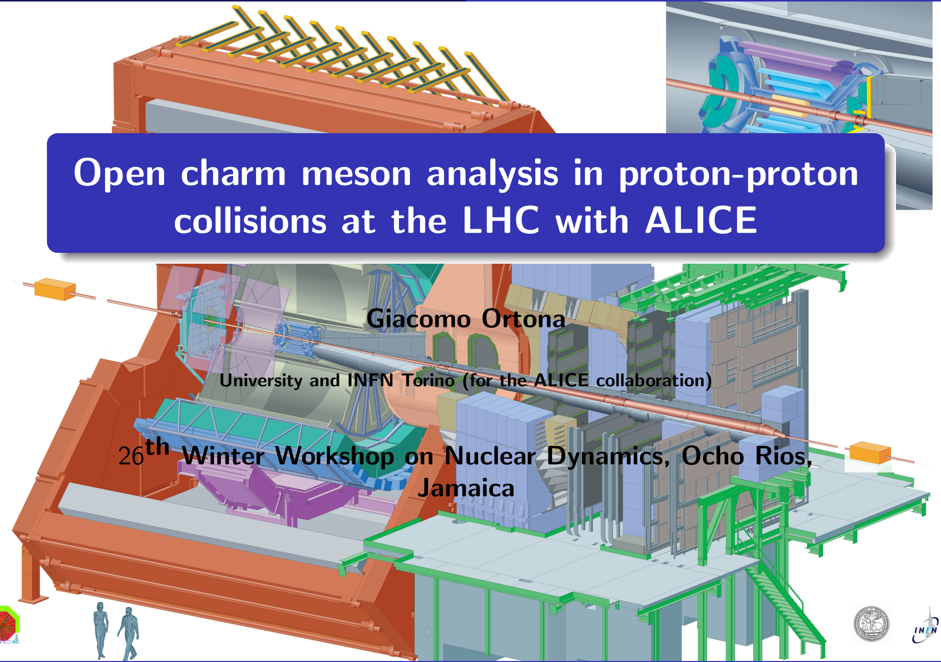
Open charm meson analysis in proton-proton collisions at the LHC with ALICE



Giacomo Ortona

University and INFN Torino (for the ALICE collaboration)

26th Winter Workshop on Nuclear Dynamics, Ocho Rios, Jamaica

Outline

1. ALICE
2. ALICE Heavy flavour program
3. D meson analysis at ALICE
   - D^0 analysis tools
   - D^+ analysis tools
4. Expectations
5. Conclusions

More to come in the next ALICE people's talks:

- Hans Rudolph Schmidt (Tuesday)
- Casper Nygaard (Wednesday)
- Rene Bellwied, John Harris, Frederick Kramer (Friday)

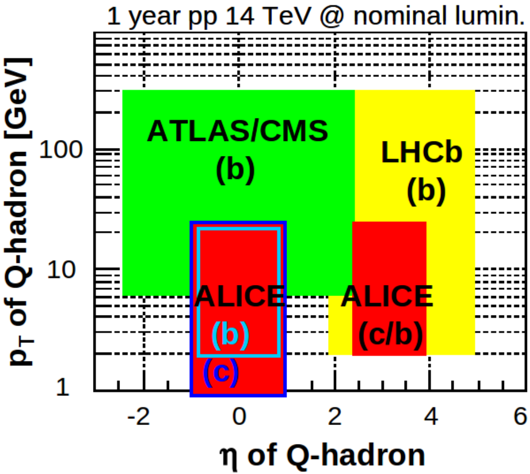
The ALICE experiment

Channels

- electronic and hadronic: $|\eta| < 0.9$
- muonic: $-4 < \eta < -2.5$

Coverage

- extends to low p_t (down to 1 GeV for D^0)
- central and forward rapidity regions
- both for b and c

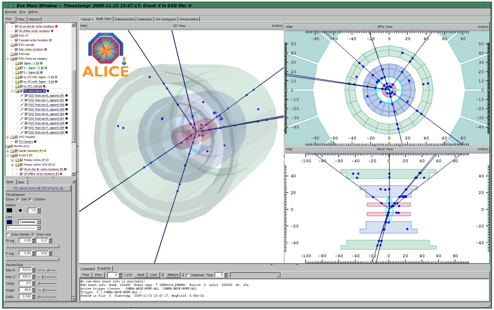


First event!

On november 23rd, 2009 ALICE saw its first proton-proton event!
$(\sqrt{s} = 900 GeV)$

In less then one month ALICE collected

- $\sim$ 400 000 events at $\sqrt{s} = 900 GeV$
- $\sim$ 40 000 events at $\sqrt{s} = 2.36 TeV$



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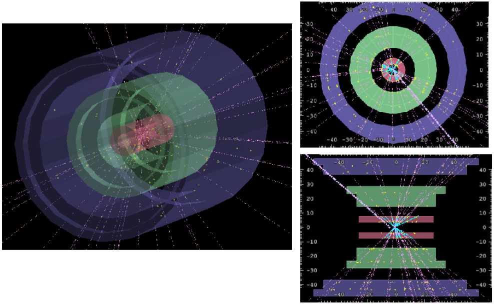

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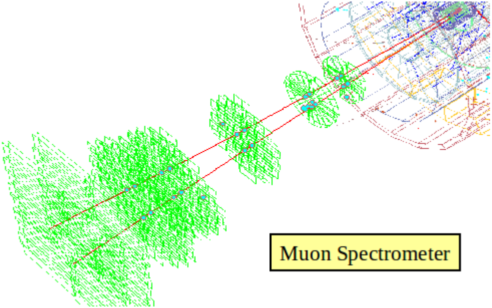
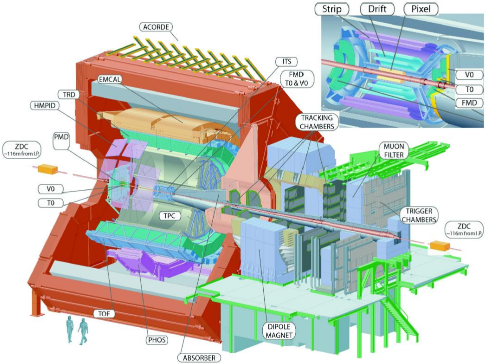


Open Charm at ALICE

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



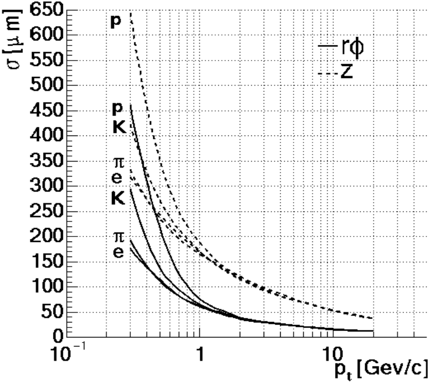
Heavy flavours at ALICE

HF are a powerful tool to investigate the hot and strongly interacting medium that will be produced at high energy collisions at the LHC.
At LHC we expect high rates of HF production.

ALICE has very good performances in HF study:

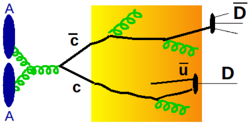
- Excellent vertexing and tracking
- electrons and muons channels are both studied in different rapidity regions
- very good track impact parameter resolution (minimum distance between track and primary vertex)
- PID is performed with several techniques ($\frac{dE}{dx}$, TOF, TRD)

Resolution on track impact parameter
central Pb-Pb



Motivations

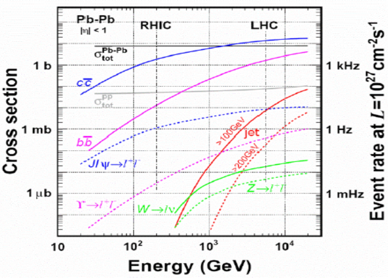
- p-p collisions
  - measurement of HF production ⇒ test of pQCD calculations
  - baseline for A-A studies
- A-A
  - study of the medium produced in A-A collisions (QGP)
    - final state effects due to the medium (Energy loss, in medium hadronization $\cdots$)
  - Quarkonium physics
- p-A
  - To disentangle initial and final state effects



Forward rapidity and low p_t charm study allows to probe extremely small ($\sim 10^{-4}$) x region

Heavy flavour production

At LHC energies much larger cross section wrt RHIC
$\Rightarrow$ much bigger c and b charm production



$\sigma_c(LHC) = \sigma_c(RHIC) \times 10$

$\sigma_b(LHC) = \sigma_b(RHIC) \times 100$

$\sigma_W(LHC) = \sigma_\Upsilon(RHIC) \times 10$

$\sigma_Z(LHC) = \sigma_\Upsilon(RHIC)$

pQCD NLO + binary scaling + shadowing gives:

	pp	pp	PbPb (5% most central)
$\sqrt{s}(TeV)$	7	14	5.5
$N_{c\bar{c}}$	~ 0.1	0.16	115
$N_{b\bar{b}}$	~ 0.003	0.007	4.6

MNR code (NLO): Mangano, Nason, Ridolfi, NPB373 (1992) 295.

D to hadrons analysis strategy

D meson (to hadrons) analysis strategy based invariant mass analysis of fully reconstructed decay topologies displaced from the interaction vertex

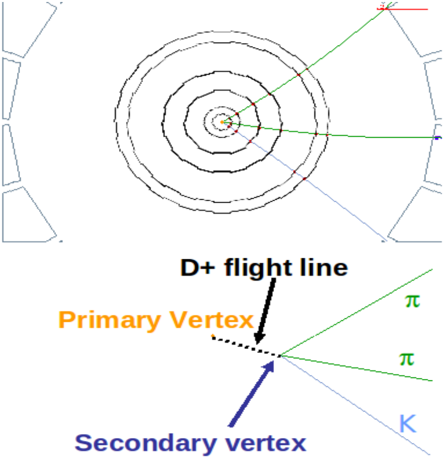
Golden channel topologies are:

Meson	Decay channel	$c\tau$	BR
D^0	$D^0 \rightarrow K^- \pi^+$	$\sim 120 \mu m$	$\sim 3.8\%$
D^0	$D^0 \rightarrow K \pi\pi\pi$	$\sim 120 \mu m$	$\sim 7.45\%$
D^+	$D^+ \rightarrow K^- \pi^+ \pi^+$	$\sim 310 \mu m$	$\sim 9.2\%$
D_s^+	$D_s^+ \rightarrow K^+ K^- \pi^+$	$\sim 150 \mu m$	$\sim 5.2\%$
D^{*+}	$D^{*+} \rightarrow D^0 \pi^+$		$\sim 67.7\%$

Thanks to ALICE very good vertexing resolution it is possible to reconstruct and analyze D meson through their hadronic decay channels

Selection Strategy

- Build pairs(D^0) / triplets(D^+) / quadruplets of tracks with the correct sign combination
- Calculate the vertex of the tracks
- Pointing of the reconstructed D meson to the primary vertex of the events
- Large impact parameter
- Possibly PID to tag decay products

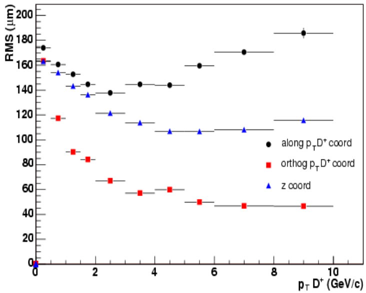


Vertexing

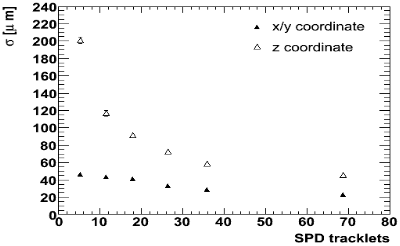
Good primary vertex resolution and secondary (decay) vertex resolution ($O(100\mu m)$) are needed to determine:

- impact parameter resolution (primary vertex)
- pointing angle
- separation between primary and secondary vertices

D^+ decay vertex



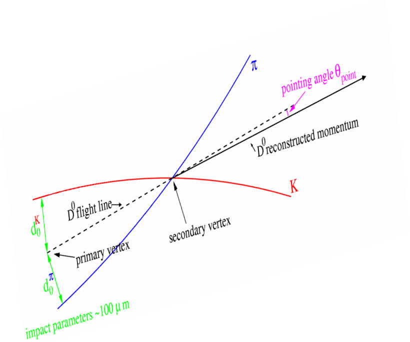
Primary vertex

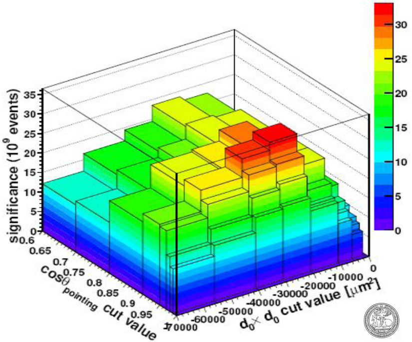


D0

$D^0 \Rightarrow K^- \pi^+$

- Pairs of opposite sign tracks
- Pointing of reconstructed D momentum to primary vertex
- Selection cut on $d_0^K \times d_0^\pi$



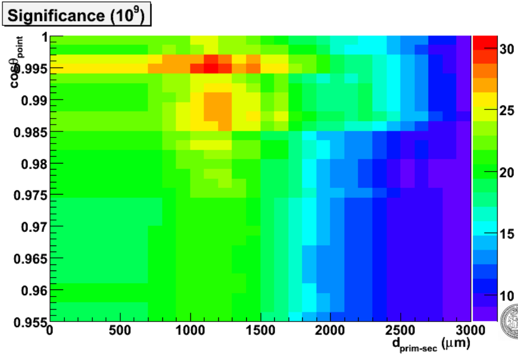


D+

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

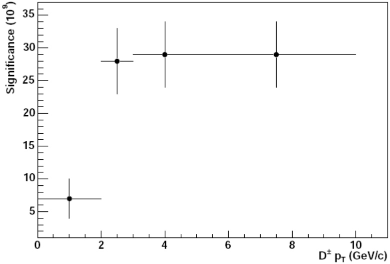
- Triplets of charged tracks with right sign combination
- Large distance ($c\tau \sim 310\mu m$) between primary and secondary vertex
- Pointing of reconstructed D momentum to primary vertex

- $3 < p_t < 5 GeV/c$

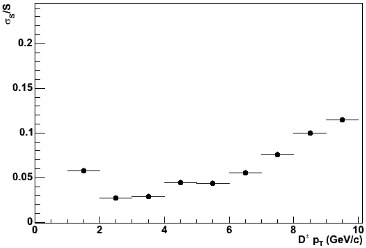


Expected results (I)

Expected significance for D^+ for pp at 14 Tev for 1 year of data taking ($\sim 10^9$ events)

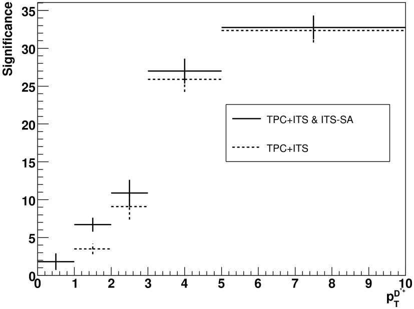


Expected statistical error ($1/\sqrt{S}$) for D^+ for pp at 14TeV for 1 year of data taking ($\sim 10^9$ events)

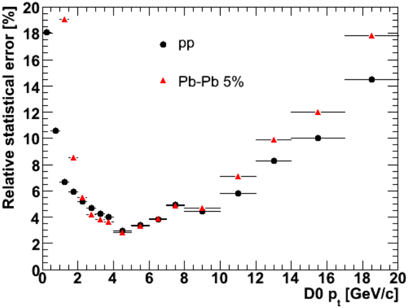


Expected results (II)

Expected significance for D^{*+} for pp at 14 Tev for 1 year of data taking ($\sim 10^9$ events)



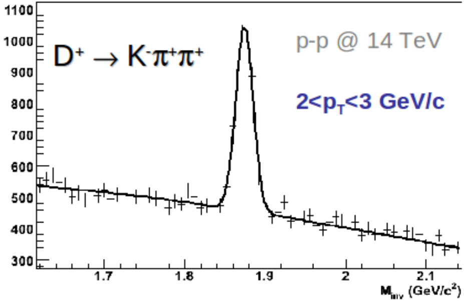
Expected statistical error ($1/\sqrt{S}$) for D^0 for pp at 14 TeV ($\sim 10^9$ events) and PbPb ($\sim 10^7$ central events) for 1 year of data taking



Expected results (III)

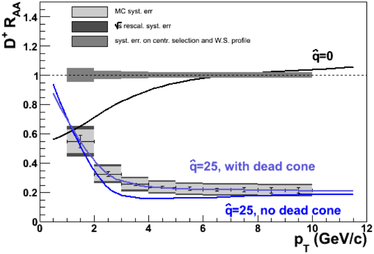
To have data on heavy flavours we need higher energy (expected in 2010) and more statistics:
First results on heavy flavours expected for late 2010

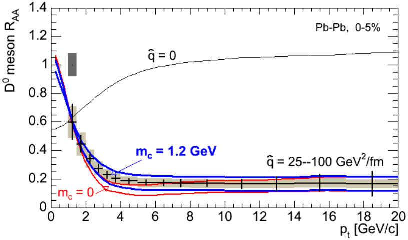
- PYTHIA, 10^9 events



Expected results (IV)

R_{AA}





E loss: Armesto, Salgado, Dainese, Wiedemann

Conclusions

- D meson analysis tool are ready, and at ALICE we expect to get
  - A large number of charmed meson (high cross section)
  - A good significance
- First physics results, at $\sqrt{s} = 900\text{GeV}$ and $\sqrt{s} = 2.36\text{TeV}$ looks very good and ALICE is obtaining the expected physics performances.

- We expect to be able to have significant results on open charm in quite a short time (1 year for D^0 and D^+, maybe even less for D^{*+})

Acknowledgements

I'm very thankful to Massimo Masera and Francesco Prino for the help they gave me to make this presentation and to Paolo Giubellino for the precious suggestions.

I also want to thanks Andrea Dainese and Elena Bruna, most of my work wouldn't have been possible without them.

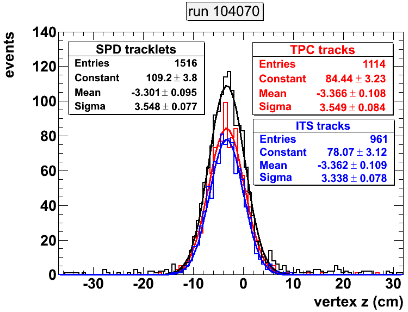
BACKUP SLIDES

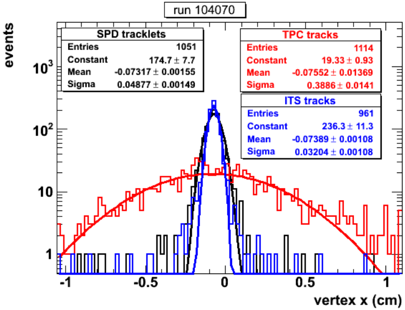
Vertexing-First results

The first physics runs of november-december collected enough data to test vertexing and track impact parameter analysis with TPC and ITS

With one single physics run (104070):

Vertex: distribution of reconstructed vertices (ITS+TPC).





ITS, SPD, TPC give the same position: good detectors alignment

Vertexing-First results

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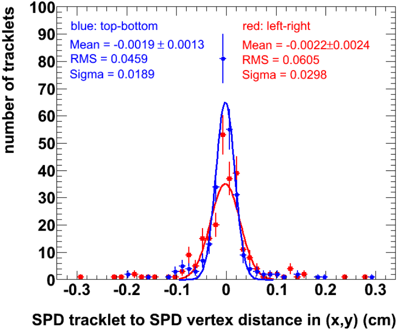
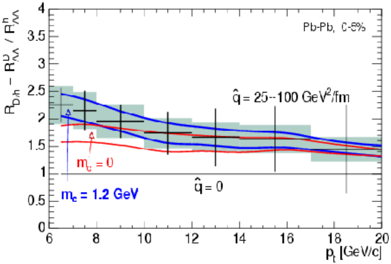
With one single physics run (104070):
Track impact parameter:

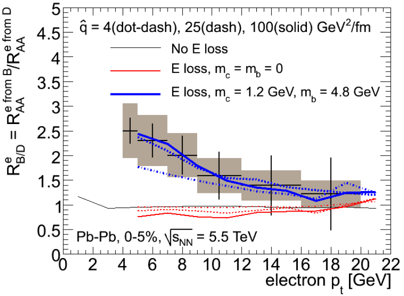


alignment error contribution: $< 15\mu m$.

Heavy-to-light ratios

- $R_{Dh}(Pt) = \frac{R^D_{AA}(Pt)}{R^h_{AA}(Pt)}$
  - probe for color charge dependence of energy loss ($\Delta E_q < \Delta E_g$)
- $R_{BD}(Pt) = \frac{R^B_{AA}(Pt)}{R^D_{AA}(Pt)}$
  - probe for mass dependence of energy loss (dead cone effect)





1 year of data taking

energy loss from Armesto et al, Phys. Rev.D71 (2005) 054027

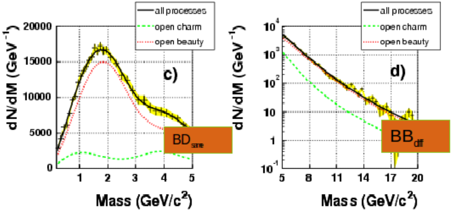
Sistematics

Most important systematics uncertainties due to:

- Acceptance, reconstruction and PID efficiencies ($\sim 10\%$)
- Centrality selection (PbPb) ($\sim 7\%$)
- Nucleon-Nucleon inelastic x-section (PbPb) ($\sim 5\%$)
- Woods Saxon parameters and nuclear density ($\sim 5\%$)
- Error on BR $D^+ \rightarrow K^-\pi^+\pi^+$ ($\sim 3.5\%$)
- Feed down from beauty
  - contamination
  - D from B are more displaced: cuts increase contamination

HF to muons

- Single muons from b dominant at high Pt → fit on distribution tails
- Single muons from c dominant at low Pt → large background



Dimuons from B:

$$BD_{same} : B \to \mu^+ + X + \bar{D} \to \mu^- + X$$
$$BB_{diff} : X + \mu^+ \leftarrow B\bar{B} \to \mu^- + X$$