$t\bar{t}$ Cross Section in the Dilepton Channels

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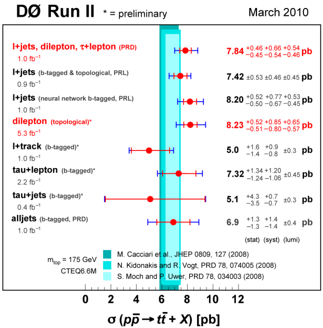
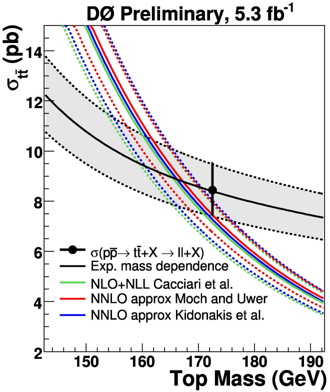
DØ France – 4th **May 2010** –

Motivation



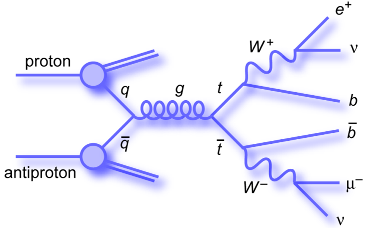


- Validation of the selection for the measurement of other top properties.
- Improve the statistical uncertainty on the dilepton $t\bar{t}$ cross section which can then lead to a more precise extraction of the top mass from cross section.

Data and Monte Carlo

Three channels considered depending on the W decay : $e\mu$, ee, $\mu\mu$.

Signal :



Summer 2009 extended data sample :

- Luminosity : 4.3fb^{-1} (p20)

Monte Carlo samples :

- $t\bar{t}$ alpgen, generated with $m_t = 172.5$ GeV
- $Z \to l^+l^-$ alpgen
- WW, WZ et ZZ pythia

Background :

- Physical : $Z \to l^+l^-$, WW, WZ et ZZ.
- Instrumental : fake electron and fake isolated muon.

Event Selection

Trigger : Inclusive (no trigger requirement) for emu, single electron OR for ee and single muon OR for mumu.

Muon :

- loose muon ID
- trackloose (luminosity dependent scale factor)(v2)
- $p_T > 15$ GeV
- TopScaledMedium isolation

Electron :

- top_tight : include a cut on the electron likelihood : $lhood > 0.85$
- $p_T > 15$ GeV
- $|z_e - z_{PV}| < 1cm$

2 jets :

- JESMU $p_T > 20$ GeV
- jets matched to tight electrons removed
- jet vertex confirmation

Final selection :

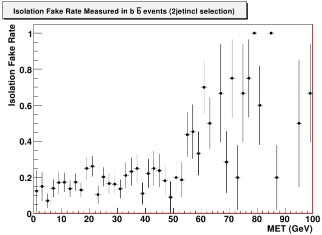
- emu : topological cut : H_T with leading lepton > 110 GeV
- ee and mumu : cut on BDT output.

Fake Muon Rate

- Background coming from events with at least one fake isolated muon
- Method used :
  - in a dimuon data sample with one non-isolated muon (tag), we count the number of probe muons that appear tight isolated (iso<0.15) in a sample of loose isolated (iso<0.5) probe muons

Result for loose track muon (loose quality) :

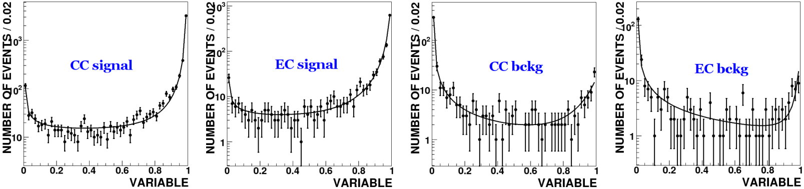
	0 jet exclusive	1 jet exclusive	2 jets inclusive
f_μ	$34.88 \pm 1.02\%$	$16.15 \pm 0.74\%$	$16.10 \pm 1.17\%$



- Number of fake muon background in the analysis :
  - number of dilepton same sign events with loose muon isolation (and all other selections identical to the signal selection) times f_μ

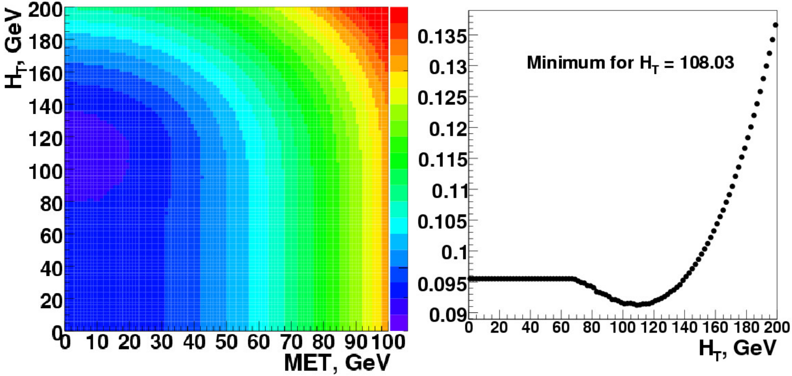
Fake Electron Estimation

- Fake electrons come from jet misidentified as electron and from real electrons produced by jets (fake isolated electrons).
- Number of fake electrons in the data can be assessed with the shape of the electron likelihood :
  - The shape of the likelihood for good electrons is fitted using a $Z \to e^+e^-$ sample.
  - The same work is done on a sample dominated by fake electrons (same sign $e\mu$, low MET, non isolated muon).
  - Fitting the likelihood distribution in the signal sample using the template shapes determined above gives the number of fake electron background in the final selection (separatly in CC and EC).



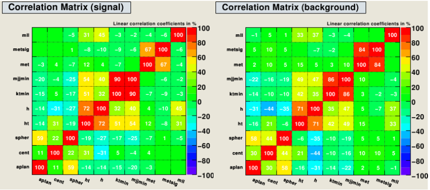
Optimizing the Selection : $e\mu$ Channel

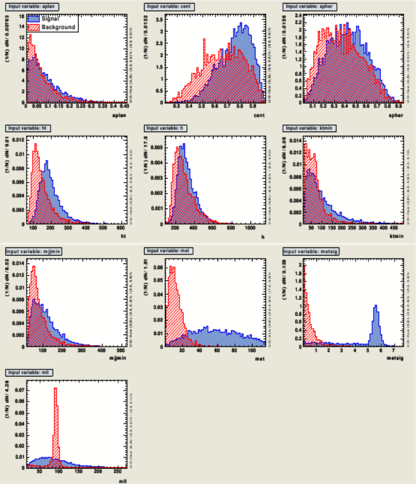
- Method for optimization : minimisation of $\sqrt{S+B}/S$ using for B : $Z \to \tau\tau$, WW, (fake) and for S : $t\bar{t}$.
- Optimal for no MET cut and $H_T > 110$ GeV.



Optimizing the ee and μμ Selection : use of a BDT.

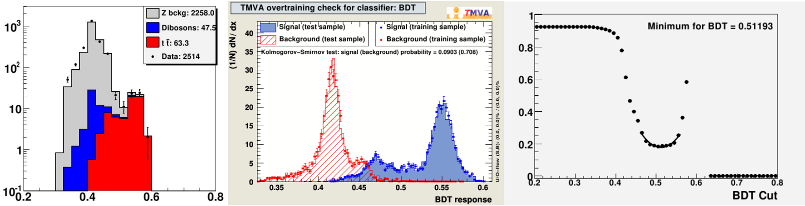
- Use of a BDT with the same input variables as the W helicity analysis : aplanarity, centrality, sphericity, Ht, H, ktmin, mjjmin, MET, METsig, mll.
- Plots for ee channel with signal : $t\bar{t} \rightarrow ee$, bckg : $Z \rightarrow ll$ and diboson.





Optimizing the Selection : ee Channel

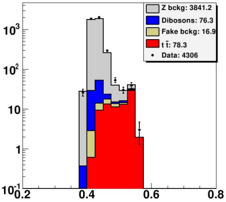
- Method of optimization : minimization of $\sqrt{S+B}/S$ for different BDT cut on the BDT output.
- Optimal for $\text{BDT} > 0.51$.

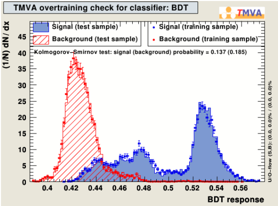


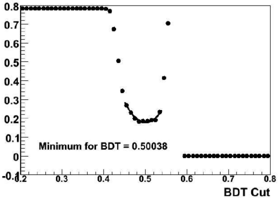
- Gain of $\sim 5\%$ in $\sqrt{S+B}/S$ with respect to simple cut selections

Optimizing the Selection : μμ Channel

- Method of optimization : minimization of $\sqrt{S+B}/S$ for different cut on the BDT output.
- Optimal for BDT > 0.50 .







- Gain of $\sim 7\%$ in $\sqrt{S+B}/S$ with respect to simple cut selections

Event Yield : eμ Channel

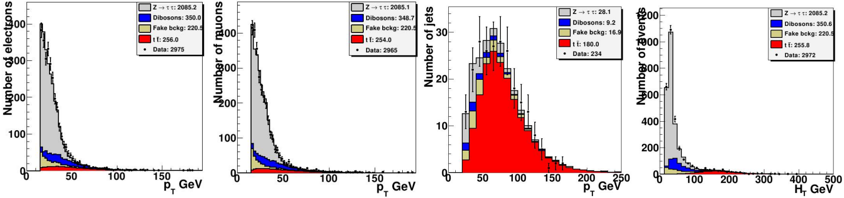
For top_tight and $H_T > 110$ GeV :

	$Z \to \tau\tau$	Dibosons	Number of fake electron events	Number of fake muon events	$t\bar{t} \to \ell\ell jj$, xsec=7.454 pb, m_t =172GeV)	Expected N of events	N of events
Inclusive selection	$2085.2^{+298.2}_{-265.1}$	$350.7^{+74.1}_{-74.1}$	$220.5^{+99.9}_{-99.9}$	-	$210.6^{+17.8}_{-17.8}$	$2866.9^{+341.3}_{-312.7}$	2975
N jets ≥ 1	$289.2^{+63.9}_{-58.7}$	$55.6^{+14.8}_{-14.5}$	$74.8^{+35.3}_{-35.3}$	$11.4^{+2.4}_{-2.3}$	$205.2^{+17.4}_{-17.4}$	$636.3^{+86.8}_{-82.4}$	684
N jets ≥ 2	$28.2^{+13.9}_{-12.5}$	$9.2^{+2.7}_{-2.7}$	$15.0^{+7.0}_{-6.9}$	$1.8^{+1.2}_{-1.1}$	$147.9^{+14.6}_{-14.6}$	$202.2^{+24.2}_{-23.1}$	234
HT (with leading lepton) ≥ 110 GeV	$11.9^{+2.7}_{-2.5}$	$6.5^{+2.1}_{-2.0}$	$8.1^{+3.9}_{-3.8}$	$2.6^{+1.1}_{-0.9}$	$143.4^{+14.3}_{-14.3}$	$172.6^{+16.5}_{-16.4}$	204

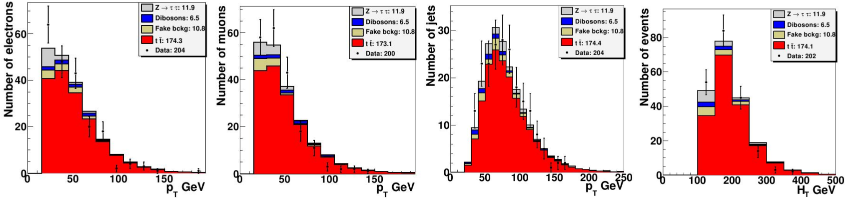
- Measured cross section ($4.3 fb^{-1}$) :
  $\sigma_{t\bar{t}} = \mathbf{9.1^{+0.8}_{-0.7}(stat) \pm 1.0(sys) \pm 0.6(lumi)}$ **pb (11% for the stat))**
- To be compared with the published result ($1.07 fb^{-1}$, PLB 679 (2009) 177) :
  $\sigma_{t\bar{t}} = \mathbf{6.7^{+1.5}_{-1.4}(stat)^{+0.7}_{-0.7}(sys) \pm 0.5(lumi)}$ **pb (22% for the stat)**

Data / Monte Carlo Comparison with Measured Cross Section : eμ Channel

Inclusive selection



Final selection



Event Yield : ee Channel

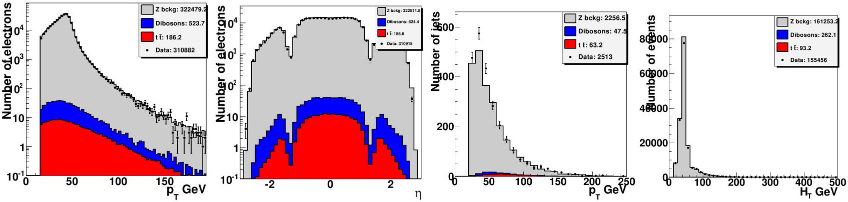
For top_tight and BDT ≥ 0.51 :

	$Z \to \ell\ell$	Dibosons	Number of fake electron events	$t\bar{t} \to \ell\ell jj$, xsec=7.454 pb, m_t =172GeV)	Expected N of events	N of events
Inclusive selection	$161255.9^{+21667.0}_{-21668.1}$	$262.2^{+56.2}_{-56.2}$	$0.0^{+0.3}_{-0.0}$	$77.7^{+7.1}_{-7.2}$	$161595.8^{+21680.7}_{-21681.9}$	155459
N jets ≥ 1	$19385.9^{+4397.4}_{-4391.2}$	$111.1^{+25.3}_{-25.3}$	$0.0^{+0.3}_{-0.0}$	$75.3^{+7.0}_{-7.0}$	$19572.4^{+4408.8}_{-4402.5}$	19433
N jets ≥ 2	$2258.0^{+875.9}_{-866.6}$	$47.5^{+11.8}_{-11.8}$	$0.0^{+0.2}_{-0.0}$	$52.7^{+5.5}_{-5.5}$	$2358.2^{+883.2}_{-873.9}$	2514
MV Selection : BDT ≥ 0.51	$8.5^{+3.4}_{-3.4}$	$2.1^{+0.8}_{-0.8}$	$0.1^{+0.2}_{-0.1}$	$36.9^{+3.8}_{-3.8}$	$47.6^{+6.2}_{-6.2}$	55

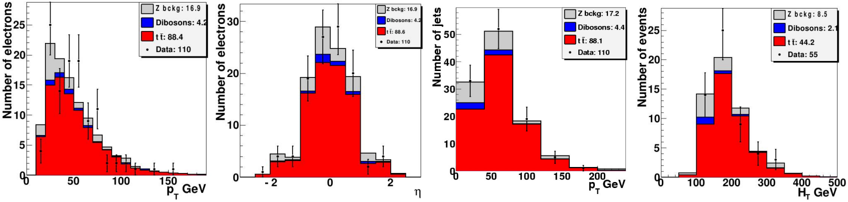
- Measured cross section (4.3fb^{-1}) :
  $\sigma_{t\bar{t}} = \mathbf{9.0^{+1.6}_{-1.4}}$**(stat)** $\pm$ **1.4(sys)** $\pm$ **0.7(lumi) pb (17.8% for the stat)**
- To be compared with the published result (1.07fb^{-1}, PLB 679 (2009) 177) :
  $\sigma_{t\bar{t}} = \mathbf{9.6^{+3.2}_{-2.7}}$**(stat)**$\mathbf{^{+1.0}_{-0.9}}$**(sys)**$\mathbf{^{+0.8}_{-0.7}}$**(lumi) pb (30.7% for the stat)**

Data / Monte Carlo Comparison with Measured Cross Section : ee Channel

Inclusive selection



Final selection



Event Yield : $\mu\mu$ Channel

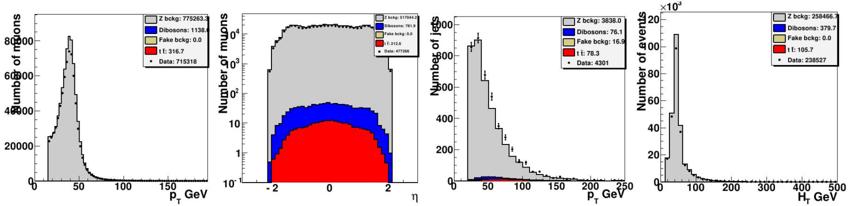
For BDT ≥ 0.50 :

	$Z \to \ell\ell$	Dibosons	Number of fake muon events	$t\bar{t} \to \ell\ell jj$, xsec=7.454 pb, m_t =172GeV)	Expected N of events	N of events
Inclusive selection	$258522.0^{+34728.0}_{-35710.3}$	$381.0^{+80.1}_{-80.1}$	-	$109.5^{+8.9}_{-8.9}$	$259012.4^{+34745.0}_{-35727.0}$	238633
N jets ≥ 1	$34358.5^{+8333.6}_{-7962.2}$	$170.6^{+37.1}_{-36.9}$	$52.2^{+3.8}_{-3.7}$	$106.9^{+8.7}_{-8.7}$	$34688.2^{+8346.3}_{-7974.5}$	31443
N jets ≥ 2	$3841.2^{+1646.9}_{-1570.0}$	$76.3^{+18.3}_{-18.3}$	$16.9^{+2.1}_{-2.0}$	$80.6^{+7.7}_{-7.7}$	$4015.1^{+1657.0}_{-1580.2}$	4306
MV Selection : BDT ≥ 0.5	$21.7^{+5.6}_{-6.2}$	$3.3^{+1.1}_{-1.2}$	$3.2^{+0.8}_{-0.7}$	$45.1^{+4.4}_{-4.3}$	$73.3^{+8.1}_{-8.8}$	72

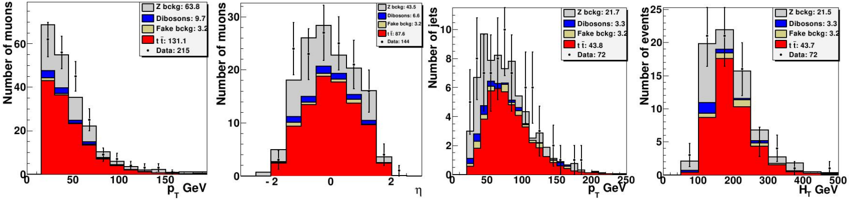
- Measured cross section ($4.3 fb^{-1}$) :
  $\sigma_{t\bar{t}} = 7.2^{+1.5}_{-1.4}(\text{stat})^{+1.3}_{-1.4}(\text{sys}) \pm 0.7(\text{lumi})$ pb (21% for the stat)
- To be compared with the published result ($1.07 fb^{-1}$, PLB 679 (2009) 177) :
  $\sigma_{t\bar{t}} = 6.48^{+3.97}_{-3.18}(\text{stat})^{+1.13}_{-0.93}(\text{sys}) \pm 0.40(\text{lumi})$ pb (55% for the stat)

Data / Monte Carlo Comparison with Measured Cross Section : μμ Channel

Inclusive selection



Final selection



Systematics

	ee, %	$e\mu$, %	$\mu\mu$, %	$\ell\ell$, % (Run IIb)	$\ell\ell$, % (Run II)
Signal modeling	4.9	4.8	4.8	$^{+5.0}_{-4.7}$	$^{+4.9}_{-4.6}$
MC background normalisation	5.8	2.3	11.1	$^{+3.4}_{-3.3}$	$^{+3.1}_{-3.0}$
Instrumental background	0.4	2.3	1.7	1.6	$^{+1.4}_{-1.4}$
Electron ID	8.9	3.9		$^{+4.2}_{-3.9}$	$^{+3.3}_{-3.2}$
Muon ID		1.7	4.9	$^{+1.9}_{-1.9}$	$^{+1.6}_{-1.5}$
Jet ID and resolution	6.5	3.2	$^{+5.9}_{-9.3}$	$^{+4.2}_{-3.9}$	$^{+3.4}_{-3.2}$
Jet energy scale	6.9	4.9	7.6	$^{+5.6}_{-5.2}$	$^{+5.2}_{-4.9}$
Trigger	0.6	5.5	7.9	$^{+4.1}_{-3.7}$	$^{+3.2}_{-3.1}$
Others	3.8	2.5	3.4	$^{+2.8}_{-2.7}$	$^{+2.7}_{-2.6}$
Total:	± 15.5	± 11.1	$^{+18.4}_{-19.8}$	$^{+11.5}_{-10.9}$	$^{+10.3}_{-9.8}$

The results are systematically limited.

Combination

- Combination of the three leptonic channels using nuisance parameters : $\sigma_{t\bar{t}} = 8.76^{+0.61}_{-0.59}(\text{stat})^{+1.00}_{-0.95}(\text{sys})^{+0.67}_{0.60}(\text{lumi})$ pb
- Combination with the previous 1fb^{-1} analysis (PLB 679, 177) : $\sigma_{t\bar{t}} = 8.44^{+0.54}_{-0.52}(\text{stat})^{+0.87}_{-0.82}(\text{sys})^{+0.67}_{0.59}(\text{lumi})$ pb

Systematic	p20 ee	p20 $e\mu$	p20 $\mu\mu$
Correlated			
Branching fractions	X	X	X
Data quality	X	X	X
Higher order, hadronization	X	X	X
Color reconnection	X	X	X
ISR/FSR	X	X	X
PDF	X	X	X
b quark modeling	X	X	X
Muon ID and scale		X	X
Muon track		X	X
Muon isolation		X	X
Electron ID and scale	X	X	
Opposite charge	X	X	
$dZ(l, PV)$	X	X	X
Vertex Z distribution	X	X	X
Jet ID	X	X	X
Jet energy resolution	X	X	X
Jet vertex confirmation	X	X	X
Jet energy scale	X	X	X
$b-$ Jet energy scale	X	X	X
JSSR Shifting on/off	X	X	X
Z p_T reweighting	X	X	X
background cross sections	X	X	X
EM lhood fit systematics	X	X	
Background modeling	X		X
Integrated luminosity	X	X	X
Uncorrelated			
Monte Carlo statistics	X	X	X
Trigger	X	X	X
EM lhood fit statistical error	X	X	
Fake muon rate		X	X

Systematic Correlation	p17	p20
Monte Carlo statistics		
Branching fractions	X	X
Data quality	X	X
Higher order, hadronization	X	X
Color reconnection	X	X
ISR/FSR	X	X
PDF	X	X
b quark modeling	X	X
Muon ID and scale		
Muon track		
Muon isolation		
Electron ID and scale		
Opposite charge	X	X
$dZ(l, PV)$	X	X
Vertex Z distribution	X	X
Trigger		
Jet ID		
Jet energy resolution		
Jet vertex confirmation		
Jet energy scale		
$b-$ Jet energy scale	X	X
JSSR Shifting on/off	X	X
Lumi reweighting		
Z p_T reweighting	X	X
Background cross sections	X	X
Background modeling		
MET modeling		
Fake EM		
Fake muon rate		
Integrated luminosity	X	X

Conclusion - Outline

Conclusion

- Measured cross sections (4.3fb^{-1}) (approved as preliminary for Moriond QCD) :
  - $e\mu$ $\sigma_{t\bar{t}} = \mathbf{9.1^{+0.8}_{-0.7}(stat) \pm 1.0(sys) \pm 0.6(lumi)\ pb}$
  - ee $\sigma_{t\bar{t}} = \mathbf{9.0^{+1.6}_{-1.4}(stat) \pm 1.4(sys) \pm 0.7(lumi)\ pb}$
  - $\mu\mu$ $\sigma_{t\bar{t}} = \mathbf{7.2^{+1.5}_{-1.4}(stat)^{+1.3}_{-1.4}(sys) \pm 0.7(lumi)\ pb}$
- Combined with the previous 1fb^{-1} analysis (PLB 679, 177) : $\sigma_{t\bar{t}} = \mathbf{8.4 \pm 0.5(stat)^{+0.9}_{-0.8}(sys)^{+0.7}_{0.6}(lumi)\ pb}$
- Dominant error is systematics.

Outline

- Work on reducing some systematics (MC stat, EM id,...)
- Reoptimize BDT for ee and $\mu\mu$
- Try to include b-tagging

Defense of my thesis the 21^{st} of June at Saclay.

Backup Slides

Optimizing the $\mu\mu$ Selection : use of a BDT.

- Use of a BDT with input variables : aplanarity, centrality, sphericity, Ht, H, ktmin, mjjmin, MET, METsig, mll.
- Plots for $\mu\mu$ channel with signal : $t\bar{t} \rightarrow \mu\mu$, bckg : $Z \rightarrow ll$ and diboson. :