ID de Contribution: **35** Type: **Talk**

Charmonium production using decays to hadronic final states at LHCb

lundi 28 mai 2018 12:45 (20 minutes)

Non Relativistic QCD (NRQCD) provides so far the most successful framework to describe the production of the $J^{PC} = 1^{--}$ quarkonium states. However, a comprehensive description of the production and polarisation of the J/ψ state at Tevatron and LHC in the complete p_T and rapidity range remains a challenge. The heavy quark spin symmetry yields direct links between the long distance matrix elements describing hadroproduction of different charmonium states. The production of linked charmonium states - η_c and J/ψ, $\eta_c(2S)$ and $\psi(2S)$, and the three χ_c states - can thus be described simultaneously.
Experimentally the production of non-1^{--} charmonium states can be studied by reconstructing their decays to fully hadronic final states. The LHCb measurement of the $\eta_c(1S)$ prompt production and production in inclusive b-hadron decays via the decay $\eta_c(1S) \to p\bar{p}$ is discussed together with its strong impact on NRQCD-based theory models. Recent LHCb measurement of the χ_c and $\eta_c(2S)$ states production in inclusive b-hadron decays using their decays to $\phi\phi$ is also presented; the discrepancy with existing theoretical prediction is demonstrated. Prospects of measuring prompt $\eta_c(2S)$ production at the LHCb using 2018 data is discussed.

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Classification de Session: Hadronic and Particle Physics - 1