C1 and K_{EW} factors parametrization in STXS bins for constraining the Higgs boson self-coupling

Fábio L. Alves (Nanjing University) on behalf of the ATLAS Collaboration

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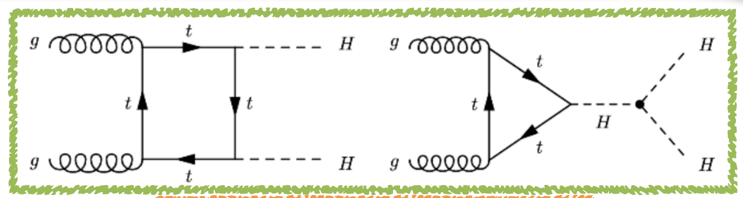
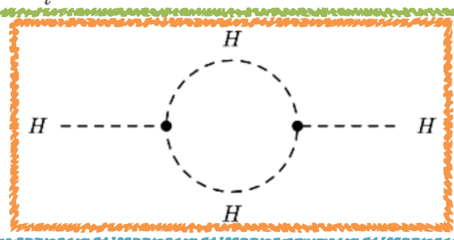
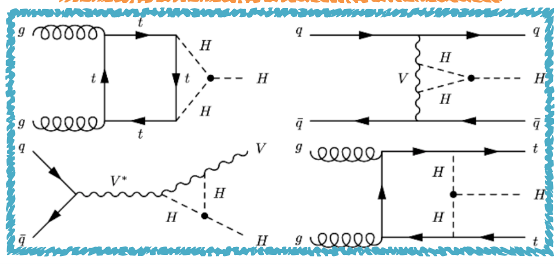
Higgs boson self-coupling (κ_λ) measurements: overview

- Measurements of the Higgs trilinear self-coupling ($\kappa_\lambda = \lambda_3/\lambda_{SM}$) can be performed through:
  - DiHiggs (HH) processes: direct searches
    HH cross sections depend directly on κ_λ at LO
  - Single H processes: indirect constraints
    - no direct dependency on κ_λ at LO
    - sensitivity through NLO EW corrections to the single H processes:
      - universal $O(\lambda_3^2)$ correction due to Higgs wave-function
      - linear $O(\lambda_3)$ correction to production and decay modes



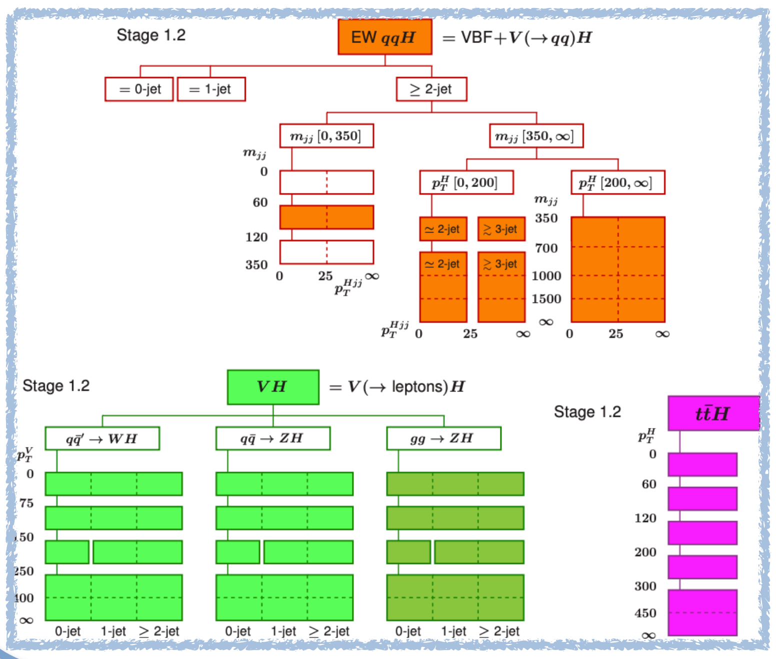




Single Higgs cross sections as a function of κ_λ

- A parametrization of the single H cross sections and BR in terms of the κ_λ in regions defined by STXS 1.2 is performed
  - Simplified Template Cross Sections (STXS): mutually exclusive regions of the phase space (highest granularity used is 1.2)

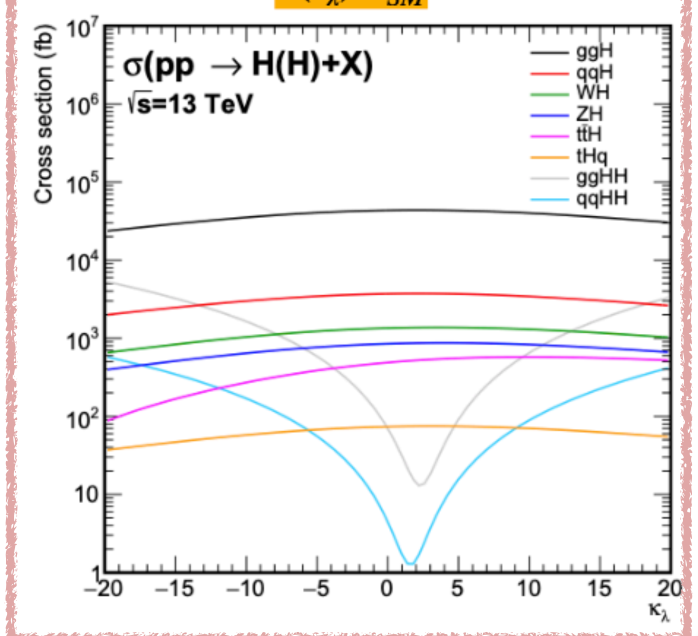
$$\mu_i(\kappa_\lambda, \kappa_i) = \frac{\sigma^{BSM}}{\sigma^{SM}} = Z_H^{BSM}(\kappa_\lambda)\left[\kappa_i^2 + \frac{(\kappa_\lambda - 1)C_1^i}{K_{EW}^i}\right]$$



- C_1 is the process and kinematic-dependent coefficients which encodes the magnitude of the κ_λ-dependent corrections (*linear correction*)
- Z_H^{BSM} is the wave function renormalization (*from universal correction*)
- K_{EW} factors represents the full set of NLO EW corrections

$$Z_H^{BSM}(\kappa_\lambda) = \frac{1}{1 - (\kappa_\lambda^2 - 1)\delta Z_H}, \text{with } \delta Z_H = -1.536 \times 10^{-3}.$$

$\sigma(\kappa_\lambda)/\sigma_{SM}$



Recipe for C1 and k-factor determination

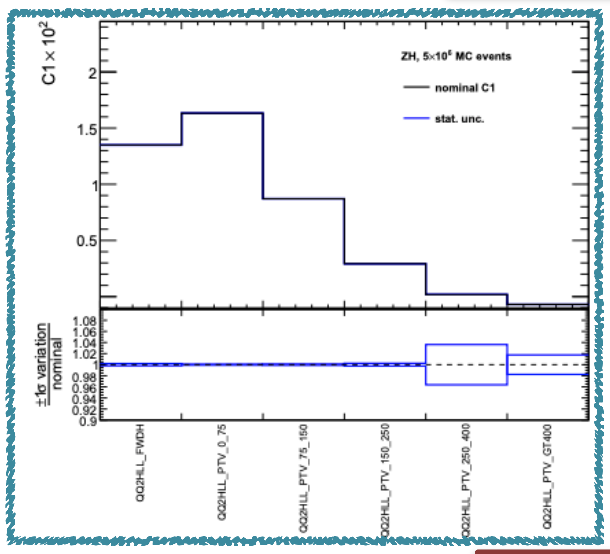
- C1 coefficients are obtained separately for the $t\bar{t}H$, $W(l\nu)H$, $Z(ll)H$, and $H(jj)$ processes:
  - only inclusive C1 for ggH production mode available
  - 5M of events are generated for each process using Madgraph5_aMC@NLO (v 2.5.5)using PDFset PDF4LHC15_nlo_mc
  - Complex mass scheme for $H(jj)$ process and on-shell mass scheme for other processes
  - Renormalization and factorization scales are set dynamically event-by-event
  - For each event, the weight representing LO cross section (w_{LO}) and the weight corrected by κ_λ−effects are computed (w_{NLO})
  - Parton shower and hadronization performed with Pythia8.245
  - Events are further classified in STXS 1.2 bins using Rivet toolkit routine and C1 for a given STXS 1.2 bin i computed as:

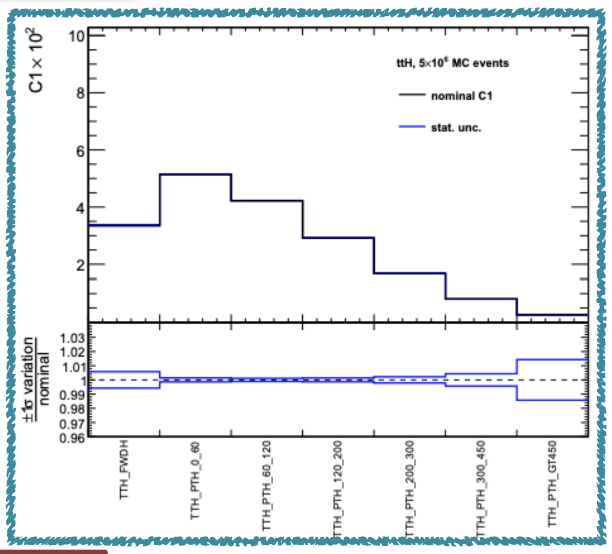
$$C_1^i = \frac{\sum_j w_{NLO}^j}{\sum_j w_{LO}^j}$$

- K_{EW} factors are determined using LHCHXS recommendations

- C1 coefficients for the $t\bar{t}H$ process show the largest sensitivity to the κ_λ variations:
  - large effect for both inclusive and differential cross section
- Uncertainties affecting C1 computation evaluated: statistical uncertainty (sample size), PDF modelling, renormalization and factorization scales
  - these source of uncertainties are found to be negligible

C_1 coefficients





K_{EW}-factors

STXS BIN	K_{EW}
QQ2HLL_FWDH	0.952
QQ2HLL_PTV_0_75	0.950
QQ2HLL_PTV_75_150	0.943
QQ2HLL_PTV_150_250	0.937
QQ2HLL_PTV_250_400	0.897
QQ2HLL_PTV_GT400	0.841
QQ2HLNU_FWDH	0.917
QQ2HLNU_PTV_0_75	0.937
QQ2HLNU_PTV_75_150	0.910
QQ2HLNU_PTV_150_250	0.879
QQ2HLNU_PTV_250_400	0.835
QQ2HLNU_PTV_GT400	0.779

STXS BIN	K_{EW}
TTH_FWDH	1.017
TTH_PTH_0_60	1.041
TTH_PTH_60_120	1.025
TTH_PTH_120_200	1.002
TTH_PTH_200_300	0.978
TTH_PTH_300_450	0.956
TTH_PTH_GT450	0.923

For more information:
[1]: Modeling of the single-Higgs simplified template cross-sections (STXS 1.2) for the determination of the Higgs boson trilinear self-coupling (LHC Higgs Working Group, Public Note) (LHCHWG-2022-002)