PROCEEDINGS OF SCIENCE

Recent results from the KEDR detector

V. M. Aulchenko[a,b] **E. M. Baldin**[a,b] **A. K. Barladyan**[a] **A. Yu. Barnyakov**[a] **M. Yu. Barnyakov**[a] **S. E. Baru**[a] **I. Yu. Basok**[a] **A. M. Batrakov**[a] **A. E. Blinov**[a] **V. E. Blinov**[a,c] **A. V. Bobrov**[a] **V. S. Bobrovnikov**[a] **A. V. Bogomyagkov**[a,b] **A. E. Bondar**[a,b] **A. R. Buzykaev**[a] **S.I.Eidelman**[*a,b], **D. N. Grigoriev**[a,c] **V. R. Groshev**[a] **Yu. M. Glukhovchenko**[a] **V. V. Gulevich**[a] **D. V. Gusev**[a] **S. E. Karnaev**[a] **G. V. Karpov**[a] **S. V. Karpov**[a] **T. A. Kharlamova**[a] **V. A. Kiselev**[a] **V. V. Kolmogorov**[a] **S. A. Kononov**[a,b] **K. Yu. Kotov**[a] **E. A. Kravchenko**[a,b] **V. N. Kudryavtsev**[a] **V. F. Kulikov**[a,b] **G. Ya. Kurkin**[a,c] **E. A. Kuper**[a,b] **I. A. Kuyanov**[a] **E. B. Levichev**[a,c] **D. A. Maksimov**[a,b] **V. M. Malyshev**[a] **A. L. Maslennikov**[a] **O. I. Meshkov**[a,b] **S. I. Mishnev**[a] **I. I. Morozov**[a,b] **N. Yu. Muchnoi**[a,b] **V. V. Neufeld**[a] **S. A. Nikitin**[a] **I. B. Nikolaev**[a,b] **I. N. Okunev**[a] **A. P. Onuchin**[a,c] **S. B. Oreshkin**[a] **I. O. Orlov**[a,b] **A. A. Osipov**[a] **I. V. Ovtin**[a] **S. V. Peleganchuk**[a] **S. G. Pivovarov**[a,c] **P. A. Piminov**[a] **V. V. Petrov**[a] **A. O. Poluektov**[a] **V. G. Prisekin**[a] **O. L. Rezanova**[a,b] **A. A. Ruban**[a] **V. K. Sandyrev**[a] **G. A. Savinov**[a] **A. G. Shamov**[a] **D. N. Shatilov**[a] **B. A. Shwartz**[a,b] **E. A. Simonov**[a] **S. V. Sinyatkin**[a] **A. N. Skrinsky**[a] **A. V. Sokolov**[a,b] **A. M. Sukharev**[a] **E. V. Starostina**[a,b] **A. A. Talyshev**[a,b] **V. A. Tayursky**[a] **V. I. Telnov**[a,b] **Yu. A. Tikhonov**[a,b] **K. Yu. Todyshev**[a,b] **G. M. Tumaikin**[a] **Yu. V. Usov**[a] **A. I. Vorobiov**[a] **V. N. Zhilich**[a] **V. V. Zhulanov**[a,b] **A. N. Zhuravlev**[a,b]

[a]*Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, 630090, Russia*
[b]*Novosibirsk State University, Novosibirsk, 630090, Russia*
[c]*Novosibirsk State Technical University, Novosibirsk, 630092, Russia*

E-mail: `eidelman@inp.nsk.su`

Recent results from the KEDR detector obtained in the charmonium energy range are reported: high-precision measurement of the J/ψ and $\psi(2S)$ masses, study of their leptonic decays and $J/\psi \to \eta_c \gamma$ decay

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1. Introduction

We report some recent results from the KEDR detector at the VEPP-4M e^+e^- collider in the Budker Institute in Novosibirsk. Currently VEPP-4M runs in the charmonium energy range. Its important feature is a capability of precise beam energy measurement ($\sim \mathcal{O}(10^{-5})$ or 10-30 keV) using two methods - resonant depolarization [1] and infrared light Compton backscattering [2]. The detector is described in detail elsewhere [3].

2. Measurement of J/ψ and $\psi(2S)$ Masses

Precise values of the J/ψ and $\psi(2S)$ masses provide a mass scale for all charm and charmonium particles. We performed a new measurement based on the combined analysis of all scans of the charmonium energy range in 2002-2008: six at the J/ψ – 2002 (4), 2005 (1) and 2008 (1) and seven at the $\psi(2S)$ – 2002 (3), 2004 (2), 2006 (1), 2008 (1), in total 7×10^5 J/ψ and 2×10^5 $\psi(2S)$ multihadronic events with more than 1000 resonant depolarization energy calibrations [4]. Analysis took into account possible correlations as well as interference with multihadronic continuum characterized by the parameter $\lambda = \sqrt{\frac{R\mathcal{B}_{\mu\mu}}{\mathcal{B}_h}}$ estimated to be 0.38 at the J/ψ and 0.13 at the $\psi(2S)$.

State	Mass, MeV	λ
J/ψ	$3096.900\pm0.002\pm0.006$	$0.43\pm0.07\pm0.08$
$\psi(2S)$	$3686.100\pm0.004\pm0.009$	$0.18\pm0.06\pm0.08$

Table 1: Final KEDR results averaged over all scans

Results obtained in various scans are consistent with each other and can be averaged to give the values listed in Table 1. These averages also agree with the previous measurements [5-10] and are more precise, see Fig. 1.

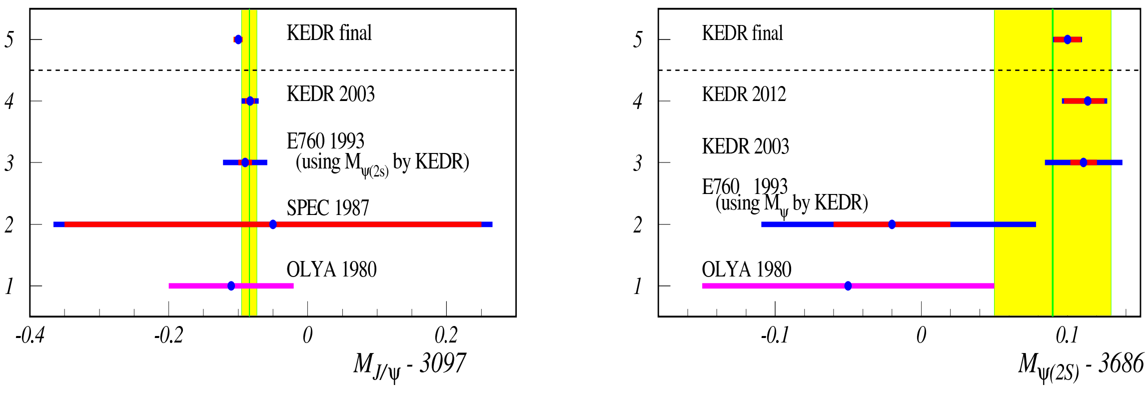

Figure 1: Comparison of the KEDR results with the previous measurements

3. Study of Leptonic Decays of J/ψ and $\psi(2S)$

3.1 Study of $J/\psi \to e^+e^-$ and $\mu^+\mu^-$

Leptonic width of quarkonium provides important information on its wave function in the origin. For an improvement of our previous measurement [11] and a study of possible systematic effects we determined the ratio of the leptonic widths of the J/ψ based on a data sample of 6.5×10^6 events. Our result $\Gamma(e^+e^-)/\Gamma(\mu^+\mu^-) = 1.0022 \pm 0.0044 \pm 0.0048$ is consistent with unity as expected [12]. Its precision is better than that of CLEO [13] and is comparable to that of BES3 [14]. Figure 2 shows its comparison with all the previous measurements [15-18].

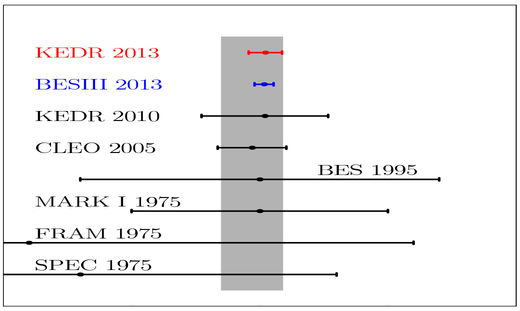

Figure 2: Measurements of $\Gamma(e^+e^-)/\Gamma(\mu^+\mu^-)$

3.2 Study of $\psi(2S) \to \mu^+\mu^-$

Information about basic properties of the $\psi(2S)$ other than mass and total width is scarce: there are only a few measurements of $\Gamma_{e^+e^-}$ with an average of 2.37 ± 0.04 keV and indirect estimates of the leptonic branching fractions $\mathscr{B}(e^+e^-) = (78.2 \pm 1.7) \cdot 10^{-4}$ and $\mathscr{B}(\mu^+\mu^-) = (78 \pm 9) \cdot 10^{-4}$ [19].

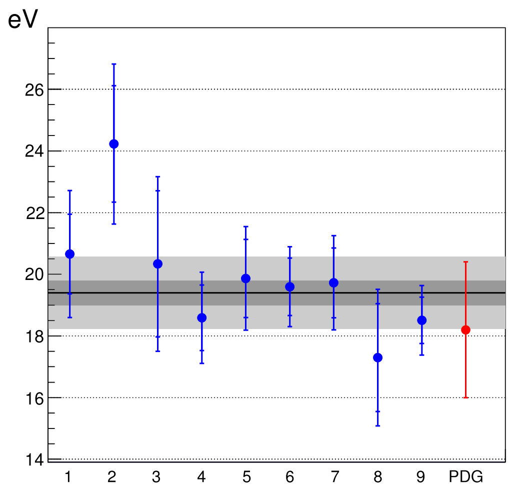

Figure 3: $\Gamma_{e^+e^-}\mathscr{B}(\mu^+\mu^-)$ from KEDR

KEDR used a data sample of ~ 7 pb^{-1} collected in nine experiments with $3.5 \cdot 10^6$ $\psi(2S)$ mesons produced to measure $\Gamma_{e^+e^-}\mathscr{B}(\mu^+\mu^-)$. Results of different experiments shown in Fig. 3 are consistent with each other and their average gives $\Gamma_{e^+e^-}\mathscr{B}(\mu^+\mu^-) = (19.4 \pm 0.4 \pm 1.1)$ eV, in agreement with and two times more precise than the "world average" constructed of various fits $\Gamma_{e^+e^-}\mathscr{B}(l^+l^-) = (18.5 \pm 2.1)$ eV.

4. Decay $J/\psi \to \eta_c(1S)\gamma$

The $J/\psi \to \eta_c(1S)\gamma$ decay is a magnetic dipole transition between two $c\bar{c}$ ground states. Until recently there was a single measurement of Crystal Ball only with the branching fraction of $(1.27 \pm 0.36)\%$ [20], much smaller than the non-relativistic prediction of 3.05%, see [21]. The CLEO measurement gave a somewhat larger value of $(1.98 \pm 0.09 \pm 0.30)\%$ [22] resulting in the average of $(1.7 \pm 0.4)\%$ with a scale factor of 1.6.

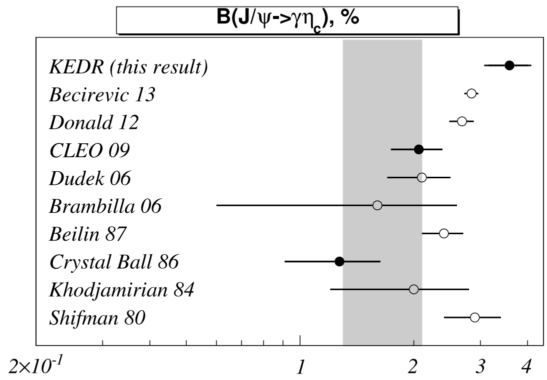

Figure 4: Summary of results on $\mathscr{B}(J/\psi \to \eta_c(1S)\gamma)$

The KEDR study based on $\sim 6 \cdot 10^6$ J/ψ decays used the inclusive spectrum of photons similarly to Crystal Ball and gave an even larger value of $(3.58 \pm 0.23 \pm 0.45)\%$. In Fig. 4 we present a summary of various results on $\mathscr{B}(J/\psi \to \eta_c(1S)\gamma)$ [23-29]. The preliminary result of KEDR is consistent with the most recent theoretical prediction from the lattice calculations [29].

5. Summary

The detailed scans of the charmonium energy range brought various high-precision results: measurement of the J/ψ and $\psi(2S)$ masses, determination of the ratio of the leptonic widths $\Gamma(e^+e^-)/\Gamma(\mu^+\mu^-)$ for the J/ψ, measurement of $\Gamma_{e^+e^-}\mathscr{B}(\mu^+\mu^-)$ for the $\psi(2S)$, study of the $J/\psi \to \eta_c(1S)\gamma)$ decay. Most of these results are still preliminary, analysis is in progress.

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