

M2 internship and PhD thesis subject proposal 2022

Title

From ordinary matter to quark gluon plasma: study of color screening as a signature of the phase transition with the LHCb fixed-target

Laboratory/research team

Laboratoire Leprince-Ringuet, École polytechnique / LHCb heavy ions

Local team

Experimentalists : Heavy ions

Benjamin Audurier (LLR, postdoc), Frédéric Fleuret (LLR), Felipe Garcia (LLR, PhD student), Émilie Maurice (LLR), Élisabeth Niel (LAL, PhD student), Patrick Robbe (LAL)

Luminosity

Vlasdislav Balagura (LLR)

Theorist

François Arleo (LLR)

Overview of the research

The core objective of the PhD thesis is to contribute to the study of the theoretically predicted phase transition between normal nuclear matter and its deconfined state: the Quark Gluon Plasma (QGP). In this extremely high density/temperature state of matter anticipated by Quantum Chromodynamics theory (QCD), the elementary constituents of matter, quarks and gluons, move freely, as opposed to what happens in normal confined nuclear matter. The detailed features of the predicted phase transition between these two states of matter, containing fundamental properties of QCD, have never been observed and remain an open question. The characterization of the phase transition will thus provide decisive information on our understanding of the early universe (few micro-seconds after the Big Bang) when deconfined quarks and gluons bound together leading eventually to the current structure of matter.

Based on the experimental results obtained in the last 20 years, it is clear, today, that measuring the phase transition needs full control and precise understanding of nucleus-nucleus collisions at centre of mass energies of ~ 100 GeV. For the first time, the required experimental conditions are met with the innovative fixed-target setup of the LHCb experiment at the Large Hadron Collider (LHC), unique in the world. From 2021, the LHC restart will provide the first opportunities to collect large fixed-target samples of proton-nuclei and lead-nuclei collisions at these energies.

The proposed PhD thesis is dedicated to the optimization and exploitation of these pioneering samples, in order to investigate the quark deconfinement mechanism, by testing the quarkonium suppression mechanism.

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 2022, including proton-nuclei and also Pb-nuclei collisions. Several stays at CERN are foreseen.
- A leading role in the early measurements (1st measurement of LHCb during Run 3) with the study of J/ψ and $\psi(2S)$ production (via their dimuon decay channels), using the new fixed-target data.
- A major role in the χ_c production in proton-nuclei and/or Pb-nuclei collisions, never done in heavy ion collisions.

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

Emilie Maurice: Emilie.Maurice@lhr.in2p3.fr