CEPC CDR updates

Kaili

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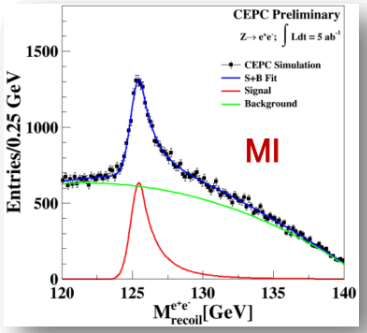
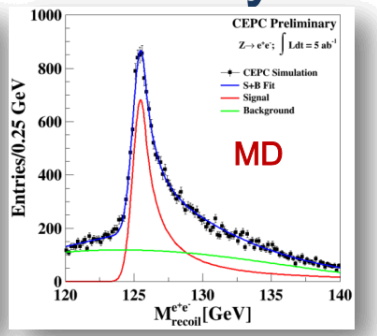
Revisit Z->ee/$\mu\mu$ H->inclusive

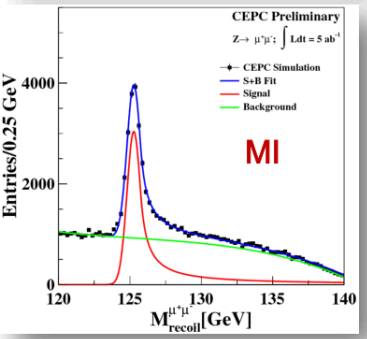
- Chen Zhenxing's paper: arxiv:1601.05352
  - And latest report on ICHEP 2016: here

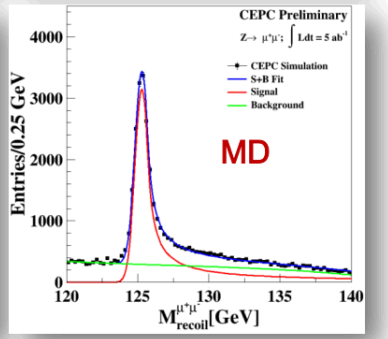
Recoil mass analysis: Z→e⁺e⁻ or μ⁺μ⁻





Model-Independent: only information from Z boson decays ➡ an inclusive measurement





Model-Dependent: SM assumption ➡ reduced background and improved m_H precision

with a 0.16% beam energy spread

Channel	Δσ(ZH)/σ(ZH)	Δm_H (MI)	Δm_H (MD)
e^+e^-	1.49%	19.2 MeV	13.1 MeV
$\mu^+\mu^-$	0.92%	6.5 MeV	5.4 MeV

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2 scenarios :

- Model-independent:

information only from Z decay;

for $\Delta\sigma(ZH)/(\sigma(ZH))$ measurement;

- Model-dependent:

besides independent preselection:

- Require $N_{charged} > 4$
- Add E_{vis} in TMVA.

Use the existing data

- Luckily, I found all the code and data Zhenxing once used:
  - data in /besfs/groups/higgs/data/workarea_chenzx/sampling/5ab/
  - $\mu\mu$ TMVA in /besfs/groups/higgs/data/workarea_chenzx/cepc/TMVA/beamsmear/4/add2gamma
  - ee TMVA in /besfs/groups/higgs/data/workarea_chenzx/Analysis/RecoMassAnaee
  - So ideally now the work is all reproducible.
- Data sample (Minor isuue: Generated ~3 years ago, reconstruction version could be outdated.)
  - signal: Z->ee/ $\mu\mu$, H->inclusive, full simulation 100k
    - 2/3 events are discarded to match the 5ab-1 Z->ll expected value
    - The remain statistics is enough so no big harm. Can use the whole data if needed in the future.
  - bkg: weight=1; Additionally, ee→$\gamma\gamma$ are added in the latest version.
    - After TMVA, bkg has 22% ee→$\gamma\gamma$, 18.8% ee->ZZ and 32.8% 2 fermion bkg.

Selection Efficiency

Table 2. Efficiencies of signal and background in the model-independent analysis

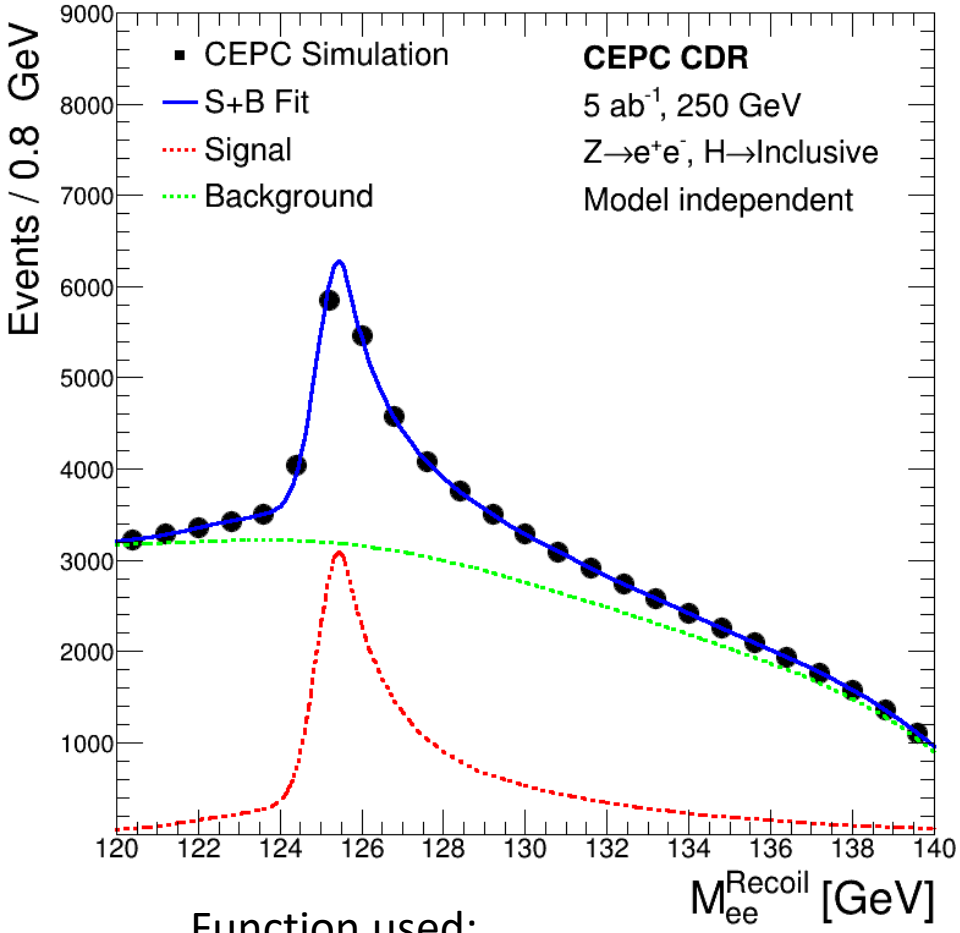
	$Z(\mu^+\mu^-)H$	ZZ	WW	ZZ or WW	single Z	$Z(2f)$	$\gamma\gamma$
total generated	35247	5347053	44180832	17801222	7809747	418595861	161925000
$N_{\mu^+} \geqslant 1$, $N_{\mu^-} \geqslant 1$	95.7%	11.95%	0.65%	3.92%	9.75%	1.64%	17.31%
120 GeV $< M_{\text{recoil}} <$ 150 GeV	93.2%	1.71%	0.23%	0.70%	1.93%	0.17%	3.06%
80 GeV $< M_{\mu^+\mu^-} <$ 100 GeV	85.5%	0.68%	0.06%	0.22%	0.22%	0.10%	0.11%
$p_{T\mu^+\mu^-} >$ 20 GeV	80.2%	0.57%	0.06%	0.17%	0.16%	0.02%	0.04%
$\Delta\phi <$ 175°	77.8%	0.51%	0.05%	0.17%	0.15%	0.01%	0.04%
BDT cut	63.0%	0.25%	0.01%	0.05%	0.06%	0.01%	0.01%
fit window	62.8%	0.25%	0.01%	0.05%	0.05%	0.01%	0.01%

fit window: $120 < M_{rec} < 140$

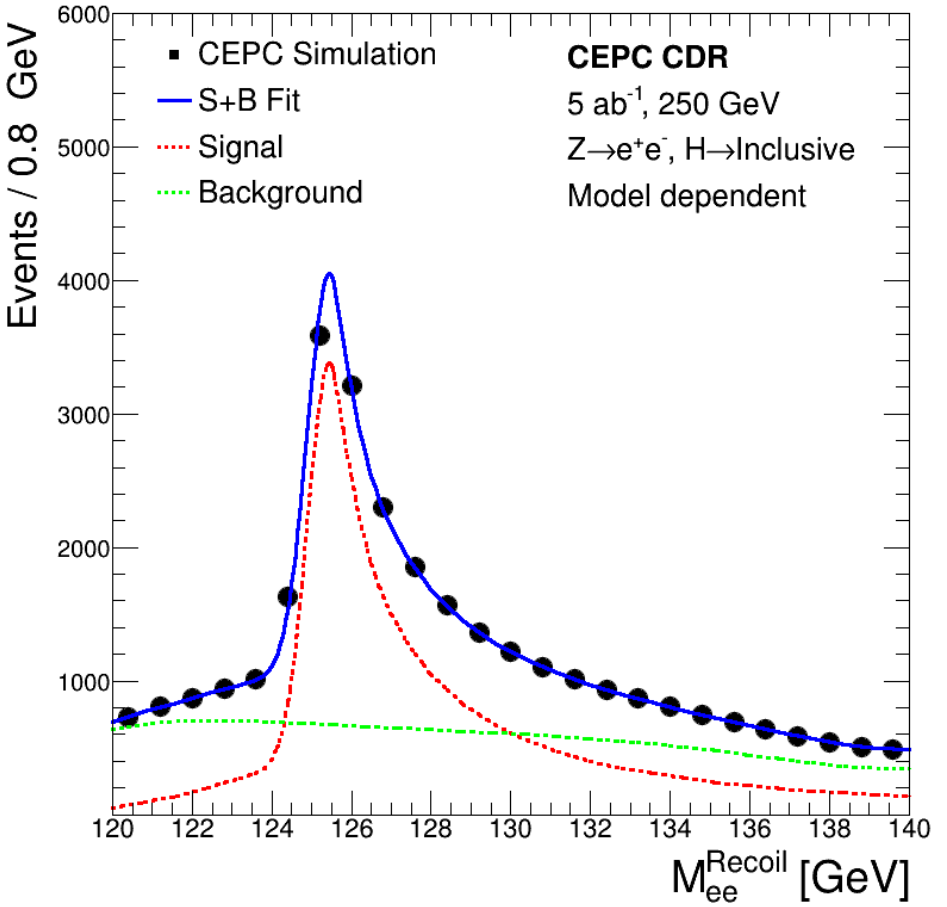
- Model dependent: Require $N_{charged} > 4$, Add E_{vis} in TMVA.
- BDT value used by Zhenxing:
  - $Z \to ee$, independent: BDT>0.05
  - $Z \to ee$, dependent: BDTG>-0.3 ee TMVA done in 2015 and no update;
  - $Z \to \mu\mu$, independent: BDT>-0.05
  - $Z \to \mu\mu$, dependent: BDT>-0.05

My fit:

Independent:
S: 14614; B: 61799;
1.51%; old result: 1.49%



Dependent:
S: 16959; B: 13883;
0.97%

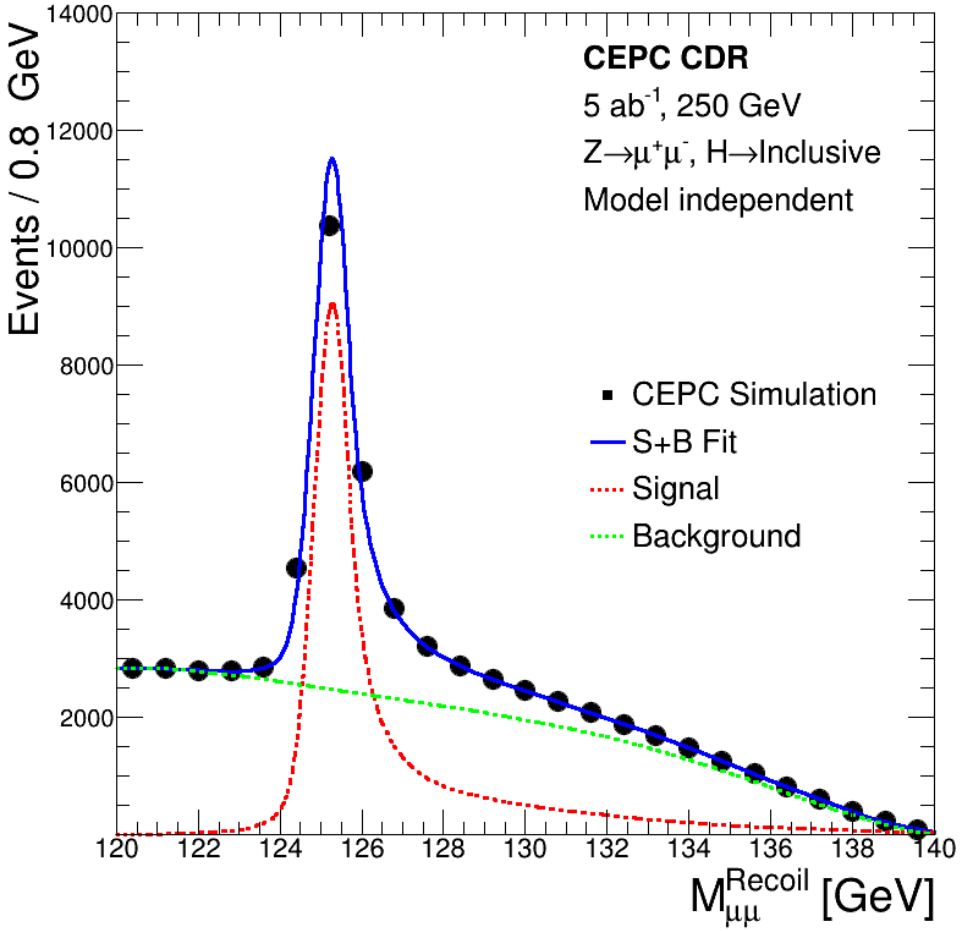


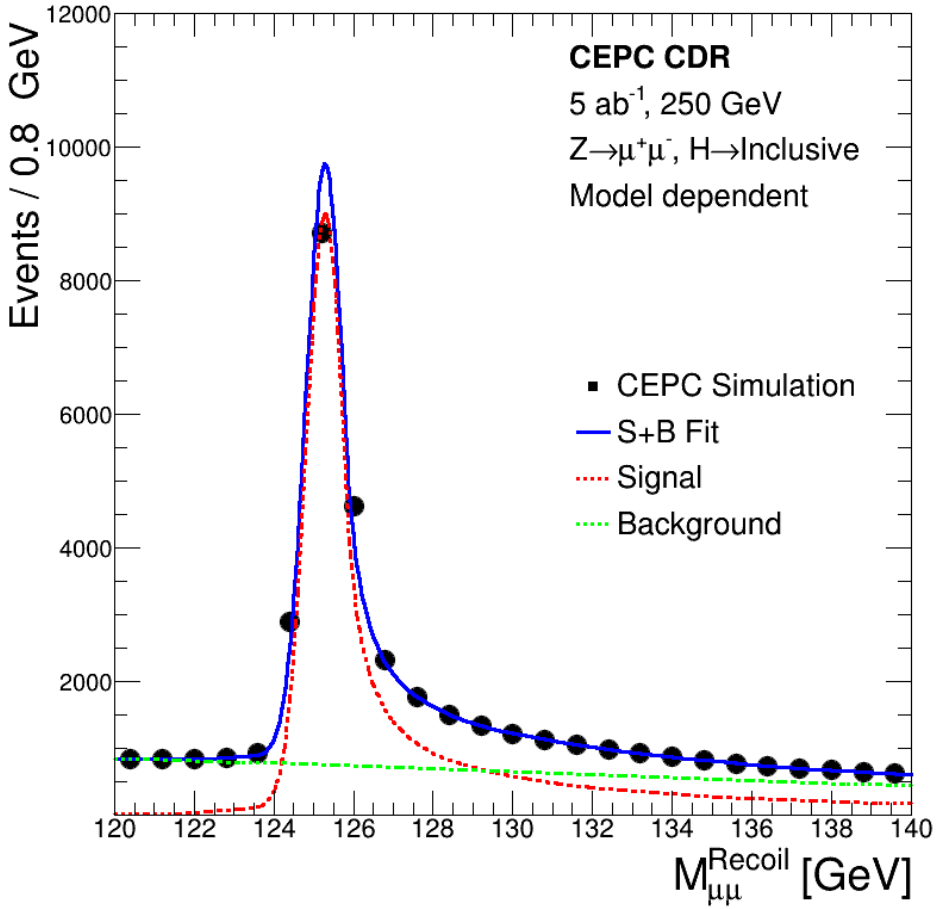
Function used:
S: Double Sided Crystal Ball;
B: 5 order chebshev;

My fit:

Independent:
S: 21372; B: 42206;
0.92%; old result: 0.92%

Dependent:
S: 23539; B: 15536;
0.76%

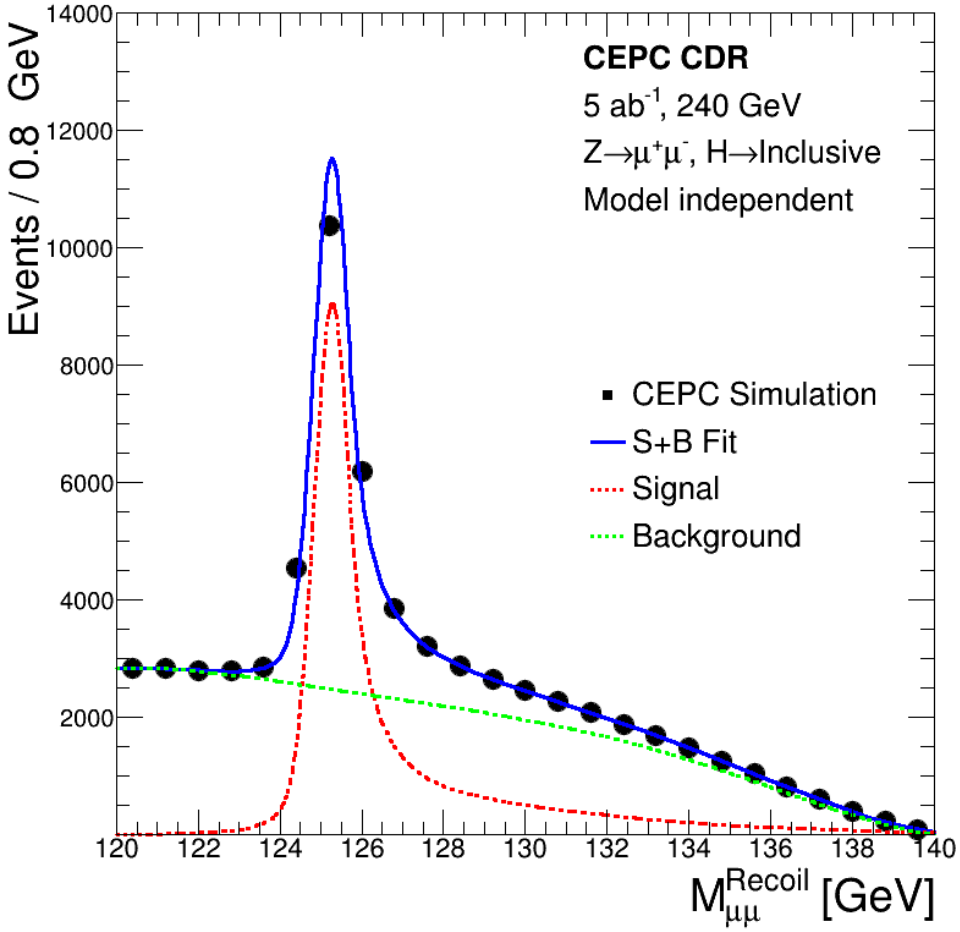




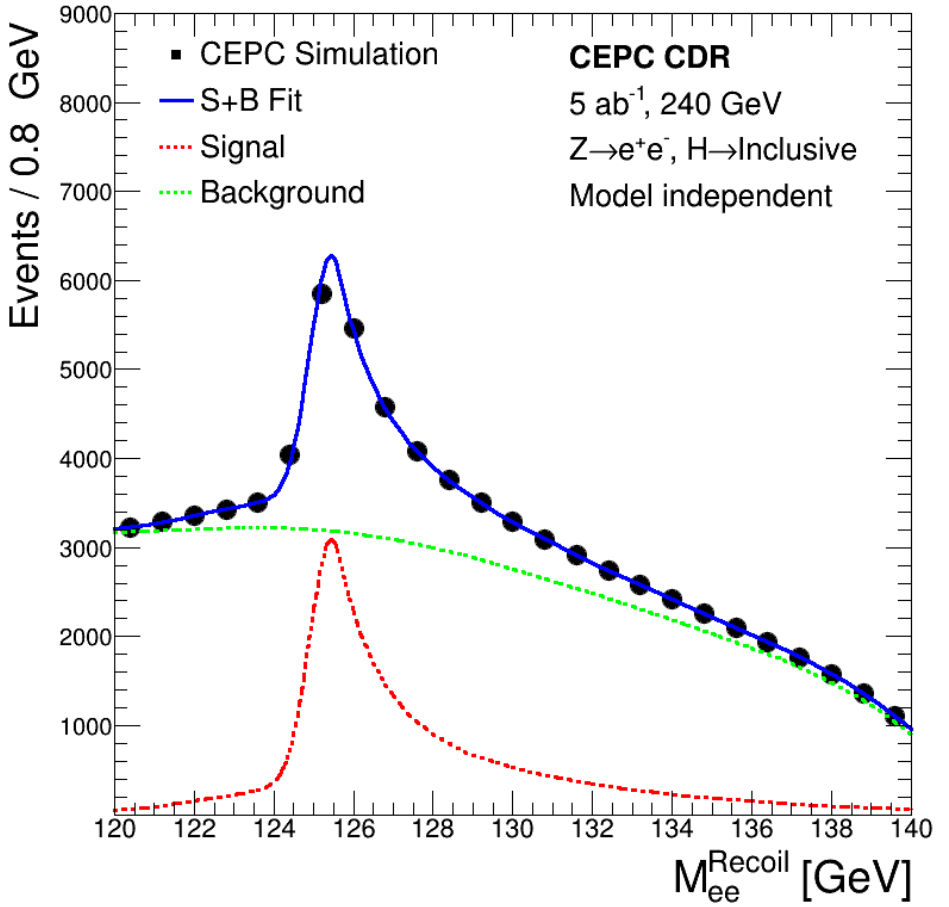
Should be the final(?) version plot style?

240GeV results

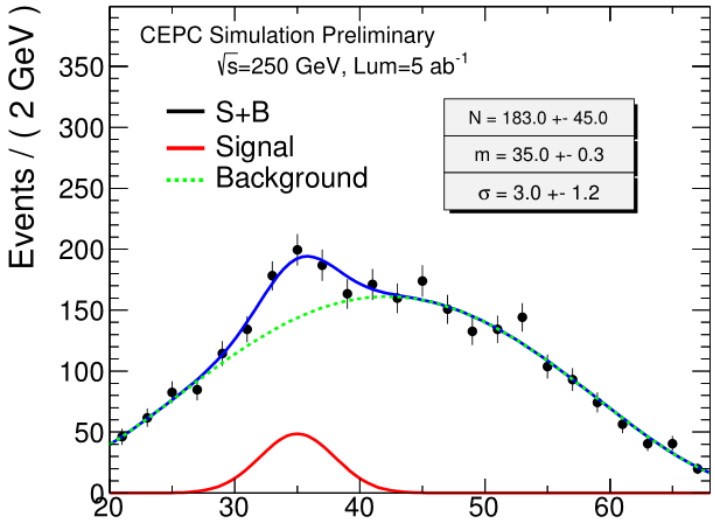
0.92% -> 0.95%



1.51% -> 1.62%

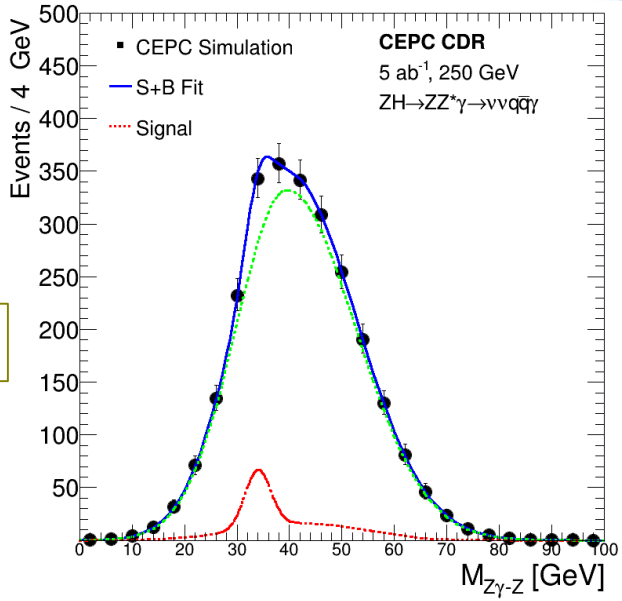


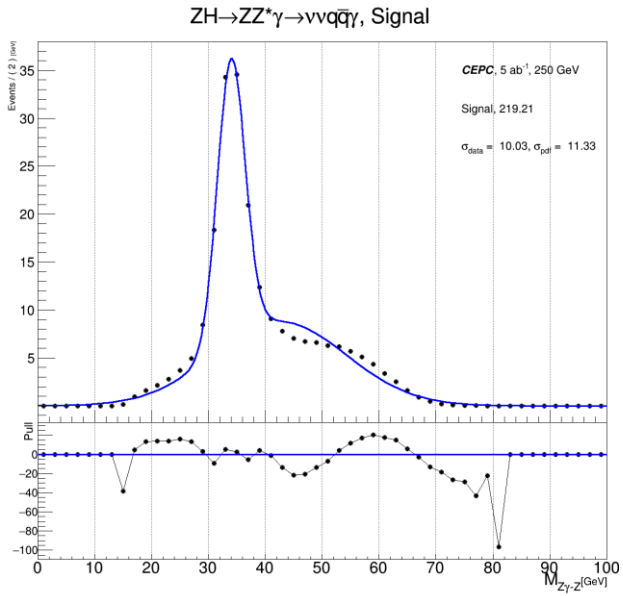
$H \to Z\gamma$



Plots in Pre_CDR:

My plot





Signal 219, bkg 2592;

Use 2 Gaussian to fit signal

Gives 19% uncertainty;

- Use 19% or 4σ in paper?

Signal plot, not so good but clearly has 2 parts;

Fit Result

	250GeV	240GeV
$\sigma(ZH)$	0.50%	0.50%
$\sigma(ZH) * Br(H \to bb)$	0.28%	0.29%
$\sigma(ZH) * Br(H \to cc)$	3.27%	3.42%
$\sigma(ZH) * Br(H \to gg)$	1.28%	1.34%
$\sigma(ZH) * Br(\mathrm{H} \to WW)$	1.00%	1.04%
$\sigma(ZH) * Br(H \to ZZ)$	5.12%	5.21%
$\sigma(ZH) * Br(H \to \tau\tau)$	0.83%	0.87%
$\sigma(ZH) * Br(H \to \gamma\gamma)$	6.62%	7.25%
$\sigma(ZH) * Br(H \to \mu\mu)$	15.9%	16.8%
$\sigma(\mathrm{vv}H) * Br(H \to \mathrm{bb})$	3.01%	3.16%
$Br_{\mathrm{upper}}(H \to inv.)$	0.42%	0.44%
$\sigma(ZH) * Br(H \to Z\gamma)$	19.41%	21.71%

backup

b/c/g

Signal		250	240
Z	H		
H->qq			
ee	bb	1.30%	1.35%
	cc	11.78%	12.35%
	gg	6.17%	6.51%
μμ	bb	1.00%	1.03%
	cc	9.44%	9.77%
	gg	4.90%	5.08%
qq	bb	0.47%	0.49%
	cc	11.19%	12.45%
	gg	3.65%	3.94%
vv	bb	0.40%	0.41%
	cc	3.84%	4.10%
	gg	1.49%	1.61%
vvH(WW fusion)			
vvH	bb	3.01%	3.16%
zh	bb	0.32%	0.32%
ZH			
Z	bb	0.28%	0.29%
	cc	3.27%	3.45%
	gg	1.28%	1.37%

WW/ZZ

Signal		250	240
Z	H		
H->WW			
ee	lvlv	9.36%	9.79%
	evqq	4.57%	4.77%
	μvqq	3.95%	4.10%
μμ	lvlv	7.35%	7.54%
	evqq	4.01%	4.07%
	μvqq	3.97%	4.07%
vv	qqqq	1.98%	2.09%
	evqq	4.68%	4.88%
	μvqq	4.18%	4.35%
	lvlv	11.30%	11.60%
qq	qqqq	1.84%	1.93%
H->ZZ			
vv	μμqq	7.96%	8.21%
vv	eeqq	39.50%	42.19%
μμ	vvqq	7.38%	7.56%
ZH			
Z	WW	1.00%	1.04%
	ZZ	5.12%	5.21%

Others

Signal		250	240
Z	H		
H->Invisible			
qq	ZZ(vvvv)	220.00%	245.00%
ee		325.00%	388.00%
μμ		229.00%	257.00%
Tot		150.24%	161.61%
H→γγ			
μμ+ττ	γγ	37.79%	41.13%
vv		9.86%	10.47%
qq		9.30%	10.39%
Tot		6.66%	7.38%
H→μμ			
qq	μμ	17.75%	18.70%
ee		61.38%	64.71%
μμ		86.10%	90.74%
vv		53.32%	56.93%
Tot		15.90%	16.84%
H→ττ			
ee	ττ	2.73%	2.86%
μμ		2.67%	2.74%
qq		0.98%	1.02%
vv		2.65%	2.81%
Tot		0.83%	0.87%