J/ψ → µµ sidebands subtraction

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CMG group meeting
The $J/\psi \rightarrow \mu\mu$

The $J/\psi$

mass = 3096.916 ± 0.011 MeV/c$^2$
declaw width = 93.2 ± 2.1 keV
decay modes:

- hadrons (87.7 ± 0.5)%
- $\mu^+\mu^-$ (5.94 ± 0.06)%
- $e^+e^-$ (5.94 ± 0.06)%

production modes:

- non prompt $B \rightarrow J/\psi + X$
- prompt
  - direct
  - $X_c \rightarrow J/\psi \gamma, \ldots$
  - $\psi_{2s} \rightarrow J/\psi \pi\pi, \ldots$
Goal of the sidebands subtraction

Aims

- measurement of $J/\psi$ cross section [CMS PAS BPH-10-002]
  → prompt-nonprompt, polarization, $X_c$ contribution,..
- measurement of momentum scale and resolution (on single track) from fit to $J/\psi \rightarrow \mu\mu$ line shape
  → (Musclefit) calibration
Goal of the sidebands subtraction

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• understand $J/\psi$ kinematicks

• control the background

• compare data-MC
Goal of the sidebands subtraction

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  $\rightarrow$ prompt-nonprompt, polarization, $X_c$ contribution,..
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We need to

- understand $J/\psi$ kinematicicks
- control the background
- compare data-MC

Sidebands subtraction of kinematic distributions
The goal

The method studies the distribution of the $J/\psi$ kinematic variables.
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data: invariant mass $\mu^+ \mu^- \rightarrow J/\psi$
The Assumption on the sidebands
A method to investigate kinematic variable distributions: the goal

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The background events in peak mass region are extremely similar to the events in the areas close to the peak.

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A method to investigate kinematic variable distributions: the goal

$J/\psi \rightarrow \mu\mu$
sidebands subtraction

Why this analysis?
Explaining the method
Applying the method
Technical details
Conclusion

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Assumption
The background events in peak mass region are extremely similar to the events in the areas close to the peak.

data: invariant mass $\mu^+\mu^- \rightarrow J/\psi$

data: fit sideband and bkg estimation

The Assumption on the sidebands
A method to investigate kinematic variable distributions: the goal
The subtraction

\[
J/\psi \rightarrow \mu \mu \text{ sidebands subtraction}
\]

5

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Introduction
Why this analysis?
Explaining the method

Applying the method
Technical details
Pt analysis
\(\Delta \eta\) and \(\Delta \phi\) study

Conclusion
The subtraction

\[ J/\psi \to \mu\mu \text{ sidebands subtraction} \]

5

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Introduction
Why this analysis?
Explaining the method
Applying the method
Technical details
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Conclusion

\[
\begin{array}{c|c|c}
\text{M}_{J\psi} & \text{Entries} & \text{Mean} \\
\hline
 & 28802 & 3.094 \\
\hline
 & & 0.04517
\end{array}
\]
The subtraction

\[ J/\psi \rightarrow \mu \mu \text{ sidebands subtraction} \]

5

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Introduction

Why this analysis?

Explaining the method

Applying the method

Technical details

Pt analysis

\( \Delta \eta \) and \( \Delta \phi \) study

Conclusion

\[ \left( \begin{array}{c}
- \\
+ \\
\end{array} \right) \cdot \left| \frac{C}{A + B} \right| \]
Technical details

Standard selections:

- **Central skim for Onia:**
  
  \[ M(\mu\mu) > 2 \text{ GeV} \]

- **PATUPLE:** official quarkonia

- **Analysis cuts:** muons couple in this order GG GT TT.

**T selection:**

- `iTrack->found() > 11;`
- `iTrack->chi2()/iTrack->ndof() < 4.0;`
- `p.pixelLayersWithMeasurement() \geq 1;`
- `fabs(iTrack->dxy()) < 3.0;`
- `fabs(iTrack->dz()) < 15.0;`
- `Muon->muonID("TrackerMuonArbitrated");`
- `Muon->muonID("TMLastStationAngTight");`

**G selection:**

- `gTrack->chi2()/gTrack->ndof() < 20.0;`
- `q.numberOfValidMuonHits() > 0;`
Technical details

Data

DATA: 226.5 nb$^{-1}$ with good runs, lumisection selection from official JSON file.

MC

- (only prompt) 75nb$^{-1}$
  /JPsiToMuMu 2MuPEtaFilter
  7TeV-pythia6-evtgen/Spring10-START3X V26-v1
- (non prompt) 122 nb$^{-1}$
  /ppMuX/Spring10-START3X_V26_S09-v1
  \rightarrow WORK ON GOING.
$P_t$ analysis

Pt distribution for $J/\psi$ peak and sidebands
$P_t$ analysis

$J/\psi \rightarrow \mu\mu$ sidebands subtraction

7
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Introduction
Why this analysis?
Explaining the method

Applying the method
Technical details
$P_t$ analysis
$\Delta \eta$ and $\Delta \phi$ study

Conclusion

Pt distribution for $J/\psi$ peak and sidebands

$P_t$, spectrum shape driven by acceptance in $\eta$
$P_t$ analysis

Pt sidebands subtraction

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Introduction
Why this analysis?
Explaining the method
Applying the method
Technical details
Pt analysis
$\Delta \eta$ and $\Delta \phi$ study

Conclusion
$P_t$ analysis

**Pt confront**

- **the Data $P_t$ spectrum is softer**

**Pt sidebands subtraction**

**Introduction**
- Why this analysis?
- Explaining the method

**Applying the method**
- Technical details
  - Pt analysis
  - $\Delta \eta$ and $\Delta \phi$ study

**Conclusion**
Why this analysis?
Explaining the method
Applying the method
Technical details
Pt analisys
$\Delta \eta$ and $\Delta \phi$ study
Conclusion

Data-MC differences

Cuts on MC

- $|\vec{p}_\mu| > 2.5$ GeV;
- $|\eta_\mu| < 2.5$

Trigger

Most efficient trigger HLT_L1 MuOpen is not in simulation.
For commissioning studies normalization is not relevant → maximize statistics.
Muons Variables

**Introduction**

Why this analysis?

Explaining the method

Applying the method

Technical details

**Pt analysis**

$\eta$ and $\phi$ study

**Conclusion**

$J/\psi \rightarrow \mu\mu$ sidebands subtraction

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Muons Variables

**Muons $\eta$**

- **Purpose**: Study of $\eta$ distribution in muons
- **Histogram**: Distribution of $\eta$ values
- **Statistics**:
  - Entries: 542620
  - Mean: 0.01284
  - RMS: 1.896

**Muons $P_t$**

- **Purpose**: Study of $P_t$ distribution in muons
- **Histogram**: Distribution of $P_t$ values
- **Statistics**:
  - Entries: 542620
  - Mean: 2.043
  - RMS: 1.335
Acceptance of the detector

Introduction
Why this analysis?
Explaining the method
Applying the method
Technical details
Pt analysis
$\Delta \eta$ and $\Delta \phi$ study
Conclusion
Acceptance of the detector

Introduction
Why this analysis?
Explaining the method
Applying the method
Technical details
Pt analysis
$\Delta \eta$ and $\Delta \phi$ study
Conclusion
Studying $\Delta \eta$ between the two muons

$\Delta \eta$ vs $P_t$

data: $\Delta \eta$ vs $P_t$
Studying $\Delta \eta$ between the two muons $\Delta \eta$ vs $M$

data: $\Delta \eta$ vs $M$ $J/\psi$
Studying $\Delta \eta$ between the two muons

**Introduction**

Why this analysis?

Explaining the method

**Applying the method**

Technical details

$\Delta \eta$ and $\Delta \phi$ study

**Conclusion**

Studying $\Delta \eta$ between the two muons

Data: $\Delta \eta : J/\psi$ and sidebands
Studying $\Delta \eta$ between the two muons

data: $\Delta \eta$ sidebands subtraction
Studying $\Delta \eta$ between the two muons

data: $\Delta \eta$ vs $P_t$ sidebands subtraction
Studying $\Delta \phi$ between the two muons

$\Delta \phi$ vs $P_t$

data: $\Delta \phi$ vs $P_t$
Studying $\Delta \phi$ between the two muons

$\Delta \phi$ vs $M$

data: $\Delta \phi$ vs $M$ $J/\psi$
Studying $\Delta \phi$ between the two muons

data: $\Delta \phi J/\psi$ and sidebands
Studying $\Delta \phi$ between the two muons

data: $\Delta \phi$ sidebands subtraction MC
Studying $\Delta \phi$ between the two muons

data: $\Delta \phi$ vs $Pt$ sidebands subtraction
There are many differences between Data and MC generated variables. But in principle now we could also work without any MC simulation.
Conclusions

There are many differences between Data and MC generated variables. But in principle now we could also work without any MC simulation.

Prospectives

The sideband subtraction is a simple but efficient tool that works on this front. This tool is now in place for analyzing new variable (like hits) to optimize the cuts for a J/psi analysis.
The images depict graphs showing distributions of $p_x$ with and without corrections.

- **$p_x$** graphs for $p_x$ over $p_x$ showing entries, mean, and RMS.
- **$p_x\psi_s$** graphs for $p_x$ over $p_x\psi_s$ showing entries, mean, and RMS.
- **$p_xGG$** graphs for $p_xGG$ over $p_xGG$ showing entries, mean, and RMS.

Each graph includes a legend for different distributions and shows the distribution of data points with error bars.
eta

**etaskovr**

- Entries: 16930
- Mean: -0.002351
- RMS: 2.398

**etajpsi**

- Entries: 16930
- Mean: -0.002351
- RMS: 2.398

**etajGpsovr**

- Entries: 412
- Mean: -0.008476
- RMS: 1.802

**etajpsi confronto**

- Entries: 16930
- Mean: -0.002351
- RMS: 2.398

**etajpsi confronto**

- Entries: 412
- Mean: -0.008476
- RMS: 1.802
DeltaPt

**DeltaPtsovr**
- Entries: 16930
- Mean: -0.04087
- RMS: 2.194

**DeltaPtGGsovr**
- Entries: 412
- Mean: -0.1691
- RMS: 3.068

**DeltaPt confronto**
- Entries: 16930
- Mean: -0.04087
- RMS: 2.194

**DeltaPtGG confronto**
- Entries: 412
- Mean: -0.1691
- RMS: 3.068