SANC: $2 \to 2$ PROCESSES

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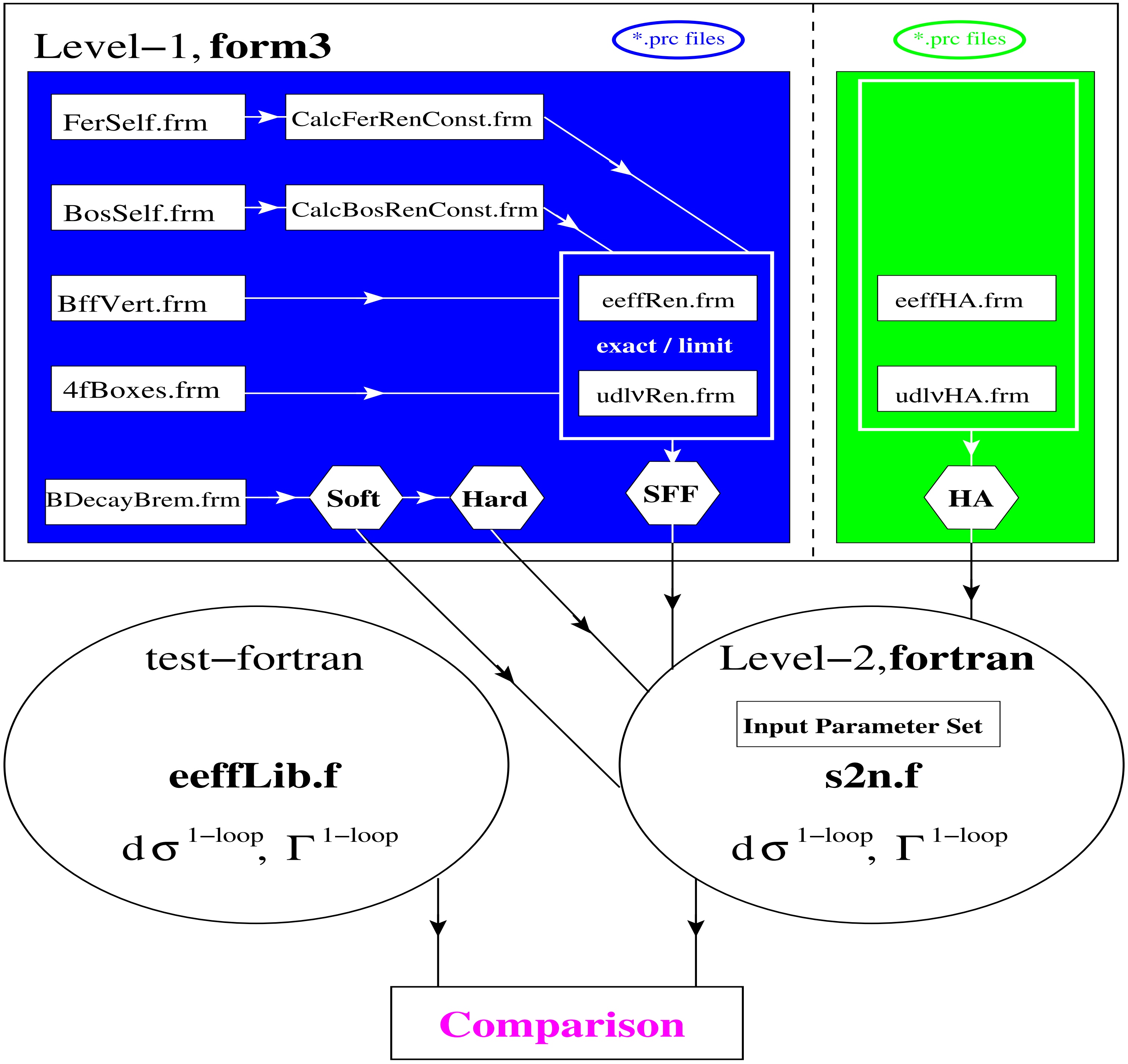
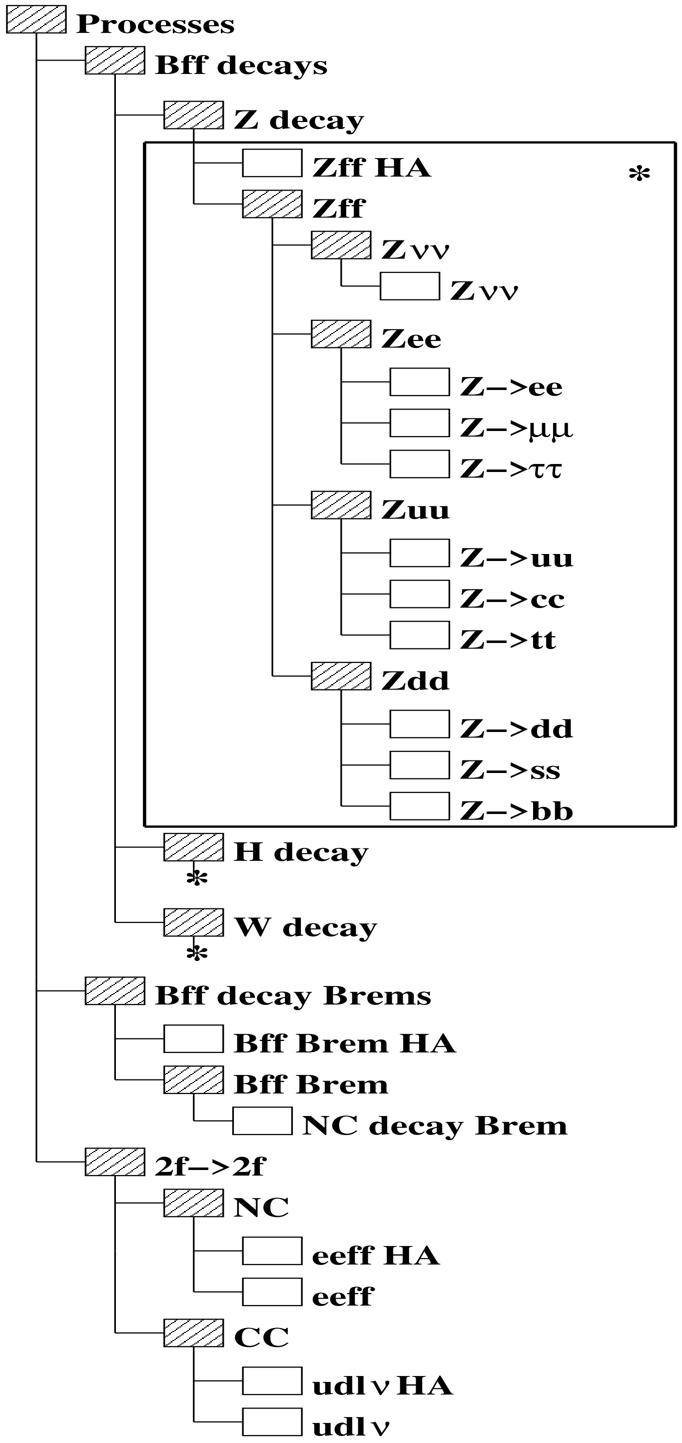

Level–1, form3
*.prc files
*.prc files
FerSelf.frm
CalcFerRenConst.frm
BosSelf.frm
CalcBosRenConst.frm
BffVert.frm
eeffRen.frm
exact / limit
udlvRen.frm
4fBoxes.frm
eeffHA.frm
udlvHA.frm
BDecayBrem.frm
Soft
Hard
SFF
HA
test–fortran
eeffLib.f
$d\sigma^{1-loop}, \Gamma^{1-loop}$
Level–2, fortran
Input Parameter Set
s2n.f
$d\sigma^{1-loop}, \Gamma^{1-loop}$
Comparison

EW part SANC


Processes
Bff decays
Z decay
Zff HA
*
Zff
Zνν
Zνν
Zee
Z–>ee
Z–>μμ
Z–>ττ
Zuu
Z–>uu
Z–>cc
Z–>tt
Zdd
Z–>dd
Z–>ss
Z–>bb
H decay
*
W decay
*
Bff decay Brems
Bff Brem HA
Bff Brem
NC decay Brem
2f–>2f
NC
eeff HA
eeff
CC
udlν HA
udlν

Automatic Calculation for Processes

COMPLETE ONE-LOOP ElectroWeak

SCALAR FORM FACTORS **(SFF)** & **(HA)** HELICITY AMPLITUDES

- **SFF** & **HA for ANY (NC):** $e^+e^- \to f\bar{f}$

- **SFF** & **HA for (CC):** $ud \to l\nu$

- **SFF for (NC)** $f\bar{f}2B \to 0$ **:** $f\bar{f}\gamma\gamma$, $f\bar{f}\gamma Z$, $f\bar{f}\gamma H$

SFF & HA for ANY (NC) $e^+e^- \to f\bar{f}$

- **IN TWO GAUGES:**
  R_ξ **and Unitary gauge for internal cross checking**

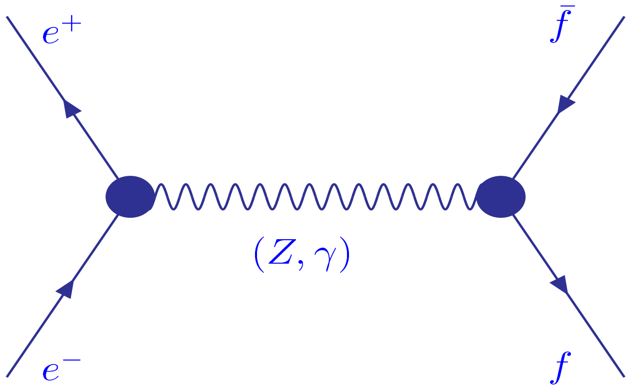
- **ALL $f\bar{f}$ CHANNELS**

- **MASSIVE CASE AND TWO LIMITS**

$\boxed{m_f \longrightarrow 0}$ $\boxed{m_{f'} \longrightarrow 0}$

ref.: A. Andonov, D. Bardin, S. Bondarenko, P. Christova, L. Kalinovskaya and G. Nanava, "Update of one-loop corrections for $e^+e^- \to f\bar{f}$, first run of `SANC` system", 34 N5 *Particles and Nuclei* **2003**

Amplitudes in L, Q, D - basis



ignore electron masses

$$\mathbf{A} \sim$$

$$\left[\mathbf{i}\gamma_\mu\left(\mathbf{1}+\gamma_5\right)\mathbf{F}_\mathbf{L}^\mathbf{e}\left(\mathbf{s}\right)+\mathbf{i}\gamma_\mu\mathbf{F}_\mathbf{Q}^\mathbf{e}\left(\mathbf{s}\right)\right]\otimes$$

$$\left[\mathbf{i}\gamma_\mu\left(\mathbf{1}+\gamma_5\right)\mathbf{F}_\mathbf{L}^\mathbf{f}\left(\mathbf{s}\right)+\mathbf{i}\gamma_\mu\mathbf{F}_\mathbf{Q}^\mathbf{f}\left(\mathbf{s}\right)+\mathbf{m_f}\mathbf{I}\mathbf{D}_\mu\mathbf{F}_\mathbf{D}^\mathbf{f}\left(\mathbf{s}\right)\right]$$

$$\mathbf{D}_\mu=\left(\mathbf{p_3}-\mathbf{p_4}\right)_\mu$$

Born-like structure

of the ONE LOOP AMPLITUDE in terms of

LL, QL, LQ, QQ, LD and QD form factors

$$A_\gamma = i\frac{4\pi Q_e Q_f}{s}\chi_\gamma(s)\alpha(s)\gamma_\mu \otimes \gamma_\mu$$

$$\begin{aligned}\mathcal{A}_Z = {} & i\frac{g^2}{16\pi^2}\, e^2\, 4 I_e^{(3)} I_f^{(3)} \frac{\chi_Z(s)}{s} \\ & \times \Big\{\gamma_\mu(1+\gamma_5)\otimes\gamma_\mu(1+\gamma_5)\mathbf{SFF}_{LL}(s,t) - 4|Q_e|s_W^2\gamma_\mu\otimes\gamma_\mu(1+\gamma_5)\,\mathbf{SFF}_{QL}(s,t) \\ & -4|Q_f|s_W^2\gamma_\mu(1+\gamma_5)\otimes\gamma_\mu\,\mathbf{SFF}_{LQ}(s,t) + 16|Q_eQ_f|s_W^4\gamma_\mu\otimes\gamma_\mu\,\mathbf{SFF}_{QQ}(s,t) \\ & +\gamma_\mu(1+\gamma_5)\otimes(-im_f D_\mu)\;\mathbf{SFF}_{LD}(s,t) - 4|Q_e|s_W^2\gamma_\mu\otimes(-im_f D_\mu)\;\mathbf{SFF}_{QD}(s,t)\Big\}\end{aligned}$$

Total scalar form factors of the one-loop amplitude

The ultraviolet-finite results for six scalar form factors are:

$$
\begin{aligned}
\mathbf{SFF}_{LL}(s,t,u) &= \left[\mathcal{F}_{L}^{zee}(s)+\mathcal{F}^{A,e}(s)\right]+\mathcal{F}_{L}^{zff}(s)+\mathcal{F}_{LL}^{ct}(s)+16k\mathcal{F}_{LL}^{\mathrm{BOX}}(s,t,u)\,,\\
\mathbf{SFF}_{QL}(s,t,u) &= \left[\mathcal{F}_{Q}^{zee}(s)+\mathcal{F}^{A,e}(s)\right]+\mathcal{F}_{L}^{zff}(s)+k\;\mathcal{F}_{L}^{\gamma ff}(s)+\mathcal{F}_{QL}^{ct}(s)+16k\mathcal{F}_{QL}^{\mathrm{BOX}}(s,t,u)\,,\\
\mathbf{SFF}_{LQ}(s,t,u) &= \left[\mathcal{F}_{L}^{zee}(s)+\mathcal{F}^{A,e}(s)\right]+\mathcal{F}_{Q}^{zff}(s)+k\;\mathcal{F}_{L}^{\gamma ee}(s)+\mathcal{F}_{LQ}^{ct}(s)+16k\mathcal{F}_{LQ}^{\mathrm{BOX}}(s,t,u)\,,\\
\mathbf{SFF}_{QQ}(s,t,u) &= \left[\mathcal{F}_{Q}^{zee}(s)+\mathcal{F}^{A,e}(s)\right]+\mathcal{F}_{Q}^{zff}(s)-\frac{k}{s_{W}^{2}}\left[\mathcal{F}_{Q}^{\gamma ee}(s)+\mathcal{F}^{A,e}(s)+\mathcal{F}_{Q}^{\gamma ff}(s)\right]+\mathcal{F}_{QQ}^{ct}(s)+16k\mathcal{F}_{QQ}^{\mathrm{BOX}}(s,t,u)\,,\\
\mathbf{SFF}_{LD}(s,t,u) &= \mathcal{F}_{D}^{zff}(s)+16k\mathcal{F}_{LD}^{\mathrm{BOX}}(s,t,u)\,,\\
\mathbf{SFF}_{QD}(s,t,u) &= \mathcal{F}_{D}^{zff}(s)+k\;\mathcal{F}_{D}^{\gamma ff}(s)+16k\mathcal{F}_{QD}^{\mathrm{BOX}}(s,t,u)\,,
\end{aligned}
$$

$$
k = c_{W}^{2}\left(M_{Z}^{2}/s-1\right).
$$

For the IJ component of a box contribution we have:

$$
\mathcal{F}_{IJ}^{\mathrm{BOX}}(s,t,u) = k^{AA}\mathcal{F}_{IJ}^{AA}(s,t,u)+k^{ZA}\mathcal{F}_{IJ}^{ZA}(s,t,u)+k^{ZZ}\mathcal{F}_{IJ}^{ZZ}(s,t,u)+k^{WW}\mathcal{F}_{IJ}^{WW}(s,t,u)
$$

Moreover,

$$
\mathcal{F}_{L,Q,D}^{\gamma(z)ff}(s)=\sum_{B=A,Z,H,W}\mathcal{F}_{L,Q,D}^{\gamma(z)B}(s)\,,
$$

except for $\mathcal{F}_{L}^{\gamma A}(s)=0$ and $\mathcal{F}_{L}^{\gamma H}(s)=0$.

$e^+e^- \to f\bar{f}$ process in the Helicity Amplitudes

16 HA for any $2f \to 2f$ process.

If the electron mass is ignored $\longrightarrow$ 6 HA, which depend on kinematical variables and our 6 SFFs:

$$
\begin{aligned}
\underline{\underline{\mathbf{HA}_{++++}}} &= 0, \qquad \underline{\underline{\mathbf{HA}_{+++-}}} = 0, \qquad \underline{\underline{\mathbf{HA}_{++-+}}} = 0, \qquad \underline{\underline{\mathbf{HA}_{++--}}} = 0,\\
\underline{\underline{\mathbf{HA}_{+-+-}}} &= s\,(1-\cos\vartheta)\,\Big(Q_eQ_f\alpha(s) + \chi_Z\delta_e[\,(1+\beta_f)\,I_f^{(3)}\mathbf{SFF}_{QL} + \delta_f\mathbf{SFF}_{QQ}]\Big),\\
\underline{\underline{\mathbf{HA}_{+--+}}} &= s\,(1+\cos\vartheta)\,\Big(Q_eQ_f\alpha(s) + \chi_Z\delta_e[(1-\beta_f)I_f^{(3)}\mathbf{SFF}_{QL} + \delta_f\mathbf{SFF}_{QQ}]\Big),\\
\underline{\underline{\mathbf{HA}_{+---}}} &= \underline{\underline{\mathbf{HA}_{+-++}}} = 2\sqrt{s}m_f\sin\vartheta\Big(Q_eQ_f\alpha(s) + \chi_Z\delta_e[I_f^{(3)}\mathbf{SFF}_{QL} + \delta_f\mathbf{SFF}_{QQ} + \frac{1}{2}s{\beta_f}^2 I_f^{(3)}\mathbf{SFF}_{QD}]\Big),\\
\underline{\underline{\mathbf{HA}_{-+++}}} &= \underline{\underline{\mathbf{HA}_{-+--}}} = -2\sqrt{s}m_f\sin\vartheta\Big(Q_eQ_f\alpha(s) + \chi_Z\Big[2I_e^{(3)}I_f^{(3)}\mathbf{SFF}_{LL} + 2I_e^{(3)}\delta_f\mathbf{SFF}_{LQ}\\
&\quad +\delta_e I_f^{(3)}\mathbf{SFF}_{QL} + \delta_e\delta_f\mathbf{SFF}_{QQ} + \frac{1}{2}s{\beta_f}^2 I_f^{(3)}(2I_e^{(3)}\mathbf{SFF}_{LD} + \delta_e\mathbf{SFF}_{QD})\Big]\Big),\\
\underline{\underline{\mathbf{HA}_{-++-}}} &= s\,(1+\cos\vartheta)\,\Big(Q_eQ_f\alpha(s) + \chi_Z[\,(1+\beta_f)\,(2I_e^{(3)}I_f^{(3)}\mathbf{SFF}_{LL} + \delta_e I_f^{(3)}\mathbf{SFF}_{QL})\\
&\quad +\delta_f\,\Big(2I_e^{(3)}\mathbf{SFF}_{LQ} + \delta_e\mathbf{SFF}_{QQ}\Big)\,]\Big),\\
\underline{\underline{\mathbf{HA}_{-+-+}}} &= s\,(1-\cos\vartheta)\,\Big(Q_eQ_f\alpha(s) + \chi_Z[\,(1-\beta_f)\,I_f^{(3)}(2I_e^{(3)}\mathbf{SFF}_{LL} + \delta_e\mathbf{SFF}_{QL}) + \delta_f(2I_e^{(3)}\mathbf{SFF}_{LQ} + \delta_e\mathbf{SFF}_{QQ})]\Big),\\
\underline{\underline{\mathbf{HA}_{--++}}} &= 0, \qquad \underline{\underline{\mathbf{HA}_{--+-}}} = 0, \qquad \underline{\underline{\mathbf{HA}_{---+}}} = 0, \qquad \underline{\underline{\mathbf{HA}_{----}}} = 0.
\end{aligned}
$$

$$
\cos\vartheta \;=\; \left(t - m_f^2 + \frac{s}{2}\right)\frac{2}{s\beta_f}, \quad \beta_f^2 = 1 - 4\frac{m_f^2}{s}, \quad \delta_f = v_f - a_f\,.
$$

Differential cross section

for the amplitude $\mathbf{HA}_{\lambda_i\lambda_j\lambda_k\lambda_l}$ each index $\lambda_{(i,j,k,l)}$ takes two values ($\pm = \pm 1$) meaning 2 times the projection of spins $e^+, e^-, f, \bar{f}$ onto their corresponding momentum.

For the unpolarized case:

$$\frac{d\sigma}{d\cos\vartheta} = \frac{\pi\alpha^2}{s^3}\beta_f N_c \sum_{\lambda_i\lambda_j\lambda_k\lambda_l} \left|\mathbf{HA}_{\lambda_i\lambda_j\lambda_k\lambda_l}\right|^2.$$

Comparison $\longrightarrow$ Agreement

$e^+e^- \to f\bar{f}$, ALL CHANNELS

- `eeffLib–ZFITTER`

SFFs $\longrightarrow$ **8–9 digits**

Complete 1-loop differential cross section $d\sigma^{(1)}/d\cos\vartheta$
$\longrightarrow$ **7–8 digits**

Total 1-loop cross section and σ^{FB} for the light fermion masses
$\longrightarrow$ **6–7 digits**

Comparison $\longrightarrow$ Agreement

$$e^+e^- \to t\bar{t}$$

- `s2n.f–eeffLib`

  Complete 1-loop differential cross-sections $d\sigma^{(1)}/d\cos\vartheta$

  $\longrightarrow$ **12–13 digits**

- `s2n.f–FeynArt`

  1-loop cross-section **without soft photons** $\longrightarrow$ **11 digits**

- `s2n.f–topfit`*

  1-loop cross-section **with soft photons** $\longrightarrow$ **8 digits**

* Bielefeld–Zeuthen group (hep-ph/0202102, J. Fleisher et al.)

SFF & HA for (CC): $ud \to l\nu$

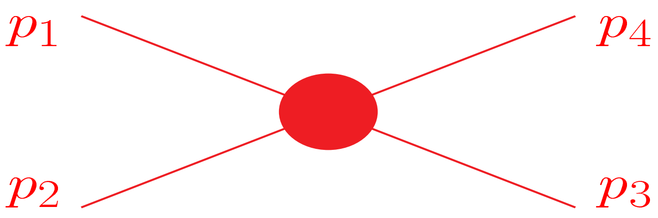
APPLICATIONS:

- **Decay:** $\mathbf{t} \longrightarrow \mathbf{bl}\nu$

- **DIS:** $\nu_\mu \mathbf{u} \longrightarrow \mathbf{e}^+\mathbf{d}$

- **Single W production :** $\mathbf{u\bar{d}} \longrightarrow \mathbf{l}^+\bar{\nu}$
  (W. Placzek's talk this morning)

Born-like structure



$$
\begin{aligned}
Q^2 &= (p_1+p_2)^2 = -s \\
T^2 &= (p_2+p_3)^2 = -t \\
U^2 &= (p_2+p_4)^2 = -u \\
s+t+u &= m_u^2
\end{aligned}
$$

$$
\begin{aligned}
\mathcal{A}_{ud\longrightarrow l\nu} \sim \frac{ig^2}{8(M_W^2+Q^2)}\Big[&\quad \gamma_\mu(1+\gamma_5)\otimes\gamma_\mu(1+\gamma_5)\,\mathbf{SFF}_{LL}(s,t,u) \\
+ &\quad \gamma_\mu(1+\gamma_5)\otimes\left(-im_u\,\mathcal{D}_\mu\right)\,\mathbf{SFF}_{LD}(s,t,u)\Big]
\end{aligned}
$$

$$m_u \neq 0$$

$$\mathcal{D}_\mu = p_3 - p_4$$

see ref: D. Bardin, P. Christova, L. Kalinovskaya, '`SANC` Status Report'
Nucl. Phys. B (Proc. Suppl.) **116** (2003) 48–52.

Comparison $\longrightarrow$ Agreement

eeffLib—s2n—ZFITTER

Input parameter: Z-mass = 91.1867, W-mass = 80.4514958, H-mass = 120.

For the **SFF**s **AGREEMENT** within **8-9** digits

s,t,u= 100. -1. -99.	$\mathrm{SFF}_{\mathrm{LL}}^{\mathrm{QED}}$	(16.607403, 6.41190095)	eeffLib
		16.607403, 6.41190095	s2n
	$\mathrm{SFF}_{\mathrm{LL}}^{\mathrm{EW}}$	(12.5405065, 0.0155681267)	eeffLib
		12.5405065, 0.0155681267	s2n
	$\mathrm{SFF}_{\mathrm{LL}}$	(1.04796481, 0.0168435724)	eeff
		1.04794194	instability in ZFITTER
s,t,u= 100. -50. -50.	$\mathrm{SFF}_{\mathrm{LL}}^{\mathrm{QED}}$	(45.962368, 6.41190095)	eeffLib
		45.962368, 6.41190095	s2n
	$\mathrm{SFF}_{\mathrm{LL}}^{\mathrm{EW}}$	(-15.2896247, 0.0157932753)	eeffLib
		-15.2896247, 0.0157932753	s2n
	$\mathrm{SFF}_{\mathrm{LL}}$	(1.05196073, 0.0168441624)	eeffLib
		1.05196079	ZFITTER
s,t,u= 100. -99. -1.	$\mathrm{SFF}_{\mathrm{LL}}^{\mathrm{QED}}$	(113.240851, 6.41190095)	eeffLib
		113.240829, 6.41190095	s2n
	$\mathrm{SFF}_{\mathrm{LL}}^{\mathrm{EW}}$	(-80.6418362, 0.0160183836)	eeffLib
		-80.6418362, 0.0160183836	s2n
	$\mathrm{SFF}_{\mathrm{LL}}$	(1.05700864,0.0168447523)	eeffLib
		1.05700876	ZFITTER

$$\mathbf{SFF}_{\mathrm{LL}}(\mathbf{s},\mathbf{t},\mathbf{u}) = \mathbf{1} + \frac{\alpha}{\mathbf{4}\pi \mathbf{s}_{\mathbf{W}}^{\mathbf{2}}}\mathbf{SFF}_{\mathrm{LL}}^{\mathrm{QED}}(\mathbf{s},\mathbf{t},\mathbf{u}) + \frac{\alpha}{\mathbf{4}\pi \mathbf{s}_{\mathbf{W}}^{\mathbf{2}}}\mathbf{SFF}_{\mathrm{LL}}^{\mathrm{EW}}(\mathbf{s},\mathbf{t},\mathbf{u}) - \boldsymbol{\Delta}\mathbf{r}$$

SFF for (NC) $f\bar{f}2B \to 0$:

$\mathbf{f\bar{f}}\gamma\gamma \longrightarrow 0$:

$$
\begin{array}{ccc}
e^+e^- & \longrightarrow & \gamma\gamma \\
q\bar{q} & \longrightarrow & \gamma\gamma \\
\gamma\gamma & \longrightarrow & t\bar{t} \\
\gamma e & \longrightarrow & \gamma e
\end{array}
$$

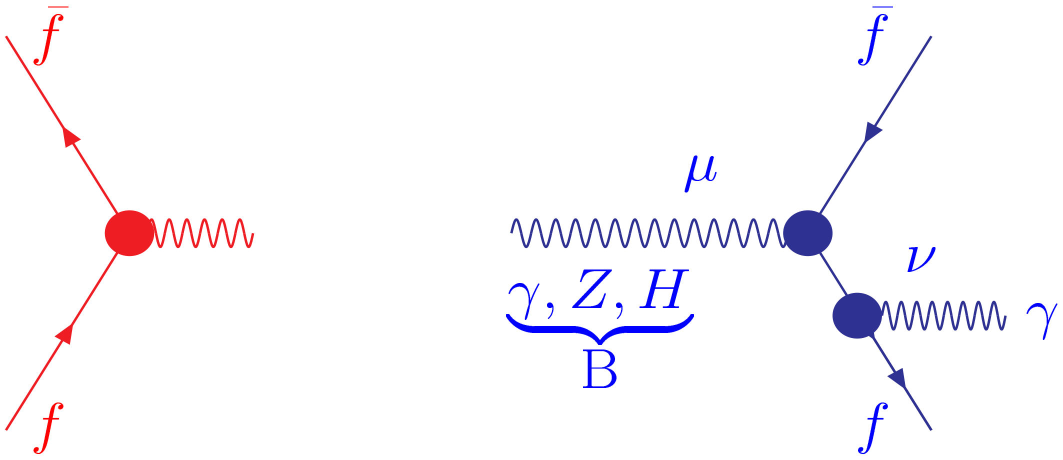
$\mathbf{f\bar{f}Z}\gamma \longrightarrow 0$:

$$
\begin{array}{ccc}
Z & \longrightarrow & f\bar{f}\gamma \\
e^+e^- & \longrightarrow & Z\gamma \\
q\bar{q} & \longrightarrow & Z\gamma \\
\gamma e & \longrightarrow & Ze
\end{array}
$$

$\mathbf{f\bar{f}H}\gamma \longrightarrow 0$:

$$
\begin{array}{ccc}
H & \longrightarrow & f\bar{f}\gamma \\
e^+e^- & \longrightarrow & H\gamma \\
q\bar{q} & \longrightarrow & H\gamma \\
\gamma e & \longrightarrow & He
\end{array}
$$

Amplitudes $B \rightarrow f\bar{f}\gamma$ in chosen basis

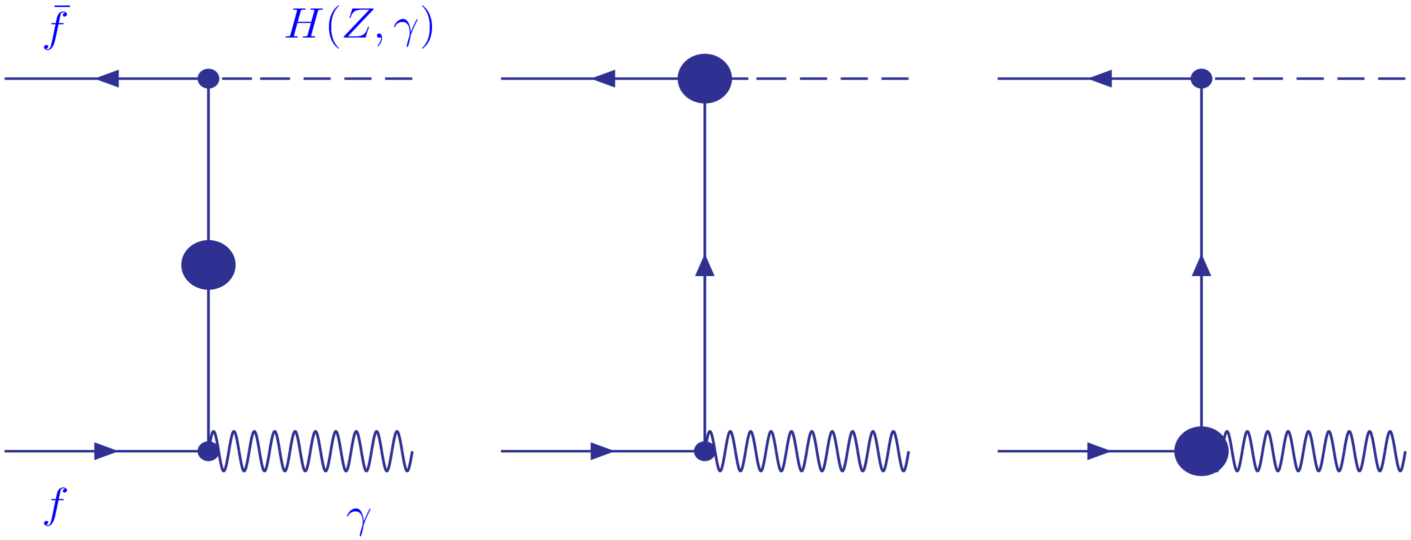


$$A_{\mu\nu} = \sum_{\mathrm{i}=1}^{20} \mathbf{SFF}_{\mathrm{i}} \cdot \mathrm{Structures}_{\mathrm{i}}(1, \gamma_5)_{\mu\nu}$$

40   40   12 STRUCTURES

$$\underbrace{\gamma \qquad Z \qquad H}_{\mathrm{B}}$$

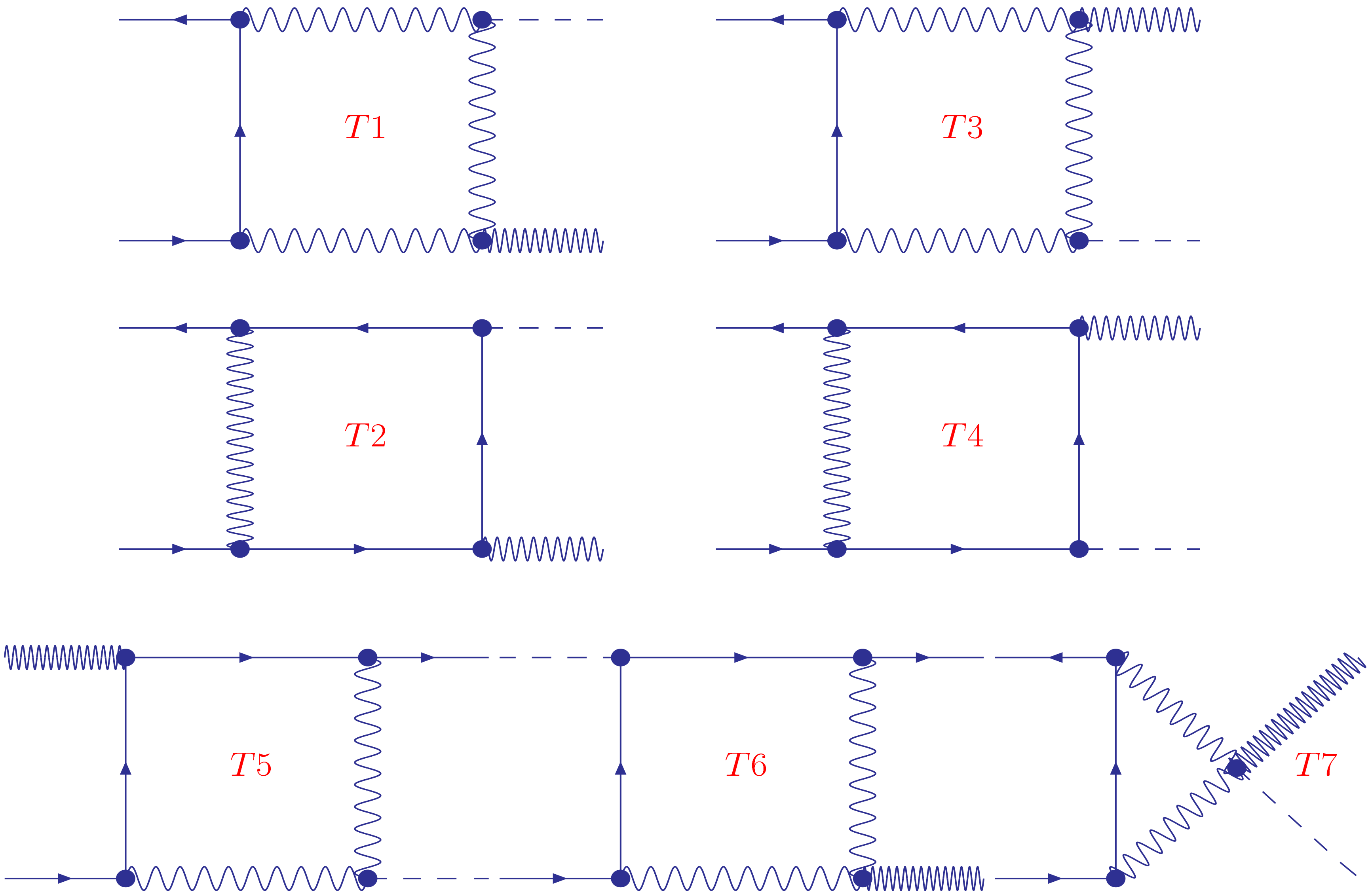
DATABASE ideology of BUILDING BLOCKS



Self-Energies **Vertices**

BANK OF PRECOMPUTED FEYNMAN DIAGRAMS
FULLY MASSIVE CASE !

Boxes topology



Gauge-invariant subsets of diagrams

		k
• $\{A \longrightarrow \xi_A\}$	**A CLUSTER**	1
• $\{Z, \phi^0 \longrightarrow \xi_Z\}$	**Z CLUSTER**	2
• $\{W, \phi^\pm \longrightarrow \xi\ \}$	**W CLUSTER**	3
• $\{H, \phi^0 \longrightarrow \xi_Z\}$	**H CLUSTER**	4

Minimum set of structures for $H \longrightarrow f\bar{f}\gamma$

$$\mathbf{A}_\nu = \sum_{\mathbf{k=1}}^{4} \mathbf{A_k} \;=\; \sum_{k=1}^{4}\Big(\mathbf{SFF_1^k}\; i\gamma_\nu + \mathbf{SFF_2^k}\;\mathbf{p_1}_\nu + \mathbf{SFF_3^k}\;\mathbf{p_2}_\nu + \mathbf{SFF_4^k}\;\hat{\mathbf{p}}_\gamma\gamma_\nu$$
$$+\mathbf{SFF_5^k}\; i\hat{\mathbf{p}}_\gamma\mathbf{p_1}_\nu + \mathbf{SFF_6^k}\; i\hat{\mathbf{p}}_\gamma\mathbf{p_2}_\nu\Big)\big(\mathbf{1};\gamma_\mathbf{5}\big)$$

$$\begin{aligned}
\mathbf{A}_\nu = \sum_{\mathbf{k=1}}^{4} \mathbf{A_k} = \sum_{\mathbf{k=1}}^{4}\Big(\quad & \mathbf{SFF_1^k}\;\Big[\frac{\mathbf{1}}{\mathbf{u}-\mathbf{m_f^2}}\mathbf{p_1}_\nu - \frac{\mathbf{1}}{\mathbf{t}-\mathbf{m_f^2}}\mathbf{p_2}_\nu\Big] \\
+ \quad & \mathbf{SFF_2^k}\;\hat{\mathbf{p}}_\gamma\gamma_\nu \\
- \quad & \mathbf{SFF_3^k}\; i\Big[\frac{\mathbf{1}}{\mathbf{u}-\mathbf{m_f^2}}\mathbf{p_1}_\nu + \frac{\mathbf{1}}{\mathbf{2}}\gamma_\nu\Big] \\
- \quad & \mathbf{SFF_4^k}\; i\Big[\frac{\mathbf{1}}{\mathbf{t}-\mathbf{m_f^2}}\mathbf{p_2}_\nu + \frac{\mathbf{1}}{\mathbf{2}}\gamma_\nu\Big]\Big)\big(\mathbf{1};\gamma_\mathbf{5}\big)
\end{aligned}$$

Limit case $H \to d\bar{d}\gamma$

$$\mathrm{SFFV}_3^2 = s_W \left(-\frac{5}{4c_W^3} + \frac{1}{c_W} - 2c_W\right) \frac{M_Z}{27} F_2^{lim}(-u,-t)$$
$$\mathrm{SFFV}_4^2 = s_W \left(-\frac{5}{4c_W^3} + \frac{1}{c_W} - 2c_W\right) \frac{M_Z}{27} F_2^{lim}(-t,-u)$$
$$\mathrm{SFFA}_3^2 = \frac{s_W}{9c_W} \left(\frac{1}{4c_W^2} - 1\right) M_Z F_2^{lim}(-u,-t)$$
$$\mathrm{SFFA}_4^2 = \frac{s_W}{9c_W} \left(\frac{1}{4c_W^2} - 1\right) M_Z F_2^{lim}(-t,-u)$$

$$\begin{aligned}
F_2^{lim}(-t,-u) = & \left(M_Z^2 - t\right)\left[\frac{(M_Z^2-t)}{st}(M_H^2 - s) + \frac{t}{s}\right] D_0(0,-m_d^2,-M_H^2,-m_d^2,-t,-u,m_d,m_d,M_Z,M_Z) \\
& + \frac{(M_Z^2-t)}{st}[(M_H^2-t)\, C_0(-m_d^2,-M_H^2,-t;m_d,M_Z,M_Z) \\
& - t\, C_0(0,-m_d^2,-t;m_d,m_d,M_Z) - u\, C_0(0,-m_d^2,-u;m_d,m_d,M_Z)\,] \\
& + \left[\left(M_Z^2-t\right)\frac{(t-s)}{st} - \frac{2}{u-M_H^2} M_Z^2\right] C_0(-m_d^2,-M_H^2,-u;m_d,M_Z,M_Z) \\
& + 2\frac{1}{u-M_H^2}\left[B_0^F(-u;M_Z,0) - B_0^F(-M_H^2;M_Z,M_Z)\right]
\end{aligned}$$

Checking

- ξ **:** ξ_A, ξ_Z, ξ

- **cancellation of UV poles**

- **vanishing of EW SFF in front of CP-odd structures**

$\gamma\gamma \to t\bar{t}$**: 40 Structures** $\longmapsto$ **24**

- **Ward identities:** $A_{\mu\nu} \cdot (p_\gamma)_\nu = 0$**,** $A_{\mu\nu} \cdot (p_\gamma)_\mu = 0$

transverse nature of photons: 24 Structures $\longmapsto$ **13**

It is time to demonsrate version 0.2