RSH signal optimisation

Abdualazem Fadol

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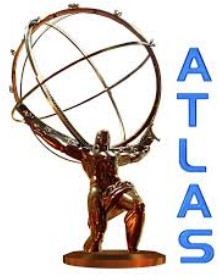

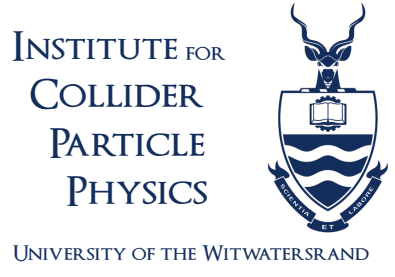

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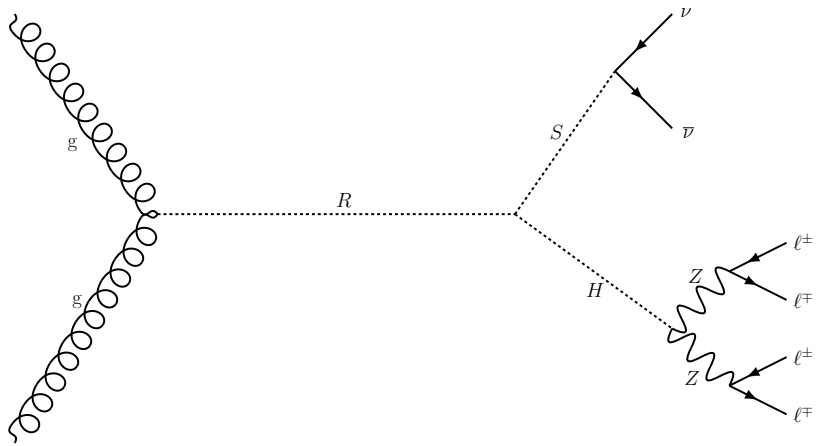
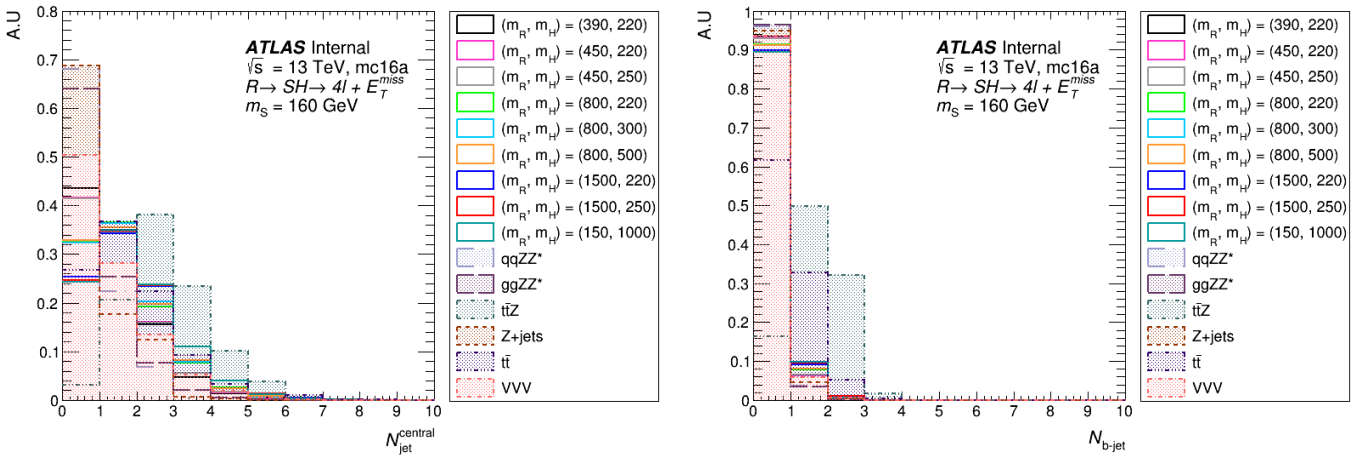


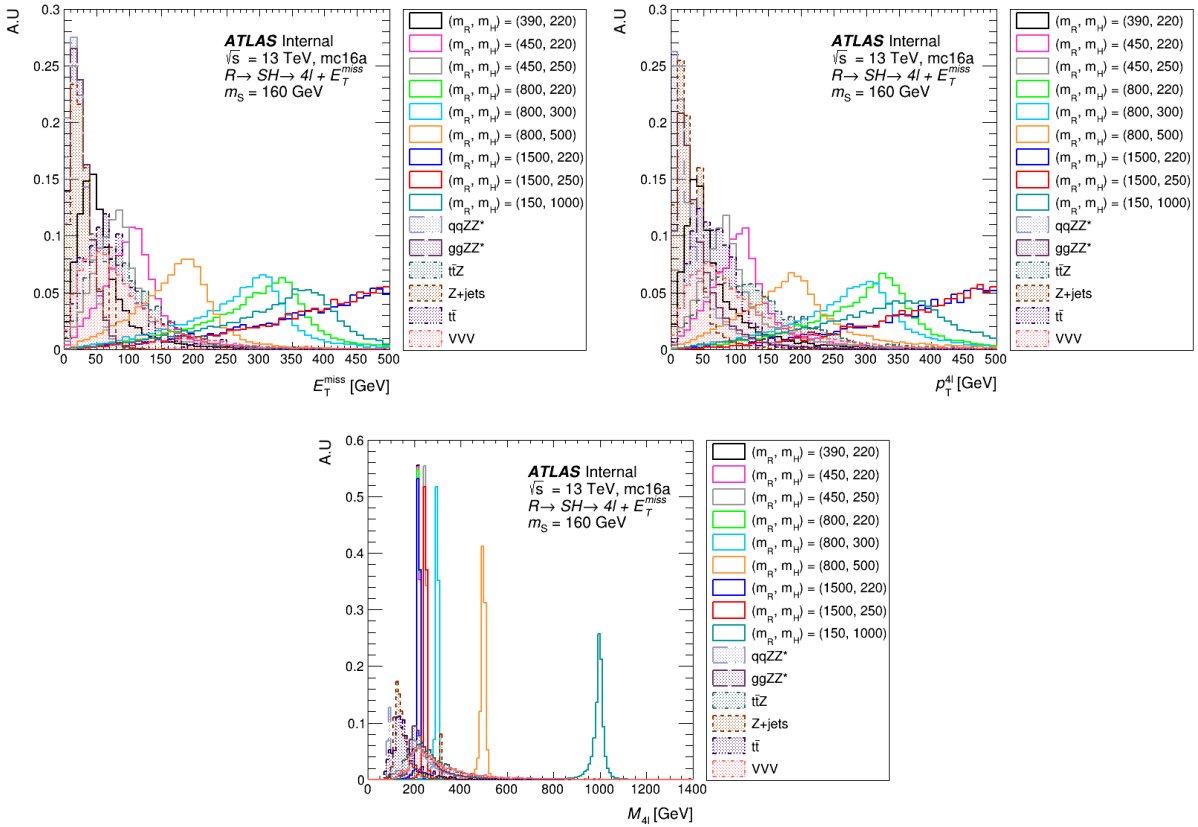
- Explores the presence of a heavy scalar boson, R;
- Produced in gluon-gluon fusion in association with Met;
- The resonance decays to lighter scalar H and S bosons;
- H decays into four leptons through ZZ bosons; and
- S decays to a pair of neutrinos.

Introduction

- Using the nominal selection, *HZZ*, for the four-lepton;
- B-veto to reject $ttZ \rightarrow 4\ell$ background;
- Events categorized into two categories:
  - $N_{jet}^{Central} = 0$
  - $N_{jet}^{Central} \geq 1$



Introduction



- Mapping $p_T^{4\ell}$ and E_T^{miss} using two techniques:
  - 2D efficiency maps: $\epsilon(S) \times [1 - \epsilon(B)]$;
  - By considering the $qqZZ^*$ background only; and
  - 2D sensitivity maps: significance defined by $s/\sqrt{S+B}$.

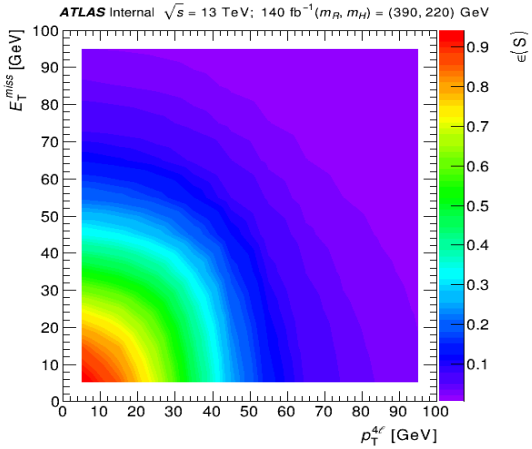
Cut-flow tables

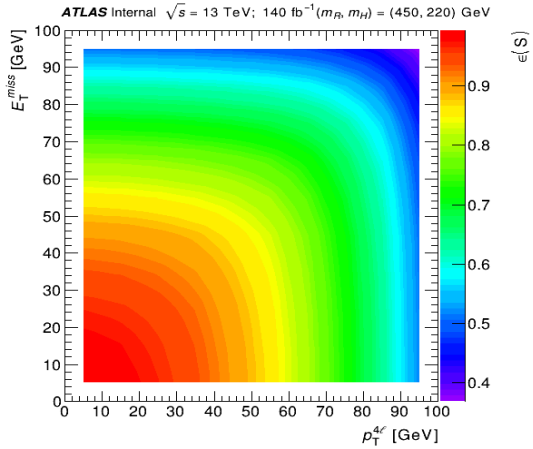
	$(m_R, m_H) = (450, 220)$	$qqZZ^*$	$ggZZ^*$	$t\bar{t}Z$	$Z + jets$	$t\bar{t}$	VVV	$s/\sqrt{s+b}$	$s/\sqrt{b}$
4ℓ	68.01±0.41	2474.93±7.43	345.02±1.04	26.89±0.61	2.59±0.24	3.28±0.56	13.74±0.15	1.26	1.27
B-veto	63.24±0.40	2358.82±7.33	330.25±1.02	4.45±0.25	2.38±0.23	1.94±0.41	12.96±0.15	1.20	1.21
$N_{\text{Cjet}} = 0$	28.20±0.26	1582.11±6.15	208.34±0.81	0.99±0.10	1.82±0.20	0.65±0.23	7.22±0.10	0.66	0.66
$(p_{\text{T}}^{4\ell} > 0$ & $E_{\text{T}}^{\text{miss}} > 0)$ GeV	28.20±0.26	1582.11±6.15	208.34±0.81	0.99±0.10	1.82±0.20	0.65±0.23	7.22±0.10	0.66	0.66

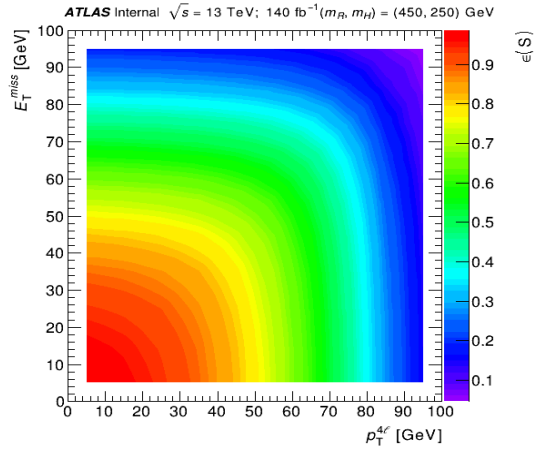
- The $qqZZ^*$ background is dominant;
- $ggZZ^*/qqZZ^*$ is 14.0%
- $t\bar{t}Z/qqZZ^*$ is 1.0%
- $t\bar{t}/qqZZ^*$ is 0.1%
- $VVV/qqZZ^*$ is 0.6%

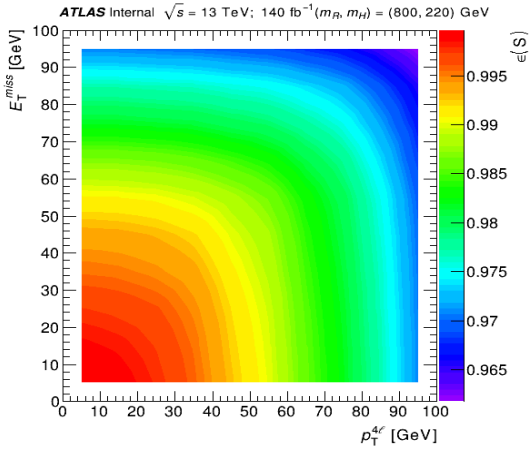
Two-dimensional efficiency mapping

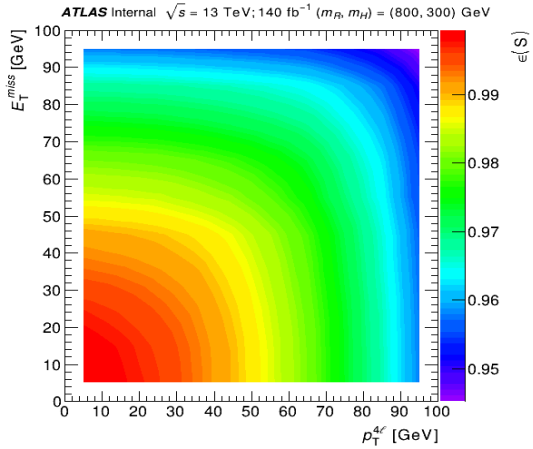
Signal efficiency

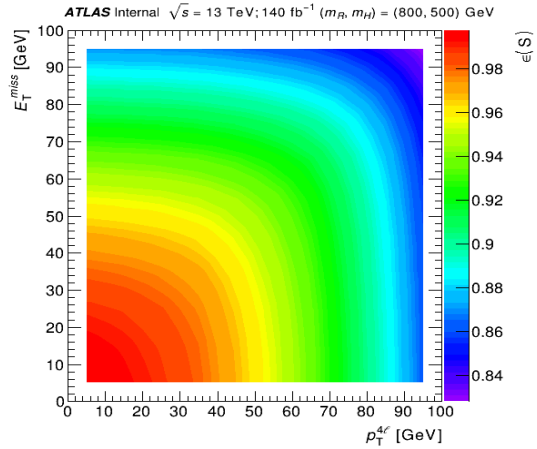




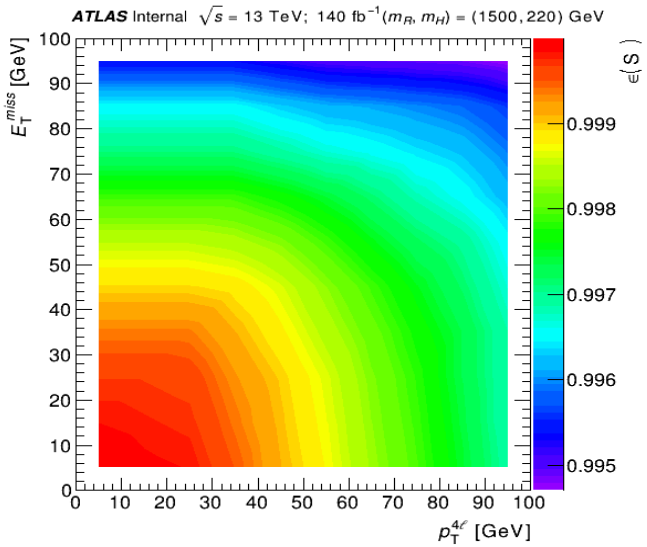


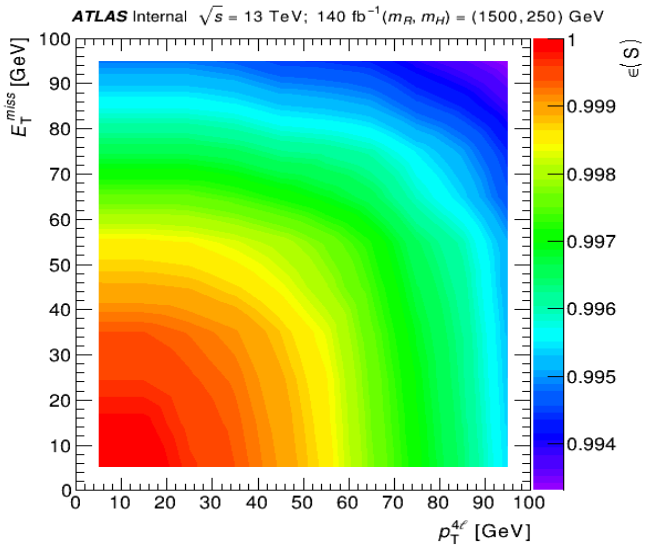


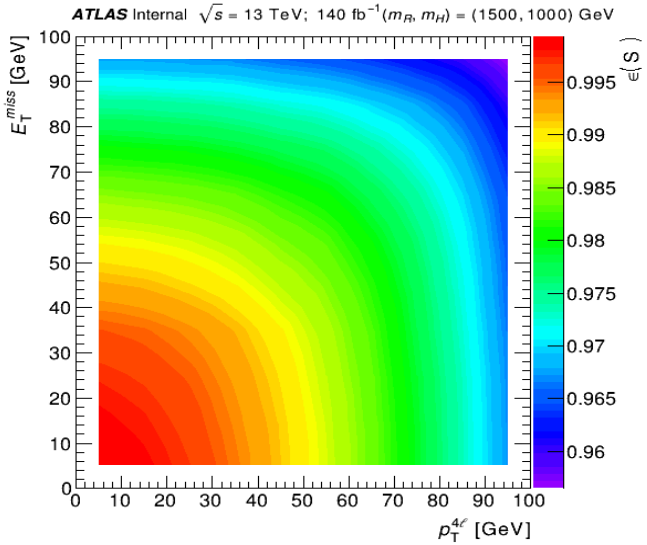




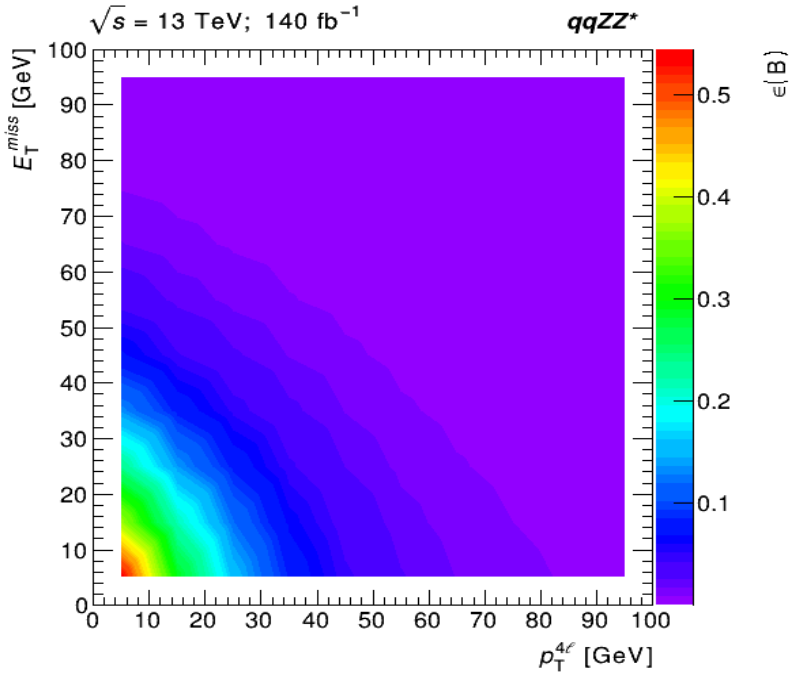
Signal efficiency

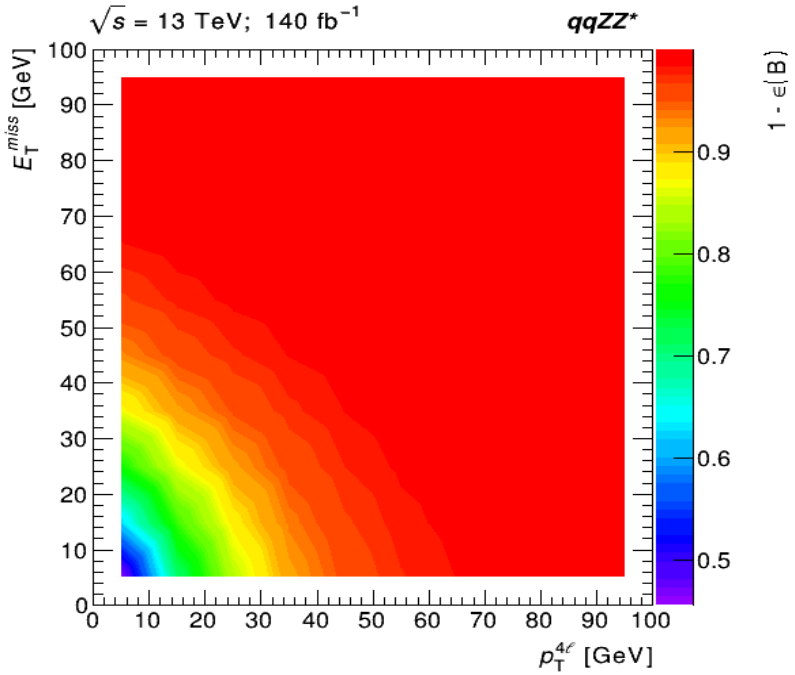




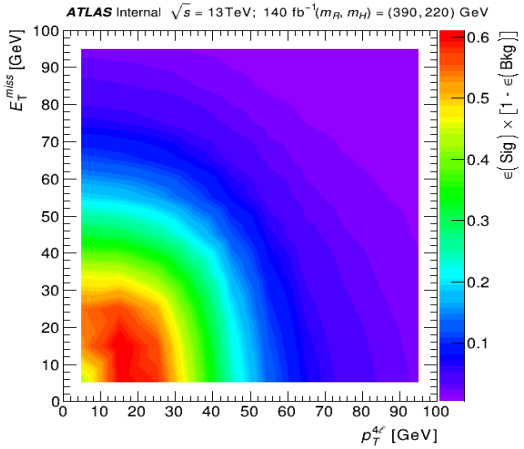


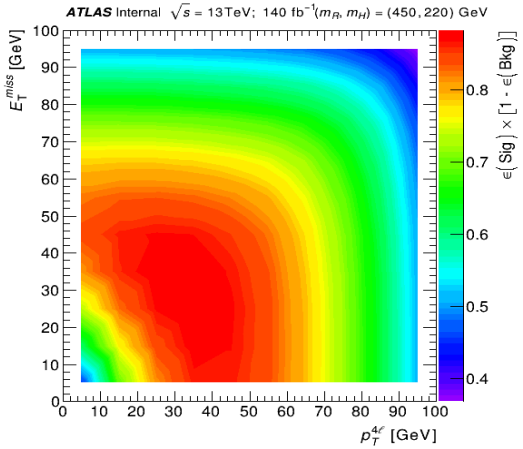
Background efficiency and rejection

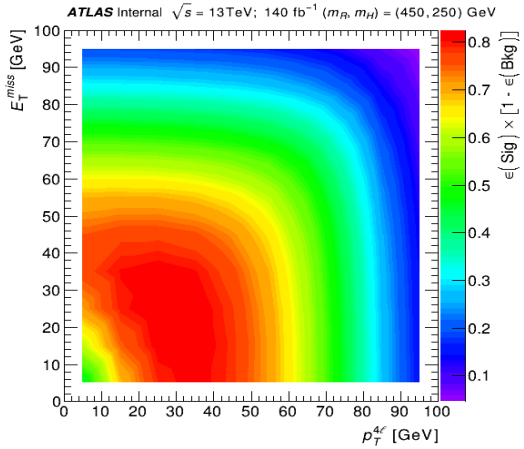


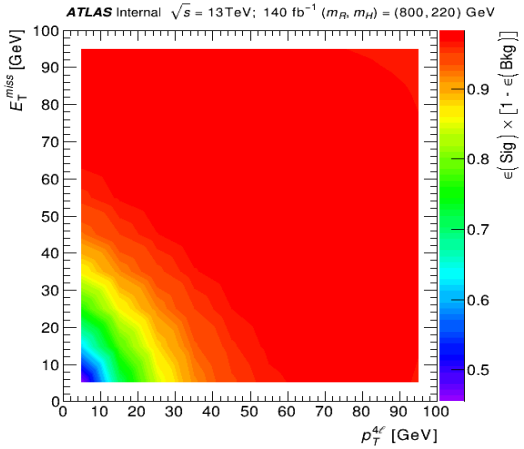


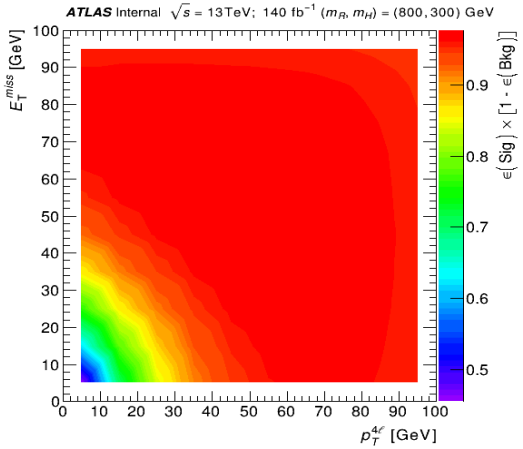
Signal efficiency times background rejection

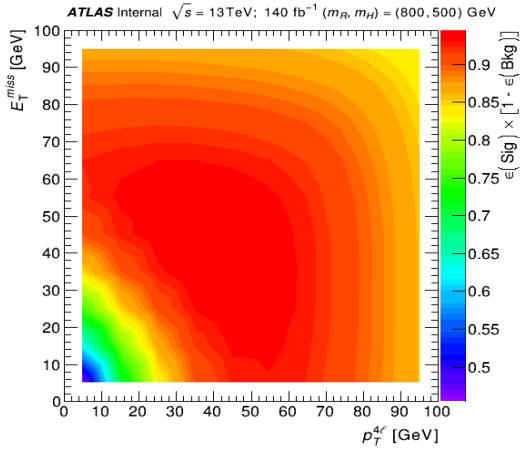




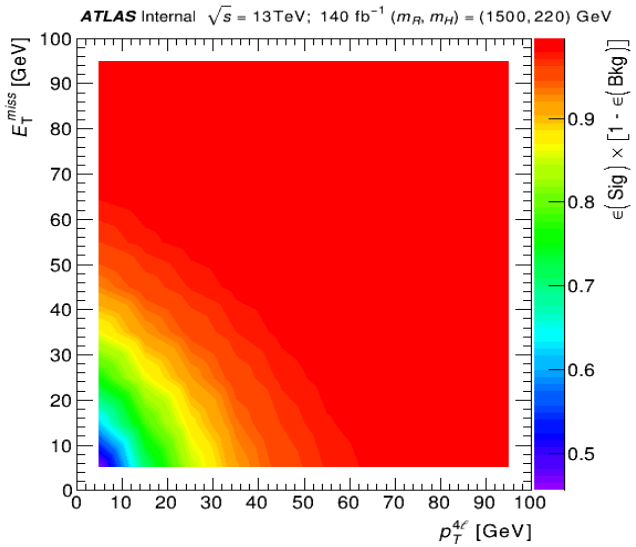


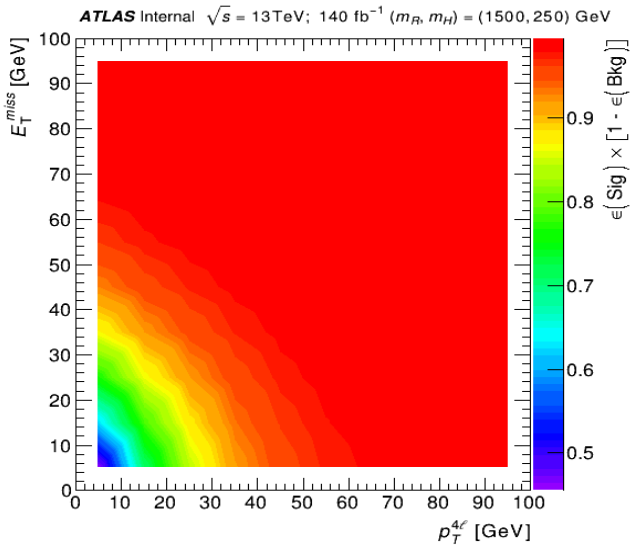


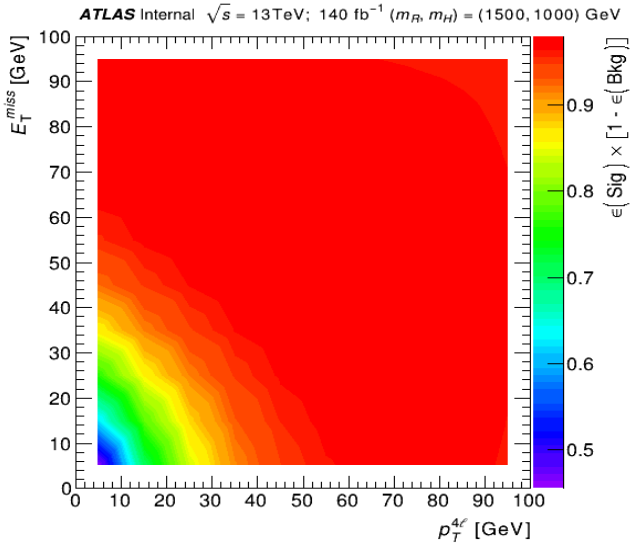




Signal efficiency times background rejection

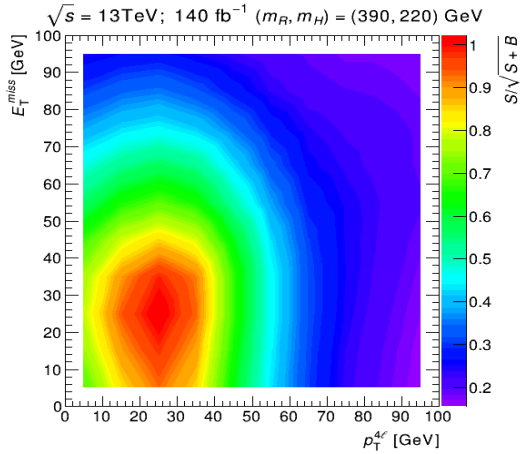


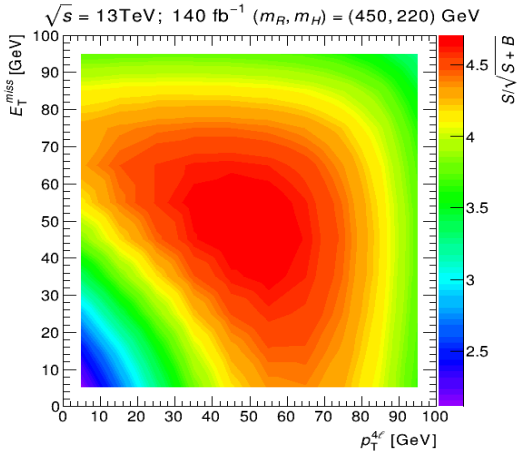


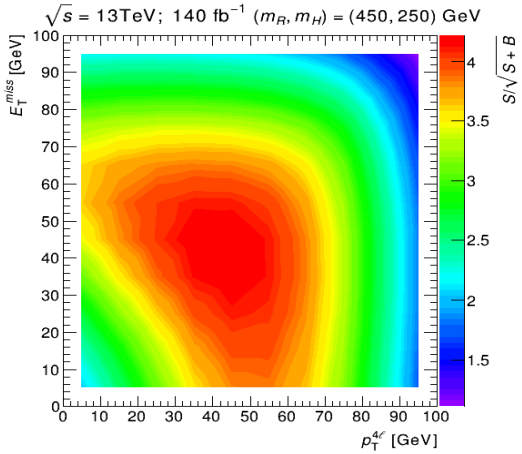


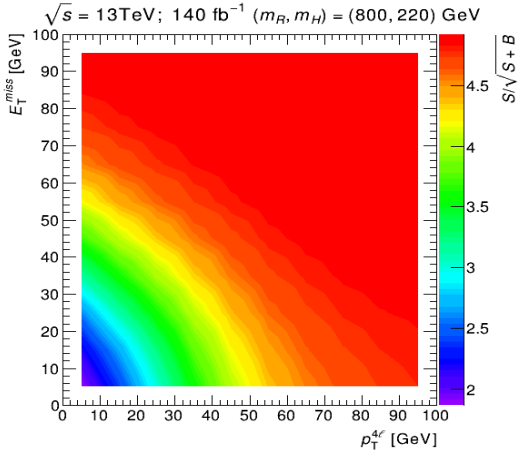
Two-dimensional sensitivity mapping

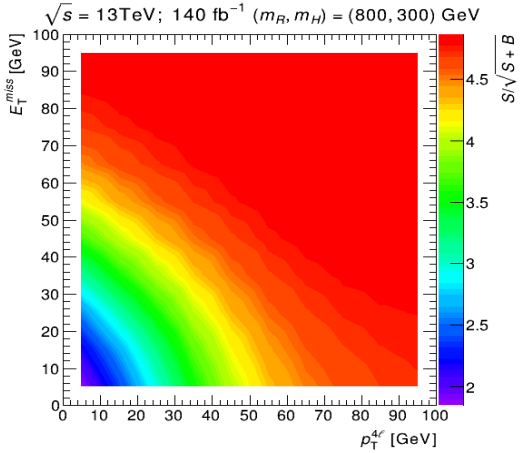
2D sensitivity mapping

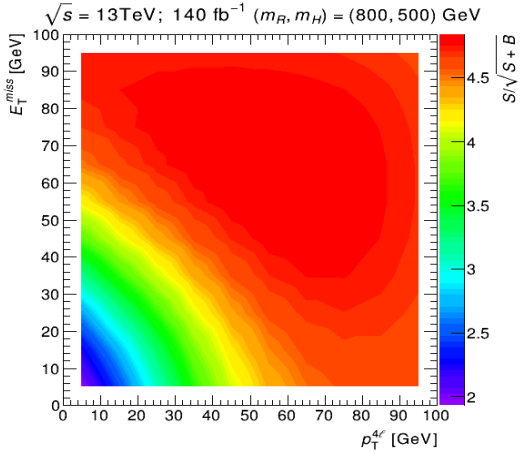




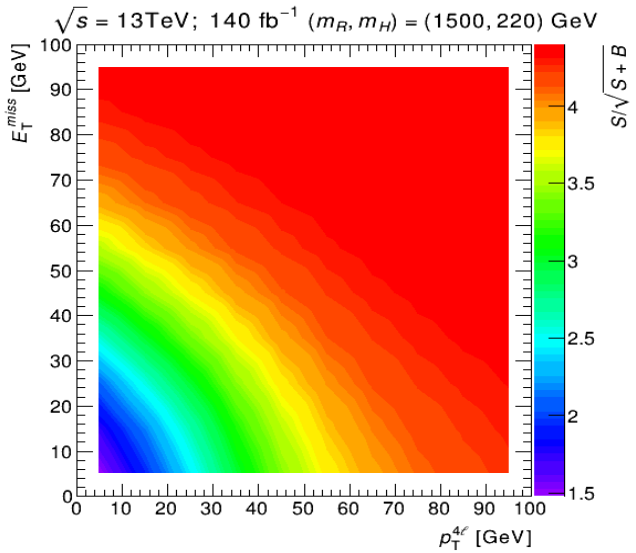


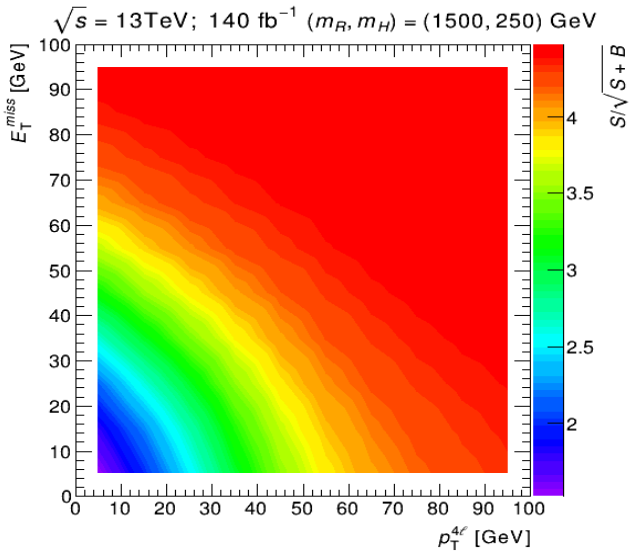


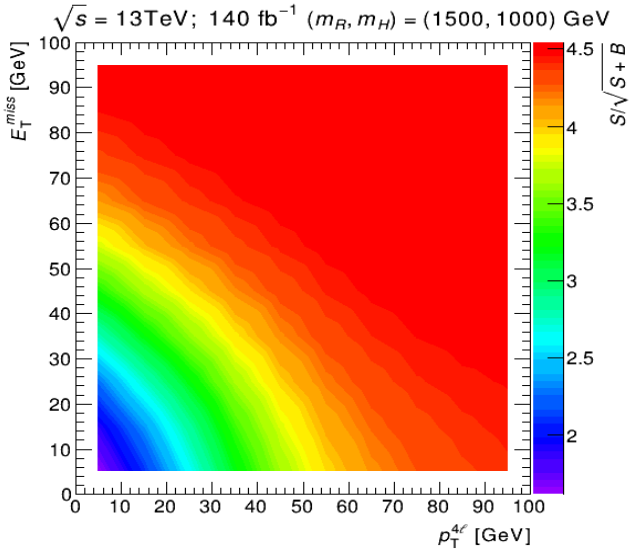




2D sensitivity mapping

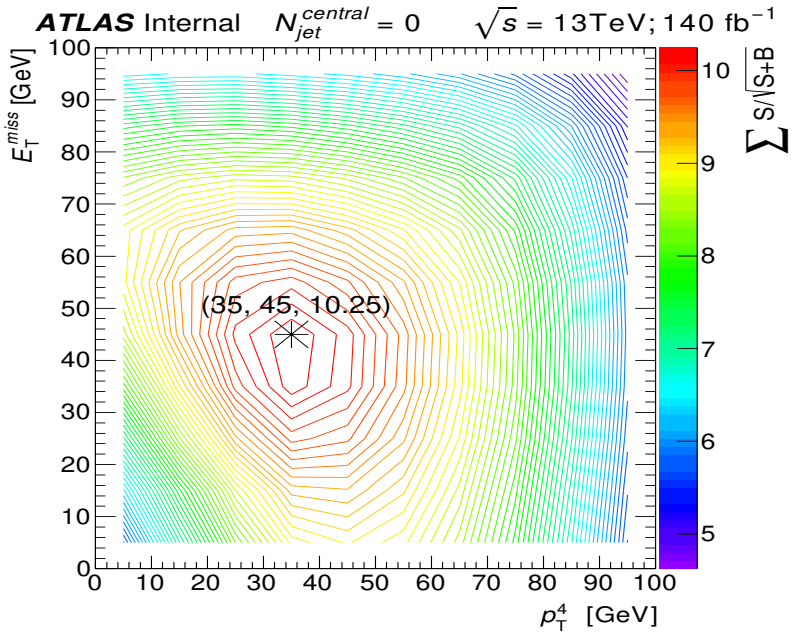


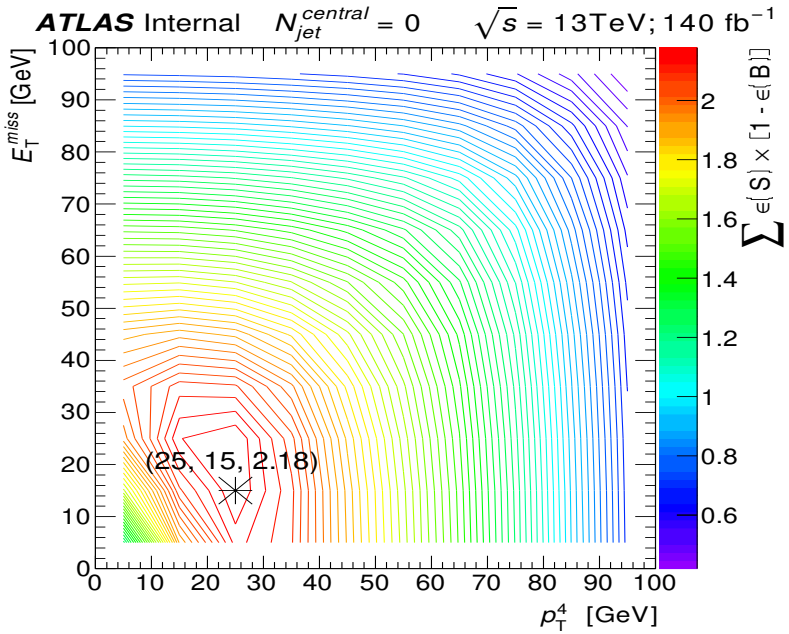




Optimisation results for the zero central jet

Low mass

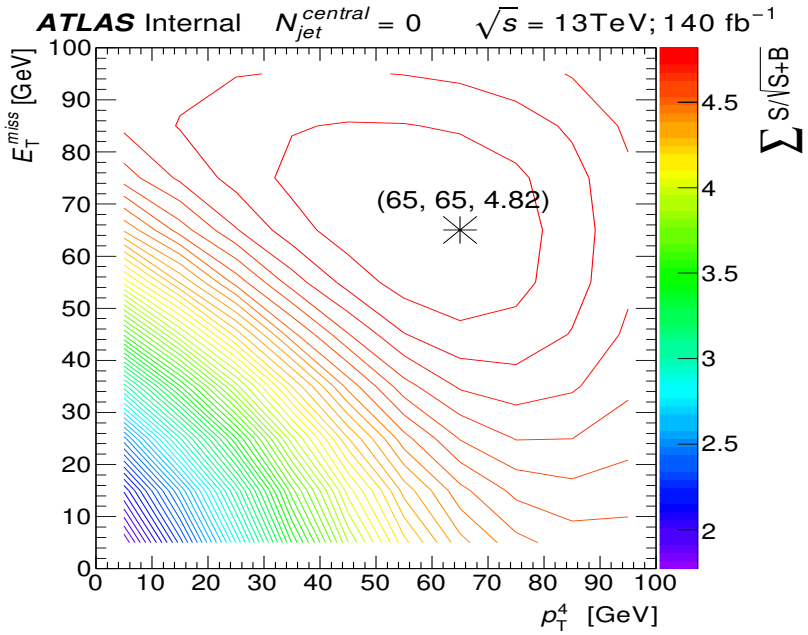


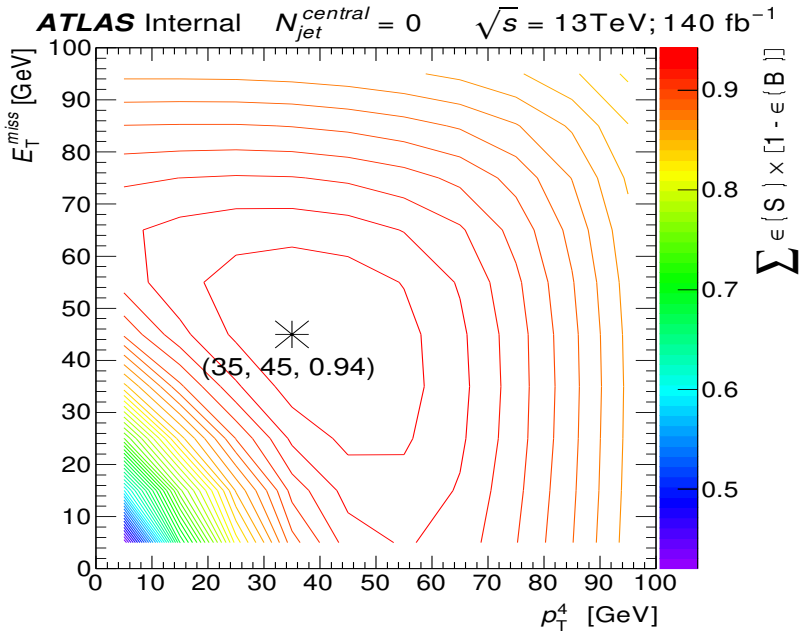


- Sum of the sensitivities (left):
  - (35, 45, 10.25)
- Sum of efficiencies (right):
  - (25, 15, 2.18)

Optimisation results for the zero central jet

Middle mass

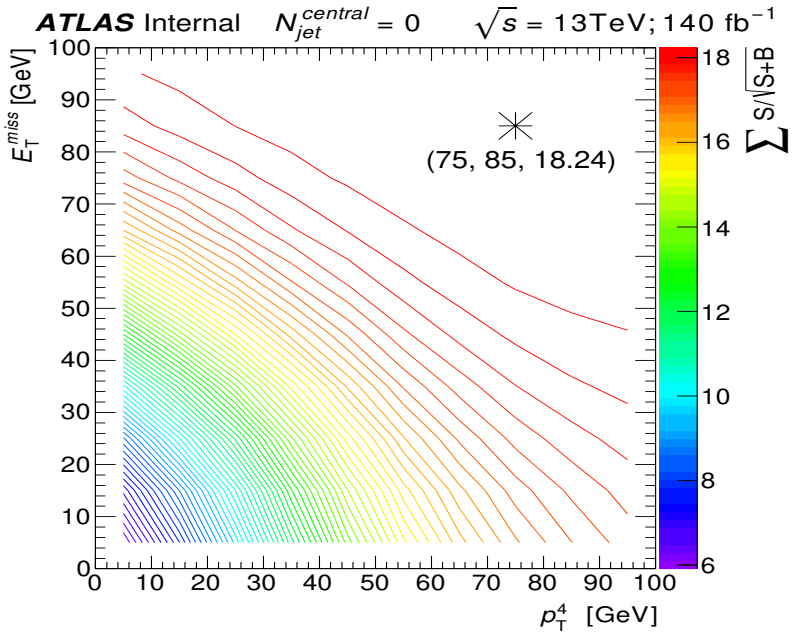


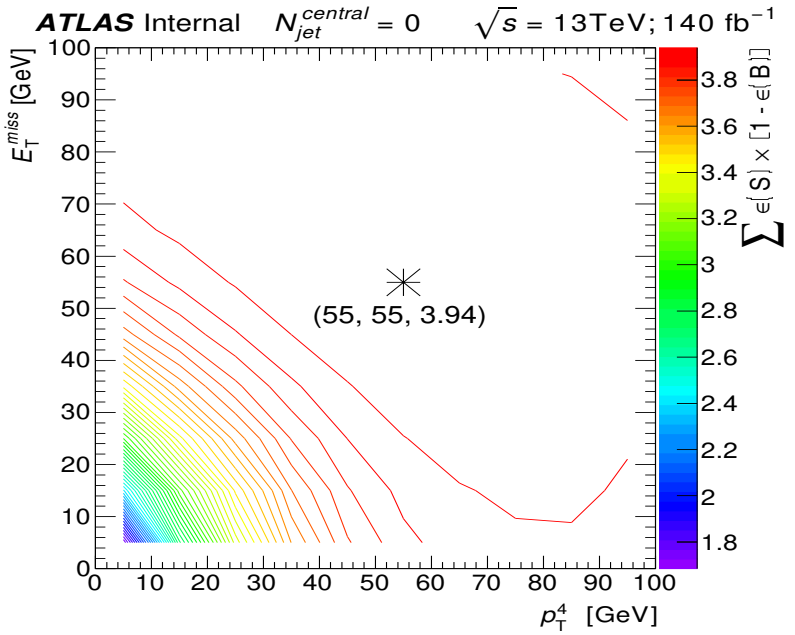


- Sum of the sensitivities (left):
  - (65, 65, 4.82)
- Sum of efficiencies (right):
  - (35, 45, 0.94)

Optimisation results for the zero central jet

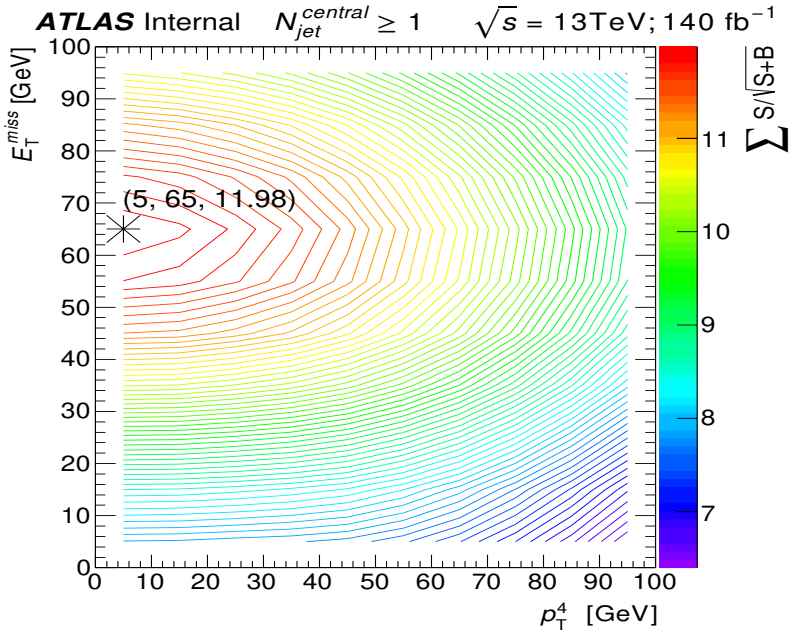
High mass

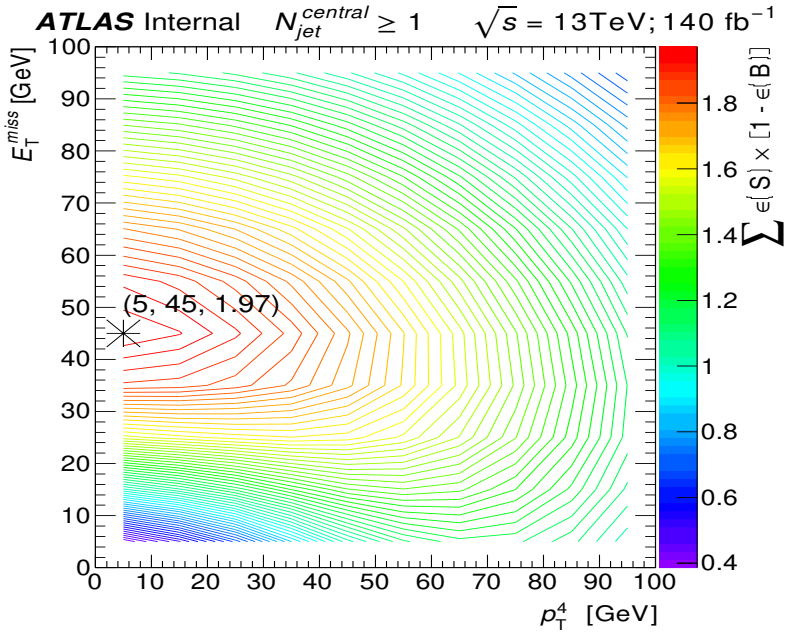




- Sum of the sensitivities (left):
  - (75, 85, 18.24)
- Sum of efficiencies (right):
  - (55, 55, 3.94)

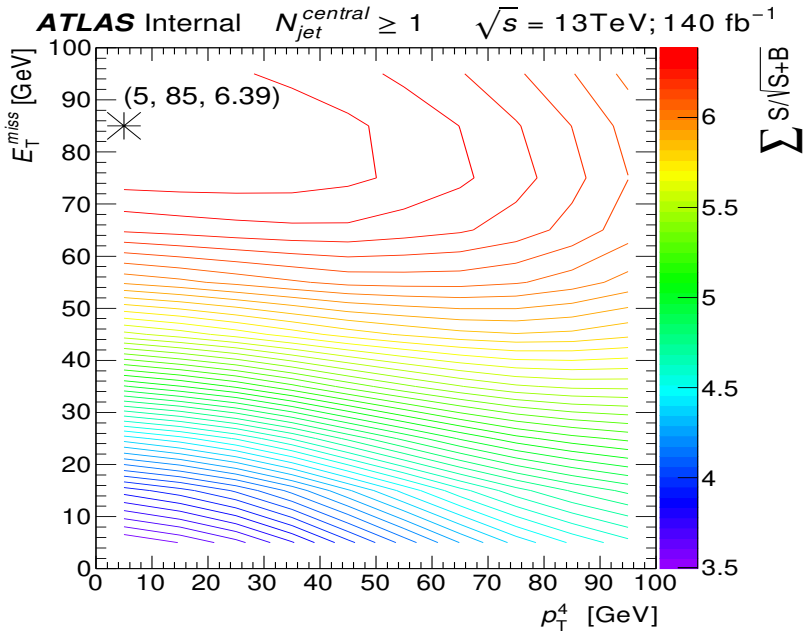
Optimisation results for one or more central jet
Low mass

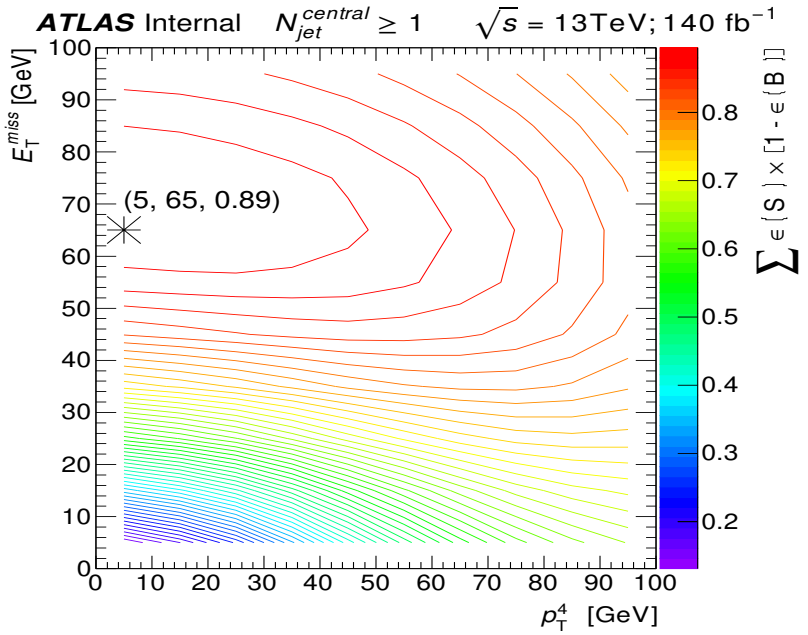




- Sum of the sensitivities (left):
  - (5, 65, 11.98)
- Sum of efficiencies (right):
  - (5, 45, 1.97)

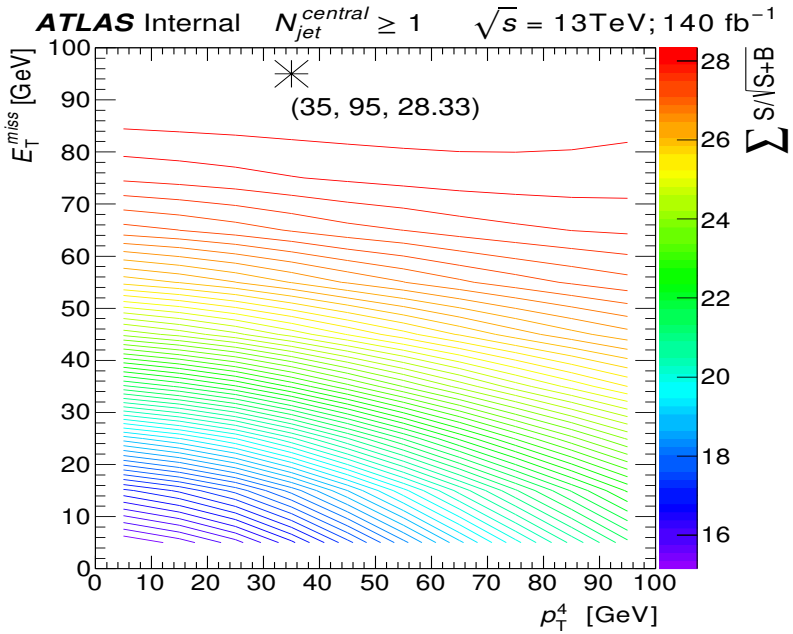
Optimisation results for one or more central jet
Middle mass

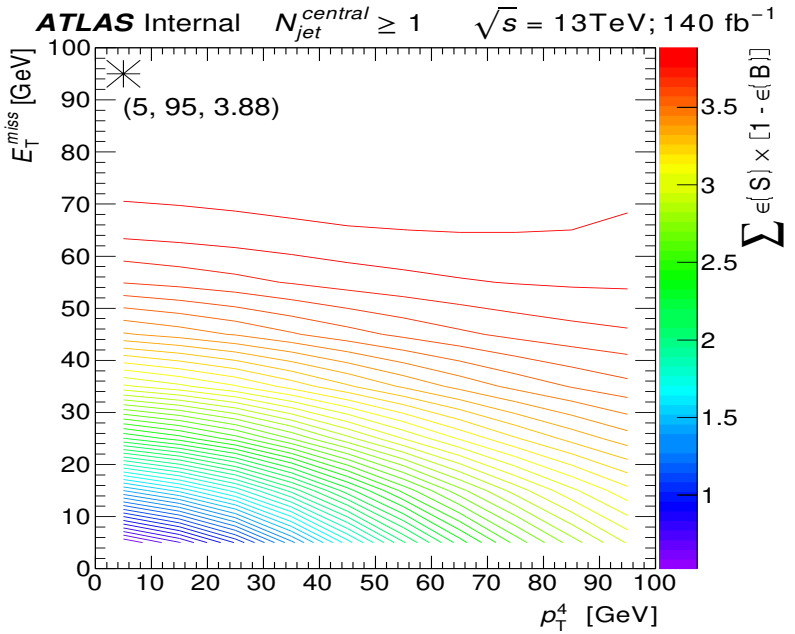




- Sum of the sensitivities (left):
  - (5, 85, 6.39)
- Sum of efficiencies (right):
  - (5, 65, 0.89)

Optimisation results for one or more central jet
High mass





- Sum of the sensitivities (left):
  - (35, 95, 28.33)
- Sum of efficiencies (right):
  - (5, 95, 3.88)

Summary

- Study the optimisation of RSH signal using cut-based optimisation;
- For $N_{jet}^{Central} = 0$
  - Sensitivities:
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (35, 45)$
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (65, 65)$
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (75, 85)$
  - Efficiencies:
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (25, 15)$
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (35, 45)$
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (55, 55)$
- For $N_{jet}^{Central} \geq 1$
  - Sensitivities:
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (5, 65)$
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (5, 85)$
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (35, 95)$
  - Efficiencies:
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (5, 45)$
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (5, 65)$
    - $(p_{\mathrm{T}}^{4\ell}, E_{\mathrm{T}}^{miss}) = (5, 95)$

Thank you!

Additional slides

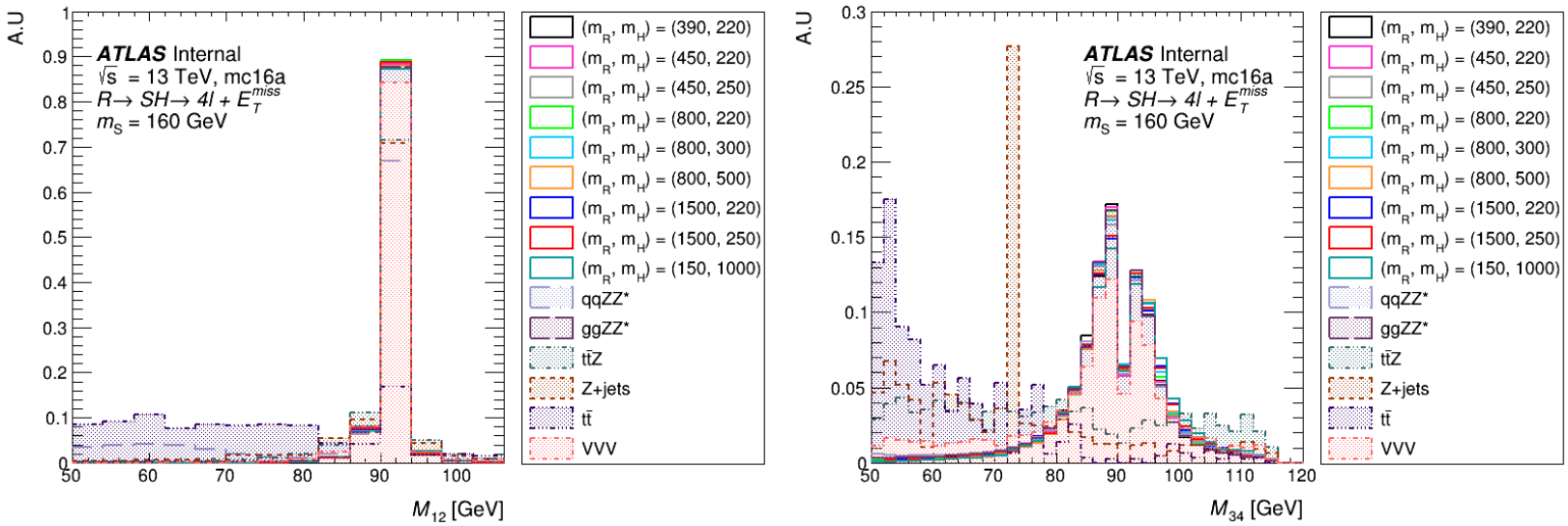
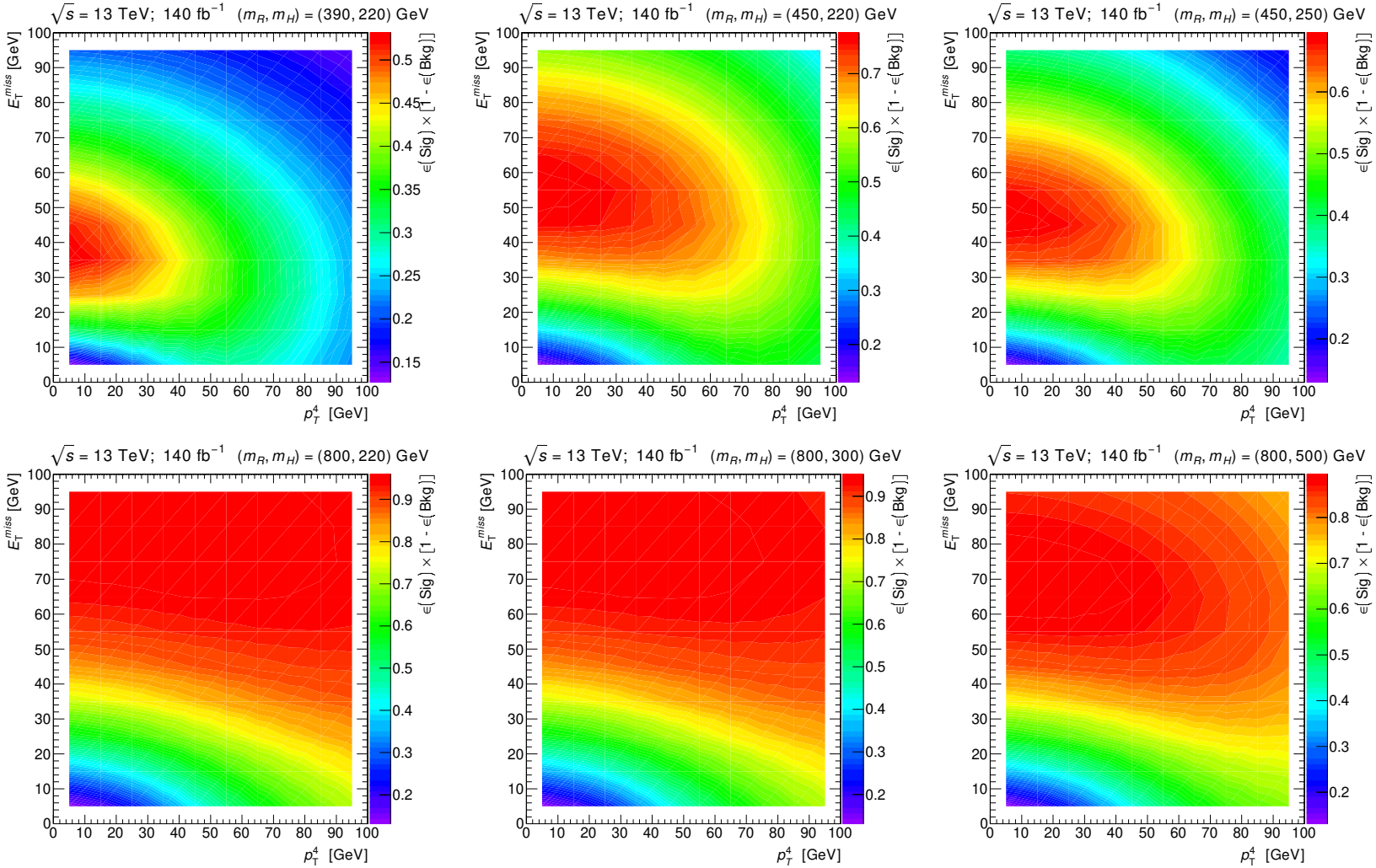


Figure: The invariant mass of the first (left) and the second (right) lepton pairs.

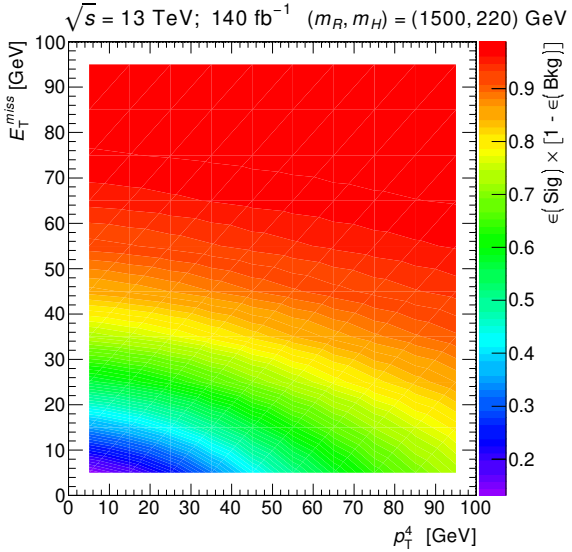
Additional slides

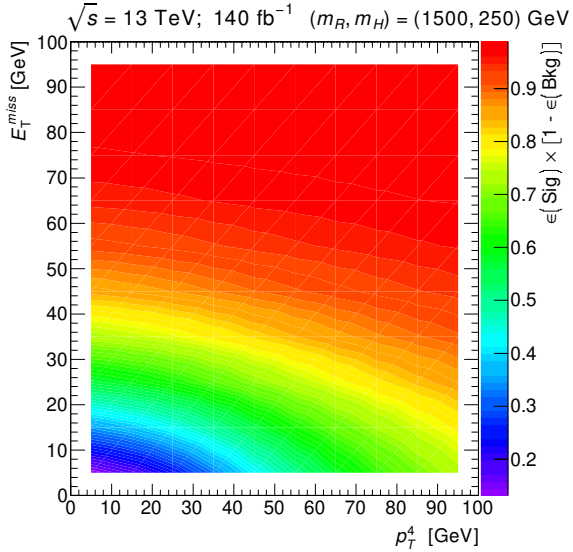
Efficiency map for one or more central jet

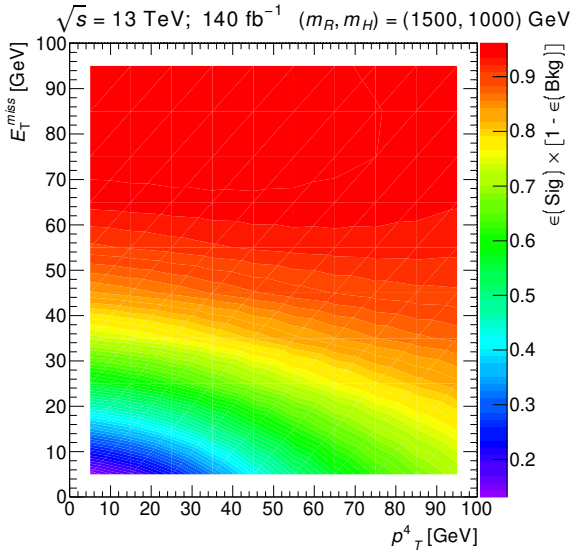


Additional slides

Efficiency map for one or more central jet

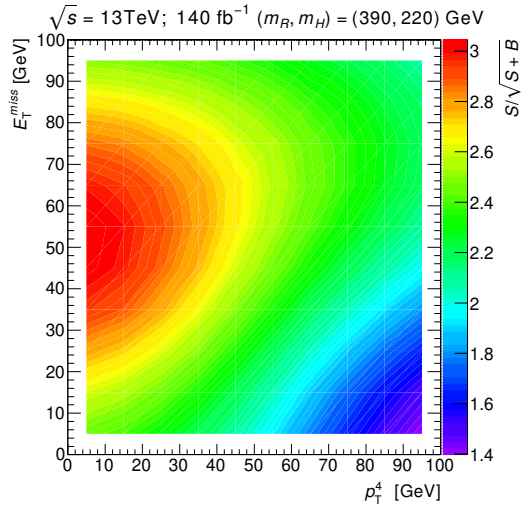


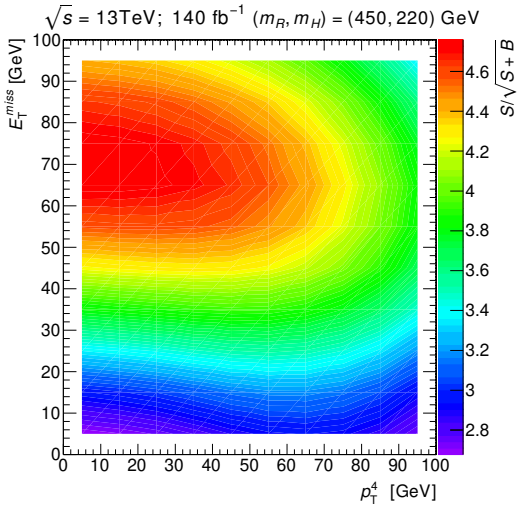


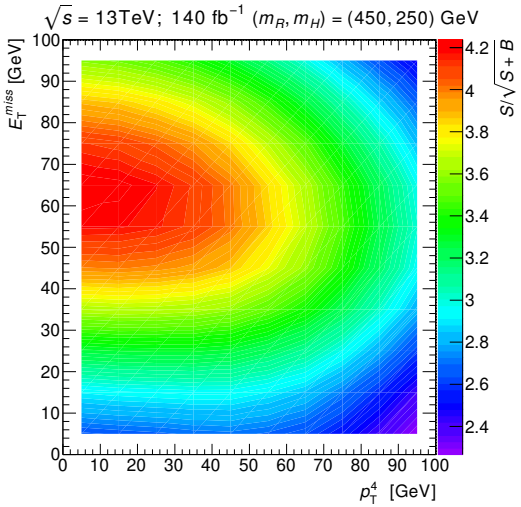


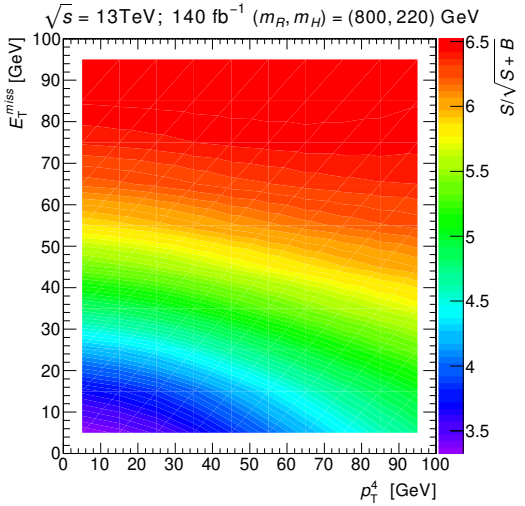
Additional slides

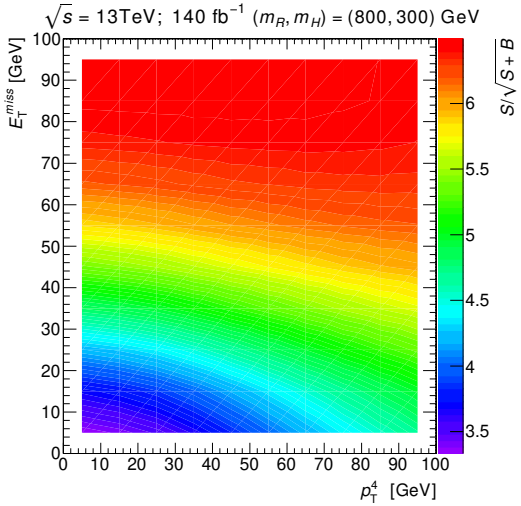
Sensitivity for one or more central jet

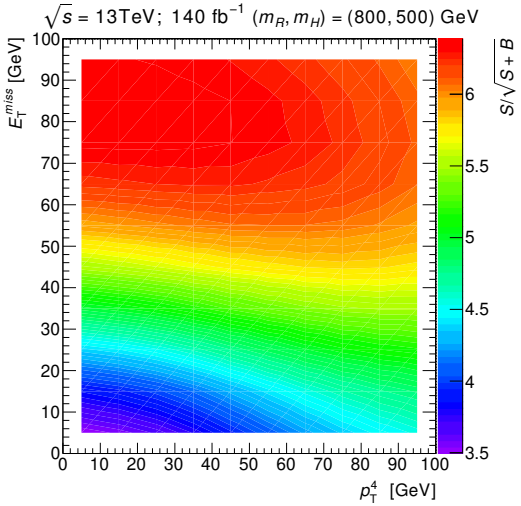






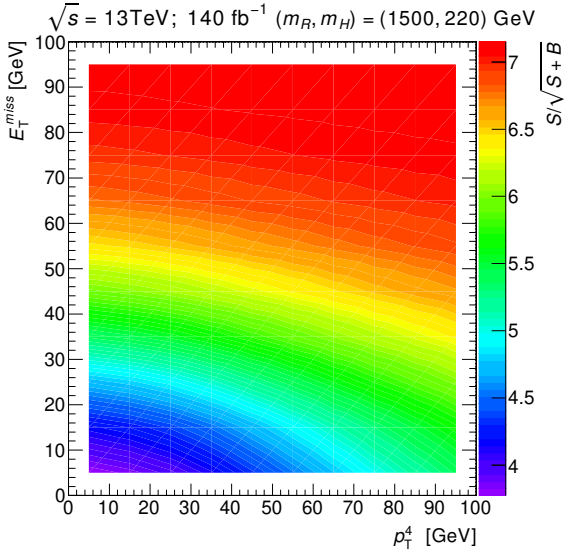


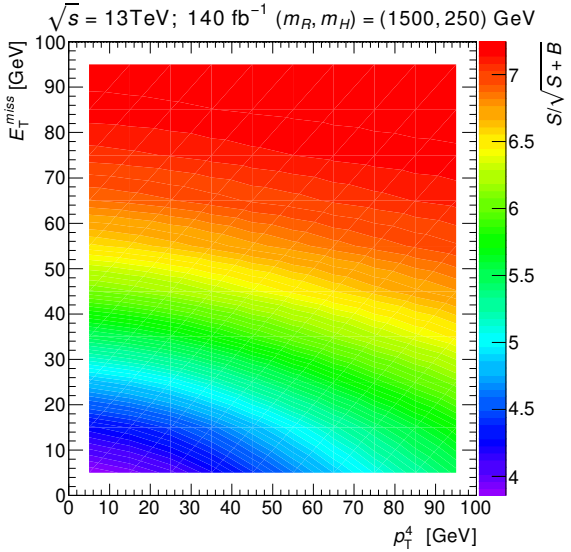


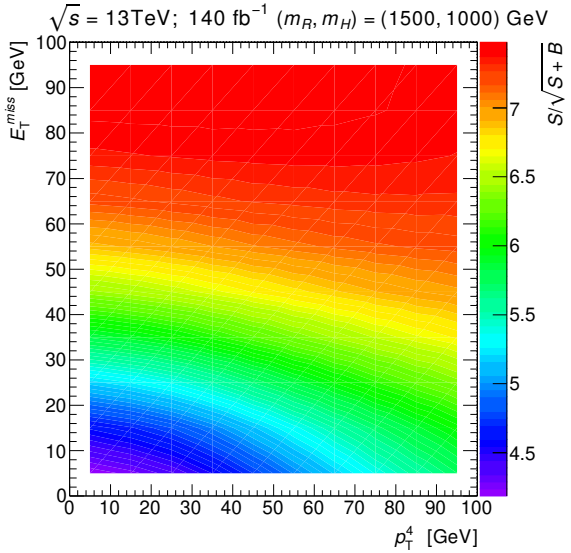


Additional slides

Sensitivity for one or more central jet







Additional slides