Opening of a PhD position at the Laboratoire de Physique Corpusculaire (LPC).

Title of the thesis: Study of quarkonium production J/Ψ, Ψ' ($c\bar{c}$) and ϒ ($b\bar{b}$) as a function of charged-particle multiplicity in proton-proton collisions at 13 TeV with the CERN-LHC ALICE experiment.

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Deadline for application: 31th of May 2016

Summary:

Quarkonia are mesons composed of a quark and an antiquark of the same flavour, 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 high-energy collisions, in particular in the ones delivered at the Large Hadron Collider (LHC) at CERN: proton-proton (pp), proton-Lead (Pb-Pb) and Lead-Lead (Pb-Pb). Their production mechanisms are not completely understood. Different models are available [1], but none of them is currently able to reproduce in the same formalism the existing measurements. In pp collisions, quarkonia are produced in association with other particles, including charged particles. These particles can be produced directly with quarkonium production or from other interactions occurring in pp collisions. Theses interactions are named Multi-Parton Interactions (MPI) [2]. It appears necessary to propose new measurements to probe the production of quarkonia at elementary level like quarkonium production as a function of the multiplicity of charged particles and compared them with theoretical models [3].

One of the physics case of LHC is the study of heavy-ion collisions, as lead-lead. In these collisions, when the temperature and / or the energy density reached in a collision are sufficiently high, the Quark-Gluon Plasma (QGP) can be produced [4]. A full understanding of measurements in Pb-Pb collisions requires studying corresponding measurements in pp collisions. During the first LHC run (2010-2013), surprising results were found in pp and p-Pb collisions at very high charged-particle multiplicities [5]. In these collisions, the number of charged particles produced is close to that produced in semi-central heavy-ion collisions at lower energies. Physics mechanisms responsible for very high multiplicity pp collisions are for the moment not well understood, MPI being a good candidate. The study of quarkonia production as a function of charged-particle multiplicity will allow studying those mechanisms.

First measurement, based on pp data at 7 TeV, showed a linear dependence of the production rate of J/Ψ as a function of multiplicity in two domains in rapidity (central and forward) [6]. A deviation is observed at high multiplicity for D mesons and J/Ψ from B mesons at mid-rapidity [7]. The CMS experiment published the measurement of the ϒ yield as a function of charged-particle multiplicity in pp collisions at 2.76 TeV that shows a different behavior for the three ϒ states.

The LHC is the biggest particle accelerator at work. It is located in a 27 km tunnel at a hundred meter underground at the France-Switzerland border at CERN. The ALICE (A Large Ion Collider Experiment) experiment is one of four major experiments installed at the LHC. The ALICE Collaboration is composed of more than 1550 physicists from all continents. ALICE is equipped with a forward muon spectrometer (2-9 degrees) for quarkonium measurements. Quarkonia are measured via their decay mode in di-muons (2 muons). Charged particles are measured in the central rapidity region.

The aim of the thesis is to study the production rate of quarkonia J/Ψ, Ψ' ($c\bar{c}$) and ϒ ($b\bar{b}$) as a function of the number of charged particles in pp collisions at 13 TeV with the ALICE experiment. The PhD student will extract J/Ψ, Ψ' and ϒ signals from experimental data by fitting invariant di-muon mass spectra in different charged-particle bins. He/she will discuss the obtained results and compare them to existing measurements and theoretical predictions. The study will be performed with AliRoot (the official software of the ALICE experiment derived from Root). A good knowledge of C++ and ROOT is required. The student will work in the ALICE-Clermont group of the Laboratoire de Physique Corpusculaire (LPC) which is currently composed of 9 researchers and teacher researchers with a leading role in the development, maintenance and operation of the ALICE muon spectrometer. The LPC is a mixed unit of research with CNRS and University Clermont-Auvergne (previously University Blaise Pascal) implied in three of the four LHC experiments. The student will participate to data taking and will be in charge of a service task. Results will be presented in collaboration meetings and international conferences and/or workshops.

The PhD program in France is three years and under a contract of employment. The position is part of the fundamental science doctoral school “Ecole doctorale des Sciences Fondamentales” of the University Clermont-Auvergne, which provides a training program. The starting date is fall 2016.

Interested candidates should contact Valérie Ramillien and Sarah Porteboeuf-Houssais (supervisors). Deadline for application is on 31th of May 2016. Application can be sent by email to the supervisors. Full applications contain a Curriculum Vitae with a brief description of their research experience, a motivation letter and a receipt of the marks and grads obtained at the bachelor and master levels. They should also provide at least two letters of recommendation, sent directly by email to the supervisors. Non full application will not be considered. Potential candidates will be contacted for an interview (possibly by videoconference) in the first two weeks of June.

[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. Sjostrand and M. van Zijl, Phys. Rev. D 36 (1987) 2019 http://ccdb5fs.kek.jp/cgi-bin/img/allpdf?198704341
P. Bartalini, (ed.) and L. Fano, (ed.), http://arxiv.org/abs/1003.4220
[3] S. Porteboeuf and R. Granier de Cassagnac, Nucl. Phys. Proc. Suppl. 214 (2011) 181 561 http://arxiv.org/abs/1012.0719
[4] T. Matsui, Phys. Lett. B178, 416 (1986) http://www.ph.utexas.edu/~cmarkert/matsui.pdf
[5] A. Andronic *et al.* submitted to Eur. Phys. J. C http://arxiv.org/abs/1506.03981
[6] B. Abelev *et al.* [ALICE Collaboration], Phys. Lett. B 712, 165 (2012) http://arxiv.org/abs/1202.2816
[7] J. Adam *et al*. [ALICE Collaboration], JHEP 1509 (2015) 148 http://arxiv.org/abs/1505.00664
[8] S. Chatrchyan *et al.* [CMS Collaboration], JHEP, vol. 04, p. 103, 2014 http://arxiv.org/abs/1312.6300