# PRODUCTION OF ELECTRON-POSITRON PAIRS BY HIGH-ENERGY GAMMA QUANTA

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1. The differential cross sections ($d\sigma/dv$) for the production of $e^+e^-$ pairs in different substances have been investigated before [1-3] (v = ratio of positron and $\gamma$-quantum energies). In [1,2] the production of $e^+e^-$ pairs was investigated for $E_\gamma \leq 323$ Mev. In [3], the photoproduction of $e^+e^-$ pairs was investigated with the aid of a diffusion hydrogen chamber for $E_\gamma$ = 10 - 1000 MeV. The results of these experiments are in qualitative agreement with the theories of Bethe-Heitler [4] and Davies-Bethe-Maximon [5]. Mork and Olsen [6] calculated the radiative corrections to the process of photoproduction of $e^+e^-$ pairs, which change only slightly the symmetry of the cross sections ($d\sigma/dv$) about v = 0.5. For example, for v = 0.01 and v = 0.99 the cross section ratio is

$$\frac{d\sigma/dv\ (v = 0.01)}{d\sigma/dv\ (v = 0.99)} = 1.05,$$

and for other values of v the asymmetry does not exceed 1 - 2%. Malamud [7] has shown that the asymmetry in the cross section ($d\sigma/dv$) does not exceed 2% for $E_\gamma$ = 968 and 662 MeV.

Thus there are at present no quantitative data on the differential cross sections for the photoproduction of $e^+e^-$ pairs at $E_\gamma \gtrsim 500$ MeV.

2. We investigated the production of $e^+e^-$ pairs by $\gamma$ quanta with energy E = 10 - 5000 MeV with the aid of the 23-liter propane bubble chamber of the JINR High-energy Laboratory. The $\gamma$ quantum source were $\pi^-p$ collisions with p = 4 and 7 GeV/c. We selected 3645 $e^+e^-$ pairs produced by the $\gamma$ quanta in the fiducial volume of the chamber. The efficiency of scanning turned out to be independent of the values of v. The procedure for measuring the electron and positron energies in the propane chamber, with allowance for radiation and ionization corrections, is described in the paper of Bem and Grishin [9].

All events were broken up into four groups, depending on the $\gamma$-quantum energy. The histograms of the distributions of the events with respect to v are shown in Fig. 1 (a, b, c, and d). Here $v = (E_+ - mc^2)/(E_\gamma - 2mc^2)$, $E_+$ = positron energy, $E_\gamma$ = $\gamma$-quantum energy, m = electron mass, N = number of events. The continuous curves correspond to the theoretical values of the cross sections ($d\sigma/dv$) for the photoproduction of the $e^+e^-$ pairs (without radiative corrections), averaged over the theoretical spectrum of the $\gamma$ quanta [9]. The theoretical and experimental distributions are normalized to a single area. The inaccuracy of the calculated theoretical curves is determined essentially by the errors in the determination of the $\gamma$-quantum energy ($\approx$17%) and does not exceed $\approx$5% [8,9]. The error in the determination of v, connected with the inaccuracy in the measurement of the electron (positron) energy ($\approx$20%), is listed in Table I.

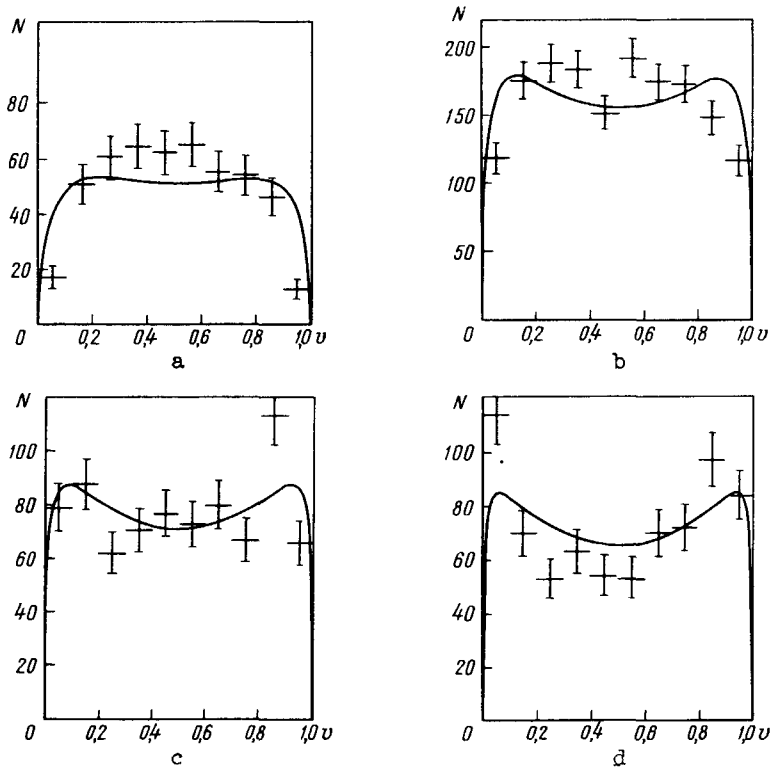


Fig. 1. Distribution of energy among the electrons and positrons in $e^+e^-$ pairs. a - $E_\gamma$ = 10 - 100 MeV, 494 events; b - $E_\gamma$ = 100 - 500 MeV, 1645 events; c - $E_\gamma$ = 500 - 1000 MeV, 776 events; d - $E_\gamma$ = 1000 - 5000 MeV, 730 events.

The obtained experimental data on the photoproduction of $e^+e^-$ pairs are in good agreement, within ±15%, with the Bethe-Heitler theory for $E_\gamma$ = 10 - 5000 MeV.

Table I

| v | 0.05 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 |
|---|---|---|---|---|---|---|
| $\sigma_v$ | 0.013 | 0.025 | 0.045 | 0.059 | 0.068 | 0.071 |

The figure also shows clearly the qualitative change in the distributions with increasing $\gamma$-quantum energy.

For all photon energies, the distributions with respect to v are symmetrical about v = 0.5 with accuracy ≈5%. Table II lists the ratios $N(v < \alpha)/N(v > 1 - \alpha)$. It is of interest to increase markedly the statistics of the event, so as to observe the radiative corrections calculated by Mork and Olsen [6].

Table II

| $E_\gamma$, MeV \ α | 0.5 | 0.2 |
|---|---|---|
| 10 - 5000 | 0.989 ± 0.033 | 1.034 ± 0.052 |
| 500 - 5000 | 0.943 ± 0.049 | 0.975 ± 0.073 |

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