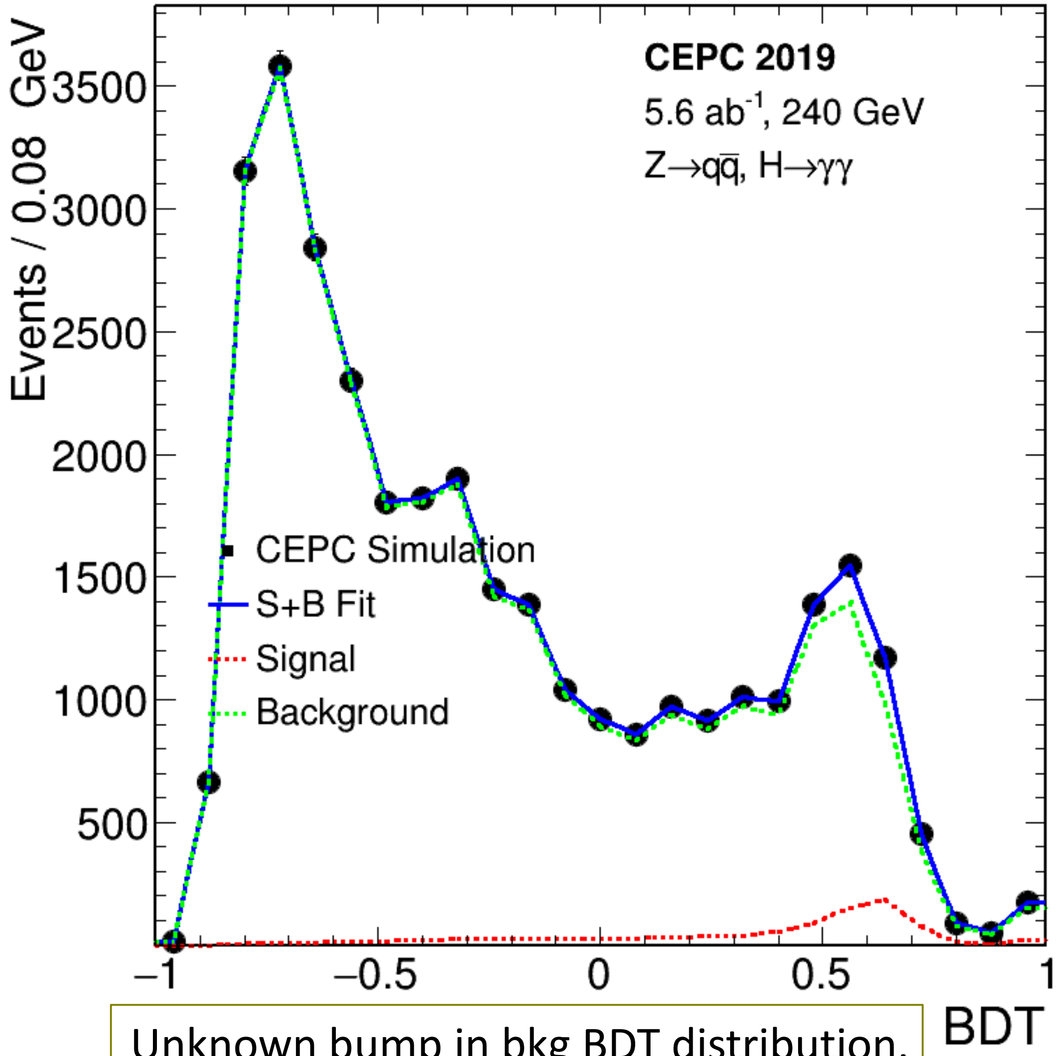
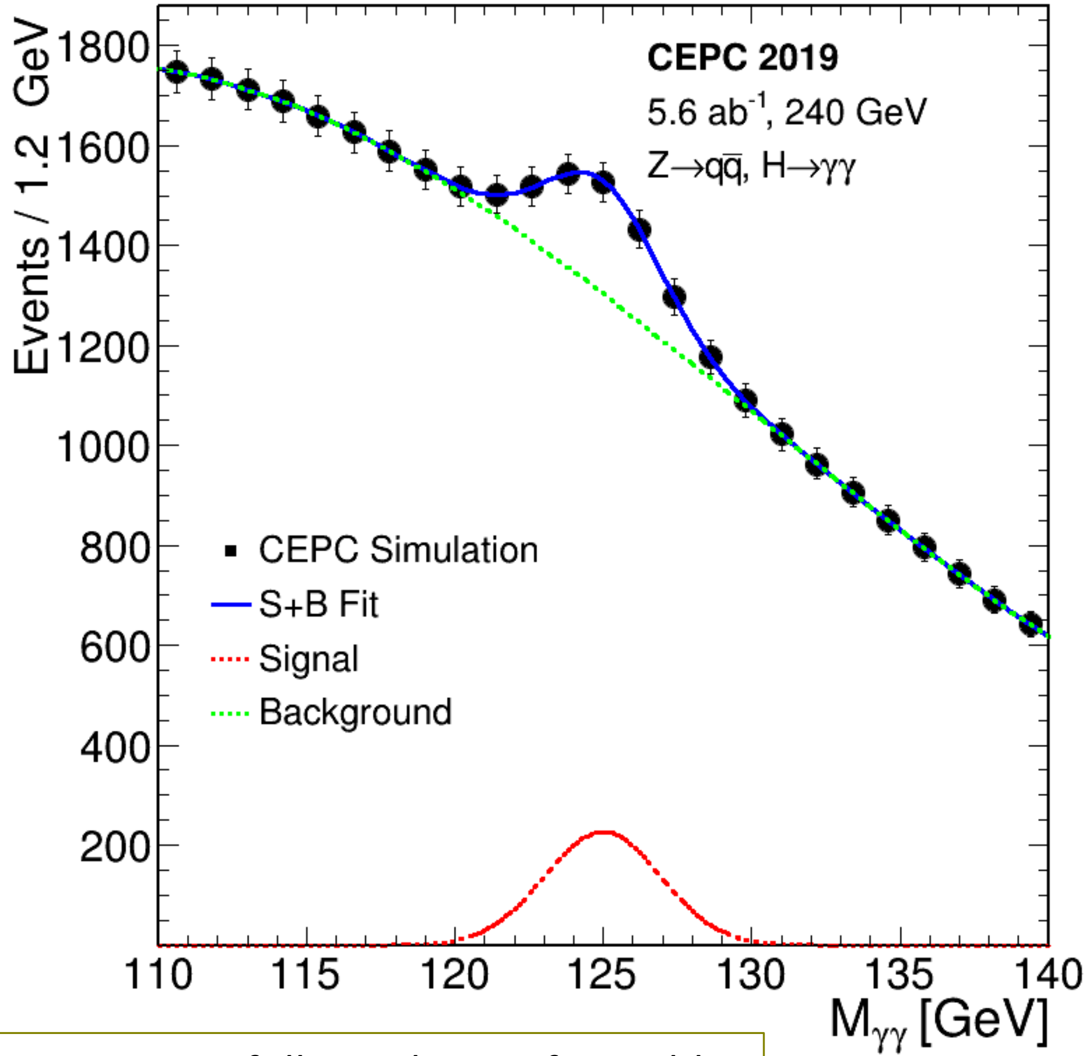
qqyy from Guo Fangyi

qqyy: 9.84% -> 6.60%
yy: 6.8% -> 5.4%

Add BDT response for 2d fit.



Unknown bump in bkg BDT distribution.
Would not show this plot in workshop.



Suggest: Turn to full simulation if possible.

Higher Energy Extrapolation @ CEPC Higgs

Kaili Zhang

2019-06-10

Existing results:240GeV, 5.6iab

($5.6ab^{-1}$)	CEPC 240
$\sigma(ZH)$	**0.50%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{bb})$	**0.27%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{cc})$	**3.3%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{gg})$	**1.3%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{WW})$	**1.0%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{ZZ})$	**5.1%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \tau\tau)$	**0.8%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \gamma\gamma)$	**6.8%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mu\mu)$	**12%**
$\sigma(\mathrm{vv}H) * \mathrm{Br}(\mathrm{H} \to \mathrm{bb})$	**3.0%**
$\mathrm{Br}_{\mathrm{upper}}(\mathrm{H} \to \mathrm{inv.})$	**0.26%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to Z\gamma)$	**16%**
Width	**2.8%**

- Fcc-ee (CERN-ACC-2018-0057) did:
  - 0.2 iab 350GeV + 1.5 iab 365GeV

$\sqrt{s}$ (GeV)	240		365	
Luminosity (ab^{-1})	5		1.5	
$\delta(\sigma BR)/\sigma BR$ (%)	HZ	$\nu\bar{\nu}$ H	HZ	$\nu\bar{\nu}$ H
$H \to$ any	±0.5		±0.9	
$H \to b\bar{b}$	±0.3	±3.1	±0.5	±0.9
$H \to c\bar{c}$	±2.2		±6.5	±10
$H \to gg$	±1.9		±3.5	±4.5
$H \to W^+W^-$	±1.2		±2.6	±3.0
$H \to ZZ$	±4.4		±12	±10
$H \to \tau\tau$	±0.9		±1.8	±8
$H \to \gamma\gamma$	±9.0		±18	±22
$H \to \mu^+\mu^-$	±19		±40	
$H \to$ invisible	< 0.3		< 0.6	

- CEPC Temporary benchmark: 2 iab 360GeV
  - 360 saves 10% energy
  - not determined yet

Signal Cross Sections

- 240GeV:
  - ZH: 196.9; vvH: 6.2; interference: ~10% of vvH; about 318:10:1; (Z->vv : vvH = 6.4:1)
  - interference are ignored in the following extrapolation.
- 350GeV: (vvH ~ 100% Z->vv), (eeH ~ 60% Z->ee)
- 360GeV: (vvH ~ 117% Z->vv), (eeH ~ 67% Z->ee)
- 365GeV: (vvH ~ 126% Z->vv), (eeH ~ 71% Z->ee)

ZZ fusion (2%) also cannot be ignored.

fb	240	350	360	365	360/240
ZH	196.9	133.3	126.6	123.0	-36%
WW fusion	6.2	26.7	29.61	31.1	+377%
ZZ fusion	0.5	2.55	2.80	2.91	+460%
Tot	203.6		159.0		
Tot Events	1.14M		0.32M		

bkg cross sections

pb	240	350	360	365	365/240
ee(γ)	930	336	325	319	-66%
$\mu\mu$(γ)	5.3	2.2	2.1	2.1	-60%
qq(γ)	54.1	24.7	23.2	22.8	-58%
WW	16.7	10.4	10.0	9.81	-41%
ZZ	1.1	0.66	0.63	0.62	-44%
tt	\	0.155	0.317	0.369	
sZ	4.54	5.72	5.78	5.83	+28%
sW	5.09	5.89	6.00	6.04	+19%

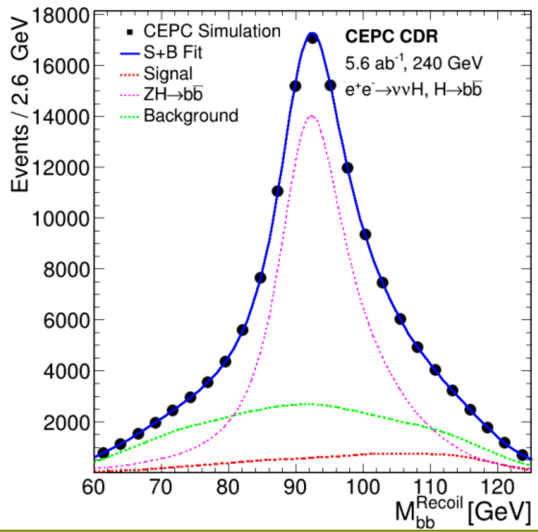
Most channels are 4f bkg dominant, usually ZZ.
$ee \to t\bar{t} \to WW^{*}b\bar{b}$ would be 6 jets/ llvv+2jets. would have similar behavior with 4f.
Need MC sample to validate the performance.

Now Assume that $t\bar{t}$ would have 20% contribution similar with ZZ.
From 0.63 to 0.7pb.

Extrapolation strategy

- yields: scale by cross section;
- shape:
  - dimuon: worse resolution; from ~0.3GeV to 1GeV;
  - diphoton: better resolution; from ~2.5GeV to 2GeV;

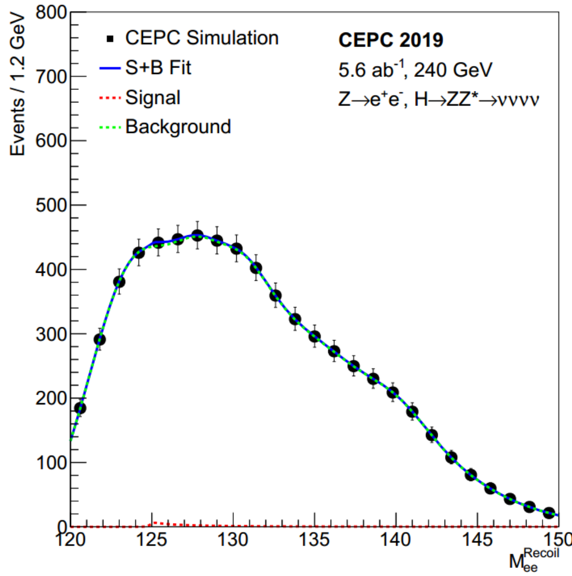
  - inv/rec mass:
    - if it is corresponding to Z/H system, would stay the same;
    - other recoil H/Z/W spectrum would also scale a factor to shift;



In 240GeV, vvH peak at 115GeV. Would shift to 235GeV instead.

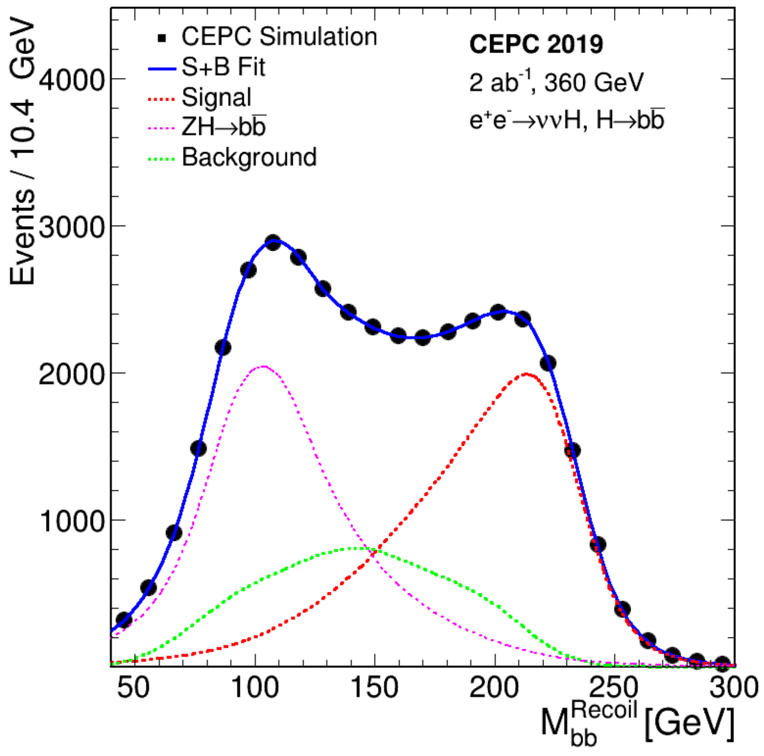
bkg shape

- phase space distribution, would spread to wider range;
  - scale 360/240, 1.5;
- if bkg scale factor 1.5, (or higher), range 120-150 would from 80-100.
  - information missing in current data files.
- In turn we assume bkg stay the same shape in signal region
  - scale 240/360, 149/269 ……
- Would check the 360GeV sample for more details.



vvH->bb

- Use Hao's fast simulation 360GeV sample
  - ZH and vvH BMR(Boson Mass Resolution) 4%, Eff 50%
  - Bkg scaled from 240 case
    - would be less if selection more strict;
  - Fix ZH part; vvH 0.95%;
  - Float ZH part; vvH 0.99%;
  - Considering other ZH constrain: 0.95%.



Results

	$5.6ab^{-1}$, 240	$2ab^{-1}$, 360	$1.5ab^{-1}$, 360
$\sigma(ZH)$	**0.50%**	****	
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{bb})$	**0.27%**	**0.62%**	**0.71%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{cc})$	**3.3%**	**6.2%**	**7.2%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{gg})$	**1.3%**	**2.4%**	**2.7%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{WW})$	**1.0%**	**2.0%**	**2.3%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{ZZ})$	**5.1%**	**12%**	**14%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \tau\tau)$	**0.8%**	**1.5%**	**1.7%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \gamma\gamma)$	**6.8%**	**9.4%**	**10.9%**
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mu\mu)$	**12%**	**29%**	**33%**
$\sigma(\mathrm{vv}H) * \mathrm{Br}(\mathrm{H} \to \mathrm{bb})$	**3.0%**	**0.95%**	**1.1%**
$\mathrm{Br_{upper}}(\mathrm{H} \to \mathrm{inv.})$	**0.26%**	****	****
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to Z\gamma)$	**16%**	**25%**	**29%**
Width	**2.8%**	**1% ?**	

Fcc:

$\sqrt{s}$ (GeV)	240		365	
Luminosity (ab^{-1})	5		1.5	
$\delta(\sigma BR)/\sigma BR$ (%)	HZ	$\nu\bar{\nu}$ H	HZ	$\nu\bar{\nu}$ H
$\mathrm{H} \to$ any	± 0.5		± 0.9	
$\mathrm{H} \to \mathrm{b\bar{b}}$	± 0.3	± 3.1	± 0.5	± 0.9
$\mathrm{H} \to \mathrm{c\bar{c}}$	± 2.2		± 6.5	± 10
$\mathrm{H} \to \mathrm{gg}$	± 1.9		± 3.5	± 4.5
$\mathrm{H} \to \mathrm{W^+W^-}$	± 1.2		± 2.6	± 3.0
$\mathrm{H} \to \mathrm{ZZ}$	± 4.4		± 12	± 10
$\mathrm{H} \to \tau\tau$	± 0.9		± 1.8	± 8
$\mathrm{H} \to \gamma\gamma$	± 9.0		± 18	± 22
$\mathrm{H} \to \mu^+\mu^-$	± 19		± 40	
$\mathrm{H} \to$ invisible	< 0.3		< 0.6	

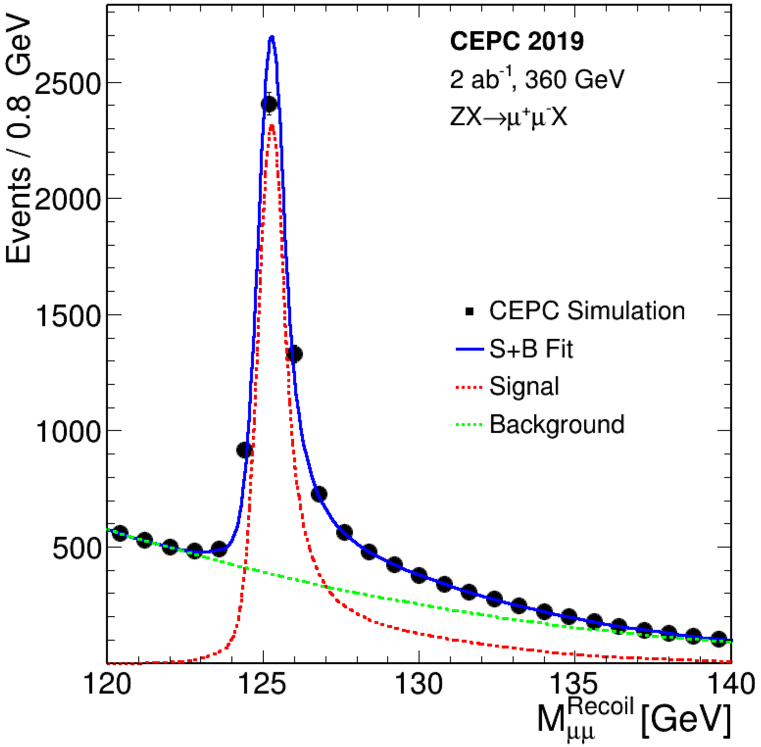
Generally, since the extrapolation is not so accurate, results are comparable. (bb is most different?)

For $\mathrm{H} \to \gamma\gamma$ and $\mathrm{H} \to \mu\mu$, resolution changes considered.
Keep diphoton resolution ~(2.5GeV) : 10.5%
2.5GeV to 2GeV: 9.40%

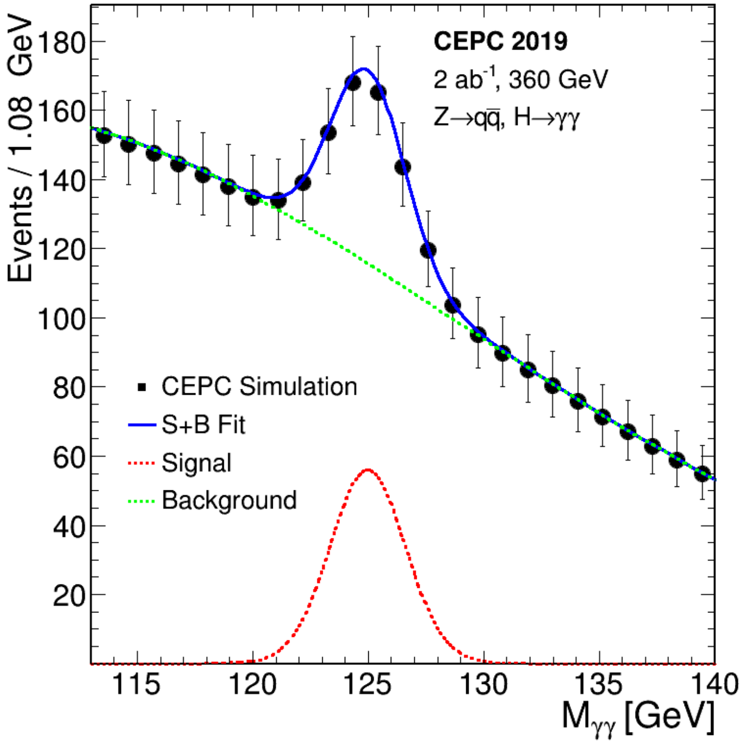
Keep dimuon resolution ~(0.3GeV): 23%
0.3GeV to 1GeV: 29%

Plots

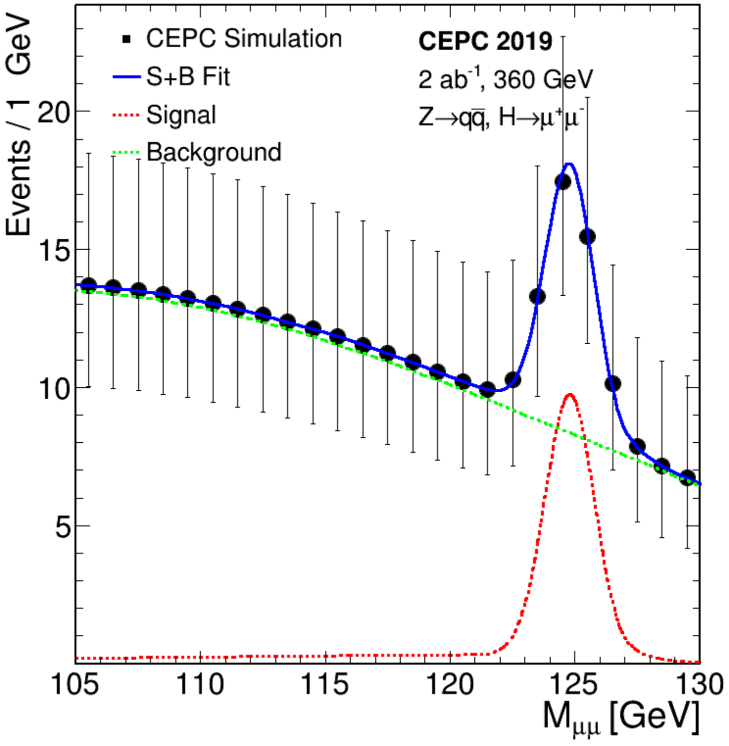
Inclusive: 0.92% -> 1.72%



Resolution: 2GeV;



Resolution: 1GeV;



Discussion

- Current extrapolation
    - mainly scale yields
        - bkg could be even lower if correct analysis strategies are applied.
    - can not deal with W/Z fusion related channels and $\sigma(ZH)$
        - several channels are studied with m_{ee}^{recoil} and $m_{missing}$ would suffer;
        - need to look into 360GeV sample