

SUSY search with two same-sign leptons and jets with the ATLAS detector using 21 fb⁻¹ of pp collisions at 8TeV

Abstract

A search for the production of supersymmetric particles decaying into final states with jets, b-jets, missing transverse momentum and two isolated leptons, e or μ , with the same electric charge (same-sign leptons) is presented. The analysis uses a data sample collected during 2012, which corresponds to a total integrated luminosity of 20.7 fb⁻¹ of $\sqrt{s} = 8$ TeV proton-proton collisions recorded with the ATLAS detector at the Large Hadron Collider. No deviation from the Standard Model expectation is observed. Exclusion limits are derived for a mSUGRA/CMSSM model, for which the parameters are chosen in such a way that the Higgs mass is compatible with the recent discovery of a Higgs-like particle at the LHC, and for a wide variety of simplified models of supersymmetry. The result significantly extends previous exclusion limits from several searches for Supersymmetry.

Introduction

Focus on strong production: look at squark / gluino decays with two same-sign leptons in the final state.

Motivation:

- gluinos are Majorana fermions : allows for same-sign lepton pair production.
- ≥ 3 leptons can occur during cascade decays.
- Standard Model background is very low.

Event selection:

- E_T^{miss} only triggers if $E_T^{\text{miss}} > 150$ GeV, single lepton triggers if leading lepton $p_T > 40$ GeV (muons) or $p_T > 70$ GeV (electrons) and dilepton triggers otherwise.
- Jets with $p_T > 25$ GeV and $|\eta| < 2.8$; if b-tagging is required the threshold p_T is lowered to 20 GeV.
- Signal leptons: isolated electrons with $p_T > 20$ GeV and $|\eta| < 2.47$ must satisfy the "tight++" selection criteria; isolated muons with $p_T > 20$ GeV and $|\eta| < 2.4$.

Standard Model background

Three event categories can be considered, depending on number of b-jets identified in the final state: 0, ≥ 1 , ≥ 3 b-jets.

Irreducible:

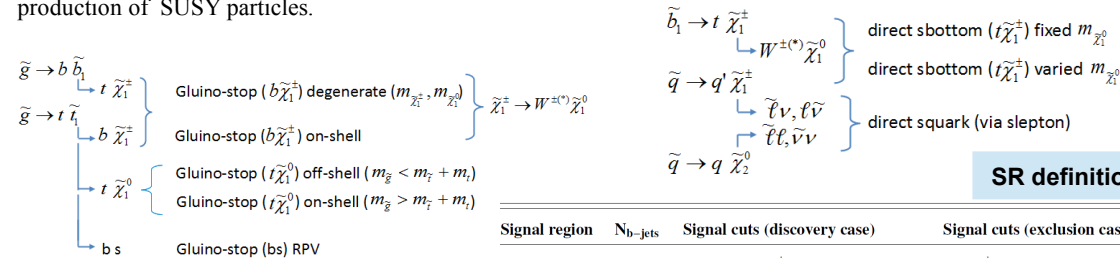
- signal regions with at least one b-jets : $t\bar{t}$ production with a vector boson, W or Z, decaying leptonically.
- signal region with a b-jet veto: diboson production (WZ / ZZ plus jets).
- these backgrounds are estimated from Monte-Carlo simulations.

Reducible:

- can be divided in charge mis-measurement, fake leptons.
- with the requirements imposed in the signal regions the only significant contribution is from $t\bar{t}$.
- **charge mis-measurement** → the probability of one electron to have a wrong charge.
- **fake leptons** stem from the weak b-hadron decay.
- these background are estimated using fully data-driven methods.

SUSY models

The results are interpreted in minimal supergravity (mSUGRA/CMSSM) and simplified models with strong pair production of SUSY particles.



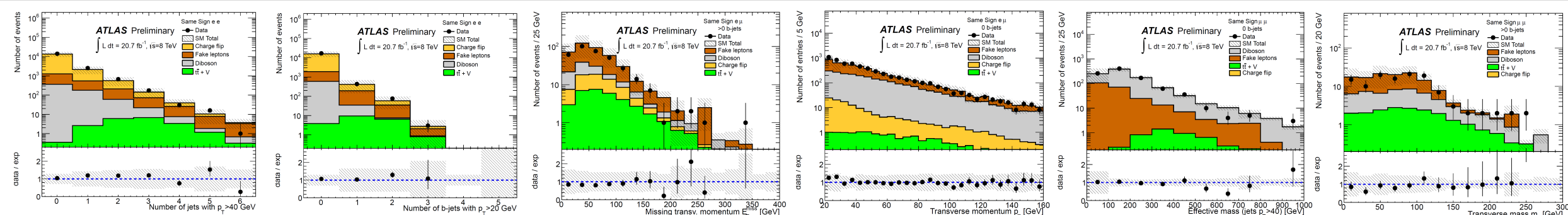
SR definitions

Signal region	N _{b-jets}	Signal cuts (discovery case)	Signal cuts (exclusion case)
SR0b	0	$N_{\text{jets}} \geq 3, E_T^{\text{miss}} > 150$ GeV $m_T > 100$ GeV, $m_{\text{eff}} > 400$ GeV	$N_{\text{jets}} \geq 3, E_T^{\text{miss}} > 150$ GeV, $m_T > 100$ GeV, binned shape fit in m_{eff}
SR1b	≥ 1	$N_{\text{jets}} \geq 3, E_T^{\text{miss}} > 150$ GeV $m_T > 100$ GeV, $m_{\text{eff}} > 700$ GeV	$N_{\text{jets}} \geq 3, E_T^{\text{miss}} > 150$ GeV, $m_T > 100$ GeV, binned shape fit in m_{eff}
SR3b	≥ 3	$N_{\text{jets}} \geq 4$	$N_{\text{jets}} \geq 5,$ ($E_T^{\text{miss}} < 150$ GeV or $m_T < 100$ GeV)

Validation regions

Event classes	VR-diboson	VR-ttW	VR-ttZ
Observed events	54	9	4
Expected background events	74 ± 13	4.2 ± 1.9	8.0 ± 2.0
Expected $t\bar{t} + V$ events	1.6 ± 0.8	2.7 ± 1.5	3.2 ± 1.1
Expected diboson events	60 ± 7	0.4 ± 0.1	3.9 ± 1.3
Expected fake lepton events	12 ± 11	1.1 ± 1.1	0.9 ± 0.5
Expected charge mis-meas. events	0	0	0

Data and expected background comparison



Background estimates are checked in e-e, e- μ and μ - μ channels, for several discriminating variables: good agreement, within estimated systematic uncertainty, is obtained.

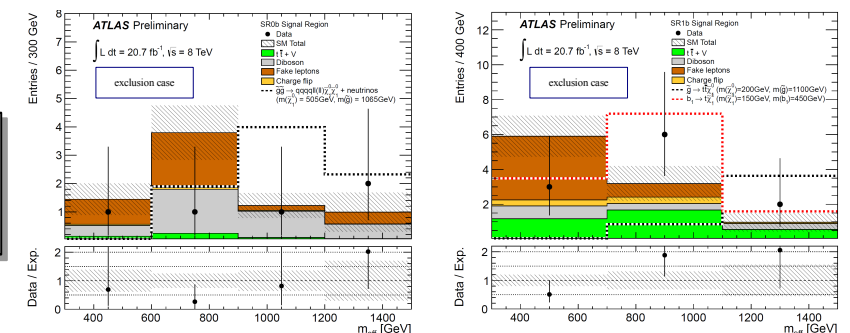
Results

Number of observed events and expected background events in the three signal regions for the **discovery** case.

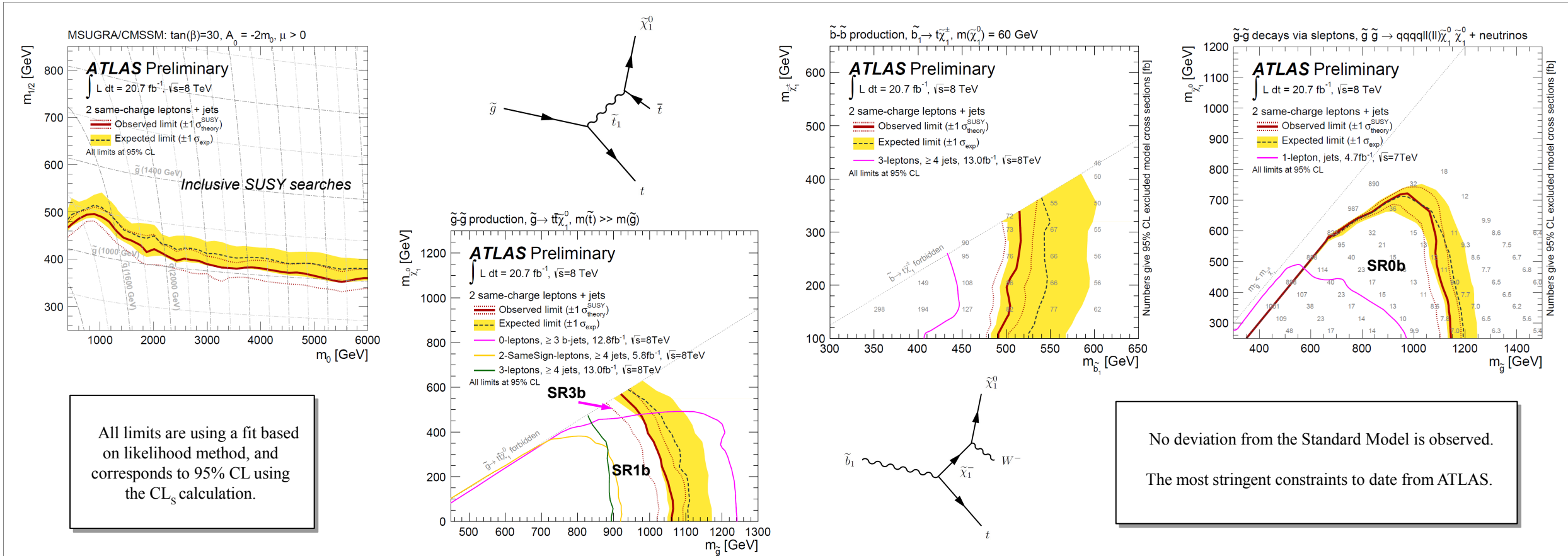
A) Discovery case	SR0b	SR1b	SR3b
Observed events	5	8	4
Expected background events	7.5 ± 3.3	3.7 ± 1.6	3.1 ± 1.6
Expected $t\bar{t} + V$ events	0.5 ± 0.4	2.2 ± 1.0	1.7 ± 0.8
Expected diboson events	3.4 ± 1.0	0.7 ± 0.4	0.1 ± 0.1
Expected fake lepton events	3.4 ± 3.1	$0.3^{+1.1}_{-0.3}$	$0.9^{+1.4}_{-0.9}$
Expected charge mis-measurement events	0.1 ± 0.1	0.5 ± 0.2	0.4 ± 0.1
p_0	0.50	0.11	0.36

Dominant source of systematic uncertainty:

- **SR0b**: systematic uncertainty on fake rate, JES, b-tagging identification
- **SR1b**: JES, systematic uncertainty on fake rate, ttV cross-section
- **SR3b**: systematic uncertainty on fake rate, ttV cross-section



Interpretations, model-dependent limits



No deviation from the Standard Model is observed.
The most stringent constraints to date from ATLAS.