

Update of $H \rightarrow \gamma\gamma$ Analysis at CLIC with $\sqrt{s} = 1.4$ TeV

Christian Grefe

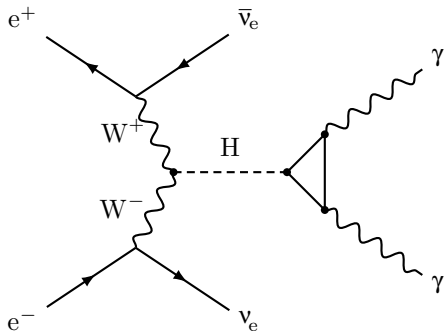
CERN PH-LCD

30. January 2013



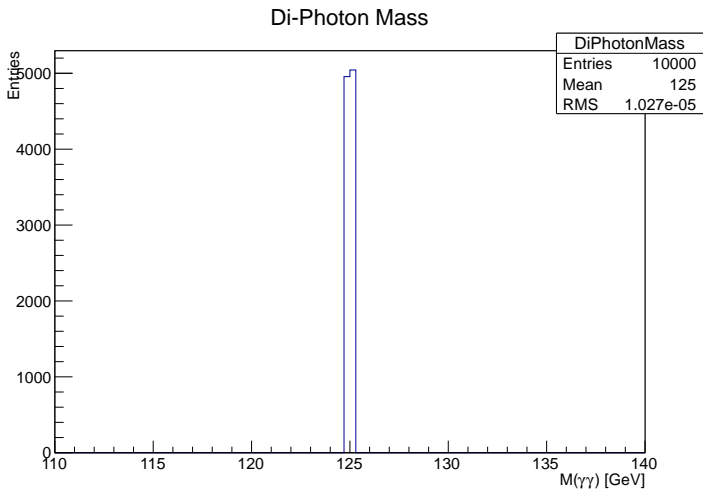
Outline

- 1 Signal
- 2 ISR Photons
- 3 Backgrounds
- 4 Conclusions

Signal ($e^+e^- \rightarrow H\nu\bar{\nu}$; $H \rightarrow \gamma\gamma$)

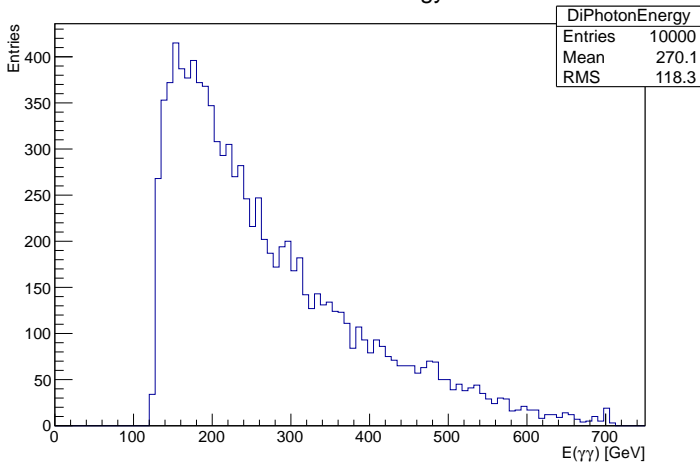
- Assuming $m_H = 125 \text{ GeV}$
- $\sigma(e^+e^- \rightarrow H\nu\bar{\nu}) \approx 271.3 \text{ fb}$ ($\sqrt{s} = 1.4 \text{ TeV}$, including ISR and CLIC BS)
- $\text{BR}_{H \rightarrow \gamma\gamma} \approx 0.0023 \Rightarrow \sigma \times \text{BR} \approx 0.62 \text{ fb}$
- $N_{\text{signal}} \approx 928/1.5 \text{ ab}^{-1}$

True Signal Distributions

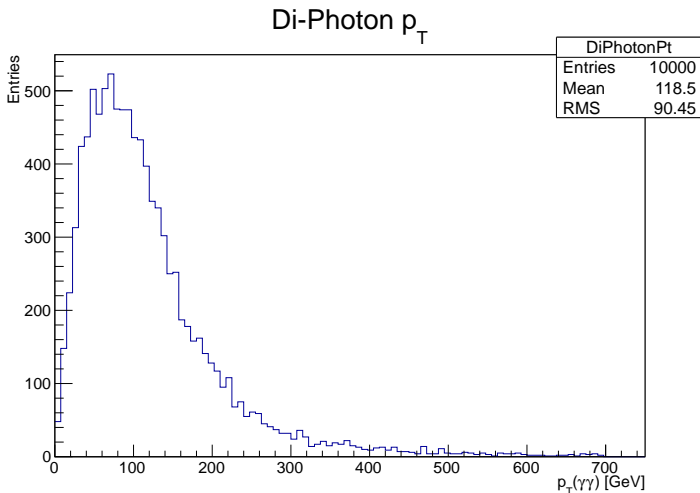


True Signal Distributions

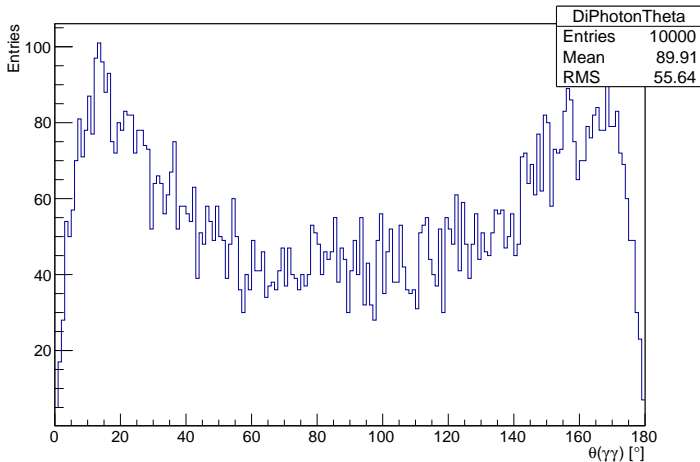
Di-Photon Energy



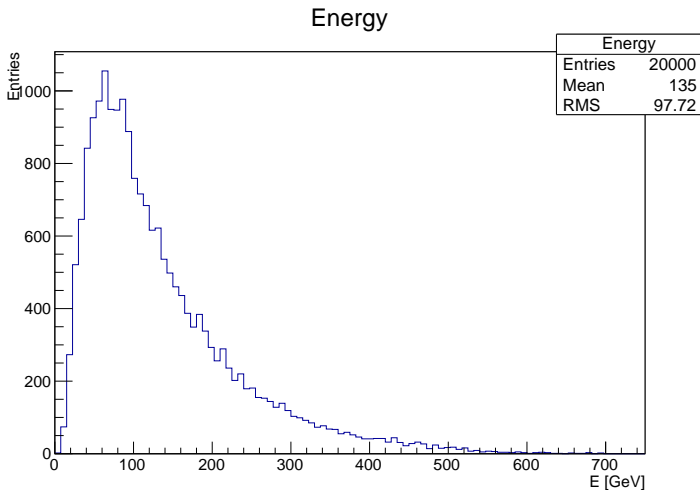
True Signal Distributions



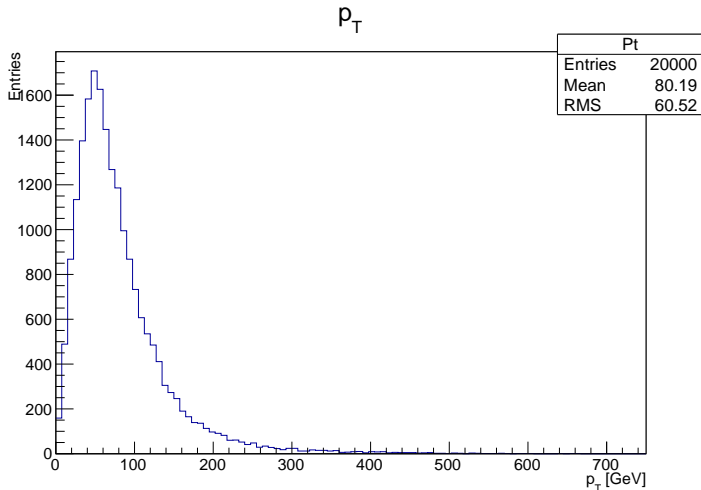
True Signal Distributions

Di-Photon θ 

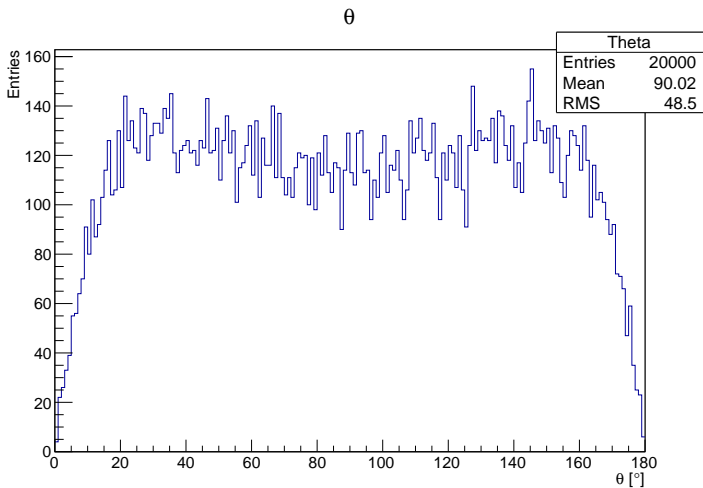
True Signal Distributions



True Signal Distributions



True Signal Distributions

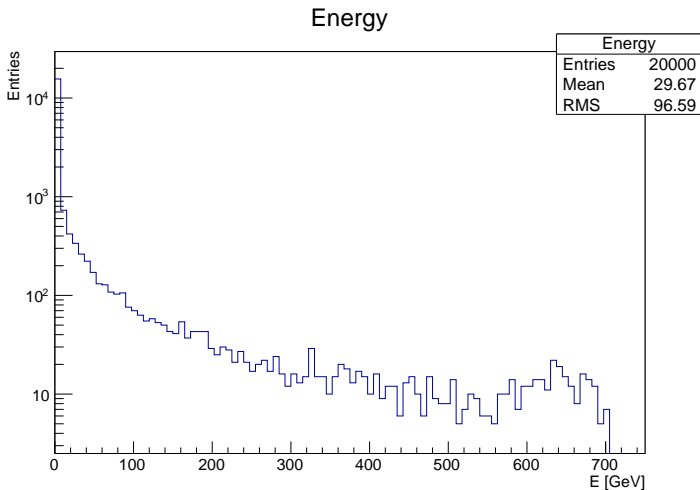


Proposed Generator Level Cuts

- $110 \text{ GeV} < M(\gamma\gamma) < 140 \text{ GeV}$ (if two photons in final state)
- $E(\gamma) > 10 \text{ GeV}$
- $p_T(\gamma) > 5 \text{ GeV}$
- $\theta(f) < 10^\circ$ or $\theta(f) > 170^\circ$ (for visible fermions)

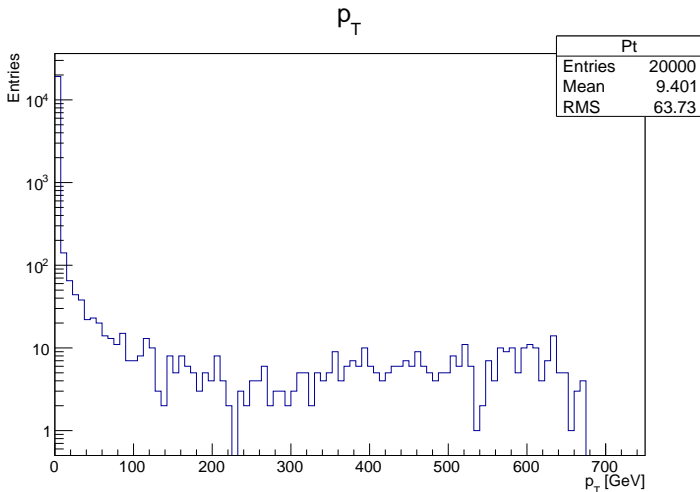
Treatment of ISR Photons

- Use WHIZARD ISR with `?isr_recoil = true`
- Plots: all photons in $e^+e^- \rightarrow H\nu\bar{\nu}$ (no Higgs decay)



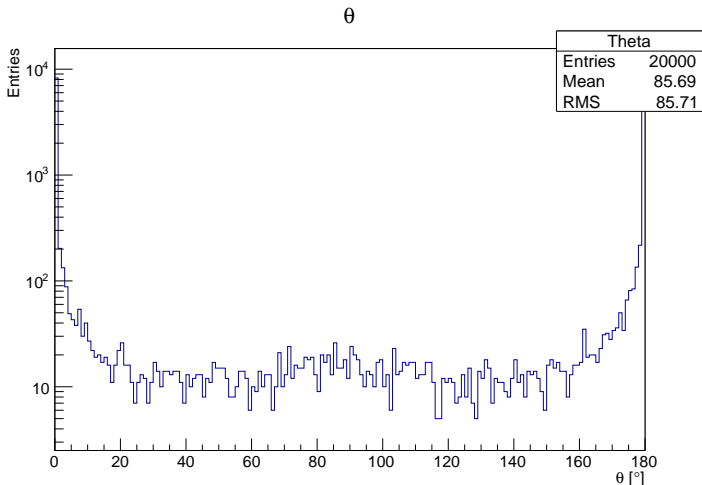
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Backgrounds (Including Generator Level Cuts)

- Using WHIZARD 2, ISR, BS and $H \rightarrow \gamma\gamma$ switched off
- Preliminary: some processes still have uncertainties $> 10\%$
- $e^+e^- \rightarrow \gamma\gamma$: 7.4 ± 0.5 fb
- $e^+e^- \rightarrow \nu\bar{\nu}\gamma$: 4490 ± 40 fb (no cut on $M(\gamma\gamma)$)
- $e^+e^- \rightarrow \nu\bar{\nu}\gamma\gamma$: 0.67 ± 0.06 fb
- $e^+e^- \rightarrow e^+e^-\gamma$: $X \pm X$ fb (no cut on $M(\gamma\gamma)$, $\theta(e) < 10^\circ$ or $\theta(e) > 170^\circ$)
- $e^+e^- \rightarrow e^+e^-\gamma\gamma$: 9.9 ± 0.9 fb ($\theta(e) < 10^\circ$ or $\theta(e) > 170^\circ$)
- $e^+e^- \rightarrow \mu^+\mu^-\gamma$: 125 ± 7 fb (no cut on $M(\gamma\gamma)$, $\theta(\mu) < 10^\circ$ or $\theta(\mu) > 170^\circ$)
- $e^+e^- \rightarrow \mu^+\mu^-\gamma\gamma$: 0.37 ± 0.04 fb ($\theta(\mu) < 10^\circ$ or $\theta(\mu) > 170^\circ$)
- $e^+e^- \rightarrow q\bar{q}\gamma$ ($q = u, d, s$): 3200 ± 400 fb (no cut on $M(\gamma\gamma)$, $\theta(q) < 10^\circ$ or $\theta(q) > 170^\circ$)
- $e^+e^- \rightarrow q\bar{q}\gamma\gamma$ ($q = u, d, s$): 3.6 ± 0.3 fb ($\theta(q) < 10^\circ$ or $\theta(q) > 170^\circ$)

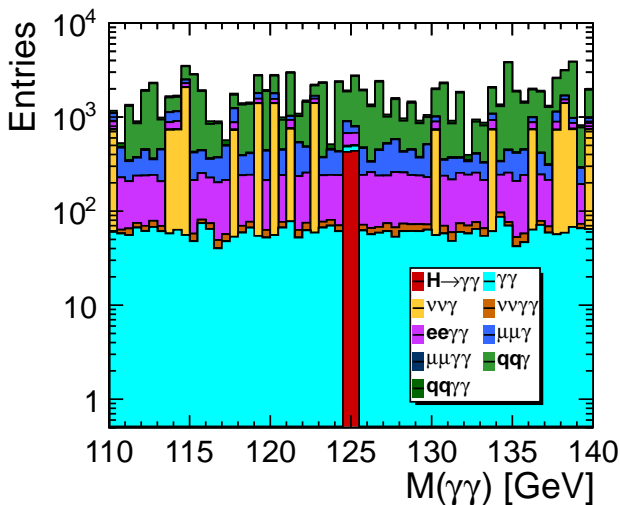
StdHep Level Cuts

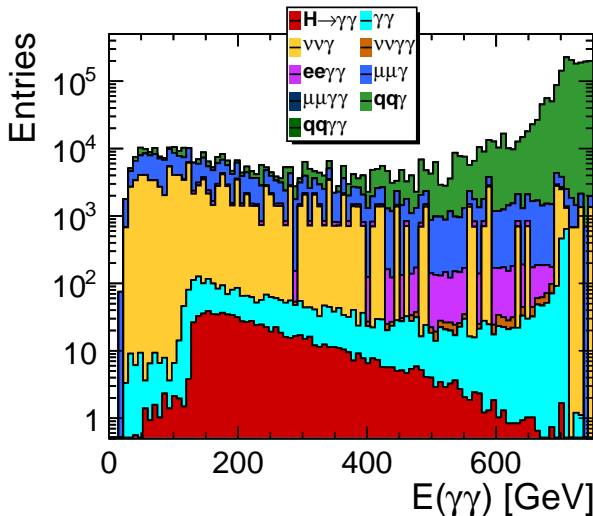
- Can not cut on ISR photons in WHIZARD: introduce StdHep level cuts
- Require at least two photons with:
 - $E(\gamma) > 10 \text{ GeV}$
 - $p_T(\gamma) > 5 \text{ GeV}$
 - $5^\circ < \theta(\gamma) < 175^\circ$
- Require at least one combination of these photons with $110 \text{ GeV} < M(\gamma\gamma) < 140 \text{ GeV}$

Event Requests

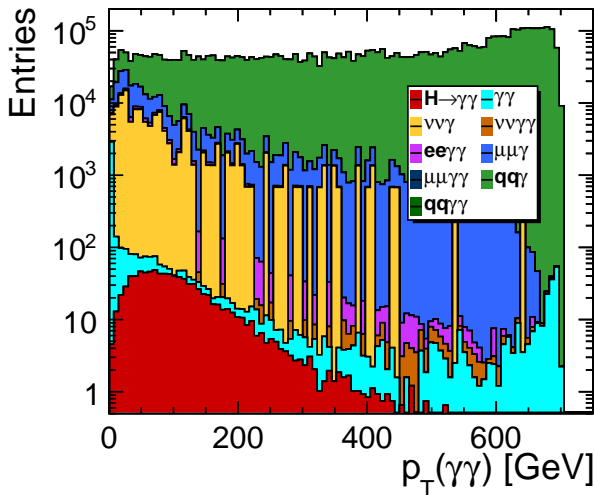
Process	Cross section [fb]	StdHep cut efficiency	kEvents in 1.5 ab^{-1}	Requested kEvents
$H \rightarrow \gamma\gamma$	0.62	0.03	1.0	50
$\gamma\gamma$	7.4	0.67	3.5	20
$\nu\bar{\nu}\gamma$	4500	0.998	135	150
$\nu\bar{\nu}\gamma\gamma$	0.67	0.37	0.6	20
$e^+e^-\gamma$	X	X	X	X
$e^+e^-\gamma\gamma$	9.9	0.33	10	20
$\mu^+\mu^-\gamma$	125	0.91	17	20
$\mu^+\mu^-\gamma\gamma$	0.37	0.19	0.5	20
$q\bar{q}\gamma$	3200	0.986	68	70
$q\bar{q}\gamma\gamma$	3.6	0.35	3.5	20
Total				390 + X

Generator Level (Scaled to 1.5 ab^{-1})

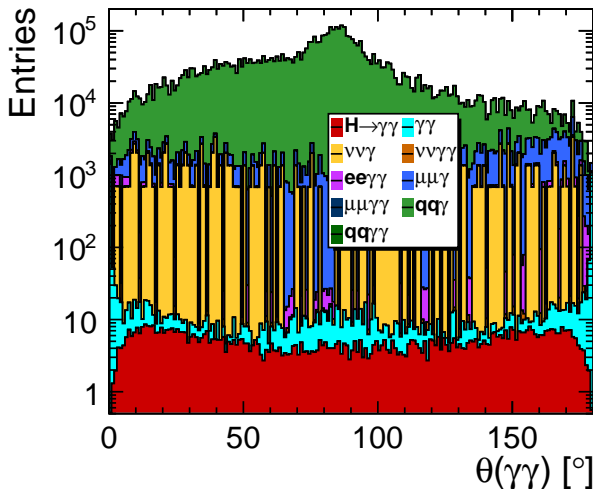


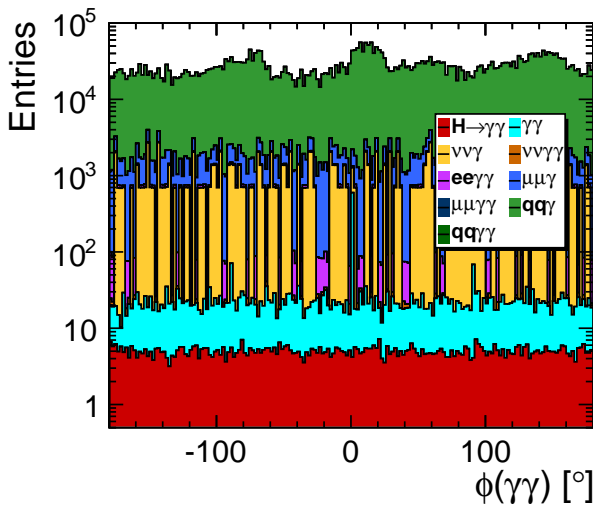
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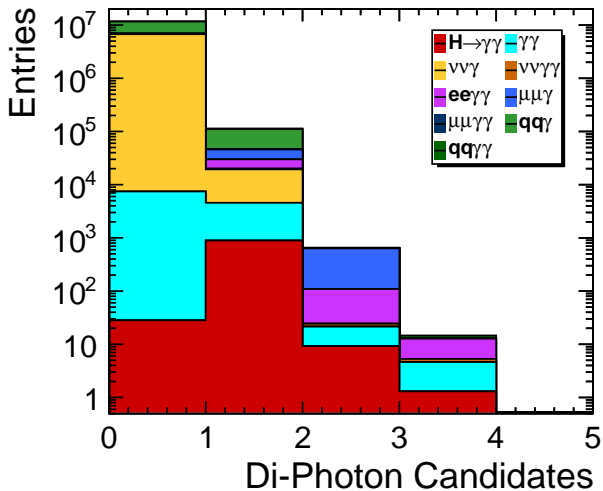


Generator Level (Scaled to 1.5 ab^{-1})



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Other Variables to Look at

- E_{miss} and $p_{T, \text{miss}}$
- $E_{\text{vis}} - E(\gamma)$
- Angular correlation between di-photon and photons in di-photon rest-frame
- ...

Conclusions / To Do List

- Verify cross sections with dedicated *ff γ* -generator
- Implement StdHep Cuts
- Start simulation and reconstruction of signal sample for a first view
- Set up multivariate classifier (BDT) using the variables above
- Determine N_{signal} from fit of shape over background
- Repeat analysis in fast simulation assuming different electromagnetic energy resolutions