Open charm production in p-p collisions at √s = 7 TeV with the ALICE detector

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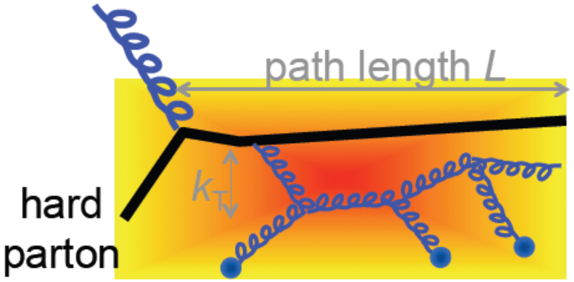
Outline

- Motivation for open charm analysis.
  - parton energy loss in the medium
  - results from RHIC experiments
  - measurement of p_T differential cross section for D mesons at new energies
  - test for pQCD
- ALICE detector: status and performance
- Charm cross section measurement in p-p collisions: strategy and status of data analysis.
- Expected performance in p-p and Pb-Pb
- Conclusions

In medium energy loss

Ultrarelativistic heavy ion collisions should form a high density deconfined medium where partons are free and interacting.

Hard partons are produced before medium thermalization and they should experience energy loss in the medium (radiative and collisional energy loss, in-medium fragmentation).



Energy loss depends on:
- **medium density** (q)
- **colour charge** (C_R - Casimir factor 4/3 for quarks, 3 for gluons)

For exemple for radiative energy loss:

$$\langle \Delta E \rangle \propto \alpha_S C_R \hat{q} L^2$$

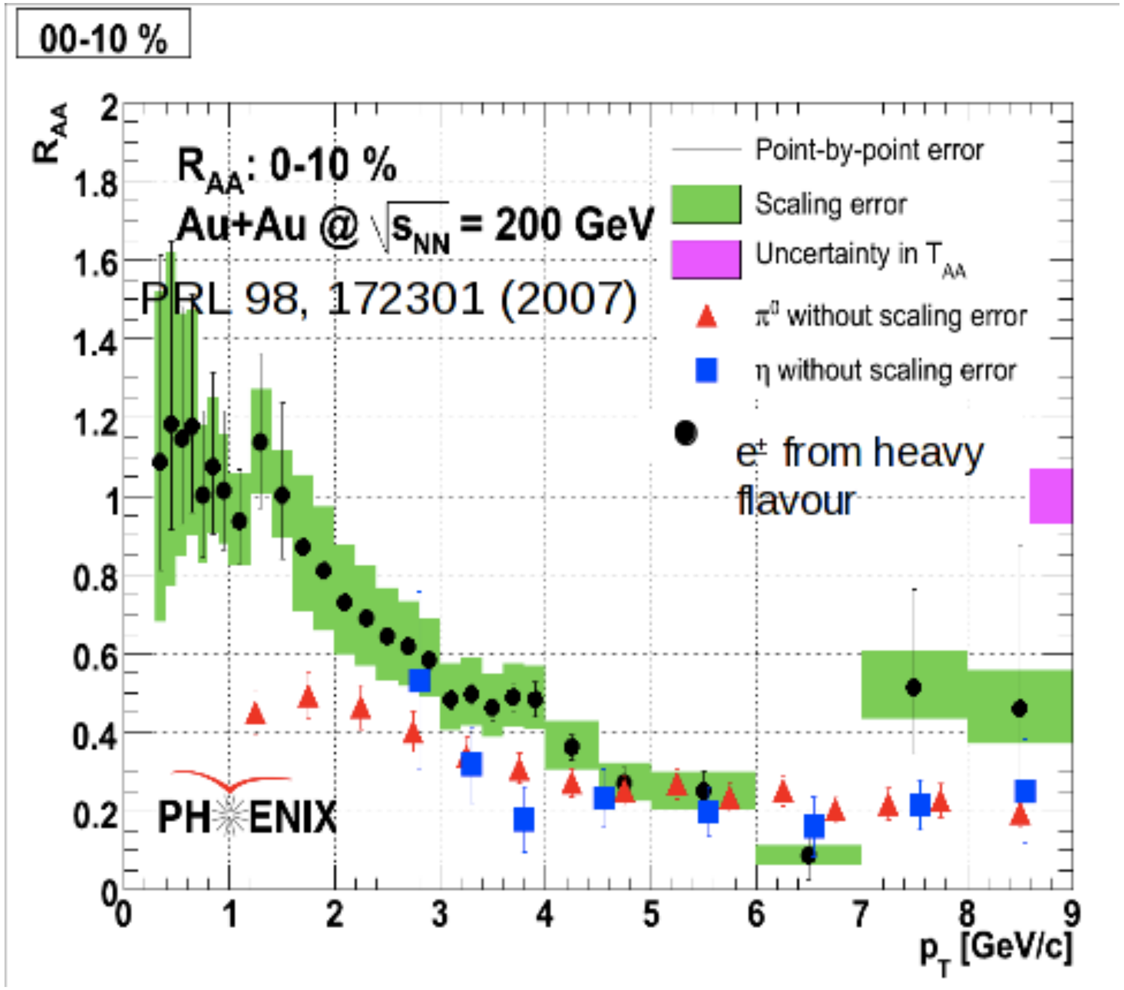
Baier, Dokshitzer, Mueller, Peigne', Schiff, NPB 483 (1997) 291.
Zakharov, JTEPL 63 (1996) 952.
Salgado, Wiedemann, PRD 68(2003) 014008.

- **mass** : radiation suppressed at small angles for massive partons – dead cone effect

Yu.L. Dokshitzer and D.E. Kharzeev, Phys. Lett. B519 (2001) 199, arXiv:hep-ph/0106202

RHIC results

Hadron suppression in central collisions interpreted as energy loss (π^0, η suppression)



Non-photonic electrons show suppression in central Au-Au collisions.
Individual suppression of c and b cannot be extracted

Heavy flavours are as suppressed as light hadrons.

Strongly interacting matter at LHC

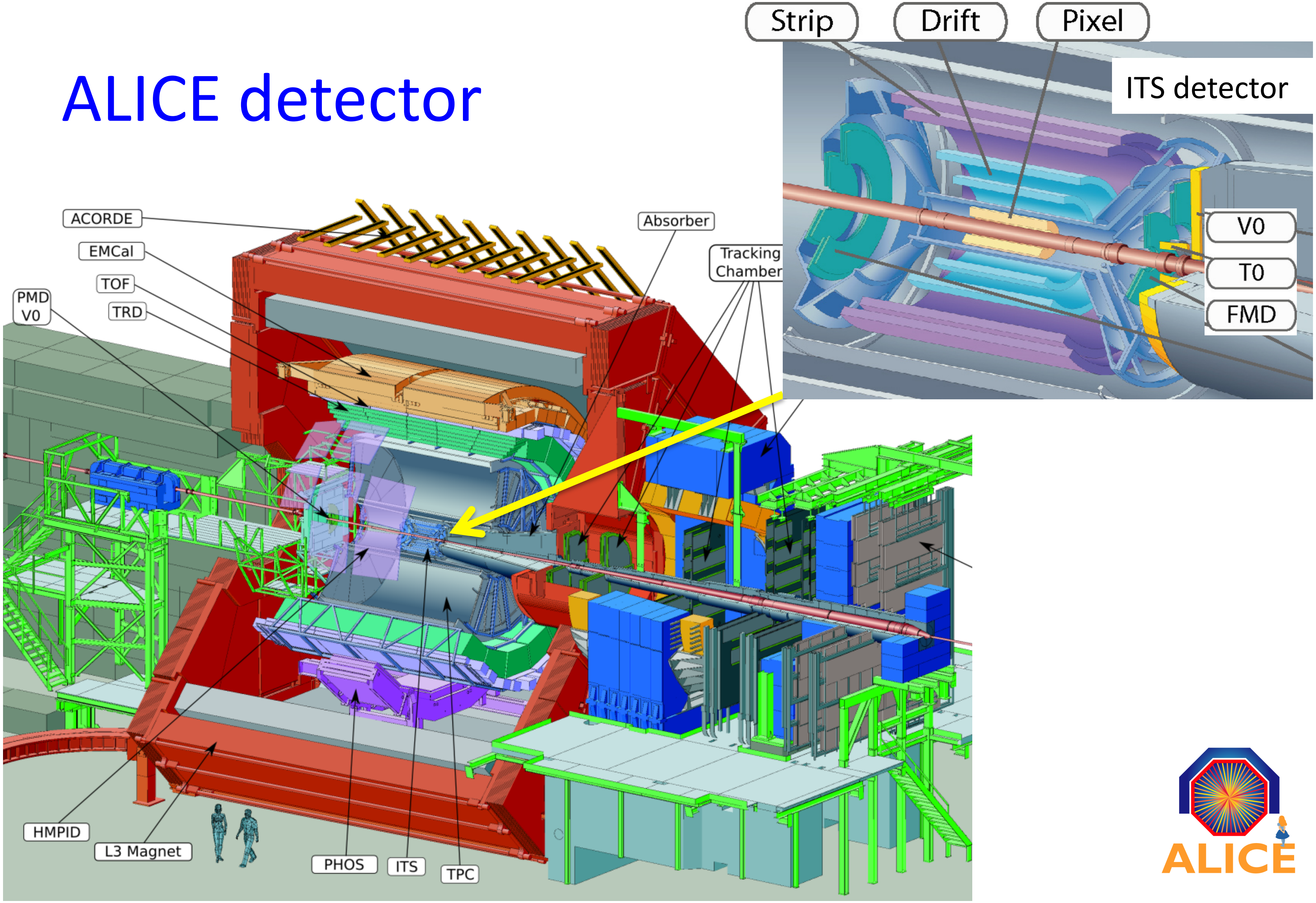
	RHIC	LHC (design)	LHC (soon)
√s	0.2 TeV	5.5 TeV	2.76 TeV
t_{QGP}	1.6 fm/c	10 fm/c	4 fm/c
ε	5-10 GeV/fm^3	15-60 GeV/fm^3	10-40 GeV/fm^3
N $c\bar{c}$	**9 /ev**	**90 /ev**	**56/ev**
N $b\bar{b}$	0.04 /ev	3.7 /ev	2/ev

Expected heavy flavour pairs produced in a central Pb-Pb collision.

Theoretical uncertainties factor 2-3

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

ALICE detector



ALICE: heavy flavour analysis in preparation

ALICE

Exclusive charm reconstruction in the central barrel ($-1< |y| < 1$)

Covered in this talk

$D^0 \rightarrow K\pi$

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

$D_s \rightarrow KK\pi$

$D^* \rightarrow D^0\pi$

$D^0 \rightarrow K\pi\rho$

$\Lambda_c \rightarrow \pi K p$

Open charm reconstruction in the muon spectrometer via single muon reconstruction ($-4 < y < -2.5$)

$B \rightarrow \mu+X$

$D \rightarrow \mu+X$

Inclusive heavy flavour reconstruction in the central barrel via electron decay

$D \mid B \rightarrow e+X$

tagged b-jets

$B \rightarrow J/\Psi \rightarrow e^+e^-$

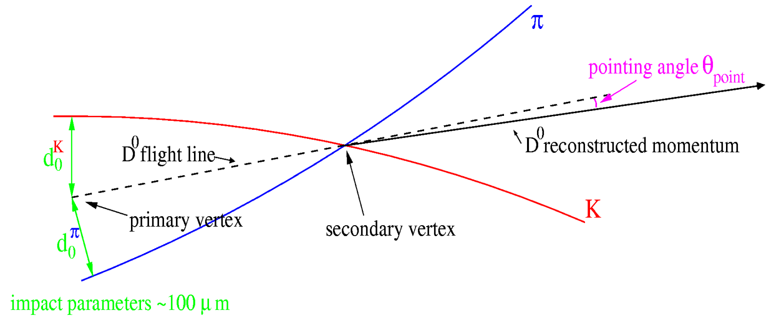
e-D^0 correlations

orange: under study

Road map to charm cross section measurement

$$\left.\frac{d^2\sigma^{D^0}(p_t,y)}{dy\,dp_t}\right|_{y=0} \approx \frac{1}{2}\frac{1}{2\,y_{max}}\frac{f_D \cdot N^{\text{reco.}}_{\text{sel.}}(p_t)|_{|y|<y_{max}}}{\epsilon \cdot \text{BR} \cdot \mathcal{L}_{\text{INT}}} = \frac{1}{2}\frac{1}{2\,y_{max}}\frac{f_D\, N^{\text{reco.}}_{\text{sel.}}(p_t)|_{|y|<y_{max}}}{\epsilon \cdot \text{BR} \cdot N^{\text{tot}}_{\text{inel}}}\,\sigma^{\text{tot}}_{\text{inel}}$$

1. Raw yield extraction
   - Topological cuts to select displaced secondary vertex
   - PID with TOF and TPC to reduce background
   - Estimation or subtraction of the remaining background with different methods (fit, like-sign, rotation, mixing events)



2. Feed down from B
   - pQCD estimation for the ratio (D from B/direct D) corrected for the ALICE efficiency and acceptance
   - Exploit impact parameter distribution of prompt D^0 and coming from B (high statistic and good understanding of the detector)

3. Yield correction with efficiency
4. Cross section normalization

Data Taking

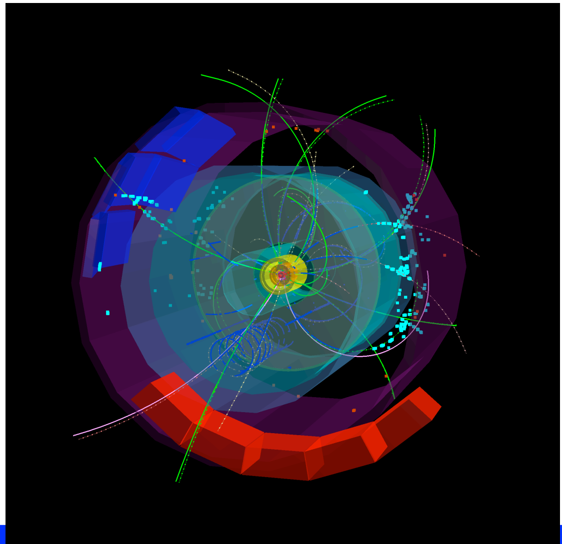
- 23 November 2009: first collisions at √s=0.9 TeV
- December 2009: data taking at √s=0.9 TeV

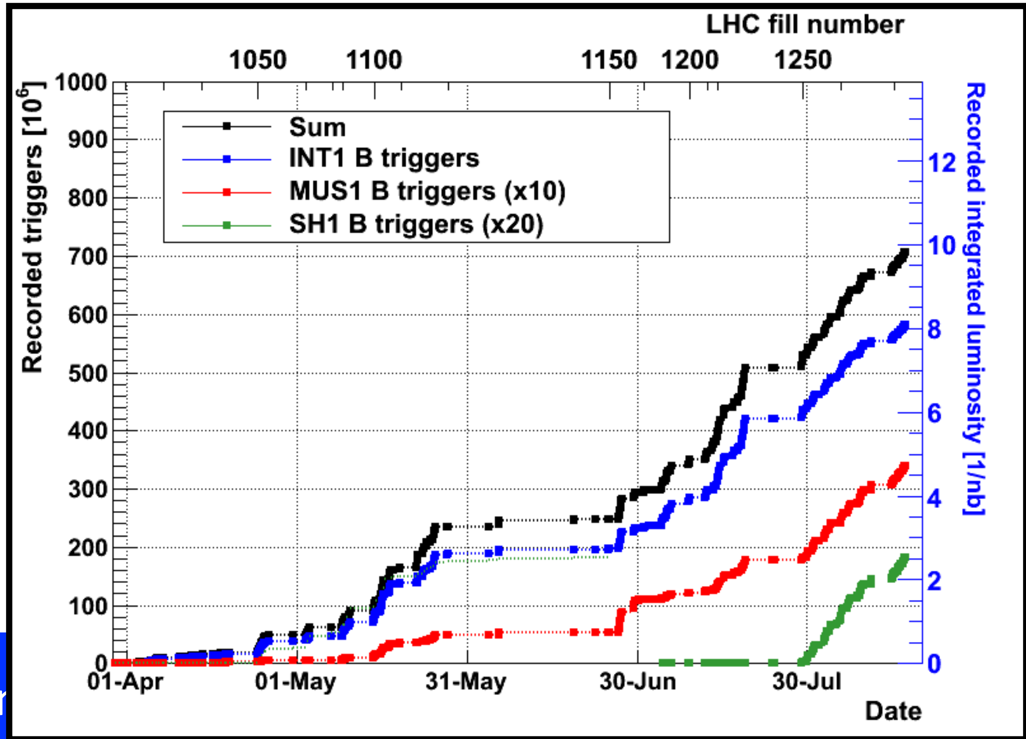
→ low statistic for charm analysis (~ 500K events)

- 30 March 2010: first collisions at √s=7 TeV
- from 30 March data taking at √s=7 TeV

about 700 M minimum bias events collected so far (17th August)

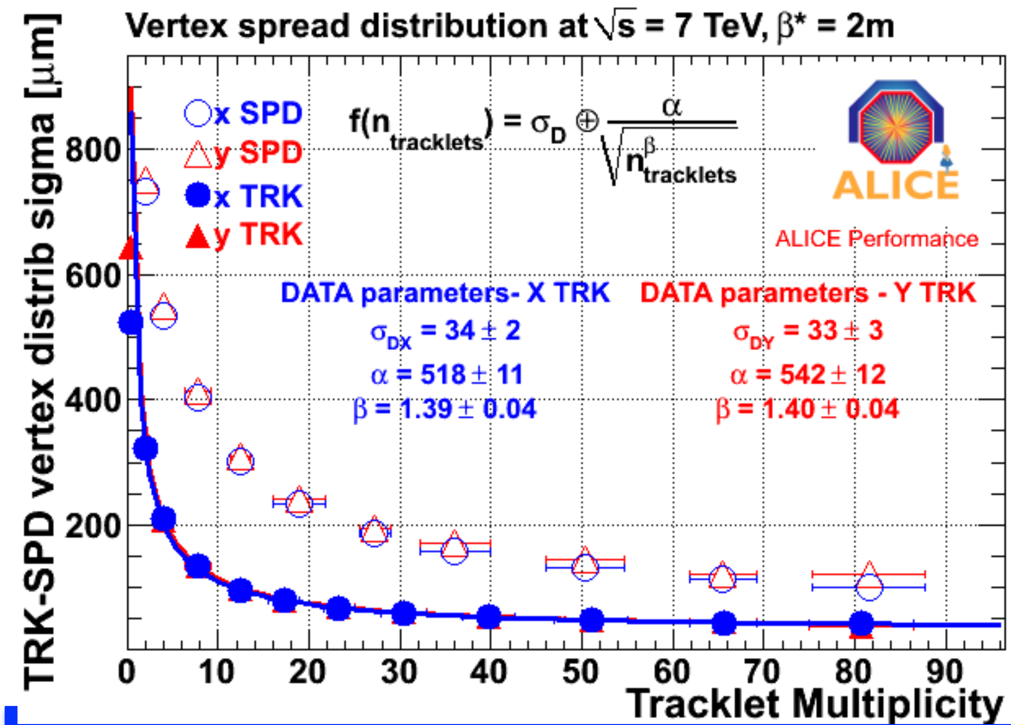
also ~ 2M at √s=0.9 TeV

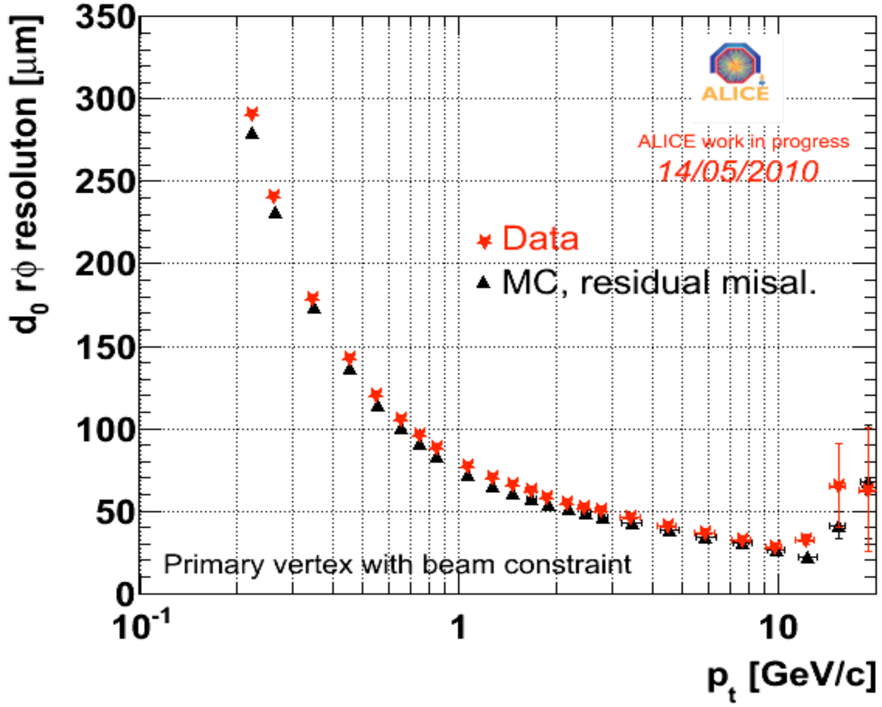




ALICE first performance (I)

With the first p-p data, ALICE started to understand the detector and its performance and obtained recently the first results.
(→ I.Belikov's talk)
Primary vertex and impact parameter resolutions are very important for the D meson study.

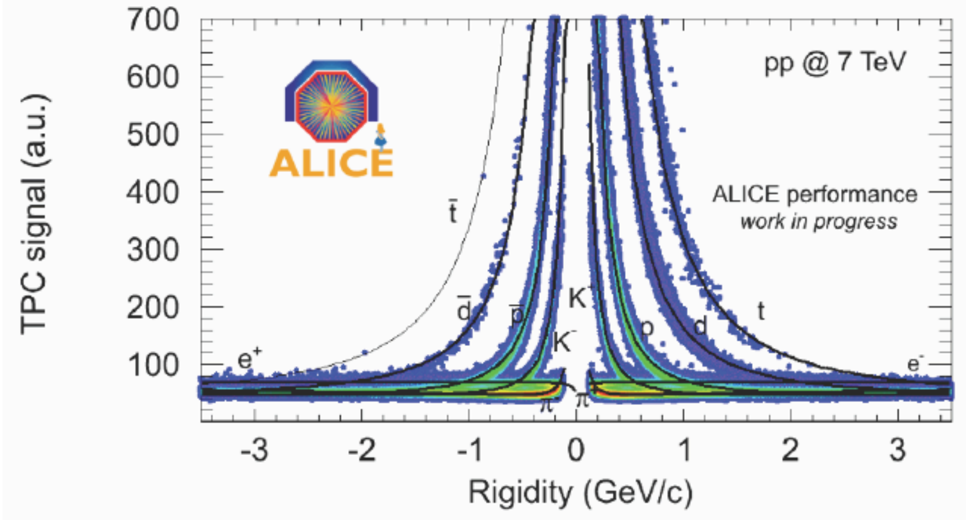


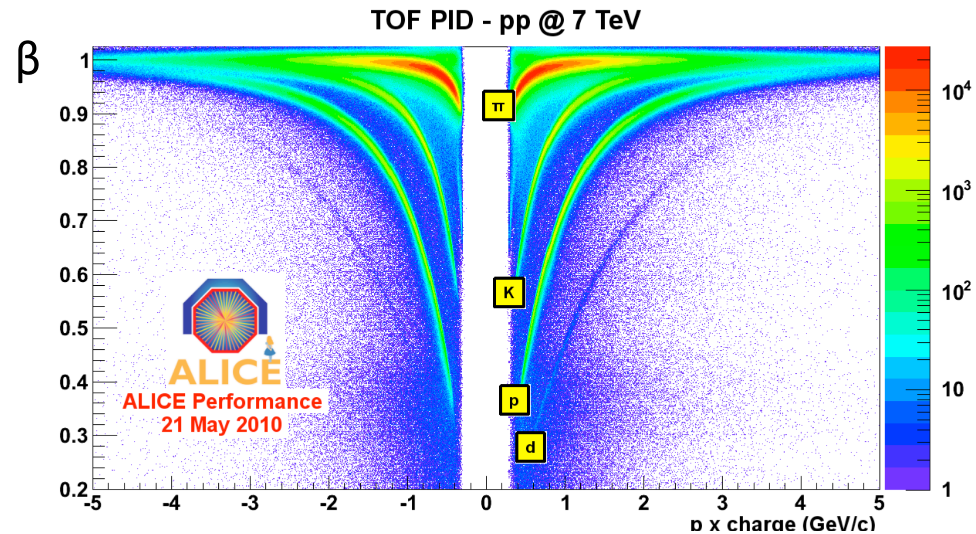


ALICE first performance (II)

- One of the main differences of ALICE with respect to the other LHC experiments is the "redundant" hadron identification capability.

- Differents detectors have been built for this task with different technologies:
dE/dx from silicon and gas detectors, time of flight, transition radiation detector…



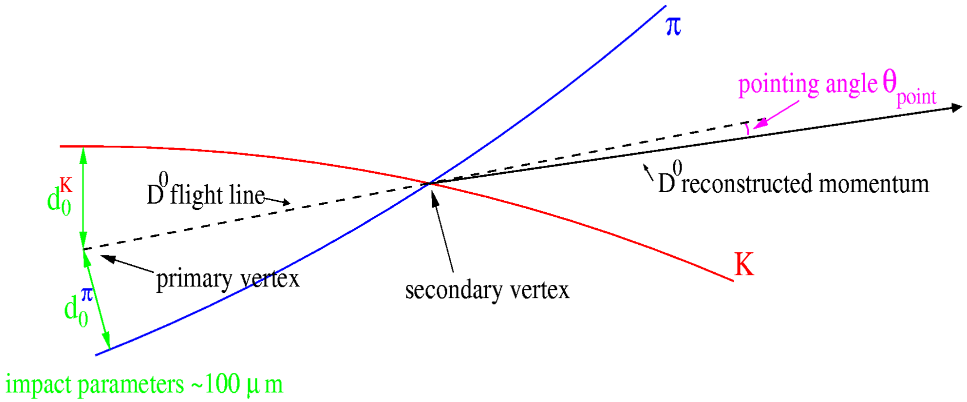


p x charge (GeV/c)

Invariant Mass Analysis

Main selections:
displaced vertex topology.

- tracks of opposite sign with large impact parameter
- good pointing of reconstructed D momentum to the primary vertex



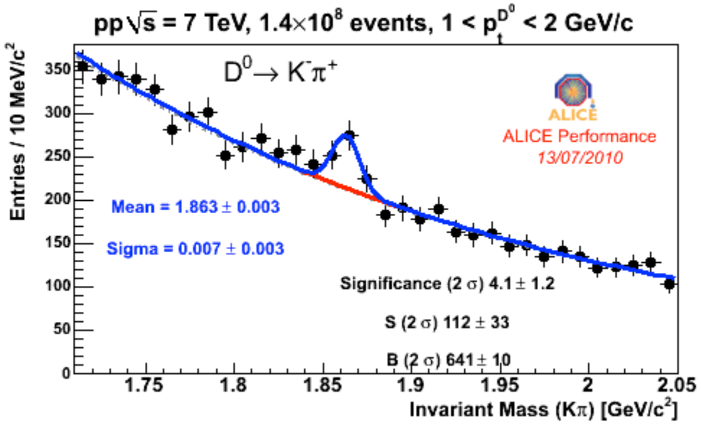
ALICE

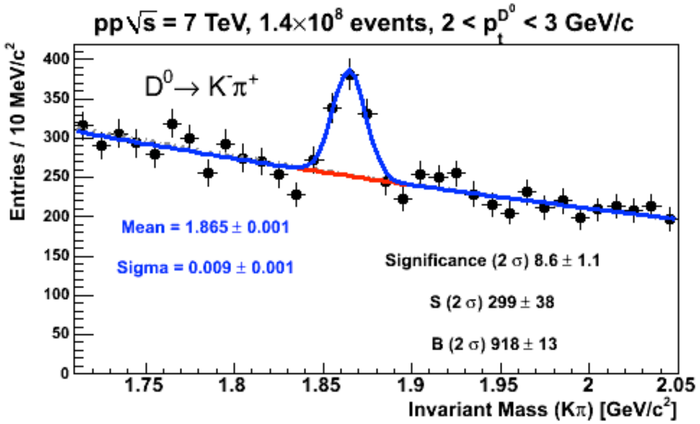
$D^0 \rightarrow K^- \pi^+$

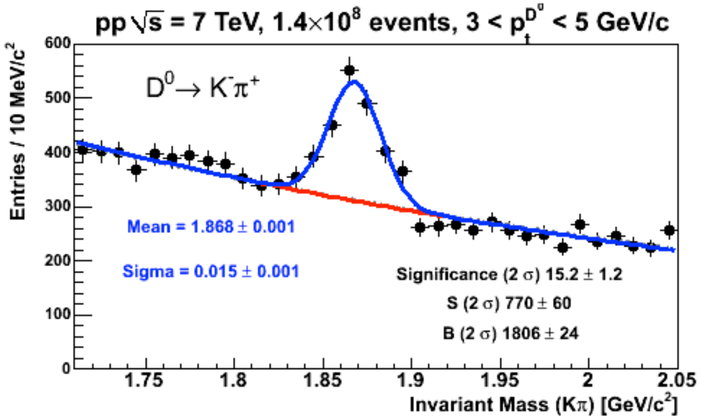
p-p at √s = 7 TeV

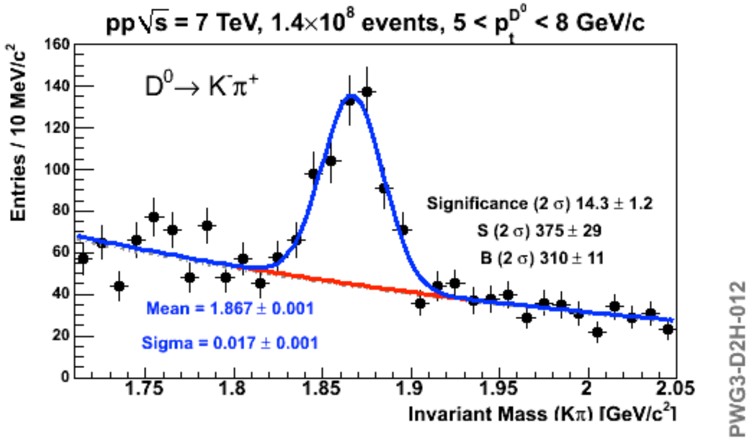
140 M events

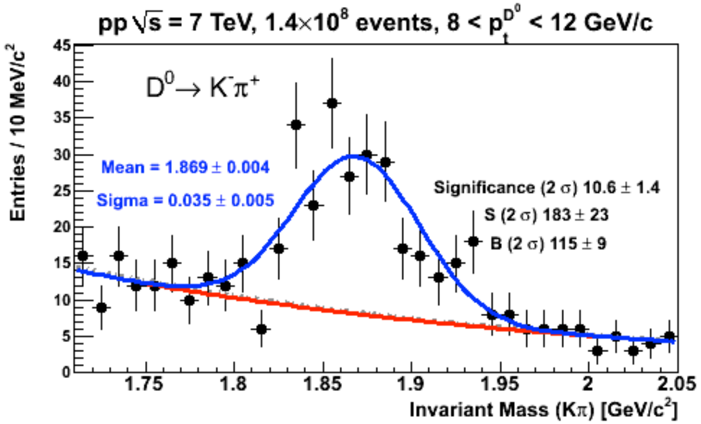
Signal seen in p_T between 1 – 12 GeV/c



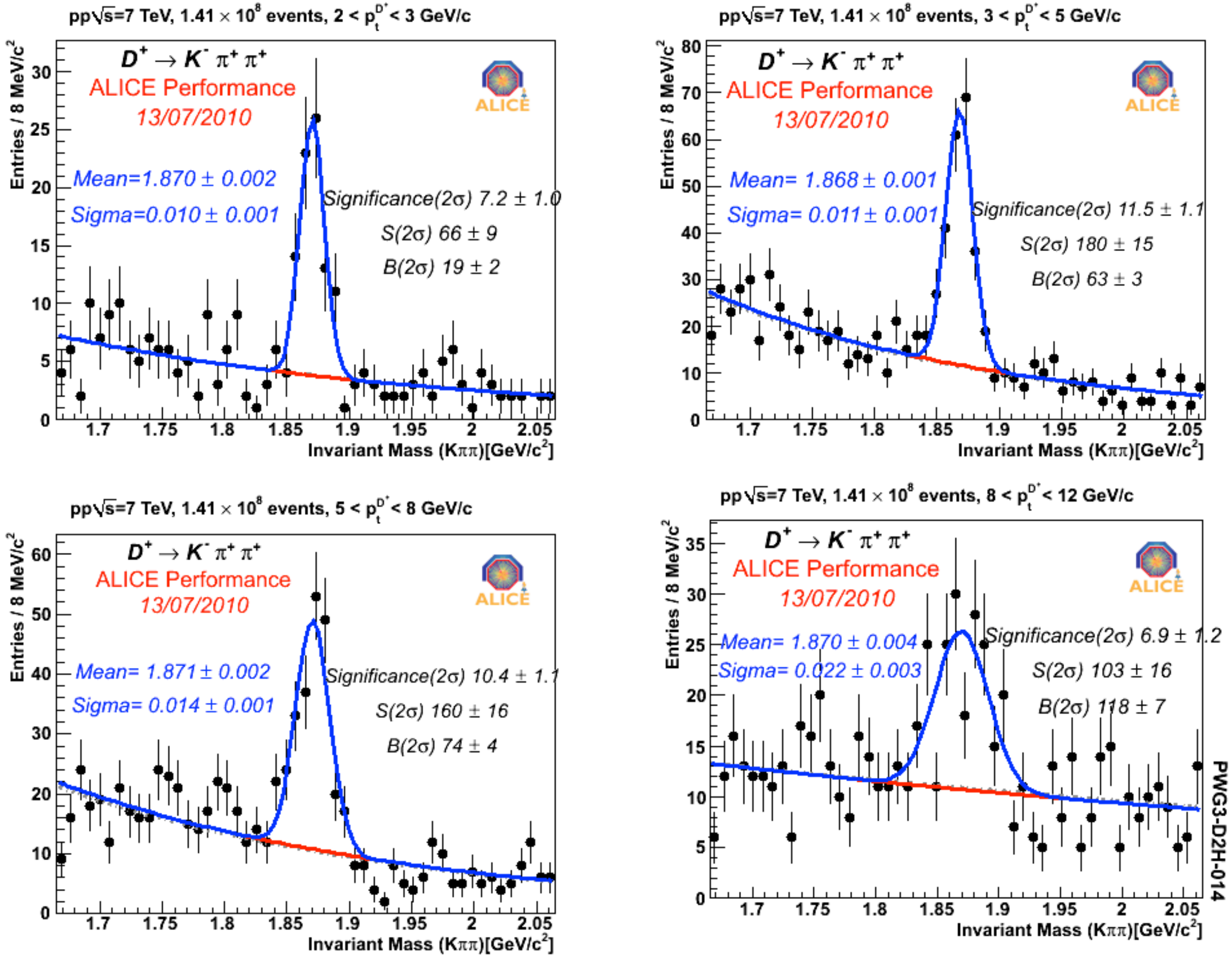








$D^+ \rightarrow K^- \pi^+\pi^+$



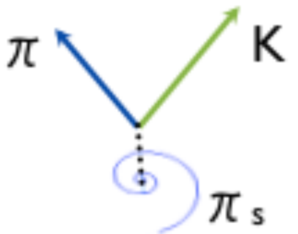
p-p at √s = 7 TeV

140 M events

Signal seen in p_T range $2 – 12$ GeV/c

ALICE

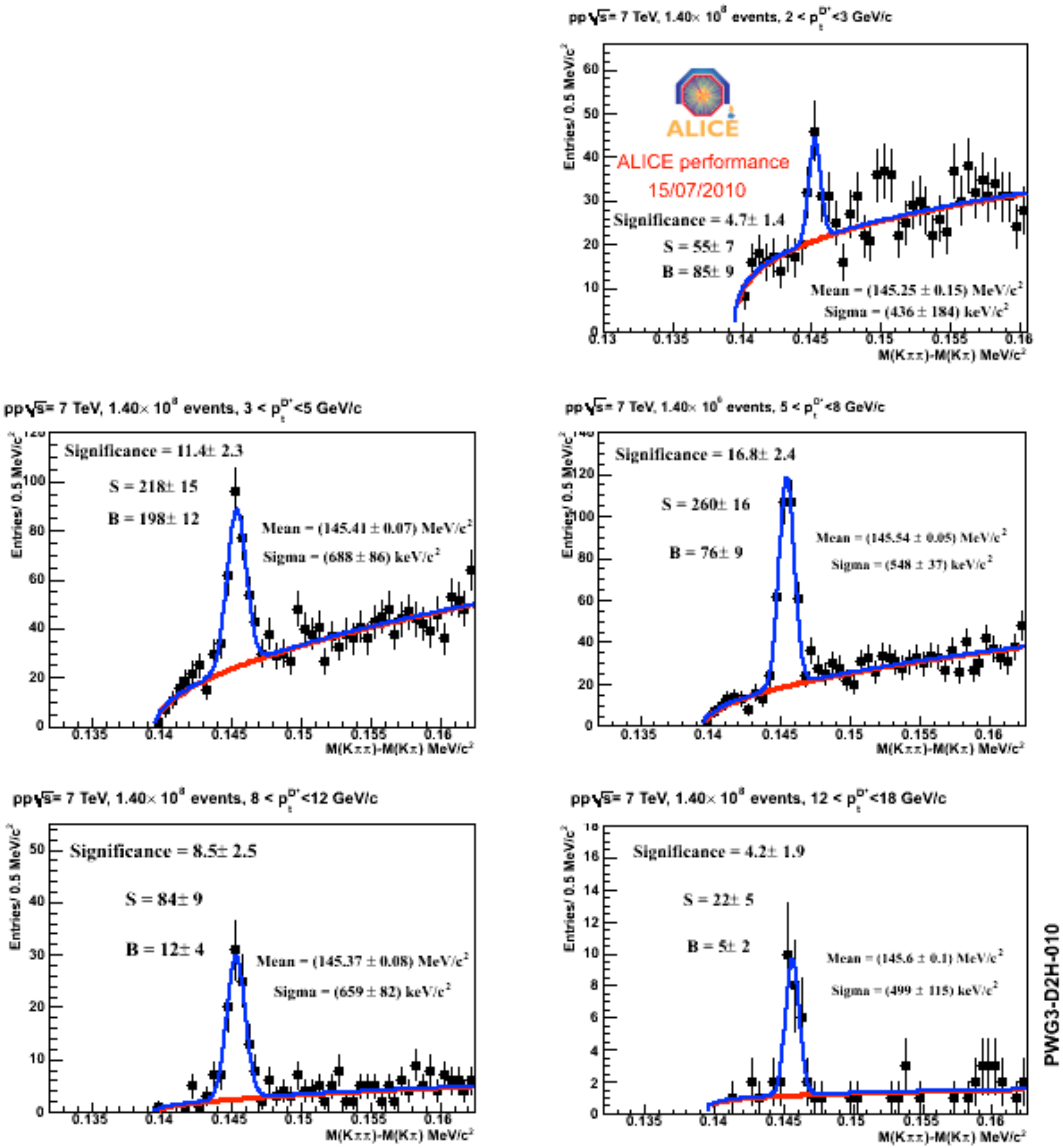
$D^{*+} \rightarrow D^0 \pi^+_{soft}$



p-p at √s = 7 TeV

140 M events

Signal is seen in the p_T range 2 – 18 GeV/c



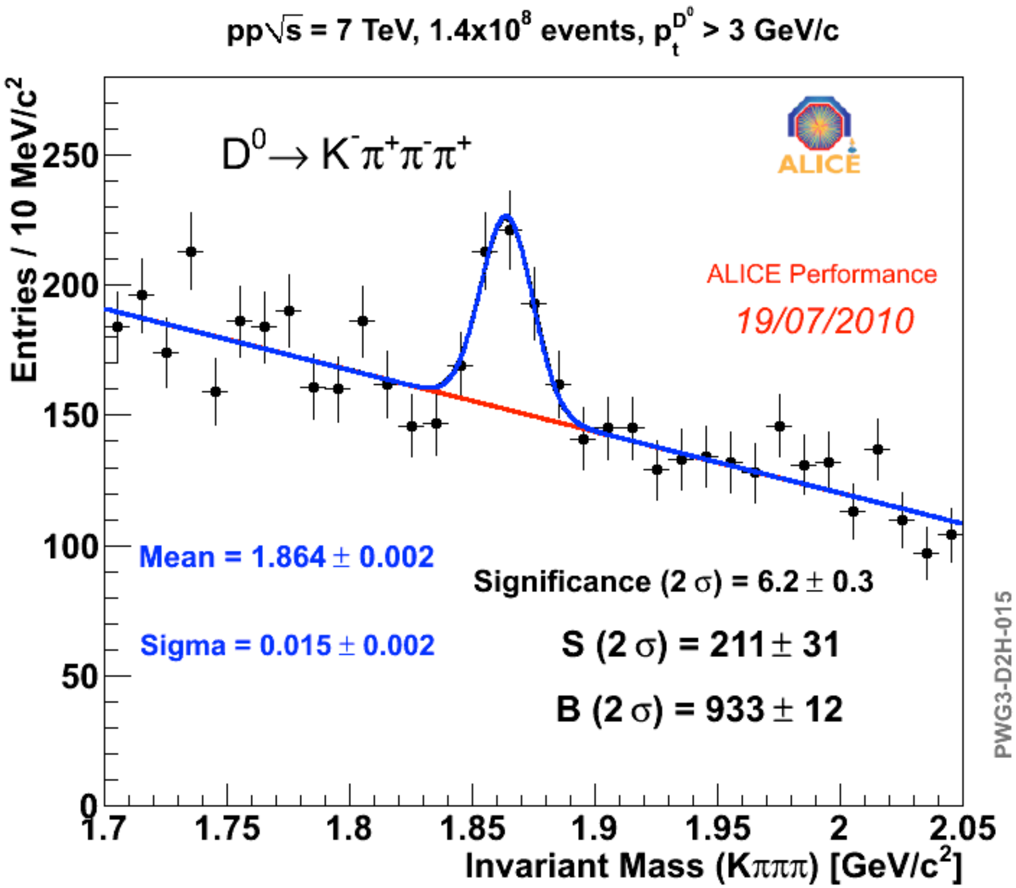
$D^0 \rightarrow K^- \pi^+ \pi^- \pi^+$

via ρ^0 resonant channel decay
p_T integrated above 3 GeV/c

good systematic check for the main channel

p-p at √s = 7 TeV

140 M events

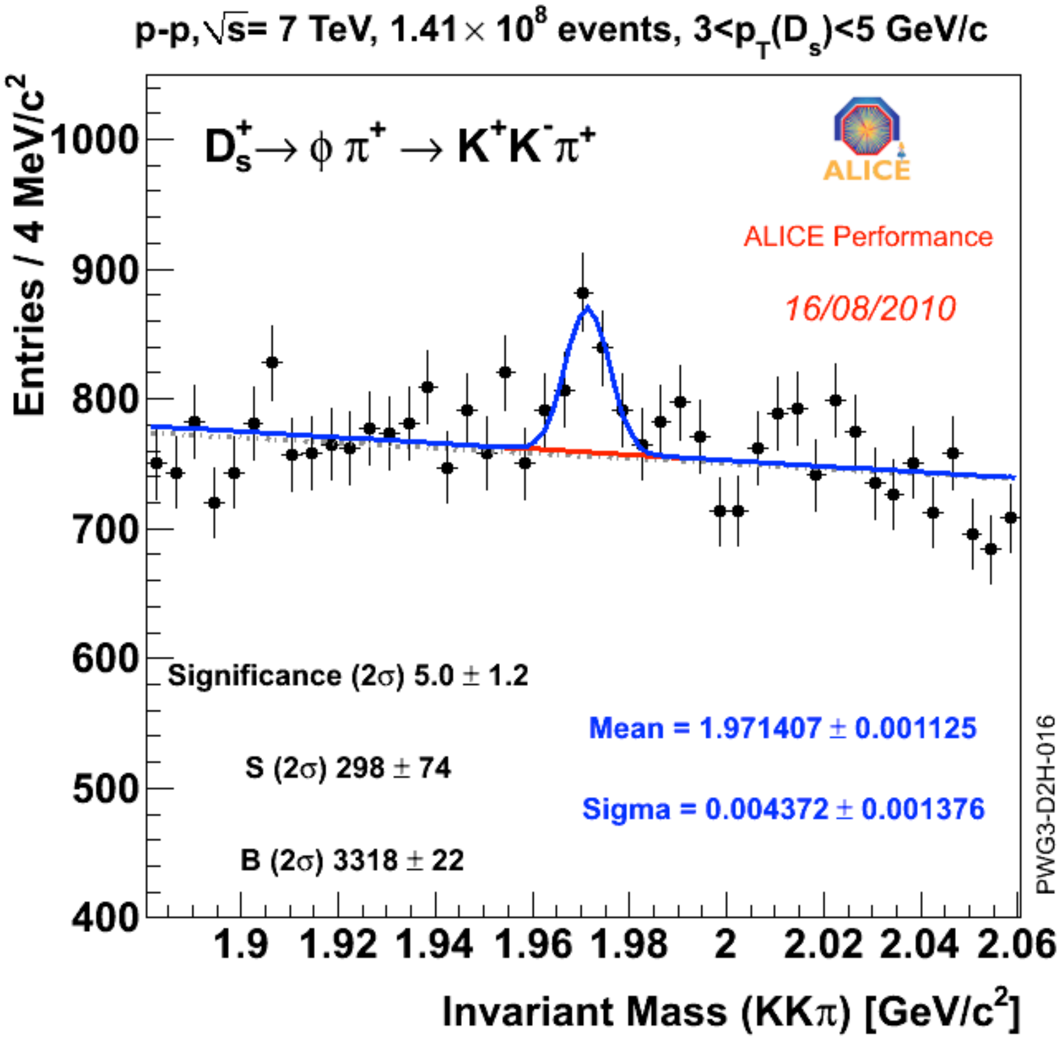


$D^+_s \rightarrow K^- K^+ \pi^+$

via ϕ resonant channel decay
p_T from 3 to 5 GeV/c

p-p at √s = 7 TeV

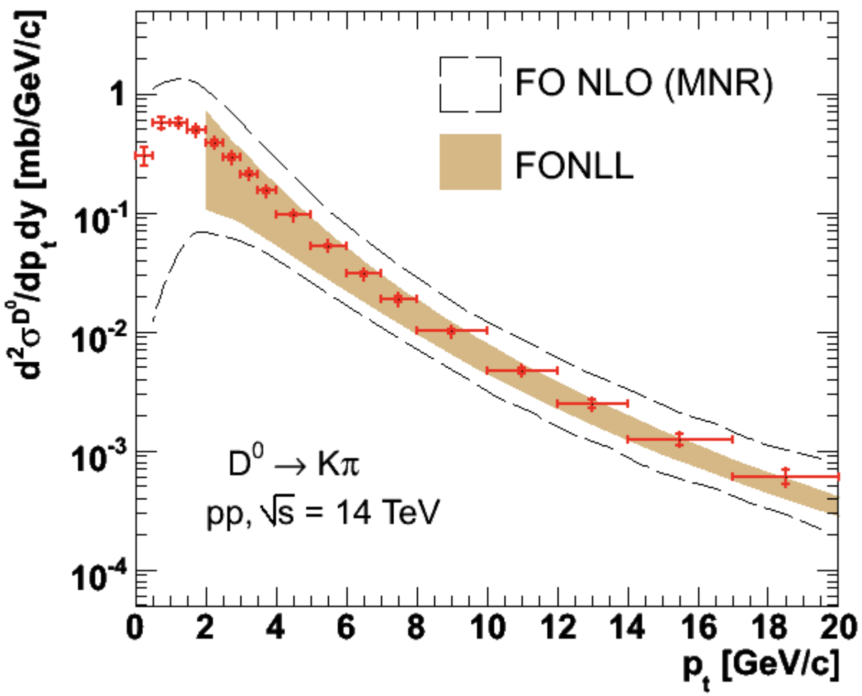
140 M events

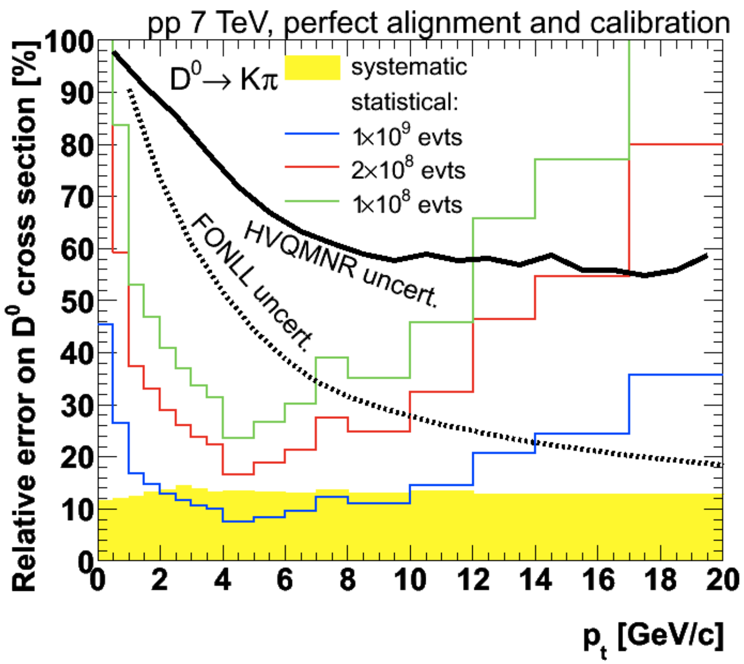


Back to MC: performance in p-p → D^0 $d\sigma/dp_T$

Expected performance for D^0 cross section measurement in ALICE compared with FONLL and FO NLO calculation for p-p collisions at √s = 14 TeV

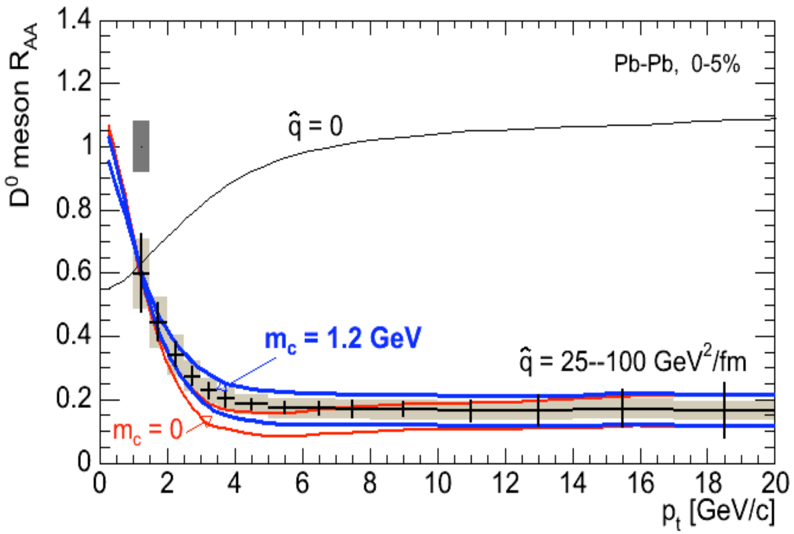
Similar performance are expected at √s = 7 TeV.
Charm yield is reduced by 35%

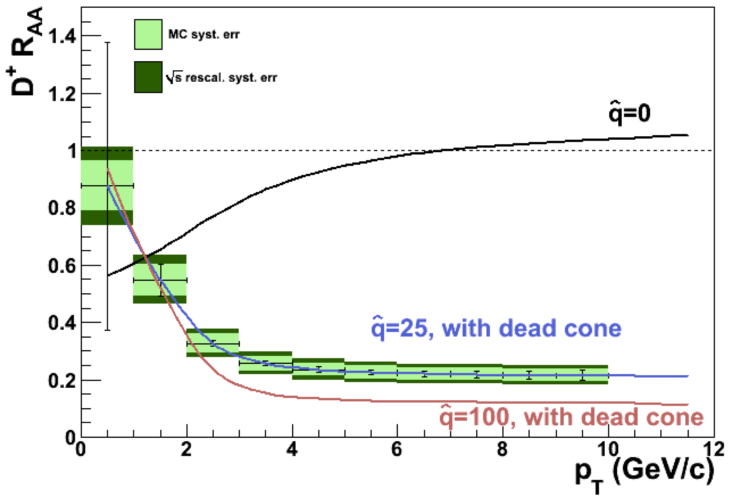




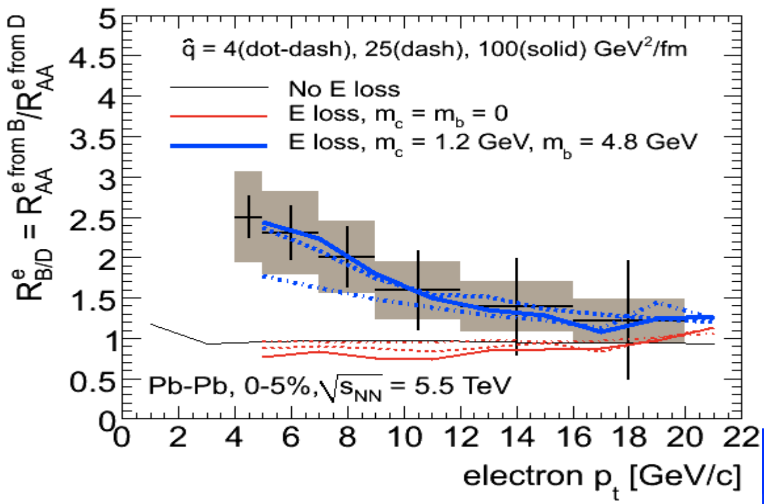
Energy loss studies with ALICE detector

$$R_{AA}(p_T) = \frac{1}{\langle N_{coll} \rangle_C} \times \frac{d^2 N_{AA}^C / dp_T d\eta}{d^2 N_{pp} / dp_T d\eta}$$





$$R_{B/D}(p_t) = R_{AA}^{\text{e from B}}(p_t) / R_{AA}^{\text{e from D}}(p_t)$$



Probes are used to study QCD energy loss as a function of:

-parton mass (dead cone effect)

-parton nature (Casimir factor)

Estimate based on 1 year of data taking at nominal ALICE luminosity (10^7 central Pb-Pb events, 10^9 pp)

Conclusions and Outlook

- Thanks to:

  - good vertex reconstruction capability

  - precise tracking down to low p_T

  - PID capability

  ALICE can play an important role in the open charm studies.

- ALICE detector performance is close to design.
- Signals of D^0, D^+, D^{*+}, D_S have been observed in different p_T bins in p-p collisions at $\sqrt{s}$ = 7 TeV (from 1-2 to 12 GeV/c for D^0, D^+, D^{*+})
- Analysis to extract the charm cross section is ongoing

Looking forward to... Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV in November 2010.

BACK UP

ALICE detector status