Search for Electroweak Production of Sleptons in Di-Lepton Final States with the ATLAS Detector

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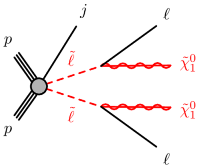
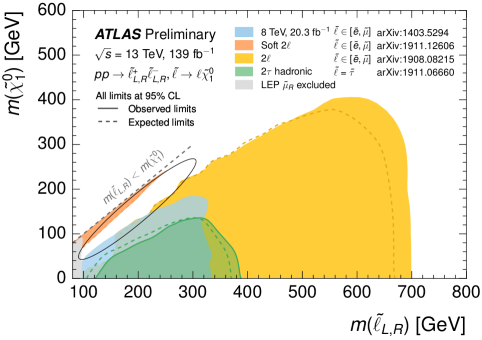
Monday 21st March, 2022

FSP ATLAS
Erforschung von Universum und Materie

MAX-PLANCK-GESELLSCHAFT

- Supersymmetry predicts for each Standard Model particle, a SUSY particle with spin differing by $\frac{1}{2}$
- Sleptons 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 $\tilde{\chi}_1^0$ via SM leptons
- Event kinematics are dependent on mass splitting: $\Delta m = m_{\tilde{\ell}} - m_{\tilde{\chi}_1^0}$



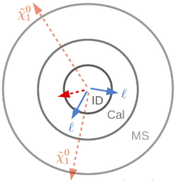


ATL-PHYS-PUB-2021-019

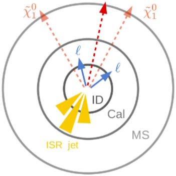
Compressed SUSY

- Targeting mass splittings below 60 GeV
- Typically events have low E_T^{miss} and soft particles

→ Initial state radiation (ISR) topology allows triggering on E_T^{miss} (requires E_T^{miss}>100 GeV)



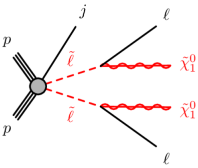
little E_T^{miss},
only soft
objects

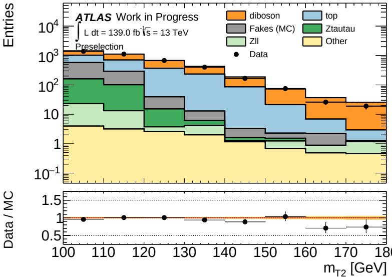


large E_T^{miss},
from ISR
recoil

Preselection

- Preselection
  - Events are selected by $E_{\mathrm{T}}^{\mathrm{miss}}$ trigger
  - Exactly 2 same flavor opposite sign leptons (e/μ)
  - $E_{\mathrm{T}}^{\mathrm{miss}} > 200$ GeV
  - ISR topology
    - At least one jet with $p_{\mathrm{T}} > 100$ GeV
    - $\Delta\phi$(leading jet, $E_{\mathrm{T}}^{\mathrm{miss}}$) > 2.0
  - maximum two jets with $p_{\mathrm{T}} > 30$ GeV
  - $\min_i(\Delta\phi(jet_i, E_{\mathrm{T}}^{\mathrm{miss}})) > 0.4$
  - b-veto
  - $\Delta R_{\ell\ell} > 0.75$



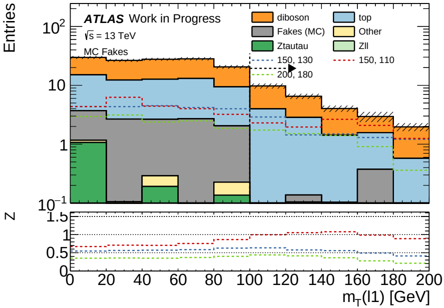


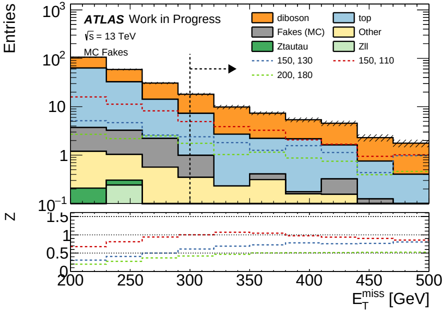
$m_{T2} = \min_{\boldsymbol{q_T}}(\max[m_T(p_{\mathrm{T}}^{\ell 1}, \boldsymbol{q_T}, m_\chi), m_T(p_{\mathrm{T}}^{\ell 2}, \boldsymbol{p}_{\mathrm{T}}^{\boldsymbol{miss}} - \boldsymbol{q_T}, m_\chi)])$,
$m_\chi = 100$ GeV

Signal region optimization

- Signal region is optimized using significance
  $Z = \sqrt{2n \ln \frac{n(B+\sigma^2)}{B^2+n\sigma^2} - 2\frac{B^2}{\sigma^2} \ln \left[1 + \frac{\sigma(n-B)}{B(B+\sigma^2)}\right]}$, n=signal+background, B=background, σ=Uncertainty(stat.+30%syst) ATL-PHYS-PUB-2020-025
- Benchmark points with $m_{\tilde{\ell}} = 150$ GeV and $\Delta m = 20/40$ GeV
- Signal region:
  - $E_{\mathrm{T}}^{\mathrm{miss}} > 300$ GeV
  - $m_T(\ell_1) > 100$ GeV
  - $m_T(\ell_2) > 100$ GeV
  - Veto events with $81.2 < m_{\ell\ell} < 101.2$ GeV

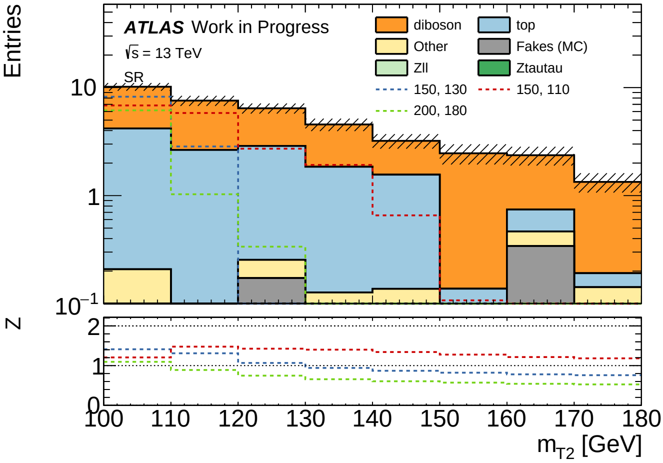
Signal region





- $m_T(\ell) = \sqrt{2p_T E_T^{miss}(1 - cos(\Delta\phi))}$
- Require $m_T(\ell) > 100$ GeV for both leptons
- Require $E_T^{miss} > 300$ GeV

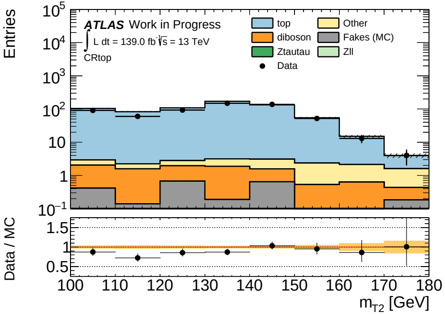
m_{T2} Distribution

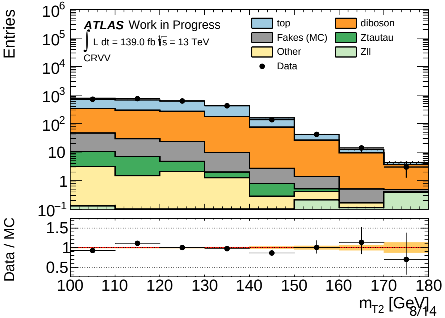


- $m_{T2} = \min_{\boldsymbol{q_T}}(\max[m_T(p_T^{\ell 1}, \boldsymbol{q_T}, m_\chi), m_T(p_T^{\ell 2}, \boldsymbol{p}_T^{miss} - \boldsymbol{q_T}, m_\chi)])$
- Split signal region into multiple bins in m_{T2} to enhance sensitivity

Irreducible background

- Diboson and top backgrounds are estimated in control regions
- Selection:
  - Includes e/μ events
  - Relaxed $E_{\mathrm{T}}^{\mathrm{miss}}$-Cut to $E_{\mathrm{T}}^{\mathrm{miss}} > 200$ GeV
  - CRtop:
    - Requires at least one b-jet
  - CRVV:
    - $m_T(\ell_2) < 100$ GeV
  - Other cuts same as signal region

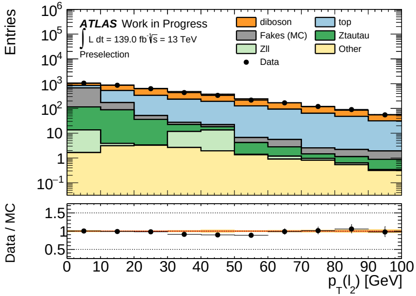




Fake background

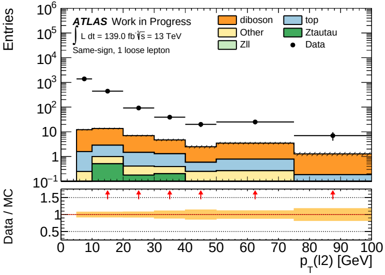
- Fake/non-prompt lepton background originates from:
  - Leptons from secondary decays (e.g. b-hadron decays)
  - Particles misidentified as leptons (e.g. pion identified as electron)
  - Photon conversion
- Fakes are an important background for low p_T leptons

→ Estimate with data-driven method

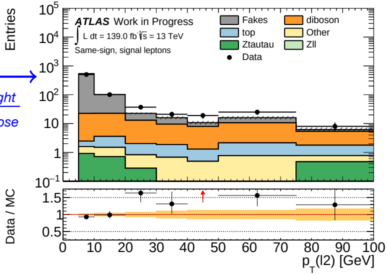


Fake factor method

- Fake background is measured in a region with a loose lepton failing the quality requirements (isolation, impact parameter cuts)
- Event yields are extrapolated to the signal region using a fake factor *F* as weight

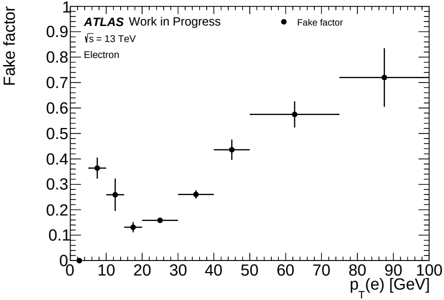


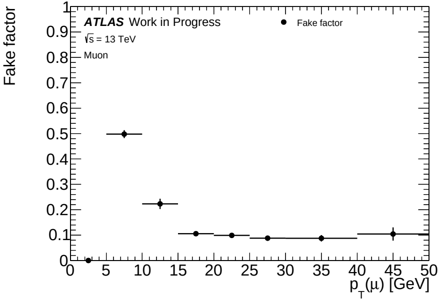
$$F = \frac{N_{tight}}{N_{loose}}$$



- $N_{\text{fake}} = (N_{\text{TL}}^{\text{data}} - N_{\text{TL}}^{\text{MC}} + N_{\text{LT}}^{\text{data}} - N_{\text{LT}}^{\text{MC}})F - (N_{\text{LL}}^{\text{data}} - N_{\text{LL}}^{\text{MC}})F_1 F_2$
- Method is validated using same-sign events

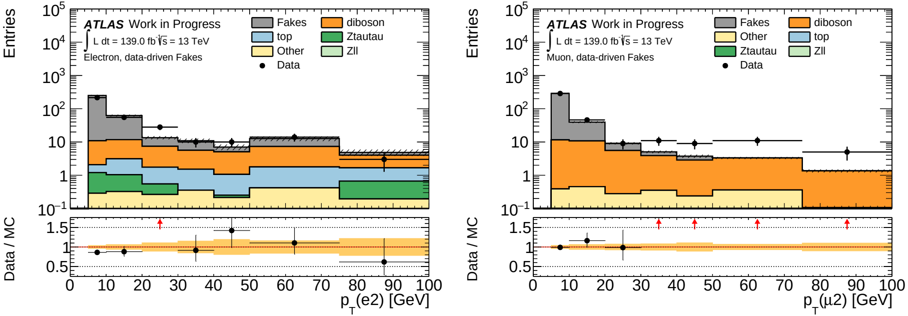
Fake factors





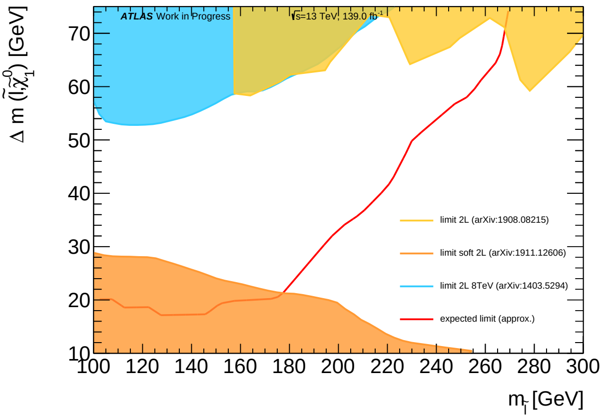
- Fake factors are estimated in a dijet region

Validation of fake estimation



- Method is validated using same-sign events with preselection cuts
- Overall good modeling except for muons with $p_{\mathrm{T}} > 30$ GeV

Expected sensitivity



- Promising sensitivity to so-far unprobed kinematic regime
- Still room for improvements at lower mass splittings

Summary

- Search for SUSY partners of the electron and muon
- Target remaining sensitivity gap for $\Delta m(\tilde{\ell}, \tilde{\chi}_1^0) \sim$ 20–60 GeV
- Signal region provides good sensitivity to close the gap