Experimental status of SUSY searches

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2011 LHC run



- ATLAS and CMS both recorded
 > 5 fb⁻¹ of pp collisions
- Most results from Summer ~1 fb⁻¹
- Expect updates for Moriond

Search strategy

- Target large cross sections from strong production
- Signature based, inclusive analyses with MET
- Simple "cut and count" style analyses
- No deviations from SM observed → limits set



SUSY searches with 2011 data

Signature	ATLAS	CMS
All-hadronic	≥ 2,4 jets (<u>arXiv:1109.6572</u>) ≥ 6,7,8 jets (<u>arXiv:1110.2299</u>) b jets (<u>ATLAS-CONF-2011-098</u>)	α _T (<u>PRL 107, 221804 (2011)</u>) M _{T2} (<u>SUS-11-005</u> including b jets) Razor (<u>SUS-11-008</u>) MHT (<u>SUS-11-004</u>) MET+b jets (<u>SUS-11-006</u>)
Single-lepton	arXiv:1109.6606 b jets (ATLAS-CONF-2011-130)	<u>SUS-11-015</u>
Dilepton	arXiv:1110.6189	SS (<u>SUS-11-010</u>) OS (<u>SUS-11-011</u> , <u>SUS-11-007</u> taus) Z (<u>SUS-11-019</u> , <u>SUS-11-017</u>)
Multilepton		RPC (<u>SUS-11-013</u>) 2.1 fb ⁻¹ RPV (<u>EXO-11-045</u>) 2.1 fb ⁻¹
Photon	Diphotons (arXiv:1111.4116)	Single and diphotons (SUS-11-009)

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

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$$\alpha_{T} = \frac{E_{T j2}}{M_{T j1j2}} = \frac{\sqrt{E_{T j2} / E_{T j1}}}{\sqrt{2(1 - \cos \Delta \varphi)}}$$

α_T and H_T based search:

- α_T > 0.55
- H_T > 275 GeV
- At least two jets with $p_T > 100 \text{ GeV}$
- Lepton veto



Backgrounds

- Z → vv from γ+jets sample with MC translation factor
- W/top from µ+jets control sample with MC translation factor
- QCD background shape from lower α_T control sample

• New in 2011 \rightarrow shape fit in bins of H_T





Also sensitivity to lower H_T signals



• Novel search in hadronic events with very high jet multiplicity

Large number of jets ≥ 6,7,8 and lower MET requirement complementary to traditional search with ≥ 2,4 jets and higher MET cut

Backgrounds in two categories

Leptonic backgrounds (W, Z + jets, leptonic top) → Extrapolate control regions using MC



Systematic uncertainties on extrapolation from JEC, JER, ID and b tag efficiencies

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 - Leptonic backgrounds (W, Z + jets, leptonic top) → Extrapolate control regions using MC
 - Multijet backgrounds (QCD and fully-hadronic top) → MET/√H_T templates



■ Data-driven technique works to around 10-20% precision → residual systematic assigned



	6 J 80 GeV	7 J 55 GeV	7 J 80 GeV	8 J 55 GeV
Data	26	45	3	4
SM	26 ± 6	39 ± 9	1.3 ^{+1.9} -0.4	2.3 +4.4 -2.7



Interpretation in Simplified Model Spectra



■ Clean way to communicate results of our searches and compare different channels → no hidden theory dependence

Single-lepton search

• Lepton (e/µ) requirement

- One electron p_T > 25 GeV
- One muon p_T > 20 GeV

 $H_T = p_T^l + \Sigma_{i=1}^3 p_T^{jet_i},$ $m_{eff} = H_T + E_T^{miss}$

- Four signal regions defined in terms of MET, m_T, m_{eff} and N_{jets}
 - Tight signal regions for CMSSM-like models with large MET and high E_T jets
 - Loose signal regions for models with more compressed particle spectra
 - Three jet signal regions for lower multiplicity squark-squark production
 - Four jet signal regions for gluino-gluino(squark) production



	3J L	3J T	4J L	4J T
Leading jet	60	80	60	60
Other jets	25	25	25	40
mτ	100	100	100	100
MET	125	240	140	200
MET/m _{eff}	0.25	0.15	0.3	0.15
m _{eff}	500	600	300	500

Single-lepton search

Backgrounds in two categories

- Fake leptons (small contribution) → fake rate method
- Leptonic backgrounds (W+jets, top) → Extrapolate control regions using MC
- Combined fit to control and signal regions including all background sources



Interpretation in Simplified Model Spectra



Shows where kinematic coverage ends → leptons/H_T too soft

Dilepton searches

• Dilepton production:

- In cascade decays of strongly produced particles
- Directly via weak pair-production

Several searches

- Opposite-sign leptons → On/off Z peak, same-flavour lepton pairs
- Same-sign leptons

 strong and weak production

Event selection

- Electron p_T > 20 GeV (25 if leading lepton)
- Muon p_T > 10 GeV (20 if leading lepton)

Dilepton searches

Backgrounds

- Fake leptons → fake rate method
- Leptonic backgrounds (Z, top) → Extrapolate control regions using MC
- Charge mis-assignment (small) → From Z control sample

Results



Dilepton searches

Flavour subtraction analysis

 Subtract number of eµ events from number of ee and µµ events (correcting for differences in efficiency)



Interpretation in Simplified Model Spectra



 Leptonic searches probe compressed mass spectra better than current hadronic analyses

Multileptons

• At least three high p_T leptons e, μ and τ (require at least one e or μ)

- Many signal/control boxes considered:
 - MET (50 GeV)/ no MET, on/off Z peak, high H_T (200 GeV)/no H_T, same-sign/opposite-sign/flavour
 - Sensitivity to EWK production
- MET threshold determines control/signal for RPC/RPV search
- Statistically combined for final limit

Backgrounds

- Irreducible: WZ+jets, ZZ+jets → estimated from simulation
- ttbar → simulation with study in control regions
- Z+jets, WW+jets, W+jets, QCD → data-driven fake rate
- Measured Z → 3 lepton background on Z peak in 2011
- Asymmetric internal/external conversions
- Higher order EWK processes important for search!



Multileptons



GGM inspired model

- Gravitino LSP
- Mass degenerate slepton co-NLSPs
- χ⁰ (bino-like) NNLSP

Multilepton signatures from:

$$\chi^0 o ilde{l}^{\,\pm} l^{\mp} o l^{\mp} + l^{\pm} + ilde{G}$$

RPV interpretation in backup

20 BSM 4 LHC UK @ IPPP, 11th-13th January 2012, Durham, UK.



Photon(s) + MET



- QCD bkgd. dominant → shape from control samples norm. at low MET
- $e \rightarrow \gamma$ fake rate measured on Z peak and used to estimate EWK bkgds.

21 BSM 4 LHC UK @ IPPP, 11th-13th January 2012, Durham, UK.

Photon(s)+MET





	2γ MET > 50 GeV	2γ MET > 100 GeV	γ MET > 200 GeV
Data	9	0	7
SM	11.3 ± 1.6	1.5 ± 1.0	7.2 ± 3.0

GGM model (J. Ruderman, D.Shih arXiv:1103.6083)

- Gravitino LSP
- Neutralino NLSP
- χ^0 (bino/wino-like) gives > 1 photon (BR γ vs Z⁰)
- Limit for fixed χ^0 mass of 375 GeV



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Conclusions

• Wide range of SUSY searches performed with 1 fb⁻¹ 2011 data

- Still > 4 fb⁻¹ to analyse for both ATLAS and CMS
- No significant deviation from the Standard Model so far

Mostly inclusive searches

- Broaden search programme in 2012
- Discussion later today on direction

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Multileptons: 3 lepton (e/µ) distributions



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Multileptons: RPV limits

