JOINT INSTITUTE FOR NUCLEAR RESEARCH

2003-230

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of the JINR Scientific Council
January 15–16, 2004

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The activity of LPP in 2003 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. CURRENT EXPERIMENTS

The **NA48** cycle of experiments is devoted to the precision measurement of the ratio ε'/ε in $K \to 2\pi$ decays, to the study of kaon and hyperon rare decays and asymmetry in charged kaon decays. The investigated parameters have to be measured more precisely than before. The obtained results have to explain the question on existence of direct CP-violation predicted by the Standard Model (SM), to bring in the appreciable contribution to studying of neutral and charged kaon characteristics.

In the NA48 experiment, the $K_L \to \pi^+\pi^-e^+e^-$ and $K_S \to \pi^+\pi^-e^+e^-$ decay modes have been studied in detail [1]. Based on the data collected during the 1998 and 1999 run periods, a sample of 1162 $K_L \to \pi^+\pi^-e^+e^-$ candidates has been observed with an expected background level of 36.9 events, yielding the branching ratio measurement $BR(K_L \to \pi^+\pi^-e^+e^-) = (3.08 \pm 0.20)\cdot 10^{-7}$. The distribution of events in the $\sin\phi\cos\phi$ variable, where ϕ is the angle between the $\pi^+\pi^-$ and the e^+e^- decay planes in the kaon centre of mass, is found to exhibit a large CP-violating asymmetry with the value $A_\phi = (14.2 \pm 3.6)\%$. For the $K_S \to \pi^+\pi^-e^+e^-$ decay channel, 621 candidates were identified in the 1999 data sample with an estimated background contribution of 0.7 event. The corresponding branching ratio has been determined to be $BR(K_S \to \pi^+\pi^-e^+e^-) = (4.71 \pm 0.32)\cdot 10^{-5}$. The combined value of this measurement with the result published in 1998 is $BR(K_S \to \pi^+\pi^-e^+e^-) = (4.69 \pm 0.30)\cdot 10^{-5}$. No asymmetry is observed in this decay mode. These results are in a good agreement with theoretical predictions based on a phenomenological description of radiative kaon decays. The form factor parameters a_1/a_2 and $\bar{g}_{M1}$ describing the direct emission process in $K_L \to \pi^+\pi^-e^+e^-$ decays and the value of the K^0 charge radius have been extracted from these data.

The $K_S \to \pi^0\gamma\gamma$ decay has been observed for the first time [2]. This result has been obtained by using the data collected in 2000. In total, 31 events of the decay $K_S \to \pi^0\gamma\gamma$ were selected at the background level of 13.7 ± 3.2 events, which lead to $BR(K_S \to \pi^0\gamma\gamma) = (4.9 \pm 1.6(\text{stat.}) \pm 0.9(\text{syst.}))\cdot 10^{-8}$. This is in agreement with the Chiral Perturbation Theory (ChPT) predictions and with the previous estimate [3] based on the data collected in 1999 during a 40 hour run with a high intensity K_S beam. In the same run, the $K_S \to \gamma\gamma$ decay rate has been measured [4]. The branching ratio $BR(K_S \to \gamma\gamma) = (2.78 \pm 0.06(\text{stat.}) \pm 0.04(\text{syst.}))\cdot 10^{-6}$, obtained from 7461 ± 172 events of the decay $K_S \to \gamma\gamma$, is significantly higher than the $O(p^4)$ prediction of the ChPT. The ratio $BR(K_S \to \gamma\gamma)/BR(K_L \to 3\pi^0) = (2.81 \pm 0.01(\text{stat.}) \pm 0.02(\text{syst.}))\cdot 10^{-3}$ has been measured for the data collected in the K_L beam.

In the **NA48/1** experiment, a new decay mode $K_S \to \pi^0 e^+ e^-$ has been observed. This result is based on the analysis of $4.2 \cdot 10^{10}$ K_S decays collected in 2002. Seven events of the decays $K_S \to \pi^0 e^+ e^-$ have been found in the region of $m_{ee} > 0.165$ GeV with only 0.15 background events [5]. The branching ratio for $m_{ee} > 0.165$ GeV/c^2 was computed:

$$BR(K_S \to \pi^0 e^+ e^-, m_{ee} > 0.165 \text{ GeV/c}^2) = 3.0^{+1.5}_{-1.2}(stat.) \pm 0.2(syst.)) \cdot 10^{-9}$$

Using a vector matrix element with no form factor dependence, the extrapolation of this result to the full m_{ee} region gives:

$$BR(K_S \to \pi^0 e^+ e^-) = (5.8^{+2.8}_{-2.3}(stat.) \pm 0.8(syst.)) \cdot 10^{-9}.$$

This allows to extract parameter $|\ a_s\ | = 1.06^{+0.26}_{-0.21}(stat.) \pm 0.07(syst.)$ from the phenomenological expressions describing the interference of direct/indirect CP-violating components in $K_L \to \pi^0 e^+ e^-$ decay:

$$BR(K_L \to \pi^0 e^+ e^-)_{CPV} = 1 \cdot 10^{-12} (15.3 a_s^2 \pm 6.8 \frac{\mathrm{Im}(\lambda_t)}{10^{-4}} + 2.8 \cdot (\frac{\mathrm{Im}(\lambda_t)}{10^{-4}})^2) .$$

Using the measured value of $|\ a_s\ |$ and the global fit for $\mathrm{Im}(\lambda_t)$ one can be obtain CP-violating component:

$$BR(K_L \to \pi^0 e^+ e^-)_{CPV} \approx (17.2_{\text{indirect}} \pm 9.4_{\text{interference}} \pm 4.7_{\text{direct}}) \cdot 10^{-12}$$

The CP conserving component can be obtained from the study of the $K_L \to \pi^0 \gamma\gamma$ decay. $BR(K_L \to \pi^0 e^+ e^-)_{CPC} = 5.8^{+0.22}_{-0.18} \cdot 10^{-12}$ suggest that the CP-conserving component is negligible.

The experiment **NA48/2** has been prepared and put in operation. The first run 2003 was carried out in the new CERN beam line of charged kaons with an upgraded NA48 set-up. The contribution of JINR group to the experiment includes:

- design and manufacture of the read-out electronics for the new unique high performance coordinate detector – KABES, working in high intensity charged beam; maintenance and operation of this electronics and the corresponding software during the run;
- maintenance and operation of the muon detector read-out electronics during the experimental run;
- putting in operation the new red-out system of the muon detector;
- simulation programme development and optimization of the experiment running conditions;
- software development for monitoring and filtering of recorded data on the base of physical characteristics;
- preparation for the prospects of precise measurement of kaon semileptonic decay ratios;
- coordination of the express analysis of data accumulated in order to obtain the first estimation of asymmetry systematics;
- participation in the data taking.

In 2002-2003, the **HERMES** collaboration started data taking with a hydrogen transversely polarized target. The LPP group has taken part in the analysis of HERMES data and performed the technical maintenance and planned work with the mini-drift vertex chambers (DVC) during the HERA shutdown.

The HERMES results on the Q^2 dependence of the generalized Gerasimov-Drell-Hearn (GDH) integrals for the proton, deutron and the neutron have been published in [6]. The first data set taken at HERMES for the deuteron and combined with previous measurements on the proton, provides an unprecedented measurement of the generalised GDH integral for the large range in photon virtuality, $1.2 < Q^2 < 12.0$ GeV^2 , and for photon-nucleon centre-of-mass energies W ranging from $1< W^2 < 45$ GeV^2 thus covering the resonance as well as the deep inelastic scattering (DIS) regions. These data allow the study of the Q^2 dependence of the full GDH integral, which is sensitive to both the Q^2 evolution of the resonance form factors and contributions of higher twists. The resonance region contribution is seen to decrease rapidly with increasing Q^2 whereas the DIS contribution remains sizeable down to the lowest measured Q^2. At higher Q^2 the data are found to be in agreement with measurements of the first moment of g_1. From data on the deuteron and proton, the GDH integral for the neutron was derived and the proton-neutron difference was evaluated. This difference is related to the fundamental Bjorken sum rule at high Q^2.

Spin-dependent lepton-nucleon scattering data have been used to investigate the validity of the concept of quark-hadron duality for the spin asymmetry A_1 [7]. Longitudinally polarized positrons were scattered off a longitudinally polarized hydrogen target for values of Q^2 between 1.2 and 12 GeV^2 and values of W^2 between 1 and 4 GeV^2. The average double-spin asymmetry in the nucleon resonance region is found to be in agreement with that measured in DIS at the same values of the Bjorken scaling variable x.

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.

H1 experiment has measured inclusive e^-p and e^+p differential cross sections for neutral (NC) and charged current (CC) DIS processes in the range of four-momentum transfer squared Q^2 between 150 and 30000 GeV^2 and Bjorken x between 0.0032 and 0.65 [8]. The NC e^-p measurement of $d\sigma/dQ^2$ shows a clear increase with respect to the positron cross section at high Q^2, consistent with the Standard Model (SM) expectation of the contribution of parity violating Z^0 exchange. For electron scattering the Z^0 exchange contribution enhances the cross section, while in e^+p scattering it reduces the cross section. As the result the parity violating structure function xF_3 is extracted. The CC cross section is observed to be larger for electron scattering than for positron scattering by up to a factor of ten at high Q^2 because of W-boson coupling to different quark flavours. The valence quark distributions xu_v and xd_v were extracted in the high x range by using NLO

QCD fit of e^-p and e^+p cross sections, respectively. At low Q^2 the NC cross section is about 1000 times larger than the CC cross section since the CC cross section is suppressed due to the propagator term dependent of M_W^2. The propagator W-boson mass $M_W = 80.9 \pm 3.7$ GeV extracted in the space-like process by using NLO QCD fit is in a good agreement with the average world value measured in time-like processes. At the highest values of $Q^2 \sim M_Z^2, M_W^2$ the NC and CC cross sections are of the similar size as expected from the SM (electro-weak unification).

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 made a substantial contribution to the running of the OTR during 2002-2003 running period as well as studies of the detector performance and particle identification [9,10]. Data taking at the HERA-B detector was finished in 2003, and Dubna 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 $J/\psi \to e^+e^-$, which is a first priority task in the HERA-B data analysis programme. 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. A special procedure based on the "event mixing" method has been developed for modeling the combinatorial background. The Dubna group contributed considerably to the testing of the MC trigger simulation procedure, which now describes well the behavior of the real trigger system. Special investigations were devoted to the selection of the $\chi_c \to J/\psi\gamma$ signal from the background.

The detailed Monte Carlo investigation of the $B - \bar{B}$ production asymmetry in pp and pn interactions at HERA-B energy has been performed [11]. 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 $l^{\pm}l^{\pm}$ coming from doubly semileptonic B decays. These Monte Carlo 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 aimed at studying the charmed and strange particle production and searching for narrow baryonia in neutron-nuclon interactions at the Serpukhov accelerator.

The acceptance of $\Lambda^+_c \to pK^0$ decays has been evaluated for the EXCHARM experiment [12]. It is shown, that the diffractive model of Λ^+_c production leads to a considerably higher acceptance than the model based on $q\bar{q} \to c\bar{c}, g\bar{g} \to c\bar{c}$ fusion and recombination of u- and d- valent quarks with the c-"sea" quark. This conclusion should be taken into account to interpret the experimental result at the

energy range close to the production threshold where the diffractive processes could dominate.

The study of ϕ-meson and Λ^0-hyperon associative production has been completed [13]. The inclusive associative cross-section $\sigma_C(\phi\Lambda^0)$ for the given particle production in neutron-carbon interactions has been measured: $\sigma_C(\phi\Lambda^0) = (614 \pm 35_{(stat.)} \pm 67_{(syst.)})$ μb/nucleus. The obtained result is the first direct measurement performed with a sufficiently high precision. The investigation of ϕ and K_S^0 associative production is in progress.

New data on the correlated Λ^0 pair production [14], and a preliminary result on the charged pion [15] and neutral kaon [16] interference correlations have been obtained. Two-particle correlations for $\Lambda\Lambda$ and $\Lambda\bar{\Lambda}$ systems produced in nC-interactions at small relative momenta were studied for the first time. Destructive correlations of Λ^0 pairs were observed while there were no corresponding correlations for $\Lambda\bar{\Lambda}$ pair production. That allows one to conclude that destructive correlations for identical hyperons is a consequence of Fermi-Dirac statistics effects. The production area size R for identical hadron pairs was defined in the framework of Goldhaber parameterization.

Preliminary data on the measurement of α parameter indicating a power dependence of Λ^0-hyperon inclusive production cross-section σ on the target nuclear weight ($\sigma = \sigma^0 \cdot A^\alpha$) were obtained [17]. The parameter α for different target nuclei has been measured:

α(C-Cu) = 0.71 ± 0.08, α(C-W) = 0.73 ± 0.09, α(Cu-W) = 0.77 ± 0.09.

The obtained results are in a good agreement with the theoretical prediction of α = 2/3. The results on the anti-hyperons production in neutron-carbon interactions have been published in [18].

The LPP specialists participate in the construction of the low-noise neutrino detector **BOREXINO** located at the underground laboratory in Gran Sasso (Italy). The second version of the prototype of the BOREXINO detector, Counting Test Facility (CTF), has been installed. During the test measurements of the PMTs to be used in the future BORXINO experiment, the data from 2200 PMTs were accumulated. A method to obtain the probability density function of the single photoelectron counting from the experimental data was proposed in [19] and applied to derive the PMT average characteristics

The results of background measurements with the prototype were used to the obtained limits on instability of the nucleons, bounded in nuclei, for decays into invisible channels (*inv*): disappearance, decays to neutrinos, etc. [20]. The approach consisted of a search for decays of unstable nuclides resulting from *N* and *NN* decays parent ^{12}C, ^{13}C and ^{16}O nuclei in the liquid scintillator and the water shield of the CTF. Due to the extremely low background and the large mass (4.2 ton) of the CTF detector, the most stringent up-to-date experimental bounds have been

established: $\tau(n \rightarrow inv) > 1.8 \cdot 10^{25}$ years, $\tau(p \rightarrow inv) > 1.1 \cdot 10^{26}$ years, $\tau(nn \rightarrow inv) > 4.9 \cdot 10^{25}$ years and $\tau(pp \rightarrow inv) > 5.0 \cdot 10^{25}$ years (all at 90% C.L.).

If heavy neutrinos with mass $m_{\nu_H} \geq 2m_e$ are emitted in the decays of ^{8}B in the Sun, then decays $\nu_H \rightarrow \nu_L + e^+ + e^-$ should be observed. The results of the background measurements with the CTF have been also used to obtain bounds on the number of these decays [21]. As a result, new limits on the coupling $|U_{eH}|^2$ of a massive neutrino have been derived: $|U_{eH}|^2 \leq 10^{-3} \div 10^{-5}$ for $m_{\nu H} = (1 \div 12)$ MeV. The obtained limits on the mixing parameter are stronger than obtained in previous experiments using the nuclear reactor and accelerators.

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.

In 2003, the COMPASS experiment continued the regular data taking started in 2002. During this time the Dubna group provided a stable operation of the detectors, which are under JINR responsibilities: hadron calorimeter HCAL1, muon detector MW1, multiwire proportional chambers MWPC, and straw chambers. The LPP physicists also participate in the analysis of the recorded data. The first preliminary data on the Λ and $\overline{\Lambda}$ polarization have been obtained.

The LPP takes part in the experiments on the 4π -detector **STAR** at the collider RHIC at the Brookhaven National Laboratory (BNL). Scientific 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 Dubna group participates in estimation of the inclusive output of the direct photons as well as electron and positron spectra in in Au-Au collisions at 200 GeV.

2. PREPARATION OF NEW EXPERIMENTS

The LPP participates in the construction of the Liquid Argon Hadronic End-cap Calorimeter (LArHEC) and Transition Radiation Tracker (TRT), according to the JINR obligations in the **ATLAS** experiment, which is under preparation at CERN.

The JINR obligations on the LArHEC of the ATLAS detector include the production of the front modules of the hadron calorimeter, study of the radiation properties of the used electronics and materials at the Dubna IBR2 reactor, preparation of the liquid argon temperature measurement system and design and serial production of preshapers – part of the hadron calorimeter readout electronics.

The major part of these activities was successfully completed in 2003. The last two of the four wheels of the hadron calorimeter have been assembled. To make feasible the combined study of electromagnetic, hadronic and forward calorimeters at the CERN SPS test beam in 2004 year, 4 special modules of the hadronic calorimeter of the smaller size compared to the standard one, have been assembled.

The main event of 2003 for the LArHEC community was the insertion of the electromagnetic, hadronic and forward calorimeters in the end-cap cryostat, connection of all cables to the feed-throughs, closing the cryostat and its preparation for cooling down and further cold tests with the full set of detectors.

Of about 105 and 48 thousands of the B- and C-type straws, respectively, have been prepared for assembling of the TRT. The 24 B-type detector structures are ready for further work, and 6 four-layer detectors of this type are completed and tested [22]. Two eight-layers detectors have been delivered to CERN and tested there.

The main effort of JINR in the **CMS** Project is concentrated on the design and construction of the CMS inner endcap detectors, where JINR bears full responsibility in the frame of the RDMS CMS Collaboration: Endcap Hadron Calorimetry (HE) and First Forward Muon Station (ME1/1). JINR also participates in Endcap Preshower (ES), development of Physics, Reconstruction and Selection program (PRS subsystem), and Computing and Core-Software (CCS subsystem).

All parts for the second HE+1 were manufactured in co-operation with IHEP (Protvino), NC HEPP (Minsk), HTTC NIKIET (Moscow), MZOR plant (Minsk), ISC and NSC KIPT (Kharkov) and delivered to CERN. Assembly and installation of mechanics and megatiles of the second Endcap hadron calorimeter have been completed at CERN. Dressing of the both calorimeters with the radioactive source is well in progress. Calibration of the 20-degree HE sector equipped with serial HE+1 megatiles was performed with high energy beams at CERN. The mass-production of cathode strip chambers (CSC) for ME1/1 is going on schedule in Dubna: 76 CSC were produced, and 40 CSC for the first endcap, tested in Dubna with a full set of electronics and delivered to CERN. Mass production of silicon radiation hard detectors in co-operation with RIMST (Zelenograd) is going according to the schedule. The Dubna regional center is prepared to assemble the detector-modules. A part of the serial detectors was tested for radiation hardness [23]. Database developed at JINR and installed at CERN to manage with the data of the detector measurements. Manufacture of strip electrodes for the Barrel drift tubes is fulfilled according to the schedule. 1800 of 3300 electrodes were delivered to the CMS DT assembly sites.

JINR physicists participate in development of physics programme and software in the framework of the CMS PRS and CCS subsystems and the RDMS CMS task force on physics processes with emphasis at the large pseudorapidity region. The new research programme of the physics beyond the SM with dimuon masses in the TeV-range in the final state was proposed [24]. The programme

includes the 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. Simulation of the new gauge bosons production has demonstrated the potential of the CMS detector for Z' discovery. Dubna physicists also significantly contribute to the following topics of the SM studies: determination of difference of decay widths of the light and heavy mass eigenstates of $B^0{}_s$, $\Delta\Gamma_s$, from the untagged analysis of the "CMS golden channel" $B^0{}_s \to J/\psi\,\varphi$ [25]; production and decays of B_c mesons; Drell-Yan muon pairs production; determination of parton structure functions using "γ + jet" and "Z + jet" processes; reconstruction of initial parton kinematics parameters at high Q^2; small-x physics. Calibration of detectors using "γ + jet" and "Z + jet" processes was studied [26].

Test and modification of the CMSIM and ORCA programs for muon track reconstruction in the endcap muon system were continued. The computing group continues to participate in the development of the concept of regional distributed centres.

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 ϕ and ω production close to the corresponding thresholds in *pp* and *np* interactions at the energy excesses above the thresholds from 30 to 100 MeV. Physicists from LPP, VBLHE, DLNP, BLTP and LIT take part in the project.

In 2003, the test-bench for the EXCHARM 2×1 m^2 proportional chambers was arranged and equipped with the gas and high voltage supply systems. The auxiliary equipment for the chamber testing, tuning and exploitation was transported from Protvino and installed at the technological area of the test-bench. The front-end and the back-end electronics as well as the necessary software are tested and prepared for exploitation. The chambers and the data readout are tested with a β-source at the test-bench in the on-line regime with the corresponding software. The air-filled Cherenkov counter (with diameter more than 3 m) is dismantled. First estimations of background conditions to detect 2-prong events are performed at the SPHERE area with the extracted deuteron beam of the Nuclotron. The advanced version of the Monte-Carlo simulation software for NIS experiment is developed and used to optimize the spectrometer layout. A prototype of the on-line software was developed and used at the test-bench.

The new project **THERMALIZATION** started in 2003 at the Serpukhov accelerator is aimed at studying multiparticle production in *pp* interactions with high multiplicity at E_p=70 GeV. The experiment uses the modernized Spectrometer with the Vertex Detector (SVD). The simulation of the SVD is in progress, and the software package for data processing was developed. The trigger concept was

worked out to register events of *pp* interactions with high multiplicity. The liquid hydrogen target was designed and its manufacturing began. The track system based on drift tubes and containing 2400 registration channels has been developed and is under construction. The Monte Carlo generator of events with high multiplicity was developed on the basis of the statistical description of the thermalized hadron systems.

3. ACCELERATION TECHNIQUES

The LPP specialists participate in construction of the Transverse Damping System at **LHC**. In 2003 the design stage was in progress according to the specifications and agreements for kickers and amplifiers. The preproduction unit (2 vacuum tanks) was tested at CERN. The investigation of transverse dynamic of the beam for damping the particle injection errors in LHC is carried out in accordance with the results of the tests of the equipment constructed for LHC. The beam oscillations damping after injection into LHC with the real parameters of the injection kicker system (CERN/TRIUMF) has been simulated for different dependences between the kick and the beam deviation in the pick-up. According to the schedule of the LHC construction, the stage of integration of the Damper's equipment in the LHC tunnel is in progress.

During 2003 the Free Electron Laser (FEL) group continued the experimental and theoretical investigations of the millimeter-wave Free Electron Maser oscillators as possible microwave power sources for the linear collider **CLIC** at CERN. A new technique was developed for measure the wave beam size and alignment of RF radiation transmission line to the test cavity. Using this technique the optimization of the transmission line has been performed. The power at the test cavity entrance has been reached at the level of half designed power. In order to eliminate the breakdown phenomena in the RF transmission line, several modifications of FEM output pattern have been investigated both with numerical simulation and experiment. In collaboration with CLIC group (CERN) and IAP RAS a new configuration of the test cavity has been developed and manufactured. The systems of stabilization of linac modulators, pre-injector and magnetic lenses have been developed and tested on the prototype.

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. In 2003, the photon diagnostic unit, equipment for photon beamline, and mirror chamber for pump-probe experiments at the TTF FEL, Phase II, have been manufactured at JINR and delivered to DESY. The design of the wiggler for PETRA storage ring was completed. Analysis of the beam and FEL physics for Phase I of TTF FEL project has been finished successfully. It confirmed that TTF FEL has been driven by the electron bunch having 3 kA peak current. Formation of the driving beam was strongly influenced

by space charge effects [27]. JINR experts took part in the theoretical and design work on diagnostic tool based on FIR coherent undulator [28]. Perspective potential extensions of TTF FEL were studied in detail: two-color FEL amplifier and efficient frequency doubler [29].

In 2003 the design project of LUE-200 was prepared in structure of the Confirmed part of Equipment design project of IREN. The settlement - theoretical works on optimization of operating modes of accelerating system and focusing system are carried out. The basic modules of the accelerator are made and installation of carrying constructions of the linac is started. The test of the accelerating sections and units of the RF-feeder has been performed at the full-scale RF-stand. The electron source - an electron gun with a pulse feed on 200 kV – is made and passes bench tests. The power supply system for the modulator of an electron gun on 200 kV is produced and tested. Of about 50% of elements of focusing and transportation systems are produced and under testing.

4. COMPUTING

In 2003 the local computer cluster of LPP has been significantly improved. A basis for using the Gigabit Ethernet protocol in the JINR local network was prepared: the cabling and test of optical links and router equipment were completed. The total power of the LPP-LHE PC farm has been increased by two times: CPU power - up to 2K Si95, disk space – up to 6 TB. The main tasks of ongoing experiments NA48, EXCHARM, COMPASS, HERA-B have been solved using the LPP-LHE PC-farm. The effective utilization of videoconference service in current research works has been started.

REFERENCES

1. A. Lai et al., Preprint CERN-EP-2003-006, Geneva, 2003.
2. A. Lai et al., Preprint CERN-EP/2003-052, Geneva, 2003.
3. A. Lai et al., Phys. Lett., Vol. B556 (2003) p.105.
4. A. Lai et al., Phys. Lett., Vol. B551 (2003) p.7.
5. J.R.Bartley et al., Phys. Lett., Vol. B576 (2003) p.43.
6. A.Airapetian et al., Eur. Phys. J., Vol.C26 (2003), p.527.
7. A.Airapetian et al., Phys. Rev. Lett., Vol.90 (2003), p.092002.
8. C.Adloff et al., Eur.Phys.J., Vol.C30 (2003), p.1.
9. N.Karpenko and A.Spiridonov, HERA-B Note 03-019, Hamburg, 2003.
10. A.Abyzov, A.Bel'kov, A.Lanyov, A.Spiridonov, M.Walter, and W.Hulsbergen, Part. Nucl. Lett. No. 5[114] (2003) p.40.
11. A.Belkov, T.Ilitcheva, and S.Shulga, e-print: hep-ph/0310077.
12. D.D. Emelianov (on behalf of the EXCHARM collabration), in Proc. of the IV Russian Conf «University of Russia" – fundamental investigations. Particle and Nuclear Physics». M., MePHI, 2003, p.27.

13. A.N. Aleev et al. Preprint JINR P1-2003-167. Dubna, 2003, p.17.

14. O.V. Bulekov (on behalf of the EXCHARM collaboration), in Proc. of the IV Russian conference «University of Russia" – fundamental investigations. Particle and Nuclear Physics». M., MePHI, 2003, p.25.

15. S.V. Eremin (on behalf of the EXCHARM collaboration), ibid, p.29.

16. I.A. Polenkevich (on behalf of the EXCHARM collaboration), ibid., p.31.

17. S.N. Shkarovsky (on behalf of the EXCHARM collaboration), ibid., p.33.

18. A.N. Aleev et al., Eur. Phys. J., Vol. C27 (2003) p.547.

19. O.Yu.Smirnov, P.Lombardi, G.Ranucci, Preprint JINR E13-2003-93, Dubna, 2003.

20. H.O.Back et al., Preprint JINR E15-2003-92, Dubna, 2003.

21. H.O.Back et al., Preprint JINR E15-2003-119, Dubna, 2003.

22. A.O.Golunov et al., Particles and Nuclei, Letters. 2003, No.2[117], p.46.

23. Ph.Bloch et al., CMS Note-2003/012-ECAL, Geneva, 2003.

24. I.Golutvin et al., e-print: hep-ph/0310336, accepted for publication by Czech. J. Phys., Vol.53 (2003).

25. A.Belkov and S.Shulga, Part. Nucl. Lett., Vol. 2[117] (2003) p. 12; e-print: hep-ph/0301105.

A.Belkov and S.Shulga, e-print: hep-ph/0310096 (accepted for publication by Comp. Phys. Comm.).

26. V.Konoplyanikov, A.Urkinbaev and O.Kodolova, CMS IN-2003/013, CMS IN-2003/036, Geneva, 2003.

27. R.Ischebeck et al., Nucl. Instr. Meth., Vol. A507 (2003), p.175.

B.Faatz et al. Nucl. Instr. Meth., Vol.A507 (2003), p.350.

V.Ayvazyan et al., Nucl. Instr. and Meth., Vol.A507 (2003), p.368.

28. G.Geloni, E.L.Saldin, E.A.Schneidmiller and M.V.Yurkov, Preprint DESY 03-031, Hamburg, 2003.

29. E.L.Saldin, E.A.Schneidmiller and M.V.Yurkov, Nucl. Instr. Meth. Vol. A507 (2003), p.101, p.106, p.439.

W.Brefeld et al., Nucl. Instr. Meth., Vol. A507 (2003), p.431.

J.Feldhaus, T.Moller, E.L.Saldin, E.A.Schneidmiller and M.V.Yurkov, Nucl. Instr. Meth., Vol. A507 (2003), p.435.

J.Feldhaus, E.L.Saldin, E.A.Schneidmiller and M.V.Yurkov, Nucl. Instr. Meth., Vol. A507 (2003), p.510.

E.L.Saldin, E.A.Schneidmiller and M.V.Yurkov, Optics Comm., Vol. 221 (2003), p.403. J.Botman et al., Preprint DESY 03-044, Hamburg, 2003. J.Feldhaus et al., Preprint DESY 03-091, Hamburg, 2003.

J.Feldhaus et al., Preprint DESY 03-092, Hamburg, 2003.

E.L.Saldin, E. A.Schneidmiller and M.V.Yurkov, Preprint DESY 03-108, Hamburg, 2003.

Макет *Т. Е. Попеко*

Получено 16.12.2003. Подписано в печать 17.12.2003.
Формат 60 × 90/16. Бумага офсетная. Печать офсетная.
Усл. печ. л. 0,93. Уч.-изд. л. 1,48. Тираж 145 экз. Заказ № 54222.

Издательский отдел Объединенного института ядерных исследований
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