Electronic width of $X(3872)$

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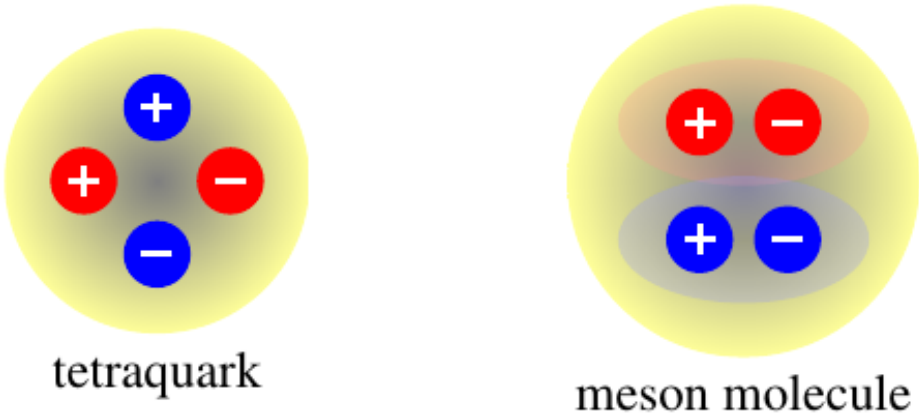
Motivation

- Recently discovered exotic charmonium like states XYZ
- What is the substructure of the X(3872)?

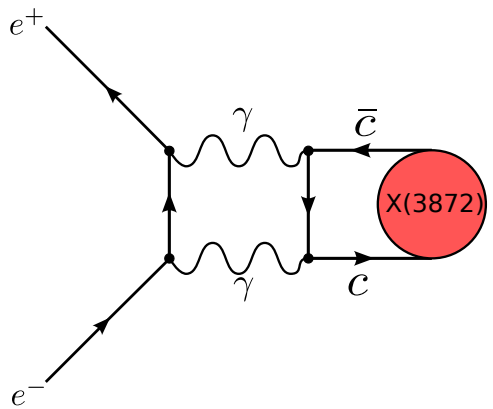


http://ellipsix.net/blog/tagged/Belle.html

- Electronic width: $\sigma(X(3872) \leftrightarrow \ell\ell) \sim \Gamma_{ee} \sim \psi(\vec{x} = 0)$
- Electronic width expected to be a model specific feature
- Theoretical predictions under construction
- More precise value of electronic width may rule out some models for structure
- Measuring Electronic width of X(3872) at BESIII

Technique of Analysis I

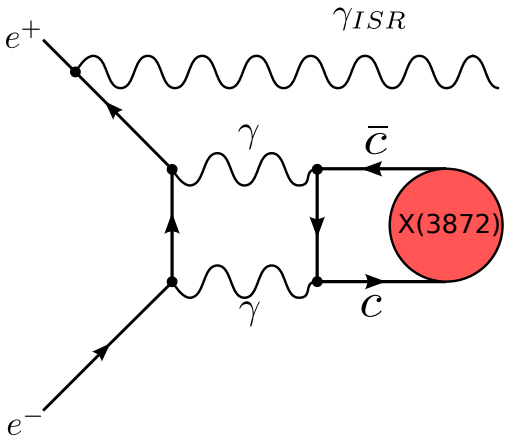
- $X(3872)$ is not a vector resonance, it has $J^{PC} = 1^{++}$
- **Problem:** $X(3872)$ can not be produced in an e^+e^- annihilation
- **Trick:** production via box diagram

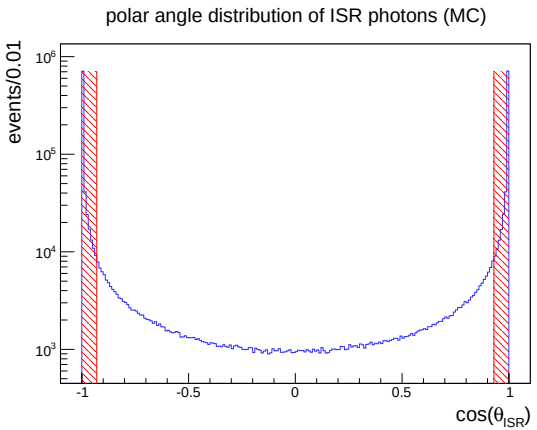


- $\mathcal{L}_{int} \approx 3\,\text{fb}^{-1}$ data at 4 energy points above 4 GeV at BESIII
- **Problem:** No data at 3.872 GeV
- **Solution:** Initial State Radiation

ISR Technique I

- e^- or e^+ can radiate a photon before collision

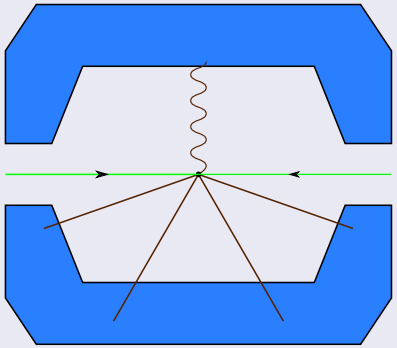




- Emission of ISR photons is suppressed by α/π
- Center of mass energy for collision reduced
- Acceptance of BESIII calorimeter: $|\cos\theta| \leq 0.93$
- Two analysis modes: ISR tagged, ISR untagged

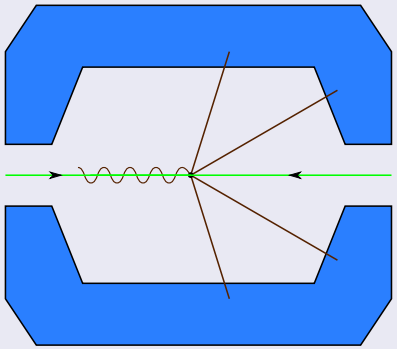
ISR Technique II

Tagged Analysis



- $J/\psi\pi^+\pi^-$ reconstructed
- ISR photon measured
  $\Rightarrow$ All particles detected

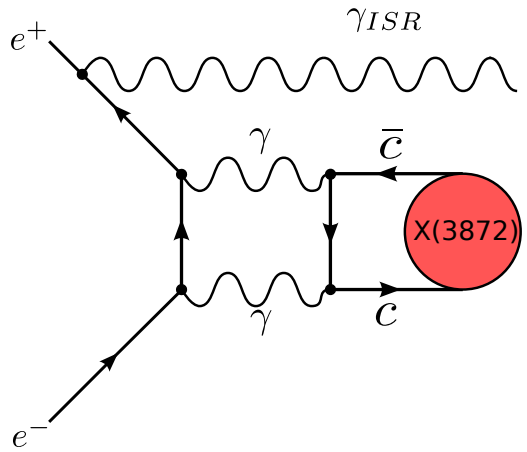
Untagged Analysis



- only $J/\psi\pi^+\pi^-$ reconstructed
- predict 4-momentum of ISR photon by demanding 4-momentum conservation

ISR untagged mode to avoid background from radiative decay
$e^+e^- \to Y(4260) \to \gamma X(3872)$

Technique of Analysis II



- Decay mode:

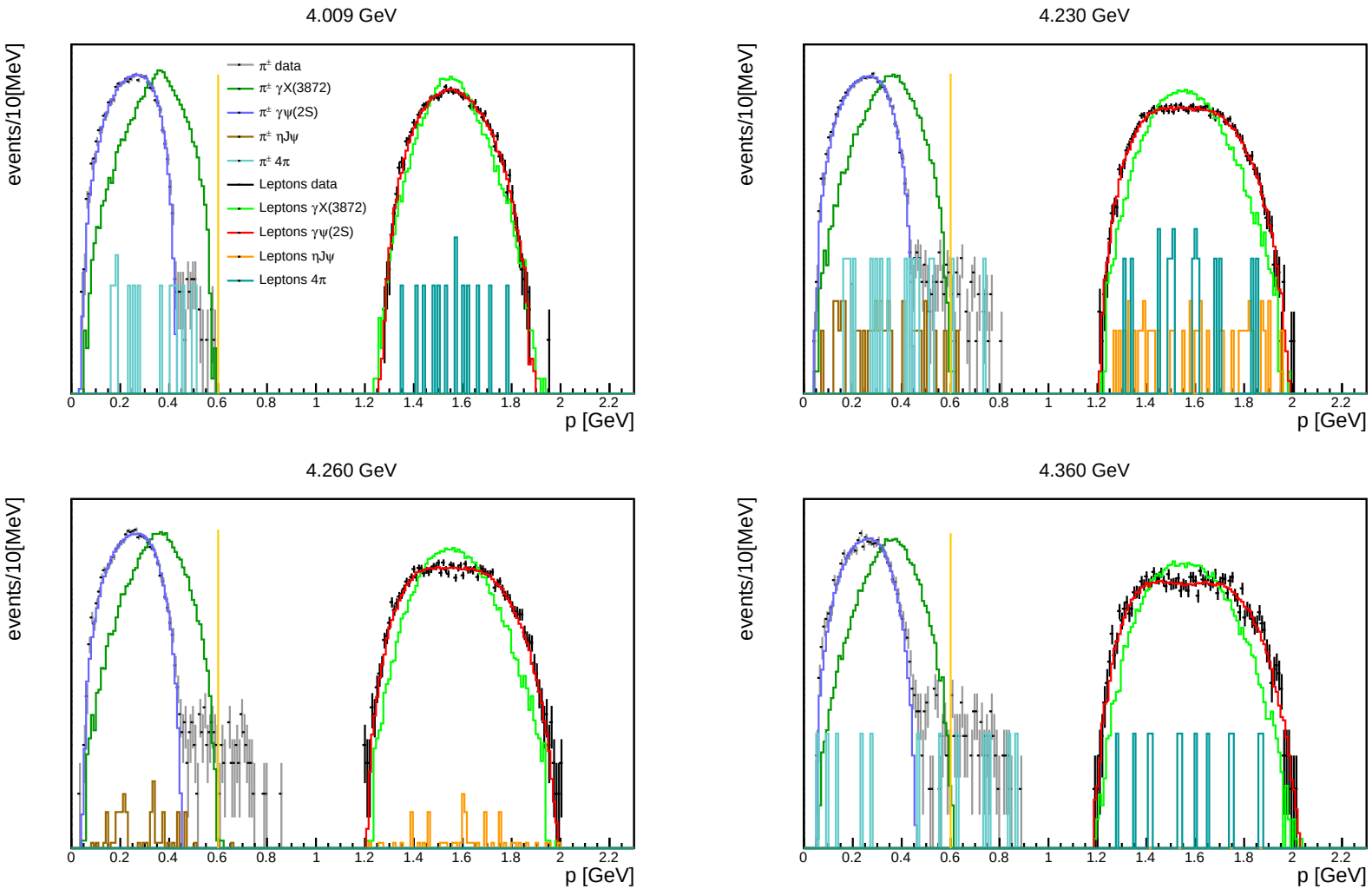
$$e^+e^- \longrightarrow X(3872)\gamma_{ISR} \longrightarrow \pi^+\pi^- J/\psi\gamma_{ISR}$$
$$\longrightarrow \pi^+\pi^-\ell^+\ell^-\gamma_{ISR} \quad , \qquad \ell = \mu, e$$

- dominating background: $e^+e^- \longrightarrow \psi(2S)\gamma_{ISR}$ (well known!)
- Relation between radiative cross section and non radiative cross section

$$\frac{d\sigma_{X\gamma}}{dm} = \frac{2m}{s} W(s,m)\sigma_X(m)$$

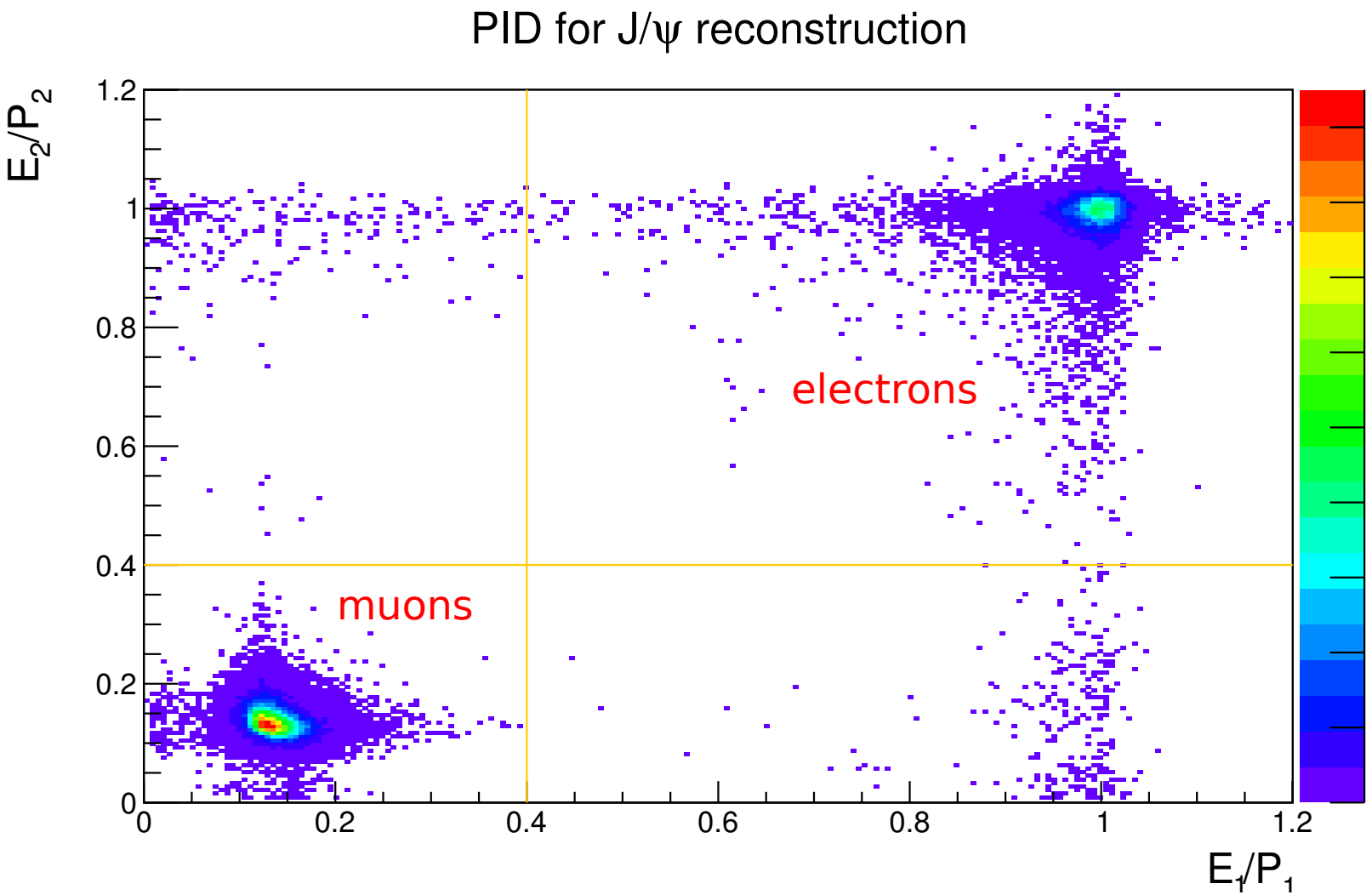
J/ψ Reconstruction I

- pions and leptons are well separated by momentum
- leptons have $p > 1.2\ GeV$

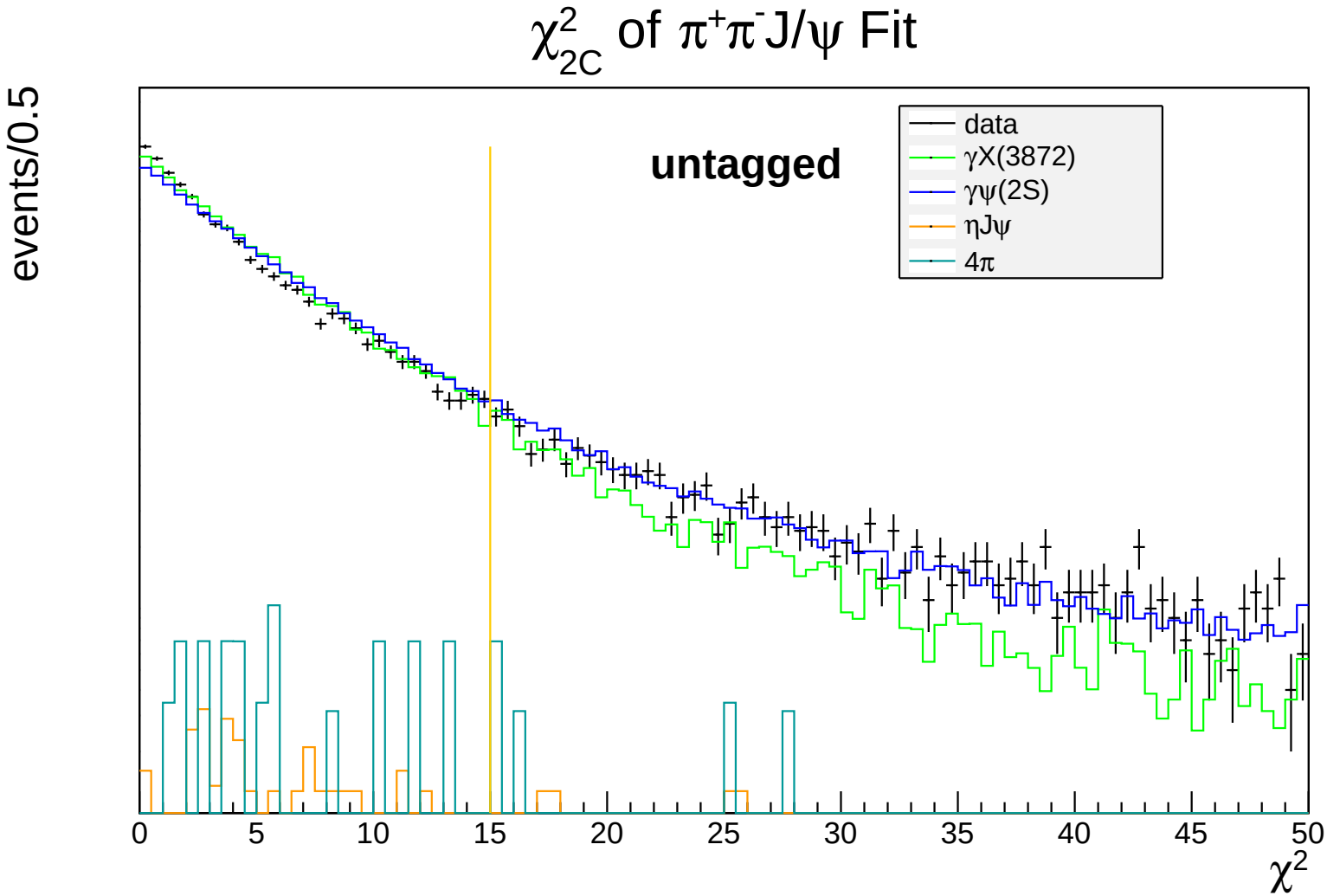


J/ψ Reconstruction II

- pions and leptons are well separated by momentum
- muons and electrons are well separated by E/p

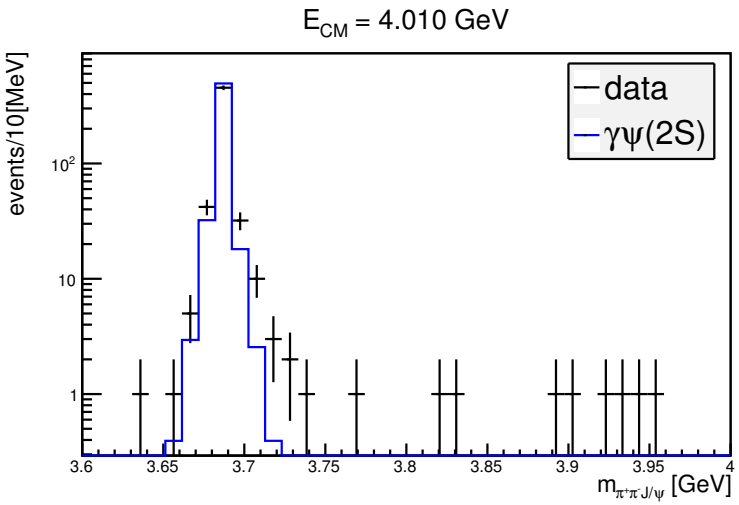


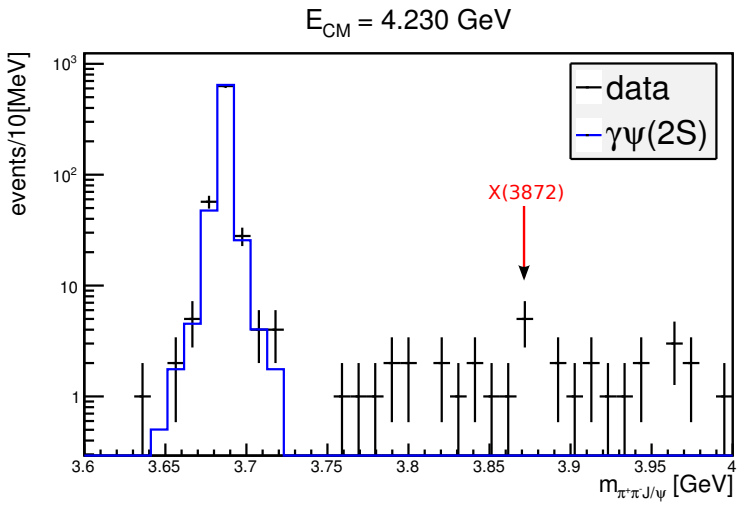
χ^2_{2C} of Untagged Kinematic Fit

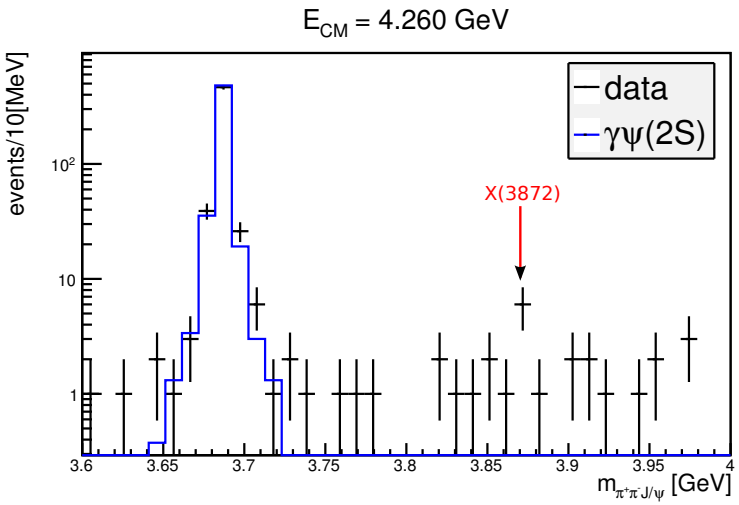


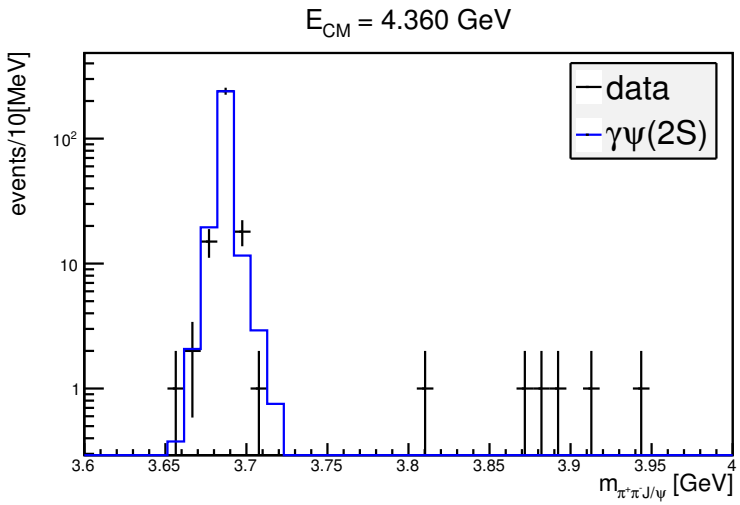
- 2C kinematic fit: $m_{miss} = 0$, $m_{\ell^+\ell^-} = m_{J//psi}$
- Rejecting $\chi^2_{2C} > 15$
- Shape of χ^2_{2C} distribution $\Rightarrow$ no additional background

Cross check with Previous Measurements (Tagged Mode)



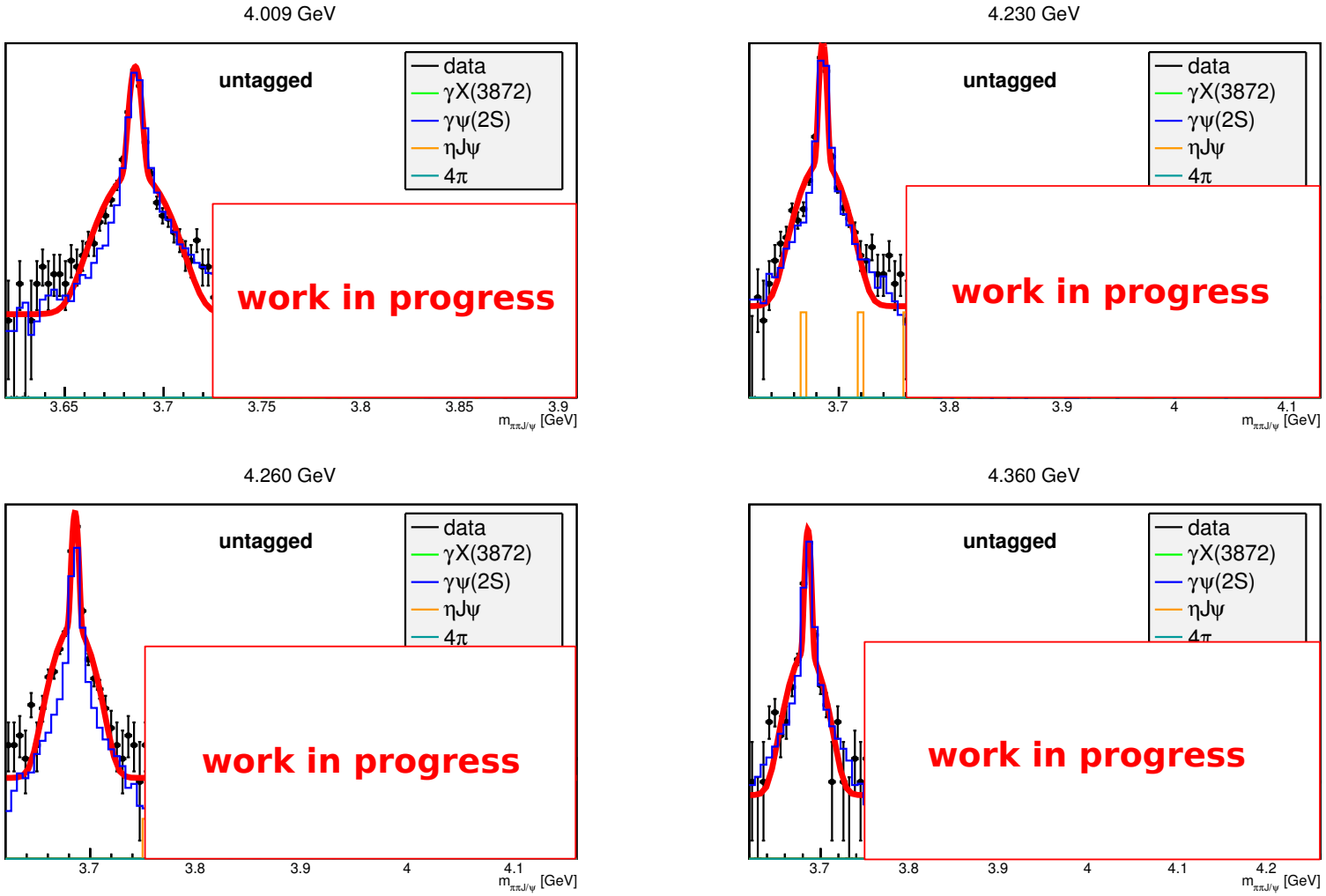






- 19 ± 0.9 $X(3872)$ events observed by direct count
- In agreement with previous result of BESIII Collaboration on $Y(4260) \to \gamma X(3872)$ Phys. Rev. Lett. 112, 092001

Untagged $m_{J/\psi\pi\pi}$ Spectrum



- Fitting $m_{J/\psi\pi^+\pi^-}$ mass spectrum with double Gaussian for $\psi(2S)$ + Gaussian for X(3872) + linear background

Determine Γ_{ee} upper Limit I

Number of observed $X(3872)$ given by:

$$\frac{dN_A^{\text{obs}}}{dx} = \mathcal{L}\varepsilon_A W(s,x)\sigma^A(m(s,x))\mathcal{B}(A \to f)$$
$$\Rightarrow N_A^{\text{obs}} = \varepsilon_A \mathcal{L}\Gamma_{ee}^A \mathcal{B}(A \to f) I_A$$

- for $A = X(3872)$, $\psi(2S)$.
- ε_A is the reconstruction efficiency
- $I_A = \int b_A(m(s,x))W(s,x)dx \qquad , \qquad x = 1 - m^2/s$
- $W(s,x)$ is the radiator function
- $b_A(m)$ is the relativistic Breit-Wigner function over Γ_{ee}^A

$$\Gamma_{ee,1}^A = \frac{N_A^{\text{obs}}}{\mathcal{L}\varepsilon_A I_A \mathcal{B}(A \to \pi^+\pi^- J/\psi)\mathcal{B}(J/\psi \to \ell^+\ell^-)}$$

$$\Gamma_{ee,2}^X = \Gamma_{ee}^{\psi(2S)} \frac{N_X^{\text{obs}}}{N_{\psi(2S)}^{\text{obs}}} \frac{\varepsilon_{\psi(2S)}}{\varepsilon_X} \frac{I_{\psi(2S)}}{I_X} \frac{\mathcal{B}(\psi(2S) \to \pi^+\pi^- J/\psi)}{\mathcal{B}(X \to \pi^+\pi^- J/\psi)}$$

Final Result

- No X(3872) signal found, only upper limit
- Log Likelihood Scan of X(3872) peak parameter for 90 % C.L. performed
- Combine the four measurements by summing up their logarithmic likelihoods
- Analysis in referee stage, cannot yet show final result here
- Good improvement compared to current PDG value: $\Gamma_{ee}^{X(3872)} < \mathcal{O}(\text{eV})$

Thank you for your attention!