Borexino/DarkSide in 2014-2019

Dubna group participated in the data taking shifts and took an active part in the physical analysis of the accumulated data in the frame of the “antineutrino”, “rare physics”, “cno” and “pp-neutrino” working groups. In particular, the group participated in the development of the analytical model for the description of the energy scale, energy resolution and the shape of the detector response; promotion of the use of new energy estimators; development of the software algorithms for the standard analytical fitter used for the analysis of 7Be and pp- Solar neutrino fluxes; for the geo-neutrino studies; for the paper on neutrino magnetic moment limits; for the “electron decay” paper; porting the analysis software (fitter) to the GPU-based systems

The main results obtained with the participation of the Dubna group and the details of the contribution are presented below,

2014

The main result of the year was a first real-time measurement of solar pp-neutrino flux published in Nature magazine [1]. The result was nominated by Physics World magazine among Top Ten Breakthroughs of the year. Dubna group played decisive role in the data analysis for this paper, the analysis group was coordinated by JINR scientist.

The results of the first stage of the Borexino experiment were summarized in the article [2].

A talk has been presented at PPP-2014 conference [I], another talk [II] has been presented at the Borexino special event (Workshop on the Borexino Physics, Laboratori Nazionali del Gran Sasso), synchronized with a Nature paper. A plenary talk at the international conference-session of nuclear physics department of the Russian academy of science "Physics of fundamental interactions". A PhD thesis and a diploma thesis have been defended in the frame of Borexino activities at JINR.

2015

In 2015 Dubna group participated in data acquisition shifts with the Borexino detector and was deeply involved in analyses of accumulated physics data in the course of “antineutrino”, ”rare physics” и ”pp-neutrino” working activities. The group has also provided one month of data taking

shifts with the Dark Side detector.

New Borexino results on Earth antineutrino flux measurement [3] and electron lifetime limits with respect to $\nu \rightarrow e+\gamma$ decay [4] are published. Scientists from DLNP made a crucial contribution to analyses and results obtained, the paper [4] was prepared by Dubna group. The first results from DarkSide-50 were published [5].

The results were reported at the international conferences of the year [III]-[V].

2016

The work on establishing the limits on the neutrino fluxes associated with gamma-ray bursts was completed, published in [6].

The limits on the WIMP-nucleon spin-independent cross sections were obtained with (1422±67) kg·days exposure of the DS-50 [7]. \The software module for the simulation of the SiPM signals was developed for DS20k simulation code.

Borexino results were reported at the international conferences of the year [VI]-[IX].

2017

Results of the analysis of season variations of the Solar neutrino flux were presented, the phase and amplitude of the variations are in agreement with expectations [8].

The Dubna group performed analysis for the paper on the neutrino magnetic moment, the new best limit on the effective moment of Solar neutrino was obtained, $\mu_\nu^{eff} < 2.8 \cdot 10^{-11}\ \mu_B$ (90% C.L.) [9].

In the frames of the multimessenger approach, a search for the gravitational events (GW150914, GW151226 and GW170104) was performed and published [10].

Borexino results were reported at the international conferences of the year [X]-[XV],

2018

Results of the most complete and precise analysis of neutrino fluxes accompanying solar thermonuclear processes were published [11]. Precision

of the flux measurement for the beryllium solar neutrinos has reached a record value of 2.7% which is twice as good as theoretical predictions. Signal from the pep reaction in the Sun is detected at the confidence level exceeding 5σ for the first time. These results are obtained with active participation of the JINR group.

Concept of the Darkside 20k experiment was published [12]. The project is 20-ton two-phase time projection chamber based on liquid argon dedicated to dark matter (DM) search. JINR group is developing the neutron veto for the project.

Results of dark matter search in the Darkside-50 detector were published: limits on spin-independent DM-nucleon scattering for WIMP particles with masses of 100 GeV, 1 TeV and 10 TeV [13]; limits on spin-independent DM-nucleon scattering for WIMPs starting from 1.8 GeV with the strongest limits in the 1.8-6 GeV range [14]; limits on the DM-electron scattering for DM particle energy up to 1 GeV [15].

Borexino results were reported at the international conferences of the year [XVI]-[XIX],

2019

This year the Borexino collaboration presented the results of the search for non-standard neutrino interactions [16]. The analysis was performed by the Dubna group physicists. A. Formozov defended a PhD thesis based on the work [17] this year. The model-independent limits on neutrino and antineutrino fluxes from astrophysical sources were set in another publication [18]. The final analysis of the geoneutrino fluxes from the Earth perfomed with the complete Borexino's dataset is published [19]. The Dubna group developed and optimized the criteria for the antineutrino selection, including the background suppression from fast neutrons; improved the quality of the data from the fast ADC (FADC) system and performed their analysis, the former was used for the antineutrino spectrum in the 1.8 - 9 MeV energy range. The group performed simulations and calculations of the background from (α,n) reactions. Also, a comprehensive review of the experimental geoneutrino study was published by O. Smirnov [20] this year.

DarkSide activity included work on the neutron veto design, and the DS50 data analysis. A technical paper on the ions mobility in liquid argon was published by the collaboration [21].

Borexino results were reported at the international conferences of the year [XX]-[XXII],

Publications

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[2] G. Bellini et al. (Borexino Collaboration), “Final results of Borexino Phase-I on low-energy solar neutrino spectroscopy”, Phys. Rev. D 89, (2014) 112007

[3] M. Agostini et al. (Borexino Collaboration). “Spectroscopy of geoneutrinos from 2056 days of Borexino data”. Phys. Rev. D 92 031101 (2015)

[4] M. Agostini et al. (Borexino Collaboration). “A test of electric charge conservation with Borexino”. Phys. Rev. Lett. 115, 231802 (2015)

[5] P. Agnes et al. (DarkSide Collaboration). “First results from the DarkSide-50 dark matter experiment at Laboratori Nazionali del Gran Sasso”. Phys. Lett. B 743 456-466 (2015)

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[7] P. Agnes et al. “Results from the first use of low radioactivity argon in a dark matter search”, Physical Review D, 93 (2016): 081101.

[8] M. Agostini et al. (The Borexino collaboration), “Seasonal Modulation of the ^{7}Be Solar Neutrino Rate in Borexino”, Astroparticle Physics 92, p. 21 (2017).

[9] M. Agostini et al. (The Borexino collaboration), “Limiting neutrino

magnetic moments with Borexino Phase-II solar neutrino data", Phys.Rev.D 96, 091103(R) (2017)

[10] M. Agostini et al. (The Borexino collaboration), "A Search for Low-energy Neutrinos Correlated with Gravitational Wave Events GW 150914, GW 151226, and GW 170104 with the Borexino Detector", Astrophys. J., 850:21 (2017).

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[14] P. Agnes et al. (DarkSide Collaboration), "Low-Mass Dark Matter Search with the DarkSide-50 Experiment", Phys. Rev. Lett. 121, 081307 (2018) [arXiv: 1802.06994].

[15] P. Agnes et al. (DarkSide Collaboration),. "Constraints on Sub-GeV Dark Matter-Electron Scattering from the DarkSide-50 Experiment". Phys. Rev. Lett. 121, 111303 (2018) [arXiv: 1802.06998].

[16] S.K. Agarwalla et al. (Borexino collaboration), " Constraints on Non-Standard Neutrino Interactions from Borexino Phase-II", arxiv:1905.03512[hep-ph]; accepted for publication by JHEP.

[17] A. Formosov, "Search for Non-Standard Neutrino Interactions with Large-Volume Liquid Scintillator Detectors", PhD thesis, 2019.; DOI: 10.13130/formozov-andrey_phd2019-05-15

[18]M. Agostini et al. (Borexino collaboration), "Search for low-energy neutrinos from astrophysical sources with Borexino", arXiv:1909.02422 [hep-ex], submitted to Astrop.J.

[19] M. Agostini et al. (Borexino collaboration), “Comprehensive geoneutrino analysis with Borexino”, Phys. Rev. D 101, 012009 (2020).

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[21]DarkSide-50 Collaboration. “Measurement of the ion fraction and mobility of 218Po produced in 222Rn decays in liquid argon”. Journal of Instrumentation, 14 (2019): P11018.

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[II] O. Smirnov, “The measurement of the solar neutrinos from the pp nuclear reaction”, Workshop on the Borexino Physics, LNGS, September 5, 2014

[III]O. Smirnov on behalf of the Borexino collaboration. “Borexino. New geoneutrino results”. Neutrino GeoScience-2015. 15–17 June 2015, Paris, France

[IV] A. Vishneva on behalf of the Borexino collaboration. “Test of the Electric charge conservation law with Borexino Detector”. The International Conference on Particle Physics and Astrophysics (ICPPA-2015) October 5–10, 2015, Moscow, Russia

[V] O. Smirnov on behalf of the Borexino collaboration. “Measurement of Solar pp-neutrino flux with Borexino: results and implications”. The International Conference on Particle Physics and Astrophysics (ICPPA-2015) October 5–10, 2015, Moscow, Russia

[VI]. A. Vishneva (on behalf of Borexino collaboration), "New limit on the electron lifetime in the Borexino experiment", AYSS-2016, 14-18 March

2016, Dubna

[VII] O. Smirnov, “Borexino. Recent results and future plans”, Международная сессия-конференция Секции ядерной физики ОФН РАН "Физика фундаментальных взаимодействий", ОИЯИ, Дубна. 12 -17 апреля 2016 г.

[VIII] O. Smirnov on behalf of the Borexino collaboration. “Geoneutrino flux measurement with Borexino detector”, Workshop：Neutrino Research and Thermal Evolution of the Earth, October 25 – 27, 2016, Sendai, Japan

[IX] A. Vishneva (on behalf of Borexino/SOX collaboration) Talk "Status of the SOX project", International Conference on Particle Physics and Astrophysics, 10-14 October 2016, Moscow, Russia

[X] O.Smirnov, “Measurement of the geo-neutrino fluxes: status and future”, International Session-Conference of the Section of Nuclear Physics of the Physical Sciences Department of the Russian Academy of Sciences “"Physics of fundamental interactions“" dedicated to 50th anniversary of Baksan Neutrino Observatory, June 6-8, 2017.

[XI] O. Smirnov on behalf of the Borexino collaboration, “Limits on the neutrino magnetic moments”, Recent development in Neutrino Physics and Astrophysics LNGS, September 4-7, 2017

[XII] O. Smirnov on behalf of the Borexino collaboration, “Borexino”, The Mount Elbrus Conference from Deep Underground up to the Sky Pyatigorsk, September 11-15, 2017.

[XIII] O. Smirnov, “Geo-neutrino : experimental status and perspectives”, Conference on Neutrino and Nuclear Physics (CNNP2017) 15-21 October 2017, Monastero dei Benedettini, University of Catania, Catania, Italy.

[XIV] O. Smirnov, on behalf of the Borexino collab., “Experimenal limits on neutrino magnetic moments (Borexino results)”, Solvay workshop on “Beyond the Standard model with Neutrinos and Nuclear physics”, Brussels, November 29-December 1, 2017.

[XV] A. Vishneva «Recent results from Borexino». Session-Conference SNP

PSD RAS, 6-8 June, 2017, Nalchik, Russia

[XVI]. A. Vishneva (on behalf of Borexino collaboration), "Effective neutrino magnetic moment limit from Borexino data", AYSS-2018, 23-27 April 2018, Dubna

[XVII] O. Smirnov, on behalf of the Borexino collab., “Solar neutrino from pp-chain and other results of Borexino”, XXVIII International Conference on Neutrino Physics and Astrophysics, Heidelberg, June 5, 2018.

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[XIX] A. Vishneva (on behalf of Borexino collaboration), "New constraints on magnetic moments of solar neutrinos in Borexino", ICPPA-2018, 22-26 October 2018, Moscow

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[XXI] O. Smirnov, “Solar and geo-neutrinos: current status and future directions”, International School of Nuclear Physics 41st Course Star Mergers, Gravitational Waves, Dark Matter and Neutrinos in Nuclear, Particle and Astro-Physics, and in Cosmology Erice-Sicily: September 16-24, 2019

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