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07.09.2017

Letter of support for the measurements of open charm production at CERN SPS energies

Dear Colleagues,

I had the pleasure to participate in the ***NA61 Beyond 2020*** workshop in July in Geneva and was impressed by the scientific potential in reach for the NA61 detector system. This letter is written in support of proposals for the SPS heavy-ion program and in particular for the measurement of open charm production in heavy-ion collisions. Let we explain my point of view in more detail.

Whereas the properties of partonic systems at vanishing baryon chemical potential have been explored with ultra-relativistic heavy-ion beams at RHIC and the LHC in the past and a strong program has been launched for the next years the properties of partonic and hadronic systems at large chemical potentials are widely unknown as well as the phase boundary in the plane of temperature versus baryon chemical potential. Present lattice QCD calculations provide valuable information at vanishing chemical potential and allow to extrapolate to small chemical potentials via susceptibilities, however, the phase boundary and the order of the phase transition cannot be calculated with present techniques or algorithms. This calls for experimental studies of heavy-ion collisions in the SPS energy regime since the extrapolations of effective models lead to very different predictions. This is partly related to the fact that together with the deconfinement phase transition the restoration of chiral symmetry might go along – in terms of a cross over at low baryon chemical potential – or not at all. At high baryon densities another phase might exist where chiral symmetry is restored to a large extent, however, the degrees of freedom are still confined (quarkyonic matter). Probably these phases become separated at a critical endpoint in the phase diagram which should be characterized by large fluctuations. Accordingly the suggestion has been to look experimentally for fluctuations in observables for low transverse momentum as a function of bombarding energy and system size, i.e. from pp to central Pb+Pb reactions. Although the systematics are far from being completed by now the present data do not show evidence for the appearance of unusual fluctuations.

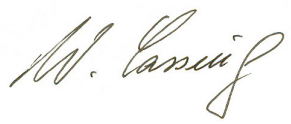
The quest, therefore, is to look for additional observables that incorporate a different (mass) scale. Here open charm mesons and intermediate mass dilepton pairs (between 1.2 GeV and 2.8 GeV of invariant mass) provide additional information in particular on the charm quark dynamics and angular correlations as well as on the light quark annihilation to lepton pairs from the approximately thermalized partonic system. Angular correlations

between D-meson pairs appear promising probes since the variation of the correlation with system size – from pp to Pb+Pb - will provide information on the interaction rates in the medium complementing traditional R_AA systematics. The intermediate mass dileptons are essentially sensitive to the partonic phase since here the contribution from hadronic decays is practically absent. However, there is a background of lepton pairs from the semileptonic decay of open charm hadrons which has to been to measured independently in order to allow for a clean subtraction.

At SPS energies the probability for charm-pair production is below 15% even in central Pb+Pb collisions at 158 A GeV such that the correlations between open charm hadrons are rather free from background once the D-mesons are properly identified. I should mention that the spectra and angular correlations of D-mesons are important observables on their own. Additionally, they are necessary ingredients for a determination of the dilepton contribution from semileptonic decays and extraction of the electromagnetic emissivity of the QGP at moderate/high baryon chemical potential.

Furthermore, apart from science aspects, we need a timely heavy-ion program and actual experiments in the near future since the Compressed-Baryonic-Matter (CBM) program at FAIR as well as the BES II and fixed-target program at RHIC will not provide experimental information in the near future. The education of young researches needs experiments, actual data and their analysis in order to guarantee the success of heavy-ion research on the long run.

Sincerely yours,



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cc: Marek Gazdzicki