$D\bar{D}$ benchmark channels

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**TECHNISCHE
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Outline

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1 Overview
   Motivation

2 $\bar{p}p \to D^+D^-$
   Selection
   Mass Resolution
   Decay Length

3 $p\bar{p} \to D^{*+}D^{*-}$
   Selection
   Reconstruction Efficiency
   Mass Resolution
   Background Study

Overview
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Motivation

$\bar{p}p \to D^+D^-$
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$p\bar{p} \to D^{*+}D^{*-}$
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Motivation

- D reconstruction capability crucial for many aspects of the physics program:
  - charmonium above $D\bar{D}$ threshold
  - open charm spectroscopy
  - charm in medium
  - $D\bar{D}$ mixing, . . .

- generic channels

- good performance test for the detector setup - focus on tracking

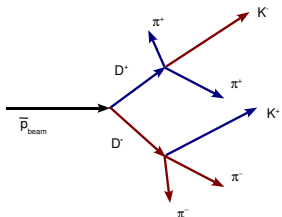- only 'charged' decays chosen

Signal/Background Estimation

- of resonant production using Breit-Wigner approach

$$\sigma_R(s) = \frac{4\pi\hbar^2 c^2}{s - 2m_p^2 c^4} \frac{B_{in}B_{out}}{1 + \left(2(\sqrt{s} - M_R c^2)/\Gamma_R\right)^2}$$

- cross section ratio signal/background in case of resonant production: $\approx 10^{-10}$

- cross section for nonresonant production assumed to be in the same order of magnitude at least at the resonant position

- therefore as much as possible background to be simulated using DPM background generator (at least 10^7)

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Overview
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Selection

$\bar{p}p \to D^+D^-$
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$\bar{p}p \to D^{*+}D^{*-}$
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- only charged decay considered
  $D^+ \to K^-\pi^+\pi^+$ (+cc.,
  BR:$9.51 \pm 0.34\%$)
- non resonant production at
 $\sqrt{s} = 3.77\,GeV$, $p_{beam} = 6.5735\,GeV/c$

selection criteria

- loose mass window cut before vertex fitting
  ($m_D = 1.7\ldots 2.1\,GeV/c^2$)
- minimum 6 charged tracks
- constraints: decay particles have to form a common vertex
- 4C fit to constrain beam (c.l.$> 10^4$)
- using 'Very Loose' lists for K/π selection so far (LH $>= 0.2$),
  different PID cuts could be used to reject background

Overview
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Selection

$p\bar{p} \to D^+D^-$
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$p\bar{p} \to D^{*+}D^{*-}$
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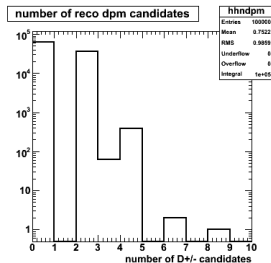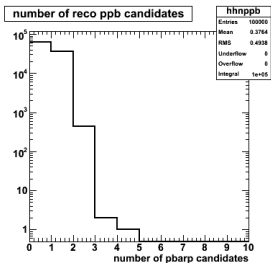
- most likely one candidate for initial system found (upper left, log scale)

- in $\approx 1\%$ more than one initial system reconstructed: left: mass distribution in this case contains combinatorical background
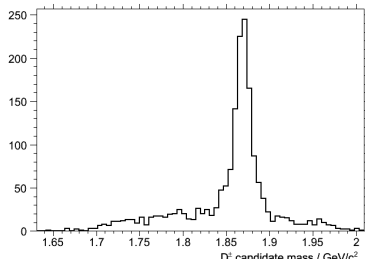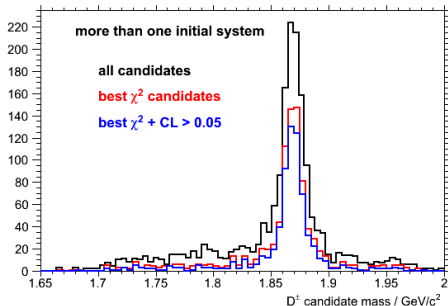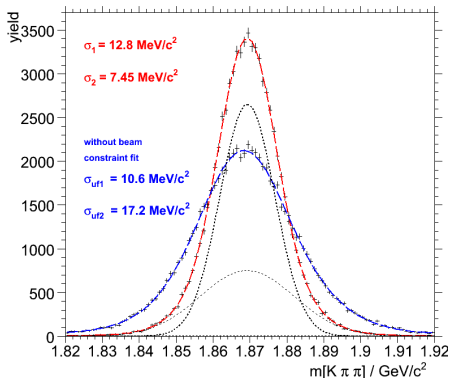
reducing combinatorics by using
4C-fit informations

- without any further constraints
- take $D^{\pm}$ candidates of initial system with lowest χ^2
- additional cut on c.l. of primary vertex: C.L>0.05 (right picture)
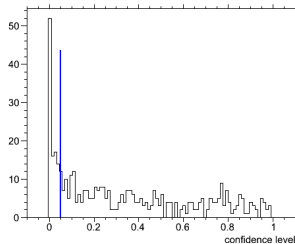
Mass resolution: $D^{\pm}$

- take all reconstructed daughter candidates after cuts
- good signal resolution
- efficiency $\epsilon = 36.8\%$ (10^5 signal events studied)
- fit with 2 Gaussian's and linear background
- 4C-fit improves resolution by $\approx 50\%$
- almost no combinatorial background left

mean peak position: $\bar{m}_{D^{\pm}} = 1.86930 \pm 0.00005\,MeV/c^2$
(MC value: $m_D^{\pm} = 1.8693\,MeV/c^2$)

Different PID cuts

- using particle ID to distinguish between K/π for secondary decay fitting
- signal efficiency drops with more stringent cuts on K/π separation
- problems in forward region
- no PID info from central tracker based on dE/dx included

Particle Lists

Very Loose	Likelihood $>=0.2$
Loose	Likelihood $>=0.3$
Tight	Likelihood $>=0.55$
Very Tight	Likelihood $>=0.7$

Overview
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Mass Resolution

$p\bar{p} \to D^+D^-$
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$p\bar{p} \to D^{*+}D^{*-}$
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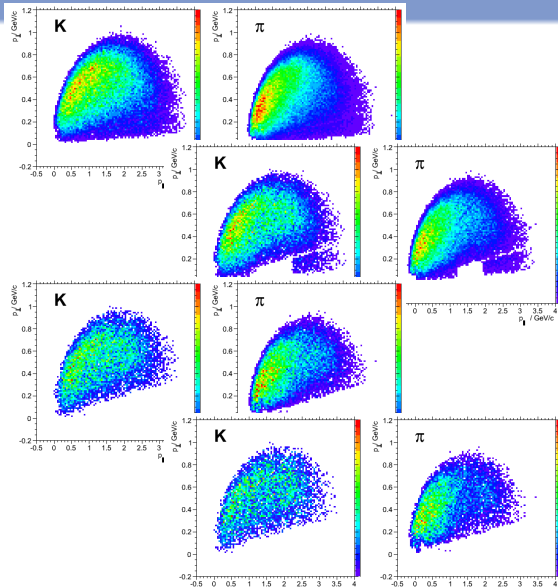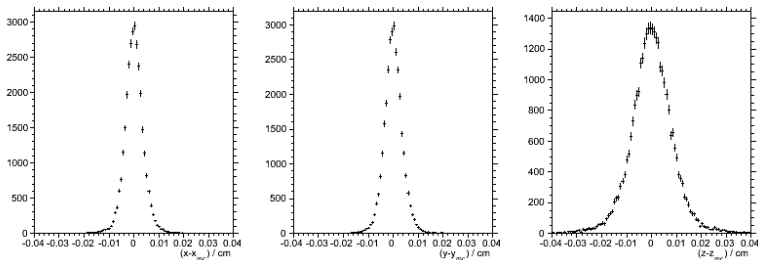# Different PID cuts

'Very Loose' list
($\epsilon_{signal} = 36.8\%$)
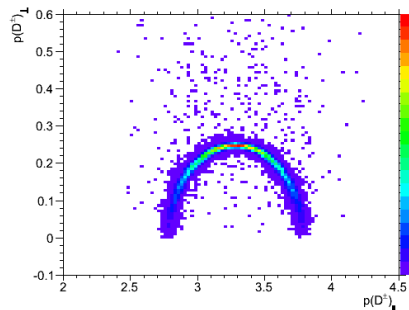shown K, π momentum
distribution

'Loose' list
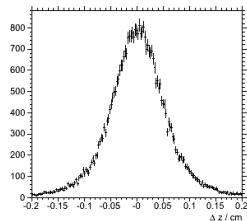($\epsilon_{signal} = 17.2\%$)

'Tight' list
($\epsilon_{signal} = 6.9\%$)

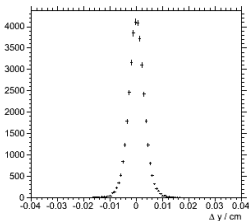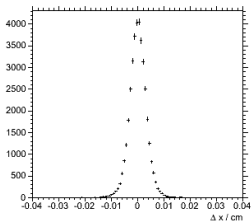'VeryTight' list
($\epsilon_{signal} = 4.0\%$)

Overview
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$p\bar{p} \rightarrow D^+D^-$
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$p\bar{p} \rightarrow D^{*+}D^{*-}$
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Decay Length

- as quality test: reconstruct decay length of D
- secondary vertex fittet with good resolution
- $\sigma_{x,y} \approx 35\mu m$, $\sigma_z \approx 77\mu m$
- due to production close to threshold and beam boost to the Ds primary resolution suffers

Overview
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Decay Length

$\bar{p}p \to D^+ D^-$
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$p\bar{p} \to D^{*+} D^{*-}$
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- good resolution in x,y plane
- $\sigma_{x,y} \approx 30 \mu m$,
- $\sigma_z \approx 480 \mu m$ caused by small opening angle between $D^{\pm}$'s $\to$ production close to threshold
- going to higher excess energies would improve z vertex resolution

Overview
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Decay Length

$p\bar{p} \to D^+D^-$
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$p\bar{p} \to D^{*+}D^{*-}$
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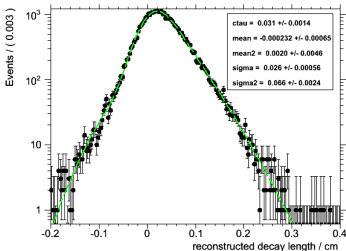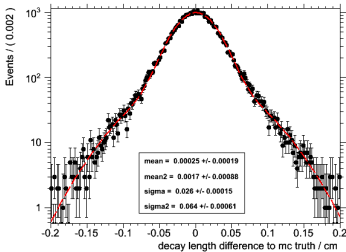
- upper picture: decay length difference to mc truth information → handle on resolution

- description with two gaussians sufficient, broader contribution 30%

- lower picture: reconstructed decay length, decay model convoluted with resolution model from previous fit

- although the resolution is not optimized the decay length can be obtained

- fit values from first resolution model as start values for combined fit
  $c\tau = 310 \pm 14\mu m$
 (MC value: $315\mu m$)

Overview

$\bar{p}p \to D^{*+}D^{*-}$

- reconstruction of whole decay tree
- $D^{*+} \to D^0\pi^+$, $D^0 \to K^-\pi^+$
- only charged decay considered $\to$ 6 charged tracks in event
- non resonant production at $\sqrt{s} = 4.04\,GeV$, $p_{beam} = 7.69814\,GeV/c$
- slow pion from D^{*+} decay, D's carrying half of the beam momentum

Overview
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Reconstruction Efficiency

$\bar{p}p \to D^+D^-$
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$p\bar{p} \to D^{*+}D^{*-}$
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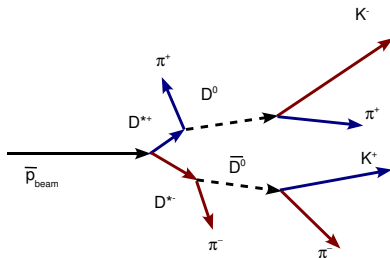
Selection Criteria

selection criteria

- loose mass window cut before vertex fitting
  ($m_{D^*} = 1.8 \ldots 2.3 GeV/c^2$)

- minimum 6 charged tracks in event

- using 'Very Loose' list for K/π selection so far (LH $>= 0.2$)

- constraints: decay products have to form common vertices $\to \bar{p}p$
  system, $D^{*\pm}$ and D^0

- 4C fit to constrain beam (c.l.$> 10^4$)
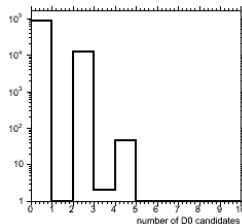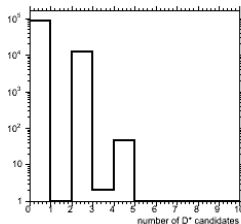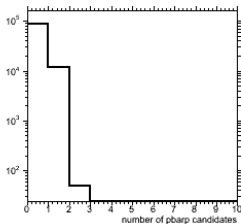
- efficiency to reconstruct initial $\bar{p}p$ system: 12.2%
- most likely only one initial system (0.4% second $\bar{p}p$ system found)
- some combinatorics from mixture of charged track from second/third vertex, but below percent level
- limiting factor: slow π form D^* decay

- π momentum from $D^{*\pm}$ decay small (upper: black distribution; blue: MC truth)
- distribution slightly shifted towards smaller values
- due to energy loss π momentum gets systematically reconstructed to low
- error on momentum not symmetric (lower picture) + systematic shift

Overview · $\bar{p}p \rightarrow D^+D^-$ · $\bar{p}p \rightarrow D^{*+}D^{*-}$
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Mass Resolution
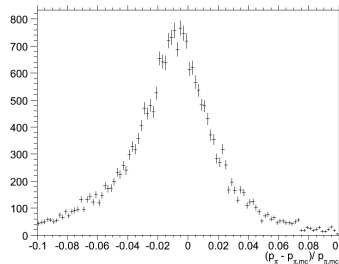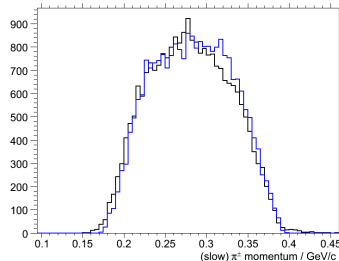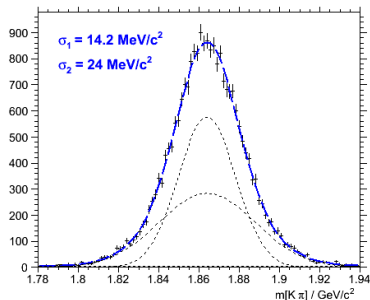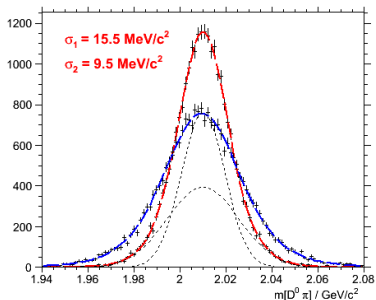
- if a D^* decay is reconstructed the corresponding D^0 is found with $\epsilon = 99.2\%$

- good signal description via two Gaussian's

- $\approx 40\%$ improvement due to beam constraint fit (red distribution, left)

Overview
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$\bar{p}p \to D^+D^-$
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$p\bar{p} \to D^{*+}D^{*-}$
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Background Study

DPM background

- so far 3.3×10^6 background events simulated - more to come in the next days/weeks
- elastic events are filtered out before detector simulation to spare time
- previous studies have shown that the beam constraint fit suppresses the background drastically
- no background event survives the selection criteria for $D^{*+}D^{*-}$ channel
- no further PID informations used to reject background, e.g. demanding a larger K likelihood in the D^0 vertex fit

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$D\bar{D}$ benchmark channels
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Summary

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

- nonresonant production close to threshold

- good mass resolution

- signal efficiency ($\approx 40\%$)

- kinematic fit improves resolution by $\approx 50\%$

$p\bar{p} \to D^{*+}D^{*-}$

- good mass resolution for $D^{*\pm}$ and D^0

- signal efficiency slower (12%), further constraints on $D^{*\pm}$ decay, additional slow pion

- so far not enough DPM background simulated

- 3×10^6 DPM events analysed and no event survives selection