About implementation of $e^+e^- \to f\bar{f}$ processes into the framework of `SANC` system

L. V. Kalinovskaya[a] *

[a] Laboratory of Nuclear Physics,
Joint Institute for Nuclear Research, Dubna, Russia

In this report it is described how an automatic calculation of the differential cross-sections of the processes $e^+e^- \to f\bar{f}$ (with an arbitrary final-state massive fermion) at one-loop level is realized within the `SANC` system [1]. The results of numerical comparison with the other calculations are presented.

1. INTRODUCTION

The virtual library of EW and QED one-loop corrections for $e^+e^- \to f\bar{f}$ has become reality. In other words, a library of analytic results for NC and CC and a database of numerical results for NC processes is accessible online at *http://brg.jinr.ru* and it is available via the web for a calculation with your own input parameter set. Possible nearest future extensions `SANC` include calculations of $2f \to 2f\gamma$ processes.

2. FIRST RUN FOR THE PROCESSES

Automatic calculation by `SANC` of any $e^+e^- \to f\bar{f}$ process was done in two gauges — R_ξ and unitary gauge for internal cross checking, for all $f\bar{f}$ channels, and in two limits: $m_f \to 0$ and $m_{f'} \to 0$ (f' is the isospin partner of f), [2].

We work in OMS renormalization scheme, see the book [3] for systematic presentation.

2.1. Born-like structure of the one-loop amplitude

The amplitude is described by six scalar form factors (SFF) LL, QL, LQ, QQ, LD and QD:

$$\mathcal{A}_\gamma = i\frac{4\pi Q_e Q_f}{s}\alpha(s)\gamma_\mu \otimes \gamma_\mu \,,$$

$$\mathcal{A}_Z = i\frac{g^2}{16\pi^2}\,e^2\,\frac{1}{4s_W^2 c_W^2}\,\frac{1}{s - M_Z^2 + i\dfrac{\Gamma_Z}{M_Z}s}$$

$$\begin{aligned}
&\times\Big\{\gamma_\mu(1+\gamma_5)\otimes\gamma_\mu(1+\gamma_5)I_e^{(3)}I_f^{(3)}F_{LL}\,(s,t)\\
&+\delta_e I_f^{(3)}\gamma_\mu\otimes\gamma_\mu(1+\gamma_5)F_{QL}\,(s,t)\\
&+\delta_f I_e^{(3)}\gamma_\mu(1+\gamma_5)\otimes\gamma_\mu F_{LQ}\,(s,t)\\
&+\delta_e\delta_f\gamma_\mu\otimes\gamma_\mu F_{QQ}\,(s,t)\\
&+\gamma_\mu(1+\gamma_5)\otimes\left(-im_f D_\mu\right)I_e^{(3)}I_f^{(3)}F_{LD}\,(s,t)\\
&+\delta_e I_f^{(3)}\gamma_\mu\otimes\left(-im_f D_\mu\right)F_{QD}\,(s,t)\Big\},\\
&D_\mu = (p_{\bar{f}} - p_f)_\mu,\;\; \delta_f = v_f - a_f = -2Q_f s_W^2.
\end{aligned}$$

The chain of the calculation leading to the SFF is shown in Fig.1.

2.2. Numerical results

By now we have numerical results only for $e^+e^- \to f\bar{f}$ NC processes.

- In the internal comparison with a code generated by `s2n.f` an agreement within 12–13 digits is reached for the complete one-loop differential cross-sections $d\sigma^{(1)}/d\cos\vartheta$ for a standard input parameter set [2].
- In a comparison for $d\sigma^{(1)}/d\cos\vartheta$ with the other codes we got the agreement: 11 digits with FeynArts [4] (without soft photons), 8–9 digits with `topfit` [5] (with soft photons, $E_\gamma^{\max} = \sqrt{s}/10$).
- In a comparison of `SANC`–`ZFITTER` for the SFF the agreement is within 8–9 digits. For the $d\sigma^{(1)}/d\cos\vartheta$ the agreement is within 7–8 digits. The results of the calculation of the σ_{tot} and σ_{FB} for the different channels are shown in the Table 1.

---

*Supported by INTAS grant N^o 00-00313.

3. ILLUSTRATIONS AND TABLES

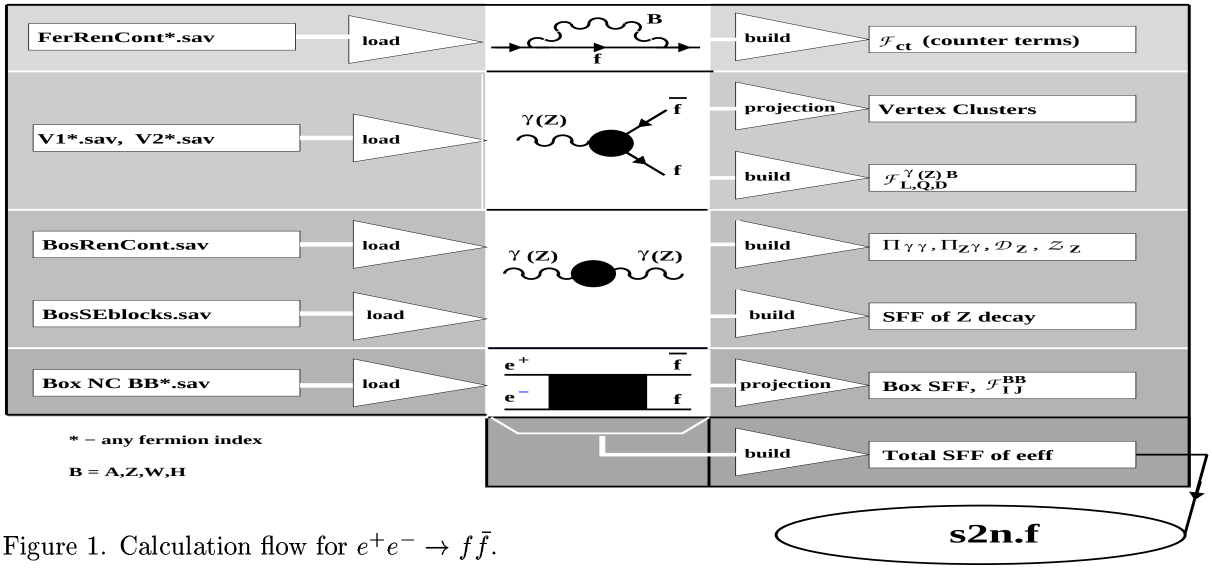

Figure 1. Calculation flow for $e^+e^- \to f\bar{f}$.

Table 1
Comparison of `ZFITTER` (first row) with `SANC` (second row).

channel	100 GeV		300 GeV	
	$\sigma_{\rm tot}$	$\sigma_{\rm FB}$	$\sigma_{\rm tot}$	$\sigma_{\rm FB}$
$\nu\bar{\nu}$, $m_\nu = 0$	84.81710	9.509864	0.320985	0.021592
	84.81710	9.509865	0.320985	0.021592
e^+e^-, $m_e = 0$	52.61662	30.78899	1.276008	0.648414
	52.61662	30.78899	1.276008	0.648414
$\mu^+\mu^-$, $m_\mu = 0.106$ GeV	52.61634	30.78885	1.276008	0.648414
	52.61634	30.78885	1.276008	0.648414
$\tau^+\tau^-$, $m_\tau = 1.77705$ GeV	52.53632	30.75010	1.275972	0.648324
	52.53661	30.75024	1.275974	0.648326
$u\bar{u}$, $m_u = 0.1$ GeV	160.8980	70.98406	2.031754	1.269556
	160.8981	70.98416	2.031754	1.269556
$d\bar{d}$, $m_d = 0.1$ GeV	193.7658	50.03208	1.149479	0.725581
	193.7658	50.03227	1.149479	0.725581
$b\bar{b}$, $m_b = 4.7$ GeV	189.6321	49.39098	1.148541	0.719805
	189.3855	49.32791	1.148565	0.719802

REFERENCES

1. D. Bardin *et al.*, these Proceedings.
2. A. Andonov *et al.*, "Update of one loop corrections for $e^+e^- \to f\bar{f}$, first run of `CalcPHEP` system", `hep-ph/0207156`, to appear in *Particles and Nuclei.*
3. D. Y. Bardin and G. Passarino, *The standard model in the making*, Oxford, UK: Clarendon (1999) 685 p.
4. T. Hahn, *Nucl. Phys. Proc. Suppl.* **89** (2000) 231–236.
5. J. Fleischer *et al.*, "One-loop corrections to the process $e^+e^- \to t\bar{t}$ including hard bremsstrahlung", `hep-ph/0203220`.