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Charm production study in p-p and Pb-Pb collisions at the LHC with ALICE

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Summary. — The ALICE experiment at the LHC will study proton-proton and heavy-ion collisions with the aim of investigating the properties of the high-density state of strongly interacting matter, expected to be produced in central Pb-Pb collisions. Open charm mesons are expected to be a powerful probe to investigate this deconfined state of the medium and they will be studied extensively in ALICE. Open charm measurements in p-p collisions is fundamental as a baseline for the interpretation of Pb-Pb results and in order to calculate the charm cross section in a new energy window.

PACS 14.40.Lb – Charmed mesons ($|C| > 0, B = 0$).
PACS 13.85.Ni – Inclusive production with identified hadrons.
PACS 13.30.Eg – Hadronic decays.
PACS 13.25.Ft – Decays of charmed mesons.

1. – Introduction

The main task of the ALICE experiment at LHC is to study high-energy heavy-ion collisions where the Quark Gluon Plasma (QGP) is expected to be formed. An important tool to investigate this high-density and strongly-interacting state of matter are the heavy quarks which are produced early in the interaction and experience all the lifetime of the hot matter. Heavy quarks are in fact produced in a time scale of $\hbar/(2m_Q c^2)$ mostly through gluon fusion, this corresponds to about 0.08 fm/c for charm quark while the formation time of QGP is estimated to be 1 fm/c. The heavy-flavoured mesons bring the information of energy loss suffered by the heavy quark due to the interaction with the medium and they can be crucial in explaining how this energy loss occurs.

In fact, the energy loss mechanism has been observed at RHIC but is not completely understood so far. One of the main sources is radiative in-medium energy loss which depends on the mass and the colour charge of the particle. The radiation is suppressed at small angles for massive partons besause of the "dead cone effect" [1] and is larger for gluons, which have stronger colour charge with respect to quarks, due to the dependence from the Casimir factor. Therefore one should observe a pattern of decreasing suppression when going from the mostly gluon-originated light-flavour hadrons ($h^{\pm}$ or π^0) to the D and then B mesons.

The observable used by the experiments to highlight the medium and nuclear effects is the *nuclear modification factor* $R_{\rm AA}$ defined as follows:

$$R_{\rm AA}(p_T) = \frac{{\rm d}^2N_{\rm AA}/{\rm d}p_T{\rm d}y}{N_{coll}\times {\rm d}^2N_{\rm pp}/{\rm d}p_T{\rm d}y}\,, \tag{1a}$$

where ${\rm d}^2N_{\rm AA(pp)}/{\rm d}p_T{\rm d}y$ is the differential cross section in nucleus-nucleus (p-p) collisions and N_{coll} represents the number of binary collisions. If A-A collisions are a simple superposition of p-p collisions this ratio should be 1. QGP formation is not the only effect which can cause a deviation from unity, therefore nuclear effects must be studied separately with p-A collisions. Moreover, besides constituting a benchmark for Pb-Pb results, p-p collisions are also interesting *per se* since the charm cross section has never been measured at the energies LHC will reach. This will allow a test of pQCD calculations.

2. – ALICE performance

The ALICE experiment is composed of a central barrel of detectors at mid-rapidity and a muon spectrometer at forward rapidity. In the analyses presented in this proceeding a subset of the central barrel detector is used, namely the Inner Tracking System (ITS), the Time Projection Chamber (TPC) and the Time-Of-Flight detector (TOF). The expected p_t resolution is $\sim 1\%$ ($p_t \lesssim 10\,{\rm GeV}/c$), the primary vertex resolution is expected to be $\sim 10\,\mu$m (in Pb-Pb) and the expected resolution on the minimum $r\phi$ distance of the prolonged track with respect to the primary vertex (impact parameter) is $\sim 60\,\mu$m for $p_t \simeq 1\,{\rm GeV}/c$. More details about the detector can be found in [2, 3]. Such performance allows the ALICE experiment to separate secondary verteces at tens of μm and therefore to perform heavy-flavour mesons analysis reconstructing hadronic decays with $c\tau$ in the $100\,\mu$m range. Several analyses are in preparation, such as $D^0 \to K^-\pi^+$, $D^+ \to K^-\pi^+\pi^+$, $D^{*+} \to D^0\pi^+$, $D_s^+ \to K^+K^-\pi^+$, $D^0 \to K^-\pi^+\pi^-\pi^+$ and $\Lambda_c^+ \to K^-\pi^+p$.

The main steps of the analysis are: a) topological criteria to select displaced secondary vertices using the significance maximization; b) subtraction of remaining background with different techniques (fit, like-sign, rotation and mixing); c) correction for feed-down from B; d) correction for efficiencies; e) D cross section.

Figure 1 shows the expected performance for the measurement of the differential cross section with a sample of 10^9 p-p events at $\sqrt{s} = 14\,{\rm TeV}$ compared to calculations and for the $R_{\rm AA}^{\rm D^0}$ with a rather pessimistic assumption on the amount of energy loss.

3. – First look at 900 GeV data

In this section some results of data taken in December 2009 are shown (fig. 2). No visible signal is expected with this sample of 368k p-p events at 900 GeV, but the comparison of background distributions is comparable to the expected Monte Carlo. Some discrepancies in the low-p_t region between data and Pythia tune D6T are evident but expected, since it is known that Pythia under-estimates the multiplicity in this region.

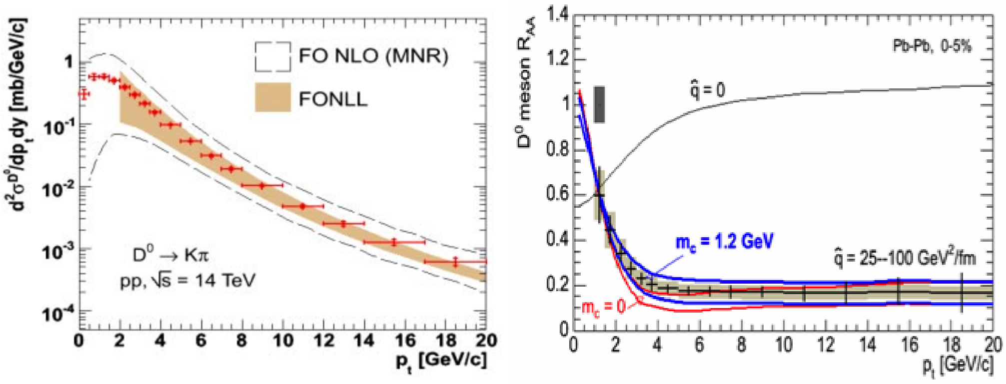

Fig. 1. – Left panel: D^0 differential cross section from simulations compared to MNR [4] and FONLL [5] calculations. Right panel: $R_{AA}^{D^0}$ as a function of p_t.

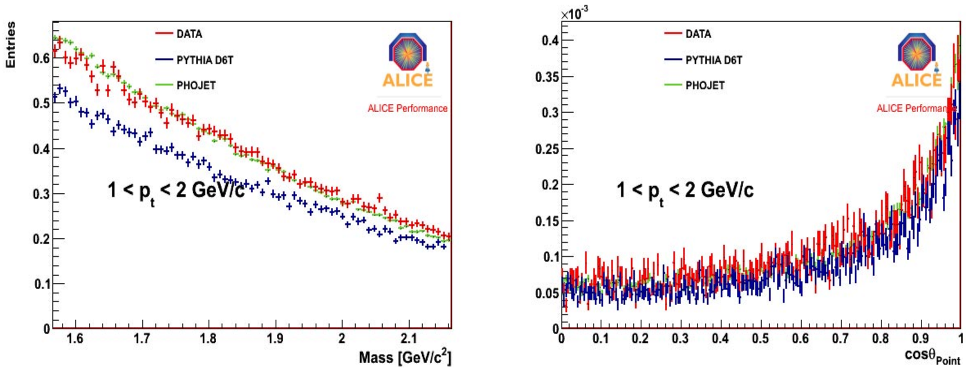

Fig. 2. – (Colour on-line) D^0 invariant mass (left) and cosine of pointing angle (right) for $\approx$ 368k p-p events at 900 GeV in D^0's p_t bin form 1 to 2 GeV/c. Red is the data, blue is the Pythia tune D6T, green is Phojet.

4. – Conclusions

ALICE is well suited to study the QGP in Pb-Pb collisions and to test pQCD predictions in p-p. First comparison between data and Monte Carlo at $\sqrt{s} = 900$ GeV indicates that the analysis procedures and the amount of background are under control. In the coming months more data will be available in proton-proton collisions at 7 TeV. The first Pb-Pb collisions are expected in autumn 2010 at $\sqrt{s_{NN}} = 2.76$ TeV.

REFERENCES

[1] Dokshitzer Yu. L. and Kharzeev D. E., *Phys. Lett. B*, **519** (2001) 199; arXiv:hep-ph/0106202.
[2] The ALICE experiment at CERN LHC, *JINST*, **0803** (2008) S08002.
[3] Carminati F. *et al.* (ALICE Collaboration), *J. Phys. G: Nucl. Part. Phys.*, **30** (2004) 1517.
[4] Mangano M. L., Nason P. and Ridolfi G., *Nucl. Phys. B*, **373** (1992) 295.
[5] Cacciari M. *et al.*, *JHEP*, **0407** (2004) 033.