$\phi$ meson production in Au+Au collisions and its reconstruction feasibility in the CBM experiment

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The CBM experiment at FAIR is aimed to study properties of QCD diagram at high baryon densities and moderate temperatures. One of the most interesting particles among other rare probes is $\phi$ meson, which consists of $\bar{s}s$ pair and can decay inside the fireball. In that case it carries a direct information about the production of $\bar{s}s$ pairs. Production of $\phi$ in heavy-ion collisions have earlier been studied in other experiments, such as HADES [1] and NA49 [2], however, the existing up to now data is rather insufficient in the CBM energy range.

To study the production of $\phi$ mesons at CBM energies and higher, and feasibility of its reconstruction, a minimum bias Au+Au events were generated in the UrQMD-3.4 model at 4–160 $A$GeV energies. For each energy 1 million of events was generated (see Fig. 1). Among these events only 10% of the most central were considered. The centrality was determined in accordance with the charged multiplicity in the rapidity window of $|y_{c.m.}/y_{beam}| < 0.5$. Additionally, $10^4$ central (impact parameter $b = 0$ fm) events generated in PHSD-3.0 model [3] were analyzed as well for comparison.

One should note that $\phi$ meson has a relatively small lifetime ($c\tau \simeq 45$ fm), and there is a certain probability for it to decay inside the fireball. For this reason $\phi$ meson is not considered as a stable particle in transport models such as UrQMD and PHSD by default. Therefore, in order to calculate the $\phi$ multiplicity they are forced to be stable with respect to decays in UrQMD and PHSD by adjusting the corresponding flag.

The precise measurements of $\phi/K^-$ ratio allows to extract the fraction of $K^-$ coming from $\phi$ decay [1]. The results of calculations for this quantity within UrQMD and PHSD are depicted in Fig. 1. Additionally, experimental data of HADES and NA49 collaborations is shown by symbols with error bars. We note that NA49 data is for Pb+Pb collisions. The data shows a plateau in energy dependence at higher collision energies. This effect is qualitatively well reproduced in UrQMD and PHSD. At low energies ($p_{lab} \lesssim 7$ AGeV), however, the data [1] show an increase of the $\phi/K^-$ ratio. Taking into account that available data in this energy range is rather insufficient, future measurements at CBM may help to clarify the presence of such effect.

In order to study $\phi$-mesons reconstructability 5 millions of central Au+Au events at 6 AGeV were simulated. $K^+$ and $K^-$ identified in the TOF detector are combined to pairs by the KF Particle Finder package. The resulting invariant-mass distribution for the $K^+K^-$ pairs is shown in Fig. 2 where the $\phi$ signal is clearly visible.

References