Summary & Prospects

Software / Higgs / Top

Roberto Salerno

Physics and Experiments session

14:00	**Simulation of IDEA**	*Lorenzo Capriotti*	
	Amphithéatre Dirac	14:00 - 14:15	
	Particle Flow for Dual Read-Out Calorimeter	*Adelina D'Onofrio*	
	Amphithéatre Dirac	14:20 - 14:35	
	Prospects for tau measurements	*Alberto Lusiani*	
	Amphithéatre Dirac	14:40 - 14:55	
15:00	**Bs --> DsK**	*Giulio Mezzadri et al.*	
	Amphithéatre Dirac	15:00 - 15:15	
	b to s tau tau	*Tristan Miralles*	
	Amphithéatre Dirac	15:15 - 15:30	
16:00	**Higgs cross section and mass with ZH processes**	*Ang LI et al.*	
	Amphithéatre Dirac	16:00 - 16:15	
	Higgs Hadronic decays	*Reham AliMohamed Mahmoud*	
	Amphithéatre Dirac	16:20 - 16:35	
	Higgs couplings to heavy flavor	*Giovanni Marchiori*	
	Amphithéatre Dirac	16:40 - 16:55	
17:00	**Higgs Self coupling**	*Luis Porteles et al.*	
	Amphithéatre Dirac	17:00 - 17:15	
	Discussion: Synergies in Higgs Physics		
	Amphithéatre Dirac	17:20 - 17:30	

18:00	**Forward-Backward Asymmetries**	*Giovanni Guerrieri*	
	Room 3	18:00 - 18:15	
	Vector Boson Scattering at FCC-ee	*Claude Charlot. et al.*	
	Room 3	18:20 - 18:35	
	Top FCNC	*Hamzeh Khanpour*	
	Room 3	18:40 - 18:55	
19:00	**Top-Beauty coupling**	*Lars Roherig*	
	Room 3	19:00 - 19:15	

Physics and Experiments session

Cover in this summary

Simulation

14:00

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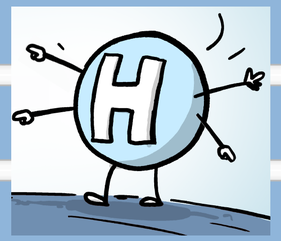

Higgs couplings to heavy flavor — *Giovanni Marchiori*
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Higgs

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Top

Physics cases ⟷ Detector concepts

Goal

Establish the **detector requirements** for optimising measurement of target **physics cases**, in particular matching experimental systematics with the expected statistical precision.

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Establish the **detector requirements** for optimising measurement of target **physics cases**, in particular matching experimental systematics with the expected statistical precision.

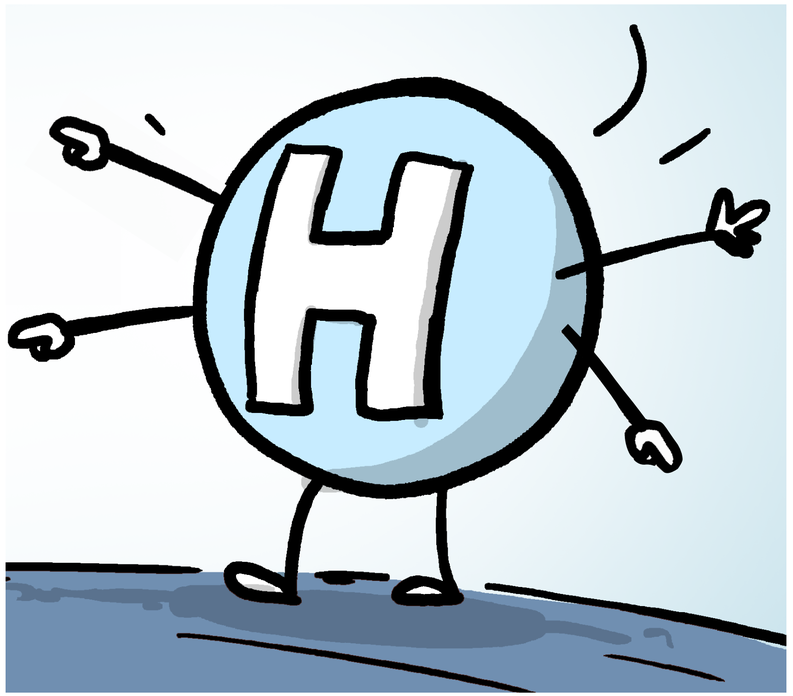
To reach the goal

Simulations of detector setup (fast sim or full sim as appropriate)
Synergies with detector experts

Higgs boson precision measurements!

m_H

Γ_H



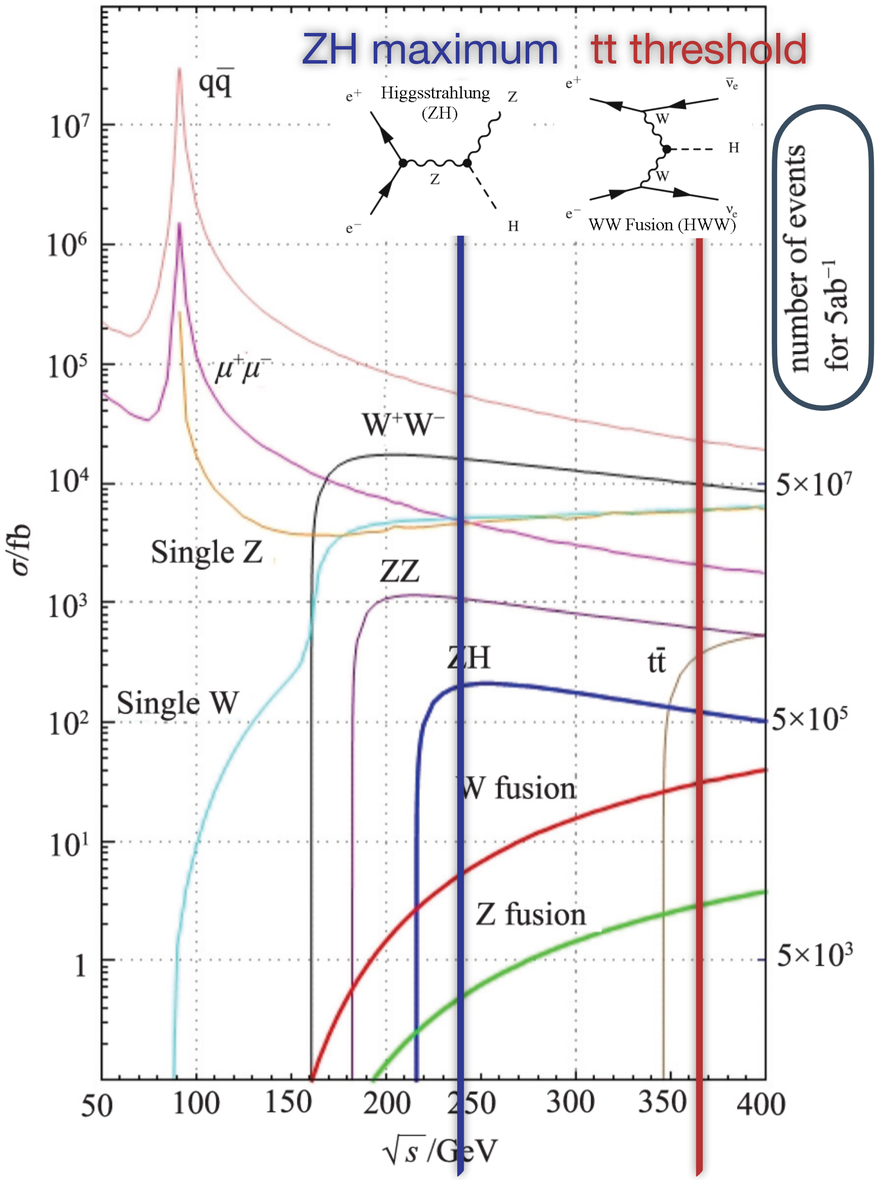
g_{HXX}

g_{HHH}

The FCCee “Higgs” factory

Diverse “Higgs” dataset every few years

Phase	Run duration [years]	Centre-of-mass energies [GeV]	Int. lumi. [ab^{-1}]	# of Higgs bosons
ZH maximum	3	240	5	10^6 ZH
tt threshold	5	345-365	1.5	2×10^5 ZH + 5×10^4 VBF
s-channel	3?	125	?	5×10^3



The measurements strategy

Measure the total ZH production cross section

$$\sigma_{HZ} \propto g^2_{HZZ}$$

Ultimate **statistical precision** for σ_{ZH} is **0.1%** considering ZH selection 100% efficient and pure

The cornerstone of the Higgs physics programme, made a selection independent of H detailed properties by counting events with a Z and using the recoiling mass method

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$$\sigma_{HZ} \times BR(H \to X\bar{X}) \propto \frac{g^2_{HZZ} g^2_{HXX}}{\Gamma_H}$$

$$\sigma_{H\nu\bar{\nu}} \times BR(H \to X\bar{X}) \propto \frac{g^2_{HWW} g^2_{HXX}}{\Gamma_H}$$

Ratio of the two $\frac{g^2_{HZZ}}{g^2_{HWW}}$

Considering exclusive decay channels measure other couplings, H width, and H self-coupling

$$\sigma_{HZ} \times BR(H \to ZZ) \propto \frac{g^4_{HZZ}}{\Gamma_H}$$

$$\sigma_{HZ} \times BR(H \to X\bar{X}) \propto \frac{g^2_{HZZ} g^2_{HXX}}{\Gamma_H}$$

Higgs mass and ZH cross-section from Z($\mu^+\mu^-$)H events

Ang LI, Gregorio Bernardi
(APC-Paris, Université de Paris, CNRS/IN2P3)

g_{HZZ}, m_H

The recoil mass method is exploited

$$m^2_{\text{recoil}} = s + m^2_{\ell\ell} - 2\sqrt{s}(E_{\ell+} + E_{\ell-})$$

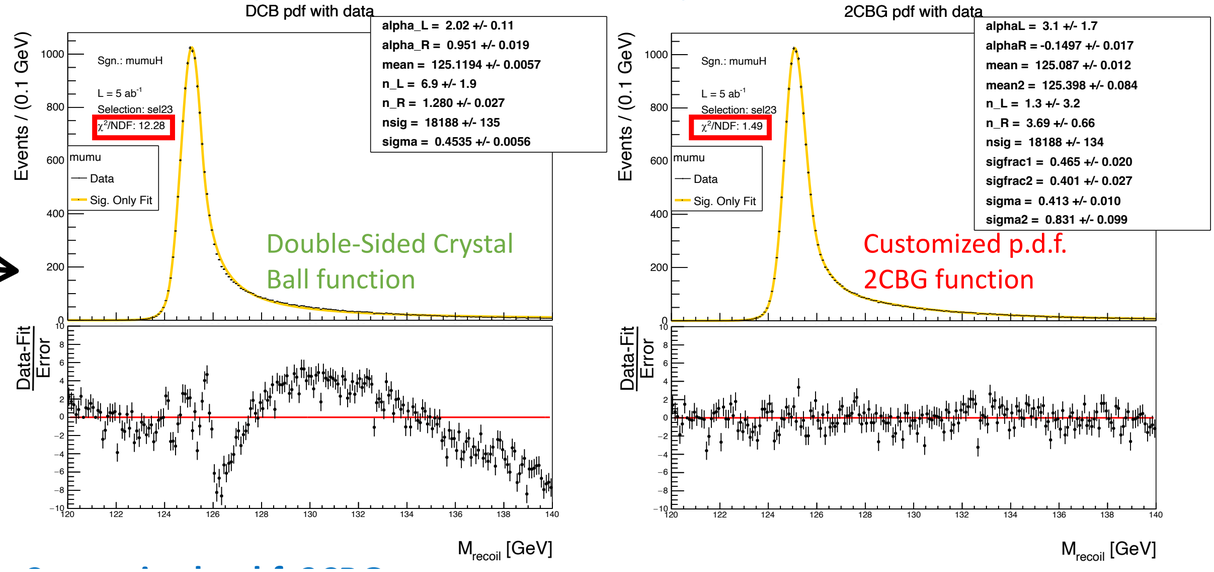
Optimised event selection

Signal modelling studied

Systematics included

Cross section and **Higgs mass** extracted

Double-sided crystal-ball fit vs. customized p.d.f.



Higgs mass and ZH cross-section from Z($\mu^+\mu^-$)H events

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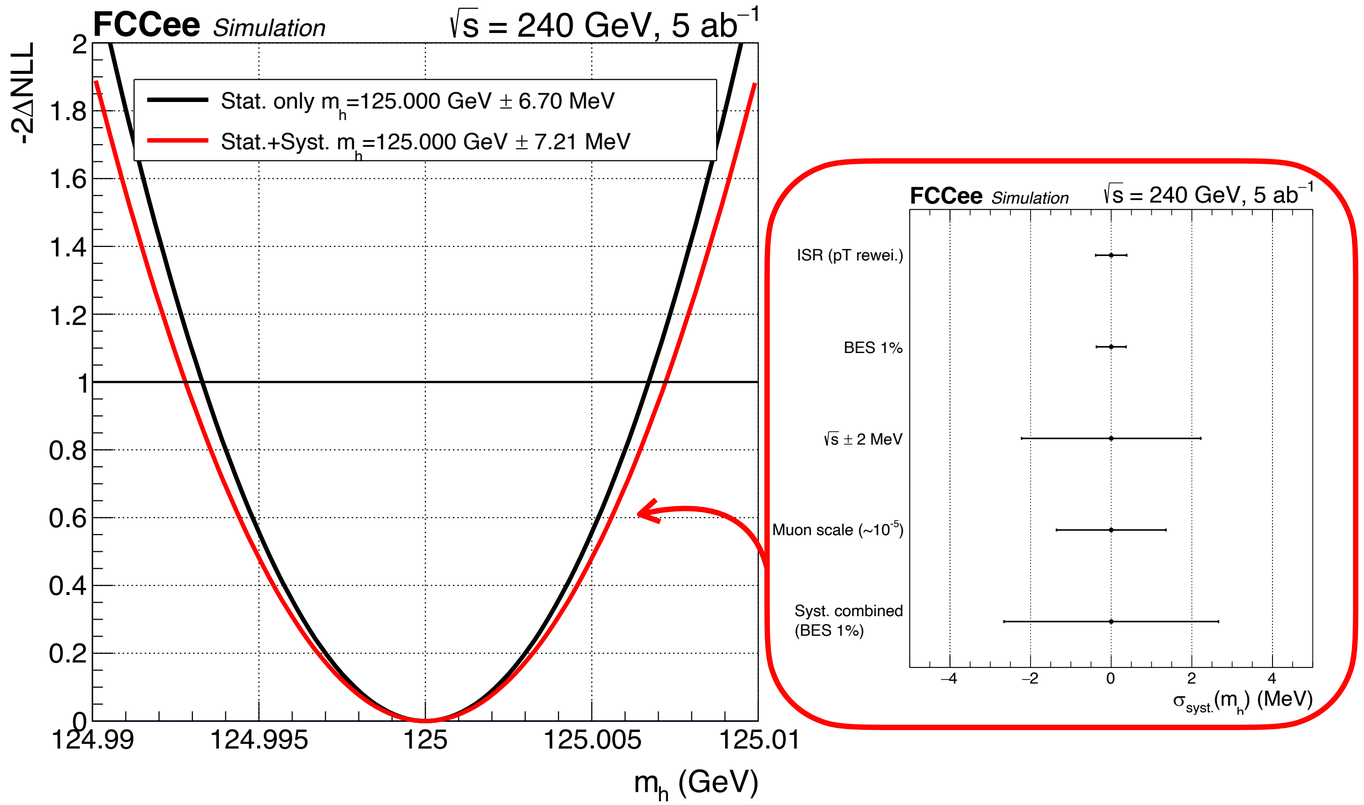
g_{HZZ}, m_H

The Higgs boson mass

Effect of systematics



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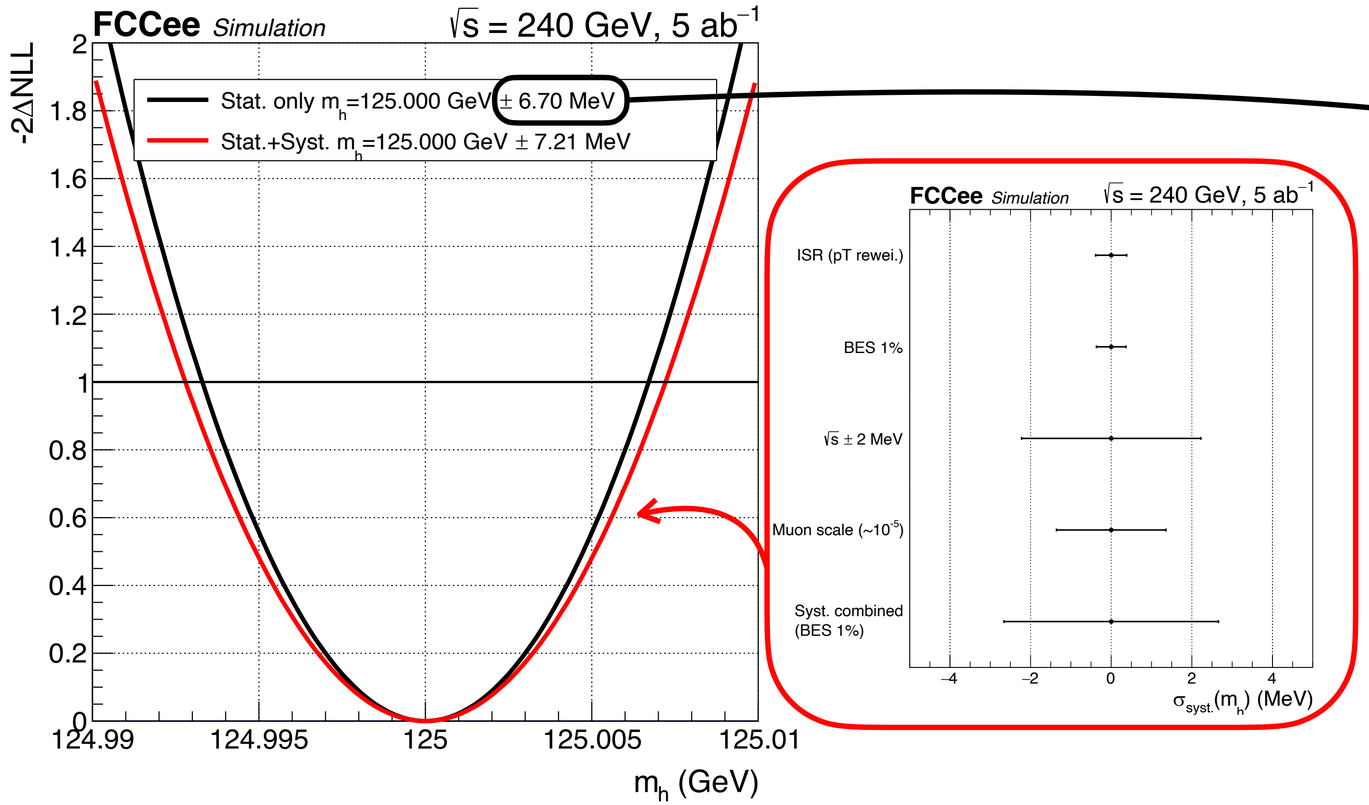
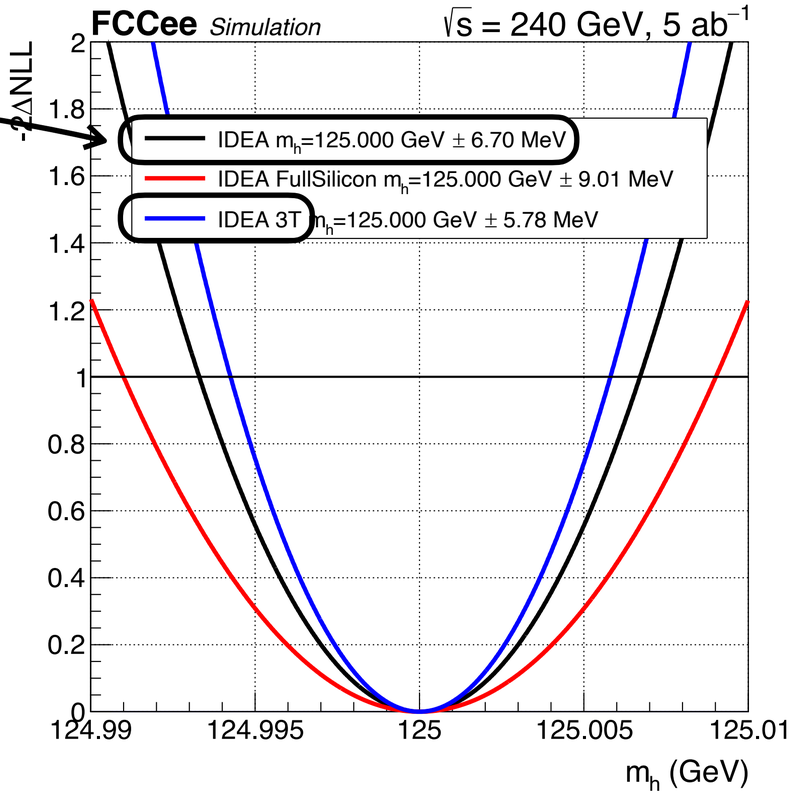


Effect of detector configurations



Measurement of hadronic Higgs boson branching ratios at FCC-ee with ZH events at √s=240 GeV

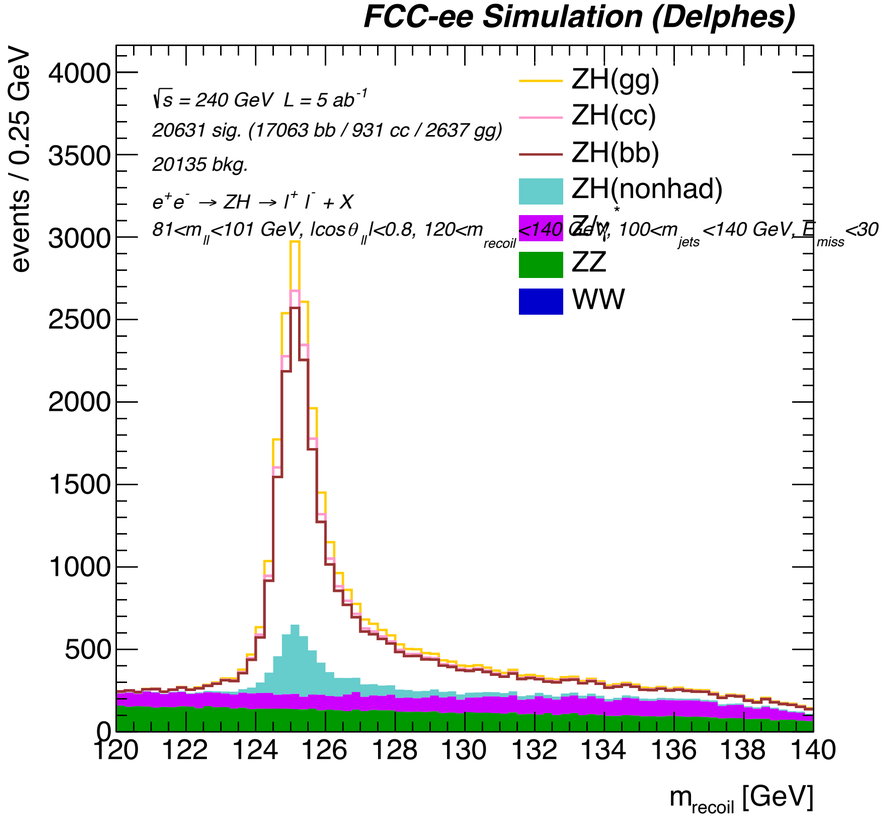
Giovanni Marchiori (APC Paris)
Work down with Alexis Maloizel and Paul Guimbard (ENS Paris-Saclay)

$g_{Hgg}, g_{Hbb}, g_{Hcc}$

After recoil, jets, Emiss selection

Estimate sensitivity to hadronic branching ratios of Higgs boson ($g_{Hgg}, g_{Hbb}, g_{Hcc}$).

Compare sensitivity when **different assumptions on efficiency/rejection of taggers** (or alternative working points) are used.



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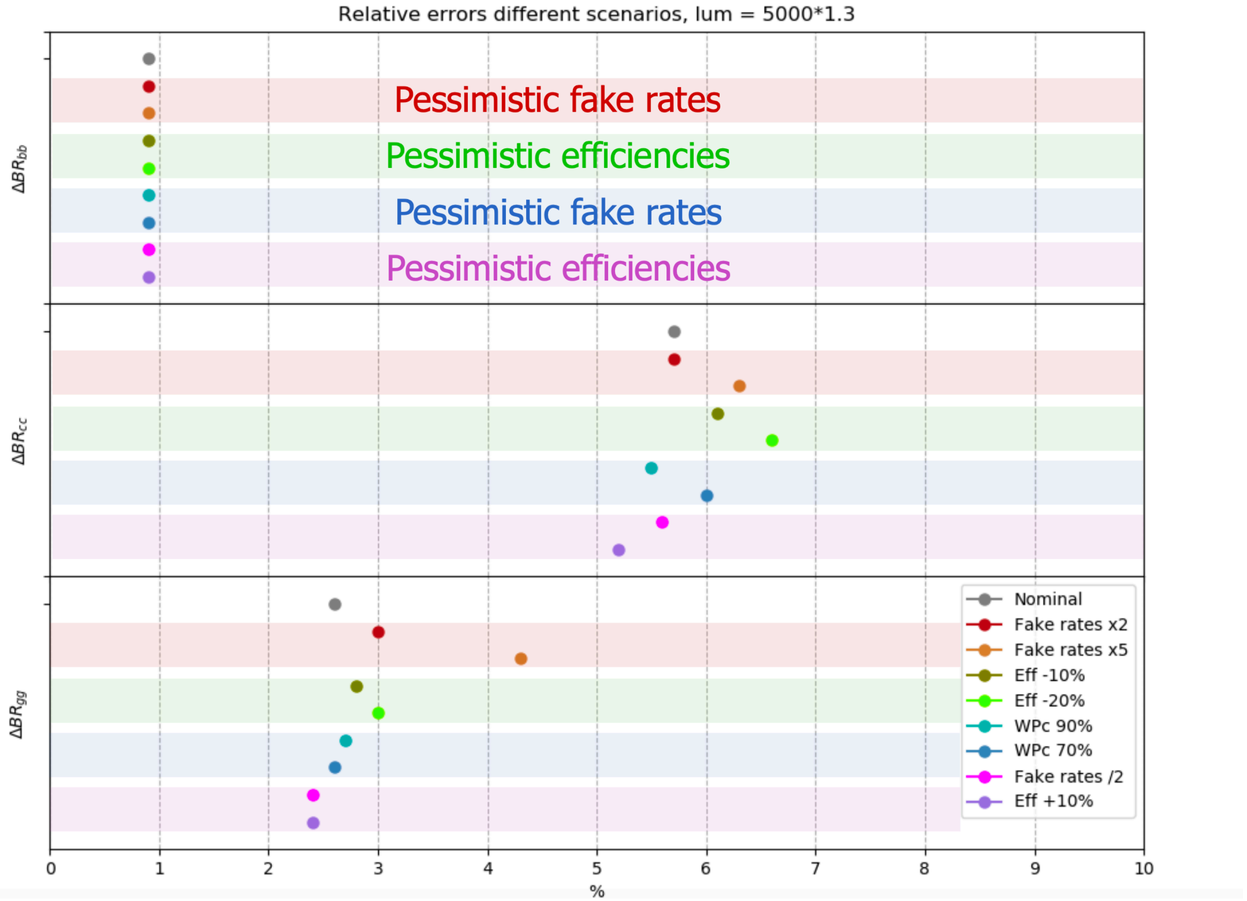
Results with various tagging performance/WP scenarios

Strategy	b-tag $\varepsilon_b, \varepsilon_c, \varepsilon_l, \varepsilon_g$	c-tag $\varepsilon_b, \varepsilon_c, \varepsilon_l, \varepsilon_g$	g-tag $\varepsilon_b, \varepsilon_c, \varepsilon_l, \varepsilon_g$
Nominal	80 / 0.4 / 0.05 / 0.7	2.0 / 80 / 0.9 / 2.5	2.0 / 5.0 / 15 / 80

Nominal Performance for flavour tagging are taken from note by Franco, Loukas, and Michele



Relative error on branching fractions

Higgs Hadronic decays at FCCee Collider

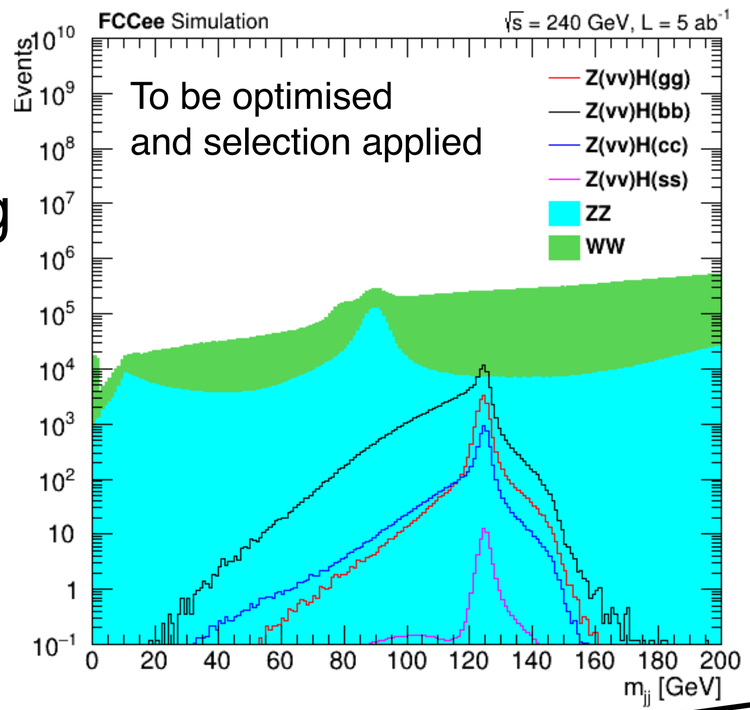
Reham Aly[1] - Jan Eysermans[2] – Michele Selvaggi[3]
Nicola De Filipplis[1] – Patrizia Azzi[4]
[1] INFN, politecnico di Bari
[2] Massachusetts Institute of Technology
[3] CERN - [4] INFN padova

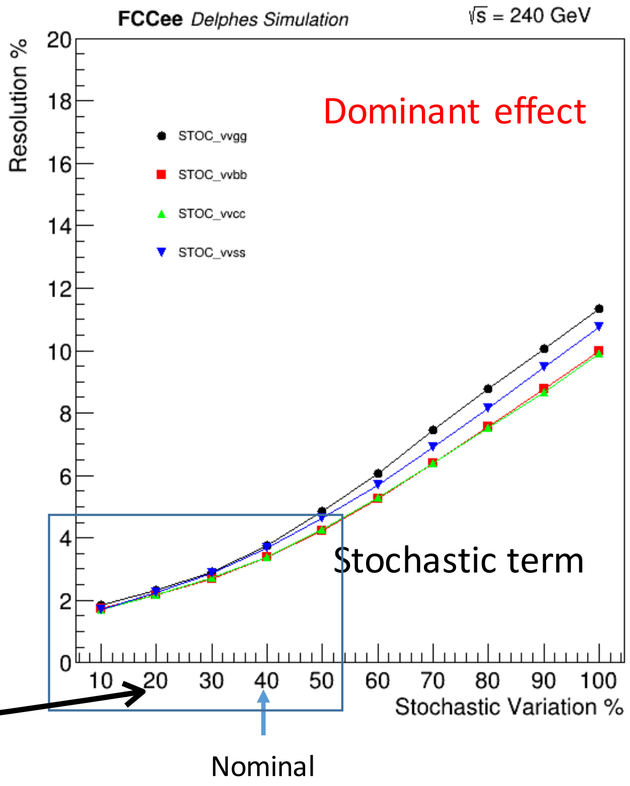
$g_{Hgg}, g_{Hbb}, g_{Hcc}, g_{Hss}$

ZH analysis with Z($\nu\nu$)H(hadronic) analysis to determine $g_{Hgg}, g_{Hbb}, g_{Hcc}, g_{Hss}$ couplings where all jets are known to come from the Higgs.

Studies for optimizing the jet algorithm and parameters with the aim of improving the signal peak resolution

Studies for detector configuration for optimising the expected precision





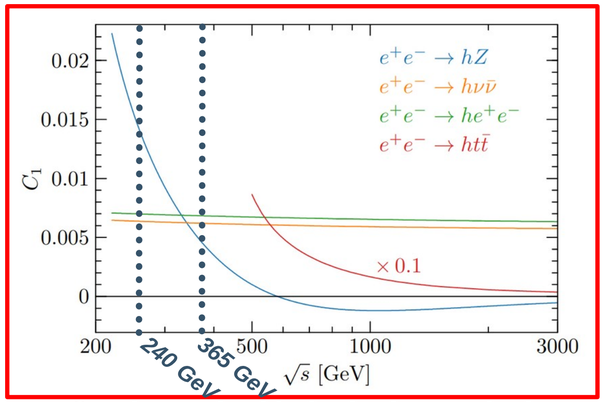
Inclusive Higgs self-coupling measurement at FCC-ee

Louis Portales

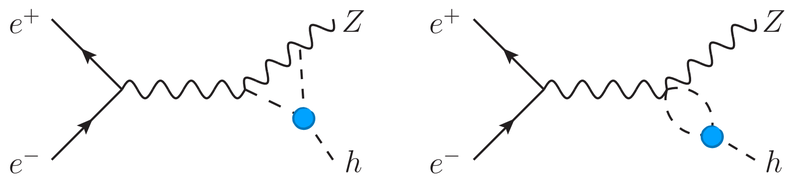
FCC-France & Italy Workshop on Higgs,Top, EW & HF Physics
Lyon – 22/11/2022

g_{HHH}

Measure the Higgs boson self-coupling that affects both Higgs boson production and decay at NLO.



Can be probed in inclusive analysis looking at the two relevant energy points



Vertex corrections (linear in k_λ)

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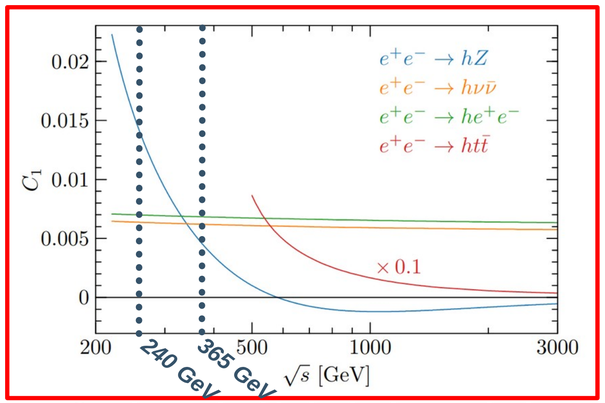

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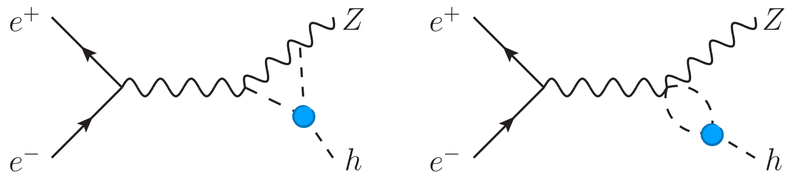

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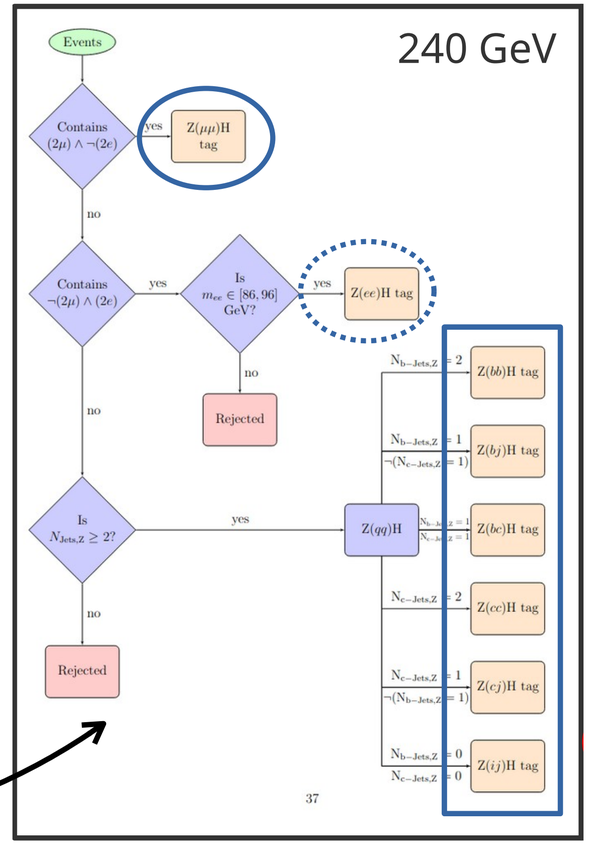

Statistics is the essence :

- combined analysis including ZH and VBF-H production @ 240 GeV & 365 GeV
- categorisation targeting exclusive Z decays

Inclusive Higgs self-coupling measurement at FCC-ee

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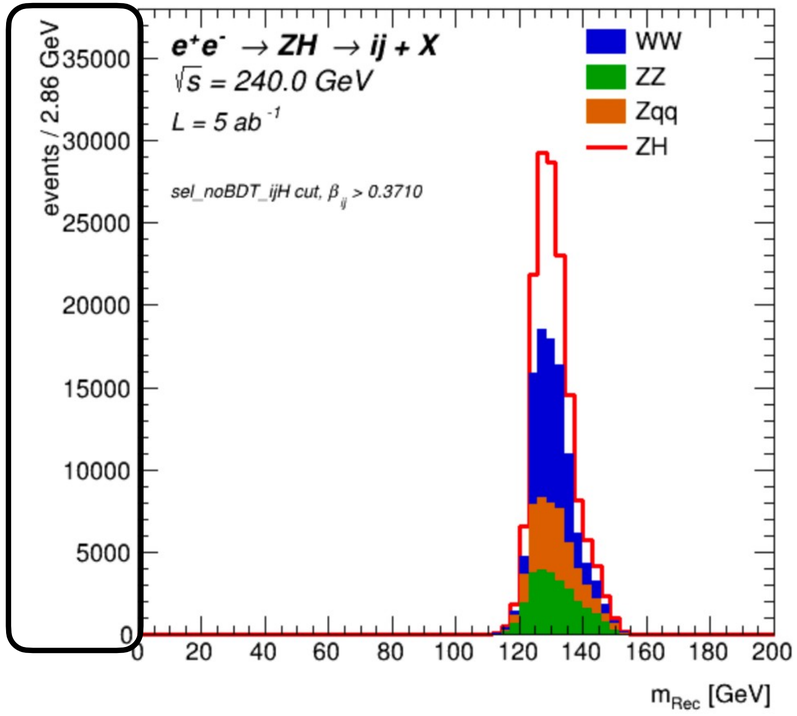
FCC-France & Italy Workshop on Higgs,Top, EW & HF Physics
Lyon – 22/11/2022

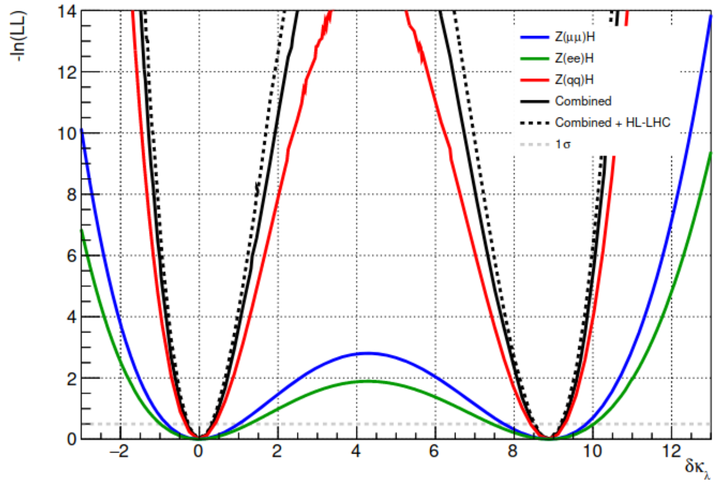
g_{HHH}

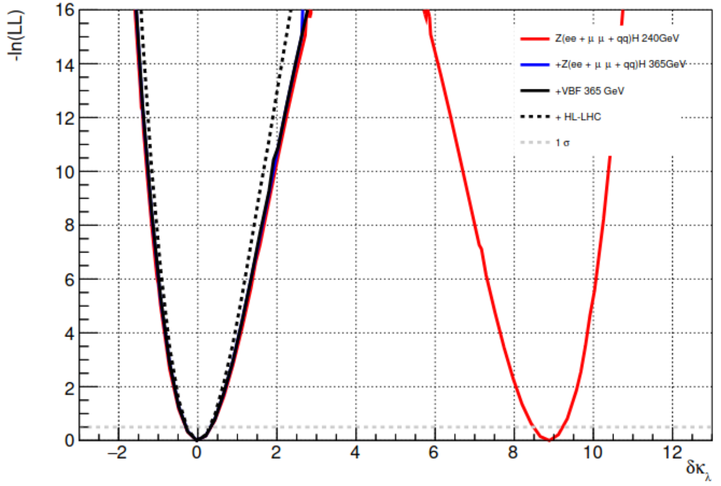
Sensivity driven by Z(qq)H category

Adding ZH@365GeV resolves degerated minima

Negligible impact from VBF







Top quark physics

EW top couplings

m_{top}

A million of $t\bar{t}$ events in a clean environment

Γ_{top}

FCNC

Probing the top quark FCNC anomalous couplings at FCCee

Hamzeh Khanpour (UDINE & ICTP)

in collaboration with

Seddigheh Tizchang (IPM), Mojtaba Mohammadi (IPM),

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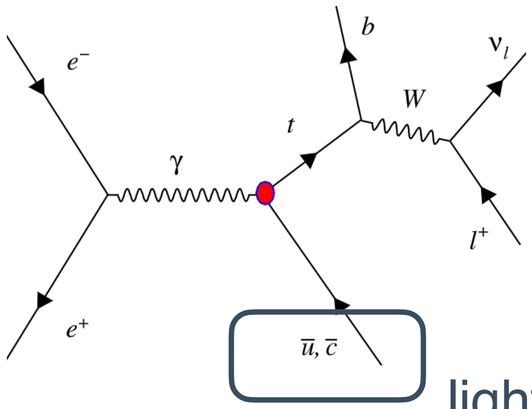

Any observation of these rare Flavor-Changing Neutral Current transitions would be a clear signal of new physics beyond the SM

Focusing on the $tq\gamma$ interactions at $\sqrt{s} = 240$ GeV in **single-top quark** production processes

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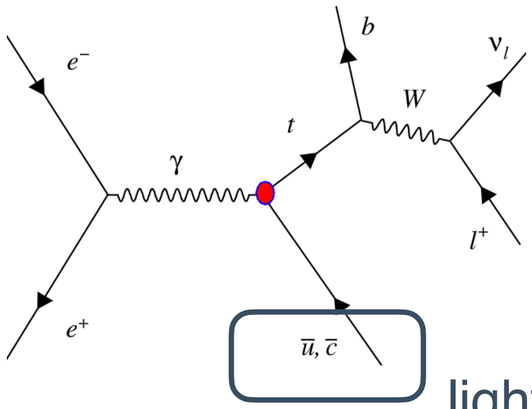
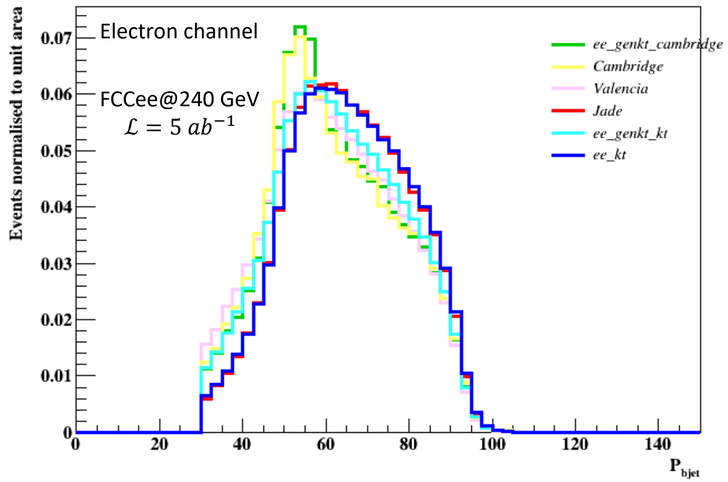


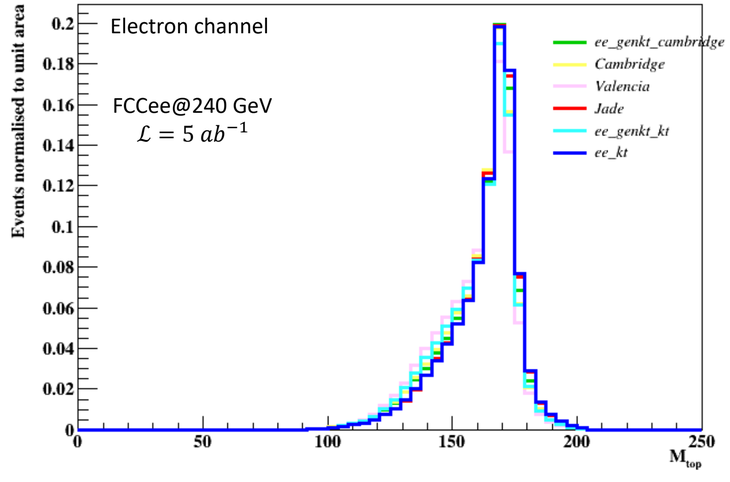
light quark

Any observation of these rare Flavor-Changing Neutral Current transitions would be a clear signal of new physics beyond the SM

Focusing on the $tq\gamma$ interactions at $\sqrt{s} = 240$ GeV in **single-top quark** production processes

Study of jet clustering algorithms and jet recombination schemes





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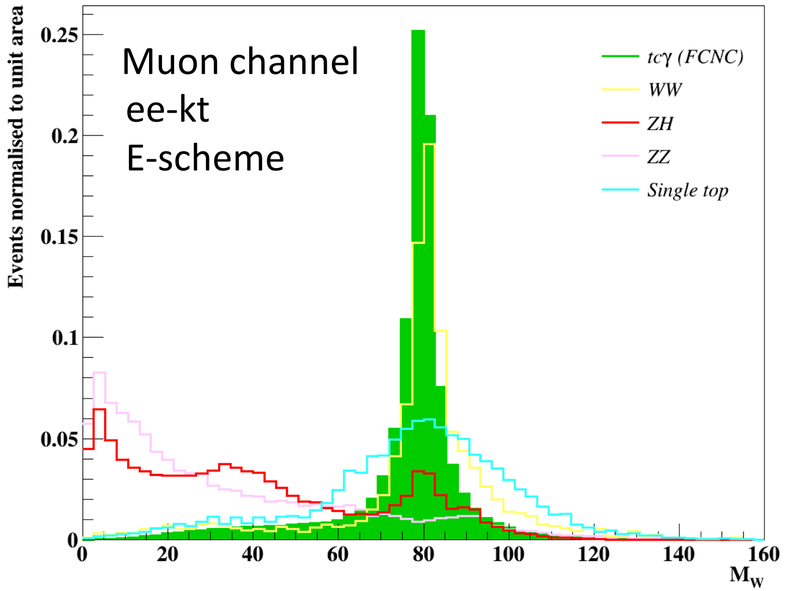
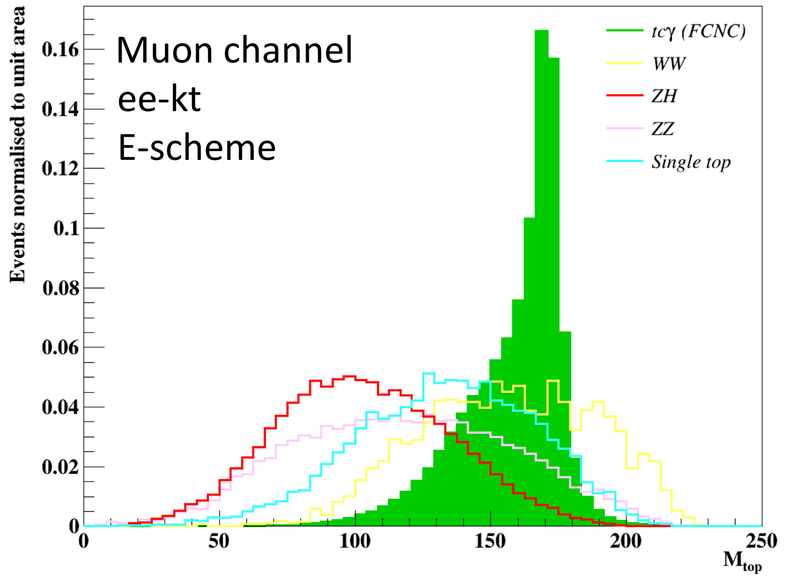




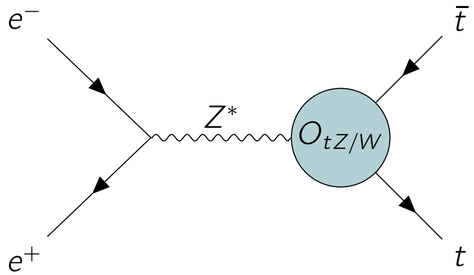
FCC-ee (240 GeV)	$Br(t \to c\gamma)$	$Br(t \to cZ)$
Electron Channel	6.19×10^{-5}	2.27×10^{-5}
Muon Channel	4.45×10^{-5}	1.63×10^{-5}

Next steps :
consider a MVA /analysis
searches for top quark FCNCs in the decay of a top quark from tt production at 365 GeV

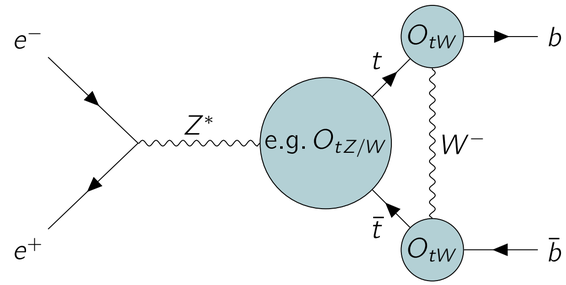
Top-beauty synergies @ FCC-ee

Kevin Kröninger[1], Romain Madar[2], Stéphane Monteil[2], Lars Röhrig[1,2]

- $\mathcal{O}(m_t) \sim 350$ GeV



- $\mathcal{O}(m_Z) \sim 90$ GeV

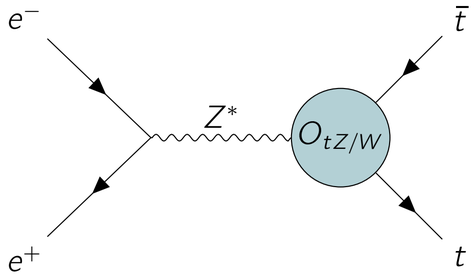


Combination of different scales to have synergies in global interpretations due to a common set of operators

Top-beauty synergies @ FCC-ee

Kevin Kröninger[1], Romain Madar[2], Stéphane Monteil[2], Lars Röhrig[1,2]

- $\mathcal{O}(m_t) \sim 350$ GeV



Top energy scale

I **Observable finding**
Top-observable simulation for different operator strenghts

II **Sensitivity to Wilson coefficient**
Measure for the sensitivity and hierarchy

III **Precision estimate**
Reconstruction in FCC-ee environment for estimate of observable precision

$Z \to b\bar{b}$ energy scale

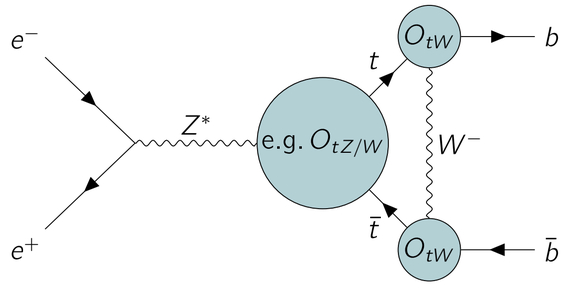
Precision limitations
Current limitations on $Z \to b\bar{b}$ observables

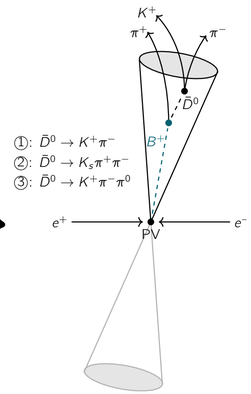
New hemisphere tagging
Exclusive tagging from B-hadron decays

Proof from simulation
Test assumptions from FCC-ee simulated $Z \to b\bar{b}$ sample

Prospective of global interpretation
Interpretation of simulated top- and beauty measurements in SMEFT framework

- $\mathcal{O}(m_Z) \sim 90$ GeV





Combination of different scales to have synergies in global interpretations due to a common set of operators

Simulation

DELPHES

DD4HEP

Geant4

Particle Flow for Dual Read-Out Calorimeter

Adelina D'Onofrio[1], Michela Biglietti[1], Biagio Di Micco[2], Roberto Di Nardo[2], Ada Farilla[1] Iacopo Vivarelli[3] , Sofia Vallecorsa[4] , Patrizia Azzi[5]

Input from detector simulation (EDM4HEP) format

↓

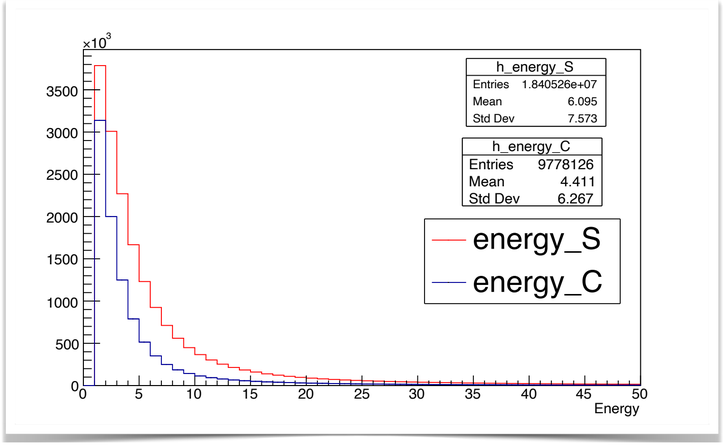
Reading using KEY4HEP *code*

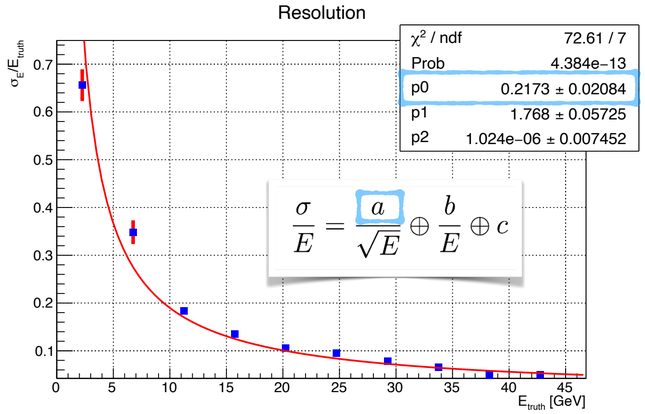
↓

Dumping algorithm, input variables for NN training

↓

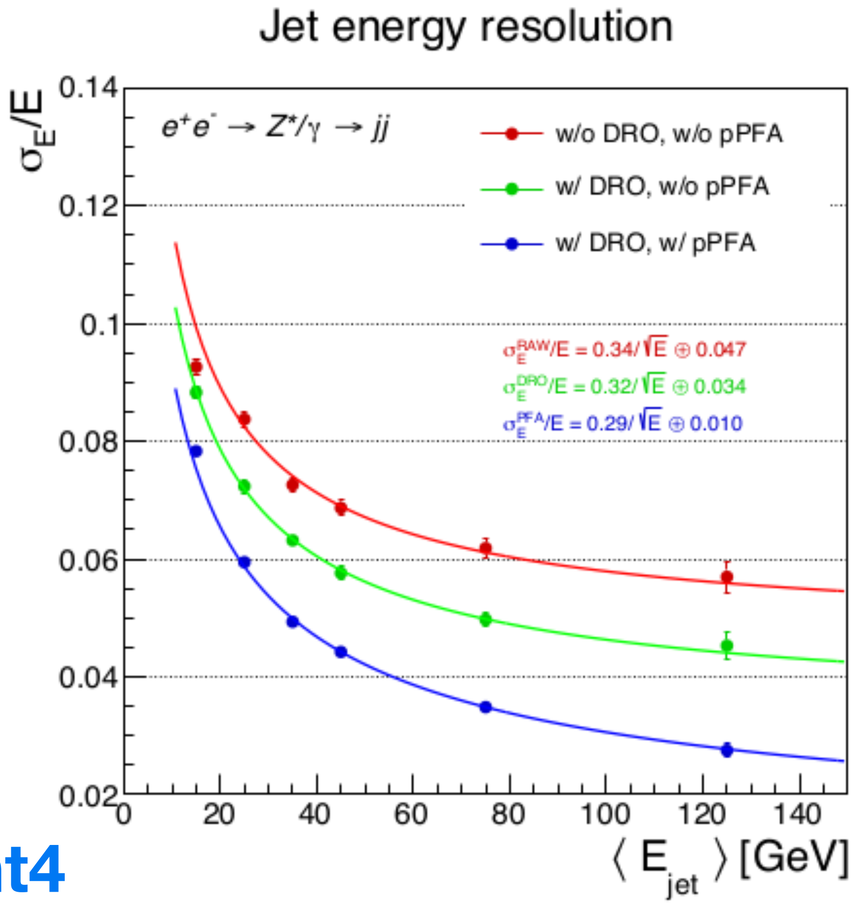
NN training using *Tensorflow* on CPU/GPU



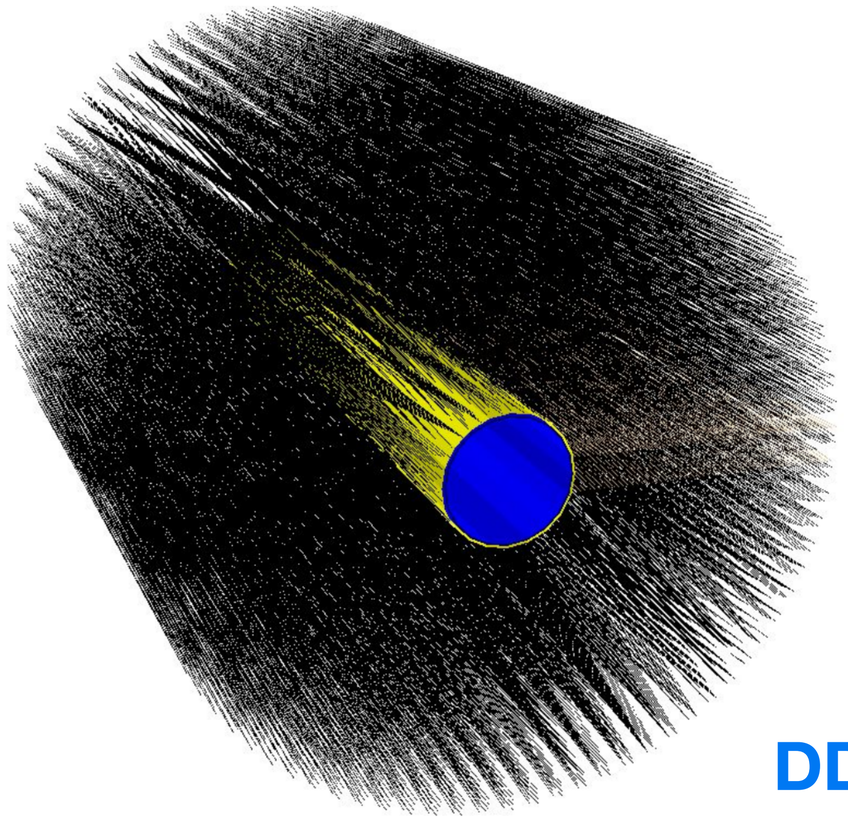


Simulation of IDEA

Lorenzo Capriotti
on behalf of the IDEA software group



Geant4



DD4HEP


Next steps scattered points

ZH hadronic decay
Better optimisation of the event selection to suppress more backgrounds
Introduction of ParticleNet
Inclusion of systematics uncertainties
Tagging of strange jet
Full simulation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Synergies

Optimised event selection for Z(ll)H
Jet clustering algorithms and jet recombination schemes
Flavour-tagging algorithm
Zbb selection (EWK-Top analyses)