Search for supersymmetry in events with large missing transverse momentum and two leptons in proton-proton collisions at 7 TeV with the ATLAS detector

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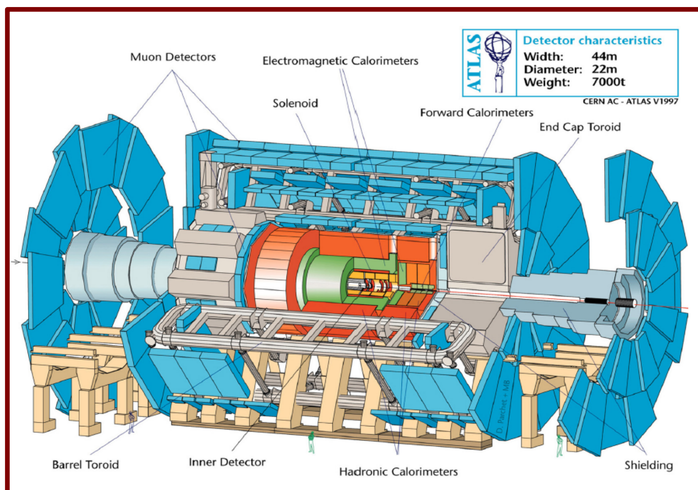
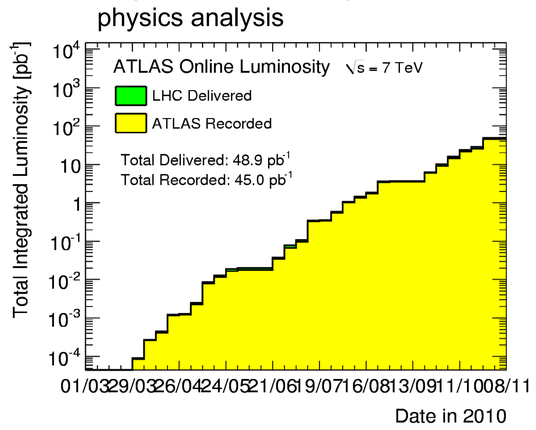
Abstract

In 2010, the Large Hadron Collider (LHC) at CERN opened up a new regime for probing physics beyond the Standard Model. The search for various manifestations of Supersimmetry is one of the main tasks of the LHC experiments. First searches for the production of SUperSYmmetric (SUSY) particles yielding large missing transverse momentum and two isolated leptons in the final state are presented. The full data sample collected in 2010 by the ATLAS experiment in LHC proton-proton collisions at a center-of-mass energy of 7 TeV, corresponding to an integrated luminosity of 35 pb-1, has been analyzed.

The ATLAS detector



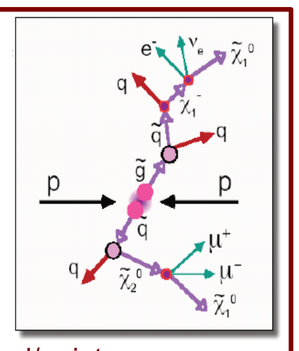
pp collisions at ATLAS in 2010
45 pb-1 recorded, 35 pb-1 usable for physics analysis



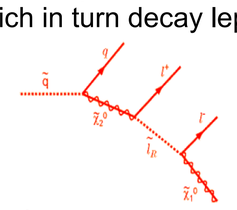
Lepton identification:
- Electrons: EM calorimetry in liquid Ar, transition radiation tracker to provide e/π separation;
- Muons: precision muon tracking with Monitored Drift Tubes, matching with Inner Detector.

SUSY searches in ATLAS

In **R-parity conserving** SUSY models, gluino-gluino production dominates at the LHC. Gluino and squark decays produce charginos and neutralinos, which in turn decay leptonically:



$\tilde{\chi}_2^0(\to \tilde{\ell}^{\pm}\ell^{\mp}) \to \tilde{\chi}_1^0\ell^{\pm}\ell^{\mp}$



- LSP is stable → large missing transverse energy (MET)
- Sparticles produced in pairs → cascade decays: high pt leptons and/or jets
- Look for an excess of events with respect to Standard Model (SM) predictions
- Main SM backgrounds: **QCD, W+jets, Z+jets, tt**

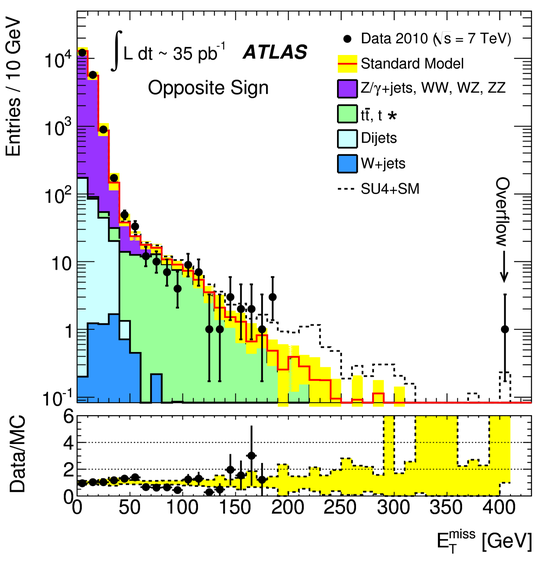
Focus on MET + 2 leptons (Opposite - OS and Same Sign - SS)

Event selection:
- Single lepton trigger
- Exactly **2** isolated leptons (**ee, eμ, μμ**), each with **pt > 20 GeV**
- Invariant mass **m(ll) > 5GeV**

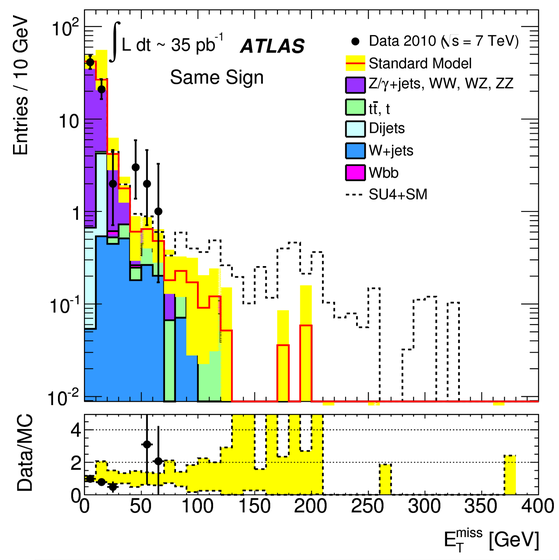
2 leptons + MET

http://arxiv.org/abs/1103.6214, submitted to EPJC Letters

OS Signal region: MET > 150 GeV



SS Signal region: MET > 100 GeV



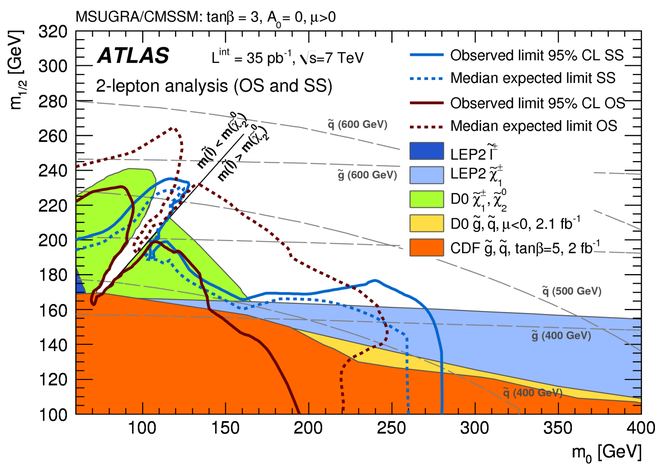
* SU4: benchmark point in mSUGRA/CMSSM parameter space with m_0=200 GeV, $m_{1/2}$=160 GeV, A_0= -400 GeV, tanβ=10, μ>0

Same Sign, $E_T^{miss} > 100$ GeV	$e^{\pm}e^{\pm}$	$e^{\pm}\mu^{\pm}$	$\mu^{\pm}\mu^{\pm}$
Data	0	0	0
Fakes	0.12 ± 0.13	0.030 ± 0.026	0.014 ± 0.010
Di-bosons	0.015 ± 0.005	0.035 ± 0.012	0.021 ± 0.009
Charge-flip	0.019 ± 0.008	0.026 ± 0.011	-
Cosmics	-	$0^{+1.17}_{-0}$	-
Total	0.15 ± 0.13	$0.09^{+1.17}_{-0.03}$	0.04 ± 0.01

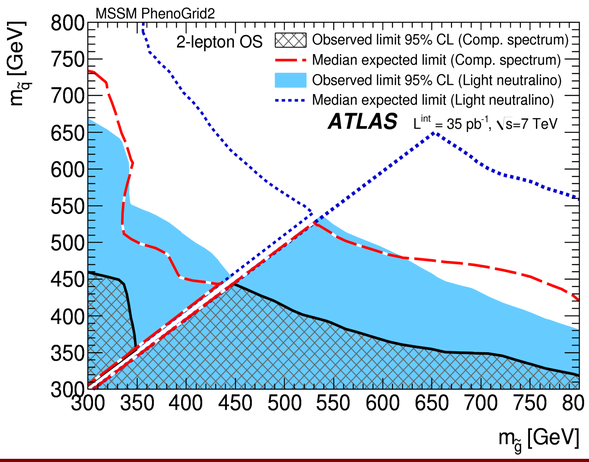
Opposite Sign, $E_T^{miss} > 150$ GeV	$e^{+}e^{-}$	$e^{\pm}\mu^{\mp}$	$\mu^{+}\mu^{-}$
Data	1	4	4
$t\bar{t}$	$0.62^{+0.31}_{-0.28}$	$1.24^{+0.62}_{-0.56}$	$1.00^{+0.50}_{-0.45}$
Z+jets	0.19 ± 0.15	0.08 ± 0.08	0.14 ± 0.17
Fakes	-0.02 ± 0.02	-0.05 ± 0.04	-
Single top	0.03 ± 0.05	0.06 ± 0.08	0.10 ± 0.07
Di-bosons	0.09 ± 0.03	0.06 ± 0.03	0.15 ± 0.03
Cosmics	-	-0.2 ± 1.18	-0.43 ± 1.27
Total	$0.92^{+0.42}_{-0.40}$	$1.43^{+1.45}_{-0.59}$	$1.39^{+1.41}_{-0.53}$

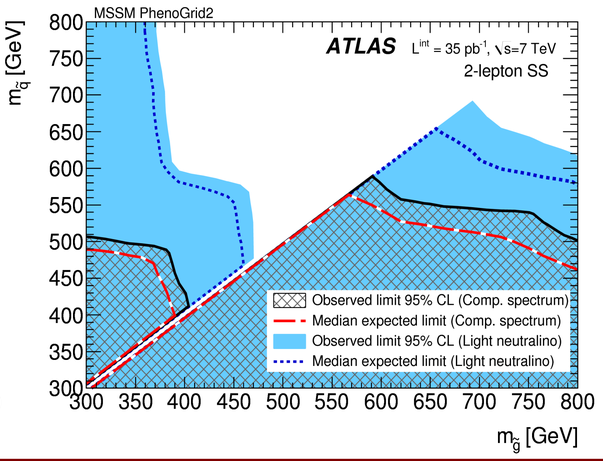
- Plots show data + Monte Carlo (MC) distributions with uncertainty for cross-sections, MC statistics, luminosity, lepton and jet energy scale and resolution.
- Tables show data + QCD, tt, W+jets, Z+jets data-driven estimation.

- 95% upper limits on cross section * acceptance * efficiency:
  - 0.07 pb (SS)
  - 0.09 pb (OS ee), 0.21 pb (OS μμ), 0.22 pb (OS eμ)



- Interpretation in more general 24 parameter MSSM framework, 2 grids:
  - Compressed particle spectrum → softer leptons
  - More favourable mass hierarchy, light LSP → harder leptons





2 leptons + MET with Flavour Subtraction

http://arxiv.org/abs/1103.6208, accepted for publication by EPJC Letters

Search of excess of Same-Flavour Opposite Sign (SFOS) over Different Flavour Opposite Sign (DFOS):

$$\mathcal{S} = \frac{N(e^{\pm}e^{\mp})}{\beta(1-(1-\tau_e)^2)} - \frac{N(e^{\pm}\mu^{\mp})}{1-(1-\tau_e)(1-\tau_\mu)} + \frac{\beta N(\mu^{\pm}\mu^{\mp})}{(1-(1-\tau_\mu)^2)}$$

- β = ratio of electron to muon (efficiency * acceptance) = 0.69 ±0.03
- τ = trigger efficiency for offline reconstructed electrons (98.5±1.1%) and muons (83.7±1.9%)

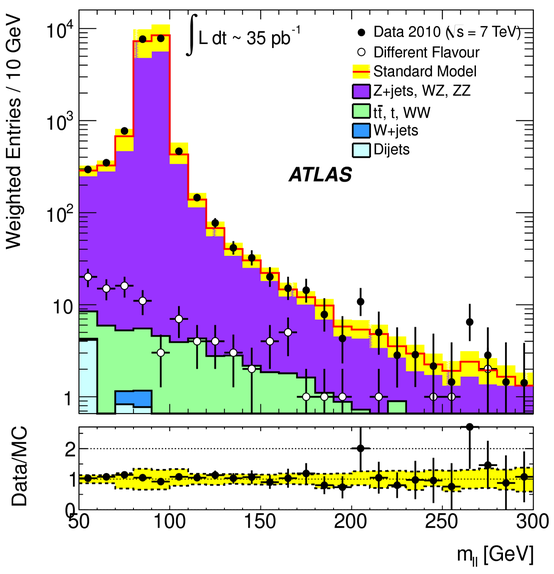
- Generated by leptons from cascade decays of neutralinos
- Small contribution from SM (Z/γ*)

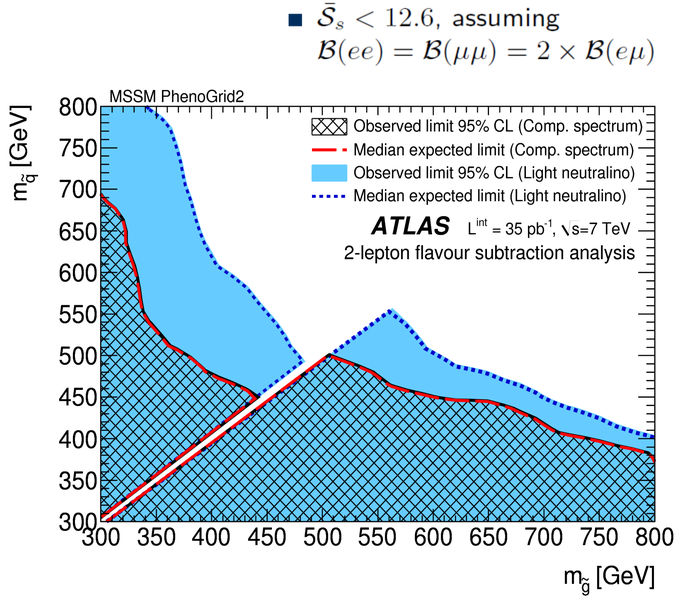
Signal region: MET > 100 GeV

	$e^{\pm}e^{\mp}$	$e^{\pm}\mu^{\mp}$	$\mu^{\pm}\mu^{\mp}$
Data	4	13	13
Z/γ^*+jets	0.40±0.46	0.36±0.20	0.91±0.67
Dibosons	0.30±0.11	0.36±0.10	0.61±0.10
$t\bar{t}$	2.50±1.02	6.61±2.68	4.71±1.91
Single top	0.13±0.09	0.76±0.25	0.67±0.33
Fakes	0.31±0.21	-0.15±0.08	0.01±0.01
Total SM	3.64±1.24	8.08±2.78	6.91±2.20

- $\mathcal{S}_{\text{obs.}} = 1.98 \pm 0.15(\beta) \pm 0.02(\tau_e) \pm 0.06(\tau_\mu)$
- $\mathcal{S}_{\text{bg}} = 2.06 \pm 0.79(\text{stat.}) \pm 0.78(\text{sys.})$

- Average contribution from New Physics (95% CL):
  - $\bar{\mathcal{S}}_s < 8.8$, assuming $\mathcal{B}(ee) = \mathcal{B}(\mu\mu),\ \mathcal{B}(e\mu) = 0$
  - $\bar{\mathcal{S}}_s < 12.6$, assuming $\mathcal{B}(ee) = \mathcal{B}(\mu\mu) = 2 \times \mathcal{B}(e\mu)$





Conclusion

No excess of events is observed in searches for events with 2 isolated leptons (electrons and muons) and large missing transverse energy with respect to SM predictions. Depending on model assumptions, squark masses between 450 and 690 GeV are excluded. With a flavour subtraction analysis, the 95% confidence lower limit on the squark mass is 503 GeV for compressed spectrum models, and 558 GeV for light neutralino models.

Poster presented at the Physics at LHC Conference (PLHC), Perugia, Italy, 6-11 June 2011.