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Top-Higgs Yukawa coupling measurement at TESLA

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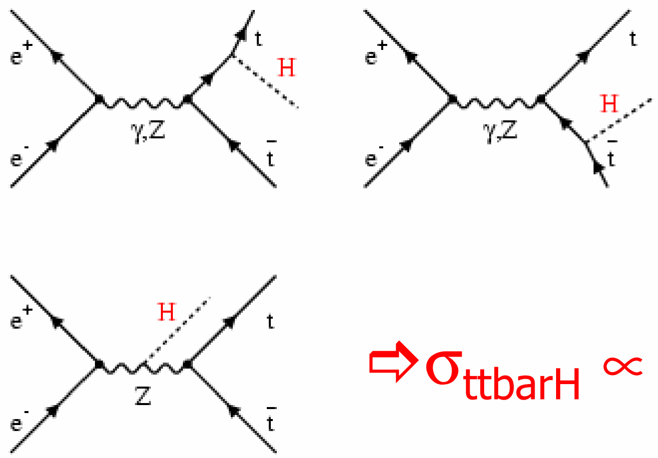
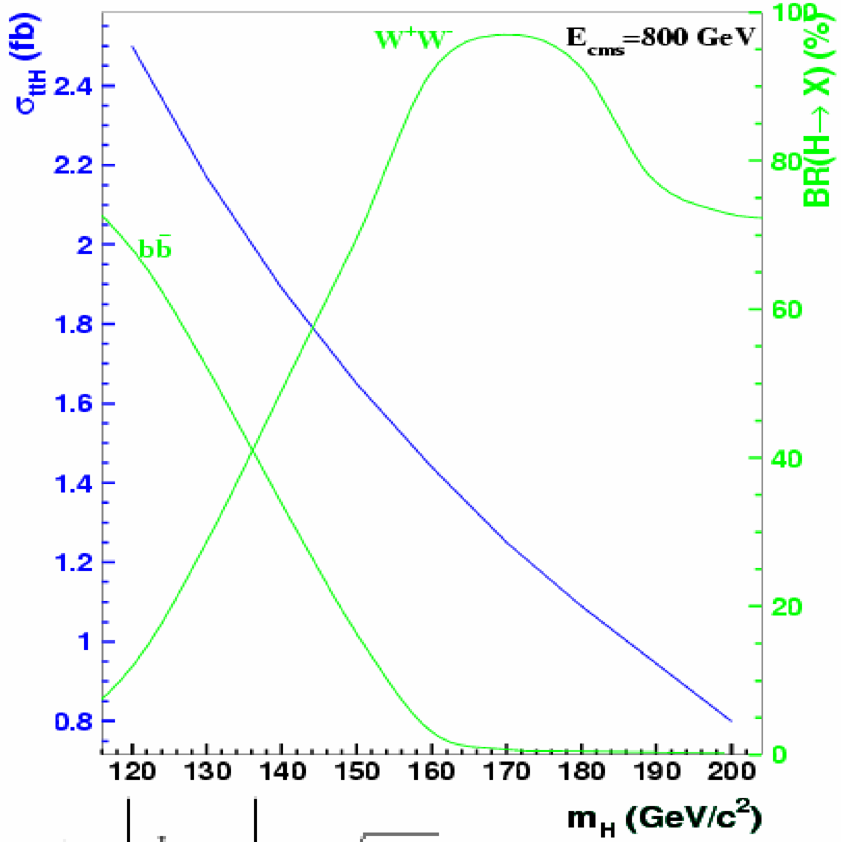
- Principle of the coupling measurement
- Background and tools
- Channels studied and results
- 6 fermions background
- Extensions of the analysis

Principle of the coupling measurement

- t-tbar-H: diagrams, σ and Br



⇨ $\sigma_{ttbarH} \propto g_{tth}{}^2$



- Uncertainty

$$\left(\frac{\Delta g_{ttH}}{g_{ttH}}\right)_{stat} \approx \frac{1}{S_{stat}(g^2_{ttH})\sqrt{\epsilon\rho L}} \text{ with } S_{stat}(g^2_{ttH}) = \frac{1}{\sqrt{\sigma_{t\bar{t}h}}}\left|\frac{d\sigma_{t\bar{t}h}}{dg^2_{ttH}}\right| \approx \frac{\sqrt{\sigma_{t\bar{t}h}}}{g^2_{ttH}}$$

$$\left(\frac{\Delta g_{ttH}}{g_{ttH}}\right)_{syst} \approx \frac{1}{S_{syst}(g^2_{ttH})}\frac{1-\rho}{\rho}\frac{\Delta\sigma^{eff}_{BG}}{\sigma^{eff}_{BG}} \text{ with } S_{syst}(g^2_{ttH}) = \frac{1}{\sigma_{t\bar{t}h}}\left|\frac{d\sigma_{t\bar{t}h}}{dg^2_{ttH}}\right| \approx \frac{1}{g^2_{ttH}}$$

Background and tools

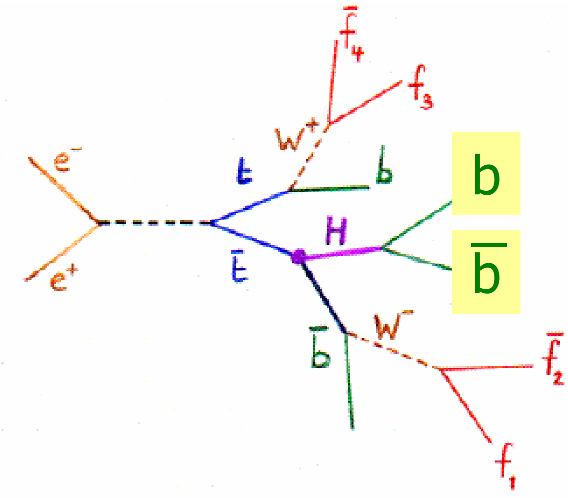
- Background:

Final State	σ (fb)
q-qbar (u,d,s,c,b)	~1600
t-tbar	~300
W^+W^-	~4300
ZZ	~240
t-tbar-Z	~4.3

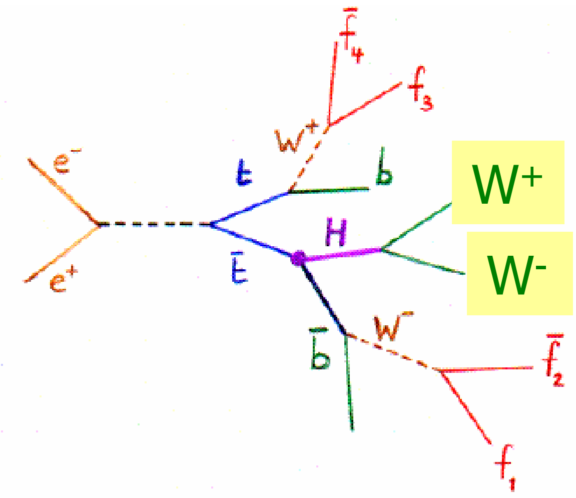
- Generation/simulation
  - t-tbar-H and t-tbar-Z generated with COMPHEP v41.10 + Pythia 6.158
  - Other Bckgds generated with Pythia
  - Simulated with SIMDET v4.
- B-tag
  - NN based, including Zvtop, impact parameter joint probabilty tag, mass and momentum of the vertex, etc.
    - ➢ Implemented in SIMDET by T.Kuhl

Channels studied

- $t\text{-}\bar{t}\text{-}H$; ($H \to b\bar{b}$)
  - Semi-leptonic channel → 4b2qlν
    - ➢ BR(ttbarH → 4b2qlν) ≈ 43.9% x BR(H → b-bbar)
  - Hadronic channel → 4b4q
    - ➢ BR(ttbarH → 4b4q) ≈ 45.6% x BR(H → b-bbar)

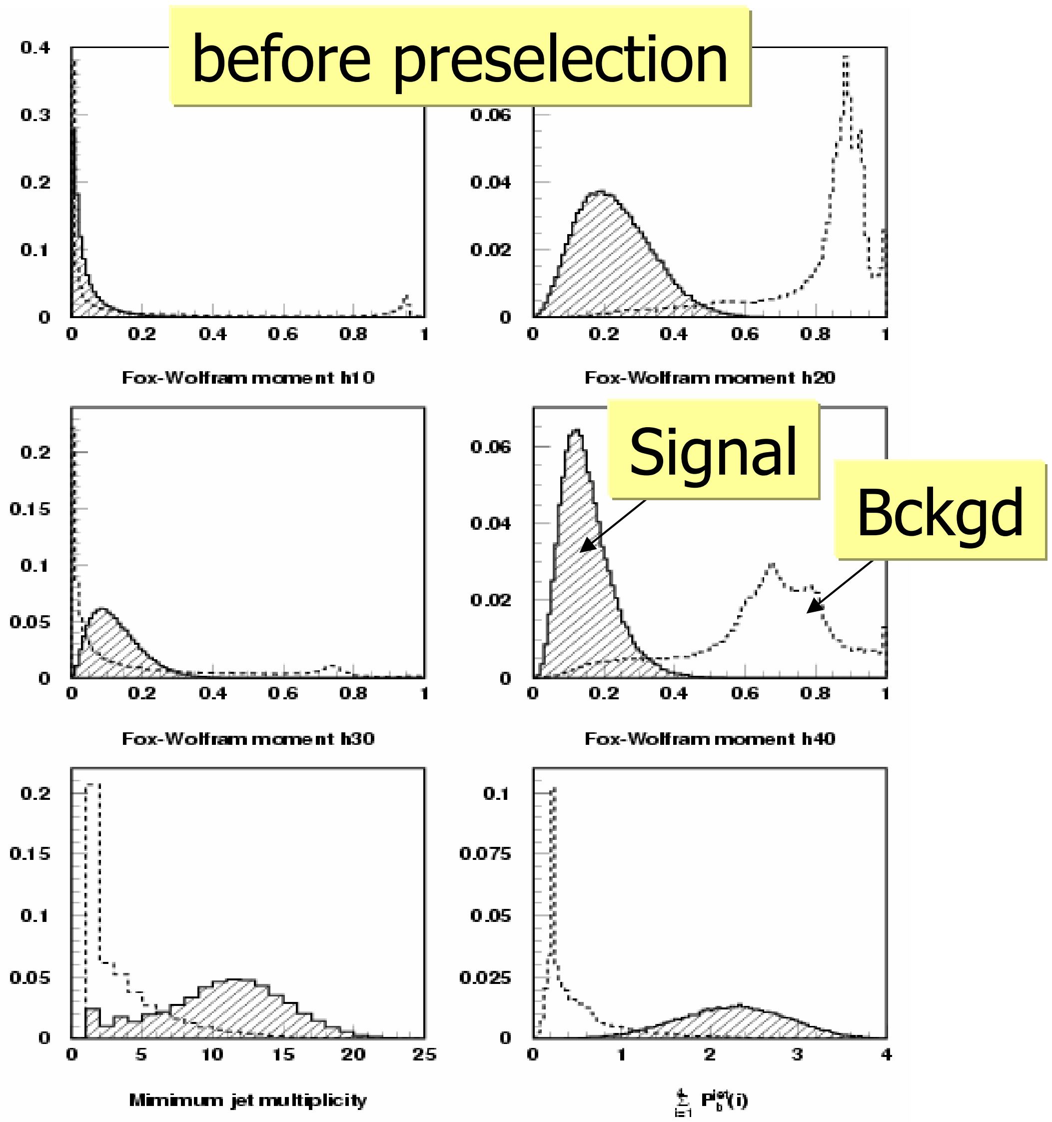


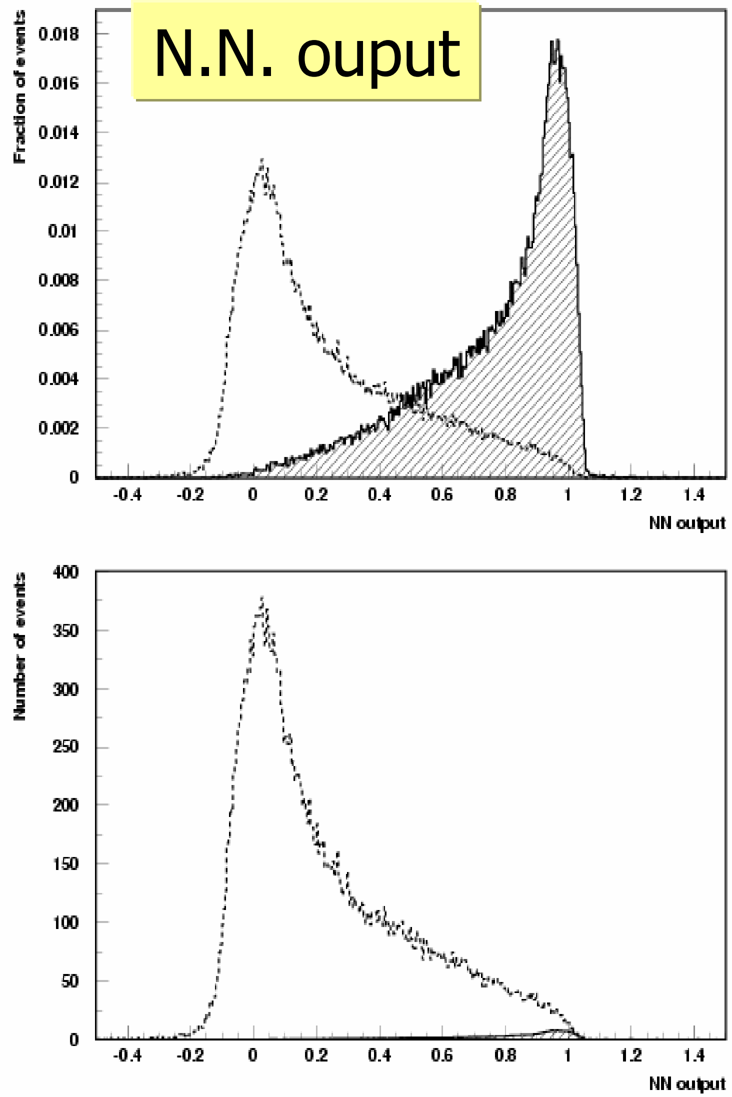
- $t\text{-}\bar{t}\text{-}H$; ($H \to W^+W^-$)
  - 2 like sign leptons + 6 jets channel → $2l^{+/-}2\nu 4q2b$
    - ➢ BR(ttbarH → $2l^{+/-}2\nu 4q2b$) ≈ 10% x BR(H → W^+W^-)
  - 1 lepton + 8 jets channel → lν6q2b
    - ➢ BR(ttbarH → lν6q2b) ≈ 40% x BR(H → W^+W^-)



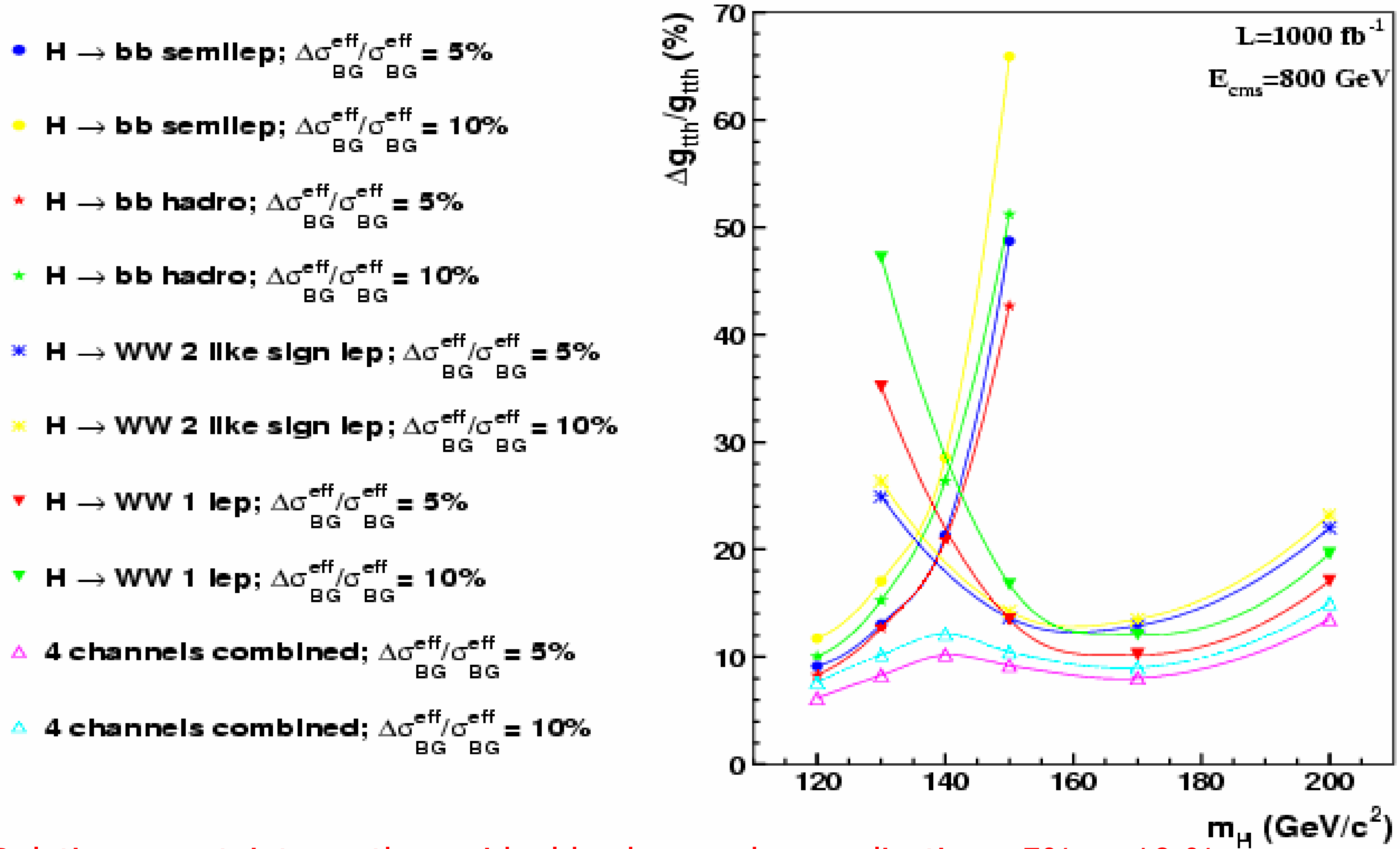
- Neural Net selection
  - ➢ Thrust, number of jets, Fox-Wolfram M., b-tag prob., etc.

Selection ($h \to b\bar{b}$, semi leptonic channel)





Results



Relative uncertainty on the residual background normalisation : 5% or 10 %

6 fermions background (1)

- Previous results don't include 6 fermions processes
- Cross-sections / generation with WHIZARD
  - At the partonic level
  - Include ISR and beamstrahlung
  - Hadronization and FSR done by PYTHIA
- Some processes receive contributions of resonant diagrams already taken into account with
  - t-tbar, W+W-, ZZ, t-tbar-Z, t-tbar-H
    - ➢ In this case these contributions are substracted from the total cross-section to avoid double counting
- Cross-section calculation and generation
  - Difficult and time consuming
  - Ambiguities arise when parton pairs are defined for fragmentation
    - ➢ Loss of resolution on the g_{ttH} measurement due to 6 f. background is an estimate

6 fermions background (2)

- Hadronic channel (m_H = 120 GeV/c^2)

Final state	$\sigma(fb)$	ϵ_{sel}
$b\bar{b}b\bar{b}b\bar{b}$	$6.4 \cdot 10^{-3}$	5.8%
$b\bar{b}b\bar{b}q\bar{q}$ $(q = u, d)$	$1.2 \cdot 10^{-1}$	1.6%
$b\bar{b}b\bar{b}s\bar{s}$	$6.3 \cdot 10^{-2}$	1.8%
$b\bar{b}b\bar{b}c\bar{c}$	$5.1 \cdot 10^{-2}$	2.0%
$b\bar{b}b\bar{b}t\bar{t}$	$6.9 \cdot 10^{-3}$	31.8%
$b\bar{b}q\bar{q}t\bar{t}$ $(q = u, d, s)$	$8.9 \cdot 10^{-3}$	12.5%
$b\bar{b}c\bar{c}t\bar{t}$	$3.5 \cdot 10^{-3}$	17.2%
$b\bar{b}t\bar{b}d\bar{u}$ *	$\sim 1 \cdot 10^{-2}$	14.0%
$b\bar{b}t\bar{b}\mu\bar{\nu}$ *	$\sim 3 \cdot 10^{-3}$	1.2%

$\Delta\sigma^{eff}_{BG} / \sigma^{eff}_{BG} = 5\ \%$

6 fermions background (3)

- Loss of resolution in the hadronic channel (m_H = 120 GeV/c^2)

$\frac{\Delta\sigma^{eff}_{BG}}{\sigma^{eff}_{BG}}$	$\frac{\Delta g_{ttH}}{g_{ttH}}$ (without 6f)	$\frac{\Delta g_{ttH}}{g_{ttH}}$ (with 6f)
5%	8.3%	$\sim$ 8.5%
10%	10.1%	$\sim$ 10.5%

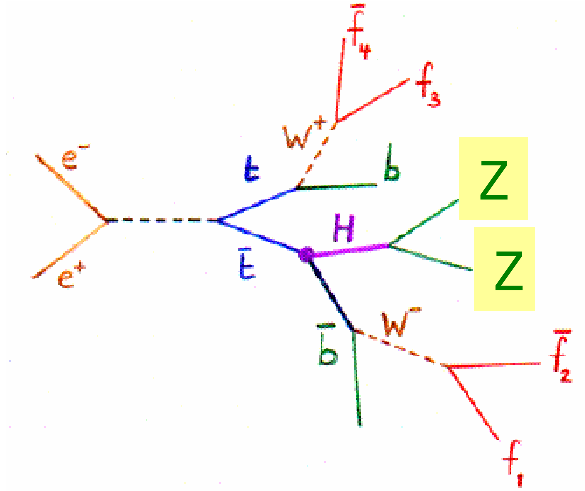
- Loss of resolution in the semileptonic channel

$\frac{\Delta\sigma^{eff}_{BG}}{\sigma^{eff}_{BG}}$	$\frac{\Delta g_{ttH}}{g_{ttH}}$ (without 6f)	$\frac{\Delta g_{ttH}}{g_{ttH}}$ (with 6f)
5%	9.1%	$\sim$ 9.3%
10%	11.7%	$\sim$ 12.1%

➢ No significant effect

Extension of the analysis

- New top mass from TeVatron:
  - $m_t = 178.0 \pm 4.3$ GeV/c^2
    - Changes the cross-sections to less than ~1%
    - Higgs mass limit ~ 250/340 GeV/c^2 @ 95/99% c.l.
    - Extension of the analysis to $m_H \simeq 300$ GeV/c^2
- Include the ($H \rightarrow ZZ$) channel
  - $26\% \leq Br \leq 30\%$ for ($200 \leq m_H \leq 300$ GeV/c^2)
  - 2 leptons + 8 jets channel → l^+l^-6q2b



Conclusion

- @ the LC, the precision of the measurement of the top Yukawa Coupling will be better than ~ 10 %

  if $m_H \leq 190$ GeV/c^2
- For a light Higgs ($m_H \simeq 120$ GeV/c^2)
  - Precision ~ 5-6 %
- First 6-fermions background simulations affect only marginaly the precision of the measurement
- The extension of the analysis is in progress (high masses, HZZ channel)

6 fermions background (4)

2 like sign lep. + 6 jets channel (m_H =150 GeV/c^2)

Final state	$\sigma(fb)$	ϵ_{sel}
$b\bar{b}u\bar{d}e^-\overline{\nu}_e$ *	~ 1.5	$8.4 \cdot 10^{-3}\%$
$b\bar{b}t\bar{b}d\overline{u}$ *	$\sim 6 \cdot 10^{-3}$	$< 0.2\%$
$b\bar{b}t\bar{b}\mu\overline{\nu}$ *	$\sim 1.5 \cdot 10^{-3}$	0.4%
$t\bar{t}q\overline{q}q'\overline{q}'$ $(q, q' = u, d, s)$	$1.2 \cdot 10^{-2}$	0.2%
$q\overline{q}t\bar{b}l\overline{\nu}_l$ $(q = u, d, s, c;\ l = e^-, \mu^-)$ *	$\sim 7.6 \cdot 10^{-2}$	0.2%
$q\overline{q}t\bar{b}d\overline{u}$ $(q = u, d, s, c)$ *	$\sim 1.3 \cdot 10^{-1}$	0.05%

* *Contribution of resonant reactions was subtracted*

The selection efficiency is shown for $\frac{\Delta\sigma_{BG}^{eff}}{\sigma_{BG}^{eff}} = 5\%$

$\frac{\Delta\sigma_{BG}^{eff}}{\sigma_{BG}^{eff}}$	$\frac{\Delta g_{ttH}}{g_{ttH}}$ (without 6f)	$\frac{\Delta g_{ttH}}{g_{ttH}}$ (with 6f)
5%	13.6%	$\sim$ 13.9%
10%	14.2%	$\sim$ 14.5%

6 fermions background (5)

1 lep. + 8jets channel (m_H =150 GeV/c^2)

Final state	$\sigma(fb)$	ϵ_{sel}
$b\bar{b}u\bar{d}e^-\bar{\nu}_e$ *	~ 1.5	0.04%
$b\bar{b}t\bar{b}d\bar{u}$ *	$\sim 6 \cdot 10^{-3}$	2.4%
$b\bar{b}t\bar{b}\mu\bar{\nu}$ *	$\sim 1.5 \cdot 10^{-3}$	3.4%
$t\bar{t}q\bar{q}q'\bar{q}'$ $(q, q' = u, d, s)$	$1.2 \cdot 10^{-2}$	7.6%
$q\bar{q}t\bar{b}l\bar{\nu}$ $(q = u, d, s, c;\ l = e^-, \mu^-)$ *	$\sim 7.6 \cdot 10^{-2}$	1.7%
$q\bar{q}t\bar{b}d\bar{u}$ $(q = u, d, s, c)$ *	$\sim 1.3 \cdot 10^{-1}$	1.2%

* *Contribution of resonant reactions was subtracted*

The selection efficiency is shown for $\frac{\Delta\sigma_{BG}^{eff}}{\sigma_{BG}^{eff}} = 5\%$

$\frac{\Delta\sigma_{BG}^{eff}}{\sigma_{BG}^{eff}}$	$\frac{\Delta g_{ttH}}{g_{ttH}}$ (without 6f)	$\frac{\Delta g_{ttH}}{g_{ttH}}$ (with 6f)
5%	13.5%	$\sim$ 14%
10%	16.8%	$\sim$ 17.5%