# Measurement of the Higgs to γγ branching fraction at 3 TeV CLIC

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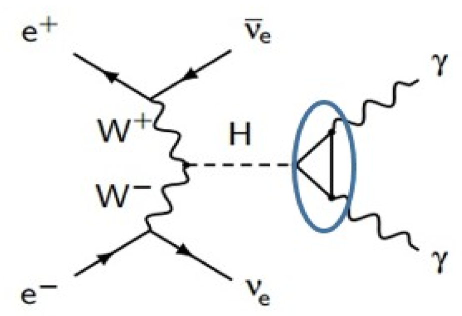
## 1. Introduction

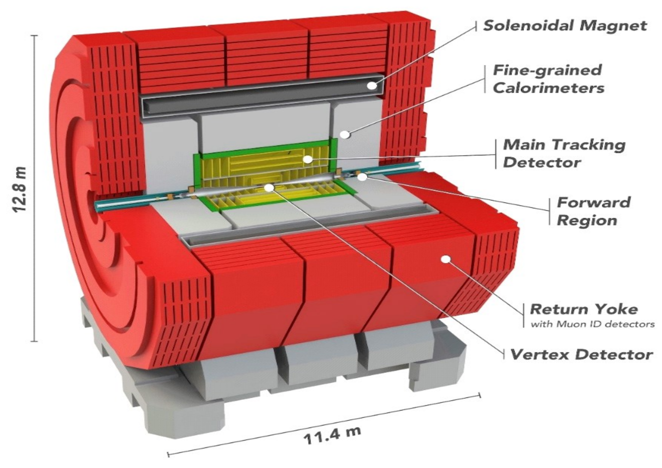
- Higgs boson couples with photons on a loop level – this channel is sensitive to BSM contributions
- Higgs decay to two photons is a rare process: BR(H→γγ) ~ 0.23% implying low signal rate.

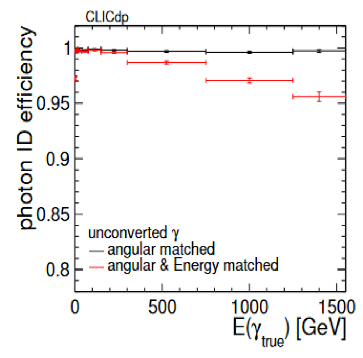



- Typical $g_{H\gamma\gamma}$ deviations in the BSM models of the Higgs sector are ≤ 4% [1]
- Utmost statistical precision of $g_{H\gamma\gamma}$ as obtained in a global fit (model independent, k-framework, EFT) is ~ 1% [1].

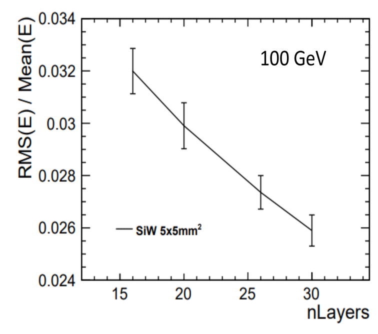
## 2. CLIC Detector

- 4 T super-conducting solenoid
- Detector system for track reconstruction is based on Si technology
- **Reconstruction and identification of particles using Particle Flow Algorithm (PFA)**
- Excellent performance of photon reconstruction and identification due to the highly granular ECAL:
  - Photon identification efficiency ~ 99%
  - Photon energy resolution is 2% - 3%




*Photon identification efficiency*

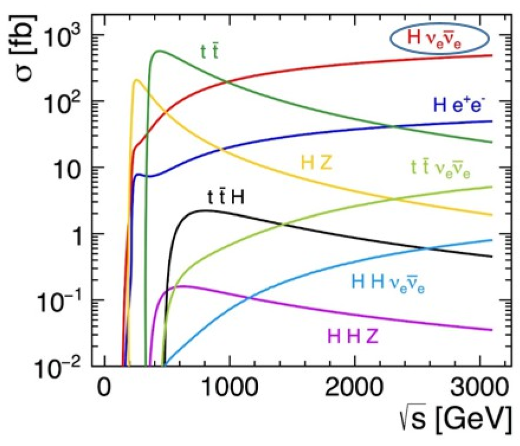



*Photon energy resolution as a function of number of ECAL layers*

## 3. Signal separation

- WW-fusion is dominant Higgs production mechanism for energies above 500 GeV, and provides access to rare Higgs decays (γγ, Zγ, μμ)

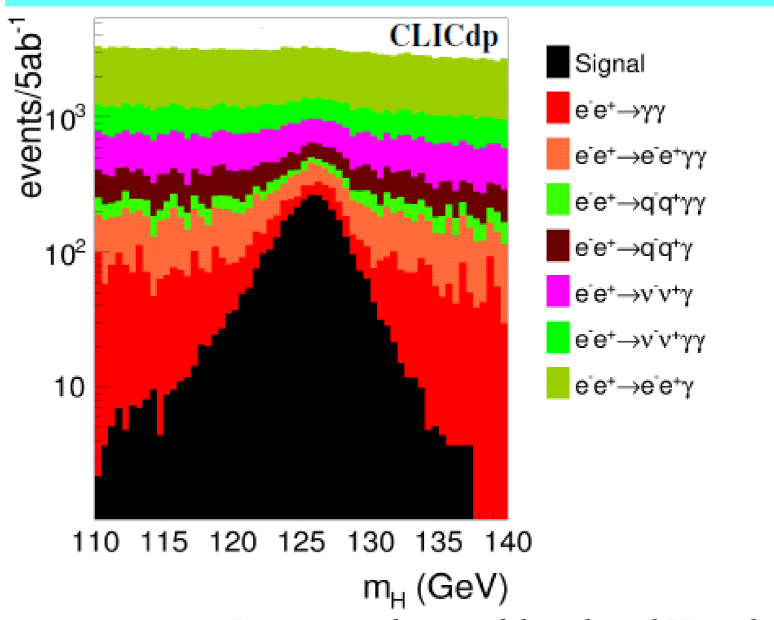
- σ(Hυυ) at 3 TeV is 415 fb
- σ(Hυυ) x BR(H→γγ) = 0.95 fb
- $N_{signal}$ ~ 4750evt/5ab$^{-1}$

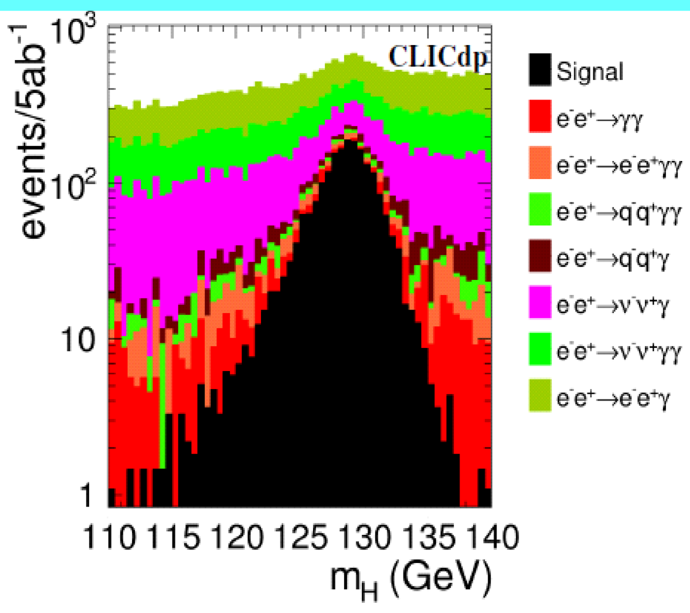



| Process | $\sigma_{effecive}$ (fb) | No. evt, 5 ab$^{-1}$ |
|---|---|---|
| σ(hνν) × BR(h→γγ) | 0.95 | 4750 |
| e⁺e⁻→γγ | 15.2 | 7.6 · 10⁴ |
| e⁺e⁻→e⁺e⁻γ | 335 | 1.7 · 10⁶ |
| e⁺e⁻→e⁺e⁻γγ | 33 | 1.5 · 10⁵ |
| e⁺e⁻→ννγ | 13 | 6.5 · 10⁴ |
| e⁺e⁻→ννγγ | 26 | 1.3 · 10⁵ |
| e⁺e⁻→qqγ | 210 | 1.1· 10⁶ |
| e⁺e⁻→qqγγ | 47 | 2.3· 10⁵ |

*Number of signal and background events expected in 5 ab⁻¹ of data at 3 TeV CLIC*

Since the signal is highly suppressed w.r.t. background, two-step event selection is employed:
- Events with 2 isolated photons with $p_T$ above 15 GeV, 15 > $p_T$(γγ) > 600 GeV, 100 GeV > E(γγ) > 1000 GeV
- MVA selection based on 12 sensitive observables in an optimized way to maximize statistical significance.




*Recontructed mass of the selected Higgs boson before (left) and after (right) MVA*

- Overall signal selection efficiency ~ 43%
- Selected number of signal events is 2080 in 5ab$^{-1}$ of integrated luminosity
- Signal to background ratio is ~ 10.

## 4. Pseudo-experiments

- Experimental data are fully simulated to include selected signal and background events → "pseudo-data".
- Pseudo-data consisting of signal and background are described by PDF functions ($f_s$, $f_b$) in order to extract the number of signal events $N_s$ in a fit of pseudo-data with the function: $f = N_s f_s(m_{\gamma\gamma}) + N_b f_b(m_{\gamma\gamma})$ (pseudo-experiment).

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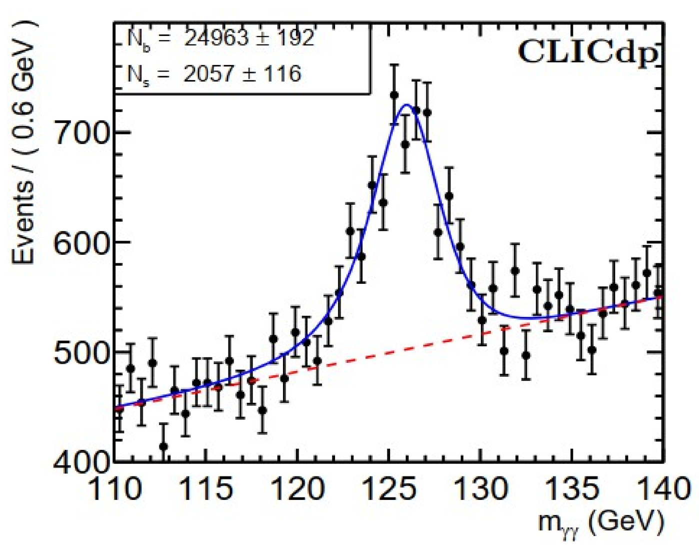
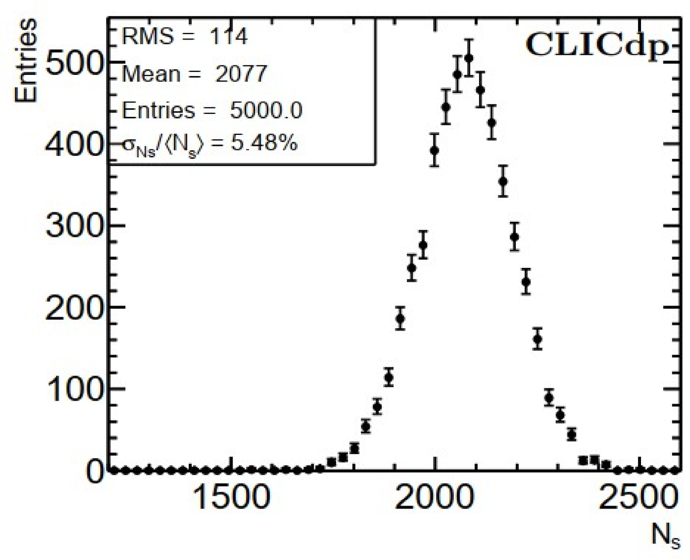
- In order to estimate the statistical dissipation of the measured number of signal events, 5000 pseudo-experiments with 5ab$^{-1}$ of data were performed. RMS of the measurement is used as statistical estimator of the uncertainty of the signal count.
- Relative statistical uncertainty of the Higgs boson to diphoton BR is found to be 5.5%




*One example of pseudo-experiment, showing diphoton invariant mass of pseudo-data.(black), corresponding fit with function f (full line), and background fit with function fb (dashed line)*




*Pull distribution of 5000 pseudo-experiments*

## 5. Discussion

- Relative statistical uncertainty of individual BR(H→γγ) measurement of 5.5% translates to absolute statistical precision to measure BR(H→γγ) deviation from the SM prediction as $BR_{SM}$ ±0.001% with the CL above 68% in the two-tail limit.
- Several sources of systematic uncertainty are considered (uncertainty of photon identification efficiency, uncertainty of integrated luminosity, photon energy resolution, uncertainty of the luminosity spectrum, background modeling). Overall systematic uncertainty is estimated to be ~ 2%.
- The obtained results supersede estimates for 3 TeV CLIC sensitivity obtained from 1.4 TeV simulation by luminosity scaling.

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