ИНСТИТУТ ЯДЕРНОЙ ФИЗИКИ
им. Г.И. Будкера СО РАН

S.E.Baru, A.E.Blinov, V.E.Blinov,
A.E.Bondar, A.D.Bukin, V.R.Groshev,
S.G.Klimenko, G.M.Kolachev, A.P.Onuchin,
V.S.Panin, I.Ya.Protopopov, A.G.Shamov,
V.A.Sidorov, Yu.I.Skovpen, A.N.Skrinsky,
V.A.Tayursky, V.I.Telnov, Yu.A.Tikhonov,
G.M.Tumaikin, A.E.Undrus,
A.I.Vorobiov, V.N.Zhilich

DETERMINATION OF THE $\Upsilon(1s)$ LEPTONIC WIDTH

BUDKERINP 92-46

НОВОСИБИРСК

Determination of the Υ(1s) Leptonic Width

S.E.Baru, A.E.Blinov, V.E.Blinov, A.E.Bondar,
A.D.Bukin, V.R.Groshev, S.G.Klimenko,
G.M.Kolachev, A.P.Onuchin, V.S.Panin,
I.Ya.Protopopov, A.G.Shamov,V.A.Sidorov,
Yu.I.Skovpen, A.N.Skrinsky, V.A.Tayursky,
V.I.Telnov, Yu.A.Tikhonov, G.M.Tumaikin,
A.E.Undrus, A.I.Vorobiov, V.N.Zhilich.

Budker Institute of Nuclear Physics
630090 Novosibirsk, Russia

ABSTRACT

Analyzing the data recorded with the MD-1 detector operated at the VEPP-4 storage ring we have determined the Υ(1s) resonance leptonic partial width and mass. We find

$$\Gamma_{ee} = 1.29 \pm 0.03 \pm 0.03 \text{ keV},$$
$$M = 9460.59 \pm 0.09 \pm 0.05 \text{ MeV}/c^2.$$

This new value of the Υ(1s) mass should supersede the previously published value [11] based on almost the same statistics.

1. INTRODUCTION

Since the discovery [1] of the Υ resonances in 1977 the results of 7 experiments on the Υ(1s) leptonic partial width measurement have been published [2-8].

The experiment on the Υ(1s) leptonic width and mass measurement at the VEPP-4 storage ring was done and the preliminary value of the leptonic width was published in 1984 [9]. The mass value was published in 1985 [11]. The leptonic width statistical error was expected to be about 2% requiring systematic error suppression down to 2÷3% level.

Here we report the results of a new data analysis on the Υ(1s) Γ_{ee} and mass with all data available.

For a narrow resonance a precise evaluation of the radiative corrections is of great importance for the determination of the leptonic width and mass. Before 1985 most of experiments in this field applied an erroneous formula for the radiative correction calculation and used a definition of Γ_{ee} inconsistent with the $\Gamma_{ee} = \Gamma_{tot} \cdot B^{exp}_{\mu\mu}$ relation which is employed for the total width Γ_{tot} determination ($B^{exp}_{\mu\mu}$ is an experimentally measured muon branching ratio). The situation was clarified by Kuraev and Fadin [10]. The new approach to the radiative correction evaluation, first used in our work [9,11], is now generally accepted [12]. The results of all experiments on Ψ and Υ meson Γ_{ee} and Γ_{tot} have been recalculated according to this approach [13,14].

2. DETECTOR AND TRIGER

The MD-1 detector [15,16,17] was in operation at the VEPP-4 storage ring in 1980÷1985. The central part of the detector consisted of the tracking system (38 multiwire proportional chambers), the shower-range system (14 stainless steel - proportional chamber sandwiches), 24 scintillation counters and 8 high pressure gas Cherenkov counters. The 11.3 kG magnetic field in the detector was oriented perpendicular to the accelerator plane.

The detector had a three level trigger scheme. The trigger information came from the scintillation counters, the shower-range and tracking systems. Three particles (including gammas) or two collinear charged particles detected in a event gave a trigger signal. The net efficiency of the trigger was 97.9% for the $\Upsilon(1s)$ hadronic decays. The total event rate including the background was about 3 Hz for a luminosity of $3\cdot10^{30}$ $cm^{-2}s^{-1}$.

3. LUMINOSITY MEASUREMENT

The luminosity was measured by the small angle Bhabha scattering with 1.5% stability [18]. The absolute calibration of the luminosity monitor was done by three independent methods:

double bremsstrahlung in a special run [18],
large angle Bhabha scattering [18],
$\mu^+\mu^-$-pair production [16].

The following values of the small angle cross section were obtained:

$$\sigma^{SA}_{DB} = (3.58 \pm 0.05 \pm 0.11)\cdot10^{-29}cm^2,$$

$$\sigma^{SA}_{LA} = (3.75 \pm 0.07 \pm 0.07)\cdot10^{-29}cm^2,$$

$$\sigma^{SA}_{\mu\mu} = (3.88 \pm 0.13 \pm 0.05)\cdot10^{-29}cm^2$$

(We have revised the systematic error of the double bremsstrahlung data since the work [18]. The additional error due to the nonlinearity of the NaJ(Tl) crystals was found which increased the systematic error from 1.6% to 3%.)

Weighting these three values gives

$$\sigma^{SA} = (3.73 \pm 0.07)\cdot10^{-29}cm^2$$

and χ^2 =2.7 for 2 degrees of freedom. Applying a scale factor of 1.2 we obtained a 2.2% accuracy for the absolute calibration of the luminosity monitor.

4. EXPERIMENTAL PROCEDURE

The experimental procedure is described in detail in the paper [11]. The integrated luminosity of 2.0 pb^{-1} was collected during 4 scans of the $\Upsilon(1s)$ region (E_b = 4710 ÷ ÷ 4745 MeV). About 90 energy calibrations were done by the resonance depolarization method [19]. The accuracy of the beam energy determination was about 60 keV for runs with energy calibration (65% of the statistics) and about 180 keV for runs between two calibrations. The background data with the beams separated were recorded during the calibration procedure.

An additional 0.4 pb^{-1} continuum data collected with the same trigger and luminosity monitor conditions but outside the energy calibration runs were employed in this data analysis.

5. EVENT SELECTION

The leptonic width of a resonance in an e^+e^--experiment can not be measured directly. Fitting the resonance curve, one can only extract the product $\Gamma_{ee} \cdot B_f$, where B_f is the branching ratio in the final mode selected in the experiment. In this work we did not suppress the $\tau^+\tau^-$ decays, in order to keep the multihadron detection efficiency as high as possible. Assuming e-, μ-universality one has $B_f = 1-2 \cdot B_{\mu\mu}$ in this case.

The event reconstruction in the MD-1 detector is rather complicated due to the small solid angle for good tracking. 40% of all charged particles cross more than 5 chambers and can be reconstructed independently ('perfect particles'). If a particle crosses more than 2 but less than 5 chambers, the event vertex position found by perfect particles is used for the reconstruction ('imperfect particles'). The perfect particles with the minimal distance from the event vertex of 3 cm or more is considered as 'background particles'.

Two different sets of criteria were chosen to select the multihadron and $\tau^+\tau^-$ events. The first set of criteria (we will refer it to as '*T*-criterion') is based, mainly, on the information from the tracking system. The second one, the '*S*-criterion', employs the shower-range system information.

In the *T*-criterion, all events were divided into four classes by number of perfect charged particles originated from the event vertex: 0,1,2 and ≥ 3. For each class the individual cuts were chosen in parameters

$$P = \sum p_i \,, \quad Pz = \sum |p_{zi}| \,, \quad Px = \sum p_{xi} \,/ \sum p_i \,,$$

where p_i, p_{xi}, p_{zi} are the particle momentum and its projections onto the beam direction and the magnetic field direction. The detector magnetic field was oriented perpendicular to the accelerator plane, so that the beam-wall background lies mainly in the machine plane and can be effectively suppressed with a **Pz** cut. The **Px** cut serves to suppress beam-gas and two-photon backgrounds. Typical cut values of the **P** parameter were less than 0.6 Gev/c.

The *S*-criterion was designed in the same way, but the events were subdivided into 3 classes by the presence of perfect particles detected in the shower-range system, by the number of charged particles and photons reconstructed in the shower-range system out of the machine plane and by the sum of particle ranges. Cuts were applied in parameters

$$R = \sum r_i \,, \quad Rz = \sum |r_i \cdot n_{zi}| \,, \quad Rx = \sum r_i \cdot n_{xi} / \sum r_i \,,$$

where r_i is a particle range (longitudinal shower size for photons) and (n_x, n_y, n_z) is a unit vector along the particle momentum.

There were some additional cuts to suppress radiated Bhabha events and the cosmic background. The number of charged particles and photons detected in the event had to be more than 3 and the number of background particles was required to be less than 4.

Detection efficiencies of about 90% were achieved (Table 1). The machine background contribution into the observed cross section was estimated by separated beams data. It was about 2% of the observed cross section at the continuum σ_c^{obs} for both selection criteria. The physical background (radiated Bhabha and two-photon processes) was about 20% of σ_c^{obs}. Both the machine and physics backgrounds were almost constant in the experiment energy range and were automatically subtracted during the fitting procedure.

We have tried to make *T* and *S* selection criteria as independent as possible to get an additional estimation of the systematic error.

Having two different criterion *T* and *S*, one can profit by their logical combinations. The numbers of events passed through *T.and.S*, *T.and..not.S* and *S.and..not.T* criteria are statistically independent and can be used in a joint fit. Such a fit reduces the statistical errors and allows one to calculate all parameters of interest and their error matrix.

6. DETECTION EFFICIENCY DETERMINATION

The detection efficiency was calculated using the Monte Carlo technique. For the simulation of the Υ decays the following branching ratios were used:

$$B(\Upsilon \to 3g, 2g\gamma) = 1-(R+3)\cdot B_{\mu\mu}$$

$$B(\Upsilon \to q\bar{q}, q\bar{q}g) = R\cdot B_{\mu\mu}$$

$$B(\Upsilon \to \tau\tau) \quad = B_{\mu\mu}$$

with $R = 3.55$, $B_{\mu\mu} = 0.0257$.

The hadronic and $\tau^+\tau^-$ decays were generated with the LUND program version 6.3 [20]. The generated events were passed through a complete detector simulation in the frame of the UNIMOD program [21]. The interaction of hadrons was simulated with the NUCRIN program [22].

Accidental signal-background coincidences were taken into account by mixing the simulated events with the 'trigger free' background events. The collection of such events was extracted from the cosmic events in which the cosmic track fully satisfied the trigger conditions.

There were two main problems with the detector simulation.

The first one was the efficiency of the true track reconstruction. In the MD-1 detector this efficiency strongly depended on the chambers efficiencies and the spatial resolution. The behavior of the proportional chambers at the edges of the sensitive volume and in the case of two close tracks was of great importance. It is difficult to simulate this behavior with the accuracy required. After the simulation of the hits in the tracking system and track reconstruction we rejected reconstructed tracks with 3.5% average probability. With 4% average probability the perfect track originated from the event vertex was considered as the background track. The first probability were obtained with two-body data ($\mu^+\mu^-$ and two-photon), the second one were obtained with the multihadron data itself.

Tracking system inefficiencies of all kinds decrease the efficiency of *T* and *T.or.S* selection criteria by 2% and 1.1% respectively. The estimated uncertainty of the charged particle multiplicity is about 3.5%. This uncertainty sets the limit on the admissible variation of the event generator parameters and is important for estimation of the systematic error resulting from the detection efficiency model dependence.

The second problem was the hadron interaction in the detector material. The simulated hadron range in the shower-range system was somewhat greater than that found experimentally. Varying the total nuclear interaction cross section in NUCRIN by as much as 20% had only a small influence on the simulated range. Too long a range for secondary particles was a probable reason and we applied the following rough correction algorithm: if the nuclear interaction had occurred during the event simulation, the products of the interaction were ignored with 15% probability. Fig.1 shows the experimental hadron range and the simulated one.

The influence of this correction on the efficiency of the *S* and *T.or.S* selection criteria were 1.6% and 0.3% respectively.

The observed and simulated distributions in some important parameters are shown in fig. 2-4. The multiplicity data are in satisfactory agreement. There is good agreement for the sphericity distributions. The observed charged particle momentum spectrum is somewhat harder than that simulated with LUND 6.3. The difference in the momentum spectra can not be explained by the residual background.

We attempted to adjust the LUND 6.3 program parameters so that it generates a harder momentum spectrum with the smallest possible variation of the mean multiplicity and sphericity. In the best case we have achieved, the decrease of the primary and observed multiplicities were 6% and 4% respectively. The observed multiplicity decreased less than the primary one due to the variation of event sphericity and the incomplete solid angle of particle detection. The track reconstruction efficiency was adjusted to compensate for the observed multiplicity decrease. The resulting distributions are shown in fig. 2-4 as the dotted histograms. The agreement of the momentum spectra was improved but at the price of some disagreement in the sphericity distributions.

We also have tried to optimize the LUND 4.3 parameters and algorithm but did not achieve a better reproduction of the experimental data.

The data simulated with those event generators (LUND 6.3* and LUND 4.3*) were used for the systematic errors estimation.

The values of detection efficiencies for different selection criteria according to LUND 6.3 and their statistical error are given in the Table 1.

Table 1. Detection efficiencies for different selection criteria according to LUND 6.3

Decay mode	*T*	*S*	*T.or.S*
$\Upsilon \to 3g, 2g\gamma$	88.1	87.5	91.8 ± 0.4
$\Upsilon \to qq, qqg$	76.7	77.8	82.6 ± 1.0
$\Upsilon \to \tau\tau$	21.9	20.5	24.2 ± 2.0
$\Upsilon \to$ hadrons, $\tau\tau$	85.2	84.7	89.0 ± 0.4

7. DETERMINATION OF Γ_{ee}

The observed dependence of the cross sections on the beam energy for events which passed the *T.and.S*, *T.and..not.S*, *S.and..not.T* selection criteria were fit to theoretical expectations with 8 free parameters: $\gamma_{ee,i}$, $\sigma^{obs}_{c,i}$, M and σ_W,

where

$\gamma_{ee,i} = \Gamma_{ee} \cdot B_f \cdot \varepsilon_i$ is leptonic width, multiplied by the decay ratio into modes detected, multiplied by the detection efficiency of the selection criterion *i* (*i =T.and. S, T.and..not.S, S.and..not.T*),

$\sigma^{obs}_{c,i}$ is the nonresonant cross section at the beam energy of 4.7 Gev for the selection criterion *i*,

M is the $\Upsilon(1s)$ mass and

σ_W is the machine energy spread.

The following formulas were used:

$$\sigma^{obs}_{i} = \gamma_{ee,i} \cdot 6\pi^2/M^2 \cdot G(W-M) \cdot (1+\delta) + \sigma^{obs}_{c,i} \cdot (9.4/W)^2,$$

$$G(x) = \left(\frac{2\sigma_w}{M}\right)^{\beta} \frac{\Gamma(1+\beta)}{\sqrt{2\pi}\,\sigma_w} \exp\left[-\frac{x^2}{4\sigma_w}\right] D_{-\beta}\left(-\frac{x}{\sigma_w}\right),$$

$$\delta = \frac{\alpha}{\pi}\left(\frac{\pi^2}{3} - \frac{1}{2}\right) + \frac{3}{4}\beta - \frac{1}{24}\beta^2\left(\frac{2}{3}\ln\frac{W}{m_e} + 2\pi^2 - \frac{37}{4}\right),$$

$$\beta = \frac{4\alpha}{\pi}\left(\ln\frac{W}{m_e} - \frac{1}{2}\right).$$

Here α is the fine structure constant, Γ is the gamma-function, $D_{-\beta}$ is the Weber parabolic cylinder function, m_e is the electron mass and $W = 2E_{beam}$.

This corresponds to the Kuraev and Fadin formula for radiative correction [10] with some small terms omitted. The accuracy of the approximation is better than 0.1%. The β^2 terms, 0.0053 numerically, was not taken into account in the works [8,13,14].

The vacuum polarization is included in the definition of the Γ_{ee}, so that $\Gamma_{ee} = \Gamma_{tot} \cdot B^{exp}_{\mu\mu}$.

We assumed that the nonresonant cross section depends on the beam energy as $1/E^2$.

The fit gives $\chi^2 = 167.$ for 178 degrees of freedom. The probability of the χ^2 for each selection criterion varies in the range 25-70%. The experimental data and the fit for *T.and.S* selection criterion are shown in fig. 5. The resultant values of leptonic widths for selection criteria *T*, *S* and *T.or.S* with three event generators are given in the Table 2.

Table 2. The leptonic width in keV for 3 selection criteria with different even generators. Data and Monte Carlo statistical errors are presented.

	T	*S*	*T.or.S*
LUND 6.3	1.273	1.286	1.286±0.025±0.005
LUND 6.3*	1.284	1.288	1.299±0.025±0.005
LUND 4.3*	1.284	1.296	1.301±0.025±0.006

We have chosen the value of the leptonic width corresponding to standard LUND 6.3 parameters and the *T.or.S* selection criterion as a resultant value of Γ_{ee} for the following reasons:

1. The standard LUND 6.3 simulation satisfactorily reproduces the observed distributions in important parameters and is tested in the other experiments;
2. The systematic error for *T.or.S* data is less than for the *S* and *T* data.

8. SYSTEMATIC ERRORS OF Γ_{ee}

Comparing the Γ_{ee} values obtained with different event generators we estimate the systematic errors arising from the detection efficiency model dependence to be about 1%.

From the variation of chamber efficiencies and nuclear interaction parameters within acceptable limits we derived 0.5% systematic error due to uncertainty of the detector response for *T.or.S* data. For *T* and *S* data this error is about 1%. The observed difference in the leptonic width with *S* and *T* selection criteria

$$\delta\Gamma_{ee} = 0.013 \pm 0.009(\text{statistical})\ \text{keV}$$

confirms this estimation.

The estimation of detection efficiency systematic error obtained by varying the most significant cuts does not contradict those given above.

We have estimated the background contribution to the systematic error by changing the nonresonant cross section energy dependence from $1/E^2$ to $1/E$ (it is a small variation in the experiment energy range). The possible dependence of the machine background on energy and $\ln^3 E$ dependence of the two-photon cross section were the motivations for this chose. The variation of the Γ_{ee} was less than 0.5%.

Varying the energies assigned to the experimental points within their errors, we estimated the systematic error resulting from the beam energy uncertainty to be about 0.5%.

The simulation of the week-to-week luminosity monitor instability gives additional 0.5% systematic error due to the luminosity measurements.

The full list of systematic errors is given below:

luminosity absolute calibration	2.2%
luminosity monitor stability	0.5%
detection efficiency model dependence	1.0%
uncertainty in the detector response	0.5%
Monte Carlo statistics	0.5%
background contribution	0.5%
beam energy uncertainty	0.5%

Combining this errors quadratically we obtain a 2.7% systematic error for our Γ_{ee} value.

9. COMPARISON TO OTHER EXPERIMENTS

Our results for the $\Upsilon(1s)$ leptonic partial width is

$$\Gamma_{ee}\cdot B_{had} = 1.187 \pm 0.023 \pm 0.031 \text{ keV},$$
$$\Gamma_{ee} = 1.286 \pm 0.025 \pm 0.034 \text{ keV}$$

with $B_{\mu\mu} = 2.57\%$.

The published results of the experiments on the $\Upsilon(1s)$ leptonic width are gathered in the Table 3 and shown in Fig. 6. Our measurement is in a good agreement with all previous ones. The χ^2 of all measurements is 4.2 for 7 degrees of freedom.

Table 3. Measurements of the $\Upsilon(1s)$ $\Gamma_{ee}\cdot B_{had}$ (in keV). Radiative corrections of all experiments before 1985 were reevaluated in [13,14].

$\Gamma_{ee}\cdot B_{had}$	Experiment
1.35 ± 0.14	PLUTO 1979 [2]
1.09 ± 0.25	DESY-Heidelberg 1980 [3]
1.13±0.07±0.11	LENA 1982 [4]
1.23±0.08±0.04	DASP-II 1982 [5]
1.17±0.06±0.10	CUSB 1983 [6]
1.37±0.06±0.09	CLEO 1984 [7]
1.23±0.02±0.05	Cristal Ball 1988 [8]
1.24 ± 0.04	world average 1990 [12]
1.19±0.02±0.03	MD-1, this experiment

The $\Upsilon(1s)$ leptonic width was also measured by ARGUS [26], but the result is not yet published.

10. $\Upsilon(1s)$ MASS

The value of the $\Upsilon(1s)$ mass obtained in this analysis is

$$M = 9460.60 \pm 0.09 \pm 0.05 \text{ MeV}/c^2.$$

It agrees with our previous results [11] very well and has the same systematic error but the statistical error is 20% less due to a 20% increase of the integrated luminosity and more efficient event selection criteria.

Averaging of this result with the results of our independent measurements [23,24] gives

$$M = 9460.59 \pm 0.09 \pm 0.05 \text{ MeV}/c^2.$$

11. CONCLUSION

With the MD-1 detector operated at the VEPP-4 storage ring we have measured the $\Upsilon(1s)$ leptonic partial width. We find

$$\Gamma_{ee} = 1.29 \pm 0.03 \pm 0.03 \text{ keV},$$
$$\Gamma_{ee}\cdot B_{had} = 1.19 \pm 0.02 \pm 0.03 \text{ keV}.$$

This value is the most precise single measurement of this width and is in good agreement with the average of previous measurements.

A new value of the $\Upsilon(1s)$ mass was found. Using all three of our independent measurements of the $\Upsilon(1s)$ mass we obtained

$$M = 9460.59 \pm 0.09 \pm 0.05 \text{ MeV}/c^2.$$

This value should supersede our previous result [11] based on almost the same statistics.

The difference of our $\Upsilon(1s)$ mass value and that of CUSB [25],

$$M = 9459.97 \pm 0.11 \pm 0.07\ \mathrm{MeV}/c^2,$$

is now 3.7 standard deviations.

Acknowledgements. The authors express their gratitude to V.S.Fadin and E.A.Kuraev for the theoretical support of the analysis. We would especially like to thank the staff of MD-1 and VEPP-4 who make possible the work described here.

REFERENCES

1. *R.Herb et al.* Phys.Rev.Lett. 39 (1977) 252.
2. *C.Berger et al.* Z.Phys. C1 (1970) 343.
3. *P.Bock et al.* Z.Phys. C6 (1980) 125.
4. *H.Albrecht et al.* Phys.Lett. B116 (1982) 383.
5. *B.Niczyporuk et al.* Phys.Rev.Lett. 46 (1981) 92.
6. *P.M.Tuts* (CUSB collaboration). Int.Symp.on Lepton and Photon Interaction at High Energy, Ithacka, N.Y. (1983) 284.
7. *R.Giles et al.* Phys,Rev D29 (1984) 1285.
8. *Z.Jakubovsky et al.* Z.Phys. C40 (1988) 49.
9. *A.S.Artamonov et al.* Preprint INP 84-97.
10. *E.A.Kuraev, V.S.Fadin.* Sov.J.Nucl.Phys. 41 (1985) 466.
11. *S.E.Baru et al.* Z.Phys. C30 (1986) 551.
12. Particle data group: Phys.Let 239B (1990) VII.157.
13. *W.Buchmueller, S.Cooper.* In 'High Energy Electron-Positron Physics' Editors: A.Ali, P.Söding (World scientific 1988), p.412.
14. *J.P.Alexander et al.* Nucl.Phys. B320 (1989) 45.
15. *S.E.Baru at al.* International Conference on Instrumentation for Colliding Beam Physics, SLAC, 1982.
16. *S.E.Baru et al.* Preprint INP 91-110, Novosibirsk 1991, to be published in Z.Phys. C.
17. *S.E.Baru et al.* Z.Phys. C53 (1992) 219.
18. *A.E.Blinov et al.* NIM A273 (1988) 31.

19. *S.I.Serednyakov et al.* Zh.Eksp.Teor.Fiz. 81 (1976) 2025; *Ya.S.Derbenev et al.* Part.Accel.10 (1980) 177.
20. *T.Sjostrand, M.Bengtsson.* Preprint LU TP 86-22.
21. *A.D.Bukin et al.* Preprint INP 84-33, Novosibirsk 1984.
22. *K.Hanssgen, J.Ranft,* Comput.Phys.Commun. 39 (1986) 37, ibid 39 (1986) 53.
23. *A.S.Artamonov et al.* Phys.Lett. 118B (1982) 225.
24. *A.S.Artamonov et al.* Phys.Lett. 137B (1984) 272.
25. *W.W.MacKay et al.* Phys.Rev D29 (1984) 2483.
26. *S.Werner.* 'Inaugural-Dissertation zur Erlangung der Doktorwürde der Naturwissenschaftlich-Mathematischen Gesamtfakultät der Ruprecht-Karls-Universität Heidelberg', Heidelberg, 1992 (unpublished).

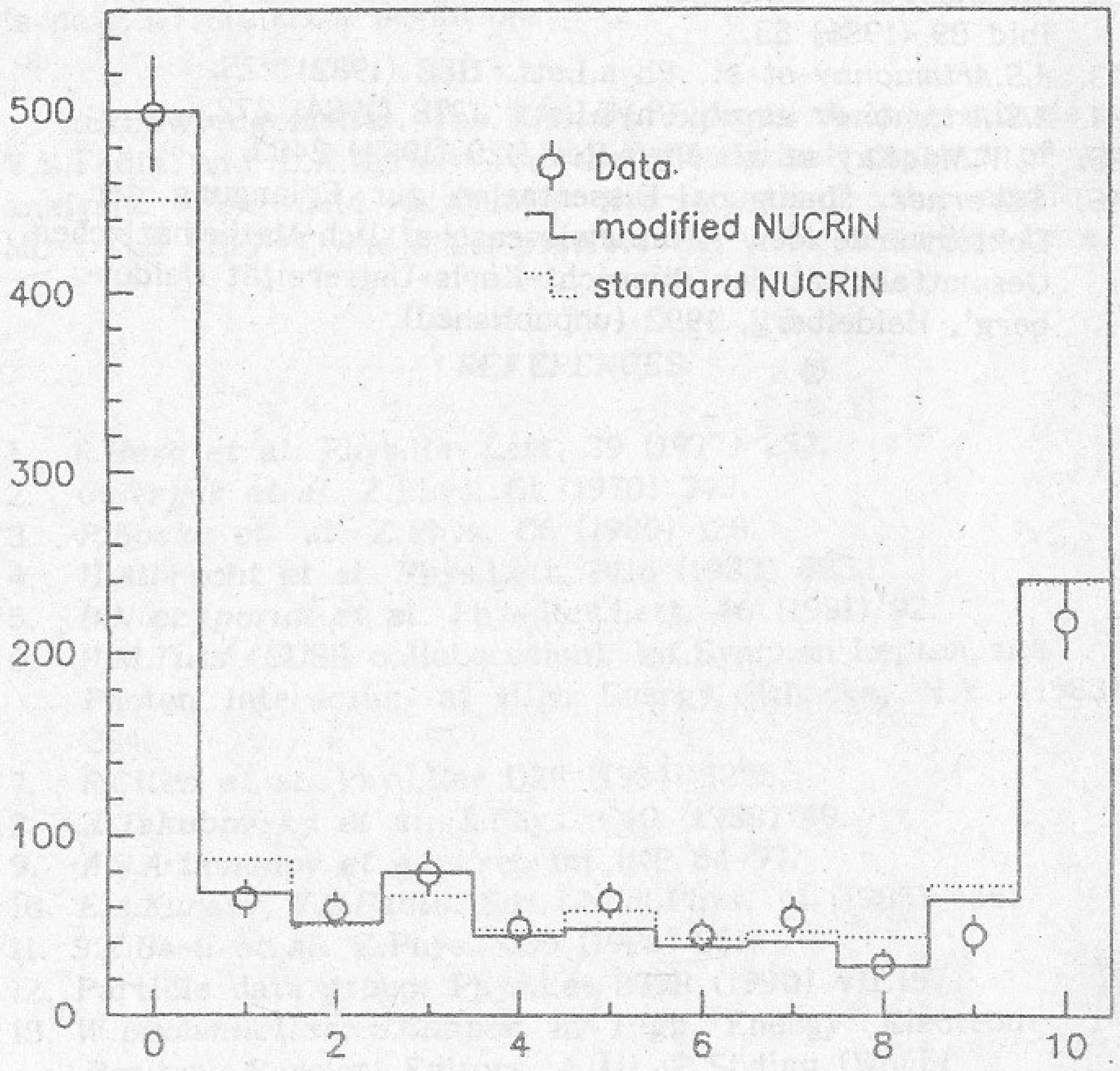

Fig.1. The charged particles range (the number of the range chamber crossed). The data (points) compared with the Monte Carlo calculation (histograms).

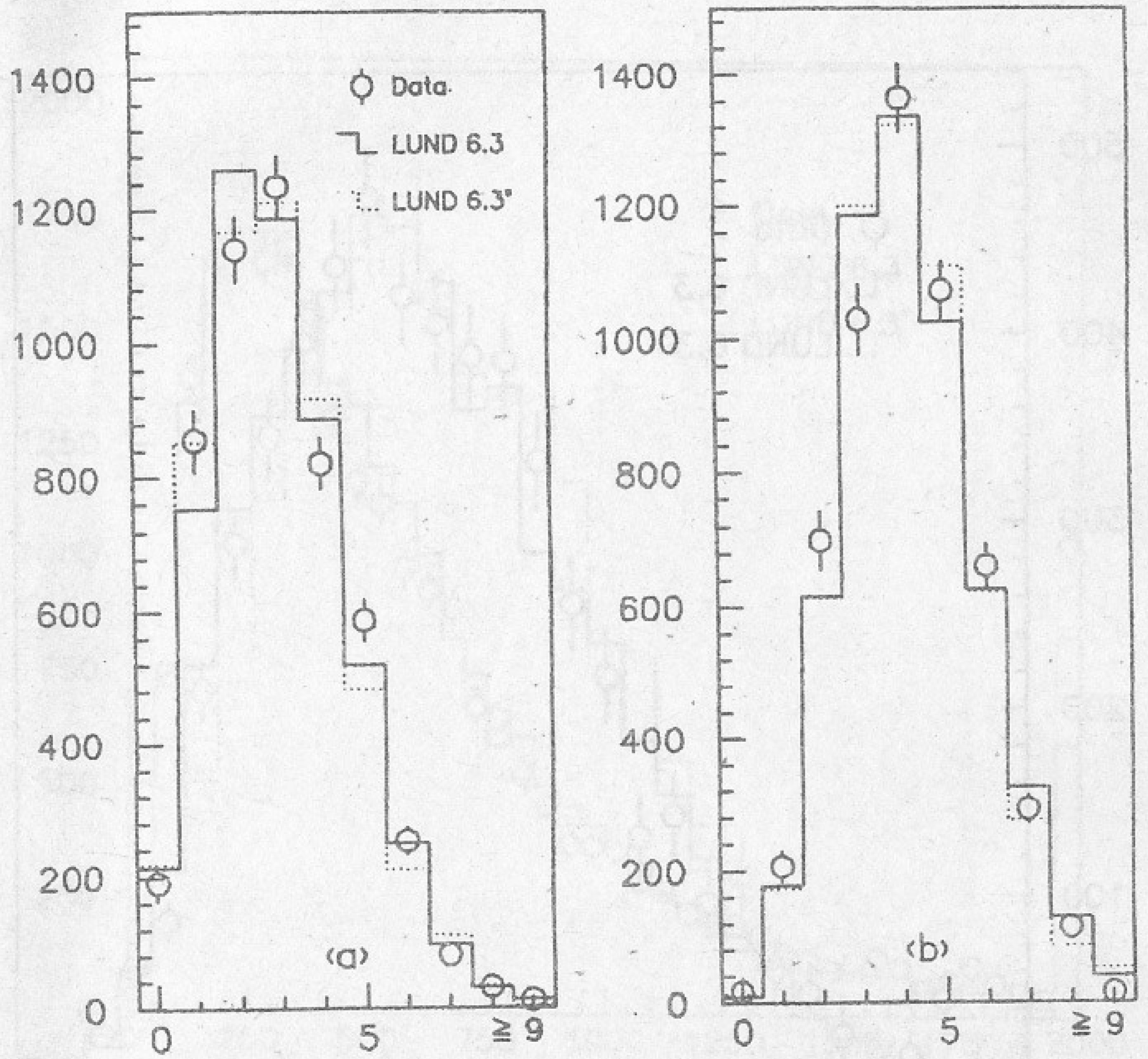

Fig.2. The uncorrected multiplicity distributions observed in the $\Upsilon(1s)$ decays (points) compared with the Monte Carlo calculation (histograms). (a) - The number of perfect particles in the tracing system. (b) - The number of particles in the shower-range system out if the machine plane.

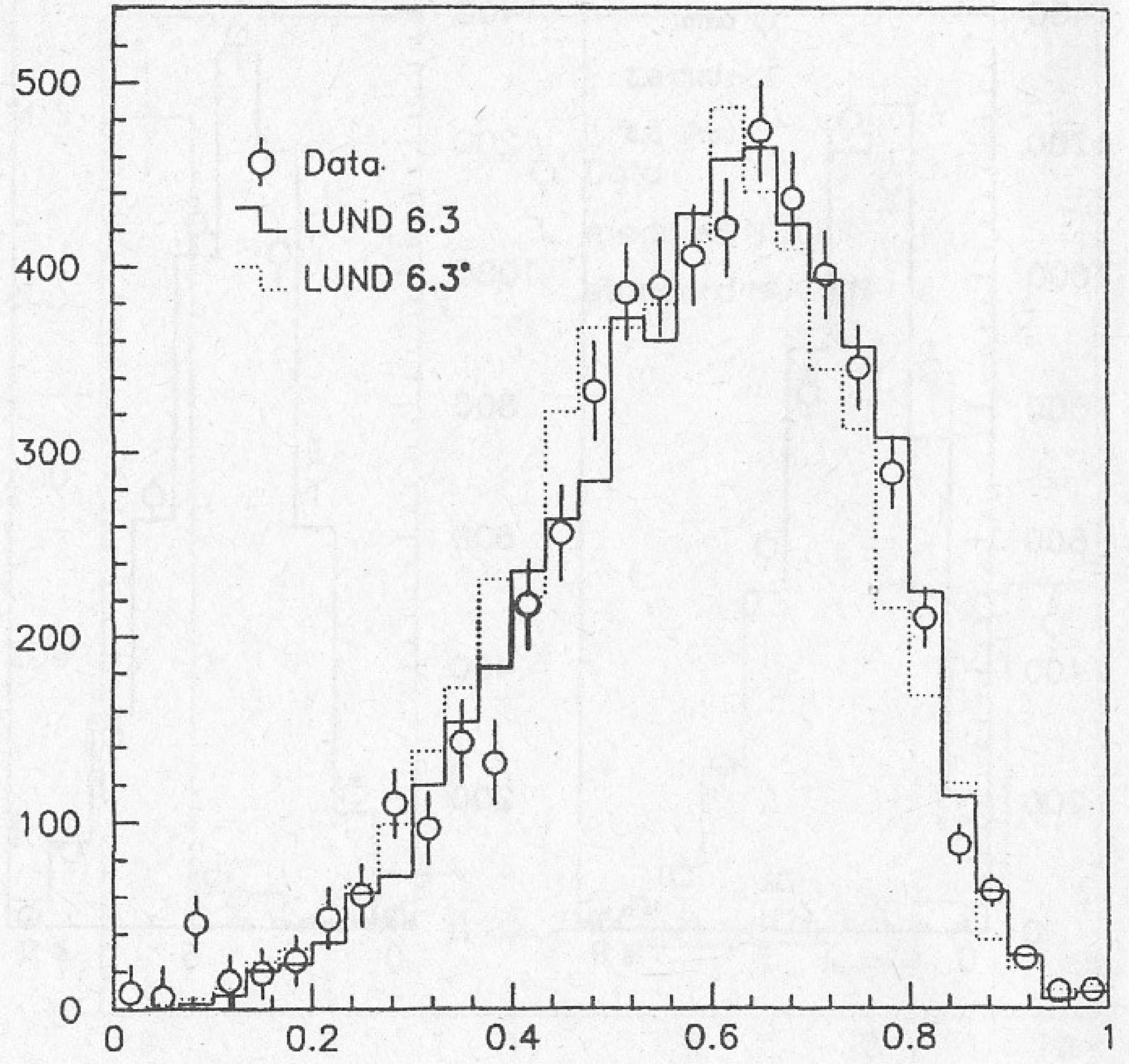

Fig.3. The uncorrected distribution in the sphericity observed in the $\Upsilon(1s)$ decays (point) compared with the Monte Carlo simulation (histograms).

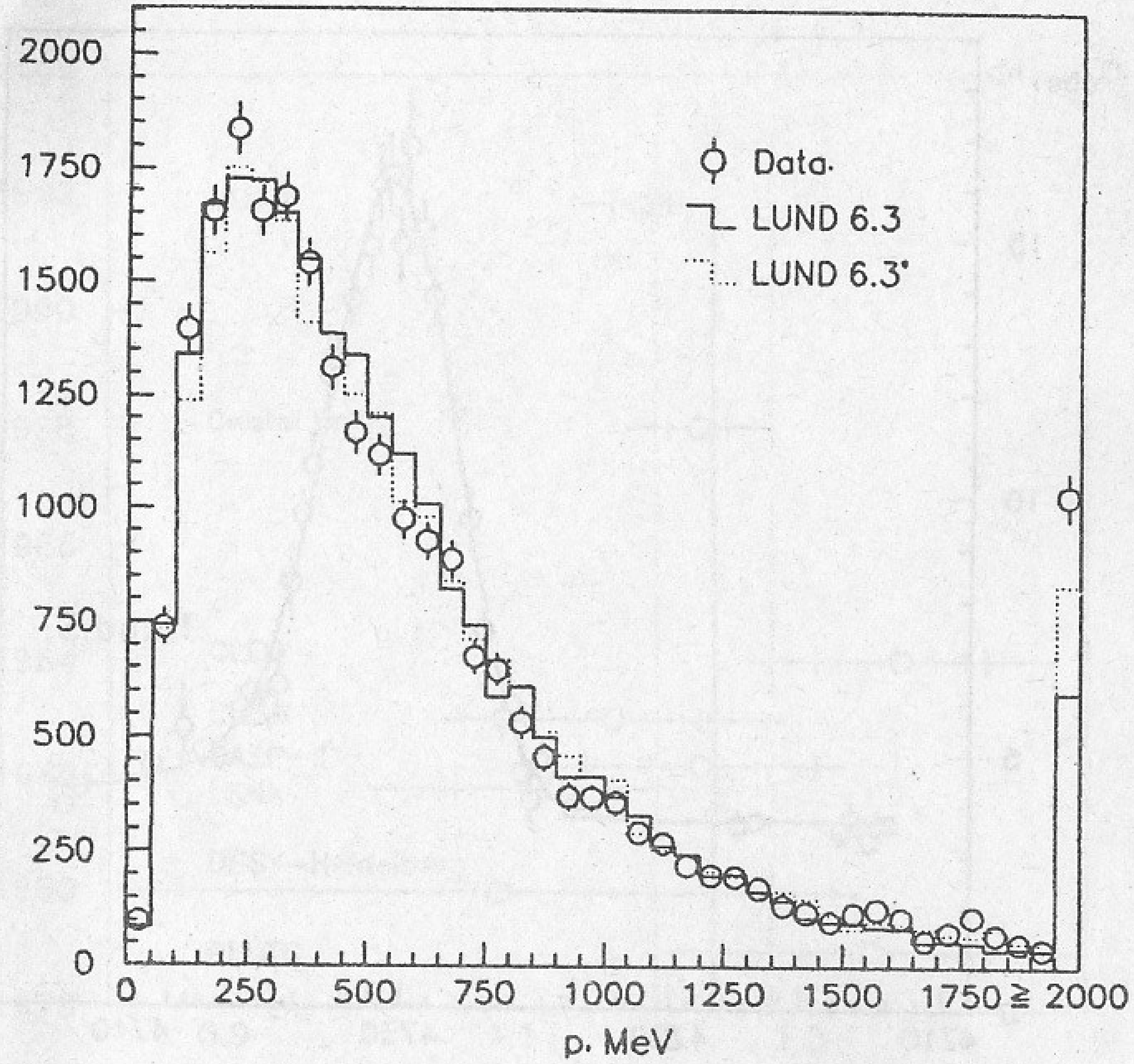

Fig.4. The uncorrected charged particle momentum spectrum observed in the $\Upsilon(1s)$ decays (point) compared with the Monte Carlo simulation (histograms).

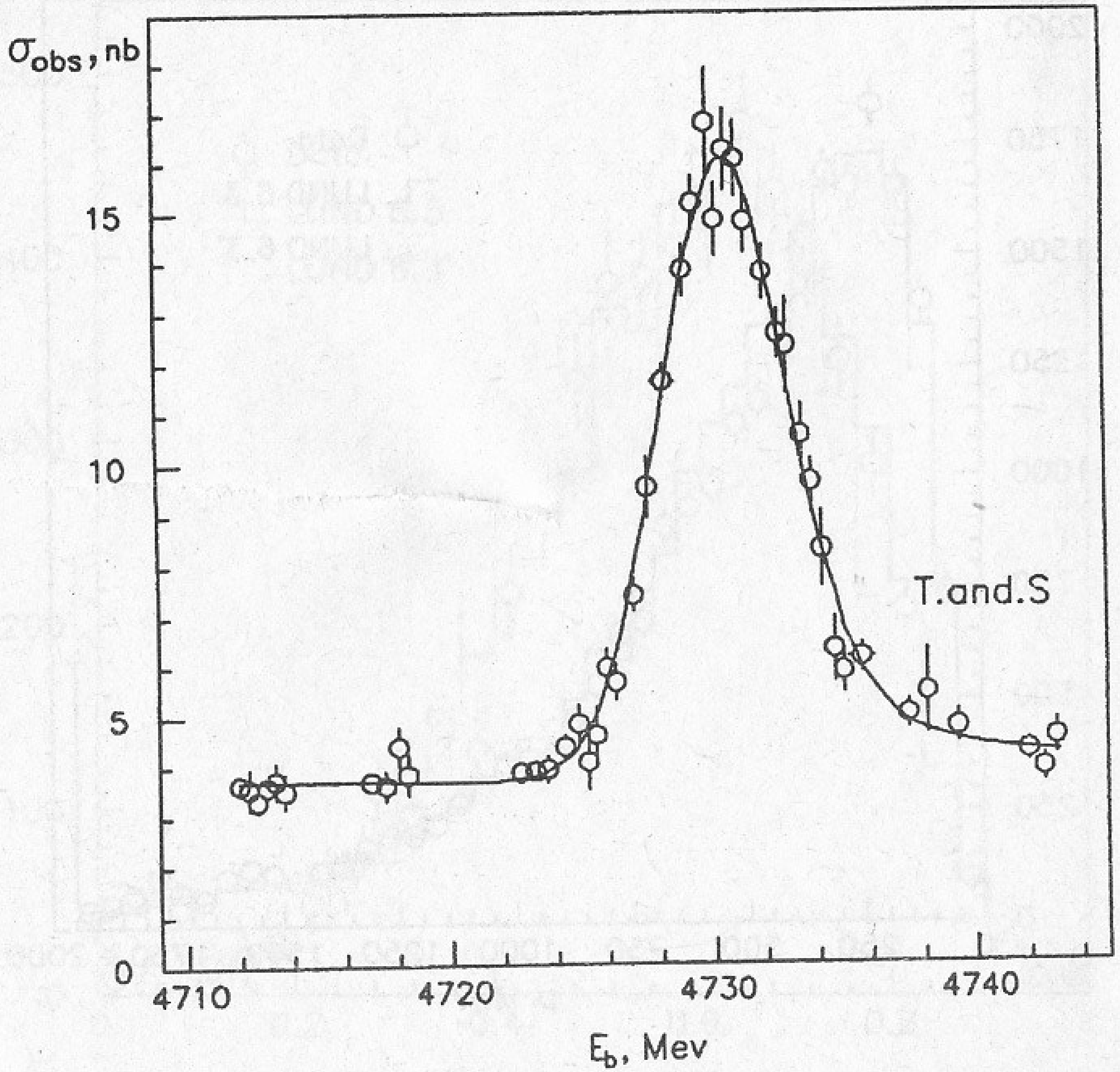

Fig.5. The measured cross section for $e^+e^- \to$ *hadrons* uncorrected for acceptance and backgrounds with *T.and.S* selection criterion.

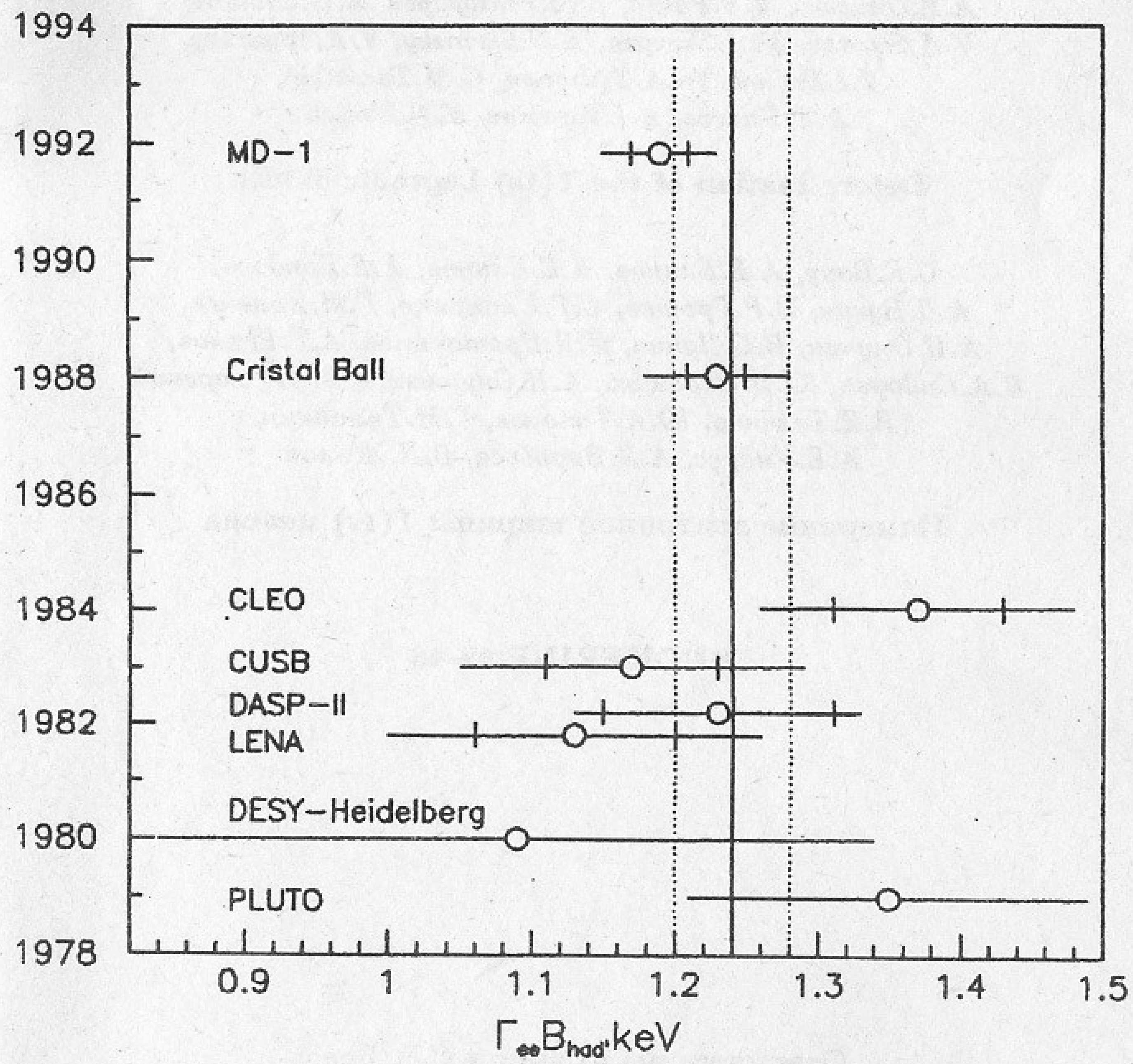

Fig.6. Compilation of $\Gamma_{ee} \cdot B_{had}$ values. The full error bars represent total errors, the small ones show statistical errors separately. The vertical lines illustrate the world average and its error (this experiment is not included). See Table 3 for references.

S.E.Baru, A.E.Blinov, V.E.Blinov, A.E.Bondar,
A.D.Bukin, V.R.Groshev, S.G.Klimenko, G.M.Kolachev,
A.P.Onuchin, V.S.Panin, I.Ya.Protopopov, A.G.Shamov,
V.A.Sidorov, Yu.I.Skovpen, A.N.Skrinsky, V.A.Tayursky,
V.I.Telnov, Yu.A.Tikhonov, G.M.Tumaikin,
A.E.Undrus, A.I.Vorobiov, V.N.Zhilich

Determination of the $\Upsilon(1s)$ Leptonic Width

С.Е.Бару, А.Е.Блинов, В.Е.Блинов, А.Е.Бондарь,
А.Д.Букин, В.Р.Грошев, С.Г.Клименко, Г.М.Колачев,
А.П.Онучин, В.С.Панин, И.Я.Протопопов, А.Г.Шамов,
В.А.Сидоров, Ю.И.Сковпень, А.Н.Скринский, В.А.Таюрский,
В.И.Тельнов, Ю.А.Тихонов, Г.М.Тумайкин,
А.Е.Ундрус, А.И.Воробьев, В.Н.Жилич

Измерение лептонной ширины $\Upsilon(1s)$ мезона

BUDKERINP 92-46

Ответственный за выпуск С.Г. Попов

Работа поступила 17 июня 1992 г.
Подписано в печать 19.06. 1992 г.
Формат бумаги 60×90 1/16 Объем 1,5 печ.л., 1,2 уч.-изд.л.
Тираж 200 экз. Бесплатно. Заказ N 46

Обработано на IBM PC и отпечатано на
ротапринте ИЯФ им. Г.И. Будкера СО РАН,
Новосибирск, 630090, пр. академика Лаврентьева, 11.