CEPC Higgs Combination

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Fit model introduction

- Uniformed, simultaneous fit framework
  - Extensibility for correlations/NPs/assumptions……
- Use individual analysis's spectrum
  - Make and fit Asimov Data
  - Get estimated precision of $\sigma * \mathrm{Br}$ and Higgs coupling κ
- Fit algo: minuit2+minos,
  - Profile likelihood scan, under tuning;
  - Show asymmetric errors

Channels Table (now 43)

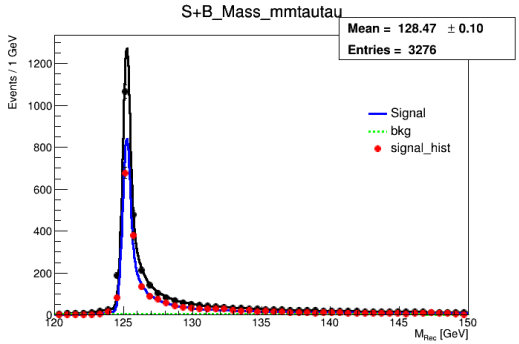
Observed=tagged signal after cutflow and in fit range.
All events are weighted and normalized to $5ab^{-1}$.

Signal Z	Signal H	Observed Events	Who takes charge	Last update
H->Inclusive				
νν	Inclusive	164170	Libo	2017.8
μμ	Inclusive	29552		
ee	Inclusive	22200		
H->qq				
ee	bb	7655	Baiyu	2017.7
	cc	351		
	gg	1058		
μμ	bb	11108		2017.9
	cc	567		
	gg	1762		
qq	bb	176542		2017.7
	cc	8272		
	gg	25293		
νν	bb	70608		
	cc	3061		
	gg	9633		
H→γγ,Zγ				
ll	γγ	93	Feng	2015
νν		309		
qq		822	Yitian	2017.4
qq	Zγ	219	Weimin	2017.9
H->Invisible				
qq	νννν	202	MoXin	2017.7
ee		8		
μμ		18		

Signal Z	Signal H	Observed Events	Who takes charge	Last update
vvH(WW fusion)				
νν	bb	10256	LiangHao	2017.8
H->WW				
μμ	μνμν	52	Libo	2017.4
	evev	36		
	evμν	105		
	evqq	663		
	μνqq	717		
ee	μνμν	44		
	evev	22		
	evμν	81		
	evqq	612		
	μνqq	684		
νν	qqqq	9022		
H->ZZ				
νν	μμjj	190	Yuqian	2016.9
μμ	νjj	200		
ee	νjj	69		
H→ll				
μμ	ττ	2068	Dan	2017.9
qq		36023		
νν		12456		
qq	μμ	71	Zhenwei	2017.8
ee		1		
μμ		4		
νν		14		

Treatment for ZH bkg

- In individual analysis
  - other ZH process is tagged as bkg, which is other channel's signal.
- Combination can correctly deal with them
  - ZZ process events in WW channel will also contribute to κ_Z;
- Exclusive ZH bkg is needed;
  - Must specify which ZH process is;
  - Preparing



In μμττ channel, ZH bkg(main WW) share the same shape as signal.

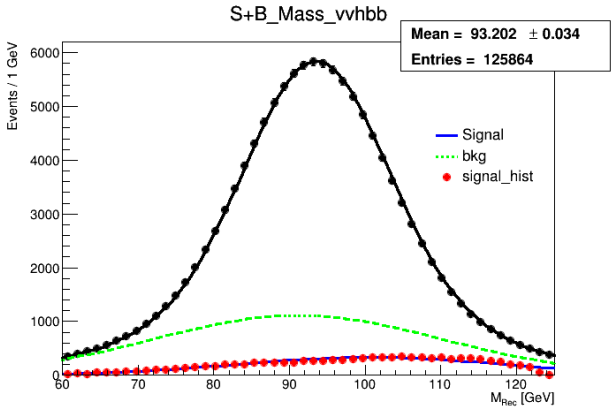
κ Framework

κ defined as the ratio of the Higgs coupling to SM expects.

$$\kappa_f = \frac{g(hff)}{g(hff;\mathrm{SM})},\ \kappa_V = \frac{g(hVV)}{g(hVV;\mathrm{SM})}$$

- LHC, ILC use 7 & 10 kappa franework as benchmark;
- In CEPC
  - For Production, ZH & WW fusion process, $\kappa_Z^2;\ \kappa_w^2;$
  - For Partial decay, no top quark κ_t like: $\kappa_Z^2,\ \kappa_W^2,\ \kappa_b^2,\ \kappa_c^2,\ \kappa_g^2,\ \kappa_\tau^2,\ \kappa_\gamma^2,\ \kappa_\mu^2,$ … …
  - For Total width Γ_H. $\Gamma_H = \Gamma_{SM} + \Gamma_{BSM}$. If we assume no exotic decay,
  - Γ_{SM} can be resolved as $0.216\kappa_W^2$+$0.0267\kappa_Z^2$+$0.578\kappa_b^2$+$0.086\kappa_g^2$+$0.0023\kappa_\gamma^2$+$0.0637\kappa_\tau^2$+$0.0268\kappa_c^2$ … …
- In pre_CDR, finished by Liu Zhen;
  - Use CrossX result as input; and fit by MMA;
  - Now this result can be a crosscheck with Zhen's.

Correlations : vvh->bb channel



- WW fusion channel contains many ZH bkg;
- Initial error is 2.89%, but must consider the uncertainty of ZH process(~0.4%)
- LiangHao assumes the error is Gaussian distribution;
  - $-\mathrm{Log}L = 0.5\left(\frac{\mu_{ZH}-1}{0.375\%}\right)^2 - P\left(data\middle|\mu_{\mathrm{ZH}}N_{ZH}Pdf_{ZH} + \mu_{\mathrm{wwf}}N_{wwf}Pdf_{wwf} + N_{SM}Pdf_{SM}\right)$ （May be optimisitic?）
- In combination, we can directly use the likelihood in Z->ee/mm/qq, H->bb channel;
- Combine Fit is $\{^{+3.13\%}_{-3.14\%}$; consistent with Hao's 3.1%

$\Delta(Br * \sigma)$ fit Result

	PreCDR	Current
$\sigma(ZH)$	0.51%	0.50%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{bb})$	0.28%	$\{^{+0.27\%}_{-0.27\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{cc})$	2.2%	$\{^{+3.45\%}_{-3.43\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{gg})$	1.6%	$\{^{+1.43\%}_{-1.42\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{WW})$	1.5%	$\{^{+1.20\%}_{-1.20\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{ZZ})$	4.3%	$\{^{+5.91\%}_{-5.74\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \tau\tau)$	1.2%	$\{^{+0.68\%}_{-0.67\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \gamma\gamma)$	9.0%	$\{^{+8.26\%}_{-8.17\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mu\mu)$	17%	$\{^{+15.8\%}_{-14.9\%}$
$\sigma(\mathrm{vv}H) * \mathrm{Br}(\mathrm{H} \to \mathrm{bb})$	2.8%	$\{^{+3.13\%}_{-3.14\%}$
$\mathrm{Br}(\mathrm{H} \to \mathrm{inv.})$	0.28%	0.18%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to Z\gamma)$	\	$4\sigma(\{^{+15.4\%}_{-14.9\%})$

In general, fit result is consistent with results of Pre_CDR and Individual studies.

Results to compare

7 κ	Minos Result	Liu_Zhen Current	Pre_CDR
κ_b	$\begin{cases}+1.34\% \\ -1.33\%\end{cases}$	$\begin{cases}+1.33\% \\ -1.37\%\end{cases}$	1.2%
κ_c	$\begin{cases}+2.23\% \\ -2.21\%\end{cases}$	$\begin{cases}+2.22\% \\ -2.24\%\end{cases}$	1.6%
κ_g	$\begin{cases}+1.57\% \\ -1.55\%\end{cases}$	$\begin{cases}+1.55\% \\ -1.58\%\end{cases}$	1.5%
κ_γ	$\begin{cases}+4.31\% \\ -4.39\%\end{cases}$	$\begin{cases}+4.25\% \\ -4.41\%\end{cases}$	4.7%
κ_μ=κ_τ	$\begin{cases}+1.40\% \\ -1.38\%\end{cases}$	$\begin{cases}+1.37\% \\ -1.41\%\end{cases}$	1.3%
κ_Z	$\begin{cases}+0.14\% \\ -0.14\%\end{cases}$	$\begin{cases}+0.14\% \\ -0.16\%\end{cases}$	0.16%
κ_W	$\begin{cases}+1.38\% \\ -1.36\%\end{cases}$	$\begin{cases}+1.34\% \\ -1.37\%\end{cases}$	1.2%

Difference in 0.01%.

with/without ZH bkg

	with ZH bkg	without ZH bkg
$\sigma(ZH)$	0.50%	
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{bb})$	$^{+0.27\%}_{-0.27\%}$	$^{+0.27\%}_{-0.27\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{cc})$	$^{+3.45\%}_{-3.43\%}$	$^{+3.45\%}_{-3.43\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{gg})$	$^{+1.43\%}_{-1.42\%}$	$^{+1.42\%}_{-1.42\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{WW})$	$^{+1.20\%}_{-1.20\%}$	$^{+1.44\%}_{-1.43\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mathrm{ZZ})$	$^{+5.91\%}_{-5.74\%}$	$^{+6.00\%}_{-5.82\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \tau\tau)$	$^{+0.68\%}_{-0.67\%}$	$^{+0.67\%}_{-0.67\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \gamma\gamma)$	$^{+8.26\%}_{-8.17\%}$	$^{+8.27\%}_{-8.18\%}$
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to \mu\mu)$	$^{+15.8\%}_{-14.9\%}$	$^{+15.8\%}_{-14.9\%}$
$\sigma(\mathrm{vv}H) * \mathrm{Br}(\mathrm{H} \to \mathrm{bb})$	$^{+3.12\%}_{-3.06\%}$	$^{+3.12\%}_{-3.06\%}$
$\mathrm{Br}(\mathrm{H} \to \mathrm{inv.})$	0.18%	0.18%
$\sigma(ZH) * \mathrm{Br}(\mathrm{H} \to Z\gamma)$	4σ	4σ

$7\ \kappa$	with ZH	without ZH bkg
κ_b	$^{+1.34\%}_{-1.33\%}$	$^{+1.36\%}_{-1.34\%}$
κ_c	$^{+2.23\%}_{-2.21\%}$	$^{+2.23\%}_{-2.21\%}$
κ_g	$^{+1.57\%}_{-1.55\%}$	$^{+1.57\%}_{-1.55\%}$
κ_γ	$^{+4.31\%}_{-4.39\%}$	$^{+4.32\%}_{-4.40\%}$
κ_μ=κ_τ	$^{+1.40\%}_{-1.38\%}$	$^{+1.40\%}_{-1.38\%}$
κ_Z	$^{+0.14\%}_{-0.14\%}$	$^{+0.16\%}_{-0.16\%}$
κ_W	$^{+1.38\%}_{-1.36\%}$	$^{+1.38\%}_{-1.37\%}$

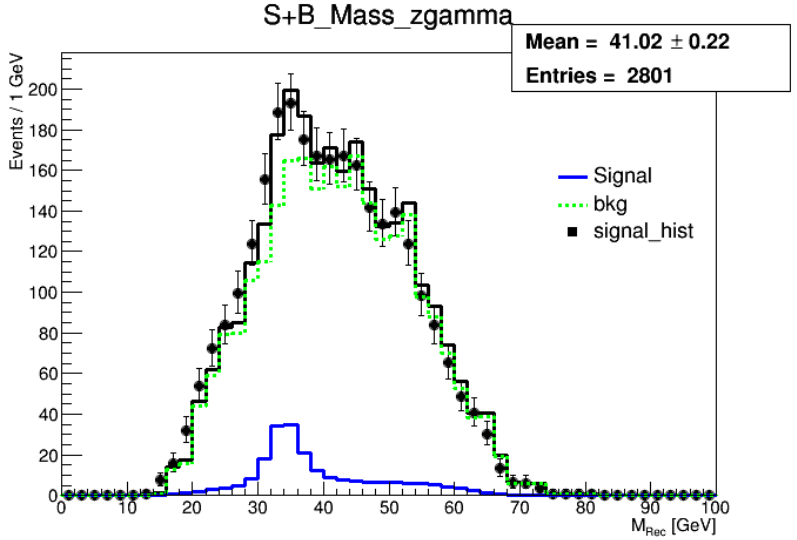
Now ZH bkg incomplete; (Main in bb/cc/gg channel, and affect ZZ/WW/tautau)
It can make some difference to the final fit.

To dos

- Likelihood Scan & Contour plot;
- Import Nuisance parameter;
- CDR & note writing

backup

Zgamma process



Weimin; binned fit ${}^{+15.4\%}_{-14.9\%}$