Tentative understanding on Compton Scattering

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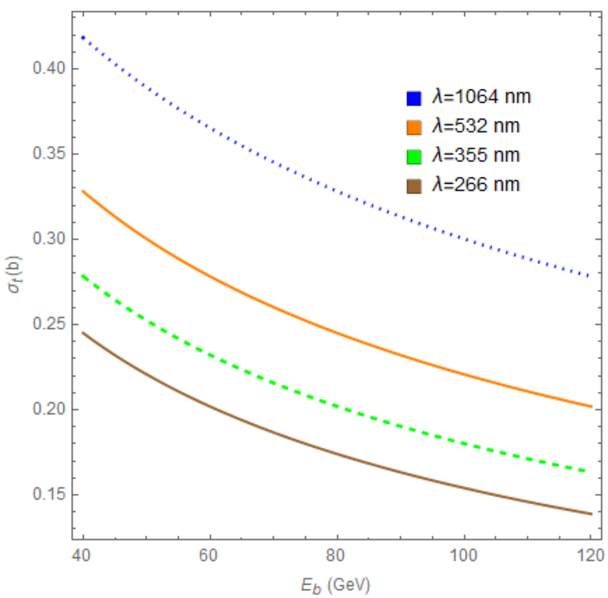
Cross Section of Compton scattering, σ_t

➢ 截面与<u>电子束流能量E_b</u>和<u>激光光子能量ω_0</u>有关。

$$\sigma_t = \pi r_e^2 \Gamma \left[\frac{2\Gamma^2 + 12\Gamma + 2}{(1-\Gamma)^2}\right] + \Gamma - 1 + \frac{6\Gamma^2 + 12\Gamma - 2}{(1-\Gamma)^3} ln\Gamma$$

$$\sigma_t = \pi r_e^2 \Gamma \left[\frac{2\Gamma^2 + 12\Gamma + 2}{(1-\Gamma)^2} + \Gamma - 1 + \frac{6\Gamma^2 + 12\Gamma - 2}{(1-\Gamma)^3} \ln\Gamma\right], \qquad \Gamma = \frac{1}{1 + \frac{4E\omega_0}{m_e^2}}.$$

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(*FCC*)
Eb = 45.6;
σt[λ_] := π * re^2 * Γ[λ] * ((2 Γ[λ]^2 + 12 Γ[λ] + 2)/(1 - Γ[λ])^2 + Γ[λ] - 1 + (6 Γ[λ]^2 + 12 Γ[λ] - 2)/(1 - Γ[λ])^3 Log[e, Γ[λ]]) / 10^-28;
                                                                                               [对数
σt[500]
0.304087
(*CEPC*)
Eb = 45.5;
σt[λ_] := π * re^2 * Γ[λ] * ((2 Γ[λ]^2 + 12 Γ[λ] + 2)/(1 - Γ[λ])^2 + Γ[λ] - 1 + (6 Γ[λ]^2 + 12 Γ[λ] - 2)/(1 - Γ[λ])^3 Log[e, Γ[λ]]) / 10^-28;
                                                                                               [对数
σt[1064]
0.401659
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Luminosity

$$L = N_e N_\gamma \frac{\cos(\alpha/2)}{2\pi} \frac{1}{\sigma_y} \frac{1}{\sqrt{\sigma_x^2 cos^2\left(\frac{\alpha}{2}\right) + \sigma_z^2 sin^2\left(\frac{\alpha}{2}\right)}}$$

$$\sigma_{x,y,z} = \sqrt{\sigma_{x,y,z-laser}^2 + \sigma_{x,y,z-e}^2}$$

Scattered photon rate

Laser-beam single pulse energy

Compton cross-section

pilots

Electron bunch charge (25nC or 6nC)

Geometrical factor

Photon rate $n = \sigma_C \frac{\mathcal{E}}{E_\lambda} \frac{Q}{q} \frac{\mathcal{F}}{4\pi\sigma_y\sigma_x}$

- $\mathcal{F}^{-1} = \sqrt{1 + \left(\frac{\sigma_z}{\sigma_x}\tan\frac{\theta_0}{2}\right)^2}$
- $\theta_0 \sim 2mrad$

Laser photon energy
(2.4eV for 0.5µm wavelengths)

Transverse beam sizes:

- $\sigma_{x,y,z} = \sqrt{\sigma_{x,y,z,laser}^2 + \sigma_{x,y,z,e-}^2}$
- $\sigma_{x,laser} = \sigma_{y,laser}$=300µm
- $\sigma_{x,e-}$ = 200µm, $\sigma_{y,e-}$=25µm, $\sigma_{z,e-}$~10mm

$$L_{chen} = 2L_{FCC}$$

Comparison between two formulae

FCC		CEPC
$25nC$ (pilot bunch)$\rightarrow 1.5625\times 10^{11}$	$6nC$ (pilot bunch) $\rightarrow 3.75\times 10^{10}$	8×10^{10}
2.4 eV (wavelength = 0.5 μm)		1.165 eV (1064 nm)
2.6×10^{15} (pulse energy = 1 mJ)		2.8 mJ/1.165 eV = 1.5×10^{16}
2 [mrad]		2.35 [mrad]
200 [μm]		54.3 [μm]
25 [μm]		7.9 [μm]
10 mm		8.5 [mm]
300 [μm]		160 [μm]
300 [μm]		160 [μm]
1.5 mm (Pulse duration = 5 ps)		8.5 [mm]
$5.9545\times 10^{32}\,[m^{-2}s^{-1}]$	$1.429\times 10^{32}\,[m^{-2}s^{-1}]$	$7.04\times 10^{33}[m^{-2}s^{-1}]$
304.0869 [mb]	304.0869 [mb]	402 mb
5.43×10^{7}	1.30×10^{7}	2.827×10^{5}

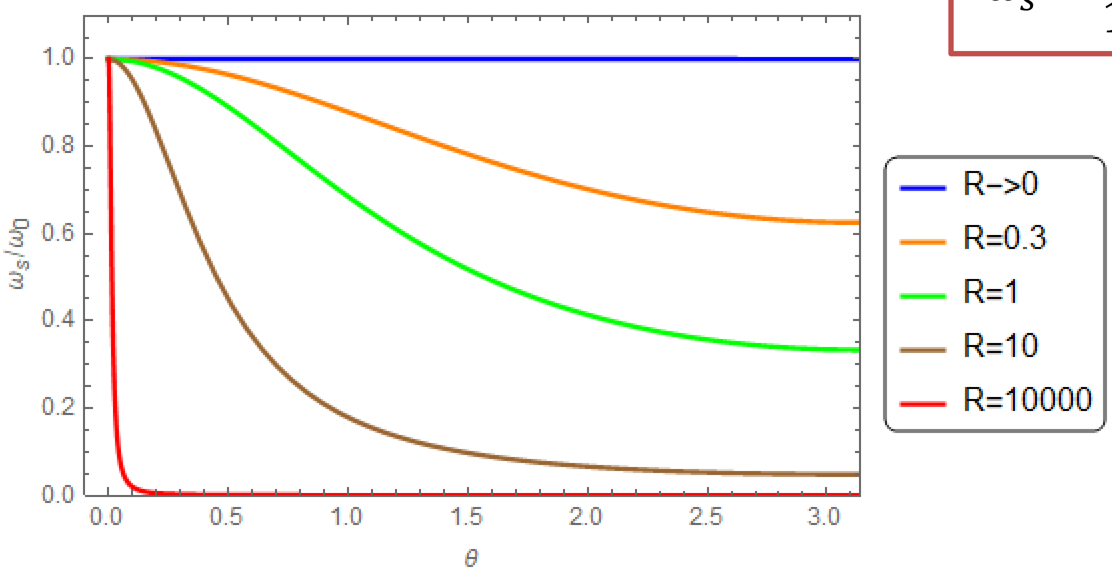
	25 nC	6 nC
Luminosity	$1.392\times 10^{32}[m^{-2}s^{-1}]$	$3.341\times 10^{31}[m^{-2}s^{-1}]$
Cross section	304.1[mb]	304.1[mb]

Clarification

Compton Scattering

普通Compton Scattering是能量高的光子撞击静止电子，光子变成能量较低的光子，电子能量增加；

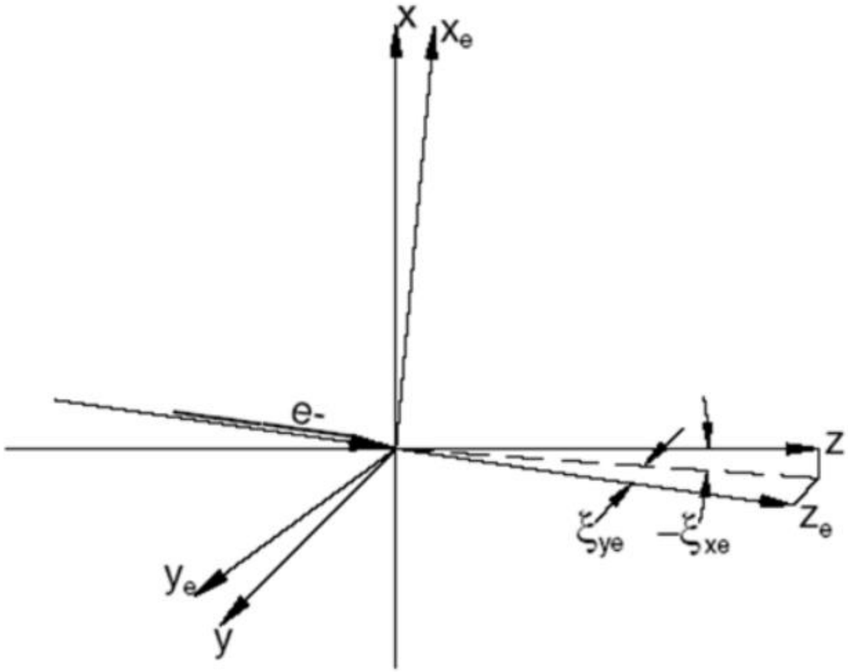
Inverse Compton Scattering是低能光子撞击高能电子，获得高能光子。



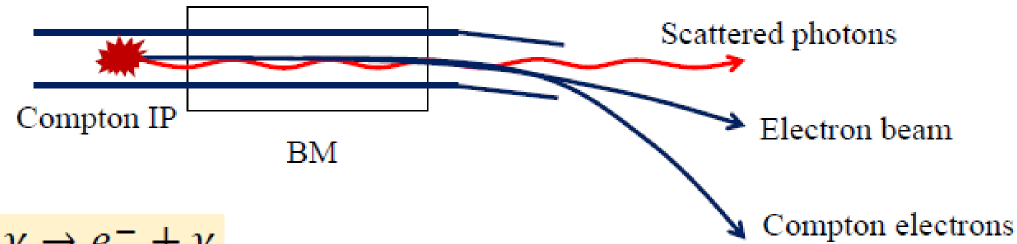
$$\omega_s = \frac{\omega_0}{1 + R(1 - \cos\theta)}$$

Compton scattering

考虑真实情况下：束流入射有一定的角度偏差、激光束有一定的带宽



Problems



$e^- + \gamma \rightarrow e^- + \gamma$

1、在Compton Scattering中，Compton electrons经过弯转铁->detector，Compton electron的束线设计对自旋反转影响大吗？Compton electrons能谱中，能量损失在什么量级？

2、Compton polarimeter 中的可观测量是什么？

3、Page 6中问题的影响

4、下一步工作安排