Science Brings Nations Together

The Czech Republic and JINR

Long-Term Fruitful Cooperation and Future Prospects

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Contents

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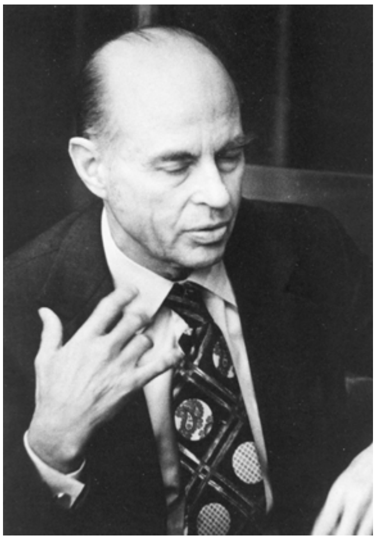
1. General information about the Czech Republic–JINR long-term fruitful cooperation

Czechoslovakia was one of the JINR founder states, and the Czech Republic continues abiding by the arrangements made by that state. At its meeting on 16–17 March 1993, the Committee of Plenipotentiaries of the Governments of the JINR Member States considered the letters of authority of the representatives of the Slovak Republic and the Czech Republic. In accord with the statements of the representatives of the governments of these countries, the Committee of Plenipotentiaries made a decision that it “recognizes Slovakia and the Czech Republic as legal successors of the Czech and Slovak Federal Republic in its rights and obligations as the JINR member, and since 1 January 1993 the Slovak Republic and the Czech Republic have been the JINR Member States.”

The Czech Republic, as earlier Czechoslovakia, is one of the leaders among the JINR Member States in the amount of participation in the JINR activities, joint research, and scientific and technological relations. A prominent contribution to the development of the Joint Institute for Nuclear Research was made by Academicians J. Kožešnik and V.Votruba, Professors I. Úlehla, J. Tuček, Č. Šimáně, M. Gmitro, I. Wilhelm and others. Czech scientists held high posts of JINR Vice-Director, Laboratory Deputy Directors, Heads of Departments and Sectors (V. Votruba, V. Petržílka, Č. Šimáně, I. Zvára, M. Finger, and others).



Professors I. Úlehla (left), Č. Šimáně (middle), M.Gmitro (right) were Vice-Directors of JINR

Many Czech physicists have gained great experience at JINR and continue collaboration with their Dubna colleagues: J.Kvasil, S.Kozubek, A.Kugler, L.Majling, J.Pleštil, I.Procházka, I. Štekl, P.Exner, S. Pospíšil, Z. Janout, and many others. As I. Úlehla said, “The Joint Institute has helped educate many of our specialists not only in nuclear physics or high- and low-energy physics themselves but also in areas of mathematics, chemistry, and technology related to theoretical and experimental problems in nuclear physics.”

Many scientific problems dealt with at JINR are being solved in close cooperation with laboratories of JINR Member States and, vice versa, many problems tackled by laboratories of JINR Member States are being solved with assistance of the Joint Institute for Nuclear Research. Speaking about the past, it is worth mentioning that such basic facilities as the U–120 cyclotron and the microtron were developed at JINR and supplied to the Czech

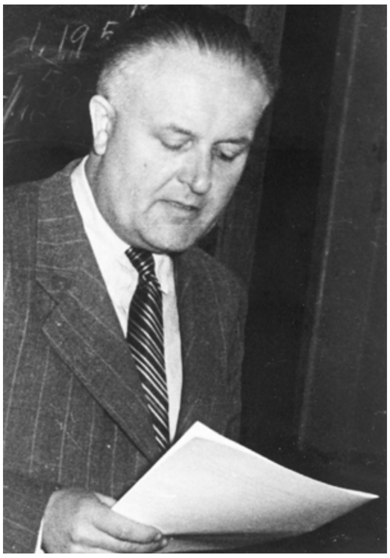
Republic. With their high skills, Czech scientists and engineers occupy a prominent place in scientific teams of JINR. Now there are 17 Czech staff members at JINR, including JINR Vice-Director Prof. Richard Lednický.

Specialists from Czech institutes come on short-term visits to the laboratories of JINR for carrying out joint research, and JINR scientists regularly go to the Czech Republic for participating in joint scientific activities and international conferences.

The Czech Republic has many times been a hospitable host of JINR workshops, including traditional ones like schools and international conferences “Symmetry and Spin” in Prague (Organizing Committee Chairman Prof. M. Finger). The first of them was held at JINR in 1975, and the latest, anniversary one, was held in Prague at the end of July–beginning of August 2010 and was attended by about a hundred of scientists from all over the world. The contributions made by Prof. Finger to development of long-term cooperation between Czechoslovak and later Czech institutes and JINR deserve high praises.

In the Czech Republic, a meeting was held to celebrate the 50th anniversary of the Joint Institute for Nuclear Research. The Chairman of the Government of the Czech Republic attended it and made a speech.

In May 2009, a seminar devoted to the 90th birthday of the outstanding scientist Prof. Č. Šimáně was held at Řež. He was Vice-Director of the Joint Institute for Nuclear Research in Dubna in 1973–1977. He was also the chairman and a member of many professional and organizing committees and advisory councils, in particular for nuclear physics and nuclear power development, a member of the Scientific Council of the Joint Institute for Nuclear Research in Dubna, a member of the scientific councils at NPI (Řež), Faculty of Technical and Nuclear Physics of Czech Technical University in Prague. He was awarded the JINR Medal of Honour for outstanding contributions to science and development of JINR.



Academician V.Votruba (left) and Prof. Č. Šimáně (right) in May 2009

J. Kožešnik (left sitting), G.N. Flerov and Č. Šimáně (right) at ceremonial devoted to awarding to academician G.N. Flerov the degree of Honorary Doctor of Prague Technical Institute in Charles University on 22.03.1980

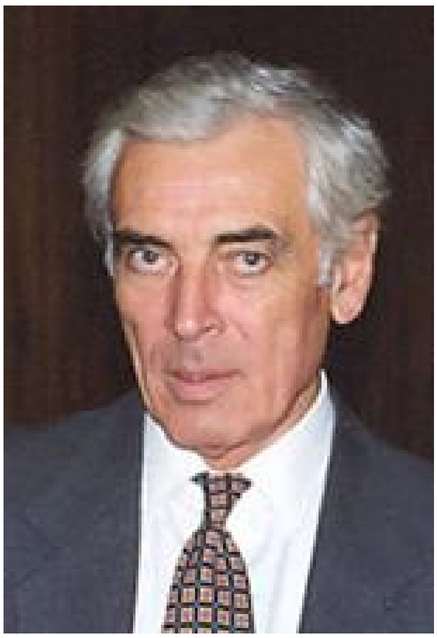
G.N.Flerov and Č. Šimáně right before the ceremonial

The Czech Republic takes an active part in the educational programme: groups of senior Czech students regularly do their practical work at JINR laboratories, which is greatly the merit of Prof. I. Štekl, Deputy Director of the Institute of Experimental and Applied Physics of the Czech Technical University in Prague and former JINR staff member. It is an important form of new cooperation. This cooperation with the Joint Institute for Nuclear Research opens up fresh opportunities for students. Now the Centre of Experimental Nuclear Astrophysics and Nuclear Physics has launched a new project for practical study of students in Dubna (Project Leader K. Smolek). It also involves the Nuclear Physics Institute (Řež, person in charge A. Kugler), Institute of Physics of Silesian University in Opava (person in charge P.Lichard), and Czech Technical University (person in charge I. Štekl).

At present almost all scientific institutions in the Czech Republic that are involved in nuclear physics research collaborate with JINR, which provides not only the modern experimental basis but also concentration of the human and scientific potential. Owing to its position in the Russian Federation, JINR opens up the way to cooperation with other Russian scientific centres. Cooperation with JINR also opens up a possibility for the Czech Republic to introduce Czech goods into the world market.

Since 1993 the Plenipotentiary of the Government of the Czech Republic to JINR has been Prof. **Rostislav Mach**, Head of the Radiation Medicine Department of the Nuclear Physics Institute, Academy of Sciences of the Czech Republic (http://www.ujf.cas.cz/).

Rostislav Mach was born on 30 September 1943. Doctor of Science (Physics and Mathematics), Head of the Radiation Medicine Department, Nuclear Physics Institute, Academy of Sciences of the Czech Republic. Graduated from the Faculty of Nuclear and Physical Engineering in the field of nuclear physics. Defended the Candidate of Science thesis at the Joint Institute for Nuclear Research in Dubna (JINR) and the Doctor of Science thesis at the Faculty of Mathematics and Physics of Charles University.



Prof**.** Rostislav Mach (left) and Prof**.** Ivan Wilhelm (right)

For many years a member of the JINR Scientific Council has been Prof. **Ivan Wilhelm**, until 2006 the rector of Charles University, a member of the Governmental Council for Science and Development (http://www.cvutmedialab.cz/).

Ivan Wilhelm was born on 1 May 1942. He graduated from the Faculty of Engineering and Nuclear Physics of the Technical University in 1964. In 1972 he became a senior lecturer, and in 1999 he was elected the professor of experimental physics. On graduation from the institute he worked at the Czech Technical University. In 1967–1970 he worked at the Joint Institute for Nuclear Research in Dubna. Over the period 1990–1994 he was the director of the Nuclear Centre of the Faculty of Mathematics and Physics at Charles University. In the years 1994–2000 he was a vice-rector of Charles University and then the Chairman of the Council of Higher Education Institutions. In 2000–2006 he was the rector of Charles University and was also elected the Chairman of the Czech Conference of Rectors. For many years he held the post of the Chairman of the Council at the Ministry for Education and then the post of the Chairman of the Programmes Council. I. Wilhelm is presently Deputy Minister of Education, Youth and Sports of the Czech Republic. He is professor, member of the JINR Scientific Council since 1993, now the co-Chairman of the Scientific Council.

Professor Ivan Wilhelm is the Doctor Honoris Causa of the Claude Bernard University in Lyon and Comenius University in Bratislava. He was awarded with The Medal of the Committee of Plenipotentiaries at JINR, Ordre des Palmes Académiques, Chevalier (Republic of France) and Order of St Gregory the Great (Vatican).

Meeting in Prague on the 50th anniversary of JINR (2006).
Left to right: R. Mach, J. Paroubek (the CR prime minister), I. Wilhelm, A.N. Sissakian

Professor Wilhelm is actively involved in experimental nuclear physics and elementary particle physics studies, and he is an author and co-author of about 100 publications. He participated in many conferences and was invited to read lectures in many foreign universities. He is a member of the Czech Republic Coordination Committee at CERN (Geneva) and the Czech Republic Coordination Committee at JINR in Dubna. He worked at the Committee of Association of European Universities and is a member of the International Association of Universities. He is a member of the Assembly of the Academy of Sciences of the Czech Republic and a permanent guest of the Research and Development Council of the Government of the Czech Republic.

At present JINR is actively collaborating with the following organizations in the Czech Republic:

- Charles University http://www.cuni.cz/
- Institute of Physics AS CR http://www.fzu.cz/
- Institute of Macromolecular Chemistry AS CR http://www.imc.cas.cz/
- Czech Technical University (CTU) Prague http://www.cvut.cz/
- Institute of Experimental and Applied Physics of CTU http://www.utef.cvut.cz/
- Nuclear Research Institute http://www.nri.cz/
- Nuclear Physics Institute AS CR http://www.ujf.cas.cz/
- Institute of Biophysics AS CR http://www.ibp.cz/
- Institute of Scientific Instruments AS CR http://www.isibrno.cz/
- Technical University of Liberec http://www.tul.cz/
- VAKUUM PRAHA Company http://www.vakuum.cz/
- Institute of Geology AS CR http://web.gli.cas.cz/

Scientists from the Czech Republic take part in the work on 33 scientific themes of the Topical Plan for JINR Research and International Cooperation in 2011:

- **Theoretical physics** (five themes);
- **Elementary particle physics and relativistic nuclear physics** (15 themes);
- **Nuclear physics** (5 themes);
- **Condensed matter physics; radiation and radiobiological research** (5 themes);
- **Networking, computing, computational physics** (2 themes);
- **Educational programme** (1 theme).

A large group of scientists from the Czech Republic headed by Prof. Miroslav Finger, Doctor of Sciences (Physics and Mathematics), professor of the Faculty of Mathematics and Physics at Charles University in Prague, and a staff member of the Joint Institute for Nuclear Research in Dubna for many years, studies spin effects in hadron–nucleon and lepton–nucleon interactions within the scope of the theme “Study of polarization phenomena and spin effects at the JINR Nuclotron-M accelerator complex”, leader A.D. Kovalenko.

Since 2002 extensive physics research has been carried out within the programme for the study of the proton, neutron, and deuteron structure and for precision hadron spectroscopy.

Participation in the COMPASS project at CERN is still the main priority of the team headed by Prof. M. Finger. The work on further development of the CMS/LHC electromagnetic calorimetry continues. Regarding further cooperation between Czech universities and JINR, the team places its hopes on the JINR plans to implement the NICA–Nuclotron–M project embracing both relativistic nuclear physics research and spin experiments with polarized particles.

A Czech participant in the studies of fragmentation and multifragmentation processes, search for manifestations of collective effects with photoemulsion nuclei at various energies in the BECQUEREL project (leader P.I. Zarubin) is Vera Bradnova, the head of the LHEP group. The leader of the ongoing NN & GDN project at JINR is A.Kovalik. Now a new project has been prepared together with Yu.A. Usov; it was reviewed and approved by the JINR PAC.

One of the leaders of the STAR project at RHIC and the theme "Investigation of nuclear matter properties and particle structure at the collider of relativistic nuclei and polarized protons" is Prof. Richard Lednický, who is now a Vice-Director of JINR. Since 1969 the professional and scientific career of R. Lednický has been connected with the Joint Institute for Nuclear Research. His main scientific interests lie within experimental and theoretical physics of elementary particles and involve investigations of multiple production of particles, femtoscopic correlations, spin effects, measurement and QCD analysis of nucleon structure functions.

JINR Vice-Director Prof. Richard Lednický (left), leader of the Czech national group at JINR, Deputy Director of DLNP A.Kovalík (middle) and Prof. I. Štekl (right)

Over the time since the foundation of JINR Czech national group has developed its inner traditions, forms of cooperation and interaction with other groups. In particular, many Czech scientists who come from the Member States do not speak Russian. Russian language groups are set up for them to learn Russian. Leaders of national groups help them in that regard. As a rule, playing an organizing role in the life of the groups are their leaders appointed by the Plenipotentiaries of the JINR Member States. The leader of the Czech national group is

Doctor of Sciences (Physics and Mathematics) Alojz Kovalík. He is also Deputy Director of the Dzhelepov Laboratory of Nuclear Problems since 2004. The Deputy leader of the national group is Věra Bradnová.

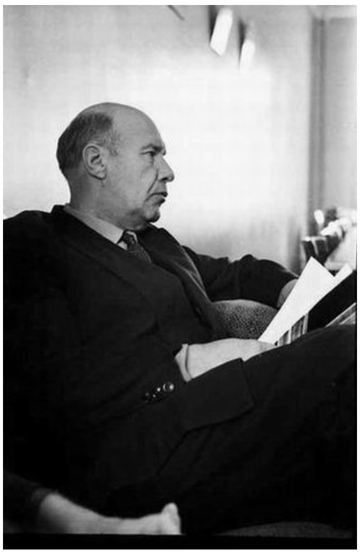
2. Contribution of the Czech Republic to scientific results of JINR

Scientific cooperation between scientists from the Bogoliubov Laboratory of Theoretical Physics and the Czech Republic

Scientists of the **Bogoliubov Laboratory of Theoretical Physics** (BLTP) over the years have accumulated unique experience of research in several fundamental areas of theoretical physics: quantum field theory and elementary particle physics, nuclear theory, theory of condensed matter and methods of mathematical physics.

The studies conducted at BLTP are interdisciplinary; they are directly integrated into international projects with the participation of scientists from major world research centres and are closely coordinated with JINR experimental programs.

Cooperation between BLTP and Czech Research centres is carried out within the **Votruba-Blokhintsev** Program. Within this program the specific research projects and joint scientific conferences are supported by the grants of the Plenipotentiary Representative of the Czech Republic.



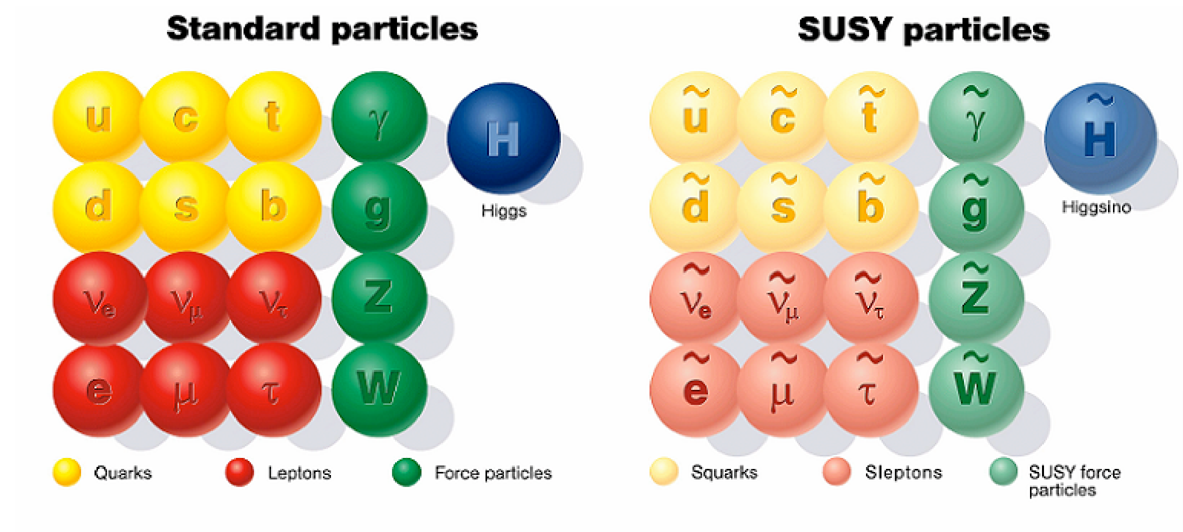
D.I. Blokhintsev (left) and V. Votruba (right)

These grants are parts of the Czech Republic contribution to the JINR budget. Within the program about 8 joint projects and 2-3 International conferences on Modern Mathematical Physics and Spin Physics with key participants and organizers from the Czech Republic were supported annually. The system of grants of Plenipotentiary Representatives of JINR Member

States was established in order to concentrate the efforts and financial resources on the most important topics of research. The Votruba-Blokhintsev Program plays the key role in organization of scientific cooperation between BLTP and Czech physicists.

During recent years **c**ooperation between the Czech scientists and BLTP was carried out within the four JINR topics of the highest priority. They are Theory of Elementary Particles, Nuclear Structure and Dynamics, Theory of Condensed Matter and New Materials, and Modern Mathematical Physics. Theoretical support of current and future experiments at JINR, CERN, GSI, DESY, and other famous experimental physics centers was in the focus of investigations. In more details the main objectives of the scientific program were as follows.

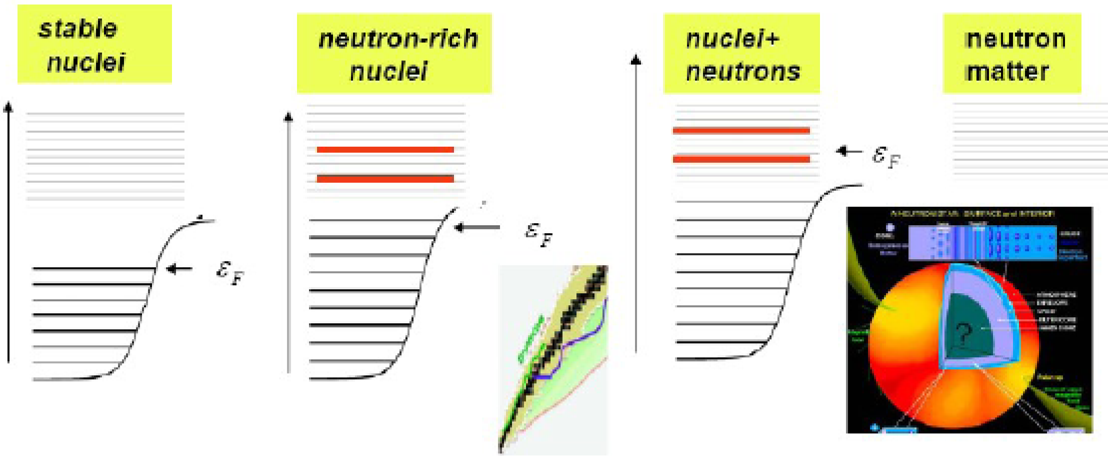
Within *Theory of Elementary Particles* the quantum field theory approaches in the framework of the Standard Model of fundamental interactions and its extensions are under joint development.



Interplay between the Standard Model and the Supersymmetry

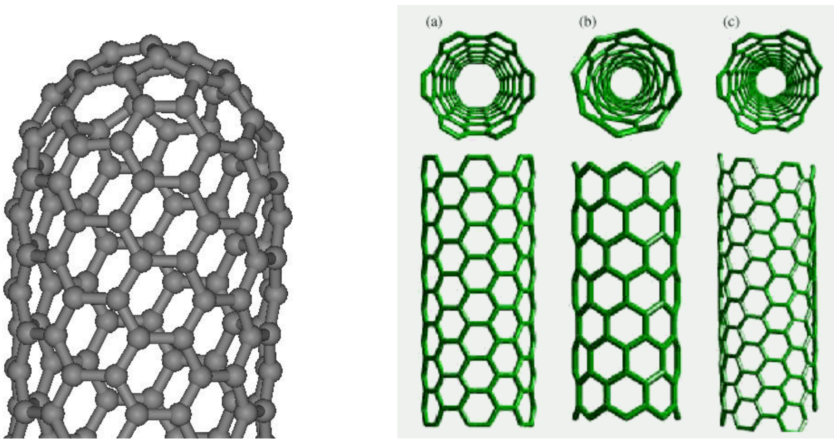
Furthermore theoretical predictions concerning expected experimental observations of the supersymmetry (SUSY), the Higgs boson, investigations of the spin structure of the nucleon, *T*-odd spin effects, jet handedness, heavy flavor physics, vacuum structure in QCD, and hadron properties in dense and hot media are under study. Elaboration of new phenomenological models to describe the hadron dynamics in the framework of general principles of quantum field theory incorporating basic experimental patterns is within main interests of the topic [1-7].

Within the topic *Nuclear Structure and Dynamics* properties of atomic nuclei within the limits of their stability; dynamics of nuclear reactions and mechanisms of production of exotic nuclides; dynamics of nuclear reactions and mechanisms of production of exotic nuclides; fundamental properties of exotic few-body nuclear, and atomic and molecular systems are under joint investigations [8-16].



Nuclear Structures and nuclear dynamics studies in Theoretical Nuclear Physics

Study within the topic *Theory of Condensed Matter and New Materials* includes investigations of theories of finite quantum systems, local and low-dimensional states of matter obtained in modern experiments. In particular, properties of quasiparticles in mesoscopic systems and the Bose-Einstein condensation in atomic traps were studied [17].



Examples of complex carbon nano-objects

Under the topic *Modern Mathematical Physics* Czech and BLTP physicists jointly develop theories of integrable systems, quantum groups and supergroups and some other subjects [18-26].

In the forthcoming years, the milestones in theoretical joint research of Czech scientists and BLTP in the field of particle physics will be determined by the physics programs of major international projects (LHC, RHIC, FAIR, K2K, etc.) as well as by “home” experimental programs, the NICA/MPD project at JINR first of all. The main attention will be paid to precision tests of the Standard Model, new physics beyond the Standard Model, the hadron structure and spin physics, mixed hadronic phase and phase transitions in strongly interacting matter, spectroscopy and heavy quark physics, neutrino physics, the dark matter problem and astroparticle physics.

Prof. Jiří Niederle is a famous Czech specialist in mathematical and particle physics. J.Niederle was very welcomed in Dubna, especially in the Bogoliubov Laboratory of Theoretical Physics, by his colleagues and friends.

The mainstream of nuclear studies at low energies during the nearest decade will be the properties of nuclei far from the valley of stability, i.e. the nuclei where the ratio of proton to neutron numbers is anomalously small or large. The Flerov Laboratory-based project DRIBS as well as several already established or planned experimental projects in Europe, United States and Japan have as their main goal the study of unstable nuclei. To support experimental efforts, theoretical studies will be developed in the same direction.

The major focus of the theoretical research program in forthcoming years is the analysis of the above-mentioned strongly correlated electron systems which involve the investigation of novel cooperative phenomena, new forms of order, low-dimensional magnetism and quantum criticality.

Extensive experimental investigations of these materials performed by neutron scattering methods at the Laboratory of Neutron Physics at JINR also strongly motivate the development of theoretical investigations in the field. The main goal of the planned investigations during the next several years is to perform "realistic" calculations, by applying advanced theoretical methods, of various response functions measured in experiments that might illuminate the complicated interplay between electronic structure, magnetic and transport properties of the considered systems.

An exhaustive study of Superstring Theory in different regimes requires search for classical and quantum superstring solutions, detailed investigation of the landscape of superstring vacua, application of modern mathematical methods to the fundamental problems of supersymmetric gauge theories, development of microscopic description of black hole physics, elaboration of cosmological models of the early Universe. Further development of the theory of classical and quantum integrable systems, quantum groups and supergroups, noncommutative geometry will play a crucial role in these integrated investigations in the forthcoming seven years.

Recent publications of BLTP and Czech scientists

1. A.V. Efremov, P. Schweitzer, O.V. Teryaev, **P. Zavada** (Prague), *"The relation between TMDs and PDFs in the covariant parton model approach."*e-Print:

arXiv:1012.5296; *“Images of Quark Intrinsic Motion in Covariant Parton Model.”*PoS DIS 2010:253, 2010. e-Print: arXiv:1008.3827.

2. H. Avakian, A.V. Efremov, P. Schweitzer, O.V. Teryaev, F. Yuan, **P. Zavada** (Prague, Inst. Phys.). *“Insights on non-perturbative aspects of TMDs from models.”* Mod. Phys. Lett. A24: 2995-3004, 2009.
3. A.V. Efremov, P. Schweitzer, O.V. Teryaev, **P. Zavada** (Prague). *“Transverse momentum dependent distribution functions in a covariant parton model approach with quark orbital motion.”* Phys. Rev. D80: 014021, 2009; *“The Pretzelosity distribution function and intrinsic motion of the constituents in nucleon.”* Published in AIP Conf.Proc.1149:547-551, 2009. e-Print: arXiv:0812.3246.
4. Yu.S. Surovtsev and **P. Bydzovsky**, *"Rho-like-meson family in the pion-pion scattering",* Proceedings of the 11th International Conference on Meson-Nucleon Physics and the Structure of the Nucleon, SLAC: eConf - C070910 (SPIRES Conf Num: C07/09/10), pp. 397-401; *"Analysis of the pion-pion scattering data and rho-like mesons",* Nucl. Phys. A807, 145-158 (2008).
5. Yu.S. Surovtsev, **P. Bydzovsky**, R. Kaminski, M. Nagy, *"Spectroscopic implications from the analysis of processes $\pi\pi \rightarrow \pi\pi$, etc"* Int. J. Mod. Phys. A24, Nos. 2&3, 586-589 (2009); *"The light-meson spectroscopy and combined analysis of processes with pseudoscalar mesons"*, Phys. Rev. D81 (2010) 016001.
6. Yu.S. Surovtsev, **P. Bydzovsky**, T. Gutsche, V.E. Lyubovitskij, *"On scalar mesons from the combined analysis of multi-channel pion-pion scattering and J/ψ decays*", Talk at the 11th International Workshop on Meson Production, Properties and Interaction, 10-15 June 2010, Krakow, Poland, 2010, p.112. To be published in Int. J. Mod. Phys. Axx, xxx (2011).
7. **P. Bydzovsky**, Yu.S. Surovtsev, R. Kaminski, M. Nagy, *Resonances in the isovector P wave of $\pi\pi$ scattering,* Published by DjaF (http://www.djaf.pl), Krakow, Poland, 2010, p.129.To be published in Int. J. Mod. Phys. A (2011).

8. V. Bondarenko, I. Tomandl, H.-F.Wirth, **J. Honzatko**, A. M. Sukhovoj, L. A. Malov, L. I. Simonova, R. Hertenberger, T. von Egidy, J. Berzicnvs, ``*Nuclear structure of ^{187}W studied with (n ,γ) and (d, p) reactions*", Nucl. Phys. A 811, 28-76 (2008).
9. W. Kleinig, V. O. Nesterenko, **J. Kvasil**, P.-G. Reinhard, and **P. Vesely**, ``*Description of the dipole giant resonance in heavy and superheavy nuclei within Skyrme random-phase approximation*", Phys. Rev. C 78, 044313 (2008).
10. V. O. Nesterenko, W. Kleinig, **J. Kvasil**, **P. Vesely**, P.-G. Reinhard, *"TDDFT with Skyrme forces: Effect of time-odd densities on electric giant resonances".* Int. J. Mod. Phys. E 17, 89-99 (2008).
11. **J. Kvasil**, **P. Vesely**, V. O. Nesterenko, W. Kleinig, P.-G. Reinhard, and S. Frauendorf, ``*Skyrme-Random-Phase-Approximation description of E1 strength in $^{92-100}Mo$",* Int. J. Mod. Phys. E 18, 975-985 (2009).
12. V. O. Nesterenko, **J. Kvasil**, **P. Vesely**, W. Kleinig, P-G. Reinhard and V.Yu. Ponomarev, ``*Spin-flip M1 giant resonance as a challenge for Skyrme forces",* J. Phys. G: Nucl. Part. Phys. 37, 064034 (11 pages) (2010); ``*Skyrme Random-Phase-Approximation description of spin-flip and orbital M1 giant resonances"* Int. J. Mod. Phys. E19, 558-567 (2010).
13. J. Erler, W. Kleinig, P. Klupfel, **J. Kvasil**, V. O. Nesterenko, and P.-G. Reinhard, ``*Self-consistent mean-field description of nuclear structure and dynamics – status report*", Phys. Part. Nucl. 41, 851-856 (2010).

14. **P. Vesely**, **J. Kvasil**, V. O. Nesterenko, W. Kleinig, P.-G. Reinhard, and V.Yu. Ponomarev, *``Skyrme random-phase-approximation description of spin-flip M1 giant resonance"*, Phys. Rev. C 80, 031302(R) (2009).
15. R. G. Nazmitdinov and **J. Kvasil**, *``Quantum phase transitions in rotating nuclei",* in the Proceedings of the XIII Intern. Symposium on Capture Gamma-Ray Spectroscopy and Related Topics (Cologne, Germany, August 25-29, 2008), AIP Conf. Proceedings Vol. 1090, pp. 347--351, AIP, New York, 2009.
16. **J. Kvasil**, V. O. Nesterenko, W. Kleinig, **D. Bozhik**, and P.-G. Reinhard, *``Skyrme-Hartree-Fock description of the dipole strength in neutron-rich tin isotopes",* arXiv: 1011.5097, 2010.
17. V.O. Nesterenko, A.N. Novikov, E. Suraud, and **J. Kvasil** *"Tunneling and transport dynamics of trapped Bose-Einstein condensates"*, J. Phys.: Conf. Ser. **248** 012033(1-9) 2010 (International Conference "Dubna-Nano2010", Dubna, Russia, 2010).

18. E.Ivanov and **J.Niederle**. *"Bi-Harmonic Superspace for N=4 Mechanics"* Phys. Rev. D80: 065027, 2009. 18.
19. **Č. Burdík** and **O. Navrátil** (Prague), *The New Formulas for the Eigenvectors of the Gaudin Model in the so(5) Case*, Physics of Atomic Nuclei, in print (2011); *Highest Weight Representation for Sklyanin Algebra sl(3)(u) with Application to the Gaudin Model*, Physics of Atomic Nuclei, in print (2011).
20. R. M. Asherova, **Č. Burdík** (Prague) et al, *q-Analog of Gelfand-Graev basis for the noncompact quantum algebra $U_q(u(n,1))$*, SIGMA 6 (2010), 010.
21. **M. Havlíček**, **S. Pošta**: T*he Diamond Lemma and the PBW Property in Quantum Algebras*, Acta Polytechnica vol. 5, 2010, pp. 40-45.
22. **Č. Burdík** and A. Nersessian (Prague), *Remarks on Multidimensional Conformal Mechanics*, SIGMA 5 (2009), 004.
23. **Č. Burdík**, **O. Navrátil** and **S. Pošta**, *The adjoint representation of quantum algebra $U_q(sl(2))$*, Jour. Non. Math. Phys. 16 63-75 (2009); *The adjoint representation of quantum algebra $U_q(sl(2))$*, Proseedings SQS07 (2008) 244-247.
24. **Č. Burdík**, **O. Navrátil**, *A New Formula for Eigenvectors of the Gaudin Model in sl(3) case, Regular and Chaotic Dynamic (2008)*, Vol. 13, No. 5, p. 403-417.
25. **Č. Burdík**, **M. Havlícek**, **O. Navrátil**, **S. Pošta**, *Ideals of the enveloping algebra U(osp(1,2))*, JGLTA, Vol 2 (2008) No 3, p. 132-136.
26. **Č. Burdík** and **O. Navrátil**, Decomposition of the Enveloping Algebra so(5), Generalized Lie Theory in Mathematics, Physics and Beyond, 297-302 2009.

Recent common meetings of Czech scientists and BLTP

1. The XVII-XIX International Colloquiums on Integrable Systems (ISQS-17,18,19) was organized by **Čestmír Burdík**, **O. Navrátil** and **Severin Pošta** in Prague, in, 2007, 2008, 2009. http://www.km.fjfi.cvut.cz/intsystems/index.php?what=2010.
2. Selected Topics in Mathematical and Particle Physics Prague 2009, which was organized by four institutions: Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Institute of Physics of the AS CR, Faculty of Mathematics and Physics, Charles University in Prague and Nuclear Physics Institute of the AS CR on the occasion of Prof. Jiří Niederle 70th birthday. Prague, Czech Republic, May 5-7, 2009, New York University in Prague (Male náměstí 11, CZ-110 00 Prague 1), organized by **Čestmír Burdík** and **Petr Závada**.

3. Advanced Studies Institute, Symmetries and Spin (SPIN-Praha-2010), Prague, 18-24 July, 2010, Devoted to the 90th anniversary of Yu. M. Kazarinov's birth. Organized by BLTP and **Miroslav Finger** from Charles University, Faculty of Mathematics and Physics, Praha, Czech Republic.
4. The Seventh International Conference Quantum Theory and Symmetries (QTS-7) organized by Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, the Bogoliubov Laboratory of Theoretical Physics of the Joint Institute for Nuclear Research and the Institute of Physics, Academy of Sciences of the Czech Republic will be held in Prague, Czech Republic, in August 7-13, 2011.

ADVANCED STUDIES INSTITUTE – PHYSICS AT LHC

LHC-Praha-2003

Prague, Czech Republic, July 6 – 12, 2003

Organized with the support of

- European Organization for Nuclear Research (CERN), Geneva
- Charles University in Prague
- Czech Technical University in Prague
- University of Florida, Gainesville

TOPICS AND SCOPE:

Conference will include invited review talks, summaries of present experimental results, presentations and discussions of the LHC physics potential.

Hosted by

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ADVANCED STUDIES INSTITUTE – SYMMETRIES AND SPIN

SPIN-Praha-2003

Prague, Czech Republic, July 12 - 19, 2003

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TOPICS AND SCOPE:

Conference will include invited review talks, summaries of present experimental results, presentations and discussions of the large spin physics experiments potential.

Organized with the support of

- **Joint Institute for Nuclear Research (JINR), Dubna**
- **International Committee for Spin Physics Symposia**
- **Charles University in Prague**
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Collaboration of the Dzhelepov Laboratory of Nuclear Problems with the Czech Republic

The collaboration between **DLNP** JINR and institutions of the Czech Republic exists in the framework of neutrino, particle and nuclear physics, education and applied research.

Neutrinos are fundamental particles which are of paramount importance in modern physics of elementary particles, grand unifying theories, cosmology and astrophysics. Their exceptional role is driven by the smallness of their masses and sharply different mixing flavor U-matrix (known in the literature as Pontecorvo-Maki-Nakagawa-Sakata (PMNS) matrix):

$$|\nu_f\rangle = \sum_i U^*_{fi}|\nu_i\rangle$$

$$U_{if} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \times \begin{pmatrix} c_{13} & 0 & s_{13}e^{-i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta} & 0 & c_{13} \end{pmatrix} \times \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

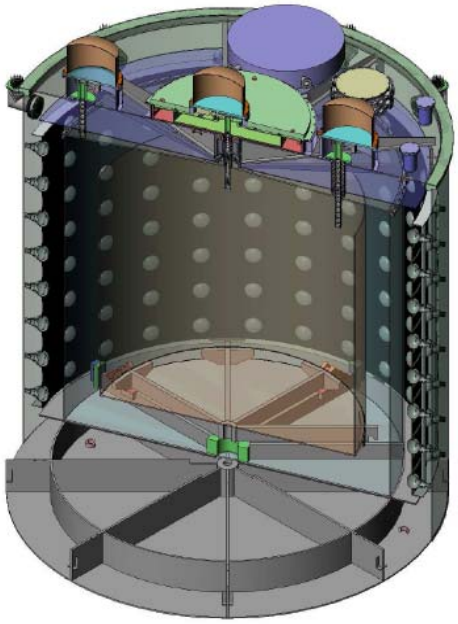
$$c_{ij} \equiv \cos\theta_{ij} \text{ and } s_{ij} \equiv \sin\theta_{ij}$$

Non zero off-diagonal elements of PMNS mixing matrix lead to a phenomenon of “neutrino oscillations” - the phenomenon predicted in Dubna by Bruno Pontecorvo in 1957 and discovered only about 10 years ago by experiments with solar, atmospheric, reactor and accelerator neutrinos. Nowadays, precision measurement of the neutrino mixing matrix parameters is of utmost importance.

The **Daya Bay reactor antineutrino experiment** is aimed at measuring one of the key parameters of the PMNS matrix, the θ_{13} angle, with the ultimate precision better than 1%. The layout of the experiment requires operation of 8 completely equivalent Antineutrino Detectors (AD) situated in the vicinity of Daya Bay and Ling Ao nuclear power plants (China) with the total thermal power about 17.4 GW.

The ADs are grouped in two “near” and one “far” detectors consisting of 2+2 and 4 ADs, respectively. Each AD consists of the target liquid Gd-doped scintillator (20 tons), the gamma-catcher (20 tons), and buffer (40 tons). The total weight of each AD is about 100 tons.

Finally, ADs are placed inside of a water pool covered from above by the resistive plate chambers (RPC) muon veto system.



The layout of the Daya Bay experiment (left) and the Antineutrino Detector (right)

The Daya Bay Collaboration consists of three parties: China, US and Europe. European part of the Collaboration is composed of physicists from the Joint Institute for Nuclear Research (Dubna), "Kurchatov Institute" (Moscow) and Charles University in Prague (Czech Republic). The collaborative work between JINR and Charles University concerns several important aspects which are outlined below.

The JINR and Charles University groups are taking part in the construction of essential parts of the Daya Bay detector, namely, liquid scintillator for ADs and muon veto system. The development of efficient and stable liquid scintillator is the basic goal in the experiments of this type. To achieve this goal the quality of all components should be systematically understood and controlled. In collaboration with the Institute of Scintillating Materials of the Ukrainian National Academy of Sciences (Kharkov, Ukraine), the JINR physicists have developed the new method of high purity 2,5-diphenyloxazole (PPO) synthesis. The full amount of PPO dopant (about 1.5 t) required for Daya Bay detector construction has been produced by this method and delivered to the experiment.

The group from Charles University participates in the construction of muon veto on the basis of RPC detectors. This system is a key instrument for reducing the cosmic background and achieving the ultimate goal of the experiment – the precision better than 1% on θ_{13}.

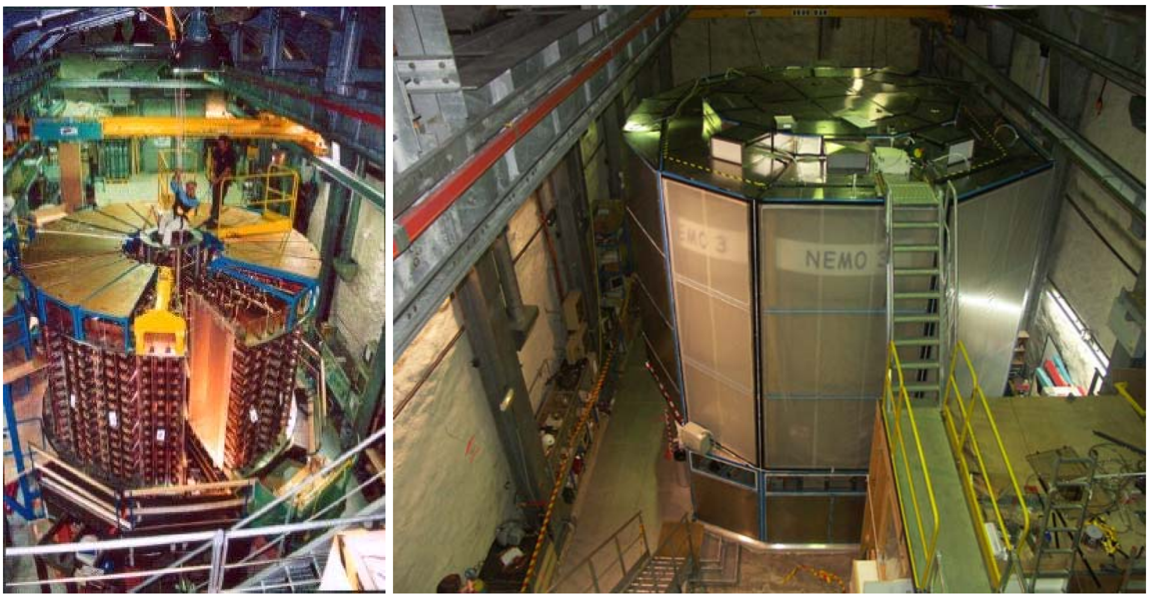
Both groups from JINR and Charles University participate in the software development and preparation for data taking and physics analysis. In particular, the groups collaborate on the development of a new method for fast neutron measurement – an important background which should be well controlled by the Daya Bay experiment. Another common task is the reconstruction of muon tracks, antineutrino energy reconstruction and detector calibration.

Special issue is the extension of the physics program of the Daya Bay experiment. In addition to the primary goal of precision θ_{13} measurement, the Daya Bay data can contribute to the understanding of neutrino mass hierarchies and possible non-standard neutrino interactions. The investigation of the Daya Bay sensitivities for these areas is performed by JINR and Charles University groups in collaboration with Prof. S.Bilenky.

For coordination of the efforts mentioned above, the joint software and data analysis meetings of JINR and Charles University groups are organized. In June 2010 the meeting was organized in Prague by Charles University (chair – Prof. R.Leitner).

The collaboration of JINR and Charles University in the Daya Bay experiment allows consolidating individual efforts and making common contribution and role of the groups more essential and visible.

Within the DLNP group, physicists of IEAP, Czech Technical University in Prague, Charles University (Faculty of Mathematics and Physics) participate in the ambitious neutrino physics project **NEMO-3** [1-15].



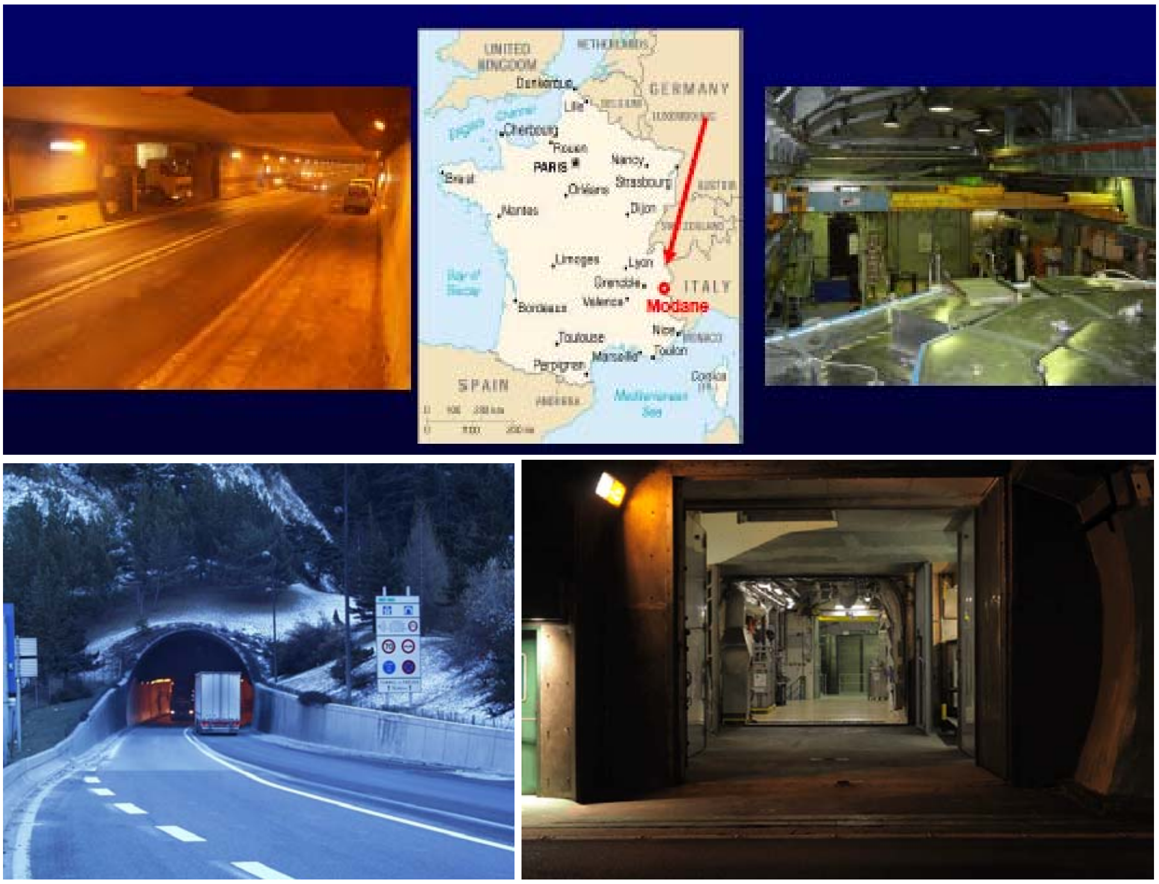
The NEMO apparatus in open (left) and closed running (right) forms

The NEMO-3 detector is located deep underground in the **Modane Underground Laboratory** (LSM, France, 4800 m.w.e.), which is one of the best places in the world from the point of view of the suppression of the cosmic ray background.

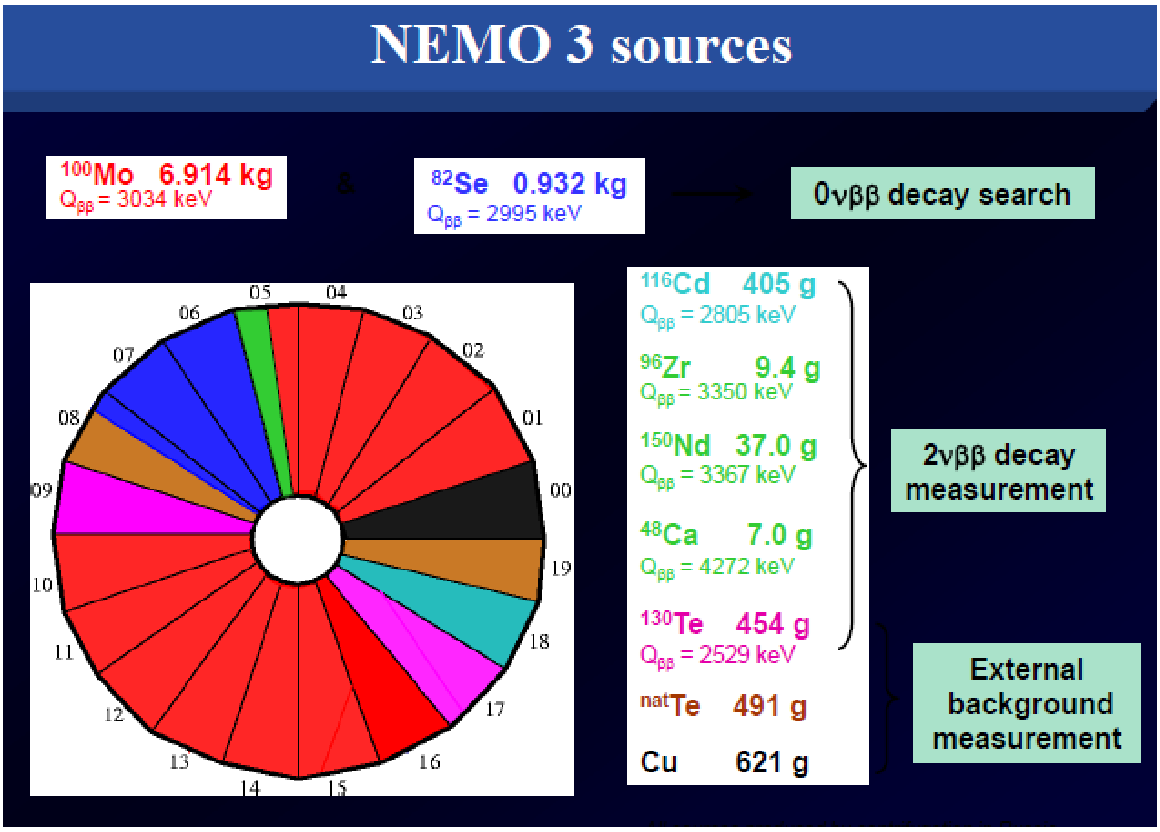
The experiment is searching for neutrinoless double-beta decay ($0\nu\beta\beta$):

$$N(A,Z) \rightarrow N(A,Z+2) + 2e^-,$$

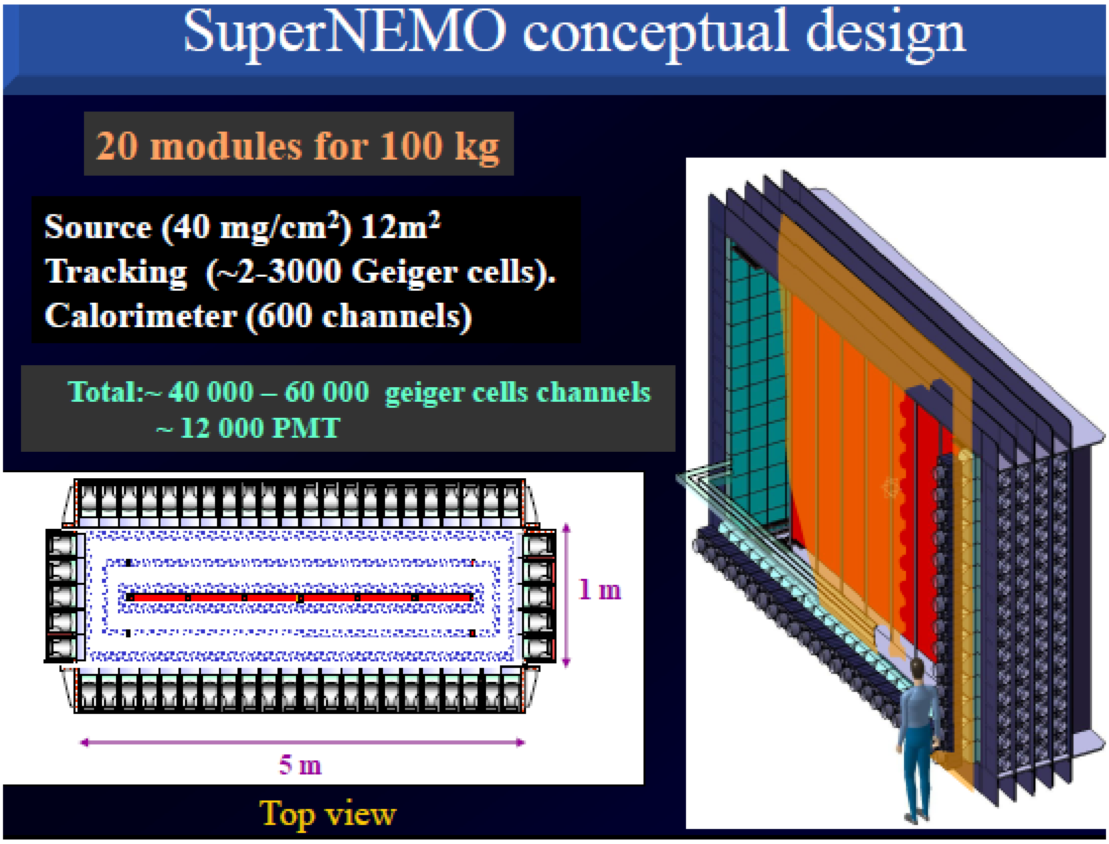
which is a famous indication of new fundamental physics beyond the Standard Model such as the absolute neutrino mass scale, lepton flavor violation and the nature of neutrino (either Dirac or Majorana).



Modane Underground Laboratory (France) is one of the best underground laboratories

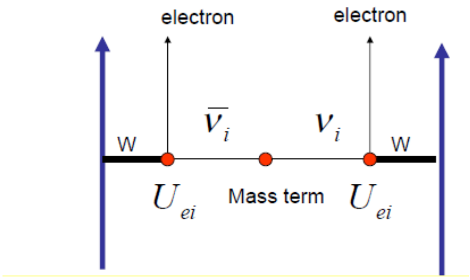


NEMO-3 was a unique setup in the world which allowed simultaneous double beta decay studies of nine isotopes



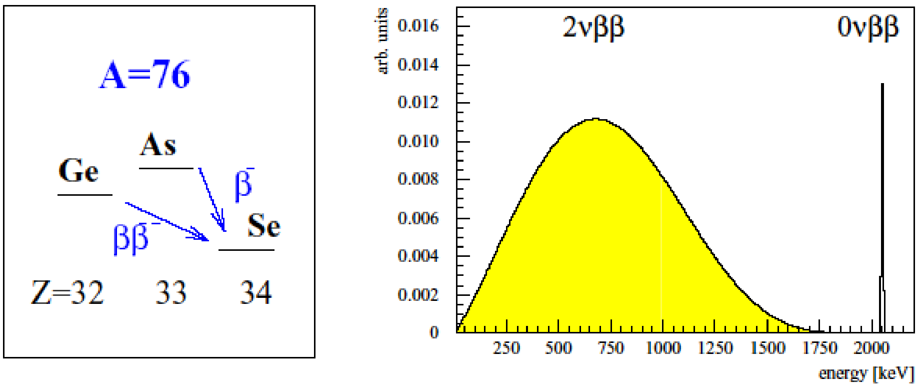
SuperNEMO is a new generation setup for the neutrinoless double beta decay search

Radon purification system for SuperNEMO was built in the Czech Republic



$$\langle m_\nu \rangle = \left| \sum_i |U_{ei}|^2 m_i e^{i\alpha_i} \right|,$$
$$= |C_{12}^2 C_{13}^2 m_1 + C_{13}^2 S_{12}^2 m_2 e^{i\phi_2} + S_{13}^2 m_3 e^{i\phi_3}|$$

The main neutrino-massive mechanism of neutrinoless double beta decay (left) and its key measure (right), being the effective neutrino mass

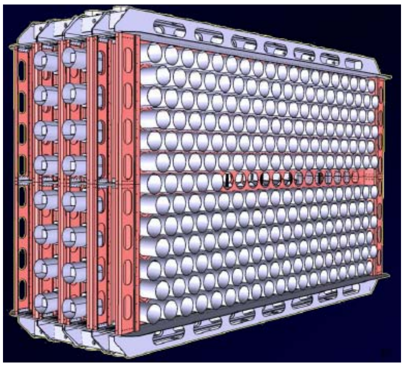


The scheme of the famous Ge-76 double beta decay (left) and the typical energy spectra of two electrons in the both modes of the double beta decay (right)

The goals of the NEMO-3 and SuperNEMO projects are to reach record sensitivities for the effective Majorana neutrino mass $<m_\nu>$ (at a level of 0.2-1.0 eV and 0.04-0.1 eV, or in half-life limits: $T_{1/2}^{0\nu\beta\beta} \sim 4\cdot10^{24}$ yr and $T_{1/2}^{0\nu\beta\beta} \sim 2\cdot10^{26}$ yr, for ^{100}Mo and ^{82}Se respectively).

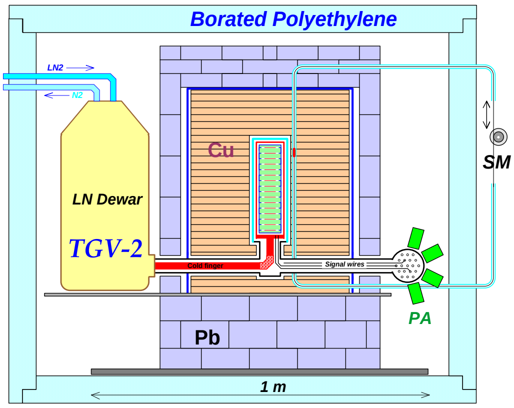
The collaboration plans first to perform the comprehensive analysis of the total statistics accumulated with the NEMO-3 apparatus, next the dismounting of the NEMO-3 detector will be started, and afterwards the construction of the Demonstrator module of the **SuperNEMO** at the same place in the LSM will begin. An extensive R&D program is underway to design the next-generation neutrinoless double beta decay experiment SuperNEMO. It will extrapolate the successful technique of simultaneous calorimetry and tracking used in the NEMO-3 to the new setup with 100 kg of source isotopes. The aim of this setup is to reach a neutrino mass sensitivity at the level of 50 meV. Due to its modular approach, the SuperNEMO project can start operation in stages step by step, with the first demonstrator module installed as early as 2012 in the LSM, and all twenty modules will be ready for running by 2012–2015.

supernemo
collaboration



The new emblem (left) and main setup unit (right) of SuperNEMO collaboration

Experiment **TGV** (Telescope Germanium Vertical) was performed in wide cooperation with scientists of the Czech Republic — I.Štekl, P.Čermák, F.Mamedov, P.Beneš (IEAP CTU Prague), A.Kovalík (DLNR JINR Dubna, NPI CAS Řež) [16-21]. Two of them (I.Štekl, P.Čermák) prepared their PhD theses on the basis of the TGV experimental results. The low background experiment TGV was performed at the Modane Underground Laboratory LSM using 13.6 g of ^{106}Cd (enrichment 75%) and the low background spectrometer TGV-2, composed of 32 HPGe detectors.



The TGV setup

The purpose of the experiment **TGV** was the investigation of one of the double beta decay processes – double electron capture (EC/EC) of ^{106}Cd. In contrast to the $\beta^-\beta^-$-decay, where the two-neutrino mode of the process has been experimentally measured for several isotopes, other double beta decay processes have never been observed in direct experiments, neither for two-neutrino nor for neutrinoless modes. The ^{106}Cd isotope is one of the most favorable candidates for studying EC/EC decay. The 2νEC/EC decay of ^{106}Cd is characterized by emission of only two palladium (Pd) X-rays (~21 keV). The 0νEC/EC resonant decay of ^{106}Cd is expected to 2741.0 keV excited state of ^{106}Pd and accompanied by emission of γ2741 keV or by γ2229 -γ512 keV cascade.

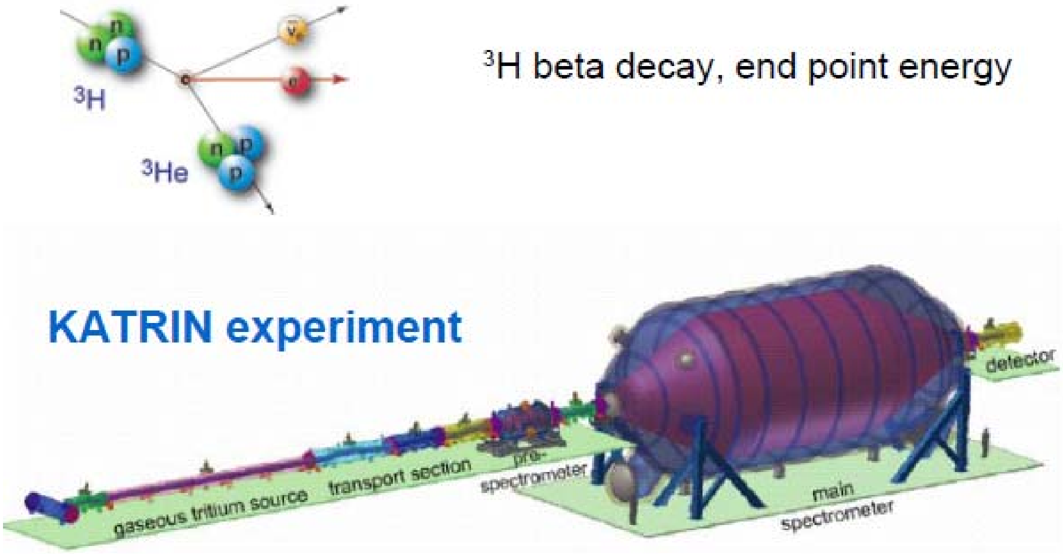
New limits (at 90% C.L.) on double beta decays of ^{106}Cd ($T_{1/2}$(0νEC/EC) > 1.7×10^{20} yr and $T_{1/2}$(2νEC/EC) > 4.2×10^{20} yr) were obtained in the experiment TGV. The latter value is more than 2 orders of magnitude higher than those obtained in experiments of other groups and reaches theoretical predictions ranging from 1.0×10^{20} yr to 5.5×10^{21} yr. The TGV result for 2νEC/EC of ^{106}Cd allows one to expect the detection of this rare process in the future.

Increase of the sensitivity of the TGV experiment 23 g of ^{106}Cd with 98% enrichment is planned for 2012. The neutrinoless 0vEC/EC decay of ^{106}Cd will be studied on a big 600 cm^3 ultra low-background detector which was bought in cooperation with the Czech Republic in 2010 and has been already mounted in the LSM (France).

The next important stage of the collaboration between DLNP and scientists from the Nuclear Physics Institute of the AS CR (Řež near Prague, Czech Republic) is the *"Precise low energy electron spectroscopy with the use of solid state radioactive sources"* project [22-29].

Under this project, joint efforts are concentrated on the investigation of nuclear structure by means of conversion electron spectroscopy, Auger effect via study of Auger electron spectra of K- and L-series and influence of physicochemical surroundings of radioactive atoms on conversion electron and Auger electron spectra.

Recently Czech scientists from DLNP participated in the development of high stability electron energy standard for the **KATRIN** neutrino project based on conversion electrons emitted in the electron capture decay of ^{83}Rb in the solid state sources.

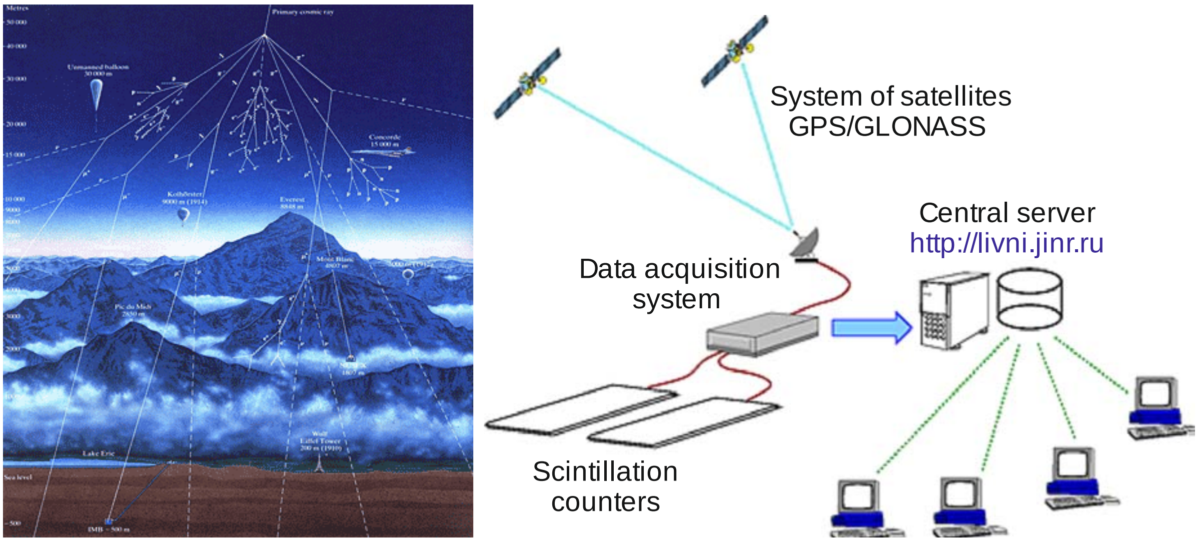


The idea (measurement of the end-point energy) and setup of the KATRIN experiment

The KATRIN experiment is a big international neutrino project to be carried out in Germany, which has very ambitious plans to reach sensitivity to the electron antineutrino mass at a level of 0.2 eV/c^2. The main contribution of Czech scientists to the project is study and monitoring of influence of surroundings of ^{83}Rb atoms on the time stability of the conversion electron energy.

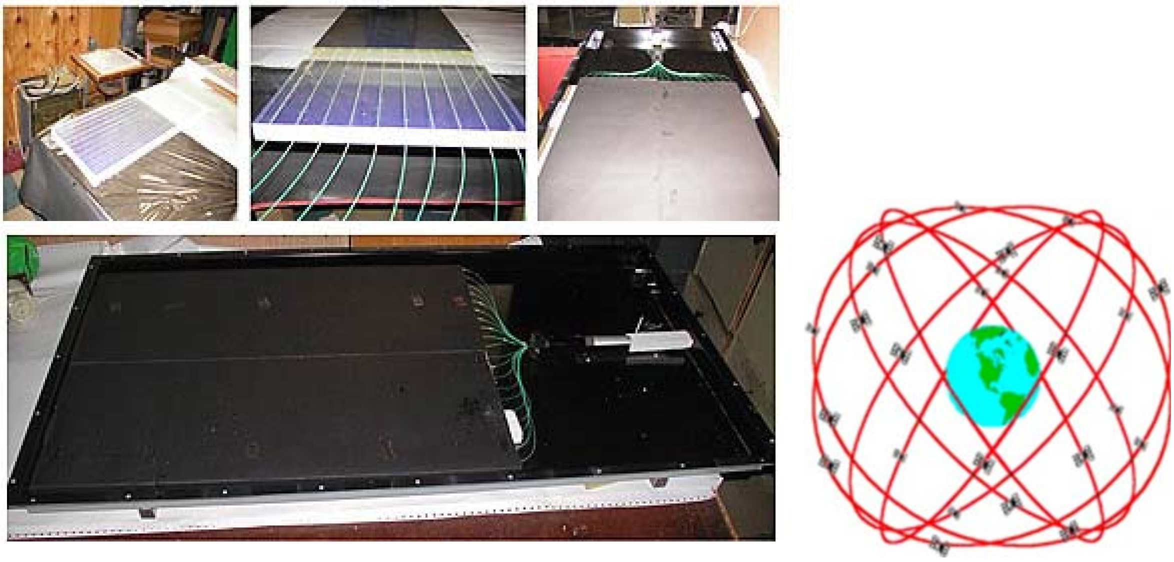
Since 2008 the physicists from DLNP JINR (Department of Collider Beam Physics) have been cooperating with the scientists (K. Smolek, P. Přidal, J. Čermák, F. Blaschke) from the Institute of Experimental and Applied Physics (IEAP) CTU, Prague, [30-34] on *Scientific education project of using experimental data on high energy cosmic rays for student education process.*

The aim of the project is the direct cooperation in detection of high energy cosmic rays between JINR detection network (RUSALKA, see http://livni.jinr.ru) and the common experimental group ALTA/CZELTA (http://www.utef.cvut.cz/czelta/czelta-en) to look for possible non-random component of the cosmic rays. The project has both scientific and educational goals.



Artistic scheme of the Extensive Air Shower (left) and general RUSALKA setup at DLNP (right)

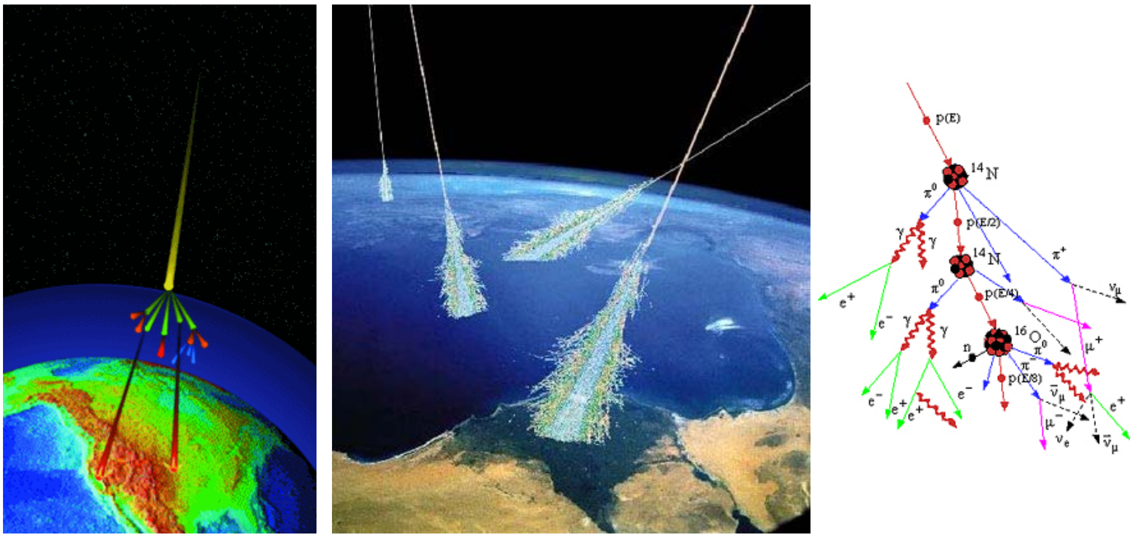
The IEAP CTU has tight cooperation with the University of Alberta that builds the detection network ALTA in Canada. In the Czech Republic, the IEAP CTU builds similar detection network CZELTA (CZEch Large-area Time coincidence Array). At present it consists of six detection stations in the Czech Republic. Ten detection systems were constructed in IEAP CTU and step by step will be located in secondary schools around the Czech Republic. In the collaboration with IEAP CTU, one detection station was installed in Košice in Slovakia. Other detection stations, which use identical hardware, were installed in London and Bucharest. The new international detection network was established. All measured data are downloaded to the central server in Prague and used for subsequent analysis.



Left: Equipment of the project RUSALKA. Right: Global positioning system (GPS)

Independent setup RUSALKA was installed at JINR by G. Shelkov, A. Zhemchugov, M. Demichev, A. Guskov, Z. Krumshtein. The pilot JINR cluster consists of 7 stations at distances 50-200 meters and has been in operation since 2008. The time resolution of the measurement is about 50 ns. This prototype was used successfully during the student practice at JINR in 2007-2009.

Both projects are complementary. The advantage of common cooperation is bigger area of detection, the possibility to study day/night effects between arrays in Canada, the Czech Republic and Russia as well as increasing number of different types of data analysis (e.g. time coincidence of events detected in different areas and with different energies).

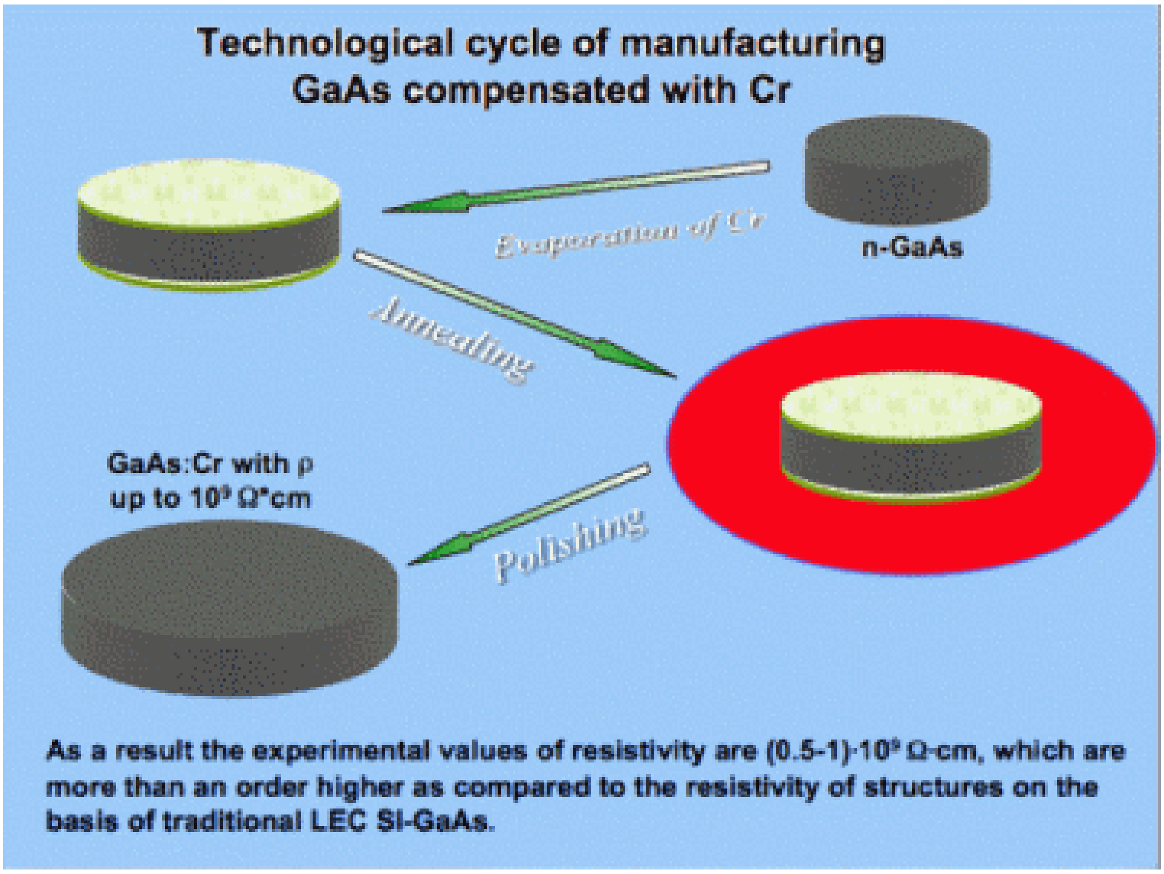


Highly energetic cosmic ray particle produces the Extensive Air Shower (EAS) in the atmosphere of the Earth (left), out-space picture of some EAS (middle) and scheme of EAS development (right)

The proposed project is planned for several years. The planned activities for the next years include continuation of the study of experimental data from JINR detection system and ALTA/CZELTA network; construction and installation of two complete detection stations at JINR; students training at JINR during regular summer student practice; development of the English version of the web-pages and data interface of the network RUSALKA; exchange visits in both institutions, optionally presentation of obtained results at conferences.

The next topic of Czech Republic–DLNP collaboration concerns *development of a large area Pixel Array Detector using GaAs sensors*. Scientific program of this modern project is R&D toward large area pixel array detector with GaAs:Cr sensors for X-ray imaging systems, both scientific and medical. Hybrid Pixel Array detectors (HPAD) are revolutionising the field of photon detection at synchrotron storage ring and free-electron sources.

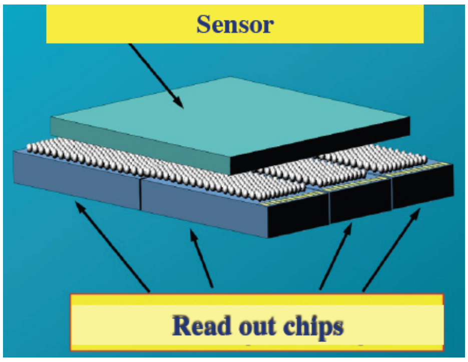
It is generally accepted that they are the detectors of the future, giving a few orders of magnitude improvement (DQE, throughput, noise performance, etc.) over the current detectors, based on CCD cameras. Examples are the Pilatus, the Medipix and the XPAD detectors developed at various places in Europe.

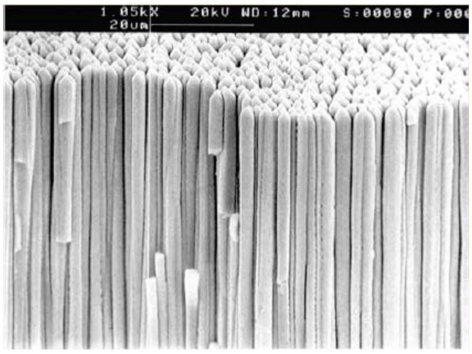


All current systems use silicon as the detecting diode layer. Silicon is by far the most perfect and most available material, but has the great drawback that the stopping power for photons above 20 keV, an area of increasing importance at storage rings, is limited. Other fields of X-ray imaging, notably medical imaging, face the same problem. Therefore, a lot of investments have been made for development of other materials that work at room temperature, like GaAs and Cd(Zn)Te.

The medical imaging industry has mainly invested in Cd(Zn)Te, since for their main applications (humans) high energies, above 100 keV, are needed, which requires very high-Z sensors. However, despite the large efforts invested over the years, the material quality of Cd(Zn)Te, especially for large areas, is still far from perfect. In photon science there is a large and growing emphasis on the energy range up to 60 to 80 keV, for which GaAs is very well suited. *A 300 micron thick, fully depleted GaAs sensor will give an order of magnitude improvement in quantum efficiency at 40 keV.* An increased absorption of the sensor automatically gives a better shielding of the sensitive underlying CMOS readout electronics (ASIC) as well.

The goals of this Czech (S.Pospíšil, I.Štekl, et al.) and JINR (G. Shelkov, A. Zhemchugov, V.Elkin, V.Kruchonok, D.Kharchenko) collaboration are the development of the necessary technology to produce GaAs-based hybrid pixel detectors and the construction of a large area pixellated detector.





Modern Pixel detector for X-ray measurements (left) and the detector crystal matrix of CsJ (right)

The production of a hybrid pixel array detector for high energy (>20 keV) X-rays will have a widespread scientific impact at storage ring sources, similar to the revolution caused by silicon based pixel detectors at the lower energies. Not only will this give an increased efficiency at higher energies, making much better use of the available photons, but many experiments will become possible in the first place. The construction of a big (about ~10x10 cm) imager that will be used at the experimental stations in real experiments will ensure a clear focus for the developments. But it is to be pointed out that also single chip assemblies (14x14 mm) and single Hexa modules (28x42 mm), and single d-Hexa modules (28 x 84 mm) can already be used in many experiments.

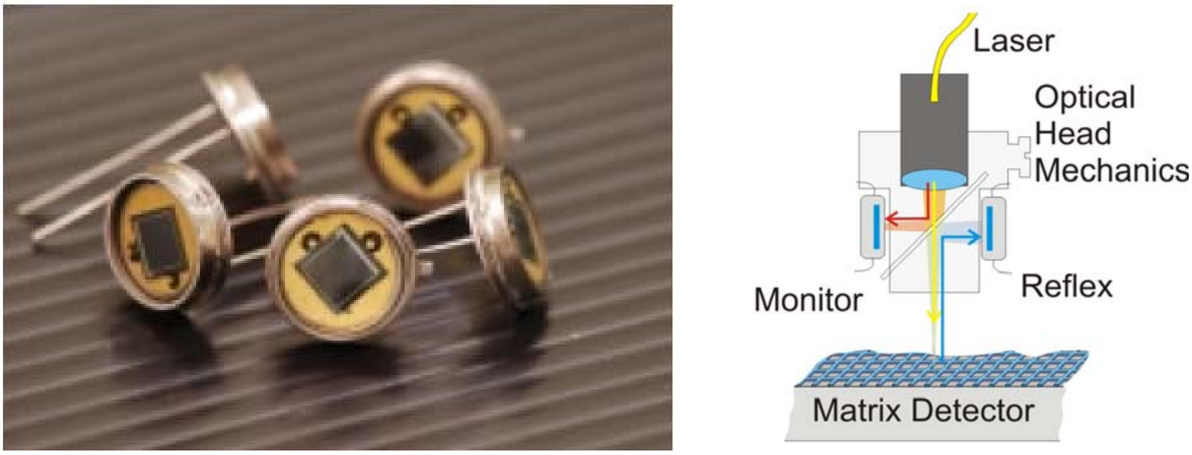
Another very important point to point out is the interest for GaAs-based pixel array detectors for molecular and medical imaging. The focused energy range favored applications with small areas with high spatial resolution and need for high efficient detector systems, e.g., small animal imaging or mammography and dental imaging.

An efficient 28x42 mm detector array and a 28x84 mm double module using six and 12 Medipix chips will be a perfect system for the synchrotron application using GaAs. The performance of these systems is strongly related to the quality and homogeneity of the GaAs wafers. A homogeneity over all detector properties like resistivity, mobility and lifetime of charge carriers should not deviate by more than 20%. Intensive material characterization and quality controlling will guarantee these detector properties.

The development of the technologies needed for large-scale and large-size GaAs(Cr) sensor production is another important goal of the project. Till now only a few, small-size sensors (14x14 mm with 256x256 pixels), were produced, and even assembled with Medipix2 chips and successfully tested. During this project one needs to improve this technology chain and QA&QC procedures. Main challenges are the surfaces quality and uniformity of the material when upscaling from 14x14 mm sensor size to 28x42 mm.

Nowadays there is well developing JINR-Charles University collaboration on novel photodectors. One of the modern revolutionary devices for the photon detection developed in the past decade is the silicon-based multipixel avalanche photo diode (MAPD). The idea of MAPD comes back to the pioneering proposals of Russian physicists Z.Sadygov et al.

The MAPD design proposed by them has been extensively developed by HAMAMATSU, Philips, Zecotek and many other companies. Further developments were also going on in Dubna in the group of Z.Sadygov at LHEP and at DLNP. The JINR physicists have designed completely original new MAPD with high sensitivity and high dynamic range for calorimetry.

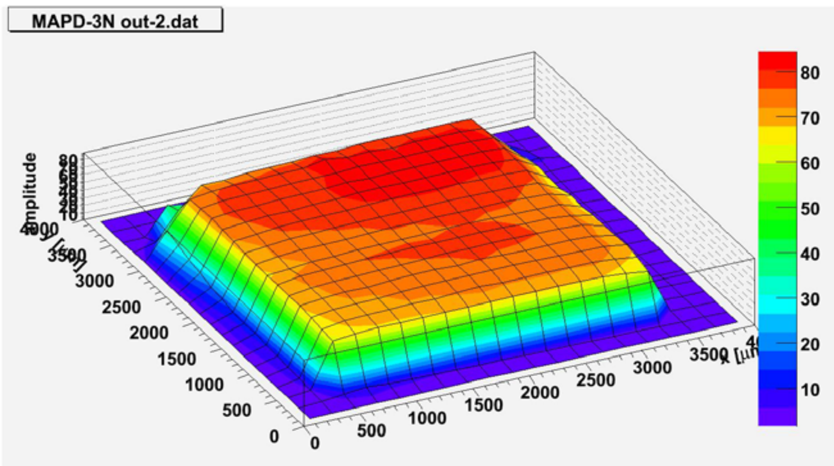


The silicon-based multipixel avalanche photo diodes (left)
and MAPD test facility at Charles University (right)

The basic task during the develpoment of MAPD is the test and measurement of the local characteristics to provide the feedback to the designers and the factory about performance and quality of the modifications introduced in the new design version.

This work was systematically done in the past years in collaboration of JINR and Charles University groups led by Dr. Z.Krumstein and Prof. R.Leitner, respectively. Special setup using focused pulsed laser beam with the beam spot of a few μm was operated at Charles University to study MAPD local characteristics and zone variation. In these measurements the laser beam power was well tunable by adjusting driving pulse amplitude, and the spot position on the MAPD was adjusted by moving laser over detector.

Several types of scans were performed: long linear scans over the whole matrix (1x1 mm) in both directions and fine scans over a single detection cell (30x30 μm) in both directions. During the scans the parameters like the sensitivity, gain, recovery time and others were measured, providing an important feedback to the MAPD designers. One of the results is presented in the figure below. The scan shows uniform response over the whole MAPD 3N type matrix.

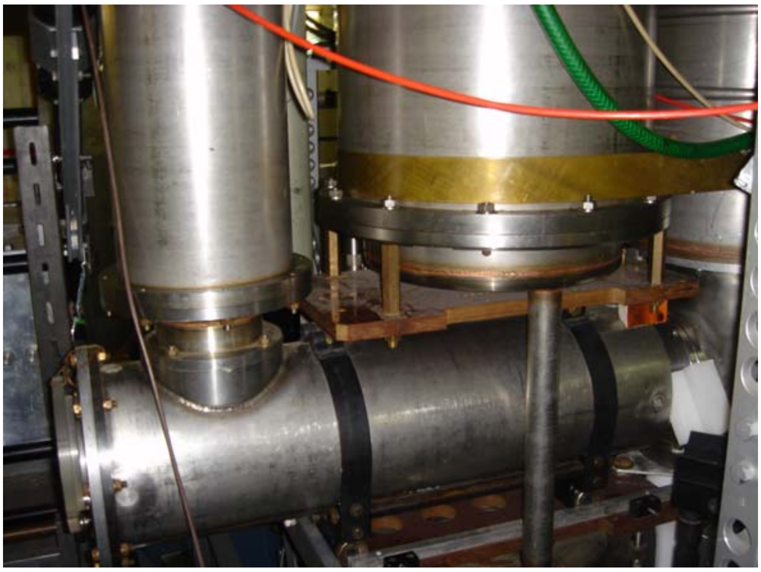


The results of test scan of whole MAPD 3N type matrix

In addition to the test of uniformity, important timing information was obtained. It was shown in the tests that MAPD device can provide time resolution better than 100 ps, which is extremely important when using MAPD in the Time Of Flight (TOF) measurements.
Being originally designed for high energy physics, MAPD is showing large potential for applications in medicine and imaging devices. For example, good time resolution of MAPD can be used in TOF PET tomography, and insensitivity of MAPD operation to the magnetic field is a key feature for constructing combined PET-MRI scanners.

Therefore, the work performed in a fruitful collaboration of JINR and Charles University groups is in a big demand from both fundamental and applied research.

Unique frozen spin polarized deuteron target cooled by the $^3He/^4He$ dilution refrigerator was constructed by joint efforts of JINR and Czech specialists [35]. Deuteron vector polarization of about 40% was obtained for the target in the form of a cylinder of 2 cm diameter and 6 cm length. The target facility includes three helium cryostats: the dilution refrigerator and two superconducting magnets providing longitudinal and transverse deuteron polarization. Deuterated 1,2-propanediol with a paramagnetic Cr (V) impurity having a spin concentration of about 10^{20} cm^{-3} is used as a target material.



Superconducting magnet system (jointly created by JINR and Czech specialists) for the Frozen Polarized Target at Van de Graaff accelerator of Charles University (Prague)

The target with a frozen deuteron polarization has successfully started its operation at the polarized neutron beam generated by the Van de Graaff accelerator of the Charles University accelerator in Prague. The experiments studying the quest of the three-nucleon interactions are in progress.

This is a good example of joint experiment which JINR has conducted outside Dubna on the unique accelerator facility of Charles University in Prague.

Recent publications of DLNP carried out together with Czech scientists

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4. F.Deppisch et al.,Prog.Part.Nucl.Phys. 64 (2010) 278.
5. R.Arnold et al., Eur. Phys. J. C 70 (2010) 927-943.
6. V.I. Tretyak et al., Asrtropat. Phys. 33(2010) 40.
7. R. Arnold et al., Phys. Rev. C 80, 032501 (R) (2009).
8. J. Argyriades et al., Nucl. Instr. Meth. A 606 (2009) 449-465.
9. R.V.Vasilyev (on behalf of the NEMO collab.) Phys. Part. Nucl. Lett. 6(3) (2009) 241.
10. V. Beillet-Kovalenko (on behalf of the NEMO collab.), subm. to PoS, EPS-HEP 2009, 272.
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17. N.I.Rukhadze, A.M.Bakalyarov, Ch.Briancon, V.B.Brudanin, Ts.Vylov, V.G.Egorov, S.V.Zhukov, D.R.Zinatulina, A.A.Klimenko, **A.Kovalík**, V.I.Lebedev, V.V.Timkin, **P.Čermák**, **I.Štekl**, Yu.A.Shitov, "New search for 0νEC/EC and 2νEC/EC decay of ^{106}Cd" Bulletin of the Russian Academy of Sciences: Physics, 2009, Vol. 73, No. 6, pp. 741–744.
18. Ch. Briançon, V.B. Brudanin, **P. Čermák**, V.G. Egorov[b] A.A. Klimenko, **A. Kovalík**, F. Mamedov, N.I. Rukhadze, V.G. Sandukovski, Yu.A. Shitov, F. Šimkovic, **I. Štekl**, V.V. Timkin, Ts. Vylov, D.R. Zinatulina, "Experiment TGV II – results of Phases I and II", Workshop on calculation of double-beta-decay matrix elements (MEDEX '09), Prague, Czech Republic, 15-19 June 2009, American Institute of Physics, New York, 2009, AIP Conference Proceedings, 1180, pp.107-111.
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25. A.Kh. Inoyatov, L.L. Perevoshchikov, **A. Kovalík**, D.V. Filosofov, V.M. Gorozhankin: J. Electron Spectrosc. Relat. Phenom., 171 (2009) 53-56 „The KLL Auger spectrum of ^{65}Cu measured from the EC decay of ^{65}Zn”.
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Collaboration of the Flerov Laboratory of Nuclear Reactions with the Czech Republic



The Flerov Laboratory of Nuclear Reactions has extensive and stable relations with Czech manufacturers of high-tech equipment. For example, in the accelerator area FLNR has been long and fruitfully cooperating with VAKUUM PRAHA. The joint work involves calculation, design, and manufacture of modern vacuum systems both for FLNR and for research centres in JINR Member States.

The vacuum systems of the FLNP accelerator U-400 was produced by VAKUUM PRAHA

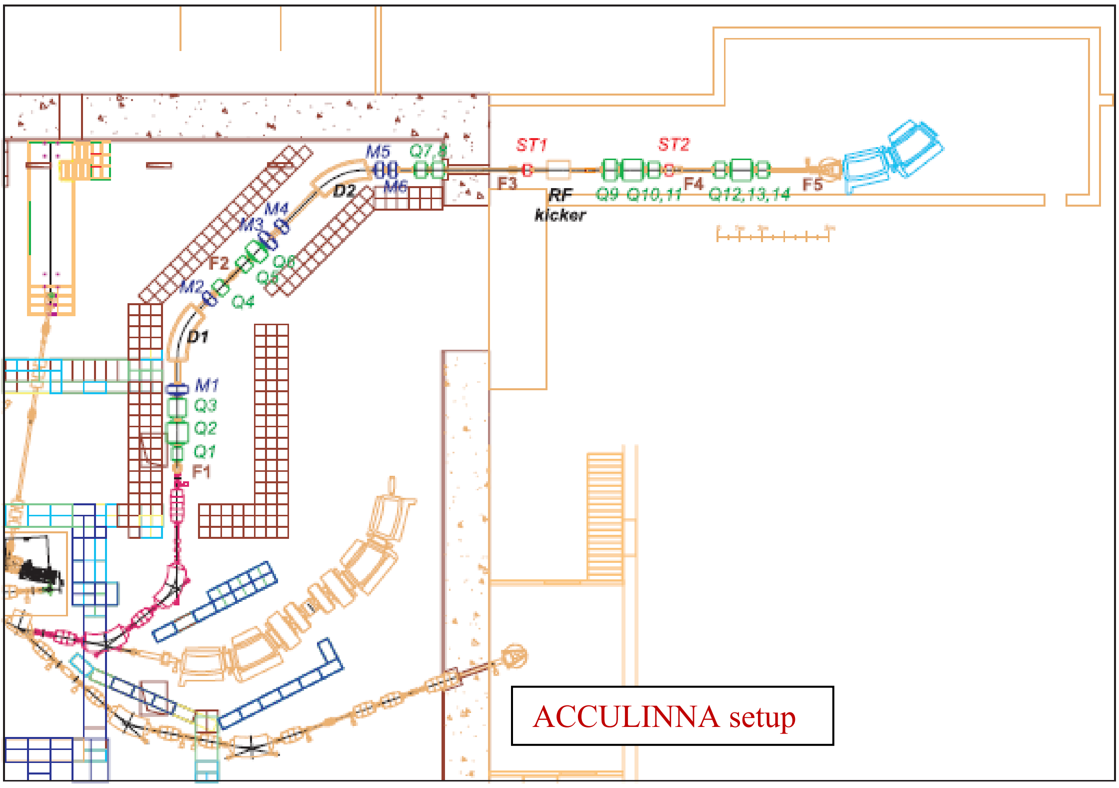
The manufactured equipment is installed at the cyclotrons of FLNR, DC-60 cyclotron complex (Astana, Kazakhstan), VINCA (Belgrade, Serbia), BIONT (Bratislava, Slovakia), etc. Now the work on delivering complete vacuum equipment at the DC-110 cyclotron complex is going on, and designs of the DC-280 cyclotron at FLNR and the new DC-2.5 accelerator for VINCA (Belgrade, Serbia) are being worked out.

At present the personnel of the accelerator departments at FLNR and the Nuclear Physics Institute (Řež) study the possibility of upgrading the U120 cyclotron in Řež and constructing accelerators for production of medical radioisotopes.

Cooperation between the Laboratory of Nuclear Reactions and Czech physicists in the studies of the structure of exotic nuclei near and beyond the nucleon drip line started long ago and successfully continues now.

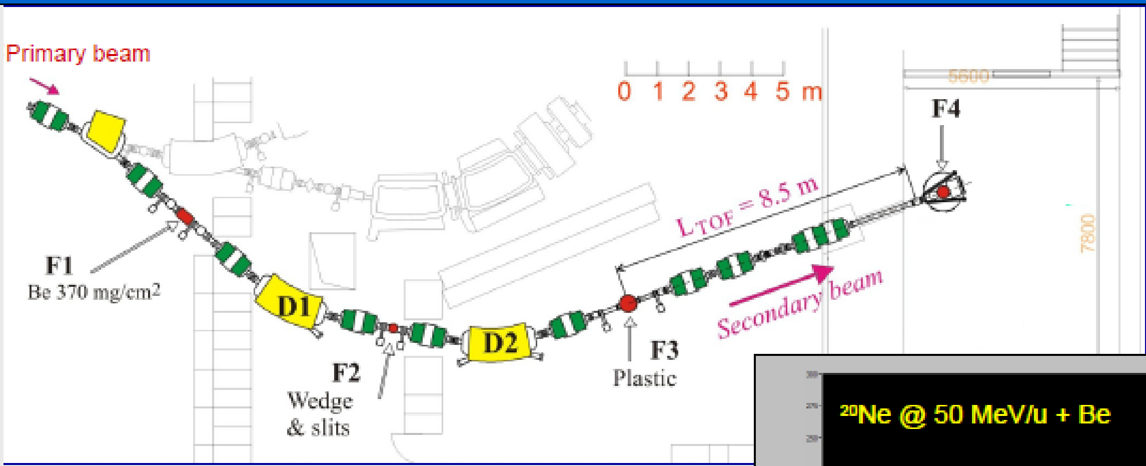
For example, experiments on the study of the effect of the cluster structure of loosely bound nuclei on enhancement of the interaction cross section in the subbarrier energy region are carried out both at LNR and at the U120 cyclotron of the Nuclear Physics Institute in Řež. The results of the experiments are important for understanding the mechanism of nuclear reactions and for obtaining new data on the structure of exotic nuclei.

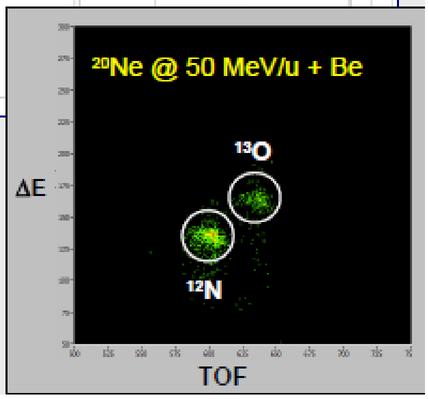
Now joint experiments with radioactive beams are carried out at the ACCULINNA fragment separator of JINR FLNR. One of the young Czech scientists, V. Chudoba, is now working on his PhD thesis devoted to the study of the ^{6}Be low-energy spectrum [1-6].



The FLNR experimental hall of U400M accelerator. The current ACCULINNA separator is located in the lower left corner of the picture and the ACCULINNA-2 separator is planned to be installed in the upper part

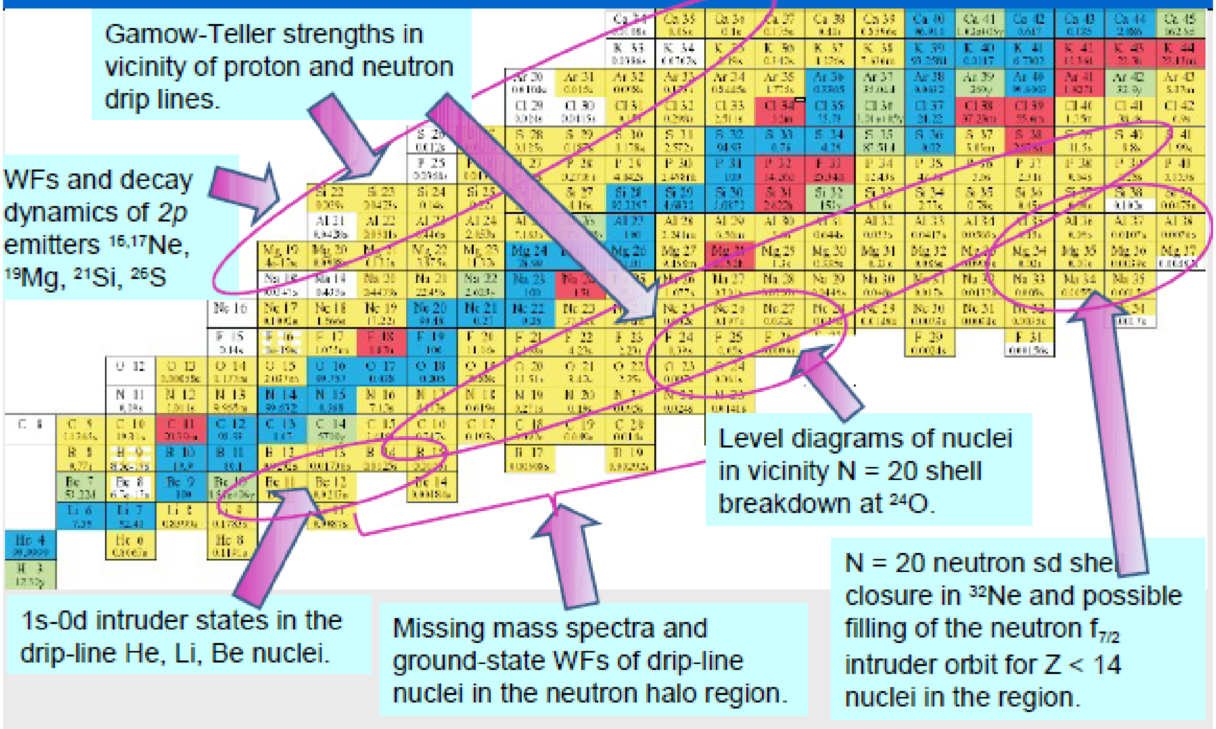
ACCULINNA @ FLNR, Dubna

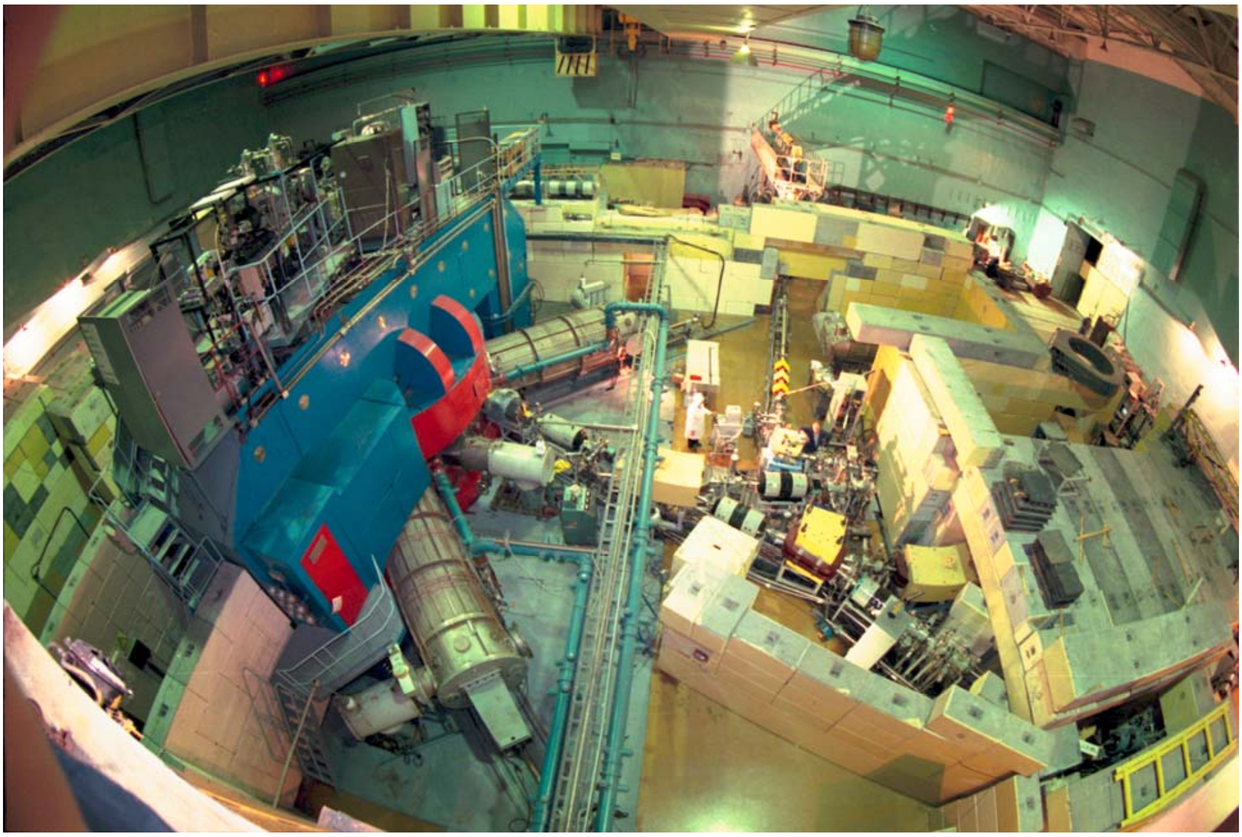




- Low-energy fragment separator, full identification of selected ions by TOF-ΔE method

Research plans at ACCULINNA-2





Cyclotron U400M of FLNR

The electronics equipment and reactor chamber in the focal plate of the ACCULINNA setup

The corresponding member of the Academy of Sciences of the Czech Republic, Honor Doctor of JINR, Chief Research Scientist of FLNR I.Zvára has already worked at FLNR during more than 50 years. His last papers are devoted to chemical identification of transactinides and study of their properties [7-8]. He believes that the superheavy elements strongly challenge both the modern experimental and theoretical chemistry [9].

Within the program for synthesis of superheavy elements LNR and the Institute of Experimental and Applied Physics of the Czech Technical University in Prague are developing a hybrid semiconductor detector of higher radiation hardness Medipix2. This promising device is intended for detecting almost all types of nuclear radiation needed for identification of superheavy elements with an efficiency close to 100%. The detector is planned to be tested at the MASHA (Mass Analyzer of Super Heavy Atoms) mass spectrometer which operates at FLNR.

Experimental setup MASHA of FLNR

Recent common Czech Republic–FLNP publications

1. A.S. Fomichev,…**V. Chudoba**,.. R.Wolski, …M. Pfutzner.. "The ACCULINNA-2 collaboration, FRAGMENT SEPARATOR ACCULINNA-2, letter of Intent, JINR preprint E13-2008-168 (2008).
2. Soft dipole mode in ^{8}He, L.V.Grigorenko, M.S.Golovkov, G.M.Ter-Akopian, A.S.Fomichev, Yu.Ts.Oganessian, V.A.Gorshkov, S.A.Krupko, A.M.Rodin, S.I.Sidorchuk, R.S.Slepnev, S.V.Stepantsov, R.Wolski, D.Y.Pang, **V.Chudoba**,

A.A.Korsheninnikov, E.A.Kuzmin, E.Yu.Nikolskii, B.G.Novatskii, D.N.Stepanov, P.Roussel-Chomaz, W.Mittig, A.Ninane, F.Hanappe, L.Stuttge, A.A.Yukhimchuk, V.V.Perevozchikov, Yu.I.Vinogradov, S.K.Grishechkin, S.V.Zlatoustovskiy, Phys.Part. and Nucl.Lett. 6, 118 (2009).

3. The ^{8}He and ^{10}He spectra studied in the (t, p) reaction, M.S.Golovkov, L.V.Grigorenko, G.M.Ter-Akopian, A.S.Fomichev, Yu.Ts.Oganessian, V.A.Gorshkov, S.A.Krupko, A.M.Rodin, S.I.Sidorchuk, R.S.Slepnev, S.V.Stepantsov, R.Wolski, D.Y.Pang, **V.Chudoba**, A.A.Korsheninnikov, E.A.Kuzmin, E.Yu.Nikolskii, B.G.Novatskii, D.N.Stepanov, P.Roussel-Chomaz, W.Mittig, A.Ninane, F.Hanappe, L.Stuttge, A.A.Yukhimchuk, V.V.Perevozchikov, Yu.I.Vinogradov, S.K.Grishechkin, S.V.Zlatoustovskiy Phys.Lett. B 672, 22 (2009).
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5. **V. Chudoba**, et al., Quest for the He-10 nucleus, Eur. Phys. J.-Special Topics, 162 (2008) 161; R. Wolski, et al., Unbound states studied by direct reactions, J. Phys. Conf. Ser., 111 (2008) 012031.
6. **V. Chudoba** et al., Low-energy spectra of ^{8}He and ^{10}He studied in (t,p) type reactions in inverse kinematics, Acta Phys. Pol. B, 40 (2009) 899.
7. A.B. Yakushev, **I. Zvara**, Yu.Ts. Oganessian, A.V. Belozerov, S.N. Dmitriev, B. Eichler, S. Hubener, E.A. Sokol, A. Turler, A.V.Yeremin, G.V. Buklanov, M.L. Chelnokov, V.I. Chepigin, V.A. Gorshkov, A.V. Gulyaev, V.Ya. Lebedev, O.N. Malyshev, A.G. Popeko, S. Soverna, Z. Szeglowski, S.N. Timokhin, S.P. Tretyakova, V.M. Vasko, and M.G. Itkis. Chemical identification and properties of element 112. Nuclear Physics A, Vol.734, p.204-207, 2004.
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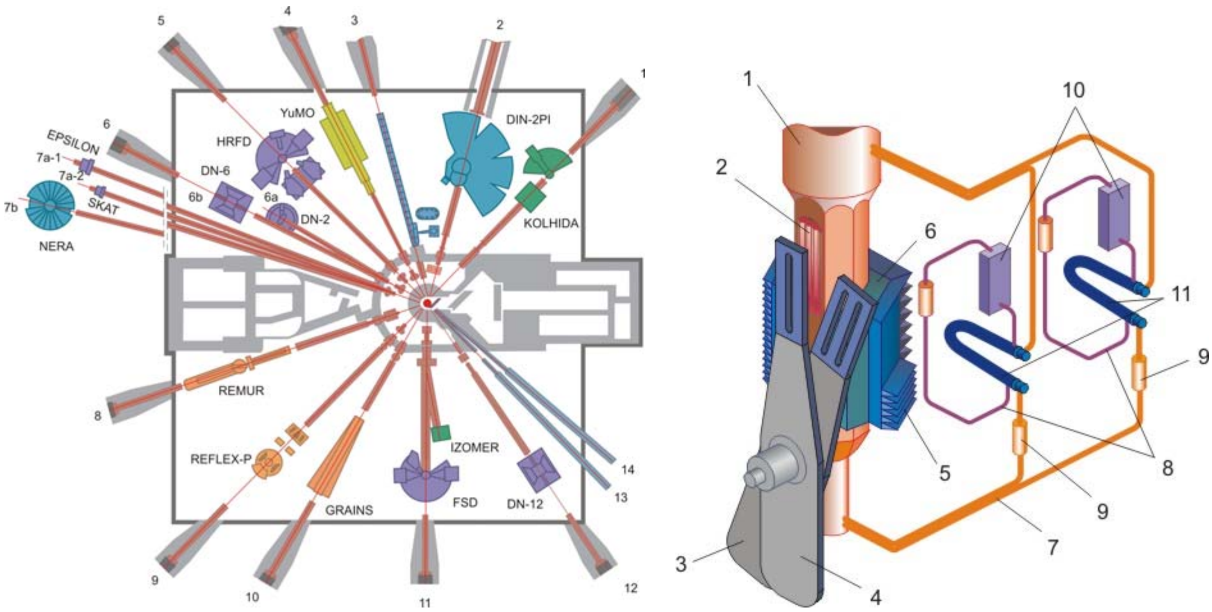
9. **I. Zvara**, Superheavy Elements Challenge Experimental and Theoretical Chemistry. Acta Physica Polonica B, Vol.34, p.1743-1759, 2003.

Collaboration of the Frank Laboratory of Neutron Physics with the Czech Republic

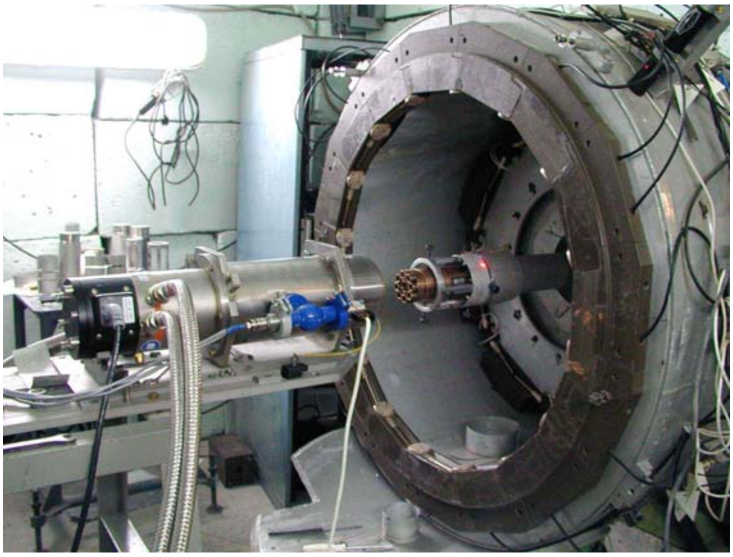
The **IBR-2M** reactor is the most powerful research neutron source in Eastern Europe, which is operated as the user facility and is available for conducting a wide range of scientific experiments by researchers from the Czech Republic and other JINR Member States.



Beams of IBR-2M (left) and its drawing (right)

A number of neutron spectrometers of the IBR-2M reactor have technical characteristics surpassing or comparable with those of the best analogues at other European neutron centres. For instance, the **DN-12** diffractometer was designed for studies of micro-samples within the wide range of simultaneously varied thermodynamic parameters, pressure range of 0–10 GPa and temperature range of 10–300 K.

Hall of reactor IBR-2M at FLNP


DN-12 diffractometer of FLNP

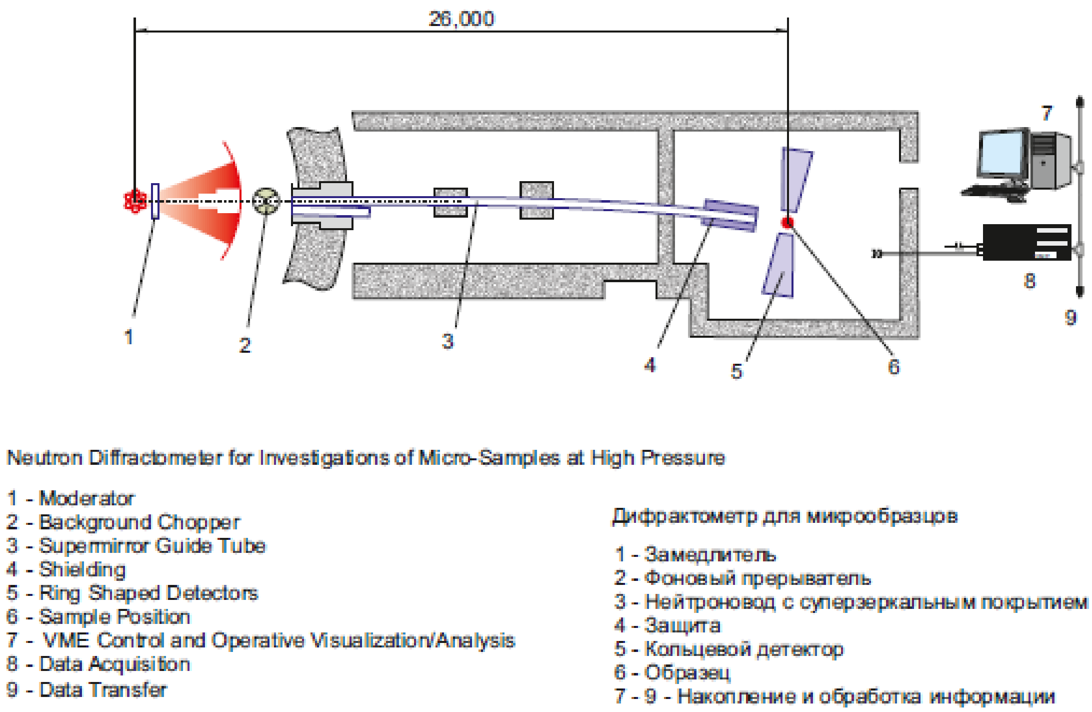
These features make the use of the IBR-2M spectrometers complex very attractive for joint scientific research. In particular, the current topics of these joint Czech Republic–JINR scientific research activities include:

- Studies of atomic and magnetic structures of strongly correlated, complex transition metal oxides as well as studies of structural and magnetic phase transition in these oxides induced by variation of thermodynamic parameters (temperature, pressure) by means of neutron scattering methods and complementary measurements of magnetic and transport properties.
- Geophysical research based on joint application of neutron texture analysis and acoustic spectroscopy. Residual stress determination in bulk materials and goods by neutron diffraction technique.

The results of these joint research activities are regularly published in refereed scientific journals and presented at international conferences [1-6]. Within the framework of the Seven-Year Plan of strategic development of JINR in the field of condensed matter physics for the period 2010-2016 the joint Czech Republic–FLNP research in the above-mentioned directions, as well as development of the instruments of the IBR-2M spectrometer facility, will be continued with highest priority.

Nowadays collaboration between FLNP and the Institute of Nuclear Physics of Řež (INP) proceeds also in the following directions of cooperation: development of mechanical testing equipment facilities for experiments in materials science; design and development of 1D and 2D very accurate position-sensitive detectors; simulations and optimization of the spectrometers, development of the VITESS software package; and enhancement of the software package to automatic adjusting/positioning processes of the spectrometers.

In 2008 at FLNP JINR in collaboration with specialists of INP (Řež) a single-axis mechanical testing machine, designed for imposing mechanical impact of both tensile and contractile character on a sample, up to the maximum value of 20 kN, was tested. Currently, the work on integration of the software package into the acquisition system of the IBR-2M FSD diffractometer is being carried out in collaboration with Czech specialists.



The scheme of future DN-6 spectrometer

In 2010 staff members of the IBR-2 Department of Spectrometers Complex (DSC), FLNP, and those of INP (Řež) started a collaborative research on design and manufacturing of a ring sectioned detector for slow neutrons at the IBR-2M **DN-6** spectrometer. Until now the test module has been tested, the main body frame has been manufactured, the concept and principal electronic schemes of the data acquisition and storage system have been worked out.

Collaborative works with Řež scientists on design and development of one- and two-axis position-sensitive detectors for slow neutrons (1D and 2D PSD) for the IBR-2M spectrometers complex are still in progress. In 2010 the 1D and 2D PSDs were successfully tested at the LVR-15 INP reactor.

Beside the above-mentioned spectrometers the IBR-2M reactor dispose of radio-analytical facility equipped with the pneumatic transportation system (PTS) **REGATA** and three "hot cells" for conducting neutron activation analysis (NAA) and radiation research. Nondestructive multi-element instrumental neutron activation analysis was recognized as a primary analytical technique in 2007, as it allows one to get high-precision and high-sensitivity results.

The NAA is widely used in the life sciences, in particular for ecological, geological, biological and medical investigations as well as in the materials science for development of new ultrapure and nano materials, etc. A distinctive feature of irradiation channels of PTS REGATA is low temperature at the irradiation position (not higher than 60–70°C as compared to that of 300-400°C at conventional reactors), which allows one to analyze biological matrices without causing them any destruction. There are two irradiation channels; the first has a cadmium shield for irradiation with epithermal and fast neutrons, and the second allows irradiation with the full neutron spectrum. This possibility makes it possible to optimize the irradiation conditions for samples of different elemental composition.

Unique functional scope of neutron activation analysis of the IBR-2 (IBR-2M) reactor, qualified staff members of the **NAA Department**, long experience in the environmental studies at the highest level within the framework of the projects supported by the IAEA and the European Union Frame Programs make collaboration with the FLNP NAA Department very attractive and fruitful for the Czech specialists.


Running REGATA (left) and chemical laboratory for conducting neutron activation analysis (right)

Furthermore, the unique possibility to use the three reactors: IBR-2M, VR-1 “Vrabec” (training reactor at the Czech Technical University in Prague) and LVR-15 (light water research reactor at Řež) – opens up the possibility for methodical investigations and the NAA techniques improvement.

Since its inception in the early 1970s the NAA Department of FLNP has been permanently in the focus of attention of Czech scientists for the diversity of scientific interests. Such prominent Czech scientists as F. Spurný, Prof. J. Kučera, I. Obrusník (all from the Nuclear Physics Institute, of the Academy of Sciences of the Czech Republic, Řež near Prague), and V. Clement (Institute of Semiconductors, Rožnov) very fruitfully collaborated with the NAA Department.

Collaboration with the Czech Technical University (Prof. K. Matejko, A. Kolros, and others) was established on a regular basis in the mid-1990s. It was supported by the annual grants of the Plenipotentiaries of the Czech Republic to JINR.

A technique of measuring neutron spectra with multi-element activation detectors (MAD) has been mastered within the framework of this cooperation, and measurements in both irradiation channels of PTS REGATA and in some beams of the IBR-2 reactor halls were conducted (K. Katovský, M. Těšínská). It is planned to continue these studies, viewed as methodologically important, at the modernized IBR-2M reactor (L. Sklenka, K. Katovský, A. Kolros and others).

Prof. C.Šimánĕ (right) and his co-worker check very accurate goniometry device which was used for adjustment of target mono-crystals in the neutron beam of IBR-2 (1981)

In the period of 2002–2004 the development of a gamma-gamma coincidence spectrometer was carried out in collaboration with the Institute of Experimental and Applied Physics of the Czech Technical University (IEAP CTU) in Prague (Prof. S. Pospíšil and others) through the Program of the targeted use of the Czech contribution to JINR.

In 2002-2007 the NAA Department of FLNP (M.V. Frontasyeva) and the Nuclear Physics Institute, Řež (J. Kučera) successfully participated in the IAEA Co-ordinatition Research Program "*Use of nuclear and related analytical techniques in studying human exposure to toxic elements consumed through foodstuffs contaminated by industrial activities*". In addition to financial support from the IAEA, these studies were supported by the grant of the Plenipotentiary of the Czech Republic in 2004.

Current plans include investigations concerning the environmental situation in industrial areas in the Czech Republic, particularly around Opava and Ostrava (Andrea Kotrlová) under the Protocol on scientific and technical cooperation with the Faculty of Philosophy and Science of the Silesian University, Opava, with the involvement of its undergraduate and graduate students.

Since 2005, during Schools targeted to participants from the JINR Member States, students from the Czech Republic are being regularly trained at the NAA Department of FLNP. In 2005, Milan Těšínský from the Czech Technical University, Prague, prepared his Master thesis "Measurement of neutron spectra at the reactor IBR-2 of FLNP JINR" based on the experimental results obtained in Dubna.

The FLNP **Department of Nuclear Physics** maintains long-term collaboration with the Czech universities and research centres. Particularly, it is the collaboration with the INP, Řež, which mainly consists in joint experiments on measurements of the intensity of double-quantum cascades occurring when slow neutrons are captured by a target consisting of separated isotopes, carried out at the INP reactor. Collaboration included J. Honzátko, I. Tomandl, A. Sukhovoj and V. Khitrov.

In the past few years the Department of Nuclear Physics has had a close collaboration with the Czech Technical University in Prague (IEAP — Institute of Experimental and Applied Physics, S. Pospíšil). With active participation of the IEAP scientists (S. Pospíšil, C. Granja, J.Jakůbek, Z. Vykydal, V. Kraus), FLNP is conducting collaborative investigations of the Medipix/Timepix pixel detector characteristics and the possibilities of its application to the experiments on spectroscopy of fission fragments and charged particles.

Prof. S. Pospíšil (left) and multi-detector setup “Romashka” (right), which can be used for experiments at the FLNP facilities

Two experiments have been performed with the help of visiting Czech scientists at JINR during the past few years; a new series of measurements is planned in the nearest future. FLNP provides the possibility to carry out such investigations at its own neutron sources – the IBR-2M reactor, which is one of the most powerful experimental pulsed sources in the world; the **IREN** apparatus, possessing a lower intensity but a tangibly higher energetic resolution at the expense of an extremely small pulse width (of order 100 nsec); and the **EG-5** electrostatic generator.

The IREN setup can be used for experiments in the field of resolved resonances requiring high energy resolution. EG-5 is a supplement facility to the IREN apparatus, providing neutrons in regard to energy up to several MeV.

The **IREN** apparatus (left, middle) and the **EG-5** electrostatic generator (right)

Moreover, it can be used as a source of accelerated light ions with energies up to several MeV. Also, FLNP is currently working on the project of multi-detector setup **“Romashka”**, which can be used, in particular, for experiments and studies of the nuclear structure carried out at the FLNP facilities. Investigations similar to these are being carried out at the INP reactor, Řež, Czech Republic.

Collaborative research with the Czech Republic has been regularly supported by the grants of the Plenipotentiary of the Czech Republic to JINR and by the Program of the collaboration between JINR and the Czech Republic (the heads of the program – Y. Kopatch and C. Granja). Also, Czech students enjoy frequent participation in summer JINR practices conducted at the FLNP facilities.

Upon results of joint scientific research of Czech scientists and the scientific personnel of the FLNP Department of Nuclear Physics, during the past several years a series of scientific papers was published and a series of related reports was made followed by presentations at international scientific workshops [7-14].

According to the Seven-Year Plan of strategic development of JINR in 2010-2016, in the direction of “Neutron Nuclear Physics” it is planned to carry out collaborative research with Czech scientists within the framework of the above-mentioned fields of common interests.

Recent publications of the FLNP carried out together with Czech scientists

1. D.P.Kozlenko, N.T.Dang, **Z.Jirak**, S.E.Kichanov, E.V.Lukin, B.N.Savenko, L.S.Dubrovinsky, C.Lathe and C.Martin “Structural and Magnetic Phase Transitions in $Pr_{0.15}Sr_{0.85}MnO_3$ at High Pressures”, Eur. Phys. J. B, v. 77, pp. 407-411 (2010).

2. **Lokajicek T.**, **Lukas P.**, Nikitin A.N., Papushkin I.V., Sumin V.V., Vasin R.N. The determination of the elastic properties of an anisotropic polycrystalline graphite using neutron diffraction and ultrasonic measurements. Carbon, 2010, (in press).

3. Nikitin A.N., Vasin R.N, Kruglov A.A., Ivankina T.I., Ignatovich V.K., **Lokajicek T.**, Fan L.T.N. Propagation of quasi-longitudinal waves at the interface of isotropic and anisotropic media: theoretical and experimental study. Physics of the Earth, 2010 (accepted for publication).

4. D.P.Kozlenko, **Z.Jirak**, N.O.Golosova and B.N.Savenko "Magnetic ground state and the spin state transitions in $YBaCo_2O_{5.5}$", Eur. Phys. J. B, v. 70. pp. 327-334 (2009).

5. D.P.Kozlenko, L.S.Dubrovinsky, **Z.Jirak**, B.N.Savenko, C.Martin, **S.Vratislav**, "Pressure-induced anti-ferromagnetism and compression anisotropy in $Pr_{0.52}Sr_{0.48}MnO_3$", Phys. Rev. B, v. 76, pp. 094408-1-6 (2007).

6. D.P.Kozlenko, N.O.Golosova, **Z.Jirak**, L.S.Dubrovinsky, B.N.Savenko, M.G.Tucker, Y. Le Godec and V.P.Glazkov, "Temperature and Pressure Driven Spin State Transitions in $LaCoO_3$", Phys. Rev. B v. 75, pp. 064422-1-10 (2007).

7. **C.Granja**, **S.Pospisil**, R.E.Chrien, S.A.Telezhnikov ``Levels of 174Yb populated in average resonance neutron capture", Nucl.Phys. A757, 287 (2005).

8. S.A.Telezhnikov, **C.Granja**, H.T.Hiep, **J.Honzatko**, **M.Kralik**, M.-E.Montero-Cabrera, **S.Pospisil** ``Primary gamma transitions in 173, 174Yb in neutron capture at isolated resonances.", Nucl.Phys. A763, 31 (2005).

9. Bondarenko V., **Honzatko J.**, **Tomandl I.**, von Egidy T., Wirth H.-F., Sukhovoj A.M., Malov L.A., Simonova L.I., **Alexa P.**, Berzins J., Hertenberger R., Eisermann Y., Graw G., Low-spin mixed particle-hole structures in 185W Nucl. Phys. A762 (2005) p. 167-215.

10. **J. Honzatko**, V. A. Khitrov, C. Panteleev, A. M. Suchovoj, **I. Tomandl** Intense two-step cascades and gamma-decay scheme of the 118Sn nucleus, Fizika B (Zagreb) 15 (2006) 189 - 206.

11. S.A.Telezhnikov, **C.Granja**, **J.Honzatko**, **S.Pospisil**, **I.Tomandl** ``A precise determination of the 64Cu binding energy " neutron capture.", in Neutron Spectroscopy, Nuclear Structure, Related Topics, Proceedings of the XIV International Seminar on Interaction of Neutrons with Nuclei, Dubna, May 24-27, 2006 E3-2007-23 Dubna (2007) p.296-303.

12. **C.Granja**, **Z.Vykydal**, Y.Kopatch, **J.Jakubek**, **S.Pospisil**, S.A.Telezhnikov ``Position-sensitive spectroscopy of 252Cf fission fragments.", Nuclear Instruments and Methods in Physics Research. A574, 472-478 (2007).

13. V. Bondarenko, **I. Tomandl**, H.-F.~Wirth, **J. Honzatko**, A.M. Sukhovoj, L.A. Malov, L.I. Simonova, R. Hertenberger, T. von Egidy, Berzics, Nuclear structure of 187W studied with (n,gamma) and (d,p) reactions, Nucl. Phys. A, 811 (2008) 28-76.

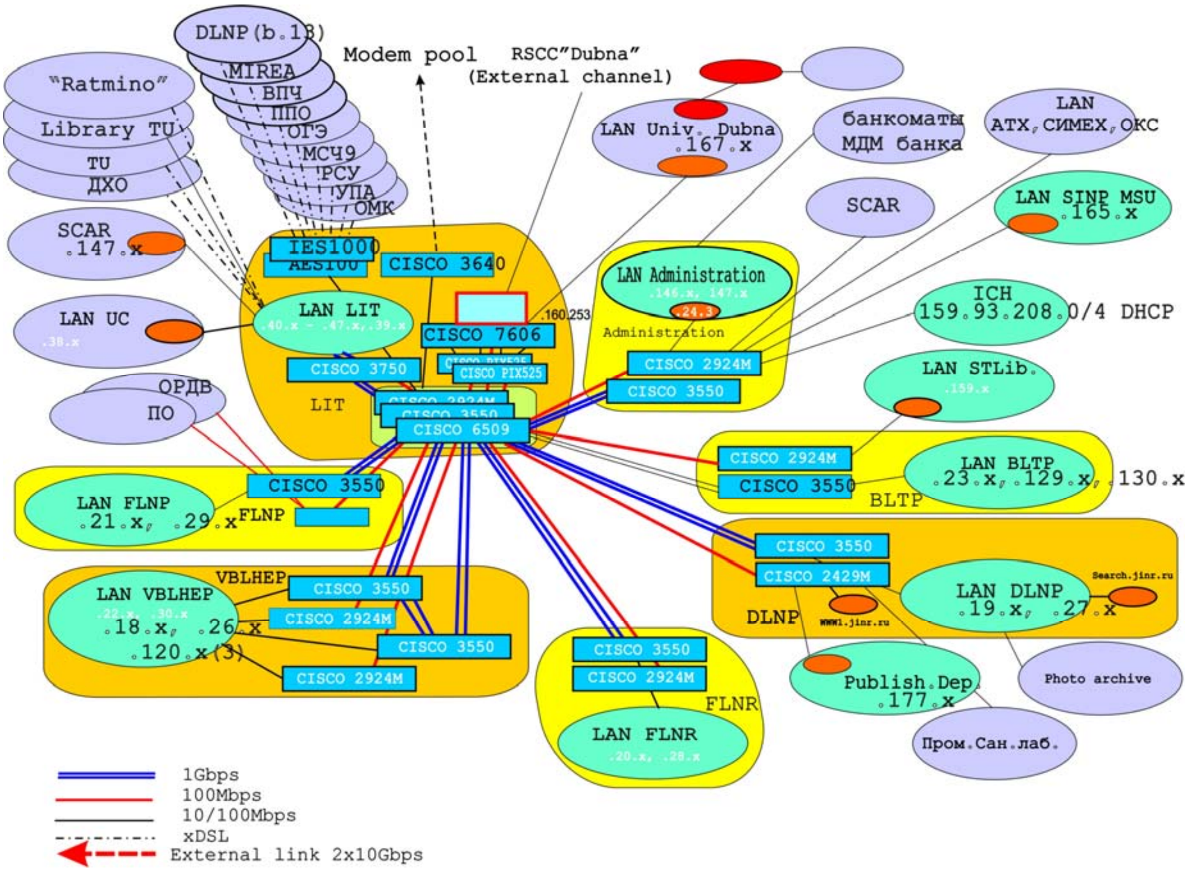
14. S.A.Telezhnikov, **C.Granja**, Yu.N. Kopatch, S.B. Borzakov, Ts. Panteleev, P.V. Sedyshev, **J. Jakubek**, **S. Pospisil** ``Registration of charged radiation from 252Cf using Timepix detector", in Neutron Spectroscopy, Nuclear Structure, Related Topics, Proceedings of the XVII International Seminar on Interaction of Neutrons with Nuclei, Dubna, May 27-30, 2009 E3-2010-36 Dubna (2010) p.51-59.

15. **František Bečvář** (Charles University, Prague), "Slow-neutron capture in the context of experimental research at Dubna", Talk at Symposium "The Centenary of Atomic Nucleus" Dubna, 11.03.2011, organized by Yu.T.Oganessian.

Collaboration of the Laboratory of Information Technologies with the Czech Republic

For more than ten years, the **Laboratory of Information Technologies** (LIT) of JINR has been actively involved in the study, use and development of advanced Grid technologies.

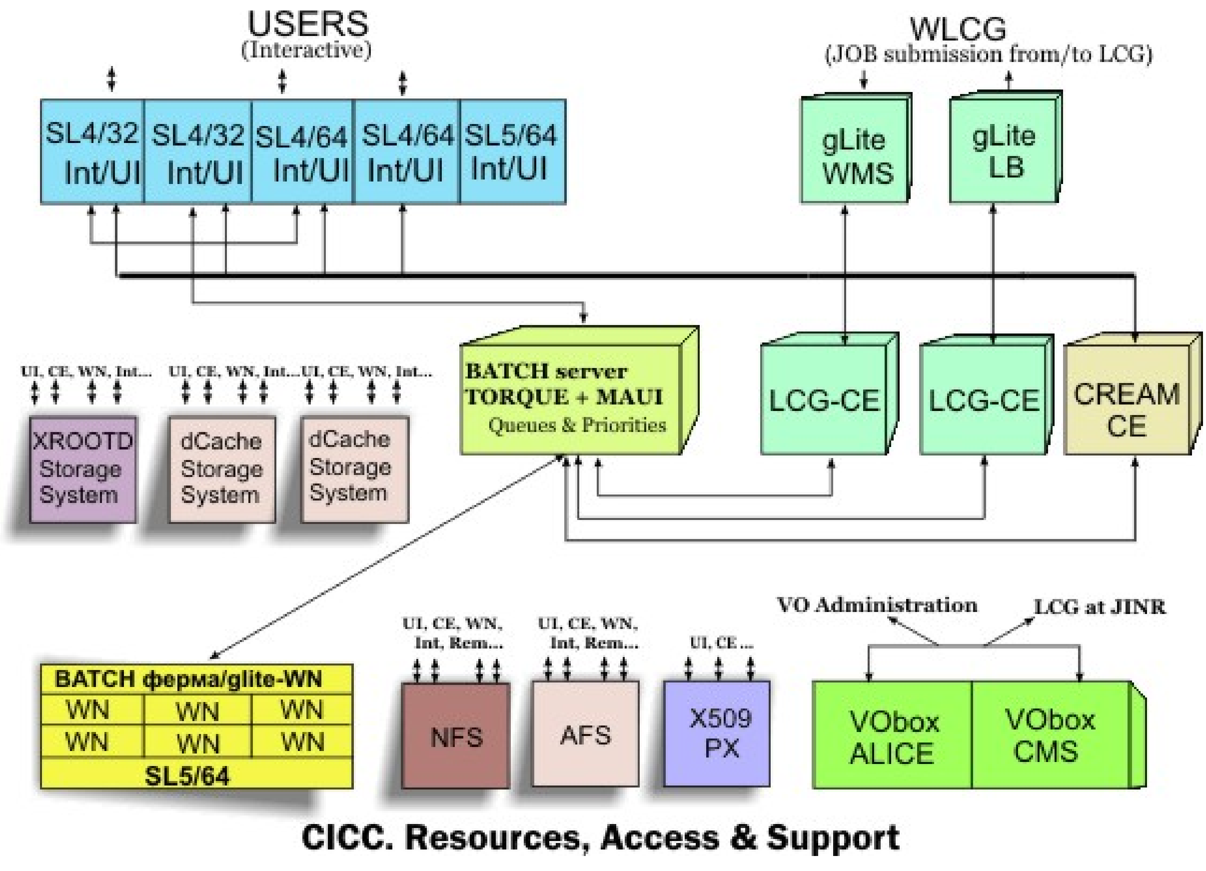
The most important result of this work was the creation of Grid infrastructure in JINR that provides the complete range of Grid services. Created JINR Grid site (T2_RU_JINR-LCG2) is fully integrated into the global (world-wide) WLCG/EGEE/EGI infrastructure. The resources of this site are successfully used in the global infrastructure, and on indicators of the reliability, the T2_RU_JINR-LCG2 site is ***one of the best*** Tier2 sites in the WLCG/EGEE/EGI infrastructure.



Scheme of JINR Grid infrastructure

A great contribution is made by LIT staff members to testing and development of Grid middleware, the development of Grid-monitoring systems and organizing support for different virtual organizations. *The only specialized conference* in Russia devoted to Grid technologies and distributed computing is organized and traditionally held at JINR. In the field of Grid the JINR actively collaborates with many foreign and Russian research centres and special attention is paid to cooperation with the JINR Member States.

Since 2003 there has been joint Project for LIT and the Institute of Physics (FZU) of the Czech Academy of Sciences on development of **Grid infrastructure** for the physics experiments. The cooperation between the JINR and the FZU AS CR is fixed under the JINR topic “Information, Computer and Network Support of JINR's Activity” with the 1st priority. The project is led by V.Korenkov from the JINR side and by M.Lokajíček from the FZU AS CR. In the project, JINR is represented by V.Mitsyn, S.Belov, N. Kutovskiy, and FZU AS CR by J. Chudoba, T. Kouba, J. Švec, L. Fiala, J. Kundrát, J. Horký.



The resources of the LIT/JINR Central Information Computing Complex are configured in such a manner that access to resources and their use is possible both for local user and for users of the WLCG/EGEE global infrastructure

The main aim of the project is the development of the JINR and the FZU AS CR Grid infrastructures, common activities on the development of Grid tools and monitoring system, especially in the framework of the WLCG and the EGEE\EGI projects, and the experience exchange. The activities planned are very important for a number of nuclear physics experiments when the large computing resources and huge storage facilities are needed.

A significant experience not only in Grid infrastructure creation but also in the development of the Grid tools has already been accumulated both at JINR and at FZU AS CR – in particular, in the development and ways of implementation of the dpm and dCache system, on configuration and tuning of the LCG sites and in the creation and usage of monitoring and accounting systems for distributed infrastructures.

LIT/JINR Central Information Computing Complex

The JINR–FZU AS CR cooperation will serve for the further development of Grid activities and a possible integration of FZU AS CR and the JINR information and computing resources. A special attention will be devoted to participation of young specialists from JINR and FZU AS CR. The current status and the results of the project will be reported at the meetings and expected to be published as a JINR communication.

During the project period it is planned to continue the development of the monitoring infrastructure (both software and hardware) of Grid infrastructures, and deploy and fit the dpm and dCache system to JINR needs.

Common publications

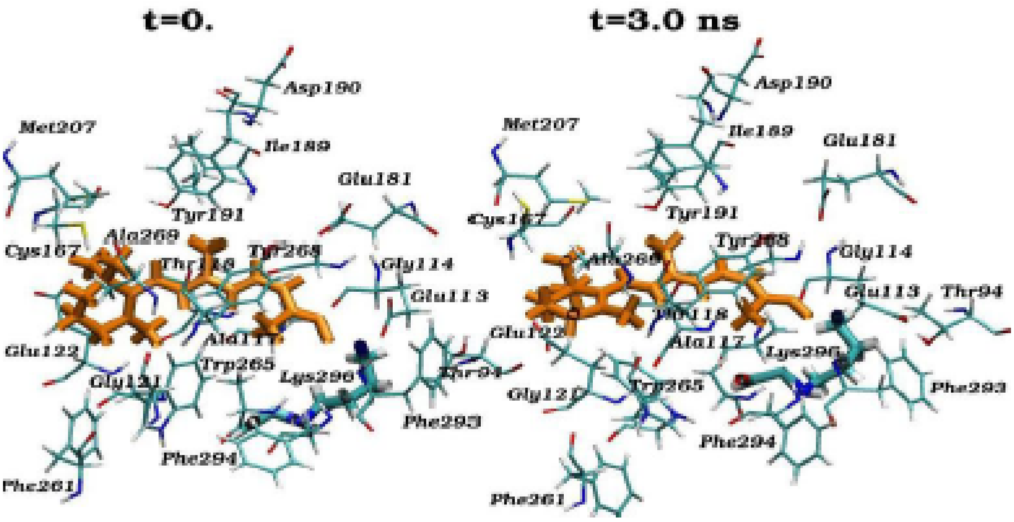
1. V. Ilyin, V. Korenkov, A. Soldatov, RDIG (Russian Data Intensive Grid) e-Infrastructure: status and plans, at NEC2009, XXII International Symposium on Nuclear Electronics & Computing, Varna, 7-14 September 2009.
2. S.D. Belov, V.V. Korenkov, N.A. Kutovskiy (JINR), Educational Grid infrastructure: status and plans, at NEC2009, XXII International Symposium on Nuclear Electronics & Computing, Varna, 7-14 September 2009.
3. **M. Lokajicek** et al., Prague Tier2 computing centre evolution, at NEC2009, XXII International Symposium on Nuclear Electronics & Computing, Varna, 7-14 September 2009
4. **T. Kouba** et al.: A centralized administration of the Grid infrastructure using cfengine at NEC2009, XXII International Symposium on Nuclear Electronics & Computing, Varna, 7-14 September 2009.
5. **T. Hubik**, **L. Kerpl**, **M. Krejcova**, **J. Kundrat**, «Deska: Tool for Central Administration of a Grid Site») and **T. Kouba**, **L. Fiala**, **J. Chudoba**, **M. Lokajicek**, **J. Svec**, «Prague WLCG TIER-2 report» - talks on GRID-2010 conference at LIT.

Cooperation between the Laboratory of Radiation Biology and the Czech Republic

For many years, fruitful collaboration has been between the Institute of Nuclear Physics (INP) Řež of the Academy of Sciences of the Czech Republic and the **Laboratory of Radiation Biology** (LRB) of JINR in a number of research fields.

The fields cover the use of thermo-luminescent and track detectors in dosimetry and radiometry, measurement of linear energy transfer and micro-dosimetry, and development of neutron spectrometry and radiometry techniques.

Czech specialists successfully participated in many radiobiological experiments with irradiated detectors at nuclear beams of the JINR Nuclotron (Laboratory of High Energy Physics) and at the medical beam of the JINR Phasotron (Laboratory of Nuclear Problems). They have participated in the measurement of characteristics of JINR's reference neutron fields and in experiments on measuring neutron yields from thick targets, etc. The results of this research allowed the publication of tens of jointly authored papers [1-8]. The INP helped very much in training the LRB staff in modern track detector-based dosimetry methods and provided appropriate practice.



Example of computer molecular modeling of biological systems at LRB

It is planned to resume cooperation with INP in modeling heavy charged particle tracks in tissues for radiobiological purposes and send a specialist to INP on an assignment to master the corresponding software.

Workshop on physical, biological and medical aspects of higher-LET radiation energy transfer in the matter was organized by JINR and was held in Prague in February 2008.

For ten years, radiobiologist Stanislav Kozubek from the Czech Republic worked successfully at JINR. The main subject of his research was the mutagenic effect of different ionizing radiations on bacterial cells. Regularities and mechanisms of the formation of different types of mutations in prokaryote cells were studied using JINR's heavy ion accelerators. He found that the dose dependences of the frequency of gene mutation formation under γ-quanta and accelerated heavy ions are described by linear quadratic functions. The quadratic character of the dose curves of mutagenesis is determined by the “interaction” of two mutually independent "hitting" events in the course of SOS repair of genetic structure lesions. An important conclusion was made that under accelerated heavy ions, the gene mutations are induced by the δ-electron region of charged particle tracks. Regularities in cell SOS response under radiations in a wide LET range were studied by SOS chromotest and λ prophage induction methods. The thesis was substantiated that clustered single-strand DNA breaks are the molecular basis of gene mutation formation, and DNA double-strand breaks are the molecular basis of structural mutations. It was established that the dependence of the relative biological effectiveness of accelerated ions on their LET is described by curves with a local maximum. On the basis of the obtained results, S. Kozubek prepared and successfully defended a Dr. Sc. thesis. Two postgraduates from the Czech Republic P. Bláha and L. Ježková have arrived this year to prepare their candidate theses.

S.Kozubek (left) discusses results with A.P.Cherevatenko (middle) and M.Bonev (right)

Publications of LRB carried out together with Czech scientists

1. Bamblevski V.P., Krylov A.R., Timoshenko G., **Spurny F.** The measurement of the absorbed dose in thin blood samples irradiated by relativistic protons. Radiat. Measurements, v. 33, 2001, p. 151.
2. **Spurny F.**, **Vlchek V.**, Bamblevski V.P., Timoshenko G.N. Spectra of the linear energy transfer measured with a track etch spectrometer in the beam of 1 GeV protons and the contribution of secondary charged particles to the dose. JINR Preprint E16-99-158, Dubna, 2000.
3. **Bamblevski**, **V.P.**, **Spurny, F.** Nuclear track detector with radiators and their use in high-energy particle fields. Radiation Measurements, v. 23, 1, pp. 215-218.
4. **Spurný, F.**, Molokanov, A.G. and Bamblevski, V.P. Spectrometry of linear energy transfer, its development and use for proton radiation therapy. Radiat. Prot. Dosim. 110(1-4) 675-679 (2004).
5. **Spurný, F.**, **Jadrníčková I.**, Bamblevski, V.P. and Molokanov, A.G. Upgrading of LET track-etch spectrometer; Calibration and uncertainty analysis. Radiat. Measur. 40, 343-346 (2005).
6. **F. Spurný**, A. G. Molokanov and V. P. Bamblevski. Passive spectrometry of linear energy transfer: development and use. Radiat. Prot. Dosim. Volume 110, Issue 1-4, pp. 675-679.
7. **Spurný, F.,** Bamblevski, V.P. Detection, Dosimetry and Microdosimetry Using High Energy 12C Beams. Radiation Measurements, Vol. 31, June, 1999, Pages: 413-418.
8. Spurný, F., Bamblevski, V. P., Molokanov, A. G., **Vlek, B.** Dosimetric and microdosimetric characteristics of high energy proton beams. Radiation Measurements, 34 (1-6), p.527, Jun 2001.
9. M. N. Bonev, **S.Kozubek**, E.A.Krasavin, K. G. Amirtajev, The λ-prophage induction in repair-deficient and wild type E. coli strains by gamma-rays and heavy ions, Int. J. Radiat. Biol., 1990,vol. 57, No 1, p. 1-13.
10. E.A.Krasavin, **S.Kozubek**, Mutagenic action of radiation with different LET. Energoatomizdat M.: 1991, 183 p.
11. **S. Kozubek**, G. Horneck, E.A.Krasavin, **L. Ryznar**, Interpretation of Mutation induction by Accelerated Heavy Ions in Bacteria, Radiation Research, 1995, vol. 141, p. 199-207.

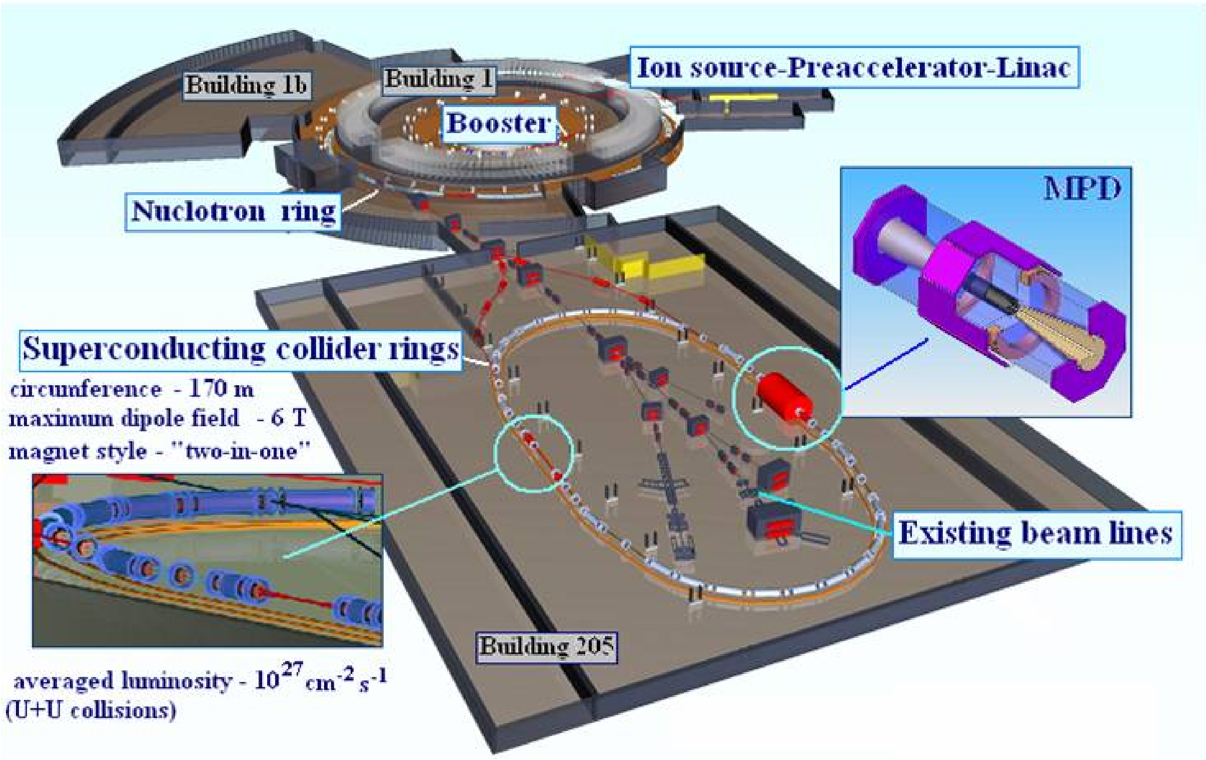
Collaboration of the Veksler and Baldin Laboratory of High Energy Physics with the Czech Republic


In 2010–2016, the **Veksler and Baldin Laboratory of High Energy Physics** (VBLHEP) will preserve its main directions of research in high-energy heavy-ion physics and modern particle physics which, in particular, include investigations of the nucleon spin structure, tests of the Standard Model, search for new physics and the study of CP violation.

The research in high-energy heavy-ion physics at JINR will be carried out at the VBLHEP accelerator complex **Nuclotron-M** and further at **NICA** collider facility, the construction of which is the primary objective of this Laboratory. At this complex, within the MPD project, an experimental study of the properties of hot and dense hadronic matter and search for the so-called “mixed phase” of such matter (i.e. a mixture of quark-gluon and hadron states) as well as for a possible phase transition will be performed at the energy of colliding particles up to $\sqrt{s_{NN}}$ =11 GeV. The Czech scientists actively participate in the NICA/MPD project. Particularly, R. Lednický is one of the Physics Coordinators of this project [1-7].

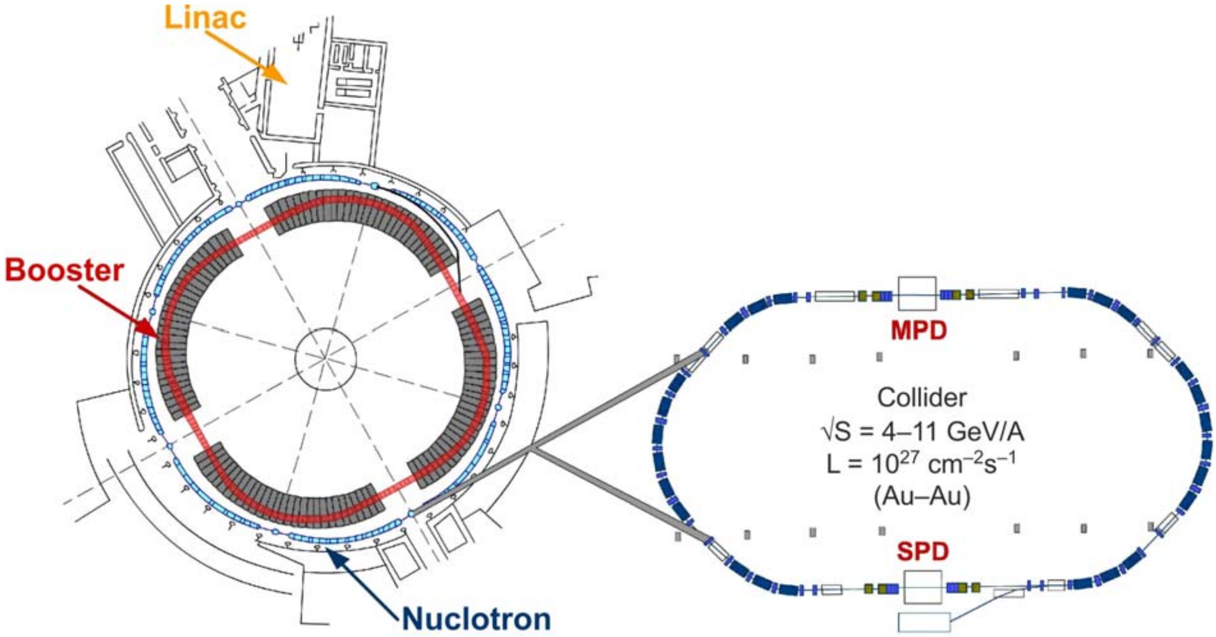

Nuclotron-M

For the JINR Member States the Nuclotron-M/NICA facility can serve as an advanced scientific-technological base, being a universal superconductive facility built on modern technological basis, where unique program in fundamental and applied research can be realized. The collision energy interval chosen for the facility and its corresponding instrumental infrastructure are optimal for research of matter in its transitions to most unexpected forms. This allows one to reach better understanding of the fundamental laws of nature, its symmetries and properties both in the evolution in time and at the very moment of creation of Universe. Unique possibilities offered by NICA are complementary to the existing world mega-scaled facilities including the LHC.



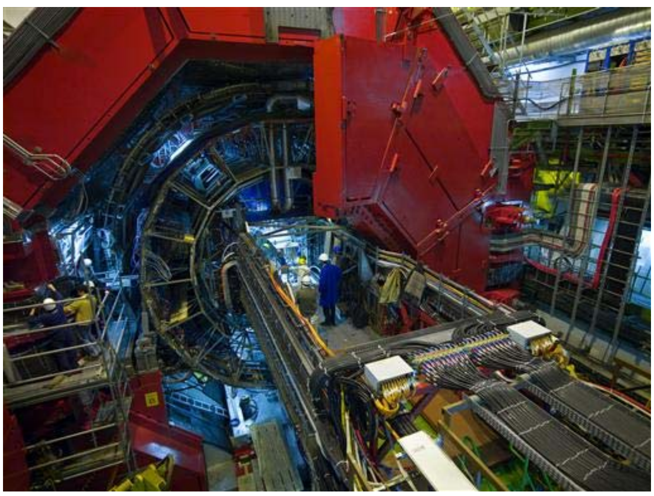
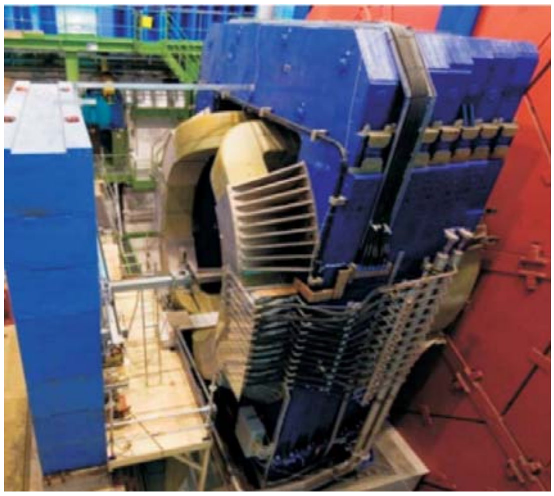
Layout of NICA accelerator complex at VBLHEP

The Nuclotron of VBLHEP



Scheme of the NICA complex of VBLHEP

The level of involvement of VBLHEP groups in research on high-energy heavy-ion physics at other world's accelerator laboratories will be defined by the progress of activities on the NICA/MPD project and the emerging opportunities for work at the Nuclotron-M/NICA accelerator complex. At the same time, VBLHEP scientists will participate in the study of the properties of nuclear matter in states with extremely high density and temperature, in the search for manifestations of quark deconfinement and possible phase transitions within joint research on heavy-ion physics in the experiments **STAR** at the RHIC collider (BNL), **NA61** (SPS) and **ALICE** (LHC) by investigating the production of various hadrons including light vector mesons and heavy quarkonia as well as in measurements of direct photon and dilepton yields.

Elements of ALICE setup at the LHC

The study of the nucleon spin structure will be carried out by JINR scientists at the VBLHEP accelerator complex and at CERN and BNL. In general, the physics of spin has long-standing history at VBLHEP and scientists from the Czech Republic have significantly contributed to this branch of particle physics. At present, a series of experiments are planned to be conducted with the extracted polarized beams of the Nuclotron-M, particularly, using a **movable polarized target.** These investigations are associated with preparations for implementing the spin program of the NICA project and are aimed at creating effective polarimetry as well as at developing technology for polarized targets and polarized particle sources.

The ultimate goal of the NICA/MPD project is to construct a collider (based on the Nuclotron-M accelerator) that will allow carrying out investigations with colliding beams of high-intensity ions at an average luminosity of $L=10^{27}\ cm^{-2}\ s^{-1}$ for Au^{+79} within the energy region $\sqrt{s_{NN}}$ = 4–11 GeV, as well as with polarized proton ($\sqrt{s_{NN}}$ up to 20 GeV) and deuteron ($\sqrt{s_{NN}}$ up to 12 GeV) beams with longitudinal and transverse polarization and with extracted ion beams as well as polarized proton and deuteron beams.

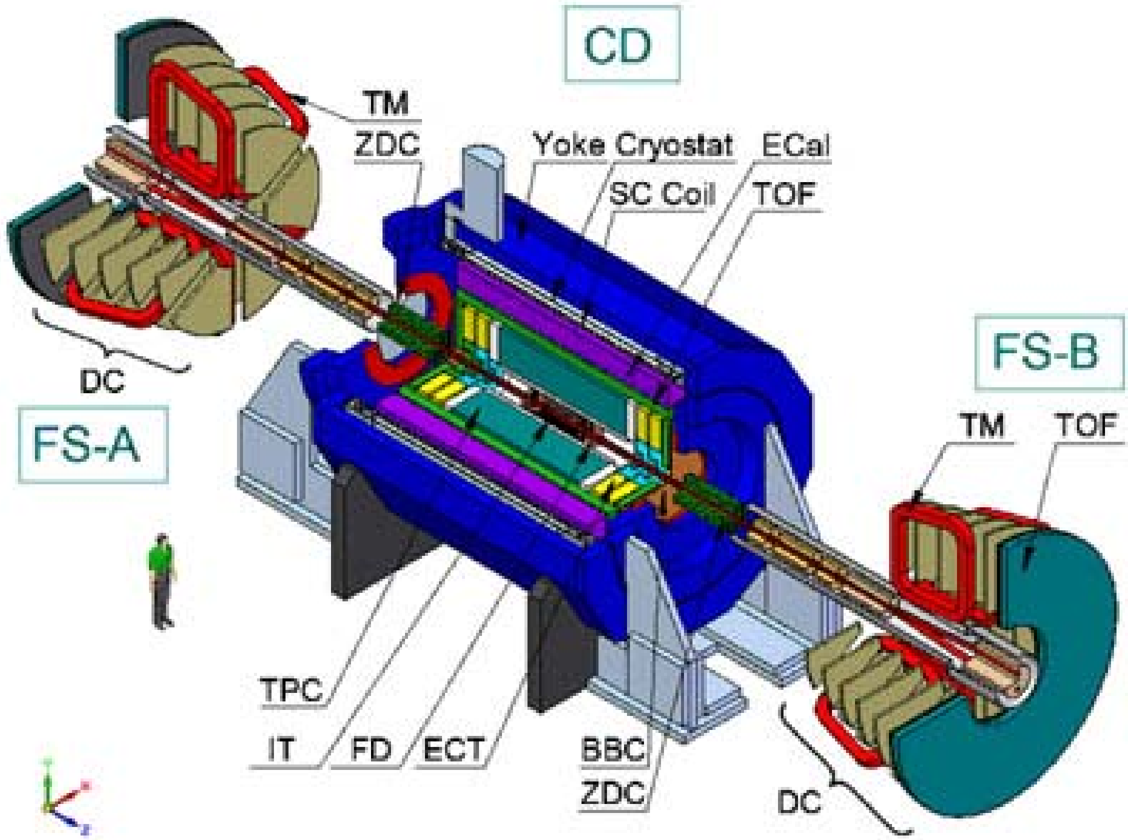
This requires creating a source of highly charged heavy ions, constructing a linear injector accelerator, designing and building a booster synchrotron, developing and constructing two superconducting storage rings, integrating the developed systems and the existing accelerator Nuclotron-M into a collider providing at least two beam intersection points. The physical start-up of the NICA facility is planned for 2017.

To use effectively the NICA collider opportunities, it is necessary to construct adequate detector setups at JINR. Such experimental instruments will be detectors MPD and SPD at VBLHEP.

The goal of the **MPD** project is experimental studies of strong interactions in hot and dense hadronic matter and a search for a possible formation of the so-called "mixed phase" of such matter. The design concept of the MPD setup envisages placing the central complex of detecting equipment in the solenoid magnetic field as well as two forward-backward detectors.

The **SPD** facility is being developed at VBLHEP for realization of the second part of the scientific program for the NICA collider, concerning investigations of the interactions of colliding light-ion beams and polarized proton and deuteron beams. This will allow setting up spin physics experiments to continue the JINR research program in this area at a brand new level.

The successful achievement of the goal, set before VBLHEP, for the construction of the NICA accelerator complex and MPD and SPD detectors requires concentration of essential resources and optimization/minimization of financing for another projects carried out at the Laboratory within the existing JINR obligations.



The scheme of the mixed-phase detector MPD setup

During the past 4 years, after approval of the NICA program by the JINR CP, running of the Nuclotron for physics research was very limited, whereas acceleration of polarized deuteron was stopped at all. The latter was motivated by the decision to design and construct the new high intensity polarized proton and deuteron source. Work on the new ion source manufacturing and tests should be completed in 2012. Modernization of the Nuclotron (project “Nuclotron-M”) had been completed in main parts by the fall 2010. Thus, the Nuclotron running with polarized beams is scheduled for 2012 and later on.

Experiments with Nuclotron-M beams extracted to fixed targets are essential part of the high-energy heavy-ion physics and spin physics at JINR. These experiments will be carried out both during the NICA collider stage and after start of its operation complementing moderate energy part of the NICA/MPD research program. The energy region covered by fixed target experiments at VBLHEP overlaps and extends further the GSI and FAIR (at SIS-100 stage) energy regions as well which gives a good ground for cooperation between JINR and FAIR.

Besides fundamental studies, it is planned to perform innovative projects in radio-biology, nuclear waste transmutation, nano-technology and other directions at the Nuclotron-M and NICA facility. Realization of the NICA project will push forward development of new technologies in industry of the JINR Member States.

Apart from taking part in scientific research programs and in the Nuclotron-M and NICA project, Czech scientists participate in education process at JINR.

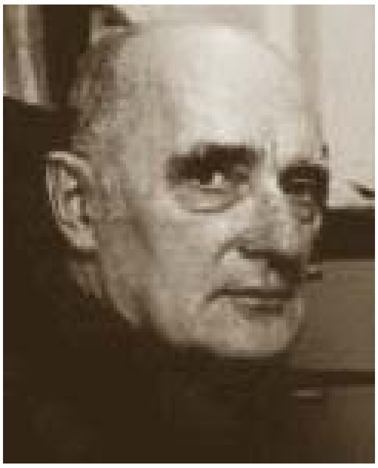
Collaborative works [8-10] within the Nuclotron-M project are aimed at modernization of the Nuclotron. Contribution of specialists and high-technology industry of the Czech Republic to realization of this project is difficult to overestimate. In the past year 4 contracts with VAKUUM PRAHA were fulfilled. Within these contracts deep modernization of vacuum system of the Nuclotron was carried out resulting in significant improvement (2 orders of magnitude) of vacuum in the accelerating system, new automatic control system for the Nuclotron vacuum system was commissioned and various vacuum equipment necessary for LUE-800 (within IREN project), for the new heavy ion source KRION-6T was installed. The company VAKUUM PRAHA (director-general P.Hedbávný, engineer-in-chief R.Bašta) was grown from Charles University in Prague and has strong collaboration with VBLHEP. Now 2 new contracts between VBLHEP and this company are open and one more is being negotiated. The FOTON company is participating in these works as well.

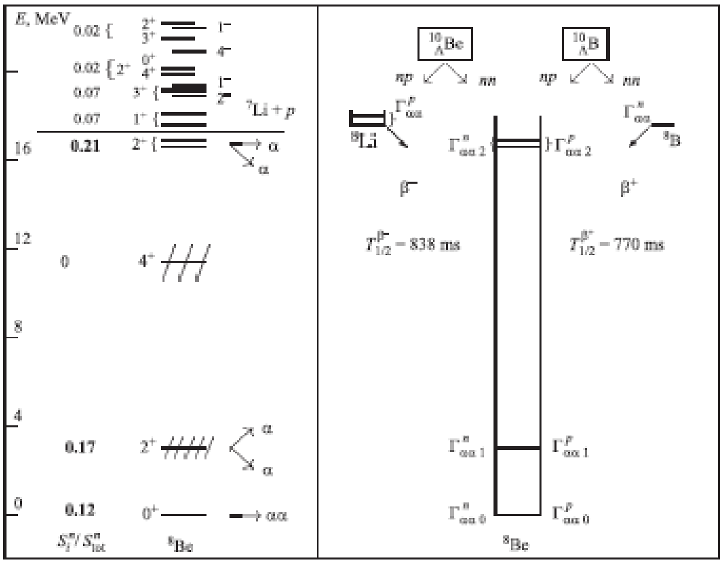
The Charles University group (M. Finger) is also going to perform R&D works and manufacturing of modern tools for diagnostics of low intensity extracted beam parameters for Nuclotron-M (profile-meters) crucially needed for experiments with fixed targets. These profile-meters will be based on scintillating fibres (SciFi) with modern multichannel photo-detectors, readout electronics and microcomputers, data transmission lines.

Collaboration with Czech specialists in the physical research. The Nuclotron-M energy range is optimal for studies of strangeness production in collisions of relativistic ions and nucleons, in particular for study of nuclei containing open strangeness (the hypernuclei). Such a study is carried out in the Division for Physics of Hadrons of VBLHEP and has long-standing history. Collaborative work with Czech scientists is aimed at continuation of studies of hypernuclei at the Nuclotron beams. It was extended recently by R&D works on new detectors for Nuclotron or NICA.

Hypernuclear physics [11-17]. Unique approach of hypernuclei research was elaborated at Dubna, based on study of high energy hypernuclei produced with excitation of accelerated nuclei beams. In these experiments the hypernuclei decay far away from the production target, allowing one to have low background sample and providing a good conditions for the life time measurements.

The first experiments were stimulated very strongly by active discussions with Prof. J.Žofka and calculations of production cross sections with his participation. Later on, Prof. L.Majling took an active and eager part in formation of scientific research program for Nuclotron accelerator. It was his idea to choose search for neutron-rich hydrogen (^{6}H and ^{8}H) hypernuclei with 4 and 6 neutrons as one of the main tasks. If such hypernuclei exist in nature, they could be the most neutral objects registered in laboratories! The ground state of the core nuclei ^{5}H is broad resonance and may be bound due to the attractive interaction between the Λ hyperon and the core nucleus. One may expect large structure change of the core nucleus beyond the neutron drip line by the addition of Λ hyperon.



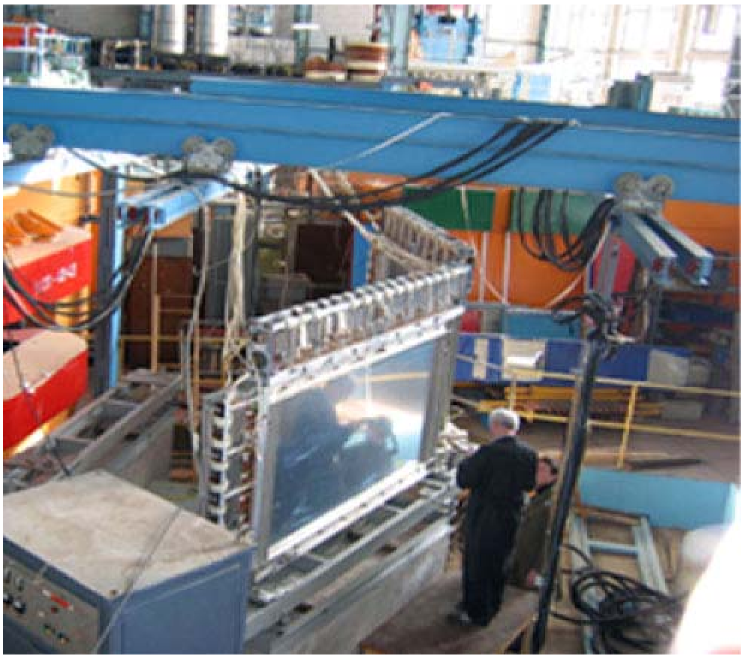


Prof. Lubomír Majling (left) and pattern of the ^{8}Be spectra produced in the ^{9}Be(p, d)Be* reaction [11] (right)

In the conventional nuclear physics, studies of neutron-rich nuclei near the neutron drip line have been carried out extensively over the years, and as a result the so-called “neutron skin” and “neutron halo” have been discovered. The structures of such nuclei have revealed interesting phenomena regarding their size, properties of excited states and so on (I. Tanihata, *et al.*, Phys. Rev. Lett. 55 (1985) 2676, T. Kobayashi, *et al.*, Phys. Rev. Lett. 60 (1988) 2599). It is also interesting and necessary to study such a neutron-rich nucleus containing a Λ hyperon, which may change properties of a halo nucleus. The structures of light Λ hypernuclei with the neutron skin or halo were already discussed theoretically (E. Hiyama, Few-Body Systems 34 (2004) 79) and we may expect rich variations of the structures.

Prof L.Majling has also suggested extending research program with study of non-mesonic decays of boron and beryllium hypernuclei. Complicated experimental skill and instruments should be used for the research tasks devoted to the study of the nonmesonic decays of hypernuclei. But, the proposed experiments provide unique possibility to obtain data necessary to find matrix elements of weak ΛN interaction. There is no other way to extract these matrix elements. On the other hand, to carry out such an experiment, high resolution detectors should be added to the **HyperNIS** spectrometer tracker and trigger system. The production of two blocks of 0.5 mm and 1.0 mm (five counters) resolution scintillating fiber (SciFi) trackers is in progress now. Main part of this detector was produced with active participation of the Czech Technical University in Prague (Prof. B.Sopko, M.Solar and others) and support of Czech Republic grants. For example, housing of the detectors will be produced in Decin very soon. Hamamatsu 16-cathode photomultiplier tubes were obtained due to Czech Republic grant support like the photomultiplier tubes with quartz windows for Cherenkov counters necessary for sophisticated trigger system.

Participation of young researchers and students in the experiments will be possible as soon as Nuclotron upgrade are completed and beams are supplied for physics experiments. For example, Institute of Experimental and Applied Physics (IEAP) in Prague has started **studies of pixel detectors** with Li beam with ultimate aim to use them to measure direction of hypernuclei before the decay. Such a possibility can improve significantly capability of the spectrometer, namely to investigate decay branching ratios of lightest hypernuclei.



At HyperNIS spectrometer site

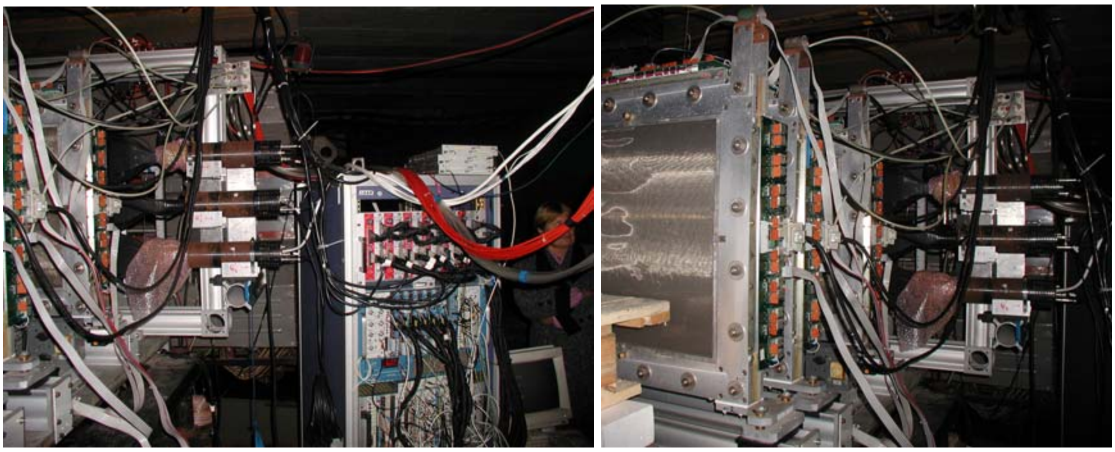
These studies are supported and carried out by Prof. S.Pospíšil and C.Granja (IEAP CTU in Prague). Young researchers of VBLHEP (A.Averyanov, A.Korotkova, D.Krivenkov) offered an interesting experiment with the use of pixel detectors instead of emulsion to study electromagnetic dissociation and clusters of nuclei like ^{9}C. IEAP group of young researchers have elaborated main part of a telescope of few pixel detectors. Together with Dubna young researchers, they should extend the telescope with two additional detectors and to find a way to integrate readout and trigger systems. Also for this the IEAP group (Prof. S.Pospišil and C.Granja) suggested to present a proposal "*Study of pixel detectors in the high intensity beams*" to find limits of radiation resistance.

Researchers from IEAP are ready to participate in tests of Time Projection Chamber (TPC) of MPD project. Namely, the use of silicon micro-strip detectors can be very useful in case of resolution tests. The problem was discussed with Prof. M.Solar. In the fall of 2011 in Dubna the prototype of TPC was ready for the tests.

Spin physics. Czech specialists are actively participating in the JINR topic *"Study of Polarization Phenomena and Spin Effects at the JINR Nuclotron-M Facility"*. The research work in this direction is concentrated mostly in the Division for Physics at Extracted Beams of Nuclotron-M (Department for Spin Physics and Few Nucleon System Problems). Participation of the specialists from the Czech Republic in theoretical and experimental studies of polarization phenomena and spin effects within the JINR topical plan is traditional, effective and important. At the present time, within the framework of this topic 26 persons are working from 5 Czech institutions – Charles University (Prague), Technical University

(Prague), ISI AS CR (Brno), TUL (Liberec), and NPI AS CR (Řež). Research program of the topic includes the following activities:

- Methodical support of the experiments at polarized beams of the Nuclotron-M and NICA facilities, including development of polarimetry systems.
- Measurement of analyzing power for the reaction $p+CH_2$ at polarized proton momentum up to 7.5 GeV/c at the setup **ALPOM-2**.
- Measurement of tensor analyzing power and spin correlation in $d \rightarrow p$ reaction in the deuteron core area with the use of polarized ^3He target and polarized deuteron beam of the Nuclotron-M. Study of 2*N*- and 3*N*-correlations in deuteron-proton elastic scattering and deuteron break-up reactions at the Nuclotron internal target.
- Modernization of the Saclay-Argonne-JINR polarized proton target (setup **PPT**), and measurements of the *np* spin observables $\Delta\sigma_T(np)$ (being the total *np* cross section differences) at 0^o scattering angle using transverse (T) polarized targets and the unique quasi-monochromatic relativistic 1.2-3.6 GeV polarized neutron beams of the Nuclotron-M. Determination of the forward scattering *NN* amplitudes over this energy region. Comparison of the obtained data with QCD motivated model calculations.
- Study of charge-exchange processes in *dp*-interactions at the setup **STRELA**.



ALPOM-2 setup at VBLHEP

- Development of theoretical models for description of the simplest nuclear systems taking into account relativistic effects, meson and quark-gluon components of the systems. Theoretical analysis of experimental data obtained at Nuclotron-M.
- Study of the properties of strongly interacting matter utilizing polarization phenomena in hadron-nucleon and lepton-nucleon interactions, and in the decay of polarized radioactive atomic nuclei.
- Study of highly excited nuclear matter and collective effects in nuclear media.

Very important contributions to the topic for experiments with polarized proton target and for education of young scientists come from Prof. F. Lehár [18] (Institute of Experimental and Applied Physics, Czech Technical University in Prague).

Prof. František Lehár

Very significant contribution is coming also from group of Prof. M.Finger (Charles University, Prague). The regular international scientific meetings “Symmetries and Spin” organized under the leadership of Prof. M. Finger in Prague attract many world famous scientists from the leading world scientific centres, like CERN, JINR, BNL, TJNL, GSI and others. The most interesting results, new ideas and proposals are discussed with active participation of Czech young scientists, PhD and graduated students.

In accordance with the above-mentioned topics the presentation will be given of the project for the development of methodical base and instruments for realization of experiments at light ion polarized beams of the JINR accelerator facility in 2012-2016 taking into account the NICA project realization, including development of polarimetry systems. Participation in the joint scientific programs and experiments, design and test of the new detectors and electronics for the use at COSY (Julich), SPS (CERN), RHIC (BNL), TJNAF (Newport News), FAIR (GSI) in accordance with the approved collaborative agreements will also be continued. Further continuation is planned of the development of the methods for calculation of the amplitudes and polarization characteristics of deuteron fragmentation and deuteron elastic scattering on protons and nuclei taking into account FSI and relativistic effects. Spin effects in hadron-nucleon and lepton-nucleon interactions will be studied.

Analysis of data from external accelerator facilities. Collaborative research with Czech scientists is performed within the Division for Physics of High Energy Heavy Ions on analysis of data from the **STAR** detector working at the heavy ion collider RHIC. One of the most interesting results was the observation of a new state of matter – strongly coupled quark-gluon plasma produced in these collisions – behaving as a hot expanding and almost ideal liquid [19]. A strong expansion with a collective velocity exceeding half the velocity of light was confirmed, in particular, by a study of femtoscopic pion, kaon, proton and lambda correlations pointing to a universal dependence of the correlation radii on the transverse mass

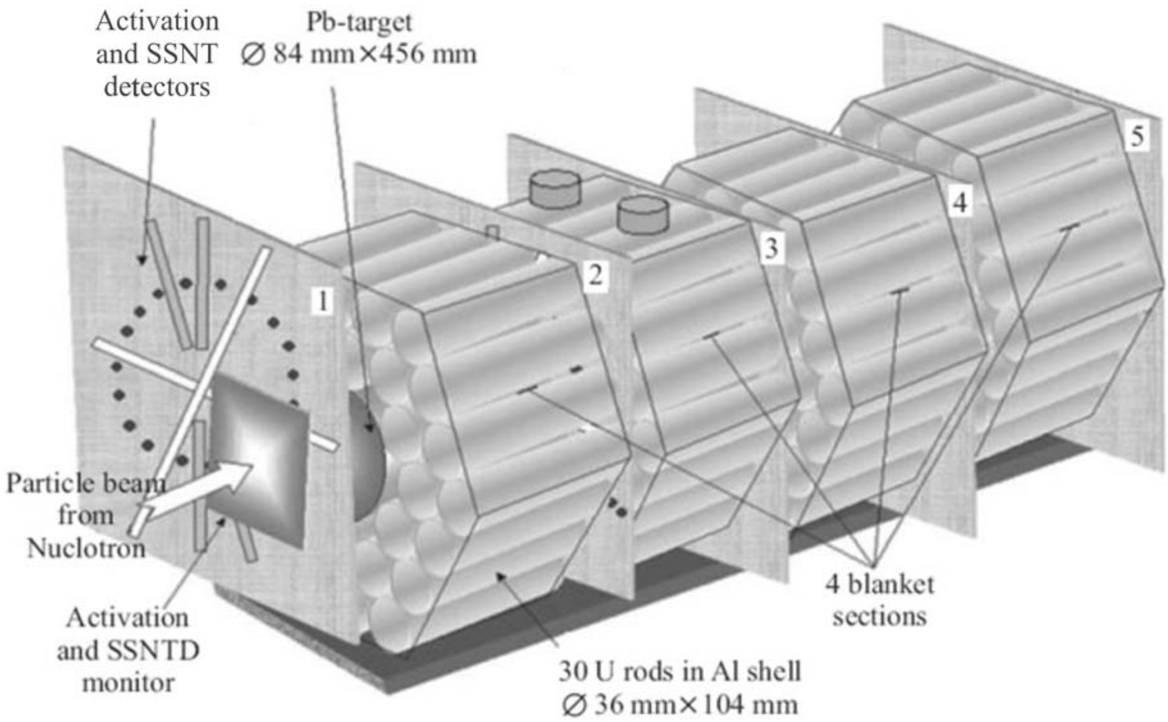
(R. Lednický being one of the principle authors) [20–22]. The formalism of femtoscopic correlations and related theory of two-particle correlations in continuous and discrete spectrum, formulated by R. Lednický in a number of original and review papers [23–29], appeared to be useful not only for a study of space-time characteristics of particle production, including space-time shifts in the production of non-identical particles and formation of near-threshold narrow resonances (with the participation of P. Chaloupka and M. Šumbera from NPI, Řež) [30,31], but also for the pionium lifetime measurement in the experiment DIRAC at CERN (with the participation of J. Smolík from IP, Prague) [32]. The data from the experiment STAR at RHIC was compared with the developed event generators [33–35] to study the consequences for particle production dynamics and to get predictions for the higher energy range available now at the Large Hadron Collider [36]. Interesting predictions have also been obtained for collisions of deformed gold and uranium nuclei [37].

New scaling features known as *z*-scaling have been found by I.Zborovský (NPI, Řež), M.Tokarev (JINR), Yu.Panebratsev (JINR), G.Skoro (Institute of the Nuclear Sciences VINCA, Belgrade).

Experimental data on inclusive spectra measured in heavy ion collisions at RHIC and SPS over a wide range of energies $s_{NN}^{1/2}$ = 9-200 GeV have been analyzed in the framework of the *z*-scaling. A microscopic scenario of the constituent interactions has been developed. Dependence of the energy loss on the momentum of the produced hadron, energy and centrality of the collision has been estimated [38–45]. The investigations have been supported, in particular, by the Ministry of Education, Youth and Sports of the Czech Republic grants LA08002 and LA08015.

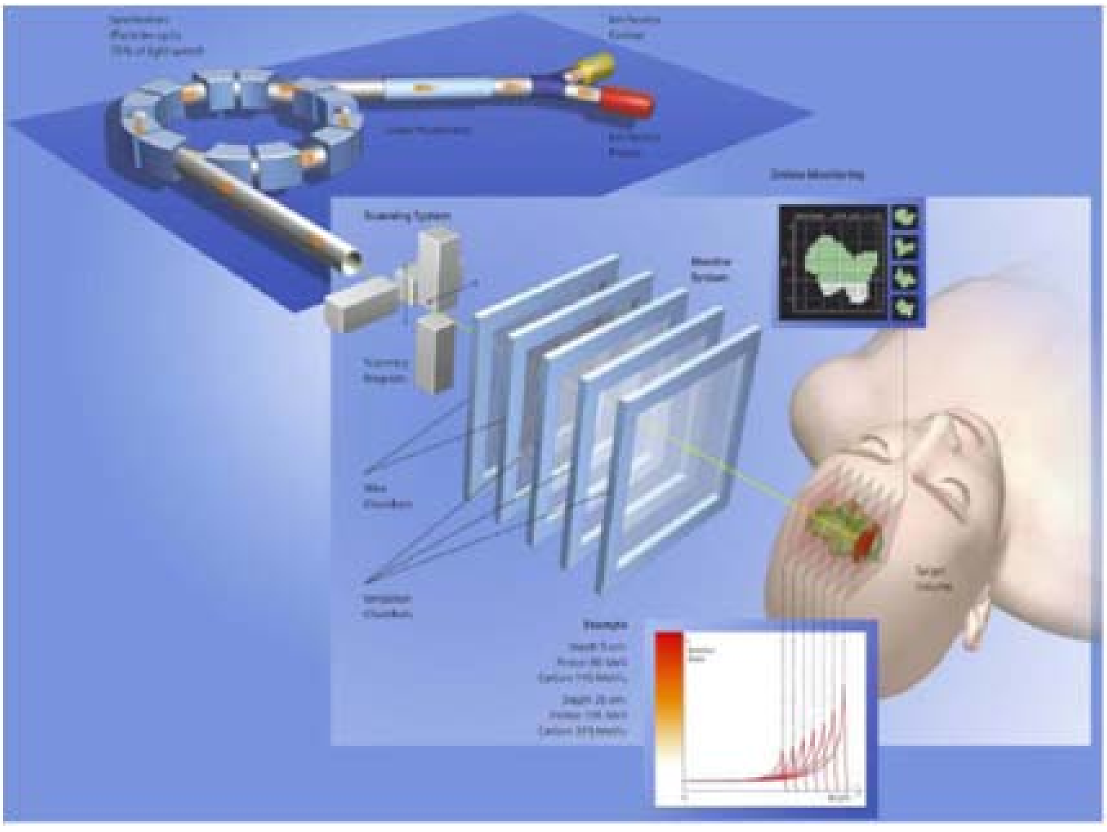
Collaboration in application of fundamental results in technologies. Common activity on the border between fundamental and applied physics is under realization within the JINR topic *"Investigation of deeply subcritical electro-nuclear systems and feasibility of their application for energy production and radioactive waste transmutation"*. The collaboration is called "Energy and Transmutation". The list of participants from the Czech Republic includes scientists from NPI, Řež (J. Adam, A.Kugler, V.Wagner, M.Majerle, A.Krása, O.Svoboda) and Czech Technical University in Prague (K.Katovský, O.Sčasný).

The main task of the collaborative research is investigation of neutron characteristics of the assemblies "lead target plus uranium blanket" (the installation "Energy plus Transmutation"), "uranium target plus lead moderator" (the installation "Quinta"), "lead target plus graphite moderator" (the installation "GAMMA-3") and "extended natural uranium target +/- graphite moderator" ("EZHIK") under protons and deuterons irradiation by Nuclotron beams with energy from 0.6 up to 6.0 GeV. Another goal of this collaboration is information on neutron energy spectra and their spatial distribution as well as investigation of opportunities for nuclear energy production and simultaneous transmutation of radioactive wastes on the basis of semi-infinite targets from natural uranium and thorium.



Layout of VBLHEP assembly for investigation of highly under-critical atomic reactors (alternative nuclear technology) and transmutation of nuclear plant waste

In the course of collaboration within this topic 5 diploma theses and 2 PhD theses were completed by Czech students as well as 2 PhD reports.



Layout of setup for radiocarbon therapy at VBLHEP

Full automatic complex for measurements of oil characteristics at VBLHEP

Another direction in applied research-and-development activity is being carried out at VBLHEP by the IEAP CTU group (Prof. S.Pospíšil and C.Granja) under proposal *"Study of pixel detectors in the high intensity beams"*. The goal is to find limits of radiation resistance of these detectors [46–73].

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3. Education of Czech specialists and students in Dubna

JINR's international character, its scientific schools, and its basic research facilities make up the grounds for its successful research activity.

Since 1970, CERN and JINR have been holding joint European schools on high energy physics that are attended by scientists from many countries of the world. Here they not only learn the latest ideas in physics but also become involved in a process that leads to better mutual understanding and rapprochement of people from different countries.

The Institute pays much attention to the tasks of increasing efficiency of the educational process due to renovation of the Institute’s infrastructure and supply of modern equipment to departments which is used for implementation of educational projects and applied research.

In this context, the success of the recent project implemented in collaboration with CERN should be mentioned – the schools for physics teachers from JINR Member States. Two schools have been held up to the present in Geneva and two in Dubna.

But JINR's development as a really international organization should also be based on the continuous inflow of the gifted youth from JINR Member States. It is exactly the task of the **JINR University Centre** (the UC) to make for this inflow. The main fields of the UC's activity include organization and conduction at the Institute's level of international actions like ***student practices and schools***; organization of visits to JINR for students, postgraduates, and secondary school pupils of JINR Member States; attracting to JINR graduate students from its Member States and other countries for doing diploma work and organization of their studies.

At the JINR University Centre laboratories (left) and lectures (right)

The International Student Practices have been organized every year since 2004 on the initiative of the UC, Moscow Engineering Physics Institute, Moscow Institute of Physics and Technology, a number of Polish universities, and the Czech Technical University in Prague. The practices are intended for graduate students of the JINR Member States and the countries that have government-level agreements with JINR. The practices are held in summer during the student holidays.

The practices are two- or three-week long. They are held so that the students would get the fullest possible information on the research performed at JINR, would perform short student research work at JINR's basic facilities; get acquainted with JINR's scientists and find for themselves their prospective scientific supervisors (those students who would like to come to JINR later for longer time to perform their diploma work or enter the JINR postgraduate studies); attend lectures by leading scientists on current issues of physics. Dr. Ivan Štekl is the Czech Republic contact person responsible for the student-related activities.

The Fourth International Summer Student School on Nuclear Physics Methods and Accelerators in Biology and Medicine was held in Prague, Chech Republic, 8 - 19 July 2007 (http://www.utef.cvut.cz/4SummerSchool/index.html).

At the Summer Student School on Nuclear Physics Methods and Accelerators in Biology and Medicine (Prague, 8–19 July 2007)

In accordance with the JINR regulations the education, teaching and preparation of well-qualified researchers, engineers and scientists for JINR Member States is one of the main goals of JINR. Therefore this process is permanently under way.

In particular, during 2008-2010 several young scientists and PhD students from the Czech Republic took part in the Dubna International Advanced Schools of Theoretical Physics (DIAS-TH) organized in JINR by leading scientists of the Bogoliubov Laboratory of Theoretical Physics (BLTP).

In fact BLTP has very good traditions of organizing International workshops and schools in Dubna. The DIAS-TH project is a sort of specialized superstructure under BLTP which organizes and controls all educational programs for students, postgraduates, and young scientists. It functions continuously and the standard schools (about 3-4 a year) are organized coherently. Other educational programs in Dubna, such as the JINR University Centre (mainly addressed to students preparing to work in experimental groups), are correlated with DIAS-TH (common programs on modern theoretical physics, workshops for students and young scientists, etc.). In a bit more details the main goals of DIAS-TH project are the following:

- Training courses for students, graduates, and young scientists in the Member States and other countries (according to special agreements and grants);
- Looking for and supporting gifted young theorists in the JINR Member States; creating databases of students and young researchers;
- Organization of schools of different scales in Dubna and coordination with similar schools in Russia, Germany, and other European countries;
- Support of the JINR experimental programs by organizing lecture courses and review lectures on new trends in modern physics;

- Cooperation with the University Centre in training students and postgraduates as well as in organizing schools for students;
- Cooperation with existing training programs in mathematics and physics for gifted schoolchildren (there are at present two such high-level programs acting in Dubna);
- Coordination of the research-training programs with workshops and conferences at JINR;
- Coordination with the schools and workshops supported by European community, UNESCO-ROSTE and other organizations;
- Publication of lectures and discussions in different forms, in particular, with the use of modern electronic equipment, etc.

Since full time of collaboration between the Dzhelepov Laboratory of Nuclear Problems and Czech institutions 7 student diploma works and 13 PhD theses were made based on the results of the joint research in the fields of nuclear spectroscopy, nuclear spin physics, elementary particle, rare decay and accelerator physics.

The aim of the common Czech Republic–JINR project RUSALKA-CZELTA (see above) is the fundamental research of high energy cosmic rays. Besides the scientific purpose, the project has also educational impact. Within the project, the network of detection stations of secondary cosmic ray showers is built. These stations are built mostly on the roofs of selected high schools in the Czech Republic and JINR. Similarly to other projects in the European Union, Canada and the United States, students of Czech high schools actively participate in this project – it contributes to improve and to make attractive their education of natural and technical sciences.

At the annually performed practices, organized by the Frank Laboratory of Neutron Physics in collaboration with JINR University Centre, students from Czech Universities become familiarized with the neutron scattering methods and their application for scientific research. It helps to attract active young researchers from the Czech Republic to scientific research using neutron scattering methods at the IBR-2M reactor spectrometers complex. In the nearest future a pre-graduation practice is planned for students from the University of Ostrava with subsequent implementation of Master's theses.

Annual practical training, organized together with the JINR University Centre on the basis of the Veksler and Baldin Laboratory of High Energy Physics, opens up to Czech students a lot of possibilities to learn methods of experimental and applied investigations as well as modern data analysis tools. Participation of the students in real research on realization of the Nuclotron-M/NICA/MPD project and in experiments with fixed targets at extracted Nuclotron beam gives good basis for their professional skill improvement and for preparation of thier diploma, magister and PhD theses. In particular, there are copious student works within the "Energy+Transmutation" program of VBLHEP. The list of Diploma theses includes:

1) Daniela Hanušová: *Model simulations of neutron fields useful for transmutation of fissile products and actinides,* FMP CU Prague, 2001;
2) Vladimír Henzl: *Experimental study of transmutation of actinides and fissile products,* FMP CU Prague, 2001;

3) Antonín Krása: *Experimental study of transmutation of fissile products,* FMP CU Prague, 2003;
4) Filip Křížek: *The study of spallation reactions, neutron production and transport in the targets that are suitable for neutron production in transmutations,* FMP CU Prague, 2004;
5) Ondřej Svoboda: *Determining of the neutron distribution in an assembly composed of a lead target and a uranium blanket irradiated by a proton beam with the energy of 0.7 GeV*, FNSPE CTU Prague, 2006;
6) Jitka Vrzalová: *Cross-sections of Neutron Threshold Reactions studied by activation method*, FNSPE CTU Prague, 2010;
7) Martin Suchopár: *Preparation of Neutron Field Measurements in the Surroundings of a Salt Channel Placed in the LR-0 Reactor Core by Means of Neutron Activation Analysis,* FJFI ČVUT Prague, 2010.

The list of PhD Reports counts:

8) Antonín Krása*: Neutron Production in Spallation Reactions of Relativistic Light Ions on Thick, Heavy Targets*, FNSPE CTU Prague, 2007;
9) Mitja Majerle*: Monte Carlo methods in spallation experiments*, FNSPE CTU Prague, 2008;
10) Ondřej Svoboda*: Spent Fuel Transmutation in Fission Reactors and Accelerator Driven Systems*, FNSPE CTU Prague, 2009.

There are PhD Theses of

11) Antonín Krása: *Neutron Emission in Spallation Reactions of 0.7–2.0 GeV Protons on Thick Lead Target Surrounded by Uranium Blanket*, FNSPE CTU Prague, 2008;
12) Mitja Majerle: *Monte Carlo Methods in Spallation Experiments*, FNSPE CTU Prague, 2009.

It is worth noting that at least during the last four years (2008–2011) the scientific program for students and postgraduates from the Czech Republic at JINR systematically included International Students' Summer Practical Works. Every year about 20 Czech participants took part in these events, which lasted 3 weeks and were based on modern scientific equipment of DLNP, FLNR, LRB, LHEP, FLNP.

It was mentioned at the beginning of this booklet that Prof. I. Úlehla has said: "The Joint Institute has helped educate many of our specialists not only in nuclear physics or high- and low-energy physics themselves but also in areas of mathematics, chemistry, and technology related to theoretical and experimental problems in nuclear physics." Today we can undoubtedly conclude that this very important process is still under well developing way at JINR.

4. Closing remarks

Nowadays the internal development of the modern science, in particular, the high-energy particle and nuclear physics as well as modern condensed matter and biological physics, strongly forces scientists from different countries to join their efforts in the fields.

Therefore the fields of the science inevitably acquire the international character. It is this character that over 55 years has been the main feature of JINR. The character has allowed JINR to survive and to bypass all obstacles of the “wrong” years of the last decades. Today JINR has ambitious 7-year plan for future development and the full budget to successfully fulfill it.

The Czech Republic is one of the oldest JINR Member States and simultaneously one of the most important scientific JINR partners. It is right place to repeat the important message that JINR–Czech Republic relations are very tight. Since the very beginning the Czech scientists strongly contributed to genuine development of JINR. It is impossible to overestimate the contributions of Czech academicians J. Kožešník and V.Votruba, Professors I.Úlehla, J.Tuček, Č.Šimáně, M.Gmitro, V.Petržílka, I Zvára, M. Finger and many others, who held high posts of JINR governing bodies. Many Czech physicists have started their scientific careers and have gained great experience at JINR. Today they have continued fruitful collaboration with their Dubna colleagues and share their experience in many Czech universities and institutes. One can name in the list J.Kvasil, S.Kozubek, A.Kugler, L.Majling, R.Mach, J.Pleštil, I.Procházka, I. Štekl, P.Exner, S. Pospíšil, I.Wilhelm, Z. Janout, and many others.

Furthermore, there is a group of new generation of Czech scientific leaders who were educated and matured at JINR. Among them are Prof. Richard Lednický (current JINR Vice-Director), Alojz Kovalík (current leader of the Czech national group at JINR, Deputy Director of DLNP), Rupert Leitner (Former Deputy director of DLNP; Charles Unviersity), Stanislav Pospíšil (Director of IEAP CTU, Prague), Ivan Štekl (Deputy Director of IEAP CTU, Prague), Č.Burdík, V.Brandová, and others. These people determine further development of many important scientific directions in the Czech Republic and at JINR.

One of the main goals of JINR is to educate, to mature national specialties for JINR Member States. The Czech Republic is among the leaders in this process. It is enough to note that at least during the last 3 years more than 60 Czech students have passed Students’ Summer Practice at JINR. Some of them have already defended their diploma theses on the JINR-based research. The other decided to work further at JINR for their PhD theses. During the last few years some young Czech scientists have appeared as JINR staff members at DLNP, FLNP, BLTP; the other young Czech scientists work on very tight basis with their JINR colleagues. The number of Czech staff members at JINR slowly increases and reached 17 persons in 2012 (8-9 position among all 18 JINR Member States).

The reason is clear – the JINR–Czech Republic collaboration in general runs on the right track of development in the most perspective and most important scientific directions of fundamental and applied physics. The booklet has clearly demonstrated the point.

Finally, one can see that the history of nuclear physics developments, the people relations and interests, the science preferences and ideas, the education priorities and ambitious future plans are intrinsically very common for Czech scientists and the other JINR Member State scientists and specialists. We all have already gained very good experience in the field, we do the same exciting work, and the best way is to do it further together.