Using Kalman Fitting Method

to Evaluate the Significance of D0 signal

from its Hadron Decay Channel

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Introduction

As I have showned before, by associating SVX hits to reconstructed central arm track, and do Kalman Fitting, we can get DCA of single track, which shows a different distribution between single pi+ and decay K-/pi+ from D0. The latter is much broader.

Therefore, it's useful to run simulation of full AuAu event (using EXODUS by Ralf) in PISA, and compare the output with running D0 from Pythia, by reconstruting tracks and get invariant mass of unlike-charge pairs. KalmanFit should be able to provide various cuts to improve our signal/background and S/sqrt(B) as number of significance.

Data Source:

1. Single D0 from running Pythia forcing charm production. Totally $4*10^9$ Pythia events generated 3.42M single D0 with Pt > 3GeV

2. 20K Full PHENIX AuAu events from EXODUS (provided by Ralf).

Procedure:

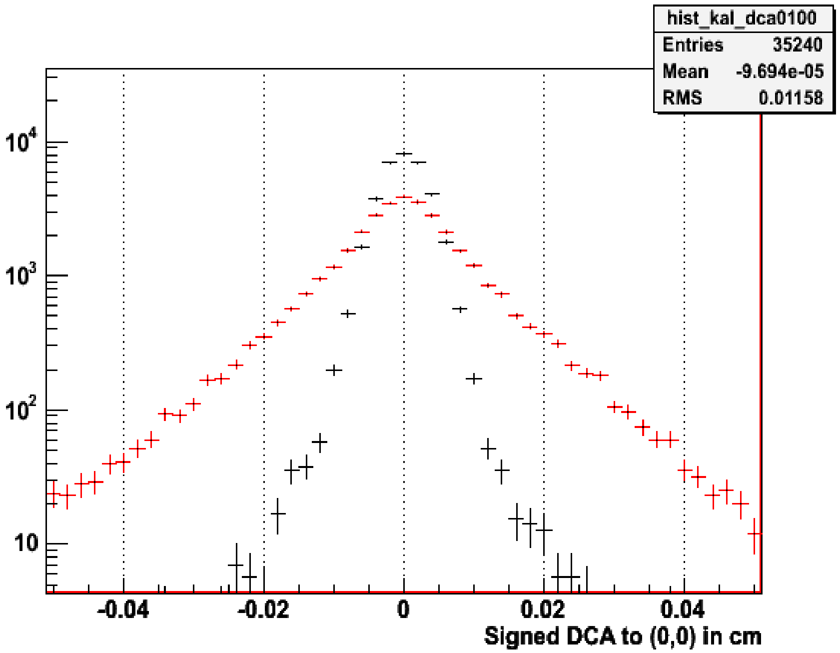
Both are thrown into PISA (seperately) as initial input, then run the normal Fun4All reconstruction code (with KalmanFit) over PISAEvent.root, and generated reconstructed tracks in central arms.

To get maximum statistics, we don't require PID while calculating invariant mass of unlike-charge pairs. All negtive charge track will be considered as K-, and all positive charge track will be taken as pi+. Meanwhile, propariate cuts will be applied to single tracks and pairs.

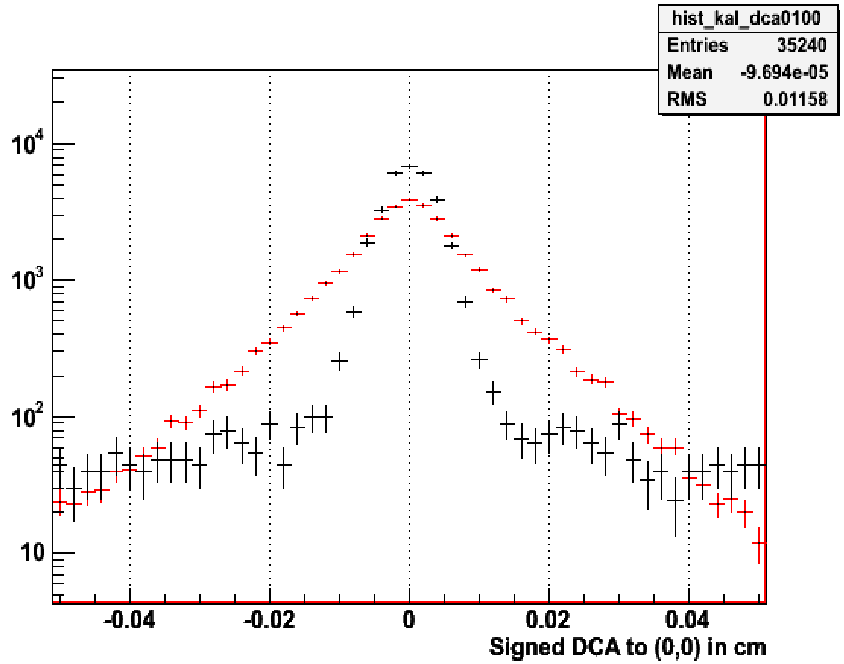
Avaliable Cuts 1:   DCA of single track

For simulation of single pi+, the sigma of DCA distribution is 33um, similar to what we get from EXODUS tracks. On the other hand, the sigma of DCA of K-/pi+ from D0 decay is much bigger.

Black: single pi+
red: K-/pi+ from D0



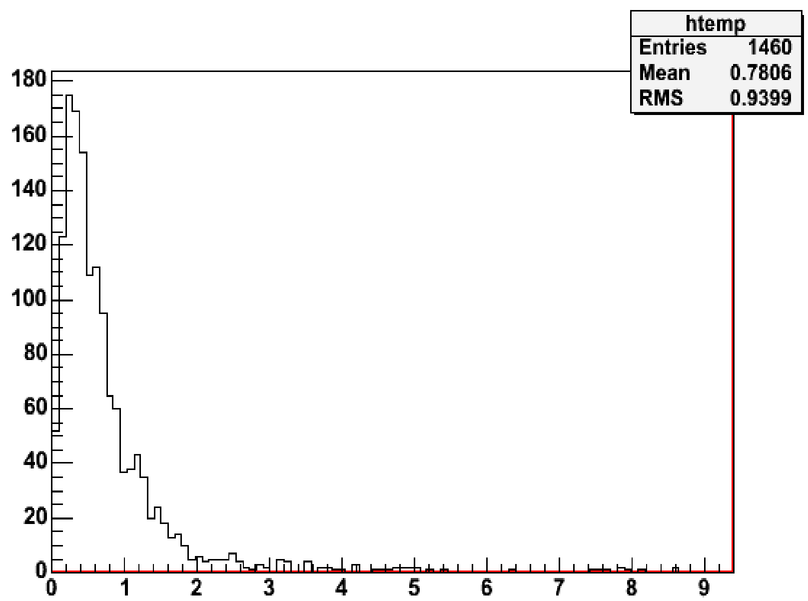
Black: EXODUS track
red: K-/pi+ from D0



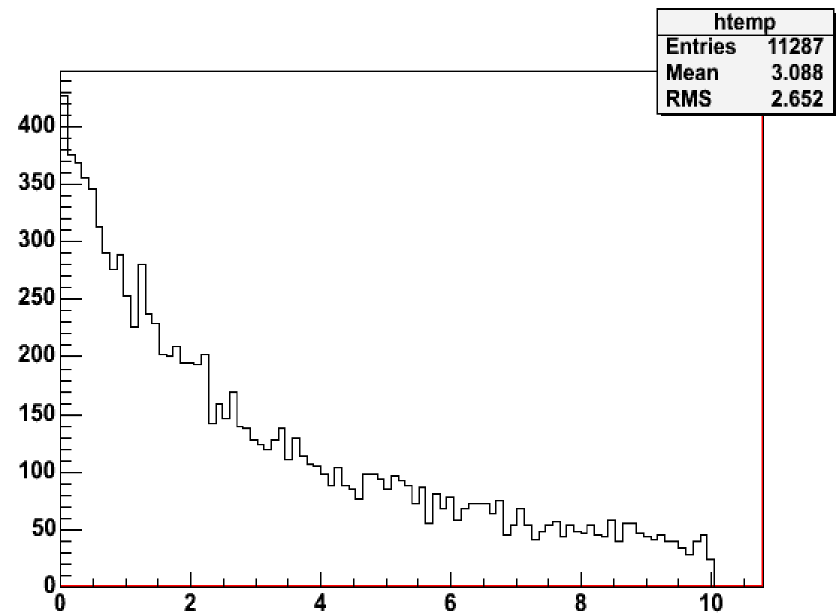
Avaliable Cuts 2:   Chi2 of KalmanFit at single track

After tracks are reconstructed with DC & PC1 hits, SVX hits will be associated to each track, then Kalman Fitting. As below, the Chi2 of Kalman Fitting from tracks of single pi+ event are different from those of EXODUS. Thus, a Chi2 cut may be helpful to remove the tail of DCA.

Single pi+



EXODUS

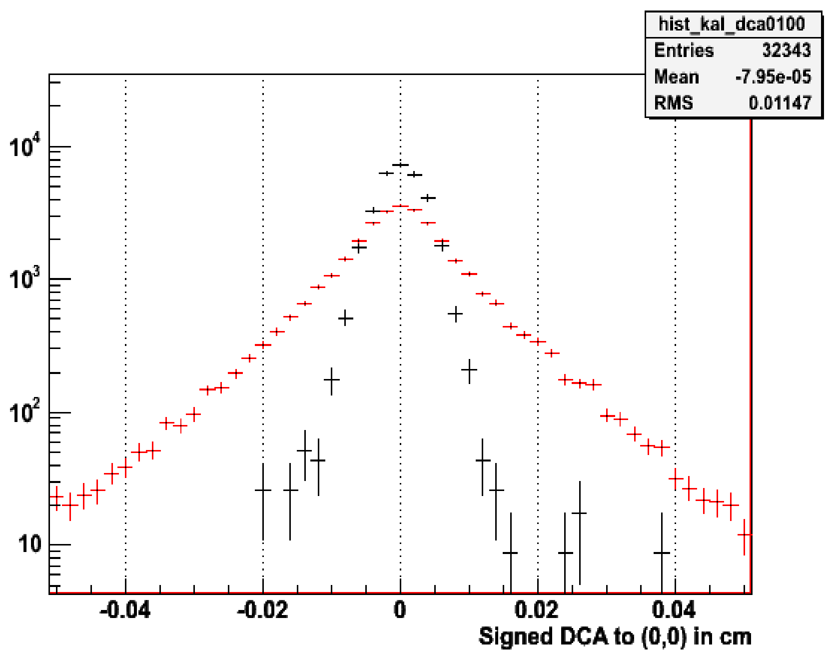


The two plots below shown how chi2 cut help removing the tail of DCA

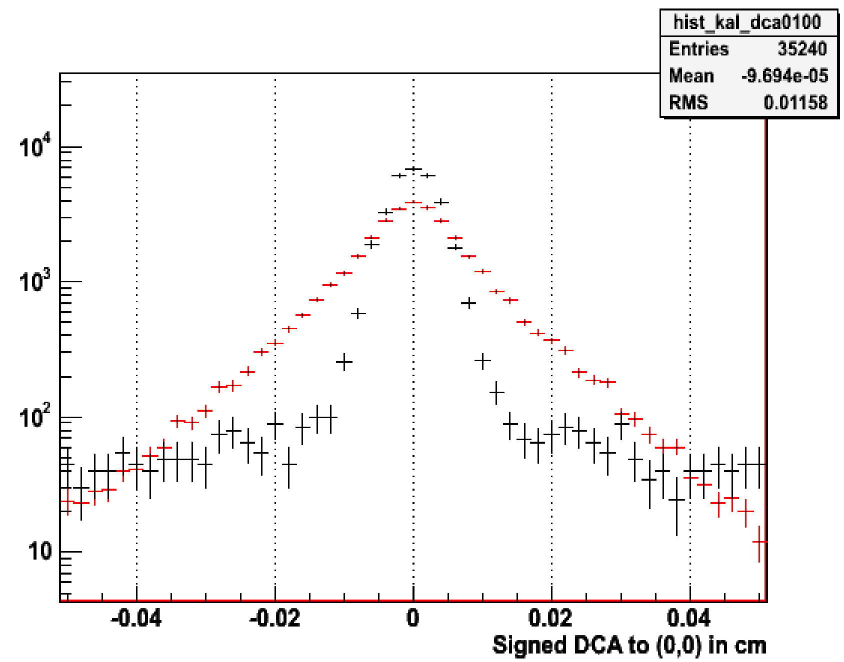
Red: K-/pi+ from D0

Black: EXODUS tracks

Chi2 < 1.0

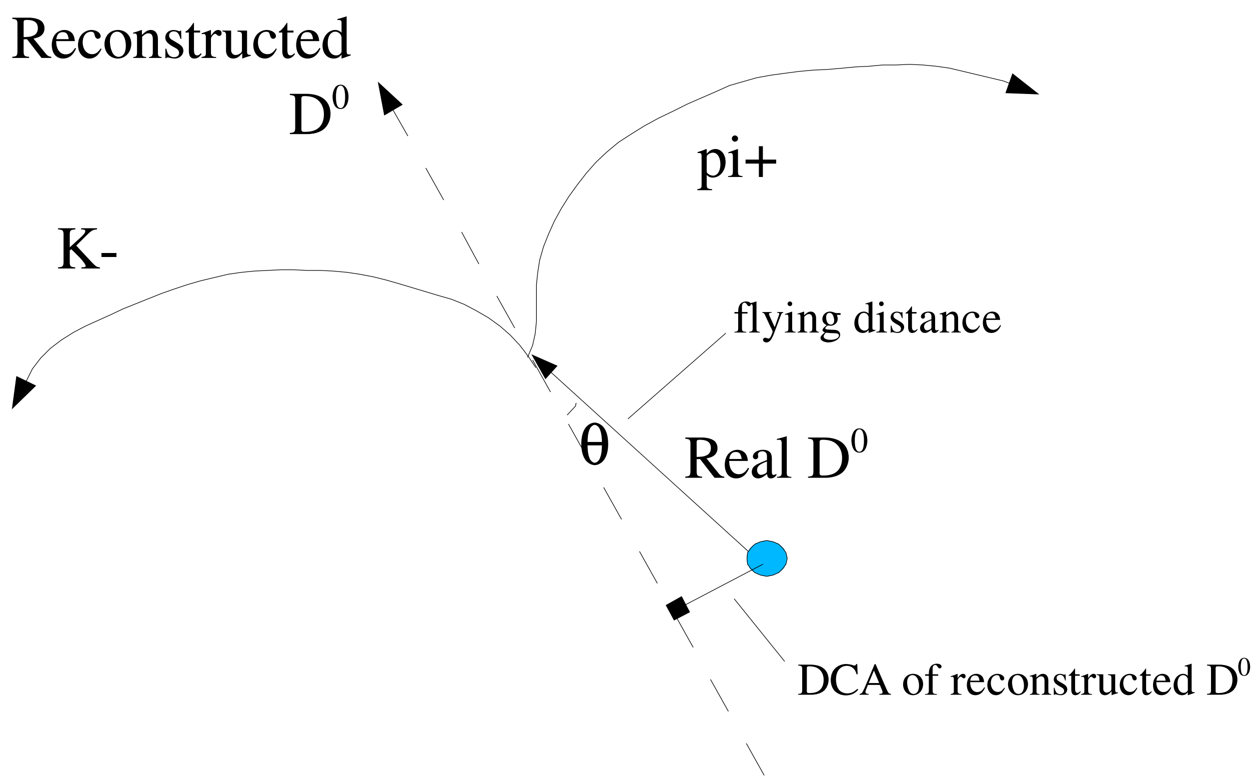


Chi2 < 999



Pair Cut for the reconstructed D^0
(combinatorics of unlike-charge pairs)

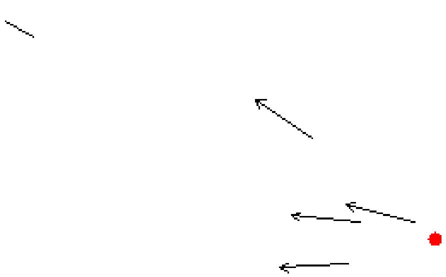
For those tracks pass single track quality cut, we can combine any unlike-charge pair to form a 'test' D^0. In reality, we will have 3 values for it: flying distance, θ and DCA, and DCA / d = sin(θ). For an ideal case, θ should be exactly zero.



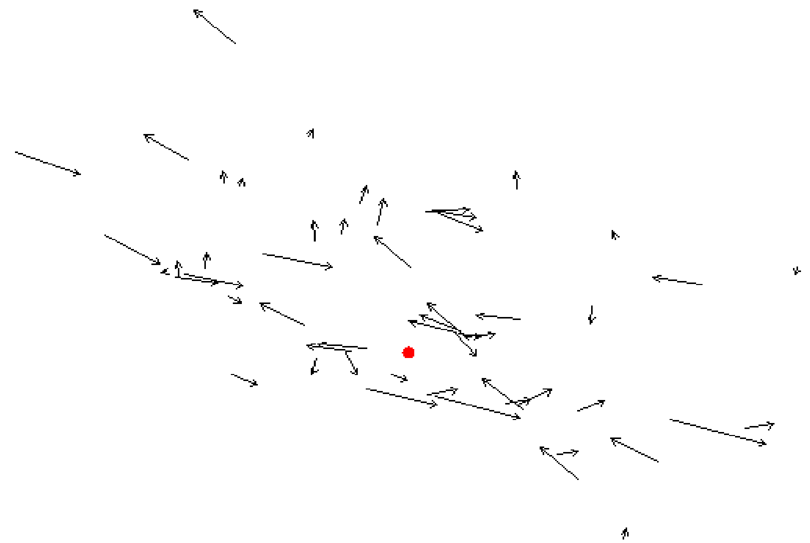
The reconstructed 'D^0'

Make tangent lines of each track at its closest point to collision vertex.
The cross-point of two lines will be the combinatorics, whose arrow starts from here, and its direction indicates the combinatorics Pt vector.

Unlike-pair from D^0 events
not necessarily K-/pi+

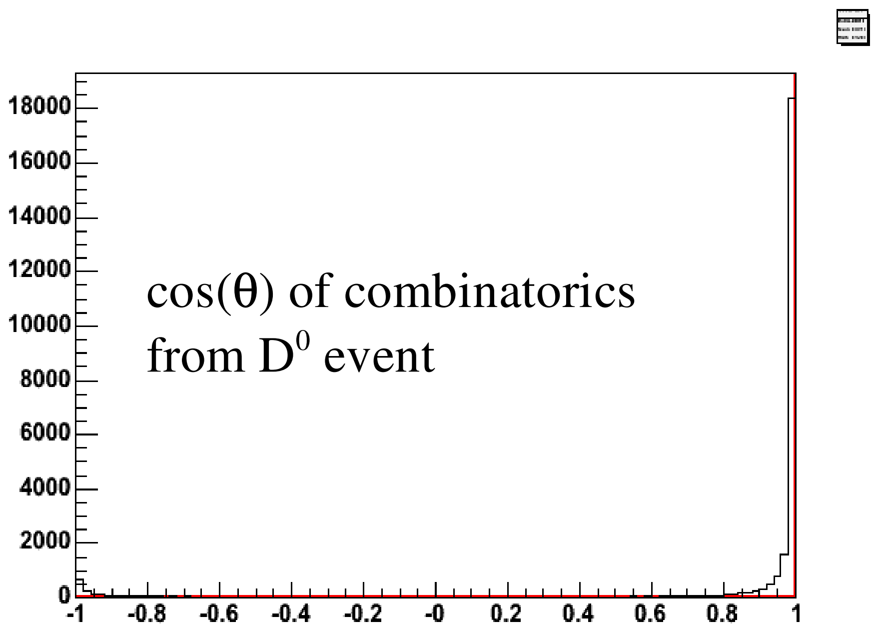


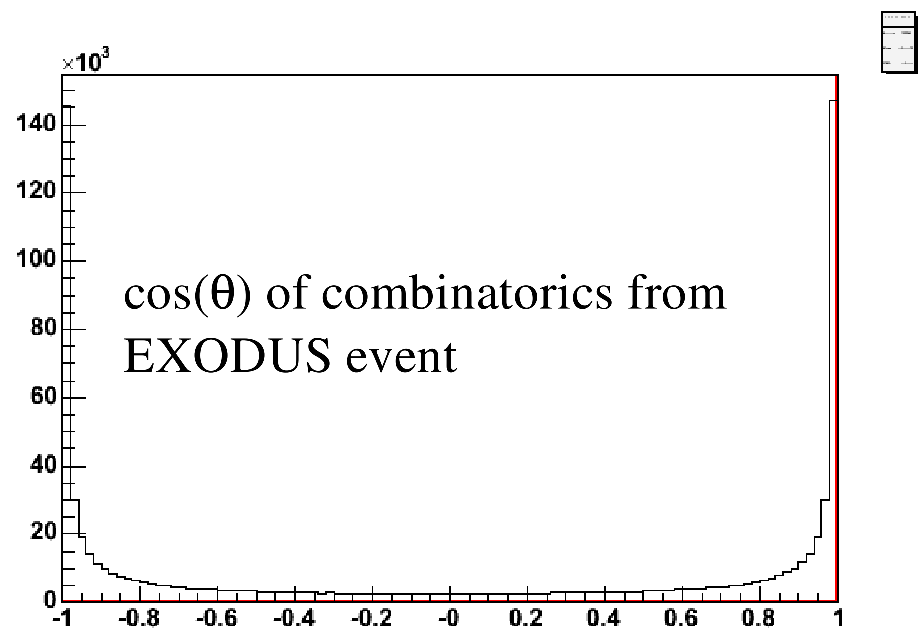
Unlike-pair from EXODUS



Each plot shows a range of 500um X 500um, and the red point at center means collision vertex

So we see θ may not exactly be Zero. And combinatorics from real D^0 give a different θ distribution to those from EXODUS.





Two Sets of Cuts:

Loose cut:

Single track: no DCA cut, no chi2 cut
Combinatorics: no cos(θ) cut

Strict cut:

Single track: DCA > 0.0033cm (1 sigma from single pi+), chi2 < 2.0
Combinatorics: cos(θ) > 0.9

Other Available Cuts:

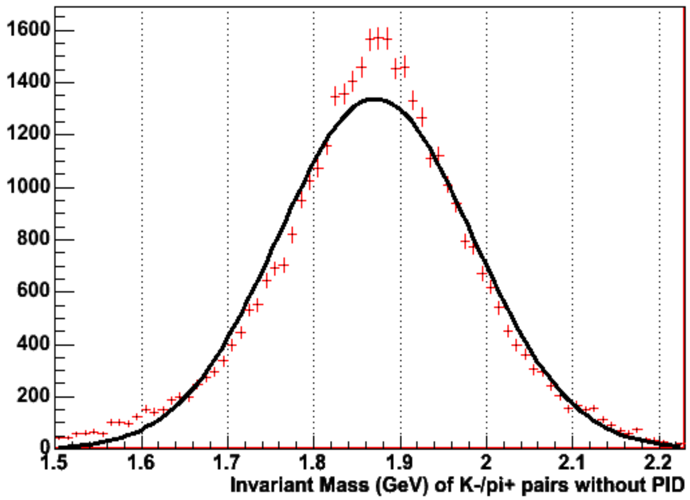
Quality of single track > 7

Pt of combinatorics > 3GeV (agrees with initial input)

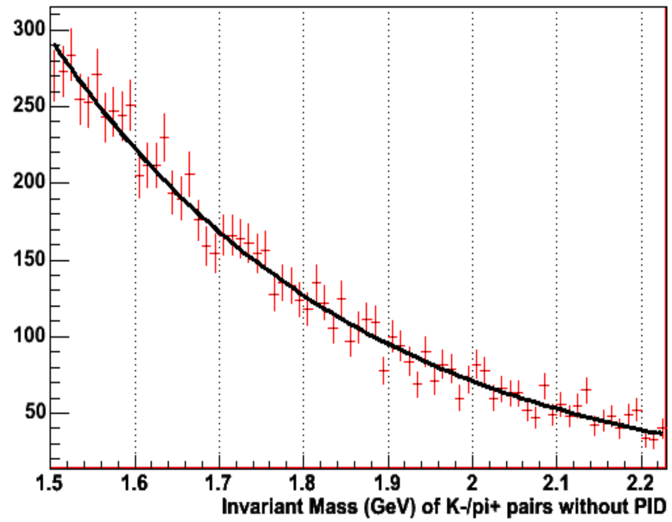
Invariant Mass Spectrum of Unlike-charge Pairs

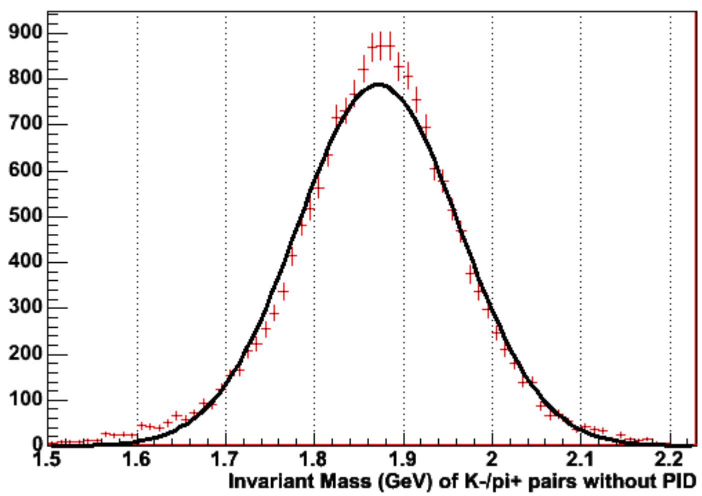
K-/pi+ from D0

EXODUS tracks

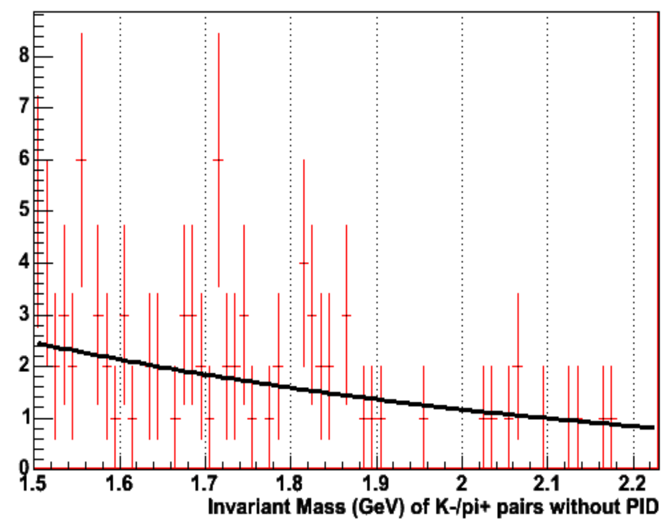


Loose Cut





Strict Cut



Statistics We Get from Inv-mass Spectrum

If we first fit a Gaussian peak to the invariant mass of Pythia, the mean is 1.872GeV (a little different from PDG value 1.8645GeV), and aussme all the statistics from unlike-charge pairs of D^0 decay tracks should contribute, while EXODUS tracks pairs only count inside PHENIX mass resolution 2% (PPG012, the Lambda paper), we will get:

loose cut:

38728 D^0 from Pythia, 954 combinatorics from EXODUS

strict cut:

18433 D^0 from Pythia, 13 combinatorics from EXODUS

Normalization Result for Run 2009:

$4*10^9$ Pythia events forcing charm production, Scale-Factor$_{\text{Pythia}}$

= 0.622/20 (cross-section) * 258 (min-bias Ncoll) / 4G = 2.006E-9

20K EXODUS events, Scale-Factor$_{\text{EXODUS}}$

= 1/20K * (109 (min-bias Npart) / 351 (5% Npart))^2 = 4.822E-6

S/B = (Pair$_{\text{Pythia}}$ * Scale-Factor$_{\text{Pythia}}$) / (Pair$_{\text{EXODUS}}$ * Scale-Factor$_{\text{EXODUS}}$)

loose cut: S/B = 38728 * 2.006E-9 / 954 / 4.822E-6 = 0.017

strict cut: S/B = 18433 * 2.006E-9 / 13 / 4.822E-6 = 0.59

And with expected min-bias AuAu events for Run 2009: 1.53E9

we can get significance = S/sqrt(S+B) * sqrt(N_evt)

loose cut: Sig = 44

strict cut: Sig = 145