

**THE NATIONAL ACADEMY OF SCIENCES OF BELARUS**



# **PROGRAM & ABSTRACTS**

## **BelINP-2017**

**1<sup>st</sup> International Symposium  
«Integration of Belarusian scientists  
in the research programs of the  
world's leading nuclear physics centers»**

**ICRANet-Minsk Workshop**

**User Meeting on Neutron Technics**



**YEAR  
OF SCIENCE  
2017**

**Minsk, 2017**

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of NAS of Belarus

# **PROGRAM**

## WEDNESDAY, APRIL 26<sup>th</sup>

Presidium of the National Academy of Science of Belarus  
Nezalezhnasci Ave., 66

**09.00-11.00** *Registration (lobby of the Presidium)*

### MORNING SESSION

#### Opening Ceremony

*(Large Conference Hall)*

*Chair: Sergei Kilin*

**11.00-11.10 Vladimir Gusakov** (Chairman of NASB Presidium),  
Welcome speech

**11.10-11.20 Alexander Shumilin** (Chairman of the State  
Committee of Science and Technology of the Republic of Belarus),  
Welcome speech

**11.20-11.30 Sergei Kilin** (Vice Chairman of NASB Presidium),  
Welcome from the Program Committee, Cooperation in nuclear  
physics: history, achievements and future

**11.30-12.10 Remo Ruffini**, Welcome from the ICRANet and  
public lecture

**12.10-12.40 Richard Lednicky**, JINR Cooperation with Belarus

*Joint photo of the Symposium*

**13.00-14.00** *Lunch*

**WEDNESDAY, APRIL 26<sup>th</sup>**

Presidium of the National Academy of Science of Belarus

**AFTERNOON SESSION****New demands, new frontiers in nuclear research**

*(Large Conference Hall)*

*Chair: Valentin Orlovich*

**14.00-14.30 Klaus Peters**, Studies of Hadron Structure and Dynamics with PANDA at FAIR

**14.30-15.00 Yuri Potrebenikov**, The international mega-science project NICA at JINR

**15.00-15.30 Alexander Milstein**, High-energy physics at Budker Institute of Nuclear Physics

**15.30-16.00** *Coffee break*

**16.00-16.30 Roberto Tenchini**, The High Energy frontier in the next twenty years and more

**16.30-17.00 Tomofumi Nagae**, Strangeness Nuclear Physics at J-PARC

**17.00-17.30 Peter Geltenbort**, ILL - the World's Flagship Centre for Neutron Science

**18.30-21.30** *Conference dinner*

**THURSDAY, APRIL 27<sup>th</sup>**

Presidium of the National Academy of Science of Belarus

**MORNING SESSION****1****Searching for cutting edge tasks for experiments in particle and high energy physics, development of the theory***(Room 216)**Chair: Yurii Kurochkin***9.00-9.30** **Viacheslav Kuvshinov**, New Experimental and Theoretical Tasks in Modern Particle and Nuclear Physics**9.30-9.50** **Viktor Tikhomirov**, Crystal applications in high energy physics for new phenomena observation and acceleration technology development**9.50-10.10** **Juozas Vaitkus**, The collaboration of Lithuania and CERN**10.10-10.30** **Alexander Pankov**, Prospects for identifying new physics scenarios at the CERN LHC**10.30-10.50** **Yurii Kurochkin**, Development of the model of hadrons as Coherent states on the horosphere of the Lobachevsky momentum space**10.50-11.20** *Coffee break***New detecting and accelerating technologies. Instrumentation for experiments at accelerators***(Room 216)**Chair: Mikhail Korjik***11.20-11.40** **Rainer Willi Novotny**, Crystals for Calorimetry: From TAPS to PANDA

**11.40-12.00 Kai-Thomas Brinkmann**, Hardware for the PANDA Detector at the FAIR Facility

**12.00-12.20 Hans-Georg Zaunick**, Construction and Assembly of the first slice segment for the PANDA-EMC

**12.20-12.40 Valery Dormenev**, PWO crystals for precise calorimetry at PANDA Experiment

**12.40-13.00 Valery Kozhemyakin**, Modern technologies and devices in nuclear instrumentation

## MORNING SESSION

### 2

#### ICRANet-Minsk Workshop

*(Room 100a)*

*Chair: Gregory Vereshchagin*

**9.00-9.50 Marco Muccino**, What can we learn from Gamma-Ray Bursts?

**9.50-10.40 Yerlan Aimuratov**, GRB 120729A and Sub-Class of S-GRBs: Phenomenological Approach

**10.50-11.20** *Coffee break*

#### ICRANet-Minsk Workshop

*(Room 100a)*

*Chair: Gregory Vereshchagin*

**11.20-12.10 Alexey Aksenov**, Numerical simulations of the gravitational core collapse and Supernova

**12.10-13.00 Stanislav Komarov**, Redshift of a finite - size object that moves in external Schwarzschild gravitational field

**13.00-14.00** *Lunch*



**AFTERNOON SESSION****1****JINR-Belarus joint research***(Room 216)**Chair: Vladimir Baryshevsky*

**14.00-14.30** **Sergei Maksimenko**, Belarus science and engineering in JINR: current status

**14.30-14.50** **Sergei Kulikov**, Development of neutron detectors for the spectrometers of the IBR-2 reactor (in Russian)

**14.50-15.10** **Stanislav Pakulyak**, JINR training programmes

**15.10-15.30** **Sergey Tyutyunnikov**, Study of interaction relativistic beams with deep subcritical systems

**15.30-16.00** *Coffee break*

**JINR-Belarus joint research***(Room 216)**Chair: Yuri Potrebenikov*

**16.00-16.30** **Yuri Kulchitsky**, Soft-QCD physics with experiment ATLAS at LHC

**16.30-16.50** **Juan Suarez Gonzalez**, The Institute for Nuclear Problems BSU in High Energy Physics Projects

**16.50-17.10** **Valery Shalyapin**, EXAFS Spectroscopy on the Kurchatov Source of Synchrotron Radiation

**17.10-17.30** **Elena Kokoulina**, High multiplicity study in hadron and nuclear interactions at LHEP of JINR

**17.30-17.50** **Dmitriy Maltsev**, Material science approaches to the problem of VVER-1000-type reactors lifetime extension

**17.50-18.10** **Mikhail Batouritski**, JINR cooperation with Belarus in the field of superconducting resonators (in Russian)

## AFTERNOON SESSION

### 2

#### **New detecting and accelerating technologies**

*(Room 100)*

*Chair: Alexander Lobko, Viktor Tikhomirov*

**14.00-14.20 Marco Lucchini**, Precision timing technologies for future detectors at collider experiments

**14.20-14.40 Sergei Tikhomirov**, New time-resolved detection technologies based on ultra-fast non-linear optical processes

**14.40-15.00 Mikhail Korjik**, New Detecting Materials and Technologies for Future HEP Experiments

**15.00-15.20 Oleg Boyarkin**, Searching for the New Physics signals at neutrino telescopes

**15.30-16.00** *Coffee break*

#### **New detecting and accelerating technologies**

*(Room 100)*

*Chair: Sergei Tikhomirov, Jouzas Vaitkus*

**16.00-16.20 Valentin Gilewsky**, Antineutrino detector for Belarus NPP

**16.20-16.40 Viktor Tikhomirov**, Optimization of the betatron-based X-ray sources

**16.40-17.00 Alexander Silenko**, Quasimagnetic resonance in storage ring electric-dipole-moment experiments

**17.00-17.20 Alexander Lobko**, Optimisation of LYSO-based cell of electromagnetic calorimeter (COMET experiment, KEK, Japan)

**17.20-17.40 Petr Evtoukhovitch**, International Projects at J-PARC

**AFTERNOON SESSION****3****ICRANet-Minsk Workshop***(Room 100a)**Chair: Marco Muccino*

**14.00-14.50** **Kuantay Boshkayev**, I - Love - Q relations in white dwarf stars

**14.50-15.30** **Linnea Hjalmarsson**, TBD

**15.30-16.00** *Coffee break*

**ICRANet-Minsk Workshop***(Room 100a)**Chair: Marco Muccino*

**16.00-16.50** **Ivan Rybak**, Evolution of cosmic topological defect networks

**16.50-17.40** **Sergey Cherkas**, Matter creation and anisotropy of the CMB background in the alternative inflation - less cosmologies

**POSTER SESSION**  
**THURSDAY, APRIL 27<sup>th</sup>**

(Lobby of Presidium)

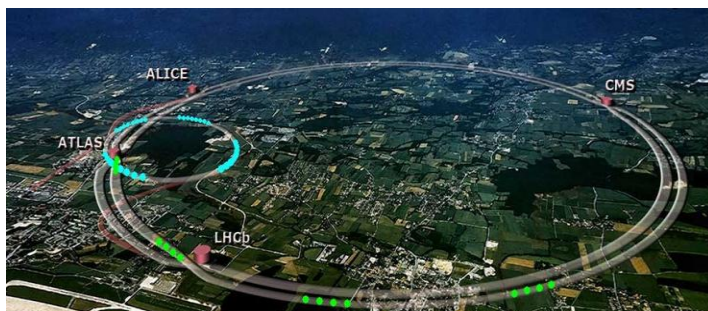
**18.00-19.00**

- 1 **Dzmitry Shoukavy, Sergei Andrukhovich**, Submersible in situ gamma-spectrometer for radioactivity measurement in the water environment
- 2 **Igor Zhuk**, Solid-state nuclear track detector technique and accelerator-driven systems. Joint research of JINR (Dubna) and JIPNR - SOSNY (Minsk). (in Russian)
- 3 **Inna Serenkova**, Physics studies: phenomenology of the Standard Model and beyond at the Large Hadron Collider
- 4 **Kristina Makarevich**, Monte-Carlo method for radiation shielding in medicine(in Russian)
- 5 **Krystsina Usheva**, Features of modelling and calculation of two-group cross-sections for neutron reflector of VVER nuclear reactor core in DYN3D code (in Russian)
- 6 **Sergei Grishin**, Creation and application of hardware-software complex for on-board charged particles spectrometer testing
- 7 **Artem Kozlovskiy**, Study of the development possibility of protective screen surface from cosmic radiation by using nanostructures based on d - metals
- 8 **Yulia Aleksiyaynak**, Analytical investigations at the reactor IBR-2
- 9 **Hien Le**, On distribution of ionization amplitudes of fission ionization chamber (in Russian)
- 10 **Viktor Andreev**, Constituent quark masses in Poincare-invariant quantum mechanics
- 11 **Andrei Manko**, The next-to-leading production hadron by pomeron mechanism
- 12 **Ekaterina Efimova**, A combined X-ray powder diffraction and EXAFS study of LaCoO<sub>3</sub>

- 13 **Andrey Terletskiy**, Multi-channel ADC electronics and DAQ of BM@N setup (in Russian)
- 14 **Viktor Red'kov, Elena Ovsiyuk**, Lobachevsky geometry and cosmological potential barrier with mirror properties
- 15 **V. Kalinnikov, E. Velicheva, I. Khodasevich, A. Grabtchikov**, Experimental measurements of spatial distribution for luminescence signal of cerium ions in GSO:Ce scintillator
- 16 **Philip Speransky**, Modeling and optimization of a wide aperture fourier high-resolution neutron diffractometer as a system of independent detectors (in Russian)
- 17 **Olga Solovtsova**, Manifestation of Quark-Hadron Duality in Electron-Positron Annihilation



**Poster exhibition of CERN, the European Organization for Nuclear Research, will be organized in the lobby of Presidium of the NAS of Belarus**



**FRIDAY, APRIL 28<sup>th</sup>**

Presidium of the National Academy of Science of Belarus

**MORNING SESSION****1****Computing technologies and data processing***(Room 216)**Chair: Michael Levchuk*

**9.00-9.30** **Mikhail Galynskii**, Alternative way to understand the unexpected results of the JLab polarization experiments to measure the Sachs form factors ratio

**9.30-10.00** **Mikhail Sergeenko**, Saturating Regge Trajectories in describing data from Jefferson Lab and LHC

**10.00-10.30** **Efrem Soukhovitski**, Cooperation in Development of the OPTMAN Code for Predictions of Optical Cross-Sections with Guaranteed Accuracy Based on Sophistications of Nucleon-Nucleus Interaction Theory

**10.30-10.50** **Andrei Tsytrinov**, Determination of Higgs boson spin in the diphoton channel with ATLAS data at LHC

**10.50-11.20** *Coffee break*

**Radiation technologies. Technical and research capabilities of Belarusian nuclear physics R&D organizations***(Room 216)**Chair: Andrei Kuzmin*

**11.20-11.50** **Igor Tarutin**, Current Technical State of Radiation Therapy and Nuclear Medicine in Belarus (in Russian)

**11.50-12.10** **Onur Karaman**, Neutron Contamination in 18 MeV Medical Linear Accelerator

**12.10-12.30** **Hanna Kiyavitskaya**, YALINA Subcritical Facility

## MORNING SESSION

### 2

#### **User Meeting on Neutron Technics**

*(Room 100)*

*Chairs: Valentin Orlovich, Jerome Beaucour*

- 9.00-9.30**     **Peter Geltenbort**, Nuclear and Particle Physics with Neutrons at the Institut Laue Langevin
- 9.30-9.45**     **Mikhail Korjik**, Scintillating Materials for Neutron Registration in a Wide Energy Range
- 9.45-10.00**    **Svyatoslav Sikorin, Andrei Kuzmin**, In-Pile and Out-of-Pile Tests and Researches on Fast Critical Assembly of High Density Uranium Carbonitride LEU Fuel
- 10.00-10.20** **Trevor Forsyth**, Neutron for Biology
- 10.20-10.40** **Natallia Strushkevich**, Structural biology of hemeproteins: X-ray limitations

**10.50-11.20** *Coffee break*

#### **User Meeting on Neutron Technics**

*(Room 100)*

*Chairs: Sergei Kilin, Trevor Forsyth*

- 11.20-11.40** **Jerome Beaucour, Duncan Atkins, Nikolai Kardjilov, Alessandro Tengtini**, Neutron Imaging for Engineering and Archaeology
- 11.40-12.00** **Alex Trukhanov**, Features of crystal structure and dual ferroic properties of the substituted M-type hexaferrites
- 12.00-12.20** **Alexander Petrov**, Double perovskite metal-oxide ferrimagnetics as prospective materials for spintronics
- 12.20-12.40** **Vadim Lakiza, Vadzim Koshman, Sergey Linevich, Andrey Likhachev**, Archaeological Investigations in Belarus (on Example of Cooperation of ILL, NASB, Society of Napoleonian Investigations (France) and Diving-Centre «Sea

Pegas» (Belarus)): Materials, Interpretation, Achievements, Perspectives

**12.40-12.50 User Meeting Closing**

## MORNING SESSION

### 3

#### **ICRANet-Minsk Workshop**

*(Room 100a)*

*Chair: Kuantay Boshkayev*

**9.00-9.50 Gregory Vereshchagin**, Cosmic horizon for GeV sources and photon-photon scattering

**9.50-10.40 Ivan Siutsou**, Anisotropy of optical depth in relativistically moving media and its implications to GRB emission

**10.50-11.20** *Coffee break*

#### **ICRANet-Minsk Workshop**

*(Room 100a)*

*Chair: Kuantay Boshkayev*

**11.20-12.10 Yuri Vyblyi**, Dark Energy and Scalar-Tensor Theories of Gravitation

**12.10-12.50 Alexander Silenko**, Classical and quantum dynamics of spinning particles with dipole moments: Towards astrophysical applications

**12.50-13.00** *Symposium Closing (Room 216)*

**13.00-20.00** *Excursion to Dudutki museum*



# **ABSTRACTS**

## **Study of the development possibility of protective screen surface from cosmic radiation by using nanostructures based on d - metals**

*Artem Kozlovskiy*

Institute of nuclear physics (Kazakhstan, Astana)

One of the actual challenges facing the developers of specialized equipment (aircraft, rocket and space technology) is to ensure high levels of operational reliability of devices and equipment under conditions of increased level of radiation effects of various types (electrons, protons and heavy charged particles, X-ray and gamma radiation). It is known that absorbed radiation doses must be equal or higher than  $10^5 \div 10^6$  rad to irreversible changes occur in the semiconductor microelectronic devices, in integrated circuits -  $10^4 \div 10^5$  rad. Currently, the problem of the radiation resistance growth is achieved in several ways: technological (the use of specialized processes and materials during the production of on-board equipment and integrated circuits), constructive - specialized trunks, local security techniques of circuit - tripling-multiplexing methods and radiation-induced defects simulation methods at the design stage of the integral chips.

In this work, we have considered obtaining a multi-layer and composite film materials based on different magnetic and non-magnetic metal subgroups, studied their physical and chemical properties, as well as conducted a theoretical calculation of the mean free path and determined the absorption efficiency based on the heavy ions screening experimental data.

## **New Experimental and Theoretical Tasks in Modern Particle and Nuclear Physics**

*Viacheslav Kuvshinov*

The Joint Institute for Power and Nuclear Research – Sosny (Belarus, Minsk)

1- QCD:

-Quark colour dissipation, instability of motion and stabilization by Higgs-boson; order-chaos transition;

-Squeezed and entangled states in jets;

-Strong instantons

2- QED:

-Luminosity for photon colliders ( $\gamma e^-$  and  $\gamma\gamma$ -collisions) taking into account the nonlinear contributions in the inverse Compton scattering;

-Polarization of colliding electrons and photon of laser wave; parameters of beams for effective boson Higgs investigation;

-Modernization of generator  $\omega$  by the advantages of diagonal spin bases in which spin 4-vectors of fermions are expressed via their 4-momenta.

Antineutrino detector for Belarus NPP.

## **New Detecting Materials and Technologies for Future HEP Experiments**

*Mikhail Korjik*

Institute for Nuclear Problems Belarus State University (Belarus, Minsk)

Presentation gives a review of the last results on the development of new materials and detecting techniques for application in high energy physics experiments. These materials and detecting techniques have to survive in the harsh irradiation environment at experimental facilities of forthcoming High Luminosity LHC and future FCC. A combining approach to select scintillation materials to operate in different parts of the detectors, particularly end cap parts and forward calorimeters is considered.

## **Crystals for Calorimetry: From TAPS to PANDA**

*Rainer Willi Novotny*

2nd Physics Institute, Justus-Liebig University Giessen (Germany, Giessen)

Organic and inorganic scintillators are among the most common used detector materials and concepts in nuclear, medium and high energy physics as well as many fields of application such as medical tomography. The development of high quality new scintillator materials has a long

history in the collaboration between the Justus-Liebig-University and the RINP at Minsk. In the revue of the last decades several new materials have been elaborated, charcterized and applied in several test experiments or operating detector systems. The report will focus on the optimization and application of lead tungstate down to very low energies, a general study of the mechanisms of radiation damage and a possible recovery in-situ as well as the search for alternative materials to become less sensitive to damage caused by high energetic hadrons. Many developments have been directly triggered by the experience with the operating calorimeter TAPS and the R&D for the future calorimeter of the PANDA detector at FAIR.

## **Optimization of the betatron-based X-ray sources**

*Viktor Tikhomirov*

Institute for Nuclear Problems Belarus State University (Belarus, Minsk)

Coauthors: *D.V. Pozdnyakov, V.N. Linev, K.V. Sosenko*

ADANI (Belarus, Minsk)

X-ray introscopy is an effective method of volumetric cargo inspection. Along with linear accelerators betatrons can be used for X-ray generation in introsopic cargo systems. Wide prospects of the latter make it vital to increase betatron efficiency, manufacturability and durability. To pursue this goal both new technology of betatron electron injector manufacturing and X-ray generation target materials are investigated. High-temperature ceramics with conducting electrode sputtering instead of tantalum tin has been considered as injector material. An electron emitting wire spiral from W with 2% CeO<sub>2</sub> was assumed to be long enough to apply a two-dimensional injector model formulated in the plane normal to the spiral and parallel to the betatron electron orbit. A usual rectangular greed was used for Poisson equation numerical integration, while inclined segments of injector surface intersections with the orbit plane were approximated by the step-wise broken lines. To make the numerical integration stable at the large ceramic dielectric constant, sharp dielectric surfaces have been smeared by the transition layers for the dielectric constant increase. An implicit integration scheme assured both high precision and stability of the solution process at small number of iterations at each time step. The

resultant electron flow space and angular distributions made it possible to find the ceramic injector configurations providing a high electron emission in a narrow angular region in the absence of the ceramic surface irradiation by electrons. Tungsten targets, usually having 0.5–1.5 mm thicknesses, are all over used for X-ray emission by accelerated electrons. Since both the electron deceleration and X-ray quantum absorption strongly and in different way depend on the target material atomic number, the elements with the highest available atomic numbers, such as tantalum, platinum and iridium, worth to be considered as a possible target material. It was found that the application of platinum or iridium target both increases the X-ray flux and reduces the thickness at which the latter reaches its maximum from 1.5 to 1 mm. The electron flux behind the target, which could harmfully irradiate the ceramic injector, is also reduced therewith.

## **High multiplicity study in hadron and nuclear interactions at LHEP of JINR**

*Elena Kokoulina*

Joint Institute for Nuclear Research (Russia, Dubna)

The main results of high multiplicity events study at LHEP of JINR are presented: the measurement of topological cross-sections at the high multiplicity, the evidence of pionic (Bose-Einstein) condensation formation for total high multiplicity, excess of soft photon yield in nuclear interactions and other interesting phenomena studying of SVD-2 Collaboration.

## **Quasimagnetic resonance in storage ring electric-dipole-moment experiments**

*Alexander Silenko*

Research Institute for Nuclear Problems, Belarusian State University (Belarus, Minsk), Joint Institute for Nuclear Research (Russia, Dubna)

A general theoretical description of a magnetic and a quasimagnetic resonance is presented. This description is necessary for a detailed

analysis of spin dynamics in electric-dipole-moment experiments in storage rings. General formulas describing a behavior of all components of the polarization vector at the magnetic resonance are obtained for an arbitrary initial polarization. These formulas are exact on condition that the nonresonance rotating field is neglected. Quasimagnetic resonances for particles and nuclei moving in noncontinuous perturbing fields are considered. Distinguishing features of quasimagnetic resonances in storage ring electric-dipole-moment experiments are investigated in detail. The exact formulas for the effect caused by the electric dipole moment are derived. We find and calculate for the first time the difference between the resonance effects conditioned by the rf electric-field flipper and the rf Wien filter. Main systematical errors are considered.

## **Lobachevsky geometry and cosmological potential barrier with mirror properties**

*Viktor Red'kov*

B.I. Stepanov Institute of Physics NAS of Belarus (Belarus, Minsk)

Coauthor: *E.M. Ovsiyuk*

I.P. Shamyakin Mozyr State Pedagogical University (Belarus, Mozyr)

Recently it was shown that Lobachevsky geometry simulates an ideal mirror, distributed in the space. The penetration depth of the field in a such medium increases with increase of the energy of the field. Also, it depends on the curvature radius of the Lobachevsky space. Since Lobachevsky model enters some cosmological models of the Universe, by using theses models we need to take into account the presence of the «cosmological mirror». It effectively should lead to a redistribution of the density of particles in the Universe. The earlier analysis assumed a static character of the space-time geometry. In this report, the generalization to the oscillating de Sitter Universe is given for the scalar and spinor fields. It is shown that the vanishing factor in the metric of space-time does not lead to a singular behavior of solutions of the wave equation for the scalar field, instead solutions have simple phase factor behavior in the time variable  $t$ , so the squared modulus of the wave function at turns to be 1.

## **Classical and quantum dynamics of spinning particles with dipole moments: Towards astrophysical applications**

*Alexander Silenko*

Research Institute for Nuclear Problems, Belarusian State University (Belarus, Minsk), Joint Institute for Nuclear Research (Russia, Dubna)

Coauthors: *Y.N. Obukhov*

Nuclear Safety Institute (Russia, Moscow)

*O.V. Teryaev*

Joint Institute for Nuclear Research (Russia, Dubna) and National Research Nuclear University "MEPhI" (Russia, Moscow)

Quite generally, astrophysical conditions are characterized by the simultaneous presence of strong gravitational and electromagnetic fields of different (usually nonstatic or nonstationary) configurations. To understand the physical processes in these conditions, it is important to explore the motion of fermion particles (electrons, protons, neutrons, neutrinos) in these fields. We study the quantum dynamics of spinning particles with dipole moments in the framework of the general-relativistically covariant Dirac theory, and construct the exact Foldy-Wouthuysen transformation for the most general case of a fermion in arbitrary strong gravitational and electromagnetic fields. Quantum and quasiclassical equations of motion are derived and a complete consistency of the quantum and classical dynamics is demonstrated. Applications to the case of the external wave configurations are discussed.

## **Measurement of Neutron contamination in 18 MV Medical Linear Accelerator**

*Onur Karaman*

Akdeniz University, Health Services Vocational School, Antalya  
(onurkaraman@akdeniz.edu.tr)

Coauthor: *A.Gunes Tanir*

Gazi University, Faculty of Science, Department of Physic, Ankara

Electron Linear Accelerators (linacs) used in radiotherapy treatments produce undesired photo-neutrons when they are operated at energies

above 10 MeV. However, the unwanted photo-neutrons production can contribute to the dose delivered to the patients during treatments. Neutron contamination contributes to the risk of secondary malignancies in patients. So, it is important to determine neutron dose during radiotherapy treatment. In this study, it is aimed to investigate the effect of field size, distance from axis and depth on the amount of in-field and out-field neutron contamination using ElektaVmat accelerator with 18 MV energy. The neutron spectra at the distance of 75, 150, 225, 300 cm from target and on the isocenter of beam were scored for 5x5, 20x20 and 40x40 cm<sup>2</sup> fields. Results demonstrated that the neutron spectra and dose are dependent on field size and distances. Beyond 225 cm of isocenter, the dependence of the neutron dose on field size is minimal. It is concluded that as the open field increases, the neutron dose decreases. It is important to remember that when treating with high energy photons, the dose from neutrons must be considered.

## **Alternative way to understand the unexpected results of the JLab polarization experiments to measure the Sachs form factors ratio**

*Mikhail Galynskii*

The Joint Institute for Power and Nuclear Research – Sosny (Belarus, Minsk)

E.A. Kuraev

Joint Institute for Nuclear Research (Russia, Dubna)

In the one-photon exchange approximation we discuss questions related to the interpretation of unexpected results of the JLab polarization experiments to measure the Sachs form factors ratio  $G_E/G_M$  in the region  $1.0 \leq Q^2 \leq 8.5 \text{ GeV}^2$ . For this purpose, we developed an approach which essentially is a generalization of the constituent-counting rules of the perturbative QCD (pQCD) for the case of massive quarks. We assume that at the lower boundary of the considered region the hard-scattering mechanism of pQCD is realized. Within the framework of the developed approach we calculated the hard kernel of the proton current matrix elements  $J_p^{\pm\delta,\delta}$  for the full set of spin combinations corresponding to the number of the spin-flipped quarks, which contribute to the proton transition without spin-flip ( $J_p^{\delta,\delta}$ ) and with the spin-flip ( $J_p^{-\delta,\delta}$ ). This



allows us to state that (i) around the lower boundary of the considered region, the leading scaling behavior of the Sachs form factors has the form  $G_E, G_M \sim 1/Q^6$ , (ii) the dipole dependence ( $G_E, G_M \sim 1/Q^4$ ) is realized in the asymptotic regime of pQCD when  $\tau \gg 1$  ( $\tau = Q^2/4M^2$ ) in the case when the quark transitions with spin-flip dominate, (iii) the asymptotic regime of pQCD in the JLab experiments has not yet been achieved, and (iv) the linear decrease of the ratio  $G_E/G_M$  at  $\tau < 1$  is due to additional contributions to  $J_p^{\delta,\delta}$  by spin-flip transitions of two quarks and an additional contribution to  $J_p^{-\delta,\delta}$  by spin-flip transitions of three quarks.

## **Studies of Hadron Structure and Dynamics with PANDA at FAIR**

*Klaus Peters*

GSI Helmholtz Centre for Heavy Ion Research GmbH (Germany, Darmstadt)

The PANDA (antiProton ANihilation in DArmstadt) collaboration at FAIR is a cooperation of more than 400 scientists from 19 countries. Its central goal is the elementary understanding of hadrons using the power of an antiproton beam. The vast difference in mass between the proton and its constituents is a manifestation of the importance of understanding the binding among quarks in the confinement regime. Exotic hadrons with their non-conventional structure, such as multi-quarks, hybrids, and glueballs will reveal uncharted properties of this binding. Proton form-factor measurements, deep virtual Compton scattering and the wide area of quark(-spin) dynamics as well as the behavior of hadrons inside nuclear media are significantly complementary aspects to understand the very nature of hadrons and are vital pieces of the experimental program of PANDA as well. Thus, open and hidden charm, lepton pairs and radiative channels, hidden strangeness and hyperons are commensurable probes to explore the imminent questions among bound states of QCD. The PANDA experiment features a modern multipurpose detector with excellent tracking, calorimetry and particle identification capabilities. Together with the high-quality antiproton beam at HESR, unprecedented annihilation rate, and sophisticated event filtering, it will be ideally suited to deliver decisive contributions to this field.

## **Material science approaches to the problem of VVER-1000-type reactors lifetime extension**

*Dmitriy Maltsev*

NRC Kurchatov institute (Russia, Moscow)

This work considers research directions on lifetime extension of VVER-1000 reactor pressure vessel steels: The first direction is individual radiation resource assessment for each reactor vessel, based on accounting for the real chemical composition of steels (primarily nickel and phosphorus content) and improving the normative approach due to additional data of specific vessels surveillance specimens. Lifetime extension is proved for Russian VVER-1000 reactor units of Novovoronezh, Kalinin and Balakovo NPP. It became possible due to a new normative approach to the individual radiation resource assessment for the VVER-1000 reactor pressure vessels. The second direction of lifetime extension is suggested for reactor pressure vessel materials with high radiation embrittlement rate. This approach assumes carrying out the recovery annealing of the most problematic metal welds with high nickel content. The recovery annealing of Balakovo NPP reactor pressure vessel (unit 1) is scheduled for 2018. • For the advanced reactor pressure vessel steels with high thermal stability and radiation resistance are developed – 15Kh2MFA-A mod. A steel and its weld. 15Kh2MFA-A mod. A steel is decided to be used for №1-4 RPV units production at Kursk NPP-2 (VVER-TOI Reactor) based on radiation resource certification of these steels for pressure vessel reactors with increased lifetime and power. Using this steel will provide reactor pressure vessel lifetime up to 80 years or more, as well as increase their safety.

## **Searching for the New Physics signals at neutrino telescopes**

*Oleg Boyarkin*

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All particle physics phenomena within the range of energies available today give impressive support to the standard model (SM) of the electroweak interaction based on the  $SU(2)_L \times U(1)_Y$  gauge group. Despite

its enormous success one is widely believed that the SM is not the ultimate truth, and, as a result, many other models have been proposed to extend the SM.

In this note we consider the possibilities of the existing and planning neutrino telescopes to detect the physics beyond the standard model. Two processes with the ultra-high energy cosmic neutrinos  $\nu_e + e^- \rightarrow N_e + e^-$ ,  $\nu_e + e^- \rightarrow W^- + z$  are investigated. It is shown that at IceCubeGen2 and ARIANNA we could observe manifestations of New Physics.

### **On distribution of ionization amplitudes of fission ionization chamber (in Russian)**

О распределении амплитуд импульсов ионизации ионизационной камеры деления

*Hien Le*

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В работе рассмотрен вопрос о распределении амплитуд импульсов ионизации в миниатюрной ионизационной камере деления (ИКД) вследствие разброса фрагментов деления по величинам заряда, массы и энергии для потоков нейтронов с различной формой спектра. Показано, что эмпирическая функция распределения импульсов по амплитуде имеет два максимума и слабо зависит от формы энергетического спектра нейтронов.

### **Features of modelling and calculation of two-group cross-sections for neutron reflector of VVER nuclear reactor core in DYN3D code (in Russian)**

Особенности моделирования и расчета двухгрупповых сечений для отражателя активной зоны реактора ВВЭР для кода DYN3D

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DYN3D - трехмерный динамический код, использующийся для расчетов динамики нейтронно-физических процессов в активной зоне реактора и успешно применяющийся для консервативных оценок расчетов при проведении детерминистического анализа безопасности. Объектами в диффузионном коде DYN3D являются отдельные ТВС и отражатель. В данной работе рассмотрены особенности моделирования отражателя для активной зоны реактора типа ВВЭР-1000 в прецизионном Монте-Карло коде Serpent. Модели отражателя разработаны таким образом, что бы потоки нейтронов в области отражателя соответствовали картине потока в полной модели активной зоны реактора. С использованием этих моделей в коде Serpent была рассчитана библиотека двухгрупповых сечений для отражателя, которая используется для расчетов в диффузионном коде DYN3D. Проверка библиотеки сечений для отражателя проводилась путем сравнения значений коэффициента критичности и нормированного распределения энерговыделения для полной модели активной зоны. Результаты расчетов данных величин в диффузионном коде DYN3D хорошо согласуются с расчетами полной модели активной зоны реактора в коде Serpent. Разница рассчитанного в двух кодах коэффициента критичности не превышает 80 pcm. Максимальная разница в рассчитанных значениях нормированного энерговыделения в топливных сборках не превышает 2%, при этом ее среднее значение по всей активной зоне не превышает 1%.

## **Prospects for identifying new physics scenarios at the CERN LHC**

*Alexander Pankov*

INP BSU & ICTP Aff. Ctr. (Belarus, Minsk)

Kaluza-Klein models with extra spatial dimensions predict the existence of the massive graviton states which can be produced as the real and virtual particles in proton high energy collisions. In this talk we summarize the prospects of discovery and identification of indirect and direct effects of respectively large and warped extra spatial dimensions in experiments of measuring the specific characteristics of the dilepton and diphoton final states at the Large Hadron Collider. Virtual effects in

the Kaluza-Klein models with large extra spatial dimensions can be discovered by the specific behavior of the dilpton and diphoton invariant-mass distributions, and their identification (in case of discovery) can be performed by the analysis of their angular distributions with integrated center-edge asymmetry. We find that the LHC with nominal energy (14 TeV) and luminosity (100/fb) has a high sensitivity to the cut-off parameter  $M_S$  in the models with large extra spatial dimensions which is as large as 8.5 TeV (7.6 TeV) for their discovery (identification) while the discovery (identification) on the mass of the Randall-Sundrum graviton resonance is of order of 4.4 TeV (3.1 TeV).

## **The Institute for Nuclear Problems BSU in High Energy Physics Projects**

*Juan Suarez Gonzalez*

Institute for Nuclear Problems Belarussian State University (Belarus, Minsk)

A review concerning the participation of INP BSU in high energy physics (experiments ATLAS, CMS, CLICKdp), experiments at JLab and participation in FCC is presented. An account of past achievements as well as present status and perspectives for the future are given.

## **Monte-Carlo method for radiation shielding in medicine (in Russian)**

Метод Монте-Карло для решения задач радиационной защиты в  
медицине

*Kristina Makarevich*

Research Institute for Nuclear Problems (Belarus, Minsk)

Примерами использования метода Монте-Карло (МК) в области радиационной защиты в медицине служат исследования, проведенные в НИИ ЯП БГУ в 2013-2016 годах в целях решения некоторых задач радиационной безопасности в учреждениях здравоохранения РБ при выполнении дентальных рентгенодиагностических исследований и лучевой терапии на

линейном ускорителе электронов (ЛУЭ). Проведено моделирование процедур контактных рентгенографических исследований зубов с использованием метода МК, реализованного в программе MCNP. Получены пространственные распределения поглощенной энергии в референтных фантомах, которые позволяют оценить поглощенные и эффективные дозы облучения пациентов в конкретных процедурах дентальной рентгенографии. С помощью МК моделирования сеанса облучения больного определены количественные характеристики вторичного нейтронного потока, образующегося в головке ЛУЭ. Моделирование показало, что в спектре нейтронов вблизи кушетки пациента присутствуют в основном быстрые нейтроны со средней энергией около 1 МэВ. Напротив, в спектре нейтронов, прошедших через стены бункера в пультное помещение ускорителя, присутствуют только тепловые нейтроны, образовавшиеся в результате рассеяния быстрых нейтронов в воздухе и стенах бункера. Эффективная доза облучения нейтронами работающего персонала незначительна и составляет не более  $6 \cdot 10^{-10}$  мЗв на одну мониторинговую единицу.

### **Optimisation of LYSO-based cell of electromagnetic calorimeter (COMET experiment, KEK, Japan)**

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*O. Missevitch* INP, (Minsk, Belarus)

*Y. Kuno*, Osaka University (Osaka, Japan)

Reasons of the energy resolution degradation of the COMET homogeneous electromagnetic calorimeter connected with non-paraxial particle trajectories were analyzed. The method for improving the uniformity of light collection of scintillation photons through the use of optimal-type reflective materials and dedicated crystal wrapping technique concerning high density scintillator was developed. The angular distribution of deposited energy in the segmented calorimeter was measured. Method of spatial reconstruction of electromagnetic

shower and relevant energy correction – reducing the error of energy measurement in the calorimeter during data handling was developed.

## **Development of the model of hadrons as Coherent states on the horosphere of the Lobachevsky momentum space**

*Yurii Kurochkin*

B.I. Stepanov Institute of Physics (Belarus, Minsk)

Possible interpretation of the model of hadrons as coherent states on horosphere of the momentum Lobachevsky space in the terms of the dynamics of quark states in the color constant field is presented.

## **JINR Cooperation with Belarus**

*Richard Lednicky*

JINR (Russia, Dubna)

An information about Joint Institute for Nuclear Research in Dubna, Russia, and its cooperation with the Belarus scientific centres and universities is given.

## **Phenomenological Approach**

*Yerlan Aimuratov*

University "Sapienza" (Italy)

We review the information on gamma-ray burst 140402A by recent analysis and interpretation within the theoretical fireshell model. Revealed exotic features are discussed. GRB 140402A is classified as a genuine short gamma-ray burst demonstrating strong observational evidences of the members of such a subclass. We also address some issues of sampling procedure, namely focus on the criteria relating on what one makes an inference on correlations and other types of phenomenological dependencies. The fact is that many works including

large surveys are based on statistical analysis of target sample, but the criteria by which they were chosen do not always correspond to well-grounded physical assumptions. In this light we implement a comparative analysis and review on this topic.

## **Hardware for the PANDA Detector at the FAIR Facility**

*Kai-Thomas Brinkmann*

II. Physikalisches Institut, JLU Gießen (Germany, Gießen)

The PANDA detector will be one of the central experimental installations at the FAIR facility. The setup of PANDA will be presented and the status of all components planned to be installed will be discussed. Selected details of test experiments and custom developments will be presented.

## **GRB 140402A and Subclass of S-GRBs: The collaboration of Lithuania and CERN**

*Juozas Vaitkus*

Vilnius University (Lithuania, Vilnius)

The report will review the collaboration of Lithuanian teams and CERN: the interests and the results.

## **Manifestation of Quark-Hadron Duality in Electron-Positron Annihilation**

*Olga Solovtsova*

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From the point of view of the quark-hadron duality, we consider a description of physical quantities and functions that are defined through the function  $R(s)$ , the normalized cross-section for the process  $e^+e^-$  annihilation into hadrons, and connected with the Adler D-function. This function defined in the spacelike region is a smooth function without traces of the resonance structure and one can expect reflects more



precisely the quark-hadron duality. We find a good agreement between our results and the corresponding experimental data down to the lowest energy scale that is not calculable within the standard perturbative QCD. We investigate the reason of such good agreement and, as a result, we formulate a criterion which we call the R-D self-duality.

## **Radiative corrections for Drell-Yan processes at LHC**

*Vladimir Zykunov*

Joint Institute for Nuclear Research (Russia, Dubna)

NLO order electroweak and QCD radiative corrections to the Drell-Yan process with high dimuon masses for experiments CMS LHC at CERN have been studied in fully differential form. The FORTRAN code READY for numerical analysis of Drell-Yan observables has been presented.

## **Belarus science and engineering in JINR: current status**

*Sergey Maksimenko*

Institute for Nuclear Problems, Belarusian State University (Belarus, Minsk)

Current status of the activity of Belarusian research an engineering organisations in is considered.

## **Constituent quark masses in Poincare-invariant quantum mechanics**

*Viktor Andreev*

Francisk Skorina Gomel State University (Belarus, Gomel)

The masses of the quarks in the Poincare-invariant quantum mechanics are the constituent masses. Even in this framework it is possible to obtain an estimate of the constituent quark masses from the Ward identity for the axial current and the current quark masses.

## **The next-to-leading production hadron by pomeron mechanism**

*Andrei Manko*

B.I. Stepanov Institute of Physics (Belarus, Minsk)

In this report the results of investigate of production hadron by pomeron mechanism are presented. Total and differential cross are obtained for the leading and the next-to-leading order for LHC.

## **Creation and application of hardware-software complex for on-board charged particles spectrometer testing**

*Sergey Grishin*

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Coauthor: V.A. Selyantiev

On-board multilayer scintillation spectrometers installed on spacecrafts are widely used for investigation of flows, bursts and variations of charged particles (electrons, protons, helium nuclei) in near-Earth space. Reliability and metrological characteristics of such instruments depend to a large extent on the quality and completeness of complex ground tests and calibrations, which are performed using specialized automated control devices. The report discusses the design concept, composition and basic characteristics of hardware and software means intended for automated monitoring of technical state and adjustment of scintillation spectrometer electronic units. Presented are the results of spectrometer testing using the created hardware and software complex, which provides: power supply for scintillation spectrometer units; control commands generation; simulation of interferences in the on-board power network; information acquisition from spectrometer scintillation blocks via 24 channels; logical signals selection and trigger signals generation; evaluation of amplitude spectra and statistical processing; scintillation spectrometer units testing; information arrays acquisition, processing and transmission via telemetry channels; test results recording and storage. Created hardware and software complex provides automation of ground testing and control process, simplifies development and debugging of algorithmic and software means, reduces

time and labour intensity required for final adjustment of scintillation spectrometer units.

### **Modeling and optimization of a wide aperture fourier high-resolution neutron diffractometer as a system of independent detectors (in Russian)**

Моделирование и оптимизация широкоапертурного нейтронного Фурье-дифрактометра высокого разрешения (ФДВР) как системы независимых детекторов

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Coauthors: *A.A. Хрущинский, С.А. Кутень* НИИ ядерных проблем при БГУ (Минск, Беларусь)

Широкоапертурный Фурье-дифрактометр высокого разрешения (ФДВР) предназначен для исследований в области физики твердого тела и материаловедении и используется в качестве детектора на исследовательских ядерных реакторах. Целью оптимизации формы детектора является снижение затрат на производство таких детекторов и увеличение их эффективности. Оптимизация конфигурации и параметров нейтронного детектора обратного рассеяния путем развития аналитических и численных методов, позволила определить вклад в функцию отклика спектрометра как конструкционных характеристик, так и геометрических, связанных с пространственной ориентацией спектрометра и отдельных его частей, а также исследовать зависимость характеристик спектрометра от размеров мишени, параметров нейтронного тракта, в частности, параметров нейтронного пучка и прерывателя. Для решения задачи о поиске аналитического вида поверхности детектора для точечной мишени и мишени конечных размеров использованы методы вариационного исчисления для представления задачи в виде уравнения Лагранжа-Эйлера. Данная методология применялась ранее для поиска формы детектора, как численного решения уравнений Лагранжа-Эйлера. По результатам вычислений формы спицы для точечной мишени получено аналитическое выражение.

## **JINR cooperation with Belarus in the field of superconducting resonators (in Russian)**

Сотрудничество ОИЯИ с Республикой Беларусь в области сверхпроводящих ускорительных резонаторов

*Julian Budagov*

Joint Institute for Nuclear Research (Russia, Dubna)

Коллаборация учёных и специалистов Республики Беларусь из НИИ ЯП БГУ, БГУ ИР, ФТИ и НПЦ по материаловедению НАН Беларуси совместно с физиками ОИЯИ разработала, изготовила и испытала три опытных образца ускорительного сверхпроводящего ниобиевого резонатора эллиптического типа на частоту 1,3 ГГц. Работа инициирована проектом Международного линейного коллайдера (ILC — International Linear Collider). Впервые в Беларуси был достигнут сверхпроводящий режим работы резонаторов и впервые получено максимальное значение нагруженной добротности резонатора, равное  $2,8101 \cdot 10^9$  при абсолютном согласовании резонатора с СВЧ трактом: КСВ = 1,0000.

## **Current Technical State of Radiation Therapy and Nuclear Medicine in Belarus (in Russian)**

Современное техническое состояние лучевой терапии и ядерной медицины в Республике Беларусь. Пути их дальнейшего развития

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В докладе рассматриваются проблемы состояния и дальнейшего развития технического обеспечения лучевой терапии и ядерной медицины в Республике Беларусь. Обсуждается проблема перевода облучения пациентов на медицинских линейных ускорителях электронов вместо гамма-терапевтических аппаратов с источниками  $^{60}\text{Co}$ , а также дозиметрическое обеспечение новых методик лучевой терапии. Применение сложных прецизионных методов облучения пациентов с помощью ускорителей существенно повысило эффективность современной

высокотехнологичной лучевой терапии, позволило практически снизить до минимума возникновение лучевых реакций и осложнений со стороны нормальных тканей и критических органов, окружающих опухолевые очаги.

В ядерной медицине применение современных диагностических эмиссионных томографов, включая позитронно-эмиссионные томографические аппараты с ультракороткоживущими радионуклидами, позволило существенно улучшить качество определения степени распространенности опухолевых процессов, вырабатывать оптимальные методы лечения пациентов, а также прослеживать состояние пациентов в период после окончания лечения.

Обсуждаются пути дальнейшего развития технических средств лучевой терапии и ядерной медицины.

## **The High Energy frontier in the next twenty years and more**

*Roberto Tenchini*  
INFN Pisa (Italy, Pisa)

I will review the prospects and opportunities for particle physics at accelerators in the energy frontier regime. In particular I will discuss hadron and lepton colliders at CERN and other major laboratories.

## **Saturating Regge Trajectories in describing data from Jefferson Lab and LHC**

*Mikhail Sergeenko*  
B.I. Stepanov Institute of Physics of the Belarus NAS (Belarus, Minsk)

A nonperturbative approach of hard scattering of hadrons at high energy is suggested. The hard-scattering mechanisms can be incorporated in an effective way by using the so called “saturated” trajectory that is independent of  $t$  at large momentum transfer. Regge trajectories are usually assumed to be linear in  $t$ , but there are both phenomenological and theoretical arguments supporting the idea of non-linear trajectories. Saturated trajectories lead to the asymptotic quark counting rules that,

model independently, determine the energy behavior of the cross section at large  $-t$ . This approach was successfully adopted to explain the large momentum transfer hadron-hadron and lepton-hadron interactions, as well as several photon-induced reactions. The resulting model is simple, economical in terms of number of parameters and most importantly consistent (with studies in the resonance region for the determination of these parameters), gives a reasonable and coherent description of all the existing data of pion photoproduction at forward and backward angles (differential cross-sections as well as single polarisation observables).

### **Submersible in situ gamma-spectrometer for radioactivity measurement in the water environment**

*Dzmitry Shoukavy*

B.I. Stepanov Institute of Physics of the Belarus NAS (Belarus, Minsk)

With the progress of nuclear technology, a numerous of anthropogenic radionuclides have entered in the water environment, for example, as a result of industrial discharges, nuclear accidents or military operations. Therefore, radiation monitoring of the water environment has been became an important task nowadays. We have developed and constructed low-background submersible in situ gamma-spectrometer on the basis of NaI(Tl) crystal for radioactivity measurement in the water environment. The detector system has been tested and calibrated both in a water tank using the reference sources and in natural conditions. The Monte Carlo simulations have been performed using the Geant4 code to study the detection efficiencies in a wide range of energies in the water environment. Good agreement between the experimental and simulated results was obtained.

### **The international mega-science project NICA at JINR**

*Yury Potrebenikov*

Joint Institute for Nuclear Research (Russia, Dubna)

The mega-science project NICA (Nuclotron-based Ion Collider fAcility) at the Joint Institute for Nuclear Research (JINR) in Dubna is a project for

exploration of extreme states of matter and investigation of the nucleon spin origin. The NICA complex is based on an operating accelerator Nuclotron which is able to provide light- and heavy-ion beams in the energy range optimal to experimental study of dense and hot baryonic matter and quite sufficient for study of the nucleon spin structure using a common experimental method: the investigation of collisions of nuclei at relativistic energies in fixed target and collider experiments. A set of superconducting rings, including collider, and 3 set-ups for fixed target (BM@N) and collider (MPD and SPD) experiments will be constructed by international collaborations. Current status and plans of the NICA project is presented in this report.

### **Determination of Higgs boson spin in the diphoton channel with ATLAS data at LHC**

*Andrei Tsytrinov*  
GSTU (Belarus, Gomel)

Here we discuss the discrimination of the Higgs boson spin decaying into two photons at the ATLAS LHC against the hypothesis of a minimally coupled spin-2 narrow diphoton resonance with the same mass and giving the same total number of signal events under the peak. We show that the center-edge asymmetry provide a strong discrimination between the possibilities of spin-0 and spin-2.

### **Experimental measurements of spatial distribution for luminescence signal of cerium ions in GSO:Ce scintillator**

*V. Kalinnikov, E. Velicheva,*  
Joint Institute for Nuclear Research (Russia, Dubna)  
*I. Khodasevich, A. Grabtchikov*  
B.I. Stepanov Institute of Physics (Belarus, Minsk)

Report contains experimental results of luminescence measurements for Ce ions doped in GSO crystal with 120x20x20 mm size for applications as a scintillator. The luminescence excited by laser radiation in the

absorption band of GSO:Ce crystal. Our data show significant inhomogeneity of the luminescence signal along and across the crystal. Under assumption of the linear relationship between intensity of luminescence and concentration of Ce ions we make conclusion that concentration of Ce ions is inhomogeneous also. Data obtained are of importance for estimations of characteristics for PETs and electromagnetic calorimeters. This work was supported by the Fundamental Research Foundation of Belarus (Grant F16D-007).

### **Crystal applications in high energy physics for new phenomena observation and acceleration technology development**

*V.G. Baryshevsky, V.V. Tikhomirov*

Institute for Nuclear Problems, Belarus State University (Belarus, Minsk)

For forty years Belarusian researches have predicted a wide range of crystal applications in high energy physics dedicated to new physical phenomena observation, particle properties measurement, beam control, generation and polarization. In particular, in 80-th the possibility to observe the phenomena induced by a strong uniform electromagnetic field was predicted and then demonstrated in dozens of CERN experiments, in which both the synchrotron-like electron-positron pair production and radiative cooling effect, enhancing the channeling radiation, were discovered. Drastic enhancement of both radiation and pair production processes in crystals can influence the functioning of both the existing Compact muon solenoid electromagnetic calorimeters at CERN and Fermi gamma-telescopes as well as can be applied to devise more effective calorimeters and gamma-telescopes in future. Another perspective application of the intensive synchrotron-like pair production process in crystals is suppression of gamma-radiation background in continuing experiments on rare kaon decays.

More phenomena, such as synchrotron-like dichroism and birefringence, radiative electron and positron self-polarization, production of polarized electron-positron pairs, electron spin polarisability, etc., will be possible to observe in the framework of the started LHC extracted beam program. A remarkable effect and channeling particle spin rotation in bent crystals enables one to observe electron magnetic moment modification as well



as to measure both magnetic and electron dipole moments of short lived charm and beauty hyperons.

The successful functioning of both the planned high-energy Large Hadron Collider phase and Future Circular Collider completely depends on the efficiency of the superconducting magnet protection by their beam collimation systems. Crystals provide unique possibilities of the latter by efficient hazardous beam halo scraping in both channeling and volume modes. To enhance the former the channeling efficiency increase by the crystal cut and the latter – the effect of multiple volume reflection from the atomic planes of one bent crystals, observed in a number of experiments in CERN and IHEP, have been proposed.

In total the numerous phenomena predicted by Belarusian scientists constitute now several directions of both fundamental phenomena investigation and accelerator physics development with wide prospects for international cooperation.

## **Modern technologies and devices in nuclear instrumentation**

### **Современные технологии и устройства в ядерном приборостроении**

*В.А. Кожемякин*

УП «АТОМТЕХ» (Беларусь, Минск)

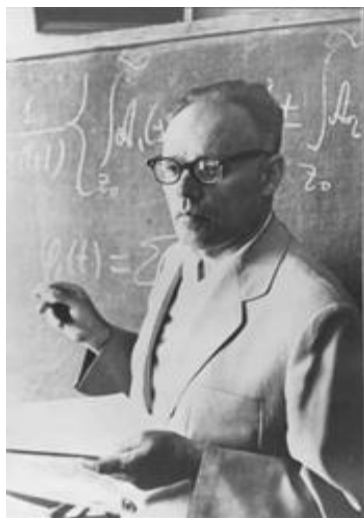
Основным элементом приборов, аппаратуры и систем, применяемых в области ядерно-физических измерений, являются детектирующие устройства для регистрации различных видов ядерных излучений. Современные технологии и устройства детектирования в области ядерного приборостроения в большинстве случаев основаны на создании и использовании блоков детектирования, представляющих собой законченные интеллектуальные устройства с тем или иным видом интерфейса, обеспечивающим их подключение к аппаратуре управления, сбора и обработки данных (устройства обработки и отображения информации, персональные компьютеры, системы верхнего уровня и т.д.). В докладе представлен широкий спектр разработанных и промышленно изготавливаемых интеллектуальных блоков детектирования на основе различных видов детекторов  $\alpha$ -,  $\beta$ -,  $\gamma$ -, X-, n-излучений, функционально законченных и используемых в

области дозиметрических, радиометрических, спектрометрических и других измерений. Располагая такого ряда устройствами, проектировщики систем, аппаратуры, приборов получают возможность для гибкой и эффективной разработки аппаратно-программных средств различного назначения, востребованных на практике. “Интеллектуальные” блоки или устройства детектирования метрологически обеспечиваются при выпуске, что значительно упрощает калибровочные процедуры для системных интеграторов. Для целей метрологического обеспечения предлагается ряд современных эталонных градуировочных автоматизированных установок и технических средств (гамма-дозиметрия, нейтронная дозиметрия, бета-дозиметрия, дозиметрия околофоновых уровней, формирование поля гамма-излучения высоких энергий, спектрометрия высоких энергий и т.д.). На основе используемых современных детекторных технологий и устройств создан ряд конкурентоспособных измерительных приборов, аппаратуры и систем для целей радиационного контроля и ядерных измерений: стационарные гамма-радиометры, гамма-спектрометры, гамма-бета-спектрометры для радиационного контроля проб окружающей среды; стационарные радиометры активности  $\alpha$ - и  $\beta$ -излучающих нуклидов в пробах; спектрометры излучения человека; портативные спектрометры-идентификаторы; мобильные и носимые радиационные сканеры; беспроботборные спектрометры почвы, стройматериалов; погружные спектрометры; поисковые, дозиметрические и спектрометрические устройства для беспилотных летательных аппаратов (самолеты, вертолеты, квадрокоптеры); дозиметрические и спектрометрические устройства для робототехнических систем; автоматические пункты радиационного контроля для систем АСКРО; системы автоматической сигнализации о самоподдерживающейся цепной реакции; измерительные каналы для систем радиационного контроля; транспортные и пешеходные радиационные мониторы; многофункциональные дозиметры-радиометры; широкая номенклатура блоков детектирования для использования в системах АСПК; аппаратура аэрогамма-съемки для пилотируемых средств; блоки детектирования для использования в составе досмотровых установок (рентгеновского и ускорительного типов); устройства детектирования на основе SiPM; прочая аппаратура и

устройства. Значительная часть из них создана в рамках совместных работ и проектов с международным участием (IAEA, JAEA, NIST, СТВТО, РТВ и др., а также ряд ведущих российских организаций).

**INFORMATION ABOUT INTEGRATION  
OF BELARUSIAN SCIENTISTS IN THE  
RESEARCH PROGRAMS  
OF THE WORLD'S LEADING  
NUCLEAR PHYSICS CENTERS**

## ON HISTORY OF INVESTIGATIONS IN THE FIELDS OF PARTICLE AND NUCLEAR PHYSICS IN BELARUS



**Fedor Ivanovich Fedorov**  
(19.06.1911 – 13.10.1994)

The first scientific works, that started development of the elementary particle physics in Belarus, were carried out by Fedor Ivanovich Fedorov. This young Belarusian physicist made his post-graduate study in Institute of Physics at the Leningrad State University under direct supervision of V.A. Fock at 1933–1936. He has applied the new method, method of Fock's functionals in the quantum field theory, to solve actual problems in quantum electrodynamics. He calculated the natural width of spectral lines and the cross-sections of Compton scattering of gamma-quanta on electrons. These results were the essence of the thesis of F.I. Fedorov "On application of method of functionals to some problems of radiation theory" (1936). Fedorov's results in theoretical optics (Drude-Born-Fedorov constitutive equations in electrodynamics, Imbert-Fedorov shift for the reflected light beam), acoustics, particle physics are well known in the world scientific society. The basic ideas of the Fedorov covariant approach to the elementary particle physics has been developed in the book F.I. Fedorov, Lorentz group (Moscow, Nauka, 1979, and second edition Moscow, URSS, 2003).

The first scientific works, that started development of the elementary particle physics in Belarus, were carried out by Fedor Ivanovich Fedorov. This young Belarusian physicist made his post-graduate study in Institute of Physics at the Leningrad State University under direct supervision of V.A. Fock at 1933–1936. He has applied the new method, method of Fock's functionals in the quantum field theory, to solve actual problems in quantum electrodynamics. He calculated the natural width of spectral lines and the cross-sections of Compton scattering of

Many well-known specialists in the particle physics and general relativity have been prepared in the Fedorov scientific school.

In the sixties F.I. Fedorov was the director-organizer of the Joint Institute of Energetic and Nuclear Research.

The scientific school in the field of nuclear optics was founded by Vladimir Baryshevsky. The several discoveries were made including the phenomenon of nuclear precession of neutrons in a pseudomagnetic field of matter with polarized nuclei [1964], the phenomenon of rotation of the plane of polarization of hard gamma quanta [1965 (theory), 1971 (experiment)].

The another scientific school was founded by Nikolai Shumeiko on the basis of both Belarusian school by F.I. Fedorov and Russian schools by S.M. Bilenky and academician D.V. Shirkov. The new methods were developed for the covariant calculation of radiative effects to observables for fundamental processes in high energy physics (known as the Bardin-Shumeiko approach).

In Belarus, as well as in many other countries of the world, the experimental base for realization of the modern experiments in the particle physics is limited. It stimulates participation of the Belarusian scientists in the work of the international research centers like CERN, JINR (Dubna), DESY, etc., and participation in the international scientific projects, such as ATLAS and CMS on LHC at CERN.

The research in the field of particle physics in Belarus is carried out at several institutions of the National academy of sciences of Belarus: B.I. Stepanov Institute of Physics (director academician N. Kazak), especially at the Center of Theoretical Physics (head Yu. Kurochkin); Joint Institute of Energetic and Nuclear Researches (director A. Kuzmin), as well as at the Research Institute for Nuclear Problems of Belarusian State University (director prof. S. Maksimenko), and at the physical departments of the Universities of Minsk, Gomel and Brest.

## **MODERN STATE OF THE FUNDAMENTAL PHYSICS IN BELARUS**

### State support

State support of the fundamental physics in the Republic of Belarus is conducted in the framework of the State Programs of the Scientific Research (SPSR). More than 20 researchers supported by the SPSR were among authors of the biggest discovery of the 21<sup>st</sup> century–discovery of the Higgs boson.

The heads of the JINR, Russian Academy of Sciences, CERN (Vladimir Kadyshevski, Alexey Sissakian, Victor Matveev, Robert Aymar), spokesman of ATLAS project Peter Jenni had supported realization of the SPSR in Belarus.

### Belarusian Republican Foundation for Fundamental Research

The Belarusian Republican Foundation for Fundamental Research (BRFFR) was established by the Decree of the Government of the Republic of Belarus in May, 1991 in order to strengthen financial support of fundamental and exploratory research in areas of natural and technical sciences and humanities, conducted by scientific organizations, higher education institutions and individual scientists within priority directions of such research. The main goal of the BRFFR is support of science by the system of grants awarded on the competitive basis in the priority research areas.

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**ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE  
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH**

Laboratoire Européen pour la Physique des Particules  
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**Professor Yury Pleskachevsky,**  
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Ref: PH/ATLAS/PJ/mmd/2009-0301

**ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE  
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH**

Laboratoire Européen pour la Physique des Particules  
European Laboratory for Particle Physics

President of the National Academy of  
Sciences of Belarus,  
The Chairman of the Presidium  
**Professor Mikhail V. MYASNIKOVICH**  
66 Independence Avenue,  
Minsk BY-220072,  
Republic of Belarus

Geneva, 27<sup>th</sup> March 2009

Your reference: DG-2005-688-O  
Our reference: Geneva, 17 March 2005

Geneva, 17 March 2005

Dear Professor Pleskachevsky,

I am pleased to inform you that the close international collaboration of Belarusian Institutes with CERN in the framework of particle physics is developing with mutual benefits. Now the whole CERN community is focusing on the completion of the Large Hadron Collider (LHC) construction in order to start physics experiments in 2007. This will be a research challenge for the next decade. The Belarusian physicists have made a significant contribution to the construction of the LHC experiments, and CERN hopes they will be able to participate in the physics programme together with other scientists from all corners of the world.

The Belarusian representatives have recently informed CERN management that the Republic of Belarus is now working on a new research programme for the period of 2006-2010. Taking into account the Co-operation Agreement between CERN and the Government of the Republic of Belarus and the strong participation of Belarusian physicists in the ATLAS and CMS experiments, we would like to express our strong support for and encouragement of the State programme of fundamental research called "Fields and Particles".

We are confident that the realization of this programme will permit the Republic of Belarus to maintain the high-level expertise of researchers in the priority area of fundamental science and its current advanced technologies. It would, as well, intensify further integration of Belarusian science into the European and the worldwide research area.

Yours sincerely,

P. Jenni

Всес. С. Енгелен  
N. Koolberg

**РОССИЙСКАЯ  
АКАДЕМИЯ НАУК**

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**Глубокоуважаемый Михаил Владимирович!**

В общении с белорусскими коллегами, работающими в области физики микромира (физики высоких энергий) и экстремальных состояний материи, стало известно, что в Республике Беларусь определяются приоритетные направления научных исследований и начинается формирование соответствующих государственных программ на 2011-2015 годы. В частности, подготовлены предложения по формированию Государственной программы фундаментальных исследований (ГПФИ) "Фундаментальные взаимодействия и широкие диапазоны энергий и их проявления в строении материи на микро- и мезоскопическом уровнях: частицы, ядра, топологически нетривиальные объекты, конденсированное состояние, плазма с кривым названием "Микромир и плазма".

Как мы знаем, такого рода программа является традиционной для Республики Беларусь, она продолжает и развивает результаты, полученные белорусскими учеными в рамках ГПФИ "Физика взаимодействий" (2000-2005 гг.) и "Частицы" (2006-2010 гг.). Несомненно, что созданный в этих программах задел является основной базой для продолжения авангардных исследований в области физики высоких энергий, фундаментальных взаимодействий, экстремальных состояний материи. ГПФИ "Микромир и плазма" служат также необходимой основой дальнейшего плодотворного сотрудничества многих институтов и университетов Беларуси с ведущими российскими научными центрами в области исследования фундаментальных

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свойств материи: ИИИ РАН, ГИЦ "Институт физики высоких энергий", ИИИФФ МГУ, ГИЦ "Курчатовский институт", ИТЭФ, ФИАН и другие.

Мы убеждены, что выполнение такой программы будет способствовать поддержанию и развитию в Вашей стране высокого уровня исследований в одном из самых приоритетных направлений физической науки и сопутствующих технологий, а также дальнейшей интеграции Беларуси в мировое научное сообщество. В этой связи выражаем глубокую поддержку включению ГПФИ "Микромир и плазма" в перечень основных научных программ Республики Беларусь на 2011-2015 года.

С уважением,  
академик-корреспондент ОИИ РАН  
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## COOPERATION

### Belarus and JINR

Belarusian scientists closely cooperate with foreign colleagues in the framework of Joint Institute of Nuclear Research in Dubna.



*Institute of Physics of the Academy of Sciences of BSSR. Beginning of the cooperation with JINR (Dubna) in the experimental particle of physics. From left to right Deputy director P. Apanasevich, professor Yu. Budagov (JINR), academician F. Fedorov, professors A. Bogush and L. Moroz.*

Belarus is a country-participant of the JINR. The Payment of Belarus in the past few years varied around \$ 1,000,000 per year. Each year more than 25 mutual projects have been realized in 10 institutions and universities of Belarus in the correspondence with Coordination plan Belarus–JINR. In particular, Joint Institute for Power and Nuclear Research – Sosny actively participates in JINR in an international project “Study of deep subcritical electronuclear systems and feasibility of their application for energy production and radioactive waste transmutation”. The experiments are carried out in the framework of a wide international collaboration “Energy + Transmutation” aiming at

study of the ADS technology for energy production and transmutation of radioactive wastes. More than 15 countries around the world are presently members of the collaboration.

Joint project of Gomel international school of Young Physicists on High Energy Physics (1971–1976) and subsequent international school-seminar “Actual Problems of Microworld Physics” had a significant impact on the development of the particle and nuclear physics in Belarus.



*Gomel school-seminar 2015*

### Belarus and CERN

Belarusian physicists from the National Academy of Sciences (B.I. Stepanov Institute of Physics: Yu. Kulchitski) have taken an active part in the ATLAS Collaboration (Spokesperson: Prof. Peter Jenni, CERN) since 1994. Our main activity in the ATLAS Collaboration framework is the hadronic Tile Calorimeter (TILECAL) Subdetector Collaboration (Project leader: Prof. Marzio Nesi, CERN). In TILECAL Sub-collaboration we work in close contact with physicists from LNP in JINR (under leadership of Prof. N. Rusakovich, Yu. Budagov).

Basing on Memorandum of Understanding signed between the National Academy of Sciences of Belarus and the CLIC (Compact Linear Collider) project of CERN (Geneva), Joint Institute for Power and Nuclear Research – Sosny participates in an international collaboration CTF3 (CLIC Test Facility). The project aims at the development, testing and extending of technologies for construction of a e-/e+ linear collider as a future option for detailed studies of the experimental physical results obtained at LHC.

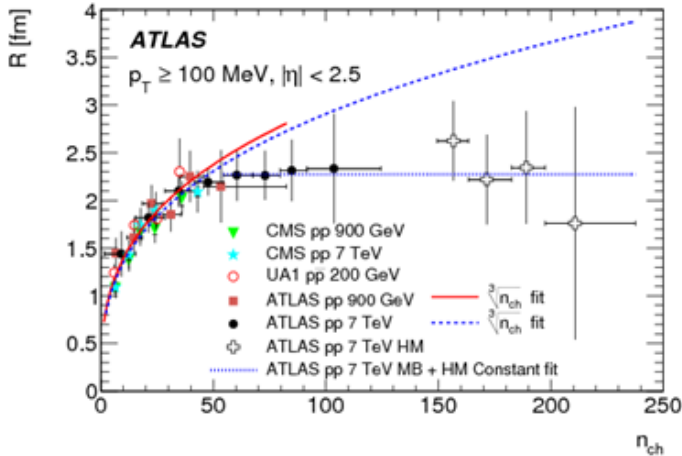


*Peter Jenni in Minsk, in the B.I. Stepanov Institute of Physics*

The main results obtained together with Belarusian physicists are related to:

1. Participation in the Test Beam performance study on the CERN SPS collider.
2. Investigation of hadronic energy resolution and linearity in the energy range from 10 to 400 GeV.
3. Investigation of non-compensation of Tile and Combined Calorimeters.
4. Investigation of hadronic shower development in the TILE Calorimeter.

One of the important ATLAS task is to study of the Bose-Einstein correlations in pp-interactions in new energy region 7–14 TeV with the research goals to measure the radius and chaoticity of like charged hadrons correlation in dependence of



*The dependence of the correlation radius of the pion pairs on the multiplicity of charged particles. It is evident that when average multiplicity of charged particles reaches 60 saturation - correlation radius does not change with the increasing of average multiplicity*

charged hadrons multiplicity, including new very high multiplicity region, transverse momentum of charged hadrons, transverse momentum of like charged pairs.

The study of BEC in pp-collisions at 0.9 and in the new energy region 7–14 TeV collected by the ATLAS experiment using the minimum-bias and high multiplicity triggers was done (Y. Kulchitsky).

The Republican Enterprise “MZOR” manufactured the absorber plates and interfaces for the CMS hadron calorimeter end-caps, and also produced special assembly tooling. The work was supervised by National Centre for Particle and High Energy Physics BSU (N.M. Shumeiko et al.). Due to excellent quality of the supplied hardware this work became a hallmark of Belarusian contribution to CERN facilities. The work was awarded the CMS Gold Medal in 2003.



*Russian and Belarusian engineers at CMS end-cap hadron calorimeter, CERN*

The scientists and engineers of the Institute for Nuclear Problems of Belarusian State University (R.V. Stefanovich et al., INP BSU) took an active part in the construction, adjustment, testing, working and maintenance of the absorbers and mounting systems.

Physicists of INP BSU (P. Starovoitov, A. Hrynevich et al.) made the substantial contribution to analysis and calibration of

hadronic jet events in ATLAS experiment data. Another group (N.M. Shumeiko, J.G. Suarez et al., INP BSU) contributed to calculation, modelling and data analysis of the background processes in CMS experiment.

The INP BSU group lead by M. Korzhik was a driving force for the development of the PbWO<sub>4</sub> (PWO) scintillation material for the high energy physics detectors. Right now, PWO is the most widely used detecting material in HEP detectors at collider experiments. CMS ECAL based on PWO played a crucial role in the discovery of the Higgs boson.



*Some monographs published with CERN and JINR experts and dedicated to the radiation detectors and experiments at LHC*

Basing on Memorandum of Understanding signed between the National Academy of Sciences of Belarus and the CLIC (Compact Linear Collider) project of CERN (Geneva), Joint Institute for Power and Nuclear Research – Sosny participates in an international collaboration CTF3 (CLIC Test Facility). The project aims at the development, testing and extending of technologies for construction of a e-/e+ linear collider as a future option for detailed studies of the experimental physical results obtained at LHC.

### Other international cooperation

B.I. Stepanov Institute of Physics is leading research organization in Belarus in the COMET experiment – a new high precision experimental search for the violation of the lepton quantum number at the charge lepton sector at the Japan Proton Accelerator Research Complex (J-PARC). This experiment would provide a very large window on new physics beyond the Standard Model. The group headed by Dz. Shoukavy together with colleagues from Budker Institute of Nuclear Physics SB RAS developed an optimal algorithm of clustering for on-line energy reconstruction of incident particles.



*The COMET Collaboration*

The Belarusian physicists from the National Academy of Sciences (B.I. Stepanov Institute of Physics) take an active part in theoretical and experimental investigations carried out at Budker Institute of Nuclear Physics, Novosibirsk, (M.I. Levchuk,

D.M. Nikolenko, A.I. Milstein) as well as at Tomsk University (M.I. Levchuk, A.I. Fiks, V.N. Stibunov). Many new important results have been obtained for numerical values of nucleon polarizabilities and for  $\pi$ - and  $\eta$ -photoproduction on the both polarized and unpolarized deuterons.

Collaboration between Belarus in particular JIPNR-Sosny and International Atomic Energy Agency is very important to ensure safety and security of nuclear research.

On October 8, 2014 was signed the Letter of Intention for Cooperation between the National Academy of Sciences of Belarus and the Institute Max von Laue-Paul Langevin which is one of the world leading centers in the area of studies based on the use of neutrons. Following reciprocal visits of the NAS of Belarus and ILL representatives the potential directions for realization of mutual activity were specified. Among these are the studies in the area of structural biology and biochemistry, material science, healthcare based on the use of neutrons and archeological artefacts studies. Series of steps were made toward a formulation of research initiatives for joint implementation.

New for Belarusian science in the field of relativistic astrophysics is presented now by ICRANet-Minsk Centre, created in close collaboration with international research organization ICRANet (International Centre for Relativistic Astrophysics Network) established in 2003. The ICRANet headquarter is in Pescara, Italy. Belarusian physics have a long tradition of gravitation research (O.S. Ivanitskaya, A.E. Levashov, A.K. Gorbatsievich, A. Minkevich etc.). The ICRANet-Minsk group headed by I. Siutsou in B.I. Stepanov Institute of Physics of NAS together with colleagues from other ICRANet organizations is studying the mechanisms of emission from Gamma-Ray Bursts, dark matter in galaxies, scalar-tensor theories of gravitation and other relativistic astrophysics' topics.





*International conference in honor of  
Ya.B. Zeldovich 95<sup>th</sup> Anniversary, 2009, Minsk*



*International conference in honor of  
Ya.B. Zeldovich 100<sup>th</sup> Anniversary, 2014, Minsk*

Obviously the scientific cooperation is very important for the development of scientific research.

## **PROGRAM & ABSTRACTS**

BelINP-2017

1st International Symposium  
«Integration of Belarusian scientists  
in the research programs of the  
world's leading nuclear physics centers»

ICRANet-Minsk Workshop

User Meeting on Neutron Technics

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