JOINT INSTITUTE FOR NUCLEAR RESEARCH

2006-171

A. I. Malakhov

THE RESULTS OF 2006 AND THE RESEARCH PROGRAMME OF THE VEKSLER AND BALDIN LABORATORY OF HIGH ENERGIES FOR 2007–2009

Report to the 101st Session
of the JINR Scientific Council
January 18–19, 2007

Dubna 2006

A. I. Malakhov

THE RESULTS OF 2006 AND THE RESEARCH PROGRAMME OF THE VEKSLER AND BALDIN LABORATORY OF HIGH ENERGIES FOR 2007–2009

Report to the 101st Session
of the JINR Scientific Council
January 18–19, 2007

Dubna 2006

1. Introduction

In 2006, the scientific program of the Veksler and Baldin Laboratory of High Energies (VBLHE) of the Joint Institute for Nuclear Research (JINR), similar to the previous years, was concentrated on Relativistic Nuclear Physics [1-8].

This report presents the some new results obtained at VBLHE in 2006 and the research program for the next three years.

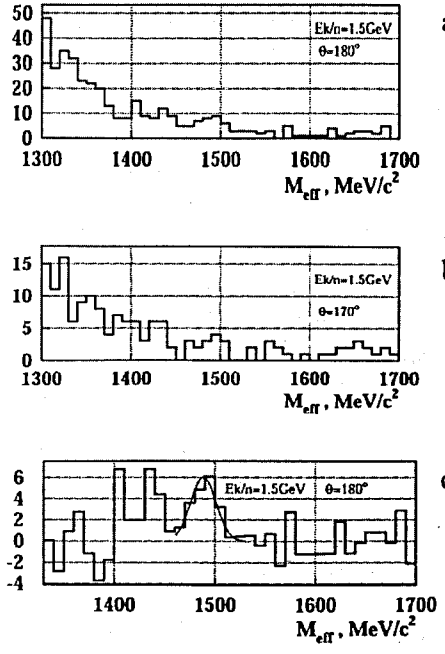
The most part of VBLHE research is performed on the own accelerator complex on the basis of the superconducting accelerator Nuclotron.

The VBLHE has international scientific co-operation with CERN, many physics centers in Russia, JINR member states, physics centers in the US, Germany, France, Japan, and other countries.

2. Some new physics results obtained at the VBLHE accelerator complex in 2006

η-Nuclei project (S.V.Afanasev –JINR, G.A.Sokol – FIAN)

The studies on the existence of η-nuclei continued within the framework of the project on deuteron-nucleus interactions [9].



The distributions of the yields of nucleon pair are shown in Fig. 1 (a,b) versus M_{eff} of these pairs in deuteron-carbon interactions at 1.5 A·GeV. The histogram in Fig. 1 (b) shows the data obtained at an arm angle of 170°. Figure 1 (a) corresponds to the back-to-back correlation coming from the two-body decay. The histogram in Fig. 1 (c) is the (180°) and the data measurements.

The ratio of the numbers of nucleon pairs was $N\{170^\circ\}/N\{180^\circ\} = 0.42 \pm 0.08(stat)$ in the mass region $1450 < M_{eff} < 1550$ MeV/c^2. It is possible to see a small peak in this mass region which can possibly be preliminary interpreted as formation of η-nuclei.

Fig. 1. Effective mass distributions in dA reaction at 1.5 A·GeV.

New data were collected in October 2006. They include 105 pairs coming from the target in *d+Cu* and *d+C* reactions at primary beam energies of 1.5A·GeV and 1.9 A·GeV. This data are being analyzed.

MARUSYA setup (A.A.Baldin)

The adjustment of the MARUSYA setup was carried out during the last run of the Nuclotron. The spectra of pions, protons and deuterons were obtained.

The particle identification is provided via time-of-flight measurements, ΔE-TOF analysis, and fast particle rejection by Cerenkov counters, momentum measurements by means of multiwire proportional chambers.

Figure 2 shows the proton and pion time-of-flight spectra for three modes of operation of the spectrometer obtained in 2006 in the reaction *C+Cu*.

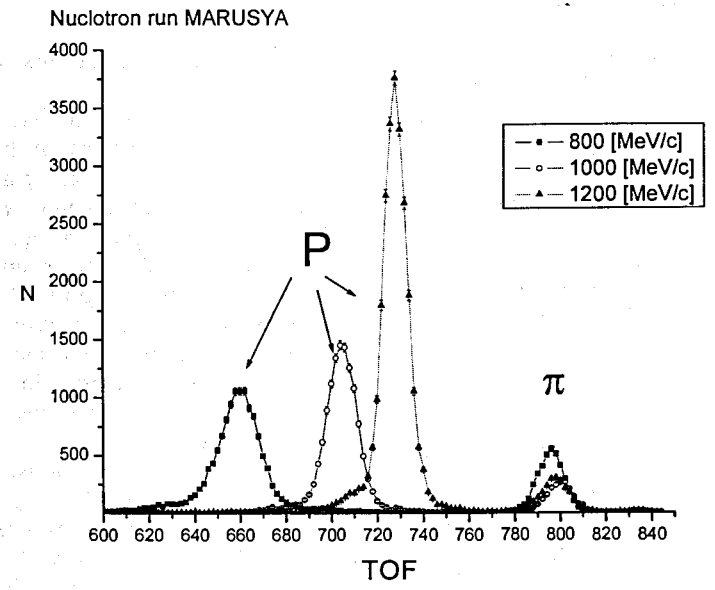


Fig. 2. Time-of-flight spectra of protons and pions obtained in the reaction *C+Cu* for three momenta of the registered particles.

Light Nuclei Structure LNS project (Light Nuclei Structure) (V.P.Ladygin)

The preliminary results on the differential cross section for the dp-elastic scattering at 500 and 550 MeV measured at the Internal Target Station (ITS) at Nuclotron in March 2005 are presented in Fig. 3.

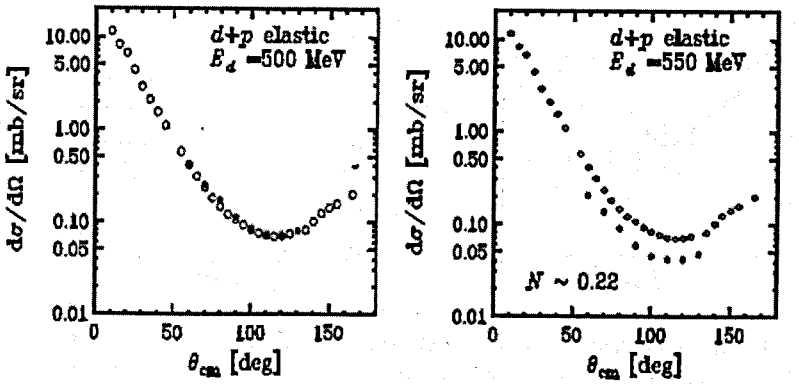


Fig 3. Differential cross section for the dp- elastic scattering measured (solid circles) at Nuclotron and (open circles) at RCNP at 500 MeV and 550 MeV of the deuteron energy.

These data were obtained in the framework of JINR-CNS (Japan) collaboration using the Japanese detection system. The shape of the cross section at 500 MeV obtained at the Internal Target Station (ITS) at Nuclotron is in good agreement with the RCNP data, at other energies the reasonable behavior (data without normalization) of the cross section is observed. The polarimeter based on dp-elastic scattering at 270 MeV was used during the June 2006 run of the Nuclotron. The results on measurements of the beam polarization are in good agreement with the results given by the low-energy polarimeter at the exit of LINAC. The latest results of LNS collaborations are published in [10, 11].

PHe3 project (V.P.Ladygin - JINR, T.Uesaka – CNS, Japan)

The PHe3 collaboration in 2006 concentrated on the analysis of the data for deuteron beam polarimetry and on the preparation of the detectors.

The preliminary results on the behavior of the vector A_y and tensor A_{yy} analyzing powers of dp-elastic scattering at 880 MeV and 2000 MeV are presented in Figs. 4 and 5, respectively. The polarization effects are large enough to provide the efficient polarimetry of high energy deuterons. It should be noted that the effect for CH_2 at 2000 MeV is also large, which simplifies the polarimetry at this energy. The curves in Fig. 5 are the results of the theoretical calculations using the CD-Bonn nucleon-

nucleon potential and recent results of partial-wave analysis for nucleon-nucleon data. The theoretical work on interpretation of the data is in progress.

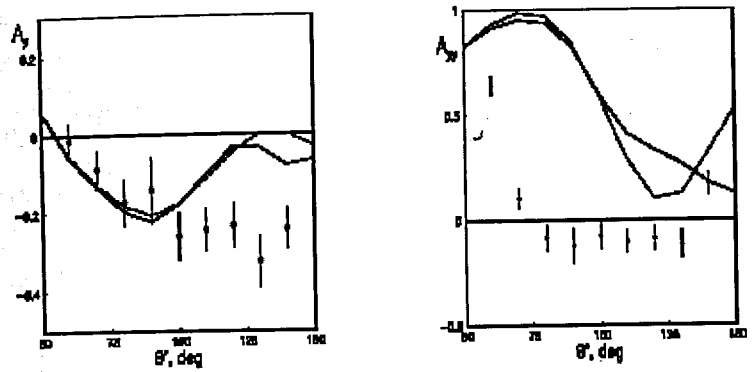


Fig. 4. Vector A_y and tensor A_{yy} analyzing powers of dp- elastic scattering at 880 MeV. The curves are the calculations using CD-Bonn nucleon-nucleon potential.

The analysis of the data on the performance of the internal target position monitor was finished, the corresponding paper was submitted for publication [8]. Methodical investigations of the detectors, DAQ for experiment at ITS continued [9].The work on the production of the registration electronics continued in 2006 as well.

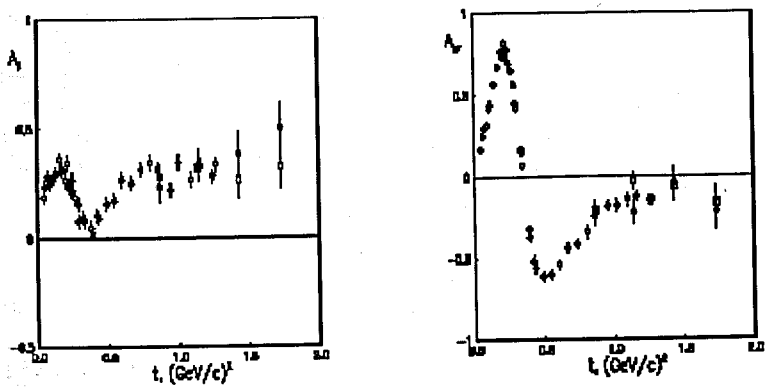


Fig. 5. Vector A_y and tensor A_{yy} analyzing powers of dp- elastic scattering at 2000 MeV. The solid circles are the data obtained at Nuclotron, open circles are the data from AGS, open squares are the data obtained for CH_2.

Observation of exotic S = -2, -1, 0, 1 multiquark states with Λ- hyperon and K^0_s–meson systems in pA collisions at 10 GeV/c (P.Zh.Aslanyan)

The experimental data from the 2 meter propane bubble chamber were analyzed for exotic baryon states search. A number of very important peculiarities were found in the effective mass spectra [12, 13].

The experimental Λ /π^+ ratio in the pC reaction is approximately two times larger than this ratio from pp reactions or from pC reactions simulated by FRITIOF model at the same energy.

(Λπ) -specrum . The $\Sigma^{*+}(1385)\rightarrow\Lambda\pi^+$ resonance from PDG with similar decay properties is registered as the test for this method .

(Λp) - spectrum. Narrow resonance-like peaks were found in spectra in the mass region of 2100, 2180,2225, 2285, 2353 and 2650 MeV/c^2 . The peak of 2180 MeV/c^2 agrees with the peak from reports of FOPI collaboration. D.Grzonka, T. Yamazaki, Y. Akaishi, P. Kienle at the ECT* workshop (Trento, June 22, 2006) evaluated this result as one of premature experiments.

(Λpp) -spectrum. There are significant enhancements in the mass region of 3138(6.1 S.D.).This peak agrees with the registered peak from reports of the E471 experiment, PS, KEK.

S=-2 H dibaryons A few events detected on the photographs of the propane bubble chamber exposed to a 10 GeV/c proton beam, were interpreted as S = - 2 light($<M_{\Lambda\Lambda}$) H^0 and heavy H^{0+} by weak decay channels of Σ^-p,$\Lambda\pi^0p$, $\Lambda\pi^-p$, $\Sigma^+p\pi^-$ and K^-pp.

(K^0_S p) and (K^0_S Λ) spectra. The recent observation of narrow, prominent exotic pentaquark baryons from antidecouplet has stirred up new interest in hadron spectroscopy. The $\Theta^+ \rightarrow (K^0_S\ p)$ effective mass distributions show resonance structures with M_Θ=1487, 1540, 1613, 1690, 1750, 1821 and 1980 MeV/c^2. The results of this experiment M_Θ=1540 MeV/c^2, Γ_Θ=9.2 MeV/c^2 agree with M_Θ and Γ_Θ from PDG-2004. This report for Θ^+ has been cited approximately 100 times. The significant enhancements was obtained for (K^0_S Λ) invariant mass spectrum in the region of 1750 and 1795 MeV/c^2 . These reports were given high appreciation by P. Palazzi, A.A. Arkhipov, D.Akers because these data conformed the predictions of M. H. Mac Gregor and Y. Nambu.

$K^0_S\pi^\pm$ spectra. The scalar mesons have vacuum quantum numbers and are crucial for a full understanding of the symmetry breaking mechanisms in QCD. There are no such mechanisms to suppress the decay $\sigma_0(600)\rightarrow\pi^+\pi^-$ or $\kappa(800)\rightarrow K\pi$. $K^0_s\pi^\pm$ spectra have significant enhancement in the mass range of 890 Mev/c^2($K^*(892)$ from PDG). The same invariant mass spectrum of $K^0_S\pi^\pm$ demonstrated peaks in the mass range of 720(>4.1 S.D), 780 MeV/c2 (>2.5 S.D.) and width Γ>29 MeV/c2, $\Gamma \approx 12$ MeV/c^2, respectively.

FAZA setup (V.A.Karnaukhov)

The new series of experiments on the study of phase transitions of nuclear matter of liquid-gas and liquid-fog types began at Nuclotron using the upgraded setup FAZA-3.

The experiments are performed using the 4π FAZA-3 setup, which differs from the previous installation FAZA-2 by the new detector module. It contains 25 tightly packed friend for friend dE/E telescopes for registration of charged particles. Each telescope consists of cylindrical ionization chambers with a diameter and a thickness of 50 mm. Anodes are made from golden wire with a diameter of 0.5 mm. Behind the chamber Si(Au) detector for measurement of the total energy of fragments is located. Its thickness is 700 μm. This module forms the trigger part of the FAZA-3 detector with five-fold telescope inherited from FAZA-2. The telescope module without electronics is shown in Fig. 6.

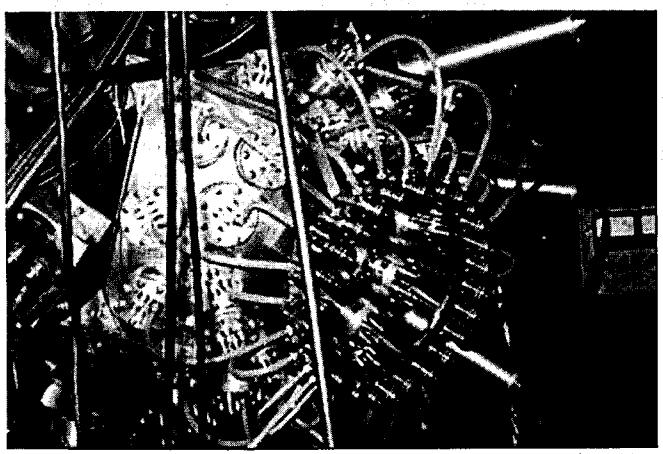


Fig. 6. Telescope module without electronics on one of twelve flanges of the installation FAZA.

BECQUEREL project (P.I.Zarubin)

For the first time at irradiation of emulsions by nuclear beams of the Nuclotron neutron-deficit isotope of carbon ^{10}C and ^{9}C were enriched. The views of the amplitude spectra of secondary nuclear beams from scintillation detectors in this experiment are shown in Figs. 7 and 8. It is possible to see nice peaks from ^{8}B, ^{9}C, ^{3}He, ^{7}Be, ^{10}C ions.

The obtained information is analyzed now. The results of previous runs of the Nuclotron are presented in [14-17].

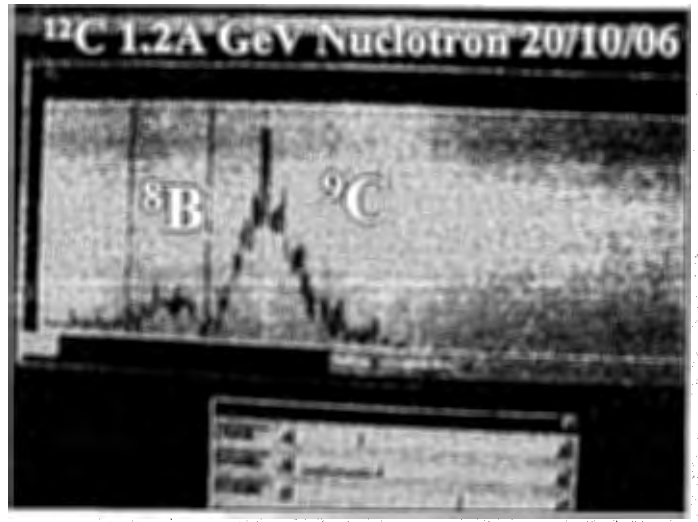


Fig. 7. The view of the amplitude spectra of secondary ^{8}B and ^{9}C nuclear beams from the scintillation detectors (BECQUEREL experiment).

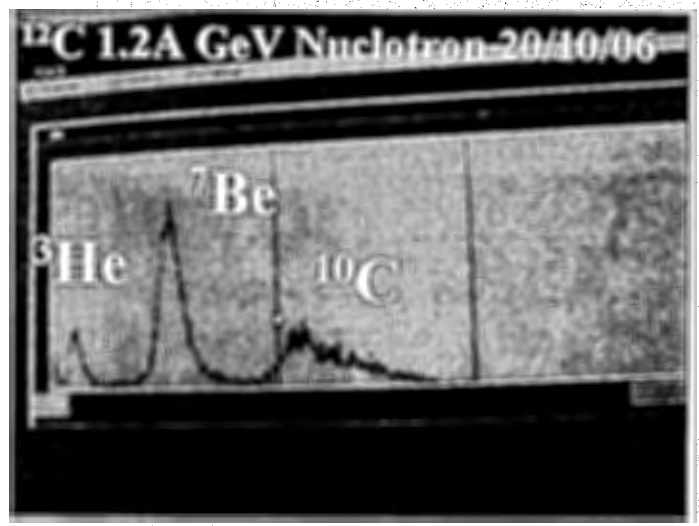


Fig. 8. The view of the amplitude spectra of secondary ^{3}He, ^{7}Be and ^{10}C nuclear beams from the scintillation detectors (BECQUEREL experiment).

CRYSTAL experiment (A.D.Kovalenko, A.M.Taratin)

In the October 2006 Nuclotron run, investigations of parametric X-ray radiation of carbon nuclei in tungsten crystals continued. In the last year, such radiation was observed at the Nuclotron in silicon crystal [18]. Preliminary results with the tungsten crystal are shown in Fig. 9. In these figures, it is possible to see X-ray spectra generated by 2 GeV/u-carbon nuclei in W crystals.

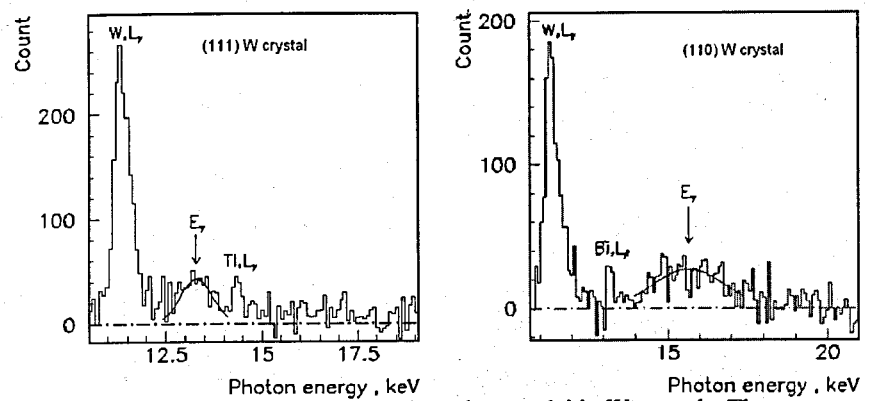


Fig. 9. X-ray spectra generated by 2 GeV/u-carbon nuclei in W crystals. The maximum Eγ are due to parametric radiation of nuclei.

ALICE TRD production (Yu.V. Zanevsky)

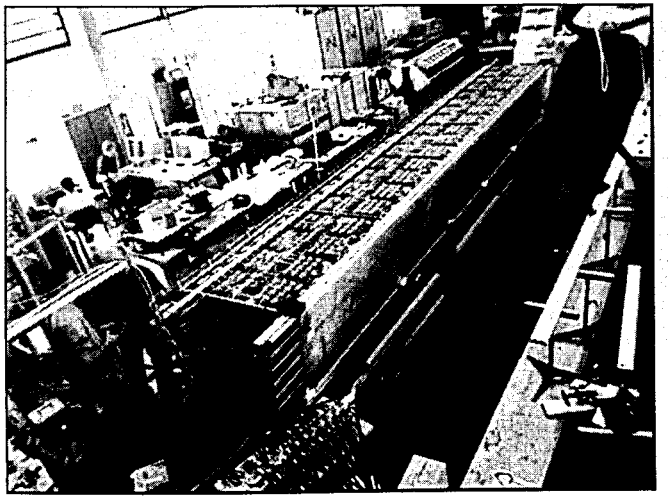


Fig. 10. View of the super module of TRD system of ALICE experiment.

For experiment ALICE at LHC (CERN) 60 chambers for Transition Radiation Detector (TRD) system were produced. The remained 20 chambers, according to the agreement, are at the stage of fabrication. The first super module containing TRD chambers was produced (Fig. 10) and installed in ALICE setup (Fig. 11).

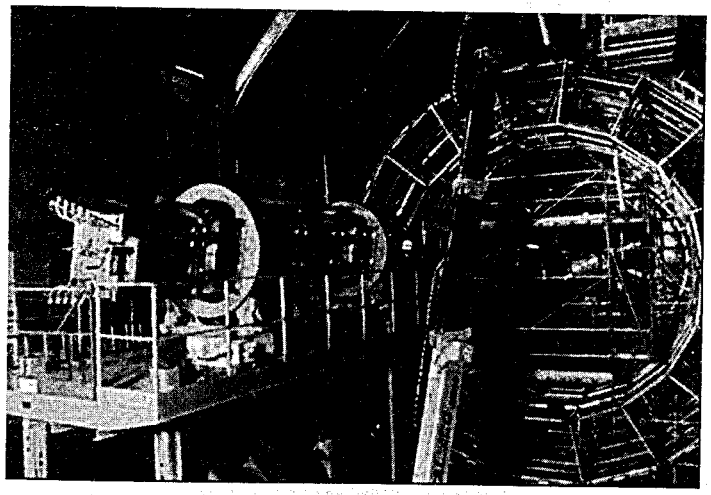


Fig. 11.The super module of TRD system of ALICE experiment in the processes of installation.

NA49 experiment (G.L.Melkumov)

Main results of the Dubna group in 2006 [19-21]:

1. Test run of the NA49 spectrometer on CERN SPS beam with reactivating the TPCs, recording events and testing new elements, the PSD (Projectile Spectator Detector) and GEM (Gas Electron Multiplication) detectors.
2. Completion of the antiproton and proton data analysis and publication of the paper in Physical Review C73, 044910 (2006) on the "Energy and centrality dependence of antiproton and proton production and the antilambda/antiproton ratio in Pb+Pb collisions between 20A GeV and 158A GeV" (Fig. 12).
3. Final results on the transverse spectra for pions and kaons in Pb+Pb collisions at 20, 30, 40, 80 and 158 A GeV. The data are in preparation for publication.
4. Contribution to a new project of the NA49-future for submission to the SPSC.

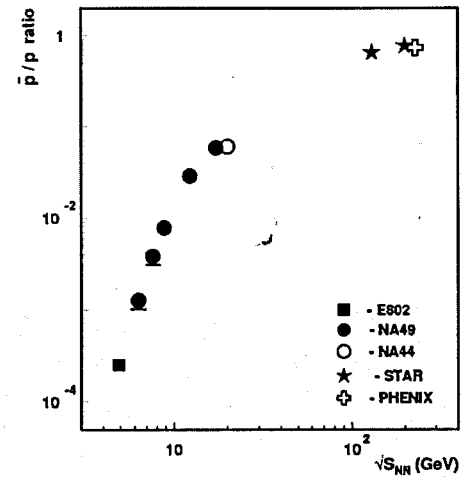


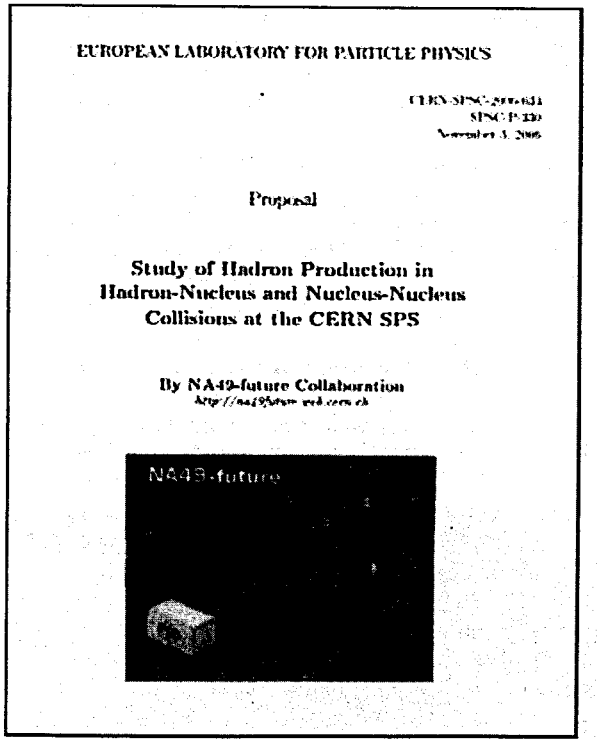
Fig.12. The ratio of antiproton and proton production in Pb+Pb collisions as a function of projectile energy.

The new project is prepared for the upgraded NA49 setup (Fig.13). The program of investigation of hadron production in collisions of nucleons and nuclei at CERN SPS is proposed.

The main tasks of the project are as follows:

- measurement of hadron production in nucleus-nucleus collisions, in particular fluctuations and long range correlations, with the aim of identification of the properties of the onset of deconfinement and finding evidence for the critical point of strongly interacting matter,
- measurements of hadron production in proton-proton and proton-nucleus interactions needed as reference data for better understanding of nucleus-nucleus reactions; in particular correlations, fluctuation and high transverse momenta will be the focus of this study,
- measurement of hadron production in hadron-nucleus interactions needed for neutrino and cosmic-ray experiments.

The experiments should be performed by the upgraded NA49 setup in the period 2007-2011.


EUROPEAN LABORATORY FOR PARTICLE PHYSICS

Proposal

Study of Hadron Production in Hadron-Nucleus and Nucleus-Nucleus Collisions at the CERN SPS

By NA49-future Collaboration

NA49-future

Fig. 13. Title page of the new project for NA49 setup at CERN SPS.

PHENIX experiment at RHIC (BNL) (A.G.Litvinenko)

This October, the workshop devoted to the upgrade of the PHENIX setup was held in Prague.

It was devoted to problems of the front calorimeter construction for PHENIX which will allow an increase in the field of studied phenomena and getting an answer to questions not only connected with nuclear interaction under high energy but also on questions about the proton structure. It is possible because RHIC can accelerate polarized protons. Physicists from America, Russia, JINR, Finland, South Korea, Czech Republic and Japan took part in the workshop.

In the first place, questions connected with construction of the prototype of the front calorimeter were discussed. The starting point was the results obtained on the first prototype, which was made by LVE JINR, INP MSU and BNL physicists. This variant of the prototype was tested at the accelerator in Protvino and completely proved the choice of concepts of the detector and agreed with the result obtained by computer modeling. Concerning the participation of JINR physicists, it was proposed by the US colleagues that they not only participate in the development of electronics, semiconductor detectors and mechanical design, but also become the coordination center of all European institutes participating in construction of the calorimeter. This proposal emphasizes not only high estimation of the work the Dubna group but also JINR capabilities as a distinguished international center with high scientific potential.

The physical results obtained in 2006 with participation of the Dubna group at PHENIX are presented in [22-26].

3. Development of the Nuclotron Accelerator Complex

Annual running time of the Nuclotron in 2006 is expected on a level of 1300-1400 hours. The typical schedule of the annual Nuclotron operation includes three beam runs of about 700 hours each. The averaged cool down time of the accelerator superconducting magnetic system is about 100 hours. The reliability of the facility operation is kept on a level of 90%. More then 75% of the total beam time was used for physics and methodical research, while the beam time devoted to the accelerator R&D did not exceed 25% of the total time. The beams requested and provided were as follows: p, d, ^{12}C (primary beams) and ^{3}He, ^{7}Be, ^{9}Be, ^{8}B, ^{9}C, ^{10}C (secondary beams). The energy of the accelerated beams varied from 0.35 GeV/u to 2.2 GeV/u for nuclei and up to 5.7 GeV for protons. The experiments were performed by 11 collaborations of physicists using the extracted and internal Nuclotron beams.

Fig. 14. General view of the new energy damp system unit.

Acceleration of the deuteron beam up to 4.32 GeV/u was also realized, however long safe operation of the accelerator magnetic system at the maximum design level cannot be guaranteed yet. The necessary upgrade of the power supply and quench detection system have been completed. The new improved unit for energy damp from the magnets in the case of quench (so-called "thyristor switch") was designed, constructed and tested (Fig.14). It is necessary to produce and put into operation seven such units for both dipole and quadrupole power supply circuits.

Providing polarized deuteron beams at the Nuclotron with intensities of up to 10^9 pps

Acceleration and extraction of polarized deuterons was demonstrated with the ion source "Polaris"in 2003. The measurements of the beam polarization performed by three independent groups at internal and extracted beams in November gave the value of about 65 %. The June 2005 run was devoted mainly to the experiment with polarized deuterons at internal target in accordance with the request of LNS/pHe3 – collaboration. The maximum intensity of the polarized beam at Nuclotron is limited by about $5 \cdot 10^8$ particles per cycle due to low beam current available from the source and limited injection time (~8 μs) to the Nuclotron.

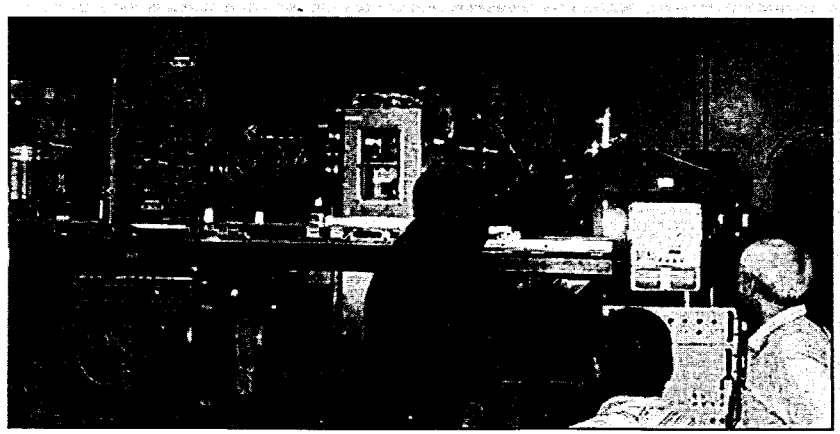


Fig. 15. General view of the CIPIOS polarized proton and deuteron source.

The main direction of development for increasing the polarized beam intensity at the Nuclotron is connected with the use of the CIPIOS polarized proton and deuteron ion source from Bloomington (Fig. 15). The decision was made by the JINR directorate and supported by the agreements with INR (Troitsk) and IUCF (Indiana University). The ion source equipment was prepared for shipping to Dubna by October 2004. Nevertheless, customs formalities are not completely finished up to

now. The preparatory work for the new equipment assembling and tests at LHE is carried out. Some parts of suitable equipment for the new polarized deuteron source were transported from DAPHNIA (Saclay) to Dubna.

Extension of heavy ion beams available for physics experiments.

The ion species available for the Nuclotron users were extended to argon and iron nuclear beams. The road to heavier ion beams at the Nuclotron is connected first of all with adequate development of the KRION-ion source (Fig. 16). The source was improved (electron string mode) and used at the Nuclotron for acceleration of N^{6+}, N^{7+}, Ar $^{16+}$ and Fe^{24+} ions in 2003. Further R&D work was connected with investigation the new possibility, namely, the design of the source with tubular electron string. The main R&D goal is to increase the ion intensity by an order of magnitude due to much larger number of electrons that can be stored within the working volume of the source. The necessary modification of the source was made and the series of experiments was carried out at a test bench during 2005 and partially in 2006. Computer simulations of the processes in the ion source were also performed. The first tubular electron beam inside the source was observed.

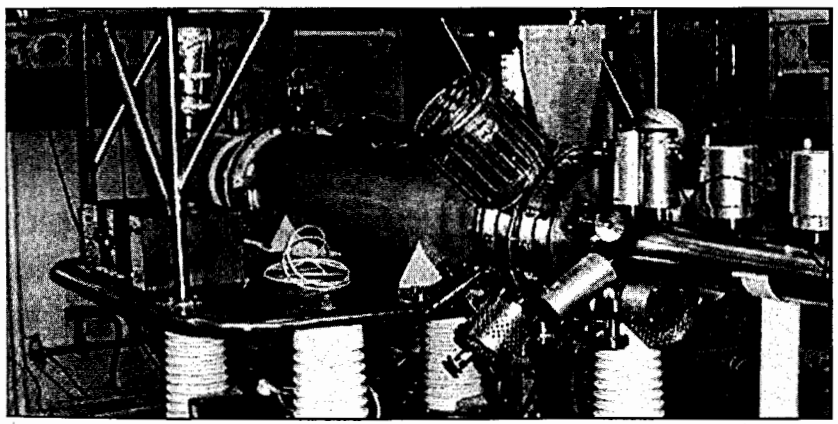


Fig.16. General view of the KRION heavy ion source at the test bench.

However, the first priority task for the ion source R&D formualted in 2006 was the obtainment of gold ions from the existing electron string version of the source. The ion source was rearranged back again to the electron string mode. The modification of the source systems aimed at achievement of highly charged Au-ions was performed. This R&D resulted in obtaining the first beams of gold ions from the source.

The scheme of the existing ion source and operation scenario is shown in fig.17.

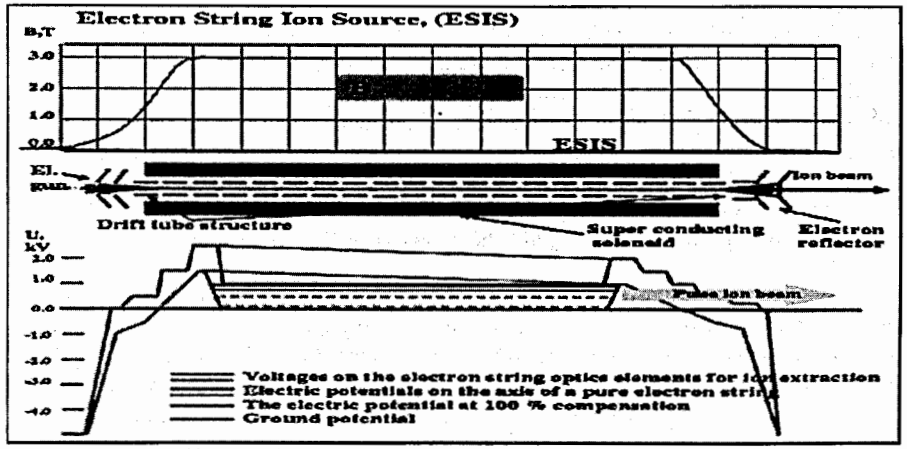


Fig.17. Schematic diagram of the electron string KRION source.

The total stored electron charge and electron current density are determined by the peak magnetic field of the superconducting solenoid. This value is limited to 3 T for the existing one. The output ion pulse duration can be varied. It was chosen approximately equal to a single turn injection into the Nuclotron. Possibilities of further application of this type of the ion source within the framework of extension of available heavy ion beams up to uranium were studied. Some of the results are presented in Table 1.

Table1. Expected parameters of uranium ion beams from the KRION source

The source version & parameters			Ion charge state		
			U^{30+}	U^{45+}	U^{55+}
KRION 2 (3T solenoid)	Pulse repetition rate	Hz	50	5	1.6
	Intensity	Ions/pulse	10^9	$7{\cdot}10^8$	$6{\cdot}10^8$
New source (6T solenoid)	Pulse repetition rate	Hz	250	27	4.5
	Intensity	Ions/pulse	$8{\cdot}10^9$	$3.5{\cdot}10^9$	$3{\cdot}10^9$

The construction of the ion source version with 6 T solenoid within the coming two years is feasible. The new important feature of the source, namely, the capability of operation at high pulse repetition rate in the case of production of heavy ions at

intermediate charge states, was considered. As one can see from the presented data, the intensity of (4-8)10^{10} U^{30+} ions per second can be obtained in the case of the source pulse repetition rate of 5-10 Hz. (6 T solenoid is assumed).

Realization of acceleration heavy ions at the Nuclotron assumes further development of injector devices, including construction of the booster ring, improvement of vacuum in the ring, increase in the accelerator magnetic field ramp and RF accelerating voltage, development of beam diagnostic and control systems, upgrade of extraction system and beam transfer lines. The proposals were developed and presented within the new project "Nuclotron-M".

Construction of prototype magnets for the booster ring

The new dipole magnet with a single-layer coil made of the new NbTi superconducting wire was designed and tested. The pulse repetition rate up to about 6 Hz was achieved. The new results were obtained also in the design of a fast-cycling quadrupole. The model 10 Hz - magnet was constructed based on the improved Nuclotron quadrupole. The front view of the magnet in the cryostat and the coil cross section are presented in Fig. 18. As one can see, the number of turns in the coil is limited to only 2 per the yoke pole instead of 5 for the standard Nuclotron case.

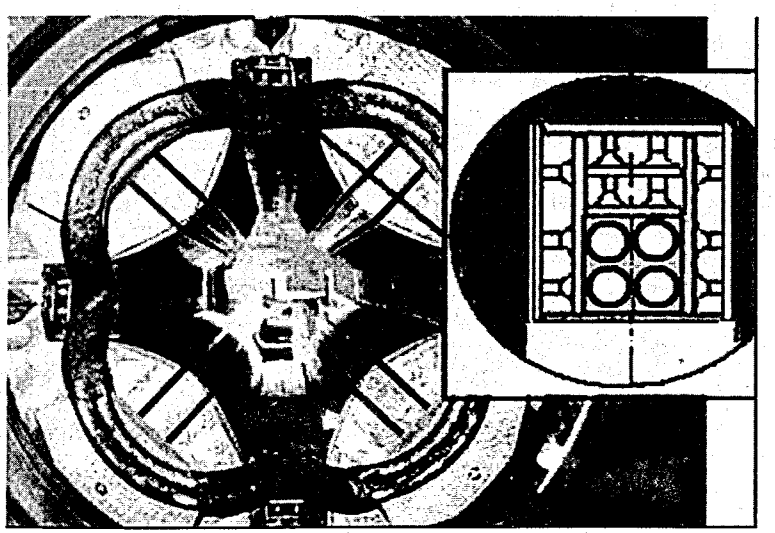


Fig.18. The new model 10 Hz quadrupole.

The upgrade of the power supply and current leads were performed at magnet test facility. The tests in August 2006 demonstrated a possibility of operation at a current level of 12.1 kA and a current ramp of 120 kA/s. The obtained results are important for the Nuclotron fast-cycling booster design.

Increase in the efficiency and reliability of the Nuclotron cryogenic supply system.

Substantial work on repair of the main helium screw compressor was performed in 2006. The compressor is under operation since 1992. Serious problems with mechanical stability of the rotating parts of the compressor occurred in December 2005 and lead to the Nuclotron run break for the period till September 2006.

4. Development of new superconducting magnets for fast cycling heavy-ion synchrotrons and beam transport channels.

Superferric 1 Hz dipole and quadrupole magnets

The work was performed within the R&D program on the design of the SIS100 synchrotron at GSI in Darmstadt. The investigations of 2 T superferric 1.4 m model dipoles operating at 4 T/s, 1 Hz were completed. The main research goal, namely, the minimization of overall AC power losses in the magnet at 4 K level was reached. The AC losses were reduced by a factor of two for both dipole and quadrupole magnets. The new stage of the JINR/GSI collaborative work is the construction of the full length dipole (about 3 m) and quadrupole (about 1.1 m) with the SIS100 specified apertures.

The work is in progress. The results were presented at the EPAC'06 and ASC'06 Conferences. The view of the new magnets inside cryostats is presented in Fig.19.

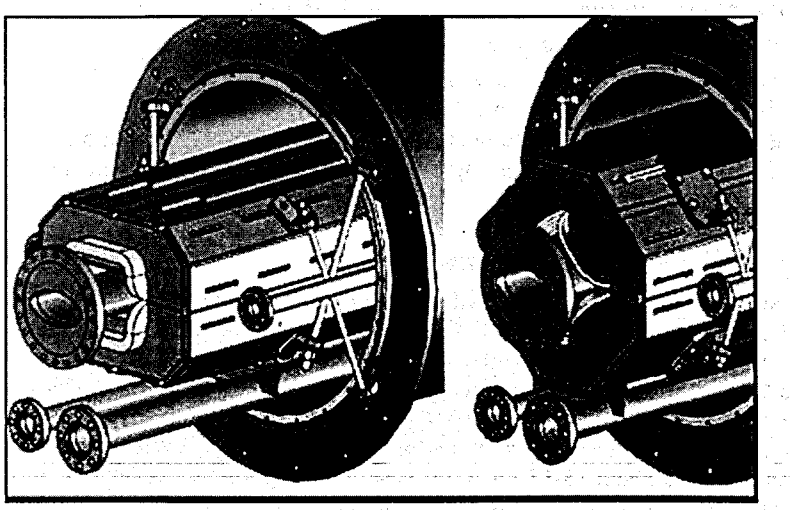


Fig. 19. View of the SIS100 prototype dipole and quadrupole magnets.

The magnet manufacturing technology is under development. In order to reduce the prototypes production cost it was proposed, in particular, to use precise laser cutting machine for manufacturing the magnet yoke lamination. It is extremely important in the case of the quadrupole yoke production, because of a very complicated profile (see Fig. 20 left). The manufactured samples of the lamination sheets are shown in Fig. 20 (right).

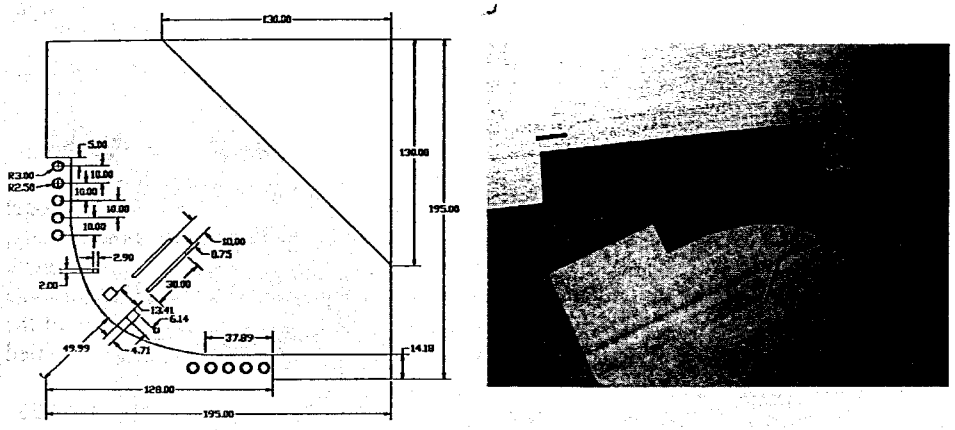


Fig. 20. The SIS100 quadrupole lamination: (left)drawing and (right) manufactured lamination.

It is proposed to use similar magnets (quadrupoles) for the beam transfer lines at the GSI FAIR facility. The same approach can be used also for the Nuclotron facility.

Fast-ramped fast-cycling 4 T dipoles

Superconducting (4-5) T dipoles based on a coil made of hollow Nuclotron-type cable can provide operation of the magnet at a magnetic field ramp of up to (2-3) T/s. Their main advantages are: 1) much higher cooling efficiency of the superconductor, and 2) much less inductance of the magnet winding in comparison with traditional dipole based on classical Rutherford cable. The double-layer coil version of such magnet was considered. It was shown that the magnet supply current can be reduced from 37 kA to about 15-17 kA n this case. The new proposal makes the problem of design and construction of the 4 T dipole much more feasible. Manufacturing and tests of the cable, operating at 12 kA, were performed.

5. Preparation of the new project for the future Nuclotron development

In accordance with the PAC decision, the project of the Nuclotron development, Nuclotron-M, was prepared and reported at the LHE Scientific Technical Council meeting. The main goal of the project is the development of the Nuclotron accelerator complex for generation of heavy ion beams with energy of up to 5 GeV/u and beam intensities of up to $5 \cdot 10^{10}$ particles per pulse. The project sections are:

- Development of heavy ion source KRION;
- Upgrade of the main power supply, quench detection and energy damp of structural magnets;
- Upgrade of the Nuclotron ring vacuum system;
- Development of the existing RF accelerator system, upgrade of the electronics and the particle capture scheme;
- Heavy ion beam extraction at maximum energy;
- Upgrade of the beam diagnostic, monitoring and control systems;
- Beam transfer lines and radiation shield;
- Development of the cryogenic supply system;
- Beam dynamics study, minimization of the particles losses during the acceleration cycle;
- Construction of the new pre-accelerator with injection and extraction beam transfer lines.

The proposed realization period is 3 years. The requested JINR budgetary funds – 2.99 M$ for 2007-2009 including the cost of materials, equipment and manpower. The realization of the project "Nuclotron-M" will also provide new possibilities for the future development of the Nuclotron toward a heavy ion collider facility. The preliminary concept of the new complex (Fig. 21) was reported at the JINR meeting in October 6-7, 2006 [27].

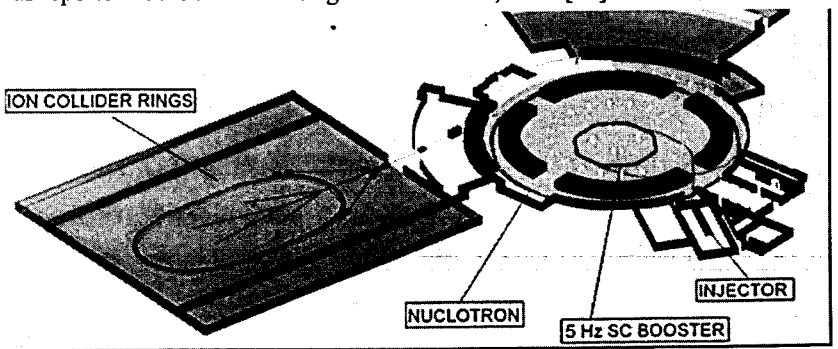


Fig.21.The proposed concept of the Nuclotron based ion collider facility.

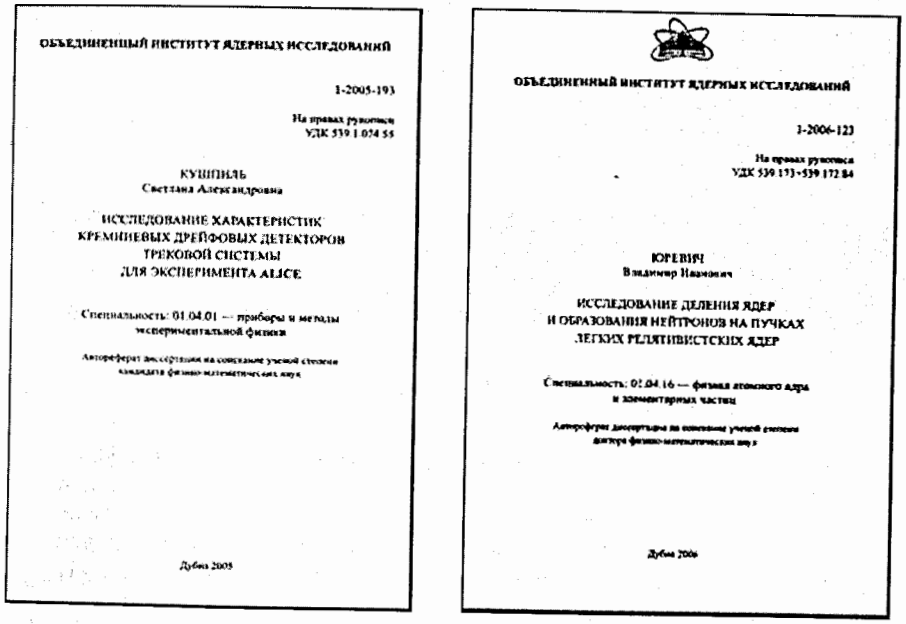
The new results obtained in 2006 are reported in 17 papers presented at the International Conferences: EPAC'2006, ASC2006, ICEC and others.

6. Miscellaneous

Some other results obtained at VBLHE in 2006 are published in [28-55].

In 2006, the Dr. Sci. thesis was defended by V. Yurevich and the PhD thesis was defended by S. Kushpil' on the basis of results obtained at VBLHE [56, 57].

The title pages of these theses are seen in Fig. 22.



ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

1-2005-193

На правах рукописи
УДК 539.1.074.55

КУШПИЛЬ
Светлана Александровна

ИССЛЕДОВАНИЕ ХАРАКТЕРИСТИК
КРЕМНИЕВЫХ ДРЕЙФОВЫХ ДЕТЕКТОРОВ
ТРЕКОВОЙ СИСТЕМЫ
ДЛЯ ЭКСПЕРИМЕНТА ALICE

Специальность: 01.04.01 — приборы и методы
экспериментальной физики

Автореферат диссертации на соискание ученой степени
кандидата физико-математических наук

Дубна 2005

ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

1-2006-123

На правах рукописи
УДК 539.173+539.172.84

ЮРЕВИЧ
Владимир Иванович

ИССЛЕДОВАНИЕ ДЕЛЕНИЯ ЯДЕР
И ОБРАЗОВАНИЯ НЕЙТРОНОВ НА ПУЧКАХ
ЛЕГКИХ РЕЛЯТИВИСТСКИХ ЯДЕР

Специальность: 01.04.16 — физика атомного ядра
и элементарных частиц

Автореферат диссертации на соискание ученой степени
доктора физико-математических наук

Дубна 2006

Fig. 22. Title pages of the theses.

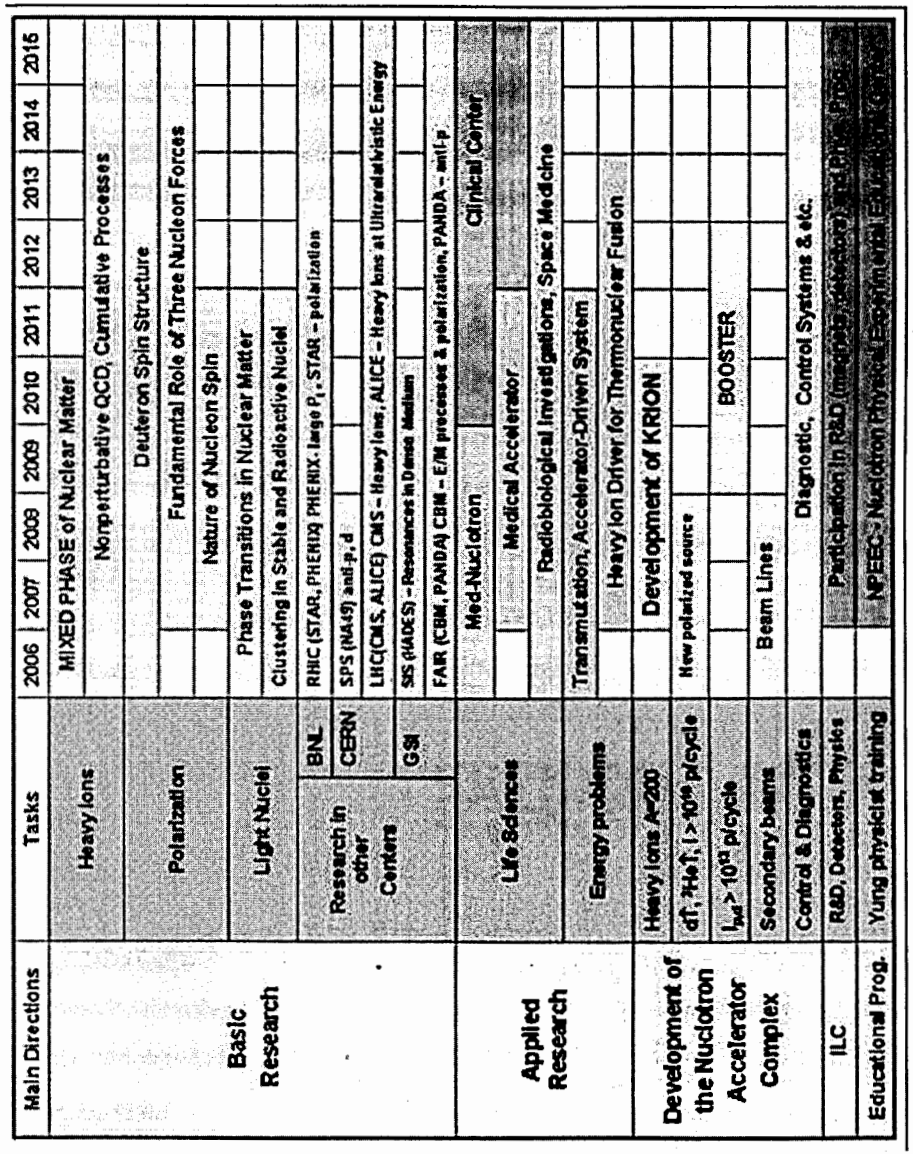


Fig. 23. Draft of the perspective program of the Veksler and Baldin Laboratory of High Energies.

7. VBLHE plans for 2007-2009.

The Program of VBLHE for 2007-2009 is based on the perspective program of research of the laboratory for 2006-2015 (Road Map). The draft of this perspective program is presented in Fig. 23.

It contains the following basic directions:

- Basic research
- Applied research
- Development of the Nuclotron Accelerator Complex
- Educational program

Basic research includes investigations of heavy ion interaction, polarizing phenomena at the Nuclotron and investigations in relativistic nuclear physics in other scientific centers.

Applied research is connected with life science and energy problems.

It is planned to develop also the accelerating complex with the purpose of obtaining higher quality particle and nuclear beams.

It is planned to have the following themes at VBLHE for 2007-2009:

Themes Related with Development of Large Installations and Carrying out Large-Scale Research

- 0983 – «Study of Multiple Production in 4π-geometry. Experiments at the Nuclotron» – First priority.
- 0941 – «Search for Non-Nucleon Degrees of Freedom and Spin Effects in Few-Nucleon System» – All-institute theme – First priority.
- 0979 – «Development of the Nuclotron Accelerator Complex» – First priority. Basic facility.

Themes: R&D, Data taking and Data analysis

- 1011 – «Investigation of the Properties of Nuclear Matter in Experiments with Nuclei and Polarized Particles (STAR) » - First priority.
- 1020 – «High-Acceptance Toroidal Spectrometer HADES. R&D of New Particle Detectors» - First priority.
- 0001 – «ALICE: A Large Ion Collider Experiment at CERN's LHC (Project ALICE)» - First priority.
- 1010 – «Investigation of Relativistic Multiparticle Interactions (Project MARUSYA)» - First priority.

- 1061 – «Development of Radiotherapy Methods with a Proton and Heavy Ion Beams of the Nuclotron of JINR (Project Med-Nuclotron)» - All-institute theme (VBLHE, DLNP, LRR) - First priority.

Financial support necessary for realization of the VBLHE program in 2007-2009 is summarized in Table 2.

Table 2.

Relativistic Nuclear Physics
2007 - 2009

Topic & Future Plan	Priority		Plan 2007	Plan 2008	Plan 2009
Development of the Nuclotron Accelerator Complex (R&D)	***0979***	**1**	**160**	**170**	**180**
Search for Non-Nucleon Degrees	***0941***	**1**	**60**	**60**	**60**
4π- geometry	***0983***	**1**	**250**	**270**	**290**
Investigation at the GSI Accelerator Complex	***1059***	**1**	**30**	**30**	**30**
NIS (LPP)	***1044***	**1**	**10**	**10**	**10**
ALICE	***0001***	**1**	**80**	**100**	**100**
MARUSYA	***1010***	**1**	**80**	**80**	**80**
STAR	***1011***	**1**	**70**	**70**	**70**
HADES	***1020***	**1**	**40**	**40**	**40**
Med-Nuclotron	***1061***	**1**	**20**	**20**	**20**
ILC	***1062***	**1**	**10**	**10**	**10**
TOTAL (k$):			**830**	**860**	**890**

References

1. A.I.Malakhov, A.N.Sisakian, A.S.Sorin, S.Vokal. Relativistic Nuclear Physics at the Joint Institute for Nuclear Research, P1-2006-93, Preprint of JINR, Dubna, 2006; A.I.Malakhov. Asymptotic Regimes in Relativistic Nuclear Physics and Particle Physics. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.44-46.
2. J.Karachuk. Invariant Properties of Pion Clasters in Different Nuclear Reactions. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.67-72.
3. L.S.Azhgirey, V.P.Ladygin, N.P.Yudin, V.N.Zhmirov and L.S.Zolin. Relativistic Deuteron Structure from Data on the Fragmentation of Polarized Deuterons. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.92-99.
4. V.L.Lyuboshitz and V.V.Lyuboshitz. The Process of Coulomb Dissociation of Weakly Bound Relativistic Nuclei and Hypernuclei within the Two-Cluster Model. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.79-86.
5. S.S.Shimansky. Cumulative Processes. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.297-305.
6. J.V.Ilic, G.P.Skoro, M.V.Tokarev. Jet Energy Density in Hadron-Hadron Collisions at High Energies. Письма ЭЧАЯ, т.3, №2(131) (2006) с.43-52.
7. Ts.Baatar, B.Batgerel, B.Khurelbaatar, G.Sharkhuu, R.Togoo. Average multiplicities of Secondary Particles Produced in π^- p and π^-C – interactions at 40 GeV/c as a Function of Target Mass. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.290-296.
8. A.A.Ershov, A.G.Litvinenko, V.P.Ladygin, S.V.Afanasiev, L.S.Azhgirey, V.A.Bodiagin, A.Yu.Isupov, A.N.Khrenov, N.A.Kruglov, A.I.Malakhov, A.A.Popeko, P.A.Rukojatkin, L.I.Sarycheva, G.N.Stoletov and V.N.Zhmirov. Experimental Investigation of Spin Phenomena in the Nucleon-Nucleus Scattering at the JINR VB LHE Synchrophasotron and Nuclotron. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.112-117.
9. M.Kh.Anikina, Yu.S.Anisimov, A.S.Artemov, S.V.Afanasev, E.V.Balandina, V.A.Baskov, V.B.Belyaev, D.K.Dryablov, V.I.Ivanov, Z.A.Igamkulov, S.Gmutsa, V.Yu.Grishina, V.A.Krasnov, A.V.Kobushkin, L.A.Kondratyuk, A.B.Kurepin, S.N.Kuznetsov, L.M.Lazarev, A.I.Lebedev, E.M.Leikin, A.N.Livanov, A.I.L'vov, M.Morhac, A.I.Malakhov, N.N.Nurgozhin,

L.N.Pavlyuchenko, V.P.Pavlyuchenko, V.V.Polyansky, S.S.Sidorin, N.V.Shevchenko, G.A.Sokol, B.S.Slovinski, E.I.Tamm, Yu.N.Uzikov, S.Wycech, N.P.Yudin. Status of the Project "η-mesonic Nuclei". Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.234-239
10. M.Janek, T.Saito, V.P.Ladygin, T.Uesaka, M.Hatano, A.Yu.Isupov, H.Kato, N.B.Ladygina, Y.Maeda, A.I.Malakhov, J.Nishikawa, T.Ohnishi, H.Okamura, S.G.Reznikov, H.Sakai, N.Sakamoto, S,Sakoda, Y,Satou, K.Sekiguchi, K.Suda, A.Tamaii, N.Uchigashima, T.A.Vasiliev, and K.Yako. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.100-105.
11. T.A.Vasiliev, T.Saito, V.P.Ladygin, M.Hatano, A.Yu.Isupov, M.Janek, H.Kato, N.B.Ladygina, Y.Maeda, A.I.Malakhov, S.Nedev, J.Nishikava, H.Okamura, T.Ohnishi, S.G.Reznikov, H.Sakai, S.Sakoda, N.Sakomoto, Y.Satou, K.Sekiguchi, K.Suda, A.Tamii, T.Uesaka, N.Uchigashima, K.Yako. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp. 106-111.
12. P.Zh.Aslanyan, V.N.Emelyanenko, G.G.Rikhvitzkaya. Exotic narrow resonance searches in the systems ΛK^0_s. PhysPartNuclLett, Vol.3, No.5 (2006) pp. 99-104.
13. P.Aslanyn. Proc. XVIII ISHEPP, Dubna, Sept. 25-30 (2006). Spin'06, October 2-7, Kyoto, Japan (2006).
14. N.P.Andreeva, D.A.Artemenkov, V.Bradnova, M.M.Chernyavsky, A.Sh.Gaitinov, N.A.Kachalova, S.P.Kharlamov, A.D.Kovalenko, M.Haiduc, S.G.Gerasimov, L.A.Goncharova, V.G.Larionova, A.I.Malakhov, A.A.Moiseenko, G.I.Orlova, N.G.Peresadko, N.G.Polukhina, P.A.Rukojatkin, V.V.Rusakova, V.R.Sarkisyan, T.V.Shchedrina, E.Stan, R.Stanoeva, I.Tsakov, S.Vokal, A.Vokalova, P.I.Zarubin, I.G.Zarubina. Light Nucleus Clustering in Fragmentation above 1 A·GeV. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.203-213.
15. N.P.Andreeva, D.A.Artemenkov, V.Bradnova, M.M.Chernyavsky, A.Sh.Gaitinov, N.A.Kachalova, S.P.Kharlamov, A.D.Kovalenko, M.Haiduc, S.G.Gerasimov, L.A.Goncharova, V.G.Larionova, A.I.Malakhov, A.A.Moiseenko, G.I.Orlova, N.G.Peresadko, N.G.Polukhina, P.A.Rukojatkin, V.V.Rusakova, V.R.Sarkisyan, T.V.Shchedrina, E.Stan, R.Stanoeva, S.Vokal, A.Vokalova, P.I.Zarubin and I.G.Zarubina. Multiparticle He Fragmentation of ^{22}Ne, ^{24}Mg and ^{28}Si in Emulsion at 4.1-4.5 A·GeV/c. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.214-222.
16. N.P.Andreeva, D.A.Artemenkov, V.Bradnova, M.M.Chernyavsky, A.Sh.Gaitinov, N.A.Kachalova, S.P.Kharlamov, A.D.Kovalenko, M.Haiduc, S.G.Gerasimov, L.A.Goncharova, V.G.Larionova, A.I.Malakhov, A.A.Moiseenko, G.I.Orlova, N.G.Peresadko, N.G.Polukhina, P.A.Rukojatkin,

V.V.Rusakova, V.R.Sarkisyan, T.V.Shchedrina, E.Stan, R.Stanoeva, I.Tsakov, S.Vokal, A.Vokalova, P.I.Zarubin and I.G.Zarubina. Clustering in light nuclei in fragmentation above 1 A·GeV. Eur. Phys. J. A27, s01 (2006) pp.295-300.

17. P.I.Zarubin, D.A.Artemenkov, G.I.Orlova. Dissociation of Relativistic Nuclei in Perepheral Interactions in Nuclear Track Emulsion. Nuclear Science and Safety in Europe, Eds. T.Cechik et al. Springer (2006) pp.189-200.
18. Yu.N. Adischev, S.V. Afanasiev, V.V. Boiko, A.N. Efimov, Yu.V. Efremov,A.S. Gogolev, A.D. Kovalenko, Yu.L. Pivovarov, A.P. Potylitsyn, S.V. Romanov, Sh.Z. Saifulin, E.A. Silaev, A.M. Taratin, S.P. Timoshenkov, S.R. Uglov, V.I. Volkov, M.A. Voevodin, V.N. Zabaev. First observation of parametric X-rays produced by moderate relativistic protons and carbon nuclei in Si crystals. Nuclear Instruments and Methods in Physics Research B 252 (2006) 111–117.
19. C.Alt, ..., B.Baatar, ..., V.I.Kolesnikov, ..., A.I.Malakhov, ..., G.L.Melkumov et al. (NA49 collaboration). Energy and centrality dependence of antiproton and proton production and the antilambda/antiproton ratio in Pb+Pb collisions between 20AGeV and 158AGeV. Phys.Rev.C73, 044910 (2006).
20. C.Alt, ..., B.Baatar, ..., V.I.Kolesnikov, ..., A.I.Malakhov, ..., G.L.Melkumov et al. (NA49 collaboration). Upper limit of D^0 production in central Pb+Pb collisions at 158 GeV. Phys. Rev. C73, 034910 (2006).
21. C.Alt, ..., B.Baatar, ..., V.I.Kolesnikov, ..., A.I.Malakhov, ..., G.L.Melkumov et al. (NA49 collaboration). Inclusive production of charged pions in p+p collisions at 158 GeV/c beam momentum. Eur. Phys. J. C45:343-381 (2006).
22. S.S.Adler, S.Afanasiev,..., A.Isupov, A.Litvinenko, A.Malakhov, V.Peresedov, L.Zolin et al. Improved measurement of double helicity asymmetry in inclulsive midrapidity pi^0 production for polarized *p+p* collisions at sqrt(s)=200 GeV. Phys. Rev. D 73, 091102(R) (2006).
23. S.S.Adler, S.Afanasiev,..., A.Isupov, A.Litvinenko, A.Malakhov, V.Peresedov, L.Zolin et al. Azimuthal Angle Correlations for Rapidity Separated Hadron Pairs in *d*+Au Collisions at $\sqrt{S_{NN}}$=200 GeV. Phys. Rev. Lett. 96, 222301 (2006).
24. S.S.Adler, S.Afanasiev,..., A.Isupov, V.Ladygin, A.Litvinenko, A.Malakhov, V.Peresedov, L.Zolin et al. Nuclear Modification of Electron Spectra and Implications for Heavy Quark Energy Loss in Au+Au Collisions at $\sqrt{S_{NN}}$=200 GeV. Phys. Rev. Lett. 96, 032301 (2006).
25. S.S.Adler, S.Afanasiev,..., A.Isupov, V.Ladygin, A.Litvinenko, A.Malakhov, V.Peresedov, L.Zolin et al. Common Suppression Pattern of η and π^0 Mesons at High Transverse Momentum in Au+Au Collisions at $\sqrt{S_{NN}}$=200 GeV. Phys. Rev. Lett. 96, 202301 (2006).
26. S.S.Adler, S.Afanasiev,...,A.Isupov, V.Ladygin, A.Litvinenko, A.Malakhov, V.Peresedov, L.Zolin et al. Measurement of Identified π^0 and Inclusive Photon Second-Harmonic Parameter v_2 and Implications for Direct Photon Production in $\sqrt{S_{NN}}$ = 200 GeV Au+Au. Phys. Rev.Lett. 96, 032302 (2006).

27. http://theor.jinr.ru/meetings/2006/roundtable/
28. M.V.Tokarev. z Scaling at RHIC. PhysPartNuclLett, v.3, №1 (130) (2006) pp.17-30.
29. I.Zborovsky, M.Tokarev. Generalized z-Scaling in Proton-Proton Collisions ai High Energies. JINR Preprint, E2-2006-34, Dubna (2006).
30. O.S.Kosmachev. Lorentz Group Representation and Classification of Stable Leptons. JINR Preprint, P2-2006-6, Dubna (2006).
31. J.Adams, ..., G.S.Averichev, V.V.Belaga, T.G.Dedovich, L.G.Efimov, J.Fedorishin, A.Kechechyan, F.I.Kulikov, A.A.Kuznetsov, S.Lehochka, Y.Panebratsev et al. Identified hadron spectra at large transverse momentum in *p+p* and *d*+Au collisions at $\sqrt{S_{NN}}$=200 GeV. Physics Letters B, V. 637, Issue 3 (2006), pp. 161-169.
32. F.Krizek, V.Vagner, J.Adam, P.Caloun, V.Henzl, D.Henzlova, A.Krasa, A.Kugler, M.Majerle, M.I.Krivopustov, V.I.Stegailov, V.M.Tsoupko-Sitnikov. The study of spallation reactions, neutron production and transport in a thick lead target and a uranium blanket during 1.5 GeV proton irradiation. Czechoslovak Journal of Physics. Vol.56, No.3 (2006) pp.243-252.
33. V.M.Bystritsky, V.G.Kadyshevsky, A.P.Kobzev, Yu.N.Rogov, M.G.Sapozhnikov, A.N.Sissakian, V.M.Slepnev, N.I.Zamyatin, E.P.Bogolyubov, Yu.K.Presnyakov, V.I.Ryzhkov, T.O.Khasaev. Portable Neutron Generator with 9-Section Silicon α-Detector. JINR Preprint, E13-2006-36, Dubna (2006).
34. N.G.Anishchenko, V.V.Bekhterev, S.L.Bogomolov, P.G.Bondarenko, V.F.Boreiko, V.I.Datskov, S.N.Dmitriev, V.M.Drobin, A.A.Efremov, E.V.Ivanov, I.E.Karpunina, MLeporis, GMalinovskiy, A.S.Nikiforov, S.V.Pashchenko, Yu.V.Romanov, V.V.Seleznev, G.P.Zvineva, V.F.Chumakov, Yu.A.Shishov, N.Yu.Yazvitskiy, B.I.Yakovlev. Superconducting magnetic system with a cryocooler for the ion source DECRIS-SC. PhysPartNuclLett, v.3, №1(130) (2006) pp. 45-62.
35. A.A.Kuznetsov, Yu.A.Panebratsev, R.Togoo, B.Baatar. Properties of the Hadronic Jets in π^- + p and π^- + C Interactions at 40 Gev/c. PhysPartNuclLett, v.3, №2(131) (2006) c.53-72.
36. V.I.Yurevich, R.M.Yakovlev, V.A.Nikolaev, V.G.Lyapin, N.S.Amelin. Investigation of neutron emission at interaction of relativistic protons and deuterons with lead targets. PhysPartNuclLett, v.3, №3(132) (2006) c.49-72.
37. Yu.V.Erchov, A.O.Golunov, I.A.Golutvin, N.V.Gorbunov, A.Yu.Kamenev, V.Yu.Karjavin, S.V.Khabarov, V.S,Khabarov, Yu.T.Kiryushin, A.M.Kurenkov, V.P.Ladygin, V.N.Lysiakov, G.V.Mescheriakov, P.V.Moissenz, K.P.Moissenz, S.A.Movchan, V.V.Perelygin, V.P.Rashevsky, V.A.Samsonov, I.V.Slepnev, D.A.Smolin, S.E.Vassiliev, T.A.Vasiliev, A.V.Zaeubin, E.V.Zubarev. Cathode Strip Chamber for CMS ME1/1 ENDCAP Muon Station. PhysPartNuclLett, v.3, №3(132) (2006) pp.73-80.
38. A.S.Artemov. Calculation of internal targets and schematic diagram of compact devices for continuous visualization of a synchrotron beams, as

exemplified by the Nuclotron. PhysPartNuclLett, v.3, №4(133) (2006) pp.48-67.
39. A.S.Artemov, S.V.Afanas'ev, V.S.Alfeev, V.V.Borisov, V.N.Karpinskiy, E.A.Matyushevskiy, N.I.Taratin. Schematic diagram and calculation of magnetic electron analyzer for investigations in the field of relativistic atomic physics at internal targets of the Nuclotron. JINR Preprint, P13-2006-64, Dubna , 2006. Submitted to PhysPartNuclLett.
40. C.Granja, L.Majling, J.Lukstins, A.Parfenov, B.Sopko and M.Solar. Relativistic Hypernuclear Beams and Hypernuclear Spectroscopy at Nuclotron. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.47-50.
41. S.Afanasiev, V.Aksinenko, M.Anikina, Yu.Anisimov, V.Arkhipov, S.Avramenko et al. The Search for the Hydrogen Hypernuclei at the Sphere Spectrometer. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.50-60.
42. L.Majling, J.Lukstins, A.Parfenov, Yu.Batusov, C.Granja, M.Solar and B.Sopko. Production of Hyperfragments at Nuclotron. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.61-66.
43. O.S.Kosmachev. Kinematical Approach and Relativistic Nuclear Physics. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.73-78.
44. S.Kouchpil. Recent Beam Test Results of the ALICE Silicon Drift Detector. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.87-91.
45. V.I.Sharov et al. Measurements of Energy Behaviours of Spin-Dependent np-observables over 1.2-3.7 GeV Energy Region. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.118-129.
46. Yu.Troyan, A.P.Jerusalimov, A.V.Beljaev, V.N.Pechenov, Yu.V.Zanevsky, E.B.Plekhanov, A.Yu.Troyan. The Study of the Low-Mass Scalar σ_0-meson at Intermediate Energies. Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.136-147.
47. V.P.Balandin et al. Status of the NIS Experiment at Nuclotron and Physics with NIS. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.148-160.
48. S.Vokal, S.Lehocka and G.I.Orlova. Dense Groups of Particles in High Energy Nuclear Interactions of Lead and Gold Nuclei in Nuclear Emulsion. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.194-202.
49. Kh.U.Abraamyan, V.V.Arkhipov, A.V.Belozerov at al. Investigations of Neutral Pion and Eta meson Production by Relativistic Nuclei on the LHE Multi-Channel Gamma-Spectrometer. Results and Perspectives. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.228-233.
50. Yu.K.Pilipenko. Molecular Beams and Jets. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.246-251.
51. A.Yu.Isupov. Software Utilities for Using on an Experimental Stand. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.252-259.
52. I.Zborovsky and M.Tokarev. Multiplicity Dependence of z-Scaling. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.260-271.
53. M.V.Tokarev. Z-Scaling and New pp Data from RHIC. .Proceedings of 8th International Workshop "Relativistic Nuclear Physics: from Hundreds of MeV to TeV", Dubna, May 23-28, 2005, Dubna (2006), pp.278-289.
54. L.N.Zaitsev, S.L.Zaitsev, I.E.Karpunina, A.D.Kovalenko, A.V.Polyushits, L.P.Roginets, A.I.Stanchik, E.P.Cherevatenko, V.F.Chumakov. Radiation resistance of electric insulation compound of superconducting magnets of accelerators. JINR Preprint, P14-2006-43, Dubna, 2006.
55. S.R.Yashemi-Nezhad, I.V.Zhuk, A.S.Potapenko, M.I.Krivopustov. Calibration of Track Detectors for Fission Rate Determination: an Experimental and Theoretical Study. JINR Preprint, E1-2006-54, Dubna, 2006.
56. V. Yurevich. Investigation of nuclear fusion and neutron formation at light relativistic nuclear beams, JINR, 1-2006-123, Dubna, 2005. Dr.Sci. Thesis abstract.
57. S. A. Kushpil'. Investigation of characteristics of silicon drift detectors of the trac system for the ALICE experiment, JINR, 1-2005-193, Dubna, 2006. PhD Thesis abstract.