Master 2 training - (Feb. - June 2023)

Measurement of inclusive quarkonium production in pp collisions at $\sqrt{s} = 13.6$ TeV with ALICE

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Quarkonia are bound states of either a charm and anti-charm quark pair (charmonia, e.g. J/ψ, χ_c and ψ(2S)) or a bottom and anti-bottom quark pair (bottomonia, e.g. Υ(1S), Υ(2S), χ_b and Υ(3S)). While the production of the heavy quark pairs in pp collisions is relatively well understood in the context of perturbative QCD calculations [1, 2, 3], their binding into quarkonium states is inherently a non-perturbative process and the understanding of their production in hadronic collisions remains unsatisfactory despite the availability of large amounts of data and the considerable theoretical progress made in recent years [4]. For instance none of the models are able to describe simultaneously different aspects of quarkonium production such as polarization, transverse momentum and energy dependence of the cross sections.

A Large Ion Collider Experiment (ALICE) [5] is one of the four major experiments based at the Large Hadron Collider (LHC). The LHC has started to operate the RUN3 campaign this year with a new energy ($\sqrt{s}$) record for pp collisions : 13.6 TeV.

This research training aims to first reconstruct quarkonia decaying into two muons using the ALICE Muon Spectrometer (located at forward rapidity) with RUN3 pp data at $\sqrt{s} = 13.6$ TeV. Quarkonia signal extraction as well as the estimation of the associated systematic uncertainties will be completed in this first part. In a second step, a preliminary quarkonia production cross section will be estimated by means of a realistic simulation of the detector. This, compared to cross section measurement made at different pp collisions energies will allow to discuss the production cross section as function of the collision energy.

The work will be developed by using C++ programmable language under the new software developed in ALICE for the analysis of LHC RUN3 data (O^2 [6]). A good knowledge of C ++ is required and knowledge of Root [7] is an advantage.

References

[1] M. Cacciari, M. Greco, and P. Nason, *J. High Energy Phys.* **9805** (1998) 007, arXiv:9803400 [hep-ph].

[2] M. Cacciari, S. Frixione, and P. Nason, *J. High Energy Phys.* **0103** (2001) 006, arXiv:0102134 [hep-ph].

[3] M. Cacciari *et al.*, *J. High Energy Phys.* **1210** (2012) 137, arXiv:1205.6344 [hep-ph].

[4] N. Brambilla *et al.*, *Eur. Phys. J. C* **71** (2011) 1534, arXiv:1010.5827 [hep-ph].

[5] K. Aamodt *et al.* (ALICE), *JINST* **3** (2008) S08002.

[6] https://github.com/AliceO2Group/O2Physics

[7] https://root.cern/install/