$D^0 \longrightarrow K\pi$ analysis in p-p

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13th September 2009

Quinto convegno nazionale sulla fisica di ALICE

Outline

- Introduction: recent results about heavy flavour @ RHIC
- Tools and results for the analysis of the D^0
- Feed down from B
- Summary

Heavy Flavor tasks in ALICE

- p-p collisions are the benchmark
  - test pQCD at small-x and large p_T
- Pb-Pb
  - High p_T quarks in a hot medium like a QGP experience an energy loss due to re-scattering and gluon radiation
  - Energy loss and in-medium hadronization are known as final state effects
- The presence of a nucleus in the initial state changes the shape of the Parton Distribution Functions (shadowing) and lead to initial state multiple-scattering (k_T broadening and Cronin Effect)
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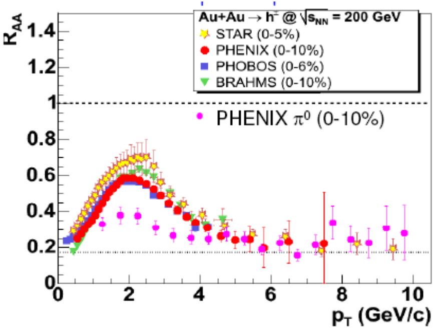
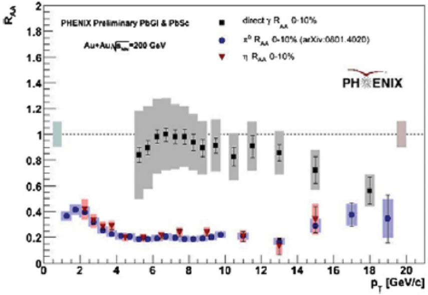
  - $\langle \Delta E \rangle = \alpha_s C_R \hat{q} L^2$
- Because $m_q \ll m_{c,b}$ study B(bq) and D(cq) spectra means study the scattering of c, b in the medium

- $R_{AA} = \frac{1}{N_{coll}} \frac{dN_{AA}/dp_T}{dN_{pp}/dp_T}$
- π^0 suppression of a factor 5 at high-p_T
- Direct photons do not experience suppression





Heavy flavour electrons @ RHIC

- STAR and PHENIX measure heavy flavour decays in $e^{\pm}X$ detecting the "nonphotonic" electrons
- Other sources of electrons are:
  - "photonic" background from Dalitz decays and photon conversions
  - nonphotonic background from $K \rightarrow e\pi\nu$ and dielectron decays of vector mesons (smaller)
- Background subtraction (PHENIX)
  - "Converter subtraction" method
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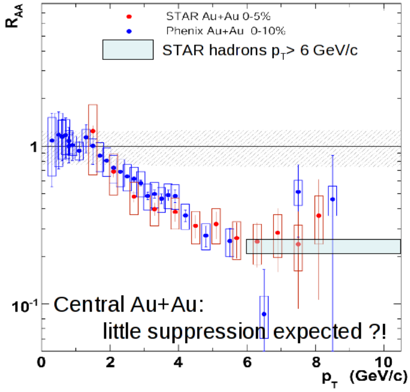
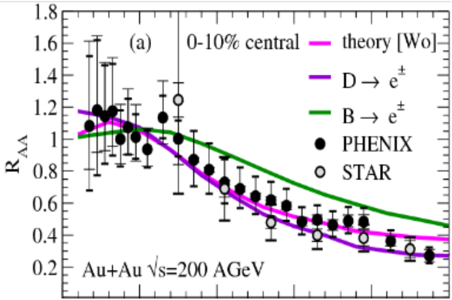
- After background subtraction:
- Central Au-Au STAR and PHENIX data inclusive c+b



Charm and bottom contribution

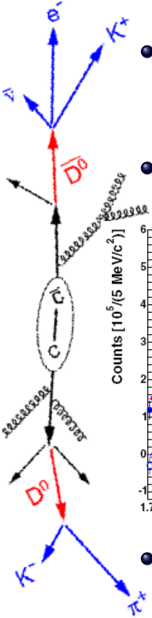


Hees-Mannarelli-Greco, PRL100 (2008)

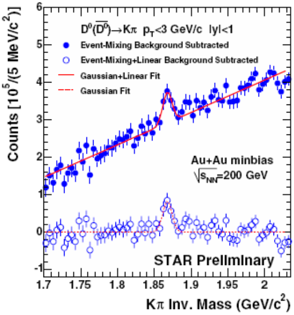
- Significant contribution from bottom is expected at large p_T
- ALICE will help to disentangle B and D contribution in the R_{AA} and v_2 spectra thanks to the higher b cross section and the *vertex detector*.

pQCD NLO + EKS98	SPS PbPb Cent	RHIC AuAu Cent	**LHC PbPb Cent**
cc	0.2	10	**115**
bb	-	0.05	**5**

$D^0 \to K\pi$ from STAR



- STAR performed also measurements of $D^0 \to K\pi$ identifying K and π from dE/dx and tracking with the TPC
- No D^0 vertex separation, large combinatorial background even after subtraction, no $R_{AA}(p_T)$



  - The selection of the signal was achieved with the mixed-event technique
    - ★ Signal observed at 4.5σ level

- ALICE has a silicon vertex detector that can improve this measurement

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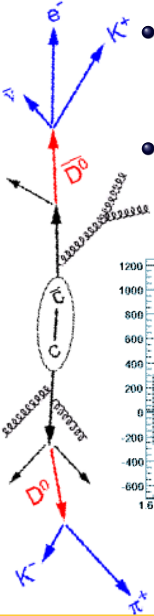

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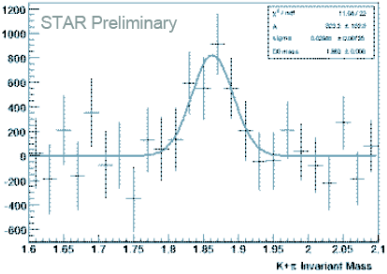
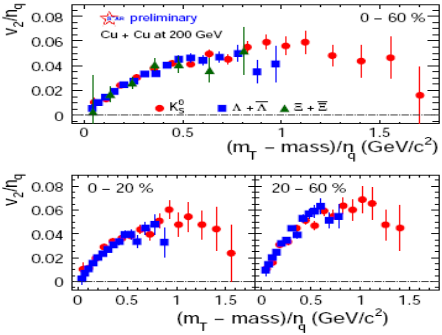


- A recent result using the silicon tracker was presented
- The background is estimated by fitting a 4^{th} order polynomial to side bands and subtracted
  - ★ signal ~ 3000
  - ★ signal/bkg $= 0.006$
  - ★ $\sigma = s/\sqrt{s+b} = 4.5$

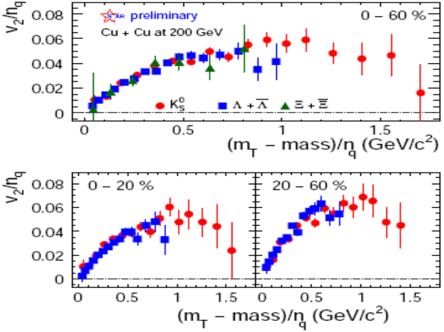
Elliptic flow

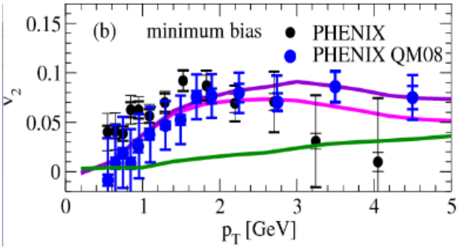
- v_2 scales with number of constituent (valence) quarks $\Rightarrow$ flow is partonic!
- Hydrodynamics with viscosity fits data



Elliptic flow

- v_2 scales with number of constituent (valence) quarks $\Rightarrow$ flow is partonic!
- Hydrodynamics with viscosity fits data
- Heavy-flavour v_2 shows that c and b are strongly coupled with medium
- More studies on heavy quark's v_2 can establish the level of thermalization reached





HF Analysis in ALICE

- D mesons can be studied in different hadronic decay channels

$$\begin{aligned} D^0 \longrightarrow \quad & K^-\pi^+ \\ & K^-\pi^+\pi^-\pi^+ \\ D^+ \longrightarrow \quad & K^-\pi^+\pi^+ \\ D_s^+ \longrightarrow \quad & K^+K^-\pi^+ \end{aligned}$$

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- In this talk I'll report some results about the D^0 meson
  - $D^0 \rightarrow K\pi$ (B.R. 3.8%) invariant mass distribution and fit
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GENERAL PROCEDURE

- An invariant mass analysis is performed to estimate signal and background yields
  - Extract the signal with a fit
- Study variables that select secondary vertex such as the pointing angle and the product of impact parameters

Event Display for heavy flavours

- Have a look to the $D^0 \longrightarrow K\pi$ decay with the Event Display

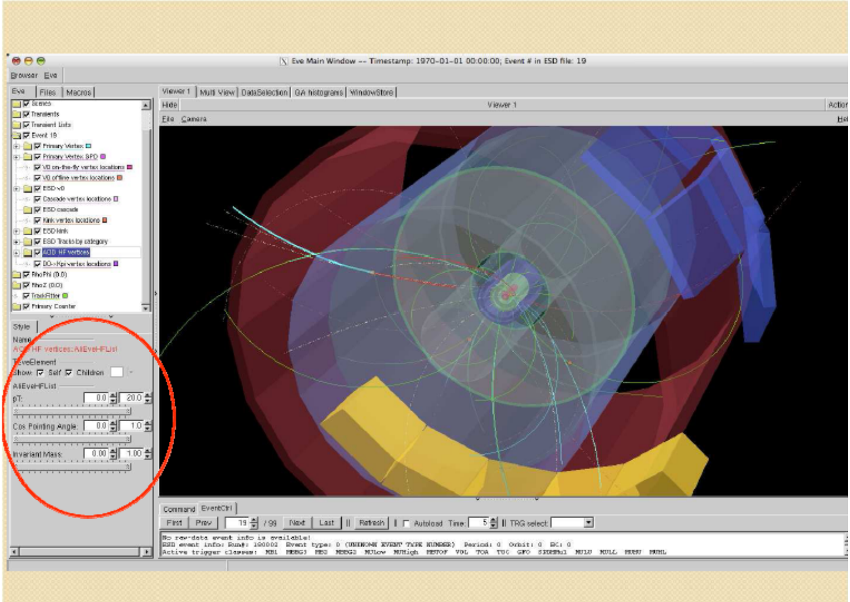
Event Display for heavy flavours

- Have a look to the $D^0 \rightarrow K\pi$ decay with the Event Display

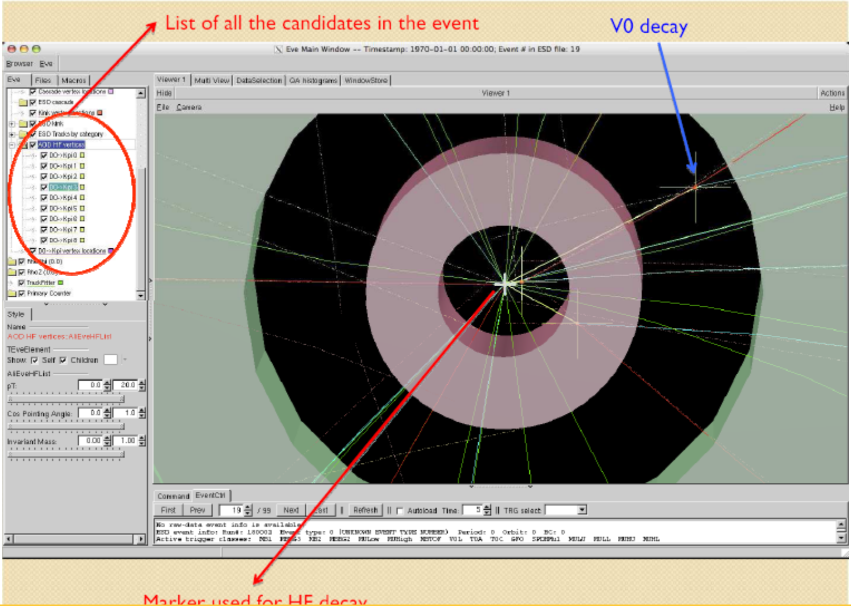
⋆ Davide Caffarri developed the Event Display tool for the HF

- Little "how to"
  - `cd` into the directory containing the ESD, the AOD and the AOD friend files
  - type `alieve`
  - Load the AOD friend: `AliEveEventManager::AddAODfriend("AliAOD.VertexingHF.root")`
  - Run the macro that scans the event: `.x visscan_init.C`
  - Execute the macro that starts from the AOD.VertexingHF selecting the candidates and creating the EVE objects: `.x aod_HF.C`

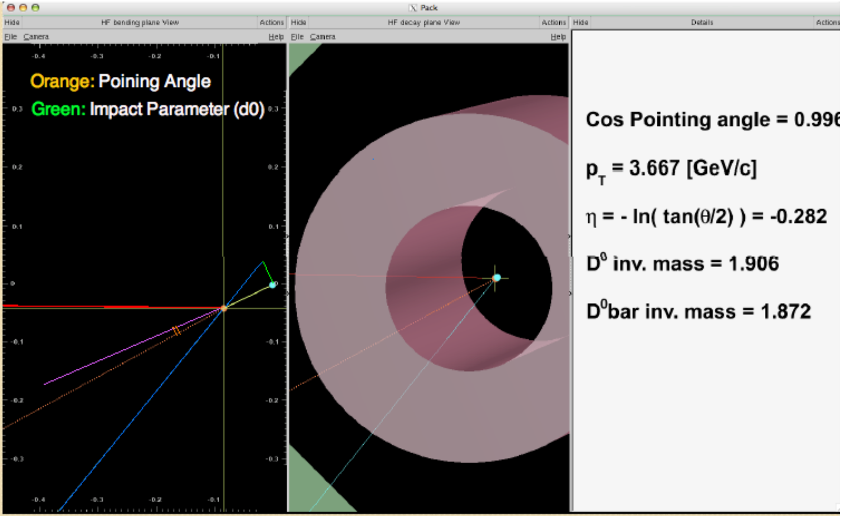
General view of the event



Zoom on the HF decay



Details



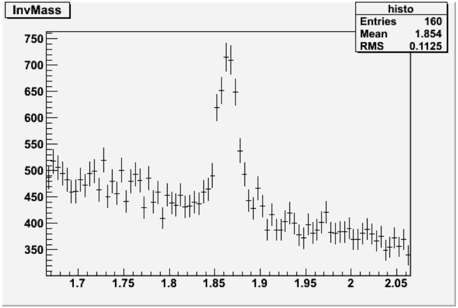
2D display with the position of the secondary

3D rotaiting display with only the selected HF decay.

Some details about D^0 features.

Fitter

- Plot invariant mass



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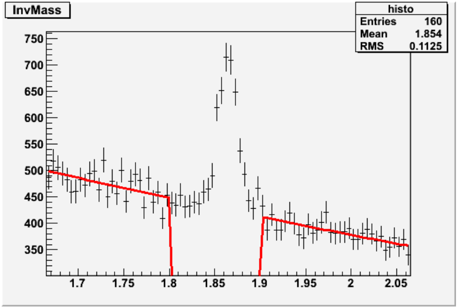

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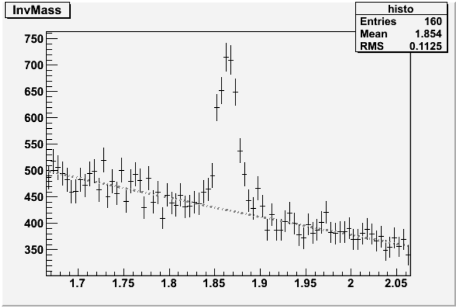

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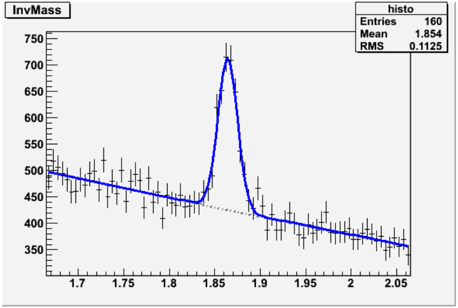

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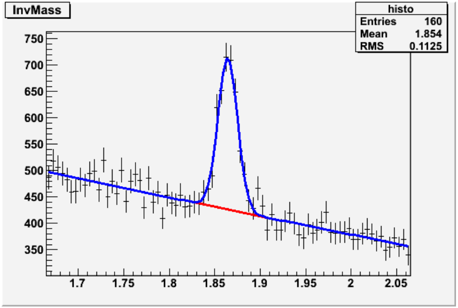
- Recalculate the background function with the final parameters



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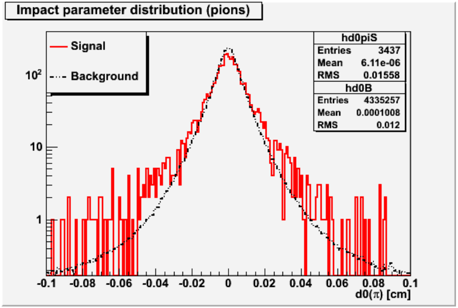
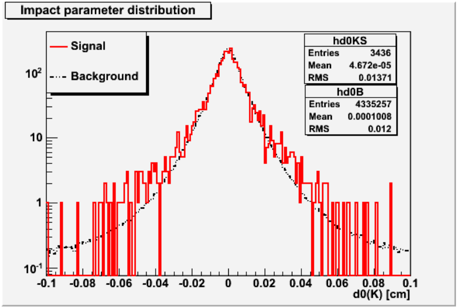
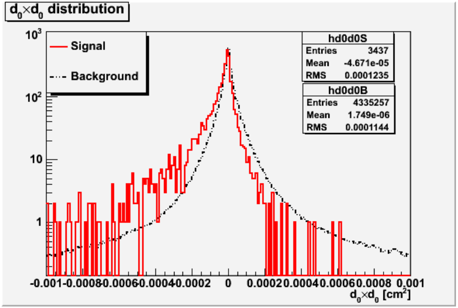
- All the results presented are from a sample of 38M events of the production LHC09a4 = p-p $\sqrt{s_{NN}} = 10$TeV minimum bias

Select cut variables: Impact parameter

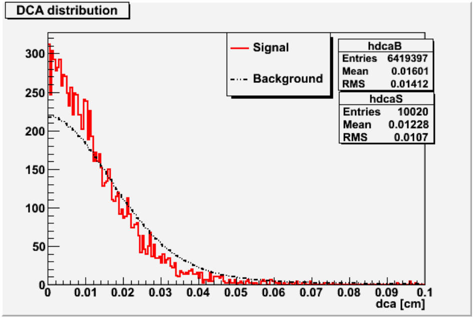


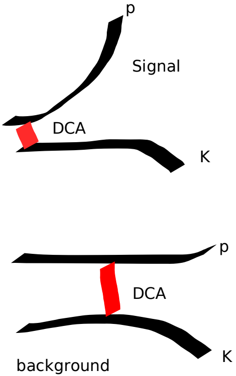




- d_0 for the two particles doesn't select very well the signal
- The product of the two is more promising

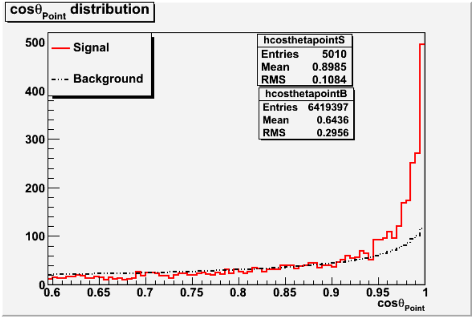
Select cut variables: Distance of closest approach

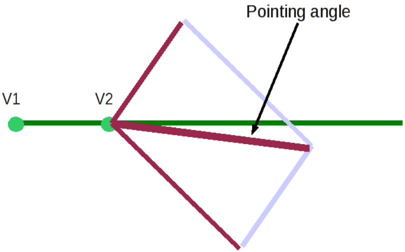




- The DCA is near to zero for the tracks coming from the same vertex
- Many background tracks can come from primary vertex $\mapsto$ little DCA
- Anyway selection feasible

Select cut variables: Pointing angle

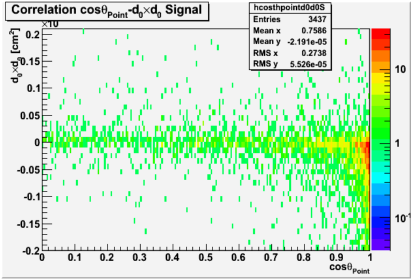




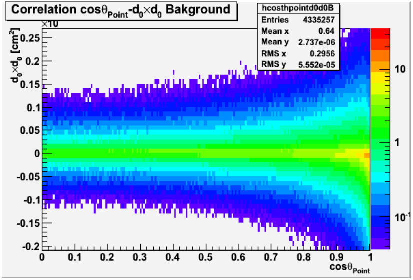
- Angle between the direction primary-secondary vertex and the sum of the momentum vectors of the decaying particles
- Very useful cut as it selects mostly tracks from secondary vertex

Correlation between $\cos\theta_{Point}$ and $d_0 \times d_0$

SIGNAL



BACKGROUND



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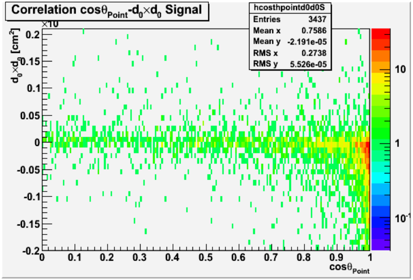

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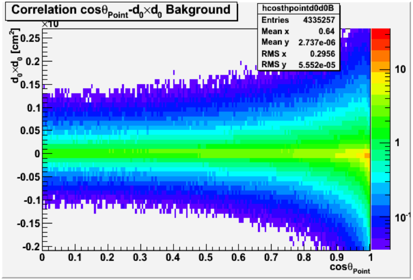

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- The cut values are still not optimize . . . work in progress!

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  - Check if the two different types of background have the same shape
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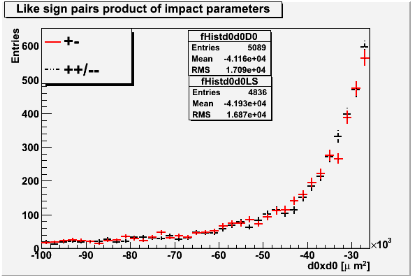
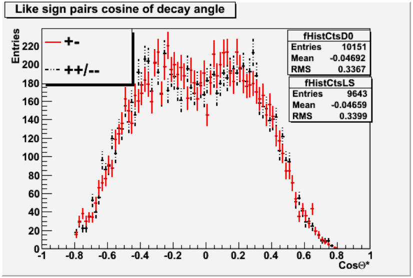
  - Check if the two different types of background have the same shape
  - If it is like this one can use LS pairs to subtract background in the invariant mass distribution
- Cuts have been applied
- RED: all particle selected as D_0
- BLACK: all pairs like sign selected

"Like sign" study (background subtraction)

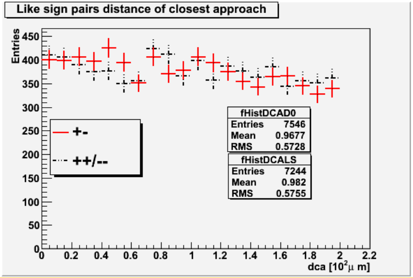
d_0



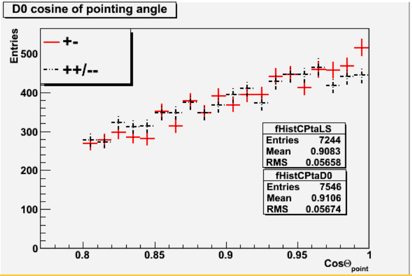
$\cos\theta^*$



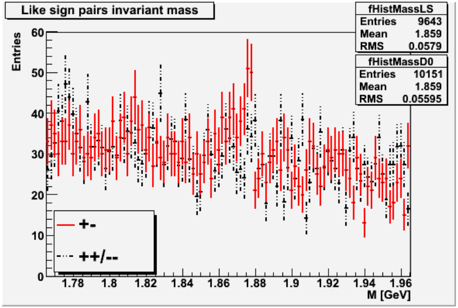
DCA



$\cos\theta_{point}$



Conclusion on "like sign"



- In this case a sample of 25M events has been used
- The distributions for LS pairs and OS background are compatible for all the considered variables
- This method is promising, work in progress ...

Tool for the mass fitting

- `AliHFMassFitter` (`$ALICE_ROOT/PWG3/vertexingHF`) performs invariant mass fit for the D mesons
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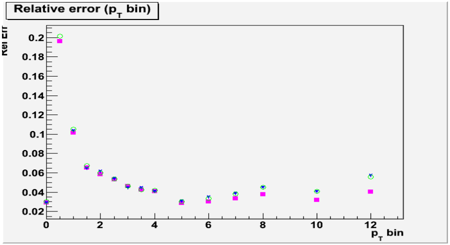
Preliminary study:

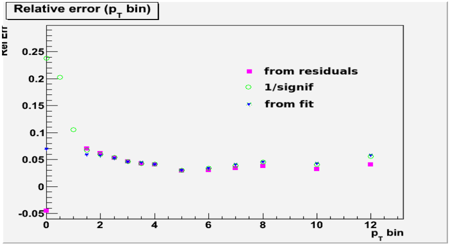
- Preliminary studies on known histograms are performed to test the fitter and to estimate the **systematic errors** with different functions;
- Signal histogram is obtained smearing a **gaussian** function with a Poissonian distribution;
- Background histogram is obtained smearing an **exponential** function with a Poissonian distribution;
- The fitter had been applied on a sample of data (D^0 so far) to estimate the efficiency on the determination of parameters through the Monte Carlo.

Systematic error on S

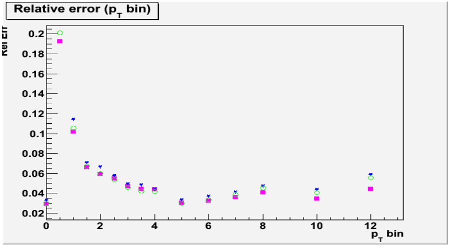
expo



linear



poli2



- Blue stars in upper plot are the sigma of the residuals $intS_{fit} - intS_{true}$ histograms;
- Pink squares are the relative errors from fit;
- Green circles are $\dfrac{\sqrt{S+B}}{S}$ that is $\dfrac{1}{significance}$.

D^0 invariant mass fit (I)

- Set of cuts applied

▷ $p_T < 1$ GeV/c

dca [cm]	$\cos\theta^*$	p_T(K) [GeV/c]	$p_T(\pi)$ [GeV/c]	$\|d_0(K)\|$ [cm]	$\|d_0(\pi)\|$ [cm]	$\|d_0 \times d_0\|$ [cm^2]	$\cos\theta_{point}$
0.04	0.8	0.5	0.5	0.05	0.05	-0.00025	0.7

▷ $1 < p_T < 3$ GeV/c

dca [cm]	$\cos\theta^*$	p_T(K) [GeV/c]	$p_T(\pi)$ [GeV/c]	$\|d_0(K)\|$ [cm]	$\|d_0(\pi)\|$ [cm]	$\|d_0 \times d_0\|$ [cm^2]	$\cos\theta_{point}$
0.02	0.8	0.7	0.7	1.	1.	-0.00025	0.8

▷ $3 < p_T < 5$ GeV/c

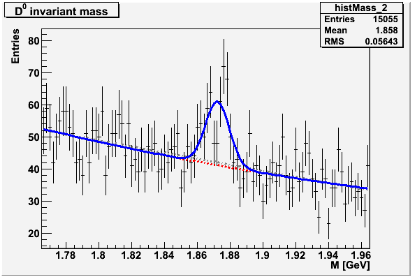
dca [cm]	$\cos\theta^*$	p_T(K) [GeV/c]	$p_T(\pi)$ [GeV/c]	$\|d_0(K)\|$ [cm]	$\|d_0(\pi)\|$ [cm]	$\|d_0 \times d_0\|$ [cm^2]	$\cos\theta_{point}$
0.02	0.8	0.7	0.7	0.05	0.05	-0.00015	0.8

▷ $p_T > 5$ GeV/c

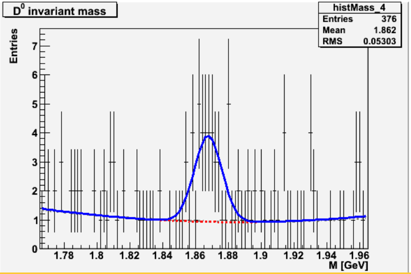
dca [cm]	$\cos\theta^*$	p_T(K) [GeV/c]	$p_T(\pi)$ [GeV/c]	$\|d_0(K)\|$ [cm]	$\|d_0(\pi)\|$ [cm]	$\|d_0 \times d_0\|$ [cm^2]	$\cos\theta_{point}$
0.02	0.8	0.7	0.7	0.05	0.05	-0.00015	0.9

D^0 invariant mass fit (II)

$2 < p_T < 3$ GeV



$p_T > 5$GeV



$3 < p_T < 5$GeV

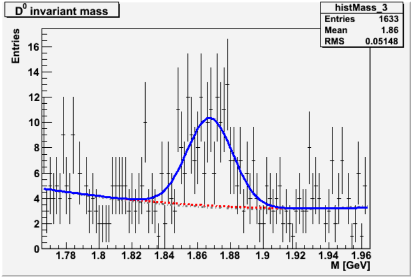


Table of results

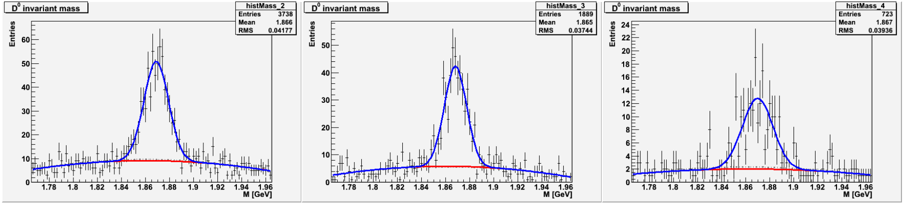
- Colours legend: Fit, MC
- Signal, background and significance in $\mathbf{1}\sigma$

bin	S	B	S/B	signif
$1 < p_t < 3$ GeV	120±20 (76)	296±6 (373)	0.2	6±1
$3 < p_t < 5$ GeV	83±10 (73)	48±3 (61)	1.2	7±1
$p_t > 5$ GeV	21±5 (23)	8±1 (6)	4	4±1

- The comparison with MC highlight a discrepancy that needs further studies
- The error on the fit of the background is very small. This may cause a wrong estimation of the error in a little range as 1σ
- More statistics can help to understand if the comparison improves "spontaneously"

LHC09a5

- *lhc09a5*: p-p @ 10 TeV with a $c\bar{c}$ pair per event with 1/3 of D^0 forced to decay in $K\pi$
- 4M events analysed

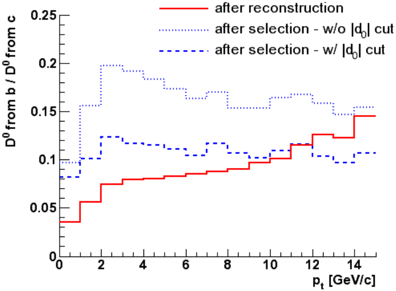


- The shape of the background is due to the *reflected signal* (K and π momentum exchanged)

bin	S	B	S/B	signif
2	365±20 (377)	92±5 (94)	4	17±1
3	288±11 (294)	25±3 (25)	6	16±1
4	117±11 (122)	25±3 (25)	5	10±1

Study of the feed-down from B

- ⋆ From Andrea Rossi
- The contribution to the D^0 signal from B decays is not negligible and has to be separated



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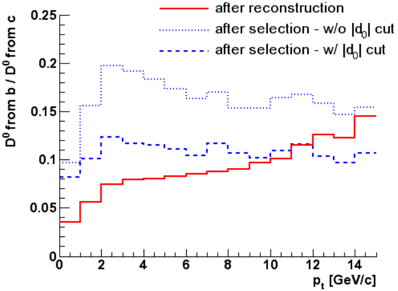


- CDF experiment developed a method to extract signal coming from B using the impact parameter d_0 which has different features in the two cases

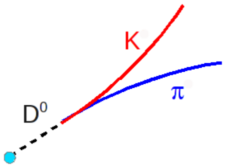
CDF method (I)

* *C.Chen, Ph.D. thesis, University of Pennsylvania, 2003,FERMILAB-THESIS-2003-14*
- The impact parameter (IP) probability distribution can be described by:

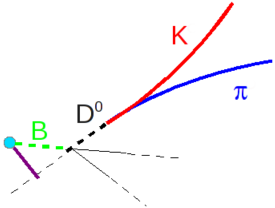
$$F(d_0) = (1 - f_D) \int F_{B \leftarrow D}(x) F_{res}(d_0 - x) dx + f_D F_{res}(d_0)$$

where: f_D is the fraction of primary D^0
$F_{B \leftarrow D}(x)$ is the IP probability distribution of D^0 coming from B
$F_{res}(d_0 - x)$ is the probability distribution due to the resolution of the detector

PRIMARY D^0: true $d_0 = 0$



SECONDARY D^0: true d_0 in general > 0



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- $F_{B \leftarrow D}$ is proportional to an exponential function with a parameter λ
- F_{res} is a Gaussian function with a width σ

Background subtraction

- To take into account the **background** an extra factor is added to the IP distribution that can be now written as:

$$F(d_0) = \frac{S}{T}\left[(1-f_D)\int F_{B\leftarrow D}(x)F_{res}(d_0-x)dx + f_D F_{res}(d_0)\right] + \frac{B}{T}\left[F_{bkg}(d_0)\right]$$

- The fraction of S and B can be determined from the invariant mass fit
- Once supposed a shape for F_{bkg} a fit on the IP distribution of particles in the side-bands of the invariant mass distribution (where there is no signal) fixes the parameters
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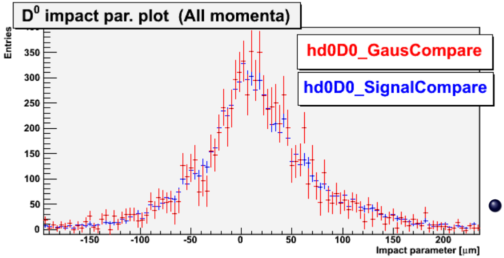
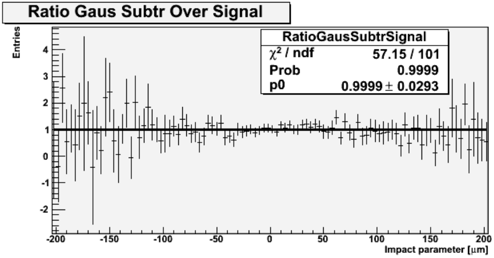
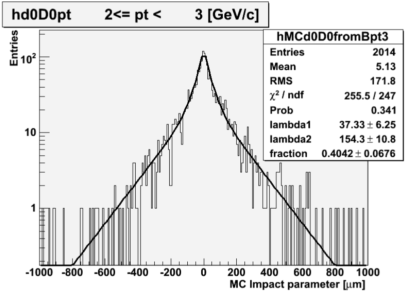
Background subtraction (II)

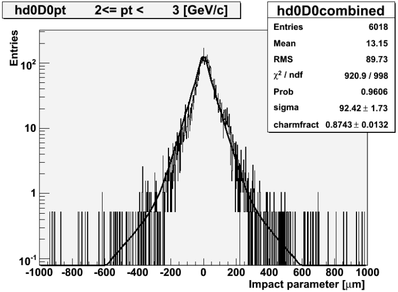




- Top plot
  - Total-background
  - True signal (fom MC)
- Bottom plot
  - Ratio

Secondary and sum of primary and secondary D^0





- *Top plot:* MC IP distribution of secondary D^0
- *Bottom plot:* contribution from prompt charm weighted with a f_D plus contribution from secondary charm weighted with $(1 - f_D)$
- Attempt to recover the input values:

	Input	Recovered
σ	85 μm	92 μm
f_D	0.85	0.87

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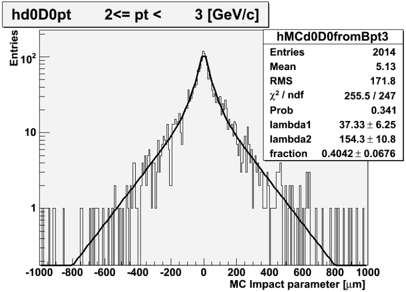

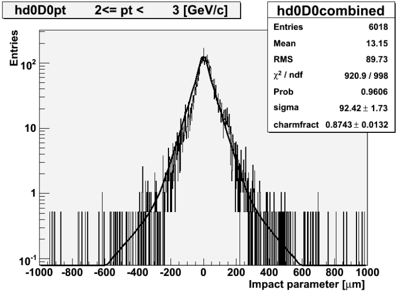

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- Work in progress . . .

Conclusions

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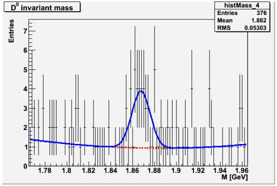

- The results presented show that the tools that have been developed so far allow to extract the signal yield
- The beauty contribution can be disentangled from charm yield thanks to an impact-parameter-based analysis