Master 2 Training
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Study of Υ ($b\bar{b}$) production rate in proton-proton collisions at 13 TeV at LHC with the ALICE experiment.

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Quarkonia are mesons composed of a quark and an antiquark of the same flavor, charm (c) or beauty (b). Their ground states are the J/Ψ ($c\bar{c}$) and the Υ ($b\bar{b}$). Quarkonia can be produced in hadron collisions at high energy, especially in the proton-proton (pp) collisions occurring at the Large Hadron Collider (LHC[1]) at CERN. Their production mechanisms are not completely understood. Different models exist [1], but none is currently able to reproduce in the same formalism the existing measurements associated to these particles.

ALICE (A Large Ion Collider Experiment) is one of four major experiments installed at the LHC. It is mainly dedicated to the study of the behavior of matter produced in heavy-ion collisions. According to Quantum ChromoDynamics, the theory of the strong interaction, when the temperature and/or the baryon density reached in a collision are sufficiently high, a quark-gluon plasma (QGP) can be produced. Quarkonia are one of the most relevant probes used to characterize the properties of the QGP, their production rate being modified by the presence of the hot and dense medium formed in the collisions [2]. Understanding measurements in heavy-ion collisions (Pb-Pb at LHC) requires prior knowledge of pp collisions. ALICE is equipped with a forward muon spectrometer [3] which allows to measure quarkonia in their di-muon (2 muons) decay mode.

In 2015, the LHC entered in a new exploitation phase, RUN II, with the higher energy ever reached in the center of mass of the collision, √s = 13 TeV, for pp collisions. Measurement of Υ production rate at this unprecedented energy, and estimation of its cross section, is essential to better understand its production mechanisms and to study the QGP. A first measurement has been performed by the LHCb experiment [4].

The aim of this training is to study the Υ production rate in pp collisions at 13 TeV with the goal of extracting the Υ production cross section from the ALICE experiment. A preliminary study was done based on 2015 recorded data, the trainee will take advantage of additional data recorded in 2016 and 2017. He/She will extract the Υ signal by studying opposite sign muon pairs, possibly as a function of rapidity and transverse momentum. A part of the training can be devoted to the study of systematic uncertainties and/or correction of detector acceptance and efficiency. The study will be performed with AliRoot (the official software of the ALICE experiment derived from Root). A good knowledge of C ++ is required. Knowledge of Root is an advantage. The trainee will have the opportunity to present his work during the meetings of the collaboration.

The ALICE Collaboration is composed of more than 1500 physicists from all continents. The ALICE-Clermont group is currently composed by 7 (teacher)-researchers and 3 PhD students. The ALICE-Clermont group has a long-standing experience in the development, maintenance and operation of the ALICE muon spectrometer. The trainee will work in collaboration with members of the group currently working on Υ in pp collisions.

[1] The LHC is the world's largest and most powerful particle collider. It lies in a tunnel 27 kilometers in circumference, as deep as 175 meters beneath the France–Switzerland border near Geneva, Switzerland.

[1] N. Brambilla *et al.*, Eur. Phys. J. C71, 1534 (2011) http://arxiv.org/abs/1010.5827;
J.P. Lansberg, Eur. Phys. J. C61, 693 (2009) http://arxiv.org/abs/0811.4005.

[2] T. Matsui, Phys. Lett. B178, 416 (1986) http://www.ph.utexas.edu/~cmarkert/matsui.pdf

[3] K. Aamodt *et al.* (ALICE Collaboration), JINST 3, S08002 (2008)
http://iopscience.iop.org/article/10.1088/1748-0221/3/08/S08002/pdf

[4] R. Aiij et al. (LHCb Collaboration) JHEP 07(2018)134 https://arxiv.org/abs/1804.09214