IL NUOVO CIMENTO Vol. 36 C, N. 1 Gennaio-Febbraio 2013
DOI 10.1393/ncc/i2013-11413-x

Colloquia: IFAE 2012

Vector meson production in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$ measured with the ALICE detector

E. A. R. Casula
Università di Cagliari and INFN, Sezione di Cagliari - Cagliari, Italy

ricevuto il 31 Agosto 2012

Summary. — Vector mesons are key probes of the hot and dense state of strongly interacting matter produced in heavy-ion collisions. Their dileptonic decay channel is particularly suitable for these studies, since dileptons have negligible final-state interactions in QCD matter. A measurement of the ϕ and ω differential cross sections was performed by the ALICE experiment in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$, through their decay in muon pairs, for $p_T > 1\,\mathrm{GeV}/c$ and $2.5 < y < 4$.

PACS 14.40.-n – Mesons.
PACS 25.75.Dw – Particle and resonance production.
PACS 24.85.+p – Quarks, gluons, and QCD in nuclear reactions.

1. – Introduction

Low-mass meson (ρ, ω, ϕ) production provides key information on the hot and dense state of strongly interacting matter produced in high-energy heavy-ion collisions. Among them, strangeness enhancement can be accessed through the measurement of ϕ-meson production, while the measurement of the ρ spectral function can be used to reveal in-medium modifications of hadron properties close to the QCD phase boundary [1]. Vector meson production in pp collisions provides a reference for these studies. Moreover, it is interesting by itself, since it can be used to tune particle production models at the LHC energy range.

We analyzed the vector mesons [2] produced in the rapidity range $2.5 < y < 4$ at the ALICE experiment [3] and detected through their decays in muons pairs.

The ALICE muon spectrometer is composed of a front hadron absorber, a set of cathod pad chambers (five stations, each one composed of two chambers) for the track reconstruction in a dipole field, two stations of two resistive plate chambers (RPC) for the muon trigger, two absorbers and an iron wall acting as a muon filter. The muon trigger is fired when at least three of the four RPC planes give a signal compatible with a tracklet in the muon trigger system. A minimum bias trigger, based on a set of forward scintillators and on a silicon pixel detector placed in the vertex region, was also used.

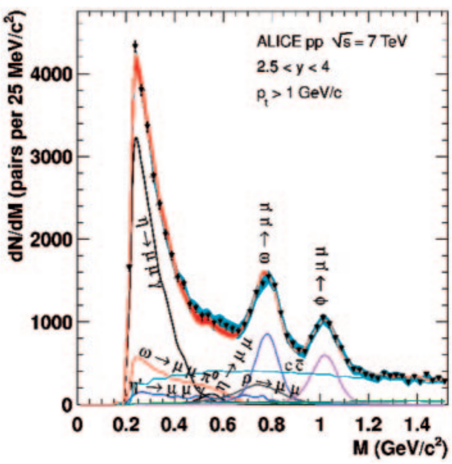

Fig. 1. – Fit to the dimuon invariant mass spectrum for $p_T > 1\,\mathrm{GeV}/c$. Blue band: systematic uncertainty from background subtraction. Red band: uncertainty in the relative normalization of the sources.

2. – Data analysis

Data were collected in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$ during the 2010 LHC run.

Muon tracks were selected asking that the tracks reconstructed in the tracking stations matched the ones in the trigger chambers and that their rapidity was in the range $2.5 < y_\mu < 4$. Muon pairs were selected requiring that the dimuon rapidity were inside the interval $2.5 < y_{\mu\mu} < 4$.

The combinatorial background in the opposite sign dimuon mass spectrum was subtracted using the event mixing technique.

The mass spectrum, shown in fig. 1, was described as a superposition of light meson decays to muon pairs, with an additional contribution coming from charm and beauty semi-muonic decays. The numbers of ϕ ($N_\phi = 3200\pm150$) and $\rho+\omega$ ($N_{\rho+\omega} = 6830\pm150$) were extracted through the fit of the dimuon invariant mass spectrum.

The cross section was extracted from a sample corresponding to an integrated luminosity $L_{\mathrm{INT}} = 55.7\,\mathrm{nb}^{-1}$, through the formula $\sigma_\phi = \frac{N_\phi^c}{BR(\phi\to\mu^+\mu^-)}\frac{\sigma_{MB}}{N_{MB}}\frac{N_\mu^{MB}}{N_\mu^{\mu-MB}}$, where N_ϕ^c is the measured number of ϕ mesons corrected for efficiency and acceptance, N_{MB} is the number of minimum bias collisions, $\sigma_{MB} = 62.3 \pm 0.4(\mathrm{stat}) \pm 4.3(\mathrm{syst})\,\mathrm{mb}$ is the minimum bias cross section in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$ [4], N_μ^{MB} is the number of single muons in the region $2.5 < y_\mu < 4$ and $p_{T_\mu} > 1\,\mathrm{GeV}/c$, collected with the minimum bias trigger, and $N_\mu^{\mu-MB}$ is the number of muons in the same region collected with the muon trigger.

We obtained $\sigma_\phi(2.5 < y < 4, 1 < p_T < 5\,\mathrm{GeV}/c) = 0.940 \pm 0.084(\mathrm{stat}) \pm 0.078(\mathrm{syst})\,\mathrm{mb}$ [2].

The systematic uncertainty comes from the uncertainty on the background subtraction (2%), the muon trigger efficiency (4%), the tracking efficiency (3%), the uncertainty on the luminosity (5%), the uncertainty on the ϕ branching ratio into dileptons (1%) and the uncertainty due to acceptance correction (2%).

In fig. 2, left side, the p_T-differential cross section $\mathrm{d}^2\sigma_\phi/\mathrm{d}p_T\mathrm{d}y$ is shown (black triangles). Point to point uncorrelated systematic uncertainties are indicated as red boxes.

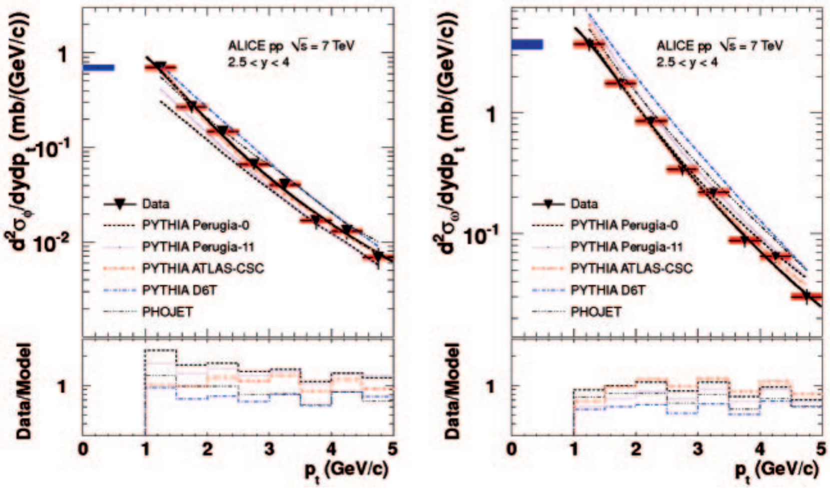

Fig. 2. – ϕ (left) and ω (right) differential cross sections compared with PHOJET and PYTHIA with several tunes.

The fully correlated systematic uncertainty, represented by a blue box on the left side of the plot, amounts to 9%. A fit to the differential cross section with a power law, $C \cdot \frac{p_T}{[1+(p_T/p_0)^2]^n}$, gives $p_0 = 1.16 \pm 0.23\,\mathrm{GeV}/c$ and $n = 2.7 \pm 0.2$.

Data are here compared with some commonly used models as PHOJET [5] and PYTHIA [6] (Perugia-0 [7], Perugia-11 [8], ATLAS-CSC [9] and D6T [10]): PYTHIA Perugia-0 and PYTHIA Perugia-11 underestimate the data, while the others are in agreement.

In fig. 2, right side, the p_T-differential cross section $\mathrm{d}^2\sigma_\omega/\mathrm{d}p_T\mathrm{d}y$ is shown (black triangles). The fit to the differential cross section with the same power law gives in this case $p_0 = 1.44 \pm 0.09\,\mathrm{GeV}/c$ and $n = 3.2 \pm 0.1$.

Comparison with the models shows that PYTHIA tunes reproduce the data, while PHOJET overestimates them.

In conclusion, both integrated and p_T-differential cross sections of ϕ and ω were measured in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$. In Pb-Pb collisions work is in progress to measure ϕ production as a function of centrality.

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