Proposals of the DLNP for the 7-year scientific programme of JINR

Presented by A.S.Kurilin

June 6, 2002

Fundamental physics

- Investigation of rare physical phenomena with a view to
- checking predictions of the particle-physics Standard Model,
- searching for effects beyond the Standard Model (supersymmetries, leptoquarks, technicolour, compositeness, extra dimensions, superstrings, *etc*),
- studying the nature and properties of the neutrino (neutrinoless double beta decay, neutrino oscillations, magnetic moment of the neutrino).

(Super)high-energy physics

- Participation in the **D0** and **CDF** experiments at the Tevatron (USA) promises new important results in the field of elementary particle physics in the near future (a few years before commissioning of CERN's LHC), such as detection of the Higgs boson "invisible" at LEP, precise study of the properties of third-generation quarks, search for and possible observation of supersymmetrical particles, extra dimensions.
- Elementary particle physics investigations at the hadron-hadron collider ***LHC*** (CERN) with the universal detector ***ATLAS*** (being constructed by joint effort of four JINR Laboratories) at appreciably higher energies and measurement accuracy.
- Preparation of the research programme and the experimental facility for the linear collider of a new generation ***TESLA***. The experience and resources of the Laboratory accumulated in the course of working at the lepton collider LEP and developing detectors for the LHC will be used in this project.

Rare processes

- Noteworthy promising investigations are experiment ***E391a*** aimed at measuring the probability for the CP-forbidden ***decay of the neutral kaon into a pion, a neutrino, and an antineutrino***. Precise measurement of this quantity is very important for clarifying the nature of the CP violation and searching for manifestations of new physics.
- Other important examples of this kind of investigations are the experiment ***PIBETA*** carried out at the PSI (Switzerland) and ***aimed at measuring the charged pion beta decay probability with a record accuracy*** and studying rare pion and muon decays forbidden by the lepton charge conservation laws, *e g* ***muon-to-electron conversion with emission of gamma quanta or a massless Goldstone boson (experiment FAMILON).***
- *Theoretical and experimental investigations of rare processes in astrophysics, including those resulting from interactions of extremely high-energy neutrinos.*

Neutrino and weak interaction physics

- The projects **NEMO-3** and **TGV-2** are aimed at searching for and detecting the ***neutrinoless and two-neutrino modes of the double beta decay*** of molybdenum, neodymium, cadmium, calcium and other nuclei. A possible future increase in the active volume of the working material in these facilities (by an order of magnitude or more) will allow unique physical results in determining the mass and nature of the neutrino. *The nature of weak interaction* will be investigated by correlation methods in experiments within the framework of the project *ANCOR*.
- Measurement of the *antineutrino magnetic moment (project GEMMA)*.
- A huge potential in what concerns investigations of neutrino properties and in particular neutrino oscillations accumulated by the Laboratory in such experiments as *NOMAD* and *HARP* (CERN) will undoubtedly ensure successful participation of LNP in the new international project *OPERA for investigation of neutrino oscillations*.
- An important step in investigation of neutrino properties, search for particles of galactic dark matter, and real-time measurement of the solar neutrino flux with the minimum energy threshold will be participation of LNP in the projects *GENIUS* (and/or *MAJORANA*) with large-mass germanium detectors placed deep underground inside a large volume of liquid nitrogen.

Nuclear reaction mechanisms and nuclear structure

- The central area in current research is investigation of ***production of light mesons in proton-nucleon collisions and cumulative processes in proton-nucleus interactions*** at 0.5–2.8 GeV carried out together with German scientists at the magnetic spectrometer ANKE with using the proton beam from the synchrotron COSY (Jülich).
- It is also important for the Laboratory to continue investigation of the muon properties and muon interaction with matter and investigation of condensed matter by the muon spin rotation method both at the Phasotron and at accelerators of other scientific centres.
- Another important task of the Laboratory in the coming years is to continue investigation of the basic characteristics of mu-catalysed fusion processes in a mixture of hydrogen isotopes, including high-density tritium, with unique equipment at the JINR Phasotron.
- Investigation of ***nuclear properties by nuclear spectroscopy methods*** remain currently important and will be continued with the YASNAPP-2 complex at the Phasotron.

Methodological investigations

- Development and production of new promising materials for particle detection.
- Construction of highly sensitive new-generation detectors and detecting systems to be used in current and future experiments in the widest possible energy range.

This area is also traditional for the Laboratory. It provides a reliable basis for gaining new results at basic facilities of JINR and good prospects for participation in the most important international scientific projects and collaborations.

Accelerator physics

- Upgrading of the **phasotron** and its beam lines in 2002–2007 is aimed at ***increasing the intensity of secondary beams by a factor of 5-–10*** for experimental investigation of mu capture, study of rare decays, μSR investigation of condensed matter, investigation of pion interaction with light nuclei at low energy, *etc*.
- The project ***LEPTA is aimed at constructing an electron-cooled positron storage ring***. When constructed, the LEPTA ring will make it possible to conduct experiments on measurement of the ortho- and parapositronium lifetime, to investigate orthopositronium annihilation with violation of the CPT theorem, to carry out direct measurement of the charge difference between the electron and the positron and other experiments.
- The objective of the project DELSY is to construct a synchrotron radiation source ***DELSY (Dubna ELectron SYnchrotron)*** at JINR. The LNP plans include work on the second phase of the project aimed at constructing the storage ring. In 2002–2007 it is also planned to calculate beam dynamics in the electron synchrotron, to upgrade the magnetic elements brought from NIKHEF, and to develop diagnostics and power supply systems for DELSY

Applied research

- ***Some 50 patients are given fractional irradiation treatment on the 150-MeV proton therapy beam annually.***
- As a continuation of this work, it is planned to develop hadron therapy beams of the Phasotron for extending the possibilities of conducting medico-biological and clinical research on treatment of tumour patients. Creation of a lithium target is planned to increase the intensity of the neutron therapy beam. Considerable efforts will be directed to improvement of therapy beam diagnostics systems and first of all proton and positron tomography.
- The recently proposed project ***SAD (Subcritical Assembly in Dubna) is aimed at seeking solutions to the burning problems of energy production and nuclear waste utilization***. Within SAD a subcritical nuclear system with a combined neutron spectrum (owing to the 660-MeV proton accelerator) will be built for experiments with long-lived fission products, investigation of actinide transmutation processes, *etc*.
- Over the period 2002–2007 it is planned to work on construction of the experimental facility ***MCIRI for separation of the Ca, Nd, and other isotopes on the basis of the cyclotron resonance***.

Young generation problem

- To draw young people into science and to train them to be real scientists is of crucial importance for the future of the Institute and Russian science in general.
- The Dzhelepov Laboratory of Nuclear Problems concentrates and will concentrate close attention on this problem relying first of all on the potentialities of the ***JINR University Centre***. There are ***two chairs (of the Moscow Physico-Technical and Engineering Physics Institutes)*** working on the basis of the Laboratory. This allows students to take part in the experiments conducted at LNP and to continue education at JINR in close contact with the scientists of the Laboratory. Tentative estimations show that successful fulfilment of all tasks set to the Laboratory requires an annual influx of some 10 young people (of which less than a half will actually stay for more than a year). Yet, a mere influx of young people (or at least their flux through the Laboratory) is not enough to fulfil successfully all the tasks assigned. The problem is deeper.
- ***It comes down to the problem of skilled scientific personnel working (almost) permanently in Dubna, capable of formulating problems in modern elementary particle physics and organizing work on their solution and capable of training young scientists.***

Shortage of leaders

- Until the early 1990s the scientific potential of JINR in HEP was constantly increasing and was "reproduced" immediately in Dubna or Protvino. The level of the scientific community at JINR was generally high (regular seminars, close working contacts, *etc*). ***Young people had who associate with and learn from.***
- Now the situation is cardinally different. It is prestigious and much more profitable to work abroad. Even when staff members of the Institute leave only to take part in joint "away" experiments, their long absence from the "native home" makes the Institute substantially impoverished.
- The scientists and specialists most gifted, skilled, experienced and thus most demanded in JINR and beyond it go away ***for a long or very long time***. As a result, the scientific potential of Dubna decreases. Accordingly, attractiveness of the Institute for the member states and particularly for the scientific youths decreases too.
- To reverse the situation is undoubtedly far from being simple. What one should begin with is to realize seriousness of the problem if, of course, we do not overestimate it.