Mass Shape Fit Issues

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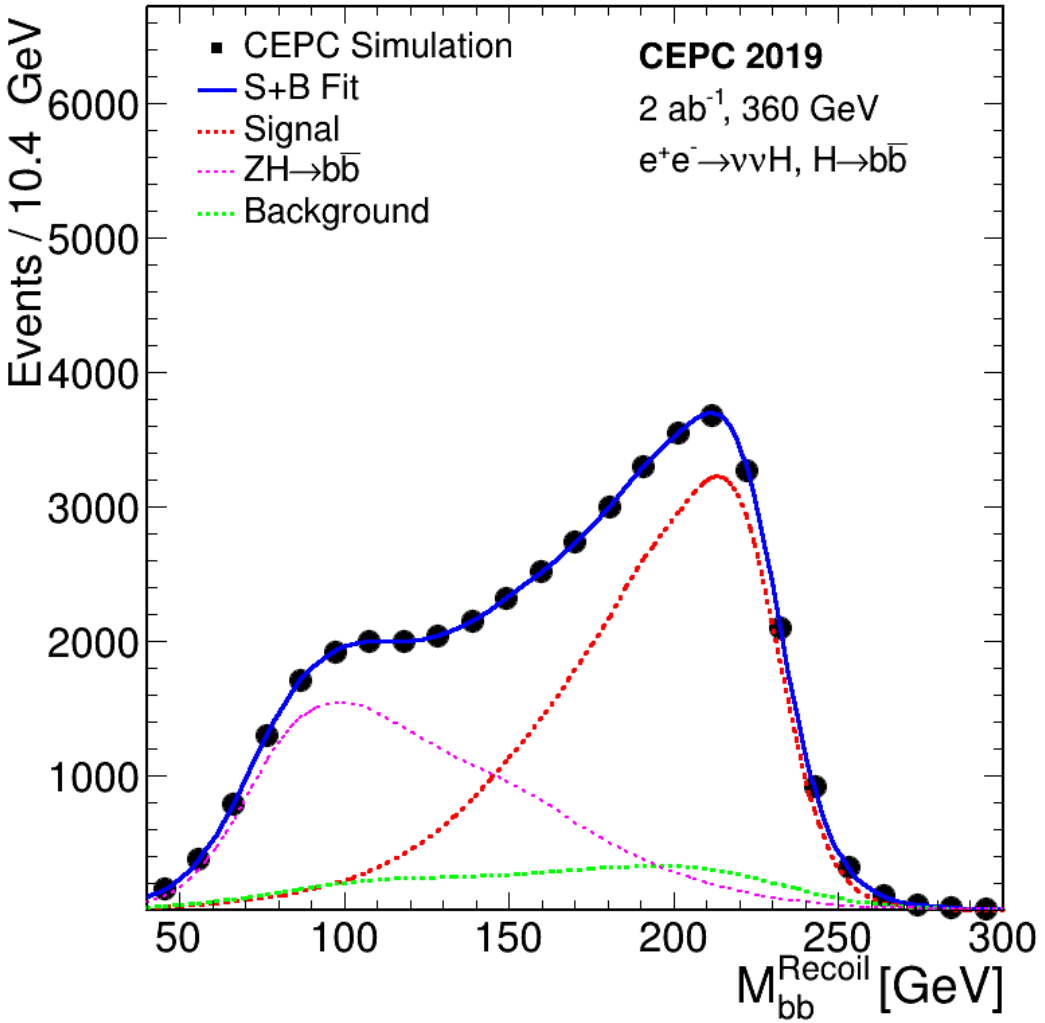
Traditional Recoil Mass

No qq, tt bkg yet.

Traditional Recoil Mass calculation

$$m^2_{recoil} = s - 2\sqrt{s}\mathrm{E}_\mathrm{h}^\mathrm{rec} + (\mathrm{m}_\mathrm{h}^\mathrm{rec})^2$$

0.764724%

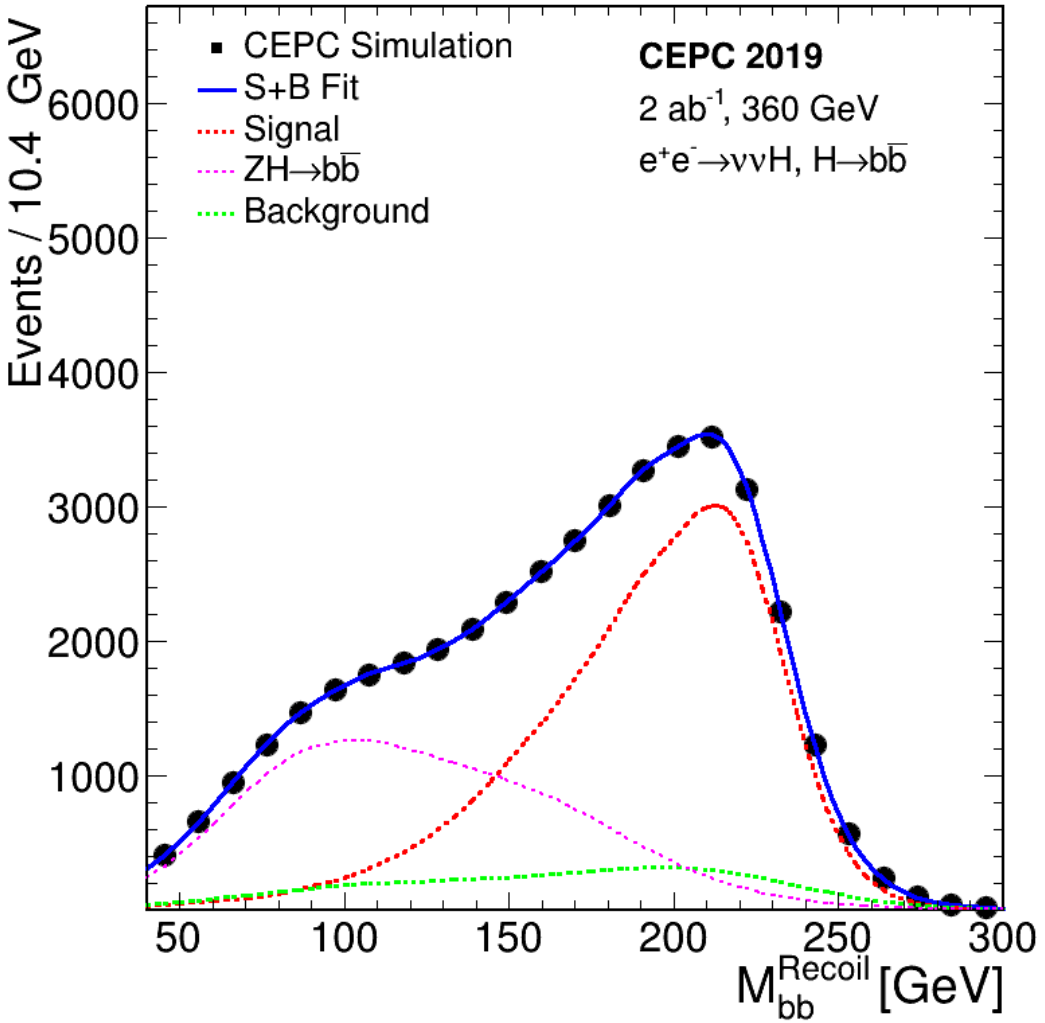


Recoil Mass with E

Recoil Mass with E

$$\left(m_{recoil}^{E}\right)^2 = s - 2\sqrt{s}E_h^{rec} + \mathrm{m_h^2}$$

0.774243%



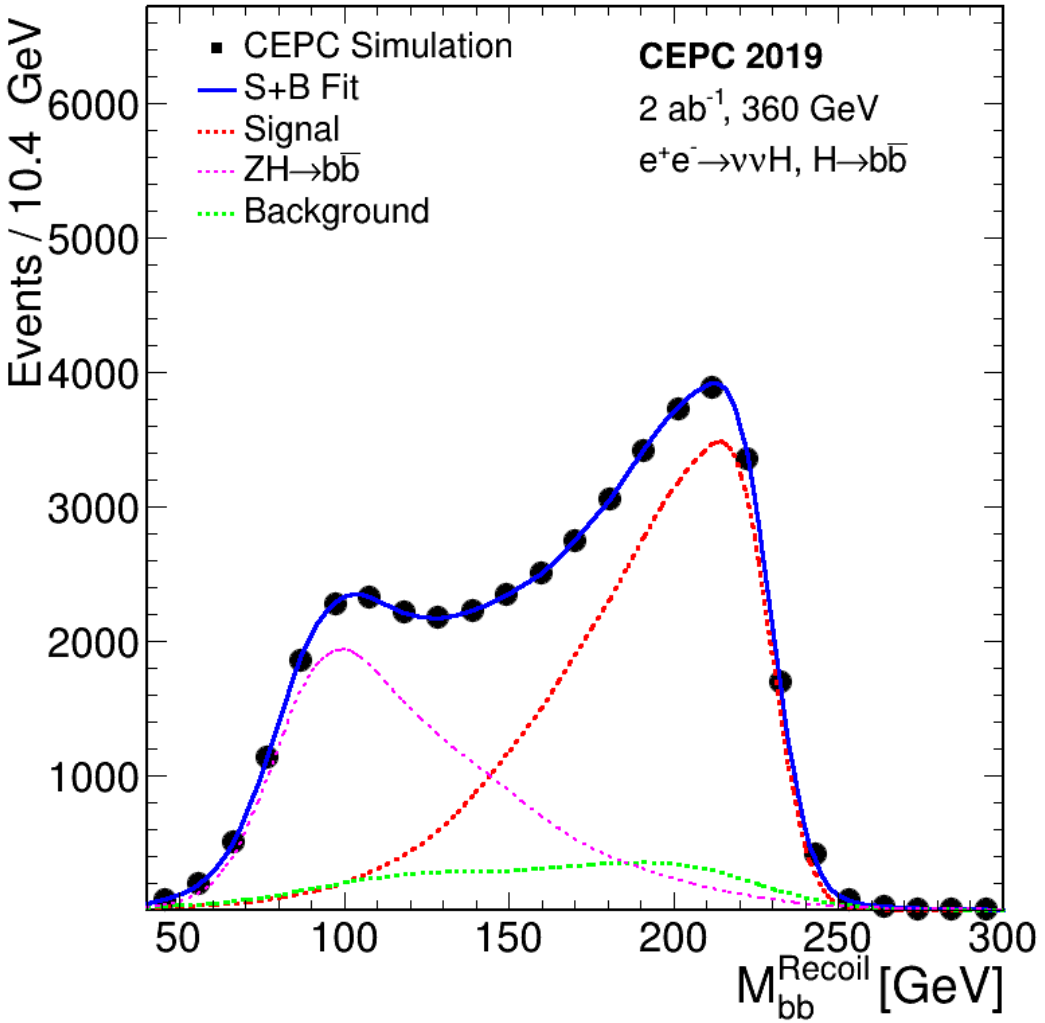
Recoil Mass with P

Recoil Mass with P

$$\left(m^{p}_{recoil}\right)^2 = s - 2\sqrt{s}\sqrt{m_h^2 + \left|p_h^{rec}\right|^2} + \mathrm{m_h^2}$$

(Fix dijet mass to mH, 125GeV)

0.756099%



Recoil Mass with scaled E/P

As $\Gamma = \frac{m_h}{m_h^{rec}}$:

$$\left(m_{recoil}^{shift}\right)^2 = s - 2\sqrt{s}\cdot\Gamma\cdot E_h^{rec} + \mathrm{m_h^2}$$

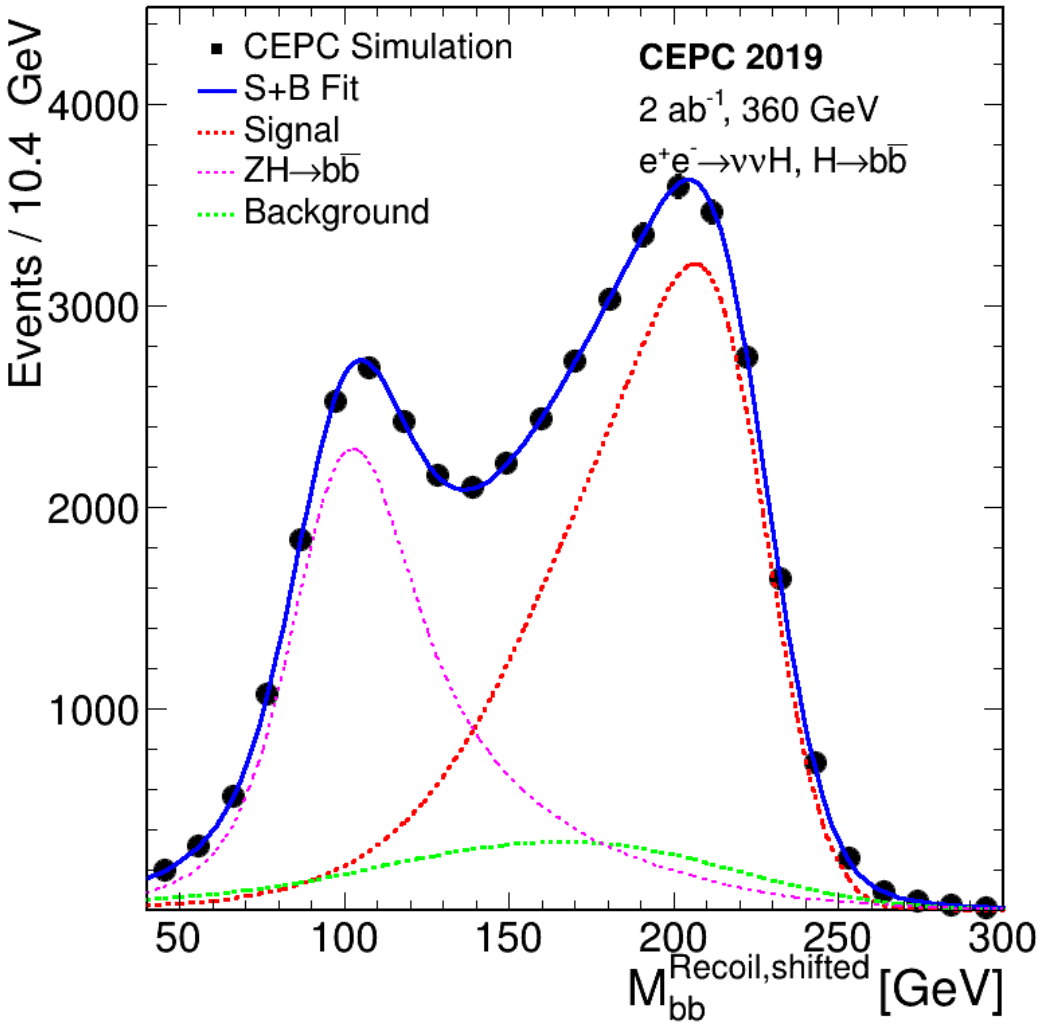
$$= s - 2\sqrt{s}\sqrt{m_h^2 + \left|\Gamma\cdot p_h^{rec}\right|^2} + \mathrm{m_h^2}$$

0.751558%

We see precision:

$$m_{recoil}^{shift} > m_{recoil}^{p} > m_{recoil} > m_{recoil}^{E}$$

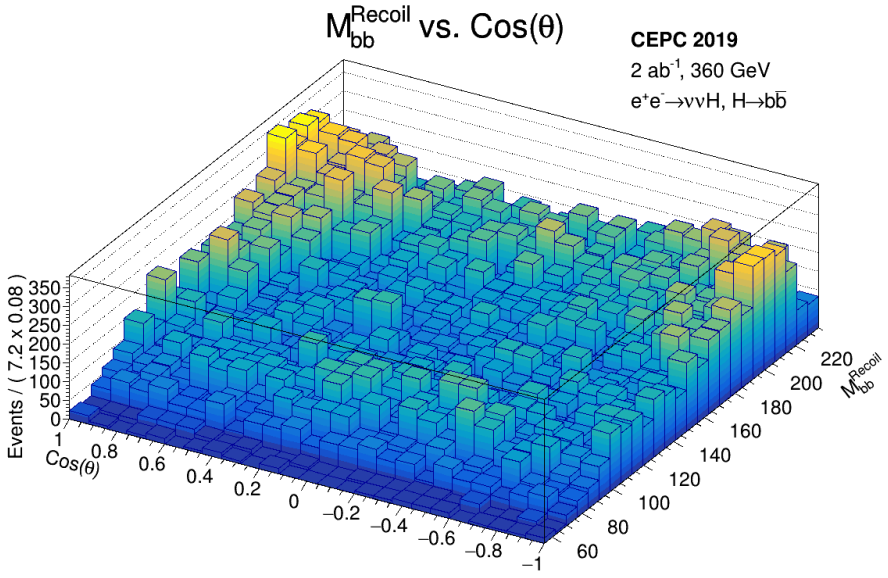
The shift recoil mass is equivalent to a simple kinematic fit.



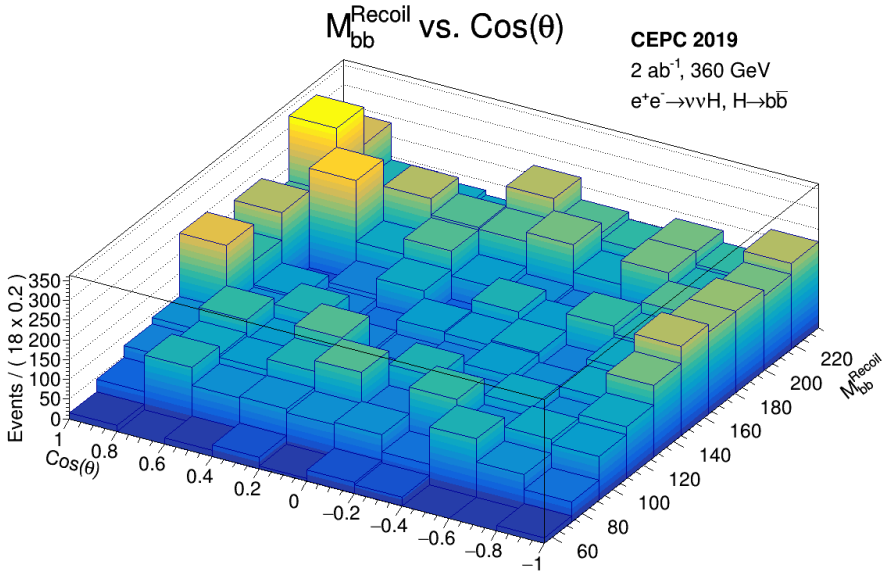
2d Recoil qq + Cos θ_{qq} Fit

- Hard to find 2d pdf to describe and fit
  - RooNDKeysPdf usually crash; RooHistPdf need small bin

Original Shape
Asymmetry but not big bias;
Cannot fit this shape so well;

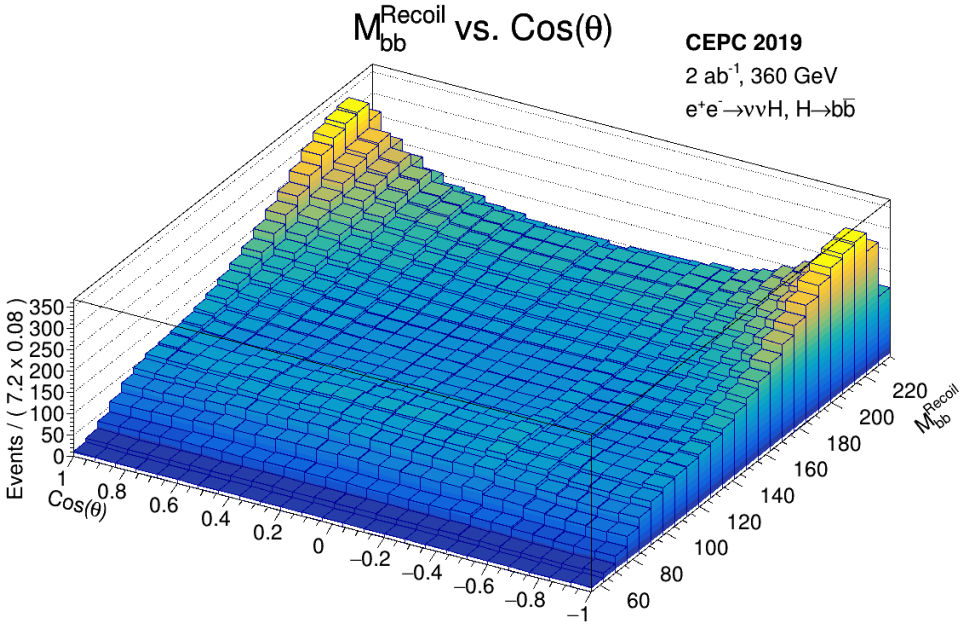


When bins 10*10;
0.753356%;
But hard to avoid the overfitting.



2d Recoil qq + Cos θ_{qq} Fit

- 1d*1d smooth pdf
  - Not considering the correlation
- Surely 2d pdf contains more information-> is that we want?



Need to determine to use which method.
In my own suggestion I would prefer 1d*1d smooth pdf.

0.756099%

Addition: Use M_{vis}

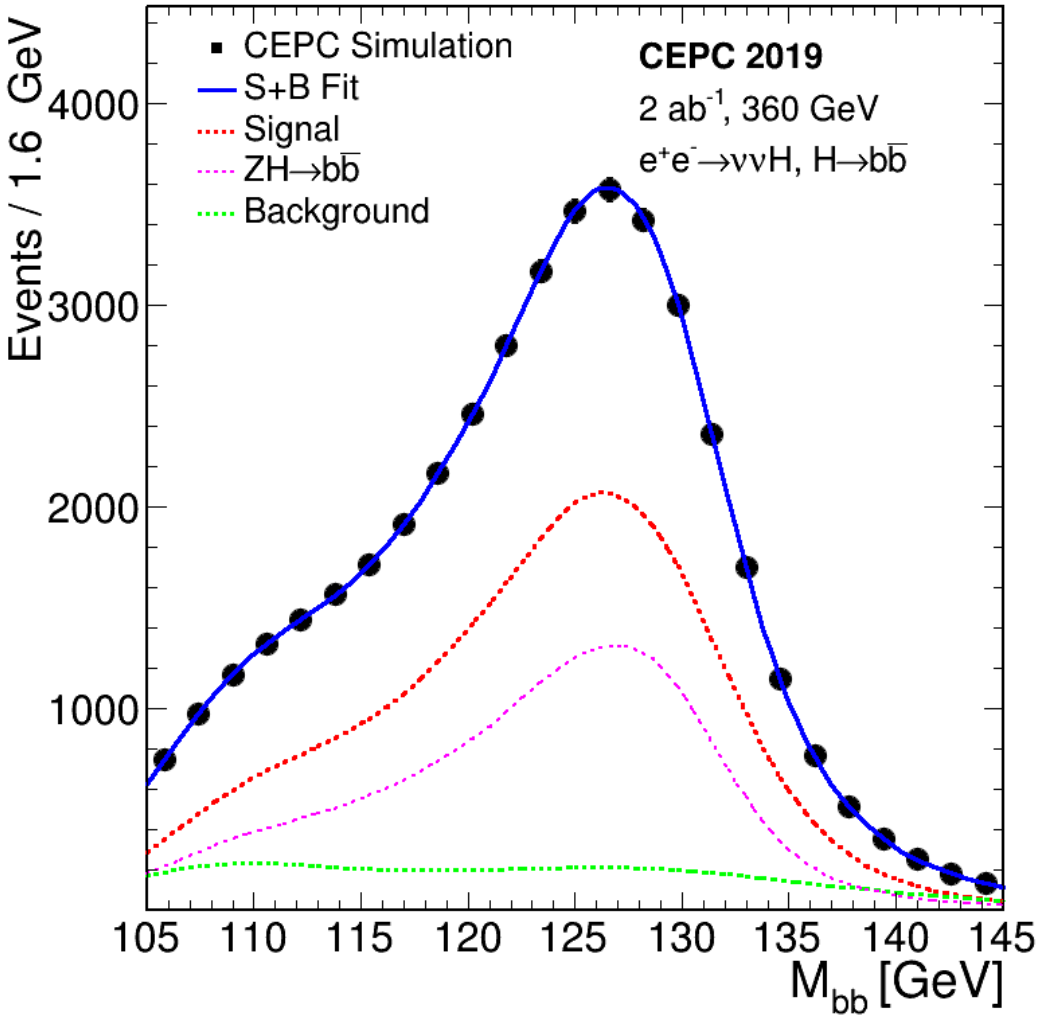
0.860352%

No shape information:

$$\frac{\sqrt{s+b}}{s} = 0.87\%$$

We see M_{bb} has no discrimination power at all, and the results are just like number counting.

Different shape information would have different benefits.



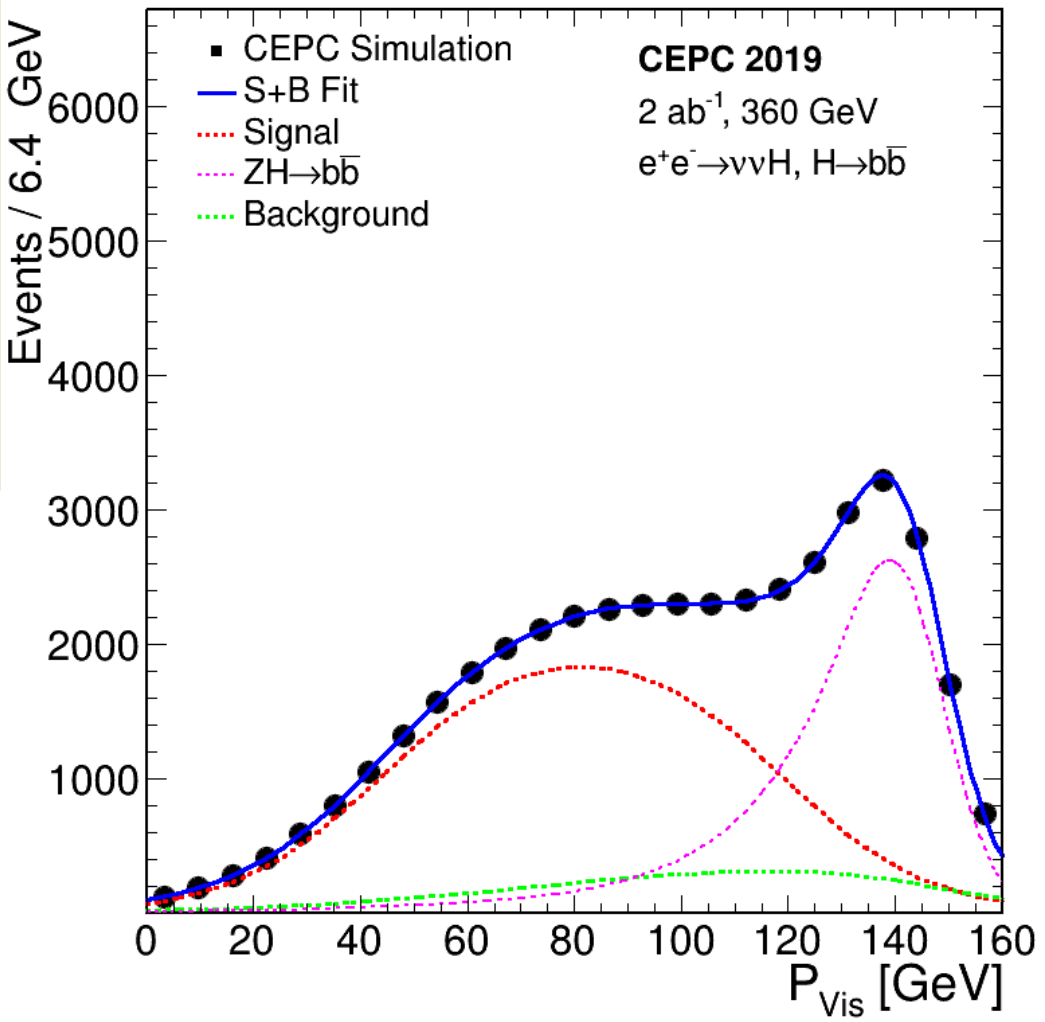
Addition: Use p_{vis}

As m^{p}_{recoil} is only determined by p_{vis},

use $p_{vis,total}$ to fit.

0.761704%

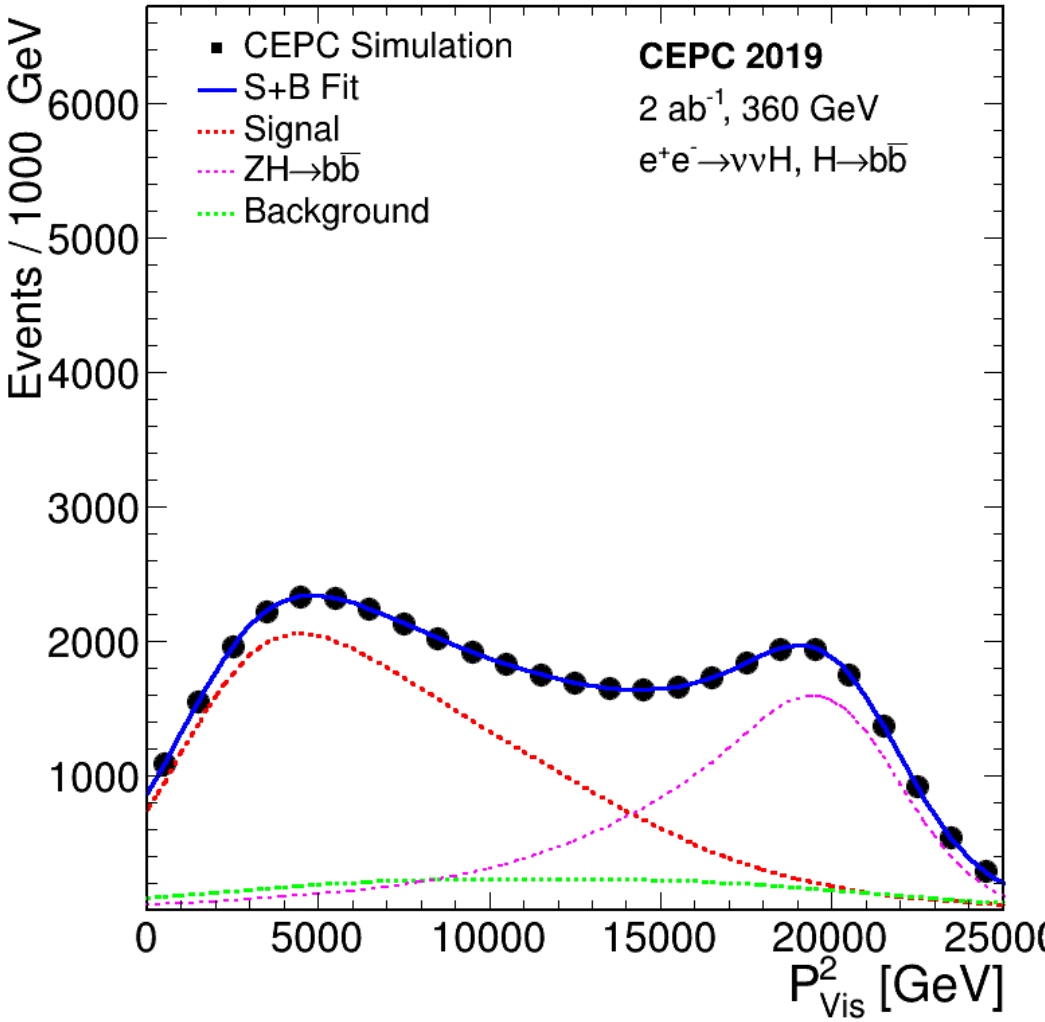
A little bit worse than m^{p}_{recoil}



Addition: Use p_{vis}^2

p_{vis}^2 : 0.757933%

Tier	Method	Precision
3	$\frac{\sqrt{s+b}}{s}$	0.87%
	M_{vis}	0.86%
2	m_{recoil}^{E}	0.77%
1	m_{recoil}^{p}	0.75%
	m_{recoil}^{shift}	0.75%
	m_{recoil}	0.76%
	p_{vis}	0.76%
	p_{vis}^2	0.76%
?	2d HistPdf Fit	0.75%



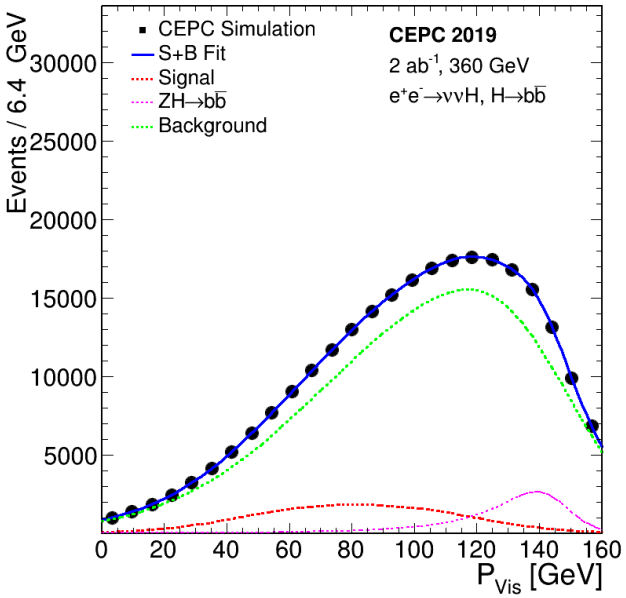
Small fluctuations could be biased.

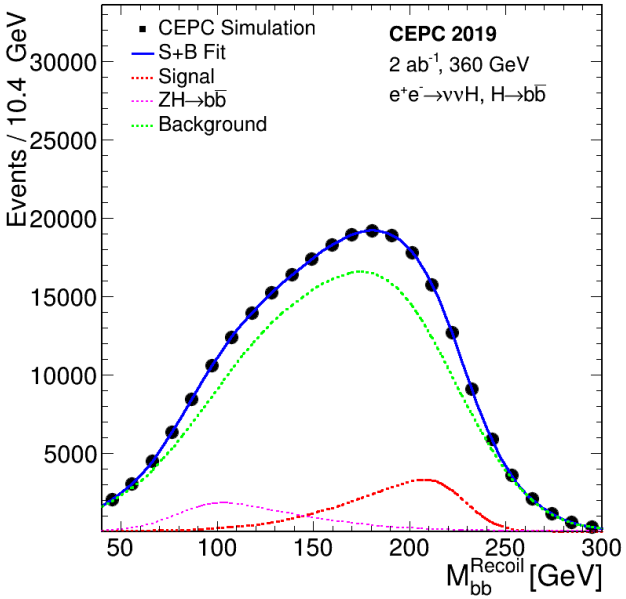
What if more bkg?

- bkg 50x

Method	Precision
$\frac{\sqrt{s+b}}{s}$	2.12985%
m^{E}_{recoil}	1.79579%
m^{p}_{recoil}	1.71843%
p_{vis}	1.81138%
p^{2}_{vis}	1.74613%
m_{recoil}	1.75134%

When bkg is larger, shape would more important in fits.





Conclusion

- Shape Matters.
  - Different recoil mass method corresponding to different correction.
  - $\left(m_{recoil}^{p}\right)^2 = s - 2\sqrt{s}\sqrt{m_h^2 + \left|p_h^{rec}\right|^2} + \mathrm{m_h^2}$
  - $\left(m_{recoil}^{shift}\right)^2 = s - 2\sqrt{s}\sqrt{m_h^2 + \left|\frac{m_h}{m_h^{rec}} \cdot p_h^{rec}\right|^2} + \mathrm{m_h^2}$
  - With assumptions. Some SM bkg can not use this shift.
- 2d pdf fit.
  - 2d RooHistPdf or 1d*1d Smooth shape;
  - personally I prefer 1d*1d. Easy to understand.
  - Need to see the 2d distribution first to avoid huge bias case.

yy+ML Signal Sample

HH->yy+multilepton

- AnalysisBase 21.2.72 and HGamCore tag v1.8.33-h024
- 1M (1l + >=2l) MC16ade events.
- σ = 27.5fb, filter weighted efficiency: #l = 1(17.1%), #l >= 2(10.0%)

- Samples: MC16a/d/e, 1M in total
  - mc16_13TeV.450697.aMcAtNloHerwig7EvtGen_UEEE5_CTEQ6L1_CT10ME_hh_yyXX1L.deriv.DAOD_HIGG1D1
  - mc16_13TeV.450698.aMcAtNloHerwig7EvtGen_UEEE5_CTEQ6L1_CT10ME_hh_yyXX2L.deriv.DAOD_HIGG1D1

Selections

- Good Event
  - Derivation; Duplicate; GRL; Trigger; DQ; Vertex……
  - B veto: WP: MV2c10_FixedCutBEff_70
- 2 Tight photons
  - Trigger: HLT_g35_loose_g25_loose/ HLT_g35_medium_g25_medium_L12EM20VH
  - Tight PID, Isolation
  - $\frac{pT_{y1}}{m_{yy}} > 0.35, \frac{pT_{y2}}{m_{yy}} > 0.25$
  - $pT_{y1} > 35\mathrm{GeV}, pT_{y2} > 25\mathrm{GeV}$
- TMW(Tight Mass Window): $\left|m_{yy} - 125.09\right| < 5\mathrm{GeV}$

Selections

- ≥ 1 Good leptons
  - IP: $z_0 < 0.5mm$; e: $\frac{d_0}{\sigma d_0} < 5$, μ: $\frac{d_0}{\sigma d_0} < 3$,
  - e: HV, OQ; μ: Not Bad;
  - Isolation, PID
  - $\eta_\mu < 2.7$, $\eta_e < 1.37\ or\ 1.52 < \eta_e < 2.47$.
  - Pt: 10 GeV
- If 2 lepton:
  - Opposite sign. Very rare for good leptons>2, so usually compare the largest 2 leptons
  - Z veto if $ee/\mu\mu(not\ e\mu)$, $|m_{ll} - 91.09| > 10$ GeV