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COMBINATORIAL BACKGROUND REDUCING IN THE EFFECTIVE MASS SPECTRA

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Introduction

In spite of the fact, that in the elementary interactions resonances are produced intensively, in nuclei-nuclear interactions resonances are hardly to be found at the intermediate energies.

It is not seldom for the combinatorial background to mask the resonances observation, particularly at small statistics and at high multiplicities. It is happening so then specially when in effective mass spectrum the phase space maximum places near with resonance peak. Therefore a methodic task to improve the resonance selection seems to us rather important. We propose a method how to reduce numerous k-particles combinations by excluding of those ones, which in any case cannot be the products of the resonance decays. This method is based on the analysis of (n=k+1,2..) particles effective masses, where k is the number of resonance product, and may be signed as "many particles mass restriction" (MPMR). The pure kinematics relations are used here only. The experimental data [1] on CC, C-p, pC interactions at 4.2 GeV/c/N were used for testing the proposed method.

Method - MPMR

Let's have a look at the three-particle combinations, composed, for example, from the particles: p,π^+,π^-. We shall use the accepted designations: P_1,P_2,P_3 for 4-momenta and m_1,m_2,m_3 – for the particles masses which compiled that combination.

In this case the effective mass of these three particles will be:

$(M_{eff3})^2=-(P_1+P_2+P_3)^2$

It is assumed, that the minimal value of the $M_{eff,3}$ is determined only by the sum of the particle masses: $Min(M_{eff,3})= m_1+m_2+m_3$. These 3-particles combinations (n=3) may be considered as a source for 3 two-particles combinations and occasionally, as a part of events, could form the "two-particle resonance" ρ-meson (k=2), for example. In this case:

$(M_{eff,3})^2=-(P_1+(P_2+P_3))^2$, $P_2+P_3=P_\rho$ and than $Min(M_{eff,3})= m_p+m_\rho$.

Thus, when we search the ρ-mesons peak, we may use a supplementary criteria to reduce the background in π^+,π^--effective mass spectrum: all π^+,π^--effective masses coming from three-particles $M_{eff,3}$ values less than the sum of proton and ρ-meson masses, have to turn out. It is a pity, that the background suppression would work from the left side of the resonance position only.

Four and more particle combinations can be used for joint production of two or more resonances searched. So, the combinations of four particles (p,

$\pi+,\pi^-,\pi^\pm$) are suitable for the study of $\Delta(1232)P_{33}$ -isobars and ρ-mesons produced simultaneously in the same interaction.

The four particles effective mass p, $\pi+,\pi^-,\pi^\pm$ will be

$(M_{eff4})^2=-(P_1+P_2+P_3+P_4)^2$ and $Min(M_{eff,4})= m_1+m_2+m_3+ m_4$. In the case of joint $\Delta(1232)P_{33}$ -isobars and ρ-mesons production: $Min(M_{eff,4})= m_\rho+ m_{\Delta(1232)}$.

In common the minimum value of n-particles (when $n<N_{total}$): $MIN(M_{eff,n})=\Sigma_n m_i$.

Some differences between the minimum values of n-particles effective mass spectra with and without resonance production:

$\delta(MIN(M_{eff,n}))=$

$MIN(M_{eff,n}$with resonances)- $Min(M_{eff,n}$ without resonances).

Some values of $\delta(MIN(M_{eff,n}))$ are shown in Table 1.

Tabl.1.

n	Group of n charged particles: Without resonances	With resonances	$\delta(MIN(M_{eff,n}))$ GeV
3	$n\ \pi$	$(n-2)\ \pi\ +\rho$	~.500
3	$p+(n-1)\ \pi$	$\pi+ N_{3/2,3/2}$	~.310
3	$n\ e^\pm$	$(n-2)\ e^\pm + \rho$	~.750
4	$p+(n-1)\ \pi$	$N_{3/2,3/2}+\rho$	~.640

Further, all two-particle combinations, coming from δ -region of the n-particles spectra, may be rejected.

Method-MPMR illustration

Full spectra of $(\pi+,\pi^-)$-mesons, $p\pi+$ and $p\pi^-$ -effective masses of the particles registered in CC-interactions at 4.2 GeV/c [2] are shown on fig.1. The places where resonances are expected are marked by strokes.

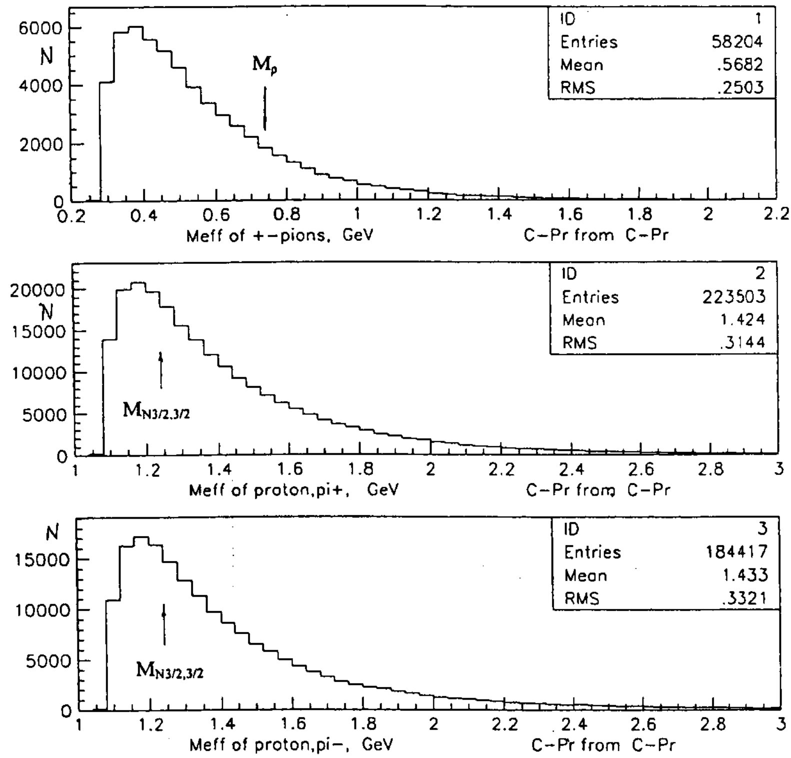

Fig. 1. Effective mass distributions for CC-interactions at 4.2 GeV/c/N: (top) effective mass $M_{\pi+,\pi-}$; (middle) - $M_{\pi+,p}$; (down) - $M_{\pi-,p}$.

From the very beginning we shall try to diminish the background on $M_{\pi+,\pi-}$ distribution (fig. 1(top)) by using the $M_{\pi+,\pi-,p} \equiv M_{eff,3}$ spectra.

The pair particle spectrum $M_{\pi+,\pi-}$, obtained from 3-particles combinations $M_{eff,3} < (m_p+m_\rho)$ cannot contain ρ– resonances at all (Fig 2, top) and so be named as "PB-3-spectrum". The spectrum $M_{\pi+,\pi-}$ coming from the region $M_{eff,3} > (m_p+m_\rho)$ is shown on Fig 2–middle. The lower spectra on Fig.2 is the result of PB-3-spectrum subtraction from the full $M_{\pi+,\pi-}$distribution (Fig 1,top). So, as seen below, on the spectra of Fig.2, the background on the left side of the expected resonance was reduced essentially. In comparison to Fig.1, here the region where the ρ-mesons may appear is displayed clearly.

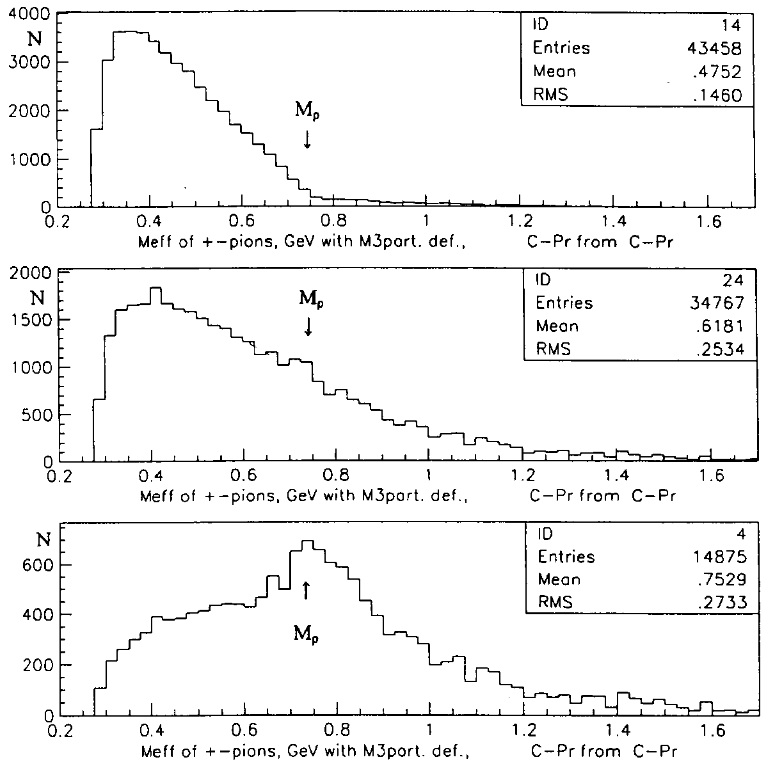

Fig. 2. Effective mass distributions $M_{\pi+,\pi-}$ for C-C-interactions at 4.2GeV/c/N;(top) for $M_{\pi+,\pi-,p}<(m_p+m_\rho)$; (middle) for $M_{\pi+,\pi-,p}>(m_p+m_\rho)$;(down) for $M_{\pi+,\pi-,p}>(m_p+m_\rho)$, but the $(\pi+,\pi^-)$-combinations coincided on top and middle pictures were extracted.

Four and more particles combinations can be used for searching the joint production of two or more resonances. So, the combinations of four particles (p, $\pi+,\pi^-,\pi^\pm$) are suitable for the study of ρ-mesons and $\Delta(1232)P_{33}$ –isobars produced together in the same interaction. In this case the PB-4-spectrum coming from the condition: $M_{\pi+,\pi+,\pi-,p}<(m_{N3/2,3/2}+m_\rho)$ is shown on fig. 3 (top). The final distribution that was obtained as a result of PB-4-spectrum subtraction from the full $M_{\pi+,\pi-}$ -(Fig.1, top) is shown on Fig.3, down. It has a clear maximum appropriate to ρ-mesons.

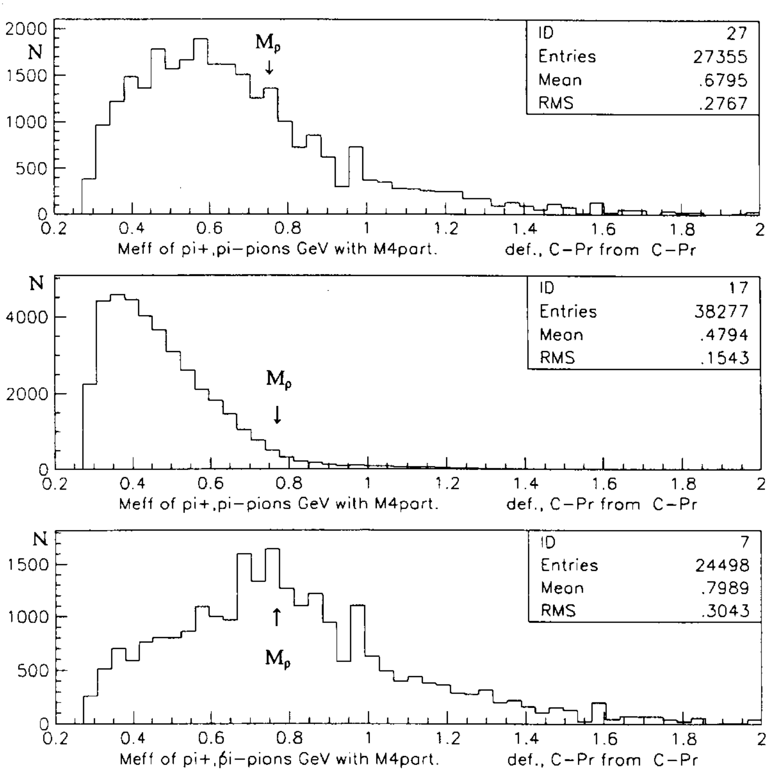

Fig 3. . Effective mass distributions $M_{\pi+,\pi-}$ for C-C-interactions at 4.2GeV/c/N;(top) for $M_{\pi+,\pi+,\pi-,\ p}<(m_{N3/2,3/2}+m_\rho)$-PB-4-spectrum; (middle) for $M_{\pi+,\pi+,\pi-,\ p}>(m_{N3/2,3/2}+m_\rho)$;(down) full $M_{\pi+,\pi+}$, -distribution (as on Fig.1) after PB-4-spectrum extraction.

After four particles analyses the cut connected with 3 particles masses limit may be applied. To illustrate this let us first subtract the PB-4-spectrum (i.e. spectrum obtained by the $(M_{N3/2,3/2}+M_\rho)$-cut –applying) from the full distribution $M_{p\pi+}$. After this from the same spectrum once more we shall subtract the PB-3-spectrum, coming from $(M_{N3/2,3/2}+M_\pi)$-cut. The resulting $M_{p\pi+}$ -distribution is shown on Fig 4.

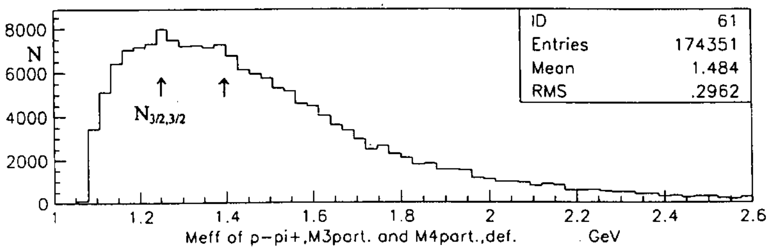

Fig.4. Effective mass distributions $M_{p\pi+}$, for C-C-interactions at 4.2GeV/c/N for $M_{3\pi,p}{}^{4}<(m_{N3/2,3/2}+m_{\rho})$, and for $M_{3\pi,p}{}^{3\,from\,4}<(m_{N3/2,3/2}+m_{\pi})$ background substractions.

Conclusion

The experimental use of the method named "many particles mass restriction, Method- MPMR" brought us to some satisfactory results. After MPMR-using the regions with $\Delta(1232)P_{33}$ and $N(1440)P_{11}$-isobars and ρ-mesons in the C-C- interaction at 4.2 GeV/c/N can be seen clearlier. But in order to achieve some real resonances study, the new distributions should be compared to the available background spectra obtained by using the method of mixed particles, for example. It seems obvious, that for false maximum avoiding such background spectra, a way through the same procedures of MPMR-method must be enabled as a real one.

The real width of the resonances must be taken in attention when the cut-limits are determined.

Besides background restriction this method also allows searching for new resonances by systematic changing of cut limits.

The results show that the method MPMR is effective particularly when two or more resonances are produced simultaneously in the same interaction. In this case the cut-limits have a great value, and a higher number of background combinations may be thrown out.

The most of the background combinations may be picked out in case if decay resonance products masses that are many times smaller then the resonance mass.

Under certain conditions this method of background restriction may serve as a trigger of suitable particles group.

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Уменьшение фона в спектрах эффективных масс

В работе предложен чисто кинематический метод уменьшения комбинаторного фона в спектрах эффективных масс на основе анализа минимальных значений многочастичных эффективных масс систем частиц, включающих продукты распада искомых резонансов. Предлагаемый метод может быть полезен при поиске и изучении резонансов во взаимодействиях с большим числом рожденных частиц и малых статистиках.

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Combinatorial Background Reducing in the Effective Mass Spectra

A pure kinematics method to decrease a combinatorial background in effective masses spectra is proposed. The minimal values of effective masses of particles, including the products of the sought-for resonances, are analysed. The method may be used for search and study of resonances at high multiplicity interactions and pure statistics.

The investigation has been performed at the Veksler and Baldin Laboratory of High Energies, JINR.

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