Higgs at PLC with linear polarization

Physics at Future Colliders workshop
2006/2007

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23-05-2007

Study of $\gamma\gamma \rightarrow higgs \rightarrow b\bar{b}$ in SM & MSSM at the Photon Collider

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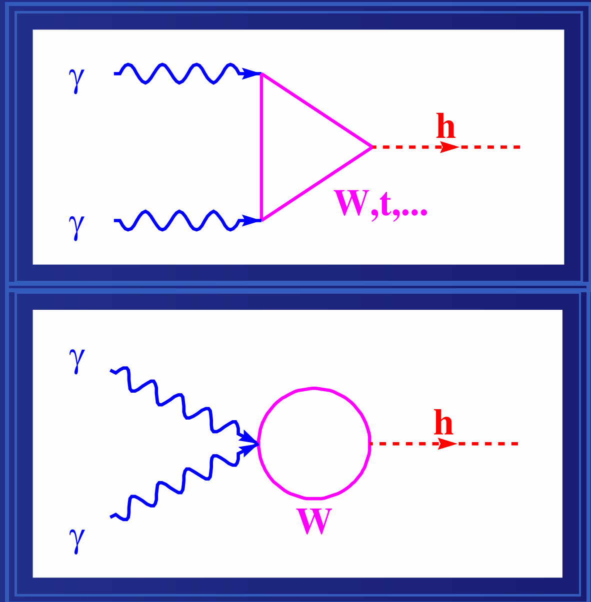
presented by J. Ciborowski
Warsaw University

Loop coupling $h\gamma\gamma$:

- Higgs-bosons can be produced as s-channel resonances
- Non-decoupling $\Rightarrow$ tests of models
- The best machine for this measurement: Photon Collider



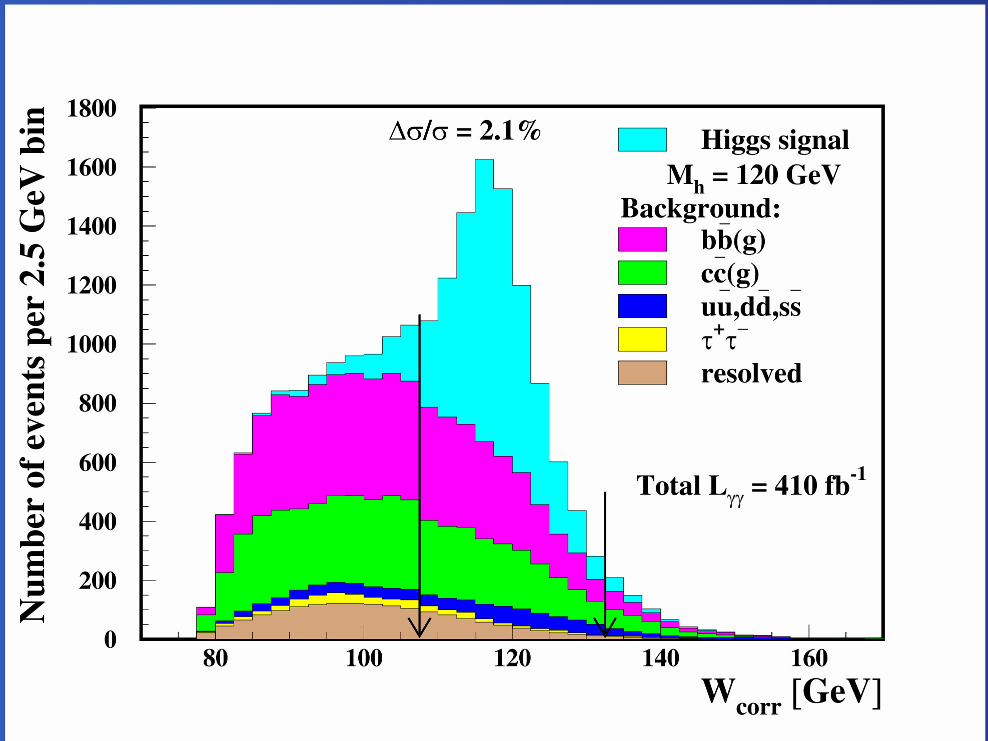
Beyond SM: $H^{\pm}, \chi^{\pm}, \tilde{q}, \tilde{l} \ldots$

hep-ph/0208234, hep-ph/0307180, hep-ph/0307183, hep-ph/0503295

presented ar LCWS05 (hep-ph/0507004, hep-ph/0507006)

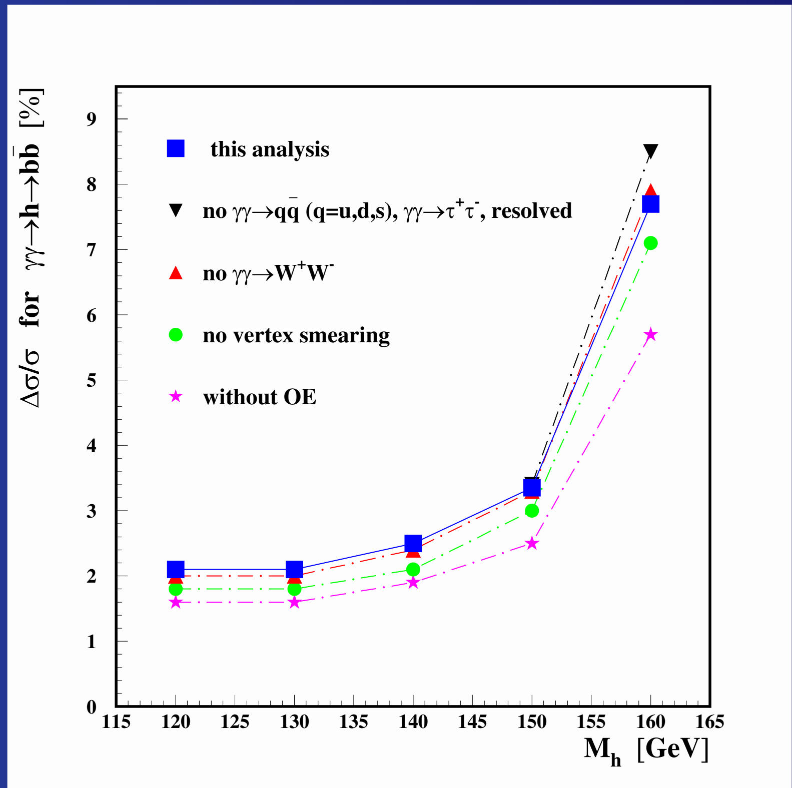
SM summary

Results for $M_h = 120$ GeV



Corrected invariant mass distributions for signal and background events

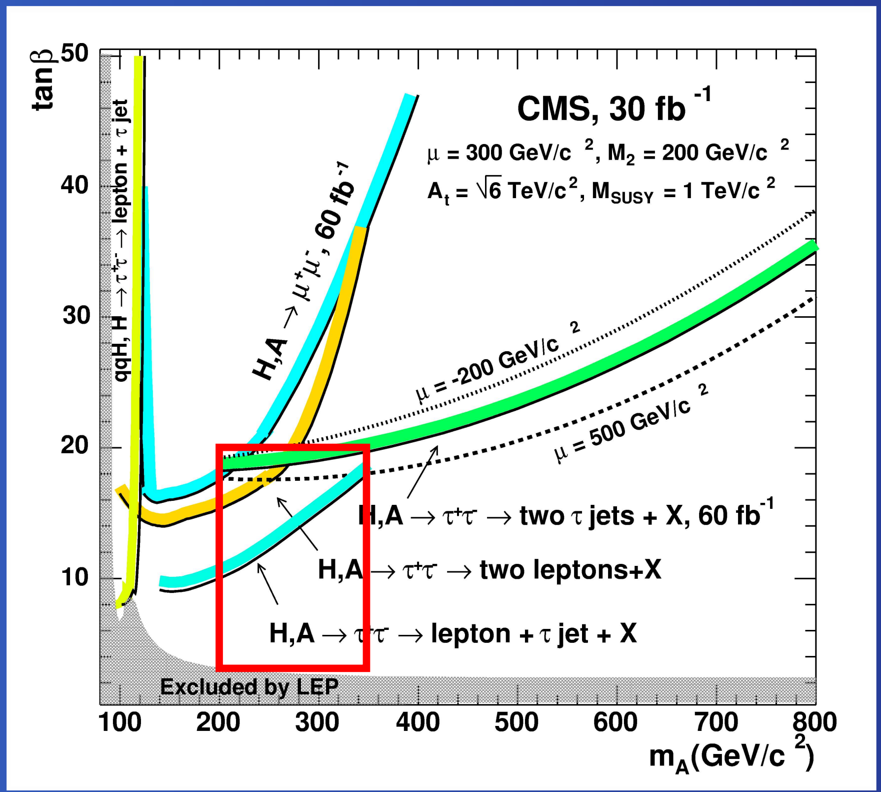
Results for $M_h = 120$-160 GeV



For $M_h = 150$, 160 GeV additional cuts to reduce $\gamma\gamma \rightarrow W^+W^-$

MSSM: LHC wedge at PLC

LHC wedge



From: CMS NOTE 2003/033
(the same results as in newer CMS CR 2004/058)

We consider four MSSM parameter sets:

Symbol	μ [GeV]	M_2 [GeV]	$A_{\tilde{f}}$ [GeV]
I	200	200	1500
II	-150	200	1500
III	-200	200	1500
IV	300	200	2450

I and III – as in M. Mühlleitner *et al.*
with higher $A_{\tilde{f}}$ to have M_h above 114 GeV

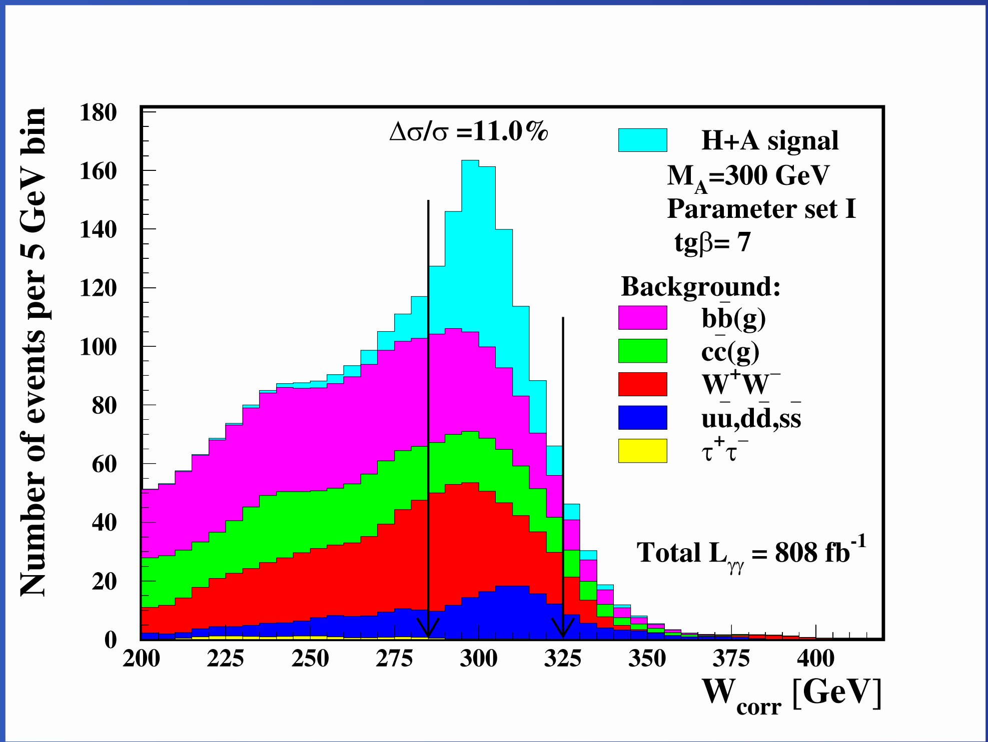
II – an intermediate scenario

IV – as in CMS NOTE 2003/033

MSSM: Precision at PLC

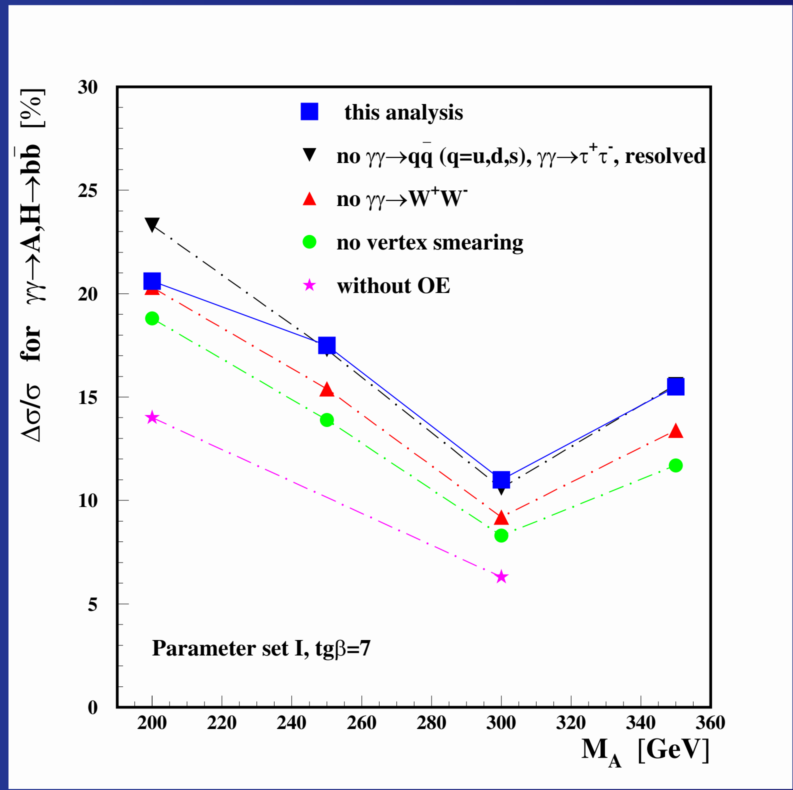
Precision of $\sigma(\gamma\gamma \to A, H \to b\bar{b})$ mesurement

Results for $M_A = 300$ GeV



Corrected invariant mass distributions

Results for $M_A = $ 200-350 GeV

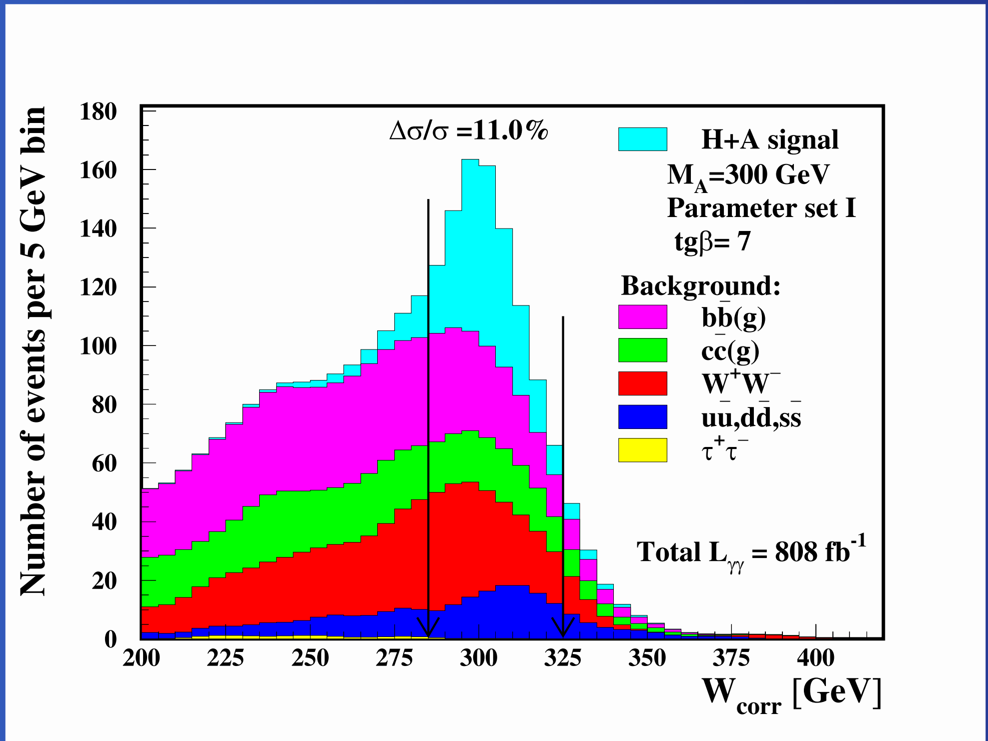


our previous results compared

MSSM: Precision at PLC

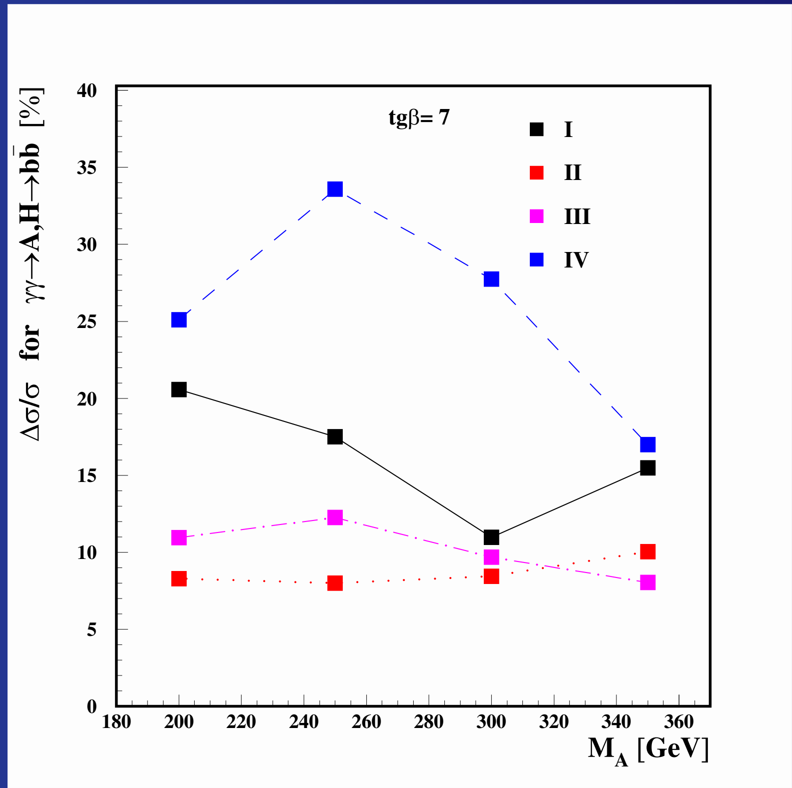
Precision of $\sigma(\gamma\gamma \rightarrow A, H \rightarrow b\bar{b})$ mesurement

Results for $M_A = 300$ GeV



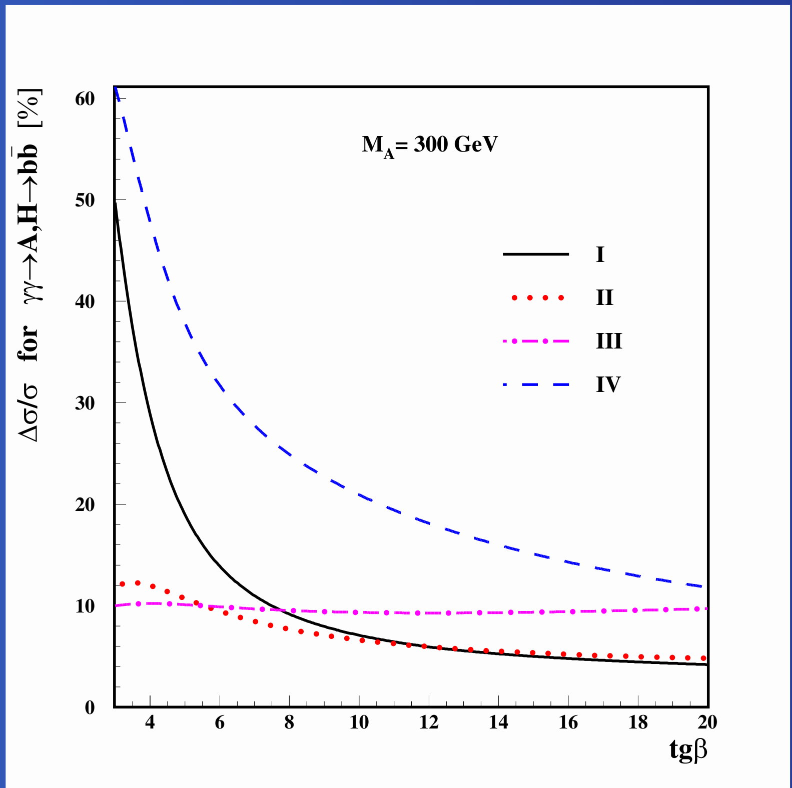
Corrected invariant mass distributions

Results for $M_A = 200$-350 GeV

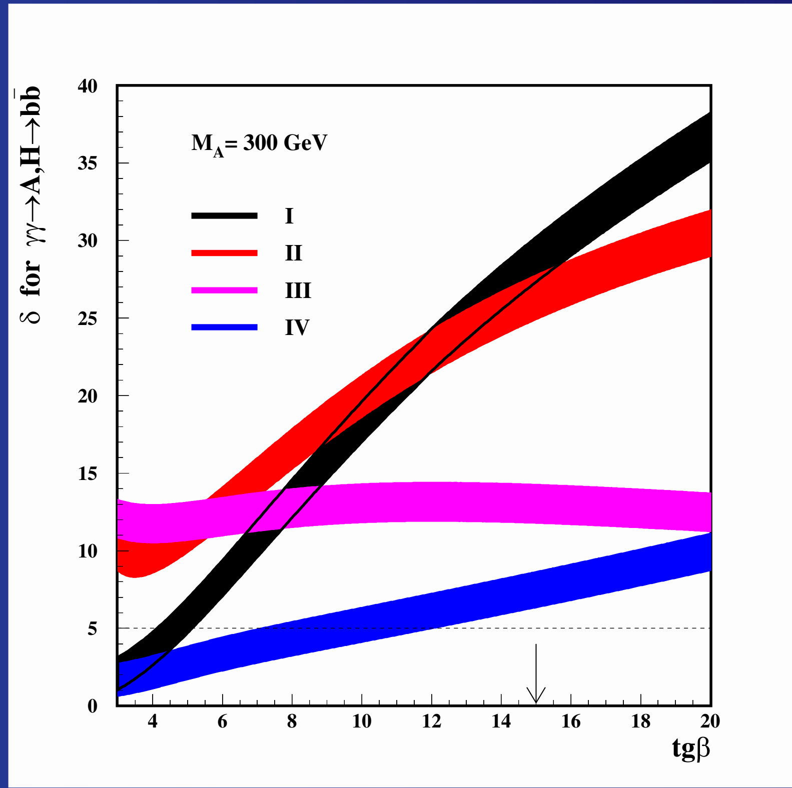


Precision & Significance

$\Delta\sigma(\gamma\gamma \to A, H \to b\bar{b})/\sigma(\gamma\gamma \to A, H \to b\bar{b})$



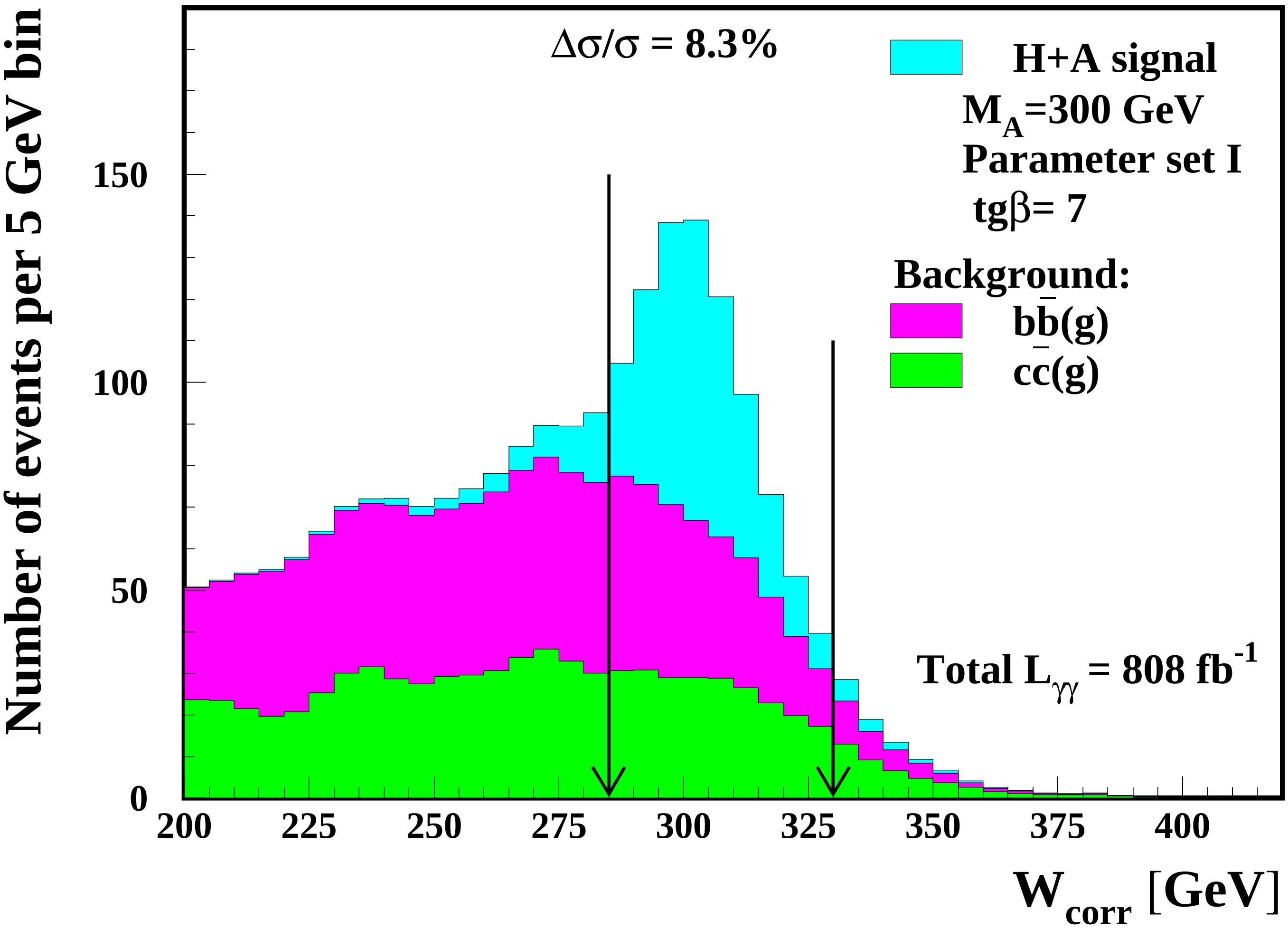
Significance for $\gamma\gamma \to A, H \to b\bar{b}$



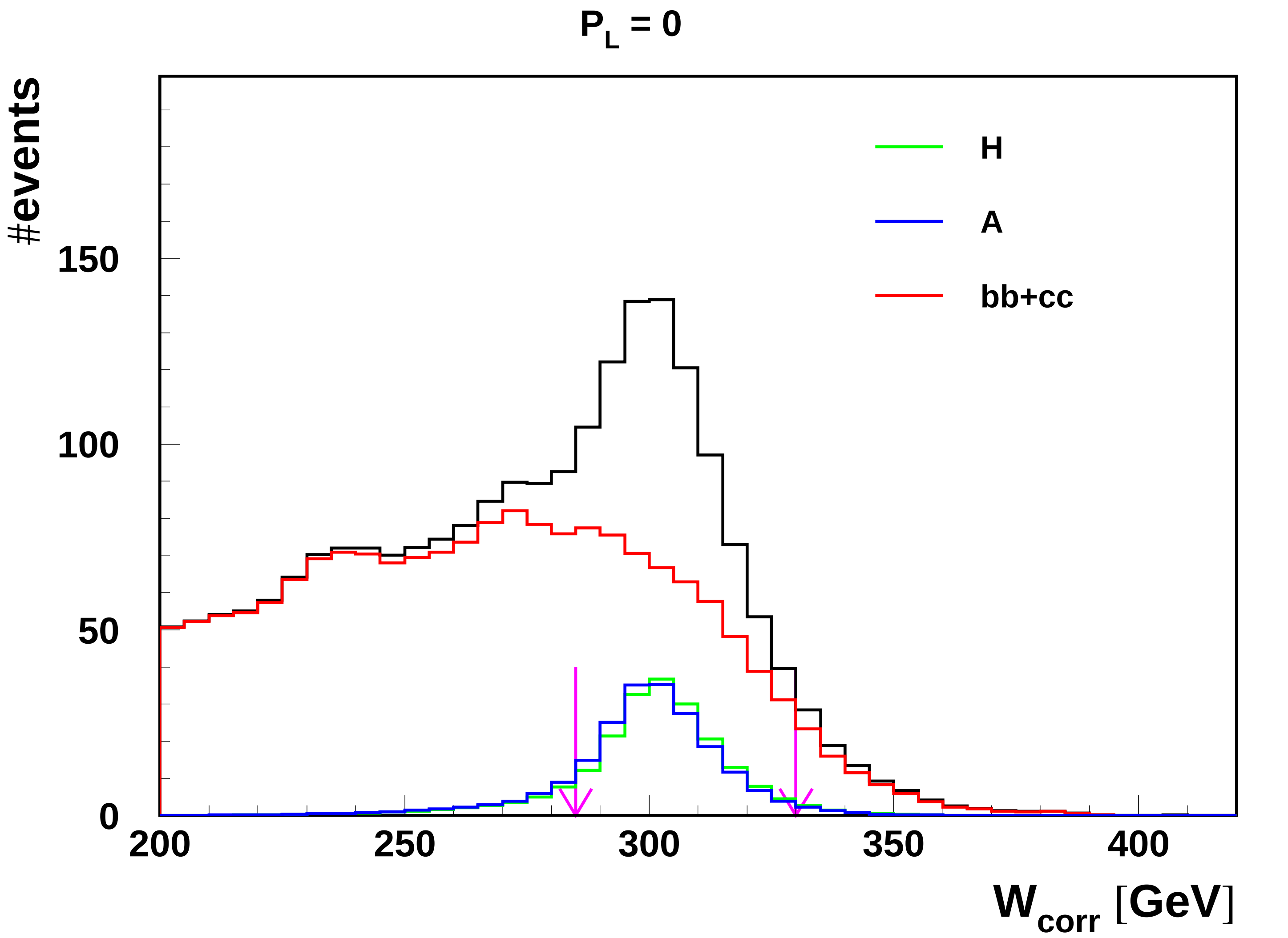
$$\frac{\Delta\sigma}{\sigma} = \frac{\sqrt{\mu_S + \mu_B}}{\mu_S}$$

$$\delta = \frac{\mu_S}{\sqrt{\mu_B}} \pm \sqrt{1 + \frac{\mu_S}{\mu_B}}$$

Arrow – lower limit at LHC



Number of events per 5 GeV bin
Δσ/σ = 8.3%
H+A signal
M_A=300 GeV
Parameter set I
tgβ= 7
Background:
bb̄(g)
cc̄(g)
Total L_γγ = 808 fb^-1
0
50
100
150
200
225
250
275
300
325
350
375
400
W_corr [GeV]



P_L = 0
#events
0
50
100
150
200
250
300
350
400
H
A
bb+cc
W_corr [GeV]

Well known facts about the average linear polarization in Compton scattering

The averaged degree of the linear polarisation of the final photons is [GKST84]

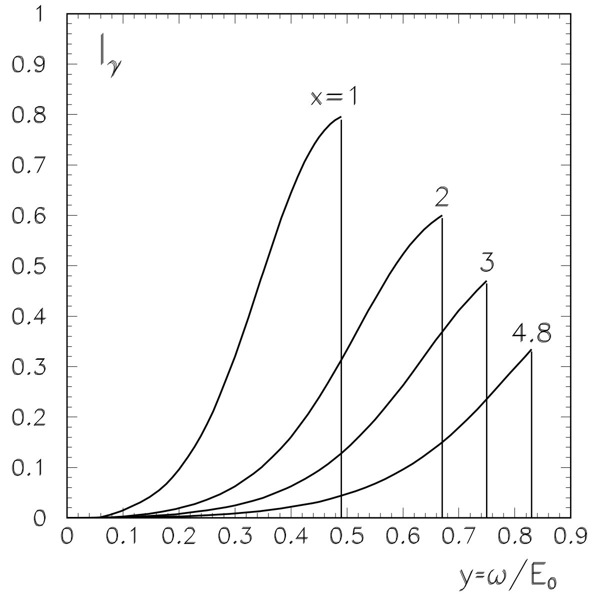
$$\langle l_\gamma \rangle = \frac{2r^2\, P_l}{(1-y)^{-1} + 1 - y - 4r(1-r) - 2\lambda_e P_c x r (2-y)(2r-1)},$$

P_c, P_l are circular and linear laser polarizations;

λ_e the helicity of initial electrons,

$$y = \frac{\omega}{E_0}, \quad x = \frac{4E_0\omega_0}{m^2c^4}, \quad r = \frac{y}{x(1-y)}$$

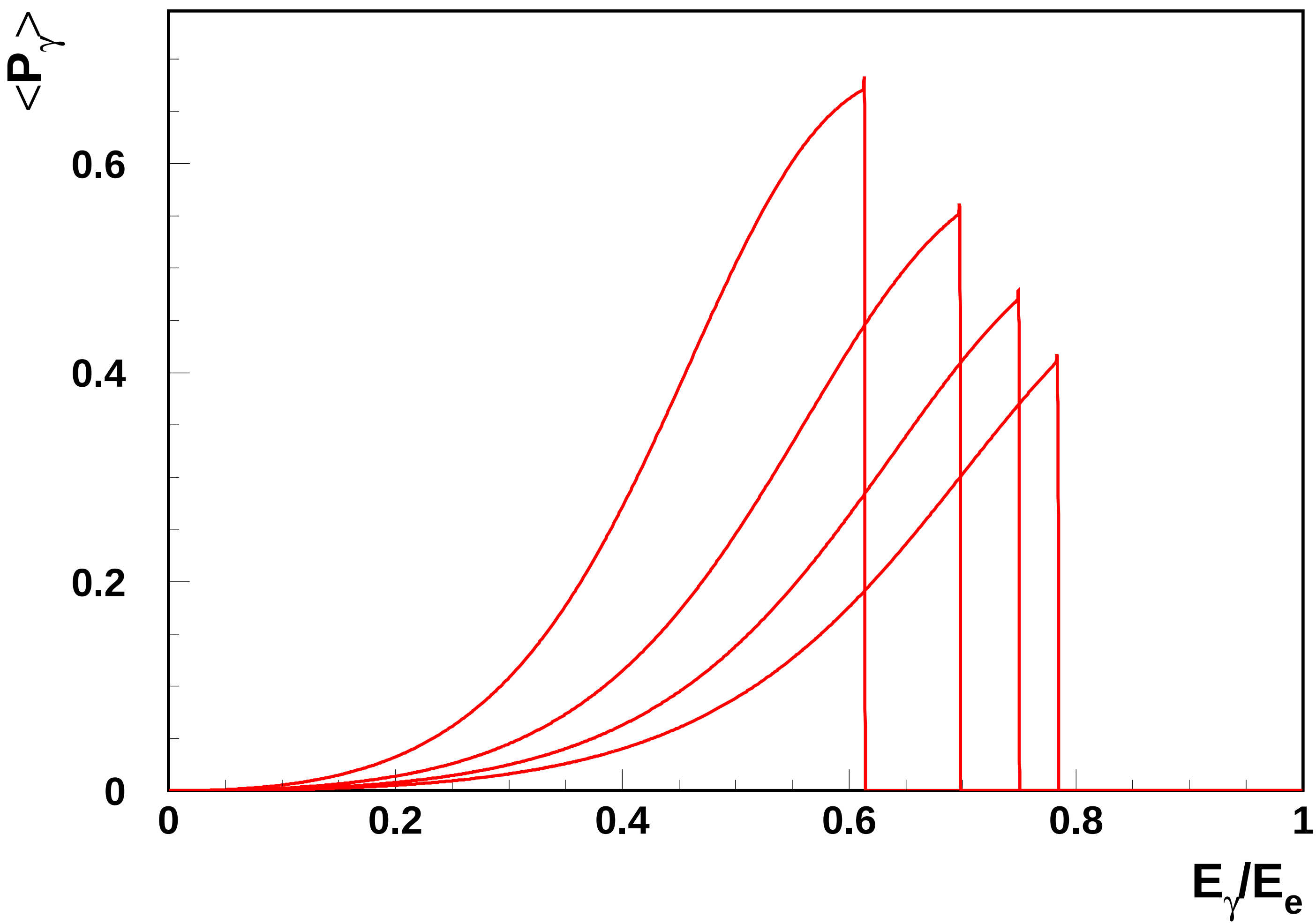
Linear polarisation of the scattered photons for various x for unpolarised electrons and $P_l = 1$.



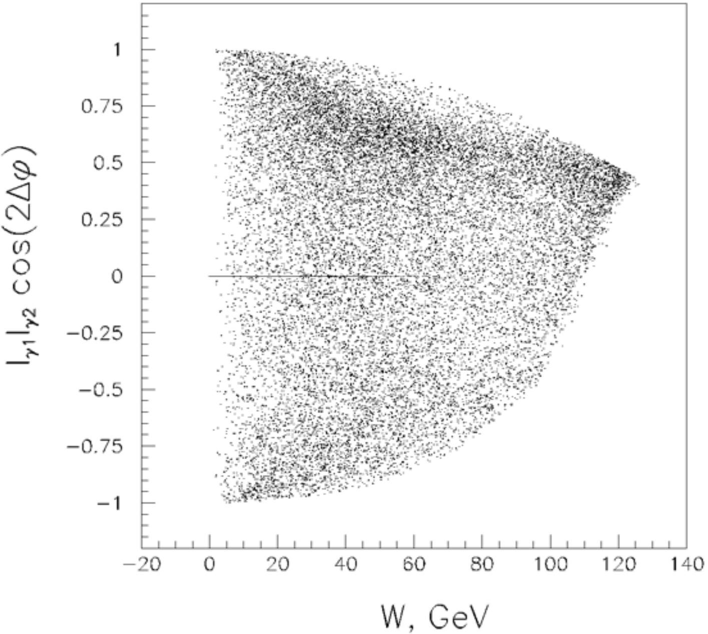
The cross section for the Higgs production

$$\sigma(\gamma\gamma \to h) \propto 1 \pm l_{\gamma,1} l_{\gamma,2} \cos 2\Delta\phi$$

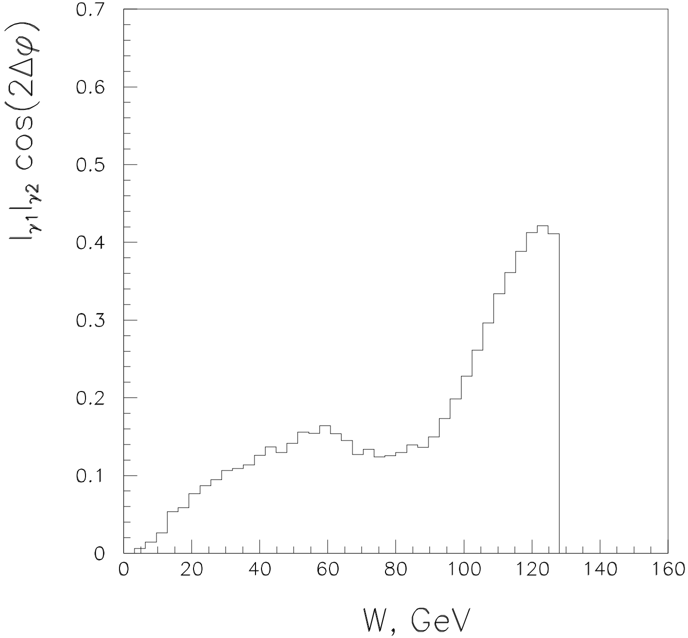
One can see that $l_\gamma \longrightarrow 0$ at $y \longrightarrow 0$.



$\langle P_\gamma \rangle$
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
E_γ/E_e



1
0.75
0.5
0.25
0
−0.25
−0.5
−0.75
−1
$l_{\gamma 1} l_{\gamma 2}\cos(2\Delta\varphi)$
−20
0
20
40
60
80
100
120
140
W, GeV



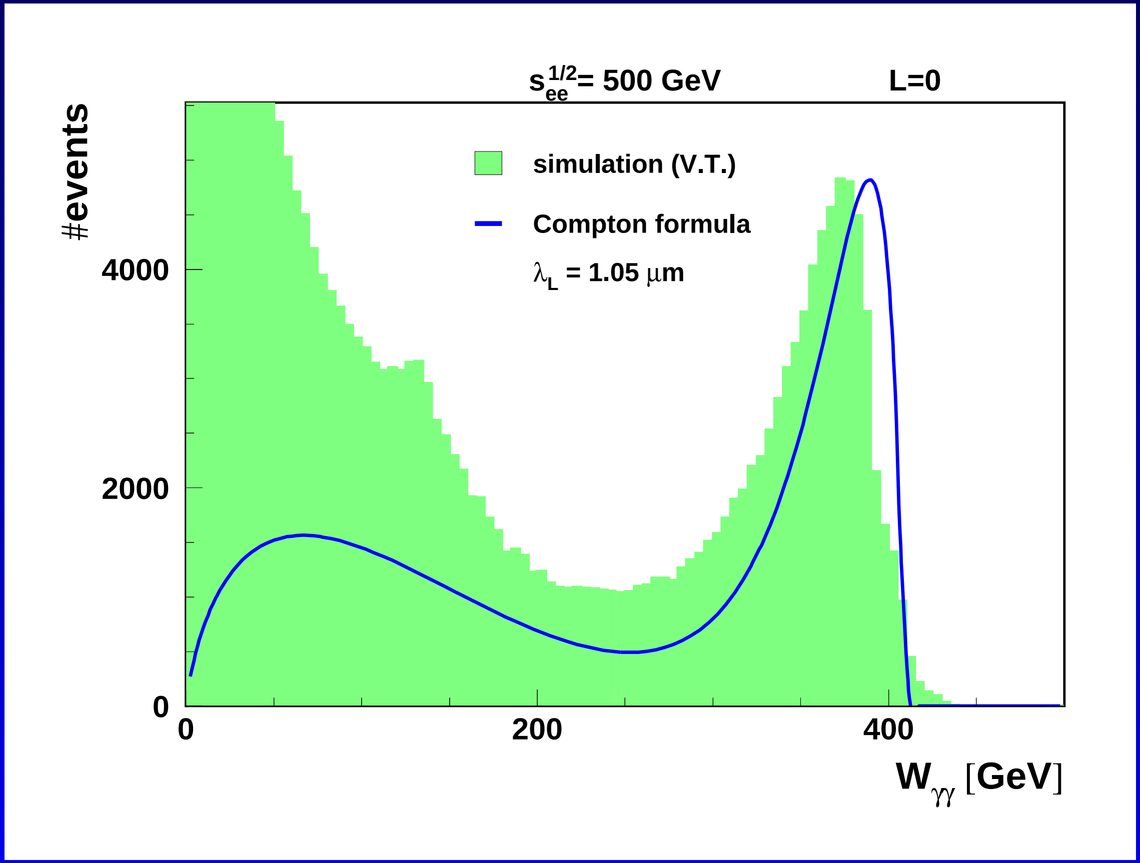
Note, the left shoulder is due to the correlations of the scattered angles.

Photon Collider

To get very high $\gamma\gamma$ luminosity we need very powerful lasers and strongly focused electron beams.

Higher order processes become important.

Compton formula fails to describe the luminosity spectrum

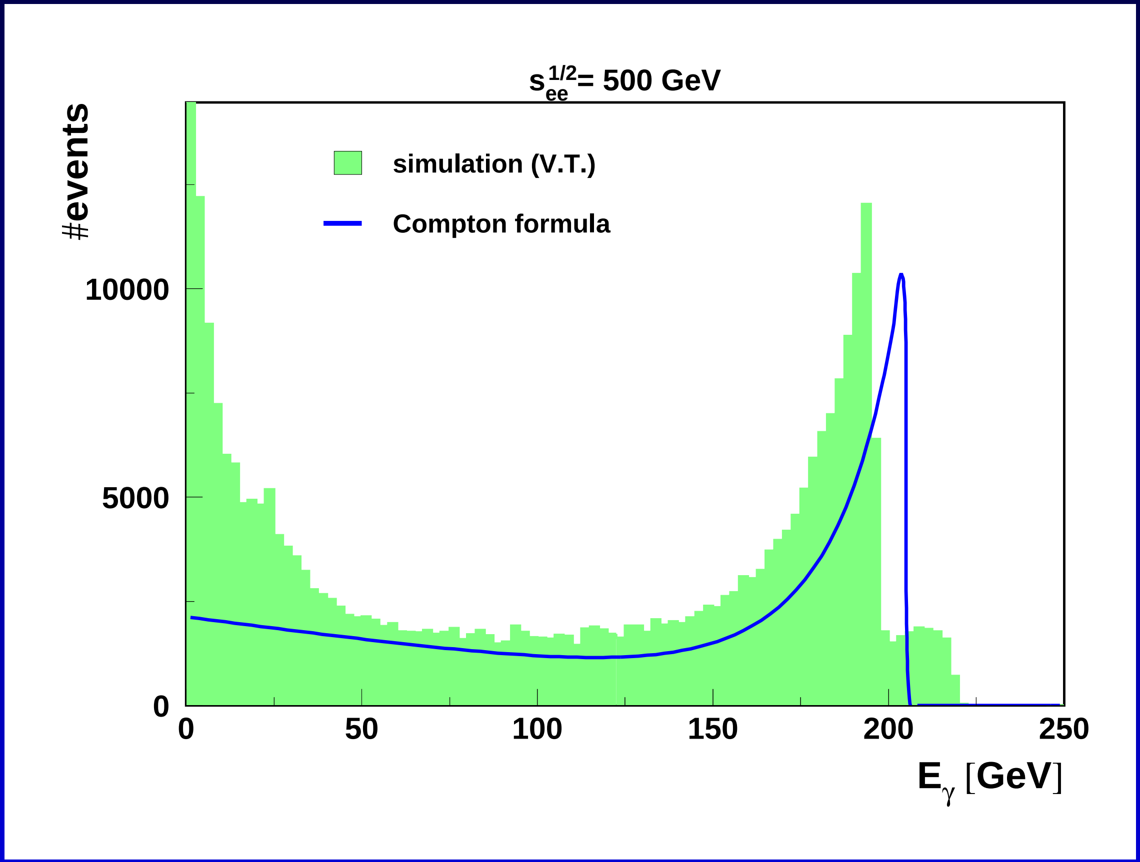


CompAZ

Parametrization of the photon energy spectrum

Compton formula

corrected for:



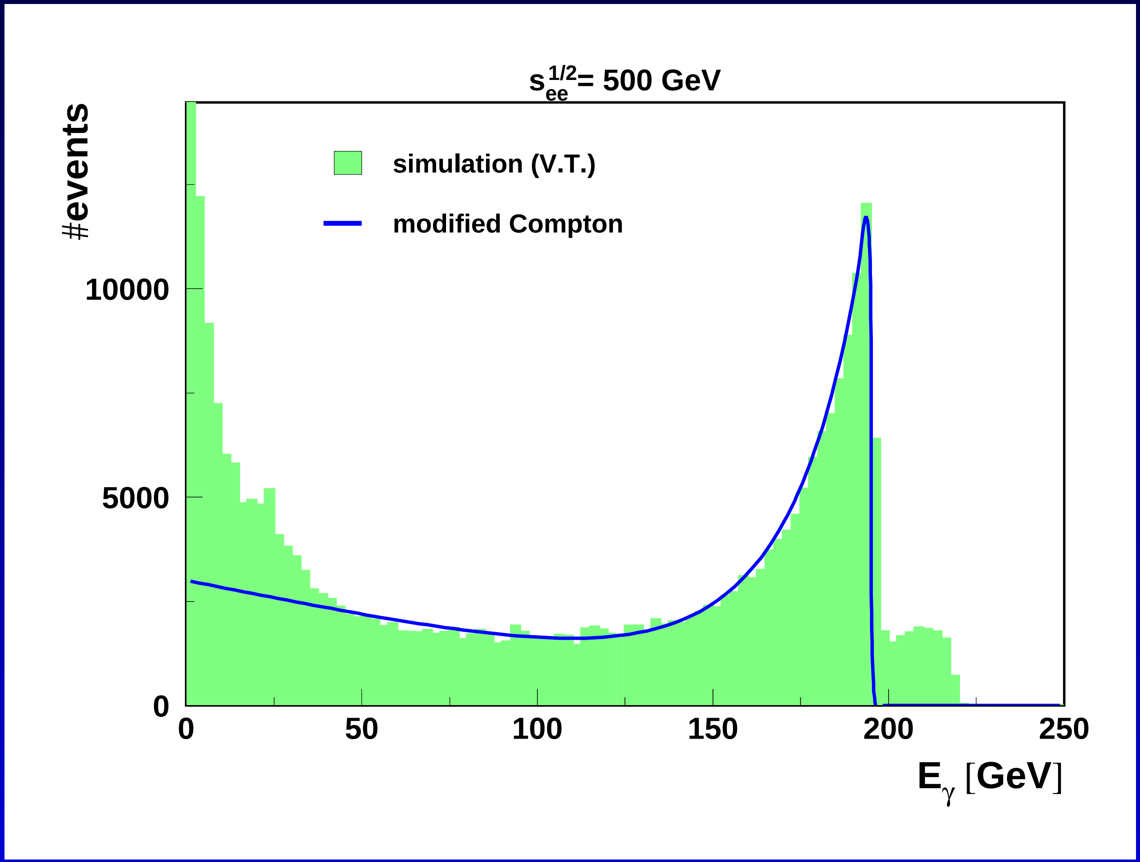
CompAZ

Parametrization of the photon energy spectrum

Compton formula

corrected for:

- nonlinear effects



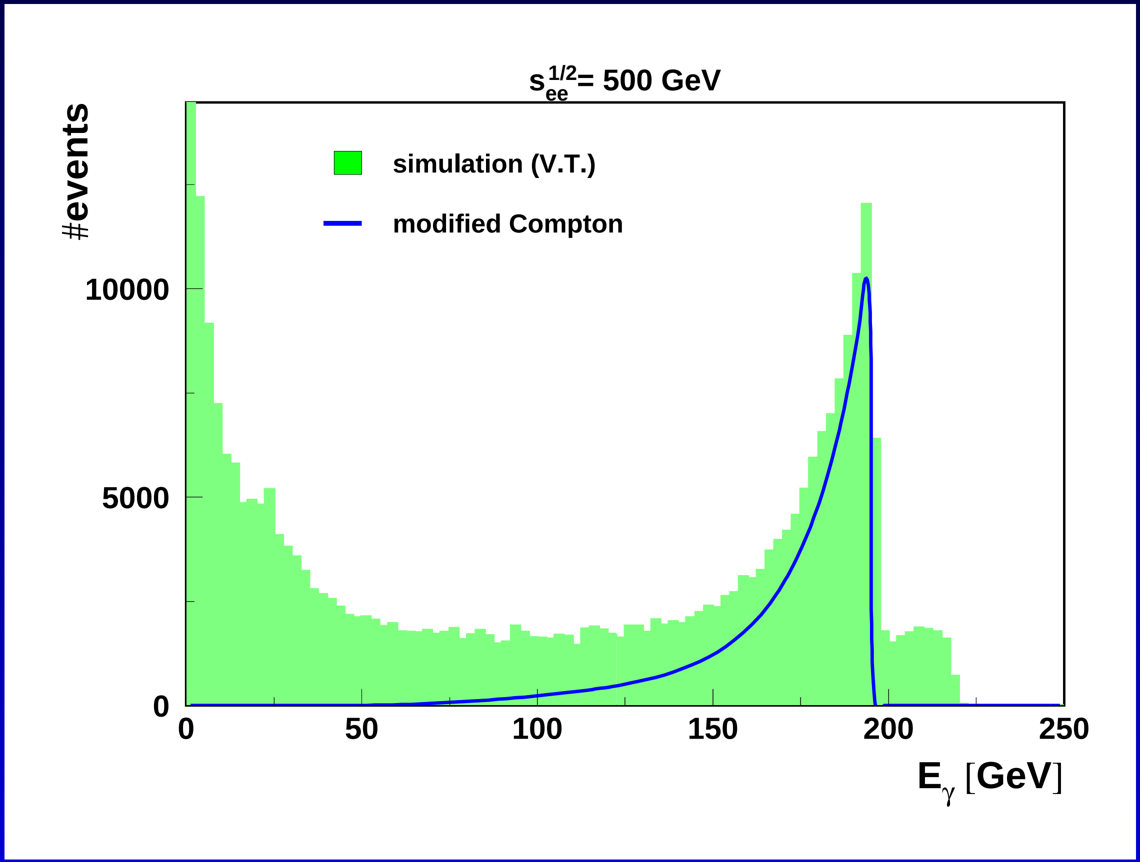
CompAZ

Parametrization of the photon energy spectrum

Compton formula

corrected for:

- nonlinear effects
- angular correlations



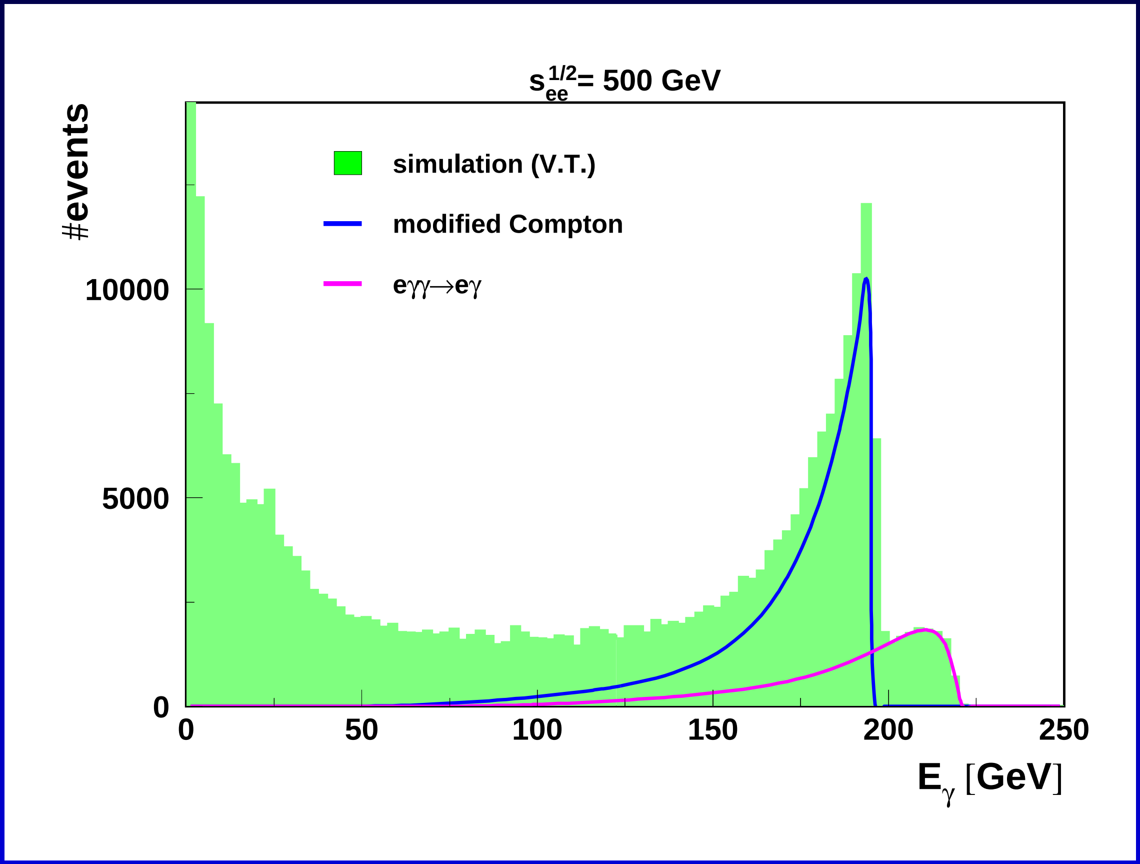
CompAZ

Parametrization of the photon energy spectrum

Compton formula

corrected for:

- nonlinear effects
- angular correlations
- two photon scattering



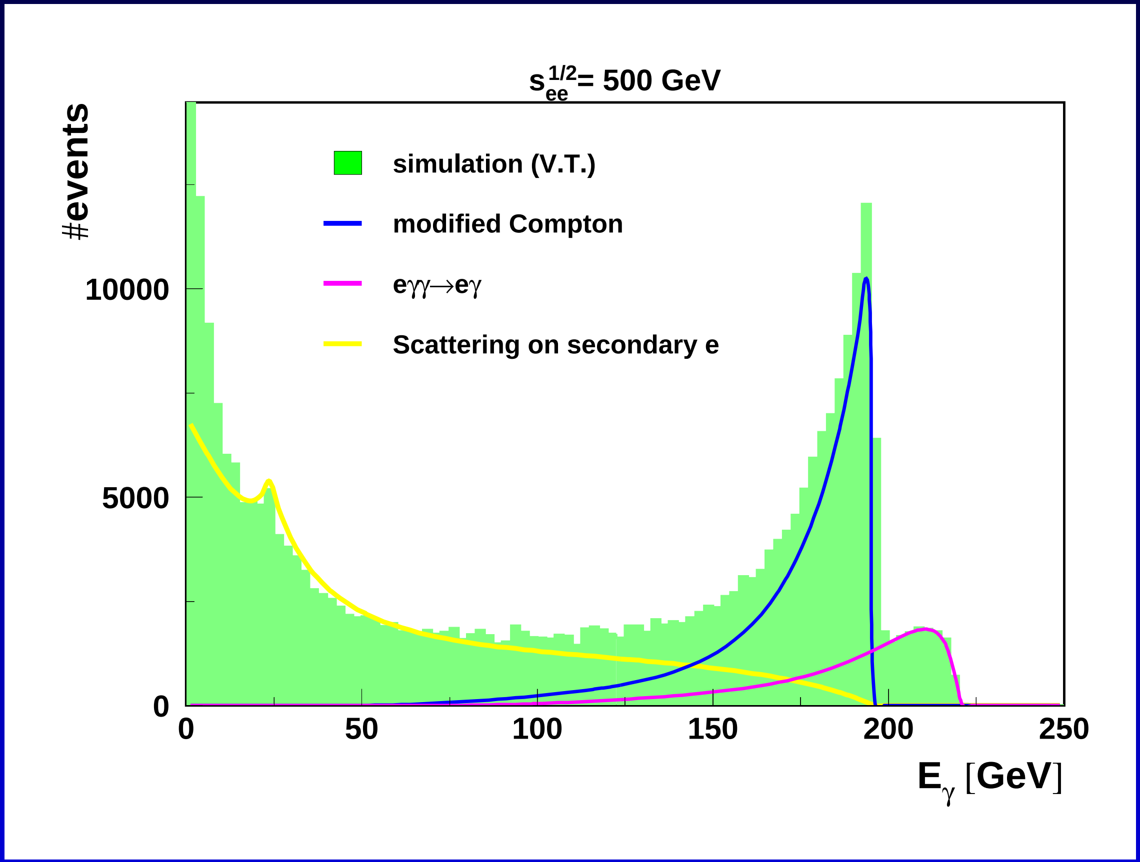
CompAZ

Parametrization of the photon energy spectrum

Compton formula

corrected for:

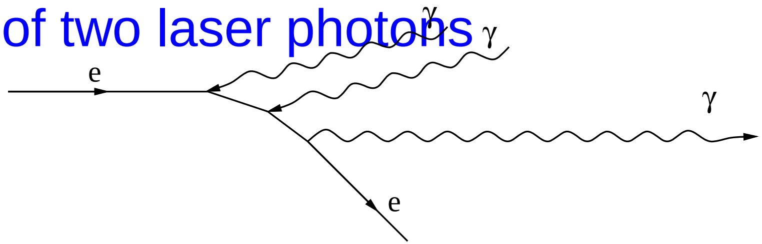
- nonlinear effects
- angular correlations
- two photon scattering
- electron rescattering



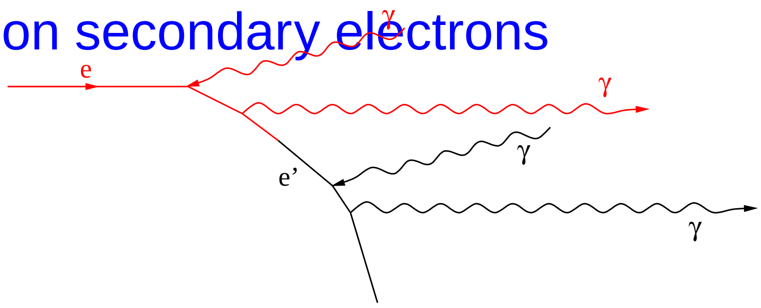
Single γ spectrum

Additional contributions from 'higher-order' processes:

- Scattering of two laser photons



- Scattering on secondary electrons



$\Rightarrow$ CompAZ model

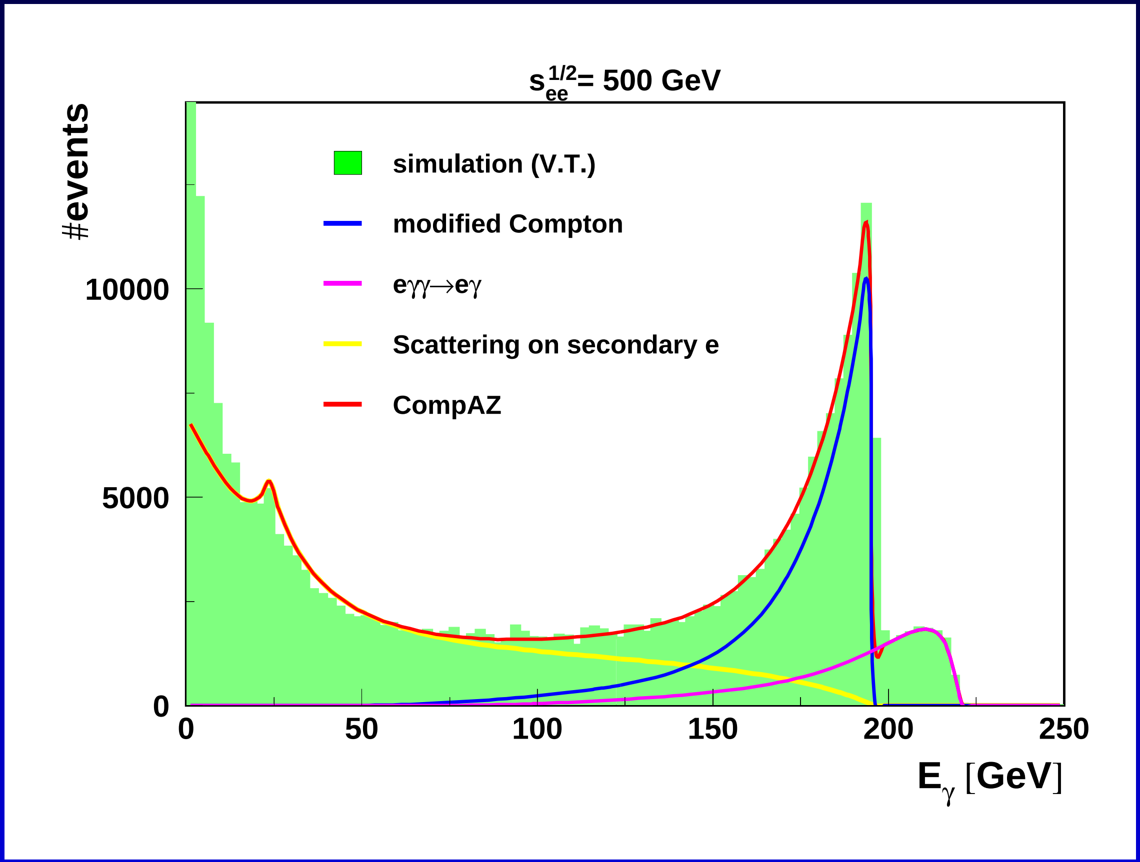
CompAZ

Parametrization of the photon energy spectrum

Compton formula

corrected for:

- nonlinear effects
- angular correlations
- two photon scattering
- electron rescattering



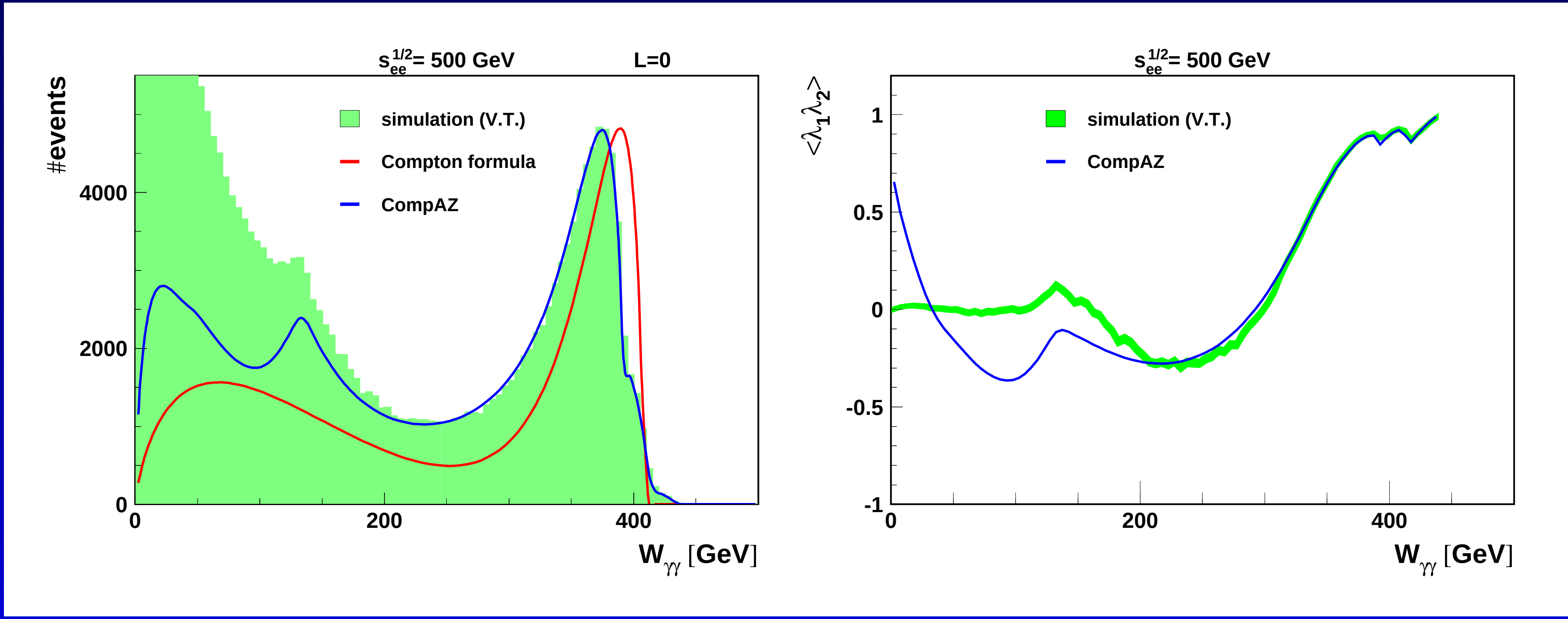
⇒ CompAZ

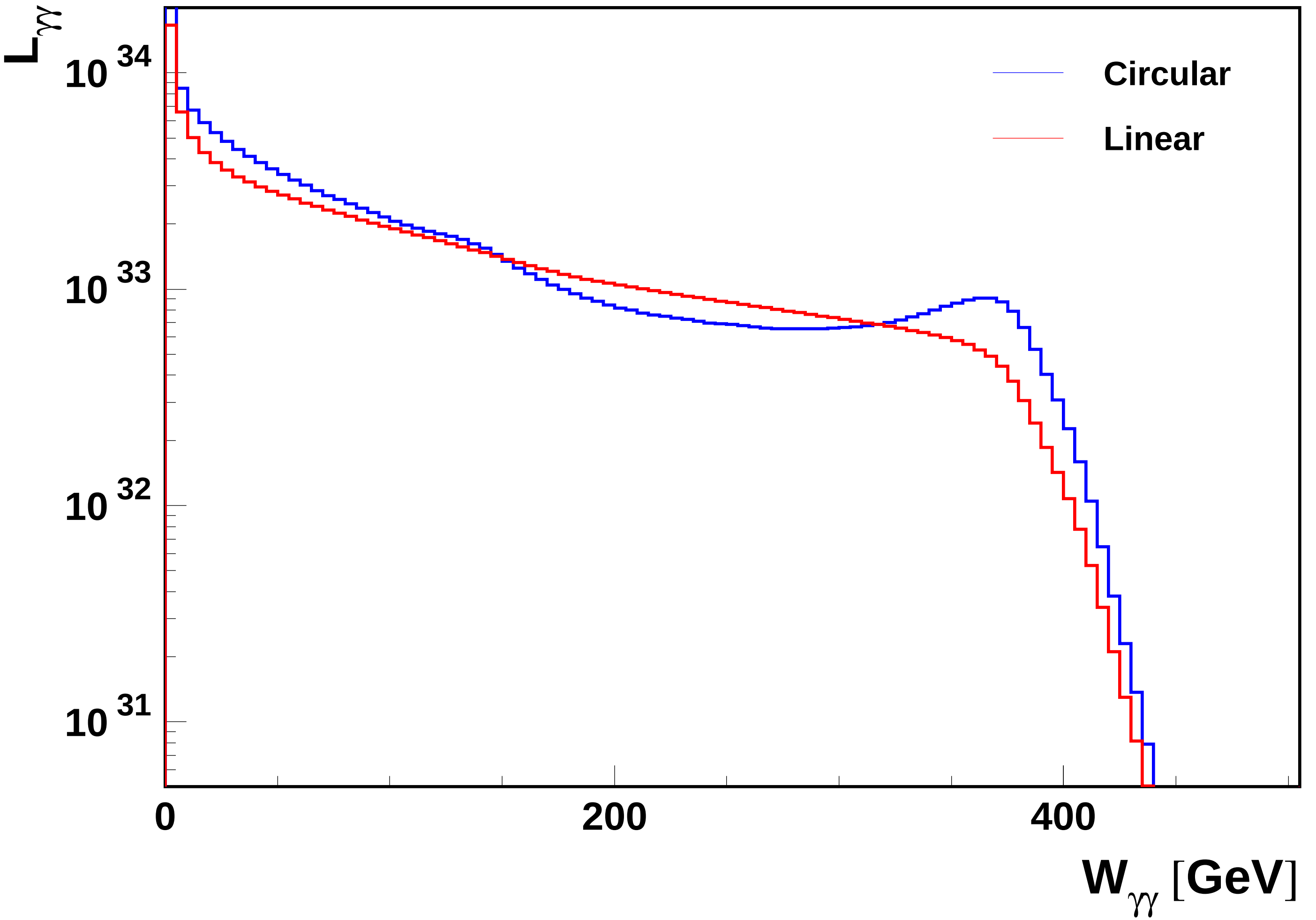
CompAZ

TESLA Photon Collider luminosity spectra parametrization

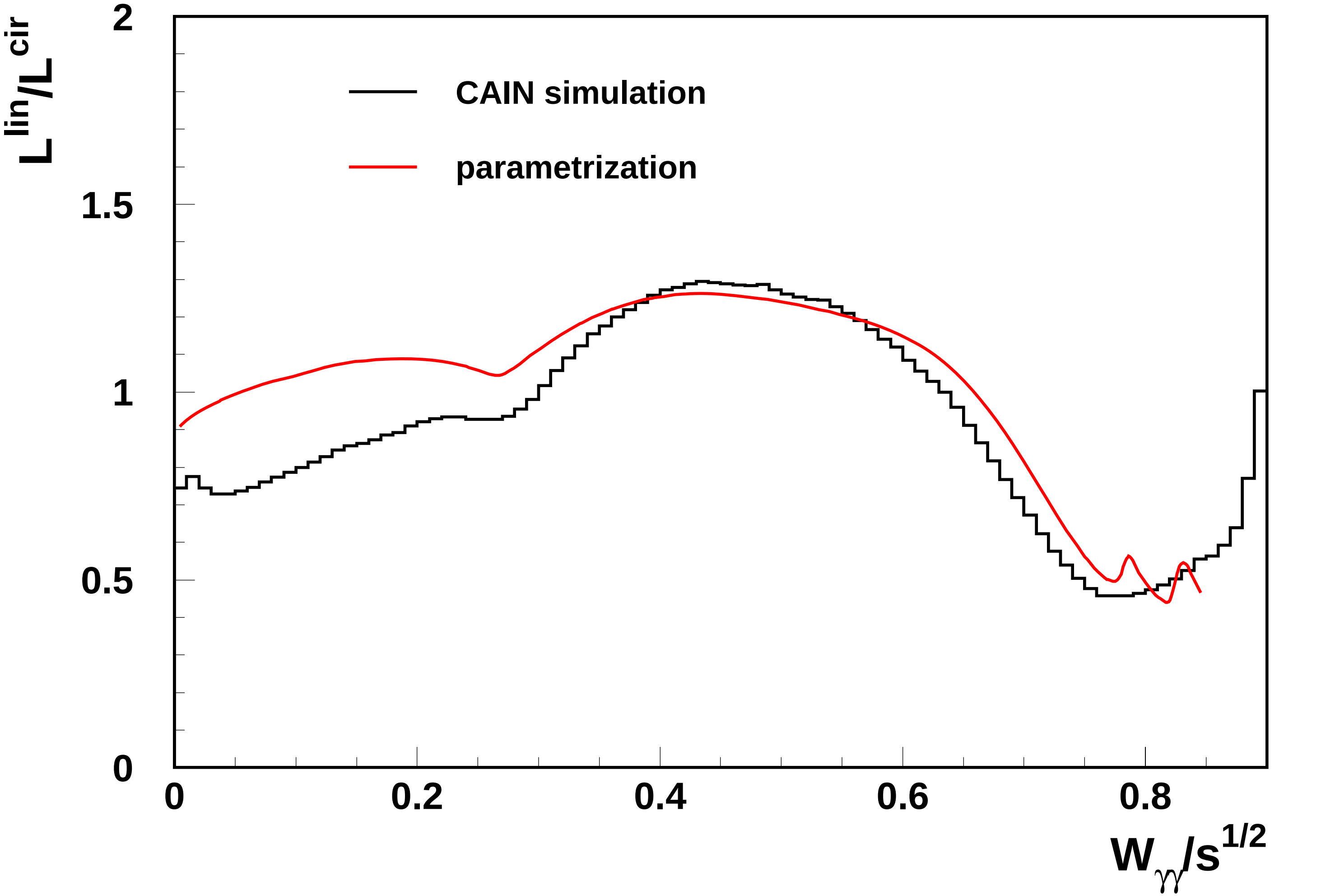
Very good description of the high energy part

$\gamma\gamma$ invariant mass   polarization

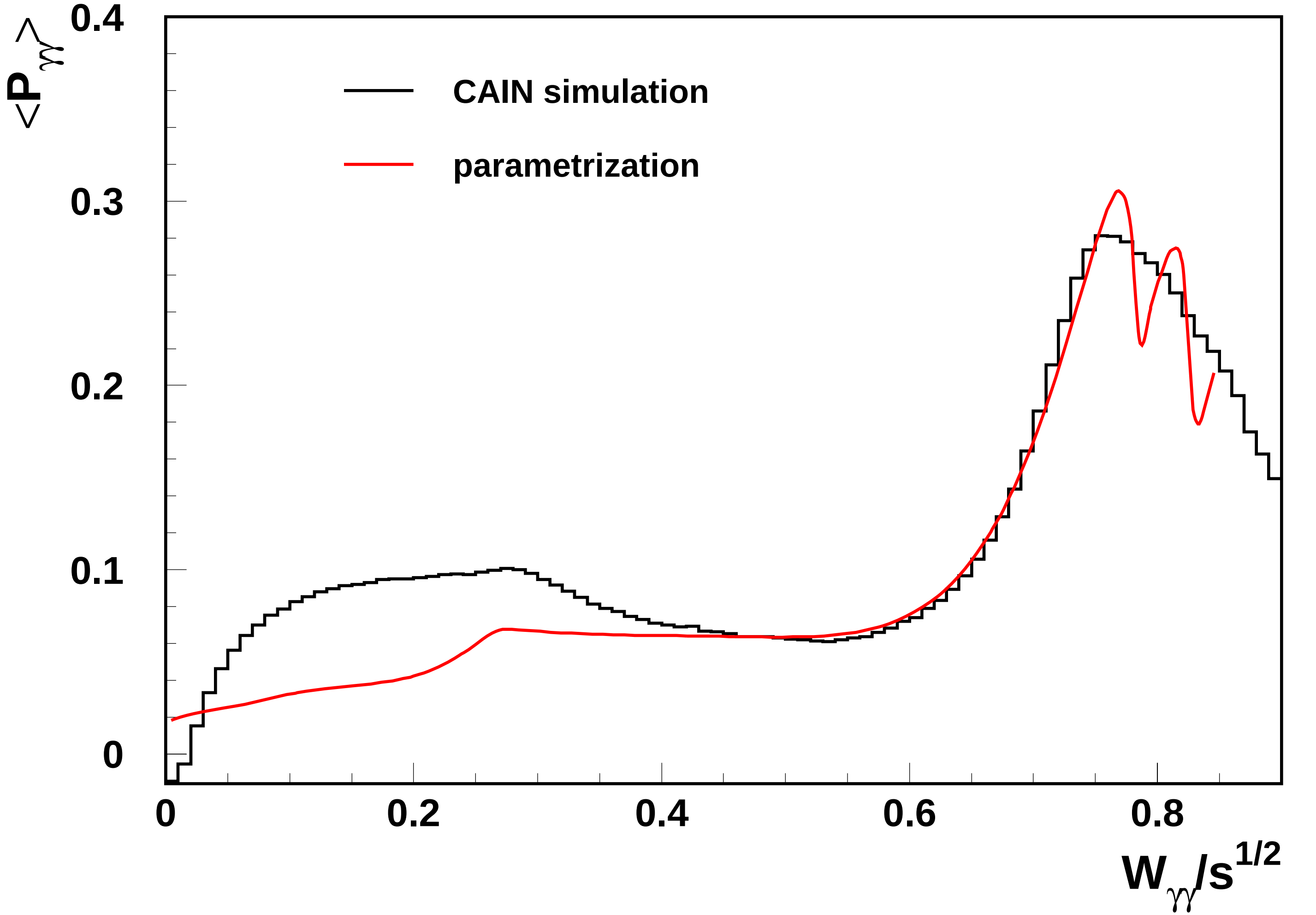




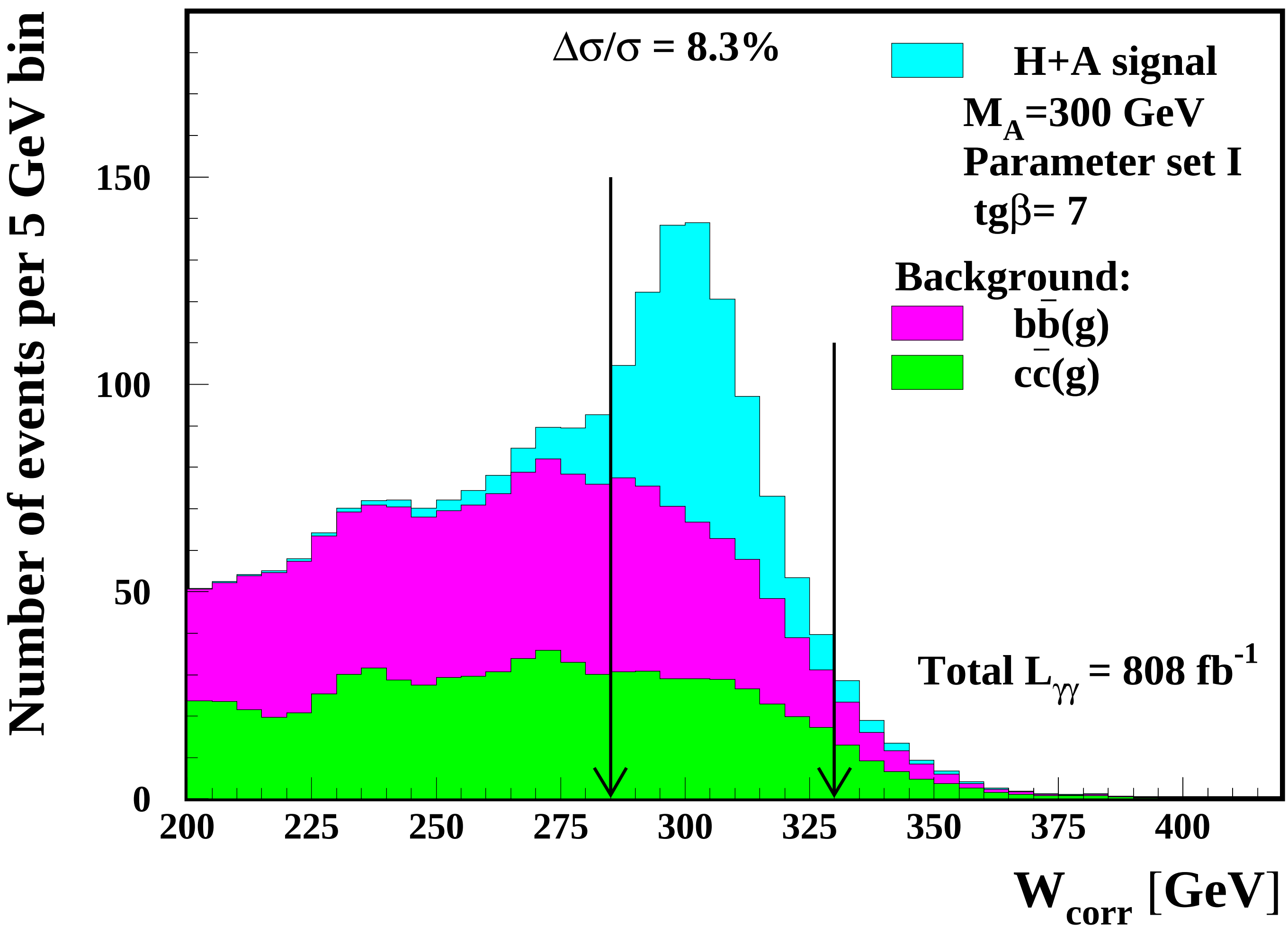
$L_{\gamma\gamma}$
10^{34}
10^{33}
10^{32}
10^{31}
Circular
Linear
0
200
400
$W_{\gamma\gamma}$ [GeV]



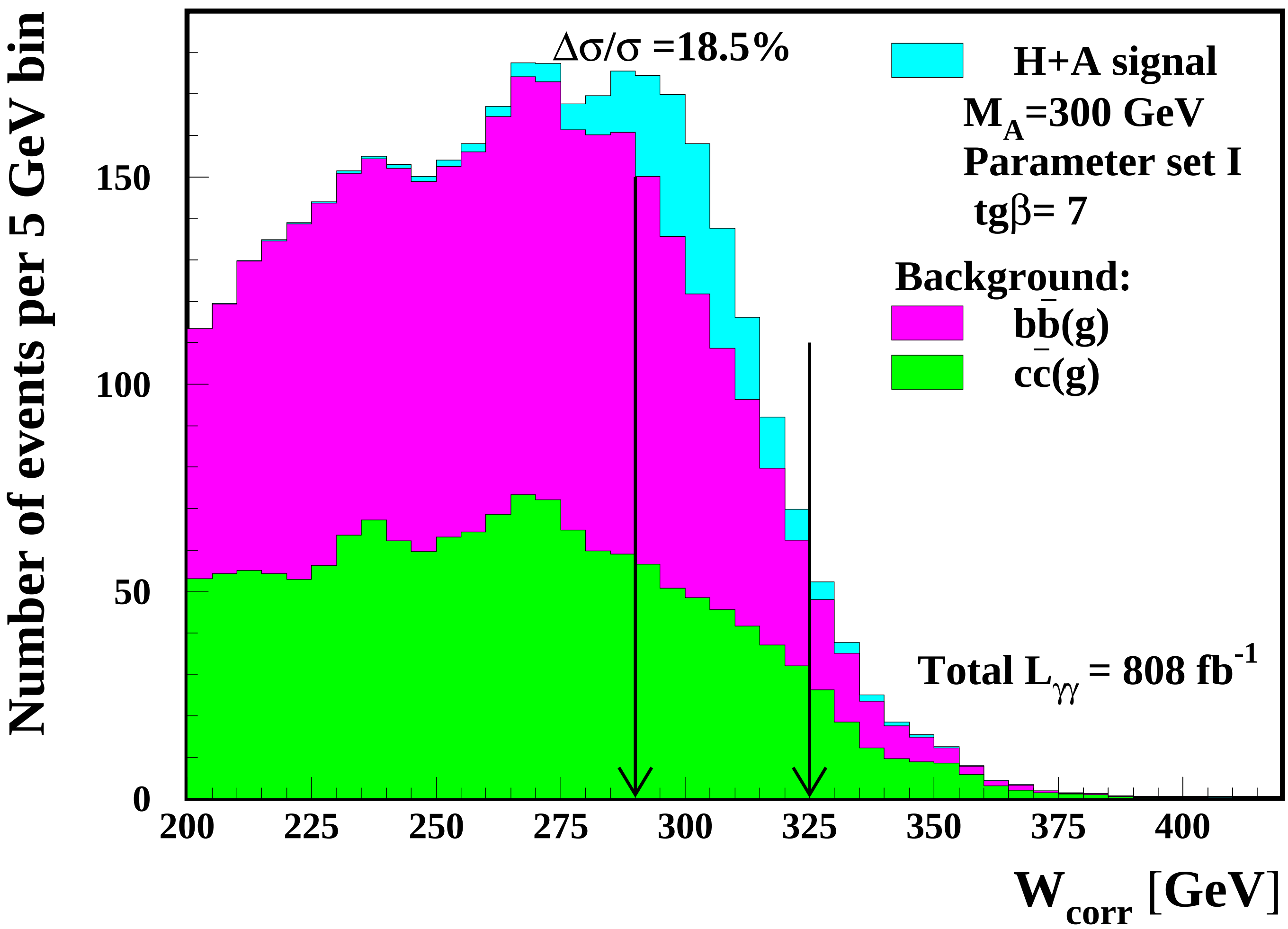
L^{lin}/L^{cir}
2
1.5
1
0.5
0
0
0.2
0.4
0.6
0.8
$W_{\gamma\gamma}/s^{1/2}$
CAIN simulation
parametrization



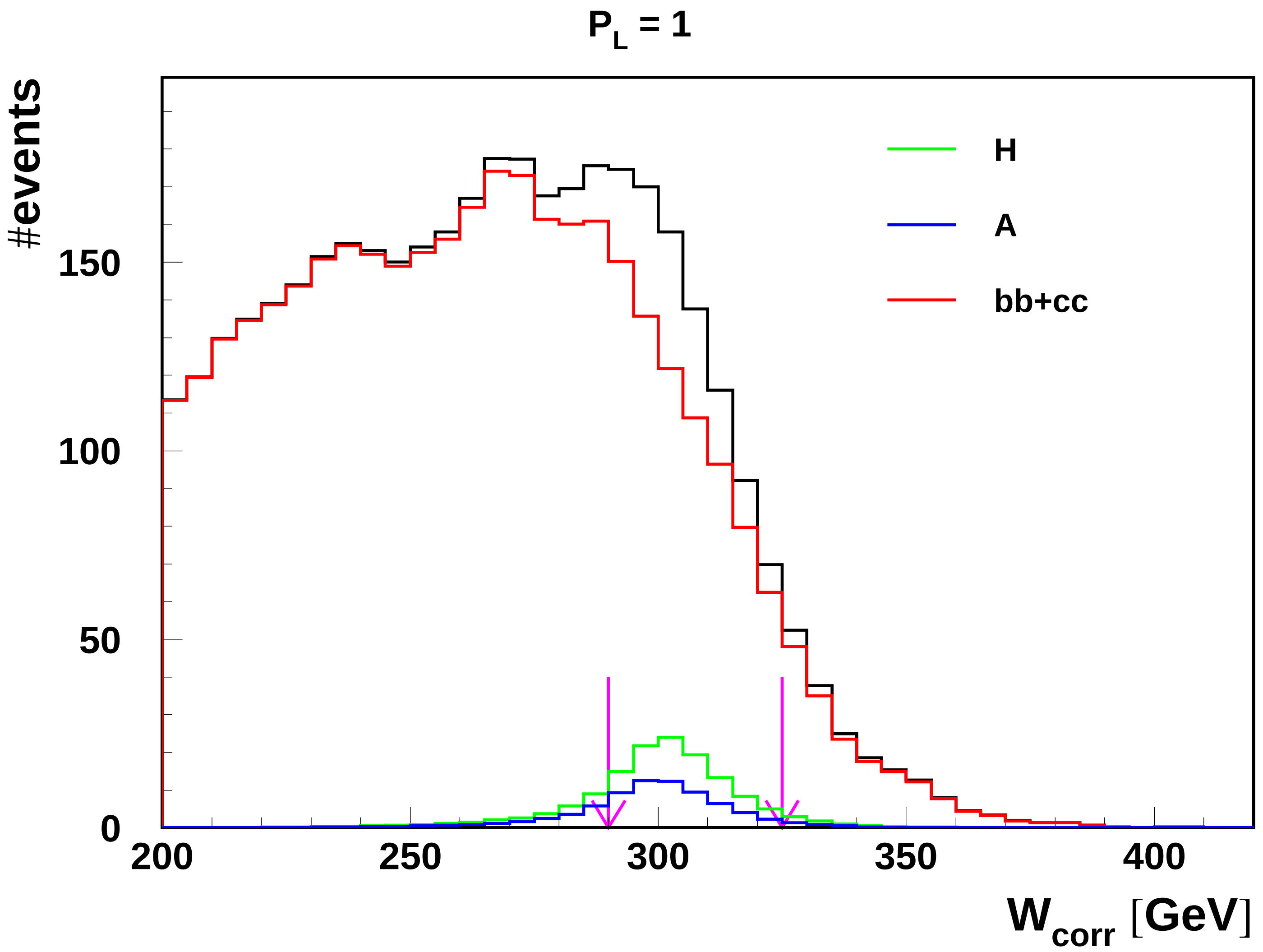
CAIN simulation
parametrization
<P_γγ>
W_γγ/s^1/2
0.4
0.3
0.2
0.1
0
0.2
0.4
0.6
0.8



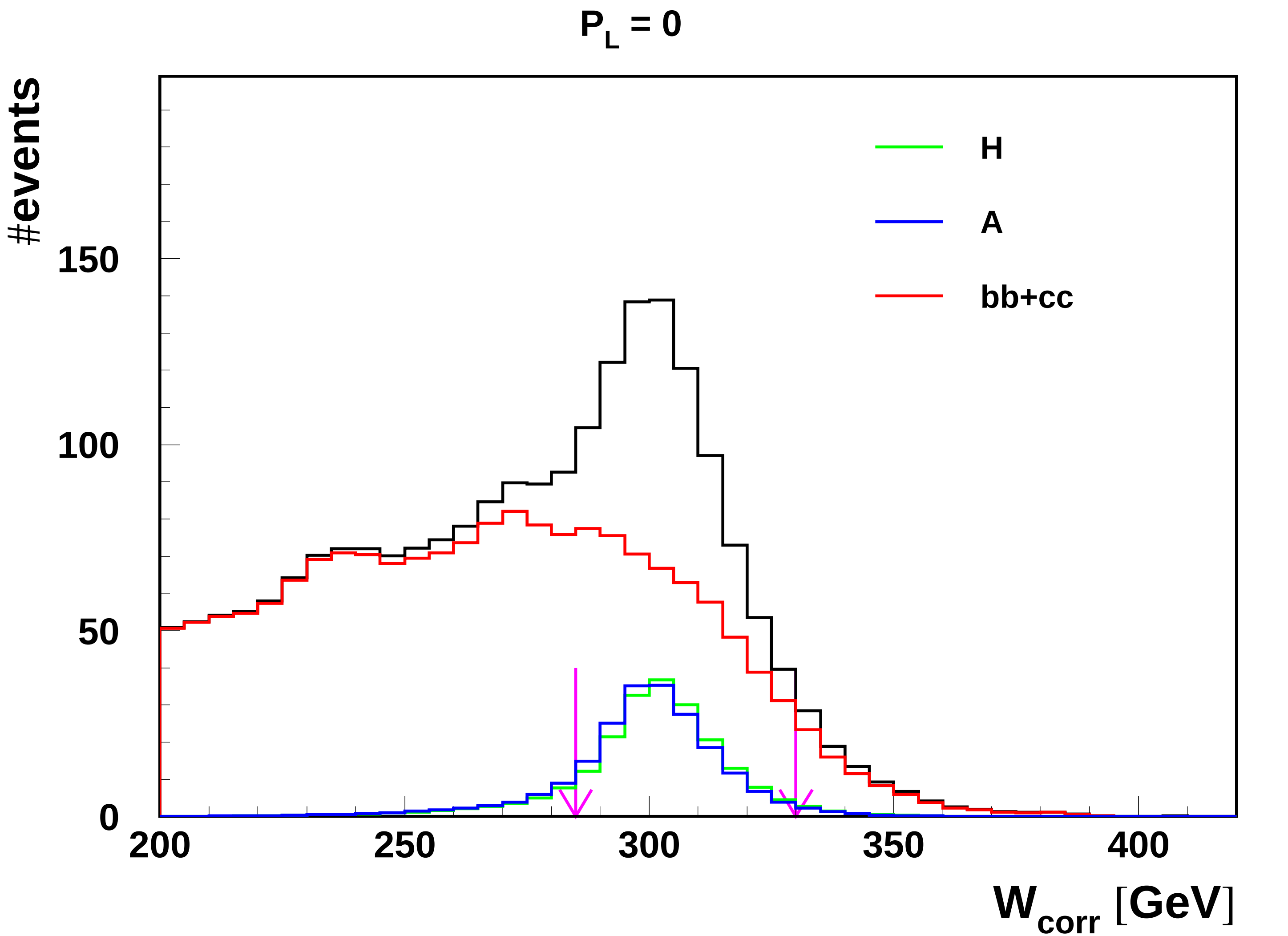
Number of events per 5 GeV bin
Δσ/σ = 8.3%
H+A signal
M_A=300 GeV
Parameter set I
tgβ= 7
Background:
bb̄(g)
cc̄(g)
Total L_γγ = 808 fb^-1
0
50
100
150
200
225
250
275
300
325
350
375
400
W_corr [GeV]



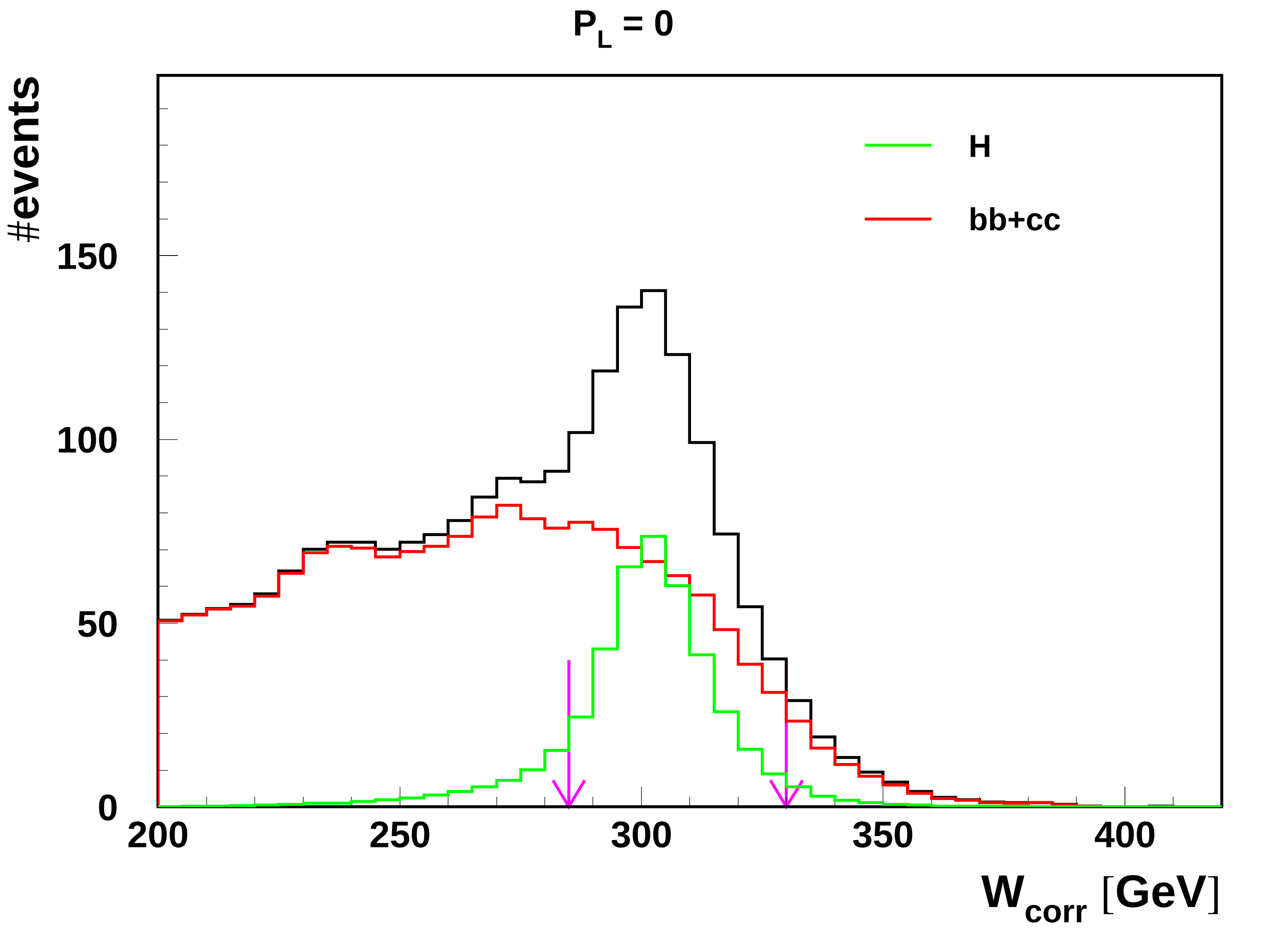
Δσ/σ =18.5%
H+A signal
M_A=300 GeV
Parameter set I
tgβ= 7
Background:
$b\bar{b}(g)$
$c\bar{c}(g)$
Total $L_{\gamma\gamma}$ = 808 fb^{-1}
Number of events per 5 GeV bin
W_{corr} [GeV]
0
50
100
150
200
225
250
275
300
325
350
375
400



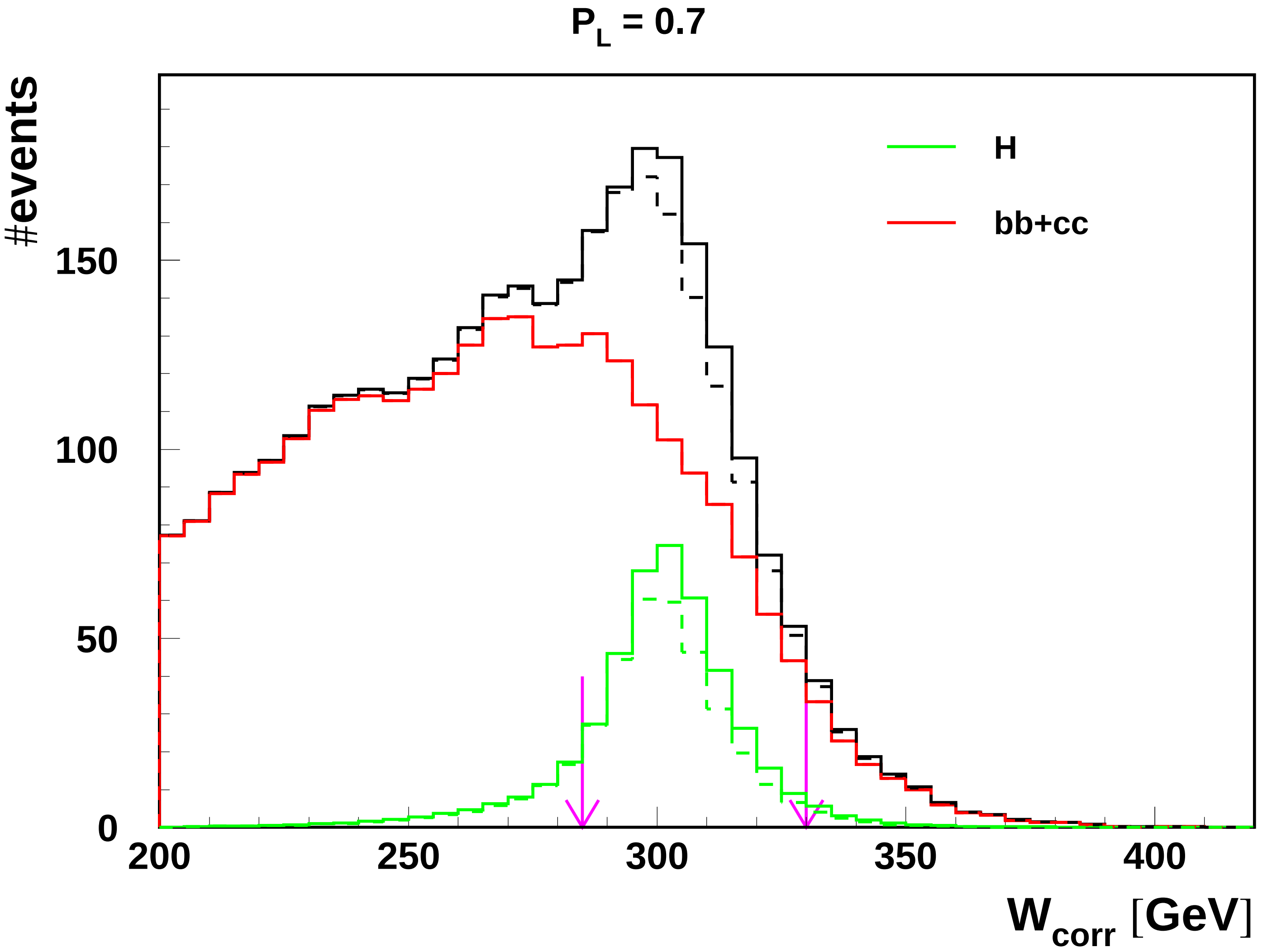
P_L = 1
#events
0
50
100
150
200
250
300
350
400
W_corr [GeV]
H
A
bb+cc



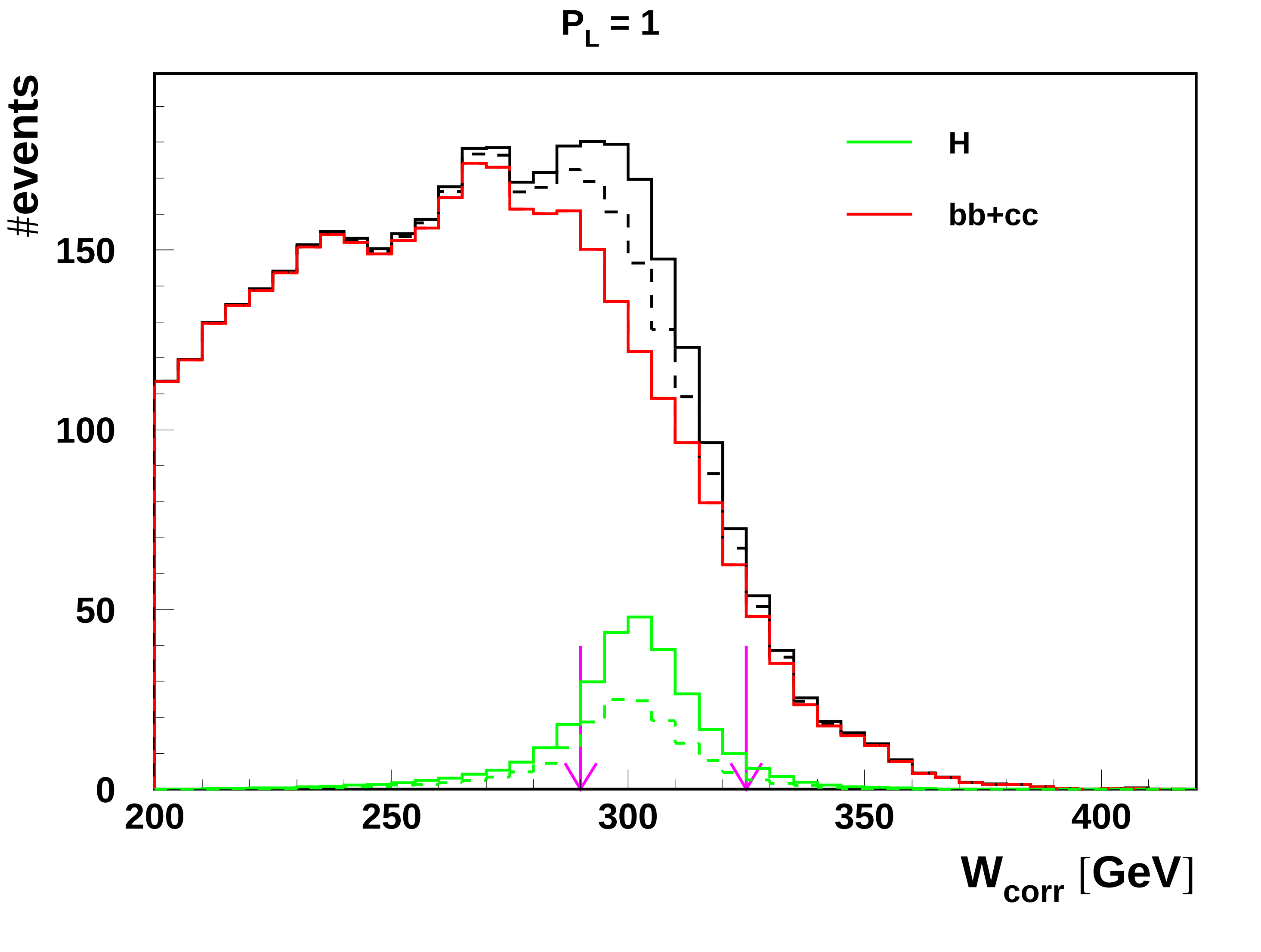
$P_L = 0$
#events
150
100
50
0
200
250
300
350
400
W_{corr} [GeV]
H
A
bb+cc



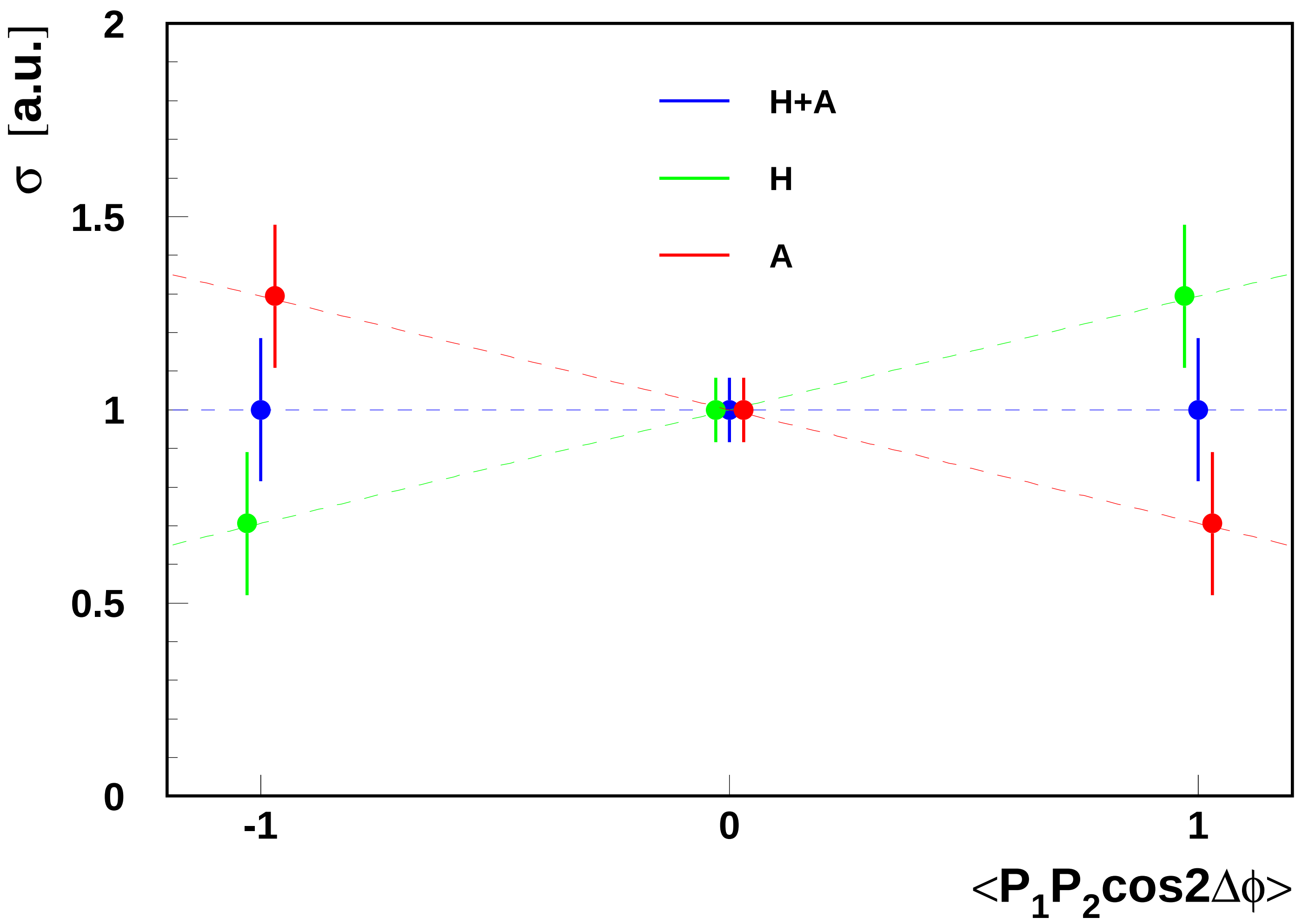
$P_L = 0$
#events
150
100
50
0
200
250
300
350
400
H
bb+cc
W_{corr} [GeV]



$P_L = 0.7$
#events
150
100
50
0
200
250
300
350
400
W_{corr} [GeV]
H
bb+cc



$P_L = 1$
#events
150
100
50
0
200
250
300
350
400
H
bb+cc
W_{corr} [GeV]



σ [a.u.]
2
1.5
1
0.5
0
H+A
H
A
-1
0
1
<P1P2cos2Δφ>

Well known facts about the average linear polarization in Compton scattering

The averaged degree of the linear polarisation of the final photons is [GKST84]

$$\langle l_\gamma \rangle = \frac{2r^2 P_l}{(1-y)^{-1} + 1 - y - 4r(1-r) - 2\lambda_e P_c x r (2-y)(2r-1)},$$

P_c, P_l are circular and linear laser polarizations;

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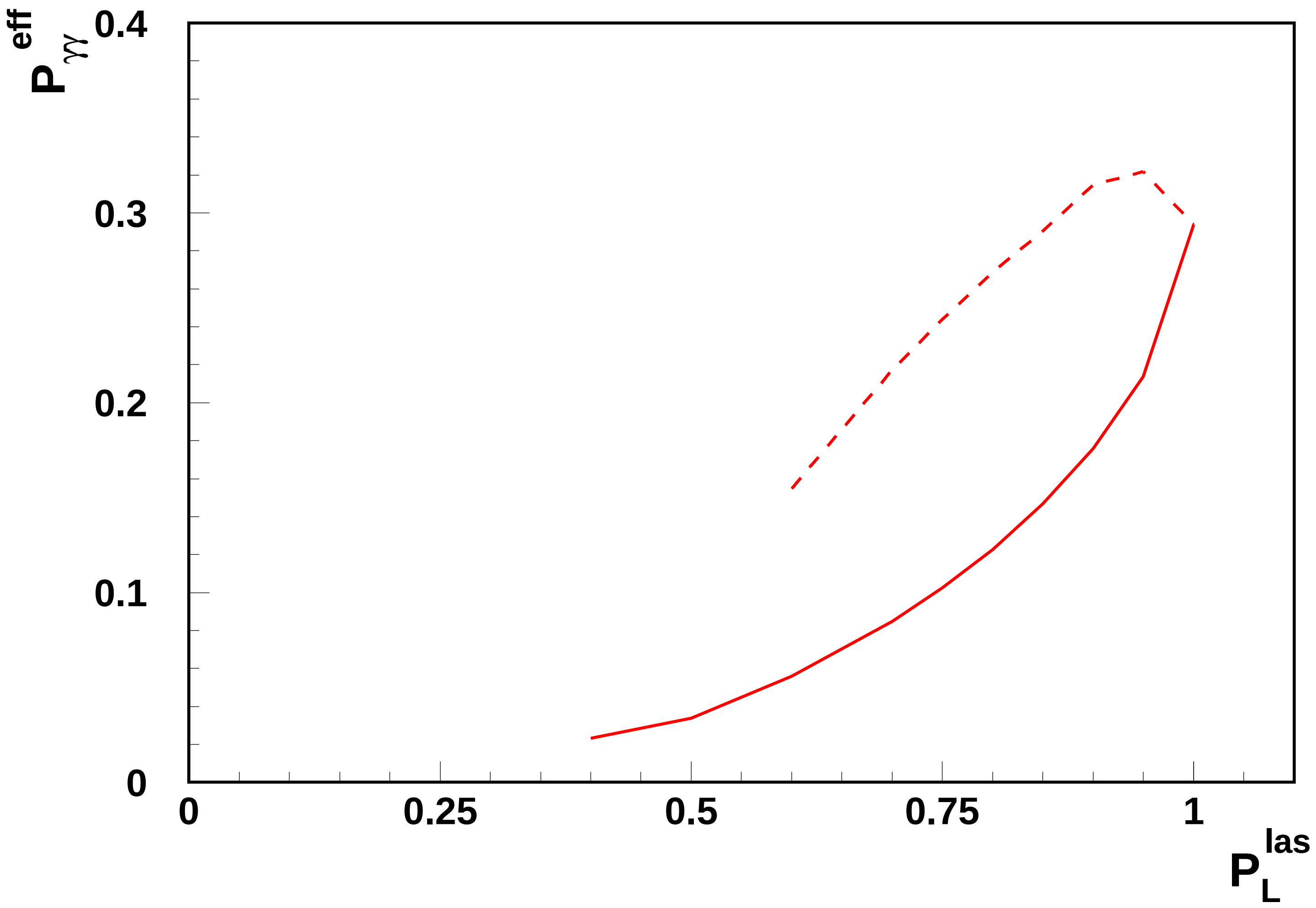
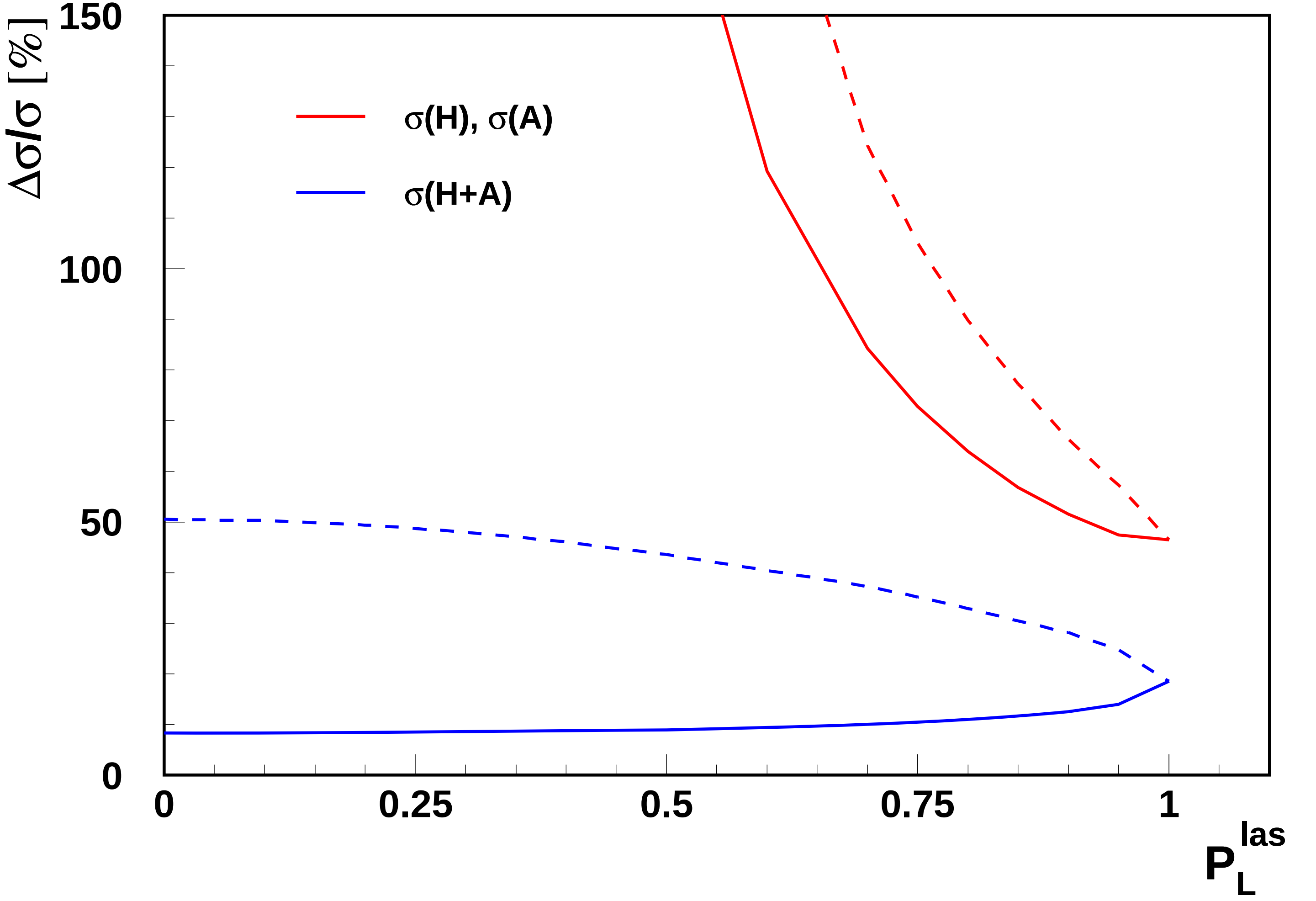
$$y = \frac{\omega}{E_0}, \quad x = \frac{4E_0\omega_0}{m^2c^4}, \quad r = \frac{y}{x(1-y)}$$



$P_{\gamma\gamma}^{eff}$
0.4
0.3
0.2
0.1
0
0
0.25
0.5
0.75
1
P_L^{las}



Δσ/σ [%]
150
100
50
0
σ(H), σ(A)
σ(H+A)
0
0.25
0.5
0.75
1
P_L^las