Measuring Higgs Hadronic Branching ratios at the ILC

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Introduction

The International Linear Collider (ILC) is a proposed electron-positron collider with center of mass energies from 200-500 GeV.

The physics that will be studied at the ILC will be essential to understand electroweak symmetry breaking and any new discoveries from the LHC. The discoveries at LHC and ILC will explain the breaking of electroweak symmetry and thus the origin of the masses of particles, and then it is most likely that we will be able to find the physics which is responsible for stabilizing the hierarchy problem, so the unification of all forces. This could lead to a more fundamental understanding of the observed matter-antimatter asymmetry in the Universe.

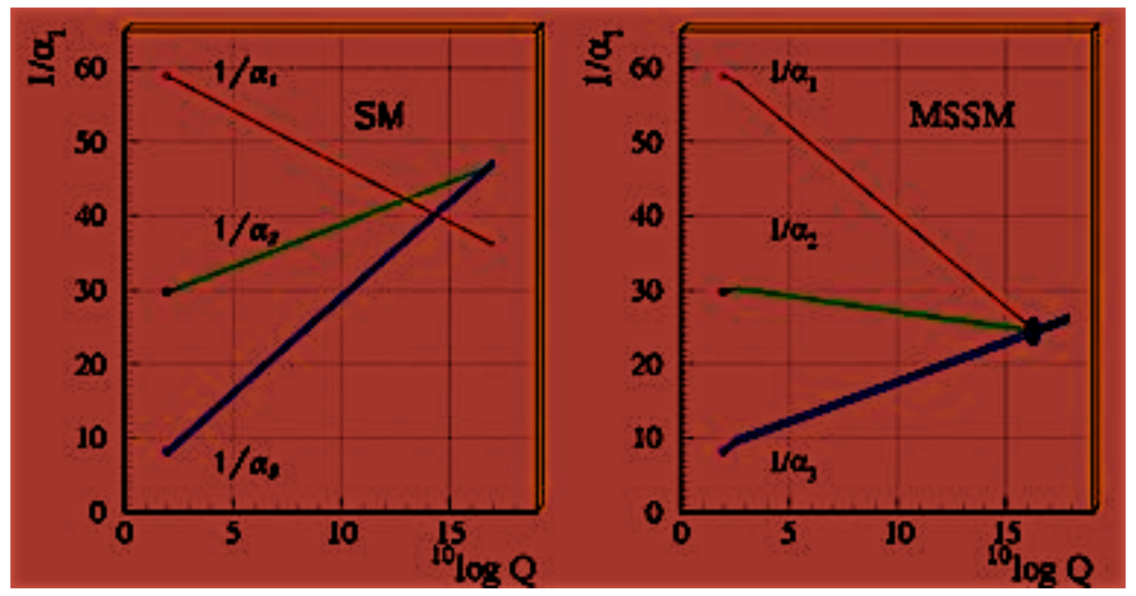
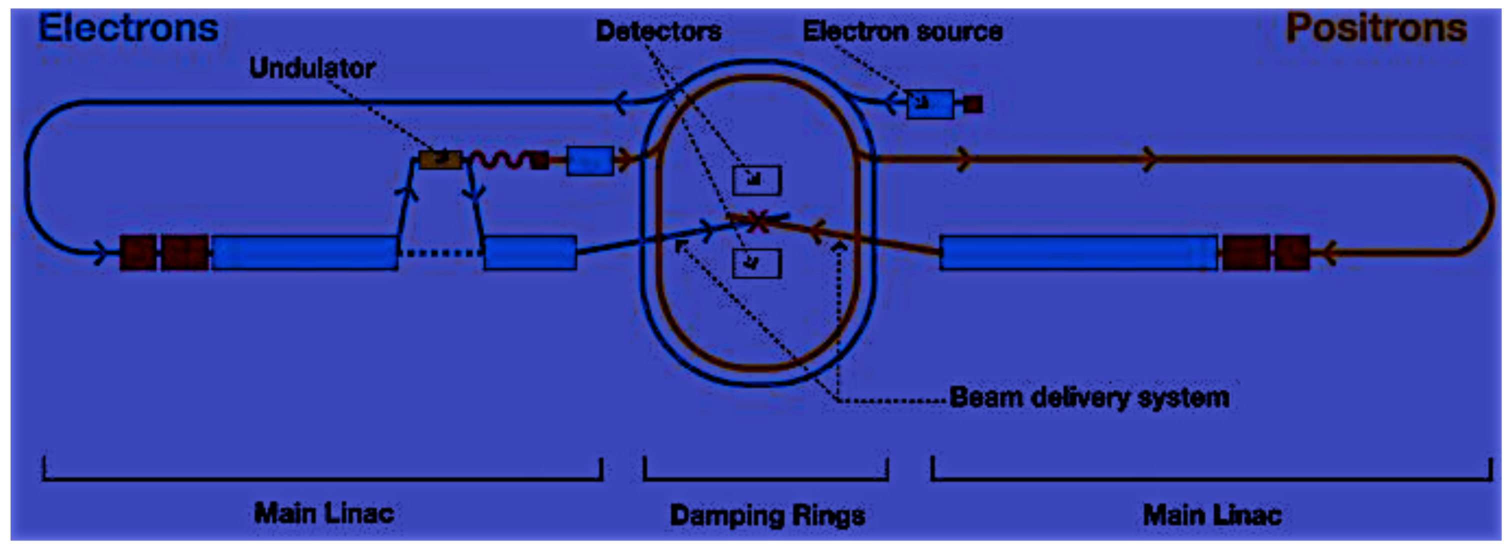


Fig 1: Left: 1/α, the inverse of couplings in SM. Right: Couplings in the Minimal Supersymmetric Standard Model (MSSM)

Physics at the ILC

The ILC is a powerful engine in terms of its energy and luminosity, so it posses difficult experimental environments. The kinematically accessible range of center-of-mass energy provides new particles production and their properties can be studied in great detail. New particles can be discovered even if their production cross sections are fairly low, and their decays are complicated. Here we know the initial momenta of particles so it allows the reconstruction of the final states with high efficiency and resolution. The center-of-mass energy is tunable allowing for precise mass and quantum number measurements from threshold scans. High-luminosity running at the Z-resonance and at the *WW* threshold, as well as e⁻e⁻, e⁻γ or γγ, collision modes, offer additional flexibility.

Fig 2: Schematic layout of the ILC



ILD

ILD is one of the proposed detector for ILC. ILD consists of Silicon Vertex Detector, Time Projection Chamber (TPC), 3-4 Tesla Solenoid, Electromagnetic and Hadronic Calorimeters and Muon Chambers. One design for the Electromagnetic calorimeter is a high granularity Silicon-Tungsten detector and iron scintillator detector for the hadronic calorimeter. The detector we used for our study is based on the initial ILD design.

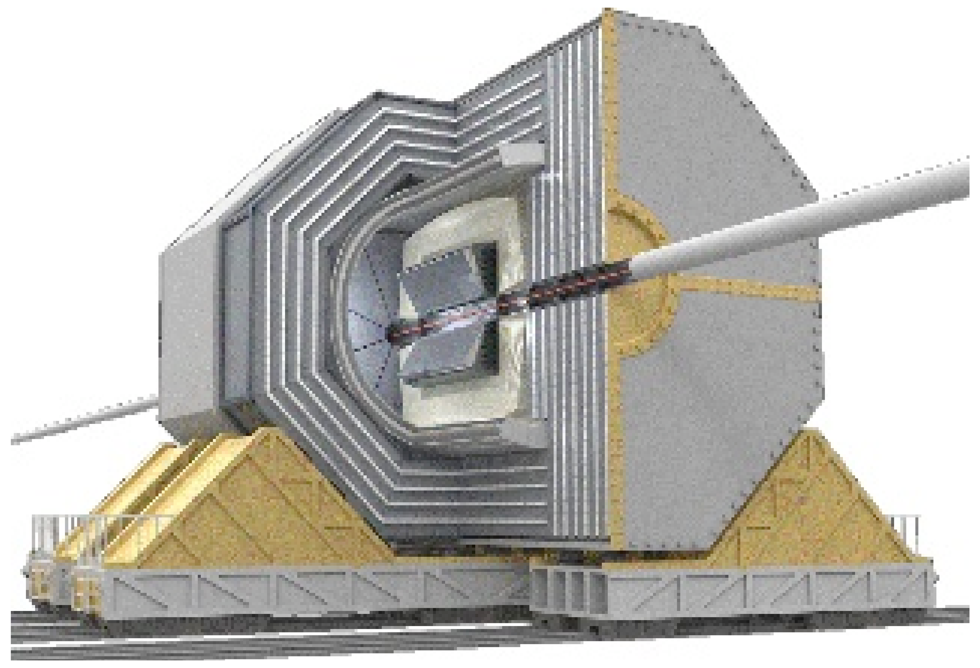


Fig 3: The ILD

Extracting Higgs branching ratio from $ZH \rightarrow l^+l^- q\bar{q}$ events

The determination of the Higgs boson branching fraction is central to the ILC physics program. In the context of the SM, this allows a test of the hypothesis that the strength of the Higgs coupling depends linearly on the particle masses. The statistical uncertainties on branching ratios are estimated, for center of mass energy 250 GeV.

The channel $ZH \rightarrow l^+l^- q\bar{q}$ is studied as it provide a clean signal. The dominant background is *ZZ* production. The event selection requires a pair of oppositely-charged muons with an invariant mass consistent with *Z* mass. The recoil mass is required to be consistent with mass of *H* as is the invariant mass of the recoiling hadronic system. Events in which the *Z* candidate is close to the beam axis are rejected to suppress background from *ZZ*. The final selection is performed by cutting on the value of a likelihood function formed from variables related to the thrust, di-jet and di-lepton masses and angular distributions. The hadronic system is reconstructed as two jets. The fraction of $H\rightarrow b\bar{b}$, $H\rightarrow c\bar{c}$ and $H\rightarrow gg$ and background present are determined from the distribution of b-likeness and c-likeness which is fitted using template made from exclusive samples of each type as shown in figure (5). The measurement accuracy obtained is (2.7±5)% for $BR(H\rightarrow b\bar{b})$, (28±5)% for $BR(H\rightarrow c\bar{c})$ and (29±5)for $BR(H\rightarrow gg)$.

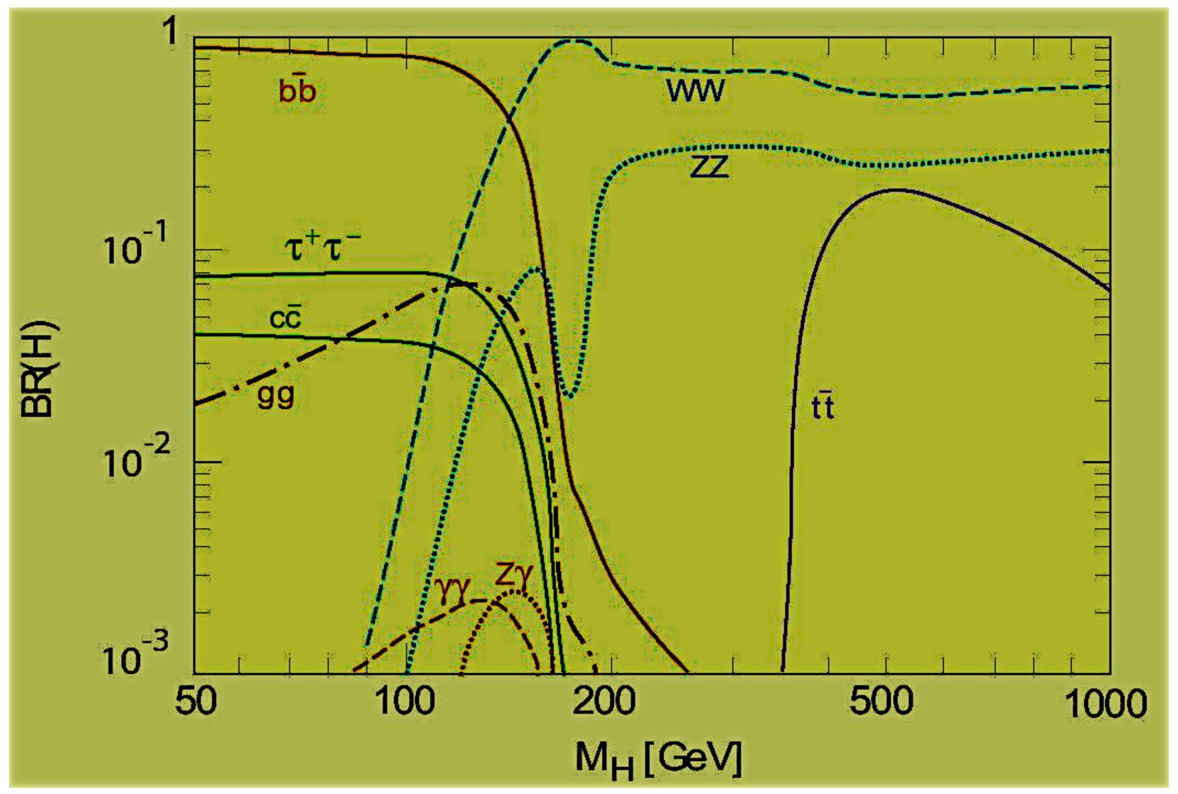


Fig 4: Higgs branching ratios

	r_{bb}	r_{cc}	r_{gg}
Electron Channel	0.95 ± 0.06	1.3 ± 0.6	1.2 ± 0.5
Muon Channel	1.0 ± 0.04	0.87 ± 0.5	0.93 ± 0.5

Table 1: The branching ratio results: *r* is the ratio between the measured BR and the SM BR. *r* should be 1, within errors.

	r_{bb}	r_{cc}	r_{gg}
Electron Channel	4%	36%	38%
Muon Channel	4%	46%	45%
Combined	3%	28%	29%

Table 2: Fit error from pseudo experiment studies. This error indicates the accuracy with which the BR can be measured at ILC.

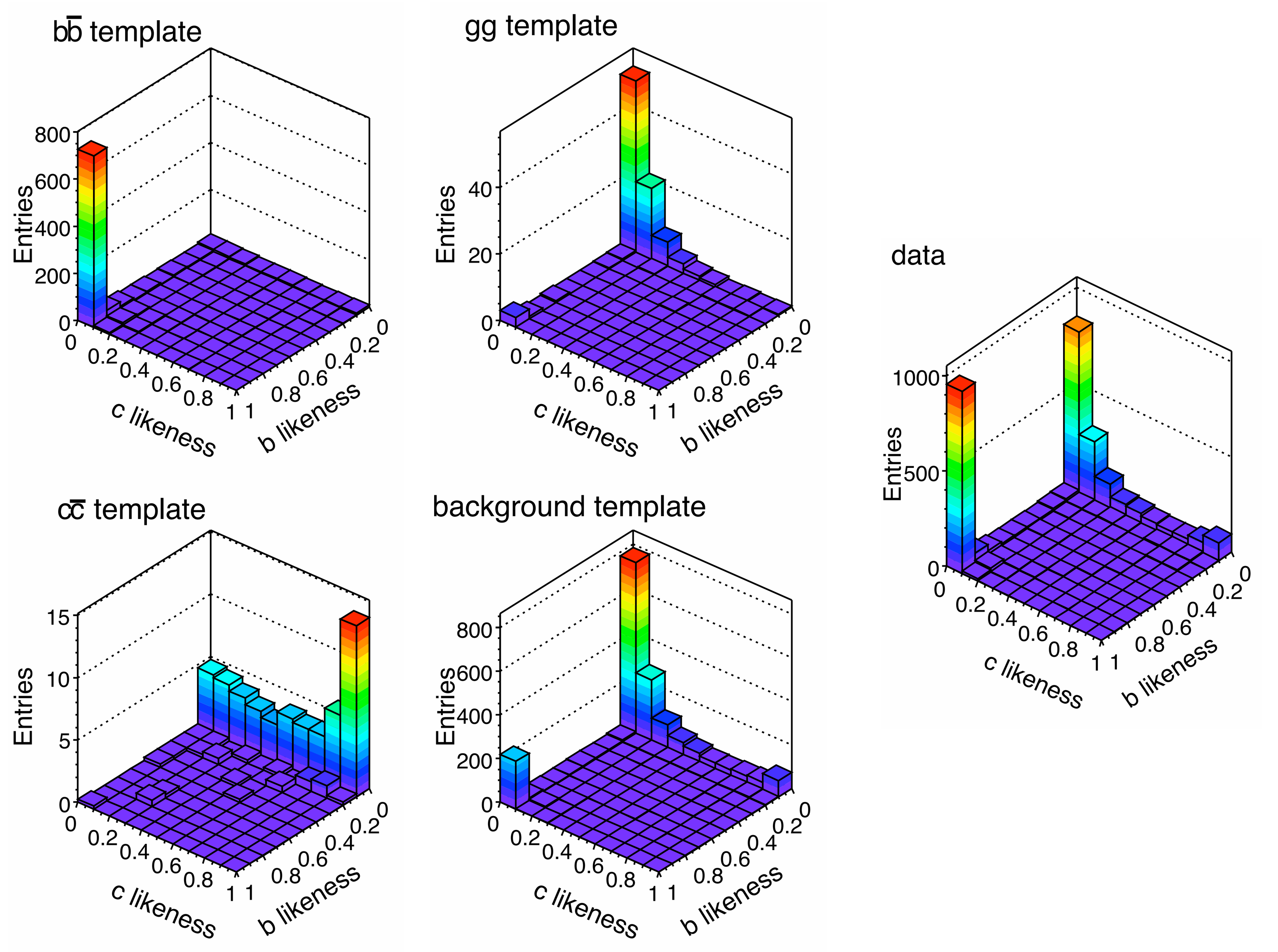


Fig 5: Flavor likeness distributions for exclusive samples of $H\rightarrow b\bar{b}$, $H\rightarrow c\bar{c}$ and $H\rightarrow gg$ and background and an independent combined “data” sample