



$J/\psi \rightarrow \omega\pi^0$ analysis

event selection, MC and backgrounds

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Event selection

$$J/\psi \rightarrow \omega \pi^0$$

$$e^+e^- \rightarrow \omega \pi_1^0 \rightarrow \pi^+\pi^-\gamma\gamma\gamma\gamma$$

$$\pi^+\pi^-\pi_2^0$$

vertex reconstruction from $\pi^+\pi^-$
 ω reconstruction through $\pi^+\pi^-\pi^0$
 π^0 identification through $\gamma\gamma$

$$\text{BR}_{\text{PDG}}(J/\psi \rightarrow \omega \pi^0) = (4.5 \pm 0.5) \times 10^{-4}$$

$$\text{BR}_{\text{PDG}}(\pi^0 \rightarrow \gamma\gamma) = 0.98823 \pm 0.00034$$

$$\text{BR}_{\text{PDG}}(\omega \rightarrow \pi^+\pi^-\pi^0) = 0.893 \pm 0.006$$

P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. **2020**, 083C01 (2020)

Charged tracks (MDC):

Origin: $V_r < 1.0$ cm,
 $|V_z| < 10.0$ cm
 $|\cos \theta| < 0.93$

Neutral tracks (EMC):

Endcap: $0.86 < |\cos \theta| < 0.92$
 $E_{\text{endcap}} > 50$ MeV
 Barrel: $|\cos \theta| < 0.8$
 $E_{\text{barrel}} > 25$ MeV

Event selection

Signal exclusive MC 20k

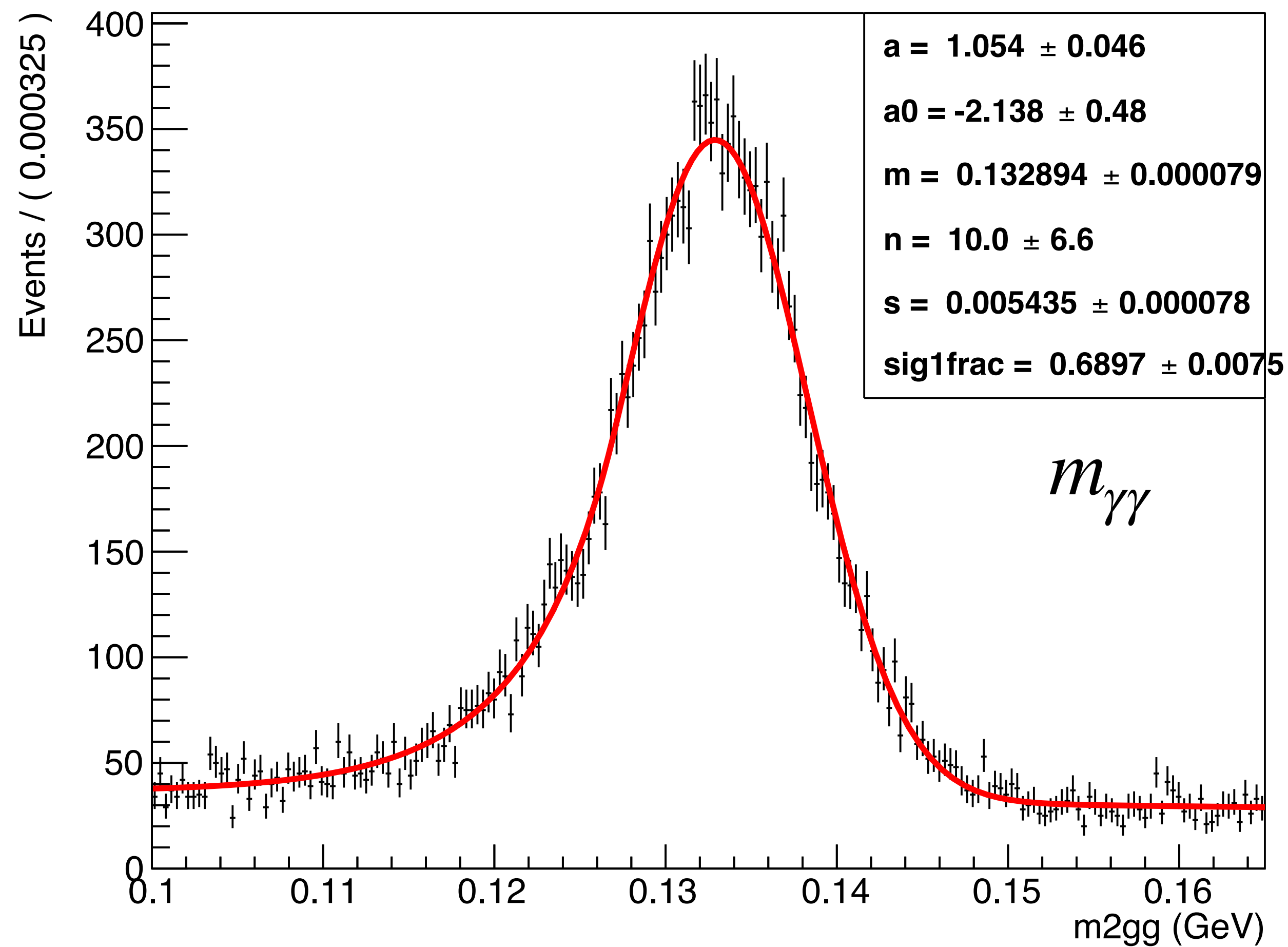
Crystal-ball plus polynomial fit on the $\gamma\gamma$ distribution

We obtain

$$\sigma_{\pi^0} = 5.45 \text{ MeV}/c^2$$

From the FWHM sigma

m2gg events



Selection "C4P2"

Signal MC 20k samples

our choice

C4

Kalman fit with 4 constraints: CM 4-momentum

P2

Minimization of $\chi^2_{\pi^0\pi^0}$

$$\chi^2_{\pi^0\pi^0} = \frac{(m(\gamma_1\gamma_2) - m_{\pi^0}^{\text{PDG}})^2}{\sigma_{\pi^0}^2} + \frac{(m(\gamma_3\gamma_4) - m_{\pi^0}^{\text{PDG}})^2}{\sigma_{\pi^0}^2}$$

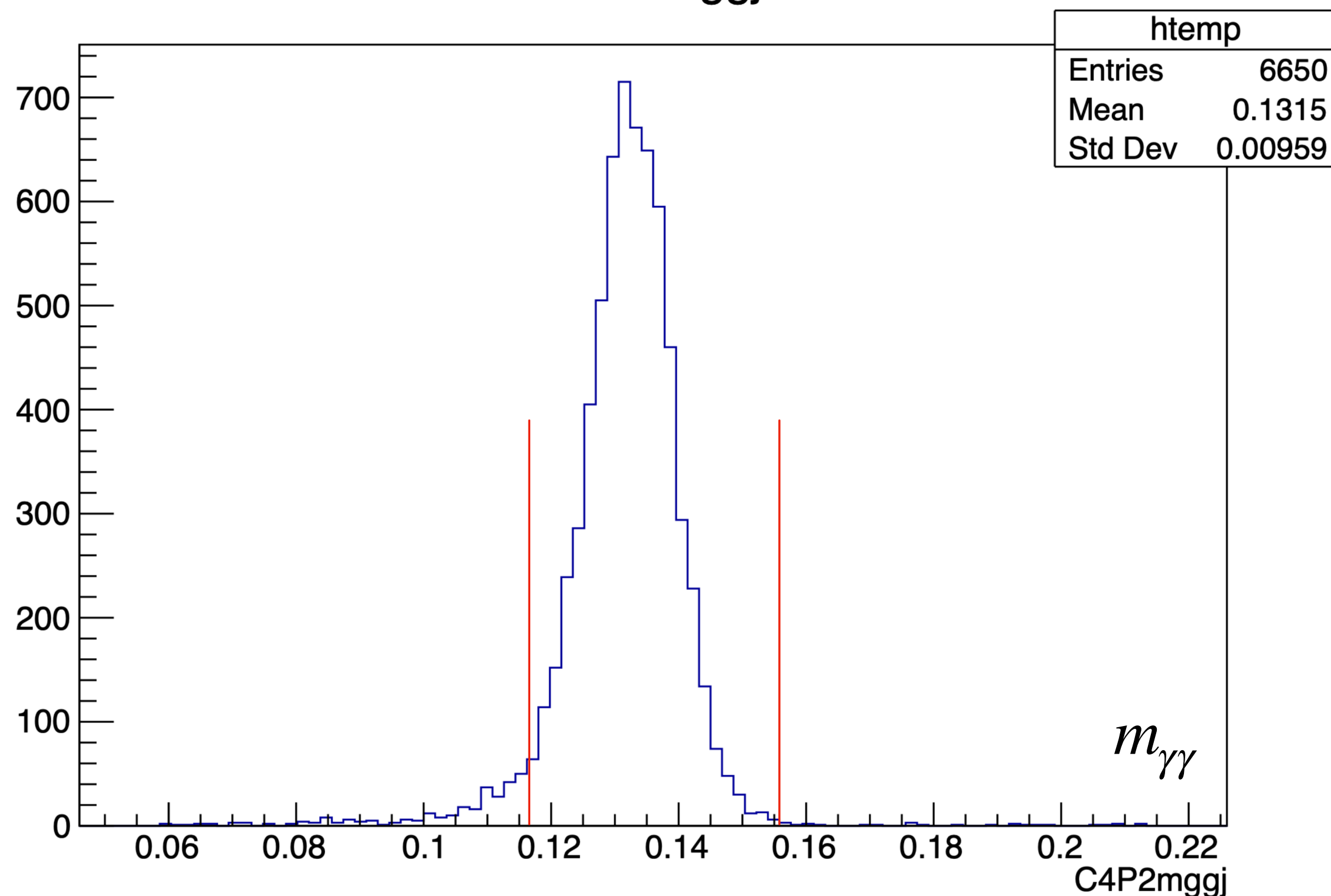
$$\sigma_{\pi^0} \simeq 5.45 \text{ MeV}/c^2$$

Efficiency of C4P2 $\sim 33.25 \%$

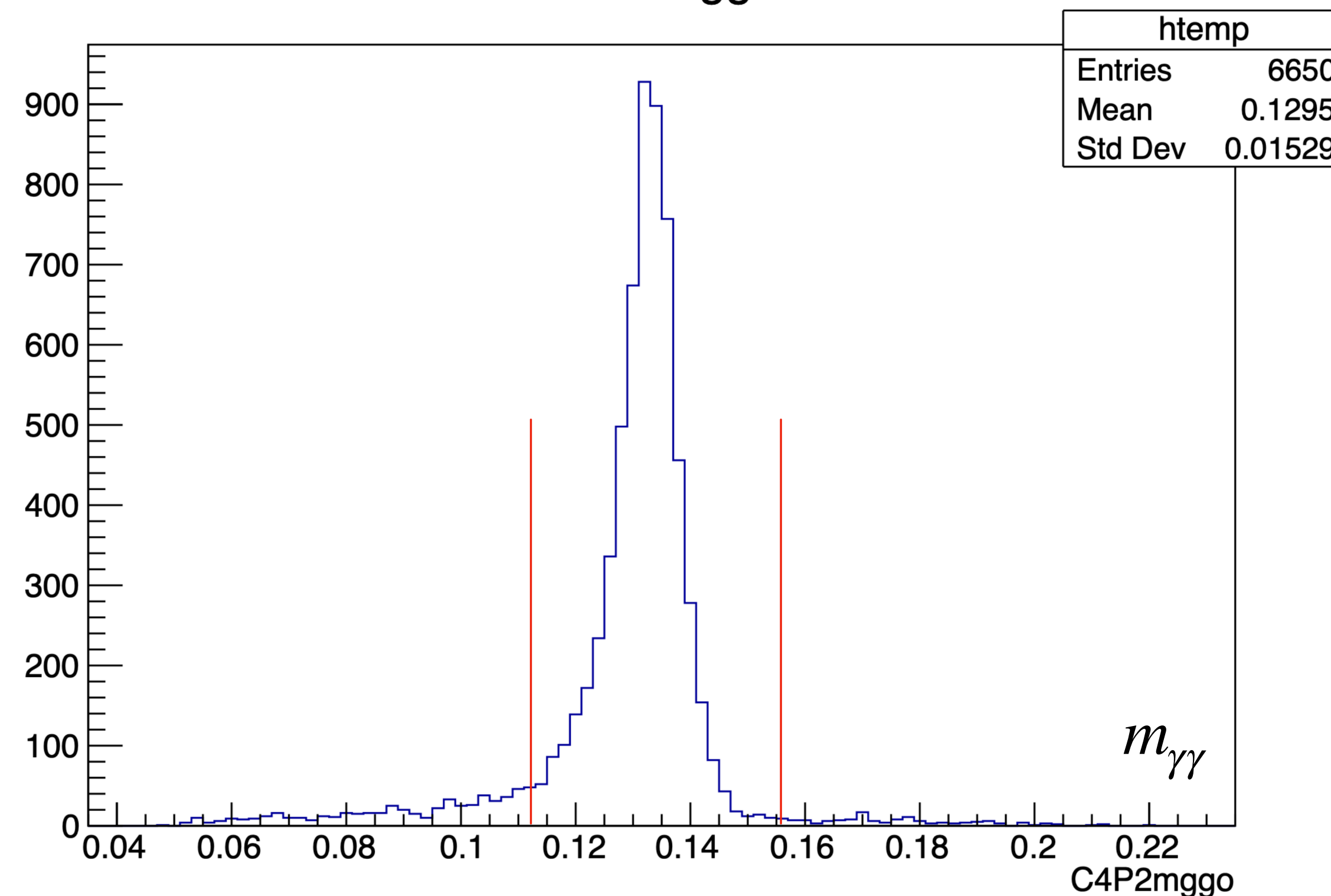
Events selected with C4P2: **6650**

$$e^+e^- \rightarrow \omega\pi_1^0 \rightarrow \pi^+\pi^-\pi_2^0(\gamma\gamma)\pi_1^0(\gamma\gamma)$$

C4P2mggj



C4P2mggo



Cut on $\gamma\gamma$ invariant mass

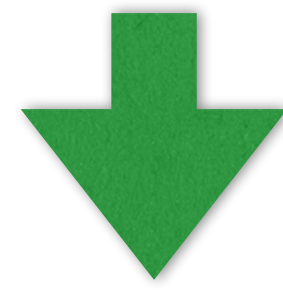
$$\sigma_{\pi^0} \simeq 5.45 \text{ MeV}/c^2$$

$$|m_{(\gamma\gamma)\pi^0} - m_{\pi^0}^{\text{PDG}}| < 4\sigma_{\pi^0}$$

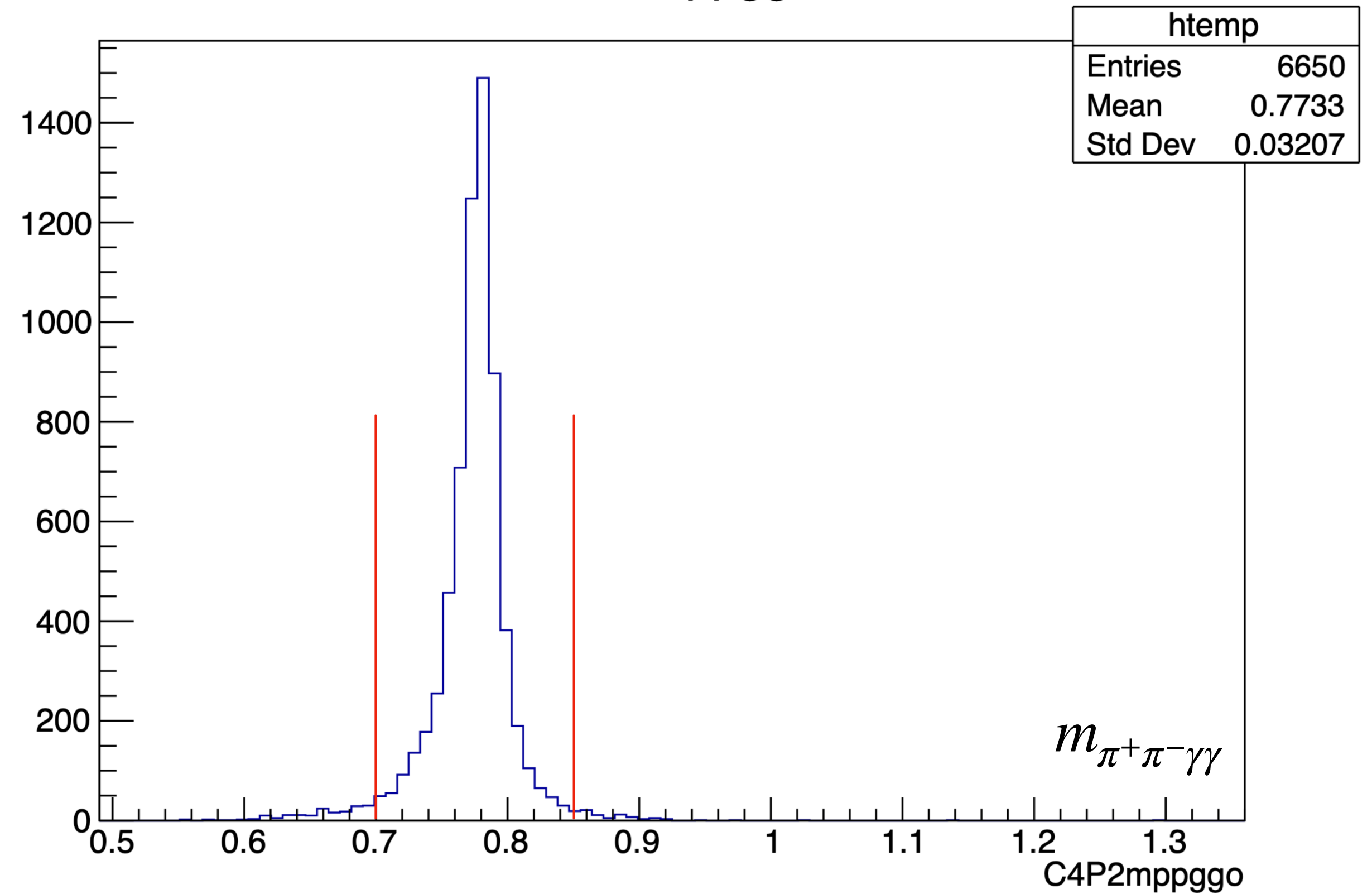
$$e^+e^- \rightarrow \omega\pi_1^0 \rightarrow \pi^+\pi^-\pi_2^0(\gamma\gamma)\pi_1^0(\gamma\gamma)$$

C4P2mppggo

Cut on $\pi^+\pi^-\gamma\gamma$ invariant mass



$$0.70 \text{ GeV} < m(\pi^+\pi^-(\gamma\gamma)\pi_2^0) < 0.85 \text{ GeV}$$



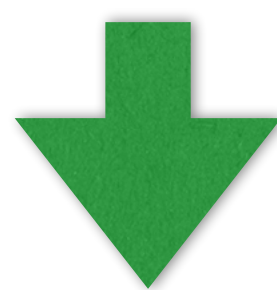
Signal MC 20k

Exclusive MC

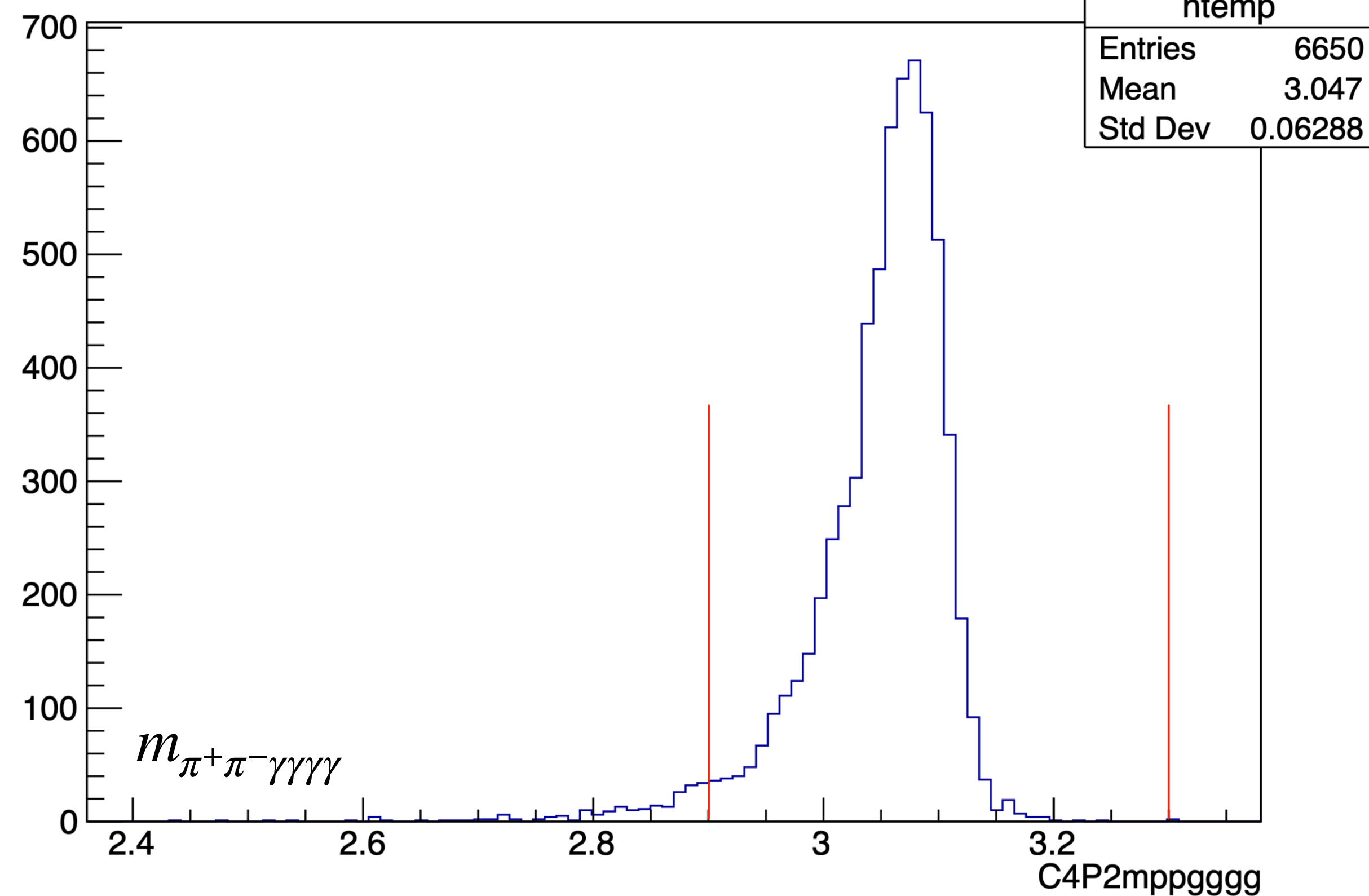
$$e^+e^- \rightarrow \omega\pi_1^0 \rightarrow \pi^+\pi^-\pi_2^0(\gamma\gamma)\pi_1^0(\gamma\gamma)$$

C4P2mppgggg

Cut on $\pi^+\pi^-\gamma\gamma\gamma\gamma$ invariant mass

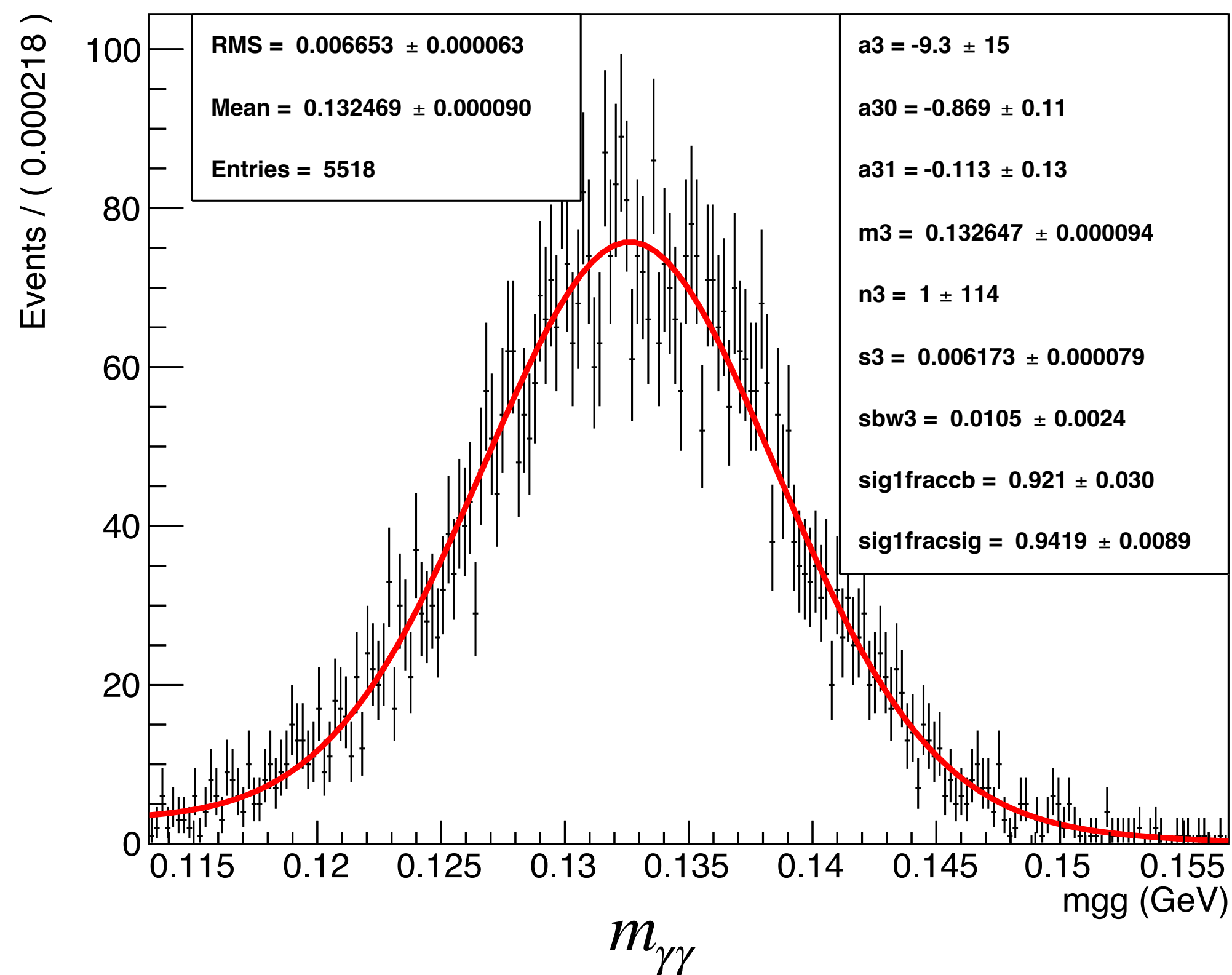


$$2.9 \text{ GeV} < m(\pi^+\pi^-\gamma\gamma\gamma\gamma) < 3.3 \text{ GeV}$$

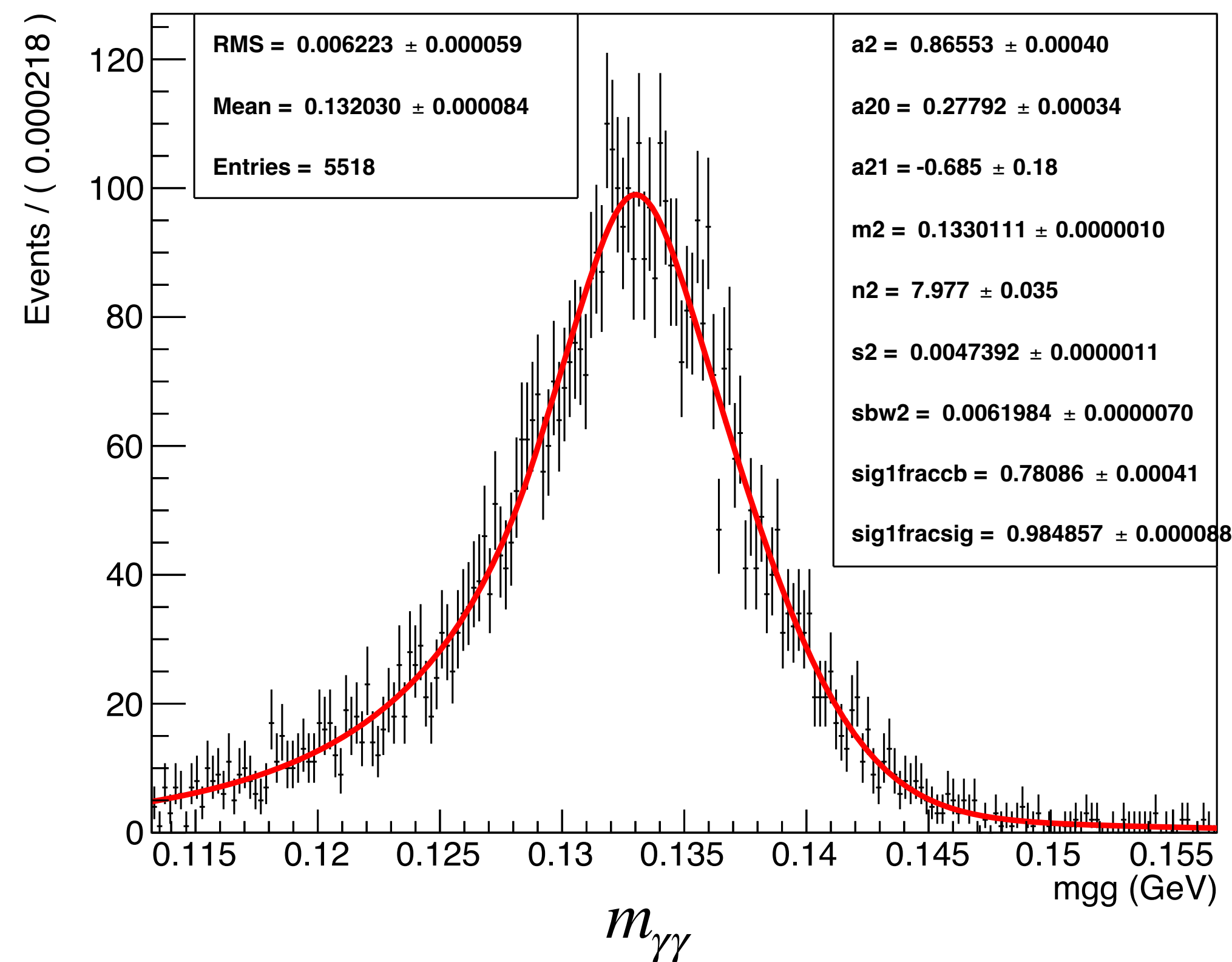


$$e^+e^- \rightarrow \omega\pi_1^0 \rightarrow \pi^+\pi^-\pi_2^0(\gamma\gamma)\pi_1^0(\gamma\gamma)$$

m_C4P2mggj



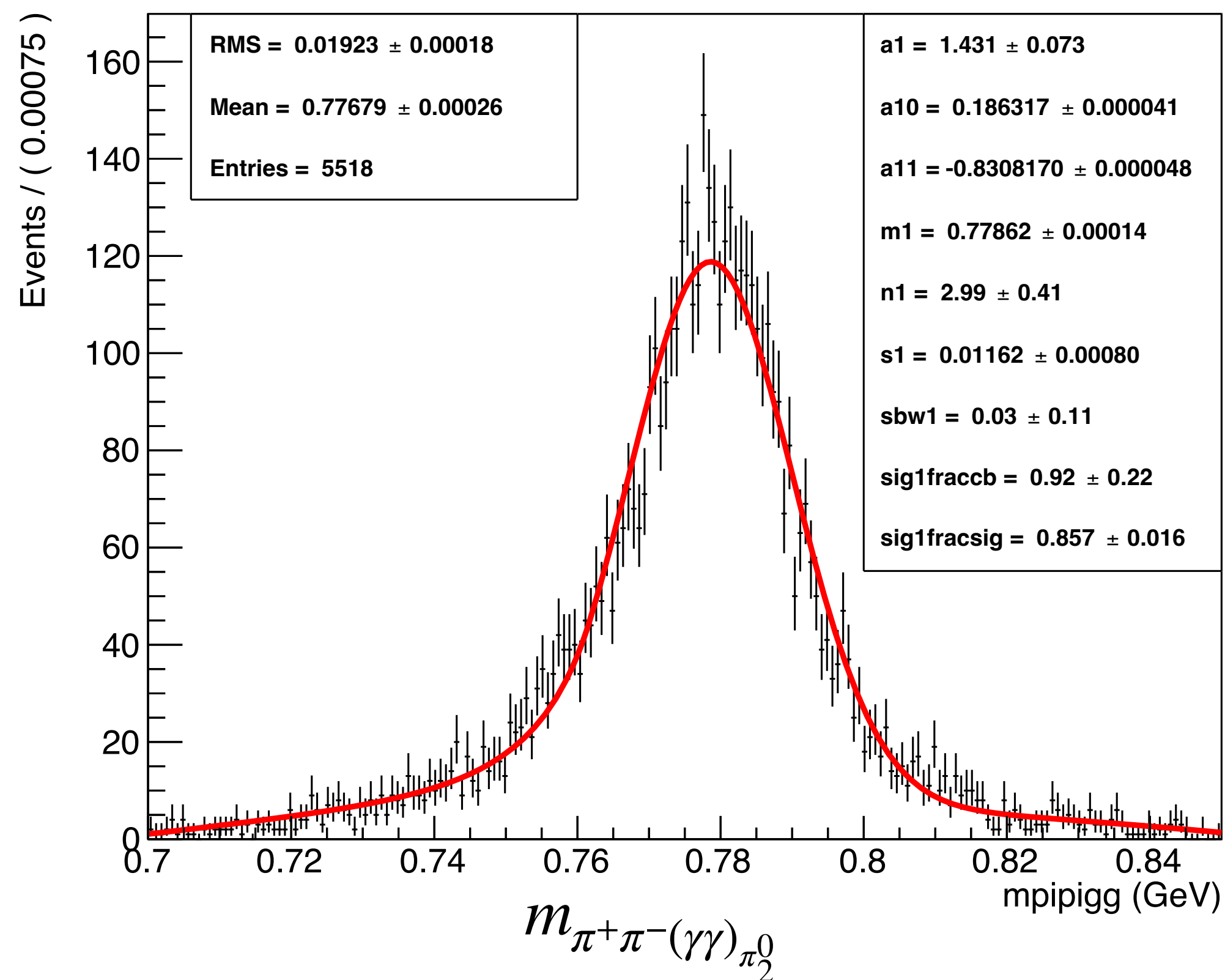
m_C4P2mggo



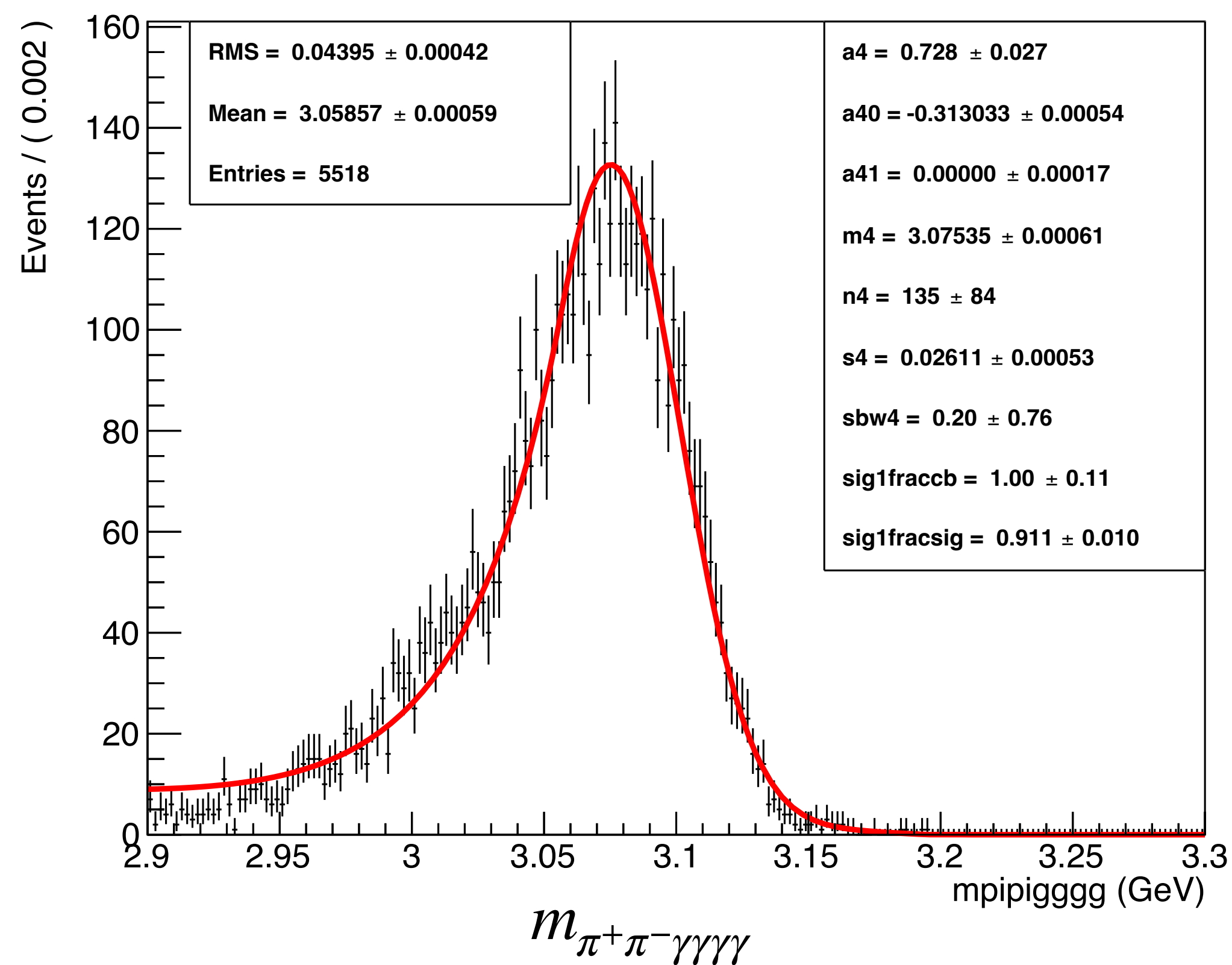
$$e^+e^- \rightarrow \omega\pi_1^0 \rightarrow \pi^+\pi^-\pi_2^0(\gamma\gamma)\pi_1^0(\gamma\gamma)$$

Efficiency with selections $\sim 25.13\%$

m_C4P2mppggo



m_C4P2mppgggg



Inclusive MC vs Real Data

$$0.70 \text{ GeV}/c^2 < m_{\pi^+\pi^-(\gamma\gamma)\pi_2^0} < 0.85 \text{ GeV}/c^2$$

$$|m_{(\gamma\gamma)\pi^0} - m_{\pi^0}^{\text{PDG}}| < 4\sigma_{\pi^0}$$

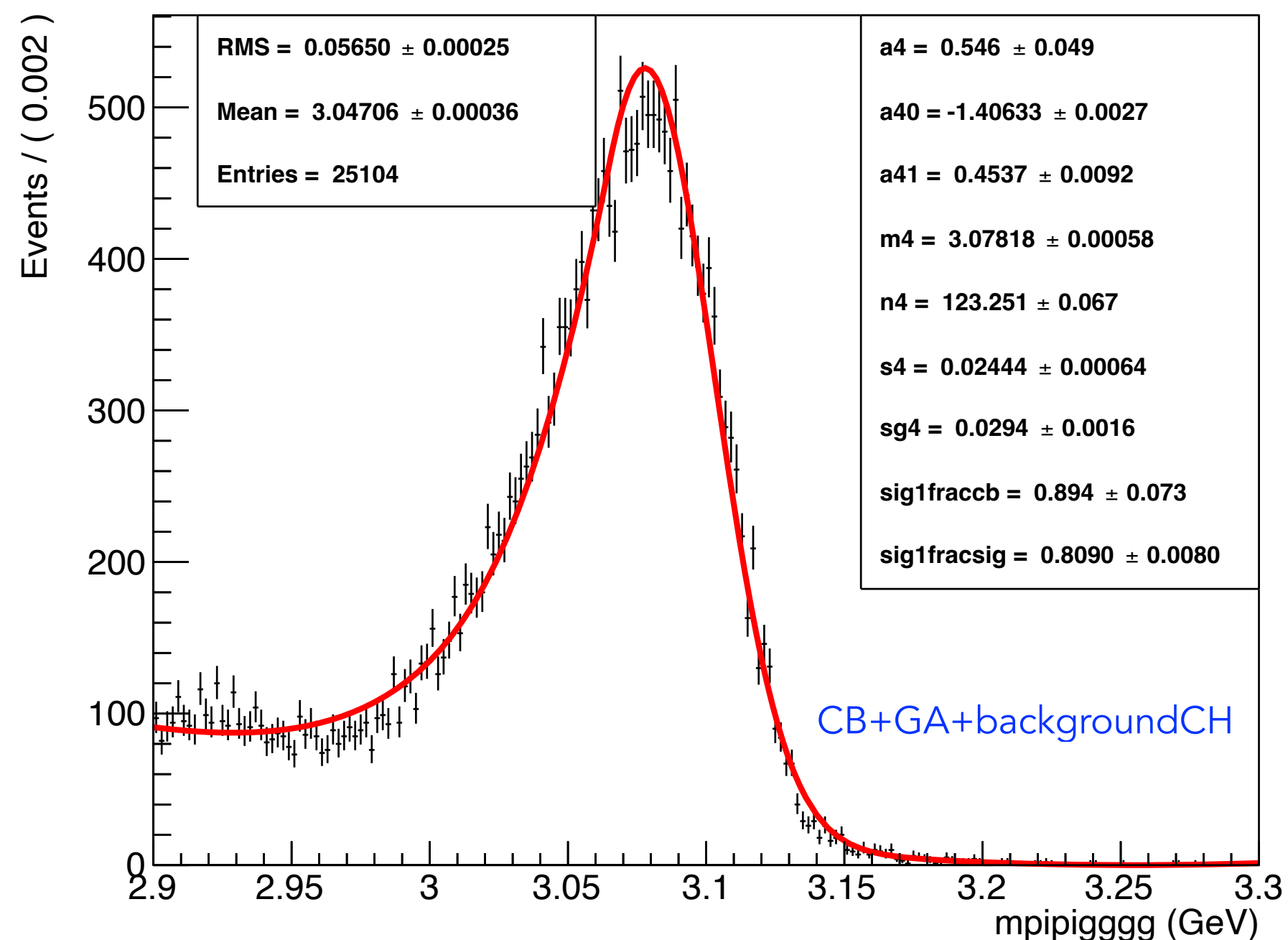
$$2.9 \text{ GeV}/c^2 < m_{\pi^+\pi^-\gamma\gamma\gamma\gamma} < 3.2 \text{ GeV}/c^2$$

Inclusive MC

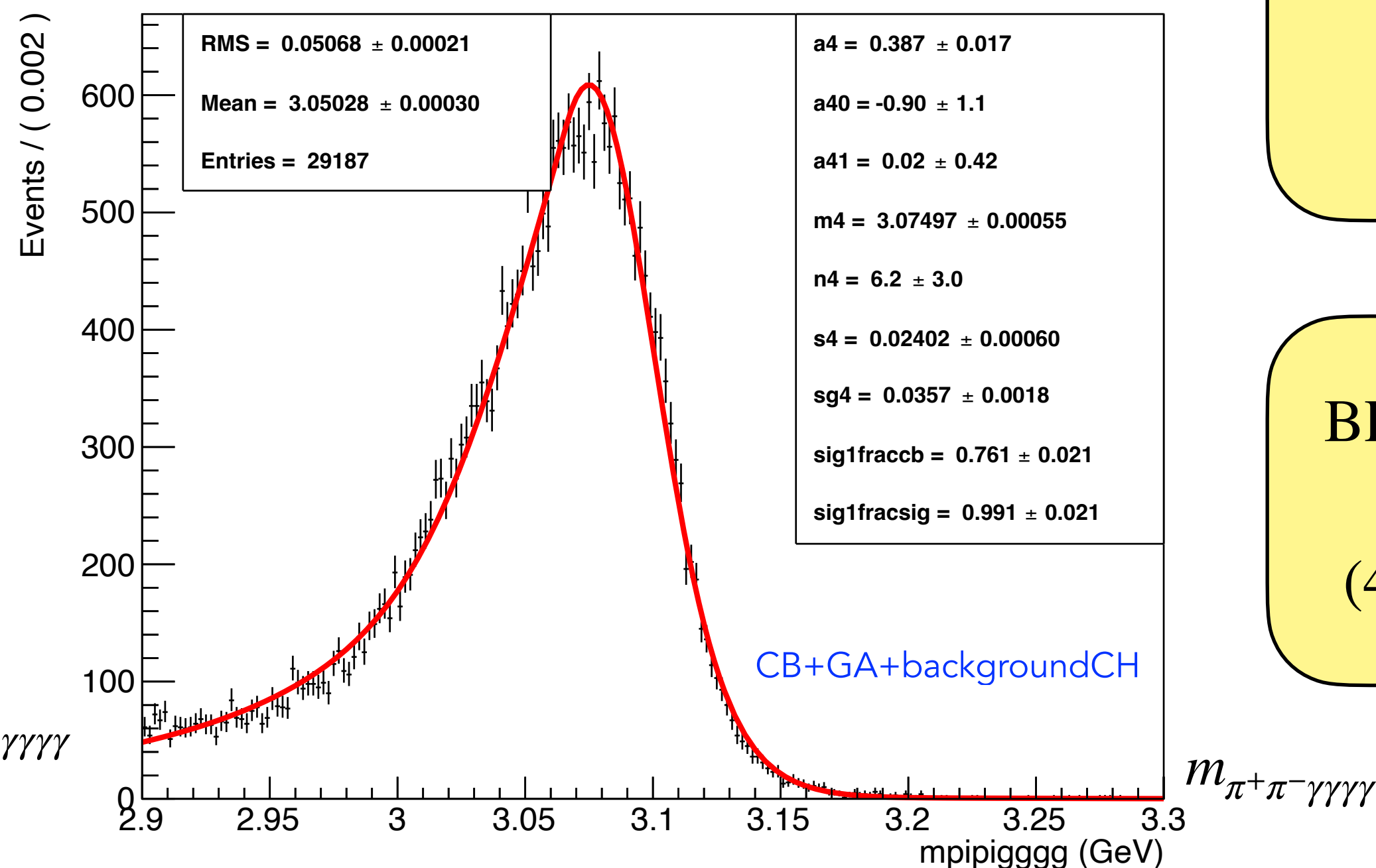
2009 (boss 775) 224M

Real Data

m_C4P2mppgggg



m_C4P2mppgggg



$$\text{BR}(J/\psi \rightarrow \omega\pi^0)$$

$$5.89 \times 10^{-4}$$

$$\text{BR}_{\text{PDG}}(J/\psi \rightarrow \omega\pi^0)$$

$$(4.5 \pm 0.5) \times 10^{-4}$$

Inclusive MC vs Real Data

$$0.70 \text{ GeV}/c^2 < m_{\pi^+\pi^-(\gamma\gamma)\pi_2^0} < 0.85 \text{ GeV}/c^2$$

$$|m_{(\gamma\gamma)\pi^0} - m_{\pi^0}^{\text{PDG}}| < 4\sigma_{\pi^0}$$

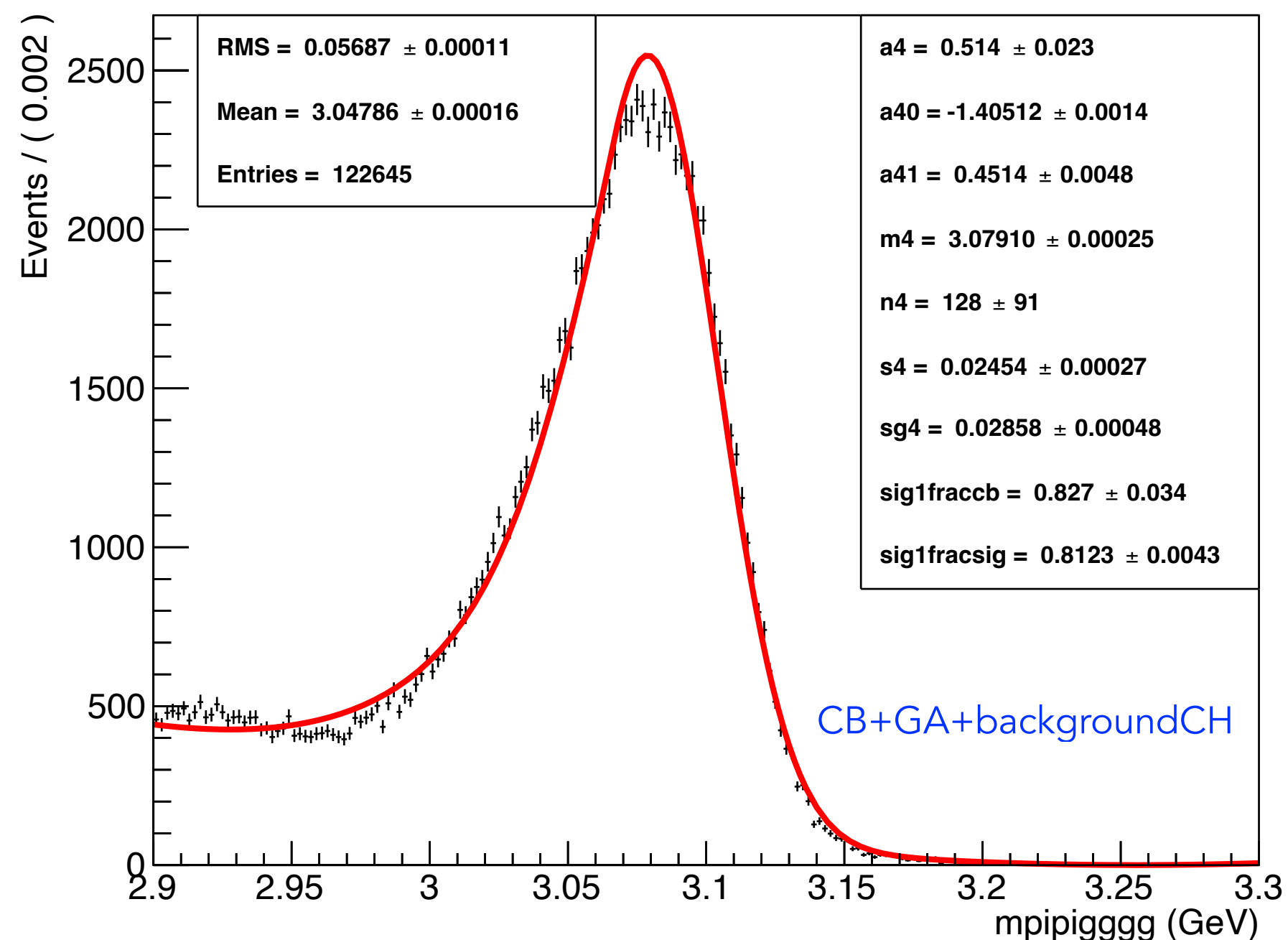
$$2.9 \text{ GeV}/c^2 < m_{\pi^+\pi^-\gamma\gamma\gamma\gamma} < 3.2 \text{ GeV}/c^2$$

Inclusive MC

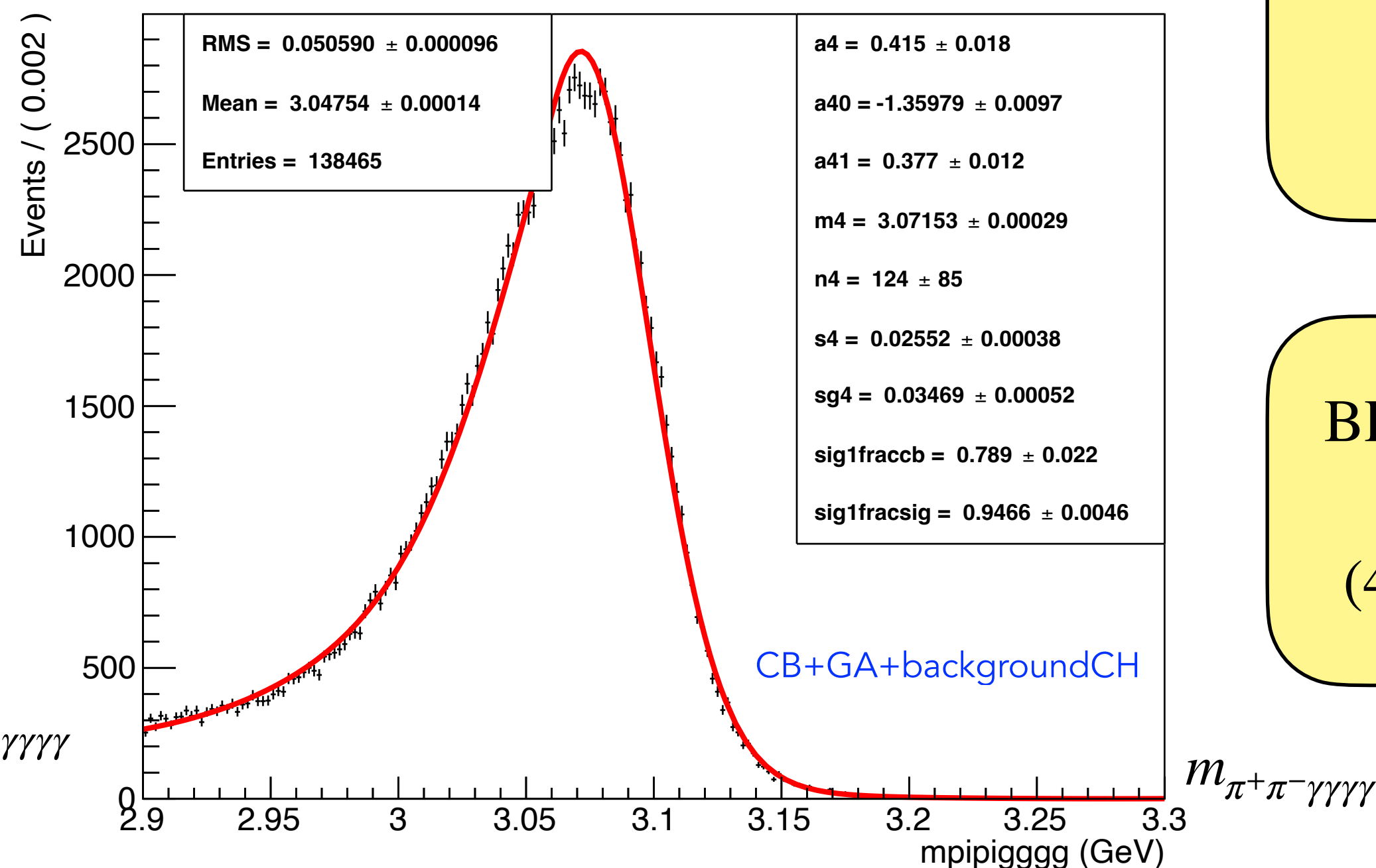
2012 (boss 775) 1087M

Real Data

m_C4P2mppgggg



m_C4P2mppgggg



$$\text{BR}(J/\psi \rightarrow \omega\pi^0)$$

$$5.50 \times 10^{-4}$$

$$\text{BR}_{\text{PDG}}(J/\psi \rightarrow \omega\pi^0)$$

$$(4.5 \pm 0.5) \times 10^{-4}$$

Inclusive MC vs Real Data

$$0.70 \text{ GeV}/c^2 < m_{\pi^+\pi^-(\gamma\gamma)\pi_2^0} < 0.85 \text{ GeV}/c^2$$

$$|m_{(\gamma\gamma)\pi^0} - m_{\pi^0}^{\text{PDG}}| < 4\sigma_{\pi^0}$$

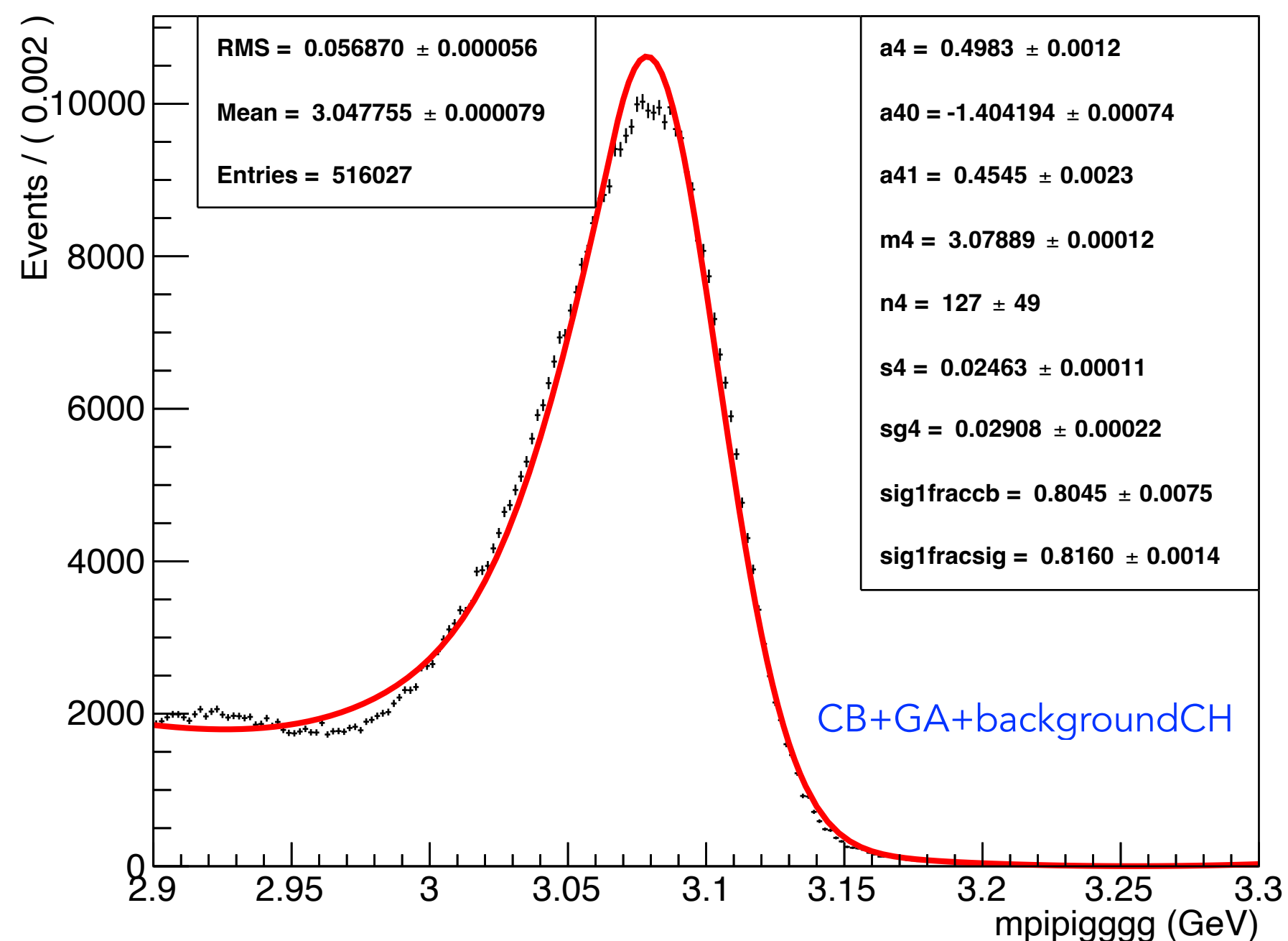
$$2.9 \text{ GeV}/c^2 < m_{\pi^+\pi^-\gamma\gamma\gamma\gamma} < 3.2 \text{ GeV}/c^2$$

Inclusive MC

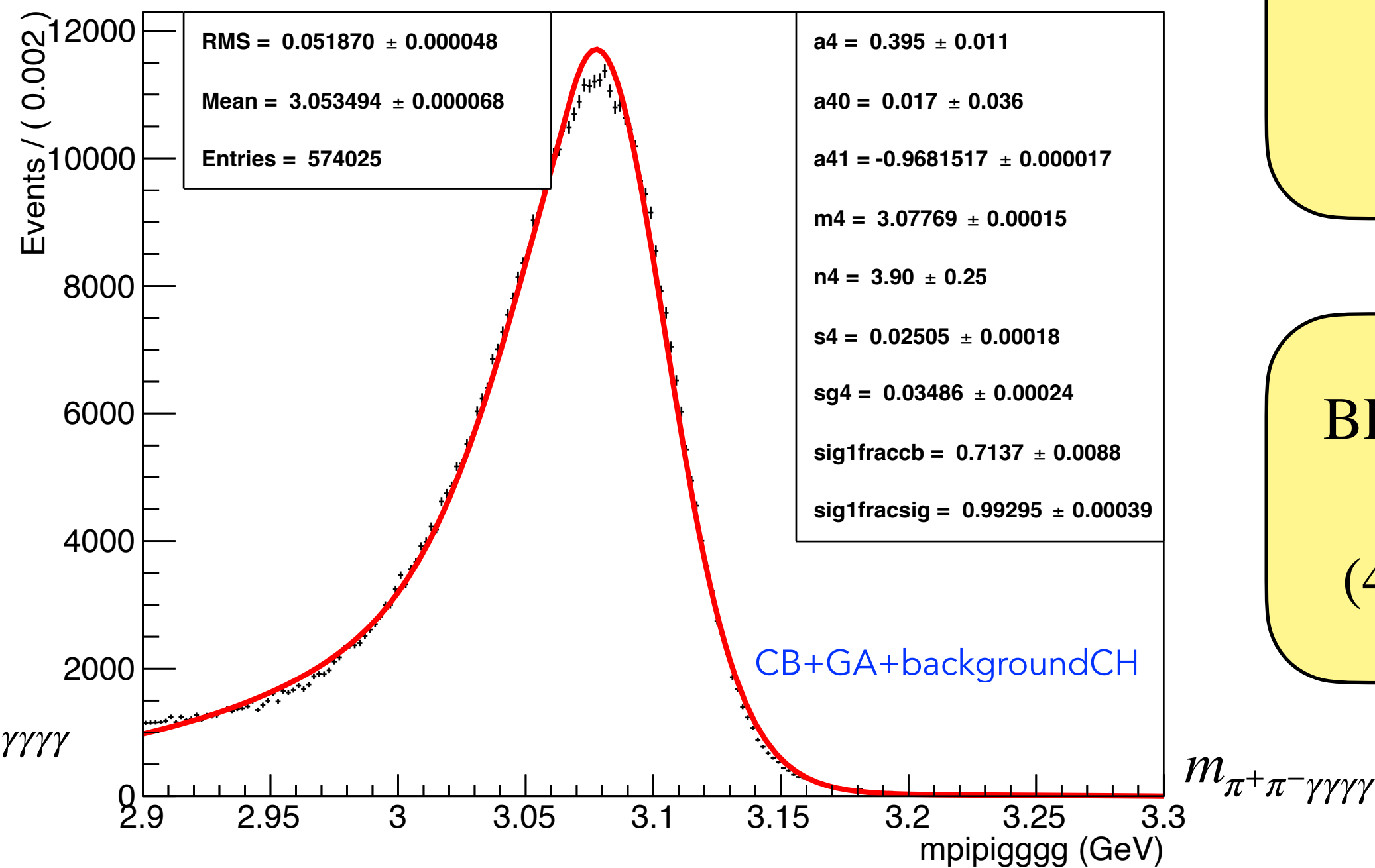
2018 (boss 775) 4600M

Real Data

m_C4P2mppgggg



m_C4P2mppgggg



$\text{BR}(J/\psi \rightarrow \omega\pi^0)$

$$5.65 \times 10^{-4}$$

$\text{BR}_{\text{PDG}}(J/\psi \rightarrow \omega\pi^0)$

$$(4.5 \pm 0.5) \times 10^{-4}$$

Inclusive MC vs Real Data

$$0.70 \text{ GeV}/c^2 < m_{\pi^+\pi^-(\gamma\gamma)\pi_2^0} < 0.85 \text{ GeV}/c^2$$

$$|m_{(\gamma\gamma)\pi^0} - m_{\pi^0}^{\text{PDG}}| < 4\sigma_{\pi^0}$$

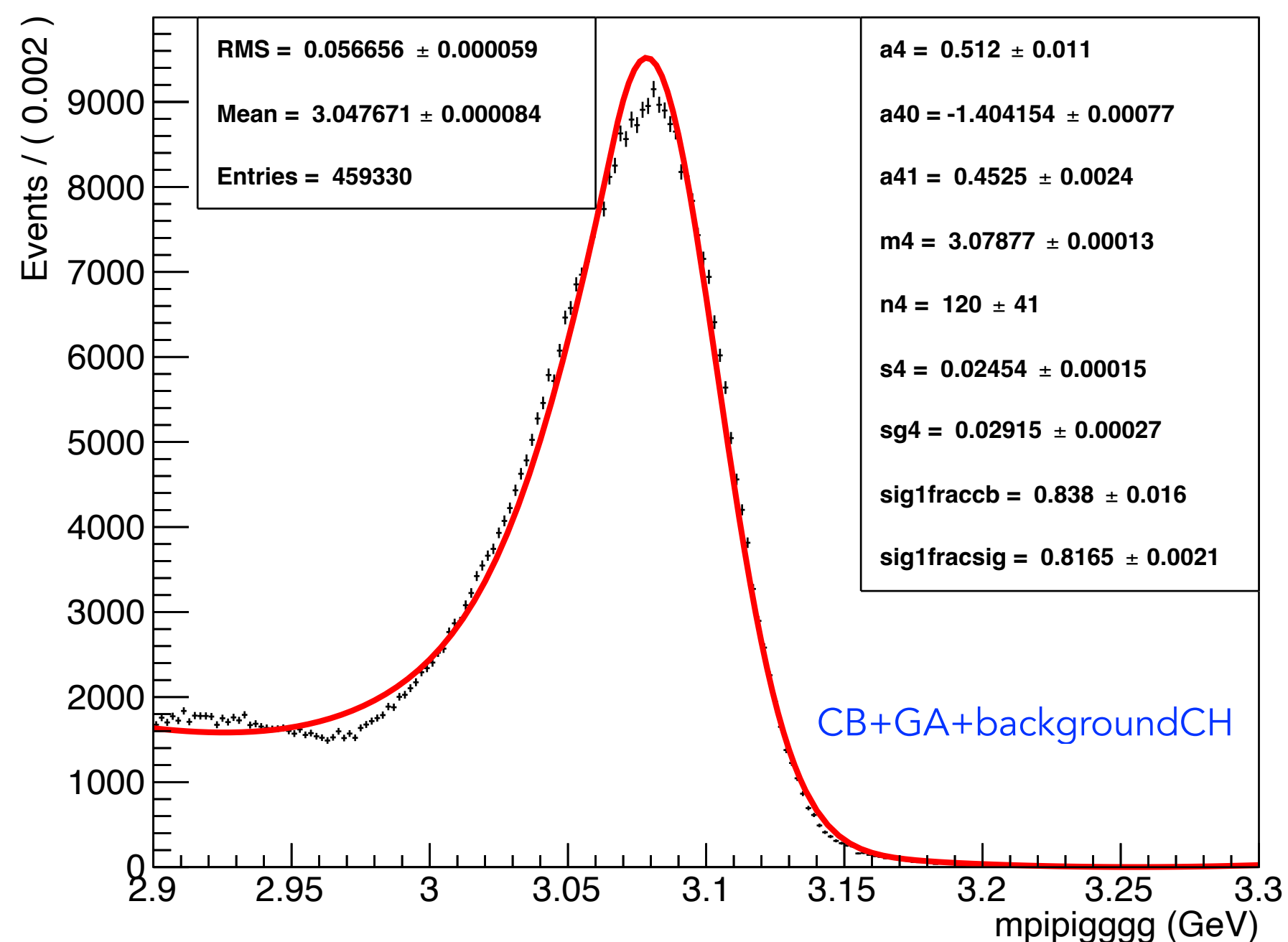
$$2.9 \text{ GeV}/c^2 < m_{\pi^+\pi^-\gamma\gamma\gamma\gamma} < 3.2 \text{ GeV}/c^2$$

Inclusive MC

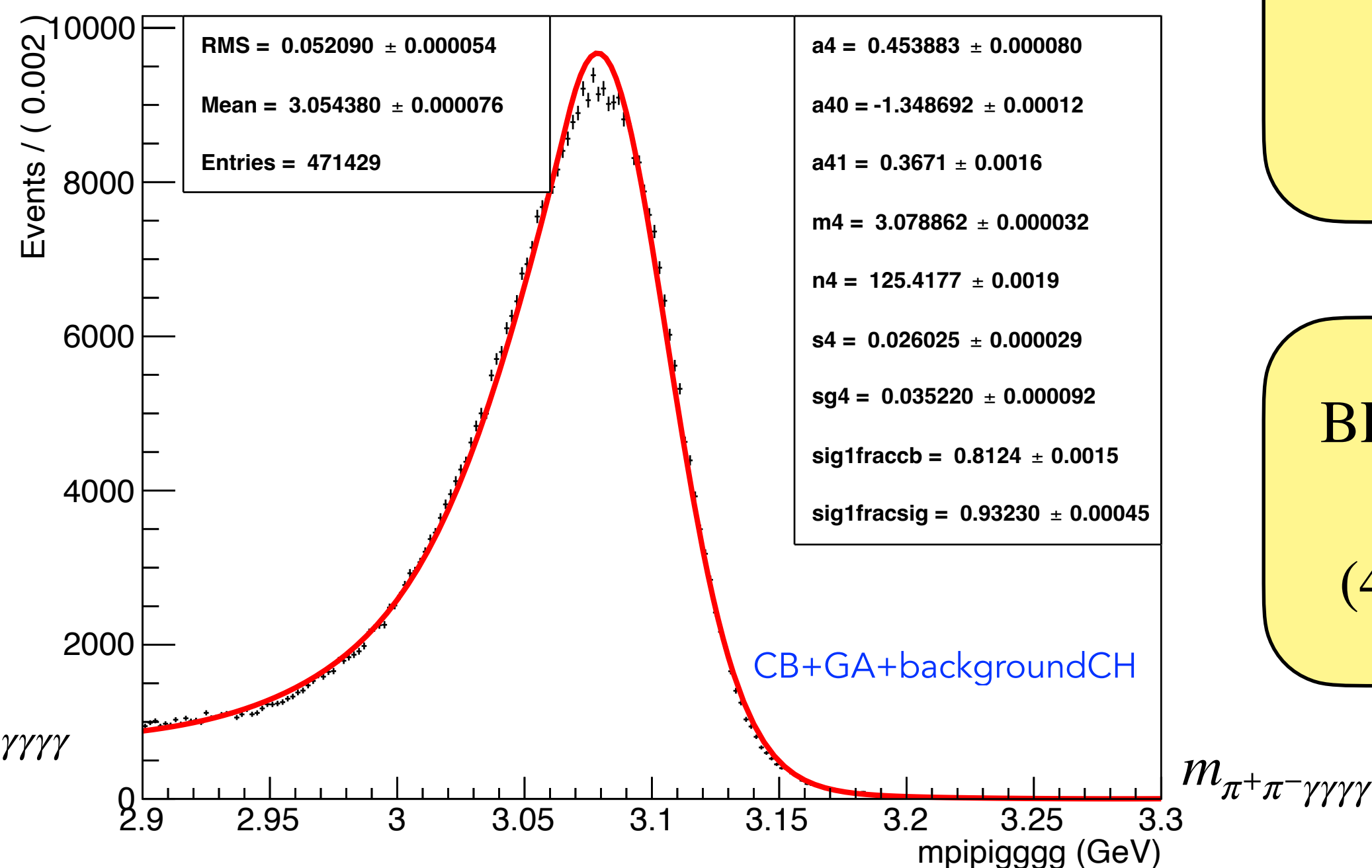
2019 (boss 775) 4100M

Real Data

m_C4P2mppgggg



m_C4P2mppgggg



$\text{BR}(J/\psi \rightarrow \omega\pi^0)$

$$4.89 \times 10^{-4}$$

$\text{BR}_{\text{PDG}}(J/\psi \rightarrow \omega\pi^0)$

$$(4.5 \pm 0.5) \times 10^{-4}$$

Inclusive MC vs Real Data

$$0.70 \text{ GeV}/c^2 < m_{\pi^+\pi^-(\gamma\gamma)\pi_2^0} < 0.85 \text{ GeV}/c^2$$

$$|m_{(\gamma\gamma)\pi^0} - m_{\pi^0}^{\text{PDG}}| < 4\sigma_{\pi^0}$$

$$2.9 \text{ GeV}/c^2 < m_{\pi^+\pi^-\gamma\gamma\gamma} < 3.2 \text{ GeV}/c^2$$

2009 (boss 775) 224M

$$\text{BR}(J/\psi \rightarrow \omega\pi^0) = 5.89 \times 10^{-4}$$

2012 (boss 775) 1087M

$$\text{BR}(J/\psi \rightarrow \omega\pi^0) = 5.50 \times 10^{-4}$$

2018 (boss 775) 4600M

$$\text{BR}(J/\psi \rightarrow \omega\pi^0) = 5.65 \times 10^{-4}$$

2019 (boss 775) 4100M

$$\text{BR}(J/\psi \rightarrow \omega\pi^0) = 4.89 \times 10^{-4}$$

$$\text{BR}_{\text{PDG}}(J/\psi \rightarrow \omega\pi^0) = (4.5 \pm 0.5) \times 10^{-4}$$

Principal backgrounds

Exclusive MC 20k samples

$$e^+e^- \rightarrow \pi^+\pi^-\pi^0\pi^0$$

Event selected: 65

Efficiency: 0,33%

Signal/background: 85

$$e^+e^- \rightarrow \omega\pi^0\pi^0 \rightarrow \pi^+\pi^-\pi^0\pi^0\pi^0$$

Event selected: 21

Efficiency: 0,11%

Signal/background: 263

$$e^+e^- \rightarrow \rho^0\pi^0\pi^0 \rightarrow \pi^+\pi^-\pi^0\pi^0$$

Event selected: 19

Efficiency: 0,10%

Signal/background: 290

$$e^+e^- \rightarrow \rho^+\pi^-\pi^0 \rightarrow \pi^+\pi^-\pi^0\pi^0$$

Event selected: 28

Efficiency: 0,14%

Signal/background: 197

$$e^+e^- \rightarrow \rho^-\pi^+\pi^0 \rightarrow \pi^+\pi^-\pi^0\pi^0$$

Event selected: 23

Efficiency: 0,12%

Signal/background: 240

$$e^+e^- \rightarrow \pi^+\pi^-\pi^0\pi^0\pi^0 \text{ negligible}$$



Backgrounds

Topology Study

Work in progress...