Top physics at LHC startup: Prospect march

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Introduction

- Top physics at start-up : prospect march.
- What can be the expected precision on ttbar cross section measurement? What's need to be developed to prepare the measurements.

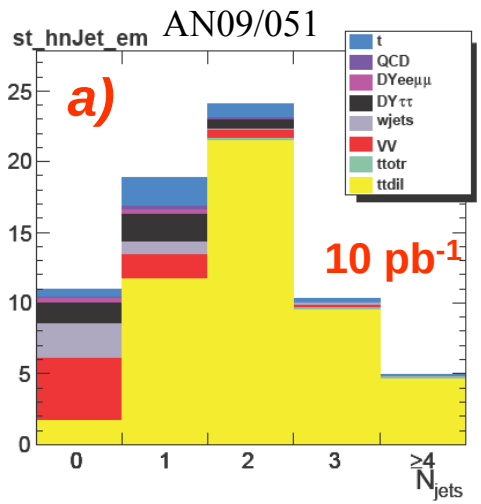
- Start-up conditions :
  - Validate data for physic analysis,
  - MC generator not tuned, simulation do not describe well the data,
  - Need to get selection efficiency from data,
  - Need to estimate background from data.

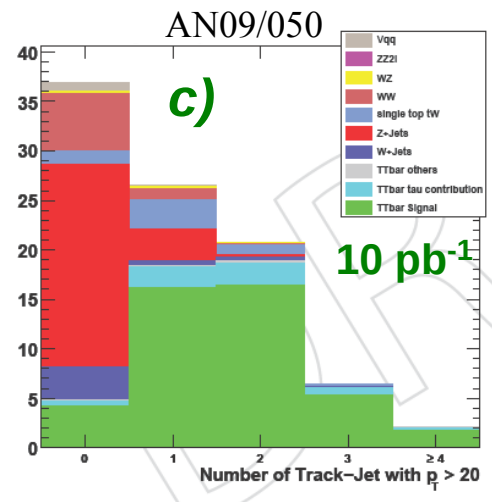
- Outlook:
  - Di-lepton cross section measurement
    - 3 different strategy,
    - Background estimate from data.
  - Muon+jets cross section, W+jets background estimate

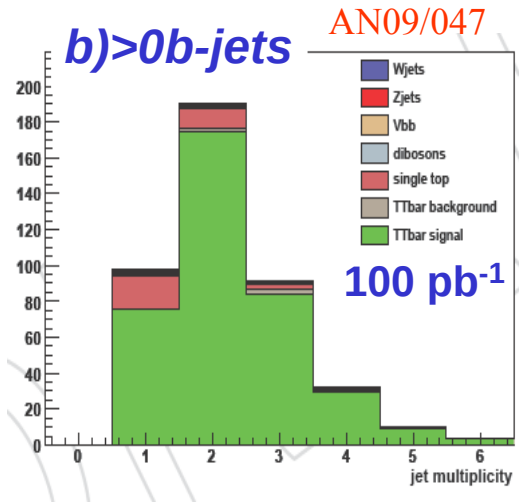
Cross section, di-lepton channel (e-e, e-mu , mu-mu)

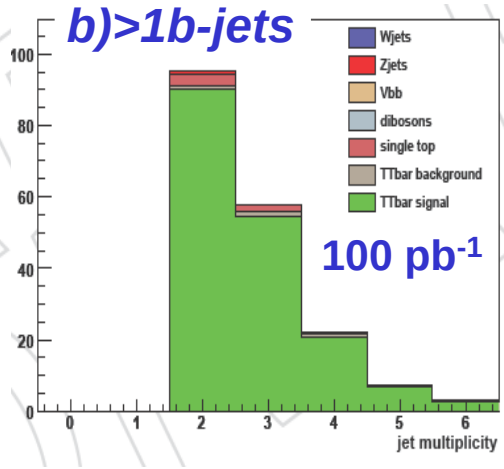
Event selection

- 3 different selections ***a***, ***b*** and ***c***.
- Lepton :
  - p_T>20GeV, |η|<2.4, tracker and calorimeter isolation.
  - Electron: loose ID+ |d0| < 400 μm.
  - Muon : norm chi2<10, NHit>10.
  - DY removal (ee, μμ) |M-91|<15 GeV/c^2
- MET selection :
  - ***a*** : MET>30(ee, μμ), >20 GeV (e,μ).
  - ***b*** : MET>50(ee, μμ), >30 GeV (e,μ).
  - ***c*** : no MET cut.
- Jet selection :
  - ***a***, ***b*** : SIS cone (0.5), p_T>30GeV, |η|<2.4
  - ***c*** : tracker jets.
- B-tagging : ***b*** only, Track counting algo.

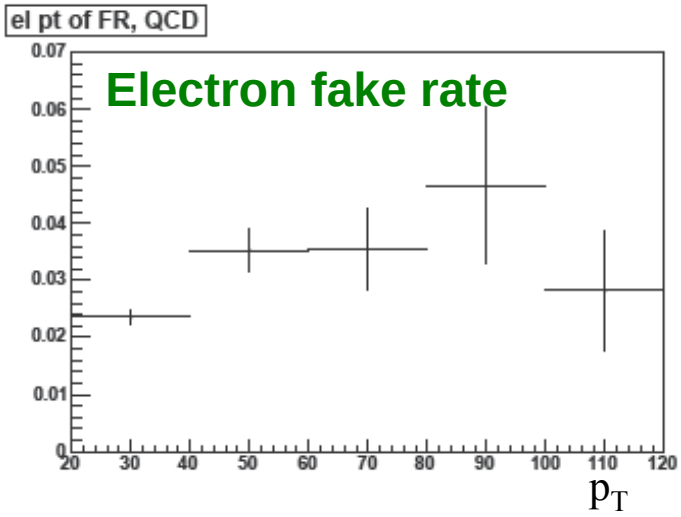


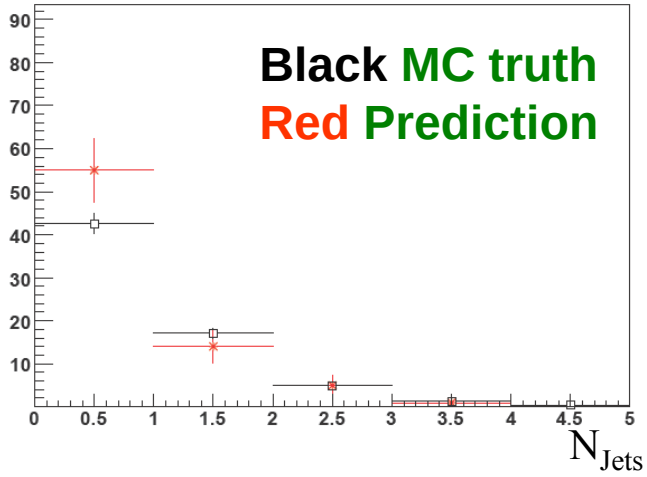






Background estimate: The fake rate method





- QCD background estimate:
  - Apply a single lepton selection on a QCD (multijets) sample and estimate fake rate ε_f.
  - Apply $\varepsilon_f \times \varepsilon_f$ on this sample.
- Estimate W+jets background (1 real lepton and 1 fake):
  - Selected W+jets events requiring 2 leptons but 1 isolated (MC or Data).
  - Multiply the event yield by the fake rate estimated in data ε_f.

Sample	Yield
$W \rightarrow \mu + e$	75
$W \rightarrow \mu + (eFO \times FR)$	66 ± 4

- Uncertainty of about 30%.

Background estimate: The Matrix Method

- In the di-leptonic channels: estimate instrumental background (due to fake isolated leptons) from data.
- We can define 3 levels of isolation: *Loose* = looser isolation requirements, *Medium* = at least 1 isolated leptons per event, *Tight* = at least 2 isolated leptons per event (standard selection).

- Then we define 3 sub-samples for each selection:
  - N_s = events containing 2 real isolated leptons (signal-like),
  - N_{W+jets} = events containing 1 real isolated leptons (W+jets-like),
  - N_{QCD} = events containing 2 fake isolated leptons (QCD+like).

- If we measure the probability for a "*Loose*" event to pass the "*Medium*" ($\varepsilon^{l\to m}$) and "*Tight*" selection ($\varepsilon^{l\to t}$), we can define a system of 3 equations and 3 unknowns.
- The solution yields the number of signal-like, W+jets-like and QCD-like events.

$$
\begin{aligned}
N^t &= \varepsilon_S^{l\to t} N_S^l + \varepsilon_W^{l\to t} N_W^l + \varepsilon_{QCD}^{l\to t} N_{QCD}^l, \\
N^m &= \varepsilon_S^{l\to m} N_S^l + \varepsilon_W^{l\to m} N_W^l + \varepsilon_{QCD}^{l\to m} N_{QCD}^l, \\
N^l &= N_S^l + N_W^l + N_{QCD}^l.
\end{aligned}
$$

$f(\varepsilon_l, \varepsilon_{fake})$

$$
\begin{aligned}
N_S^t &= \varepsilon_S^{l\to t} N_S^l, \\
N_W^t &= \varepsilon_W^{l\to t} N_W^l, \\
N_{QCD}^t &= \varepsilon_{QCD}^{l\to t} N_{QCD}^l,
\end{aligned}
$$

The matrix method (2)

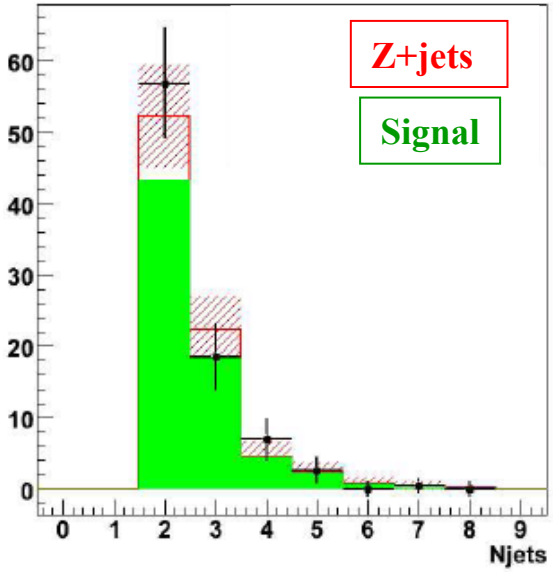
- Tested without b-tagging.
- Systematic errors:
  - Number of selected events in the loose, medium and tight samples.
  - Errors on ε_l et ε_{fake} (assume that ≈ 5 % and 10% respectively).

	Signal-like	W+jets-like	QCD-like
Nbr. of events	85.7	6.7	0.8
Stat. errors	9.5	1.6	0.7
Syst. errors	2.5	1.6	0.5
All syst. errors	9.9	2.3	0.9
Nbr. of MC events	92.8±2.8	3.7±0.9	0 ± 0

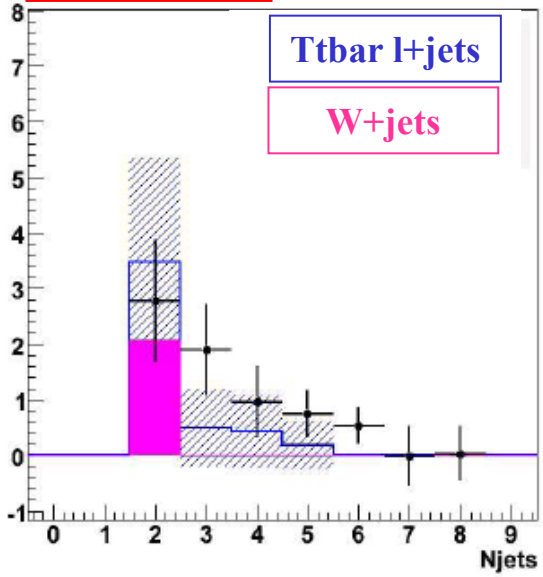
Rel erreur : 11%

Rel erreur : 34%

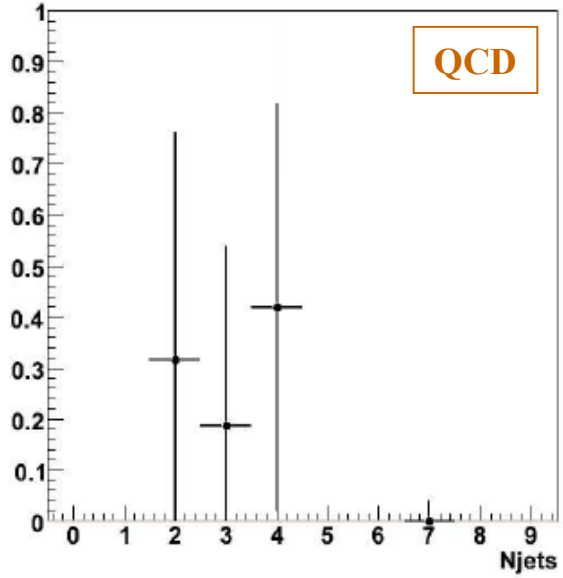
e-e channel



e-e channel

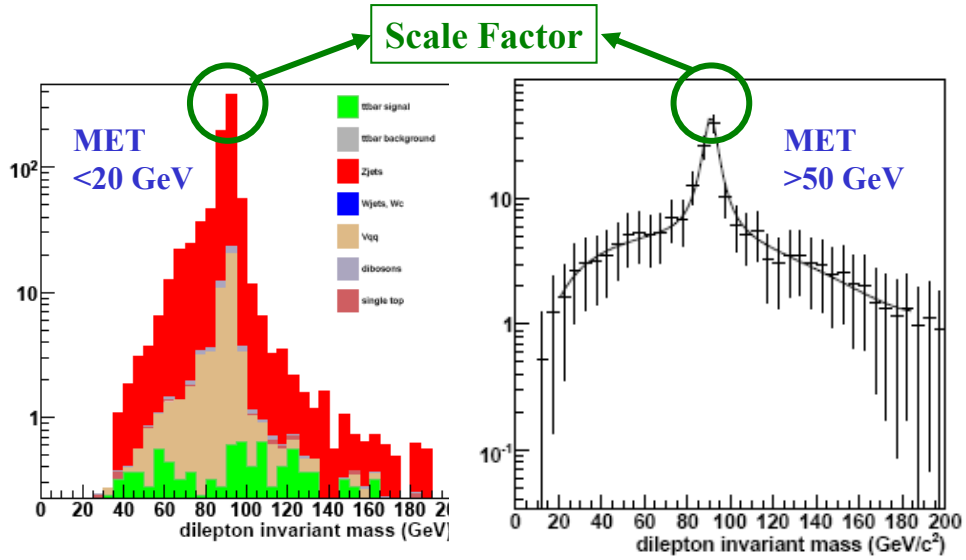


e-e channel



Background estimate: Z+jets

- Select events with a low MET (<20GeV).
- Assumed dominated by Z+jets events.
- Count the number of events outside the Z mass peak N_{tails}.
- Rescale N_{tails}:
  - fit high MET region (>50 GeV) by a polynomial(ttbar signal) + Breit-Wigner (Z peaking background),
  - use the maximum of the BW to calculate the scale factor.
- Total error estimate to be ≈ 30%.



no b-tagging	Predicted	MC truth	statistical errors	scale factor	resolution	total
$e-e$	8.9	8.3	33.6%	13.2%	6.2%	36%
$\mu-\mu$	17.1	14.4	24.1%	4.9%	12.9%	28%

$$N^{out}_{estimated} = \frac{N^{in}_{obs}}{N^{in}_{MC}} \cdot N^{out}_{MC} = N^{in}_{obs} \cdot R_{out/in}$$

Total error conservatively assumed to be 30%.

- Other method: count the number of events inside and outside the Z mass peak cut.
- This ratio is assumed to be the same in data and MC.
- Corrected by the presence of signal event in the Z mass peak region.

Systematic error on the cross section measurement

- Systematic uncertainty on the cross section measurement, for a luminosity of L=10 pb^{-1}:
  - **a** 10% for e-μ and e-e, μ-μ 16% when combined.
  - **c** 40% for e-μ, e-e 38% and μ-μ 37%

Source L=10 pb^{-1}	e^+e^- and $\mu^+\mu^-$	$e^\pm\mu^\mp$
Lepton ID	5%	5%
Lepton isolation	3%	3%
JES	8%	5%
Theory	4%	4%
All without backgrounds	11%	9%
Z/γ^*	10%	N.A.
Fake	4%	4%
MC backgrounds	5%	4%
All w/o $\mathcal{L}$	16%	10%

$$\sigma \times BR = \frac{N_{sel} - N_{bkg}}{\varepsilon_{t\bar{t}} \times \int \mathcal{L}}$$

- For L=100 pb^{-1} and with the use of b-tagging, combining the 3 channels in a single measurement **b**:
  - Asking for at least 1 b-jet :13%.
  - Asking for at least 2 b-jets : 19%.
- B-tagging allow to get a more pure sample (systematic related to background contamination decrease).
- But systematic due to b-tagging efficiency uncertainty appears.

Selection Topologique

Pedrame Bargassa

- Approche topologique & systématique des sélections :
  - Ne pas se limiter à p_T, E_T, Met. Utiliser aussi $\Delta\phi$(lepton/jet,Met), M_T(lepton,Met)...
  - A chaque étape de sélection : Utiliser {variable,coupure} la plus discriminante
- ...Approche systématique ≠ Sur-optimiser les coupures

Example dans l'état final μμ avec optimisation faite versus W/Z+jets

Sélection topologique :

Cut	Ttbar	Z+jets	W+jets		S/B
QC	259 ± 3	51727 ± 144	4.1 ± 1.4		
MET > 80	89. ± 2.	24. ± 3.0	1.4 ± 0.8		
(1,MET)<3	83. ± 2.	13. ± 2.	0.5 ± 0.5		
M( ) ≠ [75,105]	63. ± 2.	3. ± 1.	0.5 ± 0.5	Analyse 1	18
(j1,MET)<2.6	31. ± 1.	0	0	Analyse 2	

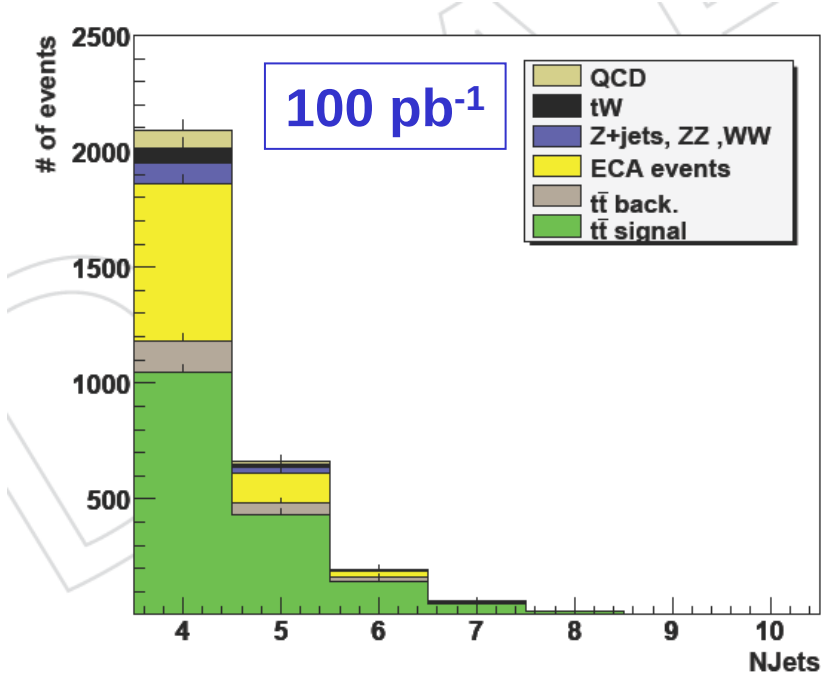
Sélection actuelle :

Cut	Ttbar	Z+jets	W+jets	S/B
All but b-tag	99 ± 2	15 ± 2	0.5 ± 0.5	6.4
b-tag(Jet1/2)	53.1 ± 1.4	0.7 ± 0.5	0	76

Muon+jets channel, W+jets background estimate

Muon+jets channel: event selection

- Event selection (not optimized, just to test the method):
  - 1 isolated muon with p_T > 20 GeV/c (+ veto on other lepton) |η|<2.1,
  - At least 4 jets with p_T > 30 GeV/c, |η|<2.4,
  - No MET nor b-tagging selection.
- About 1700 signal and 1200 background events, dominated by W+jets (≈800 events).
- A MET cut do not improve the S/B ratio.



W+jets bckg estimate: the W charge asymmetry method

- W^+ and W^- cross sections are different at LHC .
- For the single lepton channels, the number of selected events which have a selected lepton (negative charge) is different than the number of selected events which have a selected anti-lepton (positive charge) .
- W+jets background can then be estimated using this charge asymmetry.

$$\frac{N_+ - N_-}{N_+ + N_-} = \frac{\varepsilon_+ A_+ L\sigma_+ - \varepsilon_- A_- L\sigma_-}{\varepsilon_+ A_+ L\sigma_+ + \varepsilon_- A_- L\sigma_-} = \frac{A_+\sigma_+ - A_-\sigma_-}{A_+\sigma_+ + A_-\sigma_-}$$

Assuming that $\varepsilon_+ = \varepsilon_-$

- Where $N_+(N_-)$ is the number of selected W events with a positive (negative) charged lepton, ε_+ (ε_-) are the global reconstruction + selection efficiencies, L is the integrated luminosity and $\sigma_+(\sigma_-)$ the $W_+(W_-)$ cross section and $A_+(A_-)$ acceptance.

$$(N_+ + N_-)_{data} = \frac{A_+\sigma_+ + A_-\sigma_-}{A_+\sigma_+ - A_-\sigma_-}(N_+ - N_-)_{data}$$

Where (N_+-N_-) is estimated from data!

$R_\pm$ from Monte-Carlo gen.+sim.+reco.

Results

- Systematic uncertainties on $R_{\pm}$:
  - PDF uncertainty (weight method + master formula), dominant,
  - Contamination of WZ, Vqq, single top (s and t),
  - Jet Energy Scale (shift of 10%),
  - Jet Energy Resolution (smeared by 10%),

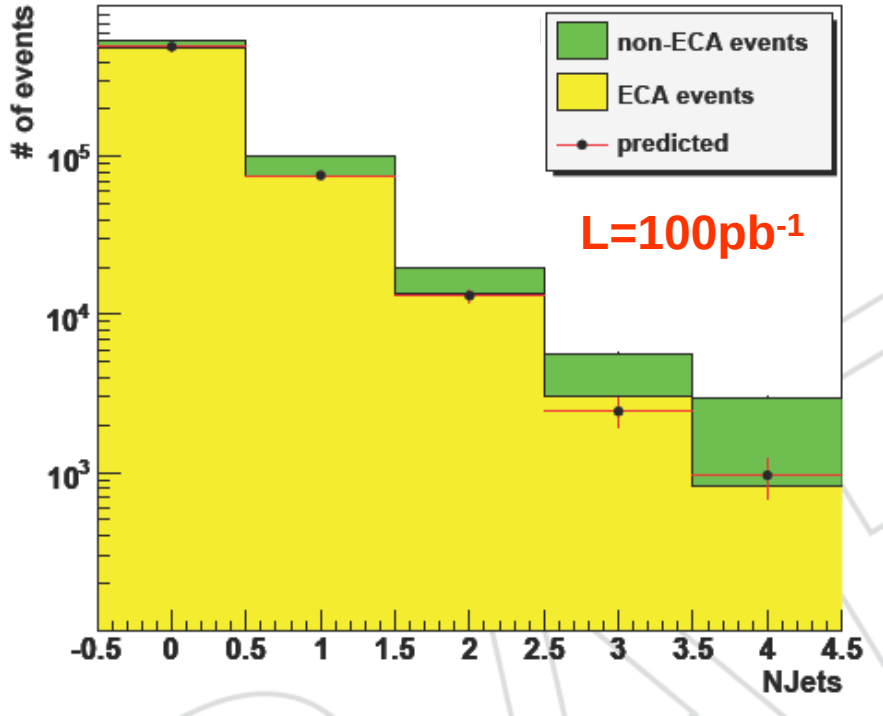
- Closure test: using a number of events equivalent to L=100pb^{-1}.

- Total uncertainty for $N_{jets}\geq 4$ of ≈30% , dominated by statistical error and PDFs uncertainty.

- For L=1 fb^{-1}, total uncertainty of about 15%.

- For low jet multiplicities, total uncertainty ≈7% (could be use for a W cross section measurement?)

Jet multiplicity	0	1	2	3	≥ 4
Data stat. L=100pb^{-1}	0.8	2.2	5.5	15.2	26.0
Monte-Carlo stat. $L_{eff}(W) = 114\text{pb}^{-1}$	0.7	1.7	4.1	8.3	14.4
Monte-Carlo stat. $L_{eff}(W) = 10 \times 114\text{pb}^{-1}$	0.2	0.5	1.3	2.6	4.6
Syst. uncertainty	7.1	6.5	8.1	13.7	10.7
Total uncertainty $L_{eff}(W) = 114\text{pb}^{-1}$	7.1	7.5	10.6	22.1	31.7
Total uncertainty $L_{eff}(W) = 10 \times 114\text{pb}^{-1}$	7.0	7.3	9.9	20.7	28.6



Conclusion

- Top di-lepton analyzes with fall08 sample pre-approved on the May the 19th. PAS TOP-09-002.
- First tests of a selection tuning procedure + topological variables.

- W+jets background estimate in a muon+jets selection: is starting the approval process PAS TOP-09-006.

- Top physics and commissioning (Top.Com):
  - Commissioning group for top PAG is being set-up and top representatives to the PVT groups were nominated.
  - Short term goal: validation of the pre-production of CMSSW_3_1_X release.
  - Long term goal: define a set of relevant variables and selections to get enough information to validate data/MC for analyzes.

Backups

Dilepton b) cut flow (1)

Applied cuts	$t\bar{t}$ signal	$t\bar{t} \to \tau\tau$	$t\bar{t}$ bkg	Z+jets	W+jets	Vbb
Triggers+Presel. + tight lepton iso.	237.9 ± 2.5	1.0 ± 0.2	8.2 ± 0.6	43396.4 ± 118.9	37.1 ± 4.2	1737.9 ± 7.4
+inv. mass cut	172.2 ± 2.3	0.6 ± 0.2	6.4 ± 0.6	1269.6 ± 21.5	4.2 ± 1.4	59.4 ± 1.4
+number of jets	131.0 ± 2.1	0.4 ± 0.2	4.8 ± 0.5	103.7 ± 6.2	3.3 ± 1.3	4.7 ± 0.4
+$\not\!\!E_T$cut	87.9 ± 1.8	0.3 ± 0.1	2.9 ± 0.4	8.0 ± 1.7	0.9 ± 0.6	0.3 ± 0.1
+1 b-tag cut	81.5 ± 1.7	0.3 ± 0.1	2.6 ± 0.4	2.9 ± 1.0	0 ± 0	0.2 ± 0.1
+2 b-tag cut	48.8 ± 1.4	0.2 ± 0.1	1.6 ± 0.3	0 ± 0	0 ± 0	0.1 ± 0.1

Applied cuts	WZ	WW	$ZZ2l2\nu$	$ZZ4l$
Triggers+Presel + tight lepton iso.	36.6 ± 0.7	30.7 ± 0.5	4.9 ± 0.1	2.4 ± 0.1
+inv. mass cut	11.7 ± 0.4	2.0 ± 0.2	0.4 ± 0.1	0.5 ± 0.1
+number of jets	0.9 ± 0.2	1.7 ± 0.2	0.1 ± 0.1	0.2 ± 0.1
+$\not\!\!E_T$cut	0.3 ± 0.1	0.9 ± 0.1	0.1 ± 0.1	0.1 ± 0.1
+1 b-tag cut	0.1 ± 0.1	0.4 ± 0.1	0.1 ± 0.1	0.1 ± 0.1
+2 b-tag cut	0 ± 0	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1

Applied cuts	tW	t-channel	s-channel	QCD	Total backgrounds	S/B
Triggers+Presel + tight lepton iso.	25.2 ± 0.8	1.6 ± 0.2	0.4 ± 0.1	819.5 ± 765.9	46100.9 ± 998.8	0.005
+inv. mass cut	8.2 ± 0.5	0.4 ± 0.1	0 ± 0	0 ± 0	1362.8 ± 20.8	0.13
+number of jets	6.4 ± 0.5	0.4 ± 0.1	0 ± 0	0 ± 0	126.2 ± 6.4	1
+$\not\!\!E_T$cut	4.1 ± 0.4	0.4 ± 0.1	0 ± 0	0 ± 0	23.3 ± 2.5	3.7
+1 b-tag cut	3.5 ± 0.3	0.2 ± 0.1	0 ± 0	0 ± 0	10.2 ± 1.5	8.0
+2 b-tag cut	1.2 ± 0.2	0.2 ± 0.1	0 ± 0	0 ± 0	3.2 ± 0.6	14.4

Table 9: Expected number of signal and background events passing the different cumulated selection criteria for the ee-channel for an integrated luminosity of 100 pb^{-1}, for which around 700 ee events are expected. The $t\bar{t}$ signal numbers include $\tau \to e$ decay. The contribution of $t\bar{t} \to \tau\tau \to ee$ is also given here. The important yield for QCD events is due to the high scale factor; there are only three events passing the preselection.

Dilepton b) cut flow (2)

Applied cuts	$t\bar{t}$ signal	$t\bar{t} \to \tau\tau$	$t\bar{t}$ bkg	Z+jets	W+jets	Vbb
Triggers+Presel + tight lepton iso.	276.7 ± 2.6	1.4 ± 0.3	1.9 ± 0.3	50501.7 ± 127.7	4.2 ± 1.4	2035.2 ± 8.0
+invariant mass cut	207.3 ± 2.4	1.0 ± 0.2	1.7 ± 0.3	1781.9 ± 25.4	0.5 ± 0.5	97.8 ± 1.8
+number of jets	158.3 ± 2.2	0.8 ± 0.2	1.3 ± 0.3	187.5 ± 8.3	0.5 ± 0.5	11.9 ± 0.7
+$\not\!\!E_T$ cut	106.5 ± 1.9	0.5 ± 0.2	1.1 ± 0.3	13.8 ± 2.3	0.5 ± 0.5	0.6 ± 0.2
+1b-tag cut	98.7 ± 1.9	0.5 ± 0.2	0.9 ± 0.2	6.2 ± 1.5	0 ± 0	0.4 ± 0.2
+2b-tag cut	57.6 ± 1.5	0.3 ± 0.1	0.5 ± 0.1	0.8 ± 0.6	0 ± 0	0.1 ± 0.1

Applied cuts	WZ	WW	$ZZ2l2\nu$	$ZZ4l$
Triggers+Presel + tight lepton iso.	43.1 ± 0.8	36.2 ± 0.5	5.8 ± 0.1	2.8 ± 0.1
+invariant mass cut	14.3 ± 0.5	3.1 ± 0.2	0.5 ± 0.1	0.6 ± 0.1
+number of jets	1.4 ± 0.2	2.4 ± 0.2	0.1 ± 0.1	0.2 ± 0.1
+$\not\!\!E_T$ cut	0.3 ± 0.1	1.5 ± 0.1	0.1 ± 0.1	0.1 ± 0.1
+1b-tag cut	0.1 ± 0.1	0.5 ± 0.1	0.1 ± 0.1	0.1 ± 0.1
+2b-tag cut	0 ± 0	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1

Applied cuts	tW	t-channel	s-channel	QCD	Total backgrounds	S/B
Triggers+Presel + tight lepton iso.	26.5 ± 0.8	0.6 ± 0.1	0 ± 0	0 ± 0	52658.2 ± 127.8	0.005
+invariant mass cut	11.1 ± 0.7	0.4 ± 0.1	0 ± 0	0 ± 0	1911.9 ± 25.5	0.11
+number of jets	8.8 ± 0.6	0.2 ± 0.1	0 ± 0	0 ± 0	214.1 ± 8.4	0.74
+$\not\!\!E_T$ cut	5.9 ± 0.5	0.2 ± 0.1	0 ± 0	0 ± 0	24.1 ± 2.5	4.4
+1b-tag cut	5.1 ± 0.4	0.2 ± 0.1	0 ± 0	0 ± 0	14.1 ± 1.8	7.0
+2b-tag cut	1.7 ± 0.2	0 ± 0	0 ± 0	0 ± 0	3.4 ± 0.7	16.5

Table 10: The tables give the expected number of signal and background events passing the different cumulated selection criteria for the $\mu\mu$-channel for an integrated luminosity 100 pb^{-1} , for which around 700 $\mu\mu$ events are expected. The $t\bar{t}$ signal numbers include $\tau \to \mu$ decay. The contribution of $t\bar{t} \to \tau\tau \to \mu\mu$ is also given here.

Dilepton b) cut flow (3)

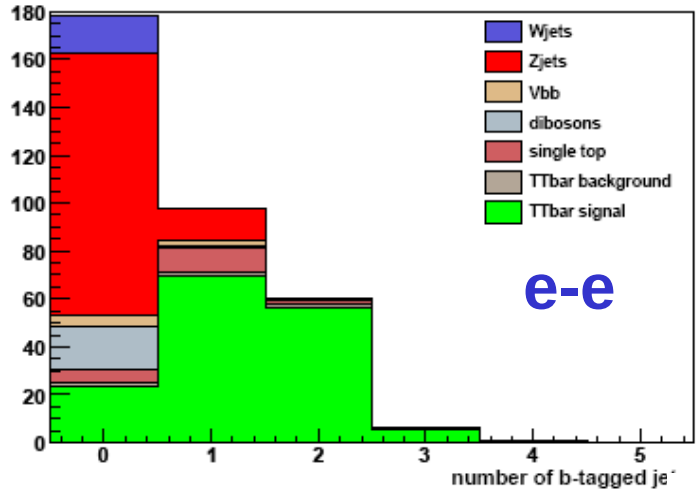
Applied cuts	$t\bar{t}$ signal	$t\bar{t} \to \tau\tau$	$t\bar{t}$ bkg	Z+jets	W+jets	Vbb
Triggers + Presel. + tight lepton iso.	516.2 ± 3.6	1.5 ± 0.3	11.6 ± 0.7	295.5 ± 10.4	54.2 ± 5.1	13.6 ± 0.7
+number of jets	378.7 ± 3.3	0.9 ± 0.2	9.5 ± 0.6	13.5 ± 2.3	7.0 ± 1.8	0.8 ± 0.2
+$\not\!\!E_T$cut	326.9 ± 3.2	0.9 ± 0.2	8.1 ± 0.5	8.8 ± 1.8	6.1 ± 1.7	0.3 ± 0.1
+1b-tag cut	302.3 ± 3.1	0.9 ± 0.2	7.1 ± 0.5	1.9 ± 0.9	1.2 ± 0.7	0.3 ± 0.1
+2b-tag cut	176.5 ± 2.5	0.7 ± 0.2	3.9 ± 0.4	0.8 ± 0.6	0 ± 0	0.1 ± 0.1

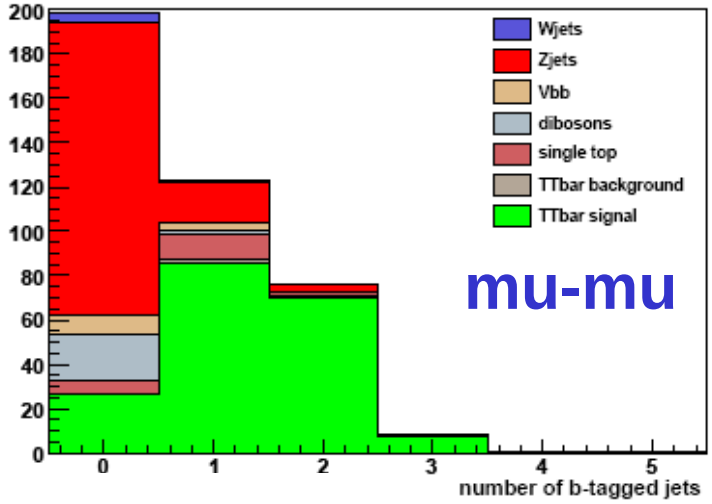
Applied cuts	WZ	WW	$ZZ2l2\nu$	$ZZ4l$
Triggers + Presel. + tight lepton iso.	5.2 ± 0.3	67.5 ± 0.7	0.1 ± 0.1	0.9 ± 0.1
+number of jets	0.8 ± 0.1	4.8 ± 0.2	0.1 ± 0.1	0.2 ± 0.1
+$\not\!\!E_T$cut	0.6 ± 0.1	3.8 ± 0.2	0.1 ± 0.1	0.1 ± 0.1
+1b-tag cut	0.2 ± 0.1	1.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1
+2b-tag cut	0.1 ± 0.1	0.3 ± 0.1	0 ± 0	0.1 ± 0.1

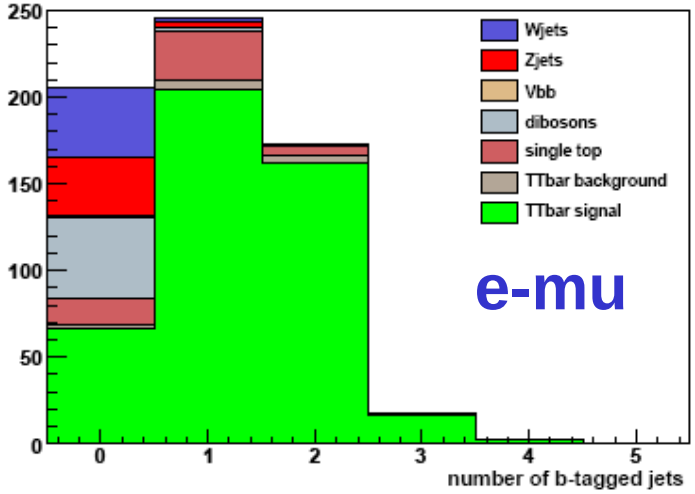
Applied cuts	tW	t-channel	s-channel	QCD	Total backgrounds	S/B
Triggers+Presel. + tight lepton iso.	53.4 ± 1.3	2.8 ± 0.3	0.2 ± 0.2	0 ± 0	505.0 ± 11.7	1.0
+number of jets	19.5 ± 0.8	1.0 ± 0.2	0.2 ± 0.2	0 ± 0	57.4 ± 2.9	6.7
+$\not\!\!E_T$cut	16.5 ± 0.7	0.8 ± 0.2	0.2 ± 0.2	0 ± 0	45.4 ± 2.6	7.2
+1b-tag cut	14.3 ± 0.6	0.8 ± 0.2	0.2 ± 0.2	0 ± 0	27.3 ± 1.3	11.1
+2b-tag cut	5.4 ± 0.4	0.4 ± 0.1	0.2 ± 0.2	0 ± 0	11.2 ± 0.5	15.7

Table 11: The tables give the expected number of signal and background events passing the different cumulated selection criteria for the $e\mu$-channel. The $t\bar{t}$ signal numbers already include $\tau \to e/\mu$ decay for an integrated luminosity of 100 pb^{-1}, for which around 1400 events are expected. The contribution of $t\bar{t} \to \tau\tau \to e\mu$ is also given here.

B-tagged jets multiplicity







Muon+jets cut flow

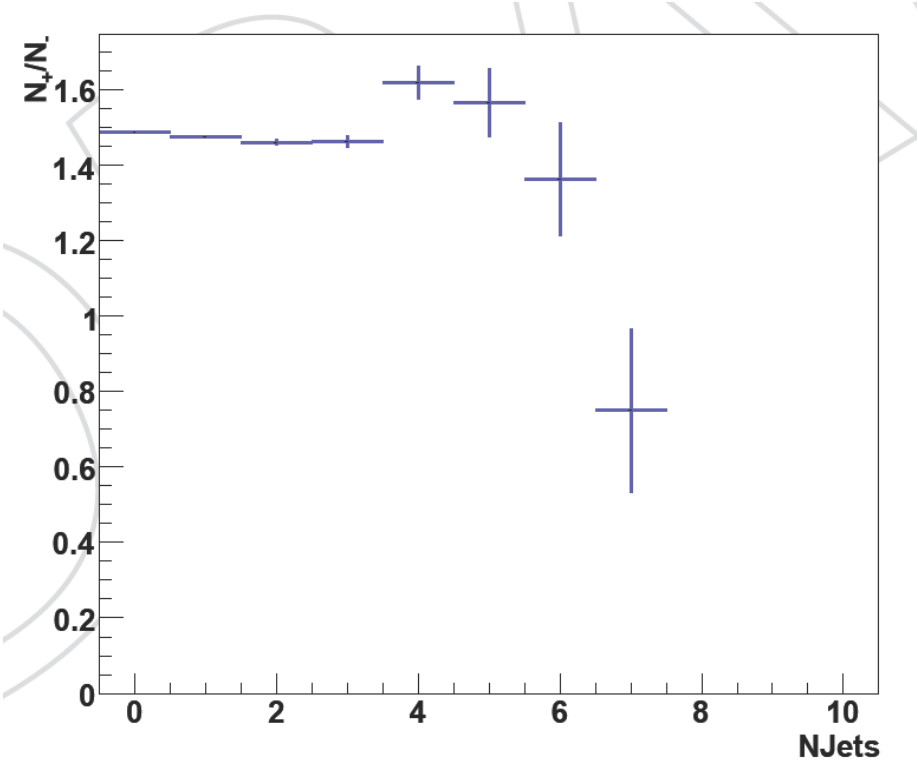
- signal events
- events with charge asymmetry (ECA), dominated by W+jets events.

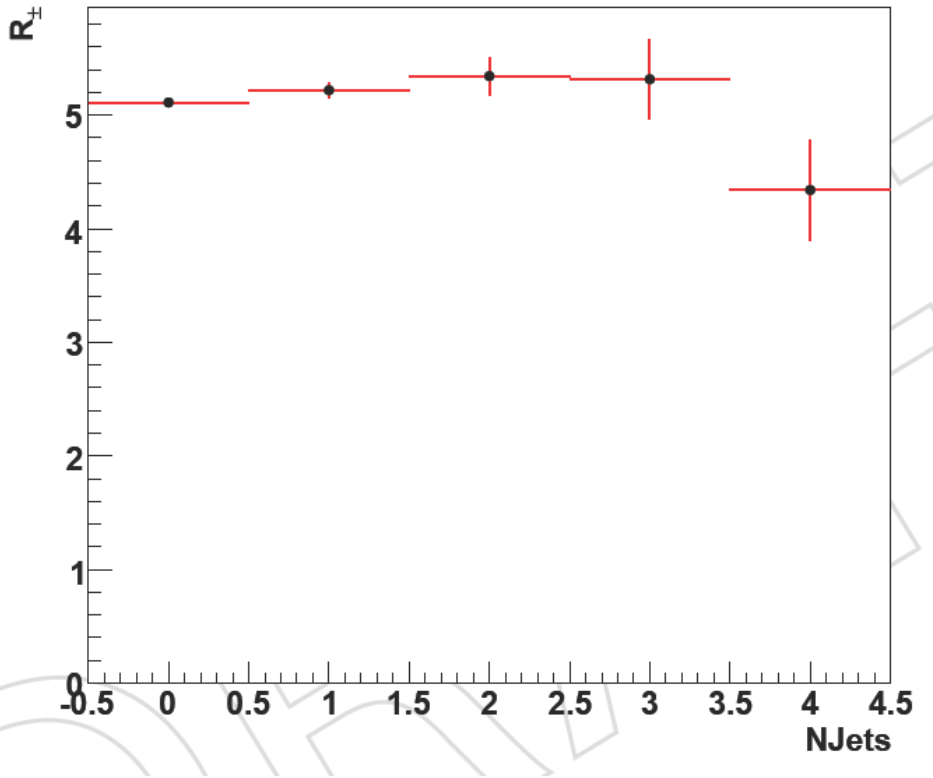
Applied cuts	$t\bar{t}$ signal	$t\bar{t}$ bkg	Z+jets	W+jets	Vqq
muon p_T, $\|\eta\|$ + trig.	4559.6 ± 5.5	3570.9 ± 10	95777.0 ± 163.9	654985.0 ± 506.3	6791.0 ± 13.3
muon isolation	3538.6 ± 7.2	1657.5 ± 7.7	88880.5 ± 159.5	572978 ± 478.5	6114.9 ± 12.8
electron rej.	3536.0 ± 7.2	1279.8 ± 6.9	88678.6 ± 159.4	572931 ± 478.5	6105.5 ± 12.8
only 1 muon	3535.6 ± 7.2	1068.3 ± 6.4	51436.3 ± 128	572929 ± 478.5	4559.8 ± 11.4
≥ 4 jets	1696.6 ± 7	200 ± 2.9	120 ± 6.6	795.7 ± 19.1	5.2 ± 0.5

Applied cuts	WZ	WW	$ZZ2l2\nu$	$ZZ4l$
muon p_T, $\|\eta\|$ + trig.	262.7 ± 1.8	237.9 ± 1.1	10.8 ± 0.1	5.6 ± 0.1
muon isolation	223.0 ± 1.7	212.3 ± 1	10.1 ± 0.1	5.3 ± 0.1
electron rej.	214.3 ± 1.7	166.5 ± 1	10.1 ± 0.1	3.7 ± 0.1
only 1 muon	181.7 ± 1.6	140.7 ± 0.9	5.6 ± 0.1	1.8 ± 0.1
≥ 4 jets	5.7 ± 0.3	1.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1

Applied cuts	tW	t-channel	s-channel	ppMuX
muon p_T, $\|\eta\|$ + trig.	516.0 ± 3.2	954.7 ± 4.2	44.7 ± 0.7	$3.15757e+06 \pm 1529.1$
muon isolation	377.3 ± 2.8	763.5 ± 3.8	32.1 ± 0.7	44728.1 ± 211.2
electron rej.	345.2 ± 2.8	763.1 ± 3.8	32.1 ± 0.7	44718.4 ± 211.1
only 1 muon	328.7 ± 2.7	763.0 ± 3.8	32.1 ± 0.7	44718.4 ± 211.1
≥ 4 jets	59.9 ± 1.2	28.5 ± 0.8	1.4 ± 0.3	97.6 ± 9.9

Rpm


N+/N-
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
NJets


R±
5
4
3
2
1
0
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
NJets

Rpm (2)