Westfälische Wilhelms-Universität Münster

Studies towards $Y(4260) \rightarrow \Psi(2S) + \eta/\pi^0$

First steps of our analysis

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Marcel Rump – March 22, 2017

Introducing our group at Münster University, Germany

- We recently started analysing BESIII data.
  → Marcel Rump (PhD student) since Nov 2016
  → Johannes Kellers (Bachelor student)

- The group keeps growing.
  → new Master student in summer 2017
  → more will come in the near future

- We would like to contribute to studies on Y(4260) decays
  → Looking into different decay channels such as

$$e^+e^- \to Y(4260) \to \Psi(2S) + \eta/\pi^0$$

using existing as well as upcoming data.

Motivation

- Y(4260) (discovered 2005) is a good candidate for an exotic state which makes it a highly interesting topic of research.
- Internal structure still not completely understood
  → Investigate how the Y(4260) decays into other particles.
  → Studies on the Y(4260) lineshape using different decay channels.
- Talk by Ryan Mitchell at the Collaboration Meeting in June 2016 showed that there could be signals in the decay channels:
  $Y(4260) \rightarrow \Psi(2S) + \eta$ and $Y(4260) \rightarrow \Psi(2S) + \pi^0$

First steps of our analyses

- Look for possible decay channels and their final states:

$Y(4260) \to \Psi(2S) + \eta/\pi^0$

$\Psi(2S) \to J/\Psi\ \pi^+ \pi^-$

$J/\Psi \to l^+ l^-$

$\eta \to \gamma\gamma,\ \pi^0\pi^0\pi^0,\ \pi^+\pi^-\pi^0$

$\pi^0 \to \gamma\gamma$

- We first studied $e^+e^- \to J/\Psi\ \pi^+ \pi^-$ and tried to reproduce the results that has been published recently Phys. Rev. Lett. 118, 092001 (2017).

→ Get a good unterstanding of BESIII detector and the analysis and simulation software.
→ Learn how to identify the sub-decay $\Psi(2S) \to J/\Psi\ \pi^+ \pi^-$, which has the same final state.

$e^+e^- \rightarrow J/\Psi\ \pi^+\pi^-$ ($J/\Psi \rightarrow l^+l^-$)

Event selection

Charged tracks

$|r_{xy}| < 1.0$ cm

$|z| < 10.0$ cm

$|\cos\theta| < 0.93$

PID

Momentum < 1.0 GeV/c : π^+/π^-

> 1.0 GeV/c : l^+/l^-

$E_{EMC} < 0.35$ GeV : μ^+/μ^-

> 1.10 GeV : e^+/e^-

4C Kinematic fit

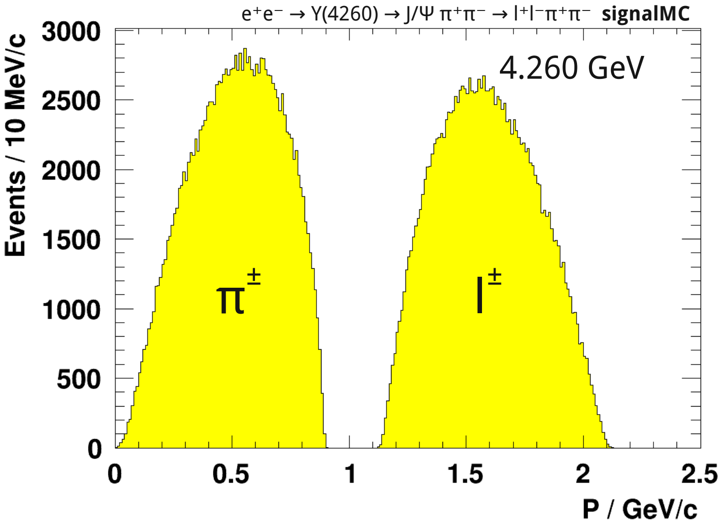
$\chi^2_{4C} < 60$

Background suppression

radiative Bhabha/dimuon

$|\cos\theta_{\pi^+\pi^-}| < 0.98$

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



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$e^+e^- \to J/\Psi\, \pi^+\pi^-$ $\quad$ ($J/\Psi \to l^+l^-$)

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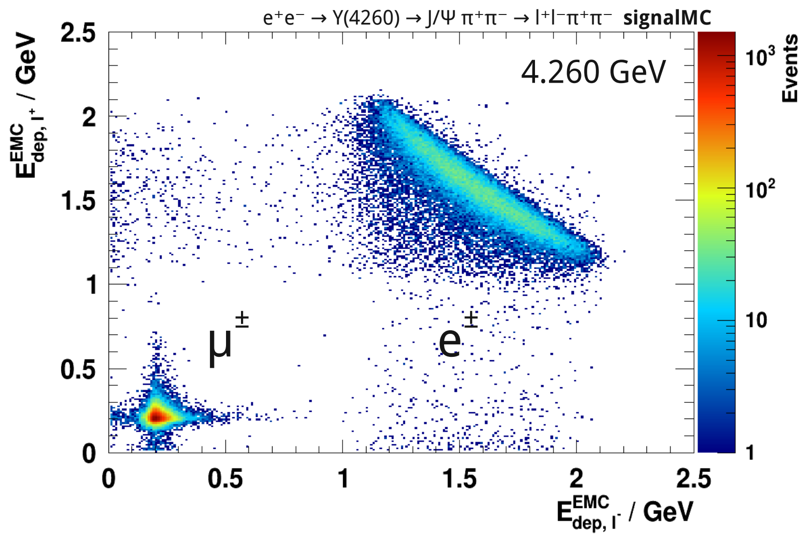
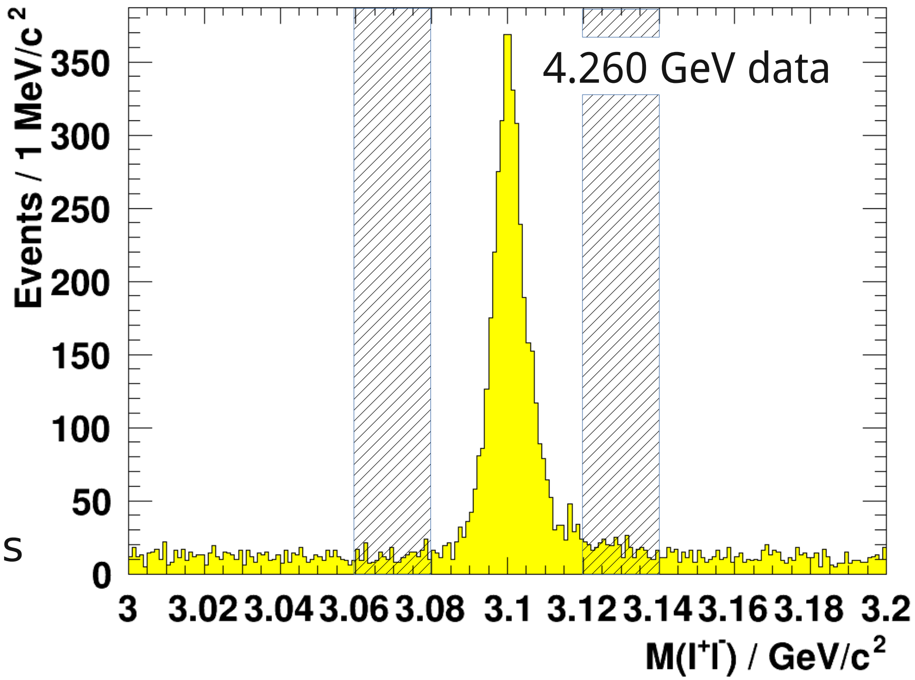


$e^+e^- \rightarrow J/\Psi\ \pi^+\pi^-$ ($J/\Psi \rightarrow l^+l^-$)

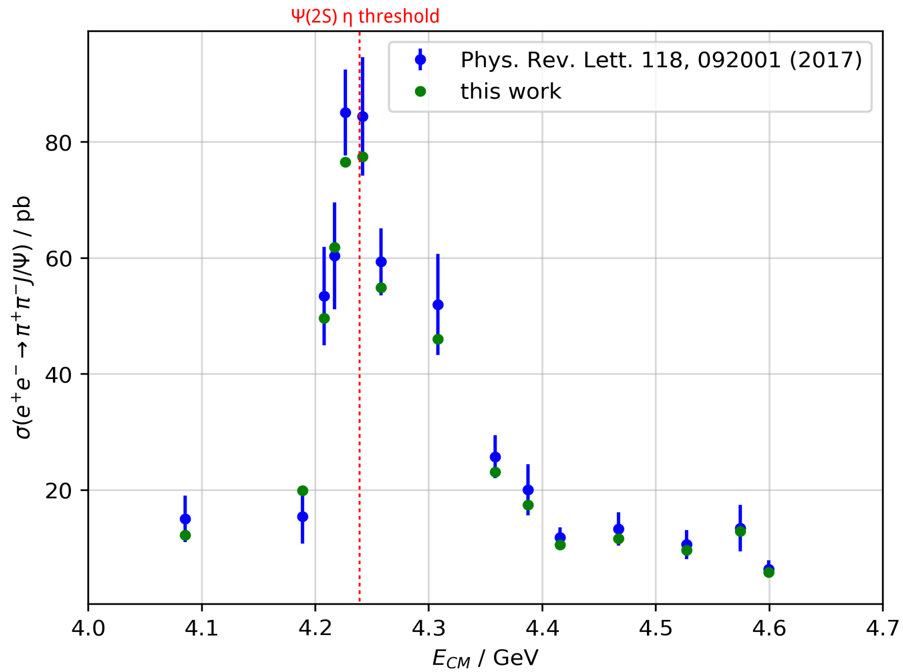
- Define the J/Ψ signal region as [3.08, 3.12]
- Define sidebands as [3.0, 3.06] and [3.14, 3.2]
- Determine signal events by subtraction of a flat background distribution, as well as detection efficiencies using MC simulation



$e^+e^- \to J/\Psi\ \pi^+\pi^-$ ($J/\Psi \to l^+l^-$)

- Our results are in good agreement with the results published early March, 2017.
- Only slight deviations which might be caused using different selection criteria.

→ Analyses and simulation well under control
→ Start analysing $e^+e^- \to \Psi(2S) + \eta/\pi^0$



Note: cross section values were calculated using integrated luminosities and radiative correction factors as cited in Phys. Rev. Lett. 118, 092001 (2017).

$e^+e^- \rightarrow \Psi(2S) + \eta$

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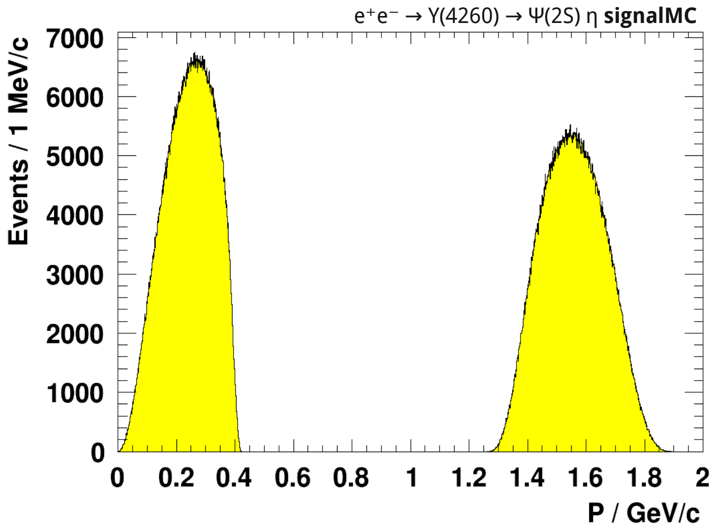
$E_{EMC} < 0.35$ GeV : μ^+ / μ^-
> 1.10 GeV : e^+ / e^-

Neutral tracks

$E_{barrel} > 25$ MeV, $E_{endcap} > 50$ MeV
$|\cos\theta| < 0.8$ or
$0.86 < |\cos\theta| < 0.92$
$0 \leq TDC \leq 14$, $\Delta\theta > 20°$



$e^+e^- \rightarrow \Psi(2S) + \eta$

$\eta \rightarrow \gamma\gamma$
$\Psi(2S) \rightarrow J/\Psi\ \pi^+\pi^-$
$\rightarrow l^+l^-\pi^+\pi^-$

- 4 charged tracks (2 leptons, 2 pions) with 0 total charge
- $N_\gamma \geq 2$
- $\chi^2_{4C} < 100$

$\eta \rightarrow \pi^0\pi^0\pi^0$
$\Psi(2S) \rightarrow J/\Psi\ \pi^+\pi^-$
$\rightarrow l^+l^-\pi^+\pi^-$

- 4 charged tracks (2 leptons, 2 pions) with 0 total charge
- $N_\gamma \geq 6$
- $\chi^2_{4C} < 180$

$\eta \rightarrow \pi^+\pi^-\pi^0$
$\Psi(2S) \rightarrow J/\Psi\ \pi^+\pi^-$
$\rightarrow l^+l^-\pi^+\pi^-$

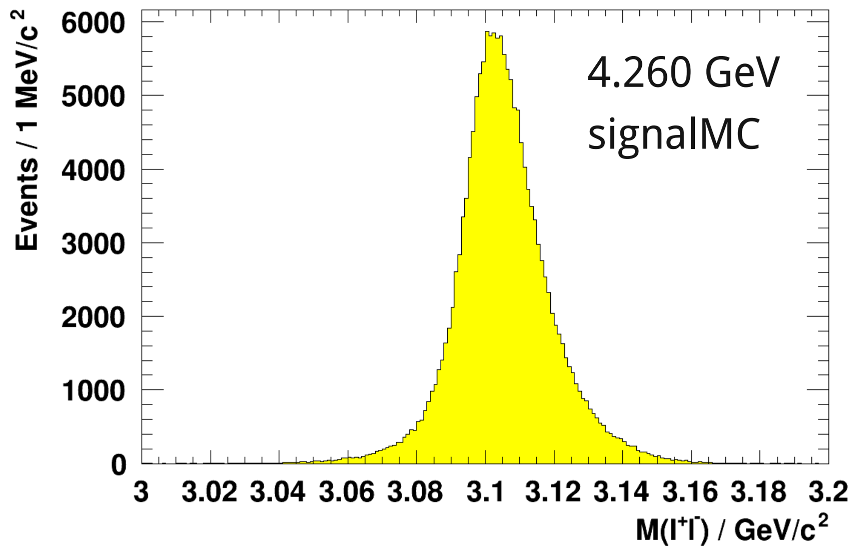
- 6 charged tracks (2 leptons, 4 pions) with 0 total charge
- $N_\gamma \geq 2$
- $\chi^2_{4C} < 140$

$e^+e^- \rightarrow \Psi(2S) + \eta$

- J/Ψ candidates:
  $|M(l^+l^-\pi^+\pi^-) - m_{J/\Psi}| < 100$ MeV/c²

- η candidates:
  $|M(\eta) - m_\eta| < 200$ MeV/c²

- π⁰ candidates:
  $|M(\pi^0) - m_{\pi^0}| < 50$ MeV/c²

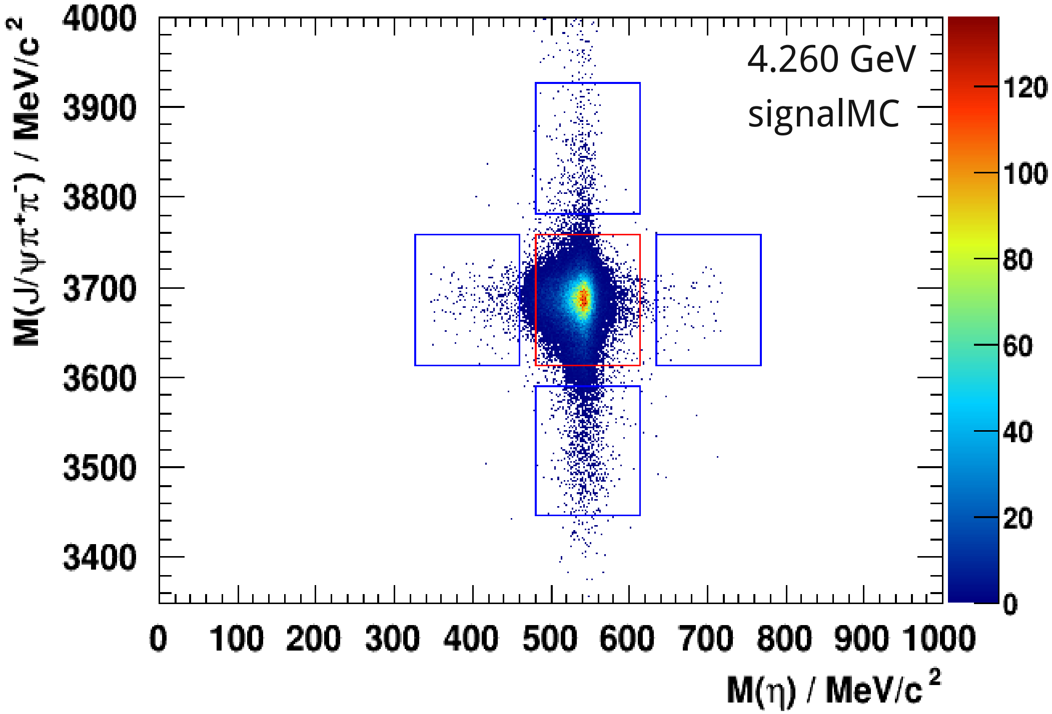


Note:
- In case of multiple events, choose smallest χ^2_{4C}.
- M(J/Ψ) is slightly to high, which will be checked.

$e^+e^- \rightarrow \Psi(2S) + \eta$

- Define signal region (±3σ) and sidebands

  → detection efficiency
  $\epsilon \approx 0.162 \pm 0.002_{stat}$
  using MC simulation



$e^+e^- \rightarrow \Psi(2S) + \eta$

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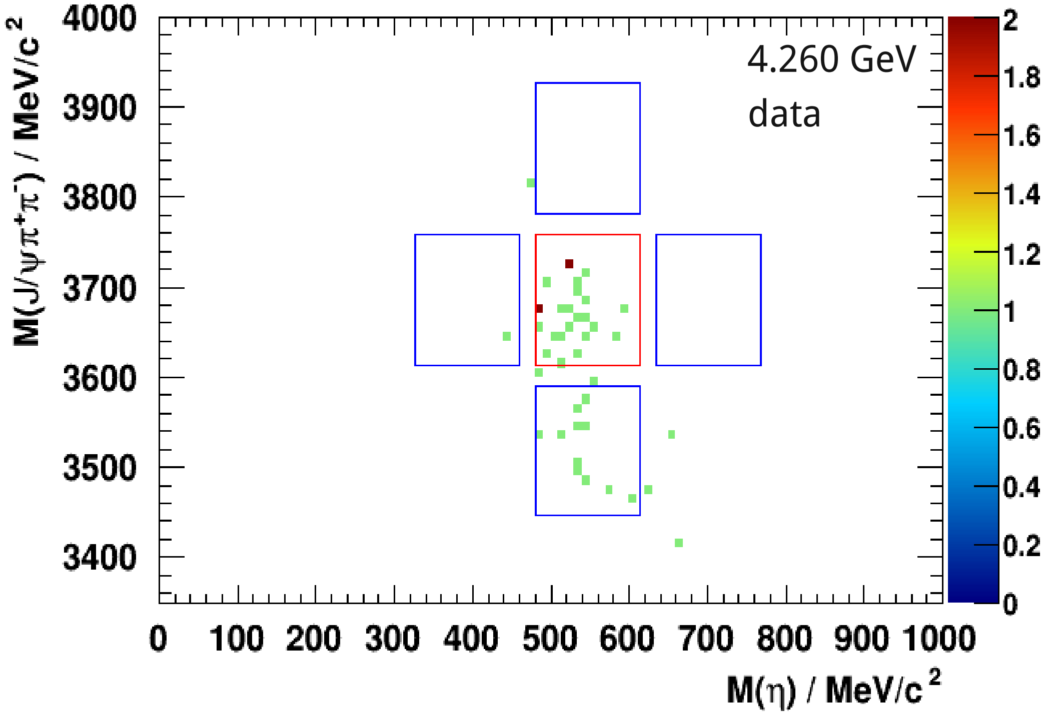

- 24 events in signal region
  → background studies

- Currently in progress:
  - Analyses of all data points 4.0 – 4.6 GeV
  - In addition the upcoming data will be analysed when available

Summary

What we have done so far ...

- At the University of Münster we started our analysis of $e^+e^- \rightarrow \Psi(2S) + \eta/\pi^0$ on existing data, which will also be performed on the upcoming data.

- As a first check we successfully reproduced the results of $e^+e^- \rightarrow J/\Psi\ \pi^+\pi^-$ that has been published early March.

- In a first iteration we applied similar idenfication techniques to start analysing the $e^+e^- \rightarrow \Psi(2S) + \eta$ channel.

Outlook

What will be done next ...

- Finish analysis of $e^+e^- \rightarrow \Psi(2S) + \eta$
  - Optimization of selection criteria
  - Background studies
  - Analysis of all data points

- Analyse $e^+e^- \rightarrow \Psi(2S) + \pi^0$ (already in progress)