Research progress

Group meeting

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April 16, 2025

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Diphoton $\nu\bar{\nu}$ sub-channel: Efficiencies

Signal efficiency

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===== Event Selection Summary =====
Total events processed: 8913
Inclusive 2 photons: 8825 (99.0127%)
E_y > 30 GeV: 7936 (89.9263%)
|cos(theta_y)| < 0.8: 5688 (71.6734%)
pT_y > 20 GeV: 5688 (100%)
M_missing > 60 GeV: 5443 (95.6927%)
110 GeV < m_yy < 140 GeV: 5346 (98.2179%)
120 GeV < E_yy < 150 GeV: 5318 (99.4762%)
Final selected events:        5318 (59.6657%)
Expected yield at 20ab^-1: 1253.91 events
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Background efficiency (by Wang Han)

3 $e^+e^- \to \nu\bar{\nu}$ process efficiency

Selections	Efficiency	Event Number
Generator	100%	82804236
Gen Filter ($M_{\gamma\gamma} >= 90GeV$)	1.80%	1491000
Delphes fast sim ($M_{\gamma\gamma} >= 90GeV$)	3.36271%	50138
$E_\gamma > 30GeV$	83.6292%	41930
$\lvert\cos\theta_\gamma\rvert < 0.8$	7.42666%	3114
$pT_\gamma > 20GeV$	99.5183%	3099
$M_{missing} > 60GeV$	99.5805%	3086
$m_{\gamma\gamma} \in [110, 140]GeV$	48.7686%	1505
$E_{\gamma\gamma} \in [120, 150]GeV$	99.6013%	1499
Total eff	0.00181%	1499

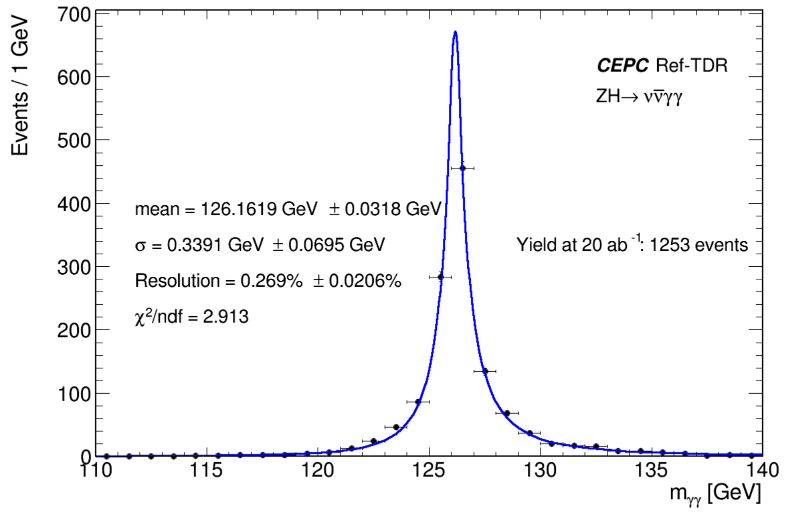
Yield at 20 ab^{-1}: 19655 events

CDR results

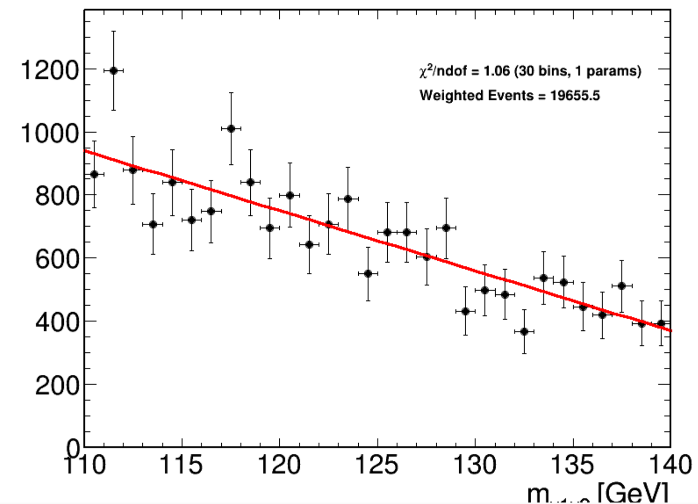
Table 4. Selection criteria and corresponding efficiencies in the $\nu\bar{\nu}\gamma\gamma$ channel. M_{missing} is the missing mass calculated from the total visible objects.

Selections	Higgs signal	$\nu\bar{\nu}\gamma\gamma$ background
Inclusive 2 photons	85.51%	0.34%
$E_{\gamma\gamma} > 30$ GeV	99.81%	20.13%
$\lvert\cos\theta_\gamma\rvert < 0.8$	70.48%	11.56%
$pT_\gamma >$ GeV	99.97%	99.26%
$M_{\text{missing}} > 60$ GeV	98.17%	99.71%
$m_{\gamma\gamma} \in [110, 140]$ GeV	97.51%	22.86%
$E_{\gamma\gamma} \in [120, 150]$ GeV	99.16%	99.58%
Total eff	57.08%	0.002%
Yields in 5.6 ab^{-1}	335.89	3640.20

Diphoton $\nu\bar{\nu}$ sub-channel: $m_{\gamma\gamma}$ signal distribution

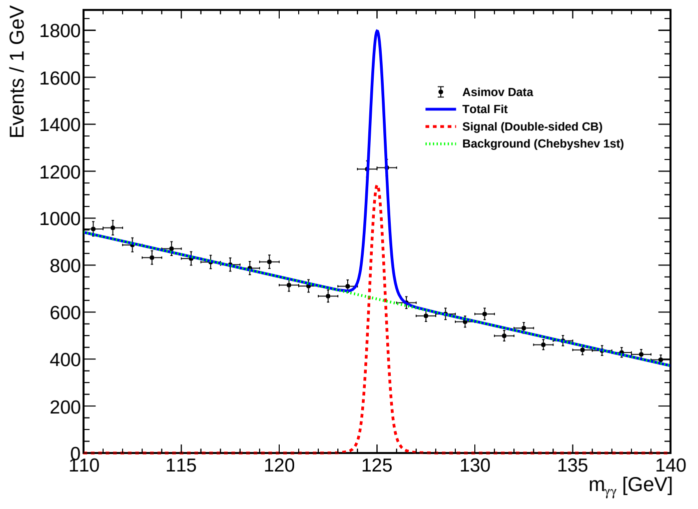


Diphoton $\nu\bar{\nu}$ sub-channel: $m_{\gamma\gamma}$ background distribution



by Wang Han

Diphoton $\nu\bar{\nu}$ sub-channel: Signal over background plot



Diphoton $q\bar{q}$ sub-channel: Efficiencies

Signal efficiency

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===== Event Selection Summary =====
Total events processed: 99800
Exclusive 2 jets and 2 photons: 90823 (91.005%)
E_y1 > 20 GeV: 82841 (91.2115%)
30 GeV < E_y2 < 100 GeV: 81358 (98.2098%)
cos(theta_yy) > -0.95: 79662 (97.9154%)
cos(theta_jj) > -0.95: 77967 (97.8723%)
pT_y1 > 20 GeV: 71433 (91.6195%)
pT_y2 > 30 GeV: 67626 (94.6705%)
110 GeV <m_yy < 140 GeV: 64266 (95.0315%)
E_yy > 110 GeV: 64266 (100%)
min|cos(theta_yj)|: 64266 (100%)
Final selected events:       64266 (64.3948%)
Expected yield at 20ab^-1: 3999.67 events
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Background efficiency (by Wang Han)

1 $e^+e^- \to q\bar{q}$ process efficiency

Selections	Efficiency	Event Number
Generator	100%	24739403
Gen Filter ($M_{\gamma\gamma} >= 90GeV$)	13.64%	3375000
Delphes fast sim ($M_{\gamma\gamma} >= 90GeV$)	13.04%	440203
$E_{\gamma 1} > 20GeV$	98.4409%	433340
$E_{\gamma 2} \in [30, 100]GeV$	25.2707%	109508
$\cos\theta_{\gamma\gamma} > -0.95$	89.5798%	98097
$\cos\theta_{jj} > -0.95$	89.6847%	87978
$pT_{\gamma 1} > 20GeV$	52.1301%	45863
$pT_{\gamma 2} > 30GeV$	74.293%	34073
$m_{\gamma\gamma} \in [110, 140]GeV$	44.2256%	15069
$E_{\gamma\gamma} > 110GeV$	100%	15069
$min\lvert\cos\theta_{\gamma j}\rvert$	99.7677%	15034
Total eff	0.0607%	15034

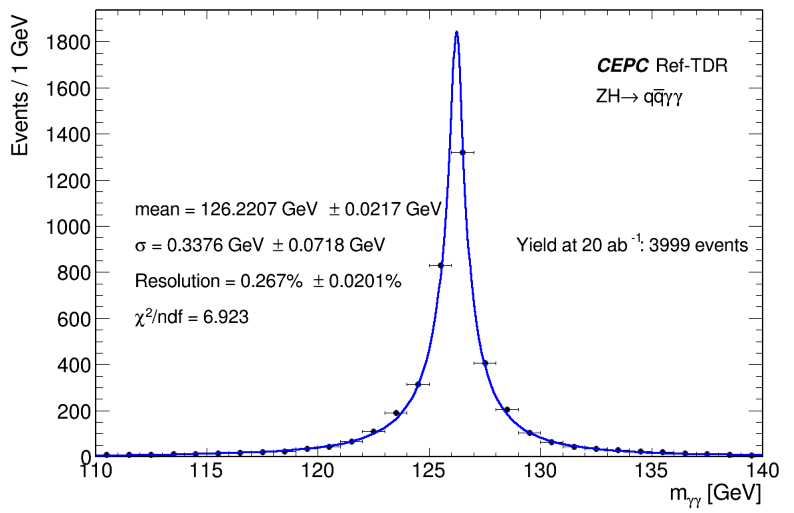
Yield at 20 ab^{-1}: 657525 events

CDR results

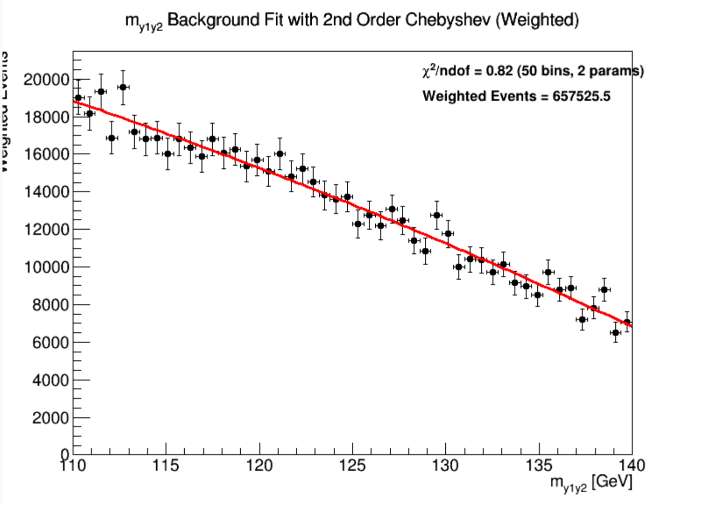
Table 2. Selection criteria and corresponding efficiencies in the $q\bar{q}\gamma\gamma$ channel. $\gamma1(\gamma2)$ is defined as the photon with lower (higher) energy, $\cos\theta_{\gamma\gamma}(\cos\theta_{jj})$ is the polar angle of the di-photon (di-jet) system, and $\min|\cos\theta_{\gamma j}|$ is the minimum $\cos\theta$ of the photon-jet pairs.

Selections	Higgs signal	$q\bar{q}\gamma\gamma$ background
Exclusive 2 jets and 2 photons	85.56%	69.57%
$E_{\gamma1} > 25$ GeV	100.00%	2.35 %
$E_{\gamma2} \in [35, 95]$ GeV	98.37%	35.33%
$\cos\theta_{\gamma\gamma} > -0.95$	95.20%	68.01%
$\cos\theta_{jj} > -0.95$	90.86%	85.54%
$pT_{\gamma1} > 20$ GeV	93.42%	56.94%
$pT_{\gamma2} > 30$ GeV	93.25%	54.54%
$m_{\gamma\gamma} \in [110, 140]$ GeV	97.50%	21.14%
$E_{\gamma\gamma} > 120$ GeV	99.47%	98.41%
$\min\lvert\cos\theta_{\gamma j}\rvert < 0.9$	71.67%	48.05%
Total eff	44.08%	0.01%
Yields in 5.6 ab^{-1}	766.64	26849.38

Diphoton $q\bar{q}$ sub-channel: $m_{\gamma\gamma}$ signal distribution



Diphoton $q\bar{q}$ sub-channel: $m_{\gamma\gamma}$ background distribution



by Wang Han

Diphoton $\mu^+\mu^-$ sub-channel: Efficiencies

Signal efficiency

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===== Event Selection Summary =====
Total events processed: 10000
Exclusive 2 muons and 2 photons: 7227 (72.27%)
E_y > 35 GeV: 6778 (93.7872%)
|cos(theta_y)| < 0.9: 5772 (85.1579%)
10 GeV < pT_y1 < 70 GeV: 5770 (99.9653%)
30 GeV < pT_y2 < 100 GeV: 5759 (99.8094%)
110 GeV <m_yy < 140 GeV: 5673 (98.5067%)
85 GeV < m^recoil_yy < 105 GeV: 5045 (88.93%)
125 GeV < E_yy < 145 GeV: 5037 (99.8414%)
Final selected events:      5037 (50.37%)
Expected yield at 20ab^-1: 154.816 events
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Background efficiency (by Wang Han)

2 $e^+e^- \to \mu^+\mu^-$ process efficiency

Selections	Efficiency	Event Number
Generator	100%	10778370
Gen Filter ($M_{\gamma\gamma} >= 90GeV$)	8.19%	882451
Delphes fast sim ($M_{\gamma\gamma} >= 90GeV$)	7.25581%	64029
$E_\gamma > 35GeV$	61.861%	39609
$\lvert\cos\theta_\gamma\rvert < 0.9$	35.8706%	14208
$pT_{\gamma 1} \in [10, 70]GeV$	92.8491%	13192
$pT_{\gamma 2} \in [30, 100]GeV$	87.1892%	11502
$m_{\gamma\gamma} \in [110, 140]GeV$	48.4611%	5574
$M_{\gamma\gamma}^{recoil} \in [85, 105]GeV$	21.4926%	1198
$E_{\gamma\gamma} \in [125, 145]GeV$	98.1636%	1176
Total eff	0.01%	1176

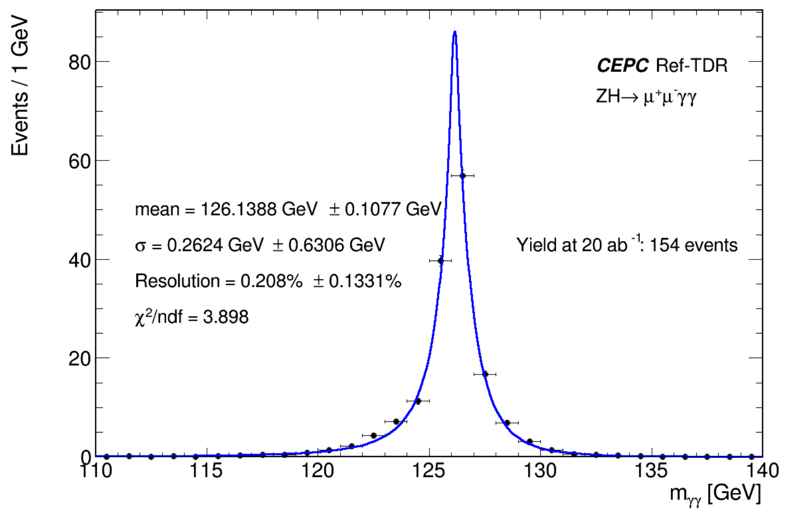
Yield at 20 ab^{-1}: 12050 events

CDR results

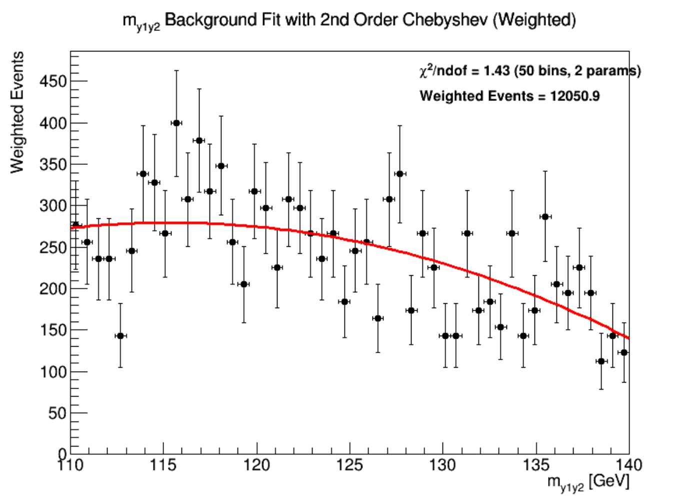
Table 3. Selection criteria and corresponding efficiencies in the $\mu^+\mu^-\gamma\gamma$ channel. $\gamma 1(\gamma 2)$ is defined as the photon with lower (higher) energy; $M_{\gamma\gamma}^{\text{recoil}}$ is the recoil mass of the di-photon system in CEPC $\sqrt{s} = 240$ GeV : $\left(M_{\gamma\gamma}^{\text{recoil}}\right)^2 = \left(\sqrt{s} - E_{\gamma\gamma}\right)^2 - p_{\gamma\gamma}^2 = s - 2E_{\gamma\gamma}\sqrt{s} + m_{\gamma\gamma}^2$.

Selections	Higgs signal	$\mu^+\mu^-\gamma\gamma$ background
Exclusive 2 muons and 2 photons	70.18%	5.18%
$E_\gamma > 35$ GeV	99.21%	8.39%
$\lvert\cos\theta_\gamma\rvert < 0.9$	83.79%	38.14%
$pT_{\gamma 1} \in [10, 70]$ GeV	99.84%	86.30%
$pT_{\gamma 2} \in [30, 100]$ GeV	99.96%	95.59%
$m_{\gamma\gamma} \in [110, 140]$ GeV	98.08%	37.62%
$M_{\gamma\gamma}^{\text{recoil}} \in [85, 105]$ GeV	80.12%	21.29%
$E_{\gamma\gamma} \in [125, 145]$ GeV	99.88%	95.86%
Total eff	45.69%	0.01%
Yields in 5.6 ab^{-1}	39.32	2662.77

Diphoton $\mu^+\mu^-$ sub-channel: $m_{\gamma\gamma}$ signal distribution



Diphoton $\mu^+\mu^-$ sub-channel: $m_{\gamma\gamma}$ background distribution



by Wang Han

Perspectives

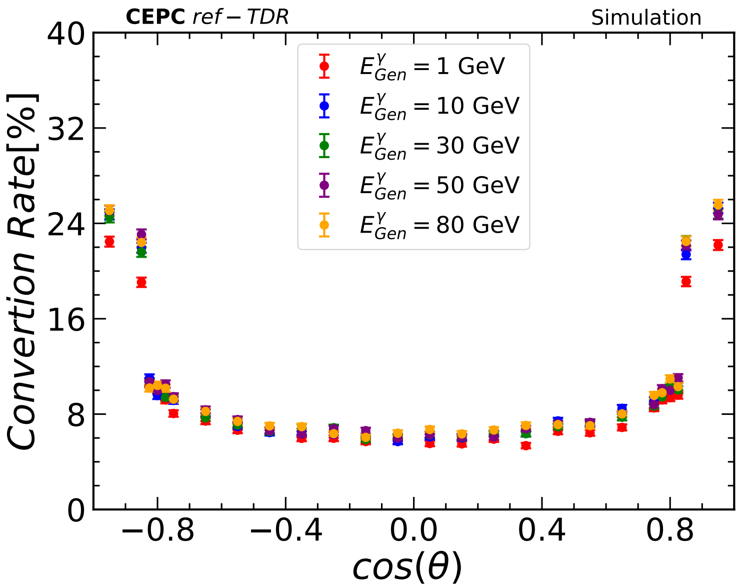
For single photon study:
*Figuring out the discrepancies in the energy resolution evolution according to truth energy (gap impact)
*Studying the gap impact (module boundaries) to to correct energy peak of PFO to truth for different energy and angle
*$cos(\theta)$ scan with more precision (smaller binning to get a better idea of the ECAL structure)
*θ angular resolution suffers from bias in energy scale (positive cos v. negative cos): we have 2 peaks thence the weird shape, will analyze again after fix from reconstruction team
*Check photon convertion rate in the crack region

For diphoton study:
*Studying systematic uncertainties
*Final results with maximum likelihood applied to get an idea on signal strength and get results for $\sigma \times BR$

Thank you!

Back-up

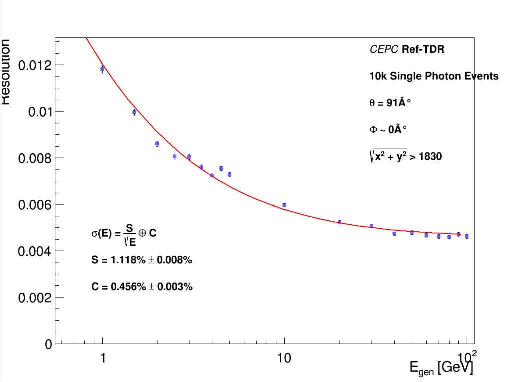
Back-up


CEPC ref − TDR
Simulation
$E^{\gamma}_{Gen} = 1$ GeV
$E^{\gamma}_{Gen} = 10$ GeV
$E^{\gamma}_{Gen} = 30$ GeV
$E^{\gamma}_{Gen} = 50$ GeV
$E^{\gamma}_{Gen} = 80$ GeV
Convertion Rate[%]
0
8
16
24
32
40
−0.8
−0.4
0.0
0.4
0.8
cos(θ)

Back-up

Discrepancies in energy resolution: due to gaps alongside θ and Φ

In center of module



In module boundary