ИНСТИТУТ ЯДЕРНОЙ ФИЗИКИ СО АН СССР

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PRELIMINARY RESULTS OF EXPERIMENTS WITH THE MD-1 DETECTOR ON THE STUDY OF TWO PHOTON PROCESSES AND Υ MESON*

ABSTRACT

The experiment at VEPP-4 storage ring with the detector MD-1 has been performed. The main feature of the detector is the transverse magnetic field to the orbit plane. The integrated luminosity of 10 pb^{-1} has been collected, about 10^5 events of Υ-meson production have been detected. The preliminary results on two photon processes $e^+e^- \to e^+e^- + e^+e^-$, $e^+e^- \to e^+e^- + \mu^+\mu^-$, $e^+e^- \to e^+e^-$ + hadr., and also leptonic width and mass of Υ-meson have been obtained.

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During the last running period (1983-1984) the storage ring VEPP-4 with the detector MD-1 was operating in the energy region of Υ-meson. During this time the integrated luminosity of about 10 pb^{-1} was collected, including 2 pb^{-1} obtained in the energy scanning mode in the resonance region for measurement of leptonic width and mass of Υ-meson. Of about 10^5 Υ-mesons are detected in all. During all the experiment a "2γ-trigger" was operating.

Up to now only small part of data has been analized and here we present only preliminary results of the performed experiment.

The detector MD-1

Scheme of the MD-1 is shown in Fig.1,2. Magnetic field in the detector is transverse to the orbit plane, field strength is 11.3 kGs. Inside the coil there are coordinate chambers, scintillation counters, gas Čerenkov counters and shower-range chambers. In addition the muon chambers are placed beyond the coil, inside and beyond the yoke [1,2].

From both sides of the main magnet there are additional bending magnets and system for tagging of scattered electrons in two photon processes (SETS). The distance between lenses nearest to the detector is 9.5 m. Of course large distance restricts possibilities for increasing the luminosity by decreasing of β-function, but allows one to obtain high detection efficiency for scattered electrons. SETS detects electrons scattered forward with the energy loss $(E_B - E)/E_B = 0.15-0.50$. Electrons with the beam energy are detected at the angles θ = 12 - 100 mradn.

In Fig.3 the detection efficiency for scattered electrons is shown as a function of the mass W of the produced system for the energy E_B = 5 GeV. Lower curve refers to the case when both electrons are detected, upper - for detection of at least one electron.

Note, that the employment of the transverse magnetic field in the detector MD-1 has allowed us to obtain one order of magnitude higher detection efficiency in comparison with detectors having a longitudinal magnetic field, where electrons can be detected only due to a scattering angle [15].

In the trigger scintillation counters, coordinate chambers and shower-range chambers are used. For Υ-meson the detection efficiency is 99% for $\Upsilon \to$ hadr, 70% for $\Upsilon \to \gamma \xi(2.2) \to \gamma K^+K^-$. For the two photon processes trigger efficiency is 40% for $\gamma\gamma \to$ hadr.

For two photon processes an additional trigger was arranged, which required a detection of both scattered electrons. In this case the requirements in the central detector are softer and the efficiency in this detector is 60% for the $\gamma\gamma \to$ hadr. process.

The luminosity is measured by the processes of single Bremsstrahlung and Bhabha scattering at small angles.

The events of elastic scattering at small angles are detected by 12 scintillation counters. The counting rate is about 0.1 kHz at the luminosity $5.10^{30} cm^{-2}s^{-1}$, the background is 10% of the effect. The error in the calculated detection cross section is determined mainly by complicity of the geometry and is about 20%. To provide high stability of luminosity measurements this system ensures compensation from beam displacement or inclinations. Besides , in the vertical plane the orbit position is fixed by the feedback from the ionization chambers measuring the centre of synchrotron radiation beam [4,11]. The control of the luminosity by ratio of numbers of electrons scattered up and down shows that instability of this ratio is 1,5%.

Detection of bremsstrahlung photons is performed both in electron and positron directions, the background level due to residual gas does not exceed 0.02%. Note that for calculation of the cross section for $e^+e^- \to e^+e^-\gamma$ one should use formulae taking into account the effect of restrictions of impact parameters by transverse beam sizes [3] . Besides that at E_B = 4.7 GeV an additional contribution 30% from $e^+e^- \to e^+e^-\gamma$ to the counting rate comes from the process of Compton backscattering of synchrotron radiation on the colliding beam $\gamma e \to \gamma' e'$.

The systematic error of this method of luminosity monitoring is about 10%. It is determined by errors in the knowledge of beam size and detection threshold. The ratio of luminosities measured in electron and positron directions was constant during the experiment with the accuracy of 0.5%. The ratio of

luminosities for small angle scattering and single bremsstrahlung was stable to within 2%.

The absolute calibration of the luminosity measurement has been performed by the process of double bremsstrahlung $e^+e^- \to e^+e^- + \gamma\gamma$, the cross section of which can be calculated with accuracy better than 1% [5] . At this moment we estimate the accuracy of absolute luminosity measurement to be 3%.

Experiment

The experiment was carried out from November 1983 to June 1984. At the beginning, the minimum β-function and the luminosity were the following: β_z = 19 cm, $L_{max} = 3 \cdot 10^{30} cm^{-2}s^{-1}$. In January 1984 the β_z-function has been decreased to 12 cm, allowing an increase of the maximum luminosity up to L_{max} = $= 5 \cdot 10^{30}$. The total integrated luminosity is equal to 10 pb^{-1} including 6 pb^{-1} in the Υ-resonance region, 2 pb^{-1} off the resonance. Another 2 pb^{-1} have been collected by means of scanning the resonance region. The background measurements were made with separated beams during 15% of the total time.

In order to exclude the possible dependence of the detection efficiency on the beam polarization during the data taking, the beams were kept unpolarized using the depolarizer.

Data taking in April was made in the following special way. The measurement of the leptonic width and mass of the Υ-meson required a repeated scanning of the Υ-resonance energy region and several calibrations of the storage ring energy per day.

The energy calibration was carried out using the resonance depolarization method developed in our Institute in 1975 [6] . This method has been used for high precision mass measurements of ϕ-meson [7] , charged [8] and neutral [9] kaons , Ψ and Ψ' mesons [10] and also Υ, Υ', Υ''-mesons [11, 12] . Similar to our previous experiments the method of synchrotron radiation backscattering on the colliding beam developed in our Institute [4] was used.

The accuracy of energy measurement depends on the beam polarization degree and was in average of 0.07 MeV (in mass scale) during the experiment. About 90 energy calibrations have been carried out. The calibrations were performed in the beginning and in the end of runs, the direction of the depolarizer frequency was varied. Besides that, several special runs with continuous energy calibration have been carried out. These measurements have shown that the energy instability during a few hours is not more than 0.08 MeV (in mass scale), the depolarizer band width is 0.24 ± 0.05 MeV.

2 γ -processes

1. $\gamma\gamma \to e^+e^-$. For the first time this process has been observed at the VEPP-2 storage ring [13] . The present experimental situation is described in the reviews [14, 15] . The total cross section of this process is equal to $7 \cdot 10^6$ nb at E_B= 5 GeV. The kinematics of particles in this process is similar to one of the process of electron-positron pair production by synchrotron radiation photons on the electrons of colliding beam. At the beam energy E_B= 5 GeV the counting rates of both these processes have comparable order of magnitude under the conditions of our experiment. At the energy E_B= 1.8 GeV the counting rate of $\gamma_{SR} e \to e + e^+e^-$ process is negligible in comparison with $e^+e^- \to e^+e^- + e^+e^-$ counting rate.

Therefore we have performed the experiment on $e^+e^- \to e^+e^- e^+e^-$ reaction at the energy E_B= 1.8 GeV. In this experiment only the produced pairs were detected. In Fig.4 the distribution of events on the pair effective mass is shown. Up to now there have been no experimental data for such small invariant masses. At present Monte Carlo simulation of this process is being fulfiled using the Vermaseren program [16] . The detector operation is computer-modelled [17] .

2. $\gamma\gamma \to \mu^+\mu^-$. For the first time this process has been observed at the storage ring ADONE [18] . The present experimental situation is described in reviews [14, 15] . In our experiment up to now, the total integrated luminosity 1.3 pb^{-1} has been analized. The events with two detected scattered electrons were selected. Both electrons were required to be off the horizontal region of ±2 mm width containing the main part of single bremsstrahlung background in proportional chambers of tagging system. In the central detector two particles were required to be in shower-range chambers. The number of selected events is 189. The visible cross-section of the reaction $e^+e^- \to e^+e^- + \mu^+\mu^-$ is equal to 0.12 ± 0.01 ± 0.03 nb^{-1}. The Monte Carlo simulation gives 0.11 ± 0.03 nb.

The analysis of the total experimental data is expected to give about 2000 events.

3. $\gamma\gamma \to$ hadr. The measurement of the total cross-section is very interesting because it will allow the theory to establish a connection between NN , γN and $\gamma\gamma$ processes. For the real photons dependence of the cross section on the effective mass of the $\gamma\gamma$-system can be written down in the form:

$$\sigma_{\gamma\gamma} = A + \frac{B}{W} + \frac{C}{W^2}$$

The experimental results have been obtained in 1979 by PLUTO [21] and in 1980 by TASSO [22] . The detailed analysis of the problems of extraction $\sigma_{\gamma\gamma}$ from experimental data is given in the review by H.Kolanosky [15] The main problems the following:

a). The effective mass W_{vis}, determined by central detector, is less than the actual mass W. The especially large error arises in the small mass region $W < 2$ GeV.

b). The model dependence on the photon mass, extrapolation to Q^2=0.

c). The model for the reaction $\gamma\gamma \to$ hadr.

In our detector when the both scattered electrons are detected there are no problems a) and b). We hope also, that requirements to the model in our case are not so stringent due to sufficiently high effeciency in the central part.

Up to now the integrated luminosity of 1.3 pb^{-1} has been analized under the same tagging condition as for $\gamma\gamma \to \mu^+\mu^-$.

In the central detector it was required that the total number of charged particles and γ-quanta to be greater than 2. Under these conditions 63 events in the effective mass region between 0.5 and 4 GeV has been selected. The total analysis will give about 1 thousand events. The optimization of the model, describing $\gamma\gamma \to$ hadrons kinematics is in progress.

Υ-meson

1. Γ_{ee}. The experimental result on the leptonic width are [26] :

1.33 ± 0.14	1979	PLUTO
1.35 ± 0.11 ± 0.22	1980	DASP II
1.13 ±0.09 ± 0.08	1982	LENA
1.15 ± 0.05 ± 0.10	1983	CUSB
1.30 ± 0.05 ±0.08	1984	CLEO [27]

Let us pay your attention to the radiative corrections. Usually for correction of experimental data the formula from the work [30] is used. Recently E.Kuraev and V.Fadin [28] have carried out the calculation of the radiative correction with the high accuracy. They have shown that result of the work [30] is wrong. The correct account of the radiative corrections leads for example to change of the leptonic width of Υ on 10%.

Our preliminary result is based on a luminosity integral of 0.9 pb^{-1}. The results of fitting is shown in Fig.5. The measured leptonic width is

$$\Gamma_{ee} = 1.05 \pm 0.04 \pm 0.15 \text{ (preliminary)}.$$

The last number is a systematic error. Using the formula from [30] for radiative correction gives result 9% lower.

2. Υ-meson mass. First high precision measurement of Υ-meson mass was performed by us in 1982 [11] . In 1983 the experiment was repeated [12] . The similar experiment has been carried out at Cornell [29] . The following values of mass (MeV) have been obtained:

9460.6 ± 0.4	Novosibirsk
9459.97 ± 0.11 ± 0.07	Cornell

Our present experiment on Γ_{ee} measurement gives simultaniously the information on Υ-meson mass. Up to now the luminosity integral 0.9 pb^{-1} has been used. All the procedure of analysis is the same as was in [12] . except account of the radiative corrections. which was been done according to the work by E. Kuraev and V.Fadin [28] . The obtained mass value

$$M_\Upsilon = 9461.0 \pm 0.3 \text{ MeV (preliminary)}$$

If we fit the data with the account of the radiative corrections according to the work [30] then the mass value of Υ is higher by 0.1 MeV.

Besides that we analise now the experimental data to extract branching ratios $Br(\Upsilon \to \mu^+\mu^-)$ and $Br(\Upsilon \to \gamma\xi) \cdot Br(\xi \to K^+K^-)$ [23, 24, 25].

In conclusion the authors express their gratitude to many of our colleagues whose labor allowed us to perform the present experiment. We thank E.Kuraev, V.Fadin and V.Serbo for useful discussions. We thank also J.Ranft, H.Mering, K.Hansgen, A. Schiller, Sh.Ritter for help in development of modelling programs.

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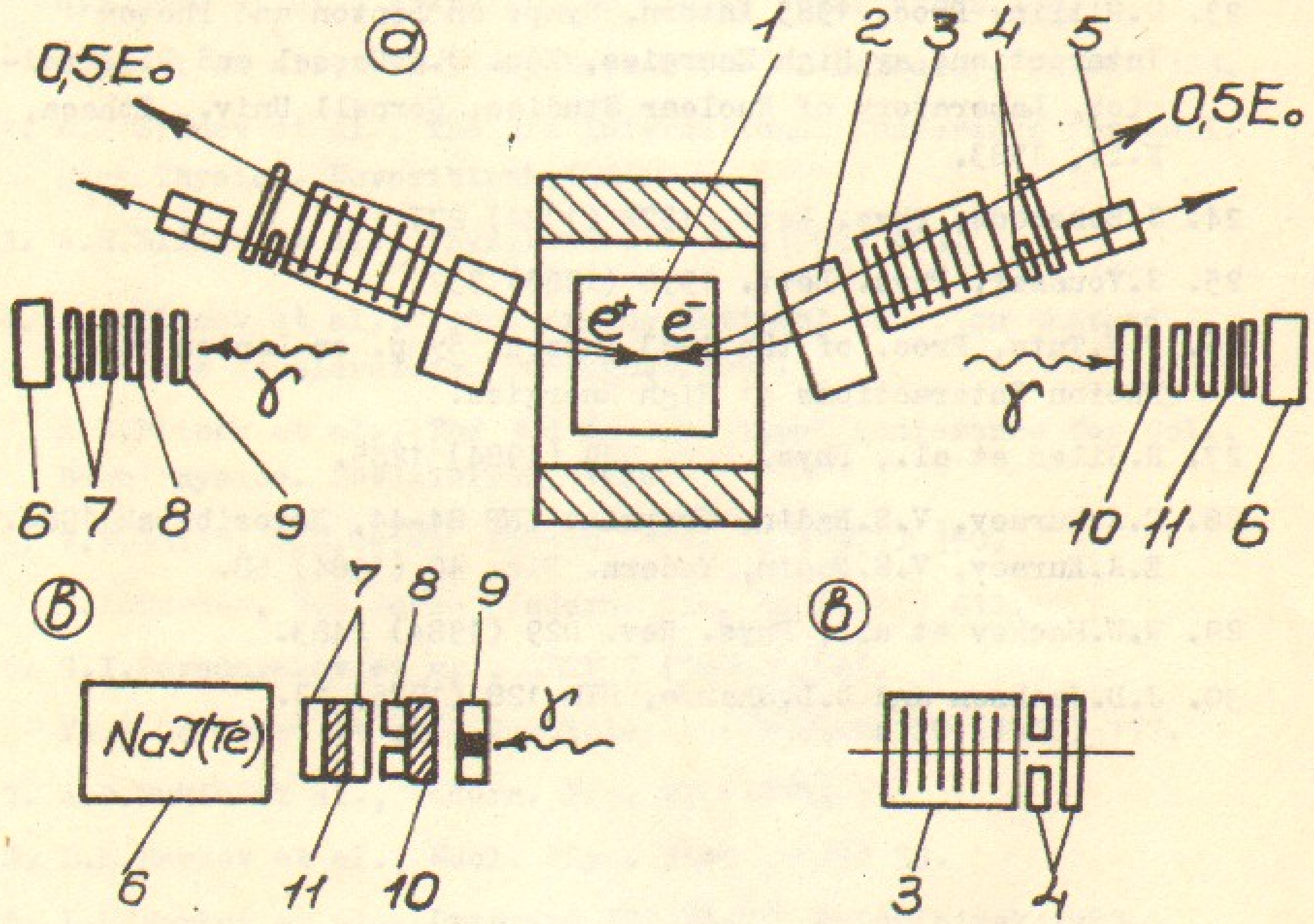

Fig.1. Layout of the detector MD-1
(a - upper view. b - section by vertical plane):
1 - central part; 2 - additional bending magnets;
3 - system for detection of scattered electrons;
4 - counters for luminosity monitoring by small angle elastic scattering; 5 - lenses; 6.8 - counters for polarization measurement by SR; 7- counters for luminosity monitoring by $e^+e^- \to e^+e^-\gamma$; 9-doubled ionization chambers; 10- lead plate of 13mm thickness; 11 - lead plate of 5 mm thickness.

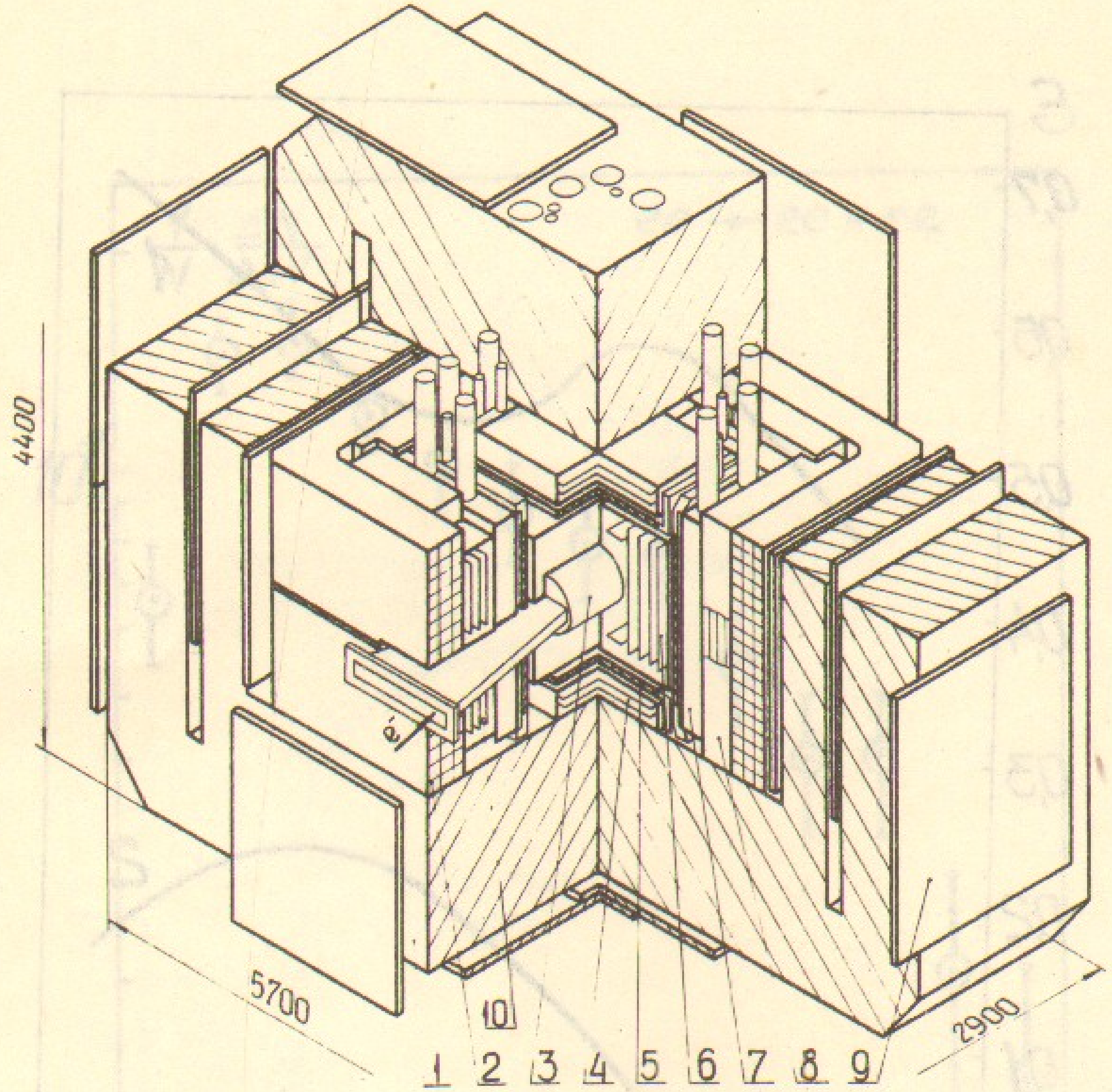

Fig.2. Detector MD-1
1 - magnet yoke; 2 - copper winding; 3 - vacuum chamber; 4,8 10 - shower-range chambers; 5- scintillation counters; 6 - coordinate chambers; 7 - gas Čerenkov counters; 9 - muon chambers.

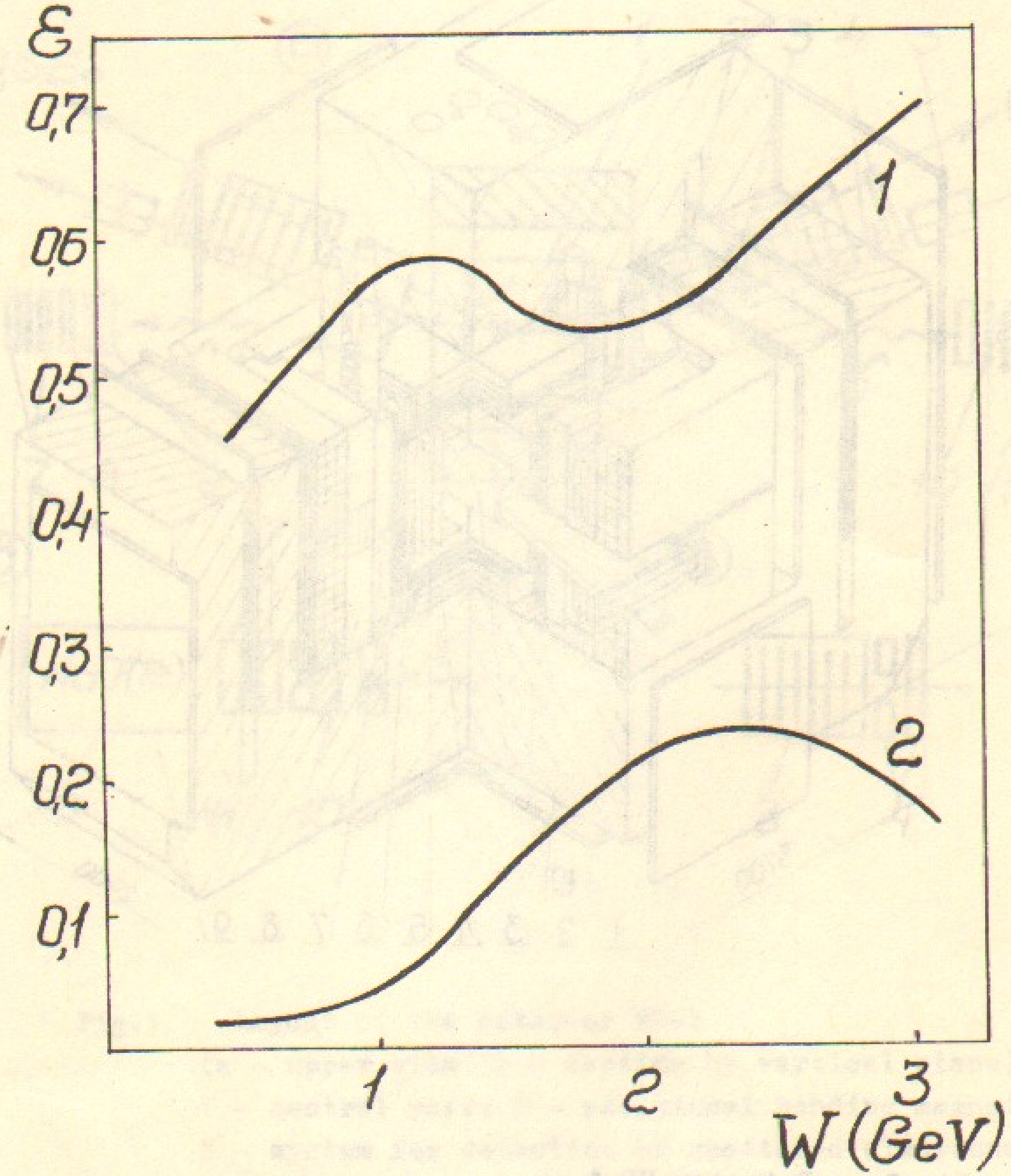

Fig.3. The detection efficiency for one scattered electron (1) and both scattered electrons (2) in the detection system of MD-1 as a function of W of $\gamma\gamma$-system

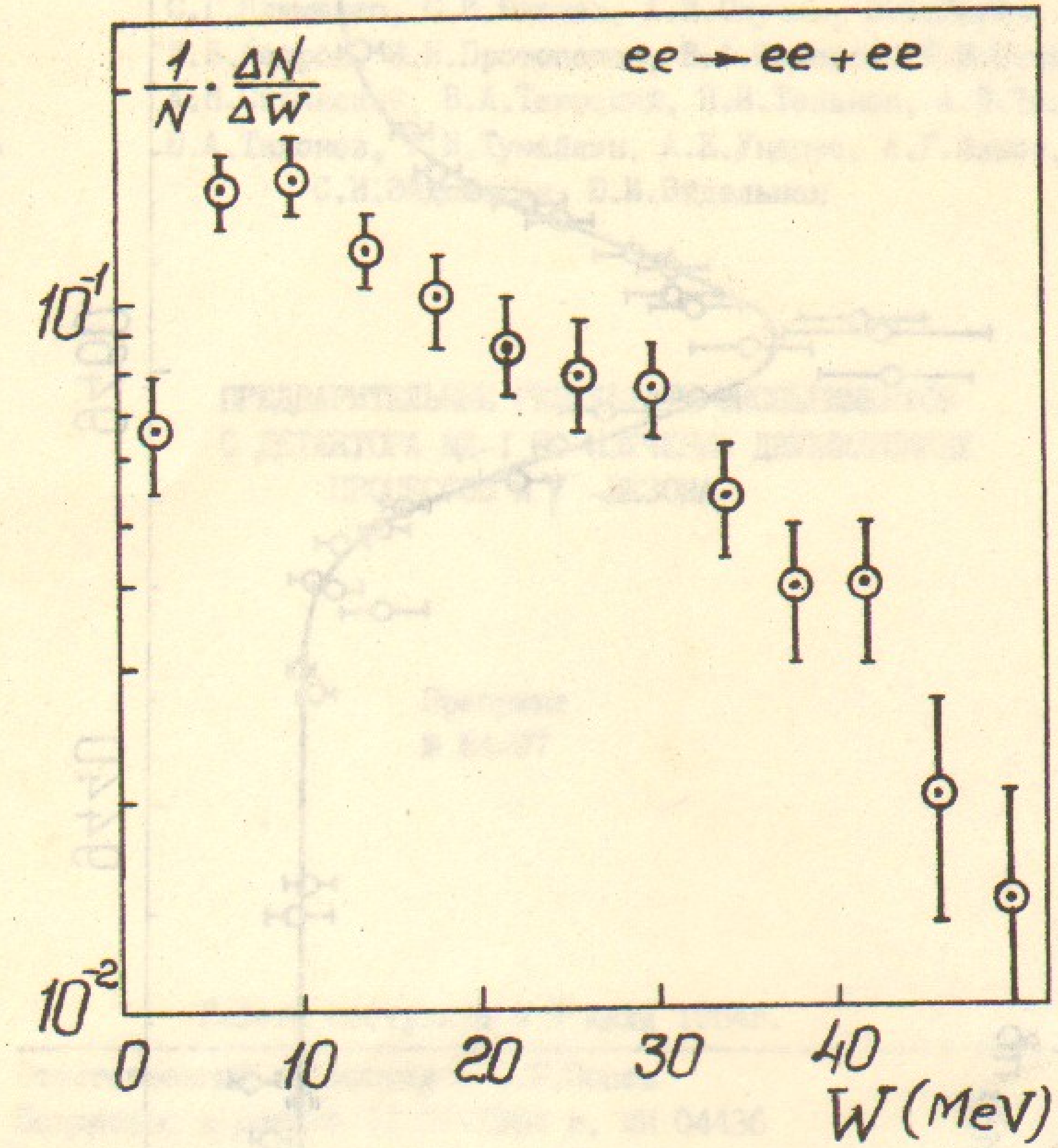

Fig.4. Distribution of invariant mass of e^+e^- pair produced in $e^+e^- \to e^+e^- + e^+e^-$ process at the energy E_B= 1.8 GeV

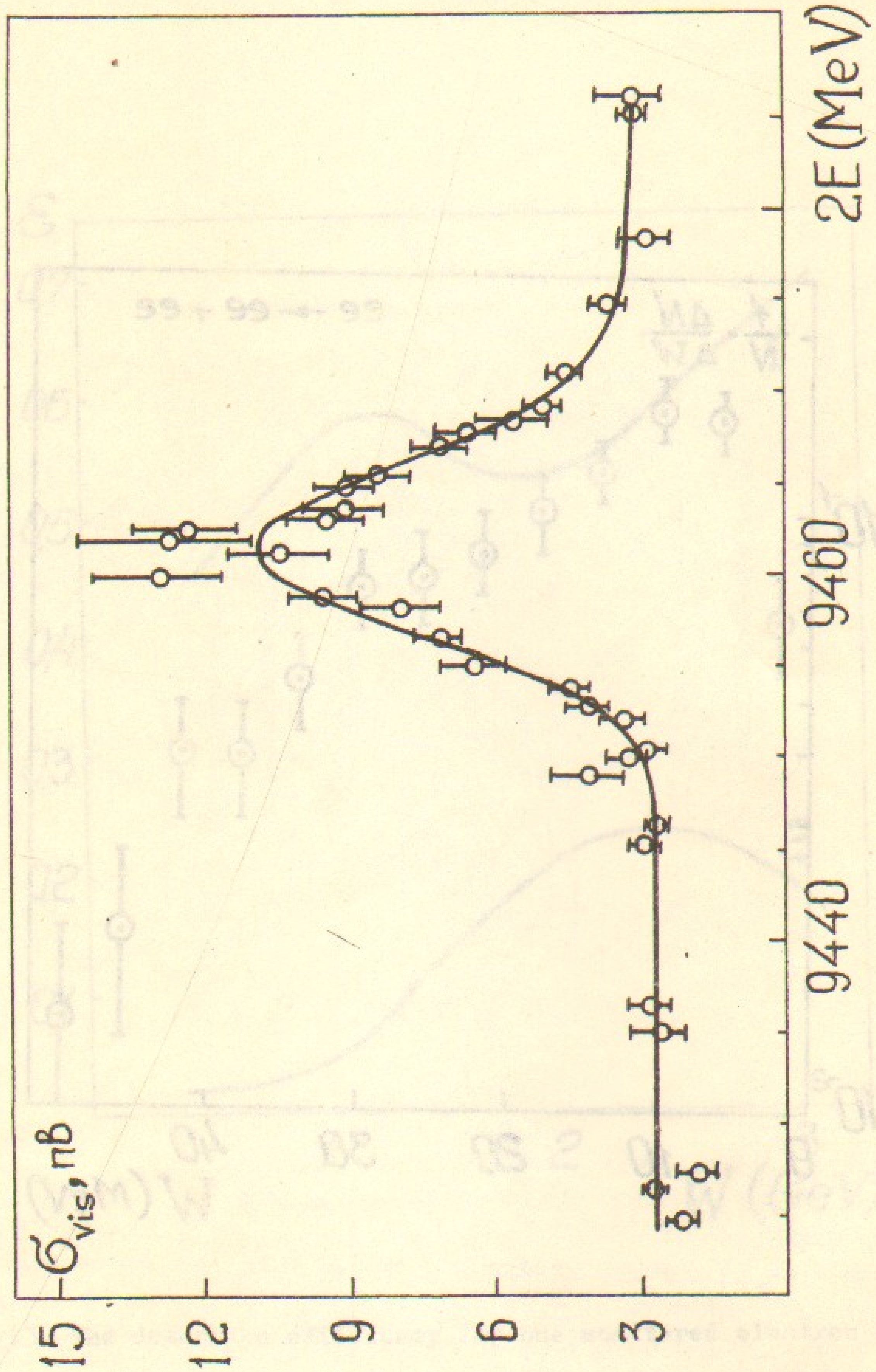

Fig.5. Observed hadronic cross section in the Υ energy region

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ПРЕДВАРИТЕЛЬНЫЕ РЕЗУЛЬТАТЫ ЭКСПЕРИМЕНТОВ С ДЕТЕКТОРА МД-I ПО ИЗУЧЕНИЮ ДВУХФОТОННЫХ ПРОЦЕССОВ И Υ-МЕЗОНА

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