PhD thesis subject proposal 2023

Title

Characterizing the color screening mechanism of the Quantum Chromodynamics with the LHCb experiment

Laboratory/research team

Laboratoire Leprince-Ringuet, École polytechnique / LHCb heavy ions

Local team

Experimentalists: Heavy ions
Oscar Boente Garcia (postdoc), Frédéric Fleuret (DR, CNRS), Chenxi Gu (postdoc, starting 2023), Kara Mattioli (postdoc), Émilie Maurice (Assistant Professor, École polytechnique), Gabriel Ricart (PhD student, CEA)

Luminosity
Vlasdislav Balagura (LLR, CNRS), Rita Sadek (postdoc)

Research project

Quark Gluon Plasma, QGP, is the deconfined state of matter, where the elementary constituents of matter, quarks and gluons, move freely, as opposed to the ordinary nuclear matter. This state of matter, anticipated by Quantum Chromodynamics theory (QCD), contains fundamental properties of quark-gluon interaction. Even if discovered 20 years ago, this deconfined state of matter remains an open and promising field of research.

Charmonia[1] melting as a probe of the color screening mechanism occurring inside a QGP, has been predicted 30 years ago but never been fully proven. The sequential melting of the first charmonia states, J/ψ, ψ(2S) and χ_c, will give precise measurement of the medium temperature, characterizing the phase transition between the ordinary matter and the QGP, which today remains an open question.

Thanks to 20 years of QGP investigations, it is clear today that the optimal experimental conditions to fully study the charmonia melting are met with the new and unique Large Hadron Collider (LHC) fixed target setup. From 2023, the LHCb experiment will collect the first large fixed-target samples of proton-nuclei and lead-nuclei at centre of mass energies of ~100 GeV. These energies are ideal to fully characterize the charmonia melting, including for the first time the 3 states: J/ψ, ψ(2S) and χ_c.

The proposed PhD subject contains two parts. First, the candidate will analyse the LHC Run 3 data with the measurement of J/ψ, ψ(2S) and χ_c production in proton-nuclei and Lead-nuclei collisions collected in 2023. She/He will compare these measurements to characterize the cold nuclear effects

[1] Charmonia are $c\bar{c}$ bound states, whose first states are J/ψ, ψ(2S), χ_c.

(standard nuclear matter impact on charmonium) and identify genuine QGP effects in lead-nuclei collisions.
In parallel, the student will define and characterize the future electronics of the LHCb detector. The LLR is currently studying the conception and design of a new tracking detector for the LHCb upgrade II (2030 horizon). This detector, using the CMOS MAPS technology (Monolithic Active Pixel Sensors), will significantly improve the LHCb detector performances regarding the QGP studies (lead-nuclei collisions). Therefore, this new detector is a critical element of the LHCb future. The candidate will be deeply involved in this new activity.

Thesis project

The proposed thesis will be the first analysis on LHCb fixed-target run 3 data. It includes:
- A participation in the data taking from 2023, including proton-nuclei and also Pb-nuclei collisions. Several stays at CERN are foreseen.
- A leading role in the χ_c production in proton-nuclei and/or Pb-nuclei collisions, never done in heavy ion collisions.
- A major role in the electronics characterization and optimization.

The interpretation of these data in the context of phenomenological work in close relationships with theorists may be an important part of the thesis project, depending on the student's interest.

The PhD student will participate in the dissemination of these results in publications and international conferences.

Master and doctoral school

- Master 2 in particle physics
- Doctoral school of Institut Polytechnique Paris

Contact

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