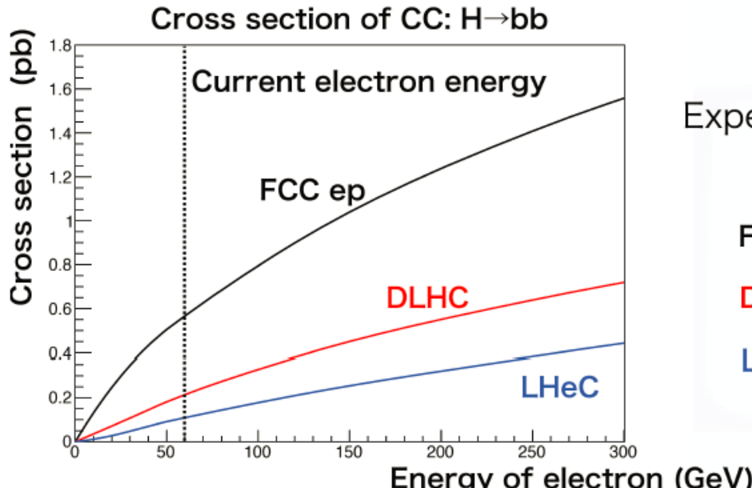
Uta Klein et al.

SM Higgs into HFL Summary

- Assume a 60 GeV polarized electron beam and 1000 fb^{-1} (~10 years running)
- Expected number of signal events and error of coupling constant from BDT results.
- Background assumed to be known to ~2%



Expected number of signal events

(E_e = 60 GeV)

FCC ep (~85,000 H→bb events)

DLHC (~35,000 H→bb events)

LHeC (~15,000 H→bb events)

$$\delta\kappa = \frac{1}{2}\frac{\delta\mu}{\mu}$$

	LHeC (E_p = 7 TeV √s ~1.3 TeV)	DLHC (E_p = 14 TeV √s ~1.8 TeV)	FCC ep (E_p = 50 TeV √s ~ 3.5 TeV)
κ (Hbb)	0.5%	0.3%	0.2%
κ (Hcc)	4%	2.8%	1.8%

as explained in the following this is incorrect.

➔Better give relative error on rate measurement or express as precision on μ_{wb}!

From Tao Hang's talk

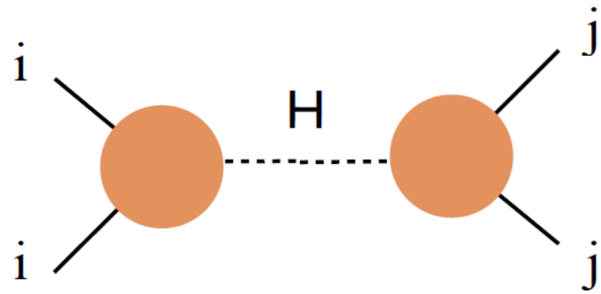
For example, take decay partial width $\Gamma_i\ (h \to i)$

$$g_{Hi} \equiv \left(\frac{\Gamma_i}{\Gamma_i^{\rm SM}} \times (g_{Hi}^{\rm SM})^2 \right)^{1/2}$$

The κ framework

$$\kappa_f = \frac{g_{Hff}}{g_{Hff}^{\rm SM}} \qquad \kappa_V = \frac{g_{HVV}}{g_{HVV}^{\rm SM}}$$

$$\frac{\Gamma_i}{\Gamma_i^{\rm SM}} = \kappa_i^2 \quad \text{and} \quad \frac{g_{Hi}}{g_{Hi}^{\rm SM}} = \kappa_i$$



$$\mu_j = \kappa_i^2 \kappa_j^2 \times \frac{\Gamma_{\rm total}}{\Gamma_{\rm total}^{\rm SM}}$$

κ parameterization

- κ_u, κ_d , κ_s, κ_e do not enter the observables much.
- κ_t, κ_c, κ_b, κ_τ, κ_μ, κ_Z, κ_W, κ_γ, κ_g, BR_{inv}, Γ_{tot}. 11 parameters.

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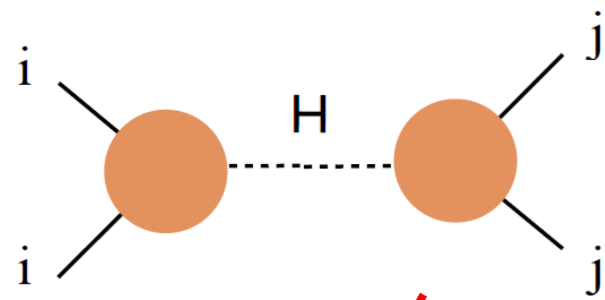

$$\mu_j = \kappa_i^2 \kappa_j^2 \cancel{\times} \frac{\Gamma_{\rm total}}{\Gamma_{\rm total}^{\rm SM}}$$

(typos, should be: μ_{ij} and divided)

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$$\delta\kappa \cancel{=} \frac{1}{2}\frac{\delta\mu}{\mu}$$

It is important to remember than $\Gamma_{tot} = (\sum \kappa_i^2 \, \Gamma_i^{SM}) + \Gamma_{inv} + \Gamma_{exo}$

relationship between uncertainties in μ_{ij} and κ_j

$\mu_{ij} = \kappa_i^2\ \kappa_j^2\ .\ (\Gamma_{tot}^{SM} / \Gamma_{tot})$

$\Gamma_{tot} = (\sum\ \kappa_j^2\ \Gamma_j^{SM}) + \Gamma_{inv} + \Gamma_{exo}$

$\partial\Gamma_{tot} / \partial\kappa_j^2 = \Gamma_j^{SM}$

$\partial\mu_{ij} / \partial\kappa_j^2 = \mu_{ij} / \kappa_j^2 - \mu_{ij} / \Gamma_{tot}\ .\ \partial\Gamma_{tot} / \partial\kappa_j^2$

$d\mu_{ij} / \mu_{ij} = [d\kappa_i^2 / \kappa_i^2\ .\ (1 - \Gamma_i^{SM}/\Gamma_{tot}^{SM})] + [d\kappa_j^2 / \kappa_j^2\ .\ (1 - \Gamma_j^{SM}/\Gamma_{tot}^{SM})]$

$= d\kappa_i^2 / \kappa_i^2\ .\ (1-B_i^{SM}) + d\kappa_j^2 / \kappa_j^2\ .\ (1 - B_j^{SM})$

When extracting the final state coupling (assuming the initial state coupling has been measured) one gets

$\Delta\kappa_j^2 / \kappa_j^2 = (\Delta\mu_{ij} / \mu_{ij} \oplus \Delta\kappa_i^2 / \kappa_i^2 \cdot (1-B_i^{SM})) / (1 - B_j^{SM})$

so, in the case of the WH-strahlung to bb final state: j=b, i=w B_b=0.58, B_w=0.21

$\Delta\kappa_b^2 / \kappa_b^2 = 2.39 \times (\Delta\mu_{wb} / \mu_{wb} \oplus 0.79\ \Delta\kappa_w^2 / \kappa_w^2)$

Conclusion

$\Delta\kappa_j^2 / \kappa_j^2 = (\Delta\mu_{ij} / \mu_{ij} \oplus \Delta\kappa_i^2 / \kappa_i^2 (1 - B_i^{SM})) / (1 - B_j^{SM})$

$\Delta\kappa_b^2 / \kappa_b^2 = 2.39 \times (\Delta\mu_{wb} / \mu_{wb} \oplus 0.79 \; \Delta\kappa_w^2 / \kappa_w^2)$ for ep→ (via WHW) H→ bb

1. From ep W-strahlung of the Higgs to bb one cannot extract κ_b without assumptions, unless both the Higgs total width and W couplings have been extracted from another process.
2. This could be done at FCC-ee, or at another e+e- or mu+mu- collider, with finite precision.
3. Even in that case the error propagation must take into account the fact that the b partial width is 58% of the total Higgs decay width.
4. However from a ratio with another process with the same initial (final) state one can extract a ratio of final (initial) couplings with possibly smaller uncertainties.
5. Under a strong assumption that only the b couplings are varied from the SM the uncertainty still must include

-- the relative error on the cross-section measurement (stats + syst)

-- the relative uncertainty on the cross-section prediction (luminosity, pdfs, EW process, applicability of pdfs obtained in DIS to Higgsstrahlung, etc…)

(-- the effect of the error in the initial state coupling)

-- all multiplied by a factor $1/(1-B_b^{SM}) = 1/(1-0.58)$ **= 2.39** which represents the cancellation in sensitivity to b coupling due to the unavoidable normalization to the total width.

My recommandation

➔ express the measurement quality as uncertainty on μ_{wb}

Then it can be included usefully in a global fit of Higgs couplings, with a strong impact I believe.