Hig2inv progress work

Tanyh
2018/11/08

1. Produce a poster for the CEPC seminar.
2. Write memo.

Higgs Invisible Decay Mode At The CEPC

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Weimin Yao[3] Susmita Jyotishmati[2] Zhenxing Chen[4] Yong Ban[4] Dayong Wang[4] Mengzhen Wang[4]

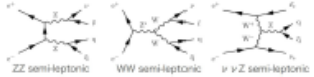
[1]Institute of High Energy Physics,China [2]University of Texas at Dallas, Richardson,USA [3]Lawrence Berkeley National Laboratory (LBNL) [4]Peking University,China

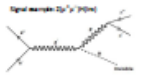
Introduction

- The Higgs invisible decay in SM is via four neutrinos with BR ~ 10^{-3}, and may new physics beyond SM suggests enhancement of invisible decay. e.g.: Higgs-portal models of dark matter interactions.
- The upper limit on the Higgs boson invisible branch ratio (BR(H→inv.)) given by the ATLAS is 23%, and the upper limit given by the CMS is 24%. Due to the fact that the hadron colliders always suffer from amounts of backgrounds, it is very difficult even for the future high luminosity LHC to test the SM directly with the BR(H→inv.).
- The precision measurement can be performed at an electron-positron collider(e.g.CEPC). Compared with the LHC, the beam energy and polarization of the initial states are precisely known and adjustable. Thus, the Higgs production cross section is available with the recoil technique that can precisely measure BR(H->inv.).
- The upper limit of BR(H→inv.) could reach 0.24% at 95% confidence level at the CEPC. It could be improved by two orders of magnitude compared to the LHC results.
- The invisible decay mode of the Higgs boson is a well motivated signature of physics beyond the SM.

Signal and Background

- Signal: $Z(\mu^+\mu^-)H(inv.)$,$Z(e^+e^-)H(inv.)$ and $Z(q\bar{q})H(inv.)$.
- Main background:

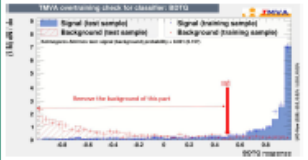




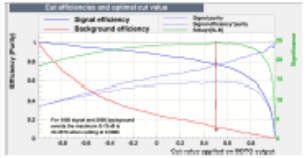
- In ZH, the leptonic decay of Z boson can be well reconstructed.

Boost Decision Tree(BDT)

- Use BDT to further suppress background.



- BDTG is chosen as the algorithm which would optimize the event selection and determine a BDT cut according to the maximum significance.



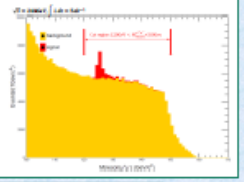
Event Selection

Table 2: Efficiencies of signal and background in the $\mu^+\mu^-$ channel

	$Z(\mu^+\mu^-)H(inv.)$	2 fermion background	4 fermion background
Total generated	6644	2395102	11350000
$N_\mu \geq 2, N_{charge} = 0$	100.0%	99.94%	99.87%
$N_\gamma \leq 3$	100.0%	98.72%	99.47%
$10GeV < P_T^{\mu^+\mu^-} < 70GeV$	70.5%	0.99 %	0.34%
$\lvert P_z^{\mu^+\mu^-} \rvert < 80GeV$	76.1%	0.08%	0.17%
$\lvert \cos\theta_{\mu^+\mu^-} \rvert < 0.5$	42.3%	0.03%	0.08%
$90GeV < E_{visible} < 110GeV$	42.1%	0.02%	0.04%
$85GeV < M_{\mu^+\mu^-} < 97GeV$	40.5%	0.02%	0.03%
$120GeV < M_{recoil} < 150GeV$	40.5%	0.02%	0.03%

- We use eight cuts conditions to select signal and suppress background.

- Cut example:

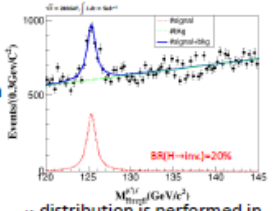


Recoil Technique

Recoil Mass:

$$m^2_{recoil}=(\sqrt{s}-E_{ff})^2-p^2_{ff}$$

- This figure is a recoil mass spectrum of leptonic channels in the measurement of the invisible decay mode of the Higgs boson with BR(H→inv.) = 20%.



- A maximum likelihood fit to the M_{recoil} distribution is performed in the region of 120GeV to 145GeV to determine the signal yield as well as the value of the Higgs mass.
- Higgs mass and ZH production cross section can be measured model-independent with using recoil mass.
- We can get the upper limit of BR(H→inv.) by using the likelihood ratio test method.

Result

- 95%CL upper limit on the BR(H→inv.) from a CEPC dataset.

	$\mu^+\mu^-H(inv.)$
Branch ratio	(1.495±0.608)%
95%CL upper limit	1.919%

Plan

- Optimize and use BDT to suppress the background.
- Analyze $Z(e^+e^-)H(inv.)$ and $Z(q\bar{q})H(inv.)$.
- Obtain the combined BR(H→inv.) and the 95%CL upper limit of BR(H→inv.).

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- The upper limit of BR(H→inv.) could reach 0.24% at 95% confidence level at the CEPC. It could be improved by two orders of magnitude compared to the LHC results.
- The invisible decay mode of the Higgs boson is a well motivated signature of physics beyond the SM.

Moxin:0.24%.CMS:0.42%. Zhen-Xing Chen:1.2%

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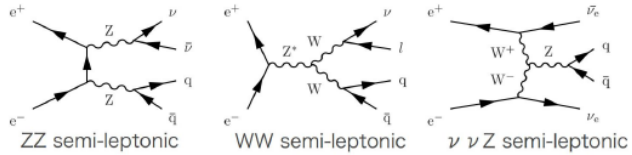

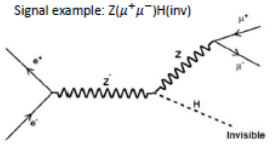

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$10GeV < P_t^{\mu^+\mu^-} < 70GeV$	79.3%	0.59 %	0.34%
$\lvert P_z^{\mu^+\mu^-}\rvert < 50GeV$	78.1%	0.09%	0.17%
$\lvert cos\theta_{\mu^+\mu^-}\rvert < 0.5$	42.3%	0.03%	0.08%
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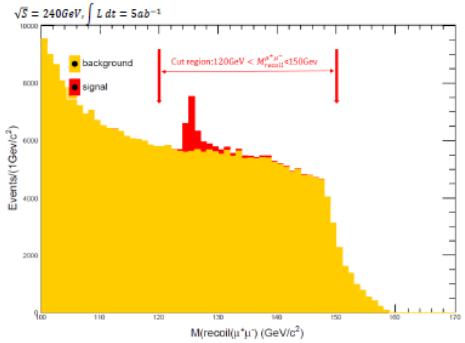

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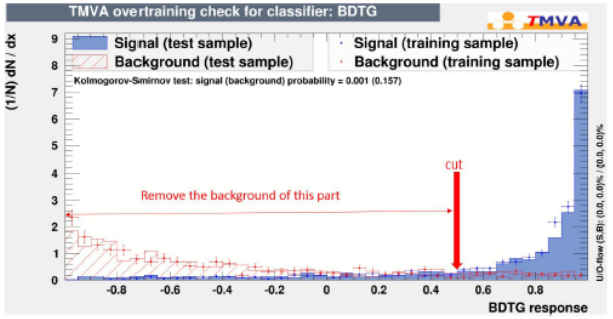

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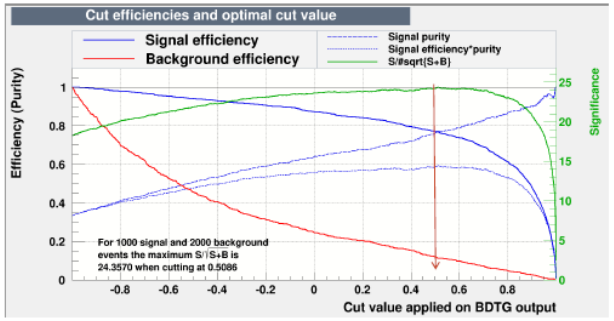

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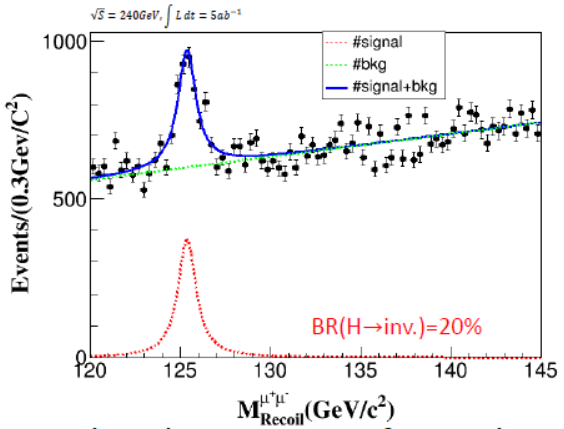

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Thank you