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RESULTS OF 2001 AND THE RESEARCH PROGRAMME OF THE LABORATORY OF HIGH ENERGIES IN 2002–2006

Report to the 91st Session
of the JINR Scientific Council
January 17–18, 2002

Dubna 2001

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1. Introduction

In 2001 the scientific programme of the Laboratory of High Energies (LHE), Joint Institute for Nuclear Research (JINR), as in previous years, was concentrated on investigations of interactions of relativistic nuclei in the energy region from a few hundred *MeV* to a few *TeV* per nucleon to search for manifestation of quark and gluon degrees of freedom in nuclei, asymptotic laws for nuclear matter at high energy collisions as well as on the study of the spin structure of the lightest nuclei [1, 2, 3]. Experiments along these lines were carried out with the beams of the LHE accelerator complex as well as of other accelerators at CERN, BNL, GSI, and others.

The LHE accelerator complex includes the old machine - Synchrophasotron and a new superconducting accelerator - Nuclotron. During the next two years the LHE research programme will be carried out on the Nuclotron.

This report presents the new results of the LHE for 2001 and the research programme for the next five years. The results of investigations for the last five years are given in the papers [1,4].

2. The Nuclotron development in 2001

During 2001 the Laboratory had three Nuclotron runs of 1280 hours totally. These runs obtained good external beams of boron (^{10}B, I≈1·10^5 particles per cycle), carbon (^{12}C, I≈8·10^9 particles per cycle) and magnesium (^{24}Mg, I≈1·10^7 particles per cycle) ions. The profiles of the carbon and magnesium extracted beams are presented in fig.1. The amplitude spectrum from the scintillation counter in the boron beam is presented in fig.2.

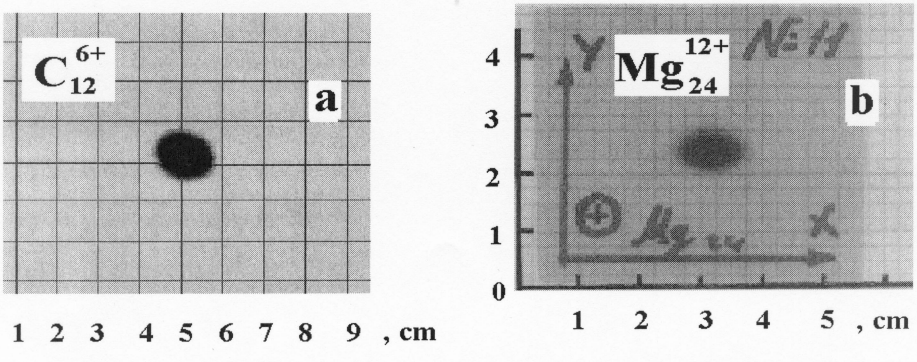

Fig.1. The profiles of the Nuclotron extracted beams of carbon and magnesium ions. Run #19, March 2001.

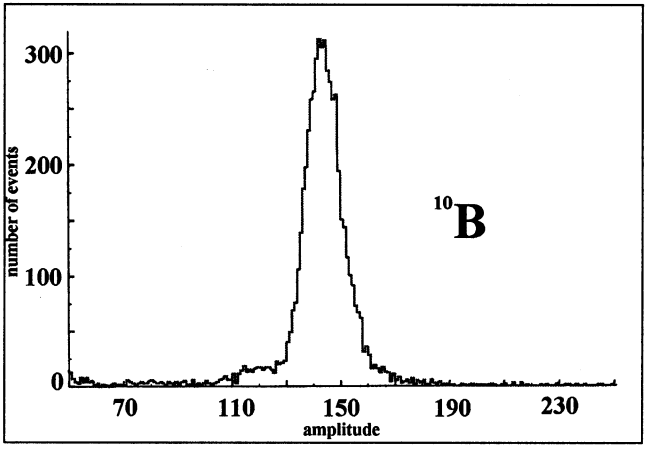

Fig.2. The amplitude spectrum from 8-mm scintillation counter in ^{10}B beam of the Nuclotron. Run #22, December 2001.

The high intensity of the deuteron and proton extracted beams up to $3.5 \cdot 10^{10}$ particles per cycle with efficiency of the extracted beam near 100% was also obtained. The time structure of the extracted beam was improved substantially.

The Nuclotron consumption of liquid nitrogen was reduced by more than two times and this achievement has given a possibility to perform long runs. The last Nuclotron run in November - December 2001 lasted more than one month, for example.

Very good information both for physics and applied research was obtained during this run.

The development of the fast cycling superconducting magnet technology by using the Nuclotron magnets as prototype for the GSI future accelerator was continued. In the framework of the LHE-GSI agreement 6 test runs were performed with different modified magnets (a new yoke and two new superconducting coils). The tests of two prototype magnets with the yoke at 80 K temperature were also carried out.

3. Physics research at the Nuclotron in 2001

In 2001 the external and internal beams of the Nuclotron were used for investigations of the physical groups.

In March and December the ^{24}Mg beam was used by the Italian group for the Pamela collaboration. We received the following letter from the Italian Leader of the Pamela collaboration after the Nuclotron run in March:

"I'm glad to thank you for your supporting to the beam test for Pamela experiment at Dubna accelerator. The works have been very fruitful with interesting results. I'd like to thank also the accelerator staff for providing a very good beam and for their cordiality. I hope that our collaboration can go on in the future for Pamela experiment and also for our other joint russian-italian space mission.

With my best regards, Piergiorgio Picozza
(Italian Head of Pamela collaboration)".

The external deuteron beam of the Nuclotron was used for investigations at STRELA set-up. The group of the STRELA collaboration tested the set-up apparatus and obtained good methodical results. The excellent amplitude resolution of new sapphire Cherenkov counters (7%) was shown and very good separation of the events with two secondary protons was obtained.

The Dubna, Marburg, Strasbourg, Juelich, Thessaloniki, Sydney collaboration obtained a lot of experimental data to study the radioactive waste transmutation in November at the Nuclotron run by GAMMA-2 set-up.

The nuclear emulsions were irradiated with the beam of ^{10}B ions for EMU01 collaboration in this December Nuclotron run.

Groups of SCAN-1 set-up and MARUSYA collaboration continued investigations at the internal Nuclotron beams. The SCAN-1 group obtained new data on cumulative production of narrow proton pairs in interactions of accelerated *p, d, He, C* with heavy targets.

The polarimeter for the Nuclotron was assembled at the internal target. It consists of symmetrical left-right detector arms (fig. 3). The set-up was tested in the last Nuclotron run by using the deuteron beam of the 1.2 GeV/n energy. The primary intensity of the beam was 10^9 ions per cycle. The time spectrum was measured from both arms for the carbon and polyethylene targets. The spectra are shown in fig. 4. The clear separation of the elastic pp scattering process is shown.

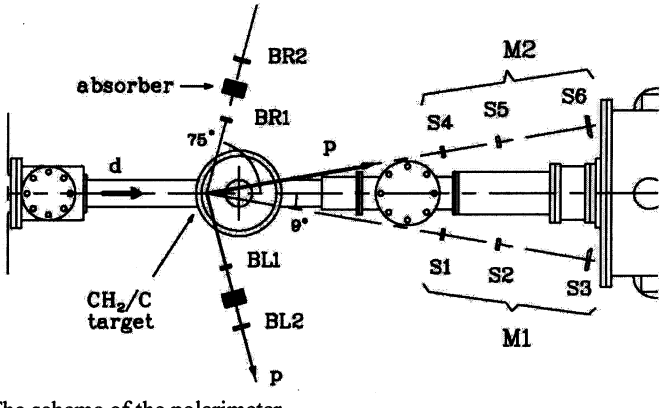

Fig. 3. The scheme of the polarimeter

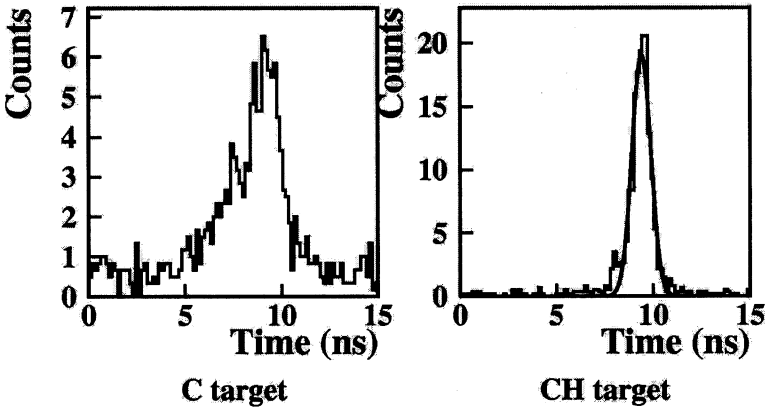

Fig. 4. The time spectra for carbon and polyethylene targets

The group of the MARUSYA set-up obtained new data on production of secondary nuclear fragments in the result of interactions of the internal Nuclotron beam with nuclear targets. These data are very important to study such a phenomenon as full destruction of nuclei which was discovered at our Laboratory by the group of Professor K.D. Tolstov.

4. Experimental results at the Synchrophasotron in 2001

In 2001 two Synchrophasotron runs of about 580 hours were performed. Two main experiments were carried out at that time.

The first experiment was related with obtaining the new data of DELTA-SIGMA collaboration to investigate energy dependence of the *np* spin-dependent cross section difference $\Delta\sigma_L(np)$ at neutron beam kinetic energies 1.4, 1.7, 1.9 and 2.0 *GeV*. DELTA-SIGMA collaboration includes physicists from Bulgaria, Czech Republic, France, Russia and Ukraine. Specialists from the Laboratory of High Energies, the Laboratory of Nuclear Problems and the Laboratory of Neutron Physics participated in this experiment. The value of $\Delta\sigma_L(np)$ was measured as difference between the *np* total cross sections for the parallel and antiparallel beam and target polarization, both oriented along the beam momentum in the longitudinal (L) direction. The polarized neutrons were transmitted through a large proton polarized target. The preliminary results of DELTA-SIGMA experiment, obtained last year, together with the foregoing results [5, 6], are presented in fig. 5.

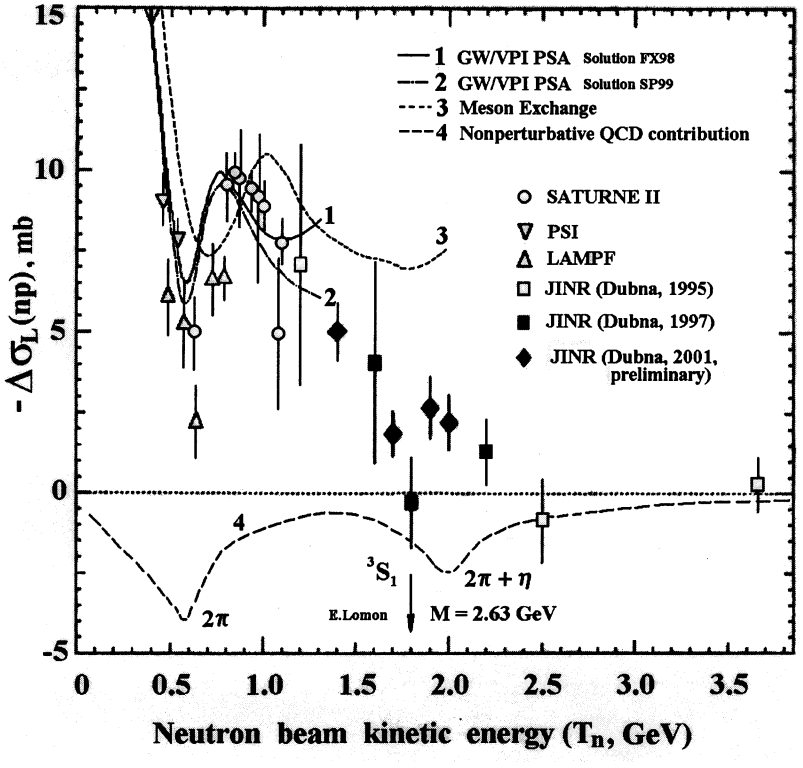

Fig.5. Energy dependence of the $\Delta\sigma_L(np)$ observables obtained with neutron polarized beam. The new 2001 points were measured at neutron beam kinetic energies 1.4, 1.7, 1.9 and 2.0 *GeV*

One of the participants of this experiment from France Professor F.Lehar wrote the following words about the last Synchrophasotron run:

"The latest run on measuring $\Delta\sigma_L(np)$ has been carried out successfully this time. We planned to measure only 3 points but managed to have measured 4 and all they were taken with small errors. The by-products of run in June were not lost; on the contrary, they have shown very nice coincidence with the analogous results obtained in October. I am very happy about that. Now we have on-line results. There are no reasons that on-line processing would influence these data. My feeling is that the measurements $\Delta\sigma_L(np)$ have been completed. It would have been a pity not to determine $\Delta\sigma_T(np)$ now when the coils exist at the Laboratory of High Energies".

The second experiment was devoted to measuring the analyzing power of reaction $p\uparrow + CH_2 \rightarrow p + \ldots$ for momenta 3.8, 4.5, 5.3 *GeV/c*. These data are necessary in the design of the new polarimeter required to measure the ratio of the proton form factors (G_{Ep}/G_{Mp}). Physicists from Bulgaria, France, Russia, Slovak Republic and the USA participated in this experiment. The special polarimeter was transported from France for this experiment. It was prepared for using in a very short period of time by the group of Dr. N.Piskunov.

Preliminary results of this experiment are presented in fig. 6. The opinion of participants of this experiment from the USA and France are written in the letter presented in the appendix 1.

Some new results obtained at the Synchrophasotron in previous runs were published in 2001 [6, 7, 8].

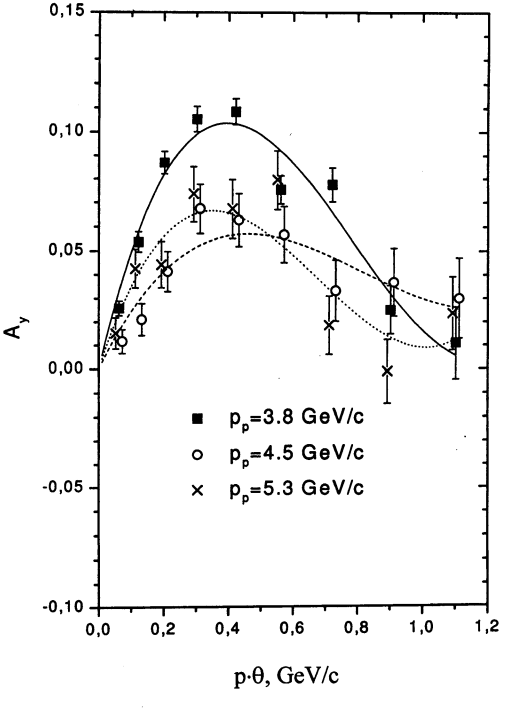

Fig.6. The results of measuring the analyzing power of reaction $p\uparrow + CH_2 \rightarrow p + \ldots$ for momenta 3.8, 4.5, 5.3 *GeV/c*. p – momenta, θ – angels of secondary particles

5. The LHE cooperation with other Scientific Centers in 2001

The LHE participates in heavy ion programme at SPS in CERN. Our physicists are involved in NA45 (CERES) (contactperson from JINR Yu.A.Panebratsev), NA49 (contactperson from JINR Dr. G.L.Melkumov) and EMU01 (contactperson from JINR Dr. P.I.Zarubin) collaborations running in SPS nuclear beams.

The main results of NA45 experiment in 2001 are as follows:

1. Analysis of 8 million *Pb+Au* 1999 data at 40 *A·GeV* has been finished. The enhancement of the e^+e^- pair yield by a factor of 4.7±1.6 in the mass range $m_{ee} > 0.2$ GeV/c^2 was observed [9].
2. Analysis of the 2000 data (32 million *Pb+Au* events at 158 *A·GeV*) is in progress. The new method to calculate electric field in the radial Time Projection Chamber (TPC) and alignment of detectors algorithm was developed. The calibration of detectors with a pion data sample was proposed.

The main results of NA49 experiment in 2001:

1. Participation in data taking on the SPS proton beam.
2. Data processing and physics analysis:
   - K^+ and K^- p_T - spectra and yields at 40 and 80 *A·GeV* *Pb+Pb* collisions were obtained [10]
   - the energy dependence of K/π ratio was studied [11] (fig.7)
   - deuteron and proton p_T - spectra from central and minimum bias 158 *A·GeV* *Pb+Pb* data were obtained [12].

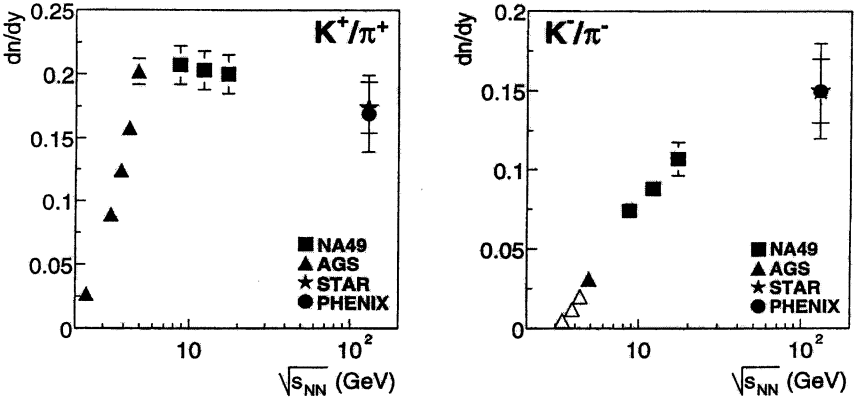

Fig.7. Energy dependence of K/π ratio in midrapidity region

The participation in preparation of ALICE and CMS experiments for LHC in 2001 were continued.

During 2001 the LHE participated in the design and the construction of the Large Dipole Magnet for the Muon Spectrometer, in organization of production of lead-tungsten crystals (in collaboration with Ukraine) for the Photon Spectrometer and in construction of the prototype of the Transition Radiation Detector for ALICE set-up.

Our physicists participated in development of the Heavy Ion programme for CMS experiment and jointly with the Laboratory of Particle Physics of JINR – in preparation of the muon chambers tested by the CMS cosmic ray system. The method of determining the *Z*-bozon source radius production based on the interference effect between two identical muons was proposed for CMS experiment [13].

Two LHE groups are involved in STAR (contactperson from JINR Prof. Yu.A.Panebratsev) and PHENIX (contactperson from JINR Dr. A.G.Litvinenko) experiments at RHIC in BNL. These groups participated in run preparation and data taking at a new nuclear collider RHIC at 130 $A \cdot GeV$ energy.

The main results of STAR experiment in 2001 are:

1. LHE group participated in Endcap EMCalorimeter (EEMC):
   - Production of EEMC tower megatile and Shower Maximum Detector (SMD).
   - Fabrication of various mechanical components.
   - Production of EEMC tower PMT and SMD/Preshower (PSD) Multi-Anode PMT "housing", including integrated magnetic shielding.
   - Participation in the design of High Voltage control system, realization of the slow control system.
   - Participation in the assembly of SMD.
2. LHE group participated in simulation of the double-spin asymmetry in processes with jet, dijets, prompt photon and gamma-jet production [14].

For the HADES experiment (contactperson from JINR Prof. Yu.Zanevsky) in GSI the LHE group has designed and constructed the low-mass drift chambers (with a spatial resolution about 70 μm), and front-end analogue electronics.

Tracking software for data analysis is under development as well.

The first experiment for dilepton production in *CC* and π/p reactions started in October 2001.

The first results from the joint JINR-RIKEN R308n experiment (spokesperson Dr. V.P.Ladygin from LHE, JINR) were obtained in 2001. In this experiment the tensor analyzing power T_{20} was measured in $d+d \rightarrow {}^3H+p$ and $d+d \rightarrow {}^3He+n$ reactions (fig.8). The sign of T_{20} is positive and negative, when ${}^3H({}^3He)$ is emitted in the forward and backward directions in c.m., respectively. This fact reflects the sensitivity of the data to the *D/S* - wave function ratio in the ${}^3H({}^3He)$ and deuteron. The data obtained for both channels $d+d \rightarrow {}^3H(0^0)+p$ and $d+d \rightarrow {}^3He(0^0)+n$ within achieved experimental accuracy are in good agreement. In this experiment the measurements of the tensor analyzing powers A_{yy}, A_{xx} and A_{xz} at 200 and 270 *MeV* over the full angular range for the $d+d \rightarrow {}^3H+p$ and in the

forward hemisphere for the $d+d \rightarrow {}^3He+n$ reactions have been also performed. The data analysis on the angular dependence of these analyzing powers is in progress.

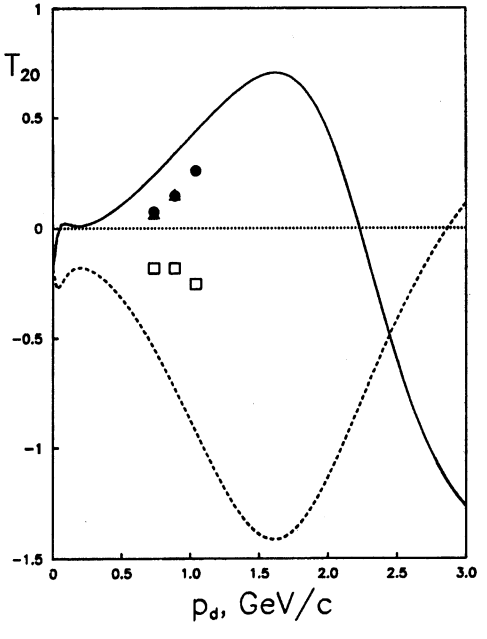

Fig.8. Tensor analyzing power T_{20} in the $d+d \rightarrow {}^3H+p$ (open symbols) and $d+d \rightarrow {}^3He+n$ (solid circles) reactions. The solid and dashed curves show the results of the ONE calculations [15] for the forward and backward emission of ${}^3H$ (${}^3He$) in the c.m.

6. Research programme for the Laboratory of High Energies in 2002-2006

According to the recommendations of the 16th meeting of the Programme Advisory Committee for Particle Physics, the Laboratory will have the following topics of the first-priority in the topical plan for JINR research:

Relativistic nuclear physics topics:

1. **Development of the Nuclotron Accelerator Complex (03-1-0979). Spokespersons: A.D.Kovalenko, A.I.Malakhov.**
   Scientific Programme: Operation of the Nuclotron, internal and external targets experiments. Development of the Nuclotron beam extraction system. Upgrade of the Nuclotron cryogenic system. Development of superconducting magnets for heavy-ion synchrotrons and beam transport channels. Increase of the beam intensity and extension of available nuclear beams. Development of the ion sources: laser, electron beam ionization scanner (CRION), polarized deuterons (Polaris). Upgrade of linac LU-20 ($Z/A \approx 0.28$). Technical design and the booster ring construction. Development of the beam transport system.
2. **Search for non-nucleon degrees of freedom and spin effects in few-nucleon systems (03-0-0941). Spokespersons: N.M.Piskunov, V.V.Glagolev, and G.Martinska.**
   Scientific Programme: Study of charge-exchange processes in *dp*-interactions. Study of polarization characteristics of different reactions with polarized and unpolarized deuterons and nucleons in inclusive, exclusive and correlation experiments (PPM, BES, SINGLET, and DELTA-SIGMA). Study of light nuclei structure at small distances and search for manifestations of non-nucleonic and quark degrees of freedom (MRS). Study of highly excited nuclear matter and collectivity effects in nuclear medium; delta and other nucleonic resonances excitations on protons and nuclei (MRS). Study of spin-spin correlations in pp elastic scattering. Modernization of the polarized proton target to study polarization characteristics of *NN* and *dN* interactions. Detector development for relativistic nuclei and polarization experiments at the Nuclotron (MRS, SINGLET, DELTA-SIGMA), CEBAF(Hall A), COSY. Preparation and performance of measurements $\Delta\sigma_T$(np). For the same energies of unpolarized neutrons, preparation and performance of measurements of cross sections for np charge-exchange at zero angle on *H, D* and *C* targets.
3. **Study of Multiple production in 4π-geometry and construction of the SPHERE spectrometer. First-line experiments at the Nuclotron (03-1-0983). Spokesperson: A.I.Malakhov.**
   Scientific Programme: Development of the SPHERE spectrometer and experiments on cumulative multiparticle production and correlated phenomena. Search for manifestation of quark-gluon degrees of freedom in collisions of relativistic nuclei and phase transitions in nuclei (SPHERE, FASA) and exotic resonances. Study of nuclear multifragmentation processes and hyper- and η-nuclei production (FASA, GIBS, and DELTA). The Continuation of experiments on the internal target of the Nuclotron: two-arm EMCalorimeter, deuteron spin structure investigation (SPHERE). Cumulative particle production by tenzor polarized deuterons. Asymptotics in nuclear collisions, nucleon clusters. Development of database for bubble chambers statistics. Detector development for relativistic heavy-ion experiments at the SPS (NA49), RHIC (PHENIX). Investigation of the ^3He spin structure at RIKEN. Creation of some prototypes of front-end electronics for primary processing; some prototypes of a logic processor; interface and network modules to organize a multichannel multiprocessor data acquisition system. Some developments of LHE-oriented architectures to create the

data acquisition system are proposed. Obtaining of the data on heat generation, neutron multiplication, balance and spectrum, fission and radiation capture integrals in the model uranium blanket and target-converter of the installation "Energy plus Transmutation". Studies of transmutation cross-sections of radioactive nuclear waste.

4. **Investigations of the properties of nuclear matter in experiments with nuclei and polarized particles (Projects DISK, STAR/LHE, CERES/NA45). (03-1-1011). Spokesperson: Yu.A.Panebratsev.**
   Scientific Programme: Investigation of the asymptotic properties of the extremely excited nuclear matter and vacuum nature of the quantum field theory in experiments at the relativistic nuclei and polarized proton collider RHIC. Study of the hot early stage of the dynamics of ultrarelativistic nuclear collisions in the experiment CERES/NA45 dedicated to the measurement of electron-positron pairs, and direct photons at CERN SPS energies. Study of the properties of polarized and unpolarized nuclear matter at small distances in experiments on cumulative and high particle production (DISK spectrometer). Study of nuclear and colour transparency in experiments at AGS (BNL) and Yerevan electron synchrotron.
5. **HADES - High-acceptance toroidal spectrometer. R&D of new particle detectors at GSI (03-1-1020). Spokesperson: Yu.V.Zanevsky.**
   Scientific Programme: A high-acceptance high-resolution spectrometer for electron pair detection in heavy-ion collisions is under construction at SIS (Darmstadt). The physics motivation includes the investigation of in-medium modification of light vector mesons (ρ, ω, ϕ) as well as a study of the dilepton continuum below the ρ/ω-region in hot dense hadronic matter. The main detector components include a ring-imaging Cherenkov detector (RICH) for electron identification, a superconducting magnet with toroidal geometry, a drift chamber system for tracking before and behind the field region and an electron trigger array with time of flight measurement and shower detection. The spectrometer has a geometrical acceptance of almost 50% for the electron pair and a mass resolution of 0,8% in ρ/ω-region. Special attention will be paid to investigation of different aspects of dilepton and photon radiation from a hot and dense nuclear medium, sources of dilepton in nuclear interaction, asymmetry and anisotropy of dielectrons and photons. High-resolution low multilayer drift chambers for the central part of the HADES spectrometer have been constructed at LHE JINR. The analogue readout electronics with the high density of integration and low power dissipation was developed at LHE; mass production of this electronics was carried out for the drift chamber system of the spectrometer. The work on track-finding software in the drift chamber system is in progress.
   Research and development of transition radiation detectors for TRD/ALICE and X-ray detectors with high spatial resolution.
6. **ALICE: A Large Ion Collider Experiment at CERN's LHC (03-1-0001). Spokesperson: A.S.Vodopianov.**
   Scientific Programme: The ALICE Collaboration proposed a dedicated detector to study high-energy heavy-ion collisions at LHC CERN. Major responsibilities of the JINR team are as follows:

Design and construction of the large dipole magnet for the muon spectrometer. Participation in the development and manufacture of the detectors for the ALICE set-up. Participation in the software development for the ALICE set-up. Preparation of the physics research programme for LHC.

7. **Investigation of relativistic multiparticle interactions. Project MARUSYA. (03-1-1010). Spokesperson: A.A.Baldin.**
   Scientific Programme: Development of the MARUSYA set-up and experiments with the extracted beam of the Nuclotron. Investigation of rare subthreshold and cumulative processes of hadronic production, antimatter production. Investigation of spin phenomena in the transition regime and single spin asymmetries. Construction of the set-up for experiments with the internal targets of the Nuclotron to study the heavy and very low-energy fragments.

And All-Institute topics:

8. **Theoretical and experimental investigations of the electronuclear method of energy production and radioactive waste transmutation (03-0-1008). Spokespersons: A.N.Sissakian, I.A.Shelaev, I.V.Puzinin, and S.Toczanovski.**
9. **CMS - Compact muon solenoid (02-7-1006). Spokesperson: I.A.Golutvin from JINR, A.I.Malakhov from LHE.**

The following topics of the second-priority are expected in the plan:

1. Studies of the threshold production and rare decays of light mesons (Project WASA) (03-1-0994). Spokesperson: B.A.Morozov.
2. Experiments "Leading particles" (Scintillation Magnetic Spectrometer MSU) and SPIN" (03-1-1033). Spokespersons: L.Sarycheva, A.Malakhov, and M.Finger.
3. Investigation of secondary particle production and neutron yield from heavy targets in nucleus-nucleus interactions. Studies of the transmutation of radioactive wastes from nuclear power installations (03-1-0940). Spokesperson: B.A.Kulakov.

During the next 5 years the LHE Directorate proposes to develop the research LHE programme according to the topical plan for JINR research. We have three main directions in our research programme [2, 16]:

1. Development of the accelerator complex.
2. Fundamental research in relativistic nuclear physics.
3. Applied research by using the accelerated particle beams and nuclear beams.

Below, is a list of the main stages of the Nuclotron development to be completed during several years (topic 0979):

1. The completion of the work on the transportation of the extracted beam to experimental facilities in the large experimental hall.
2. The development of the injector system, including the ion sources, the linear accelerator upgrade, and the booster construction.
3. The development of the cryogenic, diagnostic, and control systems.

At present it is necessary to upgrade the Nuclotron and to construct a users' center on its base for research in the field of relativistic nuclear physics by using relativistic ions over the energy range of several *GeV* per nucleon.

The schedule of the Nuclotron development in 2002-2008 is presented in Table 2.

The main regions of fundamental research of LHE are as follows:

1. Search for manifestations of quark and gluon degrees of freedom in nuclei (topics 0983, 1010 - SPHERE, DISK, MARUSYA projects)
2. Investigation of asymptotic laws for nuclear matter at high energy (topics 0983, 1011, 0001 - NA49, NA45, STAR, PHENIX, ALICE, CMS projects).
3. Study of the spin structure nucleons and of lightest nuclei (topics 0941, 0983, 1033 - DELTA-SIGMA, DELTA, SINGLET, SCAN-2, LNS, SPIN projects).

The applied studies at the LHE accelerator complex are as follows:

1. Radiobiology and space biomedicine (giving of the beams).
2. The impact of nuclear beams on the microelectronic components (giving of the beams).
3. The transmutation of radioactive waste and accelerator driven energy production (topic 1008, 0940, 0983 - ENERGY-TRANSMUTATION project).
4. The use of carbon beam in cancer therapy (Project is in the preparation) etc.

The finance resources for the LHE research topics of the first priority in 2002-2004 are presented in Table 3.

The Round table discussion on participation of Belarus in JINR at the 91st Session of the JINR Scientific Council, the information about collaboration of Laboratory of the High Energies with scientific centers of Belarus are presented in Table1.

Table 1.

Topic	Belarus scientific center
0983, 0940	The Institute of Radiative Physical-Chemical Problems of National Academy of Sciences of Belarus (Minsk)
1008	The Academy of Science and Engineering Complex 'SOSNY' (Minsk)
0941	Research Institute for Nuclear Problems of Belarusian State University (Minsk)

Table 2. The schedule of the Nuclotron development in 2002-2008.

WORK, SYSTEM	2002	2003	2004	2005	2006	2007	2008	
INJECTOR COMPLEX								
1. New laser								Ions up to Fe
2. "POLARIS" (D^-)								$N_{d\uparrow} = 10^9$ p.p.s.
3. Charge exchange injection								
4. "KRION"								Ions heavier than Fe
5. LINAC LU-20 upgrade								
6. BOOSTER								High intensities
NUCLOTRON systems								
1. Beam diagnostics, control, measurements, RF								Less beam losses
2. Cryogenic supply								To save LN_2, Save electric power
3. Quench detection, energy damp, power supply								To obtain 6 GeV/u
BEAM EXTRUCTION, BEAM LINES								
1. Second stage activities on the extraction system								To improve parameters of extracted beam
2. Development of beam lines, using superconductive elements								Save electric power
TOTAL COST K$ (Materials, equipment, design)	**294**	**300**	**300 250***	**500 250***	**500 250***	**200**	**100**	**2444* * including 750 out of budget**

Termination of the Synchrophasotron

Table 3. The finance resources for 1st priority topics of the Laboratory of High Energies in 2002-2004.

Topic	*2002*	*2003*	*2004*
03-1-0979-92/2002 (Accelerator Complex)	294	300	300
03-0-0941-91/2003 (Spin Effects)	91	90	90
03-1-0983-92/2004 (4π-geometry)	236	250	265
03-1-1011-95/2002 (STAR, NA45, DISK)	126	140	150
03-1-1020-95/2002 (HADES)	45	45	45
03-1-0001-2000/2005 (ALICE)	139	140	140
03-1-1010-99/2002 (MARUSYA)	80	80	80
02-7-1006-94/2005 (CMS) (LHE participation)	50	50	50
Total (k$)	1061	1095	1120

Appendix 1. The Letter of Thanks from the USA and France collaborators after the Synchrophasotron October 2001 run.

Professor V.G. Kadyshevsky
Director
Joint Institute for Nuclear Research
Dubna, Moscow region
Russia

Dubna, October 15, 2001

Dear Professor Kadyshevsky,

We would like to express our sincere thanks to the JINR Directorate for its support to continue the polarimeter calibration measurements at the LHE started last June. We particularly appreciate Your help and Your genuine interest in our work.

Thanks to the efforts of A. Malakhov, A. Kovalenko and all their people at the accelerator, we received beams of excellent quality and stability during the whole run.

As you saw during your visit, the data obtained are of high quality, and will be publishable in a very short time. The data will also be directly useful in the design of the new polarimeter required for the continuation of the proton form factor ratio measurements at Jefferson Lab.

We really appreciate the dedication of all the staff working at the alpha setup during this time.

Yours sincerely

C.F. Perdrisat, College of William and Mary , Virginia

V. Punjabi, Norfolk State University, Virginia

E. Tomasi-Gustafsson, DAPNIA, Saclay, France

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