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Tag and probe trigger efficiency in a $t\bar{t}$ -> electron + jets cross section measurement

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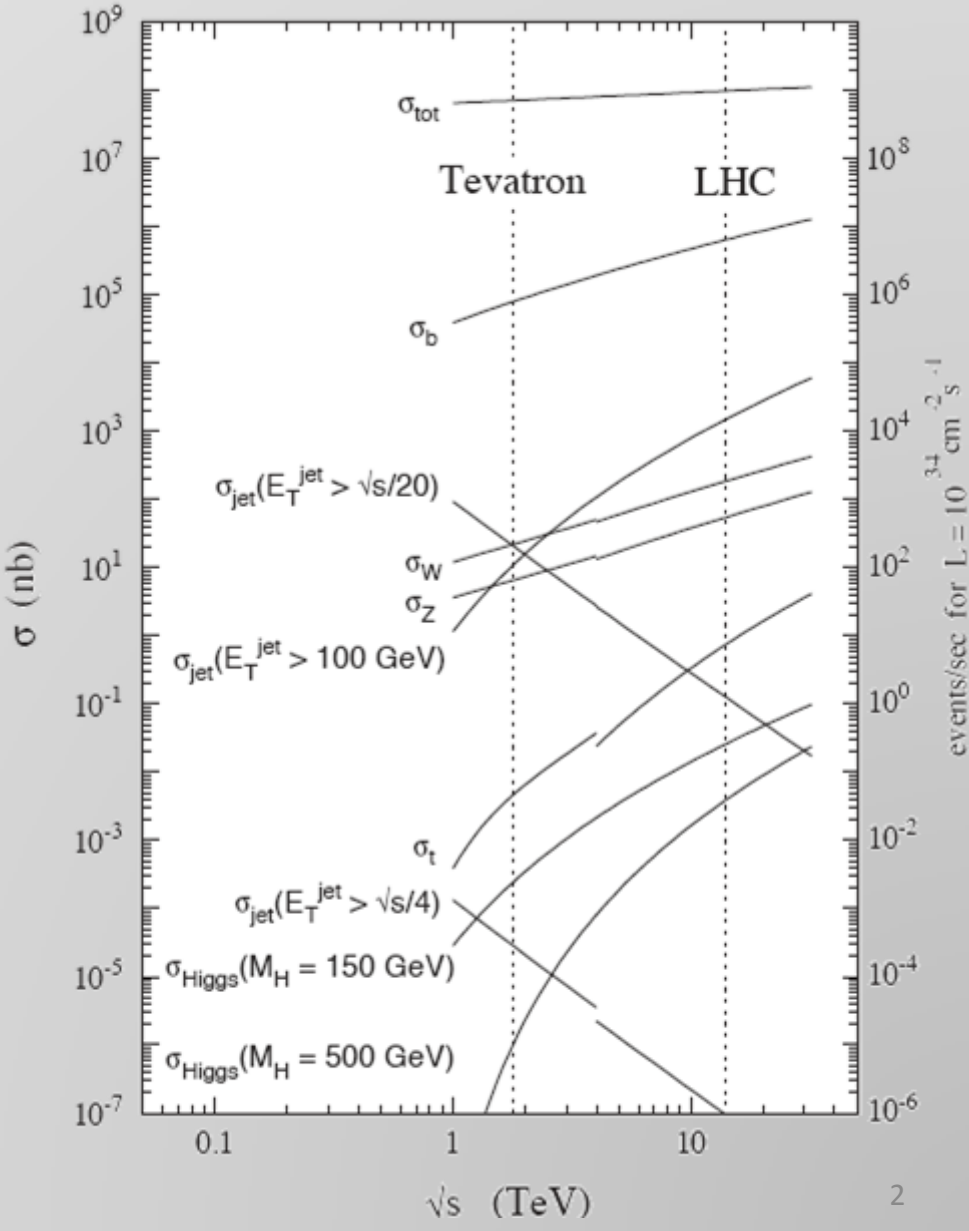
Motivation

- Large mass of the top quark makes it unique and sensitive to new Physics
- $t\bar{t}$ production cross section is 833 pb at the LHC (~100 times the Tevatron value)
- LHC is a top factory
- At 10^{33} $cm^{-2}s^{-1}$ we expect 8.3 x 10^6 $t\bar{t}$ events per year



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Introduction

- In the early days it will be important to measure the top cross section, before proceeding with more detailed precision tests of the Standard Model. As an example analysis…

Trigger efficiency from data (reduce dependence on Monte Carlo – Systematic uncertainty)

Split the Monte Carlo into two samples: 'data' and 'Monte Carlo'

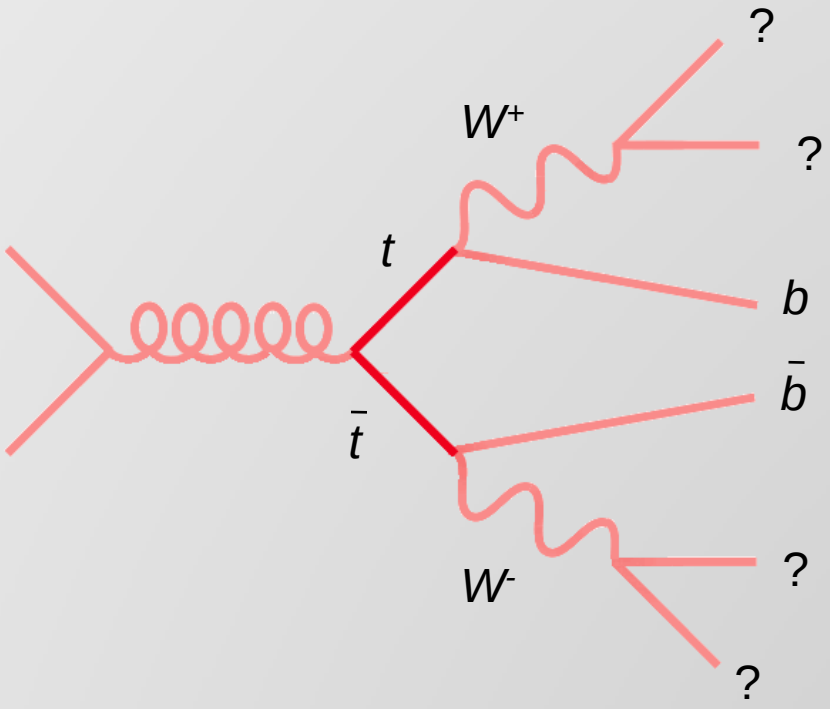
Acceptance from Monte Carlo

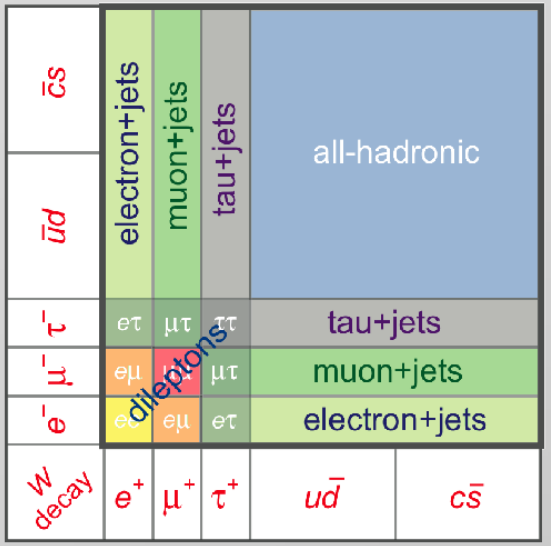
Look at *W* + jets backgrounds

No *b*-tagging, detector not well understood -> simple selection. Based on ATL-PHYS-PUB-2005-024 and ATL-COM-PHYS-2007-023

e25i trigger (isolated electron > 25 GeV)

Signal definition





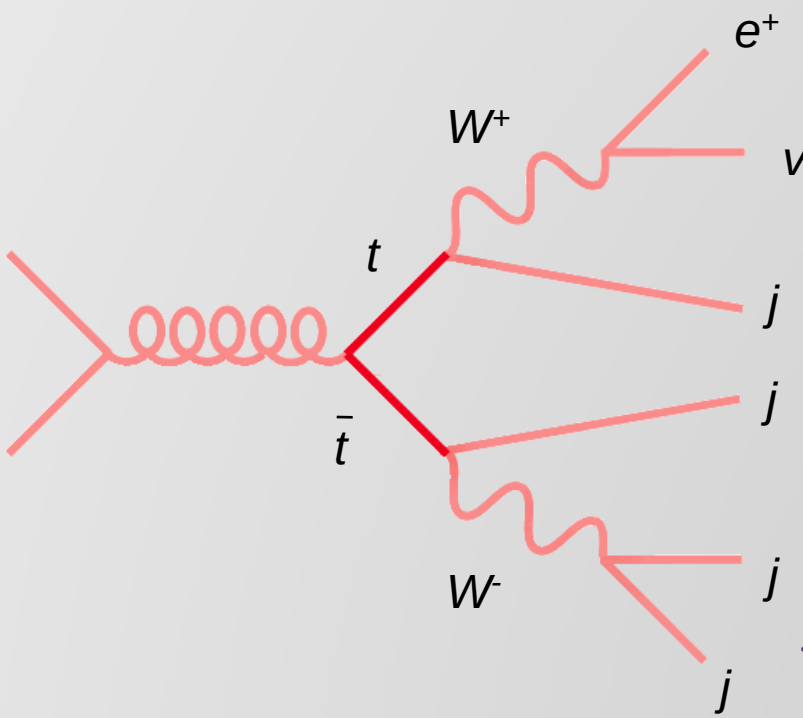
- For this study consider the electron + jets decay channel
  - One *W* decays to an electron and neutrino, the other decays to jets
  - Easy to reconstruct and trigger
- Consider only single object trigger - e25i (e15i depending on luminosity)
- Cross section for this channel is 123 pb (12,300 events – 100 pb^{-1})

Backgrounds

- The main sources for background events are *W* + jet production (where we reconstruct a real *W* boson) and misidentification of QCD events
  - Production of a *W* boson along with jets is expected to be the dominant irreducible background. If the *W* decays leptonically we expect a number of *W* + 4 jet events. Use Alpgen samples.
  - QCD multi jet events will not have the same final state as $t\bar{t}$ signal. However particles may be misidentified. Not yet looked at this but previous studies indicate it is small.

Selection

Electron p_T > **30 GeV** (Original analysis had 20 GeV cut – at odds with e25i trigger) | eta | < 2.5 . Electrons in 1.35 < | eta | < 1.65 are discarded (Crack region is not well instrumented and simulation bug)



Missing transverse energy > 20 GeV

At least 4 jets with p_T > 20 GeV (| eta | < 2.5)
At least 3 jets with p_T > 40 GeV (| eta | < 2.5)

Highest p_T combination of three jets is the 'top'

One of the two jet combinations that make the top must fulfill:
70 < dijet mass < 90 GeV

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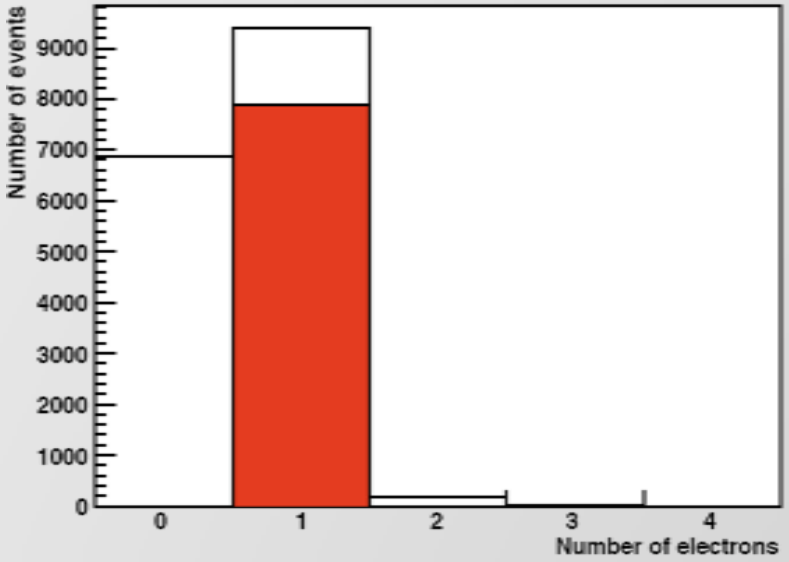
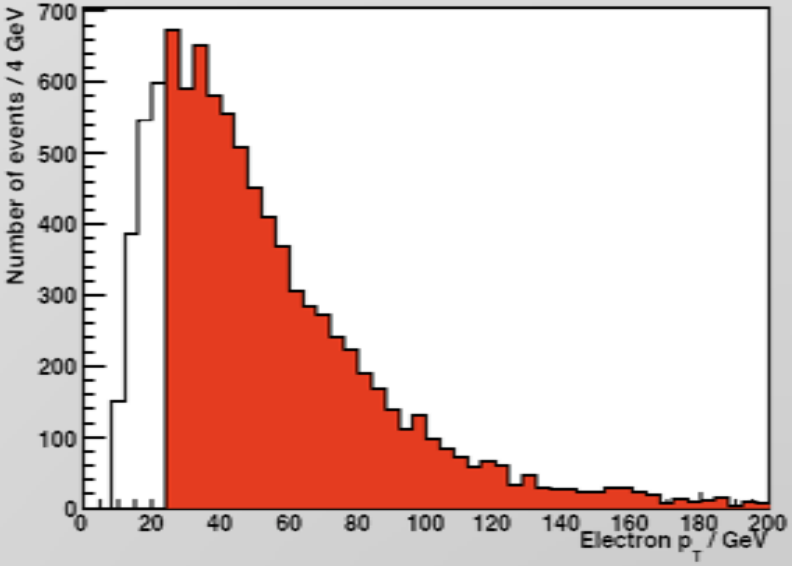
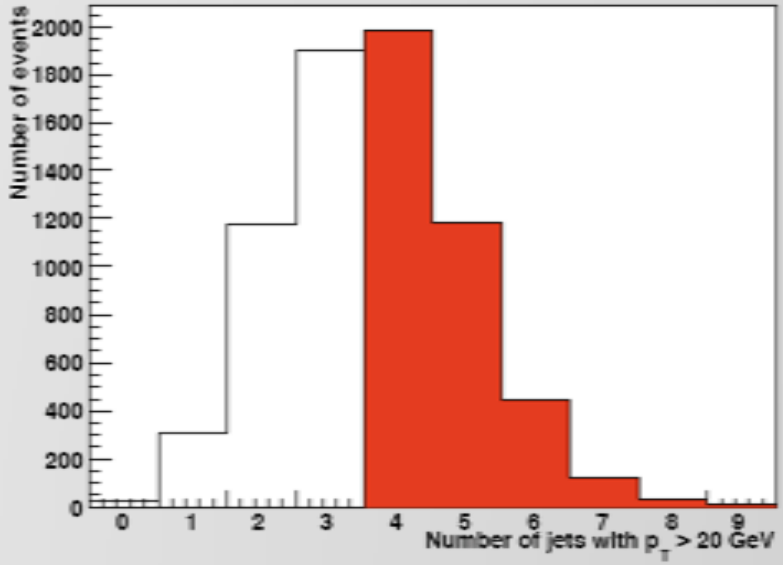
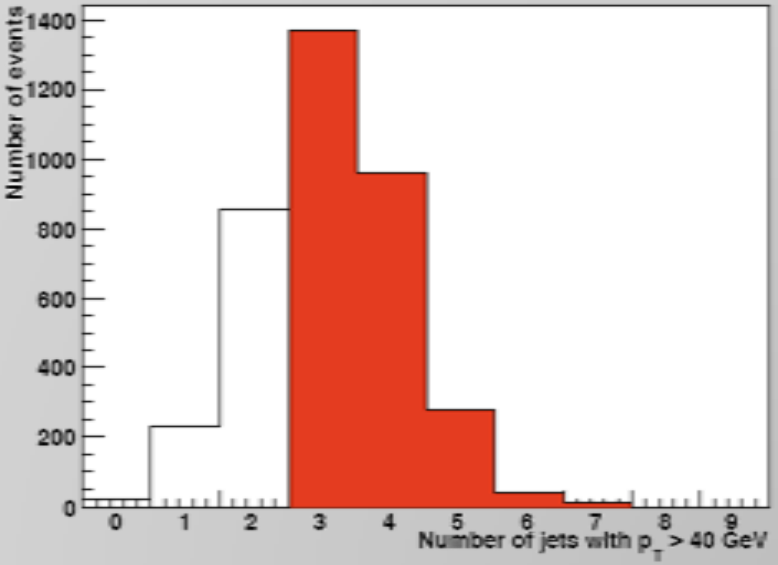
Signal Selection plots









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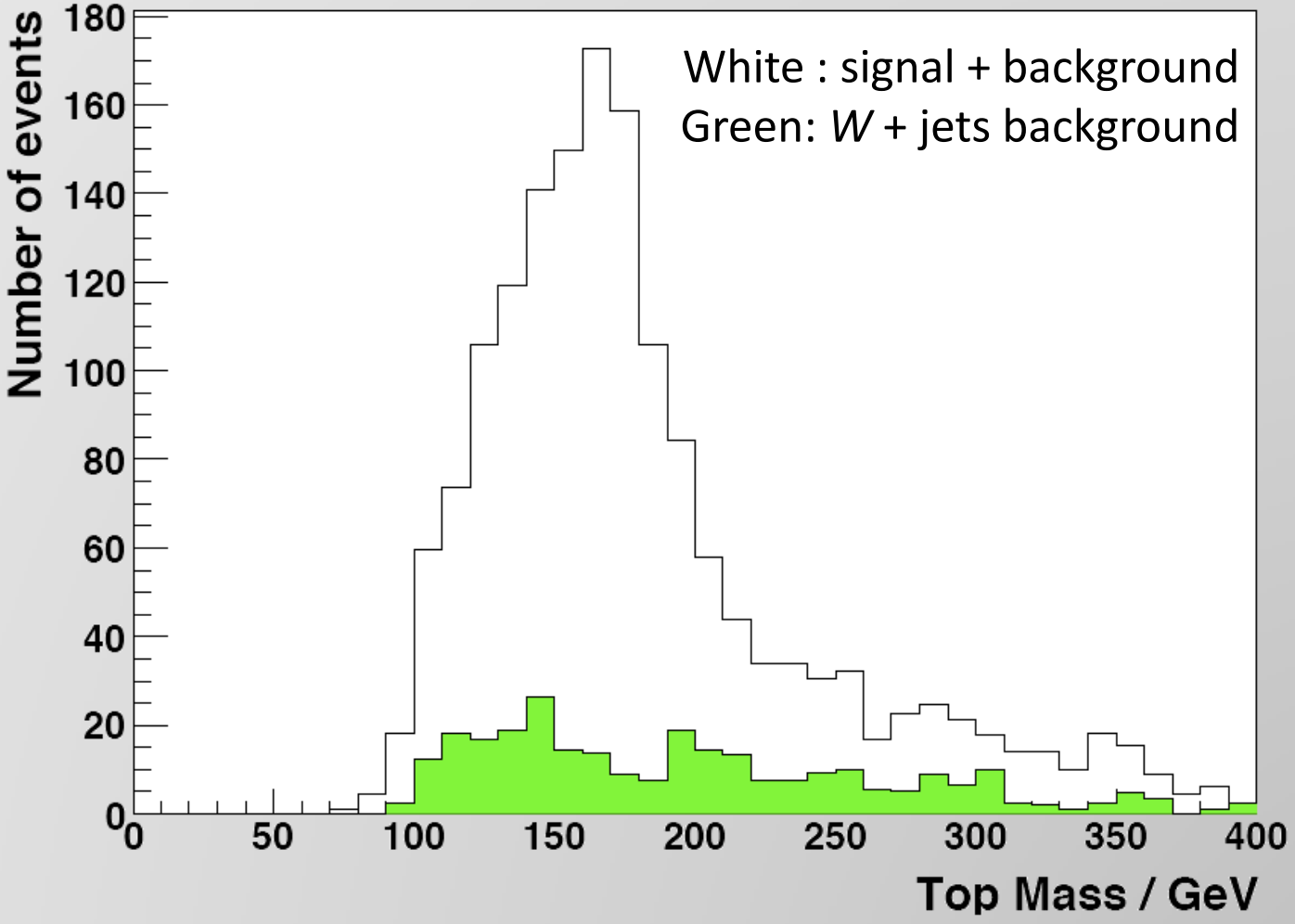
Signal and Background

	Signal		*W* + jets background	
Cut	**Sum Weights**	**Efficiency / %**	**N_{events}**	**Efficiency / %**
(Truth) $W \rightarrow e\nu_e$	12416	100	33170	100
Pass L1 EM18I	9272	75	22077	67
Pass L2 e25i	7565	61	17914	54
Pass EF e25i	6593	53	15615	47
Electron $p_T > 30$ GeV	4950	40	11135	34
Remove crack region	4400	35	10593	32
Missing $E_T > 20$ GeV	3965	32	9435	28
4 jets with $p_T > 20$ GeV	2483	20	1010	3.0
3 jets with $p_T > 40$ GeV	1777	14	475	1.4
W mass constraint	898	7.2	145	0.4

Top mass


White : signal + background
Green: W + jets background
Number of events
0
20
40
60
80
100
120
140
160
180
0
50
100
150
200
250
300
350
400
Top Mass / GeV

Calculating the cross section

$N_{detected}$: Have this from previous table (898)

From Monte Carlo here. But better ways exist (145)

$$\sigma . Br = \frac{N - N_{background}}{\mathcal{A} . \varepsilon_T . \int \mathcal{L} . dt}$$

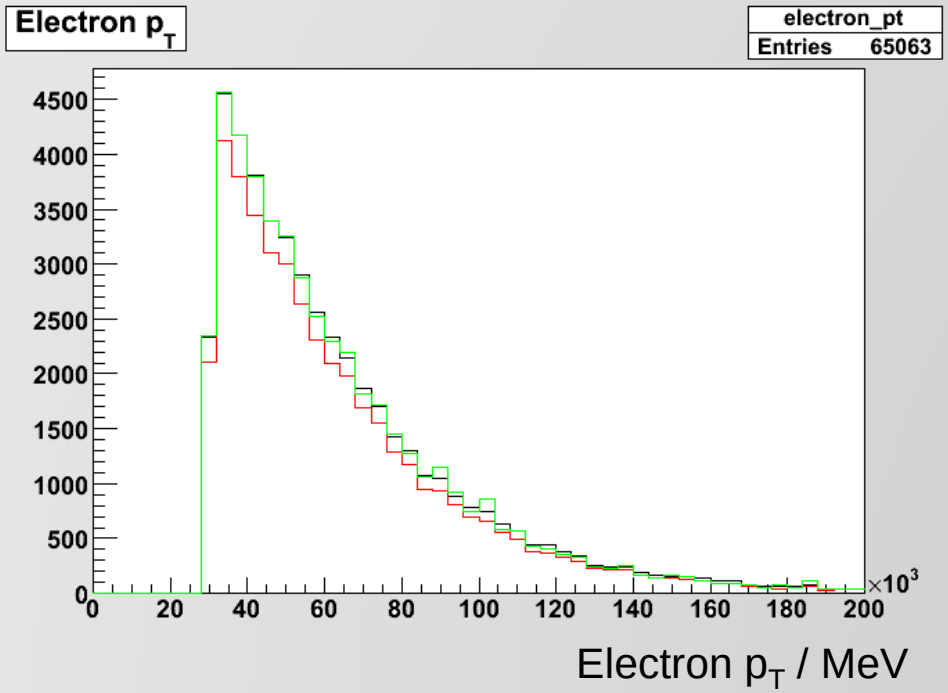
A : Acceptance - comes from Monte Carlo ~ 8 %

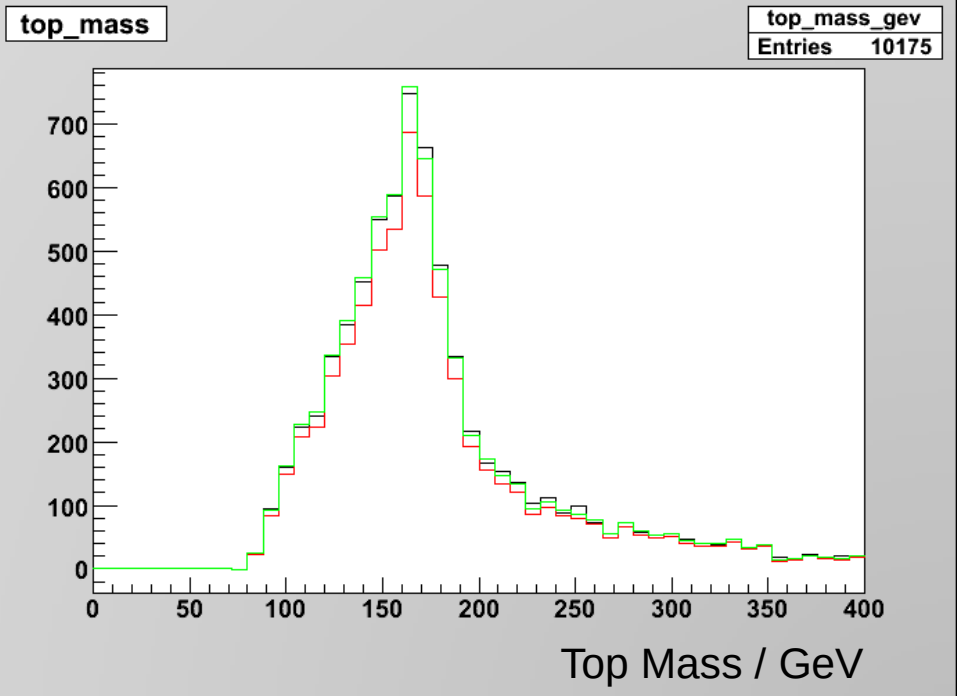
E_T : Trigger Efficiency from the tag and probe method on data

Integrated Luminosity : From Luminosity working group (100 pb^{-1} here)

Correcting the Trigger Efficiency

- Analysis with e25i trigger (red)
- Analysis without trigger (black)
- Require the trigger, but correct using *Z->ee* (green)
- Used large statistics in these plots to reduce statistical error





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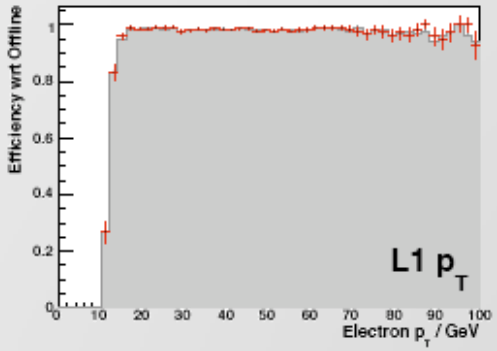
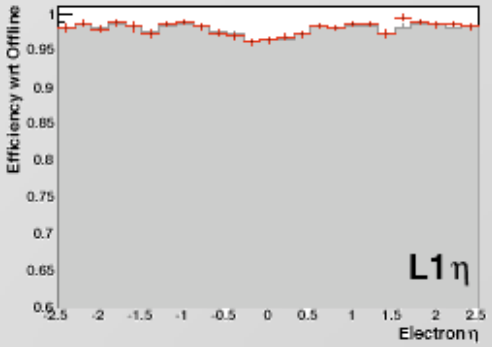
Tag and probe method

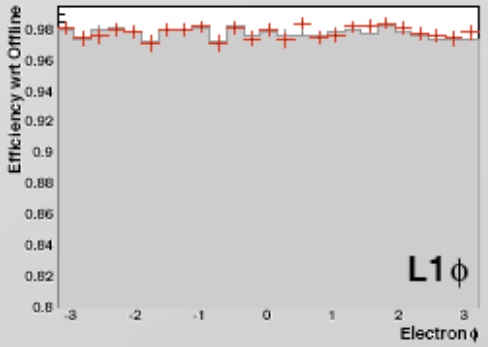
- Trigger Efficiency is process dependent, but can be calculated easily for *Z* to *ee* events (and applied to top events?)

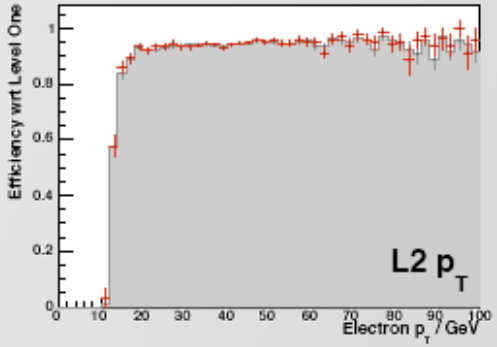
- Method
  - Use offline selection to select a sample with two electrons (20 GeV p_T cut)
  - Combine to make a *Z* mass between 70 and 110 GeV (loose, could be tighter…)
  - Calculate N_1, number of events with at least one triggered electron (e.g. e25i)
  - Calculate N_2, number of events with two triggered electrons
  - Take N_2 / N_1 for each bin in p_T, eta and phi (of the probe electron) to identify variables with which to parameterise the efficiency

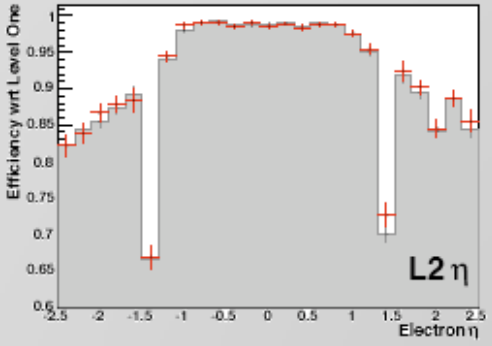
Efficiency as a function of electron kinematics

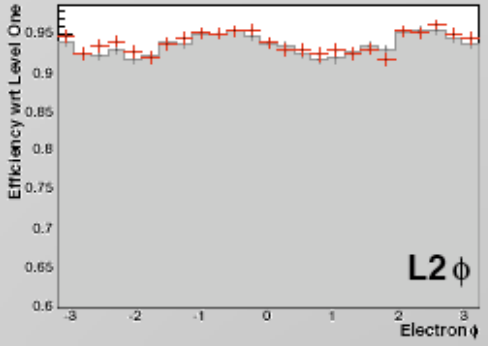


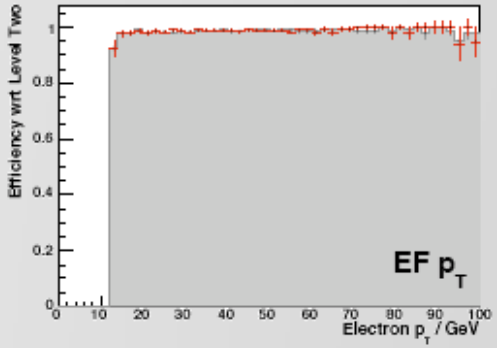


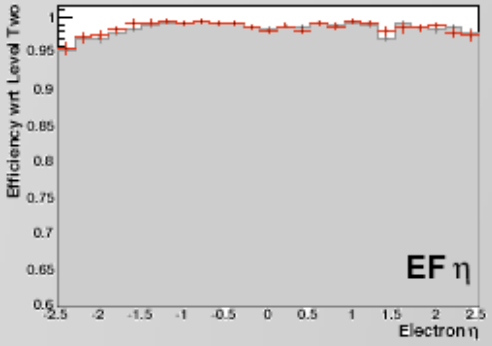


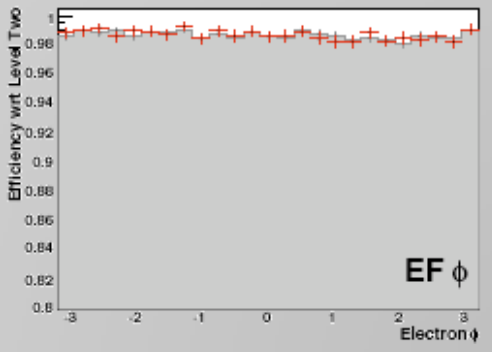




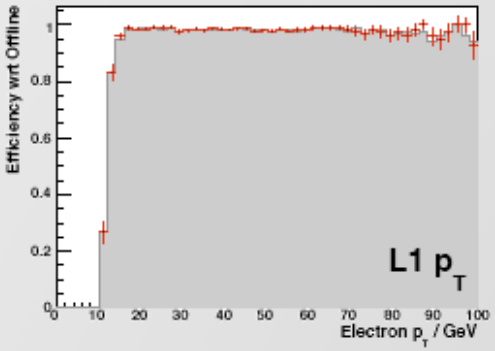


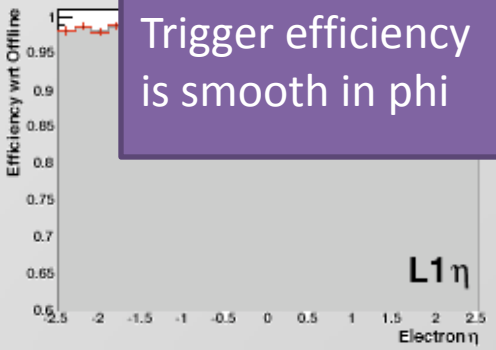


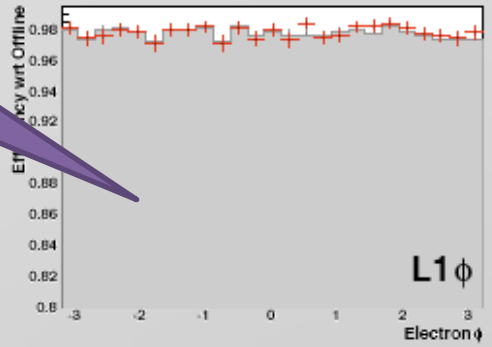




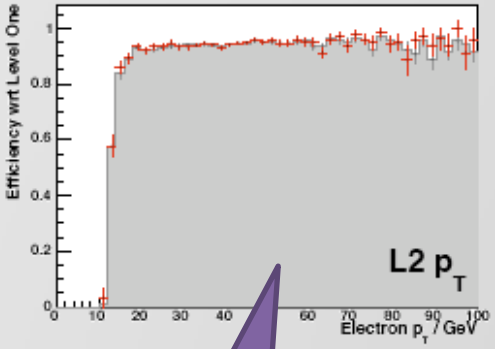
Efficiency as a function of electron kinematics

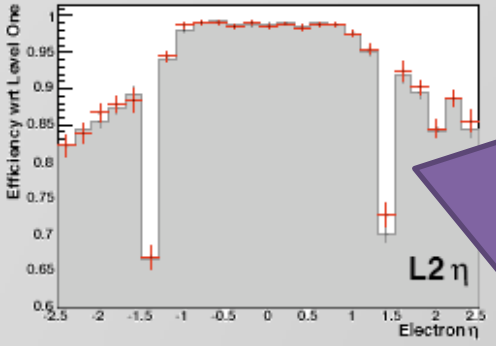


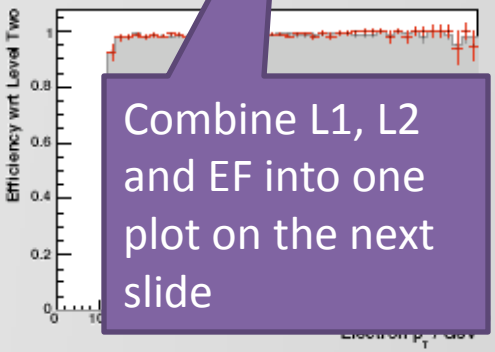


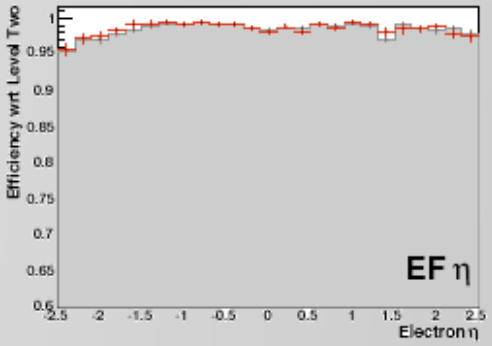


Trigger efficiency is smooth in phi









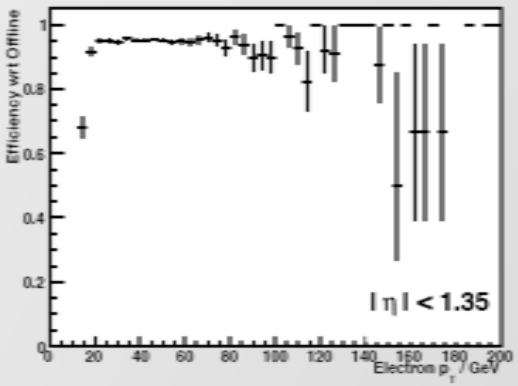
Combine L1, L2 and EF into one plot on the next slide

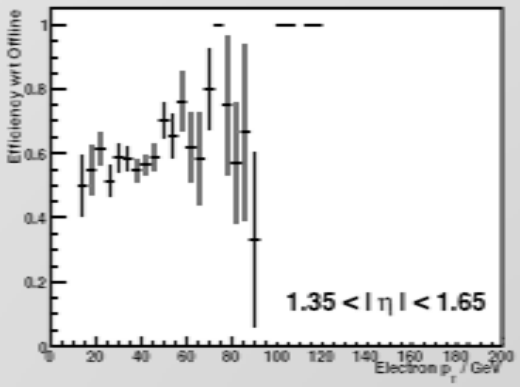
Can identify three regions in eta:

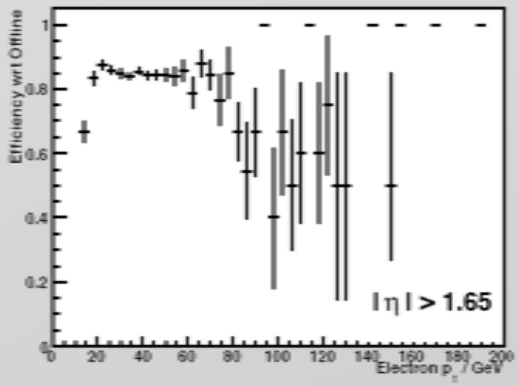
- Barrel -|eta| < 1.35
- Crack - 1.35 < |eta| < 1.65
- End-cap - |eta| > 1.65

Parameterise the trigger efficiency for the full chain (L1, L2, EF) in terms of p_T in these three regions

Efficiency parameterisation







Run over top sample (5200)

- Look up p_T and eta of the electron in the event.
- Reweight the event by multiplying the MC@NLO weight by 1 / trigger efficiency.

- Continuing from the previous table…

	Signal		W + jet background	
Cut	**Sum Weights**	**Efficiency / %**	**N_{events}**	**Efficiency / %**
W mass constraint	898	7.2	145	0.4
Correct trigger efficiency	981 (993)		170 (172)	

Conclusions and outlook

- Gives a cross section * branching ratio of 124.3 pb for electron + jets channel
- We expect 12/81 * 833 pb = 123 pb

- It is possible to measure the top cross section in 100 pb^{-1} of data without *b*-tagging
- Can obtain the trigger efficiency from *Z* -> *ee* as a function of p_T

- Need to look at QCD Background
- Systematic study
- Is it worth fitting the top mass?
- Work already ongoing for an extension to the muon + jets channel