"Off-shell effects in the associated top quark pair and Higgs boson production."

Szymon Szczypiński

simon@server.phys.us.edu.pl

Institute of Physics, University of Silesia

Katowice, Poland

Higgs boson couplings to fermion and gauge bosons

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- the Higgsstrahlung process (dominates at low energies):

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- and the WW fusion process (dominates at high energies):

$$e^+e^- \to W^*W^* \to \overline{\nu}_e\nu_e H.$$

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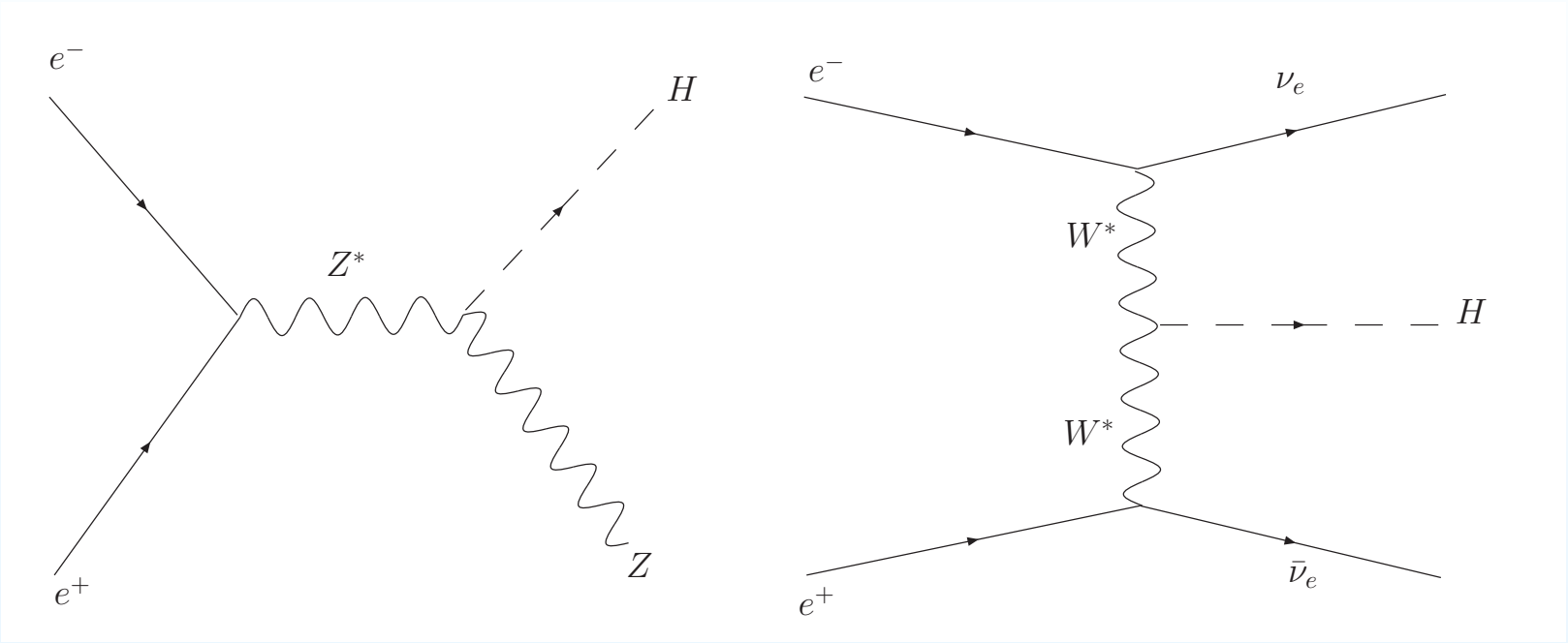

Main production mechanisms of the SM Higgs boson at linear collider.

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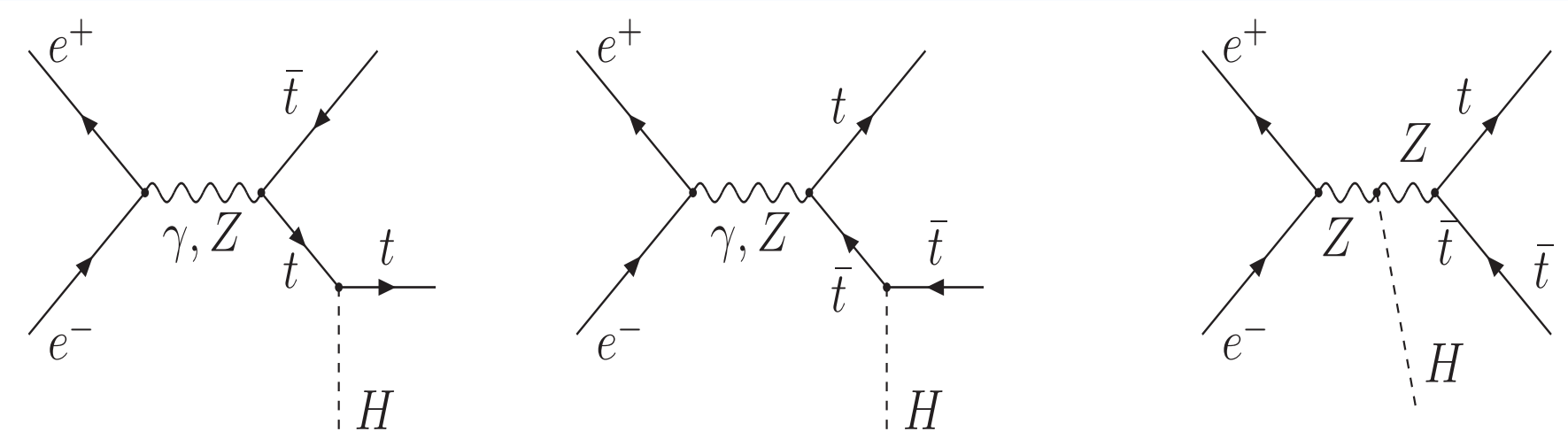
If $M_H > 2m_t$, the Higgs top Yukawa coupling can be measured from the $H \to t\bar{t}$ branching ratio.

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



Diagrams contributing to the process $e^+e^- \to t\bar{t}H$.

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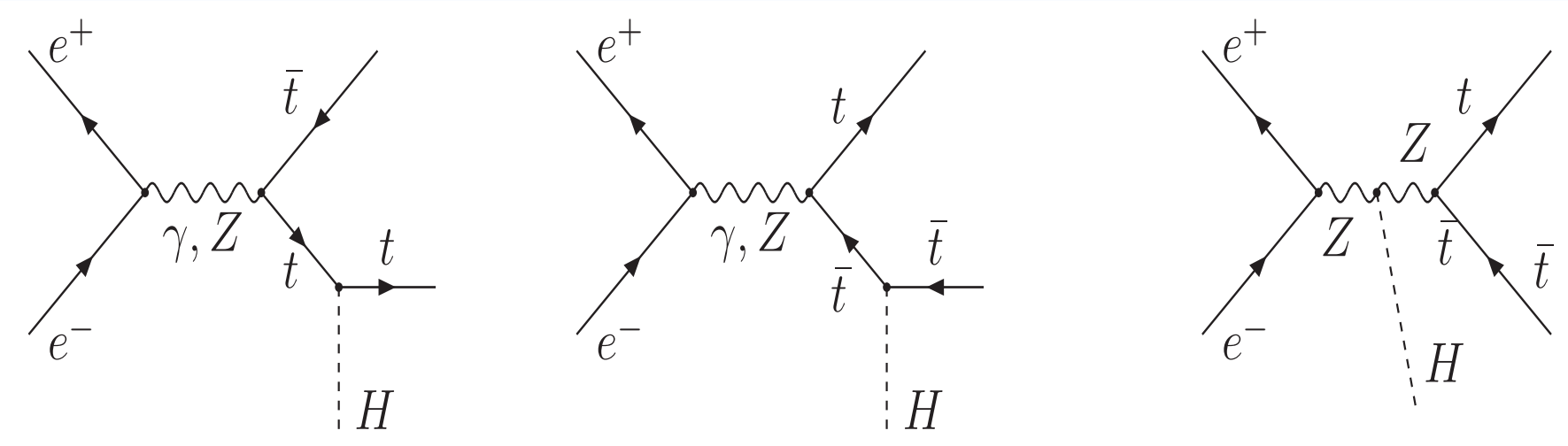
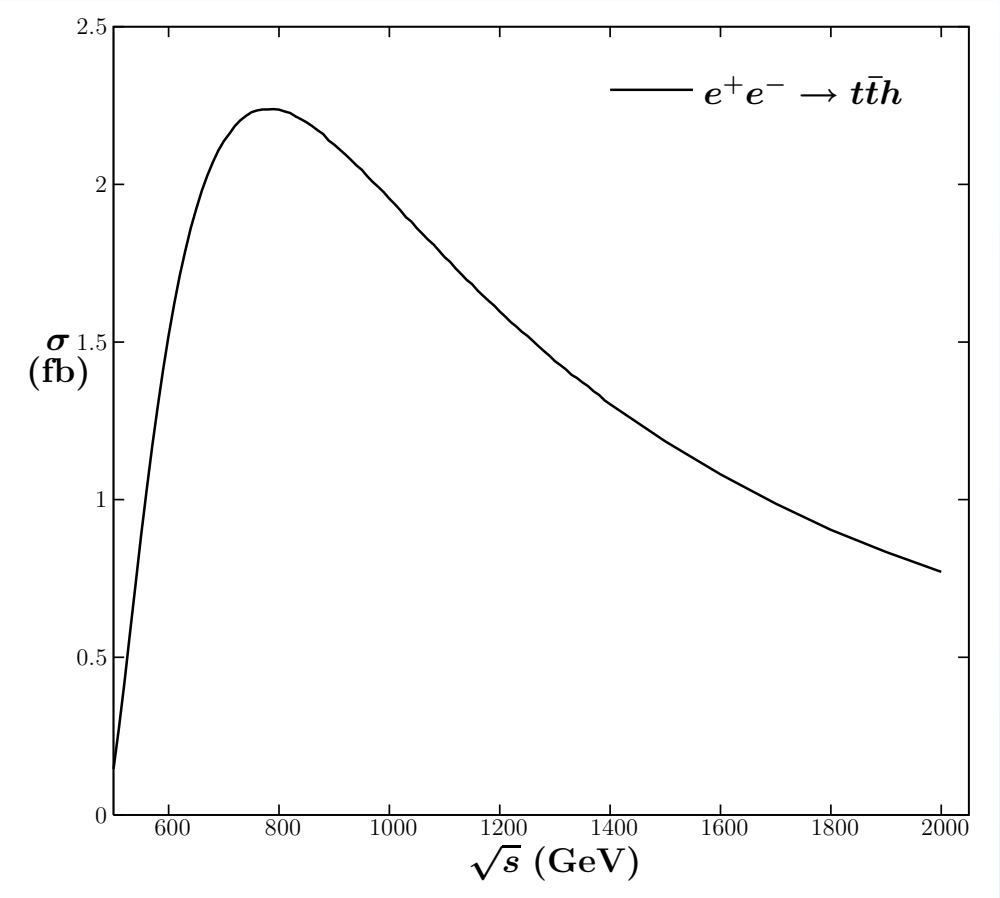


Diagrams contributing to the process $e^+e^- \to t\bar{t}H$.

Contribution from the Higgs bremsstrahlung off the Z line is small. The cross section of $e^+e^- \to t\bar{t}H$ depends mainly on g_{ttH}.

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



The total cross section of $e^+e^- \to t\bar{t}H$ as a function of CMS energy. ($M_H = 130$ GeV, $m_t = 174.3$ GeV)

Process $e^+e^- \longrightarrow 8f$.

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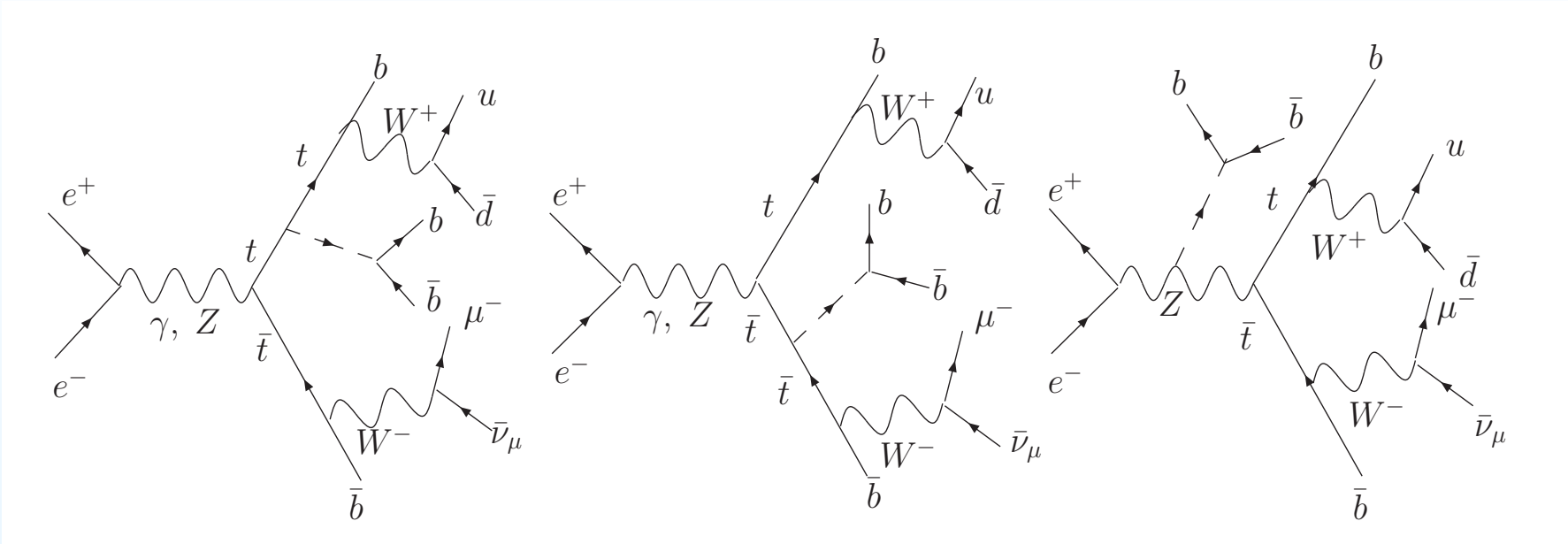
- Total cross section with the signal diagrams can be compared with the total cross section of the process $e^+e^- \longrightarrow t\bar{t}H$ in the narrow width approximation.

Process $e^+e^- \longrightarrow 8f$



Signal diagrams for the process $e^+e^- \longrightarrow bu\bar{d}\mu^-\bar{\nu}_\mu\bar{b}b\bar{b}$.

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The narrow width approximation

$$\sigma(e^+e^- \longrightarrow t\bar{t}H \longrightarrow bu\bar{d}\mu^-\bar{\nu}_\mu b\bar{b}b\bar{b}) = \sigma(e^+e^- \longrightarrow t\bar{t}H) \times \frac{\Gamma_{W^+\longrightarrow u\bar{d}}}{\Gamma_W} \times \frac{\Gamma_{W^-\longrightarrow \mu^-\bar{\nu}_\mu}}{\Gamma_W} \times \frac{\Gamma_{H\longrightarrow b\bar{b}}}{\Gamma_H},$$

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where

$$\frac{\Gamma_{t\to Wb}}{\Gamma_t} = 1$$

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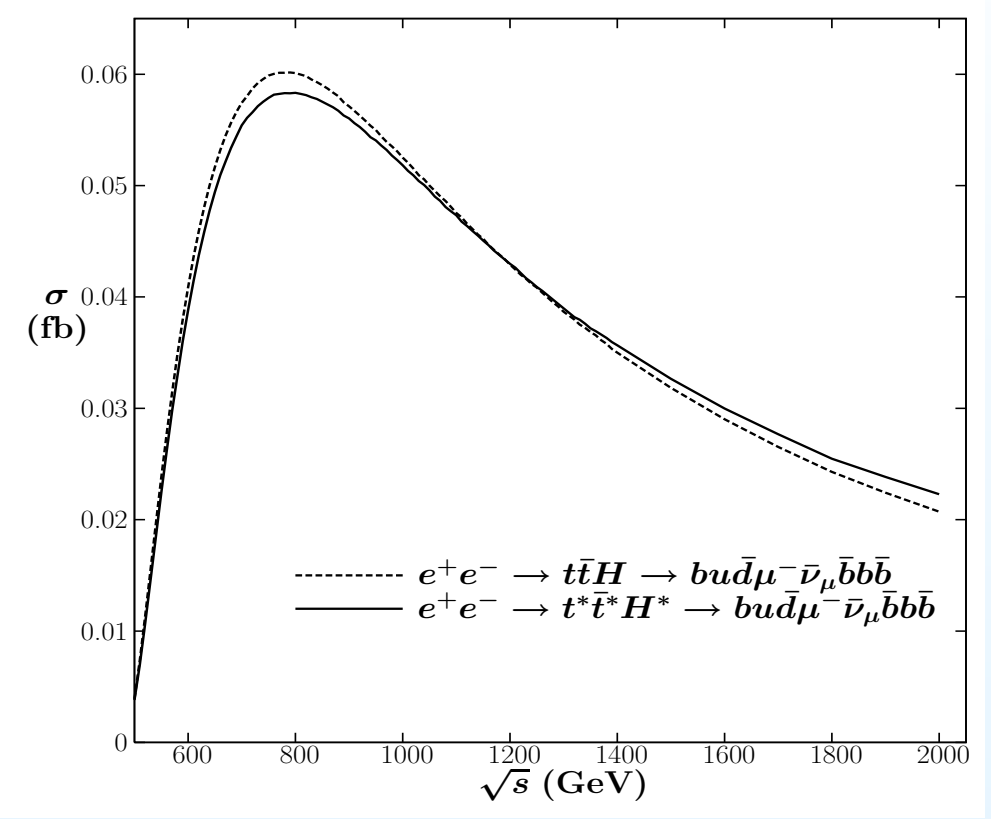

Total cross section of $e^+e^- \to bu\bar{d}\mu^-\bar{\nu}_\mu b\bar{b}\bar{b}$ and total cross section of $e^+e^- \to t\bar{t}H$ in the narrow width approximation as a function of CMS energy.

Process $e^+e^- \longrightarrow 8f$

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$\sqrt{s}$ [GeV]	σ_{8f} [at]	σ_{NWA} [at]	δ [%]
500	3.80(1)	3.92(1)	3.0
800	58.33(6)	60.06(2)	2.9
1000	51.79(6)	52.56(3)	1.3
1200	42.98(6)	42.96(2)	0.1
2000	21.89(11)	20.76(2)	5.0

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$$e^+(p1)\; e^-(p2) \longrightarrow b(p3)\; u(p4)\; \bar{d}(p5)\; \mu^-(p6)\; \bar{\nu}_\mu(p7)\; b(p8)\; H(p9)\; .$$

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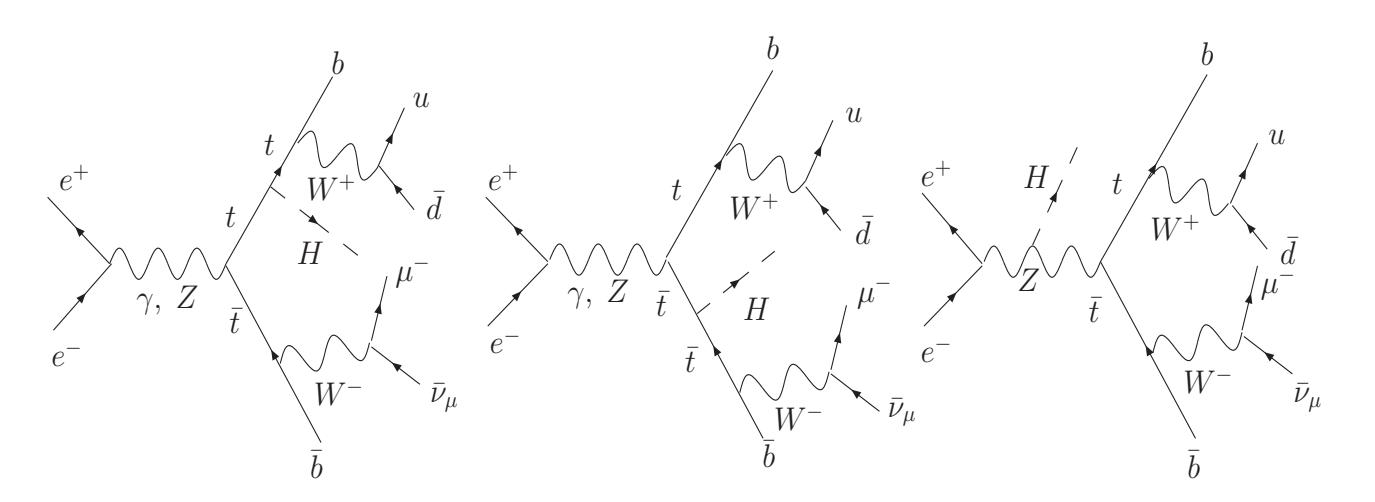

Signal diagrams for the process $e^+e^- \to bu\bar{d}\mu^-\bar{\nu}_\mu\bar{b}H$.

Process $e^+e^- \longrightarrow 6f + H$

Denote

$$m_t^* = \sqrt{(p_3 + p_4 + p_5)^2} \qquad m_{\bar{t}}^* = \sqrt{(p_6 + p_7 + p_8)^2}$$

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$\sqrt{s}$ [GeV]	σ_{all} [ab]	σ_{sig} [ab]
500	4.21(1)	4.23(1)
800	64.45(8)	64.24(8)
2000	23.99(66)	22.23(3)

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$\sqrt{s}$ [GeV]	σ_{all} [ab]	σ_{sig} [ab]
500	3.47(1)	3.48(1)
800	53.17(8)	52.95(7)
2000	19.79(61)	18.34(3)

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- The off-shell effects in the associated top quark pair and Higgs boson production has been shown.
- These effects are at the level of a few percent, they can be very important for the future experiments at linear collider.
- The full set of the Feynman diagrams for processes with eight fermions in the final state should be also consider.