Extrapolation from 250GeV to 240GeV

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Cross Section current

Cross Section, 250GeV cited from Moxin's note on cepcdoc and 240GeV calculated by Gang in Whizard 1.9.5

Type	250 GeV	240 GeV	Ratio
Signal (fb)			
Total	212.13	200.66	96.0%
Sum	214.13	203.65	95.1%
eeH	7.60	7.05	92.8%
mmH	7.10	6.77	95.4%
ττH	7.08	6.75	95.3%
vvH	48.96	46.32	94.6%
qqH	143.39	136.76	95.4%
eeH(ZZ fusion)	0.63	0.28	44.4%
vvH(WW fusion)	6.85	6.19	90.3%

Ratio=250GeV/240GeV;

Technical issue makes a difference in Total Cx and Sum Cx.

These 5 channels conclude fusion.

Calculated by e1e1h-e2e2h, n1n1h-n2n2h. (Ignore the interference)
WW fraction from 14%(250GeV) to 13.3%(240GeV).
Add all the interferences to vvH would underestimate 250GeV result, and overestimate 240GeV result.

bkg Cross Section

Type	250 GeV	240 GeV	Ratio
2 fermion			
e+e−	24992.2	24770.9	99.1%
μ+μ−	4991.9	5332.7	106.8%
τ+τ−	4432.2	4752.9	107.2%
νν	53598.4	54099.5	100.9%
veve	45390.8	45390.8	\
νμνμ	4416.3	4416.3	\
νtνt	4410.3	4410.3	\
qq	50105.4	54106.9	**108.0%**
uu	10110.4	10899.3	107.8%
dd	10010.1	10711.0	107.0%
cc	10102.8	10862.9	107.5%
ss	9924.4	10737.8	108.2%
bb	9957.7	10769.8	108.2%

Type	250 GeV	240 GeV	Ratio
4 fermion			
sw_l0mu	429.8	436.7	101.60%
sw_l0tau	429.8	435.9	101.40%
sw_sl0qq	2583.6	2612.6	101.10%
sze_l0e	82.5	78.5	95.20%
sze_l0mu	0	845.8	\
sze_l0nunu	29.6	28.9	97.90%
sze_l0tau	150.3	147.3	98.00%
sze_sl0dd	128.7	125.8	97.70%
sze_sl0uu	195.9	190.2	97.10%
szeorsw_l0l	249.8	249.5	99.90%
sznu_l0mumu	43.2	43.4	100.50%
sznu_l0tautau	14.6	14.6	99.70%
sznu_sl0nu_down	91.4	90	98.60%
sznu_sl0nu_up	56.1	55.6	99.10%
ww_h0ccbs	5.7	5.9	102.80%
ww_h0ccds	165.8	170.2	102.70%
ww_h0cuxx	3395.6	3478.9	102.50%
ww_h0uubd	0.1	0.1	100.00%
ww_h0uusd	166.6	170.5	102.30%
ww_l0ll	393.9	403.7	102.50%
ww_sl0muq	2366.4	2423.4	102.40%
ww_sl0tauq	2362.3	2423.6	102.60%
wwbosons	16218.2	16721.8	**103.10%**

Type	250 GeV	240 GeV	Ratio
4 fermion			
zz_h0cc_nots	95.7	99.0	103.4%
zz_h0dtdt	225.3	233.5	103.6%
zz_h0utut	82.8	85.7	103.5%
zz_h0uu_notd	95.6	98.6	103.1%
zz_l04mu	14.5	15.6	107.3%
zz_l04tau	4.4	4.6	105.3%
zz_l0mumu	18.2	19.4	106.7%
zz_l0taumu	17.6	18.7	106.3%
zz_l0tautau	9.2	9.6	104.6%
zz_sl0mu_down	127.8	136.1	106.5%
zz_sl0mu_up	82.5	87.4	106.0%
zz_sl0nu_down	135.2	139.7	103.4%
zz_sl0nu_up	81.8	84.4	103.1%
zz_sl0tau_down	64.4	67.3	104.6%
zz_sl0tau_up	39.8	41.6	104.5%
zzbosons	1066.4	1110.4	**104.1%**
zzorww_h0cscs	1565.4	1607.6	102.7%
zzorww_h0udud	1572.9	1610.3	102.4%
zzorww_l0mumu	214.7	221.1	103.0%
zzorww_l0tautau	205.4	211.2	102.8%

In most channels, the dominant bkg is 4 fermion; 3%

bkg extrapolation

- Most channel use bkg +3%
  - 4 fermion bkg dominant; 2 fermion are reducible after selection
- Except:
  - Z->qq/vv, H->bb/cc/gg: 2f:4f=3:1; +4%;
    - As well as Z->qq, H->vvvv; (Not in H->WW->4q; 4f dominant, +3%;)
  - H->mm Z->qq/vv, : zz_l04mu, +6%;
  - H->mm Z->mm: zz_sl0mu_down/up, +7%;
  - H->yy 2fermion;
    - Z->mm: +7%; Z->qq: +8%; Z->vv: +1%;

Signal extrapolation

- For all ZH events,
  - eeH: -7.2%;
  - mmH: -4.6%
  - qqH: -4.6%
  - vvH: -5.6%
- For $vvH, H \rightarrow bb$,
  - use the weight after selection by Liang Hao
  - WW fusion process: *0.971537
  - ZH process: *1.013535
  - SM bkg: *1.052864

bb/cc/gg

$$\Delta = \frac{\Delta\sigma_{240} - \Delta\sigma_{250}}{\Delta\sigma_{250}}$$

Signal		250	240	Difference
Z	H			
H->qq				
ee	bb	1.30%	1.35%	3.85%
	cc	11.78%	12.35%	4.84%
	gg	6.17%	6.51%	5.51%
μμ	bb	1.00%	1.03%	3.00%
	cc	9.44%	9.77%	3.50%
	gg	4.90%	5.08%	3.67%
qq	bb	0.48%	0.49%	2.08%
	cc	11.73%	12.45%	6.14%
	gg	3.68%	3.94%	7.07%
vv	bb	0.41%	0.41%	2.32%
	cc	3.90%	4.10%	5.13%
	gg	1.54%	1.61%	4.55%
vvH(WW fusion)				
vvH	bb	3.11%	3.22%	3.54%
zh	bb	0.32%	0.32%	1.82%
ZH				
Z	bb	0.28%	0.29%	3.22%
	cc	3.30%	3.45%	4.55%
	gg	1.31%	1.37%	4.65%

bb 0.28% take wwf events as ZH; if not, 0.32%;

WW/ZZ

Signal		250	240	Difference
Z	H			
H->WW				
ee	lvlv	9.36%	9.79%	4.59%
	evqq	4.57%	4.77%	4.38%
	μvqq	3.95%	4.10%	3.80%
μμ	lvlv	7.35%	7.54%	2.59%
	evqq	4.01%	4.07%	1.50%
	μvqq	3.97%	4.07%	2.52%
vv	qqqq	2.03%	2.14%	5.42%
	evqq	4.69%	4.89%	4.26%
	μvqq	4.18%	4.35%	4.07%
	lvlv	11.30%	11.60%	2.65%
qq	qqqq	1.84%	1.93%	4.89%
H->ZZ				
vv	μμqq	7.96%	8.21%	3.14%
vv	eeqq	39.50%	42.19%	6.81%
μμ	vvqq	7.38%	7.56%	2.44%
ZH bkg		10.01%	10.40%	3.85%
ZH				
Z	WW	1.05%	1.07%	2.35%
	ZZ	5.12%	5.21%	1.82%

Others

Signal		250	240	Difference
Z	H			
H->Invisible				
qq	ZZ(vvvv)	220.00%	235.00%	6.82%
ee		325.00%	349.00%	7.38%
μμ		229.00%	250.00%	9.17%
Tot		150.24%	159.88%	6.42%
H→γγ				
μμ+ττ	γγ	41.10%	44.11%	7.32%
vv		10.90%	11.45%	5.05%
qq		10.40%	11.20%	7.69%
Tot		7.38%	7.87%	6.69%
H→μμ				
qq	μμ	17.75%	18.70%	5.40%
ee		61.38%	64.71%	5.42%
μμ		86.10%	90.74%	5.39%
vv		53.32%	56.93%	6.77%
Tot		15.90%	16.84%	5.91%
H→ττ				
ee	ττ	2.72%	2.69%	-1.10%
μμ		2.26%	2.21%	-2.21%
qq		0.93%	0.97%	4.30%
vv		3.11%	3.30%	6.11%
Tot		0.79%	0.82%	3.06%

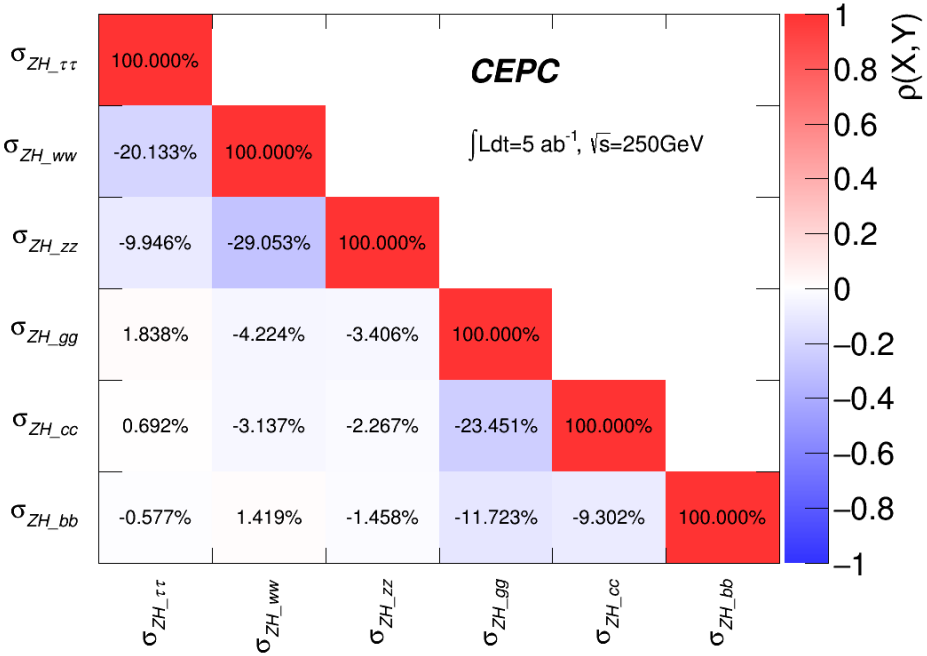
Use Dan's result in ee and mm;
Due to the better significance in v4.

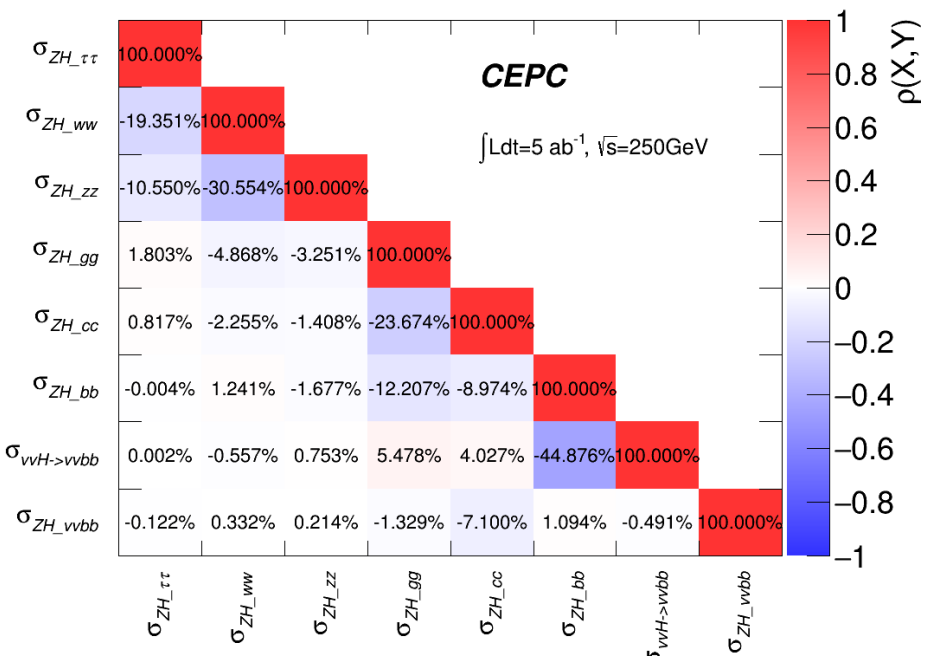
Result

	250GeV	240GeV	Difference
$\sigma(ZH)$	0.50%	0.50%	\
$\sigma(ZH) * Br(H \to bb)$	0.28%	0.29%	3.22%
$\sigma(ZH) * Br(H \to cc)$	3.30%	3.45%	4.55%
$\sigma(ZH) * Br(H \to gg)$	1.31%	1.37%	4.65%
$\sigma(ZH) * Br(\mathrm{H} \to WW)$	1.05%	1.07%	2.35%
$\sigma(ZH) * Br(H \to ZZ)$	5.12%	5.21%	1.82%
$\sigma(ZH) * Br(H \to \tau\tau)$	0.79%	0.82%	3.06%
$\sigma(ZH) * Br(H \to \gamma\gamma)$	7.38%	7.87%	6.69%
$\sigma(ZH) * Br(H \to \mu\mu)$	15.9%	16.8%	5.91%
$\sigma(\mathrm{vv}H) * Br(H \to \mathrm{bb})$	3.11%	3.22%	3.54%
$Br_{\mathrm{upper}}(H \to inv.)$	0.42%	0.44%	6.42%
$\sigma(ZH) * Br(H \to Z\gamma)$	4σ	4σ	\

250GeV Correlation

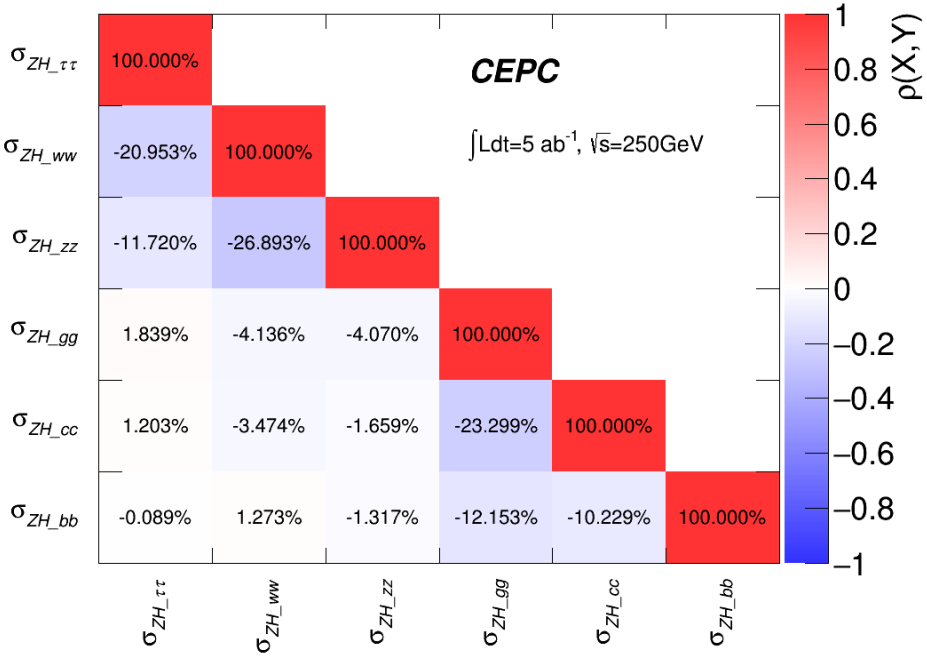
To avoid the overlap in b/c/g/w/z, current correlation between them are simplified.

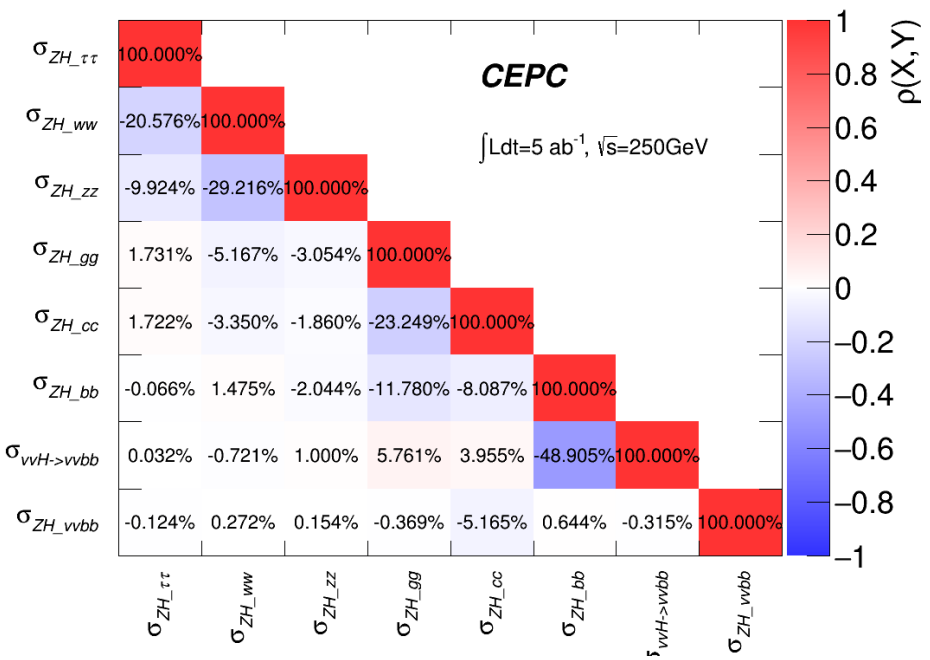




240GeV Correlation

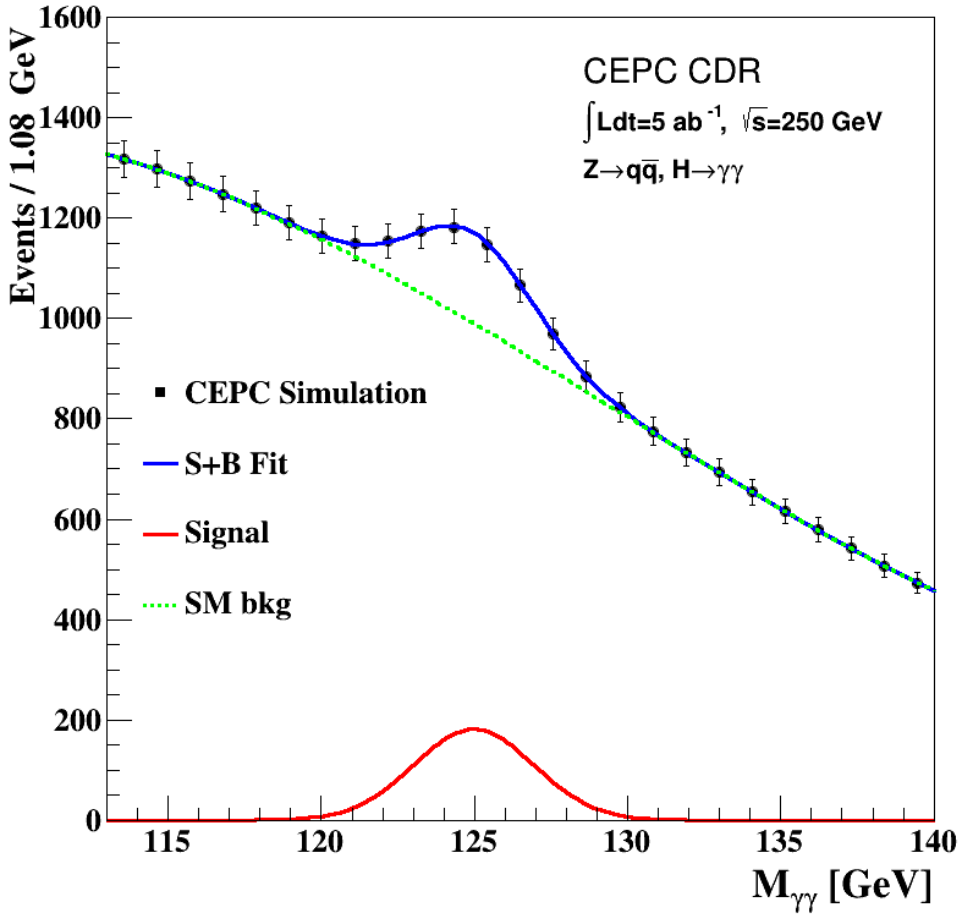
To avoid the overlap in b/c/g/w/z, current correlation between them are simplified.



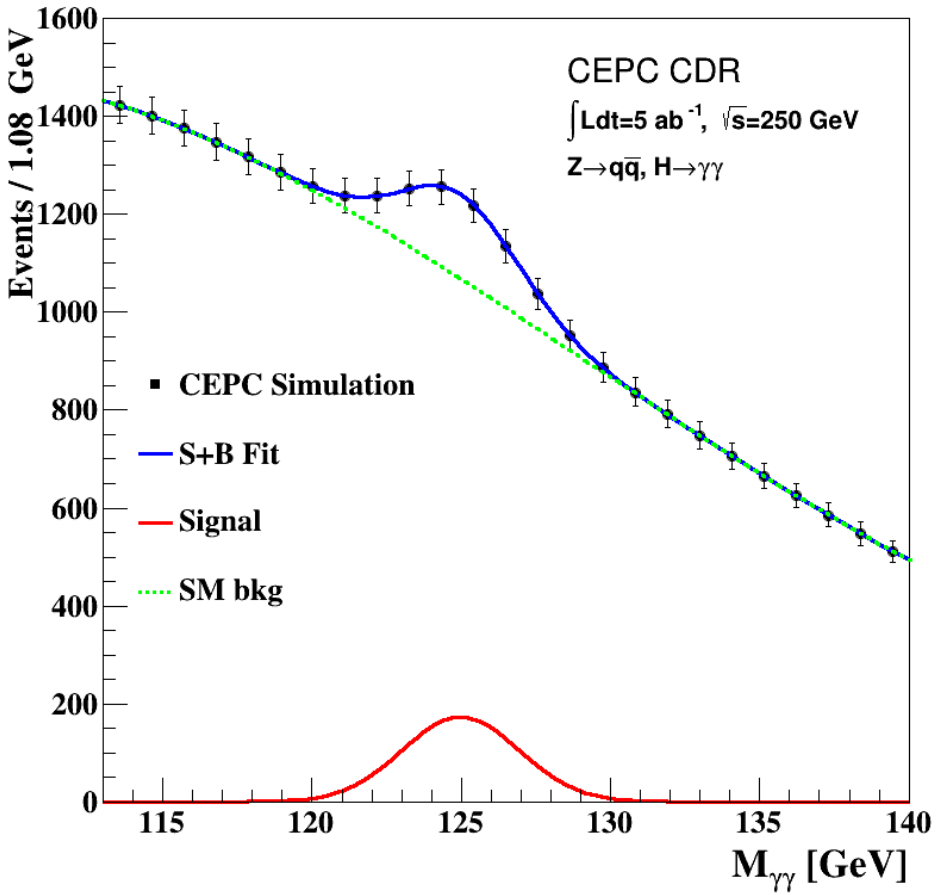


qqyy plot

250GeV



240GeV



bkg: +8%; signal: -4.6%; precision: -7.69%

κ

10κ	240GeV	250GeV	Pre_CDR
κ_b	**1.70%**	**1.63%**	1.3%
κ_c	**2.37%**	**2.28%**	1.7%
κ_g	**1.74%**	**1.68%**	1.5%
κ_γ	**4.27%**	**4.01%**	4.7%
κ_τ	**1.63%**	**1.57%**	1.4%
κ_Z	**0.25%**	**0.25%**	0.26%
κ_W	**1.49%**	**1.43%**	1.2%
κ_μ	**8.59%**	**8.13%**	8.6%
Br_{inv}	**0.44%**	**0.42%**	0.28%
Γ_H	**3.38%**	**3.26%**	2.8%

7κ	240GeV	250GeV	Pre_CDR
κ_b	**1.62%**	**1.55%**	1.3%
κ_c	**2.37%**	**2.28%**	1.7%
κ_g	**1.71%**	**1.64%**	1.5%
κ_γ	**4.24%**	**3.99%**	4.7%
κ_l	**1.56%**	**1.49%**	1.4%
κ_Z	**0.16%**	**0.16%**	0.26%
κ_W	**1.46%**	**1.40%**	1.2%

In white paper:

250GeV

	10-parameter fit		7-parameter fit	
	CEPC	+HL-LHC	CEPC	+HL-LHC
Γ_h	3.4	2.6	–	–
κ_b	1.7	1.3	1.6	1.2
κ_c	2.4	2.0	2.3	2.0
κ_g	1.7	1.3	1.6	1.2
κ_W	1.5	1.1	1.4	1.1
κ_τ	1.6	1.2	1.5	1.1
κ_Z	0.25	0.25	0.16	0.15
κ_γ	4.3	1.7	4.0	1.6
κ_μ	8.6	5.0	–	–
$\mathrm{BR}_{\mathrm{inv}}$	0.31	0.31	–	–

240GeV

	10-parameter fit		7-parameter fit	
	CEPC	+HL-LHC	CEPC	+HL-LHC
Γ_h	3.3	2.6	–	–
κ_b	1.6	1.3	1.6	1.2
κ_c	2.3	2.0	2.4	2.0
κ_g	1.7	1.3	1.7	1.3
κ_W	1.4	1.1	1.5	1.1
κ_τ	1.6	1.2	1.6	1.2
κ_Z	0.25	0.25	0.16	0.16
κ_γ	4.0	1.7	4.2	1.7
κ_μ	8.1	4.9	–	–
$\mathrm{BR}_{\mathrm{inv}}$	0.31	0.31	–	–

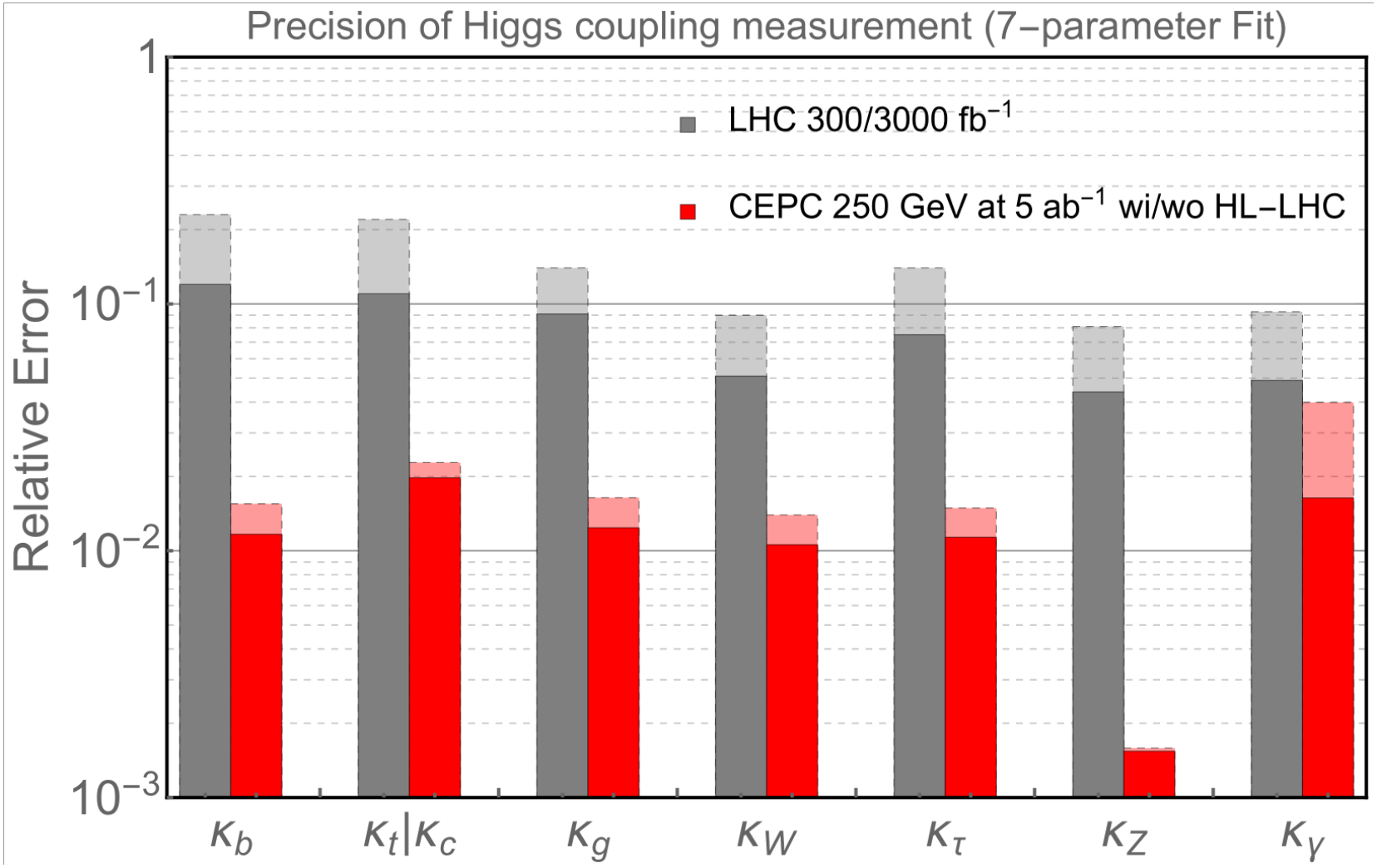
κ explaination

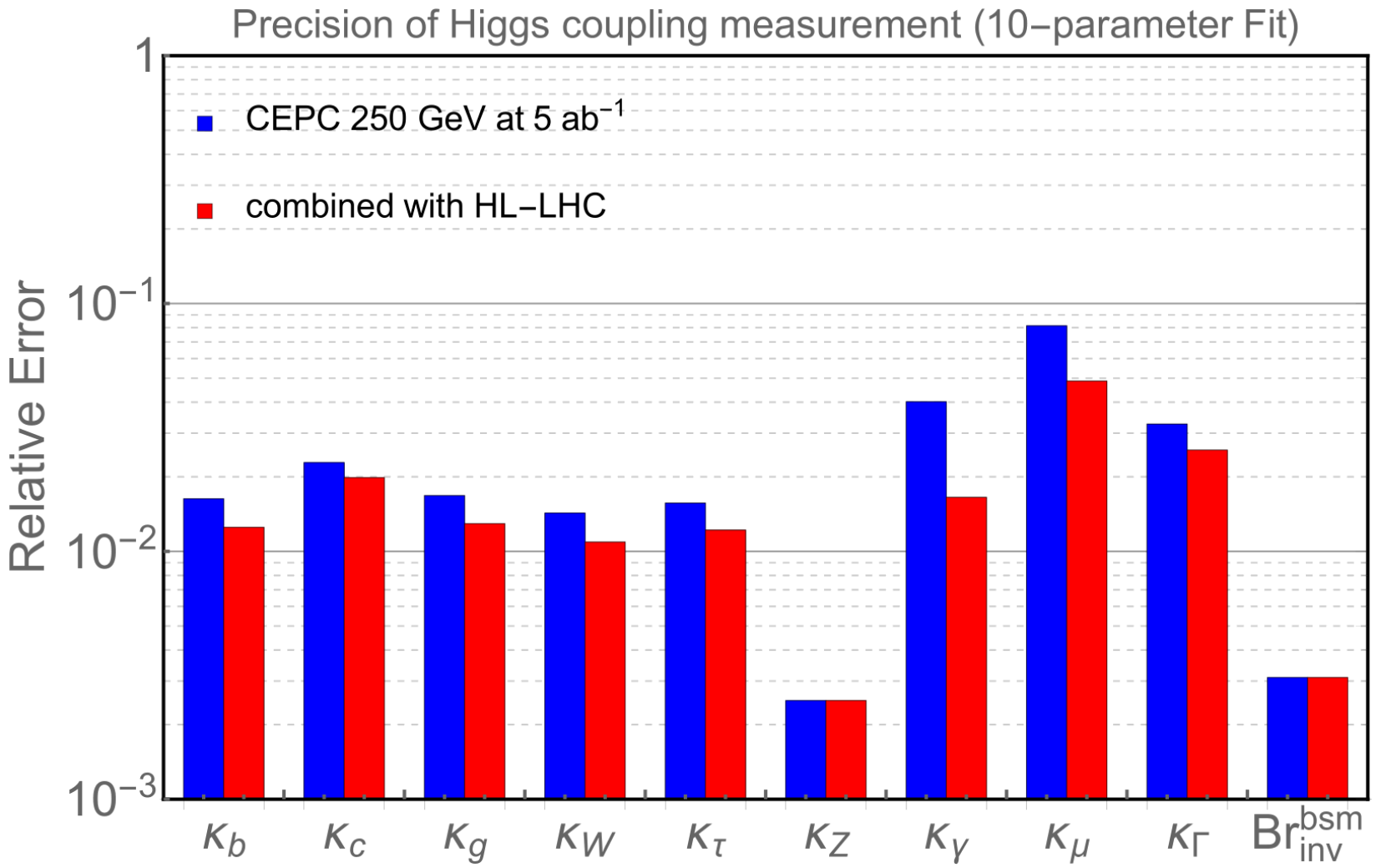
- $Z \to \mu\mu, H \to \tau\tau$ channel, the μ will be $\kappa_Z^2\kappa_\tau^2/\Gamma_H$; For $\nu\nu H \to bb$, $(\kappa_W^2\kappa_b^2)/\Gamma_H$;
  - Γ_H occurs everywhere;
- Best measurements are κ_b, κ_z. $\sigma(ZH) = 0.5\%$ constrain $\sigma(\kappa_z)$ to 0.25%.
  - Also, κ_z occurs anywhere in ZH processes. And those κ_z in production mode would not contribute anymore.
  - Only consider $\sigma(ZH) = 0.5\%$ and $\sigma(ZH) * Br(H \to ZZ) = 5.1\%$
- 7κ, Γ_{SM} can be resolved as: all κ correlated this way;

$$\Gamma_{SM} = 0.2137\kappa_W^2 + 0.02619\kappa_Z^2 + 0.5824\kappa_b^2 + 0.08187\kappa_g^2 + 0.002270\kappa_\gamma^2 + 0.06294\kappa_\tau^2 + 0.02891\kappa_c^2$$

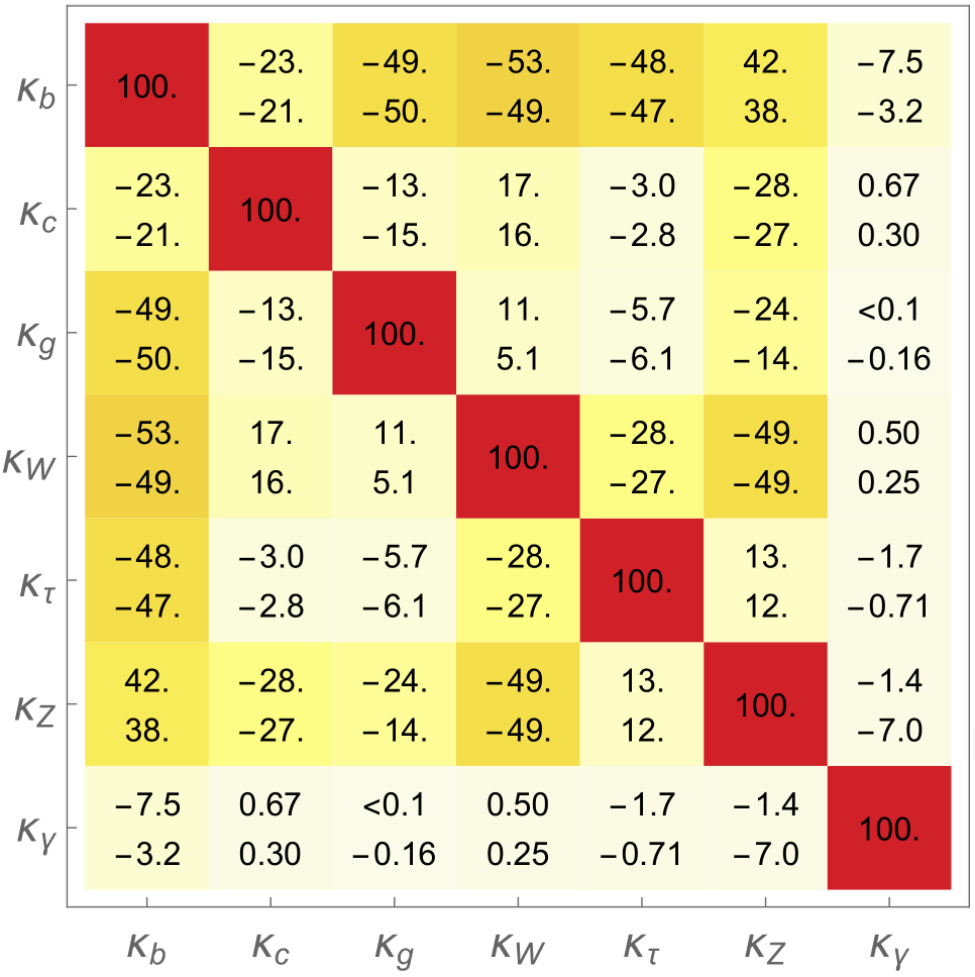
- 10 κ, independent Γ_H are constrained mainly by $H \to ZZ$ and $\nu\nu H \to bb$; gives ~3.26%;
- The only κ_τ measurement is $\sigma((\kappa_Z^2\kappa_\tau^2)/\Gamma_H)$=0.79%;
  - So it's difficult to improve κ_τ beyond 3.26%/2=1.63%; All κ result suffered from the uncertainty from Higgs width.

250GeV

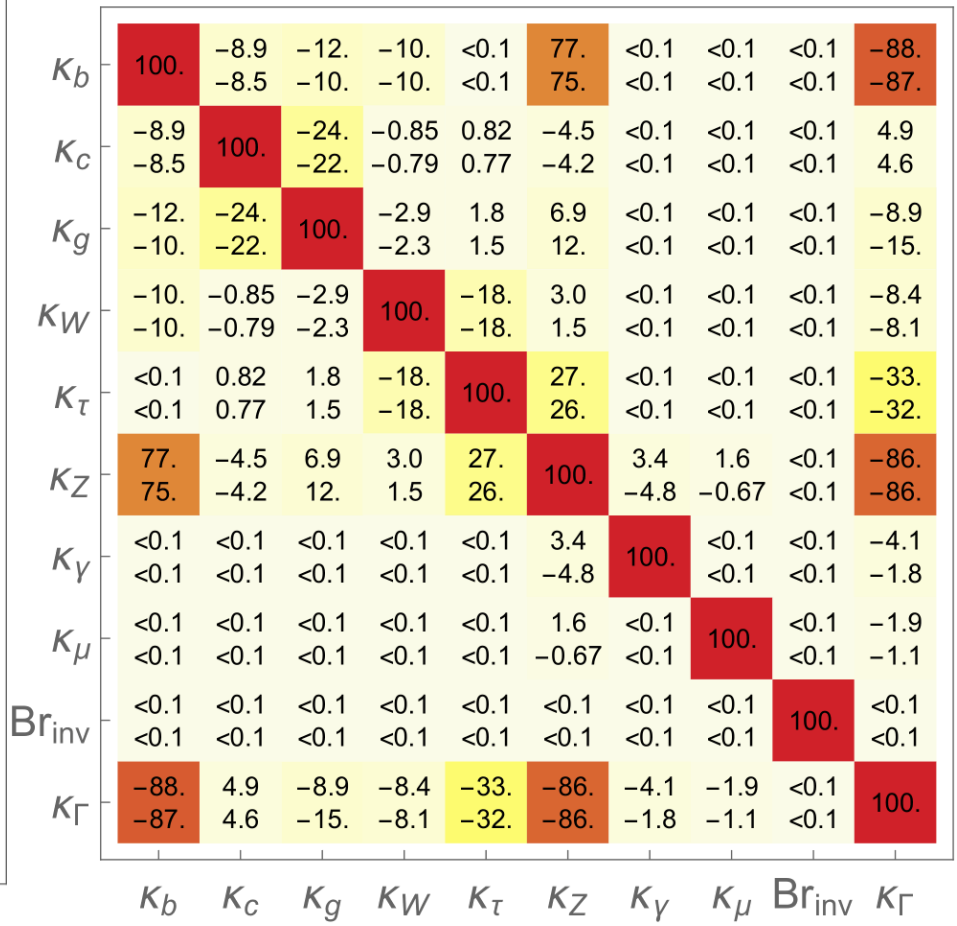

Precision of Higgs coupling measurement (7−parameter Fit)
LHC 300/3000 fb^{-1}
CEPC 250 GeV at 5 ab^{-1} wi/wo HL−LHC
Relative Error
1
10^{-1}
10^{-2}
10^{-3}
κ_b
$\kappa_t|\kappa_c$
κ_g
κ_W
κ_τ
κ_Z
κ_γ


Precision of Higgs coupling measurement (10−parameter Fit)
CEPC 250 GeV at 5 ab^{-1}
combined with HL−LHC
Relative Error
1
10^{-1}
10^{-2}
10^{-3}
κ_b
κ_c
κ_g
κ_W
κ_τ
κ_Z
κ_γ
κ_μ
κ_Γ
Br_{inv}^{bsm}

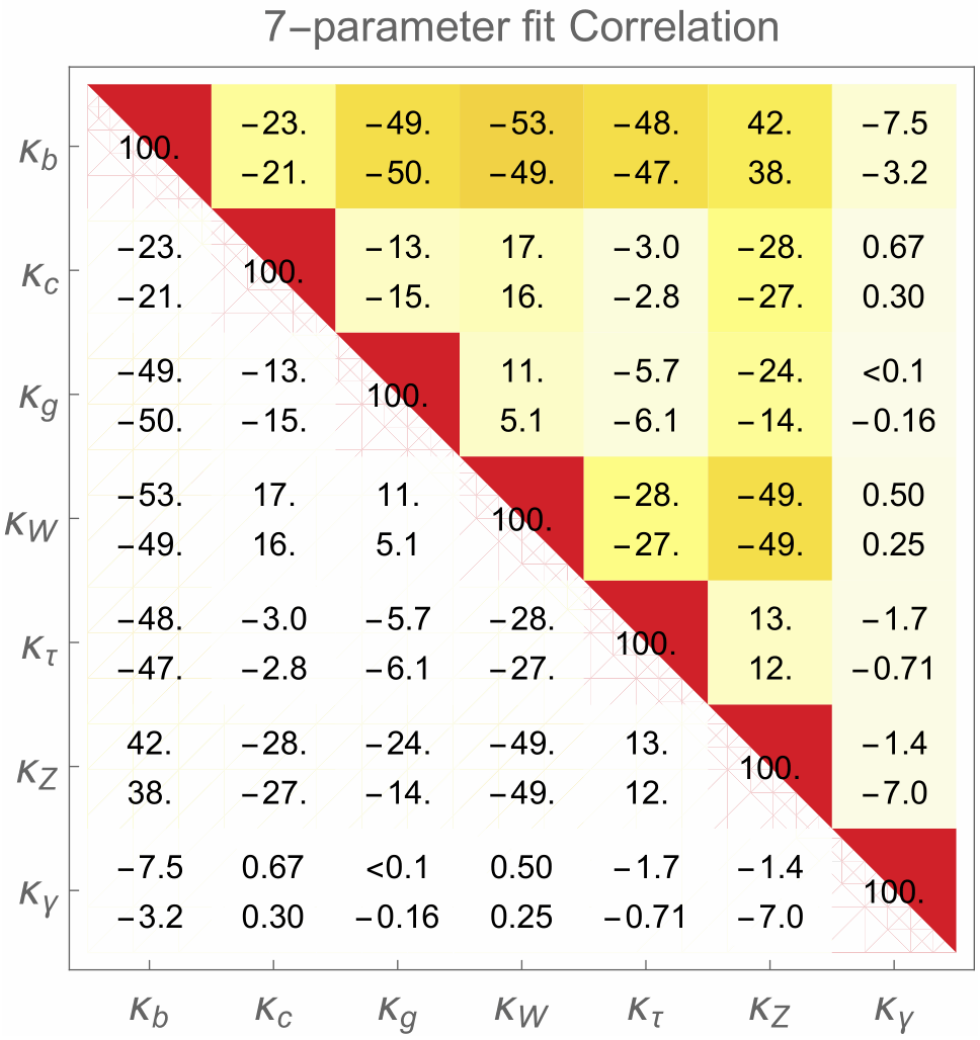
7−parameter fit Correlation



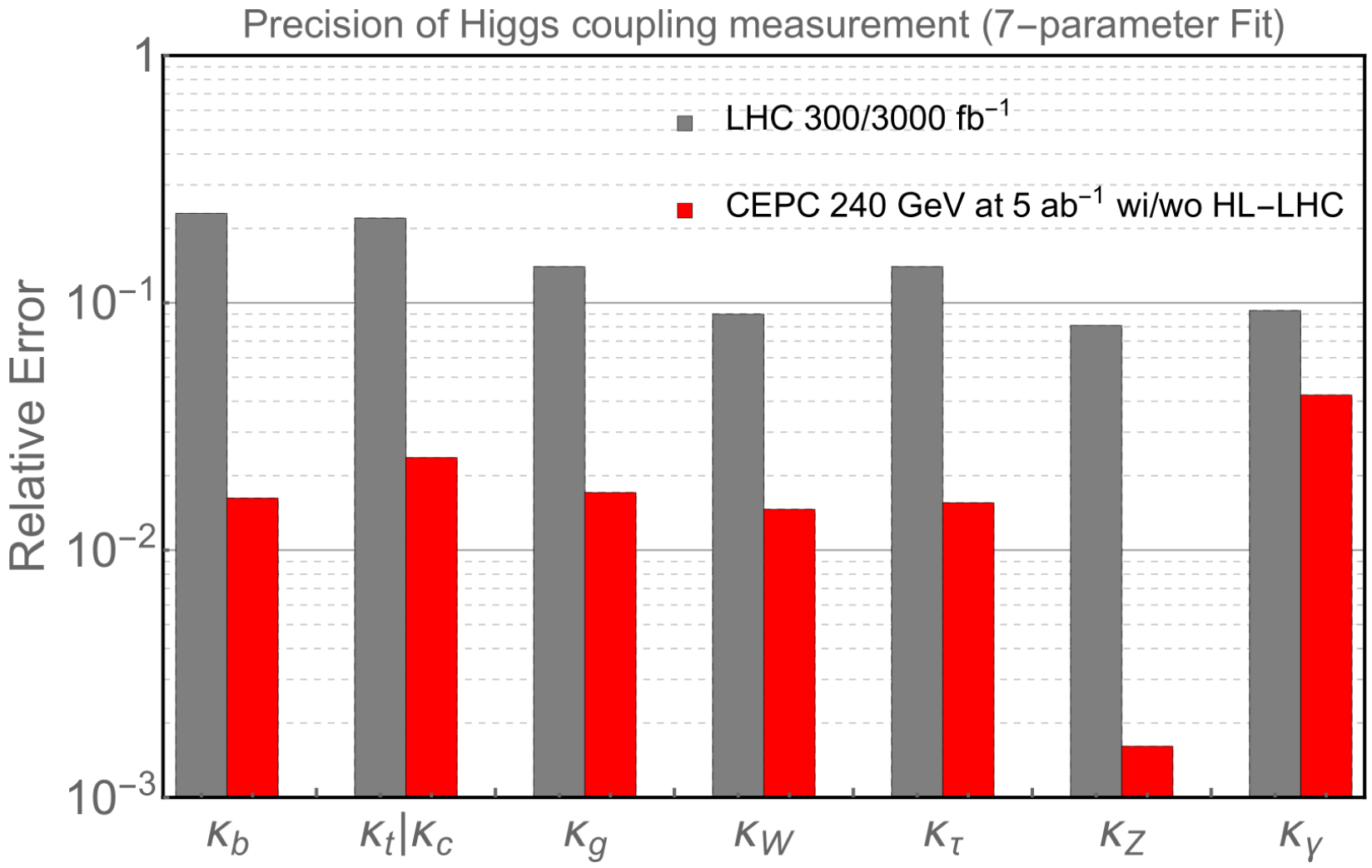
10−parameter fit Correlation

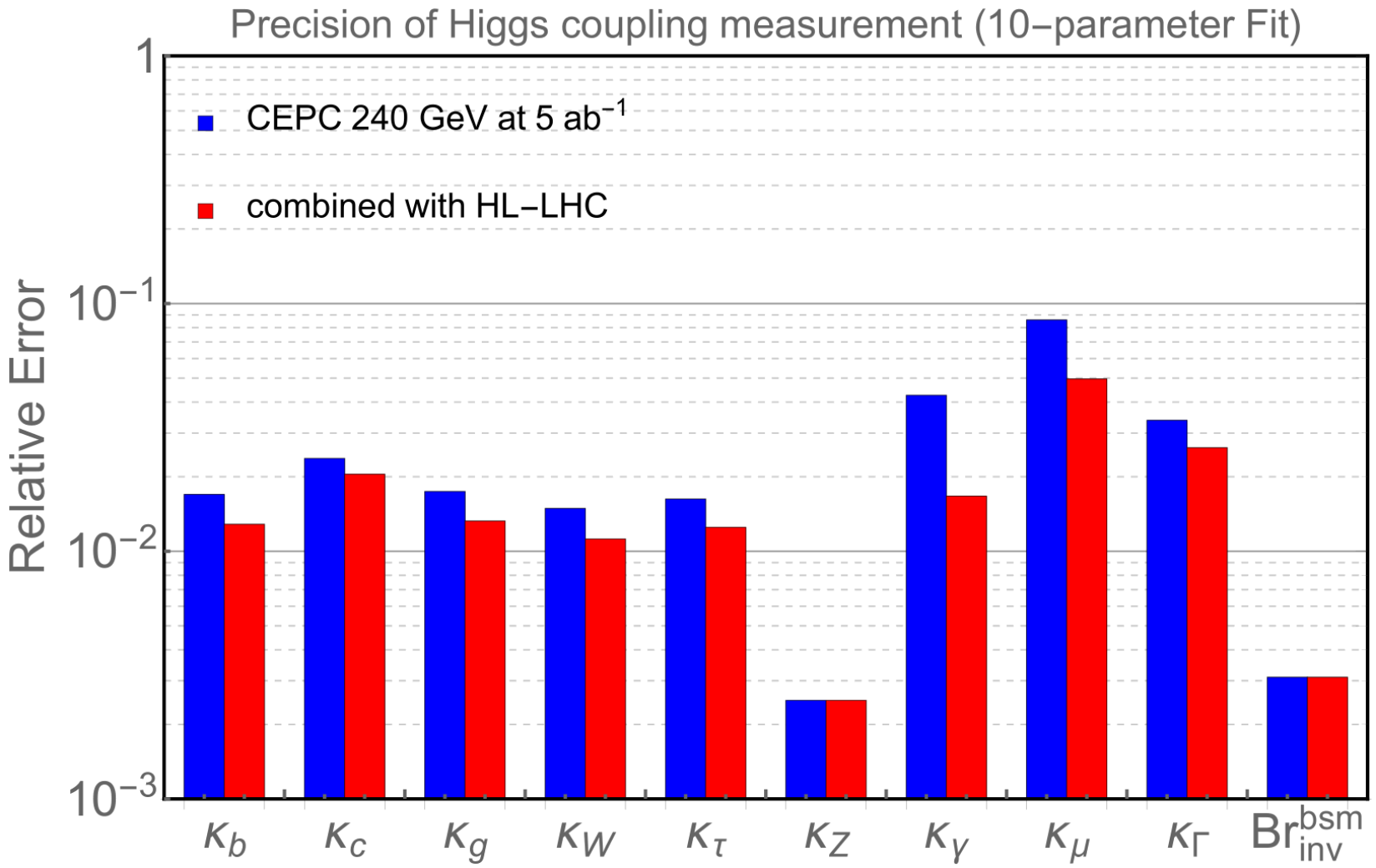


Half plane like this?



240GeV


Precision of Higgs coupling measurement (7−parameter Fit)
LHC 300/3000 fb^{-1}
CEPC 240 GeV at 5 ab^{-1} wi/wo HL−LHC
Relative Error
1
10^{-1}
10^{-2}
10^{-3}
κ_b
$\kappa_t|\kappa_c$
κ_g
κ_W
κ_τ
κ_Z
κ_γ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Relative Error
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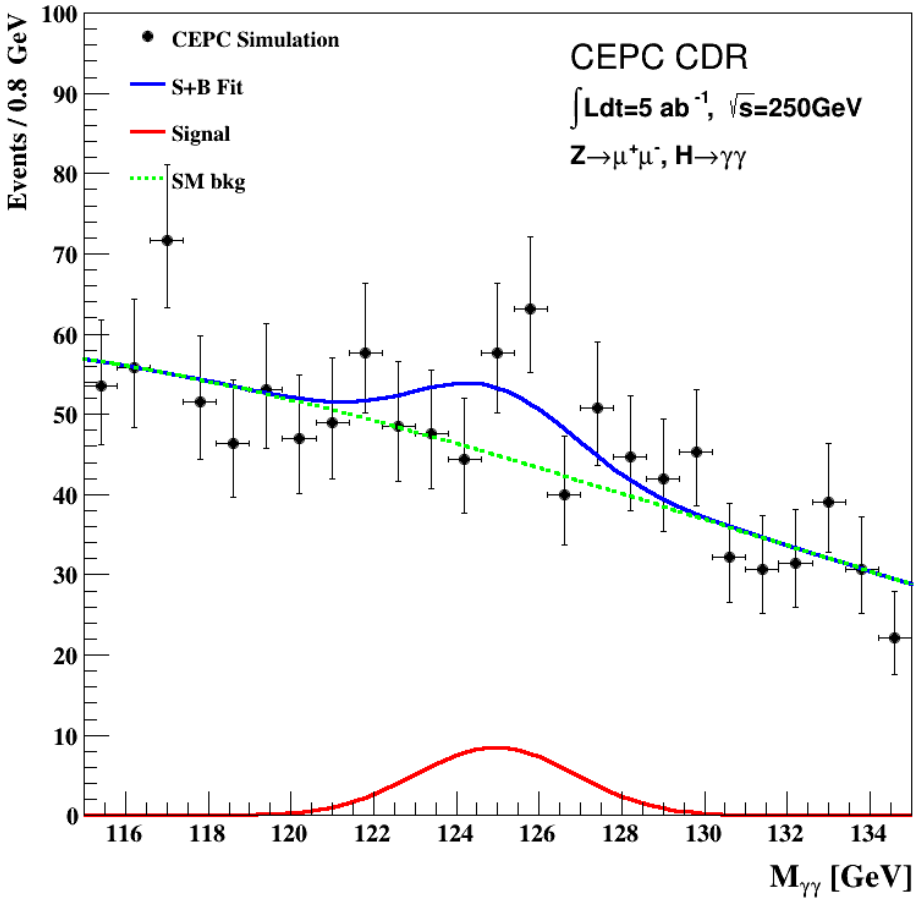
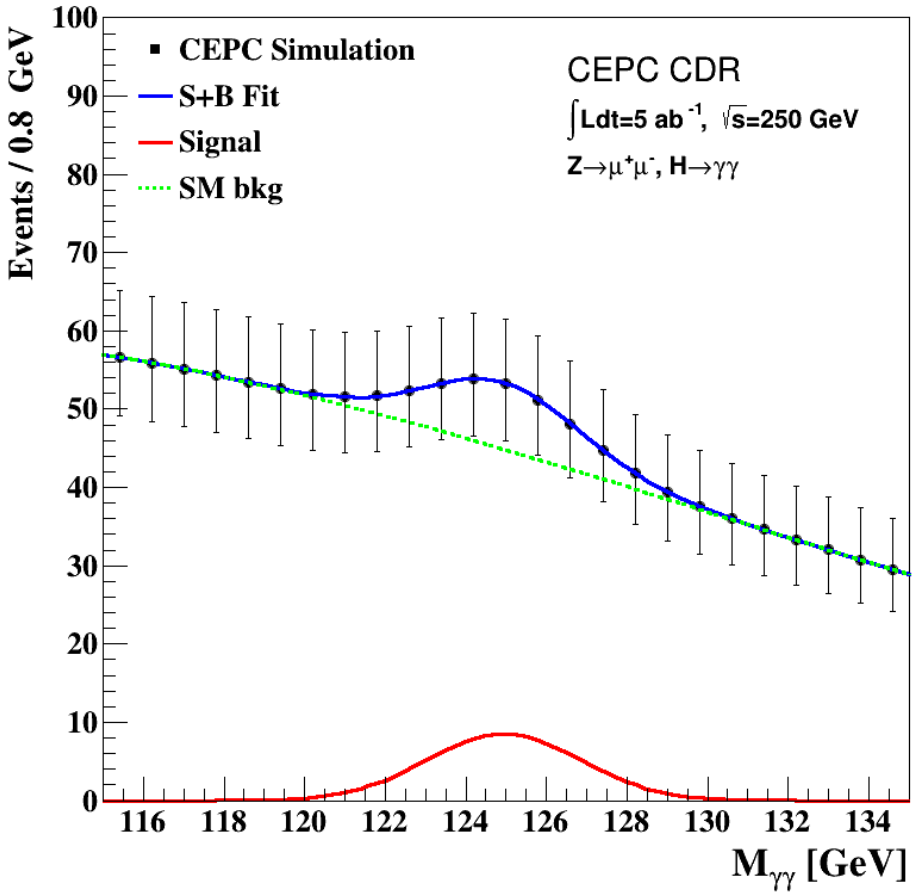
10^{-1}
10^{-2}
10^{-3}
κ_b
κ_c
κ_g
κ_W
κ_τ
κ_Z
κ_γ
κ_μ
κ_Γ
Br_{inv}^{bsm}

Plots in white paper

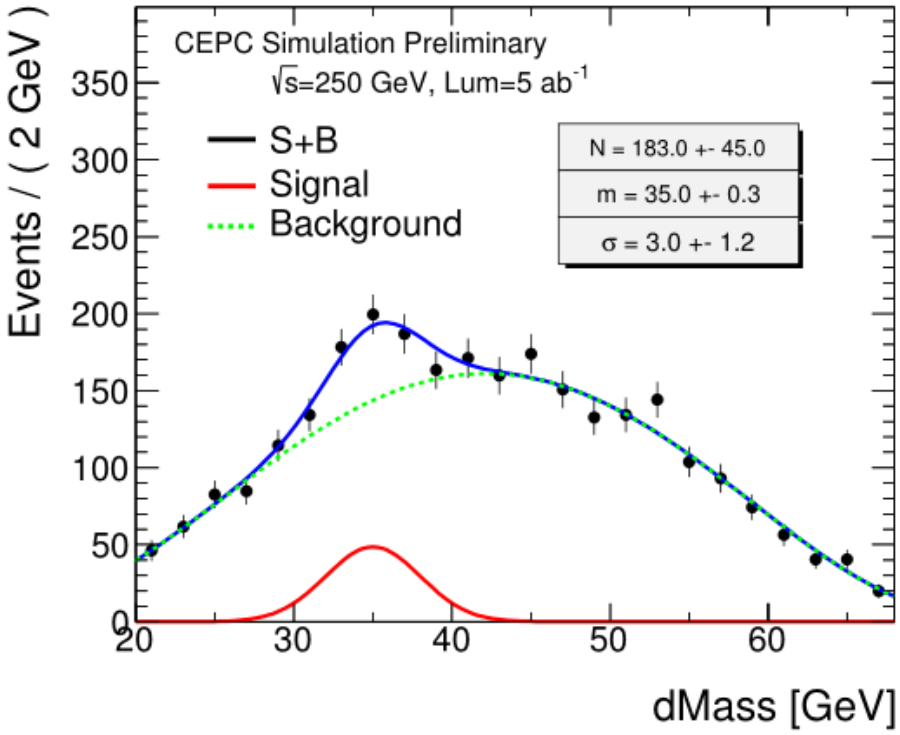
Using Asimov data;
Larger font, no x axis error.



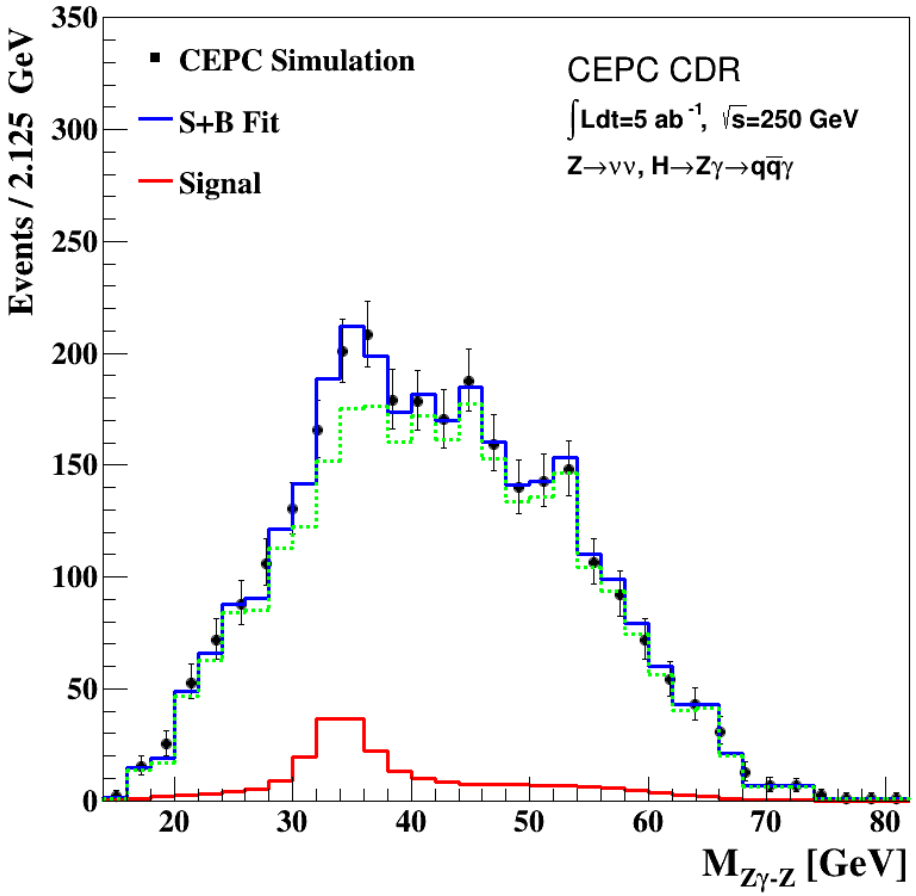


Plot to replace? qqzy

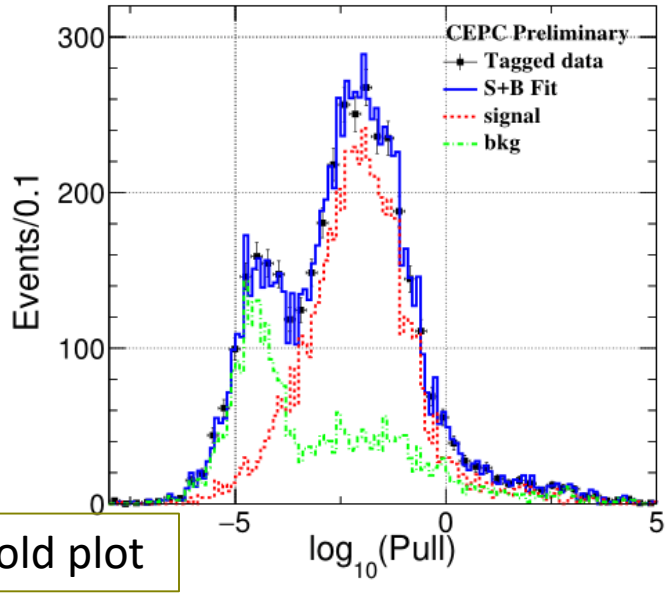
Weimin's old plot



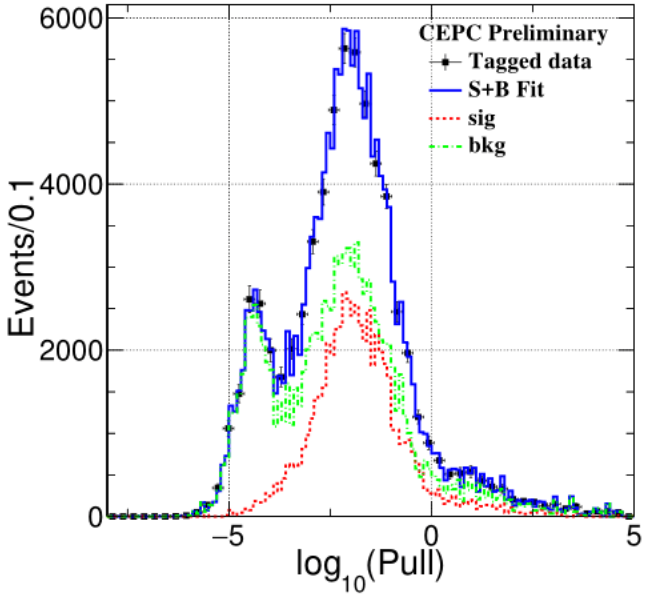
Mine; binned



Plot to replace? tautau



Dan's old plot



Mine