Recent Results from the KEDR Detector

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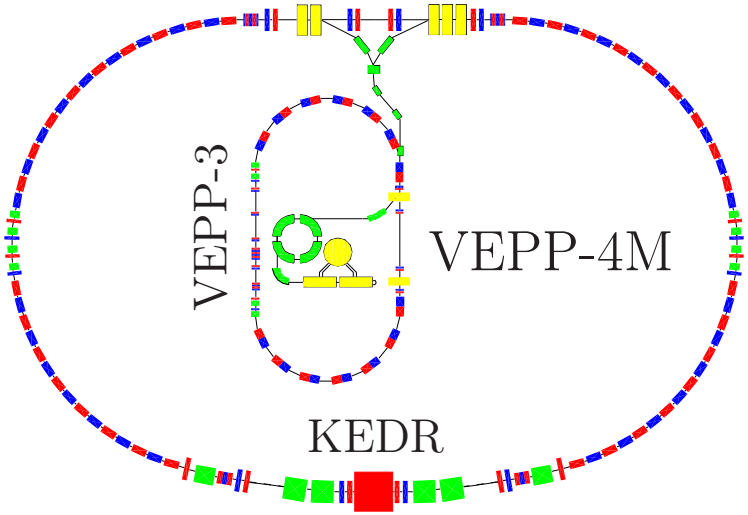
Outline

1. J/ψ and ψ' masses
2. Parameters of ψ'
3. Parameters of $\psi(3770)$
4. Search for narrow resonances
5. Conclusions

VEPP–4M collider

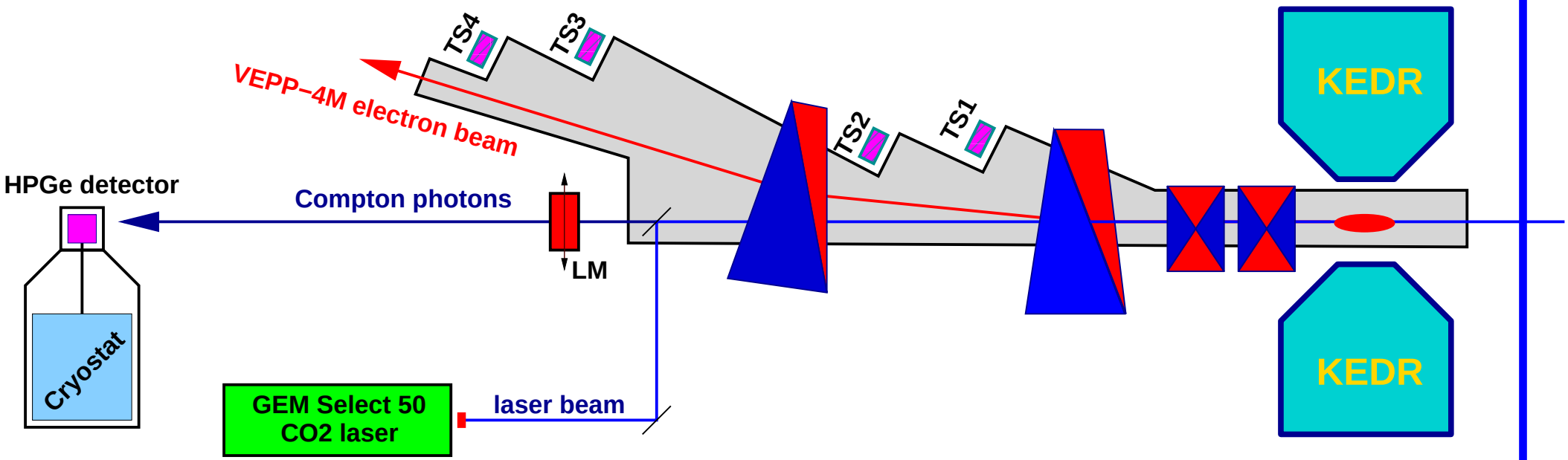


Circumference	366 m
Beam energy	$1 \div 6$ GeV
Number of bunches	2×2
Luminosity, $E = 1.5$ GeV	2×10^{30} cm^{-2}s^{-1}
Luminosity, $E = 5.0$ GeV	2×10^{31} cm^{-2}s^{-1}

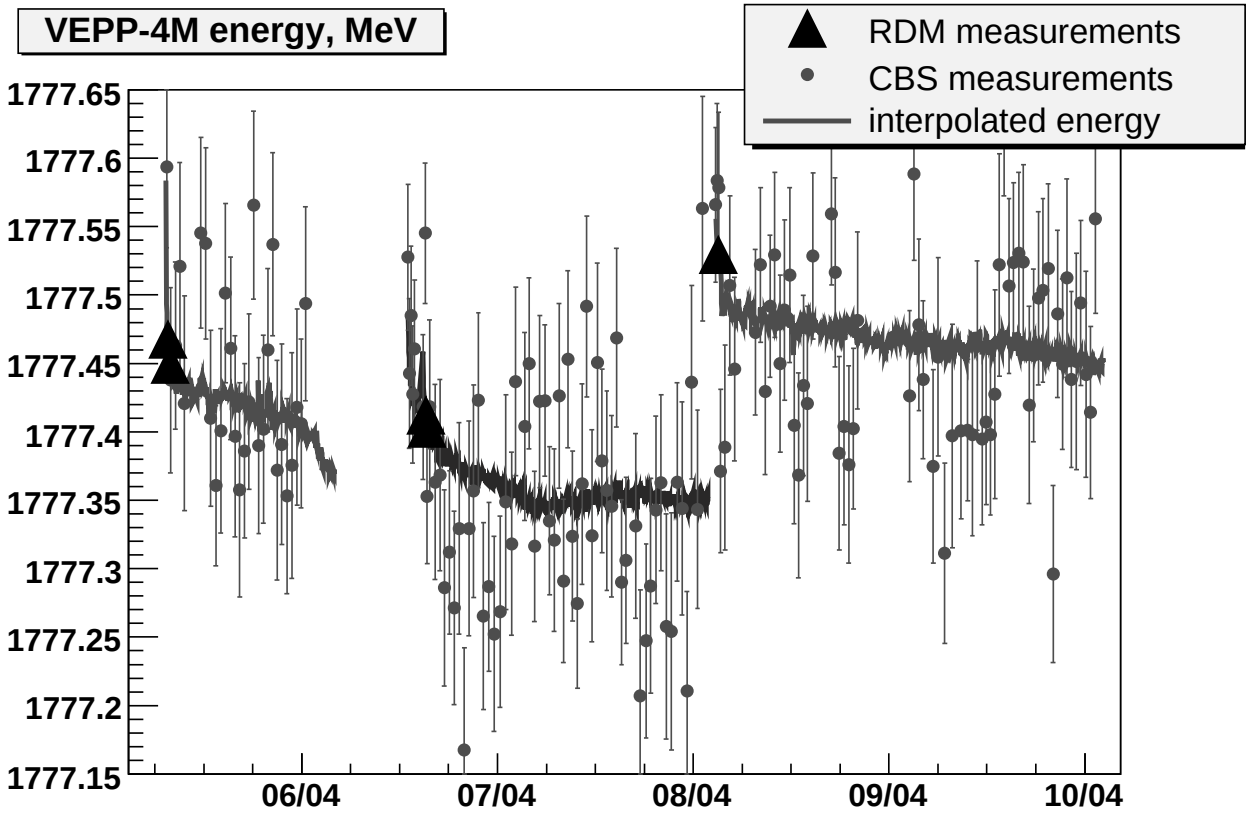
- Resonant depolarization technique:
  Instantaneous measurement accuracy $\simeq 1 \times 10^{-6}$
  Energy interpolation accuracy $(5 \div 15) \times 10^{-6}$ $(10 \div 30$ keV$)$
- Infrared light Compton backscattering:
  Statistical accuracy $\simeq 5 \times 10^{-5}$ / 30 minutes
  Systematic uncertainty $\simeq 3 \times 10^{-5}$ $(50 \div 70$ keV$)$

Compton Backscattering Monitor

Realized at BESSY-I in 1987

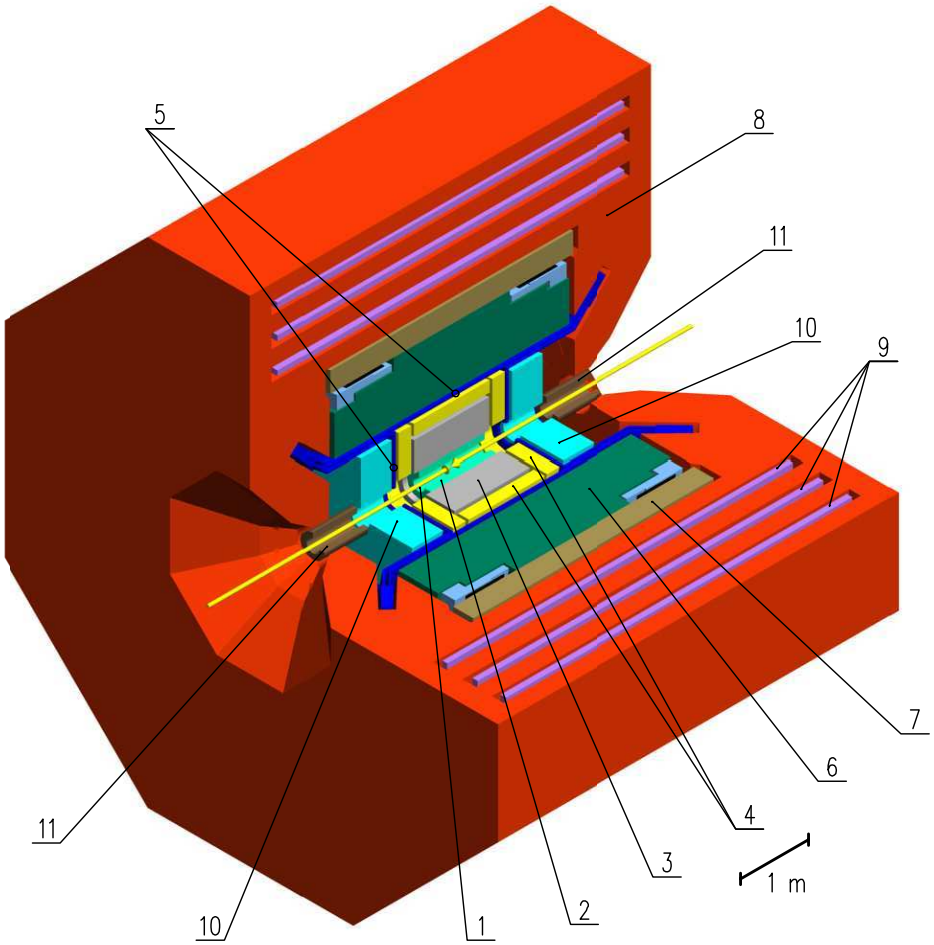


VEPP-4M Energy Behaviour



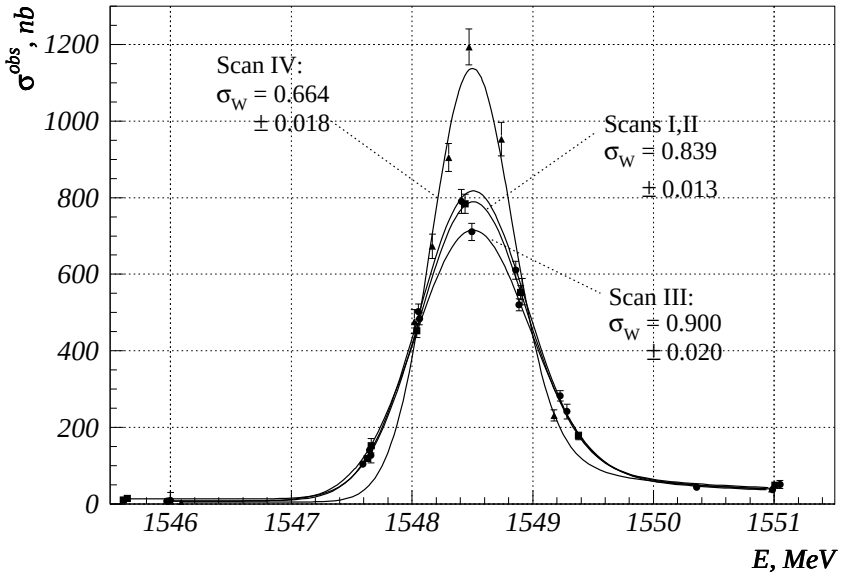
During the run, E measured by CBS and from interpolation

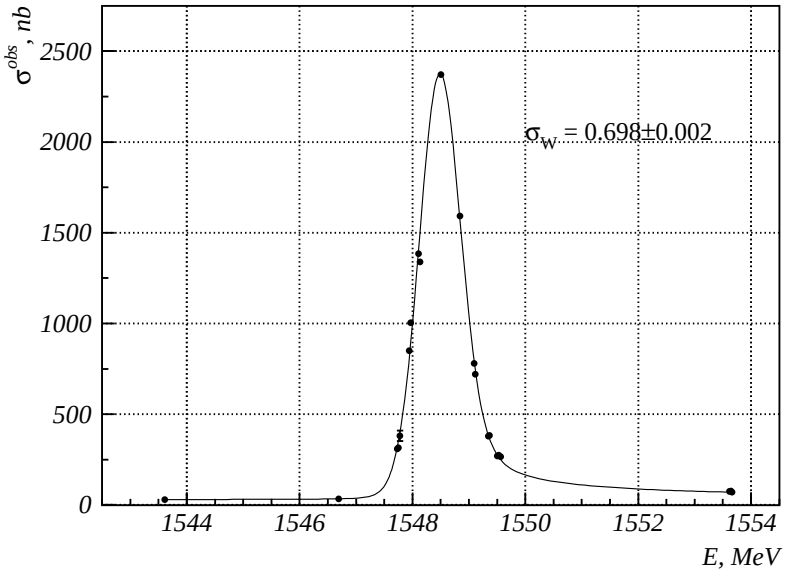
KEDR detector



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

J/ψ and ψ' Mass Measurement – I





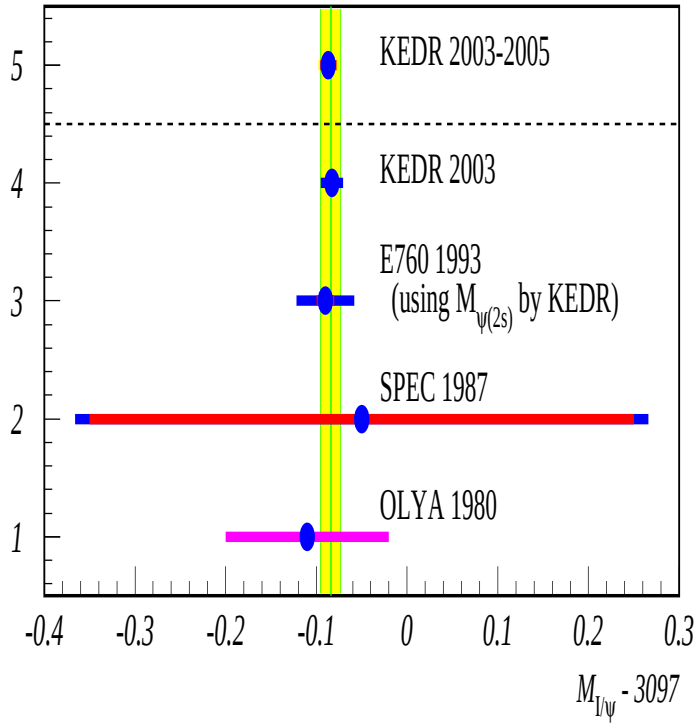
$$M_{J/\psi} = (3096.913 \pm 0.006 \pm 0.009)\ \text{MeV}$$

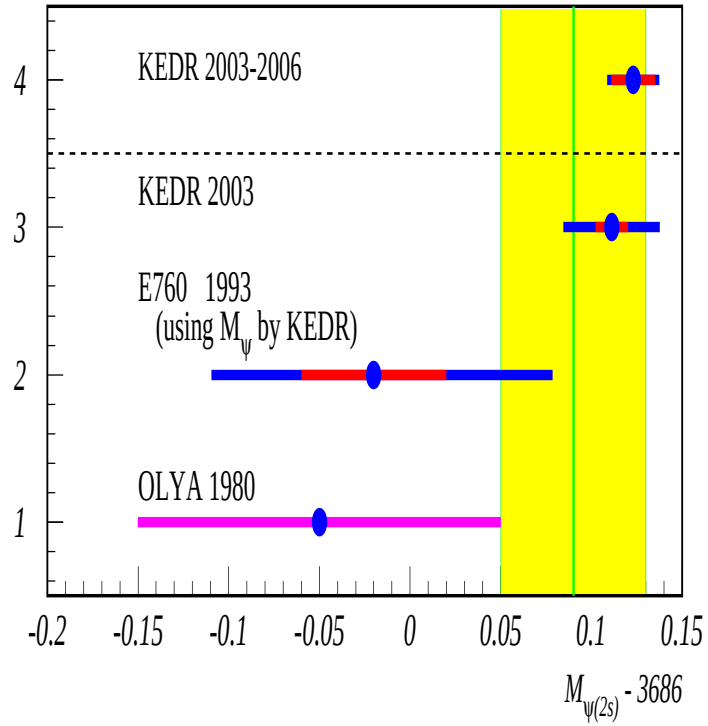
$$M_{\psi'} = (3686.126 \pm 0.007 \pm 0.011)\ \text{MeV}$$

J/ψ and ψ' Mass Measurement – II

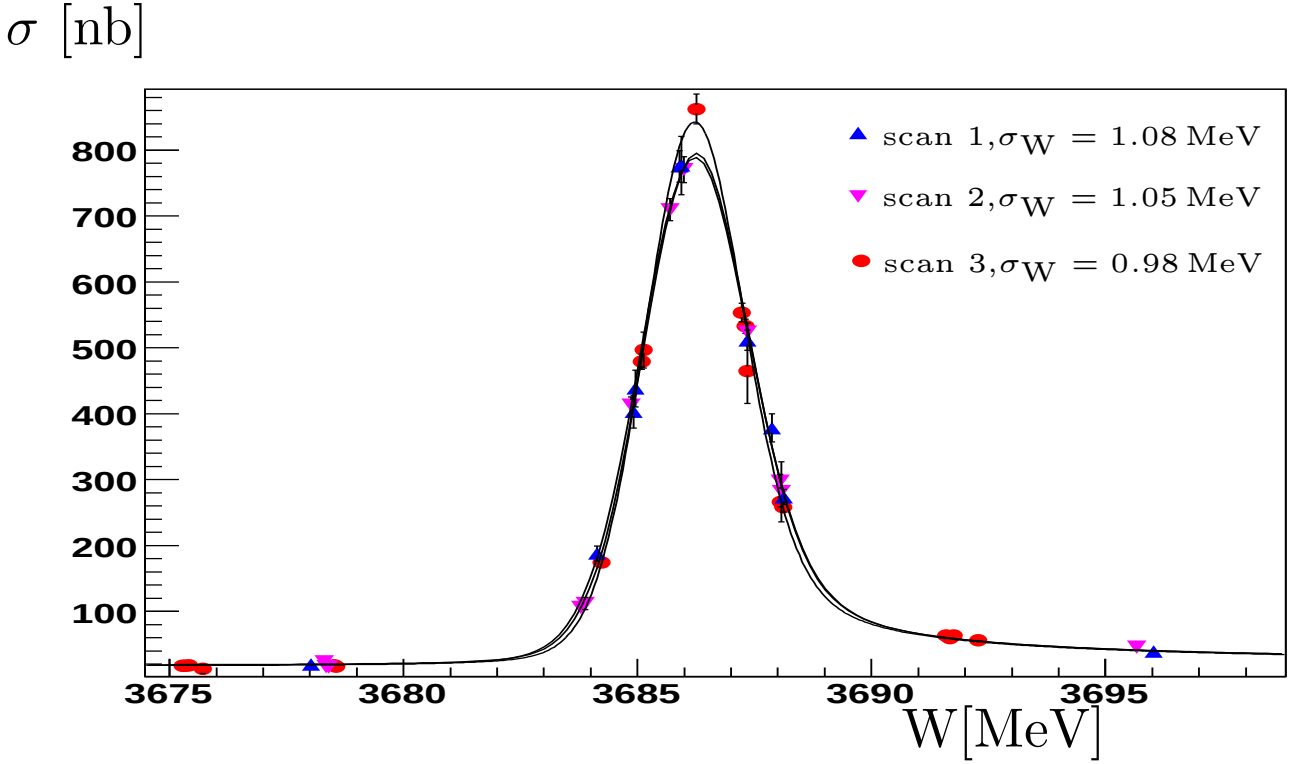
- Systematic errors in mass measurements are the main issue
- More than 20 different effects considered
- Energy spread, energy assignment, energy difference of e^+ and e^-, beam misalignment, luminosity etc.
- No significant improvement for the J/ψ
  because the additional scan had bigger systematics

J/ψ and ψ' Mass Measurement – III





Measurement of $\Gamma_{ee} \cdot \mathcal{B}(\psi' \to hadrons)$ for ψ' – I



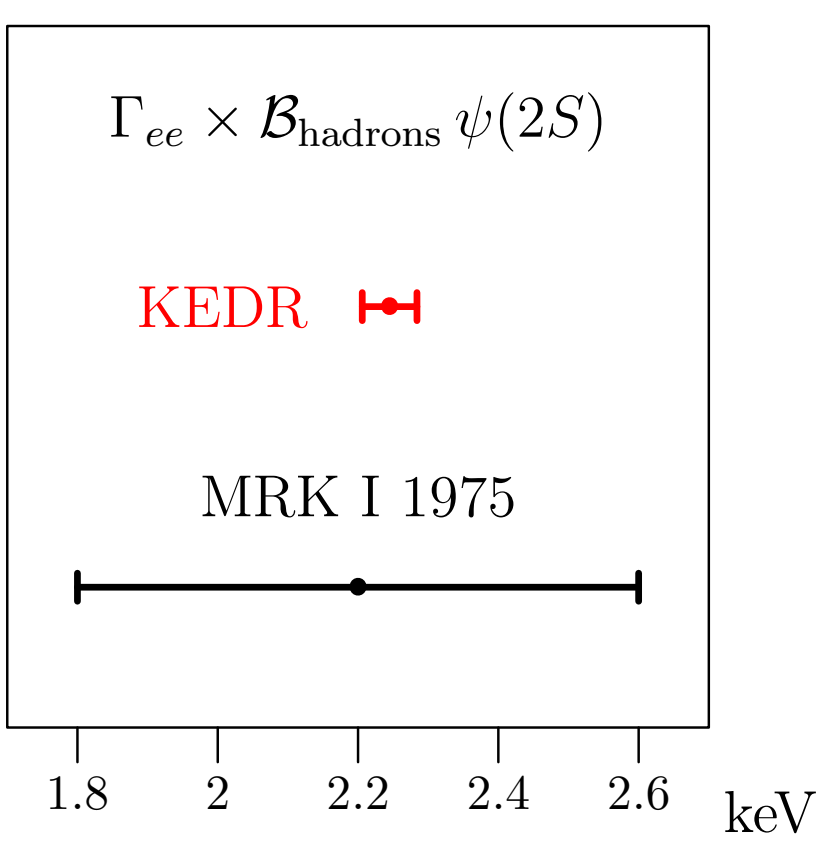
Measurement of $\Gamma_{ee} \cdot \mathcal{B}(\psi' \to hadrons)$ for ψ' – II

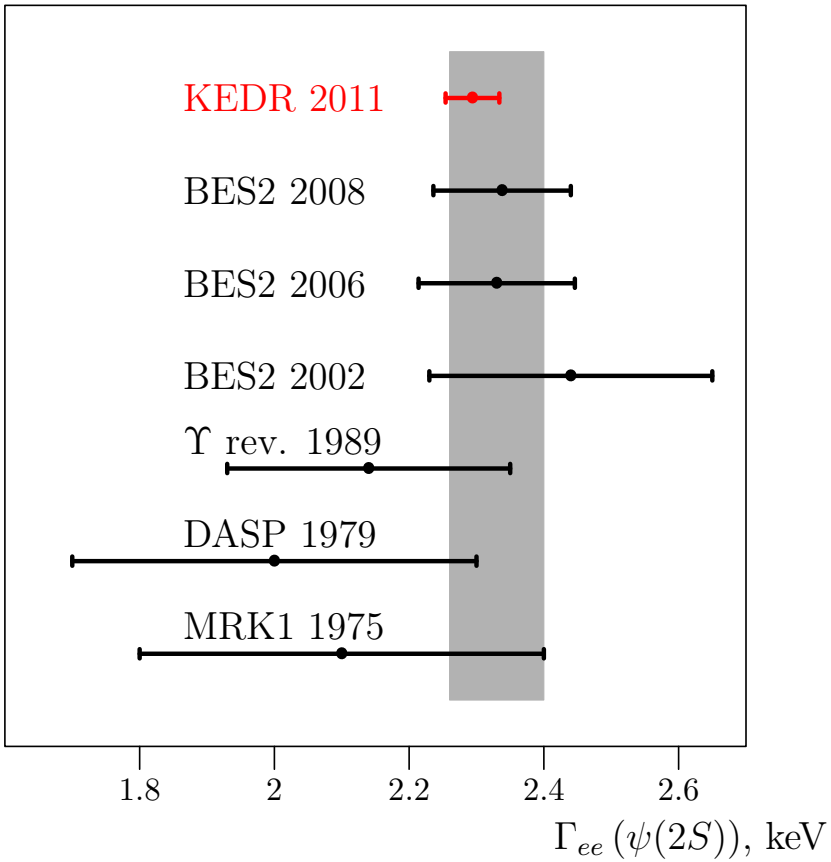
Source	Scan 1	Scan 2	Scan 3	Common 1-2	Common
Lumin.	1.6	1.7	1.2	1.6	0.4
MC gener.	0.9	0.9	1.1	0.9	0.9
Trigger	0.6	0.6	0.3	0.6	0.3
Selection	0.5	0.3	0.6	0.3	0.3
MC nucl.	0.3	0.3	0.3	0.3	0.3
Energy	0.15	0.18	0.60	0.15	0.15
MC vert. det.	0.10	0.17	0.10	0.10	0.10
Fit	0.2	0.2	0.2	0.2	0.2
Total	2.0	2.1	1.9	2.0	1.1

Measurement of $\Gamma_{ee} \cdot \mathcal{B}(\psi' \to hadrons)$ for ψ' – III

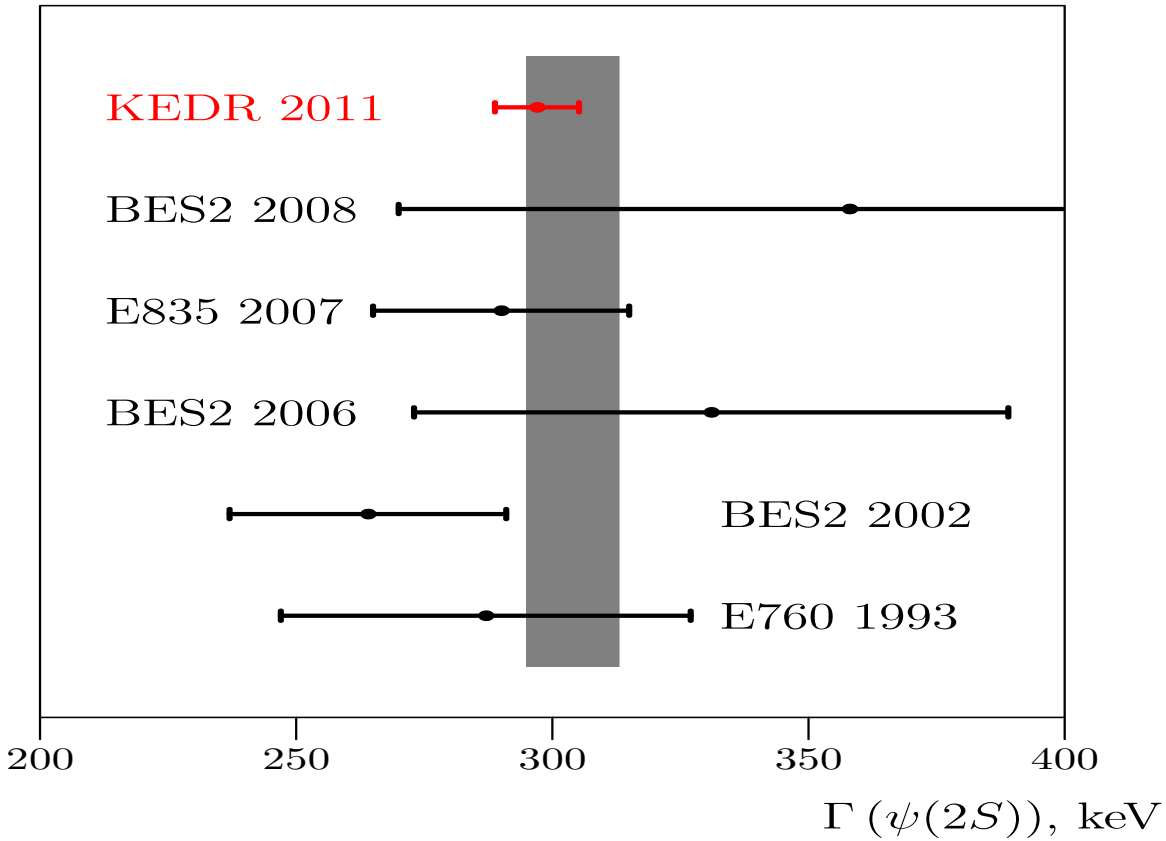
- $\Gamma_{e^+e^-} \cdot \mathcal{B}(\psi' \to h) = (2.245 \pm 0.015 \pm 0.036)$ keV,
  much more precise than the only previous direct measurement
- Using the world-average value of $\mathcal{B}_h$
  $\Gamma_{e^+e^-} = (2.294 \pm 0.015 \pm 0.037)$ keV,
  about 3 times better than the best previous one.
- Using the world-average values of $\Gamma_{e^+e^-}$ and $\mathcal{B}_h$
  $\Gamma = (297 \pm 2 \pm 8)$ keV,
  again about 3 times better than the best previous one.

Measurement of $\Gamma_{ee} \cdot \mathcal{B}(\psi' \to hadrons)$ for ψ' – IV

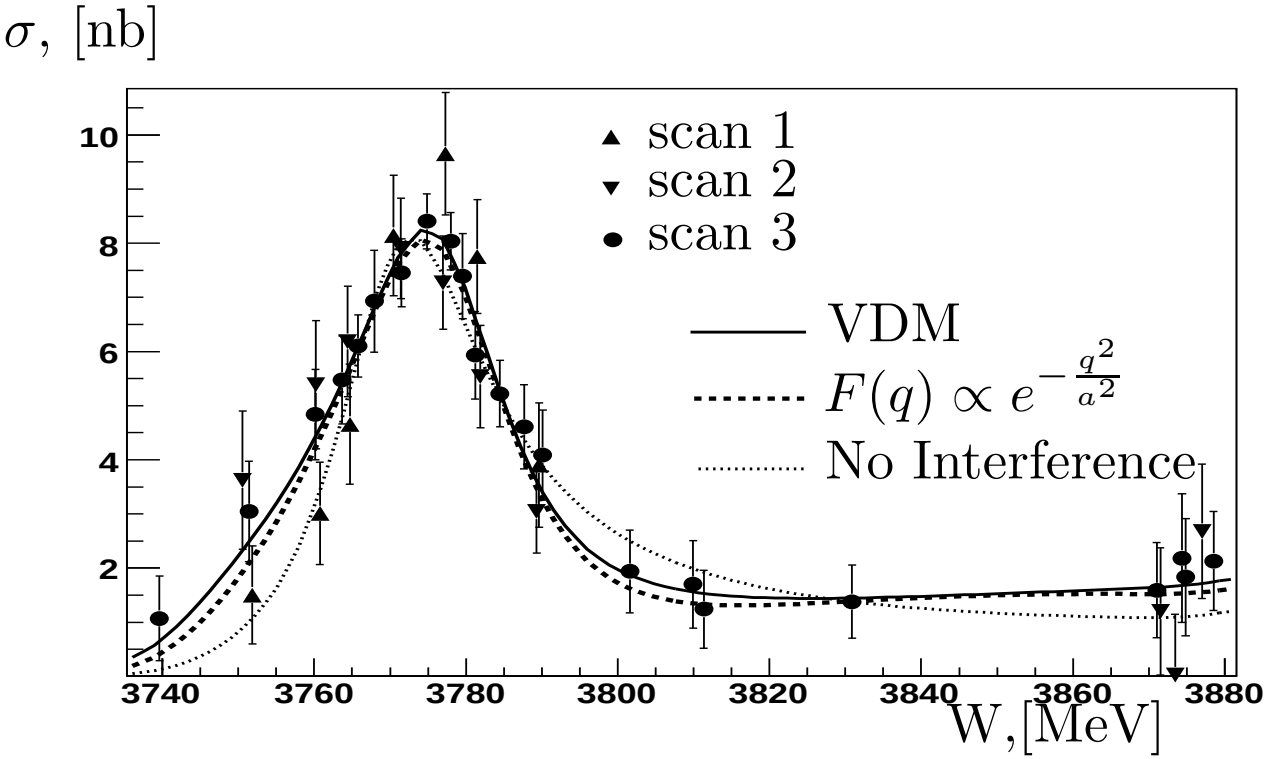




Measurement of $\Gamma_{ee} \cdot \mathcal{B}(\psi' \to hadrons)$ for ψ' – V



Determination of $\psi(3770)$ Parameters – I



$$\sigma_{D\bar{D}} \propto |\mathrm{A}_{\psi(3770)} + \mathrm{A}_{\psi\prime}\, e^{i\phi} + \mathrm{B}\, e^{i\phi}|^2$$

$$\sigma_{D\bar{D}} \propto |\mathrm{A}_{\psi(3770)} + \mathrm{B}_{\mathrm{n.r.}}\, \mathrm{F}\, e^{i\phi}|^2$$

Determination of $\psi(3770)$ Parameters – III

Model,F(q)	M,[MeV/c^2]	Γ,[MeV]	C.L. ,[%]
VDM(ψ')	3779.7 ± 1.7	24.9 ± 4.3	18.5
No Interf.	3773.2 ± 0.5	23.9 ± 2.3	2.5
$e^{-\frac{q^2}{a^2}}$	3780.5 ± 2.3	28.2 ± 4.5	15.3
constant	3778.1 ± 1.5	30.4 ± 3.9	13.7
$\frac{1}{1+aq^2+bq^4}$	3779.3 ± 1.7	25.1 ± 4.4	17.2
$\frac{1}{1+aq^b}$	3779.0 ± 1.7	24.4 ± 3.7	17.7
$\frac{1}{(W-M_{\psi'})^a}$	3780.0 ± 1.9	25.3 ± 4.7	17.6
VDM ($\psi(4039)$)	3778.2 ± 1.6	30.6 ± 3.9	12.2

Determination of $\psi(3770)$ Parameters – IV

Source	Mass, MeV	Width, MeV
$\sigma_{\rm NR}$ shape	$^{+0.3}_{-1.6}$	$^{+5.7}_{-0.5}$
R_0 variation	0.3	0.3
Event selection	0.3	0.3
Luminosity	0.1	0.1
Detection efficiency	0.1	0.1
Energy assignment	0.03	–
Total	$\approx ^{+0.5}_{-1.7}$	$\approx ^{+5.7}_{-0.7}$

KEDR: $M_{\psi(3770)} = (3779.3 \pm 1.7^{+0.5}_{-1.7})$ MeV, $\Gamma_{\psi(3770)} = (24.9 \pm 4.3^{+5.7}_{-0.7})$ MeV

PDG: $M_{\psi(3770)} = (3772.92 \pm 0.35)$ MeV, $\Gamma_{\psi(3770)} = (27.3 \pm 1.0)$ MeV

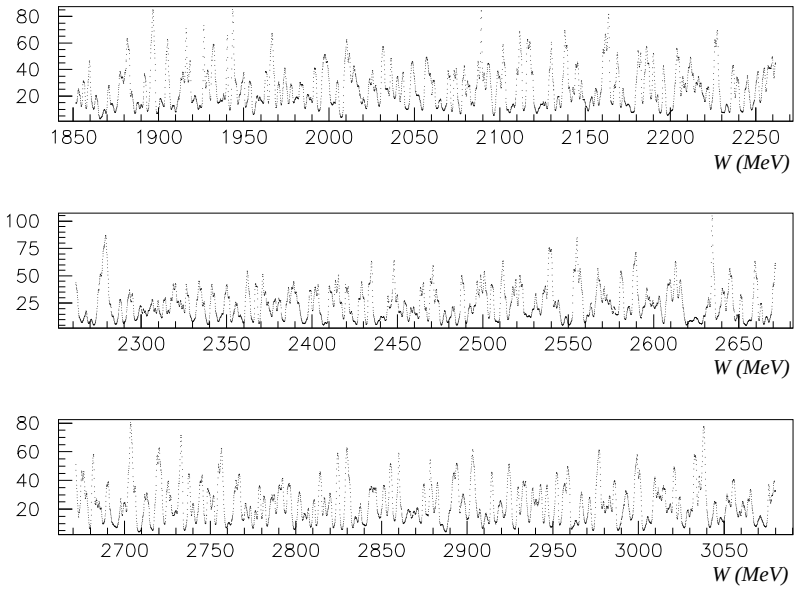
Determination of $\psi(3770)$ Parameters – V

A few general conclusions:

- Mass is higher than in previous measurements, but agrees with BaBar that also took into account interference
- Width is in reasonable agreement with previous measurements
- With our data sample we do not observe any shape anomaly
- Absolutely mandatory to take into account interference:
- There are usually two solutions with the same mass, width and likelihood, but strongly differing (a factor of up to 3) leptonic width
- While the current world-average value is $\Gamma_{e^+e^-} = 259 \pm 16$ eV, with interference effects included it is higher and might be (400-500) eV

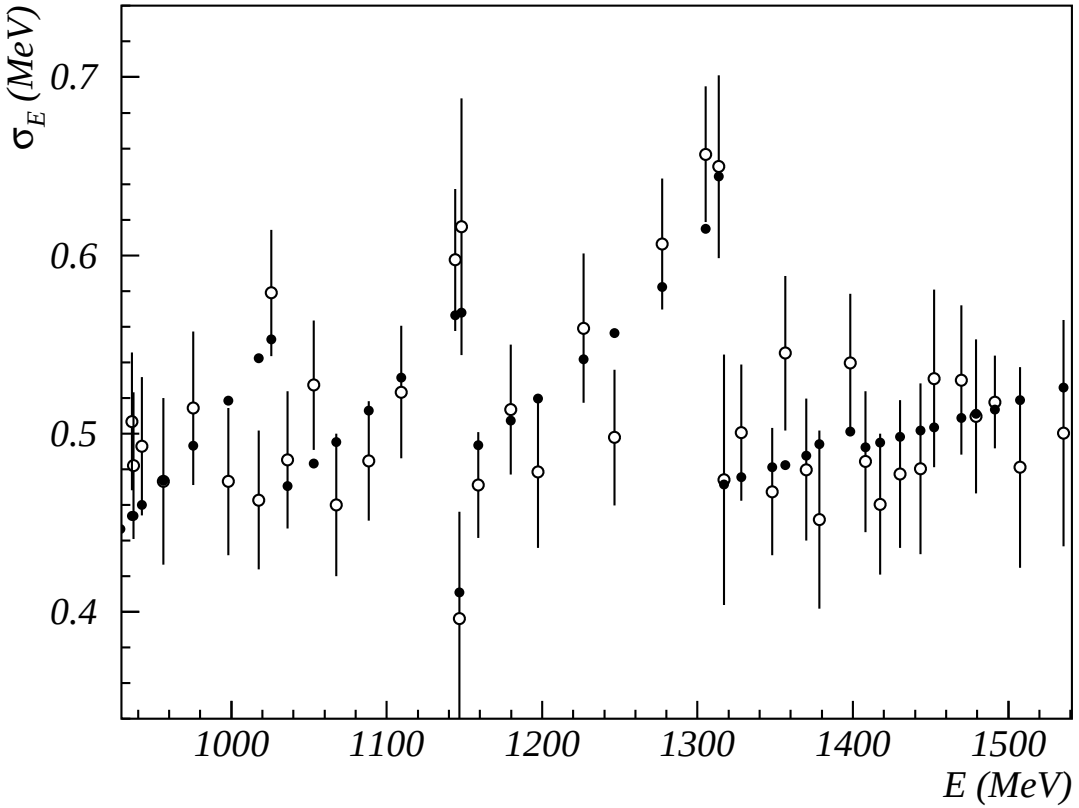
Search for Narrow Resonances – I

KEDR scanned the c.m.energy range from 1.85 to 3.1 GeV searching for narrow resonances



Search for Narrow Resonances – II

$\int \mathcal{L}dt \approx 300$ nb^{-1} was collected
in a scan with a step $\approx 2\sigma_W$ (1.4-1.9 MeV)



Search for Narrow Resonances – III

- The model: a resonance with M_R, Γ_{ee}^R on top of a flat BG
- The fits use the range $M_R \pm 13$ MeV
- M_R is varied in 0.1 MeV steps
- A systematic error of $\sim 50\%$ conservatively
- $\Gamma_{ee}^R \cdot \mathcal{B}(R \to hadrons) < 120$ eV,
  4-5 times more stringent than at ADONE in 1975-1978:
  $\gamma\gamma 2$, $B\bar{B}$ and BOSON groups scanned 1.42-3.1 GeV
- KEDR hopes to measure R in this W range to 5%

Conclusions

- Masses of J/ψ and $\psi(2S)$ measured. The accuracy reaches $(3-5)\cdot 10^{-6}$
- New precise value of $\Gamma_{e^+e^-}\cdot\mathcal{B}(\psi')$ significantly improves the values of both leptonic and total width for ψ'
- Interference effects are important for M and Γ of $\psi(3770)$
- Multiple solutions make difficult $\Gamma_{e^+e^-}$ determination for $\psi(3770)$
- No narrow states found between 1.85 GeV and J/ψ
- New R measurements are planned between 2 and 11 GeV