Issues in CEPC fit

Zhang Kaili

zhangkl@ihep.ac.cn

2018-04-09

Outline

- Various input
  - Number counting; Binned histogram, impact fit;
- H->invisible
  - shape information
- Fit result

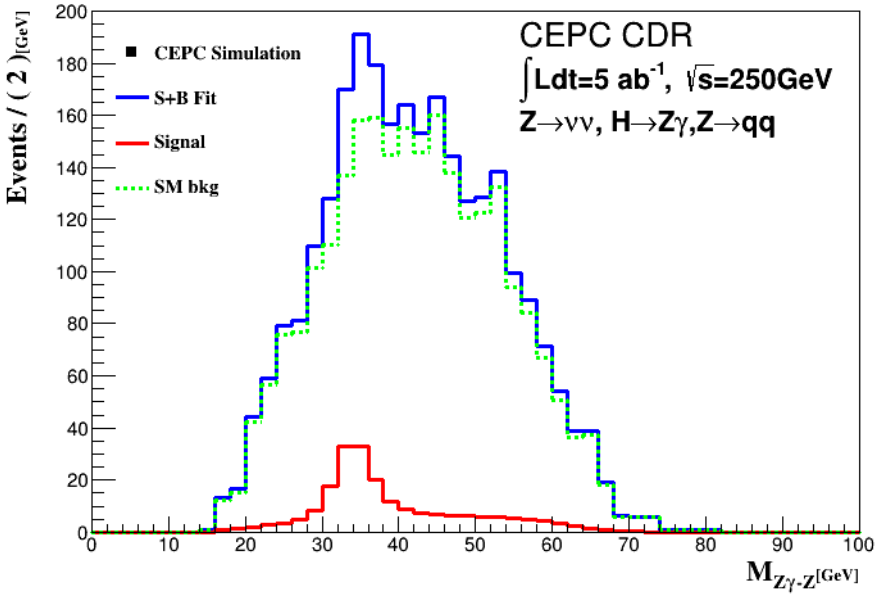
Fit for number counting

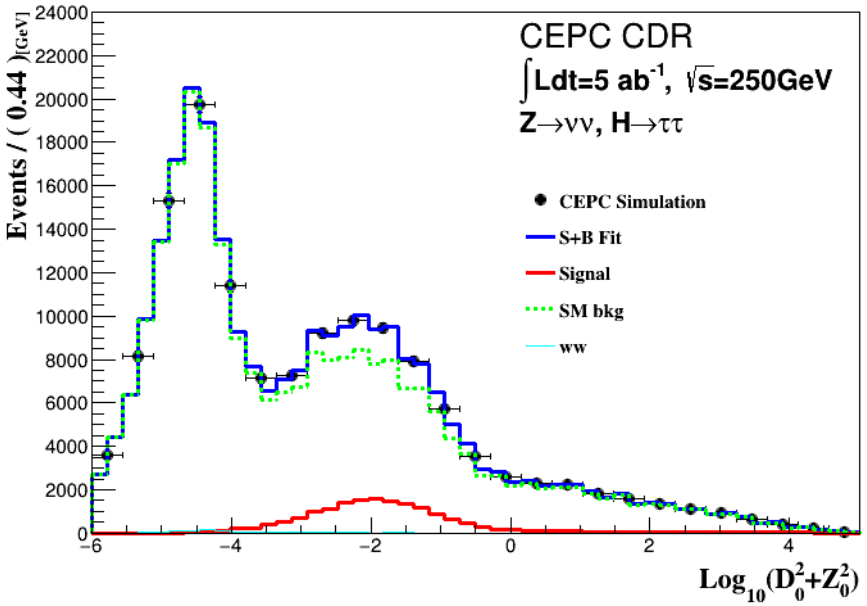
- If no available variable to show…… Like ZH->vv lvlv;
  - Create one bin dataset for them
  - Xianke's result:

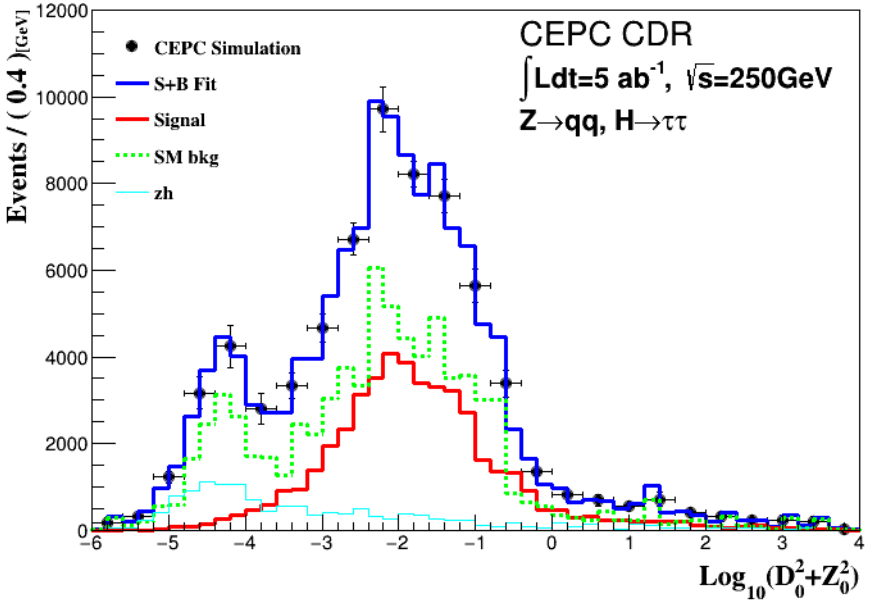
	signal	bkg	precision
evev	185.753	3036.92	30.5%
evmv	379.764	2541.68	14.2%
mvmv	205.45	2157.07	23.6%
Combined			11.3%

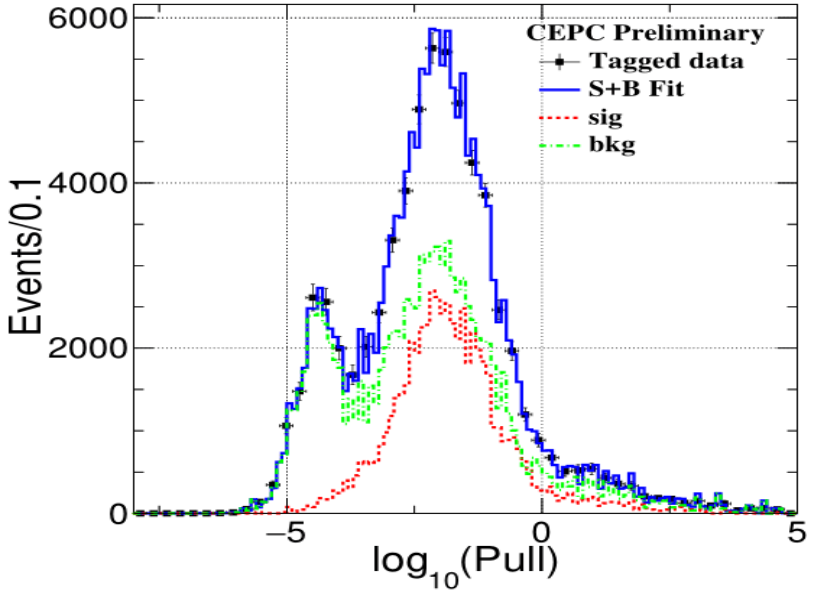
  - In the worst case, shape fit will be similar with number counting, and will be better in all other cases.

Binned fit









My qqtt impact parameter

Dan's

Inputs for the fit

- (After your final selection) distribution of signal & bkg
  - Mass(higgs & Z, invariant & recoil), 4 momentum
    - for further treatment on the shape
  - Event weight, if scaled
  - bkg, separate ZH/non ZH process and specify which ZH it is.
    - e.g H->WW, other modes like H->bb/cc/gg, ZZ, $\tau\tau$ … …
  - Mass ntuples (Most recommended) -> 1d unbinned fit
  - Flavor template/ Histograms -> 1/2d binned fit
  - esp. only signal/bkg event number -> 1d binned (1 bin) fit

We can use more npoints in Asimov data building to raise the precision;
But if the data is binned, no improvement would gain from that.
So the unbinned ntuples are most recommended.

H->invisible

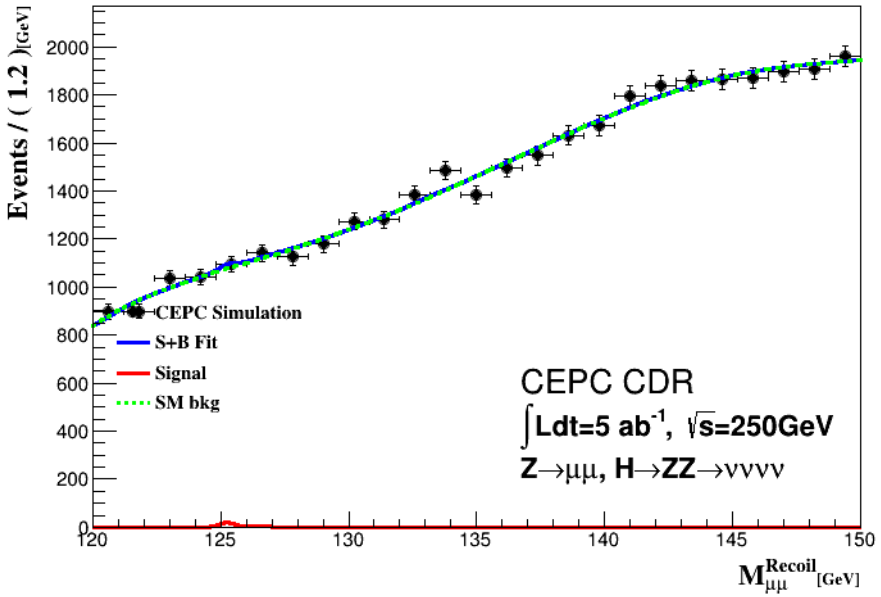
Why Z->qq has 10 times events of mm, and share the same precision?

Shape matters.

	signal	bkg	Mine
Z->ee	12.86	4205	$0.97 \pm 350\%$
Z->mm	23.69	36540	$1.00 \pm 242\%$
Z->qq	224.41	426540	$1.03 \pm 226\%$
Combined			$1.01 \pm 148\%$

- If simple number counting: ——ignore the shape distribution
  - z->mm: 500%. Current fit: 242%;
    - In fact (-597%, +402%), In low stats the asymmetric error must taken in to account.
  - If mm has the same events like qq: 82.3%
  - z->qq: 275% Current fit: 226%
    - Also gain improved from the shape information.
  - Same stats: 82.3% >> 226% > 275%.

Z->mm, variable range



The shape and range are totally different.

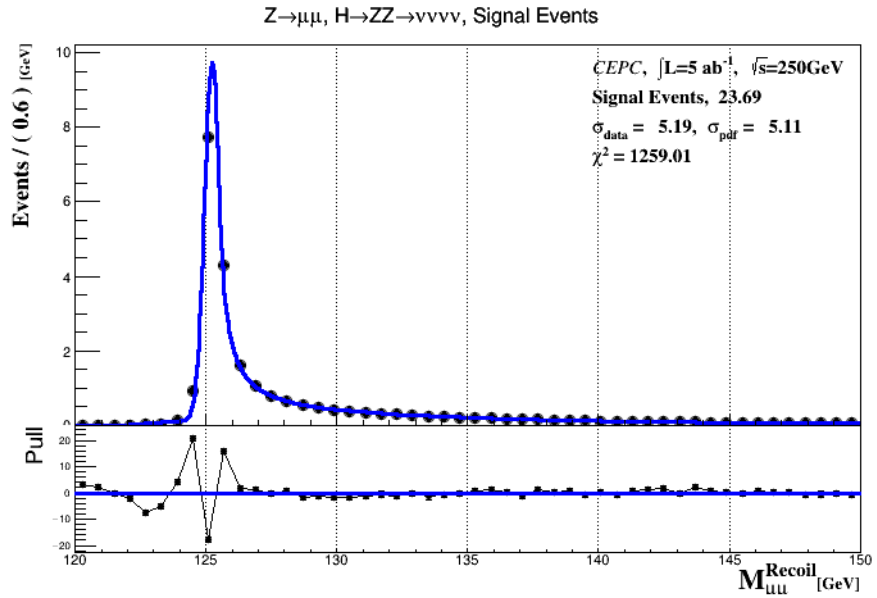
bkg with mass>130 contributes a little.

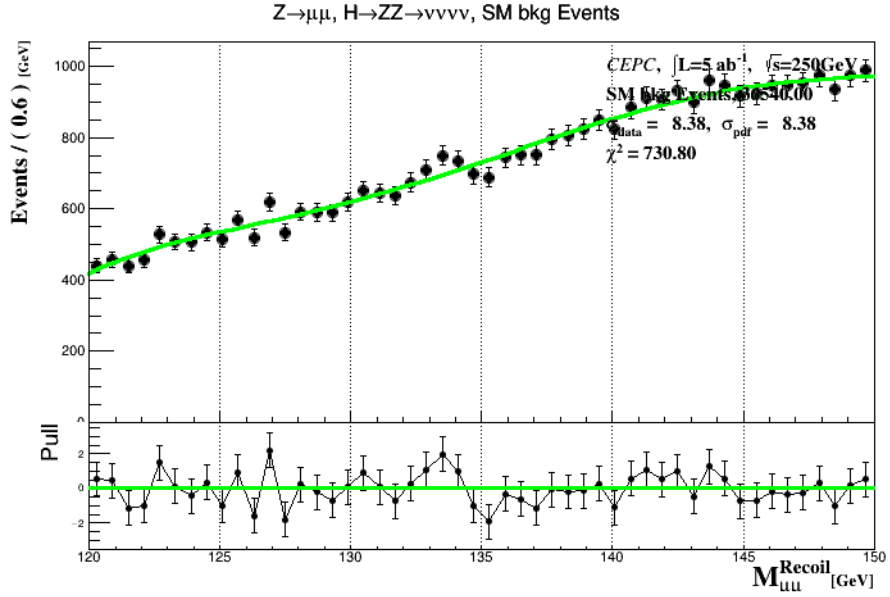
A cut on 130GeV -> signal lose;

Use shape-> correctly considered;

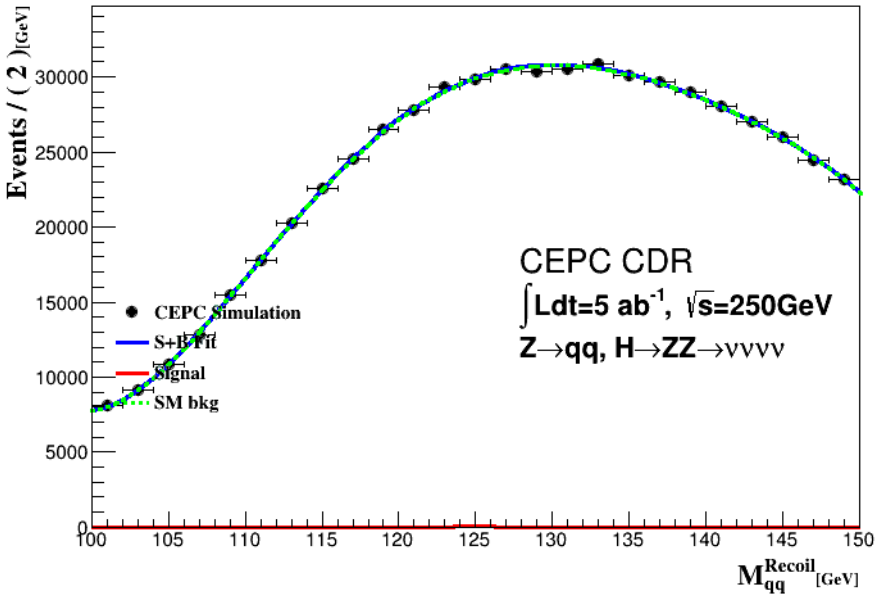
Actually use 120-130: 84.6%;

82.3% better.





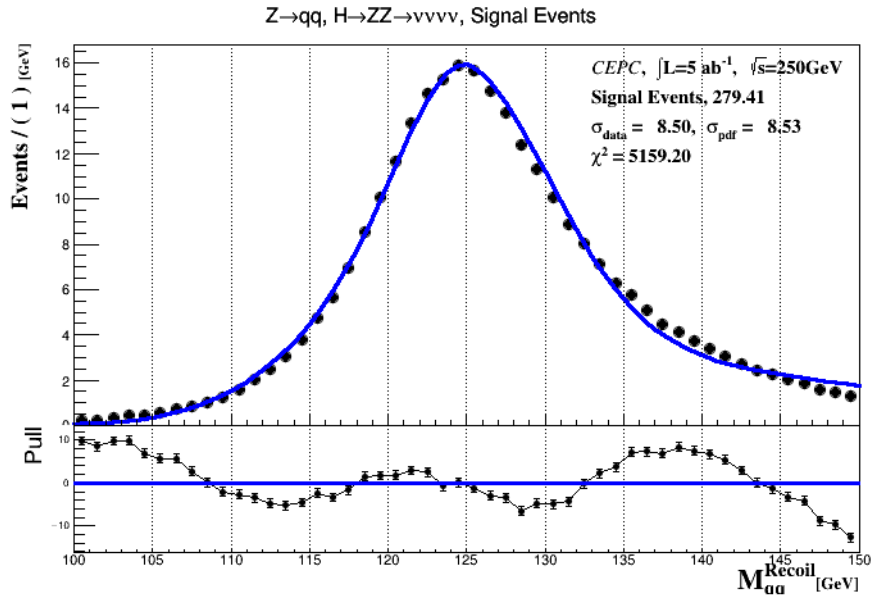
Z->qq, variable shape

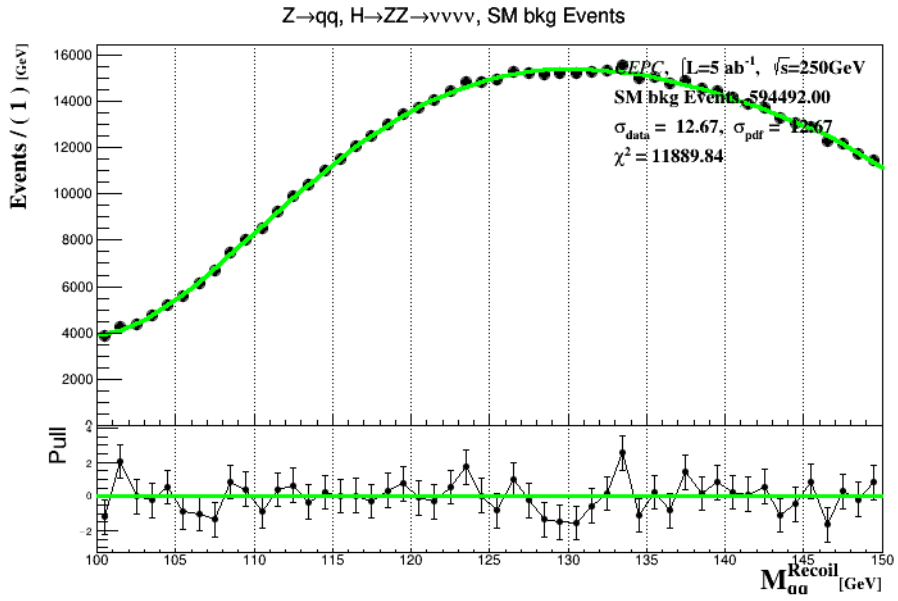


Even for the same range, different shape would help. 226% > 275%.

Shape more different, (like, a peak)

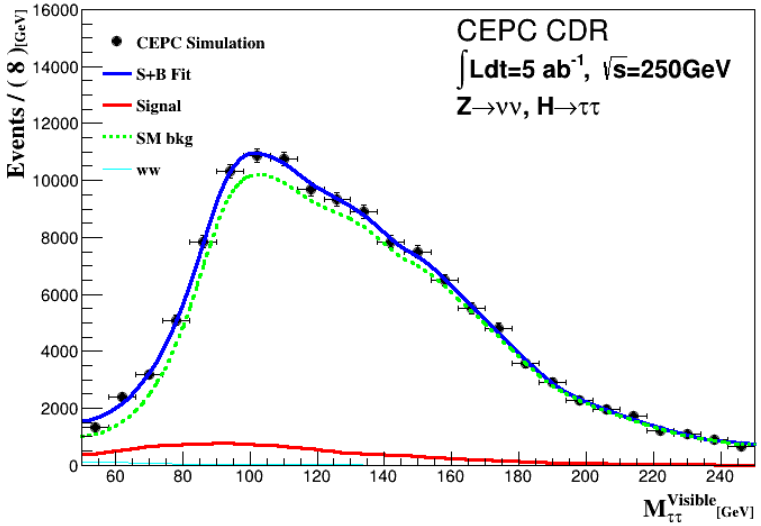
more improvement.



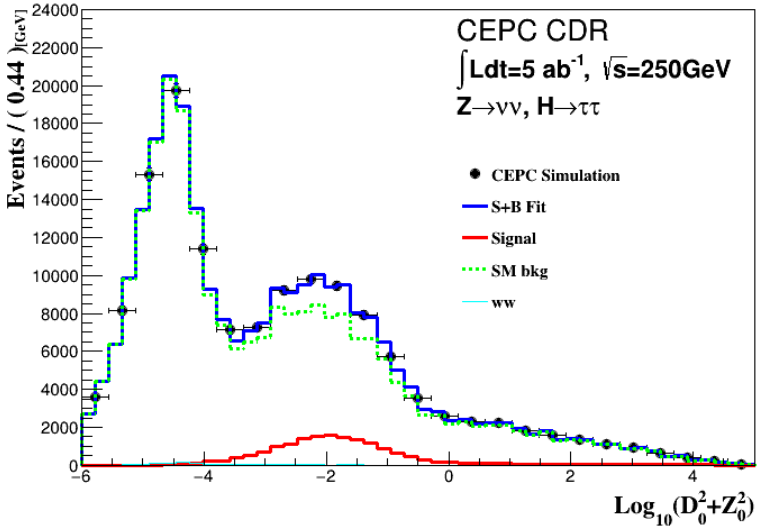


Z->ee/vv H→ττ

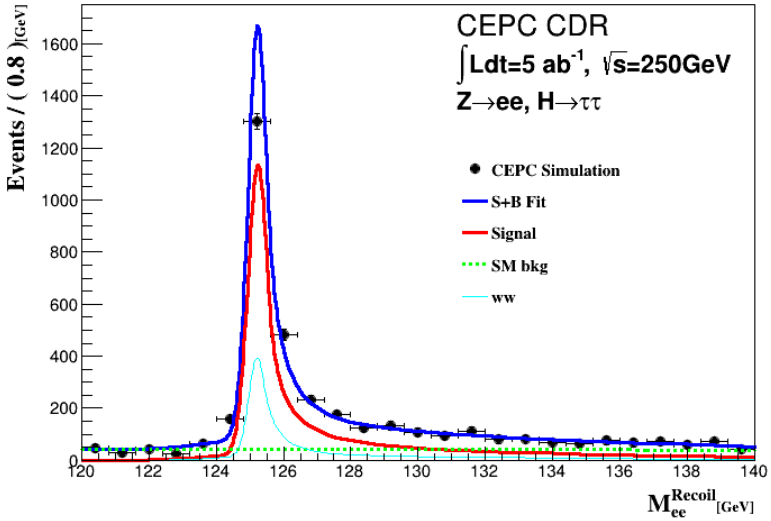
Z->vv, Visible Mass plot, 3.50%



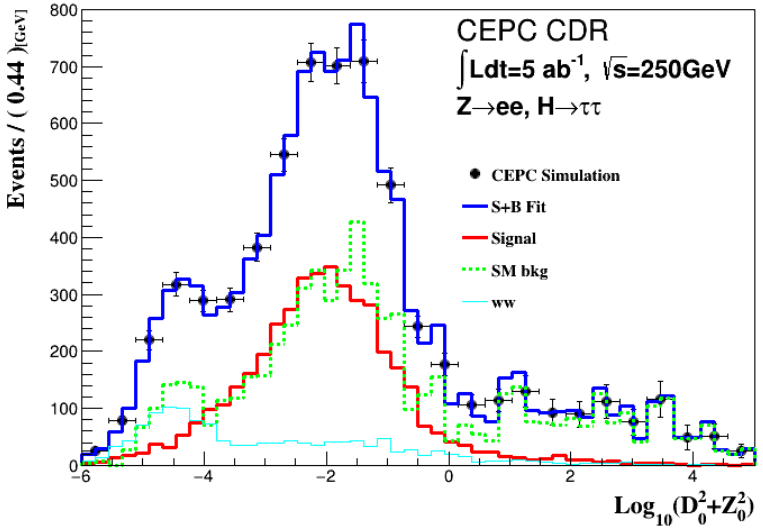
Z->vv, Impact parameter Fit, 3.10%



Z->ee, Mass plot, 2.97%



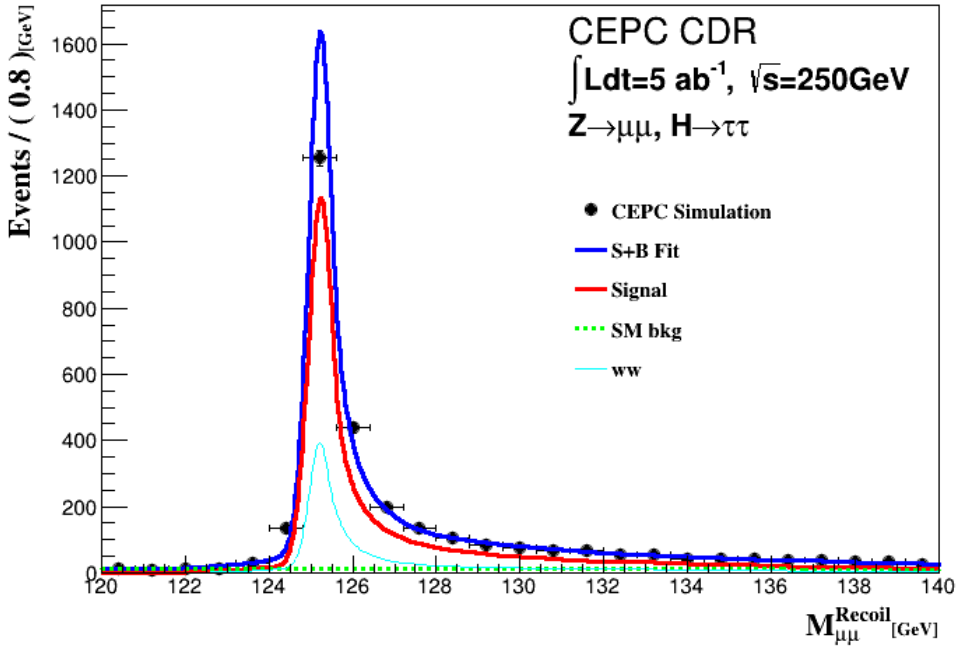
Z->ee, Impact parameter Fit, 3.37%



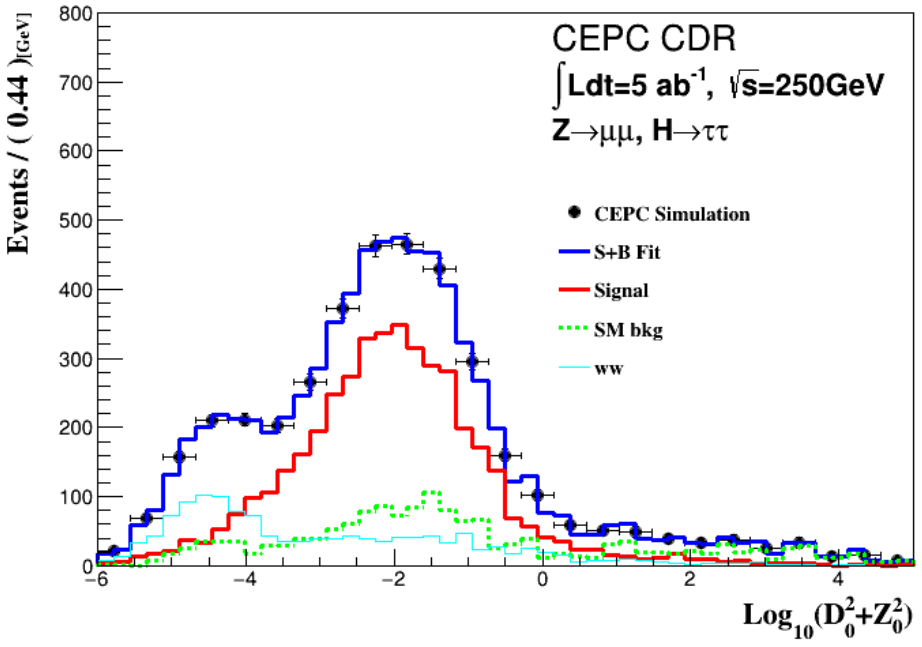
Z->mm H→ττ

But, if stats enough, variable in the same range, difference would not so obvious.
mm/ee: 4 times SM bkg.

mm, Mass plot, 2.78%



mm, Impact parameter Fit, 2.75%

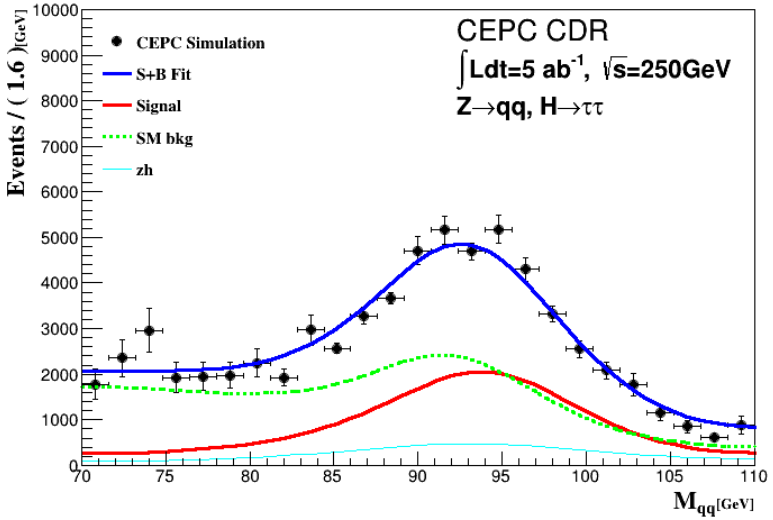


Mass fit worse may due signal loss ~4% since fit window.

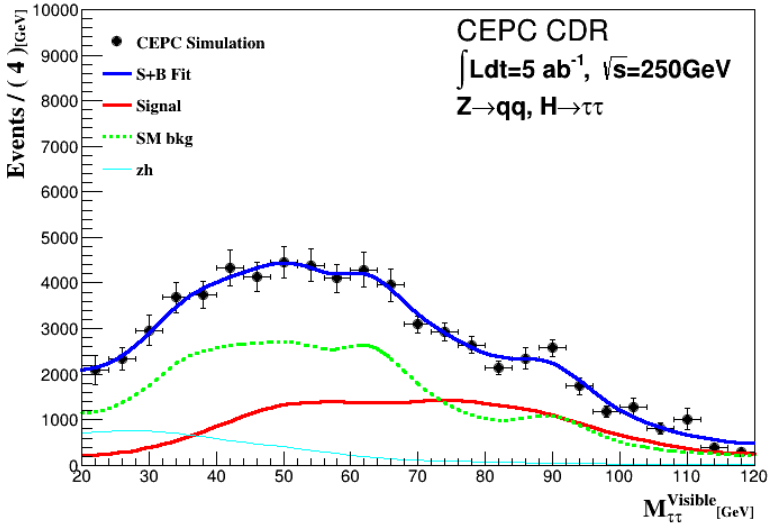
Z->qq H→$\tau\tau$

currently, choose the best result into combination.

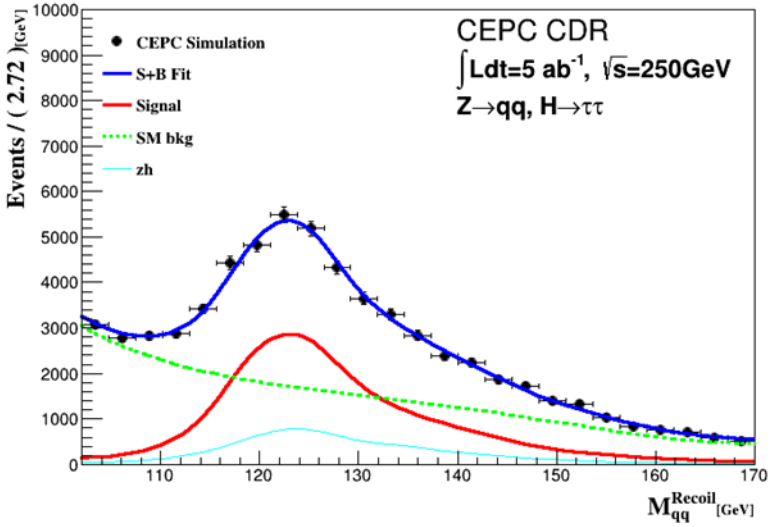
qq, qq Mass, 1.08%



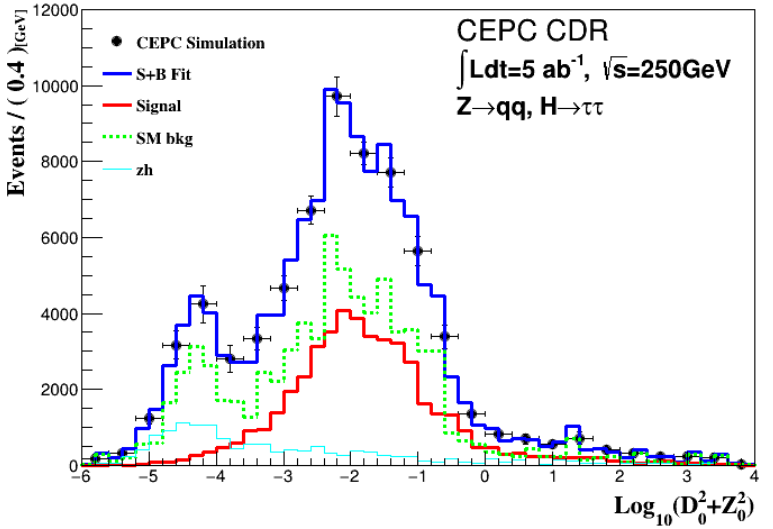
qq, Visible $\tau\tau$ Mass, 1.05%



qq, Higgs Mass (Recoil qq) plot, 1.02%



qq, Impact parameter Fit, 1.05%



Z->mm $H \rightarrow \gamma\gamma$, 3T fast simulation

By Guo Fangyi

- Signal: $e^+e^- \rightarrow ZH \rightarrow \mu\mu\gamma\gamma$
  Generated with Whizard-1.95 at $\sqrt{s} = 240\text{GeV}$

- Background: 240GeV 3T Fast simulation samples

	$\mu\mu$	$\tau\tau$	ZZ/WW	$Z + \nu$	W/Z+e
generated	20000000	10000000	1116511	219278	
$\mu\mu\gamma\gamma$ final state	1393678	6204	21507	923	0
Pass all selection	1099 (0.004%)	17 (0.0001%)	0	0	

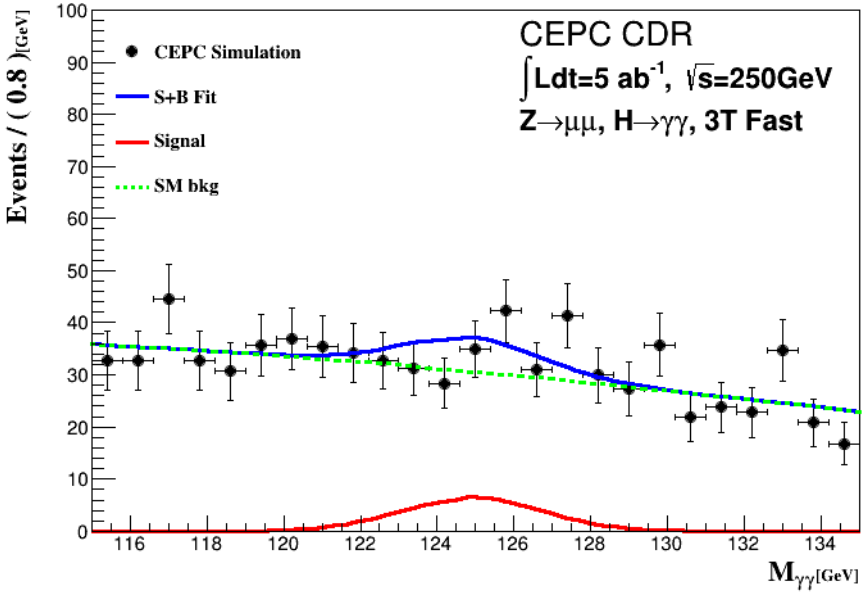
Main background: $\mu\mu$ background

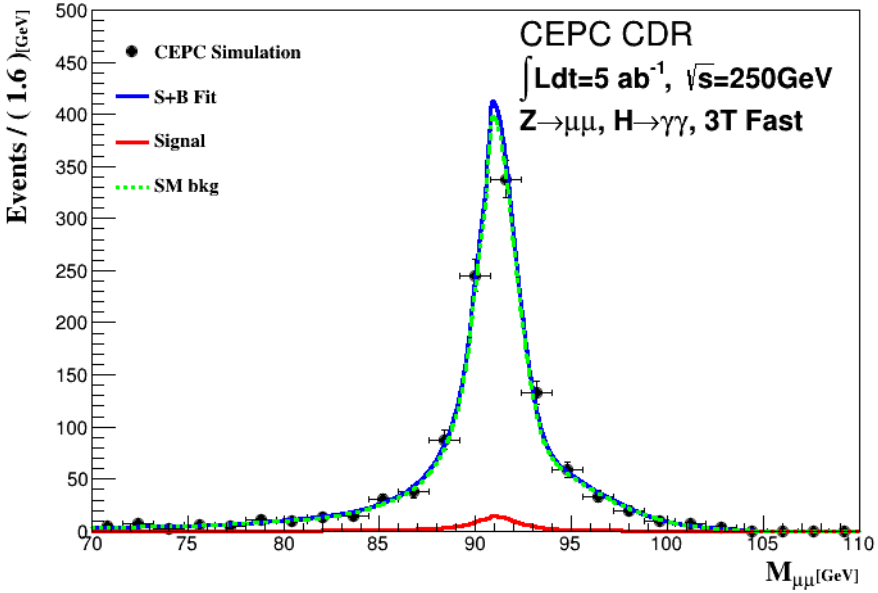
	Signal		background			
	mumu		mumu		tautau	
generated	100000		26930165		10000000	
mumuyy	138039	1.380	1393678	0.052	6204	0.001
E_y1>35	138035	1.000	264928	0.190	1711	0.276
35<E_y2<100	99557	0.721	68864	0.260	584	0.341
|costheta_y|<0.9	82895	0.833	24856	0.361	192	0.329
pT_y>20	82742	0.998	23958	0.964	185	0.964
86<recom_yy<100	64839	0.784	6118	0.255	65	0.351
110<m_yy<140	64646	0.997	2524	0.413	34	0.523
123<E_yy<142	64644	1.000	2387	0.946	27	0.794
|costheta_ly|<0.9	47048	0.728	1099	0.460	17	0.630
		0.470		4.08E-05		1.7E-6

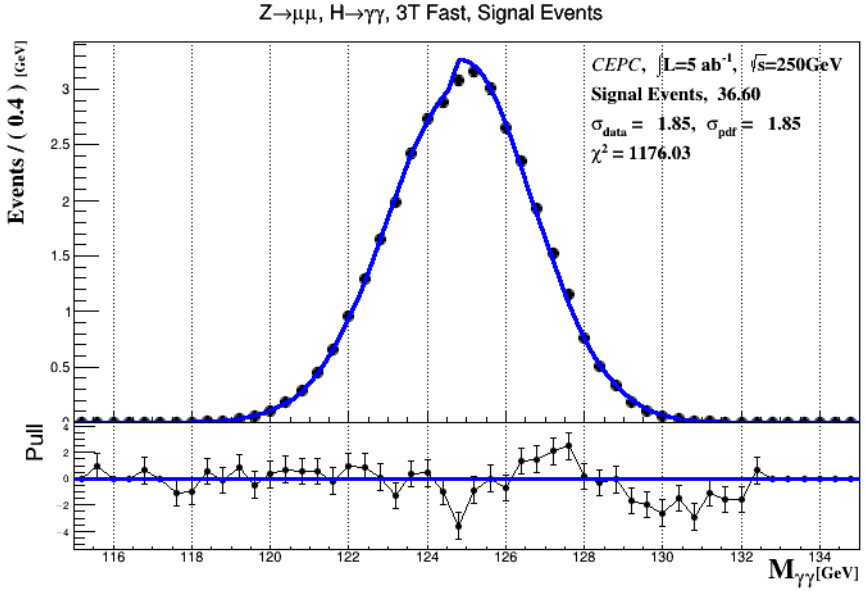
Selection efficiency : 47%

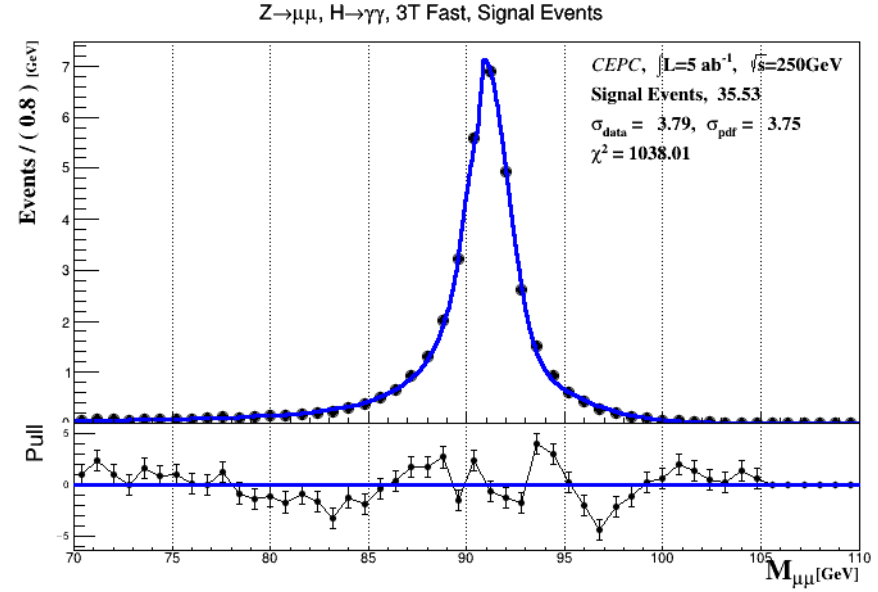
After scaling, 36 signal and 1042 bkg events left.
Could be improved.

Z->mm $H \rightarrow \gamma\gamma$, 3T fast simulation

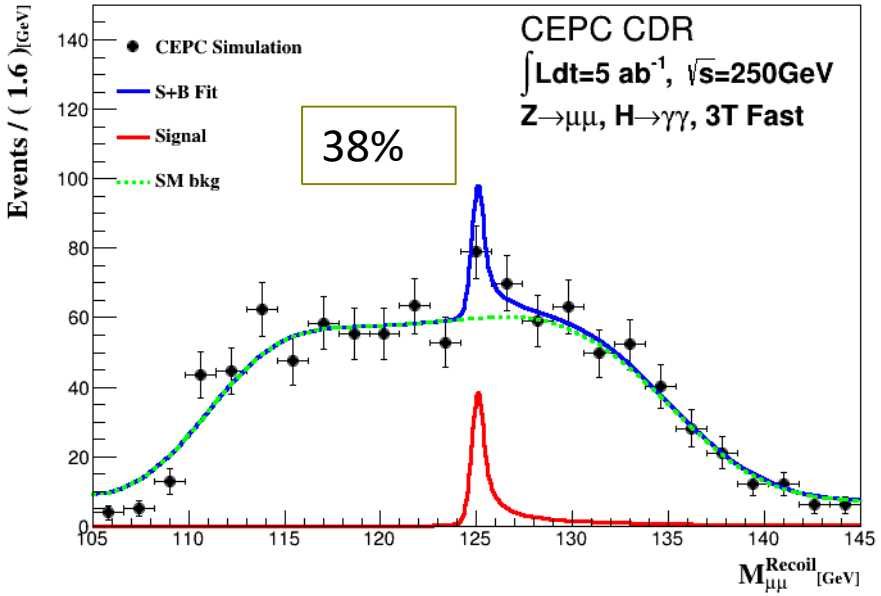


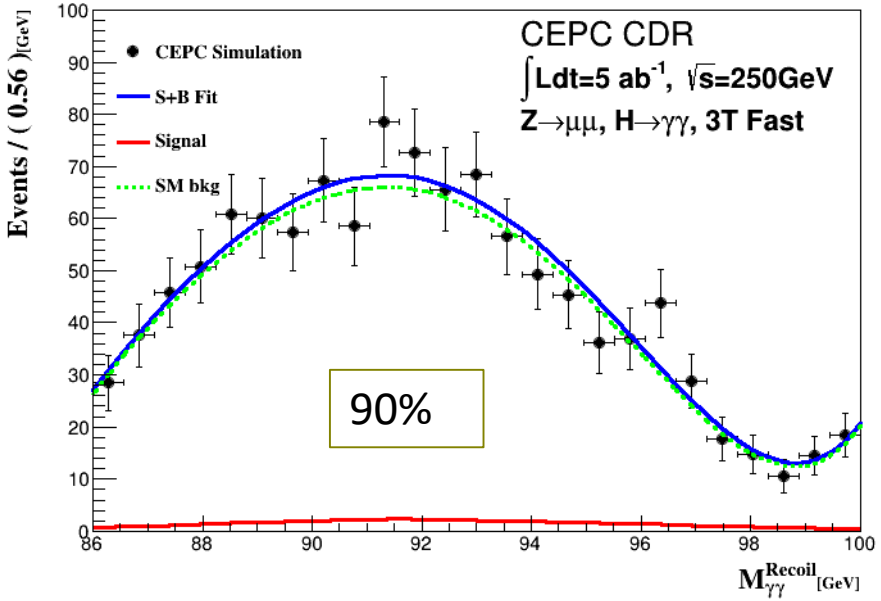


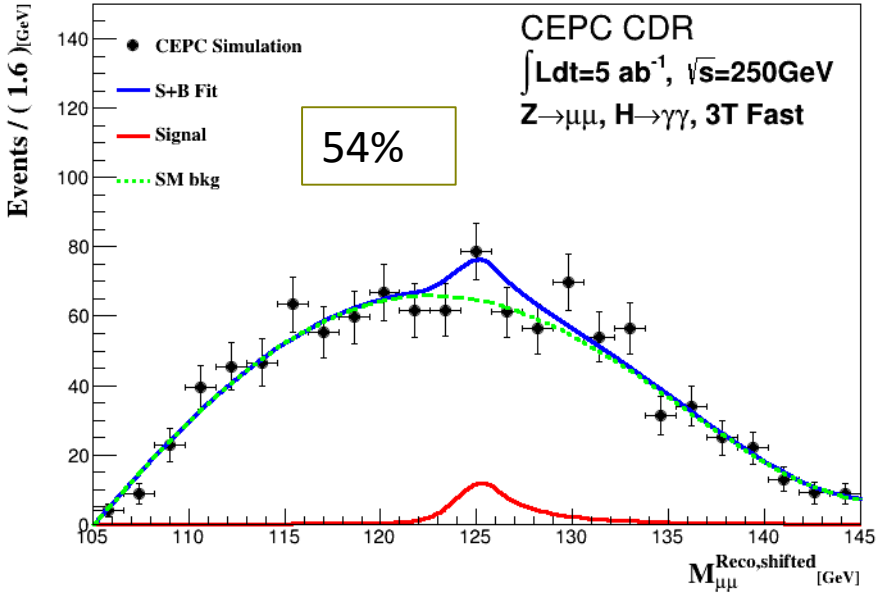


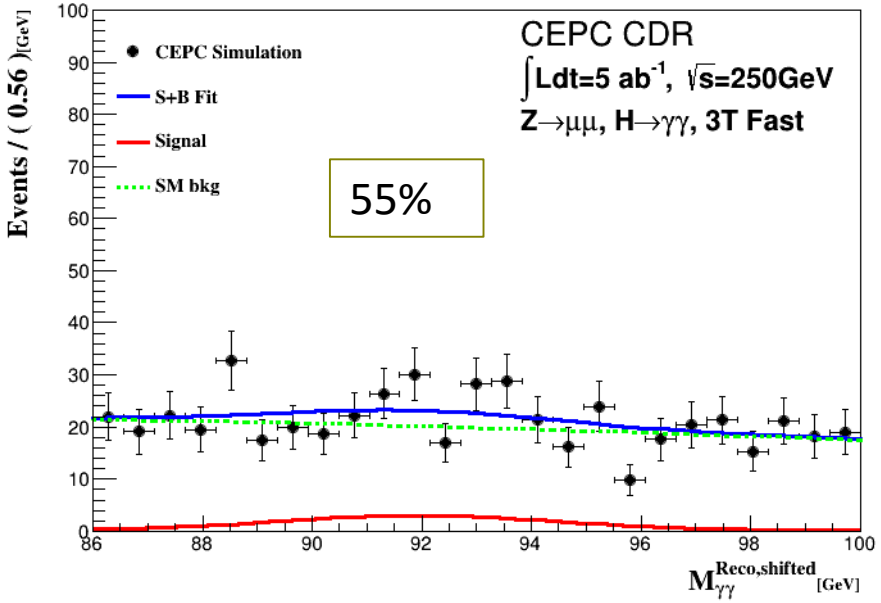


Z->mm $H \rightarrow \gamma\gamma$, 3T fast simulation









Channels Table

Done/Almost Done:

Signal		Precision
Z	H	
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		3.0%
qq		1.0%
νν		3.1%
H→γγ, Zγ		
μμ+ττ	γγ	24.8%
νν		11.7%
qq		12.8%
νν	Zγ(qqγ)	21.2%

Signal		Precision
Z	H	
H->WW		
μμ	μνμν	7.3%
	evev	
	evμν	
	evqq	4.0%
	μνqq	4.0%
ee	μνμν	9.2%
	evev	
	evμν	
	evqq	4.6%
	μνqq	3.9%
νν	qqqq	2.0%
	evqq	4.7%
	μνqq	4.2%
qq	lνqq	2.2%(ILC)
ZH bkg contribution		3.0%
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%

Signal		Precision
Z	H	
νν	bb	3.1%
Rare Decays		
H→μμ		
qq	μμ	15.9%
ee		
μμ		
νν		
H->Invisible		Br, Upper
qq	ZZ(νννν)	0.8%
ee		0.6%
μμ		0.6%

For H→$\tau\tau$, Dan's result:

Decay final state		Precision
$Z \to \mu^+\mu^-$	$H \to \tau^+\tau^-$	2.7%
$Z \to e^+e^-$	$H \to \tau^+\tau^-$	2.7%
$Z \to \nu\bar{\nu}$	$H \to \tau^+\tau^-$	4.4%
$Z \to q\bar{q}$	$H \to \tau^+\tau^-$	0.93%
Combined		0.81%

My H→$\tau\tau$: 0.88%

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%	
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{bb})$	0.28%	0.3%	0.3%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{cc})$	2.20%	3.5%	3.5%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{gg})$	1.60%	1.4%	1.4%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{WW})$	1.50%	1.0%	1.2%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{ZZ})$	4.30%	5.0%	5.2%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \tau\tau)$	1.20%	0.9%	0.9%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \gamma\gamma)$	9.00%	8.1%	8.2%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mu\mu)$	17%	15.9%	15.9%
$\sigma(\mathrm{vv}H) * \mathrm{Br}(\mathrm{H} \to \mathrm{bb})$	2.80%	3.1%	3.1%
$\mathrm{Br}_{\mathrm{upper}}(\mathrm{H} \to \mathrm{inv.})$	0.28%	0.42%	0.42%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to Z\gamma)$	\	4σ	4σ