Precision Measurement of Higgs→ $\gamma\gamma$ decay channel in CEPC

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Introduction

Higgs→ $\gamma\gamma$ decay

- Low branching ratio 0.23%
- Complex background components and large cross section
- Very clean final state topology.
- Precise photon identification and measurement.

Present precision from LHC

$\mu_{global} = 0.99^{+0.15}_{-0.14}(\mathcal{L} = 36.1fb^{-1})$ ATLAS Collaboration[1]

$\mu_{global} = 1.18^{+0.17}_{-0.14}(\mathcal{L} = 35.9fb^{-1})$ CMS Collaboration[2]

CEPC project

Operation mode

- Higgs factory $\sqrt{s} = 240GeV$, in which $\sigma_{ee\to ZH} = 203.66\ fb$
- Integrated luminosity 5.6 ab^{-1}

Detector performance

- Track momentum resolution $\Delta(1/p_T)\sim 2\times 10^{-5}\ GeV^{-1}$
- ECAL energy resolution $\Delta E/E\sim \frac{16\%}{\sqrt{E/GeV}}\oplus 1\%$

Present MC generation and simulation

- Generator: WHIZARD 1.95+MokkaC
- Simulation: a dedicated fast simulation, with parametrized detector response.

ZH($Z\to q\bar{q}$) sub-channel

MC templates

- Signal: $e^+e^-\to ZH\to q\bar{q}\gamma\gamma$
- Background: $e^+e^-\to q\bar{q}\gamma\gamma$

Event selection

- 2 high energy photon with $E_\gamma > 35GeV, p_T > 30/20GeV$ (leading/sub-leading photon)
- Cosine polar angle between di-photon/di-jet $cos\theta_{\gamma\gamma} >$ -0.95, $cos\theta_{jj} >$ -0.95
- Minimum cosine polar angel between photon and jet $\min|cos\theta_{\gamma j}| < 0.9$
- Di-photon mass window $[110, 140]GeV$

Fit model

- Signal: Double-side Crystal Ball
- Background: 2nd polynomial exponential PDF
- Combined fit on signal and background to extract the signal strength

ZH($Z\to l\bar{l}$) sub-channel

$Z\to e^+e^-$ decay is not considered because the large background from the Bhabha process.
$Z\to\mu^+\mu^-$ and $Z\to\tau^+\tau^-\to\mu^+\mu^-\nu\bar{\nu}$ decay channels are considered together, and other τ decay channels are abandoned due to the difficulty in τ reconstruction

Event selection

- $\mu\mu\gamma\gamma$ final state
- $E_\gamma > 35GeV, p_{T\gamma} > 30GeV/10GeV$
- $|cos\theta_\gamma| < 0.9$
- $M_{\gamma\gamma}\in[110,140]GeV$, $M_{\gamma\gamma}^{recoil}\in[84,\ 103]GeV$
- $\min|cos\theta_{\gamma l}| < 0.9$

ZH($Z\to\nu\bar{\nu}$) sub-channel

MC templates

- Signal: $e^+e^-\to ZH\to\nu\bar{\nu}\gamma\gamma$
- Background: $e^+e^-\to\gamma\gamma+invisiable$

Event selection

- Inclusive two photon
- $E_\gamma > 30GeV, p_{T\gamma} > 20GeV$
- $|cos\theta_\gamma| < 0.8$
- $M_{\gamma\gamma}\in[110,140]GeV$, $E_{\gamma\gamma}\in[120,150]GeV$

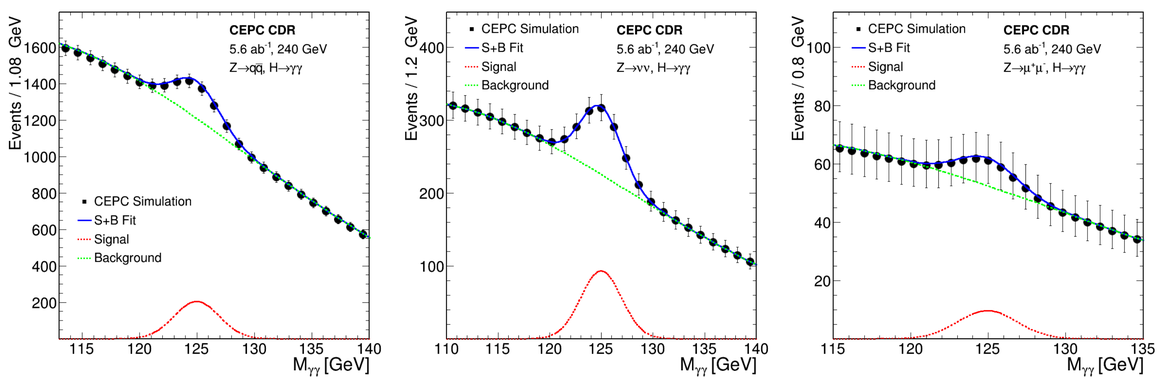

Figure1. di-photon invariant mass distributions in 3 sub-channel

Results

The combination of three sub-channel provides a final result of $\sigma(ZH)\times BR(H\to\gamma\gamma)$ measurement precision

Sub-channel	$q\bar{q}\gamma\gamma$	$l\bar{l}\gamma\gamma$	$\nu\bar{\nu}\gamma\gamma$	combined
precision	9.84%	23.7%	10.5%	6.84%

Conclusions

- A relative precision of 6.84% on $\sigma(ZH)\times BR(H\to\gamma\gamma)$ can be achieved in CEPC with $\sqrt{s} = 240$ GeV and full running time.
- This result can be improved by optimizing the event selection criteria and further categorization.

References

1. ATLAS Collaboration, *Measurements of Higgs boson properties in the di-photon decay channel with 36 fb-1 of pp collision data at* $\sqrt{s}$ = 13 *TeV with the ATLAS detector*, (2018), arXiv: 1802.04146 [hep-ex]
2. CMS Collaboration, *Measurements of Higgs boson properties in the di-photon decay channel in proton-proton collisions at* $\sqrt{s}$ = *13 TeV*, (2018), arXiv: 1804.02716 [hep-ex].