INTERNSHIP PROPOSAL

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CNRS identification code: UMR 6457
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Internship location: SUBATECH, Nantes

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR

Quark-gluon tomography of nuclei at high energy

This internship proposal is part of the ANR project "TMD-SAT", which aims to investigate the partonic structure of protons and heavy nuclei at high energies within Quantum Chromodynamics (QCD). It is intended as a preparation for a fully funded 3-year PhD within the Theory Group of the Subatech laboratory in Nantes.

Despite the great success of QCD in describing a wide variety of hadronic phenomena, including results from current experiments at the Large Hadron Collider (LHC), many fundamental questions remain. For instance, it is still not fully understood how quarks and gluons (collectively referred to as "partons") are distributed inside hadrons in such a way that the resulting bound state has a definite mass and spin, especially in the regime where the partons carry a very small fraction of the bound state longitudinal momentum. In this regime, first-principles QCD calculations predict a rapid growth in the gluon density of the target, which is eventually tamed by non-linear recombination effects.

One of the central goals of current and future collider experiments is to characterize this gluon saturation phenomenon by measuring suitable cross-sections and comparing them with precise QCD predictions. The main objective of the internship will be to analytically compute one such cross-section: very-forward photon-jet production in proton–nucleus collisions at the LHC, at leading order and possibly next-to-leading order in the strong coupling constant, within the high-gluon-density regime of the hadronic target. This calculation will allow the intern to become familiar with the formalism and develop an understanding of the rich phenomenology of QCD at hadron colliders, before moving on to more complex processes and theoretical concepts related to QCD factorization theorems with transverse-momentum-dependent (TMD) parton distribution functions.

The applicant should preferably have a solid background in quantum field theory and particle physics; however, the internship is also designed to enable highly motivated candidates to strengthen or acquire these skills as needed. The internship is expected to lead to a PhD position supported by the ANR project, provided that the internship is successfully completed and the candidate passes the selection process of the 3MG doctoral school (toward mid-May 2026). The PhD research will focus on TMD factorization at small x for various key processes sensitive to gluon saturation, at one-loop order in perturbative QCD.

References:
- *Universality of Unintegrated Gluon Distributions at small x*, F. Dominguez, C. Marquet, F. Yuan, B. Xiao, Phys.Rev.D83:105005, 2011, arXiv1101.0715
- *The Color Glass Condensate*, F. Gelis, E. Iancu, J. Jalilian-Marian, R. Venugopalan, Ann.Rev.Nucl.Part.Sci.60:463-489, 2010, arXiv:1002.0333
- *TMD Handbook*, R. Boussarie et al., arXiv:2304.03302