TOPAZ0 4.0 - Most recent upgradings

There is an agreement on using the following idea. Define

$$\alpha(M_Z) = \frac{\alpha(0)}{1 - \Delta\alpha^{(5)}(M_Z) - \Delta_{\rm top}(M_Z)}, \tag{1}$$

Moreover one has $\Delta\alpha^{(5)}(M_Z) = \Delta\alpha_{\rm lept} + \Delta\alpha^{(5)}_{\rm had}$. In all codes the input should be $\Delta\alpha^{(5)}_{\rm had}$, i.e. the top contribution to $\Delta\alpha$ is left for the code.

Inside TOPAZ0 one has

$$\Delta\alpha_{\rm lept} = 0.0314976003, \tag{2}$$

including the recently computed $\mathcal{O}(\alpha^3)$ terms of hep-ph/9803313, and $\Delta\alpha^{(5)}_{\rm had} = 0.028037 \pm 0.00065$, Z. Phys. C67(1995)585 (DEFAULT). This gives $1/\alpha^{(5)}(M_Z) = 128.878 \pm 0.089$, to which one must add the top contribution (-0.0000573514 for $m_t = 175.6\,\mathrm{GeV}$) and the $\mathcal{O}(\alpha\alpha_s)$ corrections induced by the $t-b$ doublet (-0.000010238 for $\alpha_s(M_Z) = 0.120$), giving a total of $1/\alpha(M_Z) = 128.887$.

Therefore, inside TOPAZ0, we have

OAL='Y' Default, uses $\Delta\alpha^{(5)}_{\rm had} = 0.028037$.

OAL='V' You are changing $\Delta\alpha^{(5)}_{\rm had}$ to your preferred value. This is done by calling subroutine TCAQED with the new value as argument.

There is a new option for the QED radiator:

ORAD='Y' It uses the order α^3 YFS radiator as reported by M. Skrzypek in Acta Phys. Pol. B23(1992)135 and not the one of Jadach et al. in Phys. Lett. B257(1991)173 which clearly contains typos. The typical cross section with $s'/s = 0.01$ at the peak is such that σ(ORAD= 'Y') and σ(ORAD= 'F', recommended choice) differ of about +0.02%. The difference can be ascribed to the hard non-log terms of order α^2, last six rows for eq. (3.20) p. 106 CERN 89-08, which are present in the order α^3 TOPAZ0's radiator (ORAD= 'F', G. Montagna et al. Phys. Lett. B406(1997)243), but neglected in YFS. Actually, if one switches off these terms in ORAD= 'F' the agreement YFS-F is well within 0.01%.

We argue that the 0.02% difference should not be treated as a QED uncertainty but rather due to missing non-log terms of order α^2 in YFS. These terms are contained in the TOPAZ0 option ORAD= 'F' but also in ORAD= 'A'. The latter is the radiator of eqs. (3.12)-(3.20) p. 105-106 CERN 89-08 that reproduces the complete second order calculation but doesn't include order α^3 corrections.

Some results follow where we use $M_{_Z} = 91.1867\,\mathrm{GeV}$, $m_t = 175.6\,\mathrm{GeV}$, $M_{_H} = 300\,\mathrm{GeV}$ and $\alpha_s(M_{_Z}) = 0.120$. First muons then hadrons:

$\sqrt{s}$	A	F	YFS	$10^4\times$ (1-YFS/F)
$M_{_Z} - 3$	0.2272765	0.2271885	0.2272344	-2.0
$M_{_Z} - 2$	0.4126682	0.4124799	0.4125672	-2.1
$M_{_Z} - 1$	0.8715848	0.8711554	0.8713470	-2.2
$M_{_Z}$	1.477655	1.476824	1.477146	-2.2
$M_{_Z} + 1$	1.079591	1.078754	1.078970	-2.0
$M_{_Z} + 2$	0.6287772	0.6281566	0.6282654	-1.7
$M_{_Z} + 3$	0.4078509	0.4074085	0.4074661	-1.4

$\sqrt{s}$	A	F	YFS	$10^4\times$ (1-YFS/F)
$M_z - 3$	4.439504	4.437063	4.438007	-2.1
$M_z - 2$	8.292592	8.288077	8.289888	-2.2
$M_z - 1$	17.82036	17.81085	17.81482	-2.2
M_z	30.39768	30.37983	30.38652	-2.2
$M_z + 1$	22.14409	22.12614	22.13063	-2.0
$M_z + 2$	12.79752	12.78406	12.78632	-1.8
$M_z + 3$	8.219664	8.209906	8.211106	-1.5