



Reconstruction of charmonia with PandaRoot

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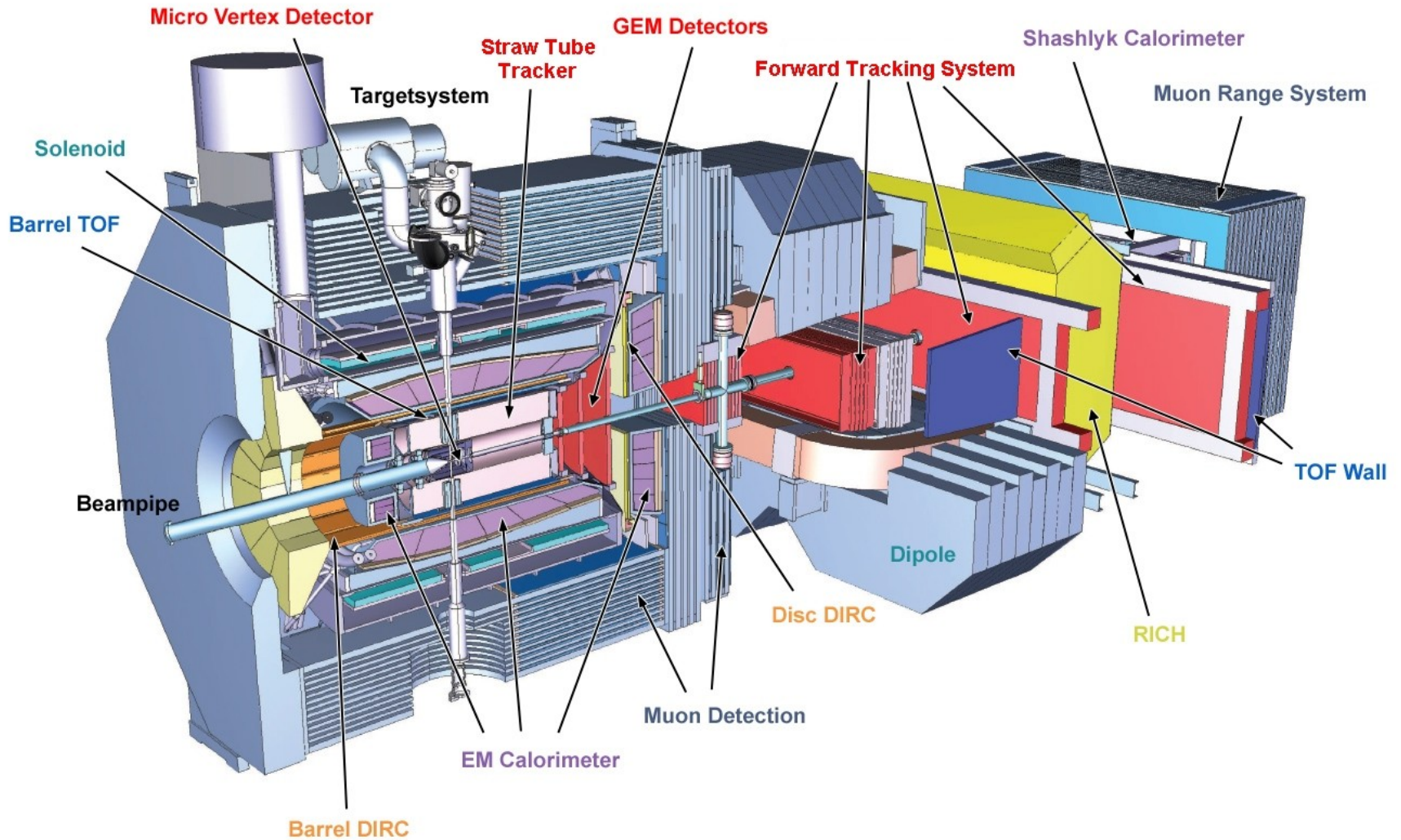
Outline

- 1. Motivation*
- 2. The PANDA detector*
- 3. Some benchmark channels.*
- 4. Summary and Outlook.*

Motivation

- 1. To get an experience with PandaRoot-based analysis by looking at some interesting physics (benchmark channels of charmonia decays)*
- 2. To get an impression on the PandaRoot current status on particle reconstruction and identification*
- 3. To re-evaluate Panda performance for charmonium states (as compared with Panda Physics Book)*

The PANDA detector – full view



Running modes

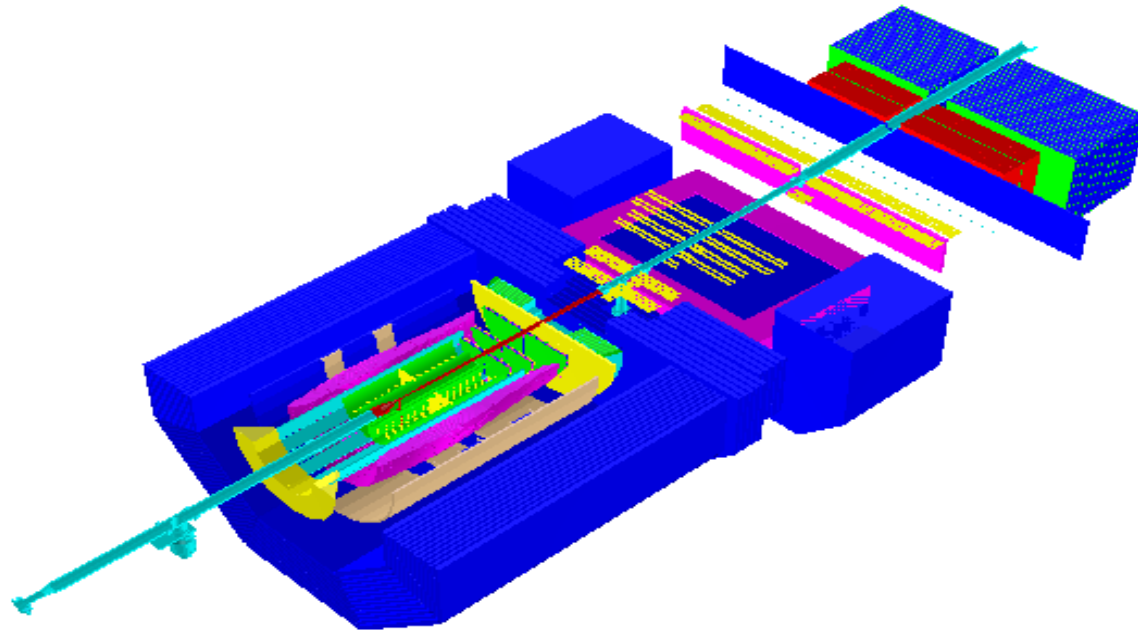
1. Formation reaction: $ppbar \rightarrow Y(4260) \rightarrow J/\psi \pi^+ \pi^-$

2. Production reaction: $ppbar \rightarrow \tilde{h}_{c0,1,2} \eta \rightarrow J/\psi \pi^0 \pi^0 \eta$

Software

1. *PandaRoot (not the latest Release mar15)*
2. *EvtGen generator*
3. *Rho analysis package*

The PANDA detector – MC view



$Y(4260) \rightarrow J/\psi \pi^+\pi^-$ analysis

$pp\bar{p} \rightarrow Y(4260) \rightarrow J/\psi \pi^+\pi^-$

Analysis is based on tutorials/rho macros

X-section = 1012 pb ($\rightarrow e^+e^-\pi^+\pi^-$ 60 pb from PANDA Physics Book)

30k events EvtGen:

2 days for High-Luminosity mode ($2 \cdot 10^{32} \text{ cm}^{-2}\text{s}^{-1}$)

20 days for High-Resolution mode ($2 \cdot 10^{31} \text{ cm}^{-2}\text{s}^{-1}$)

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

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

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

Mass constraint 1 GeV

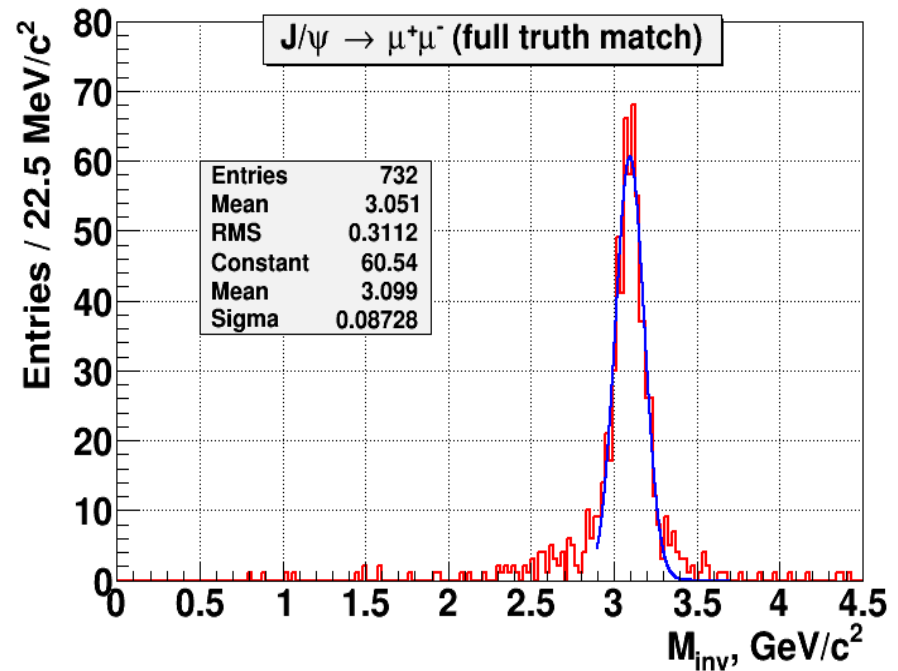
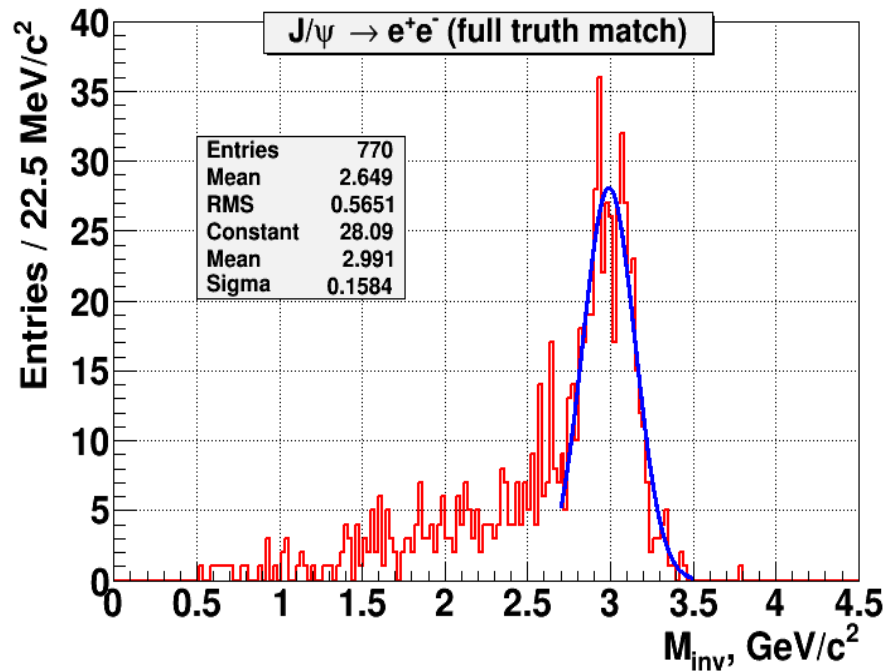
Pion ID ("PionAll")

$Y(4260) \rightarrow J/\psi \pi^+\pi^-$ analysis

$J/\psi \rightarrow e^+e^-$ and $J/\psi \rightarrow \mu^+\mu^-$

Physics Book:

$\sigma_{J/\psi \rightarrow ee} \sim 7 \text{ MeV}$

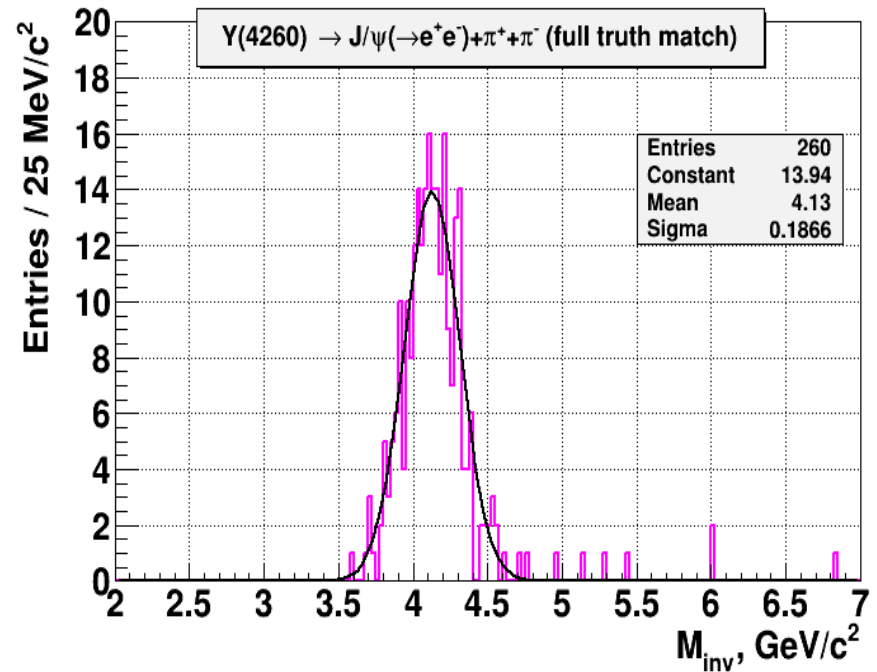
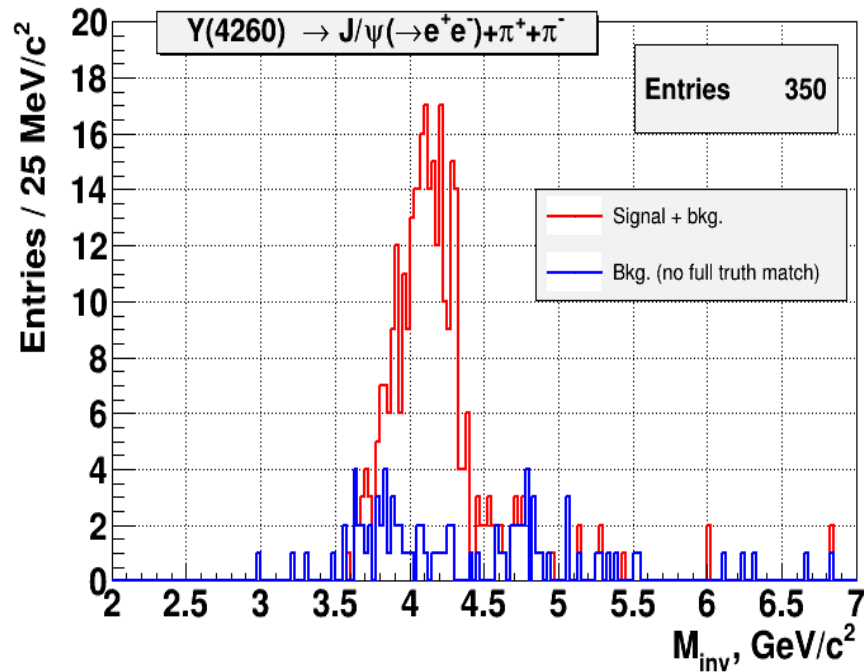


$Y(4260) \rightarrow J/\psi \pi^+\pi^-$ analysis

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

Electron ID
("ElectronLoose", "PidAlgoEmcBayes")

Efficiency = $260 / (30000 * 0.0594) = 14.6\%$

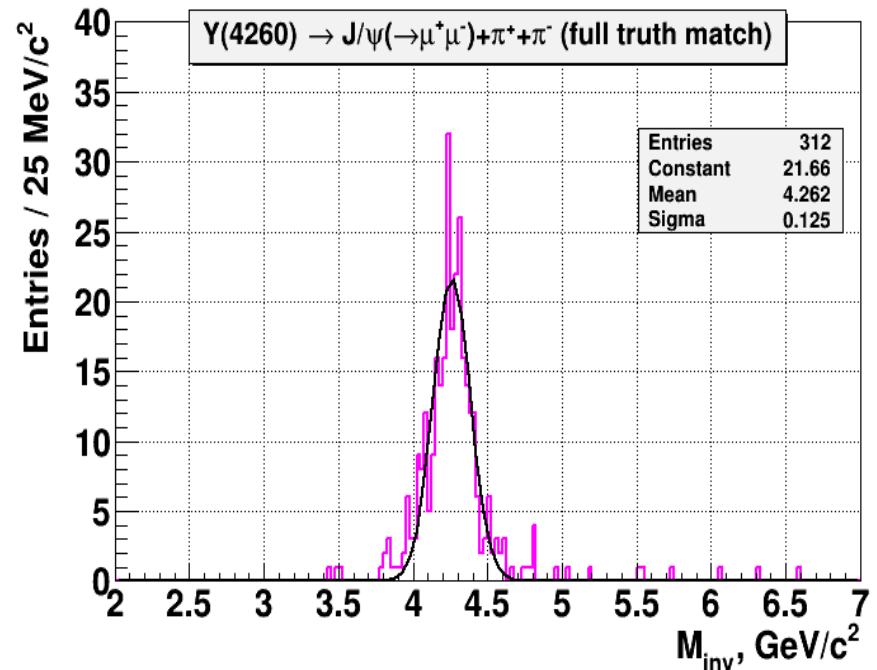
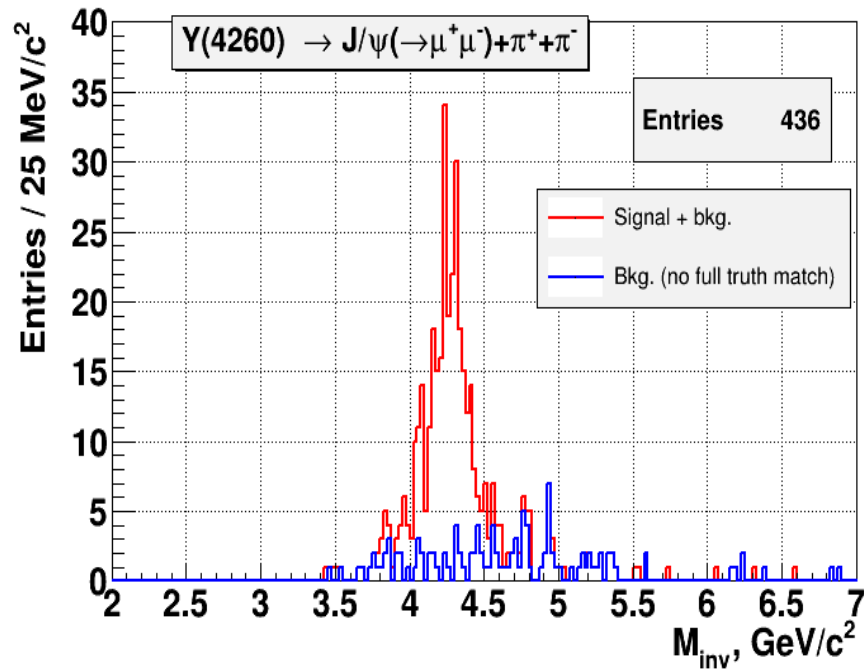


$Y(4260) \rightarrow J/\psi \pi^+\pi^-$ analysis

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

Muon ID
("MuonTight", "PidAlgoMdtHardCuts")

Efficiency = $312 / (30000 * 0.0593) = 17.5\%$



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

$ppbar \rightarrow Y(4260) \rightarrow J/\psi \pi^0 \pi^0$

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

30k events EvtGen:

4 days for High-Luminosity mode ($2 \cdot 10^{32} \text{ cm}^{-2}\text{s}^{-1}$)

40 days for High-Resolution mode ($2 \cdot 10^{31} \text{ cm}^{-2}\text{s}^{-1}$)

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

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

Photon ID (RhoGoodPhotonSelector – criterion “loose”)

4C-fit of $J/\psi \pi^0 \pi^0$ combination (prob > 0.001)

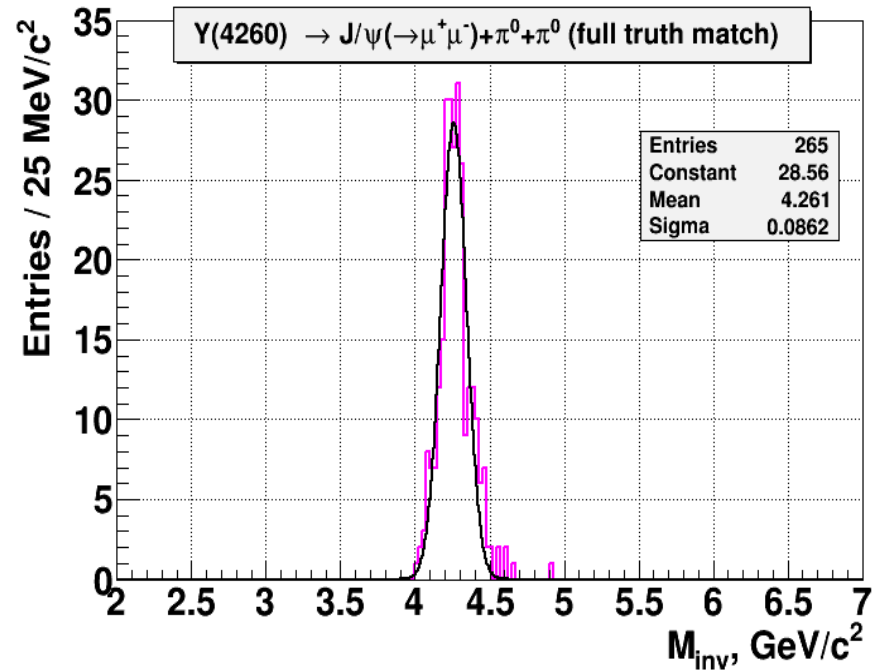
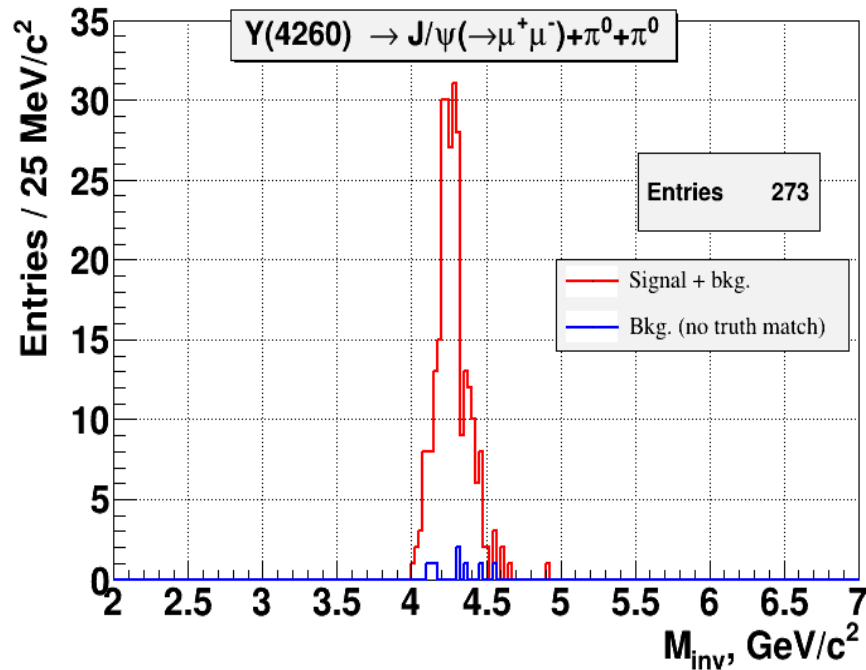
Mass constraint: $m(J/\psi) = 3.06\text{-}3.14 \text{ GeV}$, $m(\pi^0) = 0.12\text{-}0.15 \text{ GeV}$

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

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

Muon ID
("MuonTight", "PidAlgoMdtHardCuts")

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



$Y(4260) \rightarrow J/\psi \eta$ analysis

$ppbar \rightarrow Y(4260) \rightarrow J/\psi \eta$
 $\eta \rightarrow \gamma\gamma$

30k events *EvtGen*:

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

Photon ID (*RhoGoodPhotonSelector* – criterion “loose”)

4C-fit of $J/\psi \eta$ combination (prob > 0.001)
Mass constraint: $m(J/\psi) = 3.05\text{-}3.15$ GeV, $m(\eta) = 0.52\text{-}0.57$ GeV

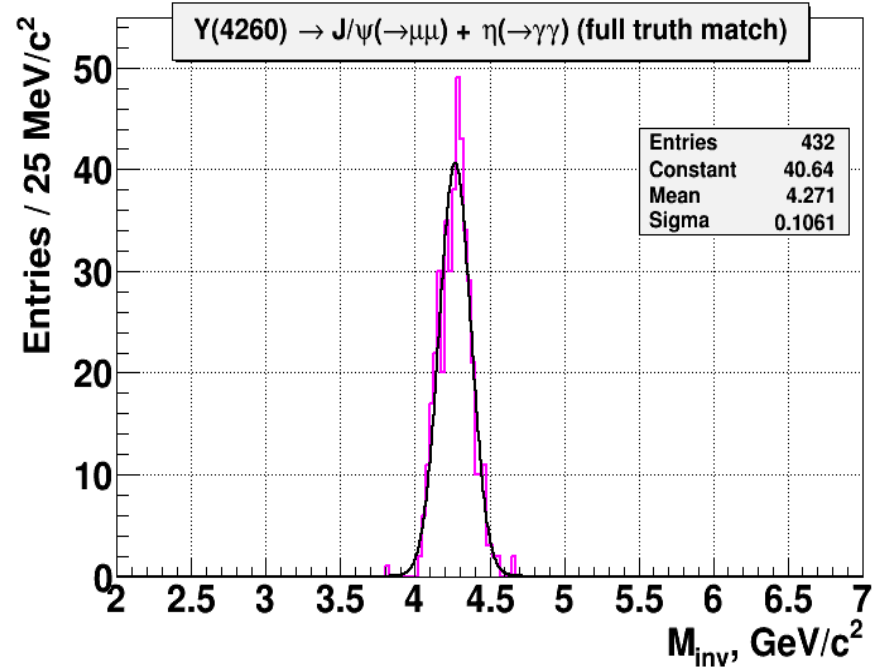
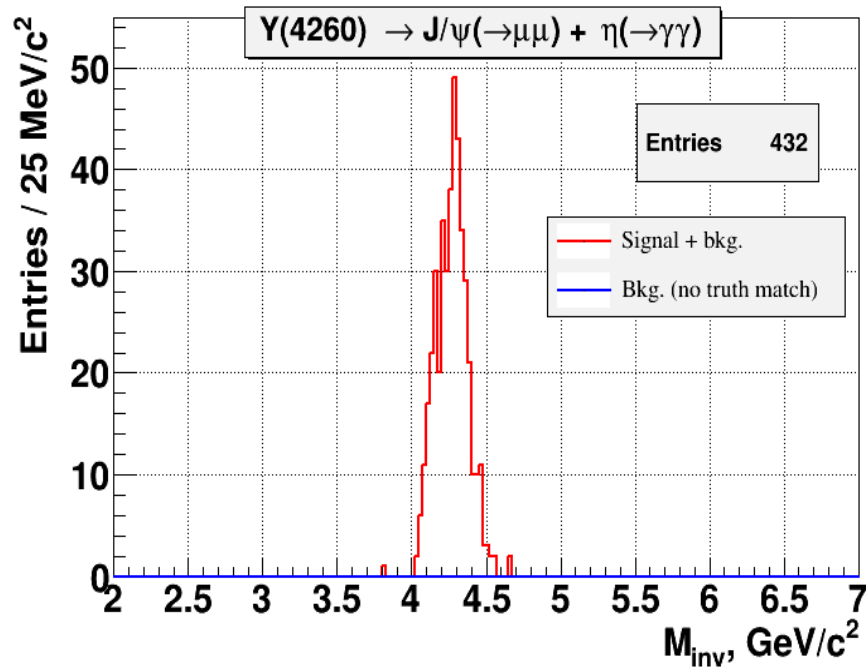
Y(4260) \rightarrow J/ ψ η analysis

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

Muon ID

("MuonTight", "PidAlgoMdtHardCuts")

Efficiency = $432 / (30000 \cdot 0.0593) = 24.3\%$



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

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

30k events EvtGen:

Photon ID (RhoGoodPhotonSelector – criterion “loose”)

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

4C-fit of $\chi_{c1} \gamma$ combination (prob > 0.001)
Mass constraint: $m(\chi_{c1}) = 3.3-3.7 \text{ GeV}$

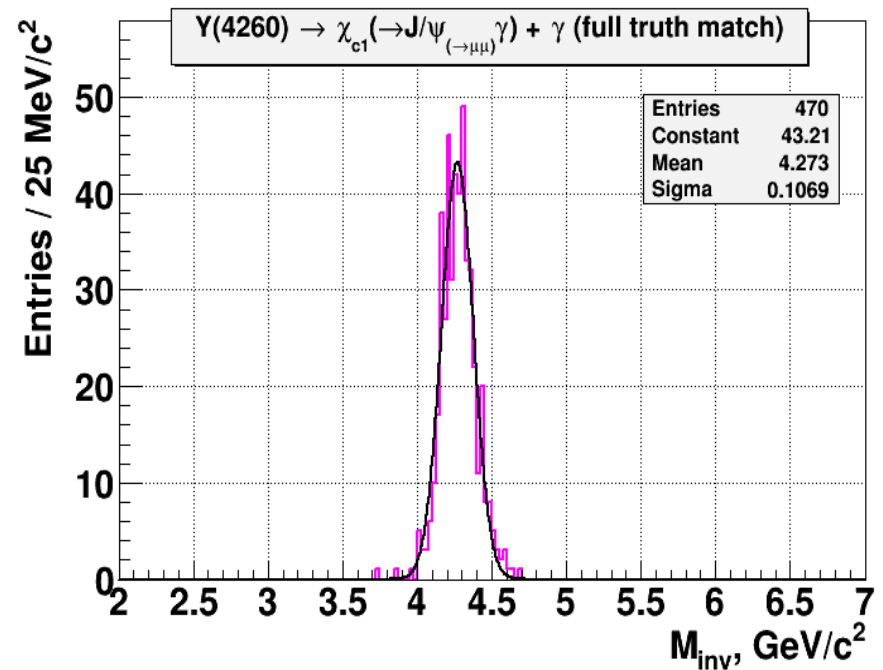
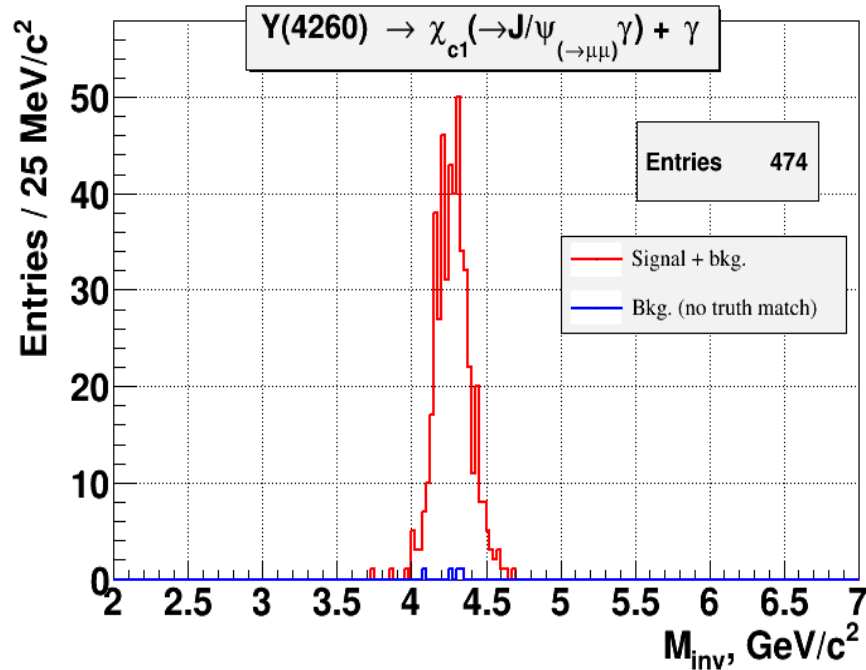
$Y(4260) \rightarrow \chi_{c1} \gamma$ analysis

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

Muon ID

("MuonTight", "PidAlgoMdtHardCuts")

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



$Y(4660) \rightarrow J/\psi \eta$ analysis

$pp\bar{p} \rightarrow Y(4660) \rightarrow J/\psi \eta$
 $\eta \rightarrow \gamma\gamma$

30k events *EvtGen*:

$J/\psi \rightarrow \mu^+\mu^-$
 J/ψ - vertex constrained fit ($\text{prob} > 0.01$)

Photon ID (*RhoGoodPhotonSelector* – criterion “loose”)

4C-fit of $J/\psi \eta$ combination ($\text{prob} > 0.001$)
Mass constraint: $m(J/\psi) = 3.05\text{-}3.15$ GeV, $m(\eta) = 0.52\text{-}0.57$ GeV

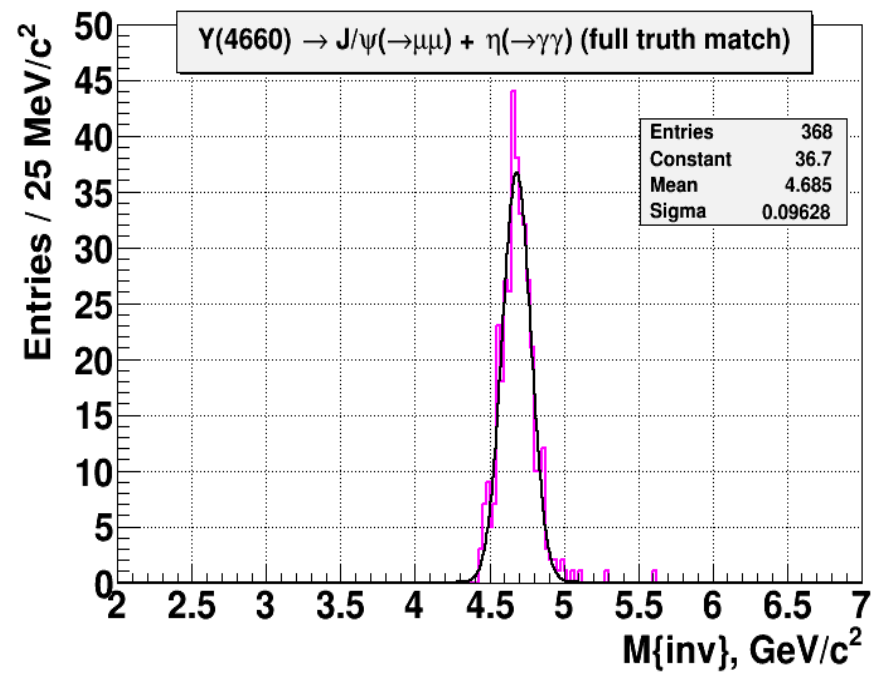
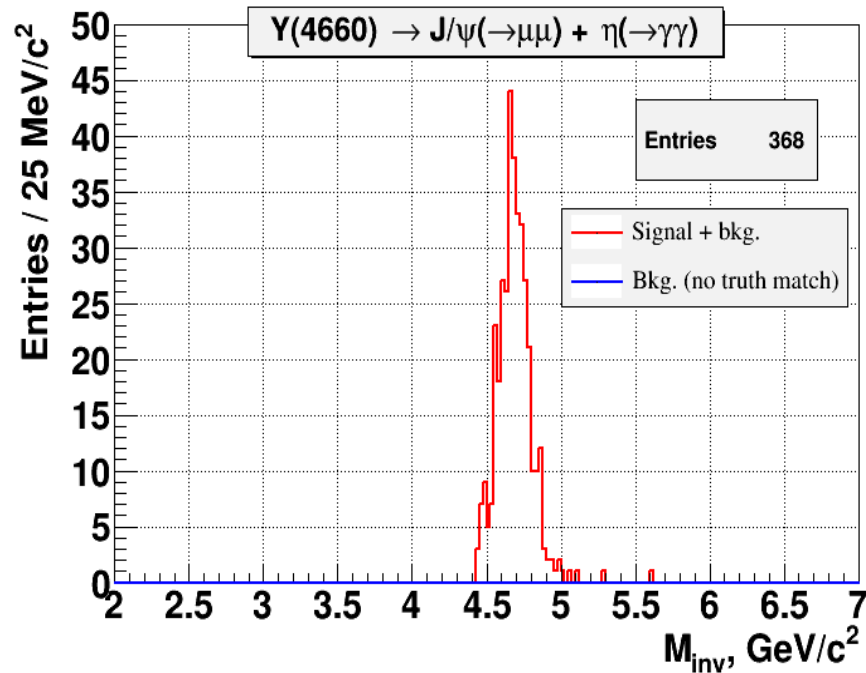
$Y(4660) \rightarrow J/\psi \eta$ analysis

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

Muon ID

("MuonTight", "PidAlgoMdtHardCuts")

Efficiency = $368 / (30000 \cdot 0.0593) = 20.7\%$

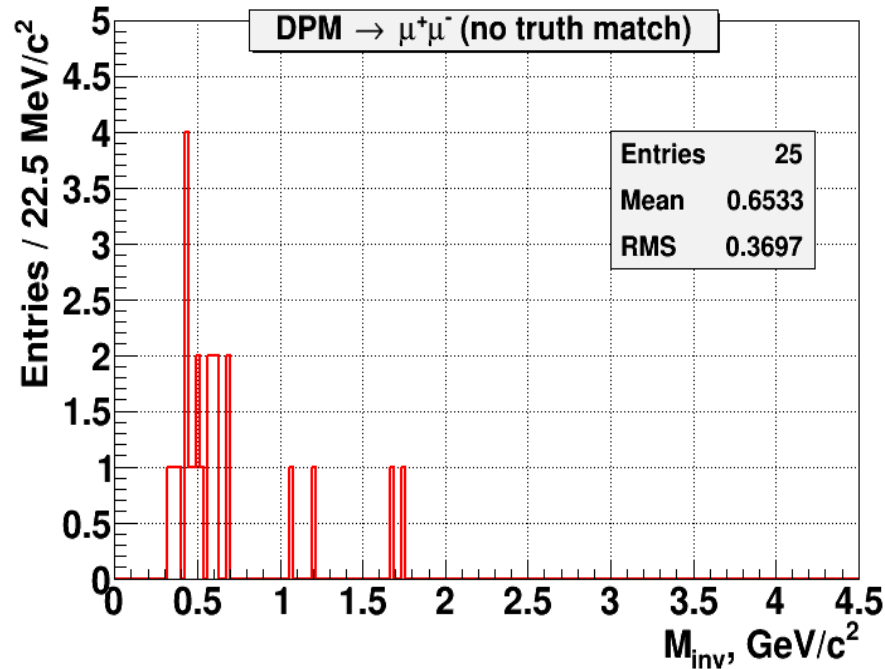


$Y(4660) \rightarrow J/\psi \eta$ analysis

$J/\psi \rightarrow \mu^+\mu^-$: DPM background

Muon ID
("MuonTight", "PidAlgoMdtHardCuts")

30000 events



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

$$D^+ \rightarrow K^- \pi^+ \pi^+, \quad D^- \rightarrow K^+ \pi^- \pi^-$$

$pp\bar{b} \rightarrow Y(4260) \rightarrow D^+D^-$

$D \rightarrow K\pi\pi$

10k events EvtGen:

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

$D \rightarrow K\pi\pi$:

D - vertex constrained fit (prob > 0.000001)

mass D : ± 0.2 GeV

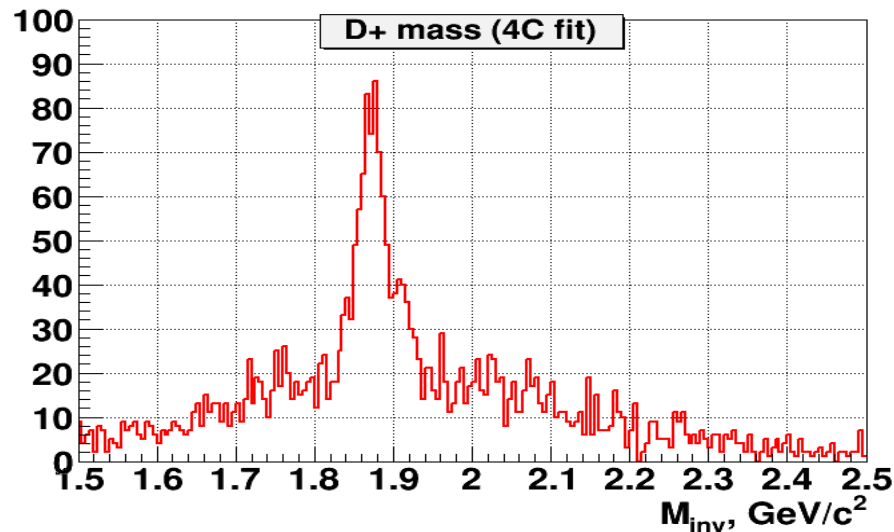
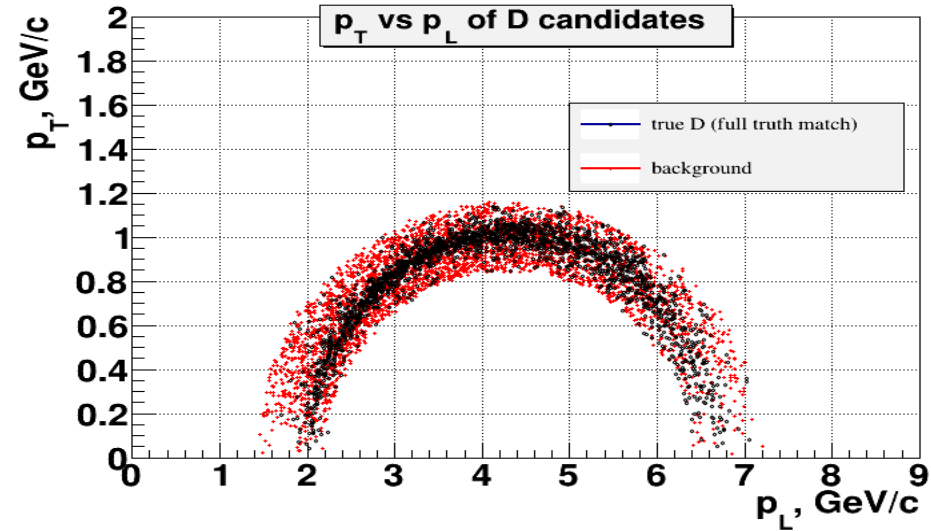
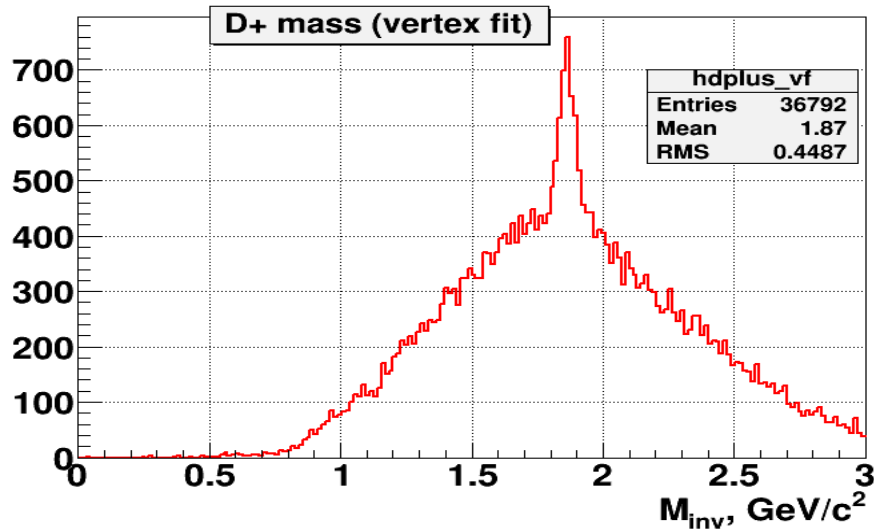
Topological cut: p_T vs p_L of D -candidates

4C-fit of DD combination

Mass constraint: $m(D) = 1.8-1.94$ GeV

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

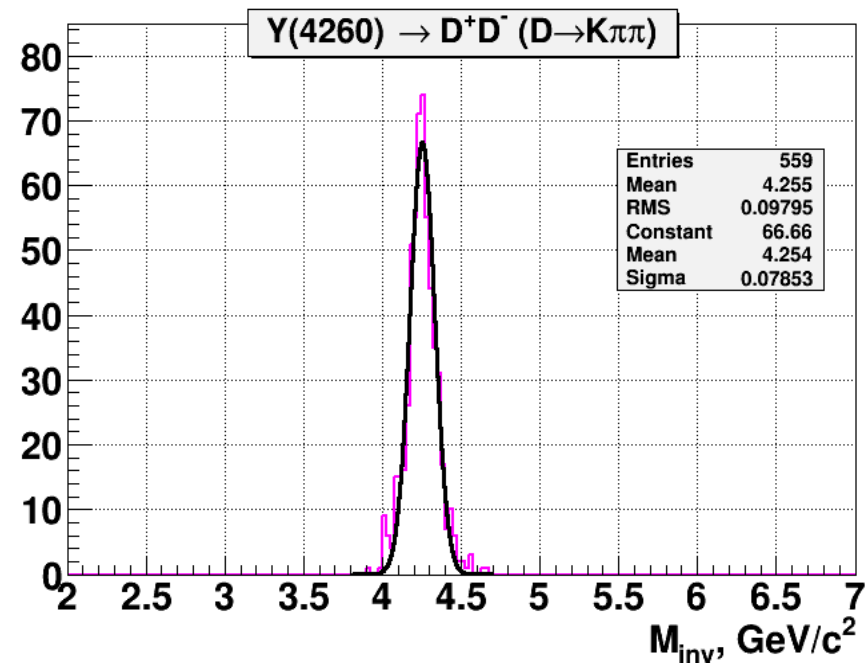
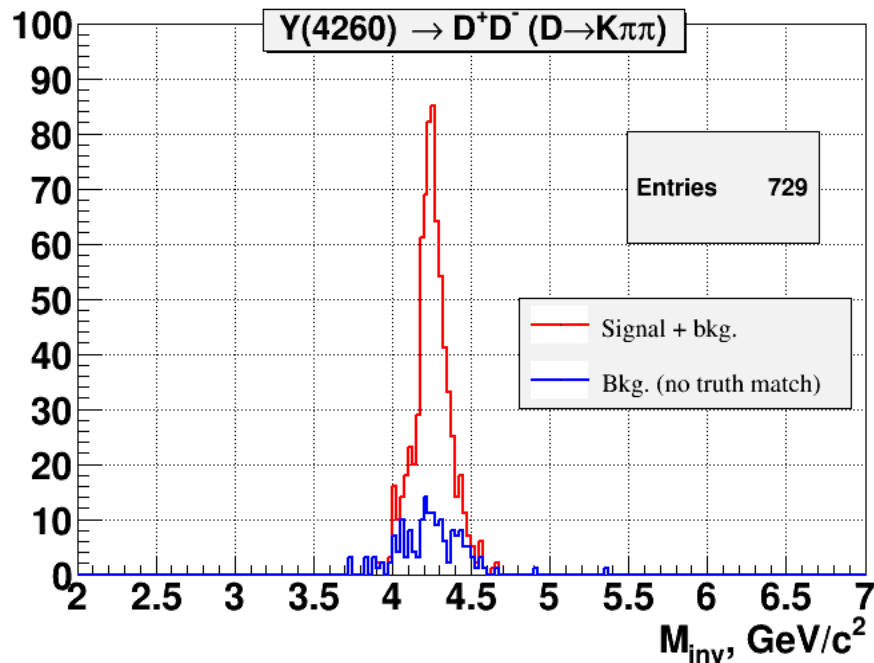
$D^+ \rightarrow K^- \pi^+ \pi^+$, $D^- \rightarrow K^+ \pi^- \pi^-$



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

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

Efficiency: $559 / 10000 = 5.6\%$



Summary

1. In charmonia decays with $J/\psi \mu\mu$ -mode seems to look better than ee (better mass resolution and lower background).
2. Decay modes with photons seem to look better than the ones with charged particles (better mass resolution and lower background).
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 some channels (to be selected), including background estimations (DPM generator) with the latest software release.*
- 2. Any suggestions how (where) to proceed?*