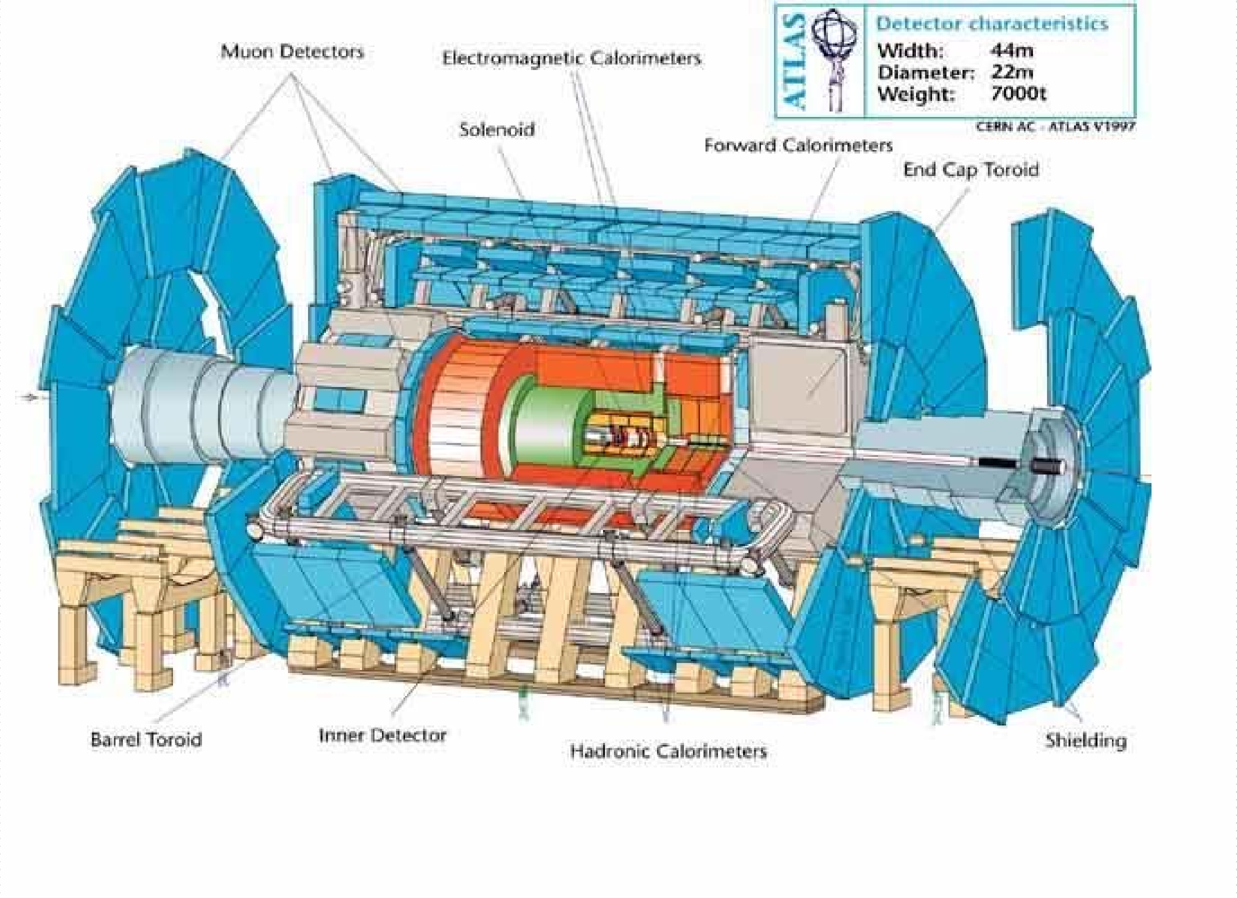
Top quark physics on **Atlas**



Motivations:

- constrain the mass of the SM Higgs boson (m_H).
- excellent probe of EWSB
- possible existence of other massive particles
- top quark events - the dominant at the TeV scale
- Calibration source for calorimetry at the LHC

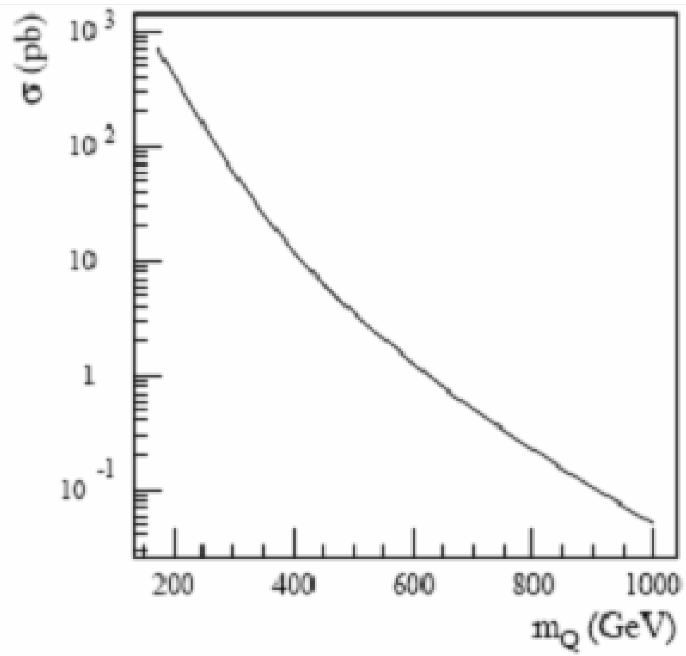


Figure 1: Predicted Standard Model cross-section, versus quark mass, for pair production of heavy quarks at the LHC.

tt selection and event yields

According to the SM, $t \rightarrow Wb$

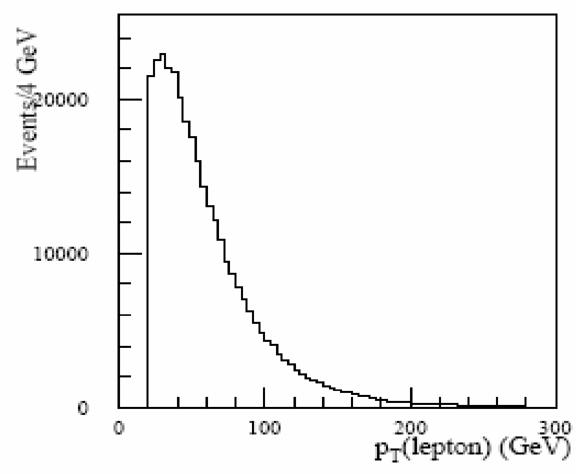
- 65.5% : $W \rightarrow jj$ or $W \rightarrow \tau\upsilon$
  - 44.4% : $t\bar{t} \rightarrow WWb\bar{b} \rightarrow (jj)(jj)b\bar{b}$

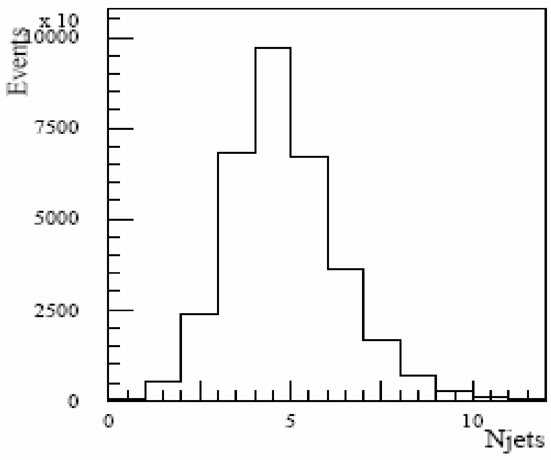
(3.7 million multi-jet events for an integrated luminosity of $10\ fb^{-1}$)

p_T(jet) threshold	Signal (%)	QCD (%)	S/B
15 GeV	7.2	.028	1/8
20 GeV	4.3	.014	1/7
25 GeV	2.5	.0056	1/6

tt selection and event yields

- 34.5% : $W \to l\upsilon$
  - 29.6% : the single lepton plus jets topology (2.5 million events for an integrated luminosity of $10\,fb^{-1}$)
  - 4.9% : dilepton events (400 000 dilepton events for an integrated luminosity of $10\,fb^{-1}$)





Measurement of the top quark mass

$$m_t = 174.3 \pm 3.2 \pm 4.0 GeV$$

For SM: $\delta m_t \leq 2 GeV$

For models beyond SM: $\delta m_t \approx \pm 1 GeV$

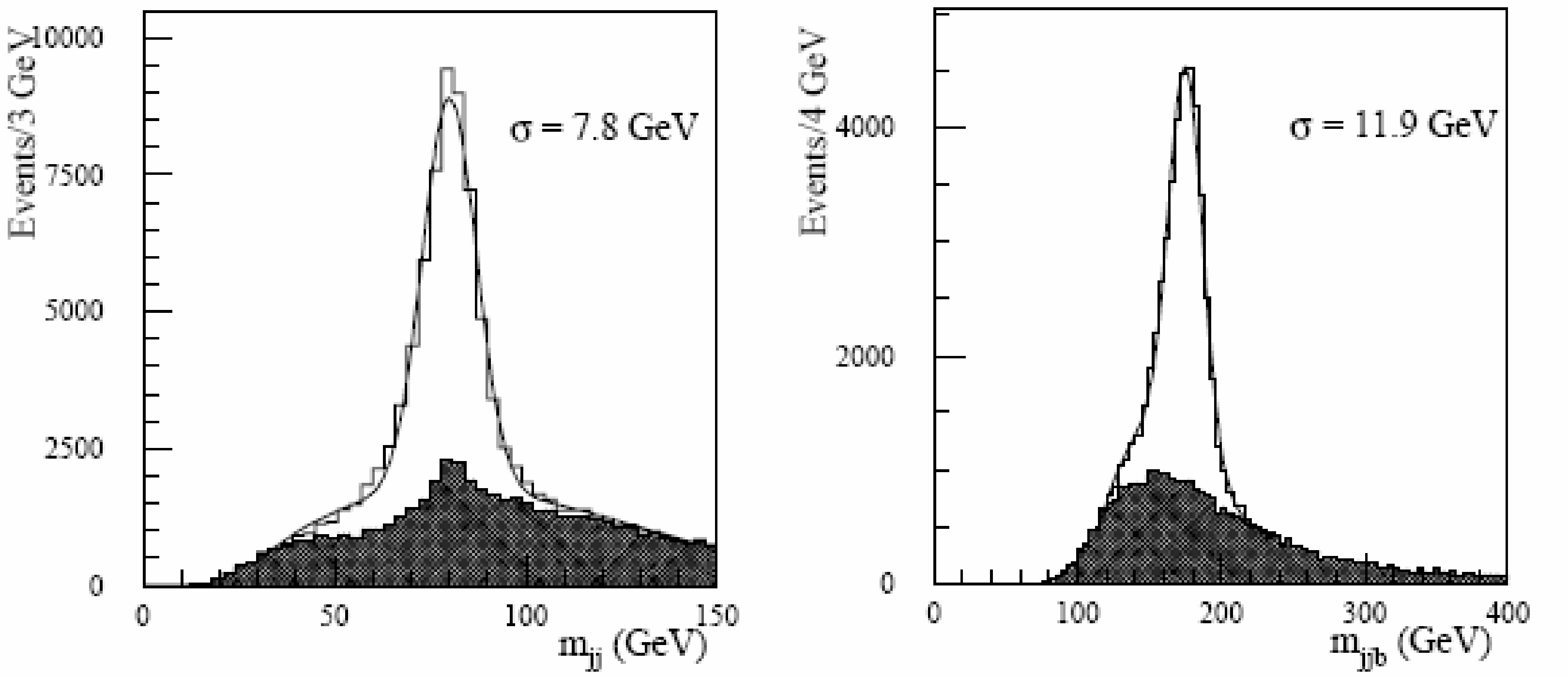
Inclusive single lepton plus jets channel

$$pp \to t\bar{t} \to WWb\bar{b} \to (l\upsilon)(jj)b\bar{b}$$

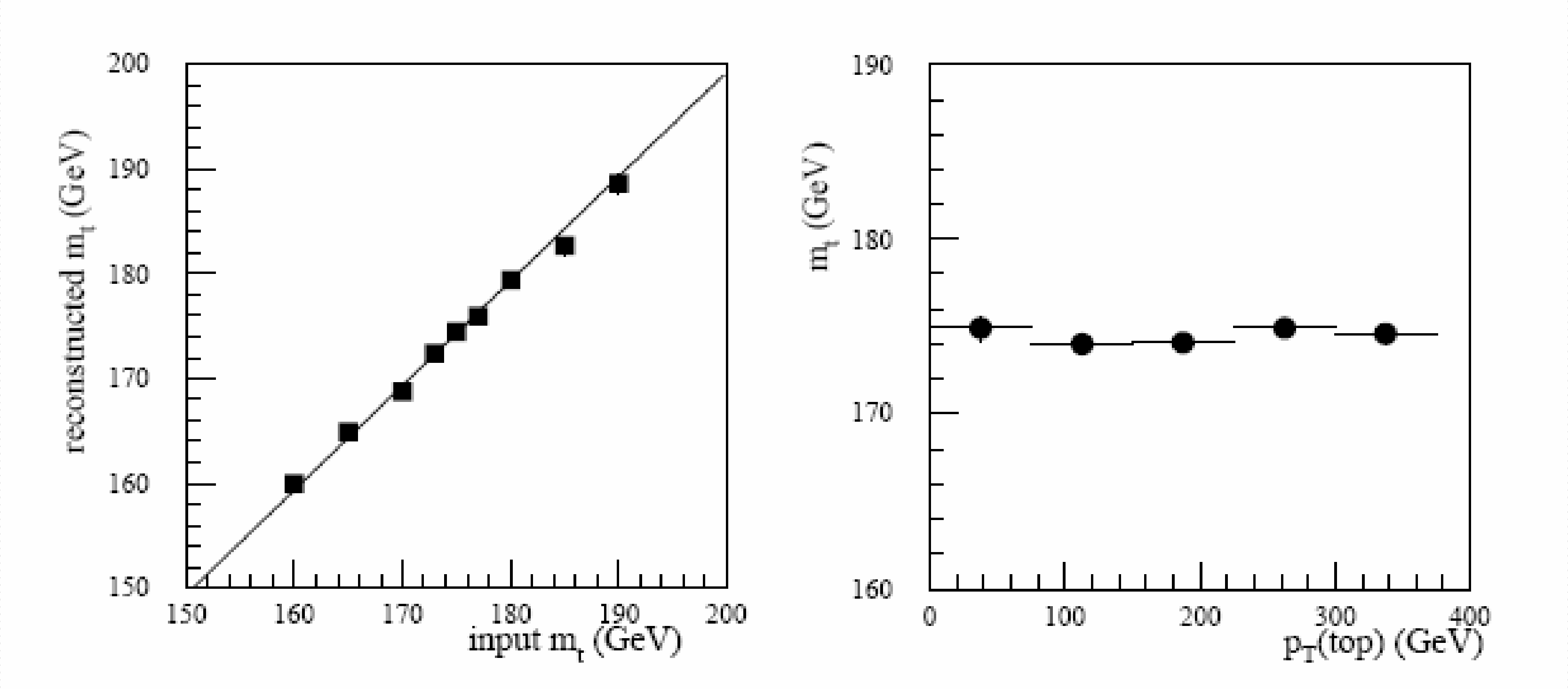
$$m_{\upsilon} = 0, E_T(\upsilon) = E_T^{miss}, m_{l\upsilon} = m_W, m_{jj} = m_W, m_{jjb} = m_{l\upsilon b} = m_t$$

Process	$p_T^l > 20$GeV $E_T^{miss} > 20$GeV	As before, plus $N_{jet} \geq 4$	As before, plus $N_{b\text{-}jet} \geq 2$	Events per 10 fb^{-1}
$t\bar{t}$ signal	64.7	21.2	5.0	126 000
W+jets	47.9	0.1	0.002	1658
Z+jets	15.0	0.05	0.002	232
WW	53.6	0.5	0.006	10
WZ	53.8	0.5	0.02	8
ZZ	2.8	0.04	0.008	14
Total background				1922
S/B				65

Inclusive single lepton plus jets channel

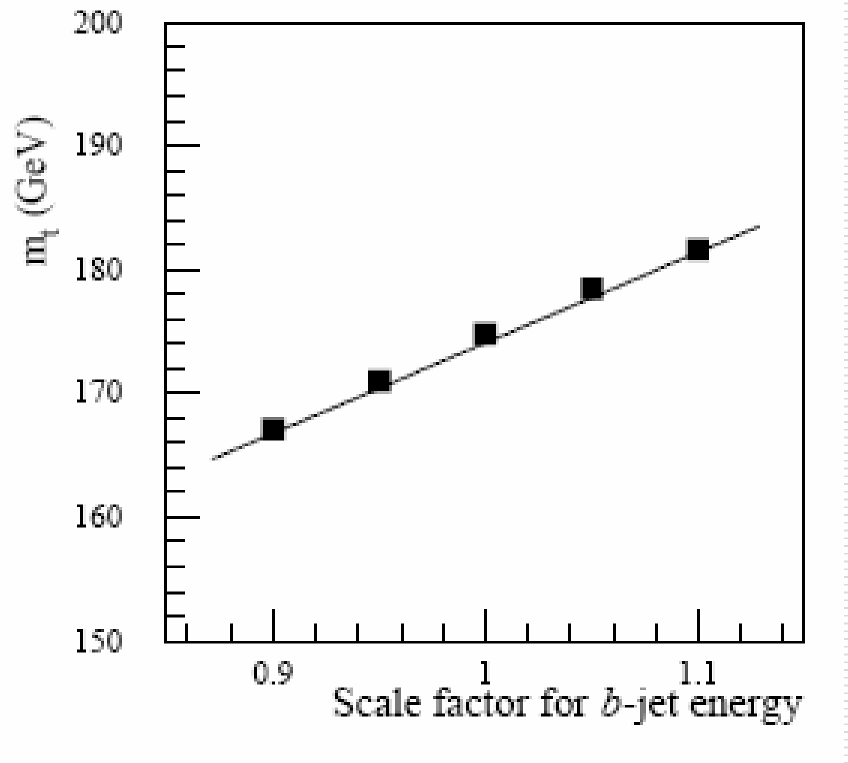


Inclusive single lepton plus jets channel



Systematic uncertainties on the measurement of m(top)

- Non-linearities in calorimeter response
- Energy lost outside the jet cone
- Detector effects (cracks, leakage)



Systematic uncertainties on the measurement of m(top)

Source of uncertainty	Comment on method	Inclusive sample $\|\Delta m_t\|$ (GeV) ΔR=0.4 (0.7)	Inclusive sample δm_t (GeV) ΔR=0.4 (0.7)
Light jet energy scale	1% scale error	0.3 (0.3)	0.3 (0.3)
b-jet energy scale	1% scale error	0.7 (0.7)	0.7 (0.7)
b-quark fragmentation	$(\epsilon_b$=-0.006)-$(\epsilon_b$=-0.0035)	0.3 (0.3)	0.3 (0.3)
Initial state radiation	ISR ON - ISR OFF	0.2 (1.3)	0.04 (0.3)
Final state radiation	FSR ON - FSR OFF	10.2 (6.1)	2.0 (1.2)
Background	-	0.2 (0.2)	0.2 (0.2)

Top quark pair production

$gg \rightarrow t\bar{t}$

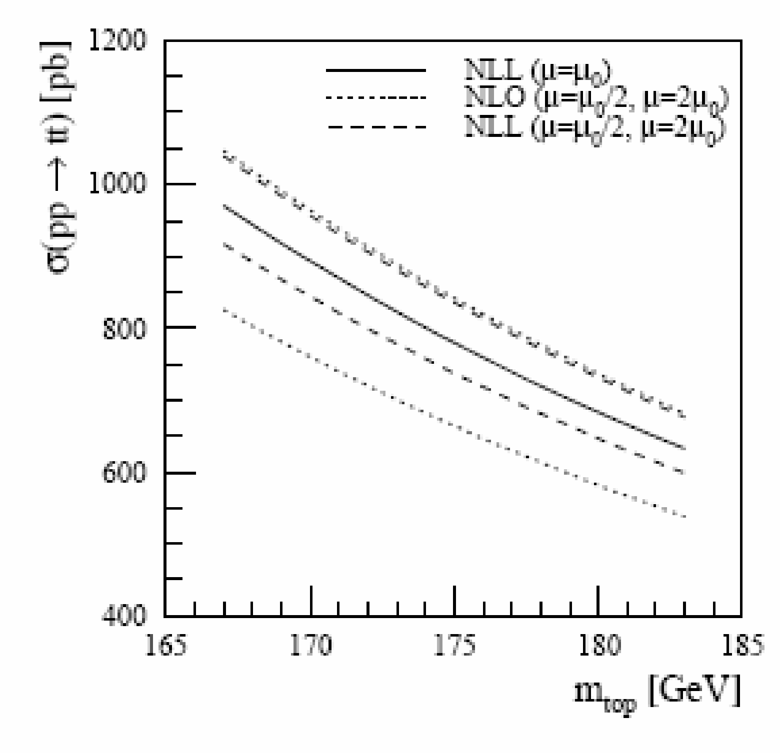
account 90% o the total tt production (gluon-gluon fusion process)

$q\bar{q} \rightarrow t\bar{t}$

(qq annihilation)

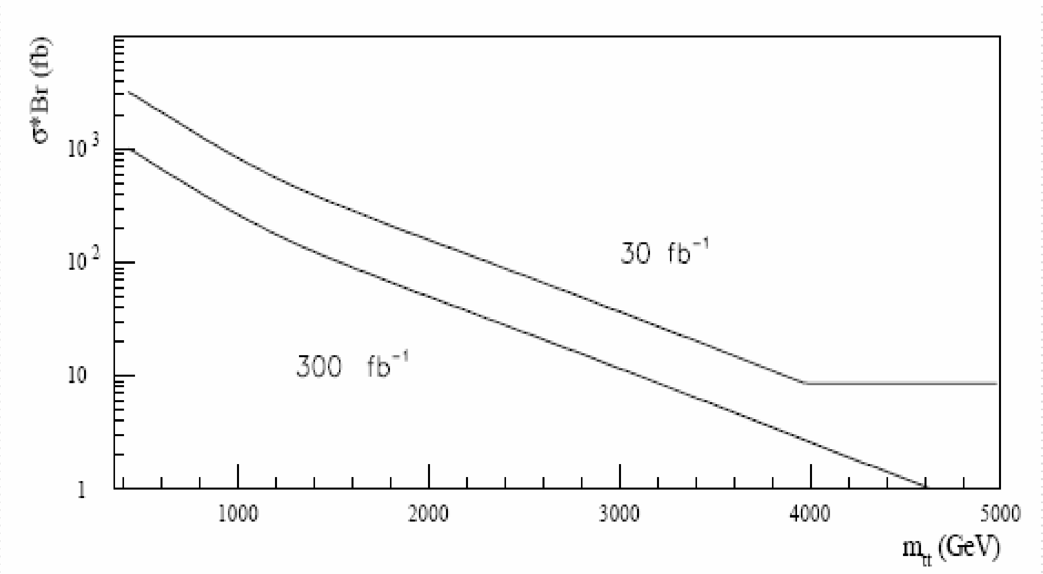
$\sigma(t\bar{t}) = 833pb$

8 million pair in one year at the low luminosity



Search for tt resonances

- Number of theories predict existence of heavy resonances, decaying to tt

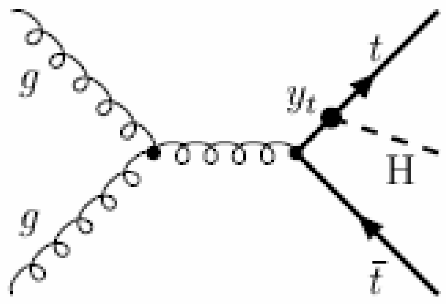


- $H \to t\bar{t}$

- Technicolor theories

Top quark decays and couplings

- BR($t \to WX$)
  - The SM, for which BR ($t \to WX$) = 100%, predicts $R_{ll/l} = 2/9$
  - Existence of a charged H leads to a large BR ($t \to Hb$)
    - $H \to \tau\upsilon$
- Top quark Yukawa coupling
  - $t \to l\upsilon b, t \to jjb, H \to bb$



Process	SM Higgs mass		
	80 GeV	100 GeV	120 GeV
$t\bar{t}H$ Signal	81	61	40
Total Backgnd	145	150	127
$\delta y_t/y_t$ (stat.)	9.3%	11.9%	16.2%

Top quark rare decays

- Flavor Changing Neutral Currents (FCNC)
  - Suppressed within SM
  - Some extensions of SM allow $BR(t \to Zq) < 33\%$

FCNC Decay	BR in SM	BR in MSSM
$t \to Zq$	$\simeq 10^{-12}$	$\simeq 10^{-8}$
$t \to \gamma q$	$\simeq 10^{-12}$	$\simeq 10^{-8}$
$t \to gq$	$\simeq 10^{-10}$	$\simeq 10^{-6}$

t -> Zq decay (tt -> (Wb) (Zq))

- $BR = 2.3*10^{-4}$
- $BR = 1.1*10^{-4}$

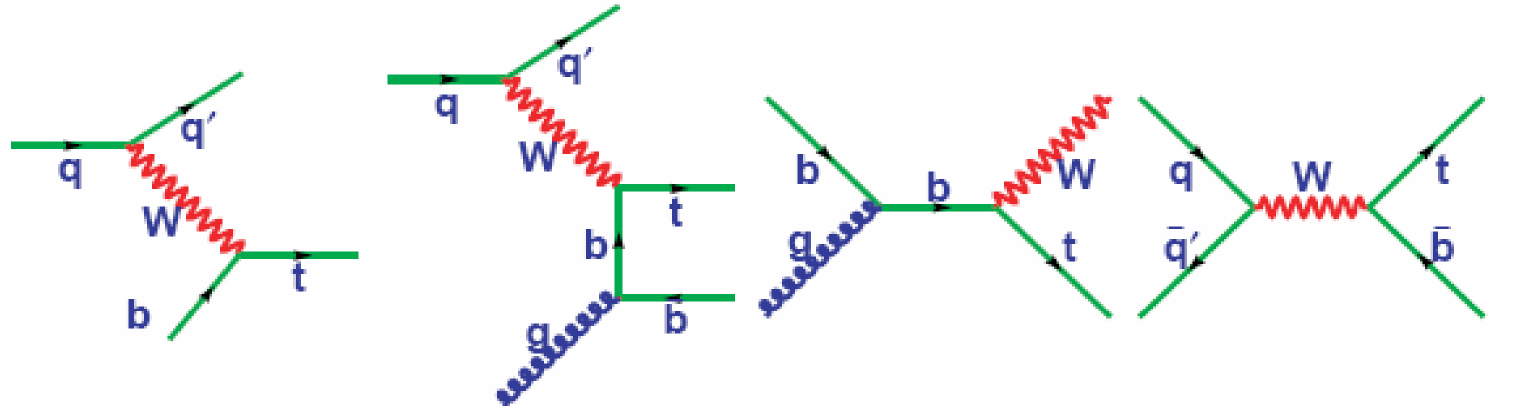
Table 18-8 Signal efficiency for the analysis of $t\bar{t} \to (Wb)(Zq)$ with $W \to jj$ and $Z \to ll$. Also listed are the numbers of accepted background events, assuming an integrated luminosity of 100 fb^{-1}.

Description of Cut	$t \to Zq$ Effic.(%)	Bkgnd Events
2l, 4 jets	14.9	60394
m_Z cut	12.8	50973
m_W cut	5.4	14170
b-tag	2.5	1379
$t \to W^+b$ mass cut	0.6	90
m_{Zq} cut	0.4	2

Table 18-9 Signal efficiency for the analysis of $t\bar{t} \to (Wb)(Zq)$ with $W \to l\nu$ and $Z \to ll$. Also listed are the numbers of accepted background events, assuming an integrated luminosity of 100 fb^{-1}.

Description	$t \to Zq$	Bkgnd Events		
of Cut	Effic.(%)	Z+j	W+Z	$t\bar{t}$
3 lep; p_T>20GeV	43.2	945	1778	1858
E_T^{miss} > 30GeV	32.7	80	1252	1600
2 j; p_T>50 GeV	19.7	31	225	596
m_Z cut	16.8	24	180	29
b-tag	8.2	10	14	10
m_{Zq} cut	6.1	0	2	5

Electroweak single top quark production



Process	σ (pb)	$\sigma \times \mathrm{BR}(W \to l\nu)$ (pb)
Wg (2-2 + 2-3)	244	54.2
Wt	60	17.8
W^*	10	2.2
$t\bar{t}$	833	246
$Wb\bar{b}$	300	66.7
Wjj	18000	4000

Electroweak single top quark production

- Cross Check the W-gluon fusion, Wt and W* cross-sections separately.
- Different sensitivities to new physics.
  - W* channel is more sensitive to an additional heavy W' boson.
  - W-gluon fusion is more sensitive to modifications of the top quark's to the other SM particles.

Conclusions

- The mass of top quark will be measured with a precision of less than 2 GeV.
- The top quark Yukawa coupling can be measured with a precision of less than 10% for a Higgs mass of 100 GeV.
- Observation of tt spin correlations, predicted in SM and used to probe CP violation or anomalous couplings.
- Heavy resonances decays could be detected.
- Studying of rare decays.
- Study of electroweak single top production.