Search for Top Squark Pair Production with zero Lepton Final States using ATLAS Run 3 Data

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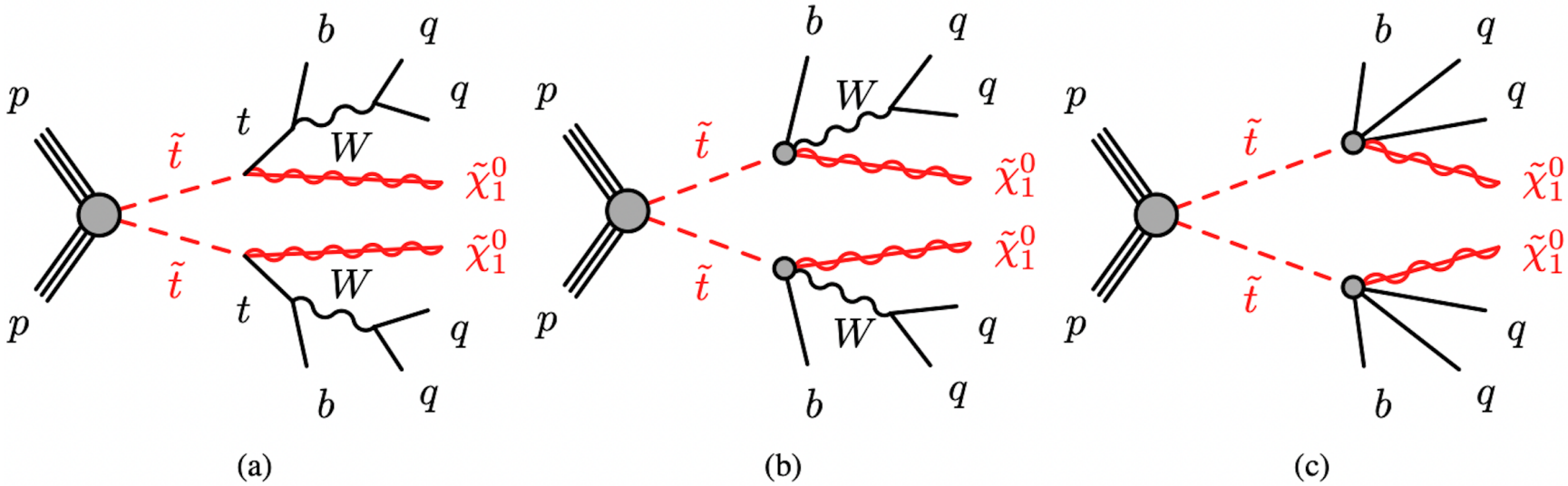
Supersymmetry

- Predicts a supersymmetric partner for every Standard Model particle
- $Q\left|Boson\right\rangle = \left|Fermion\right\rangle, Q\left|Fermion\right\rangle = \left|Boson\right\rangle$
- R-parity conservation $P_R = (-1)^{3B+L+2s}$
- Gives dark matter candidate (LSP)
- SUSY models keep the Higgs mass stable due to cancellation of bosonic and fermionic contributions
- Superpartners near the TeV scale would allow the unification of the 3 SM gauge groups at very high energies (GUT)

Stop Quark Pair Production with 0 Leptons in Final States

- Predictions see the Stop mass at the TeV scale due to the strong coupling to the Higgs boson
- Different scenarios depending on the mass splitting $\Delta m(\tilde{t}, \tilde{x}_1^0)$
- (a) $\Delta m(\tilde{t}, \tilde{x}_1^0) > m(t)$
- (b) $\Delta m(\tilde{t}, \tilde{x}_1^0) > m(W + b)$
- (c) Compressed scenario



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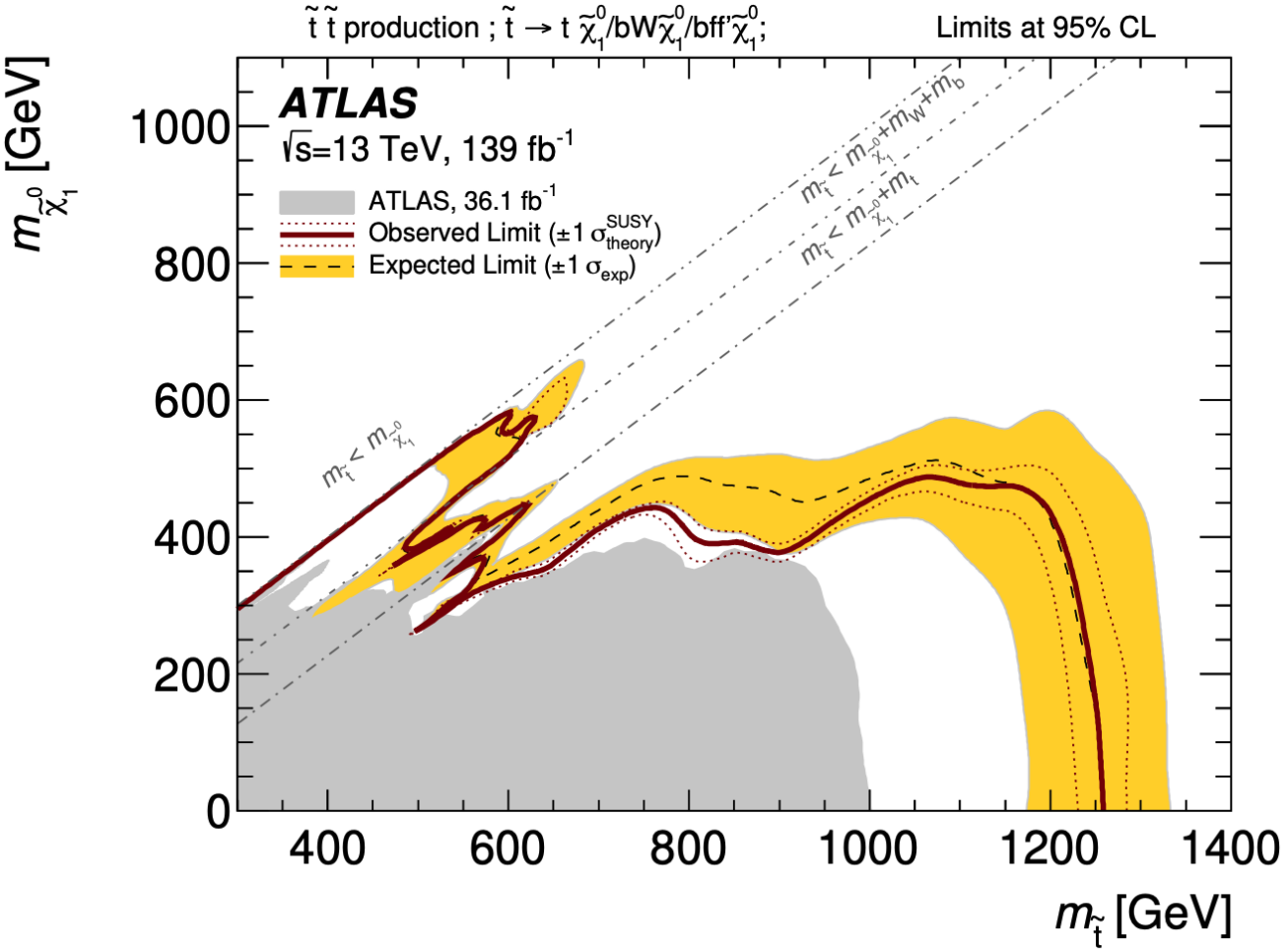
Previous ATLAS Limits

- 3 signal regions used according to the mass splittings
- Trying to increase sensitivity in the higher $m_{\tilde{\chi}_1^0}$ regions (> 400 GeV) using Run3 data



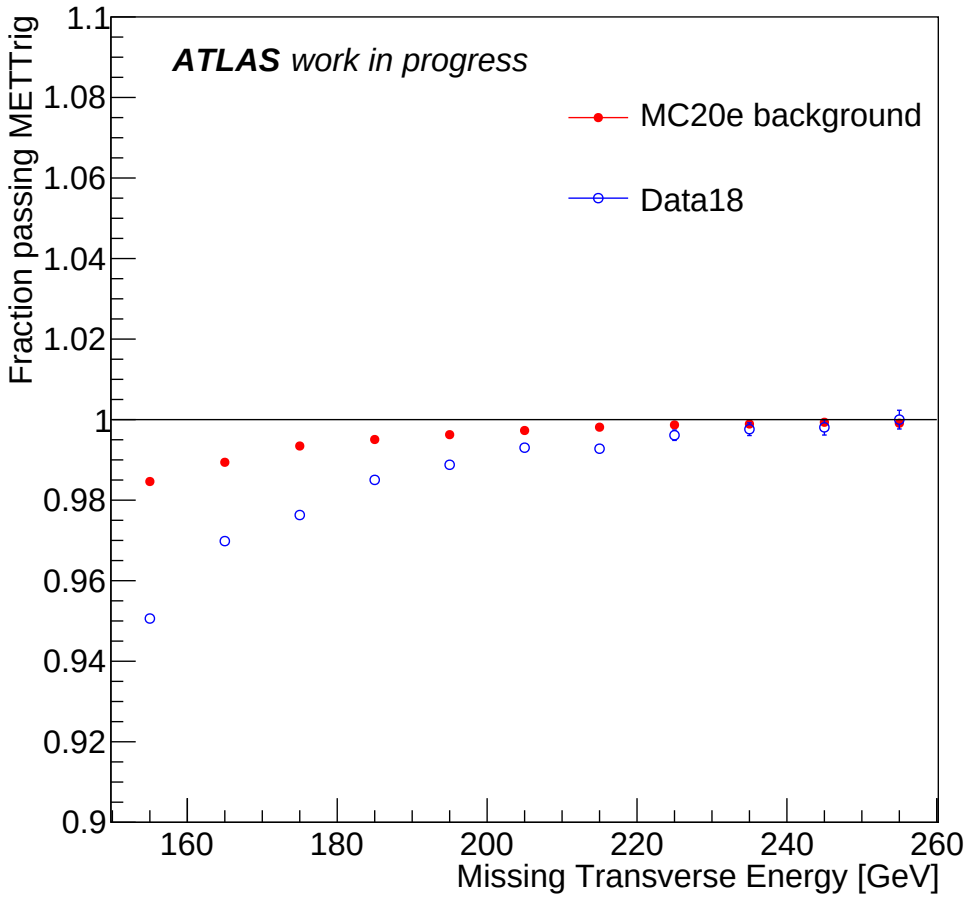
Pre-Selections

- A set of pre-selections is used to select kinematic interesting regions for this study
- The $n_{\text{lep}} = 1$ selection is kept to use as a control region

Variable	Selection
$E_{\text{T}}^{\text{miss}}$	> 220 GeV
n_{lep}	< 2
n_{jets}	> 3
n_{bjets}	> 0
$p_{\text{T}}(\text{2nd leading jet})$	> 80 GeV
$p_{\text{T}}(\text{4th leading jet})$	> 40 GeV
$\Delta\phi(\text{E}_{\text{T}}^{\text{miss}}, \text{leading 4 jets})$	> 0.4
$E_{\text{T}}^{\text{miss}}\text{significance}$	> 5

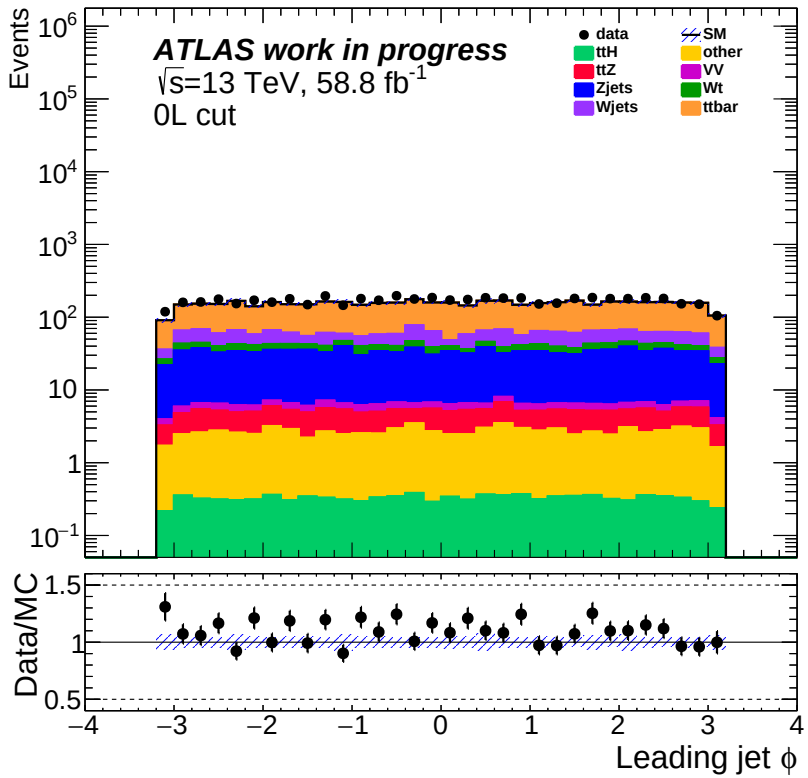
MET Trigger Study

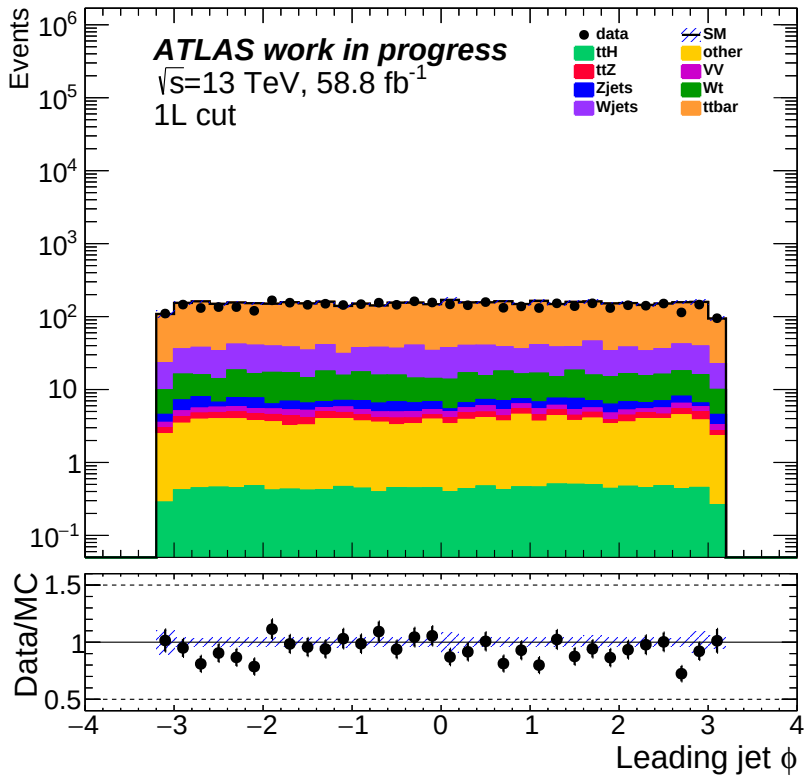
- Checking where the MET-trigger becomes almost fully efficient
- For $E_{\mathrm{T}}^{\mathrm{miss}} > 220$ GeV more than 99% of signal and background pass the trigger



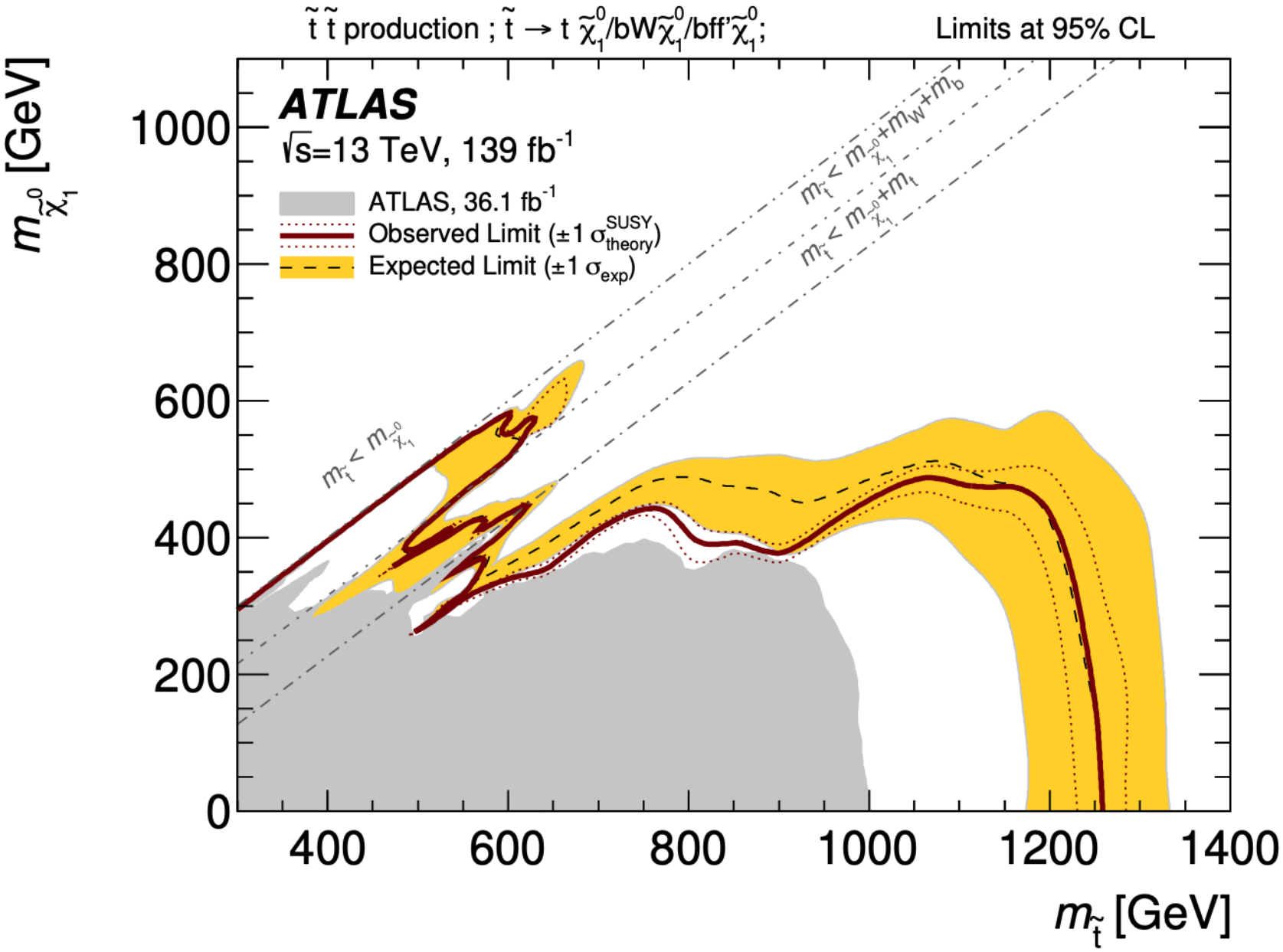
Backgrounds

- Signal final states consisting of 2 neutralinos, 2 bjets and 4 other jets
- Dominant backgrounds: tt, diboson and boson + jet events
- Unfortunately, the Run3 data vs background are not yet ready due to the introduction of a new b-tagger, therefore 2018 data is shown



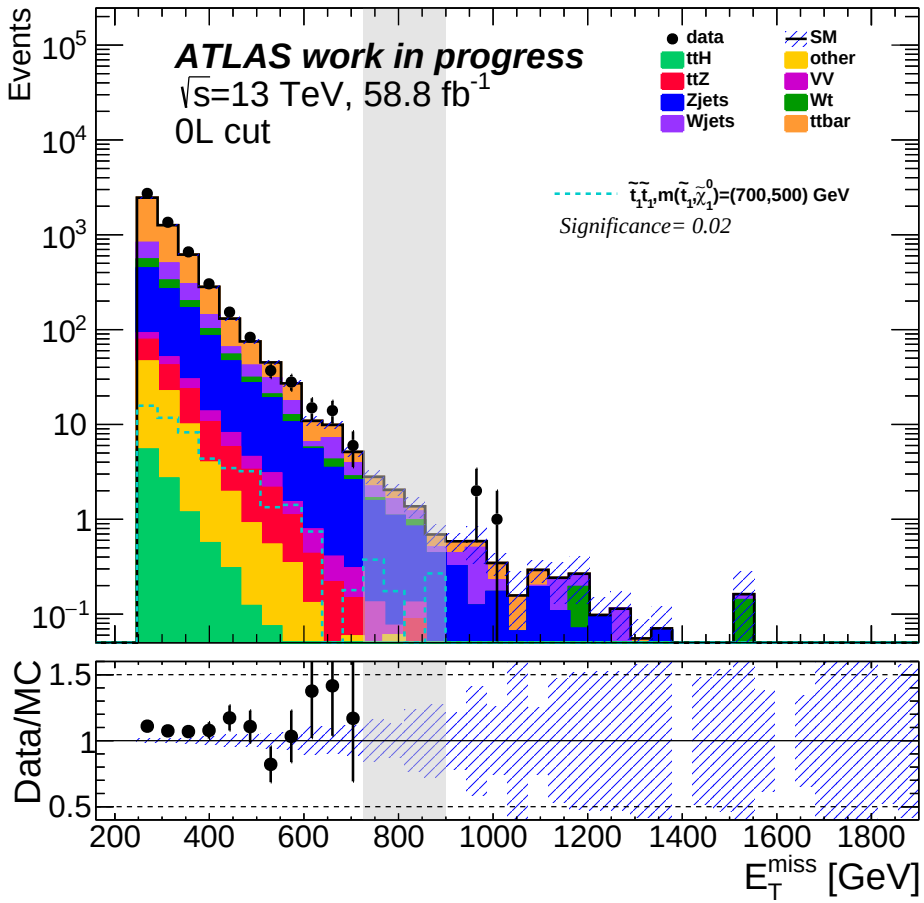


Previous ATLAS Limits

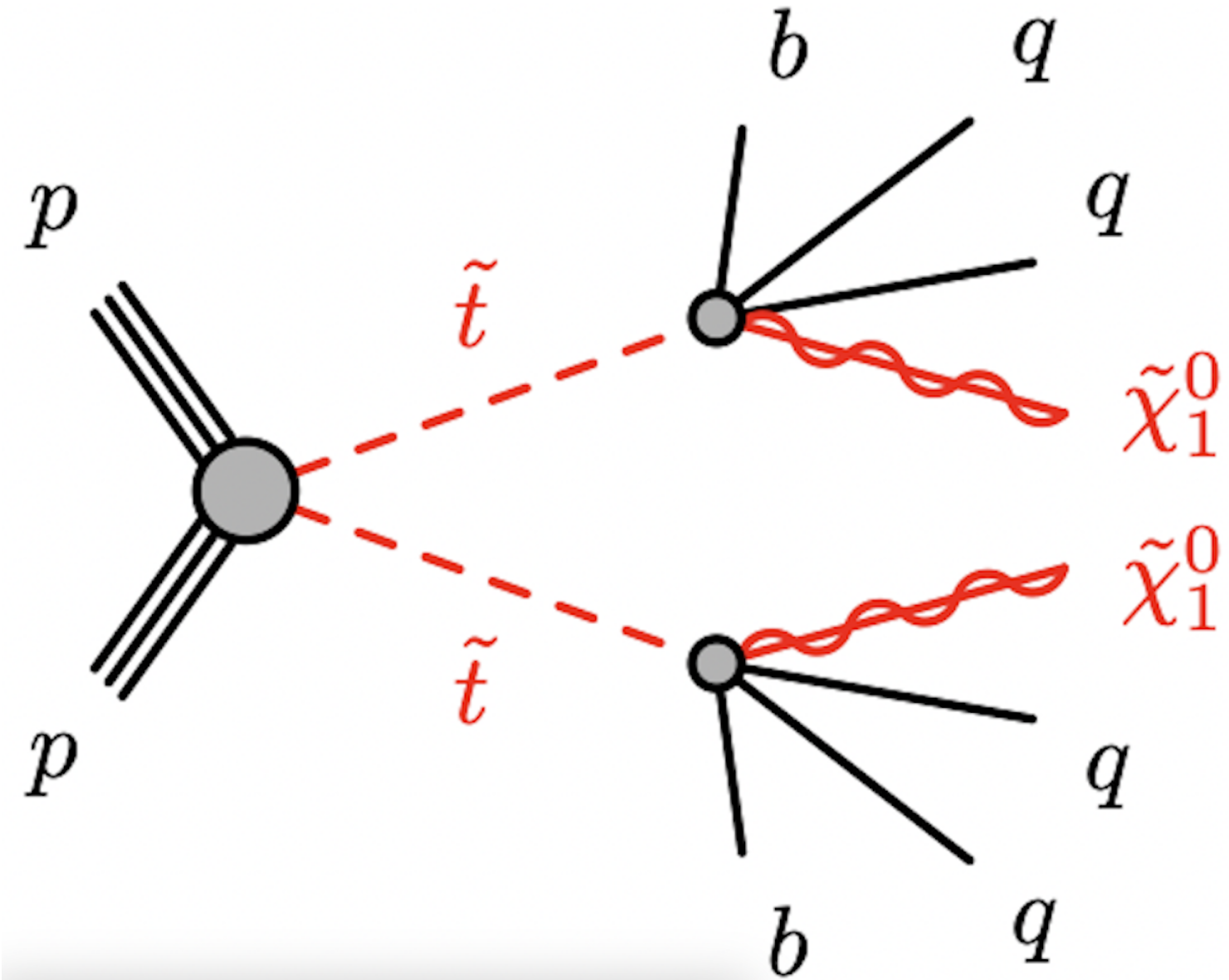


Significance as a Measure of Signal Sensitivity

- Significance $S = \frac{n_S}{\sqrt{n_B + 0.3 n_B^2}}$
- n_S amount of signal events, n_B amount of background events
- Factor of 0.3 motivated by the expected systematic uncertainty of the background prediction

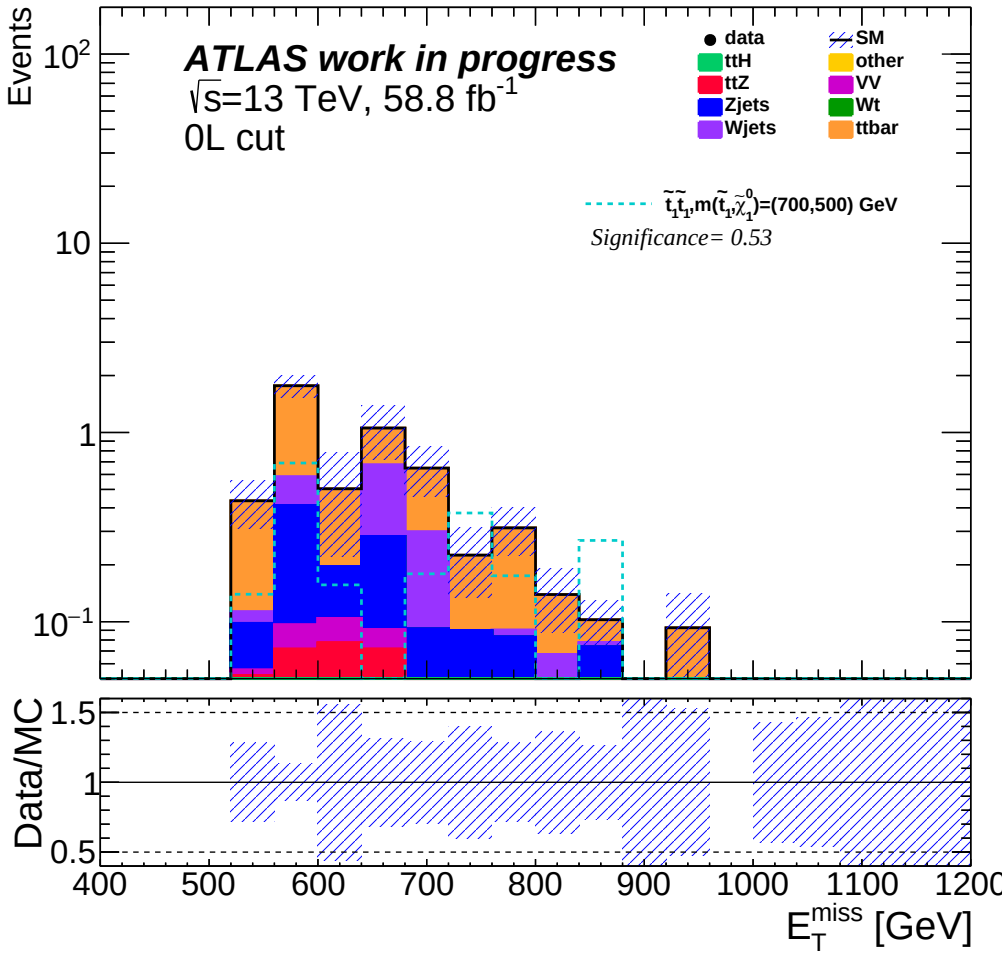


Compressed Scenario



Optimising for our Signals

- $E_{\mathrm{T}}^{\mathrm{miss}} > 550$ GeV, $p_{\mathrm{T}}(\text{leading jet}) > 400$ GeV, $n_{\mathrm{jets}} > 5$, $n_{\mathrm{bjets}} > 1$
- Significance improved to a relevant value



Conclusions and Outlook

- Supersysmmetry offers elegant solutions to some of our biggest questions regarding BSM physics
- Predictions say that stop quarks could be produced at the LHC
- Using a 0 lepton veto lets us discriminate backgrounds and explore different phase space regions
- Efficiency studies have been performed and the search is ready to start once Run3 data is processed for our requirements
- Preliminary cutbased studies using Run2 data show good sensitivity
- Additionally, machine learning techniques will be applied to increase sensitivity to our signals

Thank you!

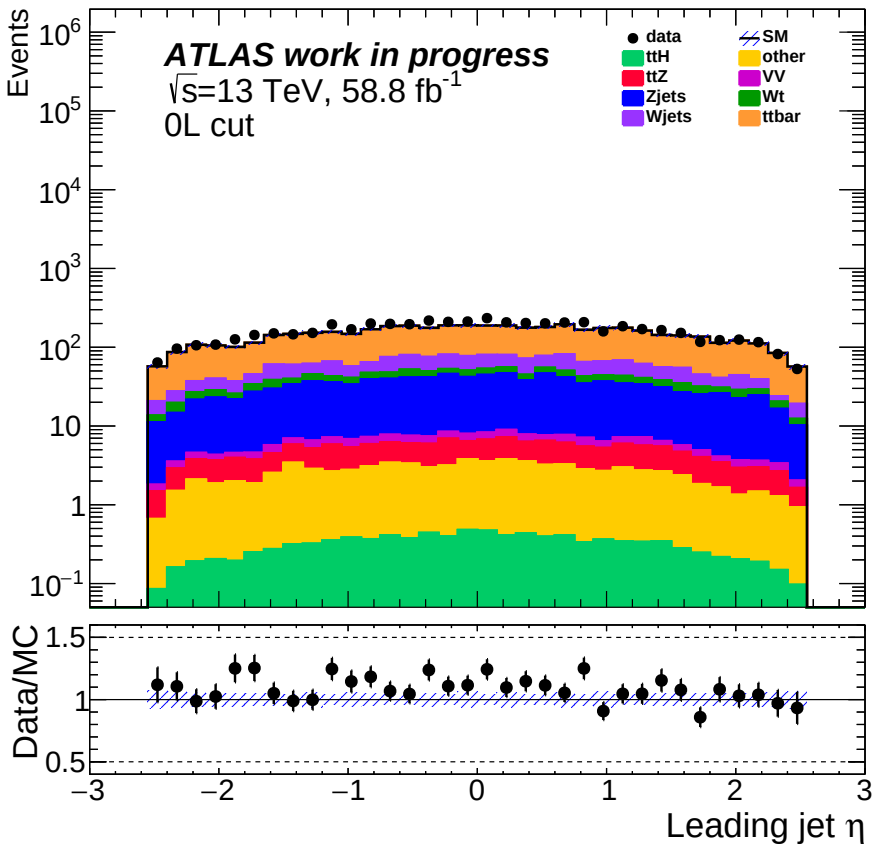
Backup

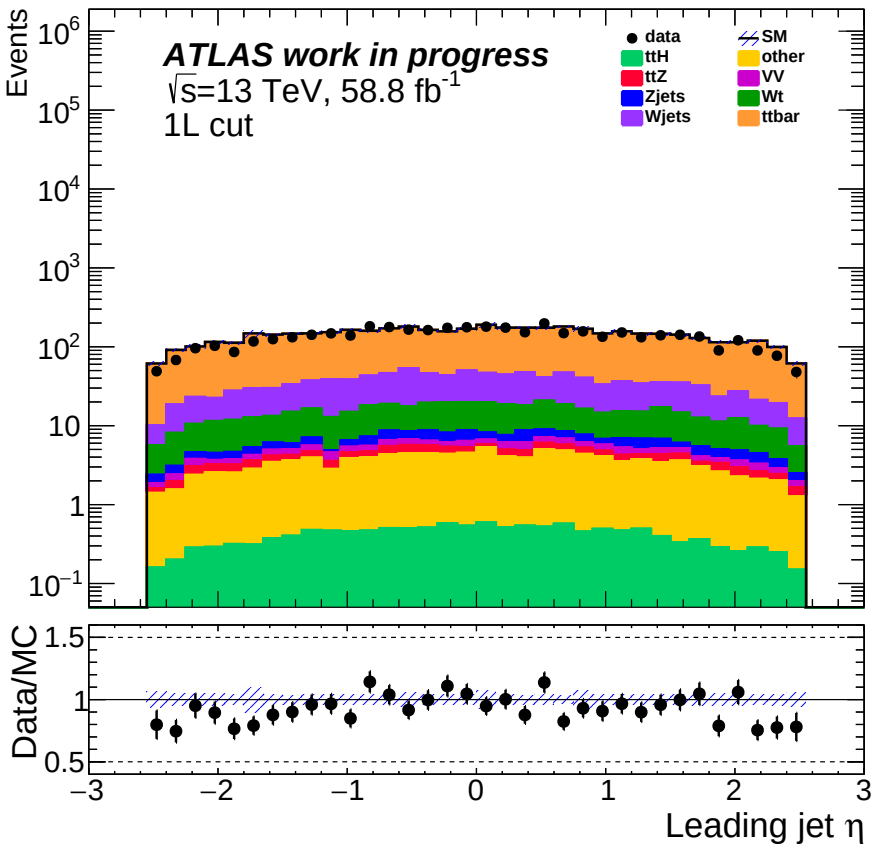
$E_{\mathrm{T}}^{\mathrm{miss}}$ Significance and $\Delta\phi(\mathrm{E}_{\mathrm{T}}^{\mathrm{miss}}, \mathrm{leading\ 4\ jets})$

- $E_{\mathrm{T}}^{\mathrm{miss}}$ significance $= \frac{E_{\mathrm{T}}^{\mathrm{miss}}}{\sqrt{\sigma_{\mathrm{L}}^2(1-\rho_{LT}^2)}}$
- σ_{L} expected longitudinal momentum resolution,
- ρ_{LT} correlation factor between transverse and longitudinal momenta
- Characterizes $E_{\mathrm{T}}^{\mathrm{miss}}$ according to the p_T and the resolutions of p_T and ϕ of all objects

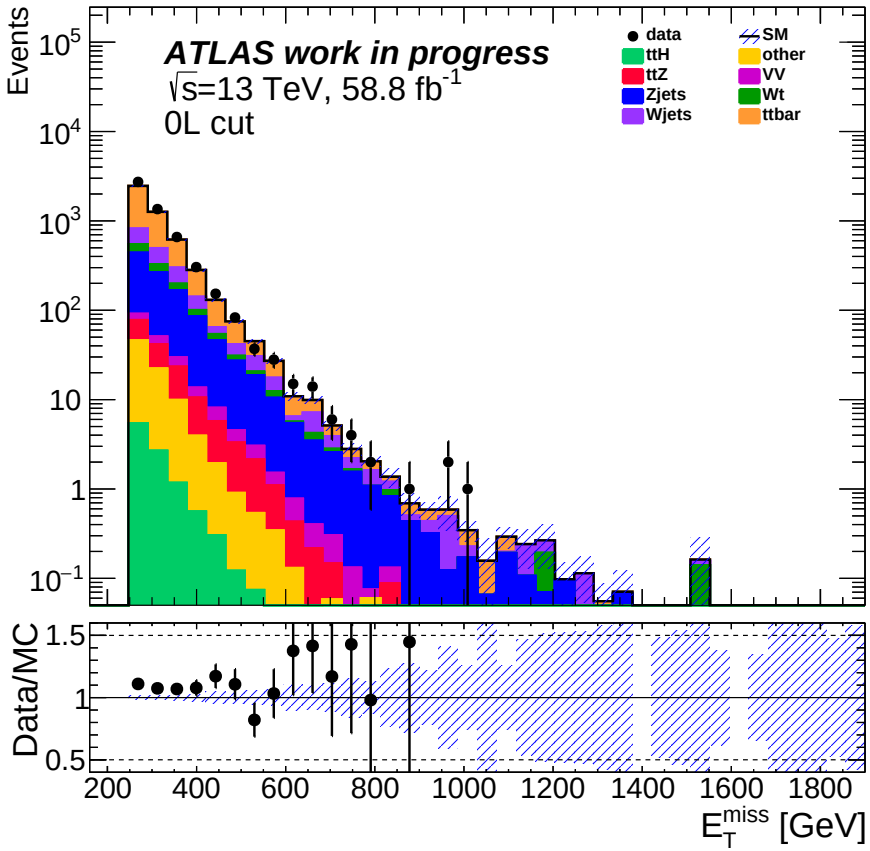
- $\Delta\phi(\mathrm{E}_{\mathrm{T}}^{\mathrm{miss}}, \mathrm{leading\ 4\ jets})$ minimum difference in azimuthal angle between the $E_{\mathrm{T}}^{\mathrm{miss}}$ and the leading four jets
- $\Delta\phi(\mathrm{E}_{\mathrm{T}}^{\mathrm{miss}}, \mathrm{leading\ 4\ jets}) > 0.4$ rejects events with mismeasured $E_{\mathrm{T}}^{\mathrm{miss}}$ originating from multijet and hadronic $t\bar{t}$ decays

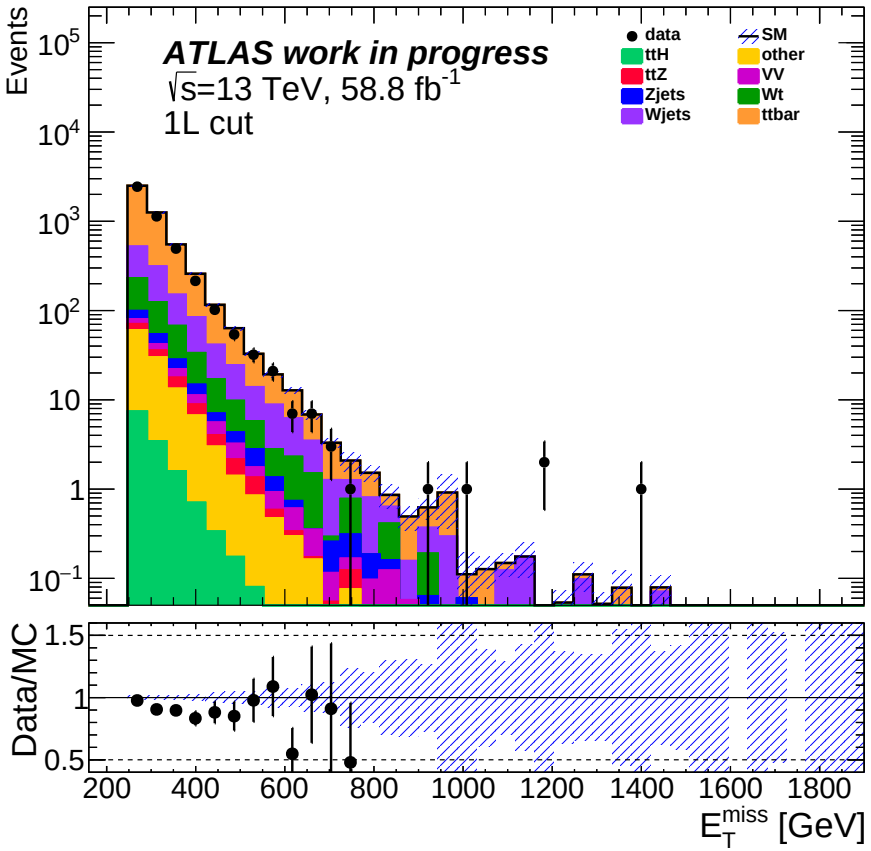
Pre-Selection Leading Jet Eta



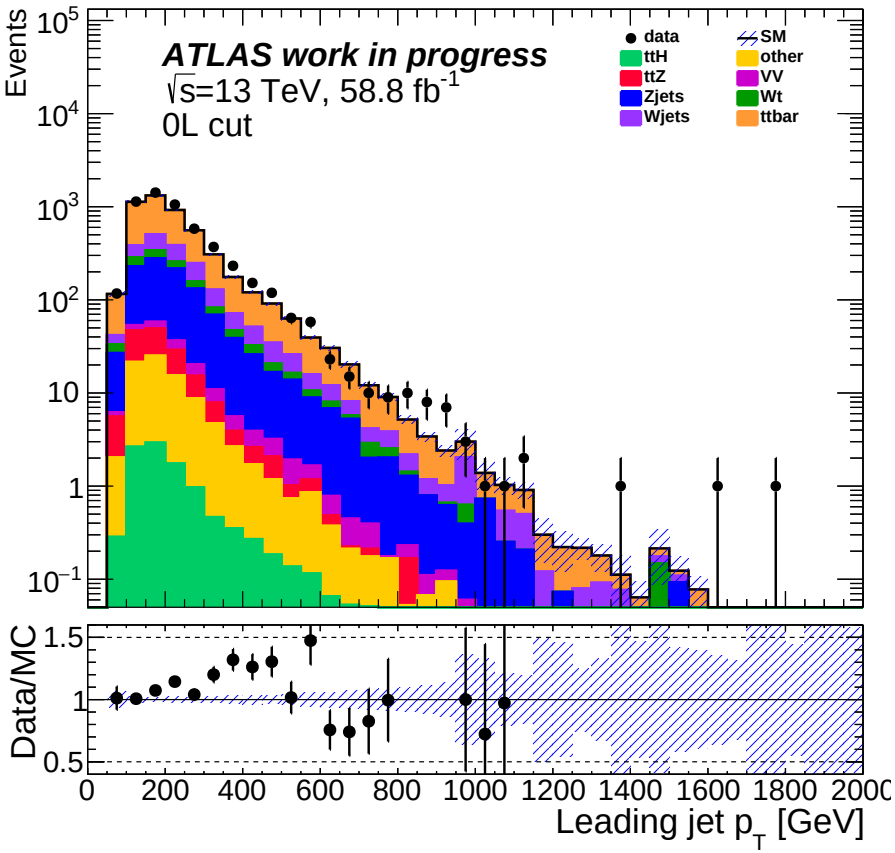


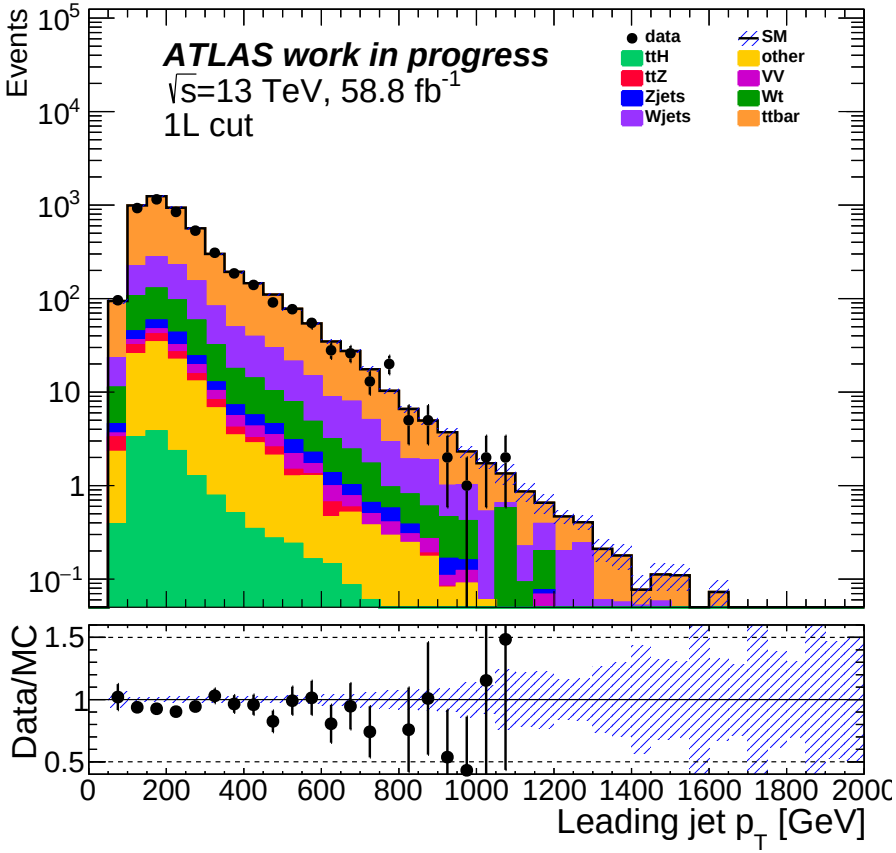
Pre-Selection MET



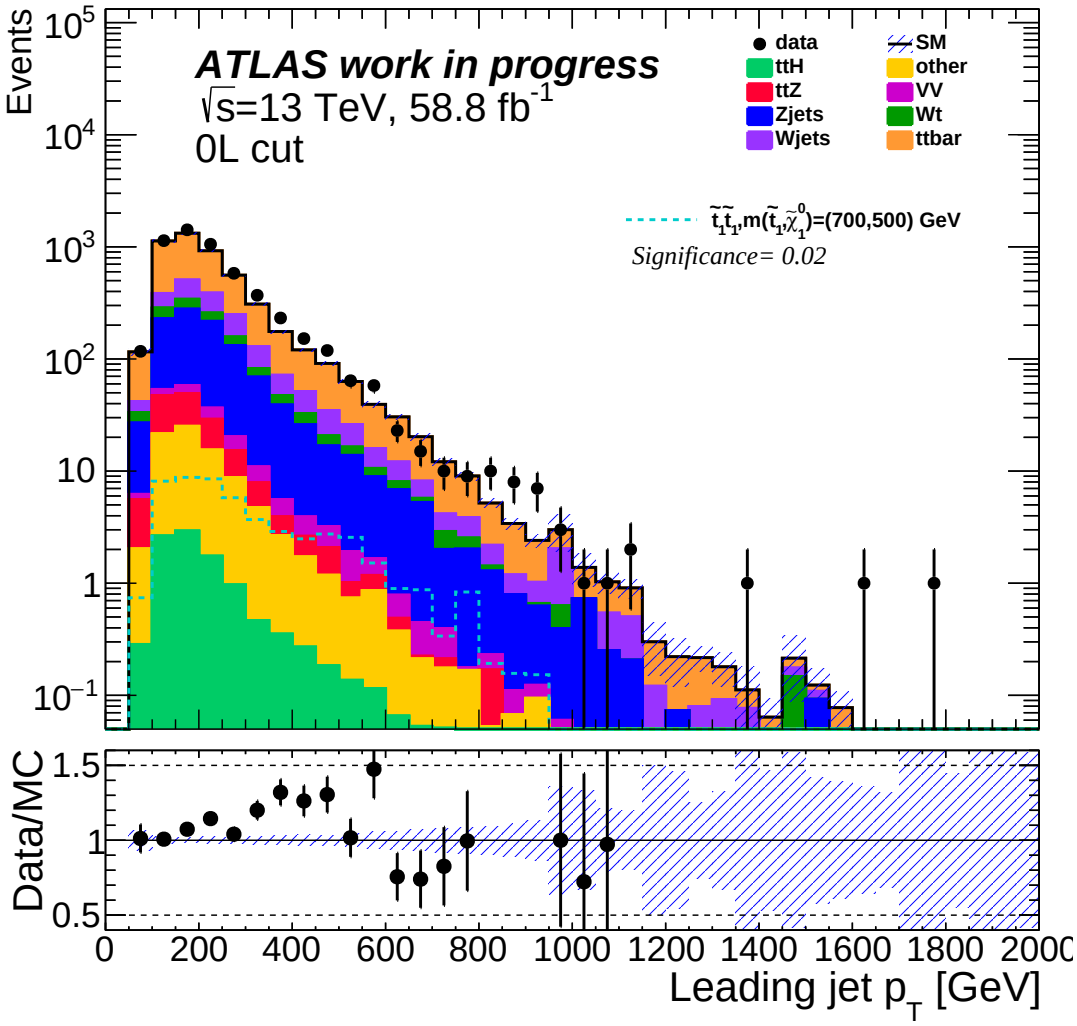


Pre-Selection Leading Jet p_T





Pre-Selection Signal Leading Jet p_T



Optimised Leading Jet p_T