



the measurement of branch ratio's upper limit of Higgs decaying into e^+e^- production in e^+e^- collisions at $\sqrt{S}=250$ GeV at CEPC

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**Physics analysis group meeting
Match 26th, 2016**

Sketch

- universal conception
- motivation
- discriminate variables to suppress background
- optimization
- calculation of upper limit

report slides and analysis note link

Progress reports concerning the H->ee channel:

- <http://indico.ihep.ac.cn/event/5098/contribution/27/material/slides/0.pptx>
- <http://indico.ihep.ac.cn/event/5098/contribution/40/material/slides/0.pdf>
- <http://indico.ihep.ac.cn/event/5098/contribution/47/material/slides/0.pdf>
- <http://indico.ihep.ac.cn/event/5102/contribution/12/material/slides/2.pdf>
- <http://indico.ihep.ac.cn/event/5102/contribution/20/material/slides/0.pdf>
- <http://indico.ihep.ac.cn/event/5102/contribution/34/material/slides/0.pdf>
- <http://indico.ihep.ac.cn/event/5102/contribution/42/material/slides/0.pdf>

- <http://indico.ihep.ac.cn/event/5102/contribution/48/material/slides/0.pdf>
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- <http://indico.ihep.ac.cn/event/5102/contribution/74/material/slides/1.pdf>
- <http://indico.ihep.ac.cn/event/5266/contribution/12/material/slides/0.pdf>
- <http://indico.ihep.ac.cn/event/5546/contribution/4/material/slides/0.pdf>

Analysis Note:

- <http://indico.ihep.ac.cn/event/5917/contribution/3/material/slides/2.pdf>

universal conception and motivation

- electro-weak symmetry spontaneous mechanism of standard model, standard model is not perfect (neutrino mass? asymmetry of matter and anti-matter?)

Higgs properties is a suitable break point for new physics

CEPC is responsible for:

- a). research precise measurement of Higgs characteristic
- b). generating pretty much Higgs bosons. (Higgs factory)

- **comparing to LHC:**

less background constituents and high Higgs detecting efficiency

- **comparing to ILC:**

CEPC and ILC could make a crosscheck on their experimental results

universal conception and motivation

- Higgs decaying production of WW ZZ $\gamma\gamma$ have been completed in pre-CDR.
- Higgs decaying model of dilepton is facilitating us to probe the Yukawa couplings properties, although it is the lightest, it is also as significant as heavy ones
- For the electron and positron are the lightest charged fermions, it will demonstrate how capable the CEPC could set a strict limit to such a coupling (it shows that it is better than CMS results by one order of magnitude) evidence of physics beyond SM

leptonic decaying channel results from CMS and ATLAS

leptonic decay channel	BR upper limit at 95%	collaboration	Journal
$h \rightarrow ee$	0.19%	CMS	Phys. Lett. B 744, 184
$h \rightarrow \mu\mu$	0.15%	CMS	Phys. Lett. B 744, 184
	0.16%	ATLAS	Phys. Lett. B 738, 68
$h \rightarrow e\mu$	0.036%	CMS	CMS-PAS-HIG-14-040
$h \rightarrow e\tau$	0.69%	CMS	CMS-PAS-HIG-14-040
	1.04%	ATLAS	unpublished
$h \rightarrow \mu\tau$	1.51%	CMS	Phys. Lett. B 749, 337
	1.43%	ATLAS	unpublished

leptonic decaying channel results from ILC

- $h \rightarrow \mu\mu$ significance = 2.75σ $500 fb^{-1}$ 1000 GeV
- $h \rightarrow e\tau$ Br =

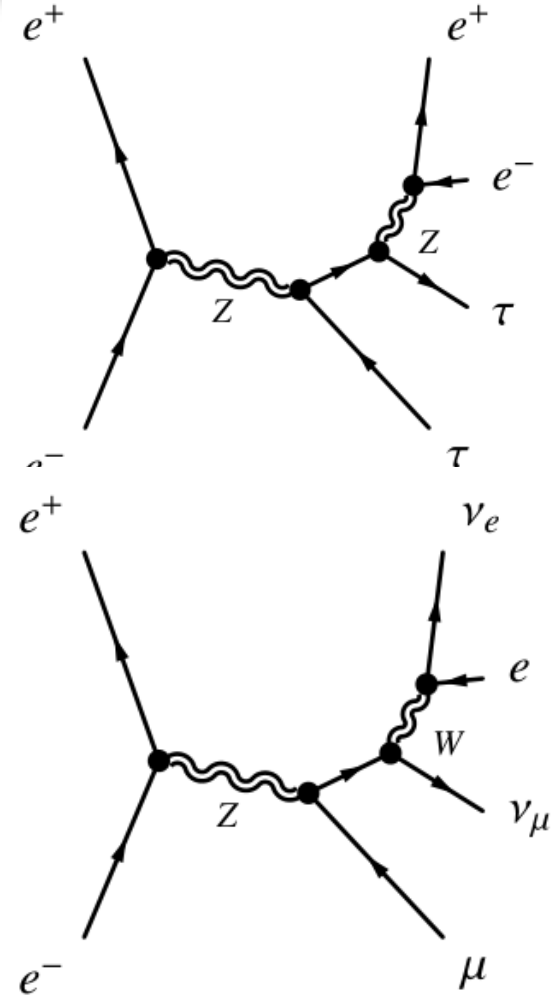
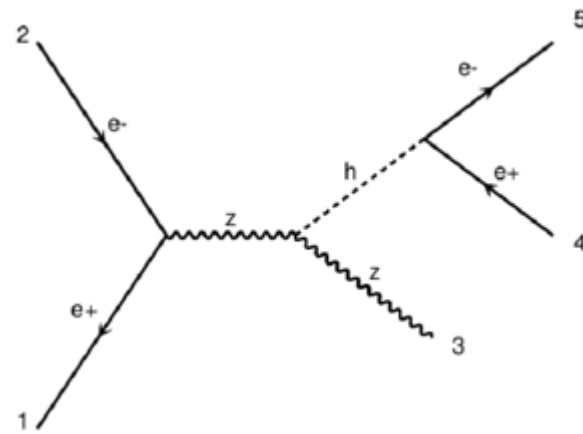
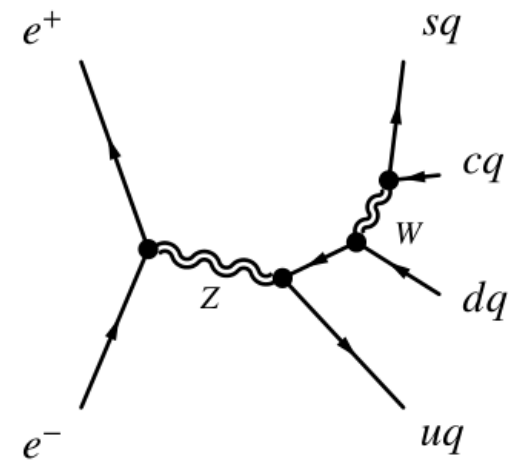
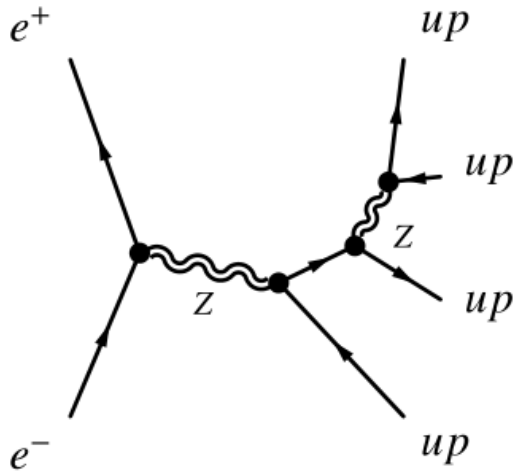
0.25%
0.16%

 (95%) $1000 fb^{-1}$ 250 GeV
- Br =

0.16%

 (95%) $1000 fb^{-1}$ 1000 GeV
- Here ILC generate Higgs boson through such ways:
 1. the associated production of the Higgs with a Z-boson
 2. the Higgs produced in association with neutrinos

signal and background



MC sample	parton level
signal sample	Madgraph
ZZ	Whizard
WW	Whizard
signal Z	Whizard
signal W	Whizard
single Z or W	Whizard
ZZ or WW	Whizard

signal:Madgraph->Pythia->Mokka->Marlin

bkg:Whizard->Pythia->Mokka->Marlin

electron PID requirement

➤ for the electron reconstruction, we use PID=11, which

1. $E_{track} < 1.5\text{GeV}$;

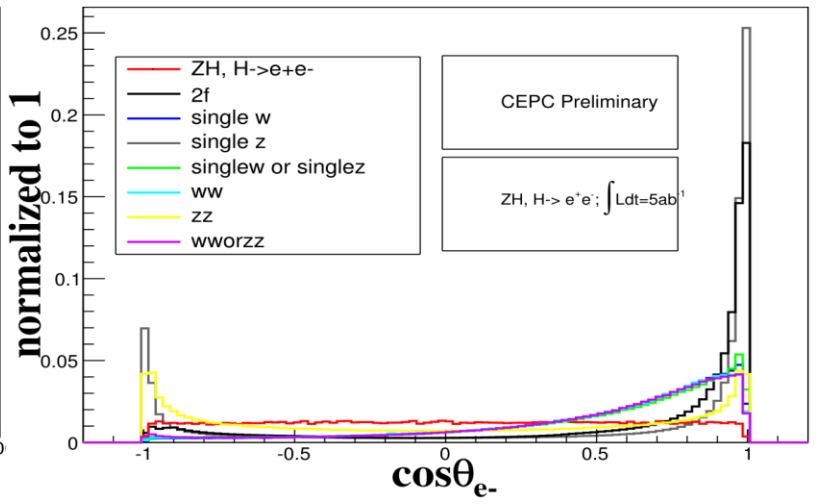
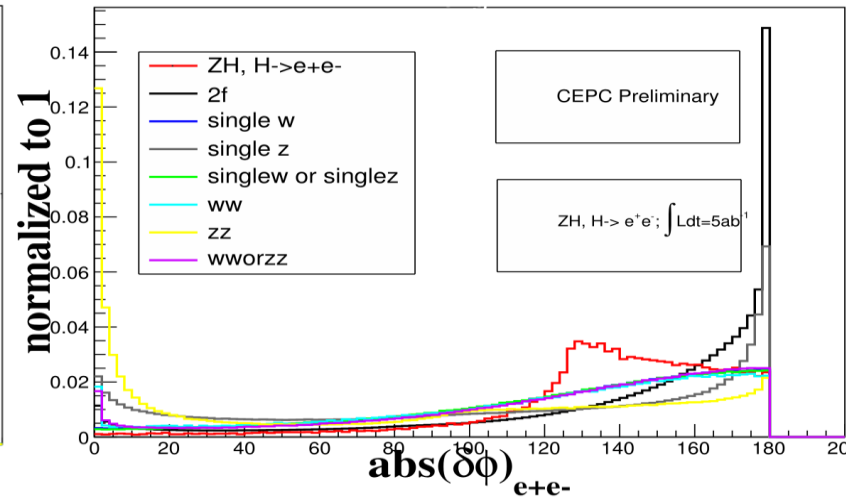
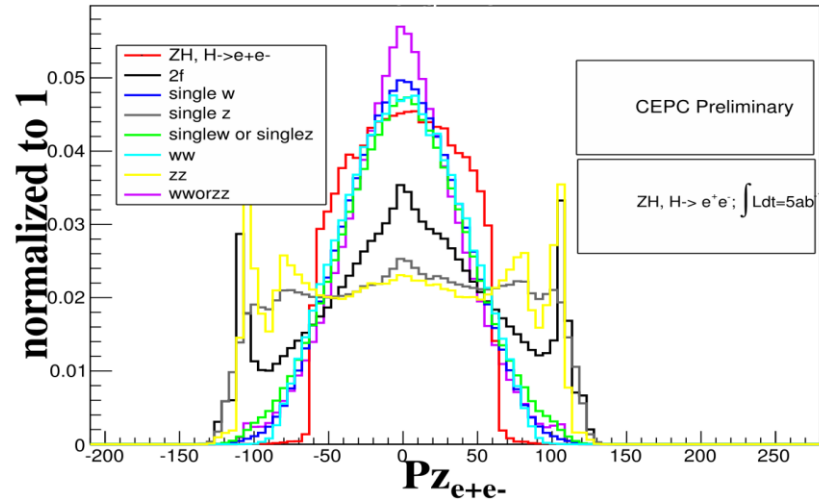
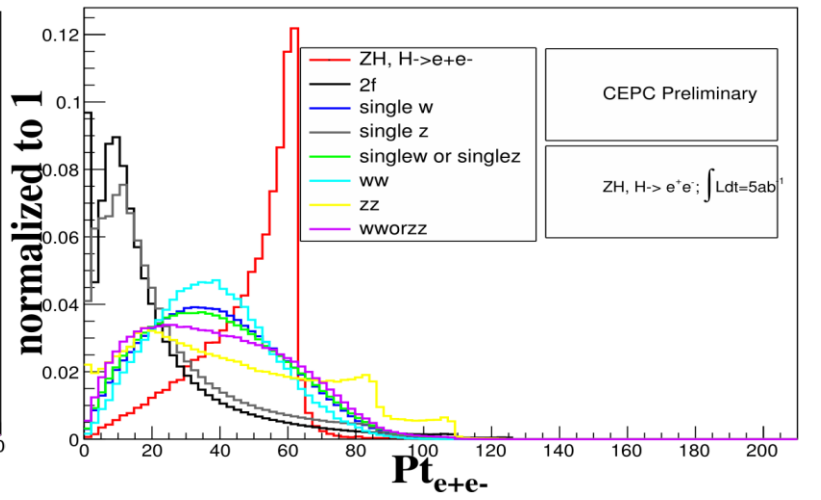
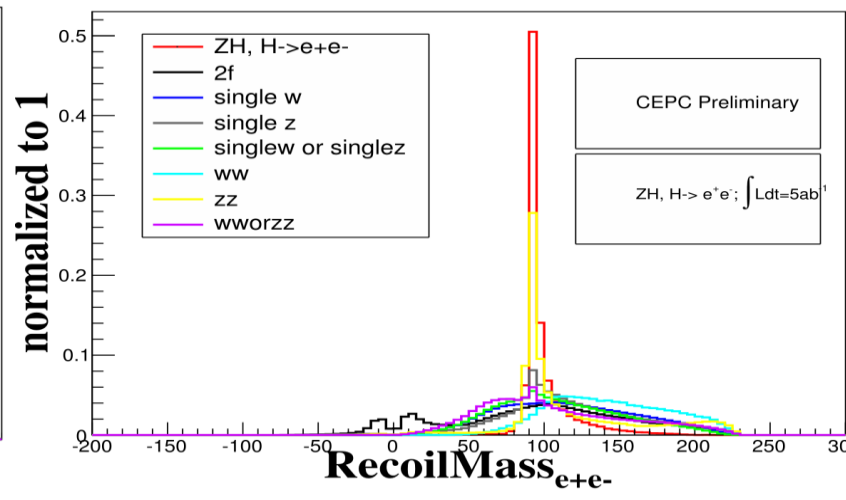
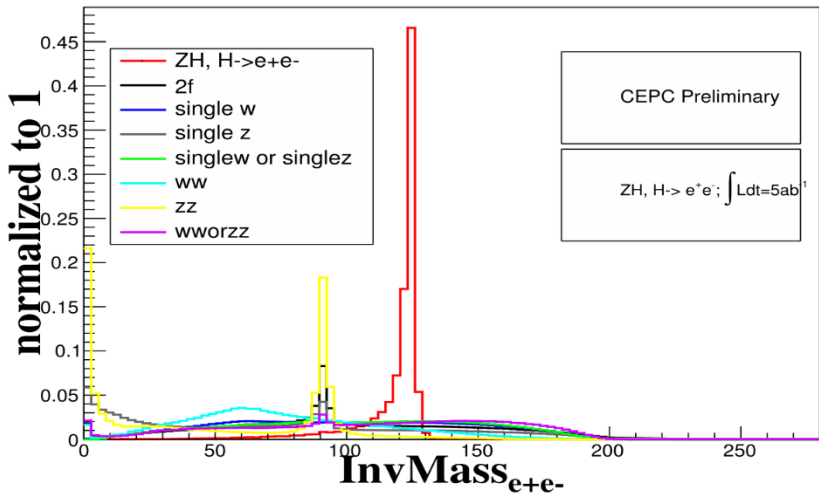
2. $\frac{E_{ecal}}{E_{ecal}+E_{hcal}} > 0.9$;

3. $\frac{dE}{dx} \in (0.17 * e^{-6}, 0.3 * e^{-6})$;

4. Hit and shape information combination

discriminate variables to suppress background

- Invariant mass of dilepton system
signal is gaussian distribution with 125 GeV peak value
- recoil mass of dilepton system
signal is gaussian distribution with 91.2 GeV peak value
- the sum of longitude momentum of dilepton
- the sum of transverse momentum of dilepton
the ISR photon influence the backgrounds P_t and P_z distribution
- the difference of azimuthal angle of the two leptons
the signal's production leptons is not back to back emitted in space
- the cosine polar angle value of the lepton production
Higgs is the scalar boson so the distribution of the $\cos\theta_{e^\pm}$ is uniform

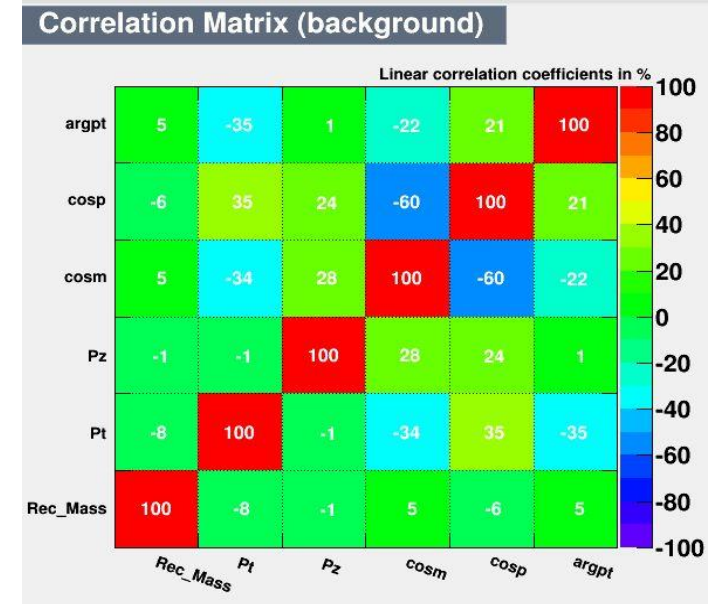
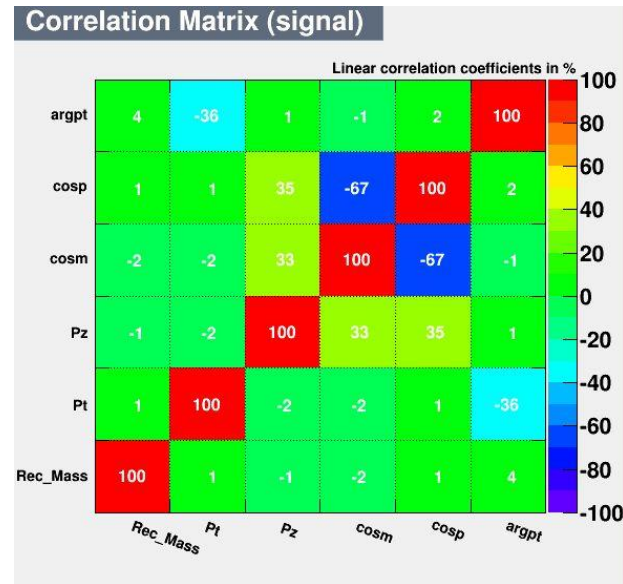
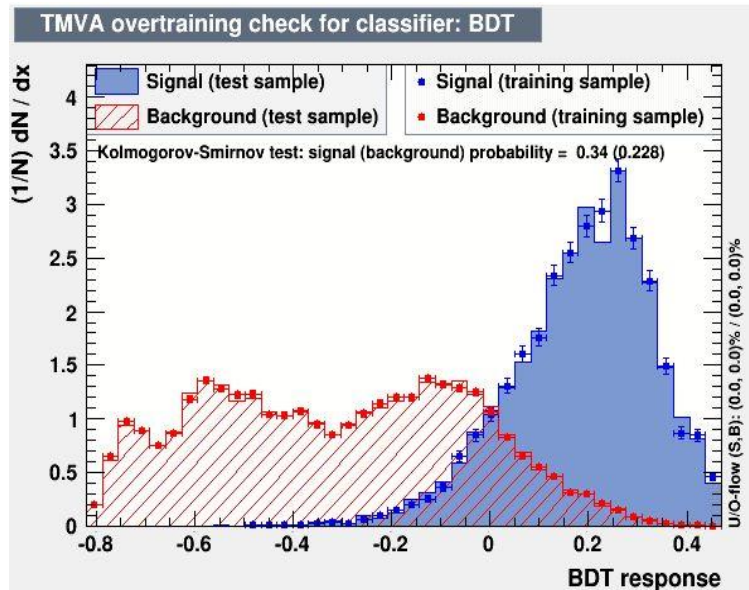


optimization and cut chain

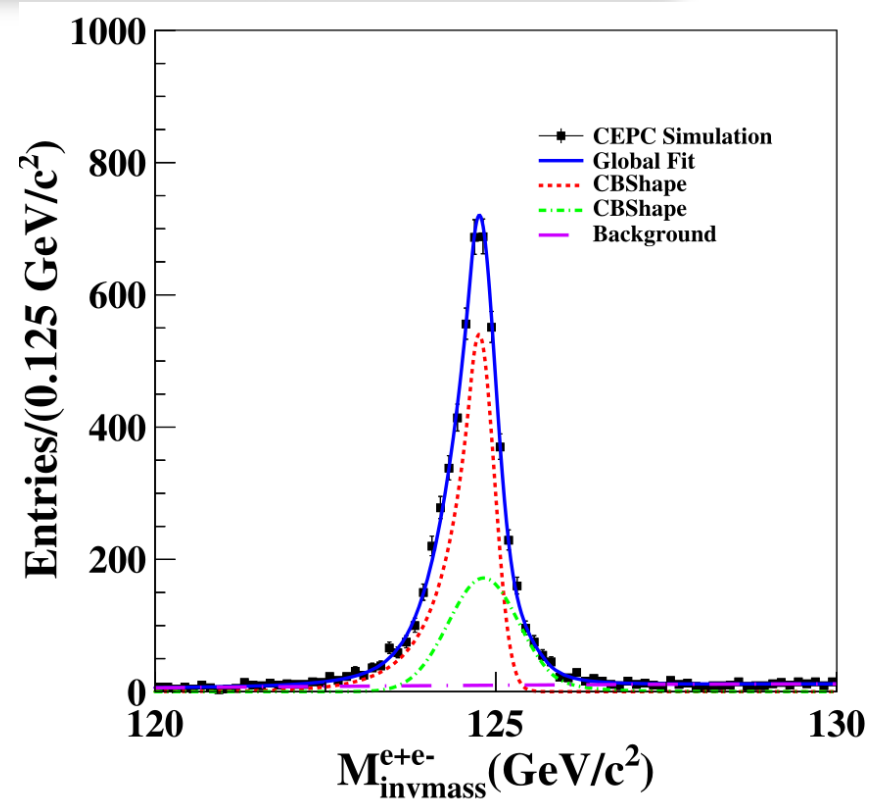
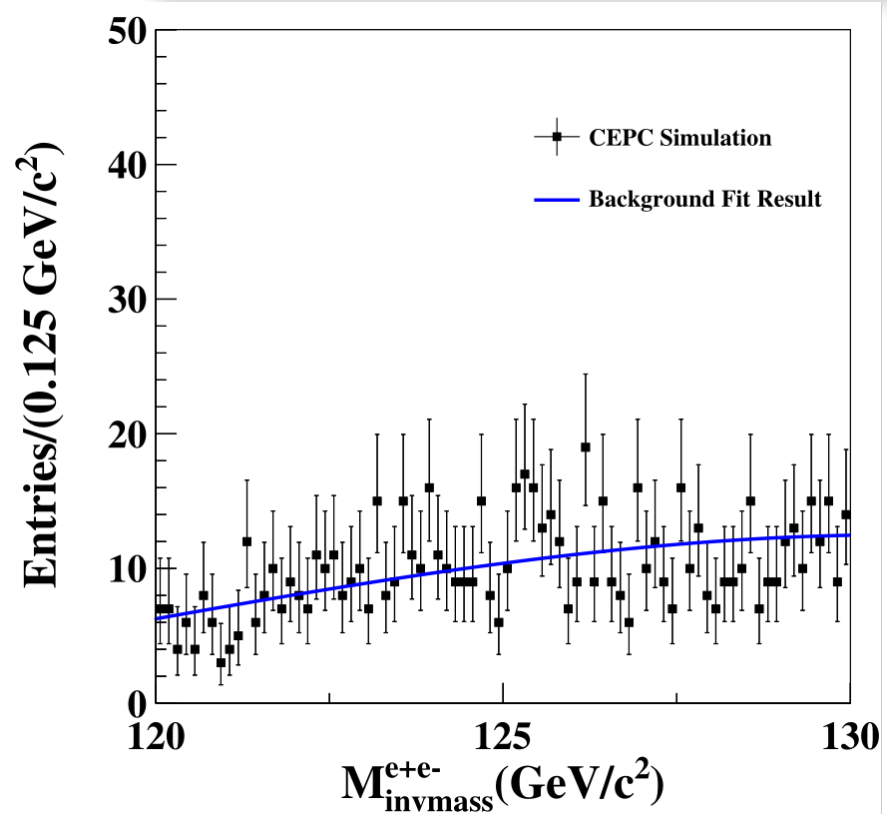
Best significance	signal	2f	single ZorW	single Z	single W	WW	ZZ	WWorZZ	Total bkg
total generate	50000	418194802	1259165	7913405	17190655	49115769	4967152	21902983	520543931
$N_{e^+} \geq 1,$ $N_{e^-} \geq 1$	44894	36822471	978594	3480494	2260761	640839	758732	814608	45756499
$120 \leq M_{inv} \leq 130$	28847	1954192	71193	126094	151950	26731	7593	55196	2392949
$90 \leq M_{recoil} \leq 93$	17015	61089	3564	6954	7255	1783	1464	2434	84543
$46 \leq Pt_{ee} \leq 63$	12032	6816	1863	1861	3652	868	682	1297	17039
$-42 \leq Pz_{ee} \leq 41$	11920	6372	1783	1750	3468	837	647	1247	16104
$ \delta\phi \geq 166$	10347	5131	1696	1651	3233	702	566	1182	14161
$\cos\theta_+ \leq -0.07,$ $\cos\theta_- \geq 0.14$	4833	241	86	48	161	20	178	70	804

BDT problem

- It is not as good as the results without the bdt cuts



statistical calculation to extract the upper limit

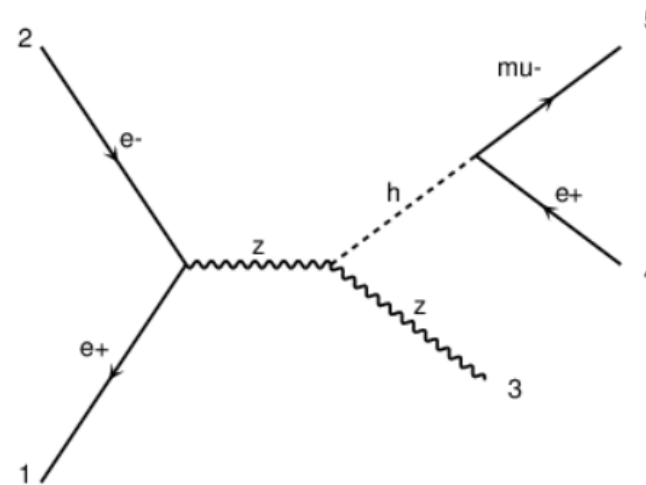
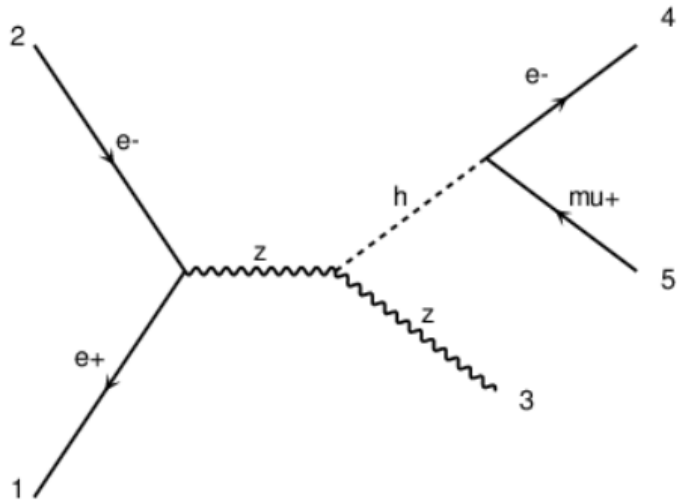


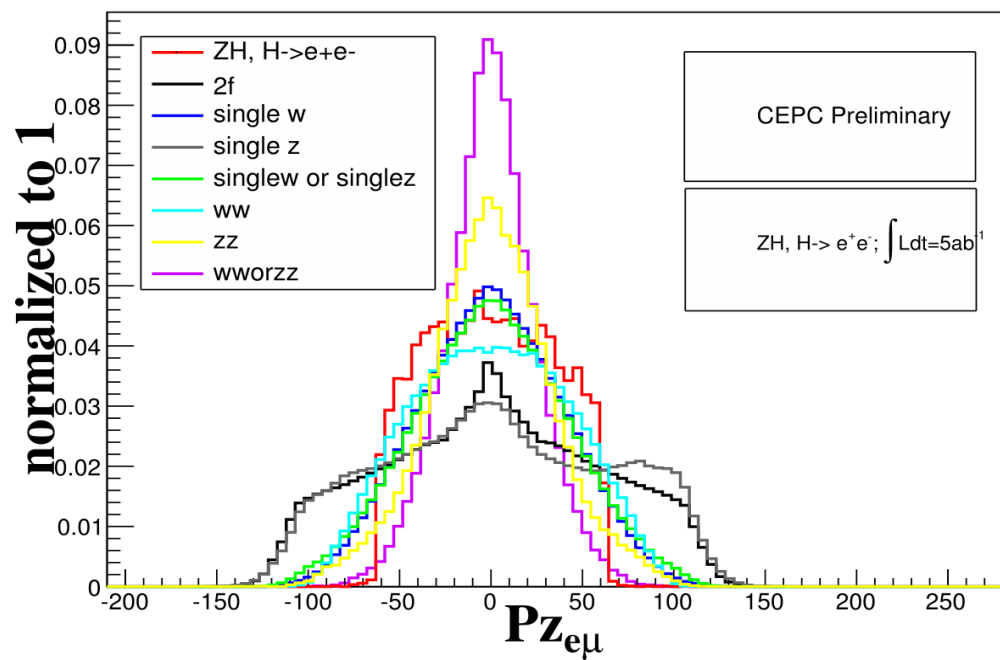
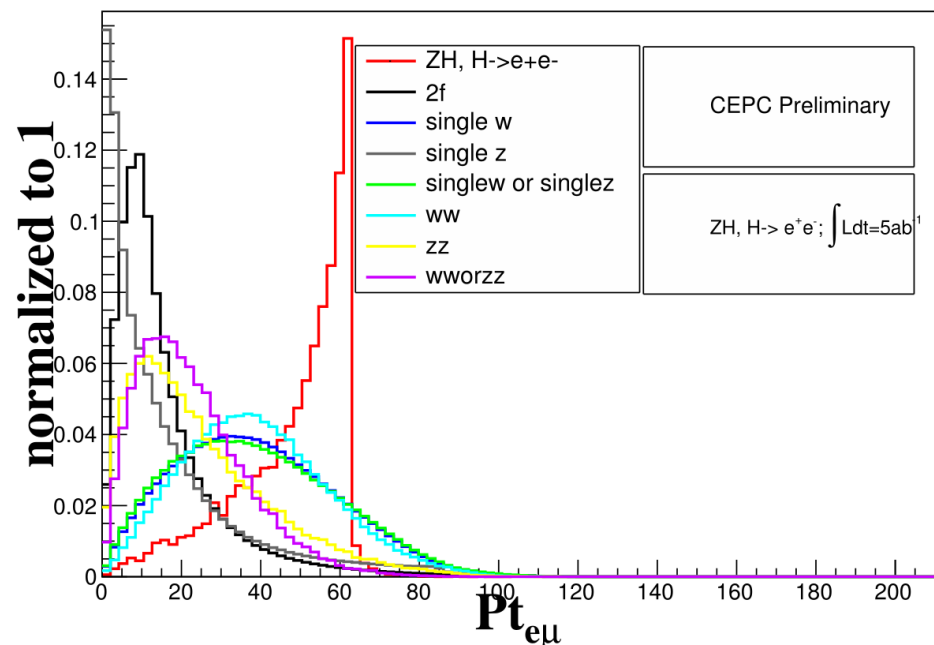
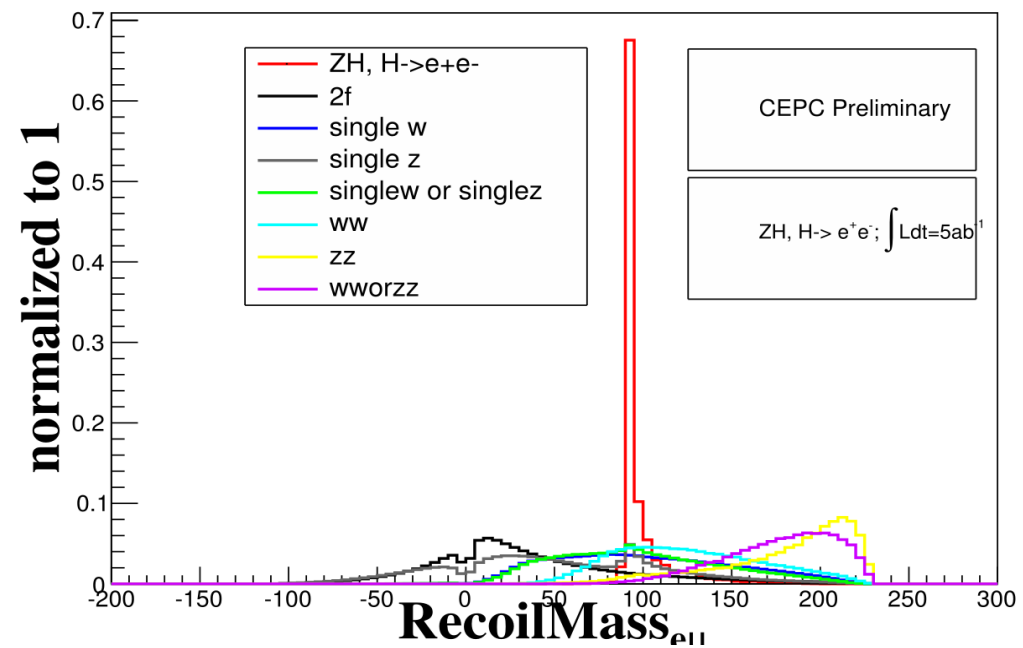
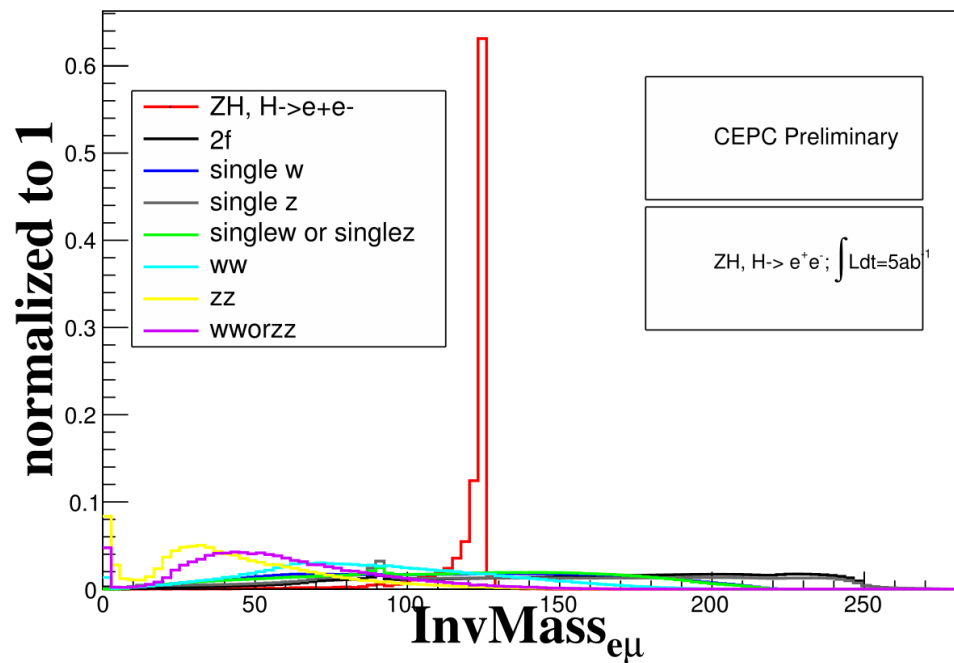
- ◆ second order Chebychev for background pdf
- ◆ double crystal ball function for signal pdf
- ◆ black points for pseudo-data

The limit results is 0.1665‰ at 95% confidence level

preliminary results of Higgs $\rightarrow e\mu$

- shows the capability of CEPC in measuring lepton flavor violating coupling
- Madgraph generator defining new coupling and vertex keeping lorentz structure invariant comparing with Higgs to ee





next research step

Beyond standard model leptonic channel research for Higgs

➤ Higgs $\rightarrow e\mu$

➤ Higgs $\rightarrow e\tau$

➤ Higgs $\rightarrow \mu\tau$

➤ Higgs $\rightarrow \tau\tau$

thanks !