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Study of hard and electromagnetic processes at CERN-SPS energies: an investigation of the high- μ_B region of the QCD phase diagram

The exploration of the phase diagram of Quantum ChromoDynamics (QCD) is carried out by studying ultra-relativistic heavy-ion collisions. The energy range covered by the CERN SPS ($\sqrt{s_{NN}} \sim 6-17$ GeV) is ideal for the investigation of the region of the phase diagram corresponding to finite baryochemical potential (μ_B), and has been little explored up to now. We propose in this document a new experiment, NA60+, that would address several observables which are fundamental for the understanding of the phase transition from hadronic matter towards a Quark-Gluon Plasma (QGP) at SPS energies. In particular, we propose to study, as a function of the collision energy, the production of thermal dimuons from the created system, from which one would obtain a caloric curve of the QCD phase diagram that is sensitive to the order of the phase transition. In addition, the measurement of a ρ - a_1 mixing contribution would provide conclusive insights into the restoration of the chiral symmetry of QCD.

In parallel, studies of heavy quark and quarkonium production would also be carried out, addressing the measurement of transport properties of the QGP and the investigation of the onset of the deconfinement transition. The document also defines an experimental set-up which couples a vertex telescope based on monolithic active pixel sensors (MAPS) to a muon spectrometer with tracking (GEM) and triggering (RPC) detectors within a large acceptance toroidal magnet.

Results of physics performance studies for most observables accessible to NA60+ are discussed, showing that the results of the experiment would lead to a significant advance of our understanding of strong interaction physics.

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