Measurement of Top Pair Production with the ATLAS Detector

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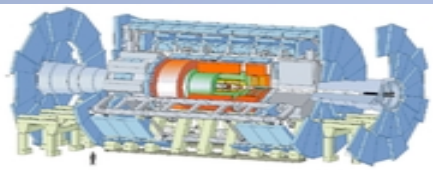
For the ATLAS collaboration

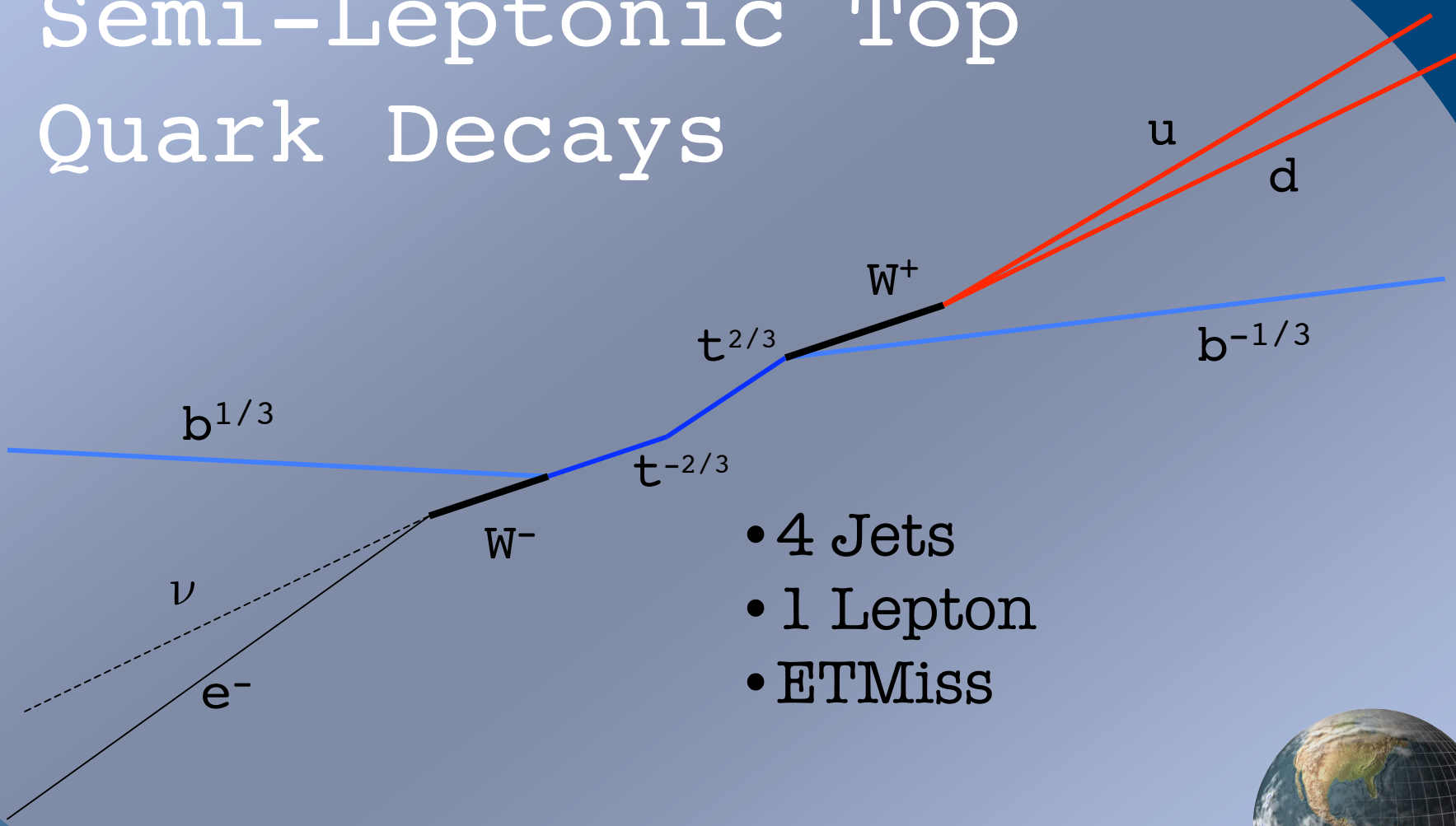
the ATLAS Experiment



Commissioning ATLAS with Top Quarks

- Top Pair X-section is large at the LHC (830 pb +- 100pb)
- Semi-Leptonic Tops have final states consisting of Jets, Leptons, Missing ET
  - Measuring Top Quarks involves all the major components of the ATLAS detector
- If we can obtain a reasonable (20% ?) Top X-section measurement with the first good dataset (100 pb-1) then ATLAS will be in excellent shape
  - The measurement represents a major stepping stone to new physics
- Need an analysis which does NOT necessarily
  - rely on b-tagging
  - rely on a precise understanding of the Jet Energy scale
- Today present the results of the ATLAS Top pair X-section Commissioning Analysis which will appear as an ATLAS CSC (Computer System Commissioning) note
- Will discuss how new physics affects the X-section

Semi-Leptonic Top Quark Decays



- 4 Jets
- 1 Lepton
- ETMiss

Commissioning ATLAS with Top

- Selection A: “Commissioning Analysis”:
  - Analyse Semi-Electronic TTBar channel
  - Electron Trigger (e25i) L1, L2, EF
  - $P_T(e,\nu) > 20$ GeV
  - 3 jets with $P_T > 40$ GeV
  - A 4^{th} jet with $P_T > 20$ GeV
  - $|\eta(\text{lep})| < 2.5$, $|\eta(\text{jet})| < 2.5$
  - Top reconstructed as the 3-jet combination with highest vector sum PT

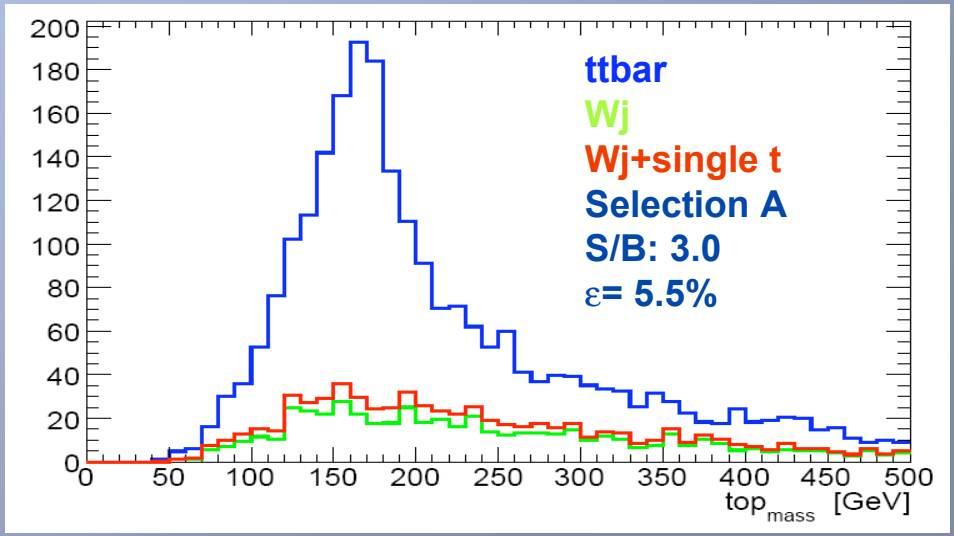
- Selection B: A plus W-mass cut:
  - Require that of the 3-jets there is a pair whose mass is within 10 GeV of W-mass

Commissioning ATLAS with Top

- Author: e-gamma
- 'medium' (isem & 0x3FF =0)
- pT > 20 GeV/c
- $|\eta| < 2.5$
- 1:37 < $|\eta|$ < 1:52 excluded
- ETcone20 < 6 GeV

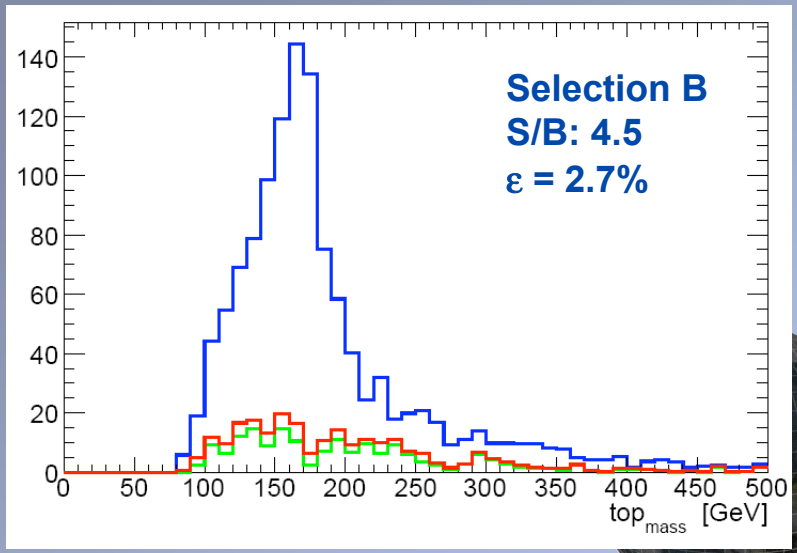
- Cone 0.4 Tower Jets
- pT > 20 GeV/c
- $|\eta| < 2.5$
- ΔR (jet, μ or e) > 0.4

Summary Plots and Results



Top peak is **clearly** visible above the major backgrounds with 100 pb^{-1} of data !

	X-sec (pb)
Sel A	860.0±2.5%
Sel B	814.1±3.4%



Method and Samples

$$\sigma_{ttbar} = \frac{N_{S+B} - N_B}{A\varepsilon \int dtL}$$

- Method Used: Counting Experiment. No need to rely on shapes of kinematical distributions.

- Used two sets of Monte Carlo Samples, D and M
  - Sample D represents "DATA"
  - Sample M represents "Monte Carlo"
  - Both D and M include the TTBar signal plus the major backgrounds to it
  - D is used to obtain N_{S+B}
  - M is used to obtain A, ε, and N_B

- ALL Samples considered are Full Simulation and are thoroughly validated by ATLAS

D and M Samples used

- TTBar samples: MC@NLO and ACERMC
  - different MC's give estimate of MC uncertainties
-
- W+Jets: Alpgen, Herwig, Pythia
- Z+Jets: Alpgen, Herwig, Pythia
- Single Top: MC@NLO and ACERMC
- New Physics: Pythia

- Normalisation of W+Jets Background

- Use the Ratio of W and Z X-sections:

$$\frac{\sigma(W)}{\sigma(W+nj)} \sim \frac{\sigma(Z)}{\sigma(Z+nj)}$$

Measure from Data

- We have considered the effect of different W normalisations.

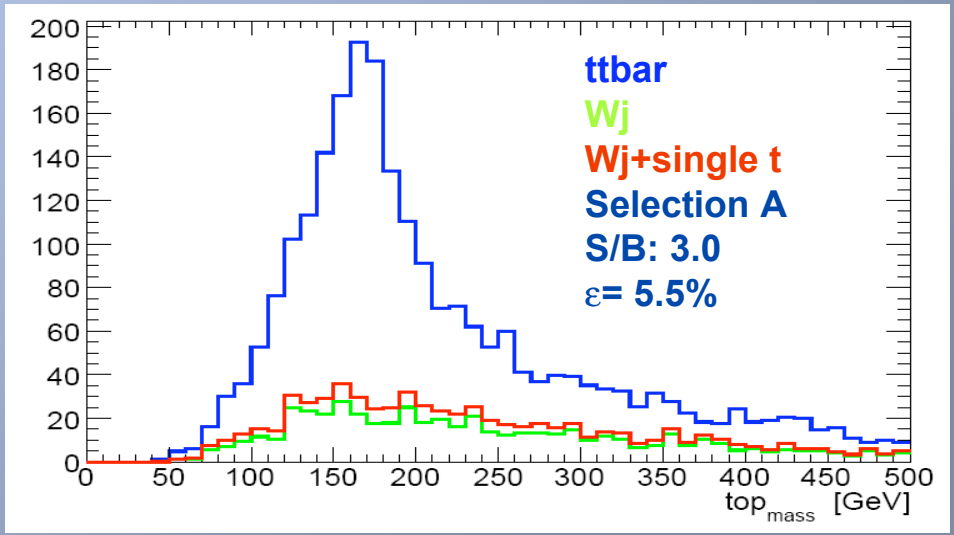
Summary of electron analysis

sample	No W cut	W cut
TTbar	**2532,3**	**1244.3**
Zee+jets	**67.9**	**21,7**
Zττ+jets	**19.3**	**5.0**
Zμμ+jets	**-**	**-**
Single top (t-channel)	**100.4**	**27.4**
Single top (s.channel)	**1.4**	**0.3**
Single top Wt	**65.9**	**35.5**
W+jets	**582.8**	**173.6**
Total Bkgd	**837.7**	**263.5**

	S/B	Aε(%)
Sel A	3	5,5
Sel B	4.7	2,7

$L = 100\ pb^{-1}$

Distributions with all backgrounds



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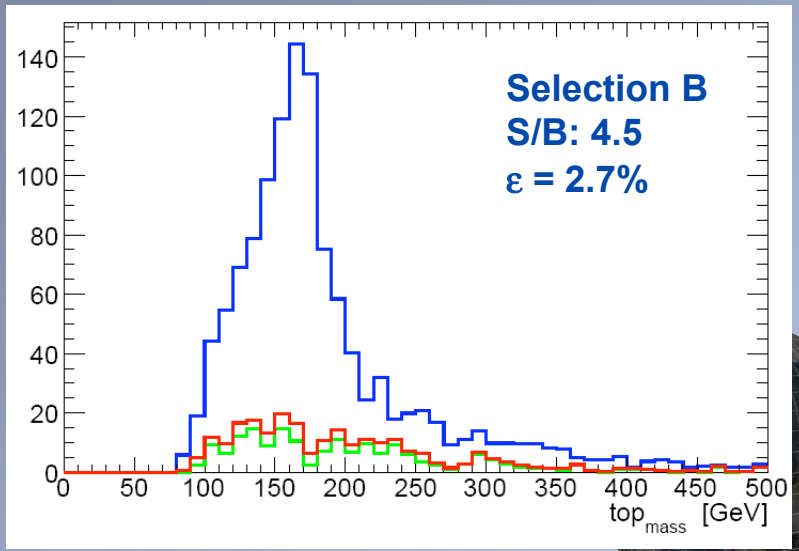


New Physics Background to TTBar

- *Many* models of new physics (Susy, Xtra dim, Technicolor, little Higgs, ……)
- Most reasonable models have *significant top activity*
  - New Particles with strong couplings to Top Quarks
  - Usually to cancel the Higgs Mass Divergence from Top
- How can we evaluate their impact?
  - Strategy: Consider what is possibly the worst case scenario:
    - A new particle which decays exclusively into Top Pairs
    - This is the case which we can expect will have the largest background to ttbar
    - X-section for new physics typically a few pb
    - ~ 500 events in 100 pb-1
    - High trigger rate
    - Standard Model gives ~ 2500 of ttbar signal events after selection A, so in principle new physics can be significant for the x-section measurement

Simulation of New Physics

- Want a full simulation sample with X -> ttbar

- Can use Z' -> ttbar samples
  - CSC sample 1TeV Z' -> ttbar
  - Note: the actual x-section for this is 0.19pb, but this assumes that Z' decays into all the other fermions.
  - The worst case scenario is a particle which decays exclusively into ttbar.
  - So we can rescale the x-section of this sample to a nominal 5pb to take this into account.
  - 500 events in 100 pb-1

Z' Efficiencies Compared to TTbar %

Sample	L1_EM25	L2_e25i	EF_e25i	Sel A	Sel B
TTBar	38.29	25.83	22.25	5.51	2.68
Z' 1TeV	36.43	26.83	23.40	10.07	4.08

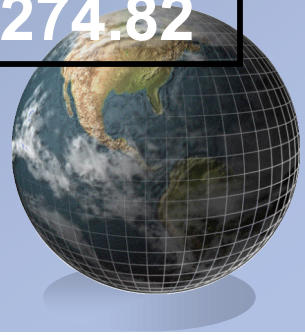
- Trigger efficiency similar
- Higher acceptance due to higher jet/lepton PT's

Results

sample	L1_e25	L2_e25i	EF_e25i
TTBar	38.13 %	25.75 %	22.17 %
Z' 1TeV	36.43 %	26.83 %	23.40 %

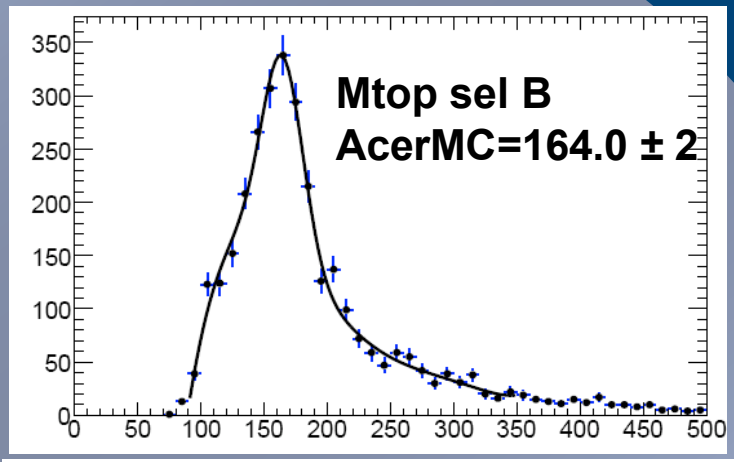
Very Small Effect →
-- 1% or so

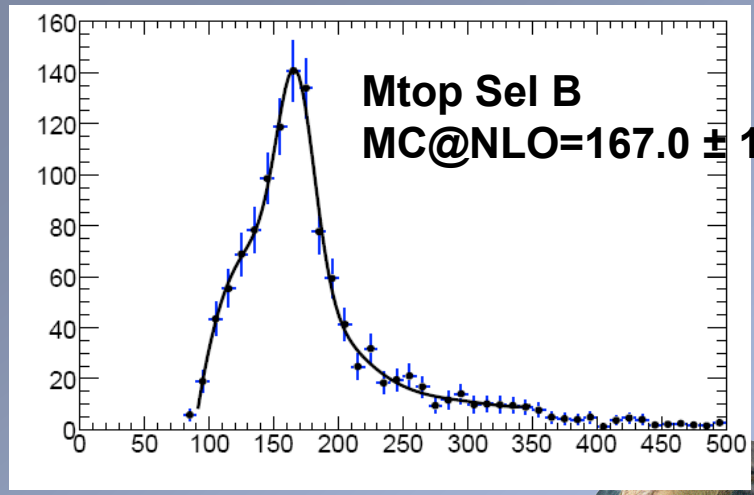
sample	No W cut	W cut
TTbar	2532,3	1244.3
Zee+jets	67.9	21,7
Zττ+jets	19.3	5.0
Zμμ+jets	-	-
Single top (t-channel)	100.4	27.4
Single top (s.channel)	1.4	0.3
Single top Wt	65.9	35.5
W+jets	582.8	173.6
Z' 1TeV	28.0	11.32
Total B	865.7	274.82



AcerMC vs MC@NLO

	MC@NLO (%)	AcerMC (%)
Trig 1	38.1	37.6
Trig 2	25.8	25.7
Trig 3	22.2	22.2
Lept sel	17.0	17.3
MET	15.5	15.7
4jets>20	7.7	8.3
3jets>40	5.5	6.2
Wmass	2.7	2.85





Syst. error on the efficiencies sel A 12%, sel B 5%

Statistical and systematic Uncertainties on x-sec

source	Sel A Systematic (%)	Sel B Systematic (%)
$\Delta\sigma/\sigma$ (stat)	2.4%	3.2%
$\Delta\sigma/\sigma$ W+jets norm	7.8%	4.3%
$\Delta\sigma/\sigma$ JES(+5%)	0.7%	0.2%
MC systematic	12%	5%
$\Delta L/L$ luminosity	20%	20%
Total	(22.9 + 20)%	(12.7+ 20)%

Note: can use Z --> ee or μ,μ to estimate L much better than 20%

Conclusions and Outlook

- Top Physics is a major stepping stone between commissioning and new physics
- Have developed a simple early analysis strategy for commissioning ATLAS with Top Pairs, based on the isolated electron or muon triggers

- Have estimated all the major backgrounds (except QCD multijet, which is almost done) including new physics, which we showed to be negligible for the standard model TTbar cross-section (at least for resonances decaying to Ttbar)

Conclusions and Outlook

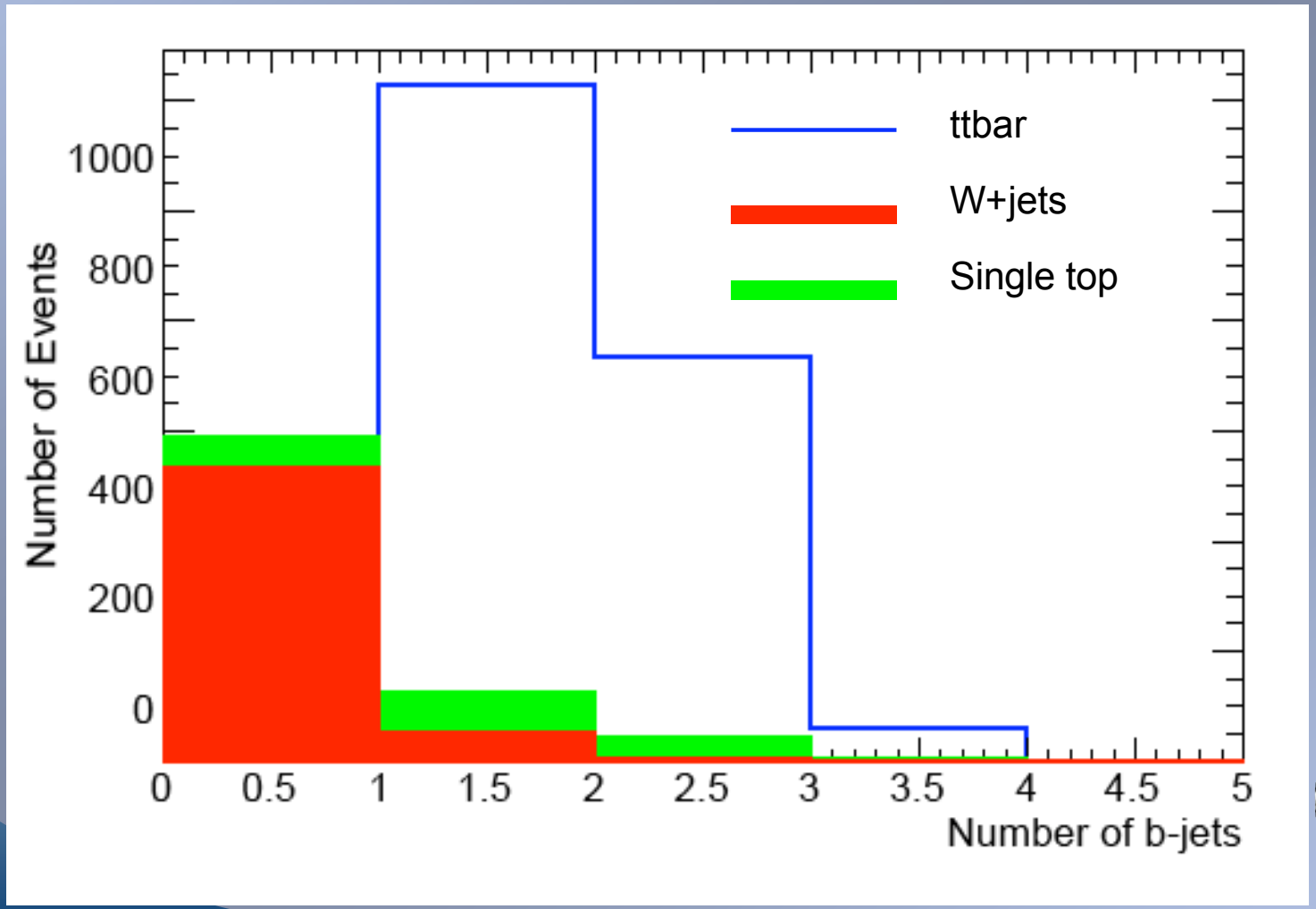
- Improve W+Jets normalisation?
- Develop a commissioning analysis without Missing ET ?
  -- If this works, can use a top rich data sample to Commission Missing ET

- Analyse the possibility for detecting new physics (eg resonances decaying to tops) with the very early data

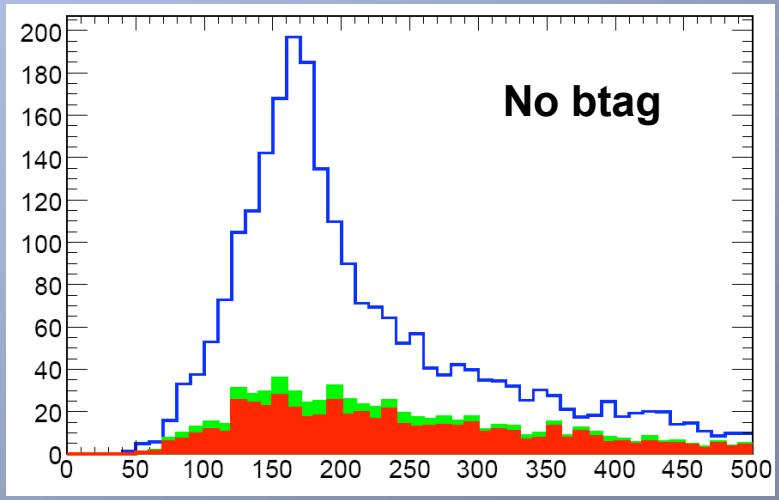
Backup

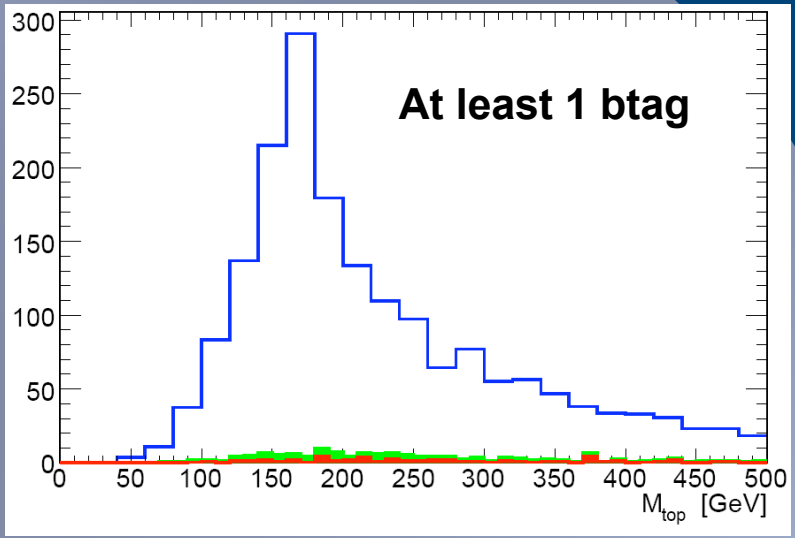
Optimistic Case: With b-tagging

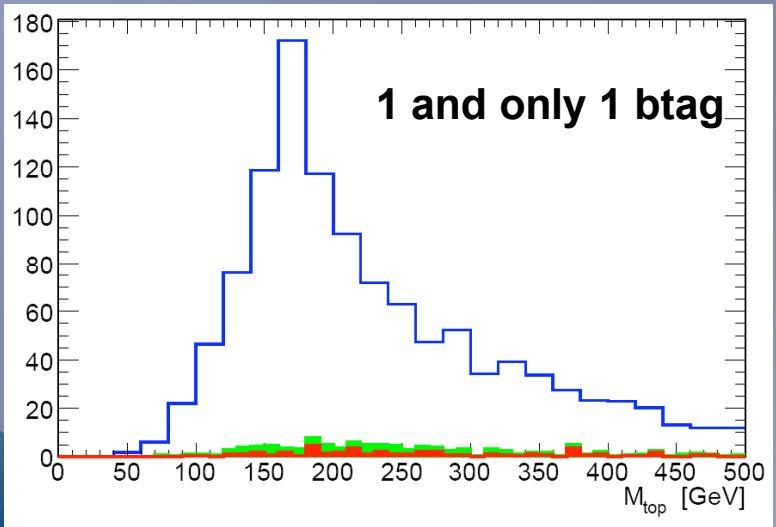
How does this analysis change with b-tagging?

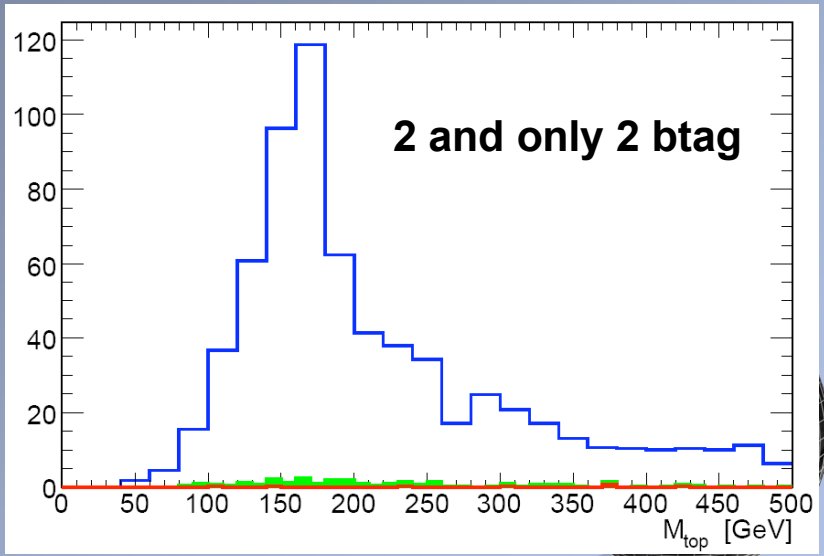


Mtop Selection A

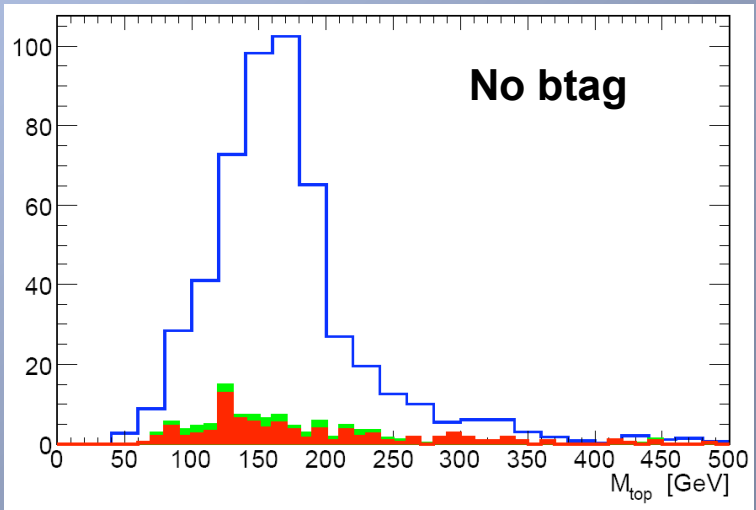


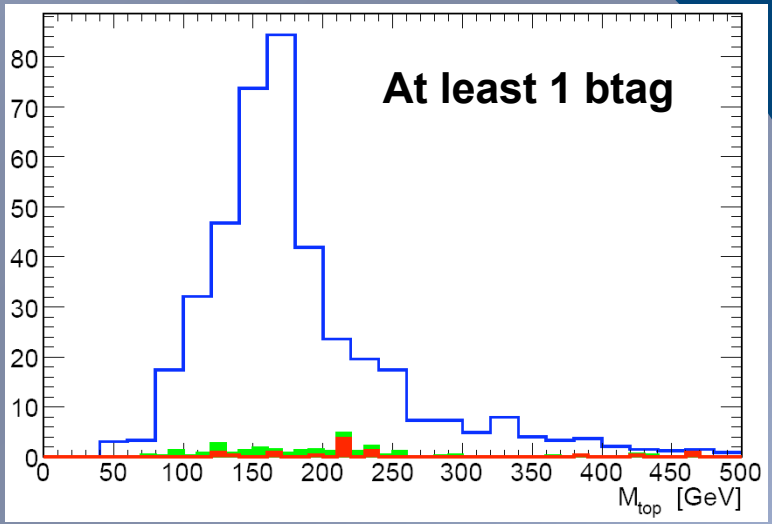


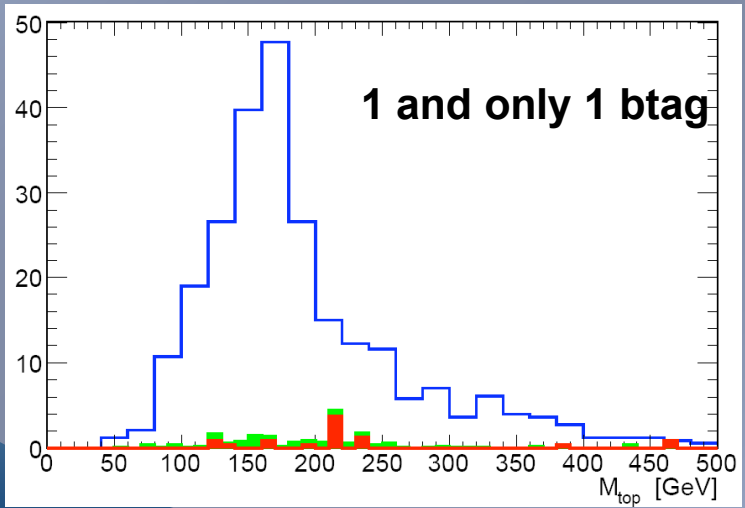


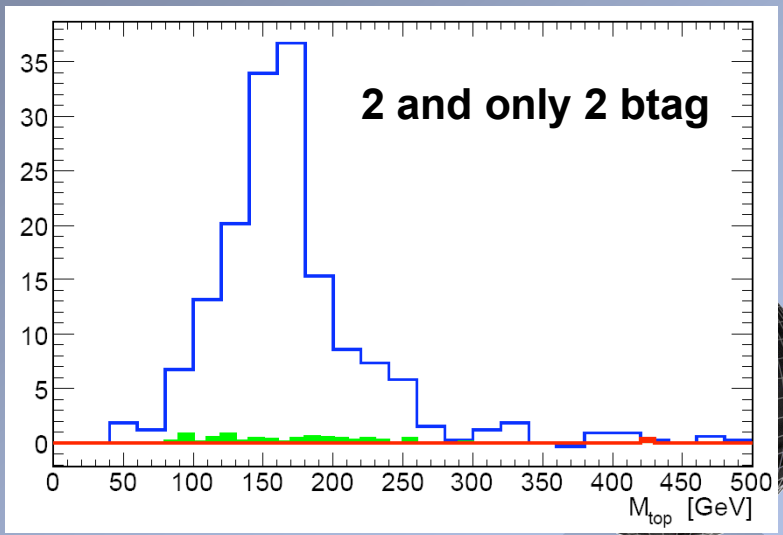


Mtop with central jets, Sel A

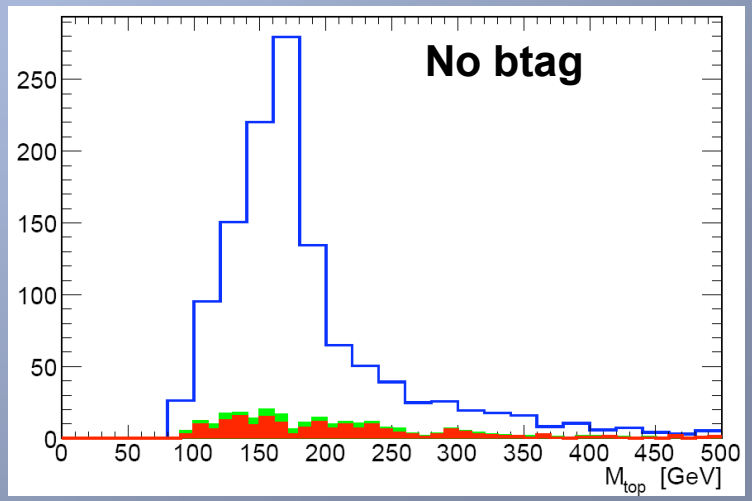


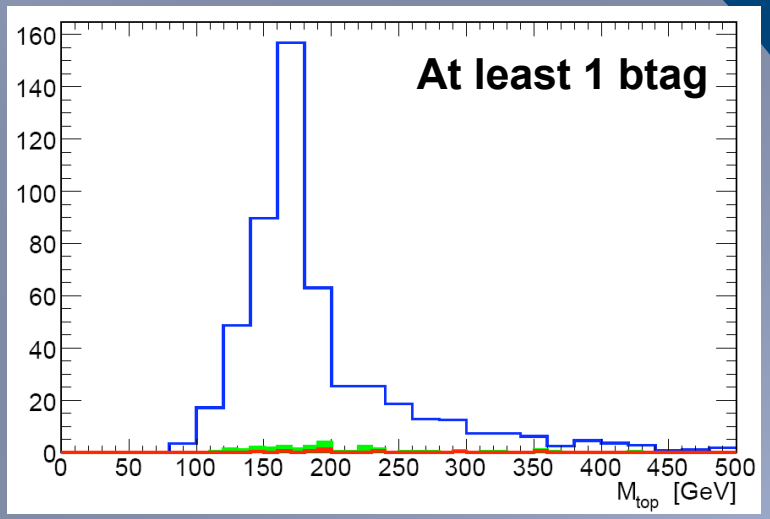


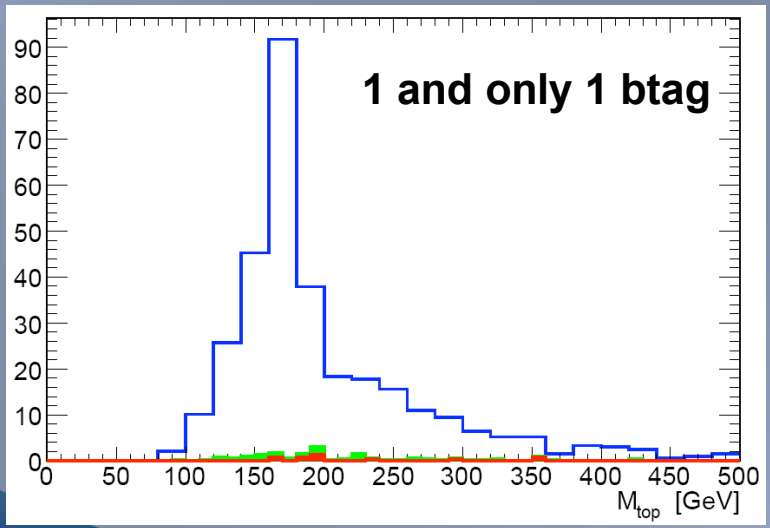


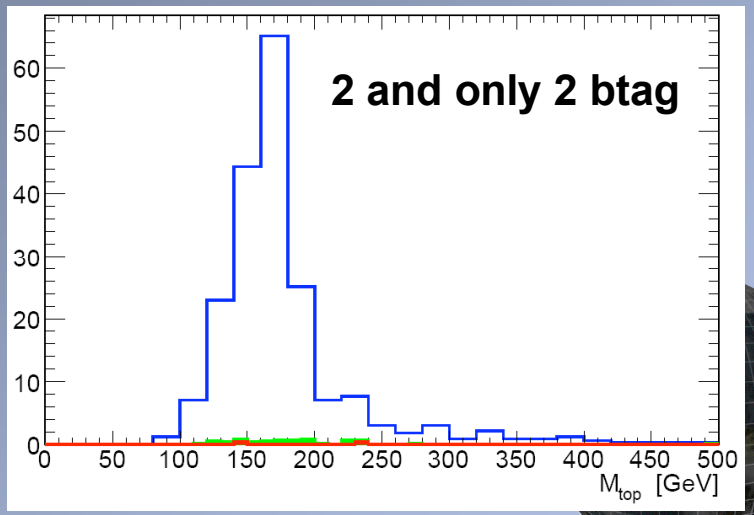


Mtop, Selection B









Effects of requiring a b-tag, Sel A

	N_{top}	N_{w+jets}	N singletop	N_{Z+jets}	S/B	ε(%)
No b-tag	2538.2	591,3	169,2	87,2	3,0	5,5
1 and only 1 tag	1231.8	51.4	76	?	16,2	2,7
1 or 2 tags	1968.7	55,4	116,0	?	17,4	4,4
2 and only 2 tags	737.7	4	37,6	?	19.5	1,7

Enriching top purity

- Two examples:
  - Require 3 leading jets to be central
  - Apply a cut on cosθ* (Angle between the i-th jet and the beam direction in the rest system of the total event (l+ν+ jets)