PROCEEDINGS OF SCIENCE

Charmonia and beauty production measurements with J/ψ events at LHCb

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We report on the possibilities of measuring charmonia and beauty production with the LHCb experiment. Using J/ψ reconstructed from $\mu^+\mu^-$ pairs, both the prompt J/ψ and the $b \to$J/ψ production cross-sections in p-p collisions at LHC energies will be determined in a pseudorapidity range of 2 to 5. Due to the very large statistics, this analysis will be possible very soon after the LHC start. Other charmonia related measurements will also be discussed, such as that of the J/ψ polarization at production or of the production of some of the new X, Y and Z states.

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1. Introduction

LHCb [1] is an experiment at the LHC (Large Hadron Collider) dedicated to precise measurements of CP violating and rare decays of b-hadrons. LHCb will operate at a luminosity of 2×10^{32} cm^{-2}s^{-1} exploiting the high number of $b\overline{b}$ pairs produced by the LHC p-p collisions: the expected number of $b\overline{b}$ pairs produced at the LHCb interaction point is $N_{b\overline{b}} \approx 10^{12}$/year. Characterized by a unique angular aperture, LHCb will explore the large pseudorapidity range: $2 < \eta < 5$.
The detector is fully installed and commissioned, and waiting for data taking at the end of 2009.
Very soon, after the LHC start, large J/$\psi\rightarrow\mu^+\mu^-$ samples will be collected by the muon trigger. These samples will allow to study both the prompt and non-prompt J/ψ production. The charmonium production mechanisms are not yet well understood. Although the prompt cross-sections measured at the Tevatron [2] are predicted by the so-called Non-Relativistic QCD theories by the introduction of the Color Octet Model, the same theories fail dramatically in the prediction of the polarization [3]. Other models have been proposed but further measurements and studies are still needed to clarify the situation.

2. J/ψ selection

Selection studies have been performed using the LHCb simulation software based on Pythia and Geant4.
In order to select J/ψ, we form pairs of oppositely charged good quality tracks identified as muons [4]. To reduce the combinatorial background the cut on the transverse momenta of the two muons, $P_t^{\mu^+}\times P_t^{\mu^-}$>$10^6$ (MeV/c)^2 is imposed, as well as the cut on the chi-squared of the vertex fit, χ^2<10, for a good vertexing quality. A mass window cut of 400 MeV/c^2 around the J/ψ mass is applied to retain enough sideband events in order to account for the background. The figure 1 (left plot) shows the dimuon invariant mass fitted with a gaussian (signal) and an exponential (background): a signal mass resolution of $\sigma = 12$ MeV/c^2 is obtained with a signal over background ratio of $S/B = 3.3$.
To separate the prompt J/ψ from the non-prompt ones, the *pseudo* proper time variable

$$t = (dz \times m^{J/\psi})/P_z^{J/\psi} \tag{2.1}$$

is used, dz being the flight distance projected along the beam axis. The figure 1 (right plot) shows the t distribution: the prompt(non-prompt) signal is represented by a gaussian peaked at zero(an exponential curve). Since the non-prompt J/ψ's are predominantly coming from the b-hadron decays, the b-quark cross-section can be obtained from the non-prompt component.

3. J/ψ cross-section measurement

The measurement of the prompt cross-section will be performed in bins of η and P_t. Monte Carlo will be largely used to correct, in each bin, for the detector acceptance and efficiency due to the reconstruction, the trigger and the offline selection. Since a very high event rate of about 18 k J/$\psi \rightarrow \mu^+\mu^-$ per nb^{-1} (that corresponds to 5 s running machine) is expected, the statistic error will be soon reduced. On the other hand systematic errors can arise from (i) the knowledge of the integrated luminosity, (ii) the modelling of the acceptance and the efficiencies in the Monte Carlo,

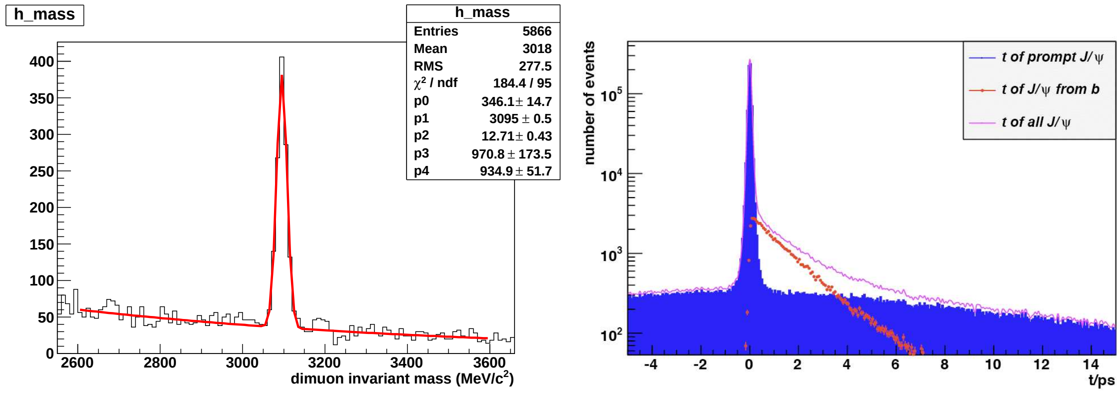

Figure 1: (Left) Dimuon invariant mass distribution fitted with a gaussian (signal) and an exponential (background). (Right) Distribution of the *pseudo* proper time for the selected J/ψ's.

(iii) the uncertainty in b-fraction and (iv) the uncertainties on the branching ratios. The simulations show that the acceptance and the efficiency depend on the J/ψ polarization and that assuming no polarized mesons leads to a systematic error on the measured cross-section up to 25%. This means that the measurement of the cross-section cannot be performed ignoring the polarization.

4. Other charmonium studies

A large number of $\psi(2S)$ will also be collected at LHCb: from 2 to 4 % of the J/ψ's. The $\psi(2S)$ state can be selected using the same offline selection as J/ψ, with a ratio $S/B \approx$1.5. Since their mass difference is very small, most of the systematic errors are cancelled in the ratio $R_\psi = \sigma_{\psi'}/\sigma_\psi$.

Another important measurement, that will help to distinguish between different models, is the ratio $\sigma_{\chi_{c2}}/\sigma_{\chi_{c1}}$. Such a measurement will be possible at LHCb reconstructing the exclusive radiative decays $\chi_{c1,2} \to$J/$\psi\gamma$.

The observation of the new exotic states X, Y and Z will also be possible and in particular the possibility of measuring the X(3872) J^{PC} quantum numbers is being evaluated.

References

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