D^0, D^+ and Λ_c decay feasibility study in the CBM experiment

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One of the major experimental challenges of the CBM experiment is to trigger on the displaced vertex of the D-meson or Λ_c decay via hadronic modes in the environment of heavy-ion collisions. This task requires a fast and efficient track reconstruction algorithm and high resolution of the secondary vertex determination. Particular difficulties in identifying the displaced vertex of the rare open charm decays are caused by weak K^0_S and hyperon decays which produce displaced vertices downstream the target, very low multiplicities of the rare open charm production, the small branching ratios as well as multiple scattering in the beam pipe and detector systems.

To study the feasibility of D^0, D^+ and Λ_c decay reconstruction in the CBM experiment, a set of 10^4 central Au+Au UrQMD events at $25A$ GeV were simulated. The D^0, D^+ or Λ_c decay to hadrons was forced (BR = 1) and added to each event in order to simulate a signal in the environment of background hadrons. A realistic STS geometry with 2 MAPS at 5 cm (thickness 300 μm) and 10 cm (thickness 500 μm) and 8 double-sided (thickness 400 μm, different z-position of the stations) segmented strip detectors was used. Assuming a 0.1 MHz interaction rate and 30 μs read-out time of the MAPS detectors, δ-electrons produced by 300 gold ions and 3 minimum bias interactions were added to each central event in order to simulate additional background hits in the MAPS detectors. The cluster finding method described in [1] was used for the STS. The primary vertex was reconstructed with high accuracy (6 μm in z direction, 1 μm in x and y) from about 450 tracks reconstructed in the STS in a non-homogeneous magnetic field by the SIMDized Kalman filter procedure described in [2].

A fast track finder was used to reconstruct D^0, D^+ or Λ_c decays. The algorithm first finds the primary vertex using all reconstructed tracks, and then the open charm particle is reconstructed from its two or three daughter particles using the primary vertex as the production point. The vertex resolution for D^0, D^+ or Λ_c is 52 μm, 56 μm and 69 μm, respectively. Because of originating from a displaced decay vertex, D^0, D^+ or Λ_c daughter tracks have a non-vanishing impact parameter at the target plane. Since the majority of the primary tracks have very small impact parameter, a large fraction (99%) of the background tracks was rejected using a cut on their χ^2 distance to the primary vertex.

The combinatorial background is suppressed mainly by the geometrical and topological vertex cuts. Multiplicities, cut efficiencies, acceptance, z-vertex resolution, mass resolution, signal to background ratios and yields per 10^{12} minimum bias interactions are calculated by using the Hadrons String Dynamics (HSD) and Statistical Model (SM), as presented in Table 1. The shape of the background in the signal invariant-mass region was estimated using the event mixing technique. The invariant-mass distributions of the resulting background plus $\bar{D}^0$ and D^0 signal are shown in Fig. 1.

Table 1: Acceptance, efficiencies, mass resolution and signal-to-background ratio (S/B, $\pm 2\sigma_m$) of D^0, D^+, and Λ_c decay reconstruction in central Au+Au collisions at $25A$ GeV. The total efficiencies result from the product of geometrical acceptance, reconstruction efficiency and cut efficiencies.

	$D^0 + D^0$	$D^+ + D^-$	Λ_c^+
decay channel	$K^\mp\pi^\pm$	$K^\mp\pi^\pm\pi^\pm$	p $K^-\pi^+$
HSD multiplicity	$1.5 \cdot 10^{-4}$	$4.2 \cdot 10^{-5}$	-
SM multiplicity	$8.2 \cdot 10^{-4}$	$8.4 \cdot 10^{-5}$	$4.9 \cdot 10^{-4}$
branching ratio	3.8%	9.5%	5.0%
acceptance	29.2%	40.1%	71.0%
z-resolution [μm]	52	56	69
total efficiency	3.95%	4.75%	0.05%
σ_{im} [MeV/c^2]	11.0	11.0	11.0
SM $S/B_{2\sigma}$ ratio	2.1 (6.4)	1.1 (2.4)	0.6
HSD $S/B_{2\sigma}$ ratio	0.16 (0.5)	0.55 (1.2)	-
SM yield/10^{12}mb	225k +78k	95k+179k	3.2k
HSD yield/10^{12}mb	41k +14k	47k+89k	-

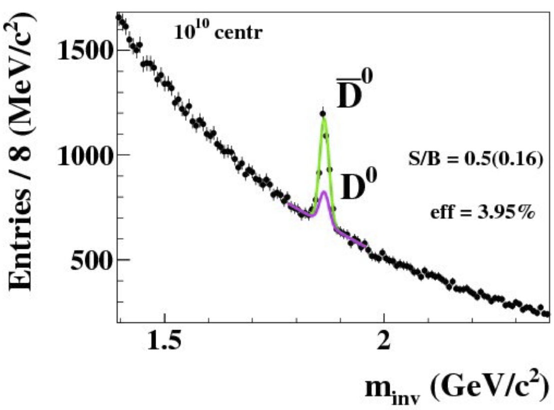

Figure 1: Reconstructed $\bar{D}^0$-mesons in 10^{10} central Au+Au collision at $25A$ GeV. The green line shows the $\bar{D}^0$ signal, the magenta one the D^0.

References

[1] A. Kotynia *et al.*, *CBM Progress Report 2009*, Darmstadt 2010, p. 7

[2] I. Kisel *et al.*, Comp. Phys. Comm. **178** (2008) 374