AB

INSTITUTE FOR HIGH ENERGY PHYSICS

CERN LIBRARIES, GENEVA
P00023325

IHEP 93-5
SW9421

M.Ya.Balatz(2), I.M.Belyaev(2), V.A.Dorofeev(1), G.B.Dzyubenko(2), I.M.Filimonov(3), S.V.Frolov(2), S.V.Golovkin(2), Yu.L.Grishkin(2), M.V.Gritzuk(2), A.D.Kamenskii(2), G.K.Kliger(2), A.P.Kozhevnikov(1), V.Z.Kolganov(2), A.S.Konstantinov(1), Yu.V.Korchagin(1), V.P.Kubarovskii(1), N.Yu.Kulman(1), A.I.Kulyavtsev(1), V.F.Kurshetsov(1), A.E.Kushnirenko(1), V.S.Lakaev(2), L.G.Landsberg(1), G.S.Lomkatzi(2), V.V.Molchanov(1), V.A.Mukhin(1), A.P.Nilov(2), Yu.B.Novoghilov(1), O.I.Pogorelko(2), A.V.Skleznev(1), V.T.Smolyankin(2), V.I.Solyanik(1), D.V.Vavilov(1), V.A.Victorov(1), V.E.Vishnyakov(2), O.A.Zemskov(2)

SEARCH FOR HEAVY PENTAQUARK EXOTIC BARYONS WITH HIDDEN STRANGENESS IN THE REACTIONS $p + N \to (p\phi) + N$ AND $p + N \to [\Lambda(1520)K^+] + N$ AT $E_p = 70$ GeV

SPHINX Collaboration (IHEP - ITEP)

(1) Institute for High Energy Physics, Protvino.
(2) Institute of Theoretical and Experimental Physics, Moscow.
(3) Moscow State University, Moscow.

Protvino 1993

UDK 681.3.06.069 M–24

Abstract

Balatz M.Ya., Belyaev I.M., Dorofeev V.A. et al. Search for Heavy Pentaquark Exotic Baryons with Hidden Strangeness in the Reactions $p + N \to (p\phi) + N$ and $p + N \to [\Lambda(1520)K^+] + N$ at $E_p = 70$ GeV: IHEP Preprint 93-5. – Protvino, 1993. – p. 20, figs. 12, tables 2, refs.: 14.

In the experiments at the SPHINX facility on the 70 GeV proton beam of the IHEP accelerator a wide program of studying of the baryon diffractive production and search for exotic baryons in these processes is being carried out. The first data for the reactions $p + N \to (K^+K^-p) + N$, $p + N \to (p\phi) + N$ and $p + N \to$ $\to [\Lambda(1520)K^+] + N$ are presented. The very sensitive upper limits for the cross sections for diffractive production of heavy narrow cryptoexotic baryon resonances with hidden strangeness in the mass region up to 4.5 GeV are obtained.

Аннотация

Балац М.Я., Беляев И.М., Дорофеев В.А. и др. Поиски тяжелых пятикварковых экзотических барионов со скрытой странностью в реакциях $p + N \to (p\phi) + N$ и $p + N \to$ $[\Lambda(1520)K^+] + N$ при энергии E_p=70 ГэВ: Препринт ИФВЭ 93-5. – Протвино, 1993. – 20 с., 12 рис., 2 табл., библиогр.: 14.

В опытах на установке СФИНКС, работавшей на 70 ГэВ протонном пучке ускорителя ИФВЭ, проводится широкая программа исследования дифракционного образования барионных состояний и поисков экзотических барионов в этих процессах. Представлены первые результаты таких исследований для реакций $p + N \to (K^+K^-p) + N$, $p + N \to (p\phi) + N$ и $p + N \to [\Lambda(1520)K^+] + N$. Приводятся очень низкие ограничения для сечений дифракционного образования тяжелых узких криптоэкзотических барионных резонансов со скрытой странностью в области масс вплоть до 4,5 ГэВ.

© Institute for High Energy Physics, 1993.

1. INTRODUCTION

During last several years the search for exotic mesons of different types has led to considerable advance in this field. About two dozens of new states have been observed which don't fit the naive quark model expectations for ordinary mesons with $q\bar{q}$ valence quark structure. These new states are serious candidates for cryptoexotic mesons (multiquark states, glueballs, hybrids). Several candidates for open exotic mesons, e.g. the states with exotic values of their quantum numbers have also been observed . General analysis of the exotic meson problem and corresponding bibliography can be found in several reviews (Refs. [1-5]).

At the same time the situation for exotic baryons practically has not changed at all and is quite far from being optimistic. Up to now the search for baryons with open exotics has yielded no serious results. The searches for cryptoexotic baryons with anomalous dynamical features caused by their complicated internal structure are now at the very beginning. In principle, the exotic baryons of this kind can be looked for in the resonance processes in the direct channel with high precision energy scanning of the cross sections for a number of exclusive reactions (see Ref. [6]). But up to now these measurements have not been performed with necessary precision. The most interesting information in searches of cryptoexotic baryons has been obtained in the study of the production reactions for $p\phi$, Y^*K, $Y\bar{Y}K$, $pK\bar{K}^*\pi$ systems (see Refs. [7-11]). In particular in these measurements several candidates for baryon states with large masses and anomalously narrow decay widths have been observed: $\Sigma(3170)$ [8], [9], $N_\phi(1960)$ [10] and $R(3520)$ [11]. The first one of these states is a candidate for pentaquark strange baryon $|uuss\bar{s}>$ and two others are candidates for 5-quark baryons with hidden strangeness $B_\phi = |udds\bar{s}>$. Searches of B_ϕ baryons in the OZI suppressed reaction of $p\phi$ production in the near threshold region has also been performed [7]. It must be stressed that the processes of the $p\phi$ production, which are OZI suppressed for the nonresonance reactions with ordinary particles, are especially interesting for the search of resonance exotic states with hidden strangeness (see the discussion of this subject in Ref. [1]).

If the strange exotic $\Sigma(3170)$ baryon really exists then one should expect that analogous nonstrange pentaquark baryon with hidden strangeness and with mass around 3 GeV also exists. If the narrow exotic U and M_ϕ mesons [12,13] with mass in the region of $3.1 \div 3.25$ GeV exist, then in the framework of the baryon-meson sypersymmetry conception it is possible to expect that the mass region of 3-4 GeV can be quite perspective for the search of new exotic baryons.

As it is stated in a number of papers the diffractive production processes with Pomeron exchange offer some new possibilities to search for exotic hadrons (see, for example, Refs. [1,10,14]). It has been originally assumed that this caused by a possible exotic component of Pomeron. But in accordance with modern conception Pomeron is a multigluon system. Thus in the processes with Pomeron exchange some special mechanisms of the exotic hadron production can be realized — see diagrams on Fig.1. Indeed, as it is apparent from the Pomeron exchange mechanism for the diffraction reactions, only the states with the same charges and flavors as for the primary hadron can be produced in these processes. Besides there is an additional limitation for the quantum numbers of the hadrons to be produced, which is stipulated by the Gribov-Morrison selection rule for changing the parity (ΔP) and spin (ΔJ) in the transitions from primary hadron to the diffractively produced hadronic system: $\Delta P = (-1)^{\Delta J}$. For example, in the proton diffraction only baryonic states with natural sets of quantum numbers $(J)^P = (1/2)^+; (3/2)^-; (5/2)^+; (7/2)^-$ etc. can be excited due to this rule. But the Gribov-Morrison selection rule is not a rigorous law and has an approximate character.

In accordance with these ideas in the experiments at the SPHINX facility on the 70 GeV proton beam of the IHEP accelerator a wide program of studying of the baryon diffractive production and search for exotic baryons in these processes is being carried out. Among the studied reactions are

$$
p+N \rightarrow \begin{cases}
(K^+K^-p)+N, & (1)\\
(p\phi)+N, \quad \phi \hookrightarrow K^+K^- & (2)\\
[\Lambda(1520)K^+]+N, \quad \Lambda(1520) \hookrightarrow K^-p & (3)\\
(\Lambda K^+)+N, \quad \Lambda \hookrightarrow p\pi^- & (4)\\
(\Sigma^o K^+)+N, \quad \Sigma^o \hookrightarrow \Lambda+\gamma,\ \Lambda \rightarrow p\pi^- & (5)\\
[\Sigma(1385)^o K^+]+N, \quad \Sigma(1385)^o \hookrightarrow \Lambda\pi^o,\Lambda \rightarrow p\pi^- & (6)\\
[\Lambda(1405)K^+]+N, \quad \Lambda(1405) \hookrightarrow \Sigma^+\pi^-;\Sigma^+ \rightarrow p\pi^o & (7)\\
(\pi^+\pi^-p+m\gamma)+N \quad (m=0-4), & (8)\\
(\omega p)+N, \quad \omega \hookrightarrow \pi^+\pi^-\pi^o & (9)\\
(\eta p)+N, \quad \eta \hookrightarrow \pi^+\pi^-\pi^o & (10)\\
(\eta' p)+N, \quad \eta' \hookrightarrow \pi^+\pi^-\eta & (11)\\
p+N \rightarrow (pp\bar{p})+N & (12)
\end{cases}
$$

as well as some other processes. Here N signifies nucleon or light nucleus (C, Be). Practically all reactions (1)–(12) are clearly singled out now. In this paper the first results of the study of reactions (1)–(3) are presented and very sensitive searches of anomalously narrow exotic baryons in the mass region ≤ 4.5 GeV are performed. In the next two publications the results of studying reactions (6) and (7) will be discussed.

2. THE SPHINX FACILITY

The general layout of the SPHINX facility is presented on Fig.2. This apparatus is a wide aperture magnetic spectrometer with proportional and drift chambers working together with multichannel γ spectrometer and system of Cherenkov detectors for the identification of charged secondary particles.

The main elements of the SPHINX facility are:

1. Detectors of the primary particle beam before the target T (scintillation counters S_o, S'_o, S_1 and S_2)[1].

2. The target T (Be 12 g/cm^2 thick or CH_2=11.2 g/cm^2, used in different runs). The guard system with counters $A_1 - A_{12}$ around the target and forward guard system with counters A_{13}, A_{14} with holes, which match the acceptance of the magnetic spectrometer. The counters $A_9 - A_{12}$ and A_{13}, A_{14} are lead-scintillator sandwiches. The counters S_3, S_4 with amplitude analysis and counters B_1, B_2 to switch off the beam particles are used for the detection of interactions in the target.

3. Hodoscopes $H_1 - H_4$ and the primary beam hodoscopes (which are not shown on Fig.2).

4. A magnetic spectrometer based on the modernized magnet SP40 with uniform magnetic field volume $150 \times 100 \times 70$ cm^3 and $P_T = 0.7$ GeV.

5. The system of proportional chambers with 32 X-, Y-, U- and V–planes with the dimensions from 12.8×12.8 cm^2 up to 180×90 cm^2. These chambers are grouped in four blocks PC1-PC4.

6. The system of drift chambers with the dimensions 200×100 cm^2 (4 double X–plane chambers and 2 double Y plane chambers with shifted signal wires to remove the left–right ambiguity).

7. The multichannel γ spectrometer which is shown schematically on Fig.2 (on the left lower part of the figure). This spectrometer includes 320 lead glass counters with dimensions $10 \times 10 \times 38$ cm^3 (from the glass F8) and 63 lead glass counters with dimensions $5 \times 5 \times 38$ cm^3 (from F101), which are arranged in the central part of the spectrometer. One counter in this region was removed and photon beam was going through the hole. The signals from the independent outputs of the phototubes of the counters in the central active part of γ detector are summed linearly and can be used for the trigger requirement if the summed signal has exceed the adjusted threshold: $E_\gamma > E_{thresh.}$.

8. Threshold Cherenkov multichannel counters $\check{C}_1$ and $\check{C}_2$ (with L = = 300 cm). Each counter has 32 independent optical channels for the detection of Cherenkov radiation. These counters are working together with scintillation

[1]The counters S_o, S'_o, which are arranged along the magnetic beam channel, are not shown on Fig.2.

hodoscope matrixes H_3, H_4. The hodoscope elements are matched geometrically with corresponding optical cells of $\check{C}_1$ and $\check{C}_2$. In the SPHINX runs the threshold Cherenkov counters used to work with air at atmospheric pressure. With the help of simple coincidence or anticoincidence logics it is possible to perform the identification of charged particles which were beyond or below the threshold of Cherenkov detection (for the atmospheric air $P^{\pi}_{thres} = 6.0$ GeV; $P^{K}_{thres} = 21.1$ GeV; $P^{p}_{thres} = 40.1$ GeV).

9. The Cherenkov multichannel spectrometer of the RICH type with the registration of Cherenkov radiation rings with the help of the photomatrix with phototubes FEU-60 (photocathode diameter is 10 mm; the total number of phototubes in photomatrix is 736). The general layout of a RICH detector is presented on Fig.3a. The effective length of the detector is 130 cm. The working media is gaseous SF_6 ($P^{\pi}_{thres} = 3.5$ GeV; $P^{K}_{thres} = 12.4$ GeV; $P^{P}_{thres} = 23.6$ GeV). Some examples of multitrack events identified by the RICH spectrometer are shown on Fig.3b-3d.

10. The trigger logic system which give possibility to produce simultaneously 4 types of trigger signals. The information for the multiplicities on the hodoscope planes, logic signals from the threshold Cherenkov counter system, signals from the elements of the guard system, amplitude information from the counters S_3, S_4 and from central active part of the electromagnetic calorimeter are used to work out trigger signals. The data acquisition system of the SPHINX facility is used for the registration of about 350-400 trigger events per accelerator spill.

3. STUDY OF THE REACTION $p + N \to (pK^+K^-) + N$

During the measurements a flux of protons $N_p = 1.12 \cdot 10^{11}$ p passed through the SPHINX target ($4.85 \cdot 10^{23}$ CH_2/cm^2). For the study of reactions (1) - (3) the apparatus was trigged by the signal

$$T_A = S_o S'_o S_1 S_2 S_3(>1) S_4(>1)(\overline{B_1 B_2}) A_{1-8}(=0 \div 1)\overline{A_{13-14}} \times \qquad (13)$$

$$\times H_1(=2 \div 5) H_2(=3) H_3(=2 \div 3) L_1(=2 \div 3) H_4(=1 \div 3) L_2(=1 \div 3).$$

Here we used the following designations: $S_i(>1)$ if the amplitude from the counter S_i exceeded the one from a single relativistic particle; $L_i(=n)$ - for the number of anticoincidence between the scintillation hodoscope cells and corresponding matched cells of the Cherenkov counter $\check{C}_i$ (i.e. the number of slow particles with $\beta < \beta_{thres.}$ in $\check{C}_i$); $H_i(=n)$ - for the multiplicity of the particles in the hodoscope H_i. The trigger signal T_A corresponded to the events with 3 charged particles in the final state which had passed through magnetic spectrometer of the setup. At least two/one of these particles gave no signals in the Cherenkov counters $\check{C}_1/\check{C}_2$, i.e. they were candidates for the protons with momentum $P_P < 40$ GeV or K mesons with $P_K < 21$ GeV. After the reconstruction of the tracks the events with two positively-charged particle and one negatively-charged particles were singled out. The summed energy of these 3 particles was to be in the limits of 66-74 GeV. The indentification of particles was performed by a maximum probability method. Thus for the event of reaction (1) it was required that for RICH counter the hypothesis of pK^+K^- identification of 3 particles in the final state had the maximal probability among all possible hypotheses $(pK^+K^-, pK^+\pi^-, p\pi^+\pi^-, pp\bar{p})$. This hypothesis was not to contradict the information from the threshold Cherenkov counters. As a result 87 thousands events of reaction (1) were singled out.

The effective mass spectra for the systems K^+K^- and pK^- in reaction (1) are presented on Fig.4. In these spectra the peaks of ϕ meson and $\Lambda(1520)$ hyperon are very clearly seen and thus reaction (2) and (3) can be singled out. For the separation of these reactions and the study of their effective mass spectra the differential method of background subtraction (under the peaks of ϕ and $\Lambda(1520)$) was used. For this the entire spectrum of effective masses $M(pK^+K^-)$ is divided into the bins with $\Delta M_i = 40$ MeV (or 20 MeV) and for each bin the numbers of ϕ mesons or $\Lambda(1520)$ baryons as well as background levels were obtained with fitting procedure in K^+K^- or K^-p effective mass distributions. The results of such effective mass fitting for several bins are presented on Fig.5.

In the region of large masses where the number of events is small the mass spectra of $p\phi$ and $\Lambda(1520)K^+$ are obtained by routine integral background subtraction method using the control sideband intervals for the background evaluation. In the mass region where both background subtraction methods can be applied they give similar results.

The same background subtraction procedures can be used not only for the determination of the effective mass spectra in (2) and (3) but also for all other characteristics of these reactions.

The event distributions for reactions (1)–(3) as a function of the transverse momentum squared are shown on Fig.6. These distributions are fitted by the form

$$\frac{dN}{dp_T^2} = C_1 exp(-b_1 p_T^2) + C_2 exp(-b_2 p_T^2). \tag{14}$$

The parameters of the slope b_1 and b_2 and the normalization coefficients C_1 and C_2 are presented in Table 1.

As is seen from Fig.6 and Table 1 there are considerable contributions of coherent diffractive production of pK^+K^- system in reactions (1)-(3) on carbon nuclei. These coherent reactions are characterized by slopes $b_1 > 30-40$ GeV^{-2} in (14).

Table 1. Parameters for the P_T^2 distributions for reactions (1)-(3)

Reaction	(1)	(2)	(3)
b_1(GeV^{-2})	32.0$\pm$ 0.6	48.0 $\pm$ 0.6	37.0 $\pm$ 1.7
C_1(GeV^{-2})	1.5$\cdot 10^6$	1.5 $\cdot 10^4$	1.4 $\cdot 10^5$
b_2(GeV^{-2})	4.3 $\pm$ 0.1	6.2 $\pm$ 0.2	4.7 $\pm$ 0.1
C_2(GeV^{-2}	2.5 $\cdot 10^5$	1.3$\cdot 10^4$	2.7 $\cdot 10^4$

4. SEARCHES OF HEAVY EXOTIC BARYONS

The effective mass spectra of $p\phi$ and $\Lambda(1520)K^+$ systems for the coherent region ($p_T^2 < 0.075$ GeV^2) and for large momentum transfer region ($p_T^2 > 0.15$ GeV^2) are presented on Figs.9 and 10. For the coherent region in both effective mass spectra some structure with the mass $M \simeq 2170$ MeV and the width $\Gamma \simeq 110$ MeV has been observed. Both these spectra have the same characteristics and therefore can be summed. The resulting mass spectrum of $X = [p\phi + \Lambda(1520)K^+]$ is presented on Fig.9. It has been obtained by summing up the $p\phi$ and $\Lambda(1520)K^+$ spectra weighted with the setup efficiencies for the corresponding processes (see Fig.10) with account of branching ratios $BR(\phi \to K^+K^-) = 0.49$ and $BR[\Lambda(1520) \to K^-p] = 0.225$.

The cross section for the coherent production of "$X(2170)$" structure is obtained

$$\sigma[\text{"}X(2170)\text{"}]|_C \cdot BR = \sigma[p + C \to \text{"}X(2170)\text{"}+$$
$$+C] \cdot BR[\text{"}X(2170)\text{"} \to p\phi + \Lambda(1520)K^+] = (790 \pm 90)\ \text{nb/C}. \qquad (15)$$

by fitting this summed spectrum. From this value the production cross section per nucleon can be estimated as

$$\sigma[\text{"}X(2070)\text{"}]|_{nucleon} \cdot BR \simeq \begin{cases} 66\ \text{nb/nucleon} & (\sigma \sim A) \\ 150\ \text{nb/nucleon} & (\sigma \sim A^{2/3}) \end{cases} \qquad (16)$$

The linear dependence of the cross section with atomic number of nucleus can take place for coherent processes.

There is no serious contradiction between the SPHINX results (15), (16) and ANL result $\sigma[\text{"}X(2170)\text{"}]|_p \cdot BR < 200$ nb (with C.L. 5σ) [7]. It must be stated that the nature of the "X(2170)" structure is unclear now and needs further study. The inverted commas in the notation of this state are used to stress this point.

The wide acceptance of the SPHINX facility makes it possible to search for heavy baryon resonances in the effective mass region up to $M \leqslant 4.5$ GeV and first of all for baryons with anomalously small decay widths, which can be candidates for exotic pentaquark baryons with hidden strangeness. For the illustration the $p\phi$ effective mass spectrum in the region of $M(p\phi) >2.75$ GeV is presented on Fig.11. There are no statistically significant heavy baryon structures in all three mass spectra under study (i.e. for $p\phi$, $\Lambda(1520)K^+$ and K^+K^-p systems). Very sensitive upper limits for the cross sections of the resonance production reactions have been obtained. They are given in Table 2 and on Fig.12.

Table 2. The upper limits (95% C.L.) for the cross sections for diffractive production of heavy baryons with narrow widths ($\Gamma \leqslant \leqslant 50$ MeV) in reactions (1)–(3) (in nb/nucleon)

M, GeV	(1)	(2)	(3)
2.3	5.09	8.64	2.42
2.4	2.87	8.00	15.35
2.5	2.71	3.89	13.11
2.6	1.38	2.50	10.37
2.7	4.13	3.80	13.19
2.96	5.70	2.23	5.37
3.5	2.55	0.27	3.42
4.0	6.53	0.43	0.91
4.5	3.87	0.71	1.69

It must be stressed that the experiments on the SPHINX setup have failed to confirm the existence of narrow heavy baryon resonance $R(3520)$ which has been seen earlier by JINR — Bucharest group in the reaction

$$\pi^- + p \to (pK^+K^*(892)^-\pi^-) + X^o \tag{17}$$

at the momentum $P_{\pi^-} = 16$ GeV with the cross section $\sigma[R(3520)]|_p \cdot BR[R(3520) \to pK^+K^*(892)^-\pi^-] = 14\ \mu b$ [11]. The SPHINX upper limits for the cross sections of $R(3520)$ production in reactions (1)–(3) are

$$\sigma[R(3520)]|_{nucleon} \cdot BR[R(3520) \to p\phi] \leq 0.27 \text{ nb/nucleon} \tag{18}$$

$$\sigma[R(3520)]|_{nucleon} \cdot BR[R(3520) \to \Lambda(1520)K^+] \leq 3.4 \text{ nb/nucleon} \tag{19}$$

$$\sigma[R(3520)]|_{nucleon} \cdot BR[R(3520) \to pK^+K^-] \leq 2.6 \text{ nb/nucleon} \tag{20}$$

(95% C.L.). These values are by 4–5 orders of magnitude lower than the cross section of $R(3520)$ production in (17) claimed in [11]. Certainly, the data of [11] and the SPHINX results are obtained in different reactions, but it is difficult to explain such big difference in the cross sections in the most of the models which can describe the nature of $R(3520)$ state. Thus the results of the SPHINX experiment have called some doubts if this unusual baryon does really exist.

It is a pleasure for us to express our gratitude to the stuff members of IHEP and ITEP for the help in carrying out the experiment. One of us (V.F.Kurshetsov) is grateful to Soros foundation for financial support.

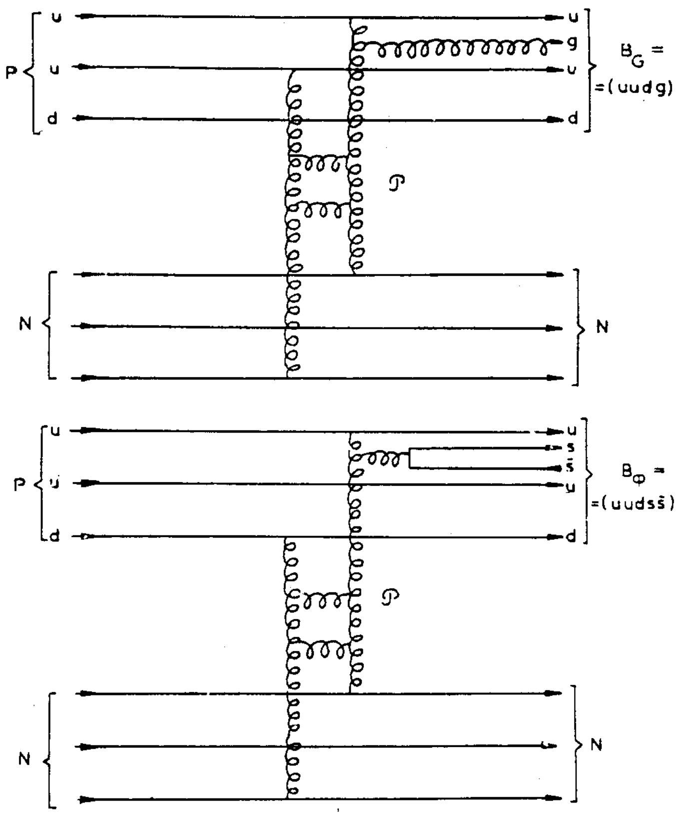

Figure 1. Diagrams for the exotic baryon production in the diffractional process with Pomeron exchange (for hybrids and multiquark baryons).

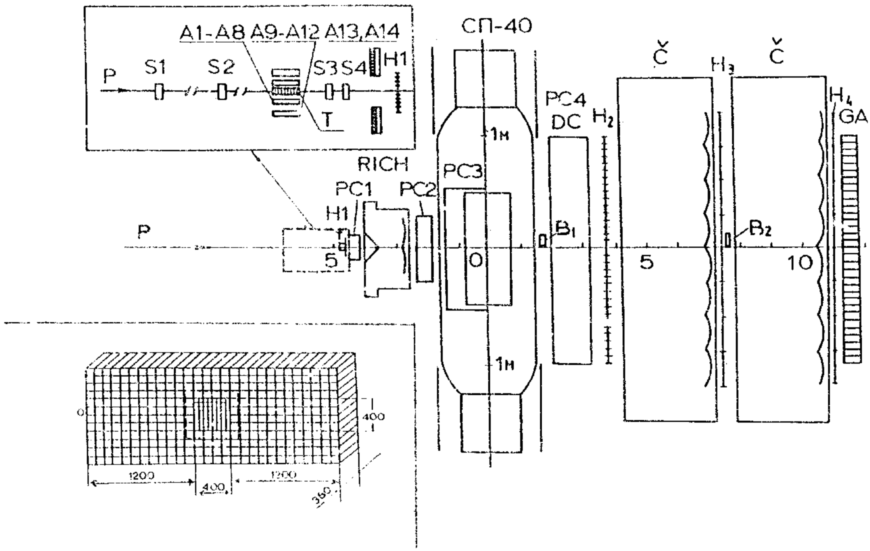

Figure 2. The layout of the SPHINX spectrometer. $S1 - S4$, $B1$, $B2$ are scintillation counters, $A1 - A14$ - scintillation guard counters, $H1 - H4$ - scintillation hodoscopes; $PC1 - PC4$ - block of proportional chambers; DC - block of drift chambers; SP - 40, a spectrometer magnet; $\check{C}_1, \check{C}_2$ - hodoscope threshold Cherenkov counters; $RICH$ - Cherenkov ring image spectrometer; $GAMS$ - hodoscope γ - spectrometer (which is present on the left lower part of the figure; dutt - dotted line points the active region of γ detector which is used for trigger requirement).

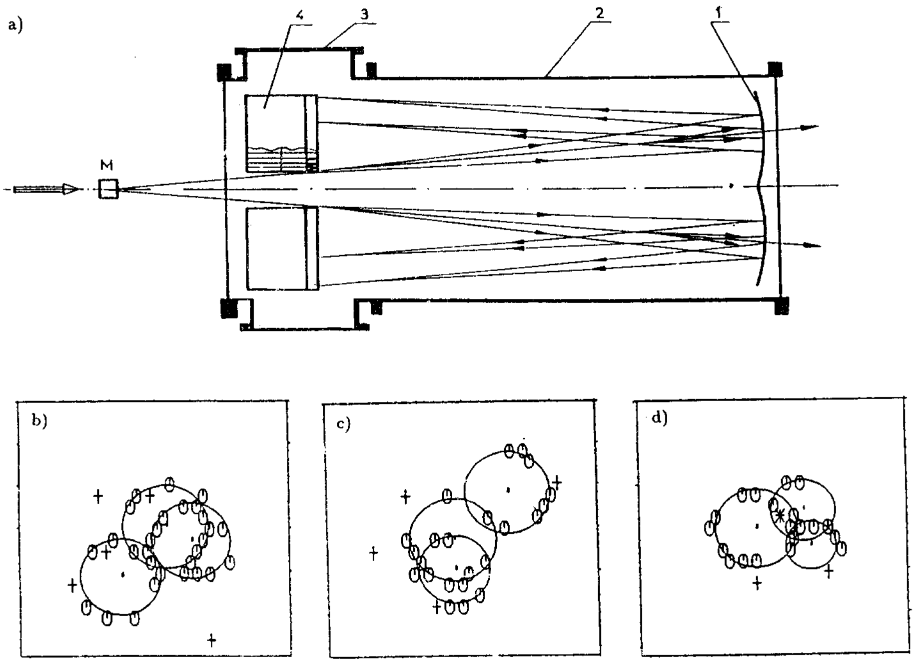

Figure 3. a) The layout of Cherenkov spectrometer with registration of the radiation rings: 1) – spherical mirror from the thin glass ($\Delta = 5$ mm, $f = 1250$ mm); 2) the body of the counter; 3) flanges; 4) photomatrix with 736 phototubes FEU-60. b,c,d) The examples of the registrating Cherenkov radiation rings on photomatrix of the RICH spectrometer for the trigger events with 3 charged particles in the final state.

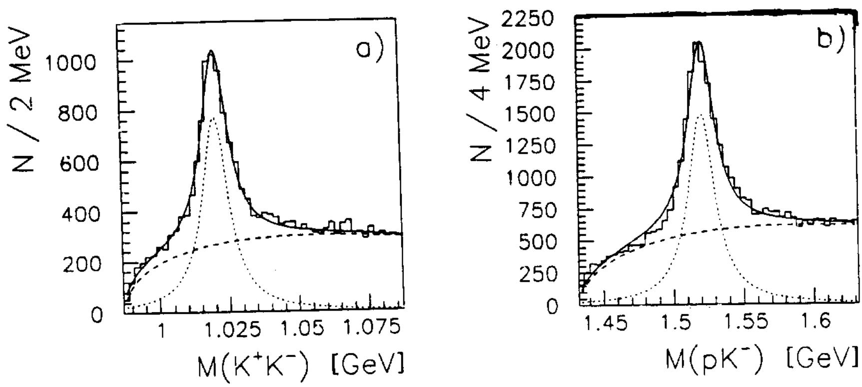

Figure 4. The data on the reaction $p+N \to K^+K^-p+N$ at $E_p = 70$ GeV: a) the invariant mass spectrum of K^+K^-; the ϕ peak with $M = 1020.0 \pm 0.2$ MeV and $\Gamma = 12.0 \pm 0.6$ MeV is clearly seen; b) the invariant mass spectrum of K^-p; the $\Lambda(1520)$ peak with $M = 1520.0 \pm 0.3$ MeV and $\Gamma = 22.0 \pm 0.8$ MeV is observed in this spectrum (the errors are statistical). The experimental data on ϕ and $\Lambda(1520)$ are in agreement with their tabulated parameters (with the account of the instrumental resolution).

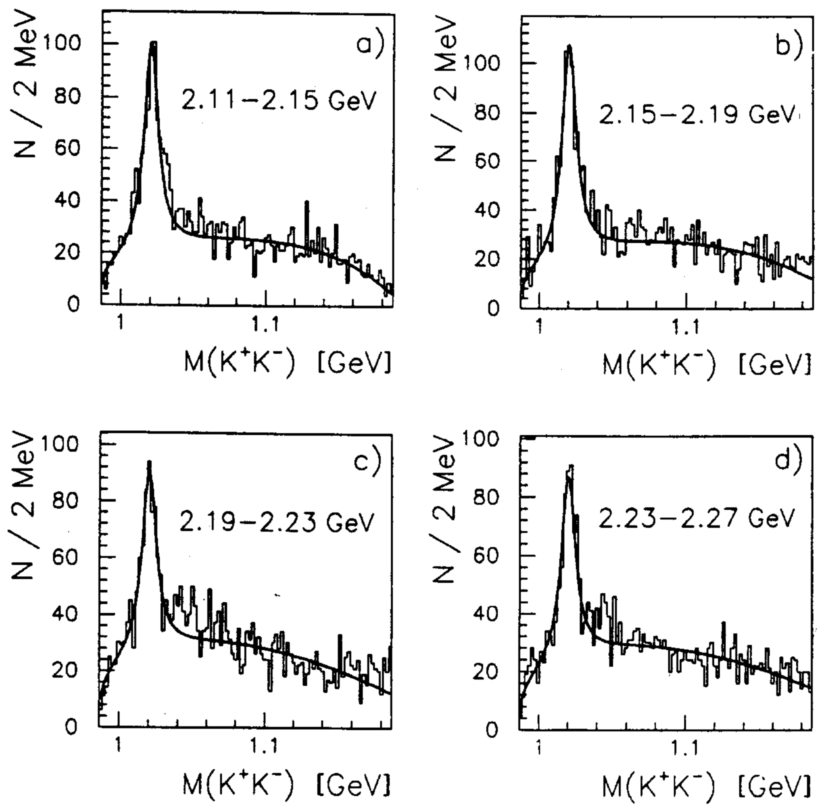

Figure 5. Illustration of the differential method of background subtraction under the ϕ peak for the selection of the reaction

$$p + N \rightarrow \quad (p\phi) + N$$
$$\quad\quad\quad\quad\quad \hookrightarrow K^+K^-$$

The effective mass spectrum for K^+K^- system in some mass intervals $\Delta M(K^+K^-p) =$ $= 40$ MeV are presented, the number of ϕ events were obtained by fitting in every bin ΔM : a) for 2.11 GeV $< \Delta M(K^+K^-p) <$ 2.15 GeV; b) for 2.15 GeV $<$ $< \Delta M(K^+K^-p) <$ 2.19 GeV; c) for 2.19 GeV $< \Delta M(K^+K^-p) <$ 2.23 GeV; d) for 2.23 GeV $< \Delta M(K^+K^-p) <$ 2.27 GeV.

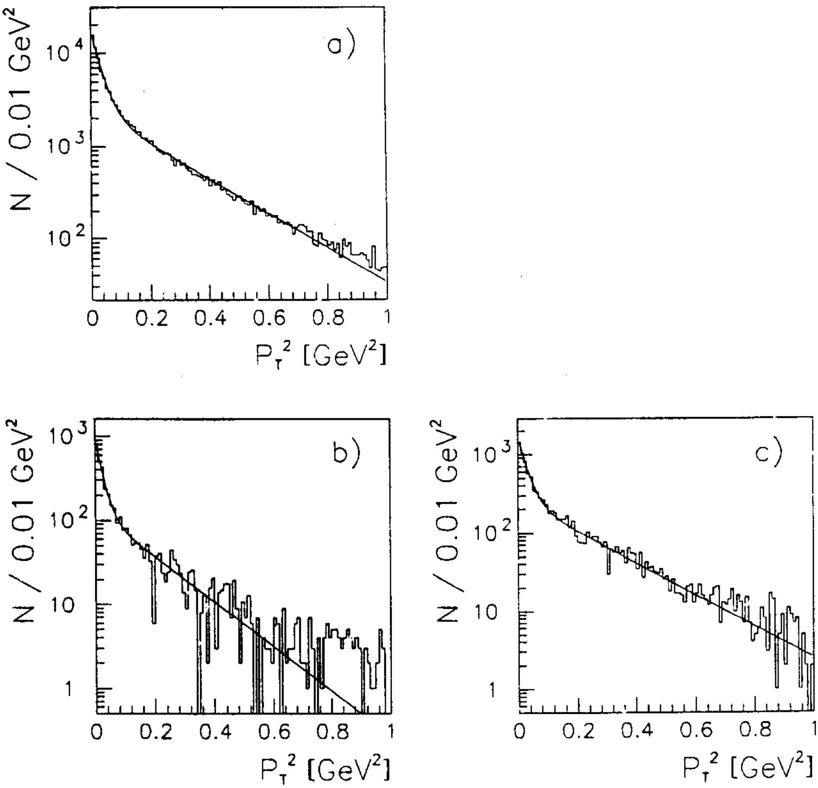

Figure 6. The P_T^2 distributions for reactions (1)–(3): a) dN/dP_T^2 for $p + N \to (p\phi) + N$; b) dN/dP_T^2 for $p + N \to (K^+K^-p) + N$; c) dN/dP_T^2 for $p + N \to [\Lambda(1520)K^+] + N$. The solid curves are the results of the fits by expression (14) with parameters from Table 1.

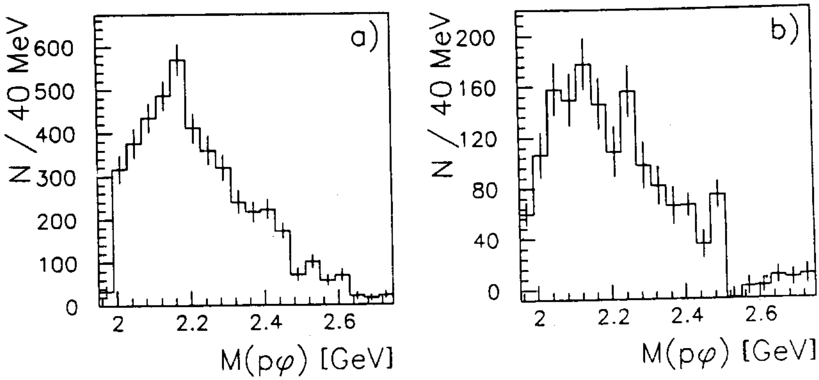

Figure 7. The effective mass spectrum of $p\phi$ system in the reaction $p + N \to [p\phi] + N$: a) $P_T^2 < 0.075$ GeV^2 (coherent process); b) $P_T^2 > 0.15$ GeV^2.

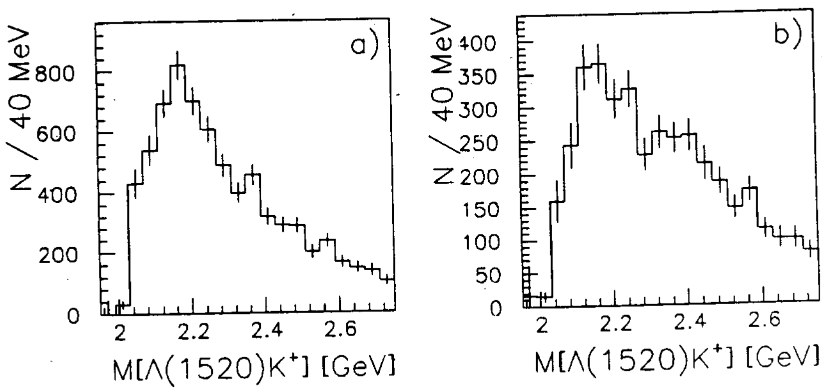

Figure 8. The effective mass spectrum of $\Lambda(1520)K^+$ system in the reaction $p + N \to$ $\to [\Lambda(1520)K^+] + N$: a) $P_T^2 < 0.075$ GeV^2 (coherent process); b) $P_T^2 > 0.15$ GeV^2.

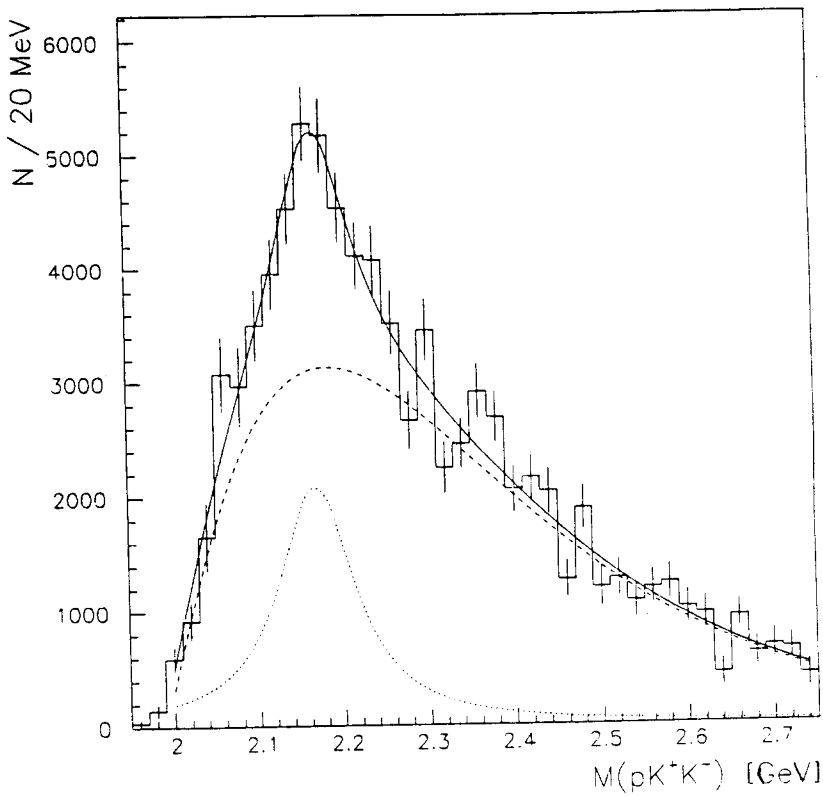

Figure 9. The summed invariant mass spectrum for $X = p\phi + \Lambda(1520)K^+$ (for $P_T^2 <$ < 0.075 GeV/c^2) in reactions (2) and (3). The events of $p\phi$ and $\Lambda(1520)K^+$ type are weighted with the acceptance of the setup with account of the branchings $BR(\phi \to K^+K^-) = 0.49$ and $BR[\Lambda(1520) \to pK^-] = 0.225$.

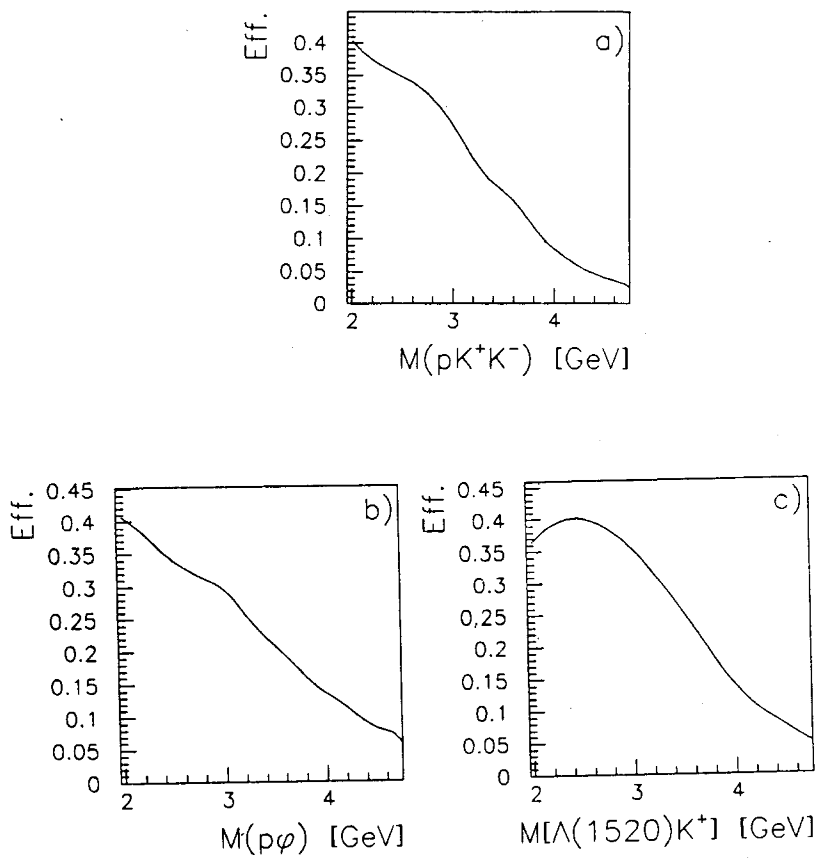

Figure 10. The efficiency of the SPHINX setup for the detection of reactions (1)–(3) as a function of the effective mass of pK^+K^- (a); $p\phi$ (b); $\Lambda(1520)K^+$ (c).

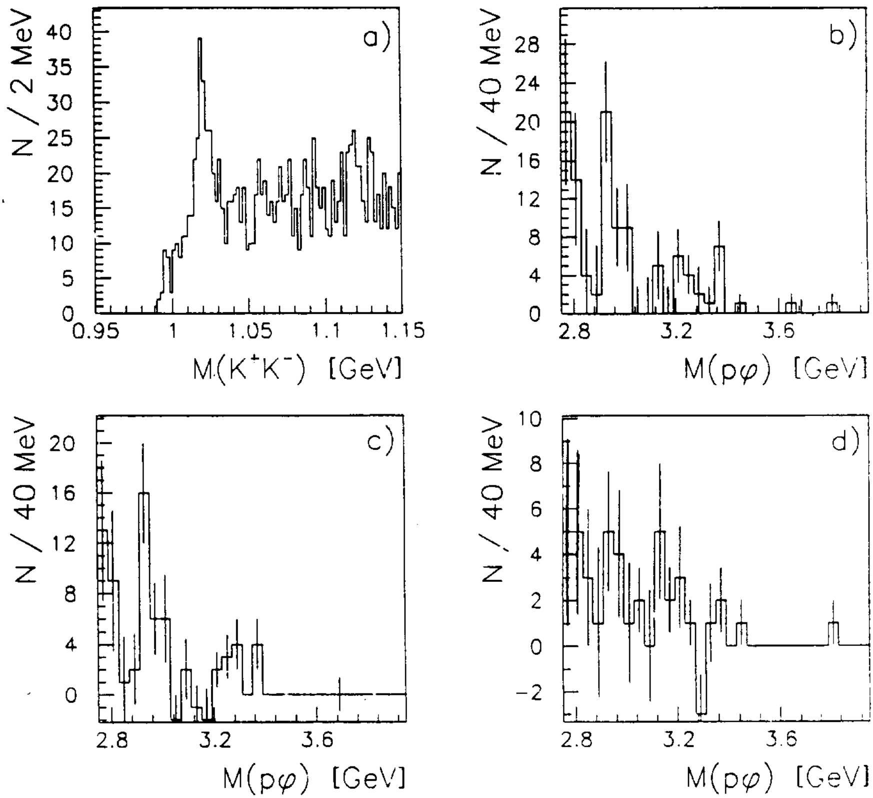

Figure 11. Search for narrow heavy baryons B_ϕ with hidden strangeness in the diffractive production reaction $p + N \rightarrow B_\phi + N$ with the decay channel $B_\phi \rightarrow \phi p$ (in the mass region $M > 2.75$ GeV). a) The mass spectrum of the K^+K^- system in the reaction $p + N \rightarrow K^+K^-p + N$ for $M(K^+K^-p) > 2.75$ GeV; from this figure and from the comparison with Fig.4a is clear that in the SPHINX experiment with good $K^\pm$ meson identification (in RICH counter) the ϕ mesons are reliably separated from the background even in the region of large mass $M(K^+K^-p)$. b) Invariant mass spectrum of the $p\phi$ system for all the values of the transverse momentum P_T. c) The same as in b) but for p_T^2 <0.075 (GeV)^2. d) The same as in b) but for P_T^2 >0.15 (GeV)^2.

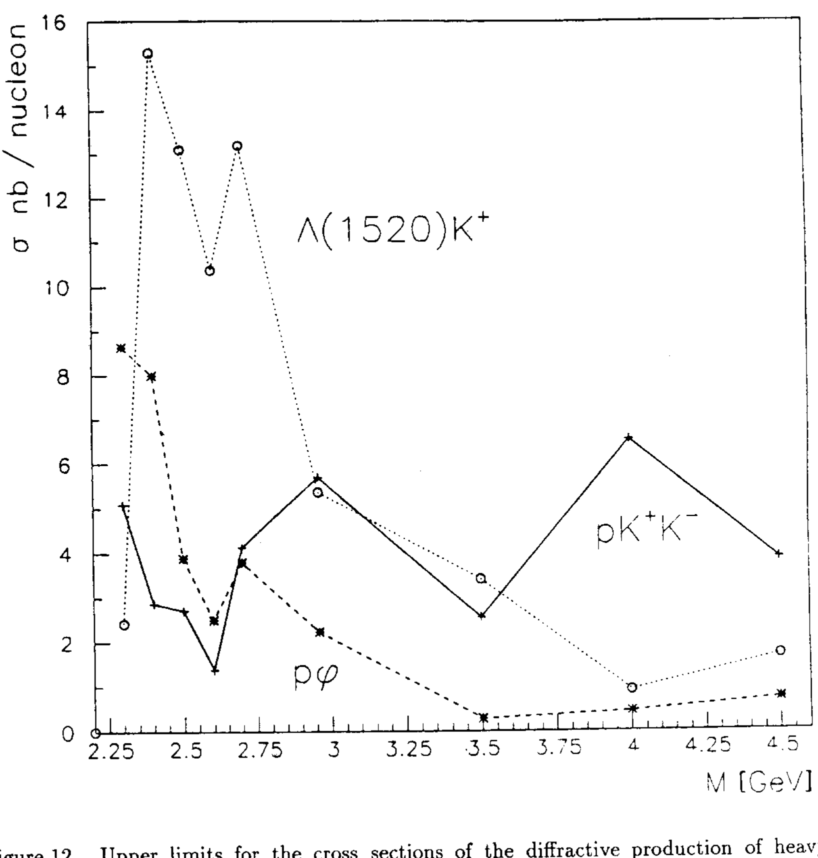

Figure 12. Upper limits for the cross sections of the diffractive production of heavy B_ϕ baryons with $\Gamma \leqslant 50$ MeV in the decay channels $B_\phi \to K^+K^-p$, $B_\phi \to p\phi$, $B_\phi \to \Lambda(1520)K^+$ (here $BR(\phi \to K^+K^-)$ and $[BR(\Lambda(1520) \to K^-p]$ are taken into account).

References

[1] L.G.Landsberg, Usp. Fiz. Nauk 160, 1 (1960) [Sov. Phys. Usp. 33(3), 169 (1990)]; L.G.Landsberg, Surveys in High Energy Physics, 6, 257 (1992).

[2] K.Peters, Invited talk on the II Biennial Conference on Low-Energy Antiproton Physics (LEAP'92), September 14-19 (1992), Courmayeur, Aosta Valley, Italy.

[3] M.Poulett, Preprint LAPP-EXP-90-10 (1990).

[4] F.E.Close, Preprint RAL-87-072, Chilton (1987).

[5] S.U.Chung, Preprint BNL 40599, Upton (1987); S.U.Chung, Nucl. Phys. 473A, 511 (1988); S.U.Chung, Z. Phys. 46C, 111 (1990).

[6] L.G.Landsberg, Yad. Fiz. 53, 1048 (1991); [Sov. J. Nucl. Phys. 53, 650 (1991)].

[7] M.W.Arenton et al., Phys. Rev. 25D, 2241 (1982).

[8] J.Amirzadeh et al., Phys. Lett. 89B, 125 (1979).

[9] J.Kinson et al., Proc. of 4th Intern. Conf. on Baryon Resonances ("Baryon-1980"), 278.

[10] A.N.Aleev et al., Z. Phys. 25C, 205 (1984).

[11] V.M.Karnakov et al., Phys. Lett. 281B, 148 (1992).

[12] M.Bourquin et al., Phys. Lett. 172B, 113 (1986).

[13] A.N.Aleev et al., Z. Phys. 47C, 533 (1990); G.T.Tatishvili, "Hadron-91", Proc. of the 4th Intern. Conf. on Hadron Spectroscopy, College Park, August 12-16, Ed. D.Peaslee (1991).

[14] H.Hogaasen, P.Sorba, Nucl. Phys.145B, 119 (1978).

Received May, 13, 1993

М.Я.Балац и др.

Поиски тяжелых пятикварковых экзотических барионов со скрытой странностью в реакциях $p + N \to (p\phi) + N$ и $p + N \to [\Lambda(1520)K^+] + N$ при энергии E_p=70 ГэВ.

Редактор А.А.Антипова. Технический редактор Н.В.Орлова.
Корректор Е.Н.Горина.

Подписано к печати I3. С5. 93. Формат 60x90/I6.
Офсетная печать. Печ.л. I,25. Уч.-изд.л. I,5. Тираж 260.
Заказ 9I7. Индекс 3649. Цена I70 руб.

Институт физики высоких энергий, I42284, Протвино
Московской обл.

I70 руб. Индекс 3649

ПРЕПРИНТ 93-5, ИФВЭ, I993