13

ИНСТИТУТ ЯДЕРНОЙ ФИЗИКИ СО АН СССР

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# SEARCH FOR NARROW RESONANCES IN $e^+e^-$ COLLISIONS IN THE MASS REGION 7.2—10 GeV

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НОВОСИБИРСК

SEARCH FOR NARROW RESONANCES IN $e^+e^-$ COLLISIONS IN THE MASS REGION 7.2-10 GeV*

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Abstract

The scanning has been performed in the energy region $2E$ = 7.2 - 10 GeV with the MD-1 magnetic detector at the storage ring VEPP-4. The integrated luminosity of about 15 $pb^{-1}$ was collected. In the process $e^+e^- \to$ hadrons no new resonances were observed. For part of this energy range the data were obtained for the first time. The existed upper limits on leptonic widths $\Gamma_{ee}$ of possible resonances were lowered by a factor of 2-8. For the $\zeta$(1p) the upper limit $\Gamma_{ee} < 40$ eV has been established.

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By historical reasons the energy region $2E$ = 7.2 - 10 GeV (excluding $\Upsilon(1S)$ ) in $e^+e^-$ collisions was not much studied. The region below 7.45 GeV was systematically investigated with detector MARK-1 at SPEAR /1/. Inside the considered energy range there are results of the scanning with detector LENA at DORIS /2/ in the regions 7.4 - 7.48 GeV and 8.67 - 9.43 GeV with the total integrated luminosity of 1.14 $pb^{-1}$ only. At the same time an existence of new narrow resonances is not ruled out in this region. Also there are some questions on the R behaviour (see Particle Properties). Recently an interest to this region has grown considerably due to observation by Crystal Ball of the charge even state $\zeta$(8.3) /3/. According to one of the models /4/ $\zeta$(8.3) is ground state of two scalar quarks. New bound states of this quarks $\zeta(1P)$, $\zeta(2P)$, $\zeta(3P)$ were predicted. These states can be observed as narrow resonances in the $e^+e^-$ annihilation. If scalar quarks interact like known quarks then leptonic width $\Gamma_{ee}(\zeta(P)) \approx 30$ eV, that is 40 times less than $\Gamma_{ee}$ for $\Upsilon(1S)$. For VEPP-4 the heights of such resonances have to be about 10% of nonresonant cross section. There is also another model /5/, which predicts $\Gamma_{ee}$ for bound states of scalar quarks by two orders higher.

In this paper we present the preliminary results of the experiment performed from September 1984 by June 1985 with detector MD-1 at VEPP-4. In the energy region $2E$ = 7.2 - 10 GeV the integrated luminosity of about 15 $pb^{-1}$ was collected. Its distribution over the energy region is shown in Fig. 1. The energy range scanning was done by step $\Delta(2E)$ = 4 - 5 MeV, while the c.m.s. energy spread in VEPP-4 is $\sigma_{2E}$ = = 4.4 $(2E/M_\Upsilon)^2$ MeV.

The average luminosity during the experiment was $(1 - 3)\cdot 10^{30}$ $cm^{-2}$ $sec^{-1}$ ( $\bar{L} \sim E^4$ ). The data in each energy point were taken for several runs. For different energy regions from 2 to 4 scannings were carried out.

The luminosity monitoring was performed by the processes of single Bremsstrahlung and small angle Bhabha scattering. The ratio of luminosities by these two methods was stable within 2%. The absolute luminosity calibration was done by the processes of double Bremsstrahlung and large angle Bhabha scattering. For the time being an accuracy of the absolute luminosity measurement is estimated to be $\pm 4\%$.

The beam energy was determined and periodically checked using the resonance depolarization method /7/. The operative energy measurement were carried out by NMR and beam pickups. As a result in each run the c.m.s. energy was known with an accuracy better than 1 MeV.

In order to exclude the possible dependence of the detection efficiency upon the beam polarization the beams were kept unpolarized using the depolarizer.

The efficiency of the trigger for $\Upsilon(1S)$ was found to be 98.5%. In this work the fast off-line processing was performed with hard selection criteria. For resonances of the masses 7.2 and 9.46 GeV we obtained efficiences $50 \pm 5\%$ and $65 \pm 5\%$ correspondingly. The efficiences were calculated using Lund routine with the Monte Carlo simulation of full histories of particles in the detector /8/.

The experimental data are presented in Figs. 2-6. Fitting of resonance curves with width equal to c.m.s. energy spread was carried out in the way similar to the paper /9/, but for the radiation corrections the formulae obtained by E.Kuraev and V.Fadin /10/ were used. They have shown that previously used formulae from the paper /11/ are not correct and overestimate $\Gamma_{ee}$ (by 10% for our case).

Data processing gave the following results. No new resonances were observed in the energy region 7.2-10.0 GeV. The upper limits for partial width $\Gamma_{ee}$ of narrow resonances at 90% confidence level are presented in Table 1 and Fig. 7. The energy range was divided into several regions with equal integrated luminosities per point. For each region the maximum $\Gamma_{ee}$ was taken.

The region 8.67-8.88 GeV was scanned with increased density of the integrated luminosity with the aim to search for $\zeta(1P)$ predicted in Tye and Rosenfeld model /4/. The upper limit obtained here is somewhat higher than the predicted $\Gamma_{ee} \approx 24$ eV. The diminution of the upper limit by a factor of 2 would require 4-5 months of data taking in this energy region. At the final analysis the obtained limits can be somewhat diminished.



In conclusion the authors express their sincere gratitude to VEPP-4 and MD-1 staff for help in the work.

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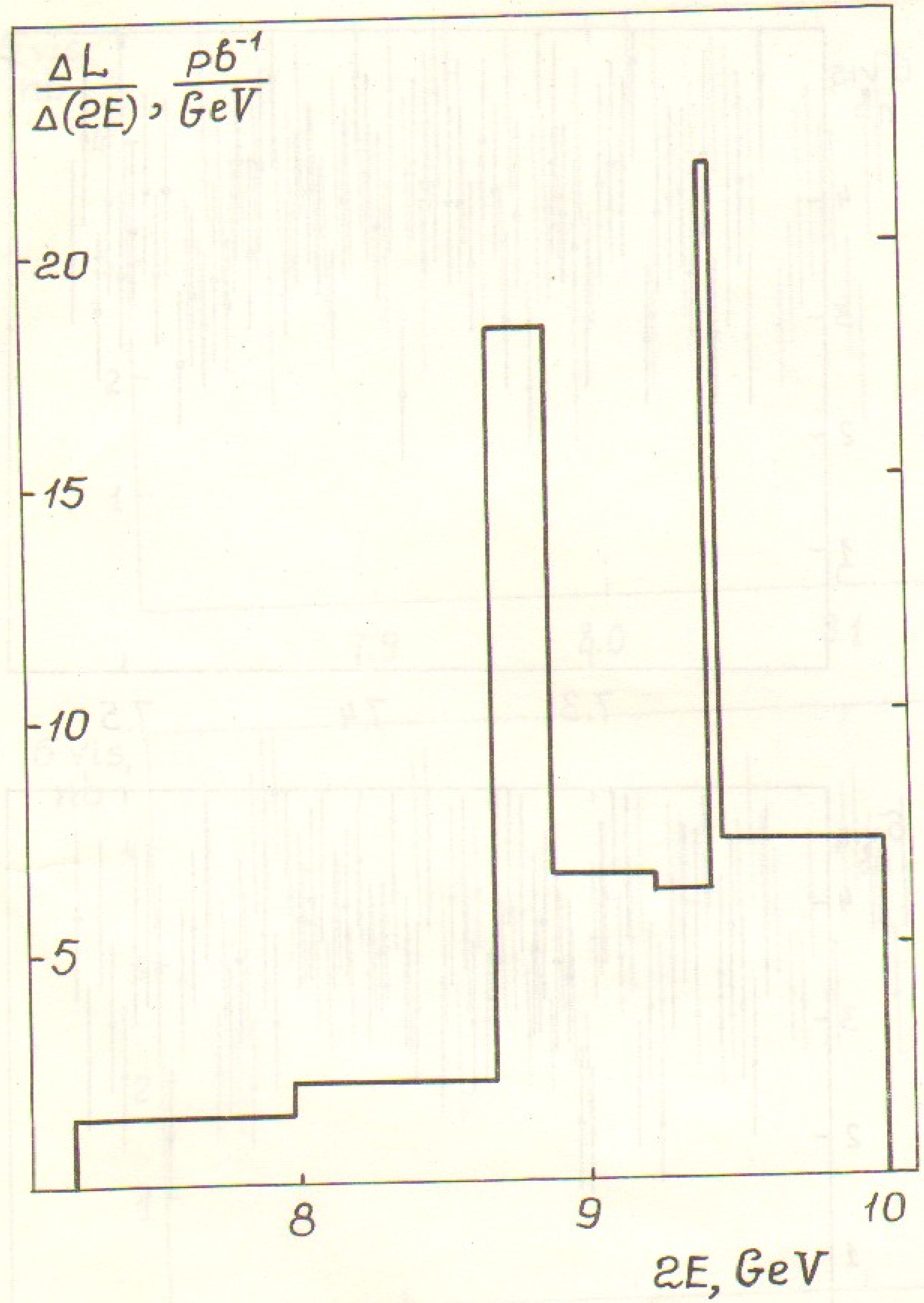


Fig. 1. Distribution of the integrated luminosity over the energy region.

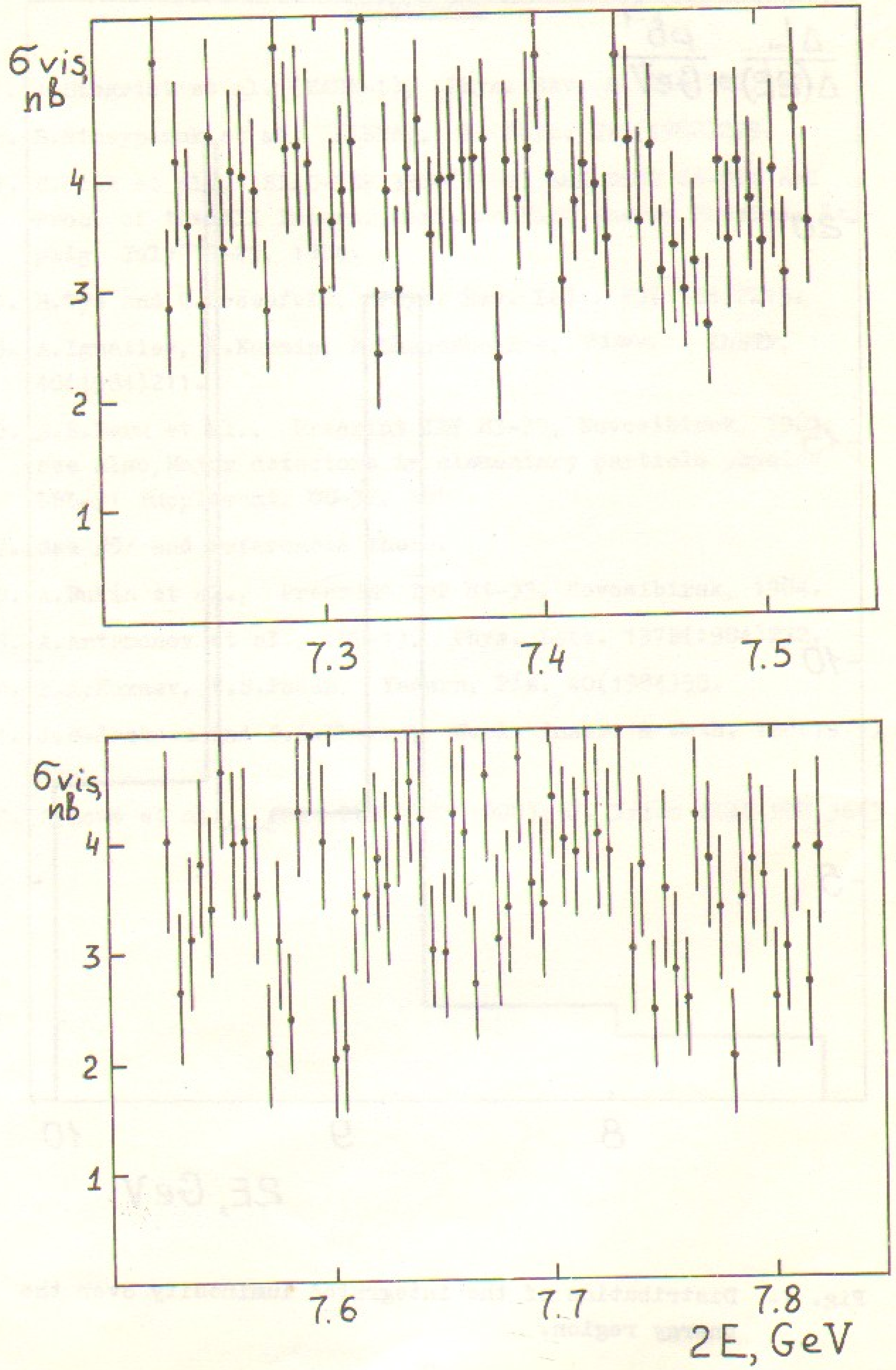


Fig. 2. The observed cross section of ee → hadr. vs c.m.s. energy.

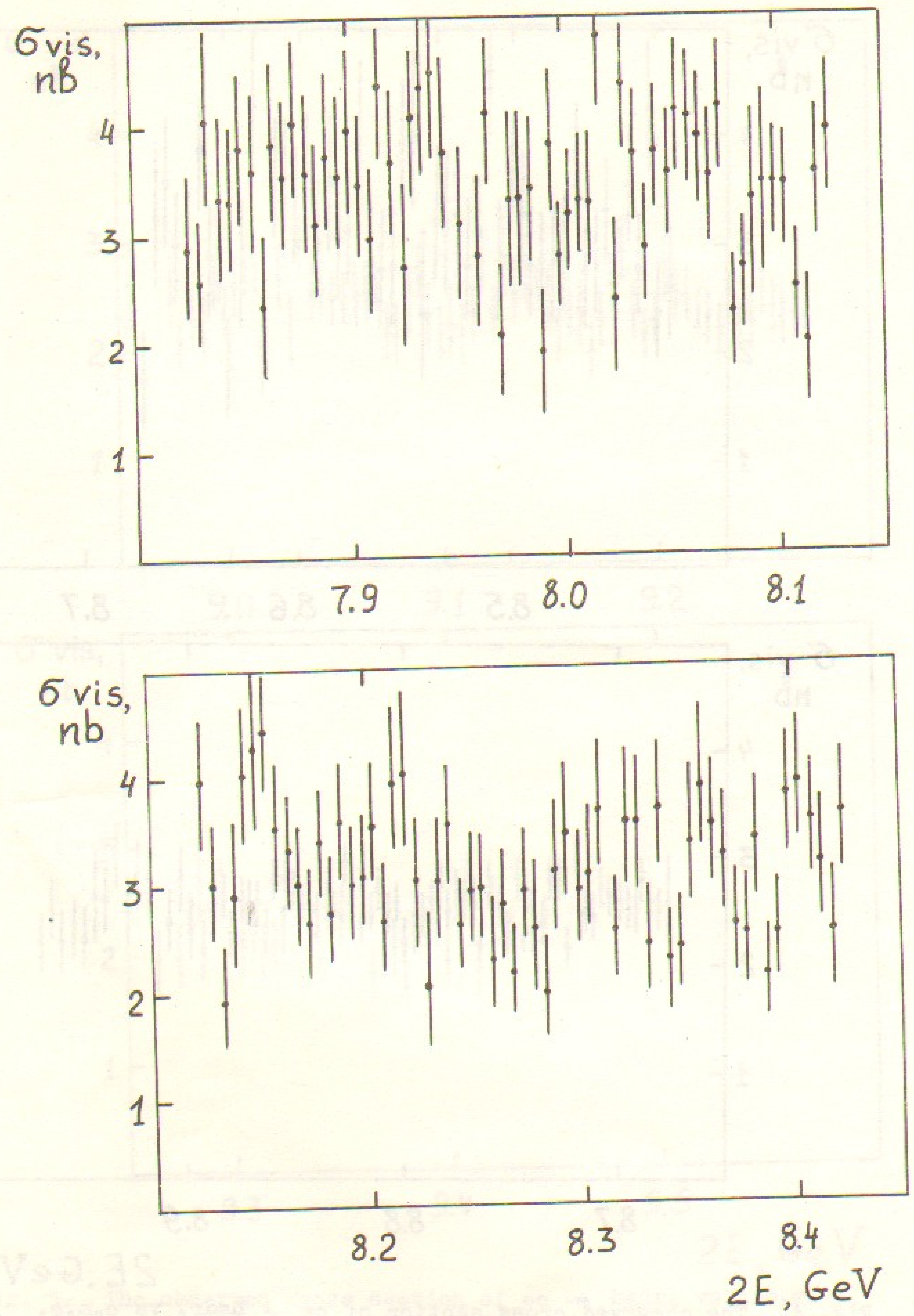


Fig. 3. The observed cross section of ee → hadr. vs c.m.s. energy.

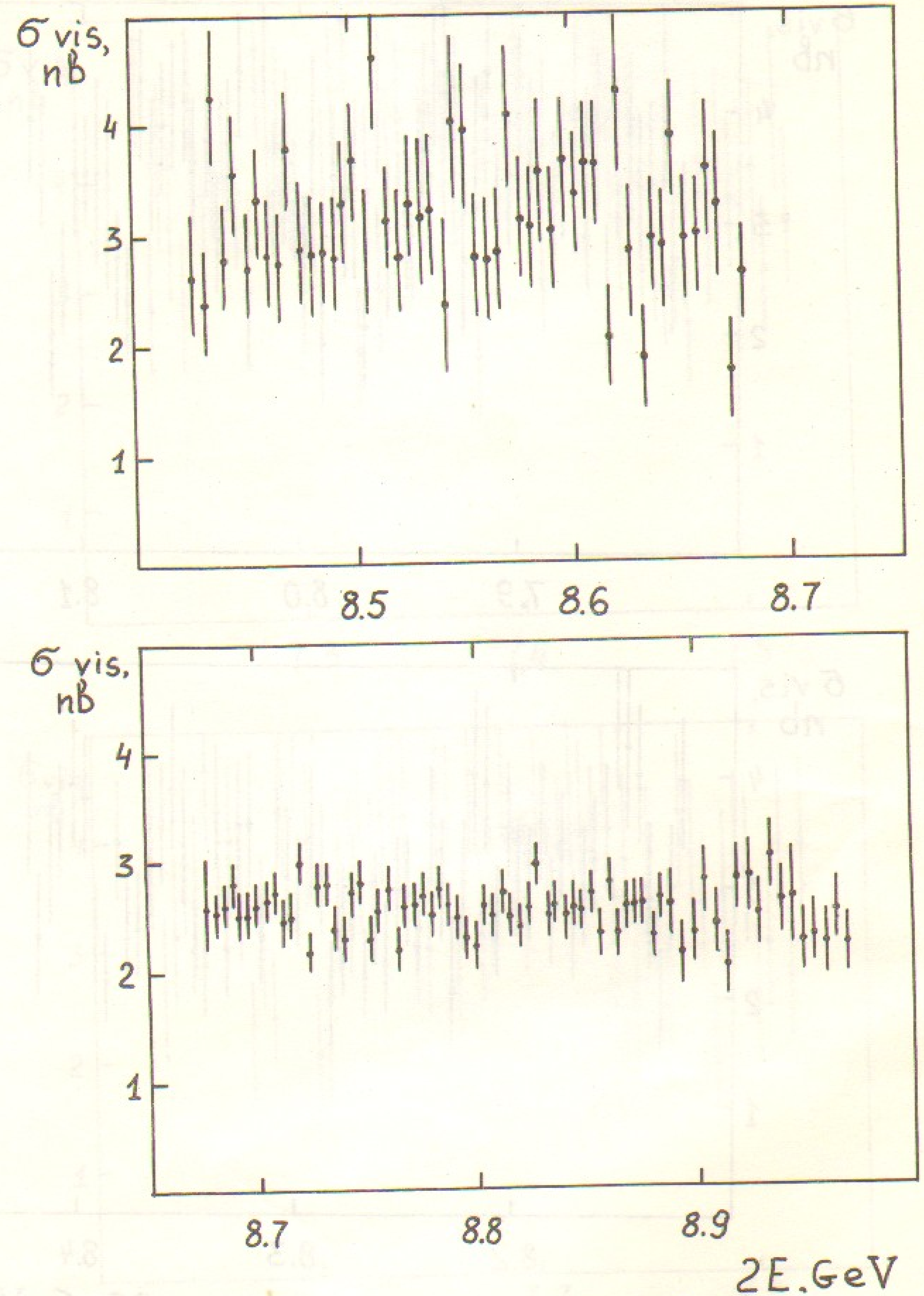


Fig. 4. The observed cross section of ee → hadr. vs c.m.s. energy.



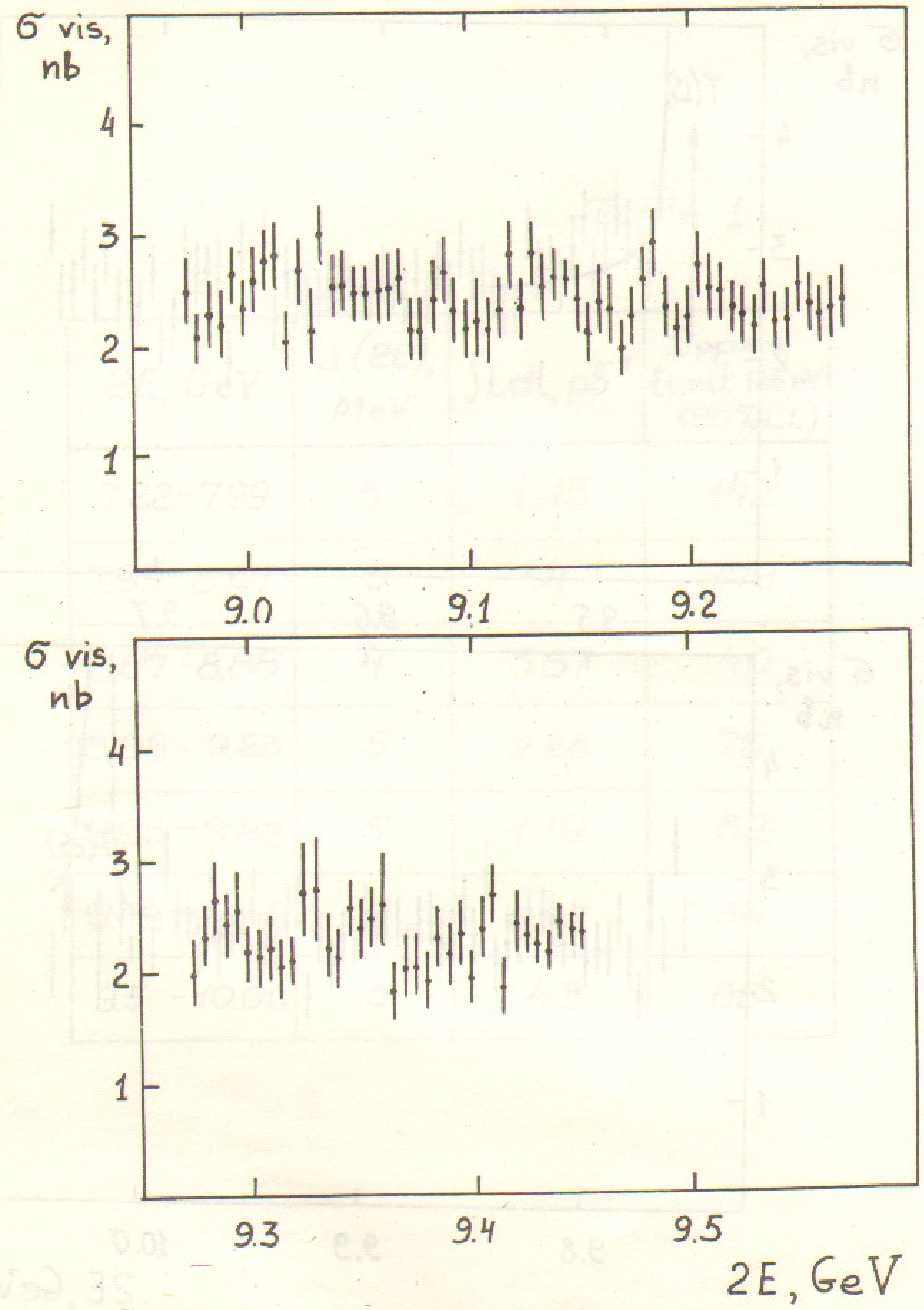


Fig. 5. The observed cross section of ee → hadr. vs c.m.s. energy.

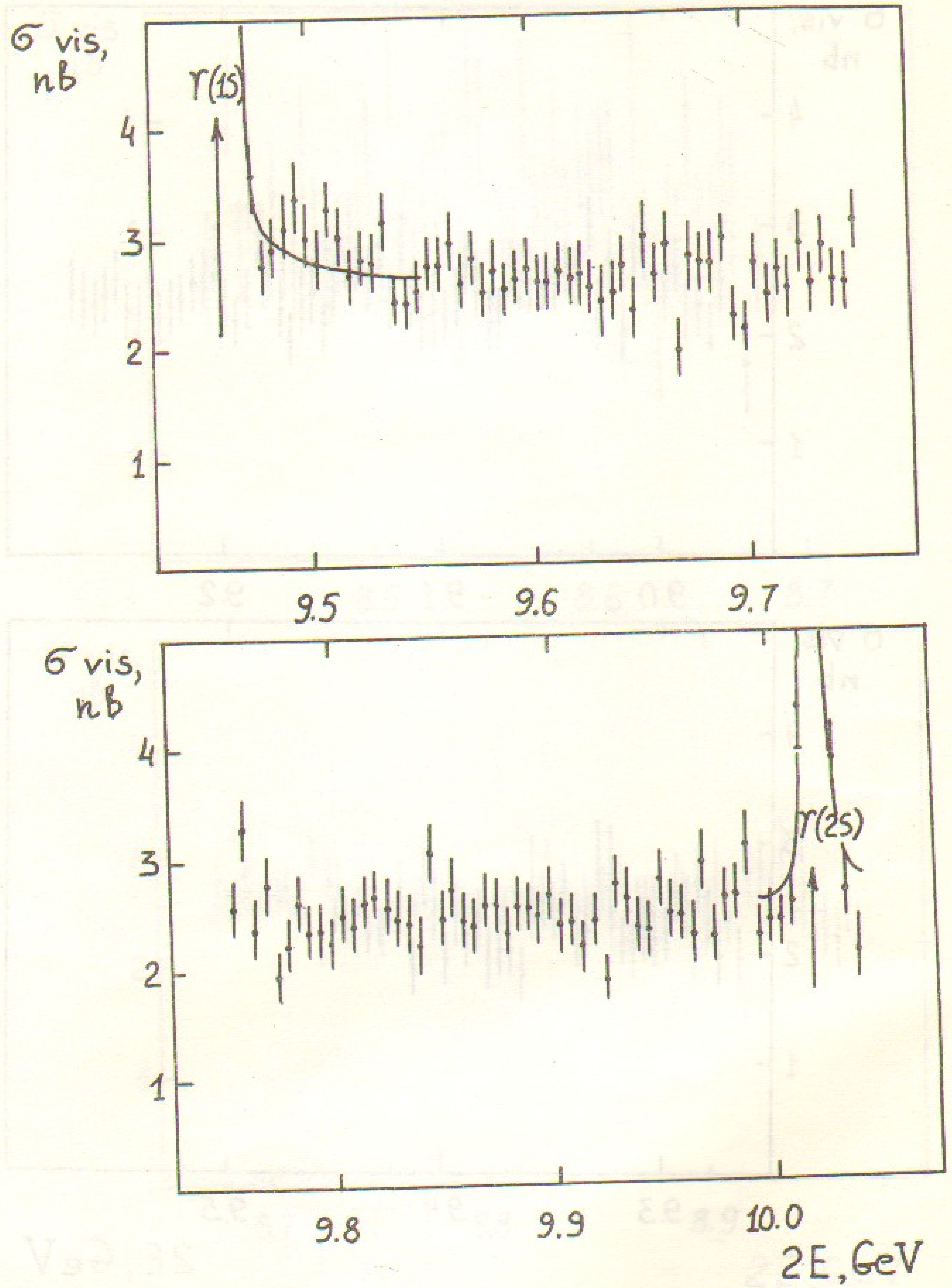


Fig. 6. The observed cross section of ee → hadr. vs c.m.s. energy.



Table 1

| 2E, GeV | Δ (2E), MeV | ∫Ldt, pb⁻¹ | Upper limit $\Gamma_{ee}$,eV (90%CL) |
|---|---|---|---|
| 7.22-7.99 | 5 | 1.15 | 142 |
| 7.99-8.67 | 5 | 1.4 | 179 |
| 8.67-8.88 | 4 | 3.87 | 40 |
| 8.88-9.23 | 5 | 2.28 | 76 |
| 9.23-9.42 | 5 | 1.19 | 82 |
| 9.42-9.445 | 5 | 0.65 | 34 |
| 9.5 - 10.00 | 5 | 4.3 | 66 |

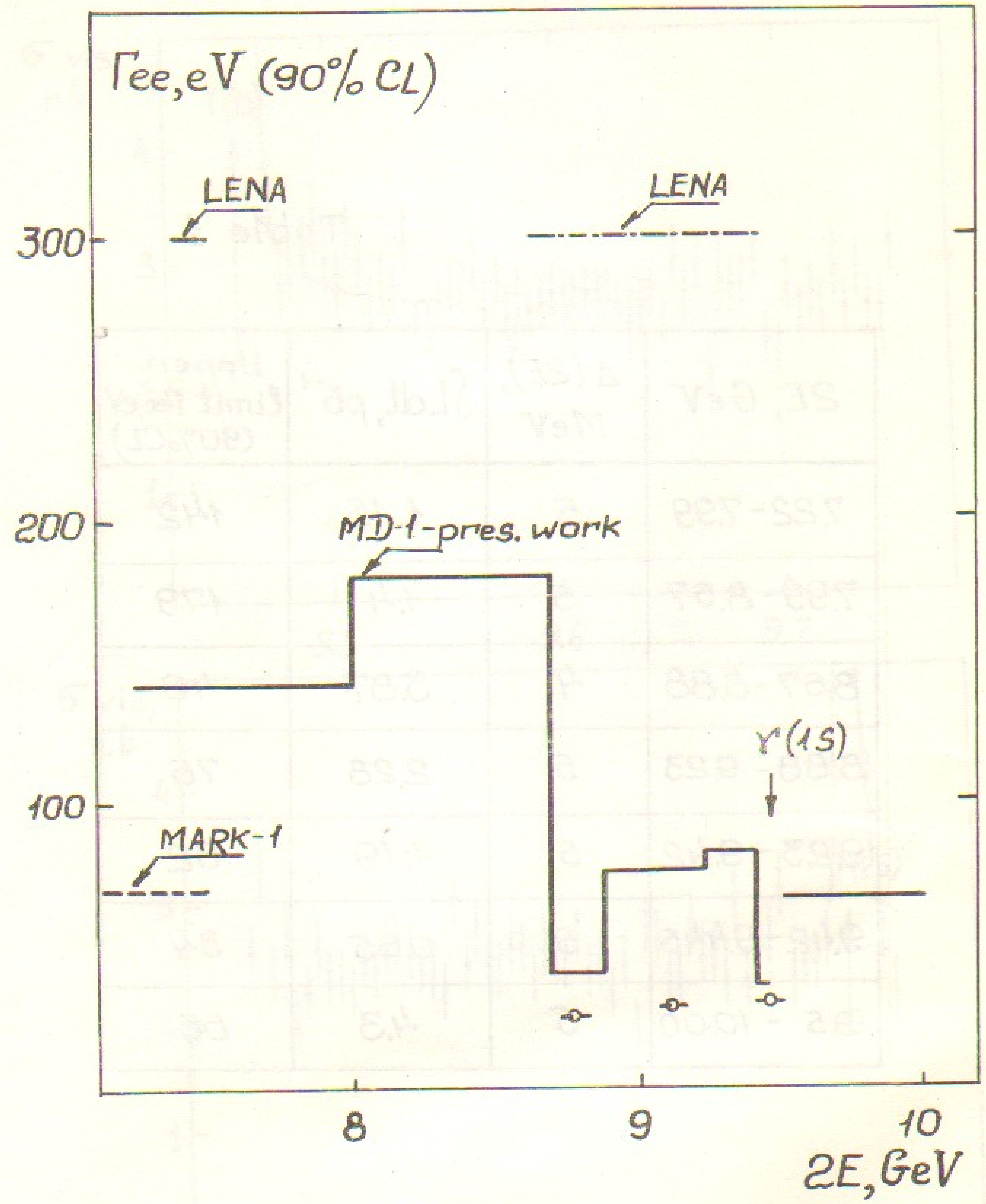


Fig. 7. Upper limits on Γee of narrow resonances (90%CL), - - - MARK-1 /1/, -.-.- LENA /2/, ——— MD-1 present work, O - predictions of Tye and Rosenfeld model for ζ(1P), ζ(2P), ζ(3P) /4/.



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ПОИСК УЗКИХ РЕЗОНАНСОВ В $e^+e^-$ АННИГИЛЯЦИИ В ОБЛАСТИ МАСС 7.2 - IO ГэВ

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