Positron Beam Polarimetry with Compton Scattering

Pavel Starovoitov

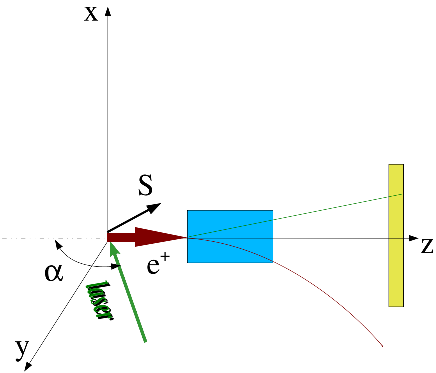
NC PHEP, Minsk

May 16, 2007

Outline

Setup

$$\gamma\,(k_1,\zeta) + e^+\,(k2,s) \rightarrow \gamma\,(p_1) + e^+\,(p_2)$$



Positron energy: $E_0 = 5$ GeV
Positron spin: $\vec{S} = (s_1, s_2, s_3)$

Laser energy: $\omega_0 = 2.33$ eV
Crossing angle: $0 < \alpha < \pi$

Differential Cross Section I

$$\frac{d^2\sigma}{d\cos\theta d\varphi} = \frac{\alpha_{EM}^2}{4E_0^2}\frac{F_0(x,y)}{\Omega_N^2}$$

$$\Omega_N = \left(1+\frac{\omega_0}{E_0}\right)+\frac{\omega_0}{E_0}\sin\alpha\sin\theta\sin\varphi-\left(\sqrt{1-\left(\frac{m_e}{E_0}\right)^2}+\frac{\omega_0}{E_0}\cos\alpha\right)\cos\theta$$

$$x = \frac{2\omega_0 E_0}{m^2}\left(1-\cos\alpha\sqrt{1-\left(\frac{m_e}{E_0}\right)^2}\right), \quad y = 1-\frac{1-\cos\theta\sqrt{1-\left(\frac{m_e}{E_0}\right)^2}}{\Omega_N}$$

Differential Cross Section II

Distribution

$$F_0(x,y) = \frac{1}{1-y} + (1-y) + 4r(1-r)\left(\zeta_1 - 1\right) + 2r\left[(1-2r)\,\psi_1 + \psi_2\right]\zeta_3$$

where

$$r = \frac{y}{x(1-y)}, \psi_1 = \frac{S\cdot k_1}{m_e}, \quad \psi_2 = \frac{S\cdot p_1}{m_e}$$

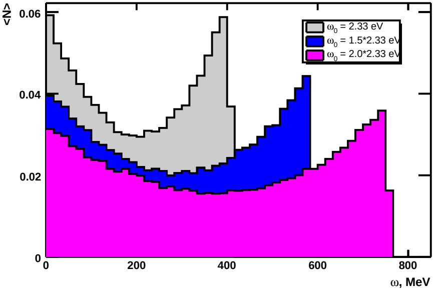
Asymmetry estimate

longitudinal	transverse
$\psi_1 \sim x$	$\psi_1 \sim \omega_0/m_e$
$\psi_2 \sim \frac{x}{\Omega_N}$	$\psi_2 \sim \frac{\omega_0/m_e}{\Omega_N}$

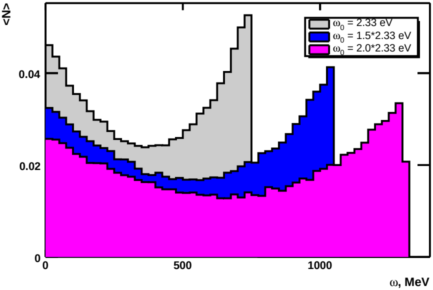
Size of x

$$x(\alpha = 180^0) \approx 0.18 \quad x(\alpha = 90^0) \approx 0.09$$

Photon Spectra

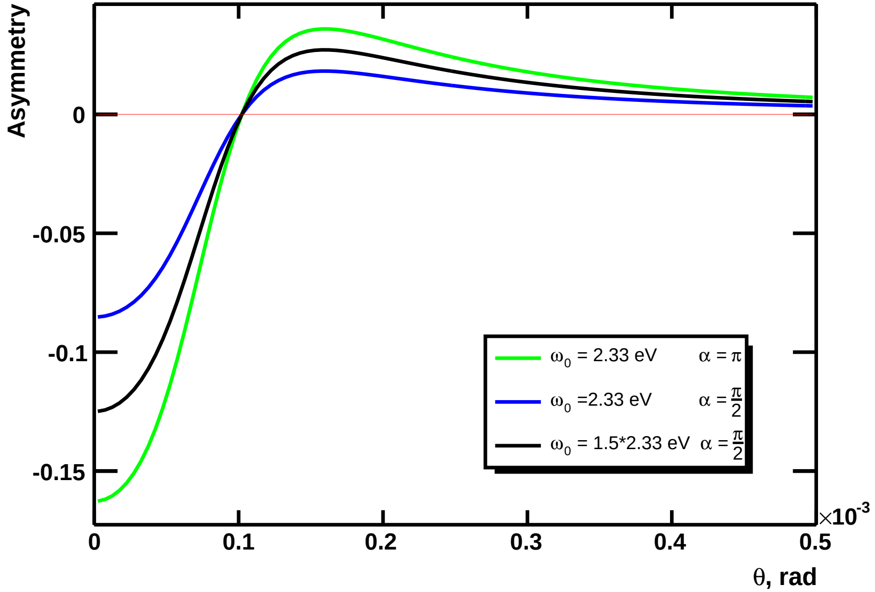


90^0 crossing

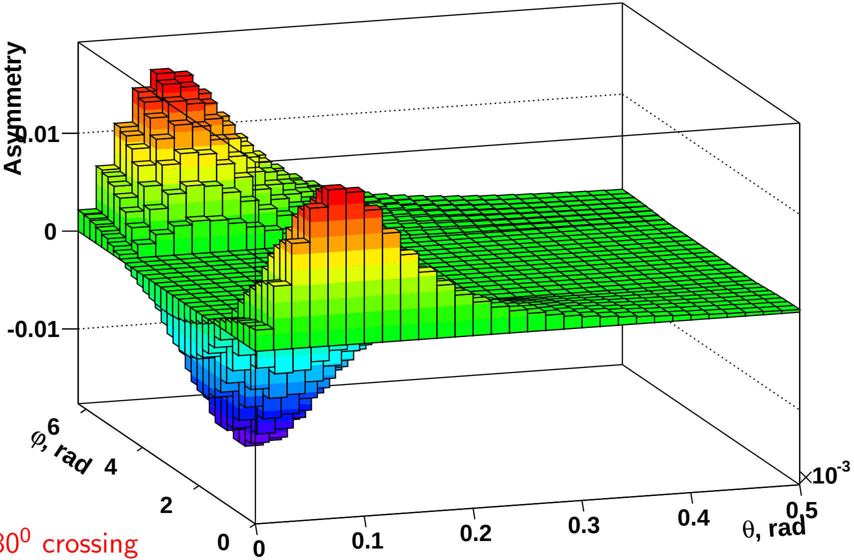


180^0 crossing

Longitudinal Positron Beam Polarization

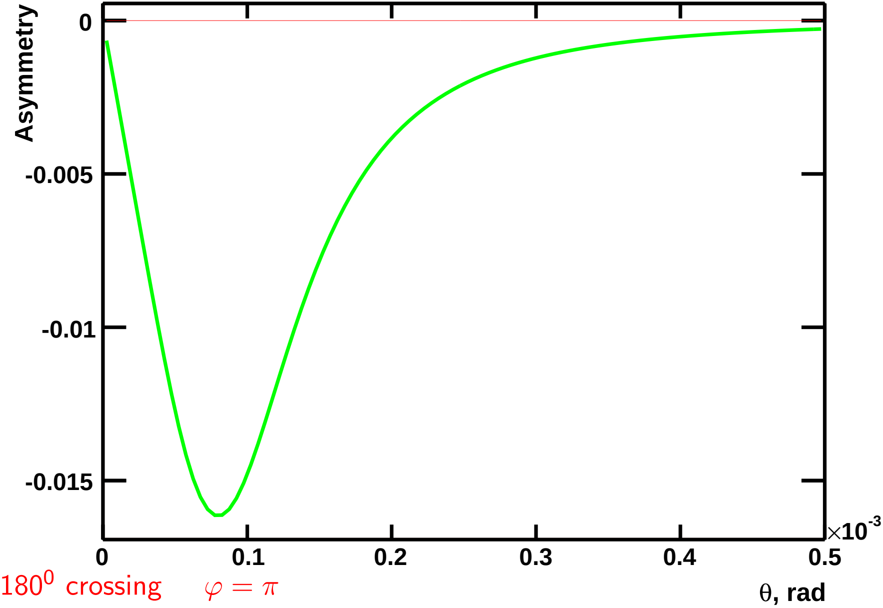


Transverse Positron Beam Polarization



180⁰ crossing

Transverse Positron Beam Polarization

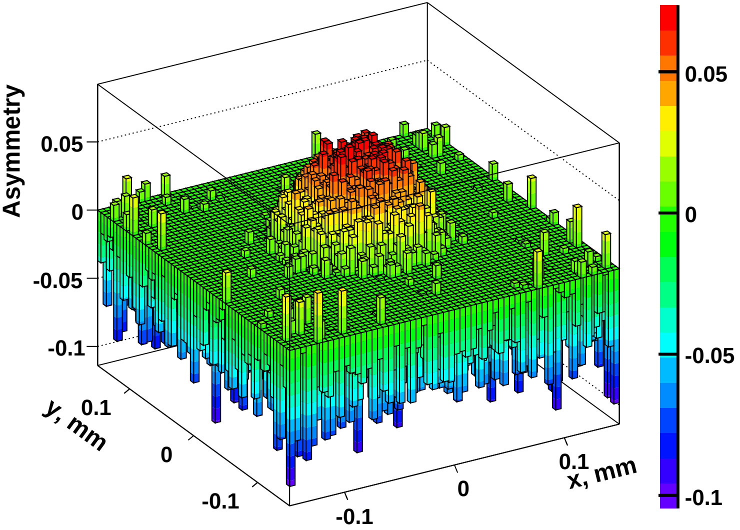


180^0 crossing $\varphi = \pi$

Transverse Positron Beam Polarization II

- Switching crossing angle from 180^0 to 90^0 decreases transverse-X asymmetry by a factor $0.25 \div 0.27$
- Doubling laser energy increases trancverse-X asymmetry by a factor $3.7 \div 4.0$

Simulations



Longitudinal beam $\pi/2$ crossing angle

Summary & Outlook

- Longitudinal asymmetry in Compton cross section changes sign at $\theta \approx 0.1$ mrad. If one chooses detector granularity according to this feature the total asymmetry will be $\sim 10\%$.
- Transverse asymmetry is about $\pm 1.5\%$ and it doesn't change sign in θ. Most probably one needs to increase laser energy by a factor 4 to get measurable asymmetry.

Next steps

- Realsitic beam conditions
- Backgroung studies