PROCEEDINGS OF SCIENCE

Charm at KEDR

V. V. Anashin[a], O. V. Anchugov[a], A. V. Andrianov[a], K. V. Astrelina[a], V. M. Aulchenko[a,b], E. M. Baldin[a,b], G. N. Baranov[a,c], A. K. Barladyan[a], A. Yu. Barnyakov[a,b,c], M. Yu. Barnyakov[a,b,c], S. E. Baru[a,b], I. Yu. Basok[a], E. A. Bekhtenev[a], O. V. Belikov[a], D. E. Berkaev[a], A. E. Blinov[a,b], V. E. Blinov[a,b,c], M. F. Blinov[a], A. V. Bobrov[a,b], V. S. Bobrovnikov[a,b], A. V. Bogomyagkov[a,b], D. Yu. Bolkhovityanov[a], A. E. Bondar[a,b], A. R. Buzykaev[a,b], P. B. Cheblakov[a,b], V. L. Dorohov[a,c], S. I. Eidelman[a,b,d], F. A. Emanov[a,b], V. V. Gambaryan[a], S. A. Glukhov[a,b], D. N. Grigoriev[a,b,c], V. V. Kaminskiy[a,b], S. E. Karnaev[a], S. V. Karpov[a], G. V. Karpov[a], K. Yu. Karukina[a,c], D. P. Kashtankin[a], P. V. Kasyanenko[a,c], A. A. Katcin[a,b], T. A. Kharlamova[a,b,*], V. A. Kiselev[a], S. A. Kononov[a,b], K. Yu. Kotov[a], A. A. Krasnov[a], E. A. Kravchenko[a,b], V. N. Kudryavtsev[a,b], V. F. Kulikov[a,b], G. Ya. Kurkin[a,c], I. A. Kuyanov[a], E. B. Levichev[a,c], P. V. Logachev[a], D. A. Maksimov[a,b], Yu. I. Maltseva[a], V. M. Malyshev[a], A. L. Maslennikov[a,b], O. I. Meshkov[a,b], S. I. Mishnev[a], I. I. Morozov[a,b], I. A. Morozov[a], N. Yu. Muchnoi[a,b], D. A. Nikiforov[a], S. A. Nikitin[a], I. B. Nikolaev[a,b], I. N. Okunev[a], A. P. Onuchin[a,b], S. B. Oreshkin[a], V. V. Oreshonok[a], A. A. Osipov[a,b], I. V. Ovtin[a,b], A. V. Pavlenko[a], S. V. Peleganchuk[a,b], V. V. Petrov[a], P. A. Piminov[a], S. G. Pivovarov[a,c], N. A. Podgornov[a], V. G. Prisekin[a,b], O. L. Rezanova[a,b], A. A. Ruban[a,b], G. A. Savinov[a], A. G. Shamov[a,b], L. I. Shekhtman[a], D. A. Shvedov[a], B. A. Shwartz[a,b], E. A. Simonov[a], S. V. Sinyatkin[a], A. N. Skrinsky[a], A. V. Sokolov[a,b], E. V. Starostina[a,b], D. P. Sukhanov[a], A. M. Sukharev[a,b], A. A. Talyshev[a,b], V. A. Tayursky[a,b], V. I. Telnov[a,b], Yu. A. Tikhonov[a,b], K. Yu. Todyshev[a,b], A. G. Tribendis[a,c], G. M. Tumaikin[a], Yu. V. Usov[a], A. I. Vorobiov[a], V. N. Zhilich[a,b], A. A. Zhukov[a], V. V. Zhulanov[a,b], A. N. Zhuravlev[a,b]

[a]*Budker Institute of Nuclear Physics*
11, akademika Lavrentieva prospect, Novosibirsk, 630090, Russia

[b]*Novosibirsk State University*
2, Pirogova street, Novosibirsk, 630090, Russia

[c]*Novosibirsk State Technical University*
20, Karl Marx prospect, Novosibirsk, 630092, Russia

[d]*Lebedev Institute RAS*
Leninsky pr. 53, 119991, Moscow, Russia

E-mail: t.a.kharlamova@inp.nsk.su.edu

*Speaker

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We review the recent results obtained by the KEDR experiment in the charmonium energy range. They include the measurements of J/ψ meson total and partial widths and exclusive branching fractions, study of D^+ and D^0 meson masses and R between 1.8 and 7.0 GeV.

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1. Introduction

We report recent results from the KEDR detector at the VEPP-4M e^+e^- collider in the Budker Institute in Novosibirsk. VEPP-4M collider was designed to operate in the beam energy from 1 to 5 GeV [1]. One of the main features of the VEPP-4M collider is possibility of precise energy determination with two methods: resonant depolarization method [2] and infrared light Compton backscattering method [3]. The KEDR detector is described in [4].

2. Measurements of J/ψ meson total and partial widths

Analysis on J/ψ meson widths measurement was based on the dataset with integrated luminosity of 230 nb^{-1} at 11 energy points. That allowed to fit the resonant shape and determine non-resonant background contributions. To measure the width hadronic and electronic channels were considered simultaneously. We performed combined fit of the data and determined $\Gamma_{ee}\cdot B_{ee}(J/\psi)$, $\Gamma_{ee}\cdot B_{hadrons}(J/\psi)$ and Γ_{ee} (J/ψ) [5].

The electronic width obtained in our analysis $\Gamma_{ee} = 5.550 \pm 0.056 \pm 0.089$ keV agrees well with the world average [6]. Figure 1 shows its comparison with the previous measurements [7-11] and lattice QCD calculations [12,13]. The values of $\Gamma_{ee}(J/\psi)$ in BESIII [7], CLEO [8] and BaBar [9] experiments were calculated from $\Gamma_{ee}\cdot B_{\mu\mu}(J/\psi)$ measured in the radiation process $e^+e^- \to \mu^+\mu^-\gamma$ with the J/ψ meson decaying to muon pair. Our measurement of leptonic width is direct measurement as the result from BES [11]. In the analysis we considered the inclusive hadronic channel as well as leptonic processes to extract partial widths of the J/ψ meson.

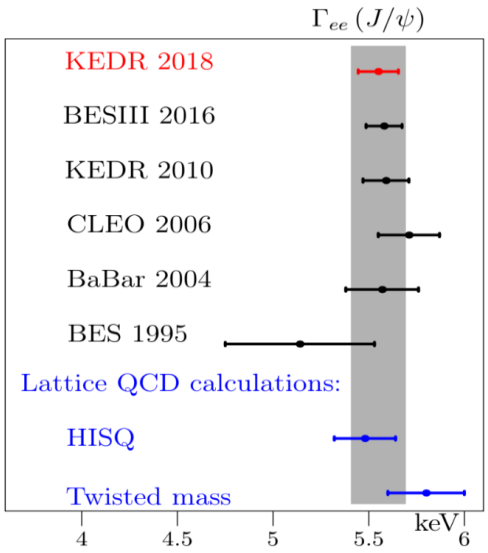

Figure 1: Comparison of the KEDR results with the previous measurements

Our result for the $\Gamma_{ee}\cdot B_{hadrons}(J/\psi)$ value (Fig. 2) is consistent with and four times more precise than the previous direct measurement in the hadronic channel [11]. Figure 2 shows $\Gamma_{ee}\cdot B_{hadrons}(J/\psi)$ and $\Gamma_{ee}\cdot B_{ee}(J/\psi)$ comparison with the previous measurements [11, 14-16].

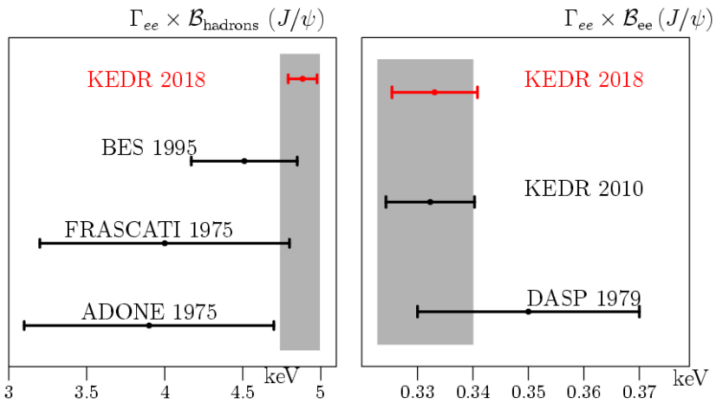

Figure 2: Measurements of $\Gamma_{ee}\cdot B_{hadrons}(J/\psi)$ and $\Gamma_{ee}\cdot B_{ee}(J/\psi)$

As a continuation of this analysis the total and hadronic widths were also measured [5]. The total width obtained is a direct measurement involving data only from KEDR experiment. New result on $\Gamma_{hadr}(J/\psi)$ is consistent with and 4 times more precise that the previous direct measurement of the hadronic width by BES collaboration [11]. In Figure 3 we present measured $\Gamma(J/\psi)$ and $\Gamma_{hadrons}(J/\psi)$ values with those obtained in previous experiments.

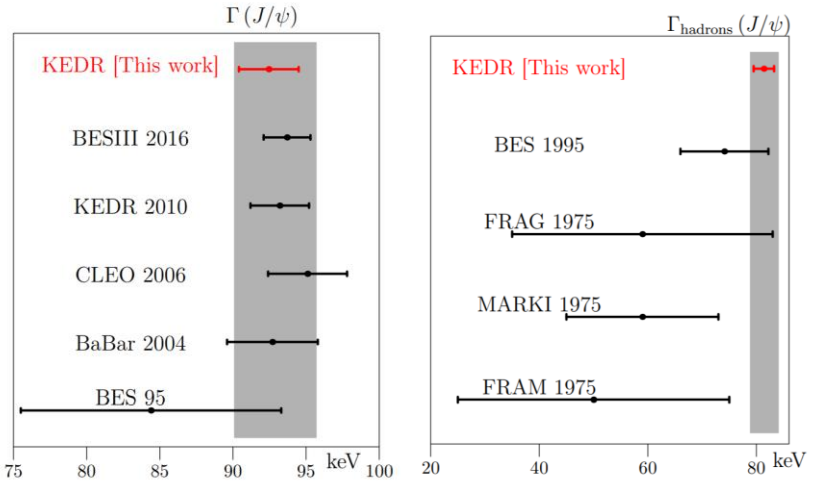

Figure 3: Measurements of $\Gamma(J/\psi)$ and $\Gamma_{hadrons}(J/\psi)$

3. Decays $J/\psi \to 2(\pi^+\pi^-)\pi^0$, $K^+K^-\pi^+\pi^-\pi^0$, $2(\pi^+\pi^-)$, $K^+K^-\pi^+\pi^-$

KEDR collaboration is also measuring branching fractions of $J/\psi \to 2(\pi^+\pi^-)\pi^0$, $K^+K^-\pi^+\pi^-\pi^0$, $2(\pi^+\pi^-)$, $K^+K^-\pi^+\pi^-$. Our preliminary results on inclusive decay modes compared with previous experiments are shown on Figure 4. The analysis uses the statistics of about 1.3 pb^{-1} at the peak of the J/ψ resonance that corresponds to 5.2 million of produced J/ψ mesons and 82.3 nb^{-1} for background estimation.

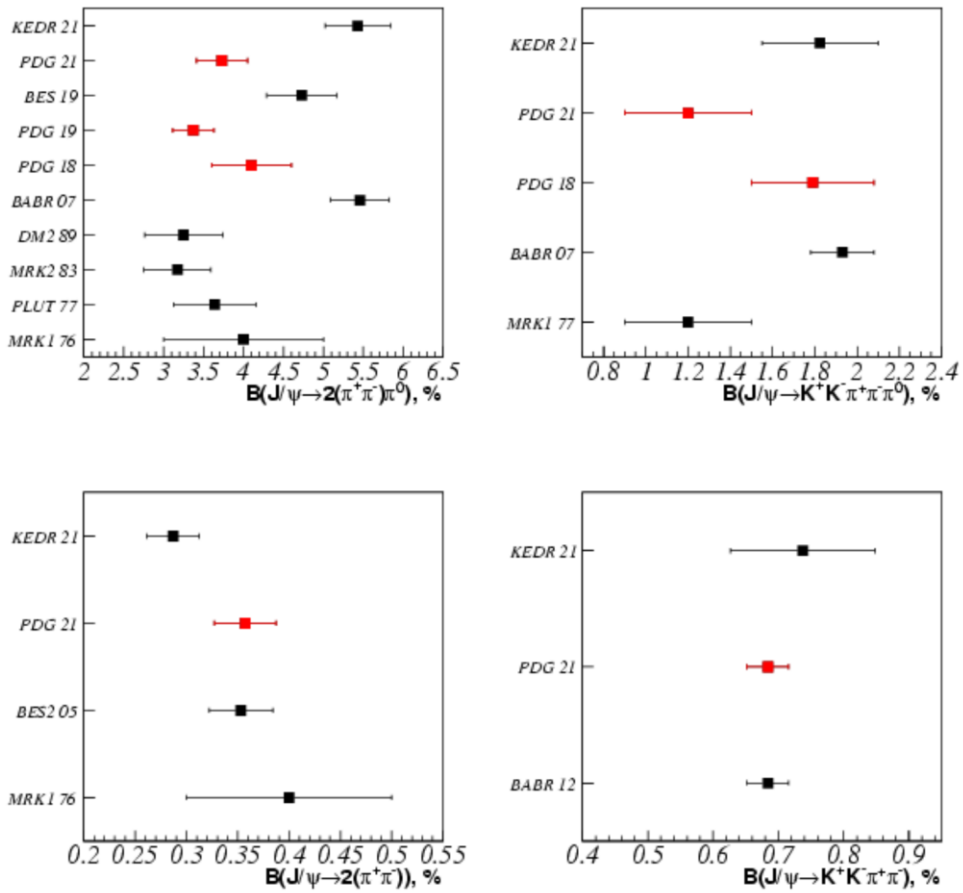

Figure 4: Summary of preliminary results on branching fractions of J/ψ meson inclusive decay modes

4. D meson masses

Neutral and charged D mesons are the ground states in the family of open charm mesons. Measurement of their masses provides a mass scale for the heavier excited states. D-meson mass is important for DD* threshold determination. This knowledge affects understanding of the $\chi_{c1}(3872)$ (X(3872)) nature [17].

Measurement of D meson masses is performed using the near-threshold $e^+e^- \to D\bar{D}$ production with full reconstruction of one of the D mesons. Neutral D mesons are reconstructed in the $K^-\pi^+$ final state, charged D mesons are reconstructed in the $K^-\pi^+\pi^+$ final state. For selections beam – constrained mass $M_{bc} = \sqrt{E_{beam}^2 - (\sum_i \vec{p}_i)^2}$ and center-of-mass (CM) energy difference $\Delta E = \sum_i \sqrt{(m_i^2 + p_i^2)} - E_{beam}$ are calculated in every event, where E_{beam} is the energy of colliding beams in the CM frame, m_i and $\vec{p}_i$ are the masses and momenta of the D meson decay products. Additional kinematic parameter $\Delta|p|$ determined as the difference of the absolute values of momenta for D decay products in the CM frame is used for D^0 selection. For the signal events the parameter ΔE is close to zero. In our analysis, we select a relatively wide region of ΔE and M_{bc} close to M_D, then perform a fit of the event density with D mass as one of the parameters,

with the background contribution taken into account. Results of selection of the D^0 and $D^{\pm}$ meson candidates are shown in Figures 5 and 6 correspondingly.

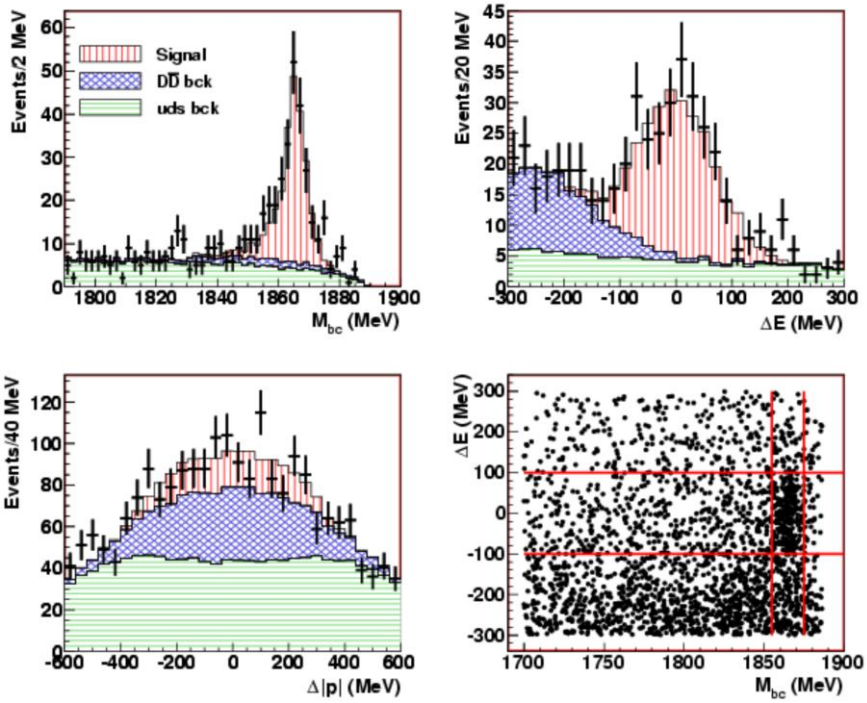

Figure 5: Selection of D^0 candidates

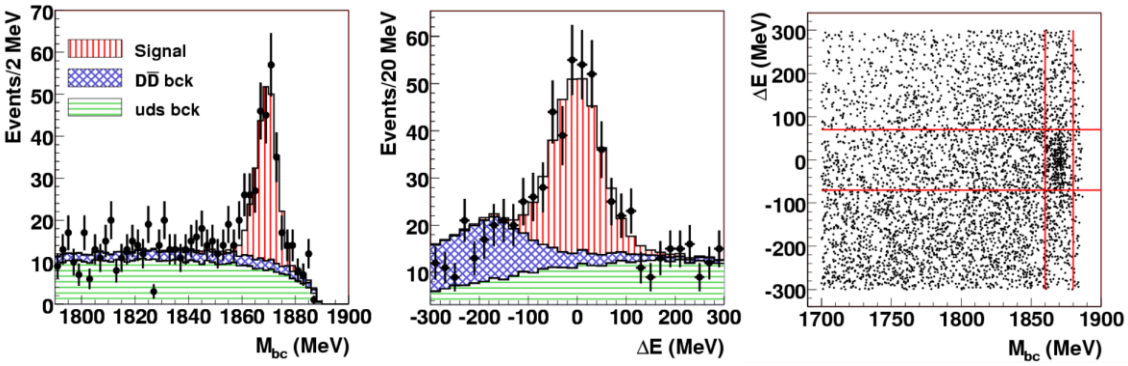

Figure 6: Selection of $D^{\pm}$ candidates

D-meson masses were measured at KEDR at 2010 [18]. But now new analysis is ongoing with increased statistics, and we aim to increase accuracy about 20% compared to previous measurement from KEDR experiment.

4. R measurements between 1.8 and 7.0 GeV

R is the ratio of the radiatively corrected total cross section of electron-positron annihilation into hadrons and muon pairs. R is crucial in various precision tests of Standard Model – determination of the running strong coupling constant $\alpha_s(s)$ and heavy quark masses, evaluation

of the hadronic contribution to the anomalous magnetic moment of the muon $(g-2)_\mu$ and calculation of the value of the electromagnetic fine structure constant at the Z^0 peak $\alpha(M_Z^2)$ [19].

On Figure 6 the most recent measurement of R are presented in the energy range between 1.8 and 3.8 GeV. R was measured at KEDR in this energy range at 13 equidistant points between 1.84 – 3.05 GeV [20]. The achieved accuracy is about or better that 3.9% at the most of energy points. For the energies above J/ψ resonance there were 9 equidistant points with total error of about or better that 2.6% [21].

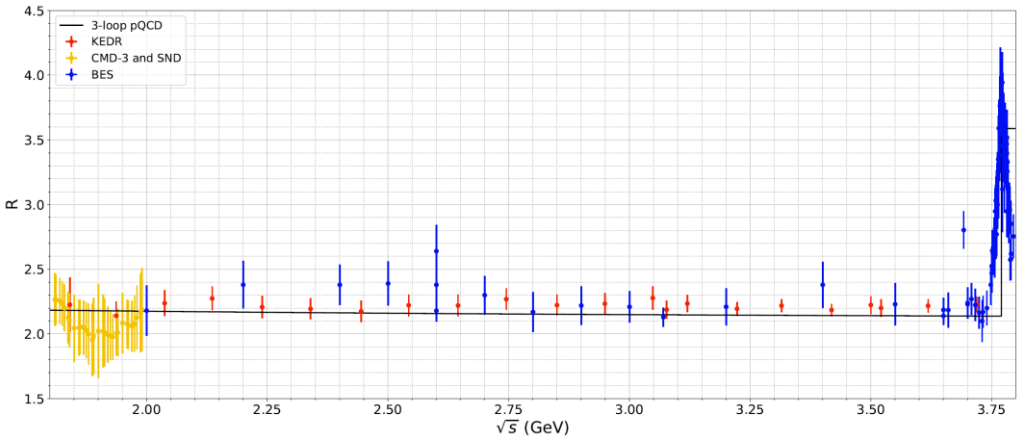

Figure 6: R measurement between 1.8 and 3.8 GeV

New data taking was done in the energy range from 4.7 to 7 GeV with integrated luminosity 13.7 pb^{-1}. The range is interesting because there are no published data between 5 GeV and 6.96 GeV [22, 23]. VEPP-4M collected statistics at 17 equidistant points in this energy range. Expected total uncertainty is expected to be about 3% with systematical uncertainty of about 2.5%.

5. Summary

New precise measurement of J/ψ total and leptonic width is presented. KEDR measured the R values at 22 center-of-mass energies between 1.84 and 3.72 GeV. Analysis of data in the energy range between 4.56 and 6.96 GeV was started, expected accuracy is less than 3%. New analyzes of the D-meson masses and branching fractions of $J/\psi \to 2(\pi^+\pi^-)\pi^0$, $K^+K^-\pi^+\pi^-\pi^0$, $2(\pi^+\pi^-)$, $K^+K^-\pi^+\pi^-$ are ongoing.

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