Online Software Trigger @ PANDA

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- Update of software trigger scheme
- Full chain MC simulation
- Outlook

Online trigger study

investigate the scheme of online trigger by studying benchmark channels

- a standalone program (generator level) has been used to estimate event rate for signal and reduction rate for background with input parameters :

  tracking efficiency, momentum resolution, mass interval, PID information

- physics benchmark channels

  134 data sets with both signal & background from the PANDA physics book

  EvtGen generator are used to test the signal efficiency :

  observed enough selection power for signal event

  background study using DPM generator :

  toal 22 sets with beam momentum p_{min} = 1.431 GeV/c and p_{max} = 15.0 GeV/c

- require background reduction rate 1/1000 with software trigger in total

Determination of events rate

Parameters I

- apply online tracking resolution by Yutie's study, which is a level of 3 - 5%
- 12 selection algorithms scan events contain signal in parallel
- Mass filtering by 2σ mass window for each algorithm/resonance
- application of p_T cut on D meson ($p_T < 300 \mathrm{MeV/c}$)

MC data

Production	
$\bar{p}p \to J/\psi\pi^+\pi^- \to e^+e^-(\mu^+\mu^-)\pi^+\pi^-$	h_c,$\psi(2S)$,X,Y
$\bar{p}p \to J/\psi\pi^0\pi^0 \to e^+e^-(\mu^+\mu^-)4\gamma$	Y
$\bar{p}p \to \chi_{c1}\gamma \to J/\psi\gamma\gamma \to e^+e^-(\mu^+\mu^-)\gamma\gamma$	$\psi(2S)$,X,Y
$\bar{p}p \to \chi_{c2}\gamma \to J/\psi\gamma\gamma \to e^+e^-(\mu^+\mu^-)\gamma\gamma$	$\psi(2S)$,X,Y
$\bar{p}p \to J/\psi\gamma \to e^+e^-(\mu^+\mu^-)\gamma$	χ_{c1},χ_{c2},X
$\bar{p}p \to J/\psi\eta \to e^+e^-(\mu^+\mu^-)\gamma\gamma$	$\eta_c(2S)$,$\psi(2S)$,X,Y
$\bar{p}p \to \pi^+\pi^-\pi^+\pi^-$	
$\bar{p}p \to \pi^+\pi^-\pi^0\pi^0 \to \pi^+\pi^-\gamma\gamma\gamma\gamma$	
$\bar{p}p \to J/\psi\eta\pi^0 \to e^+e^-\gamma\gamma\gamma\gamma$	
$\bar{p}p \to J/\psi\omega\pi^0 \to e^+e^-\pi^0\gamma\gamma\gamma$	
$\bar{p}p \to \pi^+\pi^-\pi^0 \to \pi^+\pi^-\gamma\gamma$	
$\bar{p}p \to \pi^+\pi^-\eta \to \pi^+\pi^-\gamma\gamma$	
$\bar{p}p \to J/\psi\pi^0\gamma \to e^+e^-\gamma\gamma\gamma$	
$\bar{p}p \to J/\psi\eta\gamma \to e^+e^-\gamma\gamma\gamma$	
$\bar{p}p \to J/\psi\eta\eta \to e^+e^-\gamma\gamma\gamma\gamma$	
$\bar{p}p \to \eta_c(2S)\gamma \to \gamma\gamma\gamma$	h_c
$\bar{p}p \to \pi^0\pi^0 \to \gamma\gamma\gamma\gamma$	
$\bar{p}p \to \pi^0\gamma \to \gamma\gamma\gamma$	
$\bar{p}p \to \pi^0\eta \to \gamma\gamma\gamma\gamma$	
$\bar{p}p \to \eta\eta \to \gamma\gamma\gamma\gamma$	
$\bar{p}p \to \pi^0\eta^{(\prime)} \to \gamma\gamma\gamma\gamma$	
$\bar{p}p \to \eta_c\gamma \to \phi\phi\gamma \to K^+K^-K^+K^-\gamma$	h_c
$\bar{p}p \to K^+K^-K^+K^-\pi^0 \to K^+K^-K^+K^-\gamma\gamma$	
$\bar{p}p \to \phi K^+K^-\pi^0 \to K^+K^-K^+K^-\gamma\gamma$	
$\bar{p}p \to \phi\phi\pi^0 \to K^+K^-K^+K^-\gamma\gamma$	
$\bar{p}p \to K^+K^-\pi^+\pi^-\pi^0 \to K^+K^-K^+K^-\gamma\gamma$	
$\bar{p}p \to D^+D^- \to K^-\pi^+\pi^+K^+\pi^-\pi^-$	$\psi(3770)$
$\bar{p}p \to D^{*+}D^{*-} \to D^0\pi^+\overline{D^0}\pi^- \to K^-\pi^+\pi^+K^+\pi^-\pi^-$	$\psi(4040)$
$\bar{p}p \to$ generic DPM	
$\bar{p}p \to 3\pi^+3\pi^-\pi^0$	
$\bar{p}p \to 3\pi^+3\pi^-$	
$\bar{p}p \to K^+K^-2\pi^+2\pi^-$	
$\bar{p}p \to \tilde{\eta}_{c1}\eta \to \chi_{c1}\pi^0\pi^0\eta \to J/\psi\gamma\pi^0\pi^0\eta$	$\tilde{\eta}_{c1}(4286)$
$\bar{p}p \to \chi_{c0}\pi^0\pi^0\eta \to J/\psi\gamma\pi^0\pi^0\eta$	
$\bar{p}p \to \chi_{c1}\pi^0\eta\eta \to J/\psi\gamma\pi^0\eta\eta$	
$\bar{p}p \to \chi_{c1}\pi^0\pi^0\pi^0\eta \to J/\psi\gamma\pi^0\pi^0\pi^0\eta$	
$\bar{p}p \to J/\psi\pi^0\pi^0\pi^0\eta$	
$\bar{p}p \to \tilde{\eta}_{c1}\eta \to D^0\overline{D}^{*0}\eta \to K^-\pi^+\pi^0K^+\pi^-\pi^0\pi^0\eta$	$\tilde{\eta}_{c1}(4286)$
$\bar{p}p \to D^0\overline{D}^{*0}\pi^0 \to K^-\pi^+\pi^0K^+\pi^-\pi^0\pi^0\pi^0$	
$\bar{p}p \to D^0\overline{D}^{*0}\eta \to K^-\pi^+\pi^0\pi^0K^+\pi^-\pi^0\pi^0\eta$	
$\bar{p}p \to D^0\overline{D}^{*0}\eta \to K^-\pi^+\pi^0\pi^0K^+\pi^-\pi^0\pi^0\pi^0\eta$	

→

12 algorithms

$D^0(K\pi)$
$D^0(K\pi\pi^0)$
$D^\pm(K\pi\pi)$
$J/\psi(e^+e^-)$
$J/\psi(\pi^+\pi^-\pi^0)$
$h_c(\eta_c\gamma \to \gamma\gamma\gamma)$
$D^0(\mu^\pm e^\mp)$
$D^\pm(\pi^\pm e^\mp \mu^\pm)$
$D^0(\mu^+\mu^-)$
e^+e^-
$\phi(K^+K^-)$
$D_s(\phi\pi)$

→

decision

select event if one of 12 algo. is fulfilled

reject event if none of 12 algo. are satisfied

selection can be added with various algo. $\Lambda(p\pi), \Lambda_c^+(pK^-\pi^+)$, etc.

Determination of events rate

Parameters II

- PID application in online trigger is essential
- assume 80% efficiency & 5% misidentification of PID selector for each particle
- misIDs are defined as a proportion of fallacious PID selector for certain particle, that can make combinatorial background through other particle list

PID efficiency

$$\varepsilon = \mathrm{P}(e \mid e) = \frac{\#\,\text{of accepted } e \text{ by } e \text{ selector}}{\#\,\text{of reconstructed } e}$$

Purity & Impurity

$$\begin{aligned} impurity &= 1 - purity \\ &= 1 - \frac{\mathrm{P}(e \mid e)}{[\mathrm{P}(e \mid e) + \mathrm{P}(e \mid \mu) + \mathrm{P}(e \mid \pi) + \mathrm{P}(e \mid K) + \mathrm{P}(e \mid p)]} \end{aligned}$$

misID of e

$$\mu^{e}_{misID} = \mathrm{P}(\mu \mid e) = \frac{\#\,\text{of accepted } e \text{ by } \mu \text{ selector}}{\#\,\text{of reconstructed } e}$$

$$\pi^{e}_{misID} = \mathrm{P}(\pi \mid e) = \frac{\#\,\text{of accepted } e \text{ by } \pi \text{ selector}}{\#\,\text{of reconstructed } e}$$

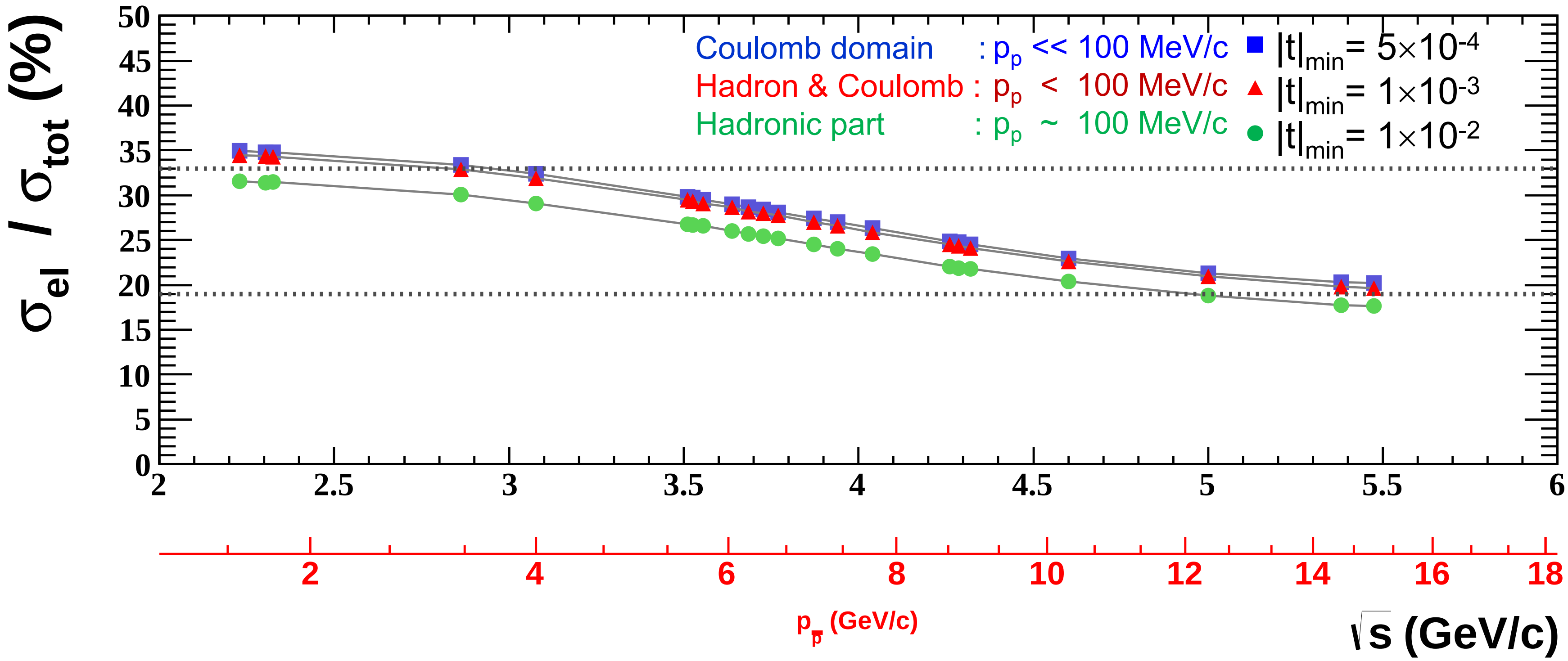
$$K^{e}_{misID} = \mathrm{P}(K \mid e) = \frac{\#\,\text{of accepted } e \text{ by } K \text{ selector}}{\#\,\text{of reconstructed } e}$$

$$p^{e}_{misID} = \mathrm{P}(p \mid e) = \frac{\#\,\text{of accepted } e \text{ by } p \text{ selector}}{\#\,\text{of reconstructed } e}$$

Determination of events rate

DPM background

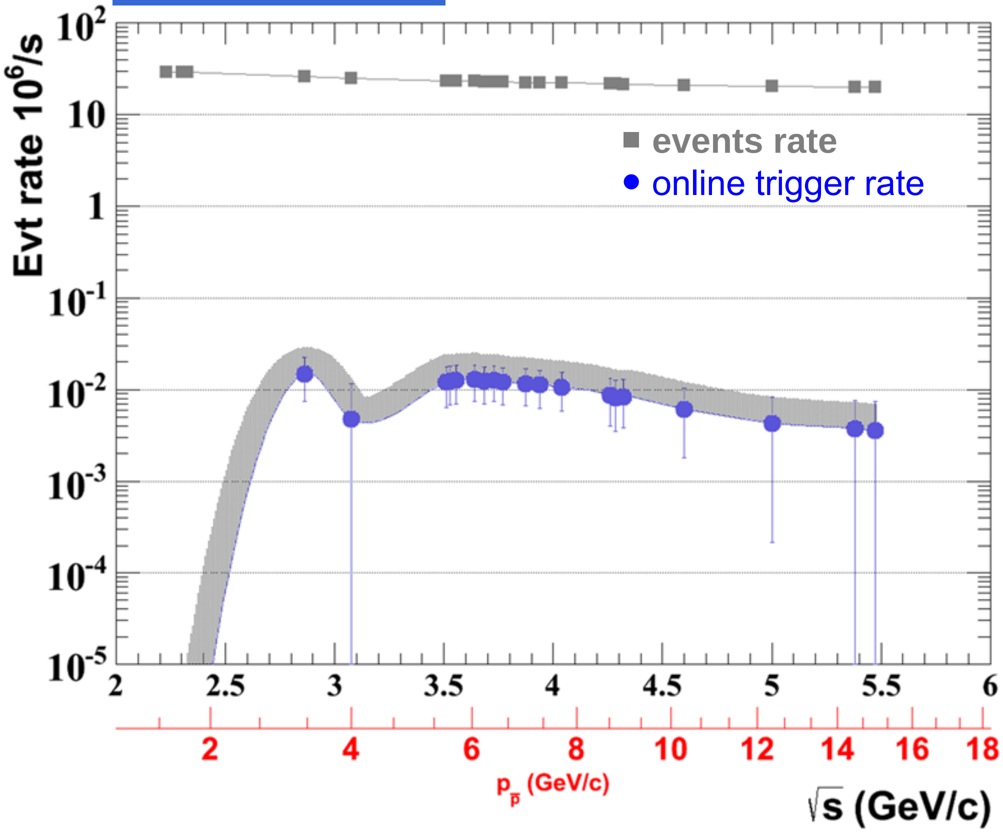
- during the study on the event rate, inelastic and elastic event given by DPM cross section are separated in the event selection
- scaled elastic and inelastic event by event selection has been separately normalized and combined to estimate the event rate



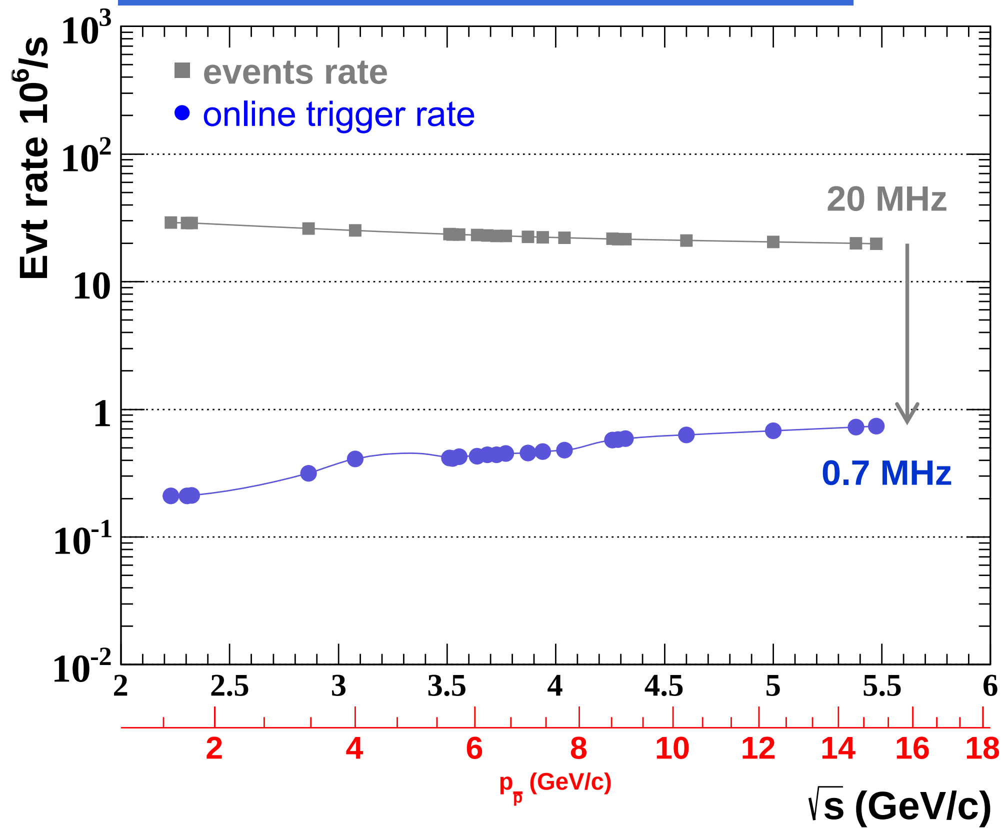
Online event rate

Background reduction rate with 12 algorithms according to DPM

elastic event



DPM event (inelastic + elastic)



systematic uncertainty

evaluated by different ratio between hadronic and coulomb part, which can adjust with cut off parameter θ_{cutoff} in DPM generator

background reduction rate ~ 10^{-1}

event rate : 20 MHz → 0.7 MHz

@ 15 GeV/c beam momentum

Determination of events rate

test software trigger scheme with full chain MC simulation

- 6 EvtGen signal data and 6 DPM background data
  0.5 - 1.5 M events / channel using PANDAroot v.17680

$$\bar{p}p \to X(3872) \to J/\psi\pi^+\pi^- \to \mu^+\mu^-\pi^+\pi^-$$
$$\bar{p}p \to X(3872) \to J/\psi\pi^+\pi^- \to e^+e^-\pi^+\pi^-$$
$$\bar{p}p \to \psi(3770) \to D^+D^- \to K^-\pi^+\pi^+K^+\pi^-\pi^-$$
$$\bar{p}p \to \psi(4040) \to D^{*+}D^{*-} \to D^0\pi^+\overline{D}^0\pi^- \to K^-\pi^+\pi^+K^-\pi^-\pi^-$$
$$\bar{p}p(\sqrt{s}=5474) \to D^+D^- \to K^-\pi^+\pi^+K^+\pi^-\pi^-$$
$$\bar{p}p \to f(2230) \to \phi\phi \to K^+K^-K^+K^-$$

DPM event (only inelastic)
cms = 2.230 GeV/c
3.077 GeV/c
3.770 GeV/c
3.872 GeV/c
4.040 GeV/c
5.474 GeV/c

- 5 selection algorithms simultaneously → 3σ mass window → count event

$$D^0(K\pi) \quad D^\pm(K\pi\pi) \quad J/\psi(e^+e^-) \quad J/\psi(\mu^+\mu^-) \quad \phi(K^+K^-)$$

- online tracking resolution is the same as like offline reconstruction value
  no p_T cut on D sector in the full chain MC simulation

- apply global PID probability for each charged track

$$\text{Prob.}(k) = \frac{\prod_i \text{Prob.}_i(k)}{\sum_j \prod_i \text{Prob.}_i(j)}$$

i = subdetectors
$j = e, \mu, \pi, K, p$
k = particle

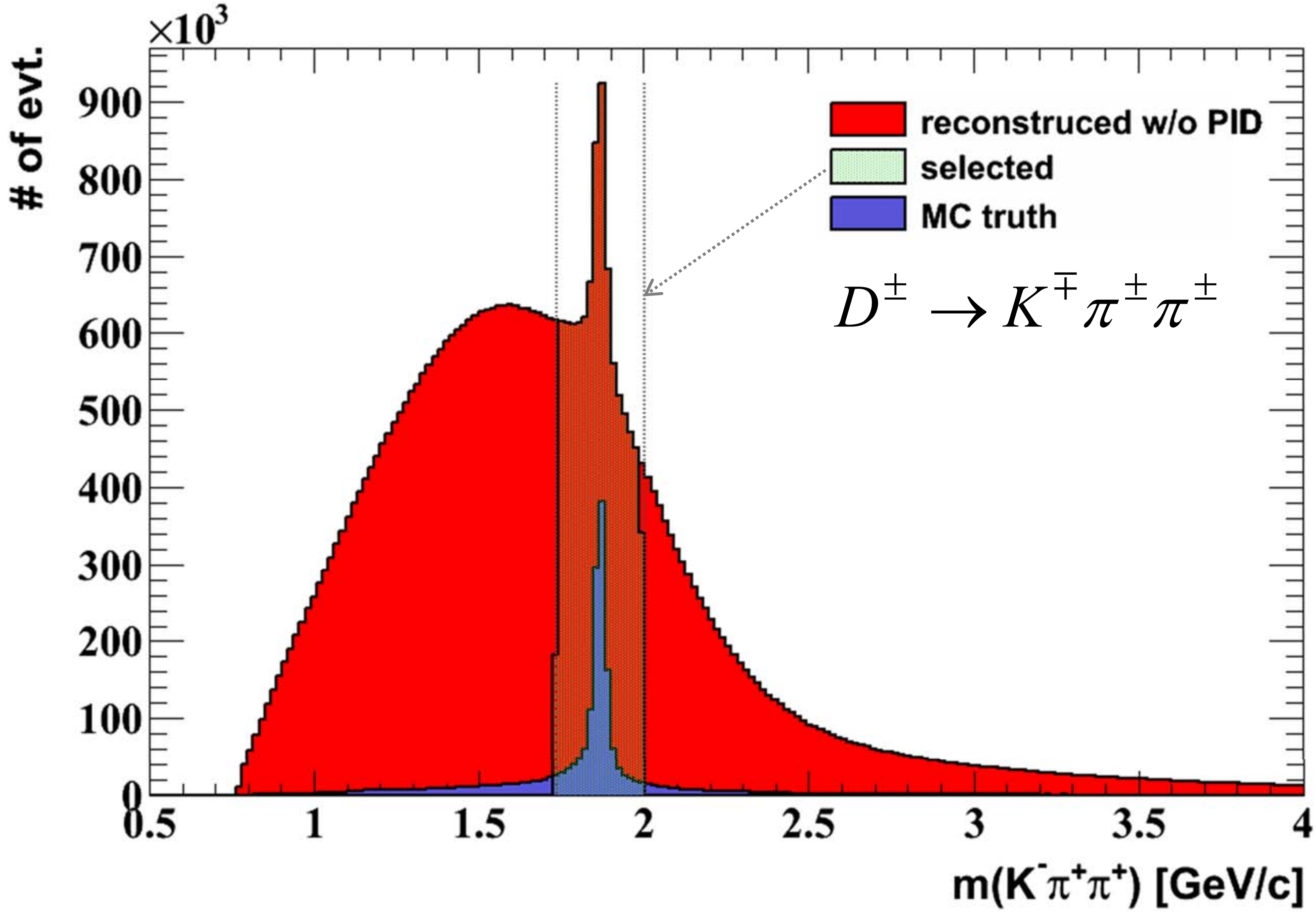
⇨

Prob.(e)
Prob.(μ)
Prob.(π)
Prob.(K)
Prob.(p)

$> [0.1, 0.5]$ for each particle

Signal (EvtGen) production

$$\bar{p}p \rightarrow \psi(3770) \rightarrow D^+D^- \rightarrow K^-\pi^+\pi^+K^+\pi^-\pi^-$$



blue distribution : reconstructed D mass with matching MC truth

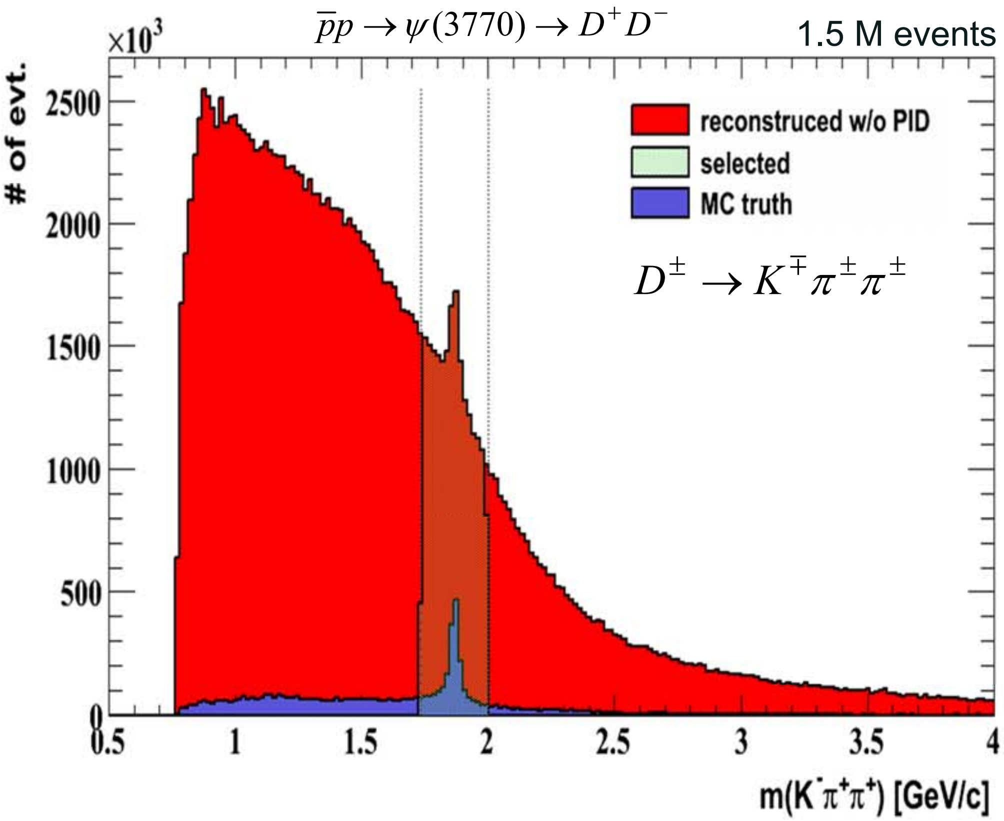
red distribution : reconstructed D from the combination of all charged track

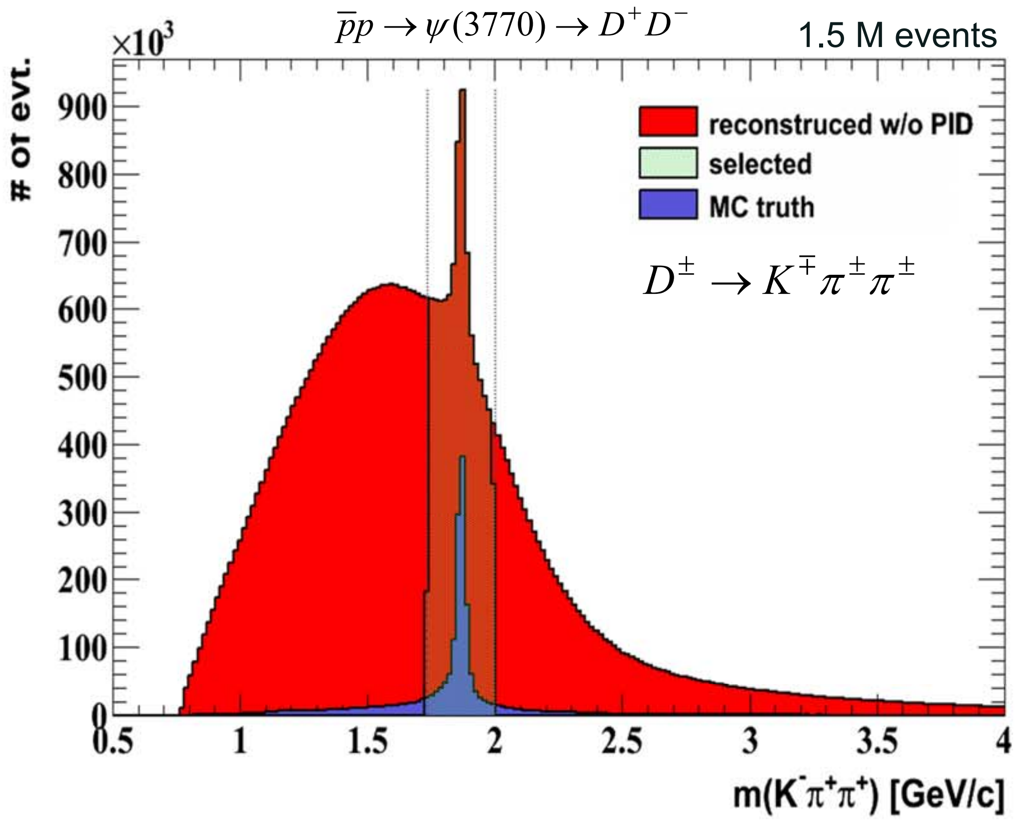
Signal (EvtGen) production

- clean up clone tracks found in the list of particle candidates

$$\text{particle}_{\text{clone}}\ (\text{track}_1, \text{track}_2) = |\Delta px, \Delta py, \Delta pz, \Delta E| < 0.1\ \text{MeV}$$

before cleanup	after cleanup





$\langle n \rangle_{\text{charged tracks}} = 6.8$ @ p=15GeV DPM

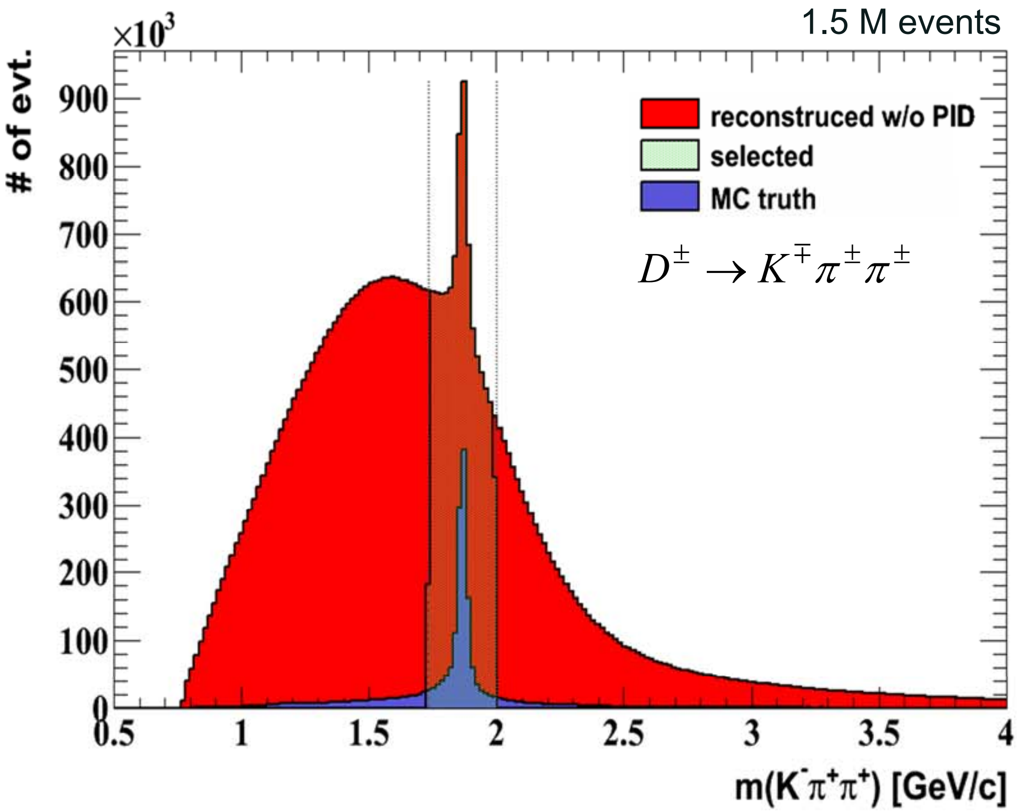
$\langle n \rangle_{\text{charged tracks}} = 5.3$ @ p=15GeV DPM

Signal (EvtGen) production

- compare $D^{\pm}$ signal between two different beam momentum

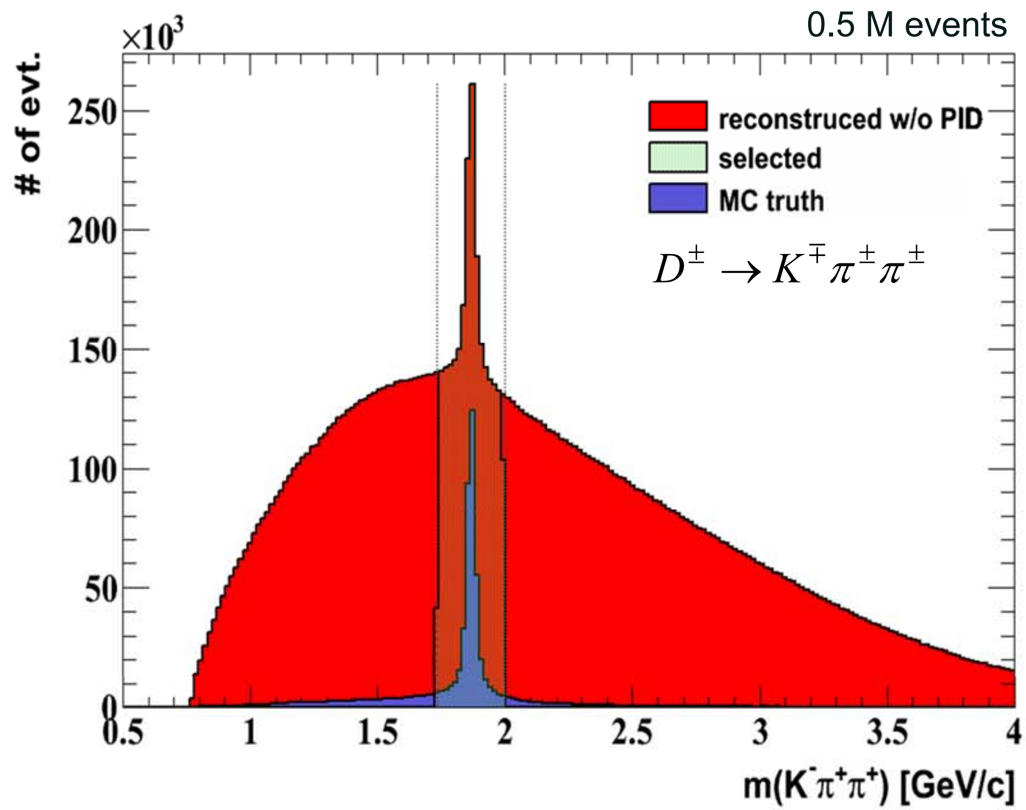
$\bar{p}p \rightarrow \psi(3770) \rightarrow D^{+}D^{-} \rightarrow K^{-}\pi^{+}\pi^{+}K^{+}\pi^{-}\pi^{-}$

$\sqrt{s} = 3.770\,\mathrm{GeV/c}$



$\bar{p}p \rightarrow D^{+}D^{-} \rightarrow K^{-}\pi^{+}\pi^{+}K^{+}\pi^{-}\pi^{-}$

$\sqrt{s} = 5.474\,\mathrm{GeV/c} \Leftrightarrow p_{\bar{p}} = 15\mathrm{GeV/c}$

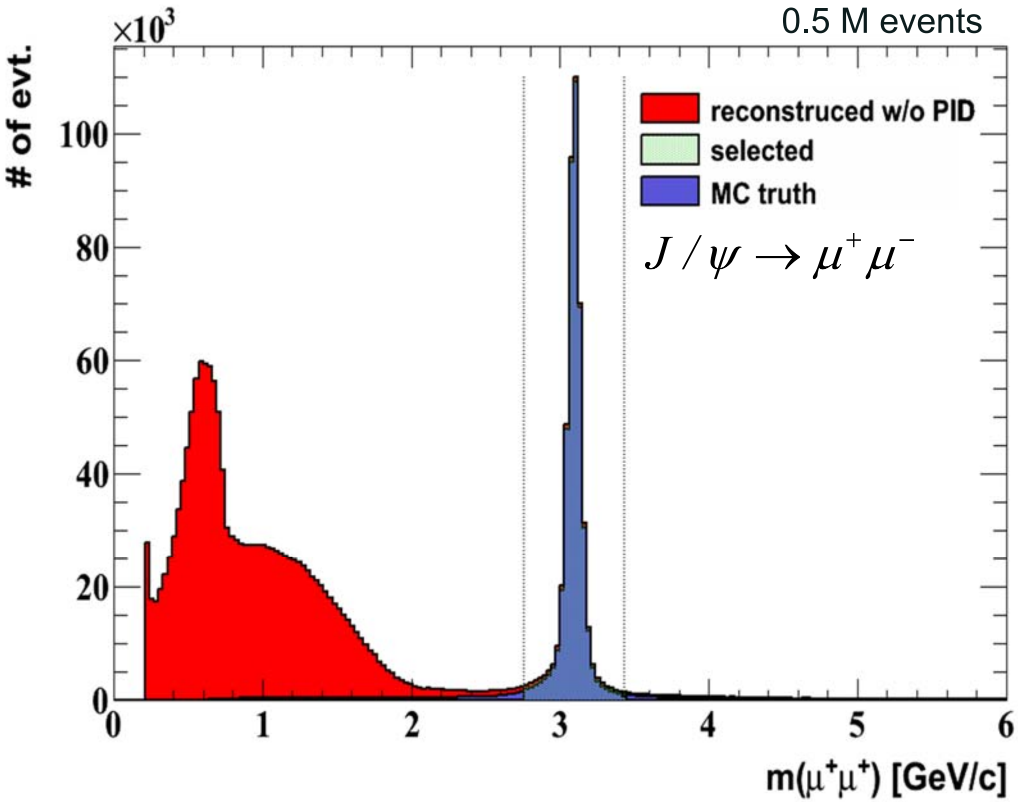


selection power and track quality looks similar → same selection might be applied

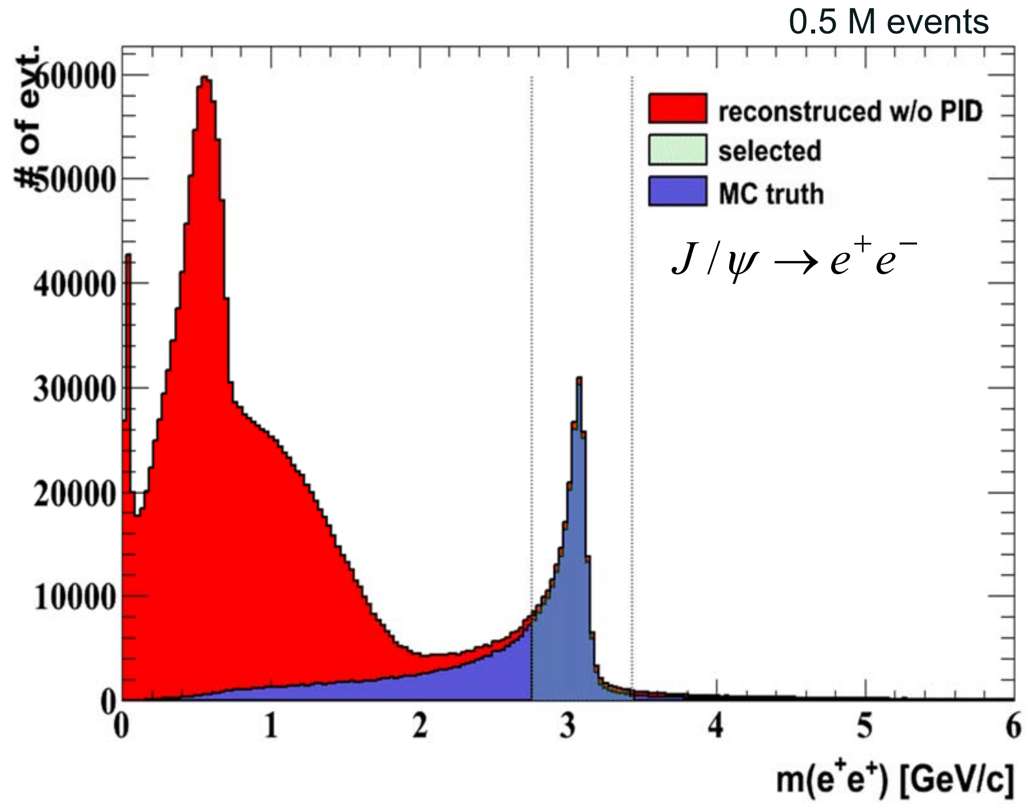
Signal (EvtGen) production

- need a calibration for the reconstructed electron energy

$\bar{p}p \to X(3872) \to J/\psi\pi^+\pi^- \to \mu^+\mu^-\pi^+\pi^-$



$\bar{p}p \to X(3872) \to J/\psi\pi^+\pi^- \to e^+e^-\pi^+\pi^-$

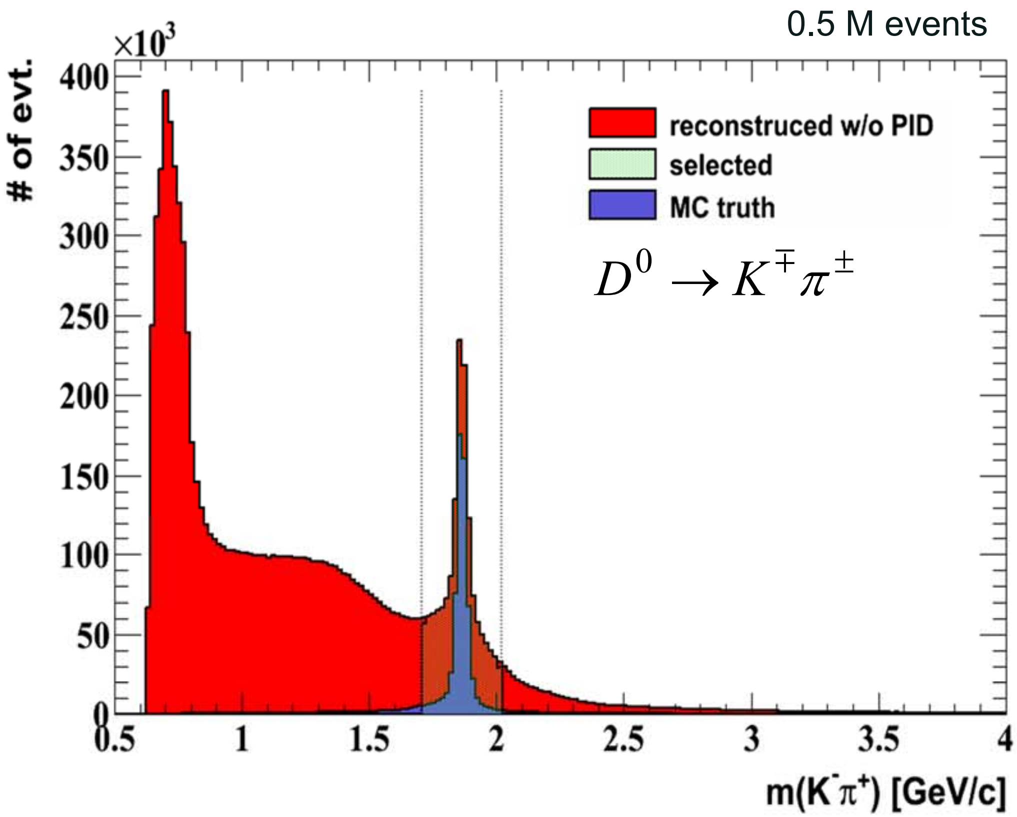


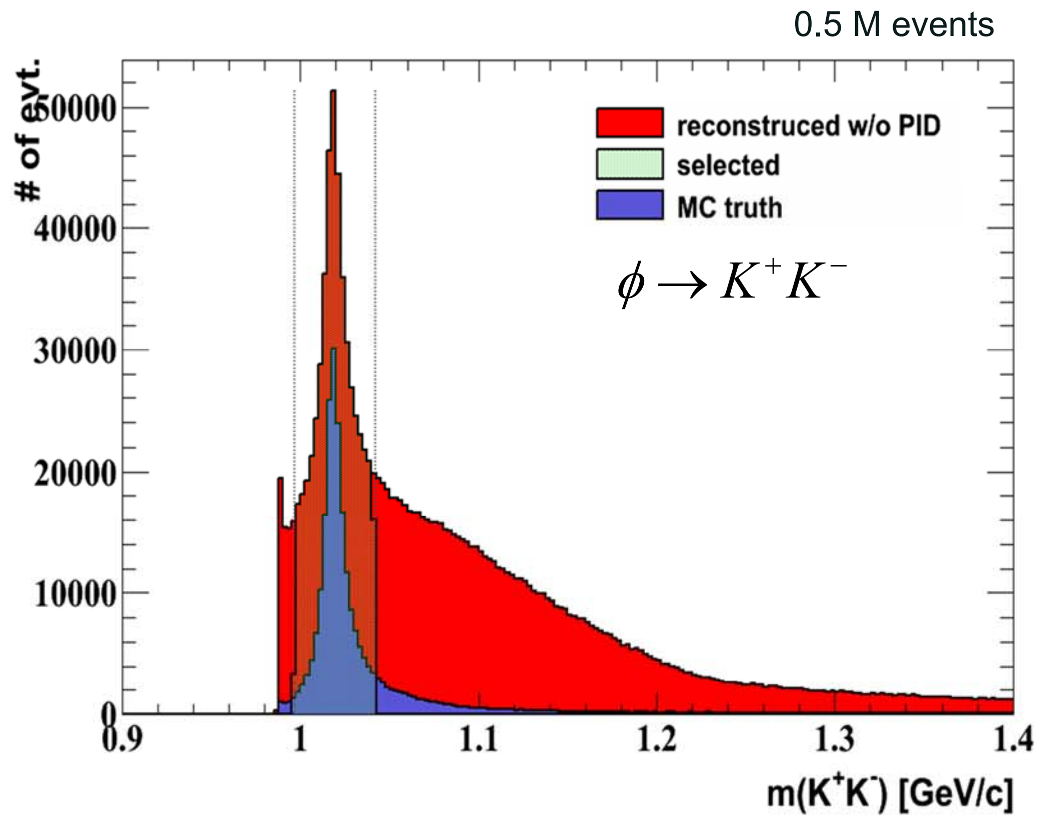
Signal (EvtGen) production

- need an improvement of track reconstruction for low energetic kaon

$$\bar{p}p \rightarrow \psi(4040) \rightarrow D^{*+}D^{*-} \rightarrow$$
$$D^0\pi^+\bar{D}^0\pi^- \rightarrow K^-\pi^+\pi^+K^-\pi^-\pi^-$$

$$\bar{p}p \rightarrow f(2230) \rightarrow \phi\phi \rightarrow K^+K^-K^+K^-$$



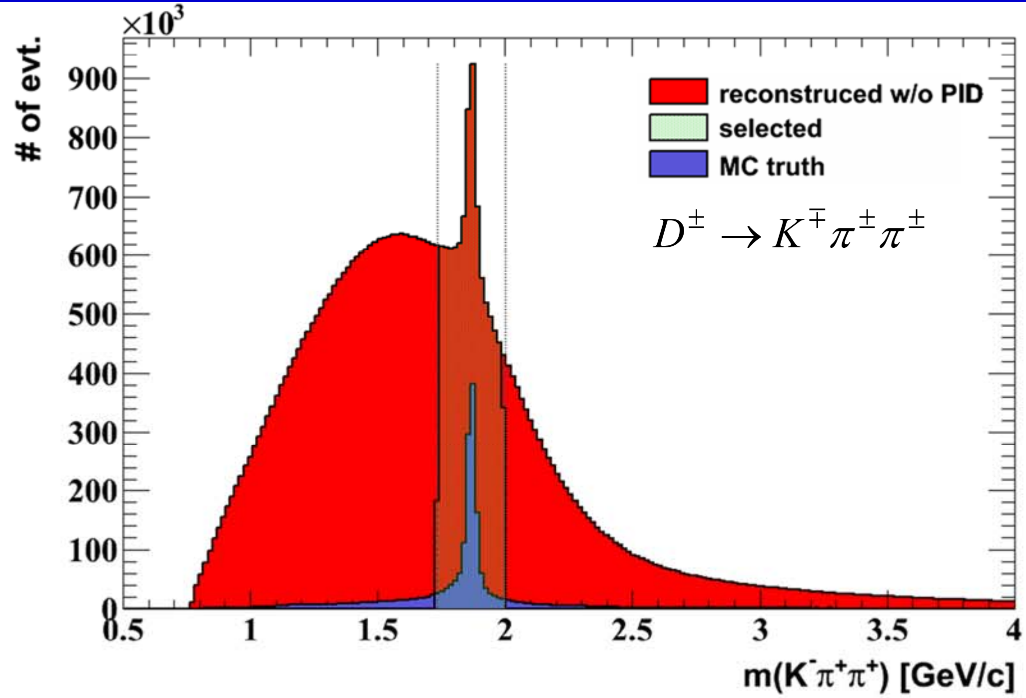


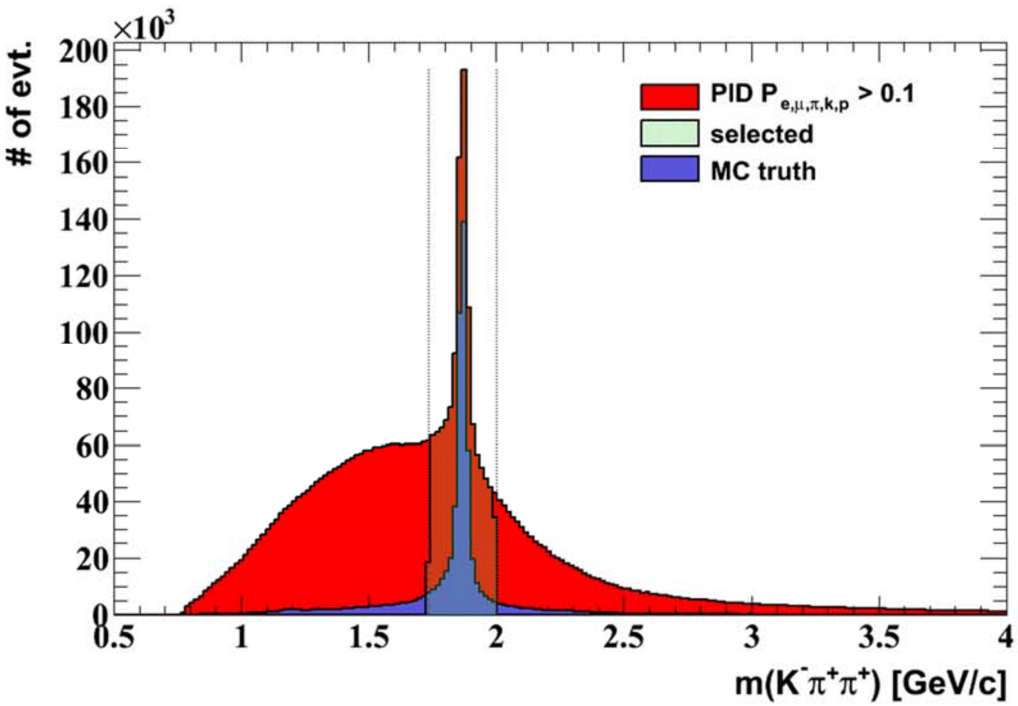
Signal (EvtGen) production

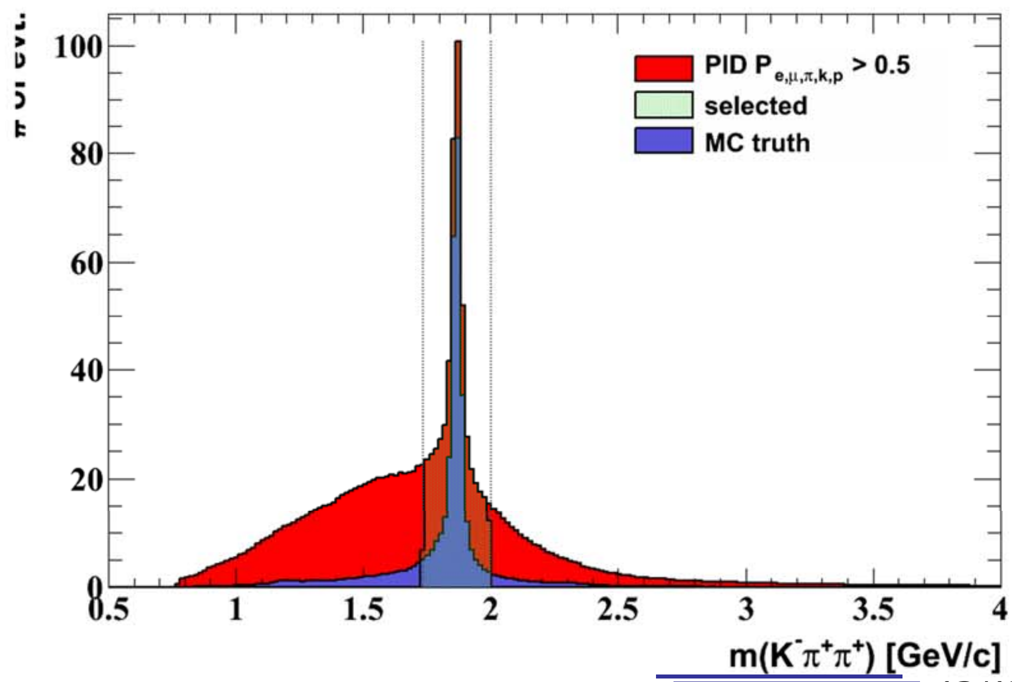
- compare invariant mass distribution with different global PID cuts

- Prob. cut has to be tuned according to figure of merit

$$\bar{p}p \rightarrow \psi(3770) \rightarrow D^+ D^- \rightarrow K^- \pi^+ \pi^+ K^+ \pi^- \pi^-$$





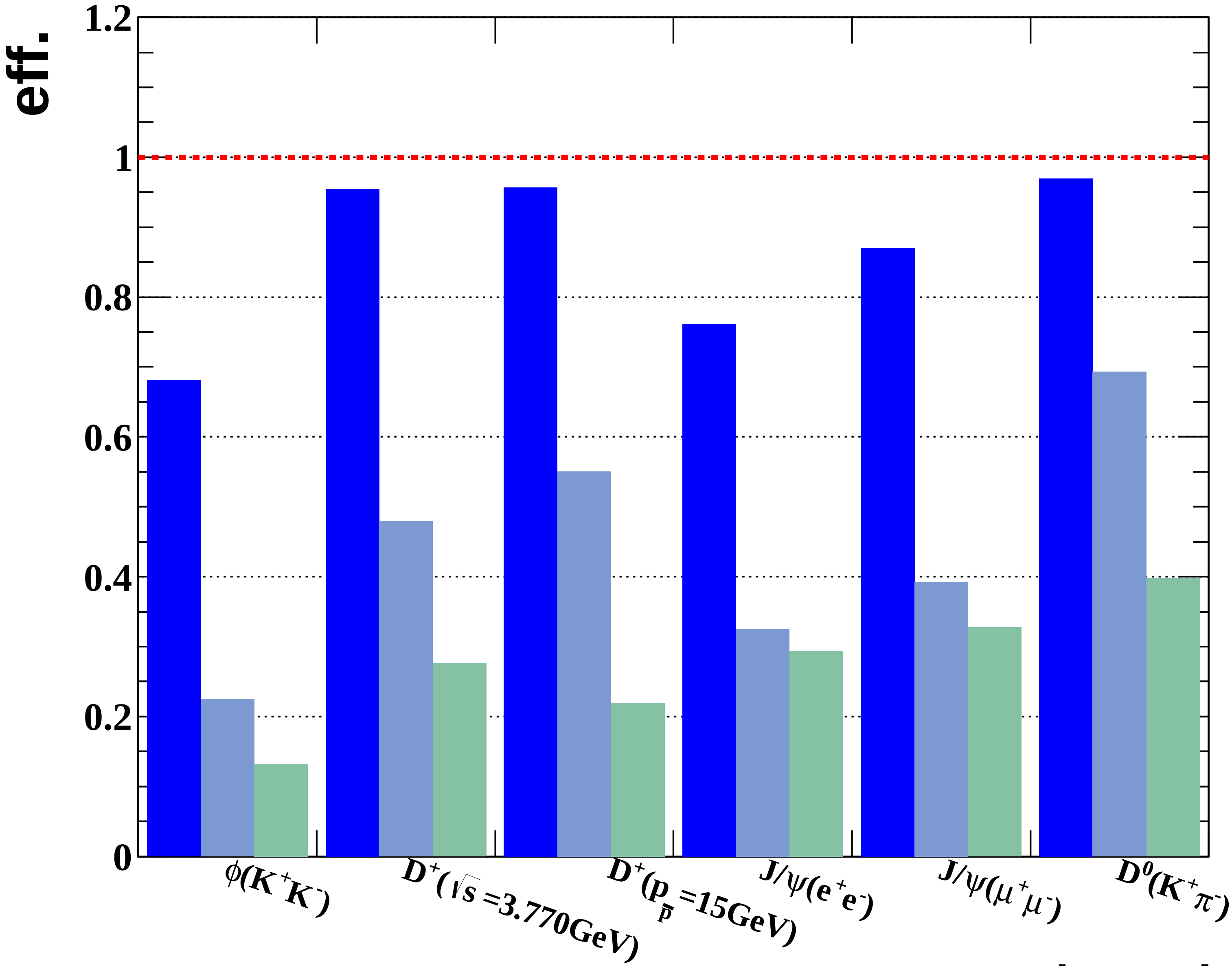


Signal efficiency

EvtGen signal data

$$eff. = \frac{N_{rec,MC}}{N_{gen,MC}}$$

where, $N_{rec,MC}$ is the number of reconstructed event accepted by one of 5 algorithms



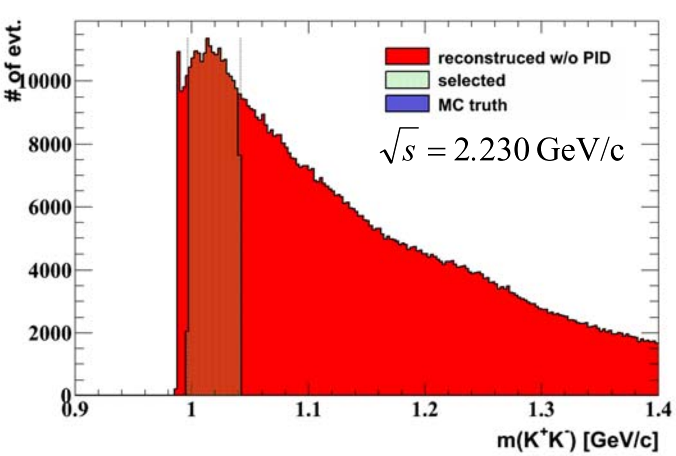
Efficiency

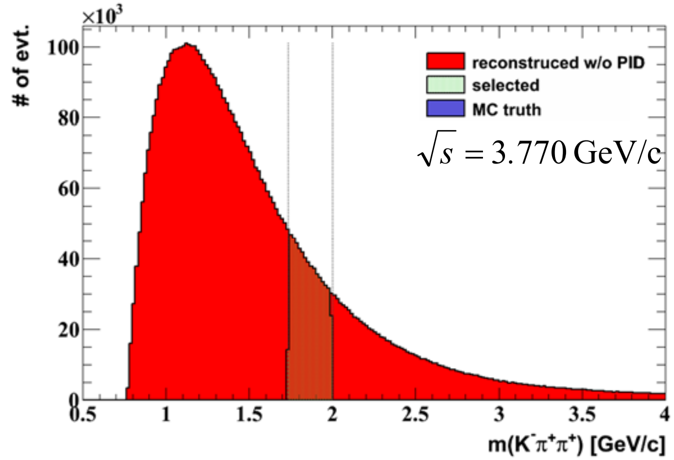
- $\varepsilon \sim 0.68 - 0.97$
- $\varepsilon \sim 0.23 - 0.70$
- $\varepsilon \sim 0.13 - 0.40$

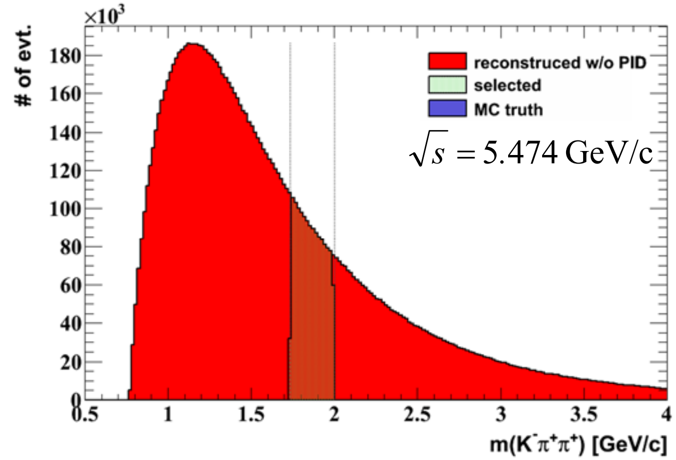
show similar result obtained from the generator level study.

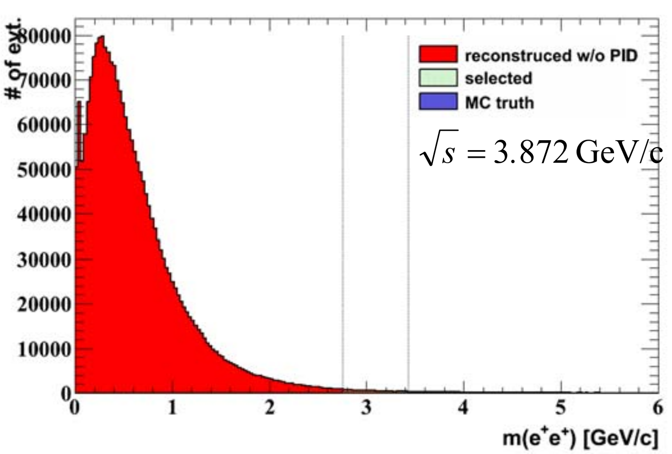
DPM background

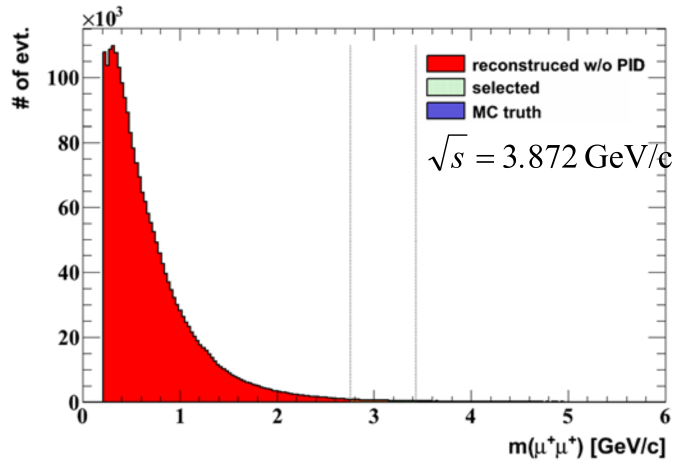
reconstructed w/o PID = all combinations from all charged tracks

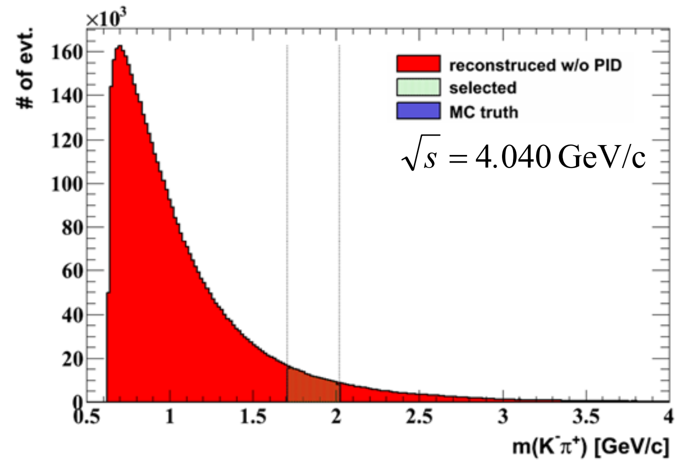








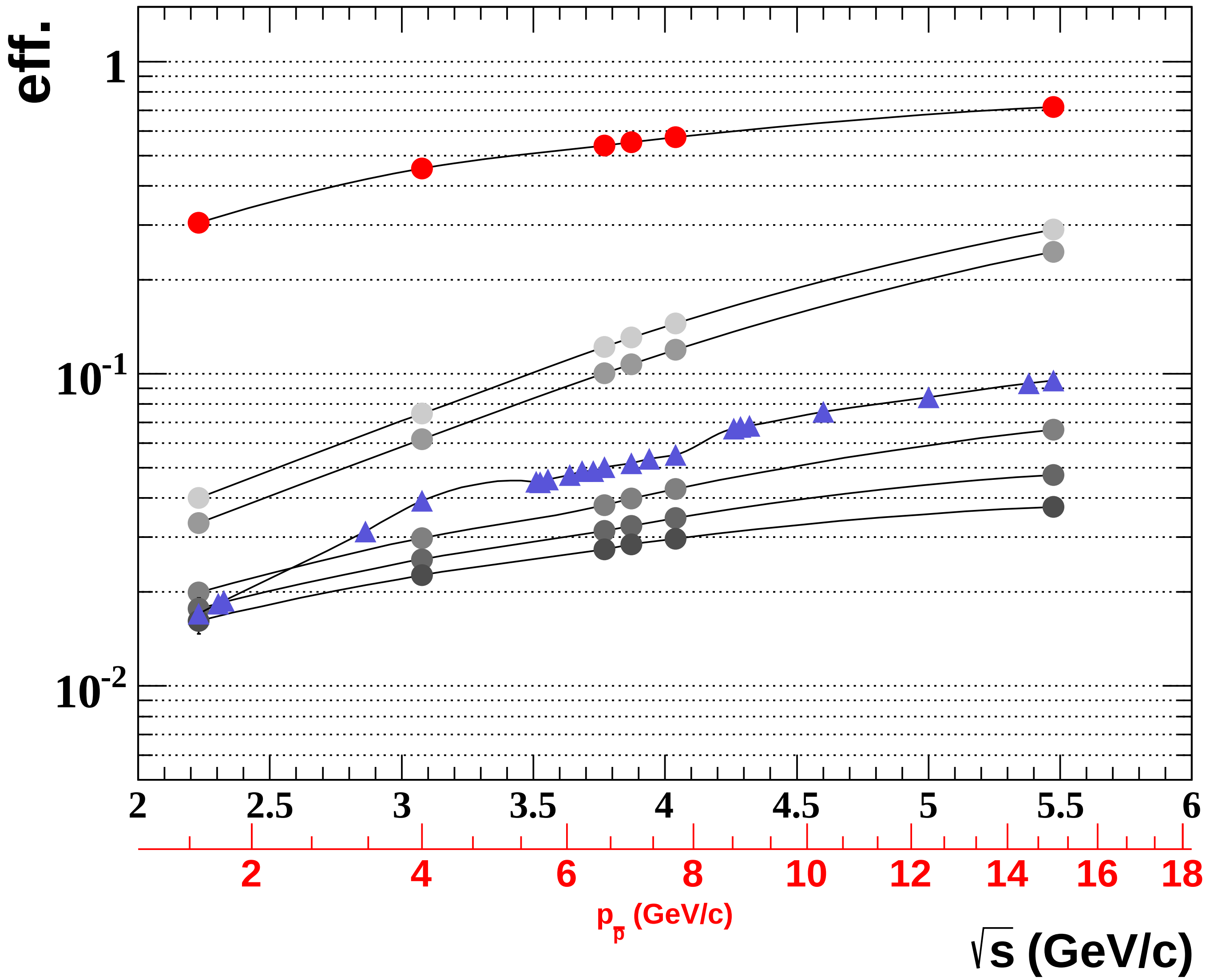




Background reduction

- Compare background reduction between simplicity and complexity way

$$eff. = \text{background recduction} = \frac{\#\text{ of event accepted by one of 5 algo.}}{\#\text{ of generated DPM event}}$$



full chain simulation

5 algorithms
- no PID
- Prob. > 0.1
- Prob. > 0.2
- Prob. > 0.3
- Prob. > 0.4
- Prob. > 0.5

result from the standalone program in the generator level

▲ 9 algorithms
80% correct PID
5% misidentification

$D^0(K\pi)\ D^0(K\pi\pi^0)D^{\pm}(K\pi\pi)$
$J/\psi(e^+e^-)\ J/\psi(\pi^+\pi^-\pi^0)$
$\phi(K^+K^-)\ D_s(\phi\pi)\ e^+e^-$
$h_c(\eta_c\gamma \rightarrow \gamma\gamma\gamma)$

Outlook

- still existing a lot of rooms for improvement of tracking and PID
- total 22 DPM production has been already finished
  more signal MC(EvtGen) including neutral tracks will be analyzed
- at present 5 selection algorithms $\rightarrow$ 12 selection algorithms with kinematic cuts in the full chain MC simulation
- fraction of misidentification found in the simulation will be applied to standalone online software trigger package
- analysis on event mixing is in progress
- assume that time order simulation should start @ 2013

Outlook

Backup

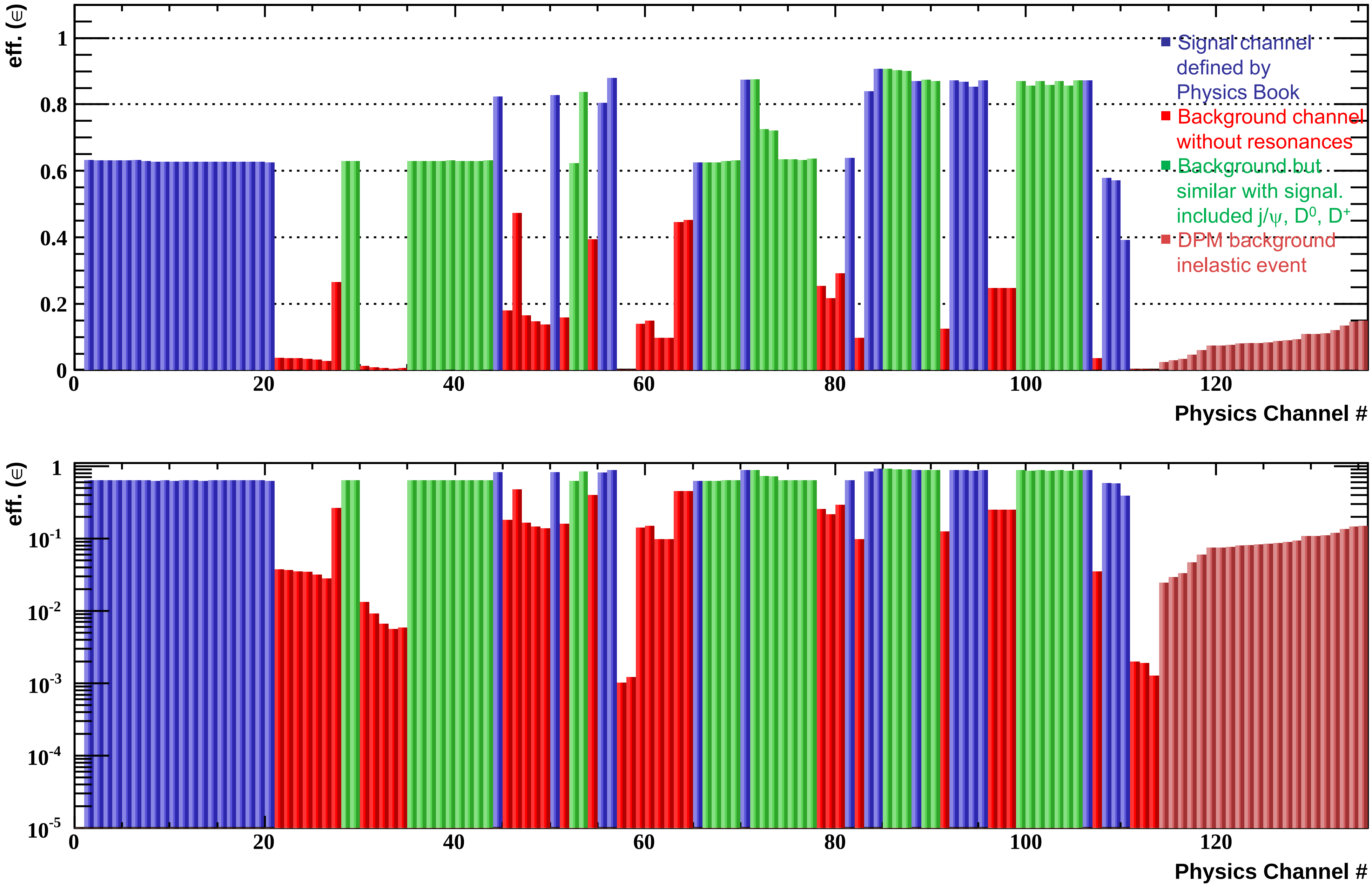
Physics channel

Production	
$\bar{p}p \to J/\psi\pi^+\pi^- \to e^+e^-(\mu^+\mu^-)\pi^+\pi^-$	h_c,ψ(2S),X,Y
$\bar{p}p \to J/\psi\pi^0\pi^0 \to e^+e^-(\mu^+\mu^-)4\gamma$	Y
$\bar{p}p \to \chi_{c1}\gamma \to J/\psi\gamma\gamma \to e^+e^-(\mu^+\mu^-)\gamma\gamma$	ψ(2S),X,Y
$\bar{p}p \to \chi_{c2}\gamma \to J/\psi\gamma\gamma \to e^+e^-(\mu^+\mu^-)\gamma\gamma$	ψ(2S),X,Y
$\bar{p}p \to J/\psi\gamma \to e^+e^-(\mu^+\mu^-)\gamma$	χ_{c1},χ_{c2},X
$\bar{p}p \to J/\psi\eta \to e^+e^-(\mu^+\mu^-)\gamma\gamma$	η_c(2S),ψ(2S),X,Y
$\bar{p}p \to \pi^+\pi^-\pi^+\pi^-$	
$\bar{p}p \to \pi^+\pi^-\pi^0\pi^0 \to \pi^+\pi^-\gamma\gamma\gamma\gamma$	
$\bar{p}p \to J/\psi\eta\pi^0 \to e^+e^-\gamma\gamma\gamma\gamma$	
$\bar{p}p \to J/\psi\omega\pi^0 \to e^+e^-\pi^0\gamma\gamma\gamma$	
$\bar{p}p \to \pi^+\pi^-\pi^0 \to \pi^+\pi^-\gamma\gamma$	
$\bar{p}p \to \pi^+\pi^-\eta \to \pi^+\pi^-\gamma\gamma$	
$\bar{p}p \to J/\psi\pi^0\gamma \to e^+e^-\gamma\gamma\gamma$	
$\bar{p}p \to J/\psi\eta\gamma \to e^+e^-\gamma\gamma\gamma$	
$\bar{p}p \to J/\psi\eta\eta \to e^+e^-\gamma\gamma\gamma\gamma$	
$\bar{p}p \to \eta_c(2S)\gamma \to \gamma\gamma\gamma$	h_c
$\bar{p}p \to \pi^0\pi^0 \to \gamma\gamma\gamma\gamma$	
$\bar{p}p \to \pi^0\gamma \to \gamma\gamma\gamma$	
$\bar{p}p \to \pi^0\eta \to \gamma\gamma\gamma\gamma$	
$\bar{p}p \to \eta\eta \to \gamma\gamma\gamma\gamma$	
$\bar{p}p \to \pi^0\eta^{(\prime)} \to \gamma\gamma\gamma\gamma$	
$\bar{p}p \to \eta_c\gamma \to \phi\phi\gamma \to K^+K^-K^+K^-\gamma$	h_c
$\bar{p}p \to K^+K^-K^+K^-\pi^0 \to K^+K^-K^+K^-\gamma\gamma$	
$\bar{p}p \to \phi K^+K^-\pi^0 \to K^+K^-K^+K^-\gamma\gamma$	
$\bar{p}p \to \phi\phi\pi^0 \to K^+K^-K^+K^-\gamma\gamma$	
$\bar{p}p \to K^+K^-\pi^+\pi^-\pi^0 \to K^+K^-K^+K^-\gamma\gamma$	
$\bar{p}p \to D^+D^- \to K^-\pi^+\pi^+K^+\pi^-\pi^-$	ψ(3770)
$\bar{p}p \to D^{*+}D^{*-} \to D^0\pi^+\overline{D^0}\pi^- \to K^-\pi^+\pi^+K^+\pi^-\pi^-$	ψ(4040)
$\bar{p}p \to$ generic DPM	
$\bar{p}p \to 3\pi^+3\pi^-\pi^0$	
$\bar{p}p \to 3\pi^+3\pi^-$	
$\bar{p}p \to K^+K^-2\pi^+2\pi^-$	
$\bar{p}p \to \widetilde{\eta}_{c1}\eta \to \chi_{c1}\pi^0\pi^0\eta \to J/\psi\gamma\pi^0\pi^0\eta$	$\widetilde{\eta}_{c1}(4286)$
$\bar{p}p \to \chi_{c0}\pi^0\pi^0\eta \to J/\psi\gamma\pi^0\pi^0\eta$	
$\bar{p}p \to \chi_{c1}\pi^0\eta\eta \to J/\psi\gamma\pi^0\eta\eta$	
$\bar{p}p \to \chi_{c1}\pi^0\pi^0\pi^0\eta \to J/\psi\gamma\pi^0\pi^0\pi^0\eta$	
$\bar{p}p \to J/\psi\pi^0\pi^0\pi^0\eta$	
$\bar{p}p \to \widetilde{\eta}_{c1}\eta \to D^0\overline{D}^{*0}\eta \to K^-\pi^+\pi^0K^+\pi^-\pi^0\pi^0\eta$	$\widetilde{\eta}_{c1}(4286)$
$\bar{p}p \to D^0\overline{D}^{*0}\pi^0 \to K^-\pi^+\pi^0K^+\pi^-\pi^0\pi^0\pi^0$	
$\bar{p}p \to D^0\overline{D}^{*0}\eta \to K^-\pi^+\pi^0\pi^0K^+\pi^-\pi^0\pi^0\eta$	
$\bar{p}p \to D^0\overline{D}^{*0}\eta \to K^-\pi^+\pi^0\pi^0K^+\pi^-\pi^0\pi^0\pi^0\eta$	

Production	
$\bar{p}p \to J/\psi\omega \to e^+e^-\pi^+\pi^-\pi^0$	Y(3940)
$\bar{p}p \to \psi'\pi^0 \to e^+e^-\pi^+\pi^-\pi^0$	
$\bar{p}p \to J/\psi\rho\pi^0 \to e^+e^-\pi^+\pi^-\pi^0$	
$\bar{p}p \to J/\psi\rho^+\pi^- \to e^+e^-\pi^+\pi^0\pi^-$	
$\bar{p}p \to \rho\pi^+\pi^-\pi^0 \to \pi^+\pi^-\pi^+\pi^-\pi^0$	
$\bar{p}p \to \rho^+\pi^+\pi^-\pi^- \to \pi^+\pi^0\pi^+\pi^-\pi^-$	
$\bar{p}p \to \omega\pi^+\pi^-\pi^- \to \pi^+\pi^-\pi^0\pi^+\pi^-$	
$\bar{p}p \to \psi'\pi^+\pi^- \to e^+e^-\pi^+\pi^-\pi^+\pi^-$	Y(4320)
$\bar{p}p \to \pi^+\pi^-\pi^+\pi^-\pi^+\pi^-$	
$\bar{p}p \to \phi\phi \to K^+K^-K^+K^-$	$f_2(2230)$
$\bar{p}p \to$ generic DPM	
$\bar{p}p \to D_s^\pm D_{s0}^*(2317)^\mp \to \phi\pi^\pm + anything$	$D_{s0}^*(2317)$
$\bar{p}p \to$ generic DPM	
$\bar{p}p \to D_s^\pm D_{s0}^*(2317)^\mp \to anything + D_s^\mp\pi^0 \to anything + \phi\pi^\mp\pi^0$	
$\bar{p}p \to D_s^\pm D_s^\mp\pi^0 \to \phi\pi^\pm D_s^\mp\pi^+\pi^-$	
$\bar{p}p \to D_s^\pm D_s^\mp\pi^0 \to \phi\pi^\pm D_s^\mp\pi^0\pi^0$	
$\bar{p}p \to D_s^\pm D_s^*\pi^0 \to \phi\pi^\pm D_s^{*\mp}\pi^0$	
$\bar{p}p \to \overline{\Xi}^+\Xi^-\pi^0 \to \overline{\Lambda}\pi^+\Lambda\pi^-\pi^0 \to \overline{p}\pi^+\pi^+p\pi^-\pi^-\pi^0$	Hyperon
$\bar{p}p \to$ generic DPM	
$\bar{p}p \to \overline{\Lambda}\Lambda\pi^+\pi^-\pi^0 \to \overline{p}\pi^+\pi^+p\pi^-\pi^-\pi^0$	
$\bar{p}p \to \overline{\Sigma}^+(1385)\Sigma^-(1385)\pi^0 \to \overline{\Lambda}\pi^+\Lambda\pi^-\pi^0 \to \overline{p}\pi^+\pi^+p\pi^-\pi^-\pi^0$	
$\bar{p}p \to p\overline{p}\pi^+\pi^-\pi^+\pi^-\pi^0$	
$\bar{p}p \to \overline{\Lambda}\Lambda \to \overline{p}\pi^+p\pi^-$	Hyperon
$\bar{p}p \to \overline{\Xi}^+\Xi^- \to \overline{\Lambda}\pi^+\Lambda\pi^- \to \overline{p}\pi^+\pi^+p\pi^-\pi^-$	Hyperon
$\bar{p}p \to p\overline{p}\pi^+\pi^-$	
$\bar{p}p \to \overline{\Lambda}\Sigma^0 \to \overline{p}\pi^+p\pi^-\pi^0$	
$\bar{p}p \to \overline{\Lambda}\Sigma(1385) \to \overline{p}\pi^+p\pi^-\pi^0$	
$\bar{p}p \to \overline{\Sigma}^0\Sigma^0 \to \overline{p}\pi^+\gamma p\pi^-\gamma$	
$\bar{p}p \to$ generic DPM	
$\bar{p}p \to \overline{\Sigma}^+(1385)\Sigma^-(1385) \to \overline{\Lambda}\pi^+\Lambda\pi^- \to \overline{p}\pi^+\pi^+p\pi^-\pi^-$	
$\bar{p}p \to D^0\overline{D}^{*0} \to K^-\pi^+K^+\pi^-\pi^0$	X(3872)
$\bar{p}p \to \pi^+\pi^-\pi^+\pi^-$	
$\bar{p}p \to$ generic DPM	
$\bar{p}p \to e^+e^-$	EMF
$\bar{p}p \to e^+e^-\pi^0$	EMF
$\bar{p}p \to \pi^+\pi^-$	
$\bar{p}p \to \pi^+\pi^-\pi^0$	

software trigger efficiency

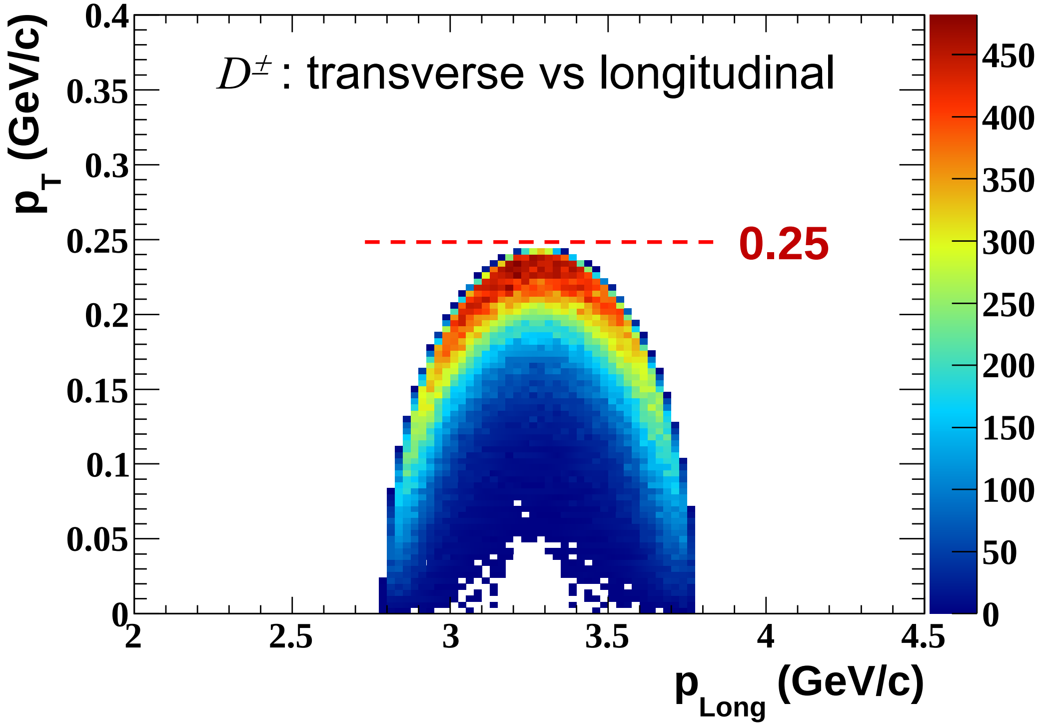
Efficiency of online physics trigger for 134 data sets (9 algorithms + Λ included)



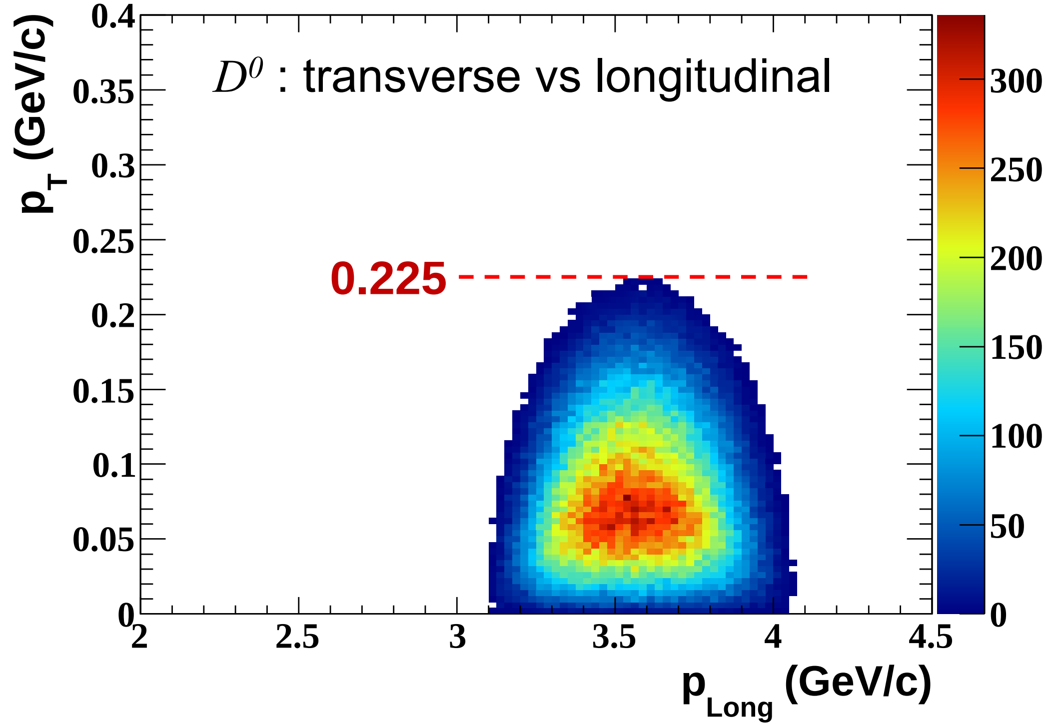
Cut on kinematic

possible way to get an improvement for signal selection and background reduction

$\bar{p}p \rightarrow \psi(3770) \rightarrow D^{+}D^{-}$



$\bar{p}p \rightarrow \psi(4040) \rightarrow D^{*+}D^{*-} \rightarrow D^{0}\pi^{+}\overline{D}^{0}\pi^{-}$



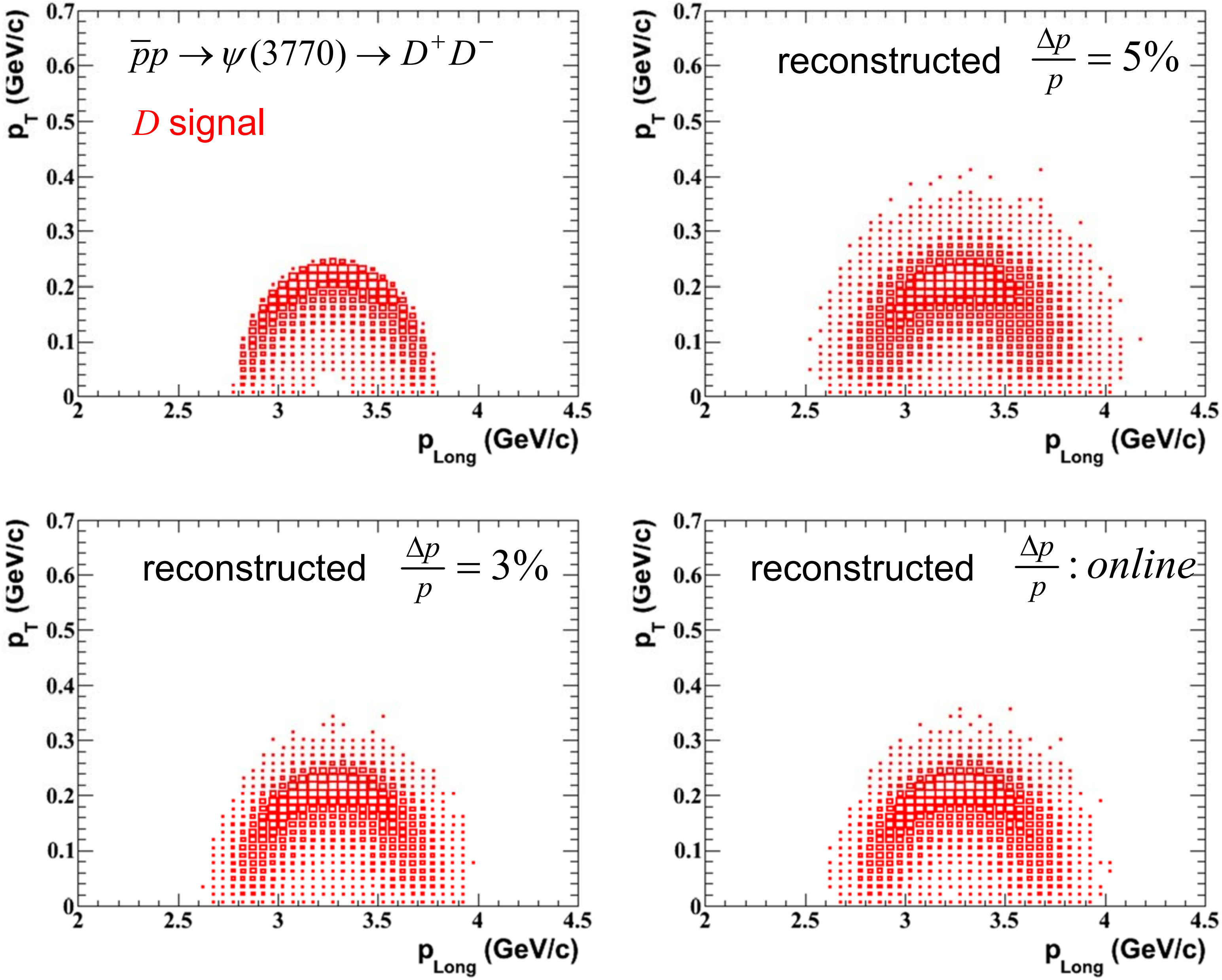
$D^{0}\overline{D}^{0} \rightarrow K^{+}\pi^{-}K^{-}\pi^{+}$

$D^{0}\overline{D}^{0} \rightarrow K^{+}\pi^{-}\pi^{0}K^{+}\pi^{-}\pi^{0}$

} same p_T distribution

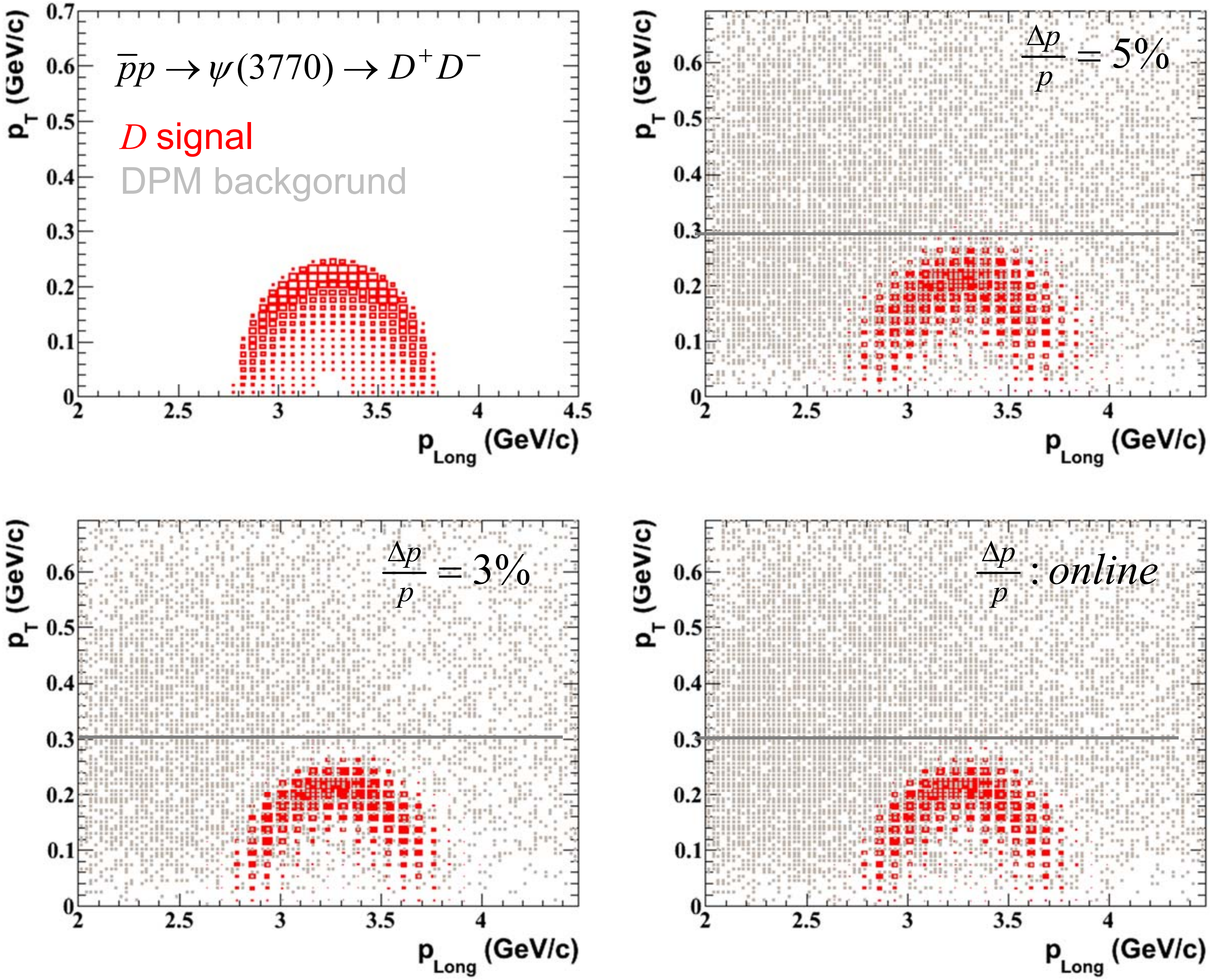
kinematic cut

Application of p_T cut in D selection



kinematic cut

Application of p_T cut in D selection



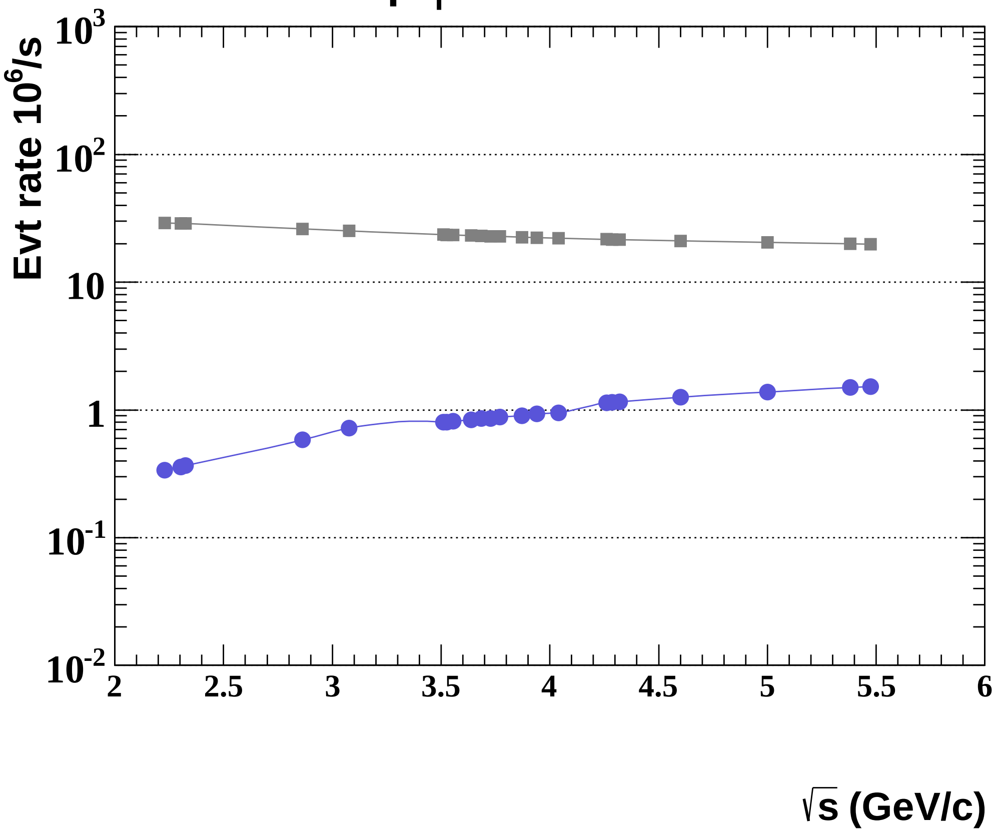
kinematic cut

Application of p_T cut in D selection

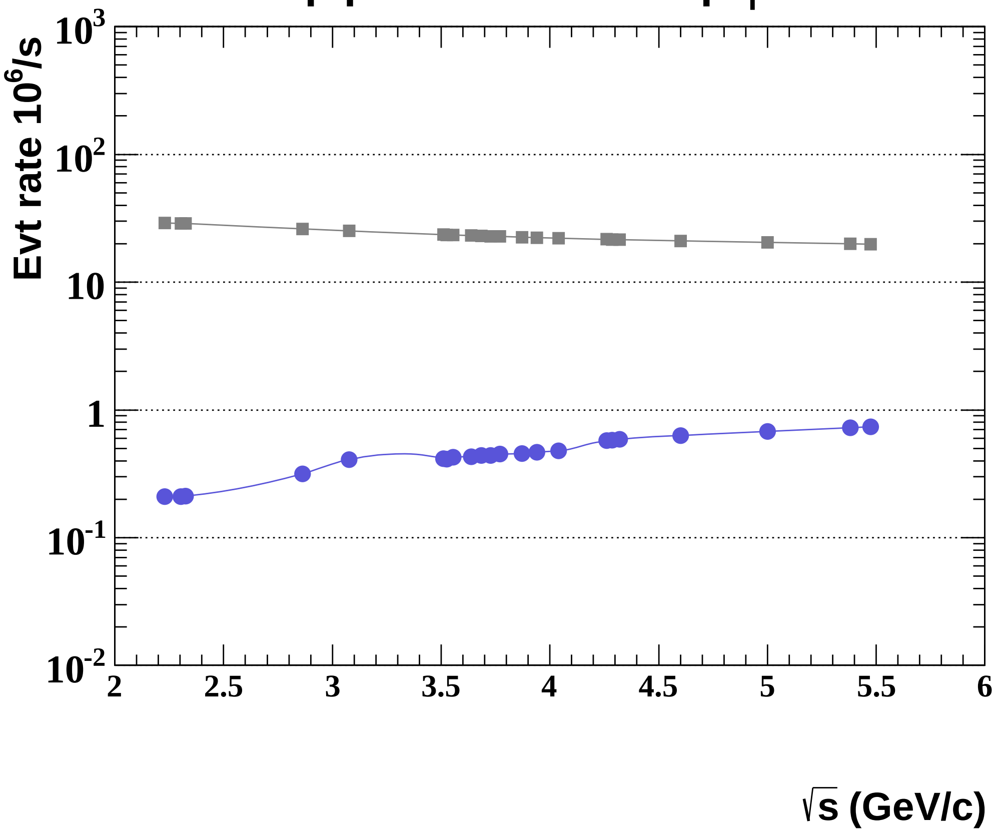
9 algorithms w/o lambda

12 algorithms w/o lambda

w/o p_T cut



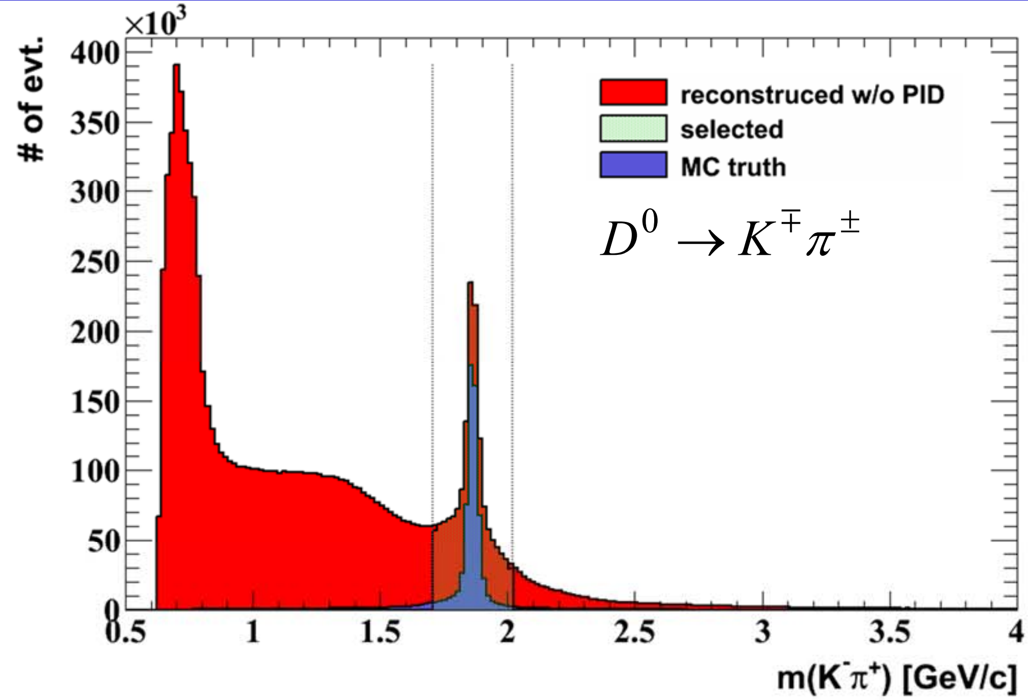
application of p_T cut

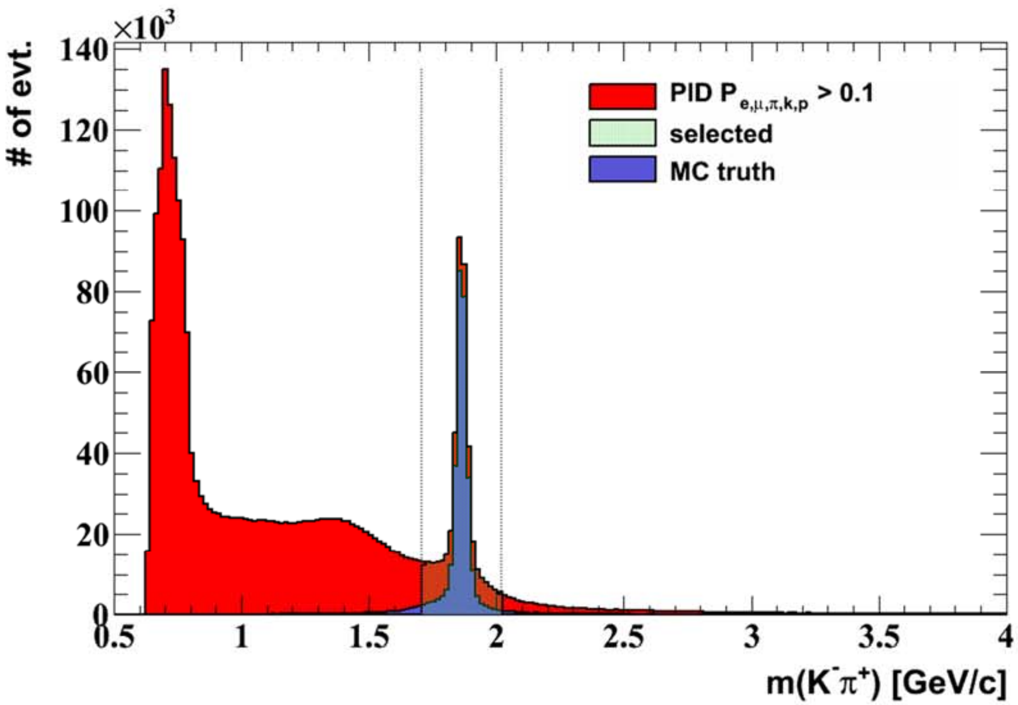


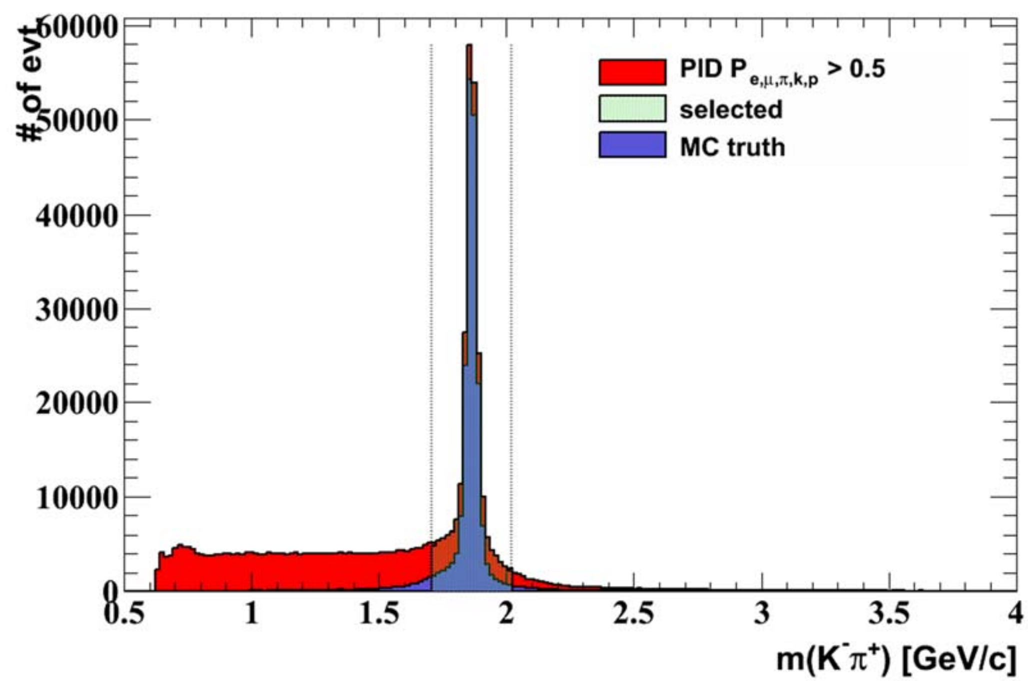
Signal (EvtGen) production

$$\bar{p}p \rightarrow \psi(4040) \rightarrow D^{*+}D^{*-}$$

$$\rightarrow D^0\pi^+\bar{D}^0\pi^- \rightarrow K^-\pi^+\pi^+K^-\pi^-\pi^-$$

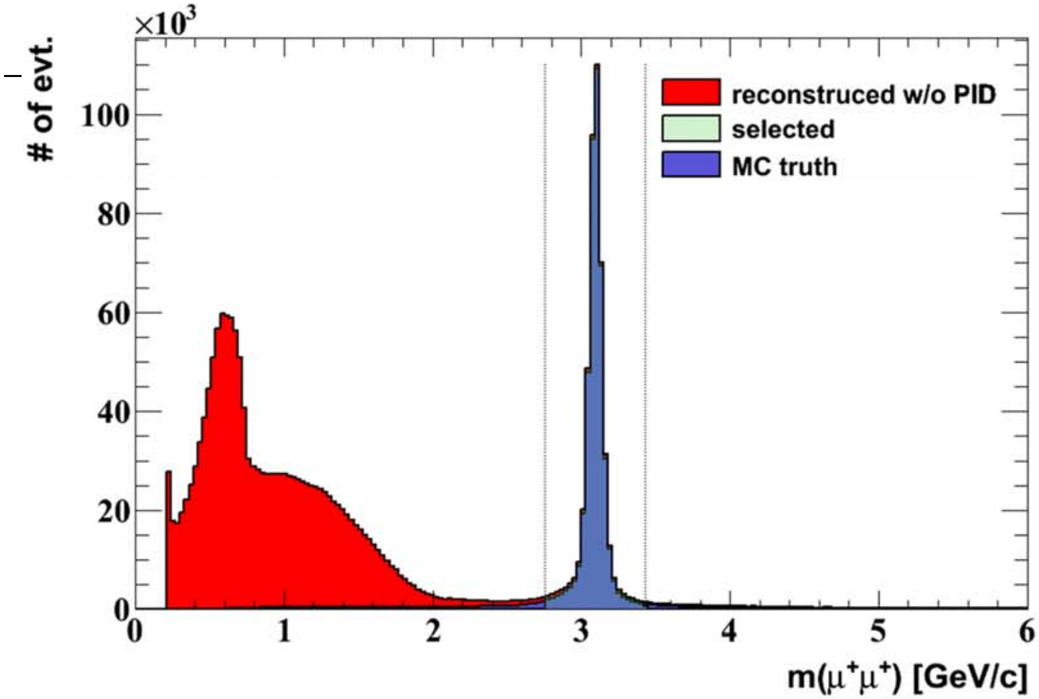


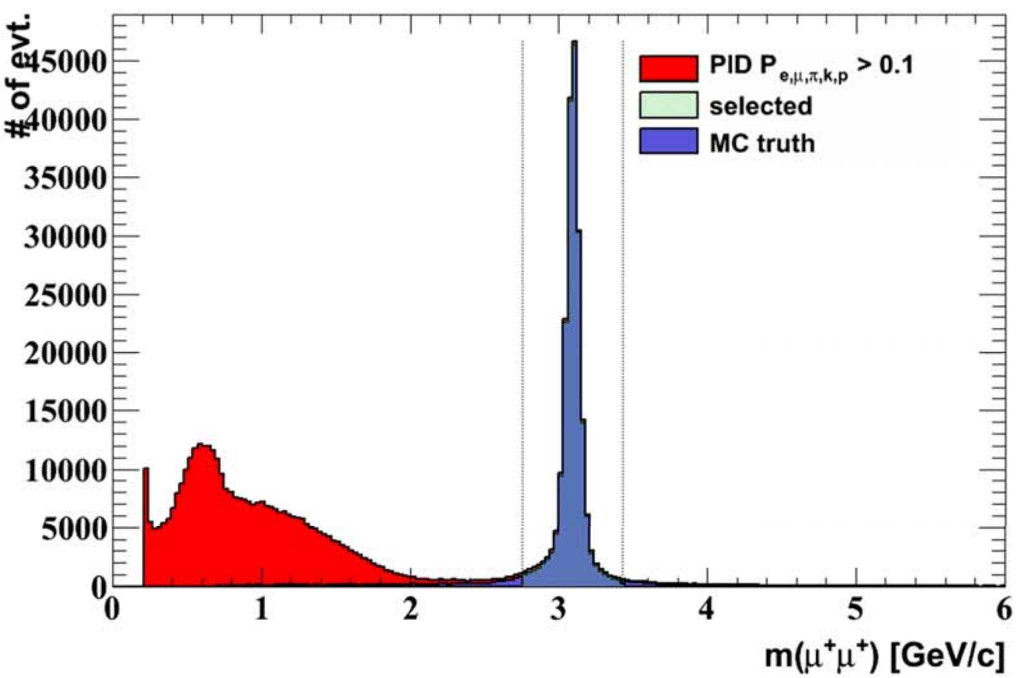


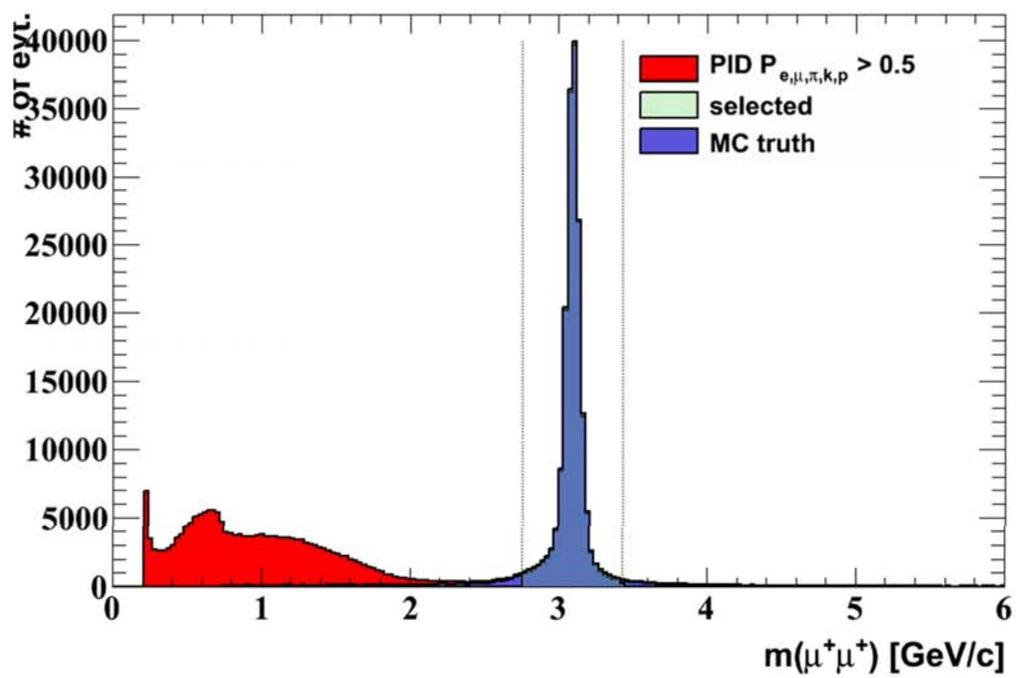


Signal (EvtGen) production

$$\bar{p}p \rightarrow X(3872) \rightarrow J/\psi\pi^+\pi^- \rightarrow \mu^+\mu^-\pi^+\pi^-$$

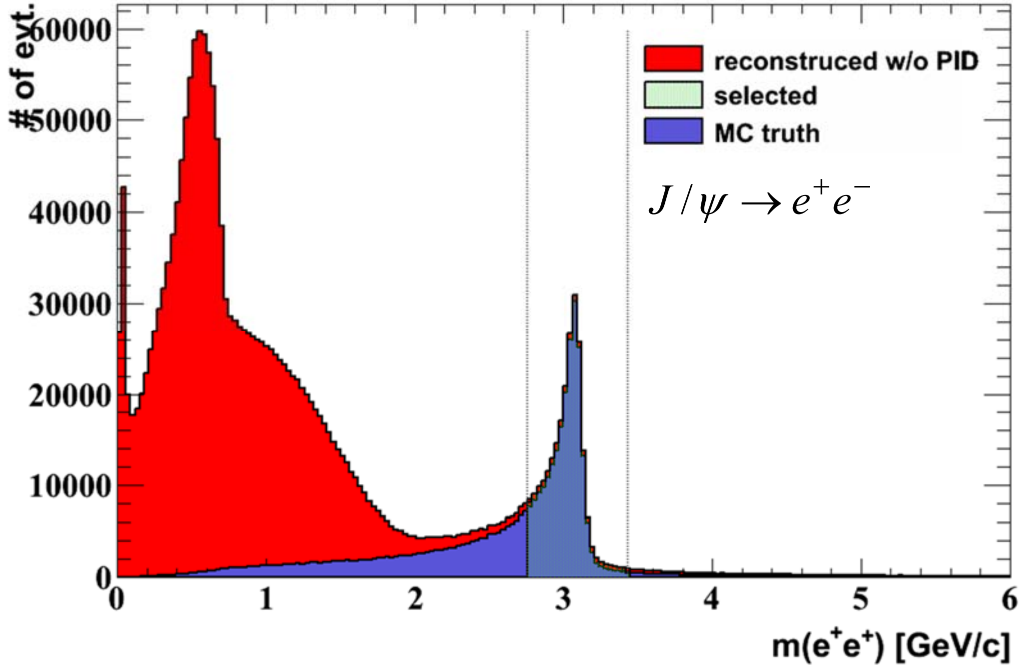


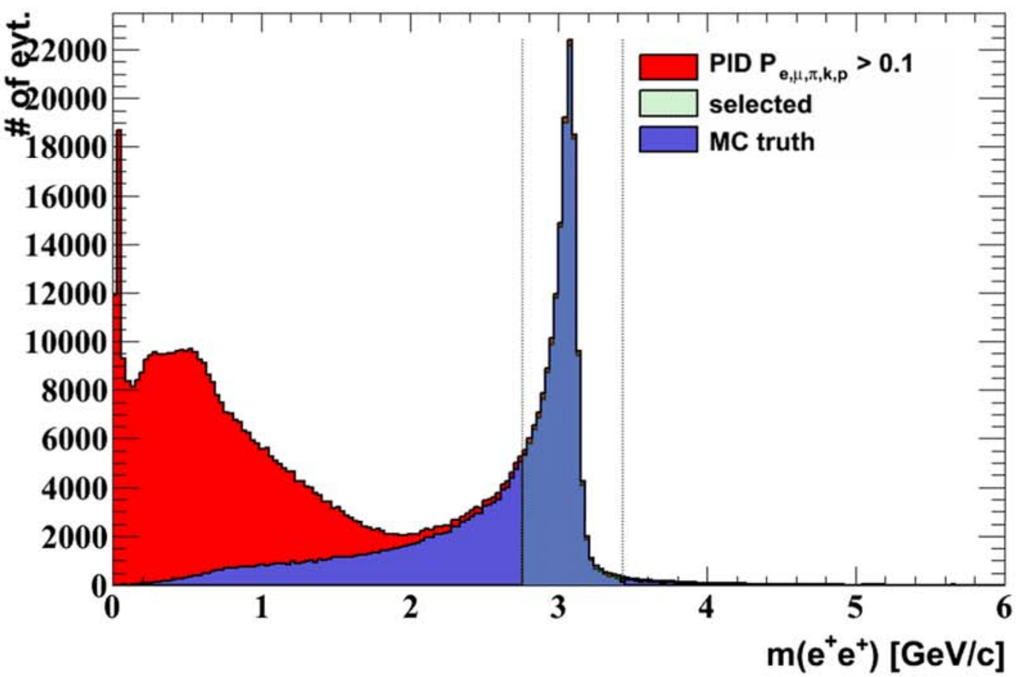


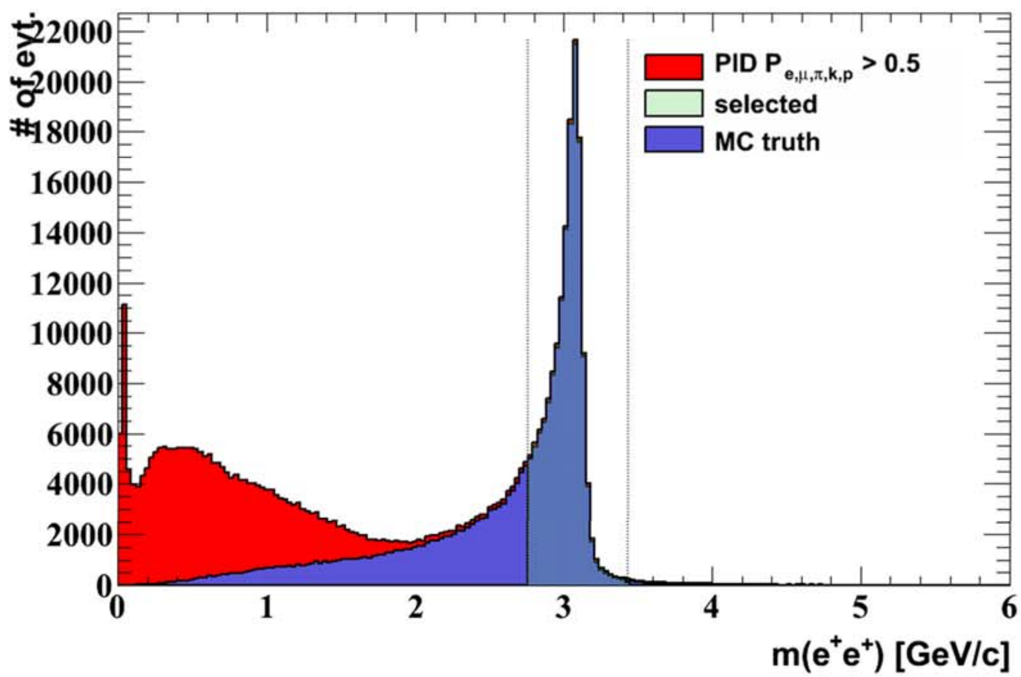


Signal (EvtGen) production

$$\bar{p}p \rightarrow X(3872) \rightarrow J/\psi\pi^+\pi^- \rightarrow e^+e^-\pi^+\pi^-$$

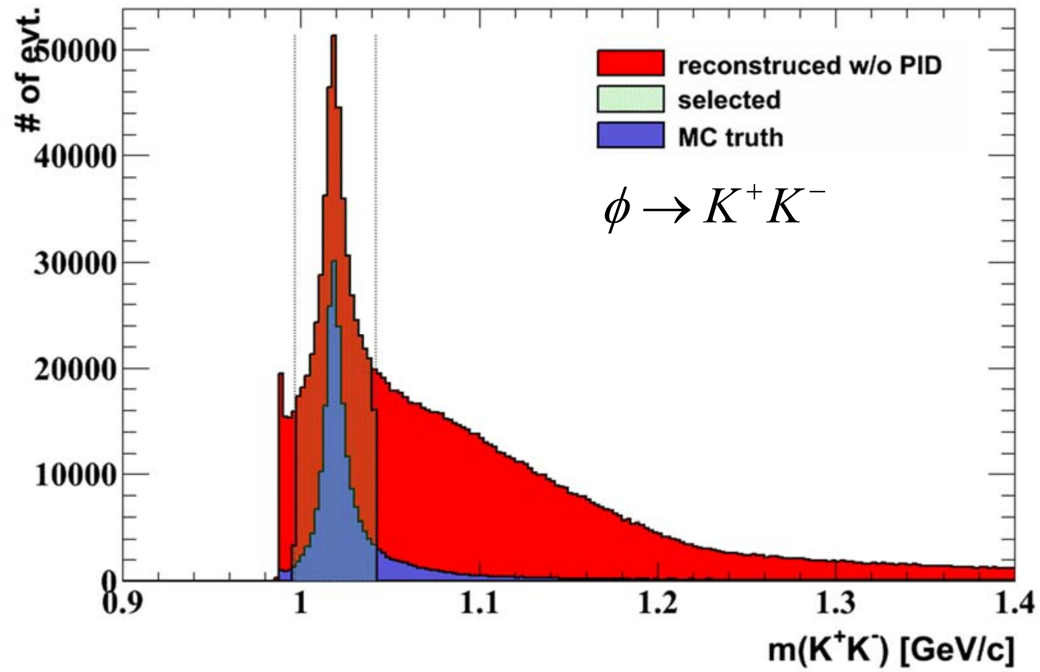


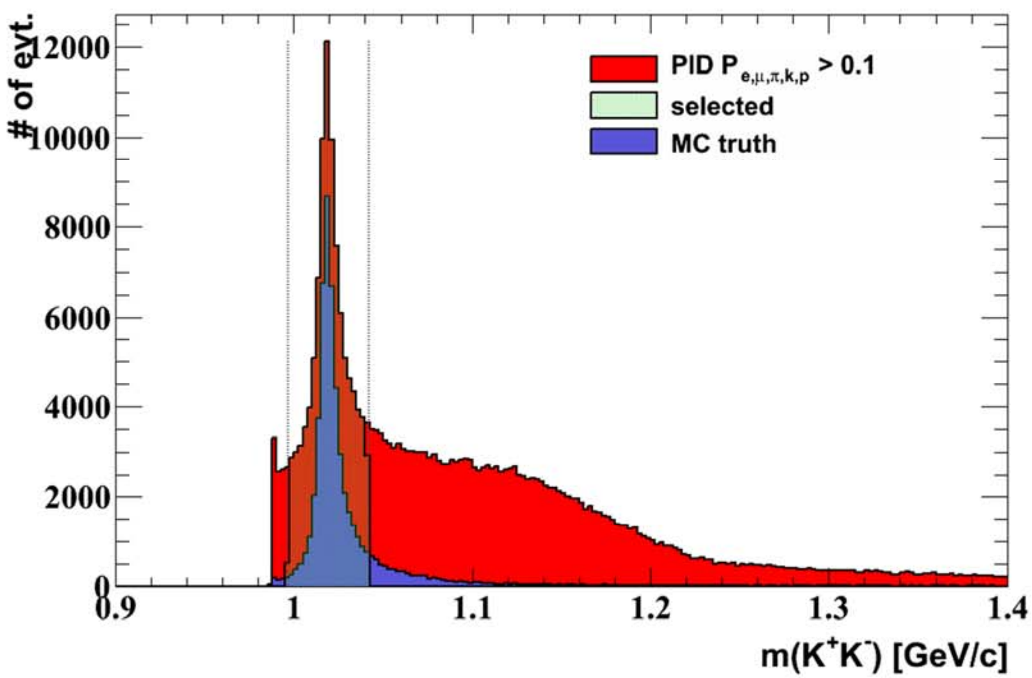


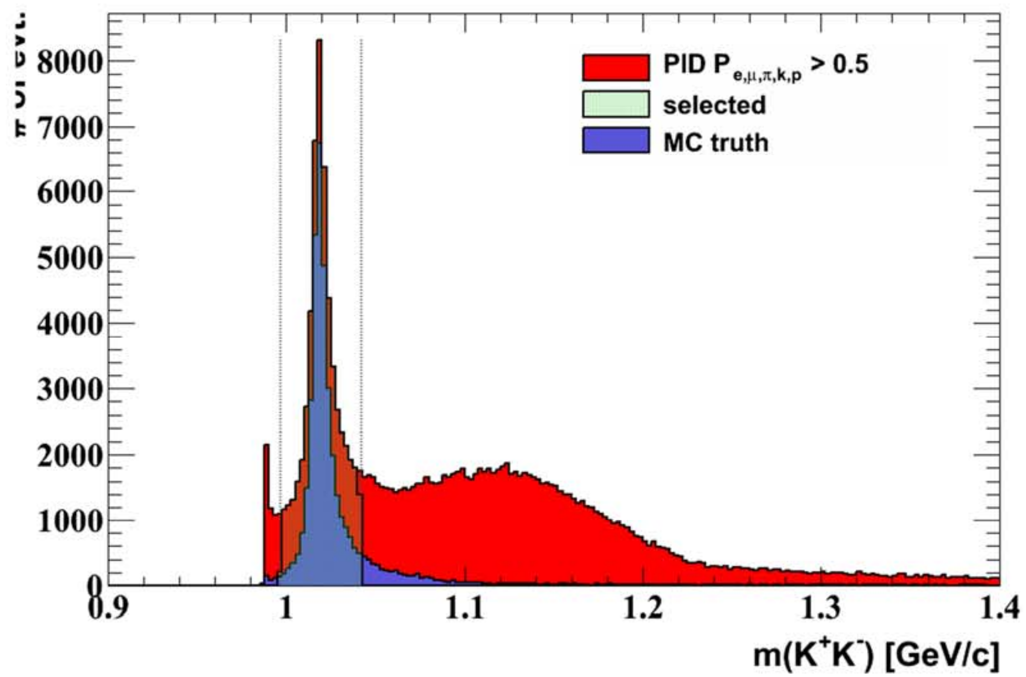


Signal (EvtGen) production

$$\bar{p}p \rightarrow f(2230) \rightarrow \phi\phi \rightarrow K^+K^-K^+K^-$$

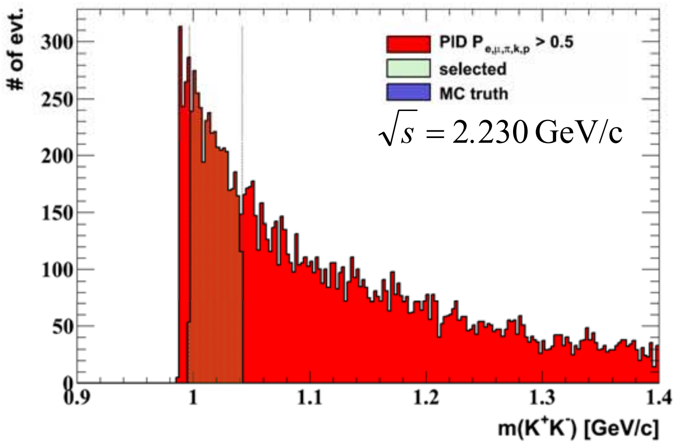


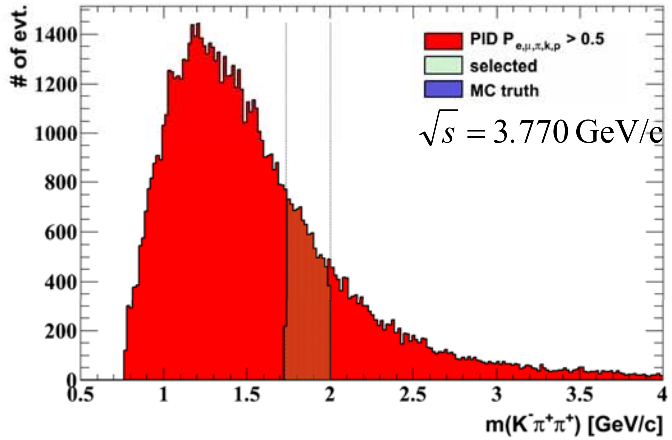


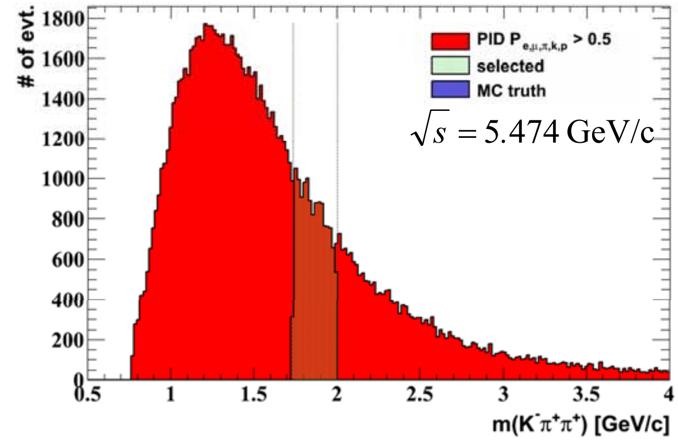


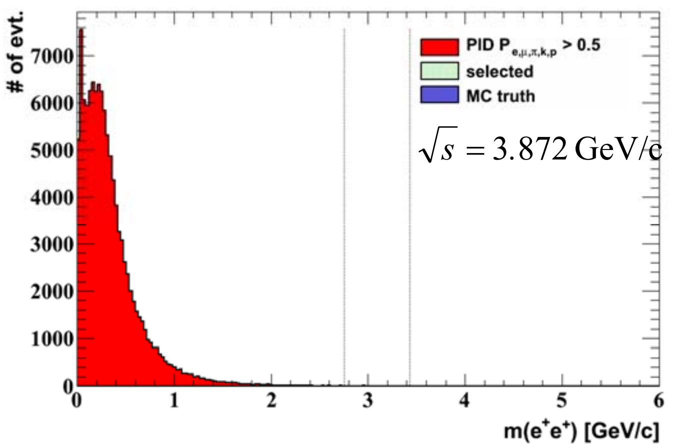
DPM background

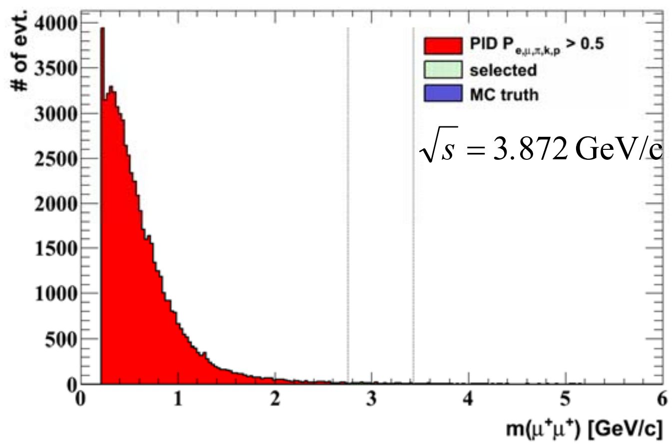
PID cut : $\mathrm{Prob.}(e, \mu, \pi, K, p) > 0.5$

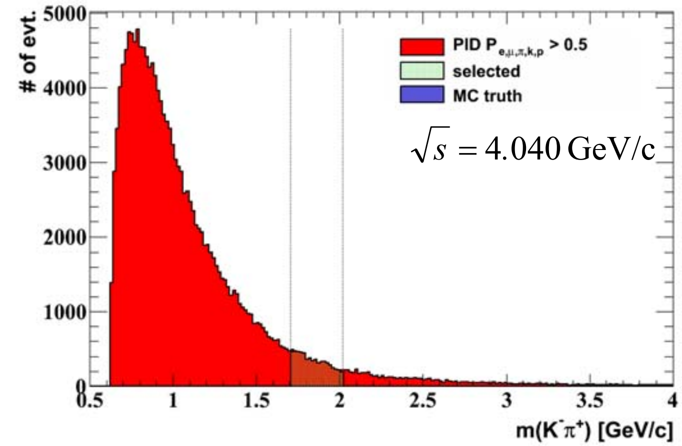












Estimate of misidentification

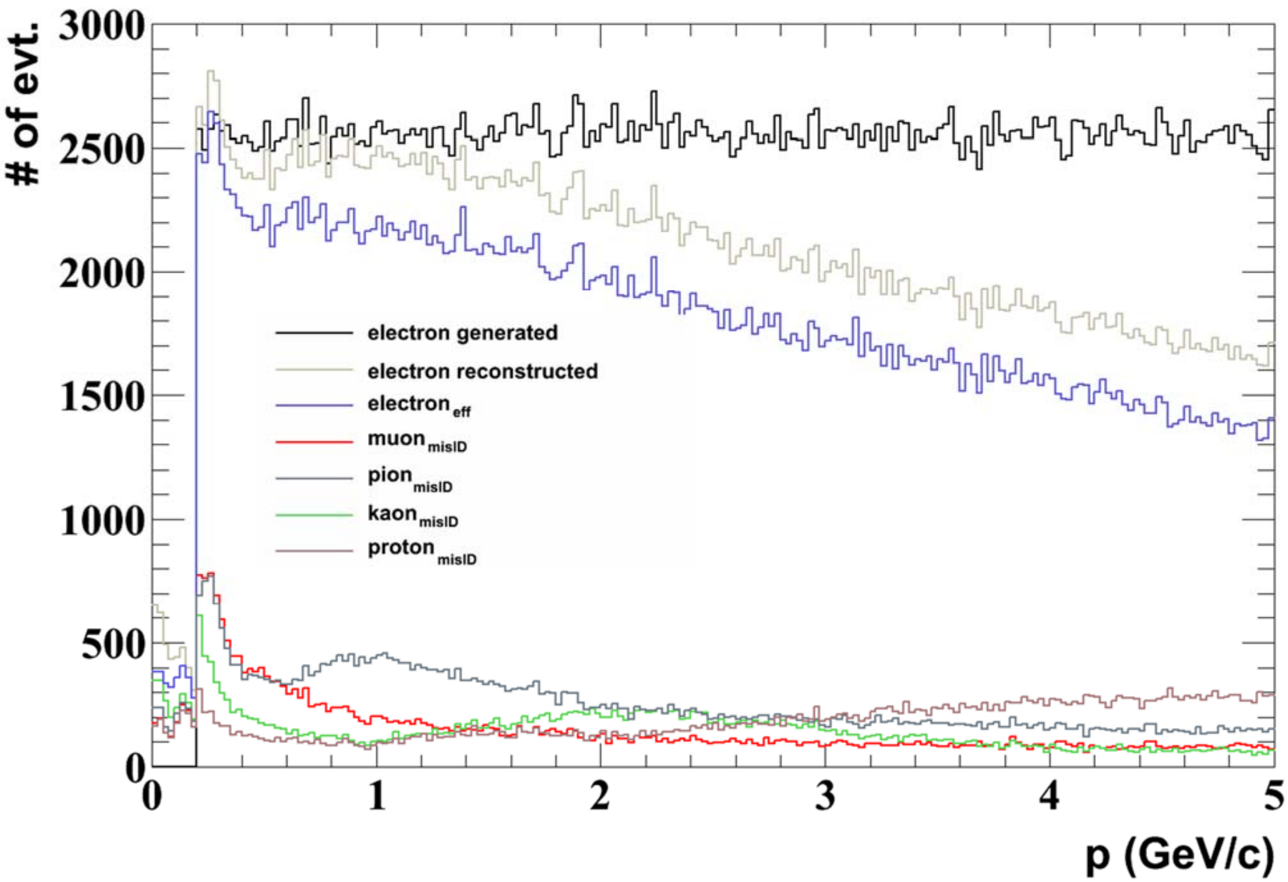
misID for electron

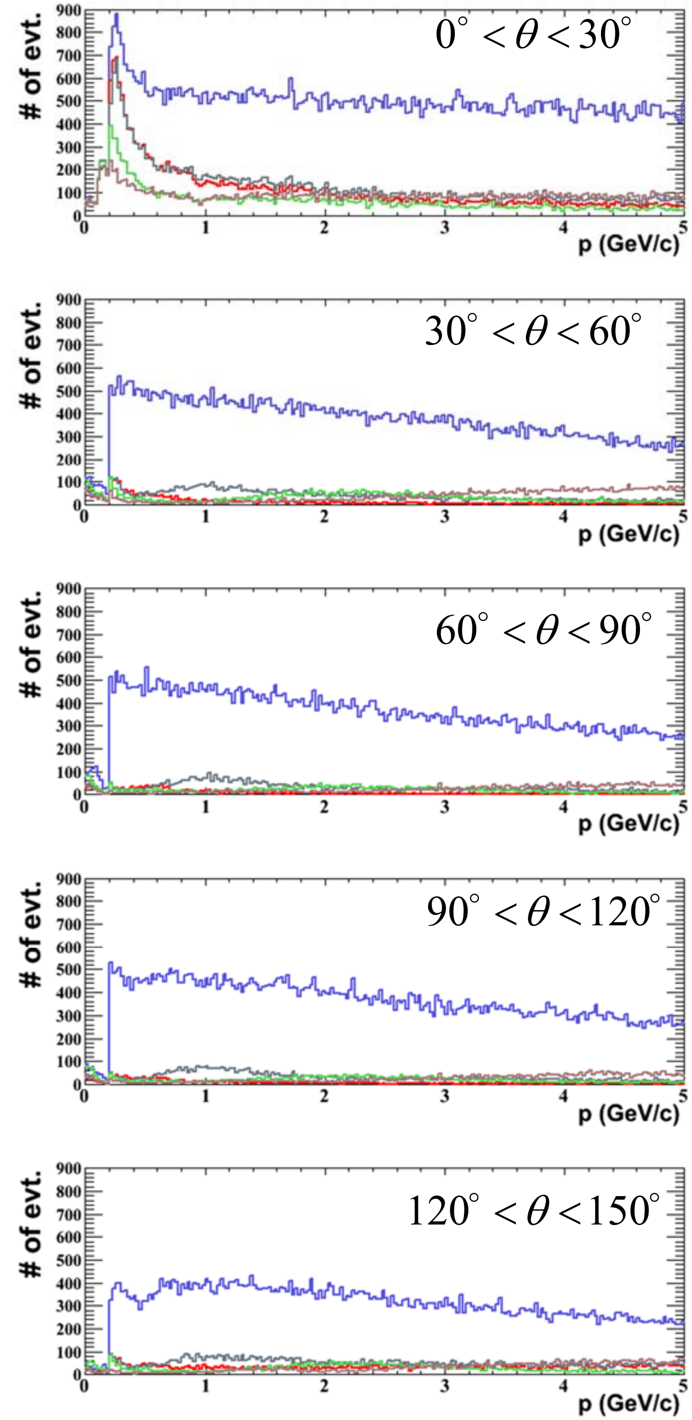
$0.2 < p < 5.0\,(\text{GeV/c})\;;\;\; 1^\circ < \theta < 148^\circ$

applied cut $\text{Prob.}(e, \mu, \pi, K, p) > 0.1$

clone tracks are cleaned up

$$\mu^{e}_{misID} = \frac{\#\text{ of accepted } e \text{ by } \mu \text{ selector}}{\#\text{ of reconstructed } e}$$





Estimate of misidentification

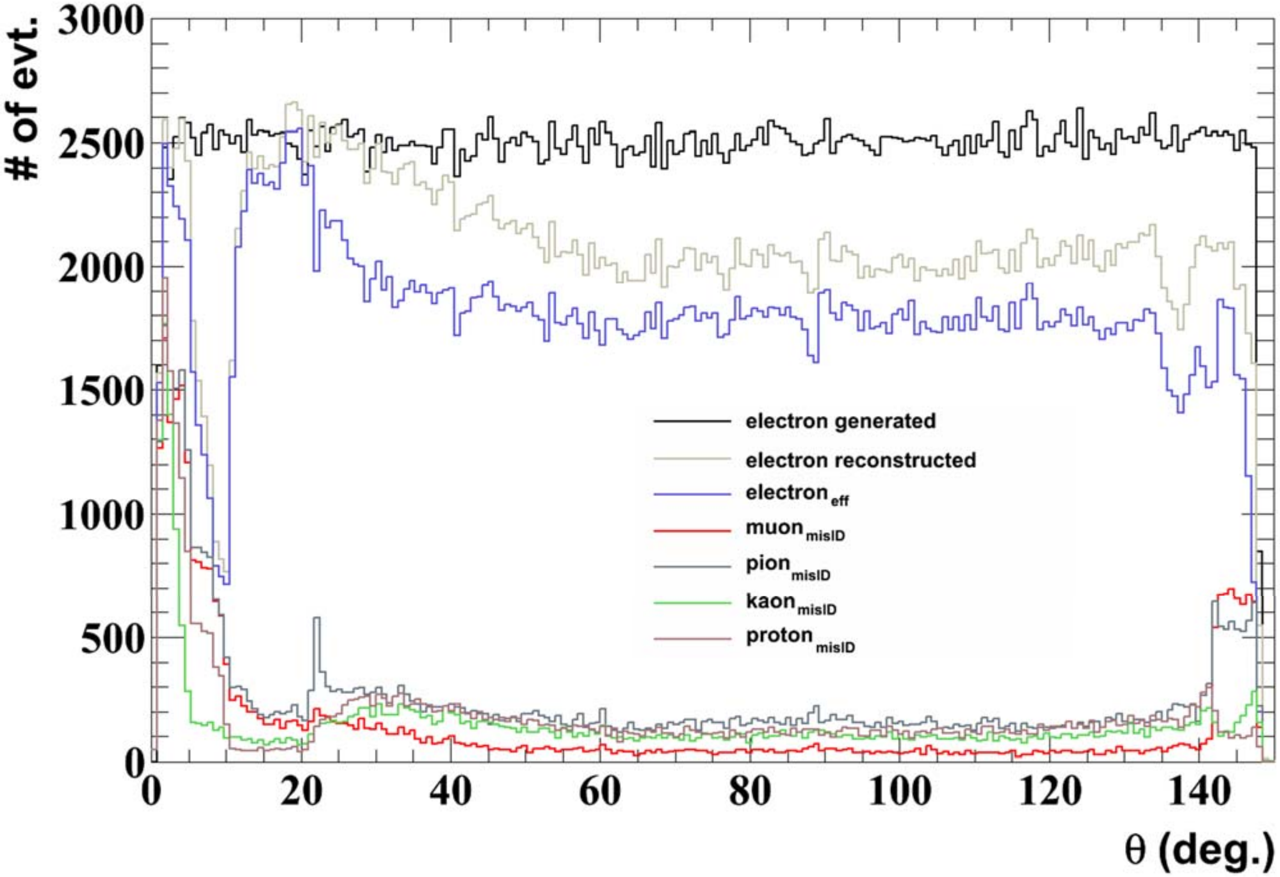
misID for electron

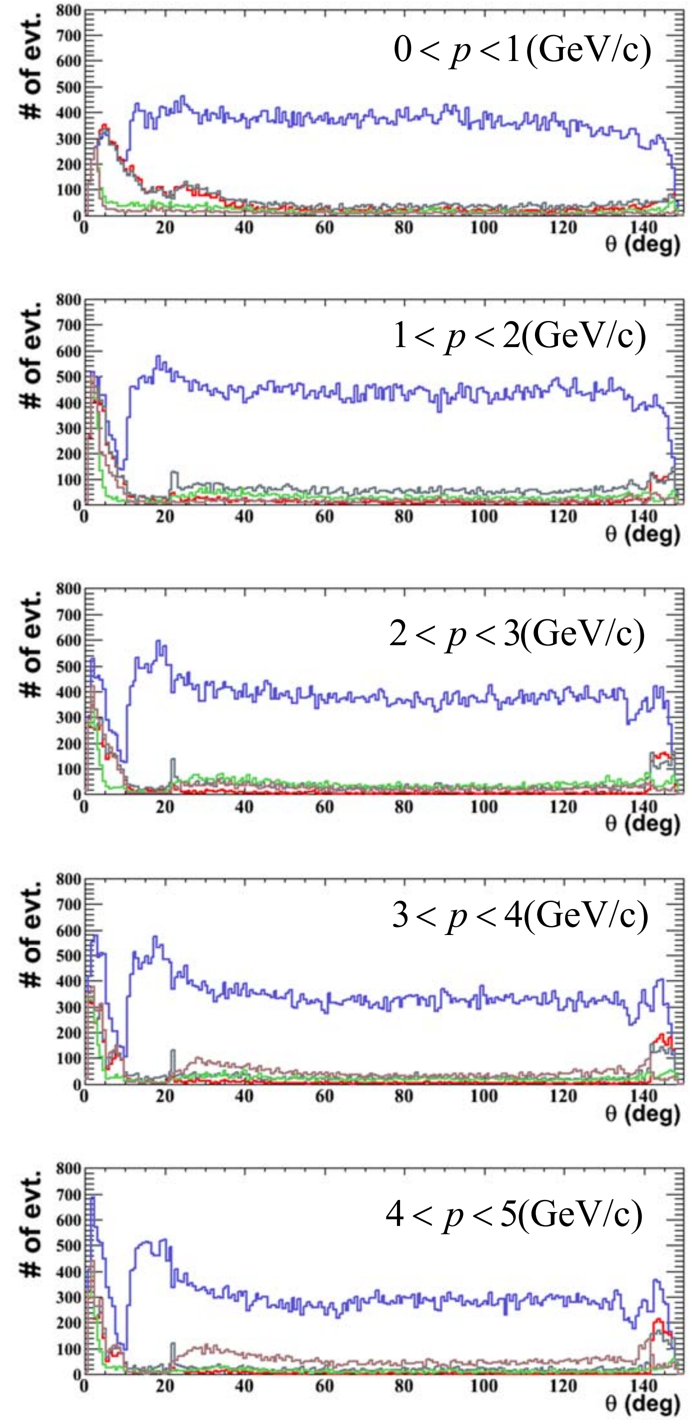
$0.2 < p < 5.0\,(\mathrm{GeV}/c)$; $1^\circ < \theta < 148^\circ$

applied cut $\mathrm{Prob.}(e, \mu, \pi, K, p) > 0.1$

clone tracks are cleaned up

$$\mu^{e}_{misID} = \frac{\#\,\text{of accepted } e \text{ by } \mu \text{ selector}}{\#\,\text{of reconstructed } e}$$





Estimate of misidentification

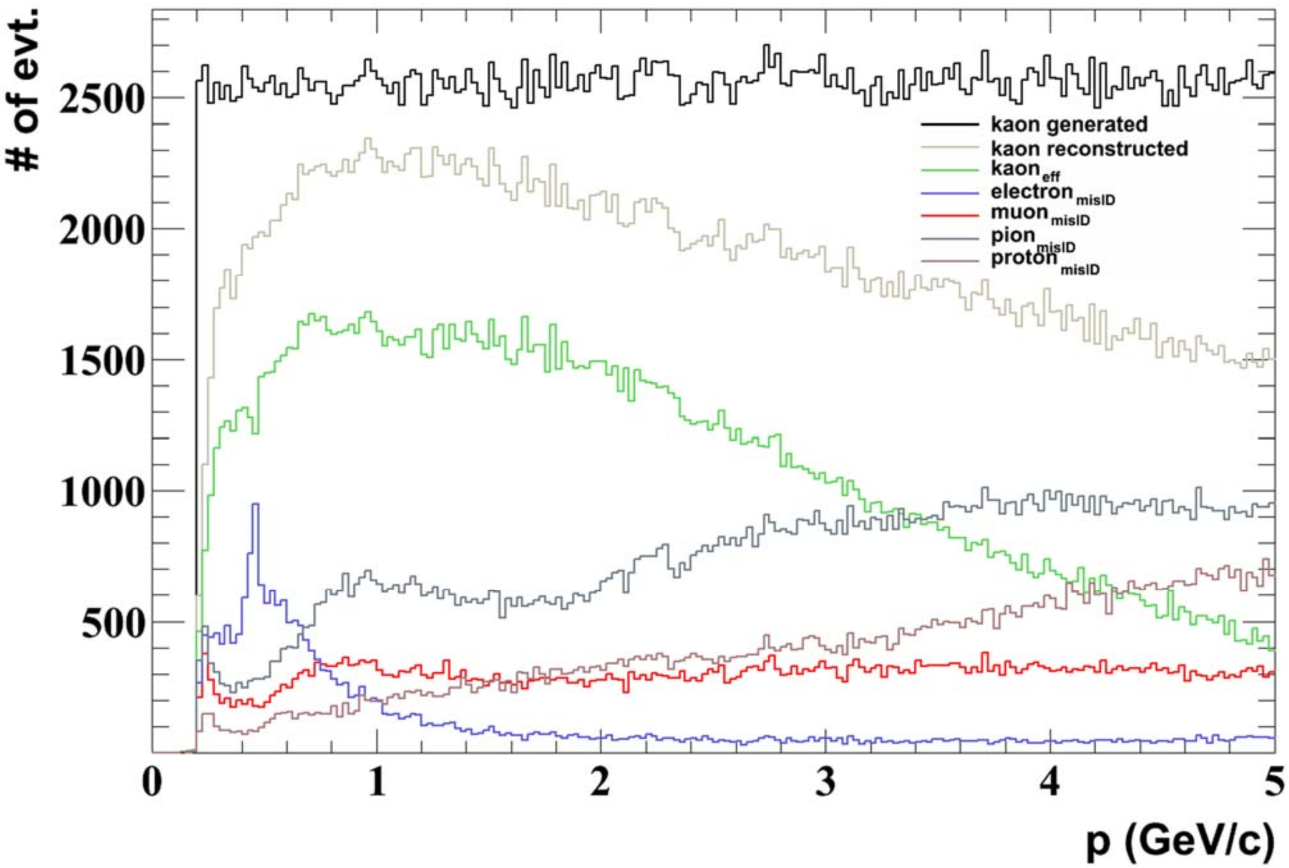
misID for kaon

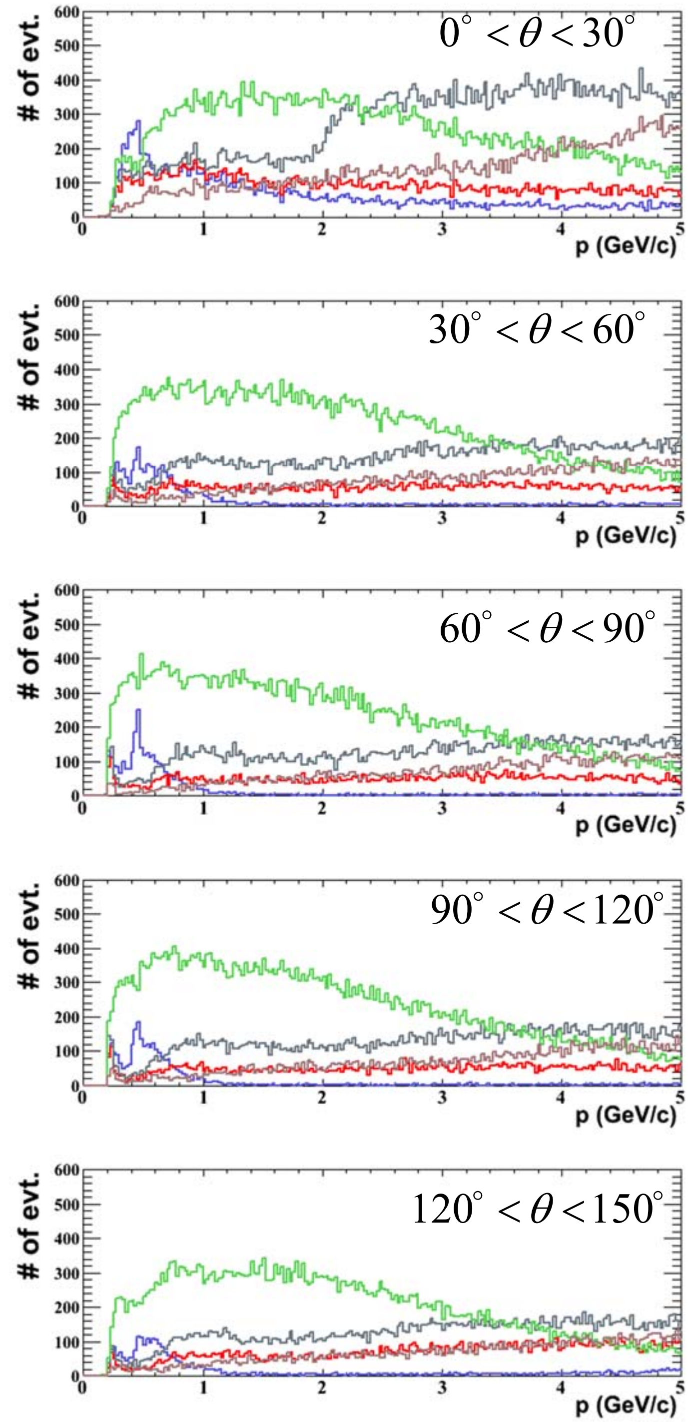
$0.2 < p < 5.0\,(\mathrm{GeV/c})\;;\;\; 1^\circ < \theta < 148^\circ$

applied cut $\mathrm{Prob.}(e,\mu,\pi,K,p) > 0.1$

clone tracks are cleaned up

$$\mu^{K}_{misID} = \frac{\#\,\text{of accepted } K \text{ by } \mu \text{ selector}}{\#\,\text{of reconstructed } K}$$





Estimate of misidentification

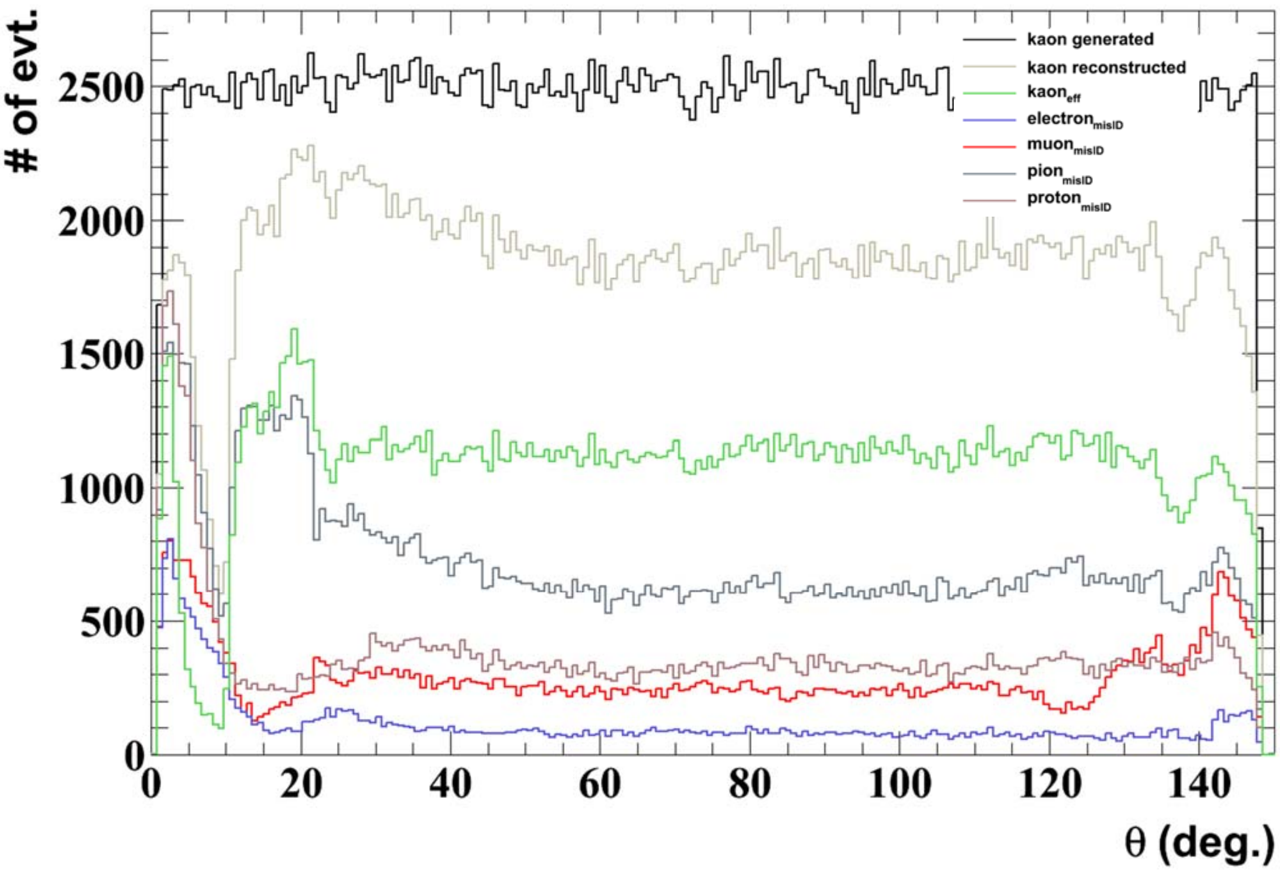
misID for kaon

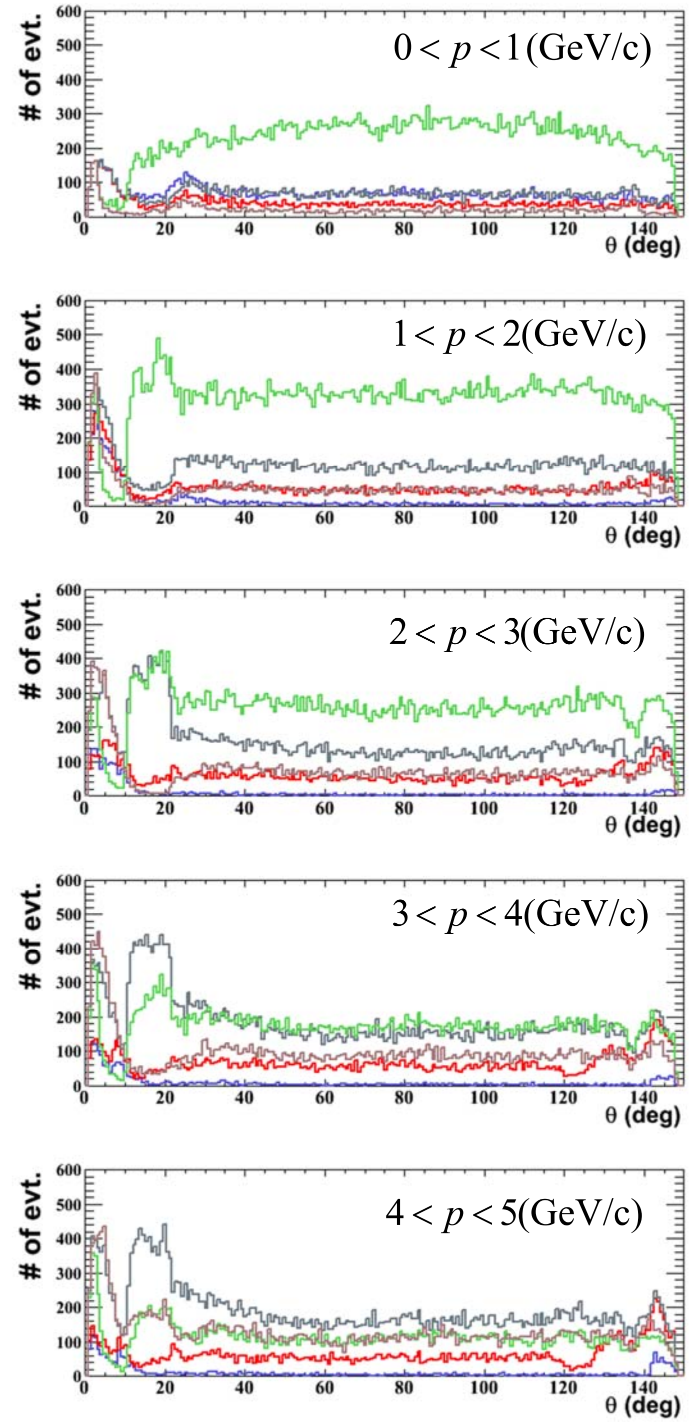
$0.2 < p < 5.0\,(\mathrm{GeV/c})\ ;\ \ 1^{\circ} < \theta < 148^{\circ}$

applied cut $\mathrm{Prob.}(e, \mu, \pi, K, p) > 0.1$

clone tracks are cleaned up

$$\mu^{K}_{misID} = \frac{\#\,\text{of accepted } K \text{ by } \mu \text{ selector}}{\#\,\text{of reconstructed } K}$$





Estimate of misidentification

- realistic misIDs are prepared with the case of Prob.(e,μ,π,K,p) > [0.1 - 0.5]
- positive and negative particle are similar
- strong momentum, theta, and cut value of Prob.(e,μ,π,K,p) dependence

misIDs positive particle @ PANDAroot

$P(e,\mu,\pi,K,p) > 0.1$ — PID reconstructed (columns) vs. MC input (rows)

MC input	e^+	μ^+	π^+	K^+	p
e^+	91.7	7.9	13.4	7.2	8.4
μ^+	7.3	84.6	30.0	6.9	9.2
π^+	9.6	31.0	80.0	14.3	13.5
K^+	6.6	21.4	36.0	59.4	20.4
p	7.2	11.3	18.2	14.2	87.3

misIDs negative particle @ PANDAroot

$P(e,\mu,\pi,K,p) > 0.1$ — PID reconstructed (columns) vs. MC input (rows)

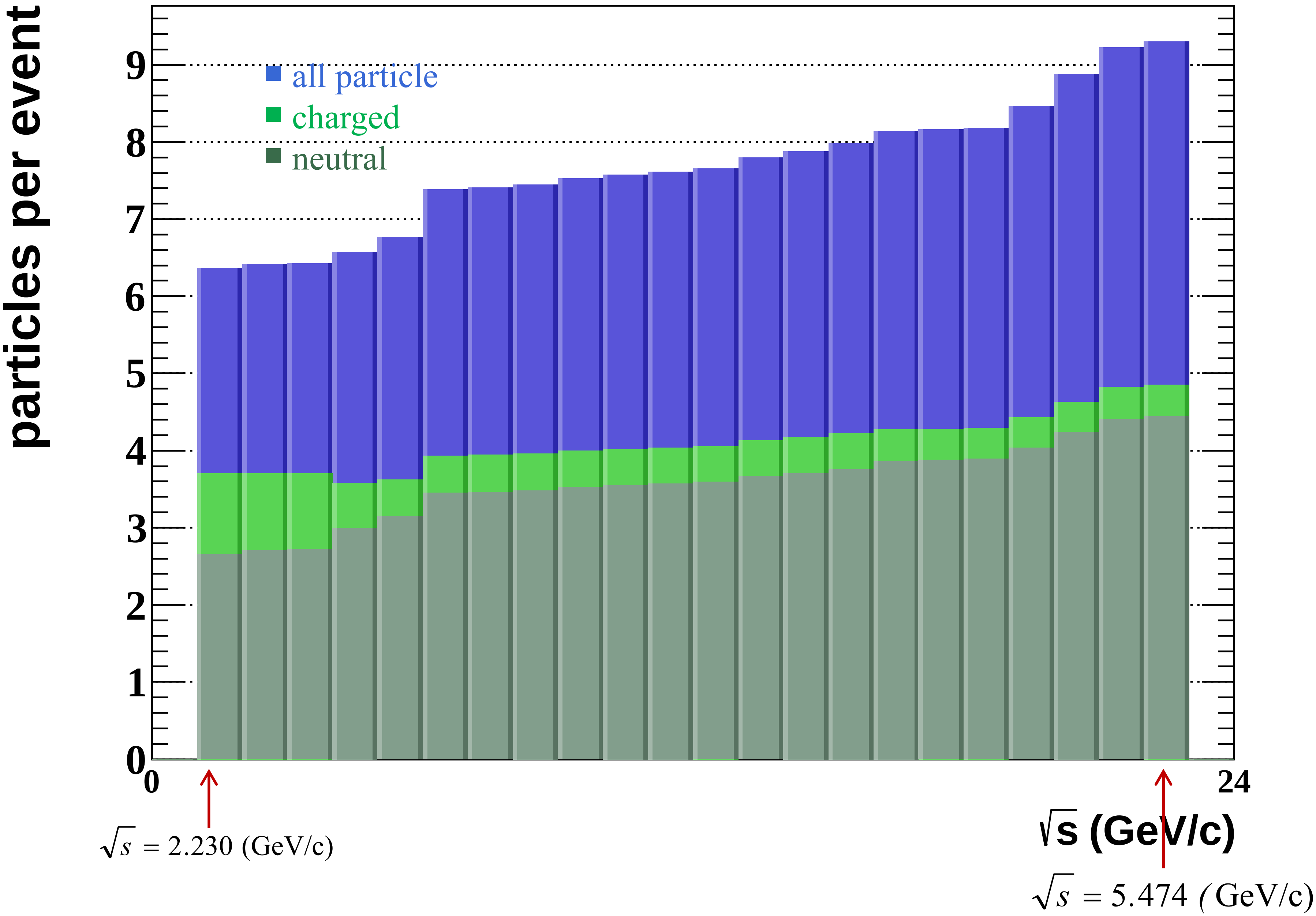
MC input	e^-	μ^-	π^-	K^-	$\bar{p}$
e^-	91.7	7.8	13.1	7.7	9.6
μ^-	7.3	84.6	31.6	6.6	7.8
π^-	9.0	30.4	81.1	14.3	14.6
K^-	6.6	16.3	40.8	61.1	21.1
$\bar{p}$	13.6	9.6	23.0	14.6	76.1

(red) = PID efficiency, off-diagonal =misID

cleaned up clone tracks

Multiplicity for inelastic event

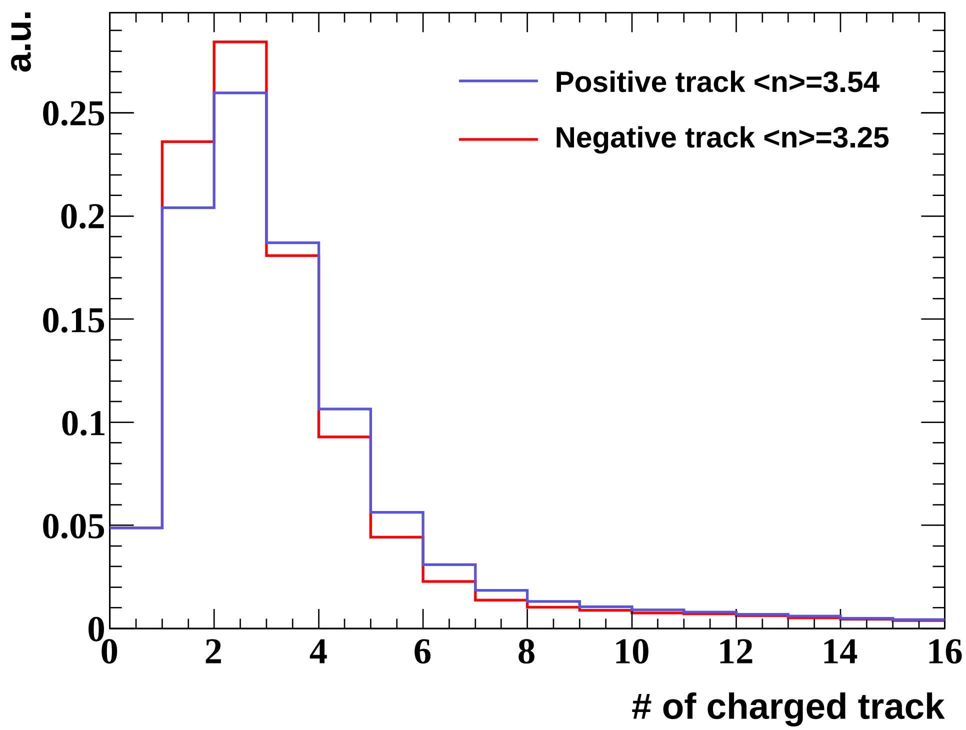
Multiplicity in generator level (DPM 22 data samples)

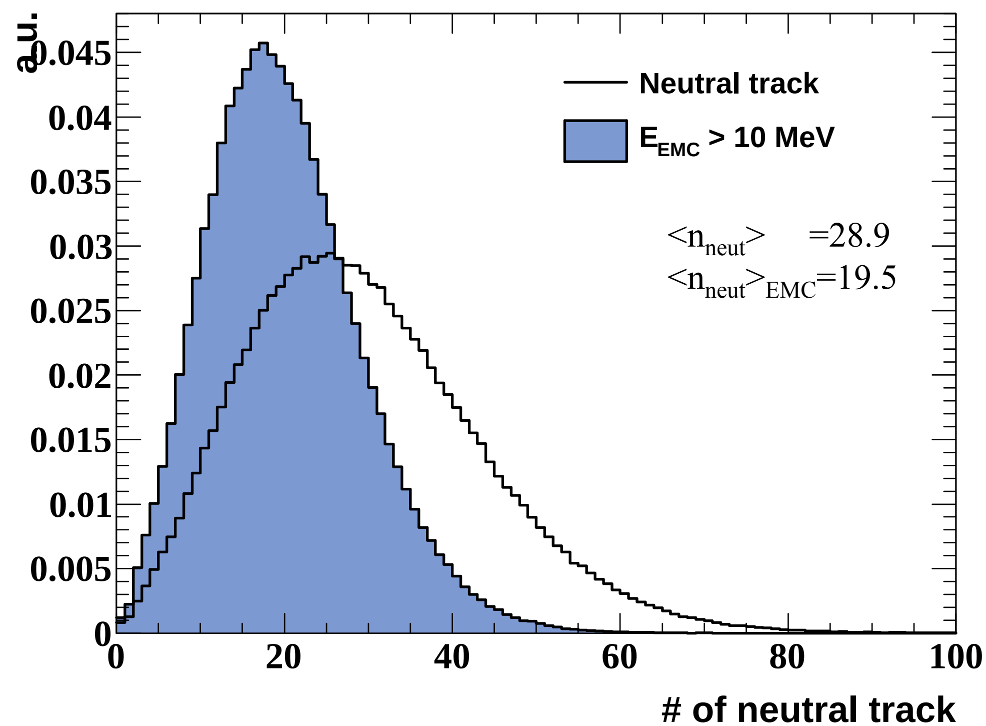


Multiplicity for inelastic event

Multiplicity in the reconstruction level for $p_{\bar{p}} = 15\,\mathrm{GeV/c} \Leftrightarrow \sqrt{s} = 5.474\,\mathrm{GeV}$

before clean up clone tracks





- 2 times larger than generated
- At $p_p = 1.413$ GeV/c
  multiplicity down to
  $\langle n_{pos} \rangle = 1.98$ & $\langle n_{neg} \rangle = 1.96$

- 10 times larger than generated
- At $p_p = 1.413$ GeV/c
  neutral track down to
  $\langle n_{neut} \rangle = 14.7$