Reconstruction of charmonia with PandaRoot

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Outline

1. Motivation.

2. The PANDA detector.

3. Some benchmark channels.

4. Summary and Outlook.

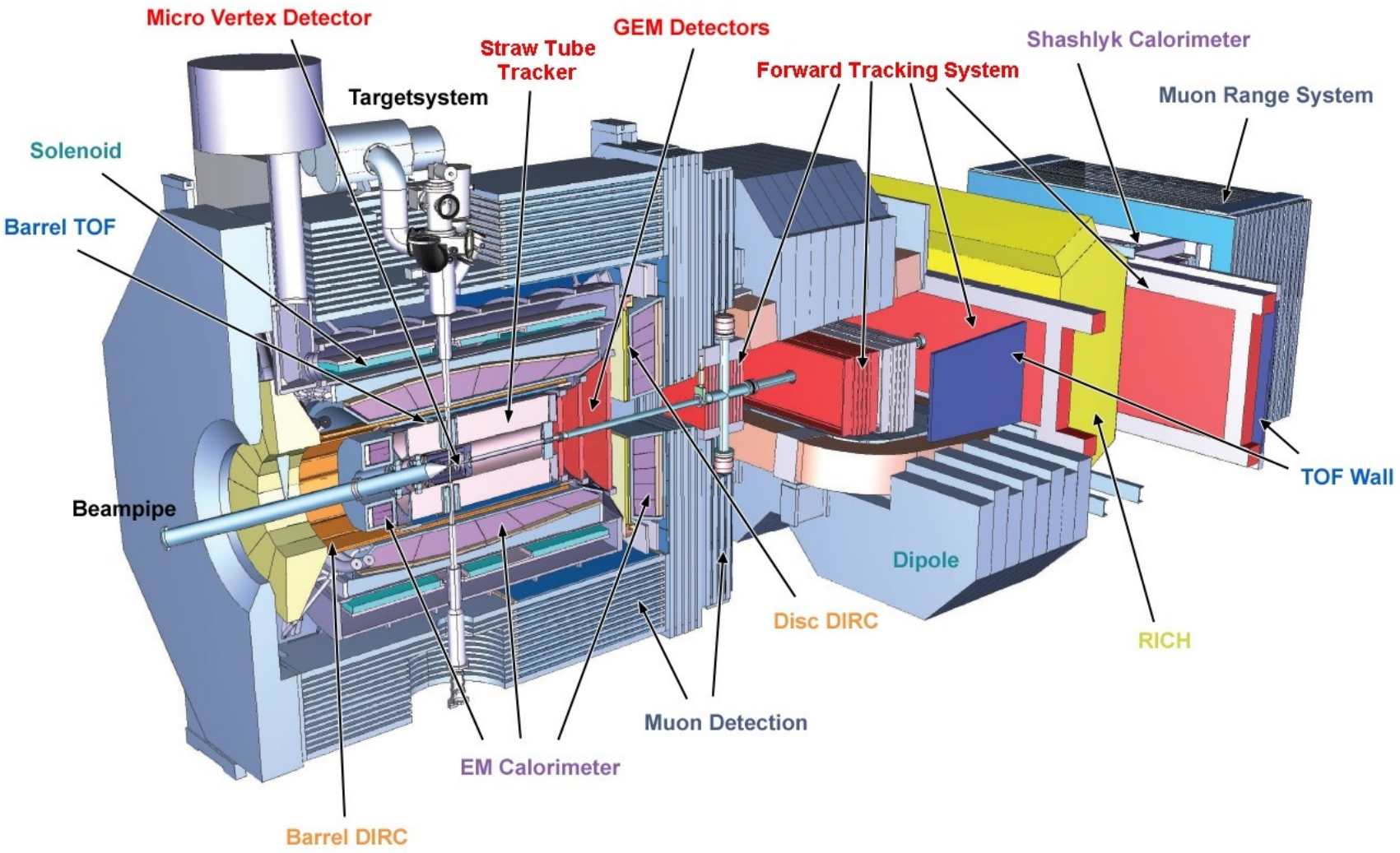
Motivation

1. To get an impression on the PandaRoot current status of particle reconstruction and identification by looking at some benchmark channels of charmonia decays.

2. To re-evaluate Panda performance for charmonium states (as compared with Panda Physics Book).

3. The work can be seen as a continuation of JINR LHEP activity on theoretical (model) predictions / description of charmonia states.

The PANDA detector – full view



Running modes

1. Formation reaction: ppbar $\rightarrow$ Y(4260) $\rightarrow$ J/ψ π+π-

2. Production reaction: ppbar $\rightarrow$ $\hbar_{c0,1,2}$ $\eta \rightarrow$ J/ψ $\pi^0\pi^0$ η

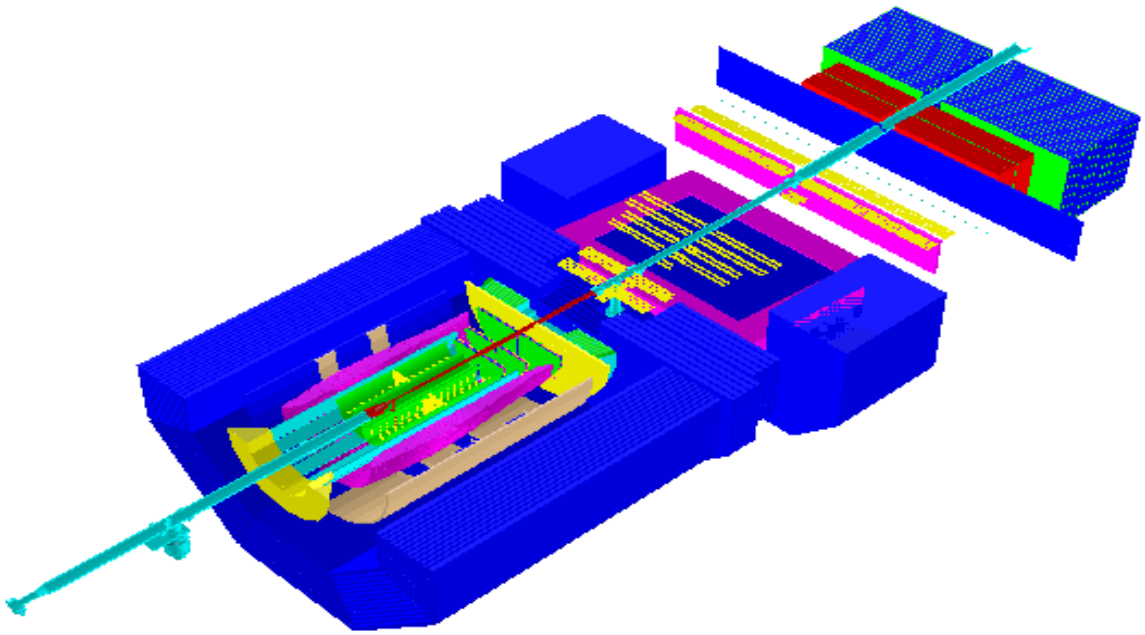
Software

1. PandaRoot (the latest Release mar15 in comparison with ~1 year old trunk – PANDA Russia Workshop https://indico.gsi.de/conferenceOtherViews.py?showSession=all&showDate=all&view=nicecompact&confId=3609)

2. EvtGen generator

3. Rho analysis package (tutorials/rho macros)

The PANDA detector – MC view



Y(4260) → J/ψ π+π- analysis

ppbar → Y(4260) → J/ψ π+π-

X-section = 1012 pb (→ e+e-π+π- 60 pb from PANDA Physics Book)

30k events EvtGen:
2 days for High-Luminosity mode ($2 \cdot 10^{32}$ $cm^{-2}s^{-1}$)
20 days for High-Resolution mode ($2 \cdot 10^{31}$ $cm^{-2}s^{-1}$)

J/ψ → e+e- (Electron ID ("ElectronLoose","PidAlgoEmcBayes"))
J/ψ → μ+μ- (Muon ID ("MuonTight","PidAlgoMdtHardCuts"))
Pion ID ("PionAll")

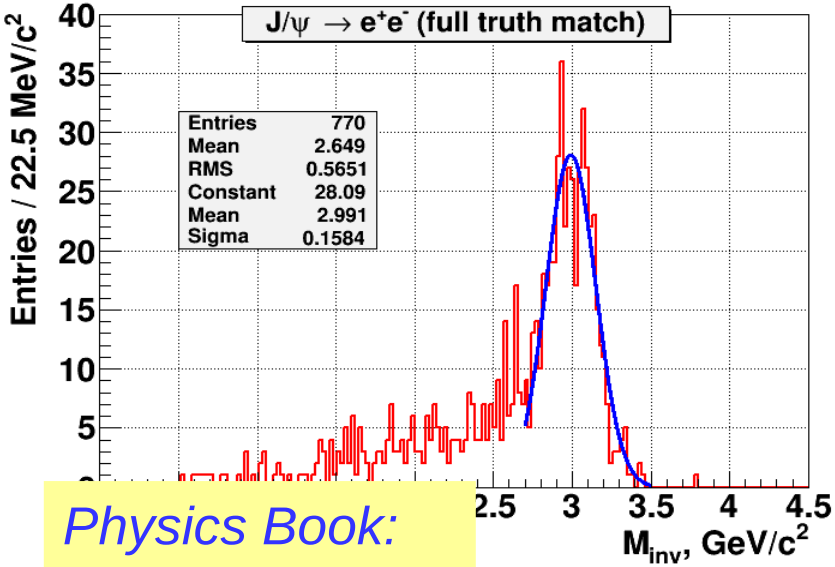
J/ψ - vertex constrained fit (prob > 0.01)
Mass constraint 1 GeV

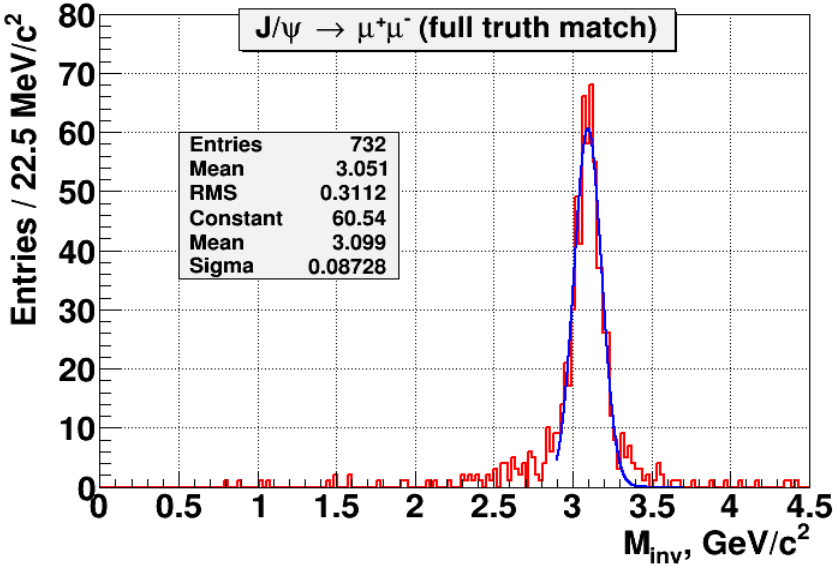
Y(4260) → J/ψ π+π- analysis

J/ψ → e+e- and J/ψ → μ+μ-

1 year old

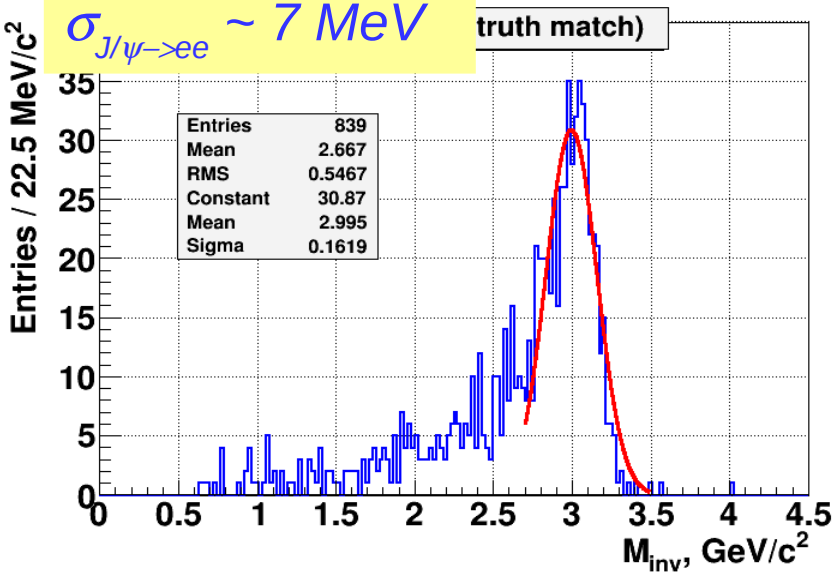
March 2015 Release

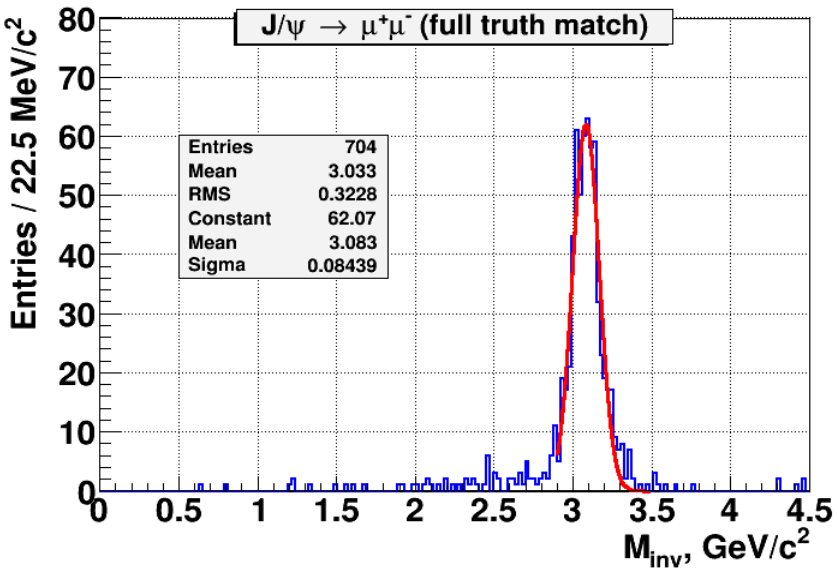




Physics Book:

$\sigma_{J/\psi->ee}$ *~ 7 MeV*



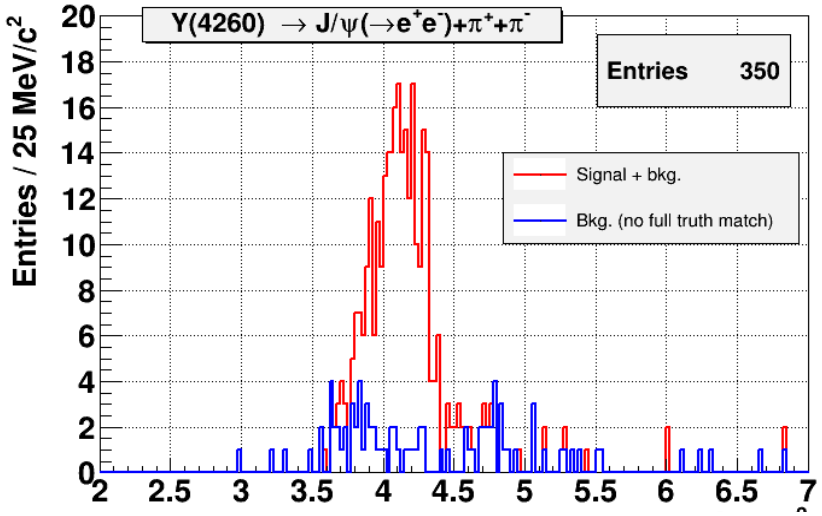


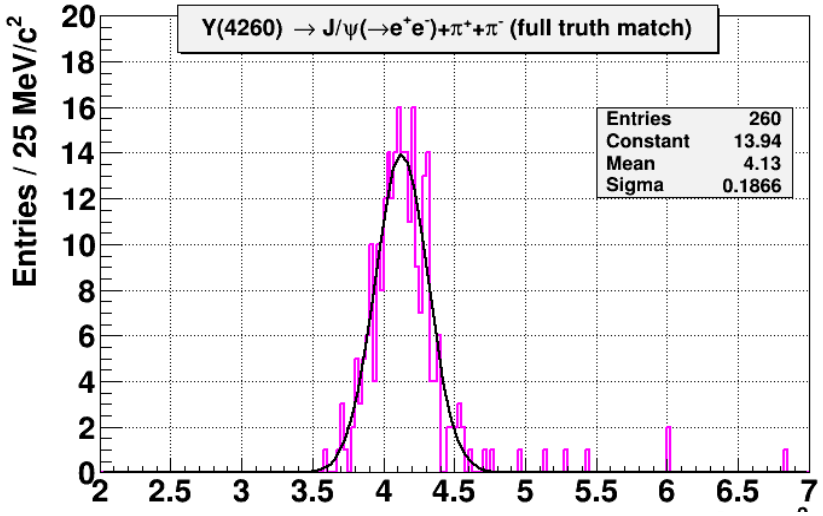
Y(4260) → J/ψ π+π- analysis

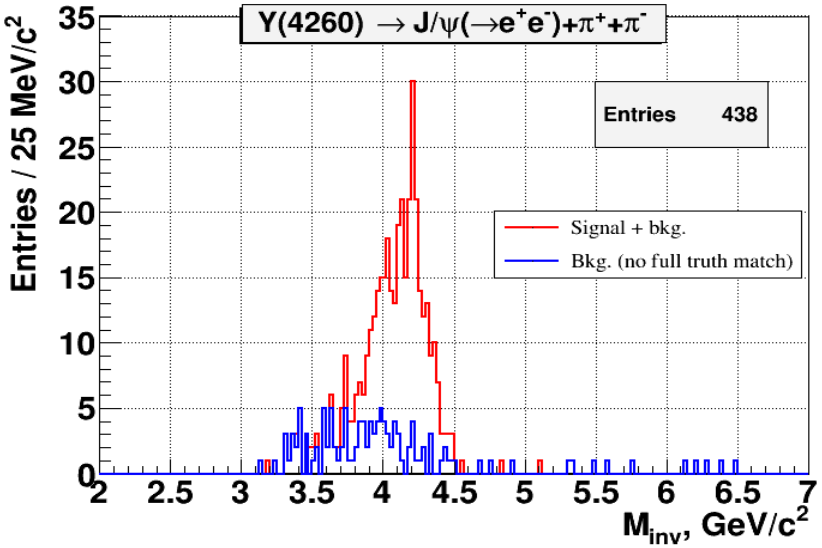
J/ψ → e+e-

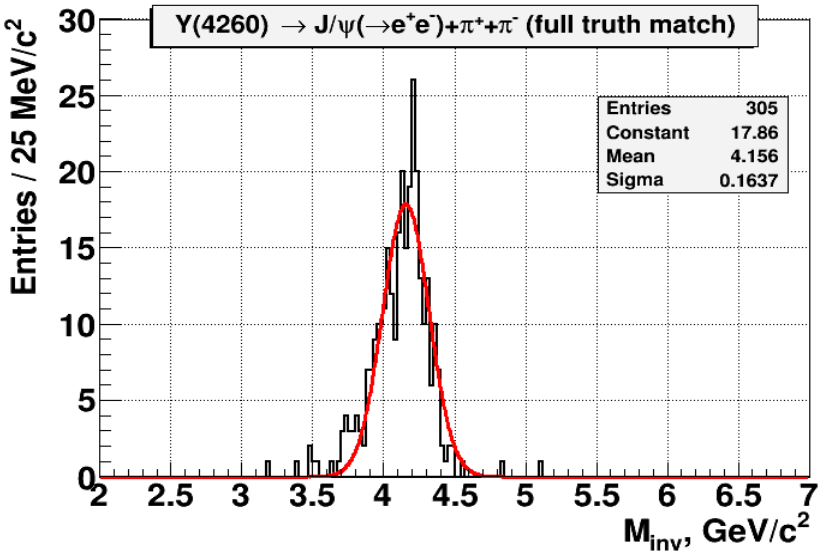
1 year old

March 2015 Release









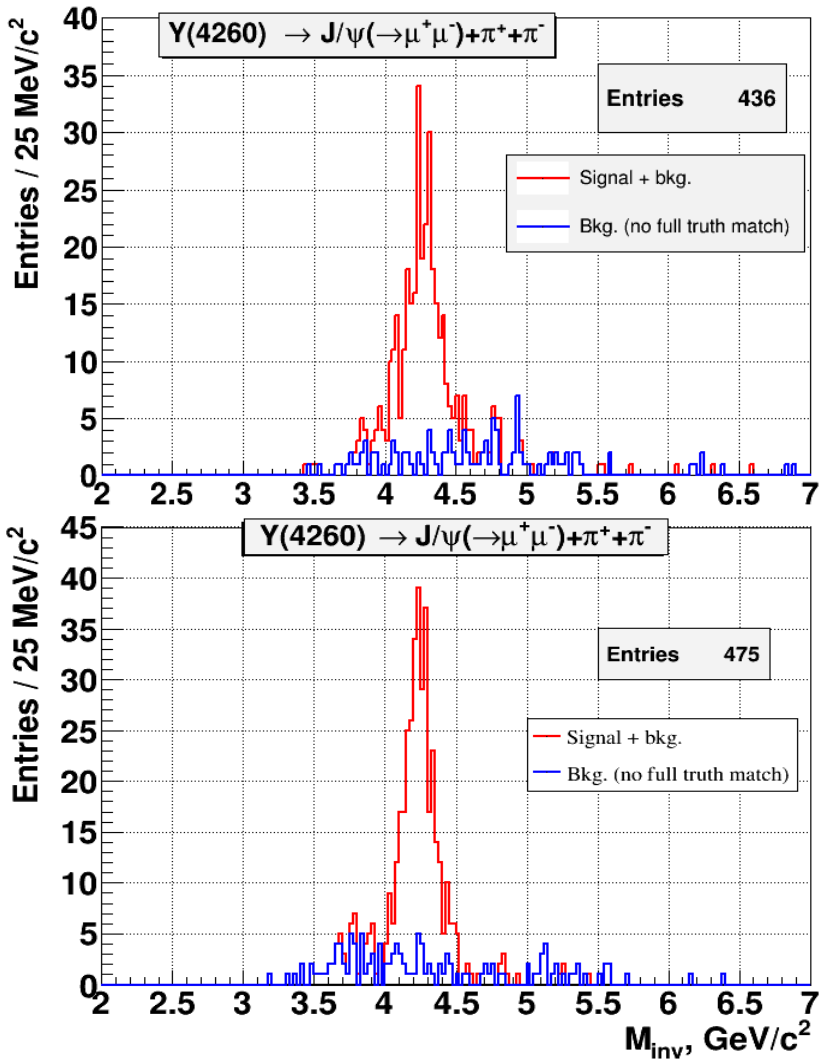
*Efficiency = 305 / (30000*0.0594) = 17.1%*

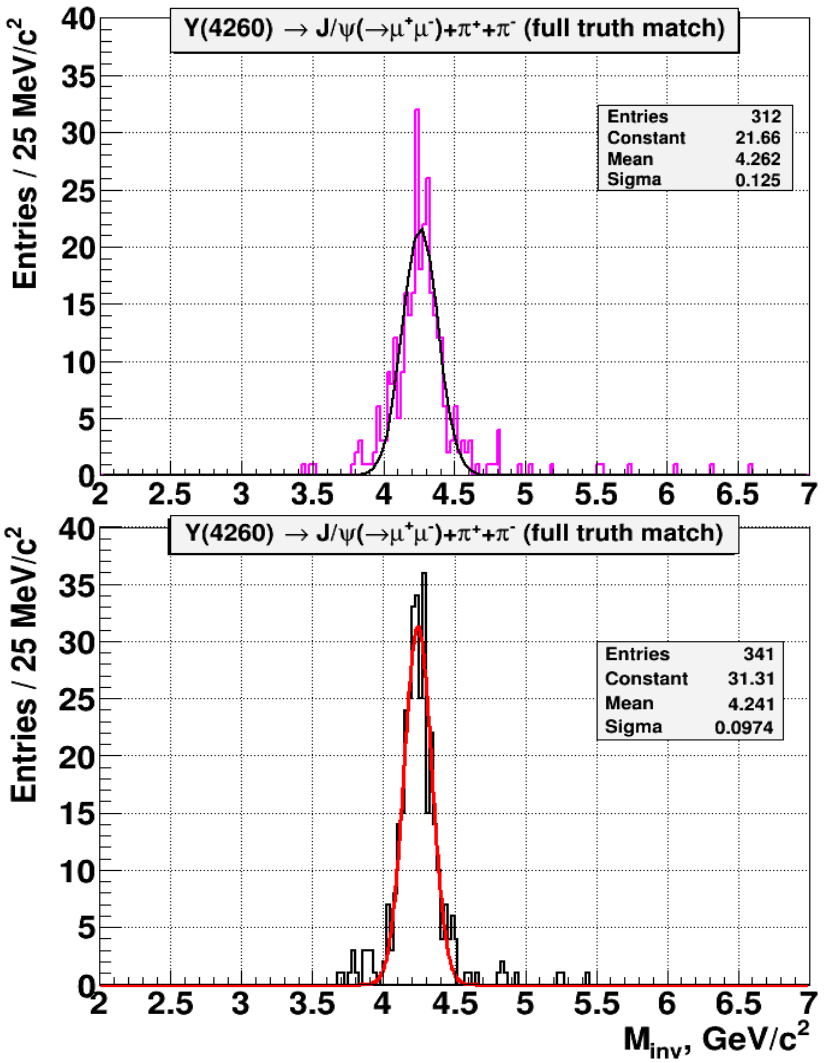
Y(4260) → J/ψ π+π- analysis

J/ψ → μ+μ-

1 year old

March 2015 Release

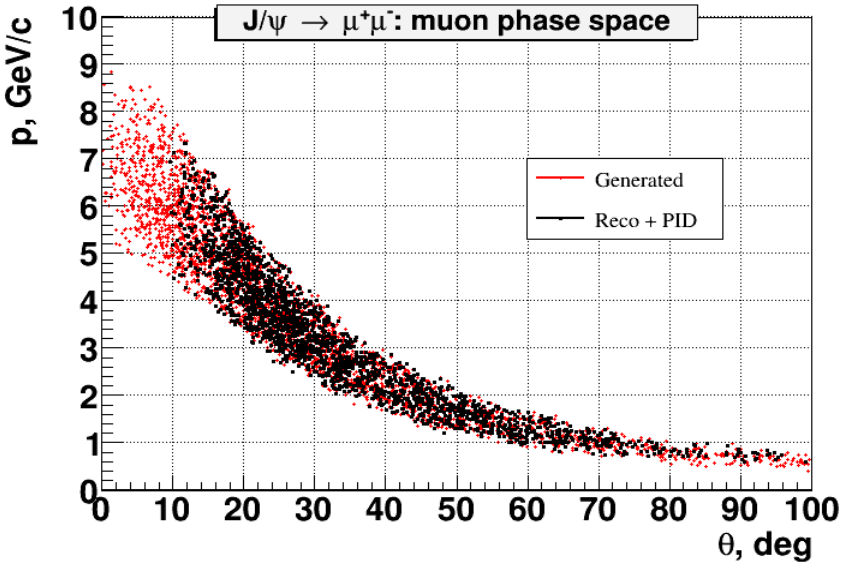


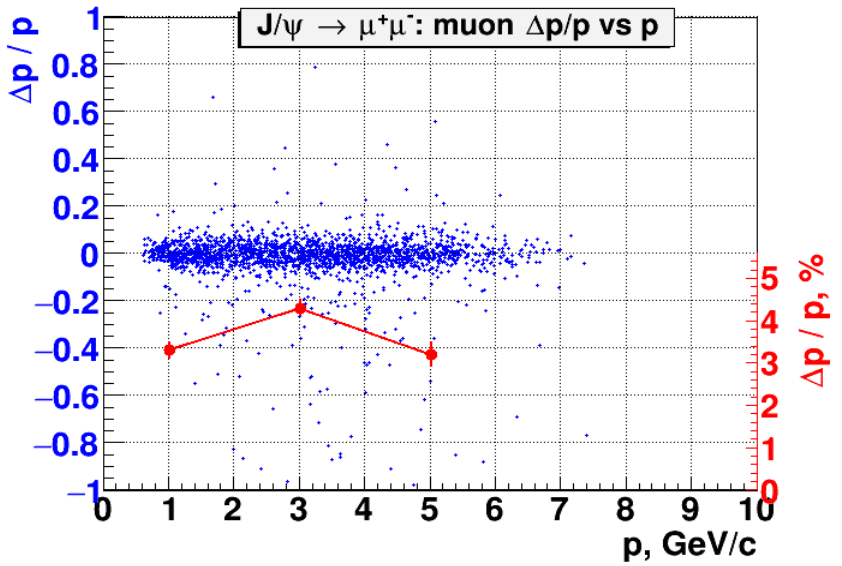


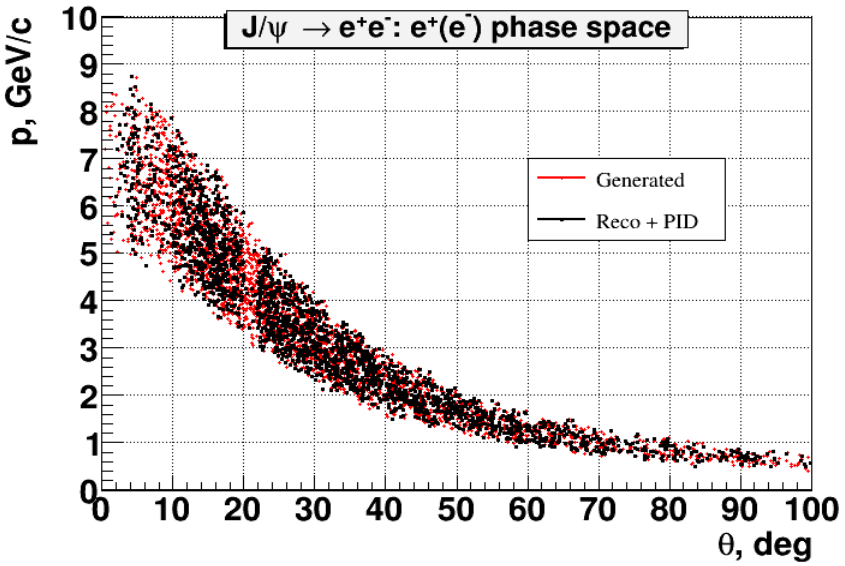
*Efficiency = 341 / (30000*0.0593) = 19.2%*

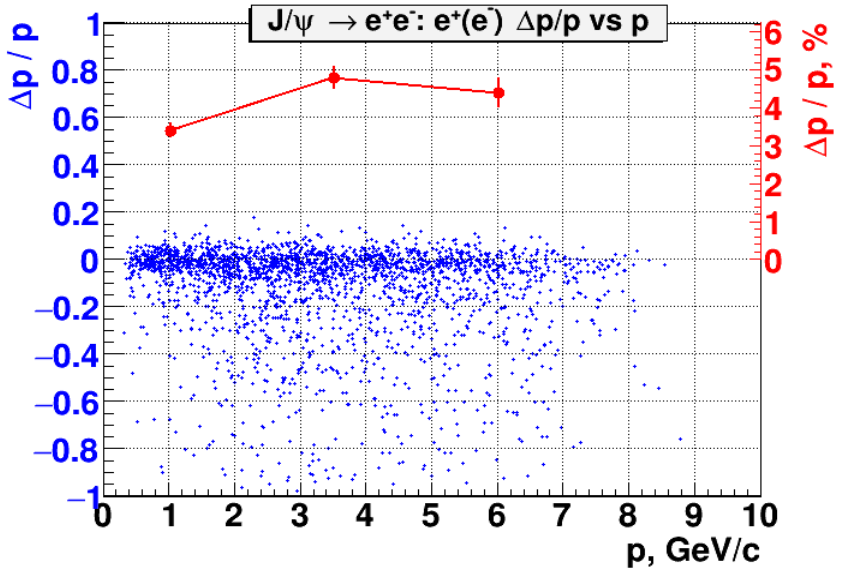
Y(4260) → J/ψ π+π- analysis

J/ψ → e+e- and J/ψ → μ+μ-



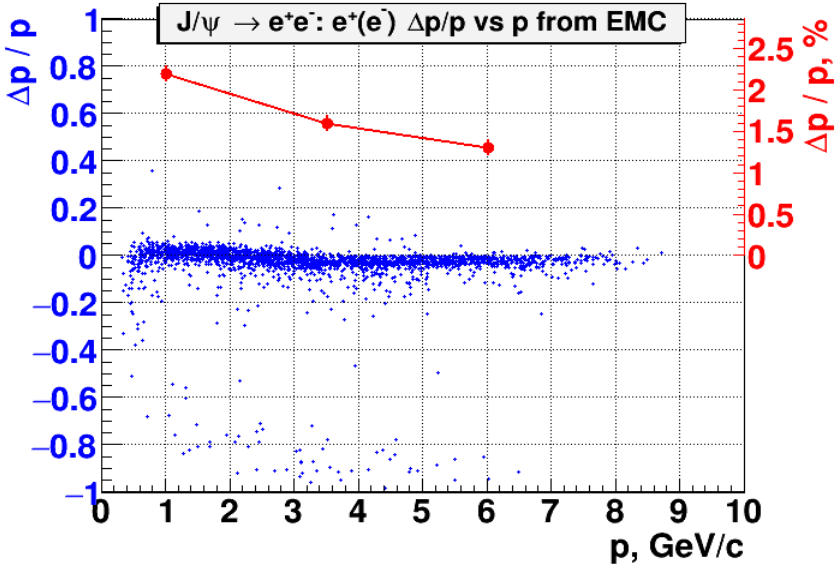


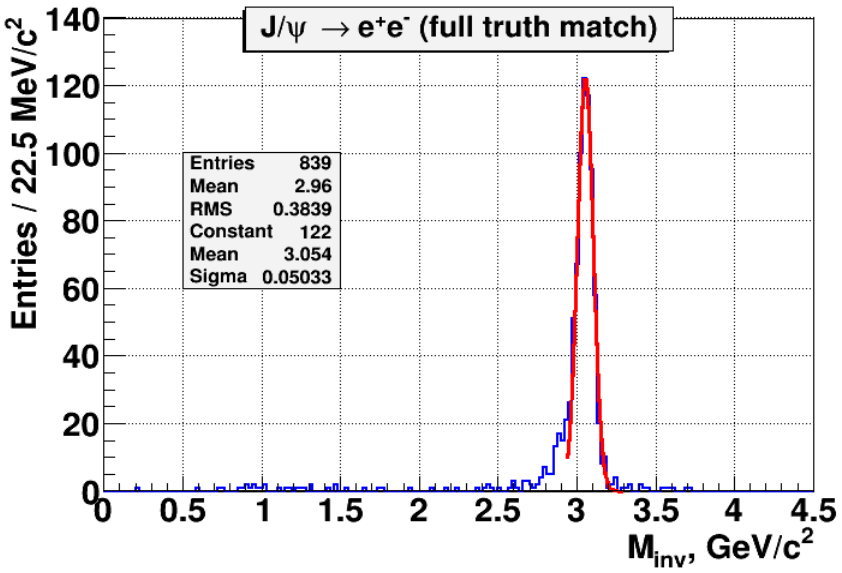


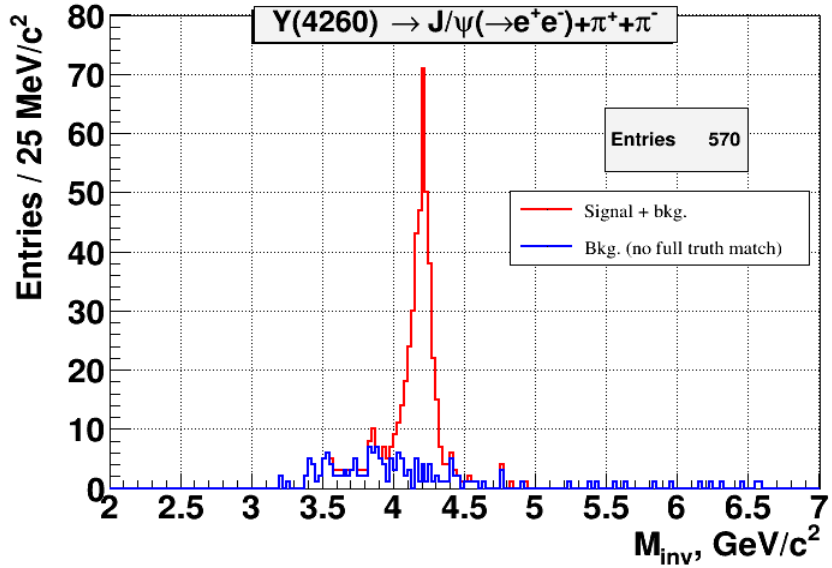


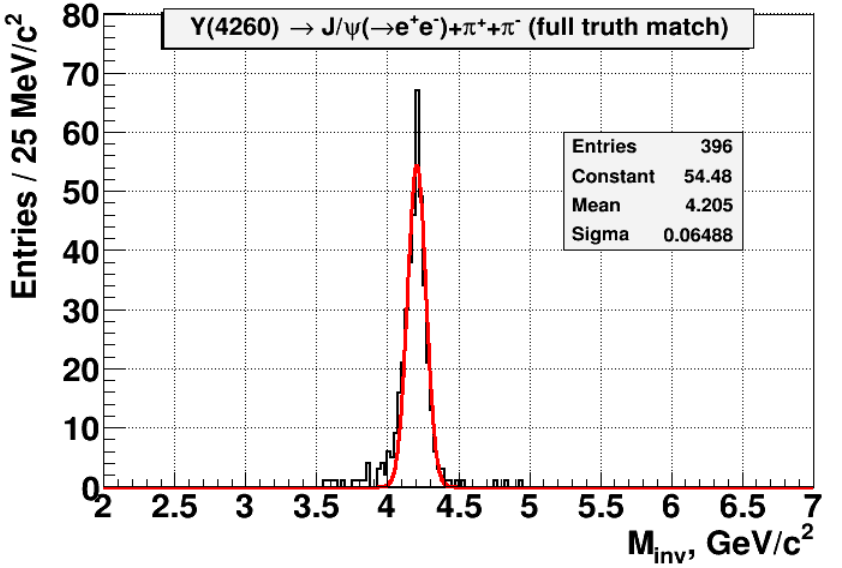
Y(4260) → J/ψ π+π- analysis

J/ψ → e+e-



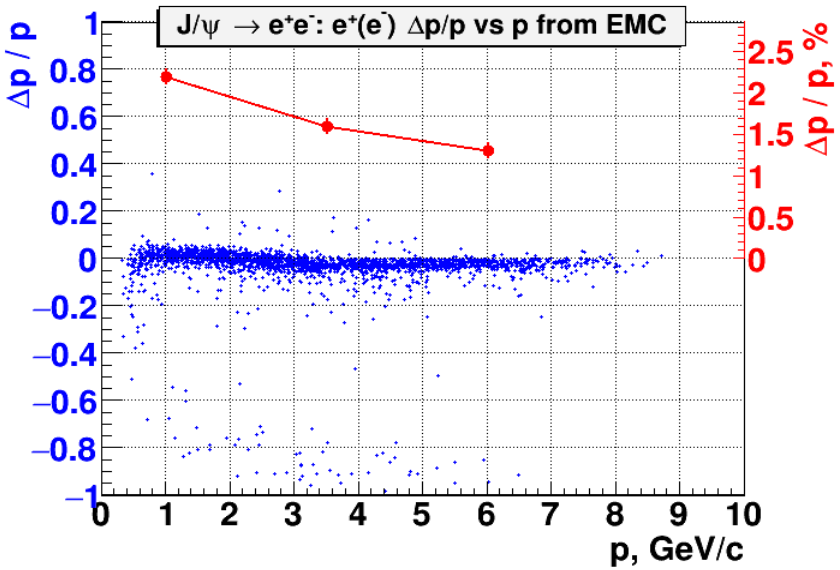


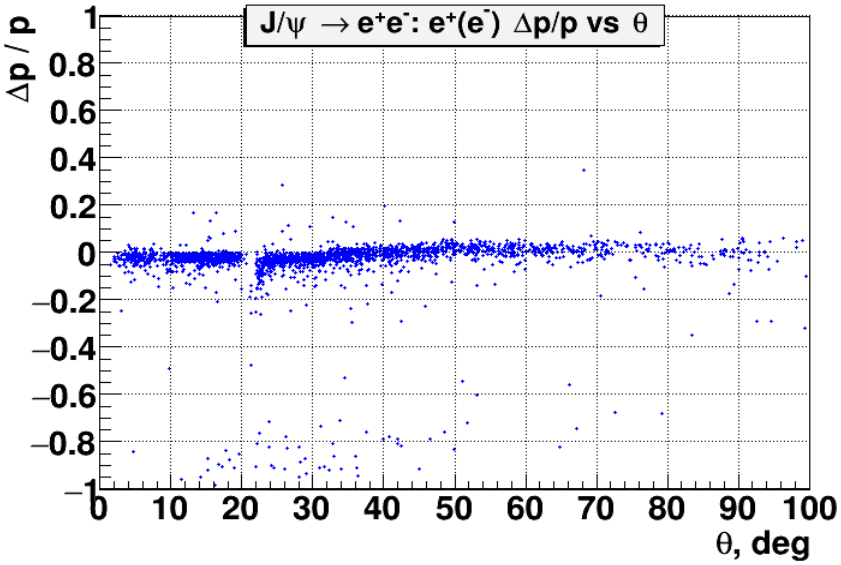




Y(4260) → J/ψ π+π- analysis

J/ψ → e+e-





$Y(4260) \to J/\psi\, \pi^0\pi^0$ analysis

ppbar $\to$ Y(4260) $\to$ J/ψ $\pi^0\pi^0$

X-section = 506 pb ($\to$ e+e-4γ 30 pb from PANDA Physics Book)

30k events EvtGen:
4 days for High-Luminosity mode ($2\cdot10^{32}$ $cm^{-2}s^{-1}$)
40 days for High-Resolution mode ($2\cdot10^{31}$ $cm^{-2}s^{-1}$)

J/ψ $\to$ μ+μ- (Muon ID ("MuonTight","PidAlgoMdtHardCuts"))
J/ψ $\to$ e+e- (Electron ID ("ElectronLoose","PidAlgoEmcBayes"))
J/ψ - vertex constrained fit (prob > 0.01)

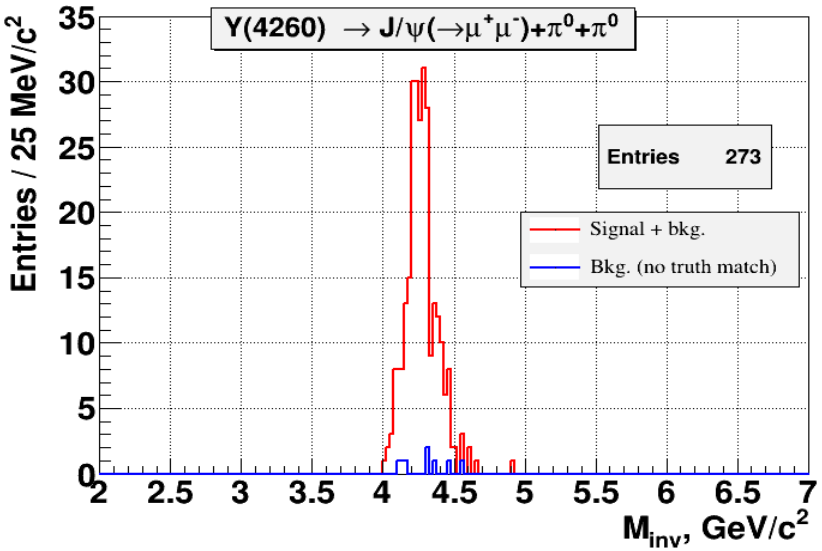
Photon ID (RhoGoodPhotonSelector – criterion "loose")

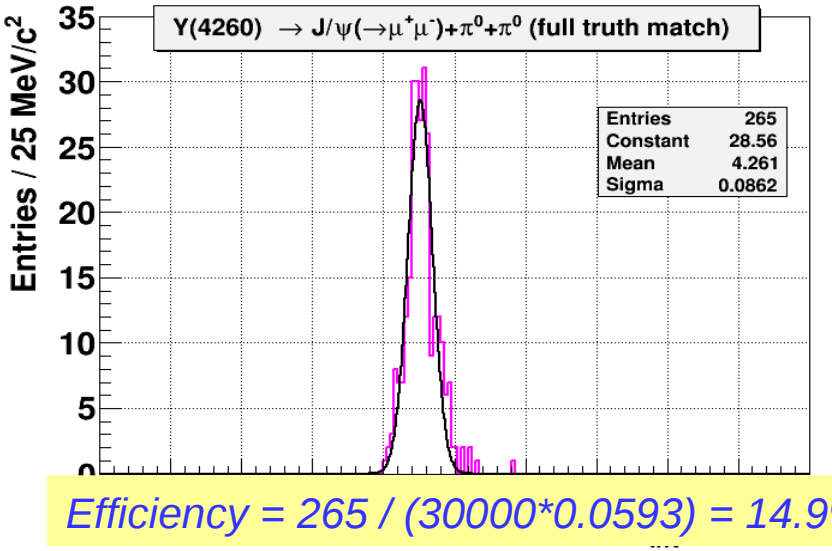
4C-fit of J/ψ $\pi^0\pi^0$ combination (prob > 0.001)
Mass constraint: m(J/ψ) = 3.06-3.14 GeV, m(π^0) = 0.12-0.15 GeV

$\Upsilon(4260) \to J/\psi\, \pi^0\pi^0$ analysis

$J/\psi \to \mu^+\mu^-$

1 year old





*Efficiency = 265 / (30000*0.0593) = 14.9%*

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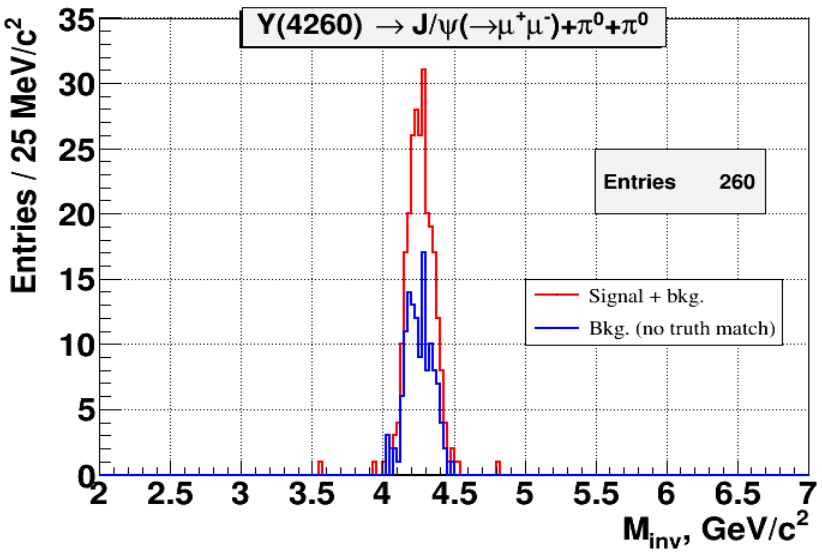
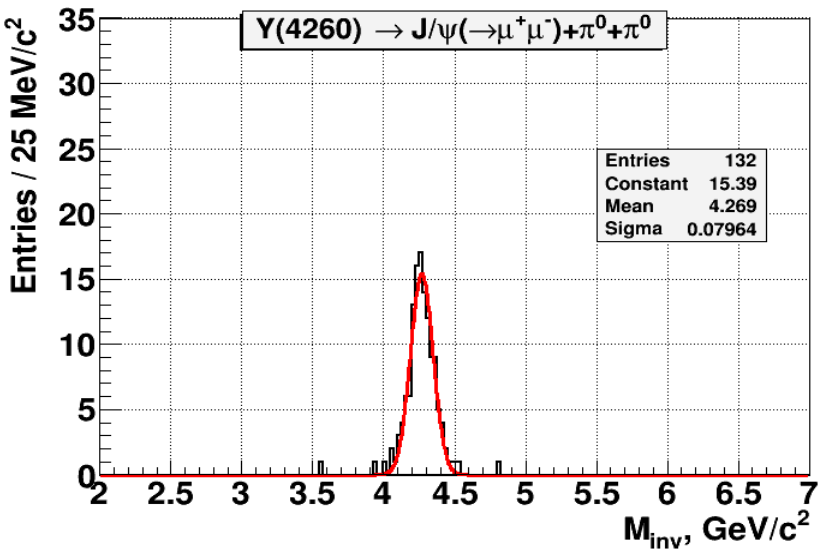
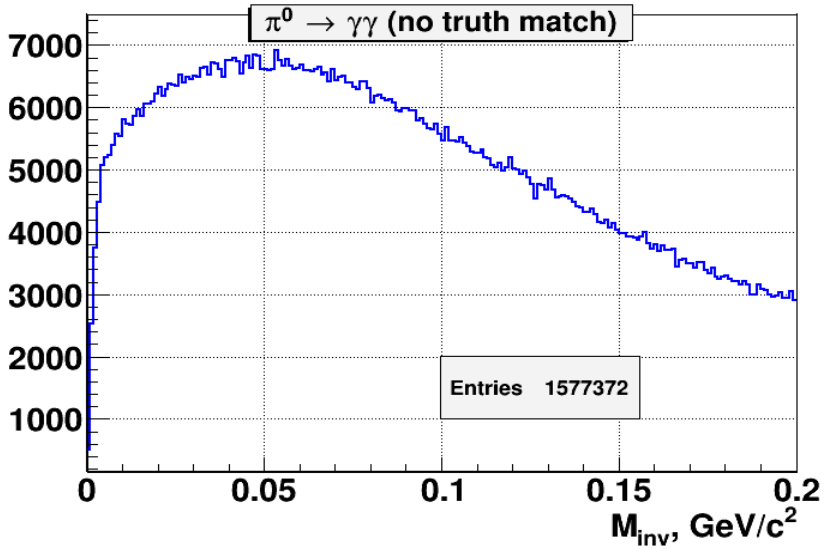




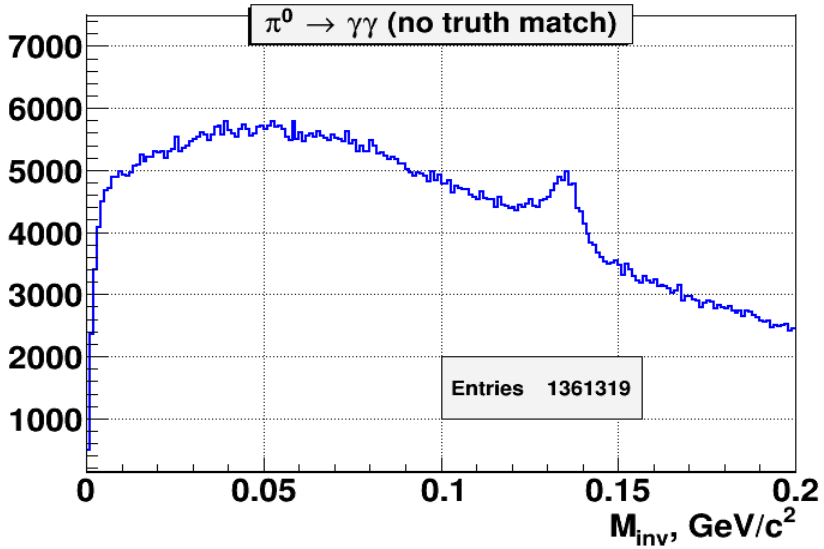
$Y(4260) \to J/\psi\, \pi^0\pi^0$ analysis

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

1 year old



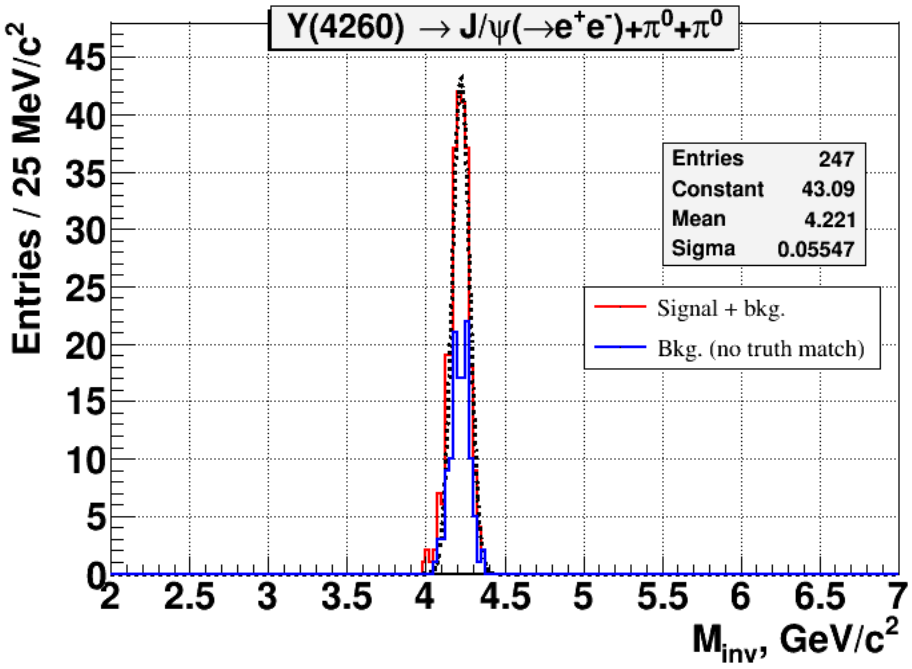
March 2015 Release



$\Upsilon(4260) \to J/\psi\,\pi^0\pi^0$ analysis

$J/\psi \to e^+e^-$

March 2015 Release



*Efficiency = 247 / (30000*0.0594) = 13.9%*

Y(4260) → J/ψ η analysis

ppbar → Y(4260) → J/ψ η
η → γγ

30k events EvtGen:

J/ψ → μ+μ-
J/ψ - vertex constrained fit (prob > 0.01)

Photon ID (RhoGoodPhotonSelector – criterion "loose")

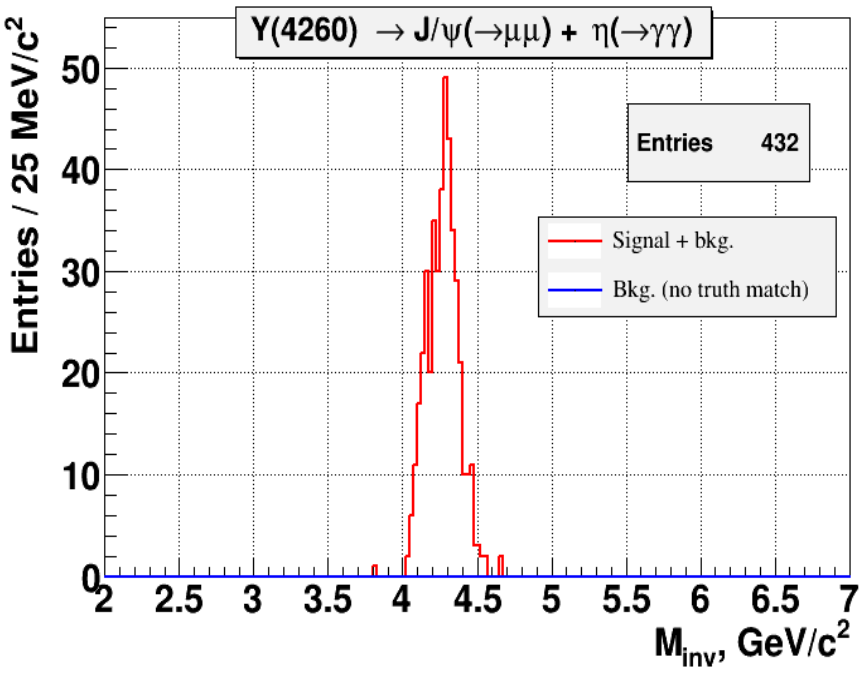
4C-fit of J/ψ η combination (prob > 0.001)
Mass constraint: m(J/ψ) = 3.05-3.15 GeV, m(η) = 0.52-0.57 GeV

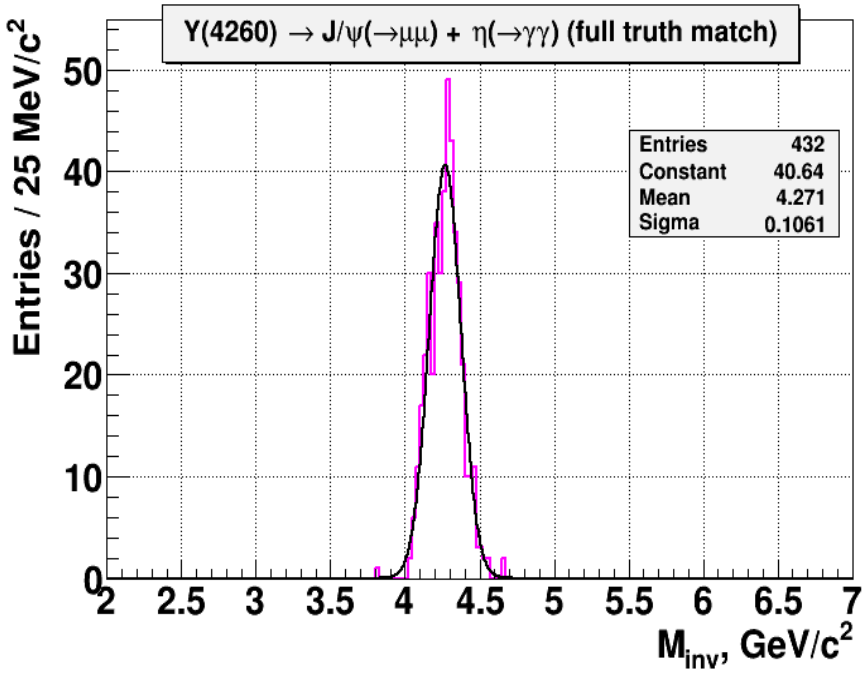
Y(4260) → J/ψ η analysis

J/ψ → μ+μ-, η → γγ

Muon ID
("MuonTight","PidAlgoMdtHardCuts")

*Efficiency = 432 / (30000*0.0593) = 24.3%*





$Y(4260) \to \chi_{c1}\gamma$ analysis

ppbar $\to$ Y(4260) $\to \chi_{c1}\gamma$
$\chi_{c1}\gamma \to J/\psi\,\gamma$

30k events EvtGen:

Photon ID (RhoGoodPhotonSelector – criterion "loose")

$J/\psi \to \mu^+\mu^-$
J/ψ - vertex constrained fit (prob > 0.01)

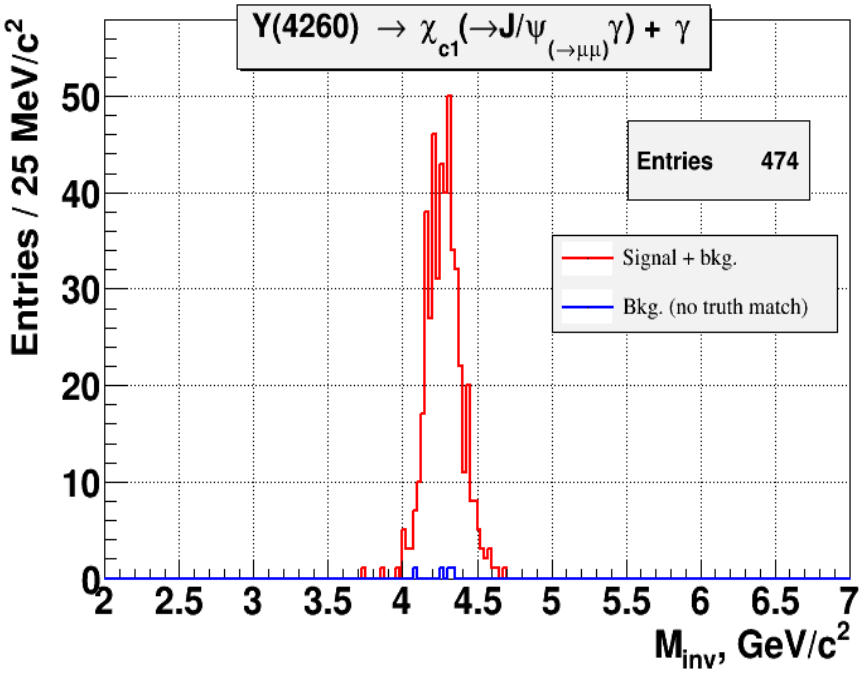
4C-fit of χ_{c1} γ combination (prob > 0.001)
Mass constraint: m(χ_{c1}) = 3.3-3.7 GeV

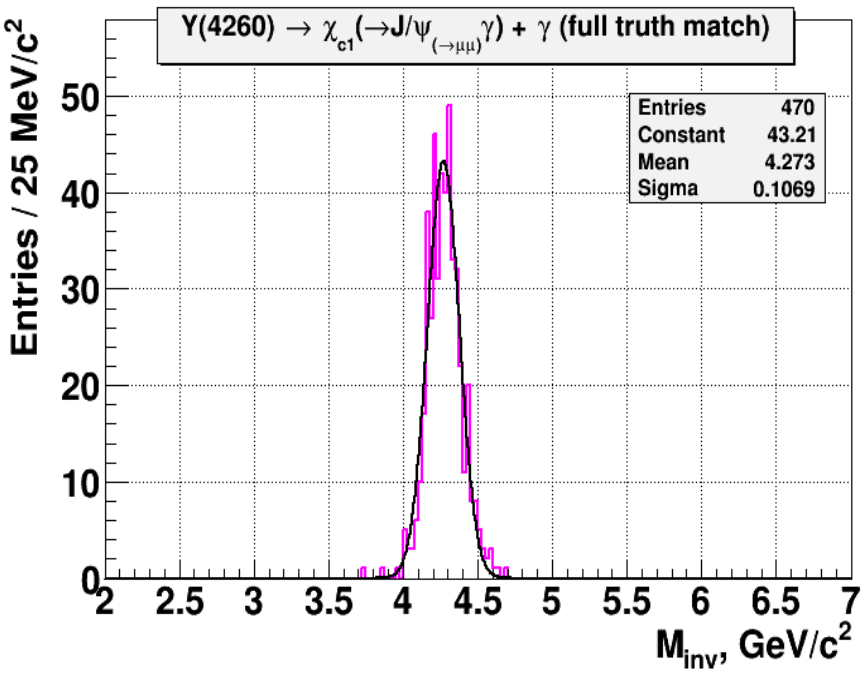
$\Upsilon(4260) \to \chi_{c1}\gamma$ analysis

$\chi_{c1} \to J/\psi\,\gamma,\ J/\psi \to \mu^+\mu^-$

Muon ID
("MuonTight","PidAlgoMdtHardCuts")

*Efficiency = 470 / (30000*0.0593) = 26.4%*





Y(4660) → J/ψ η analysis

ppbar → Y(4660) → J/ψ η
η → γγ

30k events EvtGen:

J/ψ → μ+μ-
J/ψ - vertex constrained fit (prob > 0.01)

Photon ID (RhoGoodPhotonSelector – criterion "loose")

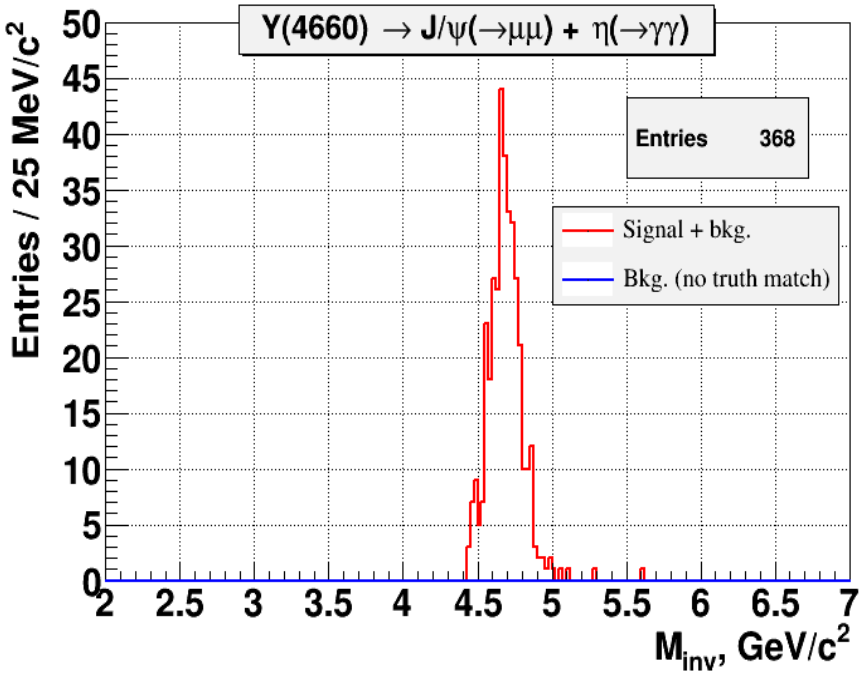
4C-fit of J/ψ η combination (prob > 0.001)
Mass constraint: m(J/ψ) = 3.05-3.15 GeV, m(η) = 0.52-0.57 GeV

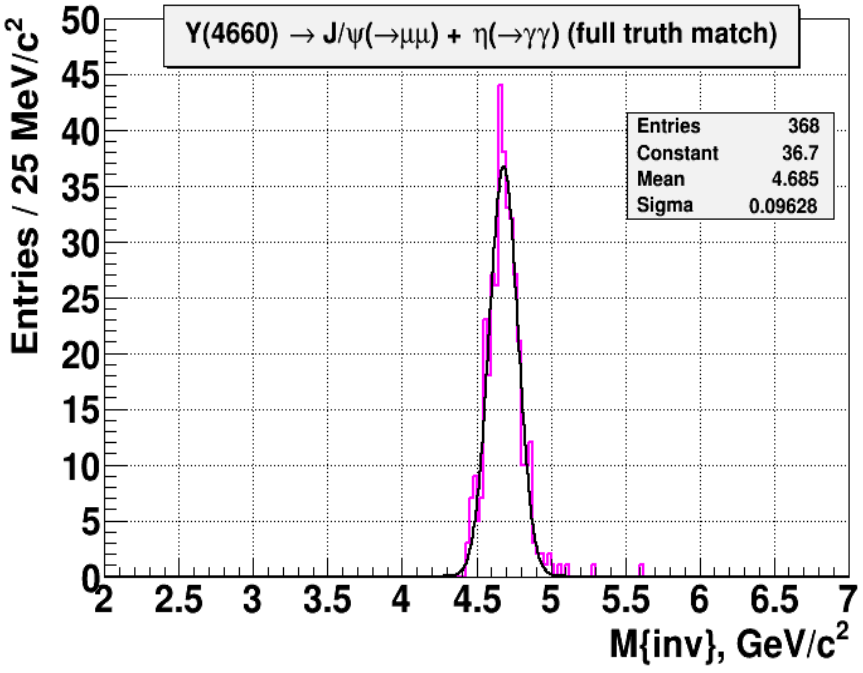
Y(4660) → J/ψ η analysis

J/ψ → μ+μ-, η → γγ

Muon ID
("MuonTight","PidAlgoMdtHardCuts")

*Efficiency = 368 / (30000*0.0593) = 20.7%*



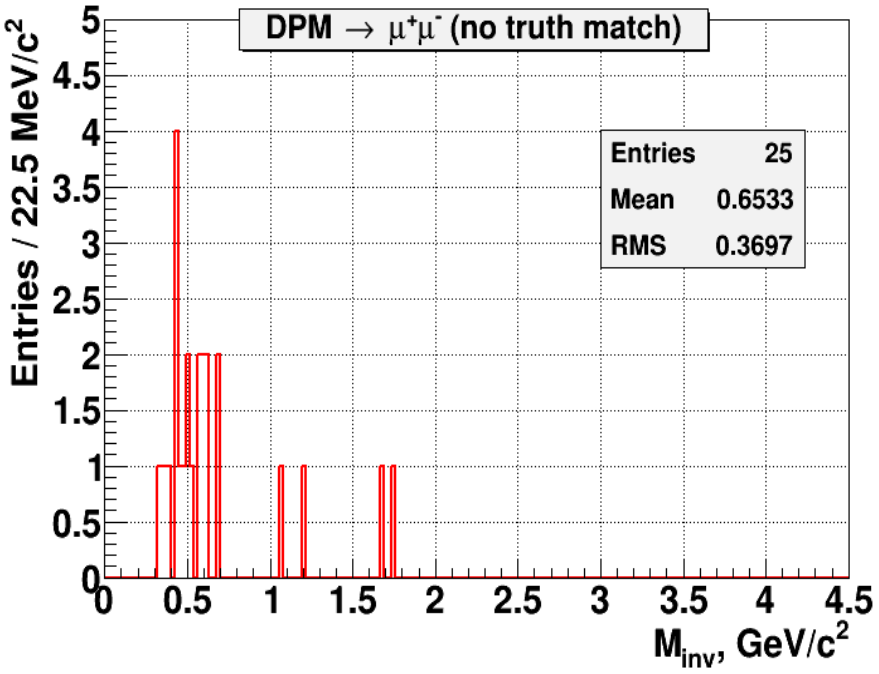


Υ(4660) → J/ψ η analysis

J/ψ → μ+μ-: DPM background

Muon ID
("MuonTight","PidAlgoMdtHardCuts")

30000 events



$Y(4260) \to D^+D^-$ analysis

$D^+ \to K^-\pi^+\pi^+$, $D^- \to K^+\pi^-\pi^-$

ppbar $\to$ Y(4260) $\to$ D+D-
D $\to K\pi\pi$
10k events EvtGen:

Pion ID ("PionAll"), kaon ID("KaonAll")

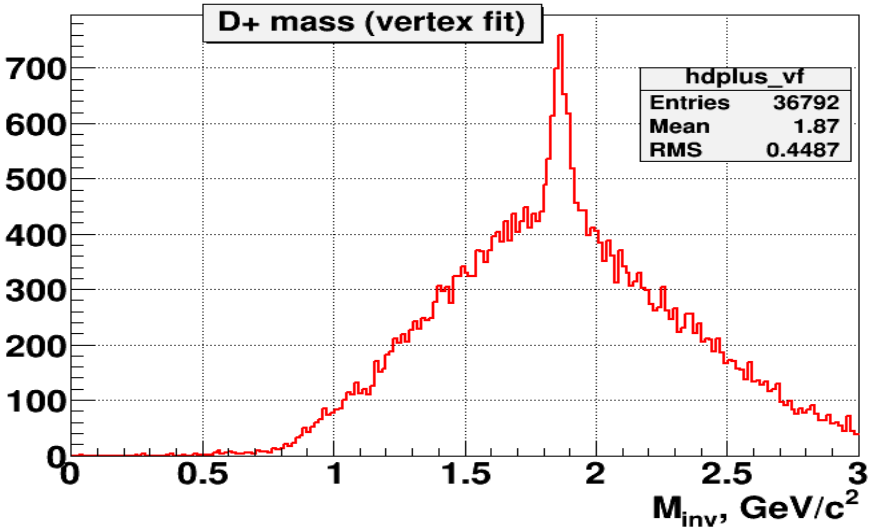
D $\to K\pi\pi$:
D - vertex constrained fit (prob > 0.000001)
mass D: ±0.2 GeV

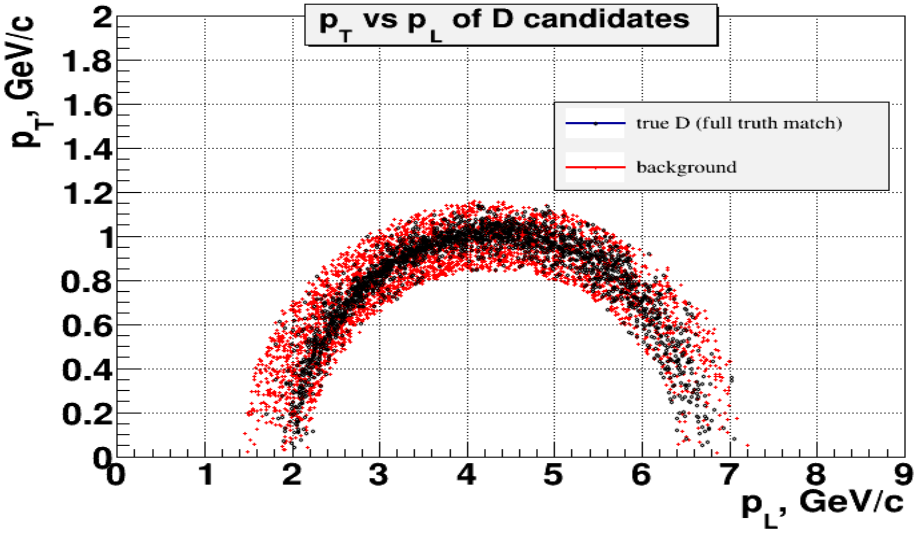
Topological cut: p_T vs p_L of D-candidates

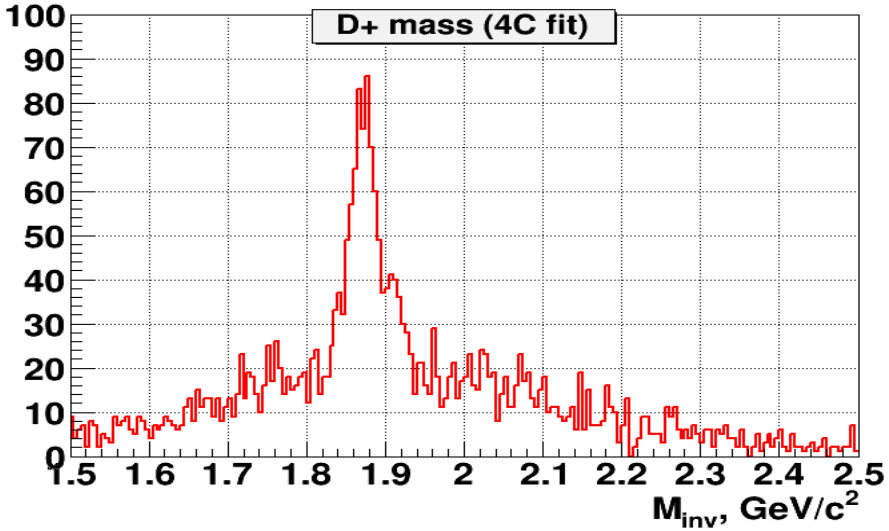
4C-fit of DD combination
Mass constraint: m(D) = 1.8-1.94 GeV

Y(4260) → D^+D^- analysis

$D^+ \to K^-\pi^+\pi^+$, $D^- \to K^+\pi^-\pi^-$



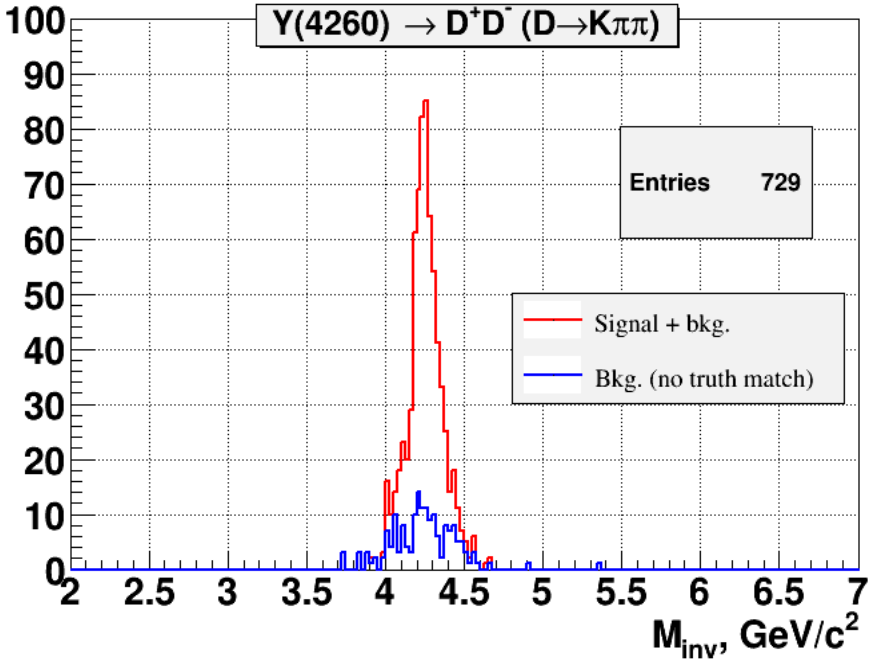


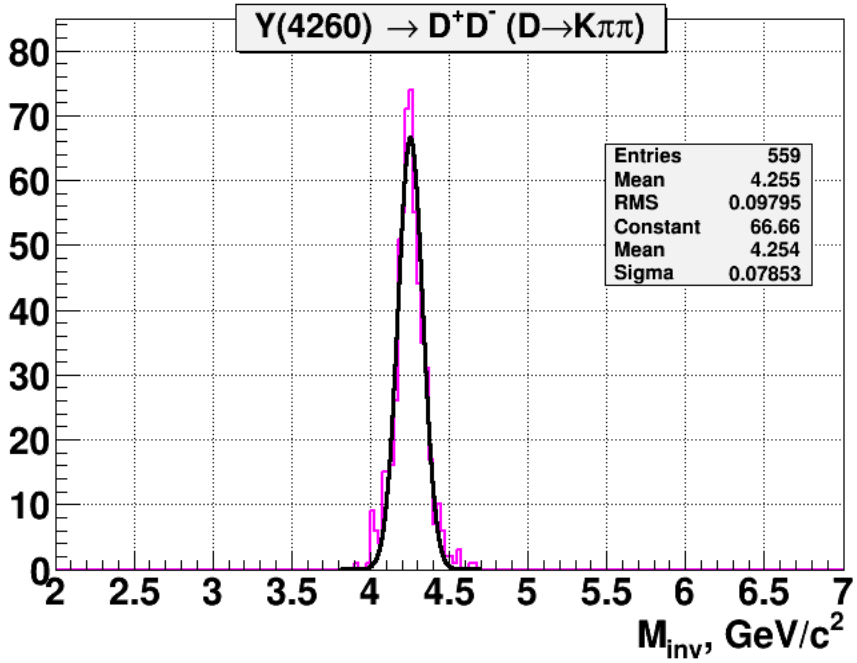


$\Upsilon(4260) \to D^+D^-$ analysis

$D^+ \to K^-\pi^+\pi^+$, $D^- \to K^+\pi^-\pi^-$

Efficiency: 559 / 10000 = 5.6%





Summary

1. In charmonia decays with J/ψ *ee*-mode seems to look better than $\mu\mu$ (better mass resolution – if electron energy is taken from EMC).

2. Decay modes with photons seem to look better than the ones with charged particles (better mass resolution) – photon MC truth association got screwed up.

3. Background contribution to modes with J/ψ (from DPM) should not be a big problem (large mass object).

4. Decays to open charm (*DD*) seem to be more challenging (and more "interesting") since they require very good particle identification and track and vertex reconstruction quality (and more sensitive to DPM contribution).

5. The results so far are not as good as in the Physics Book.

Outlook

1. More detailed analysis of D+D- channel, including background estimations (DPM generator).

2. Production reactions – event generator?