Once a Higgs candidate has been detected, how precisely does one need to measure the properties (mass, couplings, . . .) of such a state?

Georg Weiglein

DESY

Geneva, 10 / 2010

The Higgs mass as a precision observable

Precision Higgs physics at a LC will be crucial for verifying the Higgs mechanism and for determining the Higgs boson profile

The mass of a light Higgs will be a precision observable that can be used for testing the underlying physics in the same way as we nowadays use M_{Z}, M_{W}, G_{μ}, α, $\sin^2\theta_{\mathrm{eff}}$, Γ_{Z}, $g_{\mu}-2$, etc. to constrain possible effects of new physics

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How precisely would we want to know $M_{\rm H}$?

$\Rightarrow$ Fundamental parameter of nature; it is desirable to measure it as precisely as possible (as for $M_{\rm Z}$ at LEP)

Comparison: Higgs mass measurement vs. theory prediction

Exceptional case: the Standard Model

Higgs mass is a free parameter; indirect theory prediction via log. dependence of electroweak precision observables on M_{H}

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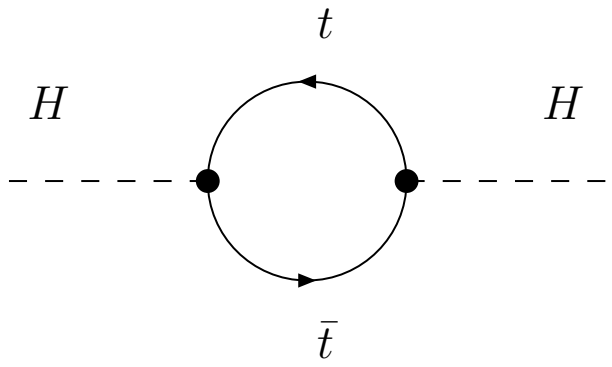
Theory prediction: significant dependence on the top quark mass



One-loop correction $\sim G_\mu m_{\mathrm{t}}^4$

Example: SUSY $\Delta m_{\mathrm{t}} \approx \pm 0.1$ GeV (ILC) $\Rightarrow \Delta m_{\mathrm{h}} \approx \pm 0.1$ GeV

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It is not obvious how to fully exploit the higher accuracy on M_{H} achievable in s-channel production at a muon collider

Higgs coupling measurements: high precision is crucial for revealing the underlying physics

LHC: Only ratios of couplings can be determined in a model-independent way

Need additional theory assumptions to extract absolute values with th. assumption

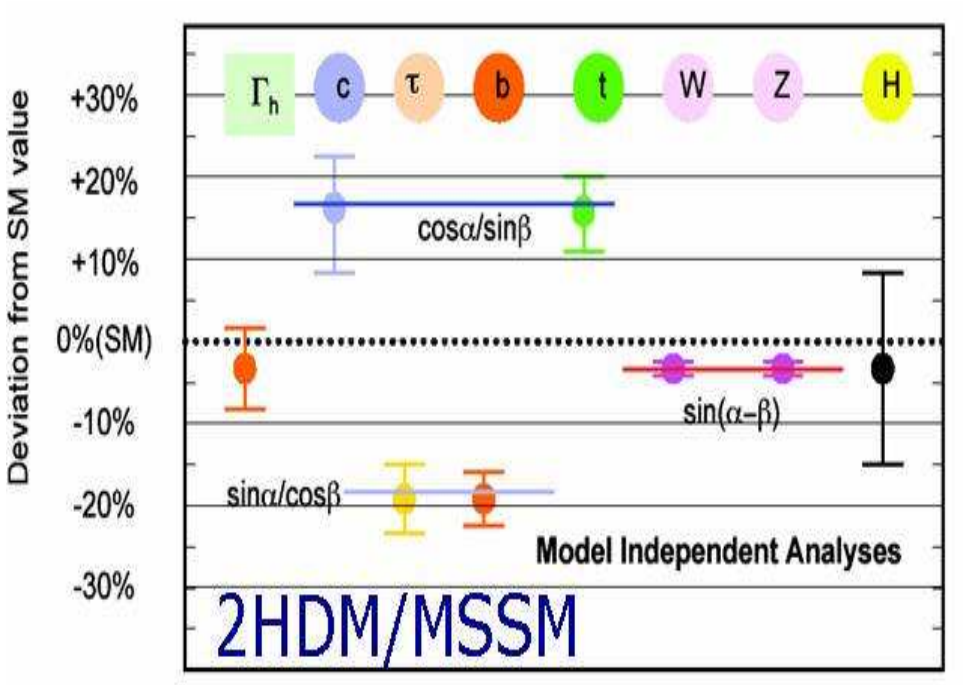
20–40% accuracies on squared couplings to fermions and gauge bosons achievable

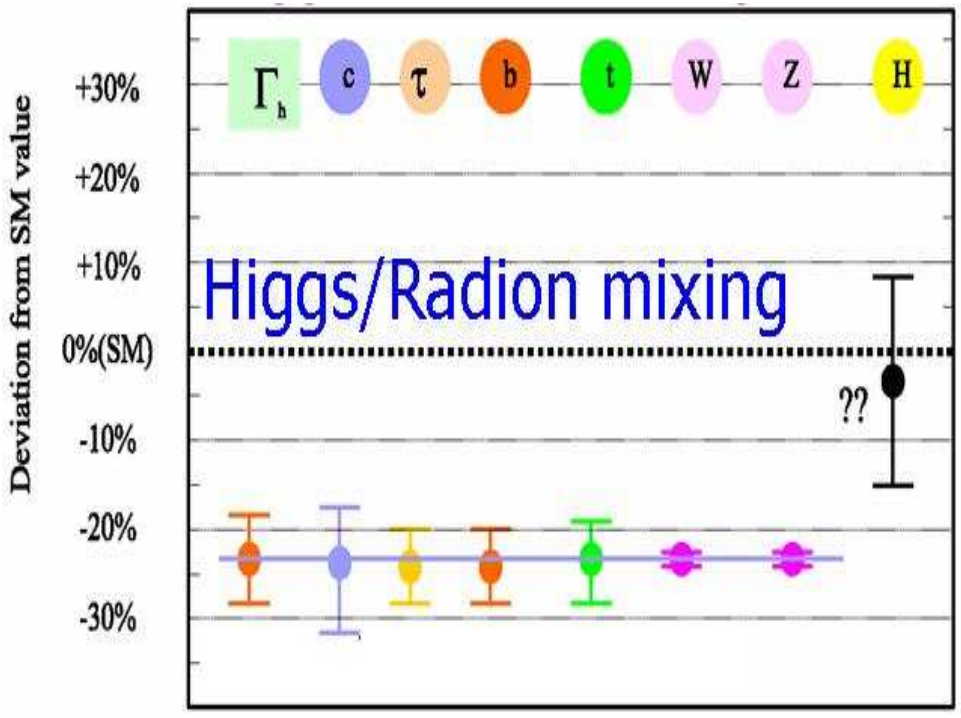
ILC: Recoil method (Higgs discovery independently of decay properties)

$\Rightarrow$ Absolute determination of squared couplings to fermions and gauge bosons at 5% level

Impact of ILC precision for the Higgs couplings

SM vs. BSM physics:





⇒ Precision measurement of Higgs couplings allows distinction between different models

The Higgs as a composite object

Renewed interest in composite Higgs models, mostly from extra dimensions

[*N. Arkani-Hamed, A. Cohen, H. Georgi ’01*]

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Signatures at LHC: new resonances, W', Z', t', KK excitations

Under pressure from electroweak precision tests

Effective field-theory description of a composite Higgs

Agreement with electroweak precision data can be improved if there is a strongly interacting light Higgs, e.g.

Little Higgs [*N. Arkani-Hamed, A. Cohen, E. Katz, A. Nelson '02*]

Holographic Higgs [*R. Contino, Y. Nomura, A. Pomarol '03*], [*K. Agashe, R. Contino, A. Pomarol '05*], . . .

Effective Lagrangian formalism for model-independent analysis of effects of a Strongly-Interacting Light Higgs (SILH) [*G. Giudice, C. Grojean, A. Pomarol, R. Ratazzi '07*]

$\Rightarrow$ Specific pattern of modified Higgs couplings

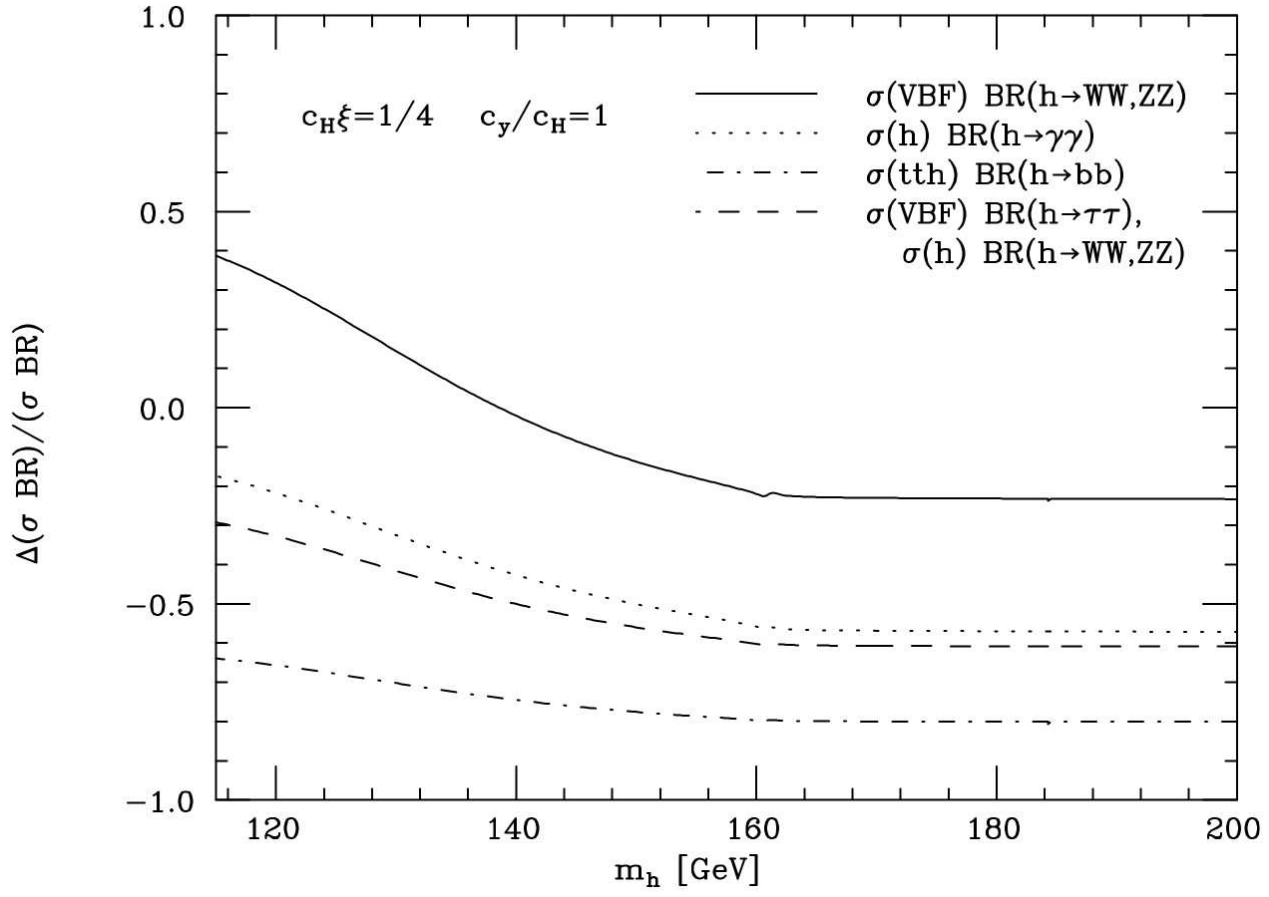
Strong WW scattering at high energies despite light Higgs

$\Rightarrow$ Need precision measurement of Higgs couplings

$+$ test of longitudinal gauge-boson scattering

Strongly-Interacting Light Higgs: deviation of $\sigma \times \mathrm{BR}$ from the case of a SM Higgs

[*G. Giudice, C. Grojean, A. Pomarol, R. Ratazzi '07*]



Sensitivity at LHC: 20–40%, ILC: 1%

$\Rightarrow$ ILC can test scales up to ~ 30 TeV

Conclusions

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- Further crucial measurements: Determination of spin, $\mathcal{CP}$ properties, access to Higgs self-coupling(s)