

Report on the JINR group participation in the BESIII experiment in 2019-2022

The JINR group worked in 2019-2022 on the following topics.

1) Partial wave analysis of $J/\psi \rightarrow K^+K^-\pi^0$.

The analysis performed by the JINR BESIII group is published in *Phys.Rev.D* 100, 032004 (2019). The analysis reveals contributions from $K^{*}_2(1430)^\pm$, $K^{*}_2(1980)^\pm$, $K^{*}_4(2045)^\pm$ decaying to $K^\pm\pi^0$. The two latter states are observed in J/ψ decays for the first time. The most precise measurements of $K^*(980)^\pm$ and $K^{*}_2(1430)^\pm$ masses and widths are obtained. Two resonance signals decaying to K^+K^- are also observed, their interpretations are suggested. The total branching ratio, as well as partial widths for decays through individual states, are reported, most of the values are reported for the first time.

2) Scalar isoscalar mesons and the scalar glueball from radiative J/ψ decays.

The BESIII data on radiative J/ψ decays to $\pi\pi$, KK , $\eta\eta$, and $\omega\phi$ constrained by two meson scattering data and data on proton-antiproton annihilation to three mesons are analyzed in the N/D approach [*PLB* 816,136227 (2021)]. The analysis revealed enhancement in the scalar meson production rate in radiative J/ψ decays. The position of the enhancement is consistent with estimations of the scalar glueball mass and the associated partial width is consistent with lattice calculation for its production in radiative J/ψ decays. The enhancement was interpreted as an admixture of scalar glueball in the wave-functions of scalar mesons. This work is performed with the leading participation the JINR BESIII group and is based on its previous experience.

3) Tensor glueball search in radiative $\psi(3686)$ decays.

A review paper discussing lack of evidence for the tensor glueball in the currently available data on J/ψ decays was published [*Phys. Lett. B* 830 (2022) 137171] with the participation of the JINR group members. Further studies of J/ψ and analysis of ψ' decays were suggested.

The first iteration of $\psi(3686) \rightarrow \gamma\pi^0\pi^0$ analysis using the BESIII data have been performed. The data from 2009, 2012 and 2021 have been processed, major background sources identified and suppressed. Currently, model independent and model dependent partial wave analysis is ongoing.

4) Cross-section measurement of the light meson production in the energy range of 2-3 GeV and around the J/ψ peak.

An analysis of the processes $e^+e^- \rightarrow \eta\pi^+\pi^-$ was performed based on the data corresponding to a total integrated luminosity of 648 pb^{-1} collected at 19 center-of-mass

energies from 2.00 to 3.08 GeV. The cross-section of this process in two channels of η decay: $\eta \rightarrow \gamma\gamma$ and $\eta \rightarrow \pi^0\pi^0\pi^0$ was measured. Based on this work P. Egorov successfully defended his bachelor and master theses in 2020 and 2022.

5) Determination of the phase between strong and electromagnetic amplitudes in J/ψ decays

The determination of the phase was performed via measuring of the $e^+e^- \rightarrow \phi\eta$ cross-section dependence as a function of collision energy. The BESIII data with the collision energy in the vicinity of the J/ψ peak (from 3.05 up to 3.12 GeV) were used. However, the obtained precision of the measurement (phase = 2.8 ± 0.8) is not acceptable. To improve it, new data in the same energy range collected for the R-scan and the tau-mass measurement calibration in 2018 were added. Another approach to reduce the phase determination uncertainty relies on precision measurements of the $J/\psi \rightarrow \phi\eta$ partial width. It was measured to be $\text{Br}(J/\psi \rightarrow \phi\eta) = (8.4 \pm 0.4 \pm 0.1) \times 10^{-4}$. The analysis was presented within the BESIII Collaboration and now undergoes internal refereeing procedures. During them the authors were asked analyze also data collected in 2021 to independently verify their finding and improve the results.

6) Cross-section measurement of the semi-inclusive reaction $e^+e^- \rightarrow J/\psi X$ above 3.8 GeV

The cross-sections of the prompt J/ψ and $\psi(3686)$ production in the e^+e^- annihilation have been measured in the energy range between 3.810 and 4.950 GeV using data samples of 22 fb^{-1} collected by the BESIII detector between 2011 and 2021. These data are important for the study of charmonia production models. Currently, the publication draft undergoes internal refereeing.

7) Search for proton-antiproton bound state in the reaction $e^+e^- \rightarrow 2p2p$ performed by a graduate student. A bachelor thesis by S. Pogodin was defended 2020.

I. Denisenko successfully defended PhD thesis “Light hadron spectroscopy and search for exotic states in the $J/\psi \rightarrow K^+K^-\pi^0$ decay and radiative J/ψ decays to two pseudoscalars” in 2021.

Software development is the main technical contribution of the JINR group to the BESIII experiment. Currently, the JINR group is one of the leading developers of the core software and physics analysis tools. Maintenance of software packages, developed earlier by JINR group, including the ROOT-based analysis framework BEAN was continued in 2019-2022. The support of the JINR segment of the BESIII distributed computing system was continued.

The results of the JINR group have been presented in the following reports:

- 1) I. Denisenko, "Light hadron spectroscopy at BESIII", 19-th Lomonosov Conference on Elementary Particle Physics, Moscow, 22 - 28, August 2019.
- 2) Ю. Нефедов, "Обзор эксперимента BESIII", сессия-конференция СЯФ ОФН РАН, Новосибирск, март 2020.
- 3) S. Pogodin, "Search for proton-antiproton bound state in the reaction $e^+e^- \rightarrow 2p2p$ in the BESIII experiment", BSc thesis, Dubna, 2020.
- 4) P. Egorov, "Measurement of the cross-section of $e^+e^- \rightarrow \eta\pi^+\pi^-$ in energy range 2.00 – 3.08 GeV", BSc thesis, Dubna, 2020.
- 5) I. Denisenko, "Partial wave analysis of $J/\psi \rightarrow K^+K^-\pi^0$ ", 9th International Conference on New Frontiers in Physics (ICNFP 2020), Crete, 4-12 October 2020.
- 6) I. Denisenko, "Partial wave analysis of $J/\psi \rightarrow K^+K^-\pi^0$ ", 5-th International Conference on Particle Physics and Astrophysics (ICPPA 2020), Moscow, 5-9 October 2020.
- 7) I. Denisenko, "Partial wave analysis of $J/\psi \rightarrow K^+K^-\pi^0$ ", XXIV International Scientific Conference of Young Scientists and Specialists (AYSS-2020), 9-13 November 2020.
- 8) I. Denisenko, "Light hadron spectroscopy and search for exotic states in the $J/\psi \rightarrow K^+K^-\pi^0$ decay and radiative J/ψ decays to two pseudoscalars", PhD thesis, 2021.
- 9) O. Bakina, poster "Proposal for the prompt inclusive J/ψ production measurement at future Super c-tau factories", Workshop on future Super c-tau factories, 15-17 November 2021.
- 10) O. Bakina, poster "Studies of charmonium decay from BESIII", 30th International Symposium on Lepton Photon Interactions at High Energies, 10-14 January 2022.