Study of D-mesons in the hadronic channel with the ALICE detector

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for the ALICE Collaboration

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Outline….

- D Mesons Analysis with ALICE
  - ✓Physics Motivation
  - ✓$D^0 \rightarrow K\pi$ Analysis
  - ✓$D^+ \rightarrow K\pi\pi$ Analysis
- Results at 7 TeV pp data
- Conclusions

Physics Motivation

Study heavy quark (charm) production

A-A collisions

* A unique probe to partonic matter
* Sensitive to initial **gluon density** and possible **medium effects**
  Parton energy loss
--- heavy quark **"dead cone"** effect

p-p collisions

Measurement of HF production → test of **pQCD** calculations
Baseline for A-A studies

p-A collisions

To disentangle initial and final state effects induced by the medium

To do a good Job on the Charm, we need:

Extremely Good Silicon detector

(Secondary vertex, life time..)

Extremely Good Particle Identification at low Pt

(Kaon,pion)

Hadronic Charm in ALICE

$D^0 \rightarrow K\pi$

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

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

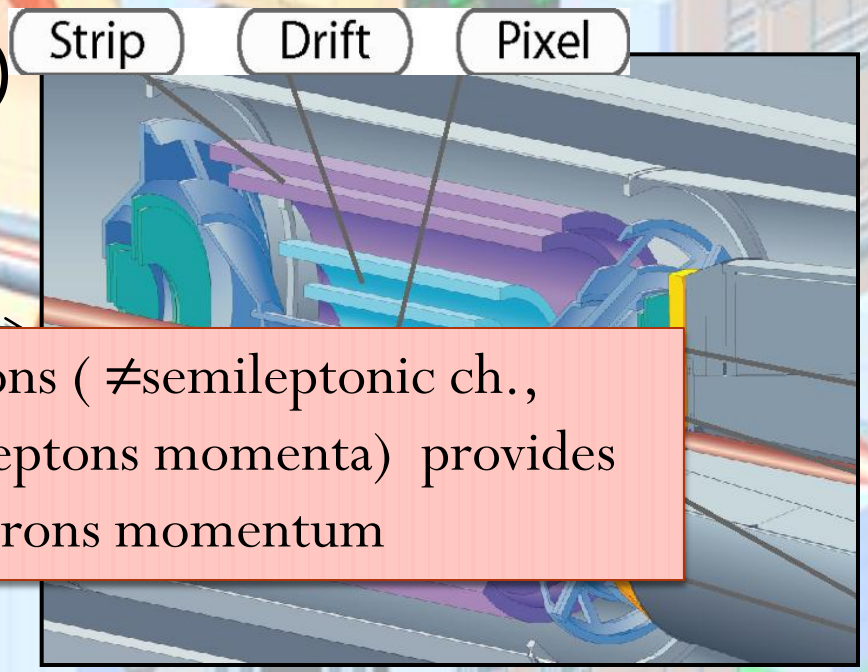
(→Talk by Yifei)

Under Study

$D_s \rightarrow KK\pi$

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

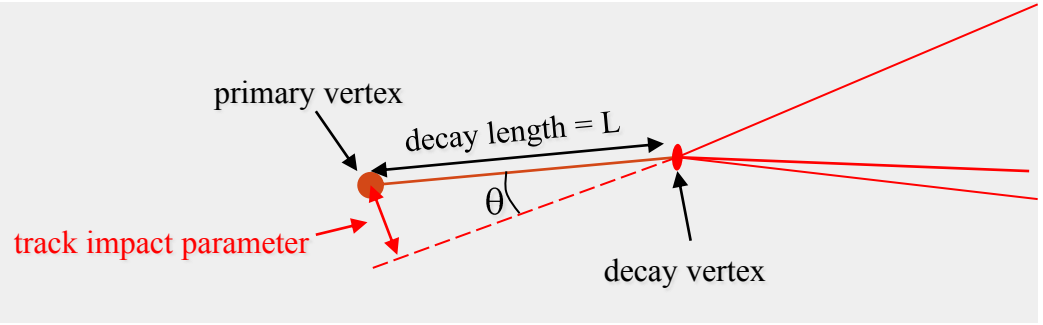
$\Lambda_c \rightarrow \pi Kp$



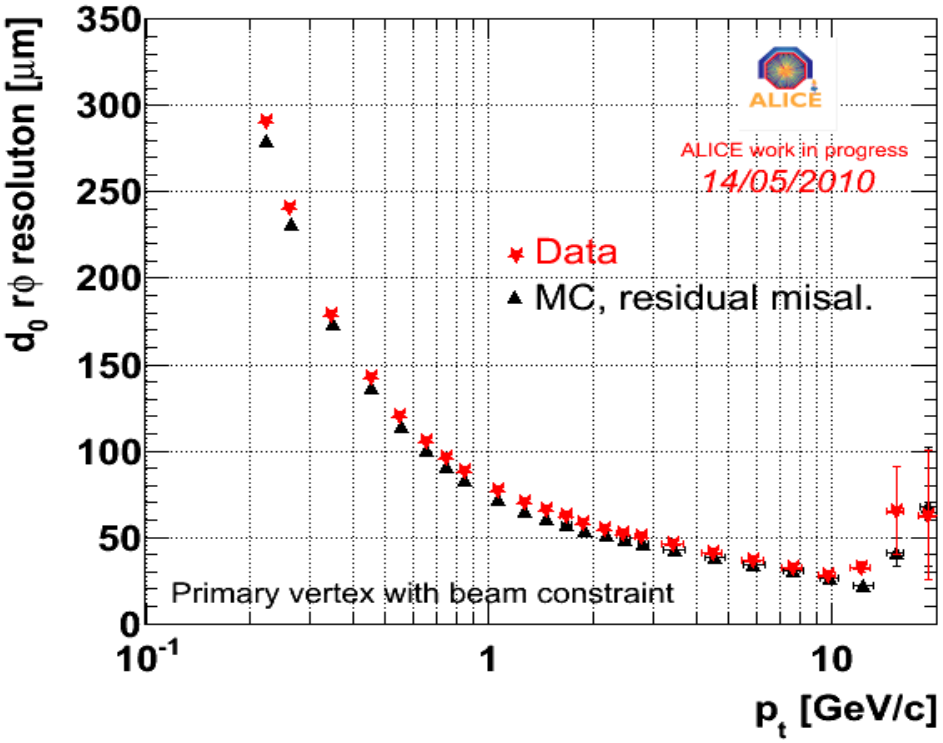
Exclusive reconstruction of charm mesons (≠semileptonic ch., weak correlation between mesons and leptons momenta) provides direct measurement of open charm hadrons momentum

Selection Strategy

- Invariant-mass analysis of fully-reconstructed topologies originating from displaced vertices
  - ⇨ build pairs/triplets/quadruplets of tracks with correct combination of charge signs and large impact parameters
  - ⇨ calculate the vertex (DCA point) of the tracks
  - ⇨ good pointing of reconstructed D momentum to the primary vertex
  - ⇨ particle identification to tag the decay products



<d0(r□)> ~c□~100-300 □m



Particle Identification Using TOF

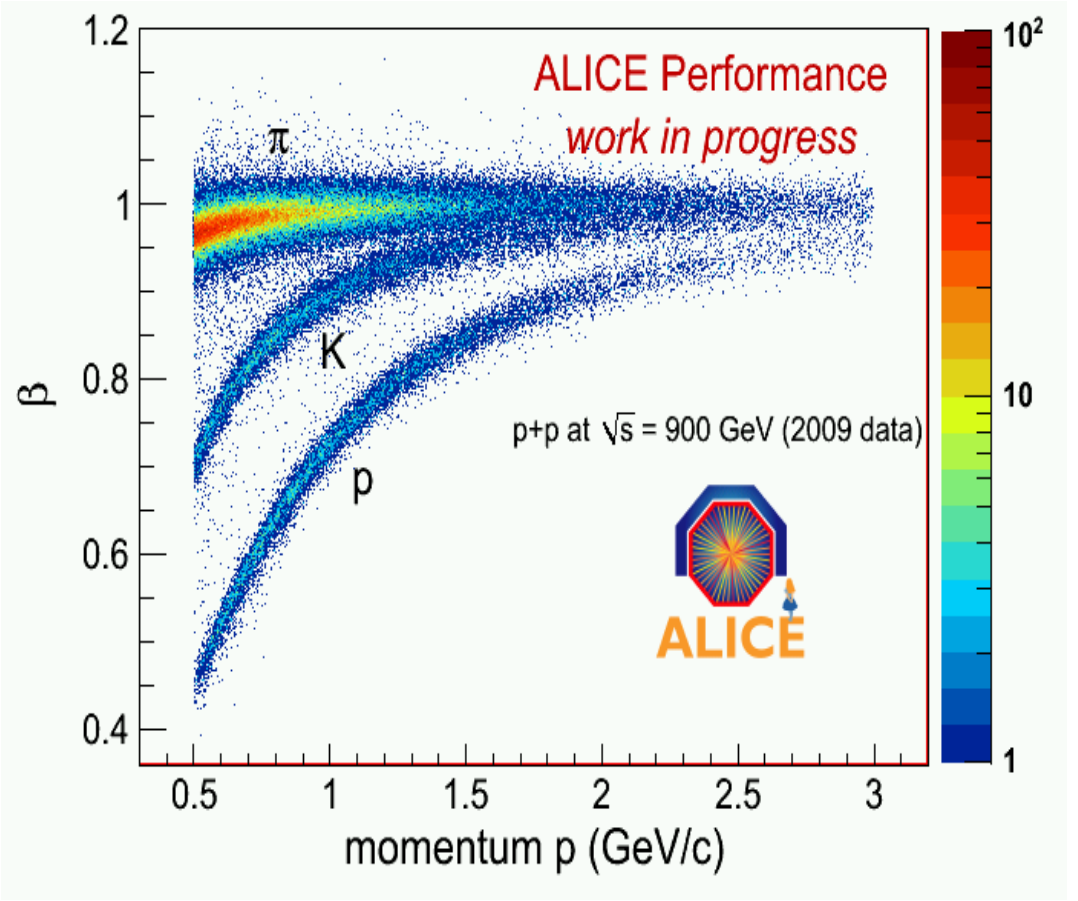
Kaon Identification to reject background at low P_t

Measured value t_M=TOF-T0
Reference value t_k=Integrated time with K mass hypothesis

Kaon compatible: $t_M - t_k < 3\sigma$

Where σ is time resolution of TOF (160ps)

K-π seperation upto 1.5 GeV/c



Particle Identification Using TPC

TPC PID using energy loss (dE/dx)

$(dE/dx_{measured}-dE/dx_{exp})<N.sigma$

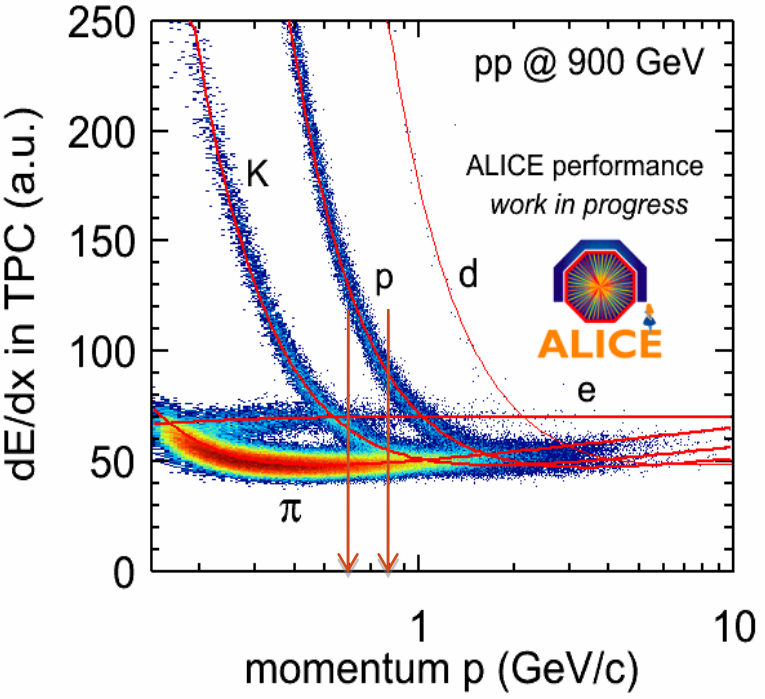
where dE/dx_{exp} from Bethe Bloch formula

sigma=TPC dE/dx resolution

identified if its energy loss is compatible with the Bethe Block for the given specie between N*sigma (N depending on the momentum range)

- Rejected if out of a 3-sigma limit for the given specie
- Unknown between N*sigma and 3.

Unknown particle are kept unless TOF PID identifies the particle to be a different

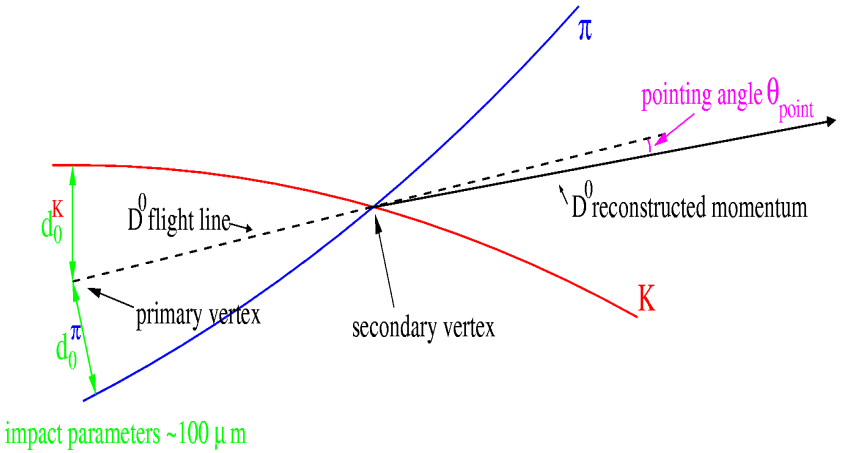


Particle	Momentum	N
Pion	0-0.6	2
	0.6-0.8	1
Kaon	0-0.6	2
	0.6-0.8	1

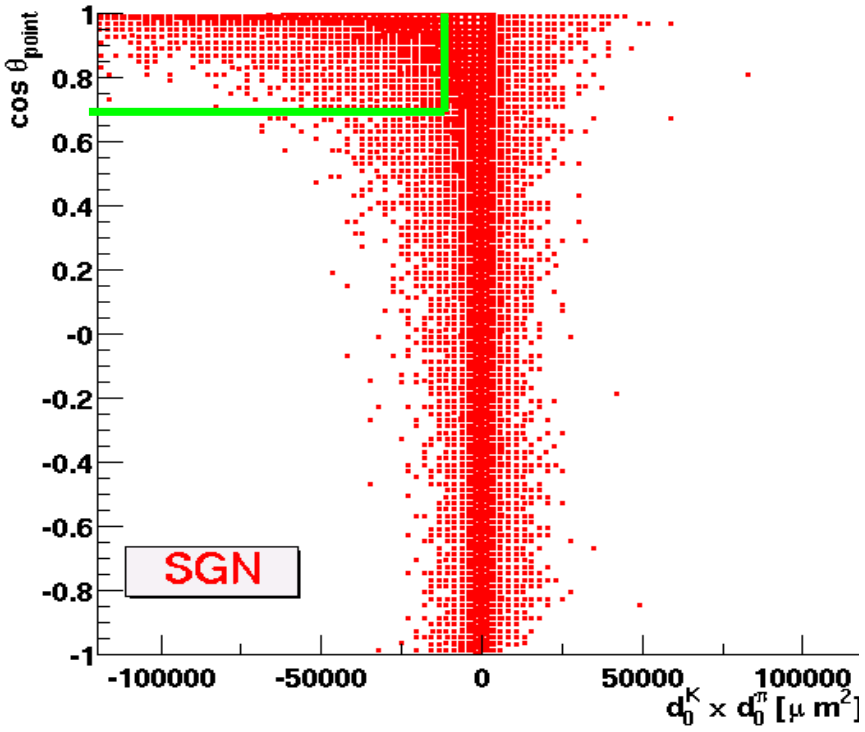
D^0 Selection Strategy

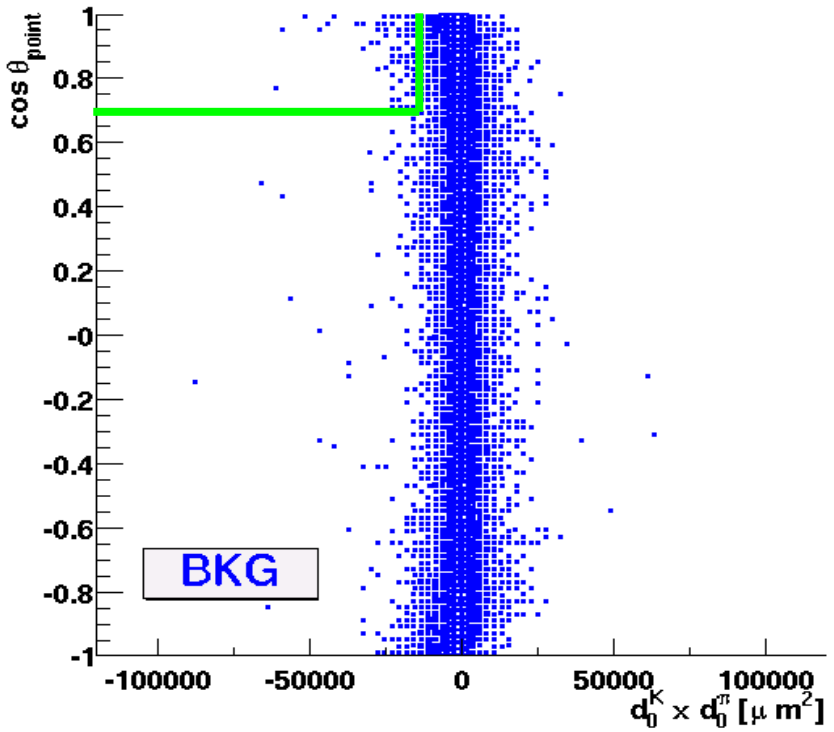
pairs of opposite sign charged track

- ✓ the product of the impact parameters of the two tracks ($d_0^k \times d_0^\pi << 0$)
- ✓ Pointing of the reconstructed D^0 momentum to the primary vertex ($\cos\theta_{point} \rightarrow 1$)



MC Simulation

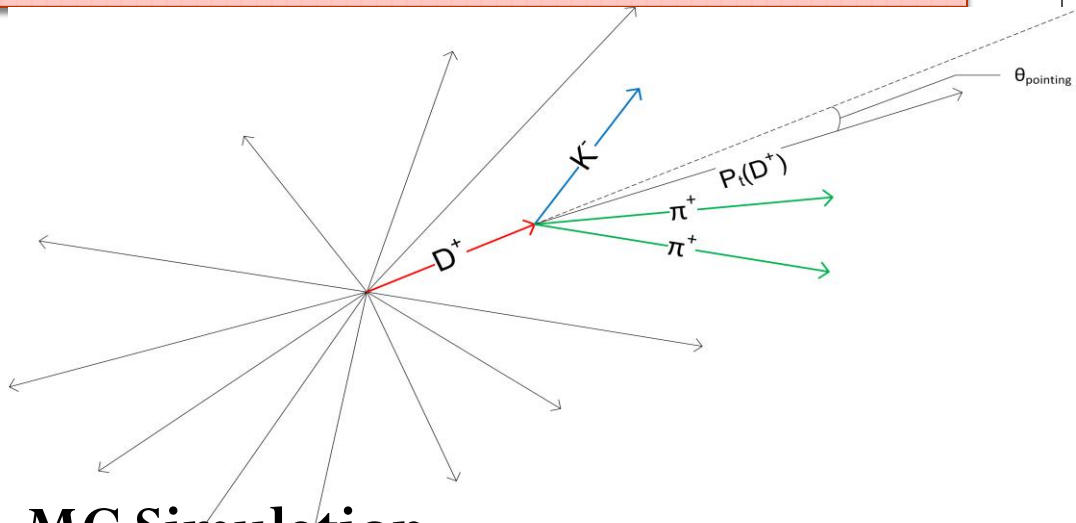




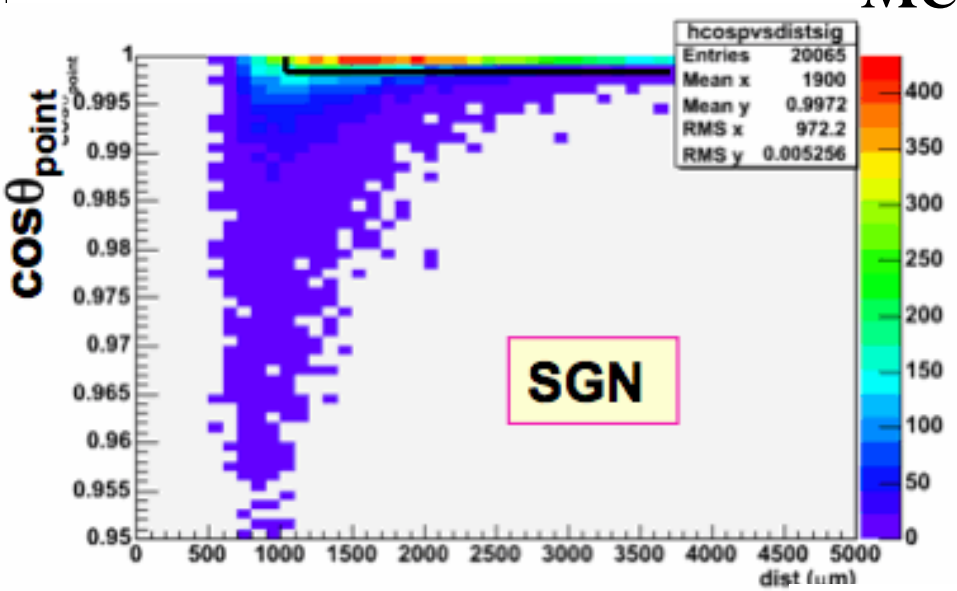
D^+ Selection Strategy

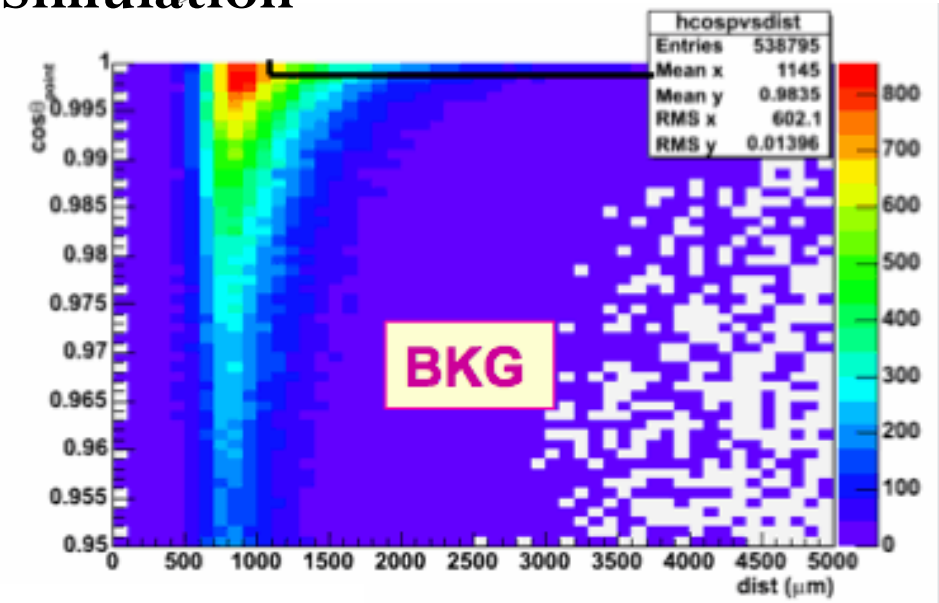
Triplet of charged tracks with correct sign combination

- distance(d_{ps}) between primary and secondary vertex.
- The reconstructed momentum should point to the primary vertex (θ_{point} ~0)



MC Simulation





$d_{PRIM-SEC}$ (μm)

Results at 7 TeV pp data : $D^0 \rightarrow K^-\pi^+$

Events: 1.25×10^8

Tracks requested:

4 Points in ITS

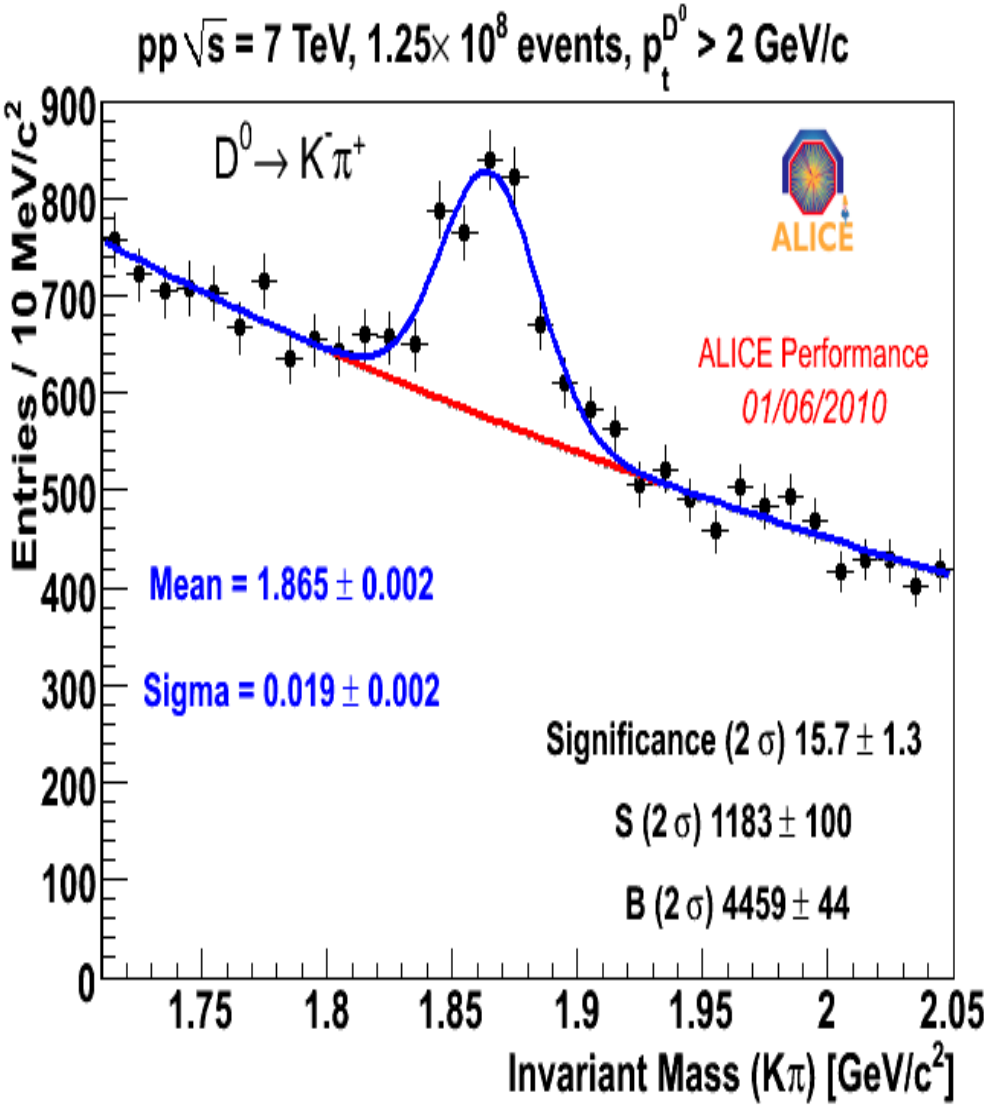
at least one in Pixel

Fit function:

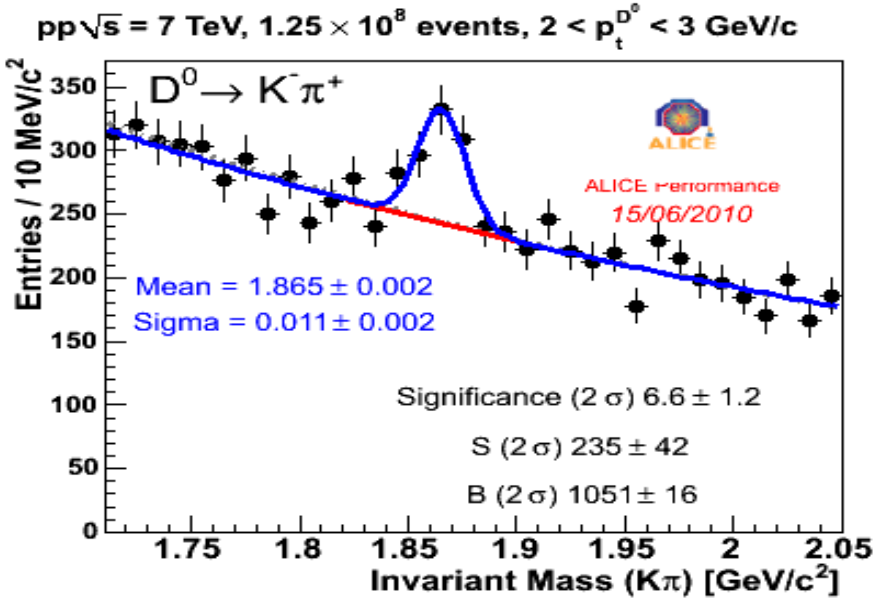
Signal → Gaussian

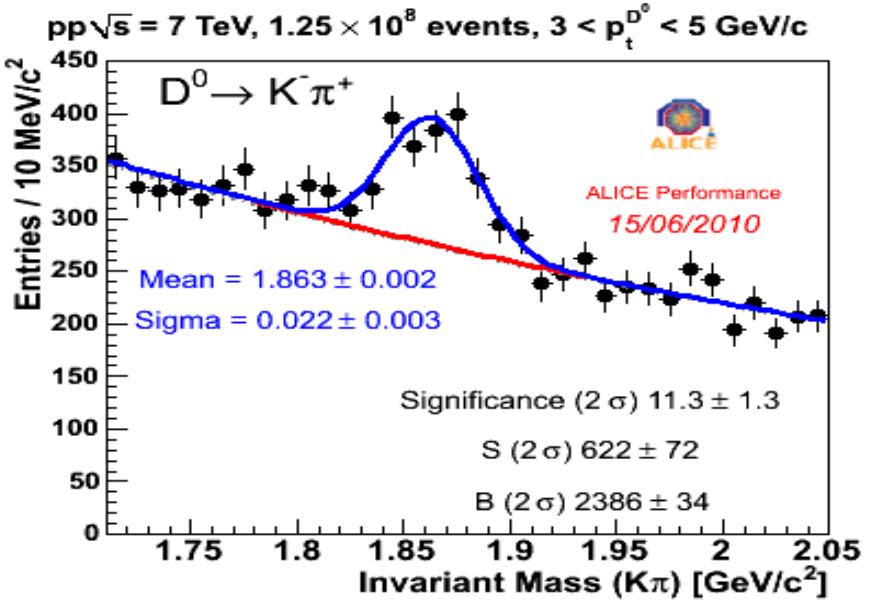
Background → Exponential

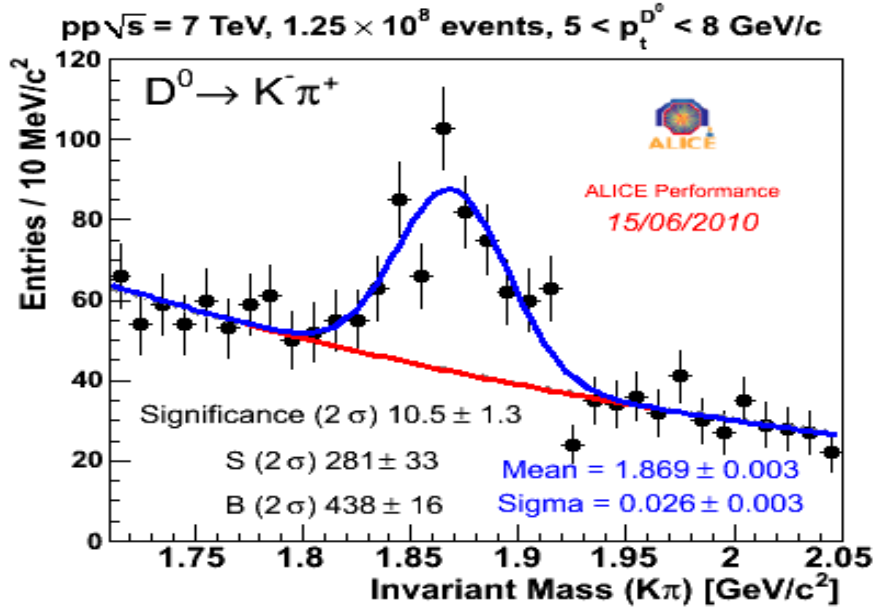
S/B(2σ) ~ 0.27

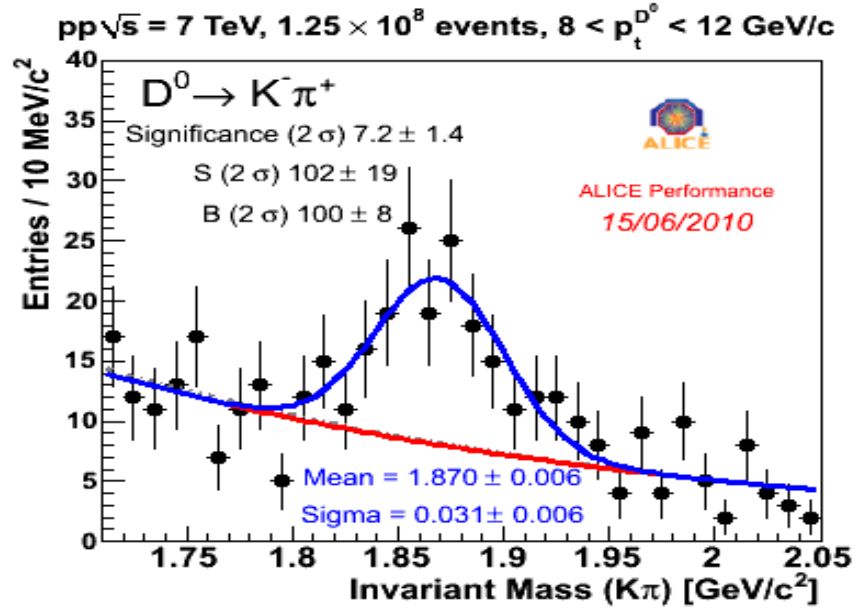


Invariant Mass Spectra in 4 P_t bins: 2-3, 3-5, 5-8 & 8-12 GeV/c









PWG3-D2H-007

Results at 7 TeV pp data : $D^+ \rightarrow K^-\pi^+\pi^+$

Events: 1.25×10^8

Tracks requested:

4 Points in ITS

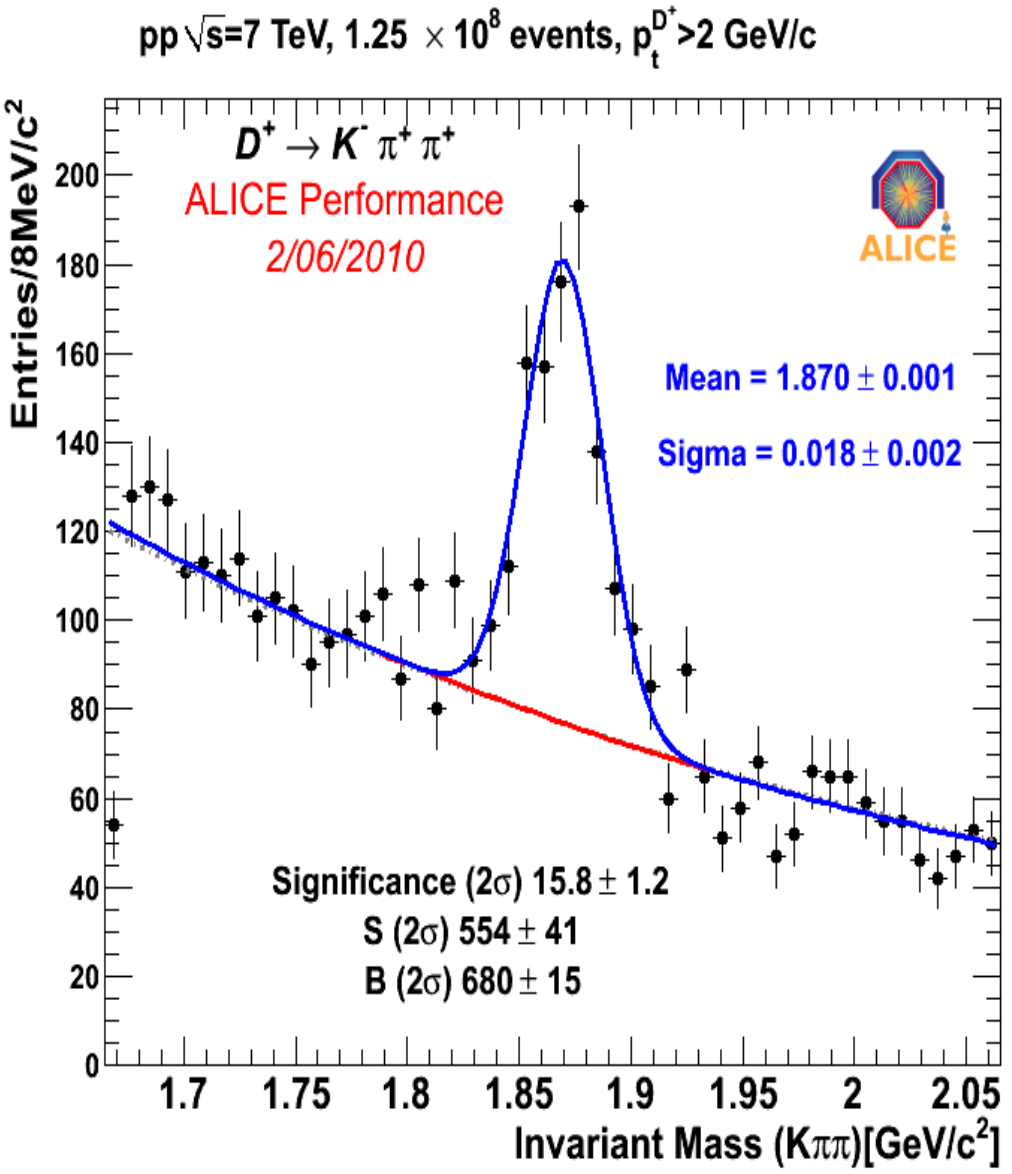
at least one in Pixel

Fit function:

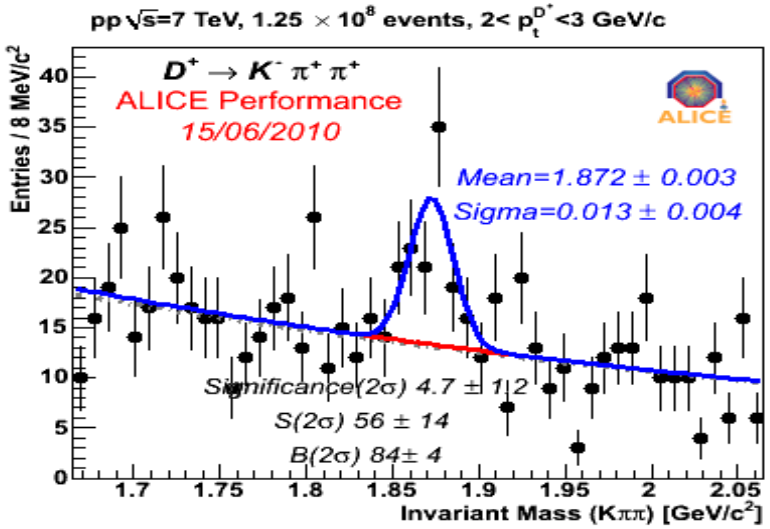
Signal → Gaussian

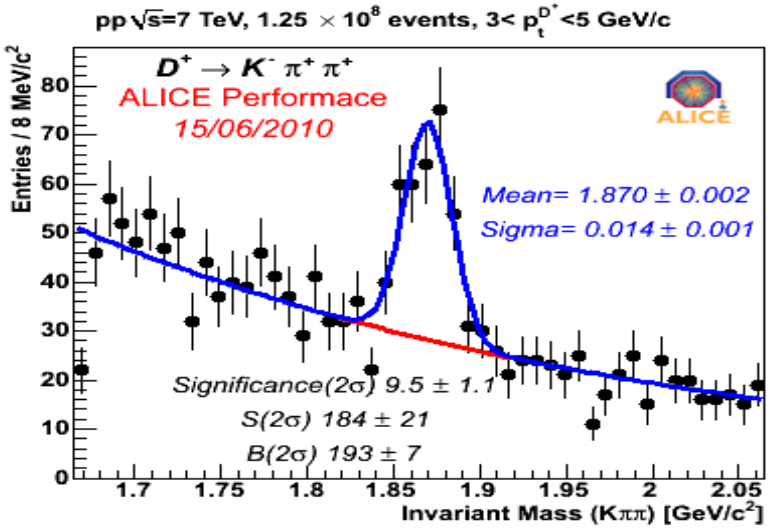
Background → Exponential

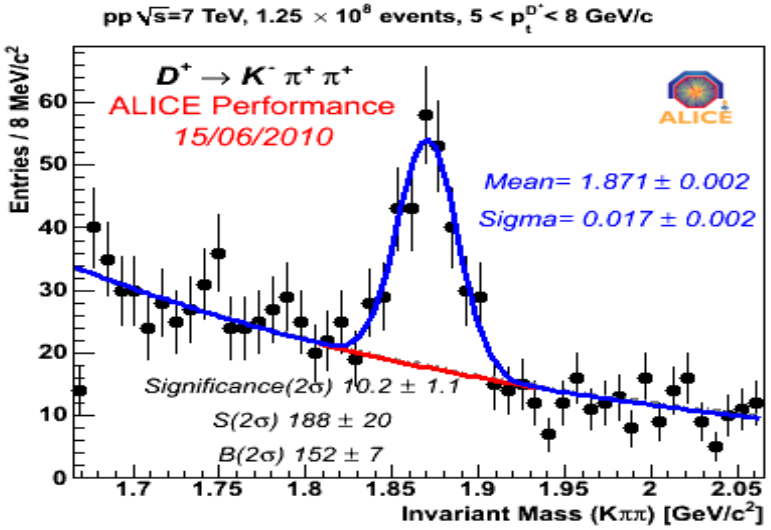
Signal/Background(2σ) ~ 0.85

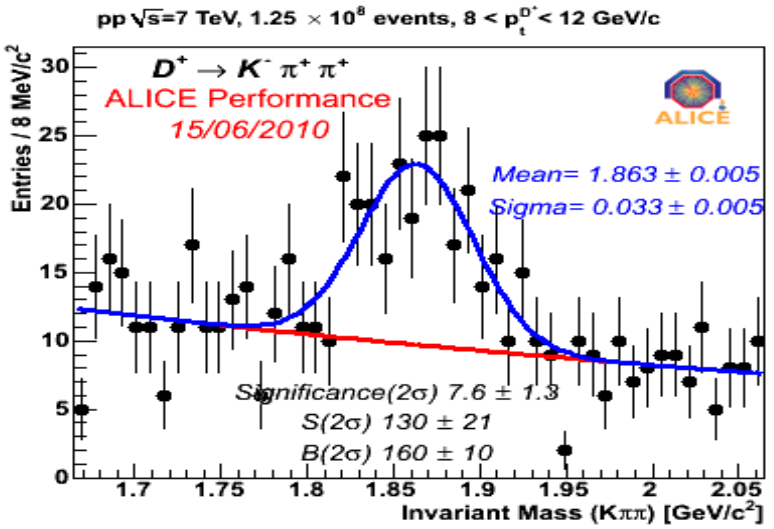


Invariant Mass Spectra in 4 P_t bins: 2-3, 3-5, 5-8 & 8-12 GeV/c









$D^0 \rightarrow K\pi$

Pt bin	SIG	BKG	SIG/BKG	Sign.	Sign. (10^9 evt)
>2 GeV/c	1183±100	4459±44	0.27	15.7±1.3	~44±4
2-3 GeV/c	236±42	1045±16	0.23	6.6±1.2	19±3
3-5 GeV/c	619±72	2377±34	0.26	11.3±1.3	32±4
5-8 GeV/c	281±33	428±16	0.66	10.5±1.3	30±4
8-12 GeV/c	102±19	100±8	1.2	7.2±1.4	20±4

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

Pt bin	SIG	BKG	SIG/BKG	Sign.	Sign. (10^9 evt)
>2 GeV/c	554±41	680±15	0.85	15.8±1.2	~44±4
2-3 GeV/c	56±14	84÷4	0.70	4.7±1.3	15±4
3-5 GeV/c	184±21	193±7	0.98	9.5±1.1	29±3
5-8 GeV/c	188±20	152±7	1.26	10.2±1.1	30±3
8-12 GeV/c	130±21	160±10	0.93	7.6±1.3	21±4

Conclusions

- ALICE has an excellent capability for Charm physics in LHC
  - ✓First D signal seen with 10^7 events !
  - ✓Significance of >15 for P_t>2GeV/c with 10^8 events.
  - ✓Expected to have a good significance for low P_t region (<2GeV/c) with 10^9 events.

And after one year of data taking…

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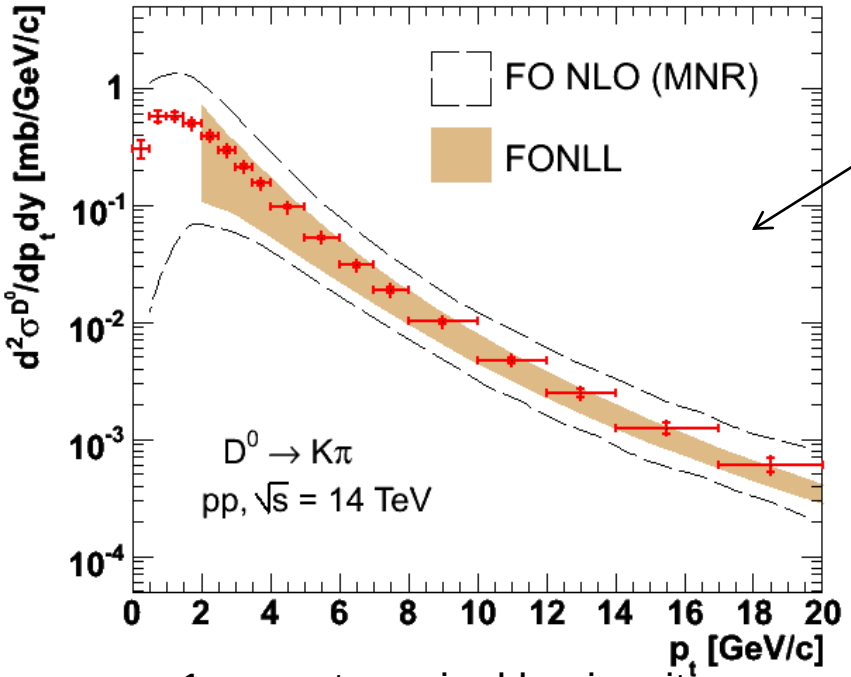
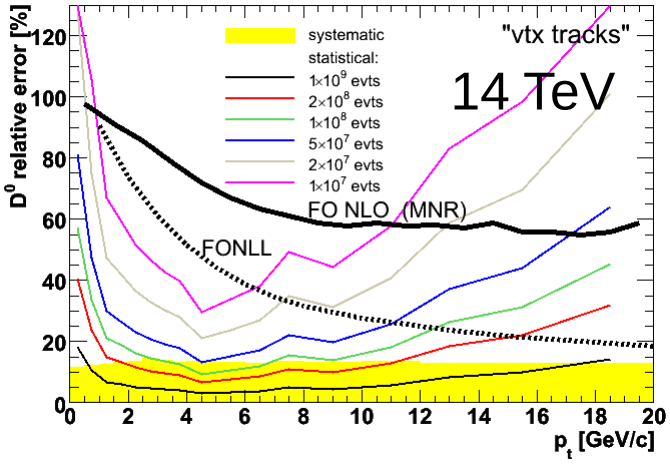
Expected Performance: Charm production measurement in pp

Expected sensitivity in comparison to pQCD:

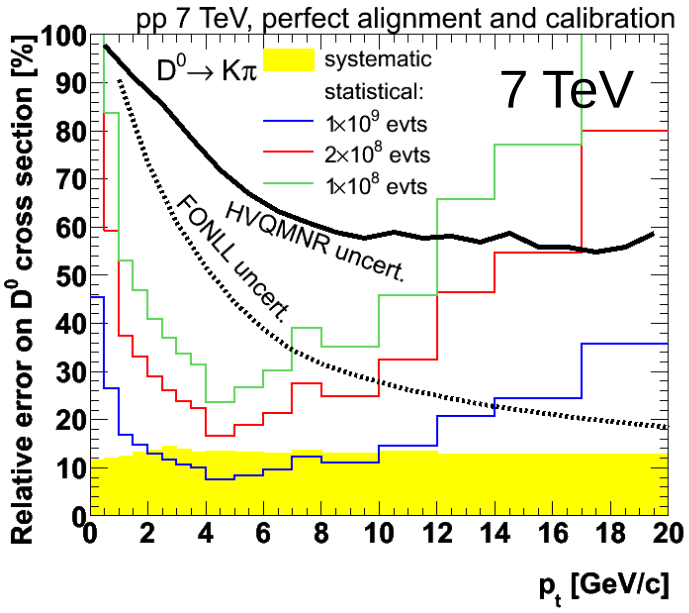
$D^0 \rightarrow K\pi$



1 year at nominal luminosity
(10^9 pp events)



10^9

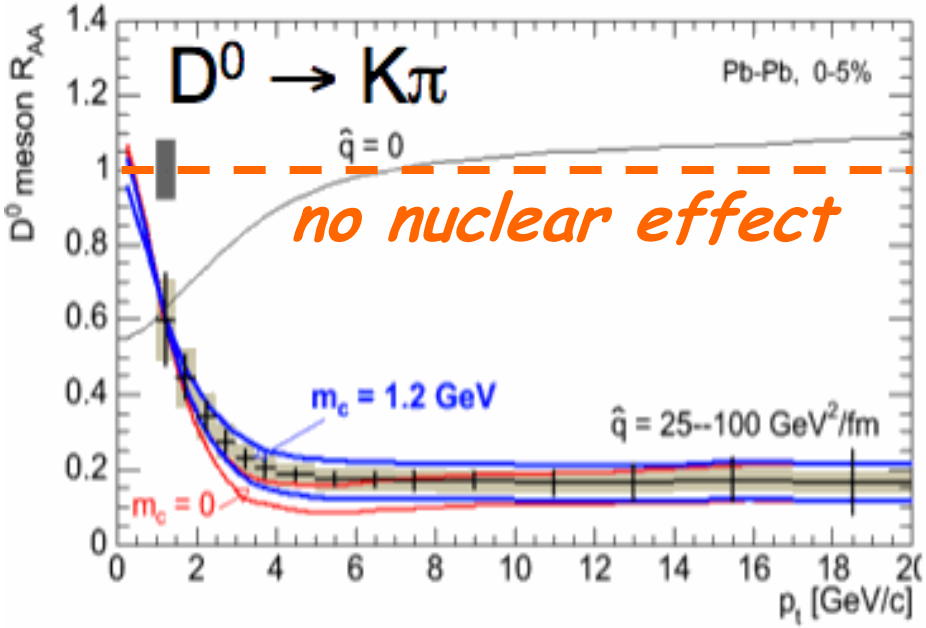


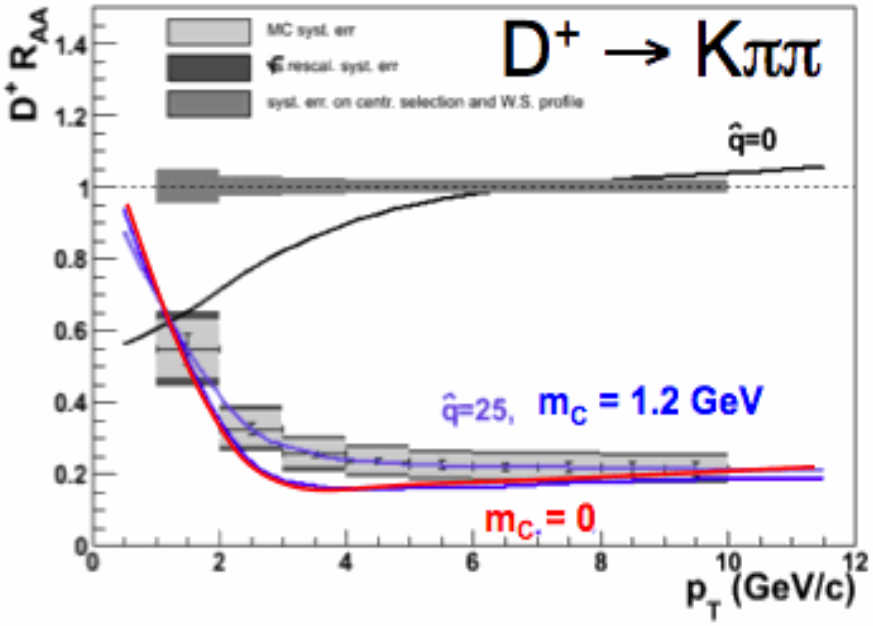
→ Sensitivity should be good also at 7 TeV

Expected Performance: Charm Energy Loss in AA

Low p_T: main effect on R_{AA} is nuclear shadowing

High p_T: main effect on R_{AA} is energy loss





1 year at nominal luminosity
(10^7 central Pb-Pb events, 10^9 pp events)

Energy loss calculation:
Armesto, Dainese, Salgado, Wiedemann, PRD71 (2005) 054027

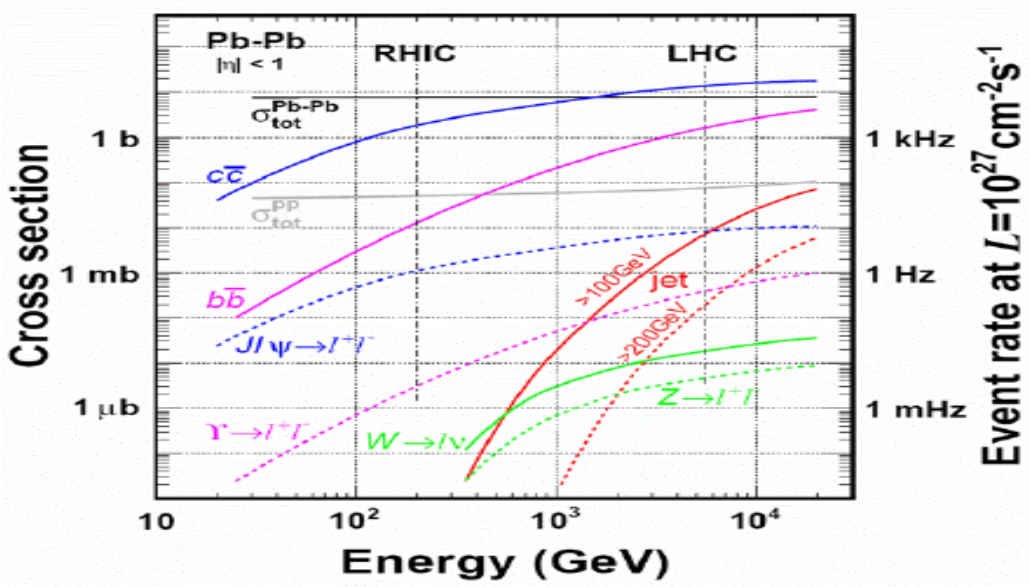
Thanks

BACK UP

Heavy Flavor at LHC Energies

- ✓ Novelity of LHC: Large hard cross-section
- ✓ HF are abundantly produced at the LHC

R. Romita's Talk



$$\sigma_c(LHC) = \sigma_c(RHIC) \times 10$$
$$\sigma_b(LHC) = \sigma_b(RHIC) \times 100$$
$$\sigma_W(LHC) = \sigma_\Upsilon(RHIC) \times 10$$
$$\sigma_Z(LHC) = \sigma_\Upsilon(RHIC)$$

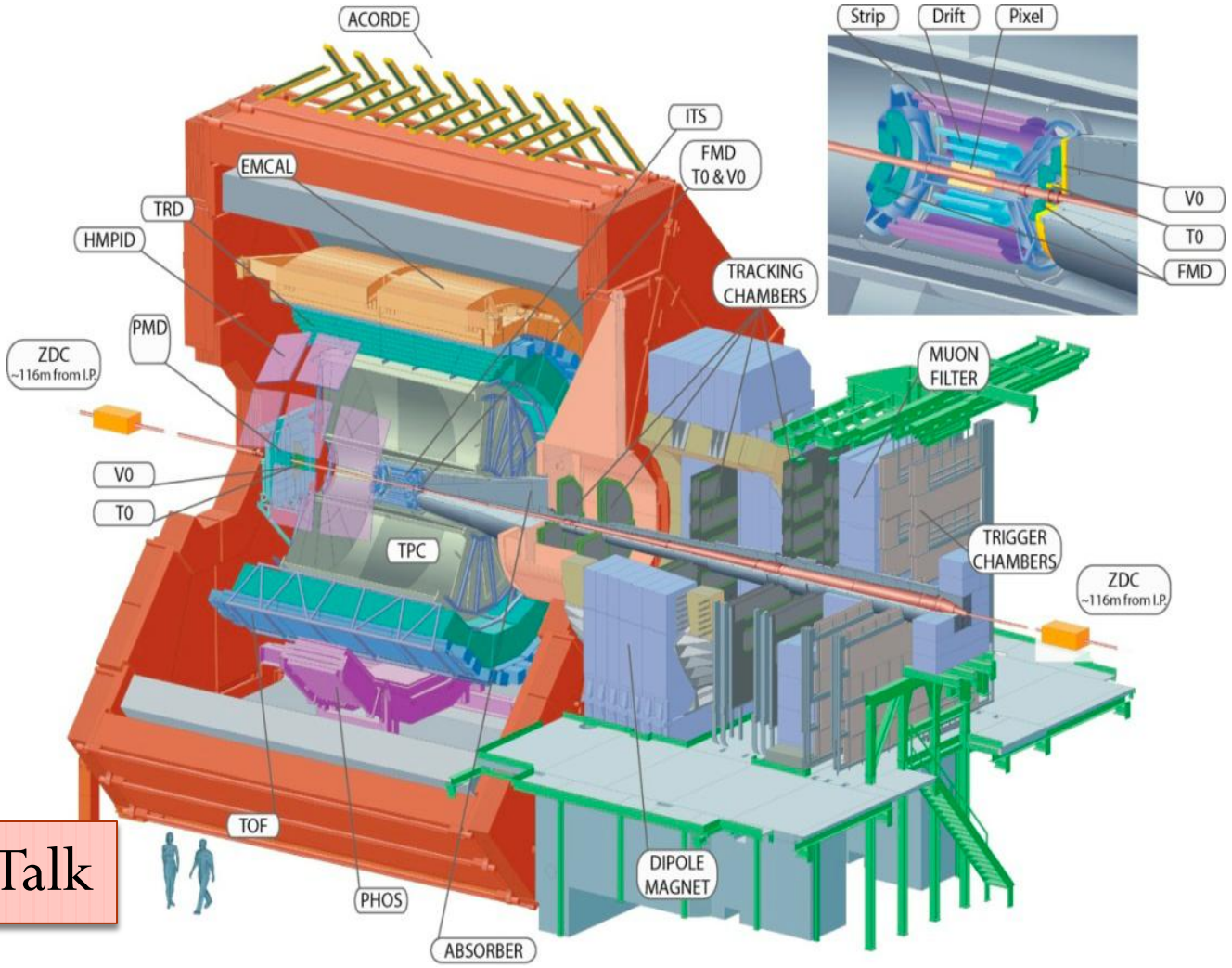
pQCD NLO + binary scaling + shadowing gives:

	pp	pp	Pb-Pb (5% most central)
$\sqrt{s}$ (TeV)	7	14	5.5
N_{cc}	~ 0.1	0.16	115
N_{bb}	~ 0.003	0.007	4.6

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

ALICE Experiment

- ALICE channels:
  - electronic (|h|<0.9)
  - muonic (-4<h<-2.5)
  - hadronic (|h|<0.9)
- ALICE coverage:
  - Extends to low-p_T region
  - central and forward rapidity regions
- Precise vertexing to identify D (ct ~ 100-300 mm) and B (ct ~ 500 mm) decays

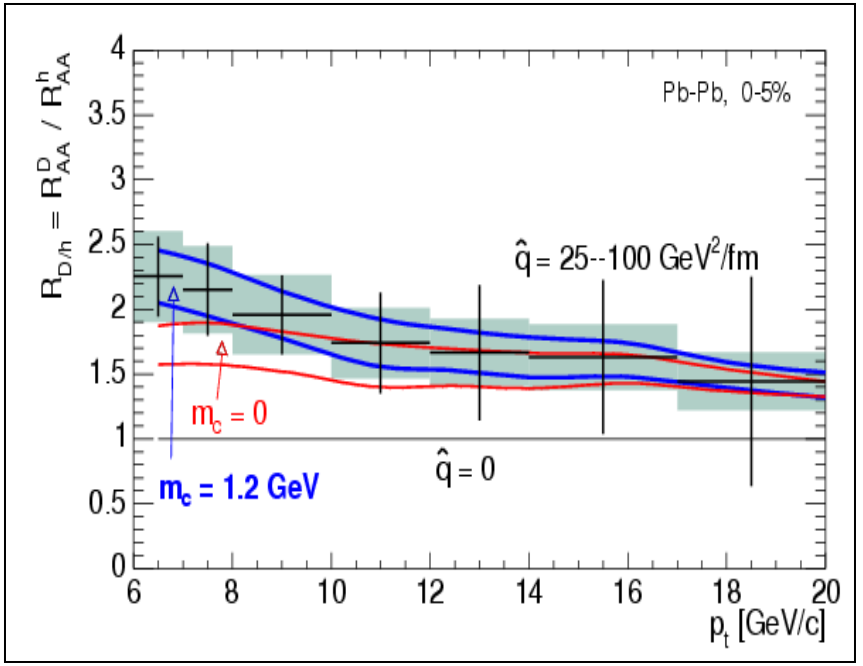


R. Romita's Talk

Heavy-to-light ratios in ALICE

Gluons→ light hadrons
and charm quark→D

probes colour-charge dep. of QCD energy loss



1 year at nominal luminosity
(10^7 central Pb-Pb events, 10^9 pp events)