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ИНСТИТУТ ЯДЕРНОЙ ФИЗИКИ СО АН СССР

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PREPRINT 86-107

НОВОСИБИРСК
1986

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A b s t r a c t

A search for the two photon production of $\eta_c$ (2980) has been performed in the reaction $e^+e^- \to e^+e^- \eta_c$. The invariant mass of the $\gamma\gamma$ -system was determined from the energy of detected scattered electrons. A limit for the two photon width $\Gamma_{\gamma\gamma}(\eta_c) < 11$ keV has been obtained.

* Submitted to the XXIII International Conference on High Energy Physics, Berkeley, July 1986.

Recently PLUTO /1/ and TASSO /2/ reported on the observation of the two photon production of $\eta_c$ (2980), the particle with intrinsic charm, in the process $e^-e^+ \to e^+e^-\eta_c \to K_s^0 K^\pm \pi^\mp$. The following quantity has been measured: $\Gamma_{\gamma\gamma}(\eta_c)\, BR(\eta_c \to K_s^0 K^\pm \pi^\mp)$. According to the data of PLUTO it is

$$.5 + .2 - .15 \pm .1 \text{ keV},$$

and from preliminary data of TASSO it is

$$1.2 \pm .6 \pm .4 \text{ keV}.$$

To deduce the value of the two photon width the authors use the MARK III measurement /3/

$$BR(\psi \to \gamma\eta_c) * BR(\eta_c \to K_s^0 K^\pm \pi^\mp) = (1.9 \pm .5)\, 10^{-4}$$

and the CRYSTAL BALL result /4/ on the decay $\psi \to \gamma\eta_c$

$$BR(\psi \to \gamma\eta_c) = (1.27 \pm .36)\, 10^{-2},$$

and obtain the following values:

PLUTO $\Gamma_{\gamma\gamma}(\eta_c) = 33 \pm 20$ keV ,

TASSO $\Gamma_{\gamma\gamma}(\eta_c) = 59 \pm 42$ keV .

Earlier CRYSTAL BALL /5/ placed an upper limit for $\Gamma_{\gamma\gamma}(\eta_c)$ from the reaction $\psi \to \gamma\eta_c \to \gamma\gamma$ : $\Gamma_{\gamma\gamma}(\eta_c) < 20$ keV. The most stringent restriction $\Gamma_{\gamma\gamma}(\eta_c) < 7$ keV has been obtained in the reaction $p\bar{p} \to \eta_c \to \gamma\gamma$ by the R704 collaboration at ISR /6/. To calculate the value of $\Gamma_{\gamma\gamma}(\eta_c)$ the authors used the CRYSTAL BALL measurement /4/ of the total width of $\eta_c$

$$\Gamma(\eta_c) = 11.5 \pm 4.5 \pm 4. \text{ MeV}$$

as well as the MARK III result /3/

$$BR(\psi \to \gamma\eta_c) * BR(\eta_c \to p\bar{p}) = (.14 \pm .07)\, 10^{-4}$$

All the results of MARK III on the branching fractions of $\eta_c$ used above were confirmed by the DM2 collaboration /7/. Thus, at the present time the experimental values of $\Gamma_{\gamma\gamma}(\eta_c)$ are not quite consistent. That can be due to rather indirect methods of $\Gamma_{\gamma\gamma}(\eta_c)$ determination requiring the use of the results of different groups.

At the period from 1983 to 1985 the MD-1 detector /8/ at the VEPP-4 collider collected an integrated luminosity of 30pb$^{-1}$

in the c.m.energy range 7.6 - 10.6 GeV. 23.5 $pb^{-1}$ of the data were collected with the tagging system of scattered electrons (TS). This very sample of events has been used to study the reaction $e^+e^- \to e^+e^-$ hadr./9/. The main specific feature of MD-1 is a magnetic field transverse to the orbit plane allowing detection of scattered electrons and measurement of their energy even with a zero transverse momentum. More detailed description of MD-1 and TS can be found elsewhere /8/.

To study the two photon production of hadrons events were selected with a double tag and more than two particles (including neutrals) in the central part of the detector. To suppress the background from single bremsstrahlung in TS we also required that an angle of both electrons with respect to the orbit plane be greater than $\theta_z > 5\cdot10^{-4}$ radian. More details on the event selection can be found in ref. 9.

Of $3.1\cdot10^7$ detected events 442 satisfied all selection criteria. These events were used for a search of two photon production of $\eta_c$ (2980). The mass of the hadronic system in the process $e^+e^- \to e^+e^-$ hadr was measured by the detected electrons. Their energy was reconstructed from the angle of rotation in the magnetic field and the coordinate in TS. The accuracy of electron energy reconstruction was $\delta E/E = 2\%$. The TS energy scale was calibrated by the process of single bremsstrahlung and during the experiment was checked by Bhabha electrons detected by TS. The uncertainty of the TS energy scale did not exceed 1.3%. The accuracy of the invariant mass determination was $\sigma_W = 90$ MeV at the mass about 3 GeV. Mass dependence of the resolution is shown in Fig. 1.

The detection efficiencies for hadrons in the central part of the detector and for two scattered electrons in TS were obtained by the Monte Carlo simulation and are presented in Fig. 2.

The experimental mass distribution of hadronic events is shown in Fig. 3. No statistically significant signal at 3 GeV is observed, the data are well described by the nonresonant cross section $\gamma\gamma \to$ hard. and the contribution of the two photon production of the $\eta'$ meson. Approximation of the data used for the nonresonant continuum a two-parameter curve $\sigma_{\gamma\gamma\to\text{hadr}} = a + b/W$ , while the $\eta'$ signal was described by the



resonance curve with a width determined by the mass resolution of $\sigma_W = 230$ MeV at W = 1 Gev. The optimal fit gave for the $\eta'$ contribution $15 \pm 5$ events corresponding to $\Gamma_{\gamma\gamma}(\eta') = 6.5 \pm 3.0$ keV. Thus the observed signal of $\eta'$ is consistent with the world-average value of $\Gamma_{\gamma\gamma}(\eta') = 4.3 \pm .3$ keV /10/.

Detection efficiencies for the two photon production of $\eta'$ and $\eta_c$ resonances were determined from the Monte Carlo simulation described in refs. 11. Up to now about 30% of all the decays of $\eta_c$ have been observed. For the simulation of remaining decay modes a statistical model of decays into pions was assumed with an average pion multiplicity of 4.5.

Analysis of the possible contribution of $\eta_c$ to the presented distribution shows that its value does not exceed 35 events. This results in the upper limit $\Gamma_{\gamma\gamma}(\eta_c) < 18$ keV at 90% confidence level.

To improve the background-effect ratio we have used the fact that at our energies the main contribution to the total cross section $\gamma\gamma \to$ hadr. comes from the diffractive production of hadrons characterized by the limited transverse momentum distribution of the final particles. By selecting from a sample above the events having particles with large angles with respect to the beam axis we decreased the number of experimental events by a factor of 4.5. The detection efficiency of $\eta_c$ decreased by a factor of 1.5 only. The resulting mass distribution after this cut is shown in Fig. 4. This time a signal from the $\eta_c$ does not exceed 14 events corresponding to the limit $\Gamma_{\gamma\gamma}(\eta_c) < 11$ keV at 90% C.L. Note that this result in contrast to the papers mentioned above gives the direct limitation for the two photon width of the $\eta_c$-meson and does not require detailed information on the decay modes of $\eta_c$ (2980).

In conclusion we should like to emphasize that our results are preliminary. Future improvements can be connected with the increase of our detection efficiency for multihadronic events in the central part of the detector, better resolution of the tagging system and considerable increase of the experimental event sample using events with small angle electrons in the TS.

## R e f e r e n c e s


1. PLUTO, Evidence for exclusive $\eta_c$ production in $\gamma\gamma$ interactions. DESY 85-130.
2. TASSO, V.Mertens, Search for two-photon production of the $\eta_c$ (2980) with the TASSO detector. $\gamma\gamma$ Workshop, Paris, 1986.
3. MARK III, R.M.Baltrusaitis et al. Hadronic decays of the $\eta_c$ (2980), SLAC-PUB-3704 (1985).
4. CRYSTAL BALL, J.E.Gaiser, Charmonium spectroscopy from radiative dacays of $J/\psi$ and $\psi'$, SLAC-255 (1982).
5. E.D.Bloom and C.W.Peck, Ann. Rev. Nucl. Part. Sci. 33 (1983) 143.
6. ISR R704, C.Baglin et al. Formation of charmonium states in antiproton-proton annihilation. EPS Intern. Europhysics Conf. on High Energy Physics, Bari, 1985.
7. DM2, A.F.Falvard, Production of C = +1 states in the decays of 8.6 millions of $J/\psi$. $\gamma\gamma$ Workshop, Paris, 1986.
8. S.E.Baru et al., Preprint INP 83-39, Novosibirsk, 1983.
   S.E.Baru et al. Proc. of the 2nd Int. Conf. on Inst. for Coll. Beam Physics, p.241, Stanford 1982.
9. S.E.Baru et al., Preprint INP 86-102, Novosibirsk, 1986.
10. P.D.G. Phys. Lett. 170B, April 1986
11. J.A.M.Vermaseren et al. Phys. Rev. D19 137 (1979).
    A.D.Bukin et al., Preprint INP 84-33, Novosibirsk, 1984.




## FIGURE CAPTIONS

Fig. 1. Dependence of the resolution in the invariant mass ($\sigma_W$) on the mass value ($W$) obtained from Monte Carlo simulation. The solid curve is the result of the approximation by a smooth function.

Fig. 2. Mass dependence of the detection efficiencies. $\varepsilon_T$ is the detection efficiency for both scattered electrons, $\varepsilon_D$ is the detection efficiency for the central part of the detector. The curves are the result of the approximation by a smooth function.

Fig. 3. Mass distributior for experimental events of the reaction $e^+e^- \to e^+e^-$ hadr. The solid curve is the result of the fit by a nonresonant continuum and the $\eta'$ contribution. Points show an expected signal from the $\eta_c$ meson at $\Gamma_{\gamma\gamma}(\eta_c) = 18$ keV.

Fig. 4. Mass distribution for experimental events of the reaction $e^+e^- \to e^+e^-$ hadr. with additional suppression of the contribution of the diffractive hadron production. The solid curve is the result of the fit by a nonresonant continuum. Points show an expected signal from the $\eta_c$ meson at $\Gamma_{\gamma\gamma}(\eta_c) = 11$ keV.

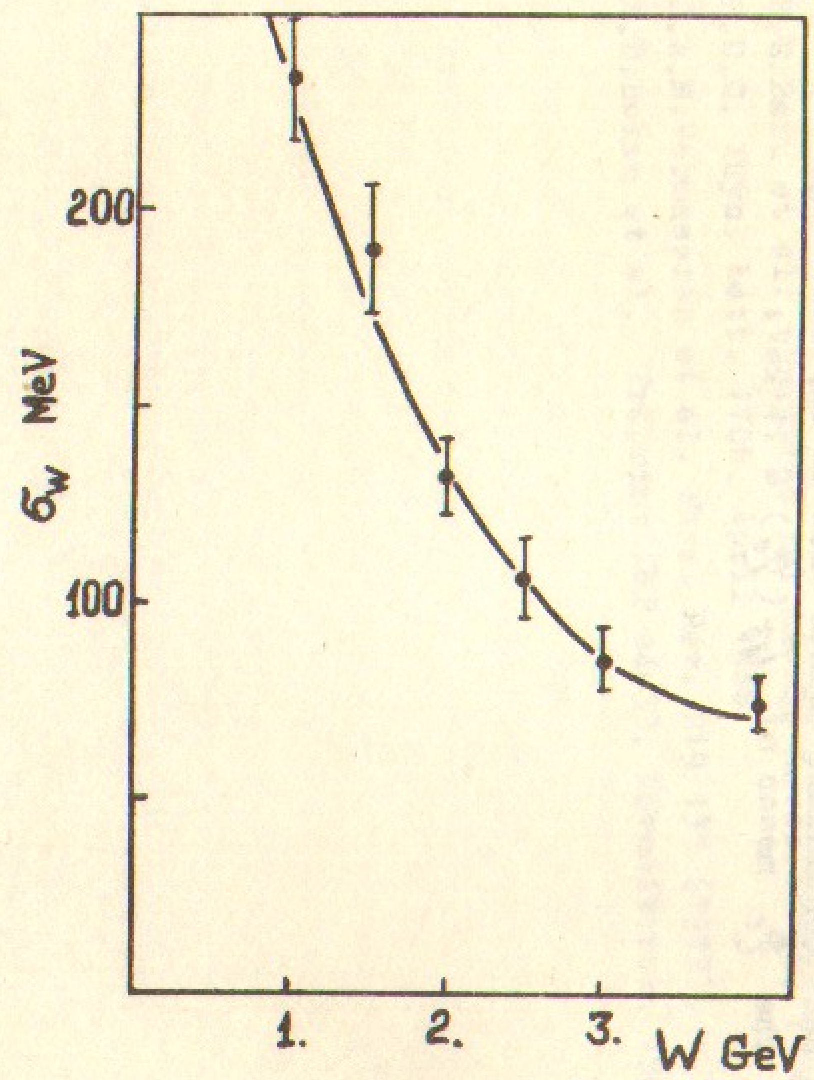


Fig. 1

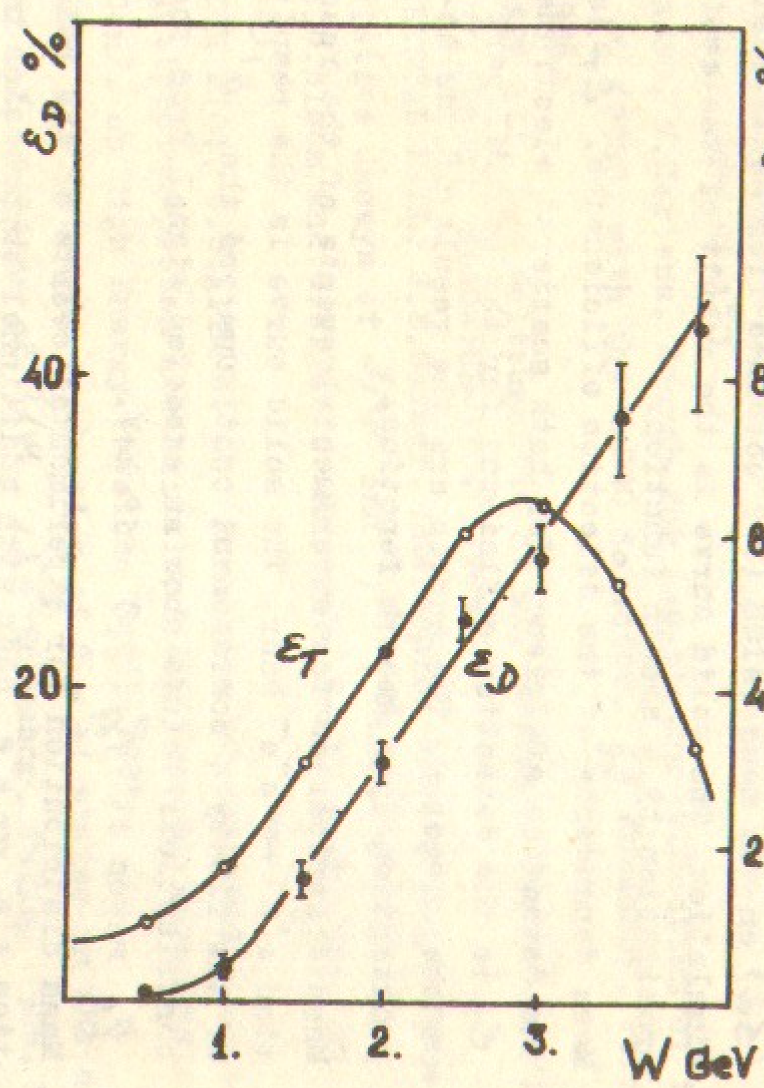


Fig. 2

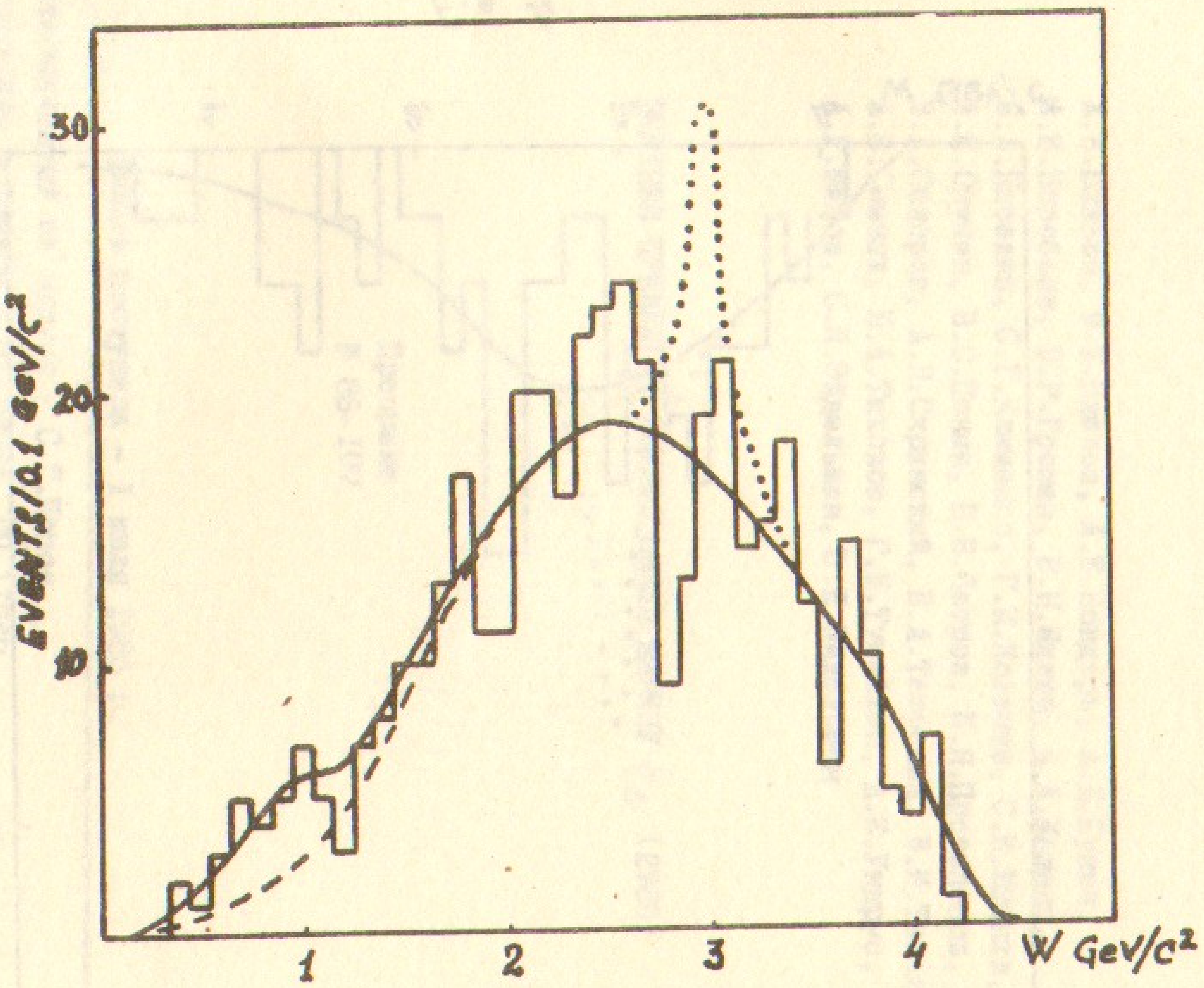


Fig. 3

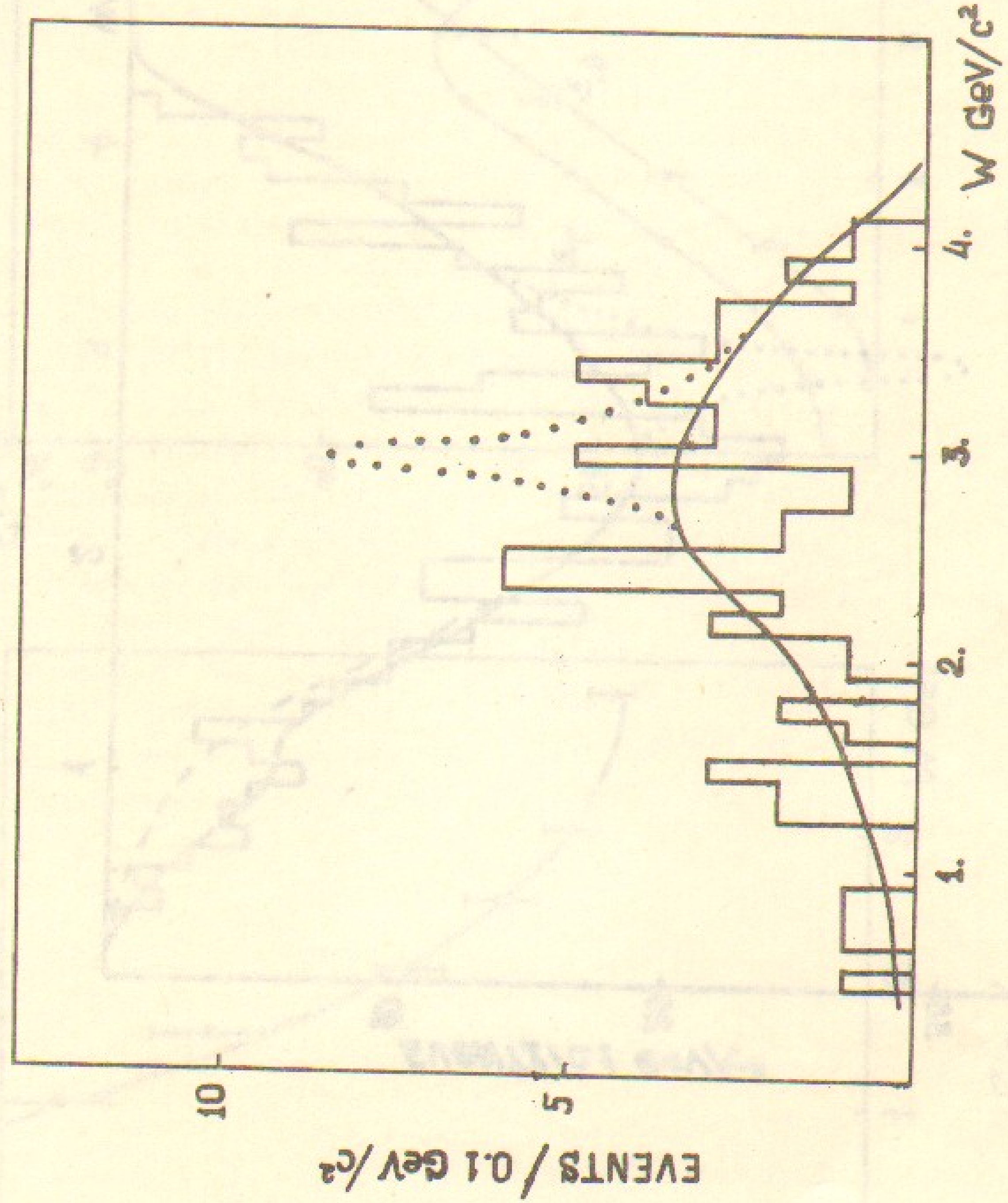


Fig. 4

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**ВЕРХНИЙ ПРЕДЕЛ НА ДВУХФОТОННУЮ ШИРИНУ $\eta_c$ (2980)**

Препринт
№ 86-107

Работа поступила - I июля 1986 г.

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Ответственный за выпуск - С.Г.Попов
Подписано к печати 2.07-1986г. МН 11767
Формат бумаги 60x90 1/16 Усл.0,9 печ.л., 0,8 учетно-изд.л.
Тираж 290 экз. Бесплатно. Заказ № 107.

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Ротапринт ИЯФ СО АН СССР, г.Новосибирск, 90