

# Higgs/Top Performance meeting

Jan Eysermans (MIT), Andrew Mehta (Liverpool), Xunwu Zuo (KIT)

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# Welcome to new conveners



**Welcome to Andrew Mehta (Liverpool) and Xunwu Zuo (KIT) to the Higgs/Top coordination team!**

**Thanks Michele (now Phys. Perf. coordinator) for all the efforts over the past years in the Higgs group**

**Please add all conveners in the loop when contacting us:**

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## Feasibility Study Report (FSR)

- First draft to be ready by the end of the year (for the SPC)
- Draft v0 for internal PED review ~ **today!**
  - We are reviewing analysis notes
  - Let us know if you have material to review that needs to go into the FSR
  - **CDS has changed link:** <https://repository.cern/>

## What we need for the FSR

- Baseline Higgs program: expected sensitivities for the Higgs couplings
- Obtain results for  $\sigma \cdot \text{BR}$
- At center of mass energies 240 GeV ( $10.8 \text{ ab}^{-1}$ ) and 365 GeV ( $3 \text{ ab}^{-1}$ )
- Split in production mode – see next slide

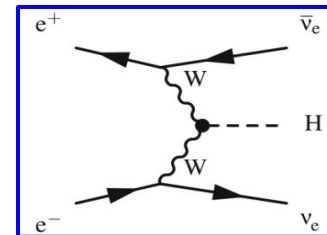
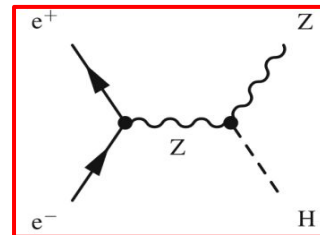
**Table 3.** From Ref. [4]: Relative uncertainty (in %) on  $\sigma_{\text{ZH}} \times \mathcal{B}(\text{H} \rightarrow \text{X}\bar{\text{X}})$  and  $\sigma_{\nu_e \bar{\nu}_e \text{H}} \times \mathcal{B}(\text{H} \rightarrow \text{X}\bar{\text{X}})$ , as expected from the FCC-ee data at 240 and 365 GeV.

$\sqrt{s}$	240 GeV		365 GeV	
Integrated luminosity	10.8 $\text{ab}^{-1}$		3.0 $\text{ab}^{-1}$	
Channel	ZH	$\nu_e \bar{\nu}_e \text{H}$	ZH	$\nu_e \bar{\nu}_e \text{H}$
H $\rightarrow$ any	$\pm 0.36$		$\pm 0.6$	
H $\rightarrow \text{b}\bar{\text{b}}$	$\pm 0.20$	$\pm 2.1$	$\pm 0.35$	$\pm 0.6$
H $\rightarrow \text{c}\bar{\text{c}}$	$\pm 1.5$	?	$\pm 4.4$	$\pm 7.1$
H $\rightarrow \text{g}\text{g}$	$\pm 1.3$	?	$\pm 2.5$	$\pm 3.2$
H $\rightarrow \text{W}^+ \text{W}^-$	$\pm 0.8$	?	$\pm 1.8$	$\pm 2.1$
H $\rightarrow \text{Z}\text{Z}$	$\pm 3.0$	?	$\pm 8.5$	$\pm 7.1$
H $\rightarrow \tau^+ \tau^-$	$\pm 0.6$	?	$\pm 1.3$	$\pm 5.7$
H $\rightarrow \gamma\gamma$	$\pm 6.1$	?	$\pm 13$	$\pm 16$
H $\rightarrow \text{Z}\gamma$	??	??	??	??
H $\rightarrow \mu^+ \mu^-$	$\pm 13$	?	$\pm 28$	
H $\rightarrow$ invisible	$< 0.2$	?	$< 0.4$	

# Splitting production mechanisms at 365 GeV

## At 365 GeV center-of-mass, significant contribution from VBF $\nu\nu H$

- This interferes with the ZH process where  $Z \rightarrow \nu\nu$
- The samples (e.g. `wzp6_ee_nunuH_Hbb_ecm365`) we have are inclusive:
  - Contains ZH + VBF + interference
- For cross-section analyses and couplings, need to split the production mode

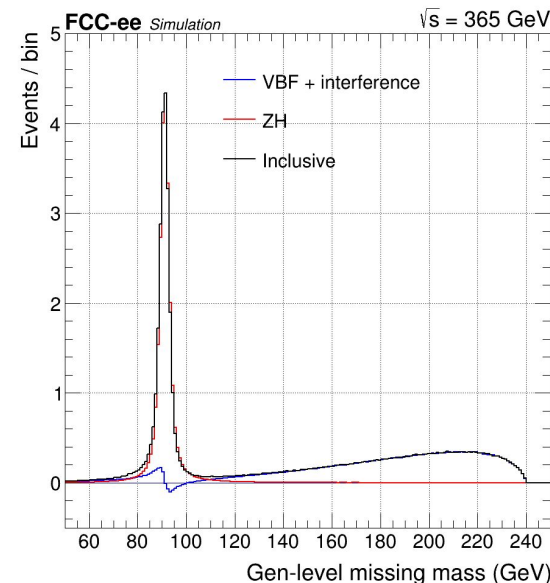


## Recipe to split the production mode

- **For ZH:** use muon neutrino sample with weight 3
- **For VBF:** use  $(\nu_e \nu_e H - \nu_\mu \nu_\mu H)$ 
  - Contains the pure VBF component + interference

## All splitted samples have been produced

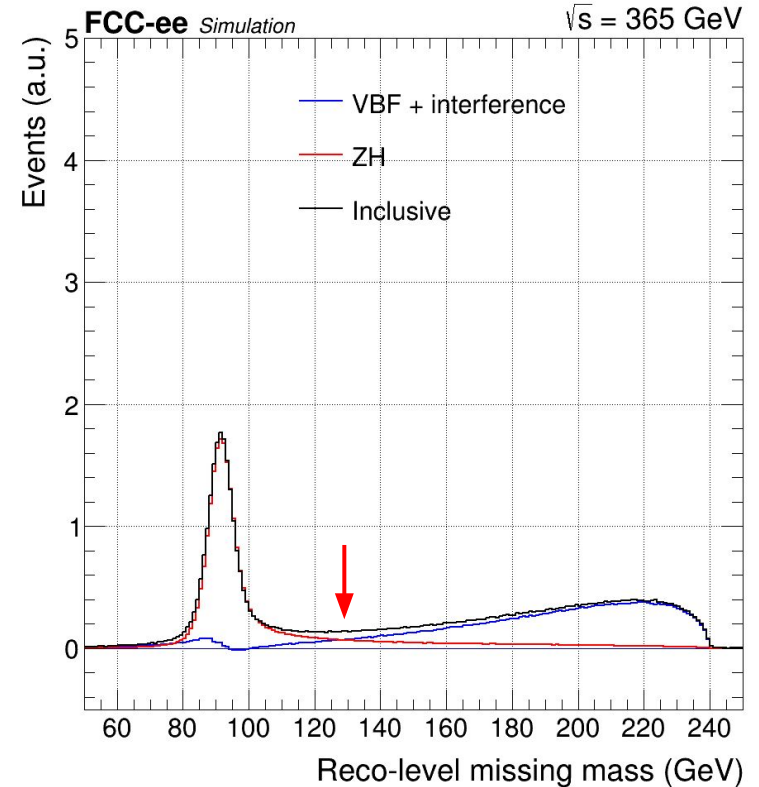
- Inclusive: `wzp6_ee_nunuH_HXX_ecm365`
- Muon neutrino: `wzp6_ee_numunumuH_HXX_ecm365`
- Electron neutrino: `wzp6_ee_nuenuH_HXX_ecm365`



# Splitting production mechanisms at 365 GeV

One can select more pure regions for both production modes for further background suppression

- Cut or categorize the events by using a cut on the missing mass at 130 GeV
- Nevertheless, both production processes have to be taken into account separately



# Where are we today?

Made a lot of progress over the past years, mainly focused at the 240 GeV threshold, but effort at 365 has started

## Missing elements for the Feasibility Study

- Higgs @ 240 GeV: **WW, ZZ, tautau** (expansion of H width efforts)
  - Work started on tautau and Z(jj)H(4l)
  - See updates today
- Higgs @ 365 GeV
  - Use the tagger trained at 240 GeV
  - (ZH, vvH)→bb (width), ZH→ WW

Parameter	FCC-ee CDR	FCCee today
H→WW	1 %	2.0 %
H→ZZ	3.6 %	4.6 %
H→gg	1.6 %	0.94 %
H→γγ	7.5 %	3.5 %
H→cc	1.8 %	1.92 %
H→bb	0.25 %	0.22 %
H→μμ	15.8 %	19.5 %
H→ττ	0.75 %	0.9%
H→Zγ		
H→ss	–	124 %
Invisible	< 0.25 %	< 0.18 %
$m_H$	5 MeV	4 MeV
$\Gamma_H$	1 %	4%
$\kappa_\lambda$	42 %	30%

## Procedure for conferences

In general, contact us (conveners) in case you would like to present material at a conference

- All abstracts have to be approved by the Higgs/Top conveners and then conference committee
- After approval, the author is responsible for abstract submission to the conference
- Abstracts should be registered in the conf. database: <https://fcc-ee-conference.web.cern.ch/>

## Higgs Hunting, 23-25 September, Paris

- <https://indico.ijclab.in2p3.fr/event/10259>
- Louis Portales will give a talk about Higgs @ FCC-ee

## Higgs 2024, 4–8 November, Uppsala

- <https://indico.cern.ch/event/1391236/>
- Looking for abstracts/speakers for 3 talks
  - Higgs at FCC-hh
  - Higgs couplings and detector requirements – Andrea Sciandra
  - Higgs properties (mass/width/CP) and det. Req – **talk not assigned yet, please nominate yourself!**

## ECFA workshop on EWK factories, 9-11 October, Paris

- <https://indico.cern.ch/event/1399276/>

## 2nd FCC Italy-France Workshop, 4-6 November, Venice

- <https://agenda.infn.it/event/37960/>



# Agenda for today



**14:00** → 14:10 **News** 🕒 10m ✎

**Speakers:** Jan Eysermans (Massachusetts Inst. of Technology (US)), Michele Selvaggi (CERN)

**14:10** → 14:30 **CP violation in the Higgs sector at FCC-ee and FCC-hh** 🕒 20m ✎

**Speakers:** Andrew Pilkington (University Of Manchester), Sarah Louise Williams (University of Cambridge (GB))

**14:30** → 14:50 **Htautau** 🕒 20m ✎

**Speakers:** Sofia Giappichini (KIT - Karlsruhe Institute of Technology (DE)), Xunwu Zuo (KIT - Karlsruhe Institute of Technology (DE))

**14:50** → 15:10 **H(jj) final states, combination and update at 365 GeV** 🕒 20m ✎

**Speakers:** Alexis Maloizel (APC, CNRS/IN2P3 and Université Paris Cité (FR)), George Iakovidis (Brookhaven National Laboratory (US))

**15:10** → 15:30 **Z(jj) HZZ-> 4 leptons** 🕒 20m ✎

**Speaker:** Mr Yehia Mahmoud (ENHEP Egyptian Network of High Energy Physics (EG))

**15:30** → 15:50 **Top threshold scan** 🕒 20m ✎

**Speakers:** Ankita Mehta (CERN), Matteo Defranchis (CERN)

**15:50** → 16:10 **Higgs to invisible with FullSim** 🕒 20m ✎

**Speakers:** Dr Andrea Sciandra (Brookhaven National Laboratory (US)), Ang Li (Brookhaven National Laboratory (US)), Diallo Boye (Brookhaven National Laboratory), UNKNOWN UNKNOWN

Backup

**Produced large batch of samples at 365 GeV for Top/Higgs studies – thanks Louis Portales!**

Samples are here: [https://fcc-physics-events.web.cern.ch/fcc-physics-events/FCCee/winter2023/Delphisevents\\_IDEA.php](https://fcc-physics-events.web.cern.ch/fcc-physics-events/FCCee/winter2023/Delphisevents_IDEA.php)

- **Higgs samples**

- All samples produced  $Z(XX)H(YY)$  with Whizard @365
- wzp6\_ee\_mumuH\_ecm365 produced with identical seed → being reproduced now
- FCNC Whizard cards debugged but to be produced centrally

- **Top samples**

- WbWb split in hadronic, semileptonic, and leptonic (Whizard)
- Center-of-mass energies 345, 350, 355 and 365 GeV

- **Background samples**

- WW/ZZ Pythia
- $Z/\gamma$  with Whizard – also Pythia under production to have same generator as 240 GeV (p8\_ee\_Zqq\_ecm365)
- Rares

**Let us know if you need additional samples**