Search for Supersymmetry in Leptonic Final States with the ATLAS Detector

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ErUM-FSP T02
ATLAS

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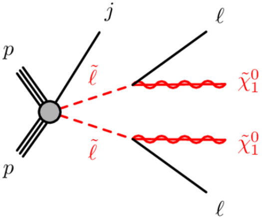
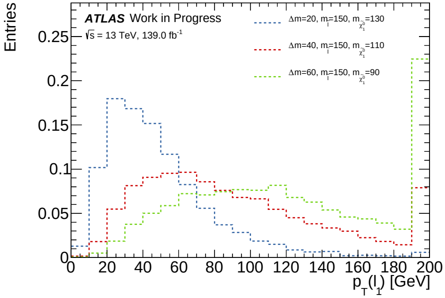
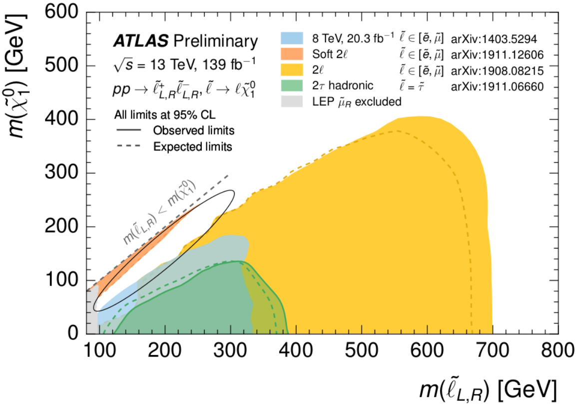
Introduction

- Supersymmetry predicts for each Standard Model particle, a SUSY particle with spin differing by $\frac{1}{2}$
- "Light" sleptons (< 1 TeV) may resolve observed muon $g - 2$ anomaly
- Considered simplified model for slepton ($\tilde{e}$,$\tilde{\mu}$) pair production:
  - Selectrons and smuons degenerate in mass
  - Decay with 100% BR into $\tilde{\chi}_1^0$ (DM candidate) via SM leptons
- Event kinematics governed by $\Delta m = m_{\tilde{\ell}} - m_{\tilde{\chi}_1^0}$
- Compressed mass spectra: leptons too soft to trigger on $\rightarrow$ Initial state radiation (ISR) topology allows triggering on E_T^{miss}





Current exclusions limits



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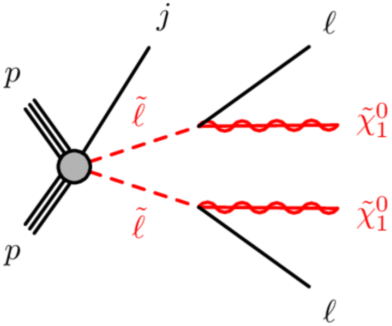
- Current exclusion limits for $\tilde{e}$,$\tilde{\mu}$ set by 2L and soft 2L analysis
- Sensitivity gap for $\Delta m(\tilde{\ell}, \tilde{\chi}^0_1) \sim 20$–$60$ GeV
- Goal: improve sensitivity to this gap with re-optimized ISR-based search

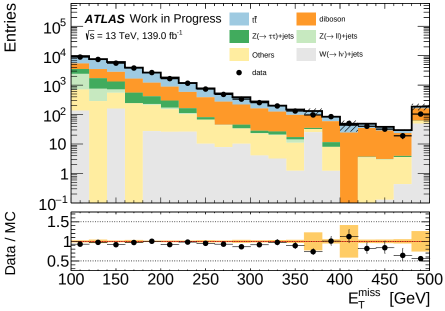
Event Preselection

- Events are selected by E_T^{miss} trigger
- Exactly 2 same flavor opposite sign leptons (e/μ)
- $E_T^{miss} > 200$ GeV
- ISR topology
  - At least one jet with $p_T > 30$ GeV
  - $\Delta\phi$(leading jet, E_T^{miss}) > 2.0
- $\min_i(\Delta\phi(jet_i, E_T^{miss})) > 0.4$ to reduce multi-jet background
- Veto events with b-jets to reduce $t\bar{t}$ background
- $p_T(\ell) > 10$ GeV to reduce low-p_T misidentified leptons
- $\Delta R_{\ell\ell} > 0.75$ to veto close-by leptons (badly modelled in simulation)



Background Estimation

- Background is estimated with Monte Carlo simulation
  - $t\bar{t}$
  - Diboson
  - $Z \to \tau\tau$
  - $Z \to ee/\mu\mu$
  - $W \to \ell\nu$
  - Other (triboson, single top)
- Background from misidentified leptons is also estimated from Monte Carlo simulation



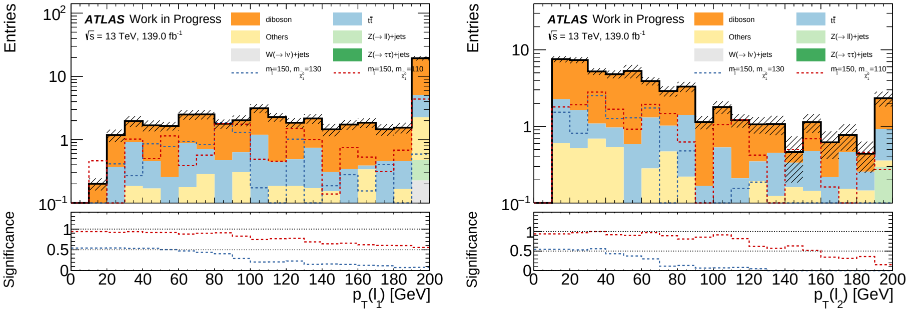
- Overall good agreement between Data and Monte Carlo

Signal region optimization

- Signal region is optimized using significance

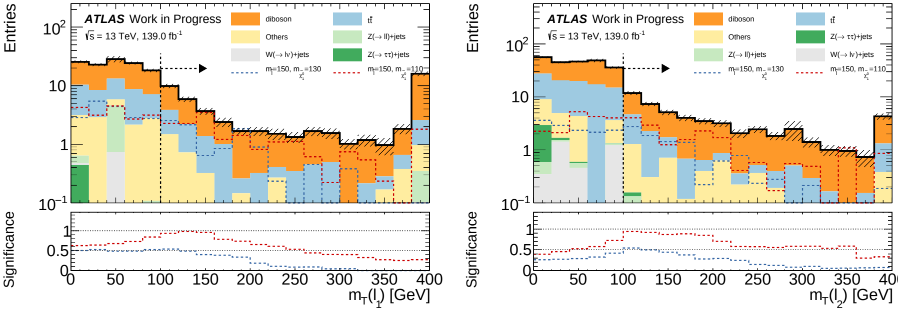
  $Z = \sqrt{2(n \ln[\frac{n(B+\sigma^2)}{B^2+n*\sigma^2}] - \frac{B^2}{\sigma^2} \ln[1 + \frac{\sigma(n-B)}{B(B+\sigma^2)}])}$
- Benchmark points with $m_{\tilde{\ell}} = 150$ GeV and $\Delta m = 20/40$ GeV
- Following cuts are applied:
  - $E_{\mathrm{T}}^{\mathrm{miss}} > 300$ GeV
  - $m_T(\ell_1) > 100$ GeV
  - $m_T(\ell_2) > 100$ GeV
  - Veto events with $81.2 < m_{\ell\ell} < 101.2$ GeV
- Showing N-1 plots in the following slides (all cuts applied except for the cut on the shown variable)

SR optimization



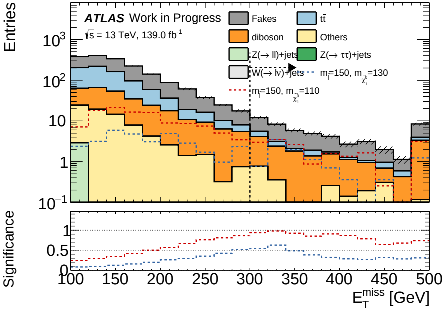
- Cut on lepton p_T does not improve sensitivity at all

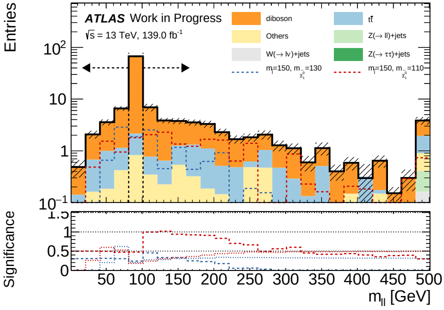
SR optimization



- $m_T(\ell) = \sqrt{2 p_\mathrm{T} E_\mathrm{T}^\mathrm{miss} (1 - cos(\Delta\phi))}$
- Apply $m_T(\ell) > 100$ GeV for both leptons

SR optimization

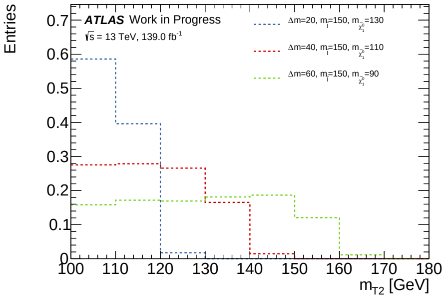


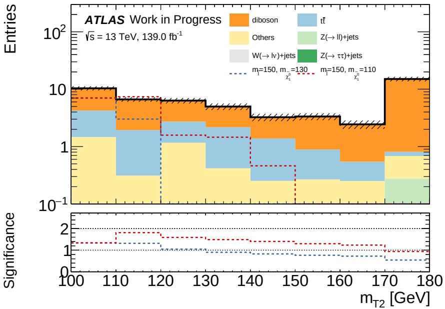


- Increase preselection cut to $E_T^{\text{miss}} > 300$ GeV
- Veto Z bosons with $|m_Z - m_{\ell\ell}| > 10$ GeV

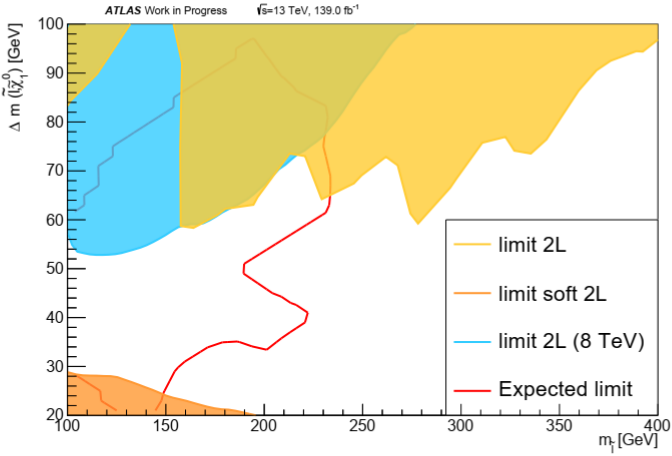
m_{T2}

- $m_{T2} = \min_{\boldsymbol{q_T}}(\max[m_T(\boldsymbol{p}_{\mathrm{T}}^{\ell 1}, \boldsymbol{q_T}, m_\chi), m_T(\boldsymbol{p}_{\mathrm{T}}^{\ell 2}, \boldsymbol{p}_{\mathrm{T}}^{\boldsymbol{miss}} - \boldsymbol{q_T}, m_\chi)])$ with $m_\chi = 100$ GeV
- Endpoint of m_{T2} distribution strongly depends on Δm
- Split signal region into multiple bins of size 10 GeV in m_{T2} to enhance sensitivity





Expected limit



- Expected limits approximated using the significance
- Sensitivity up to $m_{\tilde{\ell}} = 200$ GeV

Summary

- Presented search for new physics in final states with two leptons and ISR topology
- Target remaining sensitivity gap for $\Delta m(\tilde{\ell}, \tilde{\chi}_1^0) \sim 20\text{–}60$ GeV
- Preliminary SR optimization yields sensitivity for slepton masses up to 200 GeV
- Outlook:
  - Use machine-learning techniques to enhance sensitivity
  - Improve fake background estimation via data-driven method