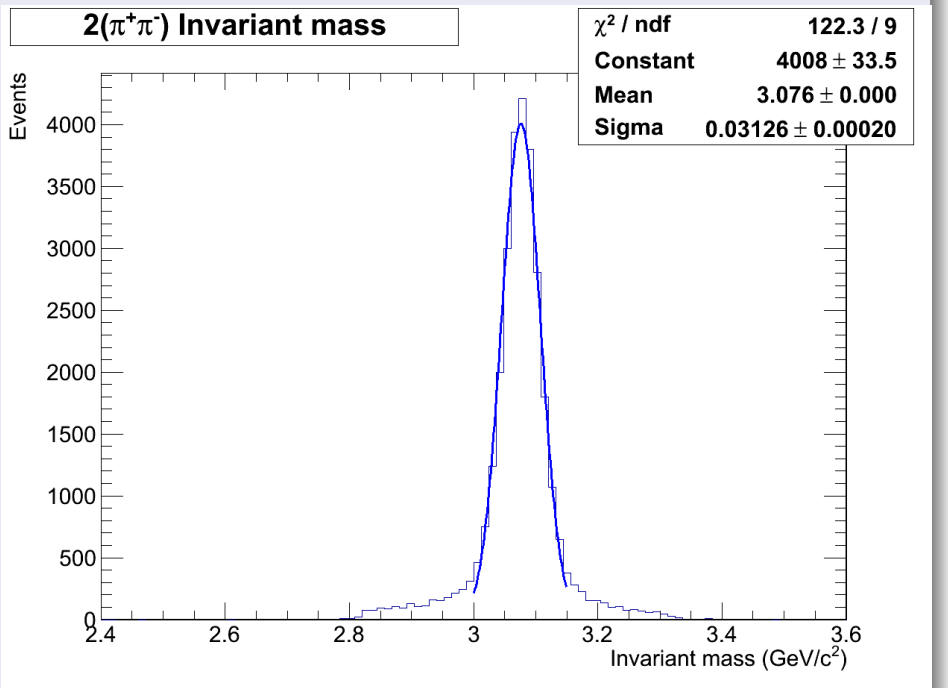
Invariant mass distribution

No clean up (Run916)



Resolution: 32.34±0.20 MeV/c^2
Efficiency (39.9±0.2)%

Clean up (Run916cu)

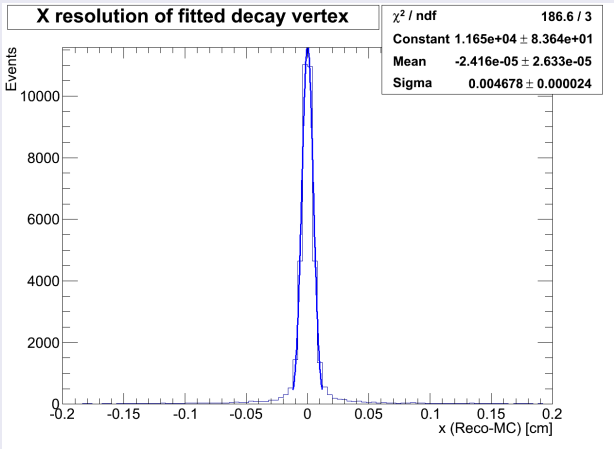


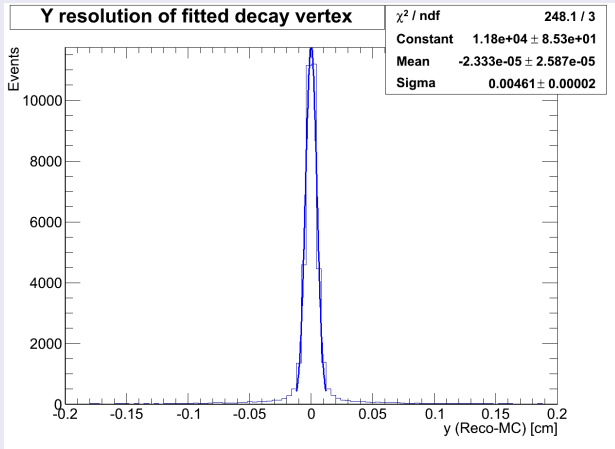
Resolution: 31.26±0.20 MeV/c^2
Efficiency (30.1±0.2)%

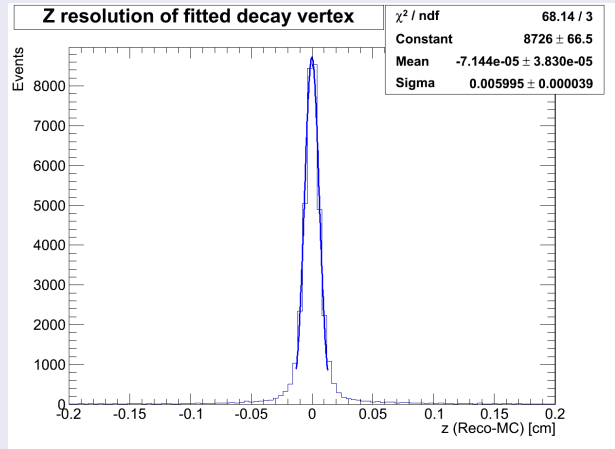
Efficiency=Number of reconstructed events/ number of generated events.
Run916: Number of generated events: 100000
Run916cu: Number of generated events: 100000

Vertex resolution

No clean up (Run916)

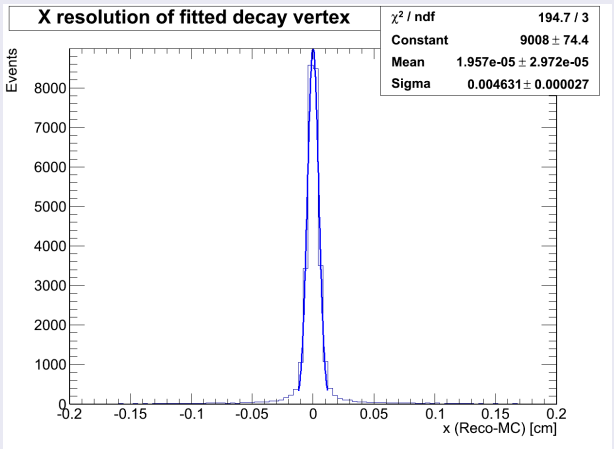


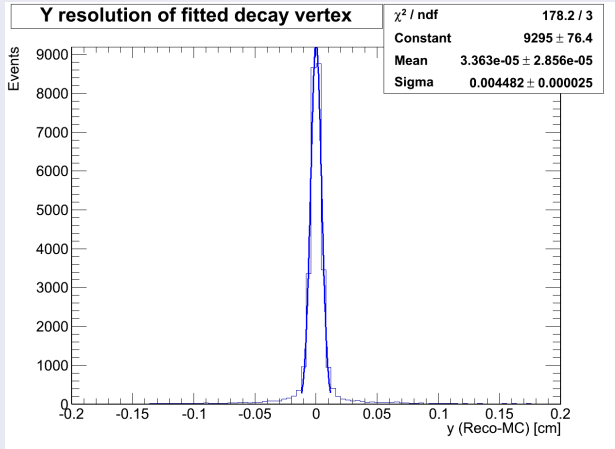


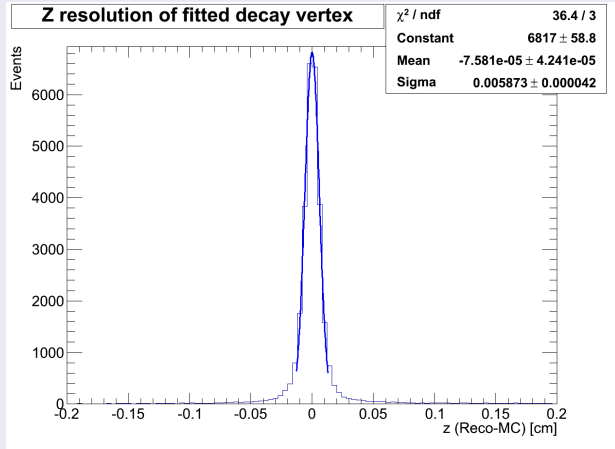


σ_x :(46.78±0.24) μm; σ_y :(46.10±0.20) μm; σ_z :(59.95±0.39) μm;

Clean up (Run916cu)





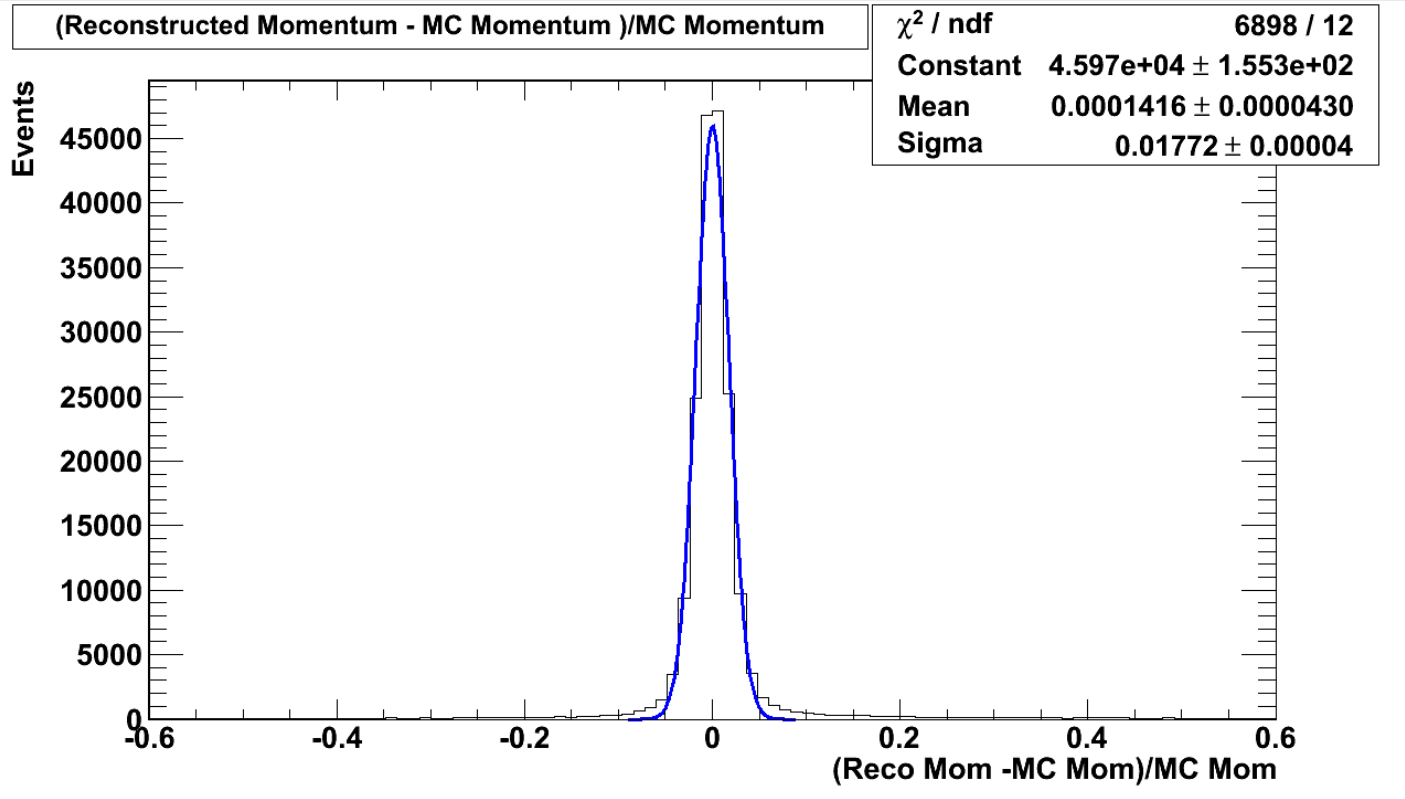


σ_x :(46.31±0.27) μm; σ_y :(44.82±0.25) μm; σ_z :(58.73±0.42) μm;

$\bar{p}p \longrightarrow \pi^+\pi^-\pi^+\pi^-$

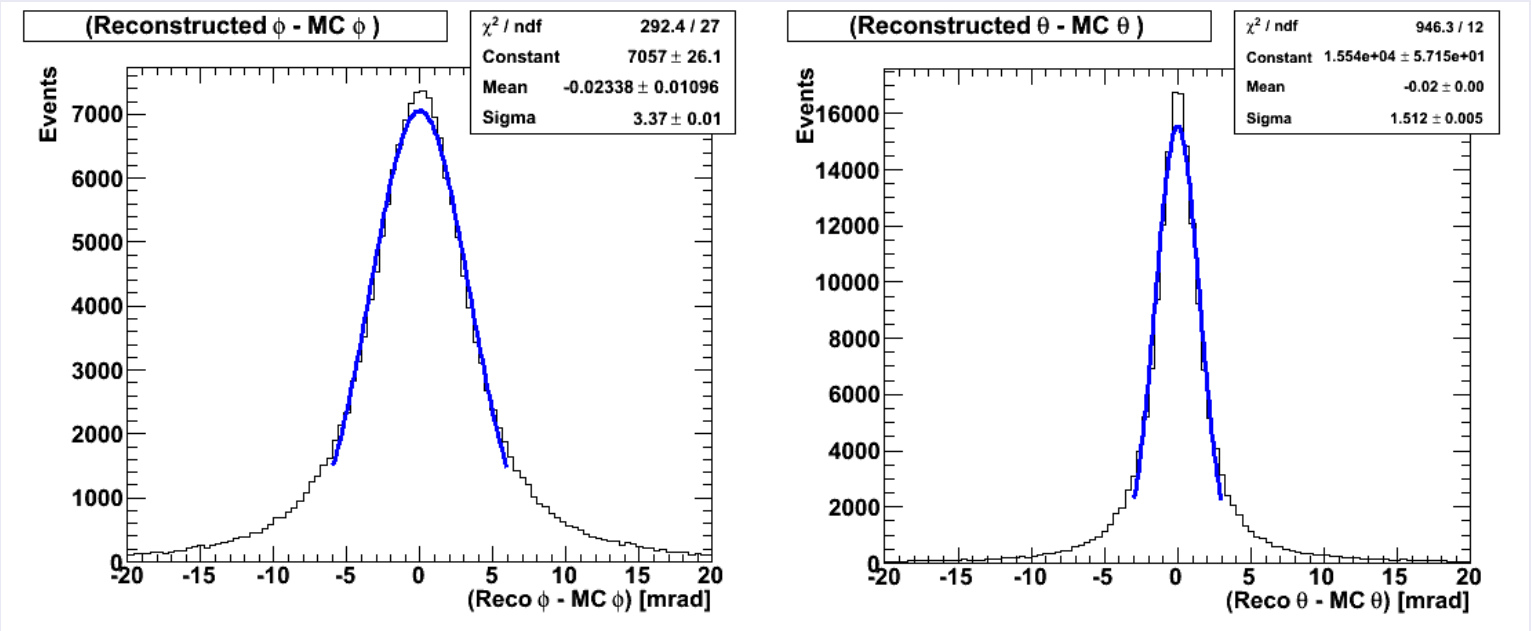
Event mixing

Single pion track reconstruction



Resolution: $(1.77 \pm 0.01)\%$

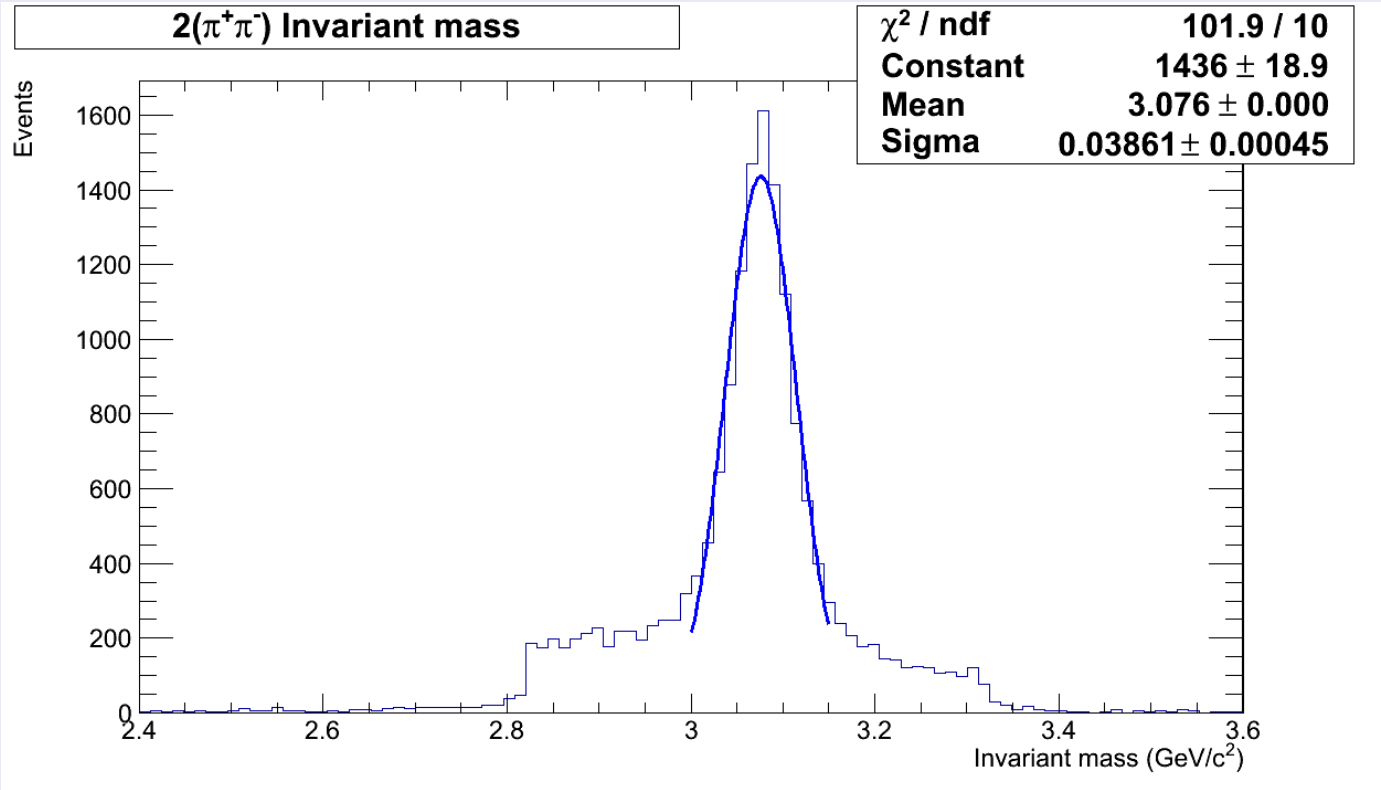
θ, ϕ resolution



$\sigma(\phi)$=(3.370±0.012) mrad
$\sigma(\theta)$=(1.512±0.005) mrad

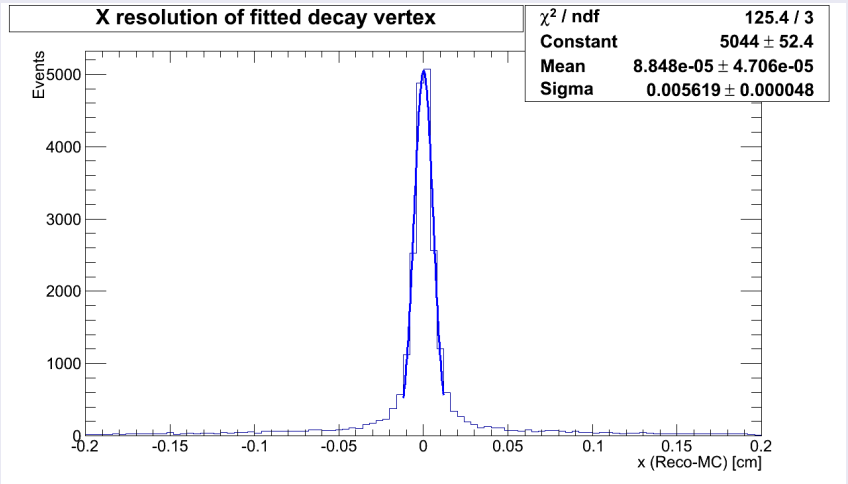
Invariant mass distribution

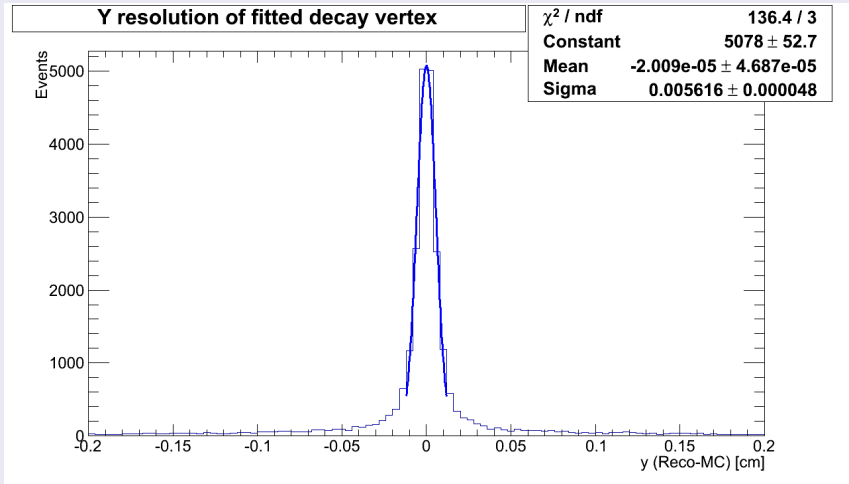
UNDER INVESTIGATION - PRELIMINARY RESULTS

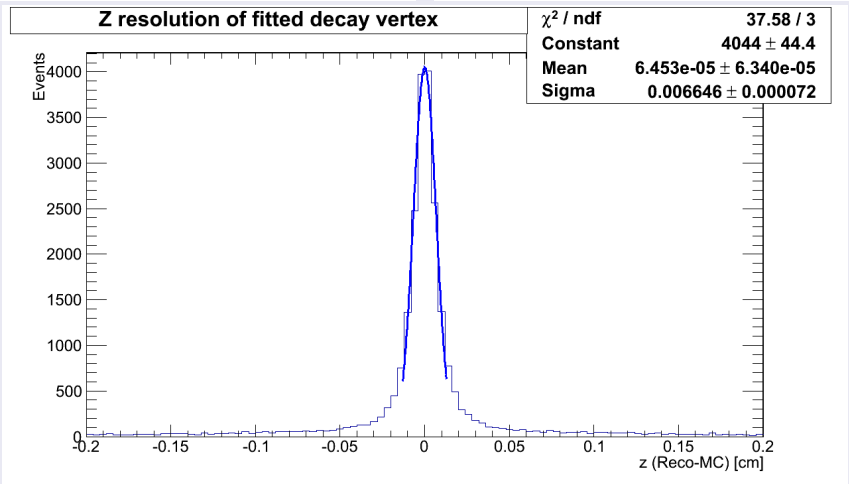


Resolution: 38.61 ± 0.45 MeV/c^2

Vertex resolution







σ_x :(56.19±0.48) μm; σ_y :(56.16±0.48) μm; σ_z :(66.46±0.72) μm;

Outlook - Only Signal events

$\bar{p}p \longrightarrow \pi^+\pi^-$	No clean up	Clean up
Single track resolution	(1.93± 0.01)%	(1.93±0.01)%
θ resolution	(0.943±0.003) mrad	(0.939±0.003) mrad
ϕ resolution	(1.829±0.005) mrad	(1.825±0.005) mrad
Invariant mass resolution	(42.03±0.16) MeV/c^2	(41.96±0.16) MeV/c^2
Invariant mass efficiency	(67.7±0.3)%	(68.6±0.3)%
Vertex: X resolution	(56.38±0.33) μm	(56.46±0.33) μm
Vertex: Y resolution	(55.57±0.33) μm	(55.77±0.33) μm
Vertex: Z resolution	(52.67±0.22) μm	(52.64±0.23) μm

$\bar{p}p \longrightarrow \pi^+\pi^-\pi^+\pi^-$	No clean up	Clean up
Single track resolution	(1.70±0.01)%	(1.70±0.01)%
θ resolution	(1.519±0.004) mrad	(1.529±0.004) mrad
ϕ resolution	(3.148±0.008) mrad	(3.104±0.008) mrad
Invariant mass resolution	(32.34±0.20) MeV/c^2	(31.26±0.20) MeV/c^2
Invariant mass efficiency	(39.9±0.2)%	(30.1±0.2)%
Vertex: X resolution	(46.78±0.24)μm	(46.31±0.27)μm
Vertex: Y resolution	(46.10±0.20)μm	(44.82±0.25)μm
Vertex: Z resolution	(59.95±0.39)μm	(58.73±0.42)μm

Outlook - Event Mixing

$\bar{p}p \longrightarrow \pi^+\pi^-$	Event Mixing
Single track resolution	(2.15± 0.01)%
θ resolution	(0.915±0.002) mrad
ϕ resolution	(2.185±0.006) mrad
Invariant mass resolution	(42.97±0.18) MeV/c^2
Invariant mass efficiency	(59.9±0.2)%
Vertex: X resolution	(63.34±0.38) μm
Vertex: Y resolution	(68.99±0.46) μm
Vertex: Z resolution	(52.41±0.20) μm

$\bar{p}p \longrightarrow \pi^+\pi^-\pi^+\pi^-$	Event Mixing
Single track resolution	(1.77±0.01)%
θ resolution	(1.512±0.005) mrad
ϕ resolution	(3.370±0.012) mrad
Vertex: X resolution	(56.19±0.48)μm
Vertex: Y resolution	(56.16±0.48)μm
Vertex: Z resolution	(66.46±0.72)μm