Table of Contents

coupling modifiers (update in 2017 for CERN Yellow Report 4)

This is the update of coupling modifiers (see CERN Yellow Report 3, Section 10.2) for Higgs-boson production and decay.

Calculation Instructions

1. Use the same SM input parameters for Higgs XS&BR calculations for CERN Yellow Report 4
2. Update for Ecm=[7,8,13,14]TeV and for MH=[124.5,125.0,125.09,125.5]GeV
3. Inclusive cross section
4. Purely N3LO/NNLO/NLO/LO QCD and no NLO EW correction
    - In LO -framework we assume that QCD corrections factorize for s (but not for EW corrections).
5. Cross section or partial decay width in significant digits
6. Also provide uncertainties in sigma and coefficients in kappa for THU and PU if possible
    - Certain THU and PU should cancel out for coefficients in kappa (ex. $_s$ etc.) but not for quark-mass.
7. Provide information if public tool is available so that EXP can calculate themselves with experimental cuts later on

1. gluon-gluon Fusion Process

- Cross sections are calculated in N3LO QCD by Zürich group (Note by Zürich group).
- QCD scales: $\mu=\mu_F=\mu_R=M_h/2$
- PDF set: PDF4LHC15_nnlo_100
- References: [Anastasiou:2014vaa,Anastasiou:2014lda,Anastasiou:2016cez,Anastasiou:2016hlm]

- Numbers in bottom-quark related cross sections and corresponding coupling modifiers have changed with respect to CERN Yellow Report 3 (see Eq. (111) and Table 38).
- For M_h=125 GeV at $\sqrt{s}$=8 TeV,
    - CERN Yellow Report 3: $_g^2 = 1.058\ _t^2 + 0.007\ _b^2 - 0.065\ _t\ _b$
    - CERN Yellow Report 4: $_g^2 = 1.042\ _t^2 + 0.002\ _b^2 - 0.040\ _t\ _b - 0.005\ _t\ _c + 0.0005\ _b\ _c + 0.00002\ _c^2$
- The main origins of these differences are:
    1. Due to change in central QCD scale from M_h (CERN Yellow Report 3) to $M_h/2$ (CERN Yellow Report 4). This affects $_{tt}$ but doesn t affect much $_{tb}$ or $_{bb}$.
    2. Due to inclusion of charm quark.
    3. Due to change in quark-mass definition from on-shell mass in CERN Yellow Report 3 (M_t=172.5 GeV, M_b=4.84131 GeV) to MSbar mass in CERN Yellow Report 4 ($M_t(M_t)$=162.7 GeV, $M_b(M_b)$=4.18 GeV and M_c(3 GeV)=0.986 GeV).
        - ◊ In the MSbar scheme the light quark masses run to a significantly lower value (at scale of $\mu \sim M_h/2$ or M_h) than their pole masses.
        - ◊ Hence there is an effect on the top-bottom interference and the bottom-bottom part (also for charm).
- It has been checked that HIGLU (M. Spira) and Zürich calculations agree perfectly with the same input condition in on-shell mass scheme.
- In the table below $_{EW}$ nor $_{tot}$ are used for calculations on as we use QCD corrections ($_{QCD}=\ _{qq}$) only and no NLO EW correction.

7 TeV

M_h [GeV]	EW [pb]	tt [pb]	tb [pb]	bb [pb]	tc [pb]	bc [pb]	cc [pb]	tot [pb]	QCD [pb]	t^2	t b	b^2	t c	b c	c^2
124.50	0.84	16.86	-0.67	0.04	-0.08	0.01	0.0003	17.00	16.16	1.043	-0.041	0.002	-0.005	0.0006	0.00002
125.00	0.83	16.71	-0.66	0.04	-0.08	0.01	0.0003	16.85	16.02	1.043	-0.041	0.002	-0.005	0.0006	0.00002
125.09	0.83	16.69	-0.66	0.04	-0.08	0.01	0.0003	16.83	16.00	1.043	-0.041	0.002	-0.005	0.0006	0.00002
125.50	0.83	16.57	-0.65	0.04	-0.08	0.01	0.0003	16.72	15.89	1.043	-0.041	0.003	-0.005	0.0006	0.00002
8 TeV															
M_h [GeV]	EW [pb]	tt [pb]	tb [pb]	bb [pb]	tc [pb]	bc [pb]	cc [pb]	tot [pb]	QCD [pb]	t^2	t b	b^2	t c	b c	c^2
124.50	1.06	21.41	-0.83	0.05	-0.10	0.01	0.0004	21.60	20.54	1.042	-0.040	0.002	-0.005	0.0005	0.00002
125.00	1.06	21.23	-0.82	0.05	-0.10	0.01	0.0004	21.43	20.37	1.042	-0.040	0.002	-0.005	0.0005	0.00002
125.09	1.06	21.20	-0.82	0.05	-0.10	0.01	0.0004	21.40	20.34	1.042	-0.040	0.002	-0.005	0.0005	0.00002
125.50	1.05	21.06	-0.81	0.05	-0.10	0.01	0.0004	21.26	20.21	1.042	-0.040	0.002	-0.005	0.0005	0.00002
13 TeV															
M_h [GeV]	EW [pb]	tt [pb]	tb [pb]	bb [pb]	tc [pb]	bc [pb]	cc [pb]	tot [pb]	QCD [pb]	t^2	t b	b^2	t c	b c	c^2
124.50	2.40	48.35	-1.76	0.10	-0.22	0.02	0.0009	48.89	46.49	1.040	-0.038	0.002	-0.005	0.0004	0.00002
125.00	2.39	48.00	-1.74	0.10	-0.22	0.02	0.0009	48.55	46.16	1.040	-0.038	0.002	-0.005	0.0004	0.00002
125.09	2.39	47.94	-1.73	0.10	-0.22	0.02	0.0009	48.50	46.11	1.040	-0.038	0.002	-0.005	0.0004	0.00002
125.50	2.39	47.65	-1.72	0.10	-0.22	0.02	0.0009	48.22	45.83	1.040	-0.038	0.002	-0.005	0.0004	0.00002
14 TeV															
M_h [GeV]	EW [pb]	tt [pb]	tb [pb]	bb [pb]	tc [pb]	bc [pb]	cc [pb]	tot [pb]	QCD [pb]	t^2	t b	b^2	t c	b c	c^2
124.50	2.70	54.39	-1.95	0.12	-0.25	0.02	0.0010	55.03	52.33	1.039	-0.037	0.002	-0.005	0.0004	0.00002
125.00	2.69	54.00	-1.93	0.11	-0.24	0.02	0.0010	54.65	51.96	1.039	-0.037	0.002	-0.005	0.0004	0.00002
125.09	2.69	53.93	-1.92	0.11	-0.24	0.02	0.0010	54.59	51.90	1.039	-0.037	0.002	-0.005	0.0004	0.00002
125.50	2.69	53.61	-1.91	0.11	-0.24	0.02	0.0010	54.28	51.59	1.039	-0.037	0.002	-0.005	0.0004	0.00002

2. VBF Process

- Cross sections are calculated in NNLO QCD with VBF@NNLO program (CERN Yellow Report 4, Appendix).
- QCD scales: $\mu=\mu_F=\mu_R=M_W$
- PDF set: PDF4LHC15_nnlo_30_pdfas
- References: [Bolzoni:2010xr,Bolzoni:2011cu]

	7 TeV					8 TeV					13 TeV					14 TeV			
M_h [GeV]	ww [pb]	zz [pb]	w^2	z^2		ww [pb]	zz [pb]	w^2	z^2		ww	zz	w^2	z^2		ww [pb]	zz [pb]	w^2	z^2
120.0	0.993	0.349	0.740	0.260		1.278	0.452	0.739	0.261		3.001	1.091	0.733	0.267		3.392	1.238	0.733	0.26
125.0	0.946	0.333	0.740	0.260		1.220	0.432	0.738	0.262		2.882	1.049	0.733	0.267		3.260	1.191	0.732	0.26
130.0	0.902	0.318	0.740	0.260		1.166	0.413	0.738	0.262		2.770	1.009	0.733	0.267		3.135	1.146	0.732	0.26

- CERN Yellow Report 3: $_{WW}$ = 0.938 (1.210) pb and $_{ZZ}$ = 0.321 (0.417) pb for $\sqrt{s}$ = 7(8) TeV for M_h = 125 GeV, which corresponds to coupling modifiers of $_W^2$; 0.745 (0.744) and $_Z^2$; 0.255 (0.256) for $\sqrt{s}$ = 7(8) TeV.

3. gg ZH Process

- Cross sections are calculated in LO QCD with VH@NNLO program.
- QCD scales: $\mu=\mu_F=\mu_R=M_{ZH}$
- PDF set: PDF4LHC15_nnlo_mc
- References: [Brein:2012ne,Harlander:2013mla] for VH@NNLO.
  [Han:1991ia,Kniehl:1990iv,Kniehl:2011aa] for original calculations for gg ZH process

7 TeV													
M_h [GeV]	$_t^2$ [fb]	$_b^2$ [fb]	$_Z^2$ [fb]	$_t\ _b$ [fb]	$_t\ _Z$ [fb]	$_b\ _Z$ [fb]	(ZZ ZH) [fb]	$_t^2$	$_b^2$	$_Z^2$	$_t\ _b$	$_t\ _Z$	$_b\ _Z$
124.50	3.87	0.005	25.07	0.04	-17.69	-0.16	11.13	0.347	0.0005	2.252	0.004	-1.589	-0.015
125.00	3.86	0.005	24.96	0.04	-17.64	-0.16	11.06	0.349	0.0005	2.256	0.004	-1.595	-0.015
125.09	3.86	0.005	24.94	0.04	-17.63	-0.16	11.05	0.349	0.0005	2.257	0.004	-1.595	-0.015
125.50	3.85	0.005	24.86	0.04	-17.60	-0.16	11.00	0.350	0.0005	2.260	0.004	-1.600	-0.014
8 TeV													
M_h [GeV]	$_t^2$ [fb]	$_b^2$ [fb]	$_Z^2$ [fb]	$_t\ _b$ [fb]	$_t\ _Z$ [fb]	$_b\ _Z$ [fb]	(ZZ ZH) [fb]	$_t^2$	$_b^2$	$_Z^2$	$_t\ _b$	$_t\ _Z$	$_b\ _Z$
124.50	5.89	0.007	36.55	0.05	-26.37	-0.22	15.91	0.370	0.0004	2.298	0.003	-1.658	-0.014
125.00	5.88	0.007	36.41	0.05	-26.31	-0.21	15.82	0.372	0.0004	2.302	0.003	-1.663	-0.013
125.09	5.88	0.007	36.38	0.05	-26.30	-0.21	15.80	0.372	0.0004	2.303	0.003	-1.665	-0.014
125.50	5.87	0.007	36.26	0.05	-26.25	-0.22	15.73	0.373	0.0004	2.306	0.003	-1.669	-0.014
13 TeV													
M_h [GeV]	$_t^2$ [fb]	$_b^2$ [fb]	$_Z^2$ [fb]	$_t\ _b$ [fb]	$_t\ _Z$ [fb]	$_b\ _Z$ [fb]	(ZZ ZH) [fb]	$_t^2$	$_b^2$	$_Z^2$	$_t\ _b$	$_t\ _Z$	$_b\ _Z$
124.50	23.47	0.021	126.80	0.14	-98.07	-0.58	51.75	0.454	0.0004	2.450	0.003	-1.895	-0.011
125.00	23.45	0.021	126.34	0.14	-97.87	-0.58	51.47	0.456	0.0004	2.455	0.003	-1.902	-0.011
125.09	23.44	0.021	126.26	0.14	-97.83	-0.58	51.42	0.456	0.0004	2.456	0.003	-1.903	-0.011
125.50	23.42	0.020	125.88	0.14	-97.66	-0.57	51.19	0.457	0.0004	2.459	0.003	-1.908	-0.011
14 TeV													
M_h [GeV]	$_t^2$ [fb]	$_b^2$ [fb]	$_Z^2$ [fb]	$_t\ _b$ [fb]	$_t\ _Z$ [fb]	$_b\ _Z$ [fb]	(ZZ ZH) [fb]	$_t^2$	$_b^2$	$_Z^2$	$_t\ _b$	$_t\ _Z$	$_b\ _Z$
124.50	28.49	0.024	151.02	0.16	-117.89	-0.62	61.12	0.466	0.0004	2.471	0.003	-1.929	-0.010
125.00	28.46	0.024	150.48	0.16	-117.65	-0.61	60.79	0.468	0.0004	2.475	0.003	-1.935	-0.010
125.09	28.45	0.024	150.45	0.16	-117.67	-0.67	60.73	0.468	0.0004	2.477	0.003	-1.937	-0.011
125.50	28.43	0.024	149.98	0.16	-117.46	-0.64	60.45	0.470	0.0004	2.481	0.003	-1.943	-0.011

- ATLAS and CMS 7&8TeV coupling paper (CERN-EP-2016-100) Table 4: 2.27 $_Z^2$ + 0.37 $_t^2$ - 1.64 $_t\ _Z$ for $\sqrt{s}$ = 8 TeV and M_h = 125.09 GeV.

---

4. tH Process

- Single-top associated Higgs production in s-ch (qqbar tHb), t-ch (qb tHq) and W-associated (gb tHW) production modes.
- s-ch cross section is small (about 4% of t-ch) and neglected.
- All the results are obtained with MG5_aMC@NLO (Note by MG5 group)
  - ♦ Standard Model results are generated with the default distribution of MG5.
  - ♦ kappa-framework results are generated using the HC_NLO_X0 model.

t-ch (qb tHq)

- Cross sections are calculated in NLO QCD with MG5_aMC@NLO
- QCD scales: $\mu=\mu_F=\mu_R=(m_H+m_t)/4$
- PDF set: PDF4LHC15_nlo_30_pdfas
- References: [Demartin:2015uha] for tH process, CERN Yellow Report 4, Section I.6.6.1.1

7 TeV							
M_h [GeV]	$_t^2$ [fb]	$_W^2$ [fb]	$_t\ _W$ [fb]	(t-ch) [fb]	$_t^2$	$_W^2$	$_t\ _W$
125.00	37.99	48.79	-74.52	12.26	3.099	3.980	-6.078
8 TeV							
M_h [GeV]	$_t^2$ [fb]	$_W^2$ [fb]	$_t\ _W$ [fb]	(t-ch) [fb]	$_t^2$	$_W^2$	$_t\ _W$
125.00	55.78	72.62	-109.7	18.69	2.984	3.886	-5.870
13 TeV							
M_h [GeV]	$_t^2$ [fb]	$_W^2$ [fb]	$_t\ _W$ [fb]	(t-ch) [fb]	$_t^2$	$_W^2$	$_t\ _W$
125.00	195.5	265.7	-387.0	74.25	2.633	3.578	-5.211
14 TeV							
M_h [GeV]	$_t^2$ [fb]	$_W^2$ [fb]	$_t\ _W$ [fb]	(t-ch) [fb]	$_t^2$	$_W^2$	$_t\ _W$
125.00	232.6	318.8	-461.3	90.10	2.582	3.538	-5.120

- ATLAS and CMS 7&8TeV coupling paper (CERN-EP-2016-100) Table 4: 3.40 $_t^2$ + 3.56 $_W^2$ - 5.96 $_t\ _W$ for $\sqrt{s}$ = 8 TeV and M_h = 125.09 GeV.

W-associated (gb HW)

- Cross sections are calculated in NLO QCD with MG5_aMC@NLO
- QCD scales: $\mu=\mu_F=\mu_R=(m_H+m_t+m_W)/2$
- PDF set: PDF4LHC15_nlo_30_pdfas
- References: [Demartin:2016axk] for tHW process, employing the DR2 technique.

7 TeV							
M_h [GeV]	$_t^2$ [fb]	$_W^2$ [fb]	$_t\ _W$ [fb]	(tHW) [fb]	$_t^2$	$_W^2$	$_t\ _W$
125.00	5.143	3.784	-6.697	2.23	2.306	1.697	-3.003
8 TeV							
M_h [GeV]	$_t^2$ [fb]	$_W^2$ [fb]	$_t\ _W$ [fb]	(tHW) [fb]	$_t^2$	$_W^2$	$_t\ _W$
125.00	8.515	6.381	-11.39	3.51	2.426	1.818	-3.244
13 TeV							
M_h [GeV]	$_t^2$ [fb]	$_W^2$ [fb]	$_t\ _W$ [fb]	(tHW) [fb]	$_t^2$	$_W^2$	$_t\ _W$
125.00	44.13	35.05	-64.01	15.17	2.909	2.310	-4.220
14 TeV							
M_h [GeV]	$_t^2$ [fb]	$_W^2$ [fb]	$_t\ _W$ [fb]	(tHW) [fb]	$_t^2$	$_W^2$	$_t\ _W$
125.00	55.46	44.49	-81.39	18.56	2.988	2.397	-4.385

- ATLAS and CMS 7&8TeV coupling paper (CERN-EP-2016-100) Table 4: 1.84 $_t^2$ + 1.57 $_W^2$ - 2.41 $_t\ _W$ for $\sqrt{s}$ = 8 TeV and M_h = 125.09 GeV.

---

5. HH Process

- See CERN Yellow Report 4 HH section on the dependence on the EFT coefficients. For HH, it doesn't make sense to have the top Yukawa varied without varying the HHH coupling. The bottom-quark loop is fairly irrelevant for HH production.

---

6. Higgs boson decay width

- The Higgs-boson decay branching ratios in CERN Yellow Report 4 have changed only below O(1%) with respect to those in CERN Yellow Report 3, hence one can use partial decay width for h gg (Table 39), h (Table 40) and h Z (Table 41) in CERN Report 3.
- Inclusion of charm quark is under investigation with HDECAY.

-- ReiTanaka - 2016-06-23

This topic: LHCPhysics > LHCHXSWG2KAPPA
Topic revision: r18 - 2017-02-10 - ReiTanaka