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AFTER@ LHC: A Fixed-Target ExpeRiment at the LHC

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We outline the physics opportunities [1] which are offered by a next generation and multi-purpose fixed-target 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 $\sqrt{s_{NN}} \simeq 115\,\mathrm{GeV}$ and PbA collisions at $\sqrt{s_{NN}} \simeq 72\,\mathrm{GeV}$. 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. 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 nuclear matter versus the features of the hot and dense matter formed in heavy-ion collisions, including the formation of the quark-gluon plasma. During the one-month lead runs, PbA collisions can be studied at a luminosity comparable to that of RHIC and the LHC over the full range of target-rapidity domain with a large variety of nuclei. Modern detection technology should allow for the study of quarkonium excited states, in particular the χ_c and χ_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 and PbA should help to understand better heavy-quark and quarkonium production, 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 test of lattice QCD in terms of dissociation temperature predictions at a $\sqrt{s_{NN}}$ where the recombination process is expected to have a small impact. The fixed-target mode also has the advantage to allow for spin measurements with polarized targets.

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