RSH signal optimisation

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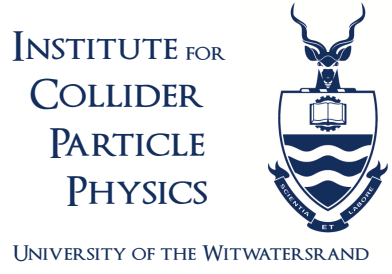
April 29, 2019



Contents

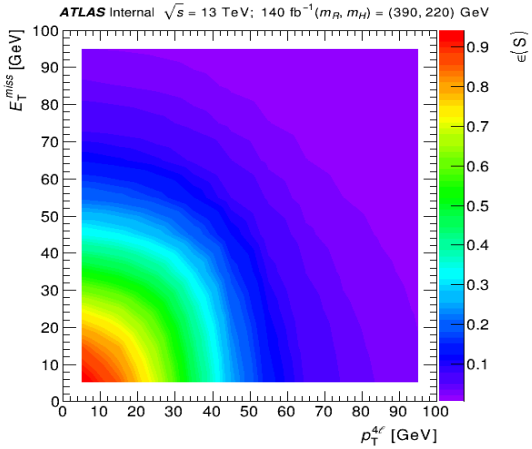
Introduction

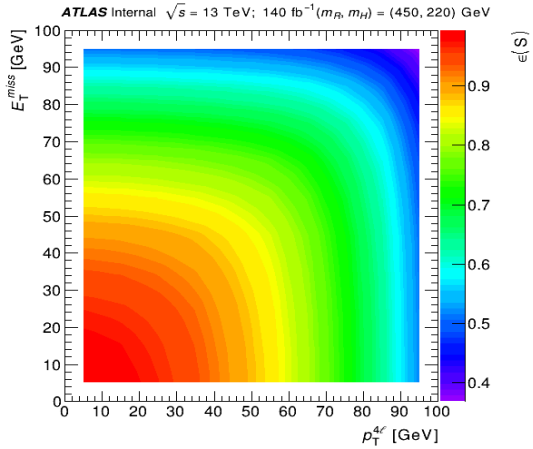
- Using the nominal selection, *HZZ*, for the four-lepton;
- B-veto to reject $ttZ \rightarrow 4\ell$ background;
- Events categorized into two categories:
  - $N_{jet}^{Central} = 0$
  - $N_{jet}^{Central} \geq 1$
- Mapping $p_T^{4\ell}$ and E_T^{miss} using two techniques:

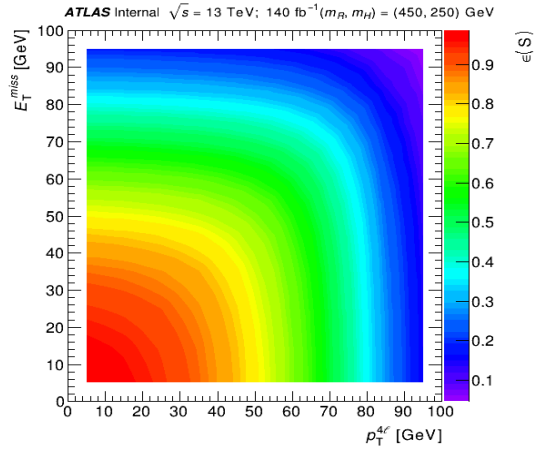
- 2D efficiency maps: $\epsilon(S) \times 1 - \epsilon(B)$;
- By considering the $qqZZ^*$ background only; and
- 2D sensitivity maps: significance defined by $s/\sqrt{S+B}$.

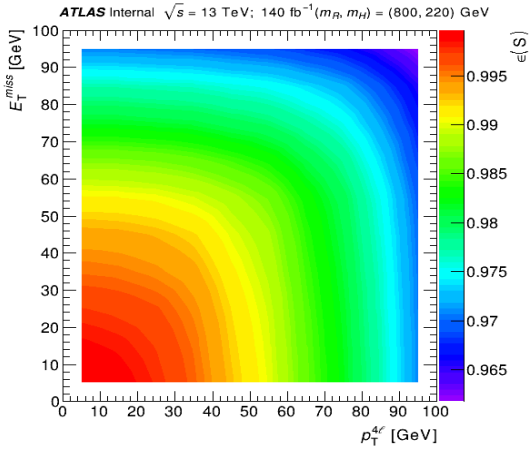
Two-dimensional efficiency mapping

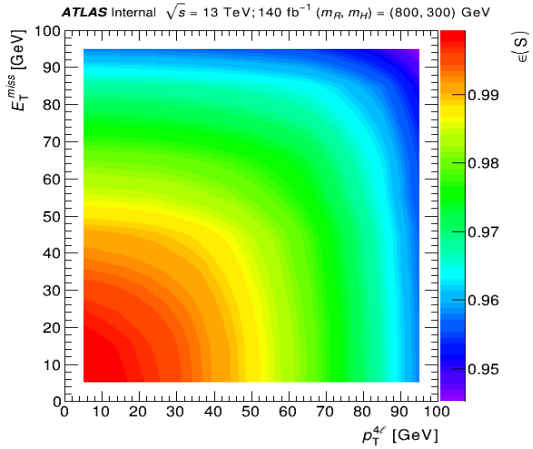
Signal efficiency

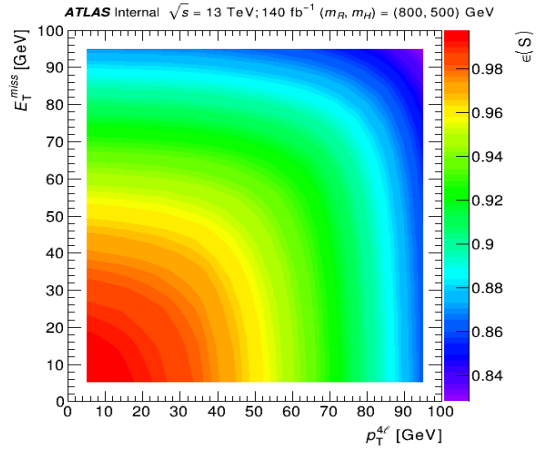




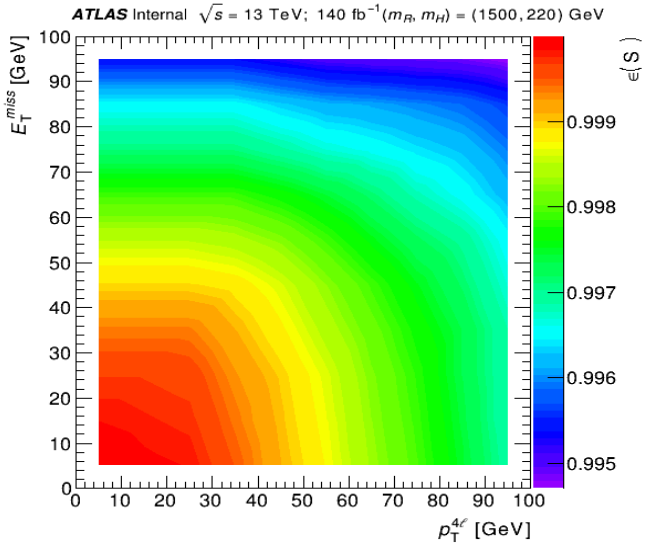


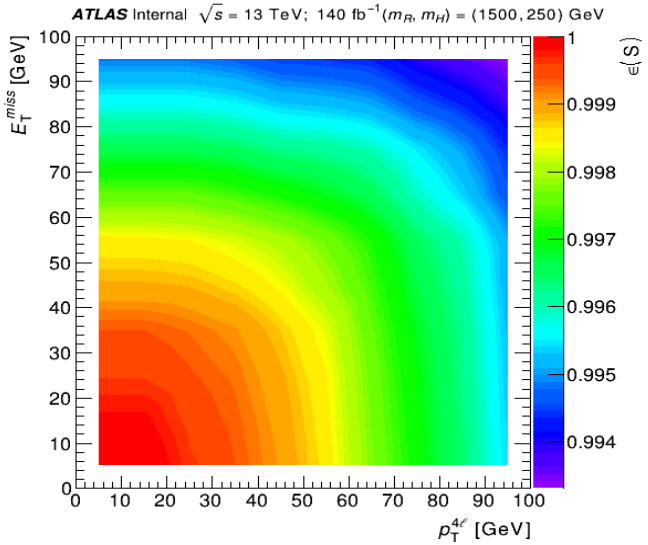


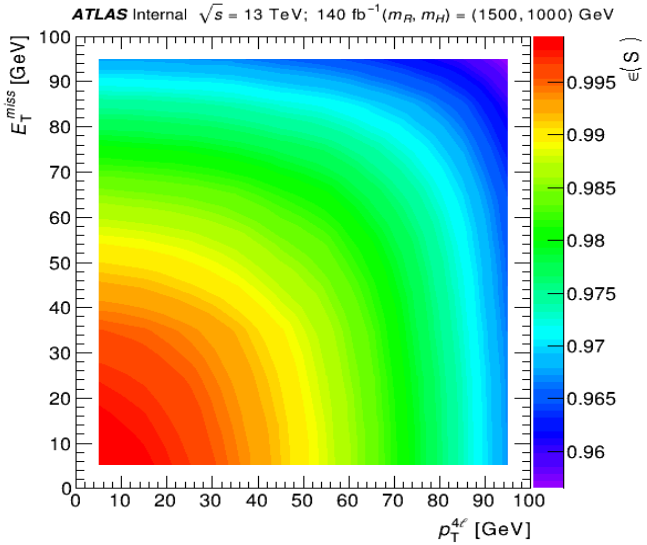




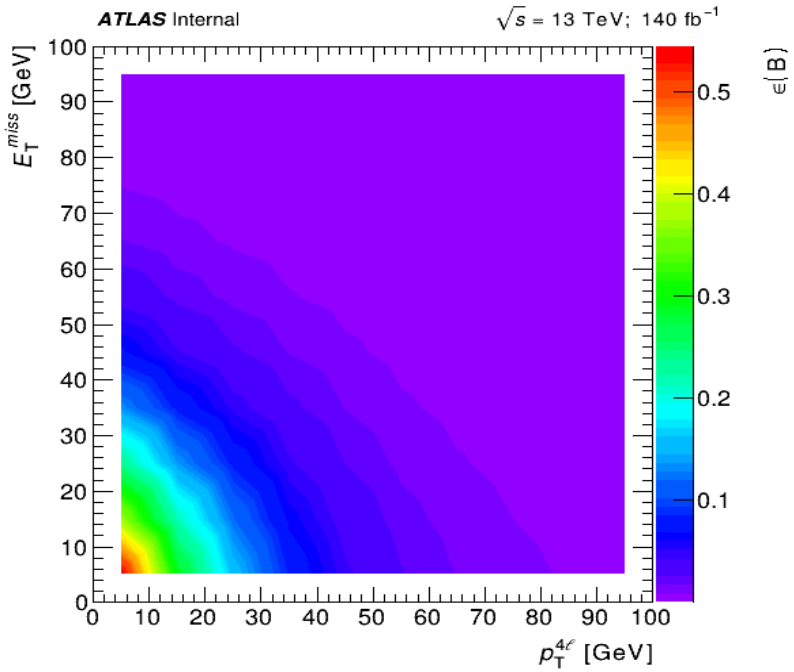
Signal efficiency

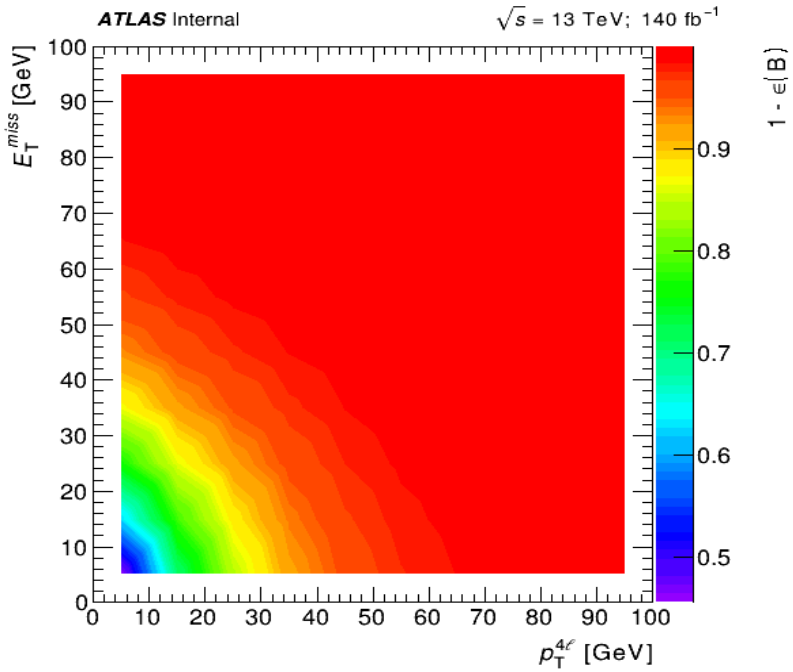




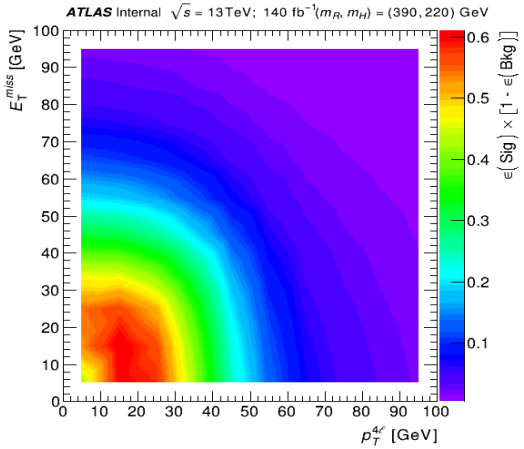


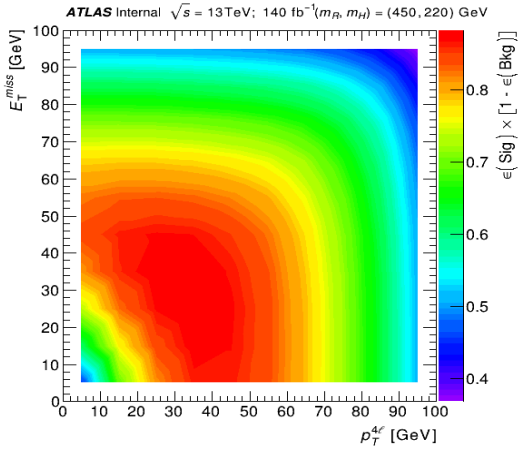
Background efficiency and rejection

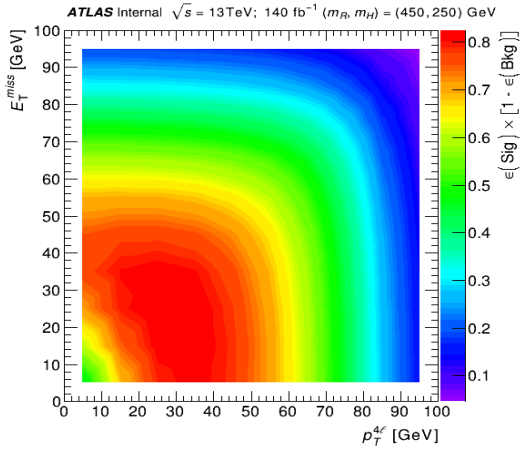


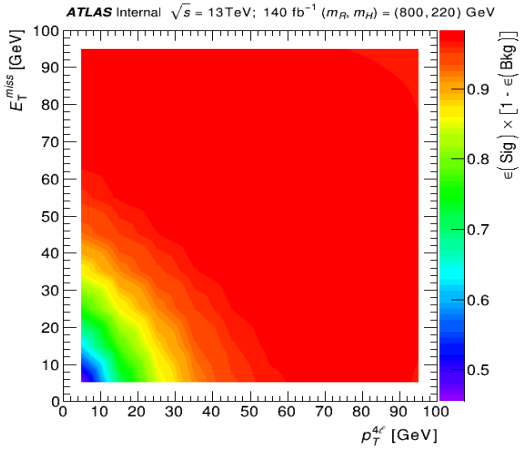


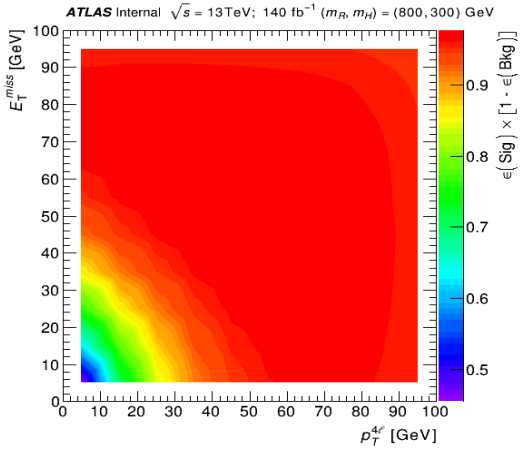
Signal efficiency times background rejection

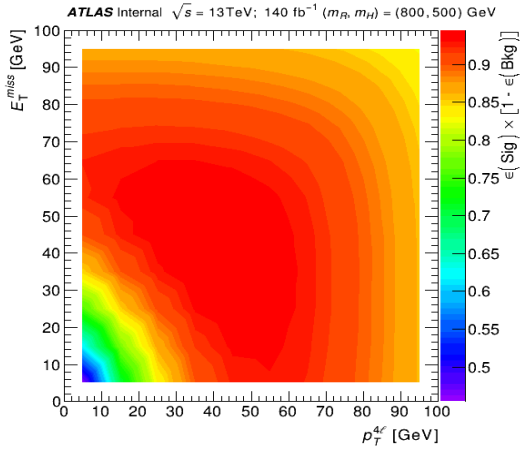




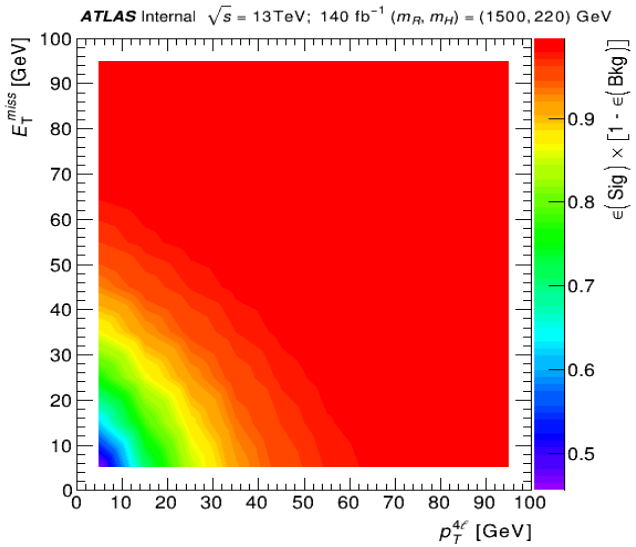


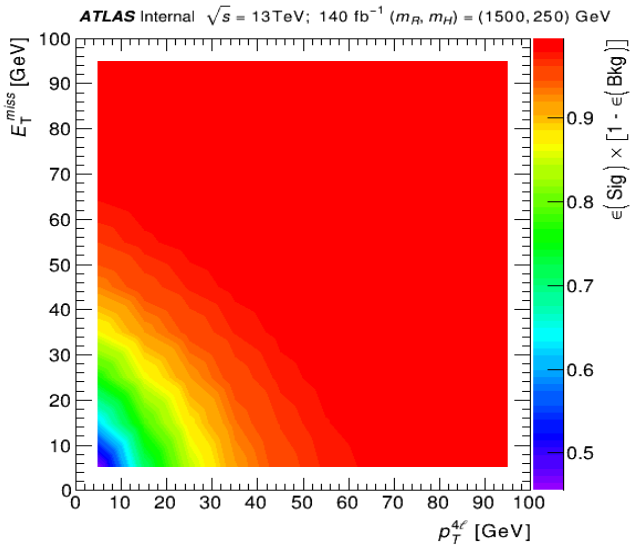


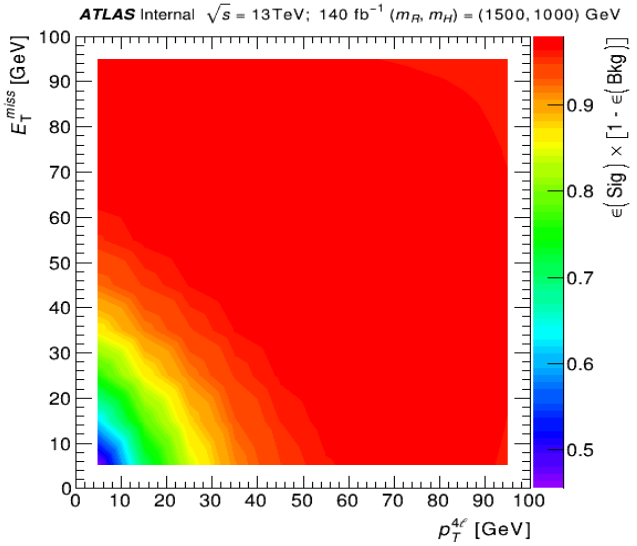




Signal efficiency times background rejection

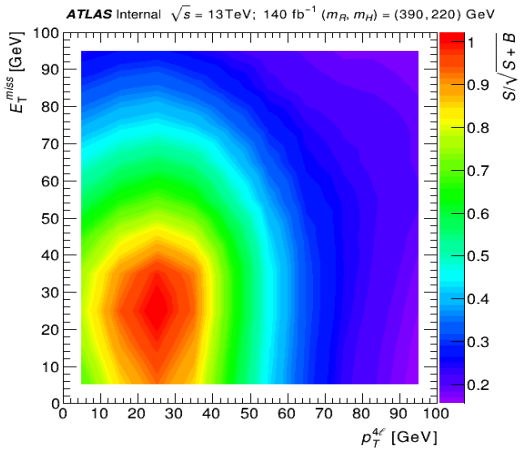


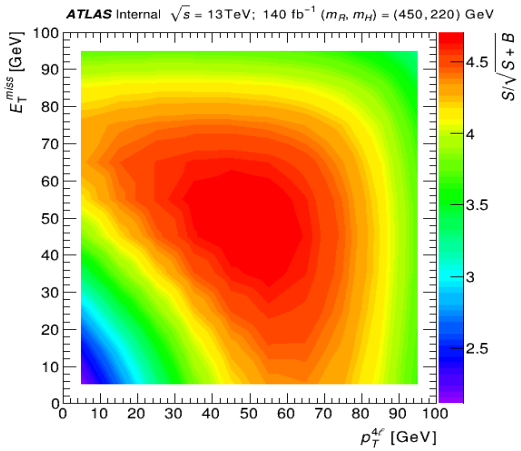


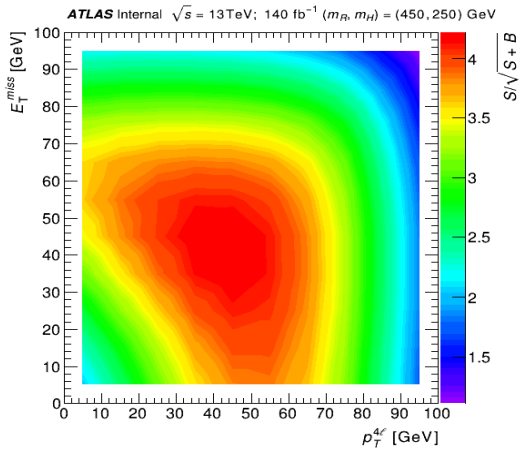


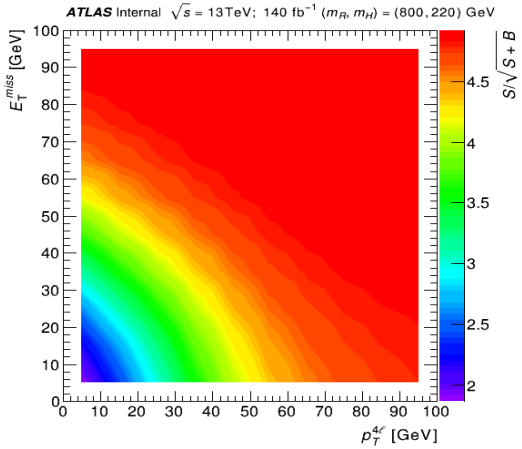
Two-dimensional sensitivity mapping

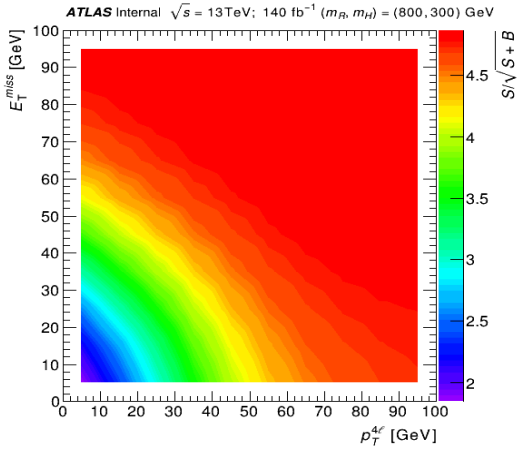
2D sensitivity mapping

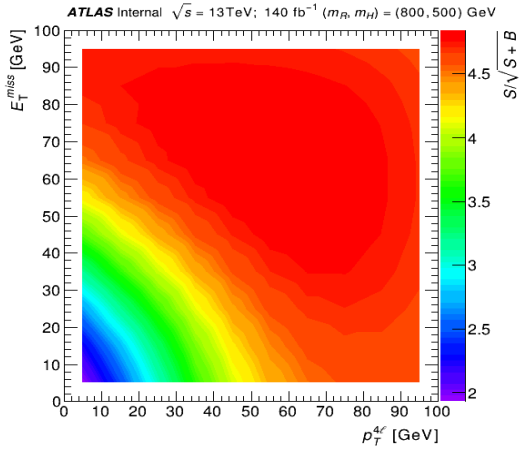




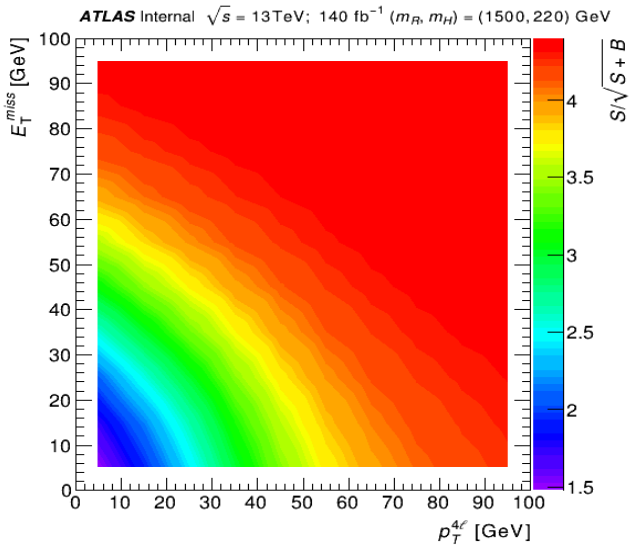


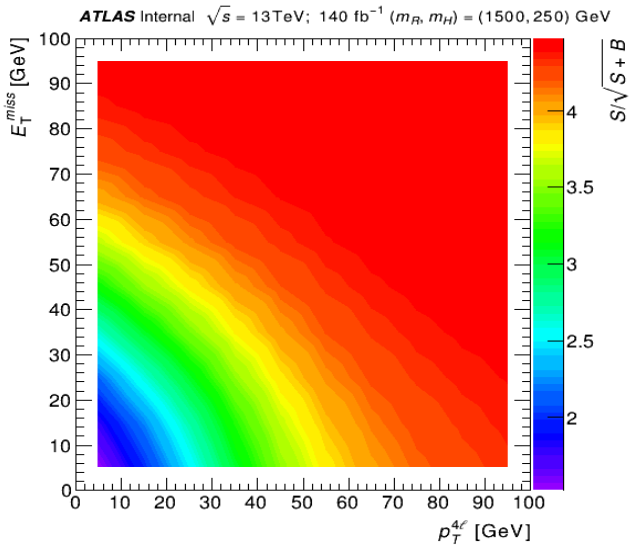


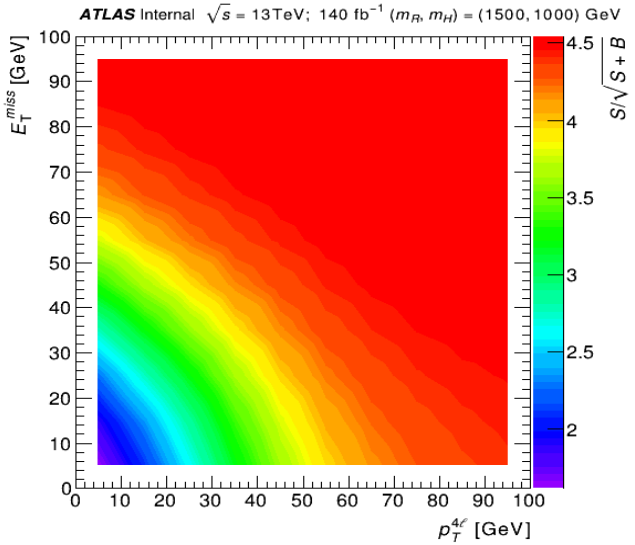




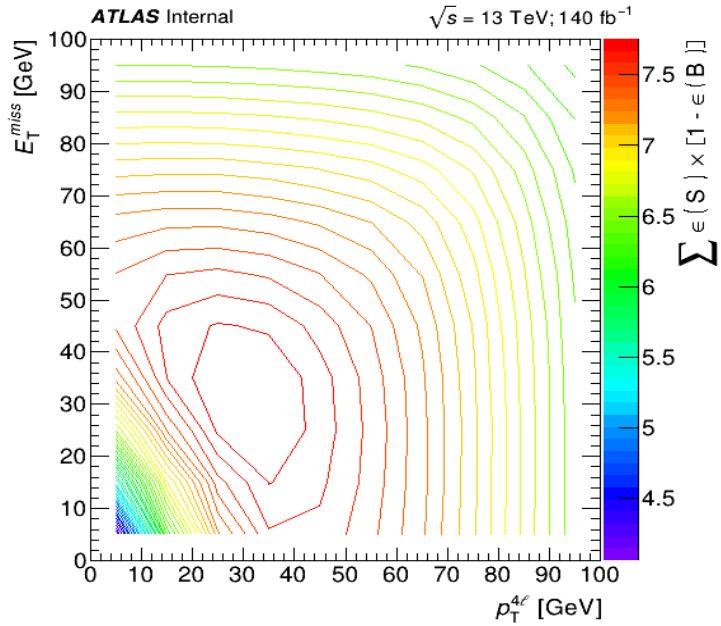
2D sensitivity mapping

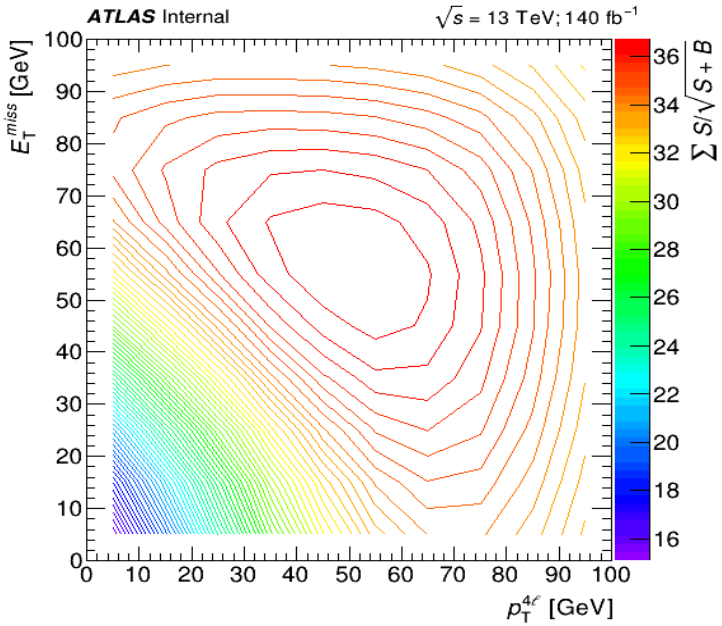






Optimisation results





- Sum of the sensitivities (left):
  - $p_T^{4\ell} > 30$ GeV
  - $E_T^{miss} > 35$ GeV
- Sum of efficiencies (right):
  - $p_T^{4\ell} > 50$ GeV
  - $E_T^{miss} > 55$ GeV

Need to make an assumption for the cross-section NWA ($\sigma \times BR(R \to SH \to 4\ell + Met)$)?

Summary

- Study the optimisation of RSH signal using cut-based optimisation;
- The efficiency optimisation appears at $p_T^{4\ell} > 30$ GeV and $E_T^{miss} > 35$ GeV;
- The optimal selection values for the sensitivity method is high than the efficiency method;
- It is around $p_T^{4\ell} > 50$ GeV and $E_T^{miss} > 55$ GeV; and
- Need to do some check to include the cross-section times the branching ratio.

Thank you!

Event selection

- Using the nominal selection, *HZZ*, for the four-lepton;

Physics Objects
Electrons
Loose Likelihood quality electrons with hit in innermost layer, $E_T > 7$ GeV and $\|\eta\| < 2.47$
Interaction point constraint: $\|z_0 \cdot \sin\theta\| < 0.5$ mm (if ID track is available)
Muons
Loose identification with $p_T > 5$ GeV and $\|\eta\| < 2.7$
Calo-tagged muons with $p_T > 15$ GeV and $\|\eta\| < 0.1$, segment-tagged muons with $\|\eta\| < 0.1$
Stand-alone and silicon-associated forward restricted to the $2.5 < \|\eta\| < 2.7$ region
Combined, stand-alone (with ID hits if available) and segment-tagged muons with $p_T > 5$ GeV
Interaction point constraint: $\|d_0\| < 1$ mm and $\|z_0 \cdot \sin\theta\| < 0.5$ mm (if ID track is available)
Jets
anti-k_T jets with *bad-loose* identification, $p_T > 30$ GeV and $\|\eta\| < 4.5$
Jets with $p_T < 60$ GeV and $\|\eta\| < 2.4$ are required to pass the pile-up jet rejection
at the 92% working point (JVT score > 0.59).
Jets with $p_T < 50$ GeV and $\|\eta\| > 2.5$ are required to pass the forward pile-up jet rejection
at the 90% working point.
***b*-tagging**
Previously selected jets with $\|\eta\| < 2.5$ passing the `MV2_c10` algorithm at its 70% working point
overlap removal
Jets within $\Delta R < 0.2$ of an electron or $\Delta R < 0.1$ of a muon are removed

Event Selection	
Quadruplet Selection	- Require at least one quadruplet of leptons consisting of two pairs of same-flavour opposite-charge leptons fulfilling the following requirements: - p_T thresholds for three leading leptons in the quadruplet: 20, 15 and 10 GeV - At most 1 calo-tagged, stand-alone or silicon-associated muon per quadruplet - Leading di-lepton mass requirement: $50 < m_{12} < 106$ GeV - Sub-leading di-lepton mass requirement: $m_{\text{threshold}} < m_{34} < 115$ GeV - $\Delta R(\ell, \ell') > 0.10$ for all lepton pairs in the quadruplet - Remove quadruplet if alternative same-flavour opposite-charge di-lepton gives $m_{\ell\ell} < 5$ GeV - Keep all quadruplets passing the above selection
Isolation Needs updating	- Contribution from the other leptons of the quadruplet is subtracted - Muon track isolation ($\Delta R = 0.30$): $\Sigma p_T/p_T < 0.15$ - Muon calorimeter isolation ($\Delta R = 0.20$): $\Sigma E_T/p_T < 0.30$ - Electron track isolation ($\Delta R = 0.20$) : $\Sigma E_T/E_T < 0.15$ - Electron calorimeter isolation ($\Delta R = 0.20$) : $\Sigma E_T/E_T < 0.20$
Impact Parameter Significance	- Apply impact parameter significance cut to all leptons of the quadruplet - For electrons: $d_0/\sigma_{d_0} < 5$ - For muons: $d_0/\sigma_{d_0} < 3$
Best Quadruplet	- If more than one quadruplet has been selected, choose the quadruplet with highest Higgs decay ME according to channel: 4μ, $2e2\mu$, $2\mu2e$ and $4e$
Vertex Selection	- Require a common vertex for the leptons: - $\chi^2/\text{ndof} < 5$ for 4μ and < 9 for others decay channels

- RSH-model can be embedded into 2HDM+S or 2HDM+a

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(will be inserted by the editor)

Phenomenological signatures of additional scalar bosons at the LHC

Stefan von Buddenbrock[a,1], Nabarun Chakrabarty[b,2], Alan S. Cornell[c,1], Deepak Kar[d,1], Mukesh Kumar[e,3], Tanumoy Mandal[f,4], Bruce Mellado[g,1], Biswarup Mukhopadhyaya[h,2], Robert G. Reed[i,1] and Xifeng Ruan.[j,1]

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[2]Regional Centre for Accelerator-based Particle Physics, Harish-Chandra Research Institute, Chhatnag Road, Jhunsi, Allahabad - 211 019, India.
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The N2HDM under Theoretical and Experimental Scrutiny

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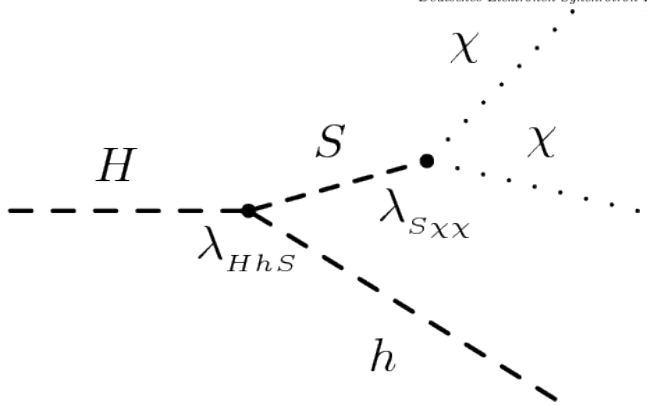

Figure: Changing $H \to R, h(125) \to H$; a theory study is going on.

Additional slides

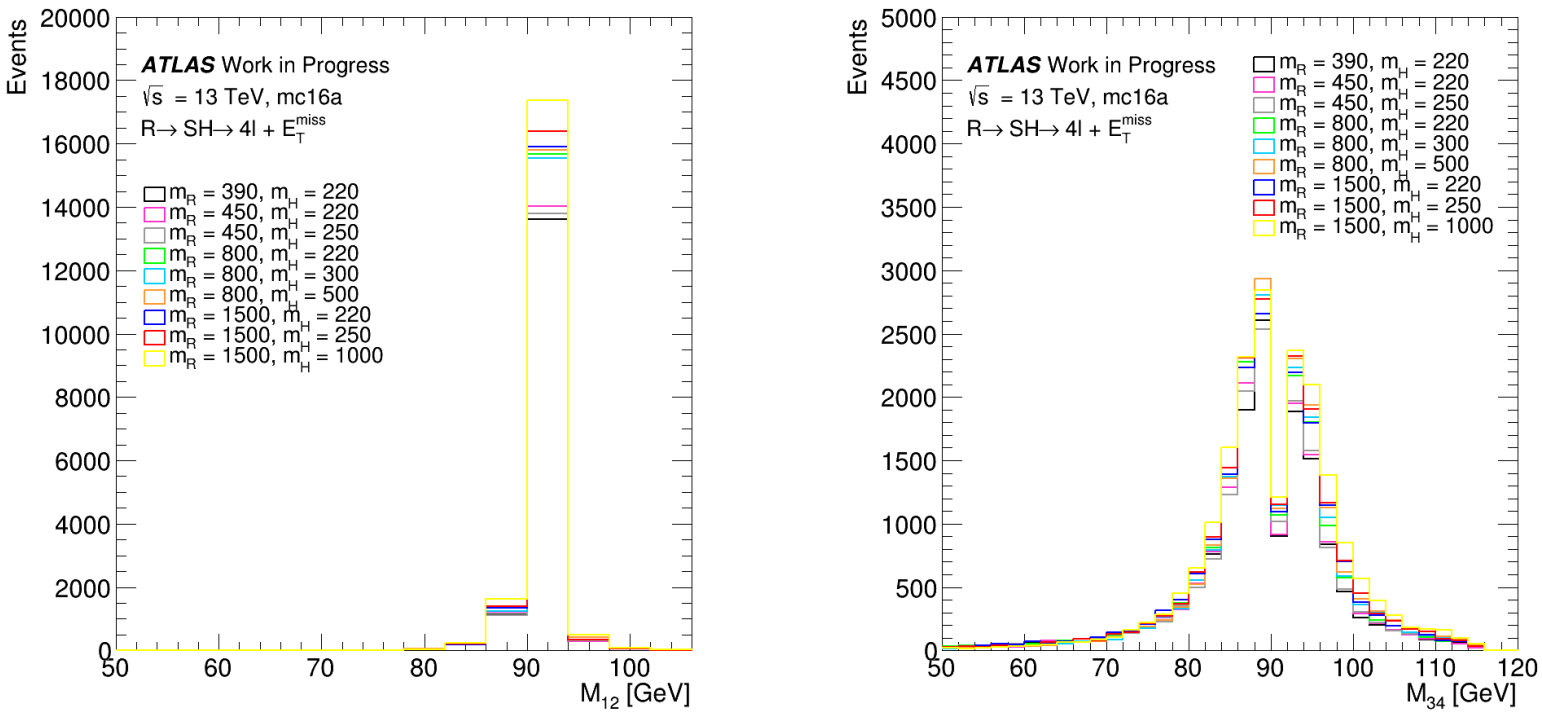

Figure: The invariant mass of the first (left) and the second (right) lepton pairs.

Additional slides

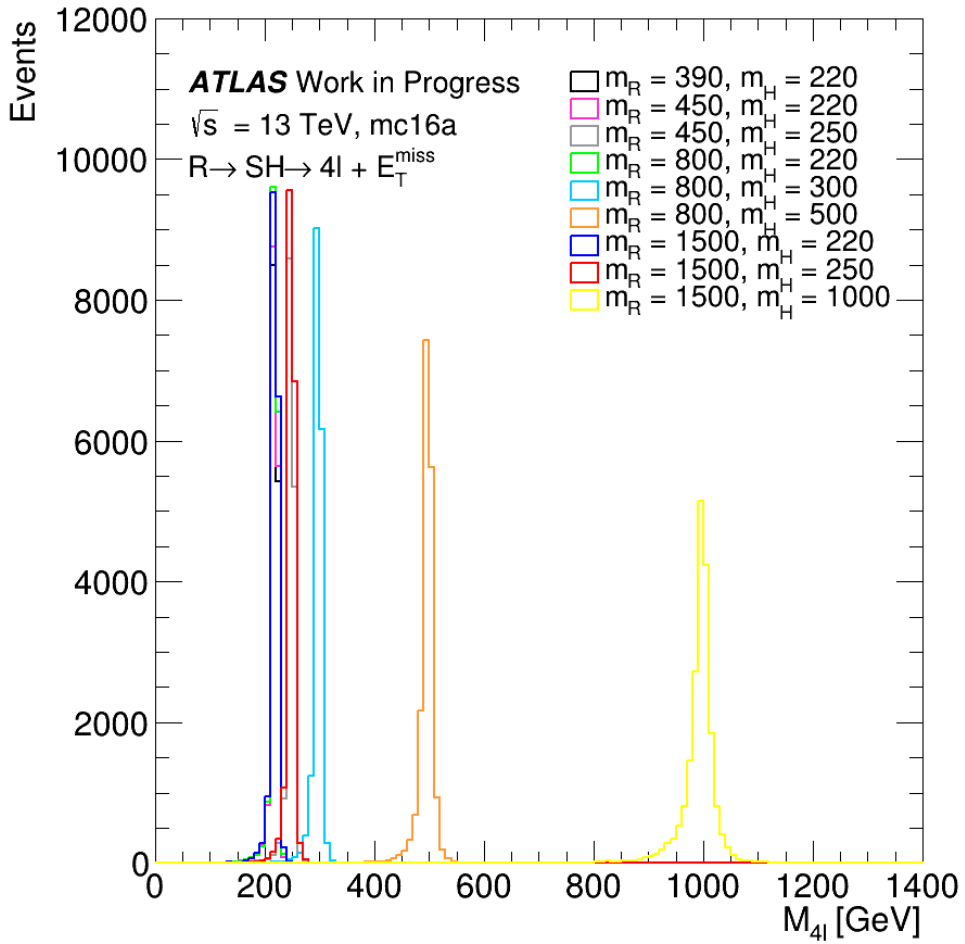

Figure: The invariant mass of the four leptons final state.

Additional slides

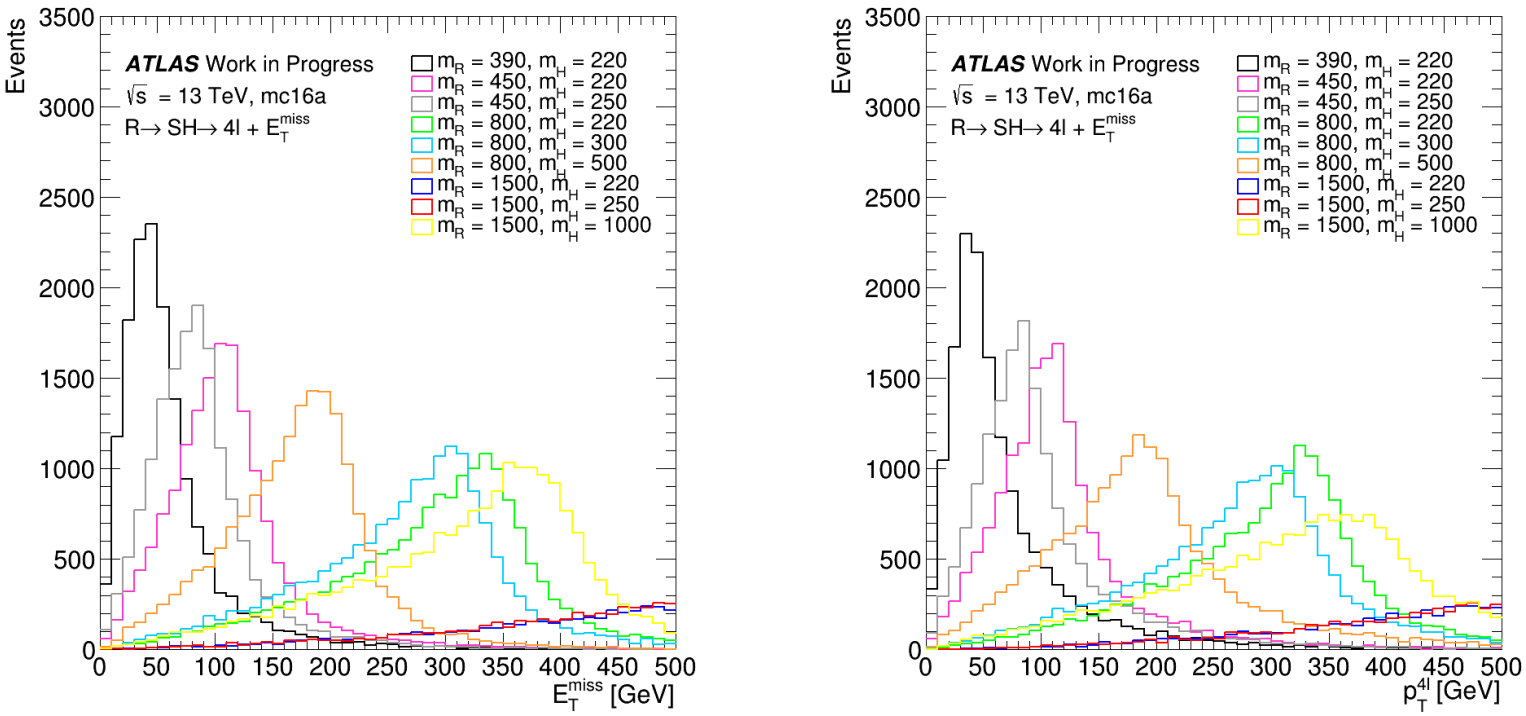

Figure: The missing transverse energy (left), and $p_{\mathrm{T}}^{4\ell}$ of the 4-lepton (right).

Additional slides

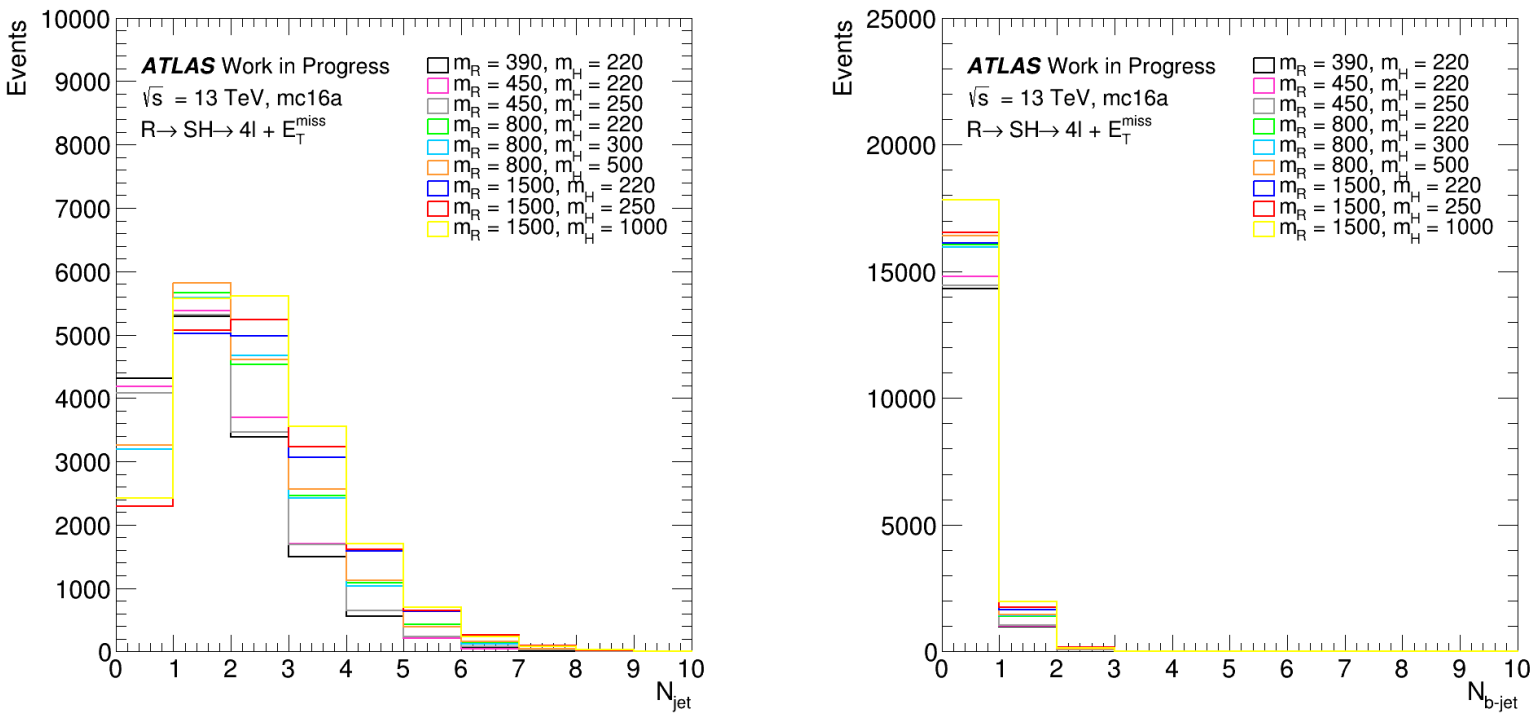

Figure: Number of the jet multiplicity (left), and number of b-jet (right).