Model Dependent Higgs Couplings

Tim Barklow (SLAC)

July 17, 2013

Model Independent Coupling Determination

Fit for 9 couplings and the Higgs total width

$(g_{Z}, g_{W}, g_{b}, g_{c}, g_{g}, g_{\tau}, g_{\mu}, g_{t}, g_{\gamma}, \Gamma_0)$

by minimizing χ^2 :

$$\chi^2 = \sum_{i=1}^{33} \left(\frac{Y_i - Y_i'}{\Delta Y_i} \right)^2 \qquad Y_i = \begin{cases} \sigma \times BR \text{ , i=1,..,32} \\ \sigma_{ZH} \text{ , } i = 33 \end{cases}$$

$$Y_i' = F_i \bullet \frac{g_Z^2 g_X^2}{\Gamma_0} \quad , \quad F_i \bullet \frac{g_W^2 g_X^2}{\Gamma_0} \quad \text{or} \quad F_i \bullet \frac{g_t^2 g_X^2}{\Gamma_0}$$

We neglect theory errors on F_i

Model Independent Coupling Summary

$$\Delta g_{Hxx} \,/\, g_{Hxx}$$

Mode	ILC(250)	ILC500	ILC(1000)	ILC(LumUp)
WW	4.8 %	1.4 %	1.4 %	0.65 %
ZZ	1.3 %	1.3 %	1.3 %	0.61 %
$t\bar{t}$	–	18 %	4.0 %	2.5 %
$b\bar{b}$	5.3 %	1.8 %	1.5 %	0.75 %
$\tau^+\tau^-$	5.7 %	2.5 %	2.0 %	1.0 %
$\gamma\gamma$	18 %	8.4 %	4.1 %	2.4 %
gg	6.4 %	2.5 %	1.8 %	0.94 %
$c\bar{c}$	6.8 %	3.0 %	2.0 %	1.1 %
$\mu^+\mu^-$	–	–	16 %	10 %
$\Gamma_T(h)$	11 %	6.0 %	5.6 %	2.7 %
self	–	88%	25 %	16 %
* BR(invis.)	$<$ 0.69 %	$<$ 0.69 %	$<$ 0.69 %	$<$ 0.32 %

* 95% C.L. limit

3

Model Dependent Coupling Fits

Alternatively, ILC can fit for the κ_i coupling scaling factors of arXiv : 1029.0040.

SFitter
ILC (250)

coupling	250 GeV
κ_W	5.6 %
κ_Z	1.1 %
κ_t	9.8 %
κ_b	6.0 %
κ_τ	7.2 %
κ_γ	18.0 %
κ_g	8.6 %

Model Independent Coupling Fits

Mode	ILC(250)	ILC500	ILC(1000)	ILC(LumUp)
WW	4.8 %	1.4 %	1.4 %	0.65 %
ZZ	1.3 %	1.3 %	1.3 %	0.61 %
$t\bar{t}$	–	18 %	4.0 %	2.5 %
$b\bar{b}$	5.3 %	1.8 %	1.5 %	0.75 %
$\tau^+\tau^-$	5.7 %	2.5 %	2.0 %	1.0 %
$\gamma\gamma$	18 %	8.4 %	4.1 %	2.4 %
gg	6.4 %	2.5 %	1.8 %	0.94 %

SFitter
ILC (LumUp)

coupling	high-lumi
κ_W	0.57 %
κ_Z	0.47 %
κ_t	1.7 %
κ_b	1.2 %
κ_τ	1.7 %
κ_γ	3.4 %
κ_g	1.7 %

This isn't right. The model dependent values should ALWAYS be better than the model indepedent values because we are adding constraints to the model independent fits when we do model dependent fits.

Model Dependent Coupling Determination Proposal

This example uses the constraints from the 7 parameter fit $(\kappa_{Z,}\kappa_{W,}\kappa_{b,}\kappa_{g,}\kappa_{\tau,}\kappa_{t,}\kappa_{\gamma})$ by ATLAS and CMS

The constraints are $\kappa_c = \kappa_t$ & $\kappa_H^2 \bullet \Gamma_0 = \sum_i \kappa_i^2 \bullet \Gamma_i$

For ILC we still fit for 9 couplings and the Higgs total width $(g_{Z,}g_{W,}g_{b,}g_{c,}g_{g,}g_{\tau,}g_{\mu,}g_{t,}g_{\gamma,}\Gamma_0)$
but now by minimizing this χ^2 :

$$\chi^2 = \sum_{i=1}^{33}\left(\frac{Y_i - Y_i'}{\Delta Y_i}\right)^2 + \left(\frac{\xi_{ct}}{\Delta\xi_{ct}}\right)^2 + \left(\frac{\xi_\Gamma}{\Delta\xi_\Gamma}\right)^2$$

where

$$\xi_{ct} = \frac{g_c}{g_c^{SM}(M_c,...)} - \frac{g_t}{g_t^{SM}(M_t,...)} \qquad \xi_\Gamma = \Gamma_0 - \sum_{i=1}^{9}\Gamma_i \quad , \quad \Gamma_i = G_i(M_H,...)\bullet g_i^2$$

$\Delta\xi_{ct}$ = theory error on ξ_{ct} obtained by propagating theory errors on $g_c^{SM}(M_c,...)$ and $g_t^{SM}(M_t,...)$
$\Delta\xi_\Gamma$ = theory error on ξ_Γ obtained by propagating (correlated) theory errors on $G_i(M_H,...)$