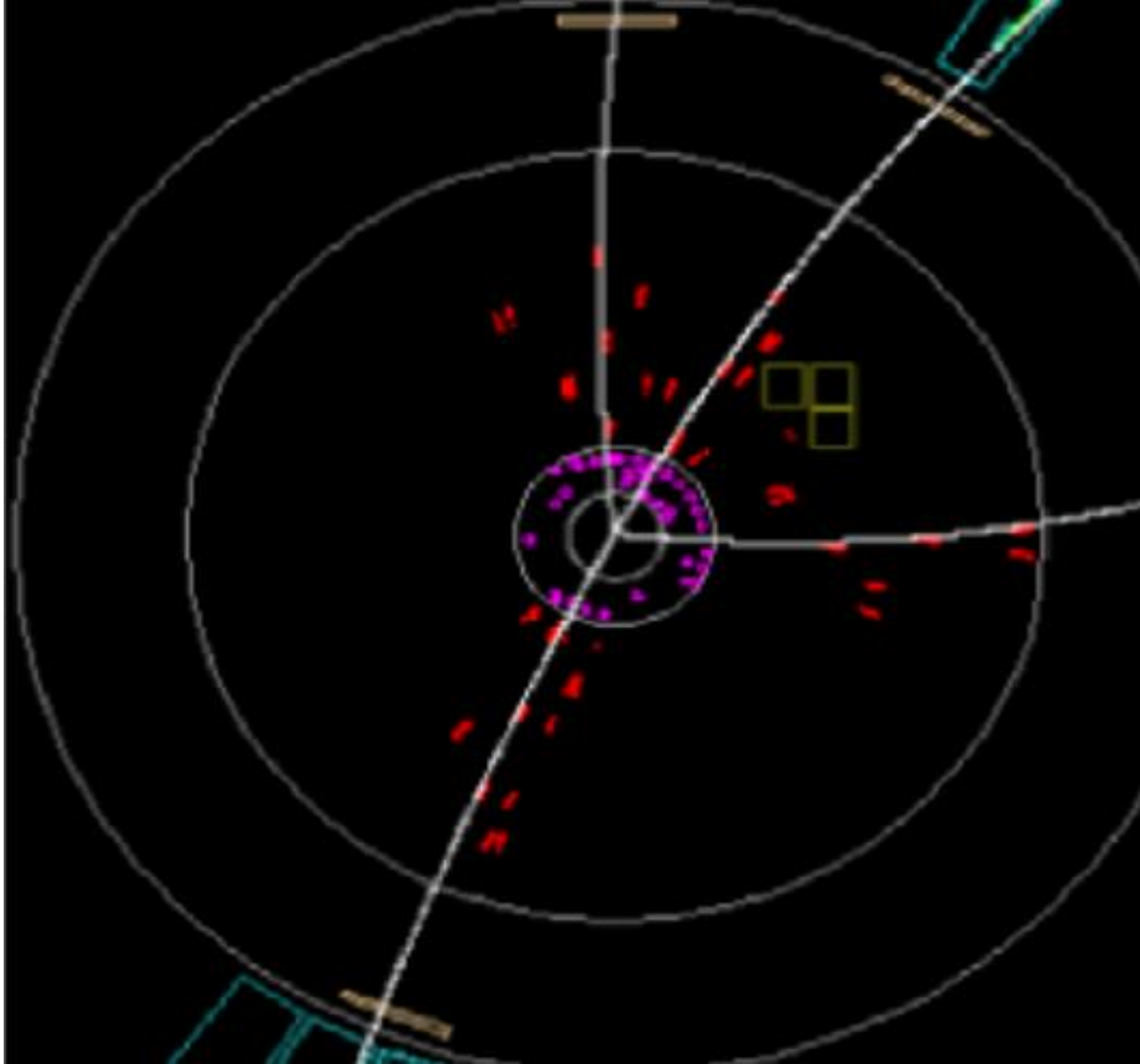
Charm at KEDR

Tatyana Kharlamova

for the KEDR collaboration

31 May - 4 June 2021

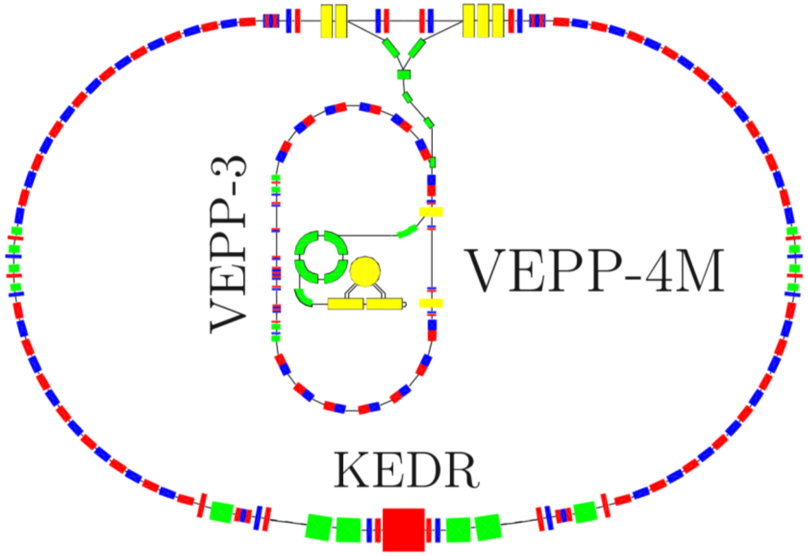
The 10th International Workshop on Charm Physics



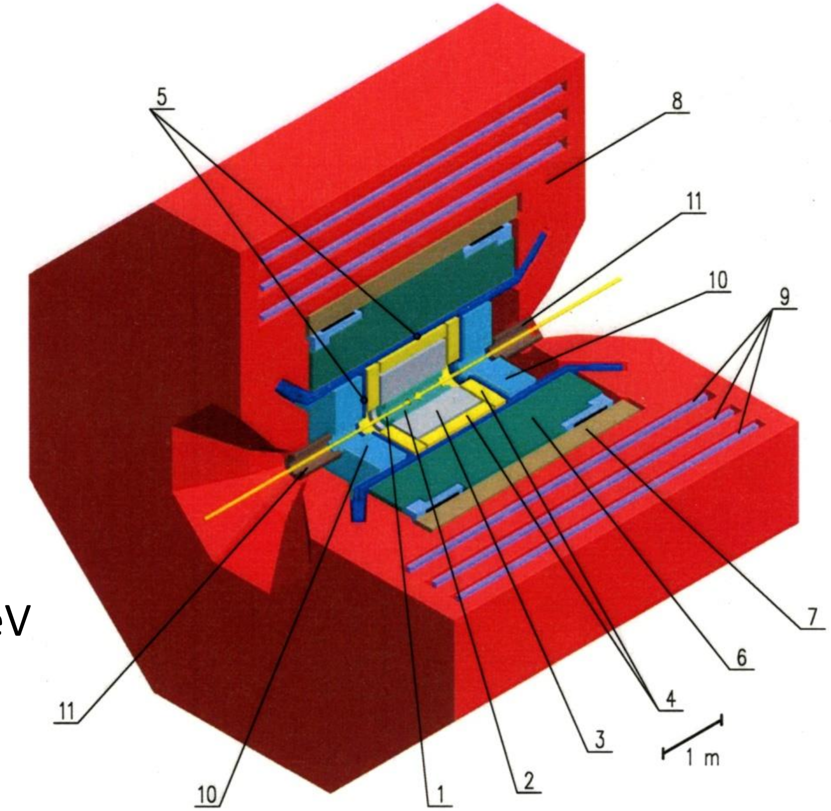
Outline

- 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
- R measurements between 1.8 and 7.0 GeV

Collider VEPP-4M and KEDR detector



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



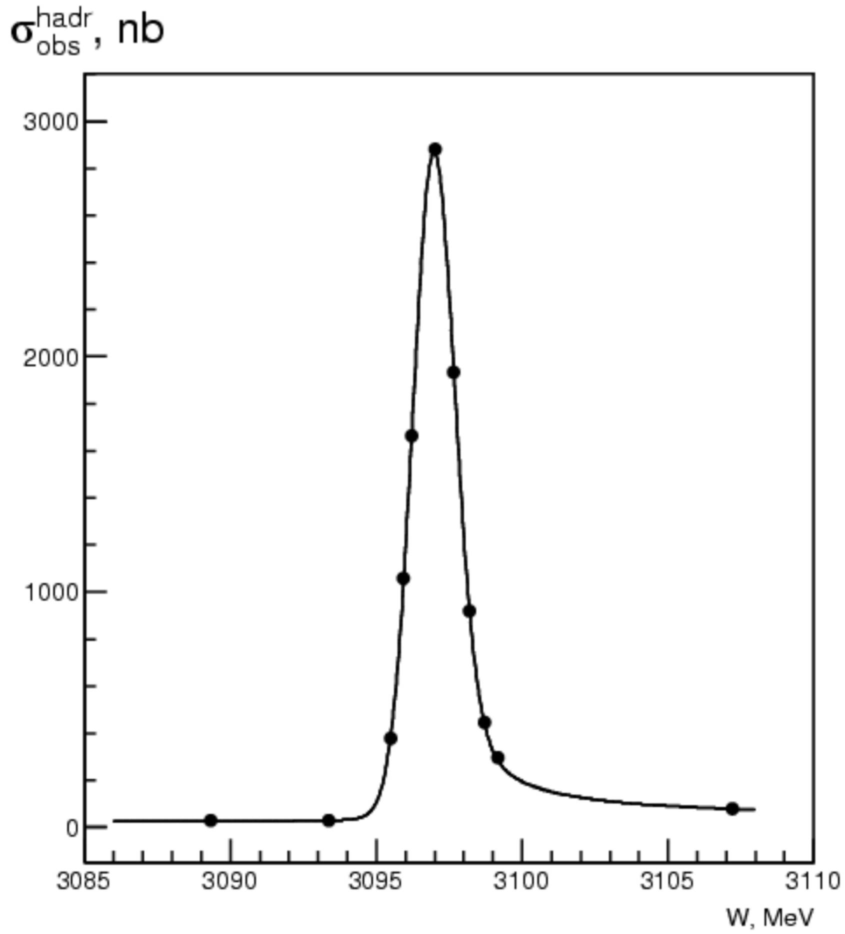
1. Vacuum chamber
2. Vertex detector
3. Drift chamber
4. Threshold aerogel counters
5. ToF counters
6. Liquid krypton calorimeter
7. Superconducting coil
8. Magnet yoke
9. Muon tubes
10. CsI calorimeter
11. Compensating s/c solenoid

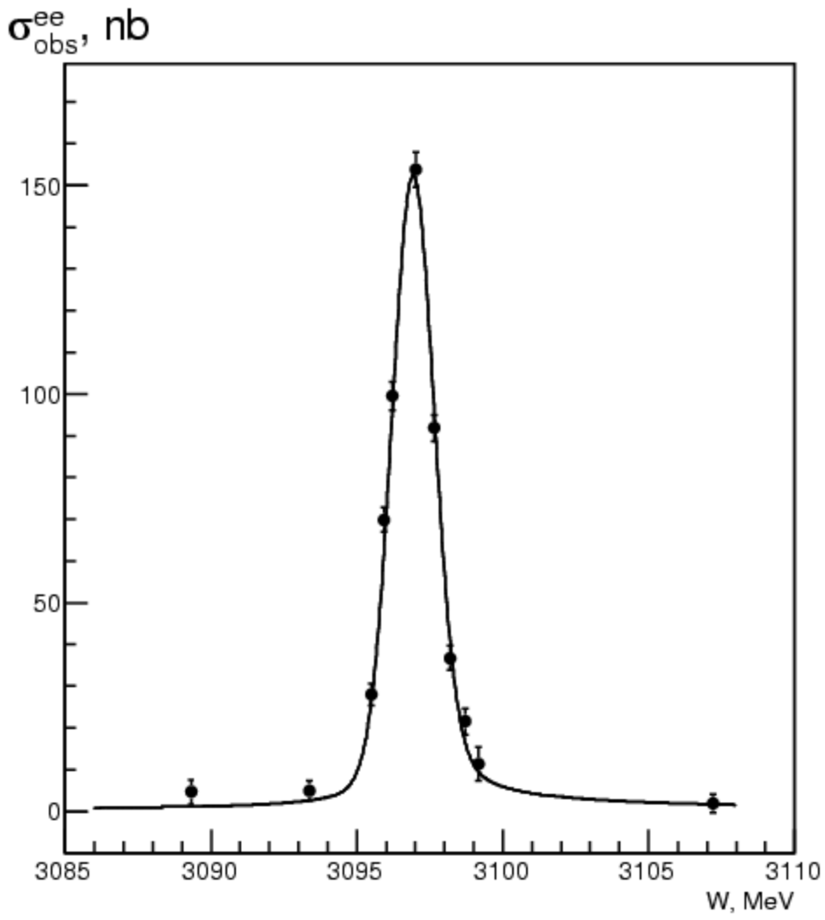
Beam energy measurement:

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

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

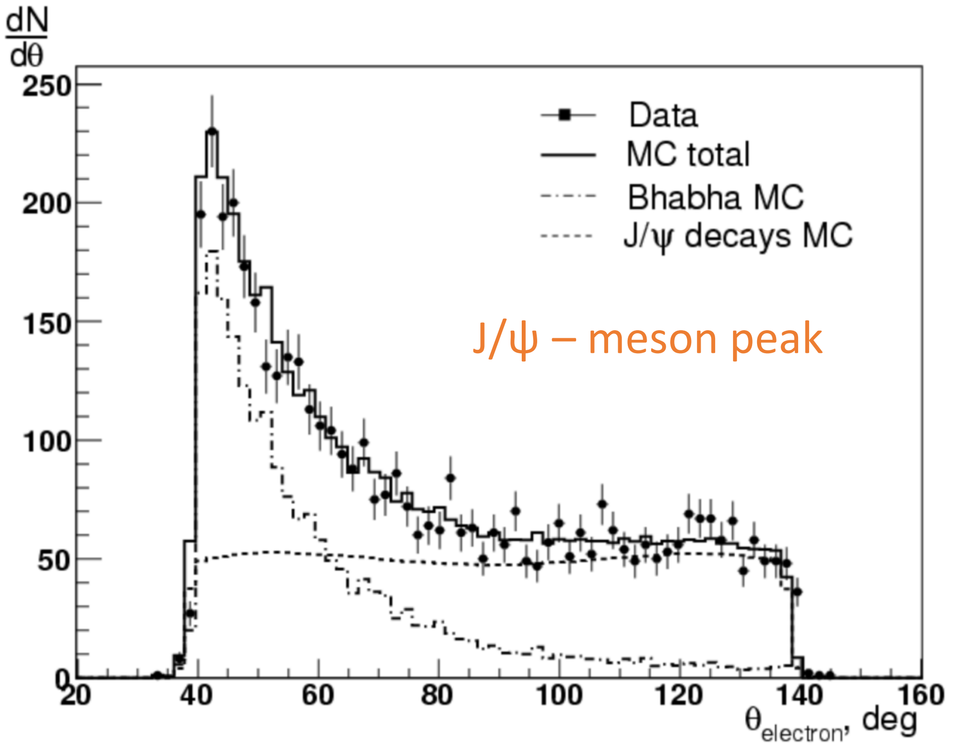




$$\int L dt = 230\ nb^{-1}$$

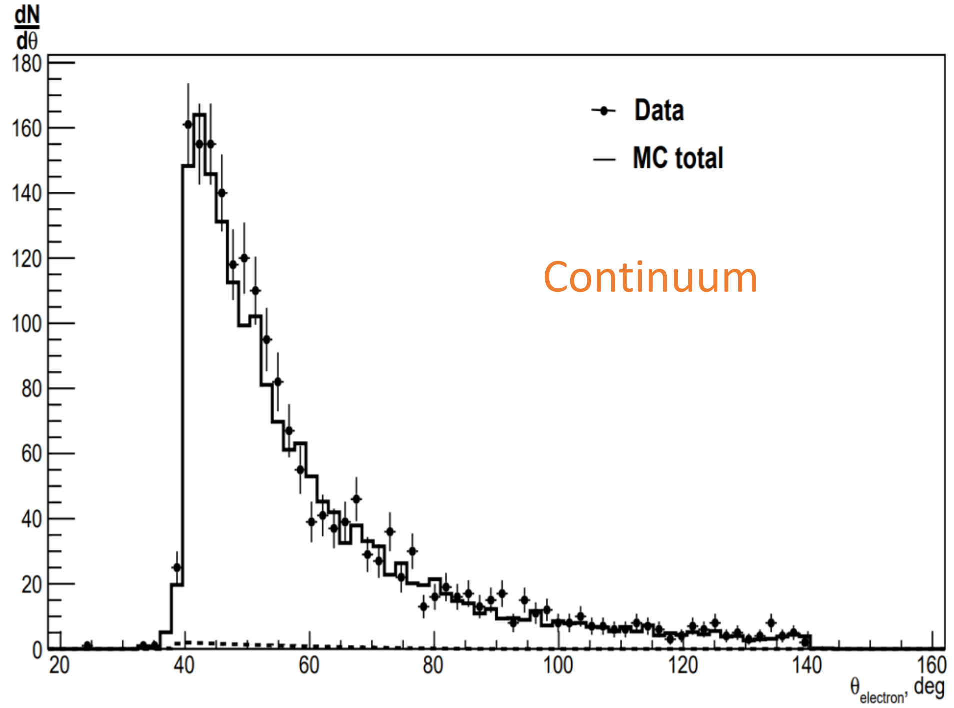
Scan at 11 points
250k J/ ψ mesons
$\sigma_W = 692 \pm 4$ keV

Luminosity measurement

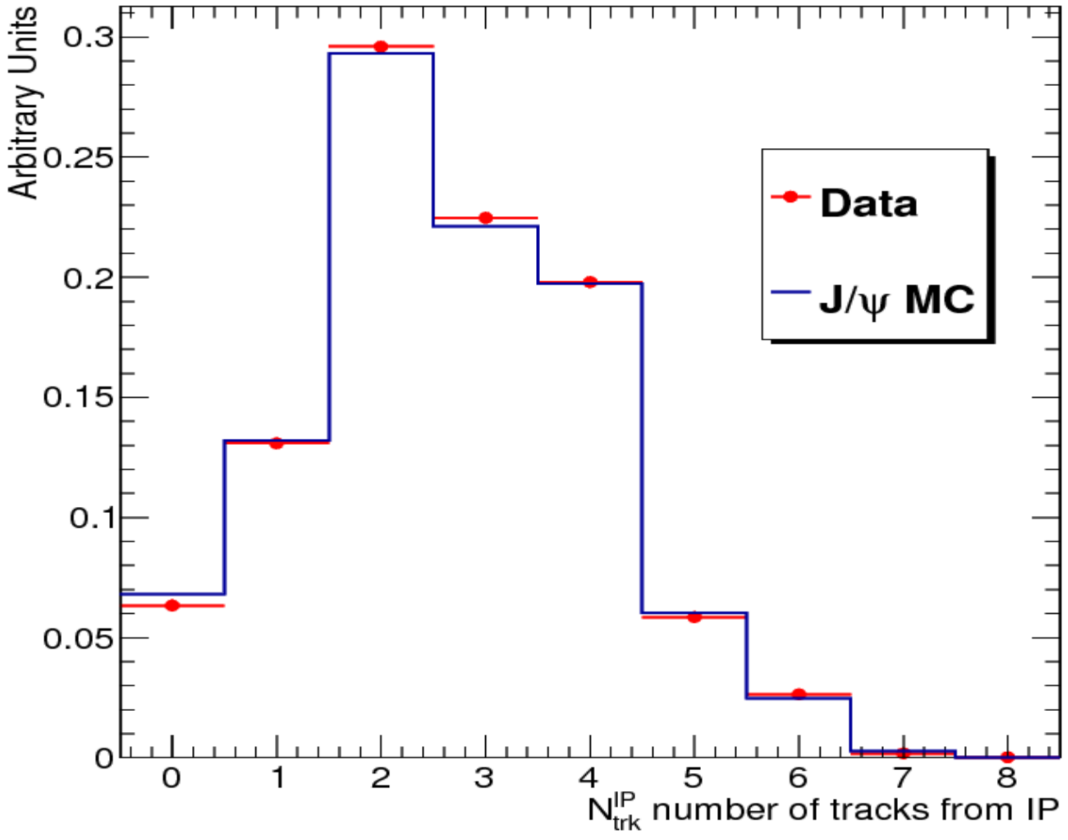


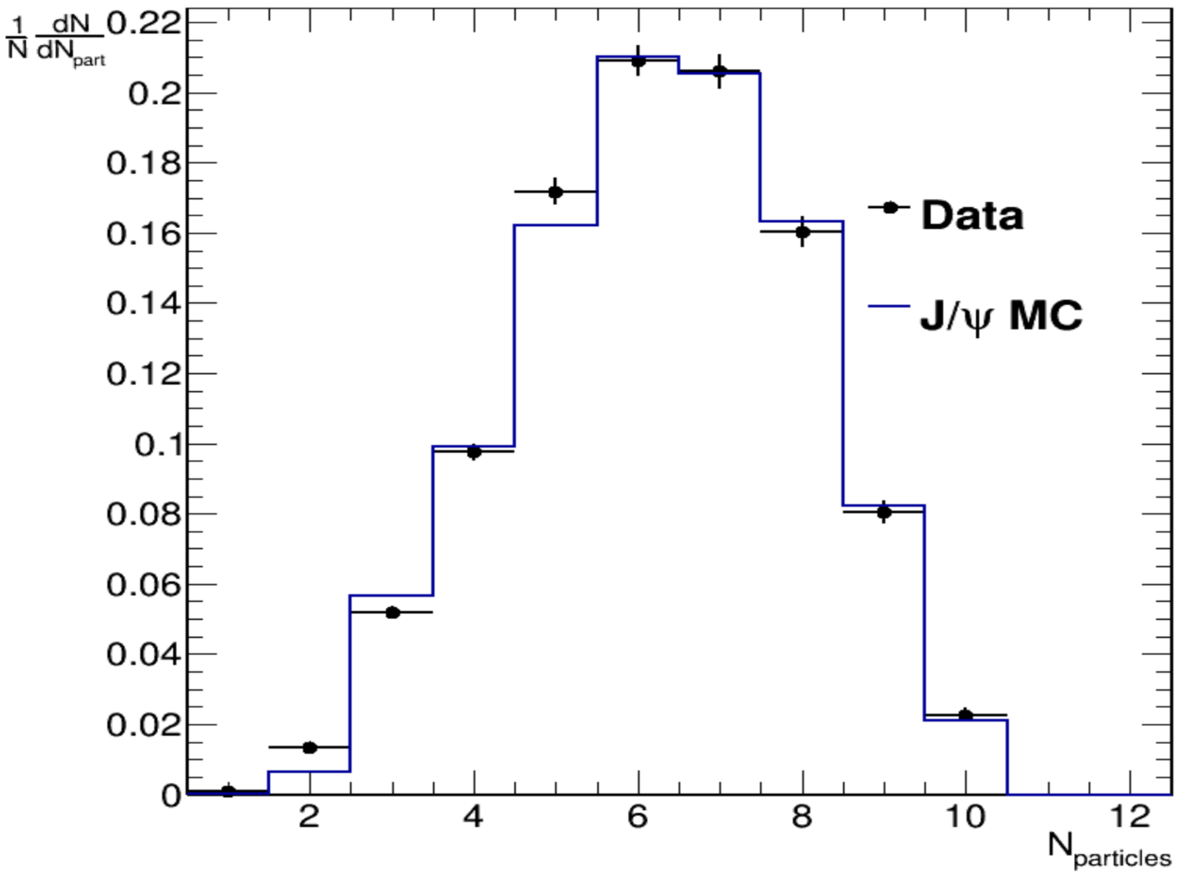
Distribution of electron polar angle for $e^+e^- \to e^+e^-$ events

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



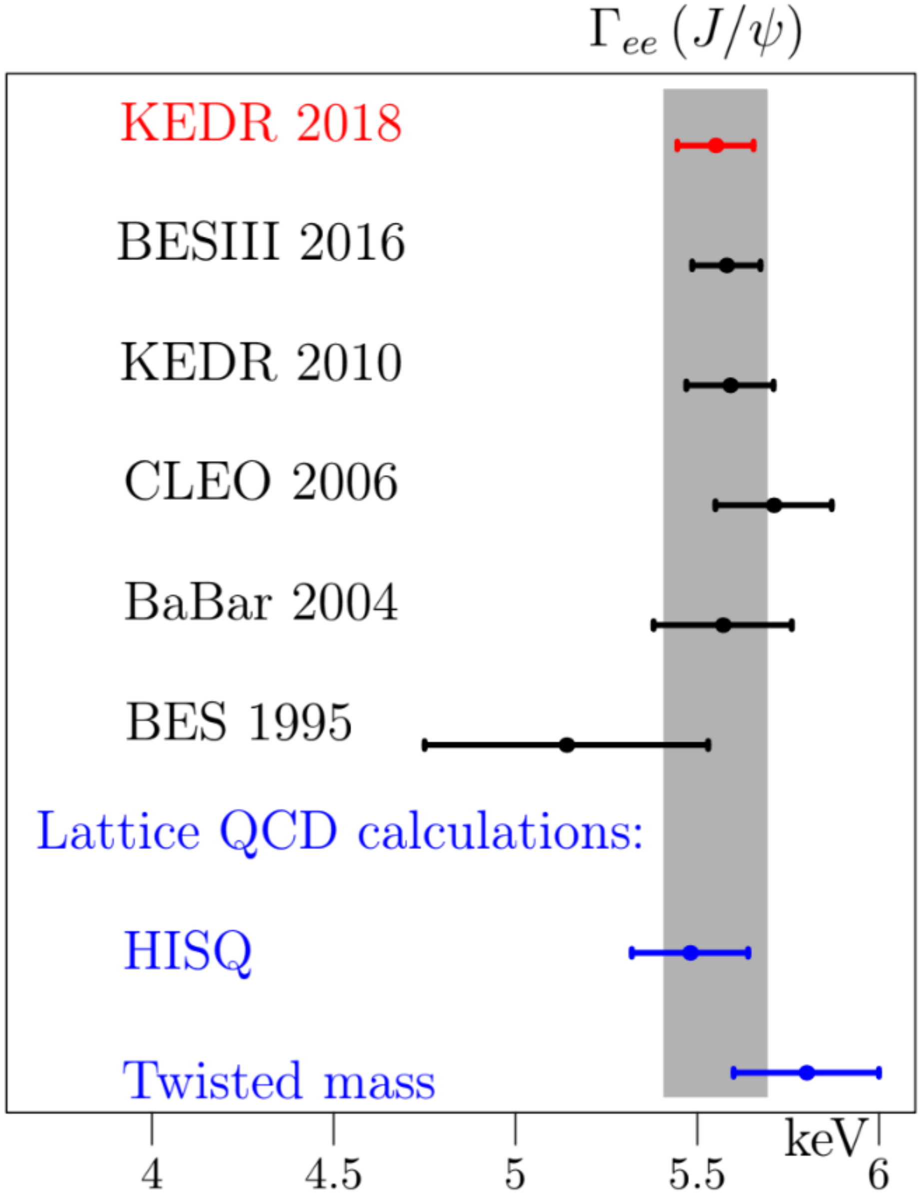
Properties of the hadronic events produced in the vicinity of J/ψ resonance





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

Measurement of leptonic width

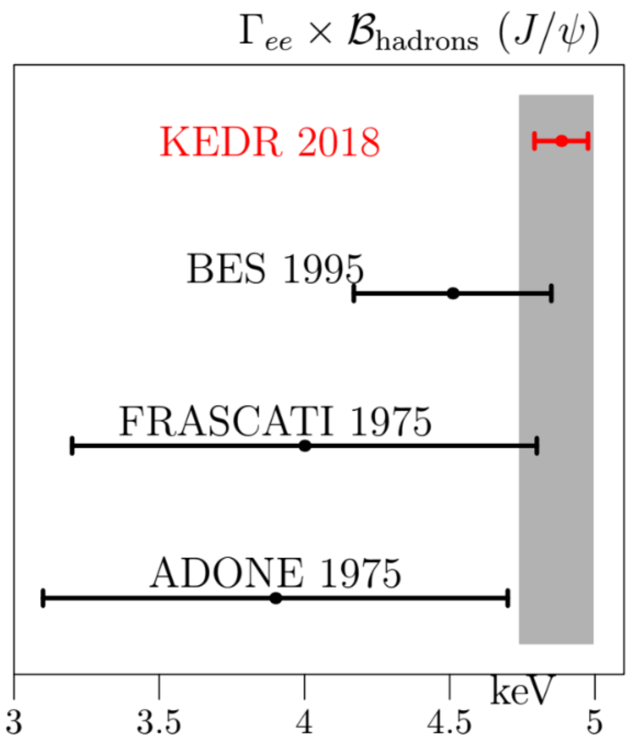


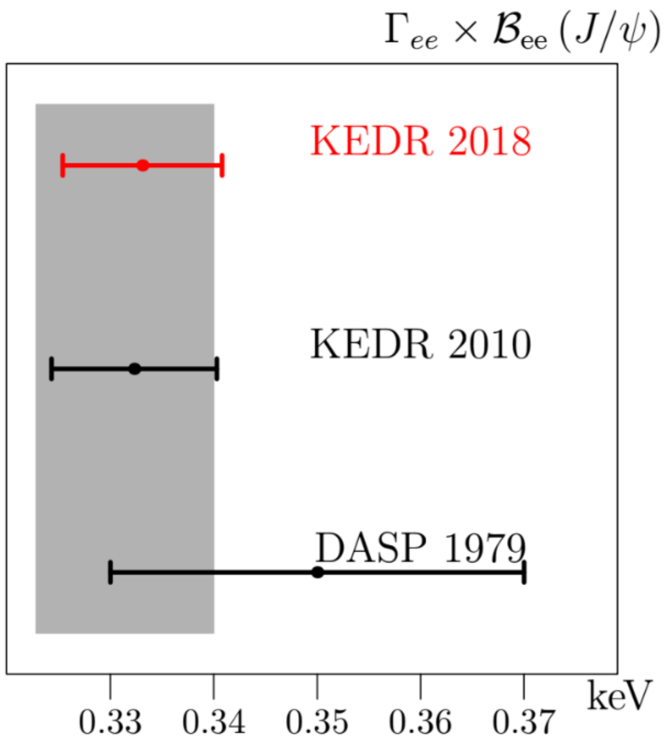
$$\Gamma_{ee}(J/\psi) = 5.550 \pm 0.056 \pm 0.089\,\mathrm{keV}$$

J. High Energ. Phys. (2018) 2018: 119

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

Measurement of $\Gamma_{ee} \cdot B_h$ and $\Gamma_{ee} \cdot B_{ee}(J/\psi)$



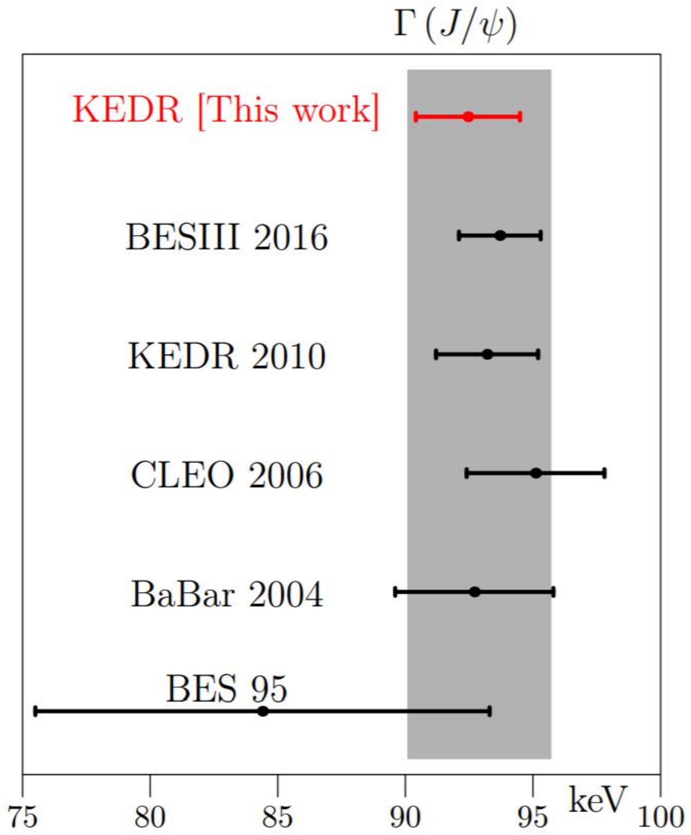


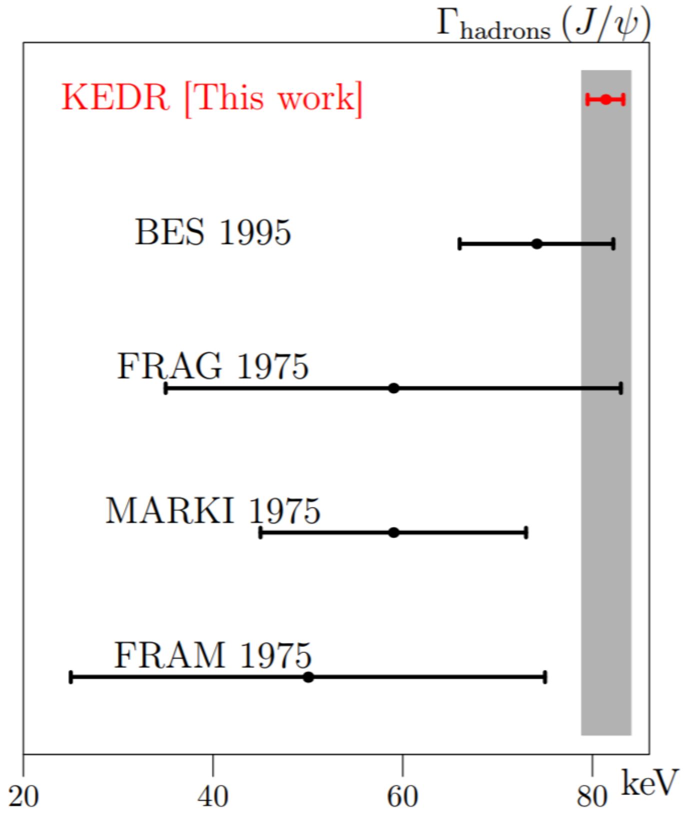
$$\Gamma_{ee}(J/\psi) \cdot \mathcal{B}_{\text{hadrons}}(J/\psi) = 4.884 \pm 0.048 \pm 0.078\,\text{keV}$$

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

J. High Energ. Phys. (2018) 2018: 119

Measurement of full and hadronic widths



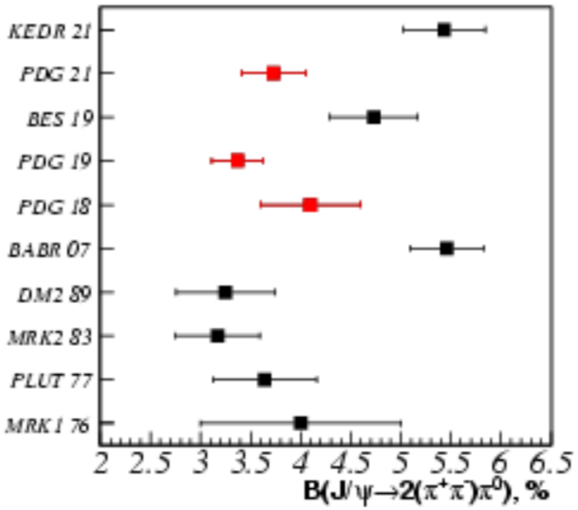


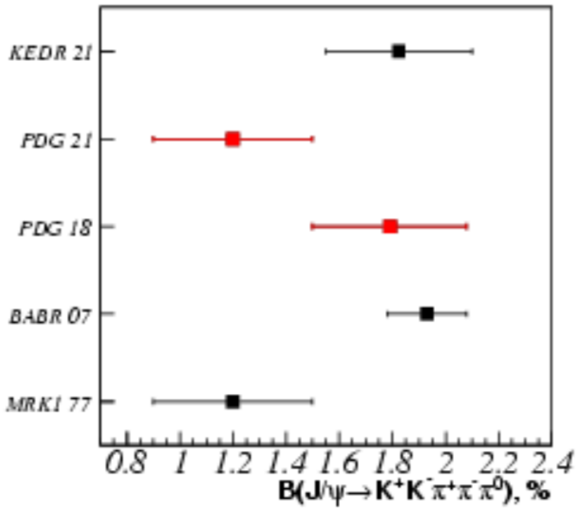
New results:

$$\Gamma(J/\psi) = 92.45 \pm 1.40 \pm 1.48 \text{ keV}$$
$$\Gamma_{\text{hadrons}}(J/\psi) = 81.37 \pm 1.36 \pm 1.30 \text{ keV}$$

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

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





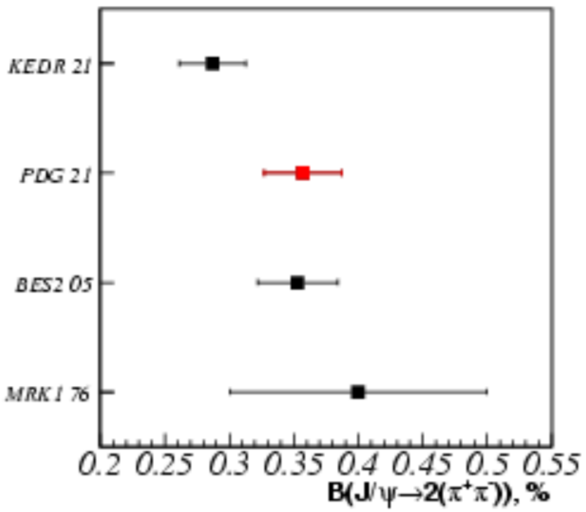
Preliminary results on inclusive decay modes!

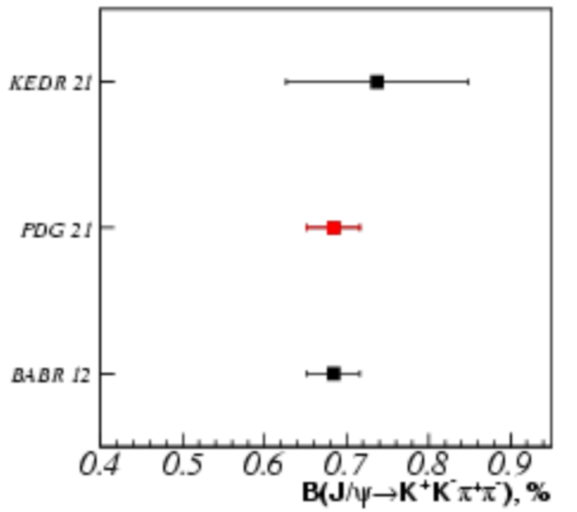
- $\int Ldt = 1315\, nb^{-1}$ $at \sqrt{s} = 3.123\ GeV$

5.2 millions J/ψ

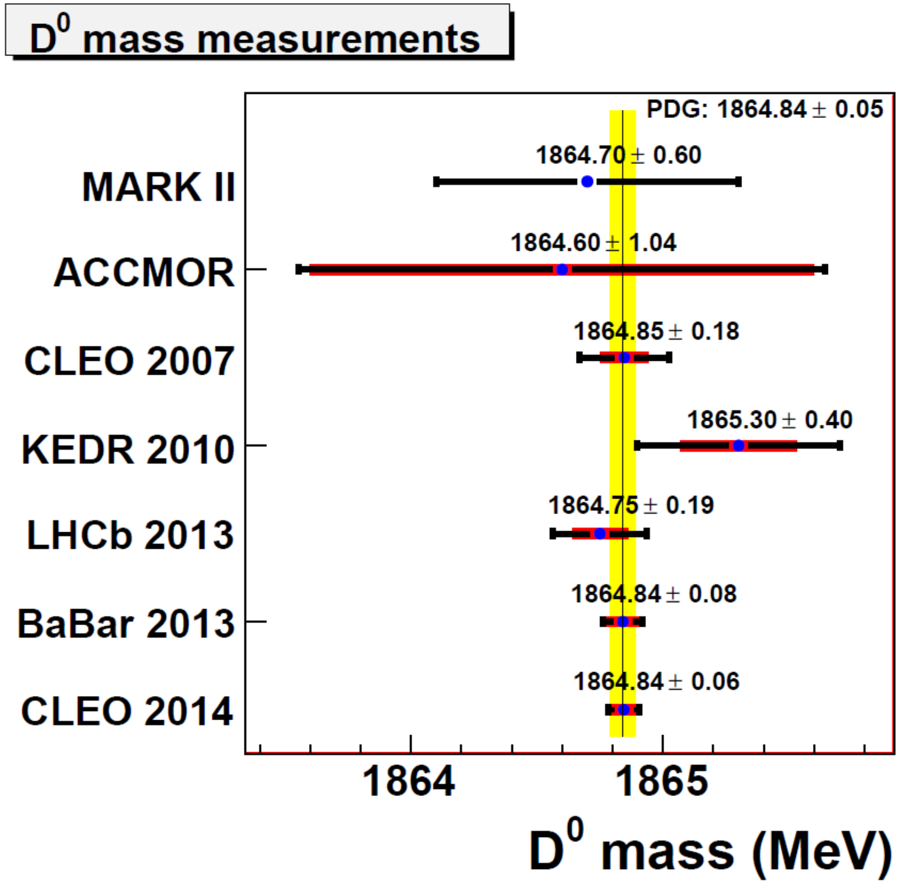
- $\int Ldt = 82.3\, nb^{-1}$ $at \sqrt{s} = 3.101\ GeV$

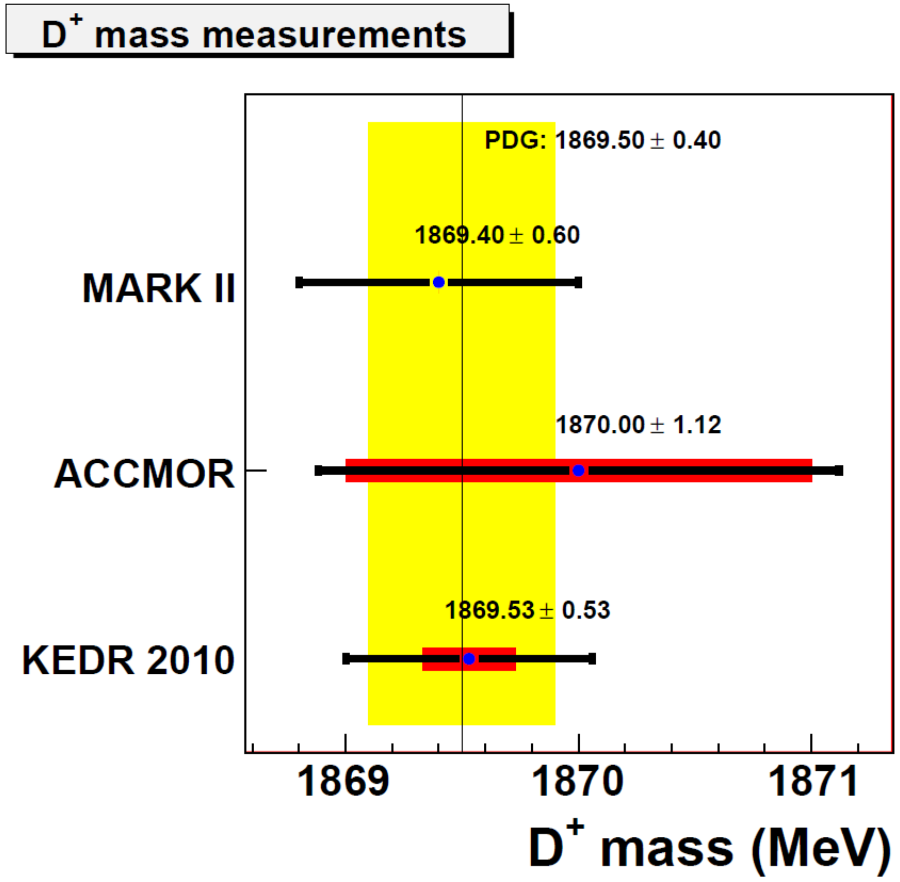
for background estimation





D-meson masses





D-meson mass is important for DD* threshold determination. This knowledge affects understanding of the $\chi_{c1}(3872)$ (X(3872)) nature. Its current explanation is a mixture of regular cc and D^0D^{*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.

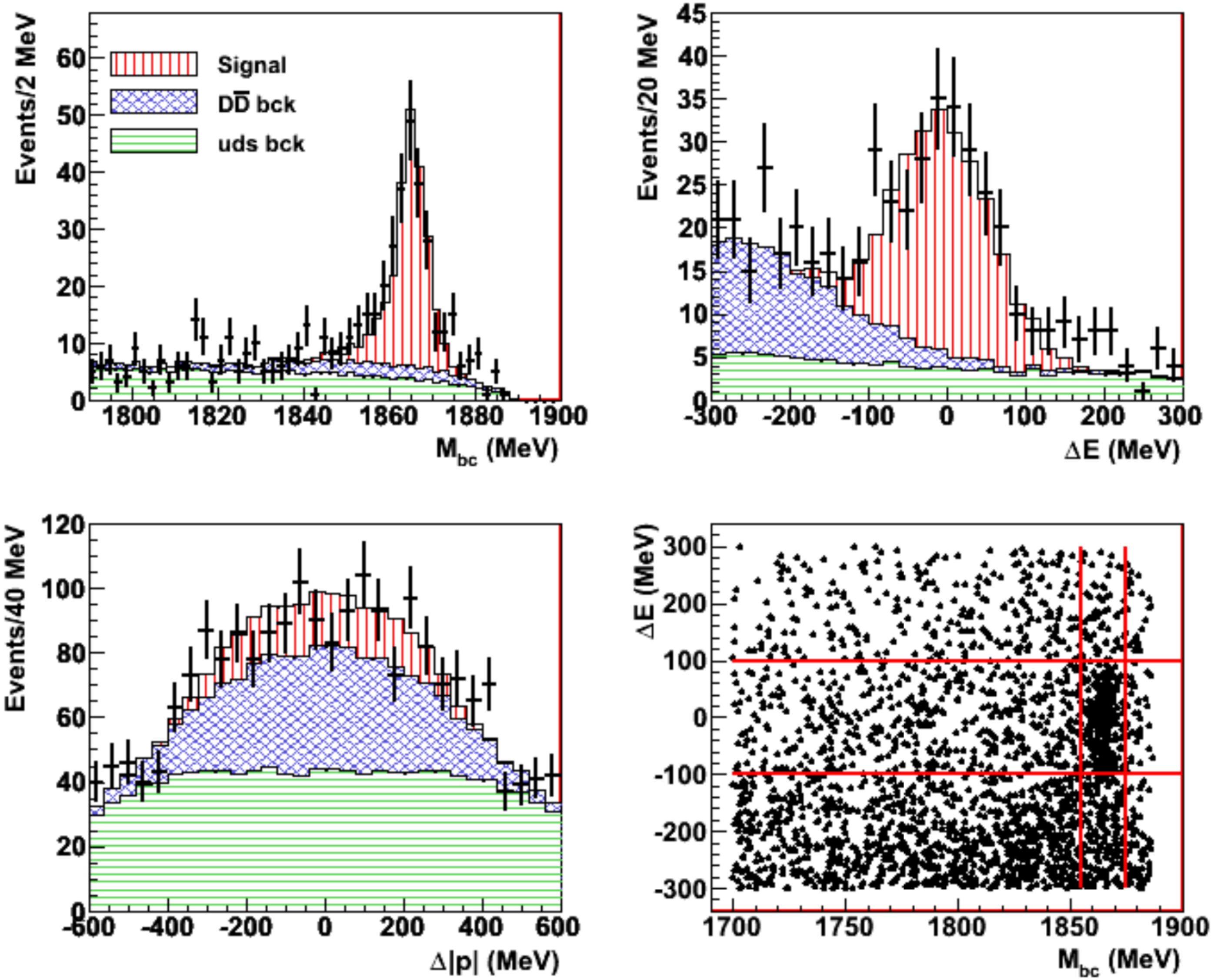
Method of D-meson mass measurement

- Process $e^+e^- \rightarrow\ \psi(3770) \rightarrow D\bar{D}$ with $\int Ldt = 4.06\ pb^{-1}$
- *One of D-mesons is fully reconstructed :*

$D^0 \longrightarrow K^- \pi^+$ *(Br = 3.95 ± 0.03%)* $D^+ \longrightarrow K^- \pi^+ \pi^+$ *(Br = 9.38 ± 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* $$\Delta E = \sum_i \sqrt{(m_i^2 + p_i^2)} - E_{beam} \sim 0$$

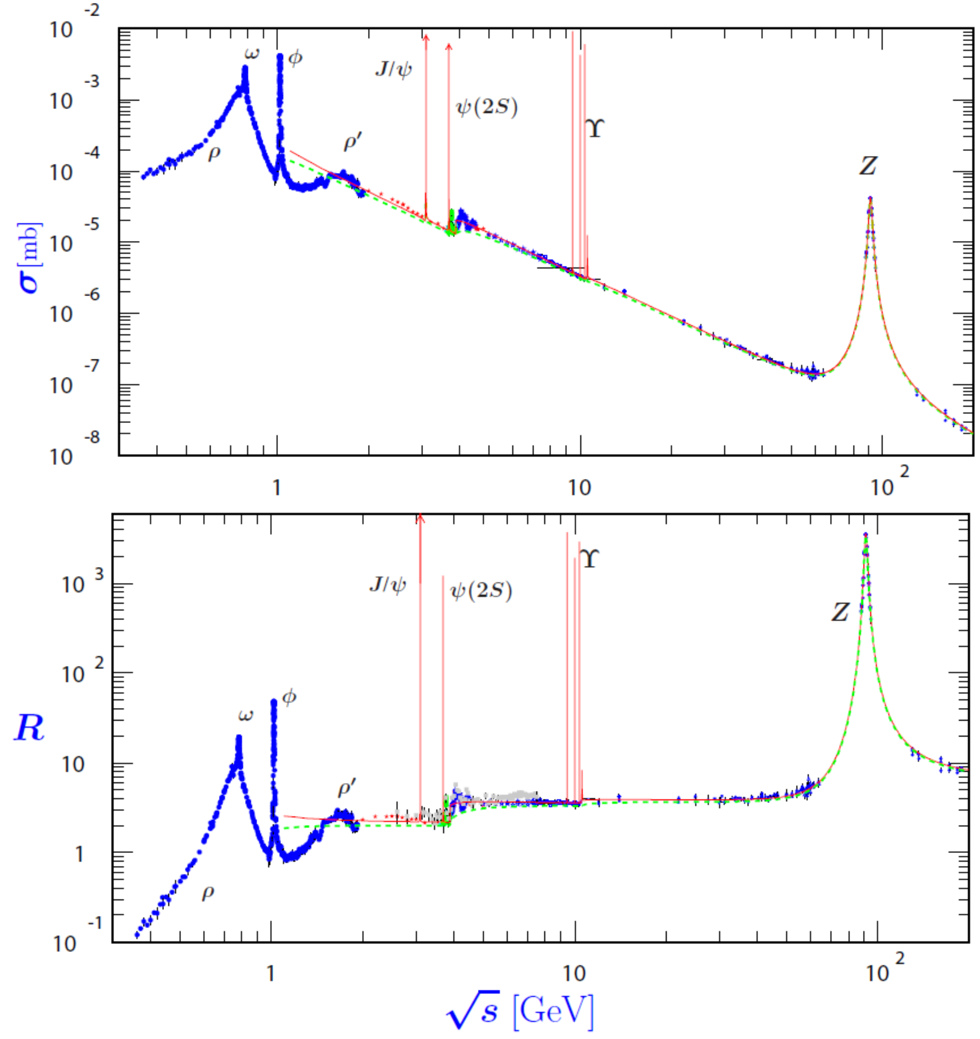
D-meson mass measurement at KEDR



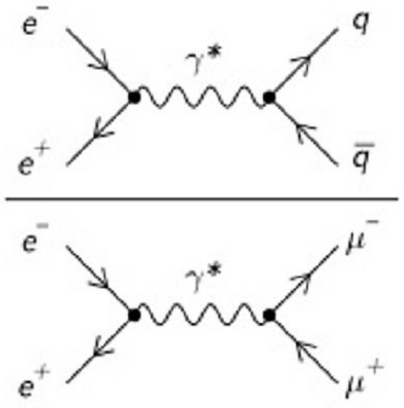
$M(D^0) = 1865.30 \pm 0.33 \pm 0.23$ MeV
(*Phys.Lett.B* 686 (2010) 84)
Uncertainties estimate for new analysis with increased statistics:
0.14 MeV (stat)
0.11 MeV (syst.)

$M(D^+) = 1869.53 \pm 0.49 \pm 0.20$ MeV
(*Phys.Lett.B* 686 (2010) 84)
Uncertainties estimate for new analysis with increased statistics:
0.16 MeV (stat)
0.12 MeV (syst.)

Motivation of R measurement



$$R = \frac{\sigma(e^-e^+ \to \text{hadrons})}{\sigma(e^-e^+ \to \mu^-\mu^+)} \approx$$



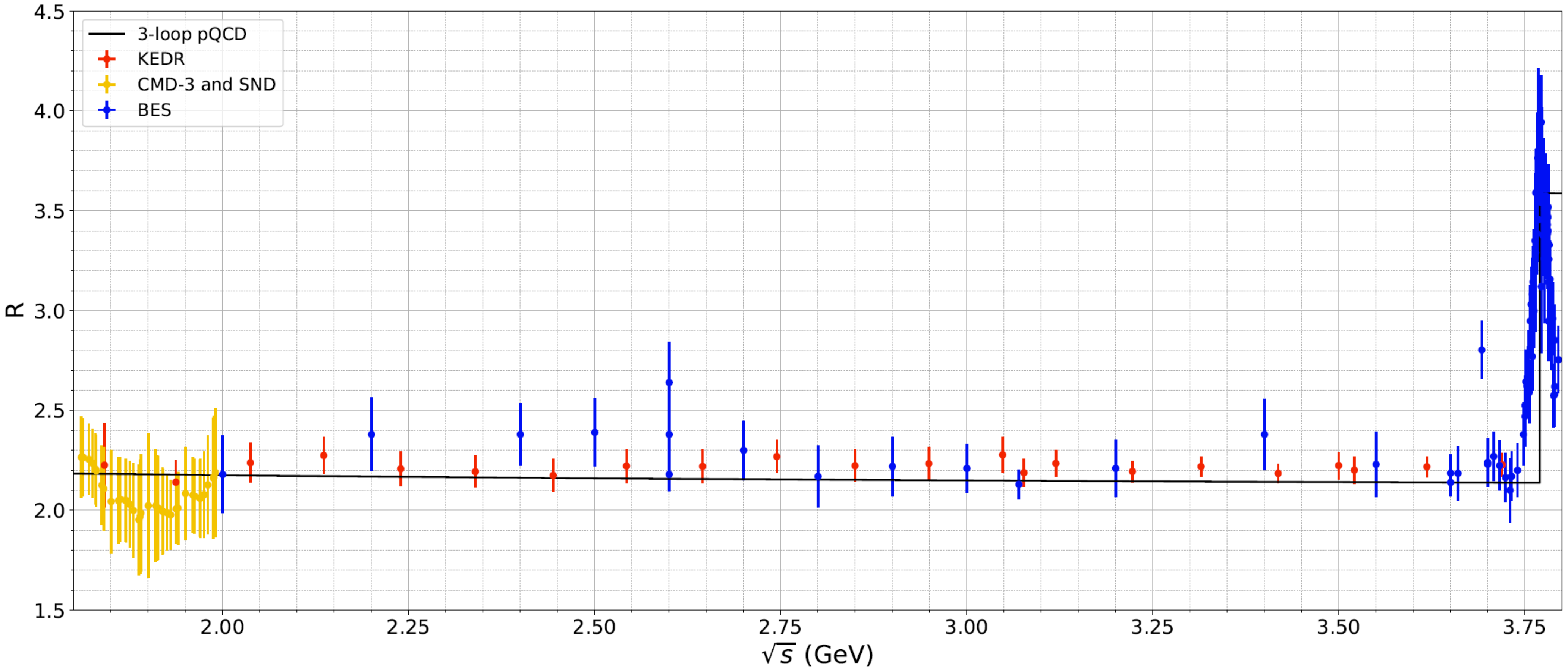
In first approximation:

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

$R(s)$ is used to determine:

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

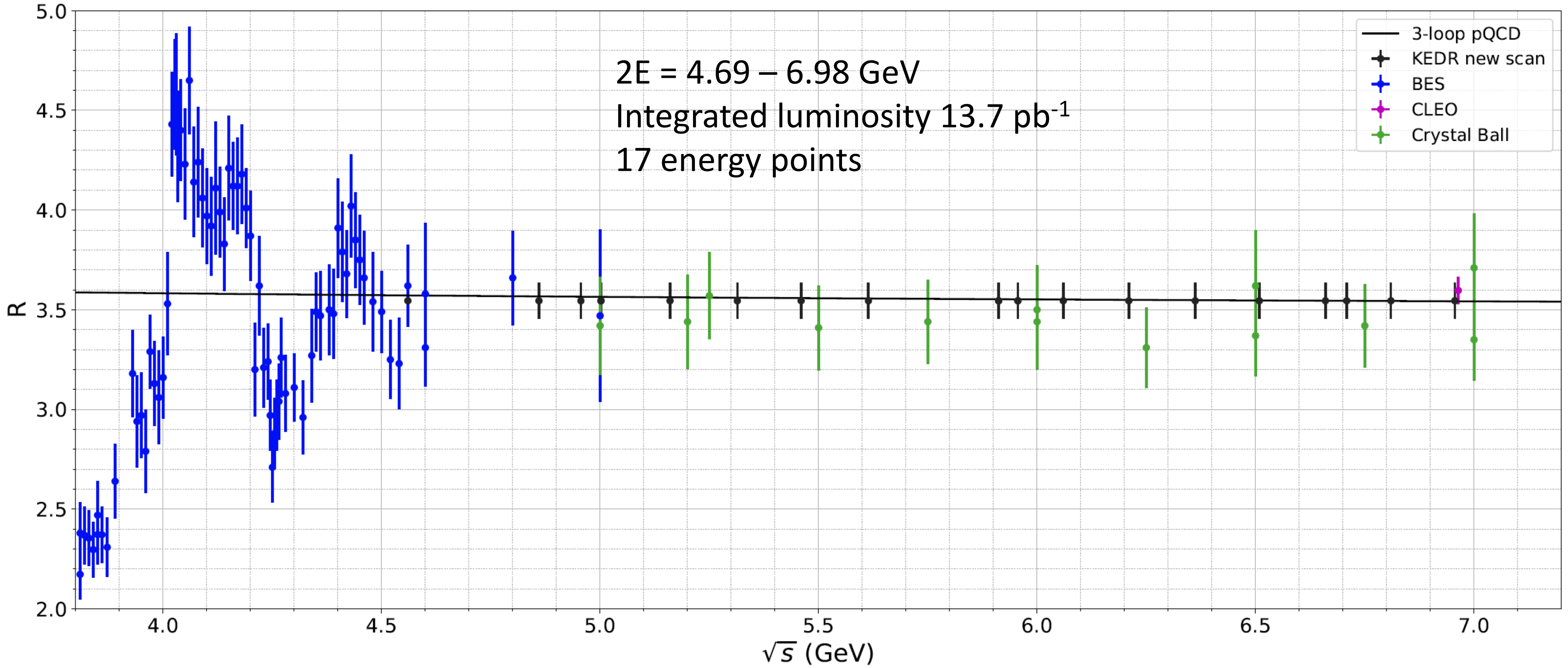
R measurement between 1.8 and 3.8 GeV



R measurement between 1.8 and 3.8 GeV at KEDR

$\sqrt{s}$, **GeV**	**N$_{points}$**	$\int \boldsymbol{Ldt, pb^{-1}}$	**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 3.8 and 7.0 GeV



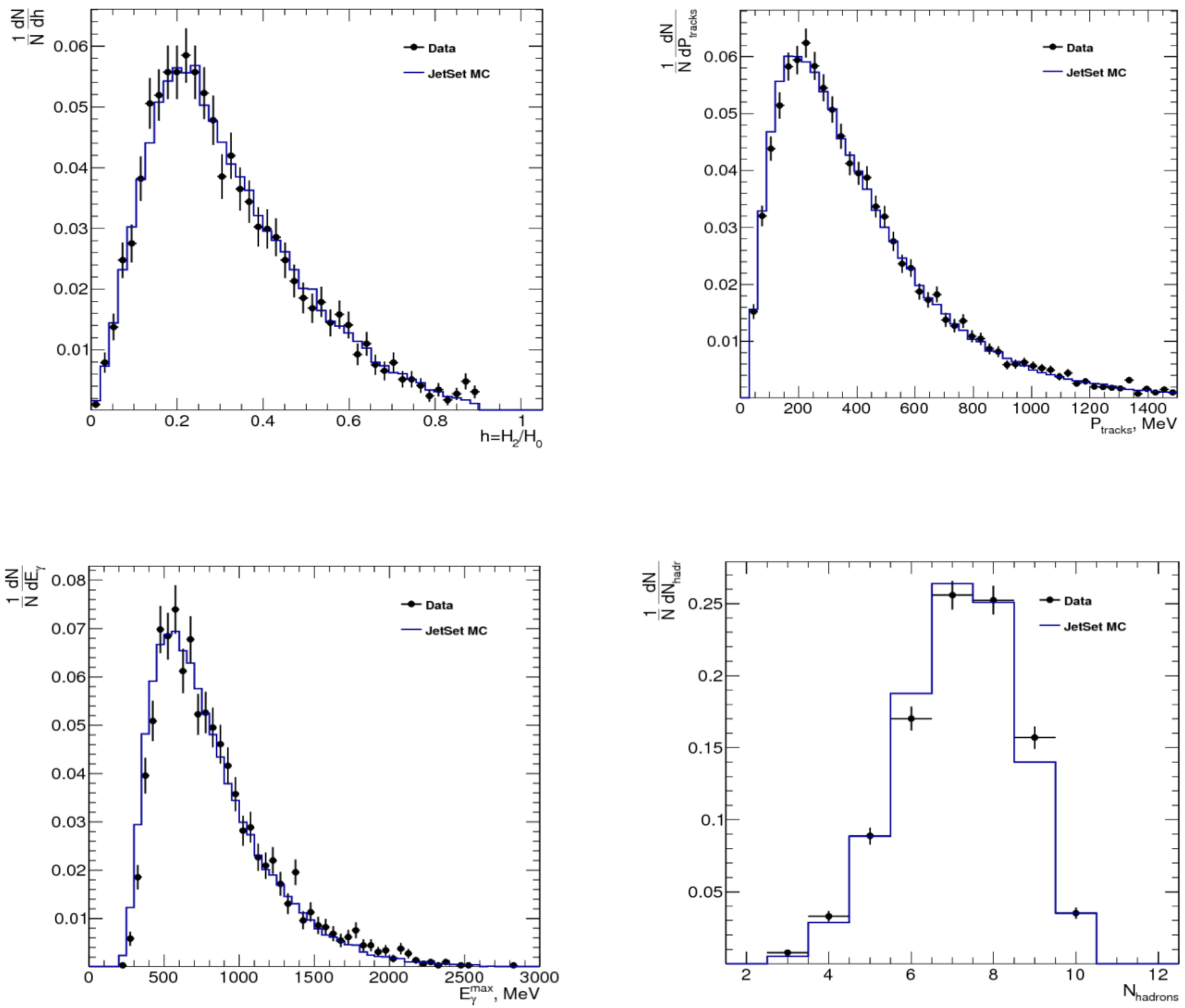
* KEDR new scan points positions are fixed at pQCD predictions
Expected total uncertainty is about 3 % (systematic uncertainty about 2.5%)

Conclusions

- 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
- 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%

Backups

Simulation of hadronic decays at 5.160 GeV



Experimental distributions and tuned JetSet MC simulation on Fox-Wolfram moments, particle momentum, maximum photon energy and multiplicity are plotted

Fair agreement of simulation with data is obtained