Exotic Higgs Decay With Hadronic Final States

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Outline

- Introduction
- Data Generation
- Cuts
- Results of scan
- Future plan and summary

Introduction

- ZH is the major production channel in 250 GeV e^+e^- collider. Using the recoil mass method, the Higgs mass can be precisely measured. Therefore, the exotic Higgs decay search in CEPC is of great interest.

- The width of 125 GeV SM-like Higgs is very narrow (≈ 4 MeV) so a small coupling to another light state leads to a sizable exotic decay branching ratio. We are looking into the exotic decay modes which are allowed in NMSSM.

Introduction

- $h \to MET$
- $h \to \tau\mu$
- $h \to R + X$
- $h \to RR$
- $h \to ZR$

- An upper limit for the sensitivity of each channel on CEPC is desired
- Scan on the mass parameter(s) in the last three channels

- Plan proposed by Prof. Tao LIU

Introduction

- $h \to MET$ — By Zhenxing Chen & Xin Mo
- $h \to \tau\mu$
- $h \to R + X$ — By Jiawei Wang
- $h \to RR$
- $h \to ZR$

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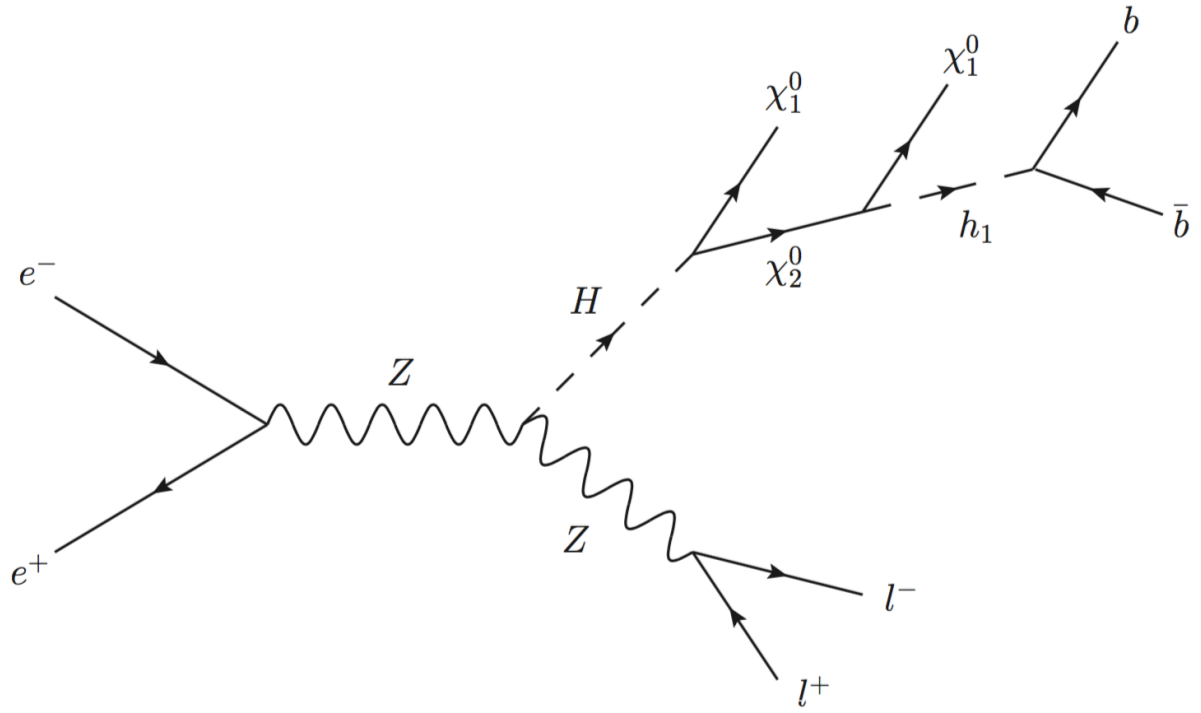
Semi-invisible Channel



Semi-invisible Channel

- Scan over the parameter space of $M_{\chi 1}$, $M_{\chi 2}$ and M_{h1}:

1) Fix $M_{\chi 1} = 0$ GeV and make exclusion contours on the M_{h1} and $M_{\chi 2}$ plane with the range:

- $10 \text{ GeV} < M_{h1} < 60 \text{ GeV}$ $(15, 25, 35, 45, 55 \text{ GeV})$
- $10 \text{ GeV} < M_{\chi 2} < 125 \text{ GeV}$ $(20, 40, 60, 80, 100, 120 \text{ GeV})$

2) Fix $M_{h1} = 30$ GeV and make exclusion contours on the $M_{\chi 1}$ and $M_{\chi 2}$ plane, with the range:

- $0 \text{ GeV} < M_{\chi 1} < 60 \text{ GeV}$ $(5, 15, 25, 35, 45, 55 \text{ GeV})$
- $10 \text{ GeV} < M_{\chi 2} < 125 \text{ GeV}$ $(20, 40, 60, 80, 100, 120 \text{ GeV})$

Data Generation

- 10000 events by MadGraph5 (version 2.3.2) NMSSM model
- Fix the final state as $h_1 \to bb$ and $Z \to \mu\mu$
- Full-simulation via Mokka (release 08-03) & Arbor (version v3_KD) with model cepc_v1

Backgrounds

- 2 jets + 2 muons
- ZH background: $ZH \rightarrow bb\mu\mu$ (/cefs/tmp_storage/yant/gridfs/cepc/user/w/weiyq/e2e2h_615)
- ZZ backgrounds:

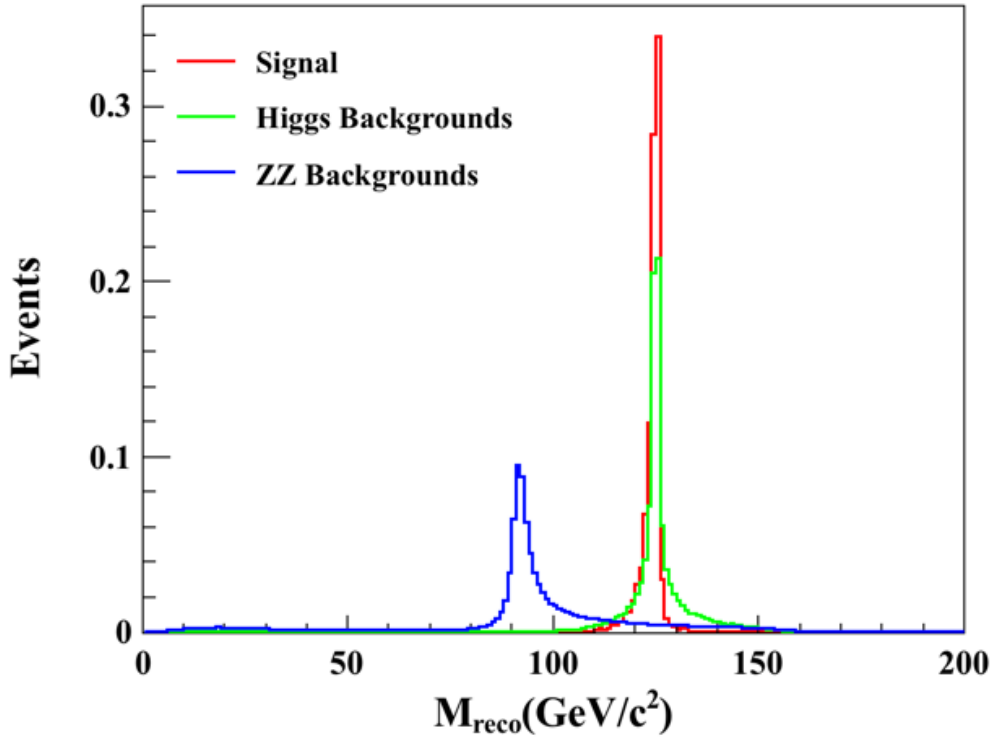
1. Leptonic: $ZZ \rightarrow 4l$ (/cefs/higgs/weiyq/E250.Pzz_l.e0.p0.whizard195_bkg)
2. Semi-leptonic: $ZZ \rightarrow 2l + 2f$ (/cefs/higgs/yant/E250.Pzz_sl.e0.p0.whizard195_bkg)

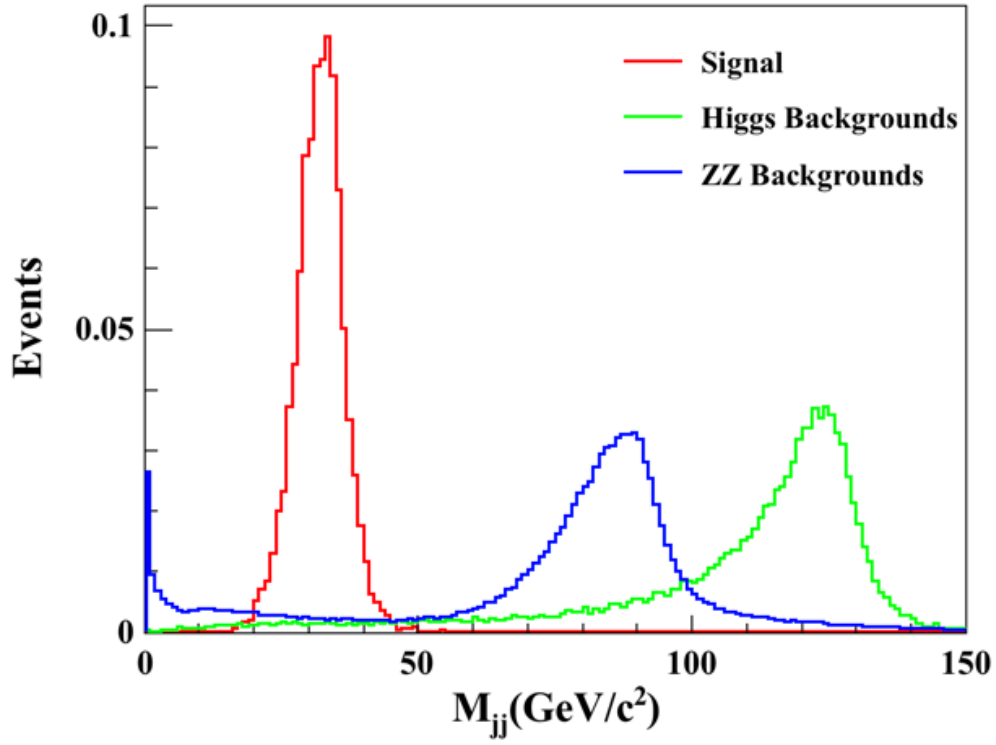
- (Tested hadronic ZZ decays, less than 10 events out of 6889948 passed pre-selection)

General Cuts

1. FSClasser (2 isolated muons + 2 jets, including m_{ll} cut, requiring $81.18\text{GeV} < m_{ll} < 101.18\text{GeV}$)
2. Recoil mass: $110\text{GeV} < m_{reco} < 140\text{GeV}$
3. B likeness: at least one jet with b likeness larger than 0.9
4. Missing energy: $E_{missing} > 20\text{GeV}$

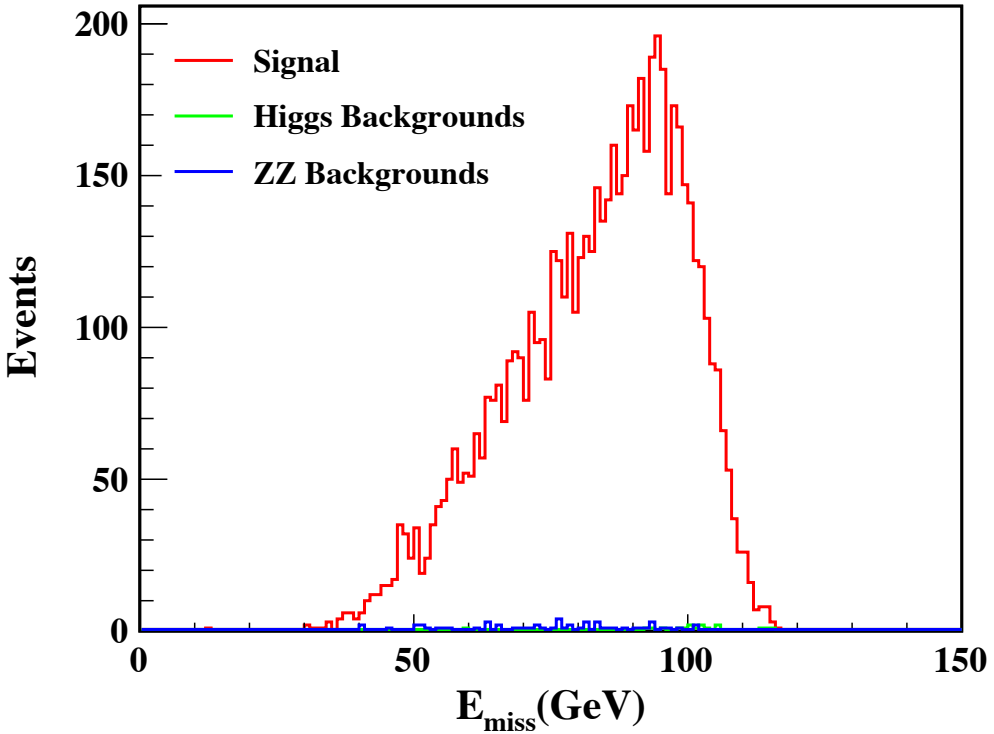
M_{reco} AND M_{jj} DISTRIBUTION (WITHOUT CUTS)



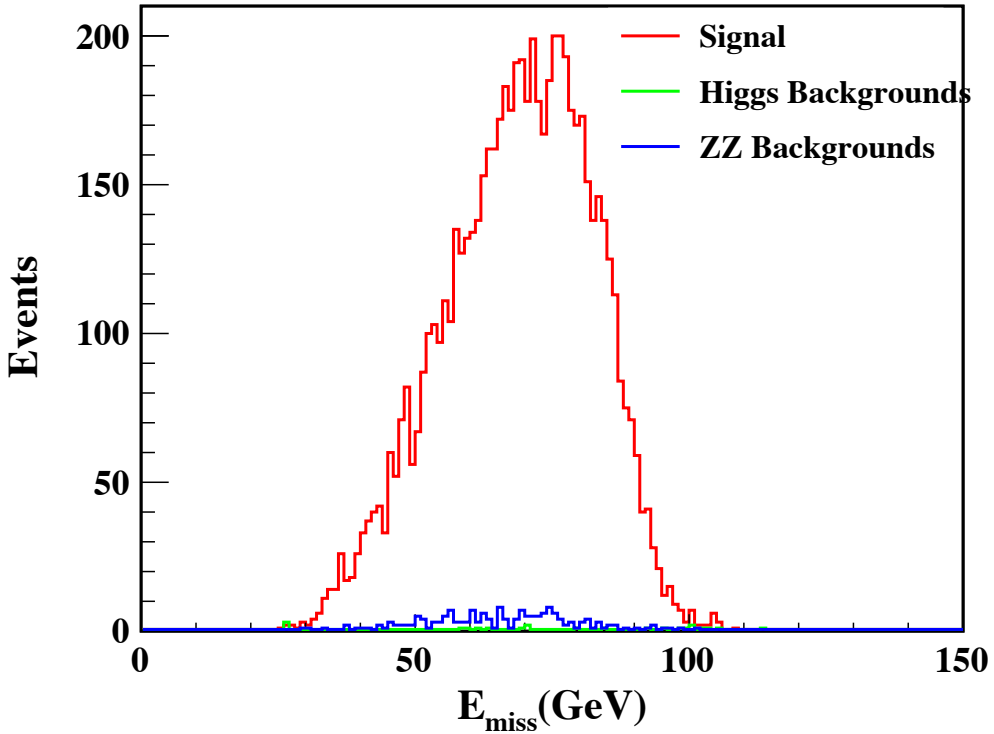


$M_{\chi 1} = 0, M_{\chi 2} = 80\text{GeV}$ and $M_{h1} = 35\text{GeV}$

$E_{missing}$ DISTRIBUTION (WITH OTHER CUTS APPLIED)



$M_{\chi 1} = 0, M_{\chi 2} = 80$ GeV and $M_{h1} = 35$ GeV



$M_{\chi 1} = 0, M_{\chi 2} = 100$ GeV and $M_{h1} = 55$GeV

Cut Flow

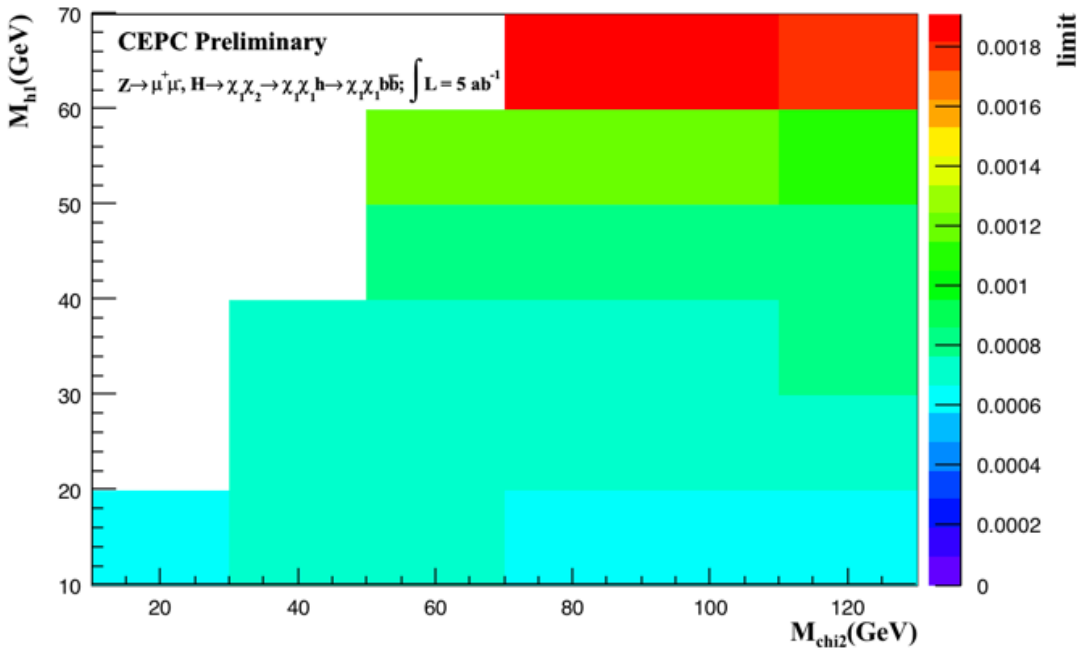
	Total	FSClasser	Recoil mass	b likeness	Missing E	mjj	Percentage
Signal	10000	8342	8273	6750	6749	6673	66.7%
Signal*	41	35	34	28	28	28	66.7%
ZH background	35849	28002	25874	13783	2399	22	0.061%
ZZ background	3004042	280140	39700	5957	3639	174	0.0058%

$$M_{\chi_1} = 0, M_{\chi_2} = 100 \text{ GeV and } M_{h_1} = 55 \text{ GeV}$$

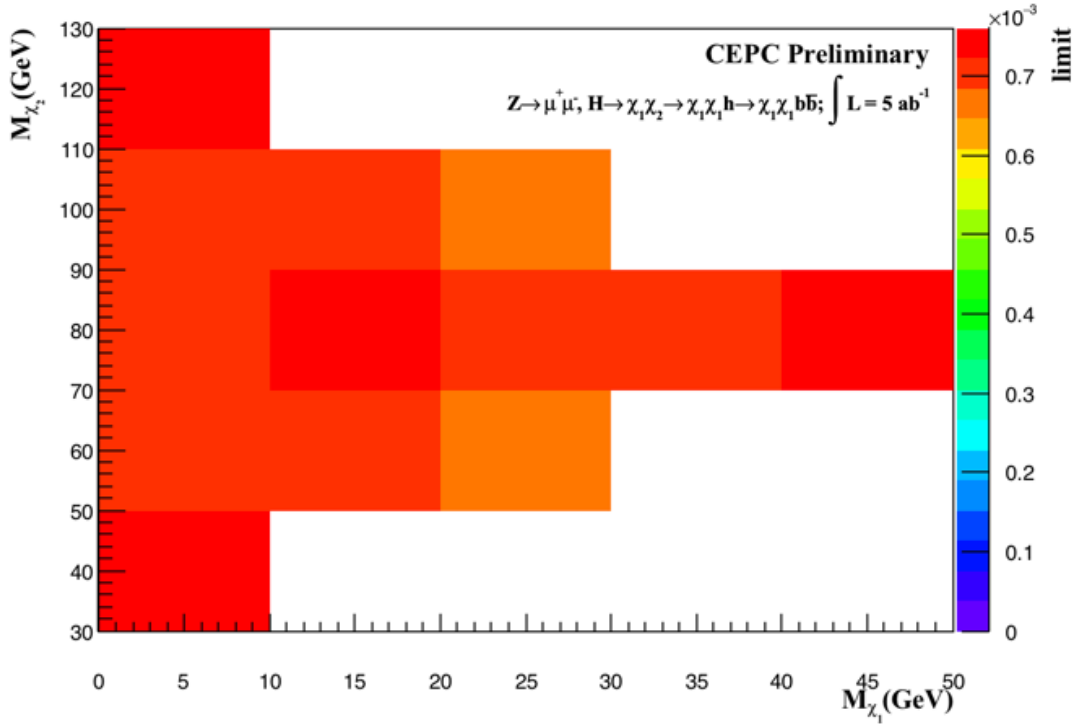
The main remaining backgrounds are from ZZ decays

For a 2 sigma significance, we need: $\frac{\text{Br}(H \text{ exotic decay})}{\text{Br}(H \text{ SM decay})} \geq 1.17 \times 10^{-03}$

Scan Results



Fixing M_{χ_1} as 0



Fixing M_{h_1} as 30 GeV

Scan Results

- The most important parameter: M_{h_1}
- Higher M_{h_1}, M_{jj} closer to Z pole and thus more ZZ backgrounds

- Other two parameters M_{χ_1} and M_{χ_2} do not influence the significance much (same level as data fluctuation)

Summary

- Full-simulated samples are analyzed using the recoil-mass method
- A distribution is obtained for the upper limit for the sensitivity of the semi-invisible channel on CEPC

- Future plan: continue the search on exotic Higgs Plan
- Will work on $h \to RR$ with $R \to qq, R \to ll$ or $R \to \gamma\gamma$

Thank You!