Ricerca di coppie di top squark in stati finali con due leptoni con il rivelatore ATLAS in collisioni pp a 13 TeV

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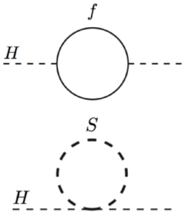
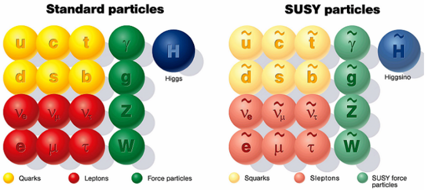
Why SUSY?

For decades the Standard Model has been subject to experimental scrutiny and has been found to be in agreement with experimental measurements. On top of all the Higgs boson discovery by ATLAS and CMS in 2012!

Still, some theoretical problems has to be fixed:



- Higgs mass not natural, divergent quantum corrections
- dark matter
- unification with gravity...



Supersymmetry tries to solve these problems by adding a new set of particles: each particle has a supersymmetric partner with spin $s - 1/2$

Consideration of naturalness suggests that the top squark (top supersymmetric partner) cannot be too heavy

$\downarrow$

It could be pair-produced with relatively large cross-sections at the LHC

$\downarrow$

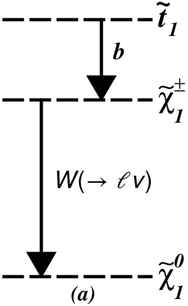
Subject of our search!

Target of the analysis

Top squark pair production with the decay:

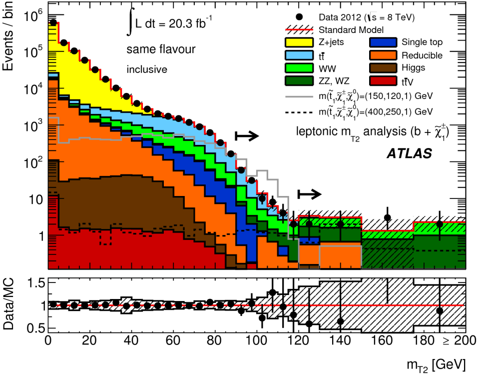
$$\tilde{t} \rightarrow b + \tilde{\chi}_1^{\pm}$$

$\tilde{\chi}_1^0$ is the lightest susy particle, assumed stable
$\rightarrow$ good dark matter candidate!



Final state:

- exactly two opposite sign isolated leptons (electrons or muons)
- significant missing transverse momentum



run1 - http://arxiv.org/abs/1403.4853

Main discriminant variable:

$$m_{\mathrm{T2}}\left(\mathbf{p}_{\mathrm{T},1},\mathbf{p}_{\mathrm{T},2},\mathbf{q}_{\mathrm{T}}\right)=\min_{\mathbf{q}_{\mathrm{T},1}+\mathbf{q}_{\mathrm{T},2}=\mathbf{q}_{\mathrm{T}}}\left\{\max\left[m_{\mathrm{T}}\left(\mathbf{p}_{\mathrm{T},1},\mathbf{q}_{\mathrm{T},1}\right),m_{\mathrm{T}}\left(\mathbf{p}_{\mathrm{T},2},\mathbf{q}_{\mathrm{T},2}\right)\right]\right\}$$

with $\mathbf{p}_{\mathrm{T}}$ = transvers momentum of the two leptons and $\mathbf{q}_{\mathrm{T}} = E_{\mathrm{T}}^{\mathrm{miss}}$

Backgrounds

Main background sources for the top squark → 2 leptons analysis

Irreducible backgrounds with two real leptons in the final state:

- diboson processes (WW, WZ and ZZ) and $t\bar{t}$ production
  MC normalized in three different control regions
- smaller sources (Wt, Z/gamma*+jets, ttW, ttZ, ttH, WH and ZH)
  directly estimated from MC

Reducible background:

- fake and non-prompt leptons
  - misidentified hadrons
  - conversions
  - leptons coming from hadronic decays

  estimated from data with the matrix method
  → subject of this presentation!

The Matrix Method

Matrix which relates the leptons selected in the signal region with the number of fake or not prompt lepton which have wrongly passed the selection.

$$\begin{pmatrix} N_{TT} \\ N_{Tl} \\ N_{lT} \\ N_{ll} \end{pmatrix} = M \begin{pmatrix} N_{LL}^{RR} \\ N_{LL}^{RF} \\ N_{LL}^{FR} \\ N_{LL}^{FF} \end{pmatrix}$$

$$M = \begin{pmatrix} r_1 r_2 & r_1 f_2 & f_1 r_2 & f_1 f_2 \\ r_1(1-r_2) & r_1(1-f_2) & f_1(1-r_2) & f_1(1-f_2) \\ (1-r_1)r_2 & (1-r_1)f_2 & (1-f_1)r_2 & (1-f_1)f_2 \\ (1-r_1)(1-r_2) & (1-r_1)(1-f_2) & (1-f_1)(1-r_2) & (1-f_1)(1-f_2) \end{pmatrix}$$

Where r and f are the efficiencies for real and fake leptons:

$$\text{efficiency} = \frac{\text{\# of leptons which pass the tight selection}}{\text{\# of leptons which pass a looser selection}}$$

The efficiencies can strongly depend on the kinematics of the events and are parametrised as a function of p_T and η

What do I mean by loose and tight?

Electrons ID:

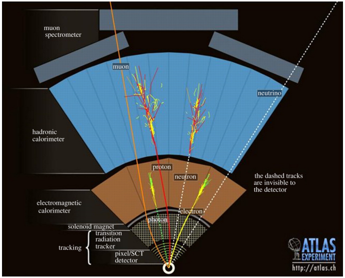
- ionization track in the inner detector
- energy release in the EM calorimeter

Muons ID:

- ionization tracks in the inner detector
- ionization tracks in the muon spectrometer

Isolation:

Consider the total energy measured in a cone built around the lepton's track, does it mostly come from the lepton itself?
$\rightarrow$ the lepton is isolated!



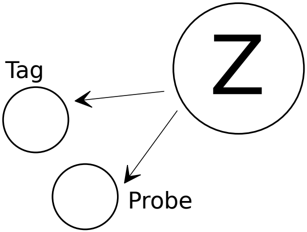
Analysis selection:

- loose $\rightarrow$ loose ID selection
- tight $\rightarrow$ tighter ID selection + isolation

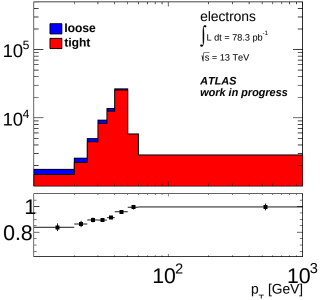
Real efficiencies

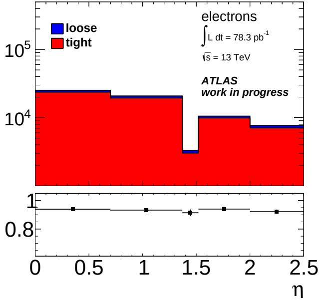
Tag and probe method

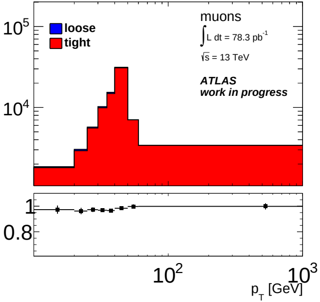
- Events with invariant mass between 81 and 101 GeV
- Tagged tight lepton with:
  - $p_T > 30$ GeV
  - $|\eta| < 2.5$
  - trigger: high p_T threshold, isolated lepton (tag)

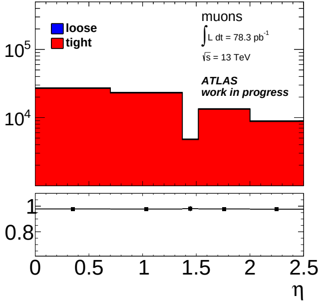


Real efficiencies









Fake efficiencies

Two different strategies for high and low p_T:

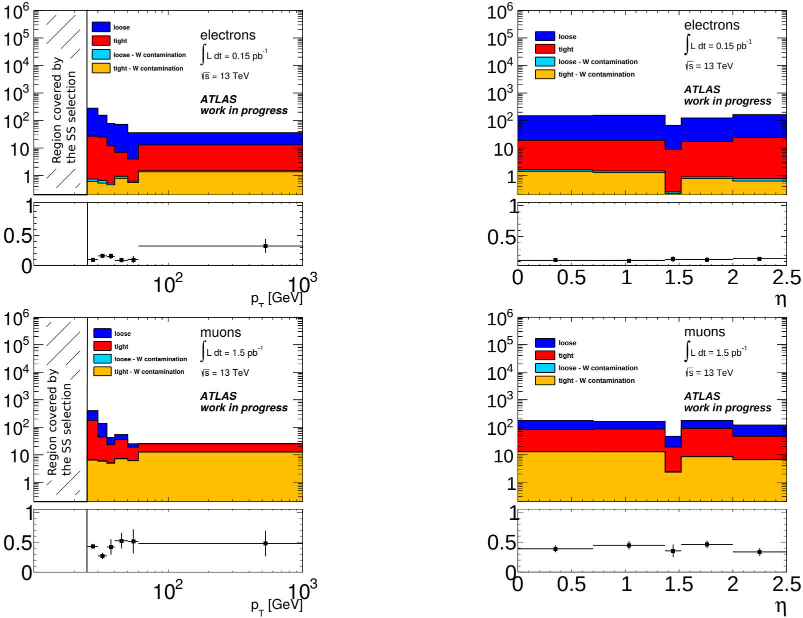
QCD multi-jet selection
for $p_T > 25$GeV:

- exactly one lepton
- at least one jet
- $E_T^{miss} < 25$ GeV
- $\Delta\phi(E_T^{\text{miss}}, l) < 0.5$
- trigger: high p_T threshold

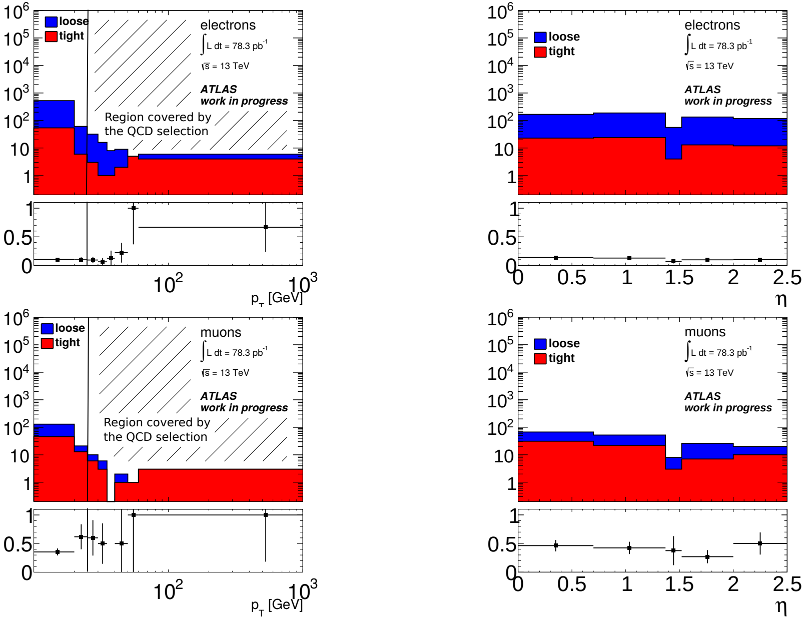
$e\mu$ same-sign selection
for $p_T < 25$GeV:

- tag: tight leading muon (electron)
- probe: electron (muon)
- trigger: low p_T threshold & isolated lepton (tag)

Fake efficiencies - $p_T > 25\text{GeV}$



Fake efficiencies - $p_T < 25\text{GeV}$



Conclusions

My project's goal is to evaluate the fake leptons background for the top squark $\rightarrow$ 2 leptons analysis with the Matrix Method:

- real efficiencies $\rightarrow$ tag&probe on Z events
- fake efficiencies $\rightarrow$ 2 different selections for high and low p_T leptons

Next steps:

- validate the method on an independent fake enriched region
  - ee and $\mu\mu$ same-sign selection
  - we don't have enough statistics yet
- check the fake composition in our selections
  - the fake rate may be different for each component
  - the fake rate measure is inclusive
  - we need the same signal region's composition in order to avoid bias