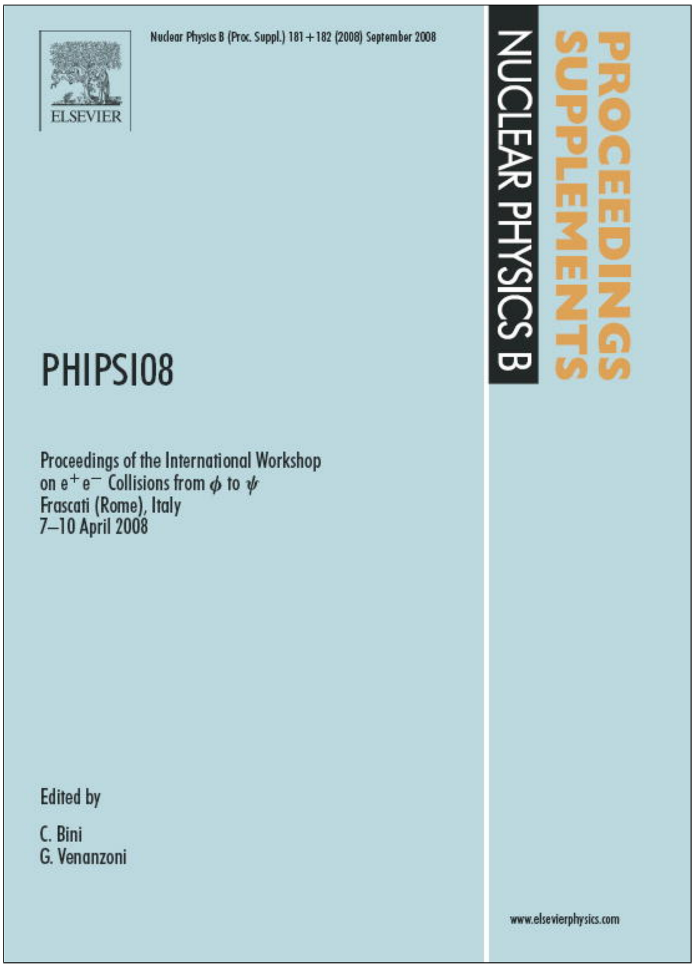
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Results on J/ψ, $\psi(2S)$, $\psi(3770)$ from KEDR

E. M. Baldin[a] for KEDR Collaboration*
V. V. Anashin[a], V. M. Aulchenko[a], E. M. Baldin[a], A. K. Barladyan[a], A. Yu. Barnyakov[a], M. Yu. Barnyakov[a], S. E. Baru[a], I. V. Bedny[a], O. L. Beloborodova[a], A. E. Blinov[a], V. E. Blinov[a], A. B. Bobrov[a], V. S. Bobrovnikov[a], A. V. Bogomyagkov[a], A. E. Bondar[a], D. V. Bondarev[a], A. R. Buzykaev[a], S. I. Eidelman[a], Yu. M. Glukhovchenko[a], V. R. Groshev[a], V. V. Gulevich[a], S. E. Karnaev[a], G. V. Karpov[a], S. V. Karpov[a], V. A. Kiselev[a], S. A. Kononov[a], T. A. Kozlova[a], K. Yu. Kotov[a], E. A. Kravchenko[a], E. V. Kremyanskaya[a], V. F. Kulikov[a], G. Ya. Kurkin[a], E. A. Kuper[a], E. B. Levichev[a], D. A. Maksimov[a], V. M. Malyshev[a], A. L. Maslennikov[a], A. S. Medvedko[a], O. I. Meshkov[a], S. I. Mishnev[a], I. I. Morozov[a], N. Yu. Muchnoi[a], V. V. Neufeld[a], S. A. Nikitin[a], I. B. Nikolaev[a], I. N. Okunev[a], A. P. Onuchin[a], S. B. Oreshkin[a], I. O. Orlov[a], A. A. Osipov[a], S. V. Peleganchuk[a], S. S. Petrosyan[a], S. G. Pivovarov[a], P. A. Piminov[a], V. V. Petrov[a], A. O. Poluektov[a], I. N. Popkov[a], G. E. Pospelov[a], V. G. Prisekin[a], A. A. Ruban[a], V. K. Sandyrev[a], G. A. Savinov[a], A. G. Shamov[a], D. N. Shatilov[a], B. A. Shwartz[a], E. A. Simonov[a], S. V. Sinyatkin[a], Yu. I. Skovpen[a], A. N. Skrinsky[a], V. V. Smaluk[a], A. M. Sukharev[a], A. A. Talyshev[a], V. A. Tayursky[a], V. I. Telnov[a], Yu. A. Tikhonov[a], K. Yu. Todyshev[a], G. M. Tumaikin[a], Yu. V. Usov[a], A. I. Vorobiov[a], A. N. Yushkov[a], V. N. Zhilich[a], V. V. Zhulanov[a], A. N. Zhuravlev[a]

[a]Budker Institute of Nuclear Physics
Lavrentiev prospect 11, Novosibirsk, 630090 Russia

New measurements of $\psi(2S)$, $\psi(3770)$ and D meson masses are presented. The results of the scans performed were used for determination of the products $\Gamma_{ee} \times \Gamma_{ee}/\Gamma$ for J/ψ and $\Gamma_{ee} \times \Gamma_{\mu\mu}/\Gamma$ for $\psi(2S)$.

1. Introduction

The first experiment carried out with the KEDR detector was a new measurement of J/ψ and $\psi(2S)$ masses [1]. The results obtained substantially increased the precision of the energy scale for the charm physics and were used in many experiments [2–6].

The present work continues a series of experiments on precise measurements of the onium resonance masses. Additionally it presents a new D meson mass measurement and determination of leptonic width of charmonia.

2. VEPP-4M collider and KEDR detector

The VEPP-4M collider [7] can operate in the wide range of beam energy from 1 to 6 GeV. The peak luminosity in the J/ψ energy region is about $2 \times 10^{30}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$.

One of the main features of the VEPP-4M is a possibility of precise energy determination. The resonant depolarization method [8,9] was implemented at VEPP-4 from the beginning of experiments in early eighties for the measurements of the J/ψ and $\psi(2S)$ mass with the OLYA [10] detector and Υ family mass with the MD-1 [10] detector.

At VEPP-4M the accuracy of the instant energy calibration with the resonant depolarization is improved to about 10^{-6}. The interpolation of the calibration results on the data taking period [1] reduces the accuracy of the energy determination to approximately $6 \cdot 10^{-6}$ ($\simeq$10 keV) in the J/ψ region.

In 2005 a new technique developed at the BESSY-I and BESSY-II synchrotron radiation

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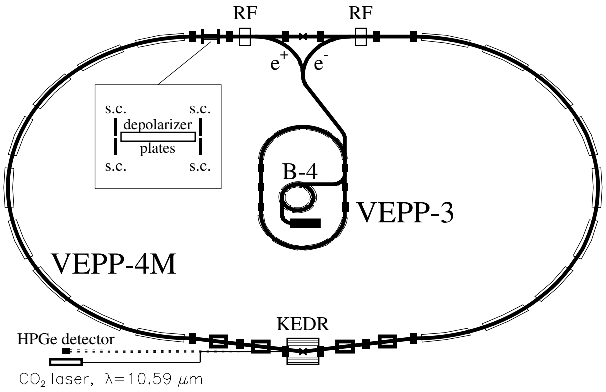

Figure 1. VEPP-4M/KEDR complex with the resonance depolarisation and the infrared light Compton backscattering facilities.

sources [11,12] was adopted for VEPP-4M. It employs the infrared light Compton backscattering and has worse precision (50÷70 keV in the J/ψ region) but, unlike the resonant depolarization, can be used during data taking.

The KEDR detector [13] is a classical type detector with the solenoidal magnetic field. It consists of a vertex detector, a drift chamber, a aerogel Cherenkov counters, a liquid krypton calorimeter with the high spatial resolution in the barrel, a CsI calorimeters in the endcaps, a time-of-flight system, a superconducting coil, a magnet yoke and a muon system inside it.

3. $\psi(2S)$ mass measurements

The result of the first precise J/ψ mass measurement at KEDR [1] is in excellent agreement with the less precise results of the previous experiments, however, in the $\psi(2S)$ case a scale factor of 1.4 is introduced in the PDG tables [14] due to some difference of the mass measured by KEDR and the combined result of the OLYA [10] and of the low energy $\bar{p}p$ experiment E760 [15] revised [14].

During the τ mass measurement [16] a few $\psi(2S)$ scans have been performed for the beam energy spread determination in 2004 and 2006.

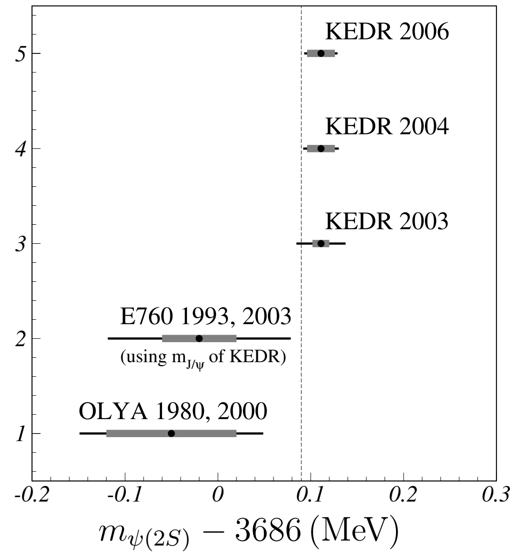

Figure 2. Comparison of $\psi(2S)$ mass measurements.

The new preliminary results on $\psi(2S)$ mass

$$m^{2004}_{\psi(2S)} = 3686.117 \pm 0.012 \pm 0.015\,\mathrm{MeV}/c^2,$$
$$m^{2006}_{\psi(2S)} = 3686.125 \pm 0.010 \pm 0.015\,\mathrm{MeV}/c^2$$

confirm the result obtained in 2003 with a small statistical uncertainty and partially correlated systematic uncertainties of about 15 keV (Fig. 2).

4. $\psi(3770)$ mass measurement

For the $\psi(3770)$ mass measurement the joint $\psi(2S)$ and $\psi(3770)$ scans should be performed (Fig. 3). The preliminary result on the $\psi(3770)$ mass is:

$$m_{\psi(3770)} = 3772.9 \pm 0.6 \pm 0.8 \text{ MeV}/c^2.$$

The result is in good agreement with the world average [14]. Currently, the main sources of systematic uncertainty are instabilities of the detection efficiency and luminosity measurements. For this result we employ the shape parameterization used in MARK-II [17] and BES [18] experiments.

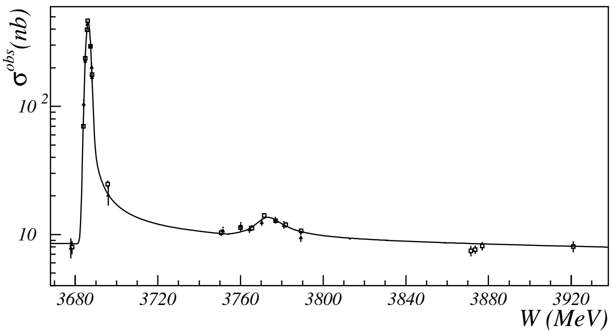

Figure 3. Cross section of $e^+e^- \to$ hadrons versus center of mass energy. The $\psi(2S) - \psi(3770)$ region in the scan 2004.

5. Measurements of D meson masses

The peak of the $\psi(3770)$ is a copious source of $D\bar{D}$ pairs . For the analysis of a D meson mass measurement we need to reconstruct one meson only. For D^0 we use the $K\pi$ and for the $D^\pm$ the $K\pi\pi$ decay modes. Two combinations are used in analysis:

$$M_D = \sqrt{E_{beam}^2 - p_D^2}$$

$$\Delta E = \sum \sqrt{p_i^2 + m_i^2} - E_{beam}$$

where M_D is the beam-constrained mass, which is calculated using well known beam energy E_{beam} and momentum of decay products of D meson p_D, and ΔE – the difference between the total energy of D meson decay products and the beam energy.

The meson masses are extracted using the unbinned fit of the $(M_D, \Delta E)$-distributions with the signal and combinatorial background shapes taken from the Monte Carlo simulation. The integrated luminosity is $0.9\,\mathrm{pb}^{-1}$.

The signal of a charged D meson is shown in Fig. 4. The fitted number of $D^+ \to K^-\pi^+\pi^+$ events is 110 ± 14. The preliminary result on the $D^\pm$ meson mass is:

$$m_{D^\pm} = 1869.39 \pm 0.45 \pm 0.29\ \mathrm{MeV}/c^2.$$

The measurement of the charged D meson mass

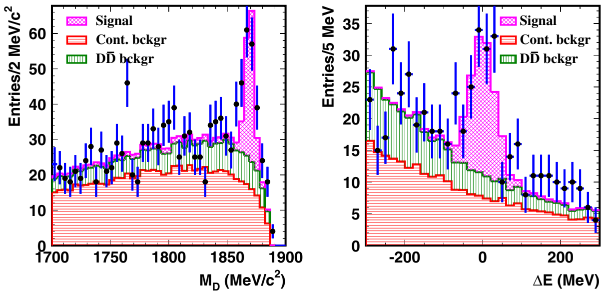

Figure 4. The M_D and ΔE distributions with the $D^\pm$ meson signal.

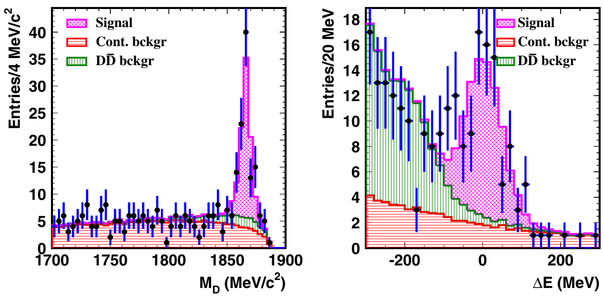

Figure 5. The M_D and ΔE distributions with the D^0 meson signal.

is presently the most precise measurement, and agrees with the world average value [14].

The signal of D^0 is shown in Fig. 5. The fitted number of $D^0 \to K^-\pi^+$ events is 92 ± 11. The preliminary result on the D^0 meson mass is:

$$m_{D^0} = 1865.43 \pm 0.60 \pm 0.38\ \mathrm{MeV}/c^2.$$

The result is in good agreement with the world average [14] and with the more precise result from CLEO-c [5].

6. Determination of leptonic width of charmonia

The results of precise scans can be used to obtain leptonic and total widths. At the moment we present the following results: $\Gamma_{ee} \times \Gamma_{ee}/\Gamma$ for

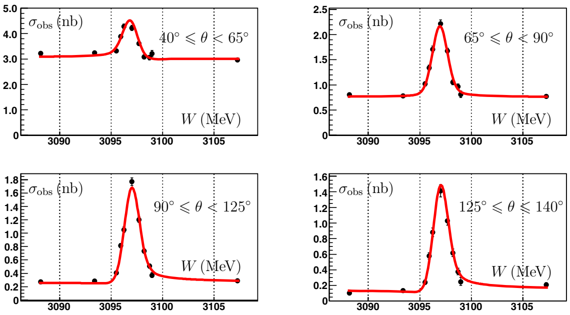

Figure 6. Cross section of $e^+e^- \to e^+e^-$ versus center of mass energy for different ranges of the electron scattering angle. The J/ψ region in the scan 2005.

J/ψ and $\Gamma_{ee} \times \Gamma_{\mu\mu}/\Gamma$ for $\psi(2S)$. Unlike determination of the branching fractions $\Gamma_{\ell^+\ell^-}/\Gamma$, to get these combinations one needs precise knowledge of the beam energy spread.

Four pictures in Fig. 6 show $e^+e^- \to e^+e^-$ cross sections measured in the single J/ψ scan for different ranges of the electron scattering angle.

At relatively small angles the Bhabha scattering prevails, at large angles the contribution of J/ψ decays dominates. The peak height is proportional to the product of Γ_{ee} and the branching ratio Γ_{ee}/Γ. The QED Bhabha is not only a background for this analysis, but it is also used for the absolute luminosity calibration. The radiative corrections and the interference effect according to [19] are taking into account. The fit of the resonance excitation curves for the 10 angular intervals yields

$$\Gamma_{ee} \times \Gamma_{ee}/\,\Gamma_{\text{total}} = 339.2 \pm 6.8 \pm 6.3\,\text{eV}.$$

It is the most precise direct measurement of this product. The result agrees with the similar product for muon decay measured by BABAR [20] and CLEO [21].

The knowledge of beam energy and its spread from the resonance scans allows us to measure the combination $\Gamma_{ee}\times\Gamma_{\mu\mu}/\Gamma$ for $\psi(2S)$ using the data collected at the $\psi(2S)$ peak and slightly below the

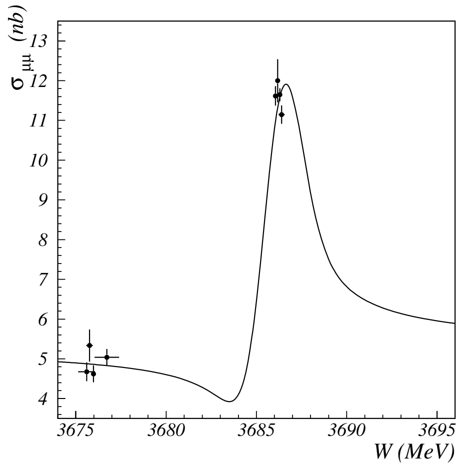

Figure 7. Cross section of $e^+e^- \to \mu^+\mu^-$ versus center of mass energy. $\psi(2S)$ region in the scans 2004–2007.

resonance (Fig. 7). The preliminary result is:

$$\Gamma_{ee} \times \Gamma_{\mu\mu}/\,\Gamma_{\text{total}} = 17.40 \pm 0.44 \pm 0.64\ \text{eV}.$$

This is the first direct measurement of the product of the electronic width by $\mathcal{B}(\psi(2S) \to \mu^+\mu^-)$.

7. Summary

The list of our recent results is presented below:

- $m_{\psi(2S)} = 3686.122 \pm 0.008 \pm 0.012\,\text{MeV}/c^2$ (preliminary)
- $m_{\psi(3770)} = 3772.9 \pm 0.6 \pm 0.8\,\text{MeV}/c^2$ (preliminary)
- $m_{D^\pm} = 1869.39 \pm 0.45 \pm 0.29\,\text{MeV}/c^2$ (preliminary)
- $m_{D^0} = 1865.43 \pm 0.60 \pm 0.38\,\text{MeV}/c^2$ (preliminary)
- $\psi(2S)$: $\Gamma_{ee}\times\Gamma_{\mu\mu}/\Gamma = 17.40\pm0.44\pm0.64\,\text{eV}$ (preliminary)
- J/ψ: $\Gamma_{ee} \times \Gamma_{ee}/\Gamma = 339.2 \pm 6.8 \pm 6.3\,\text{eV}$

All results agree well with the world average values and have comparable or better accuracy.

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