Online Software Trigger @ PANDA

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Group meeting, 28. May. 2012

Trigger basic

Level 1 trigger hardware-based

- fastest, keep up full event production in Front-End-Electronics (FEEs)
- discriminate highly in specific hardware : FPGAs & ASIC
- L1 trigger decision sensitive to beam–generated backgrounds

Level 2 trigger mixture of hardware & software

- Level 1 information plus readout from slower detector systems
- Longer processing time, fewer events
- Trigger using fast reconstruction algorithms on
  particle identification, energy deposits, coincidence, multiplicity, vertexing etc.

Level 3 trigger software-based

- Done on PC’s with CPU processes
- Full detector cross-checking
- Errors and incomplete events evaluate with simplified calibrations and geometry
- Output to storage media for physics analysis

Trigger basic

General consideration

- L2 trigger level is being integrated into L1 trigger
  - improvement of network speed and processing time
- Trigger algorithms are generally optimized for specific detectors and experiments
  - no common way
- Parameters
  - background reduction rates
  - physics signature - is the interesting events surely safe?
  - processing time
- Main key feature for trigger development lies on
  - fast response detector systems
  - good capacity of electronics in hardware
  - efficient & fast track finding algorithms in software

Trigger in PANDA

What is the challenging of online software trigger in PANDA?

- high event rate : 20 ~ 100 MHz ($N = \sigma \cdot L$)

  20 MHz average rate = 1 event in every 50 ns

- no first level hardware trigger : continuous data stream

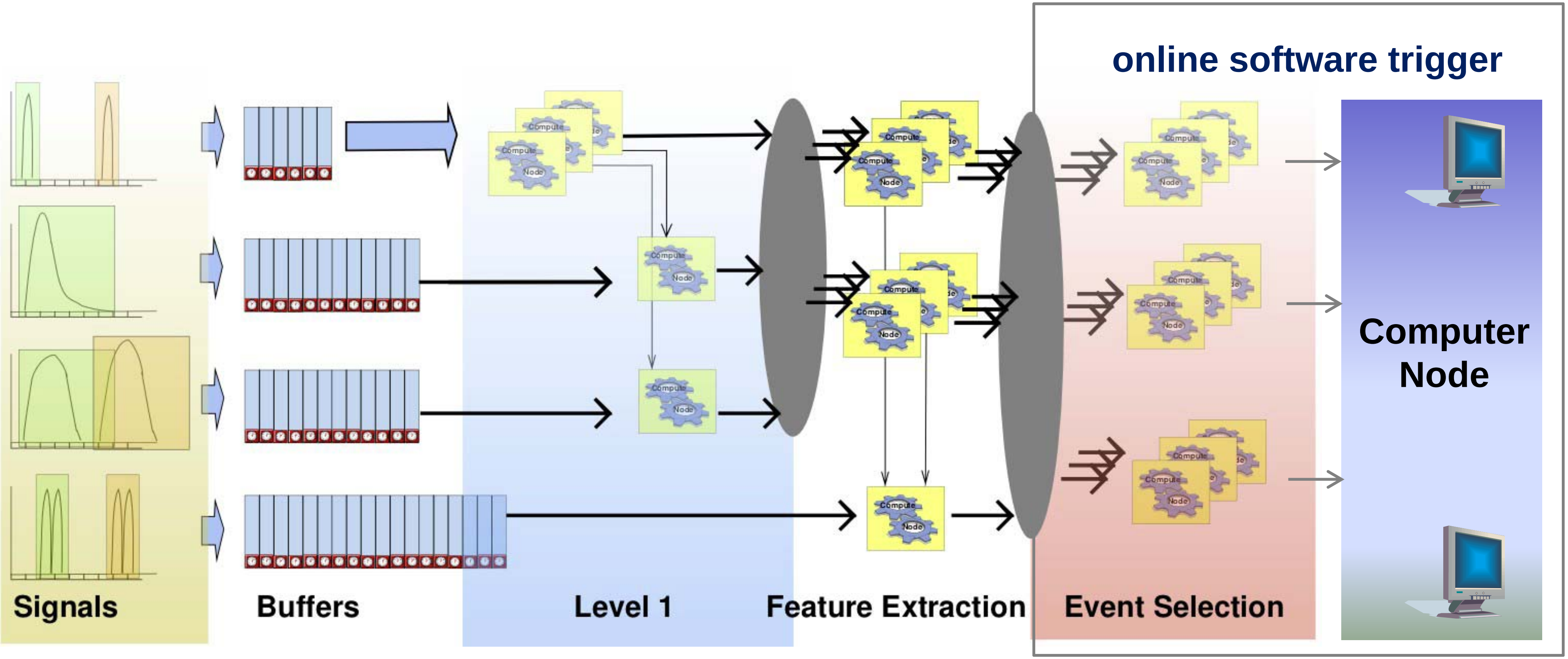
- only online software trigger in high level!

- data sorted by time stamp – but no start time t_0 from any detector

- high level software trigger require reconstruction and pattern recognition to be performed online, analyzing data streams under real time condition

PANDA DAQ

DAQ concept in PANDA



- Online software trigger means
  event building with track finding algorithms
  event selection with background rejection algorithms
- should be performed before, at, or after CN

Event building

realistic event building strategy

1st level

define t_0 (event time) and spatial information with SciTil

preparing seed(ϕ,z) for pattern recognition

2nd level

discrimination of charged and neutral particles by means of EMC correlation

photon conversion at DIRC

3rd level

central tracks from STT, MVD

Helix track → circle in 2D → conformal transformation → hough transformation

forward tracks using relative timing w/o. SciTil or from absolute timing w. forward ToF wall

4th level

PID detectors
- DIRC
- MDT
- dE/dx : STT, MVD
- E/p : EMC

5th level

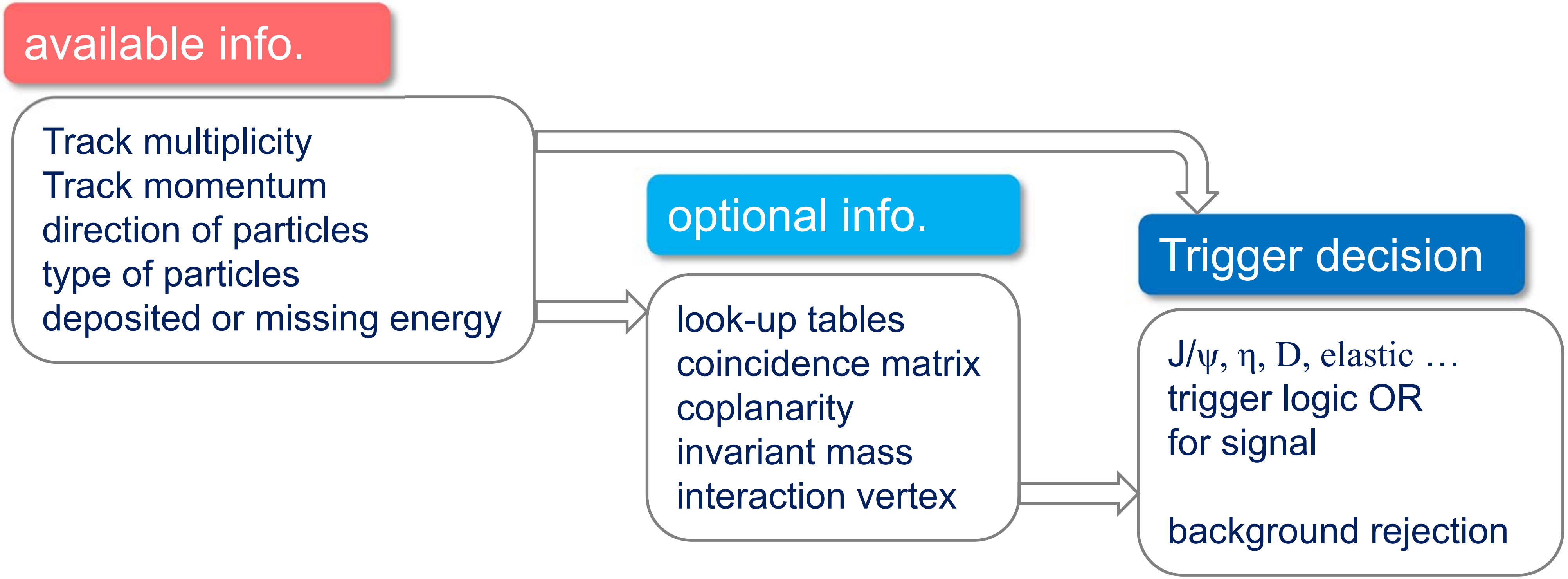
up to now, a local trigger signals can be generated, then will send to central trigger system

timing operations need to be done : helping from central trigger system

different latencies

Physics trigger @ online

Trigger on event topology after event building : physics trigger



available info.

Track multiplicity
Track momentum
direction of particles
type of particles
deposited or missing energy

optional info.

look-up tables
coincidence matrix
coplanarity
invariant mass
interaction vertex

Trigger decision

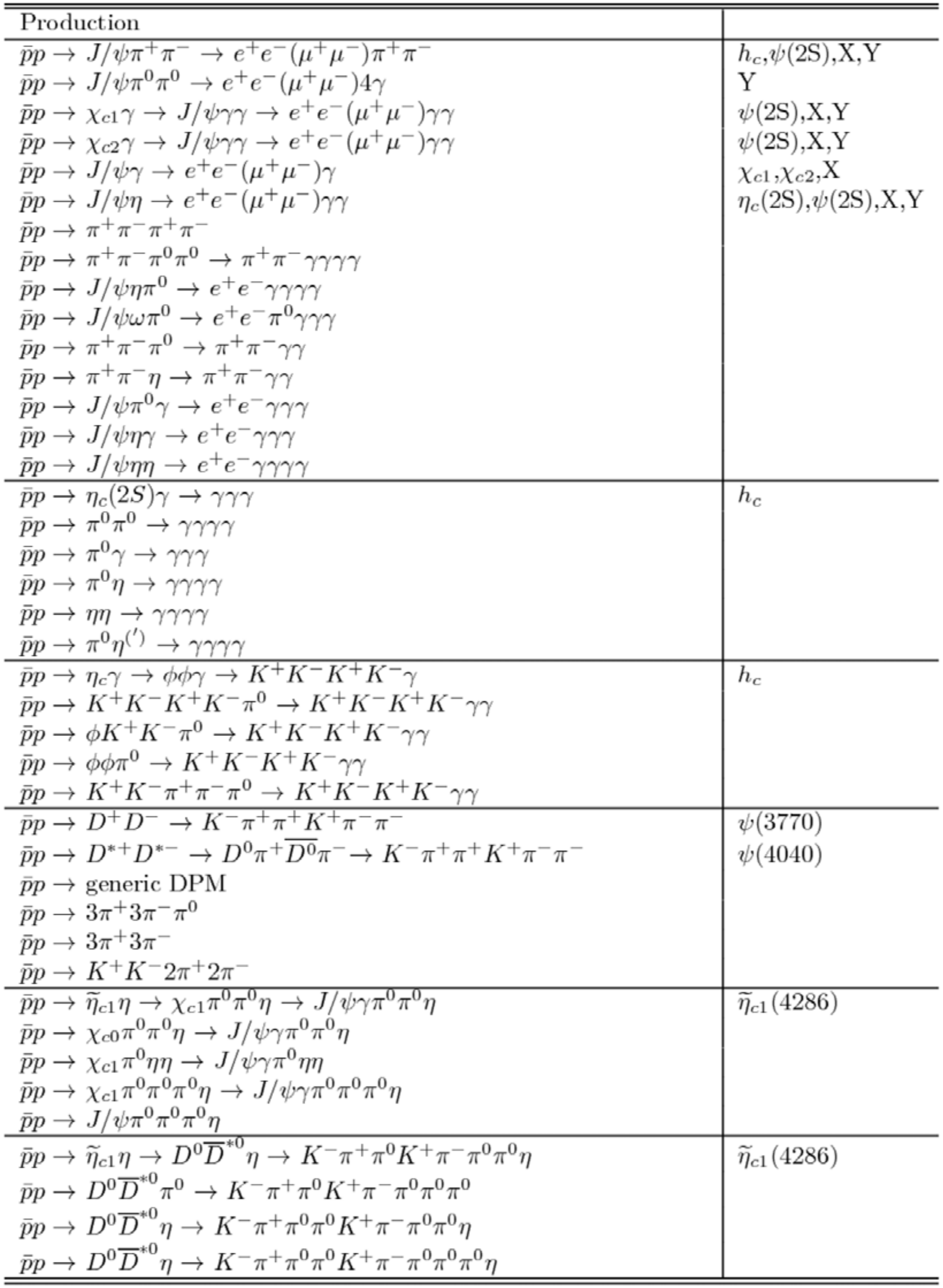
J/ψ, η, D, elastic …
trigger logic OR
for signal

background rejection

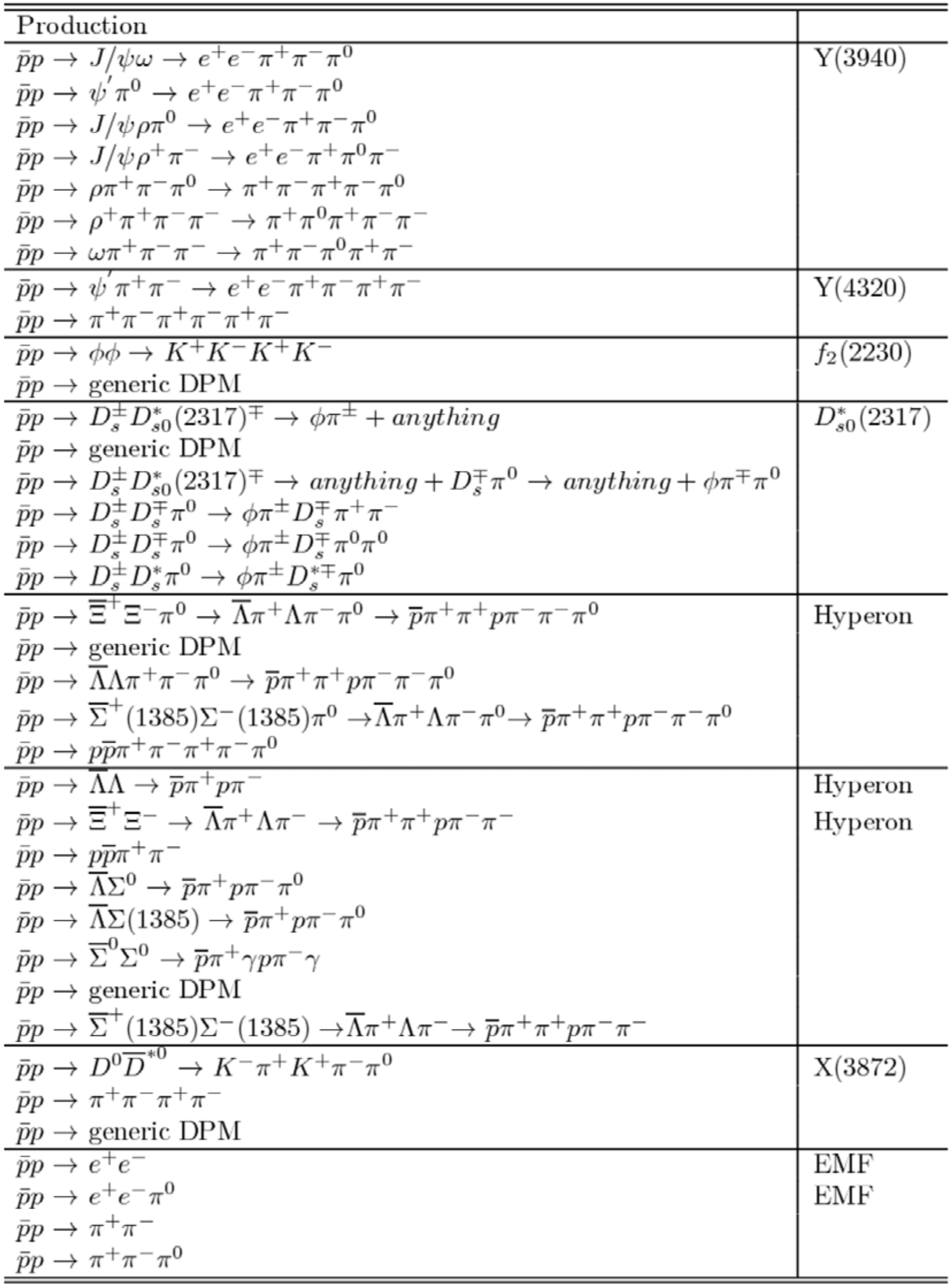
then the implementation will be put into the …

Local Unit with FPGA (VHDL)
Computer Node based on FPGA (VHDL)
Commercial Grid Computer (C++ online)
GPU parallel computing (CUDA)

Physics benchmark 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)
$\bar{p}p \to \psi^{\prime}\pi^0 \to e^+e^-\pi^+\pi^-\pi^0$	
$\bar{p}p \to J/\psi\rho\pi^0 \to e^+e^-\pi^+\pi^-\pi^0$	
$\bar{p}p \to J/\psi\rho^+\pi^- \to e^+e^-\pi^+\pi^0\pi^-$	
$\bar{p}p \to \rho\pi^+\pi^-\pi^0 \to \pi^+\pi^-\pi^+\pi^-\pi^0$	
$\bar{p}p \to \rho^+\pi^+\pi^-\pi^- \to \pi^+\pi^0\pi^+\pi^-\pi^-$	
$\bar{p}p \to \omega\pi^+\pi^-\pi^- \to \pi^+\pi^-\pi^0\pi^+\pi^-$	
$\bar{p}p \to \psi^{\prime}\pi^+\pi^- \to e^+e^-\pi^+\pi^-\pi^+\pi^-$	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
$\bar{p}p \to \pi^+\pi^-$	
$\bar{p}p \to \pi^+\pi^-\pi^0$	

MC Data

PANDA physics book

- 118 physics benchmark channels (data sets with both signal & background)

- 22 beam momentum
  p_{min} = 1.431 GeV/c, … p_{mac} = 15.0 GeV/c

- 6 DPM MC
  10 M events / channels

- 2 extra physics channel (EMF e+e- and X(3872) -> D*D)

- 10 selection algorithms

$$D^0(K\pi) \quad D_s(\phi\pi) \quad \phi(K^+K^-) \quad D^0(K\pi\pi^0) \quad h_c(\eta_c\gamma \to \gamma\gamma\gamma)$$

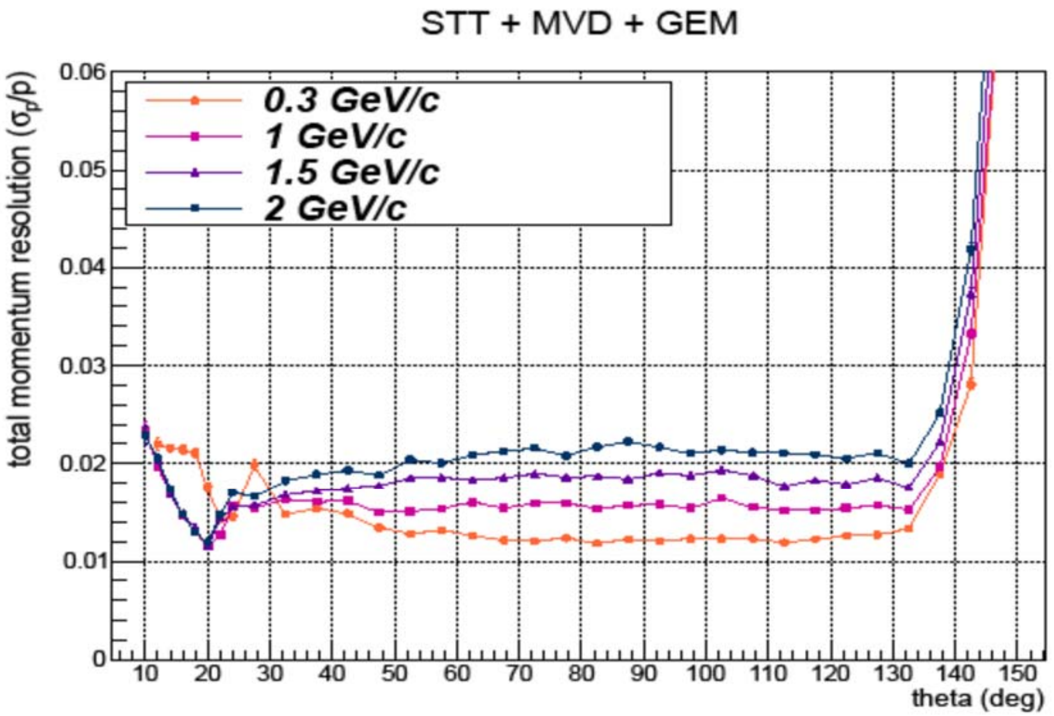
$$J/\psi(e^+e^-) \quad D^\pm(K\pi\pi) \quad e^+e^- \quad J/\psi(\pi^+\pi^-\pi^0) \quad \Lambda(p\pi)$$

online tracking so far…

momentum resolution

offline

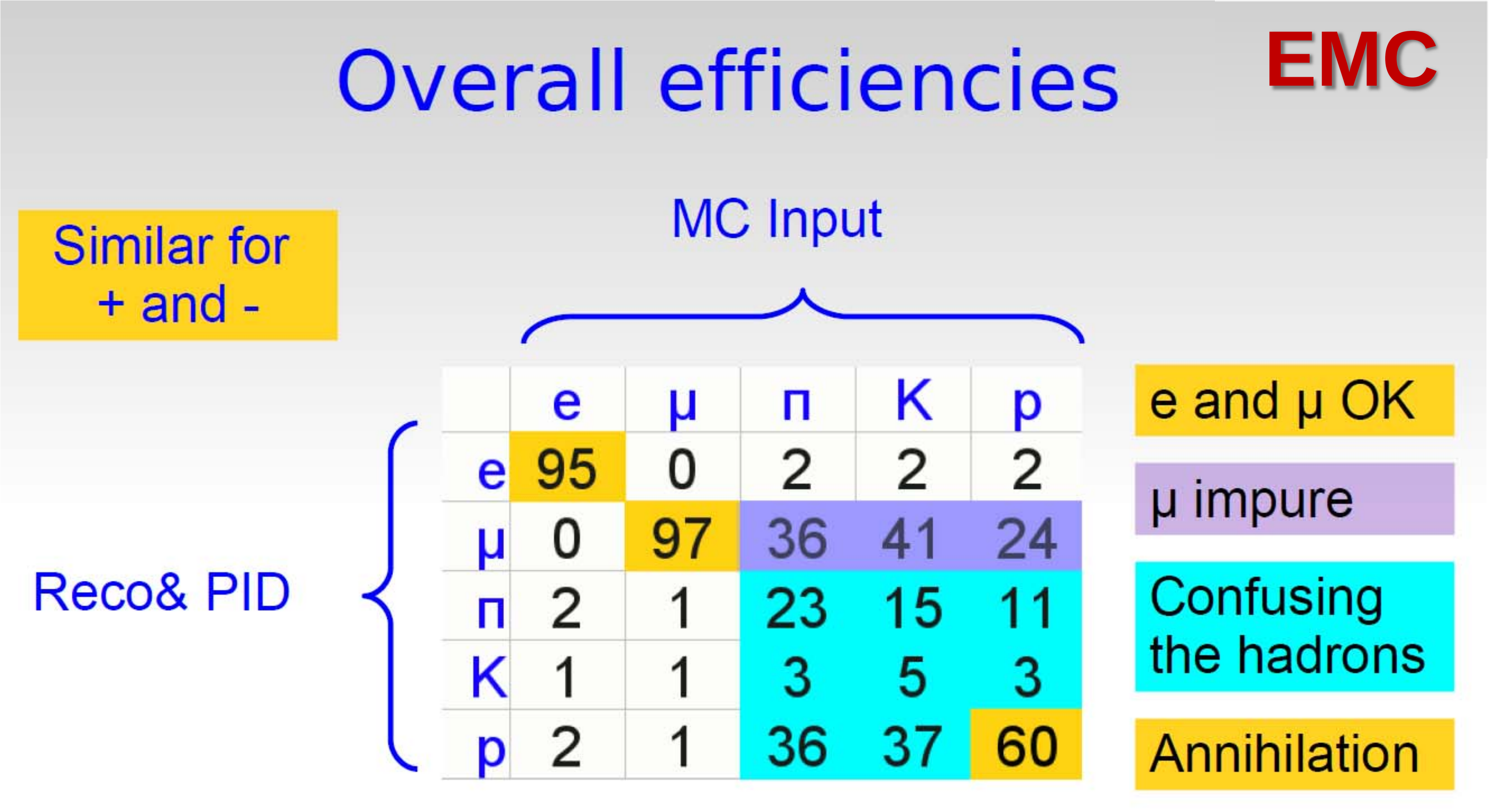
mom. resolution
in offline : 1~3%



online (FPGA Helix tracking @ barrel)

$p_T(\theta)$	1 GeV/c	2 GeV/c	5 GeV/c
$\Delta P/P$	3.8%	5.5%	12.2%

available PID



Overall efficiencies

EMC

Similar for + and -

MC Input

Reco& PID

	e	μ	π	K	p
e	95	0	2	2	2
μ	0	97	36	41	24
π	2	1	23	15	11
K	1	1	3	5	3
p	2	1	36	37	60

e and μ OK

μ impure

Confusing the hadrons

Annihilation

- EMC PID at online should be same as like offline (at least gamma)

- Seeking to find out hadron PID using DIRC, dE/dx(STT, MVD), ToF

- At the moment. 5 X 5 simple PID probability, impurity can be varied

PID application

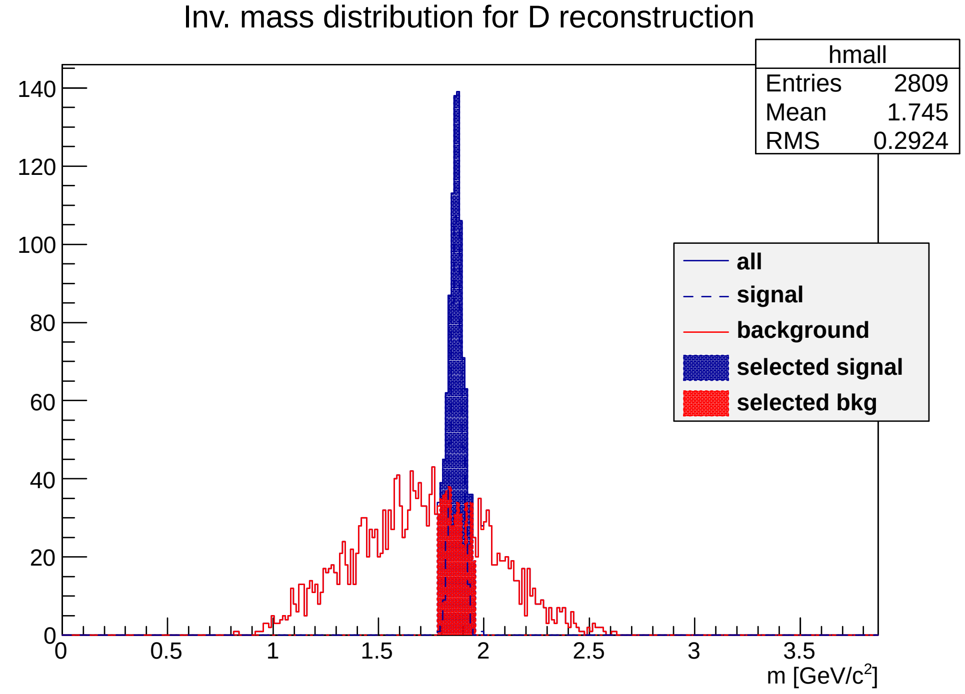
$$\bar{p}p \rightarrow \psi(3770) \rightarrow D^{+}D^{-} \rightarrow K^{-}\pi^{+}\pi^{+}K^{+}\pi^{-}\pi^{-}$$

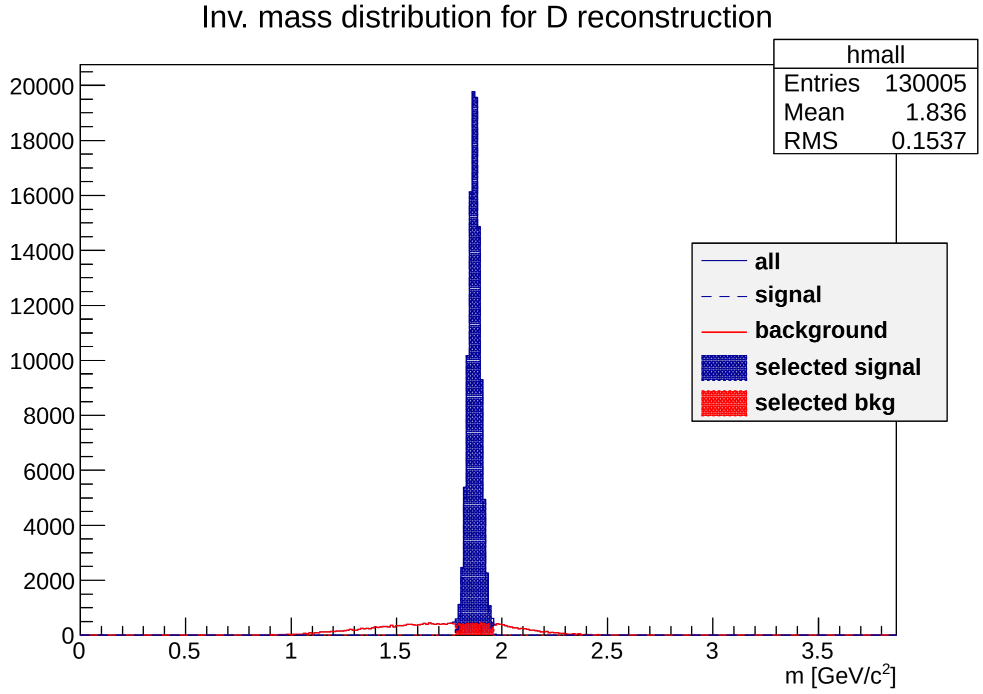
EMC value

pion 23% & kaon 6 %

and their impurity

	e	μ	π	K	P
e	80	5	5	5	5
μ	5	80	5	5	5
π	5	5	80	5	5
K	5	5	5	80	5
P	5	5	5	5	80

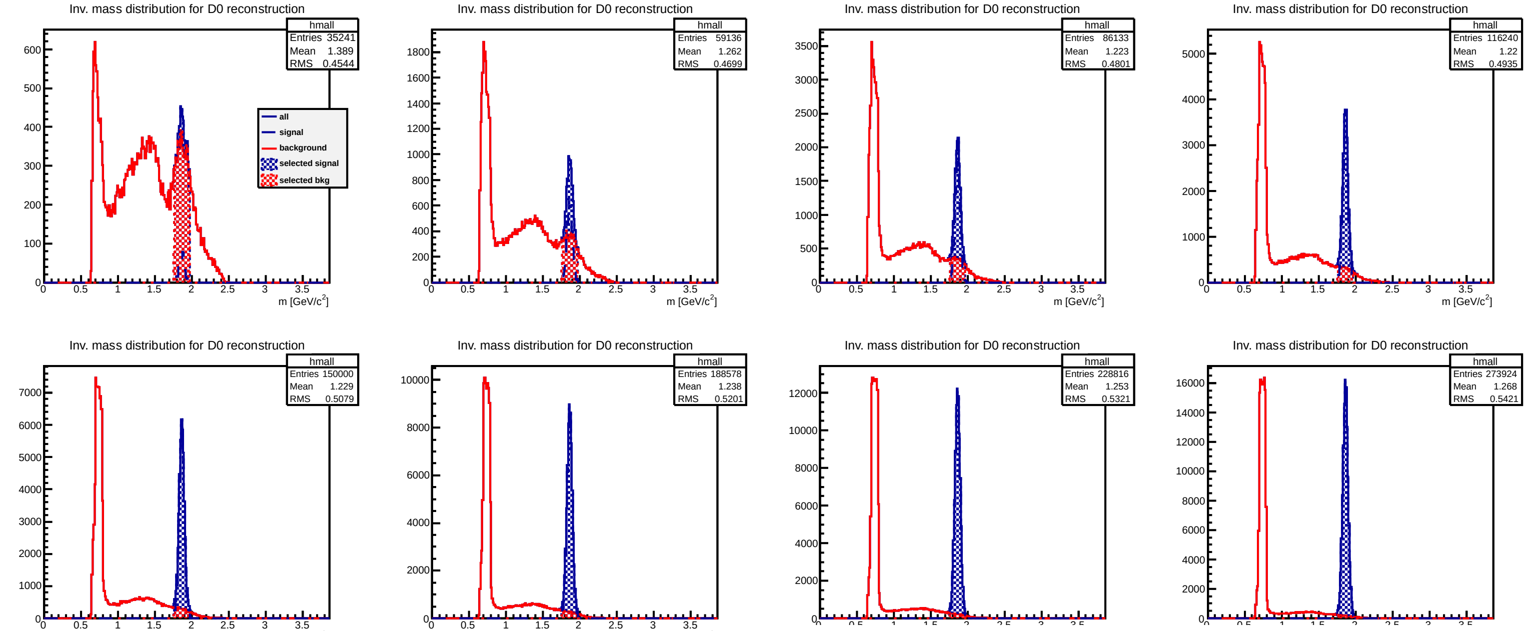




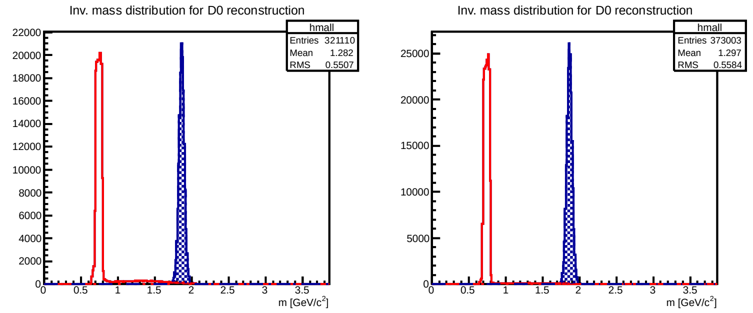
$$\varepsilon_{eff} = 0.923\%$$

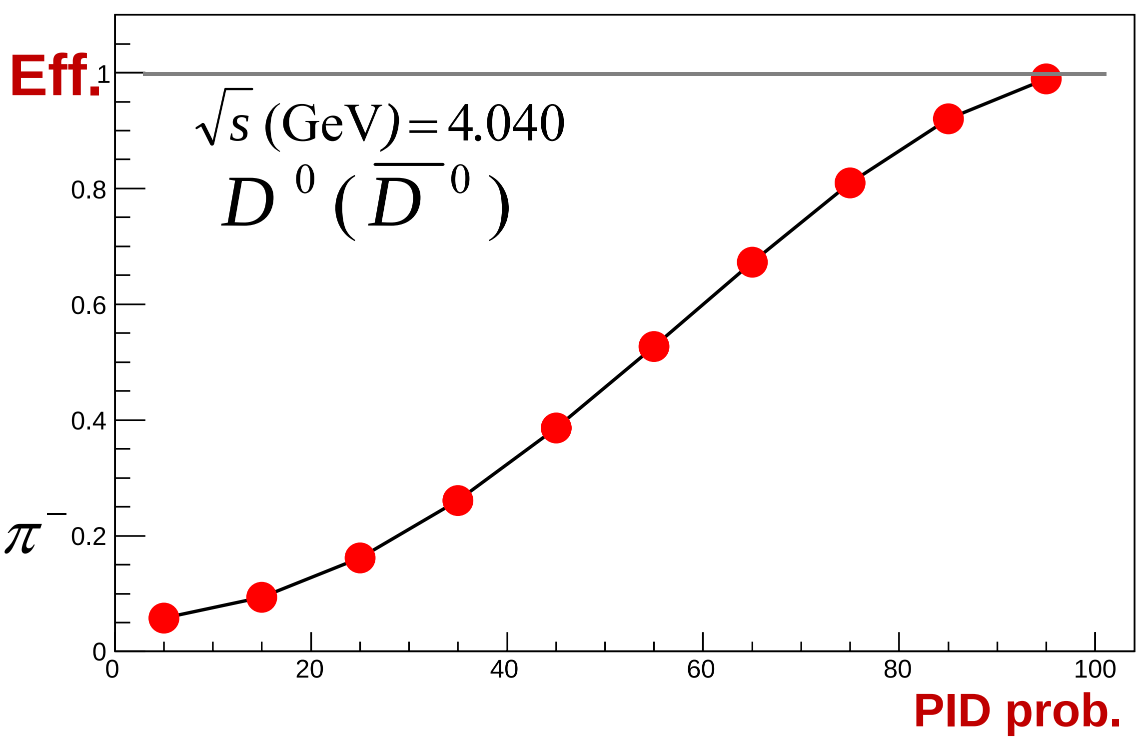
$$\varepsilon_{eff} = 76.7\%$$

PID probability



Siganl

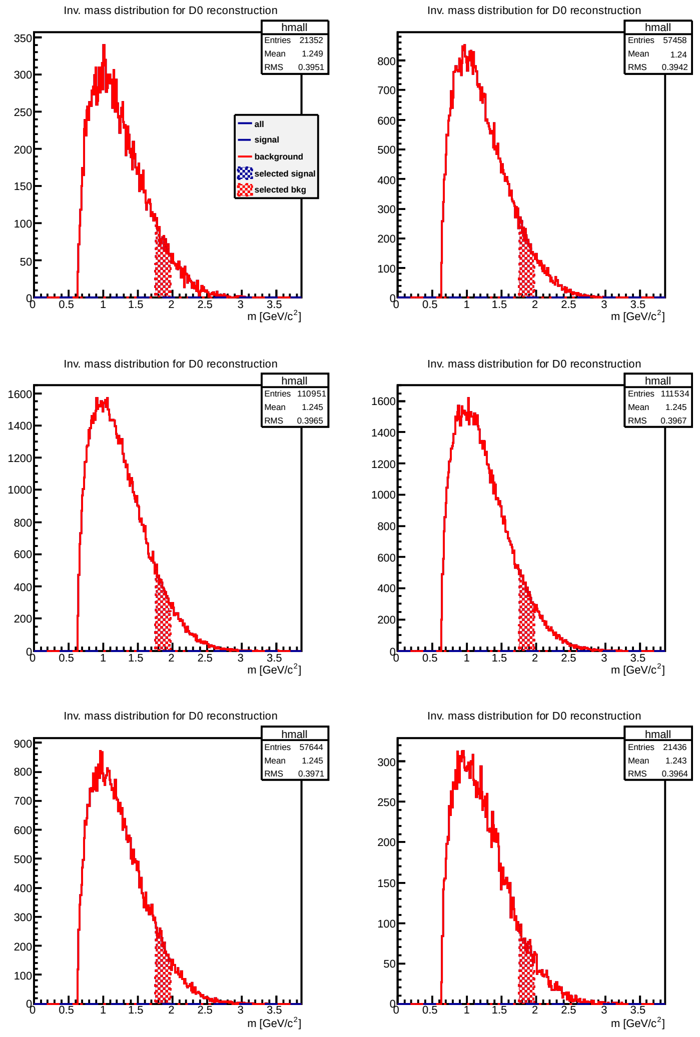




$$\bar{p}p \to \psi(4040) \to D^{*+}D^{*-}$$

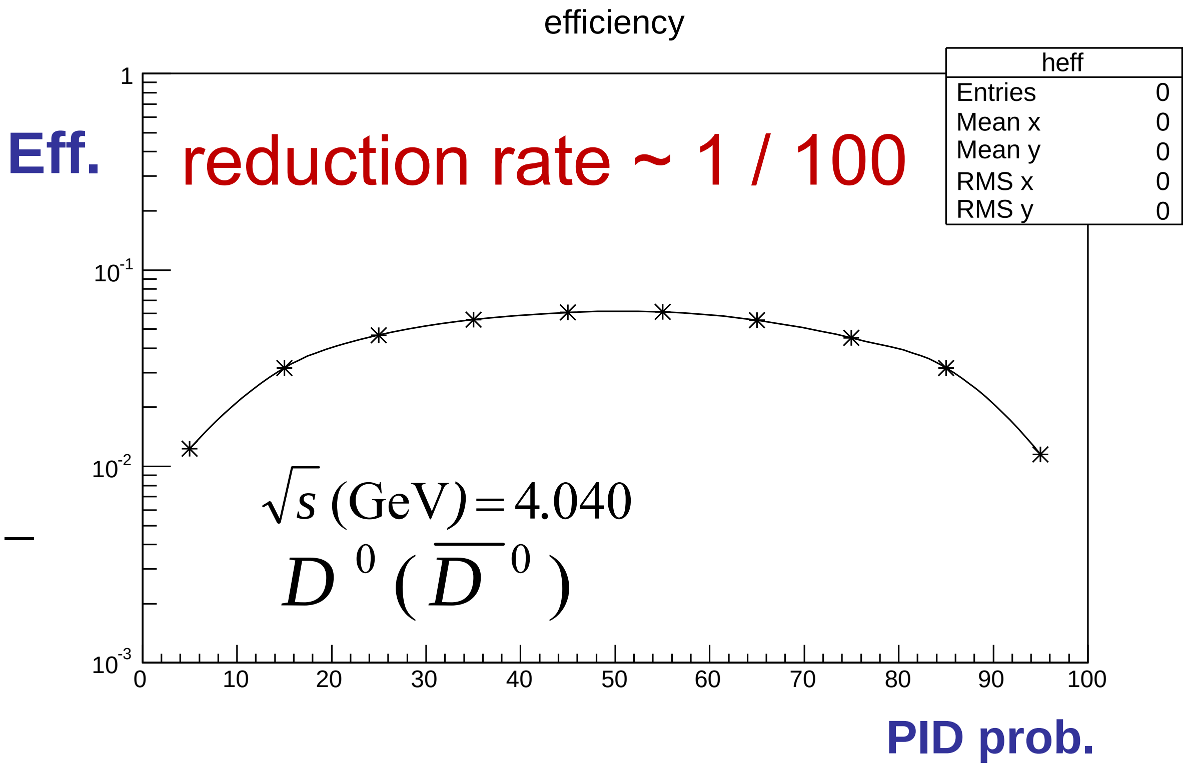
$$\to D^0\pi^+\overline{D}^0\pi^- \to K^-\pi^+\pi^+K^+\pi^-\pi^-$$

PID probability



Background

$$\bar{p}p \to \pi^+\pi^-\pi^+\pi^-\pi^+\pi^-$$



reduction rate ~ 1 / 100

$$\sqrt{s}\,(\mathrm{GeV}) = 4.040$$

$$D^0\,(\overline{D}^0)$$

PID application

Probability table : 5 X 5 simple PID probability, impurity can also be varied

		MC input				
		e	μ	π	K	P
Reco.	e	80	80	80	80	80
	μ	80	80	80	80	80
	π	80	80	80	80	80
	K	80	80	80	80	80
	P	80	80	80	80	80

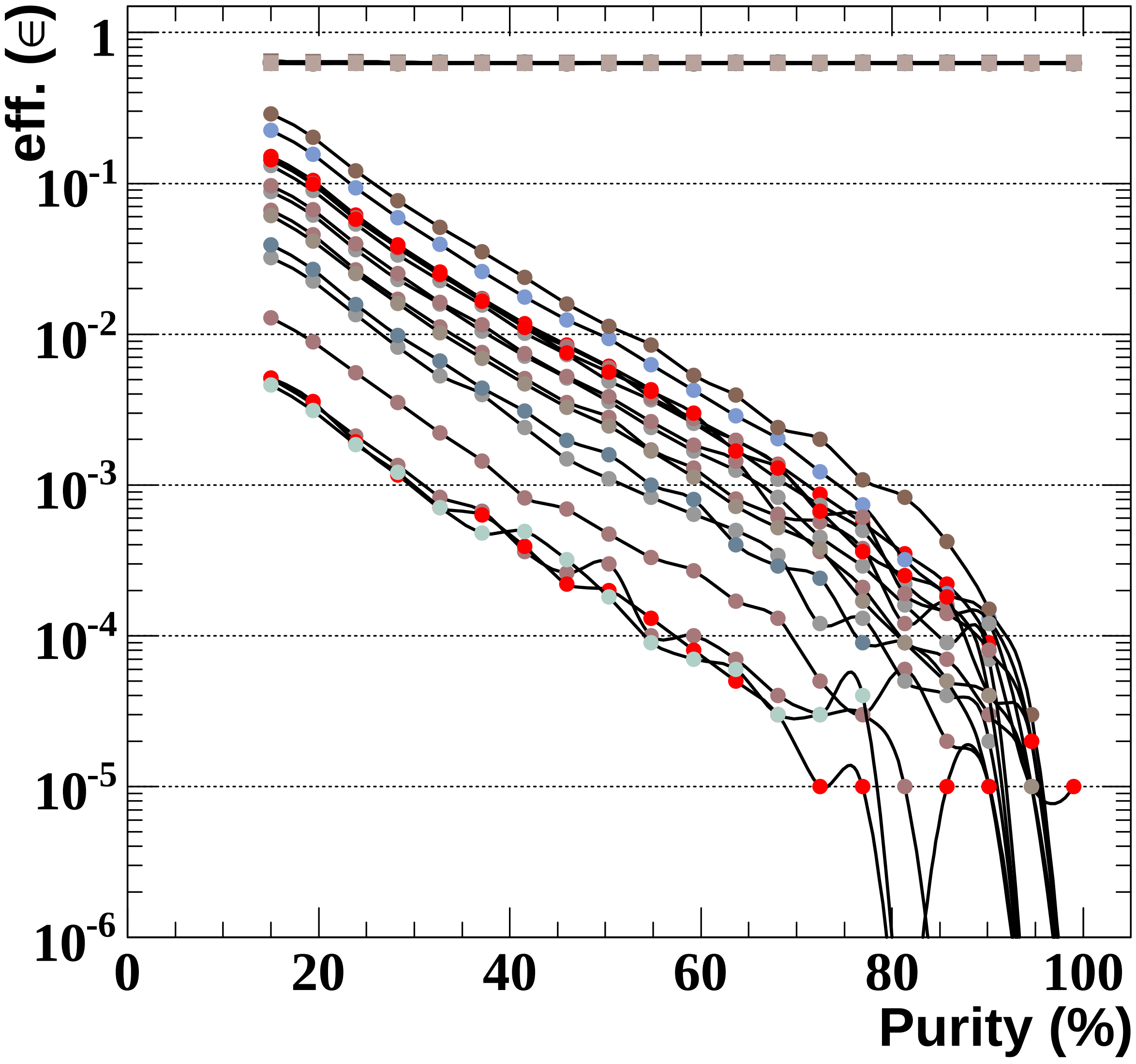
		MC input				
		e	μ	π	K	P
Reco.	e	80	1.2	1.2	1.2	1.2
	μ	1.2	80	1.2	1.2	1.2
	π	1.2	1.2	80	1.2	1.2
	K	1.2	1.2	1.2	80	1.2
	P	1.2	1.2	1.2	1.2	80

20 steps

determine signal and background efficiency

J/ψ(ee)

J/ψ mass selection : $m_{J/\psi} - 2\sigma_m < m_{e+e-} < m_{J/\psi} + 2\sigma_m$ GeV/c



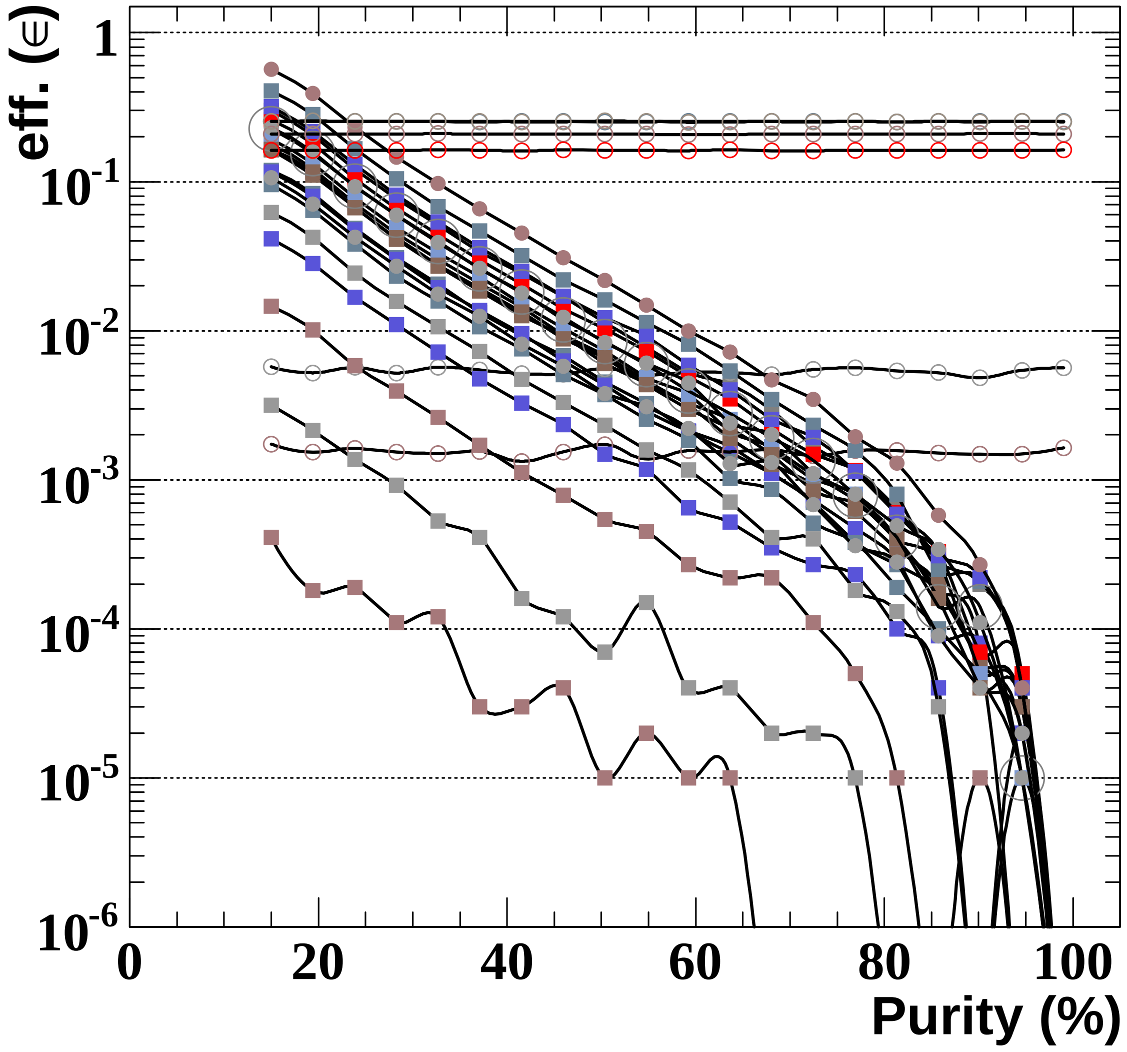
$\bar{p}p \rightarrow J/\psi X \rightarrow e^+e^-$ related

$\bar{p}p \rightarrow \pi^+\pi^-$ related

J/ψ(3pi)

$$Br(J/\psi \to e^+e^-) = 5.94\%$$

$$Br(J/\psi \to \pi^+\pi^-\pi^0) = 2.07\%$$



$\bar{p}p \to \rho\pi^0\pi^0$

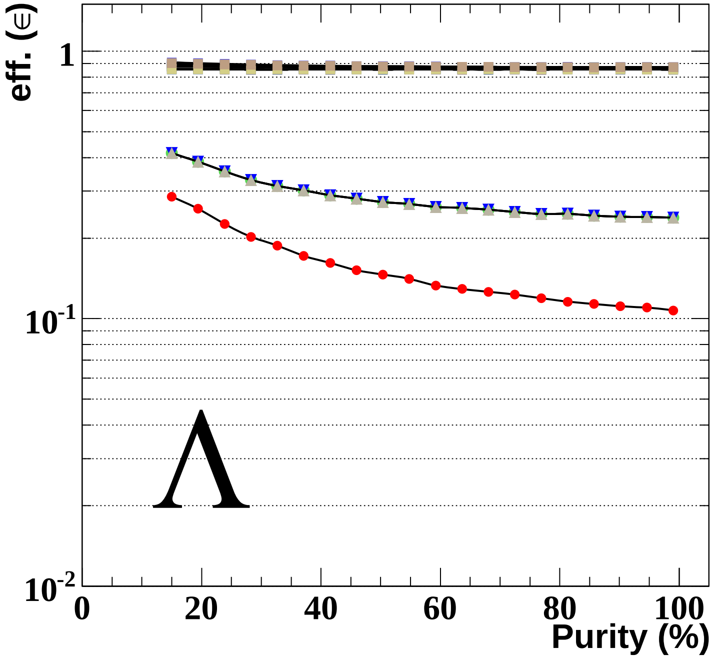
$\bar{p}p \to \rho^+\pi^-\pi^+\pi^-$

$\bar{p}p \to \omega\pi^+\pi^-$

$\bar{p}p \to \pi^+\pi^-\pi^0$ related

$\bar{p}p \to J/\psi X \to e^+e^-$ related

Λ, h$_c$



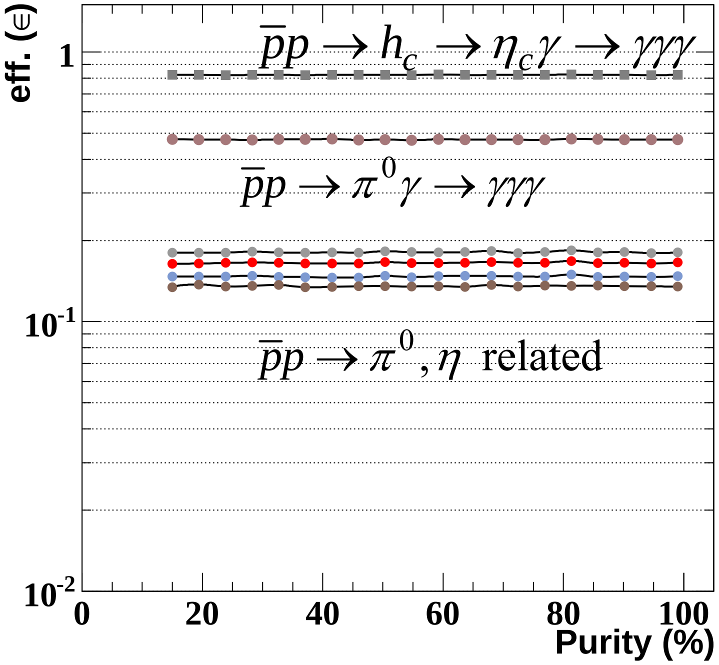
$\bar{p}p \rightarrow \Xi, \Sigma, \Lambda$ related

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

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

γ Efficicency, PID probablity = 100%

$\Delta E = 5\%, \Delta\theta = 0.003\,\deg, \Delta\phi = 0.003\,\deg$

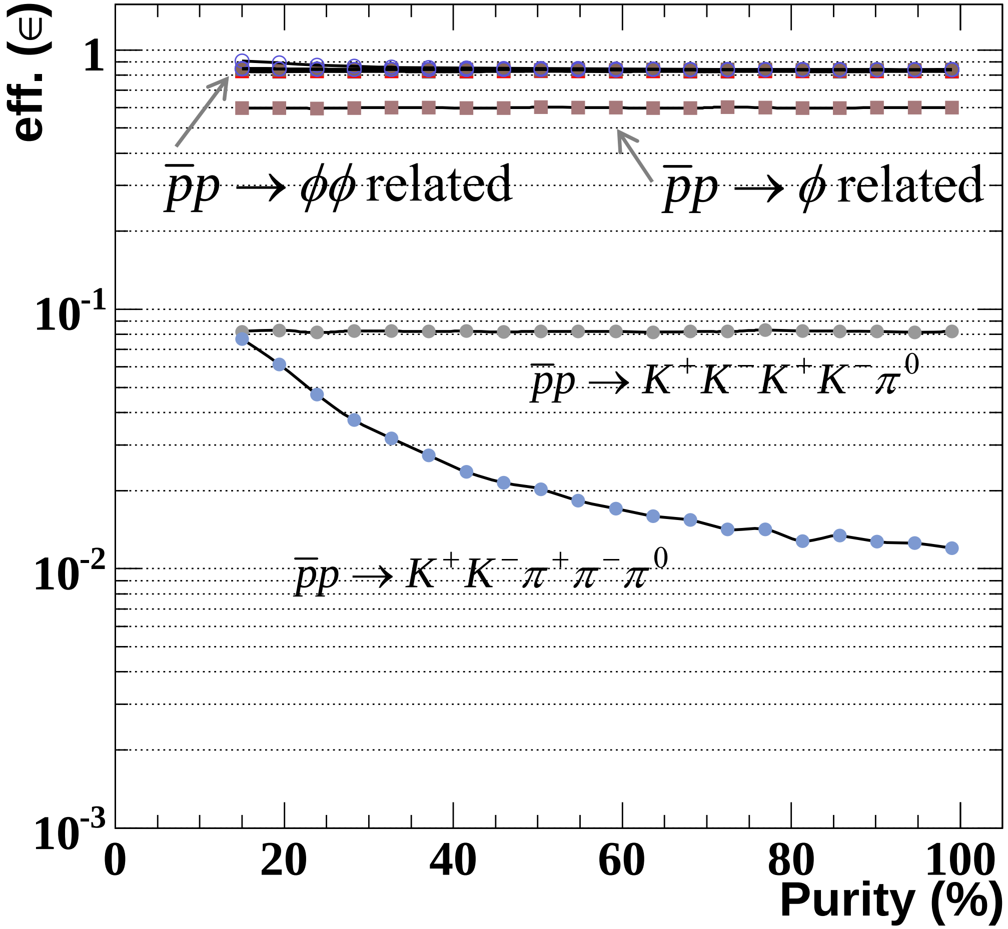


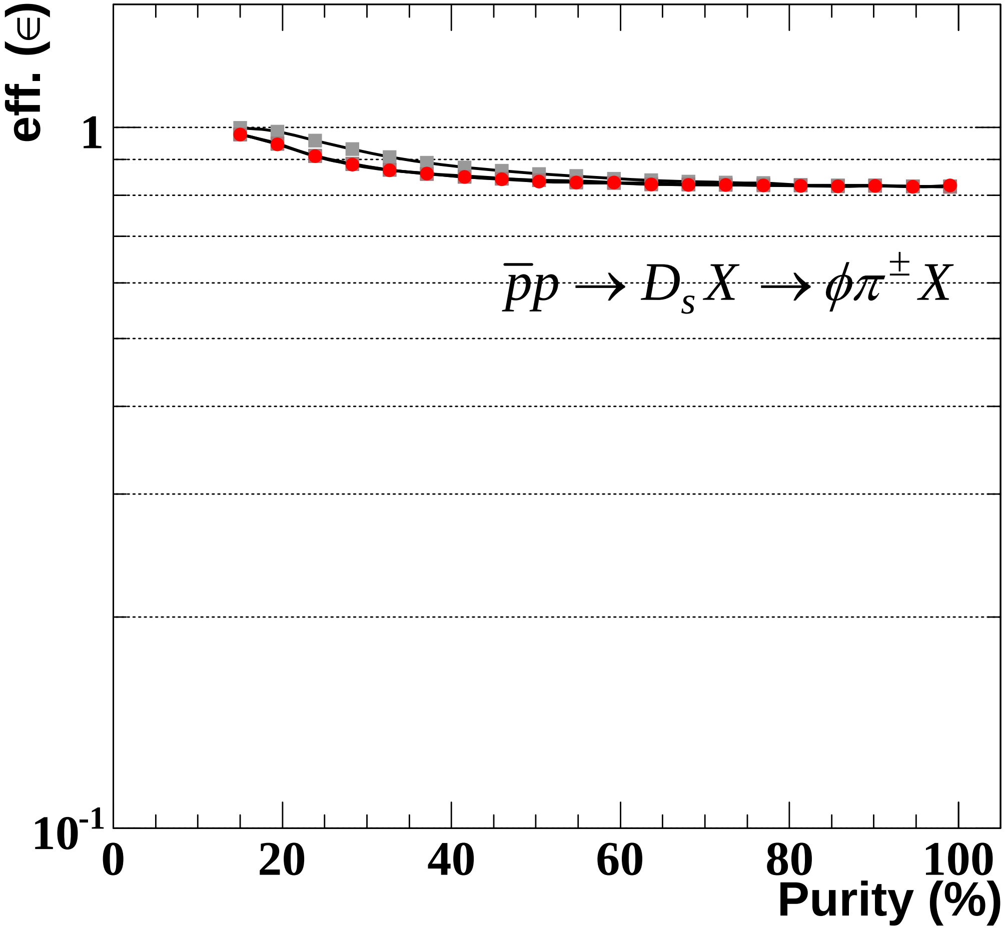
ϕ, D_s meson

$$\bar{p}p \to \eta_c\gamma \to \phi\phi\gamma \to K^+K^-K^+K^-\gamma$$

$$\bar{p}p \to \phi\phi \to K^+K^-K^+K^-$$

$$\bar{p}p \to D_s D_s^{*0}(2317) \to \phi\pi^+ X \to K^+K^-\pi^+ X$$





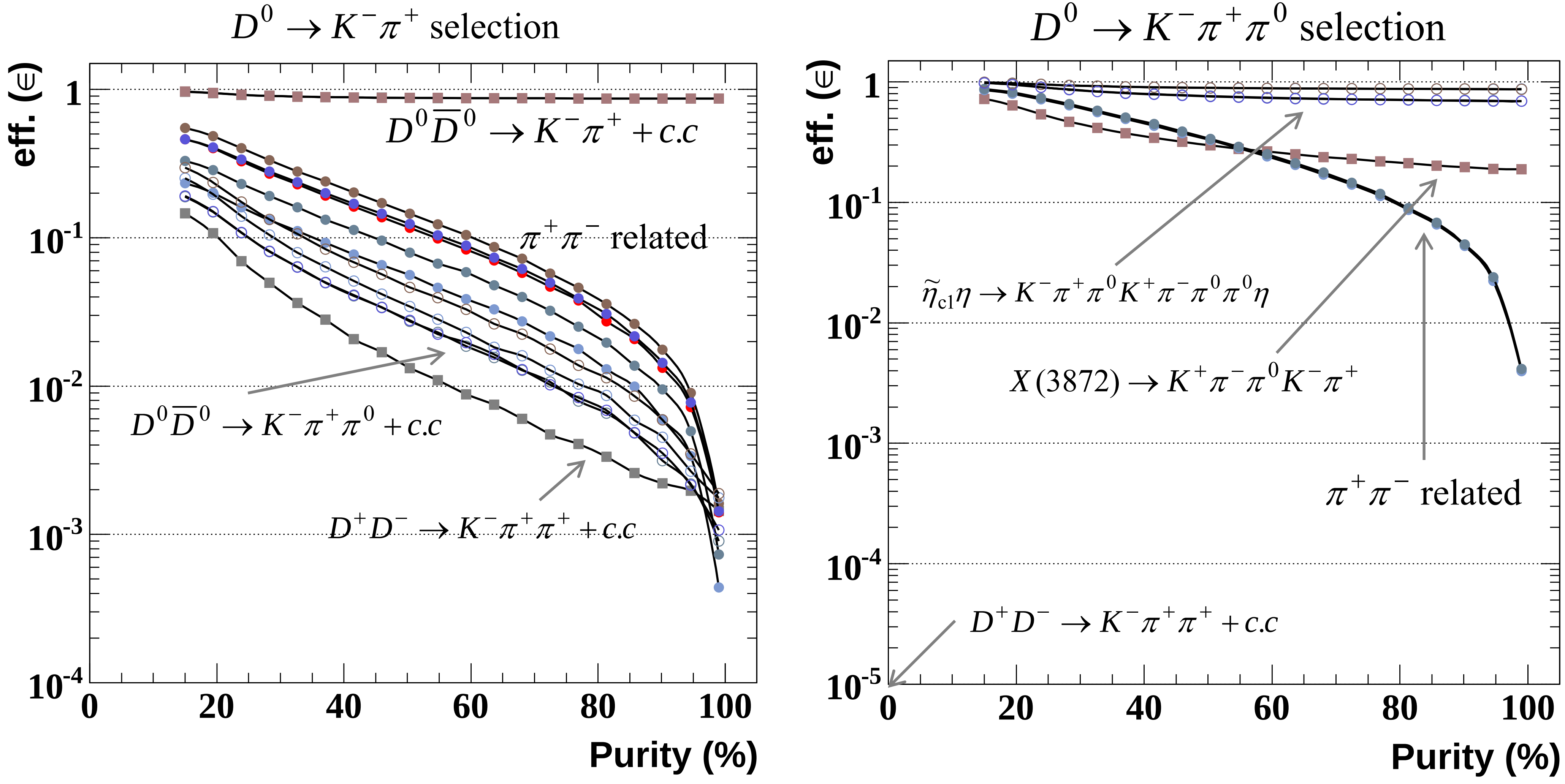
D meson

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

$$\bar{p}p \rightarrow X(3872) \rightarrow \overline{D}^{*0}D^0 \rightarrow \overline{D}^0\pi^0D^0 \rightarrow K^+\pi^-\pi^0K^-\pi^+$$

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

$$\bar{p}p \rightarrow \tilde{\eta}_{c1}\eta \rightarrow D^0\overline{D}^{*0}\eta \rightarrow K^-\pi^+\pi^0K^+\pi^-\pi^0\pi^0\eta$$



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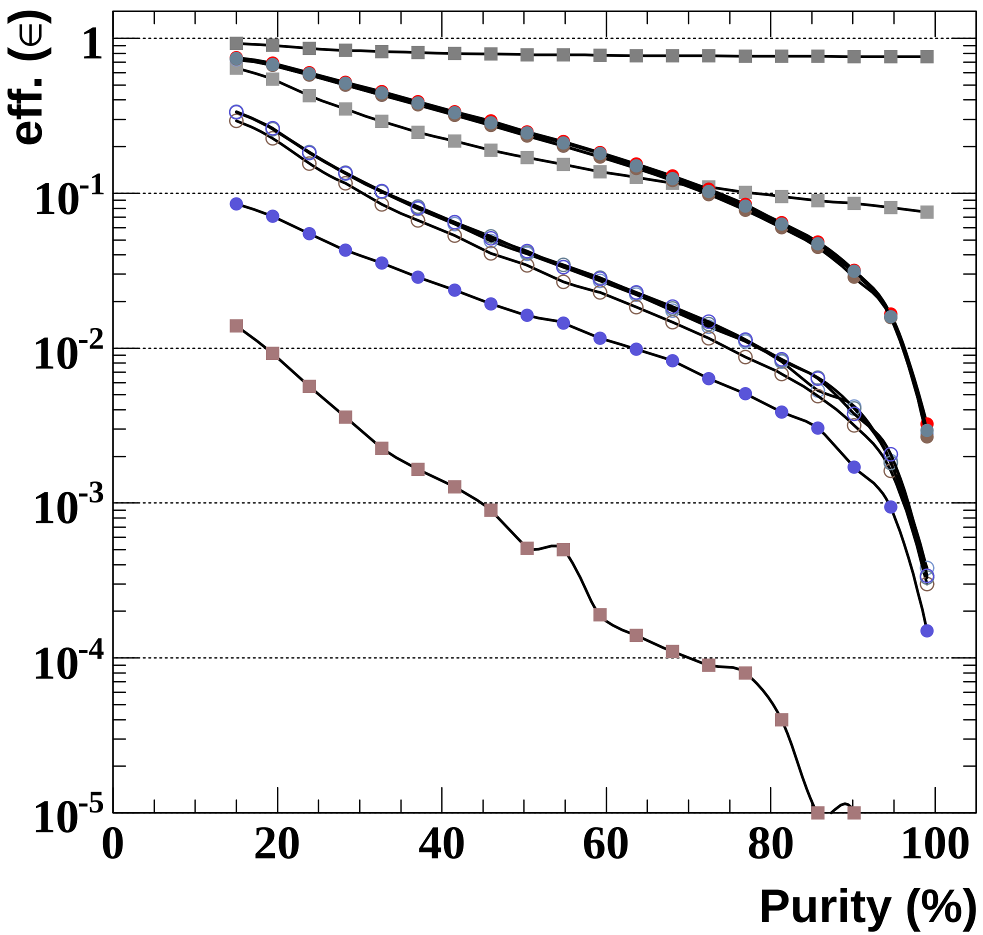
$\bar{p}p \rightarrow \psi(4040) \rightarrow D^{*+}D^{*-} \rightarrow D^0\pi^+\overline{D}^0\pi^- \rightarrow K^-\pi^+\pi^+K^-\pi^-\pi^-$

$\bar{p}p \rightarrow \tilde{\eta}_{c1}\eta \rightarrow D^0\overline{D}^{*0}\eta \rightarrow K^-\pi^+\pi^0K^+\pi^-\pi^0\pi^0\eta$



$D^+D^- \rightarrow K^-\pi^+\pi^+ + c.c$

$\bar{p}p \rightarrow \psi(3770)$

$\bar{p}p \rightarrow \psi(4040)$

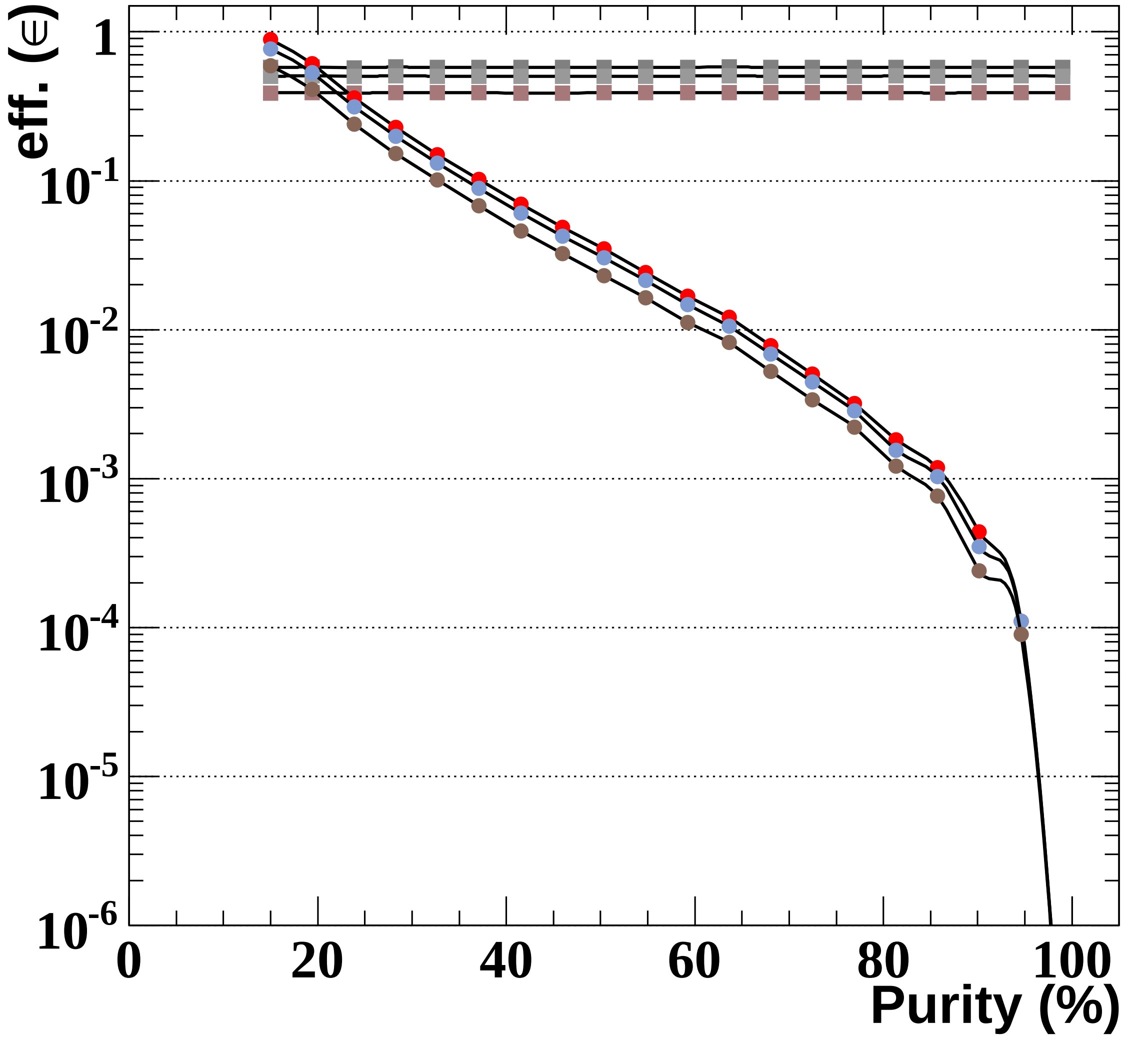
$\pi^+\pi^-$ related

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

$\pi^+\pi^-$ related

$\bar{p}p \rightarrow X(3872)$

e^+e^-

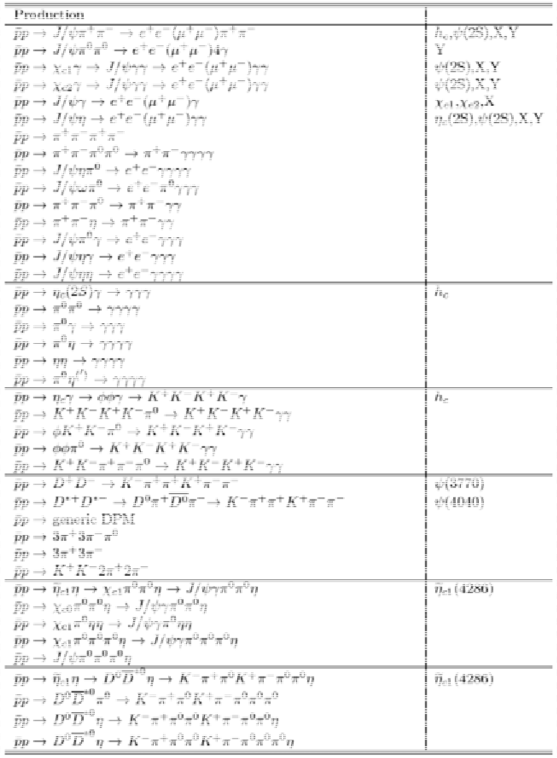


$$\bar{p}p \rightarrow e^+e^-$$

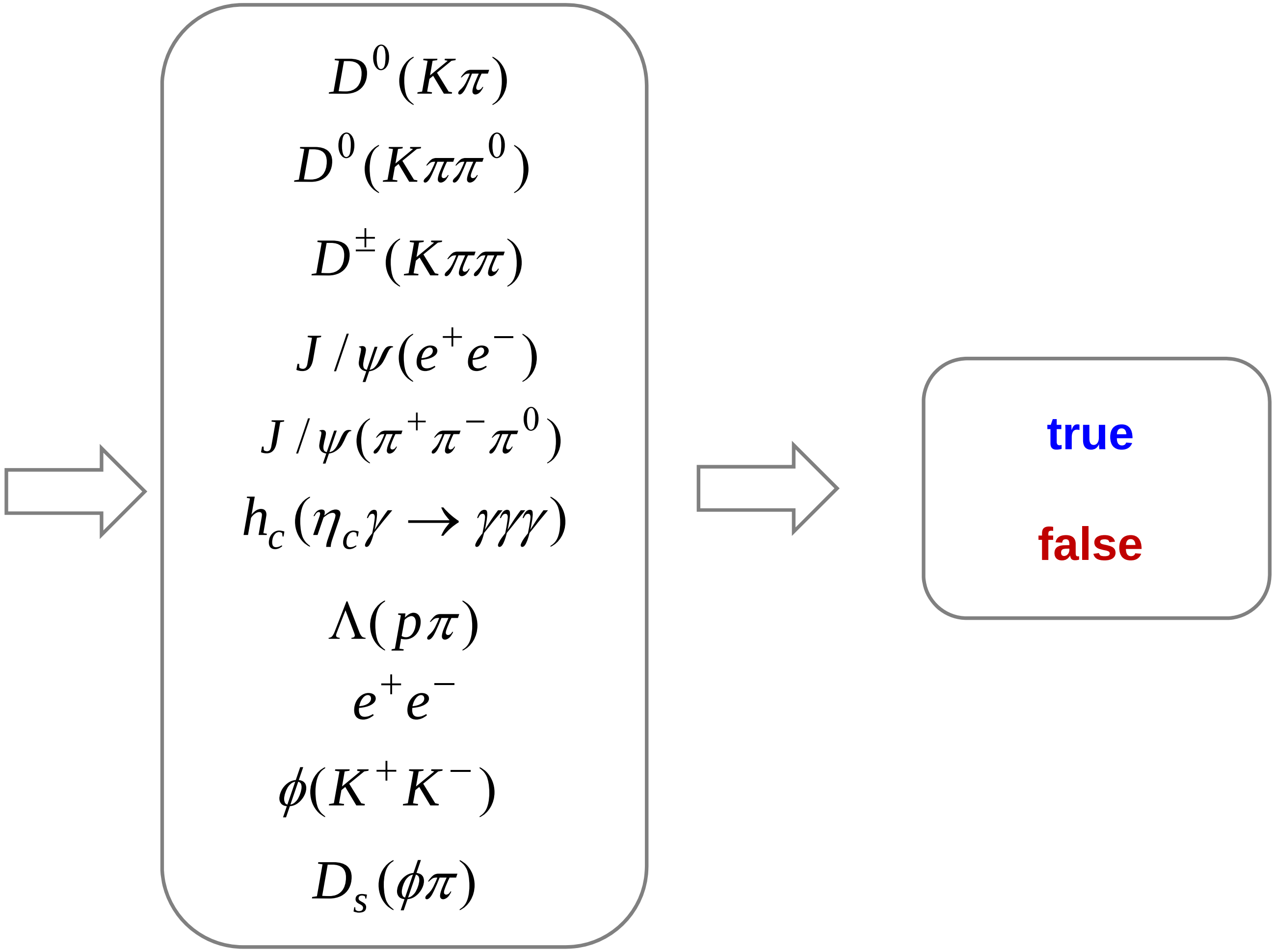
$$\bar{p}p \rightarrow \pi^+\pi^-$$

Test of algorithm II

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	
$\bar{p}p \to 3\pi^+3\pi^-\pi^0$	
$\bar{p}p \to 3\pi^+3\pi^-$	
$\bar{p}p \to K^+K^-2\pi^+2\pi^-$	
$\bar{p}p \to \tilde{\eta}_{c1}\eta \to \chi_{c1}\pi^0\pi^0\eta \to J/\psi\gamma\pi^0\pi^0\eta$	$\tilde{\eta}_{c1}(4286)$
$\bar{p}p \to \chi_{c0}\pi^0\pi^0\eta \to J/\psi\gamma\pi^0\pi^0\eta$	
$\bar{p}p \to \chi_{c1}\pi^0\eta\eta \to J/\psi\gamma\pi^0\eta\eta$	
$\bar{p}p \to \chi_{c1}\pi^0\pi^0\pi^0\eta \to J/\psi\gamma\pi^0\pi^0\pi^0\eta$	
$\bar{p}p \to J/\psi\pi^0\pi^0\pi^0\eta$	
$\bar{p}p \to \tilde{\eta}_{c1}\eta \to D^0\overline{D}^{*0}\eta \to K^-\pi^+\pi^0K^+\pi^-\pi^0\pi^0\eta$	$\tilde{\eta}_{c1}(4286)$
$\bar{p}p \to D^0\overline{D}^{*0}\pi^0 \to K^-\pi^+\pi^0K^+\pi^-\pi^0\pi^0\pi^0$	
$\bar{p}p \to D^0\overline{D}^{*0}\eta \to K^-\pi^+\pi^0\pi^0K^+\pi^-\pi^0\pi^0\eta$	
$\bar{p}p \to D^0\overline{D}^{*0}\eta \to K^-\pi^+\pi^0\pi^0K^+\pi^-\pi^0\pi^0\pi^0\eta$	



$D^0(K\pi)$

$D^0(K\pi\pi^0)$

$D^\pm(K\pi\pi)$

$J/\psi(e^+e^-)$

$J/\psi(\pi^+\pi^-\pi^0)$

$h_c(\eta_c\gamma \to \gamma\gamma\gamma)$

$\Lambda(p\pi)$

e^+e^-

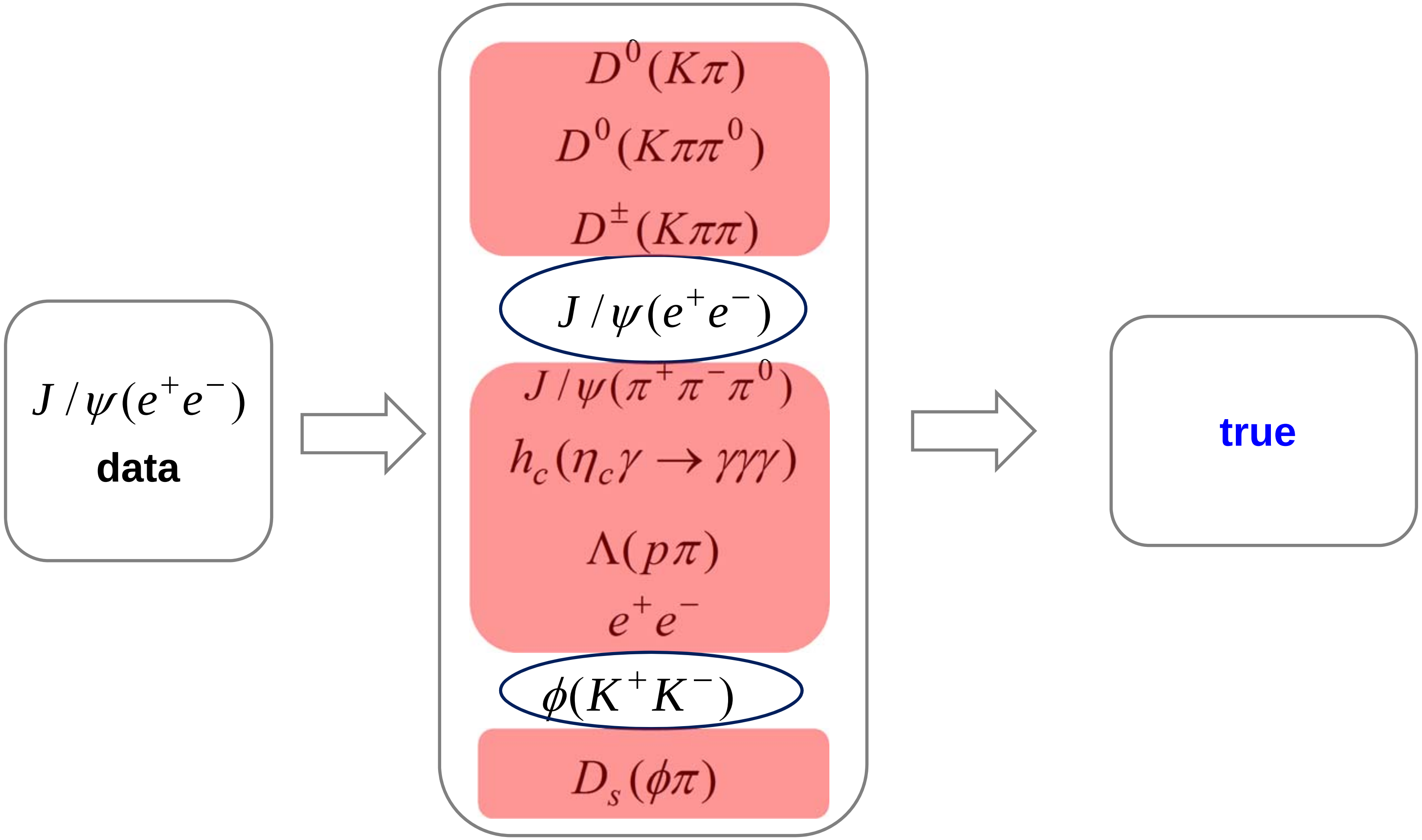
$\phi(K^+K^-)$

$D_s(\phi\pi)$

true

false

Test of algorithm II



$J/\psi(e^+e^-)$

data

$D^0(K\pi)$

$D^0(K\pi\pi^0)$

$D^\pm(K\pi\pi)$

$J/\psi(e^+e^-)$

$J/\psi(\pi^+\pi^-\pi^0)$

$h_c(\eta_c\gamma \rightarrow \gamma\gamma\gamma)$

$\Lambda(p\pi)$

e^+e^-

$\phi(K^+K^-)$

$D_s(\phi\pi)$

true

Test of algorithm II

DPM
data

$D^0(K\pi)$

$D^0(K\pi\pi^0)$

$D^{\pm}(K\pi\pi)$

$J/\psi(e^+e^-)$

$J/\psi(\pi^+\pi^-\pi^0)$

$h_c(\eta_c\gamma \rightarrow \gamma\gamma\gamma)$

$\Lambda(p\pi)$

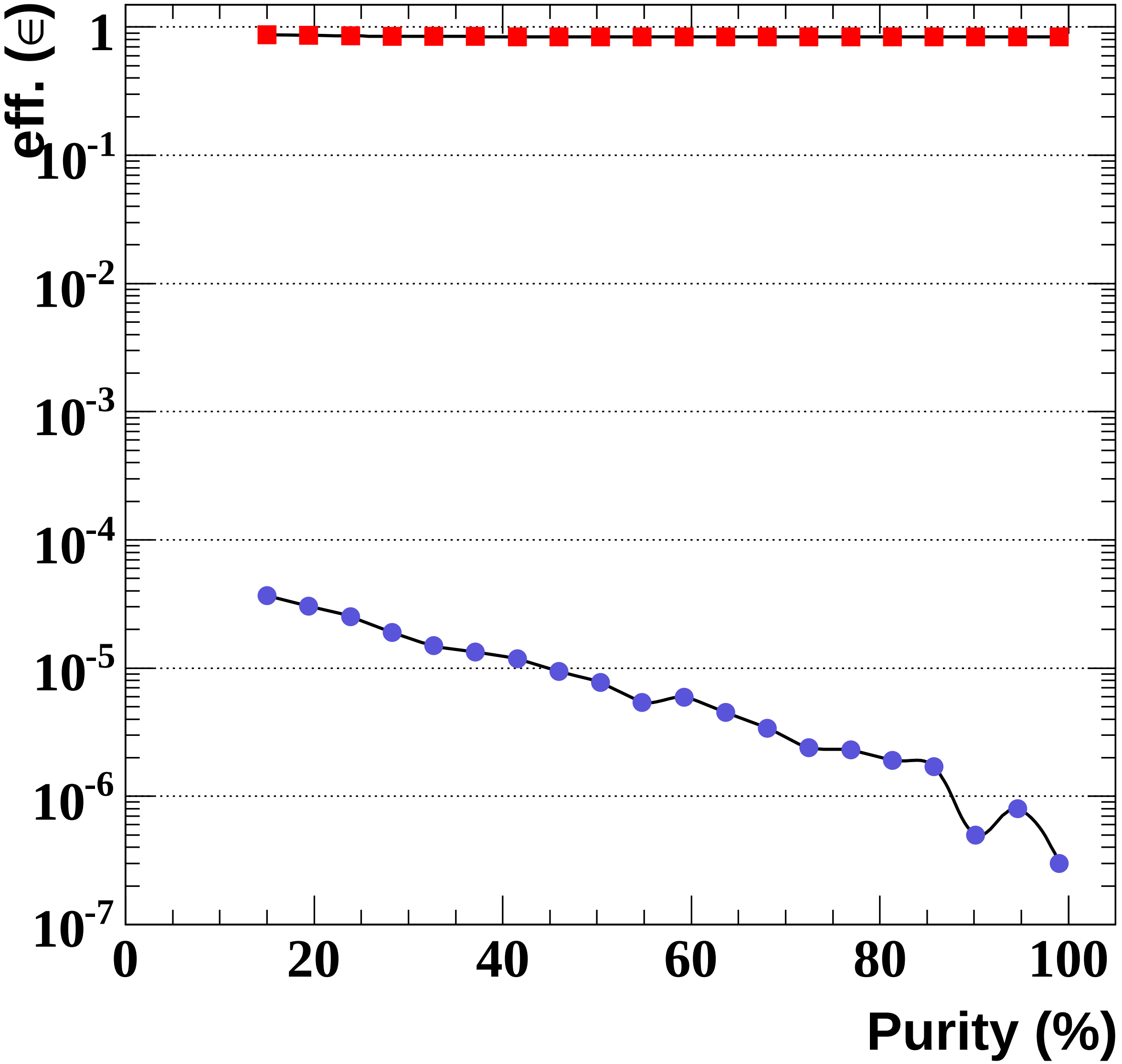
e^+e^-

$\phi(K^+K^-)$

$D_s(\phi\pi)$

false

Test of algorithm II



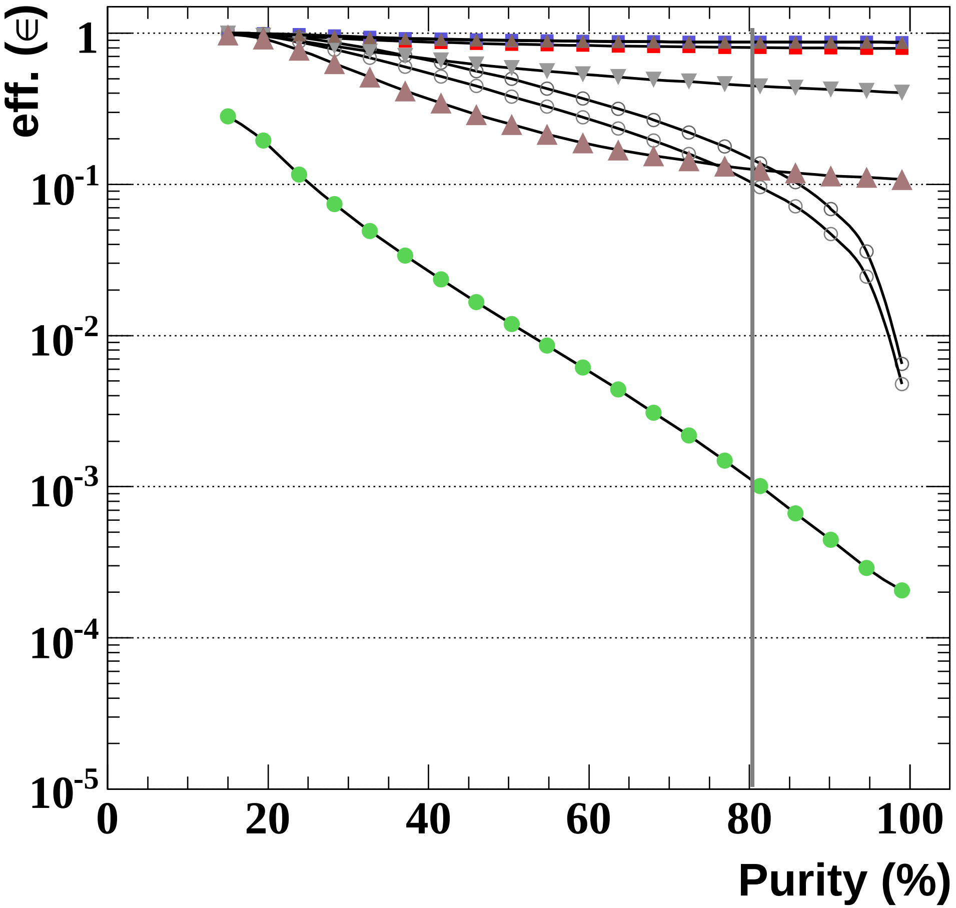
$\bar{p}p \rightarrow \phi\phi \rightarrow K^{+}K^{-}K^{+}K^{-}$

← **DPM**

$\sqrt{s} = 2.230$ GeV

Test of algorithm II

$$\sqrt{s} = 3.770 \text{ GeV}$$



$D^{+}D^{-} \rightarrow K^{-}\pi^{+}\pi^{+} + c.c$

$\overline{\Xi}^{+}\Xi^{-}\pi^{0} \rightarrow \Lambda X$

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

$\bar{p}p \rightarrow \bar{p}\pi^{+}p\pi^{-}\pi^{+}\pi^{-}\pi^{0}$

$\bar{p}p \rightarrow 3\pi^{+}3\pi^{-}$

← **DPM**

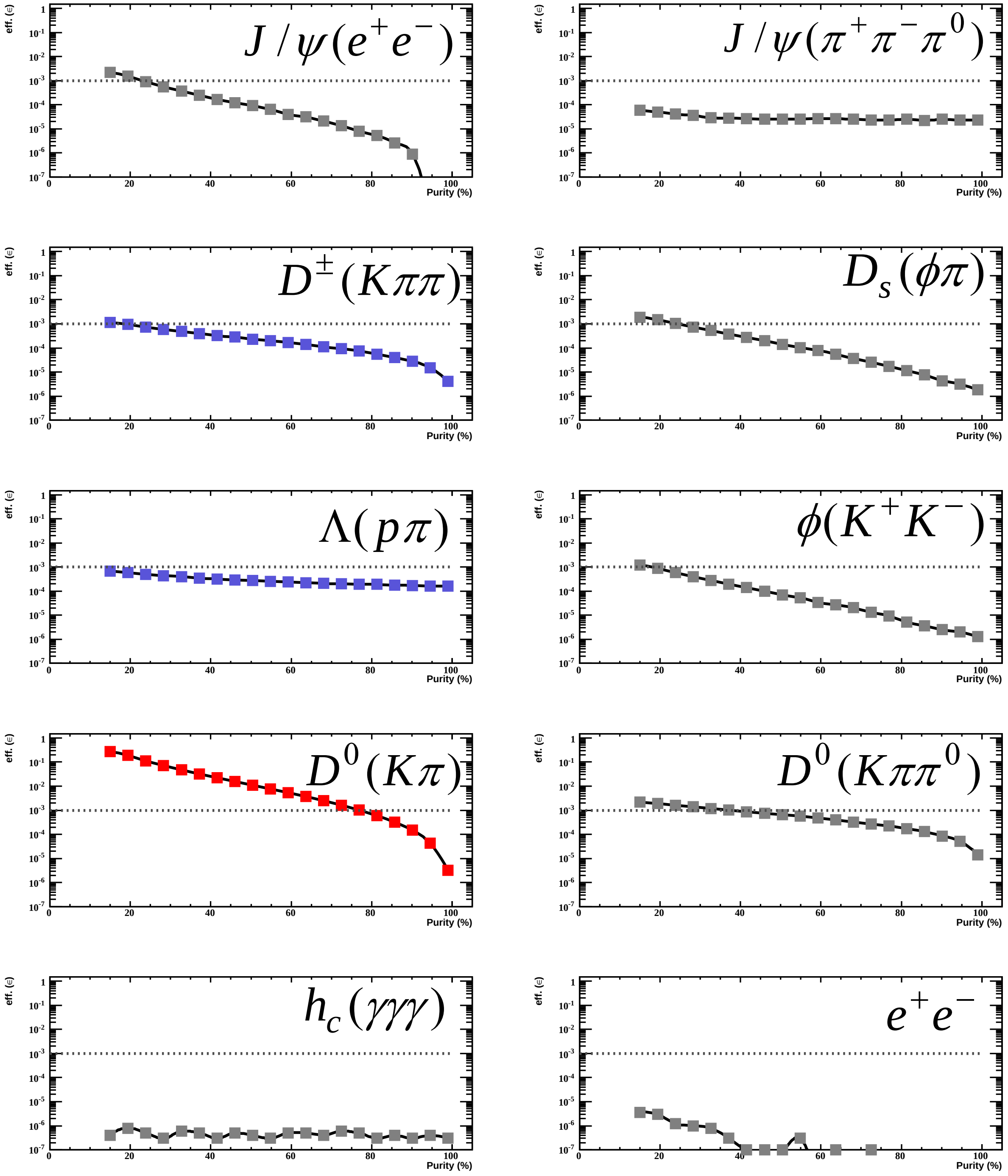
Test of algorithm II

DPM data in detail …

$\sqrt{s} = 3.770$ GeV

Identified as a signal
in each selection criteria

ε = 10^{-3} : mainly due to
$K\pi$ combination



Summary

background reduction rate ~ 1 / 1000
if we can achieve 80% PID probability and
with 5% impurities for each particles

apply more realistic values into the test
- online tracking @ target, target-endcap, and forward
- PID probability depending on θ, p, particle types.
- precise γ, μ efficiency and so on…

S/N ratio with considering cross section and branching ratio

Need your help, must have more realistic MC and
precise information about σ, for instance,

e^+e^-, $\pi^+\pi^-$, $e^+e^-\pi^0$, and $\pi^+\pi^-\pi^0$

Outlook

efficiency

branching fraction

pi0 (gg)	98.82%	
eta (gg)	39.31%	
J/psi (ee)	5.94%	
chi_c0 (J/psi g)	1.16%	
chi_c1 (J/psi g)	34.40%	
chi_c2 (J/psi g)	19.50%	
omega (pi0 g)	8.28%	
eta_c (gg)	6.30E-05	
eta' (gg)	2.22%	
phi (K+K-)	48.90%	
eta_c (phi phi)	2.70E-03	
D+ (K- pi+ pi+)	9.40%	
D0 (K- pi+)	3.89%	
D0 (K- pi+ pi0)	13.90%	
D+* (D0 pi+)	67.70%	
eta_c1~	30.00%	assumption
D0* (D0 pi0)	61.90%	
D0 (K- pi+ pi0 pi0)	5.00%	assumption
omega (pi+ pi- pi0)	89.20%	
rho0 (pi+ pi-)	100.00%	
Y(3940) (J/psi omega)	30.00%	assumption
psi' (J/psi pi+ pi-)	33.60%	
f2(2230) (phi phi)	20.00%	assumption
Ds (phi pi)	4.50%	
Ds (K+ K- pi+)	5.50%	
Ds* (Ds g)	94.20%	
Xi (Lam pi+)	99.89%	
Lam (p pi-)	63.90%	
Sig (1385) (Lam pi+)	87.00%	
Sig0 (Lam g)	100.00%	
e+ e- (EMP)	100.00%	
X(3872) (Db*0 D0)	5.00E-03	

cross section → S/N

Physics Book Data/Channels

Channel	(assumption) X-sec [barn]	total BR [%]
J/psi (ee) pi+ pi-	5.00E-11	5.94%
(VPIPI)	5.00E-11	5.94%
	5.00E-11	5.94%
	6.00E-11	5.94%
	5.00E-11	5.94%
	5.00E-11	5.94%
J/psi (ee) pi0 (gg) pi0 (gg)	3.00E-11	5.80%
chi_c1 (J/psi (ee) gamma) gamma	5.00E-11	2.04%
	5.00E-11	2.04%
	5.00E-11	2.04%
chi_c2 (J/psi (ee) gamma) gamma	5.00E-11	1.16%
	5.00E-11	1.16%
	5.00E-11	1.16%
J/psi (ee) gamma	1.00E-09	5.94%
	2.00E-09	5.94%
	1.00E-09	5.94%
J/psi (ee) eta (gg)	1.00E-10	2.34%
	1.00E-10	2.34%
	1.00E-10	2.34%
	1.00E-10	2.34%
pi+ pi- pi+ pi-	4.60E-05	100.00%
pi+ pi- pi0 (gg) pi0 (gg)	5.00E-05	97.65%
J/psi (ee) eta (gg) pi0 (gg)	3.00E-11	2.31%
J/psi (ee) omega (pi0 (gg) g) pi0 (gg)	1.00E-11	0.48%
pi+ pi- pi0 (gg)	1.20E-04	98.82%
	2.90E-04	98.82%
	3.00E-05	98.82%
pi+ pi- eta (gg)	1.54E-06	39.31%
J/psi (ee) pi0 (gg) g	5.00E-11	5.87%
	5.00E-11	5.87%
	5.00E-11	5.87%
	5.00E-11	5.87%
J/psi (ee) eta (gg) g	5.00E-11	2.34%
	5.00E-11	2.34%
	5.00E-11	2.34%
	5.00E-11	2.34%
J/psi (ee) eta (gg) eta (gg)	3.00E-11	0.92%

…….