Minimax Invariant Mass and Fake Factors

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Summer Student Project (ATLAS)

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Minimax invariant mass

Minimax invariant mass - Definition

$$m_{bl}^{minimax} = min\{max\{m_{l1,b1}, m_{l2,b2}\}, max\{m_{l1,b2}, m_{l2,b1}\}\} \quad (1)$$

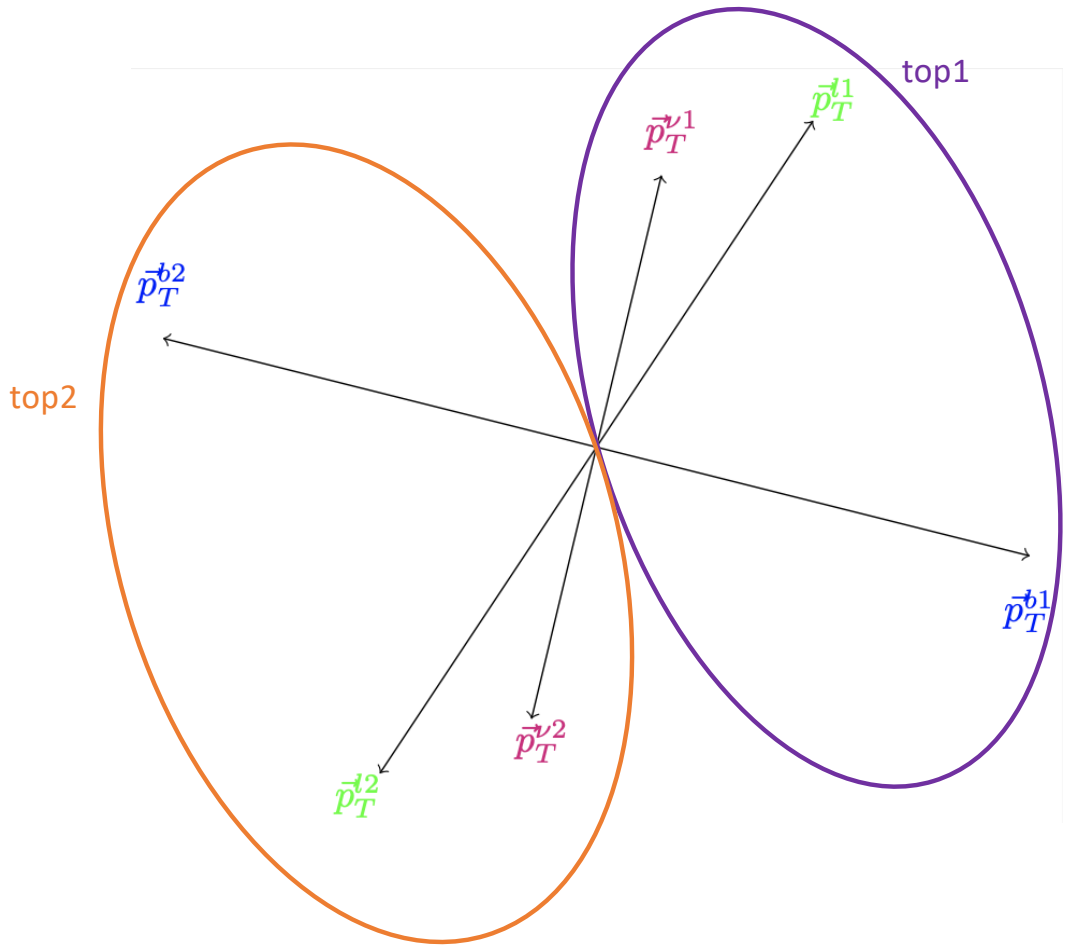
Why minimum?

Because we want to match objects near in the phase space.

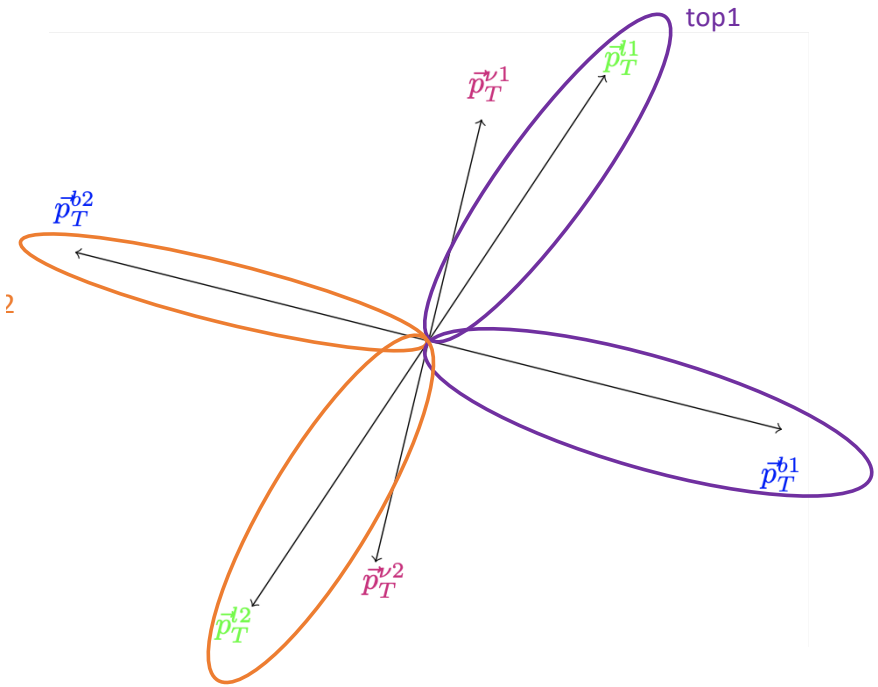
Why maximum?

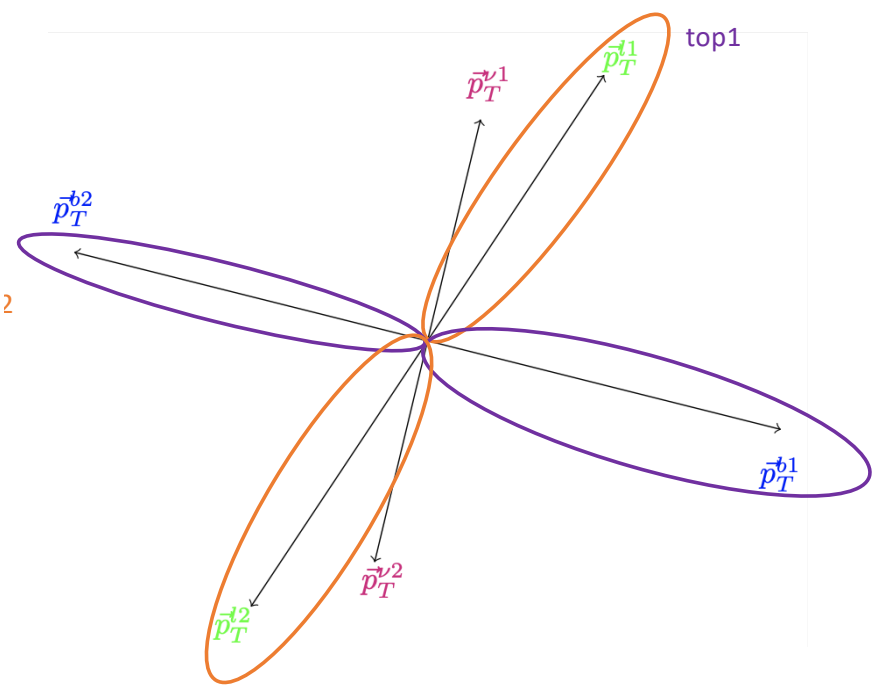
Let's see.

Minimax invariant mass - A very simple situation



Minimax invariant mass - A very simple situation





$m_{l1,b1} \sim m_{l2,b2}$

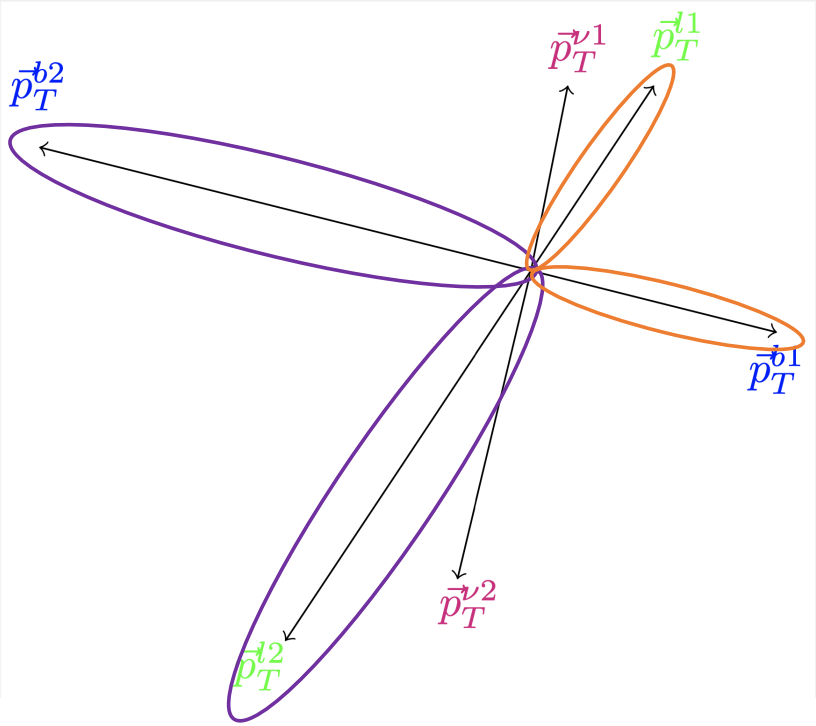
$m_{l1,b2} \sim m_{l1,b2}$

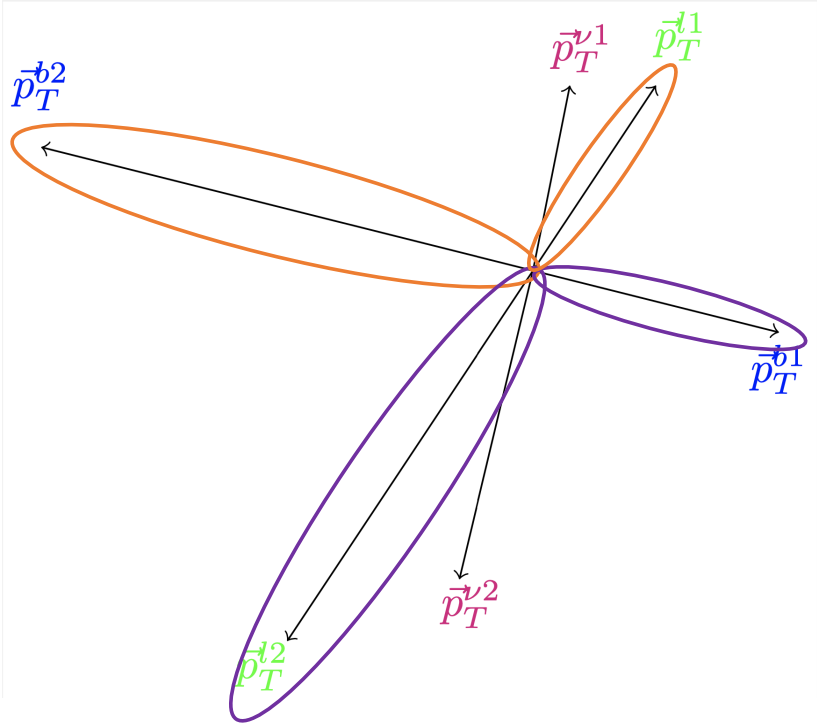
$\rightarrow$ we could take the minimum

minimax works as well:

$max\{m_{l1,b1}, m_{l2,b2}\} < max\{m_{l1,b2}, m_{l2,b1}\}$

Minimax invariant mass - A simple situation





$m_{l1,b1} < m_{l2,b2}$

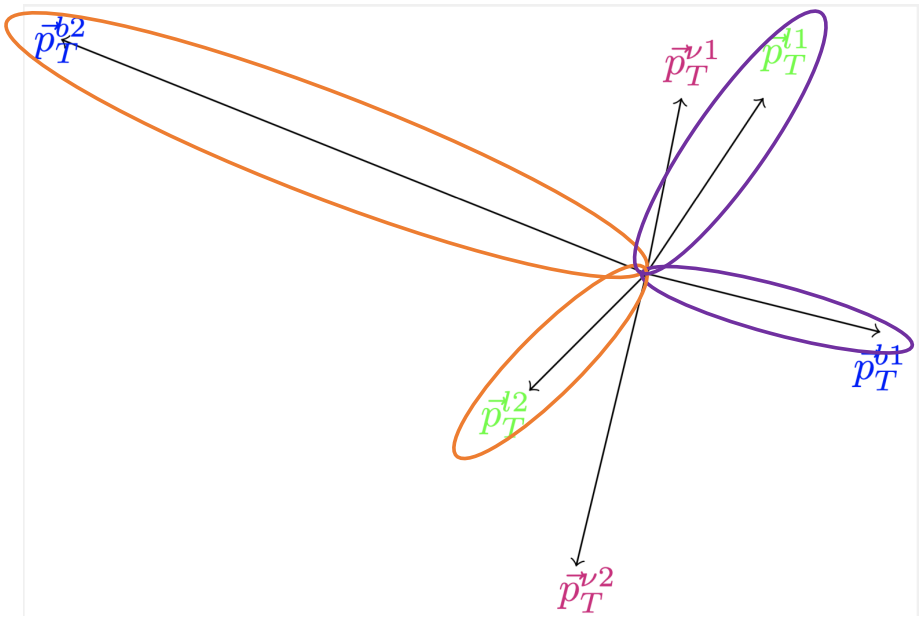
$m_{l1,b2} \sim m_{l1,b2}$

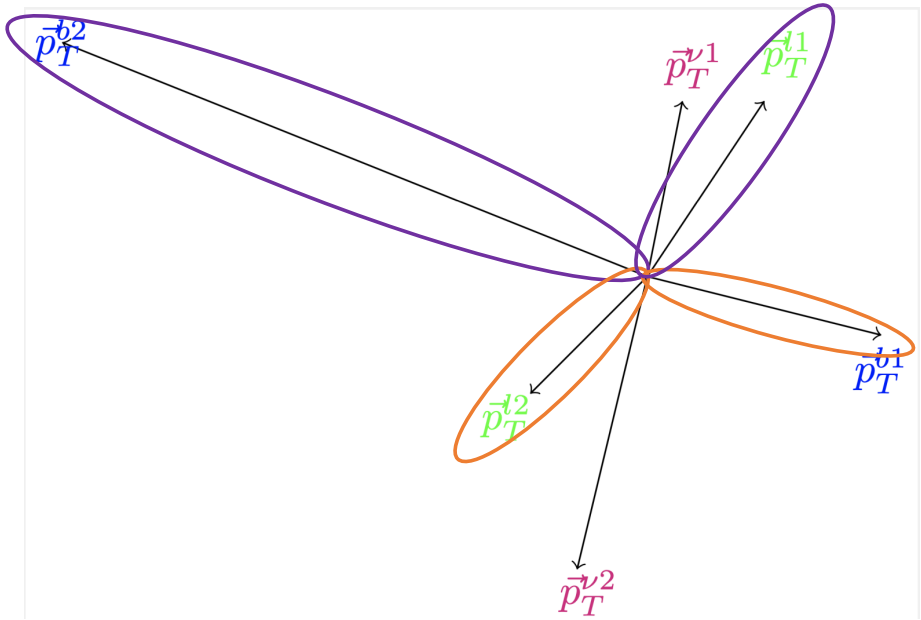
$\rightarrow$we could take the minimum

minimax works as well:

$max\{m_{l1,b1}, m_{l2,b2}\} < max\{m_{l1,b2}, m_{l2,b1}\}$

Minimax invariant mass - A tricky situation





$m_{l1,b1} < m_{l2,b2}$ $\qquad$ $m_{l2,b1} < m_{l1,b2}$

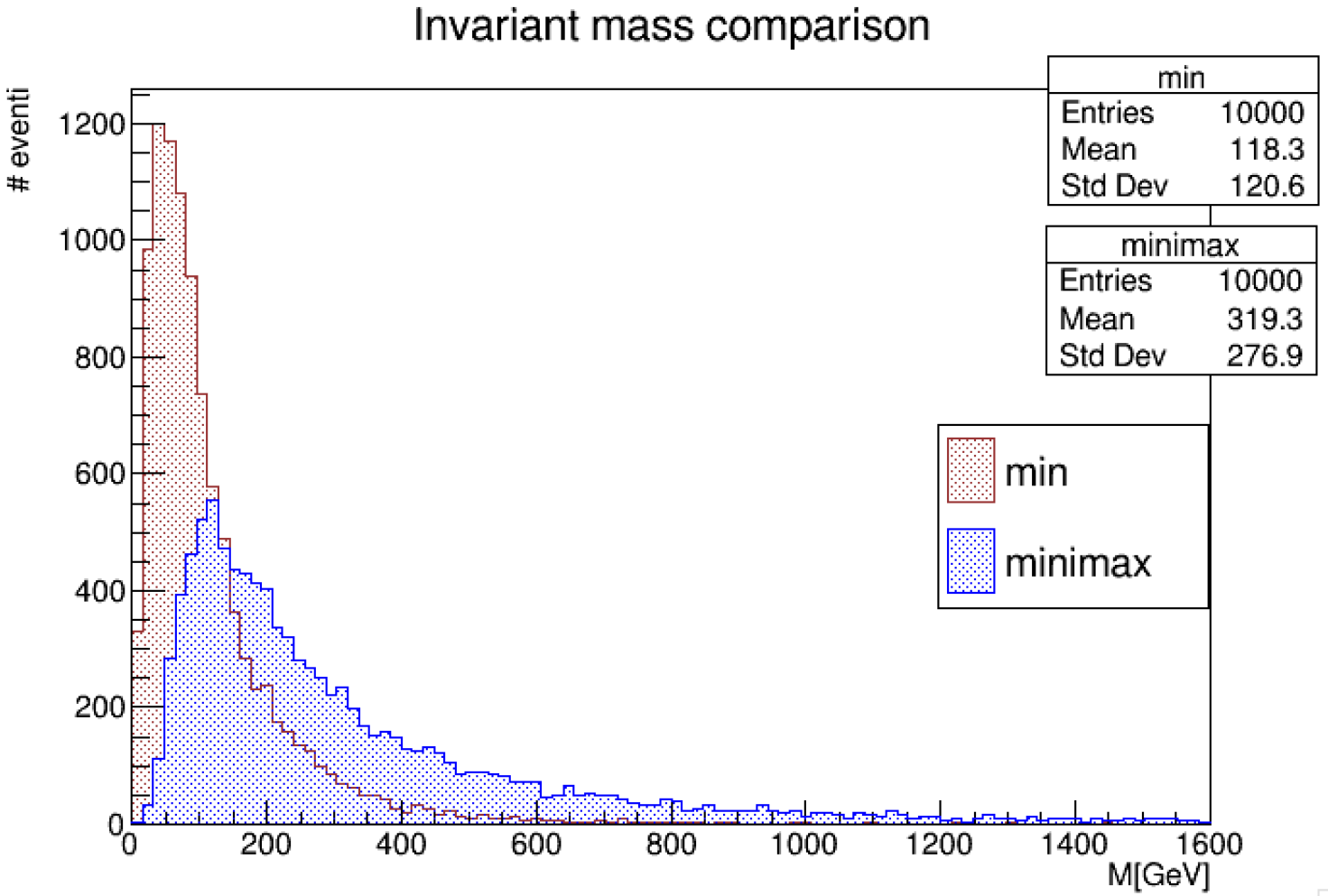
$\rightarrow$ it's not clear who is the minimum!
absolute minimum could be e.g. $m_{l2,b1}$

but minimax does its work:

$$max\{m_{l1,b1}, m_{l2,b2}\} = m_{l2,b2} < max\{m_{l1,b2}, m_{l2,b1}\} = m_{l1,b2}$$
$$min\{m_{l2,b2}, m_{l2,b1}\} = m_{l2,b2}$$

Minimax invariant mass - Simulations

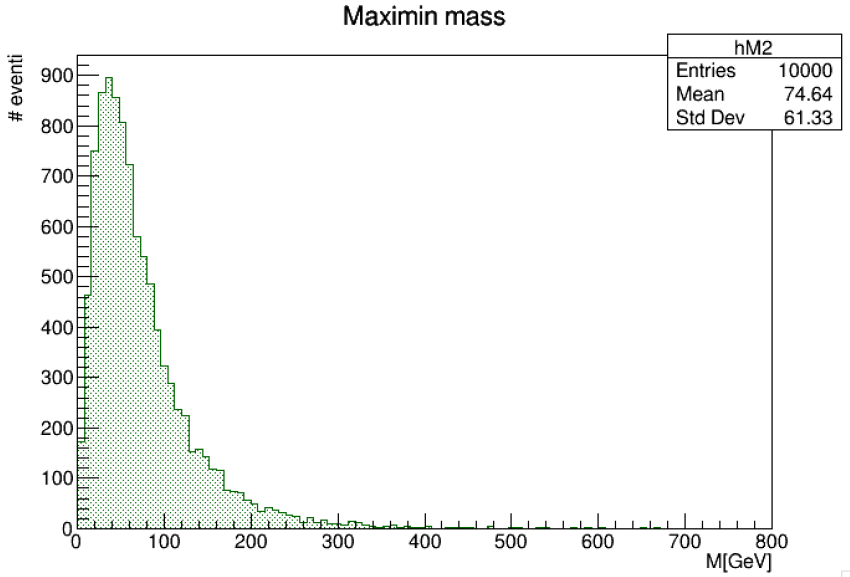
→We need the minimum of the maxima



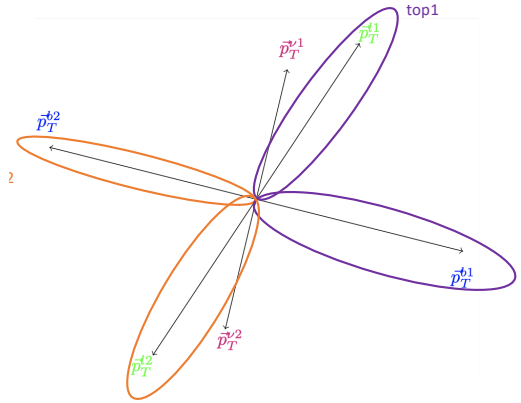
Here are some simulations

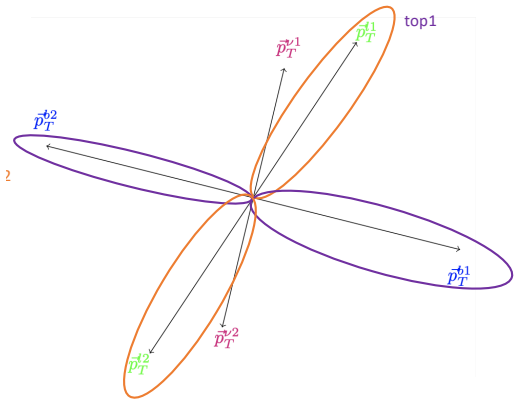
Minimax invariant mass - Simulations

Maximin doesn't work as well



It fails even in the very easy example:





Fake factors

Outlook

1. Reproducing Fake Factors (Electrons)
2. Modifying Control Region (Electrons)
3. Reproducing Fake Factors (Muons)
4. Modifying Control Region (Muons)

Fake factors

$$F = \left(\frac{N^{data}_{tight} - N^{MC}_{tight}}{N^{data}_{loose} - N^{MC}_{loose}} \right)_{CR}$$

Reproducing fake factors - Electrons Nominal CR

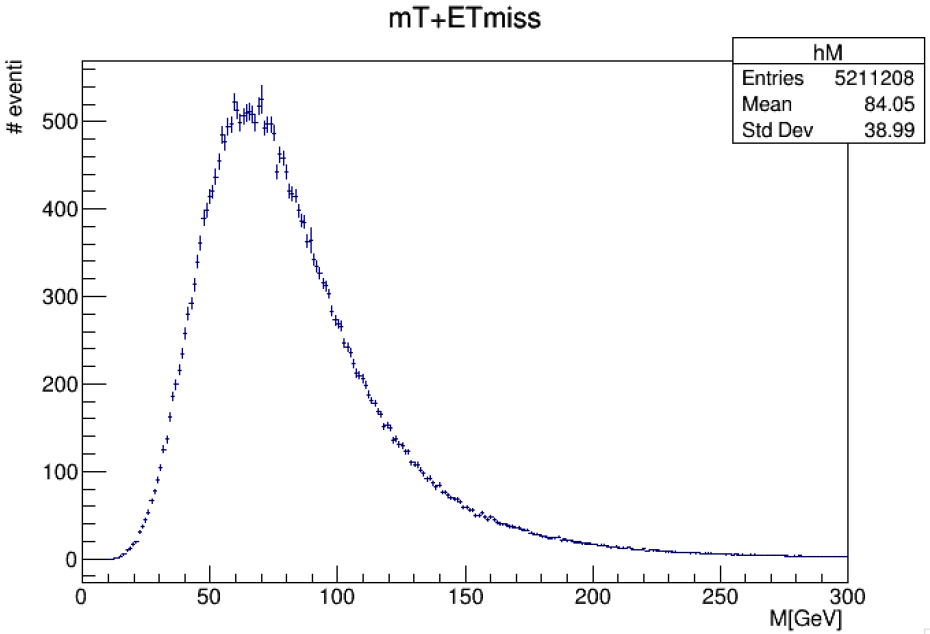
Control Region - Nominal

- $p_T^l > 30\,\text{GeV}$
- 1 b-jet
- $m_T^l + E_T^{miss} < 60\,\text{GeV}$

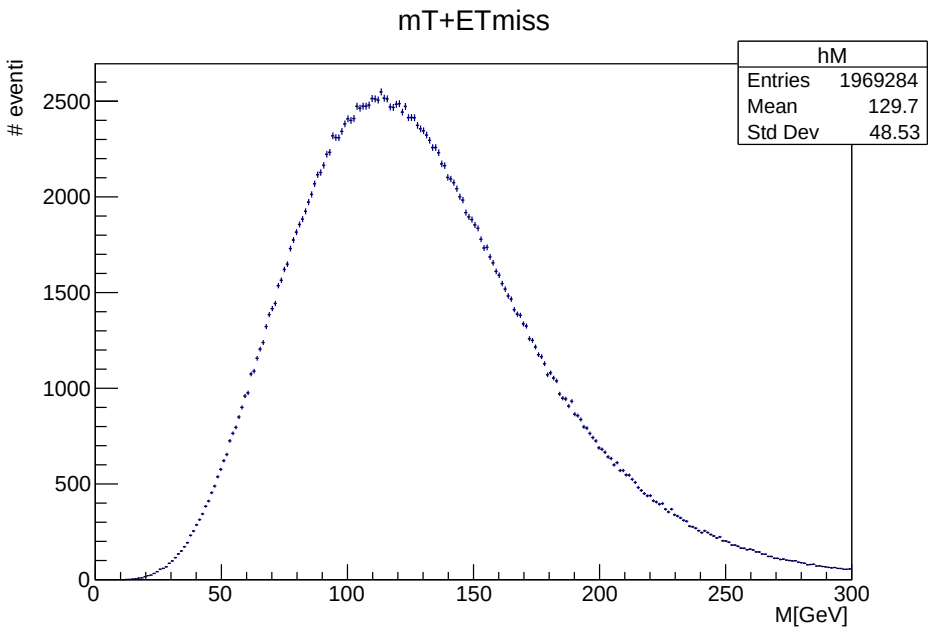
Reproducing fake factors - Electrons Nominal CR

Why 1 b-jet?
$\rightarrow$ similar to SR

Why $m_T + E_T^{miss} < 60\,\text{GeV}$?



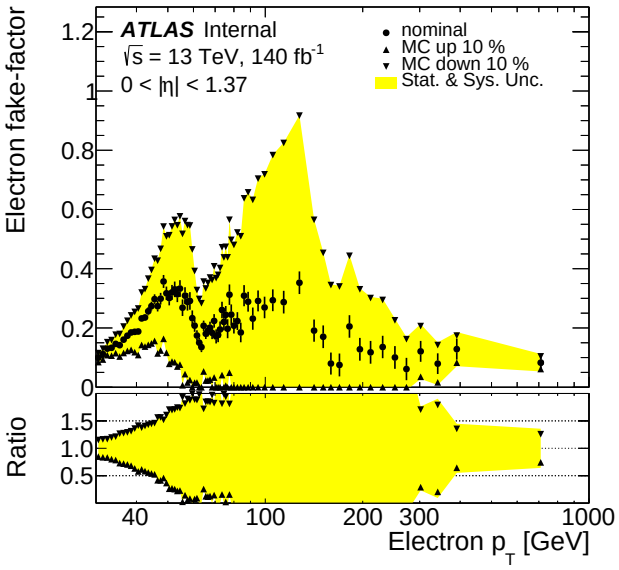
Z+jets



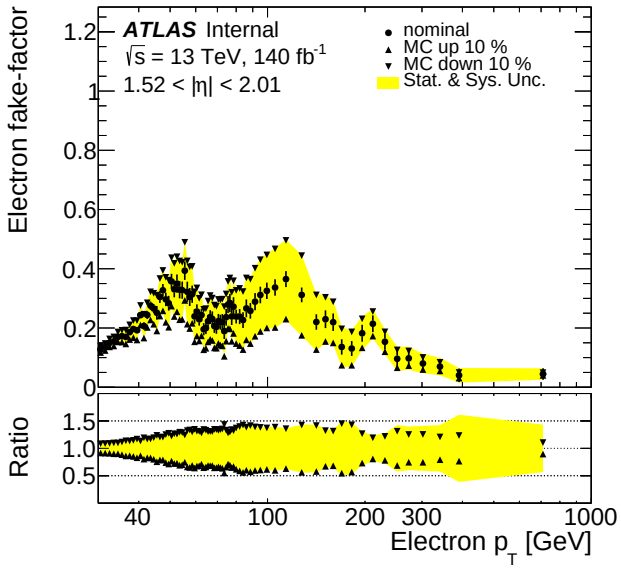
$t\bar{t}$

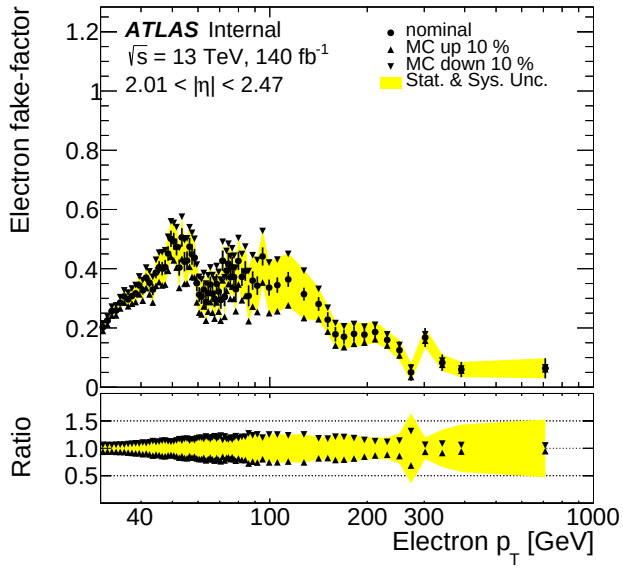
Reproducing fake factors - Electrons Nominal CR

- 1 b-jet
- $m_T^l + E_T^{miss} < 60\,\text{GeV}$



lower η
$\rightarrow$ lower number of fakes
$\rightarrow$ MC variation higher effect

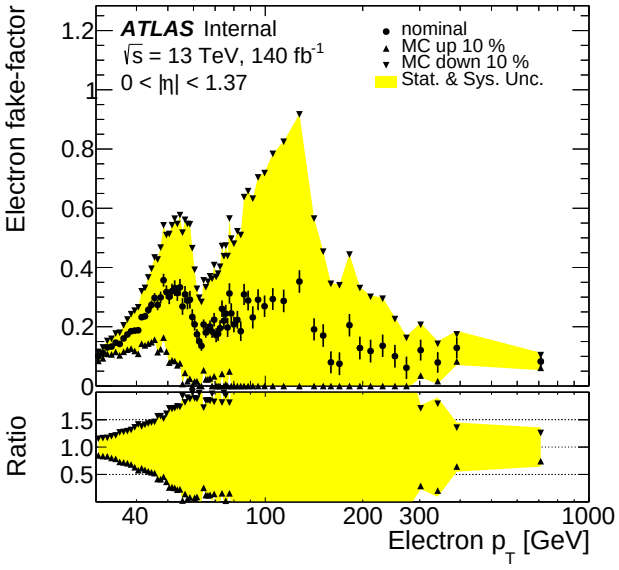




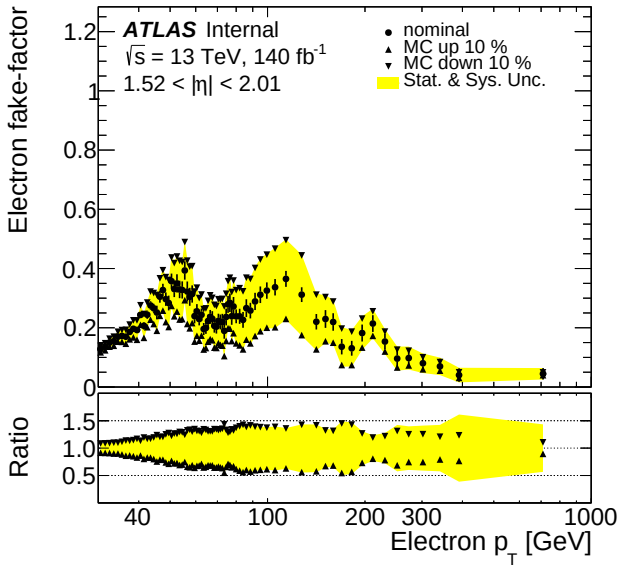
higher η
$\rightarrow$ higher number of fakes
$\rightarrow$ MC variation smaller effect

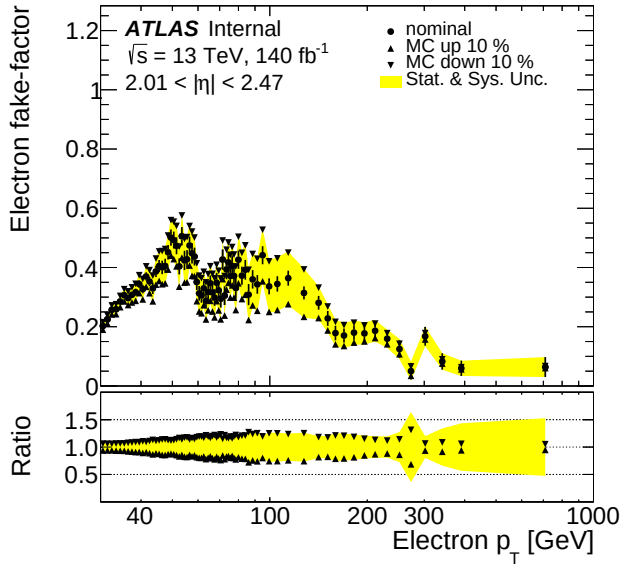
Reproducing fake factors - Electrons Nominal CR

MC up 10% → F decrease
MC down 10% → F increase



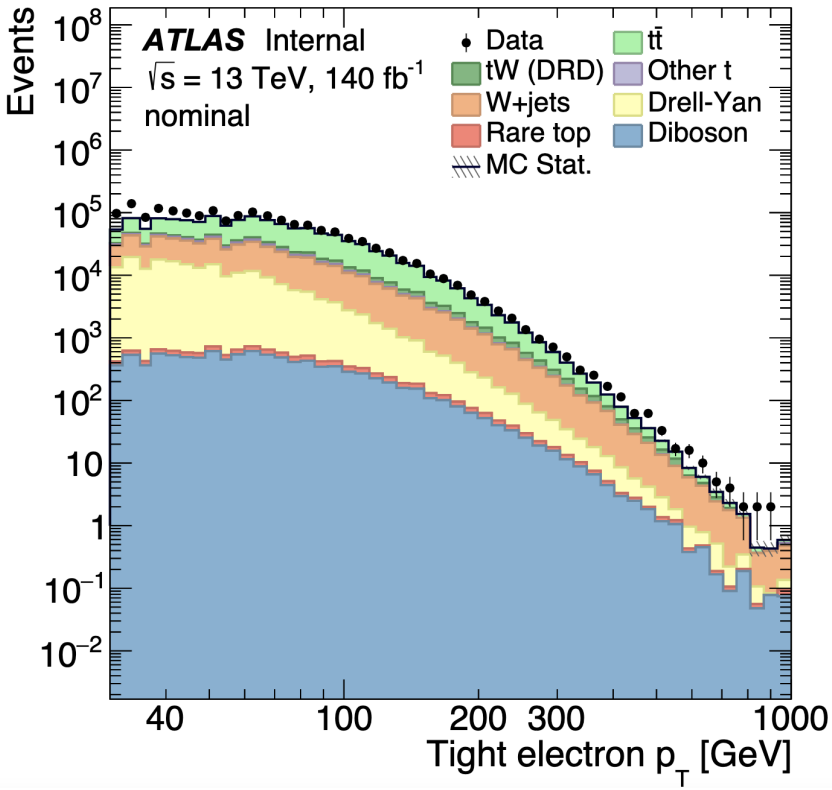
lower η
→ lower number of fakes
→ MC variation higher effect

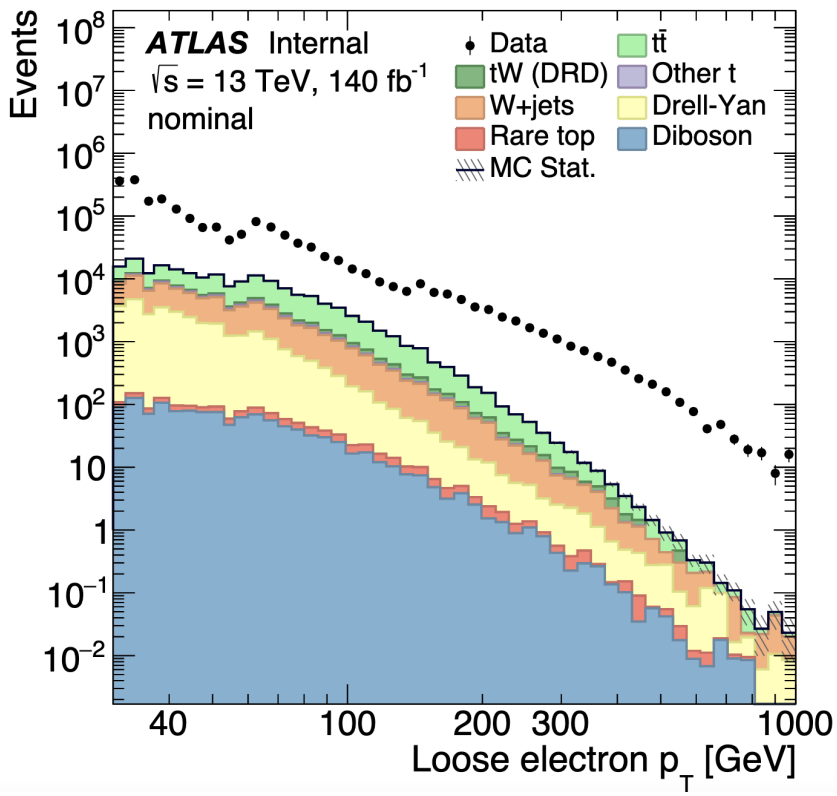




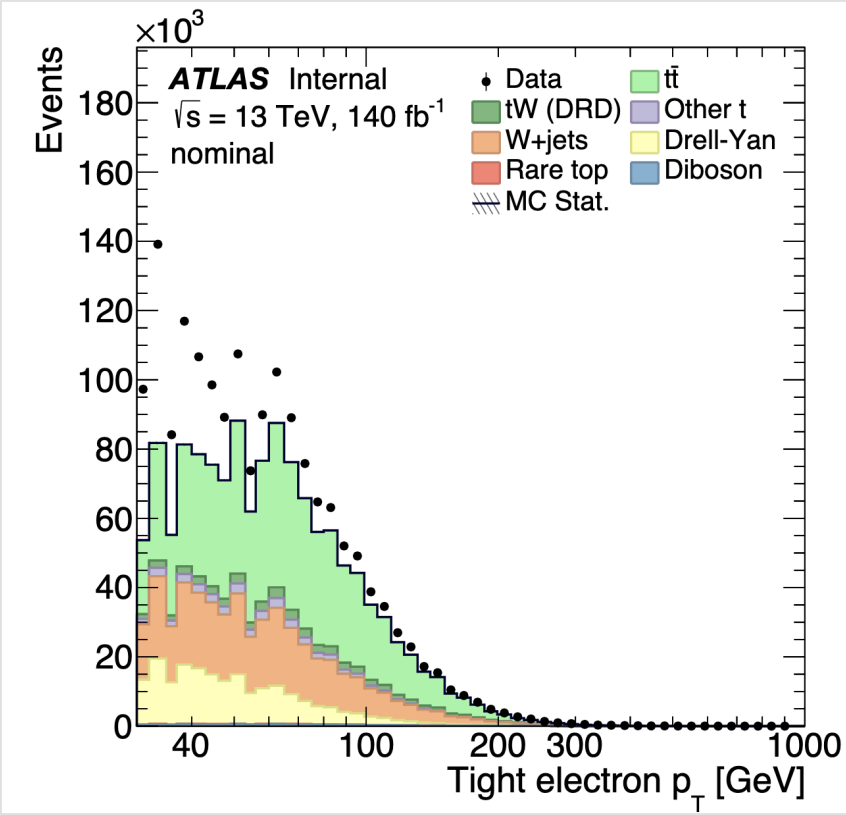
higher η
→ higher number of fakes
→ MC variation smaller effect

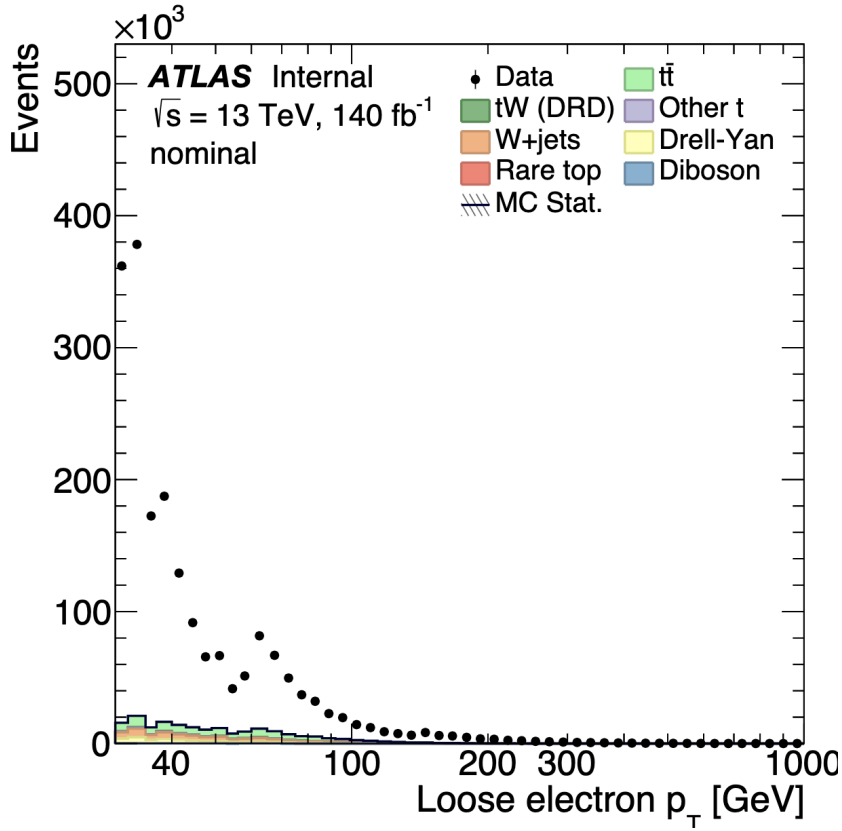
Reproducing fake factors - Electrons Nominal CR





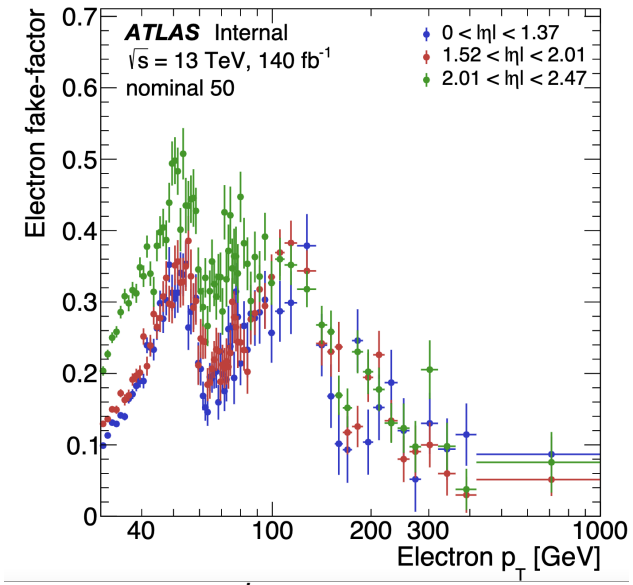
Reproducing fake factors - Electrons Nominal CR



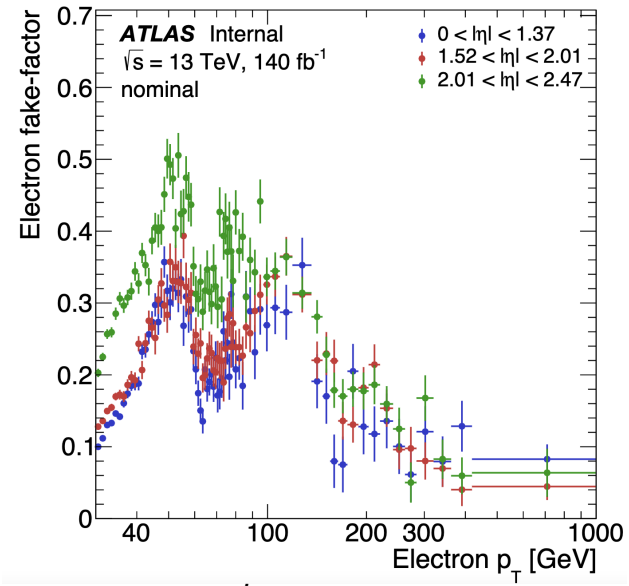


Modifying Control Region - Transverse mass

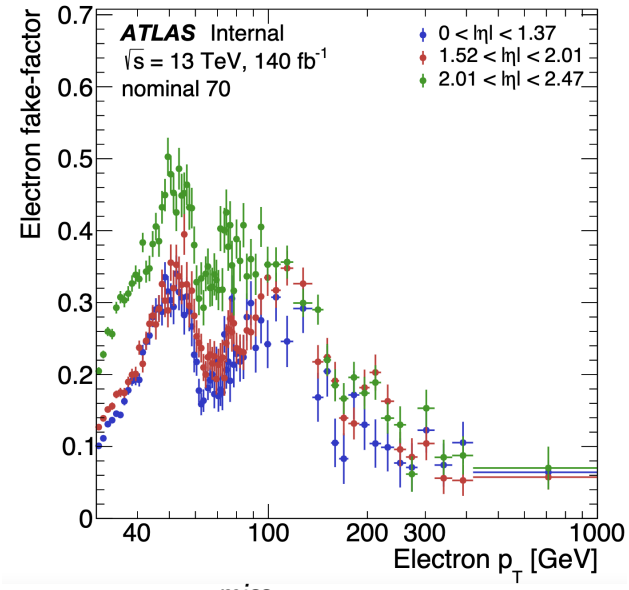
- $p_T^l > 30\,\text{GeV}$
  - 1 b-jet
- $m_T^l + E_T^{miss} < 60/50/70\,\text{GeV}$



$m_T^{l,E_t^{miss}} < 50\,\text{GeV}$



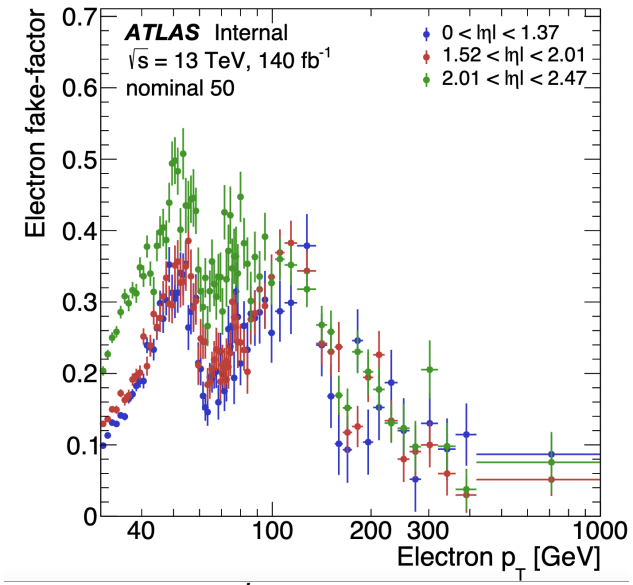
$m_T^{l,E_t^{miss}} < 60\,\text{GeV}$



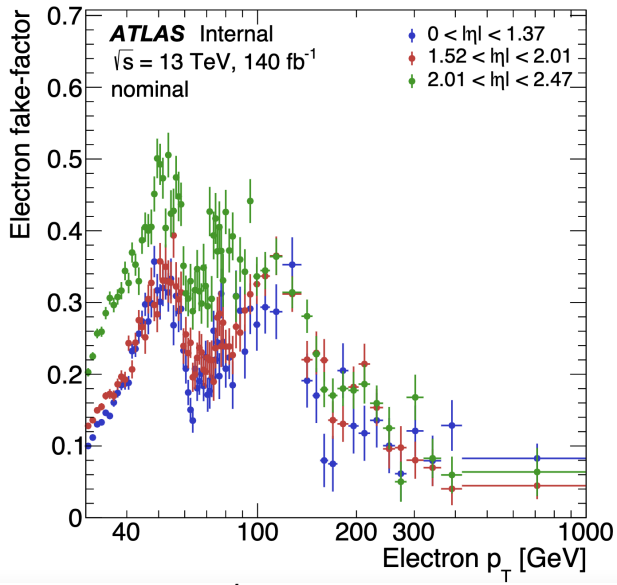
$m_T^{l,E_t^{miss}} < 70\,\text{GeV}$

Modifying Control Region - Transverse mass

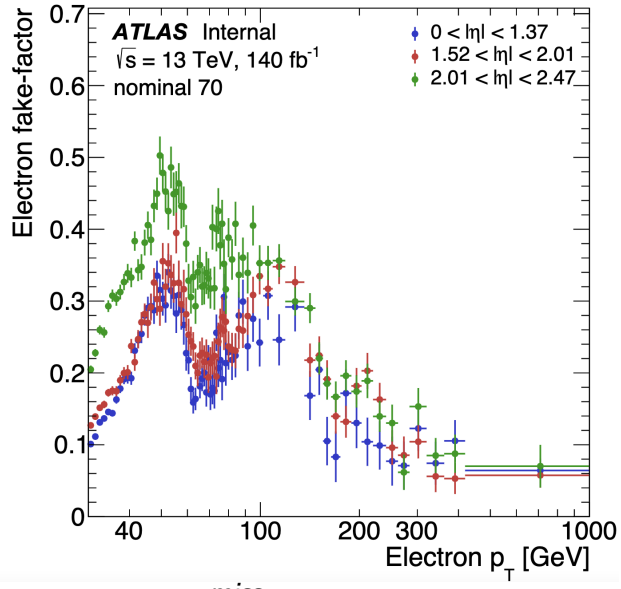
higher $\eta \rightarrow$ higher number of fakes
lower $\eta \rightarrow$ lower number of fakes



$m_T^{l,E_t^{miss}} < 50\,\text{GeV}$

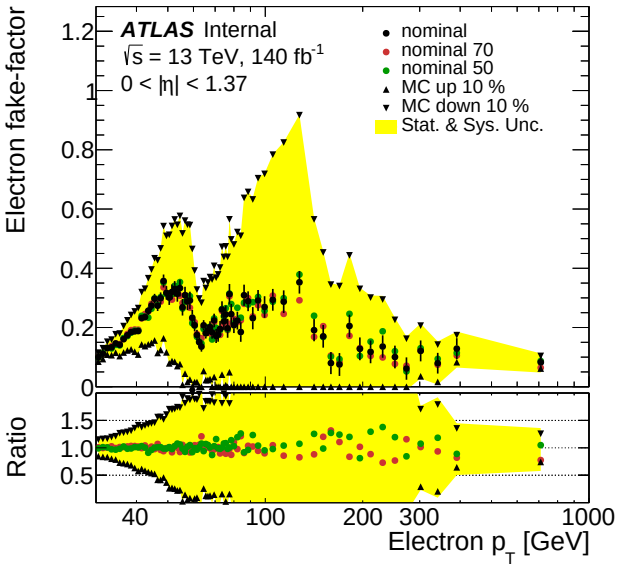


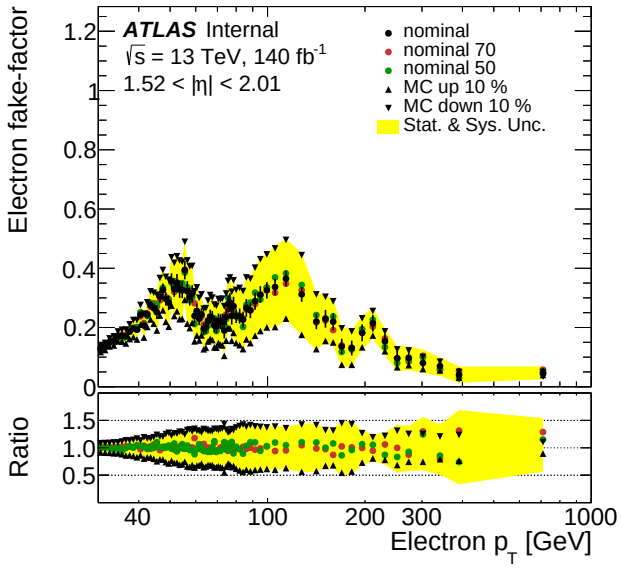
$m_T^{l,E_t^{miss}} < 60\,\text{GeV}$

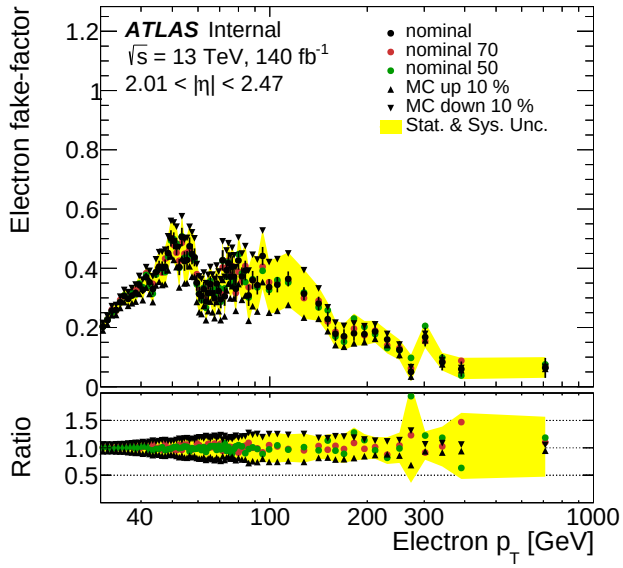


$m_T^{l,E_t^{miss}} < 70\,\text{GeV}$

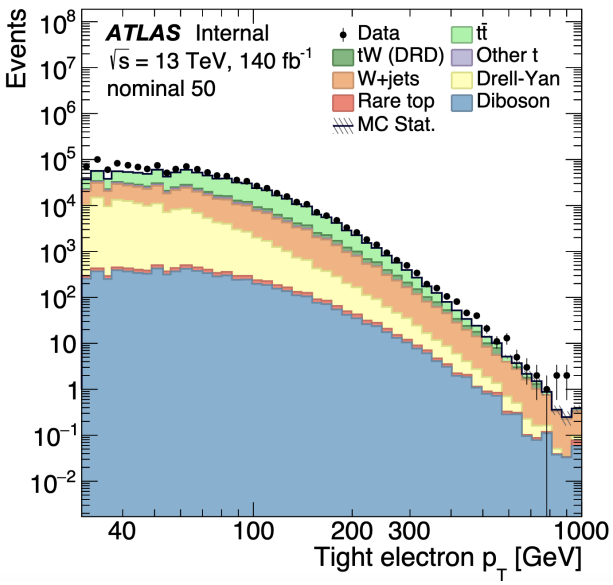
Modifying Control Region - Transverse mass

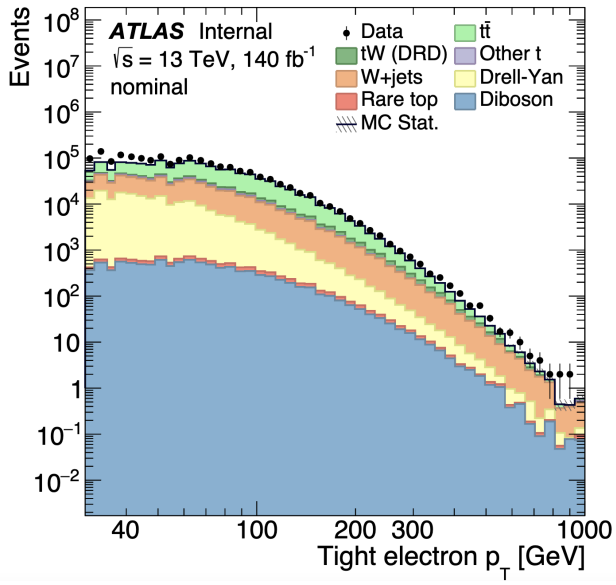


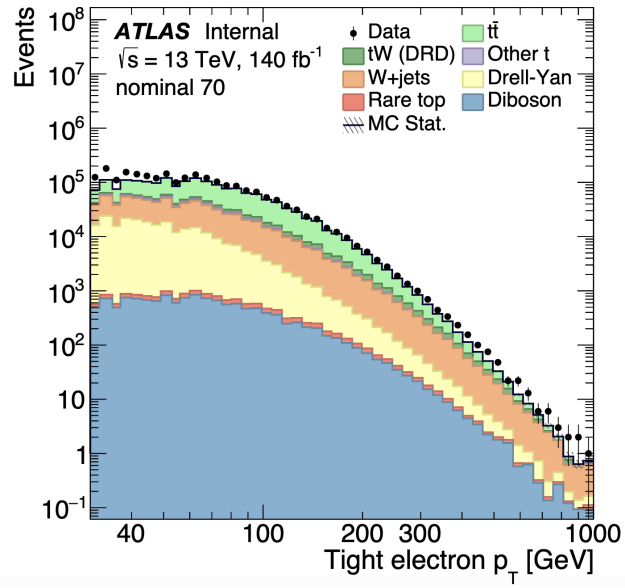




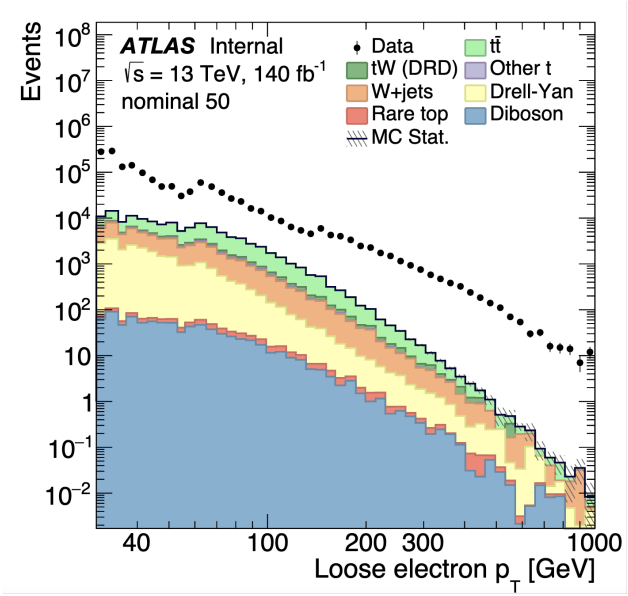
Modifying Control Region - Transverse mass

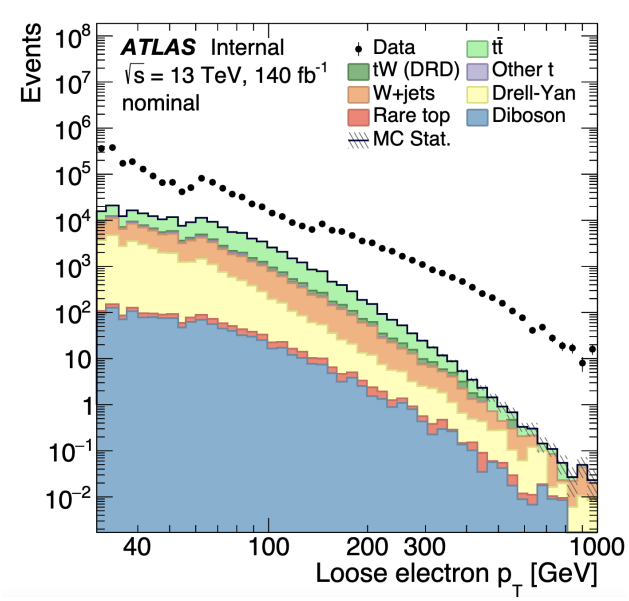


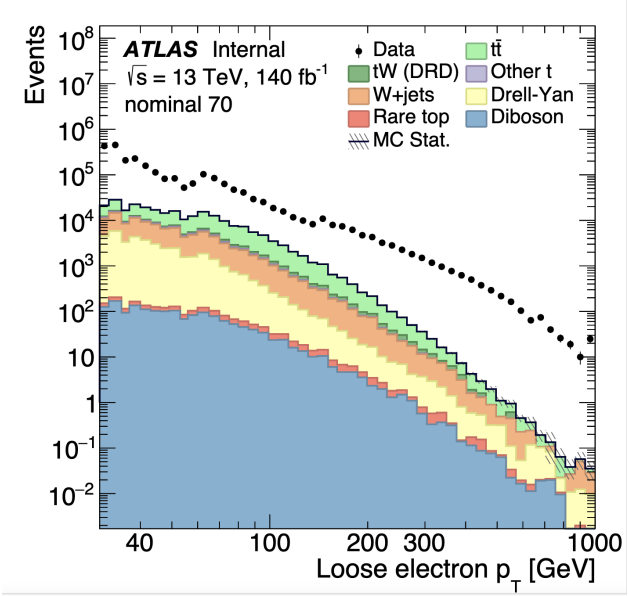




Modifying Control Region - Transverse mass

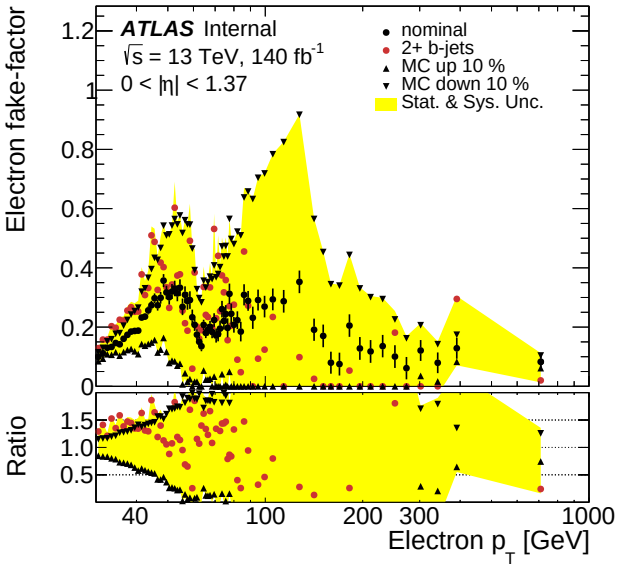


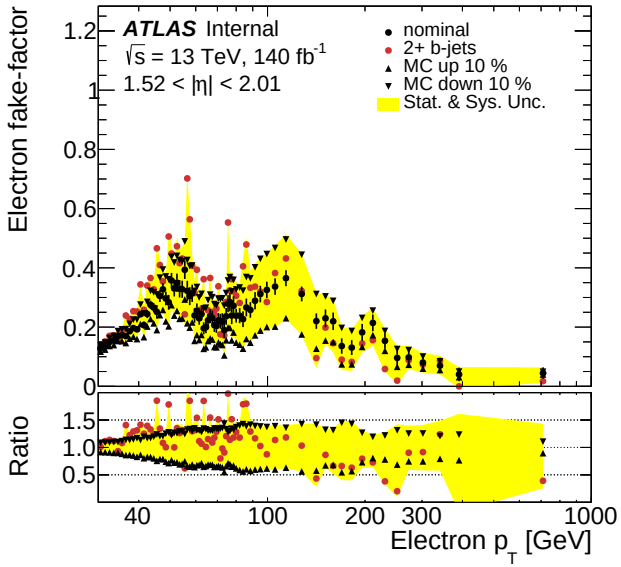


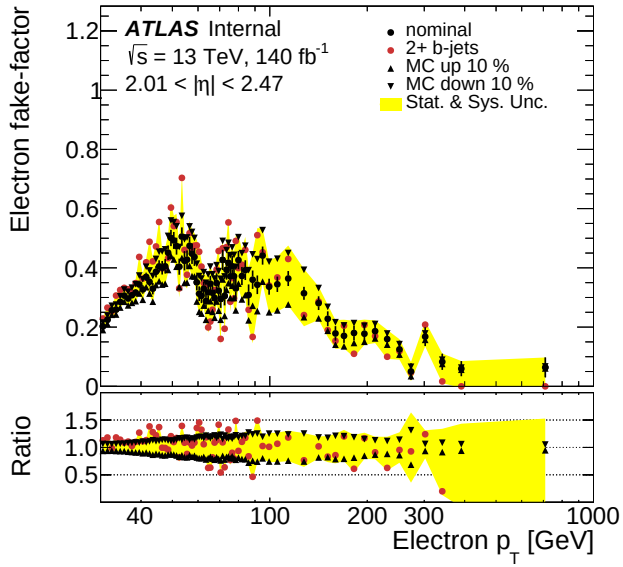


Modifying Control Region - Number of b-jets

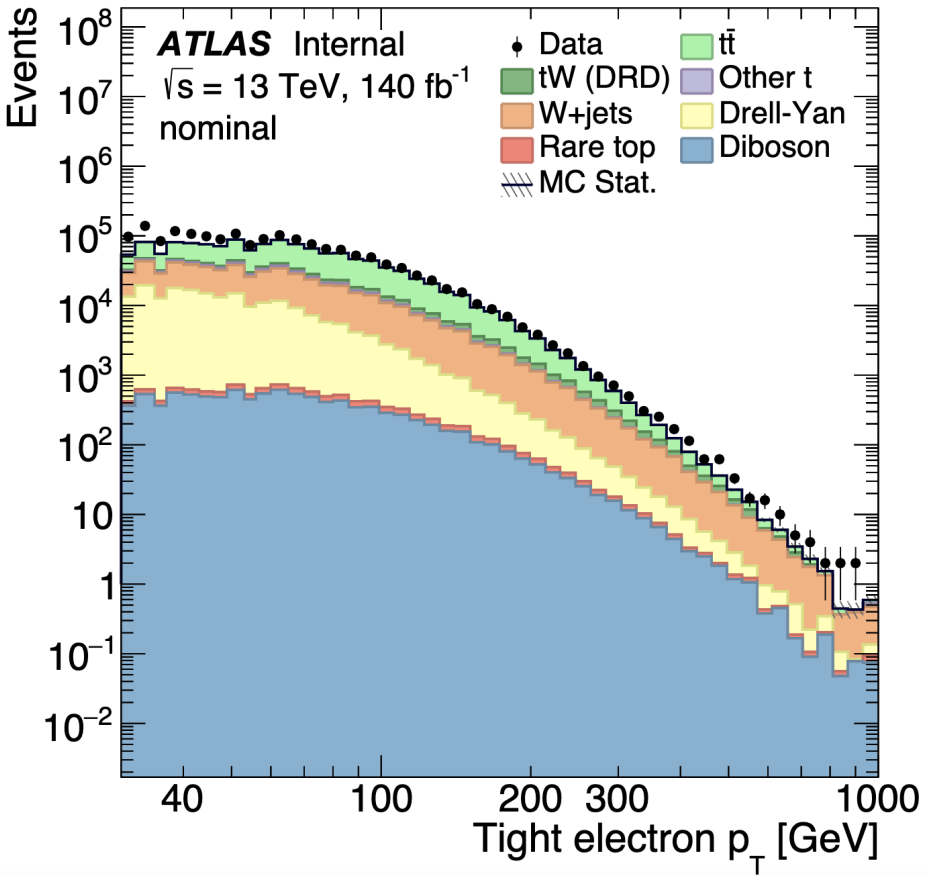
- $p_T^l > 30\,\text{GeV}$
  - 2 b-jets
- $m_T^{l,E_t^{miss}} < 60\,\text{GeV}$

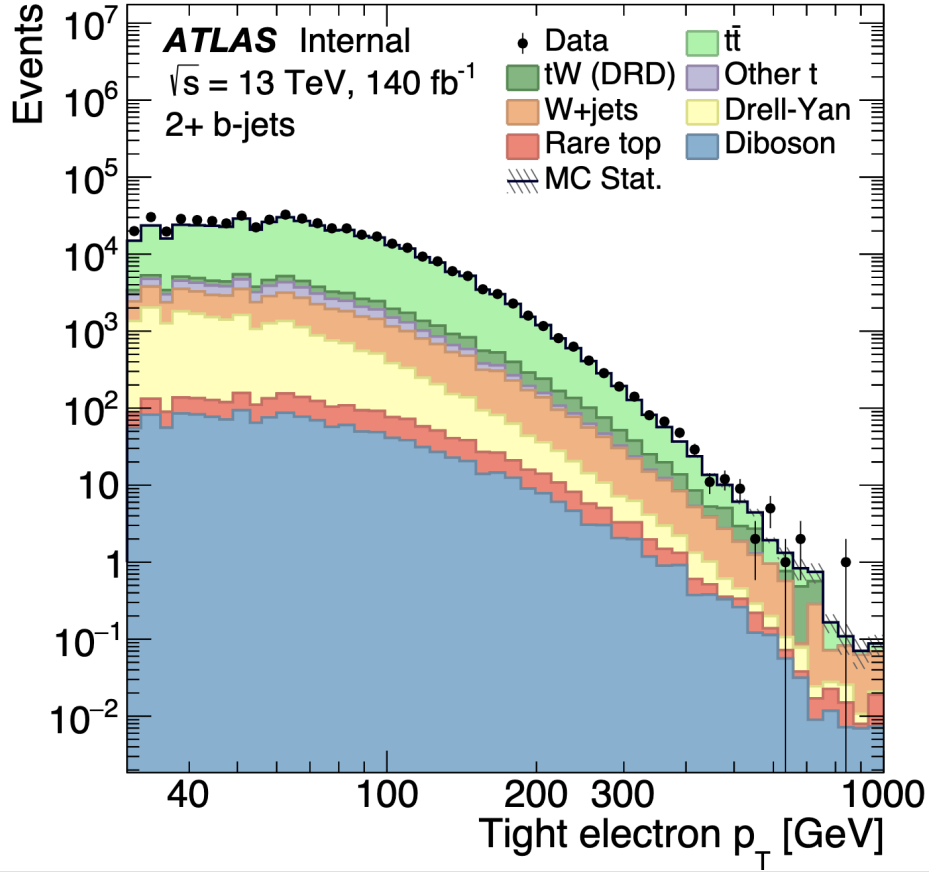




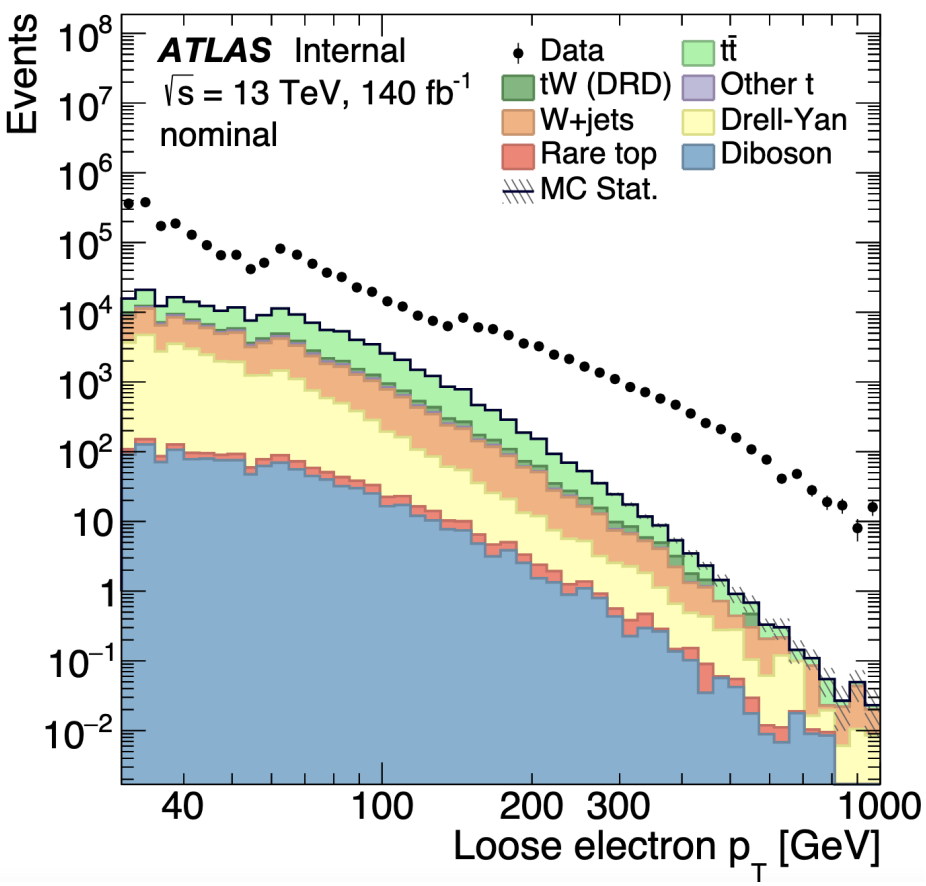


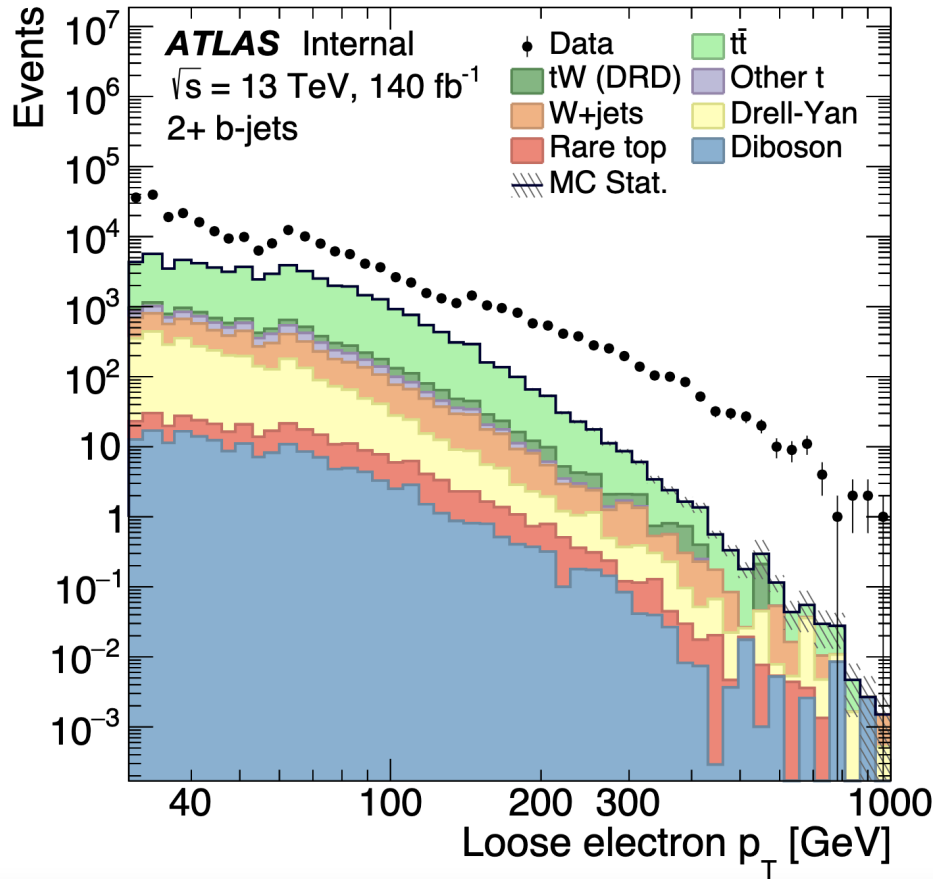
Modifying Control Region - Number of b-jets



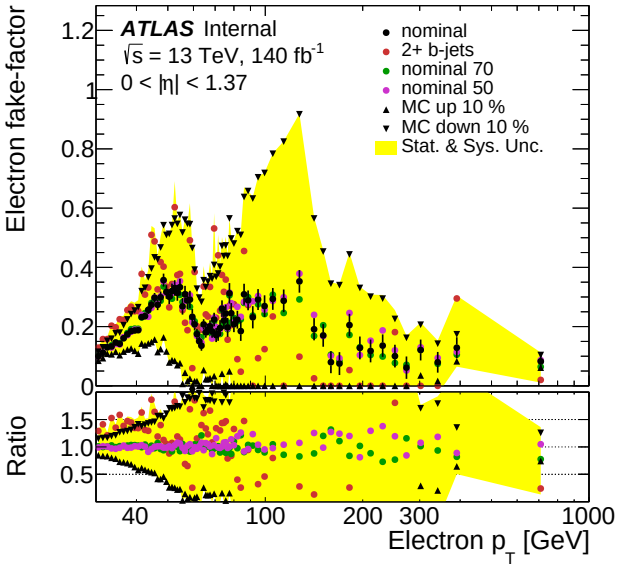


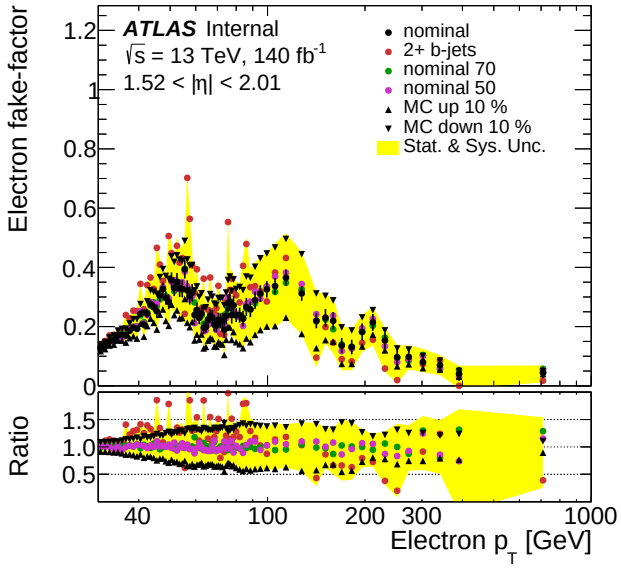
Modifying Control Region - Number of b-jets

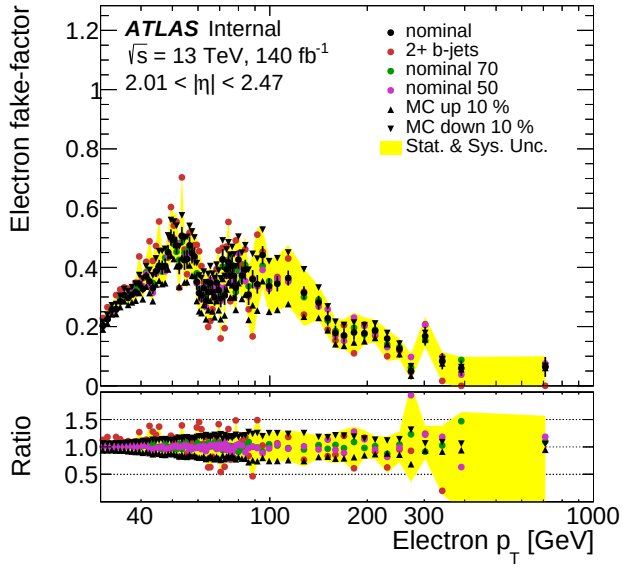




Modifying Control Region - Electrons Final Comparison





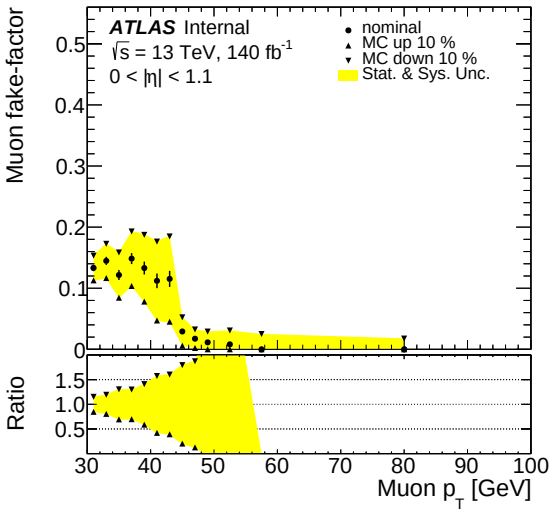


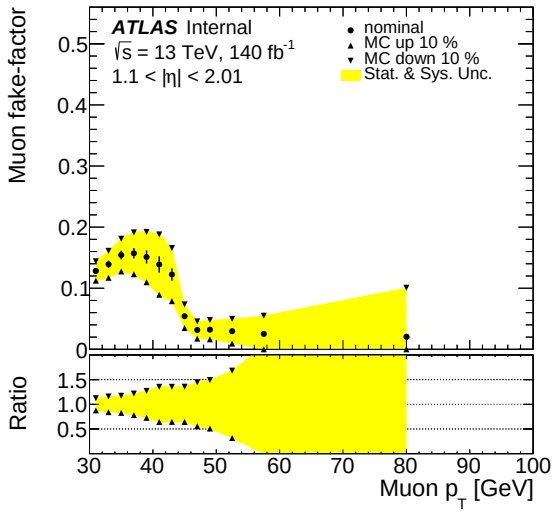
Reproducing fake factors - Muons Nominal CR

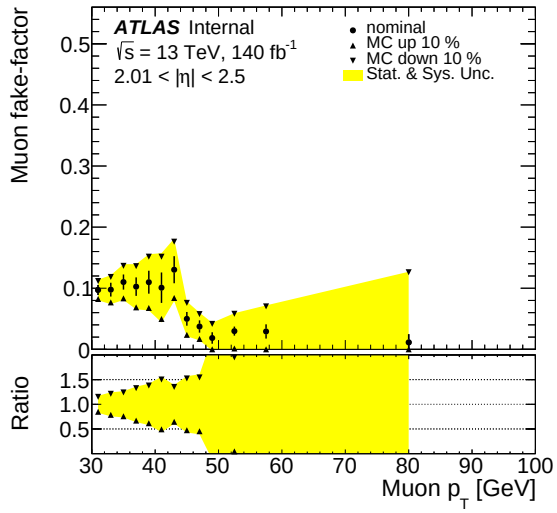
Control Region - Nominal

- $p_T^l > 30\,\text{GeV}$
- 1 b-jet
- $m_T^l + E_T^{miss} < 60\,\text{GeV}$
- $p_T^j > 35\,\text{GeV}$
- $\Delta\phi(j, \mu) > 2.7$

Reproducing fake factors - Muons Nominal CR

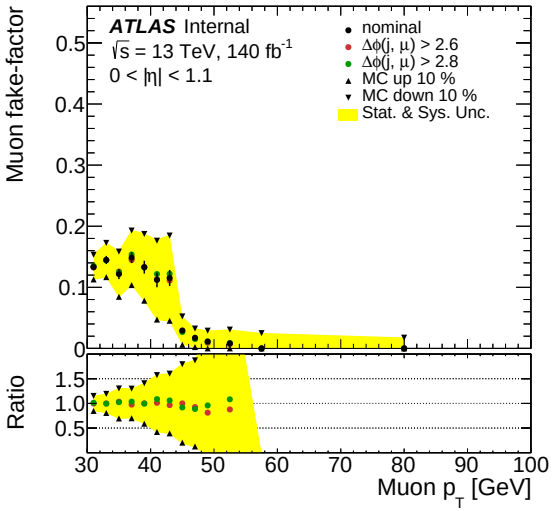


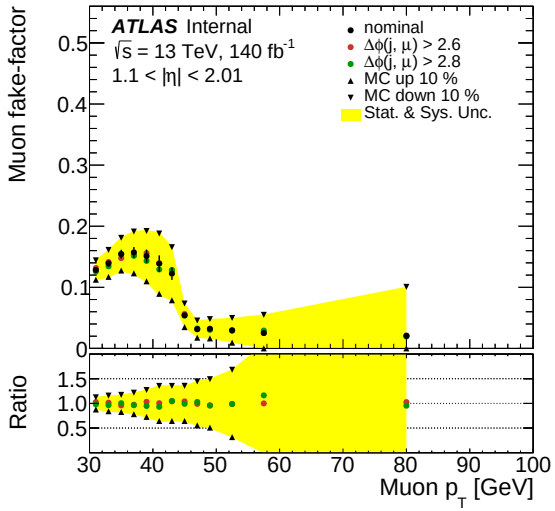


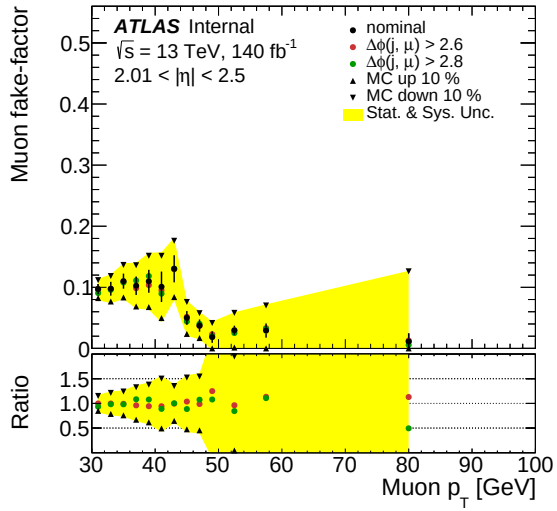


Modifying Control Region - $\Delta\phi(j, \mu)$

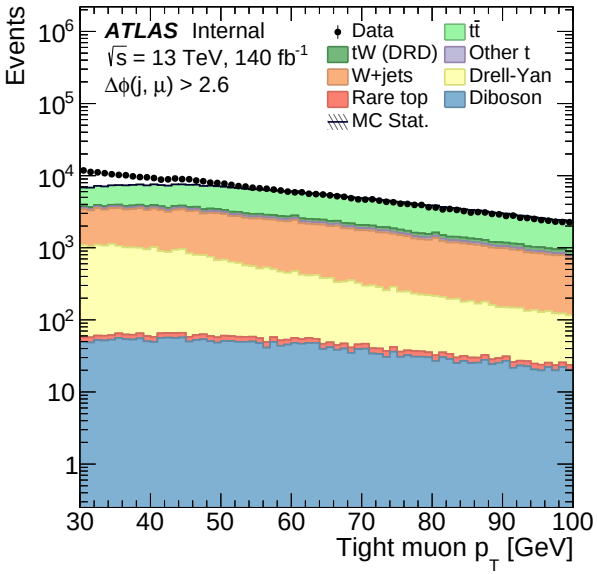
$$\Delta\phi(j, \mu) > 2.6/2.7/2.8$$

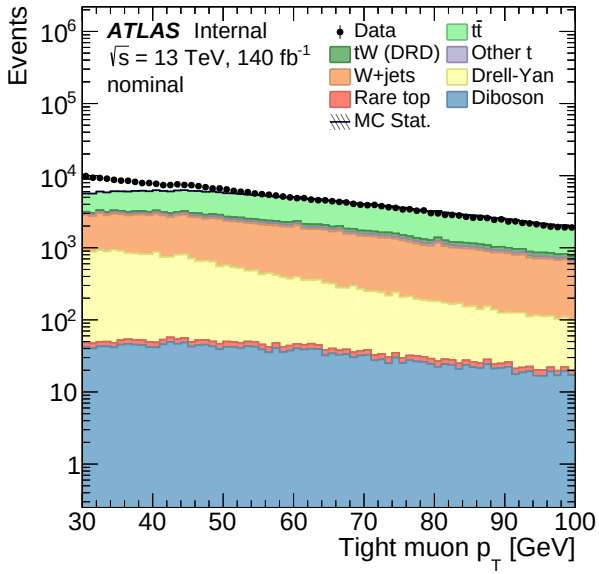


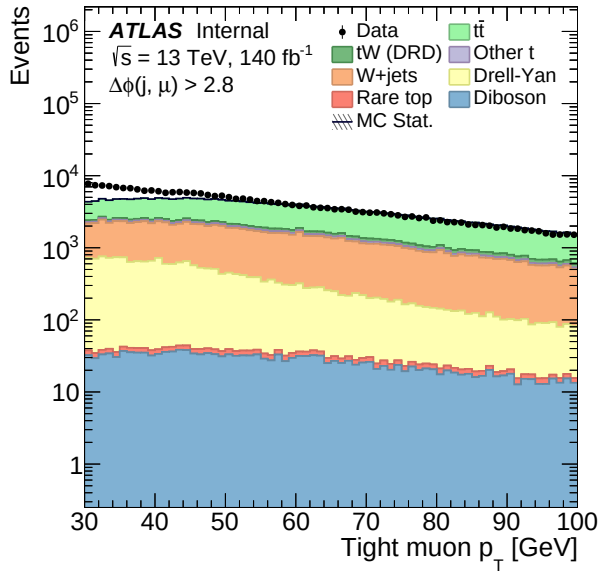




Modifying Control Region - $\Delta\phi(j, \mu)$







Modifying Control Region - $\Delta\phi(j, \mu)$