# Status of the Study of $e^+e^- \to \pi^+\pi^- J/\psi$ at $\sqrt{s} \approx 3.872\,\text{GeV}$

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# Introduction

## Data Points

| $\sqrt{s}$ | $\mathcal{L}$ |
|---|---|
| 3.8674 GeV | $111.5\,\mathrm{pb}^{-1}$ |
| 3.8713 GeV | $113.5\,\mathrm{pb}^{-1}$ |

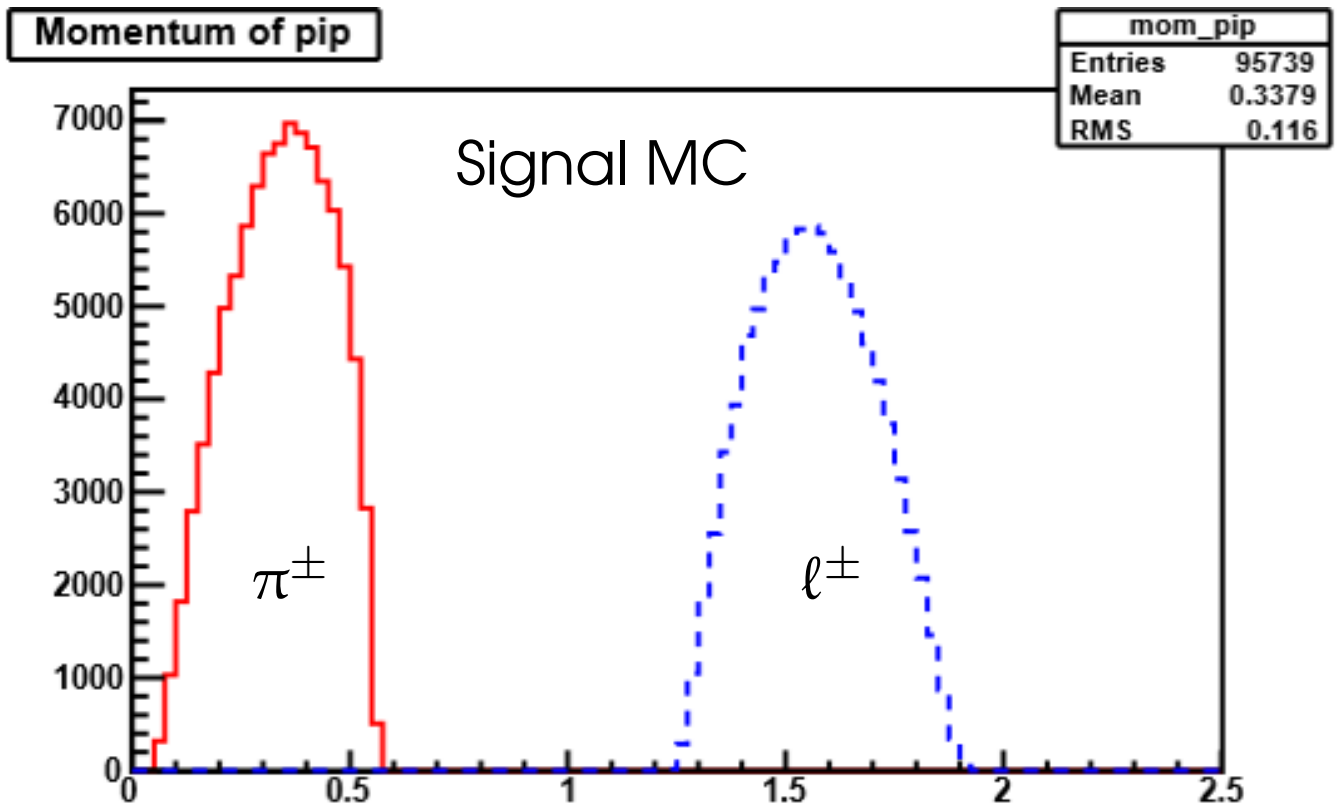
## Goal

- Measure cross section of $e^+e^- \to \pi^+\pi^- J/\psi$
  - via $J/\psi \to \ell^+\ell^-$
- Set limits on $\Gamma_{tot}(X(3872))$ and $\Gamma_{ee}(X(3872)) \times \mathcal{B}(X(3872) \to \pi^+\pi^- J/\psi)$

# Event Selection

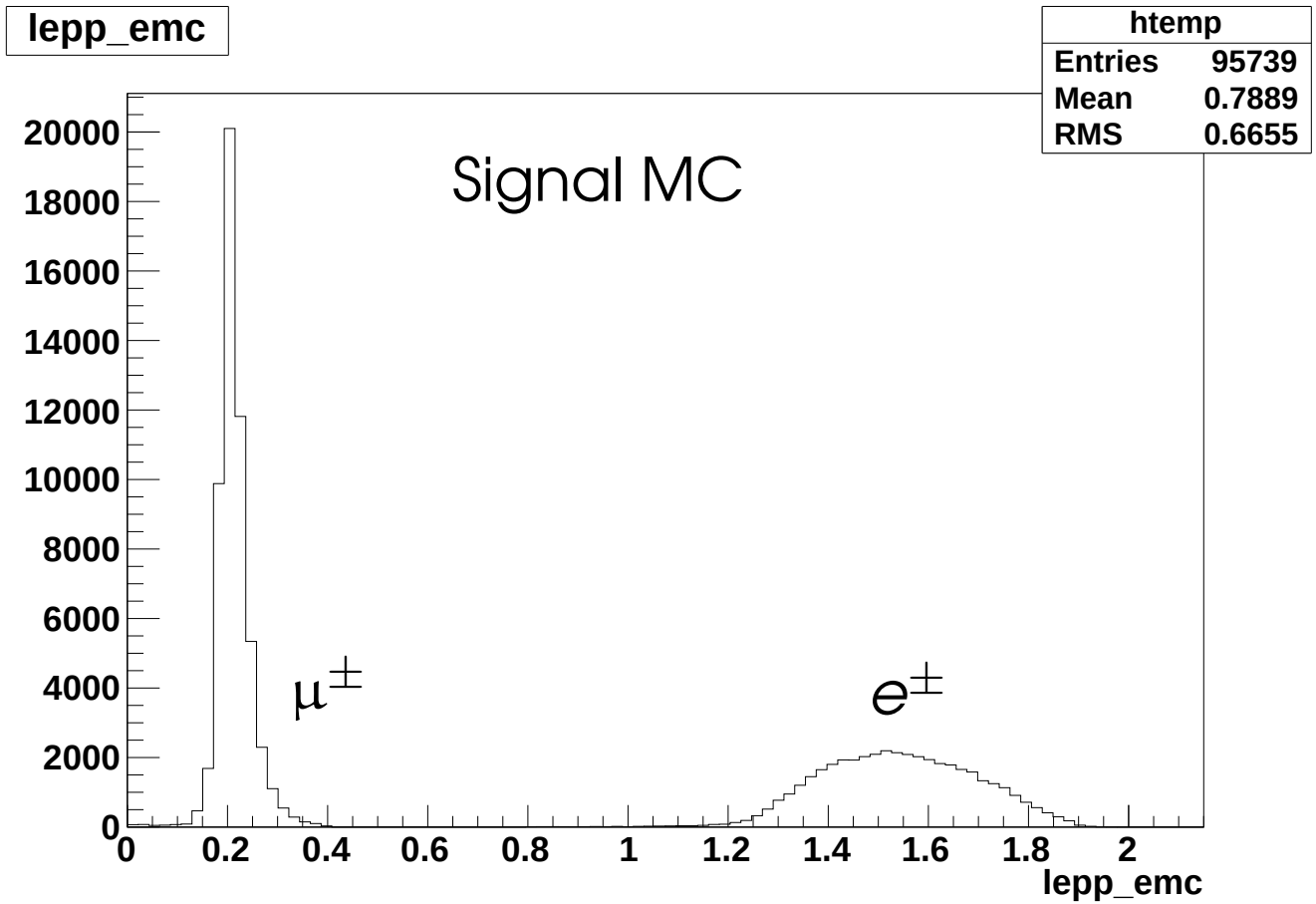
- boss version 7.02p01
- 4 good charged tracks, net charge $= 0$:
  - $|z_{POCA}| < 10\,\text{cm}$
  - $r_{POCA} < 1\,\text{cm}$
  - $|\cos\theta| < 0.93$

# Particle ID (1): $\pi^{\pm}$ or $\ell^{\pm}$?




- $\pi^{\pm}$ momenta are required to be $< 0.6\,\text{GeV}$
- $\ell^{\pm}$ momenta are required to be $> 1.0\,\text{GeV}$

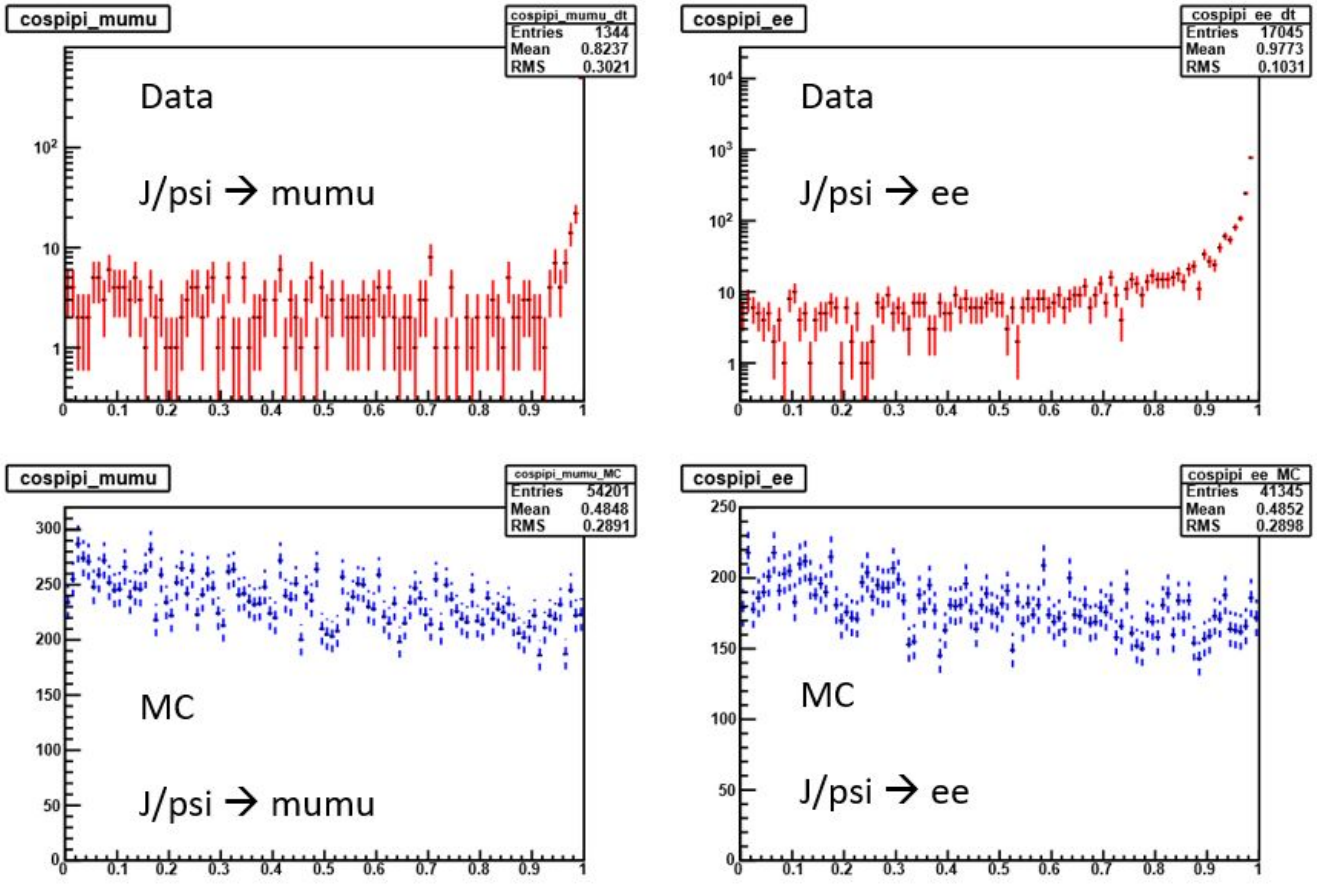
# Particle ID (2): $\mu^{\pm}$ or $e^{\pm}$?




- $\mu^{\pm}$ candidates should deposit $< 0.4$ GeV in EMC
- $e^{\pm}$ candidates should deposit $> 0.8$ GeV in EMC

# Gamma Conversion Background Rejection (1)

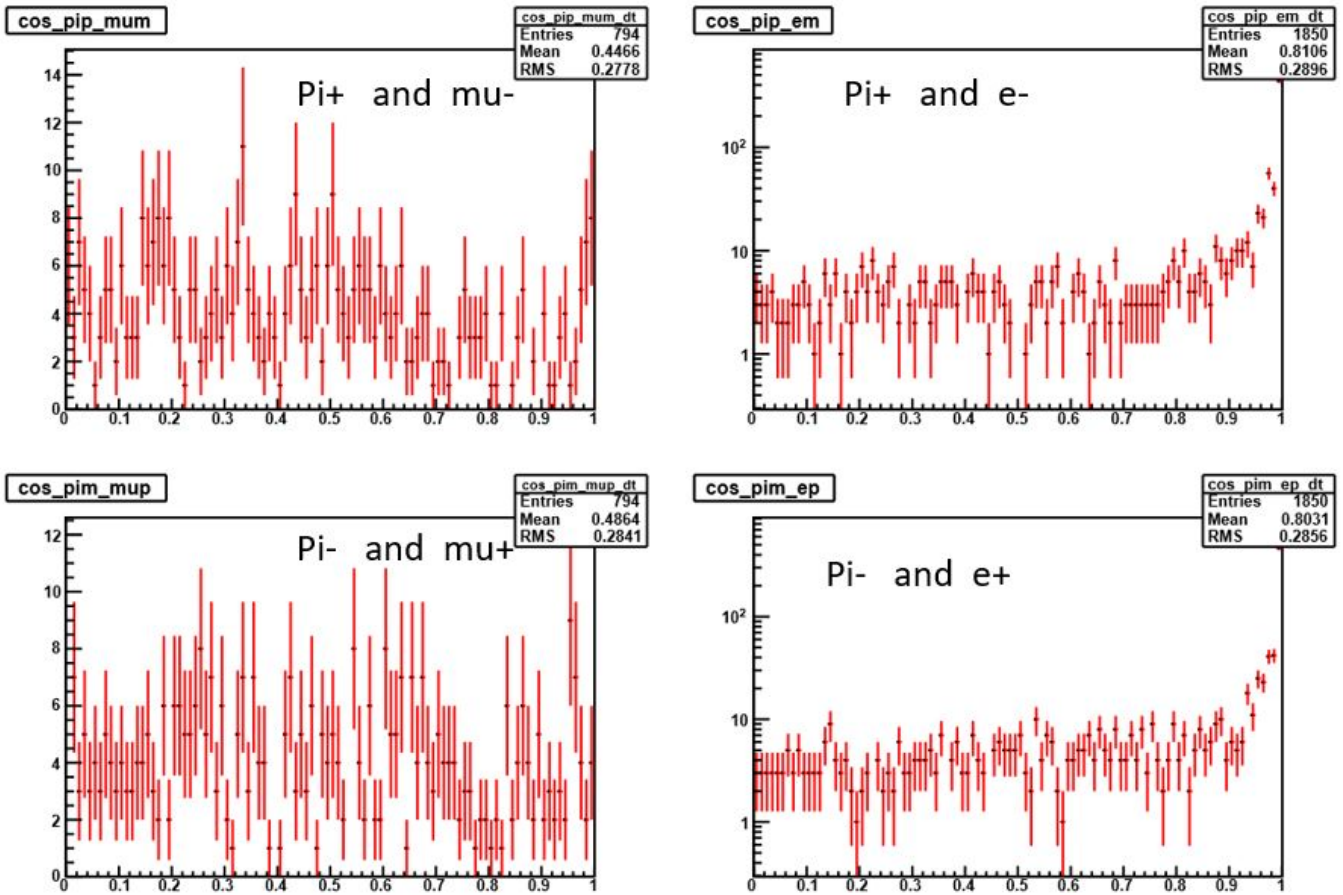
Cosine of opening angle between both $\pi^{\pm}$ candidates




Require $\cos\theta_{\pi\pi} < 0.98$

# Gamma Conversion Background Rejection (2)

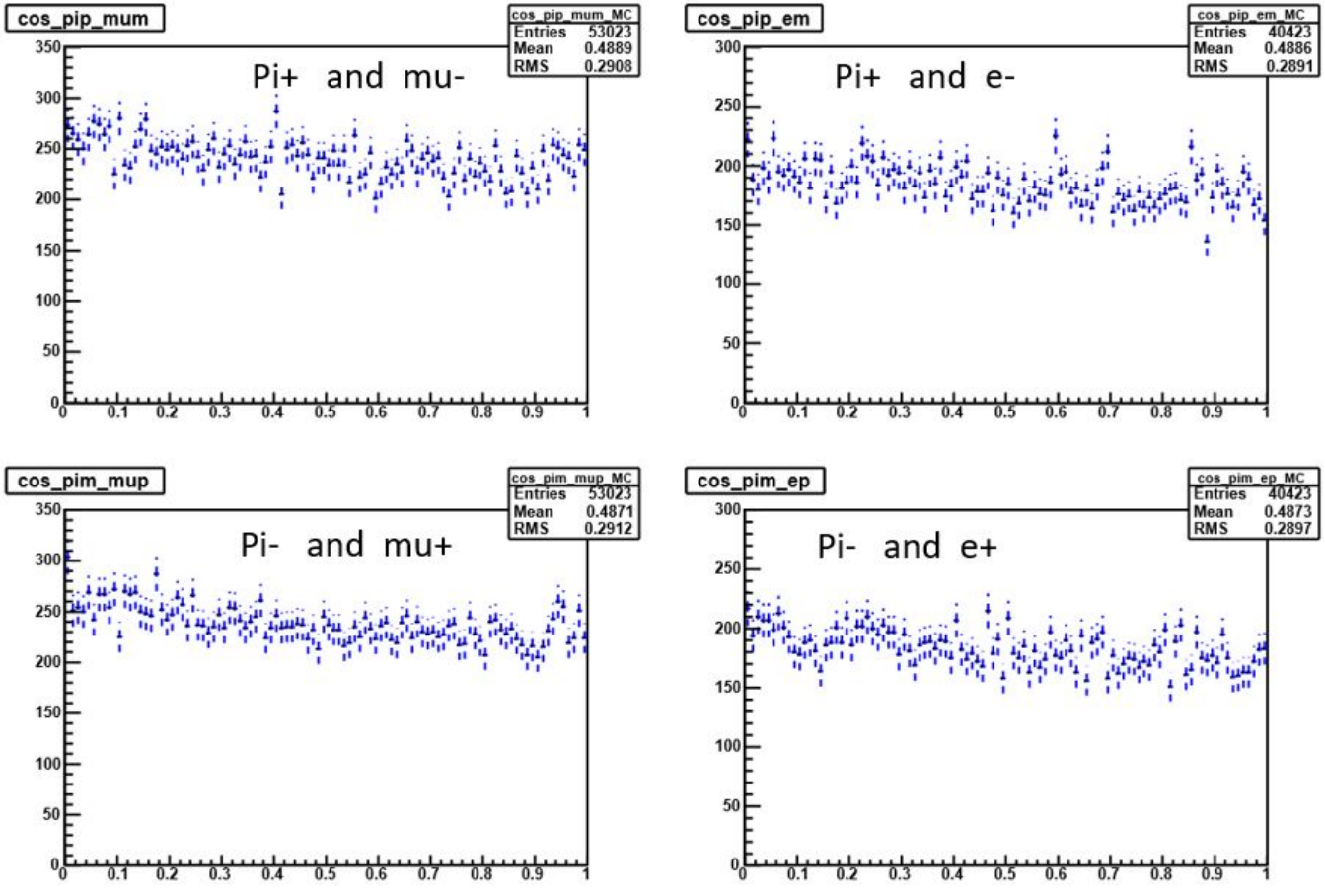
Data: cosine of opening angle between $\pi^{\pm}$ and $\ell^{\mp}$ candidates




Require $\cos\theta_{\pi^{\pm}e^{\mp}} < 0.98$

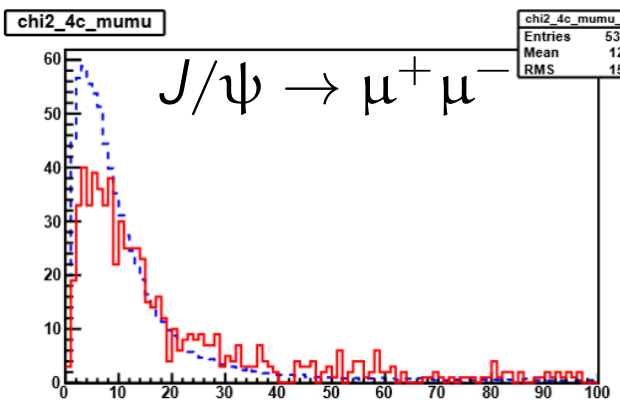
# Gamma Conversion Background Rejection (3)

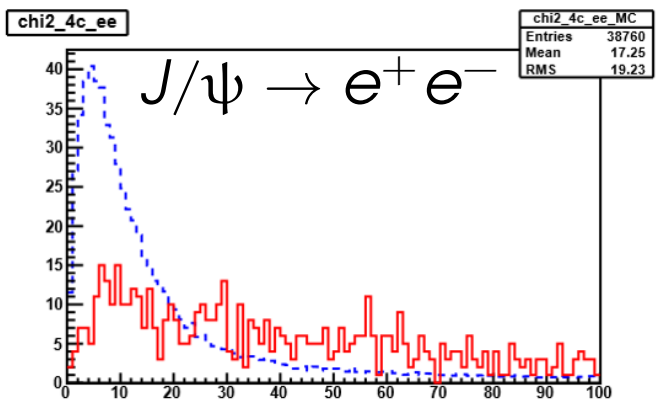
MC: cosine of opening angle between $\pi^{\pm}$ and $\ell^{\mp}$ candidates



# Kinematic Fit

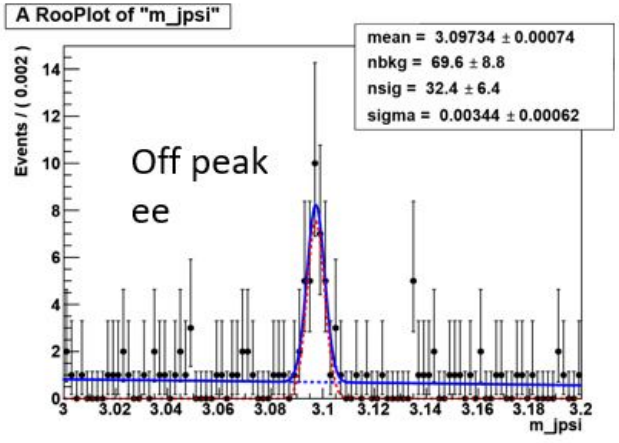
- Require a succesfull vertex fit of all four tracks
- Perform a 4C fit (total four momentum) and require $\chi^2 < 60$
- Abnormal $\chi^2$ distribution for $J/\psi \to e^+e^-$ (blue: MC, red: data)

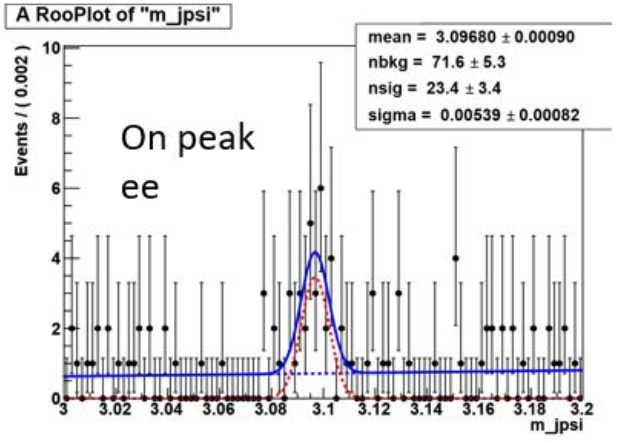


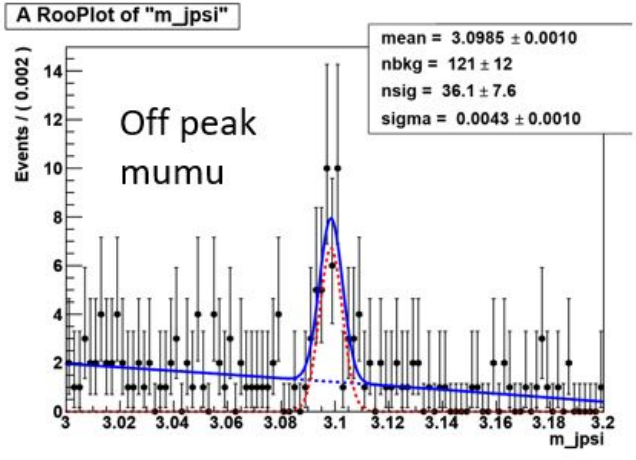



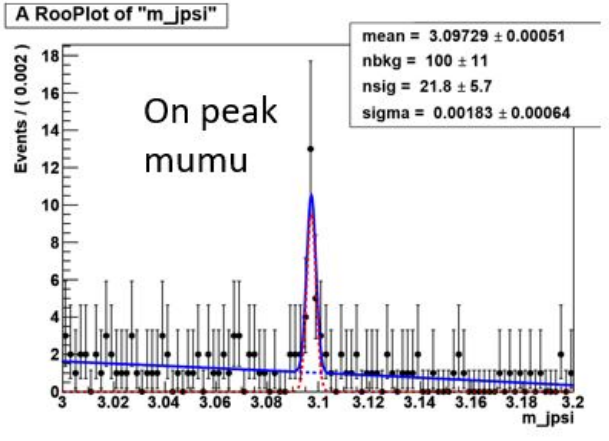
# Fit to the $\ell^+\ell^-$ Spectrum: Get $N_{obs}$ (1)

## Gaussian + linear background



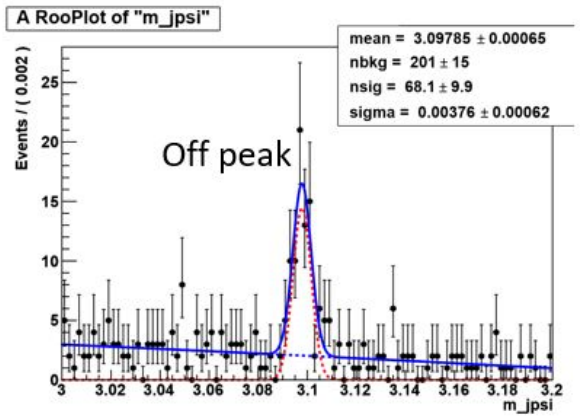



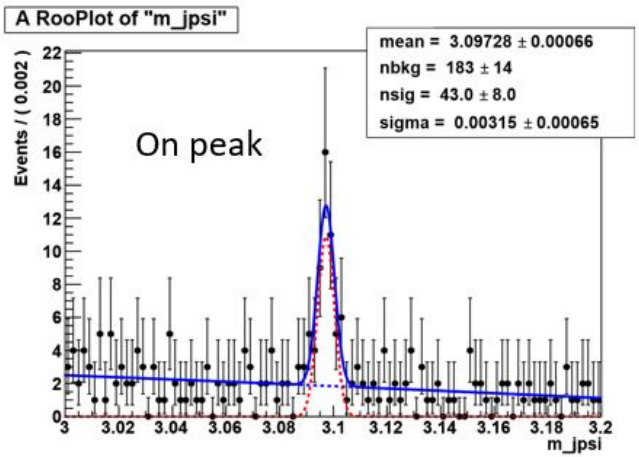



# Fit to the $\ell^+\ell^-$ Spectrum: Get $N_{obs}$ (2)

Gaussian + linear background $J/\psi \to \mu^+\mu^-$ and $J/\psi \to e^+e^-$ combined



# Preliminary Cross Section (1)

$$\sigma(e^+e^- \to \pi^+\pi^- J/\psi) = \frac{N_{obs}}{\mathcal{L}_{int}\varepsilon(1+\delta)\mathcal{B}(J/\psi \to \ell^+\ell^-)}$$

- $\mathcal{L}_{int} = 111.5\,\text{pb}^{-1}$ and $113.5\,\text{pb}^{-1}$ measured (see previous talk)
- $\varepsilon = 41.2\,\%$ determined from Signal MC
- $\mathcal{B}(J/\psi \to \ell^+\ell^-) = 11.9\,\%$ taken from PDG
- $1+\delta = 0.86$ at the moment taken from published analysis of $e^+e^- \to \pi^+\pi^- J/\psi$ (BAM-00214)

# Preliminary Cross Section (2)

Only statistical error!

| | $\sqrt{s}$ | $\mathcal{L}$ | $\sigma(e^+e^- \to \pi^+\pi^- J/\psi)$ |
|---|---|---|---|
| This analysis | 3.8674 GeV | $111.5\,\text{pb}^{-1}$ | $(14.4 \pm 2.1)$ pb |
| This analysis | 3.8713 GeV | $113.5\,\text{pb}^{-1}$ | $(8.9 \pm 1.7)$ pb |
| BAM-00214 | 3.8077 GeV | $50.5\,\text{pb}^{-1}$ | $(16.7 \pm 3.3 \pm 1.0)$ pb |
| BAM-00214 | 3.8962 GeV | $52.6\,\text{pb}^{-1}$ | $(17.1 \pm 3.4 \pm 1.0)$ pb |

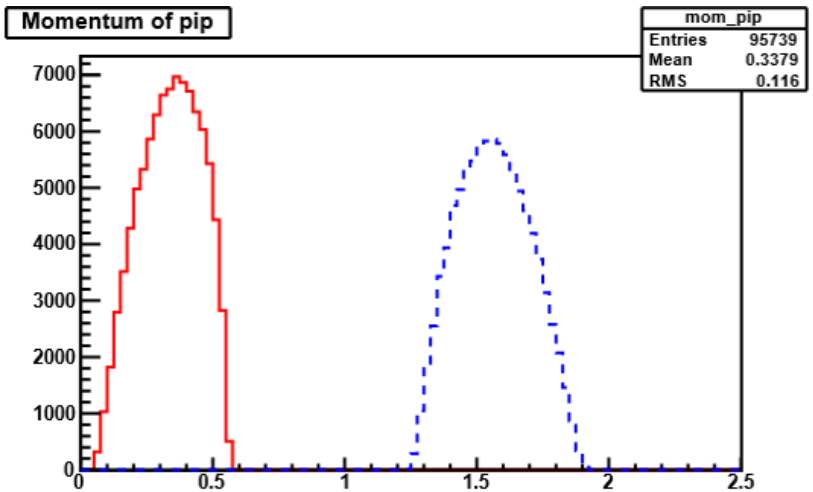
Destructive interference?
– With what? Continuum should be $1^{--}$, while $X(3872)$ is $1^{++}$ !

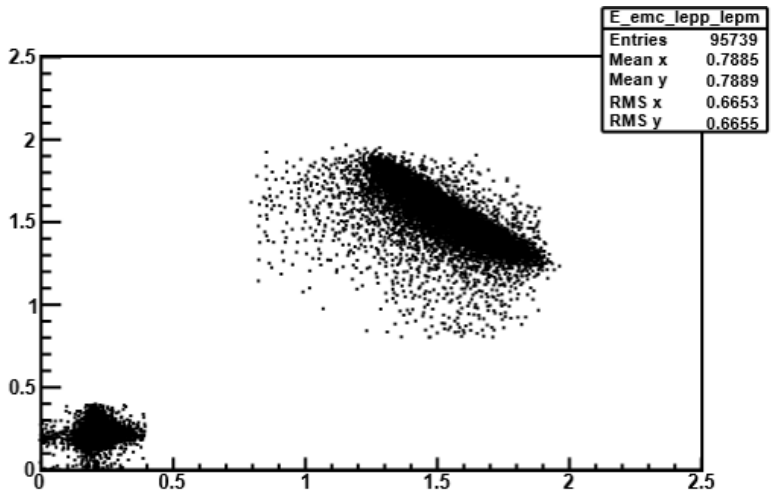
# To Do List

- Investigate abnormal $\chi^2$ distribution of 4C fit
- Determine $\sqrt{s}$ dependence of the efficiency
- Study impact of different $\pi^+\pi^-$ modelings ($\rho$ vs. PHSP)
- Study background sources ($e^+e^- \to \pi^+\pi^-\pi^+\pi^-$, $e^+e^- \to \gamma_{ISR}\psi'$, *etc.*)
- Replace Gaussian by MC-shape $\otimes$ Gaussian in fit
- Determine systematic uncertainties
- Set limits on $\Gamma_{tot}(X(3872))$ and $\Gamma_{ee}(X(3872)) \times \mathcal{B}(X(3872) \to \pi^+\pi^- J/\psi)$
- Repeat analysis when BOSS 7.0.3 is released
- ...

# Thank You!

# PID 2D Plot


Momentum of pip
mom_pip
Entries 95739
Mean 0.3379
RMS 0.116
7000
6000
5000
4000
3000
2000
1000
0
0.5
1
1.5
2
2.5


E_emc_lepp_lepm
Entries 95739
Mean x 0.7885
Mean y 0.7889
RMS x 0.6653
RMS y 0.6655
2.5
2
1.5
1
0.5
0
0.5
1
1.5
2
2.5