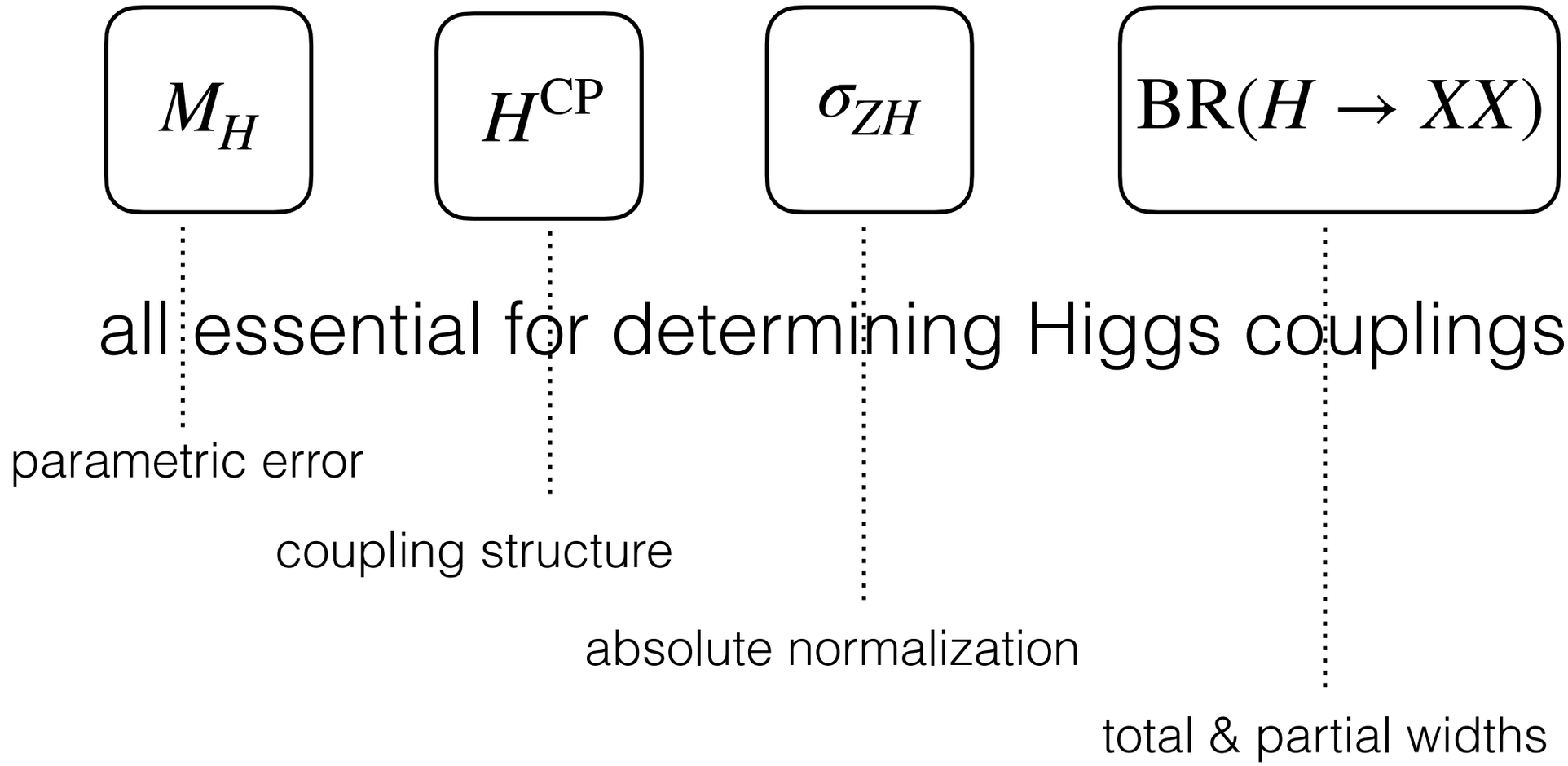
TYL application: **Higgs Physics at the ILC**

Motivation: to improve



all essential for determining Higgs couplings

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new method for σ_{ZH} measurement

- inclusive σ_{ZH} measurement is a flagship of future e+e-
- traditional leptonic recoil method uses only $Z\to e^+e^-$ and $Z\to\mu^+\mu^-$

- the new method uses $Z\to e^+e^-$ / $\mu^+\mu^-$ to extract Higgs unbiased properties: distribution of unbiased variables, like Nh±, Nb, Nc, Ne, Nτ, Nμ, Nγ, Evis, Mvis, Njets (Ycut), …

- use the signal distributions to extract signal even when missing mass squared is not usable: it allows to use other Z decay channels such as $Z\to\tau\tau$ and $Z\to\nu\nu$
- due to BR($Z\to\tau\tau/\nu\nu$), it is expected a large improvement on the statistical uncertainty
- it has been verified at the MC level, equivalent to doubling the luminosity; it needs to be established at the reconstruction level; it can also produce important constraint on detector design

BR(H->XX) measurement: a new method from old ideas

- 1- Construction of an "enriched Higgs sample" from Z decays to ee, μμ, ττ, νν (with strong cuts to have a good S/N sample)

- 2- Make a fit of ALL BRs, in order to fit the observed sample of the unbiased variables: Nh±, Nb, Nc, Ne, Nτ, Nμ, Nγ, Evis, Mvis, Njets (Ycut), …

- 3- Since the sample contains a finite numbers of events, the statistical uncertainties on all the Higgs BR, would be of binomial type, giving a better precision for small and large BRs

- this method was already used by ALEPH[1] for the tau hadronic decays, but also at SLAC just after the tau lepton discovery[2]

[1] Phys.Rept.421:191-284,2005 [2] Michael Peskin, private comm.

new method for Higgs mass measurement

- δm_H becomes one main source of systematic errors for theory prediction[1] of Γ(H->ZZ*) and Γ(H->WW*)

$$\delta g_{HWW} = 6.9 \cdot \delta M_H \qquad \delta g_{HZZ} = 7.7 \cdot \delta M_H$$

- traditional leptonic recoil method may receive large systematic error from beam energy uncertainty; also become not useful at higher $\sqrt{s}$ due to significant effect of beamstrahlung

- new method will take advantage of momentum conservation only in the transverse directions, and only need to measure direction & mass of fermions using H->ff decay processes[2], because of which H->ττ channel is very suitable: τ mass is perfectly know, and τ flying direction can be reconstructed using τ decay vertex

[1] Peskin et al, arXiv: 1404.0319 [2] Tian, ILD-PHYS-PUB-2019-001

new method for Higgs CP measurement

- Higgs can well be an admixture of CP even & odd states. Measuring its CP is important for all Higgs couplings and BSM.

$$L_{Hff} = -\frac{m_f}{v} H\bar{f}(\cos\Phi_{CP} + i\gamma^5 \sin\Phi_{CP})f$$

- H->ττ channel is an ideal one in which the transverse spin correlation of two τ can be reconstructed, as demonstrated in studies [1,2] using a novel method which can determine the neutrino momentum using τ decay planes.

- the new method is somewhat more classical, without relying on reconstruction of τ decay plane (thus complementary to above method). The two neutrino momenta can be determined using 4-momentum conservation and τ-mass constraint in the hadronic τ decay channels.

[1] Jeans, Nucl.Instrum.Meth. A810 (2016) 51-58 [2] Jeans et al, Phys. Rev. D 98, 013007 (2018)

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we (members from France & Japan) share the common interest on Higgs physics, complement with each other in expertise about τ-reconstruction, detector simulation and physics interpretation. Thus we would like to request travel support from TYL.

Thank you very much in advance!