Weekly Updates

Ryuta

12/05/2019

Status

- Gitlab repository for the paper draft

  https://gitlab.com/x-team/paper/p5_cepc_higgs_zz

  ➡ will update section by section

- Discussion with Jiayin about the EFT (p5 in this slide)

- Discussion with Manqi

  -- analysis of electron channel to be included

  ➡ will try to see the Z(->ee)H(ZZ->vvjj) first

A material for discussions

-- Has been composed at December 3rd (Tuesday) --

Ryuta

Discussion/consideration around the EFT topic

EFT : Comments received from Jiayin (at Dec.2nd 2019)

1) For the current our status, one of possible statements might be the difference of the kinematics :

"production channel" : ee->Z*->ZH->Z(->ll)H(->bb), $\sqrt{s}$ = 240 (Z*)

ee->Z*->ZH->ZH(->ZZ*) , $\sqrt{s}$ is lower than 240 GeV, for H->ZZ* .

2) There would be rooms to study further on the production channel, for example.
Even with the same process written in the paper, ee->Z*->ZH->Z(->ll)H(->bb), if nobody touches it yet for the CEPC.
From the statistical point of view, Z(->qq)H(->bb) , is also attractive, but the final S/N should be considered/studied.

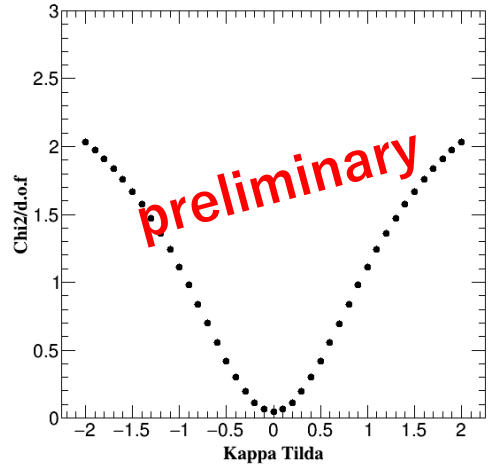
3) He also has concerns on the same study at HWW, which has higher Br. than HZZ

My personal consideration

1) Now, the same channel as the HZZ analysis has been chosen, expecting the better S/B, though the Background(=B) is not included yet.

-- total number of signal events ~ 100 (or less)

-- if we deduce the first order from the right figure, it is, with my eye, $-0.8 < \tilde{\kappa} < 0.8$ where this range is decided by $Chi2/N_{dof} < 1$

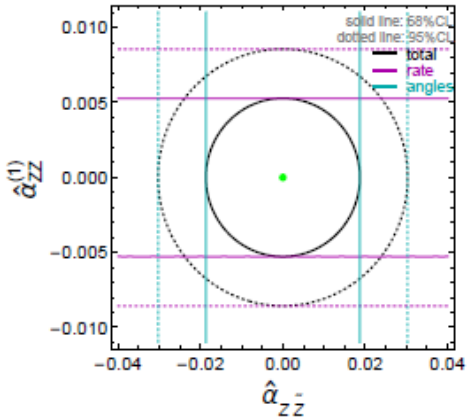


2) from the studies, using the production channel, it is as follows:

-- total number of signal events ~ several * 10000

-- depending on the parameters, the order is such as $-0.03(5) < \text{param.} < 0.03(5)$

It just shows that the limitation range reflects the statistical uncertainty.



from arXiv 1512.06877 (Liantao/Jiyayin point me) but it shows the same order in the CEPC white paper

Topic around the yield precision (=HZZ analysis)

Our current numbers

1) Our numbers (given from Kaili) is

ZZZ*	
μμνvqq	17.8 %
μμqqvv	71.5 %
νvμμqq+qqμμ	15.4 %
qqvvμμ	66.5 %
qqμμvv	54.3 %
All combined	9.44 %

$$\frac{1}{\sqrt{\frac{1}{7.2^2}+\frac{1}{7.9^2}}} = 5.32$$

2) in the white paper

Table 8. Expected relative precision for the $\sigma(ZH) \times \mathrm{BR}(H \to ZZ^*)$ measurement with an integrated luminosity $5.6\,\mathrm{ab}^{-1}$.

ZH final state		Precision
$Z \to \mu^+\mu^-$	$H \to ZZ^* \to \nu\bar{\nu}q\bar{q}$	7.2%
$Z \to \nu\bar{\nu}$	$H \to ZZ^* \to \ell^+\ell^-q\bar{q}$	7.9%
Combination		4.9%

decays. For the analysis discussed in Section 5.1, these contaminations are estimated from SM. In the combination fit, they are constrained by the $H \to WW^*$ and $H \to ZZ^*$ analyses described in Sections 5.2 and 5.3, respectively. Taking into account these across-channel contaminations properly generally leads to small improvements in precision. For example, the precision on $\sigma(ZH) \times \mathrm{BR}(H \to ZZ^*)$ is improved from 5.3% of the standalone analysis to 4.9% after the combination.

Br(H→ZZ)

Note that : CEPC_v1, 5 ab^{-1}, different MC samples/software

ZZZ*	Yield	Object reconstructed	Signal Efficiency(%)	Main Background	Accuracy (%)	Comments
μμνvqq	128	118	63.3	h->ww&zz_sl	**12.9**	Tau finder would be highly appreciated Reconstructed efficiency of electron need to be improved
μμqqvv	128	125	-	h->bb&zz_sl	>25	
eevvqq	132	91	53.8	h->ww&sze_sl	**15.8**	
eeqqvv	132	88	-	h->bb&zz_sl	>25	
vvμμqq	158	144	61.4	h->t,w&zz_sl	**11.0**	
vvqqμμ	158	149	51.9	h->w,b&zz_sl	**12.9**	
vveeqq	151	118	43.1	h->w&sze_sl	**21.3**	
vvqqee	151	134	-	h->bb&sze_sl	>25	
qqμμvv	135	115	-	h->tt&zz_sl	>25	Compare to ll recoil, qq recoil mass has much worse distinguishing power to SM background
qqvvμμ	135	122	-	h->t,w&zz_sl	>25	
qqeevv	127	107	-	h->tt&sze_sl	>25	
qqvvee	127	123	-	h->t,w&sze_sl	>25	
μμμμqq/qqμμ	43	39	69.8	h->tt&zz_sl	**19.9**	Tau finder & Electron Reconstruction
μμeeqq/qqee	43	39	60.5	h->tt&zz_sl	**21.2**	
eeeeqq/eeqqee	43	33	-	h->tt&sze_sl	>25	
eeμμqq/eeqqμμ	43	41	58.2	h->tt&sze_sl	**19.9**	

Full Simulation analysis performed on 16 independent channels.
8 Channels acquire accuracy better than 25%.

Combined accuracy: **5.4%**

If electron id efficiency ~ muon id: ***4.8%***

If tau finder (used for veto) is mature: ??

TLEP extrapolation: **4.3%**

From the slide by Manqi "Higgs Physics at the CEPC"

Comparison of different combinations

3) Refer the numbers from previous page

ZZZ*	
μμνvqq	12.9 %
eevvqq	15.8 %
vvμμqq	11.0 %
vvqqμμ	12.9 %
vveeqq	21.3 %
μμμμqq+qqμμ	19.9 %
μμeeqq+qqee	21.2 %
eeμμqq+qqμμ	19.9 %
All combined	5.44 %

All 8 channels (blue colored)

ZZZ*	
μμνvqq	12.9 %
eevvqq	15.8 %
vvμμqq	11.0 %
vvqqμμ	12.9 %
vveeqq	21.3 %
All combined	6.14 %

First 5 channels (blue colored)

We are close to this combination

ZZZ*	
μμνvqq	12.9 %
vvμμqq	11.0 %
vvqqμμ	12.9 %
All combined	7.02 %

3 channels except the “ee” channels (blue colored)

this calculation does not include the “combination fitting”
again, the each number can not directly compared with ours.

Another reference

Channels Table

All channels scaled to 5ab^{-1}

Signal Z	Signal H	Precision
H->qq		
ee	bb	1.6%
	cc	23.6%
	gg	13.3%
μμ	bb	1.1%
	cc	14.8%
	gg	8.0%
qq	bb	0.5%
	cc	11.9%
	gg	3.9%
νν	bb	0.4%
	cc	3.9%
	gg	1.5%
H→ττ		
ee	ττ	2.8%
μμ		2.8%
qq		1.0%
νν		3.1%

Signal Z	Signal H	Precision
H->WW		
ee	lνlν	9.2%
	eνqq	4.6%
	μνqq	3.9%
μμ	lνlν	7.3%
	eνqq	4.0%
	μνqq	4.0%
νν	qqqq	2.0%
	eνqq	4.7%
	μνqq	4.2%
	lνlν	11.3%
qq	lνqq	2.2%(ILC)
ZH bkg contribution		3.0%
H→γγ, Zγ		
μμ+ττ	γγ	41.0%
νν		13.7%
qq		10.3%
νν	Zγ(qqγ)	21.2%

Signal Z	Signal H	Precision
H->ZZ		
νν	μμqq	8.2%
νν	eeqq	35.2%
μμ	ννqq	7.3%
ee	eeqq	35.1%
ee	μμqq	23.0%
ZH bkg contribution		19.4%
ννH(WW fusion)		
νν	bb	3.1%
H→μμ		
qq	μμ	15.9%
ee		
μμ		
νν		
H->Invisible		Br, Upper
qq	ZZ(νννν)	0.8%
ee		0.6%
μμ		0.6%

18/5/25 Kaili Zhang 6

From the slide by Kaili "CEPC Higgs Combination" 2018.05.25 at Rome

ννeeqq : 35.2 %
<--> previous page shows 21.3 %

Therefore, it is not surely guaranteed that "ee" channel can improve the final precision as we expected

Comments

1) Can we check a bit again on $\nu\nu\mu\mu qq+qq\mu\mu$ channel

-- it might be good to have histograms with cuts at each stage.
-- one of my concern is the signal efficiency would be a little small.

2) Is it possible to have a quick look of the “ee$\nu\nu$qq” channel ?

About the contents of the draft

Case 1: Focusing fully on the HZZ analysis, including “ee” channels without EFT topic.

==> it might not happen but ,,, in case, try to compose another paper for EFT study from the production channel, together with , such as 4/6jet HZZ analysis, since we need to utilize/face the multi-jet status for that EFT study.

Case 2: Focusing on the HZZ analysis, including “ee” channels (or not) with EFT topic from the HZZ channel and/or add production channel if we can (probably, the time might not be enough ...)

How about the “kappa framework” ?

I have quickly read the references, but not quite sure yet, how we can include it in our draft. Of course, the precision of HZZ would be an input for that framework, but not sure how much effect it has, since the σ(ZH) gives much better accuracy on κ_Z