

Higgs to Invisible at FCC-ee

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FUTURE
CIRCULAR
COLLIDER



UNIVERSITY OF
LIVERPOOL

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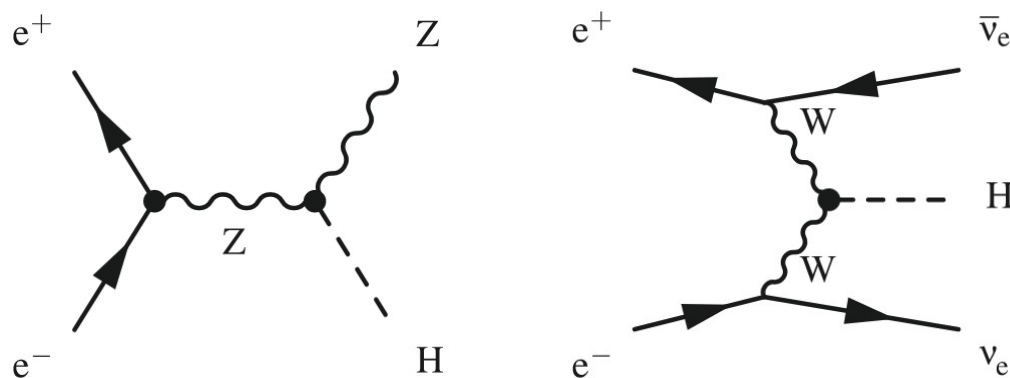


Preliminaries: FCC

- Future Circular Collider – FCC
 - A proposal for a future accelerator programme at the CERN site using a tunnel of ~ 100 km
 - Studies have considered an e^+e^- , hh or eh version, aka FCC-ee, FCC-hh, FCC-eh
 - Current proposal is to start with FCC-ee running on Z pole (~ 91 GeV), ZH (240 GeV), WW (157, 163 GeV) and $t\bar{t}$ (340–365 GeV)
- In this talk I will consider FCC-ee run on ZH to study the sensitivity to Higgs to invisible

FCC-ee at ZH

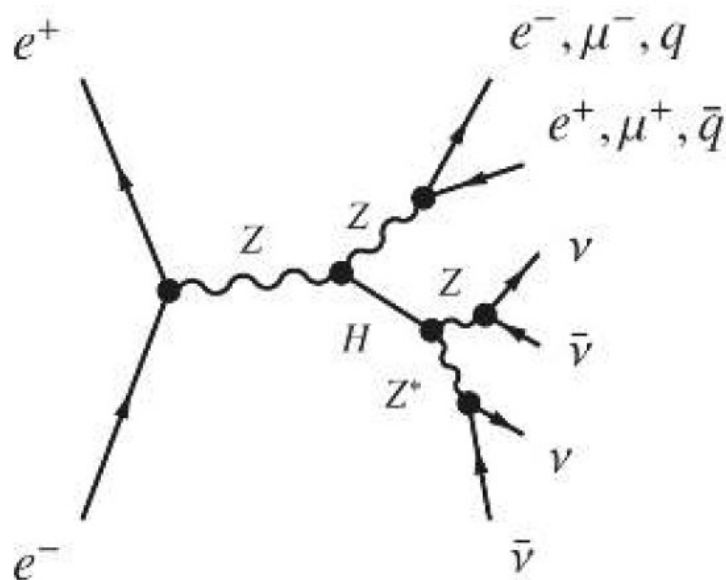
- ZH = Higgs factory mode
 - $\sqrt{s} = 240 \text{ GeV}$, Lumi $\sim 10 \text{ ab}^{-1}$ (4 exp.), Run time 3 years
 - $1.45 \times 10^6 \text{ HZ}$ and 45k WW \rightarrow H events



- Higgs physics:
 - Mass and coupling measurements using the recoil method

Recoil method and Higgs to invisible

- Recoil method: tag the Z decay and whatever recoils against it is the Higgs



Agnostic to what the Higgs boson decays
Can be used to measure Higgs properties, but also
Higgs to invisible

Invisible Higgs boson decays:
 \times BSM physics: Higgs portal for Higgs to dark matter
 \times SM decay $H \rightarrow ZZ \rightarrow 4\nu$ BR = 0.1%

Several studies exist already. Their sensitivity depend on how many Z channels can be included.

Assumptions for this study:

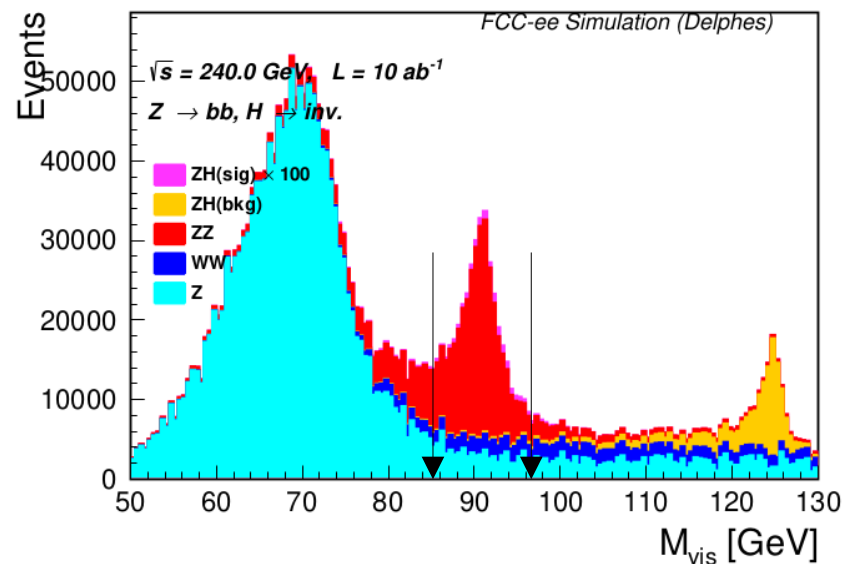
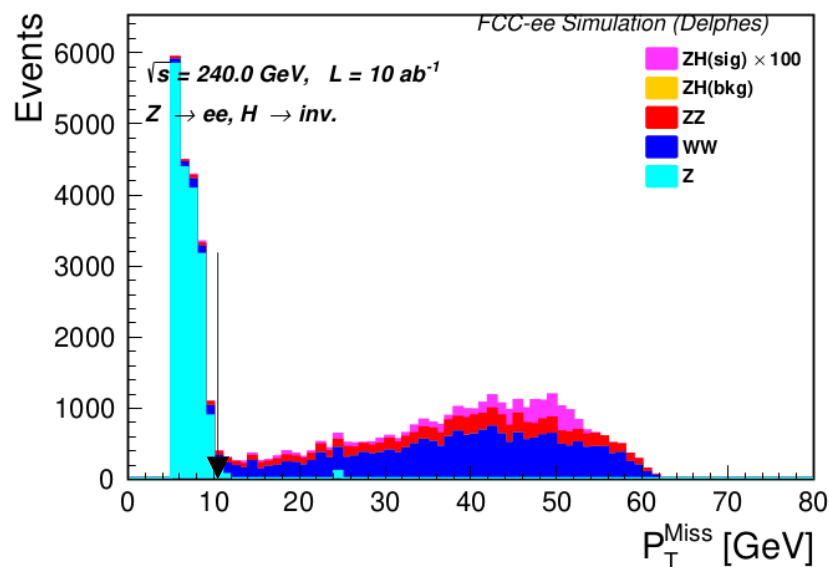
- luminosity: 10 ab^{-1}
- Only $\sqrt{s} = 240 \text{ GeV}$ event included
- Delphes simulation of IDEA detector and official FCC framework to analyse the results

Analysis overview

- Channels included: $Z \rightarrow ee, \mu\mu, bb, cc, qq$
- Higgs to invisible is simulated using the SM channel $H \rightarrow ZZ \rightarrow 4\nu$
- Flavour tagging using Particle Net algorithm FCC implementation
- Strategy to extract result:
 - fit the distribution of missing mass
- Backgrounds considered
 - Dilepton
 - ZZ/WW
 - ZH with Higgs going to visible channels

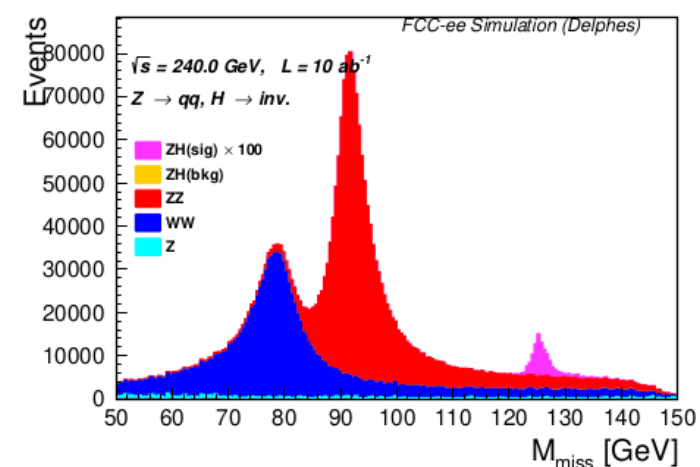
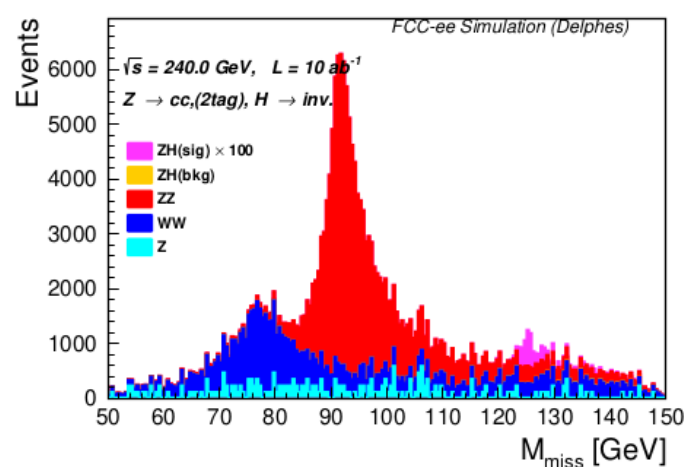
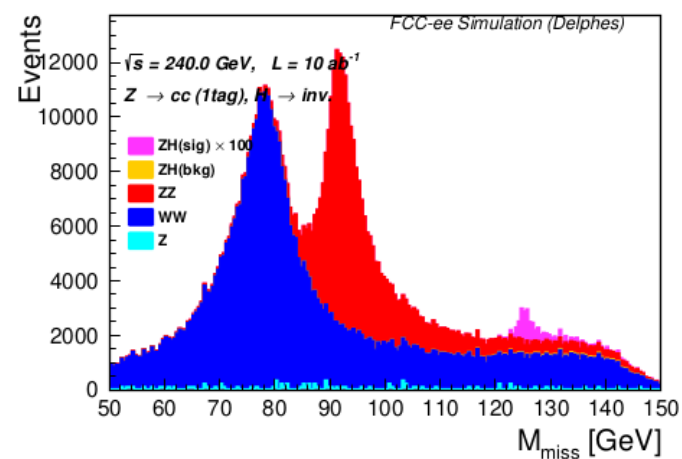
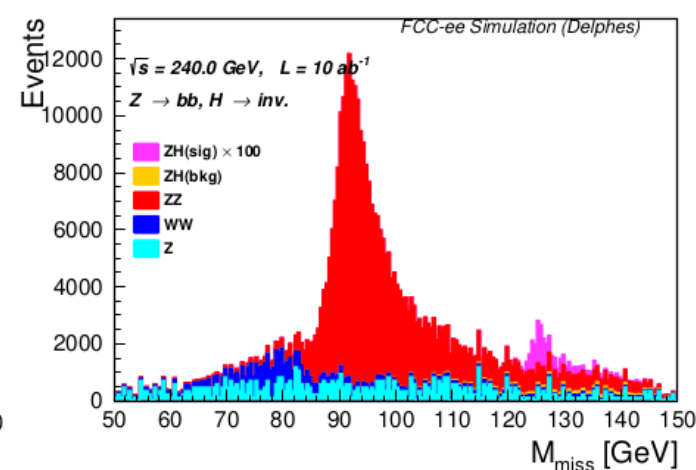
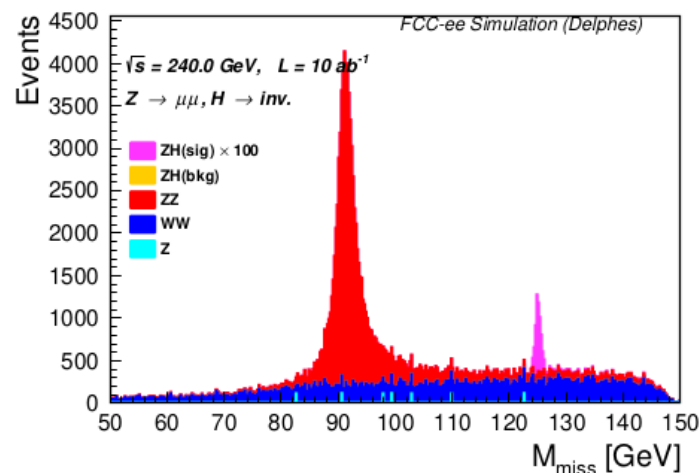
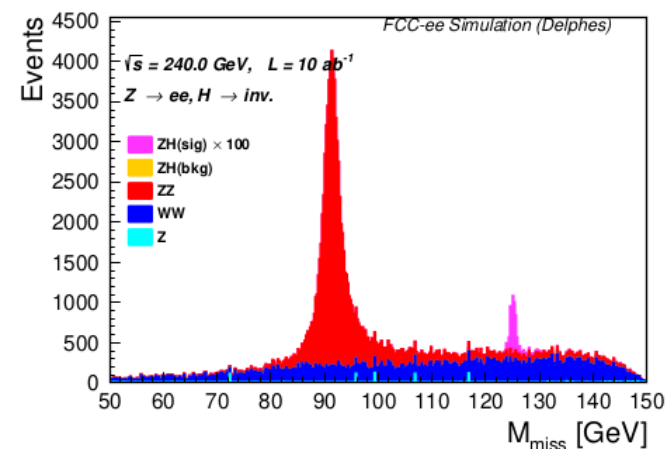
Categories and event selection

- Events are categorized in 6 channels: ee, $\mu\mu$, bb, cc (1 c-jet), cc (2 c-jets), qq
- To reject dilepton: p_T^{miss} requirement
- To be compatible with a Z boson: m_{vis} requirement



Final variable

- The final result is extracted by fitting the missing mass distribution in each channel

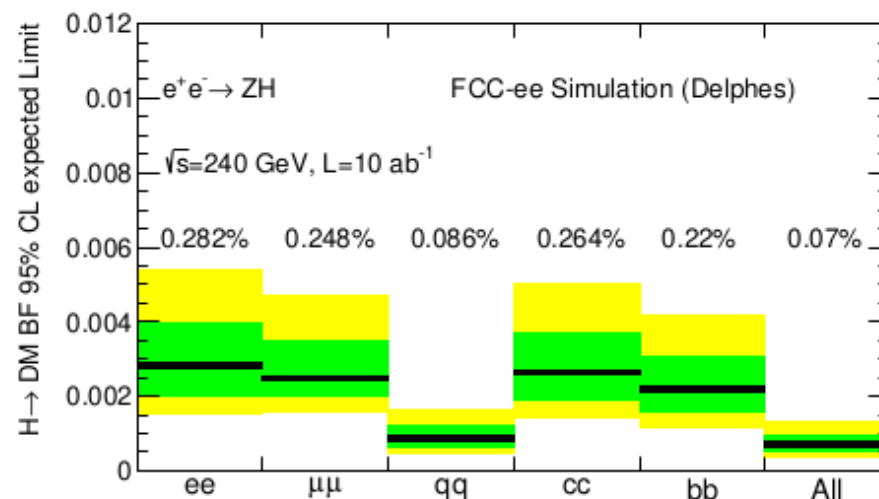
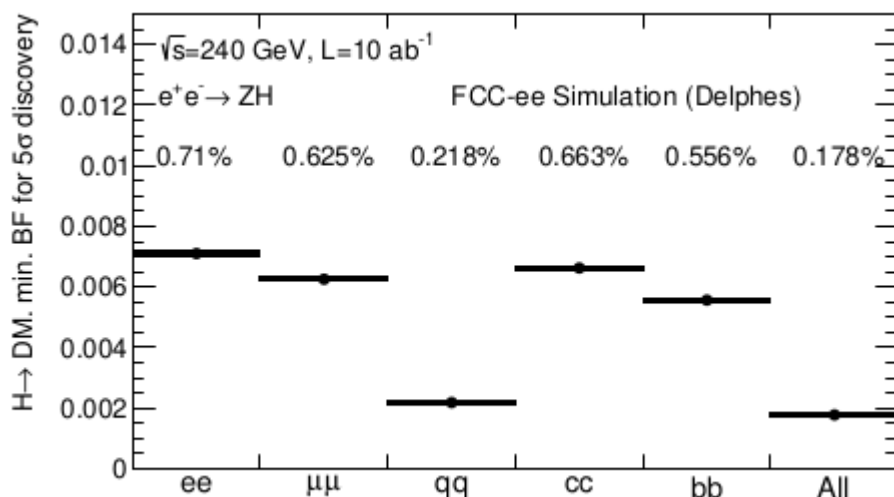
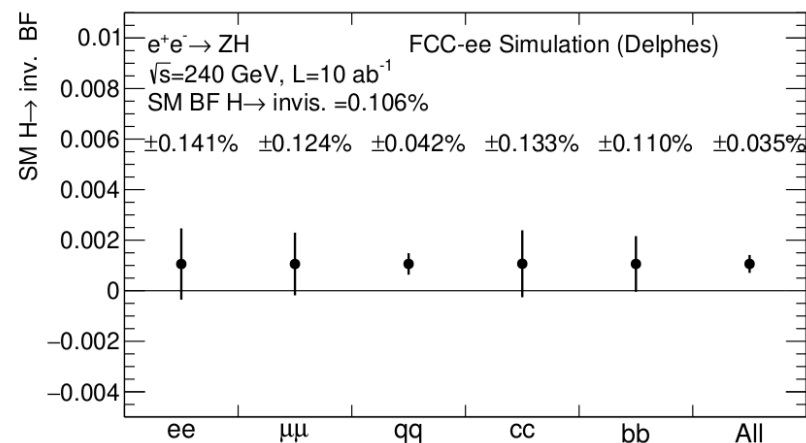


Results

- Two scenarios:
 - Scenario 1:
measure SM Higgs to invisible

Combination of all channels:
 $BR(H \rightarrow inv) = (0.106 \pm 0.035)\%$

- Scenario 2: search for DM
 SM Higgs to invisible is a background



Conclusions

- We have tried to estimate the sensitivity for Higgs to invisible in FCC
 - The work is done within the FCC team at CERN
 - We tried to study the inclusion of multiple channels
 - Results for 10 ab^{-1} :
 - We can almost measure SM $H \rightarrow \text{invisible}$
 - We can constrain $H \rightarrow \text{DM}$ ($< 0.07\%$) or discover it, if $\text{BR} > 0.18\%$
 - Documentation of the analysis will become public soon