Soft QCD results from the ALICE experiment

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1 Introduction

ALICE (A Large Ion Collider Experiment) is designed to study Heavy Ion collisions at the LHC (see [1]) and features in the barrel region a very robust tracking based on a large Time Projection Chamber (TPC) and an excellent vertexing provided by an Internal Tracking System (ITS) made of 6 layers of silicon detectors. The material budget up to the outer wall of the TPC (2.5 m) is very low ($\approx 0.11 \cdot X_0$) implying a very low p_t cutoff of 100 MeV/c for pions. Particle identification is provided, for the results shown in the following, by the Time–of–Flight detector in addition to TPC and ITS detectors. More details are given in [1]. In the following, published and preliminary results obtained by ALICE for proton-proton collisions at LHC energies will be presented, covering diffraction and total cross–section, inclusive and identified particle spectra, correlations and fluctuations. Results from the first Pb-Pb run of 2010, for which pp data constitute the necessary baseline, are presented in [2].

2 Diffraction and total cross-section

Using the two–arm VZERO scintillator hodoscope for triggering and the van der Meer scan technique, cross-section have been measured for inelastic pp interaction at 2.76 and 7 TeV energies, see Table 1. The trigger acceptance for inelastic events was about 75% at both energies. In addition the cross section for a reference inelastic process, namely production of at least one charged particle with $|\eta| < 0.8$ and $p_t > 0.5$ GeV/c, has been measured and found in agreement with the results from ATLAS and CMS experiments. Single and double diffractive cross–sections have been measured as well[1].

Energy (TeV)	Process	Cross–section (mb)
2.76	Inelastic	62.1 ± 1.6(model) ± 4.3(lumi)
7.0	Inelastic	72.7 ± 1.1(model) ± 5.1(lumi)
7.0	Inelastic, $N \geq 1$	42.4 ± 2.0

Table 1: Preliminary cross–sections measured by ALICE for various processes.

[1] M. Poghosyan for the ALICE Coll., Proc. Quark Matter 2011, 23–28 May 2011, Annecy, France.

3 Inclusive production, identified particle spectra

Charged particle $dN_{ch}/d\eta$ and multiplicity measured by ALICE in 0.9, 2.36 and 7 TeV pp collisions have been published [3], as well as charged particle p_t spectra at 0.9 TeV [4]. Preliminary p_t spectra at 2.76 and 7 TeV are shown in Fig. 1 (left), extending up to 100 GeV/c for the highest energy. Preliminary p_t spectra for identified π, K and p at midrapidity are shown in Fig. 1 (right), while spectra at 0.9 TeV are available in [5]. A fit with Lévy functions allowed us to estimate the yield and the average transverse momentum of each species with minimal extrapolation; the resulting mean p_t is shown in Fig. 2 (left), a modest increase with $\sqrt{s}$ is seen. Fig. 2 (right) shows the K/π ratio evolution from SPS through RHIC to LHC energies; this ratio is approximately energy–independent between top RHIC energy and 7 TeV.

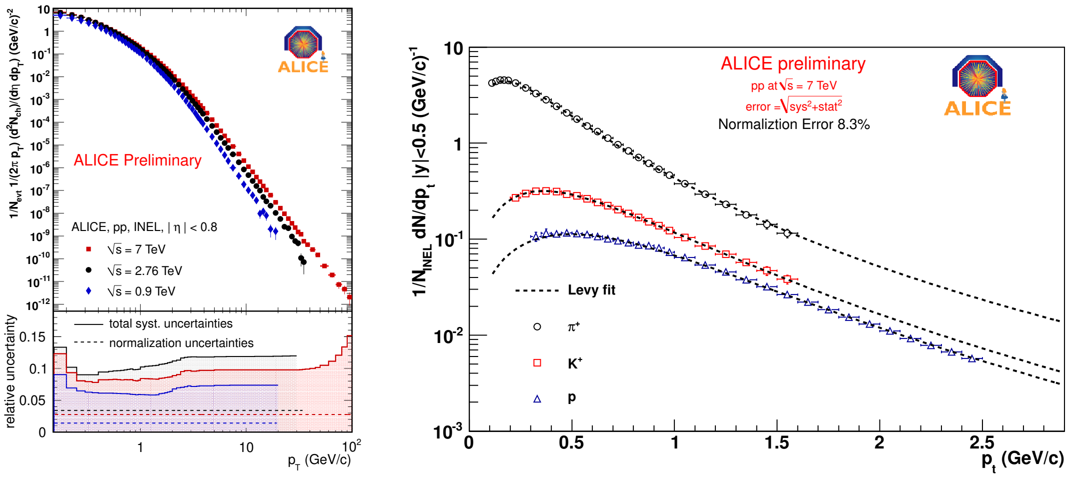

Figure 1: p_t spectra in pp collisions, for charged particles at three energies (left) and for pions, kaons and protons at 7 TeV (right).

ALICE has obtained preliminary spectra for multi–strange hadrons and resonances at 7 TeV, see Fig. 3. For Ω and Ξ[2], the antiparticle/particle ratio measured over a wide p_t range is compatible with unity. The bottom panel of Fig. 3 (left) shows the ratio of ALICE data to the recent Z2 tune of PYTHIA 6, which is seen to underpredict multi-strange baryon production, with only a marginal improvement over the Perugia-0 tune (not shown).

The preliminary spectra of some resonances: ϕ, K^{*0} and Ξ^{*0} are shown in Fig. 3 (right). The ϕ yield agrees with PYTHIA 6 (tune D6T, not shown) up to 2 GeV/c, while for higher p_t a better agreement with PHOJET is found.

[2] The mid–rapidity yield of Ξ measured by ALICE agrees with the one by CMS when one takes into account the different normalization (INEL vs. NSD).

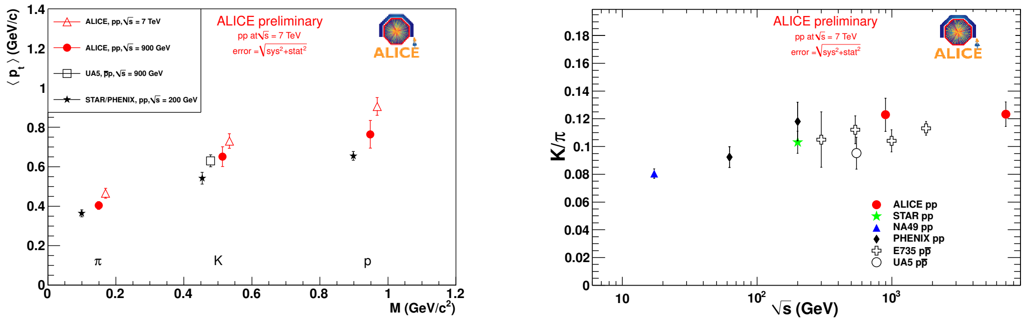

Figure 2: (left) Average transverse momentum of pions, kaons and protons from RHIC to LHC energies; (right) K/π ratio in pp and $\overline{\mathrm{p}}$p collisions vs. energy.

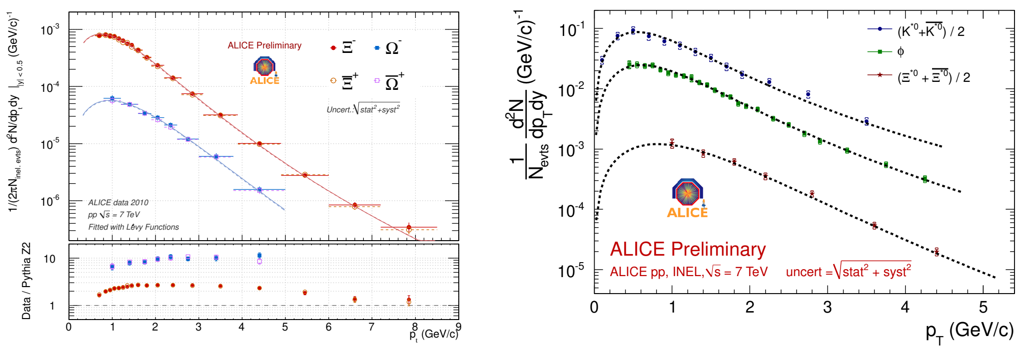

Figure 3: (left) Transverse momentum spectra of Ξ's, Ω's and of the respective antibaryons in pp collisions at 7 TeV; (right) Transverse momentum spectra of some resonances in pp collisions at 7 TeV, with Lévy-Tsallis fits.

4 Correlations and fluctuations

The space–time characteristics of the particle production region have been studied in detail for the first time in pp collisions at 0.9, 2.76 and 7 TeV, as a function of pair transverse momentum k_t and $dN_{ch}/d\eta$, see Fig. 4 (left). The three HBT radii (out, side and long) at different $\sqrt{s}$ are seen to scale vs. $(dN_{ch}/d\eta)^{1/3}$; the side and long radii grow with $dN_{ch}/d\eta$ at all k_t's, while the out radius is flat and even decreasing at high k_t. At high $dN_{ch}/d\eta$, all three radii fall with k_t.

Event–by–event fluctuations of the mean p_t are measured via a two–particle correlator C_m which is zero for statistical fluctuations only; the relative fluctuations in pp collisions at the 3 LHC energies, shown in Fig. 4 (right), show a universal behaviour vs. uncorrected multiplicity, a good baseline for the same study in Pb–Pb collisions.

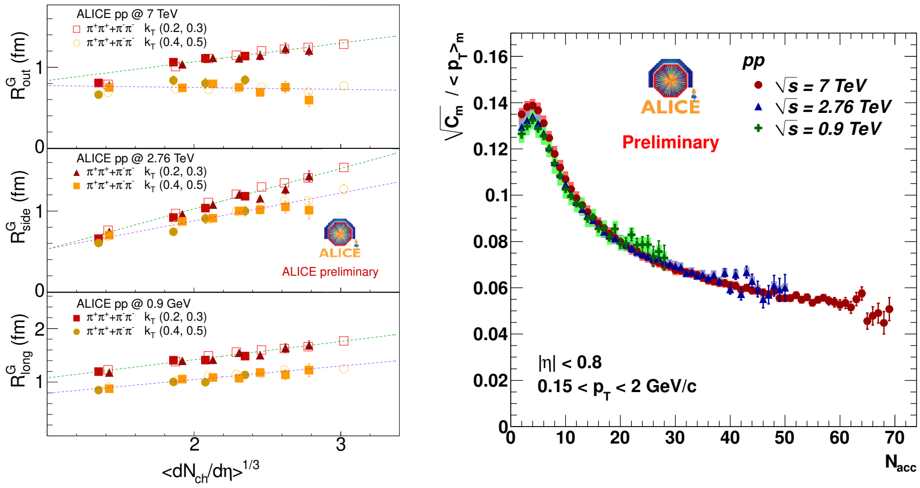

Figure 4: (left) Scaling of HBT radii in pp collisions at 3 different energies vs. $dN_{ch}/d\eta$; (right) Relative mean p_t fluctuations vs. uncorrected multiplicity.

5 Conclusions

A rich pp programme has been developed by ALICE at LHC energies. Inelastic, single and double diffraction cross–sections have been measured. The production of charged particles up to 100 GeV/c and of π, K, p, π^0, η, hyperons, ω, ϕ and resonances up to 5-10 GeV/c has been measured as well. HBT radii vs. k_t and multiplicity, and mean p_t fluctuations vs. multiplicity have been measured at three LHC energies. J/ψ and D meson cross-sections and leptons from charm and beauty decays have been measured [6] both in the barrel and in the forward muon spectrometer. Extensive comparisons with pQCD and MonteCarlo models have beeen performed. Finally, a solid baseline for the study of Pb-Pb collisions at LHC has been established.

References

[1] J. Wessels, these Proceedings.

[2] A. Morsch, these Proceedings.

[3] K. Aamodt *et al.*, ALICE Coll., Eur. Phys. J. **C 68**, 89 (2010) and 345 (2010).

[4] K. Aamodt *et al.*, ALICE Collaboration, Phys. Lett. **B 693**, 53 (2010).

[5] K. Aamodt *et al.*, ALICE Collaboration, Eur. Phys. J. **C 71**, 1655 (2011).

[6] C. Hadjidakis, these Proceedings; D. Caffarri, these Proceedings.