

Higgs couplings in the $Z(\ell\ell/\nu\nu)H$ channel at $\sqrt{s}=240$ GeV at the FCC experiment



Biennale APC

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Studying the Higgs couplings

In the Standard Model (SM), fermions inherit their mass from their coupling with the H

Our study aims at estimating the best precision with which we could measure these couplings

$$m_f = v \frac{y_f}{\sqrt{2}}$$

Any deviation from the expected value would indicate possible beyond SM processes



Heavy particles (W, Z, t)



Light particles (leptons, quarks)

Lighter, faster



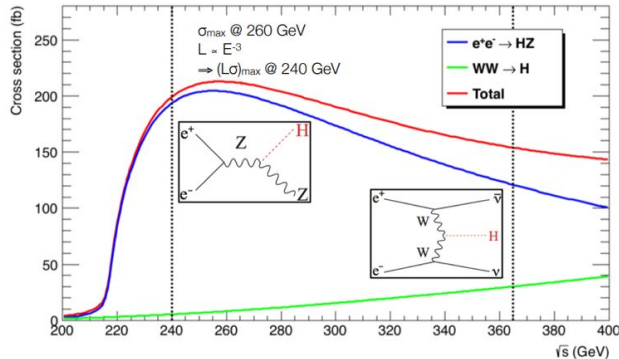
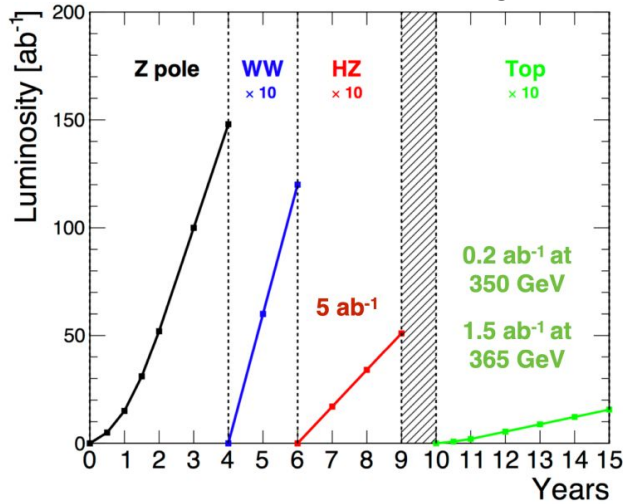
Massless particles (photons, gluons)



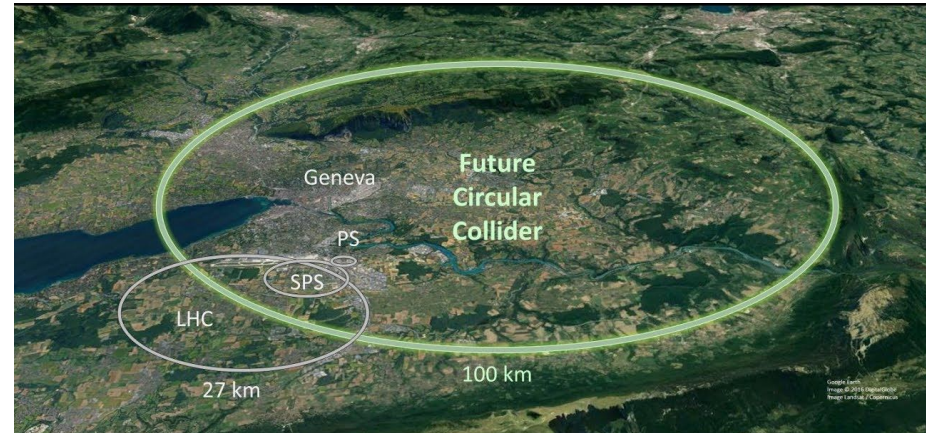
Higgs itself

The FCC experiment - FCC-ee

FCC-ee functioning schedule



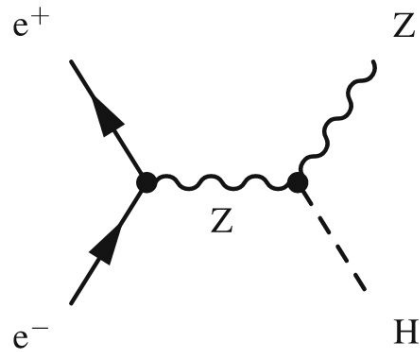
- **FCC** (Future Circular Collider)
 - $\sim 90\text{km}$ circular collider project
 - Two periods on functioning : **FCC-ee** & FCC-hh



- Great improvement on EW studies wrt **LEP**
- Higgs factory
- Great prospects for new physics (hh)

(ZH) Higgstrahlung process - Recoil Mass

- $e^+ + e^- \rightarrow Z + H$

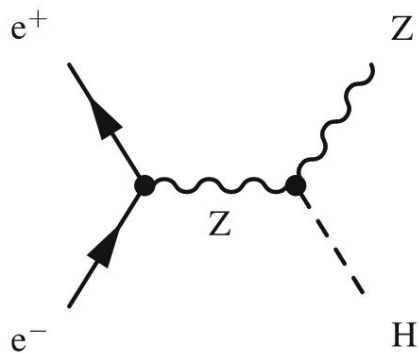
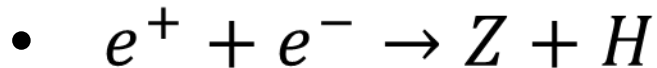


Recoil Mass :

$$(E_U + E_H, \vec{p}_U + \vec{p}_H) = (\sqrt{s}, \vec{0}) \Rightarrow M_{recoil}^2 = s + m_Z^2 - 2E_U\sqrt{s}$$

- Allows model independent measurement of the total Higgs Cross-section
- Unusable in the LHC due to the composite nature of protons

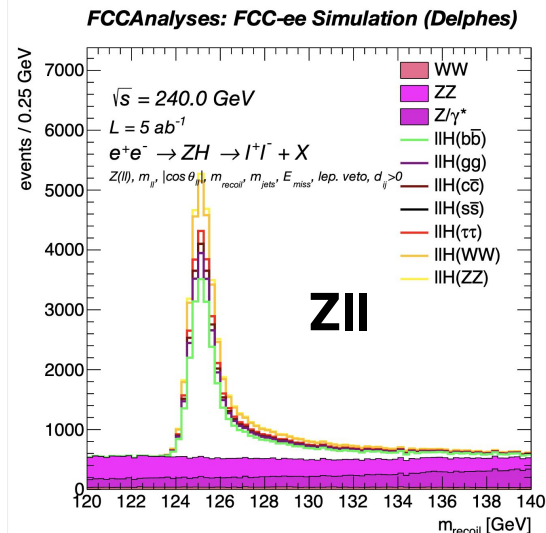
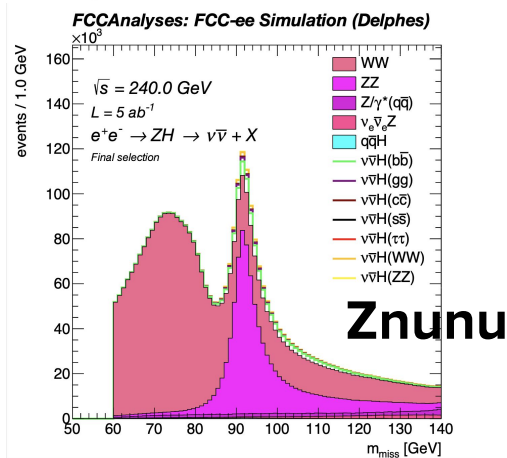
(ZH) Higgstrahlung process - Zll & Znunu



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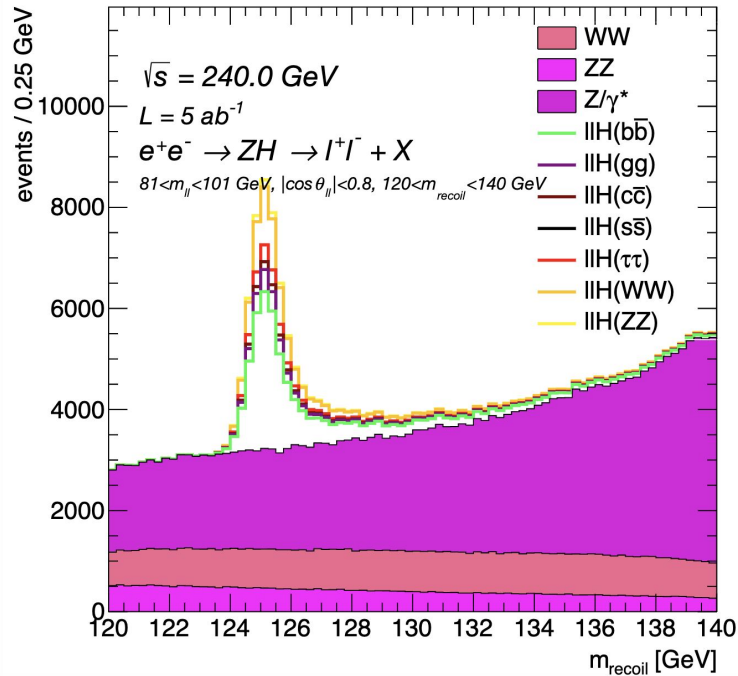
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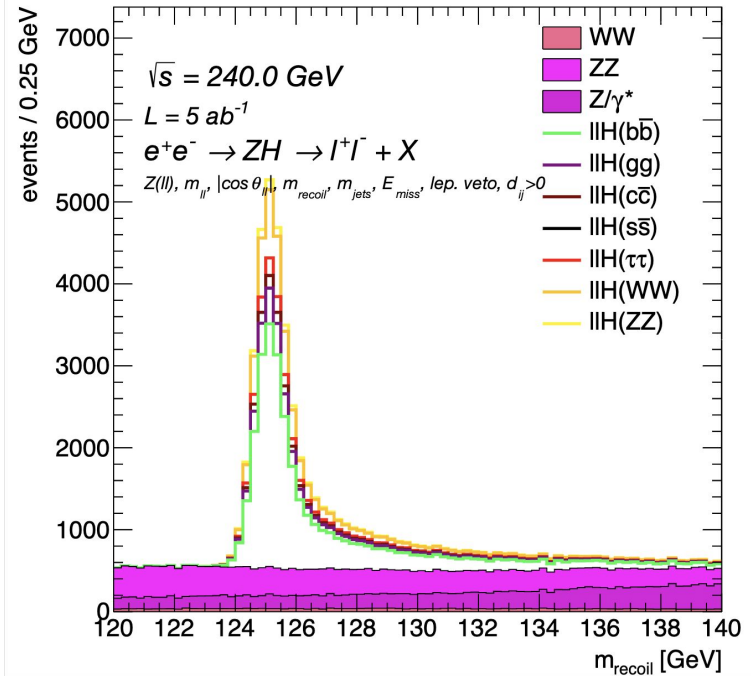


Events selection - Zll example

FCCAnalyses: FCC-ee Simulation (Delphes)



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Events categorization

We train a Neural Network to categorize the events in one of the signal channels :

$$\mathbf{H} \rightarrow \mathbf{bb/cc/gg/ss/WW/ZZ/\tau\tau} \quad (\mathbf{uu/dd/cu/bd/bs/sd})$$

We perform slight adjustments on categorization and fit simultaneously all categories to count the number of signal events

Zll+Znunu	bb	cc	gg	ss	WW	ZZ	$\tau\tau$
Precision %	0.32	2.04	1.02	130	1.48	9.52	3.72

Very promising results wrt HL-LHC prediction and other future experiments as CEPC

Parallel and future studies

- **Parallel :**
 - R&D on **ALLEGRO**'s electromagnetic calorimeter
 - Working on the upgrade of **ATLAS**' inner detector tracker

- **Future :**
 - Higgs coupling analysis at $\sqrt{s}=365$ GeV
 - Higgs self-coupling (HH) in **ATLAS** in the bbyy channel

BACKUP

- **Without looking at the Higgs decay:**

$$\sigma(ee \rightarrow ZH) \Rightarrow g_{HZZ}^2$$

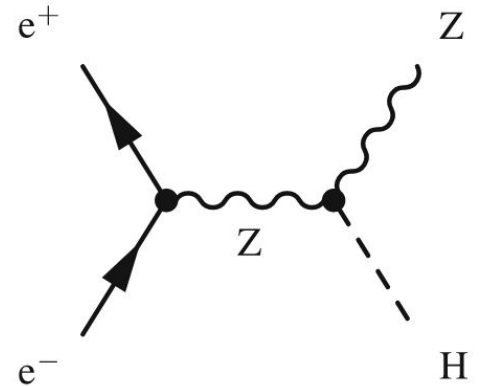
- **Reconstructing $H \rightarrow ZZ$:**

$$\sigma(ee \rightarrow ZH)BR(H \rightarrow ZZ) \propto \frac{g_{HZZ}^4}{\Gamma} \Rightarrow \Gamma$$

- **Reconstructing other Higgs Boson decays $H \rightarrow XX$:**

$$\sigma(ee \rightarrow ZH)BR(H \rightarrow XX) \propto \frac{g_{HZZ}^2 g_{HXX}^2}{\Gamma} \Rightarrow g_{HXX}^2$$

- **Looking at “invisible” Higgs decays (large missing energy) $\Rightarrow BR(H \rightarrow \text{invisible})$**



Znu visible mass for the 2D fit

