D^+ analysis in pp collisions

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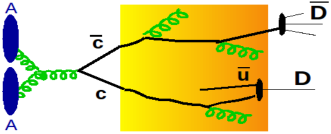
Outline

Charm as QGP probe

Why do ALICE care about charm?

Charmed particles are a good probe for QGP:

- It is produced at the very beginning of the collision
- Follows the whole fireball evolution
- Interacts strongly with the medium
- Due to higher mass, it's harder to thermalize: strong test of thermalization



In proton-proton collisions the study of heavy flavours is interesting too

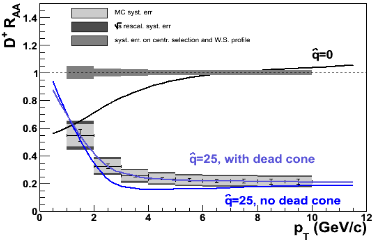
- It provides a crucial reference for Pb-Pb data
- It's a test for pQCD predictions

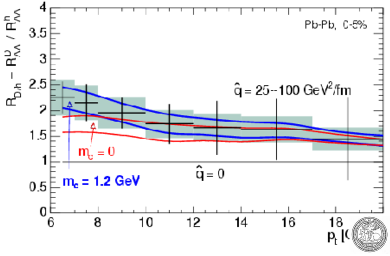
Open charm at ALICE: Energy loss

The study of open charm particles (D^0,D^+,D_s,D^*,Λ_c,...) can bring helpful informations on the nature of QGP

One of the main measurements is Energy loss

- Nuclear Modification factor: $R_{AA}(p_t) = \frac{1}{<N_{coll}>} \frac{dN_{AA}/dp_t}{dN_{pp}/dp_t}$
- An $R_{AA} < 1$, already observed at RHIC, has been interpeted as an effect of the parton energy loss in the medium
- $R_{Dh}(p_t) = \frac{R^D_{AA}(p_t)}{R^h_{AA}(p_t)}$ is a probe for colour charge dependence of energy loss
- $R_{BD}(p_t) = \frac{R^B_{AA}(p_t)}{R^B_{AA}(p_t)}$ is a probe for mass dependence of energy loss





Open charm into hadrons

At ALICE we study the open heavy flavour mesons in three different ways:

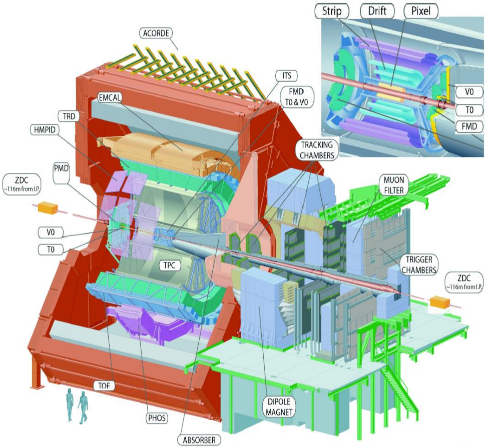
- D meson decaying via charged hadrons (K, π):central rapidity (D2H group)
- D and B mesons decaying via single electrons: central rapidity (HFE group)
- D and B mesons decaying via single muons: forward rapidity (PWG3-MUON group)

The work in this presentation is done in collaboration with all the people of the D2H group

Open charm into hadrons at ALICE

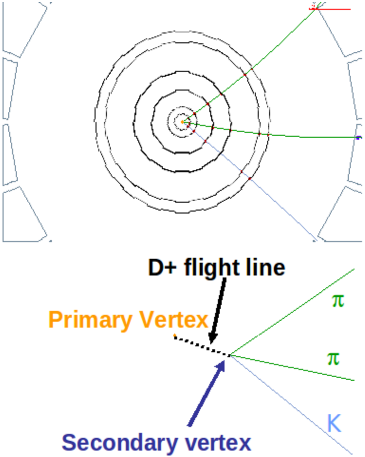
Open charm in ALICE:

- Inner Tracking System (ITS): Vertexing
  - Silicon Pixel Detector (SPD)
  - Silicon Strip Detector (SSD)
  - Silicon Drift Detector (SDD)
- Time Projection Chamber (TPC): Tracking
- Time Of Flight (TOF): K/π id



Analysis Strategy

- Apply basic quality cuts to tracks (ITS and TPC refit, at least 70 clusters in TPC ...)
- From invariant mass analysis of fully reconstructed decay topologies displaced from the interaction vertex → extract the signal
- Estimation of feed down from Beauty
- Efficiency and acceptance corrections → R. Bala
- Normalize and calculate the cross section

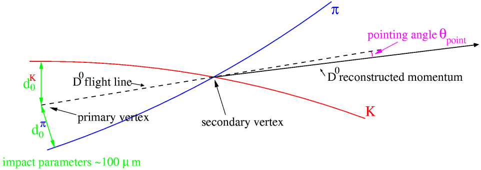


D+ channel

$D^+ \Rightarrow K^-\pi^+\pi^+$ Branching ratio $\sim$ 9.2% with a $c\tau \sim 310\mu m$

$D^+ \Rightarrow K^-\pi^+\pi^+$

- Triplets of charged tracks with right sign combination
- Large distance ($c\tau \sim 310\mu m$) between primary and secondary vertex
- Pointing of reconstructed D momentum to primary vertex
- Large impact parameter of the tracks
- conservative PID: Opposite sign particle CAN'T be a Kaon

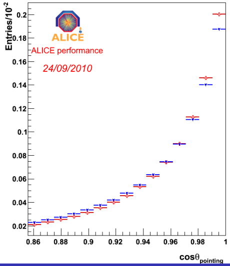


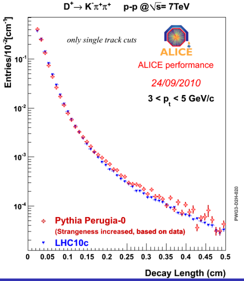
Candidates reconstruction

This work is being done jointly with R. Bala and F. Prino

Build all the possible triplets with the correct sign combination passing very loose topological and single track cuts (minimum p_t of the tracks, $cos\theta_{point}$, decay length, dispersion around secondary vertex...) having invariant mass near to D^+ invariant mass. No signal loss here.

Huge combinatorial background to be reduced applying tighter cuts and PID





Candidate selection

Apply cuts to reduce combinatorial background.

Main cuts are:

- Dispersion around secondary vertex (decay products of a real D^+ must come from the same secondary vertex)
- Distance between primary and secondary vertex
- Pointing angle of the reconstructed candidate towards the primary vertex of the event
- large value of the impact parameters ($\sum d_0^2$)

Candidate selection: PID

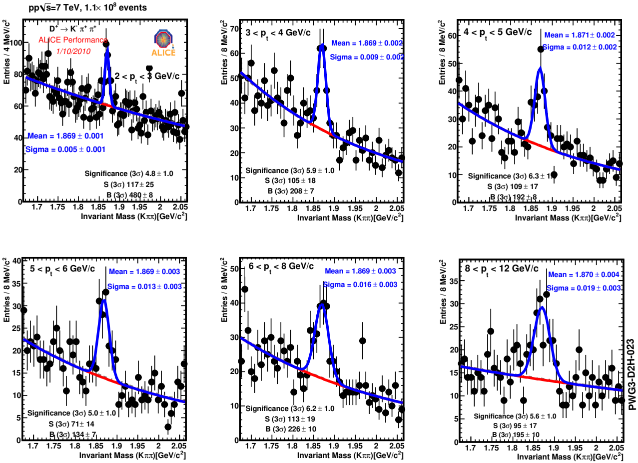
PID applied in conservative way in order to minimize the loss of signal, particles with no PID information are kept.
We use jointly PID from TOF and TPC and we vary the PID response over p_t.
For the D^+ we know that the like sign particles must be pions and opposite sign must be kaons.

TPC	$p_t < 0.6 GeV/c$	$0.6 < p_t < 0.8 GeV/c$	$p_t > 0.8 GeV/c$
$< 1\sigma$	IS K/π		K/π COMPATIBLE
$1 < \sigma < 2$	IS K/π	K/π COMPATIBLE	
$2 < \sigma < 3$	K/π COMPATIBLE		
$> 3\sigma$	K/π EXCLUDED		

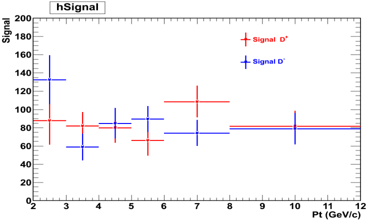
TOF	$p_t < 1.5 GeV/c$	$p_t > 1.5 GeV/c$
$< 3\sigma$	IS K/π	K/π COMPATIBLE
$> 3\sigma$	K/π EXCLUDED	

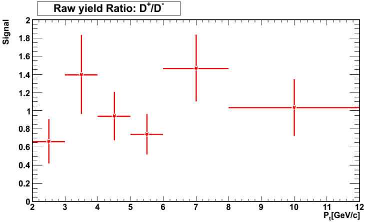
Invarian Mass spectra

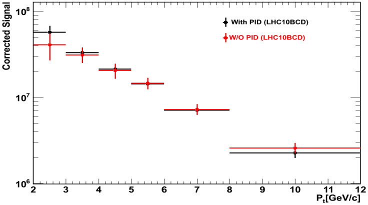
We can plot the invariant mass distribution of the candidates passing cuts and PID requirements. Then we perform a fit to extract the signal in different p_t bins.

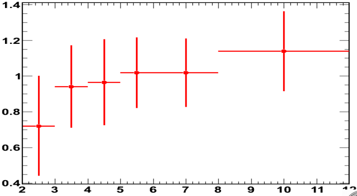


Some Checks


hSignal
Signal
Signal D+
Signal D-
Pt (GeV/c)


Raw yield Ratio: D+/D-
Signal
Pt[GeV/c]


Corrected Signal
With PID (LHC10BCD)
W/O PID (LHC10BCD)
Pt[GeV/c]

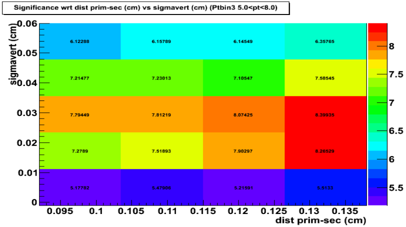


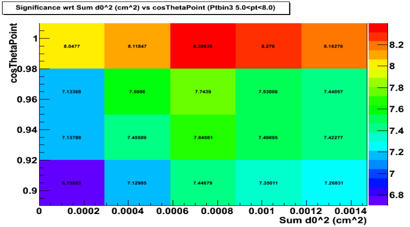
Significance maximization

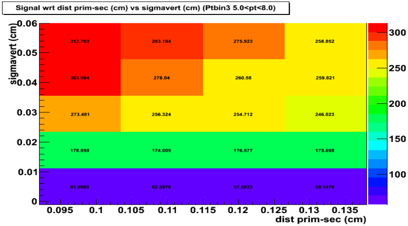
This work is being done jointly with R. Bala and F. Prino

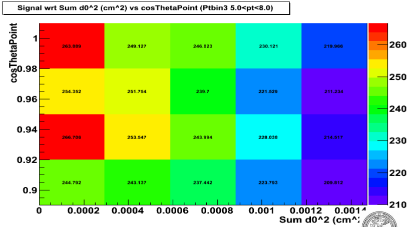
- The cuts applied in the invariant mass analysis are selected in order to maximize the significance $\frac{S}{\sqrt{S+B}}$.
- A specific analysis task has been developed in order to test at the same time several different cuts combinations stored in multidimensional vector.
- Changes in the cut also affects the Signal/Background values $\rightarrow$ there is a systematic error associated to the selection of the cuts

Exploring the cuts space



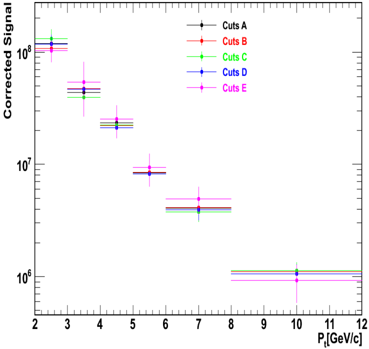


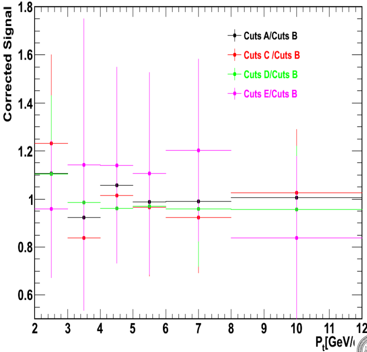




Cut selection

As there is a systematic error associated to cut selection, the maximization of the significance is not the only issue: we want to select a region where cuts are mostly stable.





From raw signal to cross section

This work is being done jointly with Davide Caffarri

One of the goal of D2H is to provide the cross section $d\sigma/dp_t$ for D mesons. We can extract the cross section from the raw yield using the formula:

$$\left|\frac{d\sigma^D(p_t)}{dp_t}\right|_{|y<0.5|} = \frac{1}{2}\frac{1}{\Delta y(p_t)}\frac{1}{BR} f_c \frac{1}{\epsilon_c}\left(N(p_t)^{raw}_{y<0.5}\right)\frac{\sigma_{CINT1B}}{N_{CINT1B}}$$

- $f_c(p_t)$: B feed-down correction
- $\frac{1}{\epsilon_c(p_t)}$: correction for efficiency
- $N(p_t)^{raw}_{y<0.5\Delta y(p_t)}$: Raw signal from the invariant mass fitter
- $\frac{\sigma_{CINT1B}}{N_{CINT1B}}$: Cross section σ_{CINT1B} measured from the VdM scans. The number of CINT1B events is counted for each decay channel through a common dedicated class.

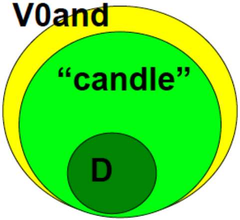
Candles

An alternative way to calculate the cross section is to pass through a "candle" to estimate the total cross section. Then:

$$\left.\frac{d\sigma^D(p_t)}{dp_t}\right|_{|y<0.5|} = \frac{N^D}{N_{inel}}\sigma_{inel} = \left.\frac{N^D}{N_{candle}}\right|_{tot} \left.\frac{N_{candle}}{N_{V0AND}}\right|_{ref} \sigma_{V0AND}$$

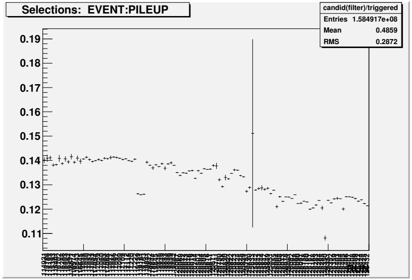
Definition of Candle:

- All events with candidate should have candle
- Should not be too sensitive to OCDB changes
- Should be stable with respect to V0AND and CINT1B over the different periods

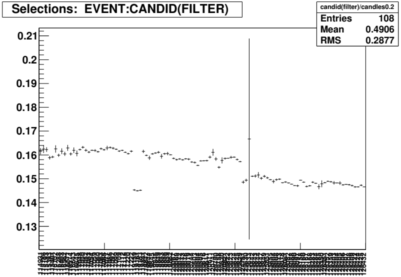


We want to use at least two methods to have a cross-check on the results.

Stability over periods: Candidates



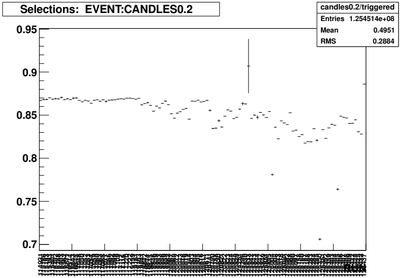
Candidates over triggered events



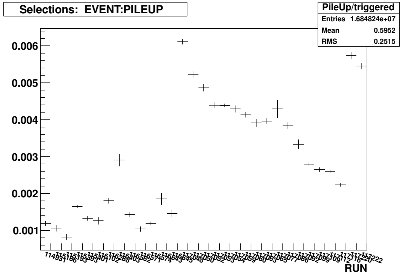
Candidates over Candles

Decreasing trend can be explained by changes in SPD configuation

Stability over periods: Candles



Candles over triggered events

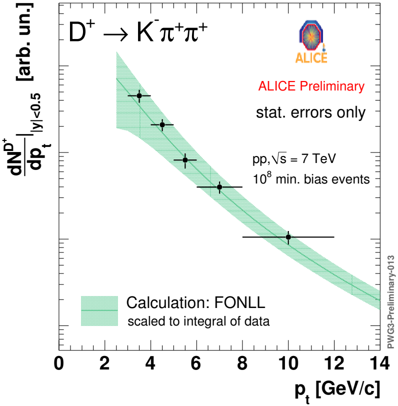


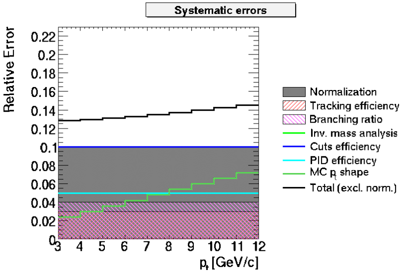
Events tagged as pileup over triggered events (LHC10b period)

$\sim$ 4% decrease of candle still not understood $\rightarrow$ Systematic.

The same tool is used to tag the fraction of events with pileup.

Results


D+ → K-π+π+
ALICE
ALICE Preliminary
stat. errors only
pp, √s = 7 TeV
10^8 min. bias events
Calculation: FONLL
scaled to integral of data
PWG3-Preliminary-013
dN^D+/dp_t |_|y|<0.5 [arb. un.]
p_t [GeV/c]
0
2
4
6
8
10
12
14


Systematic errors
Relative Error
p_t [GeV/c]
Normalization
Tracking efficiency
Branching ratio
Inv. mass analysis
Cuts efficiency
PID efficiency
MC p_t shape
Total (excl. norm.)

Summary

- Part of the ongoing analysis for the analysis of D^+ in pp collisions has been shown
- This analysis is presently carried on with F. Prino and R. Bala from the Torino group as part of the D2H group
- The status of the analysis is quite advanced, we're waiting for more statistics available in AODs