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**RESEARCH PROGRAMME
AND MAIN RESULTS IN 2004
OF THE LABORATORY
OF PARTICLE PHYSICS**

Report to the 97th Session
of the JINR Scientific Council
January 20–21, 2005

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Объединенный институт
ядерных исследований
БИБЛИОТЕКА

The activity of LPP in 2004 was concentrated on the current particle physics experiments and preparation of the new ones, R&D of the particle detectors and different acceleration systems.

1. ONGOING EXPERIMENTS

The NA48 cycle of experiments is devoted to the precision measurement of the ratio ϵ'/ϵ in $K \rightarrow 2\pi$ decays, to study kaon and hyperon rare decays and the CP -asymmetry in charged kaon decays. The present activity in the framework of NA48 is mainly related to the study of kaon and hyperon rare decays.

The major goal of NA48 has been achieved, an existence of direct CP -violation is proved (see previous reports). The $K_L \rightarrow \pi^\pm \pi^0 e^\mp \nu(\bar{\nu})$ decay was investigated [1] using the data accumulated with long-lived neutral kaon beam. The branching ratio $\text{Br}(K_L \rightarrow \pi^\pm \pi^0 e^\mp \nu(\bar{\nu})) = [5.21 \pm 0.07(\text{stat.}) \pm 0.09(\text{syst.})] \cdot 10^{-5}$ was measured from a sample of 5464 decay events with 62 background events. The form factors $\bar{f}_s, \bar{f}_p, \lambda_g$ and \bar{h} were found to be in agreement with previous measurements but with higher accuracy. The coupling parameter of the chiral Lagrangian $L_3 = (-4.1 \pm 0.2) \cdot 10^{-3}$ was evaluated from these data. 730 candidates of the weak radiative hyperon decay $\Xi^0 \rightarrow \Lambda \gamma$ with an estimated background of 58 ± 8 events [2] have been found in data taken in 1999. The $\Xi^0 \rightarrow \Lambda \gamma$ decay asymmetry has been determined to be $\alpha(\Xi^0 \rightarrow \Lambda \gamma) = -0.78 \pm 0.18(\text{stat.}) \pm 0.06(\text{syst.})$, using these data, which is the first evidence of a decay asymmetry in $\Xi^0 \rightarrow \Lambda \gamma$. The branching fraction of the decay has been measured to be $\text{Br}(\Xi^0 \rightarrow \Lambda \gamma) = [1.16 \pm 0.05(\text{stat.}) \pm 0.06(\text{syst.})] \cdot 10^{-3}$. The decay $K_S \rightarrow \pi^0 \gamma \gamma$ have been observed for the first time [3] using the data collected in 2000: 31 decay events were selected at the background level of 13.7 ± 3.2 events, which lead to the branching ratio estimate $\text{BR}(K_S \rightarrow \pi^0 \gamma \gamma) = [4.9 \pm 1.6(\text{stat.}) \pm 0.9(\text{syst.})] \cdot 10^{-8}$. This value is in agreement with the chiral perturbation theory. New measurement of the branching ratio $R = 0.4978 \pm 0.0035$ of the decay $K_L \rightarrow \pi^\pm e^\mp \nu$, denoted as Ke3, relative to all charged K_L decays with two tracks, based on data taken with the NA48 detector,

have been done [4]. The K_{e3} branching fraction and the weak coupling parameter V_{us} in the CKM matrix have been obtained: $V_{us} f_+(0) = 0.2146 \pm 0.0016$, where $f_+(0)$ is the vector form factor in the K_{e3} decay. A search for CP violating decays $K_S \rightarrow 3\pi^0$ has been performed [5] using data taken during the year 2000 with the NA48 detector. The CP violating amplitude $\eta_{000} = A(K_S \rightarrow 3\pi^0)/A(K_L \rightarrow 3\pi^0)$ has been measured to be $\text{Re}(\eta_{000}) = -0.002 \pm 0.011 \pm 0.015$ and $\text{Im}(\eta_{000}) = -0.003 \pm 0.013 \pm 0.017$ by a fit to the lifetime distribution of about 4.9 million reconstructed $K^0/\text{anti-}K^0 \rightarrow 3\pi^0$ decays. This corresponds to an upper limit on the branching fraction of $\text{Br}(K_S \rightarrow 3\pi^0) < 7.4 \cdot 10^{-7}$ at 90% confidence level. The result is used to improve the knowledge of $\text{Re}(\epsilon)$ and the CPT violating quantity $\text{Im}(\delta)$ via the Bell-Steinberger relation.

The following results have been obtained in the frame of the physics program of NA48/1 project. A new decay mode $K_S \rightarrow \pi^0 \mu^+ \mu^-$ (6 events over background 0.22) has been observed and its branching ratio

$$\text{BR}(K_S \rightarrow \pi^0 \mu^+ \mu^-) = [2.9^{+1.5}_{-1.2} (\text{stat.}) \pm 0.2 (\text{syst.})] \cdot 10^{-9}$$

has been estimated (preliminary) [6]. A branching ratio of $\Xi^0 \rightarrow \Sigma^+ e^- \nu$ decay and a value of the Cabibbo-Kobayashi-Maskawa (CKM) matrix element V_{us} have been preliminary estimated [7]:

$$\text{BR}(\Xi^0 \rightarrow \Sigma^+ e^- \nu) = [2.51 \pm 0.03 (\text{stat.}) \pm 0.11 (\text{syst.})] \cdot 10^{-4},$$

$$|V_{us}| = 0.214 \pm 0.006^{+0.030}_{-0.025}$$

Clear signal (about 100 events) of $\Xi^0 \rightarrow \Sigma^+ \mu^- \nu$ decay (and $\Sigma^+ \rightarrow p \pi^0$) has been observed [7].

The 60 days experimental run has been prepared and carried out in the beam lines of charged kaons at CERN SPS for realization of the NA48/2 physics program. More than $2.15 \cdot 10^9$ events with $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$ candidates and more than $1.30 \cdot 10^8$ events with $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$ candidates have been recorded. During two years of data taking in the NA48/2 experiment more than 4 billion $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$ and 200 million $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$ events have been recorded in total. The JINR contribution to the experimental runs includes:

- maintenance and modification of the produced read-out electronics for the coordinate detector of charged kaon beams – KABES, working in high intensity charged beam;
- maintenance and operation of new read-out electronics of the muon detector during the experimental run;
- maintenance of the continuous operation of the experimental control data recording system.

The LPP group brings full responsibility for software development for detector simulation, reconstruction of data obtained by the new read-out electronics of the muon detector, data filtering and monitoring of physical characteristics.

On the base of 2003 data the errors of the asymmetry in $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$ and $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$ decays have been estimated [8] which are one order of magnitude less than in other experiments. The branching ratio of $K^\pm \rightarrow \pi^0 e^\pm \nu$ decays has been also measured with preliminary results [9]:

$$\text{BR}(K^+ \rightarrow \pi^0 e^+ \nu) = [5.163 \pm 0.021 (\text{stat.}) \pm 0.056 (\text{syst.})] \cdot 10^{-2},$$

$$\text{BR}(K^- \rightarrow \pi^0 e^- \nu) = [5.093 \pm 0.028 (\text{stat.}) \pm 0.056 (\text{syst.})] \cdot 10^{-2},$$

$$\text{BR}(K^\pm \rightarrow \pi^0 e^\pm \nu) = [5.14 \pm 0.02 (\text{stat.}) \pm 0.06 (\text{syst.})] \cdot 10^{-2},$$

These results allowed to define the value of CKM matrix element

$$|V_{us}| = 0.2241 \pm 0.0013 (\text{exp.}) \pm 0.0023 (\text{theor.}).$$

This value is in a good agreement with the result of the E865 experiment at BNL and predictions of the SM that confirms the unitarity of the CKM matrix.

Obtained preliminary results of the NA48/2 experiment are presented at many international conferences including three presentations of JINR group representatives [10–12].

The LPP group has taken part in analysis of the HERMES data collected in 2002–2003 and performed the technical maintenance of the mini-drift vertex chambers.

The evidence for a narrow baryon state was found in quasi-real photo-production on a deuterium target through the decay channel $p K_S \rightarrow p \pi^+ \pi^-$. A peak is observed in the $p K_S$ invariant mass spectrum at $[1528 \pm 2.6 (\text{stat.}) \pm 2.1 (\text{syst.})] \text{ MeV}/c^2$ [16]. Depending on the background model, the naive statistical significance of the peak is 4–6

standard deviations and its width may be somewhat larger than the experimental resolution of $\sigma = 4.3\text{-}6.2$ MeV. This state may be interpreted as the predicted $S=+1$ exotic $\Theta^+(uudd\bar{s})$ pentaquark baryon. No signal for a hypothetical Θ^{++} baryon was observed in the pK^+ invariant mass distribution. The absence of such a signal indicates that an isotensor Θ is excluded and an isovector Θ is unlikely.

One of the most interesting new HERMES studies is the measurements of transversity distributions in the nucleon. Single-spin asymmetries for semi-inclusive electro-production of charged pions in deep-inelastic scattering of positrons are measured for the first time with transverse target polarization [17]. The asymmetry depends on the azimuthal angles of both the pion (ϕ) and the target spin axis (ϕ_S) about the virtual photon direction and relative to the lepton scattering plane. The extracted Fourier component $\langle \sin(\phi + \phi_S) \rangle_{UT}^\pi$ is a signal of the previously unmeasured quark transversity distribution, in conjunction with the so-called Collins fragmentation function, also unknown. The Fourier component $\langle \sin(\phi - \phi_S) \rangle_{UT}^\pi$ of the asymmetry arises from a correlation between the transverse polarization of the target nucleon and the intrinsic transverse momentum of quarks, as represented by the previously unmeasured Sivers distribution function. Evidence for both signals is observed, but the Sivers asymmetry may be affected by exclusive vector meson production.

The extraction of the polarized SIDIS asymmetries and quark polarized distributions is one of main aim of the HERMES. Polarized deep-inelastic scattering data on longitudinally polarized hydrogen and deuterium targets have been used to determine double spin asymmetries of cross sections [18, 19]. Inclusive and semi-inclusive asymmetries for the production of positive and negative pions from hydrogen were obtained in a re-analysis of previously published data. Inclusive and semi-inclusive asymmetries for the production of negative and positive pions and kaons were measured on a polarized deuterium target. The separate helicity densities for the up and down quarks and the anti-up, anti-down, and strange sea quarks were computed from these asymmetries in a "leading order" QCD analysis. The polarization of the up-quark is positive and that of the down-quark is negative. All

extracted sea quark polarizations are consistent with zero, and the light quark sea helicity densities are flavor symmetric within the experimental uncertainties. First and second moments of the extracted quark helicity densities in the measured range are consistent with fits of inclusive data.

The LPP participates in upgrade of H1 detector to investigate DIS processes at the ep collider HERA, DESY, specifically, in the upgrade, installation, operation, and software support of three important detectors: Forward Proton Spectrometer, Backward Proportional Chambers and Plug Detector.

Comparison of the H1 FPS leading proton structure function with the result of the analogous measurement by the ZEUS experiment and F_2^D obtained by H1 from the data with a large rapidity gap in the central detector shows good agreement between two experiments and two methods. The result proves small contribution of the proton dissociation in the large rapidity gap data.

Diffractive parton density functions (PDFs) are extracted from NLO DGLAP QCD fit to the large rapidity data. The QCD predictions based on the diffractive PDFs describe new H1 diffractive neutral current and charge current measurements at high Q^2 [20, 21].

The recent physics results have been presented by the LPP JINR group on behalf of the H1 collaboration at the 32th International Conference on High Energy Physics [22], 12th Workshop on Deep Inelastic Scattering [23] and the HERA-LHC Workshop [24].

According to the JINR commitments, LPP participated in the commissioning of the Outer Tracker (OTR) of the HERA-B detector which is a large-aperture spectrometer built to study collisions of 920 GeV protons with the nuclei of target wires positioned in the halo of the HERA proton beam. The Dubna group physicists concentrated completely on the physics analysis.

The Dubna group participates in the study of A -dependence of J/ψ production via the decay mode $J/\psi \rightarrow e^+e^-$, which is a first priority task in the HERA-B data analysis program. Various algorithms for building e^+e^- invariant mass spectra as well as fitting of J/ψ signal and its behavior for different runs and targets (carbon or tungsten) have been

studied in various intervals of the Feynman variable x_F . The Dubna group contributed considerably to the testing of the MC trigger simulation procedure. Special investigations were devoted to the selection of the $\chi_c \rightarrow J/\psi\gamma$ signal from the background.

The detailed Monte Carlo (MC) investigation of the $B - \bar{B}$ production asymmetry in pp and pn interactions at HERA-B energy has been performed. To study this asymmetry, caused at the fragmentation level by effects of asymmetric beam remnants for b and \bar{b} quarks, it was proposed to trigger the B -meson signal by selection of like-sign lepton pairs l^+l^\pm coming from doubly semileptonic B decays. These MC studies have stimulated a search for the charge asymmetry of lepton pairs in the analysis of the real data from the HERA-B.

The experiment EXCHARM is devoted to the study of charmed and strange particle production characteristics and to search for narrow baryonia in neutron-nuclon interactions at the Serpukhov accelerator.

New data on negative kaons interference correlations have been obtained [24]. The production area size R for identical kaon pairs was estimated in the framework of Goldhaber parameterization. The behavior of R indicates the reduction of particle generation area size with increasing of produced particle masses. The coherent parameter λ was measured as $\lambda = 1.70 \pm 0.01$. Preliminary data on the measurement of α parameter indicating a power dependence of anti- Λ^0 -hyperon inclusive production cross-section σ on target nuclear masses ($\sigma = \sigma^0 \cdot A^\alpha$) were obtained [25]. The result obtained with C and Cu targets, $\alpha = 0.72 \pm 0.07$, is in a good agreement with the theoretical predictions $\alpha = 2/3$. The results of the investigation of ϕ -meson and Λ^0 -hyperon associative production have been published in [27]. The study of the characteristics of charmed baryon Λ_c^+ by their decays to a neutral kaon K^0 and a proton p is in progress. There was obtained an indication on a signal in the region of the PDG mass of Λ_c^+ in the spectra of K^0p effective mass. The effective mass spectrum of K^0p was investigated in the region of 1540 – 1550 MeV/c² as well. At the K^0p effective mass equal to 1548 MeV/c² there is an indication on a signal (at the level of triple standard deviation) which could be interpreted as a penta-quark state Θ^+ decay.

The LPP specialists participate in the international project for the precise and direct determination of the flux of the solar neutrinos produced in the Be7 electron capture process in the Sun and study the phenomenon of neutrino oscillation for low energy solar neutrino spectrum using calorimetric, liquid scintillator and low background detector BOREXINO situated at underground laboratory Gran Sasso, Italy. The prototype of BOREXINO detector, Counting Test Facility (CTF), has provided the convincing evidence that the technological challenge of the experiment, the achievement in the scintillator of unprecedented radiopurity levels were accomplished successfully, thus opening the way to the realization of the milestone of the experiment. Dubna group has performed mounting and cleaning of PMT's, testing of VME electronics, and production of the analog electronic modules for the experiment. The proposal to upgrade the CTF was developed to be able to study solar pp-neutrino. The CTF data analysis gives new physical results on the limit on the flux of antineutrino from the Sun in the region of small energy using the process of inverse beta-decay of proton, new limit on the violation of the Pauli exclusion principle in nuclear processes, and search for weak-interacting pseudoscalar particle emitted in M1 transition of excited nuclei Li7.

The Common Muon and Proton Apparatus for Structure and Spectroscopy, COMPASS (NA58), has been proposed to perform a series of experiments with the high energy muon and hadron beams at CERN including a study of inclusive and semi-inclusive DIS of muons on polarized targets, search for effects of the nucleon strange sea polarization in the production of Λ hyperons, and determination of the quark and gluon contribution to the nucleon spin.

An asymmetry $A_1^d(x)$ in scattering of virtual photons on longitudinally polarized deuterons as a function of the x-Bjorken has been studied. Obtained data are in comparison with published SMC results. Expected statistics of 2002–2004 will be by factor 4 larger. D^{*+} and D^0 mesons produced in deep inelastic scattering of muons on longitudinally polarized deuterons have been studied. Events will be used for determination of gluon contributions to the spin of nucleons.

Expected accuracy for 2002–2004 statistics is $\sigma(\Delta G/G) \sim 0.25$. Collins asymmetries (azimuthal asymmetries in hadron production by muons in deep inelastic scattering of muons on transversely polarized deuterons) as a function of x -Bjorken and z – partial energy of hadrons are obtained for the first time. Spin transfer from longitudinally polarized muons to Λ and $\bar{\Lambda}$ – produced in deep inelastic scattering of muons on deuterons. COMPASS data has been obtained. The 2002–2004 statistics will exceed the world statistics. The analysis of other reactions is in progress. The preliminary COMPASS data were presented by I.Savin at the ICHEP'04 in Beijing in September on behalf of COMPASS. Detailed report on particular subjects will be presented at the International conferences in Dubna and Trieste.

The LPP takes part in the experiments on the 4π -detector **STAR** at the collider RHIC at the Brookhaven National Laboratory (BNL). An activity of the LPP group is based on the JINR contributions to the construction of the first half of the STAR Barrel Electro-Magnetic Calorimeter and the development of related subsystems and software. The installation of the last modules on the STAR magnet is expected at the end of this year and the commissioning of the calorimeter in the whole volume – at the end of 2005. The JINR group studied the performance of BEMC shower-mass detector and integrated it into the STAR data taking system. The inclusive spectra of electrons produced in dAu 200 GeV collisions were measured in collaboration of JINR, WSU and SaoPaulo groups. Based on these data, the total cross-sections for (c barc)- and (b barb)-states production were determined. This study may have important consequences for the preparation of the charmonium trigger and thus for the access of the other important signature of the quark-gluon plasma at RHIC. A study of proton-lambda correlation in AuAu-collisions at 200GeV has been done in collaboration between JINR and Nantes. Based on the known proton-lambda scattering lengths, the average size of the proton and lambda sources was found to be ~ 3 fm, close to the size of the proton source determined from proton-proton correlation function. For proton-antilambda and antiproton-lambda systems, the correlation functions have been measured for the first time and the corresponding spin

averaged scattering length was estimated. This study opens a new perspective – the correlation study of particle scattering in the systems which can hardly be accessible by other means.

2. PREPARATION OF NEW EXPERIMENTS

According to the JINR obligations in the **ATLAS** experiment, which is under preparation at CERN, the LPP participates in the construction of the Liquid Argon Hadronic End-cap Calorimeter (LArHEC) and Transition Radiation Tracker (TRT). In 2004 the fulfillment of JINR MoU obligations for the ATLAS detector construction in the field of liquid argon calorimetry has been completed. About 2000 channels of preshower circuits have been produced and mounted on the front-end boards of hadronic end-cap calorimeter (HEC). Assembly of 50 temperature probes on the rear face of the HEC2A wheel has been done. The liquid argon end-cap calorimeters have been inserted into cryostats, and cold tests of the full systems (cryostat + calorimeters) have been performed to the end of the year. The combined test of end-cap calorimeters has been performed at the SPS test beam. Study of different physics issues for the LHC collider (in particular, top-quark physics) and analysis of 2002 and 2004 test beam data has been performed. The TRT ATLAS detector assemblies were spent according to the JINR obligations.

The main effort of JINR in the **CMS** Project is concentrated on the design and construction of the end-cap detectors, where JINR bears full responsibility in the frame of the RDMS CMS Collaboration: End-cap Hadron Calorimetry (HE) and First Forward Muon Station (ME1/1). JINR also participates in End-cap Preshower (ES), development of physics program, and computing and core-software. The main JINR obligation on construction of End-cap Hadron Calorimeters is fulfilled. In co-operation with IHEP (Protvino), NC HEPP (Minsk), HTTC NIKIET (Moscow), MZOR plant (Minsk), ISC and NSC KIPT (Kharkov) both HE end-caps are delivered and assembled at CERN. Dressing of both calorimeters with radioactive source system is completed. Combined test of 20-degree HE sector and ME1/1 chamber was performed with high energy beams at CERN.

JINR obligation on proportional chamber construction for ME1/1 muon stations is also fulfilled. All ME1/1 cathode strip chambers including spares are delivered from Dubna to CERN. Preparation for chambers installation is going on in SX5 surface hall. Mass-production of silicon radiation hard detectors $63 \times 63 \text{ mm}^2$ in co-operation with RIMST (Zelenograd) is on schedule. By the end of 2004 year 1565 out of 1975 detectors paid by Russia have been already produced. Dubna regional center is prepared for assembly of detector-modules. Part of the produced detectors was tested for radiation hardness at IBR-2. Detector database was developed at JINR and installed at CERN to manage with the data of the detector measurements. JINR member states could contribute in Preshower project only if appropriate in-kind involvement will be found. Manufacture of strip electrodes for the Barrel drift tubes is on schedule. 2500 out of 3300 electrodes were delivered to CMS DT assembly sites.

The LPP takes part in development of physics program and software. The investigations are focusing at physics beyond Standard Model with dimuon masses in the TeV-range in the final state. Program includes study of production of the additional gauge bosons, horizontal gauge bosons, and double charged Higgs bosons, and also the signals of the heavy graviton resonance formation and other manifestation of extra dimensions. In 2004, the systematic studies of physics processes with hard muons in the final state ($p_T > 100 \text{ GeV}$) have been continued. The improvement of reconstruction software and the further testing the CMS detector performance to measure the high- p_T muons was performed. Based on these studies the CMS discovery potential of Z' gauge bosons as well as RS1 gravitons in the dimuon decay channel are estimated using fast Monte Carlo simulation. The possibility of discriminating between different Z' models was investigated by measuring the muon forward-backward asymmetry. It was shown that theoretical predictions can be tested at the CMS in dimuon channel up to the mass scale about 5 TeV. Also the LHC potential to observe non-resonance deviations from the SM dimuon spectra (Drell-Yan) in the TeV-invariant-mass region predicted by extra dimensions scenario with flat metric (ADD) was studied. In the framework of the DC04 data challenge and preparation CMS Physics TDR in collaboration with

subgroup of the CMS b/tau-group involved in exclusive B-decay studies, the full simulation of the decay $B^0_s \rightarrow J/\Psi (\rightarrow \mu^+\mu^-) \phi (\rightarrow K^+K^-)$ and background $b \rightarrow J/\Psi + X$ have been performed, using the dedicated Dubna SIMUB generator, for statistics expected during one year run at the CMS (of about 100 000 events). In co-operation with IHEP (Protvino, Russia) and IHEP CAS (Beijing, China), generation of Bc-meson production has been integrated in the Dubna SIMUB package. The estimates of event rates for most important Bc-decay modes at the CMS have been performed. Calibration of detectors using direct $\gamma + \text{jet}$ and $Z + \text{jet}$ channels was continued. Computing group continue participation in design of concept of regional distributed centres and annual data challenge. The development of concept of the CMS Condition Data Base is started. The development of RDMS CMS Computing model to process and analyse the expected experimental with dimuon is in the progress. The general conception and schemes based on GRID technologies were suggested. The results have been discussed at 9th RDMS CMS Annual Collaboration meeting in Minsk on November 29 – December 2, 2004. Main results have been published in [28–31].

The experiment NIS at the JINR Nuclotron is aimed at searching for effects of the hidden polarized strangeness of nucleons. The most striking of these effects is the strong violation of the Okubo-Zweig-Iizuki (OZI) rule. The major task of the project is to search for OZI-rule violation in reaction of $\phi\phi$ and $\omega\omega$ production close to the corresponding thresholds in pp and np interactions at the energy excesses above the thresholds from 30 to 100 MeV. At present a search for Θ^+ pentaquark production in pp interactions near threshold is a goal of this project as well. Physicists from LPP, VBLHE, DLNP, BLTP and LIT as well as from Poland, Germany and Ukraine are participating in the project. At present R&D and tests of different detectors, electronics and development of software are in progress.

Within THERMALIZATION project started in 2003 at the Serpukhov accelerator and aimed at studying multi-particle production in pp interactions with high multiplicity at 70 GeV, the work is continuing on the renewal of the electronics and the vertex detector, the

design and the production of the drift tube tracker for the magnetic spectrometer upgrade, the creation of the hydrogen target and the trigger system for the registration of the high multiplicity events based on the silicon strip detectors and scintillation counters. The SVD-2 experimental data obtained in proton-nucleus collisions at 70 GeV/c on IHEP accelerator have been analyzed to search for an exotic pentaquark ($uudd(s\bar{b})$) Θ^+ -baryon in a pK_s^0 decay mode. The pK_s^0 invariant mass spectrum shows a resonance structure at a mass 1526 MeV/c² with the statistical significance of 5.6 standard deviations. The values of the mass and width of this exotic baryon state are compatible with those predicted and recently reported in a number of experiments. The gluon dominance model was developed for the description of multiplicity distributions in pp-interactions. In the region from 70 to 800 GeV/c the model shows that protons remain as leading particles, and the process of multiparticle production is realized by so-called active gluons characterized by the same hadronization parameters as in the e^+e^- -annihilation. To estimate the size of the hadronization region the method has been suggested based on the soft photon data. The results are presented in [32–34].

3. ACCELERATION TECHNIQUES

According to the special agreement between CERN and JINR 30 **Screen Monitors BTVI for LHC** have been manufactured, tested and delivered to CERN in 2004. This work was carried out in cooperation with Belorussia. Real beam spot for SPS has been shown by using BTVI monitors at CERN in October, 2004.

The LPP specialists participate in construction of the **Transverse Damping System at LHC**. The creation of deflectors and powerful broadband amplifiers for transverse feedback system (TFBS) for LHC beam was a main direction of activity in 2004. The documentation developed in LPP JINR for project is being approved by various expert commissions of CERN. Joint researches with the "Elektrokhimpribor" Integrated Plant (Lesnoy) and at the Urals State Technical University (Yekaterinburg) allow to get the technologies of vacuum boxes manufacturing with guaranty of necessary quality of an internal surface

of chambers and welding, that in a result provides high vacuum in a box. A successful vacuum test of samples of chambers (manufactured from stainless steel 304L, Russia and steel 316L, Europe) was carried out at CERN in September this year. At the same time, result of works of this year became the conclusion about impossibility of guarantees on long-term operation of vacuum chambers from steel 316L due to the presence of the non-metallic inclusions exceeding more than in 2 times the required level under the European and Russian standards for high-vacuum products. These inclusions (owing to a centrifugal method of formation of pipes) are built in the threadlike structures focused along a pipe. They can be crossed by a welding seam and can become a source of micro-cracks during warming-up and pumping. According to this peculiarity the experts of CERN make in September 2004 a decision to use the Russian steel 304L for vacuum boxes. According to this decision the next iteration of the negotiations with the "Elektrokhimpribor" Integrated Plant (Lesnoy) holds now. CERN requires executing the schedule of vacuum chambers' manufacturing in time. Enterprise "Thorium" makes 26 ceramic rings of required 80 pieces. The sanction of CERN to manufacturing of electrodes and supports for kickers in JINR is received. Audit of the equipment of the high-voltage bench and its partial modernization is carried out in LPP. This will allow organizing the tests of amplifiers. The basic components for amplifiers manufacturing are got due to means of CERN and under the agreement with Russia.

Main fields of contributions from LPP to the TESLA project are X-ray FEL, $\gamma\gamma$ -collider option, and participation in the accelerator and FEL experiments on the TESLA Test Facility (TTF) at DESY. JINR experts took participation in preparation of photon diagnostics for VUV FEL at DESY. JINR manufactured control electronics for MCP radiation detectors and performed its commissioning at the TESLA Test Facility. They took part in the design of a chamber for pump-probe FEL user facility in the design and manufacturing of a prototype of permanent magnet quadrupole for XFEL and linear collider. JINR experts participated in the calculation and optimization of magnetic structure of undulators for XFEL, in the design of an infrared beamline for electron bunch length monitor based on coherent infrared radiator. A prototype

of a collimator with iris diaphragm has been manufactured by JINR and tested at DESY. It was studied of beam physics related to production of intensive, low-emittance bunches for X-ray FEL. JINR experts participated in the development of elements for cryodiagnostics for XFEL accelerator: a technique for conditioning the cryogenic TVO temperature sensors for operation in the temperature range from 4 up to 425 K has been developed; a simple and reliable technique for calibration of TVO temperature sensors in the range from 293 K to 65 K has been developed: the method uses only three reference points, but provides the results competitive with platinum temperature sensors; post irradiation behavior of different temperature sensors after gamma-irradiation up to 1 MGy at $E = 0.67$ MeV has been studied, four types of the temperature sensors were tested: carbon sensors – CRT-2 and TVO, and platinum – PRT-7 (wire) and PT1000 (thin film), the worst results were demonstrated by thin film platinum sensors: a destruction of their leads during irradiation and post-irradiation period was obtained for about 60% of sensors; 15-channel, compact, precision ($\Delta R/R < 0.01\%$) cryogenic temperature monitor has been designed, manufactured and tested, up to 16 monitors can be served by a PC providing simultaneous measurements with 240 temperature sensors. The results are presented in [35–51].

In a frame of CLIC project aimed to provide a new level of investigation in the field of particle physics by an electron-positron linear collider of TeV energy range, LPP participate in preparation of test cavity undergoing the action 10^6 pulses with power 2 – 30 MW and duration of 150 – 200 ns for studying of lifetime of accelerating structure of CLIC collider relative to pulsed repetitive heating. In 2004 cathode module of LIU-3000 linac has been modernized. As a result, the magnitudes of the electron current at the linac output and at the FEM oscillator output have been increased by 25–30%. A novel system of laser alignment of the RF transmission line has been introduced in cold measurements jointly with IAP RAS (Nizhny Novgorod) collaborators. It allowed us reduce the radiation loss within the line significantly and obtain the cold-measurement parameters close to the designed ones. A modernization of the RF line has been proposed and performed. It allowed us rise the value $W*\tau$ limiting in terms of the

electric breakdown, considerably. Here W is the RF power amplitude, τ is the RF pulse duration. Two current sources for powering focusing magnetic lenses have been manufactured and adjusted. The power supplies of the pre-injector and modulators are under adjustment process. The system of on-line control of linac parameters and FEM output ones has been developed and built. The alignment of the system has been started.

Three reports have been presented at the FEL2004 international conference. The work schedule on the completion of the 2nd stage of the Agreement and working planes of the collaborating teams were coordinated at the meeting with CLIC and IAP RAS representatives held at CERN.

In a frame of IREN construction a project of installation of modulator MK1 of LUE-200 linac is prepared. For the first accelerator section 70% of the focusing solenoids are made and installation of equipment of modulator MK1 for this section is started. The installation of the basic carrying constructions of the linac is finished. The control assembly of an electron source - an electron gun with a pulse feed on 200 kV is carried out. The source passes bench tests. At the full-scale RF-stand of the linac testing accelerating sections and units of the RF-feeder proceeded. Some theoretical works by definition of admissions on a deviation of key parameters of accelerating system and focusing system of linac are carried out as well.

4. COMPUTING

The goal of the Project is a manufacturing during 3 coming years in collaboration with LIT the computer cluster with parameters superior existing in 5 times and integrated in a distributed computer infrastructure of JINR. This cluster is considered as a basis for support of investigations on particle and nuclear physics in the LPP. The effective features for a fast access to the computer resources from the problem-oriented supported working places will be supplied. As a result of the development of LPP-LHE PC-farm from non budget resources the number of using PCs has been increased from 20 to 29, a full power of their processors has been increased more than three times – from 1.2

till 3.85K SI95 (including from 0.7 up to 2.4K SI95 – for batch computer). A disk space for users has been increase more than in 2 times – till 6.5 TB. The released computers with low power (with a frequency of CPU 400 MHz) are handed for using in the Laboratory as workstations. An upgrade of the local computer network of the Laboratory up to Gigabit Ethernet equipment has been carried out. 4 local subnets of the Laboratory have been organized. The total number of the network users through the local subnets has been increased. Equipment for wireless access of part users to the local JINR network has been installed and tested. Conference hall and hall for videoconferences have been equipped by video projectors. Special CASTOR program system has been installed on PC-farm computers for works with large data volumes. The method of integration of different PC-farm computer resources has been proposed and tested on a base of this system. New service – CDS-Agenda, has been adopted at the Laboratory server and is using for effective organization of meetings and seminars.

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