ALICE — STATUS AND FIRST RESULTS*

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(Received May 6, 2011)

Some results on the pp collisions at $\sqrt{s} = 900$ GeV, 2.36 and 7 TeV are presented. This includes multiplicity distributions, pseudorapidity and transverse momentum spectra and the antibaryon-to-baryon ration. Preliminary results from $\mathrm{Pb} + \mathrm{Pb}$ collisions are shown as well.

DOI:10.5506/APhysPolB.42.1465
PACS numbers: 13.75.Cs

1. Introduction

The ALICE experiment is the only dedicated heavy-ion experiment at the CERN LHC. Although its main aim is a search for the new state of matter, the Quark Gluon Plasma, using a broad spectrum of signatures, it has an also extended programme for the proton–proton physics. Here we show some results of the 2010 pp data taking at $\sqrt{s} = 900$ GeV, 2.36 and 7 TeV. We discuss particle density and pseudorapidity distributions and compare them with Monte-Carlo predictions. The transverse momentum spectra of identified particles at 900 GeV are also shown and the baryon number transfer in pp collisions is discussed. We also present first, preliminary results for PbPb collisions at $\sqrt{s} = 2.76$ TeV.

2. ALICE detector

ALICE, being the only dedicated heavy ion experiment at the CERN LHC, was designed as the omnipurpose detector, suitable to work in a very high particle density environment. The detailed setup of ALICE can be

* Presented at the Cracow Epiphany Conference on the First Year of the LHC, Cracow, Poland, January 10–12, 2011.

found elsewhere [1]. Here we would like to mention, that it consists of a set of tracking and particle identification detectors, covering mainly the so-called central region $|\eta| < 0.9$, however it contains also the forward muon spectrometer for μ pairs studies, smaller acceptance calorimeters and a number of small angle detectors. The ALICE acceptance is shown in Fig. 1. The ALICE physics programme covers a broad spectrum of observables, in proton–proton, proton–nucleus and nucleus–nucleus collisions at different energies. The detailed discussion can be found in [2]. The ALICE Collaboration consists of more than 1000 physicists from more than 150 institutes and 30 countries.

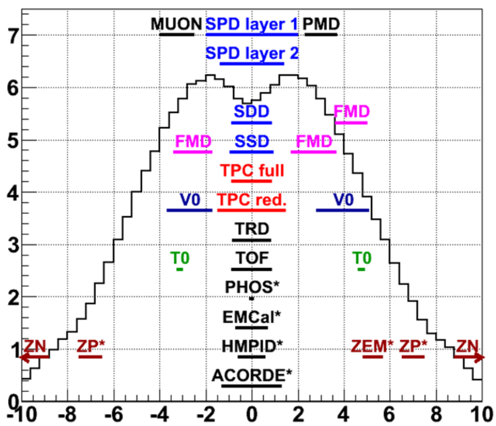

Fig. 1. ALICE components coverage in pseudo-rapidity η.

3. Multiplicity distributions in *pp*

Multiplicities have been measured using the Inner Tracking System (ITS) complemented with the 2 scintillator hodoscope, called VZERO counters. Information from VZERO counters was used for event selection and background rejection. At 0.9 GeV and 7 TeV the minimum bias trigger required a hit in either one of the VZERO counters or in the SPD detector. At 2.36 TeV, VZERO counters were turned off and the trigger required at least one hit in the SPD detector ($|\eta| < 2$). In Fig. 2 we show the multiplicity density for different energies and different event selection compared with data from lower energies (left panel) and the comparison with different model predictions (right panel). It is clearly seen that the increase of the multiplicity with the energy increasing from 0.9 to 7 TeV is significantly larger in the data than in Monte Carlo. Relevant numbers are given in Table I.

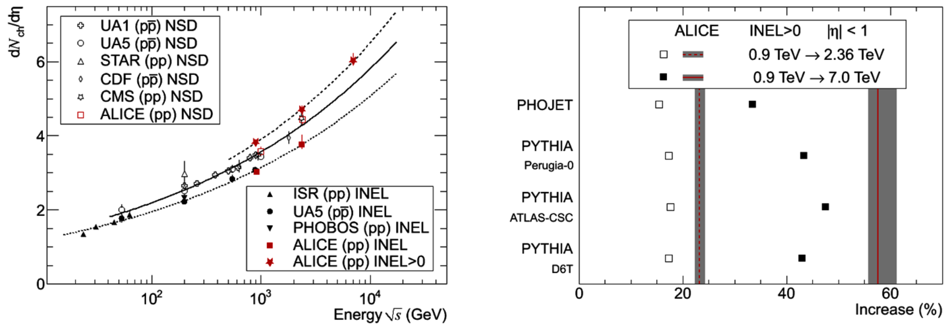

Fig. 2. Multiplicity density in pp for 0.9, 2.36 and 7 TeV, compared with data from lower energies (left panel) and the average multiplicity increase with increasing energy compared with Monte Carlo results (right panel).

TABLE I

Increase of the multiplicity density, compared with Monte Carlo.

$\sqrt{s}$ increase	ALICE (%)	MC (%)
$0.9 \to 2.36$ TeV	23.3 ± 0.4	15–18
$0.9 \to 7$ TeV	57.6 ± 0.4	33–48

4. Charged particles spectra

In this section we discuss longitudinal and transverse spectra of charged particles.

4.1. Pseudo-rapidity distributions at different energies

In Fig. 3 we compare pseudo-rapidity spectra at all three energies and different event selections with different Monte Carlo predictions. As seen, none of models describe our data simultaneously for all energies.

4.2. Transverse momentum distributions of identified particles at $\sqrt{s} = 0.9$ TeV

Transverse momentum spectra at $\sqrt{s} = 0.9$ TeV are shown in Fig 4. They are well described by the Levy function of the form

$$\frac{dN}{dp_{\mathrm{t}}} \propto p_{\mathrm{t}} \left(1 + \frac{\sqrt{m^2 + p_{\mathrm{t}}^2} - m}{nT}\right),$$

where n and T are parameters to be fitted. In Fig. 5 we show preliminary results on strange particles (K^0, Λ, $\Xi + \bar{\Xi}$) and Φ. The transverse momentum distributions are compared with Monte-Carlo predictions. One can see that predictions are well below data, specially for Λ and Ξ and higher p_{t}.

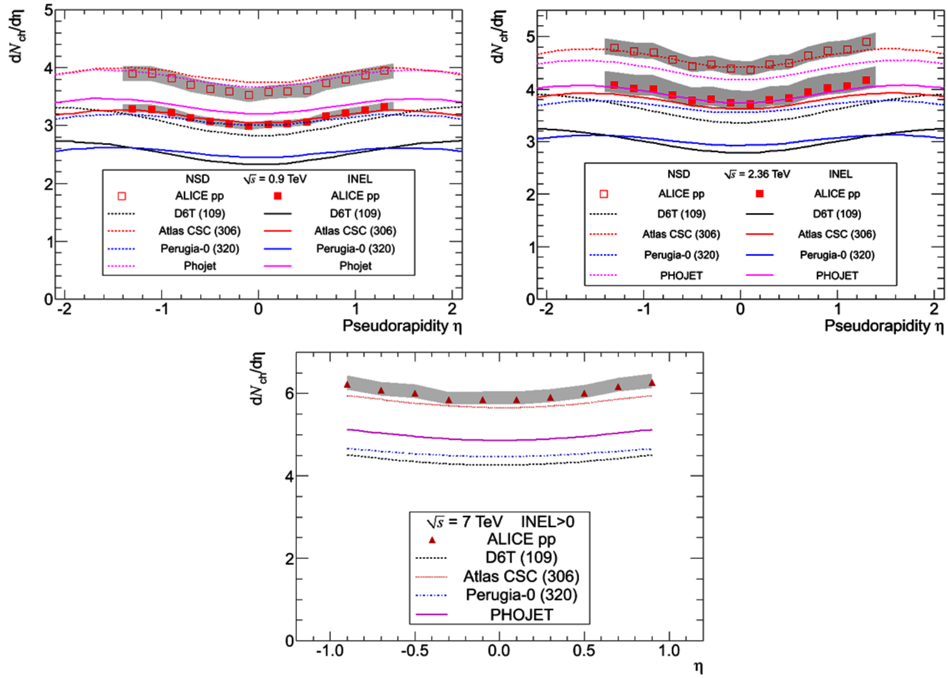

Fig. 3. Pseudo-rapidity distributions of charged particles at $\sqrt{s}$ equal to 0.9, 2.36 and 7 TeV, compared with Monte Carlo.

5. Proton-to-antiproton ratio

The deceleration of the incoming proton, or more precisely of the conserved baryon number associated with the beam particles, is often called *baryon-number transport* and has been debated theoretically for some time. Relevant references one can find in [3]. Experimental data on the $\overline{p}/p$ ratio can provide the information on the baryon-number transport mechanism. Here we present results obtained by the ALICE experiment at $\sqrt{s} = 0.9$ and 7 TeV. For the analysis we selected a very central region at the pseudo-rapidity $|\eta| < 0.5$. The baryon/antibaryon identification was done using the information of their energy losses in the TPC. In Fig. 6 we show the ratio of antiprotons to protons for $\sqrt{s} = 0.9$ and $\sqrt{s} = 7$ TeV, compared with model predictions. This ratio is close to 1 at 7 TeV and within statistical errors does not depend on the transverse momentum. In Fig. 7 ALICE results are compared with other experiments. From both Figs. 6 and 7 it is clearly seen that there is very little room for the additional stopping mechanisms.

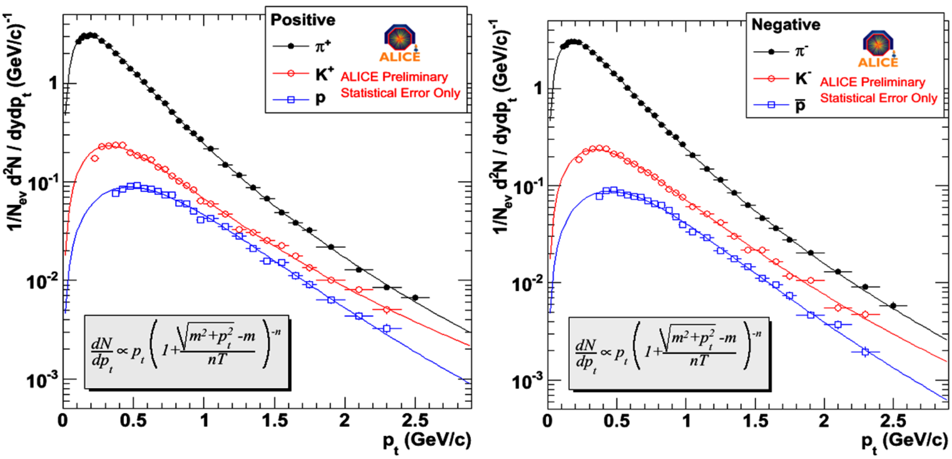

Fig. 4. Transverse momentum distributions for different particle species at $\sqrt{s} = 0.9$ TeV. Lines show the fit with Levy function.

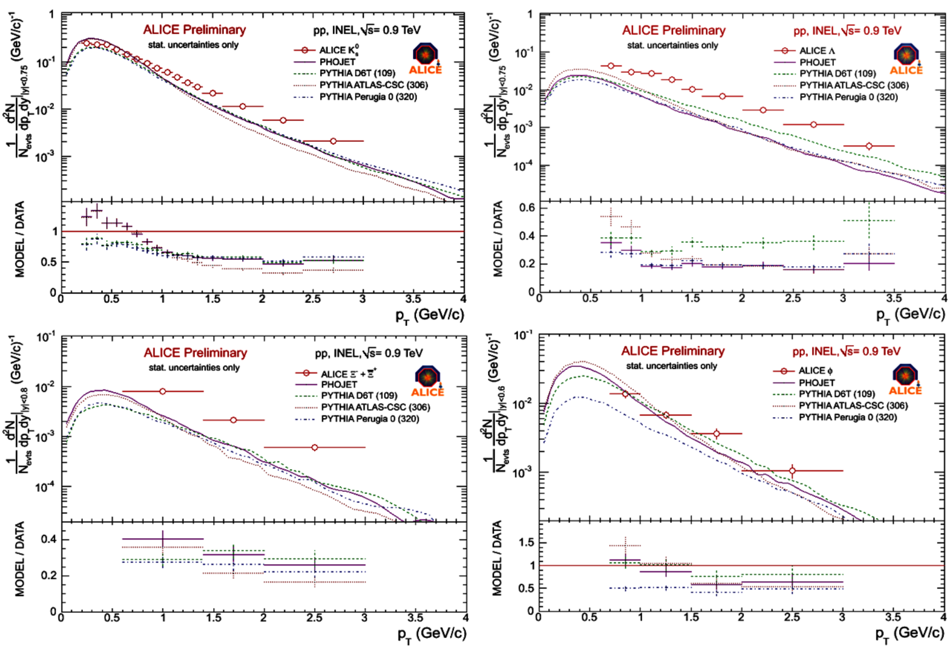

Fig. 5. Transverse momentum distributions for K^0 (upper left), $\mathit{\Lambda}$ (upper right), $\mathit{\Xi}+\bar{\mathit{\Xi}}$ (lower left) and $\mathit{\Phi}$ (lower right).

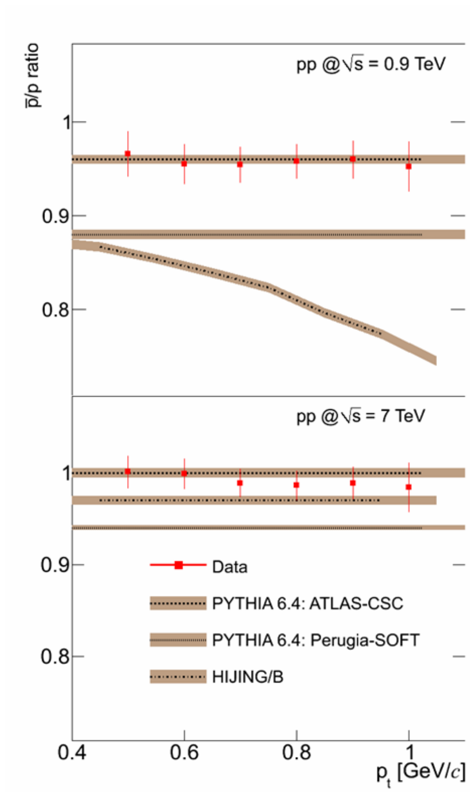

Fig. 6. Antiproton-to-proton ratio at $\sqrt{s} = 0.9$ and $\sqrt{s} = 7$ TeV.

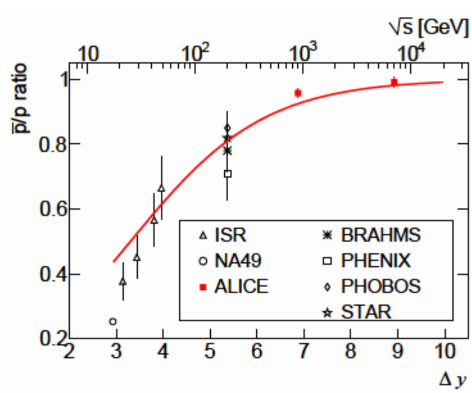

Fig. 7. Antiproton-to-proton ratio as a function of $\sqrt{s}$. It is also presented as a function of the rapidity interval Δy.

6. Pb + Pb collisions at $\sqrt{s} = 2.76$ TeV

During the 2010 heavy-ion run, LHC experiments accumulated significant amount of data. In Fig. 8 the integrated luminosity collected by all experiments is shown. Below some preliminary results from the 2010 heavy-ion run obtained by the ALICE Collaboration are presented.

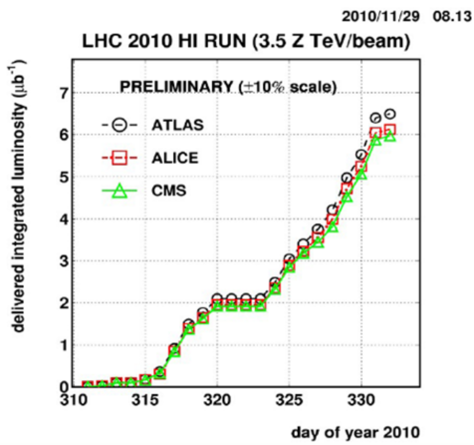

Fig. 8. Integrated luminosity collected in the heavy-ion run.

6.1. Particle density

In Fig. 9 the particle density, compared with existing data and model predictions is shown. It follows the power law, as in other $A+A$ experiments, but puts a strong constraint on some models.

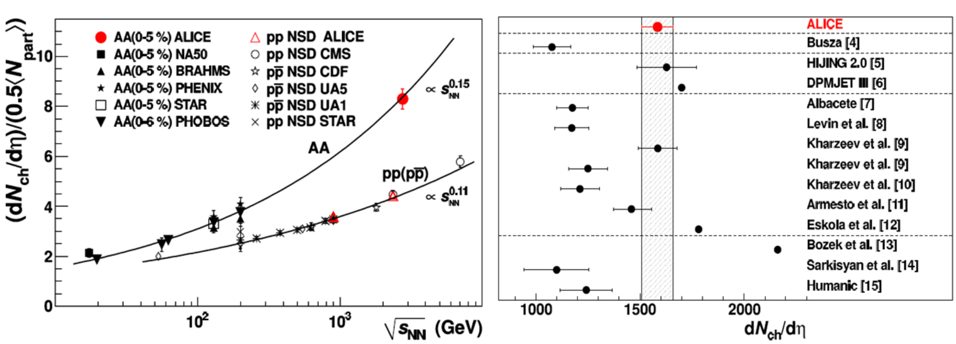

Fig. 9. Particle density as a function of $\sqrt{s}$ (left), compared with model predictions (right).

6.2. Collective effects — flow

These effects are studied by looking at the azimuthal distribution of produced particles in terms of the Fourier expansion

$$E\frac{d^3N}{dp^3} = \frac{1}{2\Pi}\frac{d^3N}{p_{\rm t}dp_{\rm t}dy}\left(1+\sum_1^\infty 2v_n\cos[n(\Phi-\Psi_R)]\right),$$

where $\Phi - \Psi_R$ is the azimuthal angle w.r.t. the reaction plane. The second coefficient v_2 in the above formula describes the so-called elliptic flow. In Fig. 10 ALICE results, together with those from the RHIC experiments are shown. The weak dependence on energy (left panel) and the similar behaviour with the collision centrality as at RHIC (with 30% increase, mainly due to the higher multiplicity, right panel), confirms the creation of the phase which behaves like the low viscosity liquid.

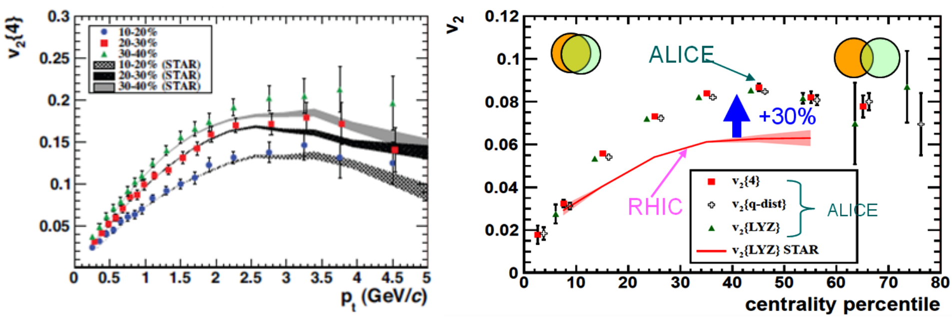

Fig. 10. v_2 dependence as a function of $p_{\rm t}$ for ALICE and STAR experiments (left) and as a function of the collision centrality (right).

6.3. Jet quenching

A quark, moving in the dense and hot quark–gluon matter, can loose its energy, leading to the dilution of a jet. This effect is usually studied using the so-called nuclear modification factor

$$R_{AA} = \frac{d^2N_{AA}/dp_{\rm t}d\eta}{\langle N_{\rm coll}\rangle d^2_{pp}/dp_{\rm t}d\eta},$$

where AA denotes ion–ion collisions and pp the elementary ones. $N_{\rm coll}$ is the number of collisions. In Fig. 11 one can see the effect of the jet suppression as the function of the event centrality and the transverse momentum.

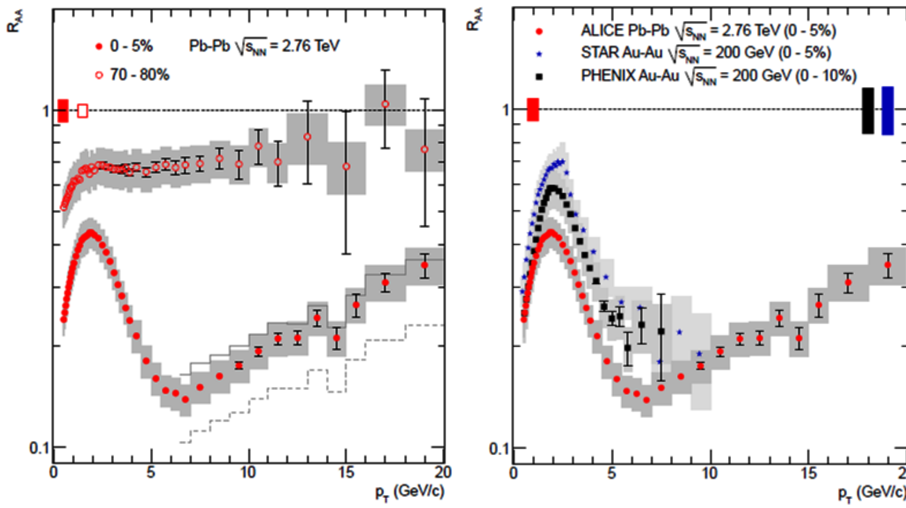

Fig. 11. Nuclear modification factor R_{AA} as a function of the event centrality and p_{t}.

6.4. Strangeness and charm production

Here some preliminary results on the strangeness and charm production are presented. In Fig. 12 the K^0 and Λ widths are shown, indicating the same good detector performance as in *pp* — no resolution deterioration is seen when moving from *pp* to PbPb. In Fig 13 the signal of J/Ψ and D^+ mesons are shown. In Fig. 14 one can see the dependence of the D^0 production on its transverse momentum.

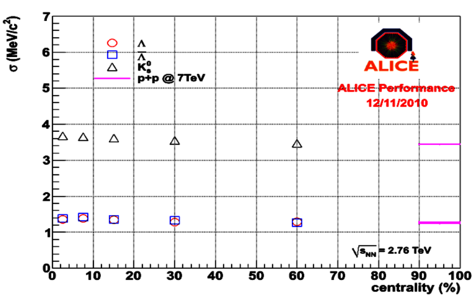

Fig. 12. Width of K^0 and Λ for PbPb and *pp* collisions.

7. Summary

During the 2010 period of data taking ALICE collected the significant sample on *pp* and PbPb collisions. Many valuable results have been obtained, including spectra, collective effects, jet quenching and other. The detector performance is excellent and very close to the design specifications.

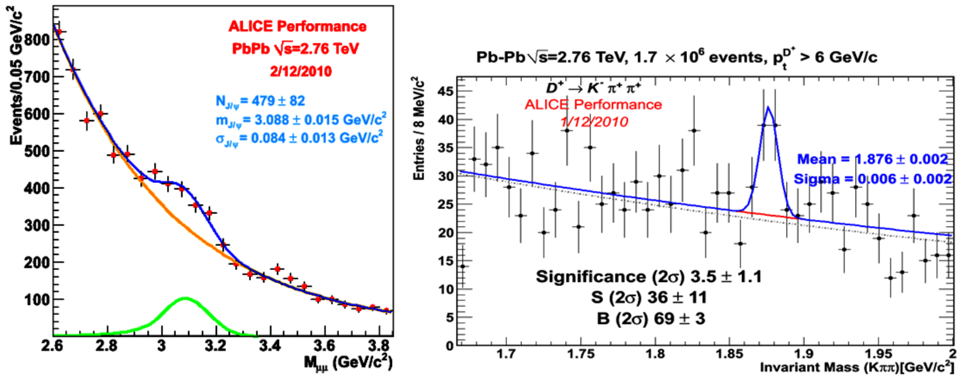

Fig. 13. J/Ψ (left) and D^+ (right) signal.

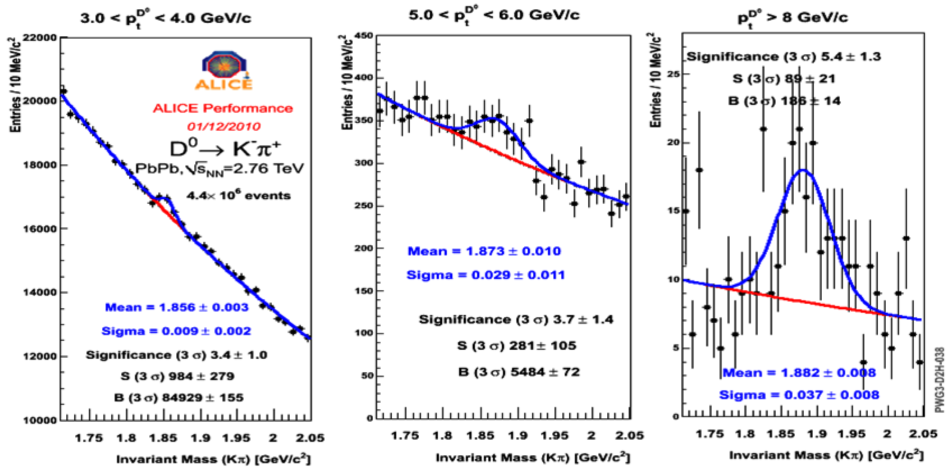

Fig. 14. D^0 production for different p_{t} intervals.

REFERENCES

[1] N. Ahmad *et al.*, "ALICE, Technical Proposal for A Large Ion Collider Experiment at CERN SPS", CERN/LHCC/95-71(1995); G. Dellacasa *et al.*, "ALICE Addendum to the Technical Design Report of the Dimuon Forward Spectrometer", CERN-LHCC-2000-046(2000).

[2] [ALICE Collaboration], *J. Phys. G* **30**, 1517 (2004); *J. Phys. G* **32**, 1295 (2006).

[3] K. Aamodt *et al.*, *Phys. Rev. Lett.* **105**, 072002 (2010).