# Search for supersymmetry in multileptonic final states with collimated $\tau$ pairs with the ATLAS detector


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# Introduction

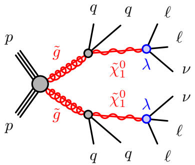
Search for R-parity violating SUSY in events with at least four leptons

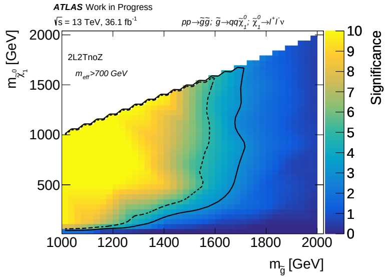
Current Analysis uses data from 2015 and 2016

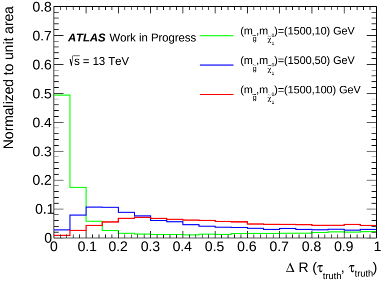
No sensitivity for low $\tilde{\chi}_1^0$ mass due to collimated $\tau$ pairs

Standard $\tau$ reconstruction fails for $\Delta R < 0.4$

$\rightarrow$ Use di-$\tau$ reconstruction to increase sensitivity



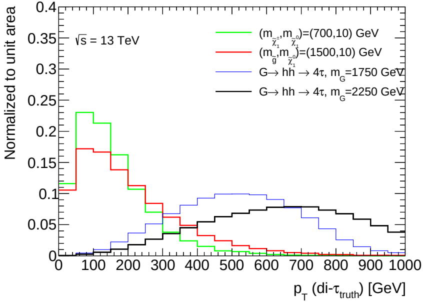



# Di-$\tau$ reconstruction

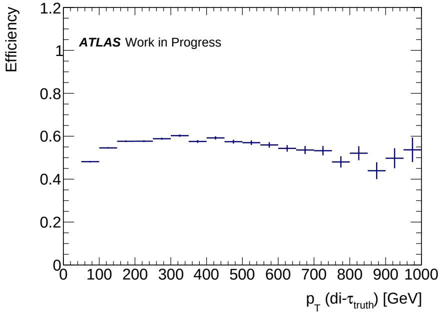
Di-$\tau$ reconstruction: reconstruct two hadronically decaying $\tau$ into a single object

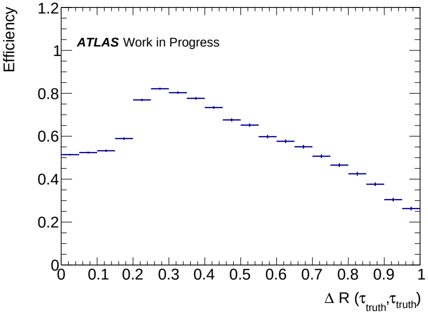
Originally developed and optimized using boosted Higgs decays

- Seeds from a jet with $R = 1.0$ ($0.4$ for standard $\tau$ reconstruction)
- $p_T > 50$ GeV (reduced from $p_T > 300$ GeV)
- $|\eta| < 2.5$
- At least 2 subjets ($R = 0.2$) with at least one associated track



# Reconstruction Efficiency




Flat reconstruction efficiency 60% for $p_{\mathrm{T}} > 150$ GeV

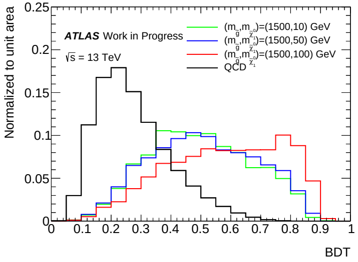
Reconstruction efficiency 80% for $0.2 < \Delta R < 0.4$

# Di-$\tau$ Identification

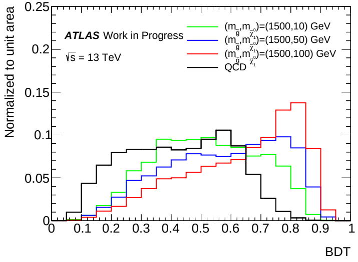
Rejection of fake di-$\tau$ from QCD jets, $t\bar{t}$

Performance of the default BDT (optimized with boosted Higgs decays)

$p_T^{\text{di-}\tau} > 300$ GeV




$p_T^{\text{di-}\tau} > 50$ GeV



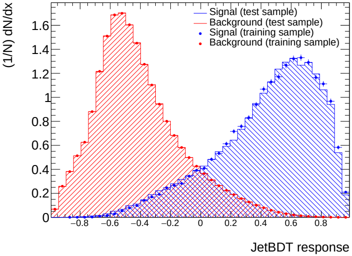

Limited background separation for $p_T > 300$ GeV

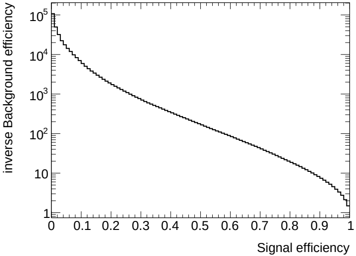
No separation for $p_T > 50$ GeV

$\rightarrow$ Optimize BDT for SUSY

BDT training using tracking and calorimeter information

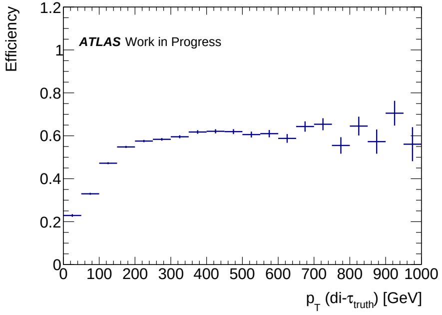
- Signal: truthmatched di-$\tau$ from SUSY gluino process
- Background: di-$\tau$ candidates from data (QCD), $t\bar{t}$, $Z \rightarrow e^+e^-$

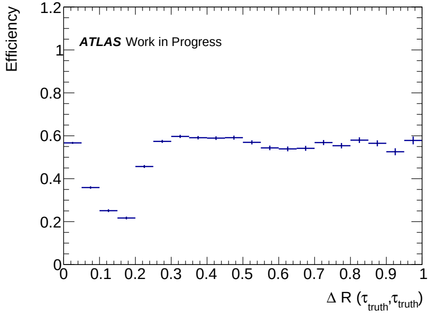


# Identification Efficiency

signal di-$\tau$: $BDT > 0.5$

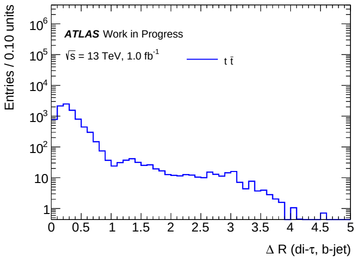


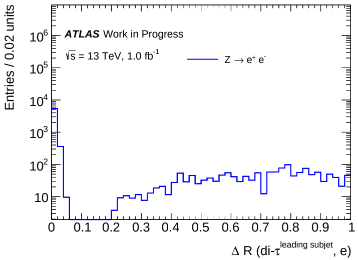




Flat identification efficiency 60% for $p_T > 150$ GeV

Identification efficiency 60% for $0.2 < \Delta R < 0.4$

# Improvement of Fake Di-$\tau$ rejection



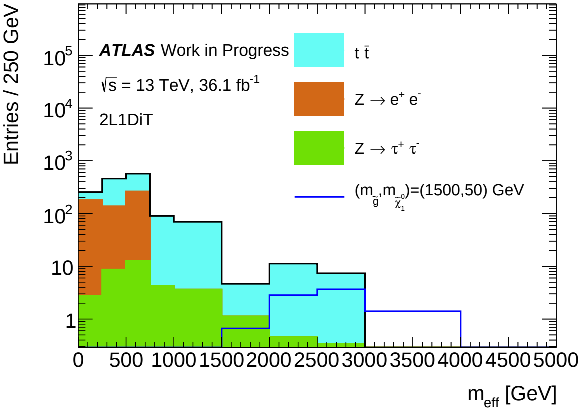




- In $t\bar{t}$: fake Di-$\tau$ from b-jets

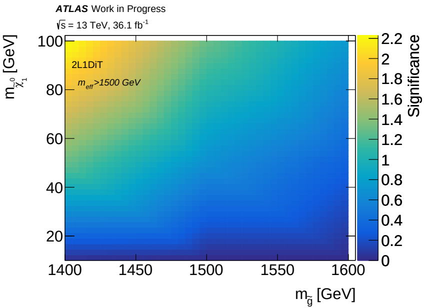
$\rightarrow$ Remove Di-$\tau$ if it contains a *b*-jet

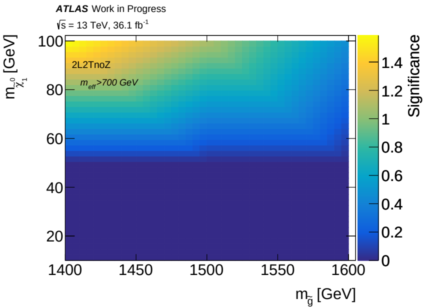
- Reject Di-$\tau$ with electrons in subjets

New region with $N_\ell = 2$, $N_\tau \leq 1$ and $N_{\text{di-}\tau} \geq 1$



# Expected Sensitivity




Improved sensitivity to low LSP masses

# Summary

- Current fourlepton analysis has no sensitivity to low LSP masses
- Use new di-$\tau$ reconstruction for collimated $\tau$ pairs
- Di-$\tau$ identification optimized for SUSY RPV models
- Improved Sensitivity with the new di-$\tau$ reconstruction

Plan: use di-$\tau$ reconstruction with full run 2 data-set (2015-2018)