Recent Results from the KEDR Detector

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We present results of precise measurements in the ψ family energy range based on the data collected with the KEDR detector at the VEPP-4M e^+e^- collider in Novosibirsk. They include: leptonic widths of the J/ψ meson, D^+ and D^0 meson masses.

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1. Introduction

The electron-positron accelerator complex VEPP-4M [1] designed for various high-energy physics experiments in the center-of-mass (c.m.) energy range from 2 to 12 GeV is currently running in the ψ family region. The luminosity at the J/ψ in a two-bunch operation mode reaches $\mathscr{L} = 10^{30}$ cm^{-2}s^{-1}.

A precise measurement of the beam energy can be performed at VEPP-4M using the resonant depolarization method based on the measurement of the spin precession frequency of the polarized beam, which depends on its energy [2]. Using the resonant depolarization, the precision of the beam energy measurement reached in the KEDR experiment is $\simeq$10 keV [3].

The detector KEDR [4] includes a tracking system consisting of a vertex detector and a drift chamber, a particle identification (PID) system of aerogel Cherenkov counters and scintillation time-of-flight counters, an electromagnetic calorimeter based on liquid krypton (in the barrel part) and CsI crystals (endcap part) and muon system installed inside the magnet yoke. The central part of the detector is placed in the magnetic field of 0.6 T created by the superconducting solenoid coil. The detector also includes a high-resolution tagging system for studies of two-photon processes. The online luminosity measurement is performed with sampling calorimeters which detect photons from the process of single brehmsstrahlung.

In this report we present the results of two recent analyses: measurement of the J/ψ leptonic width and determination of the D^0 and $D^{\pm}$ meson masses.

2. Measurement of the J/ψ Leptonic Width

A precise scan of the J/ψ meson ($\sim 2.5\times 10^5$ produced) can be used to measure its leptonic widths or more exactly the product of its leptonic width and the branching fraction of its decay into the final state, $\Gamma_{e^+e^-}\mathscr{B}_{l^+l^-}$, a basis for determination of the leptonic width $\Gamma_{e^+e^-}$ and the corresponding branching fraction $\mathscr{B}_{l^+l^-}$, $l = e,\ \mu$. The energy dependence of the cross section for both e^+e^- and $\mu^+\mu^-$ final states produced in the decay of a narrow resonance was obtained in the soft photon approximation in Ref. [5].

For $\Gamma_{e^+e^-}\mathscr{B}_{e^+e^-}$ we perform a two-dimensional approximation (c.m. energy vs. polar angle) of the data taking into account different angular dependence of the non-resonant Bhabha scattering and the resonance decay and obtain $\Gamma_{e^+e^-}\cdot\mathscr{B}(J/\psi\to e^+e^-) = 0.3355\pm 0.0064\pm 0.0048$ keV. The total systematic uncertainty of the product is 1.4% dominated by the luminosity measurement (0.8%) and drift chamber selection (0.7%). The precision of our result for $\Gamma_{e^+e^-}\cdot\mathscr{B}(J/\psi\to e^+e^-)$ is 2.4%, comparable to the world averages of $\Gamma_{e^+e^-}$ (2.6%) and $\Gamma_{e^+e^-}\mathscr{B}(J/\psi\to\mu^+\mu^-)$ (2.1%). It agrees well with $\Gamma_{e^+e^-}\cdot\mathscr{B}(J/\psi\to e^+e^-) = 0.3291\pm 0.0090$ keV obtained using $\Gamma_{e^+e^-}$ and Γ from PDG-08 [6].

To determine $\Gamma_{e^+e^-}\mathscr{B}_{\mu^+\mu^-}$ we perform a fit of the c.m. energy dependence of the cross section and obtain $\Gamma_{ee}\cdot\mathscr{B}(J/\psi\to\mu^+\mu^-) = 0.3350\pm 0.0052\pm 0.0063$ keV. Here the total systematic error is 1.9% dominated by the luminosity calibration and measurement (0.7% and 0.8%) as well as detection efficiency (0.8%). The precision of our $\Gamma_{e^+e^-}\cdot\mathscr{B}(J/\psi\to\mu^+\mu^-$ is 2.4%, comparable to the world average of 2.1%. Its central value agrees well with the world average of $0.335\pm$

0.007 keV from PDG-08 [6]. In Fig. 1 we compare our results with the previous measurements for $J/\psi \to e^+e^-$ [7–10] and $J/\psi \to \mu^+\mu^-$ [8,11–13].

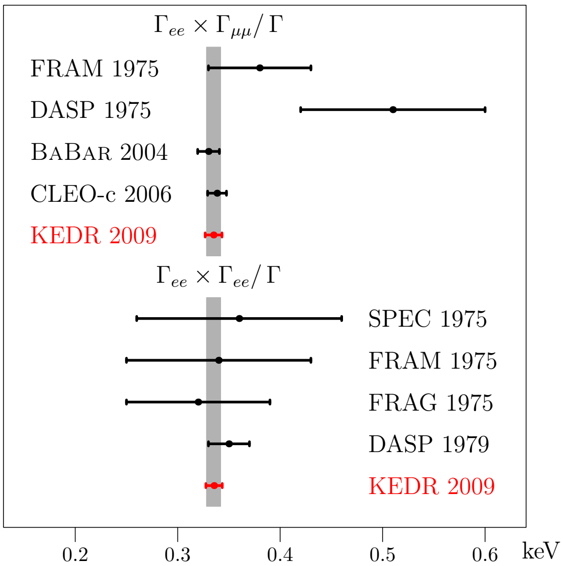

Figure 1: Comparison of KEDR leptonic widths with other measurements

3. Measurement of D^0 and $D^\pm$ Meson Masses

Measurement of D meson masses is performed using the near-threshold $e^+e^- \to D\overline{D}$ production with the exclusive reconstruction of one of the D mesons. The analysis uses a sample of 0.9 pb^{-1} accumulated with the KEDR detector at the energy of the $\psi(3770)$ resonance.

Neutral D mesons are reconstructed in the $K^-\pi^+$ final state, charged D mesons are reconstructed in the $K^-\pi^+\pi^+$ final state. The invariant mass of the D meson can be calculated as

$$M_{\rm bc} = \sqrt{E^2_{\rm beam} - (\sum_i \vec{p}_i)^2}, \quad (3.1)$$

(so-called *beam-constrained mass*), where $E_{\rm beam}$ is the energy of colliding beams in the CM frame, $\vec{p}_i$ are the momenta of the D decay products. In addition to $M_{\rm bc}$, D mesons are effectively selected by the CM energy difference

$$\Delta E = \sum_i \sqrt{M_i^2 + p_i^2} - E_{\rm beam}, \quad (3.2)$$

where M_i and p_i are the masses and momenta of the D decay products. The signal events should satisfy a condition $\Delta E \simeq 0$. In our analysis, we select a relatively wide region of $M_{\rm bc}$ and ΔE close to $M_{\rm bc} \sim M_D$ and $\Delta E \sim 0$, then a fit of the event density is performed with D mass as one of the parameters, with the background contribution taken into account. For the D^0 mesons we additionally use a kinematic parameter - the difference of the momenta of the D^0 products. Results of selection of the D^0 candidates are shown in Fig. 2.

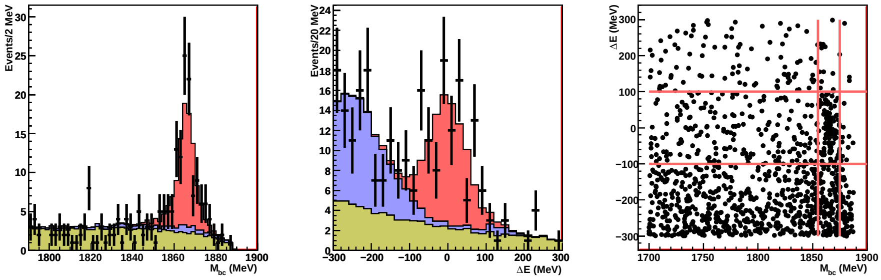

Figure 2: Selection of D^0 candidates

From 94 ± 13 events selected we obtain $m_{D^0} = 1865.53 \pm 0.39 \pm 0.25$ MeV. Dominant systematic errors come from the following sources: signal shape (0.11 MeV), background shape (0.06 MeV), radiative corrections (0.17 MeV), momentum calibration (0.10 MeV).

Results of selection of the $D^{\pm}$ candidates are shown in Fig. 3. In this case from 116 ± 16 events selected we obtain $m_{D^{\pm}} = 1869.32 \pm 0.48 \pm 0.22$ MeV. Dominant systematic errors come from the following sources: signal shape (0.11 MeV), background shape (0.11 MeV), radiative corrections (0.11 MeV), momentum calibration (0.10 MeV).

In Fig. 4 we compare our results with the most precise previous measurements for the D^0 [14–16] and $D^{\pm}$ mesons [14,15]. The values of D meson masses obtained at KEDR are in good agreement with the corresponding world-averages based on the fit including $D^{\pm}$, D^0, $D_s^{\pm}$, $D^{*\pm}$, D^{*0}, and $D_s^{*\pm}$ mass and mass difference measurements [6]. For the $D^{\pm}$ our result is the most precise direct measurement.

4. Acknowledgments

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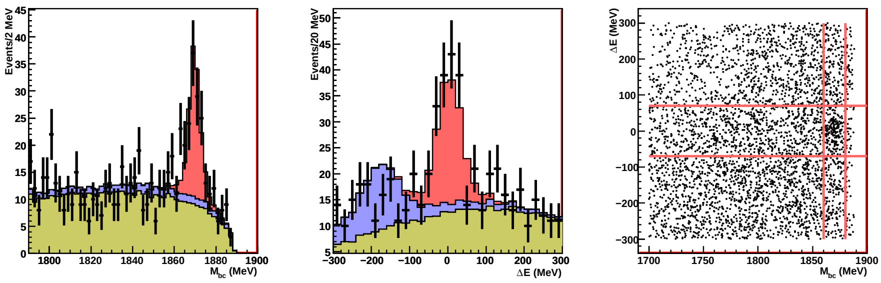

Figure 3: Selection of $D^{\pm}$ candidates

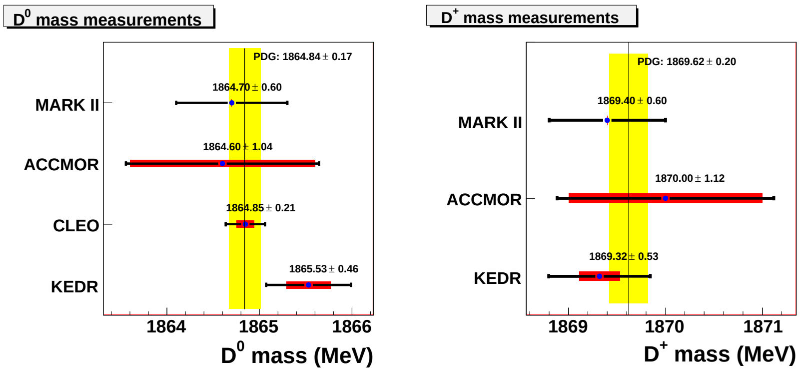

Figure 4: Comparison of KEDR *D* msson masses with other measurements

REFERENCES

1. V.V. Anashin *et al.*, Stockholm 1998, EPAC 98, 400 (1998).
2. A.N. Skrinsky and Yu.M. Shatunov, Sov. Phys. Usp. **32**, 548 (1989).
3. V.M. Aulchenko *et al.*, Phys. Lett. B **573**, 663 (2003).
4. V.V. Anashin *et al.*, Nucl. Instr. Meth. A **478**, 420 (2002).
5. Ya. Azimov *et al.*, JETP Lett. **21**, 172 (1975).
6. C. Amsler *et al.*, Phys. Lett. B **667**, 1 (2008).
7. R.L. Ford *et al.*, Phys. Rev. Lett. **34**, 604 (1975).
8. B. Esposito *et al.*, Lett. Nuovo Cim. **14**, 73 (1975).
9. R. Baldini-Celio *et al.*, Phys. Lett. B **58**, 471 (1975).
10. R. Brandelik *et al.*, Z. Phys. C **1**, 233 (1979).
11. W. Braunschweig *et al.*, Phys. Lett. B **56**, 491 (1975).
12. B. Aubert *et al.*, Phys. Rev. D **69**, 011103 (2004).
13. G.S. Adams *et al.*, Phys. Rev. D **73**, 051103 (2006).
14. R.H. Schindler *et al.*, Phys. Rev. D **24**, 78 (1981).
15. S. Barlag *et al.*, Z. Phys. C **46**, 563 (1990).
16. C. Cawlfield *et al.*, Phys. Rev. Lett. **98**, 092007 (2007).