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PROCEEDINGS

Editor: A. Olchevski

THE JINR SCIENTIFIC PROGRAMME

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1. INTRODUCTION

1.1 General information about the Joint Institute for Nuclear Research (JINR)

The Joint Institute for Nuclear Research (JINR) in Dubna was established on the basis of the convention signed by the Plenipotentiaries of the governments of the Member States of the JINR in March 1956 in Moscow. The JINR was created in order to unify the intellectual and material potential of the Member States in order to study the fundamental properties of matter.

Dubna as a town of science was founded immediately after the end of World War II. In 1947 a group of scientists led by the Academician I.V. Kurchatov initiated the construction of the then largest accelerator of charged particles — the synchrocyclotron. The accelerator was commissioned already in 1949. Extensive fundamental and applied investigations into the properties of nuclear matter immediately started at the newly established Institute for Nuclear Problems (INP) with its operating 680 MeV synchrocyclotron, headed by the young physicists M.G. Meshcheryakov and V.P. Dzhelepov, later world-known scientists.

After the INP, the Electrophysical Laboratory of the USSR Academy of Sciences (EFLAN), headed by the Academician V.I. Veksler, was set up in Dubna. A new accelerator, namely a synchrophasotron with record parameters for that time, was constructed at EFLAN.

In 1954, the European Organization for Nuclear Research (CERN) was established near Geneva to unite the efforts of Western European countries for studying the fundamental properties of matter.

About the same time, under the stimulus of the USSR Government, the countries then belonging to the socialist world took the decision to establish the JINR in Dubna from the INP and EFLAN laboratories. The same year, specialists from 12 countries (Albania, Bulgaria, Hungary, Vietnam, East Germany, China, Mongolia, N. Korea, Poland, Romania, USSR, and Czechoslovakia) came to Dubna. The town became international and investigations into many fields of nuclear physics of interest for research centres of the JINR Member States were launched there.

Many scientists and engineers from the Member States have been trained in the JINR scientific schools established by N.N. Bogoliubov, D.I. Blokhintsev, G.N. Flerov, I.M. Frank, B.M. Pontecorvo, V.I. Veksler, and other outstanding physicists. The development of different scientific directions at the JINR is connected with the names of L. Infeld and G. Niewodniczanki (Poland), G. Nadjakov (Bulgaria), H. Hulubei (Romania), L. Janossy (Hungary), N. Sodnom (Mongolia), Wang Gang Chuan (China), Nguen Van Hieu (Vietnam), V. Votruba and Ya. Kozesnik (Czechoslovakia), H. Pose and K. Lanius (Germany), and others.

The Charter of the JINR was adopted in 1956, the new edition of which was readopted in 1992, and more recently in 1999. In accordance with the Charter, the activities of the Institute are achieved on the basis of its openness, and the mutual and equal cooperation of all the interested parties to participate in research.

The aim of the Institute is:

- to carry out theoretical and experimental investigations on adopted scientific topics;
- to organize the exchange of experience when carrying out research and the exchange of information obtained as a result of these investigations through the publication of scientific papers, holding of conferences, symposia, etc.;
- to promote the development of the intellectual and professional capabilities of the scientific personnel;

- to establish and maintain contacts with other national and international scientific organizations and institutes to ensure stable and mutual cooperation;
- to use the results of the investigations of an applied nature to provide supplementary financial resources for fundamental research by implementing them into industrial, medical, and technological developments.

The results of the investigations carried out at the Institute can be used solely for peaceful purposes for the benefit of mankind.

So, until the late 1980s, Dubna was a centre that unified the efforts of leading research groups of nuclear sciences from socialist countries and the Soviet Union.

After the disintegration of the USSR, membership of the JINR underwent the following changes: the majority of Eastern European countries, such as Poland, the Czech and Slovak Republics, Bulgaria, Romania, and others continue to be Member States and contribute to the budget. Germany remains as an observer and makes a substantial financial contribution. Most of the former Soviet Union republics, which became independent states, entered the JINR as new members.

I would like to recall the words of a great Russian writer, A. Chekhov, who said: *"there is no national science as there is no national multiplication table. If the science is a national one - this is not a science anymore"*.

The JINR is a perfect illustration of this idea.

There are different ways to participate in the activities of the Institute: on the basis of membership, or bilateral and multilateral agreements in order to perform particular scientific programmes. JINR Member States contribute financially to the Institute's activities and have equal rights in its management.

At present the JINR has 18 Member States: Armenia, Azerbaijan, Belarus, Bulgaria, Cuba, Czech Republic, Georgia, Kazakhstan, D.P. Republic of Korea, Moldova, Mongolia, Poland, Romania, Russian Federation, Slovak Republic, Ukraine, Uzbekistan, Vietnam.

The JINR has special cooperation agreements concluded at the governmental level with:

- Germany (in the field of theoretical physics, heavy-ion physics, condensed matter physics, and high-energy physics);
- Hungary (in the field of condensed matter physics);
- Italy (in the field of intermediate and low-energy physics);

Among the major partners with whom JINR has long-term cooperation agreements are:

- CERN, in the field of high-energy physics;
- IN2P3 (France), in the field of nuclear and particle physics;
- INFN (Italy), in the field of nuclear and particle physics;
- FNAL, BNL, SLAC and other research centres in the USA.

Recently, special Agreements were signed with UNESCO and CLAF (Latin America Centre on Physics). The latest political changes in Eastern Europe and especially in Russia have made the JINR more and more open. New collaborating countries are welcome to join the JINR.

GOVERNING AND ADVISORY BODIES OF THE JINR

- Committee of Plenipotentiaries of the JINR Member States
- Finance Committee (one delegate from each Member State)
- Scientific Council
- Programme Advisory Committee for Particle Physics
- Programme Advisory Committee for Nuclear Physics
- Programme Advisory Committee for Condensed Matter Physics

The main fields of the Institute's investigations are theoretical physics, elementary particle physics, relativistic nuclear physics, physics of low and intermediate energies, heavy-ion physics, nuclear physics with neutrons, condensed matter physics, radiobiology and nuclear medicine, experimental instruments and methods, computing technologies.

The basic facilities of the Institute for experimental investigations are the nuclotron, the U400 and U400M cyclotrons, and the IBR-2 neutron reactor. The other JINR facilities such as the synchrophasotron, the phasotron, cyclotron U-200, and the IBR-30 reactor are mainly supported by resources which are outside the JINR budget.

The internal organization of the JINR is determined by scientific specialization. There are seven Laboratories in the Institute:

- Bogoliubov Laboratory of Theoretical Physics (BLTP);
- Laboratory of High Energies (LHE);
- Laboratory of Particle Physics (LPP);
- Laboratory of Nuclear Problems (LNP);
- Flerov Laboratory of Nuclear Reactions (FLNR);
- Frank Laboratory of Neutron Physics (FLNP);
- Laboratory of Computing Techniques and Automation (LCTA).

There are two more all-Institute subdivisions in JINR's structure:

- Department of Radiobiological and Radiation Research
- University Centre of the JINR

The total number of JINR personnel is about 6000 (including service divisions). Approximately 1100 scientists work at the Institute. The scientific policy of the JINR is established by the Scientific Council, whose members are prominent scientists from the Member States (A.A. Logunov, V.A. Matveev, R. Sosnowski, A.N. Tavkhelidze, A.N. Skrinsky, etc.) and well-known physicists from CERN, France, Germany, Italy, the USA and other countries. H. Schopper, C. Detraz, P. Spillantini, F. Legar, B. Peyot, F. Dydak, G. Trilling, M. Della Negra, and others are among the members of the SC. JINR's Director, Professor V.G. Kadyshevsky, is a Chairman of the Scientific Council.

Several associate experimental physics workshops are also part of the Institute. The personnel of the Central Division totals about 400. It is equipped with everything necessary for manufacturing large-size non-standard facilities, electronics, and has technological lines for constructing detectors for physics. Here the main units of JINR's heavy-ion cyclotrons, the U400 and the U400M, were constructed in recent years, as well as the Nuclotron — a new superconducting accelerator for relativistic nuclear physics. It is an excellent result especially in view of the difficult economic situation in Russia in recent years.

2. JINR's SCIENTIFIC ACTIVITY AND BASIC FACILITIES

Let us consider the research programmes of the JINR's main facilities and a few examples of recent results.

2.1 Nuclotron

The new superconducting accelerator, the Nuclotron (see Fig. 1) was put into operation four years ago, (A.M. Baldin et al.). It will enable an extensive programme of research in relativistic nuclear physics to be performed both in asymptotic mode (an accelerated nuclei energy higher than 4 GeV/n) and transmission

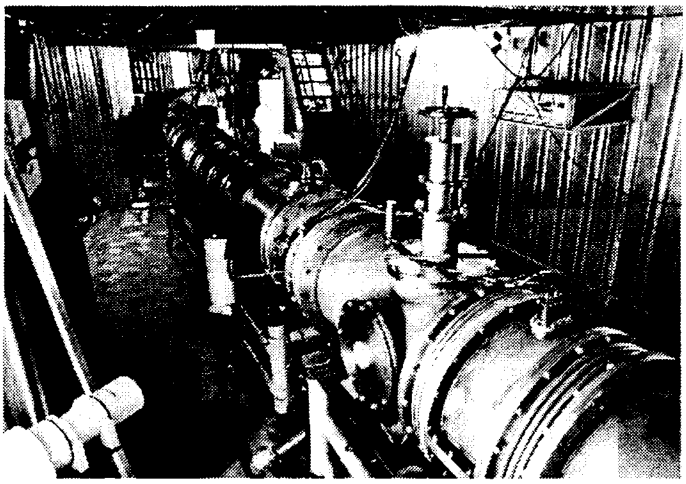


Fig. 1: The Nuclotron. A new superconducting accelerator which permits an extensive programme of research in relativistic nuclear physics to be performed.

regime (less then 4 GeV/n). In the asymptotic mode the nucleons cannot be considered as quasiparticles of nuclear matter and the influence of quark–gluon degrees of freedom in interactions of hadrons and/or nuclei should be observed.

The Laboratory of High Energies of the JINR was a pioneer in designing and constructing the first, low-cost accelerator based on low-field iron dominated superconducting magnets. The Nuclotron was built over a period of five years. The main magnetic equipment and many other systems were fabricated by JINR workshops.

The Nuclotron ring of 251 m in perimeter is installed in the Synchrophasotron technological tunnel. The total 'cold mass' of the magnetic system is about 80 t. Cooling of the system down to 4.5 K takes about 90 h. The cooling system was designed taking into account the fast cycling mode of the Nuclotron (up to 0.5–1.0 Hz), which is a specific feature of this superconducting accelerator.

The construction of the Nuclotron slow beam extraction system is at present underway, and will be commissioned at the end of 1999. The injection complex under development will consist of a buster, linac, and ion sources. This complex will allow one to accelerate nuclei from hydrogen to uranium with an intensity of 10^{13} to 10^{8} particles per pulse, respectively, in the energy range of 6–7 GeV per nucleon. Polarized deuteron beams are foreseen.

The research programme of the Nuclotron has been fulfilled and I give one recent new result on cumulative proton production. An experiment was performed on the internal deuteron 2 GeV nucleon beam of the Nuclotron, with the carbon target. It was found that in cumulative proton production, the transversal dimension of the interaction region for incoming deuterons is noticeably larger than for incoming protons (see Fig. 2).

2.2 Synchrophasotron

The synchrophasotron (Fig. 3) is an accelerator of 10 GeV protons commissioned in 1957 (V.I. Veksler, A.L. Mints et al.). In the 1970s the acceleration of nuclei heavier than hydrogen was accomplished in the broad energy spectrum from a few hundred MeV to 4.5 GeV per nucleon. The average densities of the beams range from 10^{4} to 10^{11} ions per cm^{2} s depending on the atomic number of the accelerated nuclei and the experimental requirements.

Synchrophasotron beams attract physicists from many laboratories in the world. The collaboration SPHERE (JINR+Nagoya University) recently performed a study of nuclear matter at short distances.

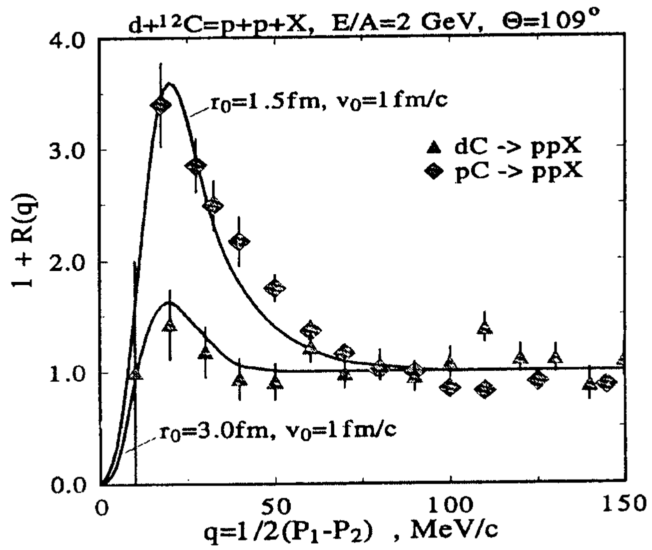


Fig. 2: Cumulative proton production.

In order to clarify the mechanism of the reactions and the structure of the non-nucleon degrees of freedom, a new experiment with polarized deuteron fragmentation into cumulative hadrons was performed. The observed difference between the Model and the Experimental Data is especially large for K = 0.2 GeV/*c*, where it would be natural to expect the manifestation of non-nucleon degrees of freedom in the deuteron wave function (Fig. 4).

2.3 Phasotron

The Phasotron is an accelerator of 680 MeV protons (M.G. Mesheryakov, V.P. Dzelepov et al.). It commenced operation in 1949, was reconstructed in 1984, and is the oldest basic facility of the JINR (see Fig. 5). Ten beam channels are available at this machine and are used to carry out experiments with pions, muons, neutrons and protons. Five secondary beams are designed to carry out medical investigations. The intensity of the extracted proton beam is 2 mkA. The research programme at the Phasotron includes low-energy proton–nuclei interactions, μ-catalysis physics, radiochemistry, and applied physics (including cancer therapy).

There is a proposal to construct the external injection of the beam into the accelerator's centre in order to increase the intensity of the phasotron accelerated proton beam 10–20 times.

2.4 U400 and U400M

At present the complex of the two heavy-ion cyclotrons (G.N. Flerov, Yu.Ts. Oganessian et al.) is an experimental base of the Flerov Laboratory of Nuclear Reactions. As you know, element 105 discovered at this laboratory was named Dubnium in honour of Dubna.

The U400 is a heavy-ion isochronous cyclotron which was constructed in 1978 (see Fig. 6). The range of accelerated nuclei is (A/Z) = 4–20, the energy is 650 Z^2/A MeV, the beam intensity is 10^{12}–10^{14} ion/s.

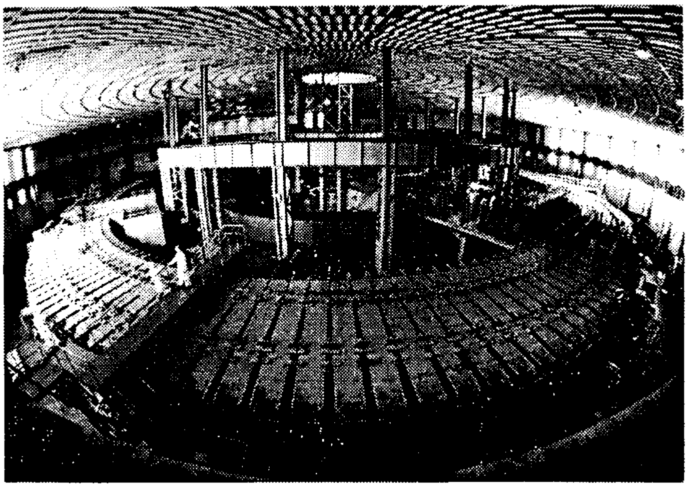


Fig. 3: Synchrophasotron.

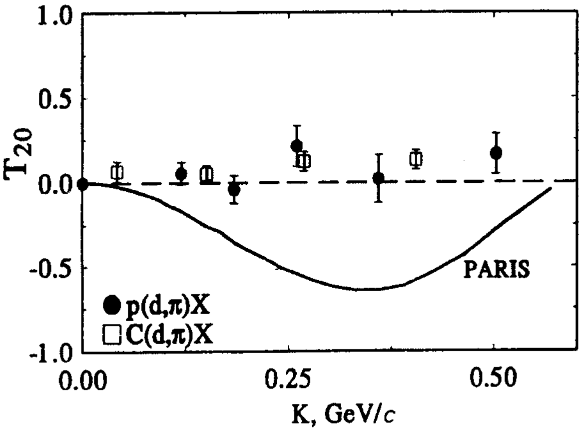


Fig. 4: SPHERE Collaboration. Measurement of the tensor analysing power T_{20} in inclusive polarized deuteron fragmentation into pion at zero angle.

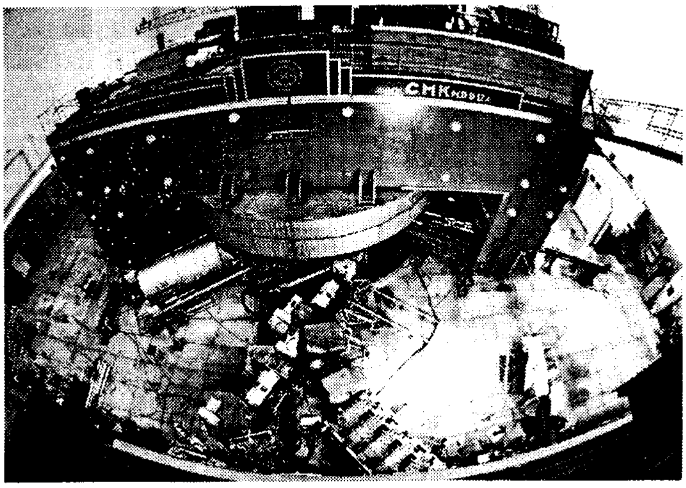


Fig. 5: Phasotron with space variation of the magnetic field, proton energy (660 + 3.1) MeV, extracted beam intensity 3 × 10^{13} p/s, duty cycle: 85%.

The U400M is an isochronous cyclotron which commenced operation in 1991–92 to accelerate heavy ions. At the U 400M cyclotron, internal ion beams of light elements from He to Ar with energies up to 50 MeV/nucleon (the maximum energy is 100 MeV/nucleon) have been obtained; an ion beam has been extracted and transported up to the FOBOS set-up; a system of channels for extracted beam transportation is being developed. To widen the range of accelerated ions at the U 400M and to increase the energy, the ECR-source DECRIS has been constructed at the Laboratory. Also, a more powerful ECR-source is being developed in collaboration with the GANIL Centre (France). The use of the ECR-type heavy-ion sources will allow the Laboratory to use less expensive separated isotopes in research on the synthesis of heavy elements or exotic nuclei. In order to obtain and transport secondary beams of radioactive nuclei, the COMBAS fragment separator with a large acceptance and high resolution is being created. The project of the future development of the Laboratory accelerator complex is linked with the production of radioactive nuclear beams in the tandem mode of operation of the U400M and U400 accelerators, and with the creation of a storage ring, acting as the third stage.

The main areas of research include the synthesis of new elements, the investigation into the chemistry of new transferium elements, and studies of the radioactive decay of heavy nuclei far from beta stability.

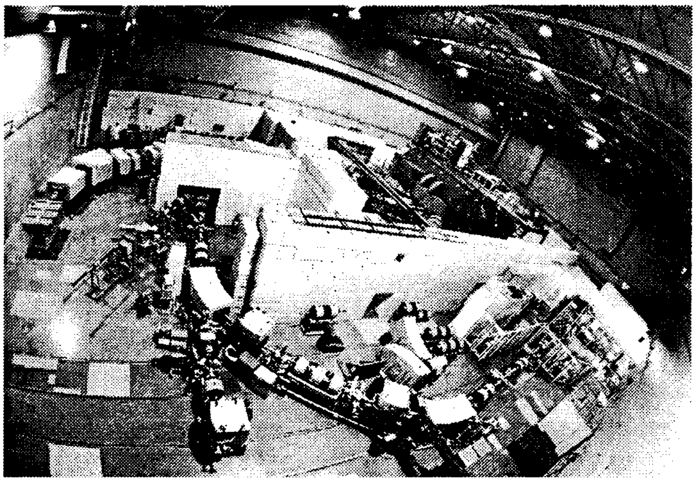


Fig. 6: U400M.

The most spectacular result obtained in 1998 at the U400 heavy-ion cyclotron was the discovery of element 114 and the island of stability. By this I mean the experimental discovery of a super heavy element with atomic number 114 and mass 289. In late December 1998, a group of scientists from the Flerov Laboratory of Nuclear Reactions, in collaboration with colleagues from the Lawrence Livermore National Laboratory (USA), synthesized a new long-lived (30 s) super heavy element of the Periodic Table with atomic number 114. In March, a second experiment was carried out aimed at the synthesis of an isotope of element 114 with mass 287, in the reaction ^{48}Ca + ^{242}Pu at the separator VASSILISSA. This experiment registered two events of the α-decay chain with spontaneous fission about 3 minutes long. This discovery has crowned the 35 year efforts of physicists from the JINR, USA, and Germany in search for a stability island for super heavy elements.

2.5 The IBR-2 fast reactor

The fast pulsed reactor IBR-2 is used for condensed matter research (D.I. Blochintsev, I.M. Frank et al.), see Fig. 7. Neutron scattering investigations in the field of condensed matter physics are conducted at IBR-2 using four main experimental techniques: diffraction, small-angle scattering, inelastic scattering, and polarized neutron optics. The principal characteristics of the IBR-2 reactor are presented below.

IBR-2 is a pulsed reactor with an average thermal power of 2 MW and a peak power in pulse of 1500 MW. Power pulses with a frequency of 5 Hz are generated by reactivity modulators.

By 2002, the principal parts of the IBR-2 reactor will have their radiation resources exhausted and will have to be replaced. The programme for upgrading the IBR-2 reactor will be elaborated over a period of 10 years (1996–2005). This programme is threefold and it includes:

- improvement of the reactor parameters,
- increase in nuclear safety and reliability of the reactor,
- updating of the reactor systems.

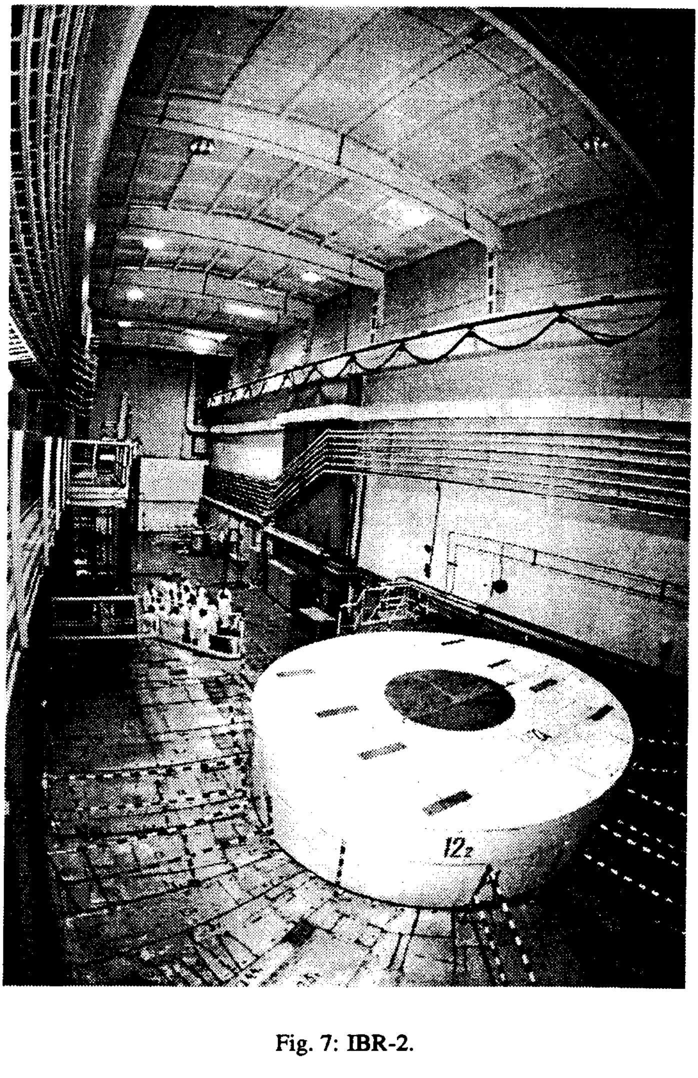


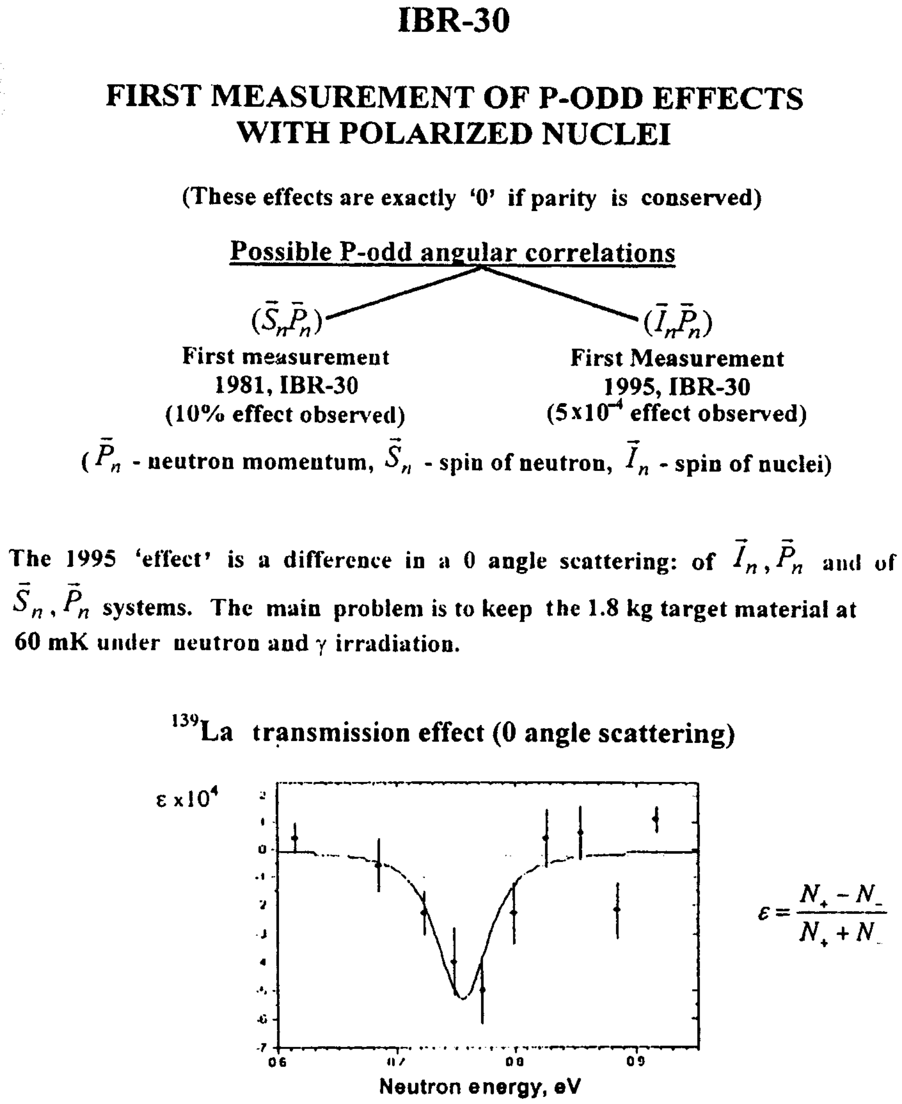
Fig. 7: IBR-2.

2.6 IBR-30 + LUE-40

The IBR-30 + LUE-40 is a pulsed neutron source consisting of the old pulsed reactor IBR-30 and the electron 40 MeV linac LUE-40 (D.I. Blochintsev, I.M. Frank et al.). The average heat power of the reactor is 10 kW, and the instant pulse power is 150 MW. It generates neutron pulses with a frequency of about or less than 100 Hz and a duration of 4.5 μs. The total neutron yield is 5×10^{14} n/s, the flux of fast neutrons is about 10^{12} neutrons/cm^2 s.

A developed set of time-of-flight neutron spectrometers allow a wide spectrum of investigations to be carried out including the study of P- and T-symmetry violation of fundamental interactions in nuclei, the electromagnetic structure of the neutron, and some problems related to fundamental nuclear physics.

At IBR-30 the first measurements of the P-odd effects with polarized nuclei were performed. The main results are illustrated in Fig. 8. The joint analysis of the $(\vec{S}_n\vec{P}_n)$ and $(\vec{I}_n\vec{P}_n)$ data permits, for the first time, the matrix element of weak N–n interactions for ^{140}La to be determined.



IBR-30

FIRST MEASUREMENT OF P-ODD EFFECTS WITH POLARIZED NUCLEI

(These effects are exactly '0' if parity is conserved)

Possible P-odd angular correlations

$(\vec{S}_n\vec{P}_n)$	$(\vec{I}_n\vec{P}_n)$
First measurement **1981, IBR-30** **(10% effect observed)**	**First Measurement** **1995, IBR-30** **(5×10^{-4} effect observed)**

($\vec{P}_n$ - neutron momentum, $\vec{S}_n$ - spin of neutron, $\vec{I}_n$ - spin of nuclei)

The 1995 'effect' is a difference in a 0 angle scattering: of $\vec{I}_n, \vec{P}_n$ and of $\vec{S}_n, \vec{P}_n$ systems. The main problem is to keep the 1.8 kg target material at 60 mK under neutron and γ irradiation.

^{139}La transmission effect (0 angle scattering)

$$\varepsilon = \frac{N_+ - N_-}{N_+ + N_-}$$

Fig. 8: Results of $(\vec{I}_n\vec{P}_n)$ measurement at IBR-30, 1995.

2.7 IREN

IREN (Intense Resonance Neutron Source) is a project aimed at constructing a high-flux pulsed neutron source to carry out investigations with resonance neutrons (Fig. 9).

The facility will comprise a modern 200 MeV electron linac and subcritical plutonium booster with a neutron multiplication coefficient of 30. The pulse rate is 150 Hz, the duration 0.4 μs, and the total neutron yield $\sim 10^{15}$ n/s. This project was started in 1994 and the IREN will commence operation in 2002.

IREN (Intense REsonant Neutron source)
A sketch of the project

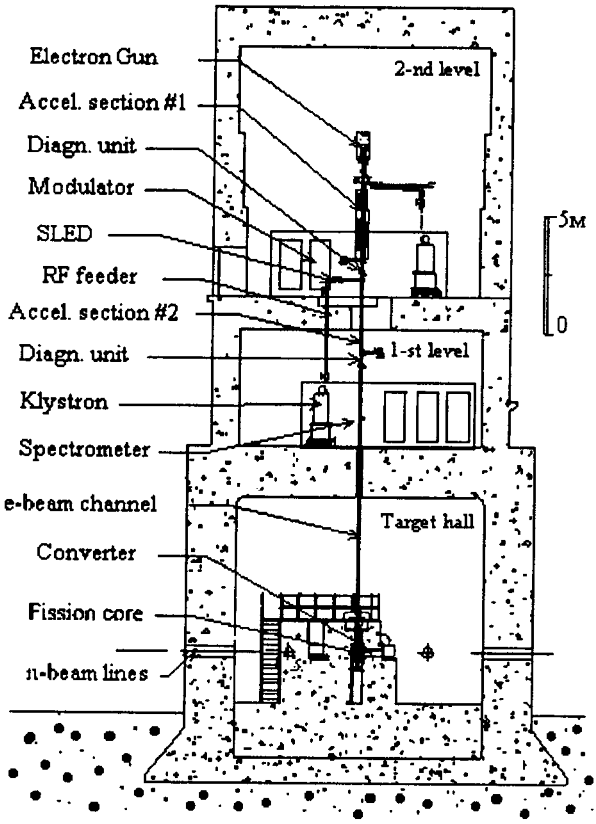


Fig. 9: The research programme for the IREN includes investigation of P- and CP- violations in slow neutron interations with nuclei and other fundamental nuclear physics topics.

3. THE JINR: A MAJOR PARTNER OF WORLD HEP LABORATORIES

Broad international cooperation is one of the most important principles of the JINR's activities. Almost all investigations are carried out in close collaboration with the JINR member state scientific centres, as well as international and national institutions and laboratories of the world. Very effective cooperation is achieved with institutes in Russia such as the IHEP (Protvino), Kurchatov Institute in Moscow, Institute of Nuclear Physics in Gatchina near St. Petersburg, ITEP (Moscow), INR (Troitsk), Lebedev Institute of Physics (Moscow), Moscow State University, Budker Institute of Nuclear Physics (Novosibirsk), and others.

Very fruitful scientific cooperation has been achieved with CERN, especially in recent years, as well as with many physics laboratories in the USA, France, Germany, Italy, and other countries. Cooperation with the Nuclear Scientific Centre of Peking University (China) is being developed, and a protocol on collaboration has been signed between the JINR and the Institute of Modern Physics of the Academia Sinica.

3.1 International collaboration

Figure 10 shows the current status of JINR's International Cooperation in High-Energy Physics (HEP).

The Directorate of the JINR is also prepared to maintain constant and long-term contacts with laboratories of other countries.

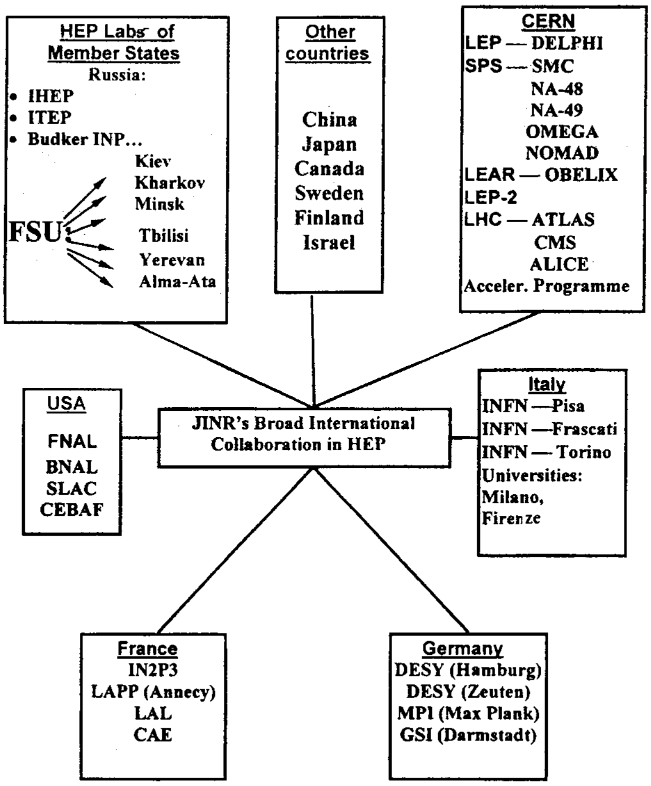


Fig. 10: JINR's international cooperation in HEP.

In 1998, approximately 1200 JINR specialists participated in joint experiments and international conferences and symposia, and more than 1000 scientists from collaborating laboratories and centres visited Dubna. The JINR also organized 10 large conferences and about 40 workshops and other meetings in 1998, and scientists from Dubna participated in more than 150 international conferences.

3.2 Cooperation with CERN

Dubna physicists are involved in a large part of the CERN experimental programme (see Table 1). A general agreement between the JINR and CERN was signed in 1992, but cooperation between the two international organizations has a very long history.

Dubna has made progress in fulfilling its obligations with respect to the LHC Programme (ATLAS, CMS and ALICE experiments, as well as the LHC machine).

Table 1: Experiments at CERN in which Dubna is involved.

Project	Location	a) Main goals b) JINR contribution
NA48	SPS CERN	a) Highest precision direct CP violation searching in neutral kaon decays. b) Subsystems design & construction; data-taking runs. Data analysis.
NA49	SPS CERN	a) Search for the predicted phase transition from hadrons to deconfined quarks and gluons in Pb+Pb collisions at the SPS. b) 900-channel time-of-flight detector for identification of $h^{\pm}$, $K^{\pm}$, p, p, d, and d. Data analysis.
NOMAD	SPS CERN	a) Search for $\nu_{\mu} \rightarrow \nu_{\tau}$ and $\nu_{\mu} \rightarrow \nu_{e}$ oscillations. b) Data-taking & analysis; new proposal preparation.
COMPASS	SPS CERN	a) Hadron structure and hadron spectrometry with high-rate hadron and muon beams; q&g contribution to nucleon spin; polarization of nucleon sea q's, etc. Glueball search for exotics. b) Hadron Cal, muon detector, large-area track chambers.
DIRAC	PS CERN	a) 5% accuracy test of low energy QCD by 10% precision $(\pi^{+}\pi^{-})$ atom life time measurement. b) Experiment proposed by JINR; drift chambers; secondary particles channel; trigger development; MC simulation & software. Data-taking RUNs, data processing & analysis.
DELPHI	LEP CERN	a) Precision measurement of m (W), search for new particles, etc. b) Maintain Hadron Calorimeter and surround Muon Chambers; physics analysis.
ATLAS	LHC CERN	a) General purpose *pp* experiment. b) Subsystems: calorimeters; muon, transition rad. det.; rad. hard. tests; phys. software & simulation; trigger and data acquisition.
CMS	LHC CERN	a) General purpose *pp* experiment. b) Subsystems: forward μ-station, hadron end-cap cal.; e/m cal. preshower; simulation. Heavy-ion physics.
ALICE	LHC CERN	a) Heavy-ion relativistic beams. Study of q-g plasma and phase transition. b) Warm dipole Magnet; large-scale Pestov counter production. Detector assembly. Data-taking runs. Data processing & analysis.
R&D for LHC Accel. Complex Elements	LHC CERN	a) Development & construction of LHC beams formation & control system elements. b) Design & construction of transverse oscillation damping system. Simulation & prototypes study.

CMS project

The JINR is participating in the CMS project in the framework of the Russia and Dubna Member States Collaboration (RDMS). The involvement of the Member States in this activity through RDMS has given them an opportunity to play leading roles and to contribute significantly to the preparation of the hadron calorimeter, electromagnetic calorimeter, and the muon detector.

Belorussian scientists and industry have developed and manufactured a special electronics scheme (for proportional chambers) which successfully passed radiation tests at CERN under the conditions corresponding to the highest LHC radiation load at maximum luminosity.

Belarus and Bulgaria are responsible for the CMS end-cap calorimetry. They assembled the very first full-scale prototype of the h-cal sector ($2 \times 2 \times 1$ m^3 in dimension and weighing 30 t).

ATLAS project

For the ATLAS Barrel Hadron Tile Calorimeter we have performed a considerable amount of work, unusual even for our large institute: in cooperation with Belarus and Slovak Institutes and industry we manufactured about 300 000 units of steel absorber plates with a very high mechanical tolerance (50 microns). All of them have been delivered to calorimeter submodule producers (Dubna, Prague, Protvino, Pisa). Two years ago we assembled the very first Module 0 of the ATLAS hadron calorimeter. The module was delivered to CERN and its beam tests proved the projected energy resolution.

ALICE project

The JINR contributes to the warm dipole magnet, the production of large-scale Pestov counters, detector assembly, data-taking runs, and data processing & analysis.

LHC damper

One of the main goals of the JINR's participation in the LHC Project is to manufacture a powerful amplifier and kicker for the Transverse Feed-back System for the LHC (Fig. 11).

LHC Damper

Development and construction of the electrostatic kickers and wideband amplifiers for the transverse damping system of the LHC

General requirements
of the Transverse Damping System
for the LHC

Admissible emittance growth	2.5%
Average damping time, ms	4.7
Gain	0.046
Amplitude on the kicker, kV	± 7.5
Average power per tube, kW	16
Bandwidth, MHz	$10^{-3} \div 3$

Fig. 11:

At the JINR, the design of, a special power device was proposed. It allows different types of damping to be used and investigated (including non-linear 'bang-bang' and 'logical' ones). Joint CERN–JINR experiments with the SPS (SL RF) have shown the effectiveness of this solution.

Scientists from the JINR made a significant contribution to CERN's scientific programme also in other experiments performed at LEP, the SPS, and the PS. For example, Prof. L. Nemenov from the JINR was elected by the Collaboration as leader of the DIRAC experiment, which successfully started its first run in late 1998.

3.3 Cooperation with IHEP (Protvino)

JINR scientists are carrying out experiments at the IHEP U-70 proton synchrotron using such set-ups as the Tagged Neutrino Test Facility, EXCHARM, HYPERON, the Neutrino Detector, and others. The most essential features of our scientific programme with respect to the 70 GeV accelerator of Protvino are summarized in Table 2.

Table 2

JINR's participation in the research at U-70

EXCHARM	Search for exotic states with strange quarks, study of the processes of production and decay of particles containing heavy quarks
HYPERON	Investigations of rare K-meson decays
NETRINO DETECTOR	Investigations of neutrino oscillations and neutrino–nucleon interactions
TAGGED NEUTRINO COMPLEX	Verification of the universal features of weak interactions; search for rare decays in neutrino interactions; search for CP-violation in K-decays
PROZA-DIBARION	Measurements of the polarization parameters of πN and NN interactions

3.4 Some new scientific results

Impressive results have been obtained in the field of particle physics. Among them a new theoretical prediction of the Higgs boson mass in the Minimal Supersymmetric Standard Model. Figure 12 demonstrates the distribution of χ^2 which depends on the Higgs boson mass — the only particle of the Standard Model which has not yet been found experimentally. The distribution was obtained using the fit of worldwide experimental data and programmes that accumulate all the theoretical data on the given model. One of the programmes used here and called 'ZFITTER', was developed by Dr. D. Bardin from the JINR, together with an international group of physicists over the last 15 years. Figure 12, illustrating this result, was kindly presented by Dr. W. Hollik.

One more example of fruitful cooperation with CERN took place in 1998. A group of physicists from Dubna, headed by Prof. A. Tyapkin, proposed a new approach to study the properties of Cherenkov radiation near the threshold. An experiment was carried out with a unique high-energy beam of lead ions at the SPS, using the equipment of NA49. For the first time, an intensity increase of Cherenkov light near threshold was registered on the biaxial crystal of triglycine sulphate. These investigations were carried out in collaboration with CERN and the Comenius University (Bratislava).

Our scientific programme is really very broad and it is therefore rather difficult to present all the important and impressive results in this short talk.

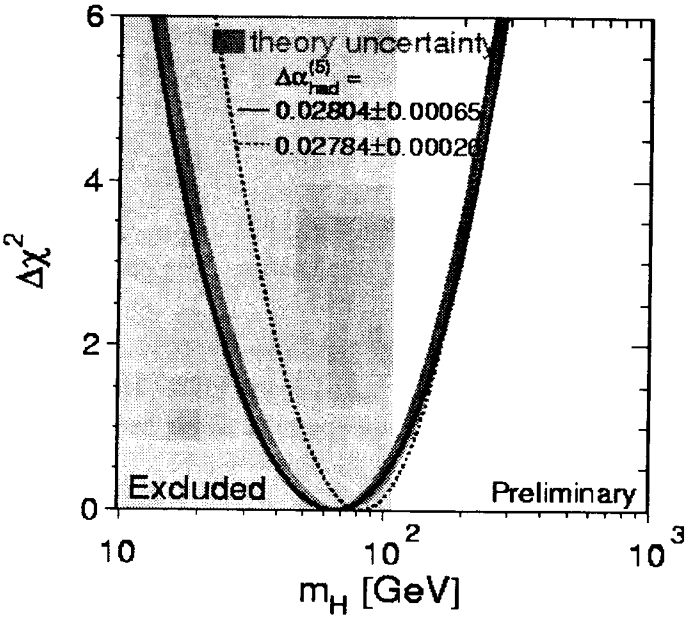


Fig. 12: Higgs mass dependence of χ^2 in the global fit to precision data. The shaded band displays the error from the theoretical uncertainties obtained from various options in the codes ZFITTER and TOPAZO.

4. DUBNA AS AN EDUCATIONAL CENTRE

The educational programme plays an important role in our activities. I would like to stress that the concept of JINR development is the integration of fundamental science, technological studies, and education.

To achieve this task, in 1991 we created the JINR University Centre and in 1994, together with the Russian Academy of Natural Sciences, 'Dubna' University.

The University Centre of the JINR offers graduate programmes in the field of:

- Nuclear Physics,
- Elementary Particle Physics,
- Condensed Matter Physics,
- Theoretical Physics at the Bogoliubov Laboratory,
- Technical Physics
- Radiobiology

Being here in Slovakia, it is my special pleasure to emphasize a very good example of cooperation in the framework of the University Centre. By this, I refer to the initiative of Prof. Stanislav Dubnička to train a specialized group of Slovakian students in Dubna for future work at the cyclotron complex in Bratislava. This complex was developed in Dubna on the order of the Slovakian government. Russia's state debt is paid to Slovakia to finance this project.

5. PLANS FOR THE NEAR FUTURE

The JINR has the following plans for the near future:

- Significant broadening of international usage of JINR's unique research machines such as the Nuclotron, the cyclotron complex U400–U400M, and IBR-2.
- Development of methodical and computing possibilities for participation in the experimental programmes of the worlds largest HEP laboratories (CERN, FNAL, DESY, IHEP and others).
- Construction of IREN.

- Development of the injector complex of the Nuclotron after putting into operation the beam slow extraction system (1999).
- Further development of the JINR University Centre.
- The use of JINR's advanced infrastructure for holding international conferences, meetings, and schools.
- Development of the DRIBS project dedicated to producing intense beams of unstable nuclei. The scientific proposal of this project outlined the exciting prospects for the investigation of nuclear structure and nuclear dynamics.
- The study of the possibility of removing the AmPS accelerator from NIKHEF to Dubna, and rebuilding it at the JINR as the new 'DELSY' facility — a third-generation synchrotron light source.

The JINR is continuing its programme of reforms to create better conditions for using its facilities and infrastructure by our users.

6. CONCLUSION

This short review only presents some general information about our research centre in Dubna. However, I would like to emphasize that over its 43 years of existence, the JINR has become a well-known international scientific centre, which incorporates the fundamental research of the structure of matter, the development and application of high technologies, and university education in the relevant fields of knowledge. The scientific policy pursued by the Directorate of the JINR has been developed in the context of the world's scientific trends. At the same time, recent years have been marked by a struggle for survival and the preservation of the Institute as a unified scientific centre in the time of radical political changes and serious economic difficulties in Russia and most of the Member States. This struggle has very often been waged under conditions close to extreme ones. Nevertheless, thanks to joint efforts, the Institute has survived, and continues to contribute significantly to world science in the field of particle physics, nuclear physics, and condensed matter physics.

In conclusion, I would like to stress the following: in order to preserve and multiply the achievements of the JINR one should take care of its three pillars, namely:

- The international character of the Institute;
- The traditions of the Dubna scientific schools;
- The attractive experimental facilities including the computing and networking infrastructure.

I would like to express my gratitude to Dr G. Arzumanyan and Mrs M. Studenova for their assistance in the preparation of these lecture notes.