STATE RESEARCH CENTER OF RUSSIA

INSTITUTE FOR HIGH ENERGY PHYSICS

IHEP 96-36

V.A.Bezzubov, S.V.Golovkin, A.G.Kholodenko, A.P.Kozhevnikov, V.P.Kubarovsky, A.I.Kulyavtzev, V.F.Kurshetsov, L.G.Landsberg, M.Yu.Matveev, V.V.Molchanov, V.A.Mukhin, V.I.Solyanik, D.V.Vavilov, V.A.Victorov

Institute for High Energy Physics, Protvino, Russia

G.K.Kliger, V.Z.Kolganov, G.S.Lomkatzi, A.F.Nilov, V.T.Smolyankin

Institute of Theoretical and Experimental Physics, Moscow, Russia

NEW DATA ON THE REACTION $p + N \to [\Sigma^0 K^+] + N$ AT $E_p = 70\,\mathrm{GeV}$

The SPHINX Collaboration (IHEP-ITEP)

The contribution talk at the International Conference PANIC-96 (22-28 May, 1996, Williamsburg, VA, USA, presented by L.G.Landsberg)

Protvino 1996

UDK 539.12.142 М–24

Abstract

Bezzubov V.A. et al. New data on the reaction $p + N \to [\Sigma^0 K^+] + N$ at $E_p = 70\,\mathrm{GeV}$: IHEP Preprint 96-36. – Protvino, 1996. – p. 12, figs. 10, refs.: 24.

New data for the coherent diffractive reaction $p + C \to [\Sigma^0 K^+] + C$ at $E_p = 70\,\mathrm{GeV}$ have been obtained with the modernized SPHINX setup. These data are in a good agreement with our previous results for the reaction under study. In the summed up mass spectrum $M(\Sigma^0 K^+)$ some structure in the threshold region with mass $\sim 1810\,\mathrm{MeV}$ and strong $X(2000)$ peak with $M = 1996 \pm 7\,\mathrm{MeV}$ and $\Gamma = 99 \pm 21\,\mathrm{MeV}$ are clearly seen. The unusual features of the massive $X(2000)$ state (small enough decay width, anomalously large branching ratios for decay channels with strange particles emission) make it a very serious candidate for cryptoexotic pentaquark baryon with hidden strangeness $|qqqs\bar{s}\rangle$. We also present new information about a narrow threshold structure with $M \sim 1810\,\mathrm{MeV}$ and new data for $M(\Sigma^0 K^+)$ and $M(p\eta)$ spectra in the reactions $p+N \to [\Sigma^0 K^+]+N$ and $p+N \to [p\eta]+N$ in nonperipheral region with $P_T^2 > 0.3\,\mathrm{GeV}^2$.

Аннотация

Беззубов В.А. и др. Новые данные о реакции $p + N \to [\Sigma^0 K^+] + N$ при $E_p = 70\,\text{ГэВ}$: Препринт ИФВЭ 96-36. – Протвино, 1996. – 12 с., 10 рис., библиогр.: 24.

В опытах с модернизированной установкой СФИНКС получены новые данные о дифракционной когерентной реакции $p + C \to [\Sigma^0 K^+] + C$ при энергии протонов $E_p = 70\,\text{ГэВ}$. Эти данные хорошо согласуются с нашими прежними результатами для исследуемой реакции. В суммарном массовом спектре $M(\Sigma^0 K^+)$ помимо околопороговой структуры с массой $M \sim 1810\,\text{МэВ}$ доминирует четкий $X(2000)$-пик с параметрами $M = 1996 \pm 7\,\text{МэВ}$ и $\Gamma = 99 \pm 21\,\text{МэВ}$. Необычные свойства этого массивного $X(2000)$-состояния (сравнительно малая распадная ширина, аномально большая вероятность для распадных каналов с испусканием странных частиц) делают его очень серьезным кандидатом в криптоэкзотический пятикварковый барион со скрытой странностью $|qqqs\bar{s}\rangle$. Представлены также новая информация о свойствах узкой околопороговой структуры с $M \sim 1810\,\text{МэВ}$ и новые данные о массовых спектрах $M(\Sigma^0 K^+)$ и $M(p\eta)$ в реакциях $p + N \to [\Sigma^0 K^+] + N$ и $p + N \to [p\eta] + N$ в непериферической области с $P_T^2 > 0.3\,\text{ГэВ}^2$.

Introduction

An extensive research program of studying the diffraction hadron production by protons with energy $E_p = 70\,\mathrm{GeV}$ and the search for cryptoexotic pentaquark baryons with hidden strangeness $B_\phi = |qqqs\bar{s}\rangle$ (here $q = u; d$ quarks) is carried out in the experiments of the SPHINX Collaboration. This program was detailed in reviews [1].

Cryptoexotic B_ϕ baryons do not have external exotic quantum numbers and their complicated internal valence structure can be established only indirectly, by examining their unusual dynamical properties which are quite different from the properties of ordinary $|qqq\rangle$ isobars. These anomalous features are as follows (see review papers [1] for more details):

1. The main OZI allowed decay modes of B_ϕ baryons to be the ones with strange particles in the final states (for ordinary isobars such decays have branching ratios at the percent level).
2. Cryptoexotic B_ϕ baryons can combine heavy enough mass values (M $> 1.8 \div 2.0\,\mathrm{GeV}$) with narrow enough decay widths ($\Gamma \leq 50 \div 100\,\mathrm{MeV}$). This is due to a complicated internal color structure of these baryons with significant quark rearrangement of color clusters in the decay processes and a limited phase space for OZI allowed $B \to YK$ decays. At the same time typical decay widths of well established $|qqq\rangle$ isobars in this mass region are of the order of $\Gamma \geq 300\,\mathrm{MeV}$.

As was emphasized in a number of papers [1–5], diffractive production processes with the Pomeron exchange offer new possibilities in the search for exotic hadrons. Originally these possibilities were associated with a model of Pomeron with small cryptoexotic $(qq\bar{q}\bar{q})$ component [2, 3]. In modern notions Pomeron is a multigluon system which permits exotic hadron production in gluon-rich diffractive processes.

The Pomeron exchange mechanism in diffractive production reactions can induce coherent processes on the target nucleus. In such processes the nucleus acts as a discrete unit. Coherent processes can be easily identified from the events distribution in the transverse momentum of the final state particle system. They manifest themselves as diffractive peaks with large values of the slope parameters determined by the size of the nucleus: $\mathrm{d}N/\mathrm{d}P_{\mathrm{T}}^2 \simeq \exp(-bP_{\mathrm{T}}^2)$, where $b \simeq (8\div10)A^{2/3}\,\mathrm{GeV}^{-2}$. Owing to the difference in the absorption of single-particle and multiparticle objects in nuclei, coherent processes could serve as an effective tool for the separation of resonance against multiparticle nonresonant background (see, for example, Ref. [7]). This suggestion can be illustrated schematically by Fig. 1.

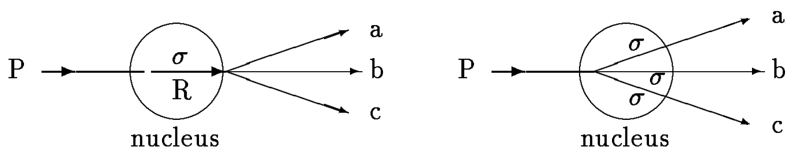

Fig. 1. Schematic illustration of the coherent suppression of nonresonance multiparticle background in the reactions $p + (Nuclei) \to R + (Nuclei), R \to a + b + c$ (resonance production) and $p + (Nuclei) \to [abc] + (Nuclei)$ (nonresonance background) due to the difference in the resonance and background absorption in the target nuclei. As a result of this coherent suppression it is possible to conclude that $\frac{\sigma_{\mathrm{coh}}(\mathrm{resonance})}{\sigma_{\mathrm{coh}}(\mathrm{background})} > \frac{\sigma_{\mathrm{noncoh}}(\mathrm{resonance})}{\sigma_{\mathrm{noncoh}}(\mathrm{background})}$.

The studies of several proton induced diffractive production processes of $p + N \to Y^0K^+ + N$ type as well as $p + N \to pK^+K^- + N$, $p + N \to pp\bar{p} + N$, $p + N \to p\pi^+\pi^-\pi^0 + N$ and some other reactions were performed in the experiments of the SPHINX collaboration with 70 GeV proton beam and polyethylene target. The SPHINX facility, which is used in these measurements, includes a wide-aperture magnetic spectrometer with scintillation counter hodoscopes, proportional chambers, drift chambers and multichannel γ-spectrometer with lead glass total absorption detectors. The charged particles in the final state were identified by means of a RICH differential Cherenkov spectrometer and two threshold gas multicell Cherenkov counters C_1 and C_2. The detailed description of the apparatus is available in Ref. [8].

As is seen from $\mathrm{d}N/\mathrm{d}P_{\mathrm{T}}^2$ plots for all the above mentioned processes there are strong narrow forward cones in these distributions with the slope $b \geq 30\div40\,\mathrm{GeV}^{-2}$, which correspond to coherent diffractive production reactions on carbon nuclei. For the isolation of the coherent production events the "soft" or "stringent" cuts in P_{T}^2 can be used:

1. The soft transverse momentum cut $P_{\mathrm{T}}^2 < 0.075\div0.1\,\mathrm{GeV}^2$; with soft cut the noncoherent background among the selected events may be as large as 30÷40%.
2. The stringent transverse momentum cut $P_{\mathrm{T}}^2 < 0.02\,\mathrm{GeV}^2$; with this cut the noncoherent background constitutes no more than 8÷10% of the selected events. The price for this low noncoherent background is a partial reducing of the coherent reaction statistics.

The data for all diffractive and coherent reactions mentioned above were used for the thorough searches for new baryon states and, primarily, some candidates for cryptoexotic baryons with hidden strangeness [8–18].

1. Previous data on the coherent diffractive reaction $p + C \to [\Sigma^0 K^+] + C$

One of the main results, obtained at the SPHINX setup was connected with the study of $(\Sigma^0 K^+)$ system in the coherent diffractive reaction

$$p + C \;\to\; [\Sigma^0 K^+] + C \qquad (1)$$
$$\hookrightarrow \Lambda\gamma$$
$$\hookrightarrow p\pi^-$$

(see [13, 15–18]). Reaction (1) was separated during the study of the events with Λ hyperon, K^+ meson and single photon in the final states for diffractive proton dissociation.

The effective mass spectrum of $\Lambda\gamma$ system for these events is shown in Fig. 2. The peak of $\Sigma^0 \to \Lambda\gamma$ decay in this spectrum is clearly seen. Thus, reaction (1) is identified and coherent events are singled out using P_T^2 distribution.

The effective mass spectrum $M(\Sigma^0 K^+)$ for coherent reaction (1) with $P_T^2 < 0.1\,\mathrm{GeV}^2$ is presented in Fig. 3. In this spectrum besides some small structure with $M \sim 1800\,\mathrm{GeV}$ in the threshold region, a strong peak $X(2000)$ is clearly observed. The main parameters of $X(2000)$ structure are:

$$\left.\begin{array}{l} M = 1997 \pm 7\,\mathrm{MeV}; \\ \Gamma = 91 \pm 17\,\mathrm{MeV}; \\ \text{statistical C.L. of the peak is 7 s.d.} \end{array}\right\} \qquad (2)$$

Such shape of mass spectrum $\Sigma^0 K^+$ (with additional structure in the threshold region) shows that $X(2000)$ peak can not be explained by nonresonant Deck-type diffractive singularity. It seems that this peak has a resonant nature.

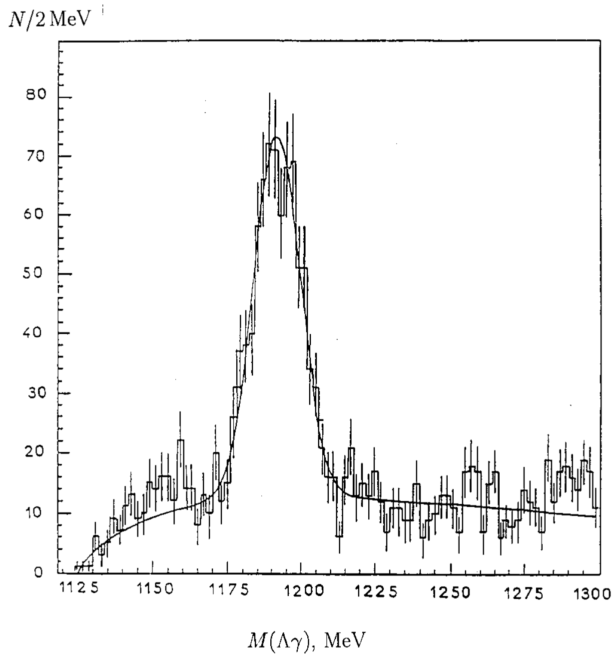

Fig. 2. The separation of the reaction $p+N \to [\Sigma^0 K^+] + N$ in the study of invariant mass spectrum $M(\Lambda\gamma)$ in the reaction $p+N \to \Lambda\gamma K^+ + N$ (old data from the SPHINX setup — see [13,16,17]).

For the searches of other decay channels for $X(2000)$ baryon state the simultaneous analysis of the SPHINX data on the coherent reactions

$$p + \mathrm{C} \;\to\; p\pi^+\pi^- + \mathrm{C} \qquad (3)$$
$$\;\to\; \Delta(1232)^{++}\pi^- + \mathrm{C} \qquad (4)$$

has been performed together with (1) and under the same kinematical conditions. Preliminary data on the reaction of $[\Delta(1232)^{++}\pi^-]$ production were obtained in our previous work [10]. The diffractive production of some isobar-like structures with mass $\approx 1460\,\mathrm{MeV}$ and $\approx 1715\,\mathrm{MeV}$ were clearly seen in these data.

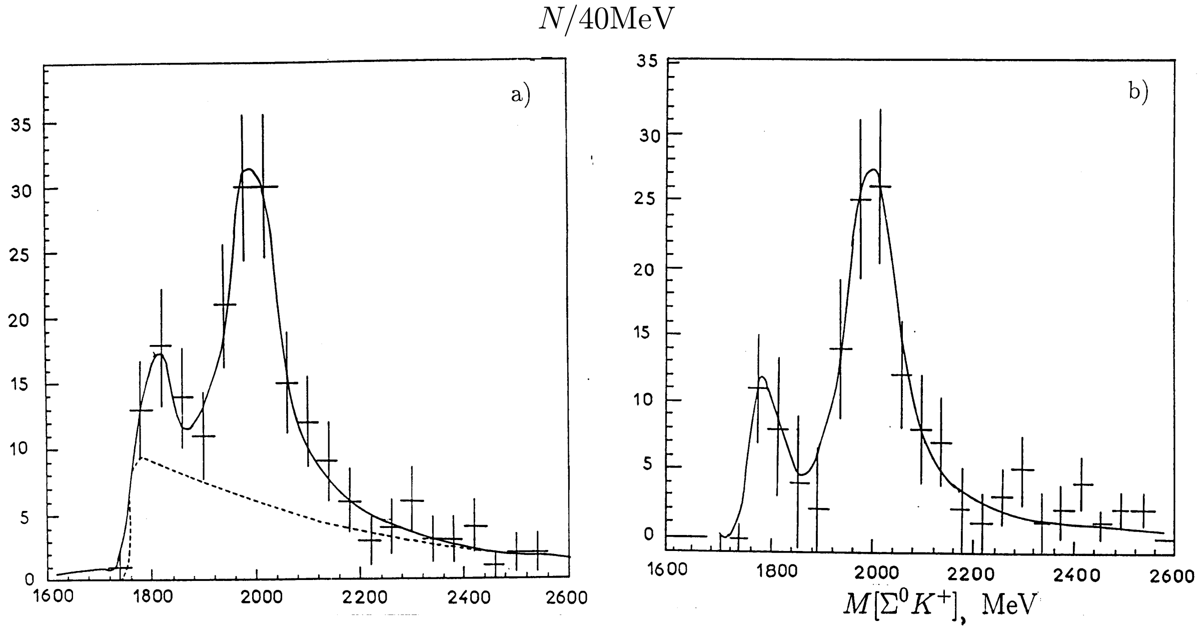

Fig. 3. The effective mass spectra $M(\Sigma^0 K^+)$ in the coherent reaction (1) ($P_{\mathrm{T}}^2 < 0.1\,\mathrm{GeV}^2$): a) for all the events in „Σ^0-band" on Fig.2; b) after side band subtraction of the background under Σ^0-peak on Fig.2 (old data from SPHINX setup — see details in Ref. [17]).

But in the mass region of $X(2000)$ state there are no such structures in all mass spectra of $M(p\pi^+\pi^-)$ and $M[\Delta(1232)^{++}\pi^-]$ in reactions (3) and (4). The lower limits for the ratios of the corresponding decay branchings were estimated to be (with 95% C.L.):

$$\mathrm{R}_1 = \frac{\mathrm{BR}\{X(2000)^+ \to [\Sigma K]^+\}}{\mathrm{BR}\{X(2000)^+ \to p\pi^+\pi^-\}} > 7.8 \qquad (5)$$

$$\mathrm{R}_2 = \frac{\mathrm{BR}\{X(2000)^+ \to \Sigma^0 K^+\}}{\mathrm{BR}\{X(2000)^+ \to p\pi^+\pi^-\}} > 2.6 \qquad (6)$$

$$\mathrm{R}_3 = \frac{\mathrm{BR}\{X(2000)^+ \to [\Sigma K]^+\}}{\mathrm{BR}\{X(2000)^+ \to [\Delta(1232)\pi]^+\}} > 0.83 \qquad (7)$$

Here the isotopic relations for the decays of $X(2000)$ baryon with isotopic spin $I = \frac{1}{2}$ were used (this state belongs to isodoublet because it is produced in the diffractive dissociation of proton).

The ratios R_1–R_3 for $X(2000)$ decays on strange and nonstrange particles are much larger than the same ratios for the decays of usual (qqq)-isobars [19].

The small enough width of $X(2000)$ baryon state as well as the anomalously large branching ratios for their decay channels with strange particles (large values of R_1–R_3) are the reasons to consider this state as serious candidate for the cryptoexotic baryon with hidden strangeness $|\, uuds\bar{s}\rangle$.

Below in this paper we present new data on reaction (1) obtained on the modernized SPHINX spectrometer.

2. The upgrade of the SPHINX setup

The SPHINX setup now is completely upgrading. This upgrading program includes a new tracking system with proportional chambers and drift tubes, a new γ-spectrometer, new electronic and trigger systems, new DAQ and on-line computers. When this modernization is finished, the SPHINX apparatus will have a possibility to work with higher intensity and with greatly increased number of recorded trigger events per the burst of accelerator (up to $2-3\cdot 10^3$ events/burst instead of $3\cdot 10^3$ events/burst, which are available now with the existing DAQ).

As the first part of this upgrading program we attained several refinements:

1. The new γ-spectrometer with $39 \times 27 = 1052$ lead glass counters with dimensions $5 \times 5 \times 42\,\mathrm{cm}^3$ instead of old γ-spectrometer [8] with 320 lead glass counters with dimensions $10 \times 10 \times 38\,\mathrm{cm}^3$ and only 63 counters $5 \times 5 \times 38\,\mathrm{cm}^3$ in the central part of photon detector. The new γ-spectrometer is a modified version of the IHEP IGD γ-spectrometer which was used previously in the EGS experiment at CERN [20].
2. Four additional planes with drift tubes [21] were installed between the threshold Cherenkov multicell counter and γ-spectrometer (see the layout of the SPHINX apparatus in Ref. [12]). In the modernized setup we removed the threshold Cherenkov counter C_2 because of the good identification capability of the Cherenkov system with RICH and C_1 detectors.
3. New trigger requirements gave a possibility to detect $\Lambda \to p\pi^-$ on the decay path $L \approx 300\,\mathrm{cm}$ (instead of $L \approx 30\,\mathrm{cm}$ in the previous runs).

As a result of all these modifications we significantly increased the efficiency and purity of Λ detection and obtained much better possibilities to identify photons in a new γ-spectrometer and to reduce the background connected with hadron showers and lost photons. This is especially important for identification of single photons (for example, in the radiative decays $\Sigma^0 \to \Lambda\gamma$). To illustrate these new possibilities we present on Figs. 4 and 5 the old and new data for identification of Λ in the reaction $p + N \to \Lambda K^+ + N, \Lambda \to p\pi^-$ and on Fig. 6 new data for the identification of Σ^0 in the reaction $p+N \to \Sigma^0 K^+ + N, \Sigma^0 \to \Lambda\gamma$ (old data for Σ^0 see on Fig. 2). It is clear from these pictures that with the partially modernized SPHINX setup we have much better conditions for the separation reactions with Λ and Σ^0 hyperons to compare with old data on these processes.

3. New data for reaction $p + C \to [\Sigma^0 K^+] + C$ in a special run with the partially modernized SPHINX spectrometer

During the study of reaction $p + N \to [\Lambda\gamma K^+] + N$ in the special testing run with the partially modernized SPHINX spectrometer the processes with $(\Sigma^0 K^+)$ system were clearly identified (Fig. 6). The background level under the Σ^0 peak is quite small. This fact simplifies the selection of reactions under study because there is no need for the background subtraction procedure in this case.

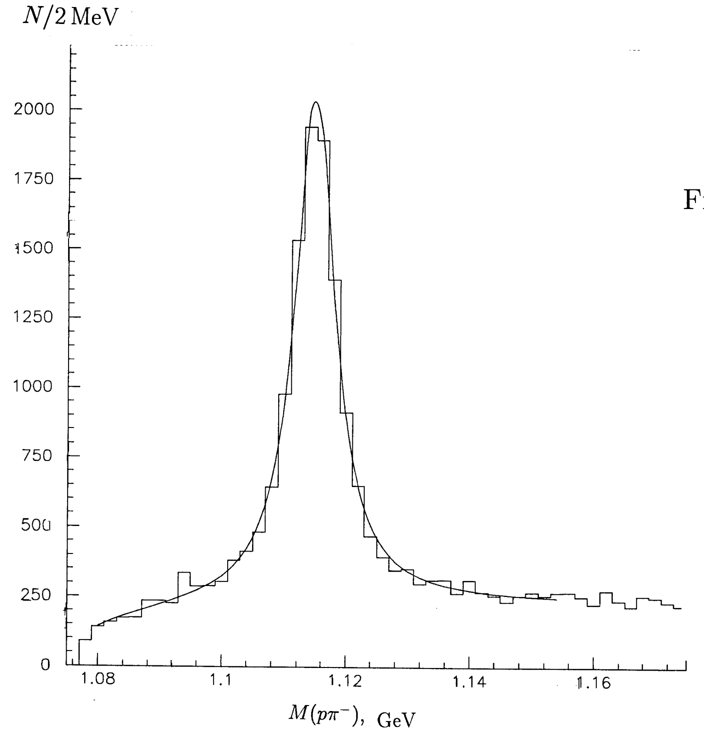

Fig. 4. The separation of the reaction $p + N \to [\Lambda K^+] + N$ in the study of the invariant mass spectrum $M(p\pi^-)$ in the reaction $p + N \to [p\pi^- K^+] + N$ at the old version of the SPHINX setup with decay path for $\Lambda \to p\pi^-$ $L \approx 30\,\text{cm}$. Here it was impossible to separate the interaction vertexes and decay vertexes.

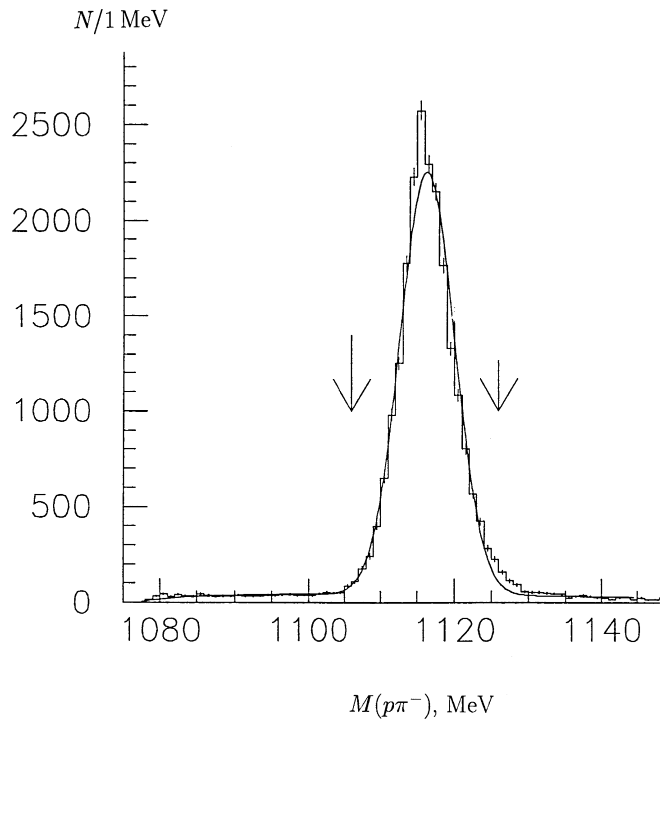

Fig. 5. The separation of the reaction $p + N \to [\Lambda K^+] + N$ in the study of the reaction $p + N \to [p\pi^- K^+] + N$ at the modernized version of the SPHINX setup with decay path for $\Lambda \to p\pi^-$ $L \approx 300\,\text{cm}$ and with a good identification of the Λ-decay vertexes. The background under Λ-peak in $M(p\pi^-)$ is significantly reduced to compare with $M(p\pi^-)$ on Fig.4.

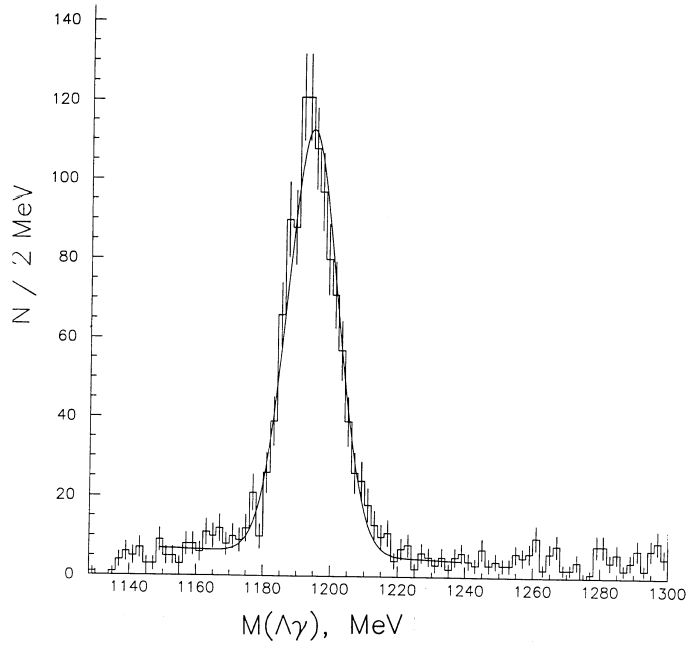

Fig. 6. The separation of the reaction $p + N \to [\Sigma^0 K^+] + N$ in the study of invariant mass spectrum $M(\Lambda\gamma)$ in the reaction $p + N \to \Lambda\gamma K^+ + N$ at the modernized version of the SPHINX setup with the better identification of $\Lambda \to p\pi^-$ decays and single photons in a new γ-spectrometer. The background under Σ^0-peak in $M(\Lambda\gamma)$ is significantly reduced to compare with $M(\Lambda\gamma)$ on Fig.2.

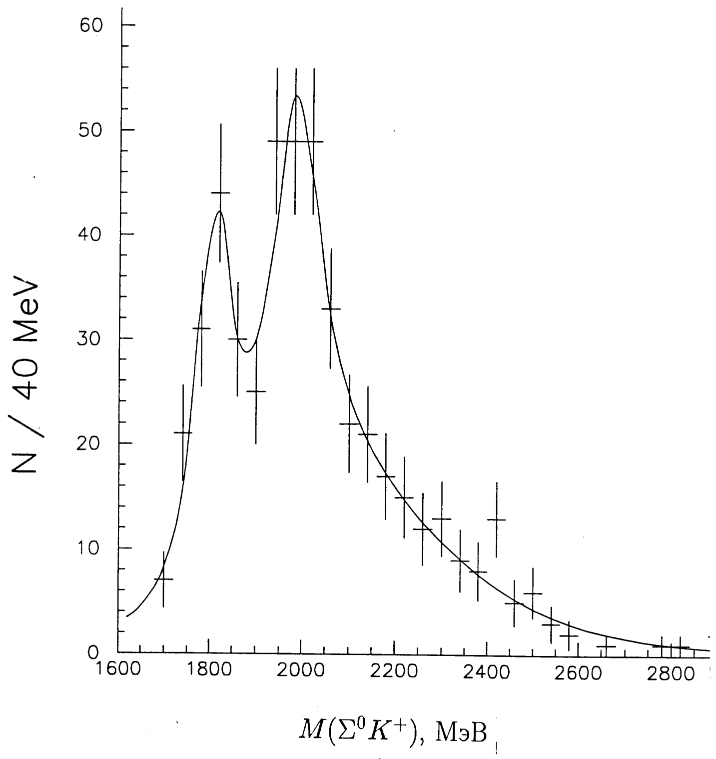

Fig. 7. The invariant mass spectrum $M(\Sigma^0 K^+)$ in the coherent reaction (1) in a special run with the modernized SPHINX setup ($P_T^2 < 0.1\,\mathrm{GeV}^2$). Because of the low value of background under Σ^0-peak in Fig.6, there was no background subtraction in $M(\Sigma^0 K^+)$. The results on $M(\Sigma^0 K^+)$ in this run are in good accordance with old data [13,16,17] — see Fig.3.

To separate the coherent reaction (1) we used a soft cut in transverse momenta $P_T^2 < 0.1\,\mathrm{GeV}^2$, as it was done with the old data. The new effective mass spectrum $M(\Sigma^0 K^+)$ for this coherent reaction is presented on Fig. 7. This spectrum is in a good agreement with the data on Fig. 3: besides some threshold structure with $M \sim 1800\,\mathrm{MeV}$ there is again the strong peak of $X(2000)$ state. The summary data of old and new expositions are presented on Fig. 8. We also used the sum of the data on Fig. 3a (unsubtracted mass spectrum) and Fig. 7 and obtained practically the same results. From the summed $M(\Sigma^0 K^+)$ effective mass spectra the averaged parameters of $X(2000)$ structure are

$$\left.\begin{array}{l} M = 1996 \pm 7\,\mathrm{MeV}; \\ \Gamma = 99 \pm 21\,\mathrm{MeV}; \\ \text{statistical C.L. of the peak} > 10\text{ s.d.} \end{array}\right\} \quad (8)$$

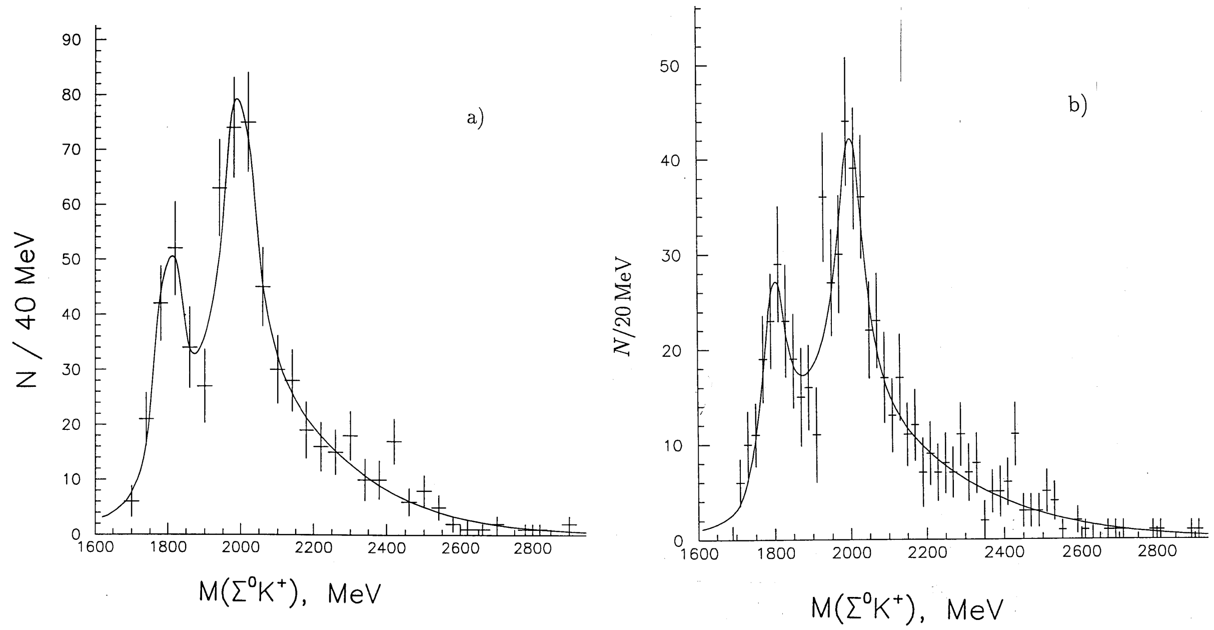

Fig. 8. The summed mass spectra $M(\Sigma^0 K^+)$ from the data on Fig.3b and Fig.7: a) with the mass bins $\Delta M(\Sigma^0 K^+) = 40\,\mathrm{MeV}$; parameters of the $X(2000)$ peak are $M = 1995 \pm 7\,\mathrm{MeV}$ and $\Gamma = 103 \pm 19\,\mathrm{MeV}$; b) with the mass bins $\Delta M(\Sigma^0 K^+) = 20\,\mathrm{MeV}$; parameters of the $X(2000)$ peak are $M = 2001 \pm 7\,\mathrm{MeV}$ and $\Gamma = 88 \pm 25\,\mathrm{MeV}$.

It is quite important to stress that the old and new data for coherent diffractive reaction (1) were obtained under different experimental conditions, with serious modifications in the setup, with different background and systematics. In spite of all these, the main results of studying the $M(\Sigma^0 K^+)$ effective mass spectra are in a good agreement between themselves, which increases our confidence in their correctness.

The increased statistics in the mass spectra $M(\Sigma^0 K^+)$ on Fig. 7 gave us a possibility for a more thorough study of the influence of stringent P_T^2 cuts on the form of these mass spectra. These cuts may reduce noncoherent background and more clearly single out the coherent process (1). As it was seen before [13, 17] more stringent P_T^2 cuts do not change significantly the form of $X(2000)$ peak. But quite unexpectedly we find their strong influence on the properties of the threshold structure with $M \sim 1800\,\mathrm{MeV}$. As is seen from Fig. 9, this structure is produced only in the region of very small P_T^2. For $P_T^2 < 0.01\,\mathrm{GeV}^2$ it is observed quite clear and has parameters

$$\left.\begin{array}{l} M = 1812 \pm 7\,\mathrm{MeV} \\ \Gamma = 56 \pm 16\,\mathrm{MeV} \end{array}\right\}. \quad (9)$$

These peculiar properties of the threshold structure are not very well understood now and need further study with enlarged statistics and in different experimental conditions (for example, in the coherent processes with heavier nuclei).

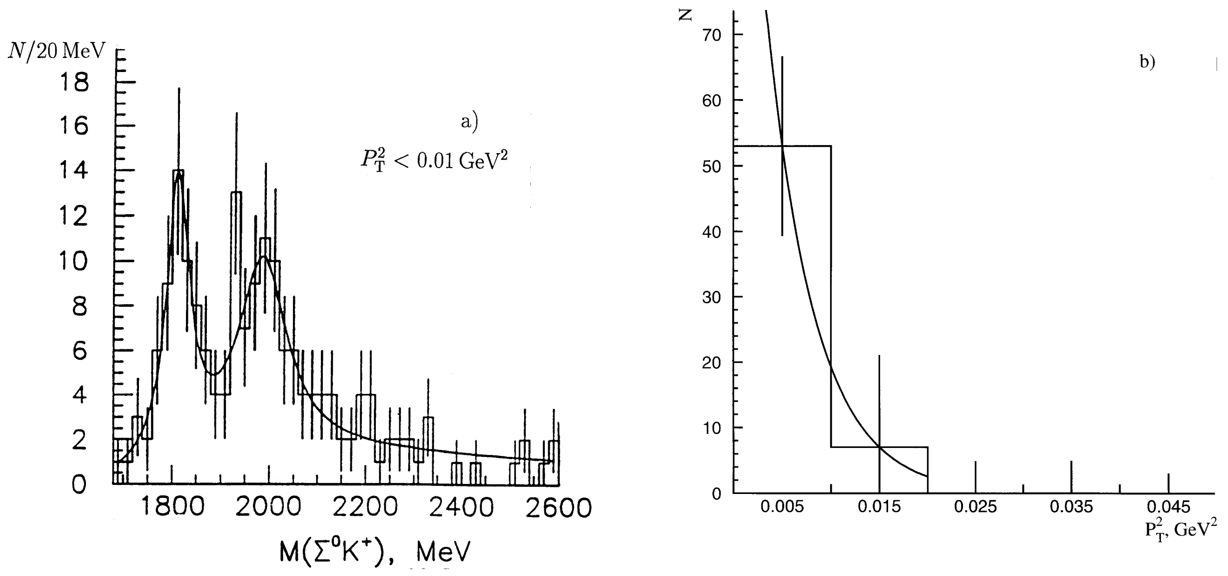

Fig. 9. Study of the narrow threshold structure in the mass spectra $M(\Sigma^0 K^+)$ in the coherent reaction (1) (in the data at the modernized SPHINX setup): a) the invariant mass spectrum $M(\Sigma^0 K^+)$ for $P_T^2 < 0.01\,\mathrm{GeV}^2$. The threshold structure with $M = 1812 \pm 7\,\mathrm{MeV}$ and $\Gamma = 56 \pm 16\,\mathrm{MeV}$ is clearly seen; b) the P_T^2 dependence for this threshold structure.

4. First data for the proton diffractive-like production reactions in a nonperipheral domain

As was discussed above the coherent diffractive production reactions seem to be quite promising processes for the study of exotic hadrons. But, certainly, this method is not unique for the exotics searches. For some states (and especially for those that are formed at small distances) the nonperipheral processes can be the most effective for their production. In these cases the best conditions for the exotic hadron searches can be obtained in the region of large enough or intermediate transverse momenta (with $P_T^2 > 0.3 - 0.5\,\mathrm{GeV}^2$), where the background from peripheral processes is strongly reduced. For example, in the study of the charge-exchange reactions $\pi^- p \to \eta\eta + \Delta^0$ and $\pi^- p \to \eta\eta' + n$, after the selection of events with $P_T^2 \geq 0.3\,\mathrm{GeV}^2$, unusually narrow meson states $X(1740) \to \eta\eta$ [22] and $X(1910) \to \eta\eta'$ [23] were observed. These anomalous states are good candidates for cryptoexotic mesons. A mechanism of multiple rescattering with the Pomeron exchange (a gluon rich process) may explain the $X(1740)$ and $X(1910)$ production [24].

The search for new baryons for large P_T^2 domain in proton induced diffractive-like reactions also seems quite interesting [1]. Here we present the first and very preliminary results obtained for the effective mass spectra $M(\Sigma^0 K^+)$ and $M(p\eta)$ for $P_T^2 > 0.3\,\mathrm{GeV}^2$ in reactions

$$p + N \;\to\; [\Sigma^0 K^+] + N \qquad (10)$$
$$\hookrightarrow \Lambda\gamma$$

and

$$p + N \;\to\; [p\eta] + N \qquad (11)$$
$$\hookrightarrow \pi^+\pi^-\pi^0$$

(for the last reaction see our Ref. [18]). On Fig. 10a the sum data of old and new expositions for reaction are given (10). Fig. 10b shows the data of old exposition for reaction (11). In spite of quite limited statistics, the structures with mass $M \approx 2350\,\mathrm{MeV}$ and $\Gamma \sim 60\,\mathrm{MeV}$ are clearly seen on these two mass spectra. They need further investigation in future experiments with enlarged statistics.

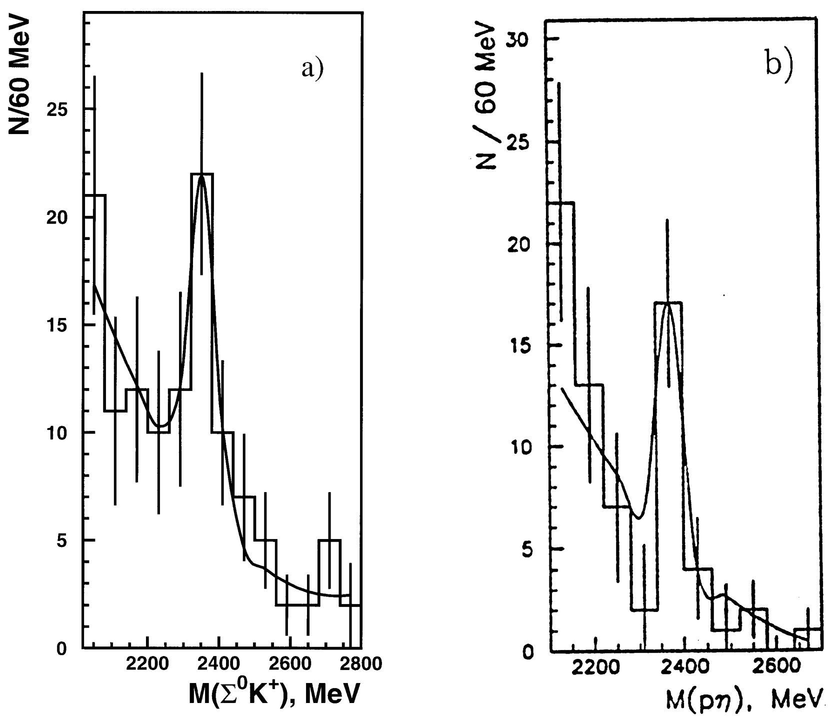

Fig. 10. a) The invariant mass spectrum in the reaction $p + N \to [\Sigma^0 K^+] + N$ (9) at $P_T^2 > 0.3\,\mathrm{GeV}^2$ (summed data of old and new runs); b) The invariant mass spectrum in the reaction $p + N \to [p\eta] + N$ (10) at $P_T^2 > 0.3\,\mathrm{GeV}^2$ (old data — see [18]). In these two spectra in nonperipheral regions of (9) and (10) some narrow structure with $M \sim 2350\,\mathrm{MeV}$ and $\Gamma \sim 60\,\mathrm{MeV}$ is seen.

Conclusion

New data for the coherent diffractive production reaction (1) were obtained with the partly upgraded SPHINX setup (with the new γ-spectrometer and with better possibilities for the detection of $\Lambda \to p\pi^-$ and $\Sigma^0 \to \Lambda\gamma$ decays). These new data are in a good agreement with our previous results for the $M(\Sigma^0 K^+)$ mass spectra in this coherent reaction [13, 16, 17].

The strong $X(2000)$ peak with $M = 1996 \pm 7\,\mathrm{MeV}$ and $\Gamma = 99 \pm 21\,\mathrm{MeV}$ together with some narrow threshold structure (with $M \sim 1810\,\mathrm{MeV}$ and $\Gamma \sim 60\,\mathrm{MeV}$ are clearly observed in these mass spectra. The last structure is produced in the region of very small transverse momenta $P_{\mathrm{T}}^2 < 0.01 - 0.02\,\mathrm{GeV}^2$. The unusual properties of $X(2000)$ baryon state (small enough decay width, anomalously large branching ratio for decays with strange particles emission) makes this state a very serious candidate for cryptoexotic pentaquark baryon with hidden strangeness ($|qqqs\bar{s}\rangle$). First results for the proton diffractive-like production reactions in a nonperipheral region (with $P_{\mathrm{T}}^2 > 0.3\,\mathrm{GeV}^2$) were also obtained in reaction (10) (in old and new data) and in (11). In spite of the limited statistics some evidences for a narrow massive structure with $M \sim 2350\,\mathrm{MeV}$ and $\Gamma \sim 60\,\mathrm{MeV}$ was observed in the mass spectra $M(\Sigma^0 K^+)$ and $M(p\eta)$ in both reactions. We hope to obtain a significant increase of statistics in new measurements with the upgraded SPHINX spectrometer.

It is a pleasure for us to express our deep gratitude to B.Grossetete, E.Kistenev, N.Koulberg, L.Montanet, B.Powell, N.Tyurin and C.Voltolini for their inestimable help which gave us a possibility to use the former IGD γ-spectrometer from the EGS experiment in the SPHINX facility.

This work was supported in part by International Science Foundation (Grant JA 2100).

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Received May 13, 1996

В.А.Беззубов и др.
Новые данные о реакции $p + N \to [\Sigma^0 K^+] + N$ при $E_p = 70$ ГэВ.

Оригинал-макет подготовлен с помощью системы LaTeX.
Редактор Е.Н.Горина. Технический редактор Н.В.Орлова.

Подписано к печати 13.05.96. Формат $60 \times 84/8$. Офсетная печать.
Печ.л. 1,5. Уч.-изд.л. 1,15. Тираж 240. Заказ 662. Индекс 3649.
ЛР №020498 17.04.97.

ГНЦ РФ Институт физики высоких энергий
142284, Протвино Московской обл.

Индекс 3649

П Р Е П Р И Н Т 96-36, И Ф В Э, 1996