Jury’s recommendations on awarding JINR annual prizes for best papers in the fields of theoretical research, experimental research, methodology and technology research, and applied technology research

Latchesar Kostov

135th session of the Scientific Council

Research papers were submitted to the competition, in the fields of:

Theoretical research — 5

Experimental research — 6

Methodology and technology research — 6

Applied technology research — 5

JURY'S RECOMMENDATIONS ON JINR PRIZES 2023

For theoretical research papers

First prizes

"Exactly solvable models of statistical mechanics and quantum field theory"
Authors: S.E. Derkachov, G.A. Sarkissian, V.P. Spiridonov

"Mechanism of complete fusion by nucleon transfer in heavy ion collisions"
Authors: A. Nasirov, G. Adamian, Sh. Kalandarov, G. Giardina, G. Mandaglio, B. Kayumov, O. Ganiev, G. Yuldasheva

Second prize

"Theoretical support of experiments for colliders"
Authors: A. Arbuzov, S. Bondarenko, Ya. Dydyshka, V. Yermolchyk, Yu. Yermolchyk, L. Kalinovskaya, A. Kampf, L. Rumyantsev, R. Sadykov

Third prize

"Weak decays of heavy hadrons in light of search for new physics"
Authors: G. Ganbold, M. Ivanov, A. Issadykov, V. Lyubovitskij, Tran Chien Thang, Zh. Tyulemissov

JURY'S RECOMMENDATIONS ON JINR PRIZES 2023

For experimental research papers

First prizes

"Diffuse neutrino flux measurements with the Baikal-GVD neutrino telescope"
Authors: I. Belolaptikov, K. Konishchev, A. Korobchenko, E. Pliskovskiy, B. Shaibonov

"New isotope ^{276}Ds and its decay products ^{272}Hs and ^{268}Sg from the ^{232}Th+^{48}Ca reaction"
Authors: F. Abdullin, A. Voinov, D. Ibadullayev, N. Kovrizhnykh, A. Polyakov,
R. Sagaidak, D. Solovyev, V. Utyonkov, Yu. Tsyganov, M. Shumeiko

Second prize

"Magnetic states of rare earth metals at high pressure"
Authors: N. Golosova, D. Kozlenko, E. Lukin, B. Savenko, V. Yushankhai

Third prize

"Search for light dark matter with NA64 at CERN"

Authors: P. Volkov, S. Gninenko, T. Enik, G. Kekelidze, V. Kramarenko, N. Krasnikov, V. Matveev,
D. Peshekhonov, V. Polyakov, K. Salamatin

JURY'S RECOMMENDATIONS ON JINR PRIZES 2023
For methodology and technology research papers

First prize

"The SFiNx detector system"
Authors: A. Isaev, R. Mukhin, A. Yeremin, A. Kuznetsova, O. Malyshev, A. Popeko, Yu. Popov, B. Sailaubekov, A. Svirikhin, E. Sokol

Second prizes

"Development of a software and algorithmic complex for the reconstruction, identification and selection of high-energy muons in the CMS experiment at the LHC"
Authors: N. Voytishin, A. Zarubin, V. Karjavin, A. Kamenev, V. Korenkov, A. Lanev, V. Matveev, V. Palchik, V. Perelygin, S. Shmatov

"Development and application of new experimental techniques at the complex ACCULINNA-2@U-400M"
Authors: A. Bezbakh, S. Belogurov, M. Golovkov, A. Gorshkov, S. Krupko, E. Nikolskii, G. Ter-Akopian, A. Fomichev, V. Chudoba, P. Sharov

Third prize

"On a ^{3}He refrigerator based on closed-cycle cryocooler cooling"
Author: A. Chernikov

JURY'S RECOMMENDATIONS ON JINR PRIZES 2023

For applied technology research paper

First prize

"The study of nanolayer materials and artificial diamonds by positron spectroscopy using a unique in Russia slow monochromatic positron injector"

Authors: A. Sidorin, O. Orlov, V. Hilinov, I. Meshkov, E. Akhmanova, M. Eseev, I. Kuziv, R. Laptev, P. Horodek, K. Siemek

Second prizes

"Neutron non-destructive structural analysis of cultural heritage materials: applied interdisciplinary studies"

Authors: B. Abdurakhimov, B. Bakirov, A. Zhomartova, S. Kichanov, D. Kozlenko, E. Lukin, K. Nazarov, B. Savenko, I. Saprikina, V. Smirnova

"Study of hardening mechanisms, residual stresses and microstructure of high-strength aluminum alloys"

Authors: G. Bokuchava, Yu. Gorshkova, I. Papushkin, V. Turchenko, R. Fernández, G. González-Doncel, L. Millán, G. Bruno, G. Kronberger, P. Halodova

Third prize

"Evaluation of the modern radiopharmaceuticals' stability using nuclear spectrometric methods"

Authors: D. Filosofov, E. Kurakina, A. Velichkov, D. Karaivanov, O. Kochetov, A. Salamatin, V. Timkin, J. Khushvaktov

For theoretical research papers

First prize *"Exactly solvable models of statistical mechanics and quantum field theory"*

S.E. Derkachov, G.A. Sarkissian, V.P. Spiridonov



Key results:

- Discovery of an unexpected relation between d=4 quantum field theory and d=2 exactly solvable models of statistical mechanics of Ising type. The non-abelian d=4 electric-magnetic duality of Seiberg is responsible for integrability of spin systems on lattices. Equality of superconformal indices of dual theories is identical to the star-triangle relation in statistical mechanics and serves as a confinement criterion. In short:

"Seiberg duality = quantum integrability"

- The most general rank one solution of the Yang-Baxter equation, the key equation for solvable models of statistical mechanics, is constructed. The problem of constructing the intertwiner for Sklyanin algebra, standing for 30 years, is solved. A new series of lattice spin systems generalizing the Baxter's eight vertex model is discovered from the finite-dimensional representations of the elliptic modular double, generalizing Faddeev's modular double.
- The star-triangle relation is realized as the equality of partition functions of d=3 supersymmetric field theories, which extends the Faddeev-Volkov relation. This identity is further extended to the systems associated with the general lens space.
- A rigorous justification of the limits from d=4 superconformal indices and d=3 partition functions to the level of complex hypergeometric functions. Construction of a new integrable quantum mechanical N-body system, obtained from the corresponding degeneration of the van Diejen model, and a computation of a new extension of the fundamental Selberg integral.
- Computation of 6j-symbols for principal series representation of the Lorentz group. These and 6j-symbols for Faddeev's modular double, arising in d=2 conformal field theory, are shown to be limits of the superconformal index of a simple d=4 supersymmetric field theory. These results are extended to the parafermionic Liouville theory, including the N=1 supersymmetric Liouville field theory.

For theoretical research papers

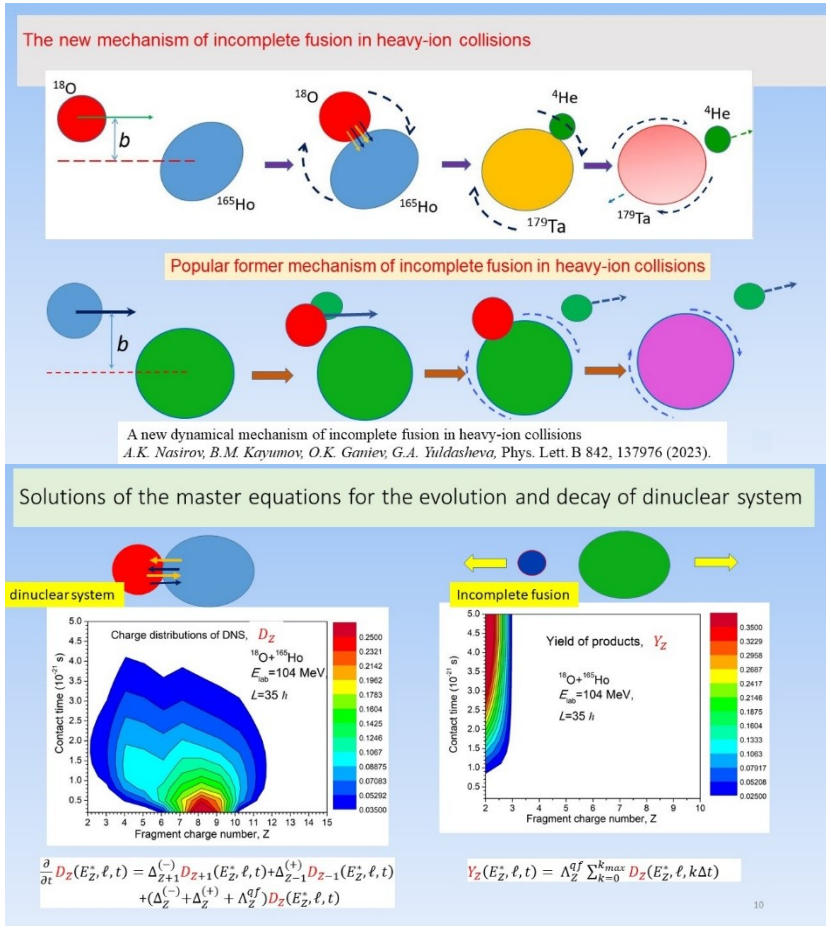
First prize ***"Mechanism of complete fusion by nucleon transfer in heavy ion collisions"***

G.G. Adamian, O.K. Ganiev, G. Giardina, Sh.A. Kalandarov, B.M. Kayumov, G. Mandaglio, A.K. Nasirov, G.A. Yuldasheva







A theoretical model has been developed to study the non-equilibrium stage of heavy ion collisions. The model is based on the dinuclear system concept suggested by Prof. Vadim Volkov to explore the mechanism of complete fusion of nuclei. The model allows us to describe and explain the phenomena of the complete/incomplete fusion and yields of reaction products observed in different experiments.

We have proved for the first time that the incomplete fusion occurs due to the appearance of the intrinsic fusion barrier and increase in the centrifugal force for the alpha particle in collisions with large orbital angular momentum. There is no need to assume that the incomplete fusion occurs due to the breakup of the projectile before contact with the target nucleus.

The advantage of this model is that it allows us to describe and explain some the experimental data which have not been analyzed by the other existing theoretical models.

For experimental research papers

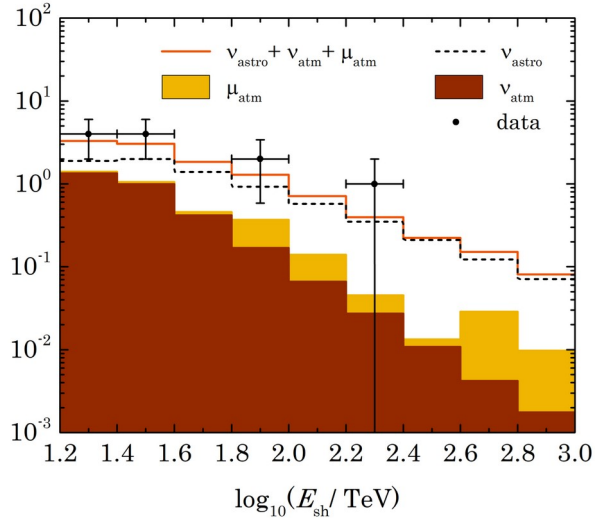
First prize *"Diffuse neutrino flux measurements with the Baikal-GVD neutrino telescope"*

I. Belolaptikov, K. Konishchev, A. Korobchenko, E. Pliskovskiy, B. Shaibonov





Reconstructed energy distributions for the upward sample



Data analysed: April 2018 - March 2022

All-sky events:

- 16 events with E > 70 TeV
- Expected background (atm. ν and μ) of 8.2 events
- Signal best fit 5.8 events
- Probability for the background-only hypothesis: 2.22 σ

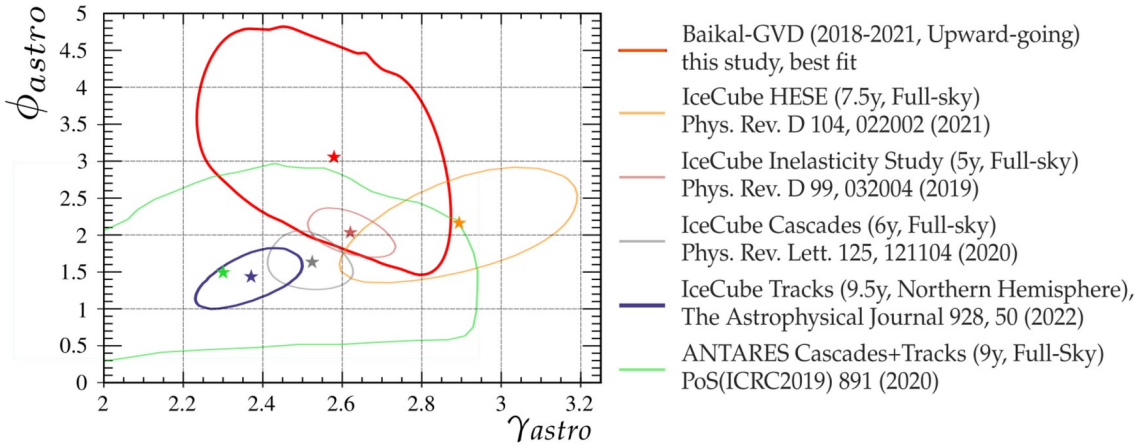
Upward-going events:

- 11 cascades with E > 15 TeV
- Expected background of 3.2 events
- Signal best fit 6.3 events
- Probability for the background-only hypothesis: 3.05 σ

We confirm the IceCube observation of astrophysical diffuse neutrino flux with 3σ significance

The best-fit parameters for the power law model:

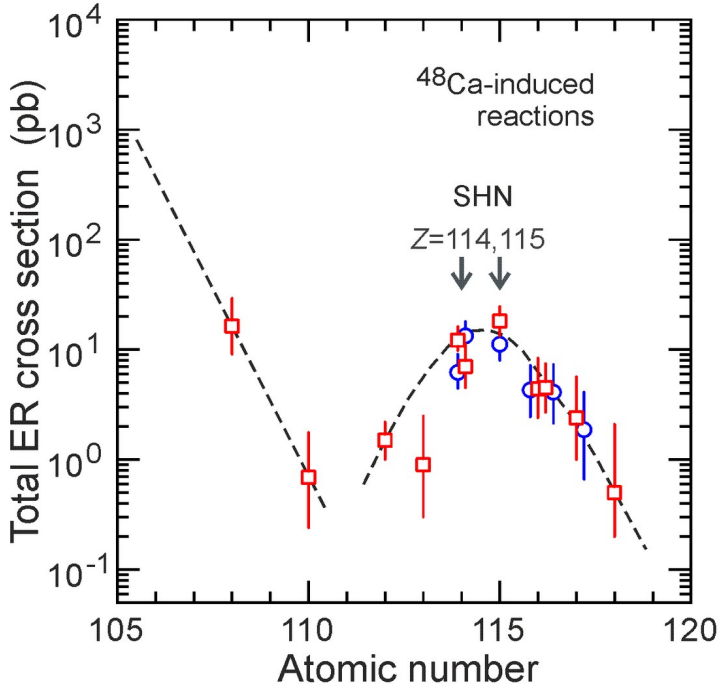
$$\Phi^{\nu+\bar{\nu}}_{astro} = 3\times10^{-18}\phi_{astro}\left(\frac{E_\nu}{E_0}\right)^{-\gamma_{astro}}$$



For experimental research papers

First prize ***"New isotope ^{276}Ds and its decay products ^{272}Hs and ^{268}Sg from the ^{232}Th+^{48}Ca reaction"***

V.K. Utyonkov, M.V. Shumeiko ,F.Sh. Abdullin, D. Ibadullayev, N.D. Kovrizhnykh, A.N. Polyakov, R.N. Sagaidak, D.I. Solovyev, Yu.S. Tsyganov, A.A. Voinov



^{232}Th + ^{48}Ca

For the first time since 1983, when the first experiments on the synthesis of Ds isotopes in direct reactions of ^{40}Ar, ^{48}Ca with isotopes of actinide elements ^{232}Th, ^{235,236,238}U were carried out, three new superheavy nuclides ^{276}Ds, ^{272}Hs, and ^{268}Sg were discovered at the DGFRS-2 separator of the SHE Factory.

The production cross section for ^{276}Ds compared to the synthesis of all transactinides with Z = 108–118 in the ^{48}Ca-induced reactions turned out to be the smallest one or close to that for ^{294}Og.

During the experiment lasting less than a month, a sensitivity of about 70 fb was achieved, which indicates a strong potential for the research of superheavy nuclei with low production cross sections.

For methodology and technology research paper

First prize

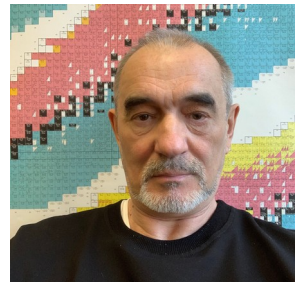
“The SFiNx detector system”









A. Isaev, R. Mukhin, A. Yeremin, A. Kuznetsova, O. Malyshev, A. Popeko, Yu. Popov, B. Sailaubekov, A. Svirikhin, E. Sokol

A new detector system SFiNx (Spontaneous Fission, Neutrons and X-rays) for on-line investigation of the SF properties of short-lived heavy nuclei synthesized in complete fusion reactions was created in FLNR (Fig. 1). The neutron registration efficiency is (55 ± 1) %.

Fig. 1. The SFiNx detector system

As a result of an experimental series on SHELS separator, the prompt neutrons yield data from spontaneous fission obtained for heavy nuclei with Z = 100 – 106. The prompt neutron yields for ^{250,254}No, ^{256}Rf and ^{260}Sg isotopes obtained for the first time and significantly refined for the isotopes ^{244,246}Fm and ^{252}No (Fig. 2).

Using the SFiNx system and the GRAND gas-filled separator at the JINR **Superheavy Elements Factory**, it will be possible for the first time to obtain data on the emission of prompt neutrons from the heaviest nuclei.

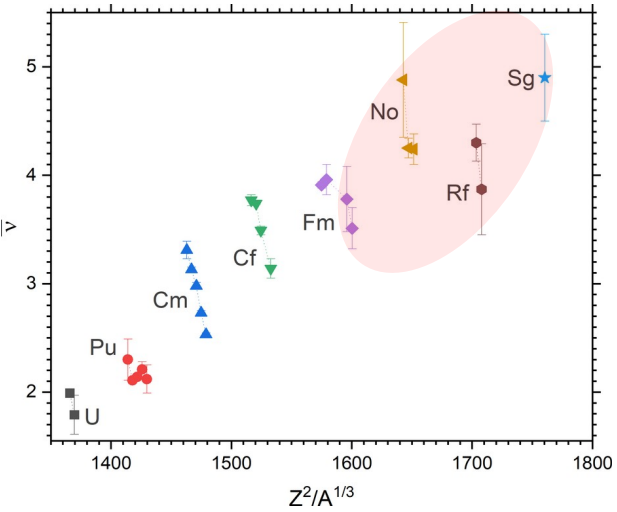


Fig. 2. Systematics of the average number of neutrons per spontaneous fission decay. The oval marks the data obtained with the SHELS separator

For applied technology research papers

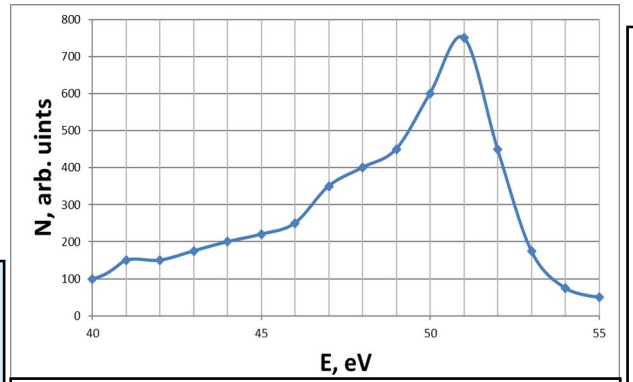
First prize *"The study of nanolayer materials and artificial diamonds by positron spectroscopy using a unique in Russia slow monochromatic positron injector"*

A. Sidorin, O. Orlov, V. Hilinov, I. Meshkov, E. Akhmanova, M. Eseev, I. Kuziv, R. Laptev, P. Horodek, K. Siemek

Positron annihilation spectroscopy (PAS) is an excellent method for detecting open volume defects at the atomic level. It is used in the field of solid state physics, as well as in materials research. PAS is currently one of the most relevant and rapidly gaining popularity in Russia and in the world of methods for studying materials. The work cycle presents the development of the Positron Injector installation and the most promising research in modern materials science in Russia.

Advantages of PAS on beam:

- *the unique capabilities of non-destructive testing*
- *extreme sensitivity to defect detection*
- *the ability to scan samples for defects in depth with extremely high accuracy.*

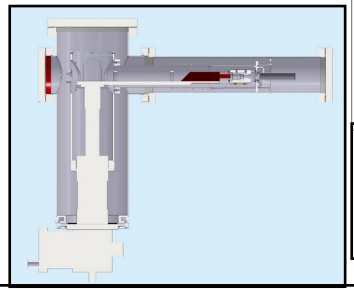


The full width at half height is 2 eV. The output of positrons is 3.3 x 10^6 positrons per second.

Synthetic diamond plates doped with nitrogen are used in the development of quantum optical networks. The possibilities of using these materials to create solid-state spin qubits are also being considered.

The helium closed-cycle cooling system of the source and moderator

- *solves the problem of limited operating time due to a shortage of liquid helium.*
- *reduce the preparation time for experiments from 6-7 hours to 3 hours.*



This work cycle presents the results of studies of radiation-resistant materials with improved physical and mechanical properties (Tomsk Polytechnic University (TPU)) and the structure of synthetic diamond (Northern (Arctic) Federal University named after M. V. Lomonosov).

TPU studies nanoscale multilayer coatings Zr/Nb, which are structural materials of the core of a nuclear reactor. Such coatings significantly increase the service life of reactors.

The Jury asks the Scientific Council to approve these recommendations

Members of the Jury

M. V. Avdeev	FLNP
I. V. Anikin	BLTP
V. V. Glagolev	DLNP
M. G. Itkis	FLNR
G. N. Knyazheva	FLNR
V. I. Kolesnikov	VBLHEP
L. Kostov	Chair of the Jury
N. Kucherka	FLNP
V. O. Nesterenko	BLTP
A. G. Olshevsky	DLNP
A. M. Povolotsky	BLTP
D. V. Podgainy	MLIT
M. G. Sapozhnikov	VBLHEP
V. I. Furman	FLNP