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CompAZ: parametrization of the photon collider luminosity spectra.

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Abstract

Simple model, based on the analytical formula for Compton scattering, is used to describe the realistic photon energy spectra of the Photon Collider at TESLA. Parameters of the model are obtained from the comparison with the full beam simulation by V.Telnov, which includs nonlinear corrections and contributions of higher order processes. Photon energy distribution and polarization, in the high energy part of the spectra, are well reproduced. Model can be used for Monte Carlo simulation of gamma-gamma events at various energies. Parametrization is also shown to be very useful for numerical cross-section calculations.

1 Introduction

Photon Collider has been proposed as a natural extension of the e^+e^- linear collider project TESLA [1]. High energy photons for $\gamma\gamma$ collisions can be obtained using Compton backscattering of laser light off the high energy electrons [2, 3, 4, 5, 6]. The physics potential of the Photon Collider is very rich and complementary to the physics program of e^+e^- and hadron colliders [1]. It is the ideal place to study the properties of the Higgs boson and the electroweak symmetry breaking (EWSB). Precision measurements at the Photon Collider open "new windows" to the physics processes beyond the Standard Model. However, precise measurements are only possible if the energy spectrum of colliding photons is well understood. Detailed simulation of the $\gamma\gamma$ luminosity spectra at the Photon Collider at TESLA has become available recently [6, 7]. In this paper a simple model based on the results of the detailed simulation is presented.

2 Compton scattering

At the Photon Collider high energy photons can be produced by the Compton backscattering of laser light off the high energy electron beam. The maximum energy of the scattered photon is

$$E_{max} = \frac{x}{x+1} E_e,$$

where x is the dimension–less parameter describing the Compton scattering,

$$x = \frac{4E_0 E_e}{m_e^2},$$

E_e is the electron beam energy, E_0 the energy of the laser photon and m_e is the electron mass. Proposed parameters of the Photon Collider at TESLA: electron beam energy E_e=250 GeV and laser photon energy E_0=1.17 eV (corresponding to $\lambda = 1.06\ \mu m$ [1]) result in the value of $x \approx 4.5$, corresponding to $E_{max} \approx 0.82\ E_e$.

The energy spectrum of the Compton backscattered photons is given by

$$\frac{1}{N}\frac{dN}{dy} = f_C(y,x) = \mathcal{N}_C \left[\frac{1}{1-y} - y + (2r-1)^2 - P_e P_L\ xr(2r-1)(2-y) \right], \quad (1)$$

where y is the fraction of the electron energy transfered to the photon $y = E_\gamma/E_e$, P_e and P_L are the electron beam and laser polarizations, $r = y/(x(1-y))$ and $\mathcal{N}_C$ is normalization factor defined by the condition:[1]

$$\int_0^1 dy\ f_C(y,x) = 1\ . \quad (2)$$

The degree of polarization of the photons scattered with energy fraction y is given by

$$P_\gamma = \frac{\mathcal{N}_C}{f_C(y,x)} \left\{ P_e\ xr \left[1 + (1-y)(2r-1)^2 \right] - P_L\ (2r-1) \left[\frac{1}{1-y} + 1 - y \right] \right\}. \quad (3)$$

The energy spectrum and polarization of the scattered photons, for $x = 4.5$ and various helicities of laser beam are shown in Fig. 1. Polarization of 85% was assumed for the electron beam. For the laser polarization opposite to the electron beam polarization the spectrum has a sharp peak at highest photon energies (solid curve in Fig. 1). This configuration seems to be the best choice for Photon Collider, resulting also in high degree of photon polarization at highest energies. The scattered photon energy spectrum and polarization expected for P_e=0.85 and $P_L = -1$, for x= 1.8, 4.5 and 7.2 (corresponding to $\lambda = 1.06\ \mu m$ and primary electron beam energies of 100, 250 and 400 GeV) are compared in Fig. 2.

[1]Same normalization condition applies to all energy distributions described in this paper, unless stated otherwise.

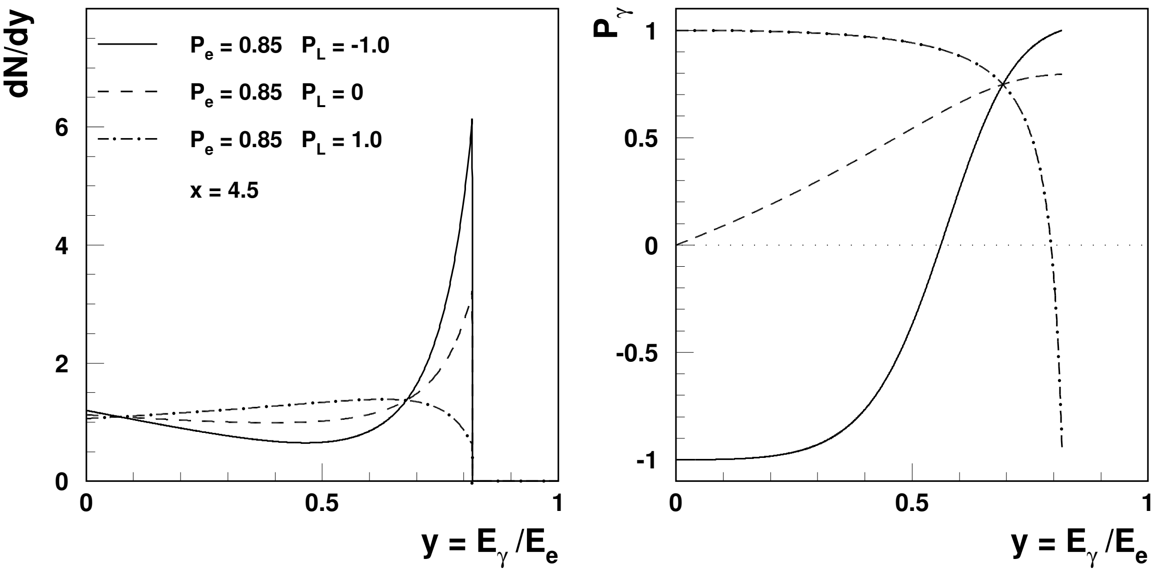

Figure 1: Energy distribution (left plot) and polarization (right plot) for photons from Compton back-scattering, for different laser beam polarizations P_L, as indicated in the plot. $x = 4.5$ corresponds to laser wave length of 1.06 μm and primary electron beam energy of 250 GeV. Electron beam polarization P_e=85%.

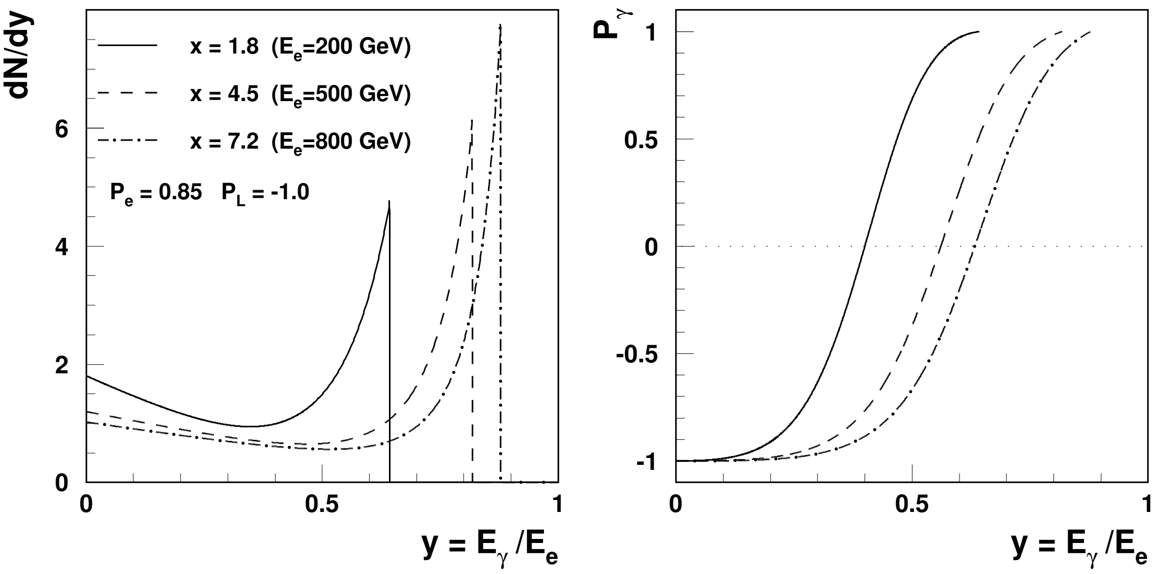

Figure 2: Energy distribution (left plot) and polarization (right plot) for photons from Compton back-scattering, for different x values (different energies of primary electron beam) as indicated in the plot. Electron beam and laser polarizations are P_e=0.85 and $P_L = -1$ respectively. Laser wave length is 1.06 μm.

E_e [GeV]	100	250	400
λ_L [μm]	1.06	1.06	1.06
$E_\circ$ [eV]	1.17	1.17	1.17
x	1.8	4.5	7.2
σ_x [nm]	140	88	69
σ_y [nm]	6.8	4.3	3.4
σ_z [mm]	0.3	0.3	0.3
f_{rep} [kHz]	14.1	14.1	14.1
$\gamma\epsilon_{x/y}/10^{-6}$ [m·rad]	2.5/0.03	2.5/0.03	2.5/0.03
$\beta_{x/y}$ [mm] at IP	1.5/0.3	1.5/0.3	1.5/0.3
b [mm]	2.6	2.1	2.7
$L_{ee}\,(geom)$ [$10^{34}\,cm^{-2}s^{-1}$]	4.8	12	19

Table 1: Parameters of the $\gamma\gamma$ collider based on TESLA. Listed for different electron beam energies E_e are: laser wave length λ_L, photon energy $E_\circ$ and resulting x parameter values; horizontal, vertical and longitudinal electron bunch sizes σ_x, σ_y and σ_z; average repetition rate, normalized beam emittances $\gamma\epsilon_{x/y}$, β-functions $\beta_{x/y}$, distance between the conversion and interaction point and estimated e^-e^- luminosity.

3 Spectra simulation

The formula (1) would properly describe the energy spectrum of the photons colliding in the Photon Collider if two conditions were fulfilled: laser power was small and primary electron beams were sufficiently wide, so that effects related to the photon scattering angle can be neglected. However, to get very high luminosity for high energy photon collisions we need both very powerful lasers and strongly focused electron beams. To find the energy spectra of colliding photons, with realistic assumptions about the laser system and the electron beams, detailed simulation programs has been prepared [6, 8].

New samples, with high statistics of simulated $\gamma\gamma$ events, have been generated recently by V.Telnov [7]. They are based on the beam and laser system layout and parameters, proposed for the Photon Collider at TESLA [1]. Electron beam energies of 100, 250 and 400 GeV have been considered. Main collider parameters, as used for the simulation, are listed in Table 1. More details of the simulation can be found in [1, 7, 9].

Energy distribution for colliding photons and the $\gamma\gamma$ center-of-mass energy distribution, obtained from the simulation of luminosity spectra [7], for electron beam energy of 250 GeV, are shown in Fig. 3. Distributions expected from the Compton scattering, as given by formula (1), are included for comparison. Realistic simulation indicates that a large fraction of colliding photons will have small energies. Also the maximum of the high-energy peak is shifted towards lower energies.

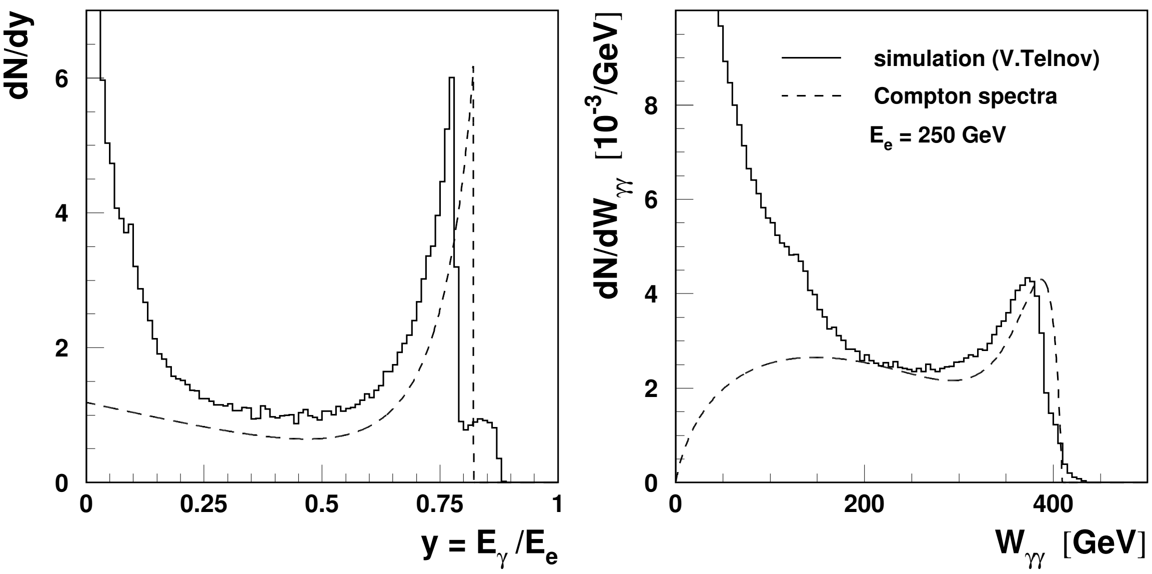

Figure 3: Energy distribution for photons (left plot) and the $\gamma\gamma$ center-of-mass energy distribution (right plot) from full simulation of luminosity spectra by V.Telnov, compared to expectations for ideal Compton scattering.

Shown in Fig. 4 (left plot) is the two-dimensional energy distribution for the colliding photons, as obtained from the simulation [7], for electron beam energy of 250 GeV. Also included in Fig. 4 (right plot) is the energy correlation between two photons calculated as the ratio of the two-dimensional energy distribution to the product of two one-dimensional energy spectra. Energies of colliding photons are clearly correlated. Majority of collisions involve photons with similar energies (large values of the ratio along the diagonal). Collisions involving one low-energy and one high-energy photon are suppressed (the ratio less than 1 in the left-upper and right-lower corner of the plot). This demonstrates that the finite beam size can not be neglected and the photon scattering angle has to be taken into account.

4 Model

Simple model studies has been performed to understand the differences between the photon energy spectra obtained from the collider simulation by V.Telnov [7] and the spectra derived from the lowest order QED predictions for the Compton scattering (1). Three effects have to be taken into account to describe simulation results: correlation between photon energy and the scattering angle, electron rescattering and nonlinear effects due to high density of the laser beam.

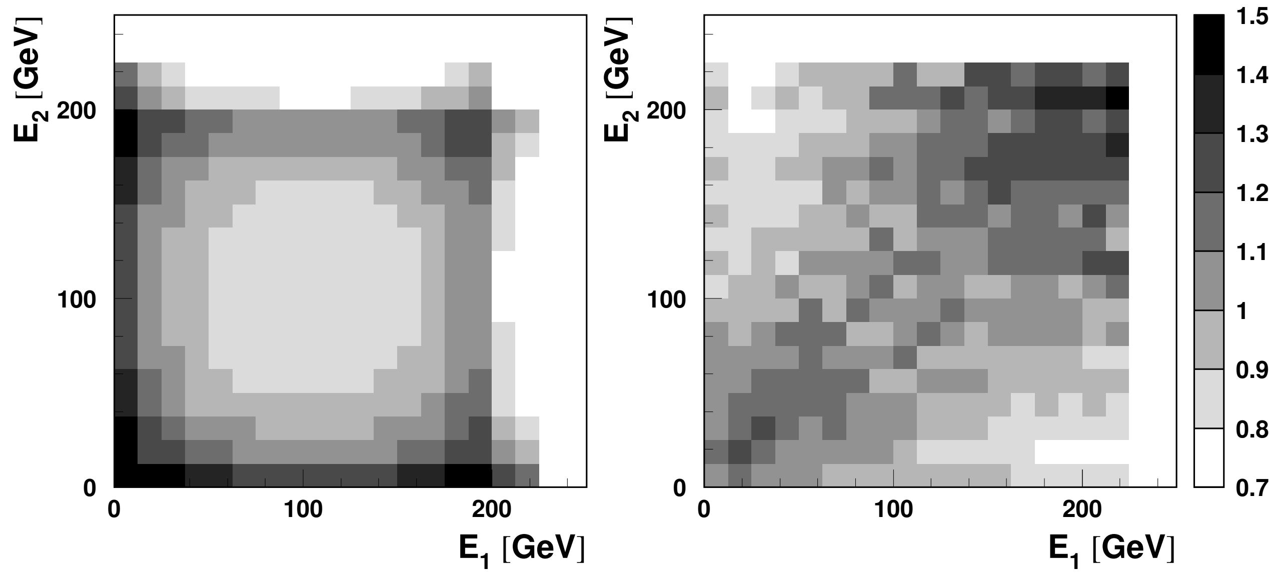

Figure 4: Two-dimensional energy distribution for two colliding photons, obtained from the full simulation by V.Telnov (left plot) and the ratio of this distribution to the simple product of two one-dimensional energy spectra (right plot).

4.1 Angular correlations

Electron beams collide with focused laser beams at the distance $b \sim 2$ mm before the interaction point. The angular spread of scattered photons is very small (due to very high Lorenz boost), but becomes important for very small beam spot sizes. Energy of the photon is related to the scattering angle θ in the laboratory frame by the formula:

$$E_\gamma \;=\; \frac{E_{max}}{1 \;+\; \gamma^2\,\theta^2}\;,$$

where γ is the boost of the electron-photon center-of-mass frame:

$$\gamma \;=\; \frac{E_e}{m_e\,\sqrt{x+1}}\;.$$

Correlation between the photon energy and the scattering angle and the expected distribution of the photon scattering angle for primary electron beam energy E_e=250 GeV ($x = 4.5$) and different laser beam polarizations are shown in Fig. 5. High energy photons are produced within a cone of $\sim 3\mu$rad, whereas the vertical size of electron beam corresponds to the angle of $\sim 2\mu$rad (~ 4 nm vertical beam spread, as expected at 250 GeV, at the distance of 2 mm from IP). Therefore the energy-angle correlations can not be neglected when calculating luminosity spectra. Due to the larger scattering angle, the effective vertical size of the photon beam increases at low photon energies. As a result, number of interactions involving low energy photons decreases. The effect of angular

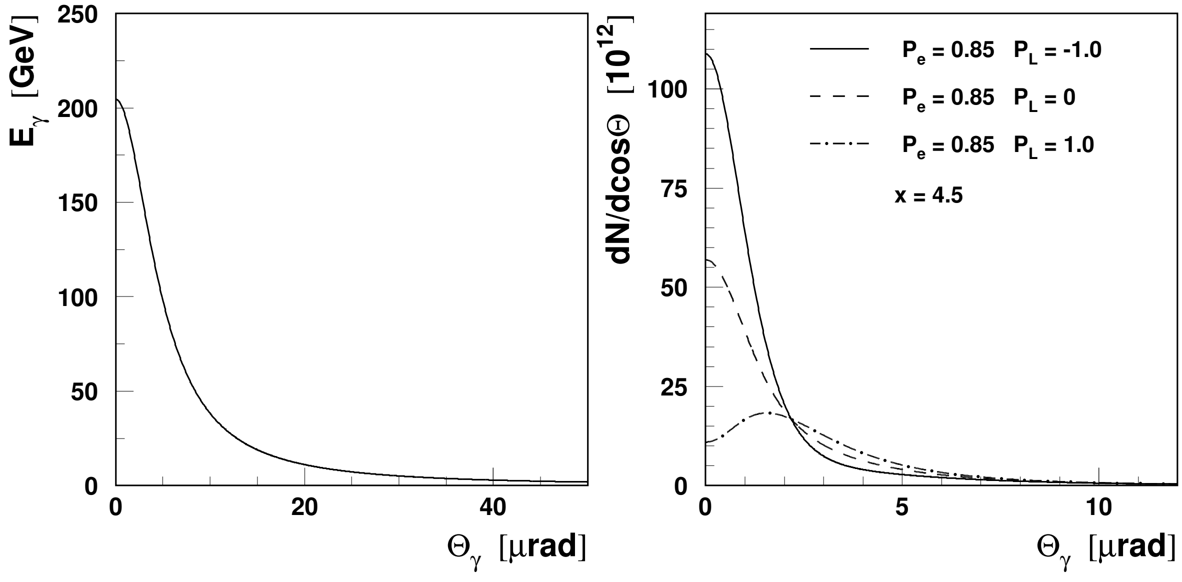

Figure 5: Energy as a function of the photon angle in the laboratory frame (left plot) and the distribution of the photon scattering angle for different laser beam polarizations P_L (right plot) for photons from Compton back-scattering.

correlations can be described by the following modification of the energy spectra [10]:

$$\frac{1}{N}\frac{dN}{dy} = f(y,x) \quad = \quad f_C(y,x) \cdot \mathcal{N} \exp\left(-\frac{\rho^2}{8}\left(\frac{x}{y} - x - 1\right)\right) \ ,$$

where the parameter ρ relates the vertical beam size σ_y and the distance b between the conversion and interaction points, $\rho \approx (m_e b)/(E_e \sigma_y)$, $\mathcal{N}$ is normalization factor and $f_C(y,x)$ is the Compton spectra, as described by eq. (1). In Fig. 6 the photon energy distribution corrected for energy-angle correlations, for $x = 4.5$, is compared with the Compton spectra. After the photon scattering angle is take into account photons with low energies, $E_\gamma < 0.5 \cdot E_{max}$, hardly contribute to the luminosity.

4.2 Electron rescattering

With high laser beam density, one can "convert" most of the electrons into the high energy photons. However, electrons after first scattering still have large energies. Scattering of laser photons on these secondary electrons results in an additional contribution to the photon energy spectra. It can be calculated by integrating over the energy fraction y' of secondary electrons:

$$\frac{1}{N'}\frac{dN'}{dy} = f'(y,x) \quad = \quad \mathcal{N}' \int_0^1 dy' \quad w_C(y')\ f_C(1-y',x) \cdot f_C(\frac{y}{y'}, y'x) \tag{4}$$

where the $w_C(y')$ is the weighting function correcting for the dependence of the Compton scattering cross section on the electron energy and $\mathcal{N}'$ is normalization factor. Secondary

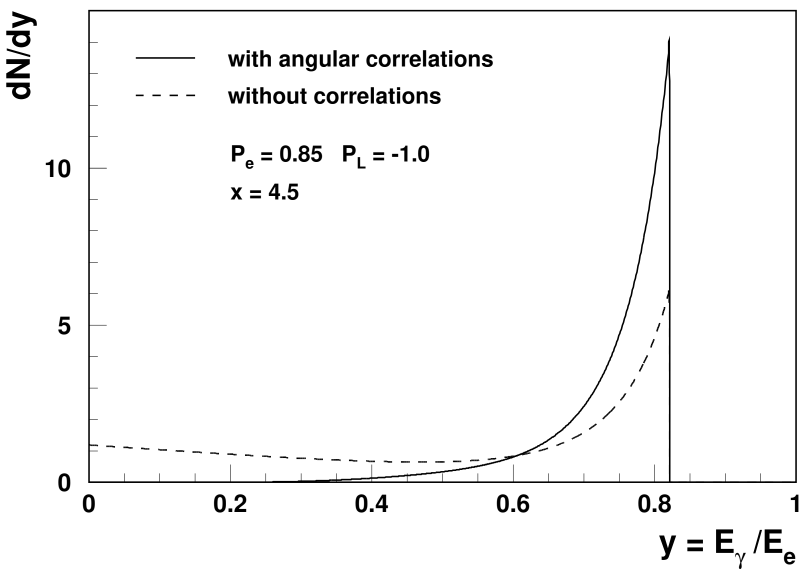

Figure 6: Energy distribution for colliding photons, corrected for angular correlations (solid line), compared with Compton spectra (dashed line).

scattering, due to lower electron energy, takes place at lower x value, $x' = y'x$. The energy distribution for secondary electrons and for photons from electron rescattering, as obtained from numerical integration of formula (4), are shown in Fig. 7. Photons from scattering on secondary electrons have much "softer" energy spectra, as compared to the Compton scattering on primary electrons. Contribution of electron rescattering significantly modifies the photon energy distribution in the low energy part.

4.3 Nonlinear effects

For very high densities of the laser beam nonlinear QED effects become important. The field of the electromagnetic wave can significantly influence the motion of an electron. The effect can be described as an effective increase in the electron mass $m_e^2 \to m_e^2(1+\xi^2)$, where ξ^2 is the parameter describing the nonlinear effects, proportional to the photon density in the laser beam [11]. For the Compton scattering nonlinear effects result in an effective rescaling of the collider parameter x:

$$x \to \tilde{x} \quad = \quad \frac{x}{1+\xi^2}$$

As a result, the energy distribution for the backscattered photons is shifted towards lower energies, as shown in Fig. 8 (left plot).

For high density of laser beam it is also possible that electron scatters on two photons instead of one. The detailed calculation of the energy distribution for photons produced in such scattering is presented in [11]. However, We found that the distribution obtained from the simulation [7] can be well approximated by the simple formula for scattering

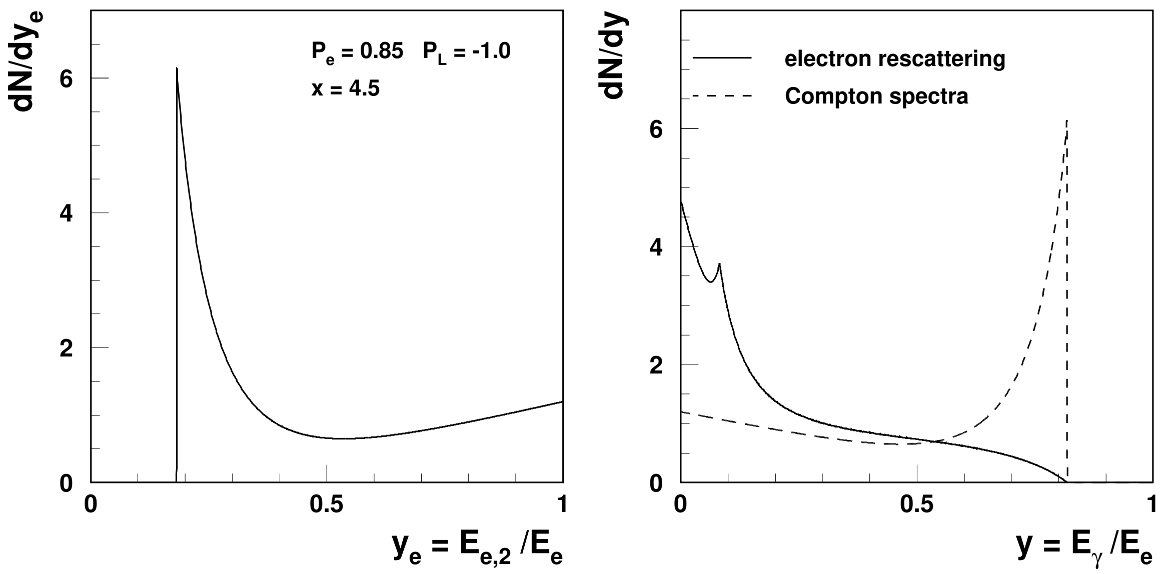

Figure 7: Energy distribution for secondary electrons (left plot) and for photons from laser beam back-scattering on secondary electrons (right plot). Energy distribution from back-scattering on primary electrons is shown for comparison.

on one photon with double energy (i.e. with $\tilde{x} \rightarrow 2\tilde{x}$) corrected by additional factor suppressing the high energy peak:

$$\frac{1}{N_2}\frac{dN_2}{dy} = f_2(y,\tilde{x}) \quad = \quad f(y,2\tilde{x}) \cdot \mathcal{N}_2 \left(\frac{2\tilde{x}}{y} - 2\tilde{x} - 1 \right)^{\delta} \ ,$$

where δ is the parameter describing suppression of the high energy part of the spectra and $\mathcal{N}_2$ is the normalization constant. The resulting photon energy distribution is compared with the distribution for one photon scattering in Fig. 8 (right plot).

5 Parametrization

5.1 Model parameters

The main aim of the presented study was to parametrize the high energy part of the luminosity spectra of the Photon Collider in a simple analytical form. It was assumed that the high energy part of the $\gamma\gamma$ luminosity spectra can be described by a simple product:

$$\frac{1}{N}\frac{d^2N}{dy_1 dy_2} \quad = \quad f_{tot}(y_1,\tilde{x})\ f_{tot}(y_2,\tilde{x}) \tag{5}$$

where $f_{tot}(y_1,\tilde{x})$ is the energy spectra for the photon. The spectra can be parametrized as a sum of three components described in the previous section:

$$f_{tot}(y,\tilde{x}) \quad = \quad n\ f(y,\tilde{x}) \ + \ n'\ f'(y,\tilde{x}) \ + \ n_2\ f_2(y,\tilde{x}) \tag{6}$$

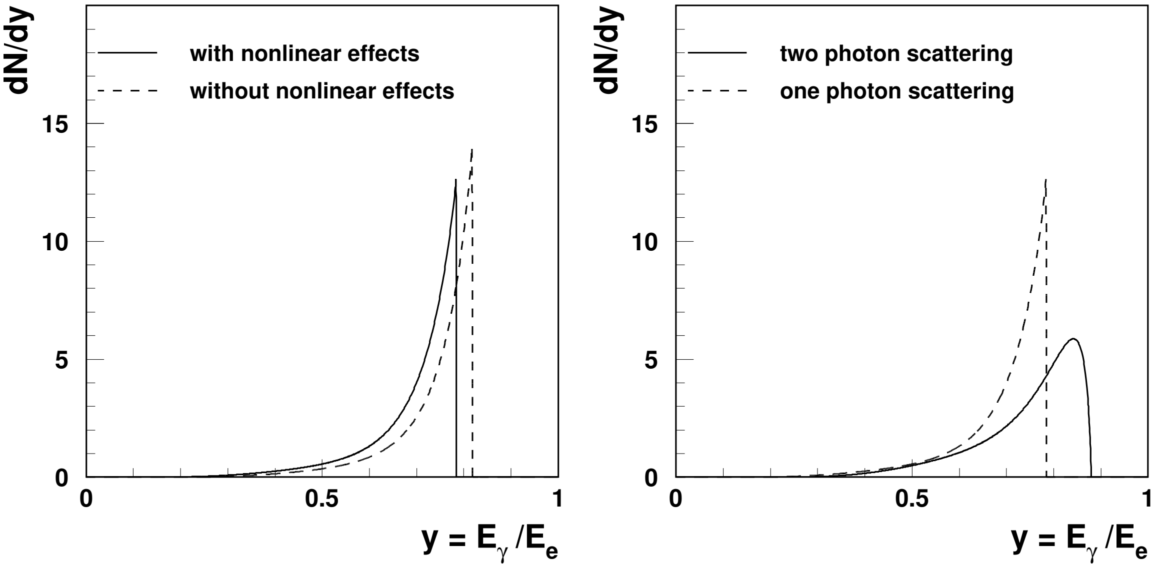

Figure 8: Energy distribution for photons from Compton backscattering (corrected for angular correlations) with and without taking into account nonlinear effects (left plot). Energy distribution for photons from electron scattering on two photons (nonlinear effect) compared to scattering on one photon (right plot).

where n, n' and n_2 are parameters describing contributions of different processes to the spectra. All together the model has 10 free parameters which can be adjusted to describe the results of spectra simulation. Only 4 of these parameters describe the shape of the contributing components:

- two parameters describing ξ^2 dependence on the beam energy: $\xi^2 = \xi_0 + E_e \cdot \xi_1$
- parameter ρ^2 describing angular correlations
- parameter δ added in description of two-photon scattering

Remaining 6 parameters are needed to describe the relative normalization of contributing processes, i.e. the dependence of the parameters n, n' and n_2 on the electron beam energy E_e. Whereas distributions f, f' and f_2 are normalized to unity, as defined by formula (2), normalization of f_{tot} is not fixed. It is evaluated from the requirement that the high energy part of the luminosity spectra is given by the formula (5).

5.2 Fit results

The formula (6) was compared with the photon energy spectra obtained from simulation by V.Telnov [7]. To minimize effects of energy correlations a cut on the energy of the second photon was imposed. For electron beam energy of 100, 250 and 400 GeV the cut was 40, 150 and 260 GeV respectively. Parameters of the model were fitted to the photon spectra, for $y > 0.1$, simultaneously at all energies.

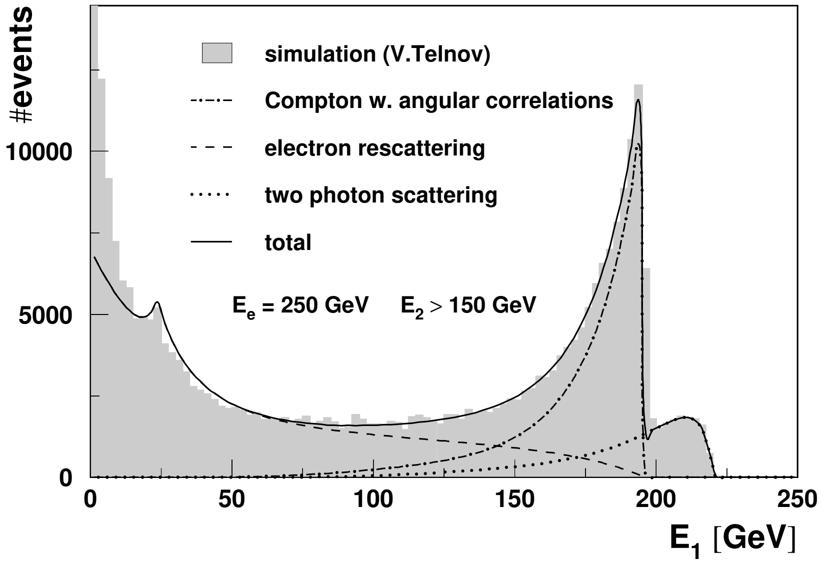

Figure 9: Comparison of the photon energy distribution obtained from full simulation of luminosity spectra, with the fitted contributions of different processes considered in the described model, as indicated in the plot.

Result of the fit to the photon energy distribution at E_e=250 GeV is shown in Fig. 9. Fitted contributions of different processes are also indicated. The model describes the spectra very well, down to $E_\gamma \sim 0.1\ E_e$. Three processes considered in the model contribute to different parts of the spectra. By summing these contributions most of details of the distribution can be well reproduced. Very good description of the photon energy distribution for $y > 0.1$ is obtained for all considered energies, as shown in Fig. 10.

Normalization of the fitted parametrization, as well as of the contributions of different processes, are shown in Fig. 9 as a function of the electron beam energy E_e. Normalization of the parametrization changes from about 0.8 at 50 GeV to about 0.55 at 500 GeV. This means that the two photon spectra obtained from the product of the two distributions, as given by eq. (5), describes between 65% and 30% of events expected from the spectra simulation [7]. 35% to 70% of the total $\gamma\gamma$ luminosity expected from simulation is due to events with one or both photons having low energy, which are not described by the presented parametrization.

Shown in Fig. 12 is the comparison of the average photon polarization resulting from the fitted parametrization with the distribution obtained from the simulation of luminosity spectra. To describe the photon polarization two additional assumptions were made in the model:

- scattering involving two photons results in very high photon polarization. It is taken from the Compton formula (3) (with $\tilde{x} \to 2\tilde{x}$) for scattered photon energies above the threshold for one photon scattering, and fixed at the threshold value for lower energies;

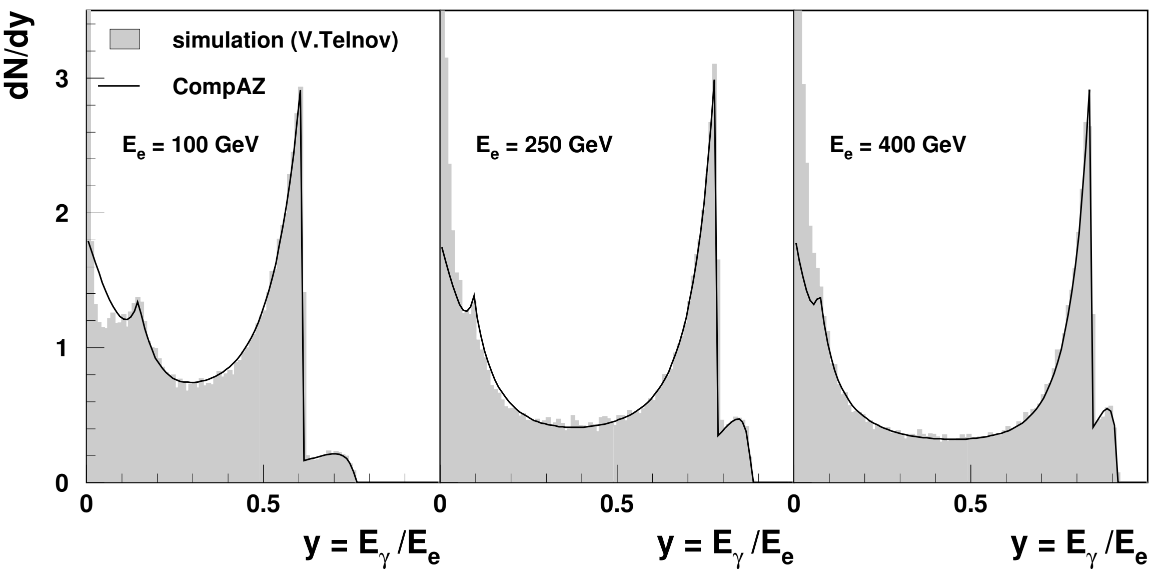

Figure 10: Comparison of the photon energy distribution from the fitted parametrization with the distribution obtained from full simulation of luminosity spectra, for three electron beam energies, as indicated in the plot. Imposed cut on the energy of the second photon is 40, 150 and 260 GeV respectively.

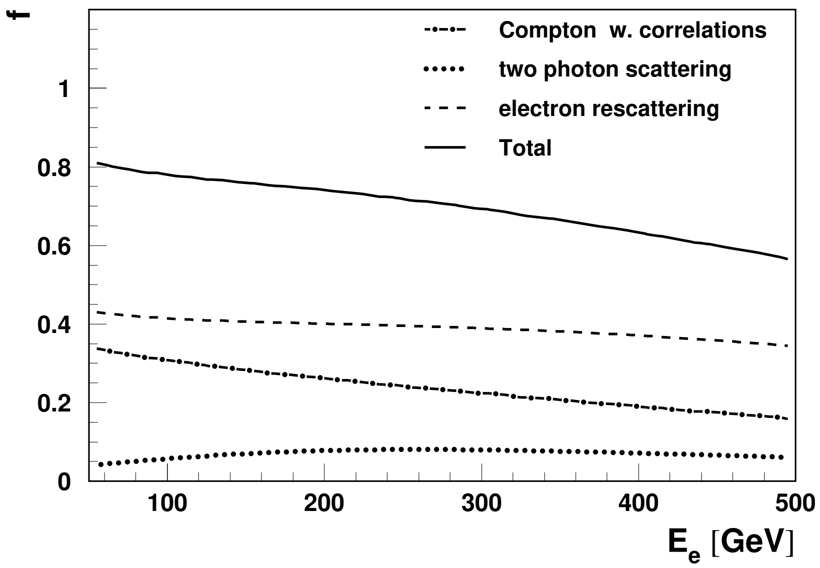

Figure 11: Normalization of the CompAZ parametrization of the photon energy distribution, relative to the distribution obtained from full simulation of luminosity spectra, as a function of the electron beam energy. Also shown are normalizations of separate processes considered in the model.

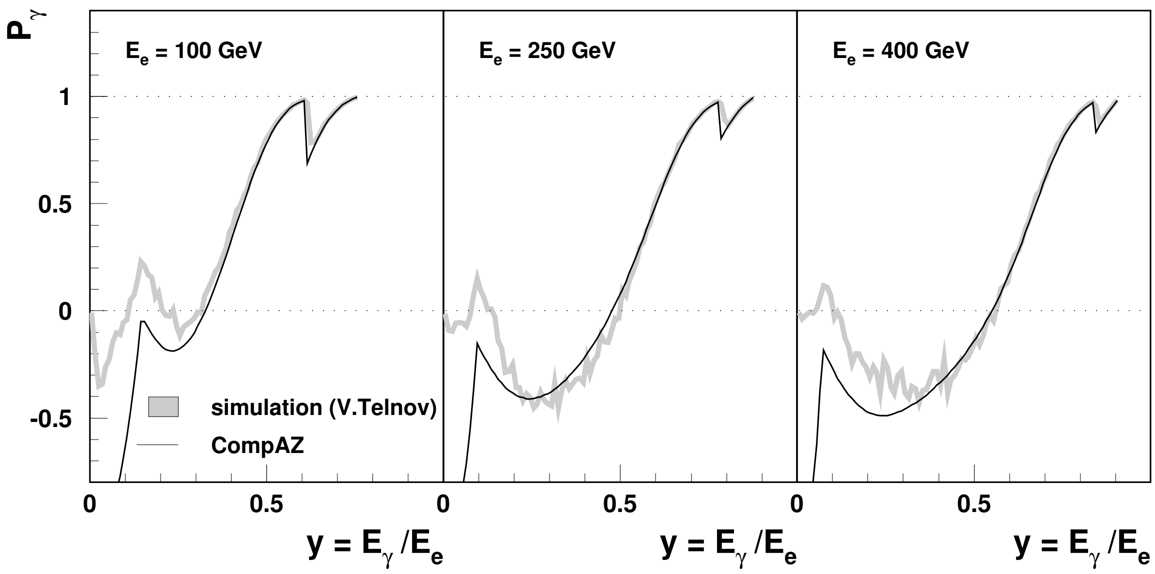

Figure 12: Comparison of the photon polarization resulting from the fitted parametrization with the distribution obtained from full simulation of luminosity spectra, for three electron beam energies, as indicated in the plot. Imposed cut on the energy of the second photon is 40, 150 and 260 GeV respectively.

- electrons undergoing secondary scattering are assumed to be unpolarized.

Both assumptions have no strong physical motivation,[2] however they were found to give the best description at the simulation level. It has to be stressed that the model was not fitted to the photon polarization distribution and no additional parameters were introduced to describe it. Very good agreement between the parametrization and the average photon polarization obtained from the simulation, is observed for $y > 0.3$.

5.3 CompAZ

The routine implementing the described spectra parametrization is called **CompAZ**. It can be used to calculate the photon energy spectra for different electron beam energies and to calculate the average photon polarization for given photon energy. Contributions from different processes can also be calculated. Additional routines were prepared for convenient event generation from the parametrized spectra. All routines can be downloaded from web [12].

Shown in Fig. 13 is the $\gamma\gamma$ center-of-mass energy distribution obtained from CompAZ compared with the distribution obtained from the simulation of luminosity spectra, for different electron beam energies. No cuts on photon energies were imposed. Proper description of the spectra is obtained for $W_{\gamma\gamma} >\sim 0.3\ W_{max}$, where $W_{max} = 2\ E_{max}$ is the

[2] As it was pointed out by V.Telnov, significant polarization is expected for secondary electrons [11].

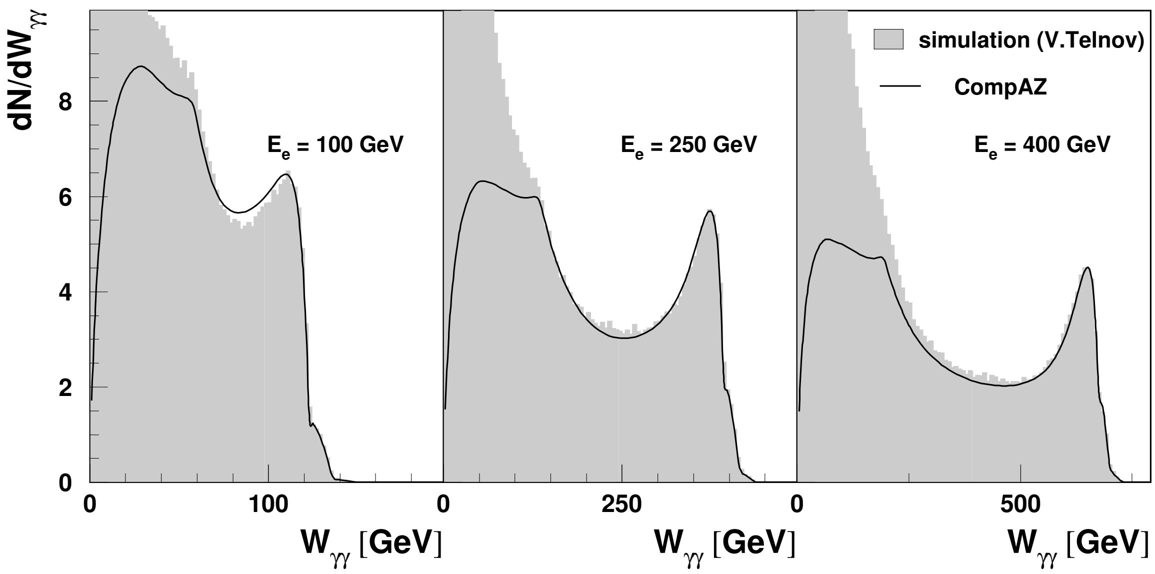

Figure 13: Comparison of the center-of-mass energy distribution obtained with the CompAZ parametrization with the distribution obtained from full simulation of luminosity spectra, for three electron beam energies, as indicated in the plot.

maximum center-of-mass energy available for two photons produced in the Compton scattering (i.e. scattering with one initial laser photon). Also the average product of photon polarizations, related to ratio of $\gamma\gamma$ collisions with the total angular momentum $J_z = 0$ and $|J_z| = 2$, is properly described for large $W_{\gamma\gamma}$. Center-of-mass energy distribution for two colliding photons with $J_z = 0$ is shown in Fig. 15. The parametrization describes very well the high energy part of the spectra, the most relevant for many physics studies.

When calculating the $\gamma\gamma$ luminosity spectra by product of two energy distributions, as given by eq. (5), possible energy correlations between two beams are neglected. Shown in Fig. 16 is the two-dimensional energy distribution obtained from CompAZ, and the ratio of this distribution to the two-photon spectra obtained from the simulation by V.Telnov [7]. In the high energy part of the spectra, when both photons have high energies, $y > 0.5\ y_{max}$, this ratio is close to 1. This shows that CompAZ properly describes this part of the spectra and no additional corrections for beam energy correlations are needed. Only for $W_{\gamma\gamma} <\sim 0.3\ W_{max}$ energy correlations become important. CompAZ overestimates the number of collisions with one high energy ($y > 0.5\ y_{max}$) and one low energy ($y < 0.3\ y_{max}$) photon (the CompAZ to simulation spectra ratio greater than 1), and underestimates the number of collisions involving two low energy photons (the ratio smaller than 1).

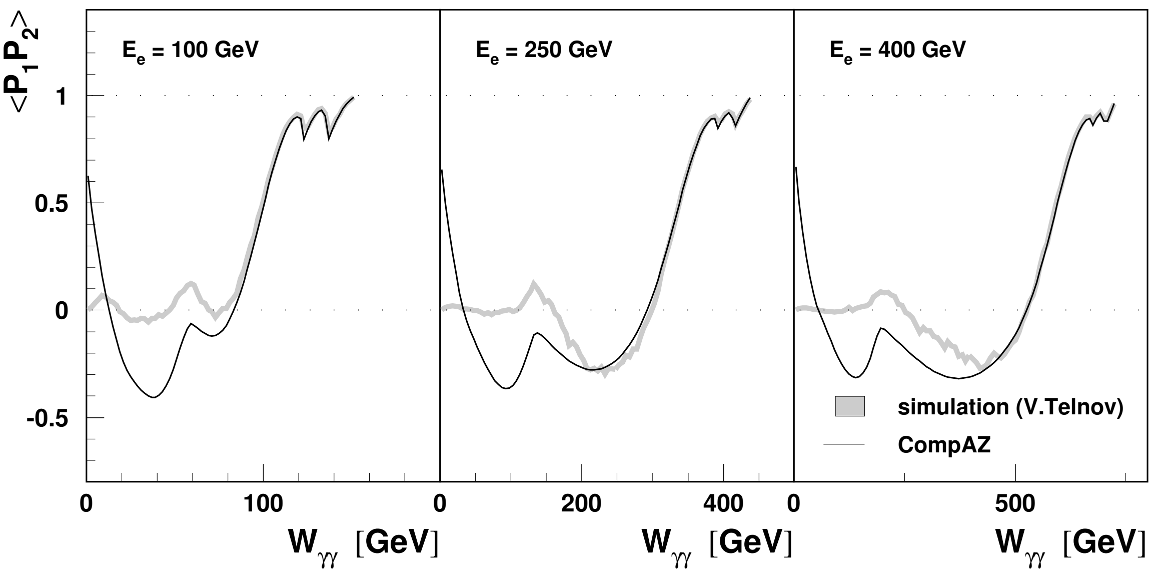

Figure 14: Comparison of the average product of photon polarizations from the CompAZ parametrization with the distribution obtained from full simulation of luminosity spectra, for three electron beam energies, as indicated in the plot.

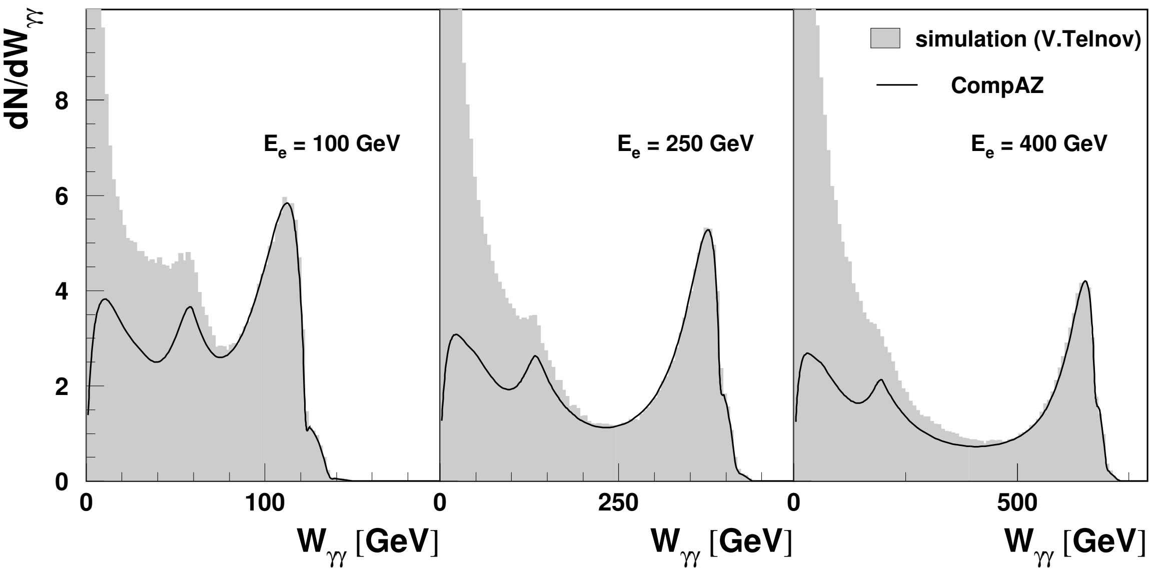

Figure 15: Center-of-mass energy distribution for two colliding photons with $J_z = 0$. Results obtained with the CompAZ parametrization are compared with the distribution obtained from full simulation of luminosity spectra, for three electron beam energies, as indicated in the plot.

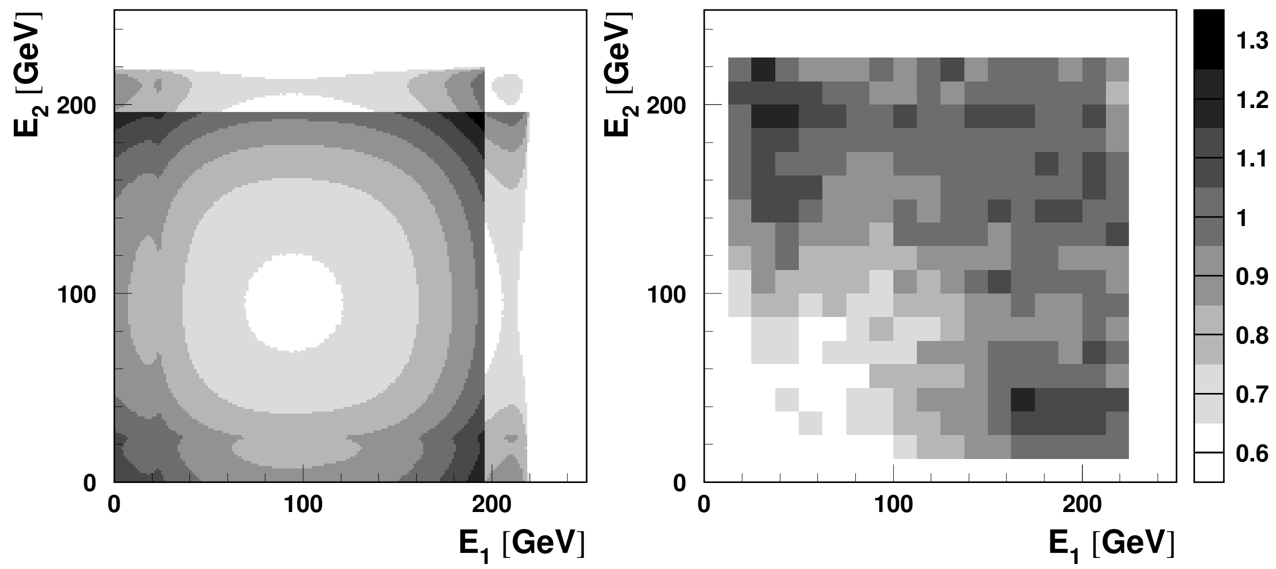

Figure 16: Two-dimensional energy distribution for two colliding photons, obtained from the CompAZ parametrization (left plot) and the ratio of this distribution to the one obtained from full simulation of luminosity spectra (right plot).

5.4 Applications

Luminosity spectra obtained from the detailed beam simulation is the best tool for accurate simulation of $\gamma\gamma$ interactions. Recently the new version of CIRCE code became available [13, 14] including description of the Photon Collider luminosity spectra based on simulation by V.Telnov [6, 7]. The CIRCE program [14] gives detailed description of the luminosity spectra in the whole energy range taking properly into account all non-factorizing contributions (energy and polarization correlations). The package includes routines for convenient event generation. However, only three selected electron beam energies have been considered so far (E_e= 100, 250 and 400 GeV). Moreover, parameters of the Photon Collider assumed in the simulation are only known with accuracy up to 10–20%, as many details of the project are still not fixed. Therefore, model resulting in the similar (or better) accuracy is also applicable for detailed studies.

As already mentioned in the previous section, dedicated routines are available for use of CompAZ for fast simulation of $\gamma\gamma$ scattering events. They have been recently used in the simulation of W^+W^- pair-production at the Photon Collider, for different electron beam energies [15]. Distribution of the $\gamma\gamma$ center-of-mass energy, $W_{\gamma\gamma}$ for $\gamma\gamma \to W^+W^-$ events generated with PYTHIA, for electron beam energy of 250 GeV, is shown in Fig. 17. Generated events were reweighted for photon polarizations. Sample of events generated using CompAZ is compared with the sample generated with the luminosity spectra from simulation [6, 7]. Very good agreement is observed. The advantage of CompAZ is that it

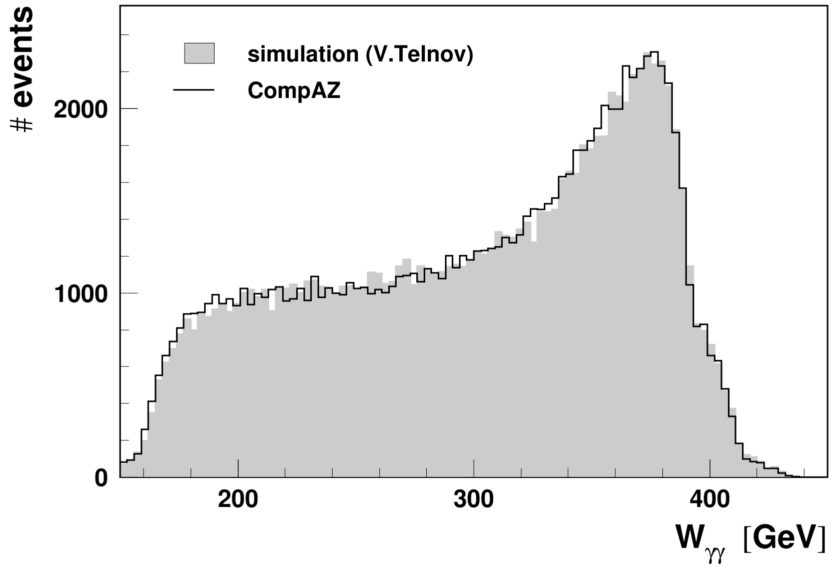

Figure 17: Distribution of the $\gamma\gamma$ center-of-mass energy for $\gamma\gamma \to W^+W^-$ events generated with PYTHIA, for electron beam energy of 250 GeV. Sample of events generated using the CompAZ parametrization is compared with the sample generated with the luminosity spectra from full simulation. Generated events were reweighted for photon polarizations.

can be easily used for any beam energy[3], giving reasonable description of the energy and polarization.

CompAZ parametrization can also be used for calculating expected event distributions without the time consuming event generation. Figure 18 shows the distribution of the measured four-jet invariant mass for $\gamma\gamma \to W^+W^-$ events. Only hadronic $W^\pm$ decays are selected. Results from the full simulation, based on PYTHIA and fast detector simulation program SIMDET, are compared with results obtained by the numerical convolution of the cross section formula with the CompAZ photon energy spectra and parametrization of the detector resolution. The agreement between both approaches is very good. Numerical integration is few orders of magnitude faster than the full simulation and can be used to extrapolate results of full simulation to other beam energies. This procedure has been recently used in the analysis of heavy Higgs production in the Photon Collider, $\gamma\gamma \to h \to W^+W^-$ [15]. Results obtained for Higgs mass of 180 GeV are compared with full simulation in Fig. 19. The method made it possible to calculate the detector level effects expected from the interference between direct W^+W^- production and $h \to W^+W^-$ decay. To estimate the effect with full event and detector simulation very large statistic of events would be needed.

[3]Parametrization can be used for $50 < E_e < 500$ GeV.

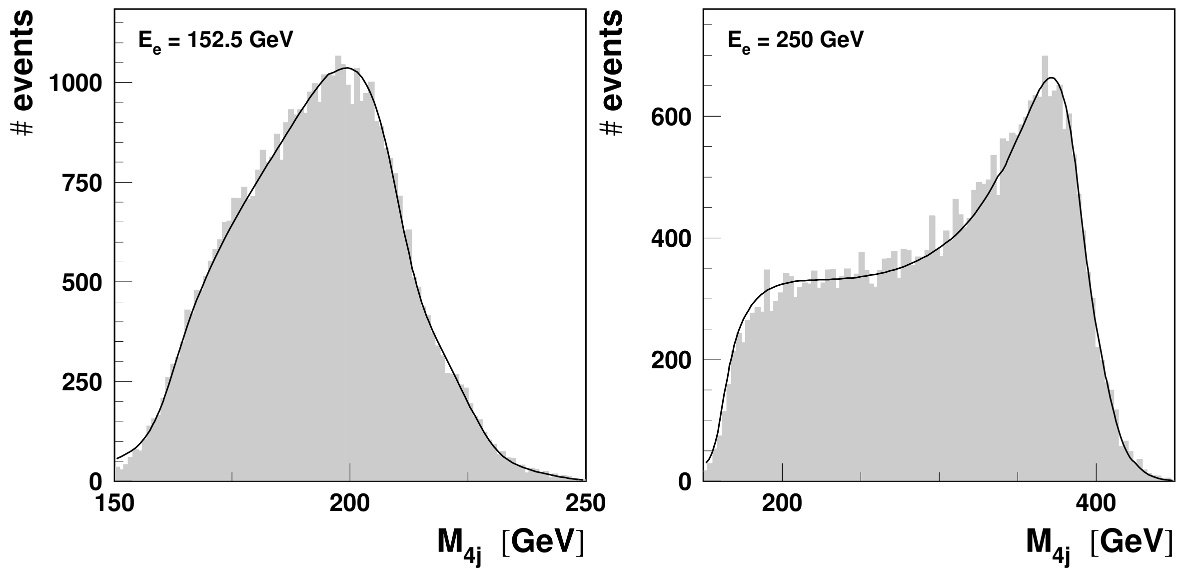

Figure 18: Distribution of the reconstructed W^+W^- center-of-mass energy for $\gamma\gamma \to W^+W^-$ events simulated with PYTHIA, using the CompAZ spectra, and SIMDET detector simulation, compared with the distribution obtained by the numerical convolution of the cross section formula with the CompAZ photon energy spectra and parametrization of the detector resolution, for electron beam energies of 152.5 and 250 GeV.

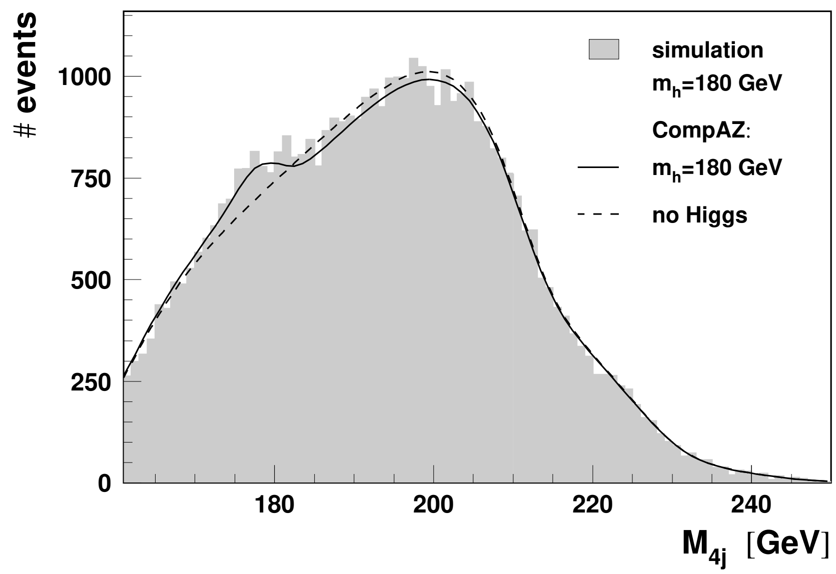

Figure 19: Distribution of the reconstructed W^+W^- center-of-mass energy for $\gamma\gamma \to W^+W^-$ events, for Standard Model Higgs mass of 180 GeV and electron beam energy of 152.5 GeV. Results from the simulation based on PYTHIA, and SIMDET detector simulation (histogram) are compared with the distribution obtained by the numerical convolution of the cross section formula with the CompAZ photon energy spectra and parametrization of the detector resolution (solid line). Distribution expected without the Higgs contribution is also indicated (dashed line).

6 Summary

Simple model, based on the analytical formula for Compton scattering, is used to describe the realistic photon energy spectra of the Photon Collider at TESLA. Parameters of the model, are obtained from the comparison with the full beam simulation by V.Telnov, which includs nonlinear corrections and contributions of higher order processes. Photon energy distribution and polarization, in the high energy part of the spectra, are well reproduced. Model can be used for Monte Carlo simulation of gamma-gamma events at various energies. Parametrization is also shown to be very useful for numerical cross-section calculations.

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