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Report to the 87th Session
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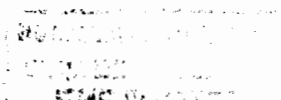

1. RESEARCH ACTIVITIES AT IHEP (Serpukhov)

A study of charmed baryon production in neutron-nucleus interactions is continued in the frame of the **OSCAR** theme at the **EXCHARM** setup [1]. The EXCHARM experiment is an extension of the scientific programme being carried out at the U-70 accelerator in Protvino and aimed at:

- searching for exotic states in hadron reactions;
- studying of strange and charmed particles hadroproduction, including polarization phenomena;
- investigating of single and double ϕ-meson production characteristics and OZI rule violation.

A clear signal from the decay $\Lambda_c \to p\pi^+\pi^+\pi^-$ has been observed (about 5 standard deviations) in the Λ_c^+ mass region. The (124 ± 20) events of double ϕ-meson production in neutron-carbon (nC) interactions have been observed. The calculated cross section of the double ϕ-meson production is

$$\sigma = (12.9 \pm 3.0_{\text{stat.}} \pm 1.3_{\text{sys.}})\ \mu\text{b/nucleon.}$$

The lower limit of the ratio of the cross section of the processes, suppressed by Okubo-Zweing-Iizuka (OZI) rule, to the total double ϕ-meson production cross section, measured in this experiment, was determined to be equal to 0.09 at 95% CL [2].

Inclusive production cross sections of strange resonance $K^{*\pm}(892)$ have been measured in nC-interactions:

$$\sigma(nN \to K^*(892)^+ X) = (0.433 \pm 0.018_{\text{stat.}} \pm 0.016_{\text{sys.}})\ \mu\text{b/nucleon},$$
$$\sigma(nN \to K^*(892)^- X) = (0.252 \pm 0.013_{\text{stat.}} \pm 0.017_{\text{sys.}})\ \mu\text{b/nucleon}.$$

Some parametrizations of invariant differential cross section have been considered and experimental values of their parameters have been obtained [3].

New precise measurements of spin density matrix element ρ_{00} of $K^*(892)^\pm$-mesons produced inclusively in neutron-carbon interactions have been carried out [4]. The values of ρ_{00} in the transversity frame are $0.424 \pm 0.011_{\text{stat.}} \pm 0.018_{\text{sys.}}$ for $K^{*+}(892)$ and $0.393 \pm 0.025_{\text{stat.}} \pm 0.018_{\text{sys.}}$ for $K^{*-}(892)$.

New precise data of polarization of Λ's produced in nC-interactions in the kinematic range of $0.1 \leq x_F \leq 0.6$ and $0.2 \leq p_t \leq 1.2$ have been obtained [5]. The polarization has nearly linear dependence within all the range of $p_t \leq 1\,\text{GeV/c}$ at fixed x_F. The polarization increases roughly linearly with increasing of x_F at fixed p_t.

2. COOPERATION WITH CERN

The construction of the **NA48** detector has been completed for the precision measurement of the ε'/ε ratio in CP violating decays of K^0-mesons into $\pi^+\pi^-$ and $\pi^0\pi^0$. The value of ε'/ε has been measured from the data recorded in 1997 [6]:

$$\text{Re}(\varepsilon'/\varepsilon) = (18.5 \pm 4.5_{\text{stat.}} \pm 5.8_{\text{syst.}}) \times 10^{-4}.$$

The JINR group has made a considerable contribution into the final data analysis, including the corrections and the systematical error estimation.

Totally 6864 events of the decay $K_L \to e^+e^-\gamma$ have been observed with an estimated background of 10 events [7]. The branching ratio is:

$$\Gamma(K_L \to e^+e^-\gamma)/\Gamma(K_L \to \text{all}) = (1.06 \pm 0.022_{\text{stat.}} \pm 0.020_{\text{sys.}}) \times 10^{-5}\,.$$

The parameter α_{K^*} describing the relative strength of the two amplitudes contributing to this decay through intermediate pseudoscalar or vector mesons, was measured to be

$$\alpha_{K^*} = -0.357 \pm 0.060\,.$$

A new precision measurement of the Ξ^0 mass has been carried out [8]:

$$m_{\Xi^0} = (1314.82 \pm 0.06_{\text{stat.}} \pm 0.20_{\text{syst.}})\text{MeV/c}^2\,.$$

The branching ratios of Ξ^0 radiative decays have been measured as:

$$\text{Br}(\Xi^0 \to \Lambda\gamma) = (1.90 \pm 0.34_{\text{stat.}} \pm 0.19_{\text{sys.}}) \times 10^{-3}\,,$$
$$\text{Br}(\Xi^0 \to \Sigma^0\gamma) = (3.14 \pm 0.76_{\text{stat.}} \pm 0.32_{\text{sys.}}) \times 10^{-3}\,.$$

A study of the polarizaton of Λ-hyperons produced in inelastic pN reactions by the 450 GeV proton beam has been performed [9]. The Λ-hyperons were detected at a fixed angle of 4.2 mrad in the momentum range from 50 to 200 GeV/c. The polarization changed from -0.053 ± 0.034 to 0.298 ± 0.074 for a transverse momentum range of Λ between 0.028 GeV/c and 0.86 GeV/c. The $\overline{\Lambda}$ polarization is consistent with zero. Two events of light gluinos have been found through the appearance of $\eta \to 3\pi^0$ with a high transverse momentum [10].

The formalism for the space charge in ionization chambers and shower detectors has been developed identifying dimensionless parameters acceptable to describe a wide range under operating conditions [11]. The results of the computation have been compared with observations made during the operation of the NA48 calorimeter.

The 1999 experimental run has been carried out with the active participation of the JINR group and about 2.5×10^6 CP violating decays of $K_L^0 \to \pi^0\pi^0$ have been accumulated. The on-line physical data monitoring has been maintained by the JINR group. The first results based on the data obtained in 1998 are being received.

According to the JINR obligations on the **ATLAS** set up, the LPP participates in the construction of the Liquid Argon Hadronic End-cap Calorimeter (LArHEC) and subsystems connected to it. The team from JINR is actively working in the following directions:

- production of front wheel serial modules of the hadronic calorimeter;
- investigations of radiation hardness of materials and electronics supposed for the ATLAS liquid argon calorimetry, study of possible liquid argon pollution due to the materials irradiation;

- participation in preparation of the ATLAS physics performance Technical Design Report, simulation, and analysis of the experimental data;
- design and construction of the liquid argon temperature measuring system;
- design and production of the certain part of the electronic chain which compensates capacity differences of the HEC calorimeter readout structure.

The absorber structure and stainless steel pieces for 4 serial HEC modules assembly were produced at the JINR Experimental Workshop. The first serial module was manufactured at JINR, shipped to CERN and checked at the SPS test beams of pions, electrons and muons.

A lot of work was done on the IBR-2 reactor at JINR to investigate properties of materials and electronics being exposed to the high neutron fluence up to the 10^{16} n/cm^2. The GaAs preamplifiers of the final design have shown stable performance in terms of the transfer function, rise time, and linearity for neutron fluences up to 3×10^{14} n/cm^2 and for gamma irradiation – up to 31 kGy. The pollution of the liquid argon due to the irradiation of materials, which are used to construct all the ATLAS liquid argon calorimeters, by neutrons with the fluence of about 1.5×10^{16} n/cm^2 were mesuared by the apparatus specially built up at the IBR-2 reactor. Numerous runs have shown that liquid argon pollution is less than 2 ppm.

To study the top quark physics in the frame of ATLAS physics performance TDR preparation, the JINR team selected the process of single top quark production. The full simulation of the process in ATLAS detector has been done and the topology carefully studied. The criteria of the wanted signal identification were formulated. It was shown that the single top quark production process may be studied with a good statistical significance.

The preshapers were designed and the first set of electronics was produced. The performance was studied at the SPS test beam with 6 first serial modules. It has shown that the design and production of the preshapers are succesful.

The main activity of LPP within Compact Muon Solenoid Project, **CMS**, was concentrated on the study, design, and integration of the CMS Endcap detectors, where JINR has got a full responsibility in frame of Russia and Dubna Member States (RDMS) of the CMS Collaboration. The main task was optimisation of separate subsystems of the Forward Muon Station (ME1/1) in view of mass-production. Analysis of the experimental data taken with the P4 ME1/1 Cathode Strip Chamber (CSC) prototype instrumented with front-end electronics based on the Minsk chips ASIC, was completed [12]. The results have confirmed that the performance of baseline CSC such as position and timing resolution, efficiency of Local Charge Trigger and track reconstruction, meets the CMS requirements. The simulation of the analog memory has shown that to provide a precise reconstruction of the pulse height maximum, the optimal number of pulse height measurements with a period of 50 ns should be equal to 6 - 8. Development of the robust method has increased the precision of the track reconstruction up to 40 mm by a factor of 1.5 in respect to the method of the least squares.

JINR co-ordinates the RDMS CMS Collaboration activity on the design and construction of the Hadron Endcap (HE) calorimeter and is responsible for the HE absorber. A full-scale pre-production prototype of the HE calorimeter sector together with the HB sector prototype is installed on the "movable table" and tested at CERN H2 beam.

Manufacture of pre-series Preshower strip-detector based on a new hard radiation Si-detector topology developed by JINR in collaboration with RIMST, Zelenograd, and CERN has started. The radiation investigations of the full-scale detectors by irradiation with fast neutrons and 24 GeV protons are continued in collaboration with CERN. The Preshower prototype with 5×5 PWO crystals prototype of electromagnetic calorimeter is tested at the CERN H4 beam with electrons energy range of 15-180 GeV.

The experimental test with "X-ray CSC prototype" has demonstrated successful operation of the Katod-1m and Anod-1m ASICs for the background rate of 1-10 MHz per channel. A full-scale mock-up of ME1/1 CSC equipped with a set of the cathode and anode readout electronics, cooling and low voltage systems, realistic layout of cables and services is worked out to study chamber integration issues.

The investigations on application of pp-collision events with the production of direct photons associated with a single hadron jet have been continued to calibrate the hadron calorimeters. It was shown that these events can be used for precise determination of the gluon component of the proton structure function in a region of very small x_F and a very large transfer momentum square. This range can be considered as a complementary one to that measured at HERA. Simulation of the trigger option for heavy ion collisions in the CMS is in the progress.

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. In 1999, within available resources, JINR has participated in construction of various COMPASS detectors which are under Dubna responsibilities defined in the Memorandum of Understanding. Modules of the Hadron Calorimeter (HCAL1), which is under full responsibilities of JINR, have been constructed at Dubna and delivered to CERN for beam tests. The total number of the delivered modules is 500, 300 of them have been tested in 1999. The movable platform for HCAL1 is being designed in Romania under contract with JINR, and after inspection at CERN the construction of the platform has started.

Taking into account the 1998 results of the straw tube prototype tests, which have shown a high efficiency ($> 99\%$) and good precision of the tubes ($120 \div 150$ μm), drawings and production area have been prepared for mass production of straw drift chambers. These chambers (15 planes) will be included in the Straw Tracking Station placed within COMPASS spectrometer after the first magnet.

JINR experts take part in refurbishing the multiwire proportional chambers (MWPC) to be used in the Large Area Tracking Detector (LAT) placed within

COMPASS before and after the second magnet. Chambers are tested with new electronics and new gas based on CF_4. The conceptual and technical design of the Muon detector (MW1), which is also under full responsibilities of JINR, has been agreed upon with collaboration. Boxes and proportional tubes for two planes of tracking chambers were produced at JINR workshop and have passed inspections and tests at CERN. Amplifiers and discriminators for the MW1 read-out system have been also tested.

The Dubna group is taking part in the COMPASS optimization and preparations of the software. The group has contributed to:

- determination of the efficiency of registration and reconstruction of Λ- and $\overline{\Lambda}$-hyperons;
- determination of the efficiency of pattern recognition and reconstruction of primary and secondary vertices;
- background from K- and Σ-decays;
- optimization of the straw tracker;
- MC description of HCAL1 and analysis of the HCAL1 tests;
- development of the MC program COMGEANT and reconstruction program;
- development of algorithms for inclusive and semi-inclusive cross section calculations;
- optimization of LAT and positions of MWPC along the set up.

3. COOPERATION WITH DESY

The Dubna group has taken an active part in data taking, data analysis and technical maintenance of the system of mini-Drift Vertex Chambers (DVC) of **HERMES** Spectrometer Front Tracking. The LPP group has performed the technical support of DVC, which provides the stable operational DVC conditions with high efficiency (98-99%) and high spatial resolution (about 200 μm). The LPP physicists have participated in analysis of the 1996 and 1997 experimental data aimed at extracting the Q^2 dependence of the generalized Gerasimov-Drell-Hearn integral for proton in the resonance region and for the region $W^2 > 1.0$ GeV^2.

Spin asymmetries of semi-inclusive cross sections for the production of positively and negatively charged hadrons have been measured in deep-inelastic scattering of polarized positrons on polarized ^{1}H and ^{3}He targets, in kinematical range $0.023 < x < 0.6$ and $1.0 < Q^2 < 10$GeV^2 [13]. Polarized quark distributions are extracted as a function of x for up- $(u+\overline{u})$ and down- $(d+\overline{d})$ flavors. The up-quark polarization is positive, the down-quark polarization is negative and the polarization of sea quarks is compatible with zero. The isospin non-singlet combination is consistent with the prediction based on the Bjorken sum rule. The moments of the polarized quark distributions are compared to the predictions based on SU3 flavor symmetry and to the prediction from the lattice QCD, it is found to be in agreement.

Exclusive incoherent electroproduction of the $\rho^0(770)$ meson with ^{1}H, ^{2}H, ^{3}H and ^{14}N targets has been studied by the HERMES experiment at squared four-momentum

transfer $Q^2 > 0.4$ GeV^2 and positron energy loss ν from 9 to 20 GeV [14]. The ratio of the ^{14}N to ^{1}H cross sections per nucleon known as the nuclear transparency was found to decrease with increasing coherence length of quark-antiquark fluctuation of the virtual photon. The data provide clear evidence of the interaction of the quark-antiquark fluctuations with the nuclear medium.

A measurement of the longitudinal spin asymmetry $A_{\parallel}$ in photoproduction of pairs of hadrons with high transverse momentum p_t has been done [15]. The data were accumulated by the HERMES experiment using the 27.5 GeV polarized positron beam and a polarized hydrogen target integral to the HERA storage ring. For h^+h^- pairs with $p_t^{h1} > 1.5$ GeV/c and $p_t^{h2} > 1.0$ GeV/c, the measured asymmetry is $A_{\parallel} = -0.28 \pm 0.12_{\rm stat} \pm 0.02_{\rm sys}$.. This negative value is in contrast to the positive asymmetries typically measured in deep inelastic scattering from protons, and is interpreted to arize from a positive gluon polarization. The value of $\Delta G/G$ was determined in the leading order of QCD to be $0.41 \pm 0.18_{\rm stat} \pm 0.03_{\rm sys}$..

According to the JINR commitments, LPP participates in the construction of the Outer Tracker (OTR) of the **HERA-B** detector designed to search for CP-violation in exclusive B-decays, mainly, in the "gold plated" decay mode $B^0 \to J/\Psi K^0_S$. The LPP provides the following items and supports them in order to carry out the HERA-B experiment:
- construction, installation, and commissioning of parts of the OTR;
- participation in the assembly, maintenance, and operation of the OTR;
- contribution to the development and maintenance of the off-line reconstruction code, the calibration code and the detector-specific code for the slow control;
- participation in the physics analysis of the data.

A specialized mass production line was set at the LPP for manufacturing the honeycomb modules by using the materials and parts supplied from DESY, Germany. All information about every wire in the manufactured chamber (wire tension, high voltage test, etc.) including results of the module test at the setup with radioactive source (dark current for wire group, wire noise, wire counting frequency, chamber efficiency) was inserted to the chamber quality data base. The direct access to this data base via Internet provides the transparency of mass production at Dubna for all participants of the HERA-B collaboration. In September 1999 the mass production program was completely fulfilled at the LPP. In total, about 300 modules have been manufactured and delivered from Dubna to DESY. This number of modules corresponds to about 40 000 channels or, respectively, to 30% of the total number of the OTR channels. The final quality tests performed in Hamburg after the delivery of the chambers produced in Dubna have shown that the number of bad wires is less than 1% (noisy channels – less than 0.3%, dead channels – 0.6%).

A strong team from Dubna consisting of physicists, engineers, and technicians also works at DESY. This group is responsible for the cabling of the OTR beginning from the drift tube modules inside the gas volumes to the TDC. For this task there were developed schemes of the OTR cable infrastructure including the labeling of all kinds

of cables (signal, high voltage, low voltage, sharc) and electronic components (ASD, TDC, HV and LV boards, trigger link boards, sharc boards). A special graphical interface program has been developed to design the cabling schemes.

An overwhelming contribution to the OTR installation, testing and commissioning is carried out by the Dubna group. Their activity covers a wide field of tasks: from the beginning of the equipment preparation for the inner and outer superlayer frames, installation and connection of modules - to testing and debugging the readout electronics and DAQ programs. While finishing the OTR superlayers commissioning, the activity of Dubna physicists involved in this task will be focused on the OTR running and data analysis.

The LPP participates in the upgrading of detectors for the **H1** experiment to investigate deep inelastic scattering of electrons on protons, specifically, in the software/hardware support of Forward Proton Spectrometer (FPS) operation and in the upgrading of the hadron Plug calorimeter. The upgrading of the Plug calorimeter includes the design of sensitive layers for the detector based on radiation hard scintillators readout by wave length shifting fibers and magnetic field resistant photomultipliers, and manufacturing of selected readout analog and monitoring electronics.

The LPP takes an active part in physical analysis of deep-inelastic scattering processes on the base of experimental data from the FPS and hadron Plug calorimeter. Measurements of the transverse energy flow have been carried out for neutral current deep-inelastic scattering events produced in positron-proton collisions at HERA [16]. The kinematic range covers squared momentum transfers Q^2 from 3.2 to 2200 GeV^2, the Bjorken scaling variable x from 8×10^{-5} to 0.11 and the hadronic mass W from 66 to 233 GeV. The transverse energy flow is measured in the hadronic centre of mass frame and is studied as a function of Q^2, x, W and pseudorapidity. A comparison is made with QCD based models. The behaviour of the mean transverse energy in the central pseudorapidity region and an interval corresponding to the photon fragmentation region are analysed as a function of Q^2 and W.

Deep-inelastic scattering events with a leading baryon have been detected by the H1 experiment at HERA using a forward proton spectrometer and a forward neutron calorimeter [17]. Semi-inclusive cross sections have been measured in the kinematic region $2 \leq Q^2 \leq 50$ GeV^2, $6 \times 10^{-5} \leq x \leq 6 \times 10^{-3}$ and baryon $p_T \leq 200$ MeV. A Regge model of the leading baryon production which consists of the pion, pomeron and secondary reggeon exchanges gives an acceptable description of the both semi-inclusive cross sections in the region of $0.1 \leq x_{IP} \leq 0.3$. The leading neutron data are used to estimate the structure function of the pion at small x.

Measurements of the energy of the leading proton detected in the FPS Horizontal Roman Pots sensitive in the diffractive kinematic range ($x_{IP} \leq 0.05$) and cross-calibration of Horizontal Roman Pots in elastic ρ-meson photo-production events have been performed [18]. The final aim of the analysis is to measure the semi-inclusive diffractive structure function $F_2^{D(3)}$ and to study the vector meson (ρ, ω, ϕ, J/ψ) diffractive photo-production cross sections.

4. OTHER EXPERIMENTS

The LPP takes part in the design and construction of the End-cap Electro-Magnetic Calorimeter (EEMC) for the 4π-detector **STAR** for the collider RHIC at the Brookhaven National Laboratory. A model of the EEMC was manufactured and tested in the 27 GeV e-beam of the accelerator U-70 (Protvino). The results of tests have confirmed the requirements of the EEMC design. Setting up of the area to produce the scintillation plates by means of molding under pressure has been created at the Serpukhov Division of LPP, JINR. The LPP physicists together with the BLTP theoreticians have shown that, under operation conditions of the STAR detector a new opportunity is revealed to measure polarization of the particles produced in multi-particle processes. The Technical design and the full scale prototype of the PMT box for the Barrel EMC (BEMC) of the STAR detector have been done by the LPP physicists at the Wayne State University to provide the timely testing of the first BEMC modules.

The LPP specialists participate in construction of the low-noise neutrino detector **BOREXINO** located at the underground laboratory in Gran Sasso (Italy). The responsibilities shared by the JINR group are mainly concerned DAQ system, detector calibration and testing, cleaning and mounting of photo-multiplier tubes (PMT). The 109 PMTs have been tested on the BOREXINO test facility and significantly improved during the test. The database containing all the PMT parameters has been created to provide parameters for the better MC simulations of the detector. On the base of the measurements the model of the PMT single electron response has been developed and succesfully integrated in the BOREXINO simulation code. The method of the fast HV tuning for the PMT gain $k = 10^7$ has been also developed and tested.

5. ACCELERATION TECHNIQUES

According to the JINR obligations on the transverse oscillation damping system for **LHC**, assembling of the prototype of the wide band amplifier and of the full-scale kicker model has been completed in 1999. Tests of the system on frequency and energy were carried out on a specialized stand of the LPP. Technical documentation for the prototype of the device has been developed and corrected on the basis of the obtained experience. Besides, the construction was completed by the elements necessary for the high precision positioning of the reper targets of the tuning system. Experimental studies aimed at the production of the NbN/Nb/NbN films with a higher first critical magnetic field were continued. Theoretical analysis of the influence of the surface smoothness of the working layer of superconducting cavities on the character of non-quadratic losses was continued.

The main direction of co-operation with DESY is developments for linear collider **TESLA** and studies in the field of free electron lasers (FEL) [19]. Conceptual

projects have been developed for an X-ray laser on free electrons which was integrated into the project of the linear collider as well as for the second place of the collision of the linear collider to carry out experiments on colliding $\gamma\gamma$ and γe beams of high luminosity. Optimization of the parameters of the X-ray FEL has been done on the TESLA Test Facility (TTF). The schemes of the X-ray range FEL have been developed and tested on the LPP stand, they provide full coherence of the output radiation (regenerative FEL-amplifier for the first phase and a two-cascade scheme for the second phase of the project).

A big amount of work was fulfilled on cryogenic supply of TTF and TESLA. Calibration of the first batch of thermometers has been carried out for the project TESLA in the range of 1.5-300 K with an accuracy of 0.01 K in the helium range of temperatures. The algorithm of processing the sensors calibration results has been improved that provides a higher precision in comparison with the earlier known methods. The behavior of the thermometers in the magnetic field up to 11 T was studied in the range from 1.5 K to 4.5 K. The metrological system for calibration of the RF-sensors of void fraction of the two-phase cryogen flows has been modernized to extend its operational range till 1.5 K and calibrate RF-sensors. A prototype of the void fraction sensor has been manufactured with a relatively big inner diameter (about 70 mm) and with improved non-uniformity of the electric field in its sensitive element. This system has been delivered to CERN. The results of studies of the properties of the horizontal two-phase helium flows used as cryogen in superconducting cryogenic systems, have been systematized.

Studies on FELs for electron-positron colliders with a scheme of two-beam acceleration **CLIC** – were carried out on the following main directions:

– development of the FEL generators and amplifiers of the millimeter range for high gradient supply of the accelerating structures of the electron-positron colliders;

– theoretical and experimental studies of the electron bunch dynamics in FEL, studies of the possibility to construct a group former for the beam driver of the two-beamed accelerator;

– studies of the possibility of grouping the driver beam and transportation of the grouped beam captured by synchronous electromagnetic wave using the travelling wave tube (TWT) scheme.

The FEL generators have been studied theoretically and experimentally. Two new schemes of Bregg reflectors have been used – with the uniformed structure of corrugated waveguide and with the corrugated waveguide with phase shift of π [20]. Numerical simulation has shown that it is possible to carry out a precision up-tuning of the output radiation frequency by means of the FEL having a Bregg reflector with a phase shifted by the corrugated waveguide. A new version of the RF-signal input device in the FEL amplifier with the efficiency of 60% has been developed and manufactured. The work was fulfilled on the accelerator LIU-3000.

Numerical simulation was applied to study the dynamics of the grouped beam in the FEL-generators with two types of the Bregg reflectors. Jointly with a group from

the LNP the specialists from the LPP have developed Cherenkov radiators on the basis of the quartz airogel having a very high quant yield and big resource. While using these radiators there is a possibility preserved to control the electron beam current and radiation power at the FEL output. Preliminary experiments have been carried out to study the grouping of the beam in several types of the FEL-generator.

It has been shown experimentally that the existing system with low phase velocity does not provide the TWT-amplifier on the saturation regime. A new system with low phase velocity has been calculated, designed and manufactured. Cold measurements of its characteristics have been done and the preparation is conducted for the experiments on the beam.

An experimental study of the model of **electron accelerator for radiation technologies** has been performed at LPP. It is a scaled model of 700 kV, 300 kW, high repetition rate accelerator. The parameters of the model are the following: electron energy – 200 kV, average beam power – 20 kW, peak current – 1 A, pulse duration – 10 μs, repetition rate – 18 kHz. The accelerator is designed as a vacuum diode with a special cathode under the sinusoidal high frequency potential. The cathode voltage is formed by high frequency $\lambda/4$ coaxial resonator with a spiral inner conductor. The resonance frequency of the coaxial resonator is equal to 18 kHz. Using the vacuum insulation allows one to increase significantly the resonator quality up to 140 and efficiency of the electrical power conversion into the power of the electron beam up to 97-98%.

The experimental study and preliminary operation of the 200 keV model of the electron accelerator have been performed. The model has a high factor of safety. Dark currents of the cathode-anode system (without mosaic cold cathode) are detected at voltage exceeding 300 kV. The experimental experience obtained with the 200 keV accelerator model will be used to construct a full scale accelerator model with the energy of about 1 MW and output power of about 330-300 kW.

The **Accelerator Complex for hadron therapy** has been designed in collaboration of specialists from LPP, different Czech Institutes and Companies, and specialists from AccSyS Inc. (USA). The designed synchrotron meets special requirements which are defined by the "active" scanning of tumors (in particular, the "raster-scanning" technique). The synchrotron will work in the mode of slow (resonant) extraction of accelerated protons with the spill duration not less than 500 ms in all the range of the output energies from 60 MeV to 220 MeV. The step of the output energy variation must be not more than 0.4 MeV with the needed accuracy better than ± 40 keV. The FWHM-spot size at the patient should be less than 5 mm to realize the "raster scanning" technique. The intensity of the extracted beam should be about 6.25×10^{10} protons in the case of 1 Hz repetition rate to provide the irradiation dose till 5 Gy in the volume of 1 litre per minute. The Proposal of the Comprehensive Oncology Center based on the designed machine will be presented to the Czech Government for financial support to be included in the State budget for 2001.

References

[1] A.N. Aleev et al. Instrum. Exp. Tech., Vol. 4, 1999, p. 1.

[2] A.N. Aleev et al. JINR Rapid Communications, No. 1 [93]-99, Dubna, 1999, p. 14.

[3] A.N. Aleev et al. Preprint JINR P1-99-136, Dubna, 1999.

[4] A.N. Aleev et al. Preprint JINR E1-99-178, Dubna, 1999.

[5] A.N. Aleev et al. Preprint JINR E1-99-77, Dubna, 1999.

[6] V. Fanti et al. CERN-EP/99-114, 1999; hep-ex/9909022.

[7] V. Fanti et al. Phys. Lett., Vol. B458, 1999, p. 553.

[8] V. Fanti et al. Print-99-036, 1999.

[9] V. Fanti et al. Eur. Phys. J., Vol. C6, 1999, p. 265.

[10] V. Fanti et al. Phys. Lett. Vol. B446, 1999, p. 117.

[11] S. Palestini et al. Nucl. Instrum. Meth. Vol. A421, 1999, p. 75.

[12] I.A. Golutvin et al. JINR Rapid Communications, No. 1 [93]-99, Dubna, 1999, p. 48.

[13] K. Ackerstaff et al. Preprint DESY 99-048, Hamburg, 1999; hep-ex/9906035.

[14] K. Ackerstaff et al. Phys. Rev. Lett., Vol. 82, 1999, p. 3025.

[15] A. Airapetian et al. Preprint DESY 99-071, Hamburg, 1999; hep-ex/9907020.

[16] C. Adloff et al. Preprint DESY 99-091, Hamburg, 1999.

[17] M. Kapichine (for the H1 Collaboration): talk presented at the 7th International Workshop on Deep Inelastic Scattering, DIS'99, Zeuthen, Germany, April 1999; Proceedings in Nucl.Phys. B (Proc.Suppl.), Vol.79, 1999.

[18] P. van Esch et al. Preprint DESY 99-158, Hamburg, 1999.

[19] E.L. Saldin, E.A. Schneidmiller and M.V. Yurkov. Nucl. Instrum. Meth. Vol. A429, 1999, p. 197.
B. Faatz et al. Nucl. Instrum. Meth. Vol. A429, 1999, p. 424.
E.L. Saldin, E.A. Schneidmiller, Yu.N. Ulyanov and M.V. Yurkov. Fusion Engineering and Design, Vol. 44, 1999, p. 341.

[20] Yu.P. Filippov. Cryogenics, Vol. 39, 1999, p. 59, p.69.

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