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Precision proton-nucleus collision studies at A Fixed-Target ExpeRiment at the LHC (AFTER@LHC)

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We outline the physics opportunities [1] which are offered by a next generation and multi-purpose fixedtarget experiment exploiting the LHC beams extracted by a bent crystal. This mature extraction technique offers an ideal way to obtain a clean and very collimated high-energy beam, without altering at all the performance of the LHC [2,3,4]. The multi-TeV LHC beams grant the most energetic fixed-target experiment ever performed, to study pp, pd and pA collisions at sqrt(s_NN) ~ 115 GeV and PbA collisions at sqrt(s_NN) ~ 72 GeV. AFTER - for A Fixed-Target ExperRiment - gives access to new domains of particle and nuclear physics complementing that of collider experiments, in particular RHIC and the projects of electron-ion colliders. The typical instantaneous luminosity achievable with AFTER in pp and pA mode [1] surpasses that of RHIC by more than 3 orders of magnitude and is comparable to that of the LHC collider mode, without pile-up thanks to the slow extraction mode. This provides a quarkonium and heavy-flavour observatory [5] in pp and pA collisions where, by instrumenting the target-rapidity region, gluon and heavy-quark distributions of the proton, the neutron and the nuclei can be accessed at large x and even at x larger than unity in the nuclear case. The nuclear target-species versatility provides a unique opportunity to study the nuclear matter versus the hot and dense matter formed in heavy-ion collisions, including the formation of the quark-gluon plasma. Modern detection technology should allow for the study of quarkonium excited states, in particular the chi(c) and chi(b) resonances, even in the challenging high-multiplicity environment of pA and PbA collisions, thanks to the boost of the fixed-target mode. Precise data from pp, pA should help to better understand heavy-quark and quarkonium production as well as their correlations with isolated photons, to clear the way to use them for gluon and heavy-quark PDF extraction in free and bound nucleons, to unravel cold from hot nuclear effects and to restore the status of heavy quarkonia as a golden probe of the QGP formation. The fixed-target mode also has the advantage to allow for spin measurements with polarized targets.

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