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# Pair-Polarimeter for High Energy Photons

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The angle correlation in $e^+e^-$ pair production by linear polarized photon was proposed for photon polarization measurements by Yang [1] and Berlin & Madansky[2]. An accurate QED calculation with analysis of the possible experimental setup was done by L. Maximon and H. Olsen [3]. The effect was used successfully for measurement of the beam polarization [4]. The limitation of the method at photon energies above 100 MeV arises from the small value of an angle between pair components.

We propose a new polarimeter for high energy photons based on the well known correlation in electron-positron pair production from an amorphous converter. Our detector design utilizes silicon micro-strip detectors that allow the construction of a compact device useful in the few GeV photon energy range [5]. The most important features of these detectors are the capability to detect two tracks separated by a very small distance ($\sim$ 100 microns) and very good position resolution, ($\sim$ a few microns). Because the typical opening angle in $e^+e^-$ pair is about $1/\gamma$ and available space for a polarimeter is about 1 meter, the distance $e^+e^-$ is about a fraction of mm. It means that at the photon energies of our interest, most of pairs have a distance $e^+e^-$ much larger than the micro strip detector limitation.

Because of the vector nature of the photon the cross section of the $Z(\gamma, e^+e^-)$ reaction has the following form:

$$\sigma = \sigma_{sym} + \sigma_{asym} = \sigma_{unp} + P_\gamma \sigma_{pol} cos(2\varphi_+ - 2\vartheta); \qquad (1)$$

where $\sigma_{sym}$ represents the part of cross section independent of the azimuthal angle, $\sigma_{sym}$ is corresponding to the unpolarized photon cross section $\sigma_{unp}$; $\sigma_{asym}$ is the azimuthally dependent part of the cross section that is proportional to the beam polarization degree $P_\gamma$, $\sigma_{pol}$ and $cos(2\varphi_+ - 2\vartheta)$. The azimuthal angles are $\varphi_+$ and $\varphi_-$ (see Figure 1). They are the angles between photon polarization plane $(\vec{k}, \vec{x})$ and plane defined by momentum of the photon and momentum of outgoing particle (positron or electron).

The opening angle between these planes is $\varphi_{+-}$. Direction of the vector PN, which connects the crossing points of the positron and electron in the detector plane, represents experimentally the most accessible parameter. The angle $\omega_\pm$, between the polarization plane and vector PN, is close to $\varphi_+$ because $\varphi_{+-} \sim \pi$ for majority events. From numerical calculation, which take average over $\varphi_{+-}$, $\theta_+$, $\theta_-$, we have found a large analyzing power for the angle $\omega_\pm$.

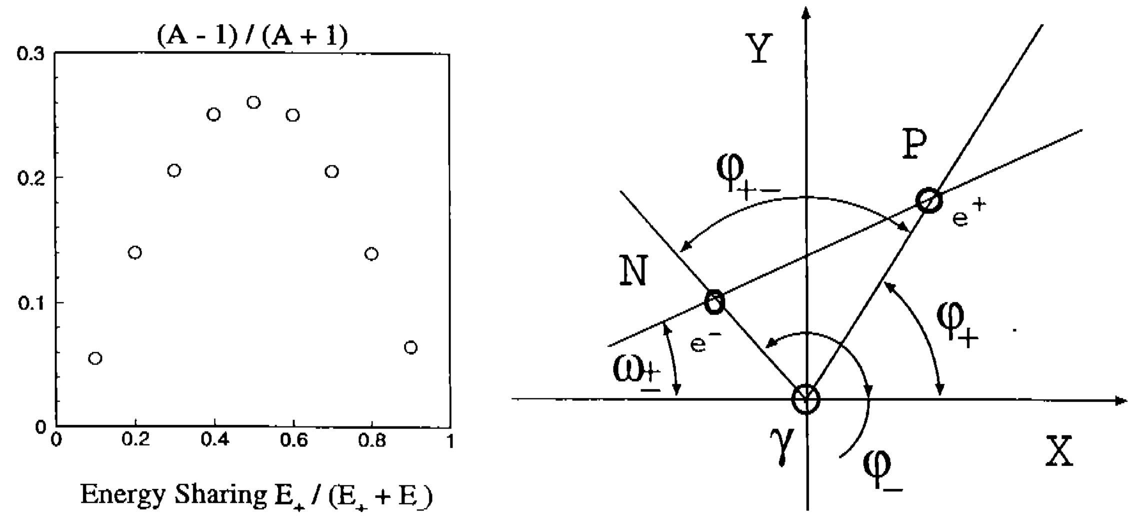


Figure 1: Angles of the pair production (right). Analyzing power vs. energy sharing (left).

A ratio $A = \sigma_{\|}/\sigma_{\perp}$ of about 1.7 in a wide range of the photon energies is obtained. We also find that $A$ is stable to the cuts on different parameters, such as a distance between the positron and electron, detector size and so on, which necessarily appear in an experiment. Multiple scattering of the pair components in the converter of 0.1% radiation length reduce the analyzing power only by 20%. The parameter A is a smooth function of energy sharing between the positron and electron with wide maximum at equal energies (see left part of the Figure 1).

We also had found that in high energy limit of $E_\gamma \gg m_e c^2$ the cross section can be expressed in compact form as a function of angle $\omega_\pm$. The $\sigma_{asym}$ is proportional to the cosine of angle $2\omega_\pm$ like it was for angle $2\varphi_+$. Numerical integration results that the asymmetry in terms of $\omega_\pm$ is considerably larger ( by a factor 1.3 - 1.4 ) than in terms of $\varphi_+$, which probably can be interpreted as combined result of two measurements with $\varphi_+$ and $\varphi_-$.

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# References

[1] Yang C.N., Physical Review **77**, 722 (1950).

[2] Berlin J.H. and Madansky L., Physical Review **78**, 623 (1950).

[3] Maximon L.C. and Olsen H., Physical Review **126**, 310-319 (1962).

[4] Barbiellini G. at al, Physical Review Letters **9**, 396 (1962).

[5] Wojtsekhowski B.B. et al., proceedings from JLab/USC/NCCU/GWU workshop on "Polarized Photon Polarimetry", June 2-3, 1998, p.257.