

Feasibility of D^0 measurement with the CBM detector

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One of the important and most challenging tasks of the planned heavy-ion experiment CBM at GSI will be the measurement of charmed mesons via their hadronic decays into pions and kaons such as $D^0 \rightarrow \pi^+ K^-$ ($c\tau = 123 \mu\text{m}$) and $D^\pm \rightarrow \pi\pi K$ ($c\tau = 315 \mu\text{m}$). The major problem of such a measurement is the large combinatorial background of uncorrelated pions and kaons. In a first step, we studied the feasibility of the D^0 detection in the tracking system of CBM. The simulation tool was GEANT4, version 4.0. The detector setup consisted of seven silicon pixel/strip tracking stations as layed out in the Conceptual Design Report; their thickness was varied between $100 \mu\text{m}$ and $1000 \mu\text{m}$.

The signal was simulated by a generator which produces D^0 mesons with a Gaussian rapidity distribution ($\sigma_y = 1.0$) and a thermal distribution in transverse momentum ($T = 300 \text{ MeV}$). For the background estimate we employed the UrQMD predictions for π^+ and K^- in central Au+Au collisions at 25 AGeV. These give 328 π^- per event with $\sigma_y = 1.05$ and $T = 127 \text{ MeV}$. The K^- multiplicity is 13; their momentum distribution is characterised by $\sigma_y = 0.85$ and $T = 151 \text{ MeV}$.

The acceptance of the tracking system covers laboratory polar angles from 6 to 27 degrees. The hits generated by the tracks in the tracking stations were fitted by straight lines (no magnetic field was considered in this first approach). Then, the invariant mass of all combinations of π^+ and K^- was calculated. By comparison of signal and background in the relevant mass region around the D^0 mass (1.8646 GeV), the sensitivity, defined by S/\sqrt{B} (if $B \gg S$), was studied.

Due to the very low multiplicity of D^0 in Au+Au collisions at 25 AGeV, the background has to be suppressed by many orders of magnitude. Cuts on the following variables of the particle pair were thus imposed:

- The angle of the positive particle in the rest frame of the pair with respect to the pair momentum (decay angle cut)
- The z coordinate of the two-track vertex recon-

structed by intersecting the two tracks (secondary-vertex cut). In case of the signal, this will give the decay vertex, which is at a distance of several $100 \mu\text{m}$ from the event vertex, while the background track pairs will intersect at the event vertex (see fig. 1). Both will be smeared by the resolution in this variable, mainly determined by the multiple scattering. For the track fit, only the first two stations were used in order to minimise this effect.

- The product of the impact parameters of both tracks, defined as the distance of the track extrapolation to the target at target- z (impact parameter cut)
- The angle between the displacement vector of the two-track vertex and the pair momentum in the laboratory frame (collinearity cut)

These cuts were adjusted to optimise S/\sqrt{B} in the signal mass region. As expected, the secondary-vertex cut $v_z > 0.3 \text{ mm}$ is the most efficient for background suppression (see fig. 1). After all cuts, the background at invariant masses close to the D^0 mass is reduced by a factor of 1.5×10^5 .

The final sensitivity depends on the (barely known) D^0 multiplicity and the resolution in invariant mass. If we take as an estimate $\sigma_m = 10 \text{ MeV}$ and $\langle D^0 \rangle = 10^{-3}$ as suggested by transport calculations with the HSD code, the 3σ detection level will be reached at $\approx 2 \times 10^6$ events at S/B of the order of 2. Taken the envisaged event rates of 1 MHz, we conclude that the measurement should be feasible. The rate of measured D^0 under these circumstances can be estimated to be 13,000 per hour. This results are obtained with thin silicon detectors ($100 \mu\text{m}$).

Because of multiple scattering, the resolution in the secondary-vertex position and thus the sensitivity decreases with increasing thickness d of the tracking stations. Fig. 2 shows the signal-to-noise ratio at 10^8 events as a function of d . Even at $d = 1 \text{ mm}$, a signal can surely be detected; the signal-to-background ratio would then be about 1/5.

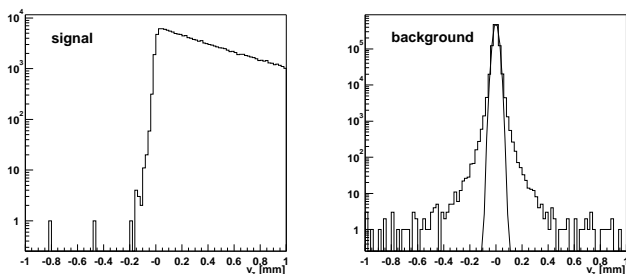


Figure 1: Distributions of the z coordinate of the two-track vertex for signal pairs (left) and background pairs (right). The latter has a Gaussian σ of $18 \mu\text{m}$.

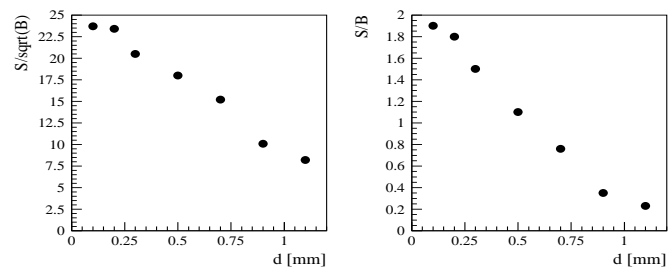


Figure 2: (left) S/\sqrt{B} and (right) S/B as a function of the thickness of the tracking stations. The former is calculated for 10^8 events.