Measurement of the Higgs Self-Coupling in the HH → VVbb channel at the FCC-hh Collider

Sylvie Braibant - Elisa Fontanesi

University of Bologna & INFN

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Future Circular Collider

The FCC Study is an international collaboration of more than 70 institutes from all over the world, born to explore different designs of circular colliders for the post-LHC era. The study will deliver the concepts for **a 100-TeV hadron collider (FCC-hh)**, providing a **Conceptual Design Report (CDR)** by 2018.

The **key physics goals** are the complete exploration of the Higgs boson sector and a significant extension of the search for physics phenomena Beyond the Standard Model (BSM).

L (ring) = 100 km

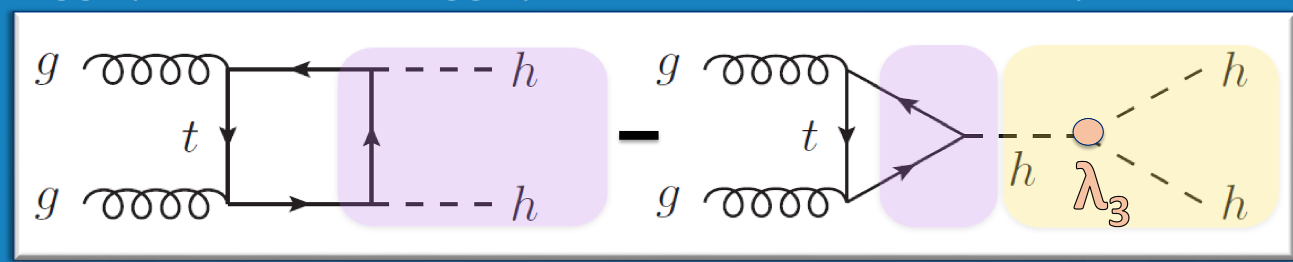
B = 16 T

$\int \mathcal{L}\, dt$ = 30 ab^{-1}

Reference: *Physics at the FCC-hh, a 100 TeV pp collider*, CERN-2017-003-M

Why HH @ FCC?

The determination of processes which involve the multi-Higgs production is crucial for analysing the Higgs potential. Di-Higgs production is the standard process for studying the **Higgs self-coupling (λ_3)**.



$$\frac{\sigma(100\ \mathrm{TeV})}{\sigma(14\ \mathrm{TeV})} \approx 40$$

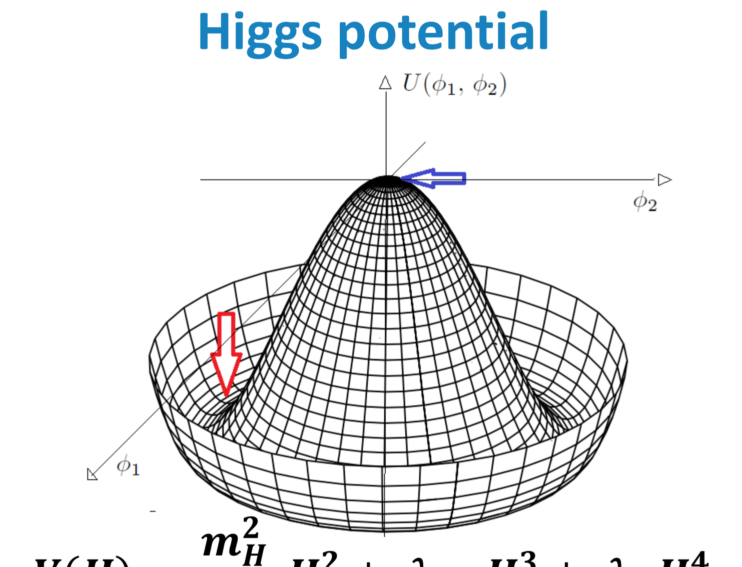
An analysis of the trilinear Higgs self-interaction can be **sensitive to new-physics effects**, providing important **tests of the validity of the Standard Model**.

Sizable corrections to λ_3 are predicted in BSM scenarios, leading, in some case, to large deviations in multi-Higgs production processes but not in other observables.

We introduce a parametrization of an anomalous coupling:

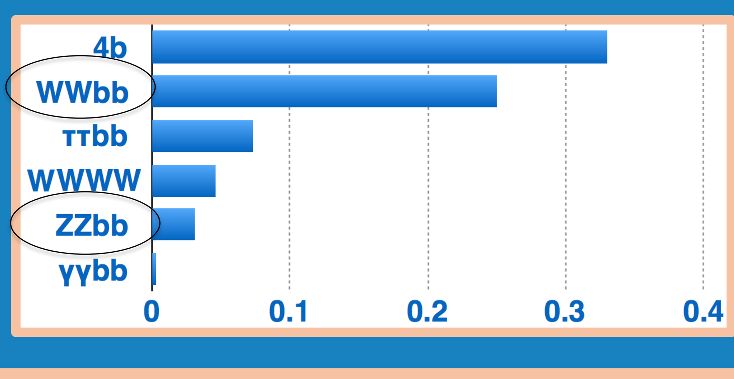
$$\lambda_3 = k_\lambda \lambda_3^{SM}$$

Higgs potential



$$V(H) = \frac{m_H^2}{2} H^2 + \lambda_3 v H^3 + \lambda_4 H^4$$

HH DECAY MODES AND BRANCHING FRACTION:



σ X BR, k_λ=1

HH → bbZZ(4l)	0.25 fb
HH → bbWW(lvjj)	62 fb

Sample generation

MADGRAPH5_amc@NLO
- Parton-level generation of the signal and the backgrounds (NLO & reweighing)

DELPHESPYTHIA8
- Parton shower & ideal FCC-hh detector parametrization

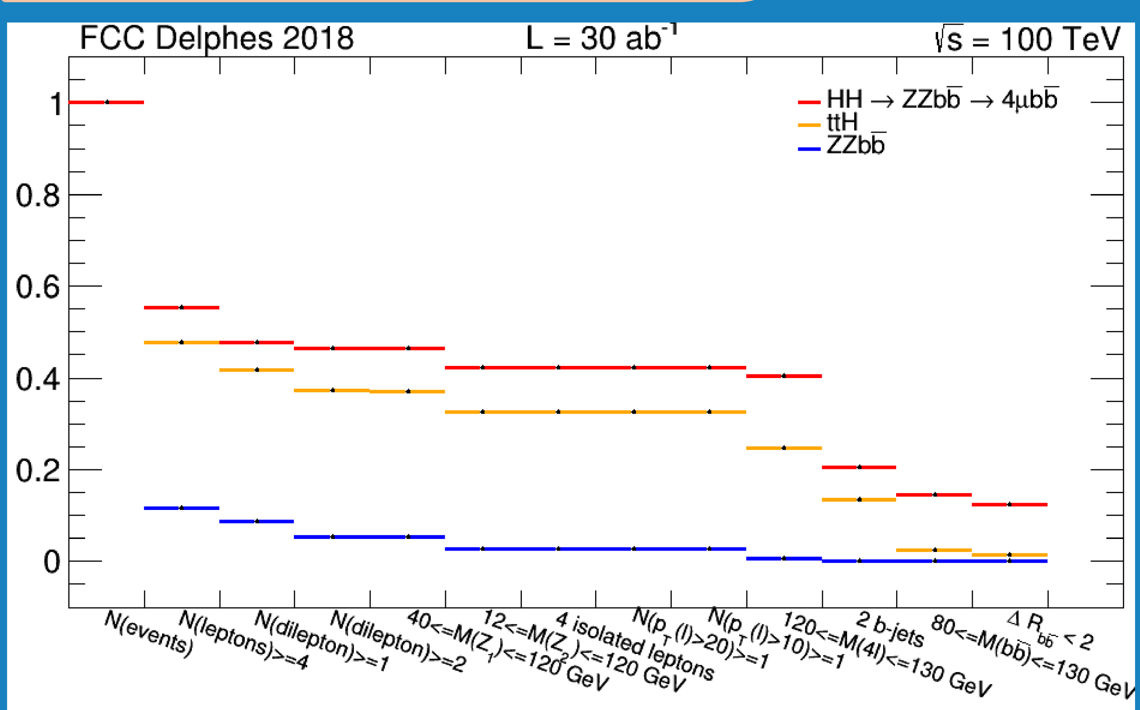
Analysis strategy and preliminary results

bbZZ(4l)

L. Borgonovi, S. Braibant, N. De Filippis, E. Fontanesi, A. Taliercio

The signal and the backgrounds are studied using an optimized **cut-flow based analysis**.

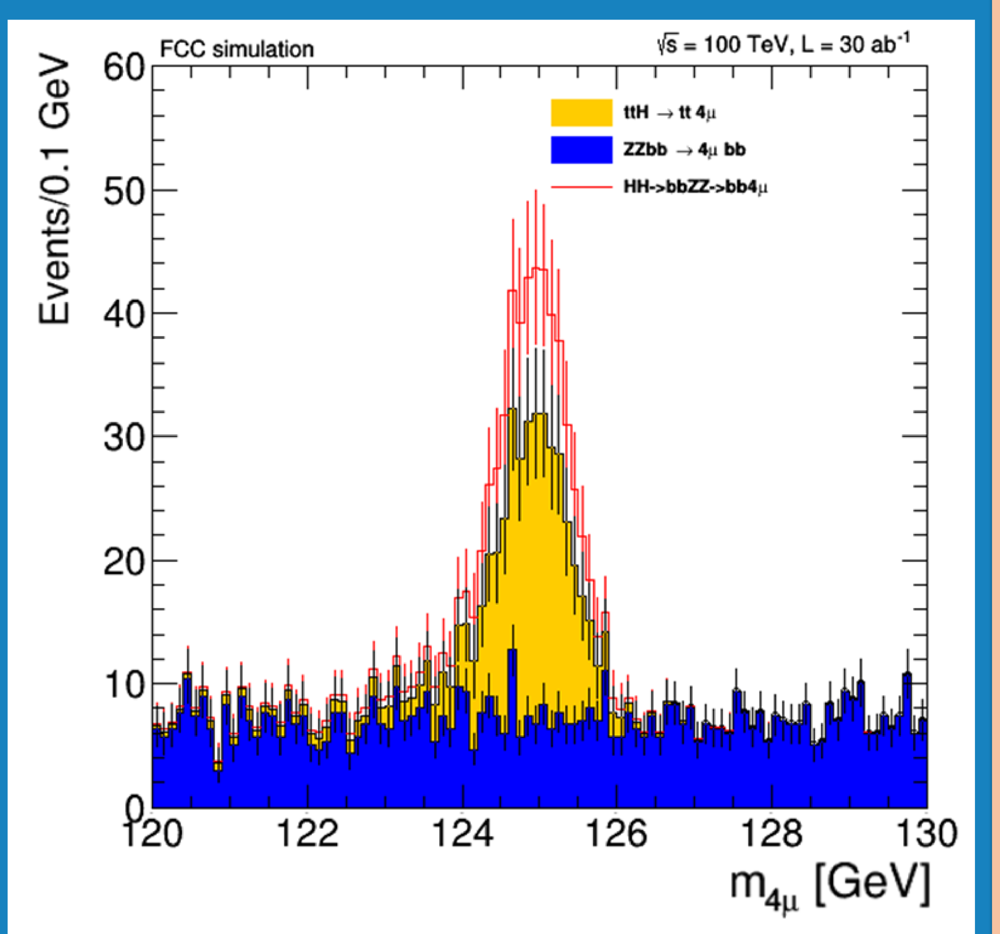
Selection: 4μ (H peak search) + 2 b-jets



- N(μ) ≥ 4
- N (di-leptons) ≥ 2
- 40 ≤ M_{Z1} ≤ 120 GeV
- 12 ≤ M_{Z2} ≤ 120 GeV
- N (isolated μ) ≥ 4
- p_T cuts
- **120 < $M_{4\mu}$ < 130 GeV**
- N (b-jets) = 2
- **80 < M_{bb} < 130 GeV**
- **ΔR(bb) < 2**

The event yields are normalised to **30 ab^{-1}**. The samples are simulated with pile-up **0**.

HH	159
ttH	332
ZZbb	716



Background

After the cuts, the most relevant backgrounds are:
- ttH (H→4l)
- ZZbb

Backgrounds to check:
- ttH (tt→blvblv, H→2l)
- Hbb →4l bb
- ZH

bbWW(lvjj)

B. Di Micco, M. Testa, M. Verducci

The signal is identified by using the **boosted decision tree (BDT) technique**: the BDT uses different shapes from leptons and jets distributions to create a BDT distribution.

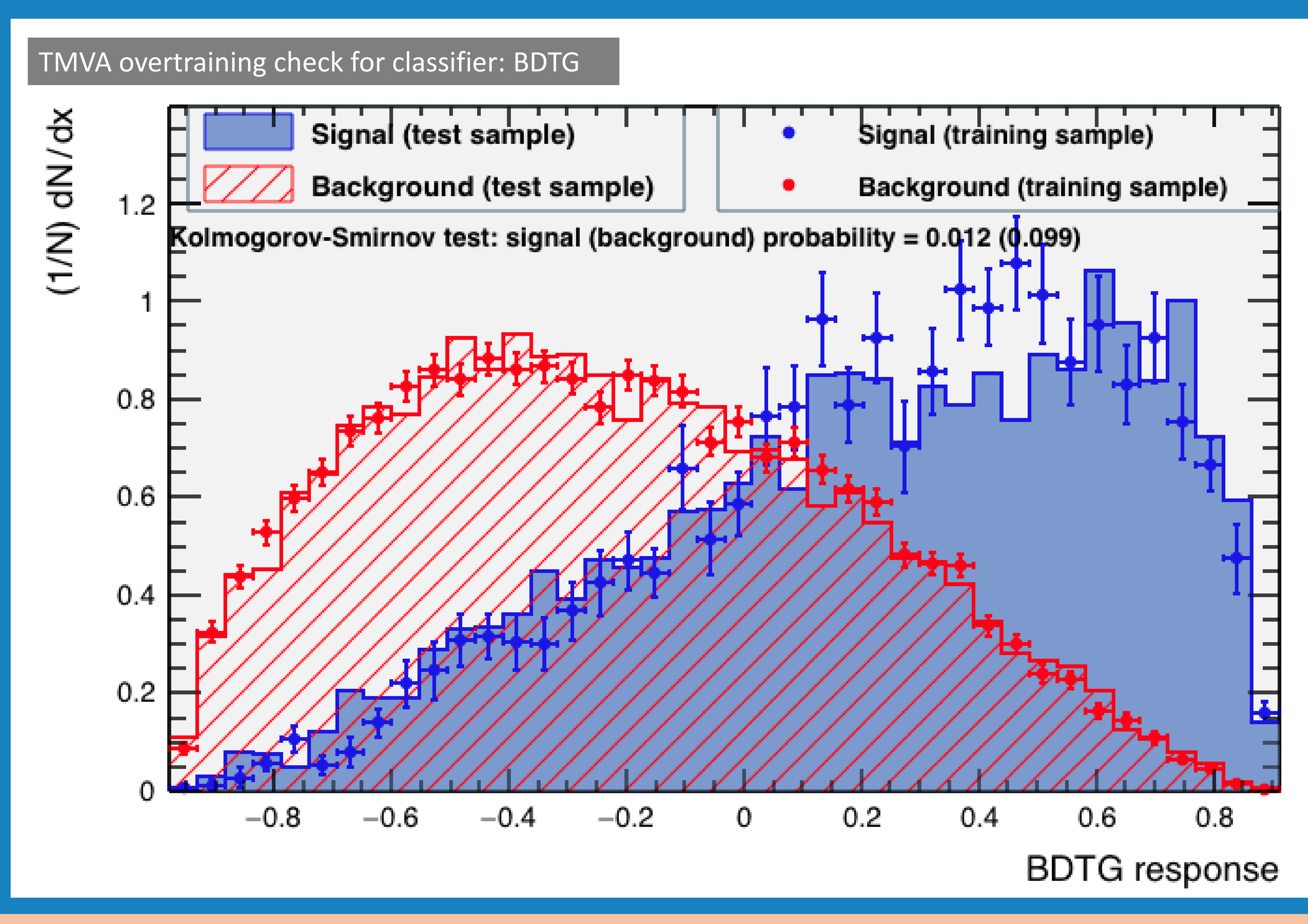
Preselection

A set of preliminary cuts are applied to improve the performance of the BDT training:
- 80 < M_{bb} < 150 GeV
- p_T (WW) > 150 GeV
- ΔR(bb) < 2.0

List of variables used in the BDT definition:
- ΔR between the two leptons
- ΔR between the two W
- p_T and invariant mass of WW
- p_T, ΔR and invariant mass of 2 b-jets
- Transverse mass (M_T) of WW
- p_T of neutrino
- M_T of the W decaying hadronically

The actual **best cut** for the BDTG is **0.61**, corresponding to a $S/\sqrt{B}$ of 1.7.

The efficiency on the signal and the rejection efficiency on background are about 0.22 and 0.98 respectively.



The samples have been rescaled to **3000 fb^{-1}**. They are simulated considering a pile-up of **50**.

Background

The most important backgrounds to consider are:
- bbWW
- V + jets

Conclusions

The goal of these FCC studies is to evaluate the sensitivity to the Higgs self-coupling for m_H = 125 GeV through the measurement of the non-resonant di-Higgs production final states at a 100 TeV collider. So far, a precision of about **10-15%** and **20%** on the SM cross-section can be estimated in the **bbZZ(4l)** and **bbWW(lvjj)**, respectively, roughly corresponding to a precision of about **30%** and **40%** on the Higgs trilinear coupling. These results will contribute to the Conceptual Design Report (CDR) of the FCC-hh (by the end of 2018).