SM-like Higgs decay into two muons at 1.4 TeV CLIC

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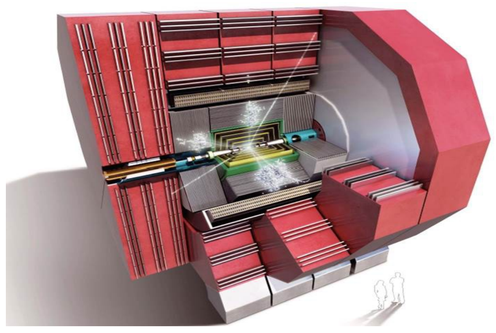
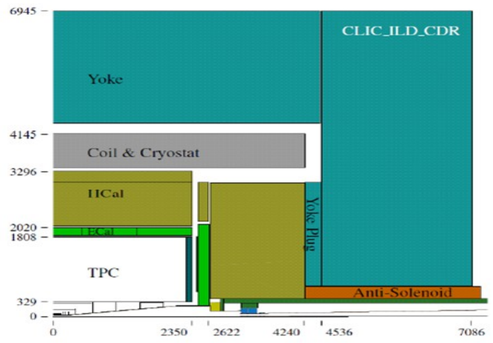
[on behalf of the CLICdp Collaboration]

1. CLIC and the ILD detector





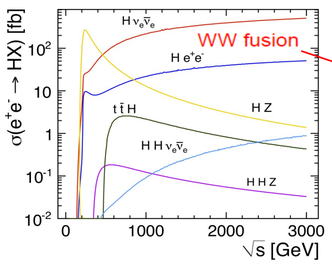
Motivation for the measurement:

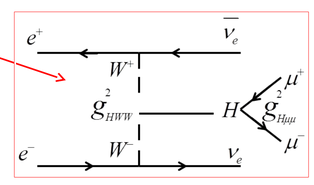
- Measurement of the Higgs branching ratios and consequently Higgs couplings provide strong test for the Standard Model and the physics beyond (2DHM, Little Higgs models or Compositeness)
- Challenge of the rare decay $H\to\mu^+\mu^-$ (78 events in 1.5 ab^{-1}):
  - Excellant μ identification required
  - Excellant p_T resolution
  - Comprehensive background suppression

Simulation:

- ILD detector for CLIC is fully simulated
- Realistic CLIC beam spectrum is taken into account
- Unpolarized beams are considered
- Beam-induced background overlaid

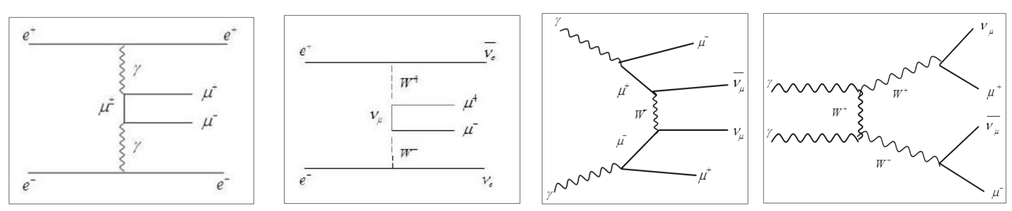
2. Signal and background





Observable:

$$\frac{g^2_{HWW}\cdot g^2_{H\mu\mu}}{\Gamma_H}$$



Preselection :

- reconstruction of two muons in an event
- di-muon invariant mass (105-145) GeV
- electron tagging

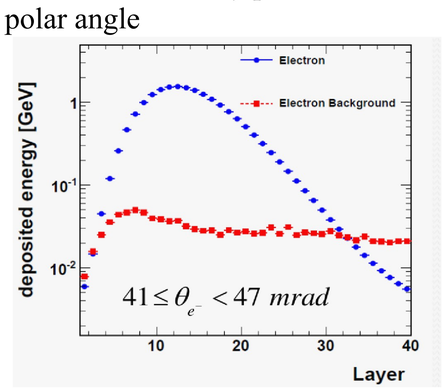
-Signal signature: two muons and missing energy

-Process with the same signature like $e^+e^-\to\mu^+\mu^-\nu\nu$ and $\gamma\gamma\to\mu^+\mu^-\nu\nu$ represent irreducible background

-Processes like $e^+e^-\to\mu^+\mu^-e^+e^-$ and $e^\pm\gamma\to\mu^+\mu^-e^\pm$ with low-angle electron in the final state reduced by MVA + electron tagging

3. Forward electron tagging and Bhabha coincidence

- Undetected electron from $e^+e^-\to\mu^+\mu^-e^+e^-$ and $e^\pm\gamma\to\mu^+\mu^-e^\pm$ background at very small angles mimic missing energy signature of the signal
- Forward region below ~ 7 deg is instrumented with calorimeters to (among others) tag (high-energy) electron
- High level of background from incoherent pairs
- Fast simulation by parametrization of background energy deposit as a function of polar angle

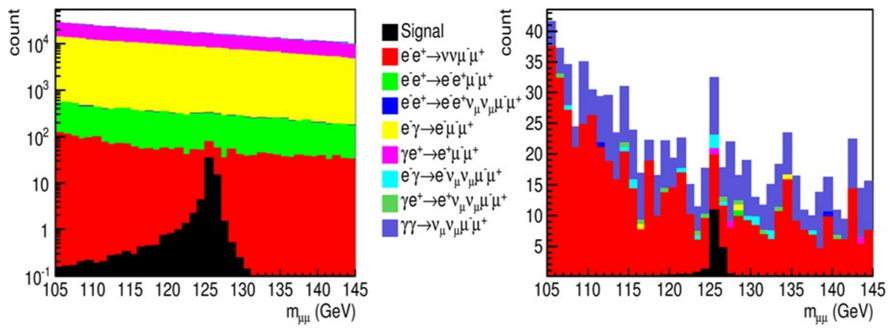


- Coincident tagging of Bhabha particles cause indiscriminate rejetion of signal. Additional cuts:
  - shower energy > 200 GeV
  - electron polar angle > 30 mrad

Process	Rejection
$e^+e^-\to e^+e^-\mu^+\mu^-$	48%
$e^\pm\gamma_{BS}\to e^\pm\mu^+\mu^-$	42%
$H\to\mu^+\mu^-$	7%

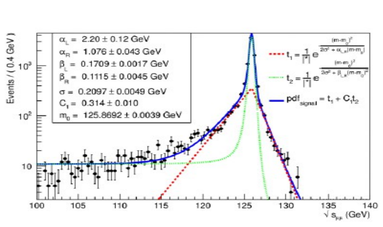
4. Selection

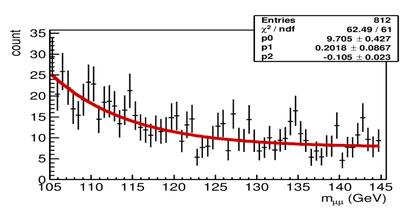
- BDT is trained on all background samples, except $e^+e^-\to\mu^+\mu^-\nu\nu$
- Trainig is done on several sensitive observables: *Evis, $p_T(\mu\mu)$, $p_T(\mu1)+p_T(\mu2)$, $\theta(\mu\mu)$,* cos *$\theta^*(\mu\mu)$, $\beta(\mu\mu)$)*
- Classifier output cut-off value (BDT>0.098) is selected to minimize relative statistical error of the measurement

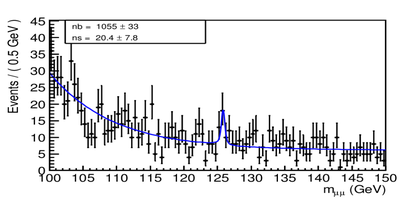


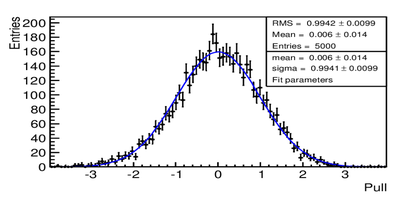
Preselection efficiency 89% BDT>0.098 Overall signal efficiency 27%

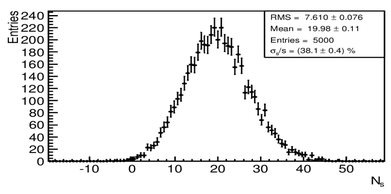
5. Signal extraction and results











- Fully simulated samples of signal and background are fitted to extract PDFs
- Expected shape of data (signal + background) for each Toy MC is fitted with f to extract number of signal Ns

$$f = k\cdot f_S + (1-k)\cdot f_{BCK} \Rightarrow N_S = k\cdot\int f_S dm$$

6. Conclusion

N_s	20±8
ε_s	27%
$\sigma_{prod}\times BR(H\to\mu\mu)$	0.05 fb
$\delta(\sigma_{WWH}\times BR(H\to\mu\mu))$	38%
$\delta(g_{H\mu\mu})$	16%

- Measurement of the branching ratio for the rare SM-like Higgs decay into two muons is simulated at 1.4 CLIC with unpolarized beams. With polarized beams (-80, +30)% the Higgs production is 2.34 times higher.
- It is shown that measurement of the branching ratio for the Standard Model Higgs decay into two muons can be performed with a statistical uncertainty of 38%. The largest contributions to the measurement uncertainty are the limited statistics of the signal and the presence of signal-like backgrounds.
- Uncertainty of the $\sigma_{prod}\times$ BR($H\to\mu^+\mu^-$) corresponds to the 16% uncertainty of the Higgs to muon coupling.
- If expected precision of all relevant Higgs couplings is taken into account, with the beam polarization (-80%) uncertainty of the Higgs to muon coupling is 11%.

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