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BESIII

Partial Wave Analysis of $J/\psi \to \gamma p\bar{p}$

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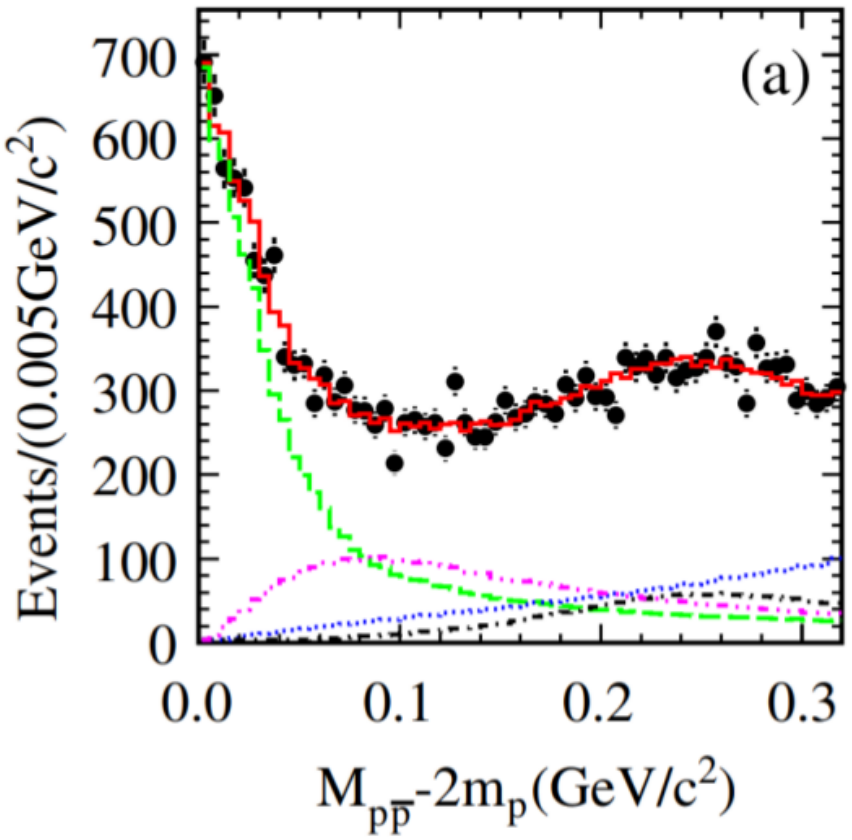
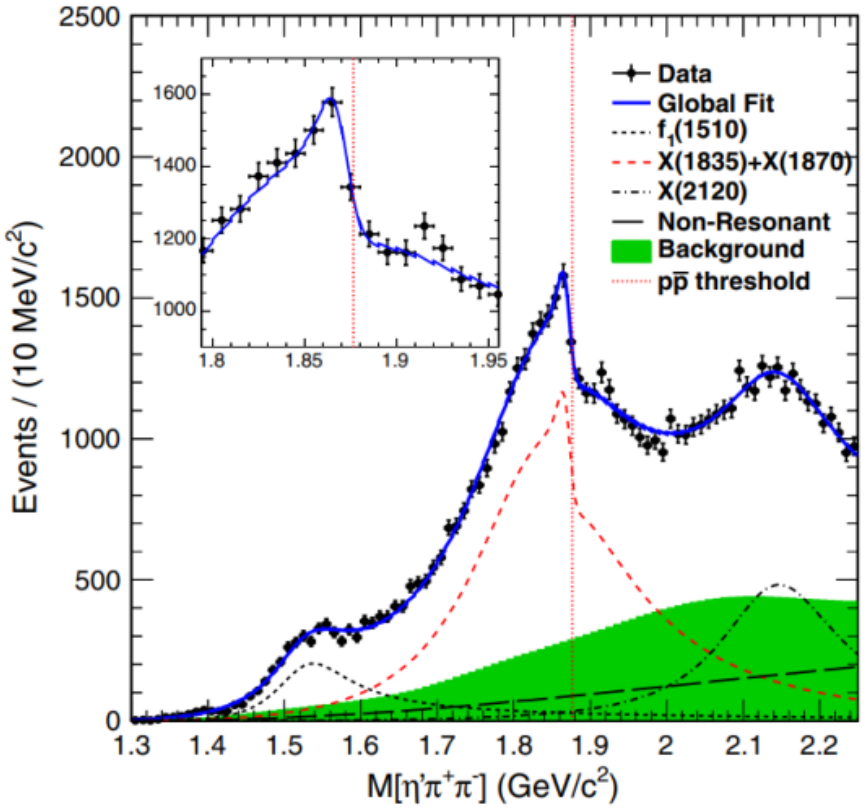
Motivation

$X(1870)$	
Mass (MeV/c^2)	$1870.2 \pm 2.2^{+2.3}_{-0.7}$
Width (MeV/c^2)	$13.0 \pm 6.1^{+2.1}_{-3.8}$

- Much more data than previous analysis of $J/\psi \to \gamma p\bar{p}$
- For the analysis of $J/\psi \to \gamma\pi^+\pi^-\eta'$, an "fast drop" structure near $p\bar{p}$ threshold in $\pi^+\pi^-\eta'$ mass spectrum was fitted with X(1835) and X(1870)





Event Selection

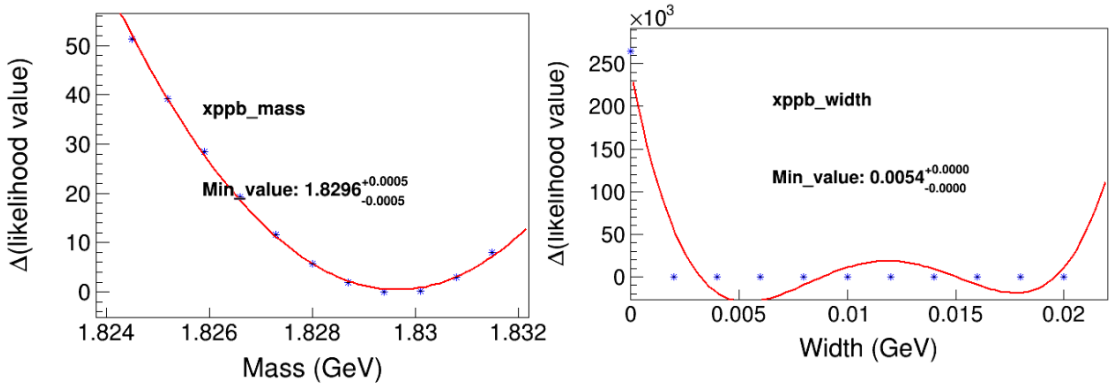
1. Good Charged tracks:
   - - Each charged track is required to originate from the interaction point, with V_{xy} <1cm, $|V_z|$ <10cm. Here V_x,V_y, and V_z are the x, y, and z coordinates of the point of closest approach to the run dependent interaction point, respectively. The $|\cos\theta|$ of each charged track is required to be less than 0.93.
   - - Require two good charged tracks and zero net charge in each event.
   - - A vertex fit is performed on both charged tracks.
   - - PID (Particle identification) is used for proton idetification using dE/dx and TOF measurements. Two charged tracks are required to be idetificated as proton. The requirements are Prob(p)>Prob(π) and Prob(p)>Prob(K).
2. Good Photons:
   - - For photons in barrel EMC region($|\cos\theta| < 0.8$), the deposit energy in EMC should be larger than 25MeV. While in Endcap EMC region($0.86 < |\cos\theta| < 0.92$), the deposit energy is required to be larger than 50 MeV.
   - - $0 \le T_{TDC} \le 14$ (in the unit of 50 ns) is applied to suppress the electronic noise and energy deposition unrelated to the physical event.
   - - The angle between photon and nearest charged particle is required to be larger then 20 degree.
   - - The photon should be isolated from antiprotons by more than 30 degree.
   - - The number of good photons should be at leat one.
3. Kinematic fit:
   - - Four-constraint (4C) kinematic fits are performed with the three final paticles to improve resolution and help to suppress background. For events with more than one photon candidates, the combination with the minimum χ^2 is used.
   - - The χ^2 of the 4C fit is requierd to be less than 20.
   - - Require $|U_{miss}| < 0.04$ GeV, where $U_{miss} = (E_{miss} - |P_{miss}|)$, and E_{miss} and P_{miss} the missing energy and momentum of all charged particles. To supress $\pi^0 p\bar{p}$ background.
   - - $P_{tr}^2 < 0.0005(\mathrm{GeV}/c)^2$, where $P_{tr}^2 = 4|P_{mss}|^2 sin^2\theta_\gamma/2$. To supress muti-photon events.
   - - To reduce the difference between data and MC simulation, the momentum of prton is require to be larger than 300 MeV/c.

Samples

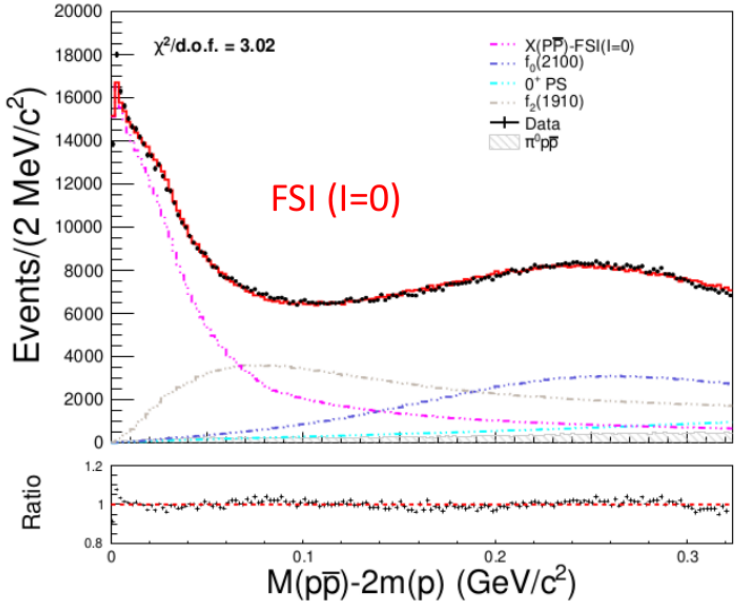
- Data samples: 10B J/ψ data samples reconstructed under BOSS version 7.0.5. collected with the BESIII detector.
- $J/\psi \to \gamma p\bar{p}$ MC samples:
  - M($p\bar{p}$)<1.91 GeV/c2 : 2.50M PHSP (Data: 0.24M)
  - M($p\bar{p}$)∈[1.91,2.20] GeV/c2 : 5.60M PHSP (Data: 5.60M)
- $J/\psi \to \pi^0 p\bar{p}$ DIY MC samples

PWA results with model from previous work

- One resonance model
  - FSI factor (I =0)
- PWA solution
  - Cann't fit well near threshold
  - The measured parameters of the X(1835) are consistent with previous work



resonance	J^{pc}	Mass (MeV)	Width (MeV)
$X(p\bar{p})$	$\mathbf{0^{-+}}$	$1829.6^{+0.8}_{-0.9}$	0^{+7}_{-0}
$f_0(2100)$	$\mathbf{0^{-+}}$	2086	284
$f_0(1900)$	$\mathbf{2^{-+}}$	1900	167
$PHSP$	$\mathbf{0^{++}}$	− −	− −



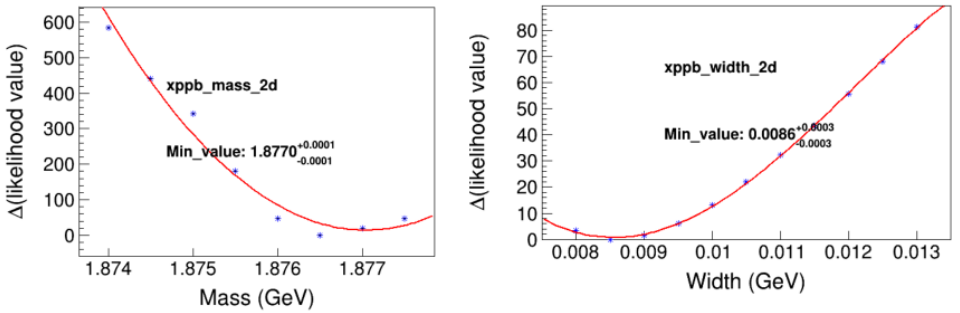
previous study

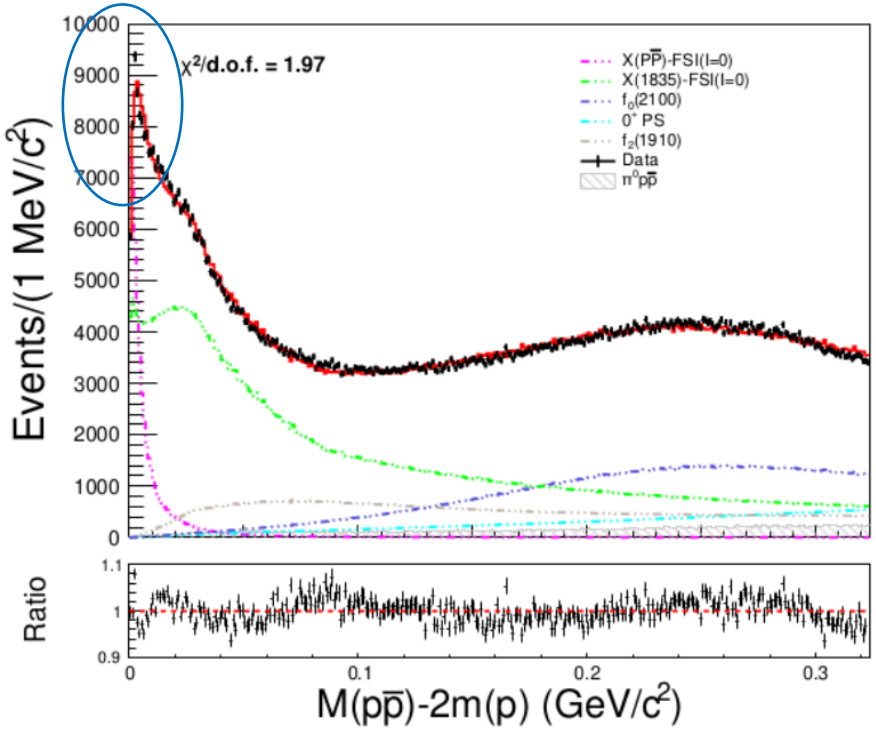
$X(1835)$	
Mass (MeV/c^2)	$1825.3 \pm 2.4^{+17.3}_{-2.4}$
Width (MeV/c^2)	$245.2 \pm 13.1^{+4.6}_{-9.6}$

PWA solution without X(1879)

- Two resonances model
  - FSI factor (I =0)
  - electromagnetic form (Sommerfeld-Gamow) factor
- PWA solution
  - The measured parameters of X($p\bar{p}$) are consistent with X(1870) in $J/\psi \to \gamma\pi^+\pi^-\eta'$ (M=$1870.2\pm2.2^{+2.3}_{-0.7}$, Γ=$13.0\pm6.1^{+2.1}_{-3.8}$)
  - The measured parameters of X(1835) are consistent with the study of $J/\psi \to \gamma K_S^0 K_S^0 \eta$

resonance	J^{pc}	Mass (MeV)	Width (MeV)
$X(p\bar{p})$	$\mathbf{0^{-+}}$	1876.4 ± 0.1	8.5 ± 0.3
$X(1835)$	$\mathbf{0^{-+}}$	1844^{+3}_{-5}	192 ± 4
$f_0(2100)$	$\mathbf{0^{-+}}$	2086	284
$f_0(1900)$	$\mathbf{2^{-+}}$	1900	167
$PHSP$	$\mathbf{0^{++}}$	$--$	$--$

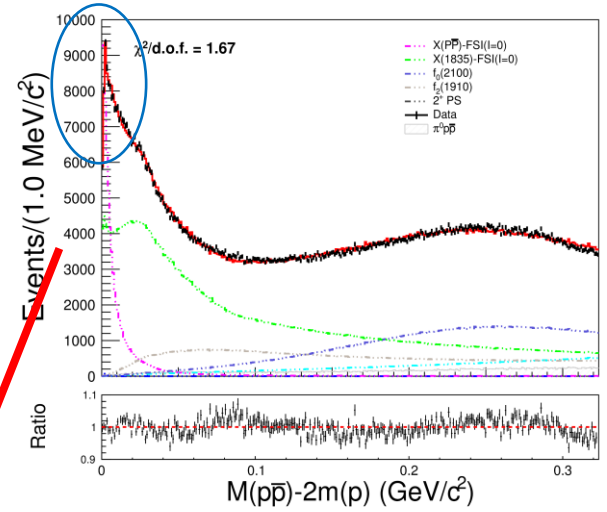


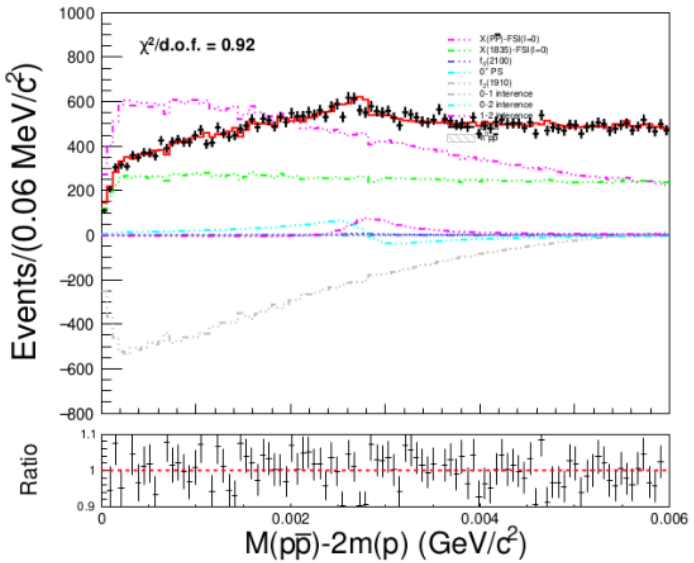


Pwa solution with X(1879)

- Two resonances model with narrow state X(1879)
  - FSI factor (I =0)
  - electromagnetic form (Sommerfeld-Gamow) factor
- PWA solution
  - The significance of the X(1879) is about 7.8σ
  - better fit result near threshold
  - Slight influence on the parameters of the $X(p\bar{p})$ and $X(1835)$

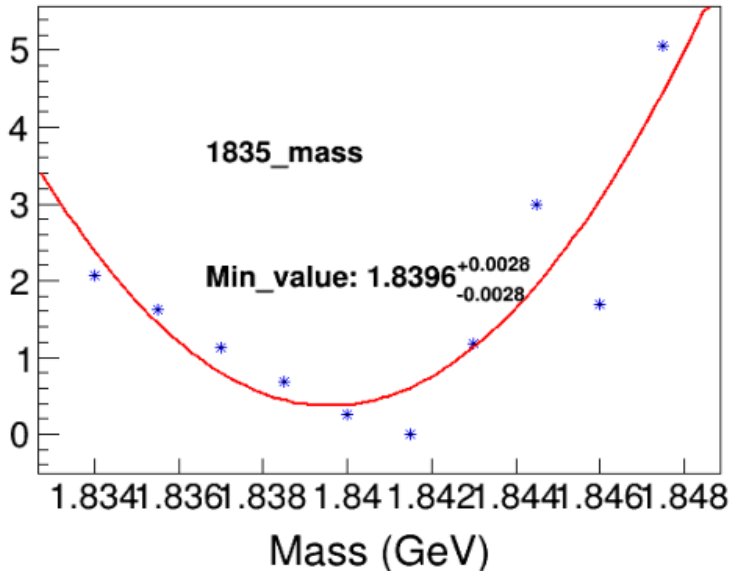
resonance	J^{pc}	Mass (MeV)	Width (MeV)
$X(p\bar{p})$	$\mathbf{0^{-+}}$	1876.4±0.1	10.0±0.2
$X(1835)$	$\mathbf{0^{-+}}$	1840^{+3}_{-5}	204 ± 3
$X(1879)$	$\mathbf{0^{-+}}$	1879.3	0.6
$f_0(2100)$	$\mathbf{0^{-+}}$	2086	284
$f_0(1900)$	$\mathbf{2^{-+}}$	1900	167
$PHSP$	$\mathbf{0^{++}}$	− −	− −

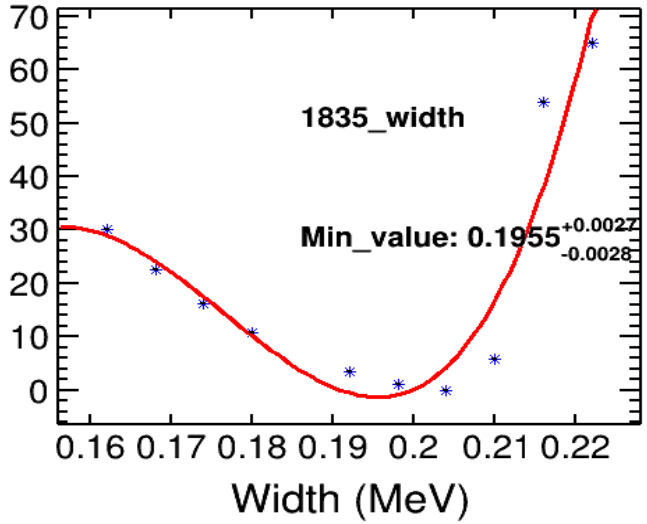




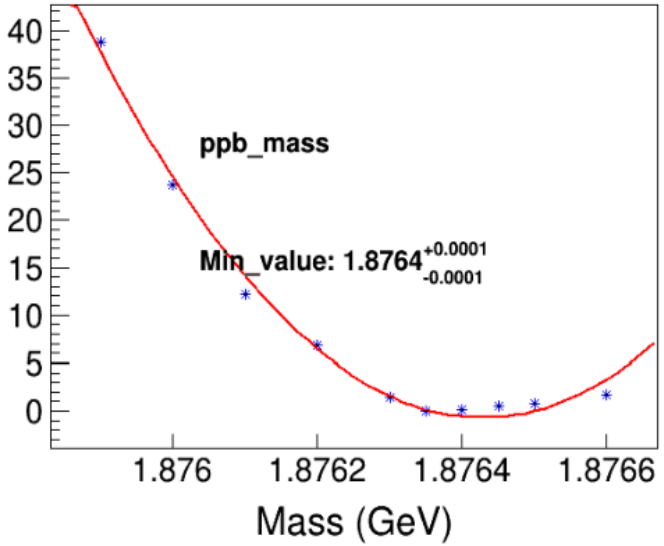
Scan curves

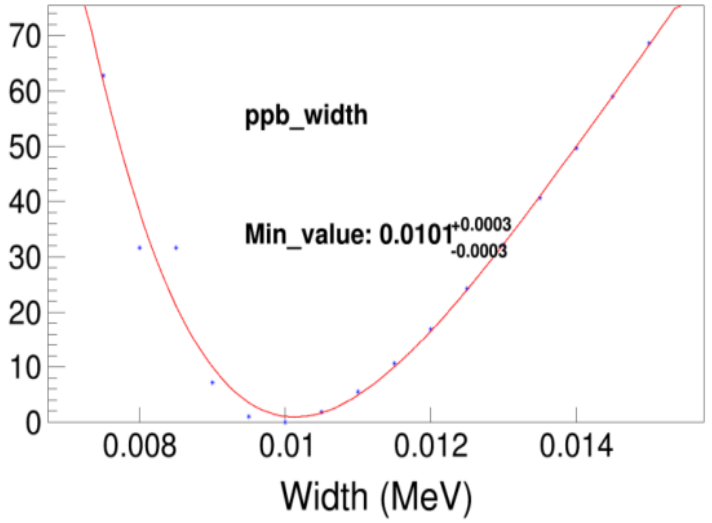
- X(1835)





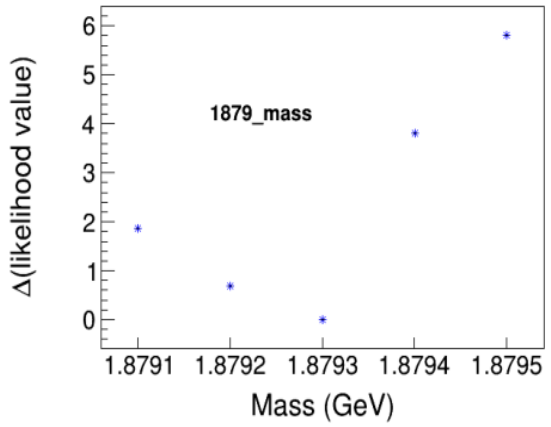
- X($p\bar{p}$)

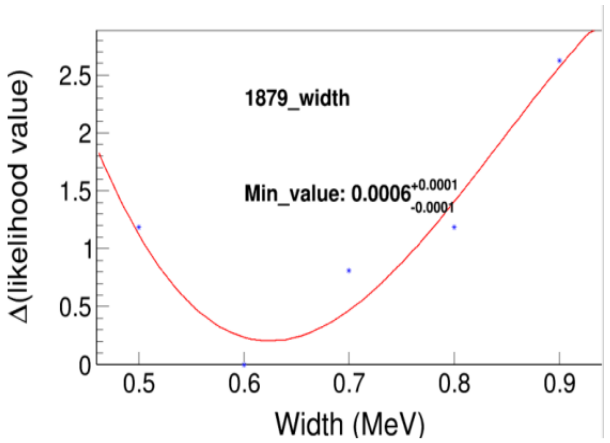




Scan curves

- X(1879)





Check the influence of the X(1879)

➢ Changes of the resonance parameters of the X(1835) and X($p\bar{p}$)

With the X(1879)

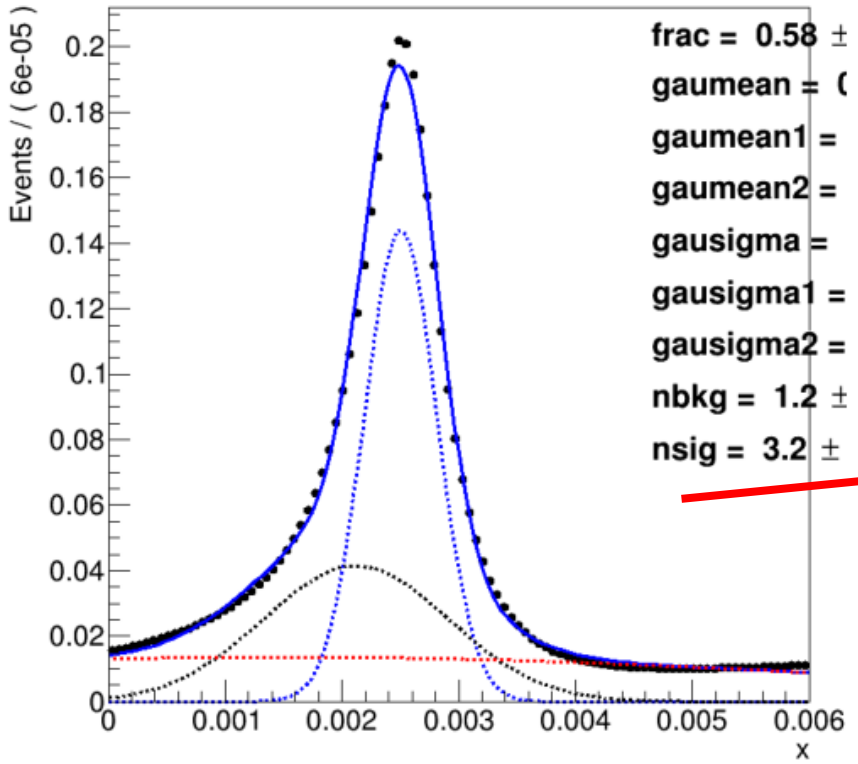
resonance	J^{pc}	Mass (MeV)	Width (MeV)
$X(p\bar{p})$	$\mathbf{0^{-+}}$	1876.4 ± 0.1	10.0 ± 0.2
$X(1835)$	$\mathbf{0^{-+}}$	1844^{+3}_{-5}	204 ± 3

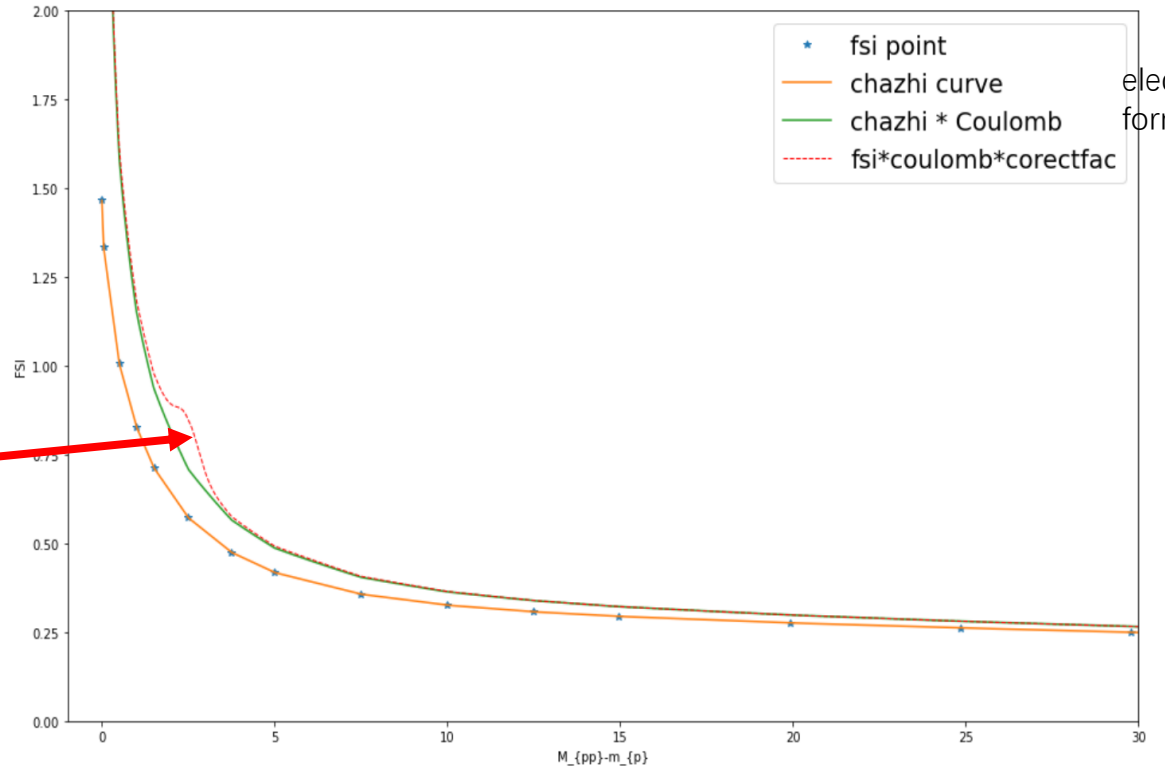
Without the X(1879)

resonance	J^{pc}	Mass (MeV)	Width (MeV)
$X(p\bar{p})$	$\mathbf{0^{-+}}$	1876.4 ± 0.1	8.5 ± 0.2
$X(1835)$	$\mathbf{0^{-+}}$	1844^{+3}_{-5}	192 ± 4

Re-tuning FSI

- Motivation: revise FSI rather than adding X(1879) to fit the bump
- $ratio = \frac{X(1879)+Inte\left(X(1879),X(p\bar{p})\right)+Inte\left(X(1879),X(1835)\right)}{X(p\bar{p})+X(1835)+Inte\left(X(p\bar{p}),X(1835)\right)}$
- revise FSI = (1+ratio) × original FSI





electromagnetic form factor

PWA solution with revised FSI

- Two resonances model
  - Revised FSI factor (I =0)
  - electromagnetic form (Sommerfeld-Gamow) factor

resonance	J^{pc}	Mass (MeV)	Width (MeV)
$X(p\bar{p})$	$\mathbf{0^{-+}}$	1876.4±0.1	10.0±0.2
$X(1835)$	$\mathbf{0^{-+}}$	1840^{+3}_{-5}	204 ± 3
$f_0(2100)$	$\mathbf{0^{-+}}$	2086	284
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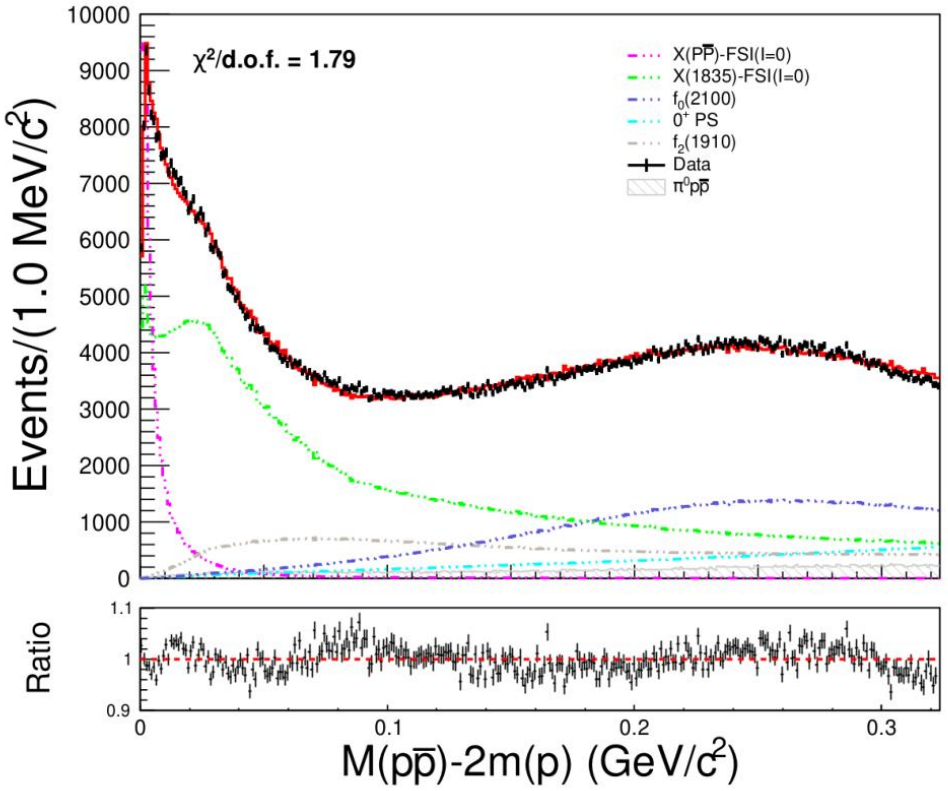
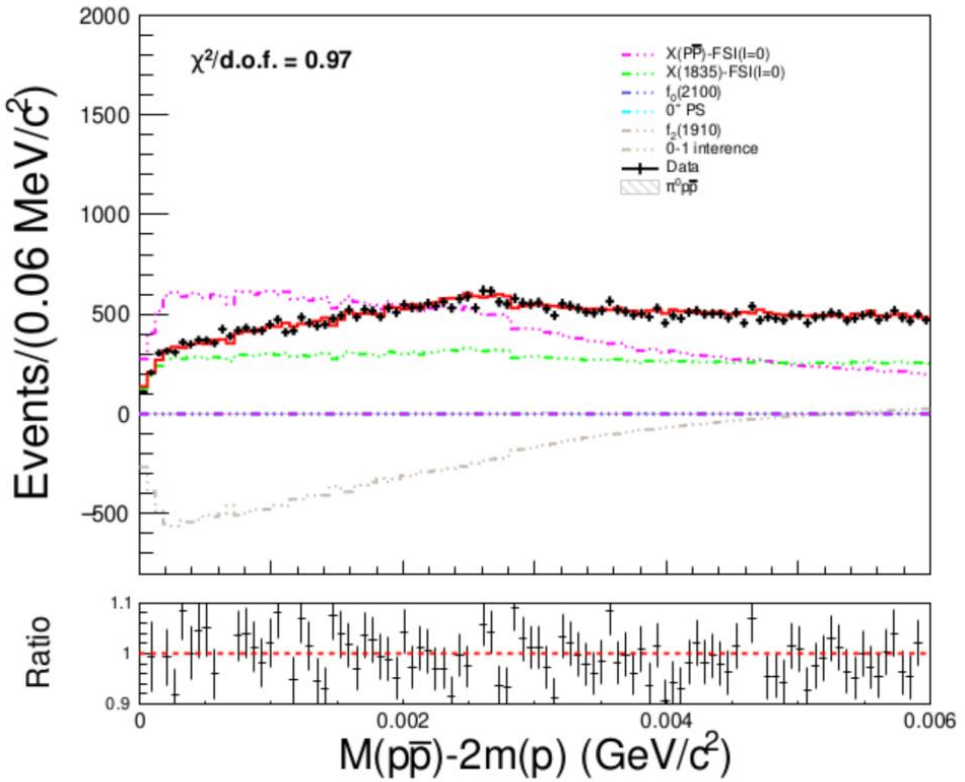
$PHSP$	$\mathbf{0^{++}}$	– –	– –





Thanks!