Search for $X(3823)$ new decay modes

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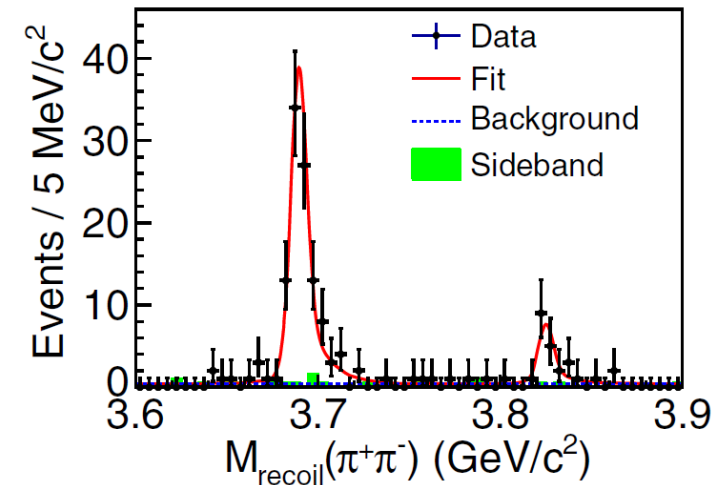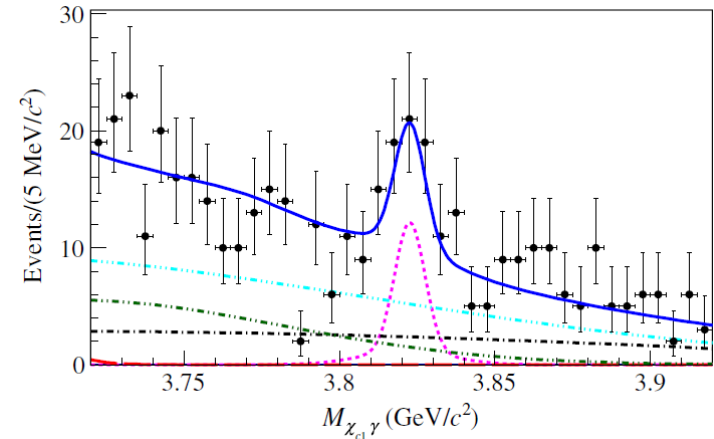[2]Insitute of High Energy Physics

Outline

Motivation

1. Evidence of $X(3823)$ is found by Belle, then BESIII observe the state.

2. Until now, only one $X(3823)$ decay mode $X(3823) \to \gamma\chi_{c1}$ is observed. More decay modes can be searched, such as $\gamma\chi_{c2}$, $\eta J/\psi$, $\pi^0 J/\psi$, $\pi^+\pi^-/\pi^0\pi^0 J/\psi$, $\gamma\chi_{c0}$. It is useful to understand the nature of $X(3823)$.

3. In this work, we will try to search for these $X(3823)$ decay modes.

Mode		Fraction (Γ_i / Γ)	Scale Factor/ Conf. Level	P (MeV/c)
Γ_1	$\chi_{c1}\gamma$	seen		299
Γ_2	$\chi_{c2}\gamma$	not seen		257

3

Data sets

Boss Version : 7.0.3 and 7.0.4

Data sets :

All XYZ data above $\sqrt{s} = 4.1$ GeV, it includes:

Old data:

4180,4190,4190scan,4200,4210,4210scan,4220,4220scan,4230,4230scan,4240,4245scan,4250,4260,4270,4280,4310scan,4360,4390scan,4420,4420scan,4470,4530,4575,4600 (25 energy points)

New data:

4130,4160,4290,4315,4340,4380,4400,4440 (8 energy points)

Data sets

Signal MC(at $\sqrt{s} = 4.416$ GeV) :

1、$e^+e^- \to \pi^+\pi^- X(3823), X(3823) \to \gamma\chi_{c1}, \chi_{c1} \to \gamma J/\psi$
2、$e^+e^- \to \pi^+\pi^- X(3823), X(3823) \to \gamma\chi_{c2}, \chi_{c2} \to \gamma J/\psi$
3、$e^+e^- \to \pi^+\pi^- X(3823), X(3823) \to \eta J/\psi, \eta \to \gamma\gamma$

Some possible backgrounds MC :

1、$e^+e^- \to \eta J/\psi, \eta \to \pi^+\pi^-\pi^0$
2、$e^+e^- \to \eta' J/\psi, \eta' \to \pi^+\pi^-\pi^0$
3、$e^+e^- \to \eta' J/\psi, \eta' \to \pi^+\pi^-\eta$
4、$e^+e^- \to \eta\psi', \psi' \to \pi^+\pi^- J/\psi$

$$X(3823) \rightarrow \gamma \chi_{c1}$$

$$\chi_{c1} \rightarrow \gamma J/\psi \rightarrow \gamma e^+ e^- / \mu^+ \mu^-$$

Event selections

Charged tracks
- $|R_{xy}| < 1cm, |R_z| < 10cm$
- $|cos\theta| < 0.93$
- $N = 4, \sum Q = 0$

Particle identification
- $\pi : P_{mdc} < 1 \text{ GeV}$
- $e : P_{mdc} > 1 \text{ GeV}\&\&E_{emc} > 1 \text{ GeV}$
- $\mu : P_{mdc} > 1 \text{ GeV}\&\&E_{emc} < 0.4 \text{ GeV}$

Good photon
- $0 \leq TDC \leq 14$
- Barrel :
  $E > 0.025 \text{ GeV}, |cos\theta| < 0.8$
- Endcap :
  $E > 0.050 \text{ GeV}, 0.86 < |cos\theta| < 0.92$
- $\Delta\theta > 10^0$
- $N_\gamma \geq 2$

4C kinematic fit
- Choose the photons with least χ^2
- $\chi^2 < 60$

Other selections
- J/ψ mass window : (3.08, 3.12) GeV
- Veto π^0 : (0.12, 0.15) GeV
- Veto η : (0.52, 0.57) GeV
- χ_{c1} mass window : (3.49, 3.53) GeV

χ^2 distribution

χ^2 distribution from 4C: $\chi^2 < 60$

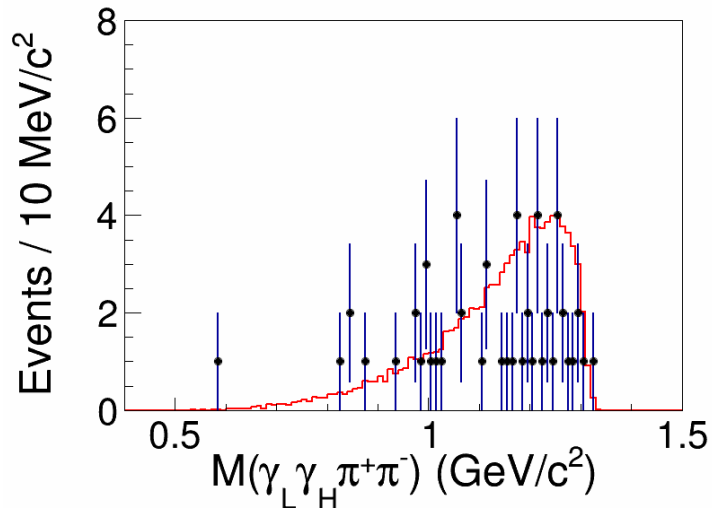# Background study
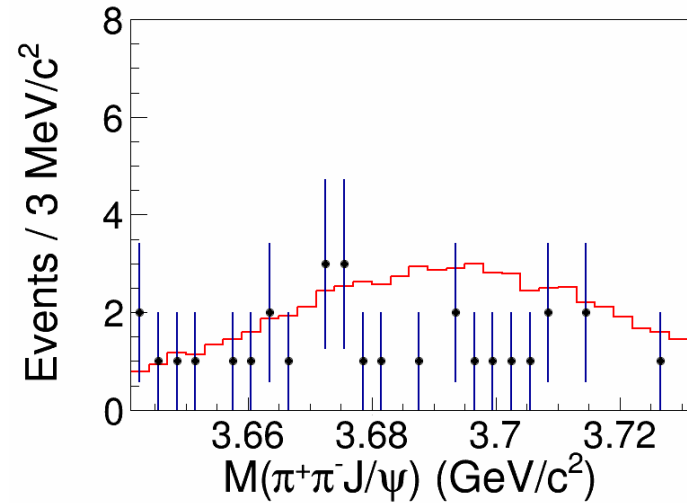

To veto π^0 and η backgrounds:

1. $M(\gamma\gamma) < 0.12 || M(\gamma\gamma) > 0.15$ GeV
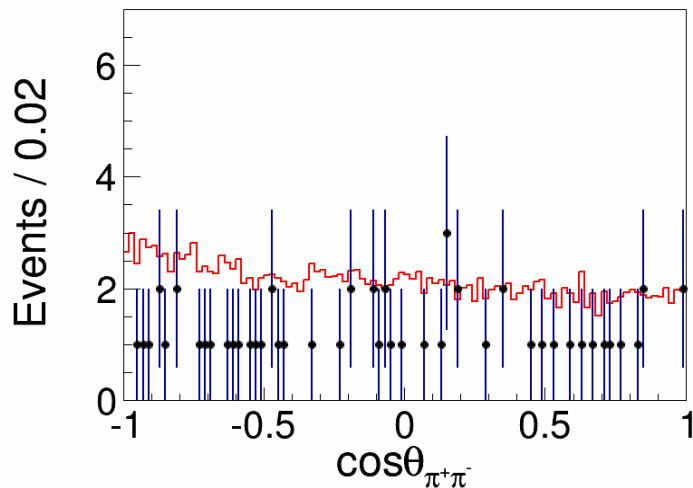2. $M(\gamma\gamma) < 0.52 || M(\gamma\gamma) > 0.57$ GeV
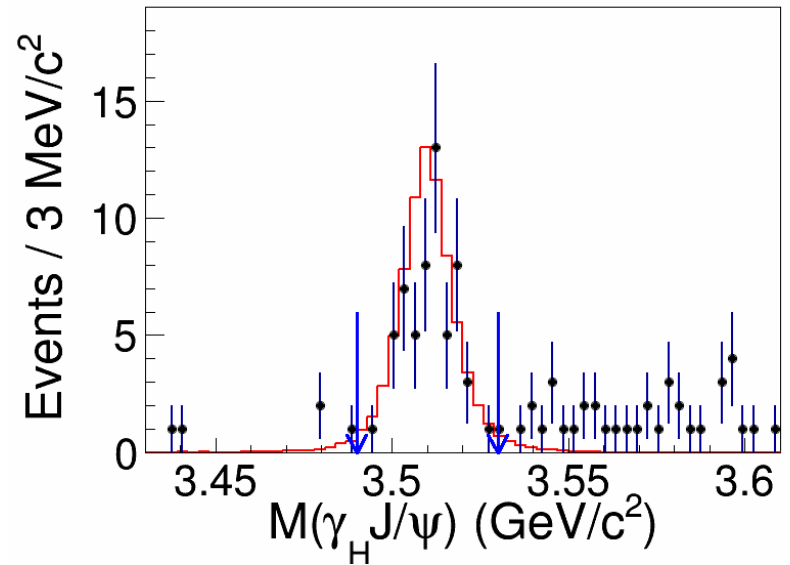
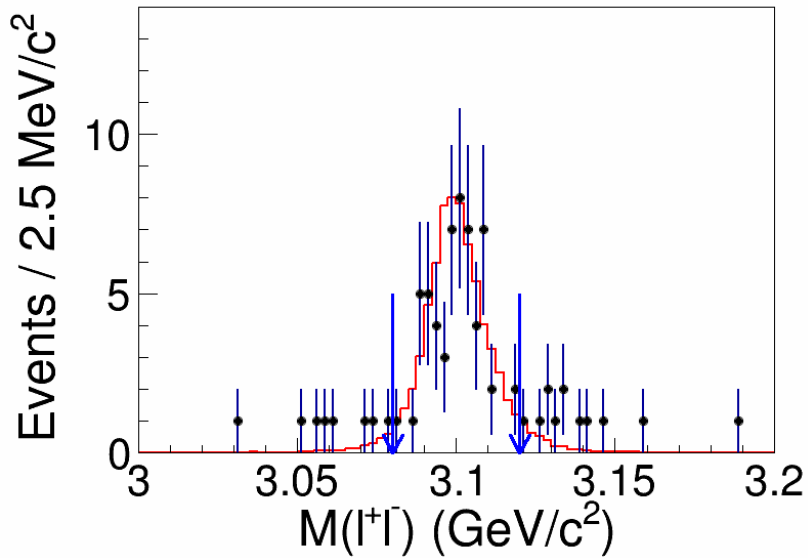# Background study

No significant η and η' events

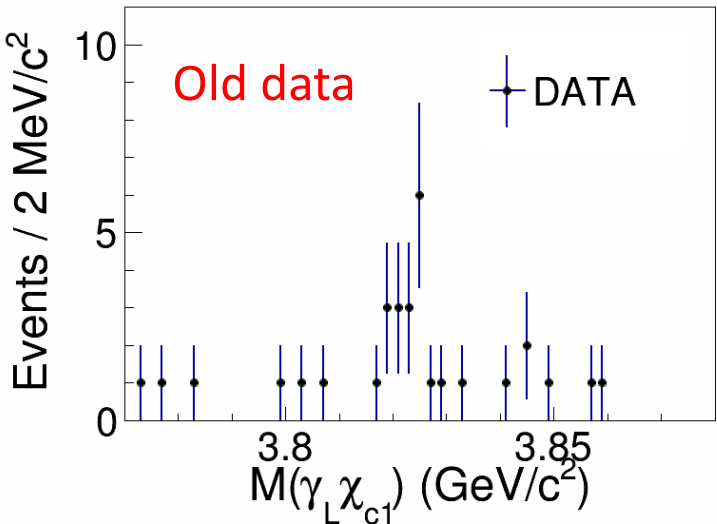No significant $\psi(3686)$ events

No significant γ conversion events

Some distributions

- J/ψ mass window : (3.08, 3.12) GeV
- χ_{c1} mass window : (3.49, 3.53) GeV

Some distributions

Old data

New data

Sum
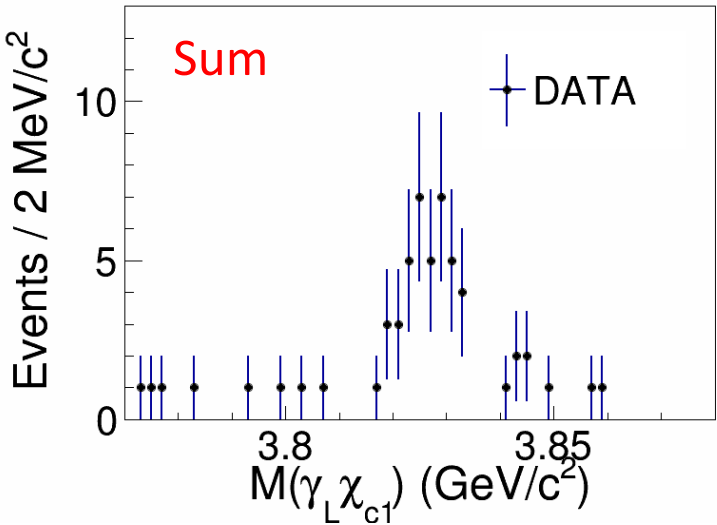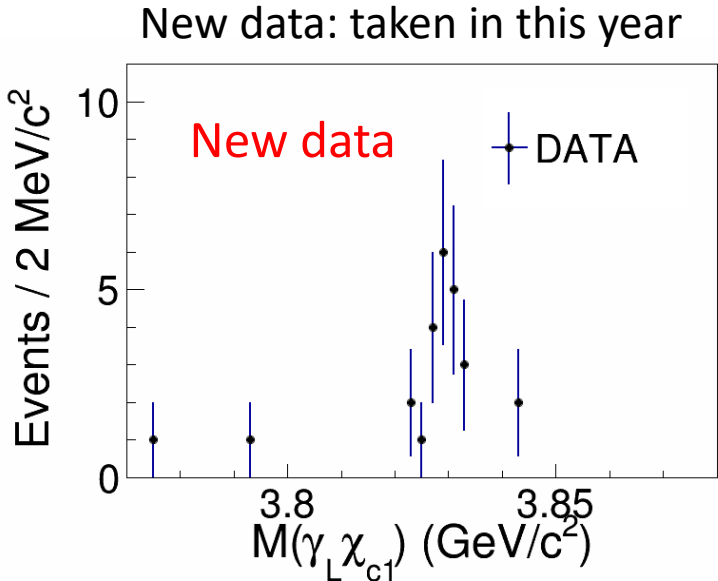
Clear $X(3823)$ signals are seen, while the mass is shifted for new data. Perhaps due to inappropriate $\mathrm{d}E/\mathrm{d}x$ correction or center-of-mass energy or ......, will update the results using offline measured center-of-mass energy and wait for the final reconstructed data.

Some distributions
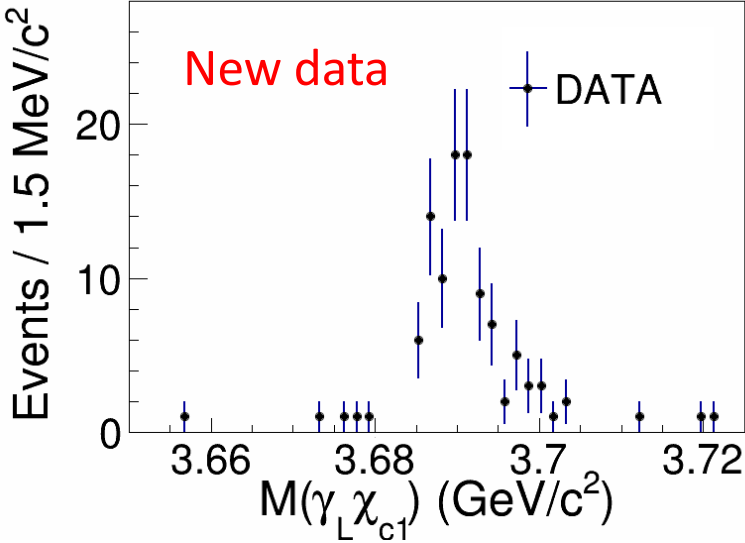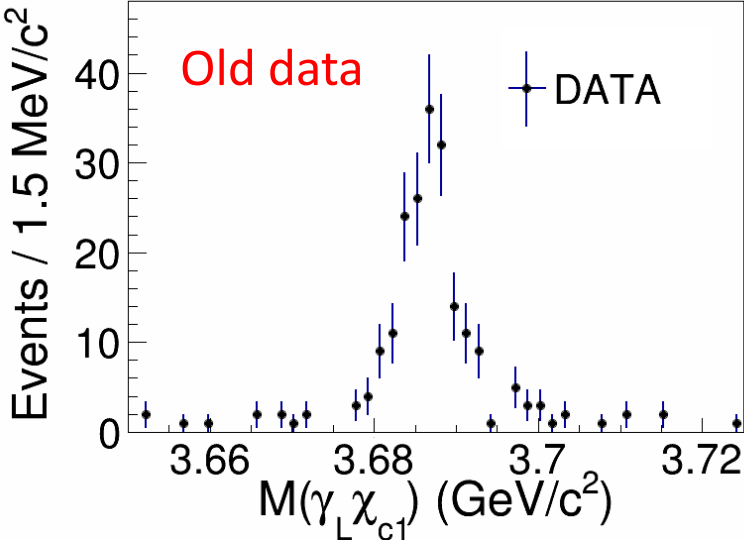
The same for $\psi(3686)$

$$X(3823) \rightarrow \gamma \chi_{c2}$$

$$\chi_{c2} \rightarrow \gamma J/\psi \rightarrow \gamma e^+ e^- / \mu^+ \mu^-$$

Event selections

Charged tracks
- $|R_{xy}| < 1cm, |R_z| < 10cm$
- $|cos\theta| < 0.93$
- $N = 4, \sum Q = 0$

Particle identification
- π : $P_{mdc} < 1$ GeV
- e : $P_{mdc} > 1$ GeV&&$E_{emc} > 1$ GeV
- μ : $P_{mdc} > 1$ GeV&&$E_{emc} < 0.4$ GeV

Good photon
- $0 \leq TDC \leq 14$
- Barrel :
  $E > 0.025$ GeV, $|cos\theta| < 0.8$
- Endcap :
  $E > 0.050$ GeV, $0.86 < |cos\theta| < 0.92$
- $\Delta\theta > 10^0$
- $N_\gamma \geq 2$

4C kinematic fit
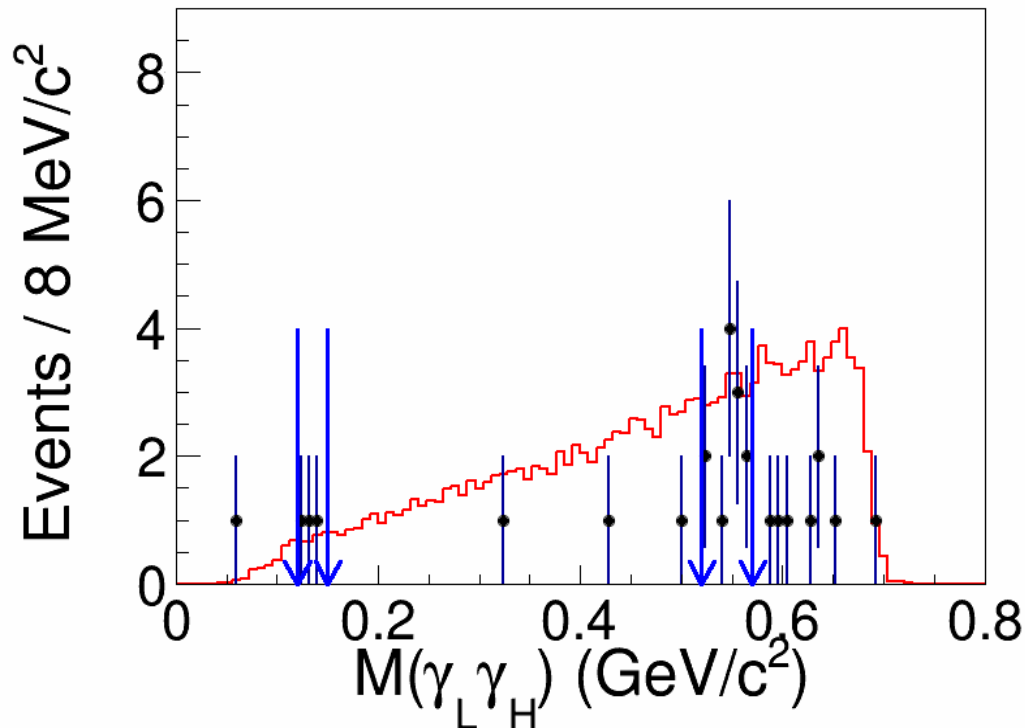- Choose the photons with least χ^2
- $\chi^2 < 60$

Other selections
- J/ψ mass window : (3.08, 3.12) GeV
- Veto π^0 : (0.12, 0.15) GeV
- Veto η : (0.52, 0.57) GeV
- Veto η' : (0.94, 0.97) GeV
- χ_{c2} mass window : (3.54, 3.57) GeV

χ^2 distribution

χ^2 distribution from 4C: $\chi^2 < 60$

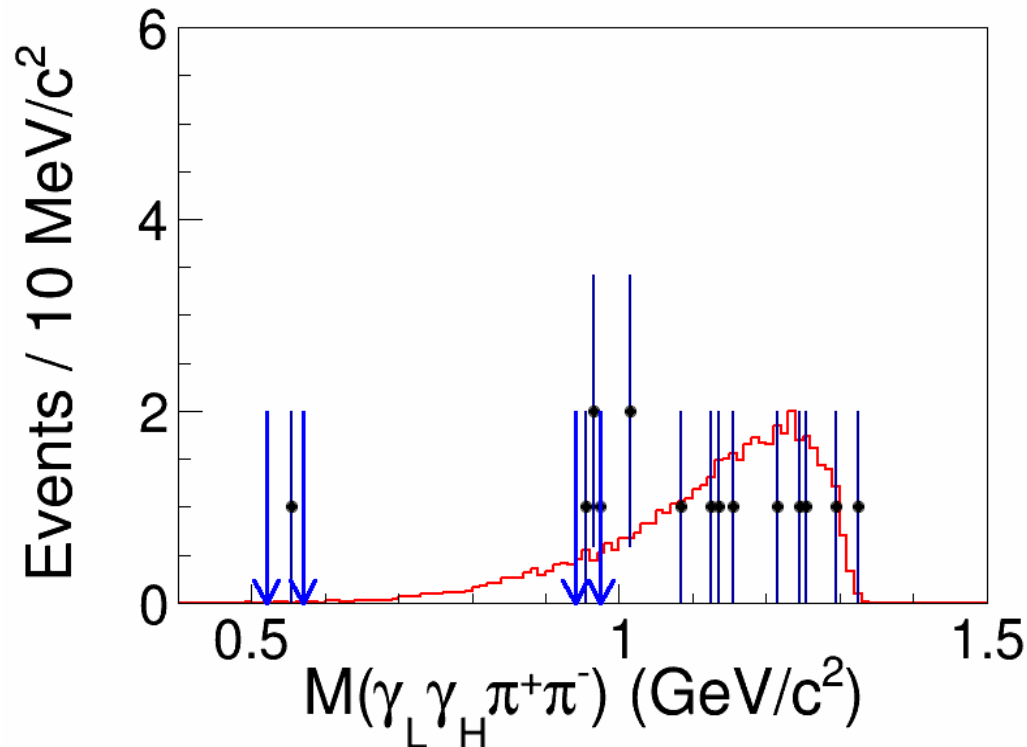# Background study

To veto π^0 and η backgrounds:

1. $M(\gamma\gamma) < 0.12 || M(\gamma\gamma) > 0.15$ GeV
2. $M(\gamma\gamma) < 0.52 || M(\gamma\gamma) > 0.57$ GeV

Background study

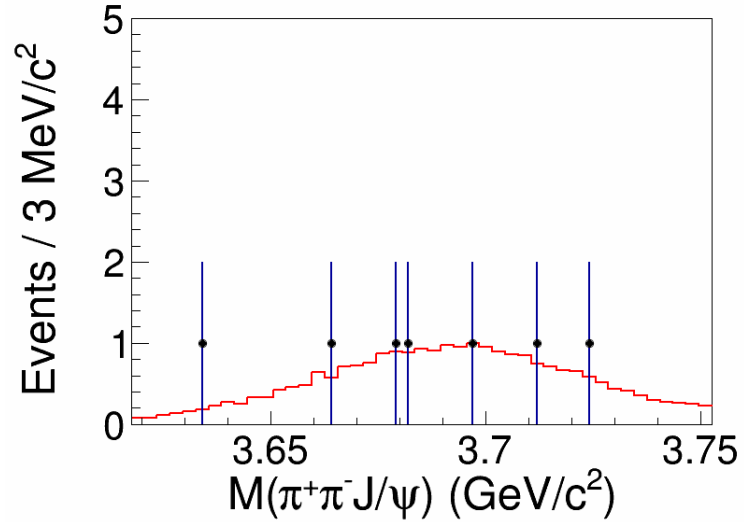To veto η and η' backgrounds:
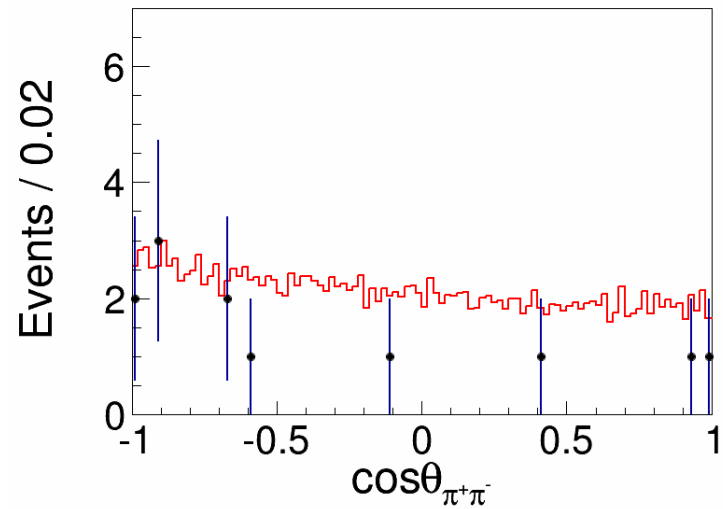
1. $M(\gamma\gamma\pi^+\pi^-) < 0.52 || M(\gamma\gamma\pi^+\pi^-) > 0.57$ GeV
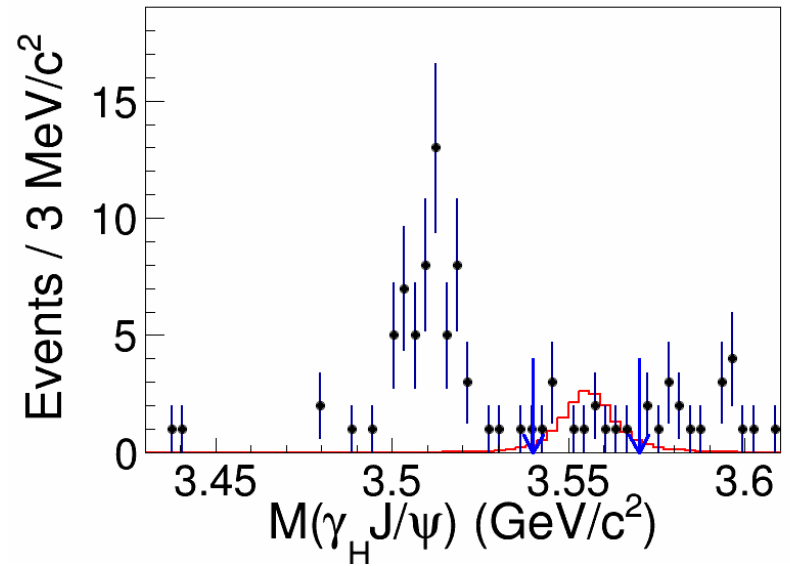2. $M(\gamma\gamma\pi^+\pi^-) < 0.94 || M(\gamma\gamma\pi^+\pi^-) > 0.97$ GeV
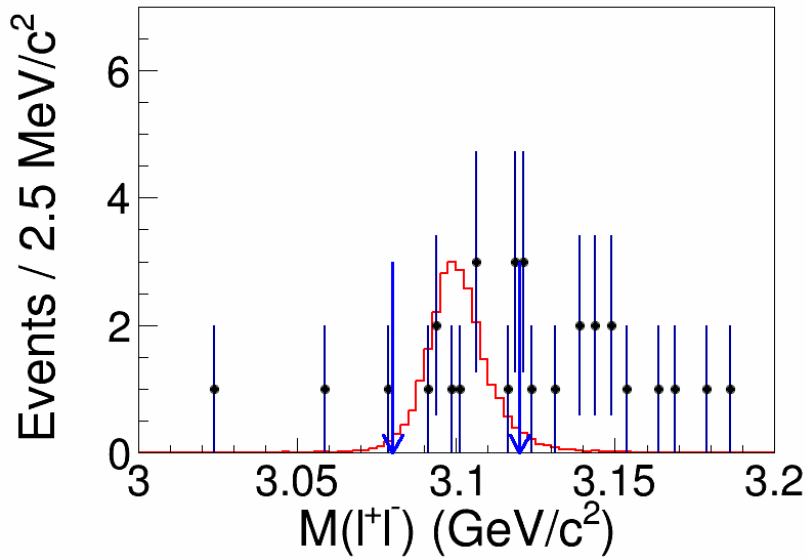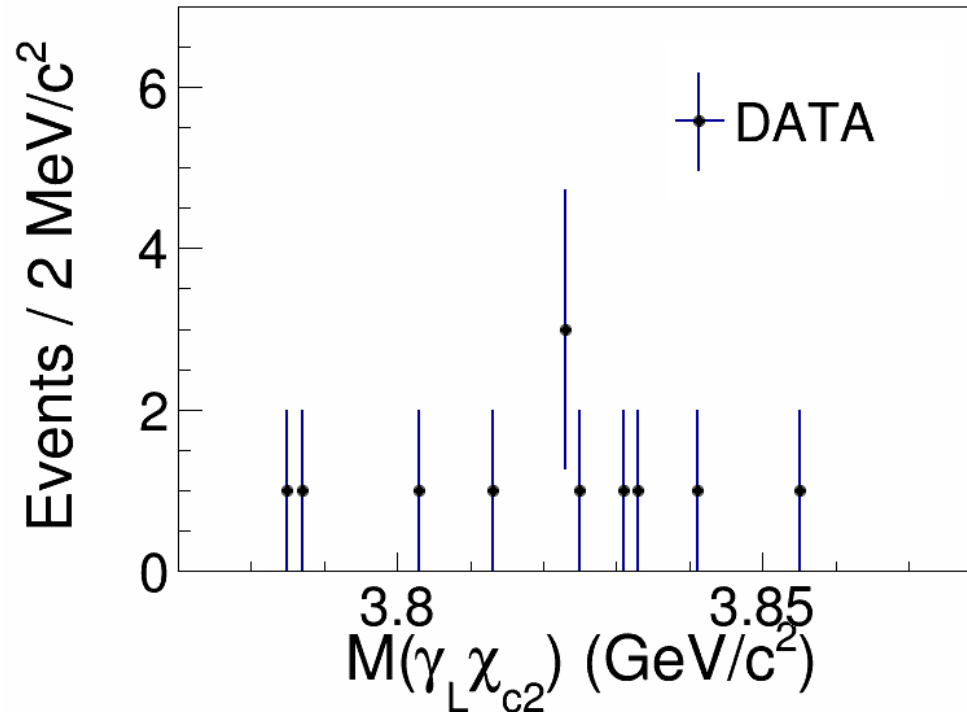
Background study

No significant $\psi(3686)$ events

No significant γ conversion events

Some distributions

- J/ψ mass window : (3.08, 3.12) GeV
- χ_{c2} mass window : (3.54, 3.57) GeV

Some distributions

There seems to be some $X(3823) \rightarrow \gamma\chi_{c2}$ events in $X(3823)$ signal region

$$X(3823) \rightarrow \eta J/\psi$$

$$\eta \rightarrow \gamma\gamma$$
$$J/\psi \rightarrow e^+ e^- / \mu^+ \mu^-$$

Event selections

Charged tracks
- $|R_{xy}| < 1cm, |R_z| < 10cm$
- $|cos\theta| < 0.93$
- $N = 4, \sum Q = 0$

Particle identification
- $\pi : P_{mdc} < 1$ GeV
- $e : P_{mdc} > 1$ GeV && $E_{emc} > 1$ GeV
- $\mu : P_{mdc} > 1$ GeV && $E_{emc} < 0.4$ GeV

Good photon
- $0 \leq TDC \leq 14$
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4C kinematic fit
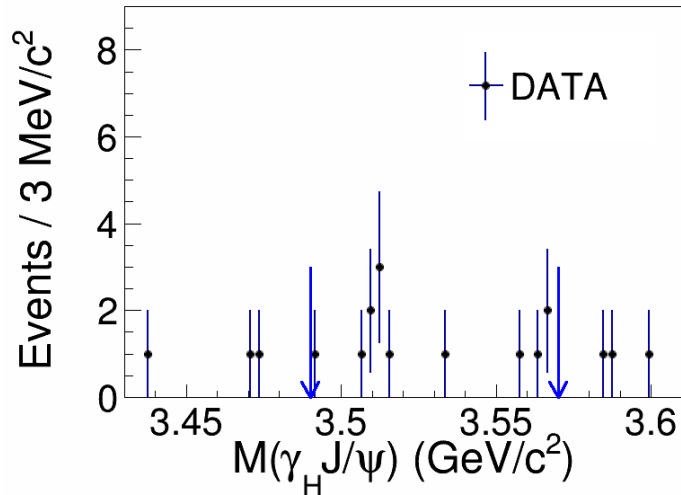- Choose the photons with least χ^2
- $\chi^2 < 60$

Other selections
- J/ψ mass window : (3.08, 3.12) GeV
- η mass window : (0.52, 0.57) GeV
- Veto η' : (0.93, 0.98) GeV
- Veto $\psi(3686)$: (3.67, 3.70) GeV
- Veto $\chi_{c1,2}$: (3.49, 3.57) GeV
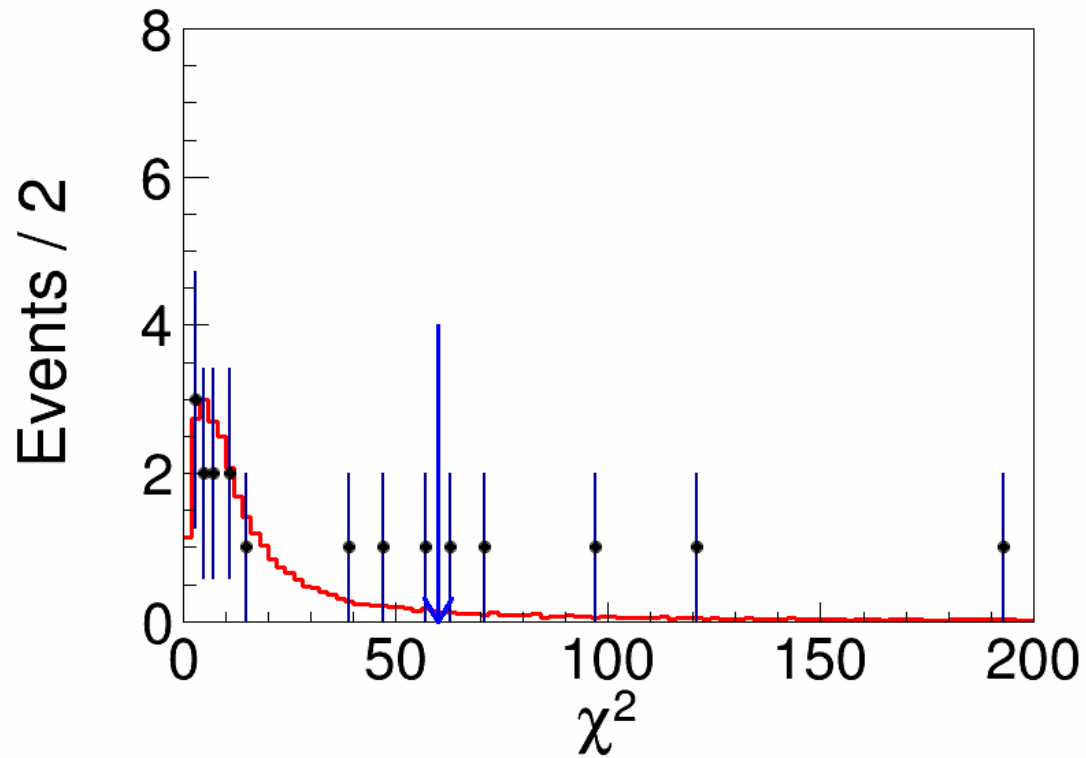
χ^2 distribution

χ^2 distribution from 4C: $\chi^2 < 60$

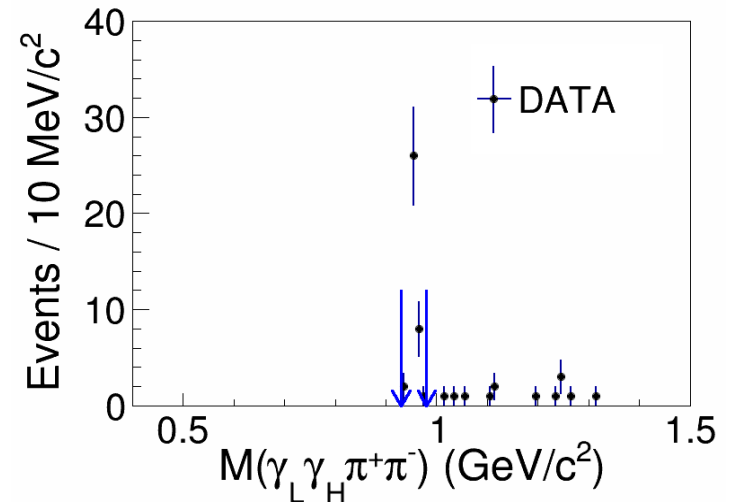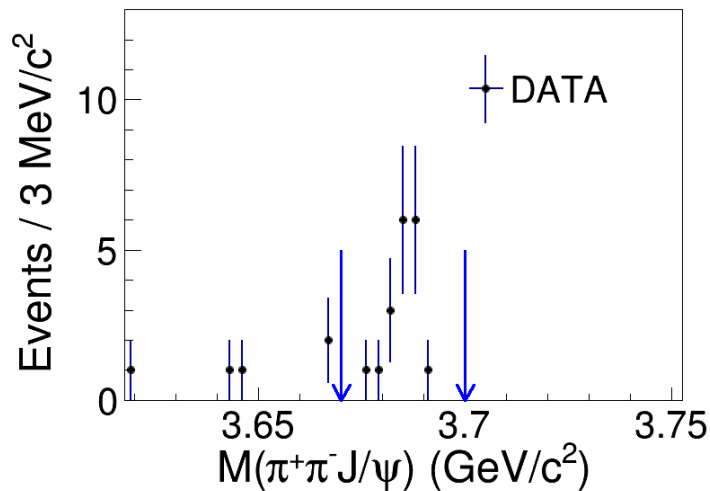# Background study

To veto $\chi_{c1,2}$ background:
$M(\gamma_H J/\psi) < 3.49 || M(\gamma_H J/\psi) > 3.57$ GeV

To veto η' background:
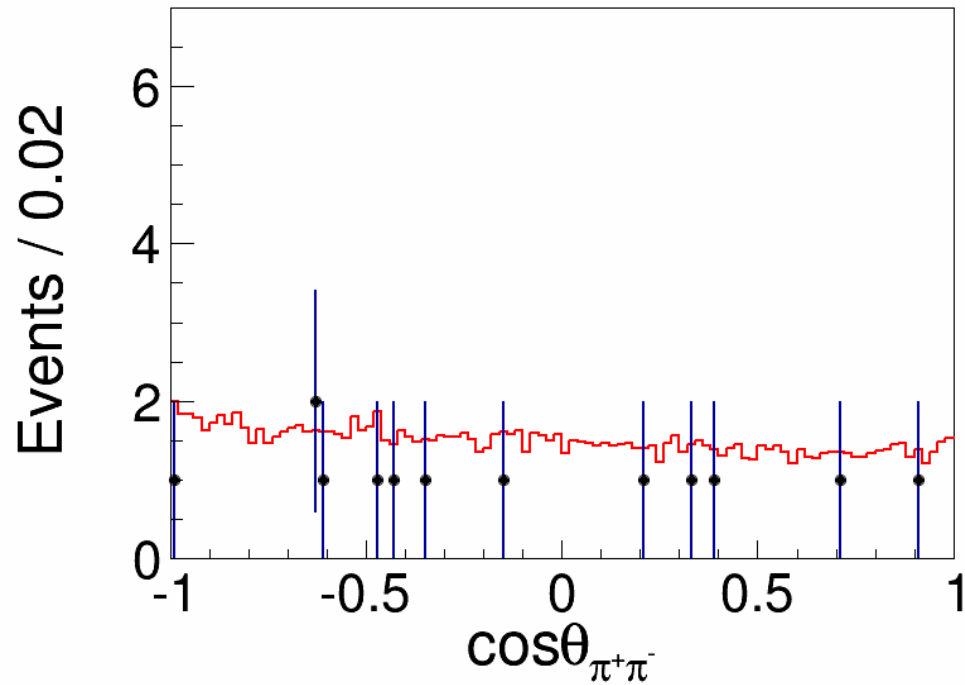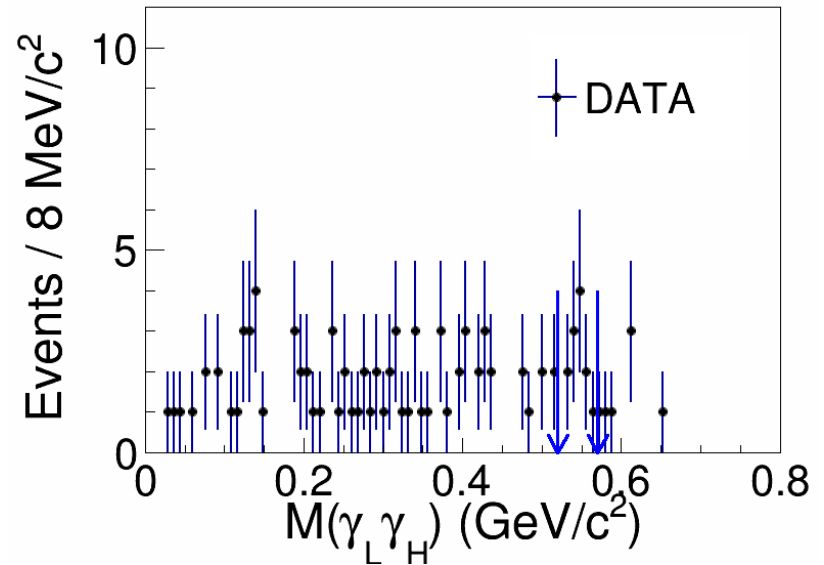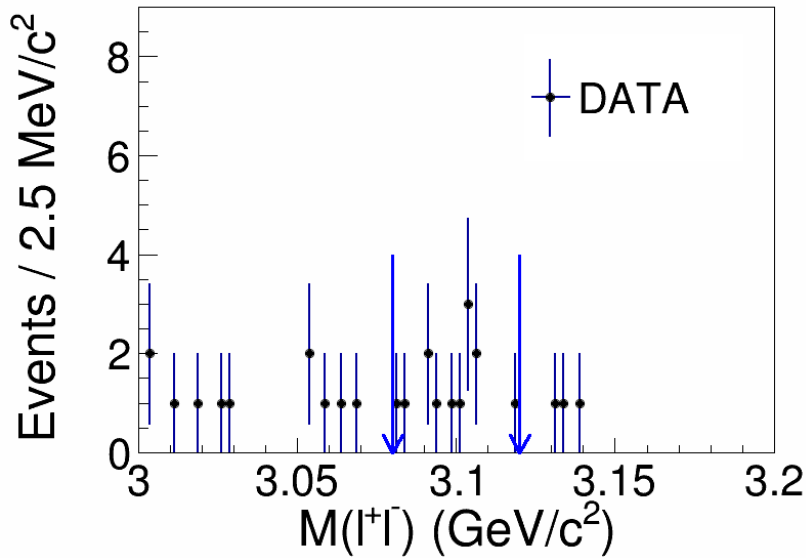$M(\gamma\gamma\pi^+\pi^-) < 0.93 || M(\gamma\gamma\pi^+\pi^-) > 0.98$ GeV

To veto $\psi(3686)$ background:
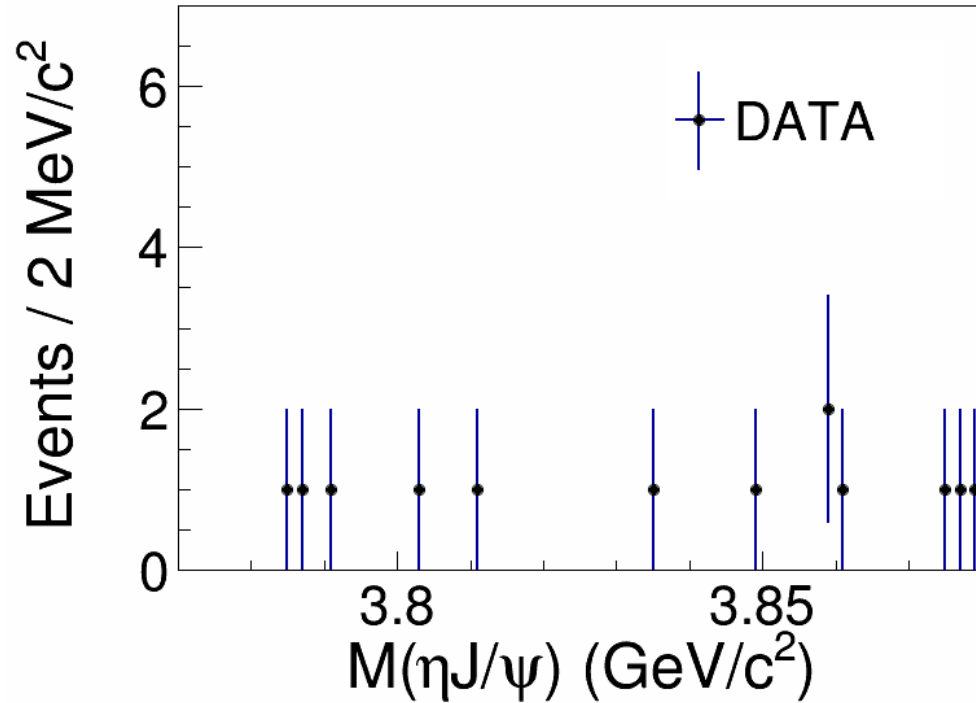$M(\pi^+\pi^- J/\psi) < 3.67 || M(\pi^+\pi^- J/\psi) > 3.70$ GeV

25

Background study

No significant γ conversion events

Some distributions

- J/ψ mass window : (3.08, 3.12) GeV
- η mass window : (0.52, 0.57) GeV

Some distributions

No significant $X(3823) \rightarrow \eta J/\psi$ events

Summary

1、Some $X(3823)$ decay modes have been studied and searched.

2、Clear signals for $X(3823) \to \gamma\chi_{c1}$, maybe some evidences for $X(3823) \to \gamma\chi_{c2}$, no significant signals for $X(3823) \to \eta J/\psi$.

Next to do

1、Analyses on $X(3823) \to \pi^0 J/\psi$, $\pi^+\pi^-/\pi^0\pi^0 J/\psi$ and $\gamma\chi_{c0}$ decay modes are ongoing.

2、Update the results using offline measured center-of-mass energy and wait for the final reconstructed data.

3、Calculate the central values or upper limits for these decay modes.

Thanks for your attention!