$\mathcal{O}(\alpha)$ Corrections to $e^+e^- \to \tilde{\mu}_\mathsf{R}^+\tilde{\mu}_\mathsf{R}^-$

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This is a short description of a program code for the calculatuion of the next-to-leading order corrections to the cross-section for $e^+e^- \to \tilde{\mu}_\mathrm{R}^+\tilde{\mu}_\mathrm{R}^-$ in the MSSM. For more information about the details of the calculation and the renormalization, see [1].

The source code for the program is available at `http://www.fnal.gov/people/afreitas`. It comes in a compressed tar archive. To install, create a directory and unpacke the archive there:

```
mkdir smu
cd smu
gunzip smu.tar.gz
tar xf smu.tar
```

The archive includes the program module *pomssm* by S. Heinemeyer [2] for the calculation of the W boson mass using the Fermi constant G_μ as an input. The code *pomssm* is contained in the tar file in a compiled and statically linked version for Linux operating systems. If you want to run the program on other operating systems, please contact S. Heinemeyer[1] for the source code of *pomssm*.

In addition, for the numerical evaluation of the loop integrals, the package *LoopTools* [3] is required, which is available at `http://www.feynarts.de/looptools`. Please refer to the documentation given at the *LoopTools* web site for installation of this package. Included in the contents of the archive is a makefile for compilation of the source files with the GNU C++ compiler. Please edit the makefile to enter the path where you installed the *LoopTools* package:

```
      ⋮
# enter LoopTools path here:
LTPATH=$(HOME)/LoopTools2                ← adapt this line in makefile
      ⋮
```

The compilation with GNU `make` yields a executable file `tint`. It is invoked by the command

`./tint` *input.dat*

where *input.dat* is a input file of the following format. Each line of *input.dat* contains two numbers, the first of which indicates a input parameter, while the second specifies the value of this parameter.

[1] `heinemey@mail.cern.ch`

parameter:	*value:*
	⋮
`1`	`0.3028221201189085`
`4`	`91.1876`
`2`	`0.05915`
`3`	`80.422`
	⋮

The following list of parameters must be provided in *input.dat* (for the notation of the MSSM parameters please refer to [1,4]):

1	$e = \sqrt{4\pi\alpha_{\text{em}}}$	9	M_{A^0}	17	$m_{\tilde{Q}1}$	25	$m_{\tilde{D}3}$
2	$\Delta\alpha(M_{\text{Z}})$	10	$\tan\beta$	18	$m_{\tilde{U}1}$	26	A_τ
3	M_{W} or G_μ	11	$m_{\tilde{L}1}$	19	$m_{\tilde{D}1}$	27	A_{t}
4	M_{Z}	12	$m_{\tilde{E}1}$	20	$m_{\tilde{Q}2}$	28	A_{b}
5	m_{e}	13	$m_{\tilde{L}2}$	21	$m_{\tilde{U}2}$	29	M_1
6	m_τ	14	$m_{\tilde{E}2}$	22	$m_{\tilde{D}2}$	30	M_2
7	m_{b}	15	$m_{\tilde{L}3}$	23	$m_{\tilde{Q}3}$	31	μ
8	m_{t}	16	$m_{\tilde{E}3}$	24	$m_{\tilde{U}3}$		

32	Q^2 ($\overline{\text{DR}}$ scale)
33	ΔE (soft-photon cut-off; typical values are 0.1…0.0001)
34	λ (IR-regulating photon mass; typical values are 0.00001…0.000000001)
0	s (squared center-of-mass energy)
95	number of Monte-Carlo points for the real photon phase-space integration
96	Level of computation 1 : Born cross-section 2 : virtual $\mathcal{O}(\alpha)$ corrections to the cross-section only (without QED) 1+2=3 : total cross-section including virtual $\mathcal{O}(\alpha)$ corrections (without QED) 4 : virtual+real QED corrections only 1+2+4=7 : complete NLO cross-section including virtual and real corrections
97	Classes of diagrams to include in the virtual correcions 1 : SM-like corrections (only SM particles attached to the Born graphs) 2 : complete SM + SUSY corrections
98	$\cos\theta_{\text{min}}$ (limits for the integration over the polar scattering angle θ,
99	$\cos\theta_{\text{max}}$ for $\cos\theta_{\text{min}} = \cos\theta_{\text{max}}$ the diff. cross-section $\text{d}\sigma/\text{d}\cos\theta$ is returned)

All masses and energy parameters are specified in units of GeV. If the parameter 3 is greater than 1, it is interpreted to be the W boson mass, if it is smaller than 1, it is interpreted as the Fermi constant and the W mass is calculated internally using full one-loop and partial higher-order corrections.

The mixing between the L- and R-sfermions of the first two generations is always neglected, while the mixing of the third generation sfermions is consistently taken into account. The CKM mixing matrix is taken to be diagonal. All SUSY parameters are assumed to be real; it is not possible to include CP-violating complex phases. The chargino and neutralino mixing matrices are calculated interally from the input, but not given as output. The SUSY breaking parameters are assumed to be in the $\overline{\mathrm{DR}}$-scheme. The one-loop corrections necessary to transform the SUSY parameters appearing in the tree-level cross-section, i.e. the slepton masses, to the on-shell scheme are taken into account in the program.

A sample input file `input.dat` is provided in the archive for the SPS1a scenario [5].

The program `tint` returns the cross-section for $e^+e^- \to \tilde{\mu}^+_{\mathrm{R}}\tilde{\mu}^-_{\mathrm{R}}$ with the complete next-to-leading order corrections in a fully inclusive way, *i.e.* including emission of soft and hard photons in the real contributions. Thus the dependence on the soft-photon cut-off ΔE drops out in the result. For the phase-space integration of the hard photon contributions a Monte-Carlo method is used. The result is returned in a file `tint.out` that contains two numbers; the first representing the calculated cross-section in fb, while the second gives the estimated Monte-Carlo error. The Monte-Carlo error is zero if no QED corrections are included.

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T. Hahn, *LoopTools 2 User's Guide* (2001), [`http://www.feynarts.de/looptools`].

[4] T. Hahn and C. Schappacher, Comput. Phys. Commun. **143** (2002) 54.

[5] B. C. Allanach *et al.*, in *Proc. of the APS/DPF/DPB Summer Study on the Future of Particle Physics (Snowmass 2001)* eds. R. Davidson and C. Quigg, [hep-ph/0202233].