

1 General Analysis Method

- NCDIS MC is from NEGLIB only (no nuage)
- The cut $20^0 \leq \phi_{12} \leq 160^0$ is applied.
- A 4D correction function (P_+, P_-, P_{t+}, P_{t-}) from ncand=34 CCDS is applied to NCDIS.
- A 2D correction function ($M_{\pi\pi}, \zeta_\rho$) from ncand=34 CCDS is applied to NCDIS.
- A renormalization factor of 1.022 is applied to NCDIS so that the number of events do not change after application of the correction functions
- A folder is saved with $20^0 \leq \phi_{12}$ cut applied for CCDIS normalization.
- NCDIS is normalized on ϕ_{12} with: $\zeta_\rho \geq 0.075$.
- $Coh\rho^0$ is normalized on a ζ_ρ plot (range 0.0-0.1) in the Rho Mass range ($0.6 \leq M_{\pi\pi} \leq 1.0$)
- OBG is normalized by number of events with mass: $0.47 \leq M_{\pi\pi} \leq 0.530$
- The χ^2 calculation (including CCDIS, NCDIS, OBG and $Coh\rho$) is then iterated until convergence.
- Coherent ϕ^0 has been added at a normalization of 200 events (0.05 factor)

Coh ρ^0 Analysis (P+,P- > **0.5**)

Chris Kullenberg

August 29, 2018

Contents

1	General Analysis Method	1
2	Zeroth Norms	6
3	Baby Ntuple Reduction	7
4	General Information	8
4.1	Summary Cut Table	8
4.2	Coh ρ^0 Cut Table	9
4.3	NCDIS Cut Table	10
4.4	CCDIS Cut Table	11
4.5	OBG Cut Table	12
4.6	QE Cut Table	13
4.7	Coh π^+ Cut Table	14
4.8	Coh π^0 Cut Table	15
4.9	CohPhi0 Cut Table	16
5	Normalizations	17
5.1	Background Normalization	17
5.2	Coh ρ^0 Normalization	21
6	Systematic Variations	23
7	MC Shape Plots	24
8	Plots	34
9	Extra Plots	81

List of Figures

1	1σ χ^2 plot for NCDIS	17
2	1σ χ^2 plot for CCDIS	18
3	Plot used for NCDIS χ^2 normalization	19
4	Plot used for CCDIS χ^2 normalization	20
5	χ^2 plot for Coh ρ^0	21
6	Plot used for Coh ρ^0 χ^2 normalization	22
7	$M_{\pi\pi}$ For Full Coh ρ^0 MC (25MeV)	24
8	$M_{\pi\pi}$ For Full Coh ρ^0 MC (30MeV)	25
9	ϕ_{12} MC Shape Comparison	26
10	ϕ_{12} in Rho Mass Range MC Shape Comparison	27
11	$E_{\pi\pi}$ MC Shape Comparison	28
12	π^+ MC Shape Comparison	29
13	π^- MC Shape Comparison	30
14	$\zeta_{\pi\pi}$ MC Shape Comparison	31
15	$\zeta_{\pi\pi}$ in Rho Mass Range MC Shape Comparison	32
16	$M_{\pi\pi}$ MC Shape Comparison	33
17	Vertex Position	34
18	$M_{\pi\pi}$ 12.5MeV	35
19	$M_{\pi\pi}$ 25MeV	36
20	$M_{\pi\pi}$ 30MeV	37
21	$M_{\pi\pi}$ 25MeV (Signal Region)	38
22	$M_{\pi\pi}$ 30MeV (Signal Region)	39
23	$M_{\pi\pi}$ 25MeV (Background Region)	40
24	$M_{\pi\pi}$ 30MeV (Background Region)	41
25	$\zeta_{\pi\pi}$	42
26	$\zeta_{\pi\pi}$ (Signal Region)	43
27	$\zeta_{\pi\pi}$ (Background Region)	44
28	$\zeta_{\pi\pi}$ (Used for χ^2)	45
29	$\zeta_{\pi\pi}$ (Rho Mass Region)	46
30	$\zeta_{\pi\pi}$ (Rho+Tail Mass Region)	47
31	ϕ_{12}	48
32	ϕ_{12} (In Rho Mass range)	49
33	ϕ_{12} (Signal Region in Rho Mass)	50
34	ϕ_{12} (Background Region in Rho Mass)	51
35	ϕ_{12} (Signal Region)	52
36	ϕ_{12} (Background Region)	53
37	ζ_{π^+} and ζ_{π^-}	54
38	ζ_{π^+} and ζ_{π^-} (Signal Region)	55
39	ζ_{π^+} and ζ_{π^-} (Background Region)	56
40	θ_{π^+} and θ_{π^-}	57
41	θ_{π^+} and θ_{π^-} (Signal Region)	58
42	θ_{π^+} and θ_{π^-} (Background Region)	59
43	$\theta_{\pi\pi}$	60
44	$\theta_{\pi\pi}$ and θ_{12} (Signal Region)	61
45	$\theta_{\pi\pi}$ and θ_{12} (Background Region)	62
46	$E_{\pi\pi}$	63
47	$E_{\pi\pi}$ (Signal Region)	64
48	$E_{\pi\pi}$ (Background Region)	65
49	$E_{\pi\pi}$ (ρ Mass Range)	66
50	$P_t\pi\pi$	67
51	$P_t\pi\pi$ (Signal Region)	68
52	$P_t\pi\pi$ (Background Region)	69
53	$P_t\pi^+$	70
54	$P_t\pi^+$ (Signal Region)	71
55	$P_t\pi^+$ (Background Region)	72

56	$P_t \pi^-$	73
57	$P_t \pi^-$ (Signal Region)	74
58	$P_t \pi^-$ (Background Region)	75
59	Ptpos and Ptneg	76
60	Ptpos and Ptneg (Signal Region)	77
61	Ptpos and Ptneg (Background Region)	78
62	PAN (Neutral Momentum Assymetry)	79
63	PAN (Neutral Momentum Assymetry (log scale))	80
64	P_π Asymmetry	81
65	P_π Asymmetry (Signal Region)	82
66	P_π Asymmetry (Background Region)	83
67	P_+	84
68	P_+ (Signal Region)	85
69	P_+ (Background Region)	86
70	P_-	87
71	P_- (Signal Region)	88
72	P_- (Background Region)	89
73	$P_t Mis$	90
74	$P_t Mis$ (Signal Region)	91
75	$P_t Mis$ (Background Region)	92
76	$M_{\pi\pi}$ 12.5MeV	93
77	$M_{\pi\pi}$ 12.5MeV	94
78	$M_{\pi\pi}$ For χ^2	95
79	$M_{\pi\pi}$ For χ^2	96
80	$M_{\pi\pi}$ For χ^2	97
81	θ_x and θ_y	98

List of Tables

1	Generated Number of MC Events	6
2	Baby Ntuple Reduction for CCDIS	7
3	Baby Ntuple Reduction for NCDIS (neglib)	7
4	Baby Ntuple Reduction for Data	7
5	Baby Ntuple Reduction for OBG	7
6	Summary Cut Table	8
7	Cut Table Coh ρ^0	9
8	Cut Table NCDIS	10
9	Cut Table CCDIS	11
10	Cut Table OBG	12
11	Cut Table QE	13
12	Cut Table Coh π^+	14
13	Cut Table Coh π^0	15
14	Cut Table CohPhi	16
15	χ^2 for NCDIS on plot: ϕ_{12} ($\zeta_{\pi\pi} > 0.075$), $P_{\pm} \geq 0.5$	17
16	χ^2 for CCDIS on plot: ϕ_{12} , $P_{\pm} \geq 0.5$	18
17	Normalization for OBG by number of events within Kaon mass range	18
18	χ^2 for Coh ρ^0 on plot: $\zeta_{\pi\pi}(0-0.1)$ In ρ Mass, $P_{\pm} \geq 0.5$	21
19	Systematic variations in background NCDIS with $P_{\pm} \geq 0.5$	23
20	Systematic variations in background CCDIS with $P_{\pm} \geq 0.5$	23
21	Systematic variations in background OBG with $P_{\pm} \geq 0.5$	23

2 Zeroth Norms

Table1 shows the generated, MC-Z-weighted number of events to pass basic cuts for the sake of Zeroth norm calculations. < See notes 2/15/11 >

The cuts include:

- 1) Fid $|x,y-5| \leq 130$; $5 < zvs < 405$
- 2) Pfermi cut
- 3) W^2 cut (DIS only)

	Gen Number	Zroth Norm
CCDIS	4,477,786.5	1,440,000
NCDIS	2,358,388.1	437,760
Coh π^0	156,611.6	4,925
Coh π^+	29,596.0	10,000
Coh ρ^0	25,235.8	1,000
QE	126,414.7	32,000
CohPhi0	4,075.9	204

Table 1: Generated Number of MC Events

3 Baby Ntuple Reduction

Cut Name	Raw	MC-Z-Weight
All Events	1843856.0	1719047.4
$W^2 > 1.96$	1757271.0	1639114.9
Pfermi<1.0	1741929.0	1624875.6
zmin<zvr<405	1721363.0	1617165.0
No Muon	274784.0	258398.5
# of Tracks	82043.0	76551.3

Table 2: Baby Ntuple Reduction for **CCDIS**

Cut Name	Raw	MC-Z-Weight
All Events	2284335.0	2136933.2
$W^2 > 1.96$	2278349.0	2131031.5
Pfermi<1.0	2259398.0	2113269.0
zmin<zvr<405	2138682.0	2012505.8
No Muon	2063056.0	1941480.8
# of Tracks	756128.0	708934.8

Table 3: Baby Ntuple Reduction for **NCDIS (neglib)**

Cut Name	Raw
All Events	12451135.0
zmin<zvr<405	12451135.0
No Muon	8761231.0
# of Tracks	956271.0

Table 4: Baby Ntuple Reduction for **Data**

Cut Name	Raw
All Events	16777216.0
At least 1 ν_0	1783028.0
zvr<zmin	1127859.0
ncand $\leq$ 4	662049.0

Table 5: Baby Ntuple Reduction for **OBG**

4 General Information

4.1 Summary Cut Table

Cut Name	CohRho	NC	CC	OBG	Other	Total	Data
1) Raw Events	524.6	113260.9	39405.8	149212.6	44097.8	346501.6	956271.0
2) OBGfid,Trig+CohGenTh	524.6	113260.9	39405.8	25207.6	44097.8	222496.7	956271.0
3) Pfermi & W2	524.6	113260.9	39405.8	25207.6	41610.1	220009.0	956271.0
4) FocP	524.6	113260.9	39405.8	22364.7	41610.1	217166.0	846077.0
5) Fid. Vol. -X	502.4	107315.6	36789.2	21577.4	39828.3	206013.0	598657.0
6) Fid. Vol. -Y	482.0	101102.4	32743.3	20957.6	38302.4	193587.8	382118.0
7) Fid. Vol. -Z	482.0	101102.4	32743.3	14206.6	38302.3	186836.7	382118.0
8) No Ph2Mu	458.8	101102.4	32743.3	6017.0	2977.7	143299.2	382118.0
9) ncand=2	417.0	38970.9	13216.3	3943.9	1492.8	58041.0	258628.0
10) tnchgd=2	404.9	33302.1	11301.3	3943.9	1379.3	50331.5	187970.0
11) +/- Tracks (V0)	399.1	26925.8	8806.9	3941.9	1323.7	41397.4	138269.0
12) Epipi>2.0	397.3	19778.5	4989.4	2177.2	839.6	28182.0	42973.0
13) P+,P->0.5	380.0	16106.9	4307.4	1644.1	646.0	23084.4	34861.0
14) Tube/Veto Cut	380.0	16106.9	4307.4	1644.1	646.0	23084.4	34861.0
15) Theta12<2.62 rad	379.7	15956.7	4275.0	1626.1	641.2	22878.8	26555.0
16) Upstream Hanger cut	377.2	15026.7	4056.2	1626.1	631.9	21718.1	23812.0
17) nsecond<4	372.5	14580.0	3879.4	1626.1	624.8	21082.8	22361.0
18) Fid. Vol. Hanger cut	348.0	12821.9	3343.7	1626.1	587.1	18726.9	19094.0
19) No Hangers fromPVert	344.0	11466.6	3011.1	1626.1	582.6	17030.4	17596.0
20) Pz>0 for pions	343.9	11451.7	3005.9	1625.7	582.5	17009.7	17406.0
21) Thprimord<0.4	332.8	9084.5	2176.1	1350.7	526.6	13470.7	14213.0
22) Nunh*fracunh<200	332.7	9081.4	2175.0	1350.7	526.3	13466.2	13985.0
23) Pt+wrt (-) > 0.05	331.9	8939.4	2154.9	530.1	307.8	12264.2	13129.0
24) Mee > 0.10	331.7	8864.4	2147.9	405.7	274.0	12023.7	12898.0
25) PneutAsym>0.5	328.1	6248.9	1344.9	317.8	272.3	8512.0	8946.0
26) PpiAsym>-0.8	309.9	6058.7	1310.8	312.4	259.6	8251.4	8365.0
27) 20<Phi12<160deg	256.3	4708.6	757.9	220.6	103.5	6046.9	6038.0
28) LH38>0.5 (OFF)	256.3	4708.6	757.9	220.6	103.5	6046.9	6038.0
29) P+,P->1.0	234.9	3092.0	564.8	166.6	82.9	4141.2	4319.0

Table 6: Summary Cut Table

4.2 Coh ρ^0 Cut Table

Cut	Raw	Z-weight	Norm0	Final
1) Raw Events	25790.0	23515.6	931.8	524.6
2) OBGfid,Trig+CohGenTh	25790.0	23515.6	931.8	524.6
3) Pfermi & W2	25790.0	23515.6	931.8	524.6
4) FocP	25790.0	23515.6	931.8	524.6
5) Fid. Vol. -X	24698.0	22519.8	892.4	502.4
6) Fid. Vol. -Y	23699.0	21608.0	856.2	482.0
7) Fid. Vol. -Z	23699.0	21608.0	856.2	482.0
8) No Ph2Mu	22561.0	20567.4	815.0	458.8
9) ncand=2	20419.0	18692.3	740.7	417.0
10) tunchgd=2	19812.0	18148.3	719.1	404.9
11) +/- Tracks (V0)	19536.0	17889.3	708.9	399.1
12) Epipi>2.0	19453.0	17809.3	705.7	397.3
13) P+,P->0.5	18605.0	17030.9	674.9	380.0
14) Tube/Veto Cut	18605.0	17030.9	674.9	380.0
15) Theta12<2.62 rad	18594.0	17021.1	674.5	379.7
16) Upstream Hanger cut	18477.0	16908.3	670.0	377.2
17) nsecond<4	18211.0	16694.9	661.6	372.5
18) Fid. Vol. Hanger cut	16964.0	15599.6	618.2	348.0
19) No Hangers fromPVert	16765.0	15418.2	611.0	344.0
20) Pz>0 for pions	16764.0	15417.2	610.9	343.9
21) Thprimord<0.4	16174.0	14916.5	591.1	332.8
22) Nunh*fracunh<200	16171.0	14914.3	591.0	332.7
23) Pt+wrt (-) > 0.05	16134.0	14879.6	589.6	331.9
24) Mee > 0.10	16123.0	14869.1	589.2	331.7
25) PneutAsym>0.5	15936.0	14704.1	582.7	328.1
26) PpiAsym>-0.8	15057.0	13891.4	550.5	309.9
27) 20<Phi12<160deg	12447.0	11486.7	455.2	256.3
28) LH38>0.5 (OFF)	12447.0	11486.7	455.2	256.3
29) P+,P->1.0	11412.0	10531.2	417.3	234.9

Table 7: Cut Table Coh ρ^0

4.3 NCDIS Cut Table

Cut	Raw	Z-weight	Norm0	Final
1) Raw Events	756128.0	693660.1	128755.5	113260.9
2) OBGfid,Trig+CohGenTh	756128.0	693660.1	128755.5	113260.9
3) Pfermi & W2	756128.0	693660.1	128755.5	113260.9
4) FocP	756128.0	693660.1	128755.5	113260.9
5) Fid. Vol. -X	716533.0	656919.6	121935.8	107315.6
6) Fid. Vol. -Y	675006.0	618515.9	114807.4	101102.4
7) Fid. Vol. -Z	675006.0	618515.9	114807.4	101102.4
8) No Ph2Mu	675006.0	618515.9	114807.4	101102.4
9) ncand=2	257783.0	237735.6	44127.9	38970.9
10) tunchgd=2	220494.0	202986.7	37677.9	33302.1
11) +/- Tracks (V0)	178245.0	164232.3	30484.4	26925.8
12) Epipi>2.0	128328.0	117970.5	21897.4	19778.5
13) P+,P->0.5	102086.0	93852.9	17420.7	16106.9
14) Tube/Veto Cut	102086.0	93852.9	17420.7	16106.9
15) Theta12<2.62 rad	101218.0	93055.6	17272.7	15956.7
16) Upstream Hanger cut	95436.0	87725.6	16283.4	15026.7
17) nsecond<4	92271.0	85222.2	15818.7	14580.0
18) Fid. Vol. Hanger cut	81130.0	75125.2	13944.6	12821.9
19) No Hangers fromPVert	72709.0	67255.9	12483.9	11466.6
20) Pz>0 for pions	72602.0	67152.3	12464.6	11451.7
21) Thprimord<0.4	56964.0	53411.2	9914.1	9084.5
22) Nunh*fracunh<200	56939.0	53392.6	9910.6	9081.4
23) Pt+wrt (-) > 0.05	56052.0	52577.7	9759.3	8939.4
24) Mee > 0.10	55591.0	52146.0	9679.2	8864.4
25) PneutAsym>0.5	39703.0	36852.8	6840.5	6248.9
26) PpiAsym>-0.8	38147.0	35395.8	6570.1	6058.7
27) 20<Phi12<160deg	29615.0	27491.7	5102.9	4708.6
28) LH38>0.5 (OFF)	29615.0	27491.7	5102.9	4708.6
29) P+,P->1.0	18499.0	17124.3	3178.6	3092.0

Table 8: Cut Table NCDIS

4.4 CCDIS Cut Table

Cut	Raw	Z-weight	Norm0	Final
1) Raw Events	141725.0	127243.1	40919.8	39405.8
2) OBGfid,Trig+CohGenTh	141725.0	127243.1	40919.8	39405.8
3) Pfermi & W2	141725.0	127243.1	40919.8	39405.8
4) FocP	141725.0	127243.1	40919.8	39405.8
5) Fid. Vol. -X	132260.0	118794.2	38202.7	36789.2
6) Fid. Vol. -Y	117578.0	105729.7	34001.4	32743.3
7) Fid. Vol. -Z	117578.0	105729.7	34001.4	32743.3
8) No Ph2Mu	117578.0	105729.7	34001.4	32743.3
9) ncand=2	46635.0	42676.1	13724.1	13216.3
10) tnychgd=2	40101.0	36492.5	11735.5	11301.3
11) +/- Tracks (V0)	31025.0	28438.0	9145.3	8806.9
12) Epipi>2.0	17917.0	16111.0	5181.1	4989.4
13) P+,P->0.5	15436.0	13908.7	4472.9	4307.4
14) Tube/Veto Cut	15436.0	13908.7	4472.9	4307.4
15) Theta12<2.62 rad	15323.0	13804.3	4439.3	4275.0
16) Upstream Hanger cut	14560.0	13097.5	4212.0	4056.2
17) nsecond<4	13862.0	12527.1	4028.5	3879.4
18) Fid. Vol. Hanger cut	11941.0	10796.9	3472.2	3343.7
19) No Hangers fromPVert	10771.0	9722.9	3126.8	3011.1
20) Pz>0 for pions	10754.0	9706.2	3121.4	3005.9
21) Thprimord<0.4	7632.0	7026.7	2259.7	2176.1
22) Nunh*fracunh<200	7627.0	7023.2	2258.6	2175.0
23) Pt+wrt (-) > 0.05	7550.0	6958.1	2237.7	2154.9
24) Mee > 0.10	7527.0	6935.6	2230.4	2147.9
25) PneutAsym>0.5	4803.0	4342.9	1396.6	1344.9
26) PpiAsym>-0.8	4668.0	4232.8	1361.2	1310.8
27) 20<Phi12<160deg	2703.0	2447.1	787.0	757.9
28) LH38>0.5 (OFF)	2703.0	2447.1	787.0	757.9
29) P+,P->1.0	2023.0	1823.9	586.5	564.8

Table 9: Cut Table CCDIS

4.5 OBG Cut Table

Cut	Raw	Z-weight	Norm0	Final
1) Raw Events	662049.0	662049.0	662049.0	149212.6
2) OBGfid,Trig+CohGenTh	111845.0	111845.0	111845.0	25207.6
3) Pfermi & W2	111845.0	111845.0	111845.0	25207.6
4) FocP	99231.0	99231.0	99231.0	22364.7
5) Fid. Vol. -X	95738.0	95738.0	95738.0	21577.4
6) Fid. Vol. -Y	92988.0	92988.0	92988.0	20957.6
7) Fid. Vol. -Z	63034.0	63034.0	63034.0	14206.6
8) No Ph2Mu	26697.0	26697.0	26697.0	6017.0
9) ncand=2	17499.0	17499.0	17499.0	3943.9
10) tnchg=2	17499.0	17499.0	17499.0	3943.9
11) +/- Tracks (V0)	17490.0	17490.0	17490.0	3941.9
12) Epipi>2.0	9660.0	9660.0	9660.0	2177.2
13) P+,P->0.5	7295.0	7295.0	7295.0	1644.1
14) Tube/Veto Cut	7295.0	7295.0	7295.0	1644.1
15) Theta12<2.62 rad	7215.0	7215.0	7215.0	1626.1
16) Upstream Hanger cut	7215.0	7215.0	7215.0	1626.1
17) nsecond<4	7215.0	7215.0	7215.0	1626.1
18) Fid. Vol. Hanger cut	7215.0	7215.0	7215.0	1626.1
19) No Hangers fromPVert	7215.0	7215.0	7215.0	1626.1
20) Pz>0 for pions	7213.0	7213.0	7213.0	1625.7
21) Thprimord<0.4	5993.0	5993.0	5993.0	1350.7
22) Nunh*fracunh<200	5993.0	5993.0	5993.0	1350.7
23) Pt+wrt (-) > 0.05	2352.0	2352.0	2352.0	530.1
24) Mee > 0.10	1800.0	1800.0	1800.0	405.7
25) PneutAsym>0.5	1410.0	1410.0	1410.0	317.8
26) PpiAsym>-0.8	1386.0	1386.0	1386.0	312.4
27) 20<Phi12<160deg	979.0	979.0	979.0	220.6
28) LH38>0.5 (OFF)	979.0	979.0	979.0	220.6
29) P+,P->1.0	739.0	739.0	739.0	166.6

Table 10: Cut Table OBG

4.6 QE Cut Table

Cut	Raw	Z-weight	Norm0	Final
1) Raw Events	129561.0	116903.9	29592.5	29592.5
2) OBGfid,Trig+CohGenTh	129561.0	116903.9	29592.5	29592.5
3) Pfermi & W2	128836.0	116251.6	29427.3	29427.3
4) FocP	128836.0	116251.6	29427.3	29427.3
5) Fid. Vol. -X	123323.0	111231.6	28156.6	28156.6
6) Fid. Vol. -Y	118713.0	107057.1	27099.9	27099.9
7) Fid. Vol. -Z	118713.0	107057.1	27099.9	27099.9
8) No Ph2Mu	1722.0	1541.5	390.2	390.2
9) ncand=2	527.0	487.7	123.5	123.5
10) tnchgd=2	508.0	470.0	119.0	119.0
11) +/- Tracks (V0)	484.0	449.8	113.9	113.9
12) Epipi>2.0	405.0	374.3	94.7	94.7
13) P+,P->0.5	357.0	328.4	83.1	83.1
14) Tube/Veto Cut	357.0	328.4	83.1	83.1
15) Theta12<2.62 rad	353.0	324.5	82.1	82.1
16) Upstream Hanger cut	353.0	324.5	82.1	82.1
17) nsecond<4	353.0	324.5	82.1	82.1
18) Fid. Vol. Hanger cut	346.0	317.8	80.4	80.4
19) No Hangers fromPVert	346.0	317.8	80.4	80.4
20) Pz>0 for pions	346.0	317.8	80.4	80.4
21) Thprimord<0.4	343.0	316.1	80.0	80.0
22) Nunh*fracunh<200	343.0	316.1	80.0	80.0
23) Pt+wrt (-) > 0.05	343.0	316.1	80.0	80.0
24) Mee > 0.10	343.0	316.1	80.0	80.0
25) PneutAsym>0.5	343.0	316.1	80.0	80.0
26) PpiAsym>-0.8	295.0	277.0	70.1	70.1
27) 20<Phi12<160deg	19.0	18.4	4.7	4.7
28) LH38>0.5 (OFF)	19.0	18.4	4.7	4.7
29) P+,P->1.0	7.0	6.9	1.7	1.7

Table 11: Cut Table QE

4.7 Coh π^+ Cut Table

Cut	Raw	Z-weight	Norm0	Final
1) Raw Events	30945.0	28076.5	9486.6	9486.6
2) OBGfid,Trig+CohGenTh	30945.0	28076.5	9486.6	9486.6
3) Pfermi & W2	30945.0	28076.5	9486.6	9486.6
4) FocP	30945.0	28076.5	9486.6	9486.6
5) Fid. Vol. -X	29688.0	26921.2	9096.3	9096.3
6) Fid. Vol. -Y	28524.0	25870.8	8741.3	8741.3
7) Fid. Vol. -Z	28524.0	25870.8	8741.3	8741.3
8) No Ph2Mu	472.0	428.4	144.7	144.7
9) ncand=2	324.0	299.5	101.2	101.2
10) tnchgd=2	316.0	291.8	98.6	98.6
11) +/- Tracks (V0)	307.0	284.3	96.1	96.1
12) Epipi>2.0	247.0	226.1	76.4	76.4
13) P+,P->0.5	196.0	180.2	60.9	60.9
14) Tube/Veto Cut	196.0	180.2	60.9	60.9
15) Theta12<2.62 rad	195.0	179.2	60.6	60.6
16) Upstream Hanger cut	195.0	179.2	60.6	60.6
17) nsecond<4	193.0	177.9	60.1	60.1
18) Fid. Vol. Hanger cut	188.0	173.1	58.5	58.5
19) No Hangers fromPVert	187.0	172.1	58.1	58.1
20) Pz>0 for pions	187.0	172.1	58.1	58.1
21) Thprimord<0.4	185.0	170.1	57.5	57.5
22) Nunh*fracunh<200	185.0	170.1	57.5	57.5
23) Pt+wrt (-) > 0.05	185.0	170.1	57.5	57.5
24) Mee > 0.10	184.0	169.1	57.1	57.1
25) PneutAsym>0.5	182.0	167.1	56.5	56.5
26) PpiAsym>-0.8	174.0	159.7	54.0	54.0
27) 20<Phi12<160deg	89.0	82.1	27.7	27.7
28) LH38>0.5 (OFF)	89.0	82.1	27.7	27.7
29) P+,P->1.0	72.0	65.8	22.2	22.2

Table 12: Cut Table Coh π^+

4.8 Coh π^0 Cut Table

Cut	Raw	Z-weight	Norm0	Final
1) Raw Events	49972.0	43406.6	1385.8	1365.0
2) OBGfid,Trig+CohGenTh	49972.0	43406.6	1385.8	1365.0
3) Pfermi & W2	49972.0	43406.6	1385.8	1365.0
4) FocP	49972.0	43406.6	1385.8	1365.0
5) Fid. Vol. -X	47459.0	41193.0	1315.1	1295.4
6) Fid. Vol. -Y	44979.0	39070.9	1247.4	1228.7
7) Fid. Vol. -Z	44972.0	39069.8	1247.3	1228.6
8) No Ph2Mu	44972.0	39069.8	1247.3	1228.6
9) ncand=2	32665.0	28498.5	909.8	896.2
10) tnchgd=2	30025.0	26184.4	836.0	823.4
11) +/- Tracks (V0)	29719.0	25924.0	827.7	815.2
12) Epipi>2.0	18087.0	15664.5	500.1	492.6
13) P+,P->0.5	12379.0	10740.0	342.9	337.7
14) Tube/Veto Cut	12379.0	10740.0	342.9	337.7
15) Theta12<2.62 rad	12319.0	10683.7	341.1	336.0
16) Upstream Hanger cut	11999.0	10420.2	332.7	327.7
17) nsecond<4	11765.0	10249.4	327.2	322.3
18) Fid. Vol. Hanger cut	10786.0	9437.1	301.3	296.8
19) No Hangers fromPVert	10702.0	9362.9	298.9	294.4
20) Pz>0 for pions	10702.0	9362.9	298.9	294.4
21) Thprimord<0.4	8737.0	7786.8	248.6	244.9
22) Nunh*fracunh<200	8724.0	7778.1	248.3	244.6
23) Pt+wrt (-) > 0.05	1017.0	916.9	29.3	28.8
24) Mee > 0.10	56.0	51.1	1.6	1.6
25) PneutAsym>0.5	29.0	27.3	0.9	0.9
26) PpiAsym>-0.8	28.0	26.3	0.8	0.8
27) 20<Phi12<160deg	14.0	12.7	0.4	0.4
28) LH38>0.5 (OFF)	14.0	12.7	0.4	0.4
29) P+,P->1.0	10.0	9.6	0.3	0.3

Table 13: Cut Table Coh π^0

4.9 CohPhi0 Cut Table

Cut	Raw	Z-weight	Norm0	Final
1) Raw Events	4171.0	3799.7	3799.7	190.0
2) OBGfid,Trig+CohGenTh	4171.0	3799.7	3799.7	190.0
3) Pfermi & W2	4171.0	3799.7	3799.7	190.0
4) FocP	4171.0	3799.7	3799.7	190.0
5) Fid. Vol. -X	4008.0	3651.3	3651.3	182.6
6) Fid. Vol. -Y	3836.0	3494.5	3494.5	174.7
7) Fid. Vol. -Z	3836.0	3494.5	3494.5	174.7
8) No Ph2Mu	3446.0	3131.0	3131.0	156.5
9) ncand=2	3041.0	2764.3	2764.3	138.2
10) tnchg=2	2866.0	2603.6	2603.6	130.2
11) +/- Tracks (V0)	2830.0	2570.8	2570.8	128.5
12) Epipi>2.0	2826.0	2567.0	2567.0	128.4
13) P+,P->0.5	2814.0	2555.4	2555.4	127.8
14) Tube/Veto Cut	2814.0	2555.4	2555.4	127.8
15) Theta12<2.62 rad	2813.0	2554.5	2554.5	127.7
16) Upstream Hanger cut	2800.0	2542.1	2542.1	127.1
17) nsecond<4	2763.0	2518.0	2518.0	125.9
18) Fid. Vol. Hanger cut	2583.0	2363.7	2363.7	118.2
19) No Hangers fromPVert	2558.0	2340.0	2340.0	117.0
20) Pz>0 for pions	2557.0	2339.1	2339.1	117.0
21) Thprimord<0.4	2442.0	2242.5	2242.5	112.1
22) Nunh*fracunh<200	2442.0	2242.5	2242.5	112.1
23) Pt+wrt (-) > 0.05	2393.0	2196.7	2196.7	109.8
24) Mee > 0.10	2259.0	2073.2	2073.2	103.7
25) PneutAsym>0.5	2249.0	2065.1	2065.1	103.3
26) PpiAsym>-0.8	2247.0	2063.1	2063.1	103.2
27) 20<Phi12<160deg	1147.0	1056.5	1056.5	52.8
28) LH38>0.5 (OFF)	1147.0	1056.5	1056.5	52.8
29) P+,P->1.0	1144.0	1053.8	1053.8	52.7

Table 14: Cut Table CohPhi

5 Normalizations

5.1 Background Normalization

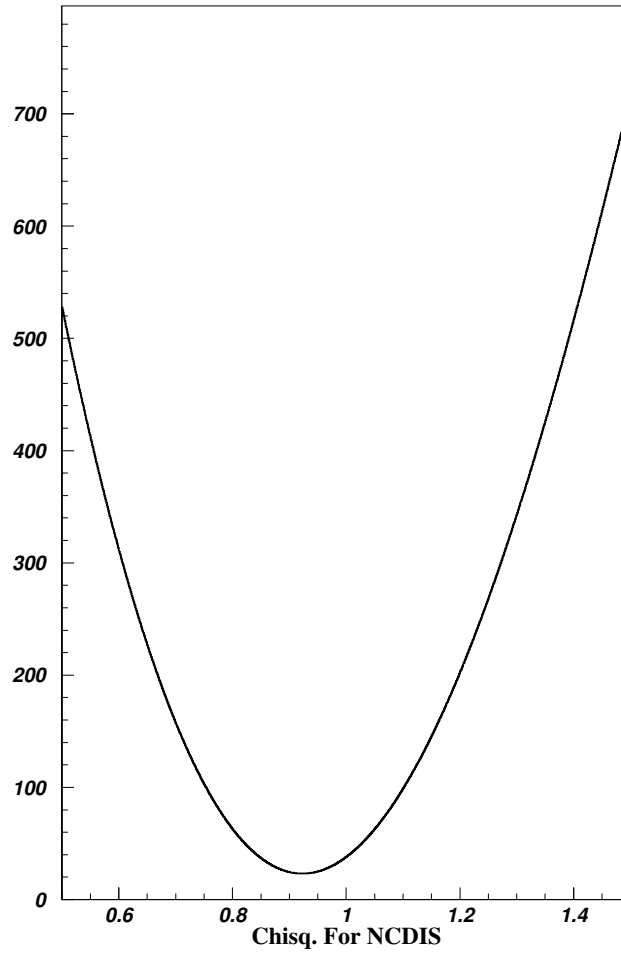


Figure 1: 1σ χ^2 plot for NCDIS

χ^2 Min 23.161		
Number of bins used: 18		
One σ : 1.134		
Norm at Min χ^2	NCDIS	
-1σ	0.923	
	0.902	(2.3%)
$+1\sigma$	0.943	(2.2%)

Table 15: χ^2 for NCDIS on plot: ϕ_{12} ($\zeta_{\pi\pi} > \mathbf{0.075}$), $P_{\pm} \geq \mathbf{0.5}$

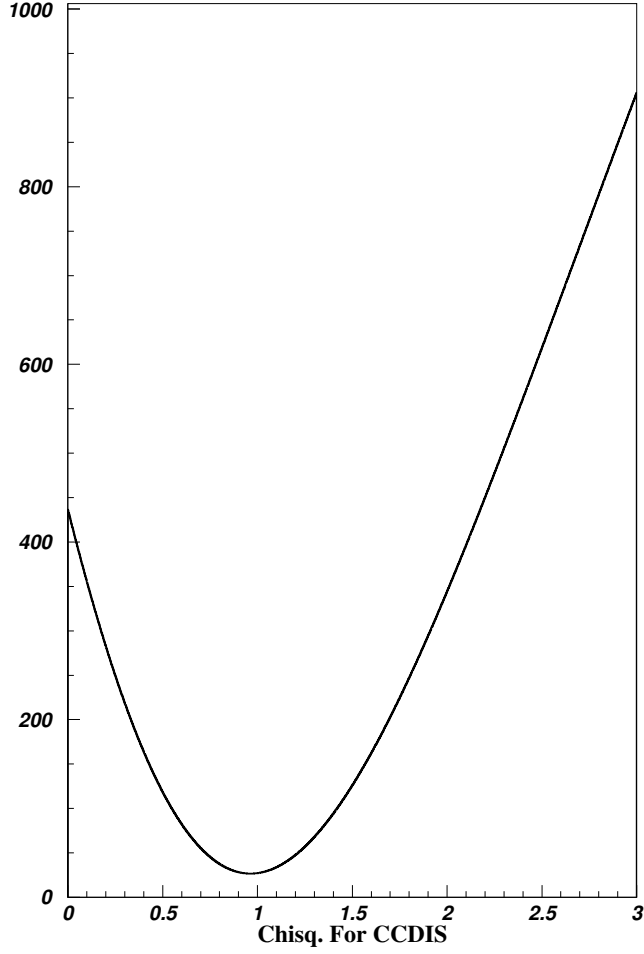


Figure 2: 1σ χ^2 plot for CCDIS

χ^2 Min 26.686		
Number of bins used: 32		
One σ : 0.913		
Norm at Min χ^2	CCDIS	
-1σ	0.963	
$+1\sigma$	0.916	(4.9%)
	1.011	(5.0%)

Table 16: χ^2 for CCDIS on plot: $\phi_{12}, P_{\pm} \geq 0.5$

OBG		
Norm at Min χ^2	0.225380	
-1σ	0.216969	(3.7%)
$+1\sigma$	0.233791	(3.7%)
Number of OBG used 718		

Table 17: Normalization for OBG by number of events within Kaon mass range

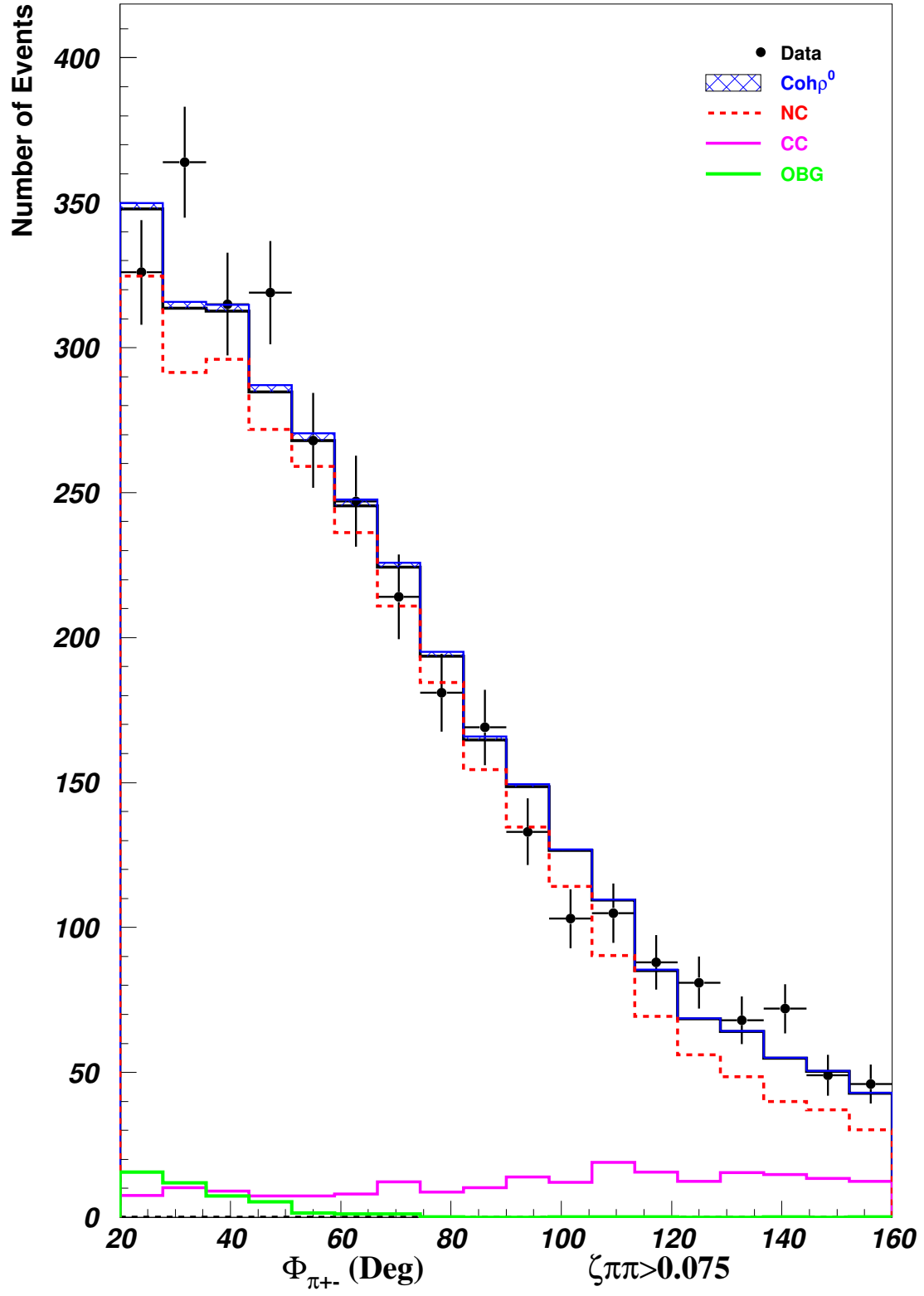


Figure 3: Plot used for NCDIS χ^2 normalization

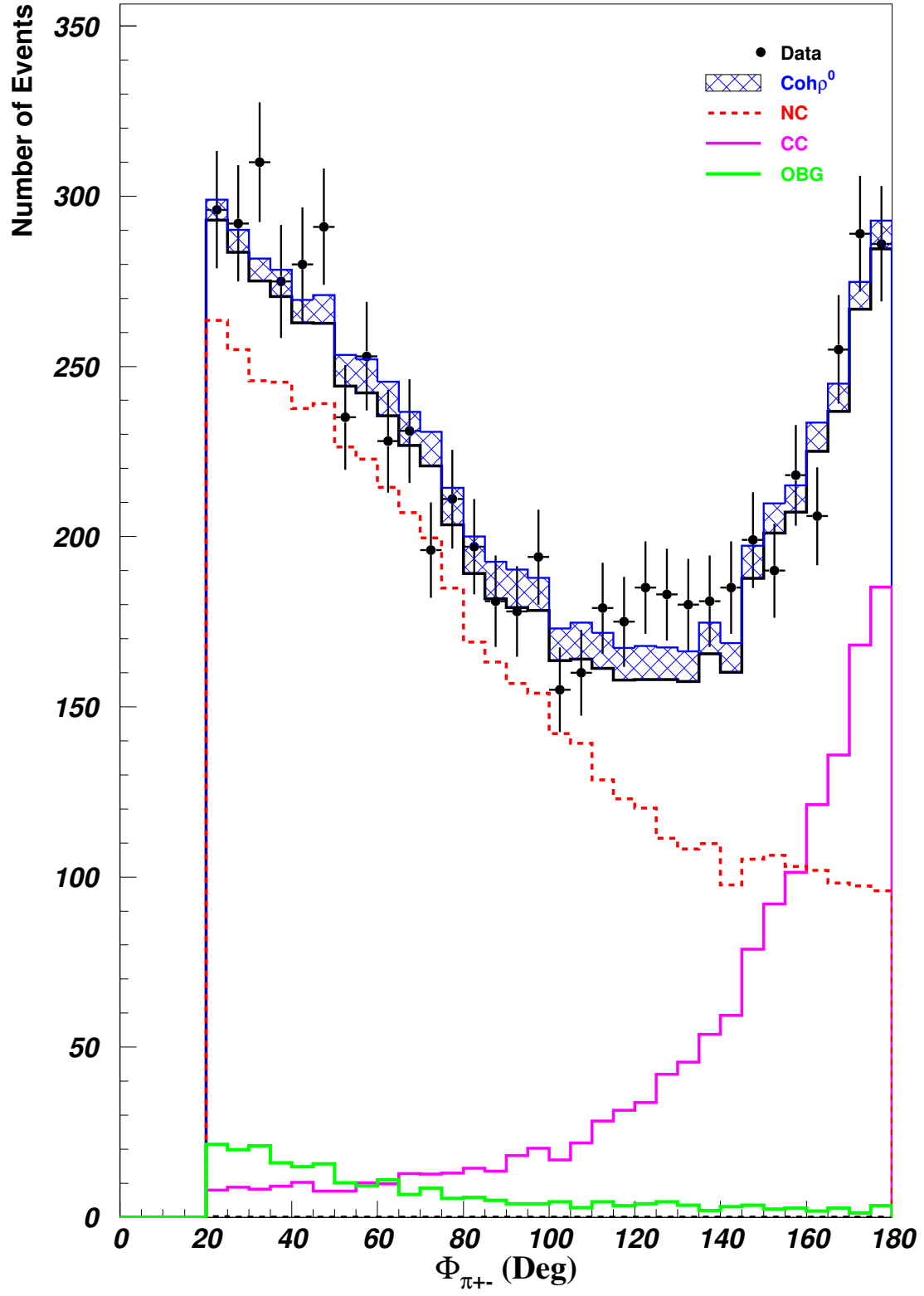


Figure 4: Plot used for CCDIS χ^2 normalization

5.2 Coh ρ^0 Normalization

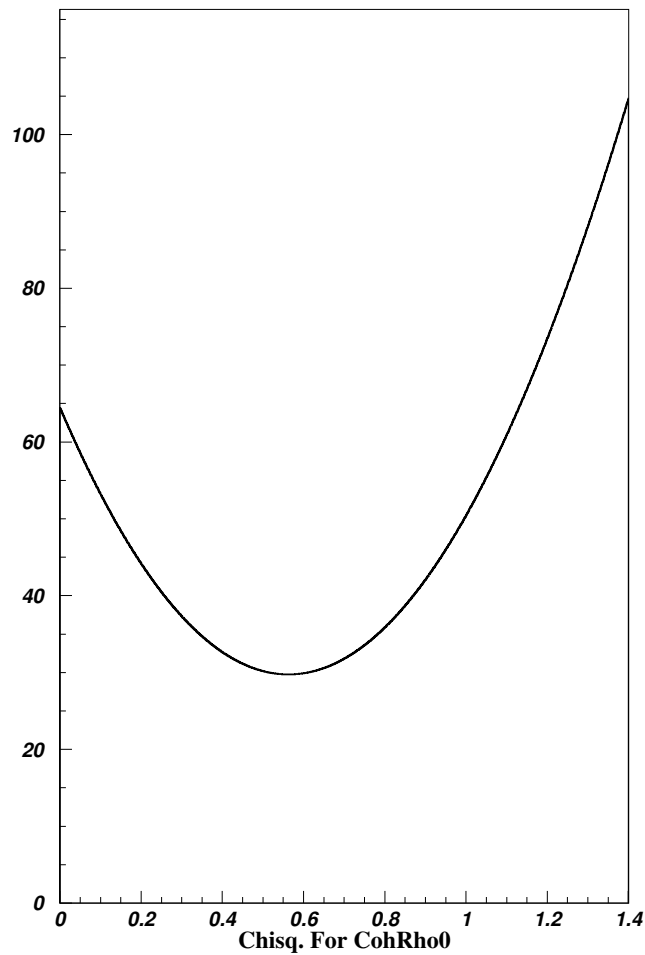


Figure 5: χ^2 plot for Coh ρ^0

χ^2 Min 29.755		
Number of bins used: 20		
One σ : 1.220		
Norm at Min χ^2	Coh ρ^0	
-1σ	0.563	
	0.458	(18.7%)
$+1 \sigma$	0.668	(18.7%)

Table 18: χ^2 for Coh ρ^0 on plot: $\zeta_{\pi\pi}(0-0.1)$ In ρ Mass, $P_{\pm} \geq 0.5$

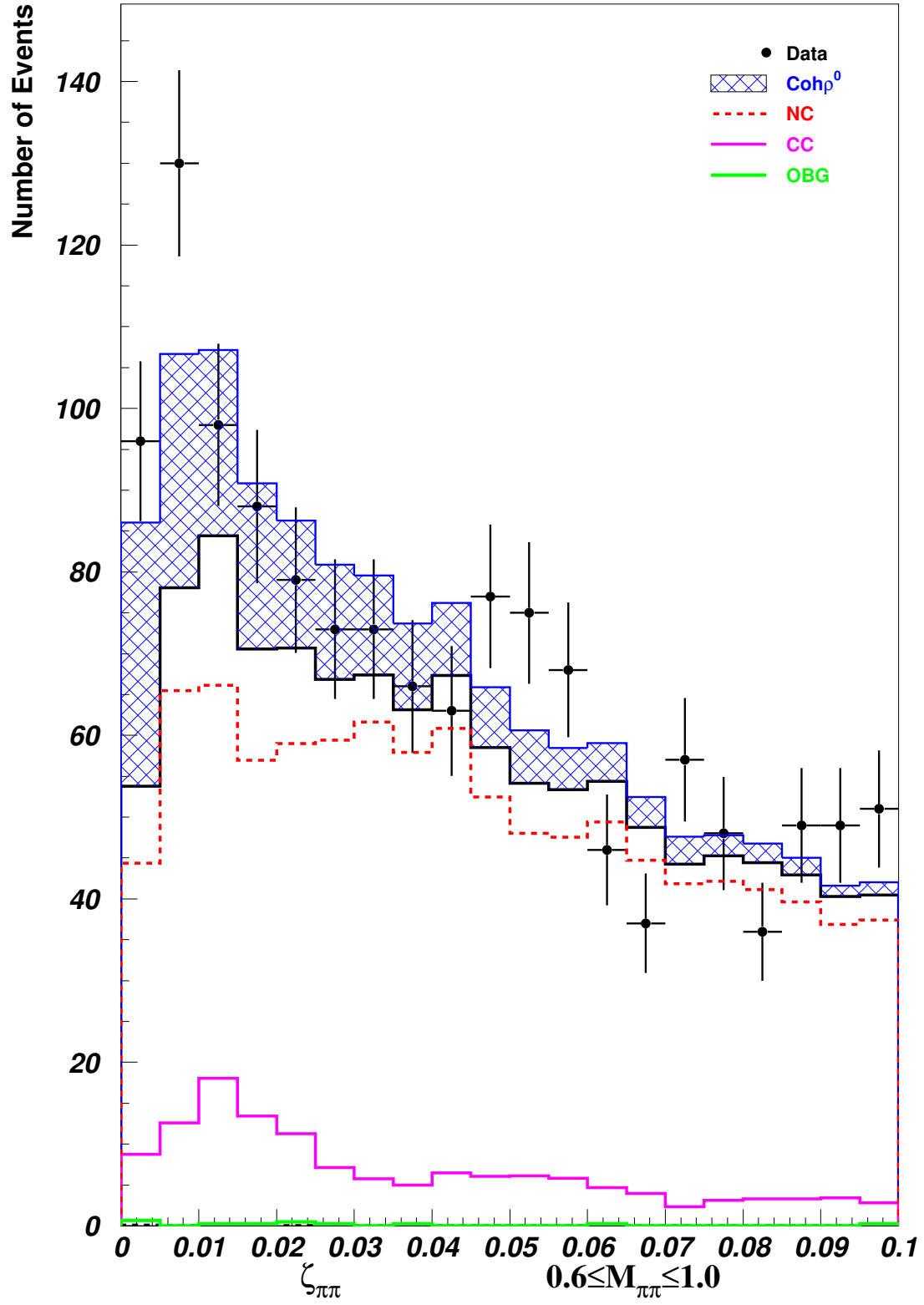


Figure 6: Plot used for $\text{Coh}\rho^0$ χ^2 normalization

6 Systematic Variations

NCDIS Stat Var				nbins:	20
BKG Variation	<i>Coh</i> ρ Norm	+1 σ	-1 σ	χ^2	σ
+1 σ	0.521	+ 0.106(20.35%)	- 0.106(20.35%)	30.529	1.235
Central	0.563	+ 0.105(18.65%)	- 0.105(18.65%)	29.755	1.220
-1 σ	0.607	+ 0.104(17.13%)	- 0.105(17.30%)	29.184	1.208
Effect:	0.563	+ 0.044(7.82%)	- 0.042(7.46%)		

Table 19: Systematic variations in background NCDIS with $P_{\pm} \geq 0.5$

CCDIS Stat Var				nbins:	20
BKG Variation	<i>Coh</i> ρ Norm	+1 σ	-1 σ	χ^2	σ
+1 σ	0.550	+ 0.105(19.09%)	- 0.106(19.27%)	29.927	1.223
Central	0.563	+ 0.105(18.65%)	- 0.105(18.65%)	29.755	1.220
-1 σ	0.575	+ 0.105(18.26%)	- 0.104(18.09%)	29.594	1.216
Effect:	0.563	+ 0.012(2.13%)	- 0.013(2.31%)		

Table 20: Systematic variations in background CCDIS with $P_{\pm} \geq 0.5$

OBG Stat Var				nbins:	20
BKG Variation	<i>Coh</i> ρ Norm	+1 σ	-1 σ	χ^2	σ
+1 σ	0.562	+ 0.106(18.86%)	- 0.105(18.68%)	29.759	1.220
Central	0.563	+ 0.105(18.65%)	- 0.105(18.65%)	29.755	1.220
-1 σ	0.563	+ 0.105(18.65%)	- 0.105(18.65%)	29.751	1.220
Effect:	0.563	+ 0.000(0.00%)	- 0.001(0.18%)		

Table 21: Systematic variations in background OBG with $P_{\pm} \geq 0.5$

7 MC Shape Plots

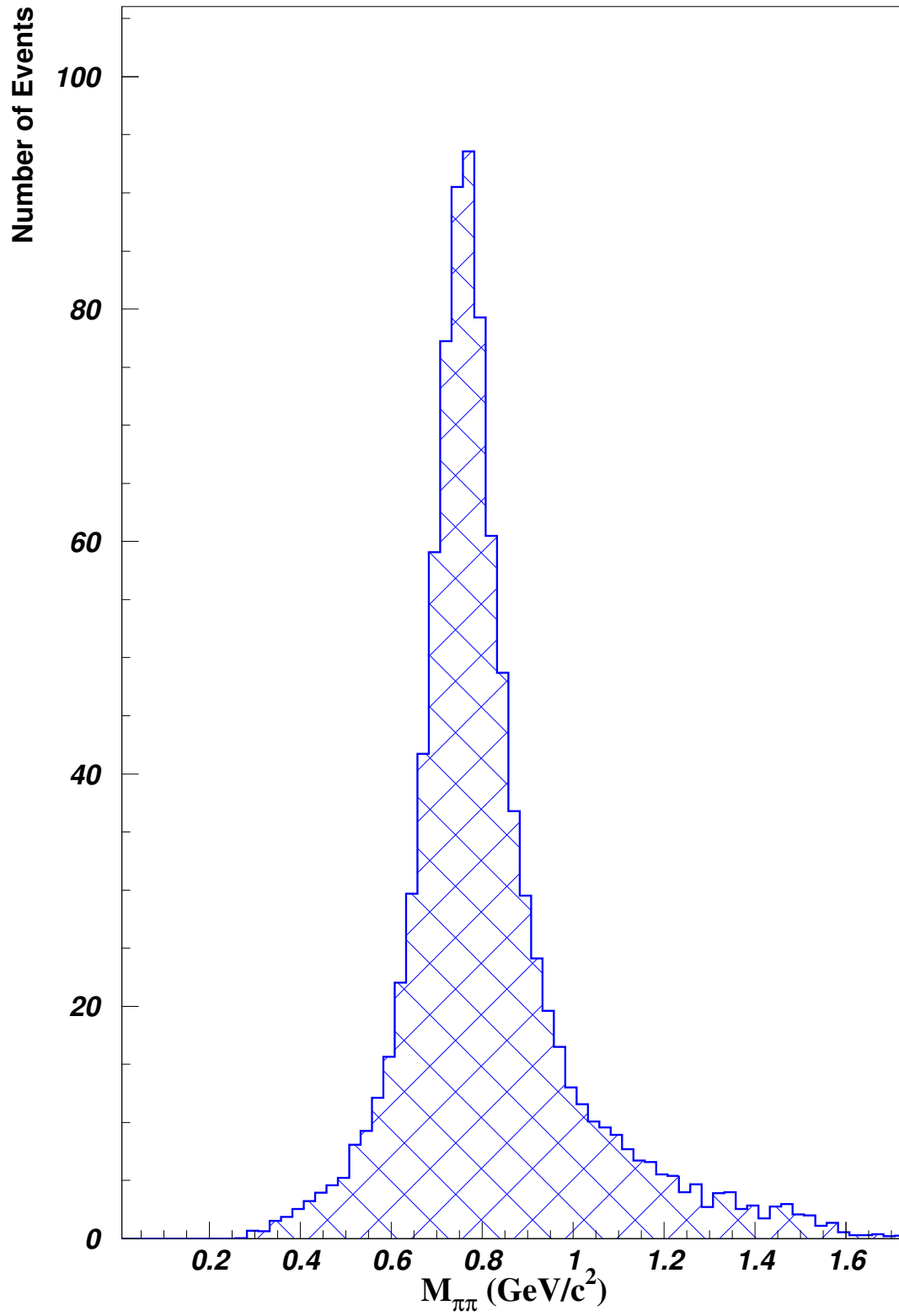


Figure 7: $M_{\pi\pi}$ For Full Coh ρ^0 MC (25MeV)

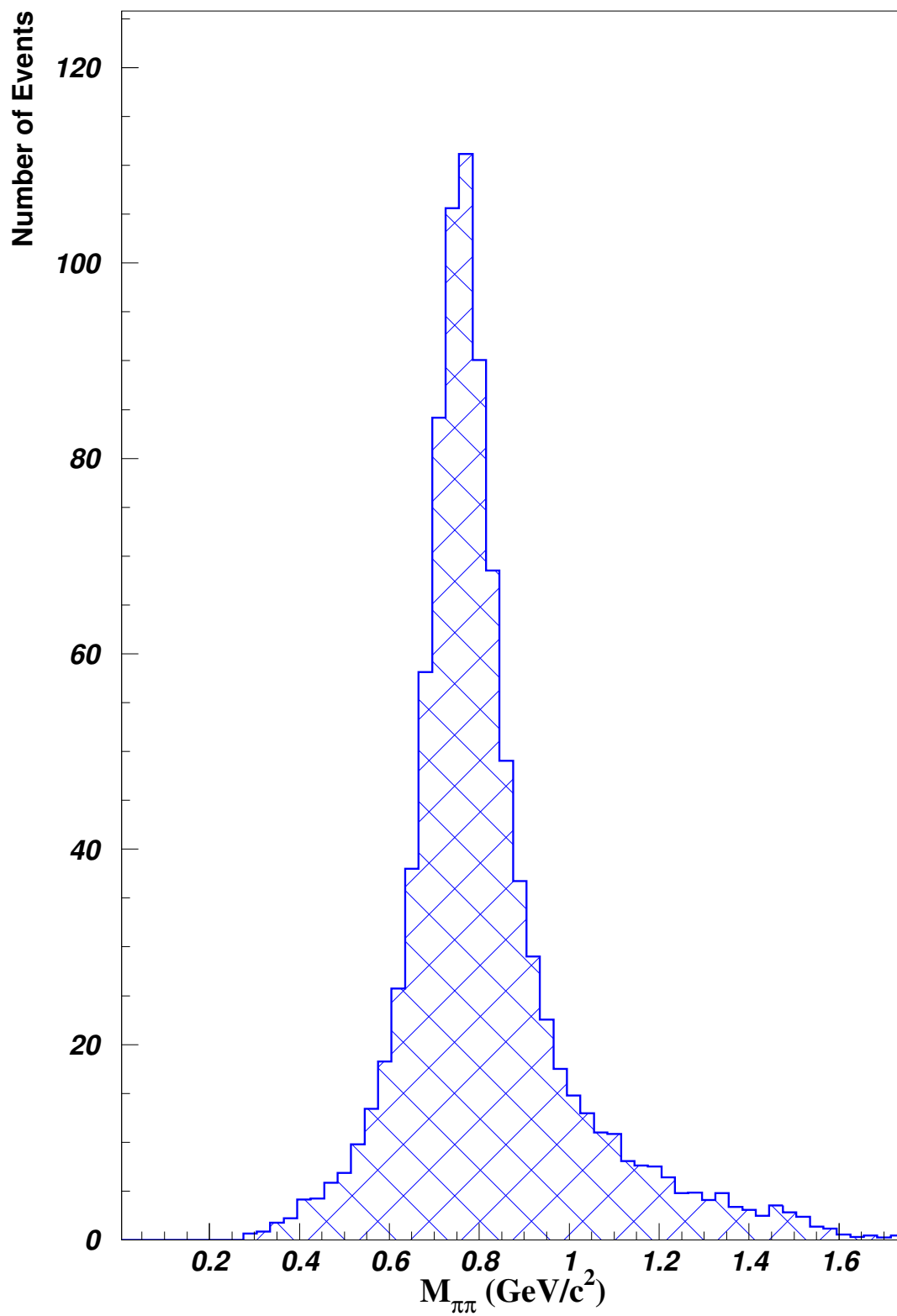


Figure 8: $M_{\pi\pi}$ For Full Coh ρ^0 MC (30MeV)

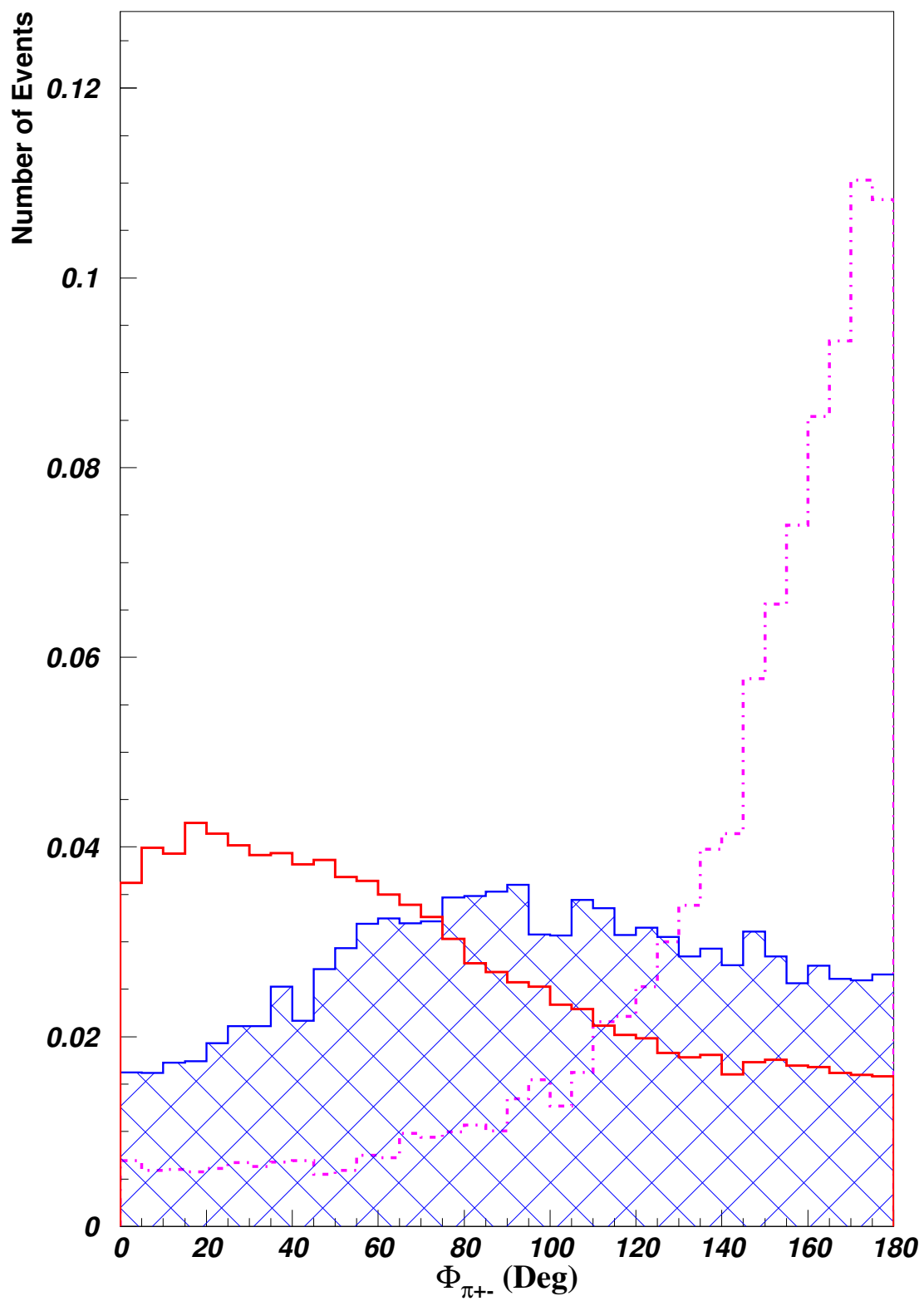


Figure 9: ϕ_{12} MC Shape Comparison

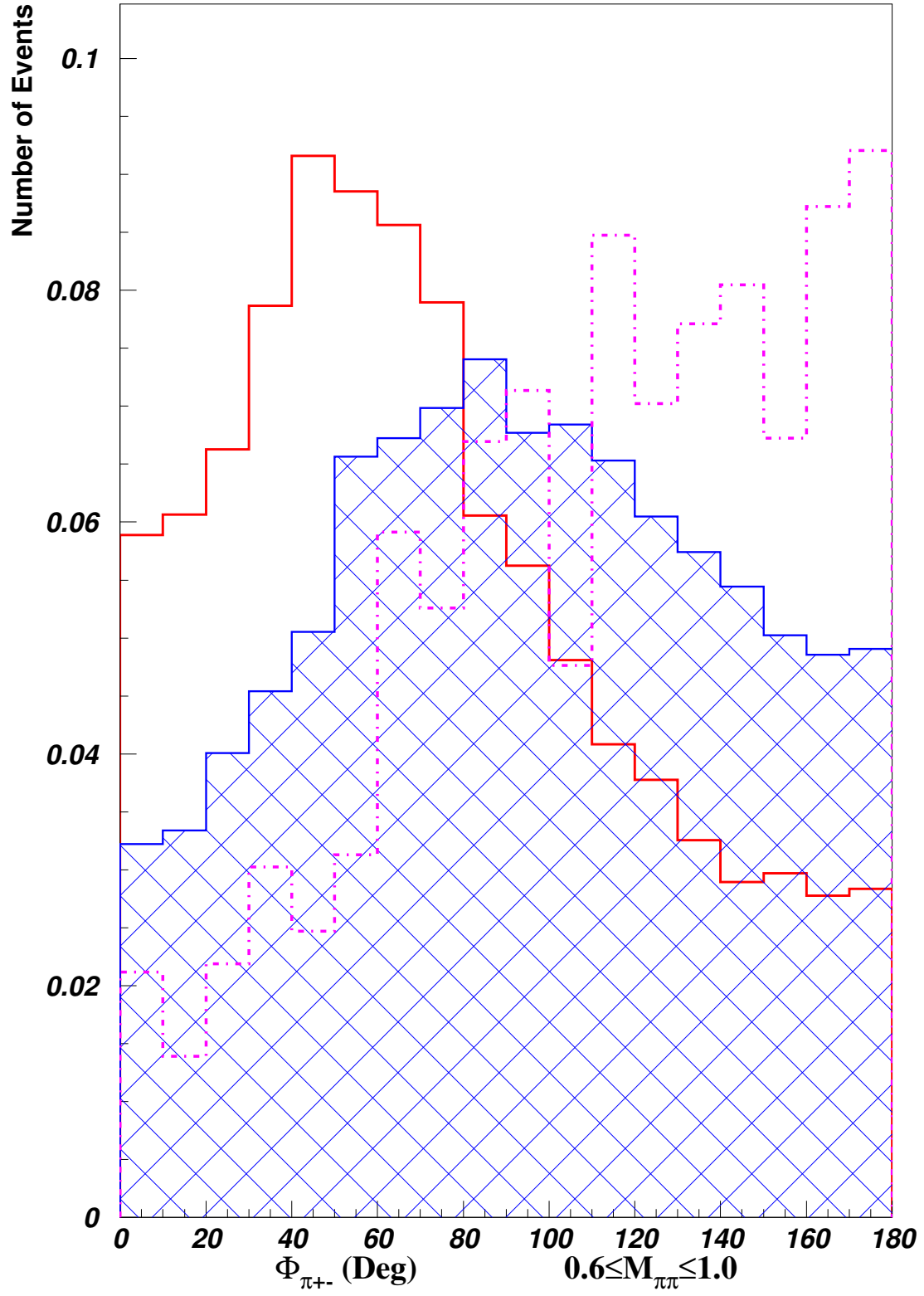


Figure 10: ϕ_{12} in Rho Mass Range MC Shape Comparison

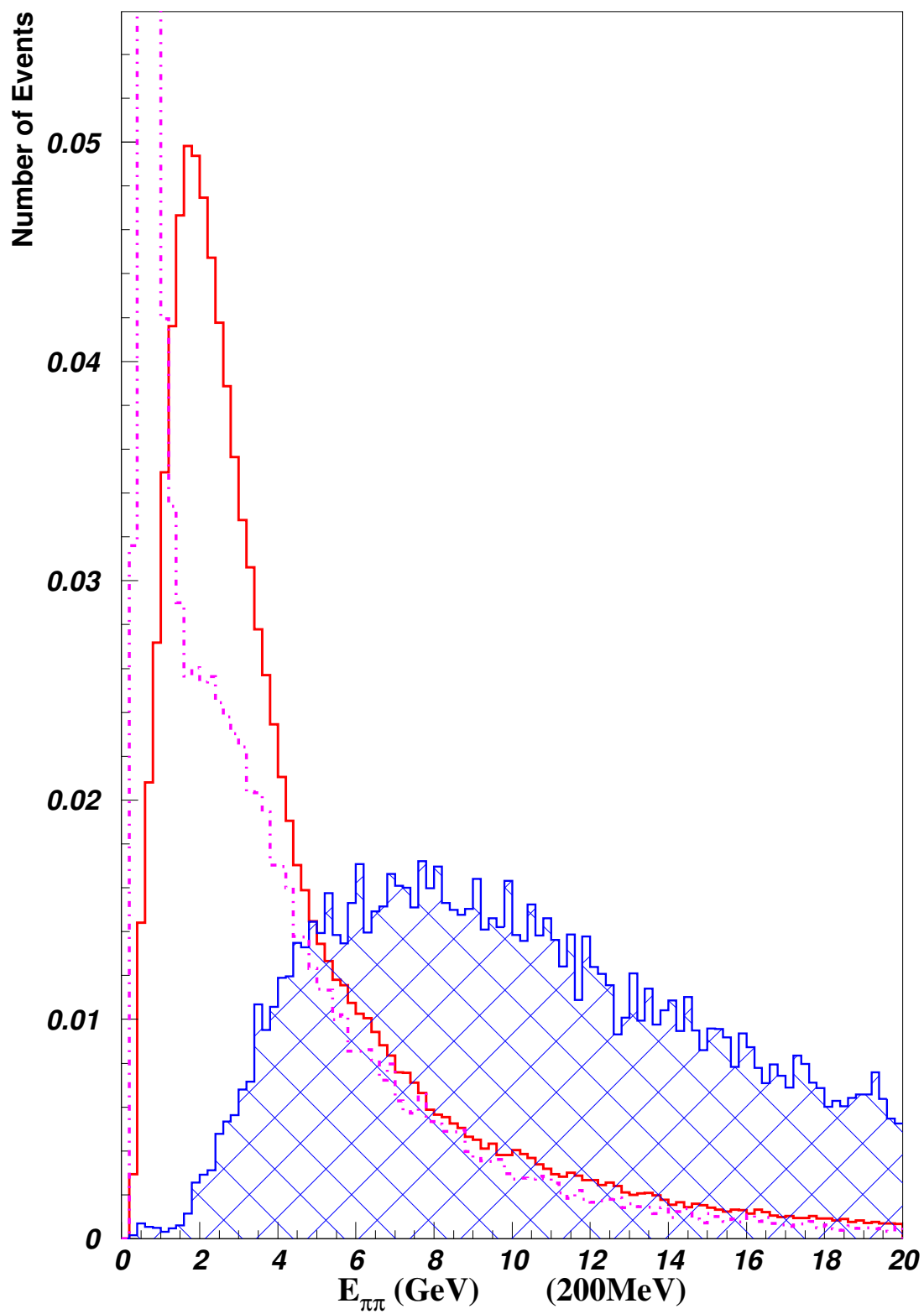


Figure 11: $E_{\pi\pi}$ MC Shape Comparison

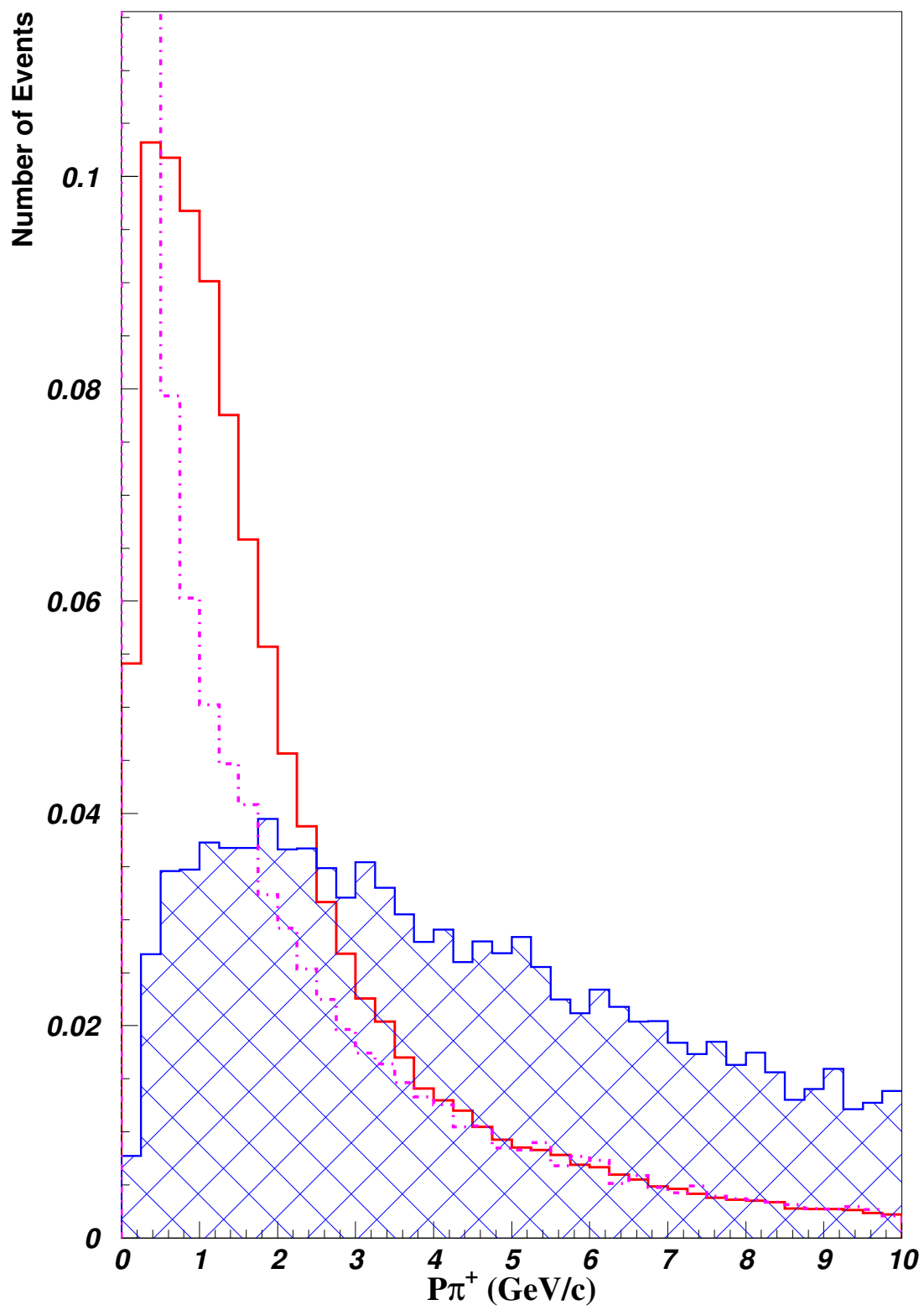


Figure 12: π^+ MC Shape Comparison

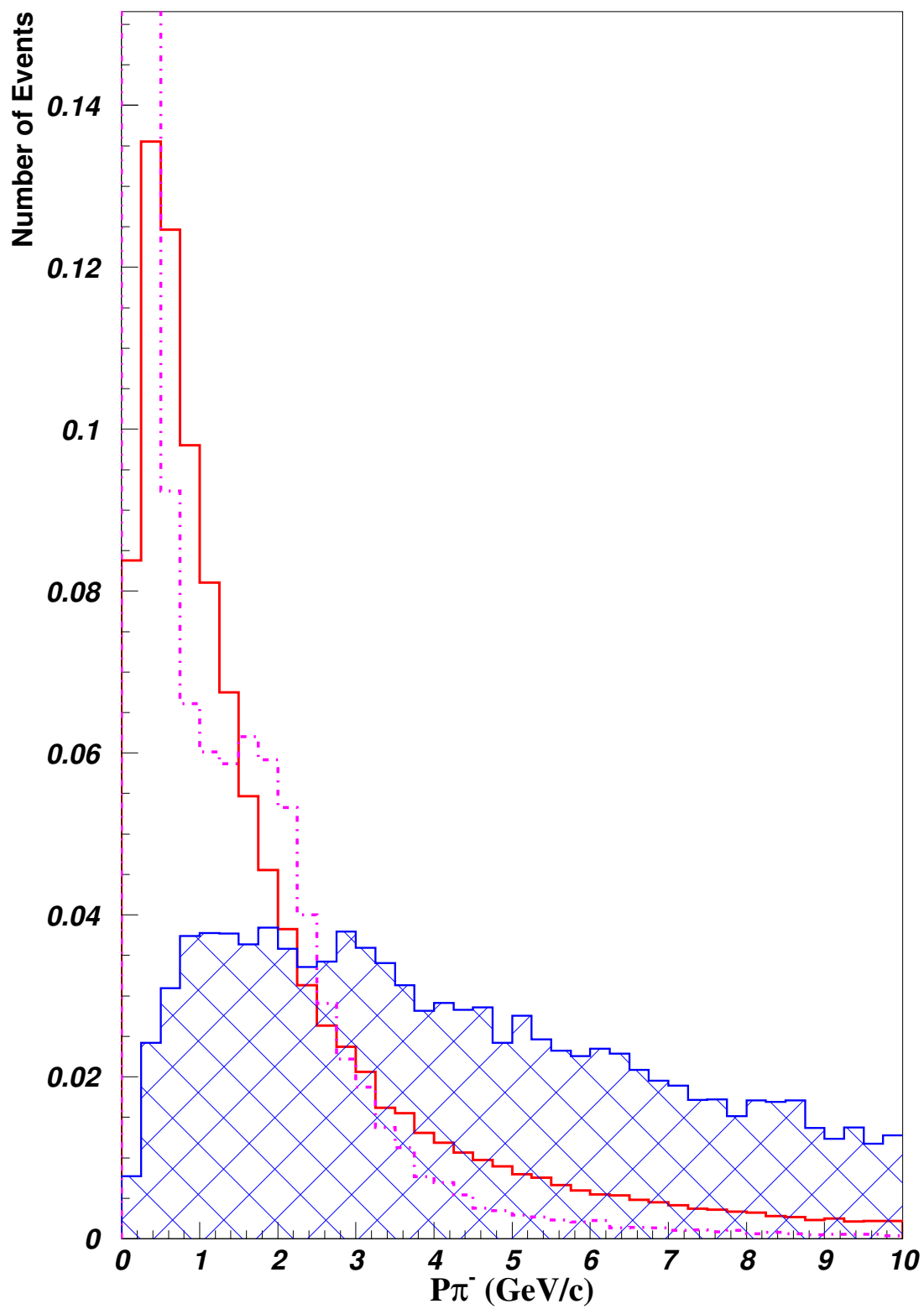


Figure 13: π^- MC Shape Comparison

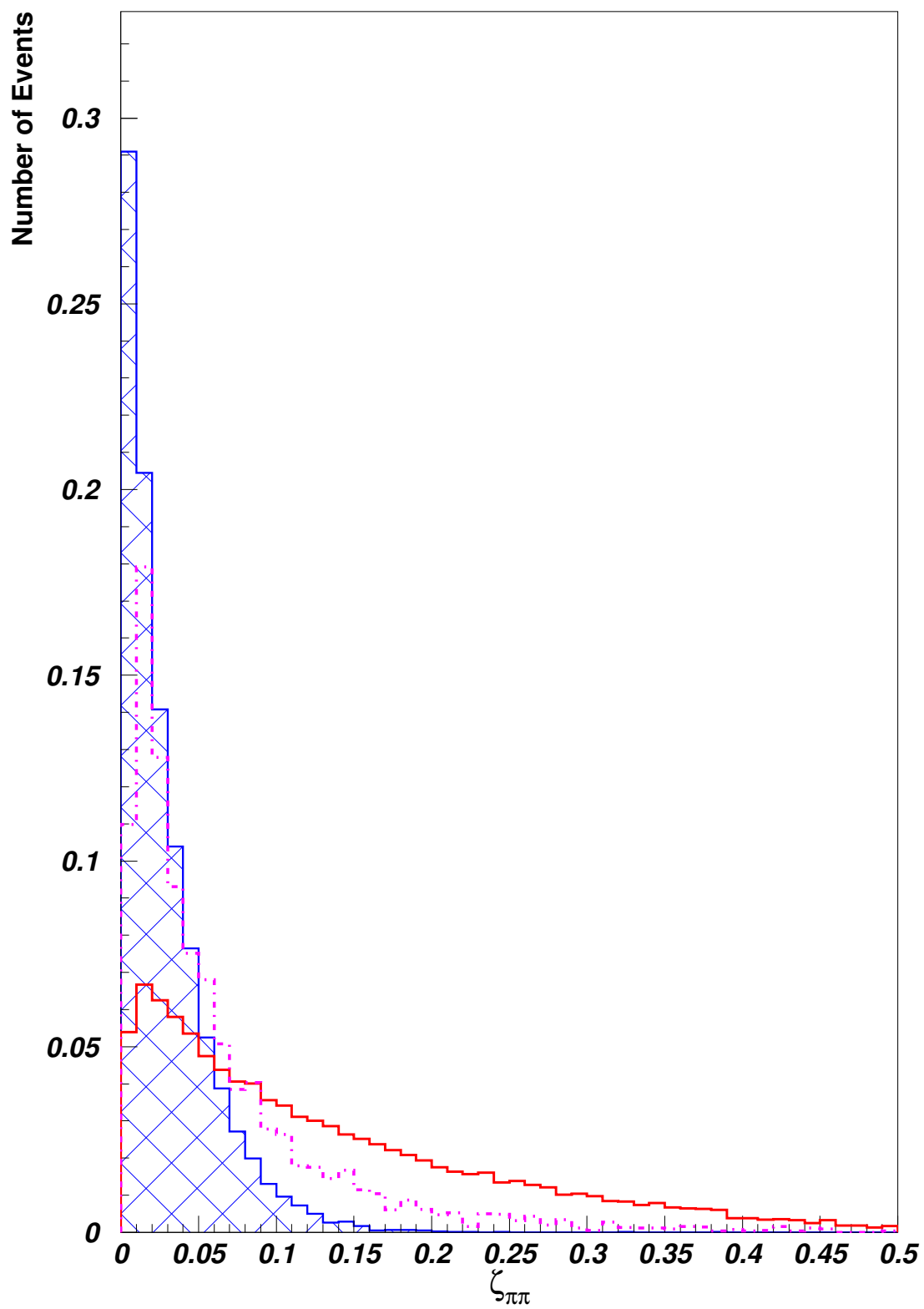


Figure 14: $\zeta_{\pi\pi}$ MC Shape Comparison

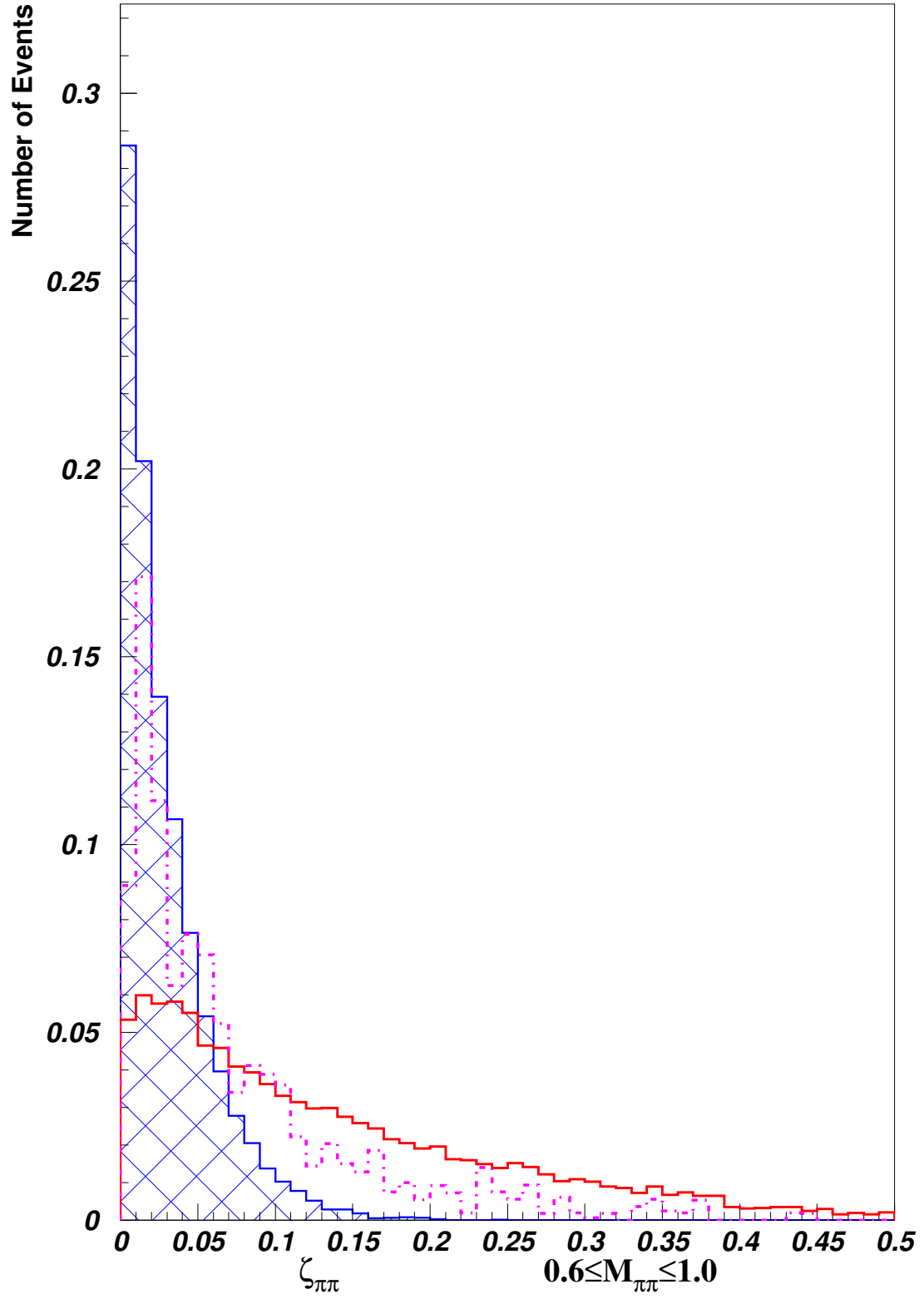


Figure 15: $\zeta_{\pi\pi}$ in Rho Mass Range MC Shape Comparison

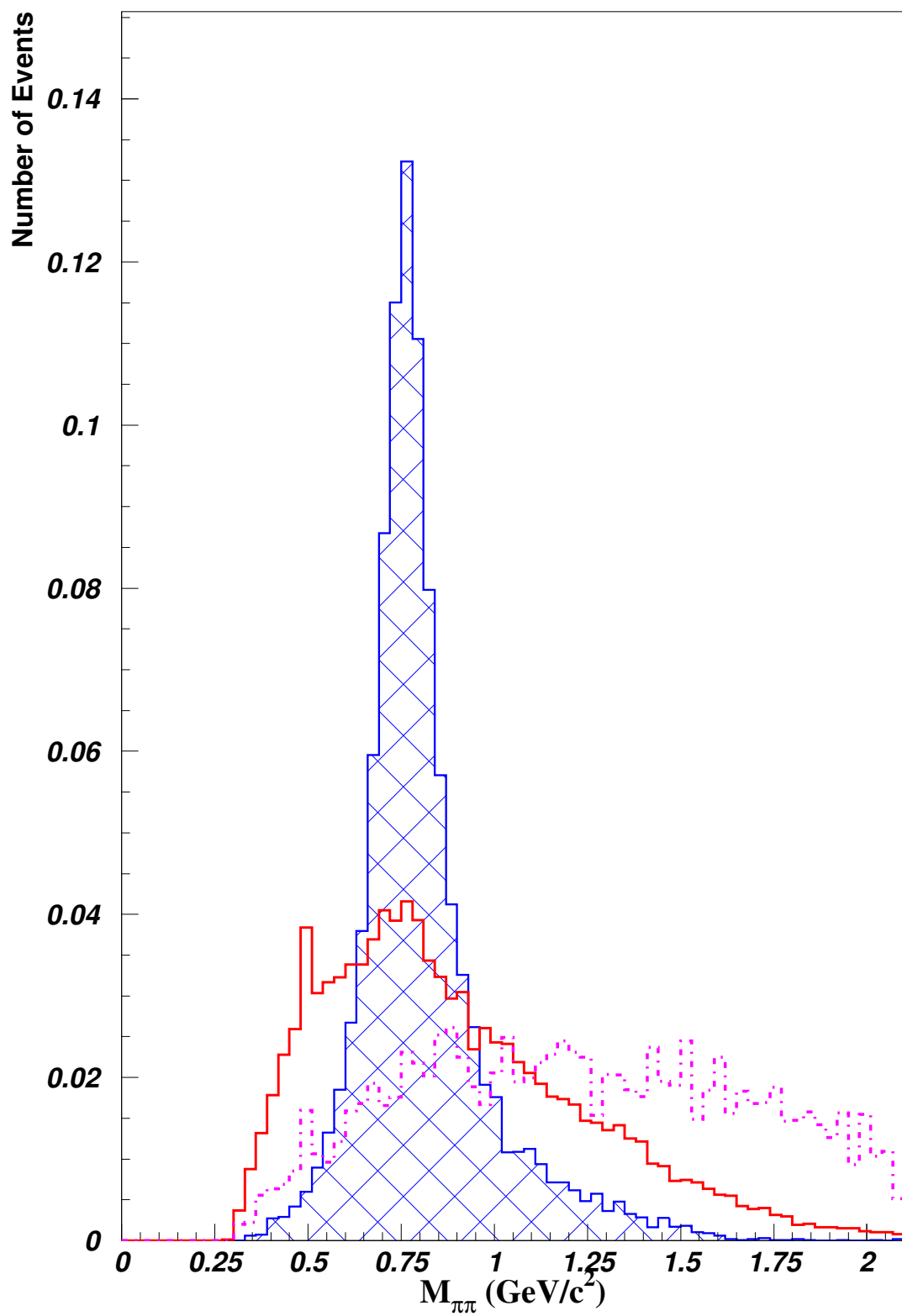


Figure 16: $M_{\pi\pi}$ MC Shape Comparison

8 Plots

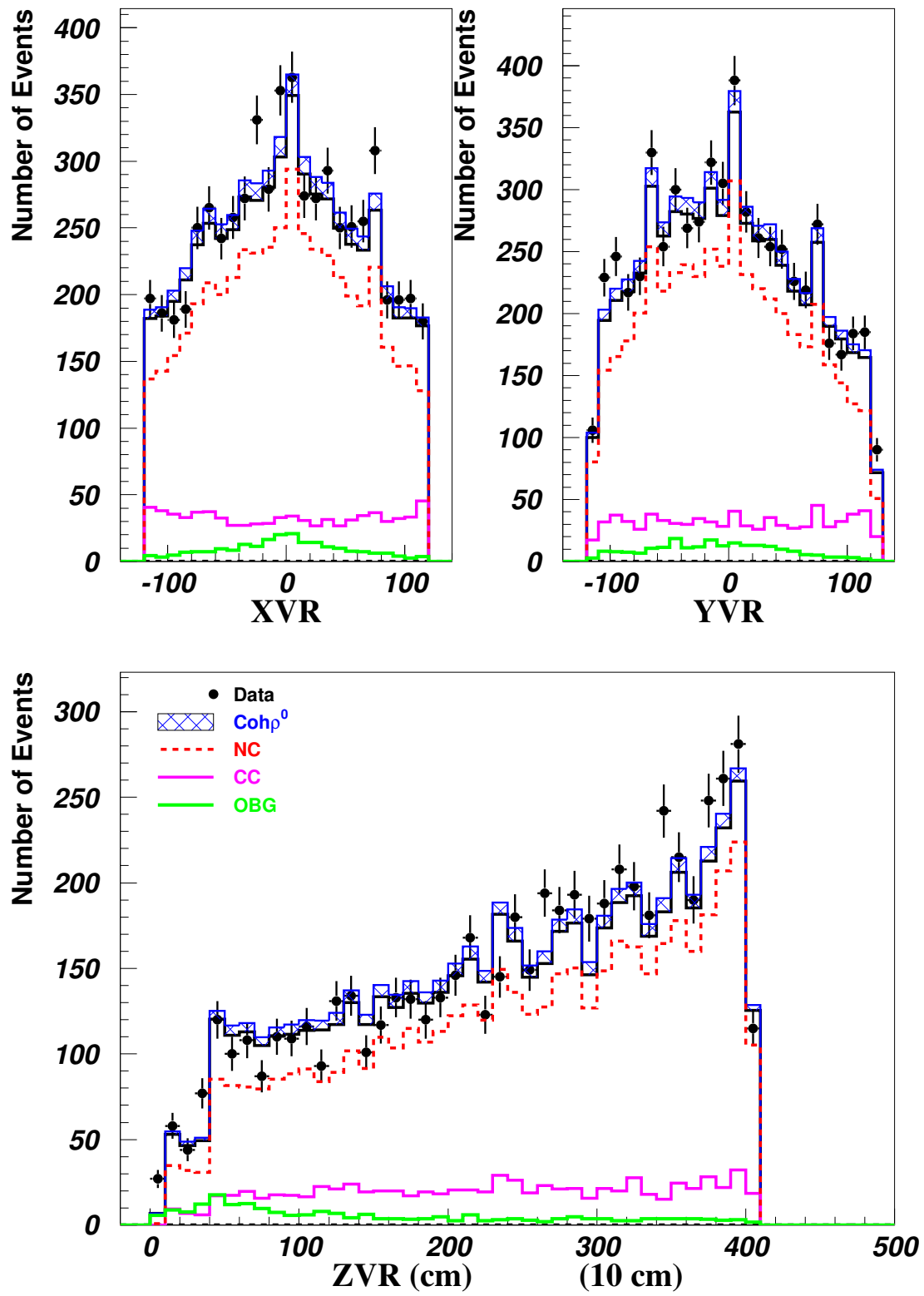


Figure 17: Vertex Position

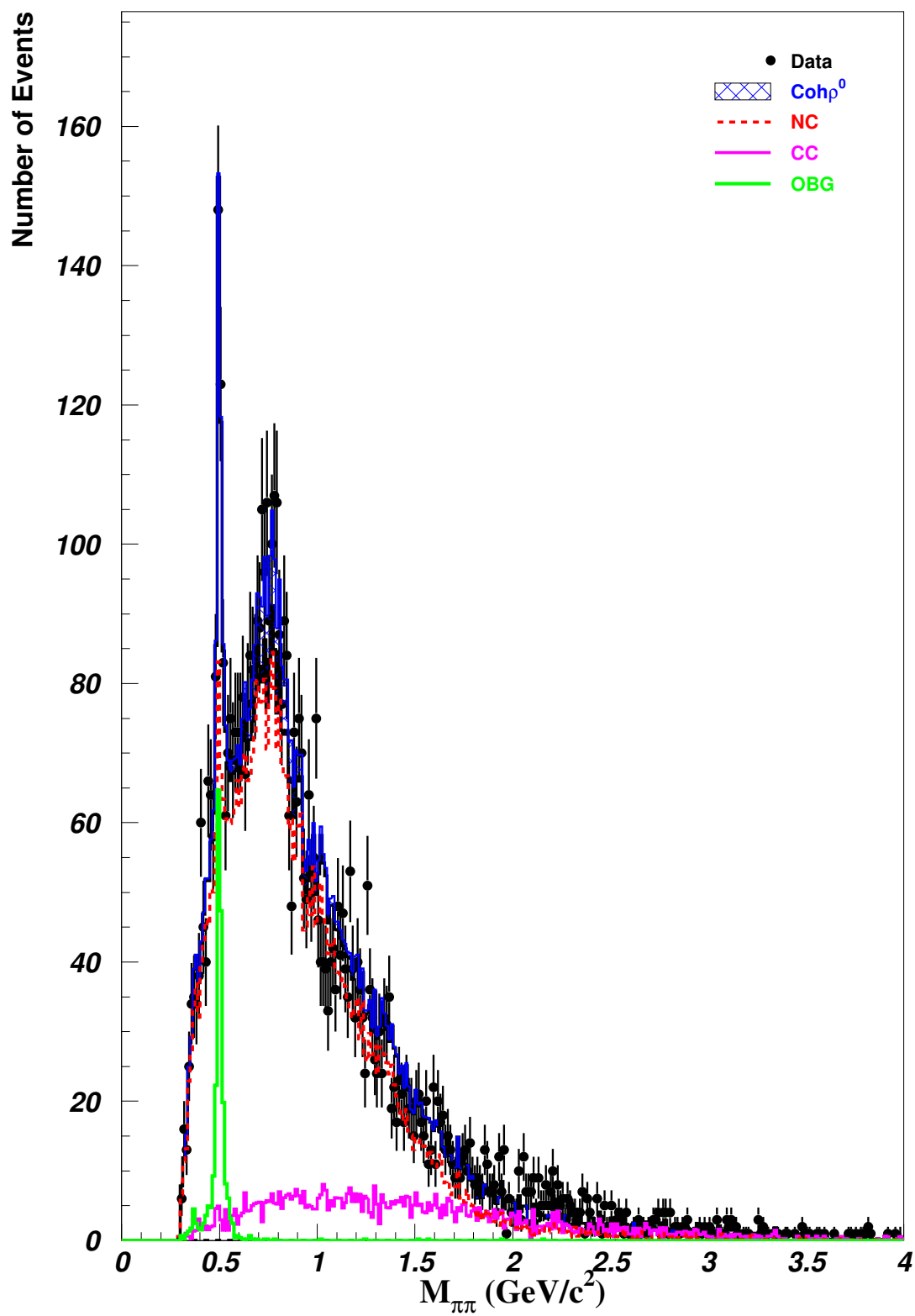


Figure 18: $M_{\pi\pi}$ 12.5MeV

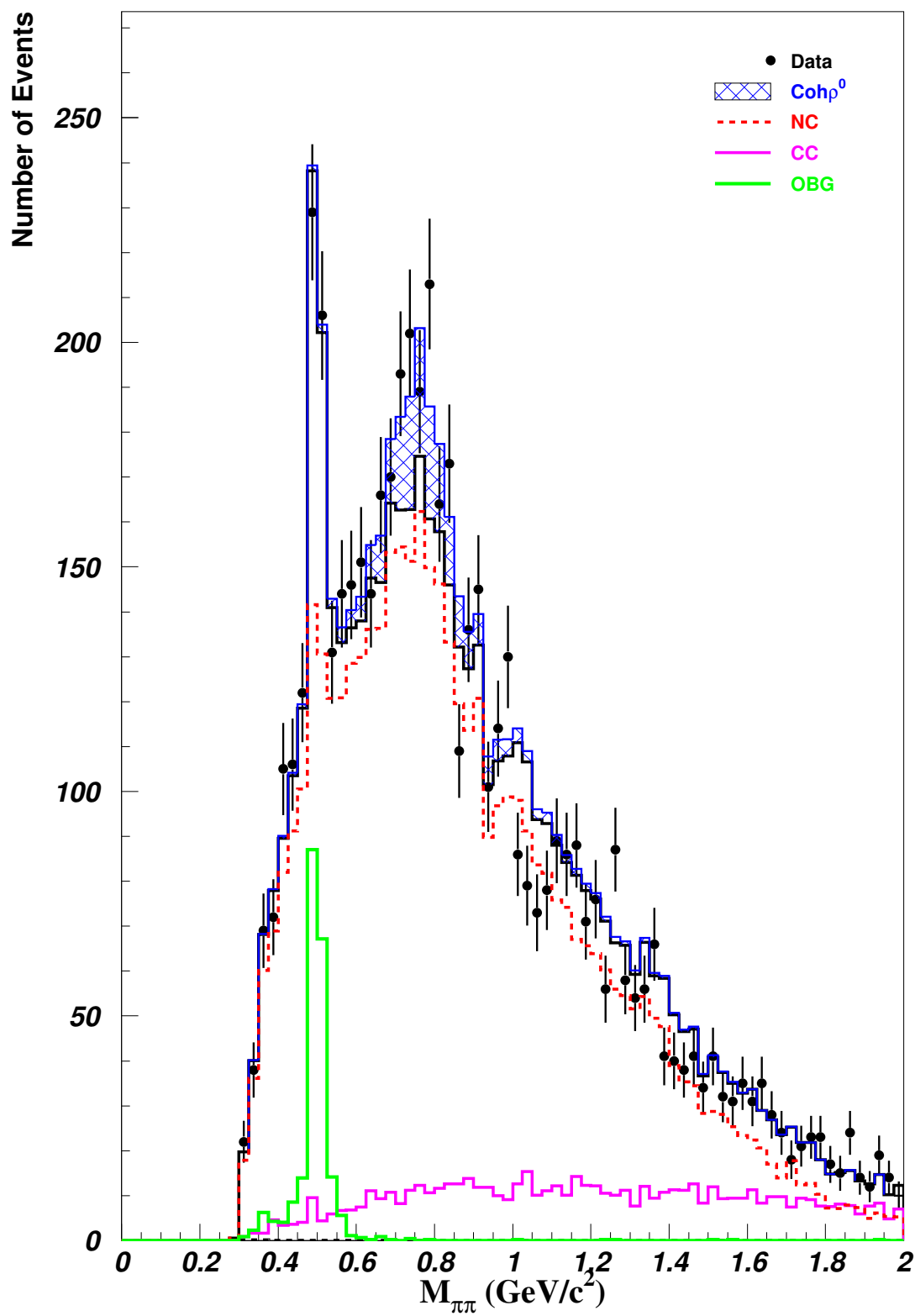


Figure 19: $M_{\pi\pi}$ 25MeV

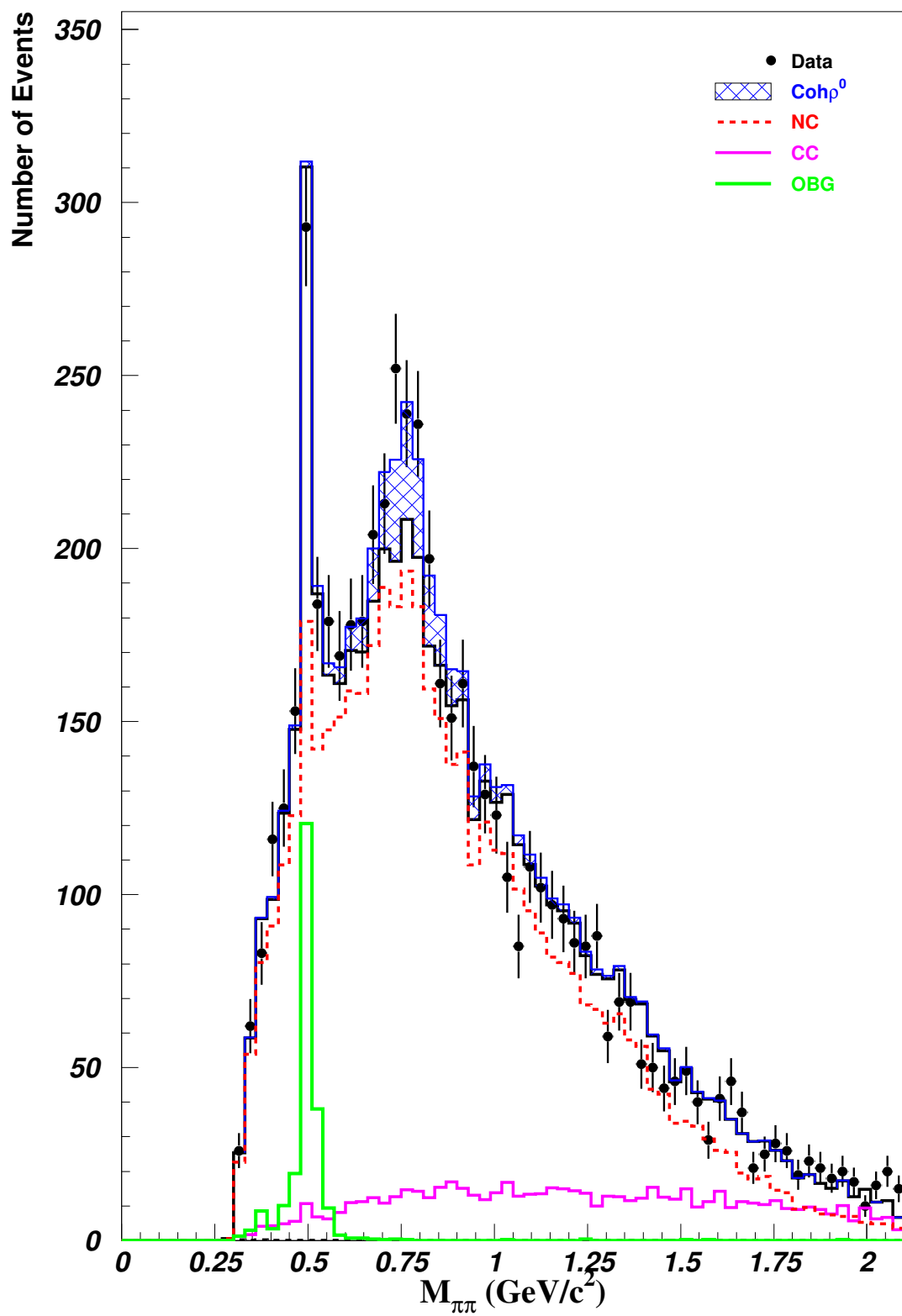


Figure 20: $M_{\pi\pi}$ 30MeV

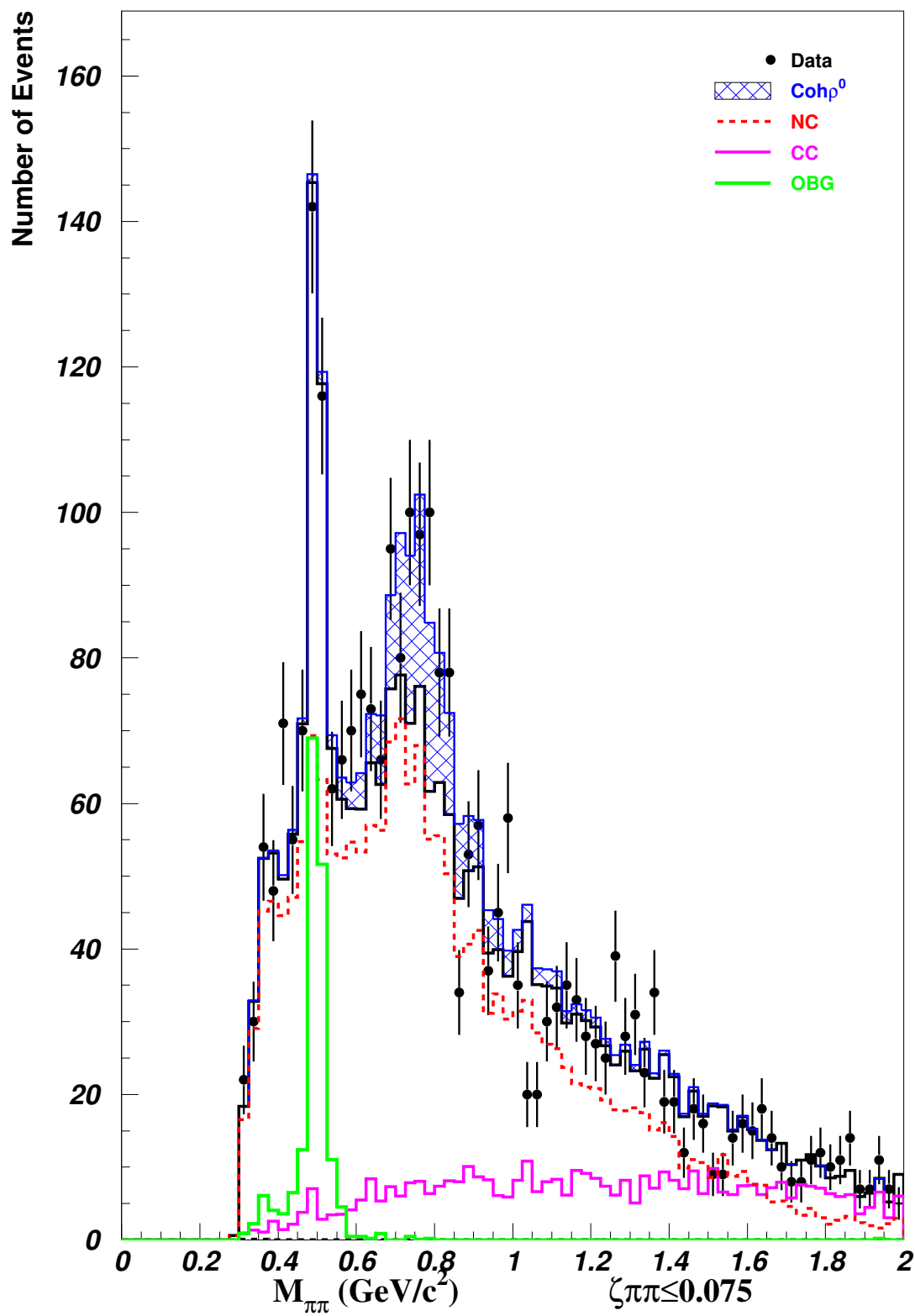


Figure 21: $M_{\pi\pi}$ 25MeV (Signal Region)

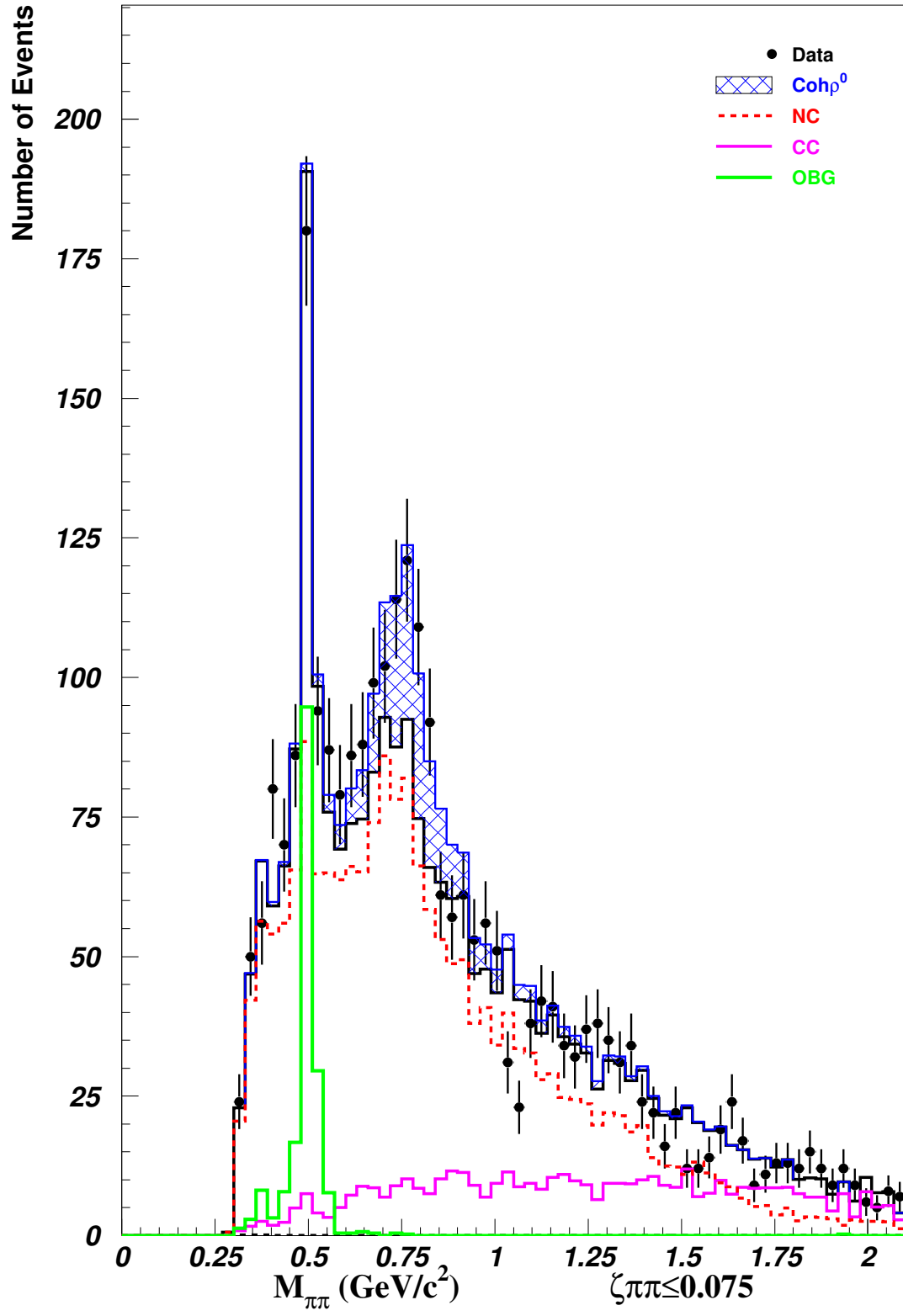


Figure 22: $M_{\pi\pi}$ 30MeV (Signal Region)

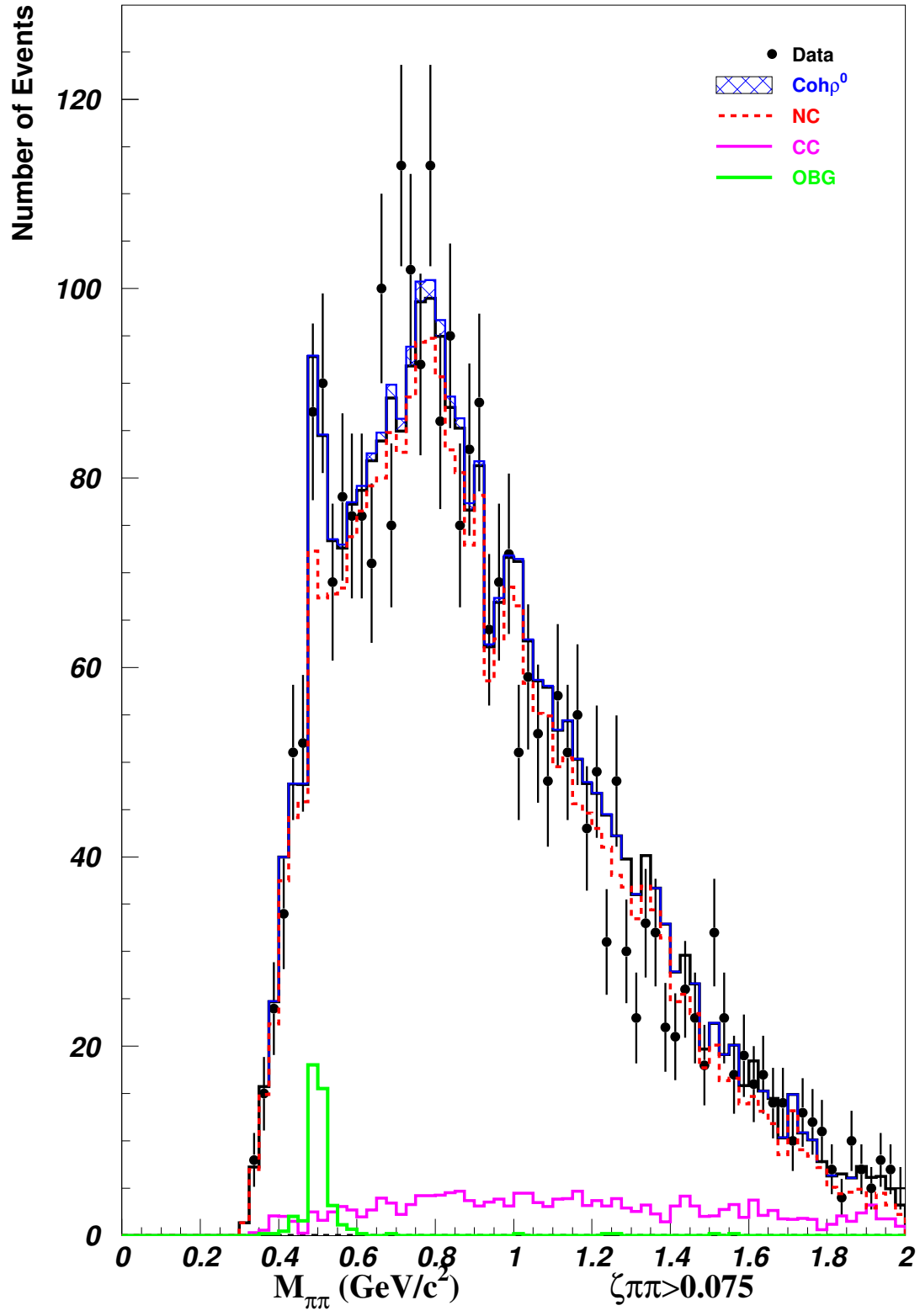


Figure 23: $M_{\pi\pi}$ 25MeV (Background Region)

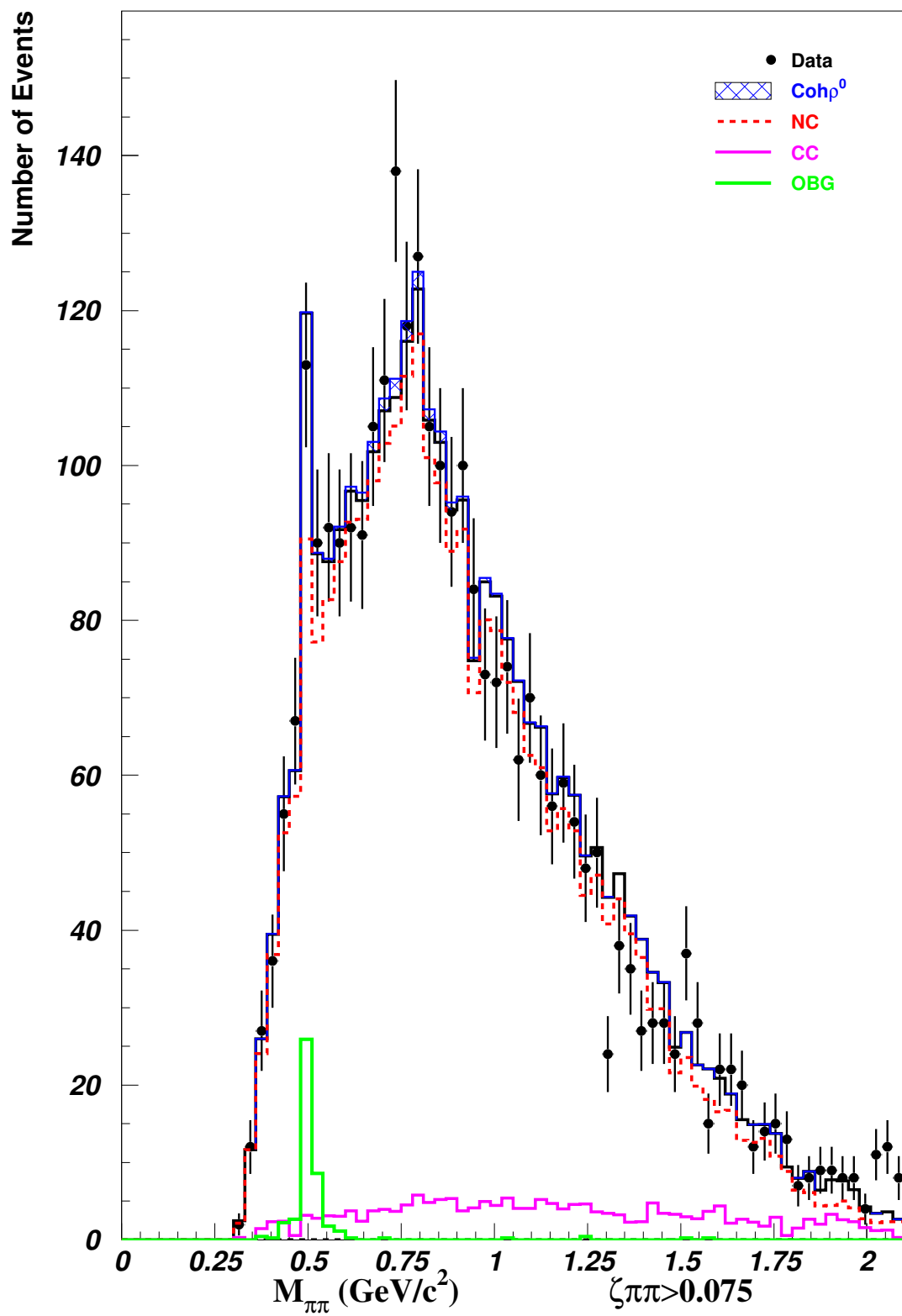


Figure 24: $M_{\pi\pi}$ 30MeV (Background Region)

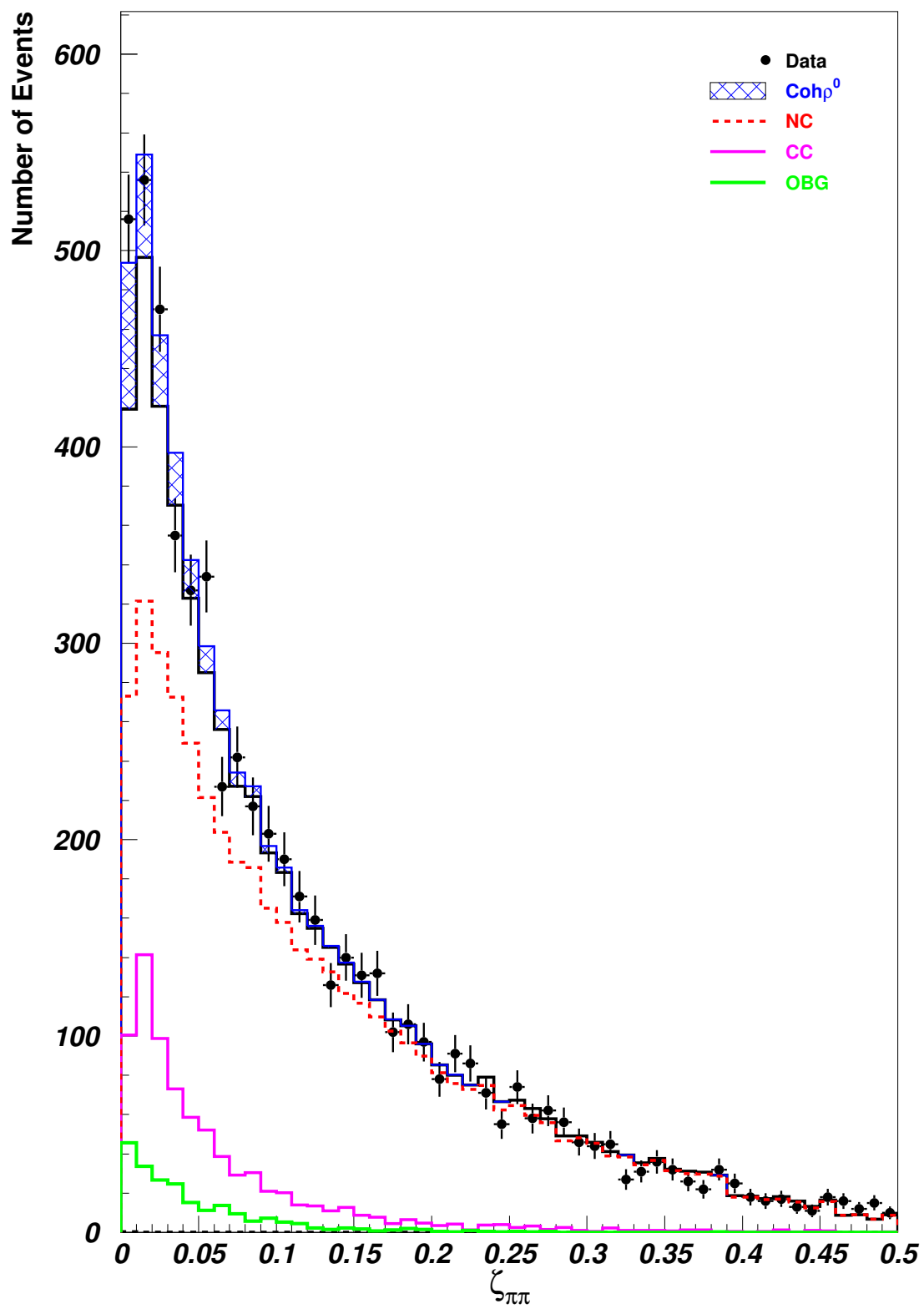


Figure 25: $\zeta_{\pi\pi}$

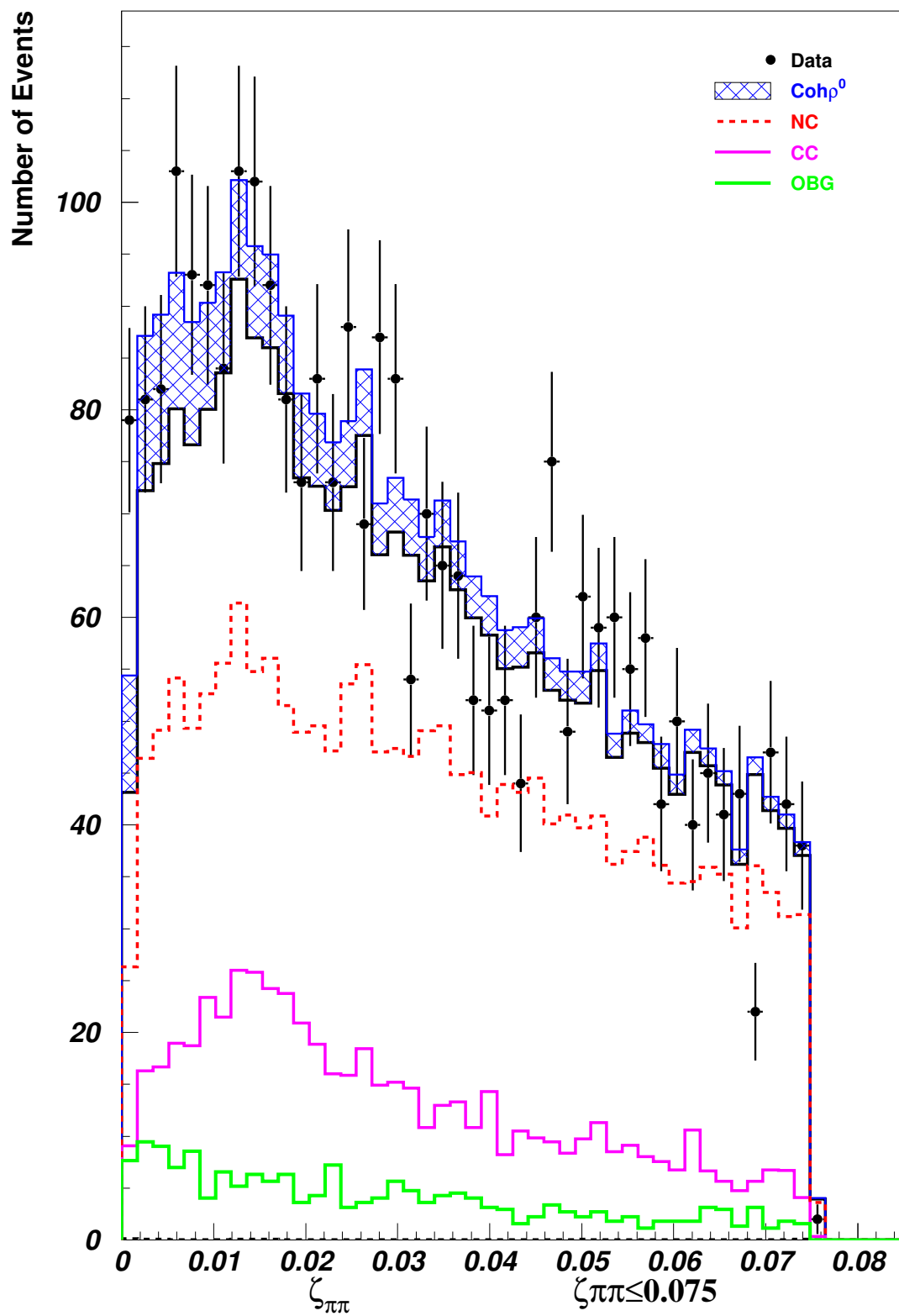


Figure 26: $\zeta_{\pi\pi}$ (Signal Region)

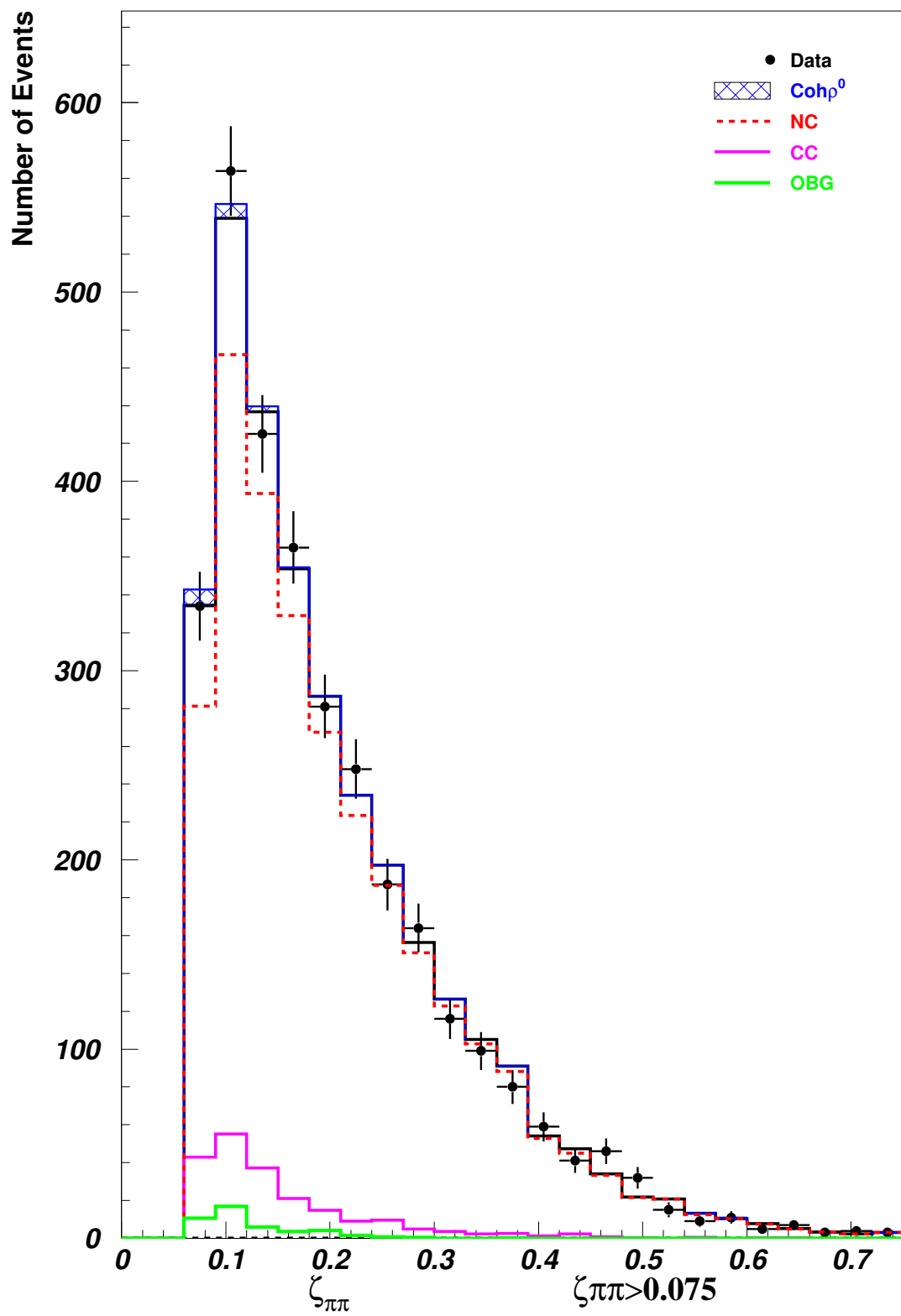


Figure 27: $\zeta_{\pi\pi}$ (Background Region)

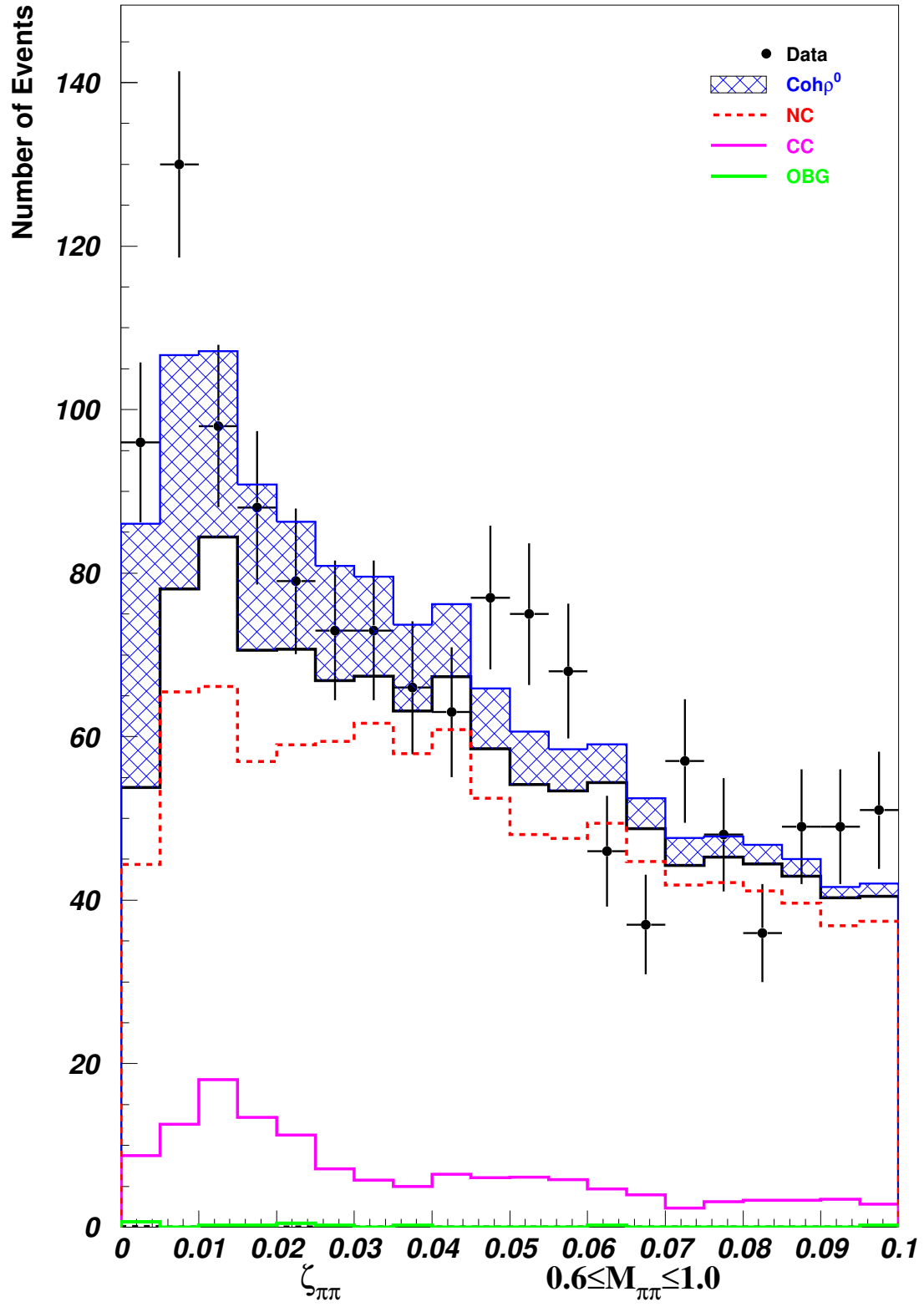


Figure 28: $\zeta_{\pi\pi}$ (Used for χ^2)

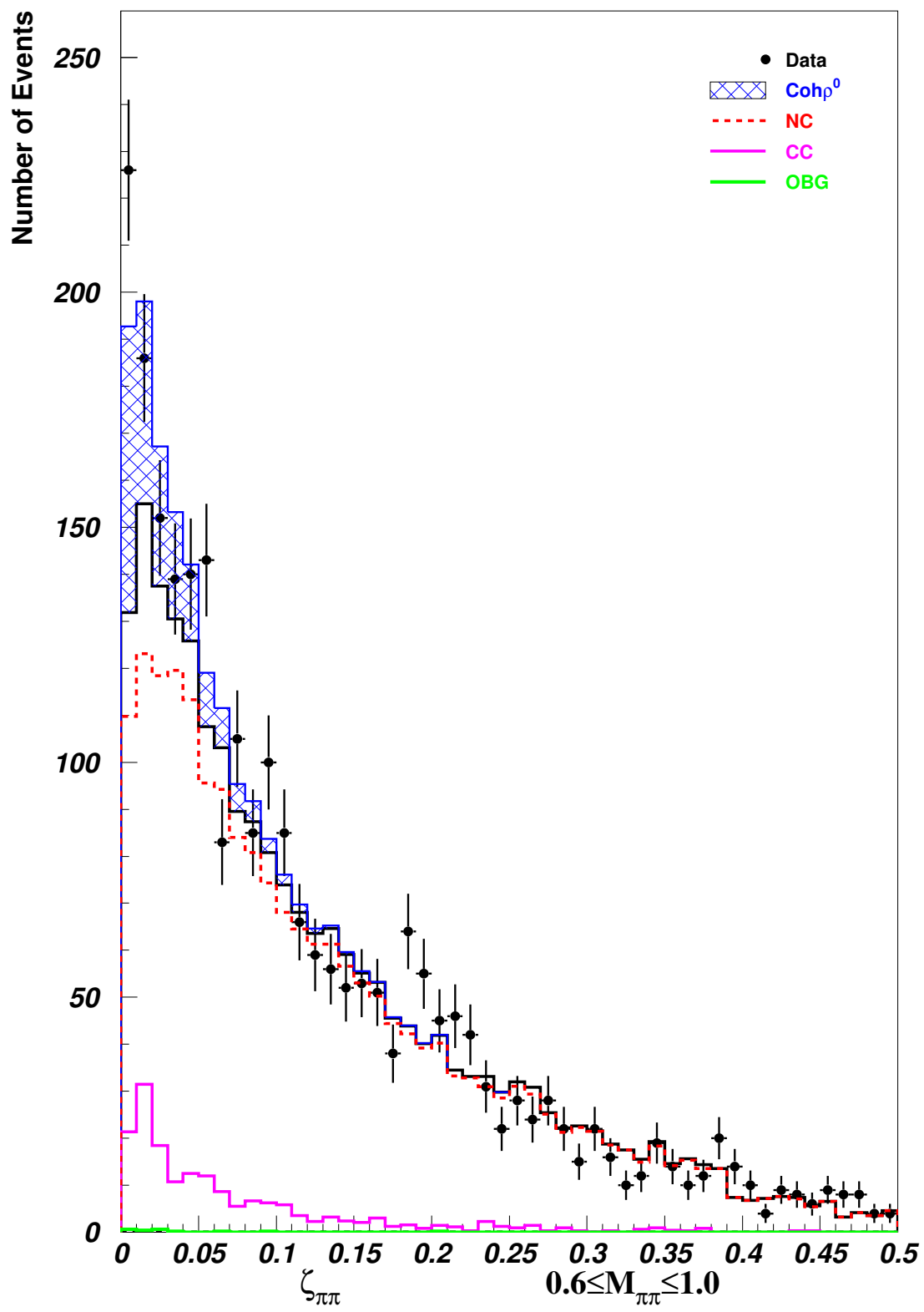


Figure 29: $\zeta_{\pi\pi}$ (Rho Mass Region)

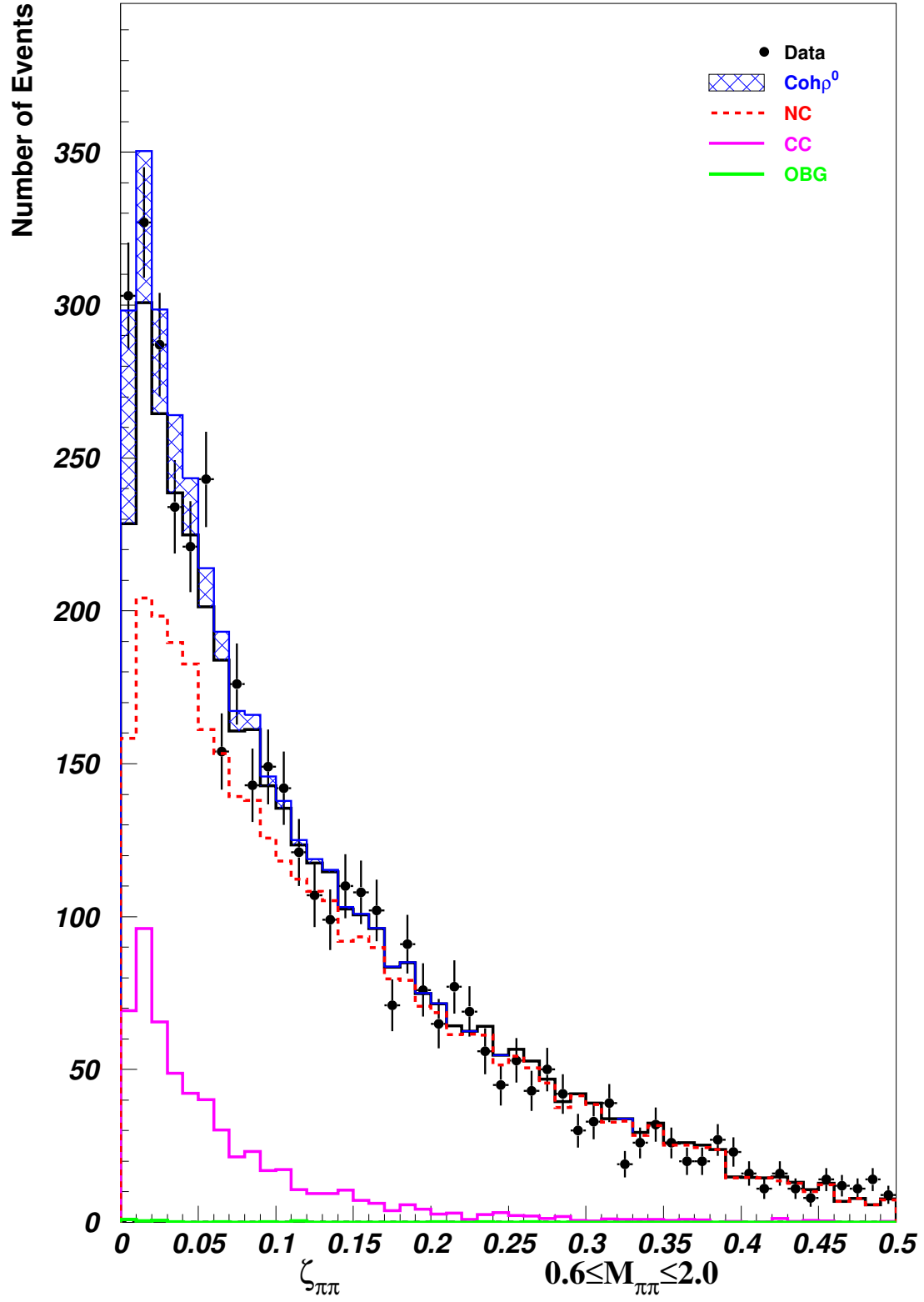


Figure 30: $\zeta_{\pi\pi}$ (Rho+Tail Mass Region)

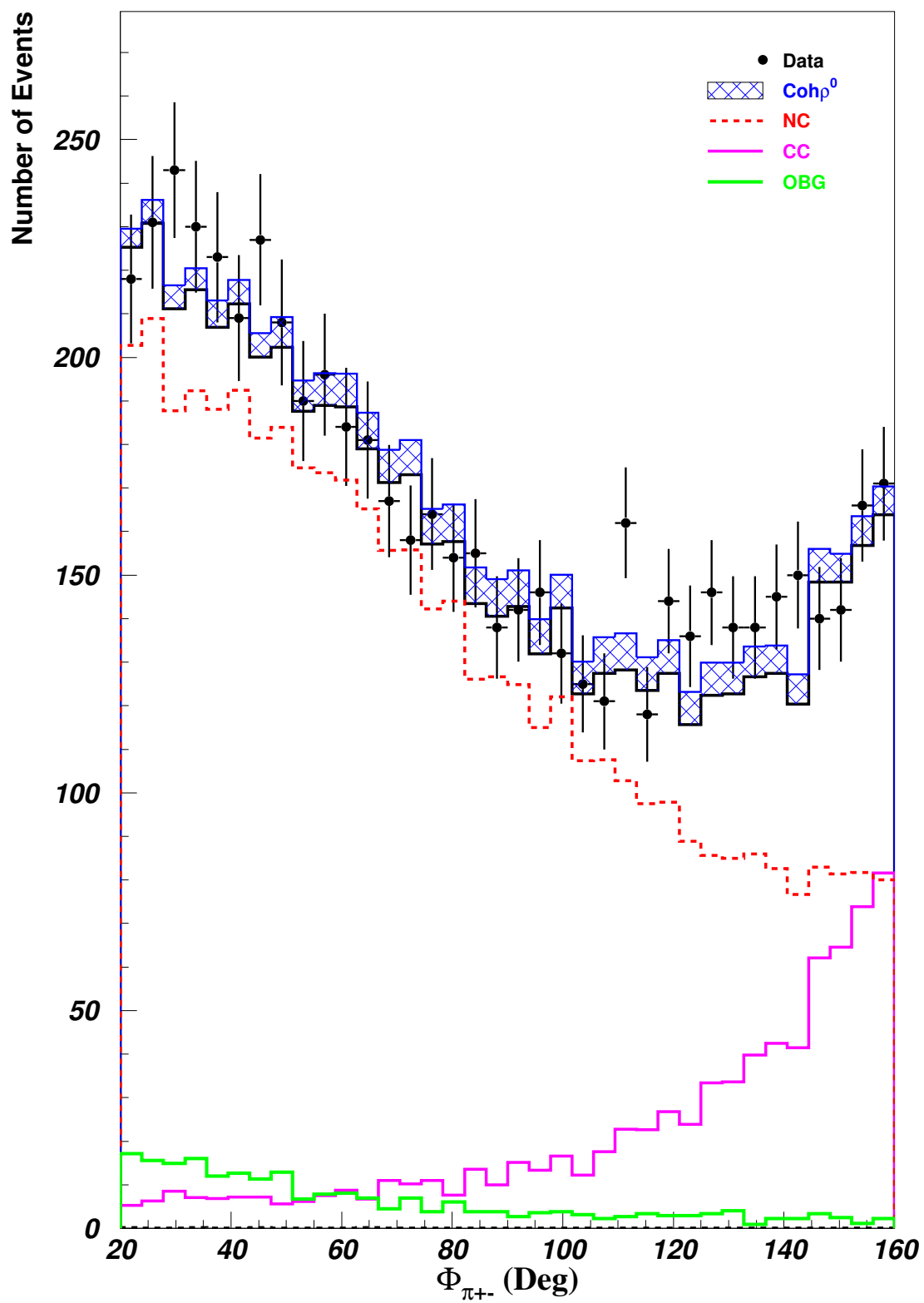


Figure 31: ϕ_{12}

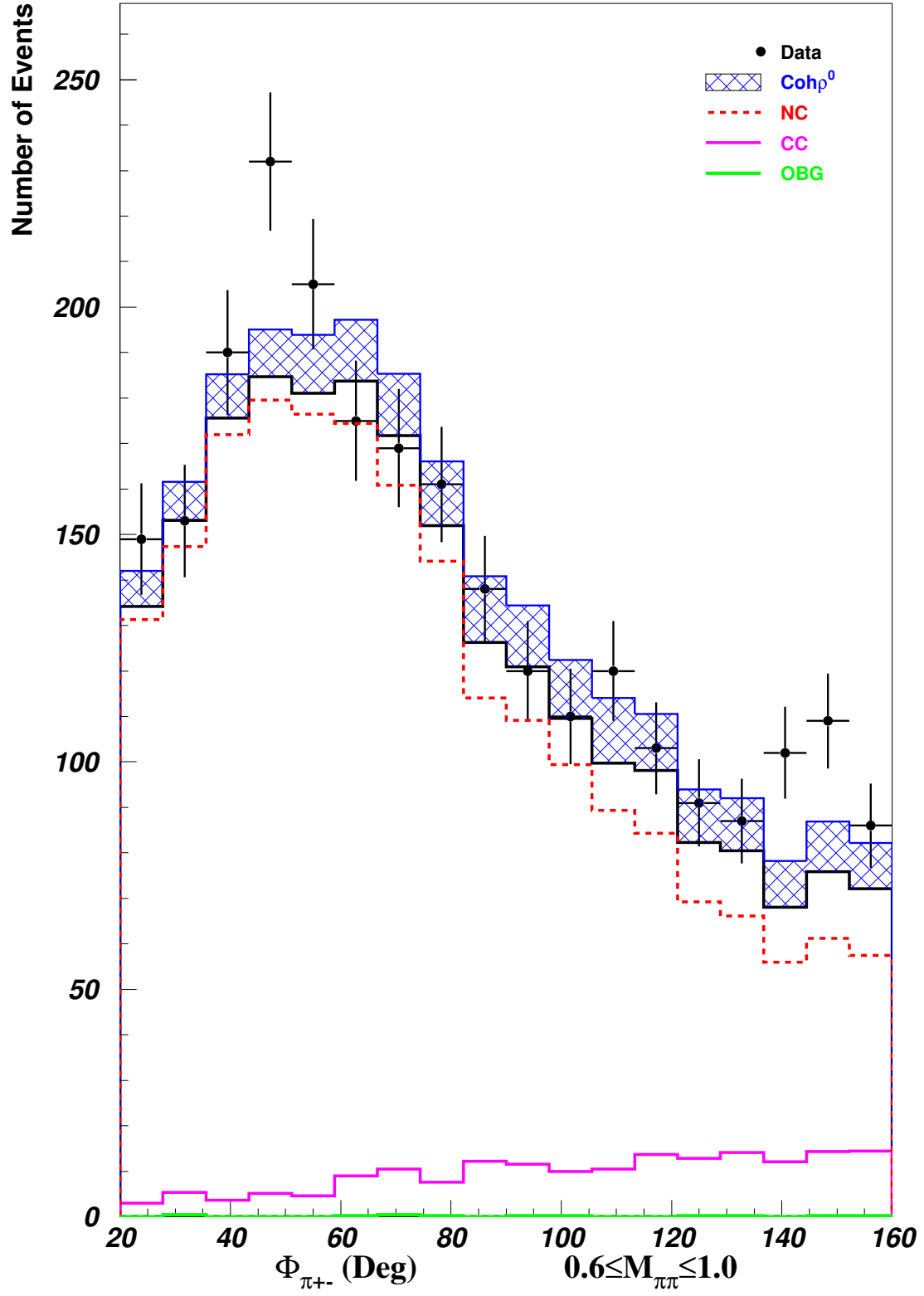


Figure 32: ϕ_{12} (In Rho Mass range)

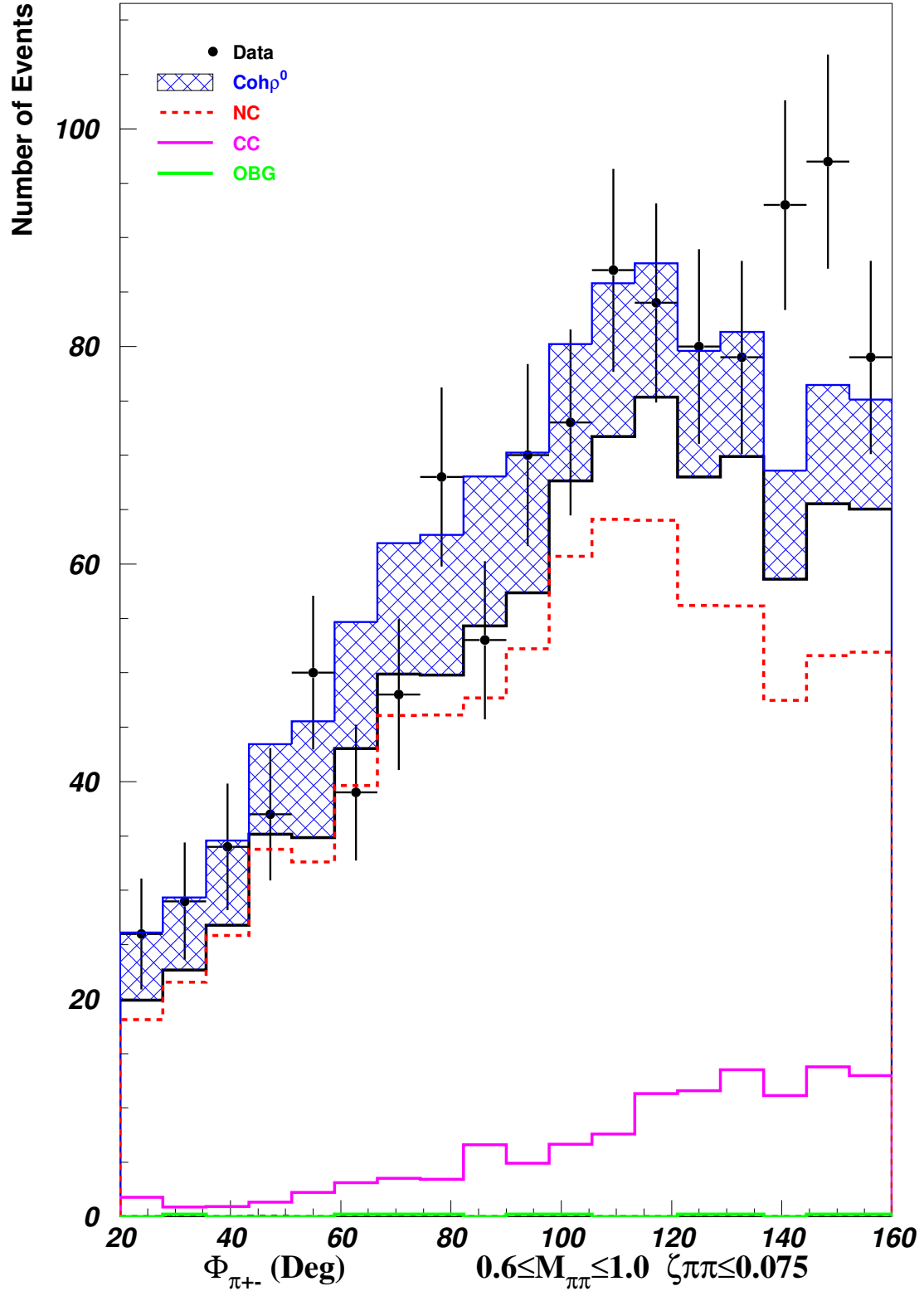


Figure 33: ϕ_{12} (Signal Region in Rho Mass)

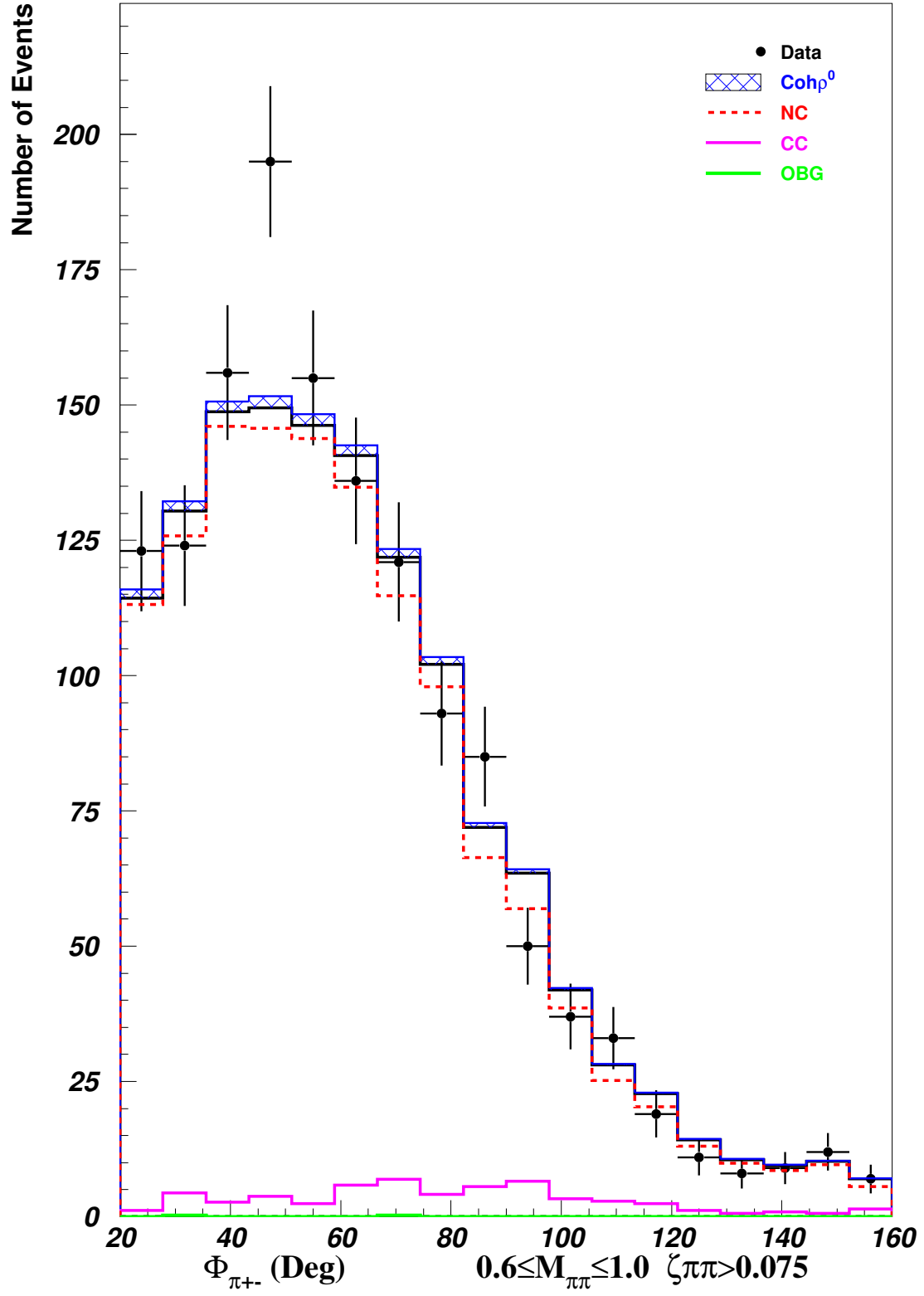


Figure 34: ϕ_{12} (Background Region in Rho Mass)

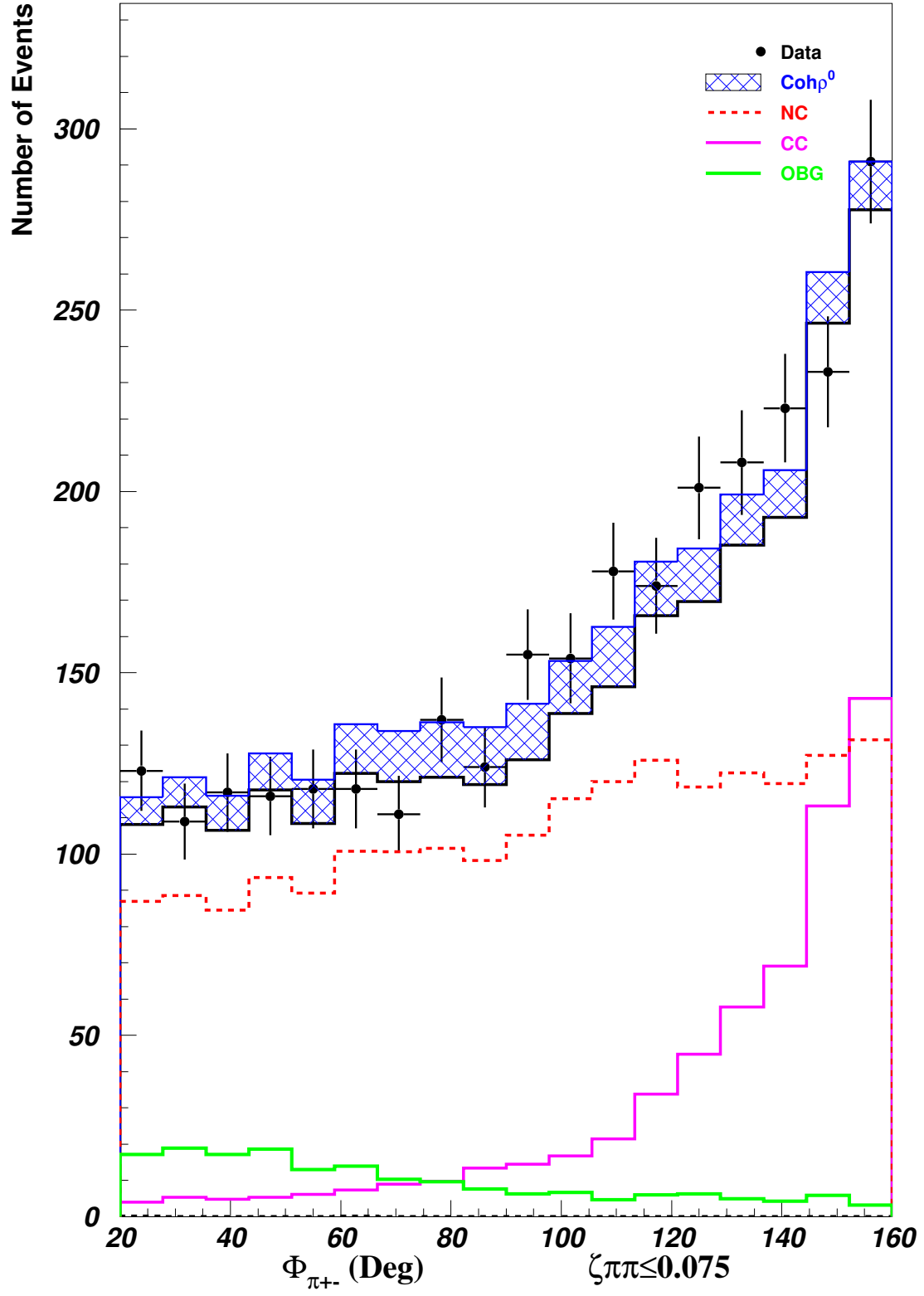


Figure 35: ϕ_{12} (Signal Region)

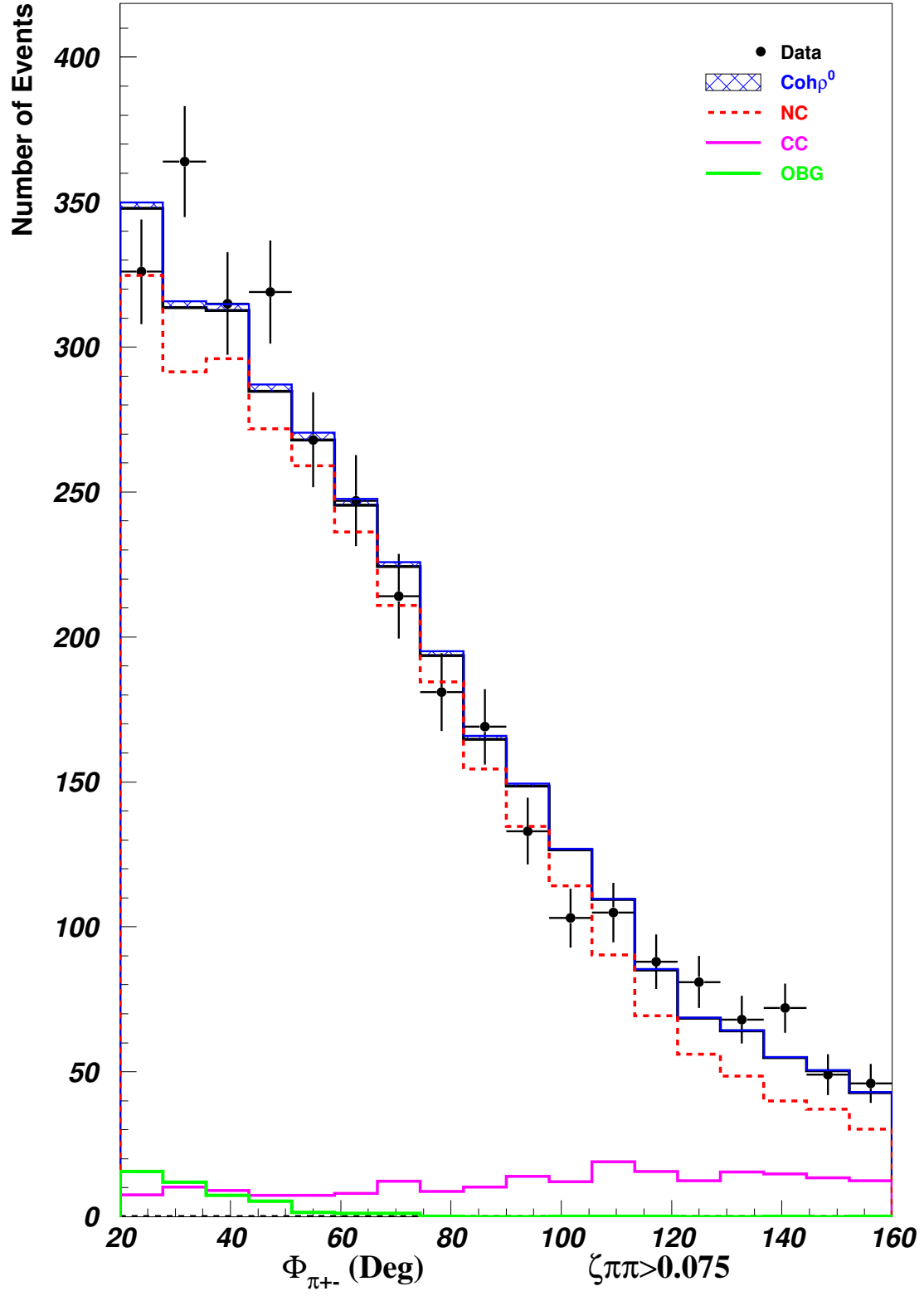


Figure 36: ϕ_{12} (Background Region)

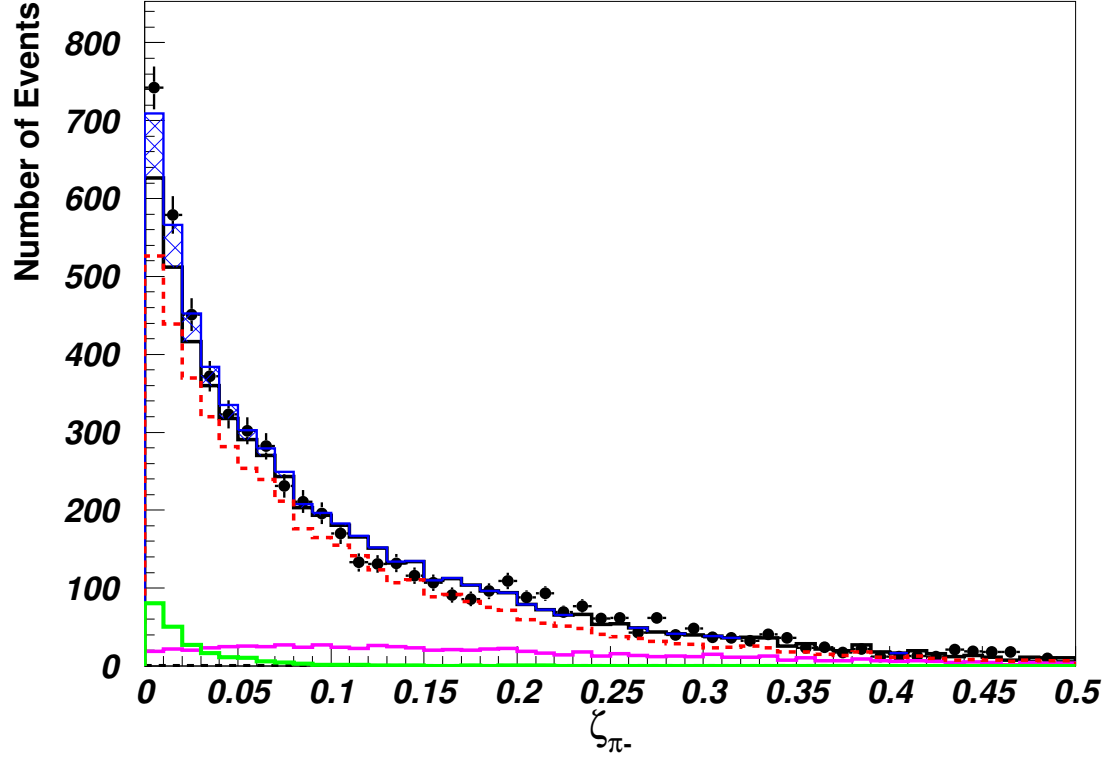
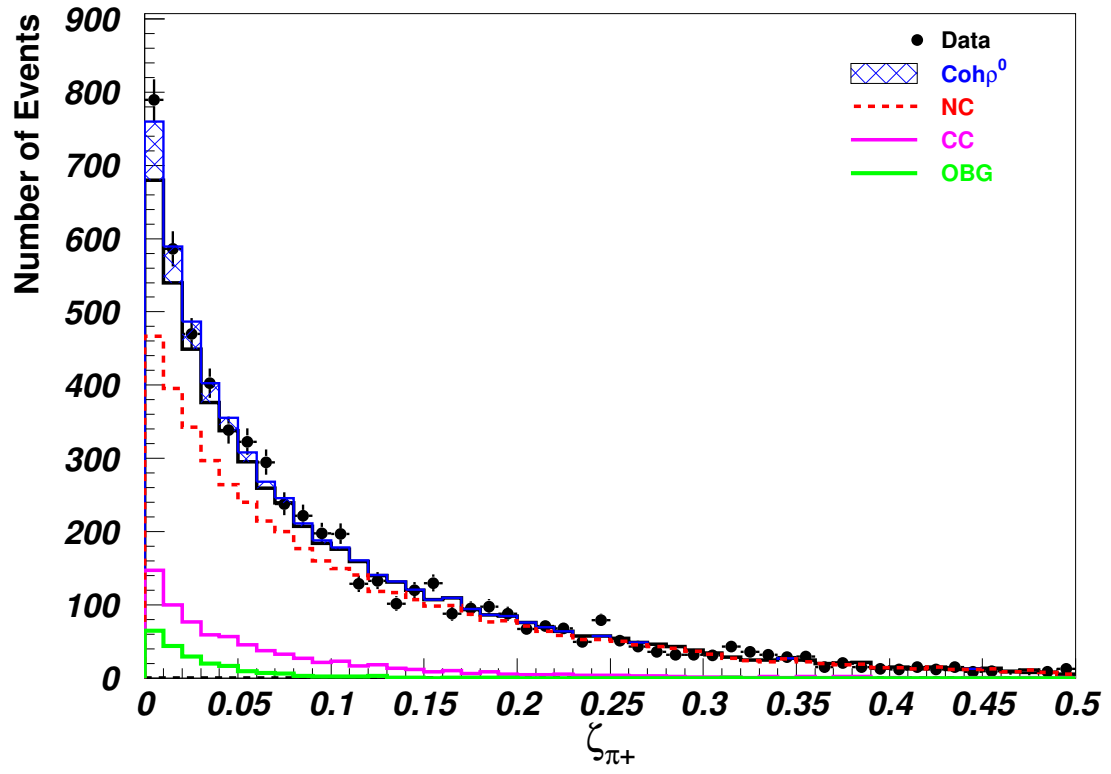


Figure 37: ζ_{π^+} and ζ_{π^-}

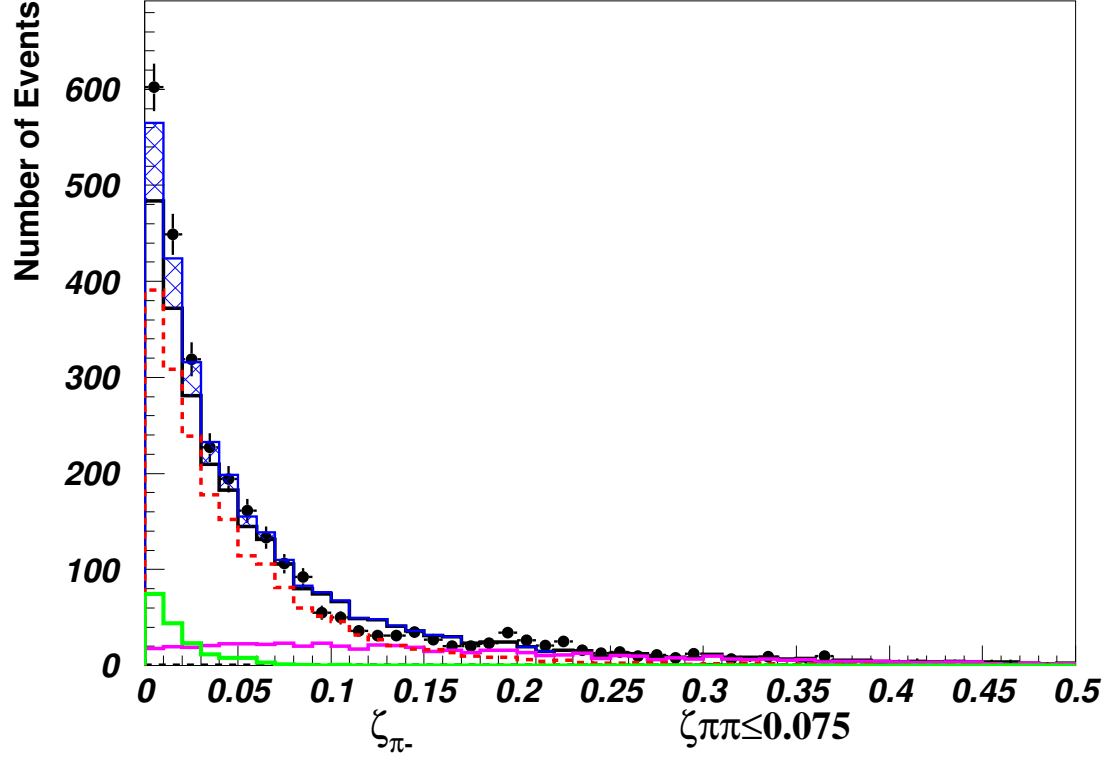
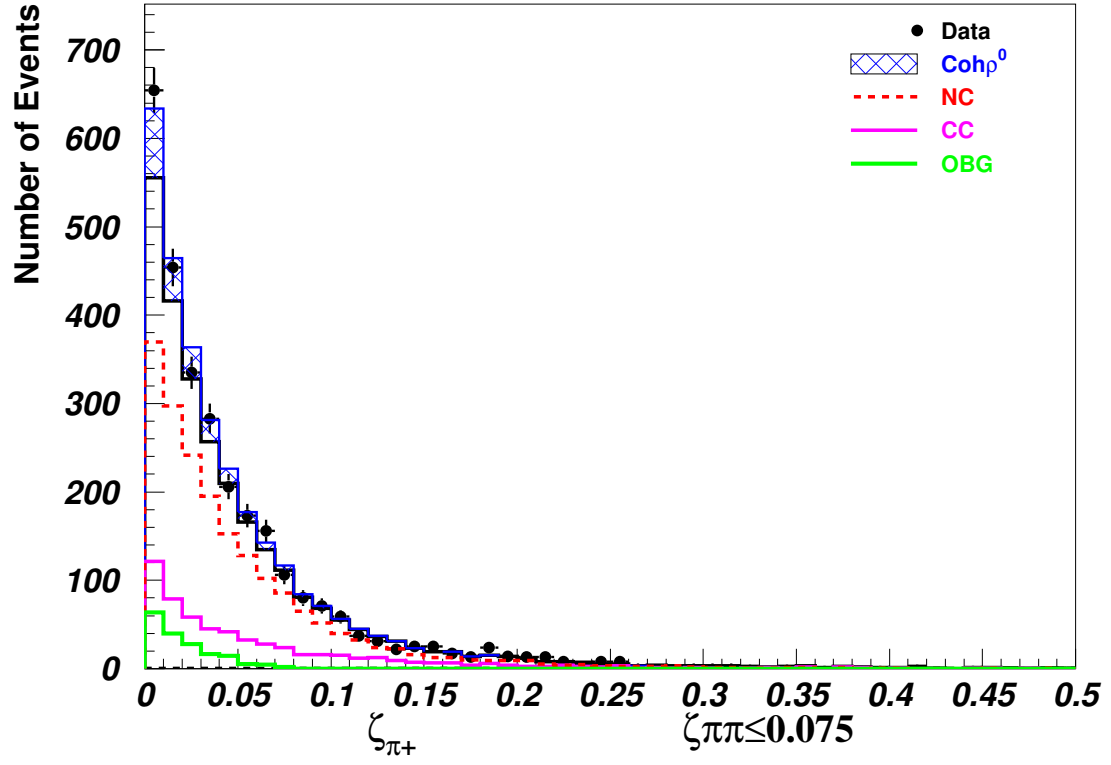


Figure 38: ζ_{π^+} and ζ_{π^-} (Signal Region)

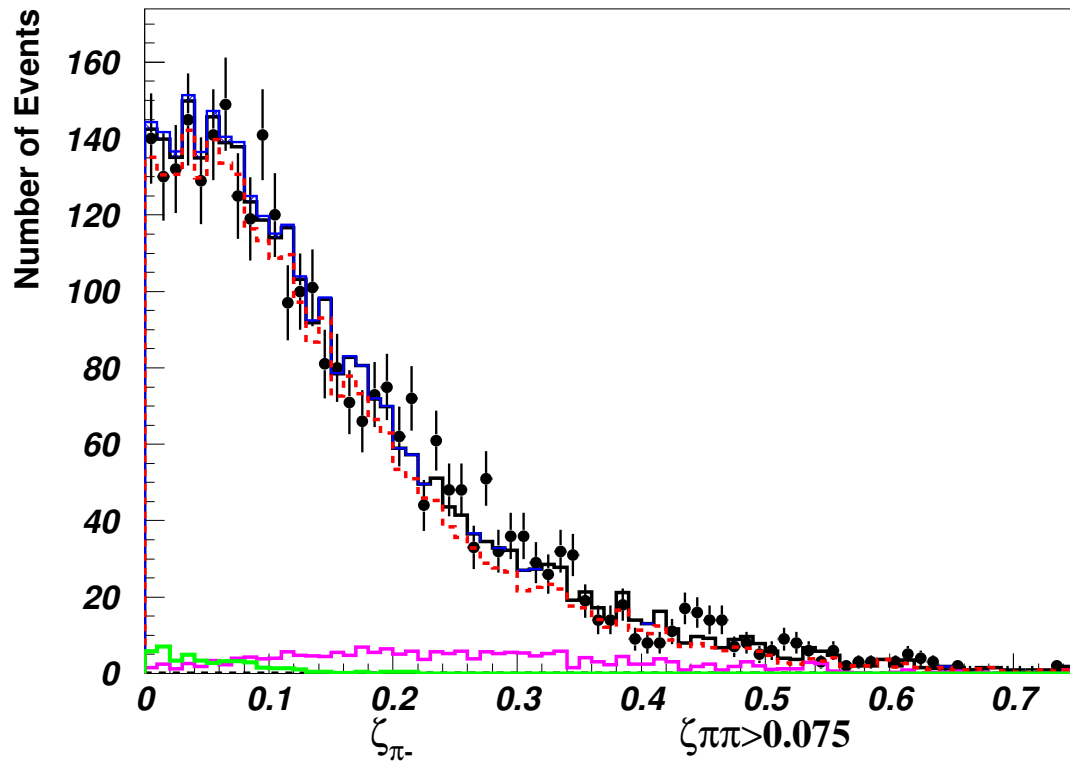
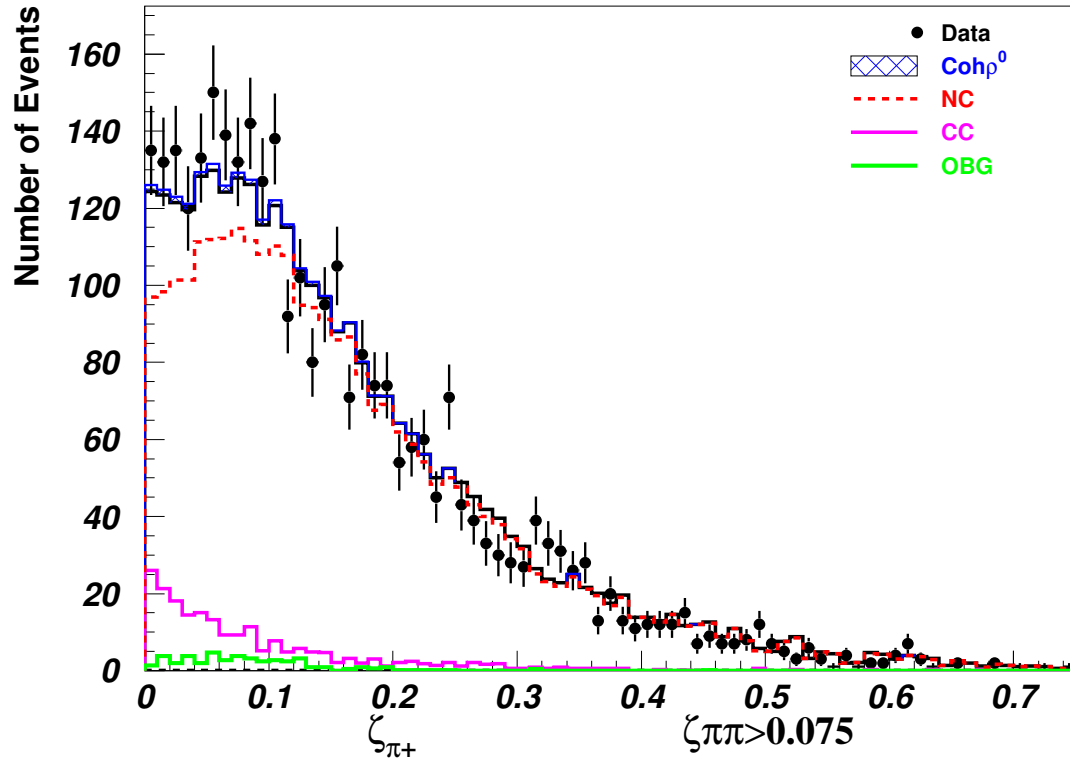


Figure 39: ζ_{π^+} and ζ_{π^-} (Background Region)

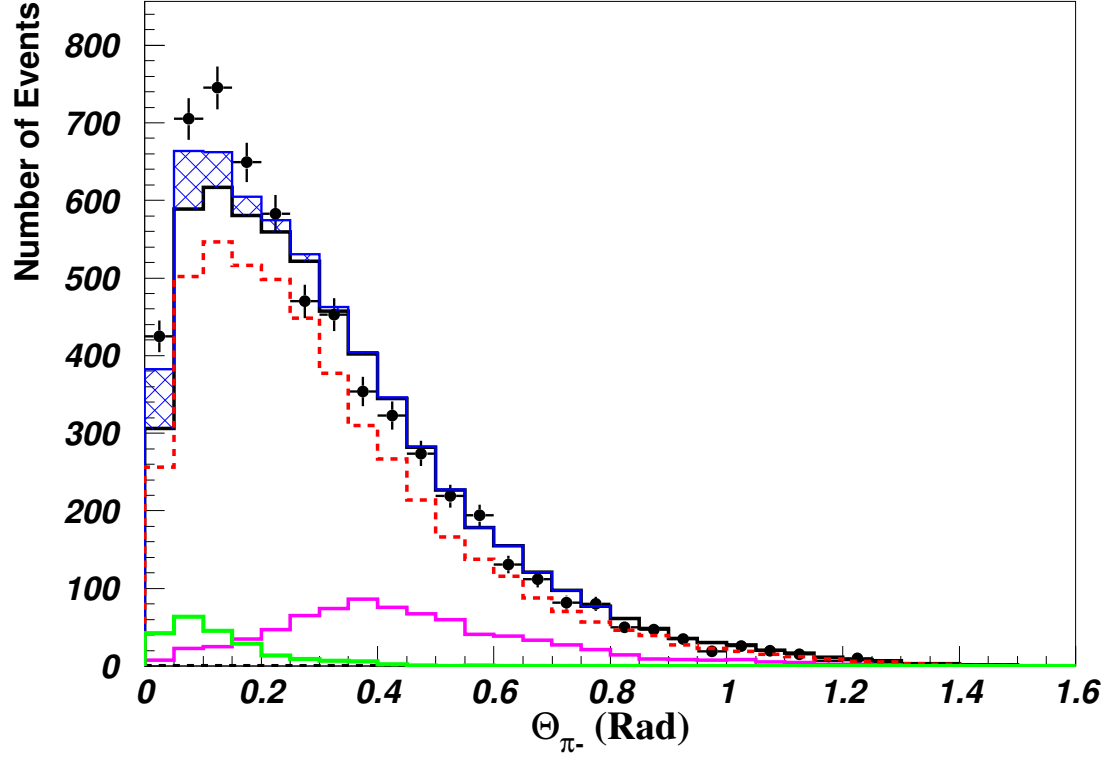
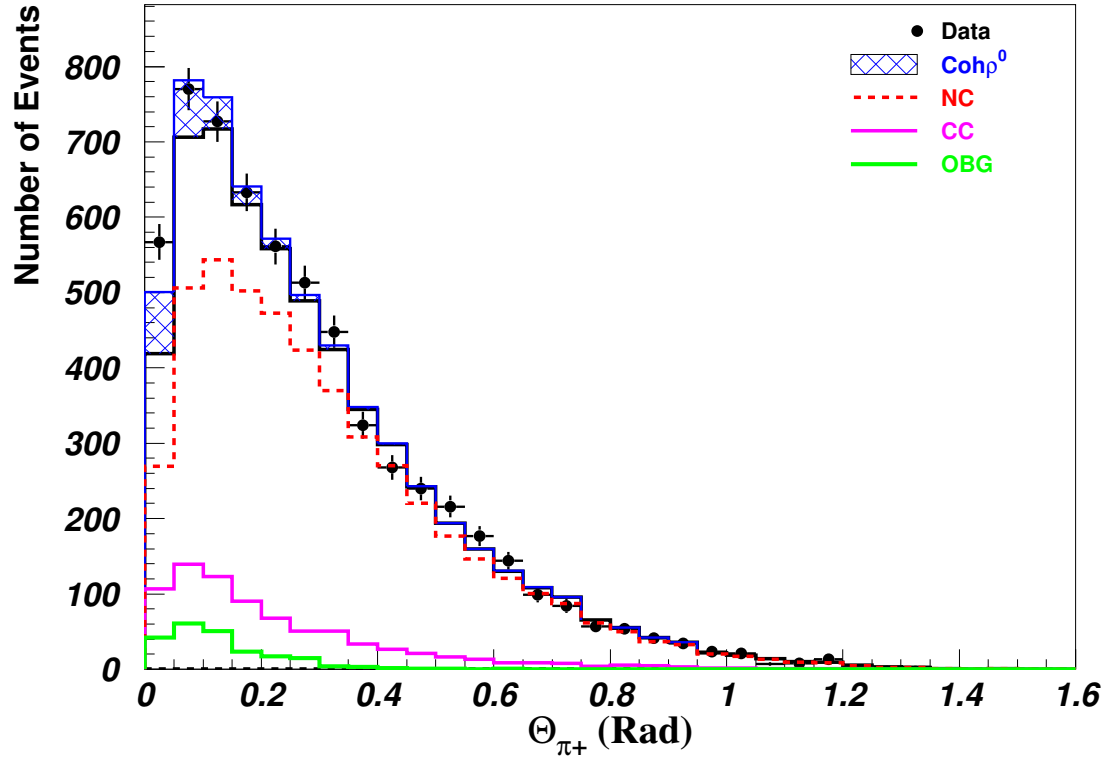


Figure 40: θ_{π^+} and θ_{π^-}

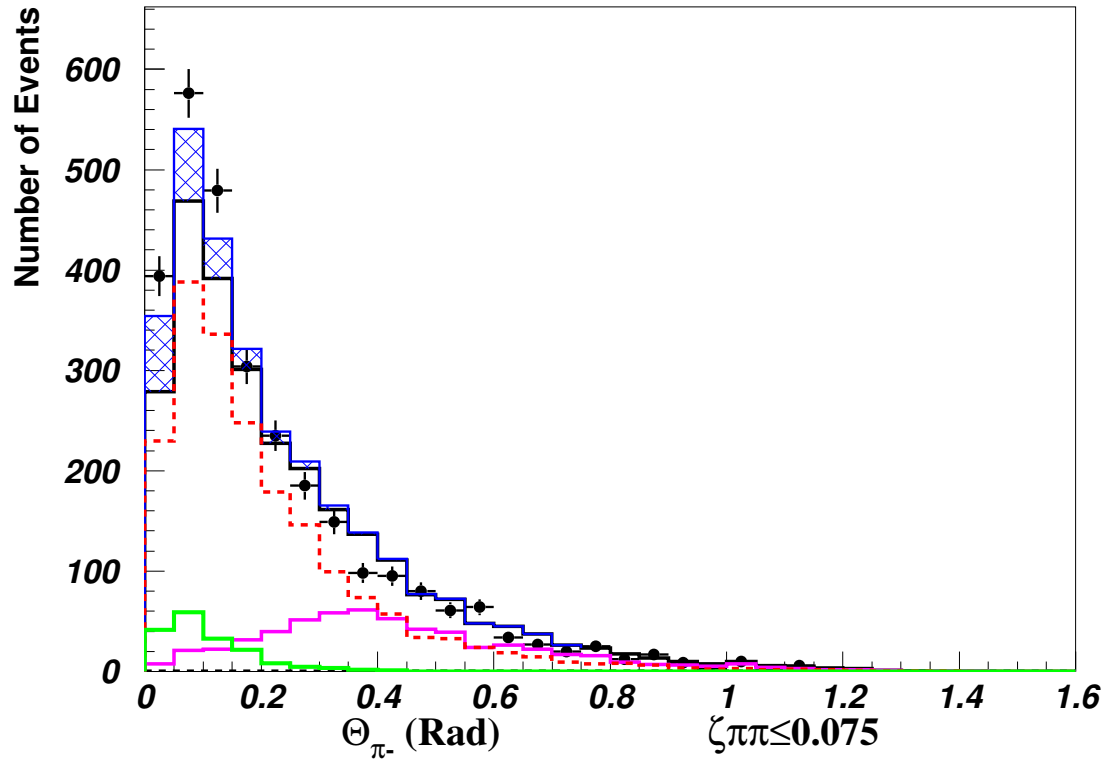
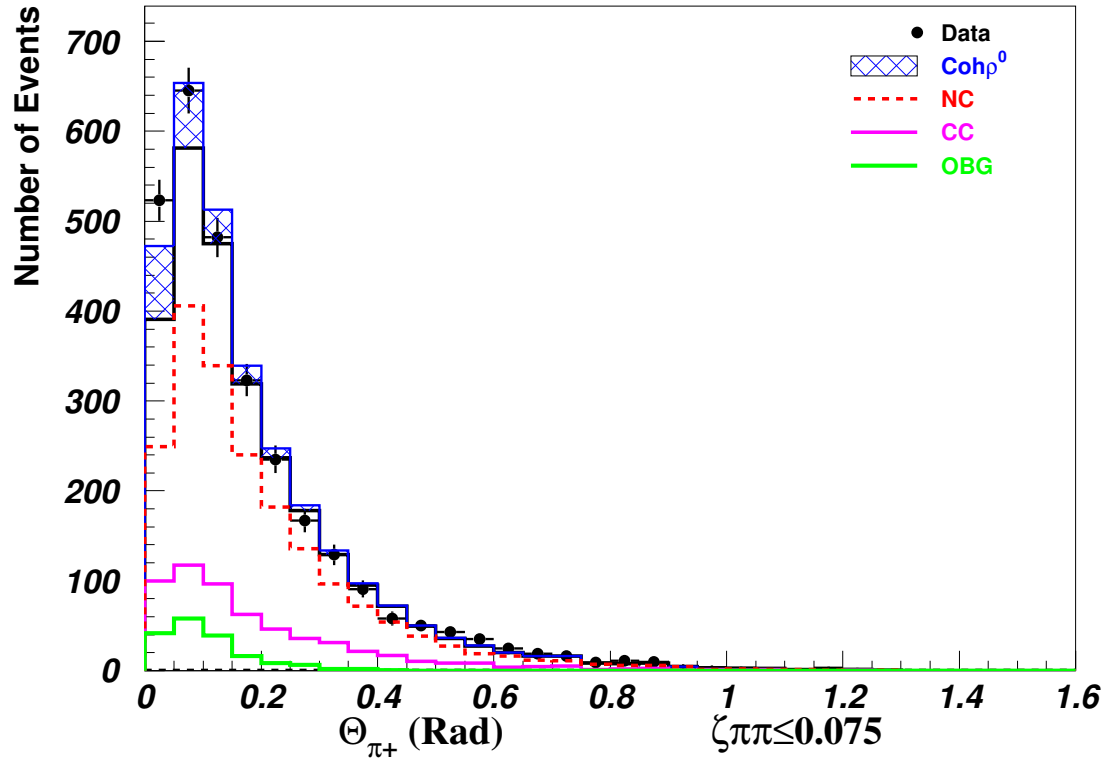


Figure 41: θ_{π^+} and θ_{π^-} (Signal Region)

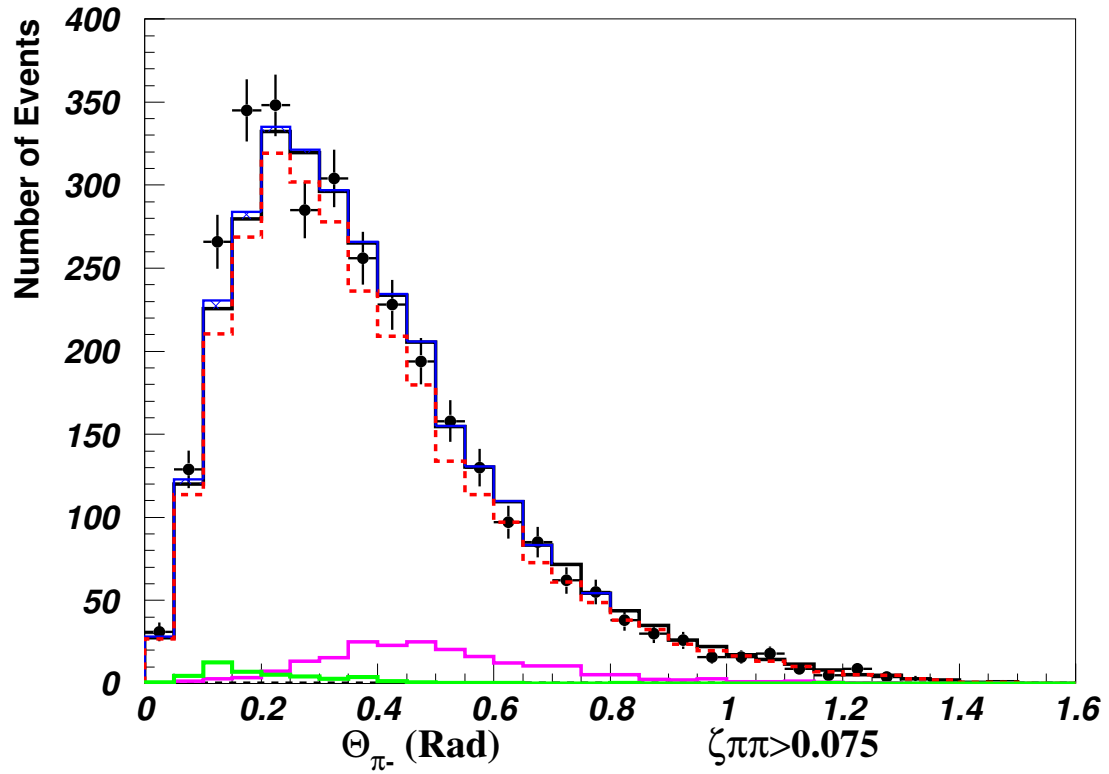
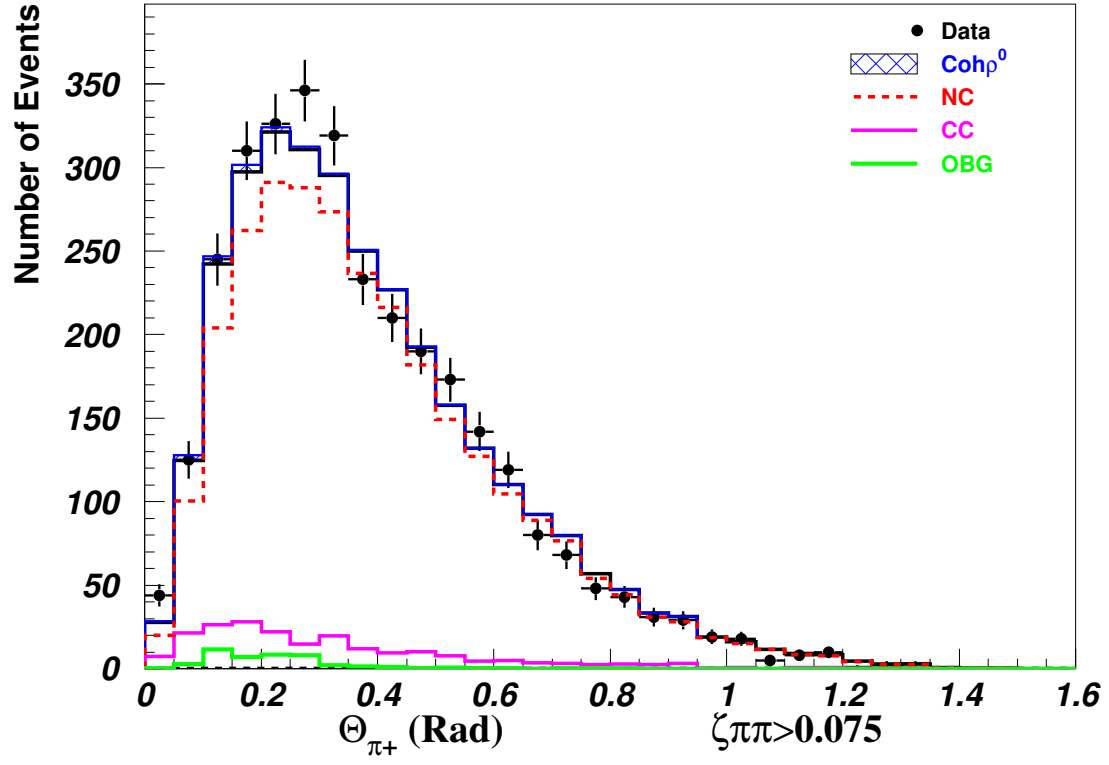


Figure 42: θ_{π^+} and θ_{π^-} (Background Region)

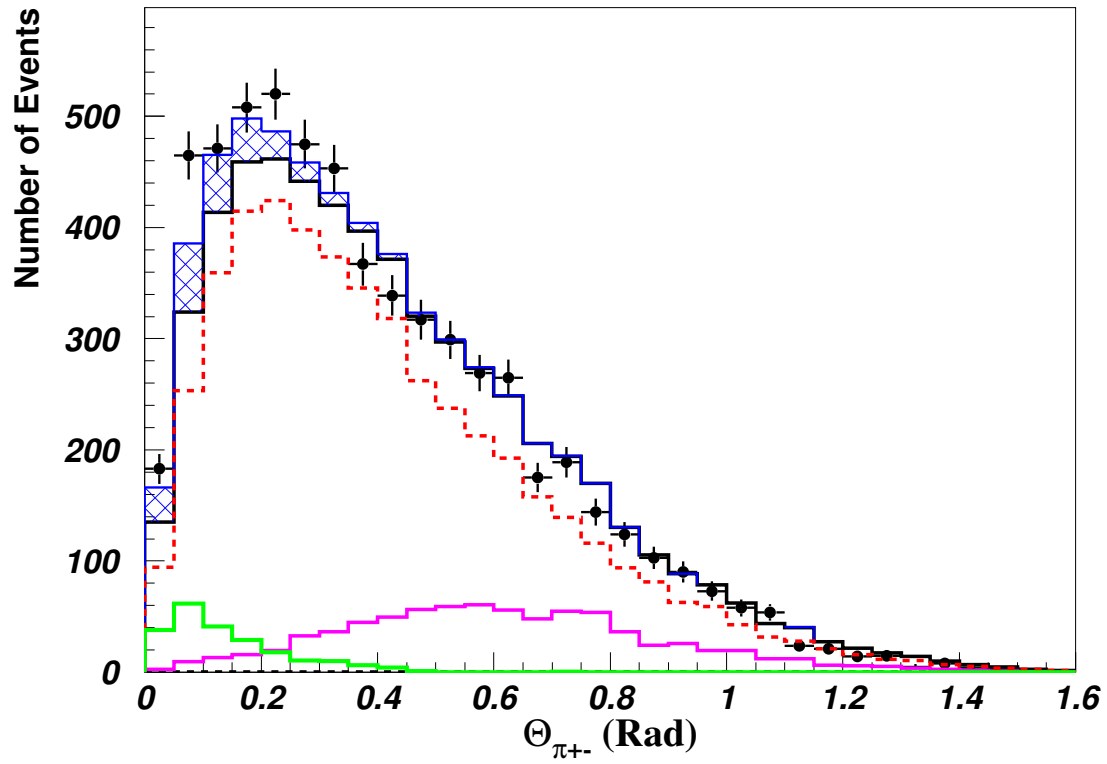
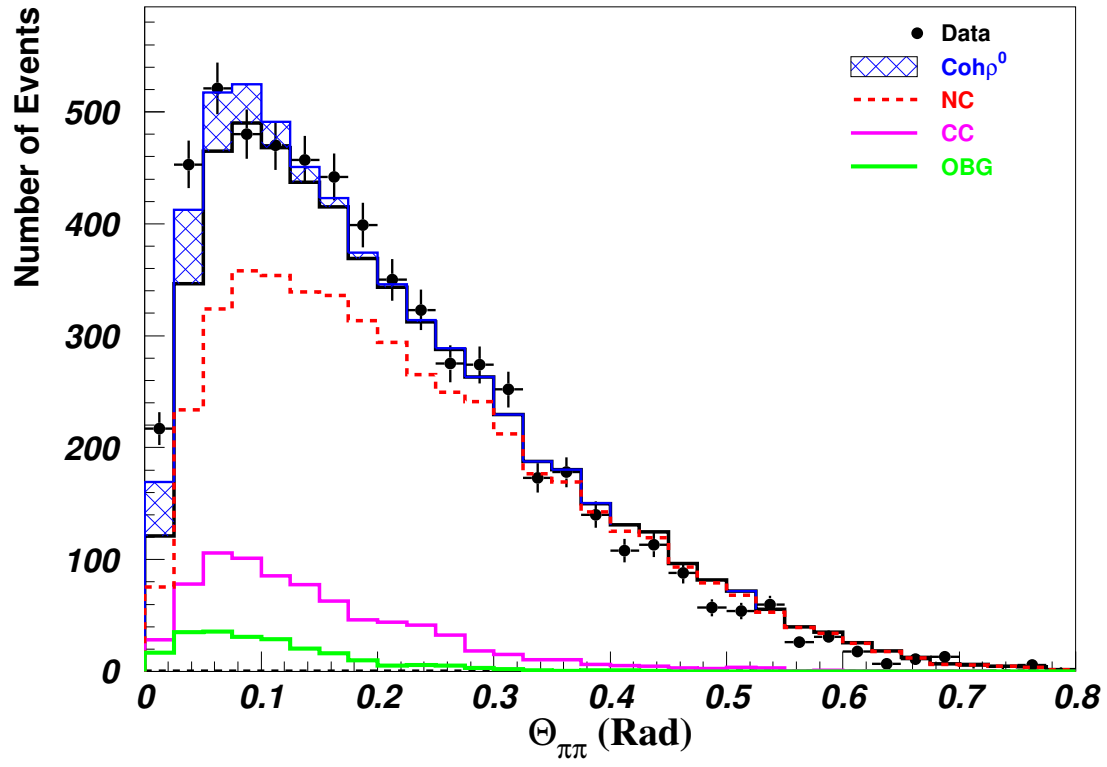


Figure 43: $\theta_{\pi\pi}$

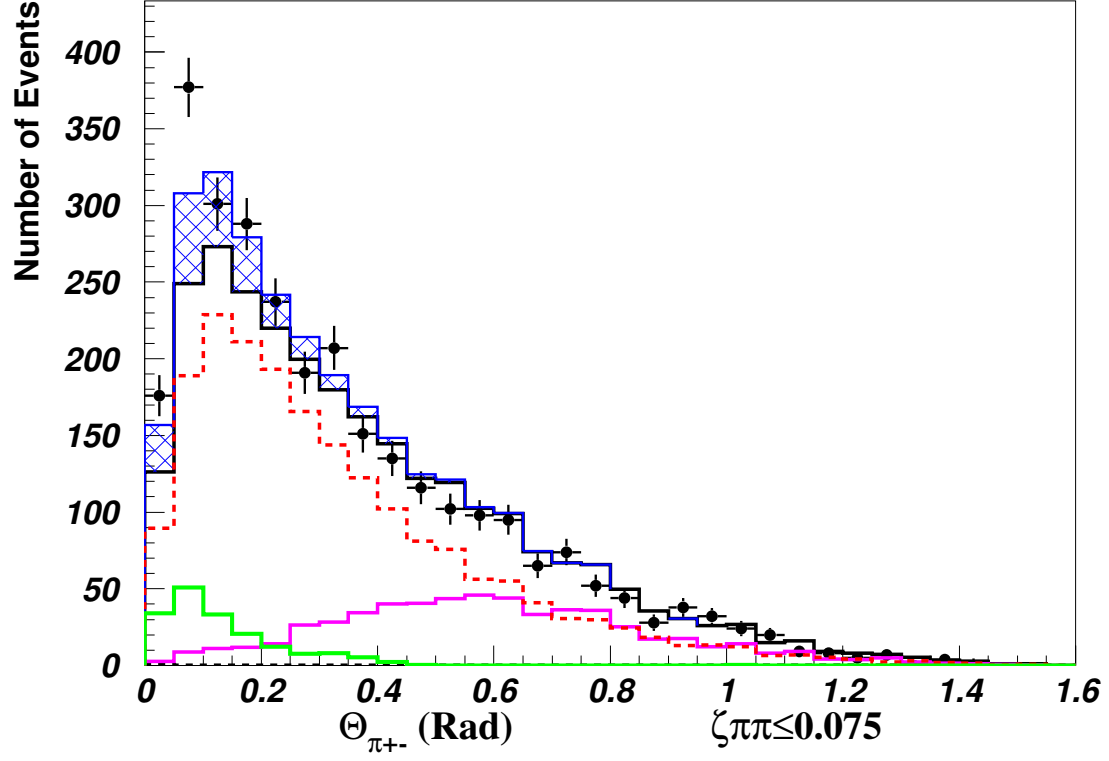
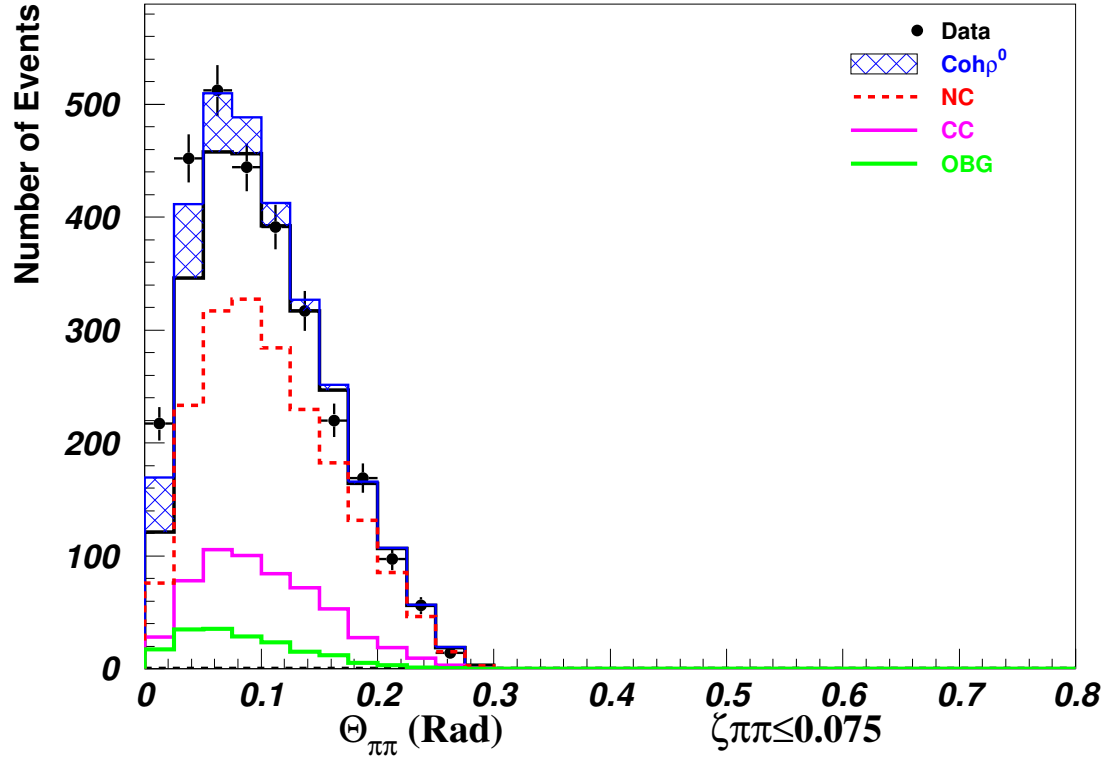


Figure 44: $\theta_{\pi\pi}$ and θ_{12} (Signal Region)

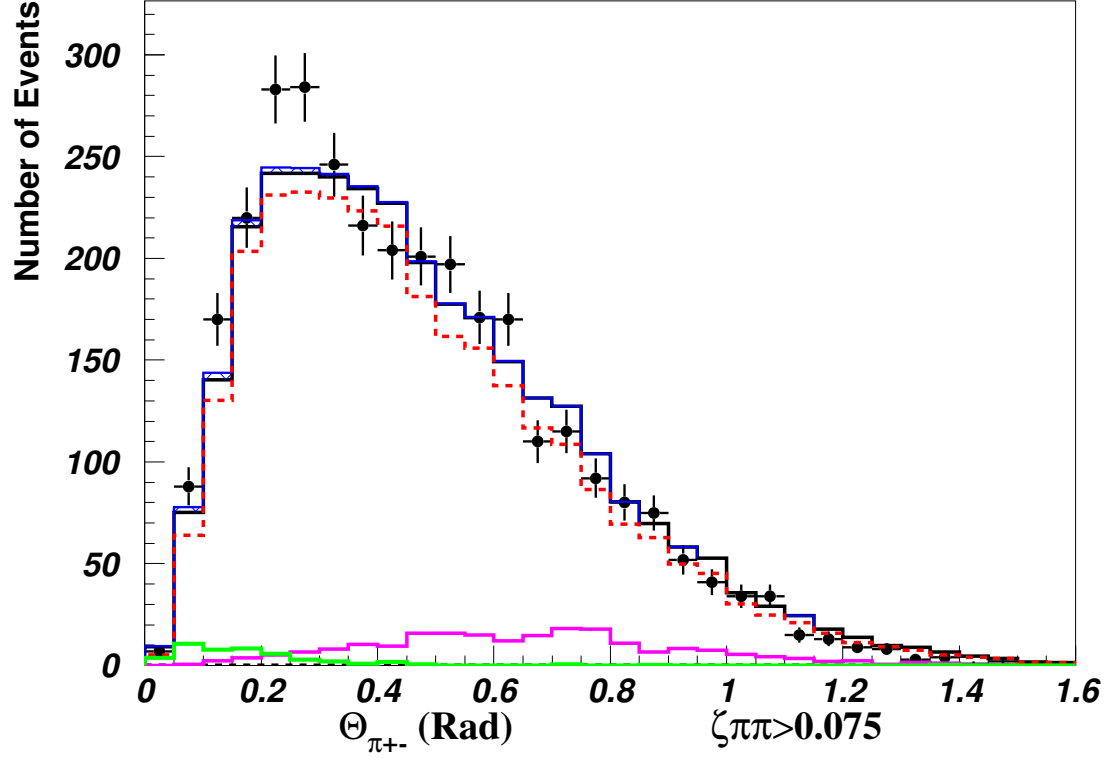
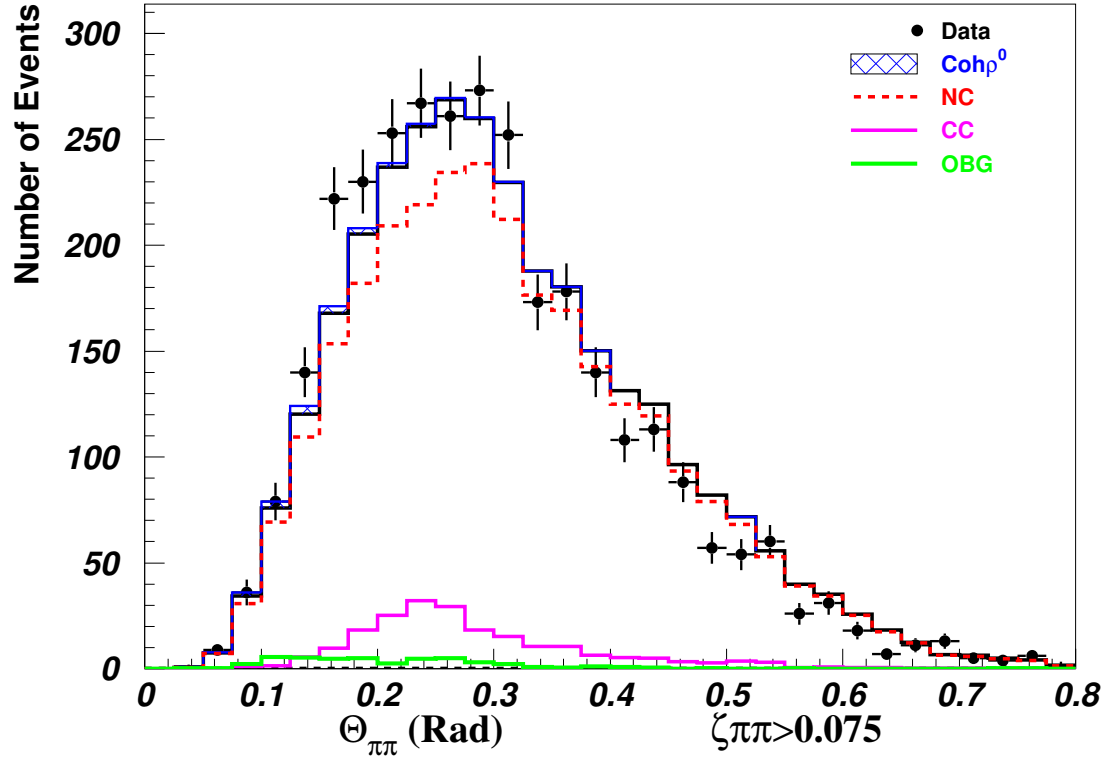


Figure 45: $\theta_{\pi\pi}$ and θ_{12} (Background Region)

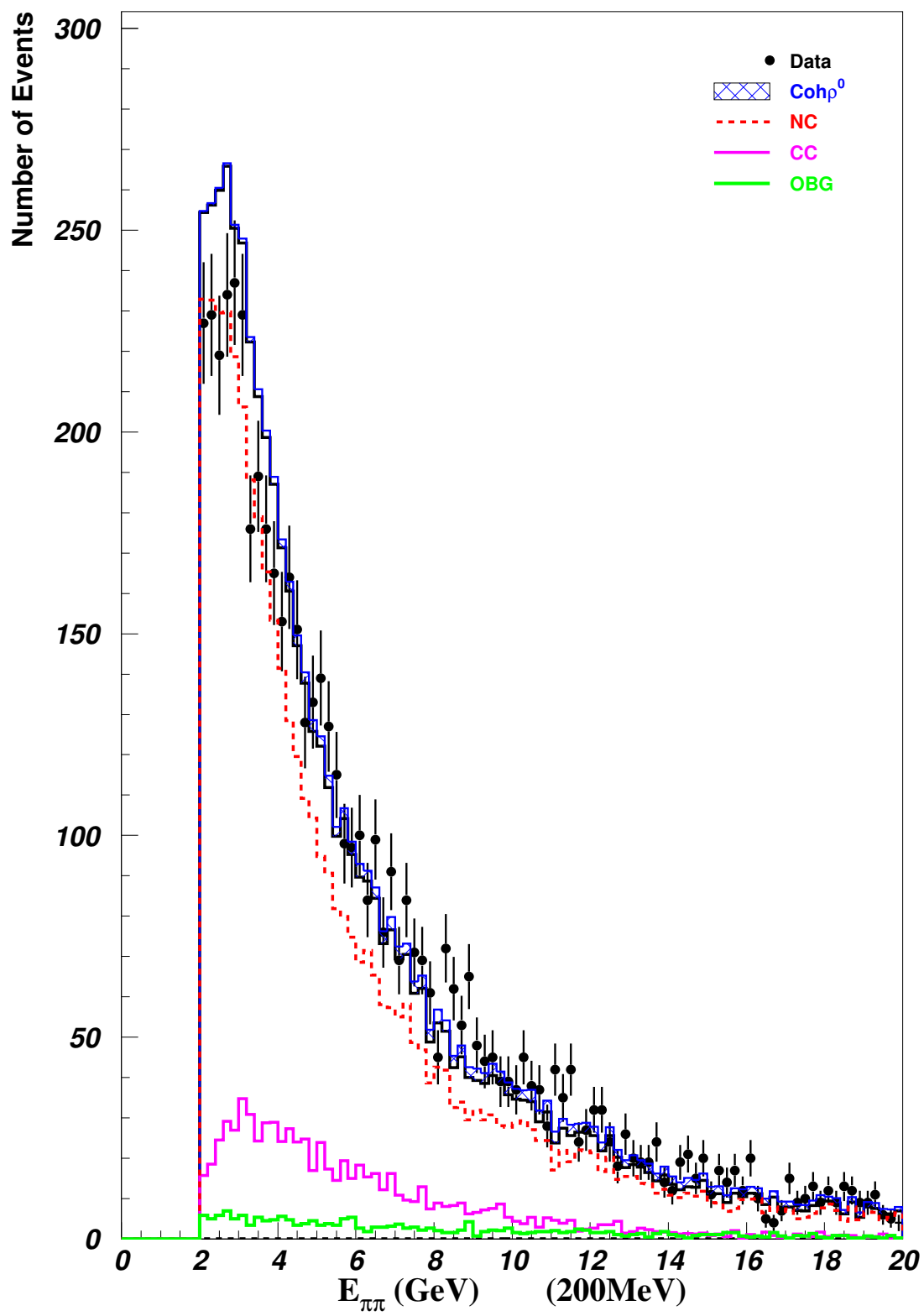


Figure 46: $E_{\pi\pi}$

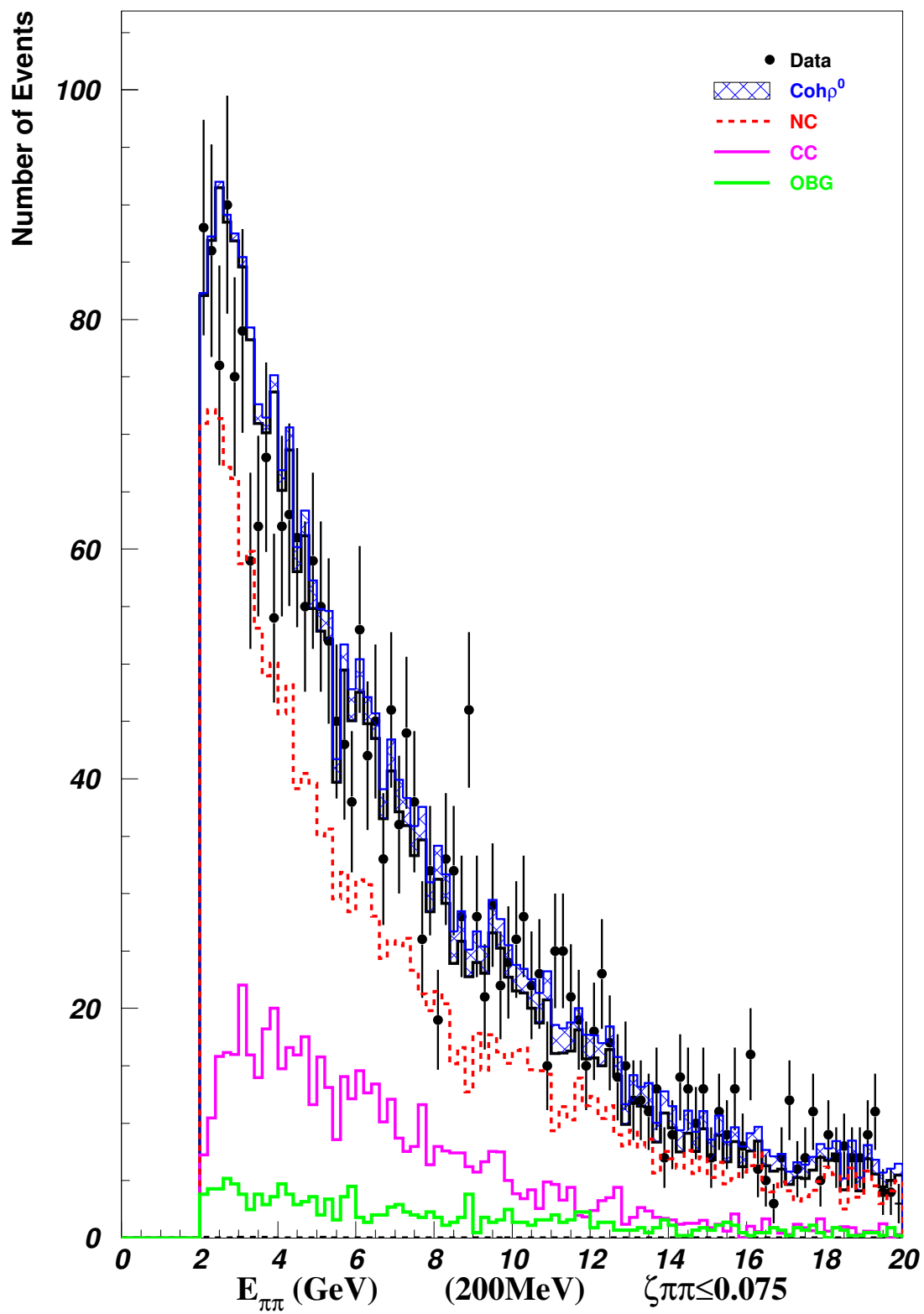


Figure 47: $E_{\pi\pi}$ (Signal Region)

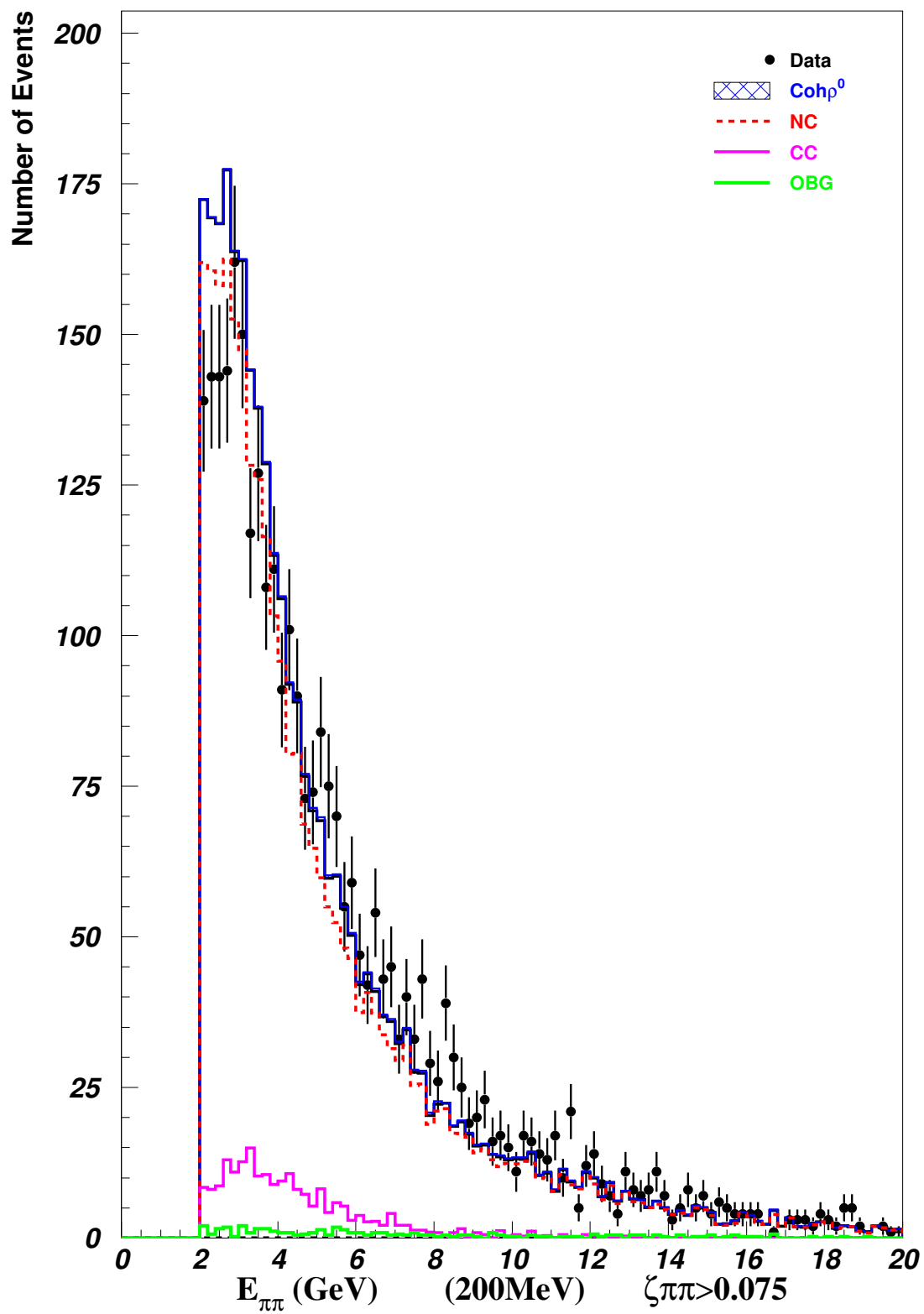


Figure 48: $E_{\pi\pi}$ (Background Region)

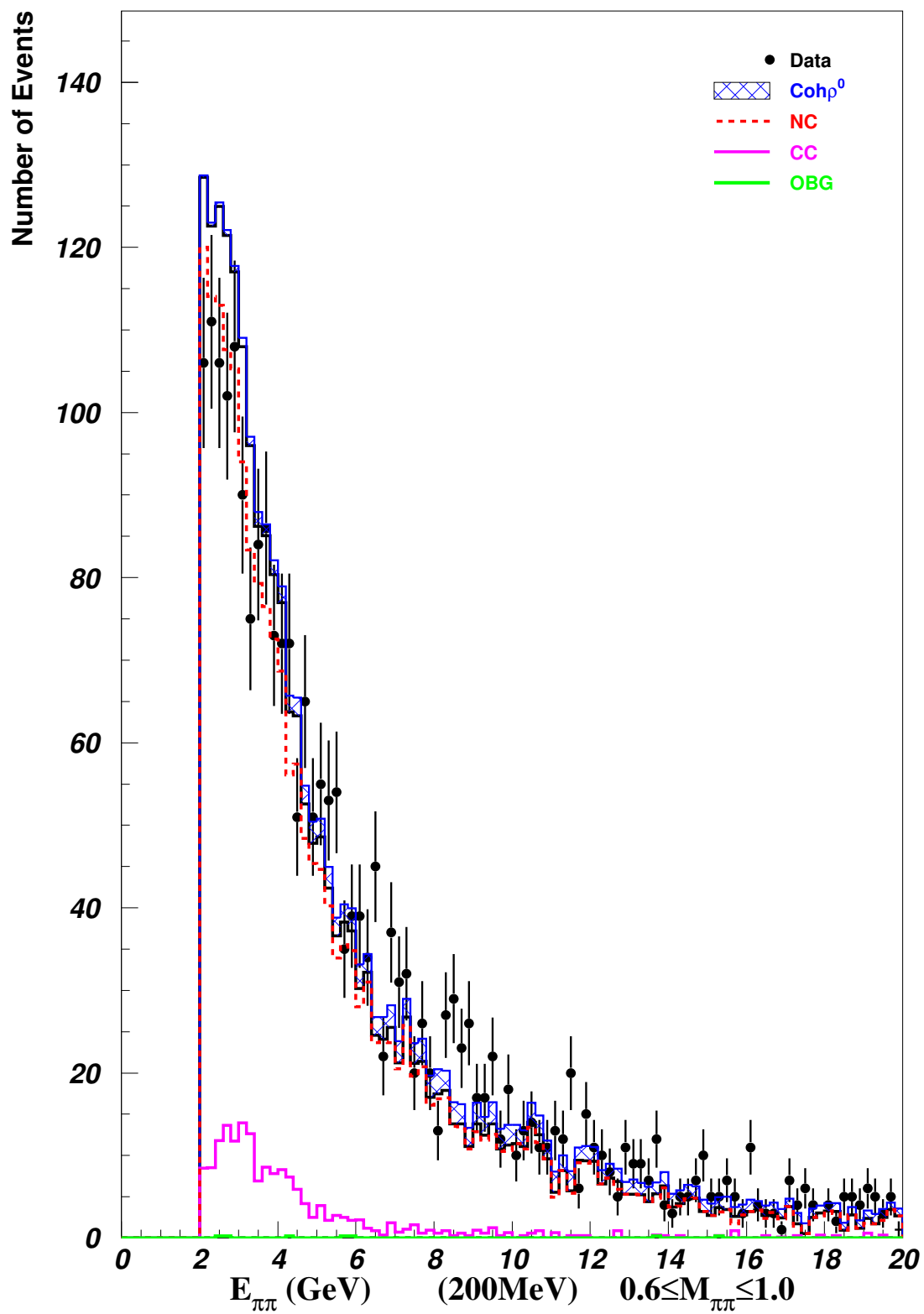


Figure 49: $E_{\pi\pi}$ (ρ Mass Range)

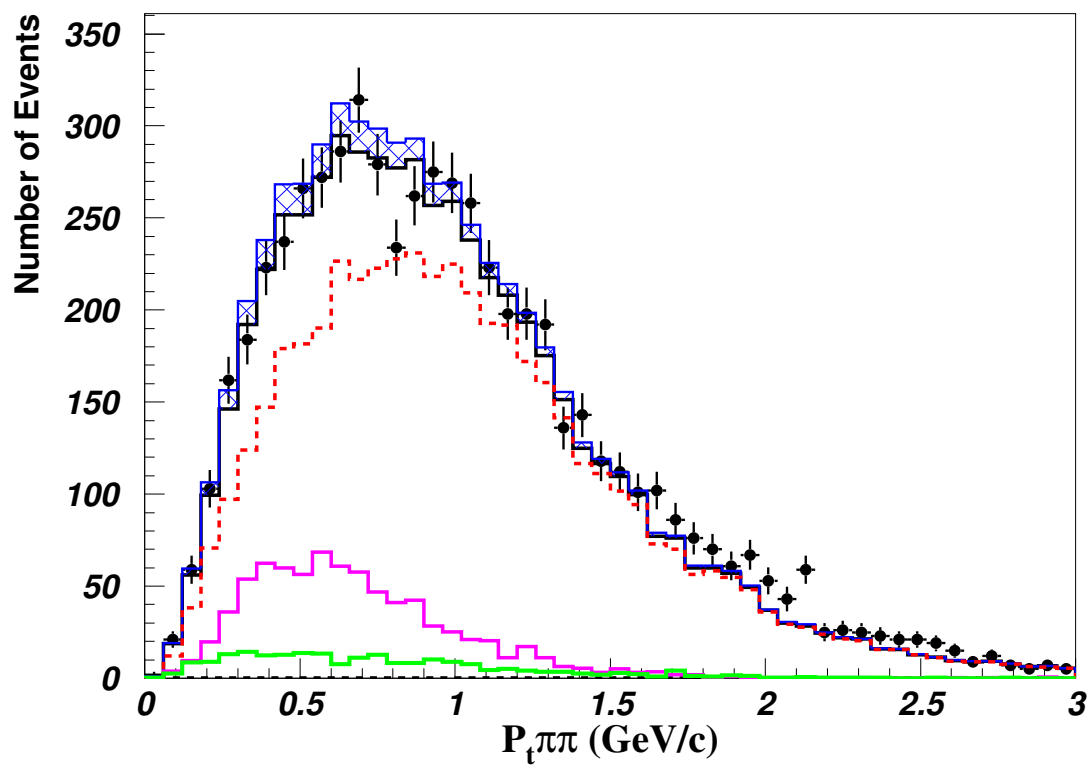
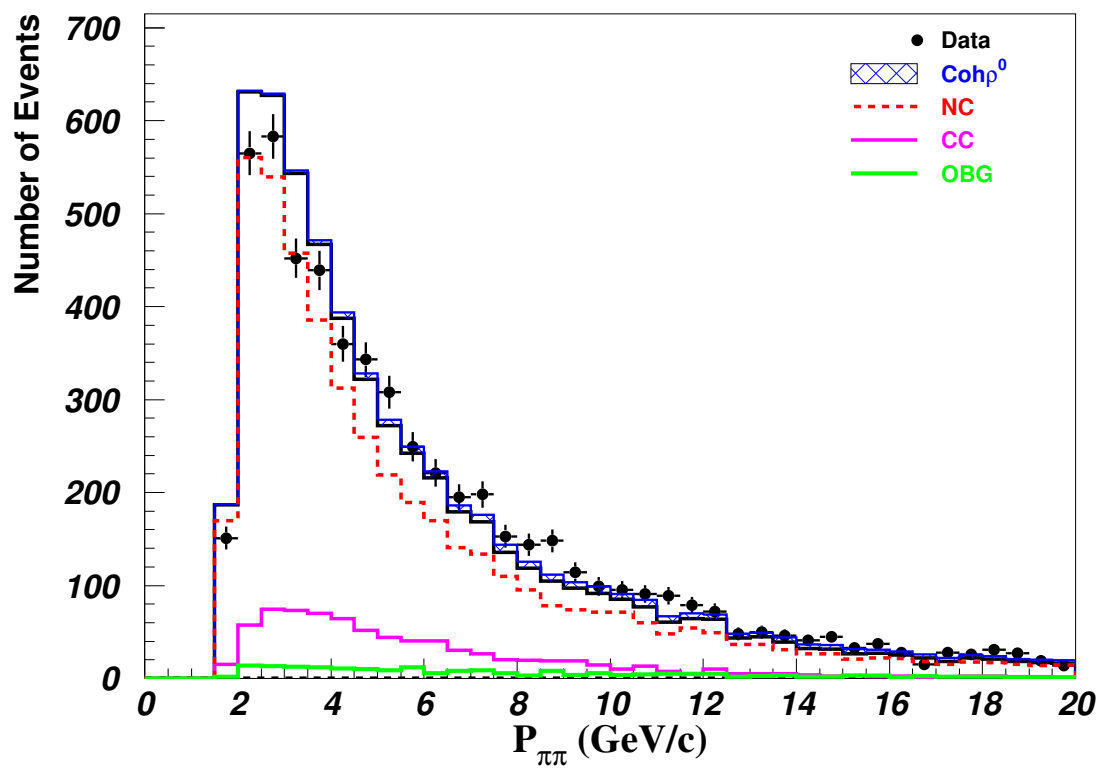


Figure 50: $P_t \pi\pi$

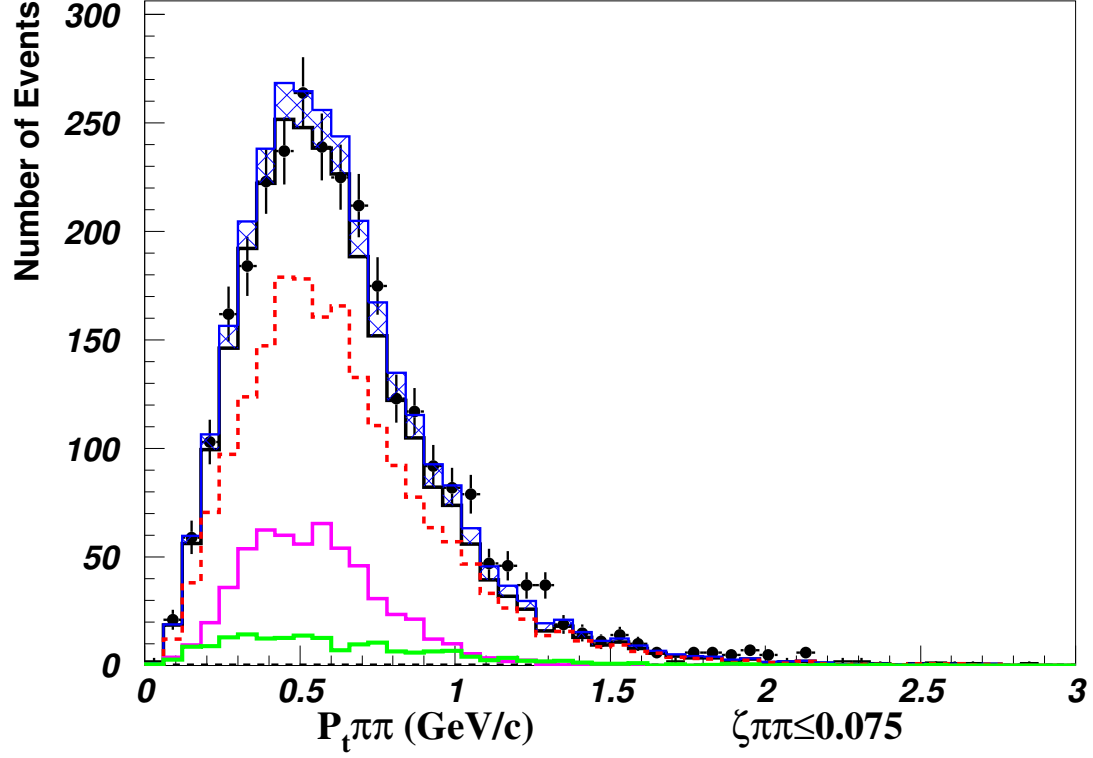
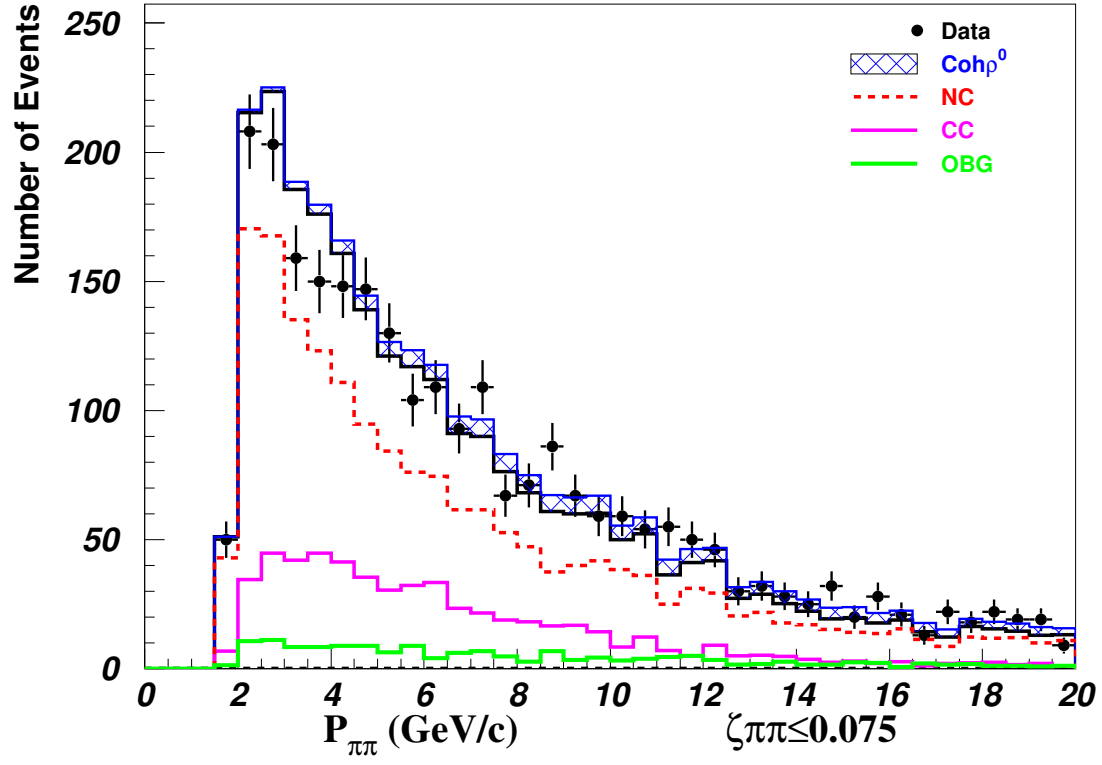


Figure 51: $P_{t\pi\pi}$ (Signal Region)

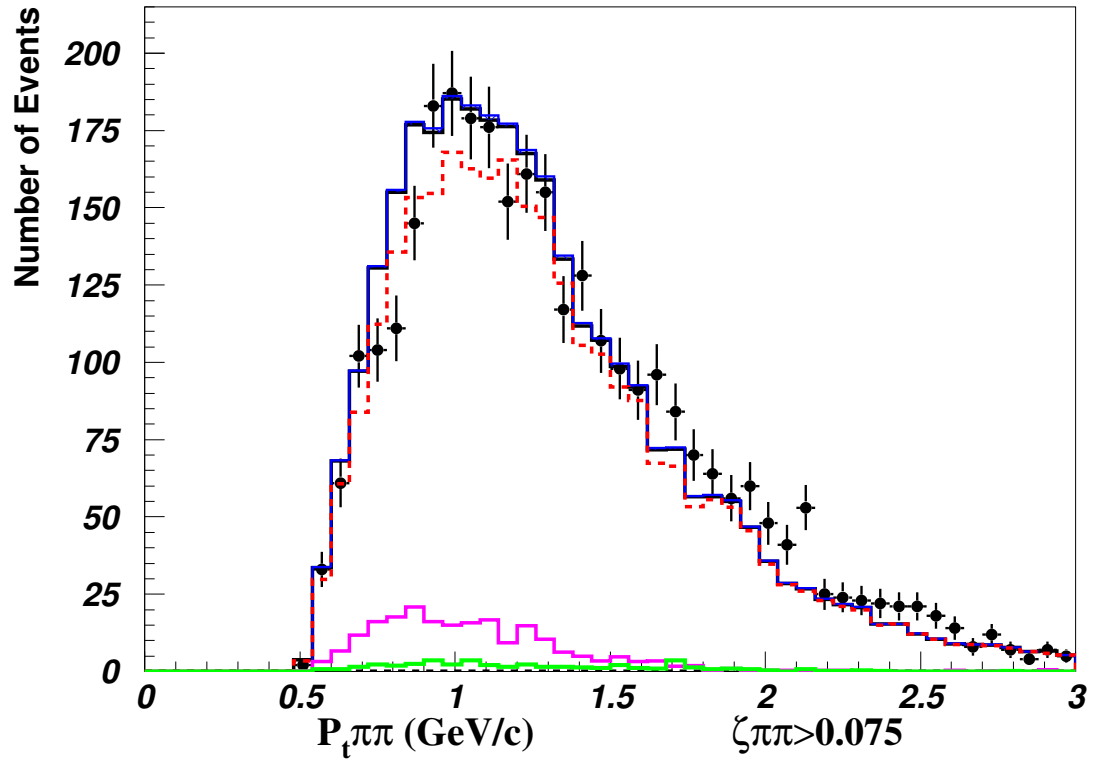
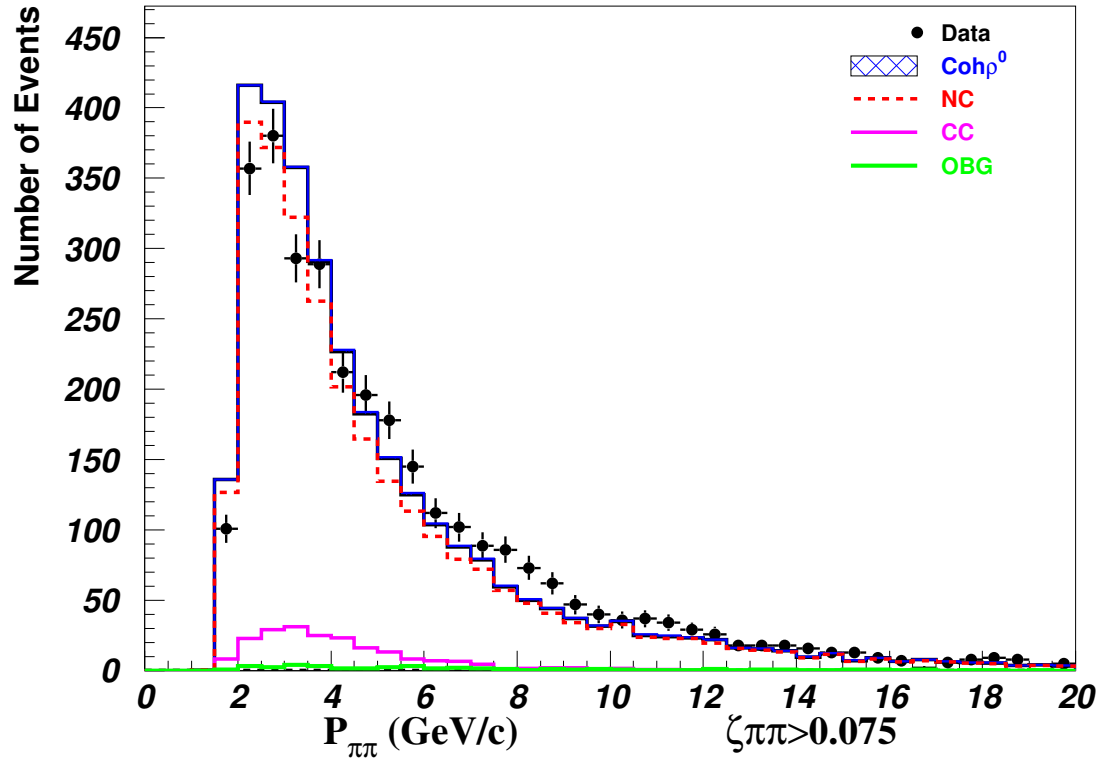


Figure 52: $P_{t\pi\pi}$ (Background Region)

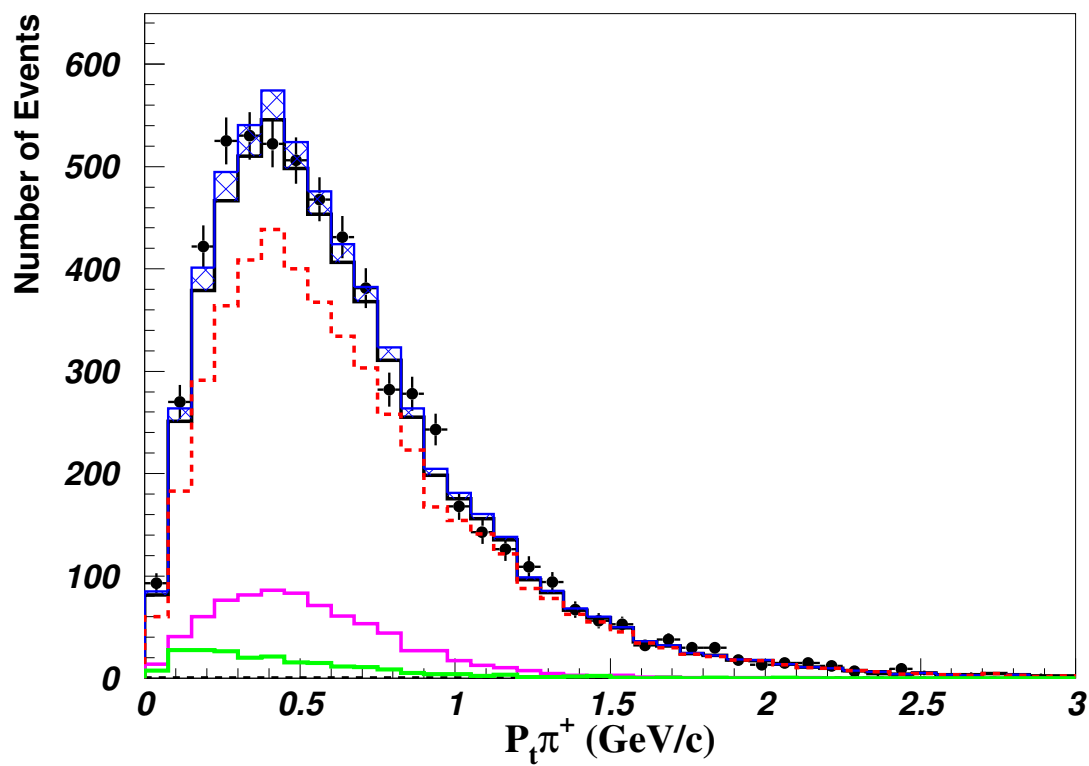
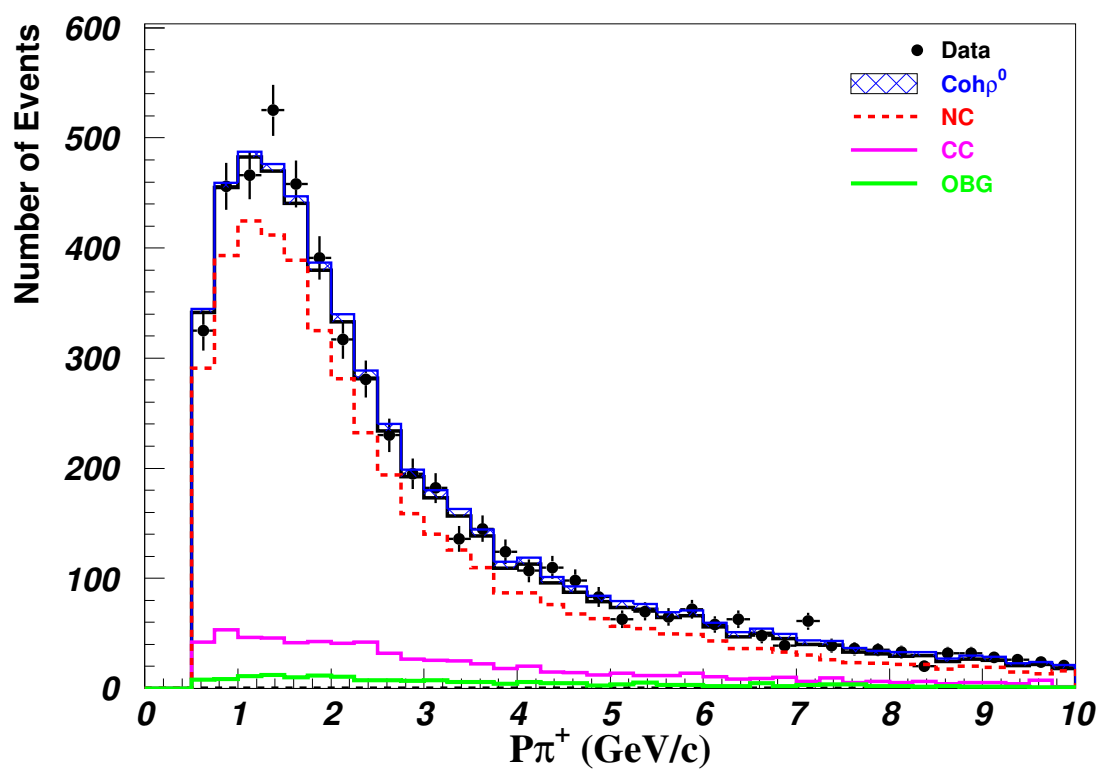


Figure 53: $P_t \pi^+$

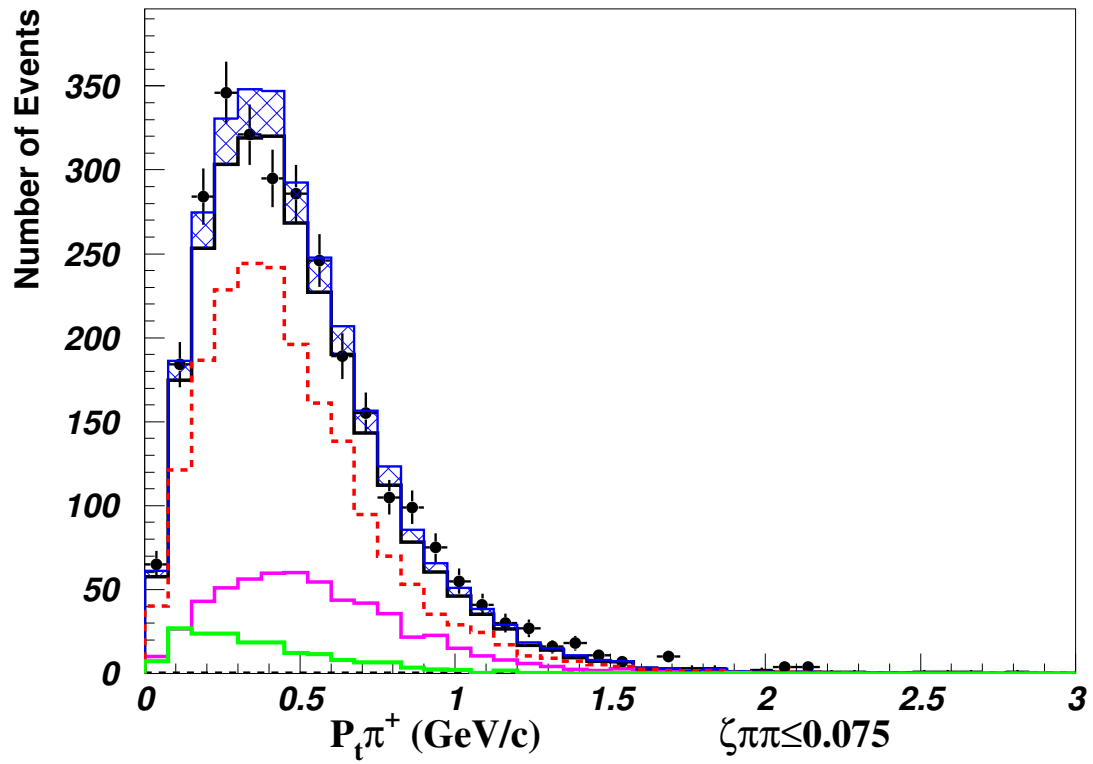
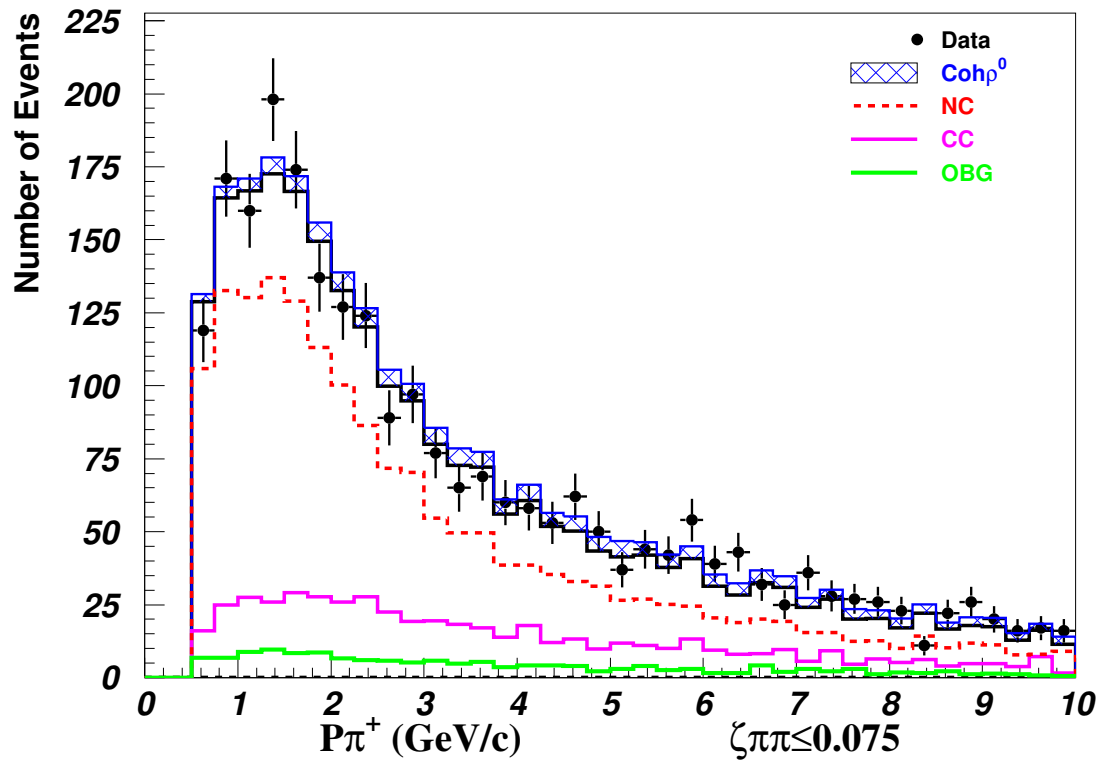


Figure 54: $P_t \pi^+$ (Signal Region)

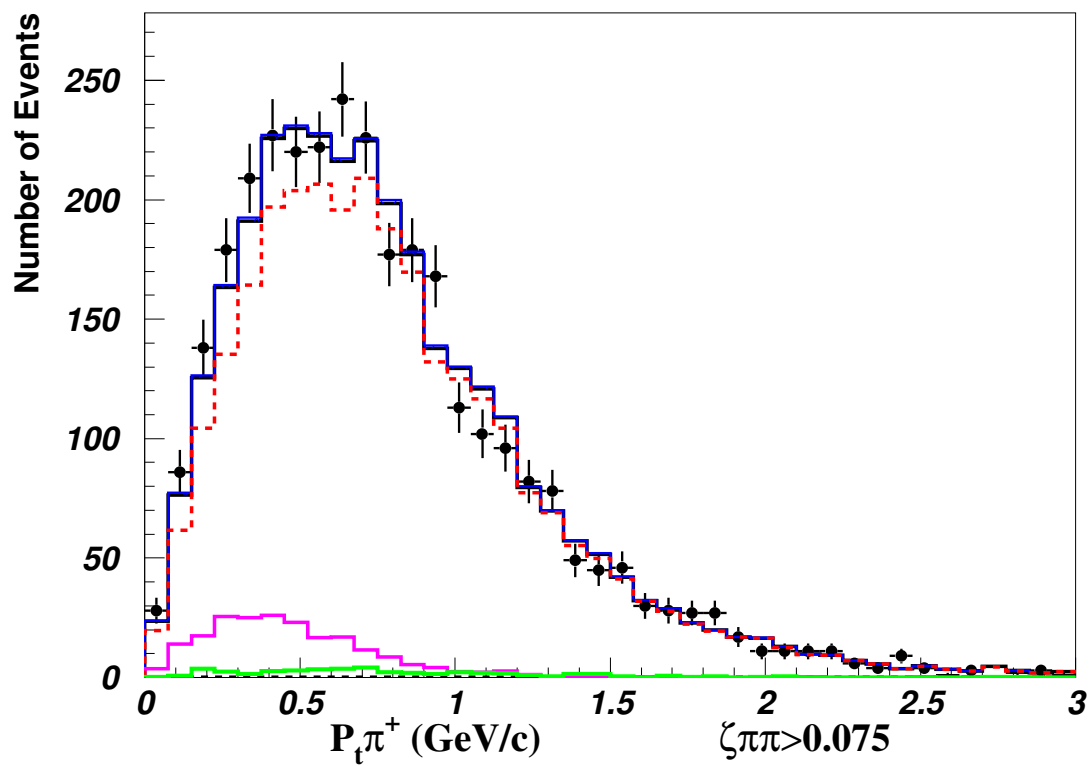
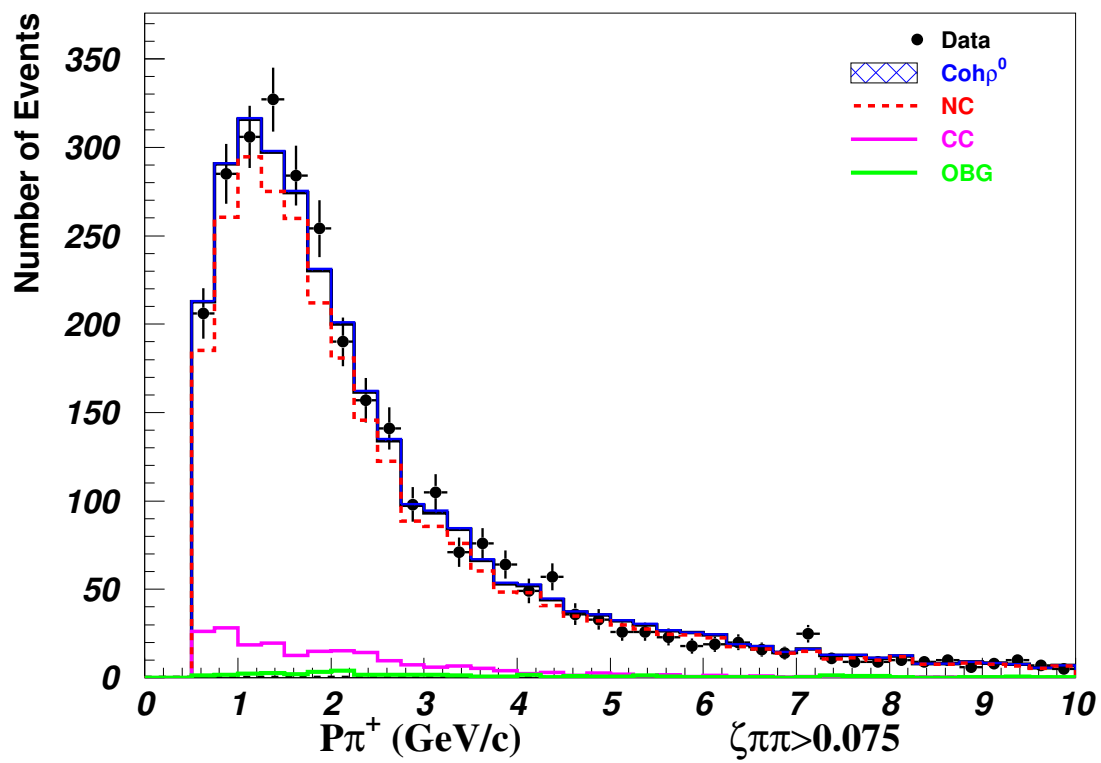


Figure 55: $P_t \pi^+$ (Background Region)

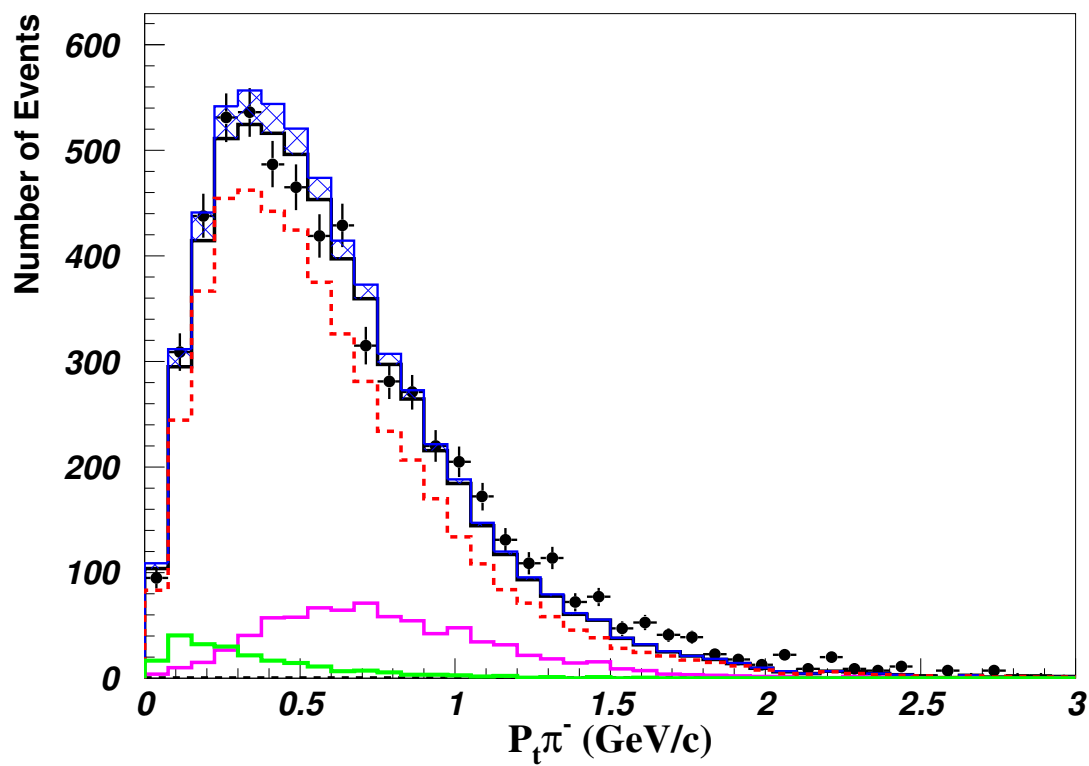
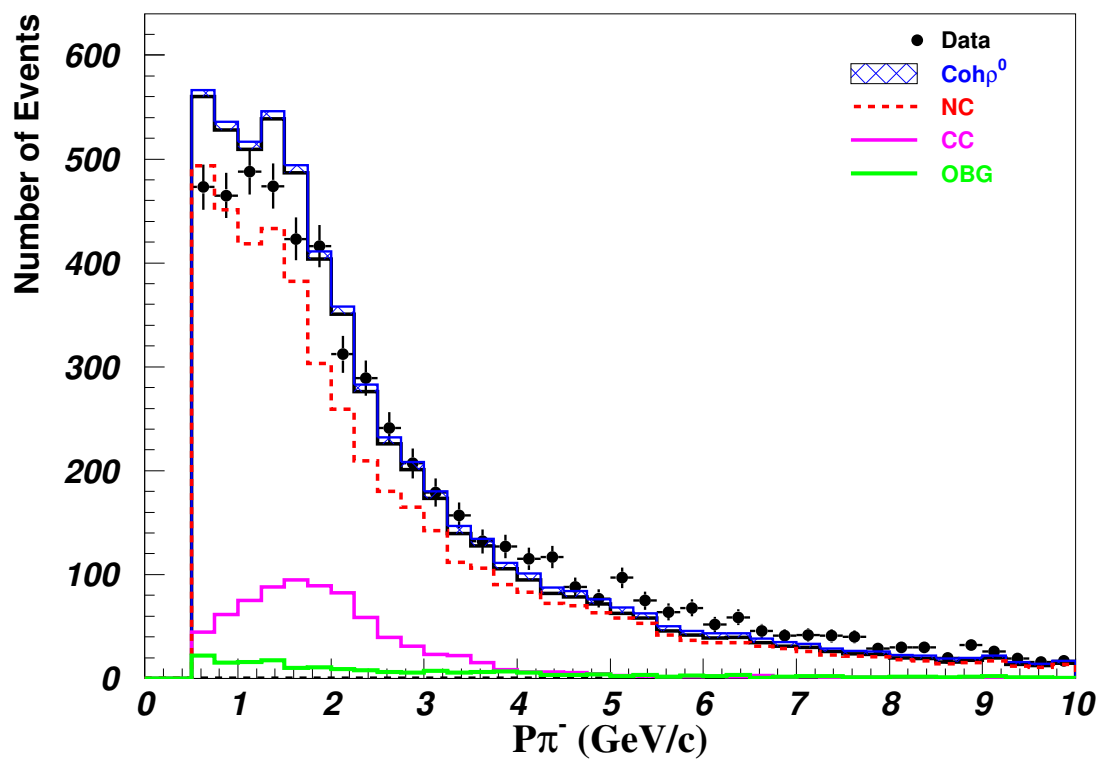


Figure 56: $P_t \pi^-$

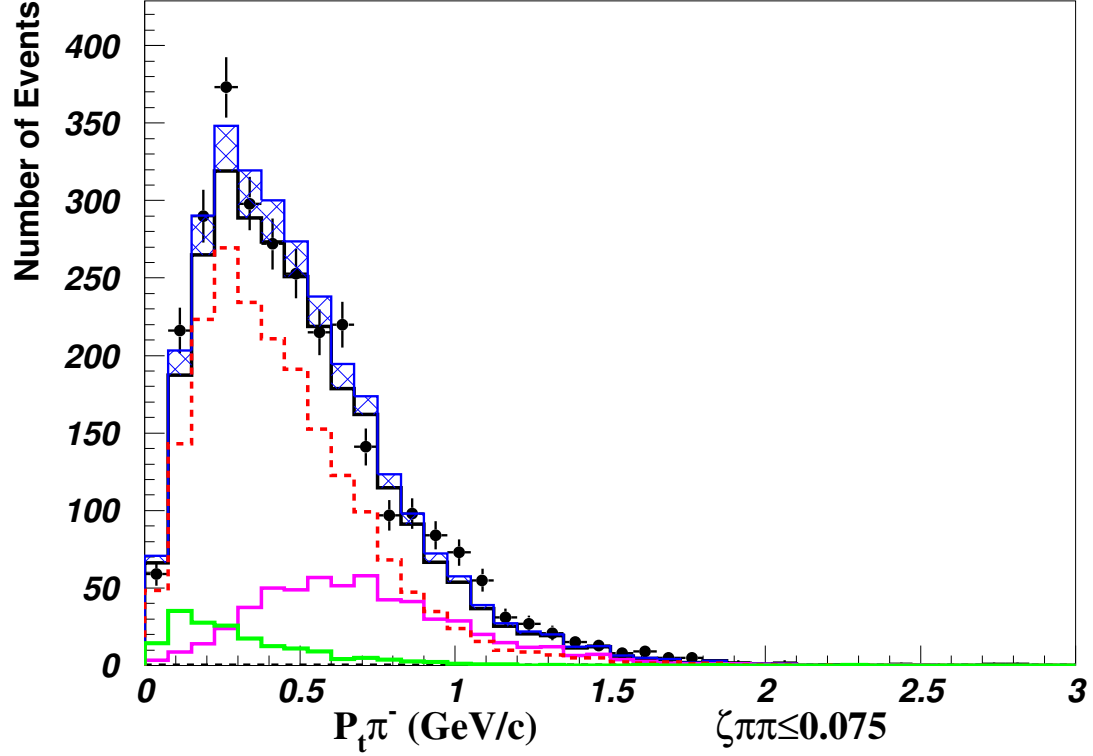
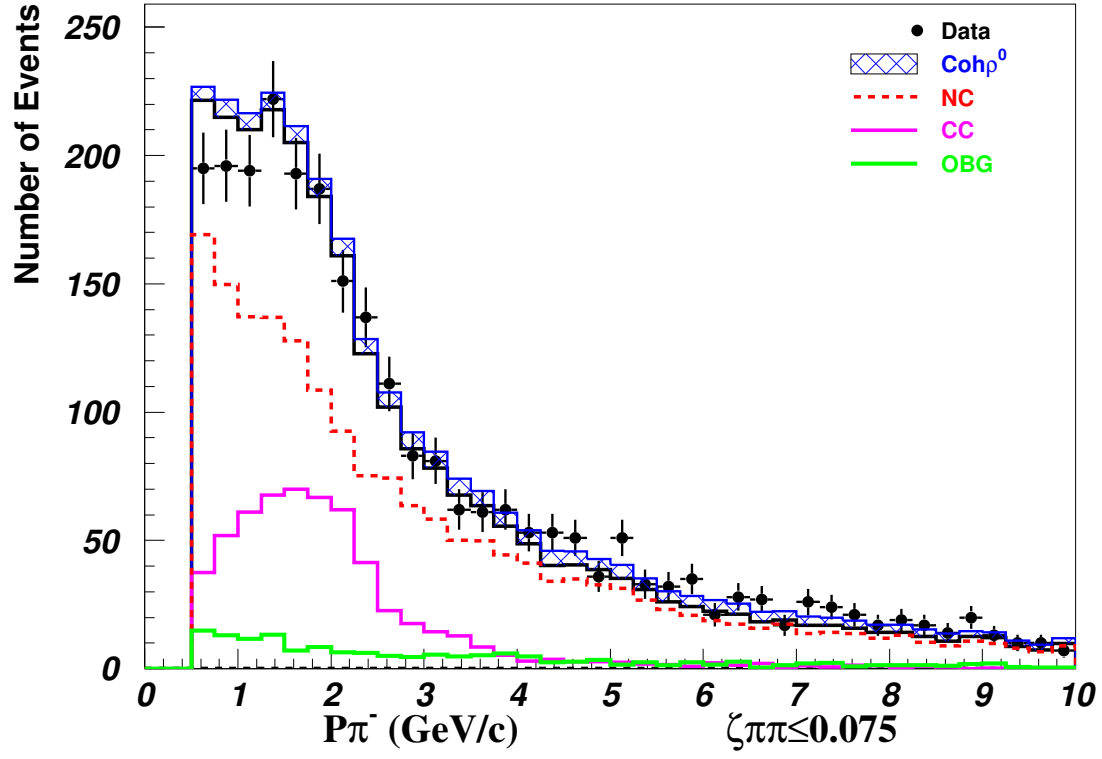


Figure 57: $P_t \pi^-$ (Signal Region)

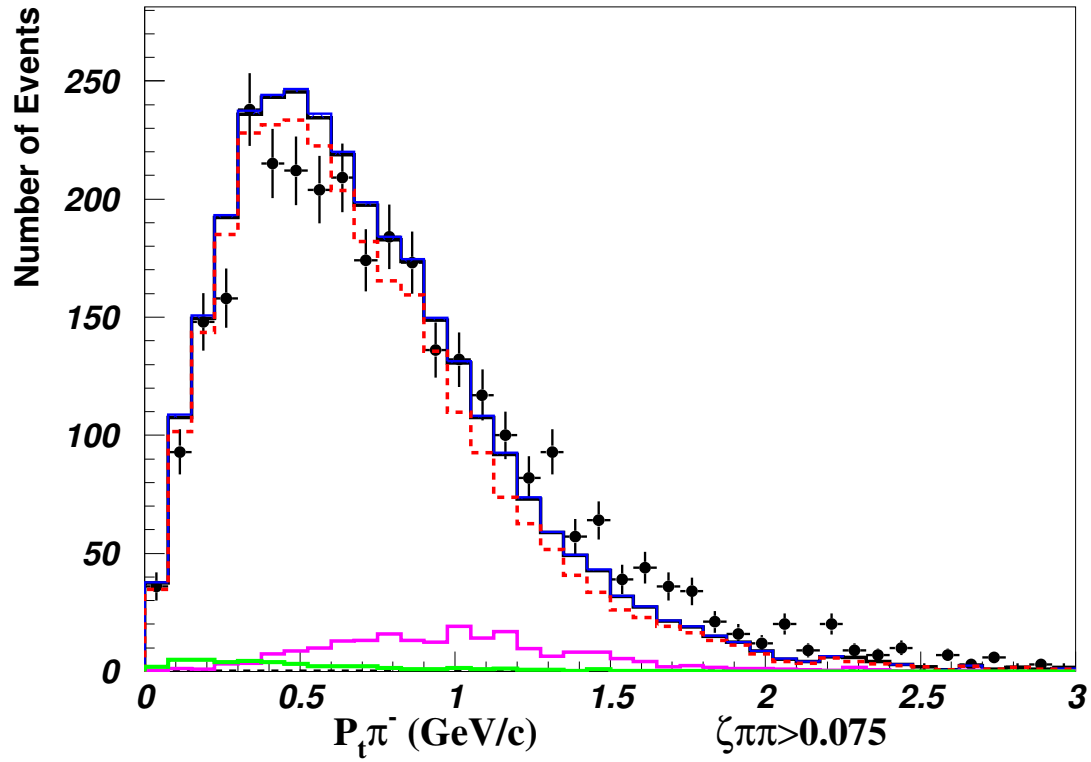
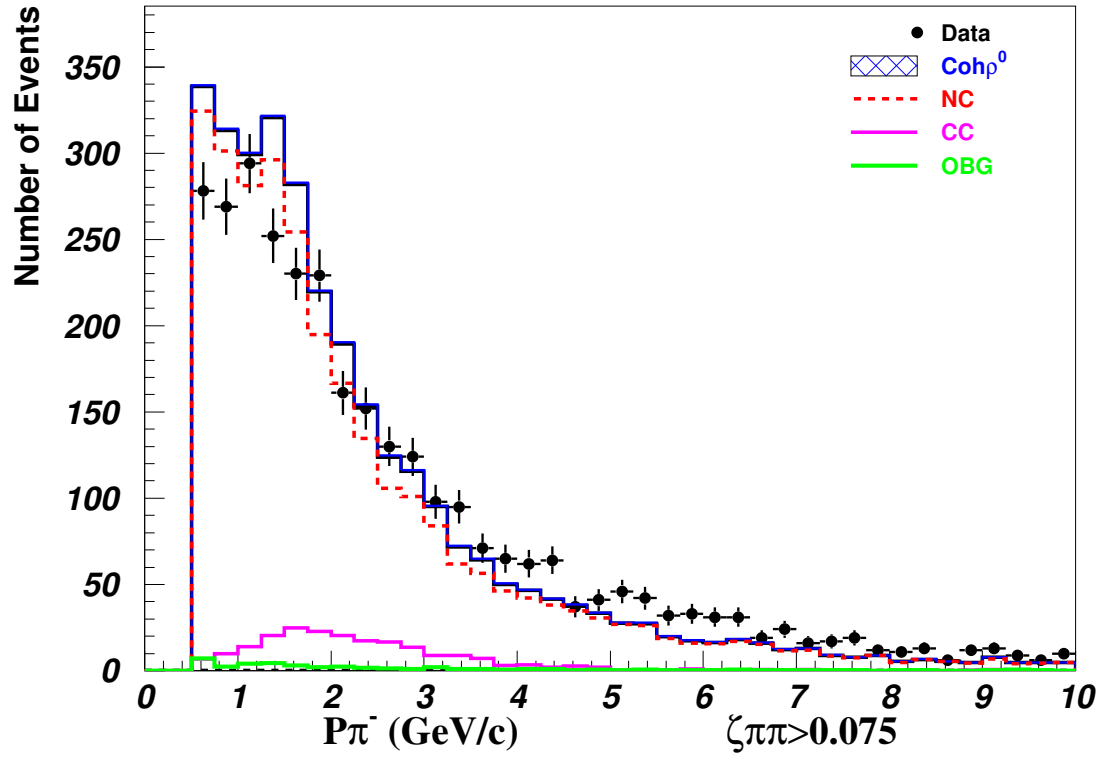


Figure 58: $P_t \pi^-$ (Background Region)

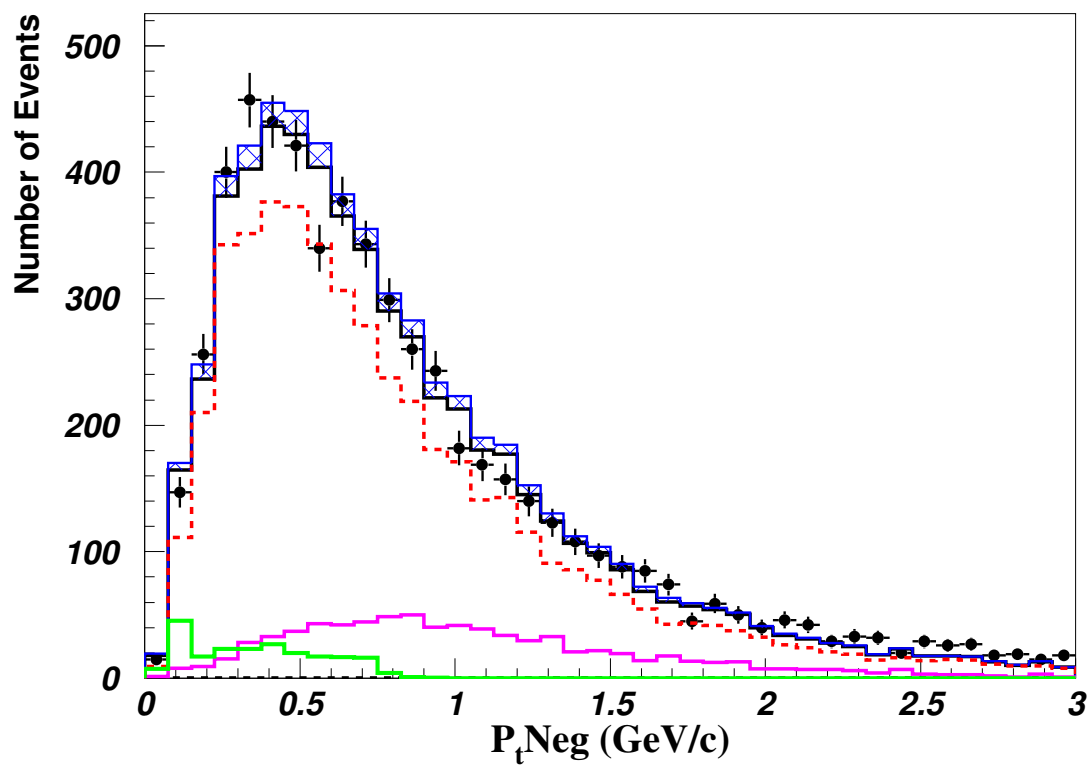
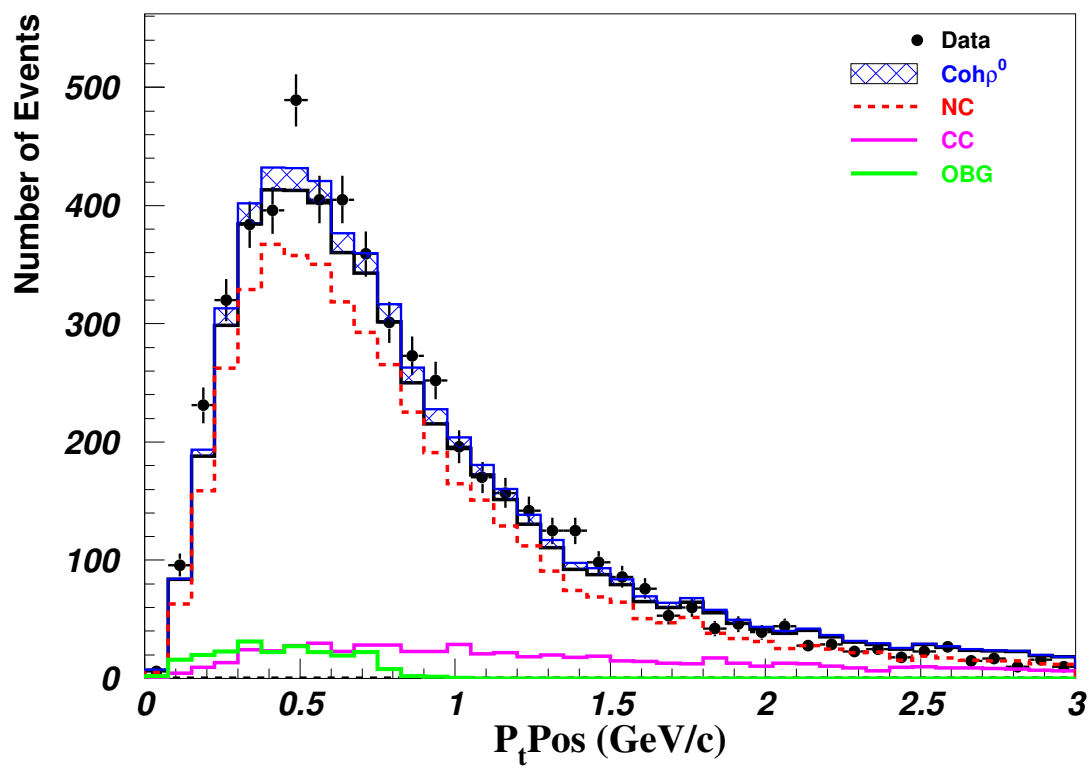


Figure 59: P_{tPos} and P_{tNeg}

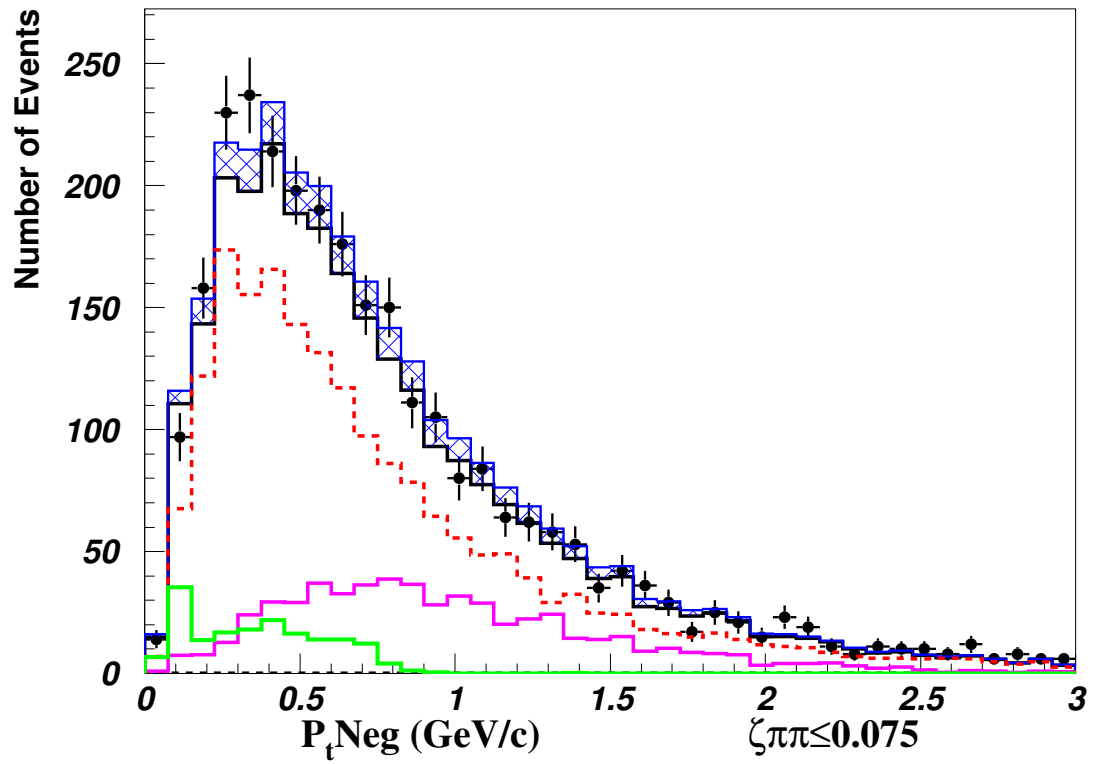
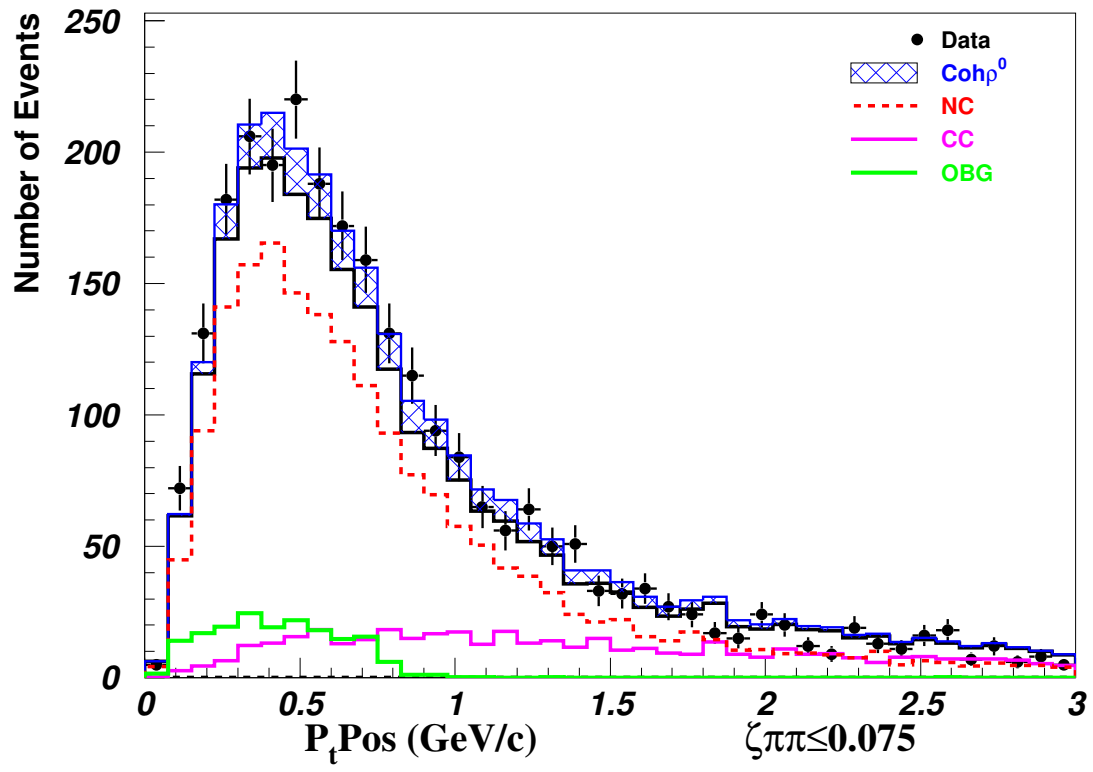


Figure 60: P_{tPos} and P_{tNeg} (Signal Region)

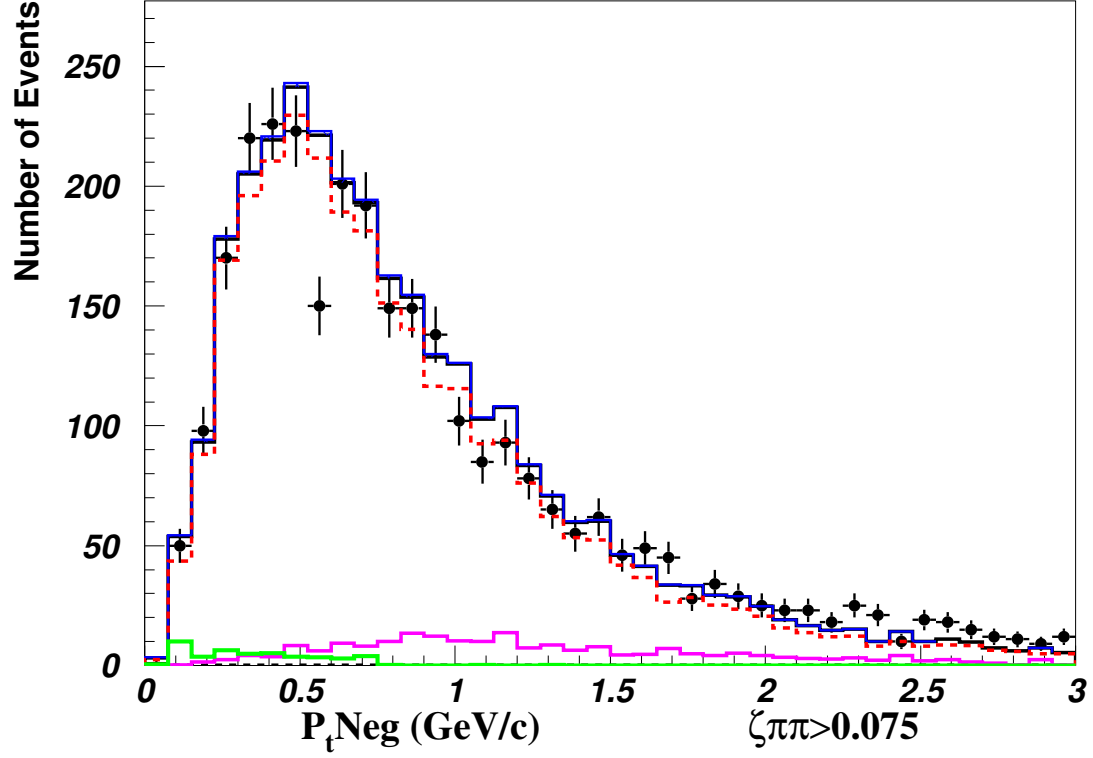
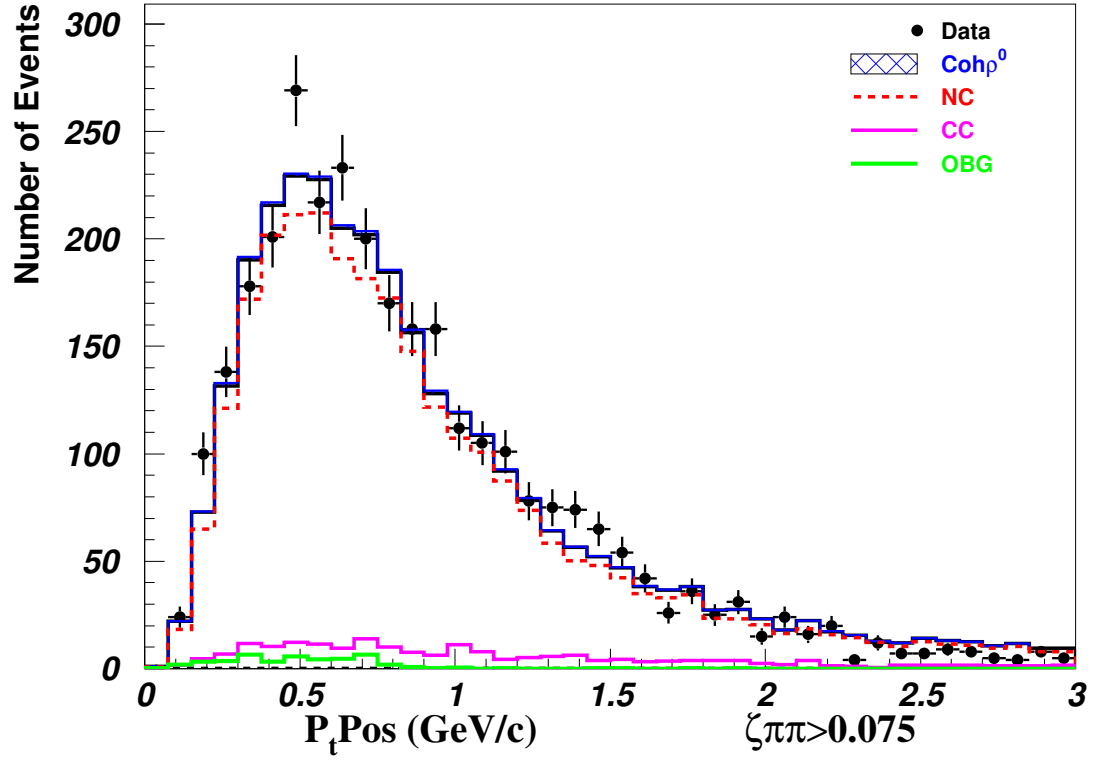


Figure 61: Ptpos and Ptneg (Background Region)

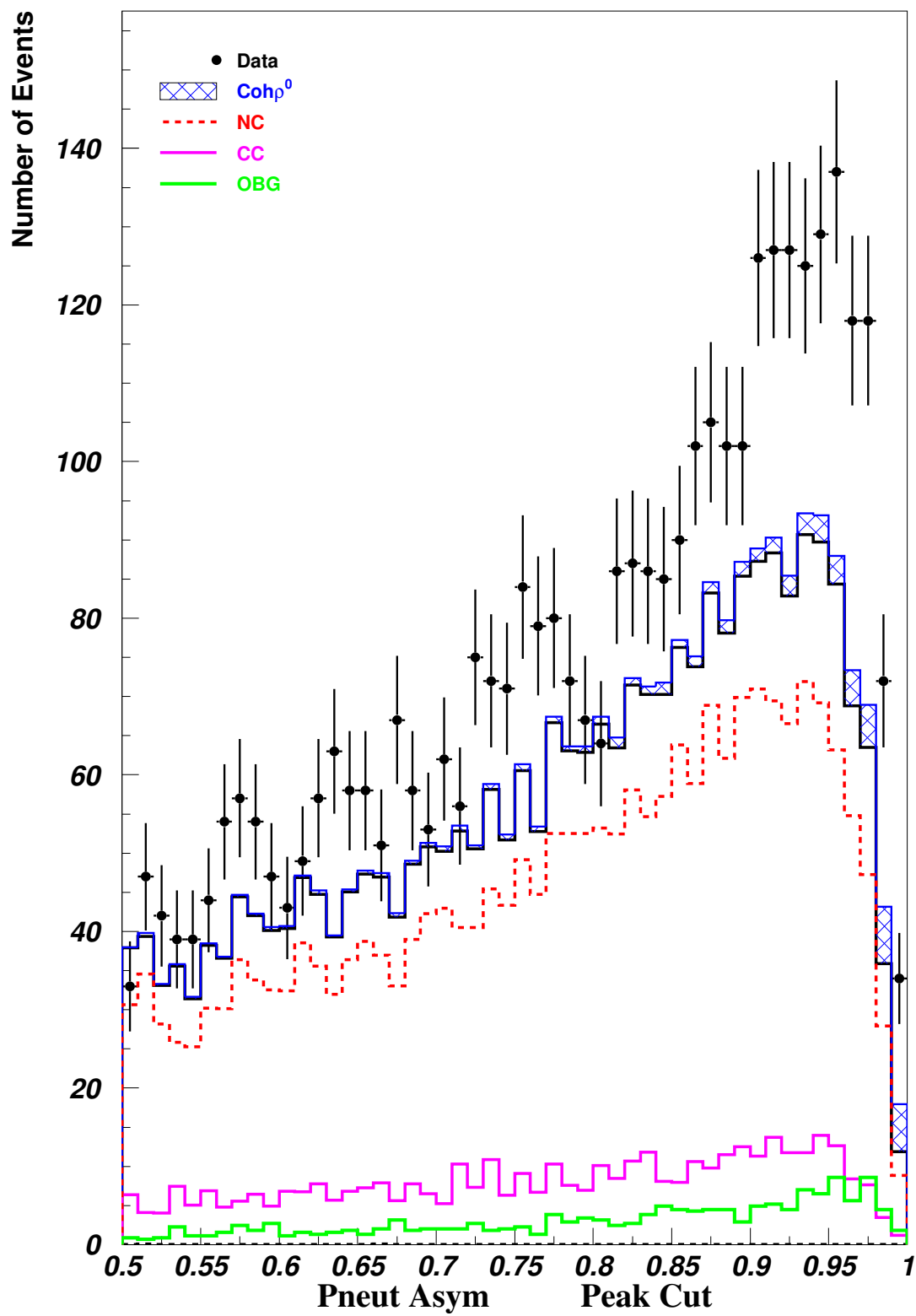


Figure 62: PAN (Neutral Momentum Asymetry)

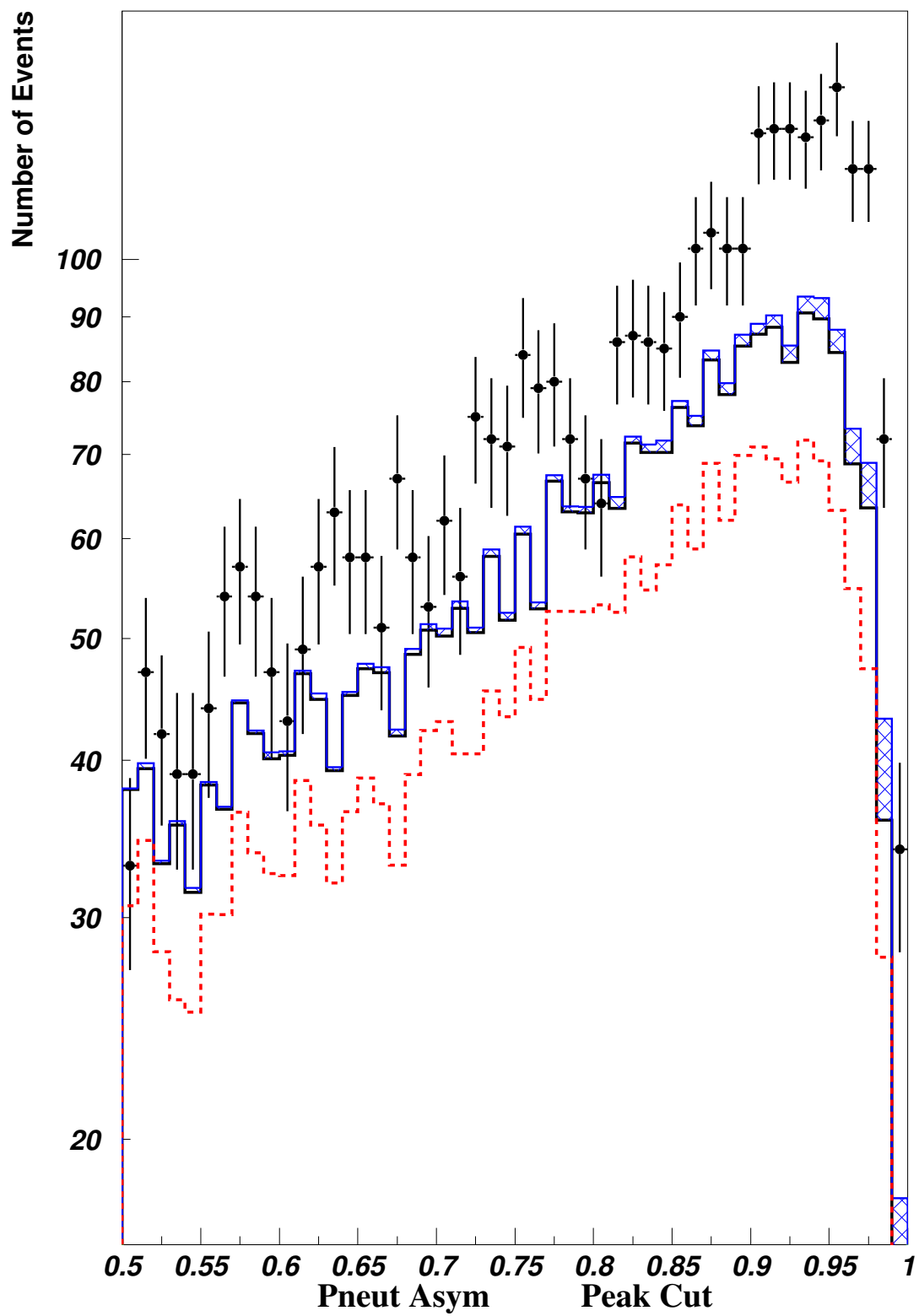


Figure 63: PAN (Neutral Momentum Assymetry (log scale))

9 Extra Plots

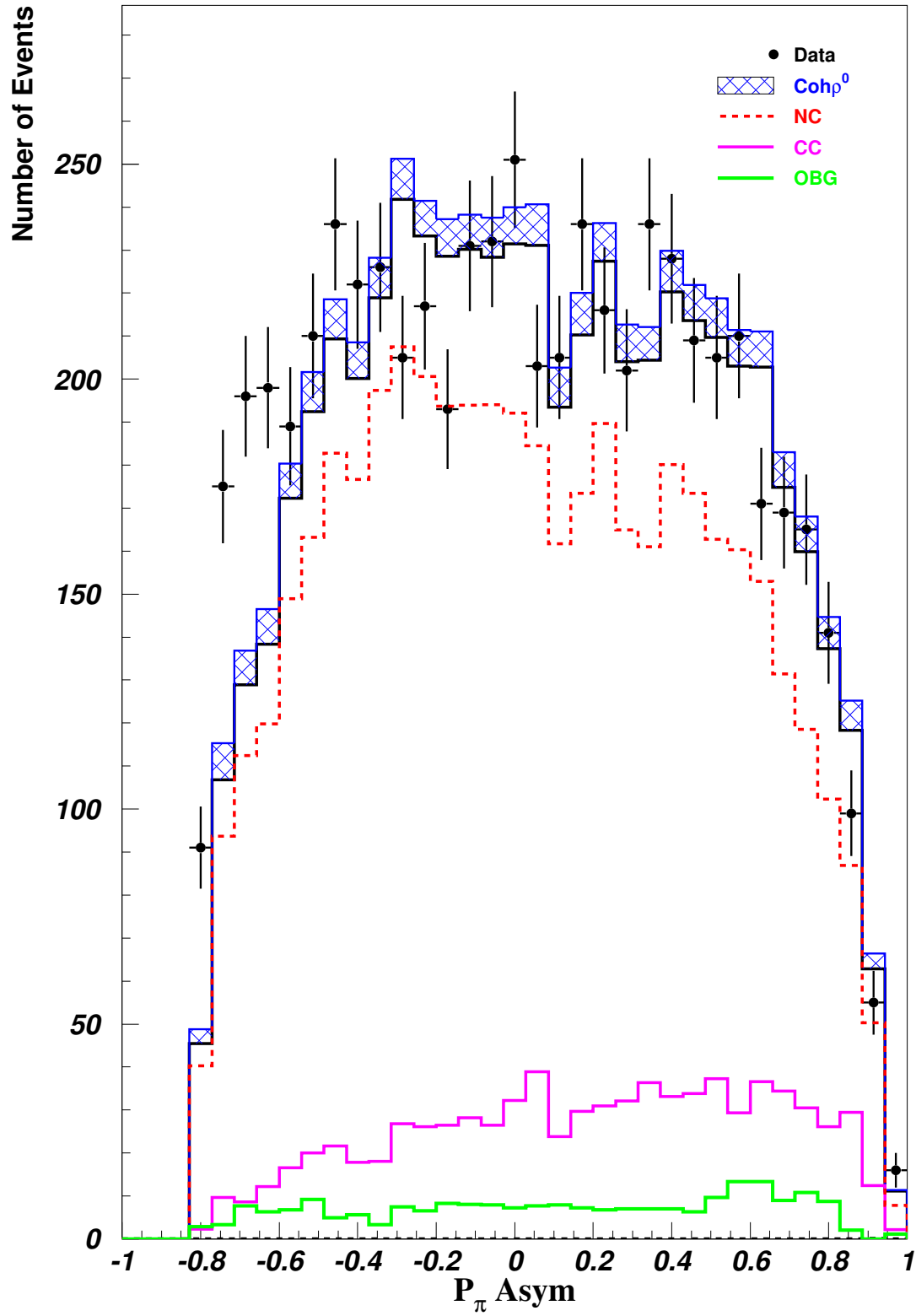


Figure 64: P_π Asymetry

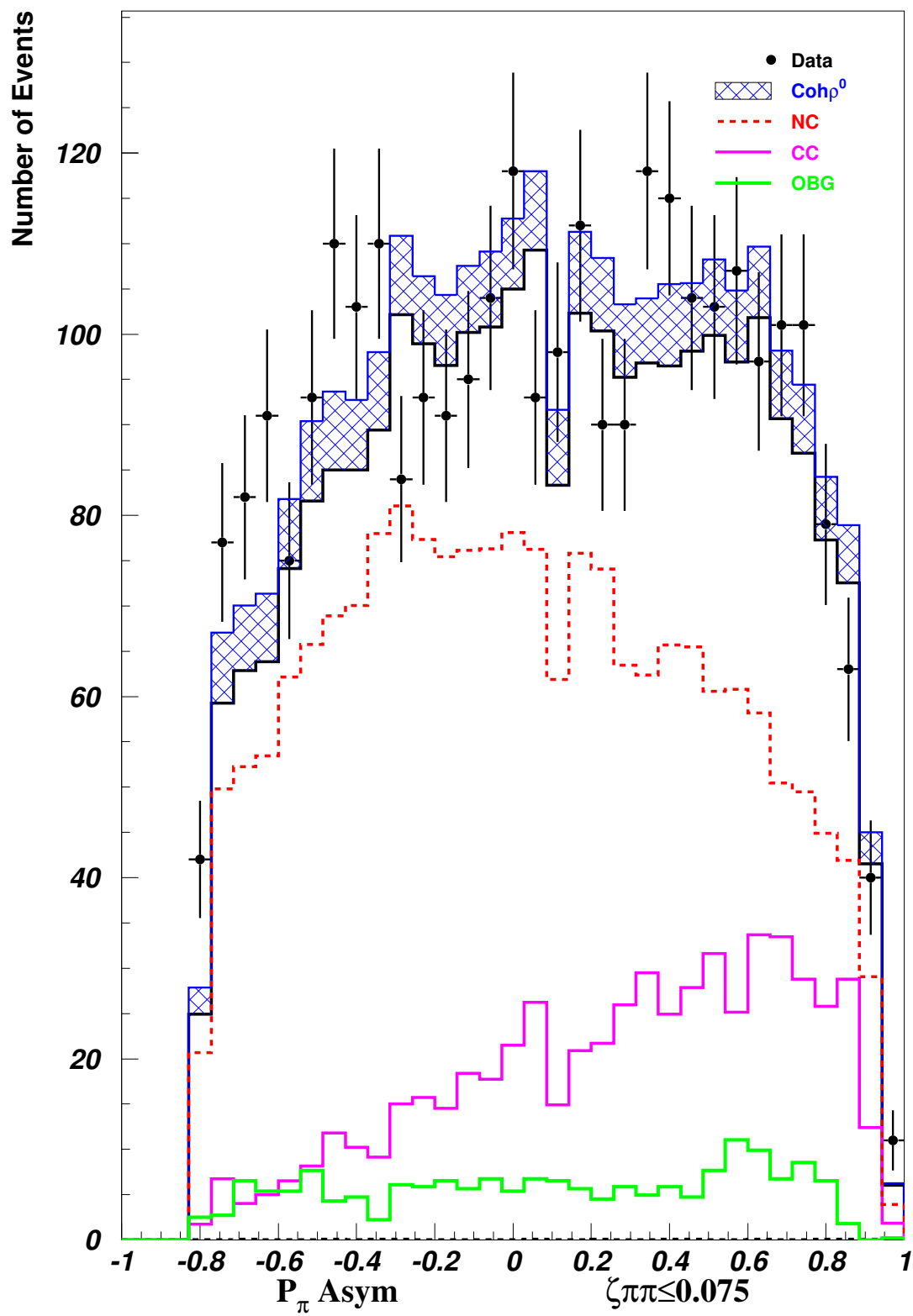


Figure 65: P_π Asymmetry (Signal Region)

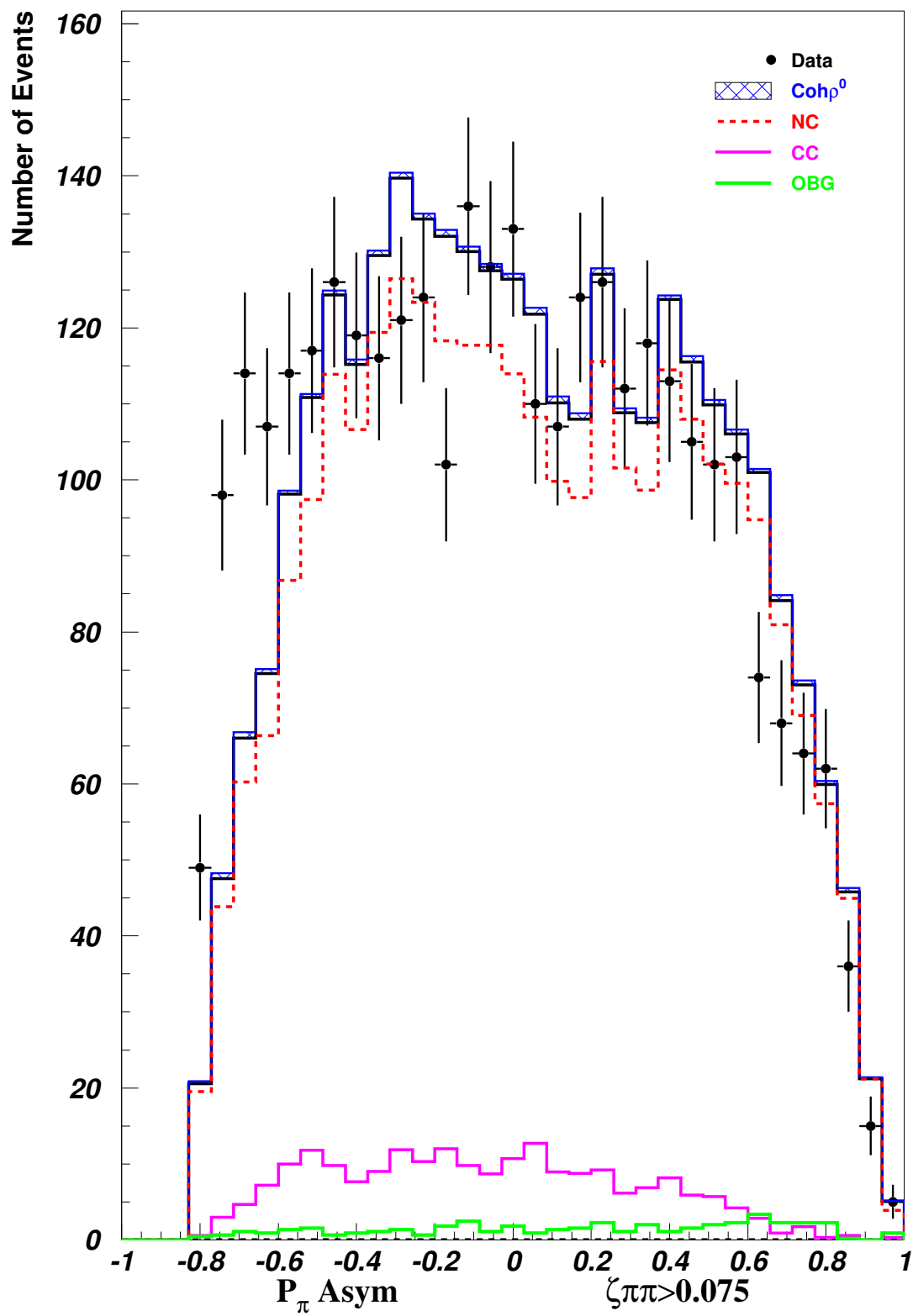


Figure 66: P_π Asymmetry (Background Region)

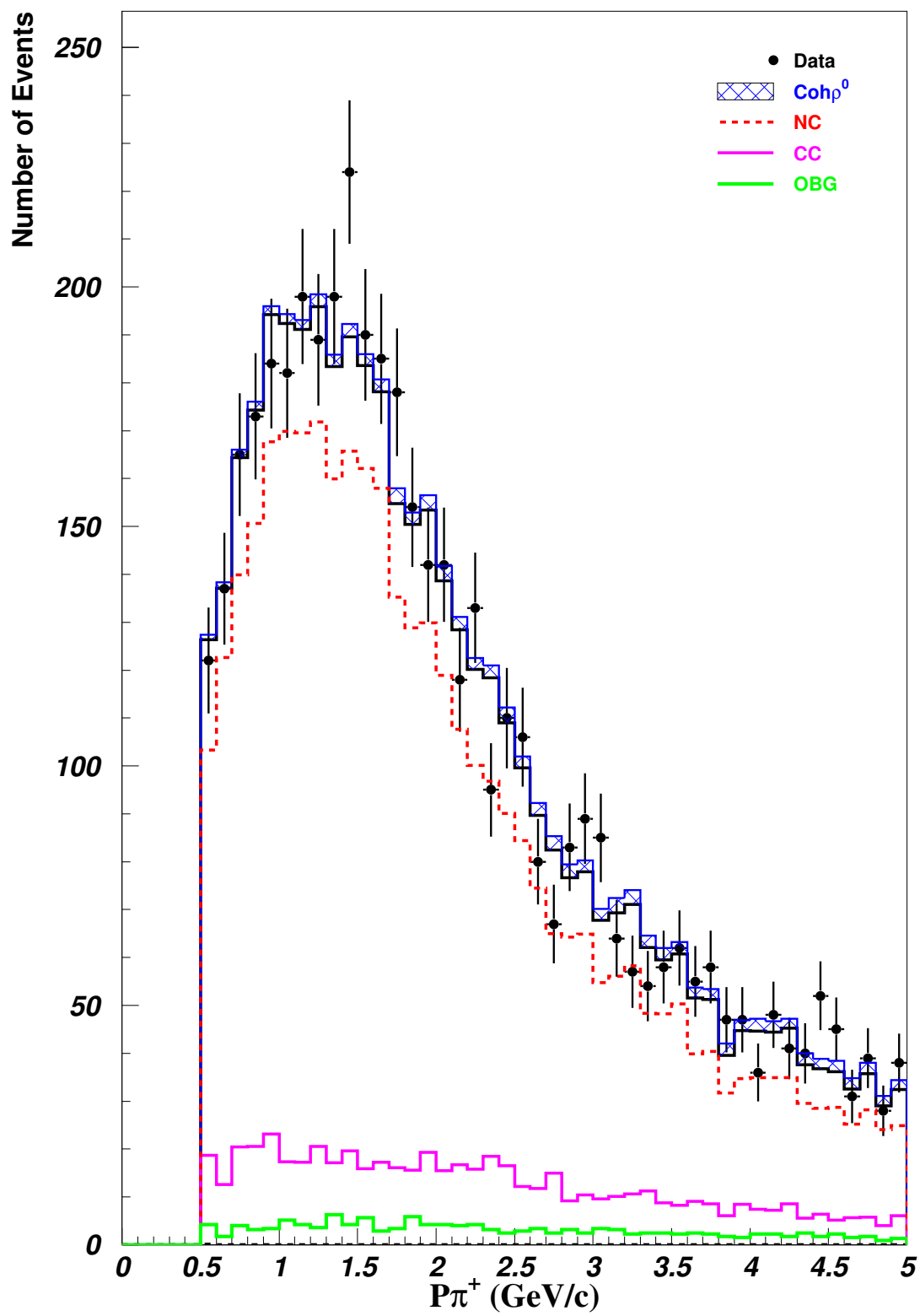


Figure 67: P_+

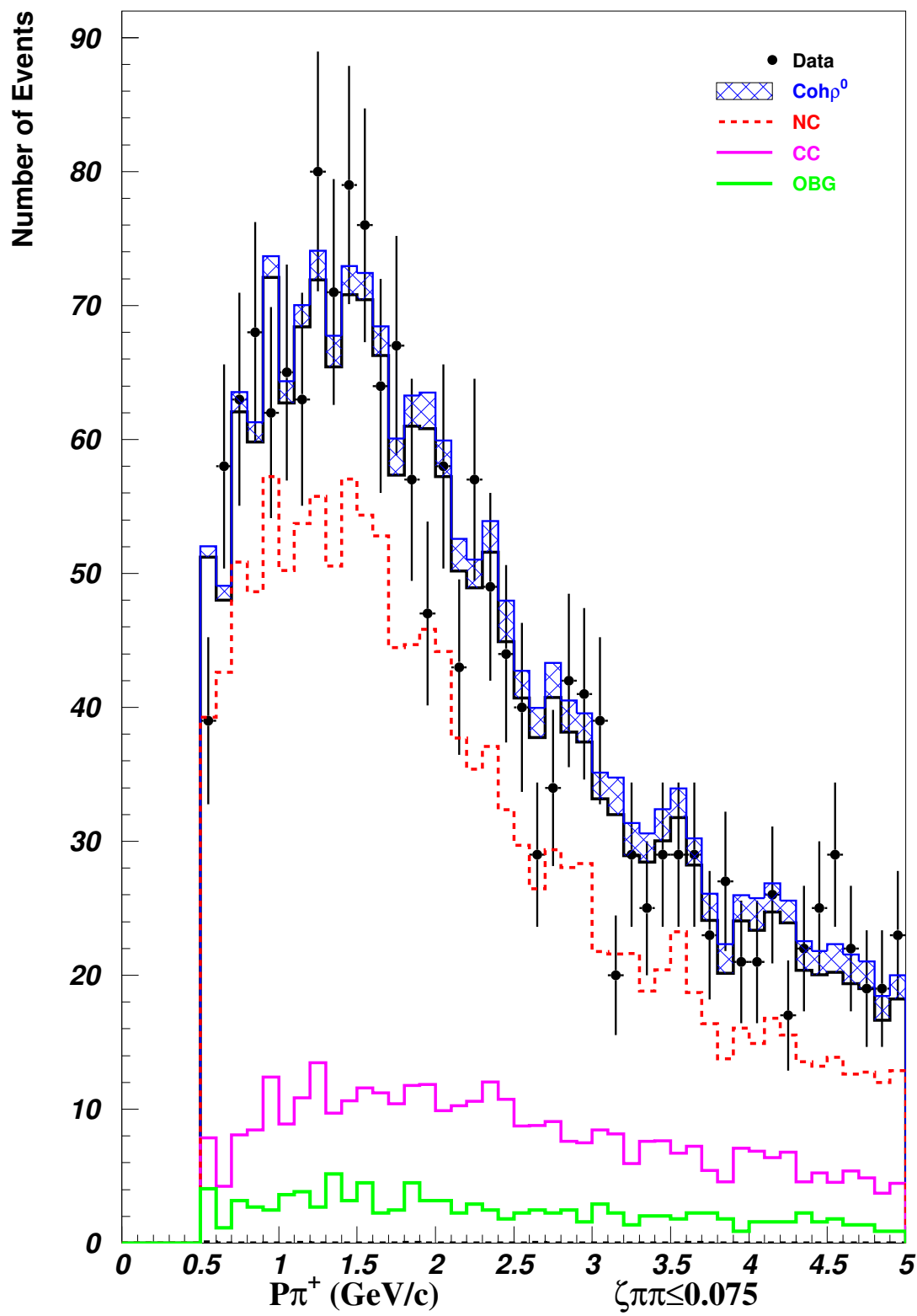


Figure 68: P_+ (Signal Region)

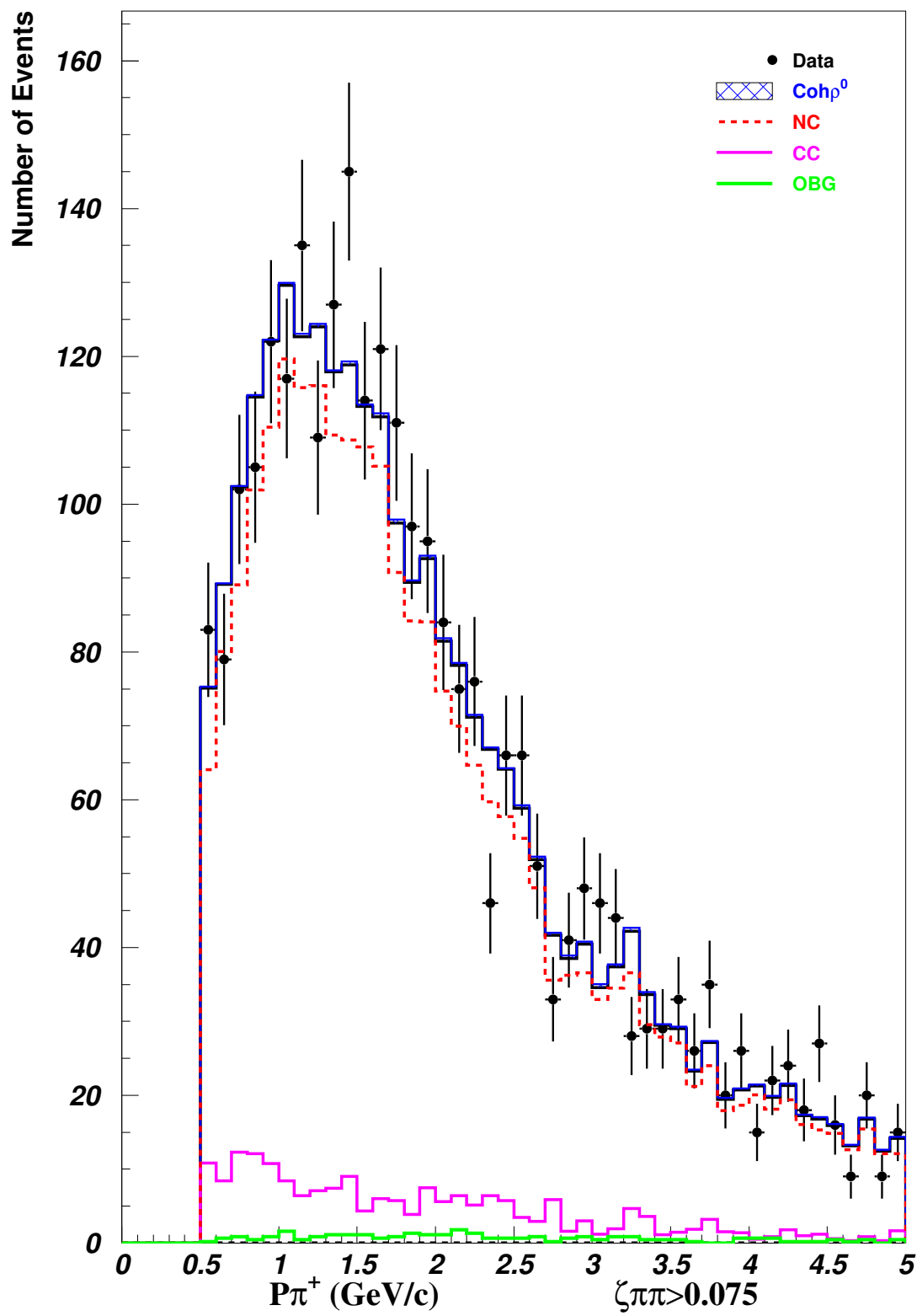


Figure 69: P_+ (Background Region)

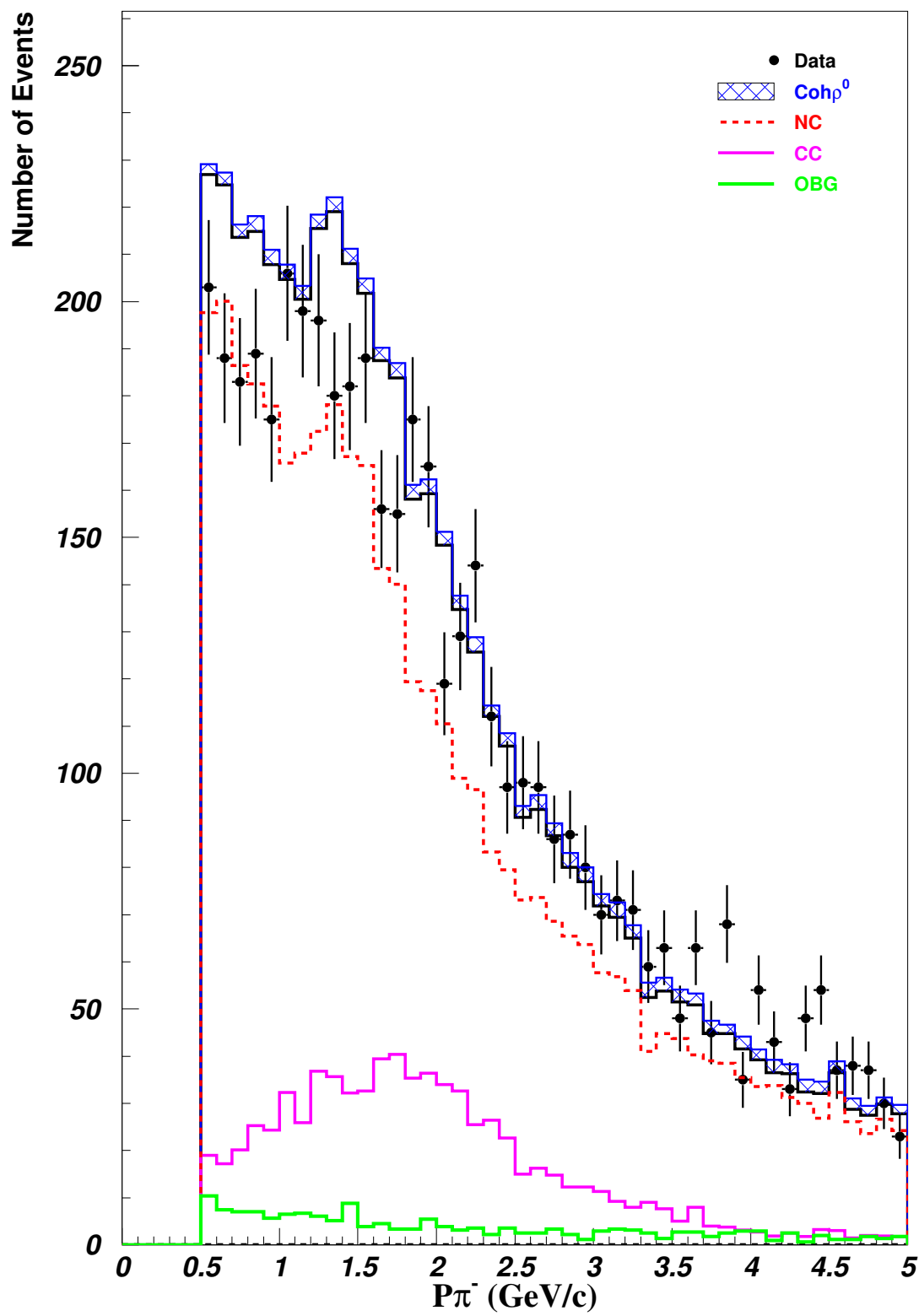


Figure 70: P_-

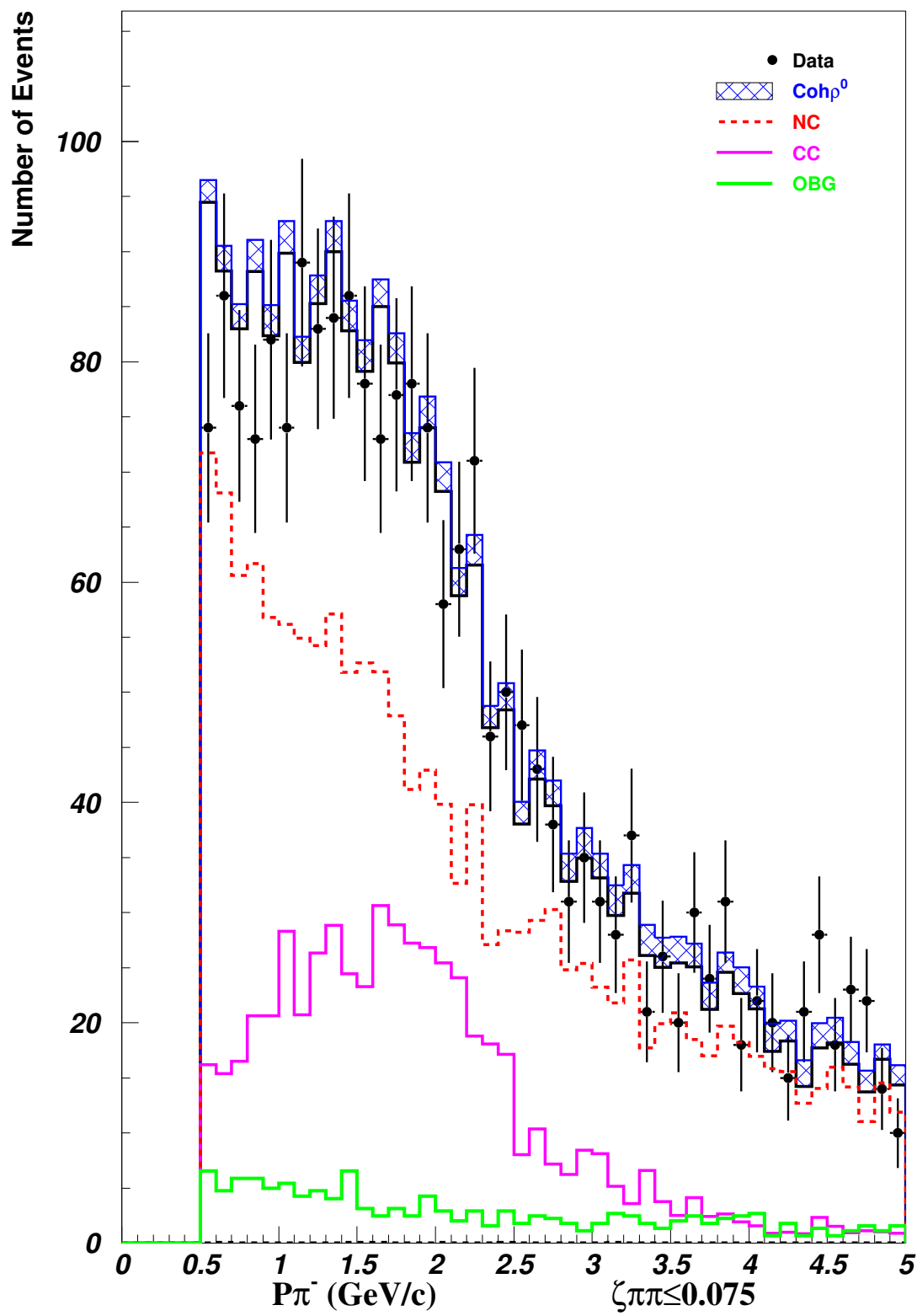


Figure 71: P_- (Signal Region)

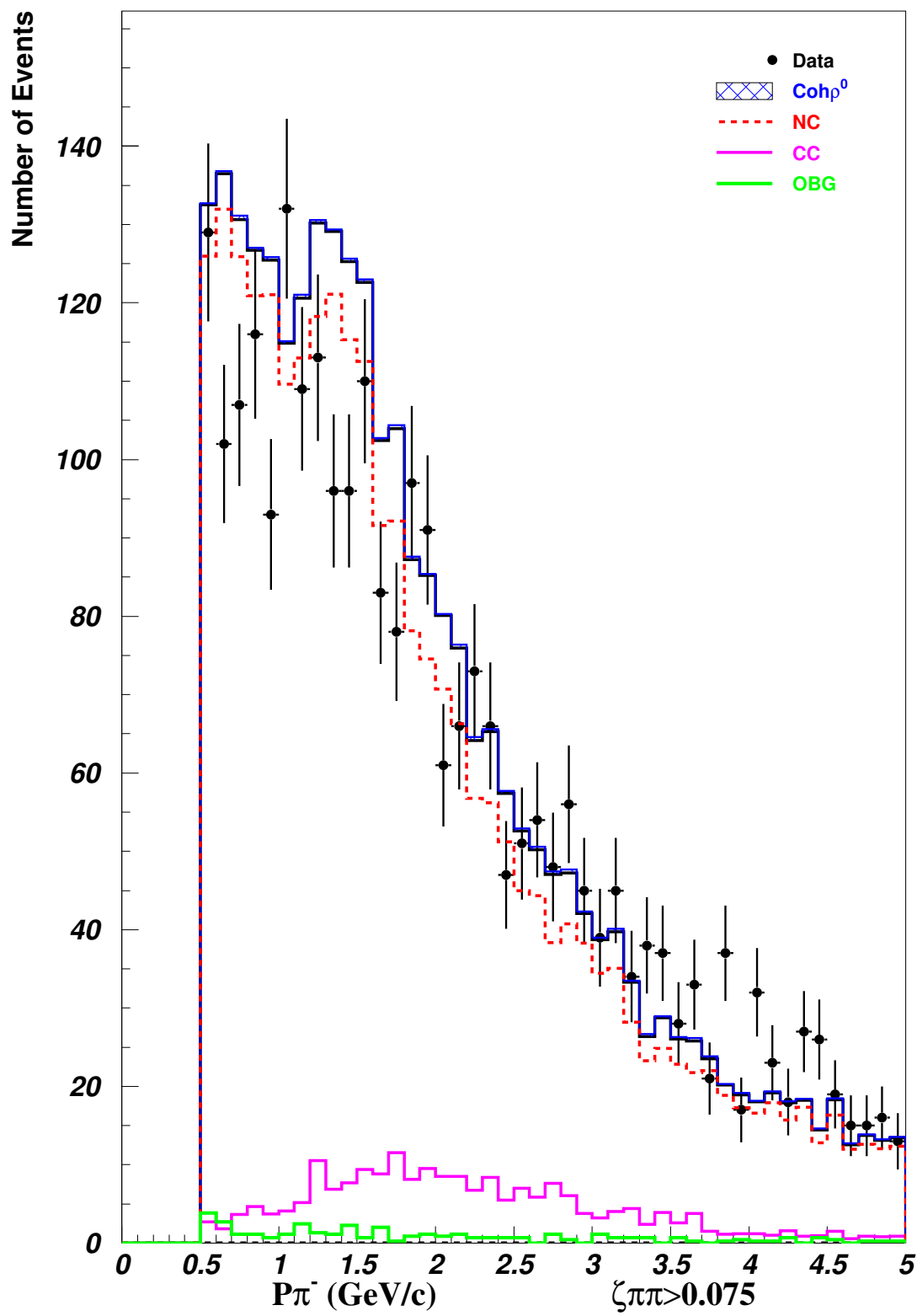


Figure 72: P_- (Background Region)

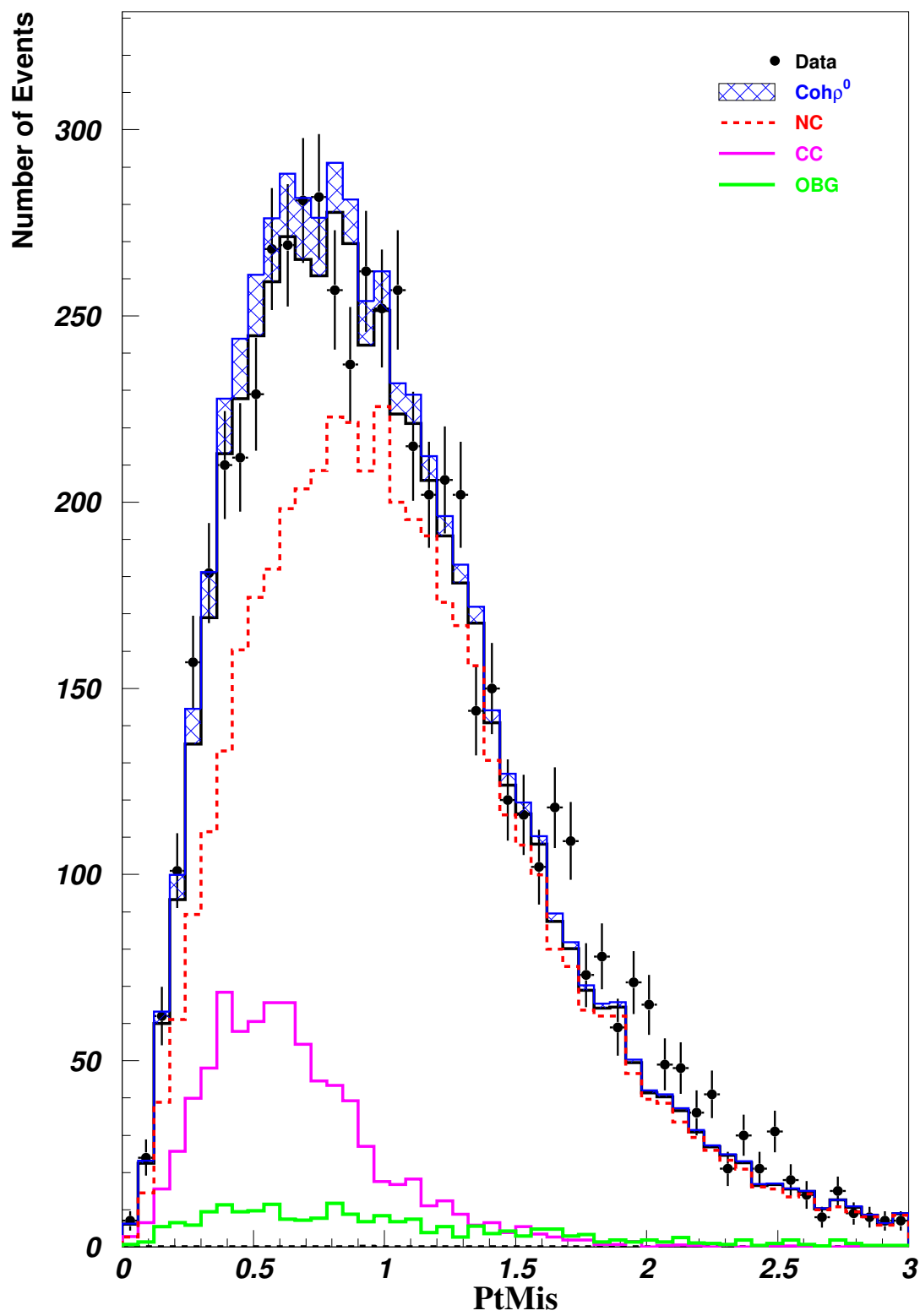


Figure 73: $P_t\text{Mis}$

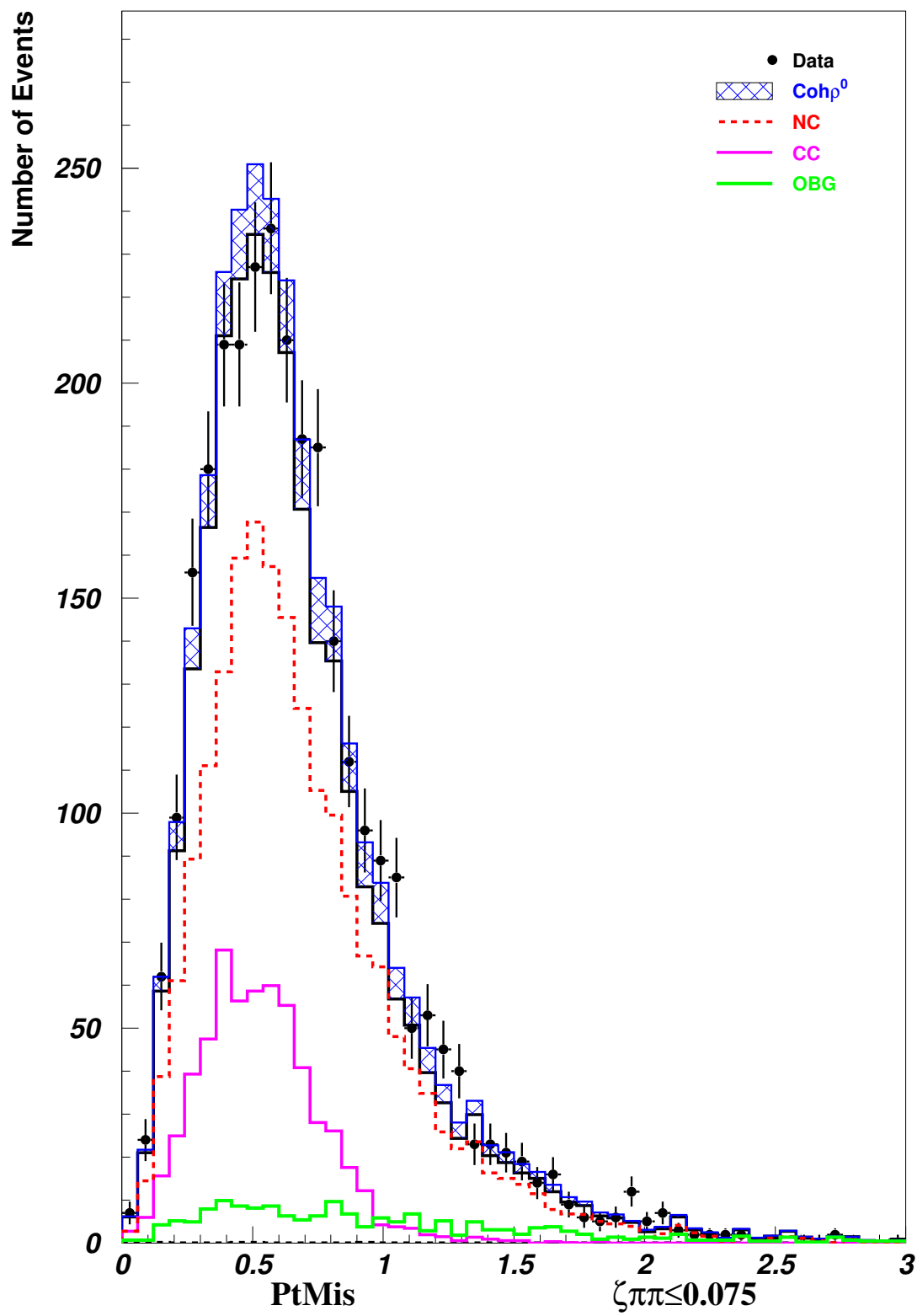


Figure 74: $P_t\text{Mis}$ (Signal Region)

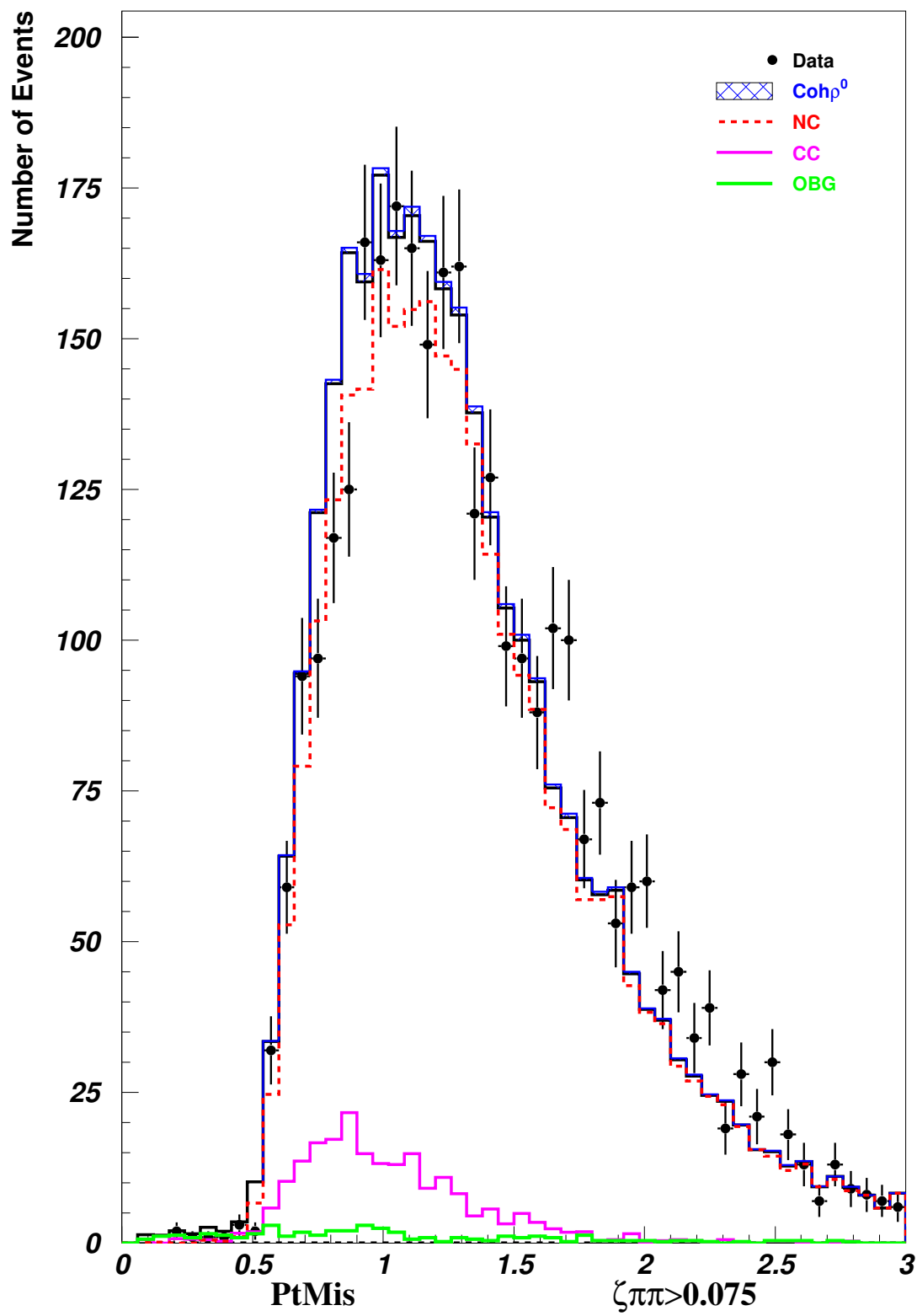


Figure 75: P_tMis (Background Region)

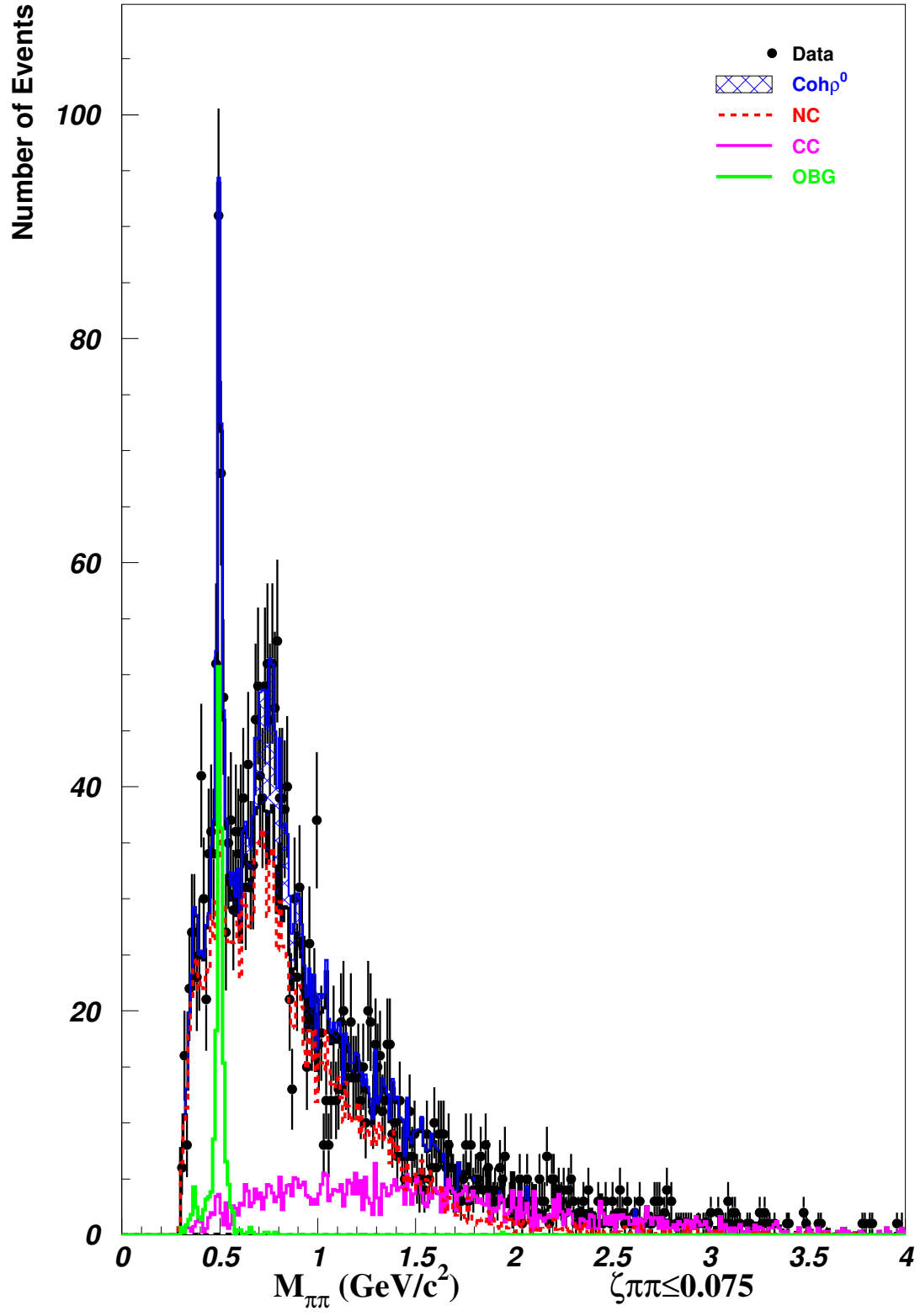


Figure 76: $M_{\pi\pi}$ 12.5MeV
(Signal Region)

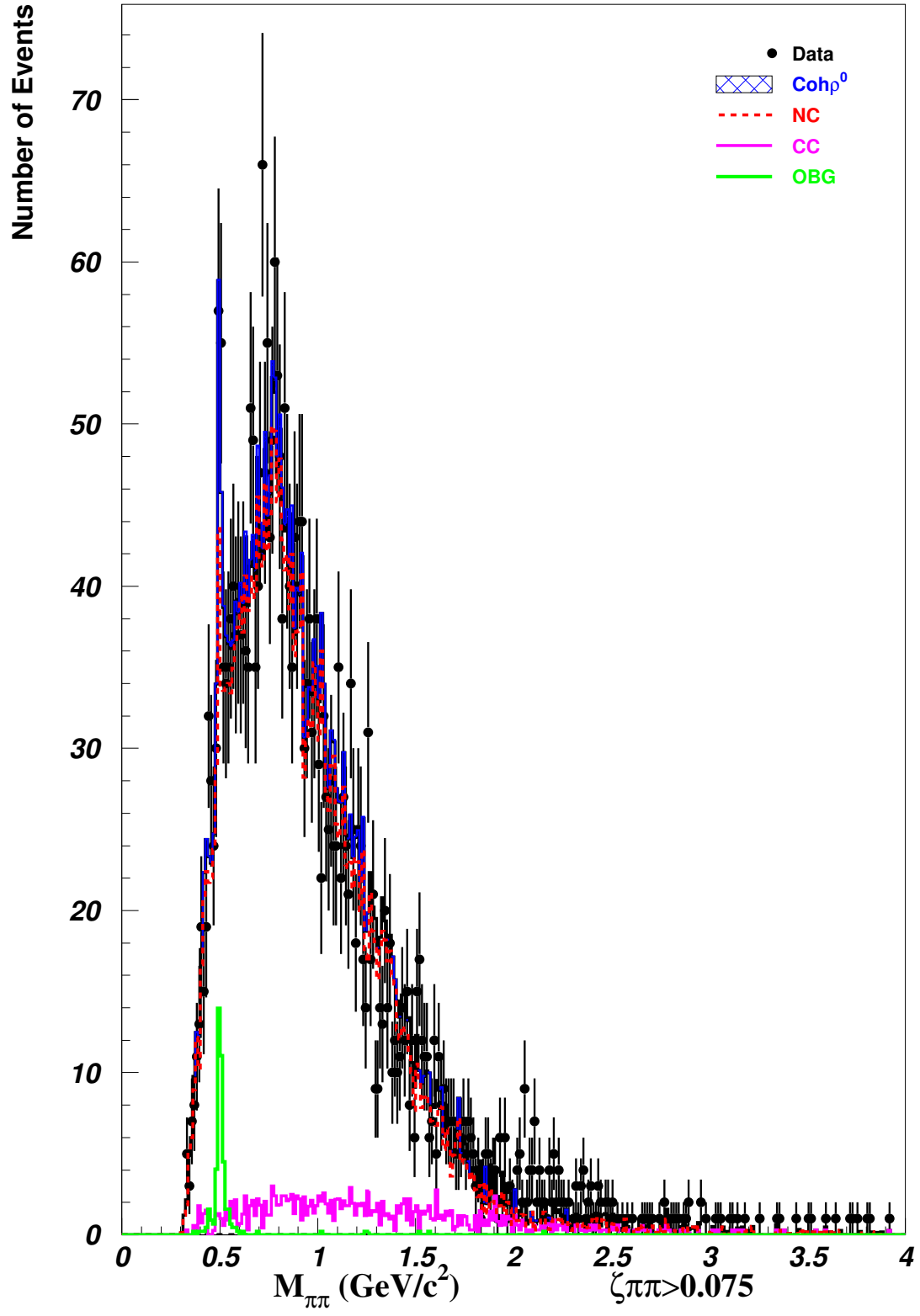


Figure 77: $M_{\pi\pi}$ 12.5MeV
(Background Region)

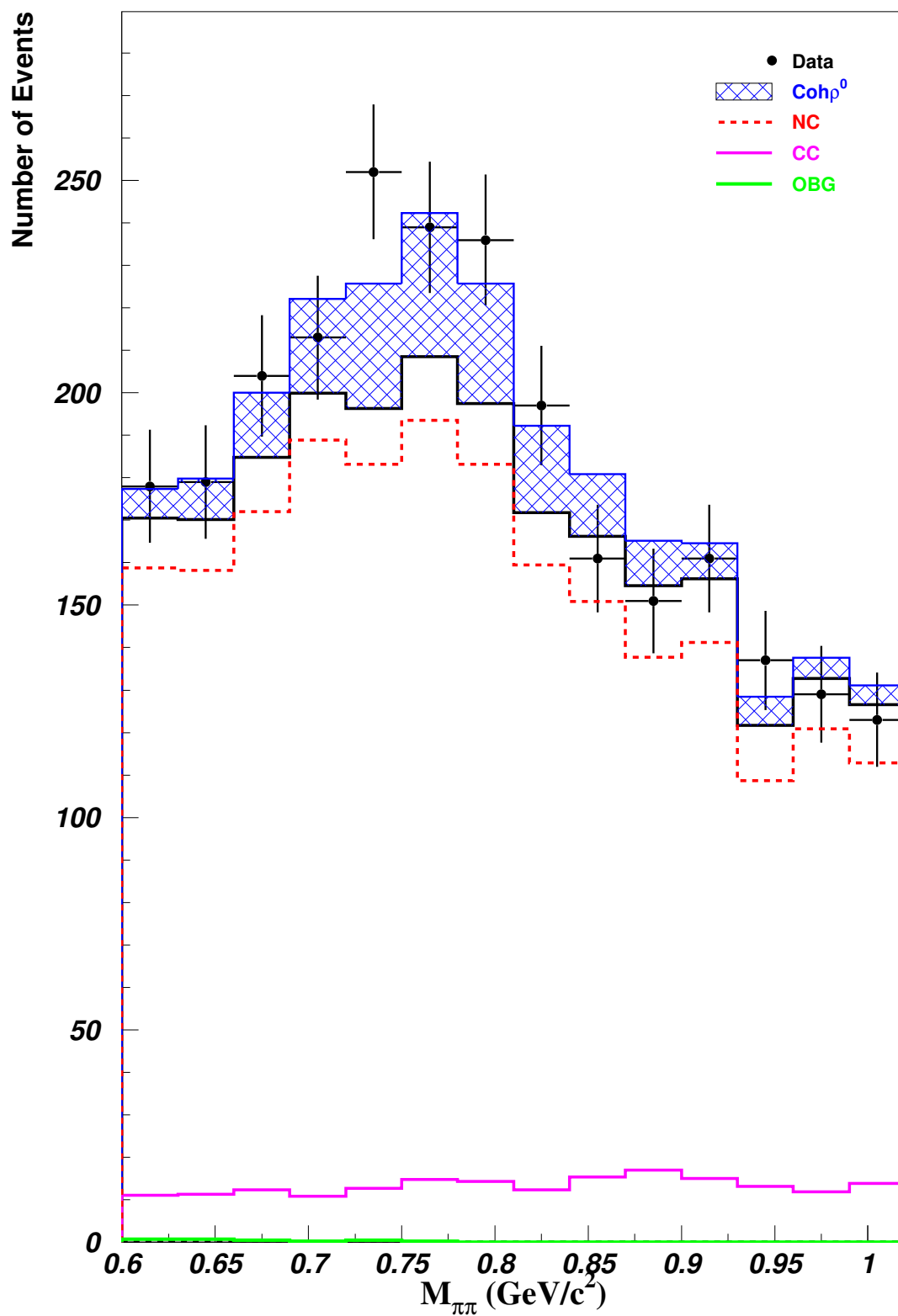


Figure 78: $M_{\pi\pi}$ For χ^2

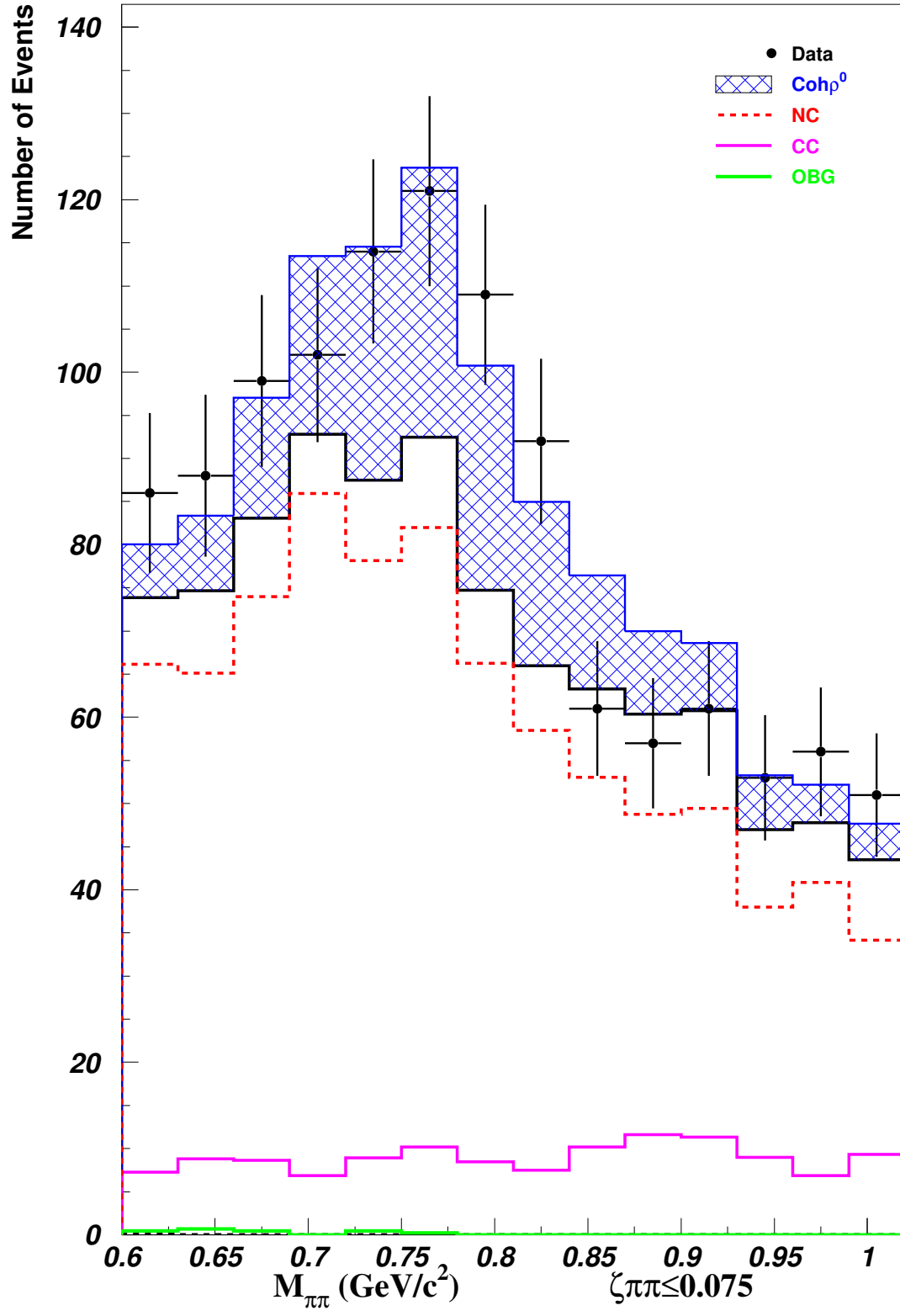


Figure 79: $M_{\pi\pi}$ For χ^2
(Signal Region)

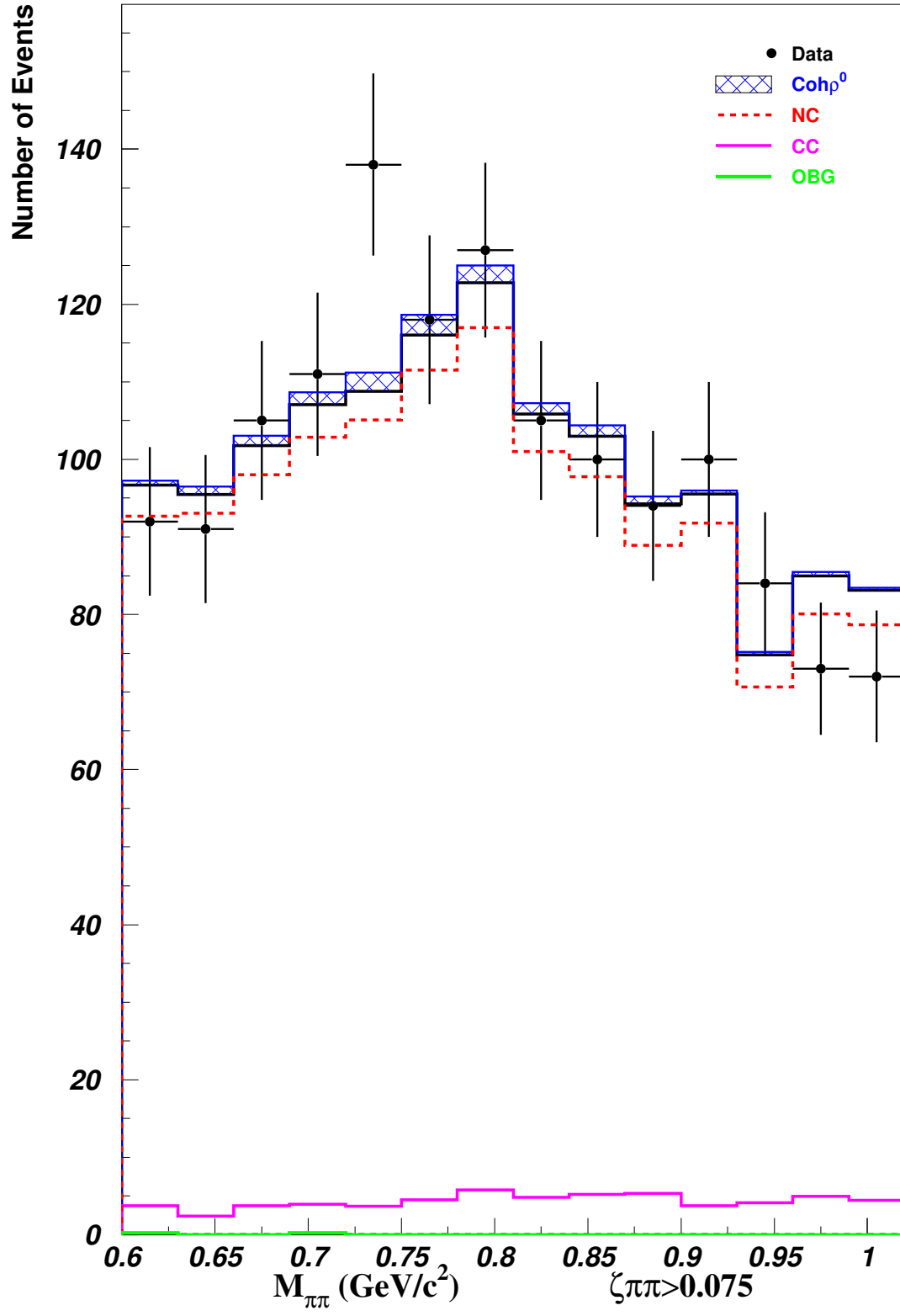


Figure 80: $M_{\pi\pi}$ For χ^2
(Background Region)

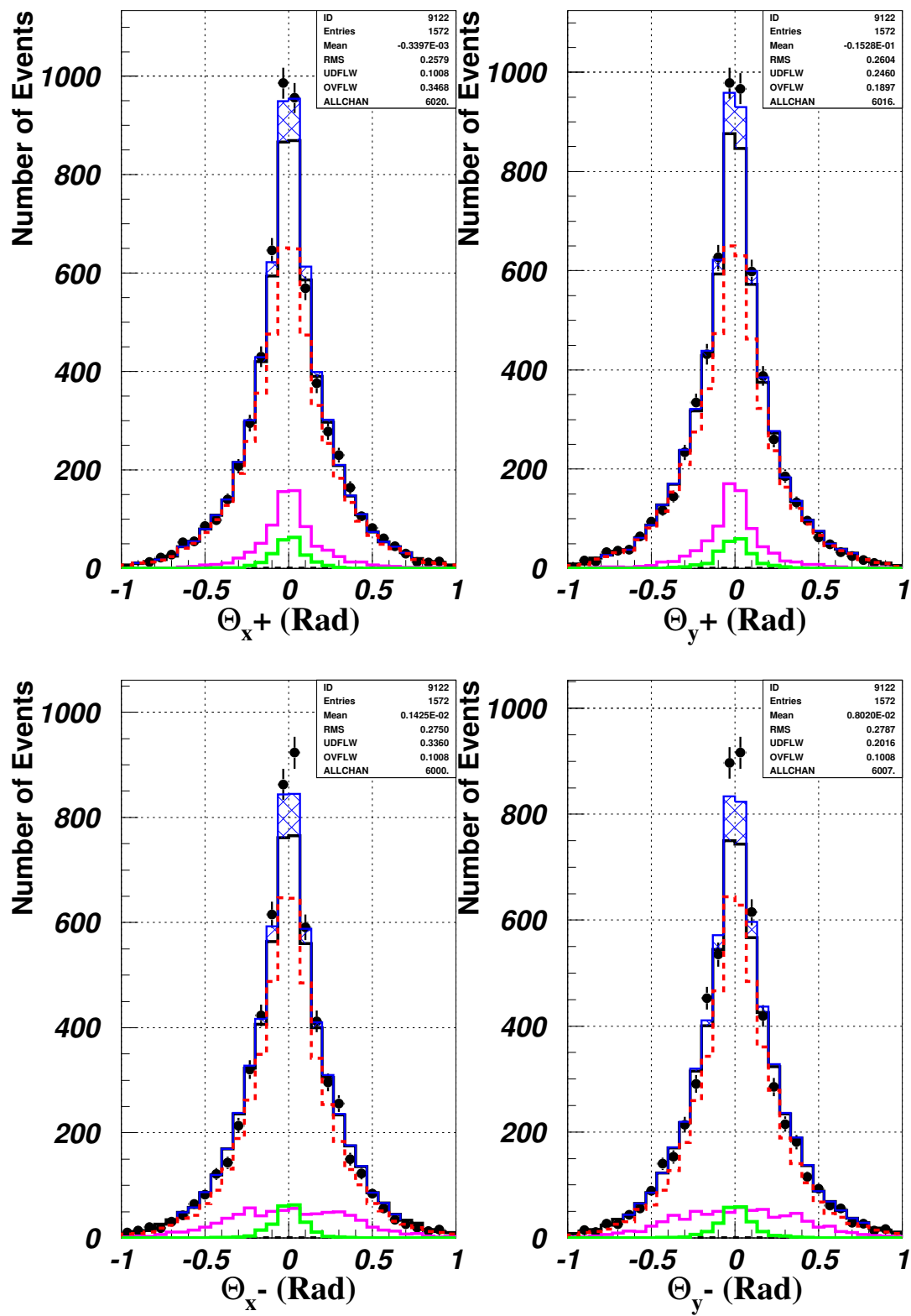


Figure 81: θ_x and θ_y