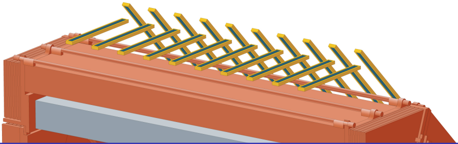
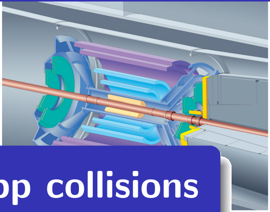
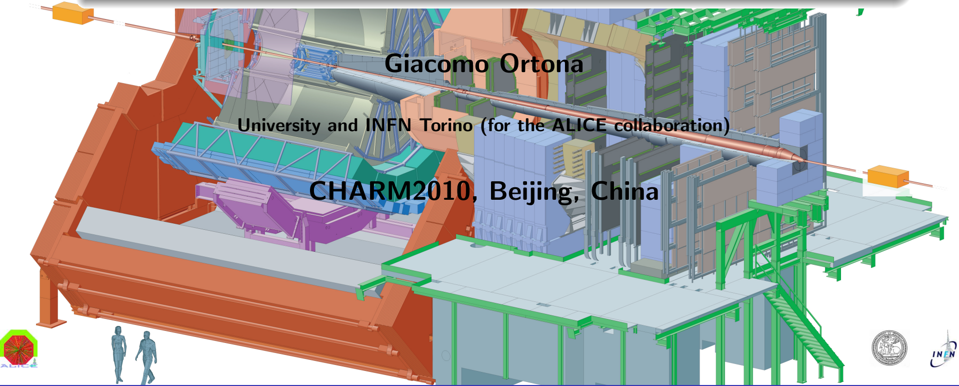




Open charm analysis on the first pp collisions at $\sqrt{s} = 7\,TeV$ with ALICE.



Giacomo Ortona

University and INFN Torino (for the ALICE collaboration)

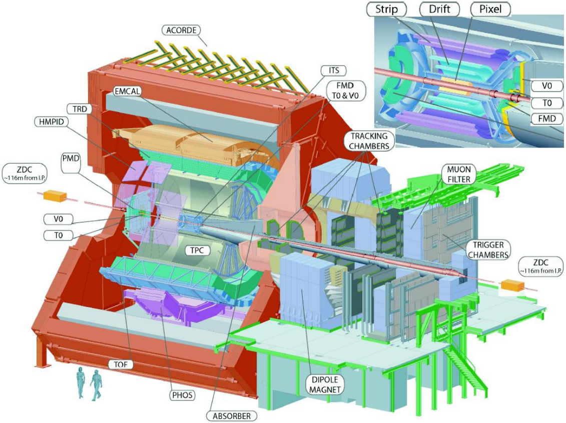
CHARM2010, Beijing, China

Outline

ALICE Detector

2010 Configuration

- ITS, TPC, TOF, HMPID, Muon arm, V0, T0, FMD, PMD, ZDC 100% ready
- TRD (7/18)
- EMCAL (4/12)
- PHOS (3/5)



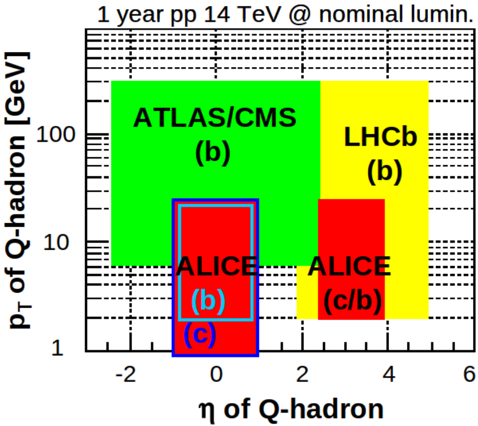
The ALICE experiment

Channels

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

Coverage

- extends to low p_t
- central and forward rapidity regions
- both for b and c



Baines et al. Proceedings of the HERA and the LHC workshop 2004-2005
CERN-2005-014 DESY-PROC-2005-001

First collisions

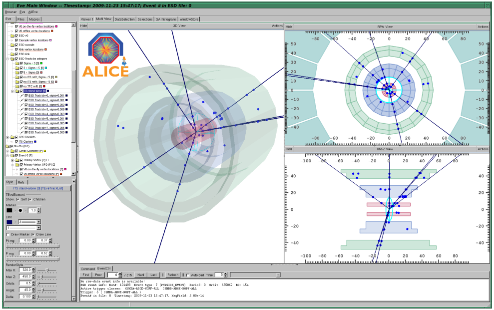
On November 23rd, 2009 ALICE saw its first proton-proton event at

$$\sqrt{s} = 900\,GeV$$

and on March 30th 2010 LHC provided the first protons collisions at

$$\sqrt{s} = 7\,TeV$$

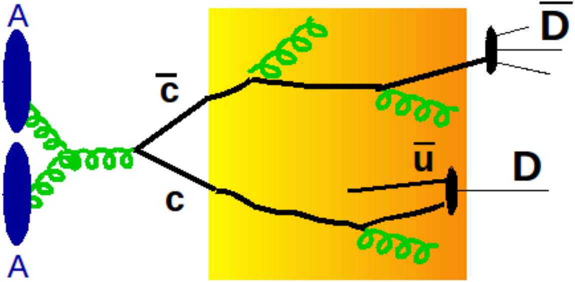
Up to now ALICE collected $8 \cdot 10^8$ minimum bias events and $5 \cdot 10^7$ muon triggered events.
The results shown in this presentations are based on ~ 100 millions events collected in April-May.



Event display of the first p-p collision at ALICE.

Motivations (I)

charm is a good probe of the hot and dense medium formed in heavy-ion collisions



- Produced at the very beginning of the collision
- follow the evolution of the "fireball"
- Interacts strongly with the medium (energy loss, in-medium hadronization...)

Motivations (II)

- p-p collisions
  - measurement of HF production $\Rightarrow$ test of pQCD calculations
  - baseline for A-A studies
- A-A
  - study of the medium produced in A-A collisions (QGP)
  - Quarkonium physics

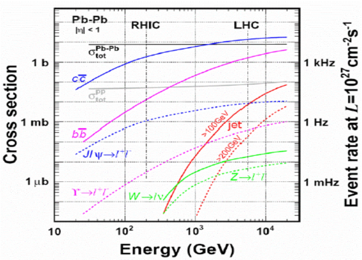
    $\downarrow$

    This talk will only present results for open heavy flavour, but results for quarkonium in the channels $J/\Psi \to e^+e^-$ and $J/\Psi \to \mu^+\mu^-$ also have been obtained at ALICE
- p-A
  - Disentangle initial and final state effects

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

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.

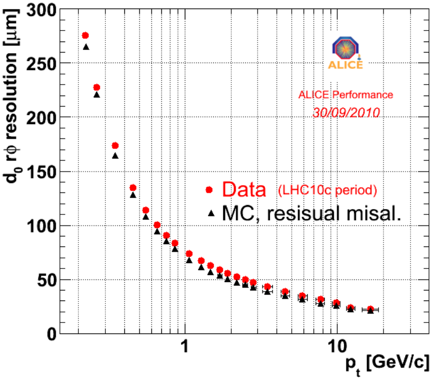
Large uncertainties ($\sim$ factor 2).

Heavy flavour at ALICE

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) for the tracking in the central barrel
- PID is performed with several techniques ($\frac{dE}{dx}$, TOF, TRD)

Resolution on track impact parameter in the rϕ plane



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

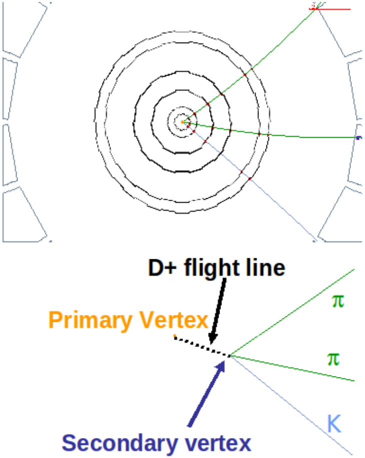
Golden channel topologies are:

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

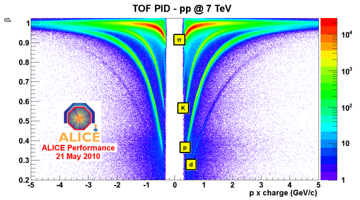
Thanks to ALICE very good vertexing resolution it is possible to reconstruct and analyze D meson through their hadronic decay channels

Analysis Strategy

- Build pairs(D^0) / triplets(D^+) / quadruplets of tracks with the correct sign combination passing single tracks selection cuts
- Calculate the vertex of the tracks and apply topological cuts (Pointing of the reconstructed D meson to the primary vertex of the events, Large impact parameter, large distance between the vertex of the event and the vertex of the tracks)
- PID to tag decay products
- Estimation of feed down from Beauty
- Efficiency and acceptance corrections



PID

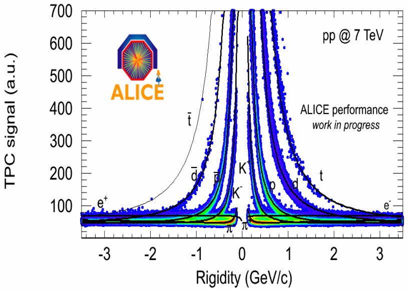


TOF

Particle identified as Kaon if the time of flight of the particle in the Kaon mass hypothesis is compatible with the measured time TOF - T0 between 3σ, where $\sigma \sim 160ps$ (current resolution).

TPC

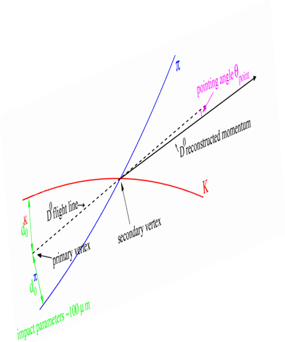
Particle identified if its energy loss is compatible with Bethe-Block prediction.

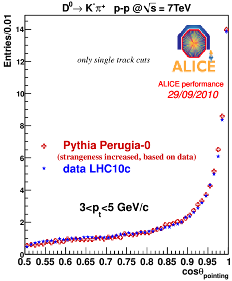


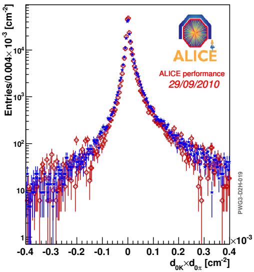
D0

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

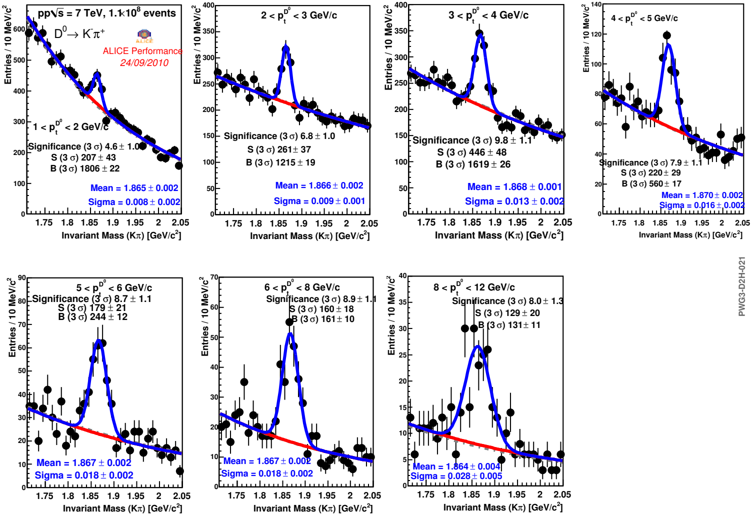
- Pairs of opposite sign tracks
- Pointing of reconstructed D momentum to primary vertex
- Selection cut on $d_0^K \times d_0^\pi$



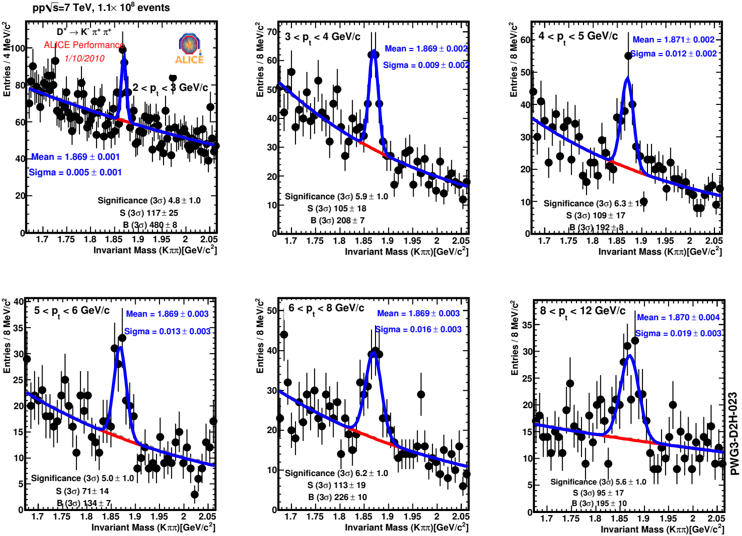




$D^0 \to K^-\pi^+$, Invariant Mass spectra



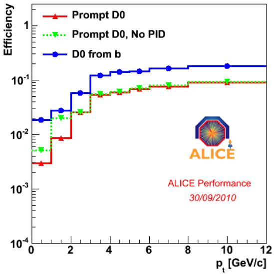
$D^+ \to K^-\pi^+\pi+$, Invariant Mass spectra

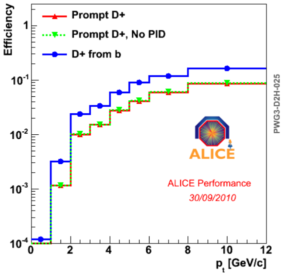


Extracting the Cross Section

Corrections are needed in order to be able to calculate the cross section:

1. Correction for the efficiency
   - from 1% to 10% increasing with p_t
   - factor 2 larger for mesons coming from B decay
2. Correction for feed down from B
   - $\sim 20\%$
   - Done using FONLL predictions for now, will be done based on data when we have more statistics
3. Absolute normalization to cross section is ongoing

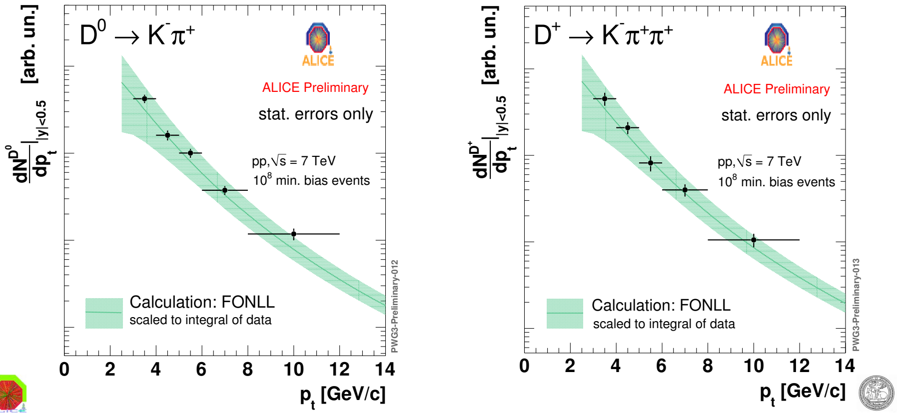




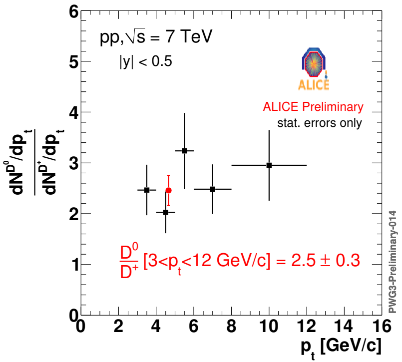
D^0 and D^+ $\frac{dN}{dp_t}$

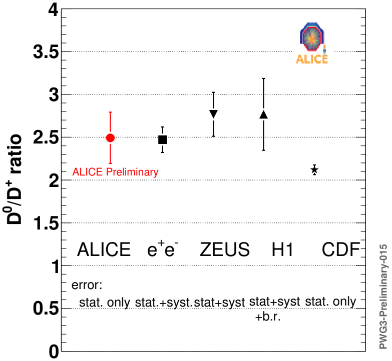
Only statistical errors, arbitrary normalization, theory is normalized to the integral of data.

Shape in good agreement between data and FONLL.



Ratio D^0/D^+

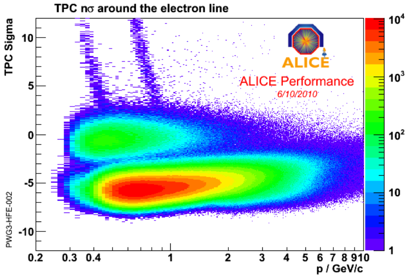




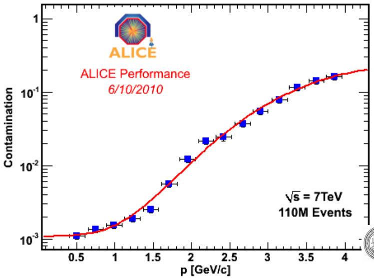
ee, H1, ZEUS: JHEP07 (2007) 074
CDF: PRL 91 (2003) 241804.

Heavy flavour to electrons - Analysis

- High quality tracks in TPC and ITS
  - Requested an hit in the innermost layer of pixels (r=3.8cm) in order to reduce contributions from photon conversion in the material
- Electron identification currently up to 4 GeV/c using TPC and TOF detectors
- data from TPC dE/dx used to estimate residual hadron contamination



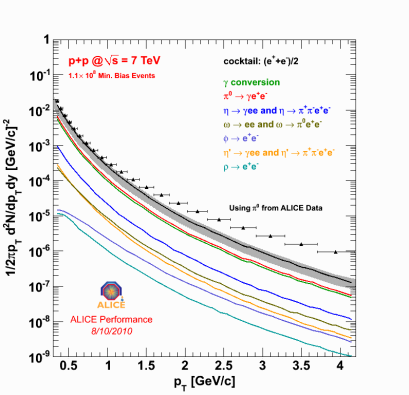
kaons and protons rejected by TOF



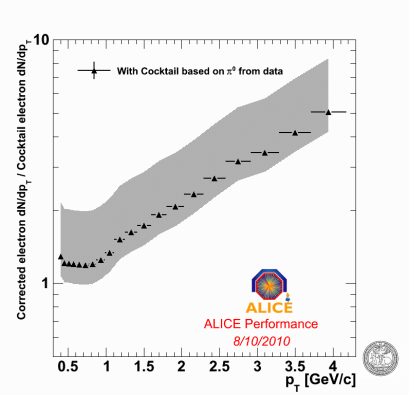
Heavy flavour to electrons - Results

Electrons from heavy flavour cross section can be obtained subtracting a "cocktail" of photonic electron sources tuned on the basis of the measured π^0 $d\sigma/dp_t$. The excess in the ratio is then given by charm and beauty deacy electron signal.

$|\eta| < 0.9$

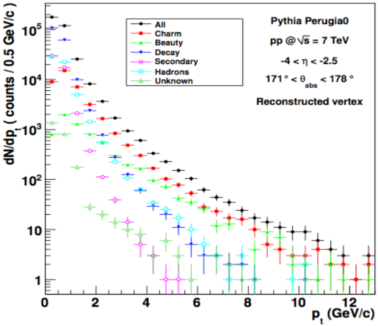


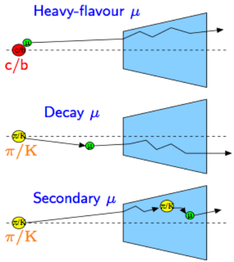
$|\eta| < 0.9$



Heavy flavour to single muons - Analysis

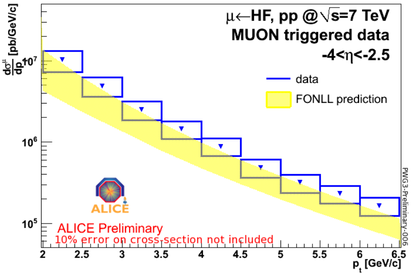
- Muon trigger signal required in order to remove hadrons and low p_T secondary muons.
- muon arm acceptance: $-4 < \eta < -2.5$
- Subtraction of decay and residual secondary muons done via MC dN/dp_T normalized to data at low p_t
- Efficiency and acceptance corrections
- Absolute cross section normalization





Heavy flavour to single muons - Results

Muons from D and B decay measured in the muon arm $(-4 < \eta < -2.5)$



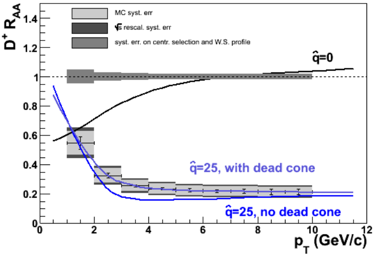
10% systematic error from cross section normalization (not shown in the figure)

Agreement both in shape and normalization with FONLL predictions

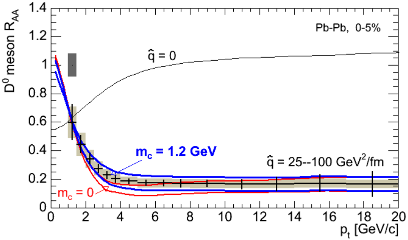
Towards Pb-Pb - R_{AA}

ALICE collaboration is looking forward for the first Pb-Pb collisions at the LHC, foreseen in November.

- Nuclear modification factor $R_{AA}(p_T) = \frac{1}{\langle N_{coll} \rangle} \frac{dN_{AA}/dp_T}{dN_{pp}/dp_T}$
- an $R_{AA} < 1$ has been observed at RHIC and interpreted due to the partons energy loss in the medium.



MonteCarlo simulation



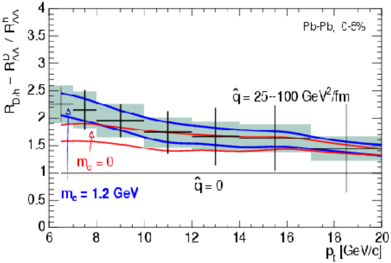
MonteCarlo simulation

1 year of data taking

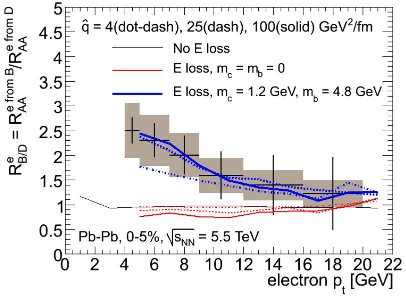
energy loss from Armesto et al, Phys. Rev.D71 (2005) 054027

Towards Pb-Pb - 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 (gluon radiation is suppressed for angles $\theta < \frac{M_q}{E_q}$)



MonteCarlo simulation
1 year of data taking



MonteCarlo simulation

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

Summary

- The ALICE experiment started to deliver its first results on heavy flavour physics
- Results compatible with pQCD predictions
- p-p data will serve as reference in the upcoming Pb-Pb collisions of November
- ALICE obtained also results for quarkonium from $J/\Psi \rightarrow \mu^+\mu^-$ and $J/\Psi \rightarrow e^+e^-$

BACKUP

PID

PID applied in conservative way in order to minimize the loss of signal, particles with no PID information are kept.

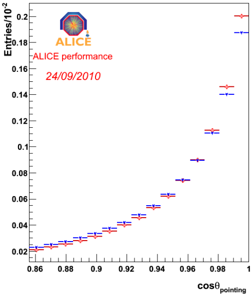
TPC	$p_t < 0.6GeV/c$	$0.6 < p_t < 0.8GeV/c$	$p_t > 0.8GeV/c$
$< 1\sigma$	IS K/π		K/π COMPATIBLE
$1 < \sigma < 2$	IS K/π	K/π COMPATIBLE	
$2 < \sigma < 3$	K/π COMPATIBLE		
$> 3\sigma$	K/π EXCLUDED		

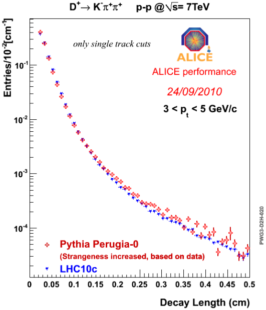
TOF	$p_t < 1.5GeV/c$	$p_t > 1.5GeV/c$
$< 3\sigma$	IS K/π	K/π COMPATIBLE
$> 3\sigma$	K/π EXCLUDED	

D+

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

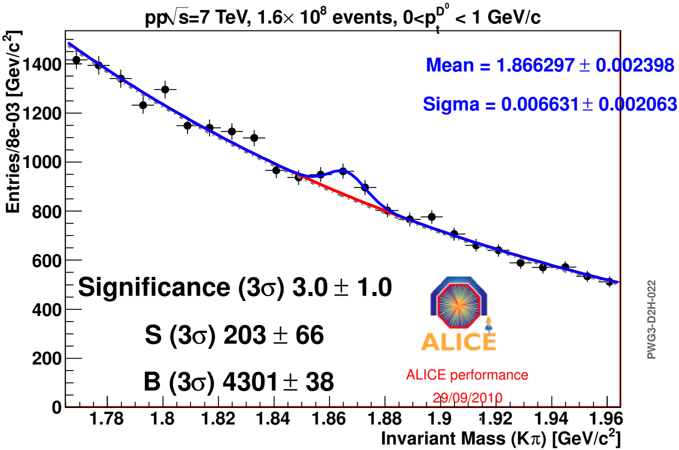
- Triplets of charged tracks with right sign combination
- Large distance ($c\tau \sim 310\mu m$) between primary and secondary vertex
- Pointing of reconstructed D momentum to primary vertex
- PID: Opposite sign particle CAN'T be a Kaon



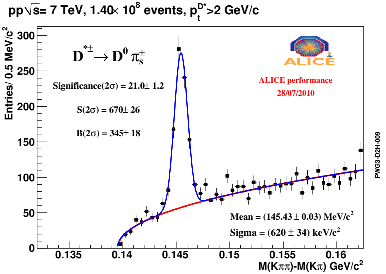


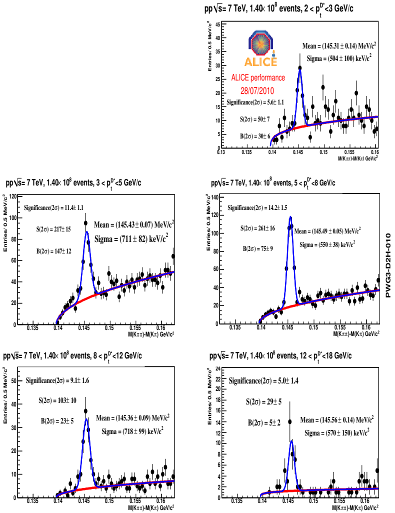
$D^0 \rightarrow K^- \pi^+$

Hint of signal for p_t below $1 Gev/c$



$D^{*+} \to D^0\pi^+$, Invariant Mass Spectra

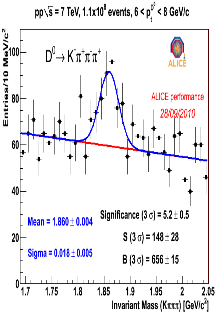


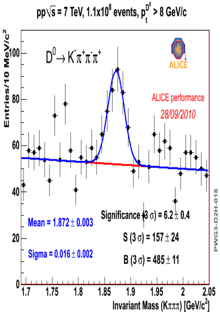


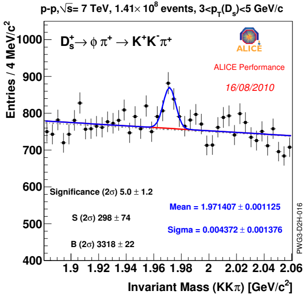
Signal for $p_t > 2GeV/c$.
Peak at $(154.43 \pm 0.03)MeV/c^2$
Width: $(0.62 \pm 0.03)MeV/c^2$
Hint of signal down to 1 GeV/c

Other channels: $D^0 \to K^-\pi^+\pi^-\pi+$, $D_s^+ \to K^-K^+\pi^+$

Signal is visible also in the channels $D^0 \to K^-\pi^+\pi^-\pi^+$ and $D_s^+ \to K^-K^+\pi^+$

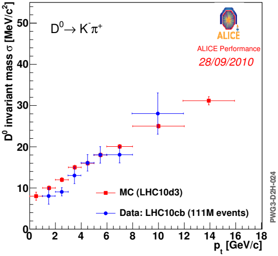


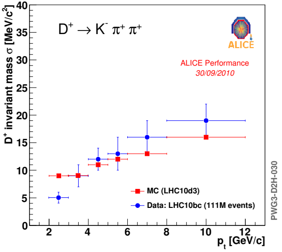




Comparison with MC

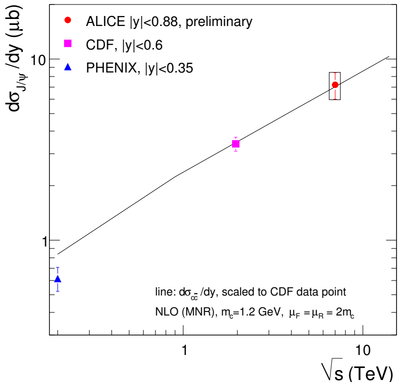
Width of the invariant mass peak for D^0 and D^+ in agreement between data and MC over the full p_t range explored.



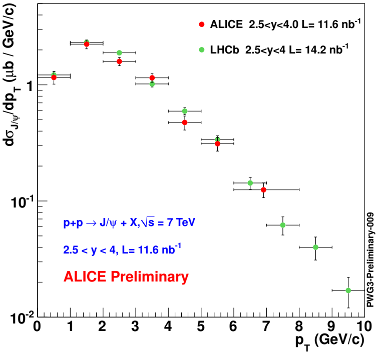


J/Ψ to electrons and muons

$J/\Psi \to e^+e-$ measured in the central barrel



$J/\Psi \to \mu^+\mu_-(2.5 < y < 4)$ measured in the muon arm



$$\sigma_{J/\Psi}(2.5 < y < 4) = 7.25 \pm 0.29(stat) \pm 0.98(syst)^{+0.87}_{-1.50}(syst.pol.)\mu b$$

J/Ψ rapidity distribution