



### Higher Energy Extrapolation @ CEPC Higgs Kaili Zhang

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# Existing results:240GeV, 5.6iab



#### • Fcc-ee (CERN-ACC-2018-0057) did:

• 0.2 iab 350GeV + 1.5 iab 365GeV

$\sqrt{s}$ (GeV)	240		365	
Luminosity $(ab^{-1})$	5		1.5	
$\delta(\sigma BR)/\sigma BR$ (%)	HZ	$\nu\overline{\nu}\;H$	HZ	$\nu\overline{\nu}\;H$
$H \rightarrow any$	$\pm 0.5$		$\pm 0.9$	
$H \rightarrow b\bar{b}$	$\pm 0.3$	$\pm 3.1$	$\pm 0.5$	$\pm 0.9$
$H \rightarrow c\bar{c}$	$\pm 2.2$		$\pm 6.5$	$\pm 10$
$\mathrm{H} \rightarrow \mathrm{gg}$	$\pm 1.9$		$\pm 3.5$	$\pm 4.5$
$H \rightarrow W^+W^-$	$\pm 1.2$		$\pm 2.6$	$\pm 3.0$
$\mathrm{H} \rightarrow \mathrm{ZZ}$	$\pm 4.4$		$\pm 12$	$\pm 10$
$\mathrm{H} \to \tau\tau$	$\pm 0.9$		$\pm 1.8$	$\pm 8$
$H \rightarrow \gamma \gamma$	$\pm 9.0$		$\pm 18$	$\pm 22$
$\mid H \rightarrow \mu^+ \mu^-$	$\pm 19$		$\pm 40$	
$H \rightarrow invisible$	< 0.3		< 0.6	

- CEPC Temporary benchmark: 2 iab 360GeV
  - 360 saves 10% energy
  - not determined yet



# **Signal Cross Sections**

- 240GeV:
  - ZH: 196.9; vvH: 6.2; interference: ~10% of vvH; about 318:10:1; (Z->vv : vvH = 6.4:1)
  - interference are ignored in the following extrapolation.
- 350GeV: (vvH ~ 100% Z->vv ), (eeH ~ 60% Z->ee)
- 360GeV: (vvH ~ 117% Z->vv ), (eeH ~ 67% Z->ee)
- 365GeV: (vvH ~ 126% Z->vv ), (eeH ~ 71% Z->ee)

ZZ fusion (2%) also cannot be ignored.

fb	240	350	360	365	360/240
ZH	196.9	133.3	126.6	123.0	-36%
WW fusion	6.2	26.7	29.61	31.1	+377%
ZZ fusion	0.5	2.55	2.80	2.91	+460%
Tot	203.6		159.0		
Tot Events	1.14M		0.32M		





# bkg cross sections



365/240	365	360	350	240	pb
-66%	319	325	336	930	ee(γ)
-60%	2.1	2.1	2.2	5.3	μμ(γ)
-58%	22.8	23.2	24.7	54.1	qq(γ)
-41%	9.81	10.0	10.4	16.7	WW
-44%	0.62	0.63	0.66	1.1	ZZ
	0.369	0.317	0.155	١	tt
+28%	5.83	5.78	5.72	4.54	sZ
+19%	6.04	6.00	5.89	5.09	sW

Most channels are 4f bkg dominant, usually ZZ.

 $ee \rightarrow t\bar{t} \rightarrow WW^*b\bar{b}$  would be 6 jets/ llvv+2 jets. would have similar behavior with 4f.

Need MC sample to validate the performance.

Now Assume that  $t\bar{t}$  would have 20% contribution similar with ZZ. From 0.63 to 0.7pb.

# Extrapolation strategy

- yields: scale by cross section;
- shape:
  - dimuon: worse resolution; from ~0.3GeV to 1GeV;
  - diphoton: better resolution; from ~2.5GeV to 2GeV;
  - inv/rec mass:
    - if it is corresponding to Z/H system, would stay the same;
    - other recoil H/Z/W spectrum would also scale a factor to shift;



In 240GeV, vvH peak at 115GeV. Would shift to 235GeV instead.



# bkg shape

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- phase space distribution, would spread to wider range;
  - scale 360/240, 1.5;
- if bkg scale factor 1.5, (or higher), range 120-150 would from 80-100.
  - information missing in current data files.
- In turn we assume bkg stay the same shape in signal region
  - scale 240/360, 149/269 .....
- Would check the 360GeV sample for more details.



# vvH->bb

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- Use Hao's fast simulation 360GeV sample
  - ZH and vvH BMR(Boson Mass Resolution) 4%, Eff 50%
  - Bkg scaled from 240 case
    - would be less if selection more strict;

- Fix ZH part; vvH 0.95%;
- Float ZH part; vvH 0.99%;
- Considering other ZH constrain: 0.95%.



## Results



	5.6ab⁻¹,	2ab⁻¹,	1.5ab⁻¹,
	240	360	360
$\sigma(ZH)$	0.50%	١	
$\sigma(ZH) * Br(H \rightarrow bb)$	0.27%	0.62%	0.71%
$\sigma(ZH) * Br(H \rightarrow cc)$	3.3%	6.2%	7.2%
$\sigma(ZH) * Br(H \rightarrow gg)$	1.3%	2.4%	2.7%
$\sigma(ZH) * Br(H \rightarrow WW)$	1.0%	2.0%	2.3%
$\sigma(ZH) * Br(H \rightarrow ZZ)$	5.1%	12%	14%
$\sigma(ZH) * Br(H \rightarrow \tau \tau)$	0.8%	1.5%	1.7%
$\sigma(ZH) * Br(H \rightarrow \gamma \gamma)$	6.8%	9.4%	10.9%
$\sigma(ZH) * Br(H \rightarrow \mu\mu)$	12%	29%	33%
$\sigma(vvH) * Br(H \rightarrow bb)$	3.0%	0.95%	1.1%
$Br_{upper}(H \rightarrow inv.)$	0.26%	١	۱
$\sigma(ZH) * Br(H \rightarrow Z\gamma)$	16%	25%	29%
Width	2.8%	1% ?	

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Generally, since the extrapolation is not so accurate, results are comparable. (bb is most different?)

For  $H \rightarrow \gamma \gamma$  and  $H \rightarrow \mu \mu$ , resolution changes considered. Keep diphoton resolution ~(2.5GeV) : 10.5% 2.5GeV to 2GeV: 9.40%

Keep dimuon resolution ~(0.3GeV): 23% 0.3GeV to 1GeV: 29%

### Plots





# Discussion



- Current extrapolation
  - mainly scale yields
    - bkg could be even lower if correct analysis strategies are applied.
  - can not deal with W/Z fusion related channels and  $\sigma(ZH)$ 
    - several channels are studied with  $m_{ee}^{recoil}$  and  $m_{missing}$  would suffer;
    - need to look into 360GeV sample