Cross section and Higgs mass measurement with Higgsstrahlung at the CEPC

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Suyu: What's Higgsstrahlung ?

energy physics community. It will operate at a center-of-mass energy of 240–250 GeV. The CEPC will accumulate an integrated luminosity of 5 ab^{-1} over ten years of operation, producing one million Higgs bosons via the Higgsstrahlung and vector boson fusion processes. This sample allows a percent or even sub-percent level determination of the Higgs boson couplings. With GEANT4-based full simulation and a dedicated fast simulation tool, we have evaluated the

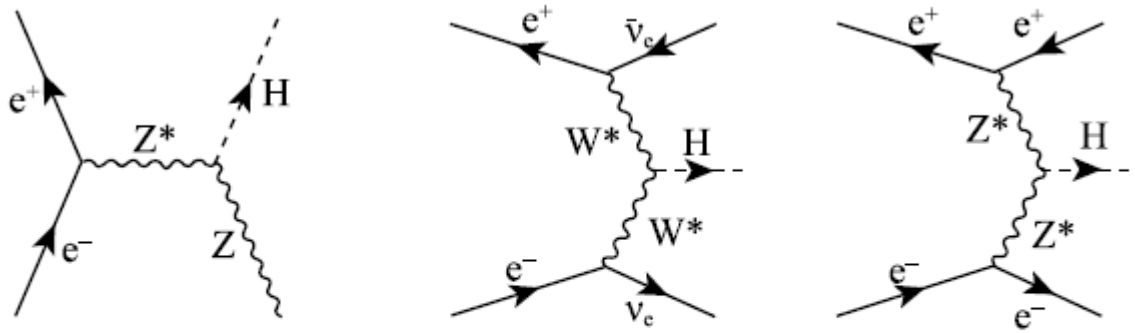
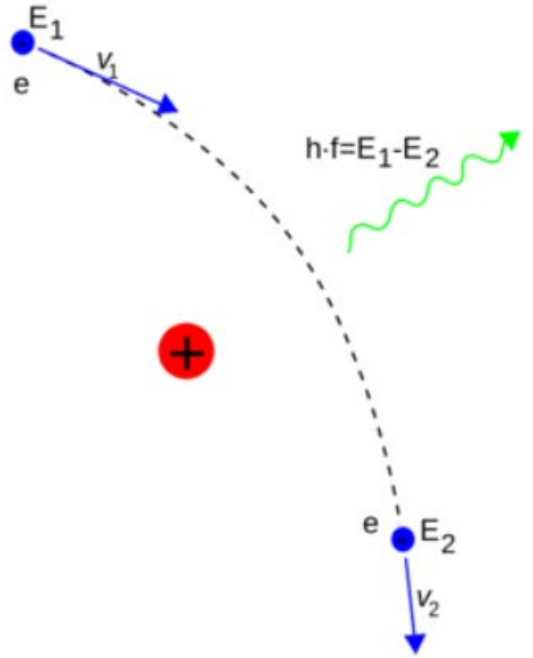


Fig. 1. Feynman diagrams of the Higgs production mechanisms at the CEPC: the Higgsstrahlung, WW fusion, and ZZ fusion processes.

The name higgsstrahlung likes bremsstrahlung.



Ryuta: The cuts to suppress the 2-fermion backgrounds are described as following:

1) Pt(mumu)>20Gev

2) Difference of azimuthal angles of the two muons < 175 degree

what are the meaning/effect of those (especially the second one)?

2 fermion backgrounds

Process	$\int L$	Final states	X-sections (fb)	Comments
$e^+e^- \to e^+e^-$	5 ab^{-1}	e^+e^-	24992.21	
$e^+e^- \to \mu^+\mu^-$	5 ab^{-1}	$\mu^+\mu^-$	4991.91	
$e^+e^- \to \tau^+\tau^-$	5 ab^{-1}	$\tau^+\tau^-$	4432.18	
$e^+e^- \to \nu\bar{\nu}$	5 ab^{-1}	$\nu\bar{\nu}$	53598.37	
$e^+e^- \to \nu_e\bar{\nu}_e$	5 ab^{-1}	$\nu_e\bar{\nu}_e$	45390.79	
$e^+e^- \to \nu_\mu\bar{\nu}_\mu$	5 ab^{-1}	$\nu_\mu\bar{\nu}_\mu$	4416.30	
$e^+e^- \to \nu_\tau\bar{\nu}_\tau$	5 ab^{-1}	$\nu_\tau\bar{\nu}_\tau$	4410.26	
$e^+e^- \to q\bar{q}$	5 ab^{-1}	$q\bar{q}$	50105.35	
$e^+e^- \to u\bar{u}$	5 ab^{-1}	$u\bar{u}$	10110.43	

the detector. By tagging the muon pairs from the associated Z boson decays, the Higgsstrahlung events can be reconstructed with the recoil mass method:

$$M_{\text{recoil}} = \sqrt{s + M^2_{\mu^+\mu^-} - 2(E_{\mu^+} + E_{\mu^-})\sqrt{s}}\,,$$

where E_{μ^+} and E_{μ^-} are the energies of the two muons, $M_{\mu^+\mu^-}$ is their invariant mass, and s is the square of center-of-mass energy. Therefore, the ZH ($Z \to \mu^+\mu^-$)

Table 2. Efficiencies of signal and background in the model-independent analysis

	$Z(\mu^+\mu^-)H$	ZZ	WW	ZZ or WW	single Z	$Z(2f)$	$\gamma\gamma$
total generated	35247	5347053	44180832	17801222	7809747	418595861	161925000
$N_{\mu^+} \geqslant 1$, $N_{\mu^-} \geqslant 1$	95.7%	11.95%	0.65%	3.92%	9.75%	1.64%	17.31%
120 GeV $< M_{\text{recoil}} <$ 150 GeV	93.2%	1.71%	0.23%	0.70%	1.93%	0.17%	3.06%
80 GeV $< M_{\mu^+\mu^-} <$ 100 GeV	85.5%	0.68%	0.06%	0.22%	0.22%	0.10%	0.11%
$p_{T\mu^+\mu^-} >$ 20 GeV	80.2%	0.57%	0.06%	0.17%	0.16%	0.02%	0.04%
$\Delta\phi < 175°$	77.8%	0.51%	0.05%	0.17%	0.15%	0.01%	0.04%
BDT cut	63.0%	0.25%	0.01%	0.05%	0.06%	0.01%	0.01%
fit window	62.8%	0.25%	0.01%	0.05%	0.05%	0.01%	0.01%

Xin: Why is impossible for the LHC to access the Higgs total width or absolute couplings in a model-independent way?

the LHC [9]. Moreover, as the Higgs boson can only be reconstructed through its decay products at the LHC, it is impossible for the LHC to access the Higgs total width or absolute couplings in a model-independent way.

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Higgs working group report

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- HL-LHC can measure the Higgs boson mass with a precision of ∼50 MeV per experiment, however has limited sensitivity to the Higgs decay total width, even with SM assumptions. Higgs factories such as ILC, CLIC, or TLEP will achieve a mass precision of about 35 MeV and measure the Higgs decay width up to ∼1.3% in precision. Through a line-shape scan, a muon collider can measure the total width directly to 4.3% and the mass to sub-MeV precision.

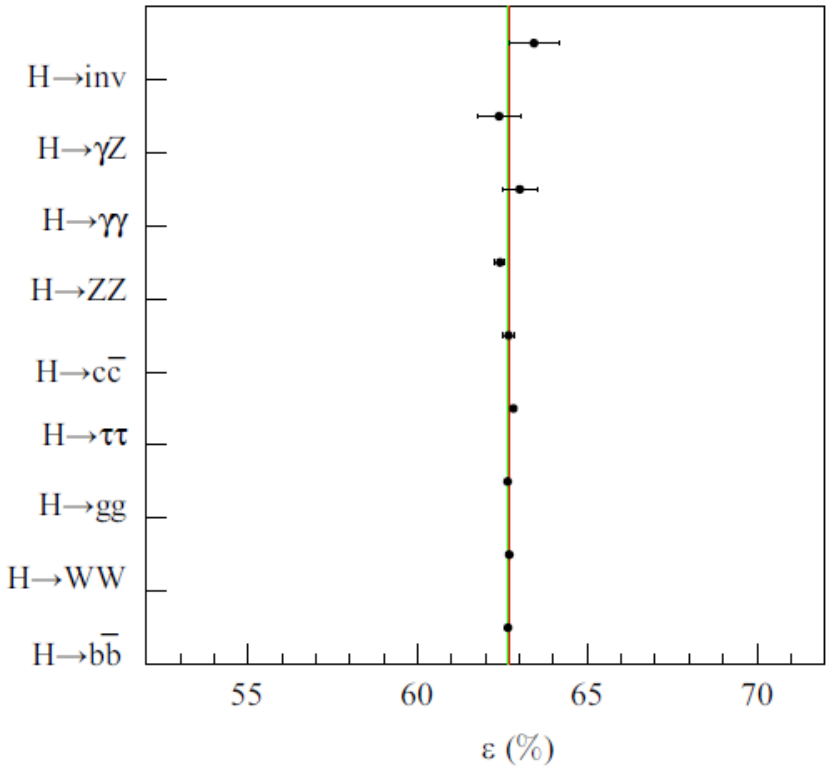
1.3.2 Models that modify the triple-Higgs coupling

Beyond the Standard Model, the triple-Higgs coupling is in general modified. The size of the modification is highly model-dependent, potentially providing model-discriminating power. Estimates of the self-coupling

- Precision tests of Higgs boson couplings to one-percent will require complementary precision programs. Proposed Higgs factories such as linear or circular e^+e^- colliders and potentially a muon collider will be able to achieve these precisions for many of the absolute couplings, and in a model-independent way.

Amit: In figure-5, If there is no significant bias to any specific Higgs Decay mode is observed, then why they have selected this channel " H-->invisible " for the determination of Higgstrahlung cross section σ_{ZH} and the Higgs mass m_H measurement at the CEPC?

The uniformity of event selection efficiency with different Higgs decay modes is studied. A SM ZH ($Z \to \mu^+\mu^-$) sample corresponding to 500 ab^{-1} has been simulated, where the Higgs boson decays inclusively. Figure 5 shows the efficiencies and no significant bias to any specific Higgs decay mode is observed. In order to evaluate



the σ_{ZH} is less than 10^{-3}, which is much smaller than the statistical uncertainty 0.97%. It is therefore reasonable to conclude the recoil mass method gives a model-independent measurement.

3.4 Measurement of the Higgs boson invisible decay mode

The invisible decay mode of the Higgs boson is a well motivated signature of physics beyond the SM [20–23]. At the CEPC, the invisible Higgs boson decay branching ratio can be determined precisely using the recoil mass method. Assuming the Higgs boson has a SM

Thank you