Application of the ω_n^k Test for J/ψ Detection in the CBM Experiment

E.P. Akishina, T.P. Akishina, V.V. Ivanov, O.Yu. Denisova
Laboratory of Information Technologies, JINR
A.I. Maevskaya
INR, Troitsk, Russia

The measurement of charmonium is one of the key goals of the CBM experiment. To detect J/ψ meson in its dielectron decay channel, the main task is the separation of electrons and pions. We present the electron/pion identification using energy losses in $n = 12$ layers of the CBM TRD detector applying the ω_n^k test.

The test criteria that check the correspondence of pre-assigned hypothesis (the null-hypothesis H_0) against all possible alternative hypotheses are called the *goodness-of-fit* criteria [1]. The most efficient criteria are based on a comparison of the distribution function $F(x)$ corresponding to the null-hypothesis H_0 with the empirical distribution function $S_n(x)$ [2]:

$$S_n(x) = \begin{cases} 0, & \text{if} \quad x < x_1; \\ i/n, & \text{if} \quad x_i \le x \le x_{i+1}, \quad i = 1, \ldots, n-1. \\ 1, & \text{if} \quad x_n \le x, \end{cases} \tag{1}$$

Here $x_1 \le x_2 \le \ldots \le x_n$ is the ordered sample (*variational series*) of the size n constructed on the basis of observations of the variable x.

The testing statistics is a measure of "distance" between the theoretical $F(x)$ and empirical $S_n(x)$ distribution functions. In [2] a new class of non-parametric statistics

$$\omega_n^k = n^{k/2} \int_{-\infty}^{\infty} [S_n(x) - F(x)]^k f(x) dx \tag{2}$$

has been proposed: $f(x)$ is the density function corresponding to H_0.

The distributions of energy losses by pions have a Landau distribution form, and it is resonable to use this distribution as H_0. First, we transfom the initial measurements to the set of a new variable λ (see details in [3]):

$$\lambda_i = \frac{\Delta E_i - \Delta E_{mp}^i}{\xi_i} - 0.225, \qquad \text{i = 1,2,...,n,} \tag{3}$$

where ΔE_i is the energy loss in the i-th absorber of the TRD, ΔE_{mp}^i – the most probable energy loss, $\xi_i = \frac{1}{4.02}$ FWHM of distribution of energy losses of pions in the i-th absorber [3], n – the number of layers in the TRD. In order to determine the value ΔE_{mp}^i and the value FWHM, the indicated distributions were approximated by the log-normal distribution.

The sample of obtained values λ_i, $i = 1, ..., n$ was ordered due to values (λ_j, $j = 1, ..., n$) and then used for ω_n^k calculation. The values of the Landau distribution function were calculated with the help of the DSTLAN function (from the CERNLIB library).

From Monte-Carlo simulation we exactly know which particle we deal with, and one can choose for a combinatorial background only "real" electrons. For a good signal-to-background ratio, the electron identification purity is a crucial factor. The reconstructed track participates in the combinatorial background if it satisfies the following criteria: a) track vertex is inside the target; b) p_t is more than 1.2 GeV/c; c) RICH identifies track as an electron: the ring radius is 5.9 to 7 cm; d) full energy loss in all TRD layers is 70 keV.

Figure 1 shows the dielectron invariant mass spectra for background (top histogram) and J/ψ (bottom peak) after the above described ("abcd") cuts.

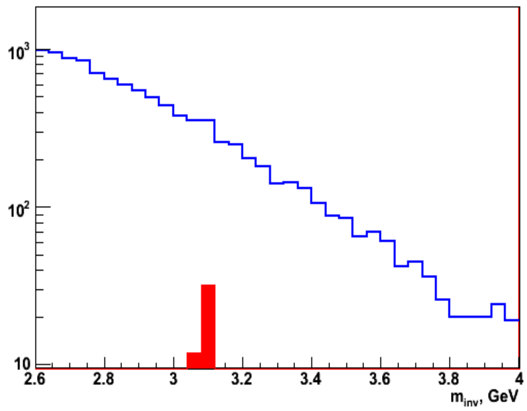

Fig. 1: Dielectron invariant mass spectra for background (top histogram) and J/ψ (bottom peak) after application cuts "abcd"

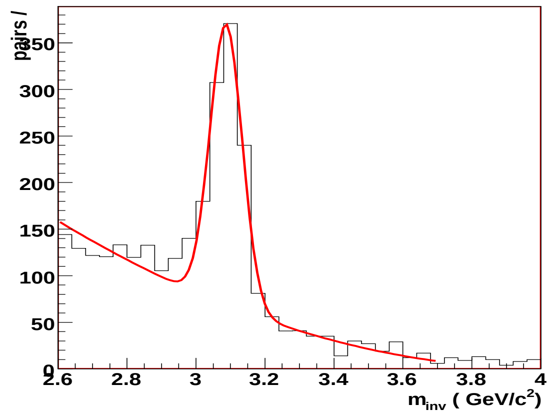

Fig. 2: Invariant mass spectrum for particles identified as electrons by RICH and TRD for J/ψ and corresponding amount of central background events after "abcd" and $\omega^8_{12} > 11$ cuts

Figure 2 presents an invariant mass spectrum for particles identified as electrons by RICH and TRD for J/ψ and a corresponding amount of central background events after "abcd" and $\omega^8_{12} > 11$ cuts.

References

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[2] V.V. Ivanov and P.V. Zrelov, Int. J. Comput. & Math. with Appl.,vol. **34**, No. 7/8, (1997)703-726; JINR Communication P10-92-461, 1992 (in Russian).

[3] P.V. Zrelov and V.V. Ivanov: NIM **A310**(1991)623-630.