Performance studies on the CBM-TRD using J/ψ

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The Transition Radiation Detector (TRD) will be one of the key components of the CBM experiment. It will be used for particle tracking and for the identification of electrons and positrons [1]. J/ψ production in the di-electron channel is a unique physics process to study the performance of the TRD. We here derive a limit on the TRD coordinate resolution, which provides useful information to determine the size of readout pads, using the ratio of reconstructed J/ψ signal to background as performance figure.

Simulations are performed in the cbmroot software framework. The TRD is implemented with three stations at 450 cm, 675 cm and 900 cm downstream of the target, respectively. In this geometry configuration, each station has four layers. Each layer has a 29 mm thick radiator followed by a 6 mm thick gas detector. J/ψ signals are produced by the HSD code for central Au+Au collision at 25A GeV and forced to decay into electron-positron pairs. Background events are generated using the UrQMD event generator for the same collision system. Electron-positron pairs decaying from J/ψ and background events are subsequently mixed together. This mixed sample is then used as input for the detector simulation. A global tracking method which uses spatial hits from the TRD and the silicon tracking system (STS) is applied for track reconstruction. To focus on the TRD performance, only idealized digitisation is used for the STS. Monte-Carlo generated hits from the TRD are smeared with different values to simulate the detector resolution. The transverse momentum p_t of electrons and positrons is required to be larger than 1 GeV/c. Figure 1 shows the invariant-mass spectrum of reconstructed electron-positron pairs from this simulation.

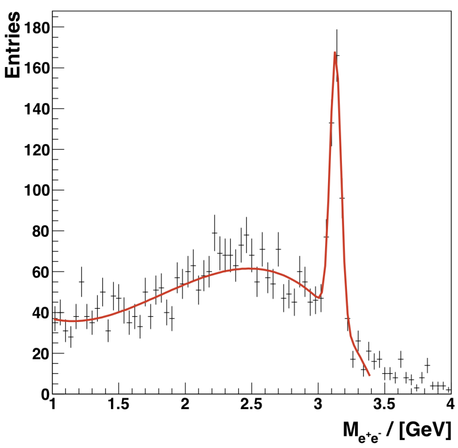

Figure 1: Invariant-mass spectrum of reconstructed e^+e^- pairs

The ratio of signal to background from the invariant-mass spectrum of e^+e^- provides a useful way to check the detector performance. However, this ratio cannot be directly extracted from Figure 1, since the proportion of J/ψ signals to background events in this simulation (1 : 1) is far from reality. Experimentally, J/ψ is a very rare physics process. Thus, the combinatorial background formed by one of the decay daughters and one electron or positron from the background events is significantly enhanced compared to the reality. This distorts the background in the e^+e^- invariant mass spectrum dramatically. A reliable ratio of signal to background can be obtained by removing this distorted combinatorial background source in the simulation. Figure 2 shows the ratio of signal to background extracted from the e^+e^- invariant-mass spectrum for different position smearing of the TRD hits. Here, the above mentioned combinatorial background was removed. the S/B ratio is found the stay constant when the hit resolution is less than 1 mm.

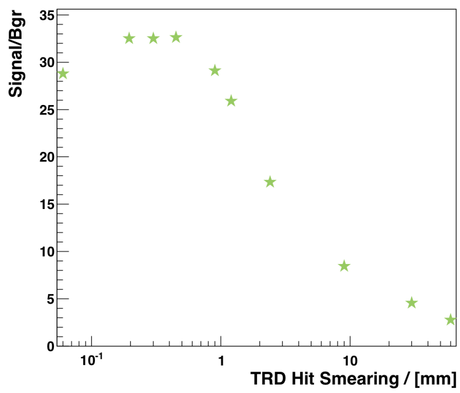

Figure 2: Ratio of signal to background for J/ψ as a function of smearing of TRD hits

In summary, studies on a mixed sample of J/ψ and UrQMD events provide a limit on the coordinate resolution of the TRD. The signal-to-background ratio is found to drop significantly when the hit resolution is worse than 1 mm. Further studies need to be carried out on the MC data with more realistic detector digitisation and clustering. A feasibility study on the TRD online trigger for J/ψ can also be performed using a standalone TRD tracking method developed by M. Krauze, A.Bubak and W.Zipper.

References

[1] B. Friman *et al.*, *The CBM Physics Book*, Springer Series: Lecture Notes in Physics, Vol. **814**, 2011