Form №24

Participation of JINR in the Physics Research Programme
at the BEPCII/BESIII

BESIII/JINR

02-2-1123-2015/2019

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PROJECT APPROVAL LIST

Participation of JINR in the Physics Research Programme
at the BEPCII/BESIII

BESIII/JINR

02-2-1123-2015/2019

Alexey Zhemchugov

APPROVED BY THE JINR DIRECTOR

AGREED

JINR VICE-DIRECTOR

CHIEF SCIENTIFIC SECRETARY

CHIEF ENGINEER

HEAD OF THE SCIENCE ORGANIZATION DEPARTMENT

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APPROVED

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Contents

Abstract

The BESIII experiment at the electron-positron collider BEPCII is running at the Institute of High Energy Physics (Beijing, China) since 2008. The experiment is aimed at studies of hadron spectroscopy, tests of various aspects of QCD, charmed hadron decays, and precision test of the SM, as well as the probes of new physics beyond the SM. Nowadays, the BESIII experiment is playing important role in the world in the τ-charm domain and is leading in the research of exotic XYZ states discovered during the last two decades.

JINR group is participating in the BESIII experiment since 2005. This project is aimed at a continuation of BESIII data analysis by the JINR group, focused on the physics of charmonium production and decays and the search and study of exotic charmonia and charmoniumlike structures. Specifically, the measurement of the inclusive prompt production of charmonia at the collision energy above 4 GeV, the study of the J/psi decay structure by determination of the phase between amplitudes of strong and electromagnetic interactions in the number of exclusive processes and the search for bound $p\bar{p}$ states will be carried out.

Currently, the JINR group is one of the leading software developers in the BESIII collaboration. In the scope of the project, the maintenance of software packages, developed earlier by the group, will be continued and a research of the possible use of machine learning algorithms for the recognition of particle tracks in the BESIII inner tracker is planned.

The requested project budget is 75 kUSD for 2020-2022.

Аннотация проекта

Эксперимент BESIII на электрон-позитронном коллайдере BEPCII работает в ИФВЭ АН КНР (Пекин, Китай) начиная с 2008 года. В основные задачи эксперимента входят исследования в области спектроскопии адронов, проверка предсказаний квантовой хромодинамики, изучение распадов очарованных частиц, а также проверка предсказаний Стандартной модели и поиски "новой физики" за ее пределами. На сегодняшний день, эксперимент BESIII играет важную роль в мировых исследованиях чармония, очарованных частиц и тау-лептонов и является лидером в изучении экзотических XYZ-состояний, открытых в последние десятилетия.

Группа сотрудников ОИЯИ участвует в эксперименте BESIII с 2005 года. Данный проект нацелен на продолжение участия сотрудников ОИЯИ в анализе данных BESIII для получения новых результатов о процессах рождения и распада состояний чармония и для изучения экзотических чармониев и чармониеподобных структур. В частности, предлагается выполнить измерение инклюзивного сечения прямого рождения состояний чармония в электрон-позитронной аннигиляции с энергией выше 4 ГэВ, изучение структуры распада J/psi путем измерения разности фаз между амплитудами сильного и электромагнитного взаимодействия в ряде эксклюзивных процессов, а также поиск связанных $p\bar{p}$ состояний.

В настоящее время группа ОИЯИ является одним из ведущих разработчиков программного обеспечения в коллаборации BESIII. В рамках данного проекта будут продолжены работы по поддержке программных пакетов, разработанных ранее группой ОИЯИ, а также будет выполнено исследование возможности использования алгоритмов машинного обучения для распознавания треков частиц во внутреннем трекере установки BESIII.

Бюджет проекта составляет 75 тыс. долларов США на 2020-2022 год.

Introduction

The BESIII experiment at the electron-positron collider BEPCII started its operation in the Institute of High Energy Physics (Beijing, China) in 2008. BEPCII is designed to collide e^+e^- beams in the energy range of $\sqrt{s}$ = (2 - 4.6) GeV. In April 2016 the instantaneous luminosity reached the design value of 1.0 $\times 10^{33}$ $cm^{-2}s^{-1}$ at a center-of-mass energy of 2 $\times$ 1.89 GeV. The Beijing Spectrometer III (BESIII) is a highly precise general-purpose detector designed for high luminosity $e^+ e^-$ collisions in the tau-charm energy region. The main tasks of the experiment are the studies of charmonium physics, physics of charmed mesons, tau leptons and light hadron spectroscopy.

The physics data taking was started in March of 2009. Since then, about 20 fb^{-1} of integrated luminosity was collected at different energy points. By using these data samples, the BESIII Collaboration has published about 200 papers, which have been making great contributions to hadron spectroscopy, tests of various aspects of QCD, charmed hadron decays, and precision test of the SM, as well as the probes of new physics beyond the SM. Nowadays, the BESIII experiment is the world leader of researches in the tau-charm energy domain and one of pioneers in studies of exotic XYZ states discovered during the last two decades.

JINR group is participating in the BESIII experiment since 2005. The main research goals of the group are the understanding of the physics of charmonium production and decays and the search and study of exotic charmonia and charmoniumlike structures. However, in recent years, a number of interesting results in light hadron spectroscopy and the studies of D-meson decays have been obtained by the group as well. This project is aimed at a continuation of BESIII data analysis by the JINR group, focused on the measurement of the inclusive prompt production of charmonia at the collision energy above 4 GeV, on the study of the J/psi decay structure by determination of the phase between amplitudes of strong and electromagnetic interactions in the number of exclusive processes and on the search for bound $p\bar{p}$ states.

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, distributed computing and physics analysis tools. Besides the maintenance of software packages, developed earlier by JINR group, a research of the possible use of machine learning algorithms for the recognition of particle tracks in the BESIII inner tracker is planned in the scope of the project.

Current status of the BESIII experiment

The main task of the BESIII experiment is the studies of charmonium physics, physics of charmed mesons, tau leptons and light hadron spectroscopy in the electron-positron collisions in the energy range of (2 - 4.6) GeV. The experiment takes data since 2009 and it is run by the international BESIII Collaboration of about 500 members from 14 countries. World largest samples of J/ψ, ψ(2S), ψ(3770), ψ(4040), ψ(4180), Y(4260) and unique data of tau pair production near threshold, R-value scans etc. have been obtained.

The electron-positron collider BEPCII is a double ring machine with a luminosity which is optimized for 1.89 GeV beam and reaching 1.0×10^{33} $cm^{-2}s^{-1}$. An upgrade of the machine is planned in 2019-2020. The goal of the upgrade is to increase the maximum beam energy up to 2.45 GeV (thus reaching maximum collision energy of 4.9 GeV) and to implement a top-up injection while in collision operation, which will allow improving of the integral luminosity during the data taking by (20-30) %.

The BESIII detector is placed inside a 1 T superconducting solenoid and the steel structure of its flux return. The coil of the superconducting magnet is located outside of the electromagnetic calorimeter and has a mean radius of 1.482 m and a length of 3.52 m. The multilayer drift chamber (MDC) surrounds the beryllium beam pipe. Two superconducting quadrupoles are inserted in the conically shaped MDC end caps as close as possible to the interaction point. The time-of-flight (TOF) system is located outside of the main drift chamber, consisting of two layers of plastic scintillator counters in the barrel part and of MRPC chambers in the end-cap. The CsI(Tl) electromagnetic calorimeter (EMC) is placed outside of the TOF system and inside the solenoid. The muon identifier (MUC) consists of layers of resistive plate chambers (RPCs) inserted in gaps between steel plates of the flux return yoke. The polar angle coverage of the spectrometer is $21° < \theta < 159°$, and the solid angle coverage is $\Delta\Omega/4\pi = 0.93$. An upgrade of the detector is planned in 2019 with a view to replacing the existing inner part of the MDC by the cylindrical GEM tracker (CGEM).

Among the many interesting results obtained in recent years (58 papers have been published by the Collaboration in 2017-2018 and many more analyses are ongoing), it is particularly interesting to note the ones from the studies of exotic hadrons and of hyperon pair production near threshold.

Perhaps the most remarkable BESIII result so far was an observation of the charged charmonium-like state $Z_c(3900)$ in 2013, followed by an observation of other charmonium-like states $Zc^0(3885)$, $Zc^{\pm}(4025)$, $Zc^0(4020)$ in the final states containing a charged pion and a low mass charmonium state, and in pairs of charmed mesons ($D^{(*)}D^*$). A similar pattern of states is also observed in the bottomonium system by B-factories. The quantum numbers of $Z_c(3900)$ have been measured to be $J^p=1^+$ [*PRL119, 072001(2017)*]. Recently, a new charged charmonium-like structure with the mass around 4030 MeV was observed by BESIII in the mass spectrum of ($\pi^{\pm}\psi(3686)$) for data at $\sqrt{s}$ = 4.416 GeV [*PRD96,032004 (2017)*]. Later, a neutral analog with a mass around 4040 has been established at this energy point in the system of ($\pi^0\pi^0\psi(3686)$) [*PRD97 052001 (2018)*]. It is still not clear whether these are the same states as the ones observed earlier by Belle in Y(4360) decay [*PRD91, 112007 (2015)*].

A series of new vector ($J^{PC} = 1^{--}$) charmonium-like states, e.g., the Y (4260), Y(4360), and Y(4660), have been observed by BaBar and Belle in the past decade. Recently, two resonant structures were observed in the processes $e^+e^- \to \pi^+\pi^- J/\psi$ at BESIII indicating that the Y(4260) resonance reported by previous experiments actually consists of two structures Y(4220) and Y(4320) [PRL118, 092001 (2017) , PRL118, 092002 (2017)].

Large data sample collected by BESIII at $\sqrt{s}$ = 4574.5, 4580.0, 4590.0 and 4599.5 MeV gave an opportunity to measure the cross section of the $e^+e^- \to \Lambda^+_c \Lambda^-_c$ process with unprecedented precision. The non-zero cross section near the $\Lambda^+_c \Lambda^-_c$ production threshold has been confirmed. At center-of-mass energies $\sqrt{s}$ = 4574.5 and 4599.5 MeV, the higher statistics data enabled to measure the Λ_c polar angle distributions. From these, the Λ_c electric over magnetic form factor ratios ($|G_E/G_M|$) are measured for the first time. They are found to be 1.14 ± 0.14 ± 0.07 and 1.23 ± 0.05 ± 0.03, respectively [PRL120 (2018) 132001].

The capability of BEPCII to operate near the $\Lambda\bar{\Lambda}$ mass threshold allowed studying the process $e^+e^- \to \Lambda\bar{\Lambda}$ using data samples at $\sqrt{s}$ = 2.2324, 2.400, 2.800 and 3.080 GeV. The Born cross section is measured at $\sqrt{s}$=2.2324 GeV, which is 1.0 MeV above the threshold, to be $305 \pm 45^{+66}_{-36}$ pb. The substantial cross section near threshold is significantly larger than that expected from theory, which predicts the cross section to vanish at threshold [PRD97 (2018) 032013]. In order to have an overall consistent picture of these unexpectedly observed phenomena, more data, in particular close to the relative thresholds, are needed.

Results of the JINR group in 2017-2018

The JINR group worked in 2017-2018 on the following topics.

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

A scan of the J/ψ peak region was performed by the BESIII experiment in 2012. Our group analyzed these data in 2017-2018 in order to measure the cross-section of a number of exclusive processes. We have measured the cross-section of exclusive reactions with final states $\omega\pi^0$, ωη and φη at 17 different energy points. The preliminary estimation of the phase between the amplitudes of strong and electromagnetic interactions has been done (Fig. 1). The analysis will be finalized in 2019.

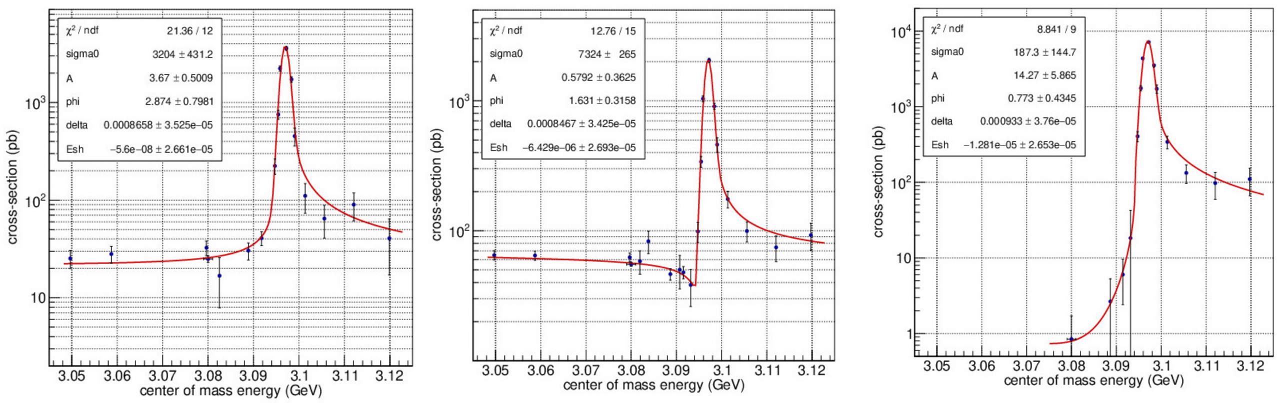

Fig. 1: Preliminary results of cross-section measurement and a lineshape fit for three exclusive processes $e^+e^- \rightarrow \varphi\eta$ (left), $e^+e^- \rightarrow \omega\pi^0$ (center) and $e^+e^- \rightarrow \omega\eta$ (right). The fit paratemeter "A" indicates the ratio of strong to electromagnetic amplitude, and "phi" is the phase angle between the two contributions.

2) Cross-section measurement of the semi-inclusive reaction e+e- → J/ψX above 4.0 GeV

Measurement of the prompt J/ψ production cross-section in the e^+e^- annihilation in the center-of-mass energies from 3.810 GeV to 4.600 GeV has been performed. An internal publication is being prepared.

3) Study of threshold enhancement in the J/psi radiative decays to a baryon and an antibaryon has been performed by a graduate student. A bachelor thesis has been prepared in 2017.

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 2017-2018.

The parallel implementation of the software for partial wave analysis (PWA) for calculations on heterogeneous computing systems using OpenMP, MPI and CUDA technologies has been developed. A significant calculation speedup which is especially important to analyze large data samples and to use complicated physics models to describe the signal was demonstrated using the cluster HybriLIT at the Laboratory of Information Technologies of JINR.

The support of the JINR segment of the BESIII distributed computing system was continued. The solution to include cloud resources into the distributed computing system using the 'cloud bursting' concept has been implemented. The monitoring system for the BESIII grid was extended to cover the cloud resources.

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

1) D. Seitova, "Study of threshold enhancement in the J/psi radiative decays to a baryon and an antibaryon at BESIII experiment", BSc thesis, Dubna, 2017

2) V. Tokareva, I. Denisenko, «Parallel framework for partial wave analysis for the BESIII experiment» - NEC'2017, Montenegro, Budva, Becici, 25 September - 29 September 2017

3) Yu. Nefedov, «Status and prospects of the BESIII experiment», Super-ctau-factory physics workshop, Novosibirsk, 18-19 December 2017.

4) I. Denisenko, "Light hadron spectroscopy at BESIII", Charm'2018, Novosibirsk, 21-25 May 2018

5) I. Boyko, "Recent results from the BESIII experiment", XXIV International Baldin Seminar, 18 September 2018

Purpose and objectives of the project

The purpose of the project is to study the charmonium production and decays and to search for and study the exotic charmonia and charmoniumlike structures using the BESIII data. To achieve this purpose, the data analysis of the BESIII experiment must be continued with the following objectives.

The inclusive prompt charmonium production

A study of the inclusive prompt production of J/ψ and ψ(2S) in the e^+e^- annihilation is a way to test the interconnection between perturbative and non-perturbative effects in the NRQCD factorization approach *[PRD 51, 1125 (1995)]* and to put an additional constraint to the color-octet Long Distance Matrix Elements (LDMEs) *[EPJC77 (2017) 597]*. Until now the corresponding cross-section was measured at $\sqrt{s}$ =10.6 GeV by BaBar, Belle and CLEO just below the ϒ(4S) resonance. There are a lot of works devoted to the comparison of LO and NLO NRQCD predictions with these experimental results in order to estimate the contribution of the $e^+e^- \rightarrow$ J/ψ g, $e^+e^- \rightarrow$ J/ψgg and other hard subprocesses. New experimental results in the range of $\sqrt{s}$ below the J/ψ cc threshold (~ 6 GeV) could be useful to clarify the contribution of the color octet channel.

The behavior of the inclusive production cross section for J/ψ and ψ(2S) and polarization of the produced charmonia as a function of the $\sqrt{s}$ could be sensitive to production and decay of known and unknown exotic charmonium-like states. On the other hand, the direct comparison of the measured cross-section of the inclusive prompt J/ψ and ψ(2S) production with the sum of known cross-sections for exclusive channels could put an upper limit for possible hidden channels of e^+e^- annihilation.

Measurement of the prompt J/ψ production cross-section in the e^+e^- annihilation in the center-of-mass energies from 3.810 GeV to 4.600 GeV has been performed by the JINR group in 2017-2018. In the scope of the project we are going to consider and to include into the analysis new data collected by the experiment, taking into account the possible reach of the range up to 4.9 GeV after the BEPCII upgrade. Then, we plan to perform a similar measurement of the prompt ψ(2S) production cross-section. Finally, we are going to measure inclusive J/ψ polarization in the energy range above 4 GeV.

Measurement of cross-sections in the region of J/ψ peak

The relative phase between the strong and electromagnetic (EM) amplitudes of quarkonium decays is a basic parameter that provides insight into the dynamics of quarkonium decays. In perturbative QCD the phase is predicted to be 0° or 180° at lowest order *[PRL 59, 621 (1987), Nucl. Phys. B 246, 52 (1984)].* However, the phase difference had been obtained experimentally in many J/ψ decay channels by comparing decay rates of different final states in model-dependent way, and turned out to be about 90º in contrast to this prediction. There is no widely accepted explanation of this fact, while a theoretical hypothesis exists that this 90º is a general law of nature *[PRD63, 054021(2001)].*

A new method to determine the relative phase by measuring the cross-section lineshape in the region close to J/ψ production has been proposed recently *[PLB 593 (2004) 89–94].* The energy shape of the cross-section in this region is determined by the interference between i) non-resonant production $e^+e^- \to \gamma \to$ hadrons and ii) resonant production $e^+e^- \to J/\psi \to \gamma \to$ hadrons; $e^+e^- \to J/\psi \to ggg \to$ hadrons. Analysis of the cross-section as a function of energy allows us to observe the interference between the resonance and continuum amplitudes and measure the phase angle.

We already have measured the cross-section lineshape for exclusive reactions with final states $\omega\pi^0$, ωη and φη and obtained a preliminary estimation of the phase.

In the scope of this project, we are planning an independent measurement of the branching fraction of decay $J/\psi \to \varphi\eta$ using the BESIII data $\psi(2S)\to\pi^+\pi^- J/\psi$. Firstly, it will verify the result obtained by our fit. Secondly, the joint data fit will allow reducing the error on the phase angle between strong and electromagnetic amplitudes in this channel. For the channel $e^+e^- \to \omega\eta$, we are planning to include into our analysis a data point with the energy 2.9 GeV (R-scan 2015). The integrated luminosity of this point is 105 pb^{-1}. This data point will allow us to estimate the amplitude from the non-resonant production of ωη. This will significantly reduce the error when we fit the cross-section.

We are also going to extend our analysis, taking into consideration other channels like KK^* and φη'.

Search for bound $p\bar{p}$ states

The BESII observation of $p\bar{p}$ near-threshold enhancement in $J/\psi\to\gamma p\bar{p}$ attracted the significant interest of theoreticians. Baryon-antibaryon near-threshold enhancements were also observed in $\psi(2S)\to\gamma p\bar{p}$, $\psi(2S)\to\pi^0 p\bar{p}$, $\psi(2S)\to\eta p\bar{p}$, in e^+e^- annihilation ($e^+e^- \to \Lambda\bar{\Lambda}$, $e^+e^- \to \Lambda_c\bar{\Lambda}_c$) and in some channels of B- and D-mesons decays. One of the most discussed interpretations is a bound $p\bar{p}$ or hyperon-antihyperon state (baryonium), while other interpretations of near-threshold enhancements like these also exist. To understand the nature of these enhancements we suggest studying the decay mode $J/\psi \to \pi^- p\bar{n}$ and to search for $J/\psi \to \rho^0 p\bar{p}$, $J/\psi \to \rho^+ n\bar{p}$ and $J/\psi \to \rho^- \bar{n}p$. We are also going to search for $e^+e^- \to 2(p\bar{p})$ in the energy range above 4 GeV and then to study $p\bar{p}$ pairs near threshold.

Software development

Maintenance of software packages, developed earlier by JINR group, including the ROOT-based analysis framework BEAN and the distributed computing system will be continued. We also expect that the upgrade of the machine and especially the detector will require the respective further development of the core software.

Another interesting task is related to the possible use of machine learning algorithms for the recognition of particle tracks in the BESIII inner tracker. Traditional tracking algorithms, such as the combinatorial Kalman filter, are inherently sequential, which makes them rather slow and hard to parallelize on modern high-performance architectures (GPUs). As a result, they do not scale well with the expected increase in the detector occupancy in high-luminosity conditions. Machine learning algorithms are well suited for multi-track recognition problems because of their ability to reveal effective representations of multidimensional data through learning and to model complex dynamics through computationally regular transformations that scale linearly with the size of input data and are easily distributed across computing nodes. In the course of the project an algorithm based on recurrent neural networks of deep learning will be developed to search for and reconstruct tracks of elementary particles in data from tracking detectors. Since ML approach is already used in BESIII for BESIII CGEM cluster reconstruction and particle identification, coordination with the developers from IHEP Beijing is foreseen. Taking into account the upgrade plans of BEPCII, an algorithm like this will allow to resolve the possible bottleneck in the BESIII tracking and to speed up the event reconstruction. We also expect that this work will be an important contribution to the design of the proposed super charm-tau factories in Novosibirsk, Russia and in Beijing, China.

Work plan

In 2020 the following physics results are planned to be obtained:

- Measurement of the branching fraction of decay $J/\psi \to \varphi\eta$. Final results on the phase shift measurement in $e^+e^- \to \varphi\eta$.
- Measurement of the prompt $\psi(2S)$ production cross-section.
- Search for $e^+e^- \to 2(p\bar{p})$ above 4 GeV.
- Preparation of the PhD thesis on light hadron spectroscopy by I.Denisenko.

In 2021 the following physics results are planned to be obtained:

- Re-analysis of the channel $e^+e^- \to \omega\eta$ including the data point with the energy 2.9 GeV. Final results on the phase shift measurement in this channel.
- Measurement of the prompt J/ψ and $\psi(2S)$ production cross-section in the energy range 4.6-4.9 GeV.
- Study of the decay mode $J/\psi \to \pi^- p\bar{n}$ and search for $J/\psi \to \rho^0 p\bar{p}$, $J/\psi \to \rho^+ n\bar{p}$ and $J/\psi \to \rho^- \bar{n}p$

In 2022 the following physics results are planned to be obtained:

- Phase shift measurement using other channels like KK^* and $\varphi\eta'$.
- Measurement of inclusive J/ψ polarization in the energy range above 4 GeV
- Preparation of the PhD thesis on the inclusive prompt charmonium production by O.Bakina.

Resources

All works in the scope of the project will be carried out by the staff of the DLNP (4.5 FTE[1]), BLTP (0.5 FTE) and LIT (0.5 FTE). The total project team is 5.5 FTE.

No hardware or material contribution to the experiment is expected from JINR. The project costs are estimated on the base of participation of the JINR group mostly in the BESIII software development, data-taking (shifts), Monte-Carlo simulation and physics analysis and include essentially the travel expenses.

[1]O.Bakina - 1 FTE, I.Boyko - 0.3 FTE, G.Chelkov - 0.1 FTE, D.Dedovich - 0.3 FTE, I.Denisenko - 1 FTE, A.Guskov - 0.3 FTE, Yu.Nefedov - 0.5, FTE, S. Kotov - 0.5 FTE, A.Zhemchugov - 0.5 FTE.

Short SWOT[2] analysis

Strengths of the project

1. Currently, BESIII offers the world best conditions for studies in tau-charm domain and no competing projects are foreseen in the next 5 years.

2. The JINR group is a member of BESIII collaboration since 2005 and has already the necessary knowledge and skills concerning the experiment conditions, the detector operation, software tools and data processing techniques.

3. The huge amount of data is already available.

4. The planned upgrade of BEPCII and BESIII will allow taking a unique data sample at the collision energy 4.6-4.9 GeV.

Weaknesses of the project

1. The project team needs more PhD students to be involved into the data analysis.

Opportunities

1. Two projects of Super-ctau factories (in China and in Novosibirsk) are being discussed now. The experience gained in BESIII experiment will allow the project team to take part in the physics research program development for Super-ctau factories and to continue studies at the new generation of machines.

Threats

No threats are identified.

[2]SWOT – strengths and weaknesses, opportunities, threats

Form №26

Proposed Time-Schedule and Necessary Resources
for implementation of Project
Participation of JINR in the Physics Research Programme

at the BEPCII/BESIII

Parts and systems of set-up, resources and sources of financial support.	Cost of parts of set-up. Required financial support.	Profile proposed by Laboratory.		
Main parts and equipment (kUSD)				
		2020	**2021**	**2022**
Materials	–	–	–	–
Equipment	–	–	–	–
Travel costs	**75**	**25**	**25**	**25**
Necessary manpower support (man-hours)				
JINR Central workshop:	–	–	–	–
LNP: - workshop; - design bureau	–	–	–	–
Accelerator, Reactor	–	–	–	–
Computer	–	–	–	–
Maintenance & Operational	–	–	–	–
Sources of financial support (kUSD)				
JINR budget	75	25	25	25
Extra – budgetary (grants, agreements, sponsors etc.)	–	–	–	–

Project Leader A. Zhemchugov

Deputy Project Leader A. Guskov

Form №29

Financial Resources Needed for Project realization

Participation of JINR in the Physics Research Programme
at the BEPCII/BESIII

No	TASKS	Total value	2020	2021	2022
	Direct costs of the Project				
1	Accelerator, reactor	–	–	–	–
2	Computer	–	–	–	–
3	Materials	–	–	–	–
4	Equipment	–	–	–	–
5	R&D	–	–	–	–
7	Travel resources				
	a) in non-ruble area	69	23	23	23
	b) in ruble area	6	2	2	2
	Total direct cost:	**75**	**25**	**25**	**25**

Project Leader A. Zhemchugov

Deputy Project Leader A. Guskov

Director of the Laboratory V.Bednyakov

Main planning engineer of the Laboratory G.Usova