



JOINT INSTITUTE FOR NUCLEAR RESEARCH

2008-14

A. G. Olchevski

**DZHELEPOV LABORATORY OF NUCLEAR PROBLEMS:
RESEARCH ACTIVITIES IN 2007**

Report to the 103rd Session
of the JINR Scientific Council
February 21–22, 2008

Dubna 2008

The Dzhelapov Laboratory of Nuclear Problems (**DLNP**) carries out experimental research in high energy particle physics, investigation of nuclear structure and nuclear reactions, study of condensed matter properties; theoretical support of the experimental research; medico-biological investigations; development of new detector and accelerator systems as well as new experimental methods and facilities. Modern important trends in experimental astroparticle and underground physics as well as the newest and most interesting of neutrino physics topics are also under close consideration in the Laboratory.

Elementary Particle Physics

The main results of the **JINR/CDF** group in 2007 are the measurement of the top-quark mass (M_{top}) and the efficient operation of the CDF II. A contribution of principal significance to precise single M_{top} measurement in the “dilepton” mode at the integrated luminosity of 2.1 fb^{-1} , $M_{top} = 167.7 \pm 4.2(stat.) \pm 3.1(syst.) \text{ GeV}/c^2$ was made [1]. The method was updated for the top mass measurement in the dilepton decay channel. To increase the number of the selected events, the so-called lepton + track selection was used.

A new measurement of the top quark mass on the basis of dilepton events was carried out using the lepton transverse momentum information [2]. The preliminary result corresponding to the integrated luminosity of 1.8 fb^{-1} is $M_{top} = 156 \pm 20(stat.) \pm 4.6(syst.) \text{ GeV}/c^2$. The efforts of the Dubna group are focused on the efficient and stable operation of the CDF detector for the broad c,b,t quark physics study at the highest available energies.

In **2008** the CDF collaboration plans to reduce the absolute error of the M_{top} to $1.7 \text{ GeV}/c^2$, which will enable one to establish a new indirect limit on the Higgs boson mass, to continue the investigation of the role for the selection of the muon events in the region $0.6 \leq |\eta| \leq 1.0$ (this is important for the Level1 Muon trigger at the

Tevatron luminosity above $5 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$), to increase the muon trigger based data samples selection.

Within the framework of the **D0** project the first direct observation of the charged beauty baryon Ξ_b , which contains quarks from all the three generations, b, s and d, occurred [3]. The data obtained with the D0 setup of the FNAL Tevatron (USA) during the years 2002–2006 were used. 35 Millions proton-antiproton interactions at the cms energy of 1.96 TeV with muon pairs in the 2.5–3.6 GeV/c^2 mass region were analyzed. In these events, J/ψ particles and charged Ξ hyperons and antihyperons from the common secondary vertex were reconstructed. With additional cuts applied for suppressing the combinatorial background, 51 events with the effective mass of the $(J/\psi \Xi)$ system within the 5.2–7.0 GeV/c^2 mass region were detected. Their $(J/\psi \Xi)$ mass distribution has the peak (19 events) at 5774 MeV/c^2 of width 37 MeV/c^2 . The probability for such a peak to arise from background fluctuations does not exceed 3.3×10^{-8} (background level is 3.6 events). All the test samples of the events have no peculiarities within this $(J/\psi \Xi)$ mass region (Fig.1). The peak has been interpreted as the decay $\Xi_b \rightarrow J/\psi + \Xi$. The measured mass of the Ξ_b agrees with theoretical predictions.

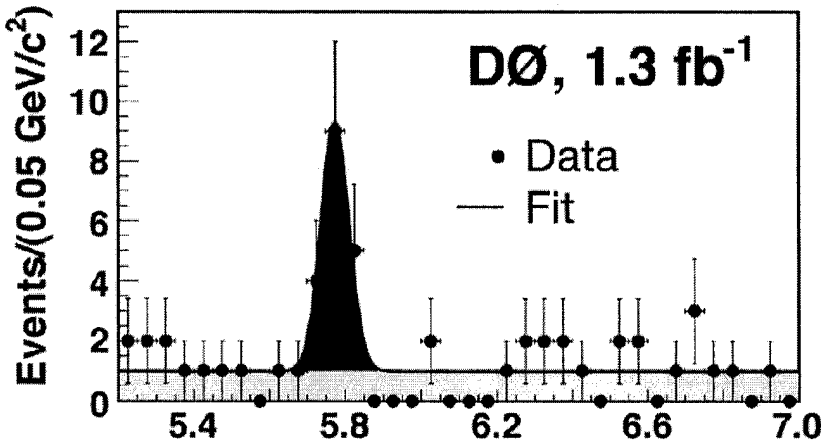


Fig.1. Event from the peak of the $(J/\psi \Xi)$ mass distribution

In 2007 the main activity under the **ATLAS** project was concentrated in the following four fields: commissioning of the ATLAS muon chambers produced in previous years at JINR and installed in 2006; preparation for the physics research after the beginning of ATLAS data taking, installation and support of ATLAS software at JINR; distributed analysis of ATLAS data based on the Grid technology and data preparation geometry description in ATLAS official software.

During 2007 all of 84 BMS/BMF muon chambers which were installed in 2005/6 were successfully integrated in the ATLAS. They passed through pretests and now are under the cosmic muon tests. The JINR group studied the possibility of precise measurement in ATLAS Drell-Yan processes both for measurements of the inclusive and differential cross sections and for ATLAS muon spectrometer calibration using the $Z \rightarrow \mu\mu$ decay. The precise measurements of this process will allow one to improve significantly the knowledge of electroweak theory and to determine precisely the LHC luminosity. As a result, the event selection procedure which is characterized by high efficiency (90%) and low background (2%) was developed. The huge statistics of this process (of the order of 10 million per year) would allow this channel to be used for the luminosity monitoring with the precision about 1% per 24 hours.

The poor knowledge of the proton structure function is the dominant source of theoretical uncertainties of predictions of almost all LHC processes. The most efficient way to improve the knowledge of the proton structure function is the precise measurement of the double differential cross section $pp \rightarrow Z \rightarrow \mu\mu$ (versus P_T and η). The procedure which allows determination of this cross section with a high (2-3 %) precision has been developed by JINR group. The precise determination of the real efficiency of the muon spectrometer is a very important task, which is vital for various precision measurements. The JINR group has developed a method in which one of the muons from the $pp \rightarrow Z \rightarrow \mu\mu$ reaction is used as a «tag», which allows determination of the spectrometer efficiency from the probability of reconstruction of the second muon. The main difficulty of this method is a low

background selection of the $Z \rightarrow \mu\mu$ events using the muon spectrometer information for only one of the two muons. The special selection procedure which provides a relatively low background level ($\sim 3.8\%$) was developed. It was demonstrated that this method allows efficiency determination with precision better than 1%.

In the beginning of 2007 the JINR storage element (SE) was integrated into the ATLAS Distributed Data Management system (DDM). In August 2007 JINR took part in the DDM functional tests. During 2007 more than 6 TB of the ATLAS data were copied to the JINR SE using the DDM (including M4 data), both via the central data distribution and by user subscriptions. After large-scaled upgrade of the JINR CCIC, the computing power increased by a factor of 7 and reached 0.6 MSi2K.

In 2008 the group plans to integrate the muon chambers into the ATLAS detector, to prepare for the physics start-up and data taking. The study of the processes with lepton pair in the final states, its application to the LHC luminosity determination and measurement of the proton structure function will be continued. Also, the distributed analysis of the data in cooperation with the ATLAS Distributed Analysis Group will be started after appropriate preparations.

Within the framework of the ATLAS TileCal electromagnetic cell level calibration constants for the TILECAL Modules at 20 and 90 degrees is performed [4]. We have determined the electromagnetic calibration constants for 11% of the TILECAL modules. In the case of the global constant this value will be $2.6 \pm 0.1\%$. The average values for these modules are 1.154 ± 0.002 pC/GeV and 1.192 ± 0.002 pC/GeV at 20 and 90 degrees for the flat filter method, and 1.040 ± 0.002 pC/GeV and 1.068 ± 0.003 pC/GeV for the fit filter method. These average values for all cells of the calibrated modules agree with the weighted average calibration constants for separate modules within the errors. The global constants which should be used for the electromagnetic calibration of the ATLAS Tile hadronic calorimeter data within ATHENA were presented. These constants are 1.15 pC/GeV in flat filter method and 1.04 pC/GeV for the fit method.

An impact of the selection criteria tested in a broad range of selection cuts has been investigated with the Geant3 simulation package for the pseudorapidities $\eta=0.35$ and 0.45 and incident energies in the range from 10 to 180 GeV [5]. From the investigation it follows that the experimentally used selection criteria have a noticeable but not critical impact on determination of the e/h ratio. At the same time it can be stated that the shift of the e/h ratio caused by the selection cuts has a negative sign, i.e. the events with higher π^0 energy are preferred by the criteria; the effect is more profound for higher incident energies; the average shift of the e/h for all incident energies and the experimentally used cuts is about -1.5% . With the MC result on the e/h shift the value of the e/h ratio can be corrected.

The production of magnetic monopoles via $\gamma\gamma$ fusion at LHC energy pp-collisions was studied [6]. On the assumption that the monopole spin is 0, $1/2$, 1, the monopole-antimonopole pair production cross section by this mechanism at LHC energies was estimated and analyzed.

In **2008** the collaboration plans to continue the hadronic calibration of the ATLAS calorimeter, the dead material energy loss studies based on the Monte Carlo hadronic calibration data, the investigation of the ATLAS Combined calorimeter performance on the basis of the experimental data for minimum-bias events, hadronic decays of τ leptons and jets and use the results of the hadronic calibrations will be used for the reconstruction of the real processes.

During 2007, the detailed physics program of the JINR group in the **BES-III** experiment was elaborated. It consists of the following topics: τ physics, QCD experimental tests two-photon physics, and charm physics and charmonium study. A possibility to studying of the Lorentz structure in lepton decays of τ , including measurement of Michel parameters and a search for the anomalous tensor coupling at BES-III, was shown. The conservative estimates based on Monte-Carlo simulation suggest that the current precision of the Michel parameters can be improved by a factor of 2-4, and the limits on the anomalous coupling constant can be improved by at least a factor of 10. Inclusion of the hadronic tau decays into the

analysis can significantly improve the precision. A detailed proposal was included in the BES-III Physics Book. Another task is the measurement of hadron spectral functions in τ decay, where BES-III could provide an independent cross-check of existing measurements.

Measurement of QCD fragmentation functions can be carried out at BES-III. The excellent particle identification at BES-III makes it possible to measure separately the fragmentation functions into pions, kaons and protons, in the new region of Q^2 . Preparation for the data analysis is under way. A study of the azimuthal correlation of two hadrons in the opposite hemispheres is also promising at BES-III. The acoplanarity of two hadrons may give access to the Collins fragmentation functions due to quark-antiquark transverse spin correlation in the process $ee \rightarrow q \bar{q} \rightarrow hhX$. A similar study, based on the 30 fb^{-1} data sample was recently reported by the Belle Collaboration. A clear non-zero effect was observed.

The study of hadron production in two-photon collisions at the BES-III is important for a number of reasons. Two-photon events with hadronic final state can act as a background for other channels studied at BES-III, and must be taken into account. However, two-photon reactions can provide interesting results as well, since the experimental knowledge of hadron production by two photons is rather poor. For example, a crucial test of chiral perturbation theory (ChPT) can be made by measuring π^0 pair production. A detailed proposal on two-photon physics based on Monte Carlo simulation was included into the BES-III Physics Book.

The JINR group works on taking into account the existing experimental knowledge of hadron production by two photons at low energies, and tries to overcome lack of theoretical description. A dedicated Monte Carlo event generator is being developed by the group to provide a reliable tool for calculating hadron production in two-photon reactions at low energies. The JINR group also studied selected decays of scalar charmoniums and D^0 . This study includes Dalitz analysis of η_c decay into $3P$ state, and measurement of branching ratios and polarisation for

η_c , χ_c , D^0 to the 2V state. The physics analysis technique is being elaborated, and specialised physics analysis tools are being developed.

Specialized analysis techniques, like partial wave analysis (PWA) and Dalitz analysis, are being studied. Two JINR workshops on BES-III physics were held in Dubna in 2007. In the second one scientists from IHEP CAS and Irkutsk University took part together with JINR physicists. The physics program of the BES-III/JINR project was reported at the 102nd Session of the JINR Scientific Council.

The JINR group participated in the development of the core off-line software. Several important components were developed, including the event mixing service and the navigation service to match reconstructed and Monte-Carlo events. The former is necessary to take into account effects of machine background in the Monte-Carlo simulation, the latter allows better understanding of the reconstruction code and performance tuning. The JINR group takes part in the development of the physics analysis tools, where several event generators are integrated into the BES-III software.

In January **2008** the BES-III setup was put into operation. A technical run with cosmic ray data taking is scheduled to last until May 2008. In August 2008 the physics data taking is planned to begin. The main task for the JINR group in the first half of 2008 is to participate in the technical run and detector calibration with cosmic rays. After the physics run starts, participation in the physics data taking and data analysis according to the BES-III/JINR physics program is the top priority for the group. Relevant theoretical studies are also necessary. Work on improvement of analysis tools and off-line software development should be continued.

The present status of the **SANC** project [7] includes theoretical predictions for practically all Standard Model (SM) $1 \rightarrow 2$ and $1 \rightarrow 3$ decays and many $2 \rightarrow 2$ processes at the one-loop precision level. SANC version v1.10 is accessible from servers at CERN <http://pcphsanc.cern.ch/> (137.138.180.42) and Dubna <http://sanc.jinr.ru/> (159.93.75.10). Within the ATLAS theme, the group continues the precision study of Drell-Yan processes [8]. The precision calculations of the

semi-leptonic decay widths of the top quark was finished [9]. The recent investigations of the SANC group are devoted to the multi-cross-channel approach to the $ffbb$ processes. It allows the results to be applied both to e^+e^- and to γe modes of a linear collider, e.g. ILC. This universal approach was originally suggested in [7] and was developed in [10, 11]. These new results were also presented at the international conference ACAT2007 [12].

During **2008** the SANC system is supposed to be extended to more complicated processes up to $1 \rightarrow 4$ decays and $2 \rightarrow 3$ processes. In particular, it is planned to complete the implementation of CC $ffbb$ processes; to include the processes $gg \rightarrow BB$, $\gamma\gamma \rightarrow BB$ ($B=\gamma, Z, H, W$), to continue creation of environment for one-loop calculations of $5 \rightarrow 0$ processes.

The main purpose of the **DIRAC** experiment is the lifetime measurement of $\pi^+\pi^-$ atoms to test low-energy QCD predictions. In 2007 the JINR group completed the setup tuning and the 5 month data taking run with the Pt target at the upgraded DIRAC setup for observation of π^+K^- and π^-K^+ atoms and lifetime measurement of the $\pi^+\pi^-$ atom. Data processing and analysis (processing of the data obtained in 2001–2003) yielded the value of the $\pi^+\pi^-$ atom lifetime with the systematic and theoretical errors at a level of 10%. The system of microdrift chambers was installed in the DIRAC setup. The scan over electronic thresholds and high voltage was performed at the current working loading rate to find the operating range and accuracy of the detector.

In **2008** the collaboration plans to install a new front-end and readout electronics for downstream detectors and new trigger electronics, increasing the Muon Detector aperture, and to perform 6 months' data taking run for improvement of the $\pi^+\pi^-$ atom lifetime, and for the first measurement of the lifetime of π^+K^- and π^-K^+ atoms.

The **TUS** space experiment is aimed to measure the energy spectrum, composition and angular distribution of the Ultra High Energy Cosmic Ray

(UHECR) at $E \approx 10^{19} - 10^{20}$ eV to study the GZK cutoff region. The TUS mission is now planned for operation at the Small Space Apparatus (SSA) separated from the main Foton-4 satellite, to be launched in 2010. The R&D stage of the TUS project was completed in 2006. In 2007 the technological prototypes of some TUS detector components were produced. Preliminary results were presented at the ICRC2007 conference in Merida Mexico [13, 14].

In the new design the mirror-concentrator consists of six Fresnel and one central parabolic mirror segments. The mirror segments will be arranged on one plane of the honey comb plastic base. The full mirror area is 2 m^2 , the focal distance is 1.5 m. The new steel mold is now under production at the DNC facility. The aim is to produce and test the technological Fresnel mirror of carbon plastic during this year. The special software package for the analysis of the ECLIPCE raw data measurements for the mirror and mold was developed.

The main aim of the **2008** year is production of the full-scale technological TUS apparatus and tests. A few Japanese and European groups joined the TUS project considered to be a pathfinder for the next-generation space fluorescent detectors for UHECR study.

The aim of the **NUCLEON** project is direct CR measurements in the energy range $10^{11} - 10^{15}$ eV and charge range up to $Z \approx 40$ in the near-Earth space to resolve mainly the “knee problem”: a change in the slope and composition of the CR spectrum from $E^{-2.7}$ to $E^{-3.0}$ at $\sim 10^{15}$ eV. Of special interest to JINR is the search for a signal of a heavy particle with $M \approx 0.5 \text{ TeV}$ as expected for the lightest and stable SUSY or WIMP particle that is needed for the dark matter understanding. The other point of interest for JINR is the precise measurements of the CR anisotropy in the knee region.

The **NUCLEON** mission is planned for operation at the COSMOS type satellite to be launched in 2009. Technological **NUCLEON** trigger modules, including FE and digital electronics of the DAQ system, were designed and

produced. The technological trigger modules were successfully tested in the 300 GeV CERN SPS accelerator pion beam [15, 16].

The main aim of **2008** is production of the flight NUCLEON apparatus. A special thermostabilized tool was designed and produced at JINR for the long-term stability test of the NUCLEON detectors at the “a la space” conditions.

Low and Intermediate Energy Physics

Measurement of the reactor antineutrino magnetic moment (NMM) is based on additional electromagnetic (EM) contribution to the standard weak (W) ν -e scattering. Experimentally, one measures the energy spectrum of electron recoil caused by both W and EM scattering of the neutrinos, the lower recoil energy T, the higher NMM sensitivity. The **GEMMA** spectrometer consists of a 1.5 kg HPGe detector surrounded with a combined active + passive shielding and placed under a 3 GW reactor 2 of the Kalininskaya Nuclear Power Plant 13.9 m away from the core center. The antineutrino flux of $2.73 \cdot 10^{13}$ $\nu/\text{cm}^2/\text{s}$ scatters weakly on the electrons of the Ge crystal, and the energy spectrum of the recoil electrons is registered. Comparing the low energy part of the spectra measured with the reactor ON and OFF, one can extract the electromagnetic contribution and thus to estimate the NMM value.

Different techniques are used to suppress the background (physical and instrumental); as a result, one succeeded in reducing the threshold to as low as 3 keV (Fig.2). Analysis of the 2005/2006 data taken for 6200 (reactor ON) and 2064 (OFF) hours allowed [17] the world’s best upper limit for the NMM: $\mu_\nu \leq 5.8 \cdot 10^{-11}$ in units of Bohr magneton (90% CL). At present, further data taking is in progress.

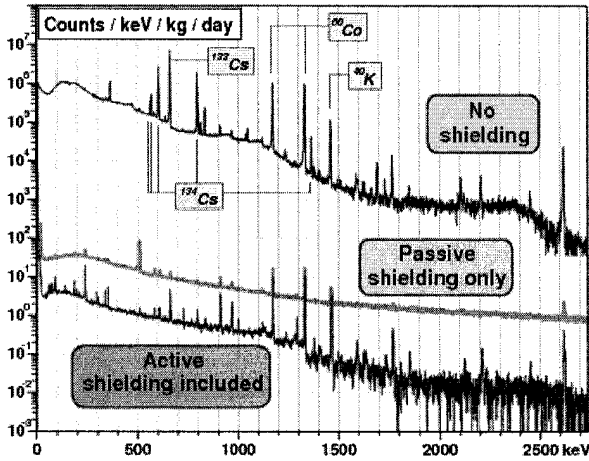


Fig.2. Background suppression with shielding

In 2008 the GEMMA II experiment will be prepared. Within the framework of this project there is a plan to use the antineutrino flux of $\sim 5.4 \cdot 10^{13} \bar{\nu}_e / \text{cm}^2 / \text{s}$, to increase the mass of the germanium detector by a factor of 4 and to decrease the background level. These measures will make it possible to achieve the NMM limit at the level of $1.5 \cdot 10^{-11} \mu\text{B}$.

Considerable progress in development of the new international GERDA (Germanium Detector Array) experiment was made in 2007. The main purpose of the experiment is to search for neutrinoless double beta decays ($0\nu\beta\beta$) of ^{76}Ge . The $0\nu\beta\beta$ decay is one of the most sensitive probes of still unknown neutrino properties such as the neutrino type and the neutrino mass scale. GERDA will operate with bare germanium detectors (enriched in ^{76}Ge) immersed in liquid argon (LAr). The experimental setup is under construction in the underground laboratory of LNGS (Italy). In Phase I the existing enriched detectors from the previous Heidelberg-Moscow (HdM) and IGEX experiments are employed, in Phase II the new segmented detectors made from recently produced enriched material will be added. To reach the background level required for Phase II ($< 10^{-3} \text{ cts/keV} \cdot \text{kg} \cdot \text{y}$) new methods have been developed to suppress the intrinsic background of the detectors.

Construction of the main experimental infrastructure started with ordering water tank and the cryogenic vessel. Welding of the vessel heads and cylindrical parts of the cryostat is under way. The existing eight enriched germanium detectors of HdM and IGEX are handled, characterized and tested, the same energy resolutions as previously are obtained. They are being refurbished for mounting in the cryo liquid. 35 kg of new enriched Ge was procured from Russia for Phase II detectors. Non-enriched and 18-fold segmented detectors were successfully tested for resolution and pulse shape analysis. Purity levels and purification techniques for liquid argon were investigated and an extensive program of radioactive purity screening of materials, which are used for detector construction is being carried out. New background suppression methods such as detector segmentation and anti-coincidence with LAr scintillation are developed. The performance of the water Cherenkov veto was studied and the main photodetector was developed. The sensitive radon detector was developed and tested in the underground laboratory. The LArGe test facility with 1 tonna of liquid argon was designed. All elements of LArGe are produced and prepared for building up [18].

Installation of the main GERDA infrastructures in LNGS will start in 2008. The first major step performed in 2007 was the mounting of the water tank base plate. Subsequently, the cryogenic vessel will be erected underground. After completion of a series of tests including leak tests and evaporation rate measurements, the water tank construction will be completed. The construction of the GERDA building with the platform supporting the clean room and lock will follow. In parallel, detector tests and background measurements with phase I detectors will be carried out in the test facility LArGe. The GERDA collaboration aims to complete the major installations in 2008 and to start detector commissioning.

The **NEMO-3** detector located in the Modane Underground Laboratory (LSM, France) is searching for the neutrinoless double-beta decay ($0\nu\beta\beta$)



which would be an indication of new fundamental physics beyond the Standard Model such as the absolute neutrino mass scale, the nature of neutrino (either Dirac or Majorana), and neutrino hierarchy. The goals of the NEMO/SuperNEMO projects are to reach sensitivities 0.2-1.0/0.04-0.1 eV for the effective Majorana neutrino mass $\langle m_\nu \rangle$ ($T_{1/2}^{0\nu\beta\beta}({}^{100}\text{Mo}) \sim 4 \cdot 10^{24} / T_{1/2}^{0\nu\beta\beta}({}^{82}\text{Se}) \sim 2 \cdot 10^{26}$ years) respectively.

In 2007 the NEMO-3 detector was taking data under conditions kept stable since February 2003. The current NEMO-3 exposure is ~ 1178 days. The detailed analysis of background components was carried out during 2007 including development of the external background model and evaluations of the following activities: ${}^{222,220}\text{Rn}$ in the tracking chamber; ${}^{210}\text{Pb}({}^{210}\text{Bi})$ on the Geiger wires; foil contaminations of ${}^{214}\text{Bi}$, ${}^{208}\text{Tl}$, and β -emitters (K, ${}^{234\text{m}}\text{Pa}$, etc.). The preliminary results were obtained for $2\nu\beta\beta$ -decay of ${}^{130}\text{Te}$ (Fig.3):

$$T_{1/2}^{2\nu\beta\beta}({}^{130}\text{Te}) = 7.6 \pm 1.5 \text{ (stat)} \pm 0.8 \text{ (syst)} \times 10^{20} \text{ y}$$

and for the $2\nu\beta\beta$ -decay of ${}^{130}\text{Mo}$ to the excited state [19]:

$$T_{1/2}^{2\nu\beta\beta}({}^{130}\text{Mo}(0^+, 1130 \text{ keV})) = 5.7^{+1.3}_{-0.9} \text{ (stat)} \pm 0.8 \text{ (syst)} \times 10^{20} \text{ y}.$$

Large-scale SuperNEMO R&D was carried out with a focus on the calorimeter design (7% FMHM @ 1MeV e^- was reached for small scintillators, a great number of tests with different scintillators (plastic, liquid, non-organic) and different PMs (sizes, quantum efficiencies, manufacturers) were performed; tracking chamber (design and tests of tracker prototypes and wiring robot); ultra-low radioactivity measurements (a BiPo-I prototype detector aimed to measure ${}^{208}\text{Tl}$ and ${}^{214}\text{Bi}$ contaminations in thin source foils with 1uBq/kg sensitivity is running in Modane), possibilities of source (${}^{82}\text{Se}$ and ${}^{150}\text{Nd}$) enrichment and purification, simulations.

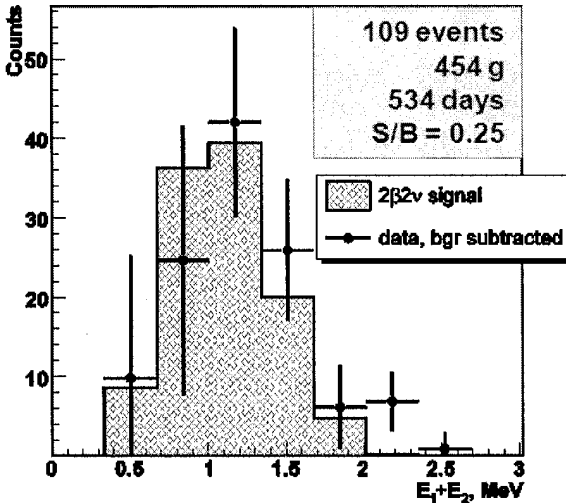


Fig.3. Signal of the $2\nu\beta\beta$ -decay of ^{130}Te from the NEMO-3 data

In 2008 the NEMO-3 collaboration will support data taking required maintenance and data analysis to be focused by publication of the results of the background studies and $2\nu\beta\beta$ -decay measurements for all isotopes installed in NEMO-3 (^{100}Mo , ^{82}Se , ^{116}Cd , ^{150}Nd , ^{96}Zr , ^{130}Te , and ^{48}Ca). The new results of $0\nu\beta\beta$ -decay search (^{100}Mo , ^{82}Se) will be obtained using the blind analysis technique. Intensive SuperNEMO R&D will be continued in all directions described in order to prepare the technical design report (TDR) by the end of 2008.

For the study of the dd reaction in the ultralow energy region the LESI collaboration proposed the method for formation of an intense deuteron beam by using the pulsed ion source with the closed Hall current. In 2006-2007 the experiments devoted to study of the dd reaction in the deuteron collision energy range 2-6 keV were carried out at SNPI TPU (Tomsk) [20]. The experimental setup includes the plasma Hall accelerator, a solid-state D_2O or CD_2 target installed in the accelerator chamber, 8 plastic counters ($100\times 100\times 375 \text{ mm}^3$) for detection of 2.5 MeV dd -neutrons, diagnostic equipment for collecting information on parameters of the accelerated-deuteron flow generation process, optical detectors and electrostatic

multigrid spectrometer of charged particles for measurement of the deuteron beam energy distribution.

There is an essential difference between the results of the *dd*-experiments with the CD_2 and D_2O targets on the one hand and the TaD, TiD targets on the other. One of the causes for this difference can be connected with electron screening of the interacting deuterons in the metallic targets saturated with deuterium. The difference is absent between our experimental *dd*-results and the data obtained by other physical groups with the D_2 gaseous target.

For testing and obtaining unambiguous information about existing of the screening effect and its value it is necessary to perform experiments with different types of targets (TaD, TiD, ZrD, CD_2 , D_2 , D_2O) and by different methods. In 2008 the collaboration plans to improve the characteristics of the Hall accelerator and diagnostics equipment and to measure the effective cross section and astrophysical *S*-factor for *pd* reaction in the collision energy region 4-12 keV with use of the Hall accelerator.

The **EDELWEISS** experiment is aimed at the searching for non-baryonic cold dark matter in the form of WIMPs. The direct detection principle consists in the measurement of the energy released by nuclear recoils produced in an ordinary matter target by elastic collisions of WIMPs from the galactic halo. The EDELWEISS detectors are cryogenic Ge bolometers with simultaneous measurement of phonon and ionization signals. A comparison of the two signals provides a highly efficient event-by-event discrimination between nuclear recoils (induced by WIMP and also by neutron scattering) and electronic recoils (induced by β or γ radioactivity). The main constraints are an extremely low event rate (<1 evt/kg/year) and a relatively small deposited energy (<100 keV).

EDELWEISS-II uses three different types of detectors: 320 g Ge/NTD, 400 g Ge/NbSi with two NbSi Anderson insulator thermometric layers for active surface event rejection that were developed within the EDELWEISS collaboration, and a new type of detectors, the 400 g Ge/NTD/INTERDIGIT recently developed for the same purpose of active surface event rejection due to a special interdigitized

electrodes scheme. EDELWEISS-II was initially funded for a 28 detector stage (21 Ge/NTD and 7 Ge/NbSi detectors). Data acquisition with this setup started in the summer 2007. Forty additional detectors (50% Ge/NbSi and 50% Ge/NTD/INTERDIGIT) will be added in two incoming years to enhance progressively the sensitivity. The EDELWEISS experiment is located in the Laboratoire Souterrain de Modane (LSM) in the Frejus Tunnel highway connecting France and Italy in the Alps. 1800 m of rock (4800 mwe) reduce the muon flux down to $4 \mu\text{m}^2/\text{day}$. The EDELWEISS-II experiment installation was completed at the end of 2005.

The Dubna team participates in the follow parts of EDELWEISS-II project: assembly and commissioning of EDELWEISS-II, data taking; low background study and development of neutron and radon detection methods; detector simulations and data analysis. To study low background at EDELWEISS-II, Dubna group builds and runs high sensitive neutron and radon detectors at underground laboratory. The neutron detector is based on special ^3He counters placed inside of a PE moderator for measurement of fast neutrons.

The results of measurements at LSM demonstrated that the average detected rate corresponding to the "neutron" peak at the ^3He counters underground was ~ 150 counts/day. Such a high rate allows efficient monitoring of neutron flux changes with time. Now these measurements continue for almost 1.5 years. The internal background rate of the detector is estimated to be below 3 counts/day from measurements performed underground with the detector placed inside the additional 30 cm shielding. As follows from the preliminary results of MC estimation of the detector efficiency, the detector has sensitivity to the neutron flux at a level of $\sim 10^{-8}$ neutrons per cm^2 per second. The Dubna group plans to build one more neutron detector with bare ^3He counters for direct monitoring of the flux of thermalized neutrons. This detector will be delivered to LSM in 2008.

The detector was delivered to the site in August 2007 and is used for continuous radon measurements in the cryostat. During the last runs, the mean phonon channel energy resolution was measured to be 2 keV while the best results

are at the level of 1.2 keV for the Ge/NTD detectors. The detectors were operated at ~ 20 mK. Work is in progress to achieve a resolution close to 1 keV for all detectors. Energy resolutions of the ionization channels were around 1.5-2 keV. Discrimination capabilities better than 99.9% are obtained for recoil energy threshold varies from 20 keV to 35 keV.

The first goal of the EDELWEISS experiment is to reach sensitivity of 10^{-7} pb with the existing detectors by summer **2008**. The next goal is to reach the sensitivity of 10^{-8} pb with the best and quicker chances of success. For this, the new detectors built with the experience obtained from NbSi runs, interdigitised electrodes detector development, and ^{210}Pb -free surfaces detector study will be used. To reach the 10^{-8} pb sensitivity, about 1200 kg.d exposure (post cuts) is required assuming no events are seen. Under progressive integration of new detectors (every 4 months) for a total mass of 16 kg (about 40 to 50 detectors), this goal can be reached by summer/autumn 2009.

The main goal of the NN project is to measure spin-dependent total cross-section differences $\Delta\sigma_L$ and $\Delta\sigma_T$ for the neutron energy 16.2 MeV. During 2007 the experimental study of the nd-scattering with polarized particles was continued at the VdG accelerator of the Charles University. The total cross section difference was measured using the classical transmission method. The polarized neutron beam incident on the polarized target was monitored by two thin scintillation detectors. Behind the target two scintillation detectors were placed to detect transmitted neutrons. All detectors are located along the beam axis.

In 2007 the DAQ, neutron detectors, and the polarized target were upgraded. For the signal processing and data acquisition the CAMAC system was used. Some modernization of the trigger and DAQ allowed approximately two-fold suppression of the gamma background. The main responsibility of the JINR LNP group was modification of the polarized target and operation of the target system during experimental runs.

In this year $\Delta\sigma_L$ measurements were carried out in October. The polarized target uses deuterated propanediol as a target material. The measurement consisted of several 24-hour runs for each deuteron spin orientation. After each run the spin of the target was reversed. During the October run over 20 000 000 raw events were collected with 5 pairs (positive and negative) of deuteron spin polarization the average negative polarization being about 34% and the average positive polarization about 28%. The expected statistical error of the $\Delta\sigma_L$ is about 60 mb. Now the data obtained are being analysed using program based on the standard physics analysis software (ROOT, etc.) and special routines for the background subtraction and cross-section determination.

For **2008** the next experimental run is planned to increase the nd interaction data accuracy.

The **GDH** project [21] covers an important spin physics problem – experimental verification of the Gerasimov-Drell-Hearn (GDH) sum rule with the new “MAMI C” accelerator stage. Measurement using the combination of the new Mainz-Dubna frozen spin target, the linearly and circularly polarized photon beam and the Crystal Ball detector will allow the determination of polarization observables with high quality.

The JINR part of the collaboration is the design and construction of the $^3\text{He}/^4\text{He}$ dilution cryostat for New Frozen-spin Polarized Proton-Deuterium Target. In accordance with our common plans this Cryostat was tested at JINR in January-April 2007 and after that was transferred to Mainz. At present this Cryostat is installed as a part of the New Polarized Target and its main parameters are under tuning now. In November 2007 stable operation of the Dilution Refrigerator at the working temperature below 30 mK was achieved.

For GDH in **2008** the collaboration plans to finish all tasks of the Dilution Refrigerator, including tests of the Superconducting Magnet, and to install it in the beam area of “MAMI-C” to make full test of the whole facility as a New Polarized Target.

Within the framework of the **PIBETA** project the final results of the analysis of the experimental data on radiative pion decay (RPD) were obtained. The decay $\pi^+ \rightarrow e^+ \nu \gamma$ was studied in three broad kinematic regions using the PIBETA detector and a stopped pion beam. The $\pi^+ \rightarrow e^+ \nu \gamma$ data set was used to extract the weak axial F_A and vector F_V pion form factors. The RPD data set was used for probing the Standard Model. As a result the amount of data acquired during the PIBETA experiment is an order of magnitude greater than those obtained in previous studies. Radiative pion events were recorded in three overlapping phase space regions (with opening angle $\theta_{e^+\gamma} > 40.0^\circ$):

$$\text{A: } E_e, E_\gamma \geq 56.0 \text{ MeV};$$

$$\text{B: } E_e \geq 20.0 \text{ MeV}, E_\gamma \geq 56.0 \text{ MeV};$$

$$\text{C: } E_e \geq 56.0 \text{ MeV}, E_\gamma \geq 20.0 \text{ MeV}.$$

To reconstruct the full response of detector the GEANT3 based simulation of the PIBETA detector was used.

The data were processed according to the following scheme. In region A, form factors do not depend on transfer momentum squared and they are insensitive to tensor interaction, which is why the axial form factor can be studied in it. For that reason, region A was used to find the axial form factor. The vector form factor was fixed at the value $F_V = 0.0259$. Region B is more sensitive to tensor interaction and it was used to analyze tensor form factors. Region C can be used to determine the dependence of the pion form factors on the transfer momentum squared to the lepton pair (parameter a)

The results of SM minimizations: $F_V = 0.0259$ is fixed, $F_A = 0.0127(7)$, $\gamma = 0.49(1)$, $a = 0.0$. A hypothetical tensor term to the decay rate amplitude resulted in the upper limit $|F_T(0)| \leq 5.1 \times 10^{-4}$ at the 90% confidence limit. This limit is more than an order of magnitude smaller than the ISTRAC collaboration re-analysis result.

The relative probability of the leptonic pion decay $\pi \rightarrow e \nu$ is planned to be measured with an accuracy 0.05–0.1%. This value is one of the most significant arguments in favor of existence of μ -e universality and confirms the V-A version of electroweak interaction. At the same time the accuracy of experimental measurements is about an order of magnitude lower than that of calculations based on the Standard Model (SM). Since one of the most important lines of investigation in model elementary particle physics is search for SM applicability limits, the proposed project is aimed at increasing the measurement accuracy of $R_{e/\mu}^{\text{exp}}$ by an order of magnitude. The measurements will be carried out at PSI by using the PIBETA facility.

It is also proposed to search for the $\mu^+ \rightarrow e^+ \gamma$ decay, violating the lepton number conservation law, with a sensitivity 10^{-14} to the main decay mode. Even non-observation of the decay at the foreseen level of sensitivity would place a stringent constraint on these theories and on the general nature of the new physics, and will thus be of crucial importance in pointing out the future directions of particle physics.

The experiment will be carried out at the π E5 beam line, PSI, providing the world's most intense beam of "surface" muons. To achieve the result, it is proposed to construct a new facility comprising detectors with the best possible resolution for both e^+ and γ . The main elements of the detector are the positron spectrometer and the photon calorimeter. This greatly decreases the flux in the detector. A completely new detector with the best possible positron and photon energy, time and position resolution for searching for the decay $\mu^+ \rightarrow e^+ \gamma$ with a relative sensitivity of 10^{-14} was tested with the beam (MEG).

In plans for **2008** include new runs for taking data on $\pi^+ \rightarrow e^+ \nu$ and $\mu^+ \rightarrow e^+ \gamma$ decays. Experimental data collected in 2007 will be processed.

Within the framework of the **SPRING** project single pion production was studied with the ANKE setup at COSY, Jülich. The differential cross section of the reaction $pp \rightarrow pp\pi^0$ was measured in the beam energy range T_p between 0.5 and 2.0 GeV at forward angles of the proton pair production $\theta_{pp}^{cm} = 0^\circ - 18^\circ$. When the

excitation energy of proton pairs $E_{pp} < 3$ MeV, such diprotons $\{pp\}_s$ are in the 1S_0 state. Therefore, the reaction $pp \rightarrow \{pp\}_s \pi^0$ is the isospin-spin partner of the kinematically analogous process $pp \rightarrow d \pi^+$, which was the subject of extensive experimental study for many years. On the contrary, for the $pp \rightarrow \{pp\}_s \pi^0$ reaction the only data away from the threshold energy region were limited to $T_p < 0.425$ GeV. Combined study of both reactions at ANKE aims to get a better insight into the reaction dynamics.

In the measured angular dependences of the cross section at the zero diproton angle a minimum is observed for $T_p \leq 1.4$ GeV whereas at 2.0 GeV a forward peaking is seen. The energy dependence of the cross section at zero degrees is shown in Fig.4. An increase in the cross section at 2.0 GeV together with a drastic change of the angular distribution form indicate transition to another reaction mechanism at energies where isobar states higher than $\Delta(1232)$ are excited. Some of the observed features are similar to those of $pp \rightarrow d \pi^+$. However, the ratio of the forward differential cross sections of the two reactions, corrected for different FSI in the relevant nucleon pairs, is very low and hence demonstrates significant suppression of the single pion production associated with a spin-singlet final nucleon pair, Fig.5. While such a suppression is known and understandable in the near-threshold and the $\Delta(1232)$ regions, its explanation at higher energies requires new theoretical investigations.

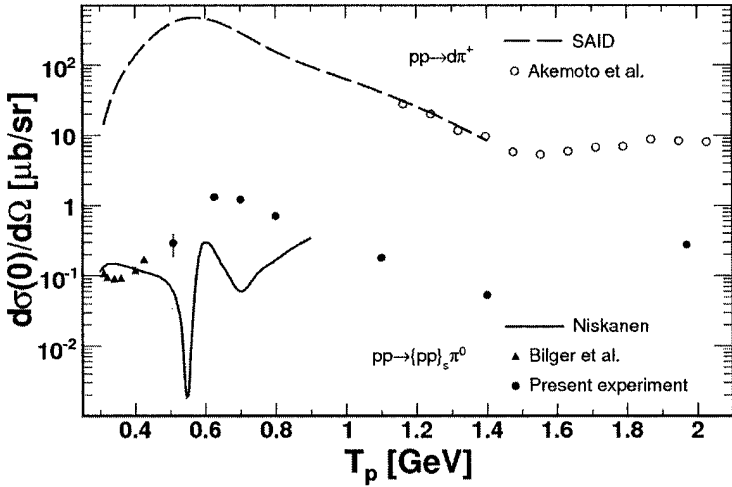


Fig.4. Differential cross section for the $pp \rightarrow \{pp\}_s \pi^0$ reaction with $E_{(pp)} < 3$ MeV. Closed circles are the ANKE result, the triangles are the CELSIUS data. The solid curve corresponds to the prediction of the J.Niskanen model. For comparison, the cross section for the $pp \rightarrow d\pi^+$ reaction is shown: the dashed curve is the SAID parametrization, open circles are the KEK results.

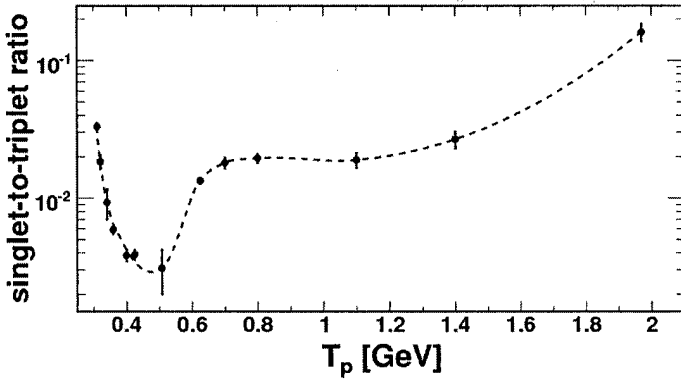


Fig.5. Energy dependence of the singlet-to-triplet ratio $|A_s|^2/|A_t|^2$ obtained from comparison of cross sections of the $pp \rightarrow \{pp\}_s \pi^0$ and $pp \rightarrow d\pi^+$ reactions. The curve is to guide the eye

All activities within the SPRING project are closely associated with a broad international cooperation and are fulfilled in the international collaborations ANKE and PAX. The closest cooperation is with the Institute of Nuclear Physics of the Research Center Julich (Germany). Furthermore, there exists cooperation with scientific centers of Italy, Georgia and other countries participating in the project PAX.

In 2008 it is planned to perform measurements of the process $p\bar{p} \rightarrow pp\pi^0$ at COSY with a polarized proton beam, to take part in the study of the reaction $\bar{d}p \rightarrow ppn$ with the use of a polarized deuteron beam and a polarized hydrogen target and in experiments on beam depolarization, which is a preparatory stage of the PAX project. Development and upgrading of the electronics and data acquisition system for the silicon detectors used in ANKE and PAX experiments will continue. The data handling and analysis will be done for the new, obtained at the end of 2007, data on the pion production reaction $pp \rightarrow (pp)\pi^0$ and other processes for the proton beam energies 0.35-2.4 GeV.

DUBTO is a joint JINR-INFN (Italy) experiment dedicated to studies of pion-nuclear interactions at energies below the Δ -resonance making use of visualization techniques such as the self-shunted streamer chamber technique, developed at JINR, and nuclear photoemulsion. The streamer chamber is filled with the working gas mixture (at present, ${}^4\text{He}+10^{-3}$ admixtures) at atmospheric pressure ($\rho_{\text{He}}^4=0.000178 \text{ g/cm}^3$) and serves simultaneously as a triggerable vertex detector and the tracking device; the chamber is situated in a magnetic field and is equipped with two CCD video cameras for registration of nuclear events occurring in the chamber volume.

The main results of the experiment include: increased statistics for determination of the branching ratios of the following two-prong $\pi^+{}^4\text{He}$ reaction channels with application of the ANN technique ($\pi^+{}^4\text{He} \rightarrow \pi^+{}^4\text{He}$, $\pi^+{}^4\text{He} \rightarrow \pi^+{}^4\text{He}+\gamma$, $\pi^+{}^4\text{He} \rightarrow \pi^+{}^4\text{He}+n$); the first observation of the reaction channel $\pi^+{}^4\text{He} \rightarrow \pi^+{}^4\text{He}+\gamma$; the first experimental evidence for excitation of the negative Δ -

resonance in the knockout of a neutron bound in the ${}^4\text{He}$ nucleus: $M_{\Delta^-}=1160$ MeV, $\Gamma/2=20$ MeV; further study of resonance behaviour of the invariant masses M_{π^+nn} and M_{π^-pp} measured in breakup reactions $\pi^{\pm 4}\text{He}\rightarrow\pi^{\pm 4}ppnn$ in helium and in nuclear photoemulsion; first direct estimation of the muon neutrino mass from a $\pi^+\rightarrow\mu^+\nu$ decay event ($m_\nu<2.2$ MeV).

In **2008** the DUBTO equipment, damaged during the fire of 9 April 2005, will be completely repaired and put into operation. Then the collaboration plans to perform runs in the pion beam of the JINR Phasotron and to continue the systematic study of elastic and inelastic pion-nucleus interactions.

The main purpose of the **MUON** project is investigation of the muon properties and muon interactions with matter. In spite of a long history of studying a wide range of impurities in semiconductors, there exist numerous problems related to the basic properties of shallow acceptor centers in semiconductors with diamond crystal structures. The capture of a negative muon by a germanium atom results in formation of a muonic atom ${}_{\mu}\text{Ga}$ imitating a gallium shallow acceptor impurity. The evolution of the polarization of μ^- in the 1S-state of the muonic atom is governed by the interaction of the muon spin with the electron shell of the muonic atom, the acceptor center (AC), and by interactions of this acceptor center with the media.

In 2007 the behavior of negative muon polarization in Ga doped germanium was studied. The concentration of gallium was about $3\cdot 10^{14}$ cm^{-3} . The observed temperature dependence of the muon spin relaxation rate and spin precession frequency shift in the external magnetic field of 2.5 kOe is shown in Fig.6.

In **2008** the next upper limit follow for the hyperfine constant A_{hf} of the interaction between magnetic moment of muon and paramagnetic electron shell of the acceptor center ${}_{\mu}\text{Ga}$ in germanium from the muon spin precession frequency shift: $A_{\text{hf}}<10$ MHz. To the best of our knowledge the hyperfine constant of Ga acceptor in germanium has not been determined until now. Further experiments in germanium with different concentration of gallium are required to find out the precise value A_{hf} and to get more detailed information on relaxation mechanisms of

the acceptor center. By determining the local magnetic fields in the sample the μ SR-method can help to understand better peculiarities magnetic phenomena in the systems containing nanomagnets

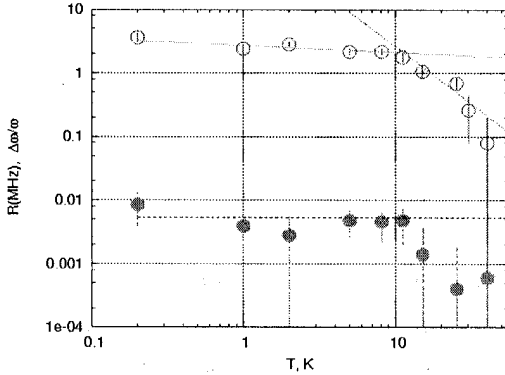


Fig.6. Temperature dependencies of the polarization damping rate (opened circles) and spin precession frequency shift (closed circles) of the negative muon in Ge

Within the framework of the **CATALYSIS** project the gamma detection system with cosmic background rejection was developed [22]. The main part of the detection system consists of two large γ detectors covering the solid angle $\approx 25\%$. They are of sandwich type (BGO+plastic) viewed by the same PMs. The BGO crystal is aimed to detect 23.8 MeV γ 's from the reaction $d(d,^4\text{He})\gamma$. The plastic scintillator casing surrounding the BGO crystal serves as an active shield against accidental radiation (mainly cosmic rays).

The pulse-shape analysis was applied to select "useful" and background events in Monte Carlo simulation using the difference in scintillation time (300 ns for BGO and 10 ns for plastic). The calculations and modeling of the main physical processes in the detectors and the target were performed (Fig.7) in order to optimize the overall geometry and to develop the design of the overall apparatus [23].

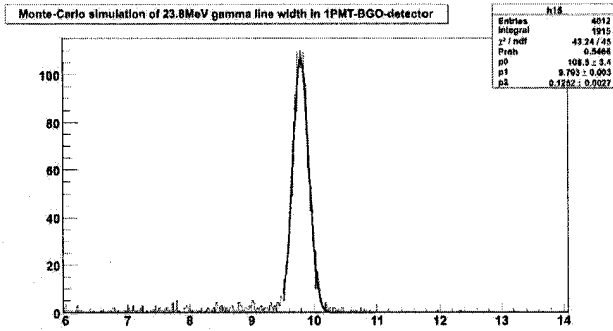


Fig.7. The result of simulation for 23.8 MeV gamma-line including selection criteria

In 2008 the collaboration plans to perform the first measurement of the rate of deuteron radiative capture from the state of the μ -molecule of deuterium. The reaction $d+d \rightarrow {}^4\text{He}+\gamma+23.8 \text{ MeV}$ belongs to the deuterium burn processes in stars and in hot plasma. The direct way of observing the p-wave channel of deuteron radiative capture is provided by Muon Catalyzed Fusion (MCF) from the bound state ($J=1$) of the muonic molecule. There is a plan to determine the rate of radiative capture using the muon beam of the JINR Phasotron with the help of the specially designed deuterium high-pressure target and a system of unique gamma-detectors within the TRITON installation. The measurements will be performed at the level of accuracy 10^{-7} with respect to the yield of the main dd-fusion channels. The expected experimental result is the direct determination of the input of a p-wave mechanism at the edge of the MCF-method accuracy.

Relativistic Nuclear Physics

In 2007 the FASA collaboration had a run on the Nuclotron to study dynamics of thermal multifragmentation in collisions of relativistic deuterons (2.5 GeV per nucleon) with a gold target. For this experiment a new counter array was

added to the FASA setup [24]. It consists of 25 telescope-spectrometers, which make it possible to measure the correlations of intermediate mass fragments (IMF). The total number of fragmentation events detected during this experiment is 10^8 . The IMF-IMF correlation data are under analysis now, it is very time consuming.

The value of the critical temperature for the nuclear liquid-gas phase transition is a crucial parameter of the nuclear equation of state. It is found to be $T_c = (19.5 \pm 1.2)$ MeV by analysis of the fissility of hot nuclei. This result is in accordance with the value obtained by the FASA collaboration from the multifragmentation data [25]. Thus, the contradictory situation in this field is resolved (see Fig.8).

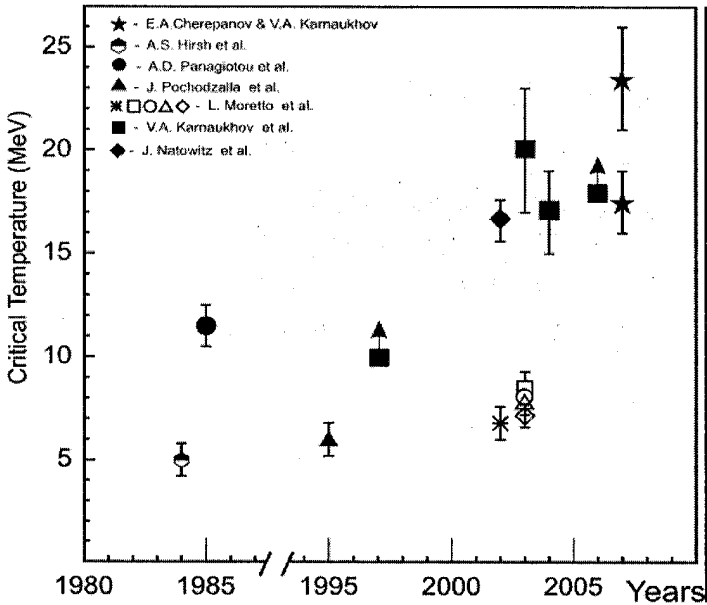


Fig.8. Experimental estimations of critical temperature for the nuclear liquid-gas phase transition. The values by the FASA collaboration are located in the upper-right corner. The values from the fragmentation study (black squares) are significantly larger than those obtained by Moretto et al. in Berkeley. This contradictory situation is resolved in favor of the Dubna results by our analysis of the fission data (stars)

It is of great interest to continue experimental to get new information on the dynamics of the thermal multifragmentation process. In 2008 the collaboration plans to have one or two runs on the Nuclotron with relativistic deuteron or ^4He beams. New measurements of IMF-IMF correlation function will be made with the specification of charges and energies of both coincident fragments. The detailed information on the total time scale of the process becomes available. The preliminarily experimental data on the existence of two sources of IMF emission exists. This hypothesis will be verified by the analysis of the correlation function in respect to the relative velocity of coincident fragments. The data analysis will be performed within the modified INC+Exp+SMM model (Intranuclear cascade + Expansion + Statistical Model of Multifragmentation).

Applied Scientific Research

The main goal of the topic **“Further Development of Methods and Instrumentation for Radiotherapy and Associated Diagnostics with the JINR Hadron Beams”** is to carry out medico-biological and clinical investigations on cancer treatment, to upgrade equipment and instrumentation, and to develop new techniques for treatment of malignant tumours and for associated diagnostics with medical hadron beams of the JINR Phasotron in the Medico-technical complex (MTC) of DLNP [26].

In January 2007 the transportation channel of the therapeutic proton beam to treatment room № 1 which had been damaged by the fire of 2005 was completely repaired. After that regular sessions of proton therapy aimed to investigate its efficiency to treat different kinds of neoplasm were resumed. The investigations were performed in collaboration with the Medical Radiological Research Centre (Obninsk) and the Radiological Department of the Dubna hospital.

During the reviewed period (January to November 2007) six treatment sessions, total duration of 25 weeks, were carried out and an extra session is

supposed to be in December. 80 new patients were fractionally treated with the medical proton beam. The total number of the single proton irradiations (fields) has exceeded 3700. Other 42 patients were irradiated with the Co-60 gamma-unit "Rokus-M" (more than 1000 fields).

Within the framework of the development and upgrading of the technical support of the 3D conformal proton radiotherapy, a "Konica Minolta" X-ray digital scanner "Rigius 170" was purchased and put into operation. It allowed significant (about 2 times) shortening of the time required to carry out verification of the patient's position in the proton treatment sessions and a simultaneous increase in its accuracy.

Radiobiological researches were also continued [27]. Earlier it was already shown that both preliminary and subsequent laser irradiation of fibroblasts led to an increase in the survival of cells damaged by ionizing radiation. Further investigation of the mechanism of radioprotective effect of 633 nm optical radiation on fibroblast cells shows that the radioprotective action of the laser radiation is transferred to the fibroblast cells according to the mechanism of the "bystander" effect via direct intercellular communication through gap junctions, as well as via medium transfer from the laser-irradiated ones to non irradiated cell population. The radioprotective action of laser radiation was also established when unirradiated cells were co-cultured with irradiated cells.

The data obtained remove the problems that in practice may arise from the large size of the surface stricken by the ionizing radiation, since they make it possible to divide this surface into segments of size $\sim 25 \text{ cm}^2$, and to irradiate only 1 cm^2 from each segment by the He- Ne laser for the sake of radioprotection.

The study of the combined action of gamma radiation and protons on mouse cells for the determination of the optimum combined irradiation regimen in radiotherapy shows that the result of combined irradiation depends on the sequence of radiation, each irradiation dose, and also on the time interval between two types of irradiation. In collaboration with the Laboratory of Radiation Biology the researches on chromosomal damages in cells were continued using the model of

human blood lymphocytes at different stages of the cell cycle after the proton beam irradiation.

In collaboration with the Laboratory of Information Technologies the work on 3D simulation and visualization of the spatial arrangement of the animal male sperm genome was continued. Several Institutes from the JINR member-states took part in the theme. In 2007 dosimetry characteristics of various kinds of thermoluminescent and track detectors were studied together with the INP (Prague, Czech Rep.), INP (Cracow, Poland) and INRNE BAS (Sofia, Bulgaria).

A set of experiments on verification of the treatment planning software algorithms of the dose field calculation using radiochromic films and anthropomorphous Alderson phantom were continued With the Great Poland Cancer Centre (Poznan, Poland). Influence of the collimator material and aperture on the shape of the clinical proton beam depth-dose distributions was studied. For small collimator apertures the shape of the depth-dose distribution is distorted especially in the collimators made of materials with large atomic number.

In 2008 the collaboration plans to continue clinical research on proton radiotherapy of different neoplasms with the JINR Phasotron beams in treatment room No 1; to test the developed technique of prostate cancer treatment with the proton beam; to develop hardware and software for verification of patient's set-up based on the X-ray digital detector; to develop the equipment for dynamic conformal irradiation of deep seated neoplasms with the proton beam; to continue studies of dosimetric characteristics of various types of thermoluminescent and track detectors at the proton beam; to study regularities of the manifestation of the adaptive response and "bystander" effect at the combined irradiation of fibroblast cells by different kinds of ionizing radiation; to continue investigation of the molecular spectra of gene mutations induced by radiation in animal and human cells. The computer simulation of the 3D genome macro architecture in the irradiated animal germ cells with the "position effect" of gene will be carried.

References

1. G. Bellettini et al. "Top Quark Mass Measurement in the 2 fb^{-1} Tight Lepton and Isolated Track Sample using Neutrino Phi Weighting Method", CDF/PHYS/TOP/GROUP/9048, 2007.
2. V. Giakoumopoulou et al. "Measurement of the top quark mass from the lepton P_t in the dilepton channel, at 1.8 fb^{-1} ", CDF/PHYS/TOP/PUBLIC/8959, 2007.
3. V.M.Abazov et al. Physical Review Letters 99 (2007) 052001
4. Y.Kulchitsky et al. "Electromagnetic Cell Level Calibration for ATLAS Tile Calorimeter Modules", ATL-TILECAL-PUB-2007-001; CERN-ATL-TILECAL-PUB-2007-001.- 82 p., CERN, Geneva.
5. J.Budagov et al. "Study of the selection criteria impact on the e/h ratio measurement in Tile Calorimeter", ATL-COM-TILECAL-2007-004; 20 Feb 2007 . 14 p, CERN, Geneva.
6. Yu. Kurochkin et al. Mod.Phys.Lett. A21, 2873-2880 (14/12/2006).
7. D.Bardin et al. Comput. Phys. Comm. 177 (2007) 738-756.
8. Andonov et al. Particles and Nuclei Letters, 6 (2007) 757-771.
9. Arbuzov et al. Eur.Phys.J.C51:585-591,2007.
10. D. Bardin et al. Eur.Phys.J.C52:83-92,2007.
11. D. Bardin et al. "Electroweak radiative to the three channels of the process $f(1) \text{ anti-}f(1) \text{ ZA} \rightarrow 0$ ". Submitted to EPJC; arXiv:0710.3083 [hep-ph].
12. D. Bardin et al. ACAT2007: XI International Workshop on Advanced Computing and Analysis Techniques in Physics Research, Amsterdam, the Netherlands, 23-27 April 2007, PoS(ACAT)077,2007.
13. L. Tkachev et al. "Status of the TUS space detector preparation for UHECR study". Proc. of the 30th ICRC, Merida, Yucatan, Mexico.
14. L. Tkachev et al. "R&D of the Fresnel optical system for the TUS space detector". Proc. of the 30th ICRC, Merida, Yucatan, Mexico.

15. А.Г. Воронин и др. ПТЭ, 2007. Т.50. N2. С.39-49.
16. А.Г. Воронин и др. ПТЭ, 2007. Т.50. N2. С.50-58.
17. A.Beda et al. Yad. Fiz. (Rus.) 70 (2007) 1, [hep-ex/0705.4576].
18. L. Pandola et al. NIM A 570 (2007) 149-158.
19. R.Arnold, and the NEMO Collaboration, Nucl.Phys. A781, 209 (2007).
20. V.M. Bystritsky et al. Proceedings of the International Conference on Muon Catalyzed Fusion and Relative Topics, MCF-07, Dubna, Russia, 18-21 June, 2007.
21. Usov Yu. "The Cryostat for Mainz University", JINR NEWS, 3/2007.
22. D.L. Demin et al. Status of the dd-gamma experiment, Proc. MCF-07, 18-21 June 2007, Dubna, Russia.
23. V.P. Volnykh. Application of GEANT4 toolkit in dd-gamma experiment in Dubna, Proc. MCF-07, 18-21 June 2007, Dubna, Russia.
24. В.В. Киракосян и др., ПТЭ №1(2008) 1.
25. V.A. Karnaukhov et al. Critical Temperature for the Nuclear Liquid-Gas Phase Transition (from Multifragmentation and Fission), submitted to Phys.Rev. C (see also arXiv:nucl-th/070310v1 2007).
26. Молоканов А.Г. Формирование глубинного дозного распределения радиотерапевтического протонного пучка фазотрона ЛЯП ОИЯИ. Сообщение ОИЯИ Р-18-2007-90, Дубна, 2007.
27. К. Ш. Восканян, Г. В. Мицын, В. Н. Гаевский. Радиозащитное действие излучения гелий-неонового лазера на клетки фибробластов. Авиакосмическая и экологическая медицина, 2007, № 3, с.32-35.

Отпечатано методом прямого репродуцирования
с подготовленного лабораторией оригинала.

Макет *Т. Е. Попеко*

Получено 5.02.2008. Подписано в печать 6.02.2008.
Формат 60 × 90/16. Бумага офсетная. Печать офсетная.
Усл.-печ. л. 2,25. Уч.-изд. л. 2,37. Тираж 115 экз. Заказ № 56050.

Издательский отдел Объединенного института ядерных исследований
141980, г. Дубна, Московская обл., ул. Жолио-Кюри, 6.
E-mail: publish@jinr.ru
www.jinr.ru/publish/