Constrain HZZ couplings from NewPhys in Higgs Production

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Outline

- Introduction
- Z polarization & CPV in azimuthal angle
- Preliminary estimations
- Discussions

Introduction

- CEPC is anyhow a Higgs factory
  - Various of prod xsec & branchings have been well simulated
  - More delicate exploration on HZZ coupling ?
- HZZ coupling Beyond SM
  - An EFT approach with 4 more parameters
  - Extra Lorentz structures
- Observables in □ → □□ from Higgs-Strahlung
  - Total xsec
  - decay angle
  - Possible CPV from azimuthal angle
- Preliminary estimation with only statistics

HZZ coupling BSM

ÅFollowing the FeynRule implementation

ÅPlease let us know if there is something more general or appropriate

$$\mathcal{L}_{HZZ} = -\frac{1}{4} g^{(1)}_{hzz} Z_{\mu\nu} Z^{\mu\nu} h - g^{(2)}_{hzz} Z_\nu \partial_\mu Z^{\mu\nu} h + g^{(3)}_{hzz} Z_\mu Z^\mu h - \frac{1}{4} \widetilde{g}_{hzz} Z_{\mu\nu} \widetilde{Z}^{\mu\nu} h.$$

ÅCan we explore the BSM paras on CEPC ?

In strahlung the □□ can be absorbed so that there are only 3 new paras

Observables - $\square \to \square\square$ Total xsec

$$\sigma = \int_{-1}^{1} dcos\vartheta \int_{-\pi}^{\pi} d\varphi \int_{-1}^{1} dcos\hat{\vartheta} \frac{d\sigma}{dcos\hat{\vartheta} dcos\vartheta d\varphi}$$

$$= K \frac{128\pi C_0 \ s}{9} Q$$

$$Q = g_0^2 [1 + 2\frac{g_3'}{g_0}] Q_0 + g_1 g_0 Q_1$$

$$Q_0 = E_Z^2 + 2m_Z^2, \qquad Q_1 = \frac{1}{2}\beta^2 E_Z s^{3/2}$$

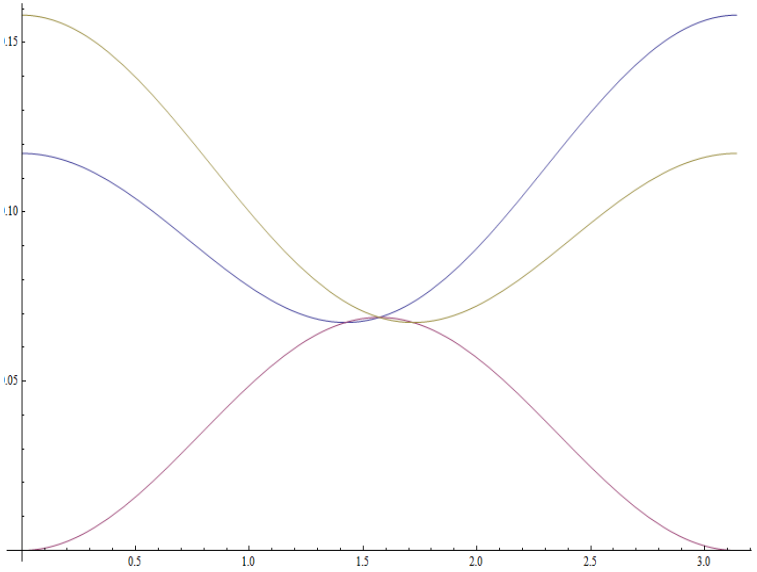
$$K = K(s, m_Z^2, m_H^2, |\mathbf{p}_l|)$$

$$= \frac{1}{4} \frac{\beta(m_Z^2/s, m_H^2/s)}{32\pi s} |\frac{1}{s - m_Z^2}|^2 \frac{\pi}{\Gamma_Z} \frac{|\mathbf{p}_l|}{32\pi^3 M_Z^2}$$

7.95 fb

Observables – Z polarization

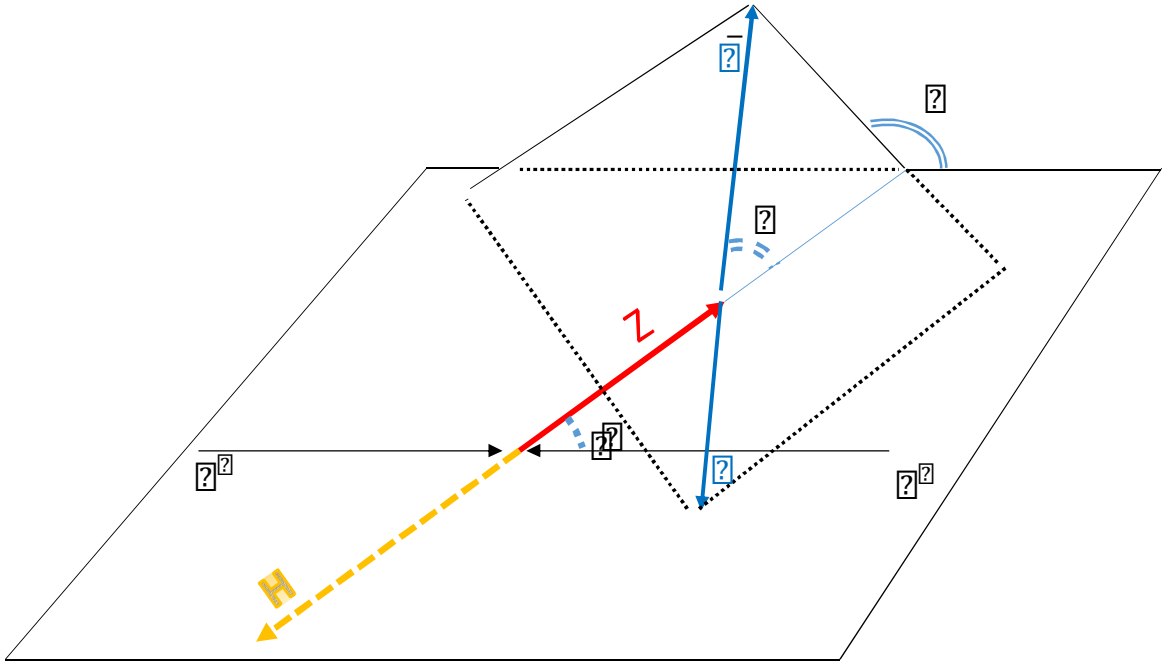
$$\frac{d\sigma}{\sigma d cos\vartheta} = \frac{3M_Z^2}{8(a_f^2+v_f^2)\ Q}$$
$$\{g_0^2(1+2\frac{g_3'}{g_0})[\Gamma^-(\vartheta)+\Gamma^+(\vartheta)]$$
$$+[g_0^2(1+2\frac{g_3'}{g_0})\frac{E_Z^2}{M_Z^2}+g_1 g_0\frac{Q_1}{M_Z^2}]\Gamma^0(\vartheta)(10)$$



Observables – azimuthal angle

$$\frac{d\sigma}{\sigma d\varphi}|_{\vartheta \gtrless \pi/2} = \frac{M_Z^2}{16\pi Q}$$
$$\{\frac{8Q}{M_Z^2} - 4g_0^2(1+2\frac{g_3'}{g_0})c_{2\varphi}$$
$$\pm 6\frac{\pi a_e v_e}{(v_e^2+a_e^2)}[g_0^2(1-2\frac{g_3'}{g_0})\frac{E_Z}{M_Z} + g_0 g_3' \frac{Q_1}{E_Z M_Z}]c_\varphi$$
$$-8g_0\tilde{g}s\beta s_{2\varphi} \pm 3g_0\tilde{g}s\frac{\pi a_e v_e}{v_e^2+a_e^2}\frac{E_Z}{M_Z}s_\varphi\}$$

The $\square_{\square}$ & $\square_{\square}$ terms will not present if investigated with full decay angle


Z
H

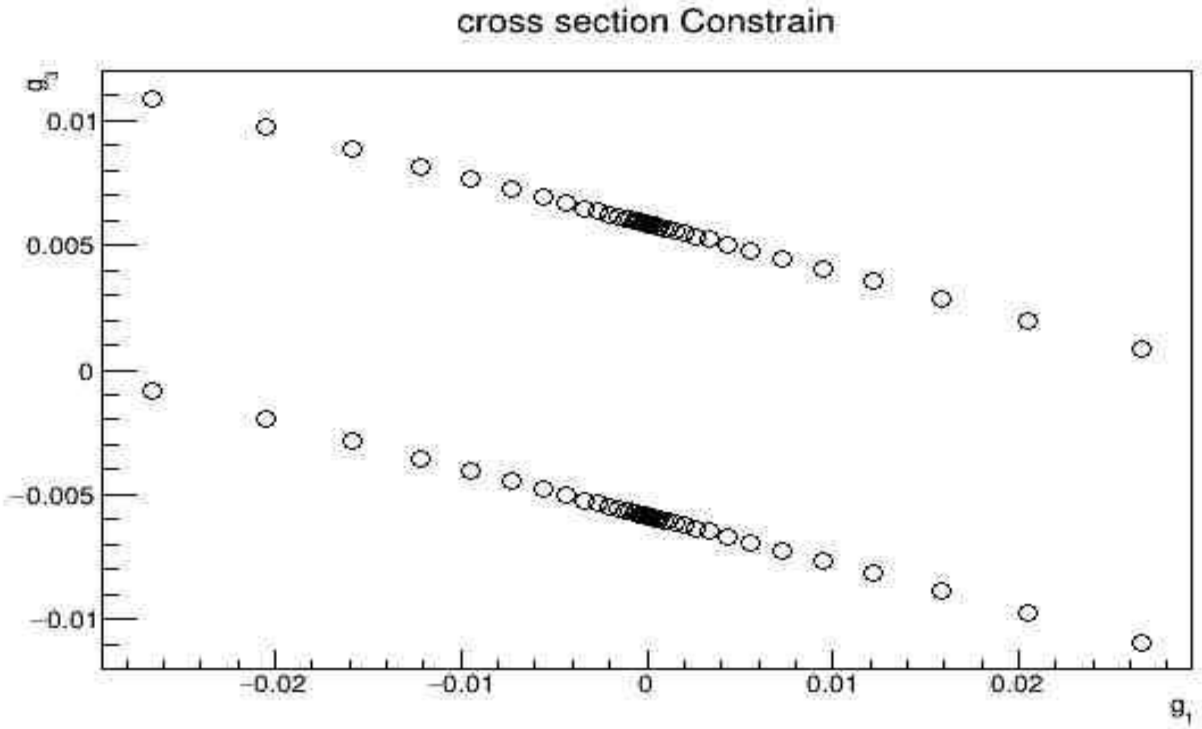
Preliminary estimations

- CEPC (detector) setup
  - $\sqrt{s}$ = 240 GeV
  - Lumi = 5000/fb
  - Association Z decay to leptons, with Lep ID effi = 0.9
  - Higgs decay to bottom pair, Btag effi = 0.8
  - Systematics @ same level of statistical errors

  - All backgrounds are neglected

  - Gaussian $\sqrt{N}$ for total xsec
  - CL 95% by Pearson χ^2 from histograms

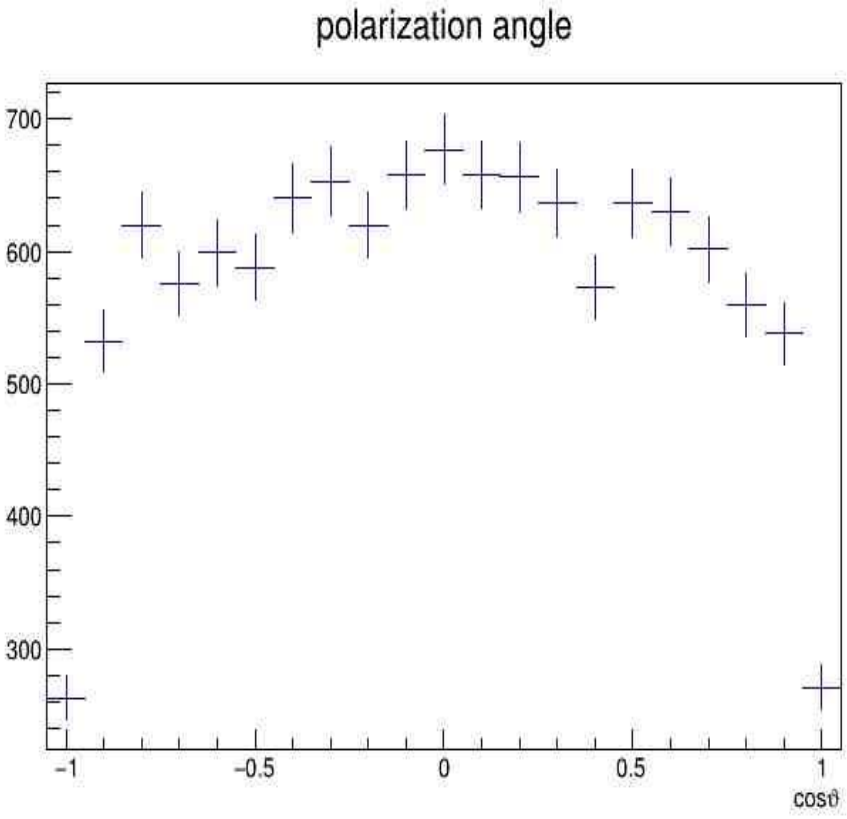
Constraint from xsec

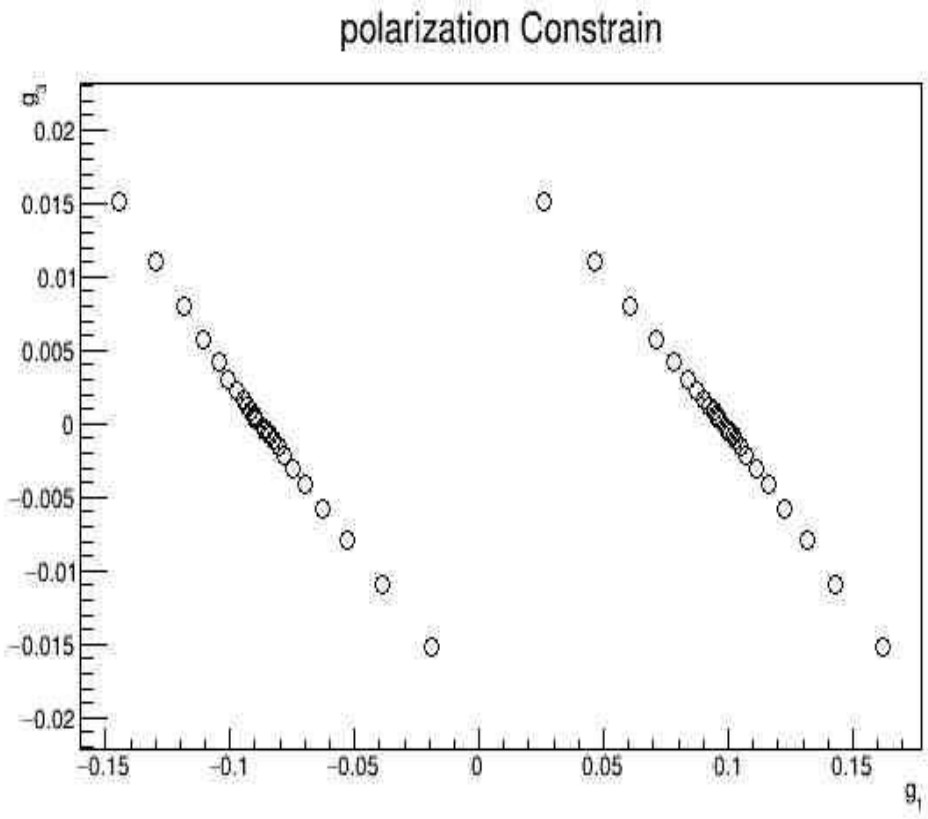


CEPC can see something in total xsec if $|?_?| > 0.01$ or $|?_?| > 0.02$

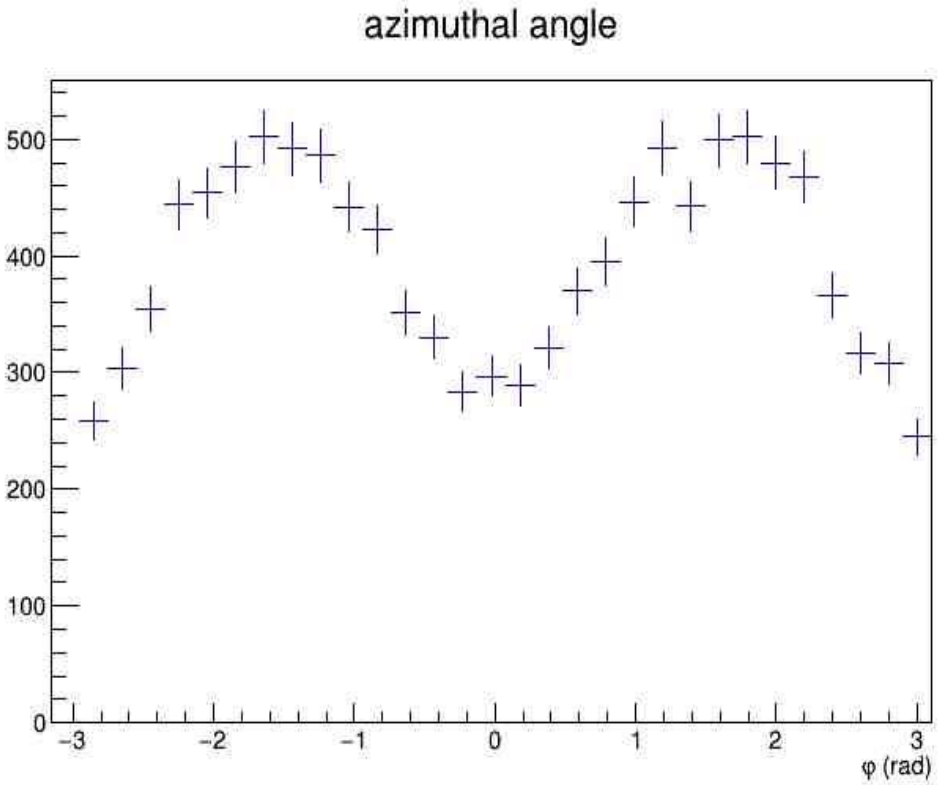
Please note the cancelling effect : $|?_?|$ can not be fixed by single xsec

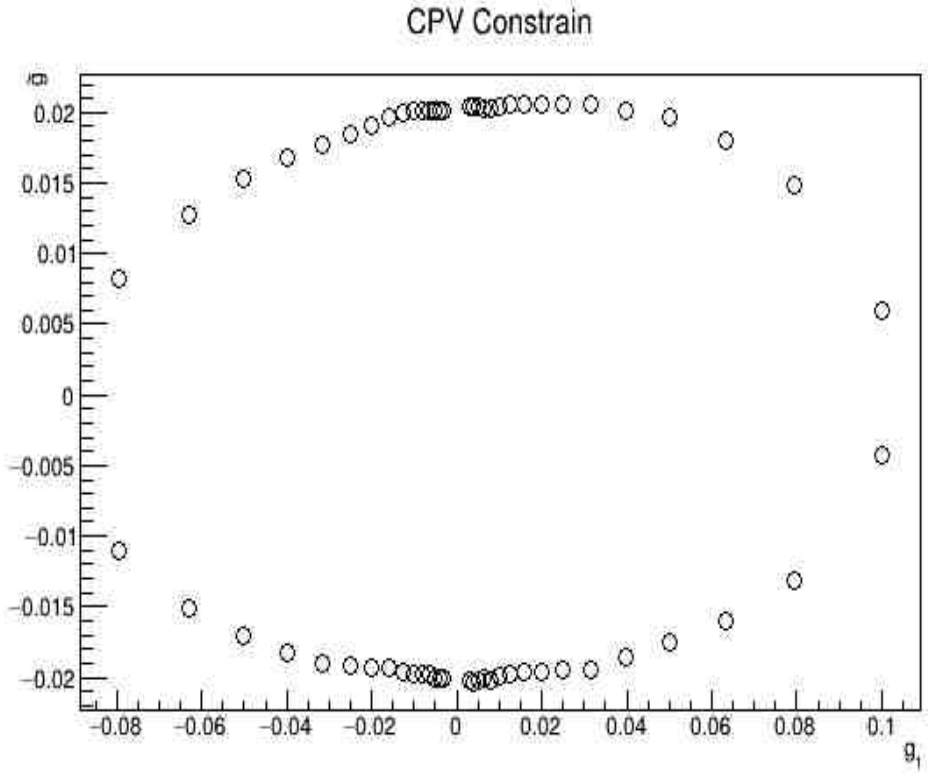
Constraint from Z polarization





Constraint from azimuthal angle





CEPC may see a distortion of azimuthal angle if $|\tilde{d}| > 0.02$

Discussions

- Simple subject seeming feasible
  - Many similar theoretical studies have taken places
    - Meaningful to explore HZZ coupling
    - God-ashore (高大上）
  - A Simplest implementation
    - Shortest formulae & easiest plot
      - Even a student can continue easily
  - Events generation is possible
    - Needing nothing more than support of *LHE* format
- Full simulation samples ?
  - If you agree to that they are interesting & helpful
  - Start from here-estimated paras
  - Nothing more than demonstrating an intention
    - Manpower vs time scale

Discussions (ctd)

- Backgrounds control
  - Exclusive $\nu\bar{\nu}H \to \nu\bar{\nu}b\bar{b}$ vs inclusive recoiled $e^+e^- \to Z + X \to \mu^+\mu^- + X$?
    - Higher statistics in inclusive vs easier background in exclusive
    - Just add the two (polarization & azimuthal) plots to the current analysis
  - Control plots for angle's resolution
- Full fitting vs current cheap&rude procedure
  - Obviously the constraints from angles will become much tighter
  - Minimizing with fullSim samples vs likelihood fitting with forms
    - Convolution of systematics
  - Carefulness against over-sophisticated things
- Energy distribution if $H \to b\bar{b}^*$?
- Your suggestions ?