



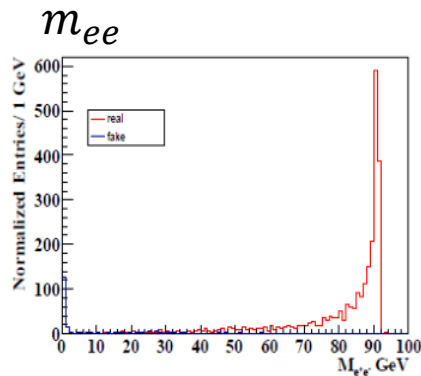
Updates on Higgs Combination

Zhang Kaili, IHEP

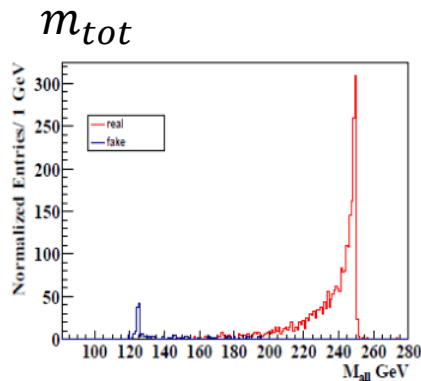
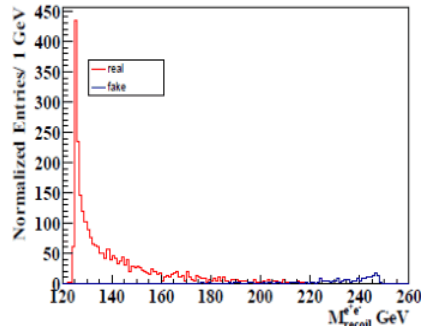
Wang Jin, Liu Zhen

2018-02-05

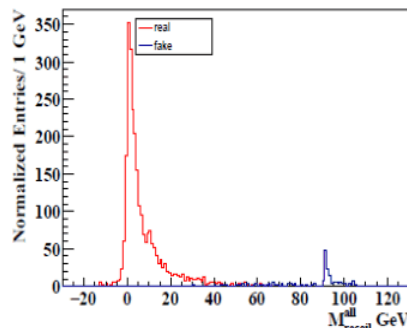
ZH → eeμμ



m_{ee}^{Recoil}

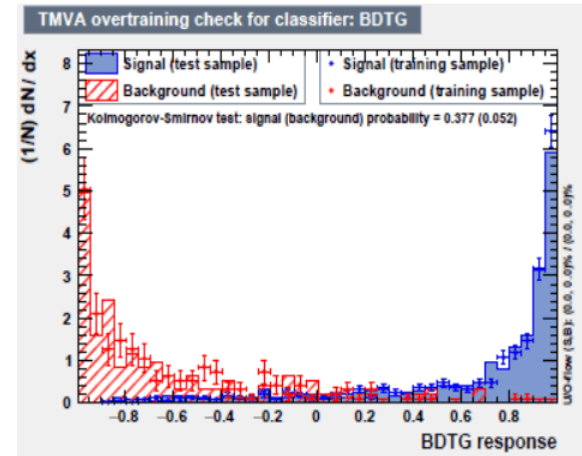


m_{tot}^{Recoil}



ZeeHuu

After the requirement $M_{\mu^+\mu^-}$ within [120-130] GeV, $M_{\mu^+\mu^-}$, M_{recoil_μ} , $E_{\mu^+\mu^-}$, M_{recoil_e} , $M_{e^+e^-}$, $\cos_{\mu^+\mu^-}$, $P_{T_{\mu^+\mu^-}}$, $P_{Z_{\mu^+\mu^-}}$, \cos_{μ^-} and \cos_{μ^+} are used by BDTG



$M_{recoil_e} < 150$ $M_{recoil_all} > 137$

Category	signal	ZZ	WW(SW)	ZZorWW	SingleZ	2f
Preselection	4.7	18	0	9	22672	8.0
$120 < M_{\mu^+\mu^-} < 130$	4.3	0	0	0	747	0.0
$90.5 < M_{recoil_\mu} < 92.5$	2.5	0	0	0	34	0.0
$\cos_{\mu^+\mu^-} < -0.603$	2.5	0	0	0	33	0.0
$P_{T_{\mu^+\mu^-}} < 62.5$	2.5	0	0	0	31	0.0
$138.5 < E_{\mu^+\mu^-} < 139.7$	2.2	0	0	0	8	0.0
efficiency	46.8%					

Significance=0.74

Kinematic limit

$\cos_{u_u} < -0.603$

$P_t < 62.5$

$E_{u_u} < 140$

Response < 0.5

Significance=1.5

ZH → μμ μμ

Find the minimized fake events

$$\delta = \left(\frac{\text{pair1}.M}{\Delta Z}\right)^2 + \left(\frac{\text{pair2}.M}{\Delta H}\right)^2$$

ΔH \ ΔZ	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
0.5	12	10	7	6	6	5	5	5	5	6	6	8	9	8	8
0.6	13	12	11	9	7	5	5	5	5	5	5	5	6	6	8
0.7	13	12	12	11	10	7	6	5	5	5	5	5	5	5	6
0.8	13	13	12	12	11	10	8	7	5	6	5	5	5	5	5
0.9	14	13	13	12	12	12	10	9	7	6	5	6	5	5	5
1	14	14	13	13	12	12	12	10	10	7	7	6	5	6	5
1.1	15	14	13	13	13	12	12	12	11	10	8	7	6	5	6
1.2	17	14	14	13	13	13	12	12	12	11	10	9	7	7	6
1.3	17	15	14	14	13	13	12	12	12	12	11	10	9	7	7
1.4	17	16	14	14	13	13	13	12	12	12	12	11	10	10	8

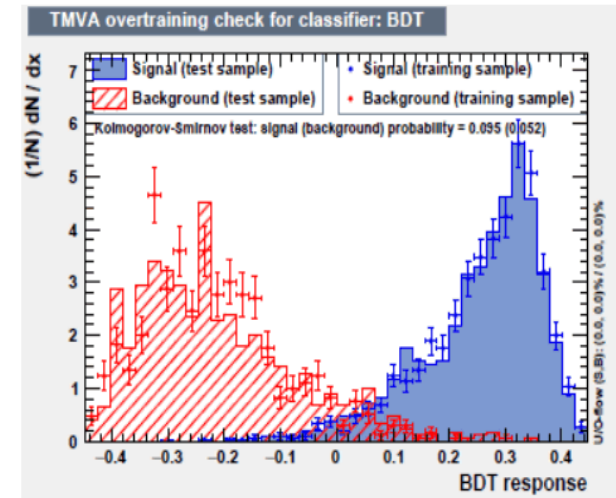
Delta_Z=1.5, Delta_H = 0.75

Category	signal	ZZ	WW(SW)	ZZorWW	SingleZ	2f
Preselection	6.6	17631.0	0	0	0	0.0
120 < E _{μ+μ-} < 130	6.0	1685.2	0	0	0	0.0
90.6 < M _{recoil_μ} < 93.4	3.9	128.8	0	0	0	0.0
90.2 < M _{μ+μ-(Z)} < 92.8	3.2	58.1	0	0	0	0.0
cos _{μ+μ-(H)} < -0.603	3.2	50.0	0	0	0	0.0
cos _{μ+μ-(Z)} < -0.364	3.2	47.0	0	0	0	0.0
138.0 < E _{μ+μ-(H)} < 139.8	3.0	15.5	0	0	0	0.0
P _{T_{μ+μ-(H)}} < 62.5	3.0	14.7	0	0	0	0.0
efficiency	45.5%					

Significance=1.2

ZuuHuu

After the requirement $M_{\mu^+\mu^-}$ within [120-130] GeV, $M_{\mu^+\mu^-(H)}$, $M_{recoil_{\mu}}(H), M_{\mu^+\mu^-(Z)}$, $M_{recoil_{\mu}}(Z)$, $E_{\mu^+\mu^-(H)}$, $\cos_{\mu^+\mu^-}$ are used by BDT method. The significance is 1.5σ



Cos_u_u < -0.603

Pt < 62.5

138 < E_u_u < 140

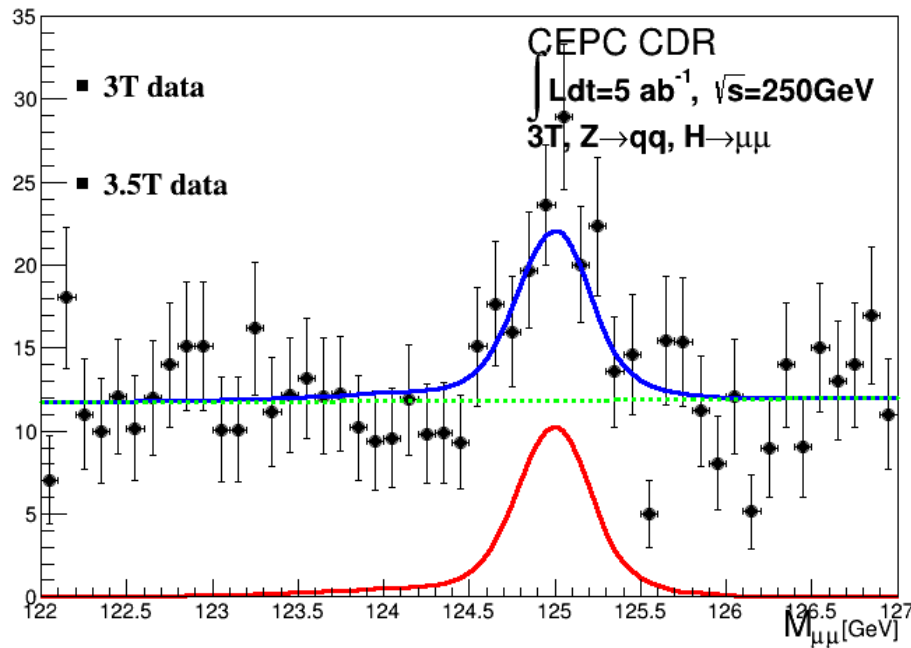
Response < 0.2

Significance=1.5

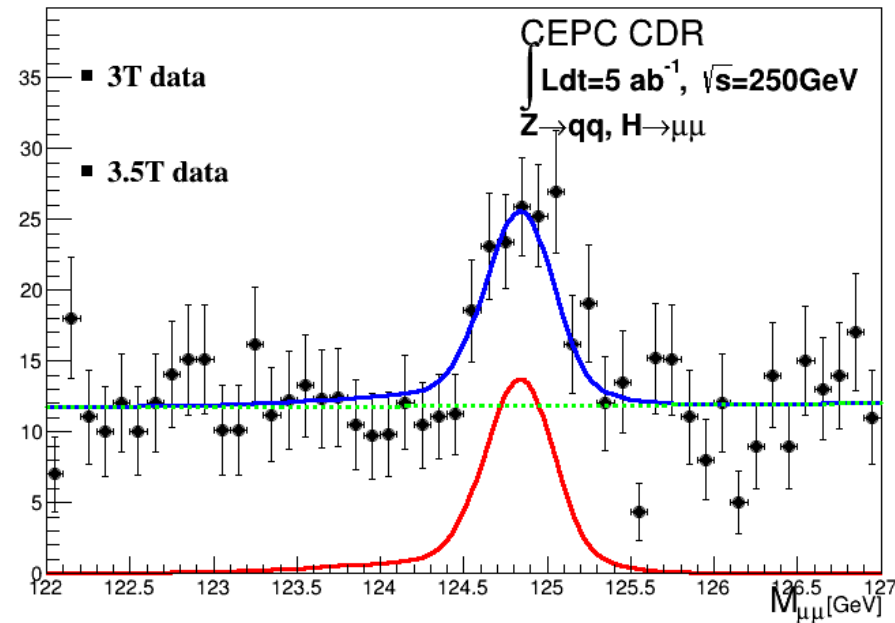
$Z \rightarrow qq, H \rightarrow \mu\mu$ Remove Z mass window:



3T: 21.6%



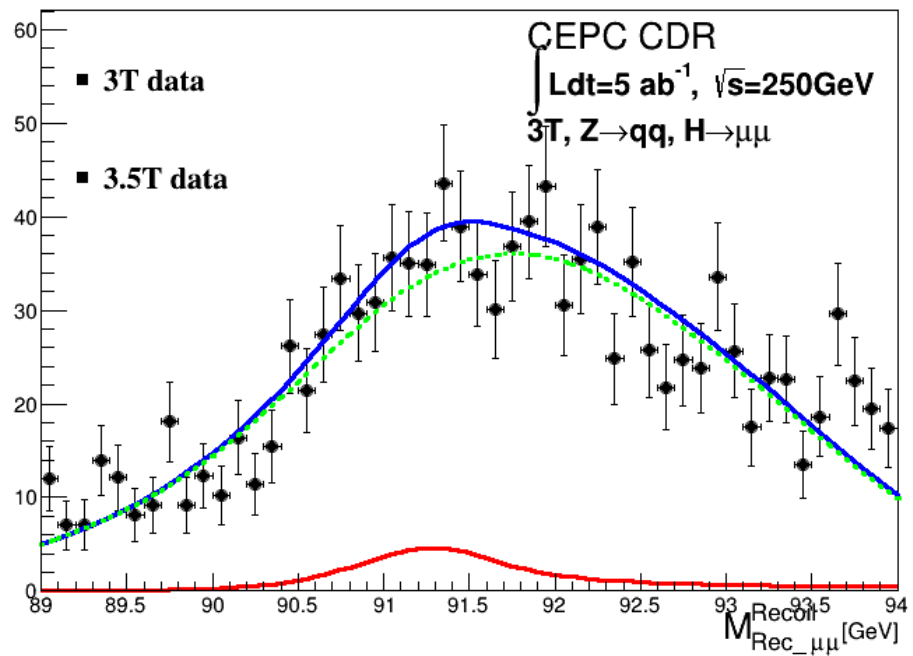
3.5T: 17.6%



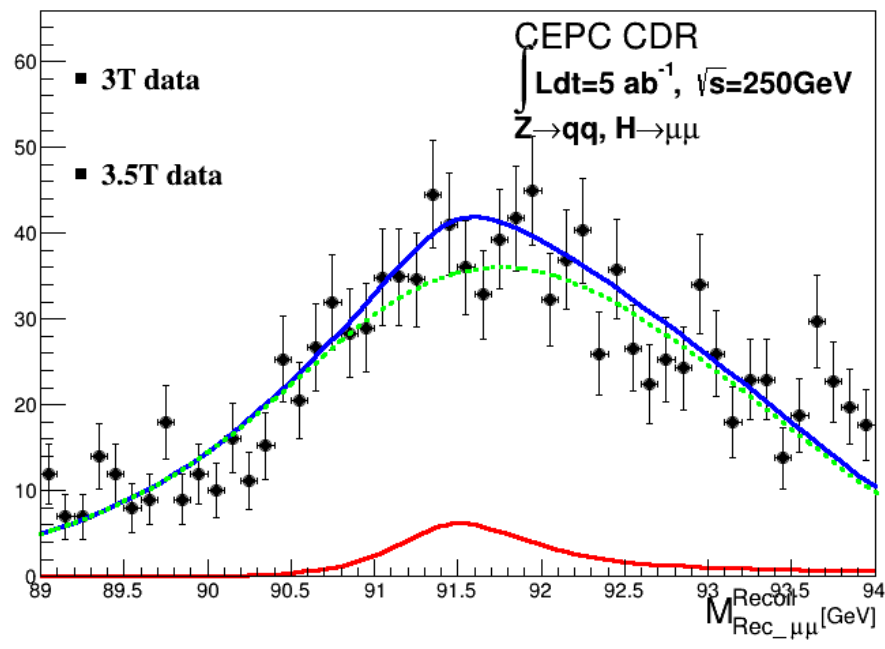
Combined $H \rightarrow \mu\mu$: 16.3%
 Previous with Z mass window: 16.5%
 (CEPC v1)
 Combined, with Z mass window: 15.4%

Remove Z mass window:

3T



3.5T



bb/cc/gg, vvH->bb:

- Current Z->vv, H->bb work by Baiyu contains vvH->bb;
- So μ_{bb} 0.29%
 - Using ZH->vvbb 0.40%
 - not all from ZH processes, multi counting;
 - didn't include correlation with vvH.
- When fit vvH->bb 3.11%, we also have ZH->bb 0.33%
 - ee/mm/qq same as Yu's, vv come from the vvH channel ZH part;
 - Here ZH->vvbb 0.56%
 - Anti-correlated with vvH, -46%;
- Use 0.29% or 0.33% for ZH, H->bb?
 - Or ——0.3%?

Done/Almost Done:

Channels Table

Signal		Precision	Signal		Precision	Signal		Precision	
Z	H		Z	H		Z	H		
H->qq			H->WW			vvH(WW fusion)			
ee	bb	1.6%	μμ	μμνν	7.3%	vv	bb	3.1%	
	cc	23.6%		eeνν		Rare Decays			
	gg	13.3%		eeμμνν		H->μμ			
μμ	bb	1.1%		eeqq	4.0%	qq	μμ	15.4%	
	cc	14.8%		μμνν	4.0%	ee			
	gg	8.0%		eeνν	9.2%	μμ			
qq	bb	0.5%	ee	eeνν	4.6%	H->Invisible		Br, Upper	
	cc	11.9%		eeqq		4.6%	qq	ZZ(vvvv)	0.3%
	gg	3.9%		μμνν		3.9%	ee		1.1%
vv	bb	0.4%	vv	qqqq	2.0%	μμ		0.7%	
	cc	3.9%		eeνν	4.7%				
	gg	1.5%		μμνν	4.2%				
H->ττ				qq	lvqq	2.2%(ILC)			
ee	ττ	3.0%		ZH bkg contribution		3.0%			
μμ		2.8%		H->ZZ					
qq		1.9%	vv	μμqq	8.2%				
vv		3.7%	vv	eeqq	35.2%				
H->γγ, Zγ			μμ	vvqq	7.3%				
μμ+ττ	γγ	24.8%	ee	eeqq	35.1%				
vv		11.7%	ee	μμqq	23.0%				
qq		12.8%	ZH bkg contribution		19.4%				
vv		Zγ(qqγ)	21.2%						

Need to be done:	
Z	H
ττ	Anything
qq	WW
	ZZ
ee	γγ
ee	ττ

Unfinished channels

Implement this table in the draft?



	Z	ee	$\mu\mu$	$\nu\nu$	qq	$\tau\tau$
WW	ev+ev					
	$\mu\nu+\mu\nu$					
	ev+ $\mu\nu$					
	ev+qq					
	$\mu\nu+qq$					
	qq+qq					
	ev+ $\tau\nu$					
	$\mu\nu+\tau\nu$					
	$\tau\nu+\tau\nu$					
	$\tau\nu+qq$					
	Z	ee	$\mu\mu$	$\nu\nu$	qq	$\tau\tau$
ZZ	ee+qq					
	$\mu\mu+qq$					
	$\nu\nu+qq$					
	ll+ll					
(Invi)	$\nu\nu+\nu\nu$					
	qq+qq					
	ll+ $\nu\nu$					

Need to be done:	
Z	H
$\tau\tau$	Anything
qq	WW
	ZZ
ee	$\gamma\gamma$
ee	$\tau\tau$

For WW and ZZ:
 Green: done
 Yellow: Extrapolated
 Gray: undertaking by Xianke
 Blue: studied as ZH bkg

For $Z \rightarrow \nu\nu, WW \rightarrow l\nu l\nu$,
 Preliminary result from Xianke gives 1012 signal and 38054 bkg. Update soon.

Prof. Shih-Chieh is studying the ZZ channel.

Fit results

Standalone: Regardless any ZH bkg contribution;
Different impact on w/z and b/c/g/ τ .

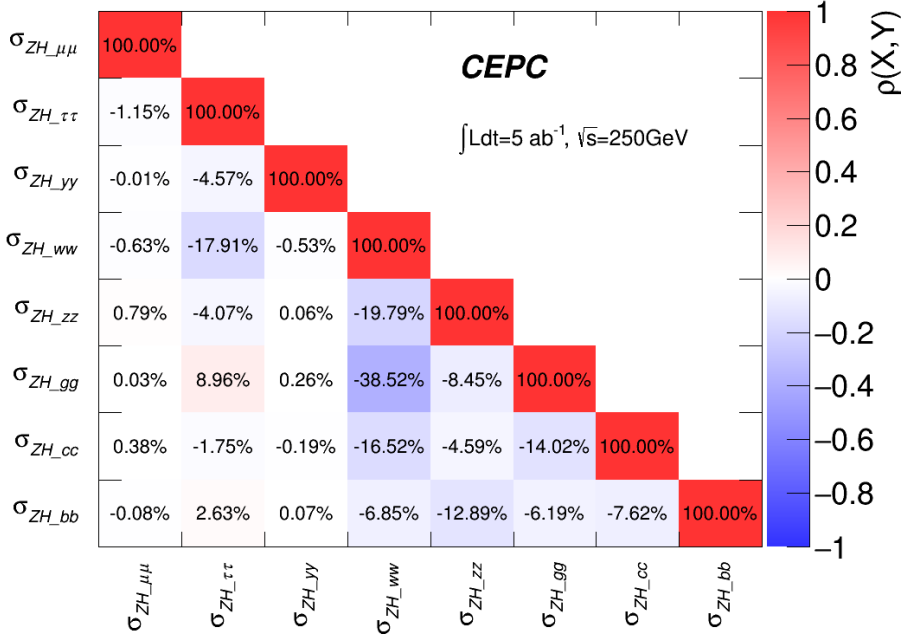
(5ab ⁻¹)	Pre_CDR	Combined	Standalone
$\sigma(ZH)$	0.51%	0.50%	
$\sigma(ZH) * \text{Br}(H \rightarrow \text{bb})$	0.28%	0.29%	0.28%
$\sigma(ZH) * \text{Br}(H \rightarrow \text{cc})$	2.20%	3.53%	3.52%
$\sigma(ZH) * \text{Br}(H \rightarrow \text{gg})$	1.60%	1.42%	1.36%
$\sigma(ZH) * \text{Br}(H \rightarrow \text{WW})$	1.50%	1.02%	1.16%
$\sigma(ZH) * \text{Br}(H \rightarrow \text{ZZ})$	4.30%	5.03%	5.20%
$\sigma(ZH) * \text{Br}(H \rightarrow \tau\tau)$	1.20%	1.35%	1.32%
$\sigma(ZH) * \text{Br}(H \rightarrow \gamma\gamma)$	9.00%	8.08%	8.15%
$\sigma(ZH) * \text{Br}(H \rightarrow \mu\mu)$	17%	15.40%	15.40%
$\sigma(\text{vv}H) * \text{Br}(H \rightarrow \text{bb})$	2.80%	3.11%	3.11%
$\text{Br}_{\text{upper}}(H \rightarrow \text{inv.})$	0.28%	0.24%	0.24%
$\sigma(ZH) * \text{Br}(H \rightarrow Z\gamma)$	\	4 σ (21.2%)	4 σ (21.2%)

Universally show results
with one digit after
decimal point?

Correlations in channel

- Correlation for $\gamma\gamma$ and $\mu\mu$ are from $\tau\tau$ MC truth pdg id.
- We didn't actually detect these bkg. Should remove?
- gg and ww : in $bb/cc/gg$ flavor template fit, gg and ww share the similar shape. (Both b likeness and c likeness are small.)
- $\tau\tau$ and ww : $\tau\tau$ channel's main bkg.

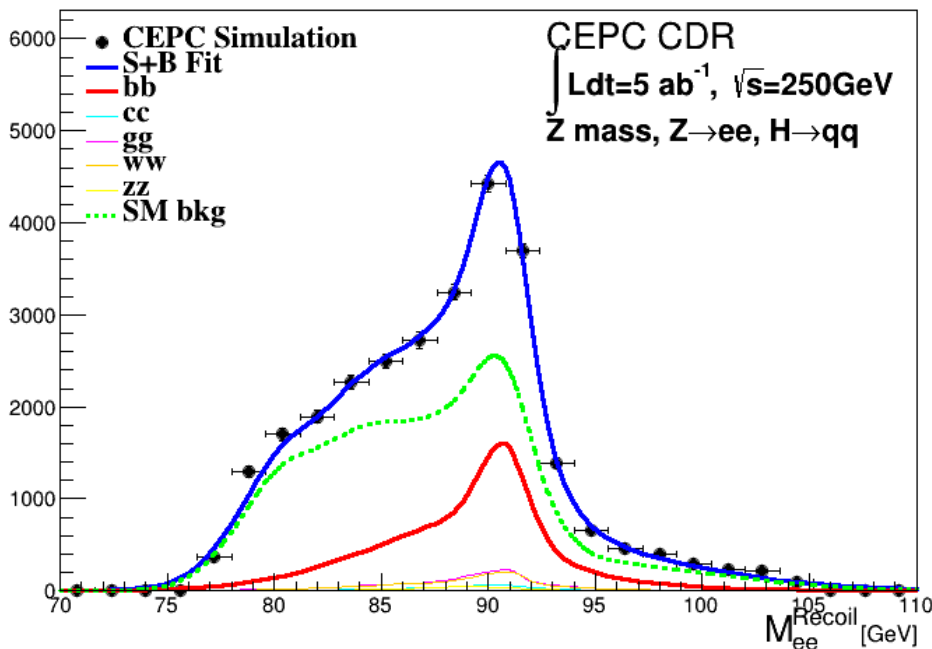
Combined measurement



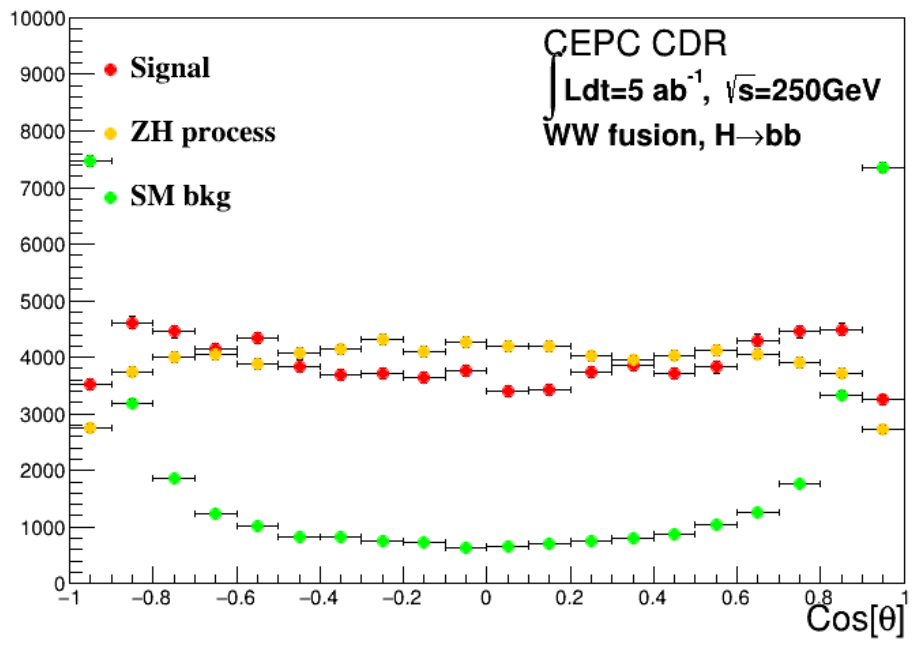
Esp., $vvH \rightarrow bb$ and $ZH \rightarrow bb$ is -46%.

Plot

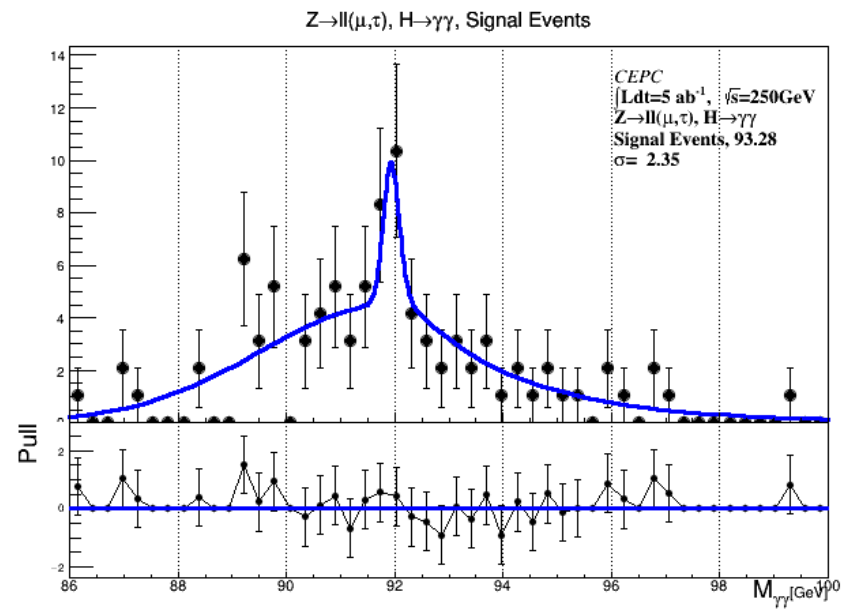
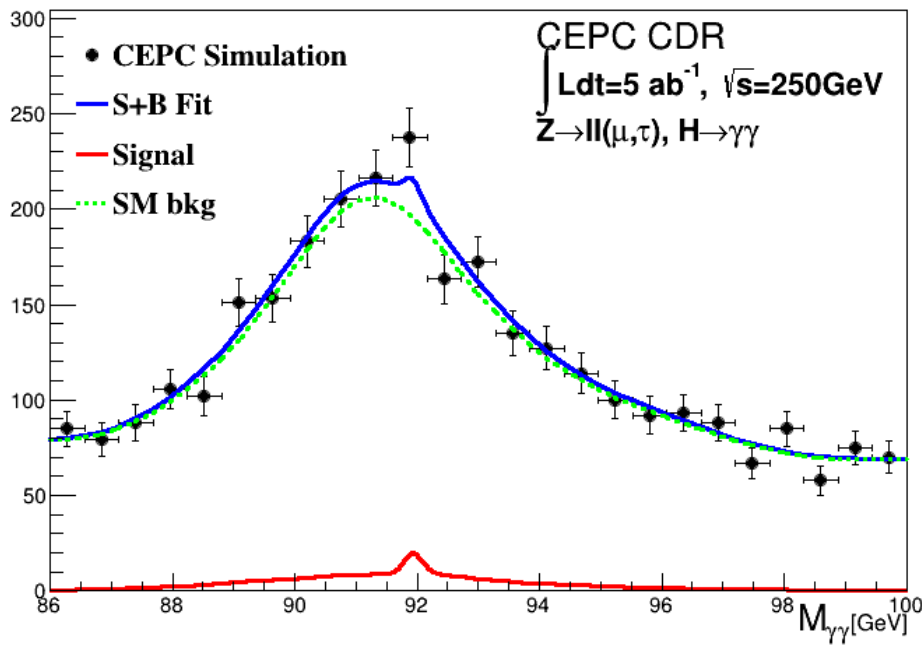
Use bigger label/legend;



Polar angle distribution for $\nu\nu H \rightarrow bb$



Recoil Mass of $l\gamma\gamma$



Shape may not be good.....