Partonų sklaidos atradimas lengvųjų jonų susidūrimuose

Discovering Partonic Rescattering in Light Nucleus Collisions

Alexander Huss[1], Aleksi Kurkela[1,2], Aleksas Mazeliauskas[1], Risto Paatelainen[1], Wilke van der Schee[1], Urs Achim Wiedemann[1]
[1]Theoretical Physics Department, CERN, CH-1211 Genève 23, Switzerland
[2]Faculty of Science and Technology, University of Stavanger, 4036 Stavanger, Norway
aleksas.mazeliauskas@cern.ch

Experiments with ultrarelativistic collisions of heavy ions (AA), e.g., gold (AuAu) or lead (PbPb), at CERN Large Hadron Collider (LHC) and BNL Relativistic Heavy Ion Collider (RHIC) have provided ample evidence for the creation of a new state of matter—the quark-gluon plasma (QGP). The QGP is a high-temperature and density state of matter in which the fundamental partonic degrees of freedom, i.e., quarks and gluons, are manifest. Theoretical interpretation of experimental results leads to a picture of a sub-atomic size ($\sim 10^{-14}$ m) droplet of dense and strongly interacting matter, which can be successfully described by macroscopic theory of fluid dynamics.

One of important experimental signatures of QGP is the suppressed production of high-momentum hadrons (h) and jets (j), which is a result of partonic rescattering of high-momentum quarks or gluons in the QGP. The suppression is quantified by the nuclear modification factor $R^{j,h}_{\rm AA}$, with $R_{\rm AA} < 1$ indicating suppression. Much of the recent experimental effort at the LHC has gone into characterizing emergent QGP properties as a function of the size of the collision system. Peripheral AA collisions involve a smaller number of nucleons $N_{\rm part}$ and are labelled by the larger centrality percentage in Fig. 1 (top). In most peripheral AA collisions and proton-nucleus (pPb) collisions with $N_{\rm part} \sim O(10)$ the partonic rescattering is not conclusively established as shown in Fig. 1 (bottom).

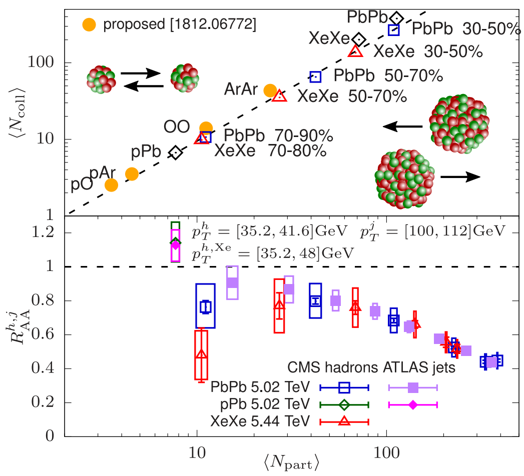

Fig. 1 (top) The number of binary nucleon-nucleon collisions as a function of participating number of nucleons in minimum bias nucleus-nucleus, proton-nucleus and centrality selected heavy-ion collisions. (bottom) Measured hadron and jet suppression relatively to pp. Fig. from [1].

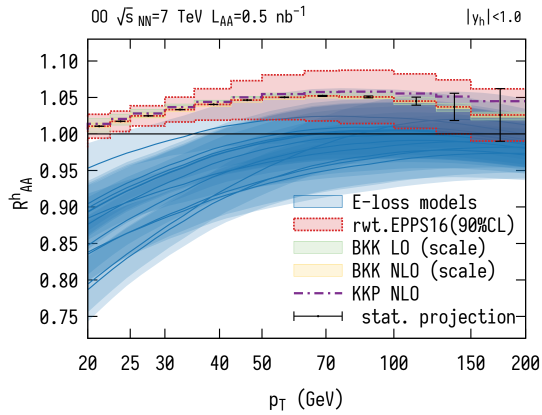

Fig. 2 Hadron spectra modification in oxygen-oxygen collisions relatively to pp with (blue) and without (red) parton rescattering in the medium. Fig. from [1]

In our Letter [1] we demonstrated that the proposed oxygen-oxygen collisions at the LHC will provide unprecedented sensitivity to parton energy loss in a system whose size is comparable to those created in very peripheral heavy-ion collisions. We performed next-to-leading order calculations in perturbative QCD and showed that $R_{\rm AA}$ baseline in the absence of partonic rescattering is known with up to 2% theoretical accuracy in inclusive oxygen-oxygen collisions (see Fig. 2). We further studied a broad range of parton energy loss models [2] and we found that the expected signal of partonic rescattering can be disentangled from the baseline by measuring charged hadron spectra in the range 20 GeV $< p_T <$ 100 GeV as shown in Fig. 2. Therefore the special run of oxygen-oxygen collisions at the LHC run 3 has high chance of discovering partonic rescattering in such small collision systems.

Reikšminiai žodžiai: LHC, sunkieji jonai, kvarkų–gliuonų plazma, QCD

Literatūra

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[2] A. Huss, A. Kurkela, A. Mazeliauskas, R. Paatelainen, W. van der Schee and U. A. Wiedemann, Phys. Rev. C **103** (2021) no.5, 054903 doi:10.1103/PhysRevC.103.054903 [arXiv:2007.13758 [hep-ph]].