

# Studies towards $e^+e^- \rightarrow p\bar{p}$ and $e^+e^- \rightarrow p\bar{p}\omega$ above 4 GeV

Status of our analysis

Marcel Rump, University of Münster



## Motivation

Investigations in progress in Münster of possible XYZ decays into  $p\bar{p}$  and  $p\bar{p} X$

In detail:

- $e^+e^- \rightarrow p\bar{p} \omega$  (this talk  $\sqrt{s} > 4$  GeV)
- $e^+e^- \rightarrow p\bar{p}$  ( $\sqrt{s} > 4$  GeV)
- $e^+e^- \rightarrow p\bar{p} \pi^0$  ( $\sqrt{s} > 4$  GeV)
- $e^+e^- \rightarrow p\bar{p} X$  ;  $X = \text{meson}(s)$
- ISR:  $e^+e^- \rightarrow \gamma p\bar{p} (X)$  (in preparation)

## Analysis of $e^+e^- \rightarrow p\bar{p}$ (X) events

Look for different  $p\bar{p}$  final states in the datasets above 4 GeV

- such as  $p\bar{p}\omega$  (presented in this talk)
- using standard particle identification criteria (have to be optimized later)

For now: BOSS version 6.6.5p01

(Recently installed 7.0.2p01 to also analyze new XYZ data)

## Event selection ( $p\bar{p} X$ )

### Charged tracks:

$$|V_r| < 1.0 \text{ cm}$$

$$|V_z| < 10.0 \text{ cm}$$

$$|\cos \theta| < 0.93$$

### PID:

$$P(p) > P(\pi), P(K)$$

$$P(p) > 0.001$$

### Neutral tracks:

$$E_{\text{barrel}} > 25 \text{ MeV}, E_{\text{endcap}} > 50 \text{ MeV}$$

$$|\cos \theta| < 0.8, \quad 0.86 < |\cos \theta| < 0.92$$

$$0 \leq \text{TDC} \leq 14, \Delta\theta > 20^\circ$$

## Event selection ( $p\bar{p}\omega$ )

### Kinematic fits:

6C kin. fit for event selection

$$e^+e^- \rightarrow p\bar{p}\omega$$

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

$$\pi^0 \rightarrow \gamma\gamma$$

→ Choose combination with smallest  $\chi^2 < 100$

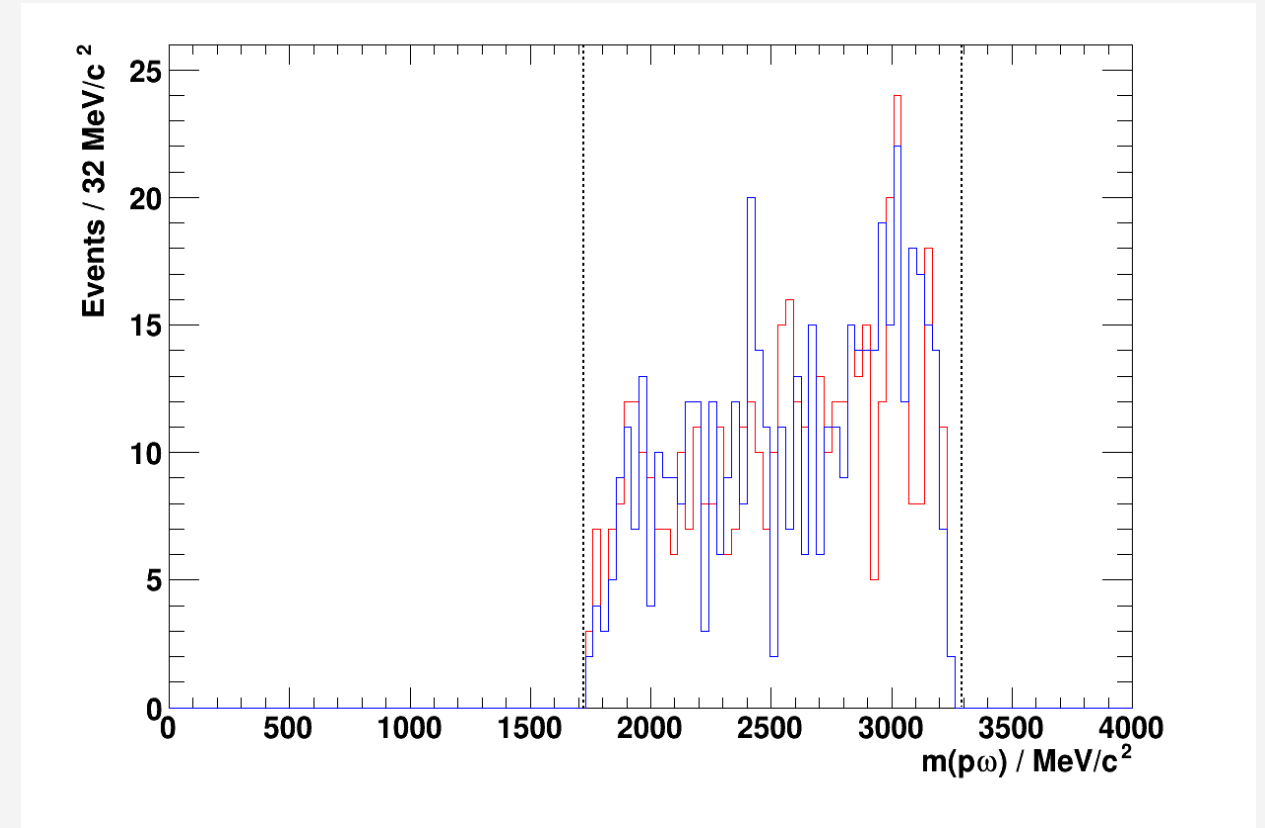
4C kin. fit to improve momentum resolution

$$e^+e^- \rightarrow p\bar{p}\pi^+\pi^-\gamma\gamma$$

→  $\chi^2 < 100$

## $e^+e^- \rightarrow p\bar{p}\omega$ invariant masses

- Invariant mass distribution of  $p\omega$  ( $\bar{p}\omega$ )
- Distribution as expected between kinematic limits
- No significant structures observed from e.g. nucleon resonances etc.



( $p\omega$  invariant mass for 4.230 GeV dataset, not corrected for acceptance)

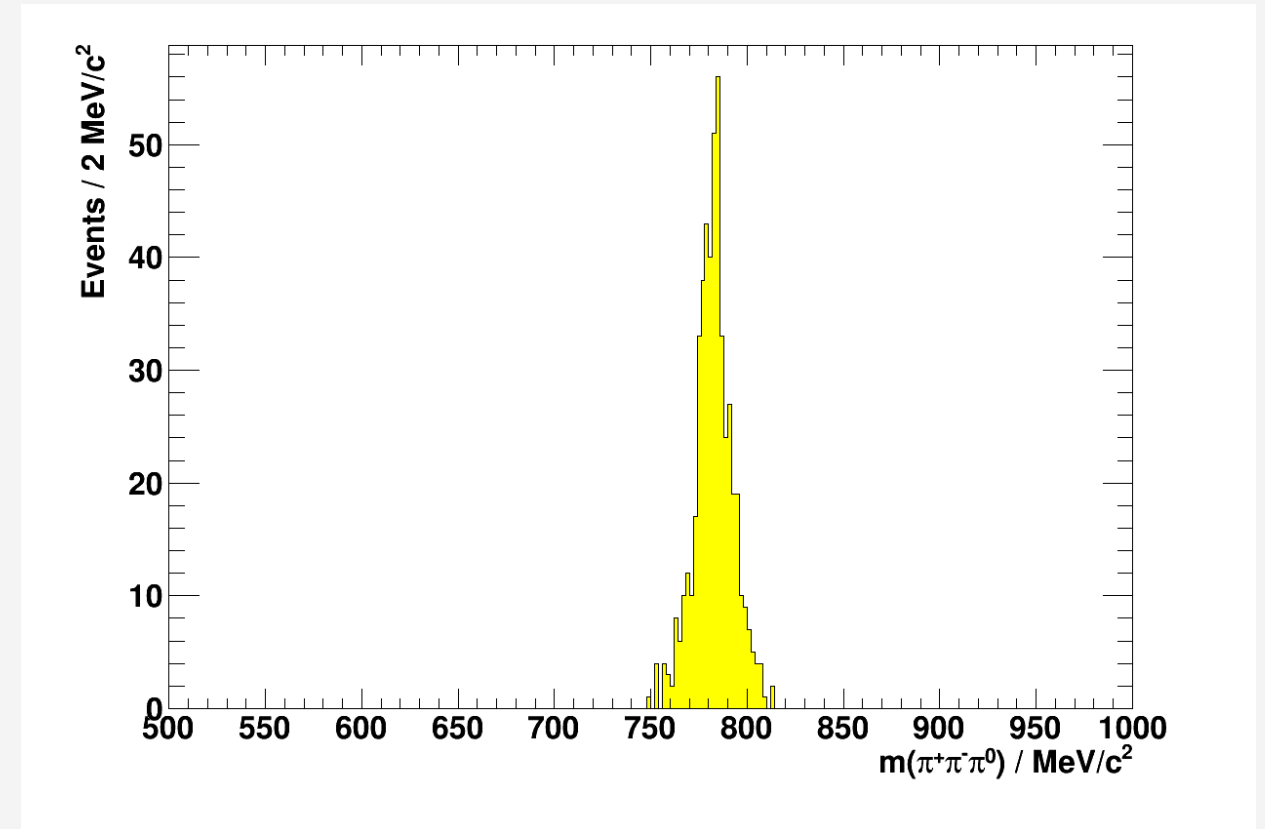
## Identification of $p\bar{p}\omega$

Choose mass window:  $|m(\pi^0) - m_{\pi^0}| < 50 \text{ MeV}/c^2$

Clear signal peak at  $\omega$  mass (**782.65 MeV**)

→ For now all events in this peak are assumed to be signal events.

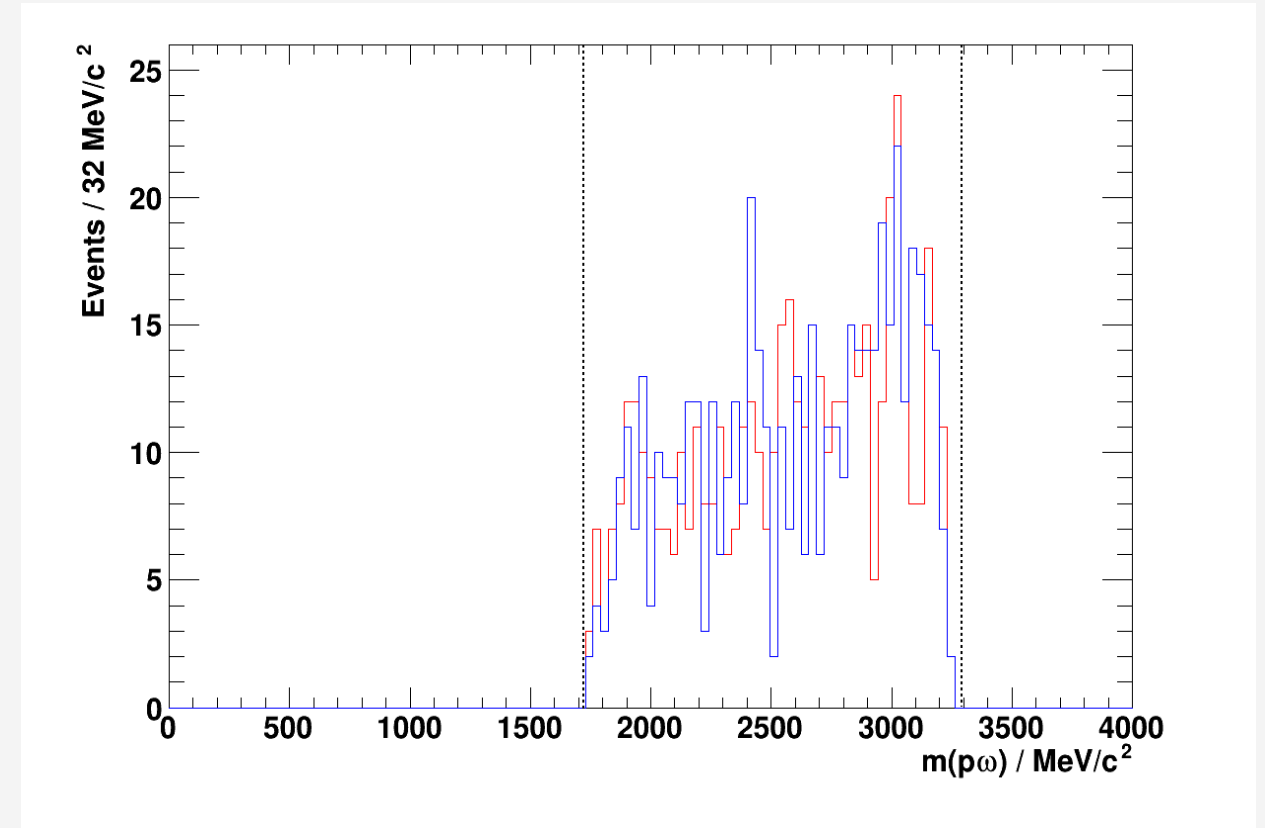
→ Background studies have to be done next.



( $\pi^+\pi^-\pi^0$  invariant mass for 4.230 GeV dataset)

## $e^+e^- \rightarrow p\bar{p}\omega$ invariant masses

- Invariant mass distribution of  $p\omega$  ( $\bar{p}\omega$ )
- Distribution as expected between kinematic limits
- No significant structures observed from e.g. nucleon resonances etc.



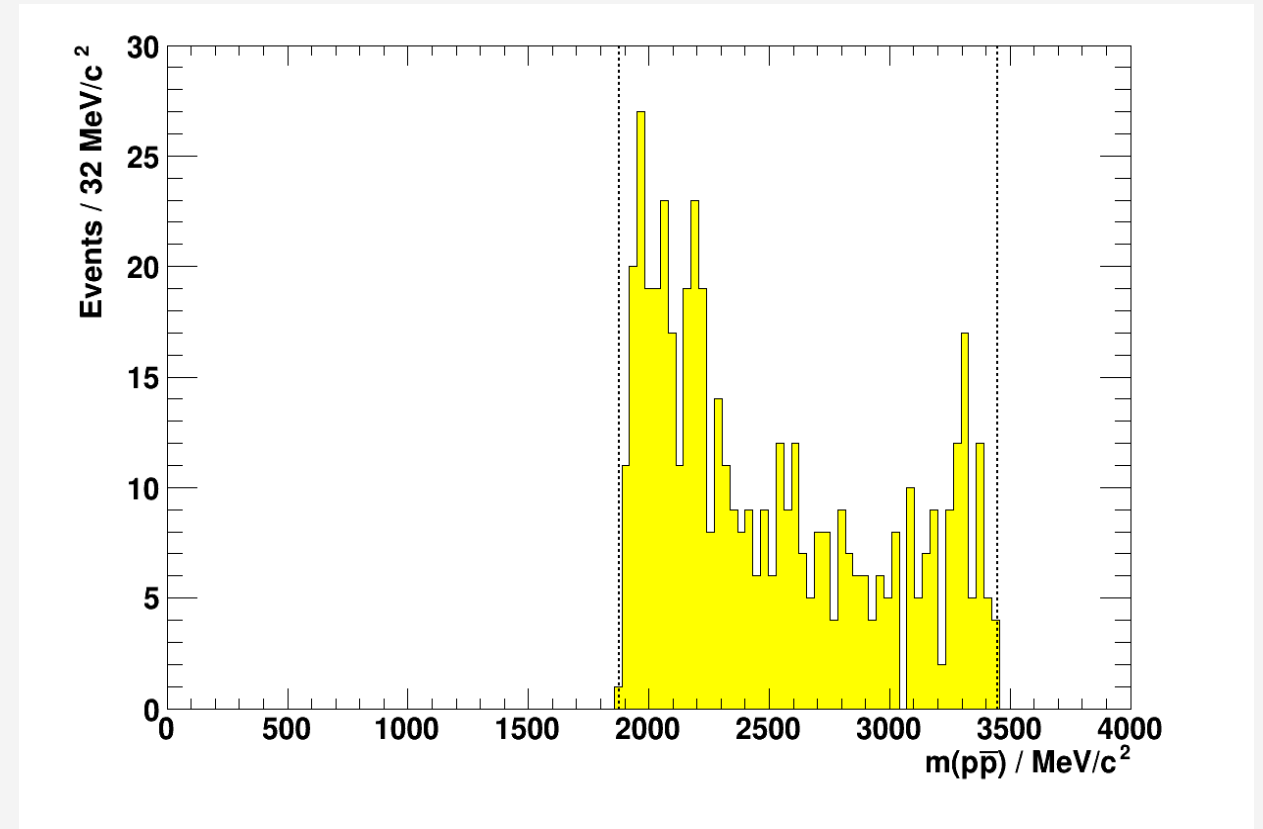
( $p\omega$  invariant mass for 4.230 GeV dataset, not corrected for acceptance)



## $e^+e^- \rightarrow p\bar{p}\omega$ invariant masses

- Invariant mass distribution of  $p\bar{p}$  system
- Distribution as expected between kinematic limits
- No contribution from  $J/\psi$
- Visible enhancement at low invariant masses

Note: not yet corrected for acceptance



( $p\bar{p}$  invariant mass for 4.230 GeV dataset, not corrected for acceptance)

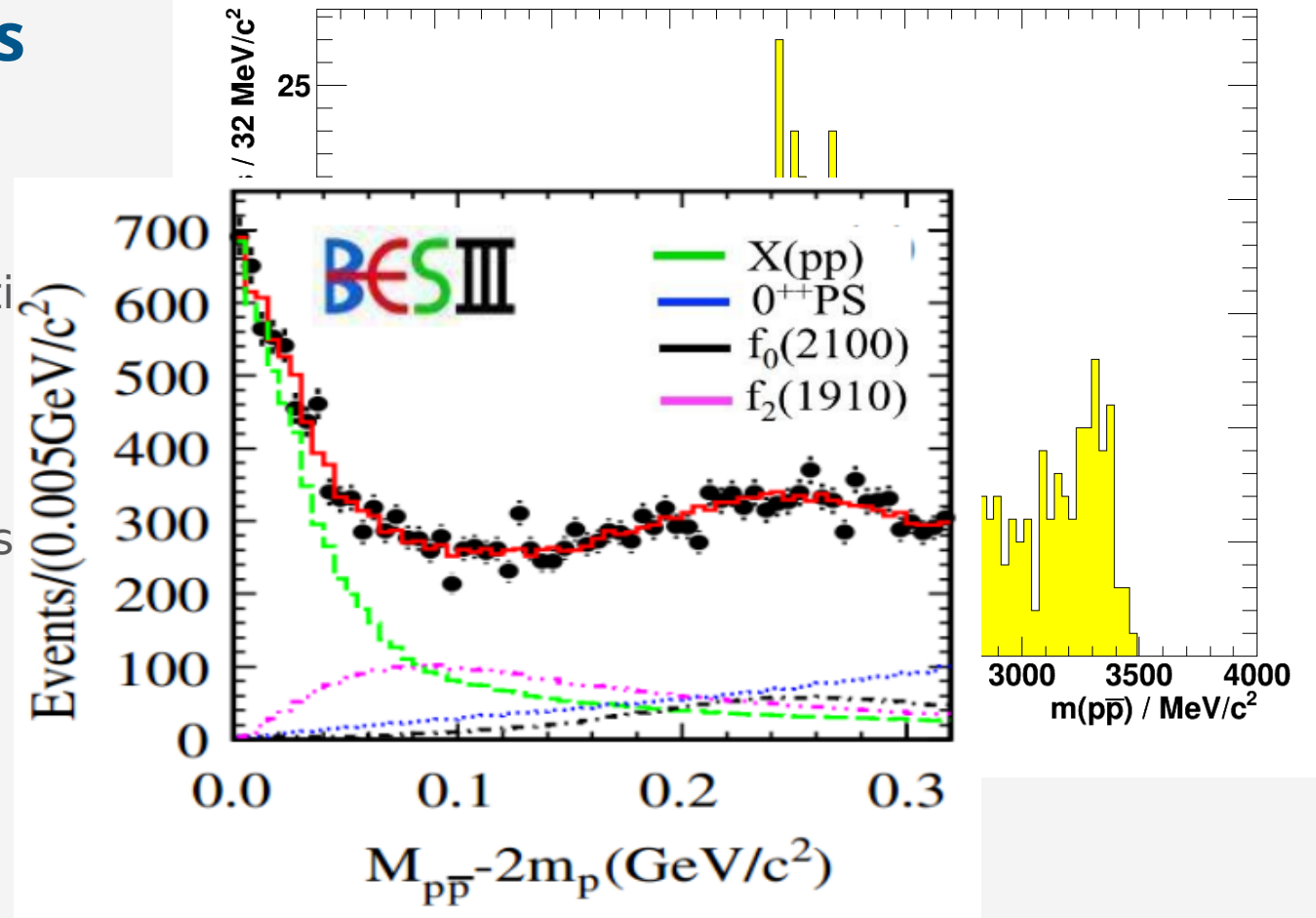
## $e^+e^- \rightarrow p\bar{p}\omega$ invariant masses

- Invariant mass distribution of  $p\bar{p}$
- Distribution as expected between kinematic limits
- No contribution from  $J/\psi$
- Visible enhancement at low invariant mass

→ similar structure seen in  $J/\psi \rightarrow \gamma p\bar{p}$

hints towards  $X(p\bar{p})$

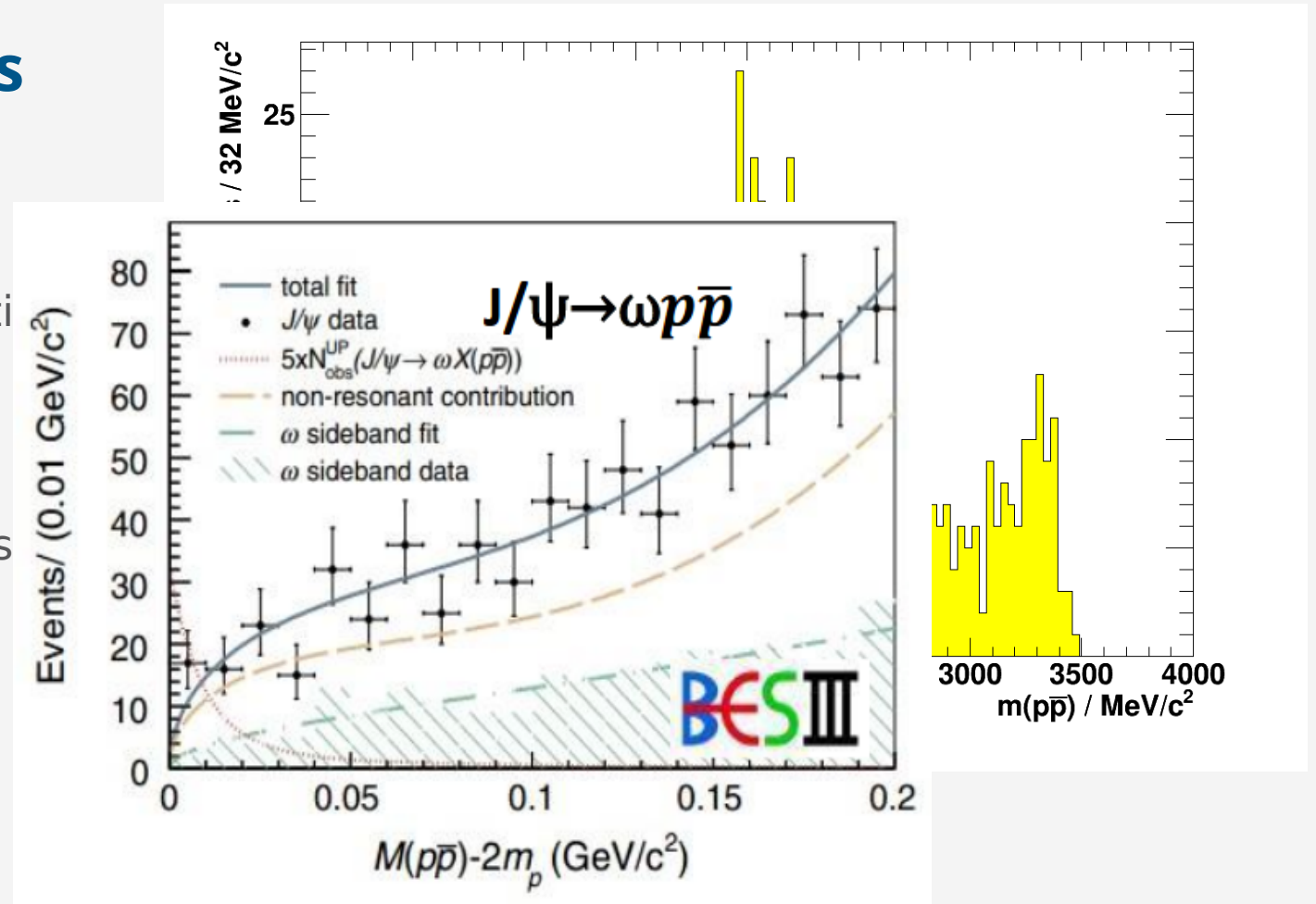
PRL 108, 112003(2012)



## $e^+e^- \rightarrow p\bar{p}\omega$ invariant masses

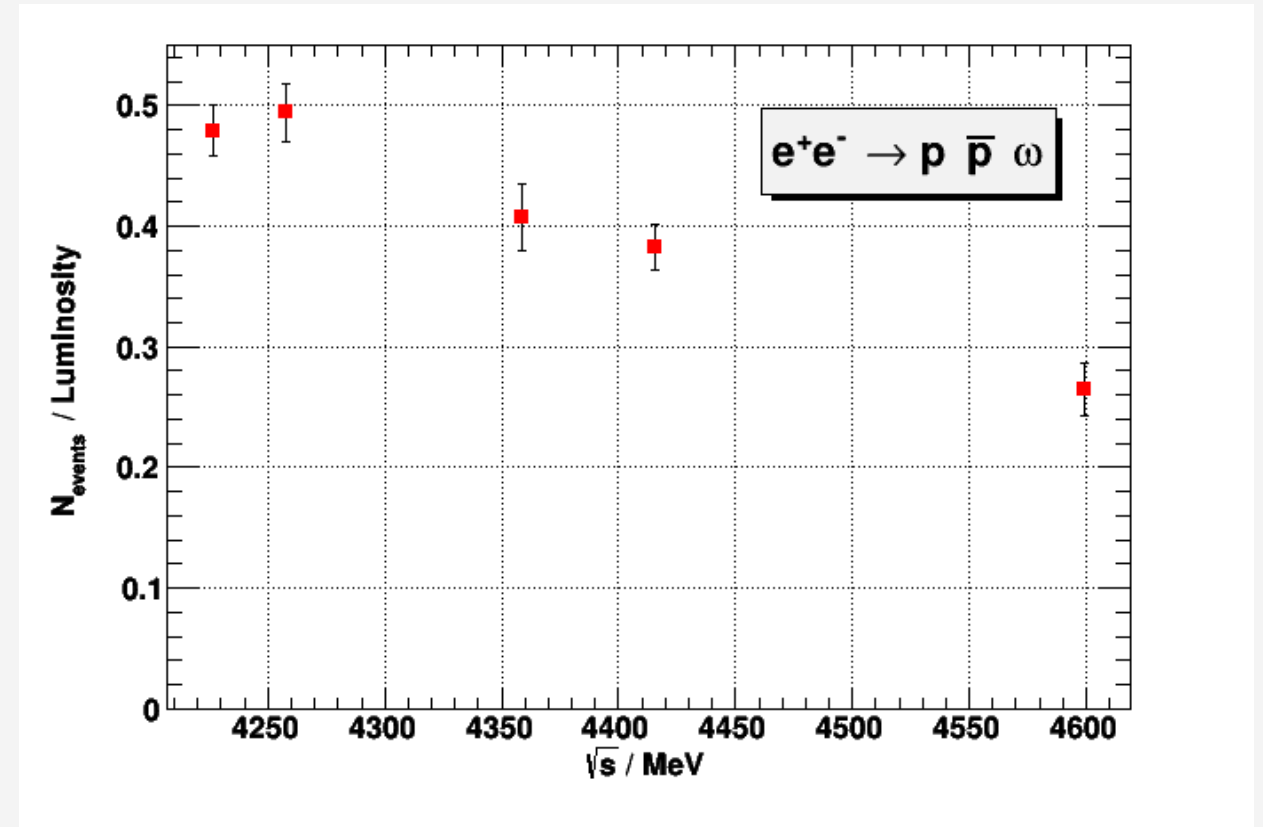
- Invariant mass distribution of  $p\bar{p}$
- Distribution as expected between kinematic limits
- No contribution from  $J/\psi$
- Visible enhancement at low invariant mass
  - similar structure seen in  $J/\psi \rightarrow \gamma p\bar{p}$  hints towards  $X(p\bar{p})$
  - but not seen in  $J/\psi \rightarrow \omega p\bar{p}$

PRD 87, 11204(2013)



## $e^+e^- \rightarrow p\bar{p}\omega$ event yields

- Monte Carlo simulation in preparation
- Analysis of new XYZ datasets currently in progress



## Summary & Outlook

- We found clear signals of the  $p\bar{p}\omega$  final state in different datasets around 4 GeV
  - Investigate cross sections (also include new XYZ data)
- Enhancement at low invariant masses of  $p\bar{p}$  (in  $e^+e^- \rightarrow p\bar{p}\omega$ )
  - Similar structures seen in different  $J/\psi$  decays
  - Will be further analyzed
- Looking into further  $p\bar{p}$  final states, such as  $p\bar{p}$ ,  $p\bar{p}\pi^0$ , ...
  - Topics for new students (Johannes Blooms, Frederik Weidner)
- Energy scan using ISR:  $e^+e^- \rightarrow \gamma p\bar{p} X$