To hall hands

This addendum follows a request from Stefan Dittmaier: one branch of numbers to be produced for our activities concerns CC03 $\mathcal{O}(\alpha)$ (what about NC02?). Once radiative corrections are switched on the question of Renormalization Scheme (RS) and of Input Parameter Set (IPS) becomes relevant. Let's summarize what one should use:

$$M_{_Z} = 91.1867 \text{ GeV}, \quad 1/\alpha(0) = 137.0359895, \quad G_{_F} = 1.16637\, 10^{-5} \text{ GeV}^{-2}. \tag{1}$$

As far as masses are concerned one should use:

- **Leptons**

$$m_\mu = 0.51099907 \text{ MeV}, \quad m_\mu = 105.658389 \text{ MeV}, \quad m_\tau = 1.77705 \text{ GeV}. \tag{2}$$

- **Quarks**. For light quarks one should make a distinction; for phase space:

$$\begin{aligned} & m_u = 5 \text{ MeV}, \qquad m_d = 10 \text{ MeV}, \\ & \text{only relevant for single} - W, \end{aligned} \tag{3}$$

while, in principle, they should *not* be used in deriving $\alpha_{\text{QED}}(s)$ from $\alpha_{\text{QED}}(0)$. Here the recommendations is as follows:

- An important issue concerns the evaluation of α_{QED} at the mass of the Z. There is an agreement in our community on using the following strategy. Define

$$\alpha(M_{_Z}) = \frac{\alpha(0)}{1 - \Delta\alpha^{(5)}(M_{_Z}) - \Delta_{\text{top}}(M_{_Z}) - \Delta_{\text{top}}^{\alpha\alpha_S}(M_{_Z})}, \tag{4}$$

  where one has $\Delta\alpha^{(5)}(M_{_Z}) = \Delta\alpha_{\text{lept}} + \Delta\alpha^{(5)}_{\text{had}}$. The input parameter should be $\Delta\alpha^{(5)}_{\text{had}}$, as it is the contribution with the largest uncertainty, while the calculation of the top contributions to $\Delta\alpha$ is left for the code. This should become common to all codes.

  Codes should include, for $\Delta\alpha_{\text{lept}}$, the recently computed $\mathcal{O}\left(\alpha^3\right)$ terms of [1] and use as default $\Delta\alpha^{(5)}_{\text{had}} = 0.0280398$, taken from [2]. Using the default one obtains $1/\alpha^{(5)}(M_{_Z}) = 128.877$, to which one must add the $t\bar{t}$ contribution and the $\mathcal{O}(\alpha\alpha_{_S})$ correction induced by the $t\bar{t}$ loop with gluon exchange, [3].

Therefore, light quark masses should *not* appear in the evaluation of $\alpha_{\text{QED}}(M_{_Z})$. If they do, please make sure that you end up with

$$\begin{aligned} 1/\alpha(M_{_Z}) \quad &= \quad 128.887, \\ \text{for} \quad & \quad M_{_Z} = 91.1867\, GeV, \quad m_t = 175 \text{ GeV}, \\ & \quad M_{_H} = 150 \text{ GeV}, \quad \alpha_{_S}(M_{_Z}) = 0.119. \end{aligned} \tag{5}$$

If you need a subroutine that computes $\delta\alpha$ you could have a look inside

- TOPAZ0 `http://www.to.infn.it/~giampier/topaz0.html` or
- ZFITTER `http://www.ifh.de/~riemann/Zfitter/zf.html`.

Furthermore, one should use

$$\alpha_{S}(M_{Z}) = 0.119, \quad M_{H} = 150 \text{ GeV}, \quad M_{W} = 80.350 \text{ GeV}. \tag{6}$$

The quantities Γ_{Z}, Γ_{W} should be understood as computed in the MSM, i.e. $\Gamma_{Z} = 2.49471$ GeV for our IPS.

Now we come to the most important point, what to do with IPS in the presence of radiative corrections. In principle, all RS and all IPS are equally good and accepted, and differences are true estimates of some component of the theoretical uncertainty. However, we want to make sure that differences are not due to technical precision. The IPS that we want to specify is over-complete, let us repeat,

$$\begin{aligned} G_{F} &= 1.16637\,10^{-5} \text{ GeV}^{-2}, \qquad 1/\alpha(M_{Z}) = 128.887, \\ M_{Z} &= 91.1867 \text{ GeV}, \quad M_{W} = 80.350 \text{ GeV}, \\ \alpha_{S}(M_{Z}) &= 0.119, \quad M_{H} = 150 \text{ GeV}. \end{aligned} \tag{7}$$

Clearly, once radiative correction are on, $s_\theta = s_\theta^{\text{yourscheme}}$ and we don't care anymore what you use since enough RC should be included to make all schemes equivalent to $\mathcal{O}(\alpha)$. Thus, for $\mathcal{O}(\alpha)$ numbers s_θ drops out. Perhaps we should give the highest marks to schemes where M_{W} is in the IPS; after all, they measure M_{W} at LEP 2 and any scheme where M_{W} is not a primary quantity in the IPS is as bad as a scheme for LEP 1 where M_{Z} is a derived quantity.

Nevertheless, we can use the overcompleteness of the present IPS to set some internal consistency: perhaps it is a good idea to have an over-complete set of IPS, nevertheless consistent so that everybody can make his favourite choice of the RS. Since we include values for $\alpha(M_{Z})$ and for G_{F} we can, as well, fine-tune the numbers so that the internal relations hold, to the best of our knowledge. The recommendation, in this case, would be as follows:

- write down your favorite equation

  $$f\,(M_{Z}, M_{W}, m_t, M_{H}, \alpha_{S}(M_{Z}), \alpha(0), G_{F}) = 0, \tag{8}$$

  keep everything fixed but m_t which, in turn, is derived as a solution of the consistency equation (for OMS this involves typically Δr). Even this solution is RS-dependent but variation should be minimal, sort of irrelevant. Therefore, if you are not willing to do it yourself, you could use the following result (derived from TOPAZ0):

  $$m_t = 174.17 \text{ GeV} \quad \textbf{Default for CC03 } \mathcal{O}(\alpha). \tag{9}$$

  You see, with $M_{W} = 80.350\,GeV$ and $M_{H} = 150\,\text{GeV}$ we are in a lucky situation, m_t doesn't change too much.

More solutions?

M_H [GeV]	m_t [GeV]
100	170.03
150	174.17
180	176.14
250	179.90

References

[1] M. Steinhauser, Phys. Lett. B429 (1998) 158.

[2] S. Eidelman and F. Jegerlehner, Z. Phys. C67 (1995) 585.

[3] B. Kniehl, Nucl. Phys. B347 (1990) 86.