Table of Contents

Standard Model Input Parameters at LHC for RUN-1 (7&8TeV)

These are the Standard Model input parameters agreed among ATLAS, CMS, LHCb and theory community for Higgs cross section calculations. The same parameters can be used for other SM and BSM processes at LHC.

Lepton&Quark Masses †

e	μ	
0.510998910(13) MeV	105.658367(4) MeV	1776.84(17) MeV
u	**c**	**t**
100 MeV	1.40 GeV	172.5 +- 2.5 GeV
d	**s**	**b**
100 MeV	100 MeV	4.75 GeV

* Note: The charm and bottom masses are the pole masses used in the MSTW2008 PDF set.

Light quark masses

Light quark masses as used in parton show Monte Carlos are in some cases (e.g.HERWIG) effective masses used to regulate the parton shower in the infrared region (HERWIG also uses massive gluons), and as such may be treated more as a semi-perturbative QCD model parameter specific to a given generator rather than a SM parameter.

Charm and Bottom quark masses

We propose a process dependent choice of the quark masses since this issue cannot be generalized. The best choice should be given depending on the process. The current best fits for the MSbar masses are (hep-ph/0702103,arXiv:0907.2110),

MSbar mass	$m_c(m_c)$	$m_b(m_b)$
	1.28 GeV	4.16 GeV

These MSbar masses are obtained from fits to the QCD sum rules in charmonium and bottomonium systems and should normally be considered as the primary input. One could start from the MSbar values and compute the needed mass. The pole masses obtained from the values above strongly depend on the order of the calculation:

pole mass	m_c	m_b
1-loop	1.42 GeV	4.49 GeV
2-loop	1.56 GeV	4.69 GeV

On the other hand if we are going to use MSTW2008 PDFs, we are forced to use 4.75 GeV as the bottom pole mass. This should correspond to the 1-loop pole mass. Whatever we do, we are always forced to make a compromise due to consistency, *i.e.* to use mass values fitted at the order at which your observable is calculated and to be consistent with the input, in particular with the PDFs.

(*Comments from Michael Spira, February, 2010*).

MSbar running masses for the quarks

- Input values are $m_c(m_c)$ = 1.28 GeV, $m_b(m_b)$ = 4.16 GeV and m_t^{pole} = 172.5 GeV.

M_H	$m_c(M_H)$	$m_b(M_H)$	$m_t(M_H)$

125.0 GeV	0.61614 GeV	2.7645 GeV	169.22 GeV
125.5 GeV	0.61593 GeV	2.7636 GeV	169.16 GeV
126.0 GeV	0.61573 GeV	2.7627 GeV	169.10 GeV

- These masses include only QCD running.
- Full listings of running quark mass for M_H = [120,130] GeV with ΔM_H=0.1 GeV step (Link for the data file).
- It has to be kept in mind that the gluon fusion cross section as well as ttH production are expressed in terms of the top pole mass at (N)NLO. (M. Spira, May 2013)

How to plot Higgs boson couplings with Yukawa and gauge bosons as a function of mass

Please check the note by M. Spira (May 2013).

1. one can work with either 1) quark pole-mass M_Q, 2) MSbar mass $m(M_Q)$ or 3) MSbar mass $m(M_H)$,
2. according to LHC Higgs XS WG LM subgroup's interim recommendation (arXiv:1209.0040), the relation between observed $_f$ and partial decay width is $_f^2 = _{ff} / _{ff}^{SM}$,
3. for $_{ff}$ as a function of coupling, use formula (11), (10) or (9) according to the mass definition,
4. for $_{ff}^{SM}$, use predictions from LHC Higgs XS WG's CERN Report (i.e. BR(H>ff)*x $_{total}$),
5. then deduce the measured coupling $_f x g_Q$ as defined in formula (8), (7) or (6) according to the mass definition,
6. the SM prediction in coupling vs mass plot is given by formula (8), (7) or (6) according to the mass definition.
7. then plot the couplings $_f$ (19) and $_V$ (20) in the single line.
8. in this way the electroweak symmetries can be tested by comparing the coupling factors with the line predicted by the SM for all coupling factors.

(M. Spira, R. Tanaka, May 2013)

Gauge Boson Masses and Widths

PDG Values †

W	M_W	$_W$
	80.398(25) GeV	2.141(41) GeV
Z	**M_Z**	**$_Z$**
	91.1876(21) GeV	2.4952(23) GeV

For the gauge boson widths $_W$ and $_Z$ (and for other derived parameters) each code should use values consistent in the Electroweak Standard Model in the required order of the calculation (NLO for NLO, etc.). In general it is not recommended to use NNLO parameters in NLO calculations as these may violate symmetries or sum rules, like the the condition that branching ratios should add up to one. Differences in the derived parameters should enter the theory parametric errors. Those codes that cannot provide the gauge-boson widths internally should use the following reference values at NLO.

NLO Width	$_W$	$_Z$
	2.08872 GeV	2.49595 GeV

Please note that W-width derived at NLO differs by -2.44% than PDG value.

(*Discussed at CERN workshop and comments from Ansgar Denner, July 5-6, 2010*).

Electroweak Radiative Corrections

G_μ	$1.16637(1)\times10^{-5}$ GeV^{-2} †

For EW radiative corrections, it is more complicated than QCD because of renormalization and the treatment of unstable particles are complicated. For the treatment of resonances complex-mass scheme, fixed-width scheme and pole-mass scheme can be taken. Also for the renormalization scheme which defines relations between electroweak couplings and parameters beyond the leading order, various schemes exist such as (0) scheme, (M_Z^2) scheme and the G_F scheme. For further detail, please refer to *the Binoth Les Houches Accord* arXiv:1001.1307, Section 5.1 - 5.3.. If we agree on, then this SM input parameter page could be extended.

(*Comments from Giampiero Passarino, February, 2010*).

QCD $_s$

Default $_s(M_Z)$ values

PDF set	LO	NLO	NNLO	Reference
MSTW2008	0.1394	0.1202 + 0.0012 - 0.0015	0.1171 +- 0.0014	Eur. Phys. J. **C64** (2009) 653
NNPDF2.0		0.119 +- 0.0012		arXiv:1004.0962
CTEQ6,6		0.118 +- 0.002 (90% C.L.)		arXiv:1004.4624
ABKM09		0.1179 +- 0.0016	0.1135 +- 0.0014	Phys. Rev. **D81** (2010) 014032
HERAPDF1.0		0.1176 +- 0.002 (PDG)		JHEP **01** (2010) 109
GJR08/JR09	0.1263 +- 0.0015	0.1145 +- 0.0018	0.1124 +- 0.0020	Phys. Rev. **D79** (2009) 074023

Default $_s(M_Z)$ errors

- $\Delta\ _s$=+-0.0012 for 68%C.L. and $\Delta\ _s$=+-0.0020 for 90%C.L. (PDF4LHC group recommendation)

Please check PDF prescriptions.

References

† C. Amsler *et al.* (Particle Data Group), Physics Letters **B667** (2008) 1 and 2009 partial update for the 2010 edition.

-- ReiTanaka - 12-Feb-2010

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