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THE TOTAL YUIELDS OF $K^+(890)$, $\Sigma^+(1385)$ AND Σ^0 IN NEUTRINO-INDUCED REACTIONS AT $< E_\nu > \approx 10$ GeV

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Abstract

Agababyan N.M., Ammosov V.V., Atayan M. et al. The Total Yuields of $K^+(890)$, $\Sigma^+(1385)$ and Σ^0 in Neutrino-induced Reactions at $< E_\nu > \approx$ 10 GeV: IHEP Preprint 2006–13. – Protvino, 2006. – p. 5, figs. 3, tables 2, refs.: 12.

Using the data obtained with SKAT bubble chamber, the total yields of $K^+(892)$, $\Sigma^+(1385)$ and Σ^0 are estimated for the first time in neutrino-induced reactions at moderate energy $< E_\nu > = 10.4$ GeV. It is shown, that the recently observed enhancement of the K^0 and Λ yields in νA interactions as compared to νN interactions is contributed only slightly by the $K^+(892)$ and $\Sigma^+(1385)$ production. The contribution of resonances to the K^0 and Λ yields is found to be in qualitative agreement with higher energy ($< E_\nu > \geq 40$ GeV) data. It is shown, that the energy dependence of the $K^+(892)$ mean multiplicity in νN interactions is approximately linear in the range of $< E_\nu > \approx$ 10-60 GeV, while that for Σ^0 in νA interactions ($A =$ 20-21) is approximately logarithmic in the range of $< E_\nu > \approx$ 10-150 GeV.

Аннотация

Агабабян Н.М., Аммосов В.В., Атаян М. и др. Полные выходы $K^+(890)$, $\Sigma^+(1385)$ и Σ^0 в нейтринных реакциях при средней энергии $< E_\nu > \approx$ 10 GeV: Препринт ИФВЭ 2006–13. – Протвино, 2006. – 5 с., 3 рис., 2 табл., библиогр.: 12.

Полные выходы $K^+(892)$, $\Sigma^+(1385)$ и Σ^0 впервые оценены в нейтринных реакциях при средней энергии $< E_\nu > = 10.4$ ГэВ. Показано, что $K^+(892)$ and $\Sigma^+(1385)$ дают малый вклад в недавно наблюденное увеличение выходов K^0 and Λ по сравнению с νN-взаимодействиями. Найдено, что вклад резонансов в выходы K^0 и Λ находится в качественном согласии с данными при более высоких ($< E_\nu > \geq 40$ ГэВ) энергиях. Показано, что энергетическая зависимость средней множественности $K^+(892)$ в νN-взаимодействиях приблизительно линейна в области $< E_\nu > \approx$ 10-60 ГэВ, в то время как для Σ^0 в νA-взаимодействиях ($A =$ 20-21) она приблизительно логарифмическая в области $< E_\nu > \approx$ 10-150 ГэВ.

As it has been shown recently [1,2], the total mean multiplicity of neutral strange particles (K^0, Λ) in neutrinonuclear interactions exceeds noticeably that in νN interactions. As a result, the ratio of yields of strange and non-strange mesons, $R(K^0/\pi^-)$, exhibits a significant A-dependence [2]. While the multiplicity gain for Λ is shown to be dominated by secondary intranuclear processes $\pi N \to \Lambda X$, only a small fraction of that for K^0 can be attributed to secondary reactions $\pi N \to K^0 X$ [2]. In this context, it is interesting to investigate the nuclear medium influence on the total yields of other strange particles, in particular, of Σ^0 hyperon and strange resonances $\Sigma(1385)$ and $K(892)$, in neutrino-induced reactions.

Hitherto, the total yield of Σ^0 is measured only in νA interactions at $A = 20$ [3,4,5] and $A \approx 12$ [6], while those for $\Sigma(1385)$ and $K(892)$ are extracted for νN [7,8,9], as well as for νA interactions at $A \approx 12$ [6]. These studies are performed at relatively high energies, the mean neutrino energy being in the range of $< E_\nu > =$ 40-150 GeV.

In this work, the first attempt is undertaken to estimate the total yields of Σ^0, $\Sigma^+(1383)$ and $K^+(892)$ in neutrino-induced reactions at moderate energies, $< E_\nu > \approx 10$ GeV. To this end, the data from the SKAT bubble chamber [10], filled with a propane-freon mixture, were used (see [2] and references therein). The total number of accepted events with the invariant mass of the hadronic system $W > 1.8$ GeV (exceeding the threshold value for the strange resonance production) was equal to 4888, the corresponding mean neutrino energy being equal to $< E_\nu > 10.4$ GeV. The selection criteria for the decay of neutral strange particles and the procedure of their identification were similar to those applied in [11]. The number of accepted neutral strange particles (V^0's) was 104 out of which 44(60) had the biggest probability to be identified as $K^0(\Lambda)$. The corresponding average multiplicities, corrected for the decay losses, are $< n_{V^0} >= (8.13 \pm 0.80) \cdot 10^{-2}$, $< n_{K^0} >= (4.97 \pm 0.75) \cdot 10^{-2}$ and $< n_\Lambda >= (3.21 \pm 0.41) \cdot 10^{-2}$.

For the further analysis the whole event sample was subdivided, using several topological and kinematical criteria, in the 'quasinucleon' subsample ($A = 1$) and the nuclear subsample, the latter having an effective atomic weight $A \approx 21$ (see [2,12] for details). The mean multiplicities of K^0 and Λ in these subsamples are, respectively, $< n_{K^0} >_N = (3.44 \pm 0.86) \cdot 10^{-2}$, $< n_{K^0} >_A = (5.07 \pm 0.76) \cdot 10^{-2}$ and $< n_\Lambda >_N = (2.19 \pm 0.50) \cdot 10^{-2}$, $< n_\Lambda >_A = (3.33 \pm 0.43) \cdot 10^{-2}$.

The effective mass distributions for systems $\Lambda\gamma$, $\Lambda\pi^+$ and $K^0\pi^+$, plotted in Fig. 1, indicate on signals (being, do to the restricted statistics, of low confidence level) near the masses of, respectively, Σ^0, $\Sigma^+(1385)$ and $K^+(892)$ for the nuclear subsample and of $K^+(892)$ for the 'quasinucleon' subsample. No signals are seen for the systems $\Lambda\gamma$ and $\Lambda\pi^+$ in the 'quasinucleon' subsample (not shown). The dashed curves in Fig. 1 represent the background distributions

obtained by particle combinations from different events of similar topologies and normalized to the experimental distributions outside the signal region. The distribution on the $\Lambda\gamma$ effective mass is corrected for the efficiency of the γ detection. The effective mass resolution for the systems $\Lambda\gamma$, $\Lambda\pi^+$ and $K^0\pi^+$ around the the signal region is equal to, respectively, 40, 58 and 47 MeV. The distributions were fitted as a sum of the fixed background distribution and a Gaussian one (for the case of $\Lambda\gamma$) or a relativistic Breit-Wigner distribution (for the case of $\Lambda\pi^+$ and $K^0\pi^+$) taking into account the experimental mass resolution (see the solid curves in Fig. 1).

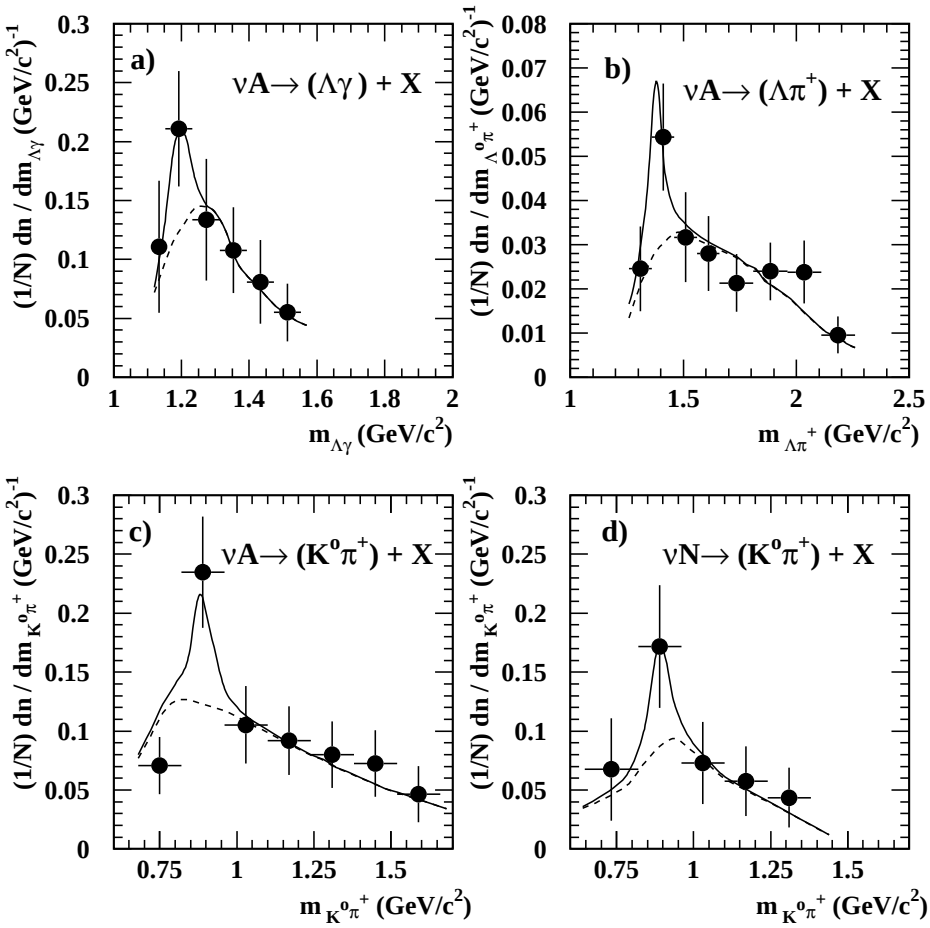

Figure 1. The effective mass distributions for systems $\Lambda\gamma$, $\Lambda\pi^+$ and $K^0\pi^+$.

The extracted mean multiplicities of $K^+(892)$, $\Sigma^+(1385)$ and Σ^0, as well as those for K^0 and Λ, are presented in Table 1. The upper limits of $< n(\Sigma^+(1385) \to \Lambda\pi^+) >_N$ and $< n(\Sigma^0) >_N$ for 'quasinucleon' interactions are estimated by simply subtraction of the normalized background distribution from the experimental one. The last column of Table 1 shows the nuclear multiplicity gain, $\delta_h =< n_h >_A - < n_h >_N$.

Table 1. The mean multiplicities $< n >_N$ and $< n >_A$ of strange particles and the multiplicity gain $< n >_A - < n >_N$ (in 10^{-2}).

Particle	$< n >_N$	$< n >_A$	$< n >_A - < n >_N$
K^0	3.44±0.86	5.07±0.76	1.63±0.86
$K^+(892) \to K^0\pi^+$	0.88±0.53	1.02±0.48	0.14±0.53
Λ	2.19±0.50	3.33±0.43	1.14±0.48
$\Sigma^+(1385) \to \Lambda\pi^+$	<0.13	0.39±0.21	<0.39±0.21
Σ^0	< 0.53	0.82±0.45	$< 0.82 \pm 0.45$

For the first time, an indication is obtained that this gain for resonances, $\delta_{K^+(892)}$ and $\delta_{\Sigma^+(1385)}$, plays only a minor role in that for daugther particles, being significantly smaller than δ_{K^0} and δ_Λ, respectively.

The decay contribution to the mean multiplicities of K^0 and Λ is quoted in Table 2 and compared with the available data [3,4,5,6,7,8,9] in Fig. 2. The data of Fig. 2 do not indicate on a noticeably energy or A- dependences for the ratios $R(K^+(892)/K^0)$ and $R(\Sigma^0/\Lambda)$ which are more or less consistent with averaged values 0.16±0.01 and 0.09±0.02, respectively (see dashed lines in Figs. 2a and 2c), while the data on $R(\Sigma^+(1385)/\Lambda)$ demonstrate larger discrepancy, mainly due to the value at $< E_\nu > = 45$ GeV for $A \approx 12$ [6].

Table 2. The decay contribution to the mean multiplicities of K^0 and Λ.

Ratio	νN	νA
$K^+(892)/K^0$	0.26±0.17	0.20±0.10
$\Sigma^+(1385)/\Lambda$	<0.08	0.11±0.06
Σ^0/Λ	< 0.18	0.24±0.14

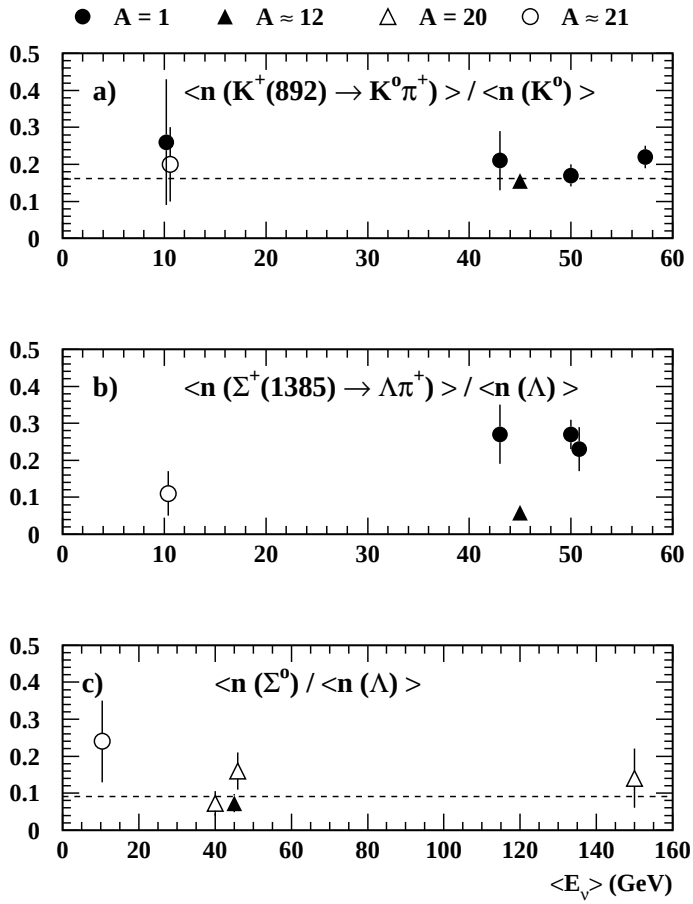

Figure 2. The E_ν-dependence of the decay contribution to the total yields of K^0 and Λ.

The energy dependence of $< n(K^+(892)) >_N$ (corrected for the decay mode $K^+(892) \to K^+\pi^0$) and $< n(\Sigma^0) >_A$ (at $A \approx$ 20-21) is plotted in Fig. 3. As it is seen, the data on $< n(K^+(892)) >_N$ in the energy range $< E_\nu > \approx = 10-60$ GeV can be described by a linear dependence $< n(K^+(892)) >_N = b \cdot (< E_\nu > - E_\nu^{thr})$ with $b = (1.12 \pm 0.12) \cdot 10^{-3}$/GeV, while the energy rise of $< n(\Sigma^0) >_A$, being much weaker, is consistent, in the range of $< E_\nu > \approx = 10-150$ GeV, with a logarithmic dependence, $< n(\Sigma^0) >_A = a \cdot \ln(< E_\nu > / E_\nu^{thr})$ with $a = (2.60 \pm 0.56) \cdot 10^{-3}$, where E_ν^{thr} is the threshold neutrino energy for the corresponding resonance production.

In conclusion, the total yields of $K^+(892)$, $\Sigma^+(1385)$ and Σ^0 are estimated for the first time in neutrino-induced reactions at moderate energies ($< E_\nu > \approx 10$ GeV). The contribution from the decay of those particles to the yields of K^0 and Λ is found to be rather small, being in a qualitative agreement with other, higher energy ($< E_\nu > \geq 40$ GeV) data. It is shown, that only a small fraction of the nuclear enhancement of the K^0 and Λ yields (observed recently in [1,2]), $< n_K^0 >_A - < n_K^0 >_N$ and $< n_\Lambda >_A - < n_\Lambda >_N$, respectively, can be contributed by the $K^+(892)$ and $\Sigma^+(1385)$ production. It is shown, that in a wide energy range, the energy dependence of $< n(K^+(892)) >_N$ in νN interactions is approximately linear, while that of $< n(\Sigma^0) >_A$ in νA interactions (for $A \approx$ 20-21) is consistent with the logarithmic one.

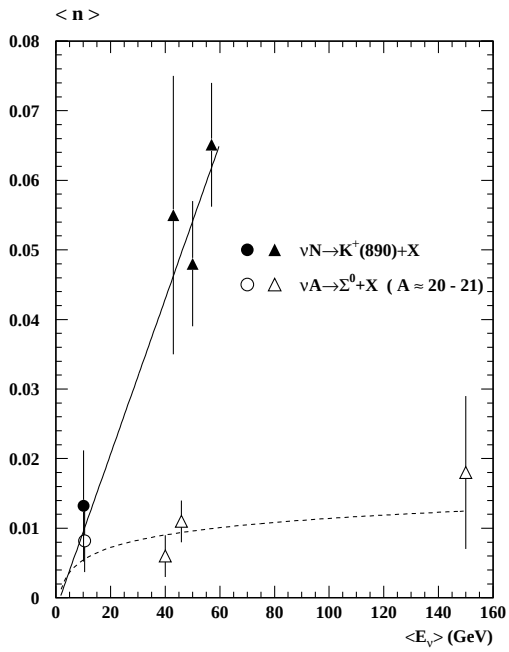

Figure 3. The E_ν-dependence of $< n(K^+(892)) >_N$ and $< n(\Sigma^0) >_A$ for $A \approx$ 20-21.

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