Prospects for inclusive searches for supersymmetry in ATLAS

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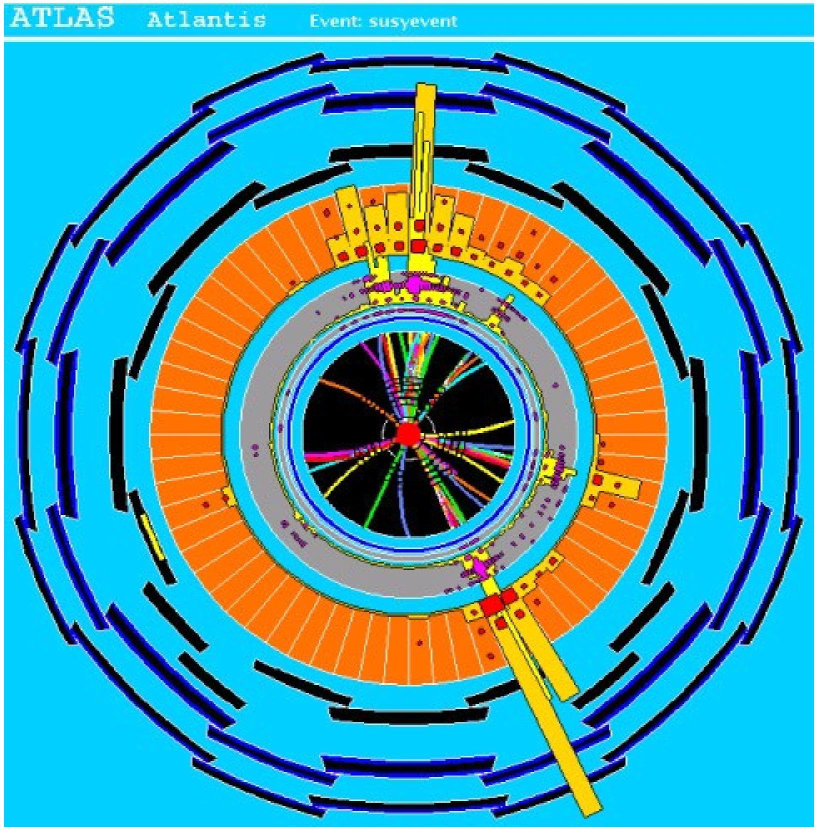
on behalf of the ATLAS Collaboration



Introduction

Supersymmetry is one of the most promising extension of SM

- dark matter candidate
- solves Higgs hierarchy problem

Assume R-Parity Conservation

→

- SUSY particles produced in pairs
  - if light, abundant production of squarks & gluinos
- cascade decay into LSP
- LSP escapes detection

↓

Signature: high p_T jets plus missing transverse energy

maybe additional leptons or photons

Strategies for Discovery

detailed studies on specific benchmark points for various signatures

- understanding of events
- develop analysis strategies
- inclusive in respect to jet multiplicities
- leptonic signatures exclusive for better combination in future

scans over subsets of SUSY parameter space

- large number of signal points → use of fast simulation (ATLFAST1)
- try cuts developed in detailed studies on broad range of models

develop techniques to estimate background from data

Studies on Benchmark Points

Overview of all detailed studies

Zero-lepton mode

- Four or more jets
- Two or more jets
- Three or more jets

One-lepton mode

- Four or more jets
- Two or more jets
- Three or more jets

Two-lepton mode

- Opposite sign dipletons
  - Four or more jets
- Same sign dipletons
  - Four or more jets

Three-lepton mode

- Three-lepton+jet
- Three-lepton+E_T^{miss}

Tau mode

b-jet mode

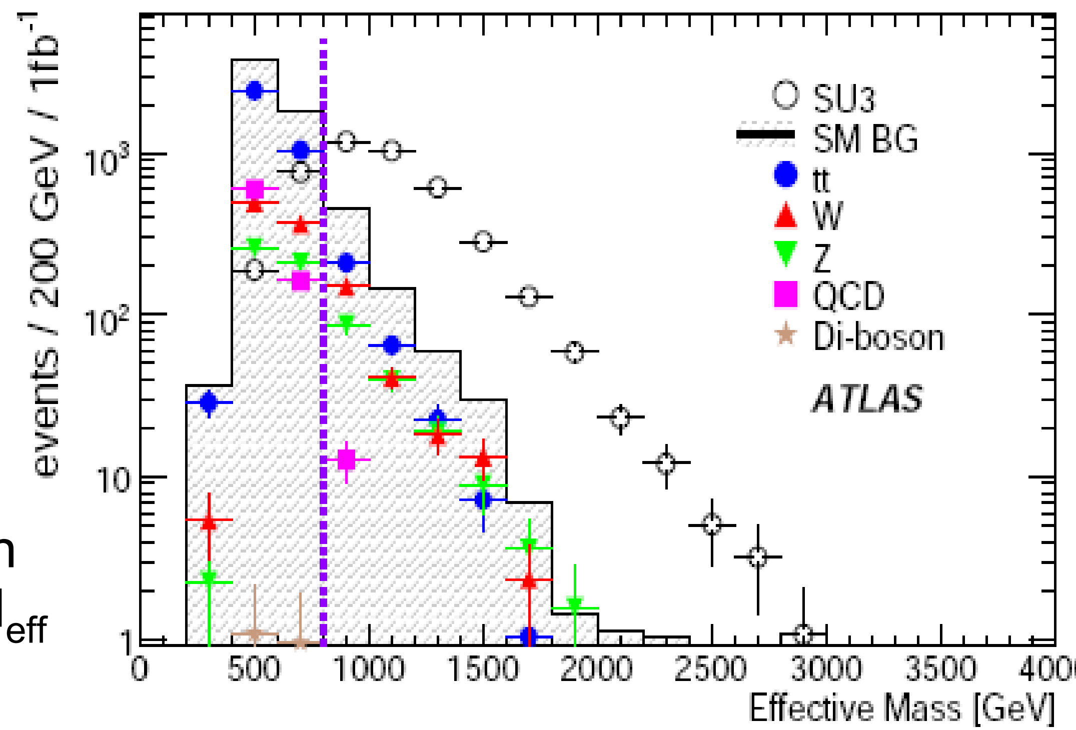
examples for 14TeV and 1fb^{-1} on the following slides

4-Jet-Zero-Lepton-Mode

Event Selection:

- J70_X70 combined trigger (jet + E_T^{miss})
- At least 4 jets with p_T > 100, 50, 50, 50 GeV & E_T^{miss} > 100 GeV
- $E_T^{miss} > 0.2 \cdot M_{eff}$; $M_{eff} = E_T^{miss} + \Sigma\, p_T(jet_i)$
- Transverse sphericity $S_T > 0.2$
- $\Delta\Phi(jet_j - E_T^{miss}) > 0.2;\ 1 \le j \le 3$
- Veto events with isolated e or μ
- Effective Mass M_{eff} > 800 GeV

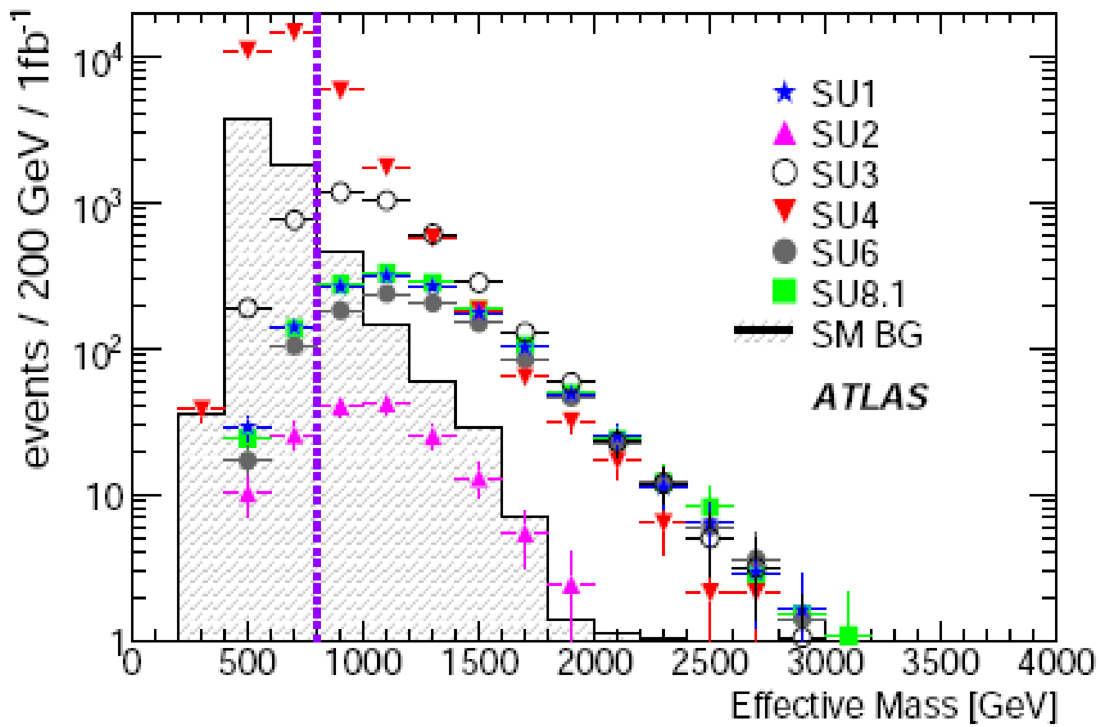
M_{eff} distribution before last M_{eff} cut



S/B ratio large in region of high M_{eff}

4-Jet-Zero-Lepton-Mode

M_{eff} distribution before last M_{eff} cut for various benchmark points



All benchmark points accessible with significance $Z_n > 5$ besides SU2 (dominated by direct gaugino production)

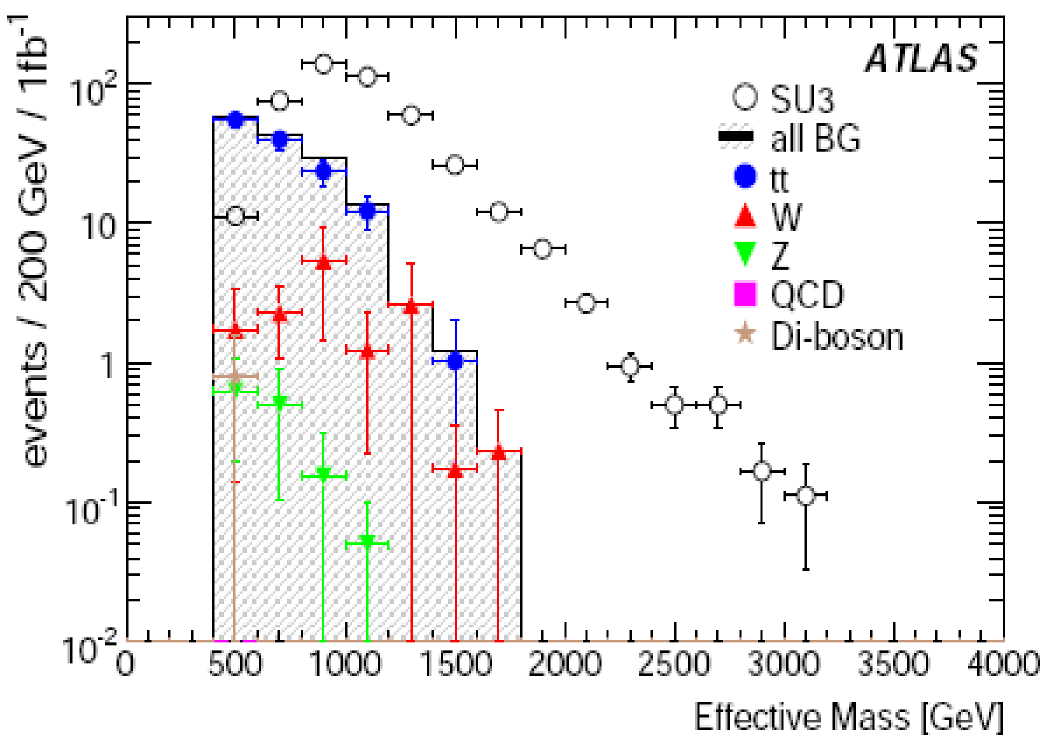
Z_n: convolution of poison with gaussian (syst. errors)

One-Lepton-Mode

Event Selection:

- J70_X70 combined trigger
- Exactly one isolated lepton with p_T > 20 GeV
- No additional lepton with p_T > 10 GeV
- At least 4 jets with p_T > 100, 50, 50, 50 GeV & E_T^{miss} > 100 GeV
- E_T^{miss} > 100 GeV and $E_T^{miss} > 0.2 \cdot M_{eff}$
- Transverse sphericity S_T > 0.2
- Transverse mass M_T > 100 GeV
- Effective Mass M_{eff} > 800 GeV

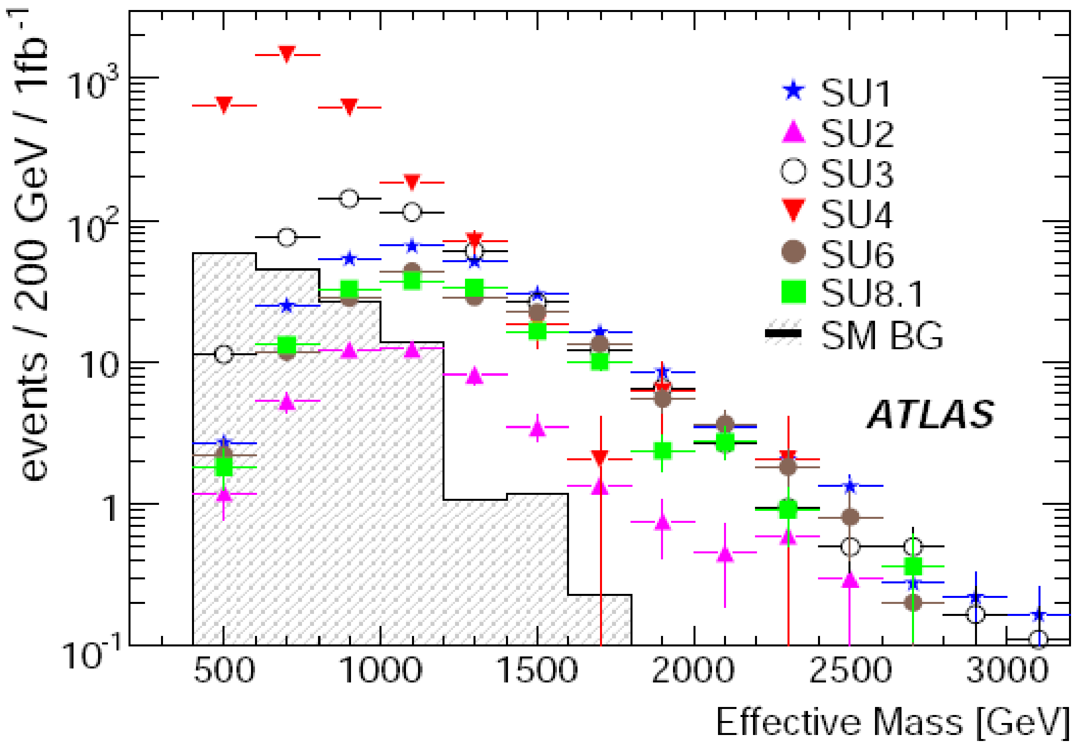
M_{eff} distribution before last M_{eff} cut



QCD background drastically reduced
main contribution from tt and W/Z

One-Lepton-Mode

M_{eff} distribution before last M_{eff} cut for various benchmark points

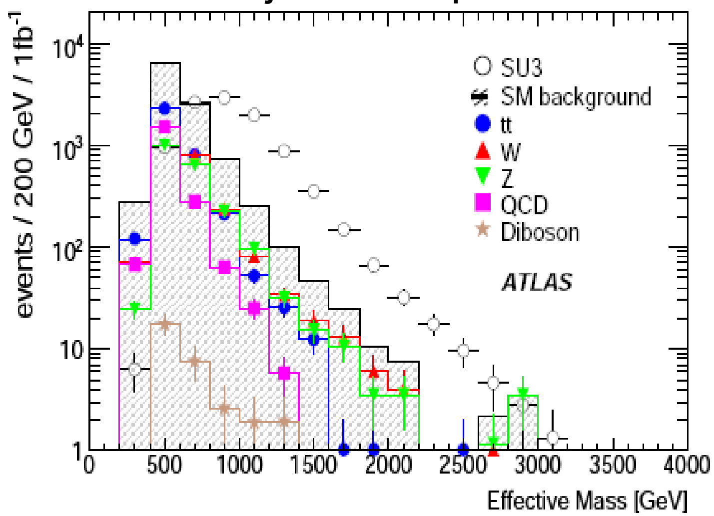


With harder M_{eff} cut even SU2 within reach

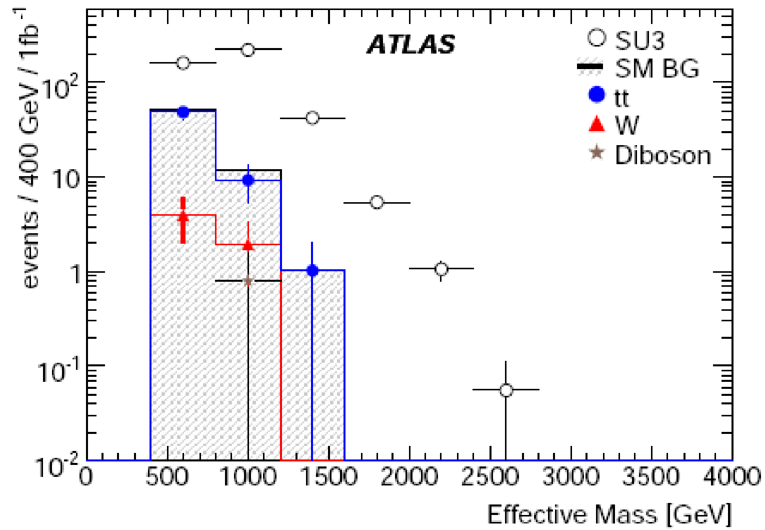
(given relative background uncertainties do not increase)

Examples for other Modes

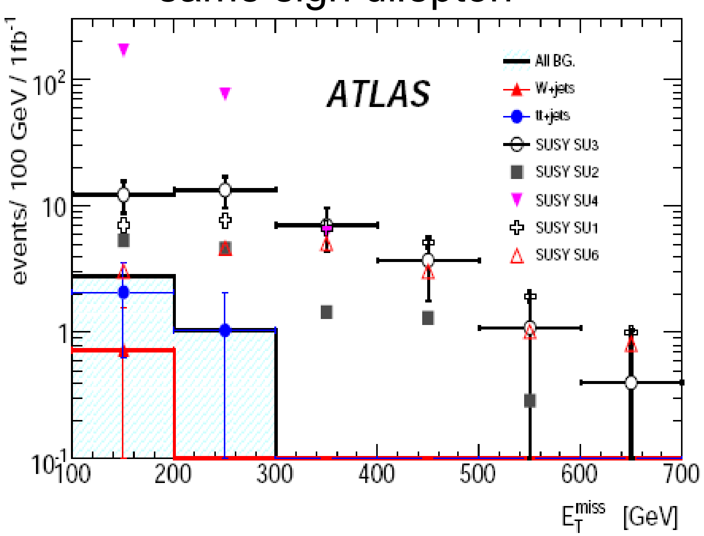
two jet zero lepton



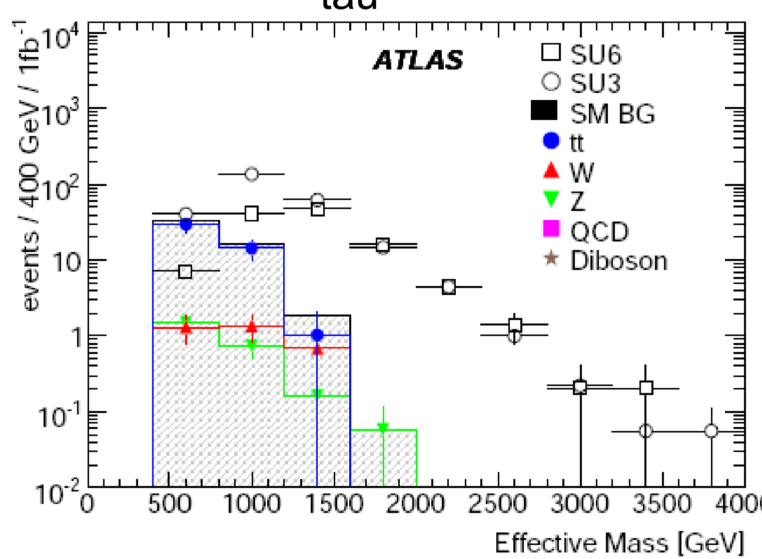
one lepton two jets



same sign dilepton



tau

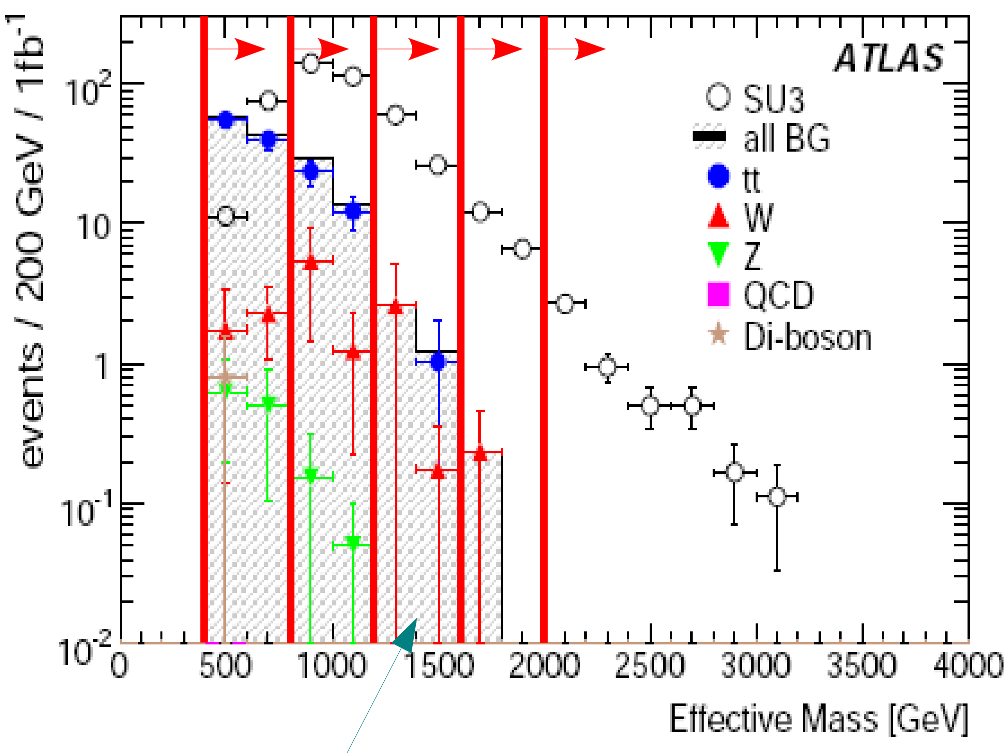


Detailed studies cover a wide range of different possible signal topologies

Scans in SUSY Parameter Space

Scan a subset of the parameter space for different SUSY models

- generate events for various points in the parameter space
- apply cuts from detailed studies to each signal point
- scan M_{eff} distribution for greatest deviation from SM



Meff scan step size 400 GeV

finding the optimal M_{eff} cut

- calculate probability p to find D data events if B SM events are expected
- choose region with lowest p
- correct p for multiple testing via a Monte Carlo method
- calculate significance

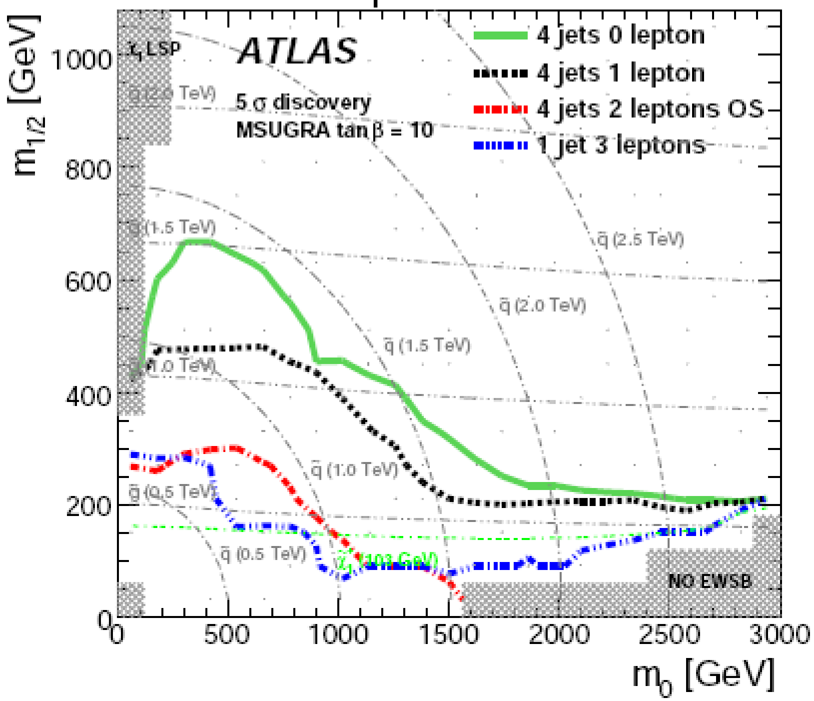
Discovery Reach for mSUGRA

leading order cross sections

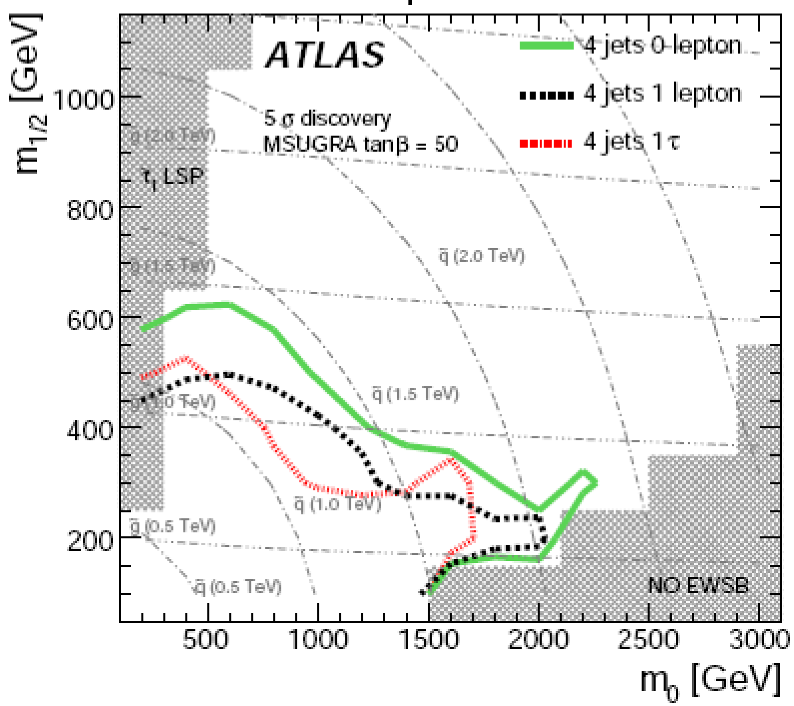
events reconstructed with fast detector simulation (ATLFAST1)

uncertainties on background: 50% (QCD), 20% (other)

tan β = 10



tan β = 50



4 jet 0 lepton is most promising mode

1 lepton mode less sensitive to QCD background

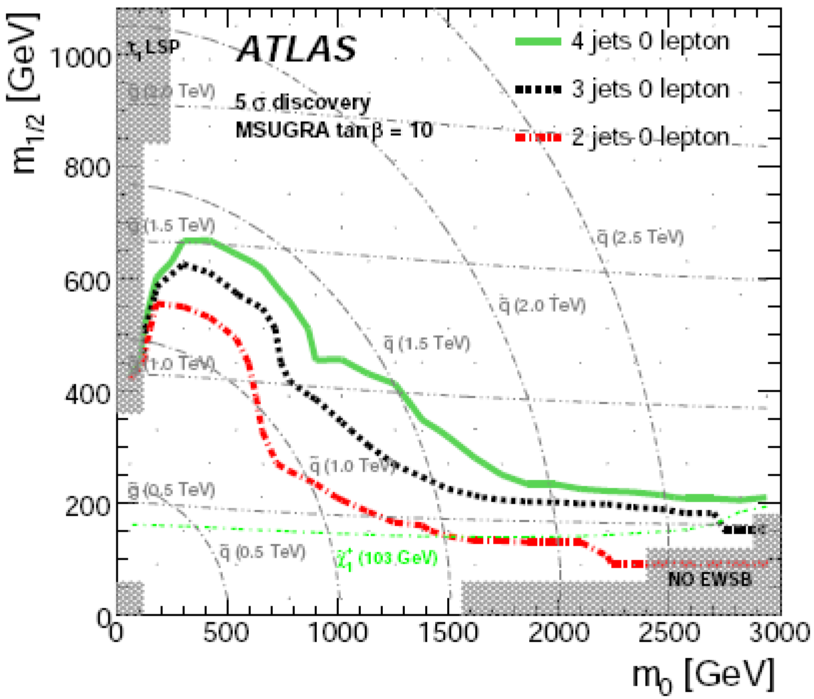
tau mode may help for large tan β

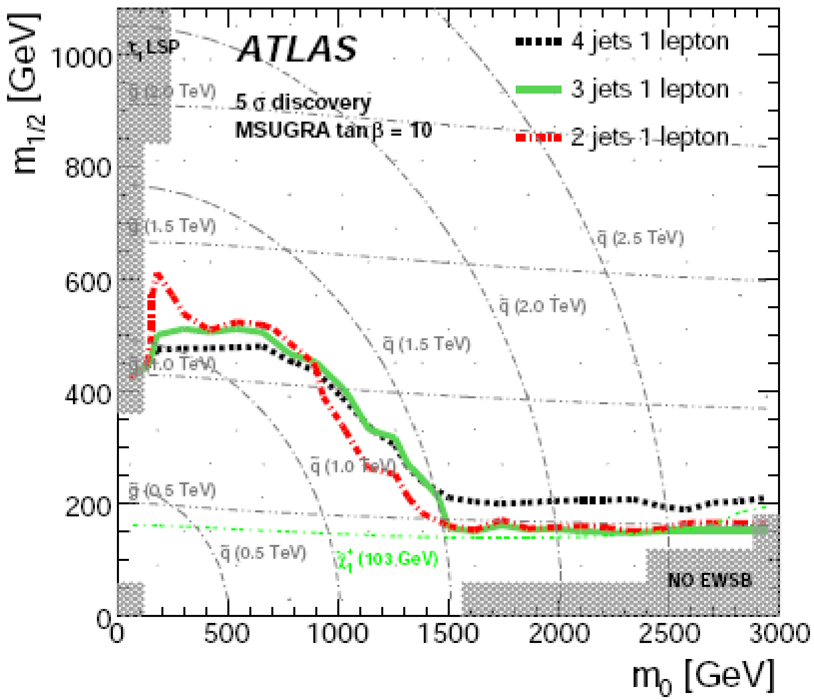
Discovery Reach for mSUGRA

Comparison of different jet multiplicities in

zero lepton mode

one lepton mode



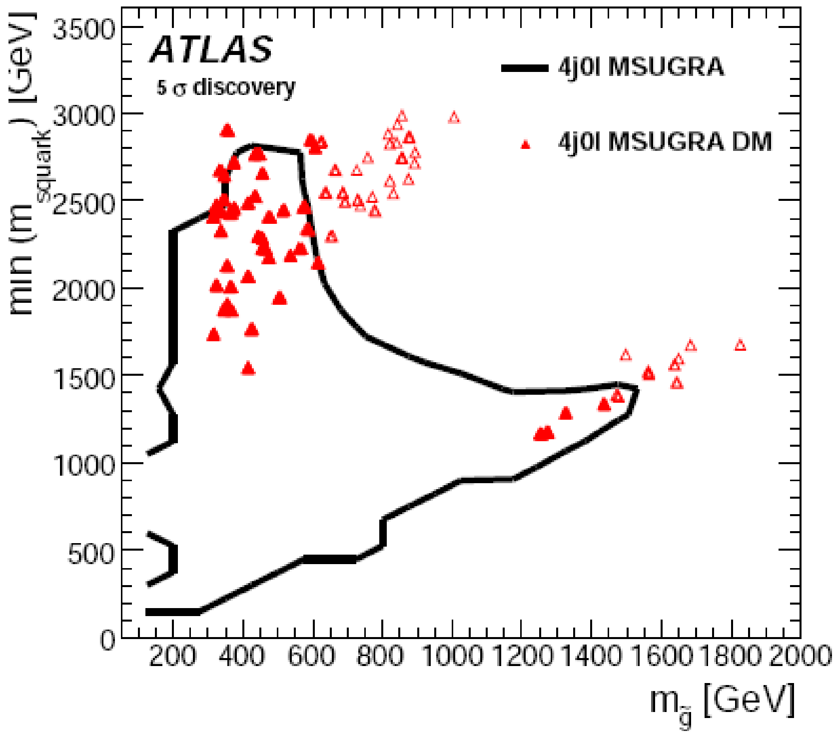


4 jet mode performs best

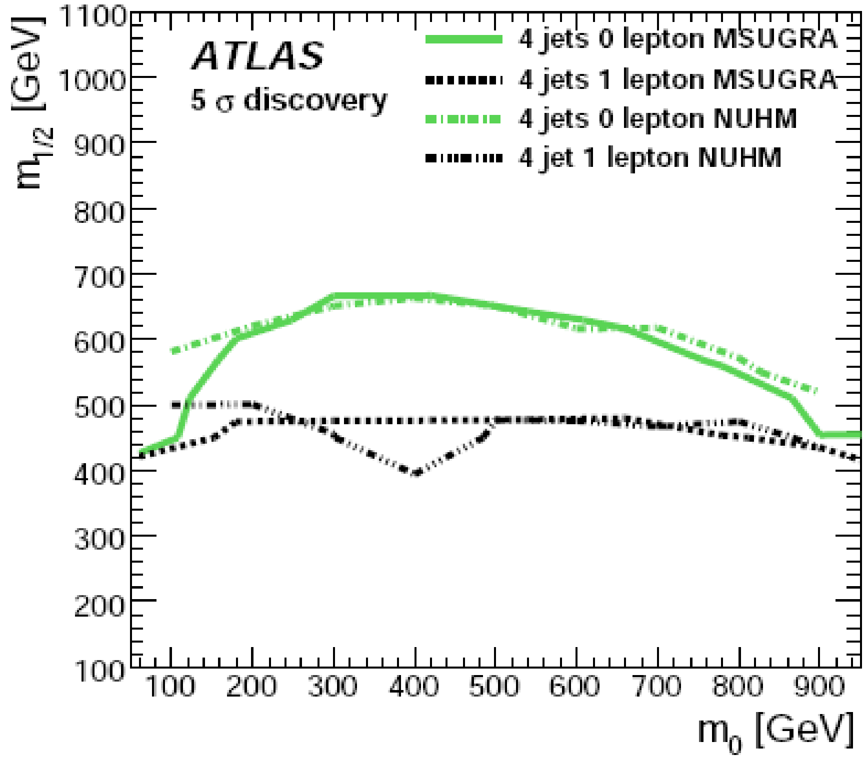
different jet multiplicities compatible

Discovery Reach for Other Models

mSUGRA with DM constraints



Non Universal Higgs Mass Model



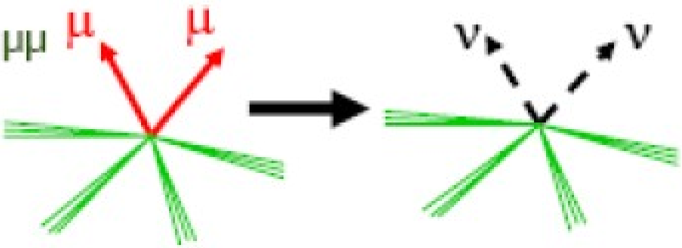
Discovery reach similar to the one for mSUGRA

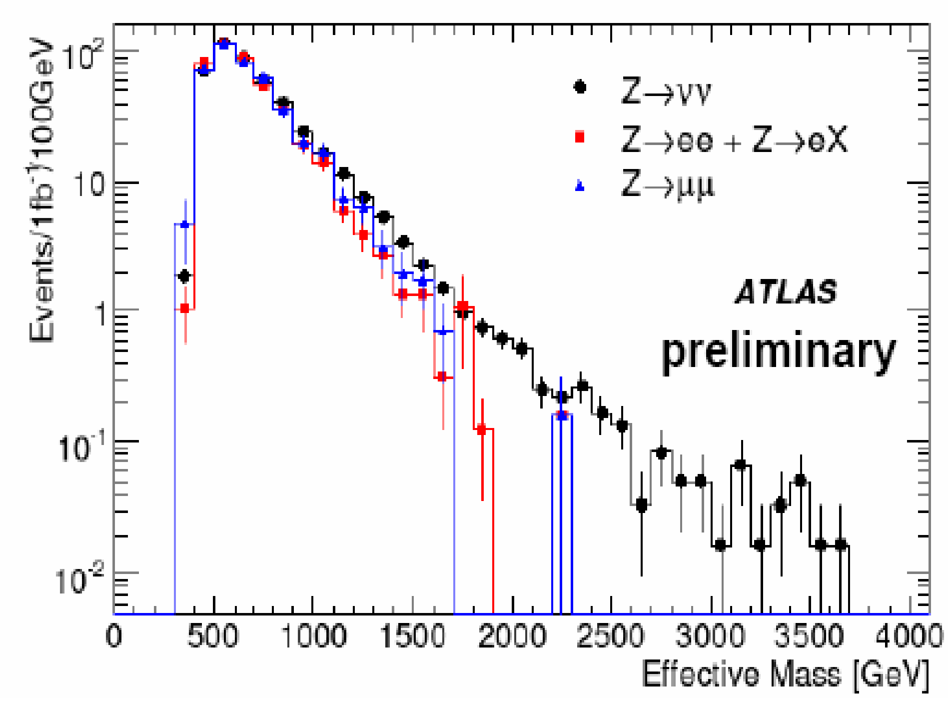
Background Estimation

Example: estimation of Z background

$Z \rightarrow \nu\nu$ + jets irreducible background for SUSY searches in 0 lepton channel

idea:
estimation from $Z \rightarrow l^+l^-$ + jets





estimation works well
within ~20% uncertainty for 1fb^{-1}

Reach at Different Center of Mass Energies

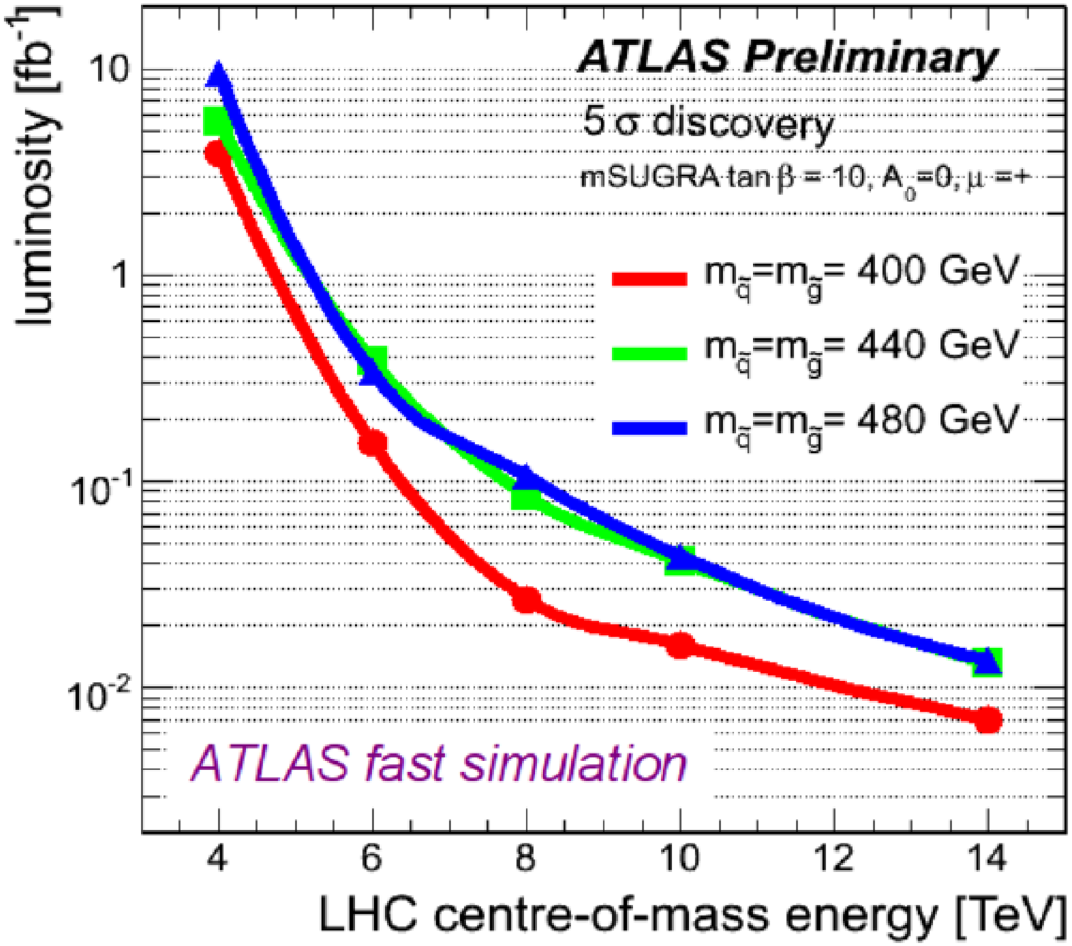
Disclaimer

- studies done for LHC Chamonix meeting 2009
- intended to serve as rapid turn-around information for LHC operating strategy
- using simpler techniques and approximations than usual for ATLAS results

- mSUGRA model with equal mass squarks and gluinos
- events generated for 6 different center of mass energies
- events reconstructed with fast detector simulation (ATLFAST1)
- 100% systematic error on background
- lepton+jets+E_T^{miss} channel (better understood in early data)

Reach at Different Center of Mass Energies

5σ discovery reach for three masses beyond Tevatron limit



new ATLAS benchmark:
200 pb^{-1} @ 10 TeV

Tevatron limit in this model: ~400 GeV

three investigated masses above Tevatron limit accessibly with ~50 pb^{-1}

Summary & Conclusion

- Detailed studies were developed on different signal benchmark points
- Scans over parameter space for different SUSY models show promising discovery reach
- First studies for 10 TeV show discovery potential well beyond the Tevatron limit even for early data

- Monte Carlo studies are currently redone for 10 TeV
  - wider range of signal models
  - better background (error) estimation from data

We are looking forward to an exciting period of first data taking

Backup

SUSY Benchmark Points

SU1 $m_0 = 70$ GeV, $m_{1/2} = 350$ GeV, $A_0 = 0$, $\tan\beta = 10$, $\mu > 0$. Coannihilation region where $\tilde{\chi}_1^0$ annihilate with near-degenerate $\tilde{\ell}$.

SU2 $m_0 = 3550$ GeV, $m_{1/2} = 300$ GeV, $A_0 = 0$, $\tan\beta = 10$, $\mu > 0$. Focus point region near the boundary where $\mu^2 < 0$. This is the only region in mSUGRA where the $\tilde{\chi}_1^0$ has a high higgsino component, thereby enhancing the annihilation cross-section for processes such as $\tilde{\chi}_1^0\tilde{\chi}_1^0 \to WW$.

SU3 $m_0 = 100$ GeV, $m_{1/2} = 300$ GeV, $A_0 = -300$ GeV, $\tan\beta = 6$, $\mu > 0$. Bulk region: LSP annihilation happens through the exchange of light sleptons.

SU4 $m_0 = 200$ GeV, $m_{1/2} = 160$ GeV, $A_0 = -400$ GeV, $\tan\beta = 10$, $\mu > 0$. Low mass point close to Tevatron bound.

SU6 $m_0 = 320$ GeV, $m_{1/2} = 375$ GeV, $A_0 = 0$, $\tan\beta = 50$, $\mu > 0$. The funnel region where $2m_{\tilde{\chi}_1^0} \approx m_A$. Since $\tan\beta \gg 1$, the width of the pseudoscalar Higgs boson A is large and τ decays dominate.

SU8.1 $m_0 = 210$ GeV, $m_{1/2} = 360$ GeV, $A_0 = 0$, $\tan\beta = 40$, $\mu > 0$. Variant of coannihilation region with $\tan\beta \gg 1$, so that only $m_{\tilde{\tau}_1} - m_{\tilde{\chi}_1^0}$ is small.

SU9 $m_0 = 300$ GeV, $m_{1/2} = 425$ GeV, $A_0 = 20$, $\tan\beta = 20$, $\mu > 0$. Point in the bulk region with enhanced Higgs production