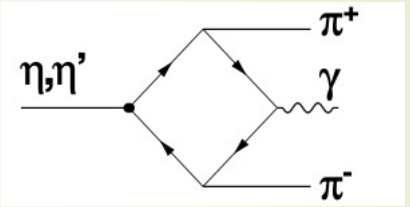
Updated Study of $\eta' \rightarrow \gamma\pi^+\pi^-$ Decay Dynamic



Liqing Qin

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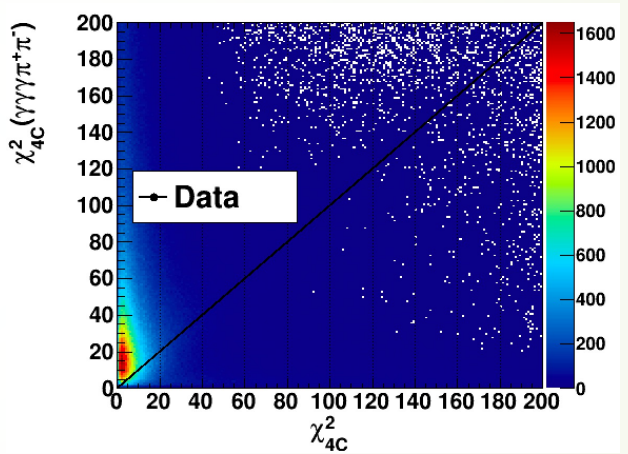
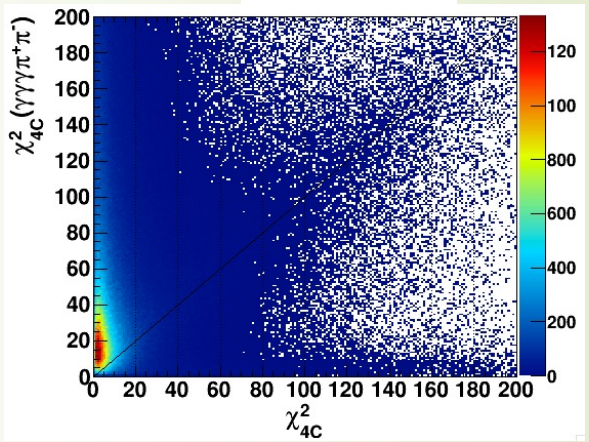
Selection criteria for $J/\psi \rightarrow \gamma\eta'$, $\eta' \rightarrow \gamma\pi^+\pi^-$

$E_\gamma^{CMS} = 1.4$ GeV

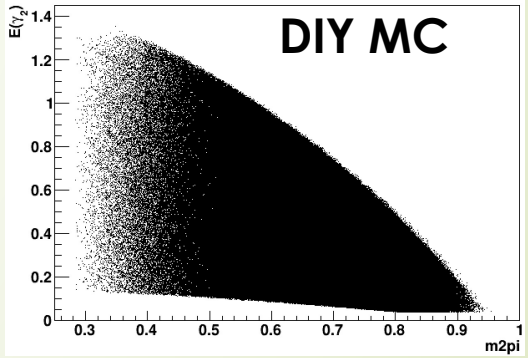
- Common ones for the **good charged tracks** and **good photons** candidates:
  - N_ch =2, net_ch= 0
  - $N\gamma \geq 2$, where the deposited energy is larger than 40 MeV for barrel rather than 25 MeV.
- PID: without any PID
- **Vertex Fit**
- **4C Kinematic Fit**
  - $\chi^2(\pi^+\pi^-\gamma\gamma) < 100$
  - Photon with maximum energy is taken as the radiative one from J/ψ.
  - $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$

DIY MC



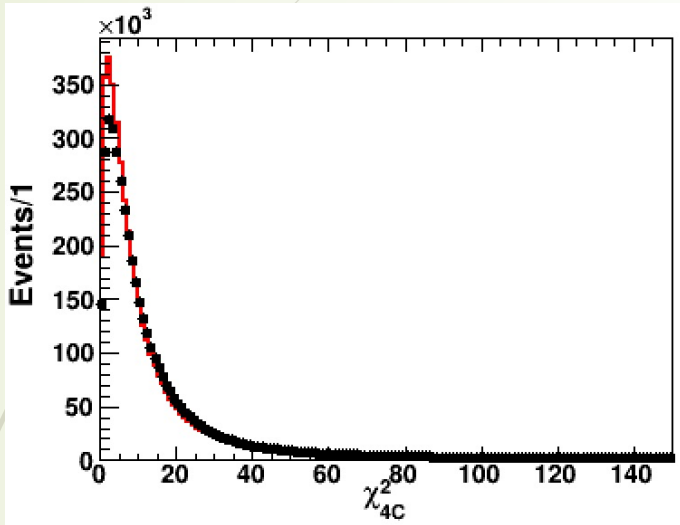


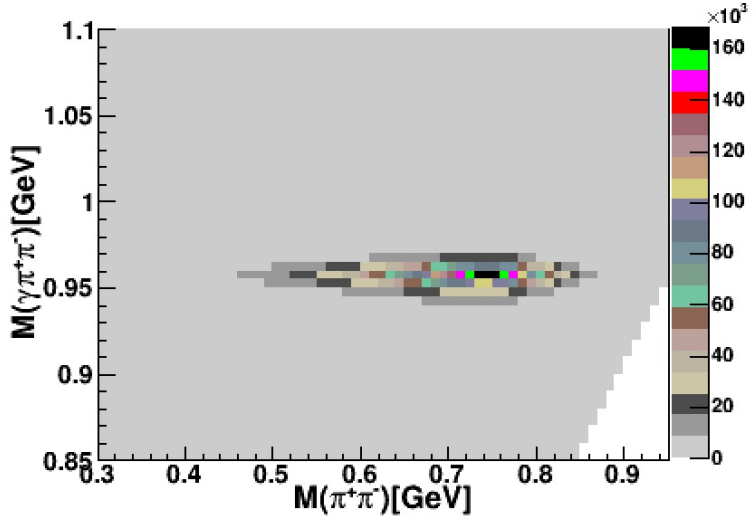
- **Veto background events with π^0 in the final state:** $J/\psi \rightarrow \pi^+\pi^-\pi^0$, $\gamma\pi^+\pi^-\pi^0$, …
  - $|M(\gamma\gamma) - m_{\pi^0}| > 20$ MeV

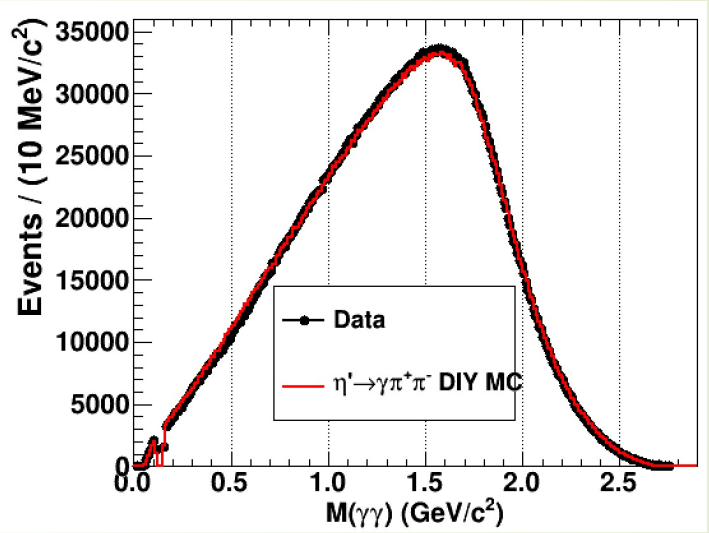


Selection criteria

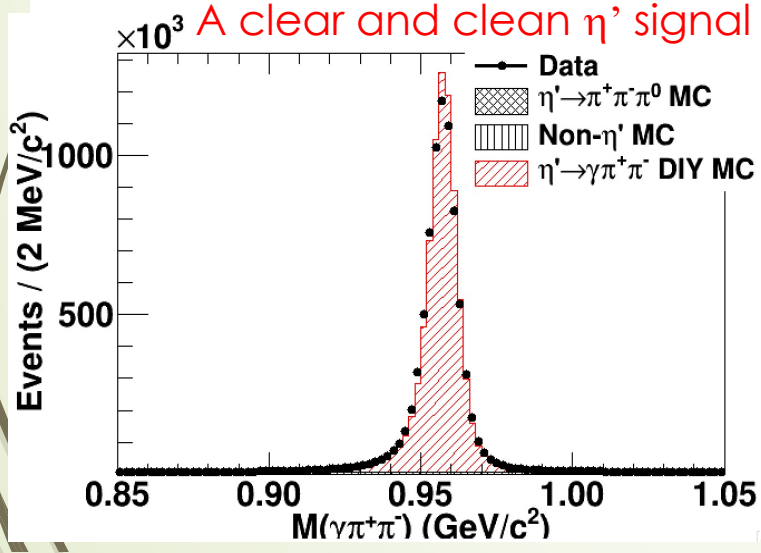
- **Data vs DIY MC of η' → γπ⁺π⁻**

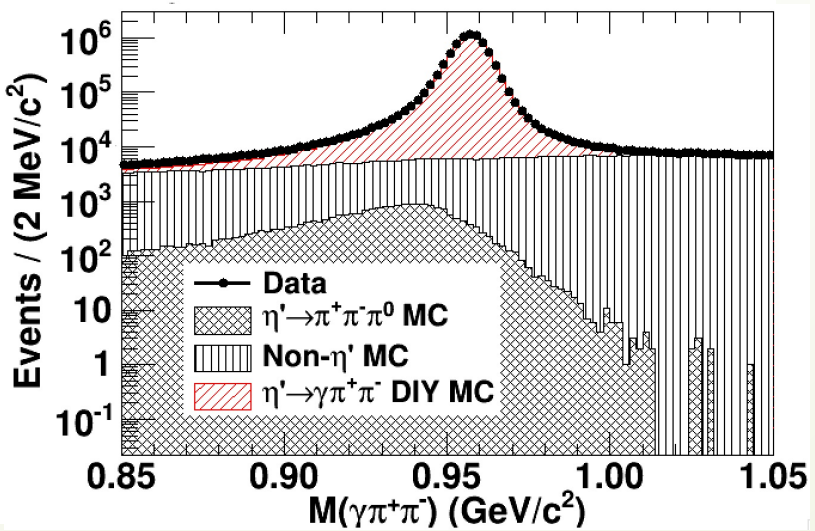






A clear and clean η' signal





- η' candidates:

  $|M(\gamma\pi^+\pi^-) - m_{\eta'}| < 20$ MeV

- Non- η':

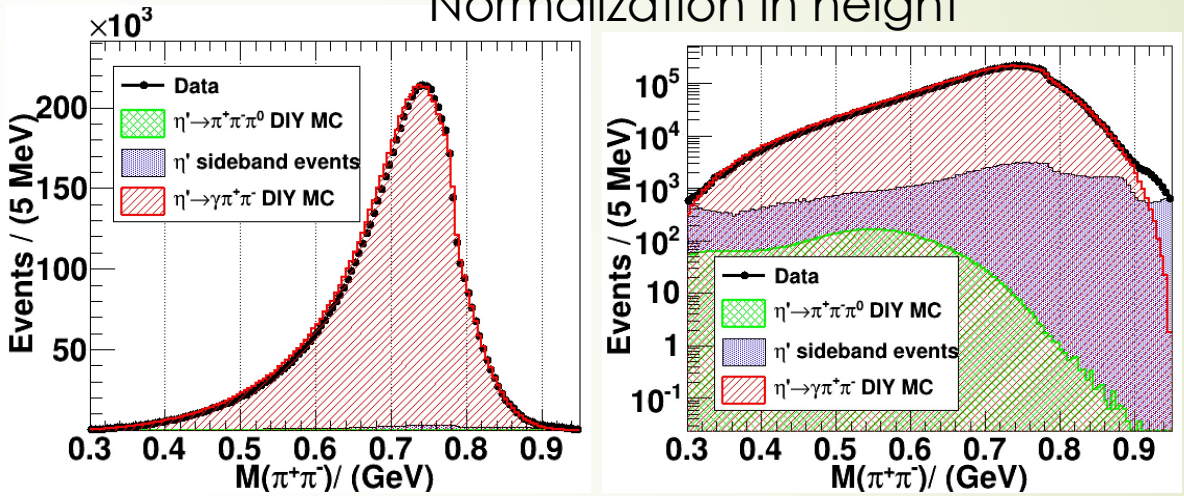
  $40\ \text{MeV} < |M(\gamma\pi^+\pi^-) - m_{\eta'}| < 60$ MeV

Selection criteria

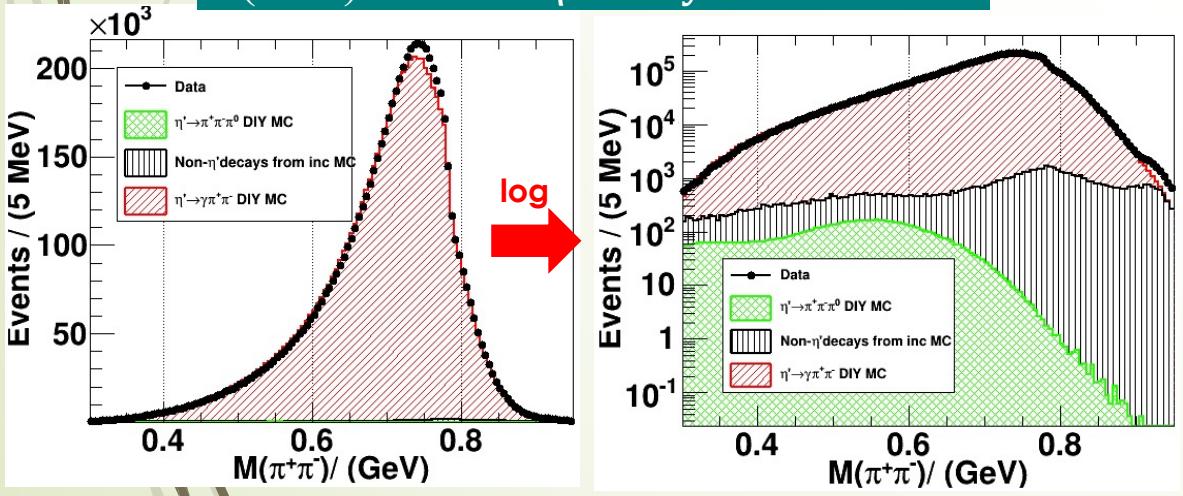
- Peaking bkg: $\eta' \rightarrow \pi^+\pi^-\pi^0$

$\eta' \rightarrow \pi^+\pi^-\pi^0$	Cases	N_gen	N_ survived	ε (%)	N_normalized
09+12 DIY mc	signal region	6,200,000	274,014	4.42	1061
	sideband region		109,901	1.77	426
18+19 DIY mc	signal region	40,000,000	1,688,220	4.22	6777
	sideband region		685,091	1.71	2750

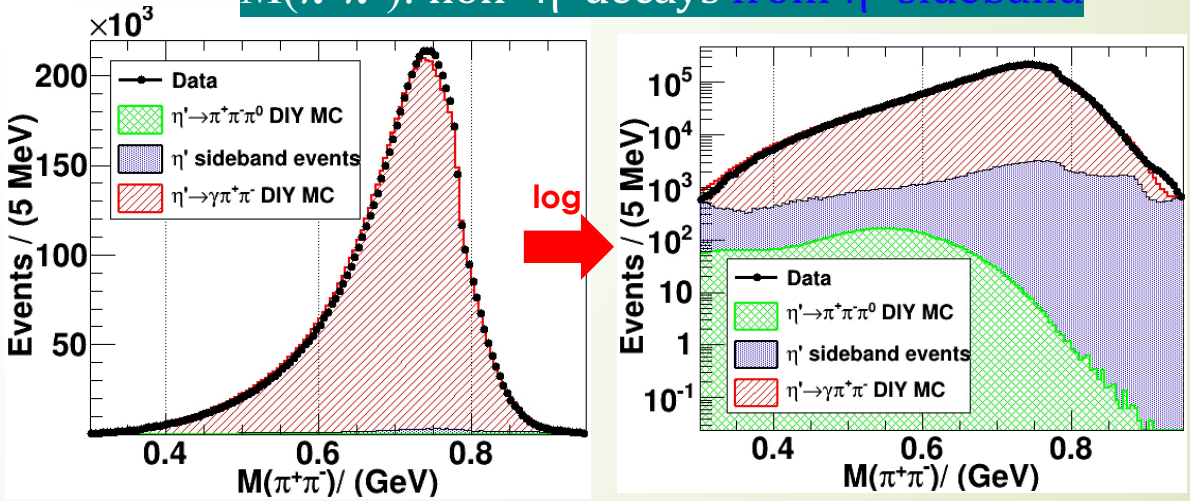
Normalization in height



M($\pi^+\pi^-$): non–η' decays from inc. mc

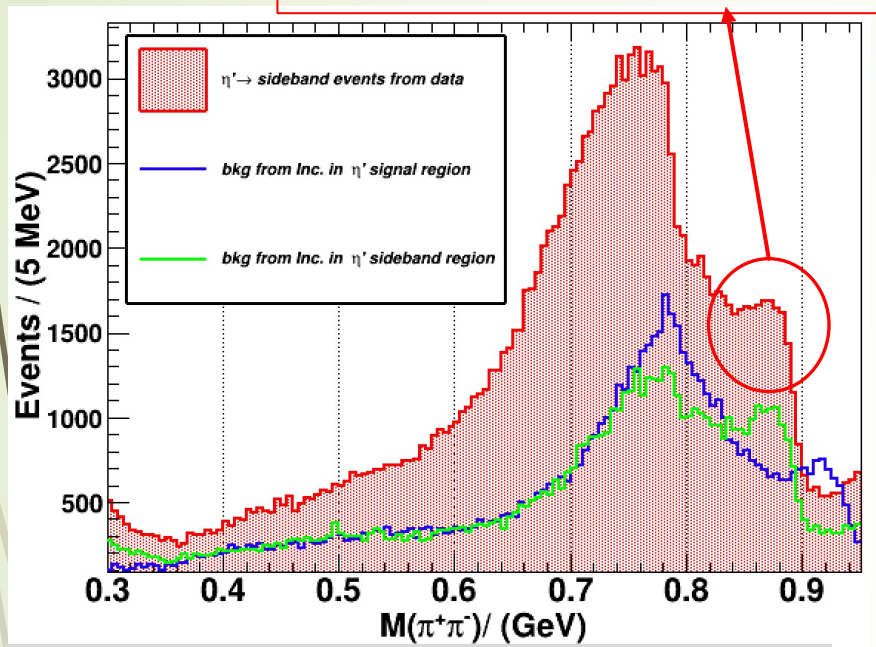


M($\pi^+\pi^-$): non–η' decays from η'-sideband



A Further Check on the sideband events

Bump at ~0.86 GeV is due to the lower sideband of η'

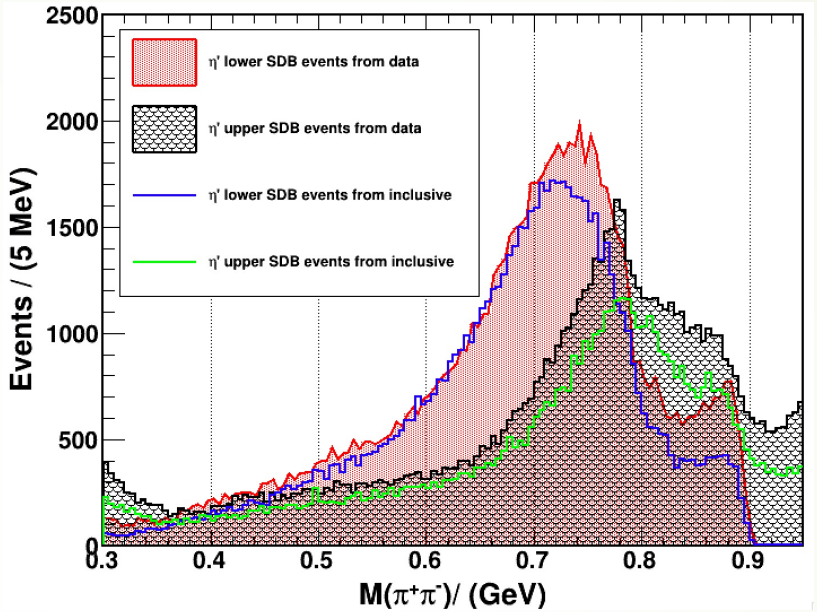


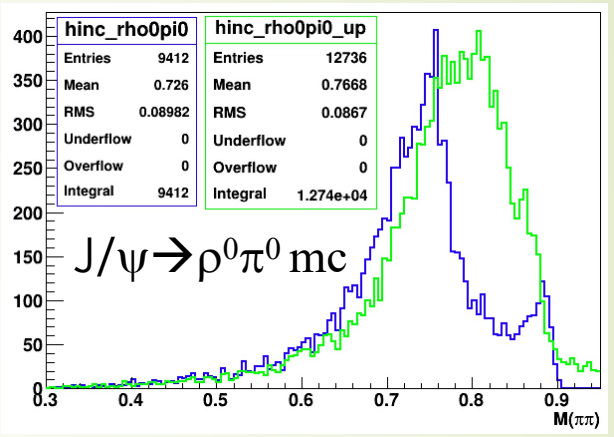
1) Exacted the background events from **inclusive mc** within η' signal/ sideband region, respectively.

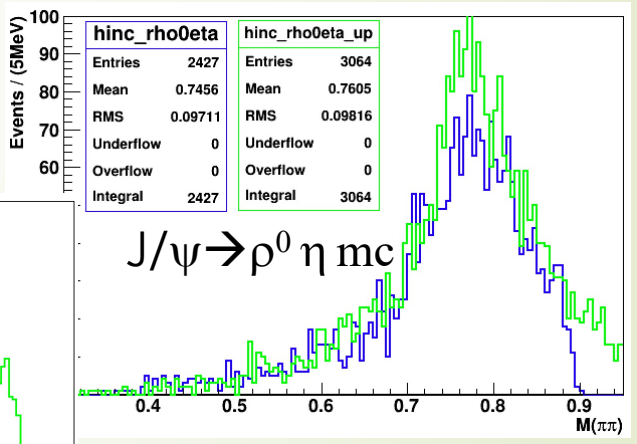
2) It seems that the **η' sideband events** can not describe the background in **η' signal region?**

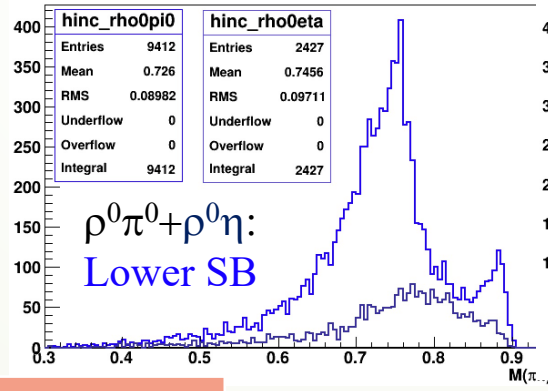
3) Need correction?

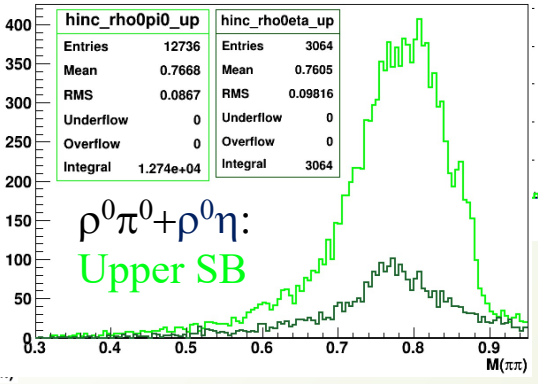
Lower/upper sidebands of η' between data and **inc.**









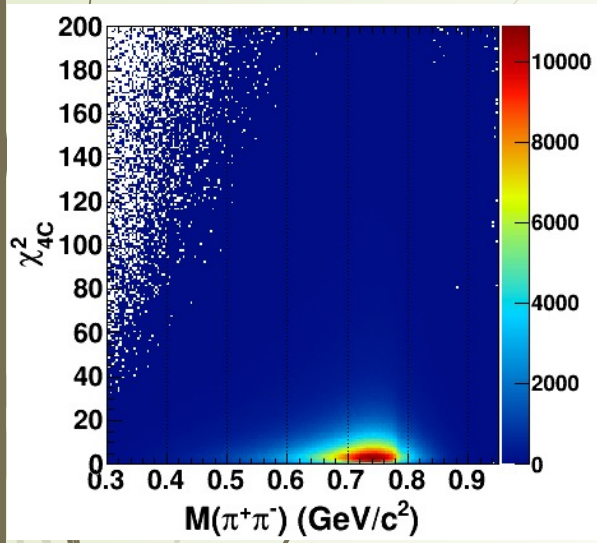


Signal:	$B(J/\psi \to \gamma \eta') = 5.6\times10^{-3}$	$B(\eta' \to \gamma\pi^+\pi^-) = 28.9\%$	Product Br $= 1.618\times10^{-3}$
bkg1:	$B(J/\psi \to \rho^0\pi^0) = 5.6\times10^{-3}$	$B(\pi^0 \to \gamma\gamma) = 98.8\%$	5.533×10^{-3}
bkg2	$B(J/\psi \to \pi+\pi-\eta) = 4\times10^{-4}$	$B(\eta \to \gamma\gamma) = 39.41\%$	1.5764×10^{-4}

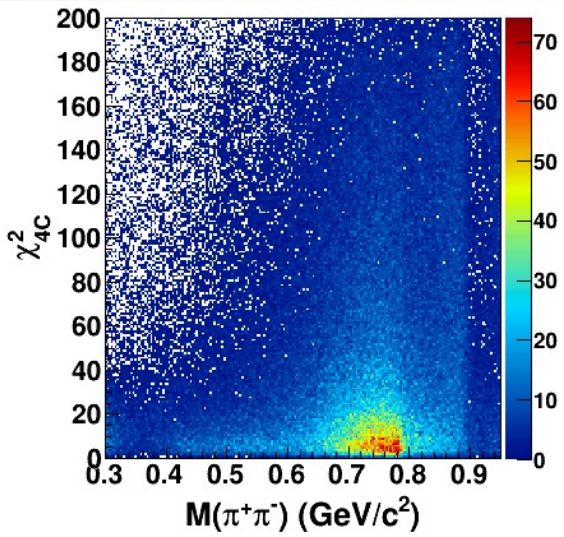
Scatter plots about $M(\pi^+\pi^-)$: Data

$\chi^2(\pi^+\pi^-\gamma\gamma)$ vs $M(\pi^+\pi^-)$

Within η' signal region

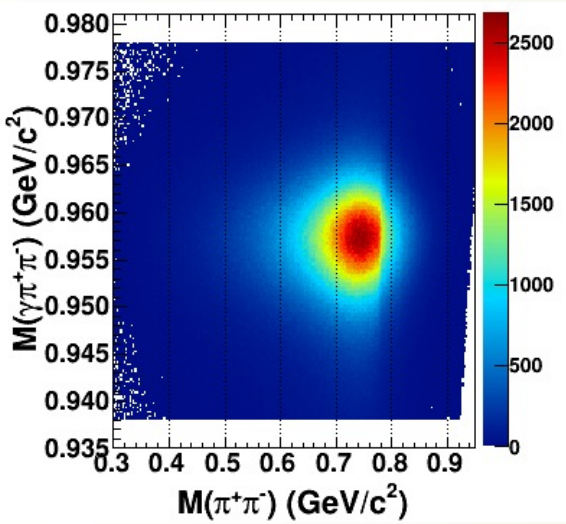


Within η' sideband region

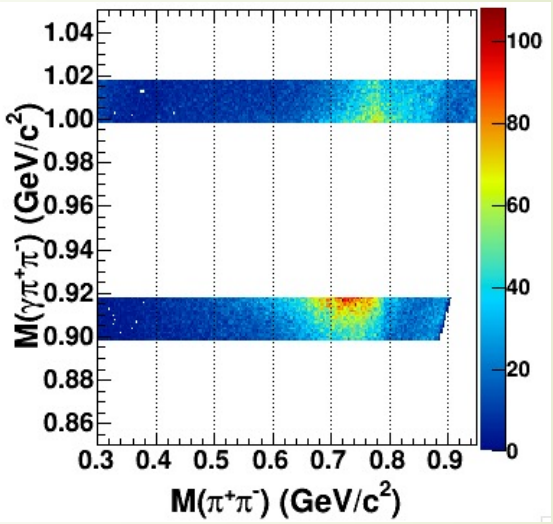


$M(\pi^+\pi^-\gamma)$ vs $M(\pi^+\pi^-)$

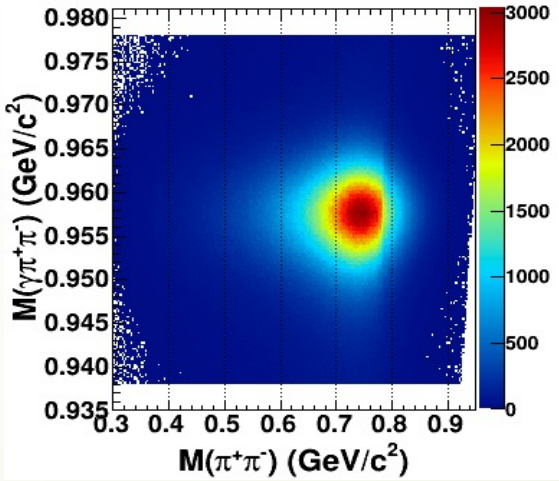
Within η' signal region

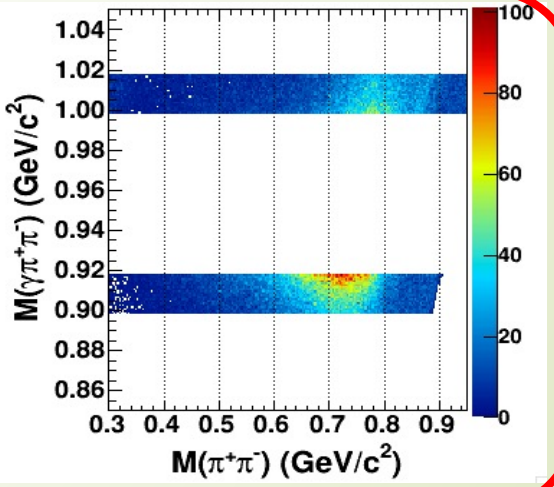


Within η' sideband region



Inclusive mc





Background study with inclusive MC

Without cut: $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$

Table 1: Event trees and their respective initial-final states.

index	event tree (event initial-final states)	iEvtTr	iEvtIFSts	nEvts	nCmltEvts
1	$e^+e^- \to J/\psi, J/\psi \to \eta'\gamma, \eta' \to \pi^+\pi^-\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma)$	0	0	7777179	7777179
2	$e^+e^- \to J/\psi, J/\psi \to \eta'\gamma, \eta' \to \pi^+\pi^-\gamma\gamma_{FSR}$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma_{FSR})$	3	2	117891	7895070
3	$e^+e^- \to J/\psi, J/\psi \to \pi^0\rho^0, \rho^0 \to \pi^+\pi^-$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma)$	1	0	25019	7920089
4	$e^+e^- \to J/\psi, J/\psi \to \pi^0 h_1(1170), h_1(1170) \to \pi^0\rho^0, \rho^0 \to \pi^+\pi^-$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma\gamma)$	7	1	13696	7933785
5	$e^+e^- \to J/\psi, J/\psi \to \pi^0 h_1(1170), h_1(1170) \to \pi^-\rho^+, \rho^+ \to \pi^0\pi^+$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma\gamma)$	2	1	11085	7944870
6	$e^+e^- \to J/\psi, J/\psi \to \pi^0 h_1(1170), h_1(1170) \to \pi^+\rho^-, \rho^- \to \pi^0\pi^-$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma\gamma)$	5	1	11027	7955897
7	$e^+e^- \to J/\psi, J/\psi \to \eta'\gamma, \eta' \to \pi^0\pi^+\pi^-$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma)$	4	3	8415	7964312
8	$c^+c^- \to J/\psi, J/\psi \to \rho^0\eta, \rho^0 \to \pi^+\pi^-, \eta \to \gamma\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma)$	12	0	5408	7969720
9	$e^+e^- \to J/\psi, J/\psi \to e^+e^-\gamma_{FSR}\gamma_{FSR}$ $(e^+e^- \to e^+e^-\gamma_{FSR}\gamma_{FSR})$	16	7	4594	7974314
10	$e^+e^- \to J/\psi, J/\psi \to e^+e^-\gamma_{FSR}$ $(e^+e^- \to e^+e^-\gamma_{FSR})$	25	11	4185	7978499
11	$e^+e^- \to J/\psi, J/\psi \to \pi^+\pi^-\omega, \omega \to \pi^0\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma)$	15	3	3388	7981887
12	$e^+e^- \to J/\psi, J/\psi \to \pi^+\pi^-\eta\gamma, \eta \to \gamma\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma)$	9	3	2725	7984612
13	$e^+e^- \to J/\psi, J/\psi \to \pi^0\rho^0, \rho^0 \to \pi^+\pi^-\gamma_{FSR}$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma_{FSR})$	17	2	2475	7987087
14	$e^+e^- \to J/\psi, J/\psi \to \pi^+\pi^-\eta, \eta \to \gamma\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma)$	18	0	2454	7989541
15	$e^+e^- \to J/\psi, J/\psi \to \eta_c\gamma, \eta_c \to \pi^0\pi^+\pi^-$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma)$	34	3	2093	7991634
16	$e^+e^- \to J/\psi, J/\psi \to \pi^0\rho^0, \rho^0 \to \pi^+\pi^-\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma)$	23	3	1629	7993263
17	$e^+e^- \to J/\psi, J/\psi \to e^+e^-$ $(e^+e^- \to e^+e^-)$	13	5	1243	7994506

Background level: 1.51%

where the ratio of peaking bkg $\eta' \to \pi^+\pi^-\pi^0$: ~0.1% (7.0%)

Background study with inclusive MC

With cut: $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$

index	event tree (event initial-final states)	iEvtTr	iEvtIFSts	nEvts	nCmltEvts
1	$e^+e^- \to J/\psi, J/\psi \to \eta'\gamma, \eta' \to \pi^+\pi^-\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma)$	0	0	7604955	7604955
2	$e^+e^- \to J/\psi, J/\psi \to \eta'\gamma, \eta' \to \pi^+\pi^-\gamma\gamma_{FSR}$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma_{FSR})$	4	3	91480	7696435
3	$e^+e^- \to J/\psi, J/\psi \to \pi^0\rho^0, \rho^0 \to \pi^+\pi^-$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma)$	1	0	23565	7720000
4	$e^+e^- \to J/\psi, J/\psi \to \rho^0\eta, \rho^0 \to \pi^+\pi^-, \eta \to \gamma\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma)$	8	0	5338	7725338
5	$e^+e^- \to J/\psi, J/\psi \to e^+e^-\gamma_{FSR}\gamma_{FSR}$ $(e^+e^- \to e^+e^-\gamma_{FSR}\gamma_{FSR})$	10	5	4403	7729741
6	$e^+e^- \to J/\psi, J/\psi \to e^+e^-\gamma_{FSR}$ $(e^+e^- \to e^+e^-\gamma_{FSR})$	16	7	4118	7733859
7	$e^+e^- \to J/\psi, J/\psi \to \eta'\gamma, \eta' \to \pi^0\pi^+\pi^-$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma)$	2	1	3460	7737319
8	$e^+e^- \to J/\psi, J/\psi \to \pi^0 h_1(1170), h_1(1170) \to \pi^0\rho^0, \rho^0 \to \pi^+\pi^-$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma\gamma)$	5	2	2980	7740299
9	$e^+e^- \to J/\psi, J/\psi \to \pi^+\pi^-\eta, \eta \to \gamma\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma)$	11	0	2422	7742721
10	$e^+e^- \to J/\psi, J/\psi \to \pi^0 h_1(1170), h_1(1170) \to \pi^+\rho^-, \rho^- \to \pi^0\pi^-$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma\gamma)$	3	2	2187	7744908
11	$e^+e^- \to J/\psi, J/\psi \to \pi^0 h_1(1170), h_1(1170) \to \pi^-\rho^+, \rho^+ \to \pi^0\pi^+$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma\gamma)$	19	2	2091	7746999
12	$e^+e^- \to J/\psi, J/\psi \to e^+e^-$ $(e^+e^- \to e^+e^-)$	9	4	1224	7748223
13	$e^+e^- \to J/\psi, J/\psi \to \pi^+\pi^-\omega, \omega \to \pi^0\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma)$	24	1	1046	7749269
14	$e^+e^- \to J/\psi, J/\psi \to \pi^+\pi^-\eta\gamma, \eta \to \gamma\gamma$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma)$	7	1	997	7750266
15	$e^+e^- \to J/\psi, J/\psi \to \pi^0\rho^0, \rho^0 \to \pi^+\pi^-\gamma_{FSR}$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma\gamma_{FSR})$	14	3	958	7751224
16	$e^+e^- \to J/\psi, J/\psi \to \eta\omega, \eta \to \gamma\gamma, \omega \to \pi^+\pi^-$ $(e^+e^- \to \pi^+\pi^-\gamma\gamma)$	13	0	855	7752079
17	$e^+e^- \to J/\psi, J/\psi \to \eta'\gamma, \eta' \to \mu^+\mu^-\gamma$ $(e^+e^- \to \mu^+\mu^-\gamma\gamma)$	32	12	807	7752886

Background level: 0.87%

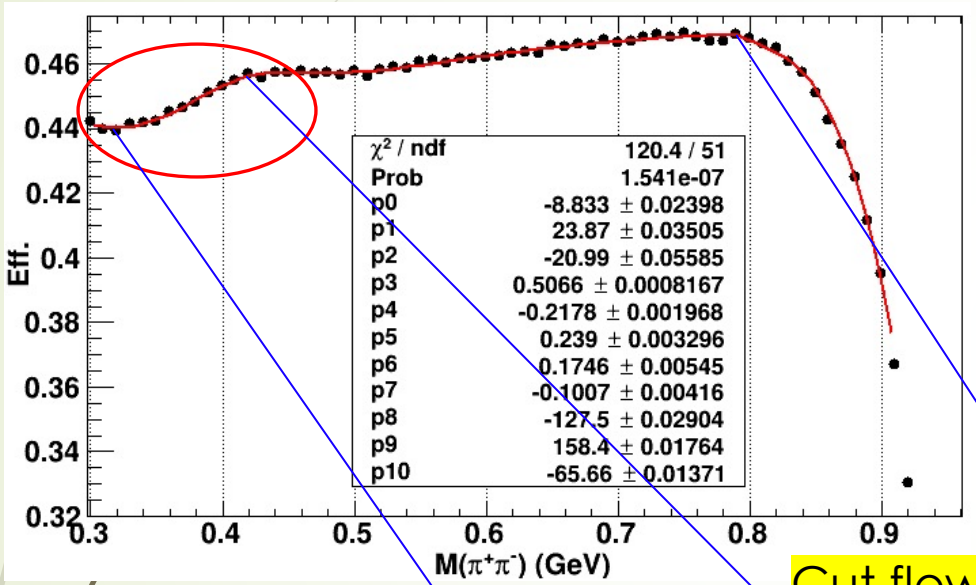
where the ratio of peaking bkg $\eta' \to \pi^+\pi^-\pi^0$: ~0.045% (5.1%)

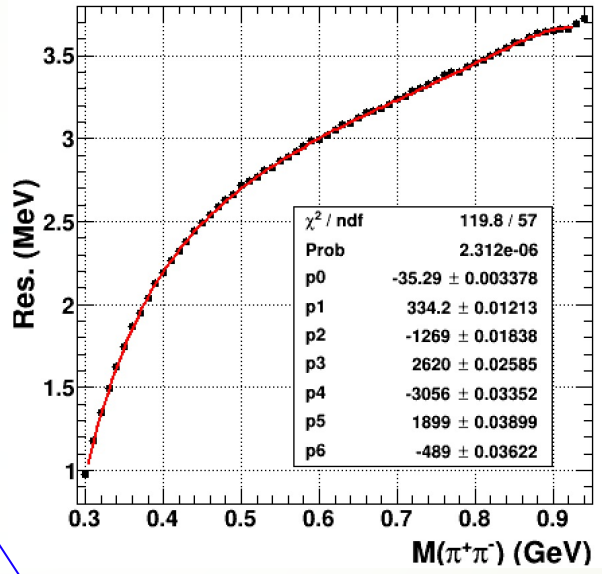
Efficiency loss: ~ 2.65%
Veto background: ~44.2%

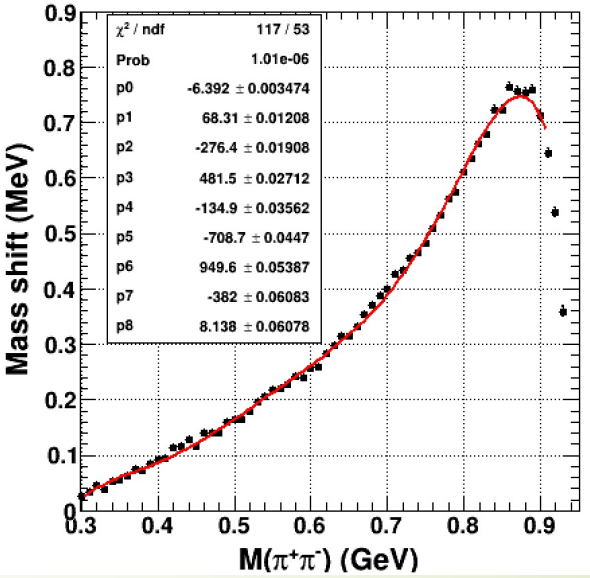
Cut of $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$ is applied to further suppress the background.

Corrections for the dipion mass spectrum

- $M(\pi^+\pi^-)$–dependent **detection efficiency**, **mass resolution**, and the **mass shift**

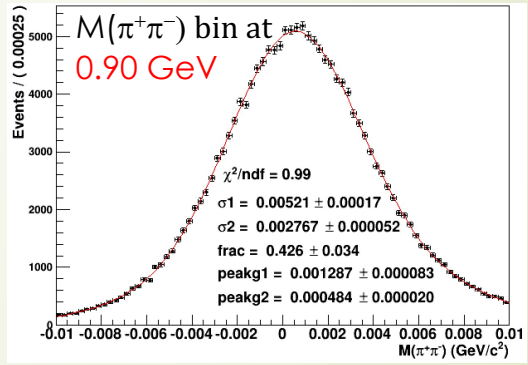






Cut flow

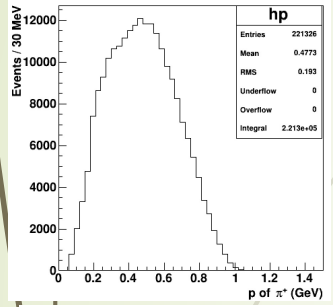
cuts	ε of $M(\pi^+\pi^-)$ bin at 0.32 GeV	ε of $M(\pi^+\pi^-)$ bin at 0.42 GeV	ε of $M(\pi^+\pi^-)$ bin at 0.79 GeV	ε of $M(\pi^+\pi^-)$ bin at 0.90 GeV
after pre-sel.	47.53%	49.50%	50.97%	47.93%
$\lvert M(\gamma\gamma) - m_{\pi 0} \rvert > 20$ MeV	99.57%	99.66%	99.45%	99.64%
$E_{\gamma 2} > 40$ MeV	99.97%	99.97%	99.64%	89.77%
$\chi^2(\pi^+\pi^-\gamma\gamma) < 100$	97.89%	97.71%	96.93%	95.64%
$\lvert M(\gamma\pi^+\pi^-) - m_{\eta'} \rvert < 20$ MeV	94.90%	94.86%	95.83%	96.35%
$\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$	97.69%	97.59%	97.66%	98.00%

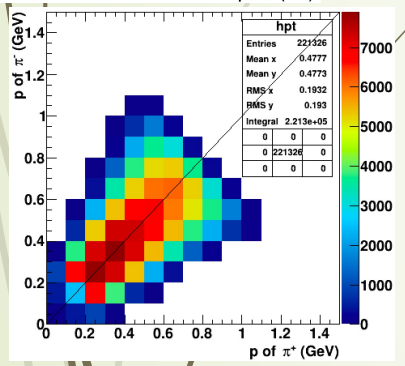


Momentum of π^+ vs π^-

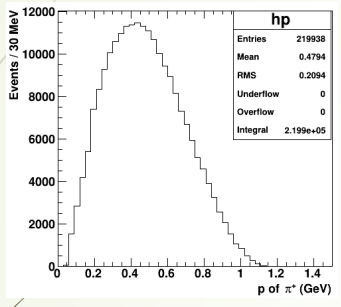
reconstructed after 4C fit

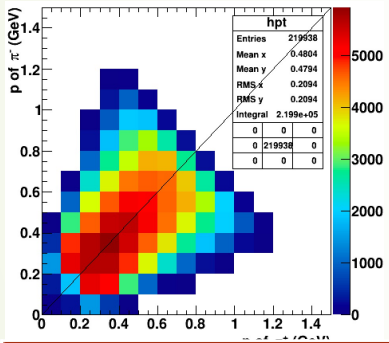
$M(\pi^+\pi^-)$ bin at 300MeV



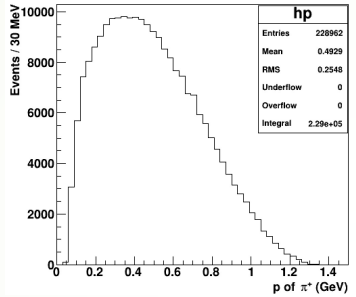


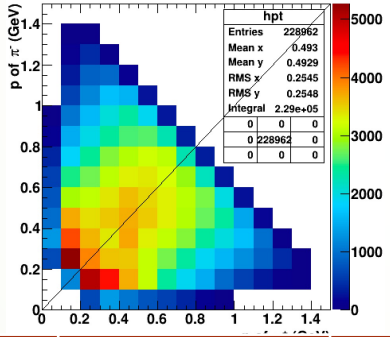
$M(\pi^+\pi^-)$ bin at 320MeV



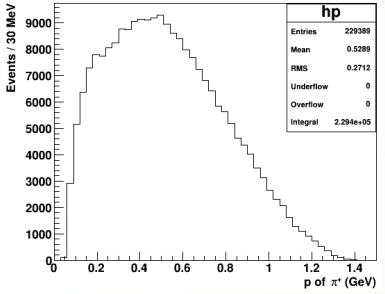


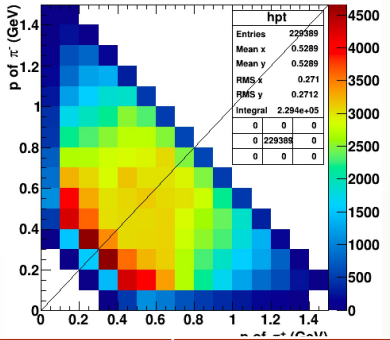
$M(\pi^+\pi^-)$ bin at 420MeV



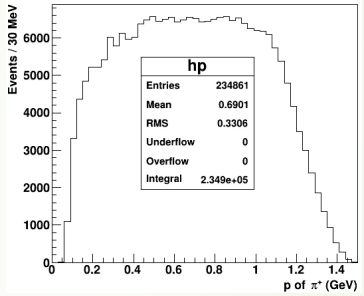


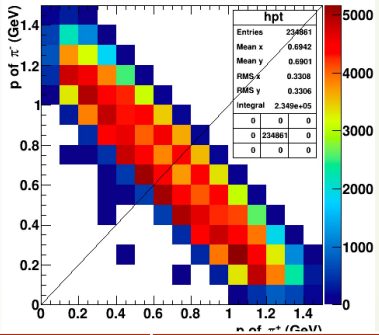
$M(\pi^+\pi^-)$ bin at 520MeV



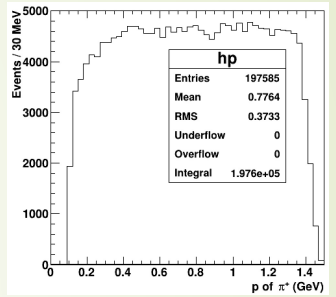


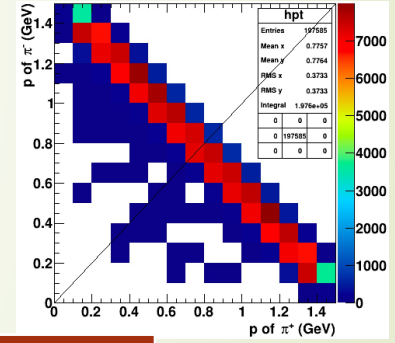
$M(\pi^+\pi^-)$ bin at 790MeV



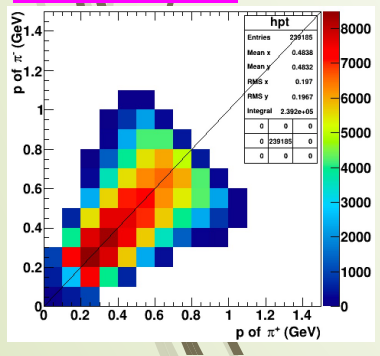


$M(\pi^+\pi^-)$ bin at 900MeV

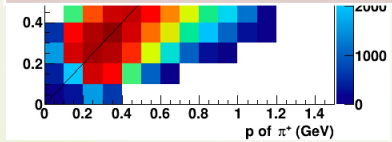


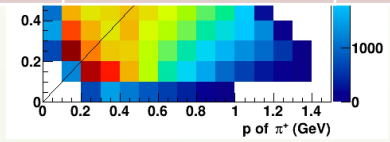


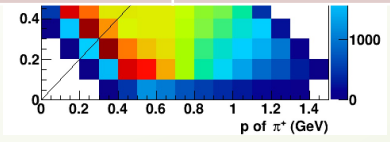
at truth level

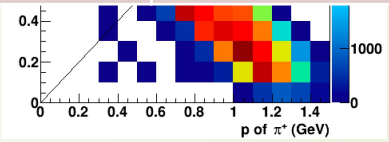


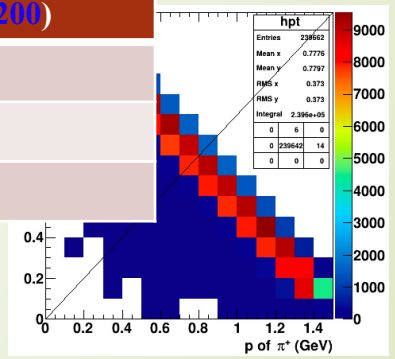
Rec.[%] \ Truth[%]	p(π+)≤150MeV(200MeV)	p(π+) >150MeV (200MeV)	p(π+)≤150MeV&& p(π−)≤150MeV (200)	p(π+) >150MeV&& p(π−) >150MeV (200)
$M(\pi^+\pi^-)$ bin at 0.32 GeV: 44	10.1 (16.5)	89.9 (83.5)	3.7 (8.1)	83.6 (75.2)
$M(\pi^+\pi^-)$ bin at 0.42 GeV: 45.7	9.2 (15.4)	90.8 (84.6)	0 (0.7)	81.8 (69.9)
$M(\pi^+\pi^-)$ bin at 0.52 GeV: 45.8	7.9 (13.3)	92.0 (86.7)	0 (0)	84.0 (73.4)





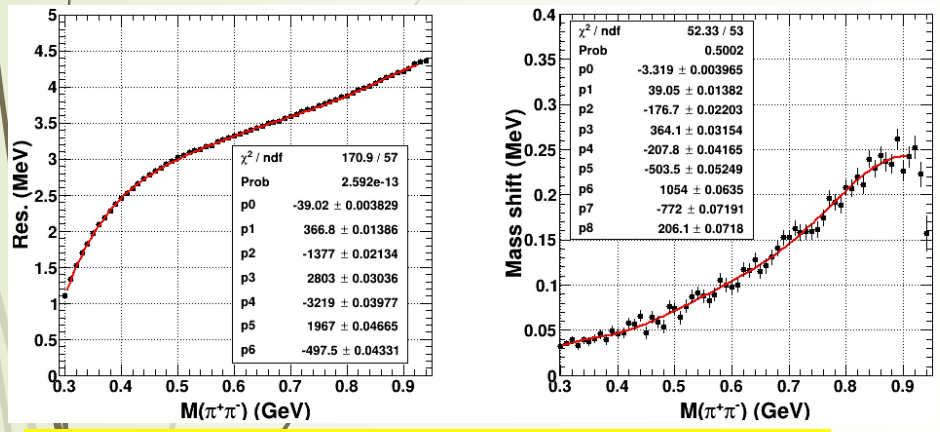






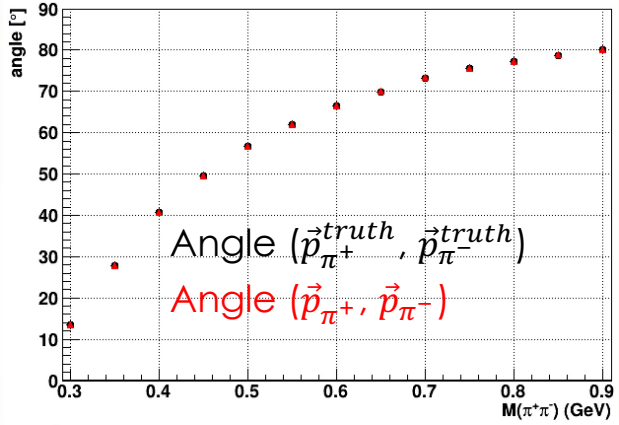
A Further Check on The Corrections

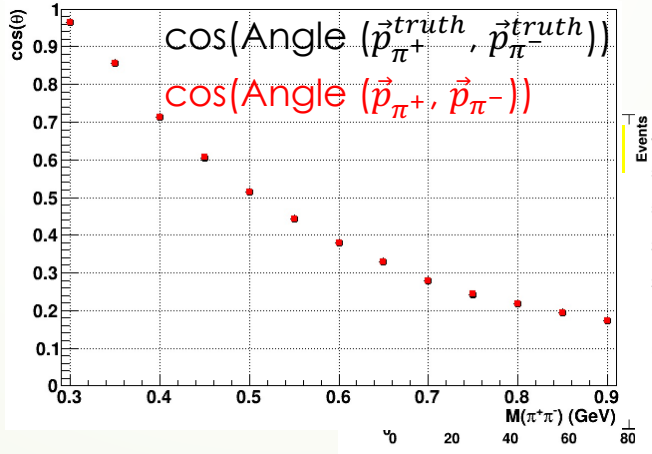
- M($\pi^+\pi^-$)–dependent **mass resolution**, and the **mass shift**, where the M($\pi^+\pi^-$) is reconstructed with info. before 4C-kinematic fit.



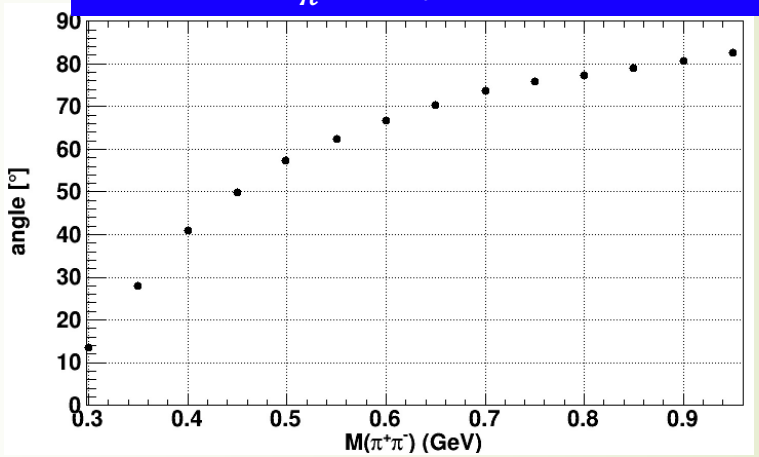
Similar line-shape as those obtained after 4C-kinematic fit

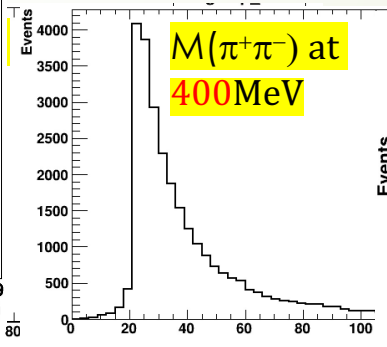
with 4c-fit: Resolution is improved, while the mass shift is getting larger.

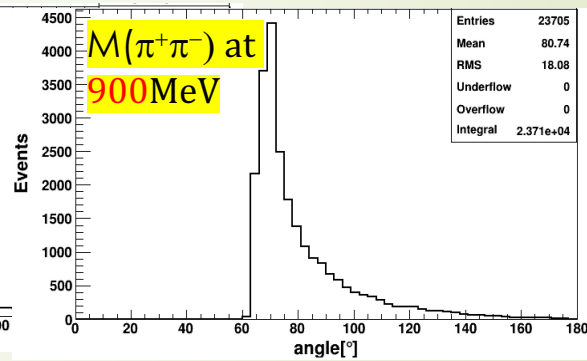




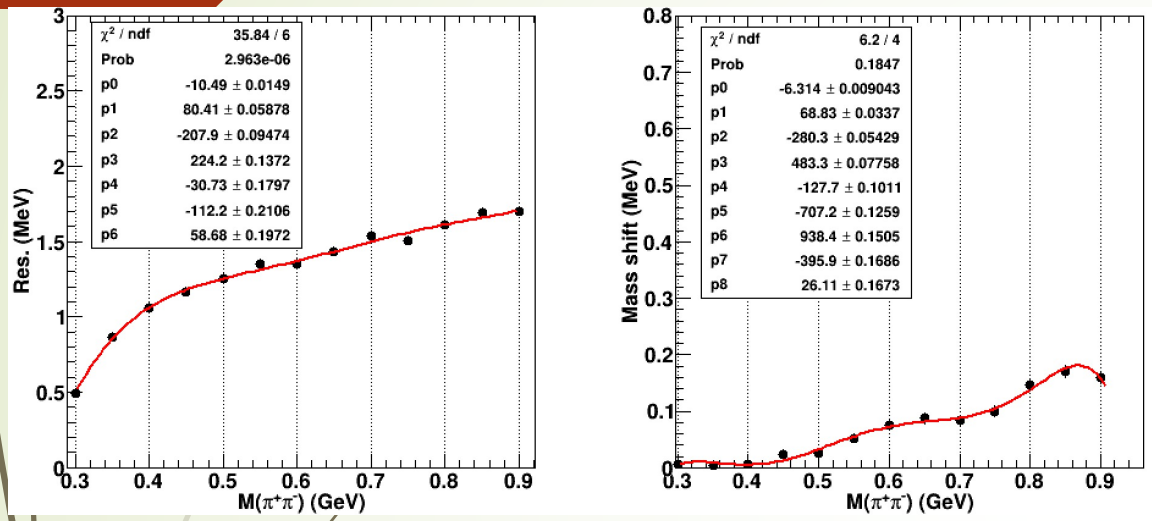
Angle ($\vec{p}_{\pi^+}^{rec}$, $\vec{p}_{\pi^-}^{rec}$): in degree



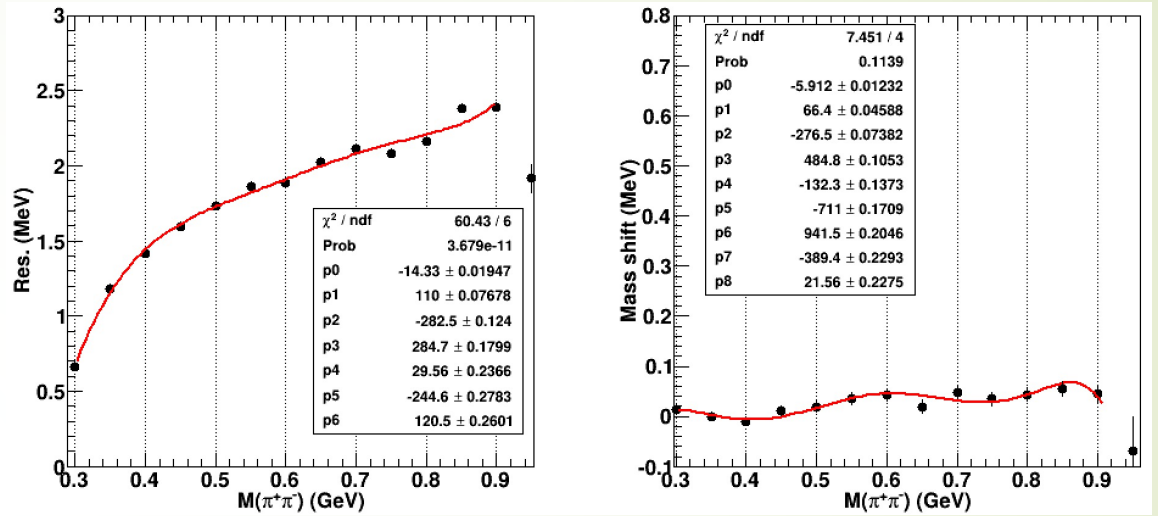




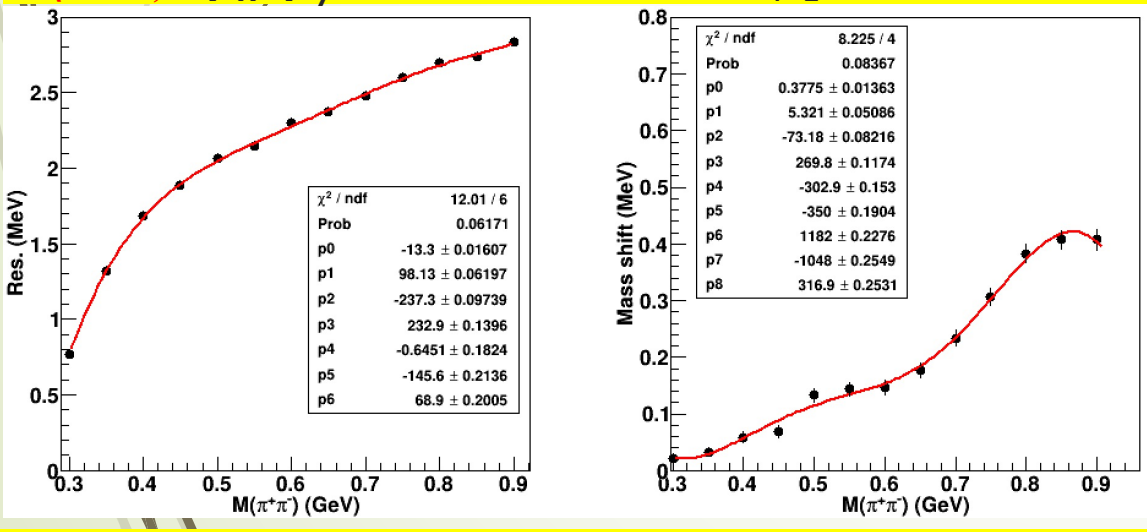
$M(\pi^+\pi^-)$: p_x, p_y **at truth level**, while the p_z is from 4c.



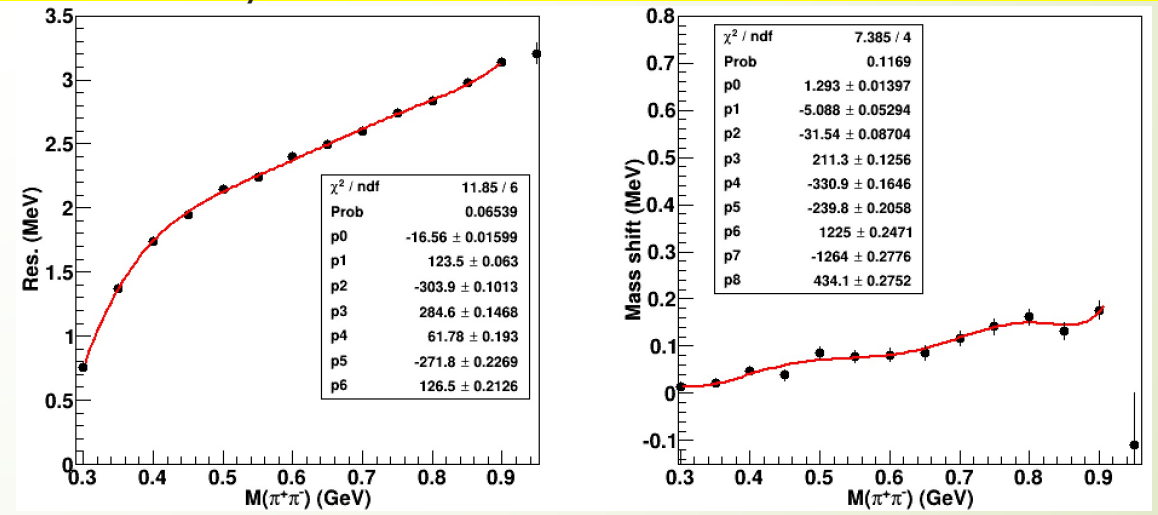
$M(\pi^+\pi^-)$: p_x, p_y **at truth level**, while the p_z is from info. before 4c.



$M(\pi^+\pi^-)$: p_x, p_y **from 4c**, while the p_z is at truth level.



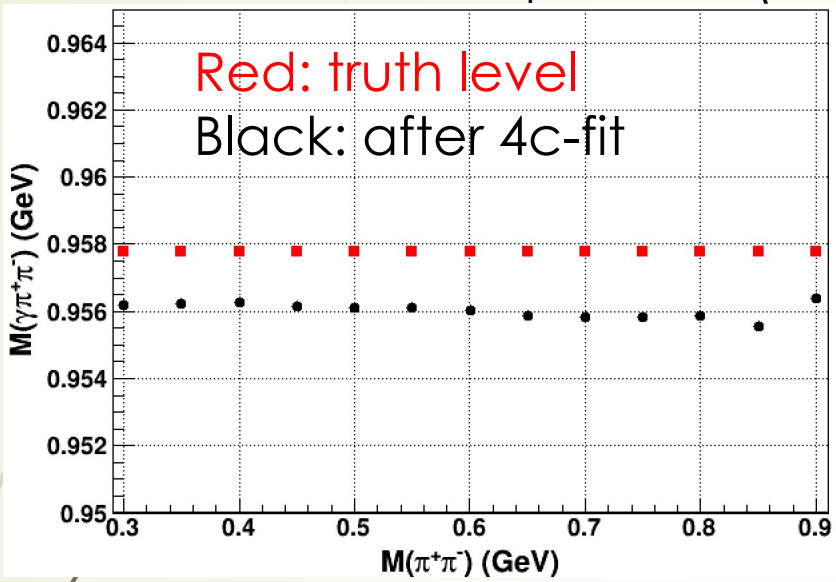
$M(\pi^+\pi^-)$: p_x, p_y **from** info. before 4c, while p_z at truth level

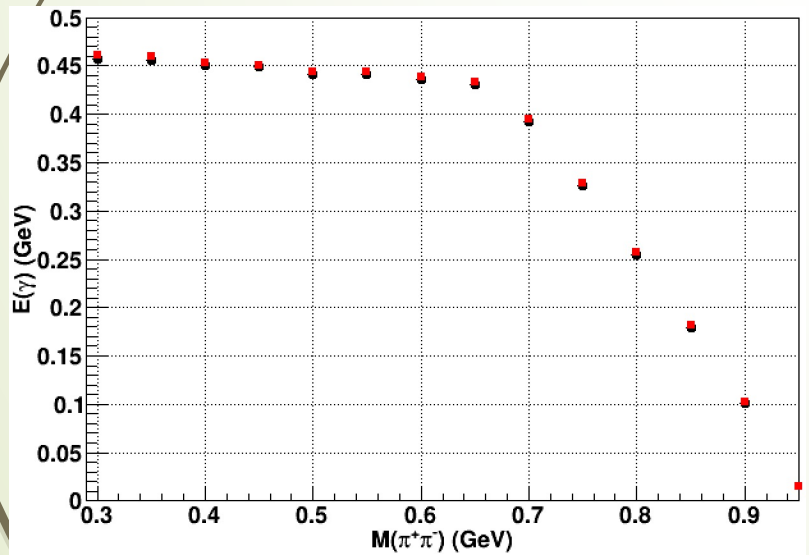


Line-shape of mass shift is similar as those obtained after 4C-kinematic fit.

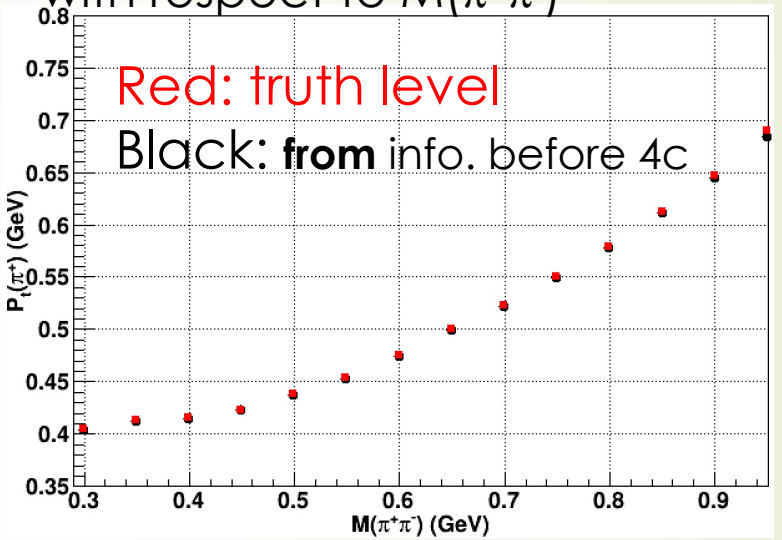
mass shift is sensitive to p_t

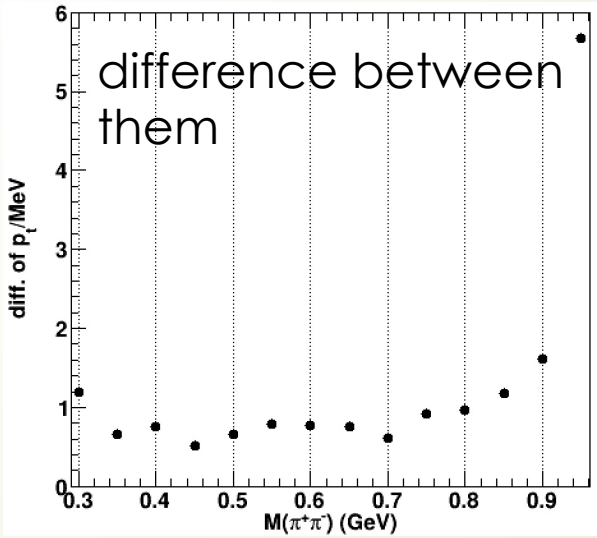
The mean value of $M(\gamma\pi^+\pi^-)$, $E(\gamma)$ distribution with respect to $M(\pi^+\pi^-)$





The mean value of $P_t(\pi^+)$ distribution with respect to $M(\pi^+\pi^-)$





Method 2:

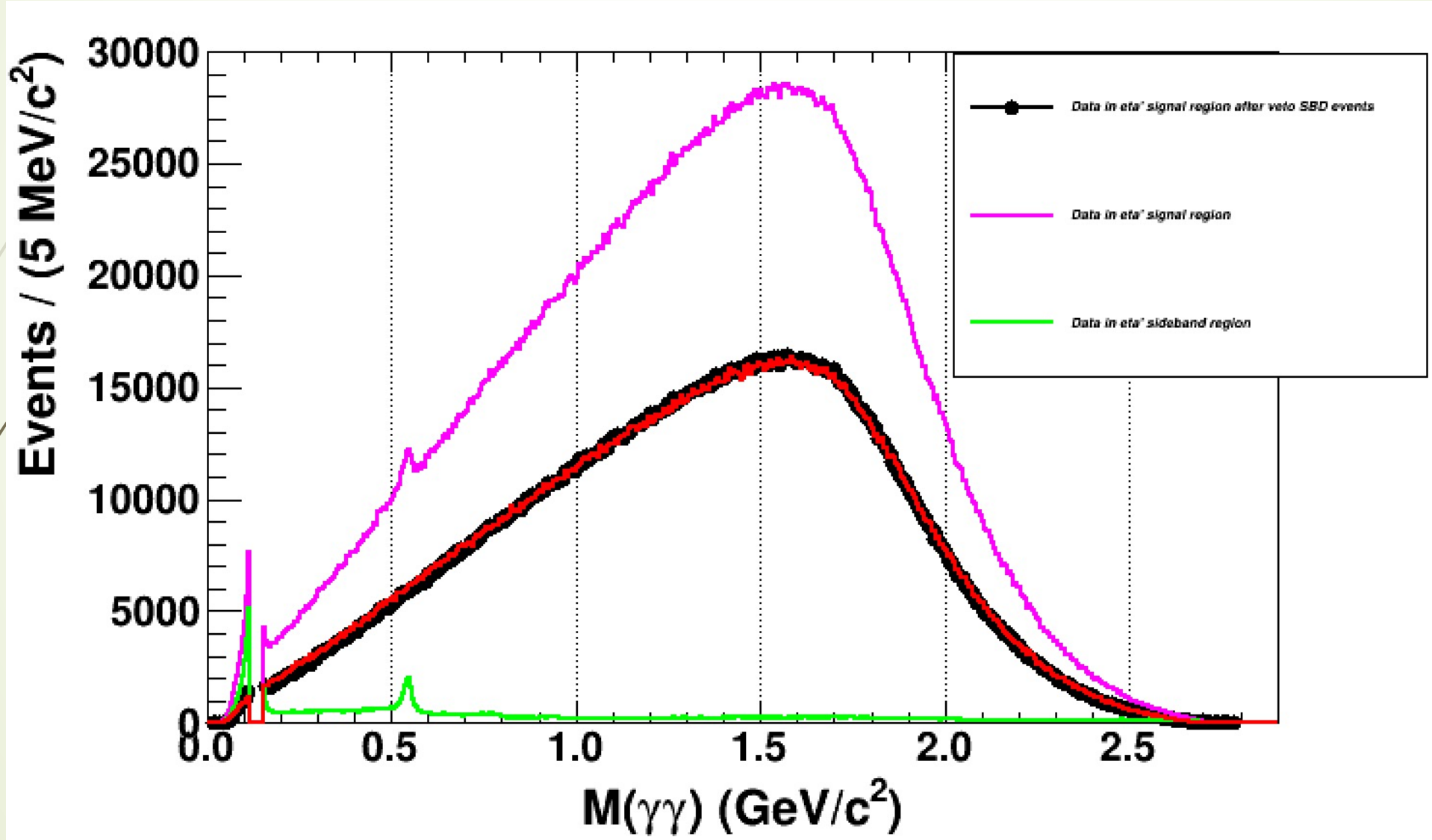
With another two cuts: $\chi^2(\pi^+\pi^-\gamma\gamma) < 30$

- 1c of η', $\chi^2(\eta')$
- **1c of π^0, $\chi^2(\pi^0)$**
- **1c of η, $\chi^2(\eta)$**

$\chi^2(\eta') < \chi^2(\pi^0)$, $\chi^2(\eta') < \chi^2(\eta)$

η signal is still observed in M(γγ) in data!

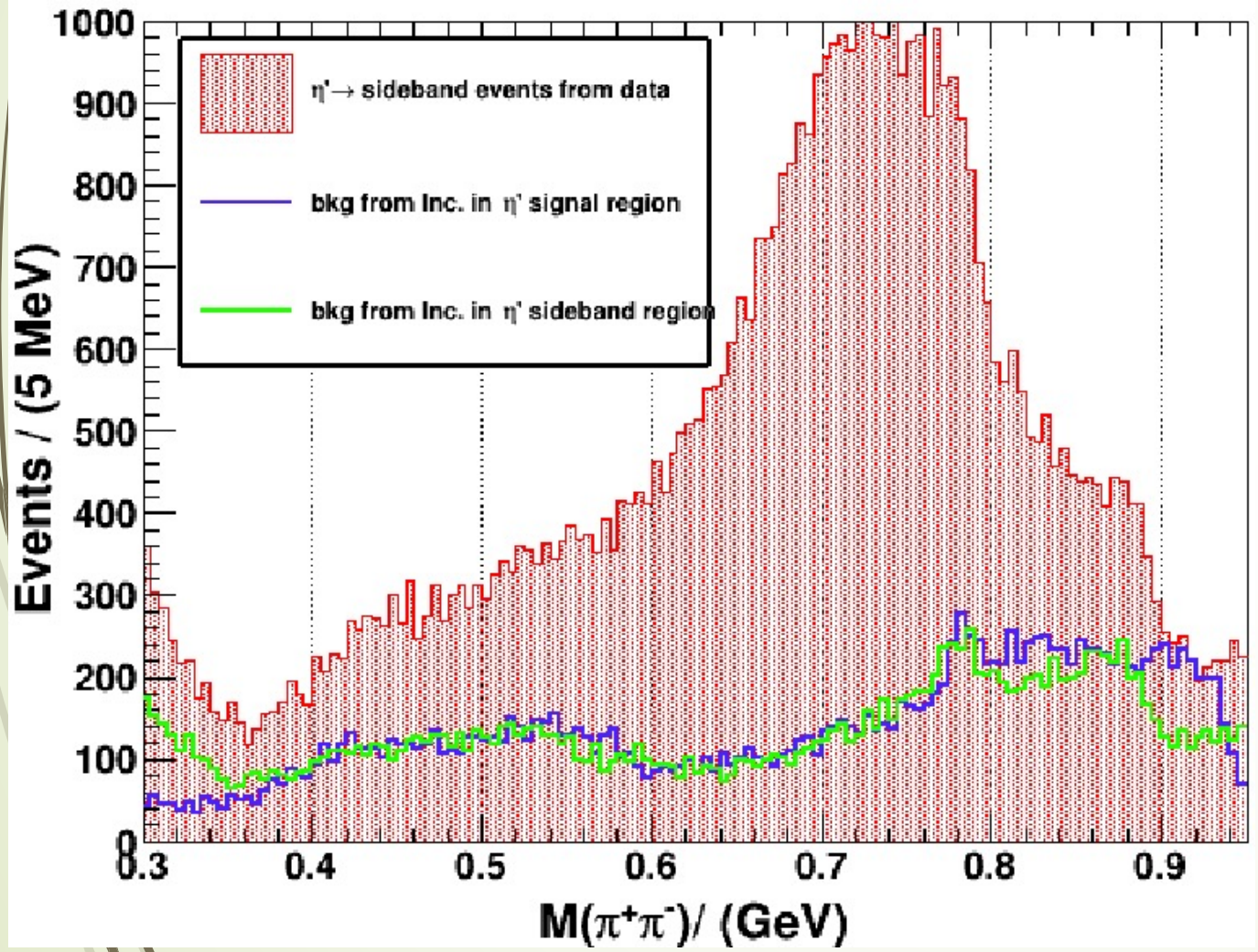
Suppressed the η (J/ψ →ρη) is needed.

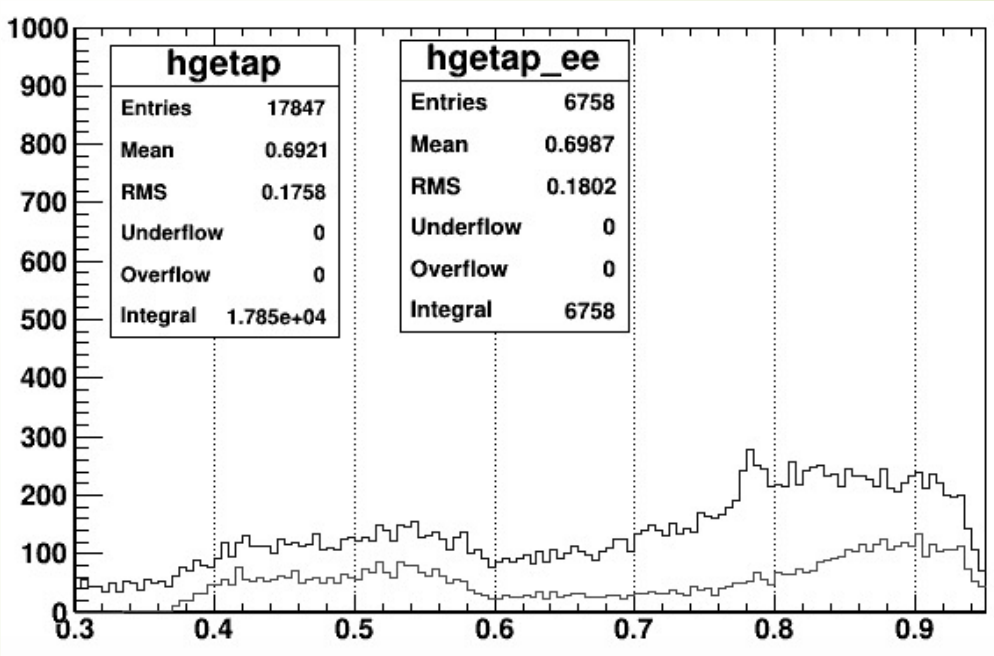


Method 1:

With another two cuts: $\chi^2(\pi^+\pi^-\gamma\gamma) < 30$, $|M(\gamma\gamma) - m_\eta| > 20$ MeV

Background level: 0.87% → 0.5%





Model-dependent study

- Differential rate: $[d\Gamma/dM(\pi^+\pi^-)] = [k_\gamma^3 q_\pi^3(s)/48\pi^3]|\mathcal{A}|^2$, $k_\gamma = (m_{\eta'}^2 - s)/(2m_{\eta'})$, $q_\pi(s) = \sqrt{s - 4m_\pi^2}/2$
- Decay amplitude:

$$\mathcal{A} = \frac{BW_\rho^{\mathrm{GS}}(s)(1 + \delta \frac{s}{M_\omega^2} BW_\omega(s)) + \beta BW_{\rho'}^{\mathrm{GS}}(s)}{1+\beta} \times 2\sqrt{48\pi M_\rho^{-4}} + \alpha,$$

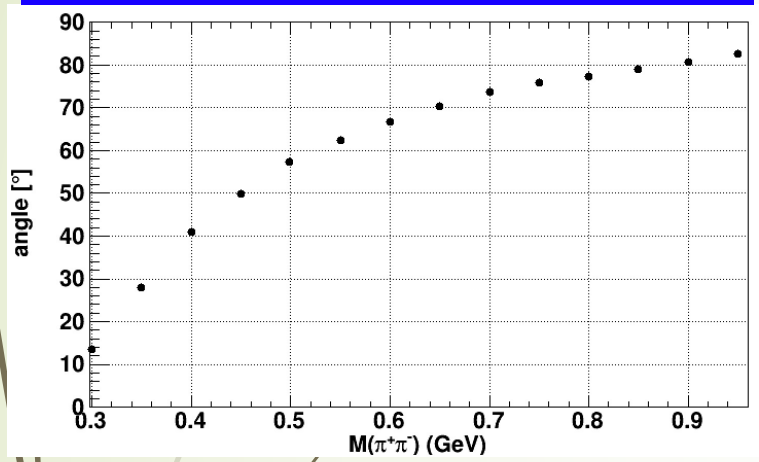
δ, β: **complex** parameters.

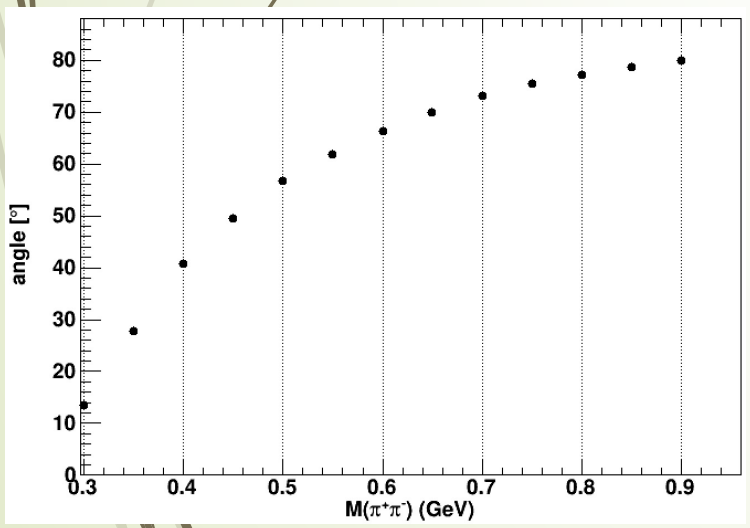
α: a constant accounting for the **box** anomaly.

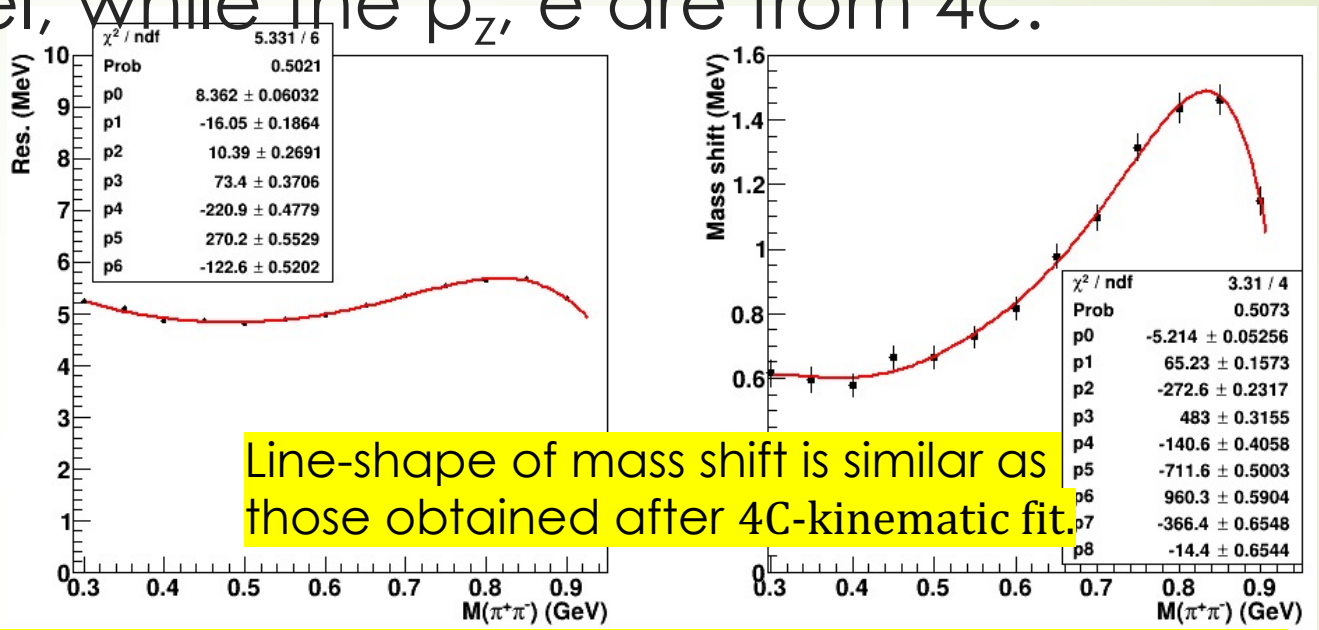
- The PDF is constructed to be: $PDF(m) = \sigma_{\mathrm{res}}(m) \otimes (\epsilon(m) \times \frac{d\Gamma}{dm}) + BKG(m)$

Re-calculate the $M(\pi^+\pi^-)$ with p_x, p_y at truth level, while the p_z, e are from 4c.

Angle $(\vec{p}_{\pi^+}^{rec}, \vec{p}_{\pi^-}^{rec})$: in degree

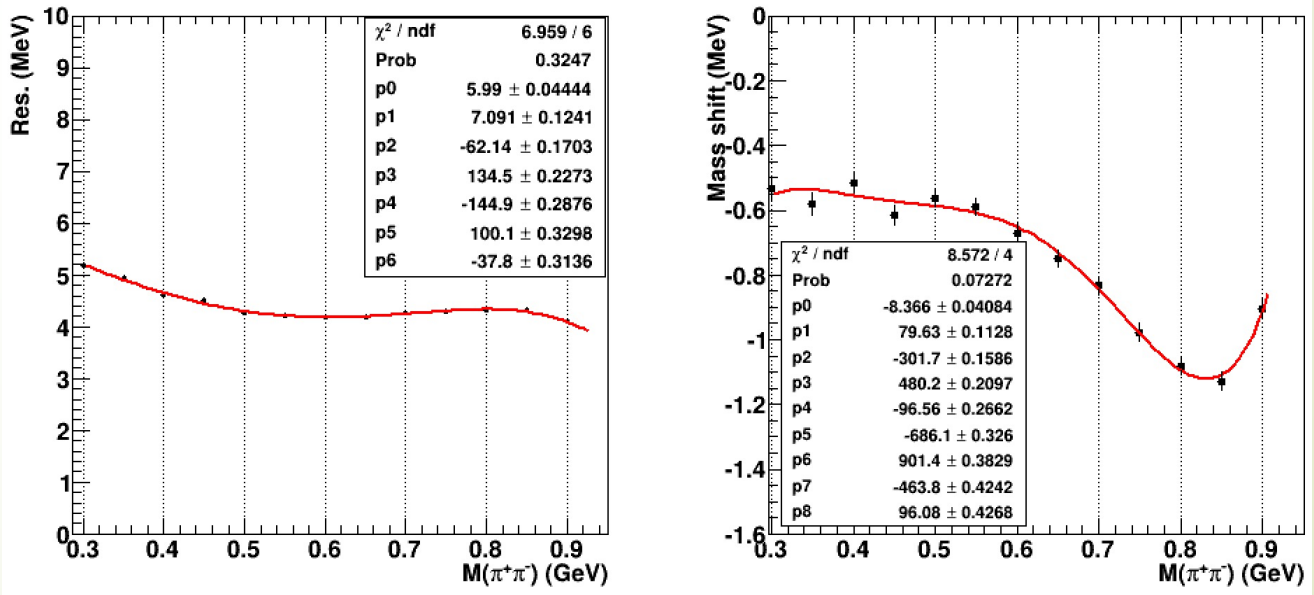






Line-shape of mass shift is similar as those obtained after 4C-kinematic fit.

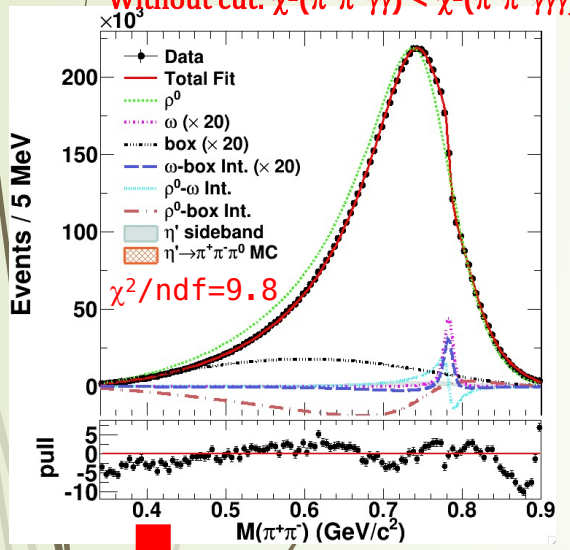
$M(\pi^+\pi^-)$: p_x, p_y from 4c, while the p_z, e are at truth level.



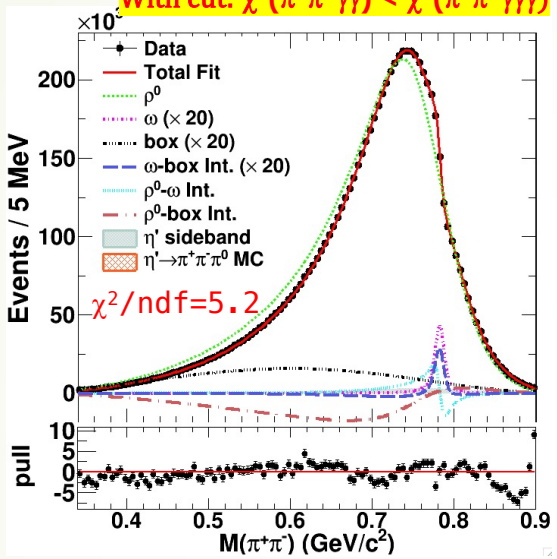
Model-dependent study

Model 1:ρ^0-ω-box anomaly

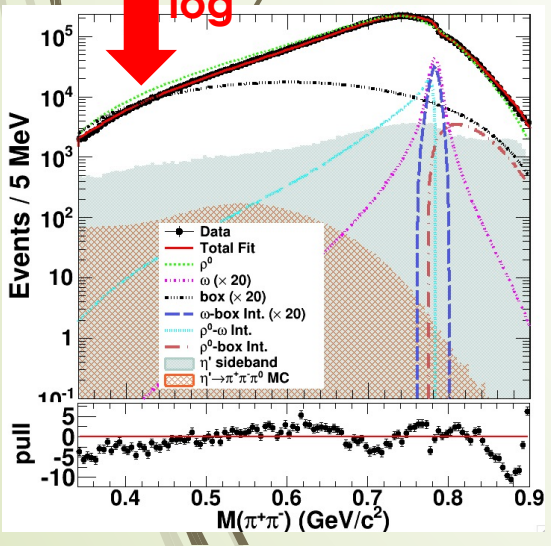
Without cut: $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$



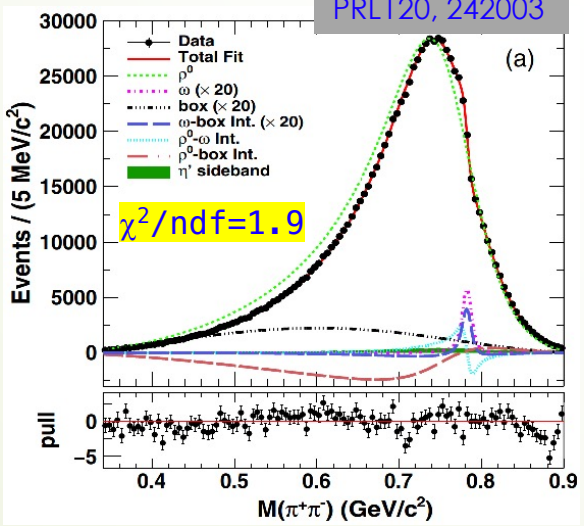
With cut: $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$



log

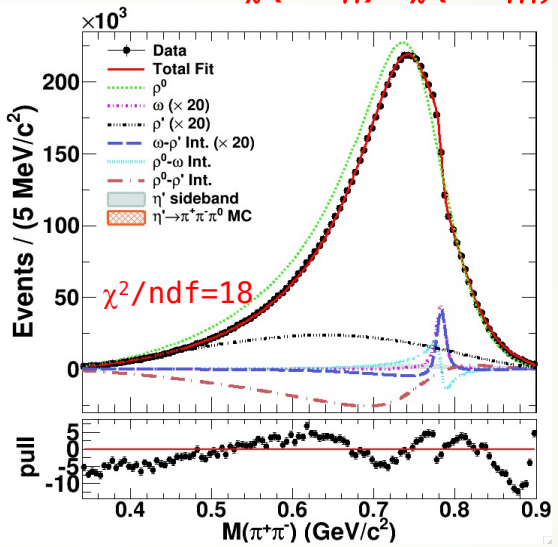


PRL120, 242003

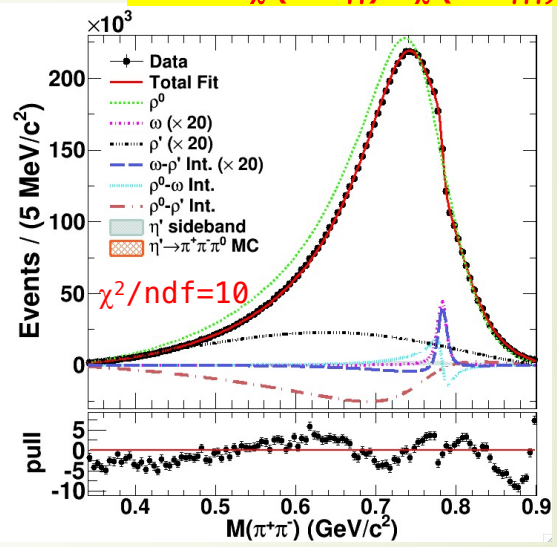


Model 2: ρ^0-ω-$\rho(1450)$

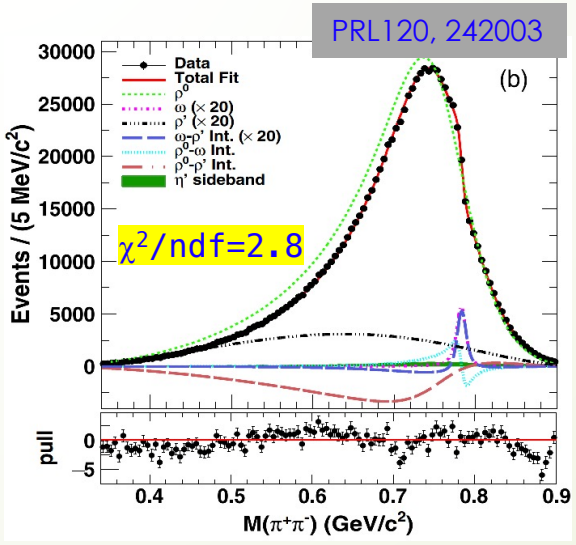
Without cut: $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$



With cut: $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$



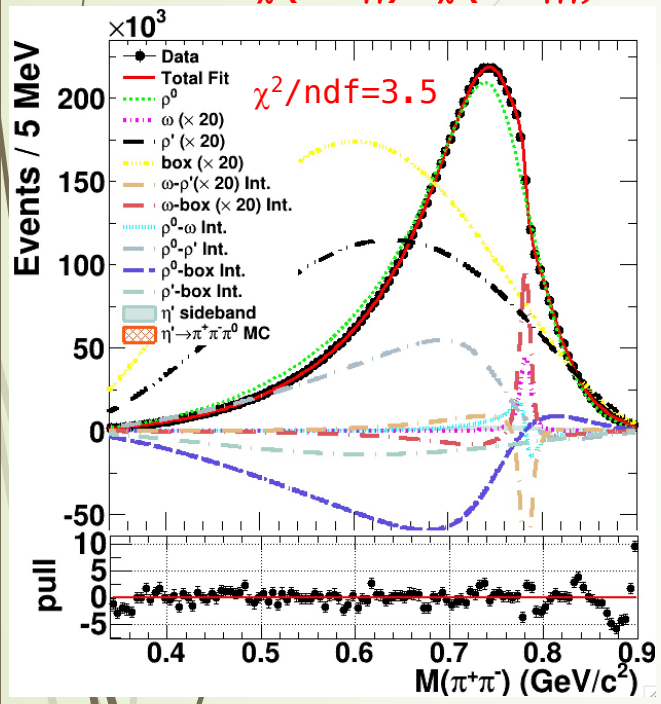
PRL120, 242003



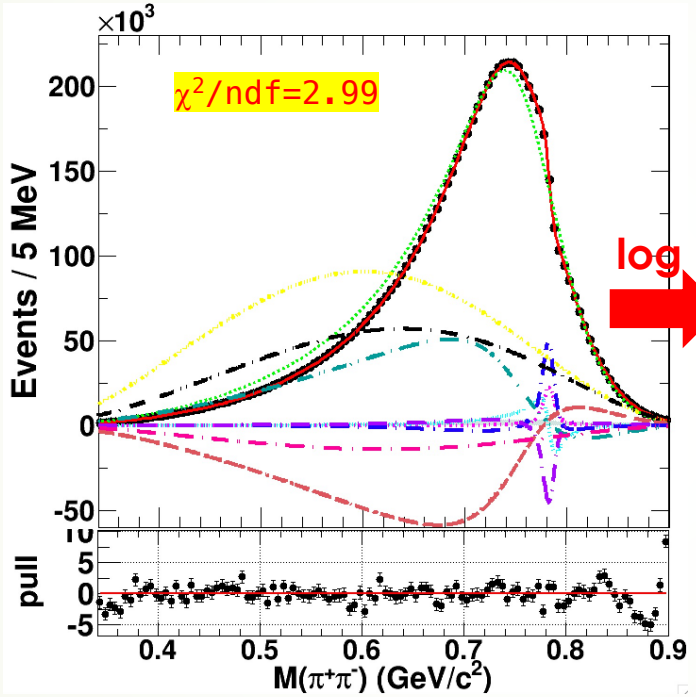
Model-dependent study

Model 3: ρ^0-ω-$\rho(1450)$-box anomaly

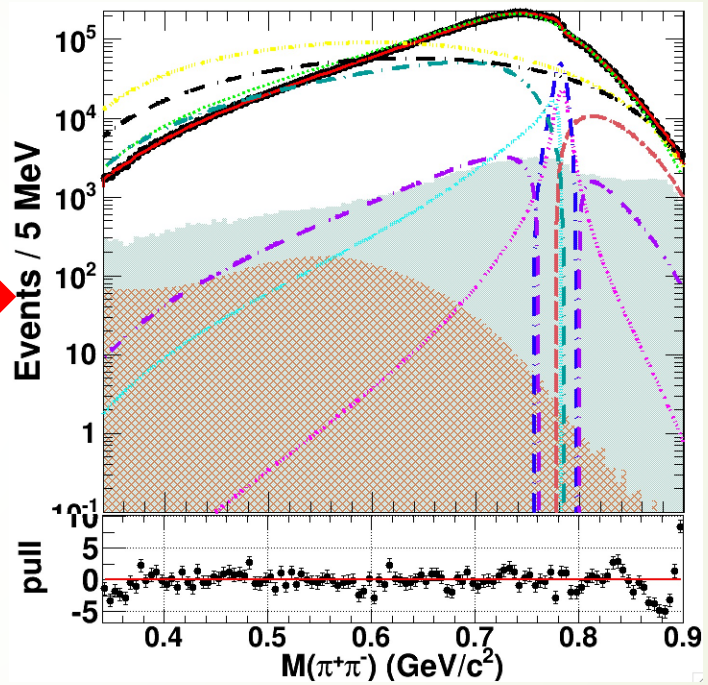
Without cut: $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$

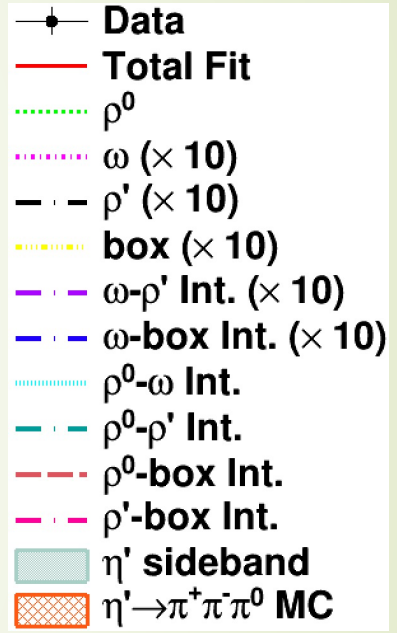


With cut: $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$



log





NLL = −7962492

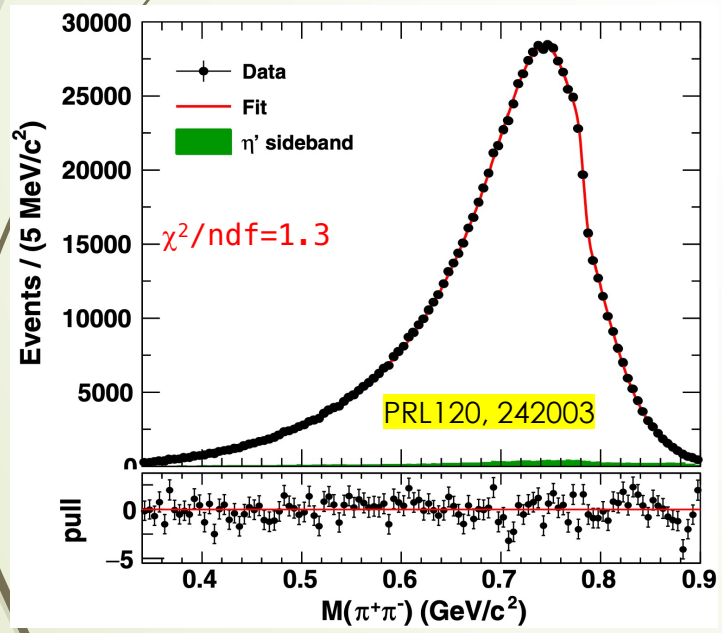
Model-independent study

- Based on a combination of chiral perturbation theory (ChPT)-extended from SU(3) to U(3), and a dispersive analysis.
- **Decay amplitude follows:** $\mathcal{A} = NP(s)F_V(s)$

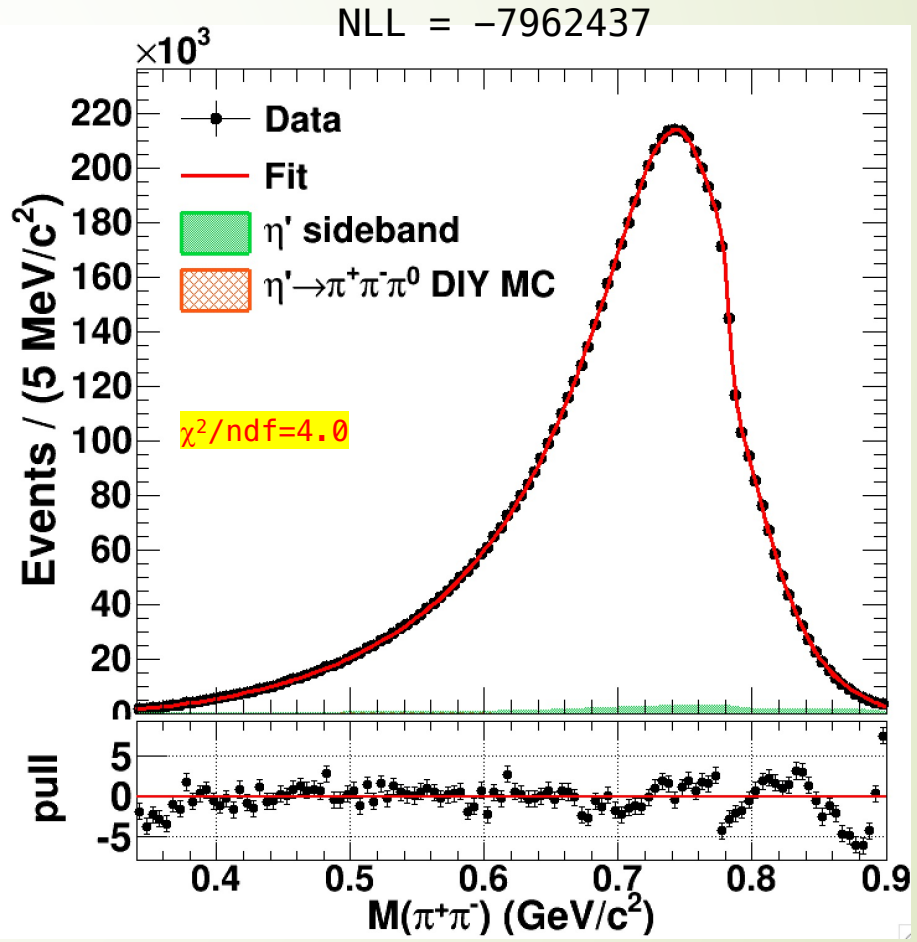
  where N is a normalization factor, and

  $P(s) = 1 + \kappa s + \lambda s^2 + \xi BW_\omega + \mathcal{O}(s^4)$

  need to be refined?



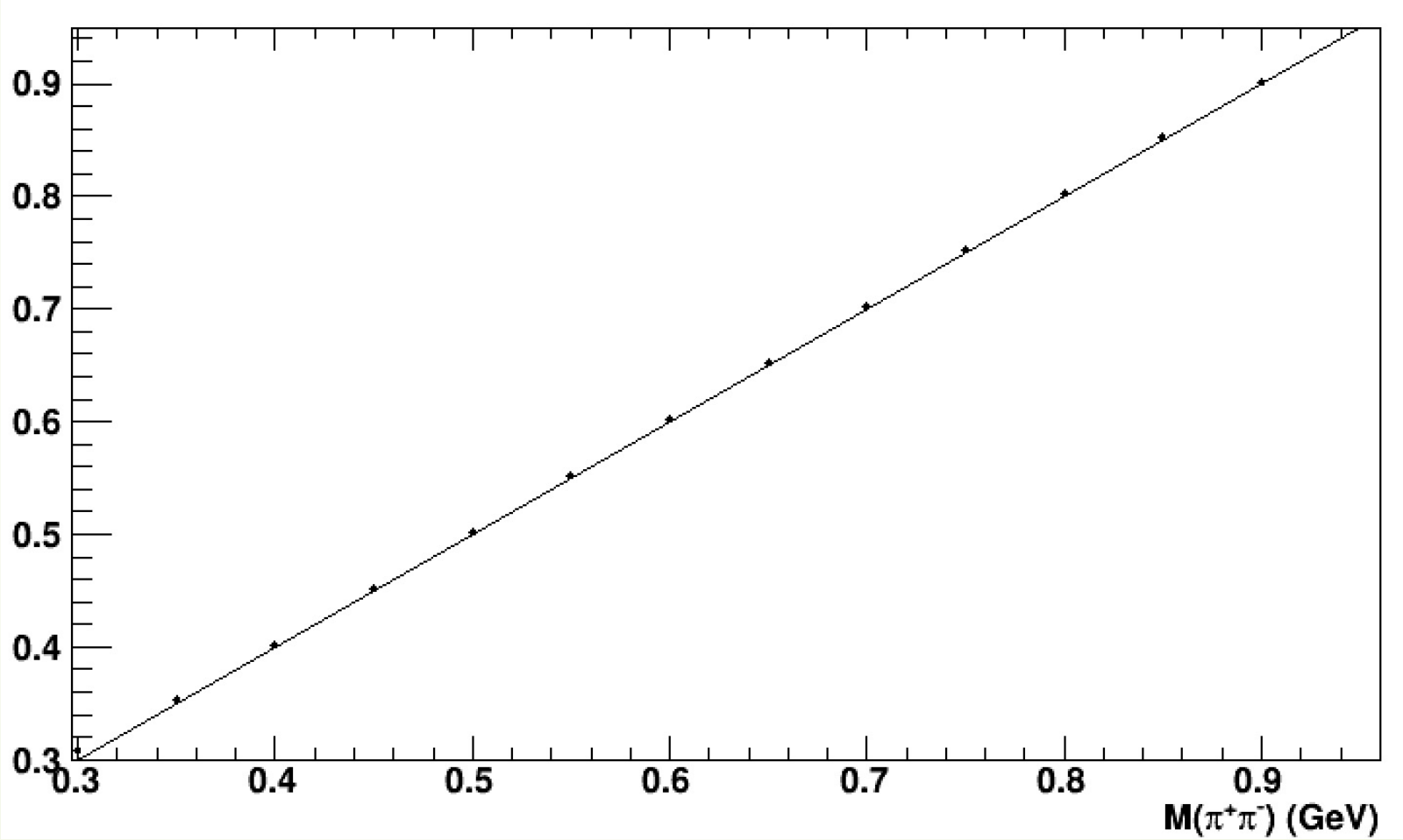
With cut: $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma\gamma\gamma)$



Next to do

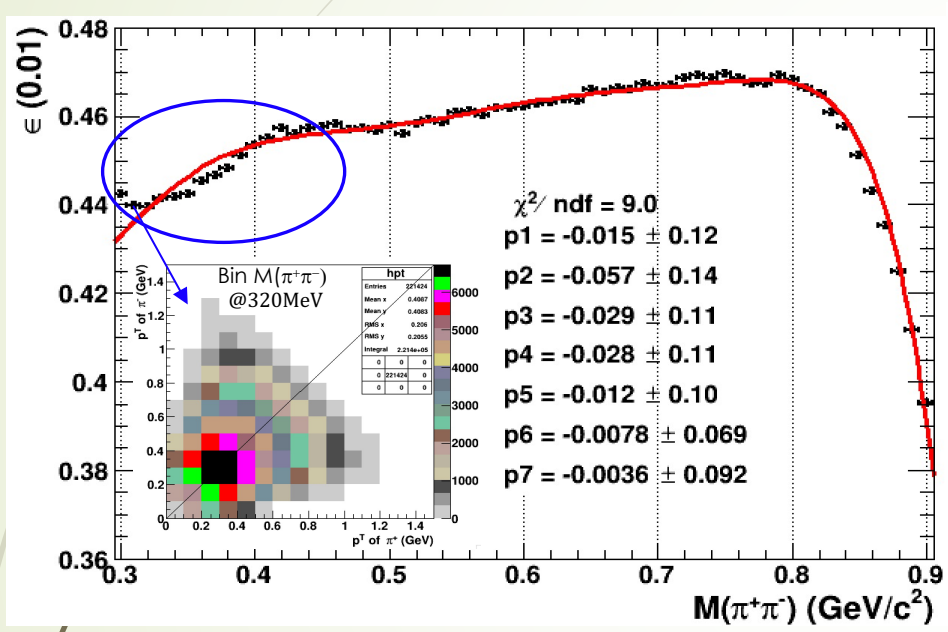
- To further suppress the remaining backgrounds:
  - Add 1C of η'
  - Perform another 4C-fit under $J/\psi \rightarrow \pi^+\pi^-\gamma$: $\chi^2(\pi^+\pi^-\gamma\gamma) < \chi^2(\pi^+\pi^-\gamma)$?
  - a strict requirement of $\chi^2(\pi^+\pi^-\gamma\gamma)$?

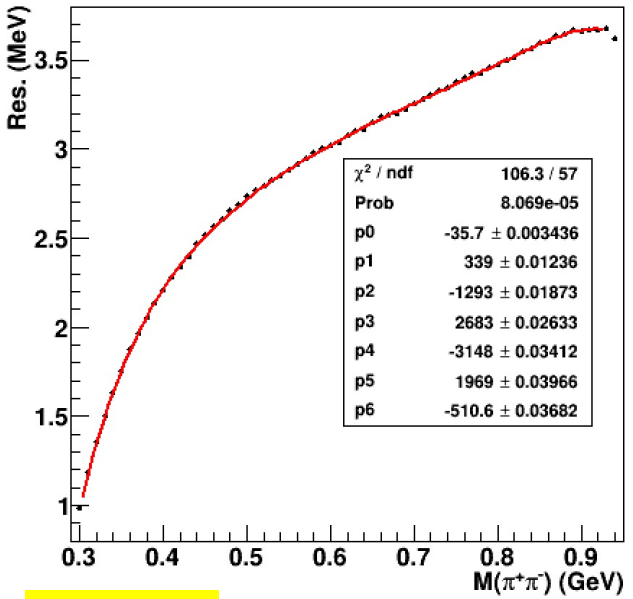
backup

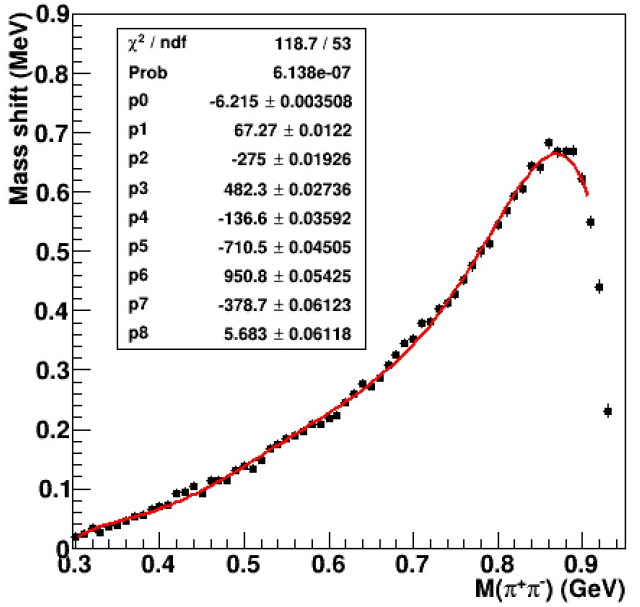

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.3
0.4
0.5
0.6
0.7
0.8
0.9
M(π⁺π⁻) (GeV)

Corrections for the dipion mass spectrum

- $M(\pi^+\pi^-)$–dependent **detection efficiency**, **mass resolution**, and the **mass shift**



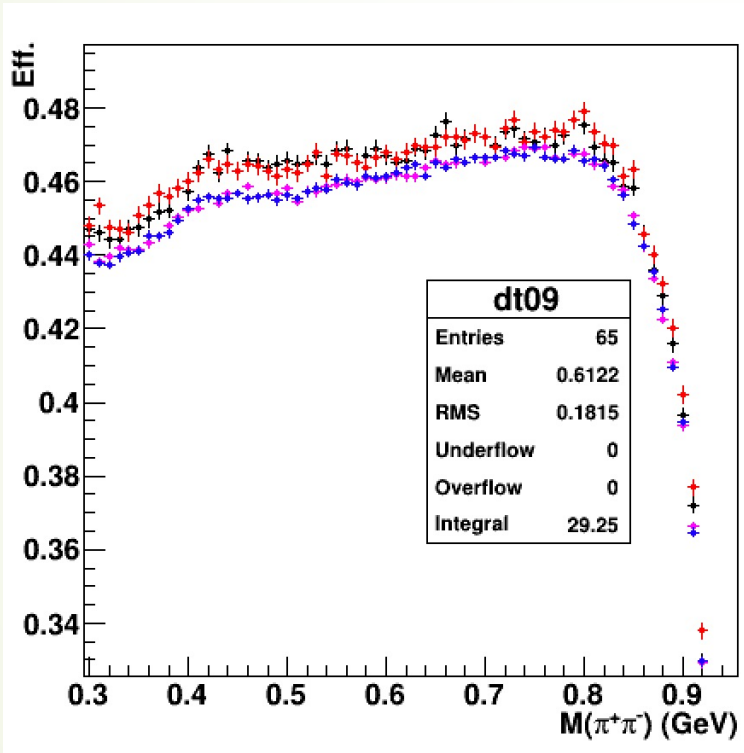


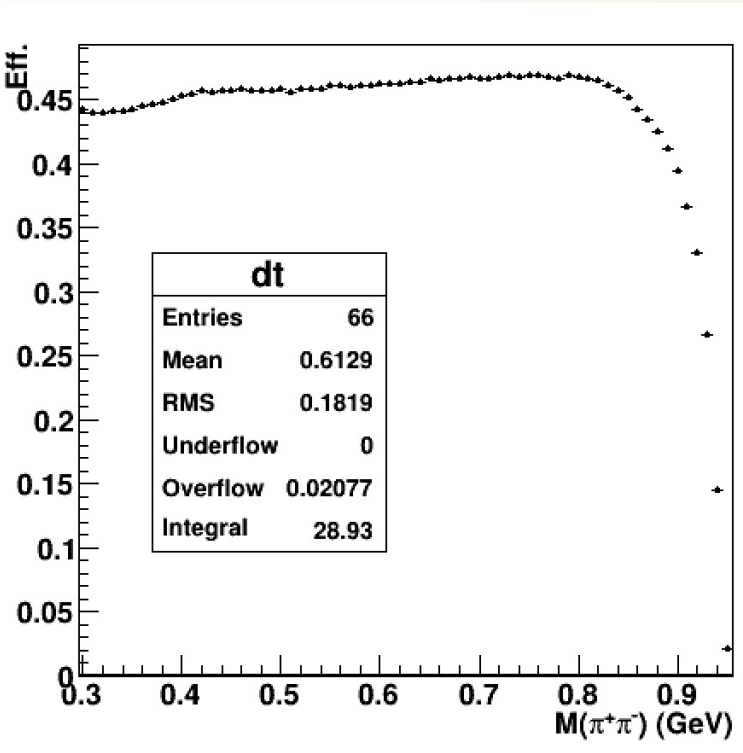


Cut flow

cuts	ε of $M(\pi^+\pi^-)$ bin at 0.32 GeV	ε of $M(\pi^+\pi^-)$ bin at 0.42 GeV	ε of $M(\pi^+\pi^-)$ bin at 0.79 GeV	ε of $M(\pi^+\pi^-)$ bin at 0.90 GeV
$E_{\gamma 2} > 40$ MeV	47.40%	49.41%	50.69%	42.89%
$\chi^2(\pi^+\pi^-\gamma\gamma) < 100$	46.40%	48.28%	49.14%	41.01%
$\lvert M(\gamma\pi^+\pi^-) - m_{\eta'} \rvert < 20$ MeV	44.01%	45.77%	47.08%	39.51%
$\lvert M(\gamma\gamma) - m_{\pi 0} \rvert > 20$ MeV	43.95%	45.71%	46.91%	39.50%
Relative diff. of ε	7.12%	7.34%	7.46%	17.28%

$M(\pi^+\pi^-)$–dependent detection efficiency for 4 runs

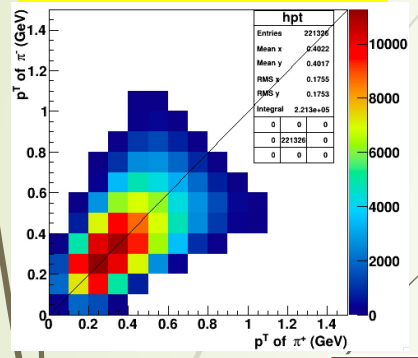




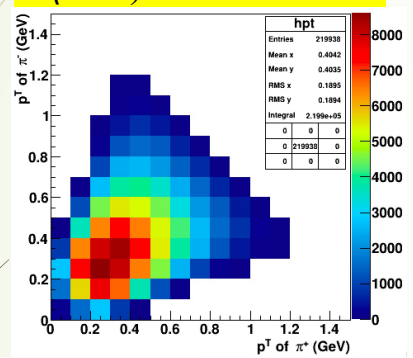
Transverse Momentum of π^+ vs π^-

reconstructed after 4C fit: p^T

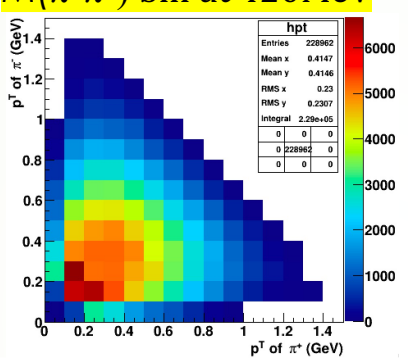
$M(\pi^+\pi^-)$ bin at 300MeV



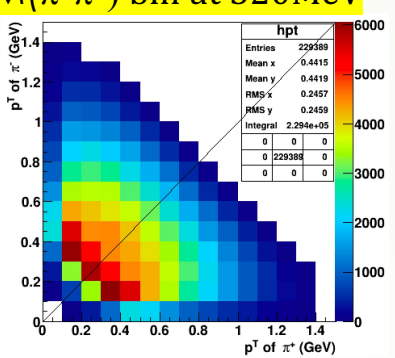
$M(\pi^+\pi^-)$ bin at 320MeV



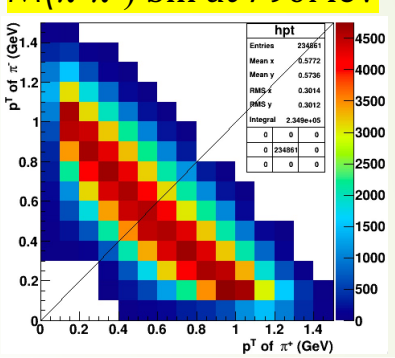
$M(\pi^+\pi^-)$ bin at 420MeV



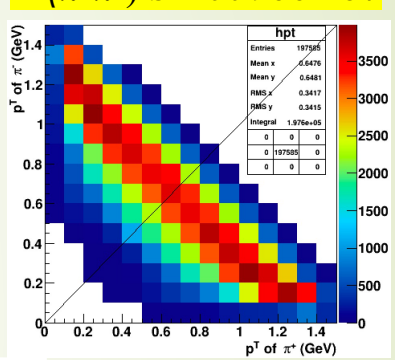
$M(\pi^+\pi^-)$ bin at 520MeV



$M(\pi^+\pi^-)$ bin at 790MeV

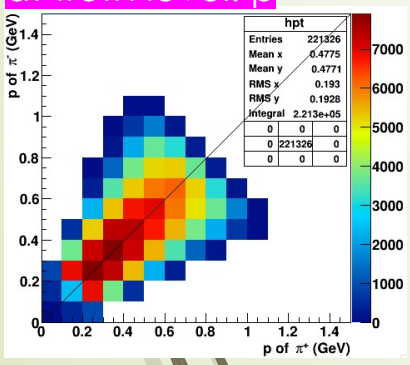


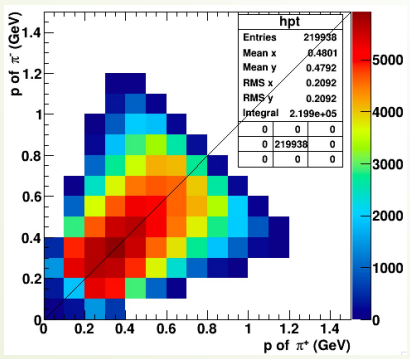
$M(\pi^+\pi^-)$ bin at 900MeV

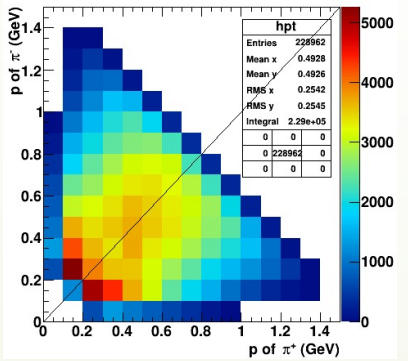


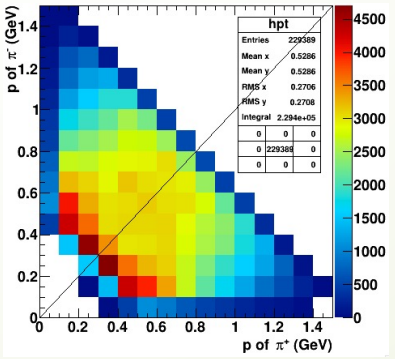
ε of rec.	p(π+)≤150MeV(200MeV) [%]	p(π+) >150MeV (200MeV) [%]	p(π+)≤150MeV&& p(π–)≤150MeV (200) [%]	p(π+) >150MeV&& p(π–) >150MeV (200) [%]
$M(\pi^+\pi^-)$ bin at 0.32 GeV: 44	3.8 (8.4)	96.2 (91.6)	0.07 (1.1)	92.4 (84.4)
$M(\pi^+\pi^-)$ bin at 0.42 GeV: 45.7	7.0 (12.9)	93.0 (87.1)	0 (0.5)	86.0 (74.6)
$M(\pi^+\pi^-)$ bin at 0.52 GeV: 45.8	6.3 (11.7)	93.7 (88.3)	0 (0)	87.4 (76.7)

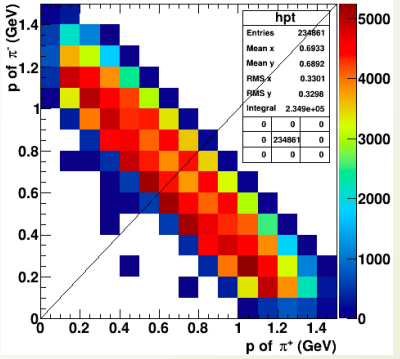
at truth level: p

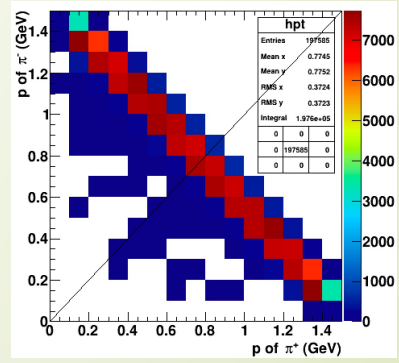






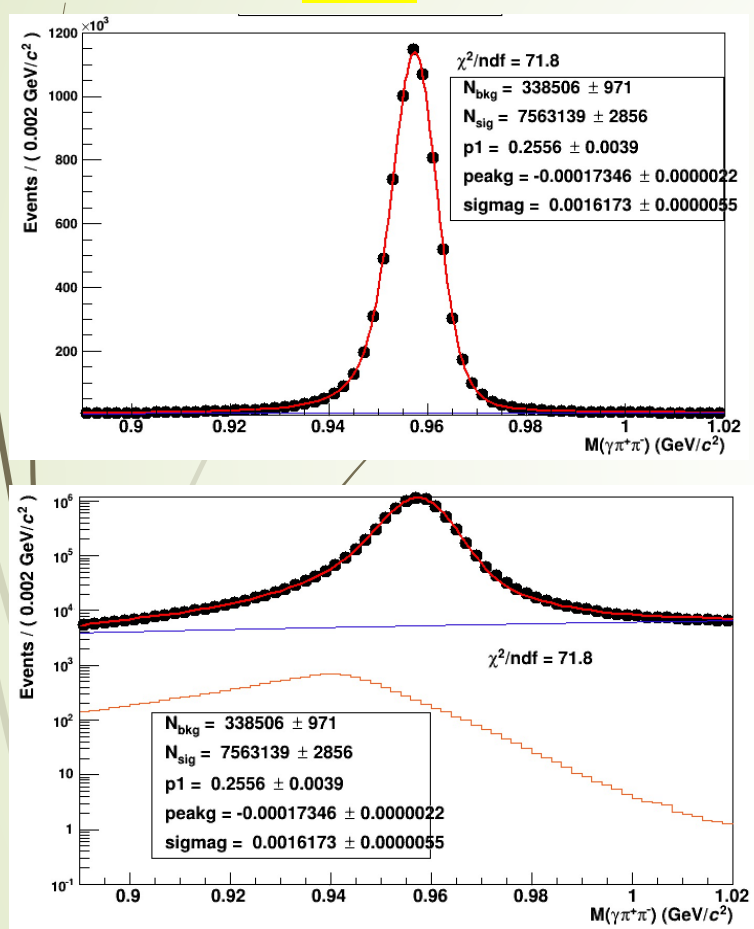






Check on the bkg level: a fit to M(γπ+π–)

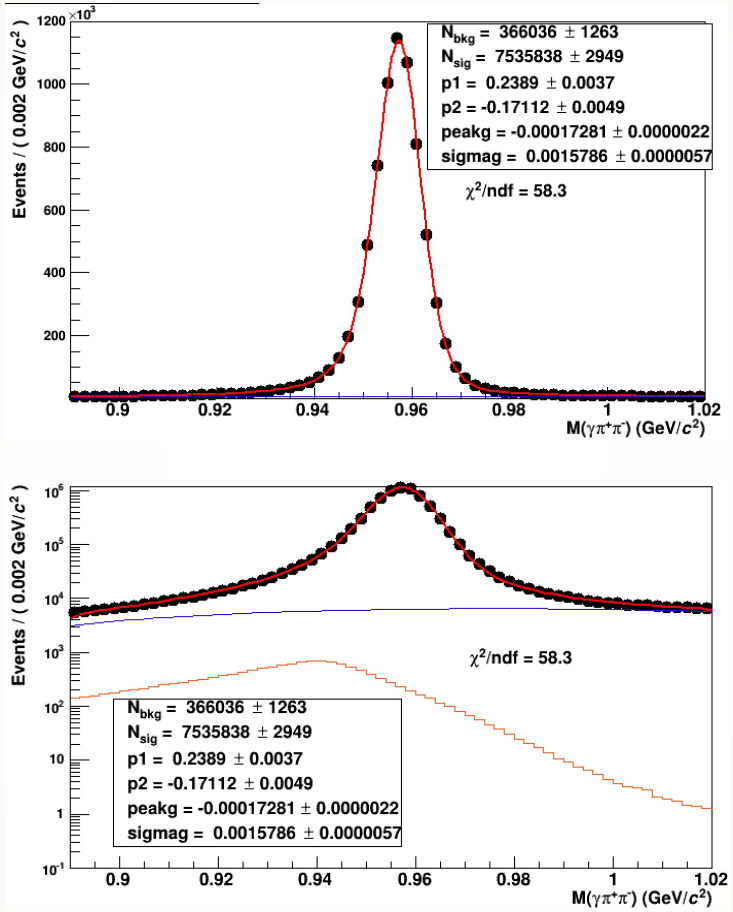
data



	Within η' signal region	Within η' sideband region
Nbkg	105385	105385

Background level: 1.45%

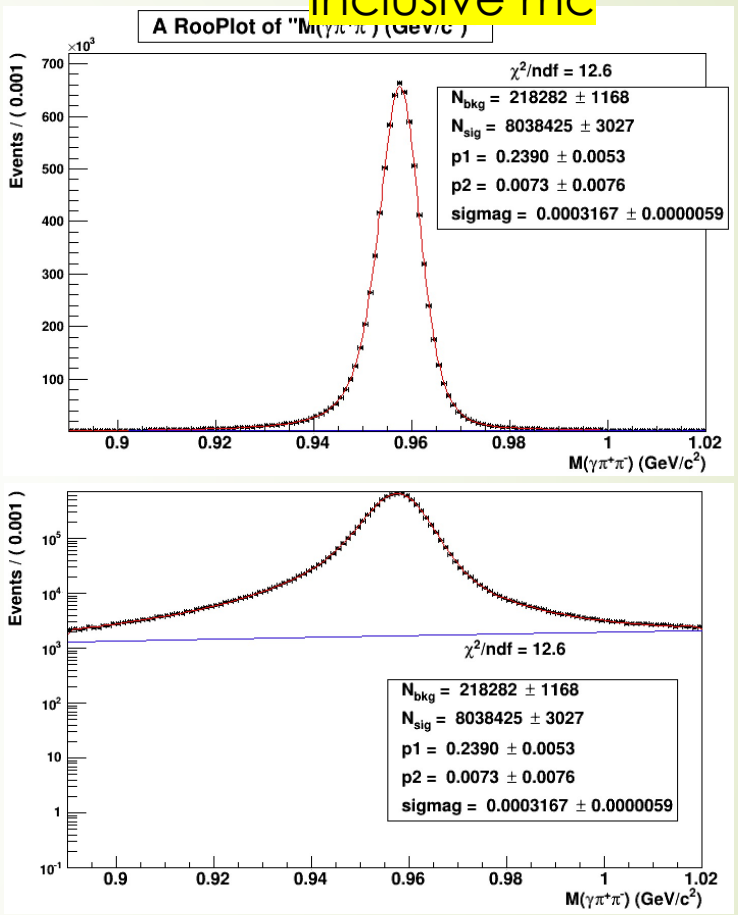
data



	Within η' signal region	Within η' sideband region
Nbkg	124728	104014

Background level: 1.7%

Inclusive mc

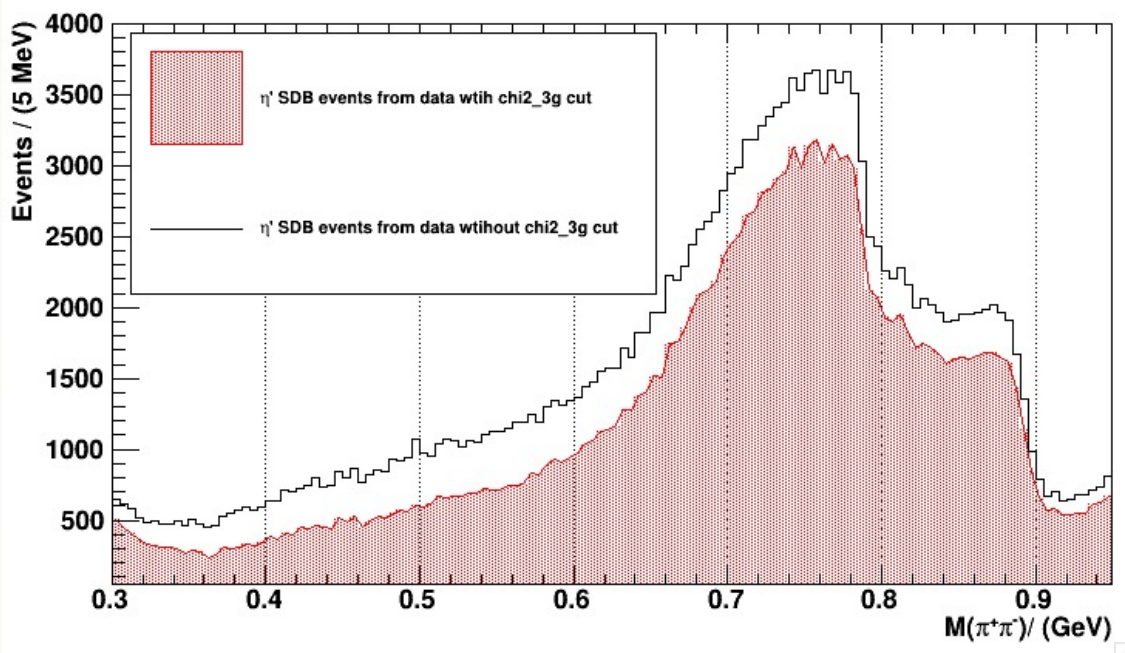


	Within η' signal region	Within η' sideband region
Nbkg	67611	68171

Background level: 0.89%

A Further Check on the sideband events

η' sideband events from data with/without cut of $\chi^2(\pi^+\pi^-\gamma\gamma\gamma)$



Efficiency loss of this cut for data:

$|157017 - 200957| / 200957 = 22\%$