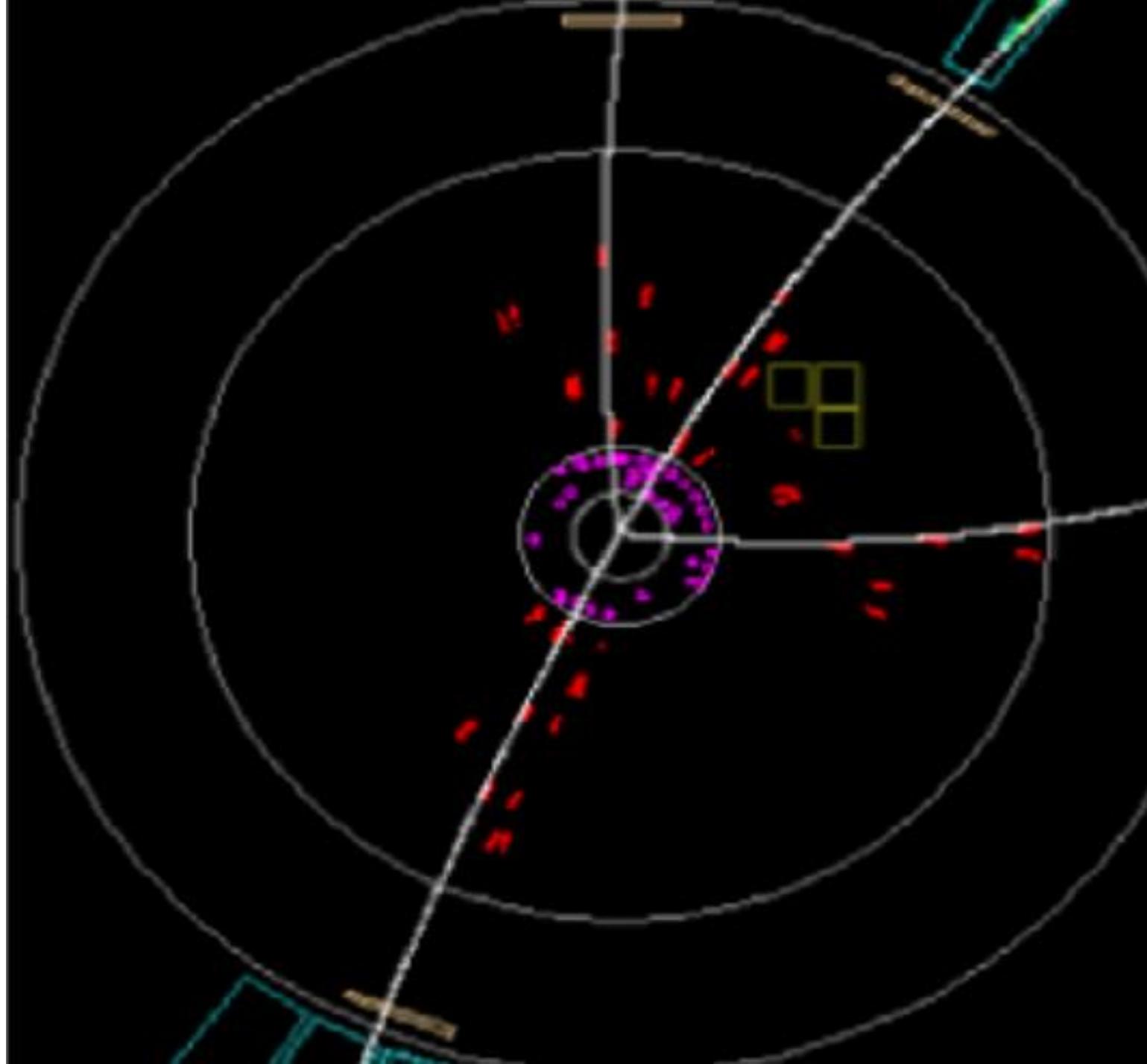




Recent results from the detector

Tatyana Kharlamova
for the KEDR collaboration
15-19 May 2021

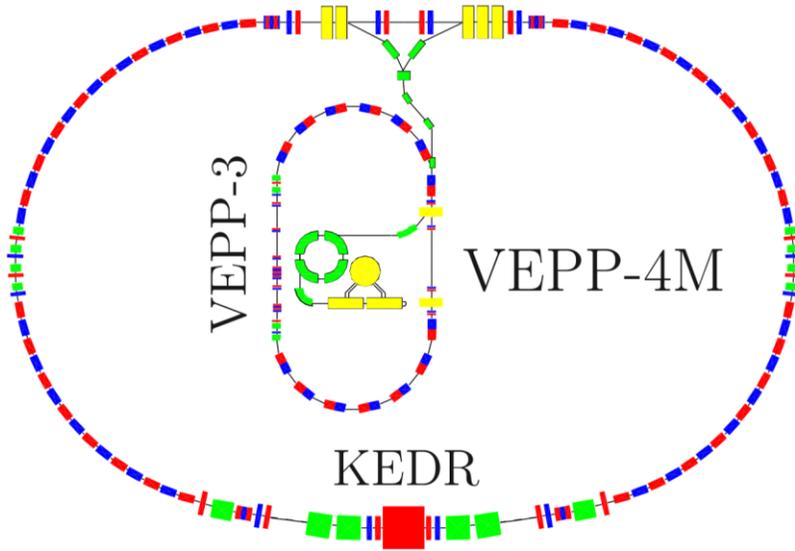
The 14th International Workshop on Heavy
Quarkonium



Outline

- R measurements between 1.8 and 7.0 GeV
- Measurements of J/ψ meson total and partial widths
- Measurements of the branching fractions of $J/\psi \rightarrow 2(\pi^+\pi^-)\pi^0$, $K^+K^-\pi^+\pi^-\pi^0$, $2(\pi^+\pi^-)$, $K^+K^-\pi^+\pi^-$
- D meson mass measurements

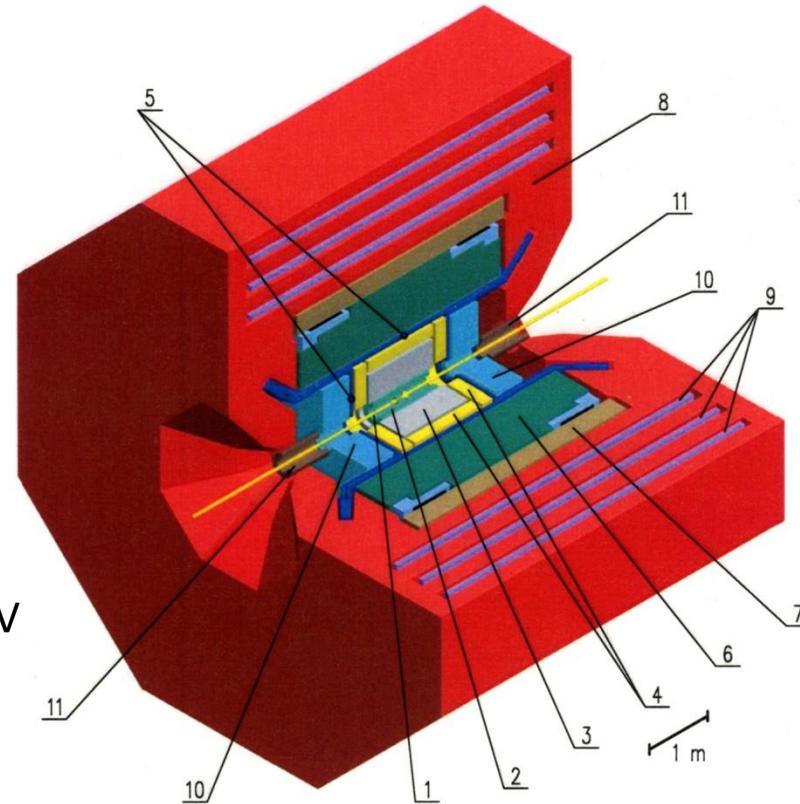
Collider VEPP-4M and KEDR detector



Beam energy	1 – 5 GeV
Number of bunches	2 x 2
Luminosity at 1.5 GeV	$2 \cdot 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$
Luminosity at 5.0 GeV	$2 \cdot 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$

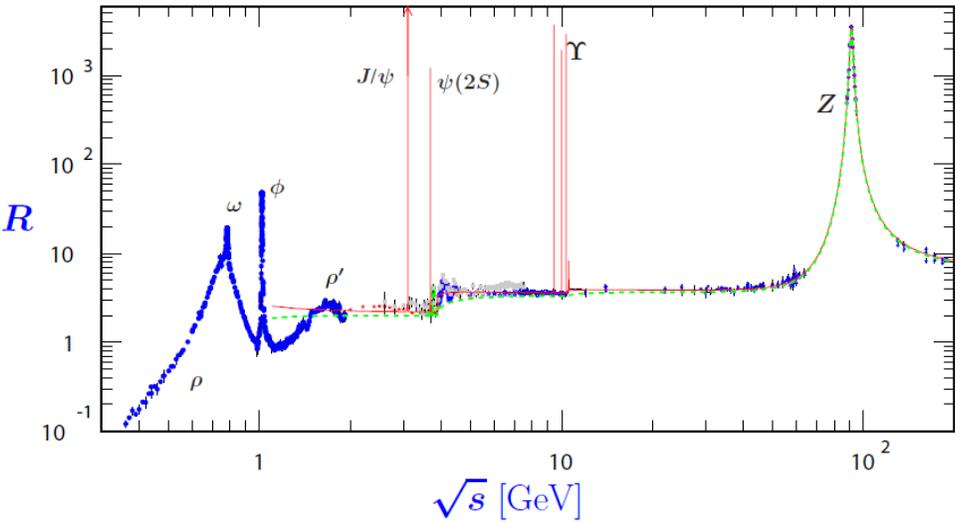
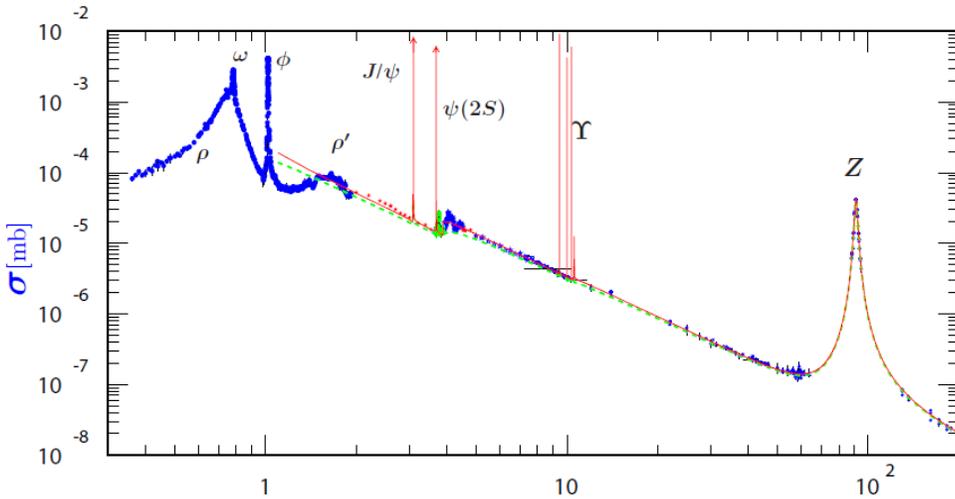
Beam energy measurement:

- Resonant depolarization method
 - Instant measurement accuracy 1 keV
 - Energy interpolation accuracy 10-30 keV
- Infrared light Compton backscattering
 - Monitoring with accuracy 100 keV



1. Vacuum chamber
2. Vertex detector
3. Drift chamber
4. Threshold aerogel counters
5. ToF counters
6. Liquid krypton calorimeter
7. Superconducting coil
8. Magnet yoke
9. Muon tubes
10. CsI calorimeter
11. Compensating s/c solenoid

Motivation of R measurement



$$R = \frac{\sigma(e^-e^+ \rightarrow \text{hadrons})}{\sigma(e^-e^+ \rightarrow \mu^-\mu^+)} \approx \frac{\text{[Feynman diagram for } e^-e^+ \rightarrow q\bar{q}\text{]}}{\text{[Feynman diagram for } e^-e^+ \rightarrow \mu^-\mu^+\text{]}}$$

In first approximation:

$$R(s) \simeq 3 \sum e_q^2$$

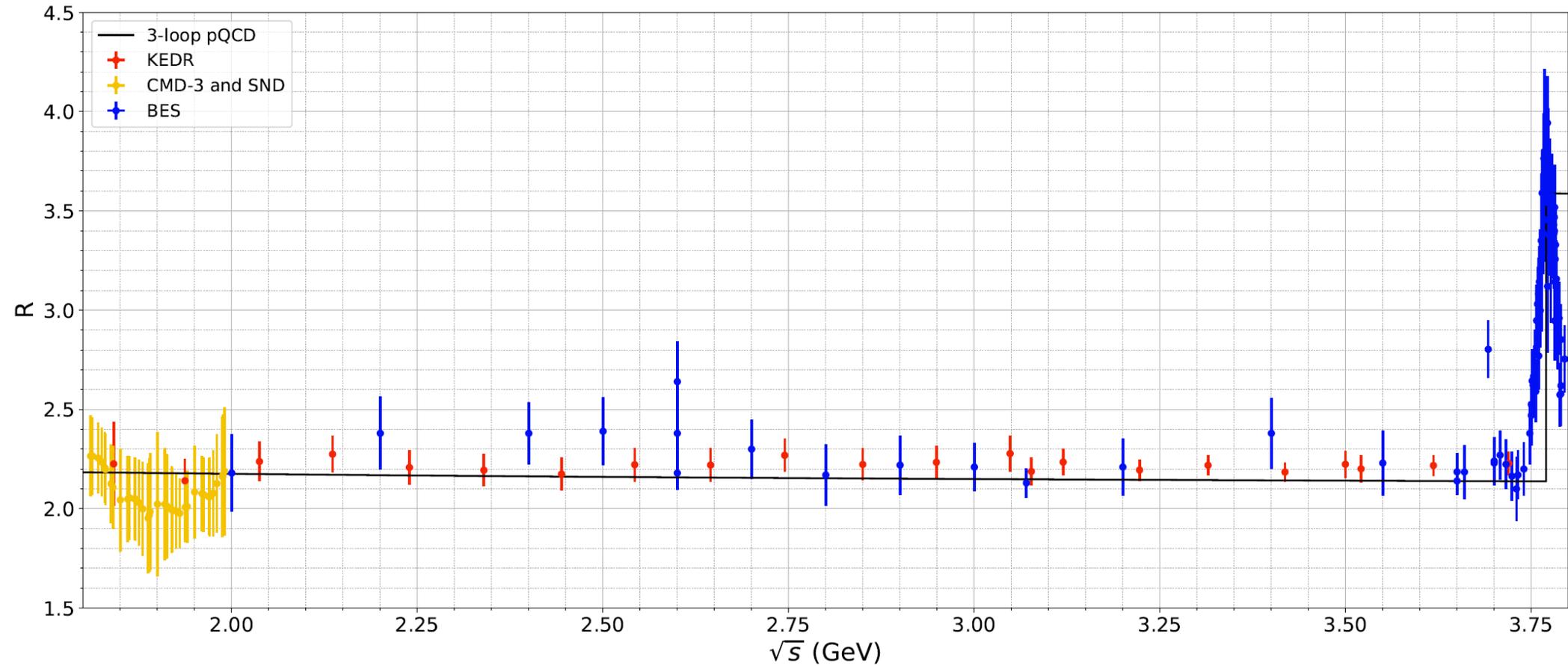
R(s) is used to determine:

- $\alpha_s(s)$
- $(g_\mu - 2)/2$
- $\alpha(M_Z^2)$
- m_Q

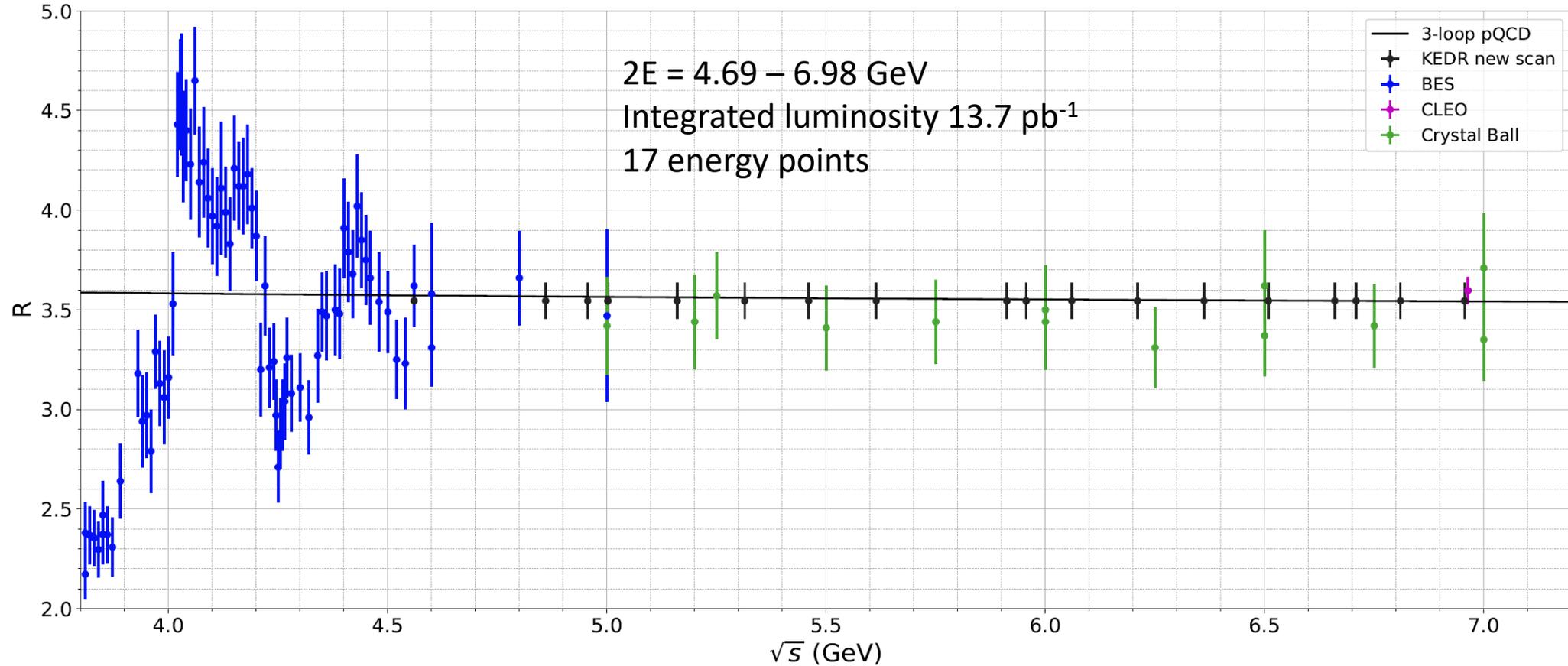
R measurement between 1.8 and 3.8 GeV at KEDR

\sqrt{s} , GeV	N_{points}	$\int Ldt, pb^{-1}$	Unc., %	Ref.
1.84 - 3.05	13	0.66	≤ 3.9 total (≈ 2.4 syst.)	V.V. Anashin. Phys.Lett. B 770 (2017) 174
3.08 - 3.72	9	1.3	≤ 2.6 total (≈ 1.9 syst.)	V.V. Anashin. Phys.Lett. B 788 (2019) 42

R measurement between 1.8 and 3.8 GeV



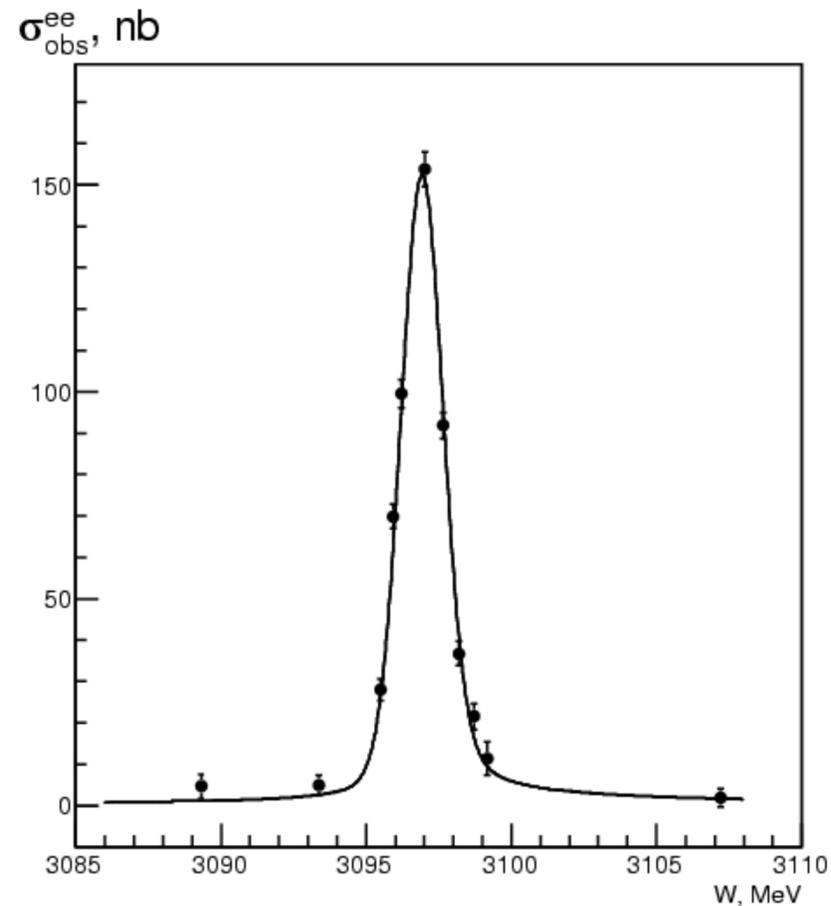
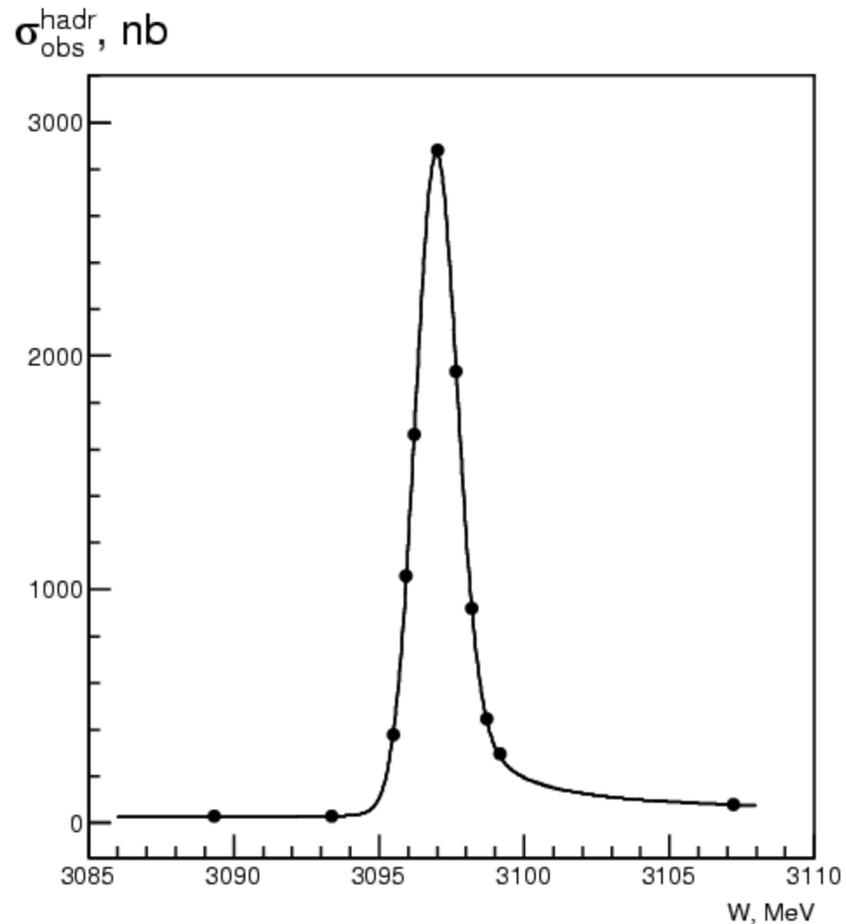
R measurement between 3.8 and 7.0 GeV



* KEDR new scan points positions are fixed at pQCD predictions
Expected total uncertainty is about 3 % (systematic uncertainty about 2.5%)

Measurement of J/ψ leptonic widths

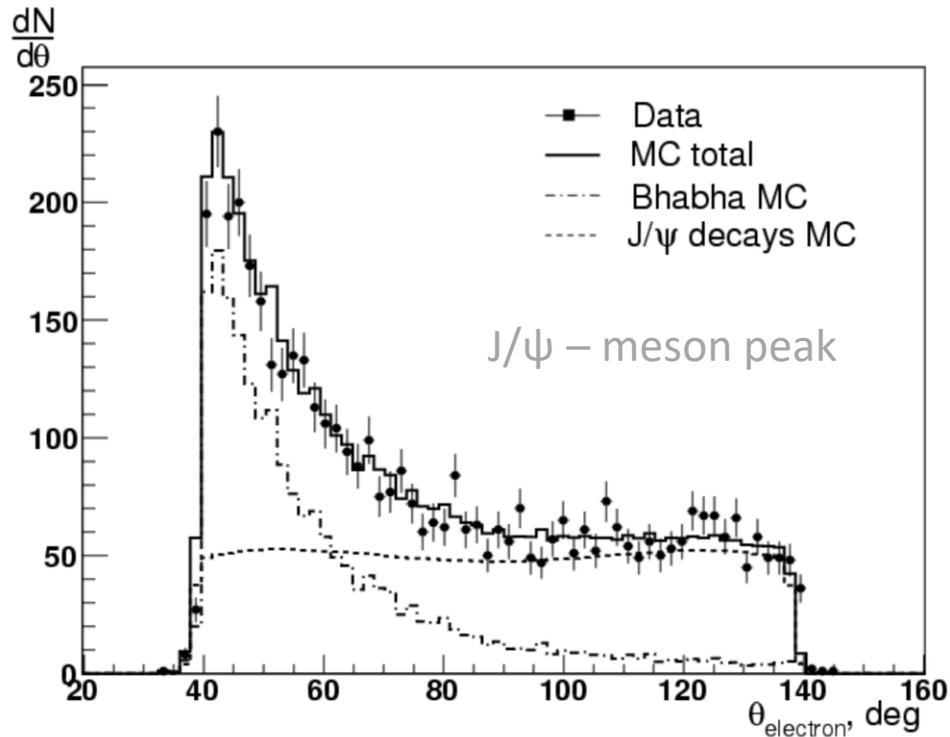
- Combined fit of hadronic and leptonic events
- Free parameters: $\Gamma_{ee} \cdot B_{ee}(J/\psi)$, $\Gamma_{ee} \cdot B_h(J/\psi)$ or $\Gamma_{ee}(J/\psi)$, and also : $m(J/\psi)$, R_L , σ_W , σ_0



$$\int L dt = 230 \text{ nb}^{-1}$$

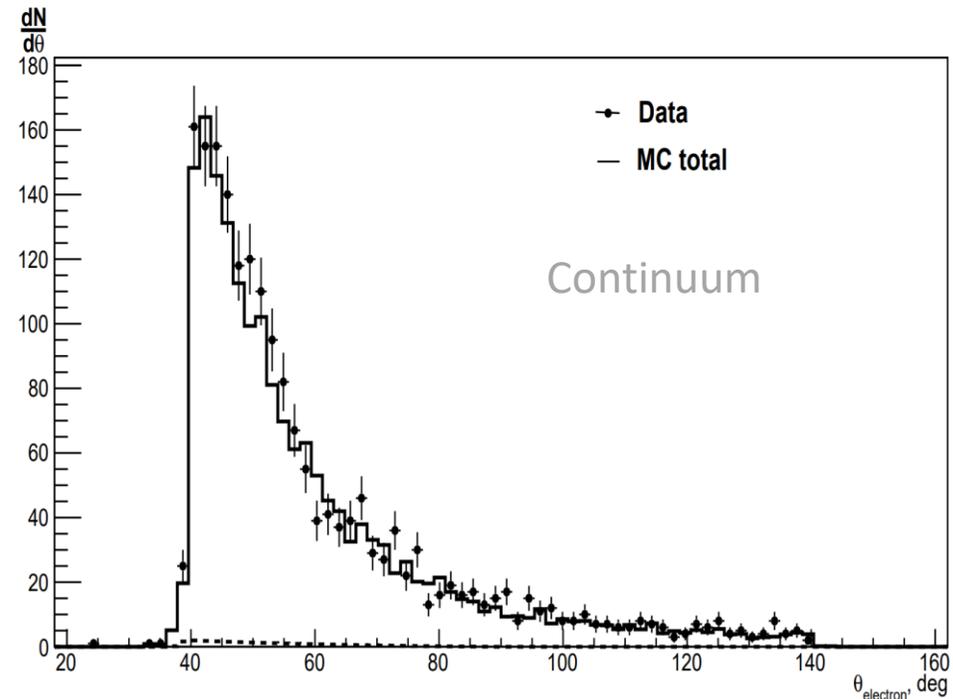
Scan at 11 points
250k J/ψ mesons
 $\sigma_W = 692 \pm 4 \text{ keV}$

Luminosity measurement

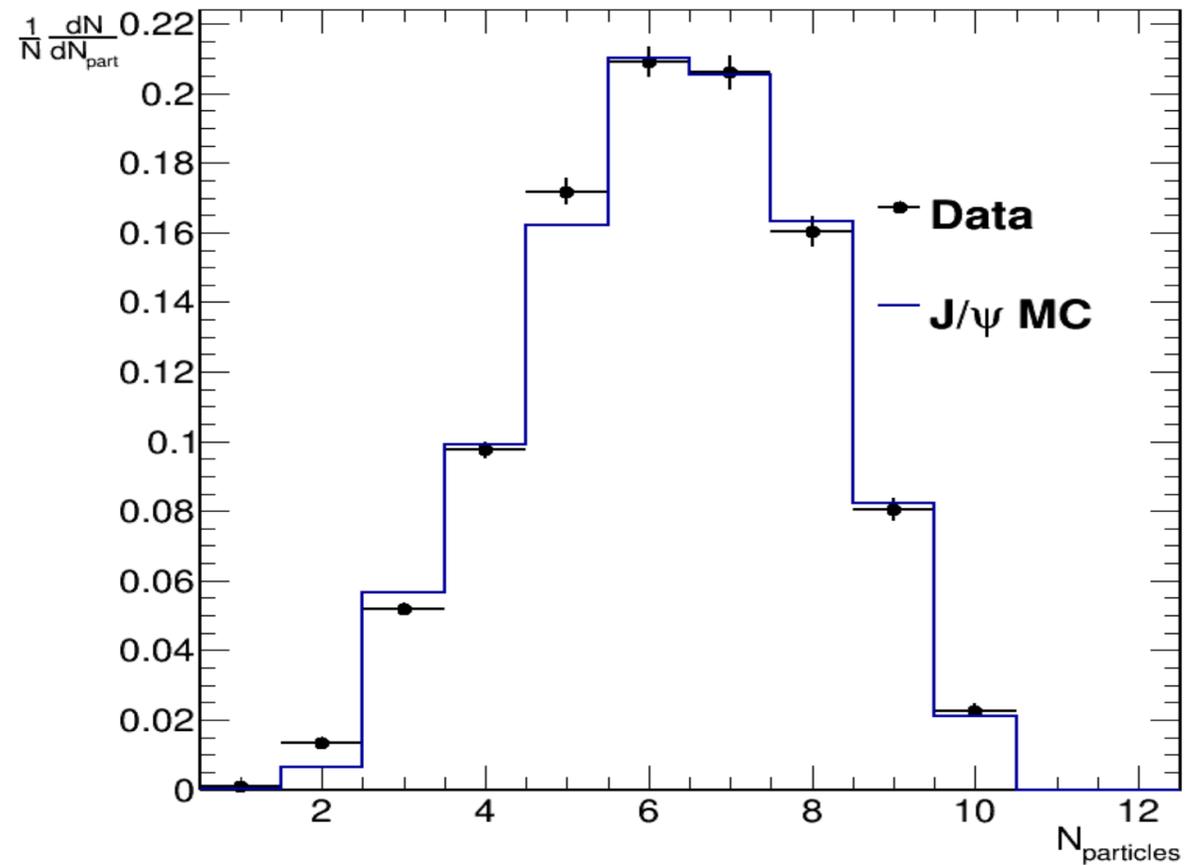
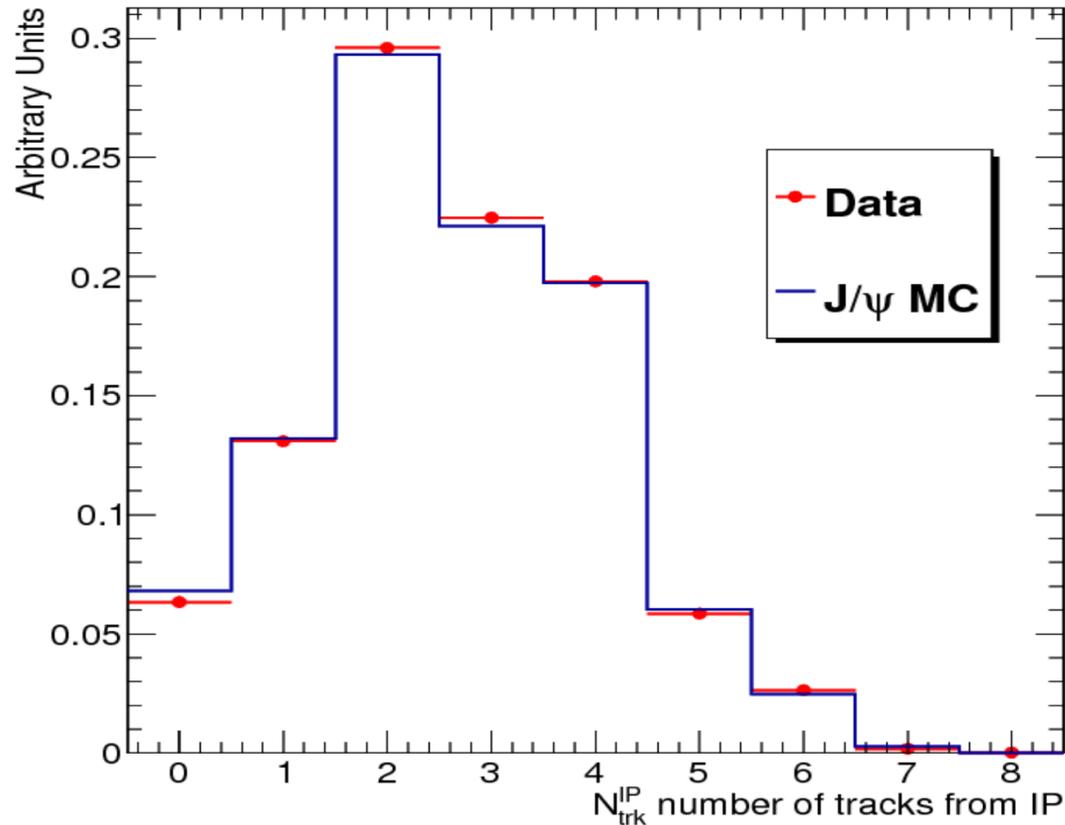


Distribution of electron polar angle for $e^+e^- \rightarrow e^+e^-$ events

- The relative luminosity was measured by bremsstrahlung luminosity monitor
- The absolute luminosity was calculated using e^+e^- events in the barrel LKr calorimeter

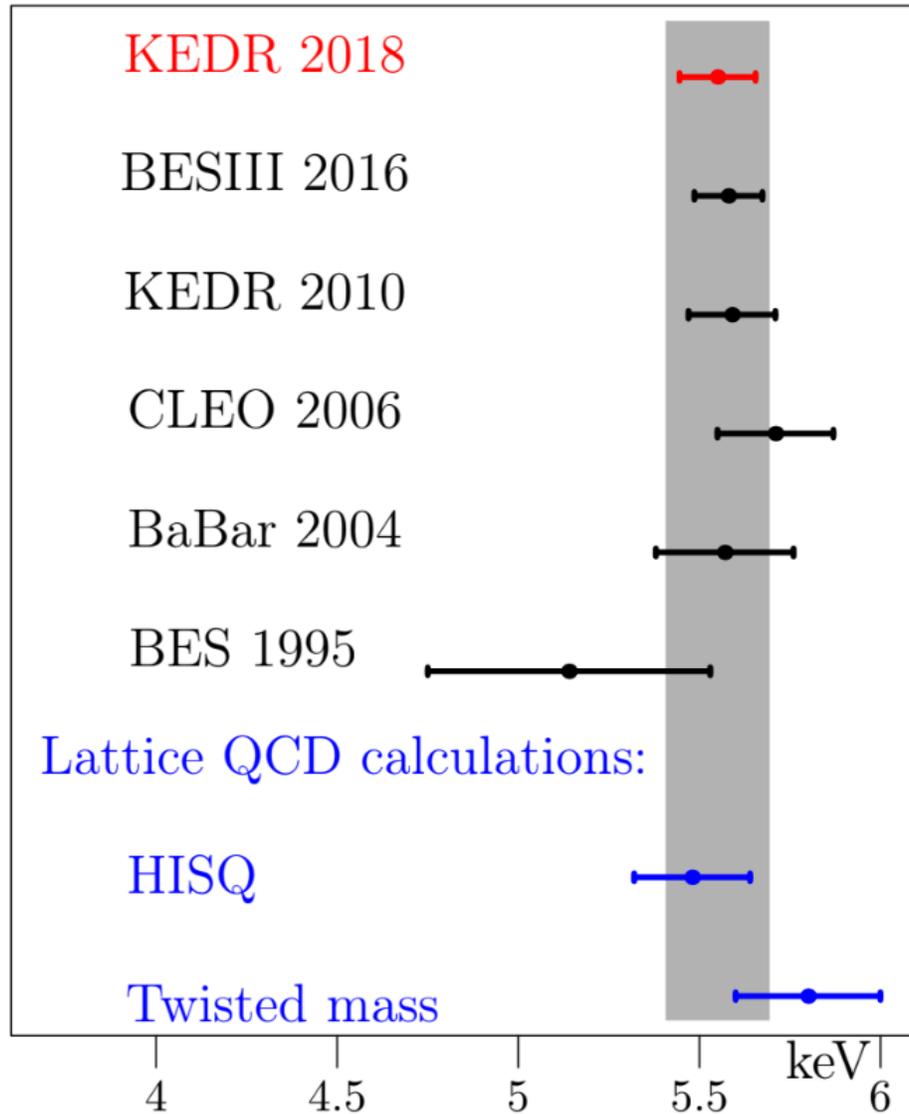


Properties of the hadronic events produced in the vicinity of J/ψ resonance



Tuning of JETSET parameters in BES generator
[Phys. Rev. D 62 (2000) 034003]

Measurement of $\Gamma_{ee}(J/\psi)$

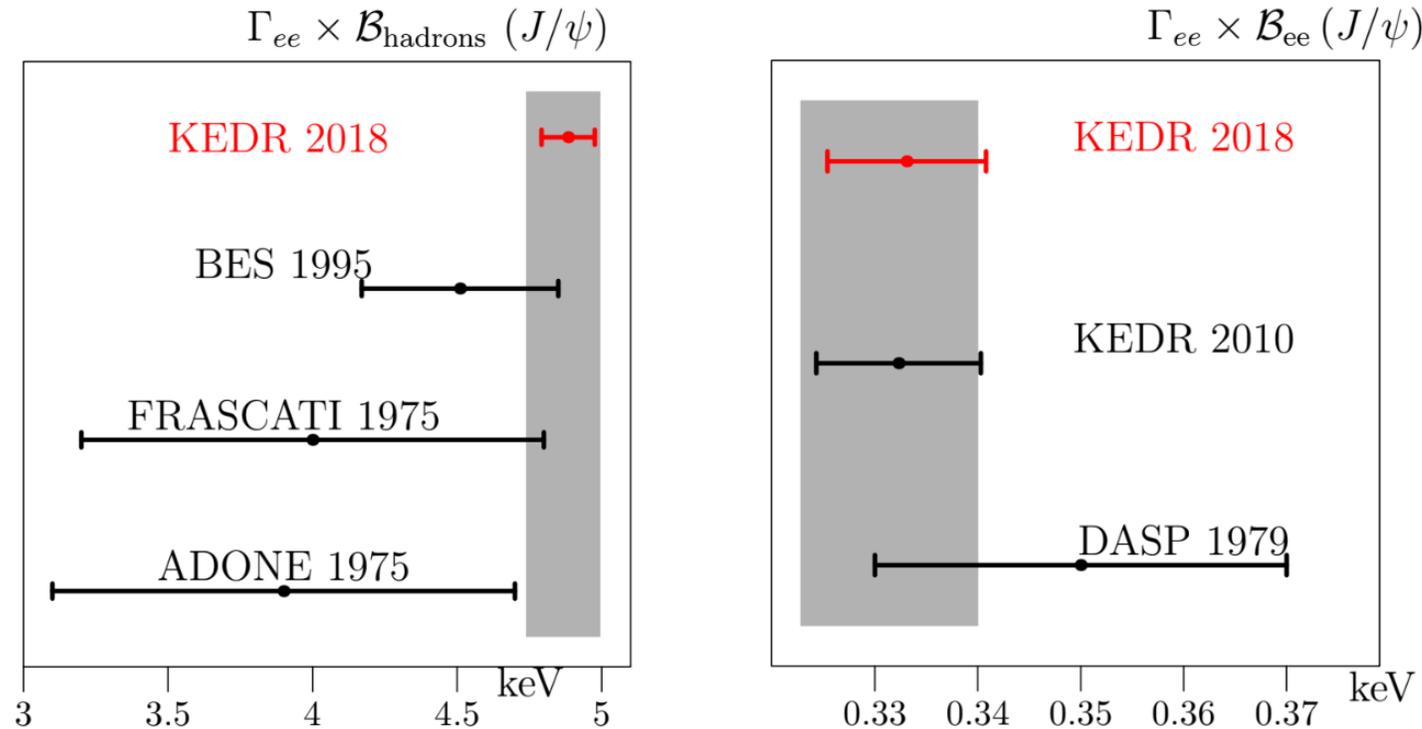


$$\Gamma_{ee}(J/\psi) = 5.550 \pm 0.056 \pm 0.089 \text{ keV}$$

[J. High Energ. Phys. \(2018\) 2018: 119](#)

*To note: Agreement in $\Gamma_{ee}(J/\psi)$ obtained from hadronic and leptonic decays confirms the assumption that interference phases are not correlated

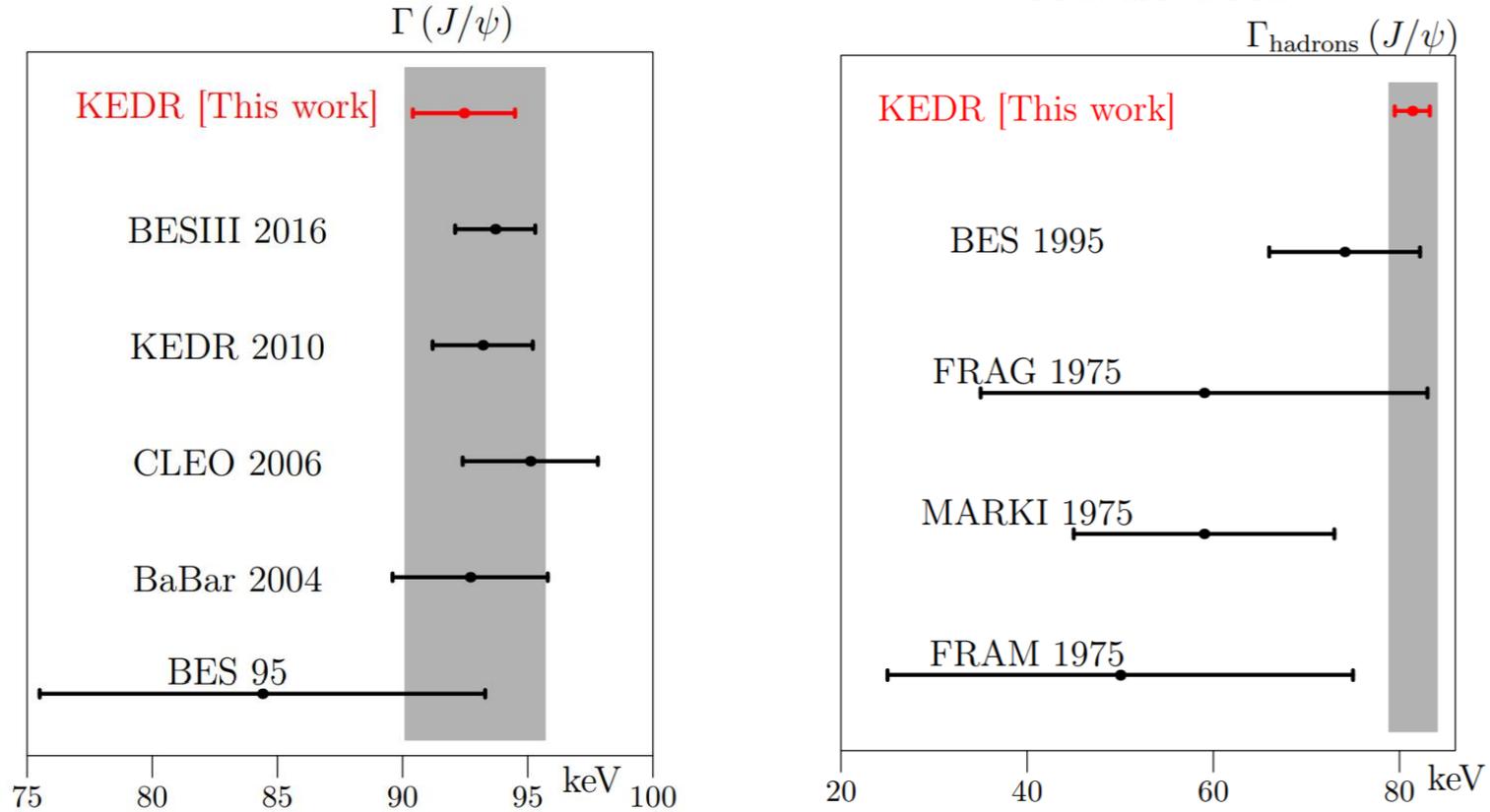
Measurement of $\Gamma_{ee} \cdot \mathcal{B}_h$ and $\Gamma_{ee} \cdot \mathcal{B}_{ee}(J/\psi)$



$$\Gamma_{ee}(J/\psi) \cdot \mathcal{B}_{\text{hadrons}}(J/\psi) = 4.884 \pm 0.048 \pm 0.078 \text{ keV}$$

$$\Gamma_{ee}(J/\psi) \cdot \mathcal{B}_{ee}(J/\psi) = 0.3331 \pm 0.0066 \pm 0.0040 \text{ keV}$$

Measurement of Γ and $\Gamma_{\text{hadrons}}(J/\psi)$



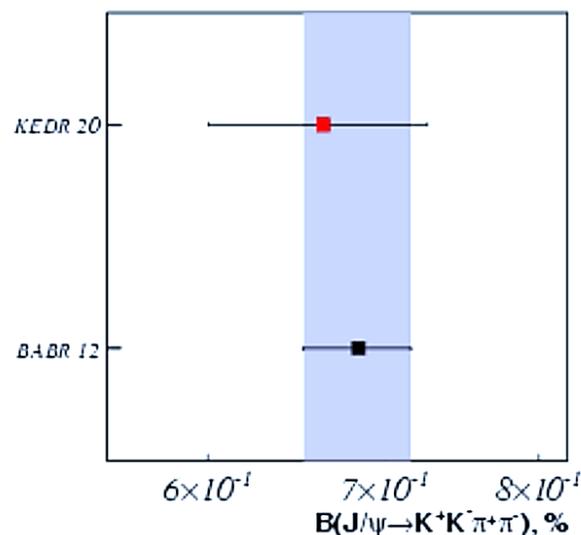
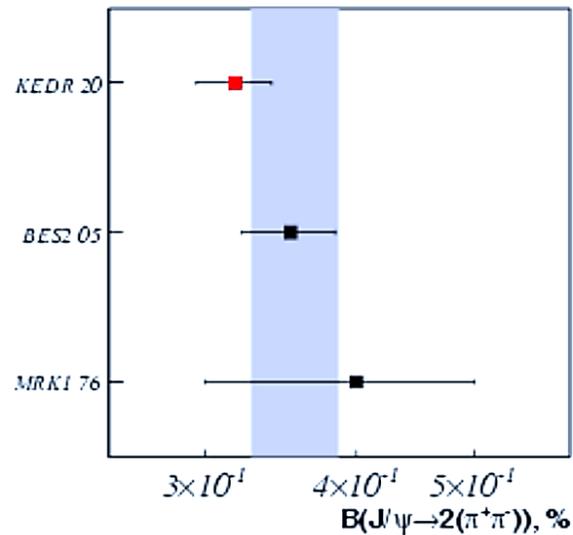
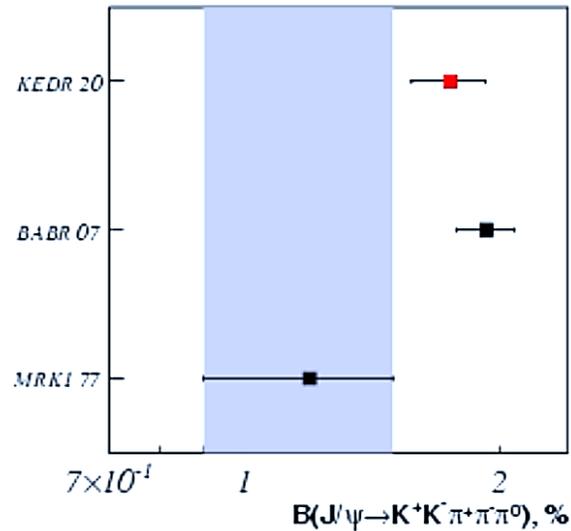
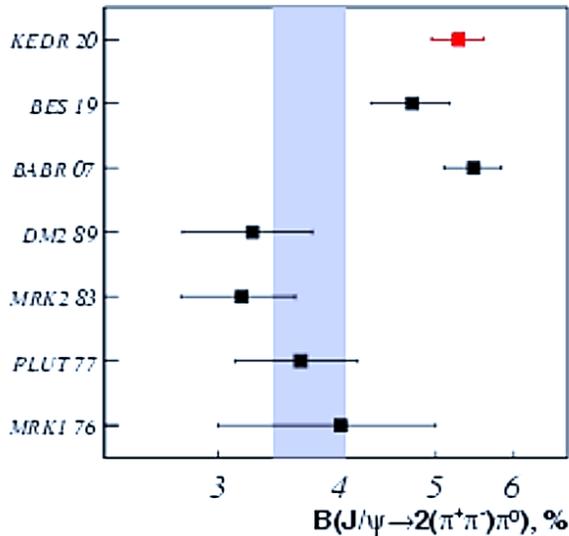
New results

$$\Gamma(J/\psi) = 92.45 \pm 1.40 \pm 1.48 \text{ keV}$$

$$\Gamma_{\text{hadrons}}(J/\psi) = 81.37 \pm 1.36 \pm 1.30 \text{ keV}$$

J. High Energ. Phys. 2007 (2020) 112

Measurements of the branching fractions of $J/\psi \rightarrow 2(\pi^+\pi^-)\pi^0$, $K^+K^-\pi^+\pi^-\pi^0$, $2(\pi^+\pi^-)$, $K^+K^-\pi^+\pi^-$



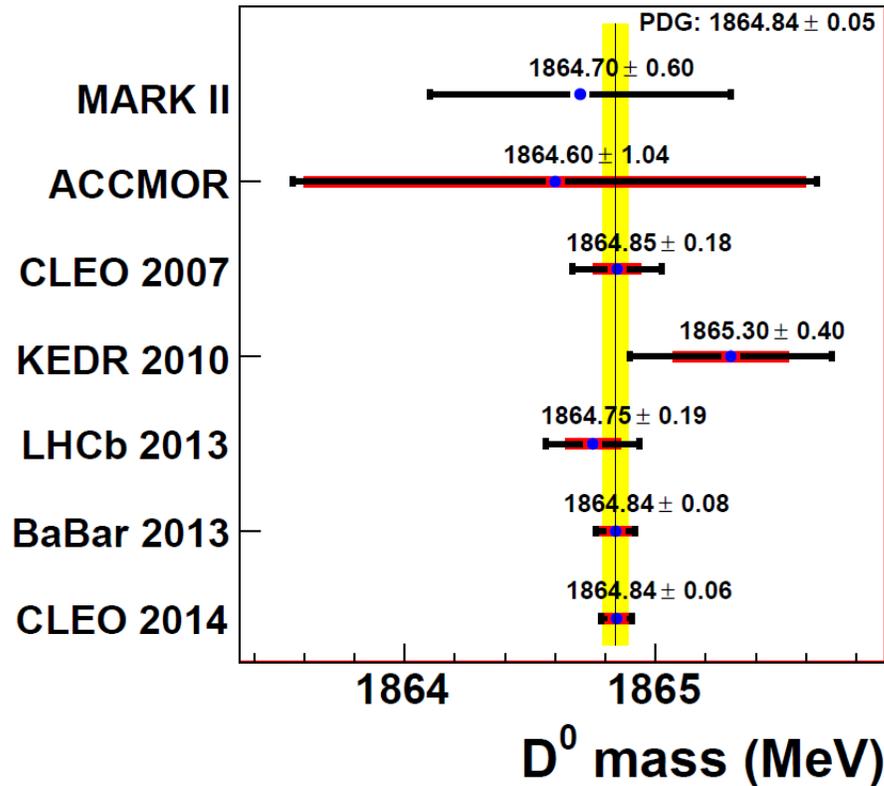
Preliminary results on inclusive decay modes!

- $\int L dt = 1315 \text{ nb}^{-1}$ at $\sqrt{s} = 3.123 \text{ GeV}$
5.2 millions J/ψ

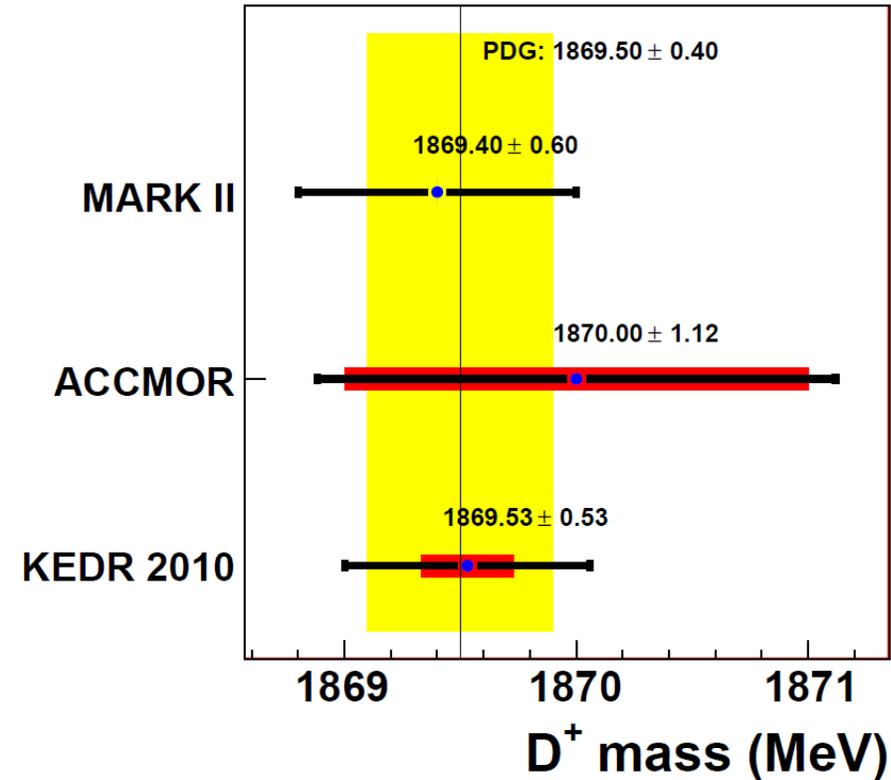
- $\int L dt = 82.3 \text{ nb}^{-1}$ at $\sqrt{s} = 3.101 \text{ GeV}$
for background estimation

D-meson masses

D⁰ mass measurements



D⁺ mass measurements



D-meson mass is important for DD* threshold determination. This knowledge affects understanding of the $x_{c1}(3872)$ (X(3872)) nature. Its current explanation is a mixture of regular cc and D⁰D^{*0} molecule. Can it have D⁺D⁻ in addition? To answer this question the sum of D and D* masses should be measured as accurate as possible.

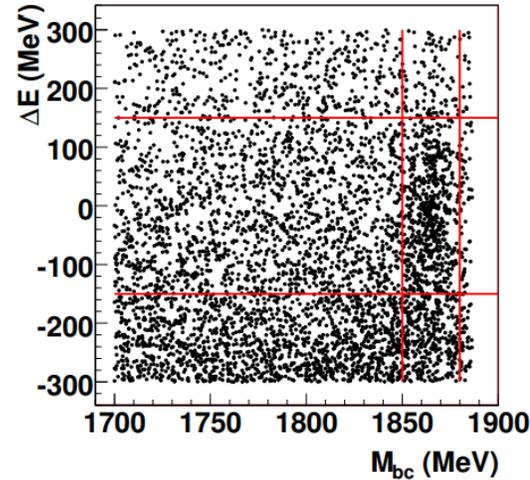
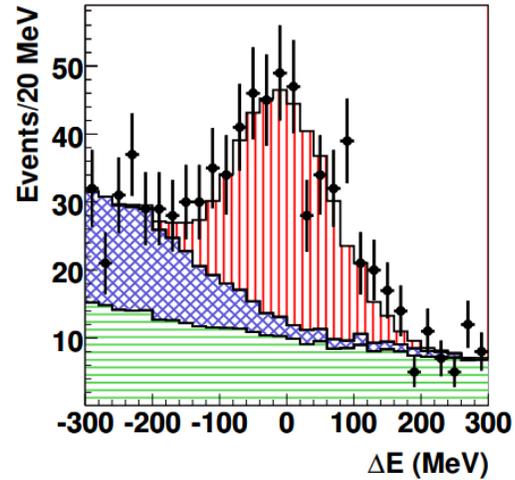
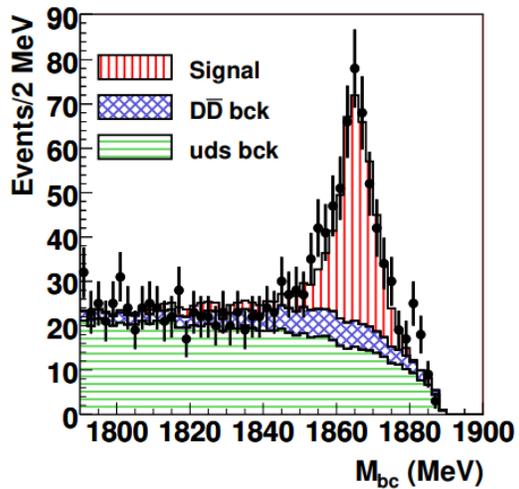
Method of D-meson mass measurement

- Process $e^+e^- \rightarrow \psi(3770) \rightarrow D\bar{D}$ with $\int Ldt = 4.06 \text{ pb}^{-1}$
- One of D-mesons is fully reconstructed :
 $D^0 \rightarrow K^- \pi^+$ ($Br = 3.95 \pm 0.03\%$) $D^+ \rightarrow K^- \pi^+ \pi^+$ ($Br = 9.38 \pm 0.16\%$)
- Key parameters for event selection:

- Beam-constrained mass
$$M_{bc} = \sqrt{E_{beam}^2 - \left(\sum_i \vec{p}_i\right)^2}$$

- CM energy difference
$$\Delta E = \sum_i \sqrt{(m_i^2 + p_i^2)} - E_{beam} \sim 0$$

D-meson mass measurement at KEDR

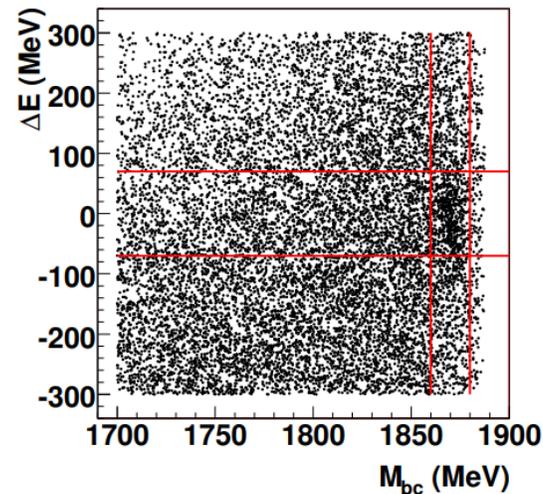
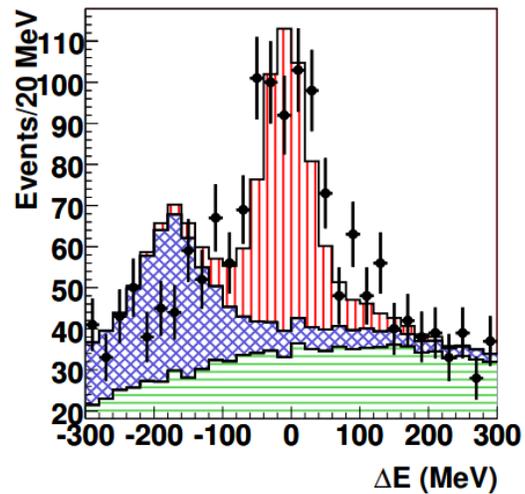
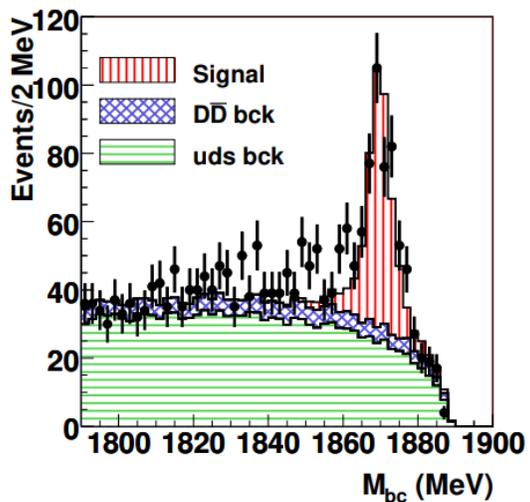


$M(D^0) = 1865.300 \pm 0.330 \pm 0.230$ MeV
(*Phys.Lett.B* 686 (2010) 84)

Uncertainties estimate for new analysis with increased statistics:

140 keV (stat)

110 keV (syst.)



$M(D^+) = 1869.53 \pm 0.49 \pm 0.20$ MeV
(*Phys.Lett.B* 686 (2010) 84)

Uncertainties estimate for new analysis with increased statistics:

153 keV (stat)

117 keV (syst.)

Conclusions

- KEDR has 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 precise measurement of J/ψ total and leptonic width is presented
- Branching fractions of $J/\psi \rightarrow 2(\pi^+\pi^-)\pi^0$, $K^+K^-\pi^+\pi^-\pi^0$, $2(\pi^+\pi^-)$, $K^+K^-\pi^+\pi^-$ were measured
- New analysis of D-meson masses is ongoing with aim to increase accuracy 2 times compared to previous measurement