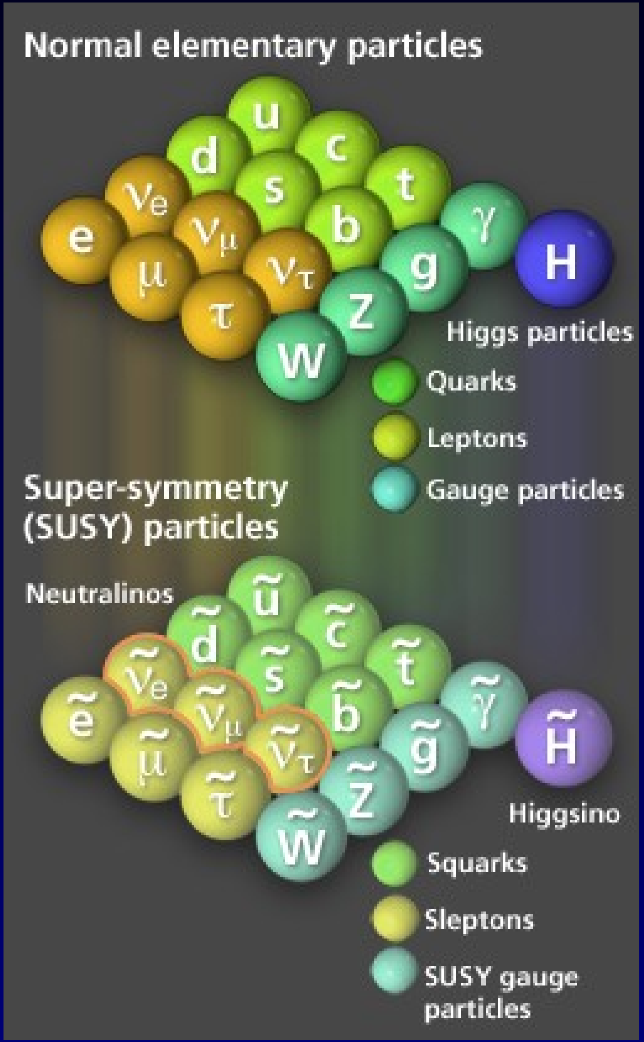
# ATLAS searches for supersymmetry in Jets+MET channels



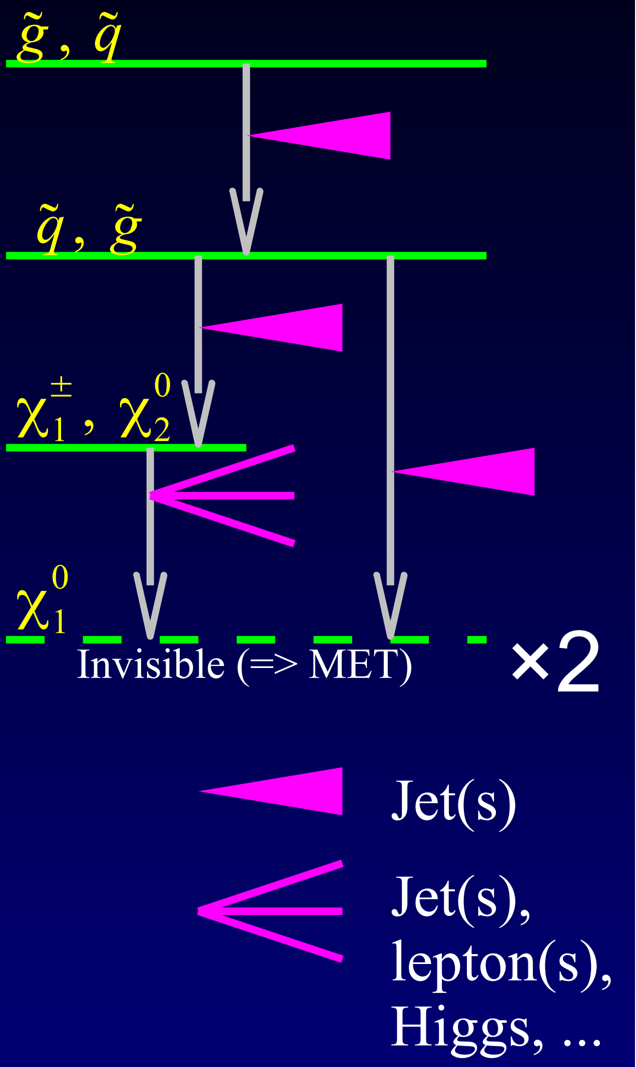

Michael Flowerdew (MPP Munich)
On behalf of the ATLAS Collaboration

# *Outline*

- Supersymmetry and ATLAS searches
- The ATLAS detector in 2010
- SUSY analyses, the 0-lepton channels
- Signal selection, statistical methods
- Background estimation
- Results
- Interpretation
- Summary and outlook

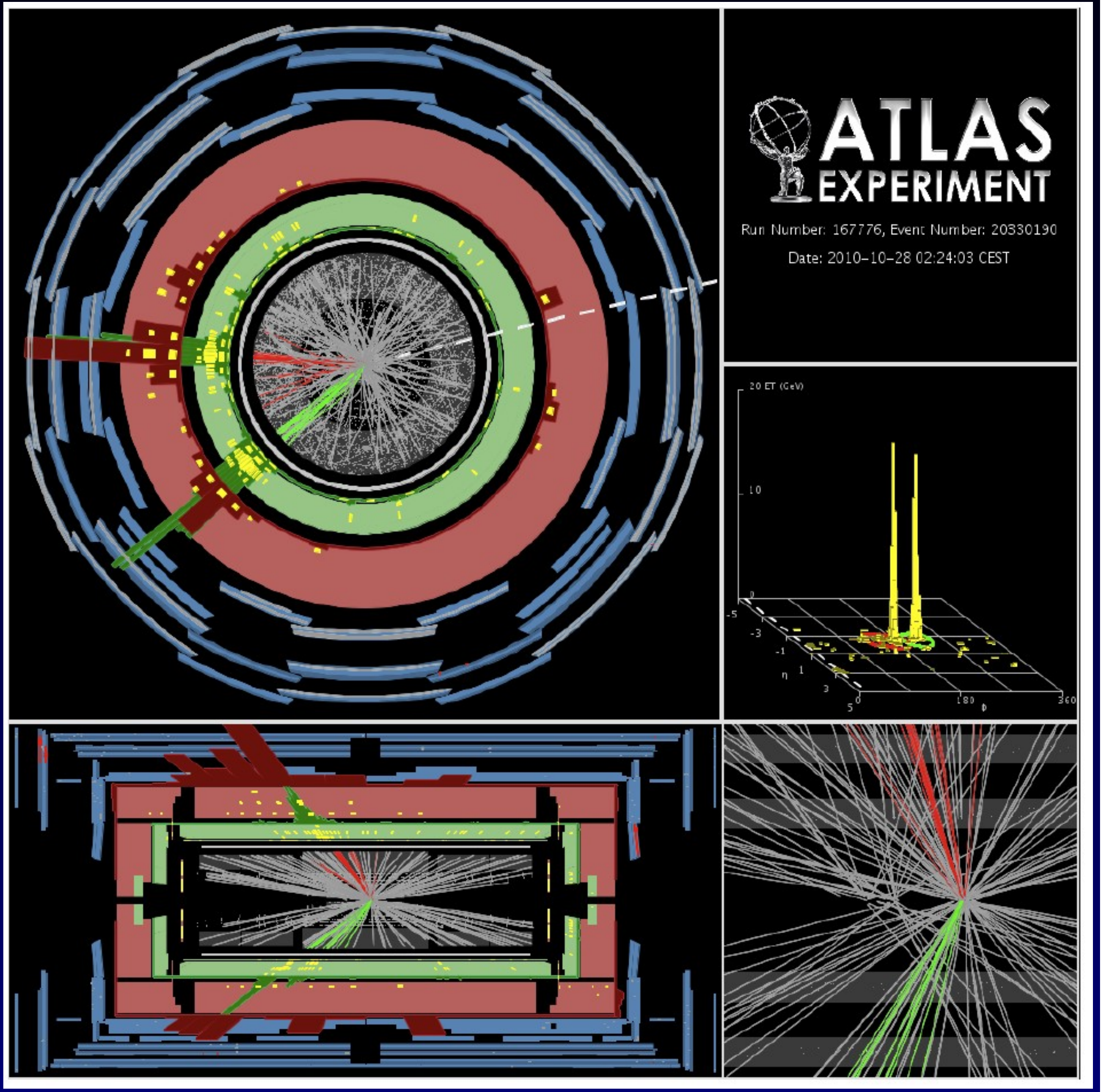
# Supersymmetry

- Extension to Standard Model, solving many problems
  - Higgs mass stability/fine tuning
  - Gauge coupling unification
  - Dark matter candidate
- R-parity conservation:
  - Sparticles created in pairs
  - Lightest Supersymmetric Particle (LSP) is stable and non-interacting
- Typical signature in a hadron collider:
  - High $p_T$ jets
  - Missing $E_T$ (MET)
  - Leptons, depending on mass hierarchy
- Parameters unknown => **model-independent**, **inclusive** searches

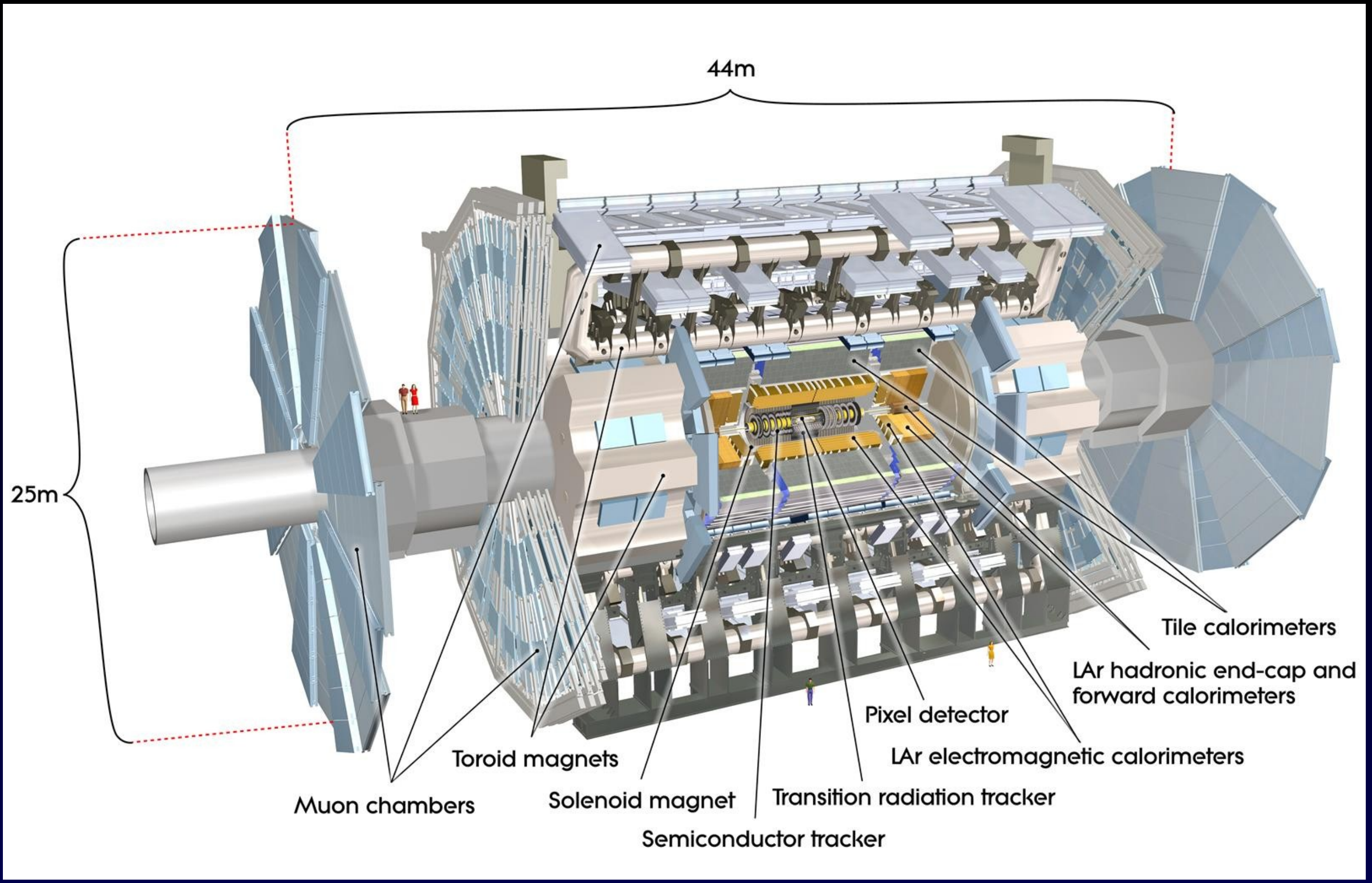


# SUSY searches in ATLAS

- A collection of related "Missing $E_T$-based" analyses performed on data in 2010
  - Jets + MET + lepton veto
  - 1 lepton + jets + MET
  - 2 leptons (OS/SS) + MET
  - 2 leptons (Flavour subtraction) + MET
  - 3+ leptons + jets + MET
- Plus more exclusive final states
  - MET + b-jet, τ, γ, …
  - RPV scenarios
  - (Quasi-)stable long-lived signatures



# *The ATLAS detector*

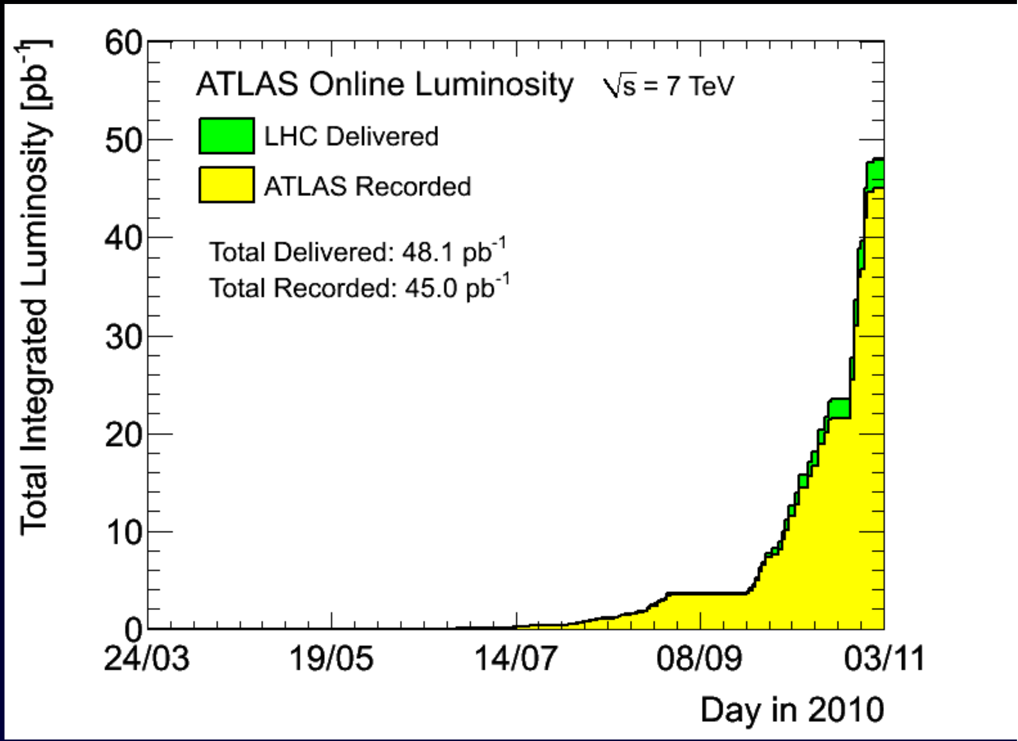



- **Inner detector**: charged particle tracks and vertices, 2T solenoidal magnetic field
- **Liquid argon and Tile calorimeters:** electromagnetic and hadronic showers
- **Muon spectrometer:** muon tracks, toroidal magnetic field

- The largest LHC detector
- Commissioned using test beams and cosmic runs until 2009
- p-p measurements at $\sqrt{s}$ = 1.8, 2.36 and 7 TeV, and Pb-Pb at $\sqrt{s_{NN}}$ = 2.76 TeV

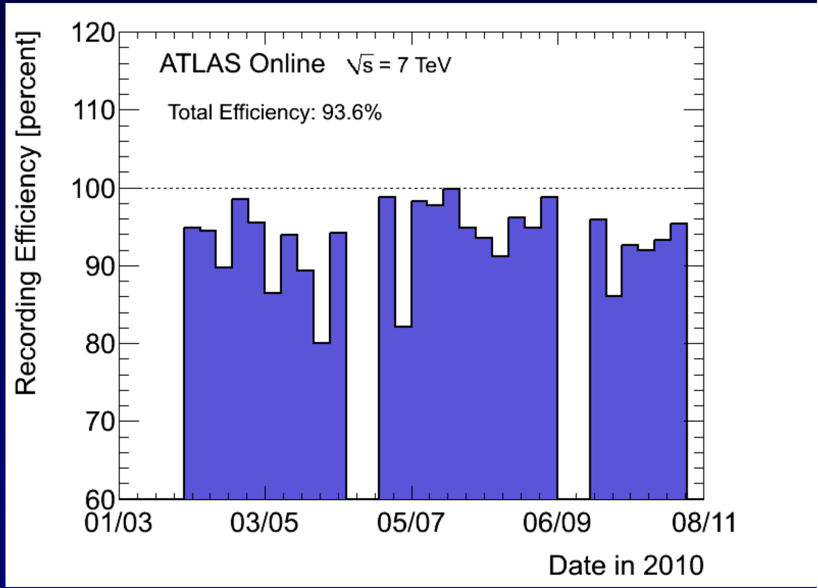
# ATLAS 2010 data collection

- About 45 $pb^{-1}$ recorded pp collisions (48 $pb^{-1}$ delivered)
- High operating efficiency
  - Trigger/DAQ efficiency: 93.6%
  - Subdetector efficiency: >90%




| Inner Tracking Detectors | | | Calorimeters | | | | Muon Detectors | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pixel | SCT | TRT | LAr EM | LAr HAD | LAr FWD | Tile | MDT | RPC | CSC | TGC |
| 99.1 | 99.9 | 100 | 90.7 | 96.6 | 97.8 | 100 | 99.9 | 99.8 | 96.2 | 99.8 |

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams in pp collisions at √s=7 TeV between March 30th and October 31st (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future.



# Jets + MET channels

- Possibility of direct squark/gluino decay to LSP gives pure jets + MET signature
  - Rejection power for complex cascades too
    - Non-leptonic cascades, lepton out of acceptance, ...

"Jets+MET"
arXiv:1102.5290

- Potentially large stop/sbottom mass splitting motivates search involving b-jets
  - Strong mixing between L and R states ~ $m_f$
  - Direct production or $\tilde{g} \rightarrow \tilde{b}_1 b / \tilde{t}_1 t$

"b-jets+MET"
arXiv:1103.4344

- Lepton veto ensures orthogonality with other searches
  - Leptons + MET: 10.10 am today
  - Leptons/γ* + jets + MET: 11.40 am today
- However, jets+MET analysis does **not** veto b-jets

# SUSY object selection

Luminosity (good data quality): 35 $pb^{-1}$

Trigger: $\varepsilon > 97\%$ in signal region
Vertex: > 4 tracks

Jet selection:
AntiKt jets, R=0.4
MC-based calibration
$p_T > 20$ GeV
$|\eta| < 2.5$

b-jets:
$p_T > 30$ GeV
Displaced vertex
$L > 5.72\sigma(L)$
$\varepsilon_{tag} = 50\%$ (b),
1% (u,d,s,g)

Electron selection:
$p_T > 10/20$ GeV
$|\eta| < 2.47$

Muon selection:
$p_T > 10/20$ GeV
$|\eta| < 2.4$
$\Sigma p_T$ ($\Delta R < 0.2$) < 1.8 GeV

MET:
MET = "Simplified" calo MET (+ specific e/μ corrections)

Overlap removal:
Jets with $\Delta R < 0.2$ from electron removed
Electrons/muons with $\Delta R < 0.4$ from jet removed

Event veto:
"Bad" jet quality ($p_T^{jet} > 20$ GeV)
Reconstructed electron or muon

Yellow: differences for b-jet analysis

NB: $\eta = -\ln\left(\tan\left(\frac{\theta}{2}\right)\right)$, $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$

# Signal regions

Jets+MET:

| | | A | B | C | D |
|---|---|---|---|---|---|
| Pre-selection | Number of required jets | $\geq 2$ | $\geq 2$ | $\geq 3$ | $\geq 3$ |
| | Leading jet $p_{\mathrm{T}}$ [GeV] | $> 120$ | $> 120$ | $> 120$ | $> 120$ |
| | Other jet(s) $p_{\mathrm{T}}$ [GeV] | $> 40$ | $> 40$ | $> 40$ | $> 40$ |
| | $E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV] | $> 100$ | $> 100$ | $> 100$ | $> 100$ |
| Final selection | $\Delta\phi(\text{jet}, \vec{P}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$ | $> 0.4$ | $> 0.4$ | $> 0.4$ | $> 0.4$ |
| | $E_{\mathrm{T}}^{\mathrm{miss}}/M_{\mathrm{eff}}$ | $> 0.3$ | – | $> 0.25$ | $> 0.25$ |
| | $M_{\mathrm{eff}}$ [GeV] | $> 500$ | – | $> 500$ | $> 1000$ |
| | $m_{\mathrm{T2}}$ [GeV] | – | $> 300$ | – | – |
| | Target signature: | $\tilde{q}\tilde{q}$ | $\tilde{q}\tilde{q}$ | $\tilde{g}\tilde{g}$ | $\tilde{g}\tilde{q}$ |

b-jets+MET:

$\geq 3$ jets ($\geq 1$ $b$-tagged)

$p_{\mathrm{T}}^{\mathrm{jet}} > 120, 30, 30$ GeV

$E_{\mathrm{T}}^{\mathrm{miss}} > 100$ GeV

$\Delta\phi(\text{jet}, \vec{P}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}} > 0.4$

$E_{\mathrm{T}}^{\mathrm{miss}}/M_{\mathrm{eff}} > 0.2$

$M_{\mathrm{eff}} > 600$ GeV

Target signature:

$\tilde{g} \to \tilde{b}_1 b$ or $b\bar{b}\tilde{\chi}_1^0$

$$m_{\mathrm{T2}}\left(\mathbf{p}_{\mathrm{T}}^{(1)}, \mathbf{p}_{\mathrm{T}}^{(2)}, \not{\mathbf{p}}_{\mathrm{T}}\right) \equiv \min_{\not{\mathbf{q}}_{\mathrm{T}}^{(1)}+\not{\mathbf{q}}_{\mathrm{T}}^{(2)}=\vec{E}_{\mathrm{T}}^{\mathrm{miss}}} \left\{\max\left(m_{\mathrm{T}}\left(\mathbf{p}_{\mathrm{T}}^{(1)}, \not{\mathbf{q}}_{\mathrm{T}}^{(1)}\right), m_{\mathrm{T}}\left(\mathbf{p}_{\mathrm{T}}^{(2)}, \not{\mathbf{q}}_{\mathrm{T}}^{(2)}\right)\right)\right\}$$

$$M_{\mathrm{eff}} = \sum_{jets} p_{\mathrm{T}}^{i} + E_{\mathrm{T}}^{\mathrm{miss}}$$

$m_{\mathrm{T2}}$ sensitive to $\tilde{q} + \bar{\tilde{q}} \to q + \bar{q} + 2\tilde{\chi}_1^0$

# Profile likelihood method

- Sensitivity limits set using a profile likelihood method

$$L(\, n \mid s, b, \theta \,) = P_{\mathrm{S}} \times C_{\mathrm{syst}}$$

- $n$: # observed data events
- $s$, $b$: Signal/background hypothesis
- $\theta$: Systematic uncertainties
- $P_{\mathrm{S}}$: Poisson prob. for events in signal region
- $C_{\mathrm{syst}}$: Systematic uncertainty constraints (correlated Gaussian nuisance parameters)

- Test statistic $\Lambda(s)$:

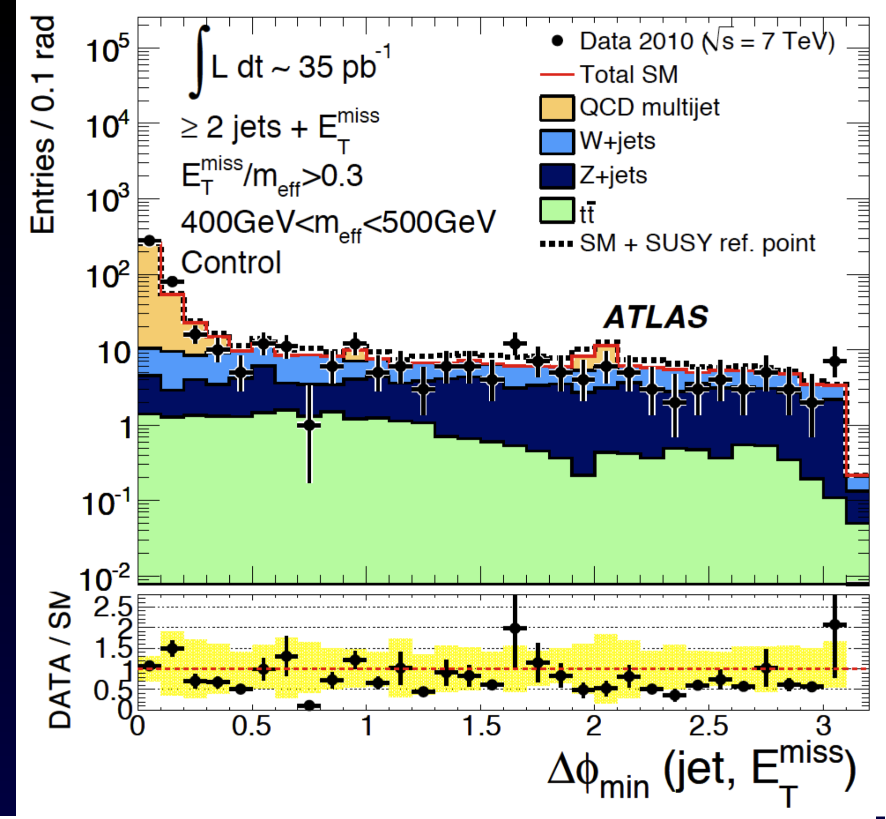
$$\Lambda(s) = -2\left[\ln L(n \mid s, \hat{\hat{b}}, \hat{\hat{\theta}}) - \ln L(n \mid \hat{s}, \hat{b}, \hat{\theta})\right]$$

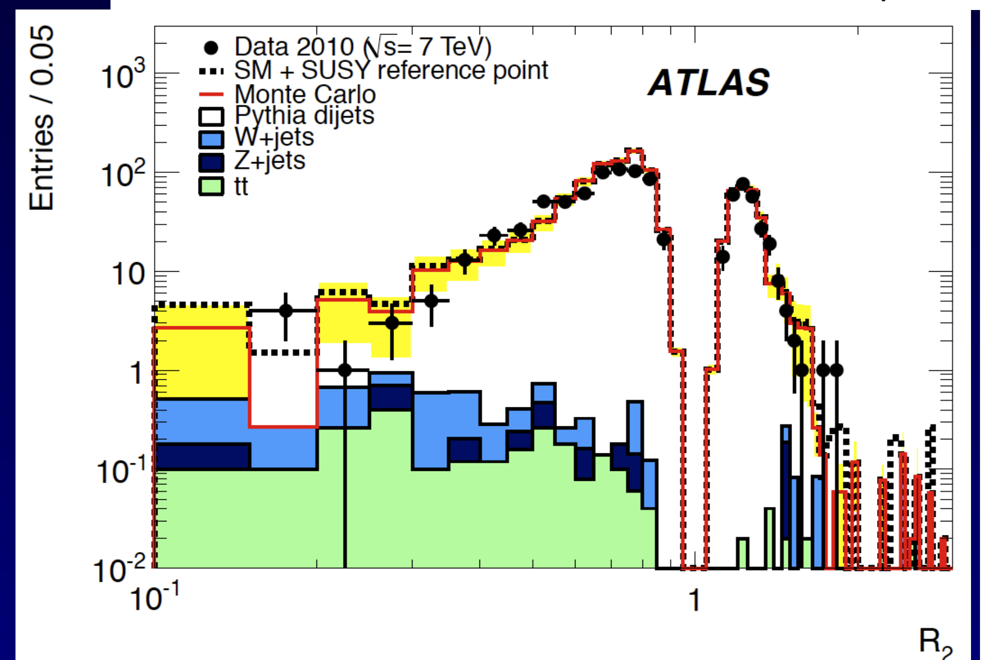
- $\ln L(n \mid s, \hat{\hat{b}}, \hat{\hat{\theta}})$: Maximal -ln($L$) for given $s$
- $\ln L(n \mid \hat{s}, \hat{b}, \hat{\theta})$: Maximal -ln($L$) $(\hat{s} \geqslant 0)$

- $p$-values determined using pseudoexperiments

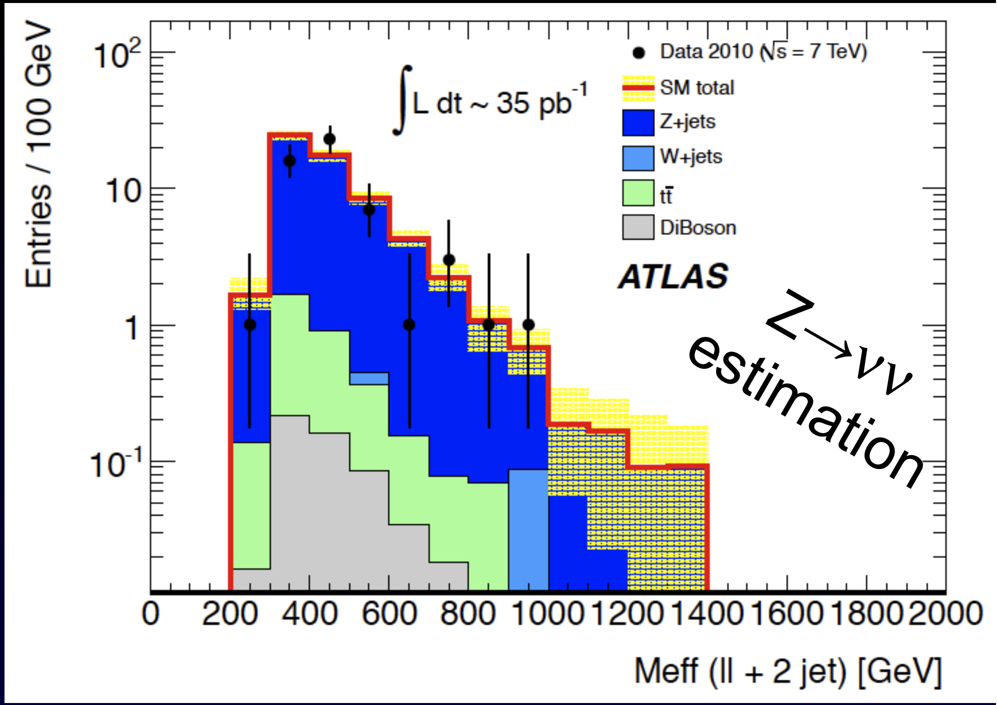
# QCD background estimation (including heavy flavour b/c production)

- Fake MET includes misreconstruction and b/c → νX
  - MET associated with a jet
- Monte Carlo prediction normalised using Δϕ< 0.4 control region
  - Large MC statistical uncertainties
  - ± ~100% stat. + syst.
  - Alternative: MET/$M_{eff}$ cut inverted
- Data driven approach:
  - Gaussian and non-Gaussian jet response measured from low MET control sample
  - Events with low MET smeared by combined resolution function

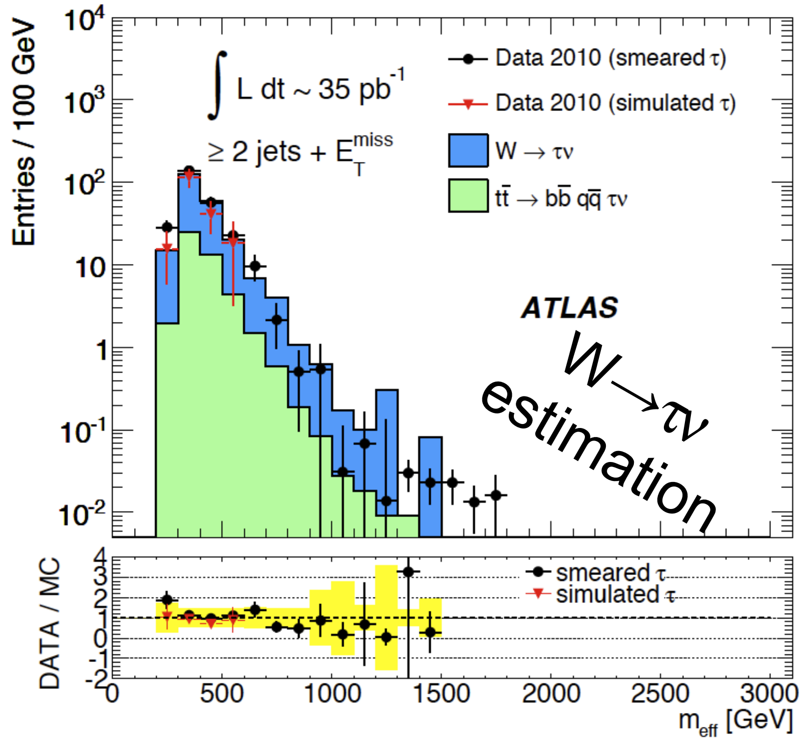


# *W, Z, top background*



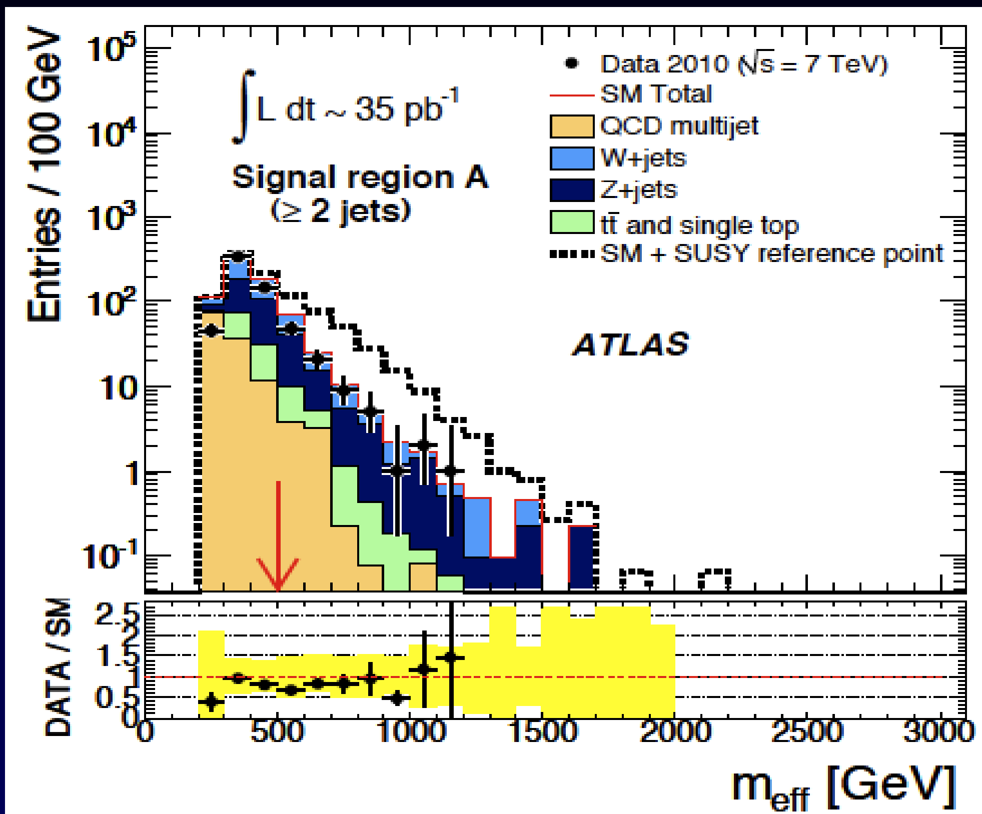

- Non-QCD background contributions:
  - Z(→νν) + jets
  - W+jets or ttbar with τ (→hadrons) or misidentified e,μ




- Data-driven methods:
  - Remove leptons from Z→ll, W→lν (=> Z→νν and lost leptons)
  - Tau "replacement" from W→μ ν seed events
- Statistical limitations => Use MC predictions
  - ALPGEN (W,Z)
    - NNLO normalisation (±5%)
  - MC@NLO (ttbar)
    - NLO+NLL normalisation (+6.5%-9.5%)
  - Uncertainty from control region checks

Jets+MET

# Jets+MET results




Example mSUGRA point:
$m_0 = 200$ GeV
$m_{1/2} = 190$ GeV
$A_0 = 0,\ \tan\beta = 3,\ \mu > 0$

$\sigma_{fid} = \sigma \times \varepsilon \times A$

- Main systematic uncertainties:
  - Uncorrelated background uncertainties [u]
  - Jet energy scale [j]
  - Luminosity [L]

Model-independent limits:

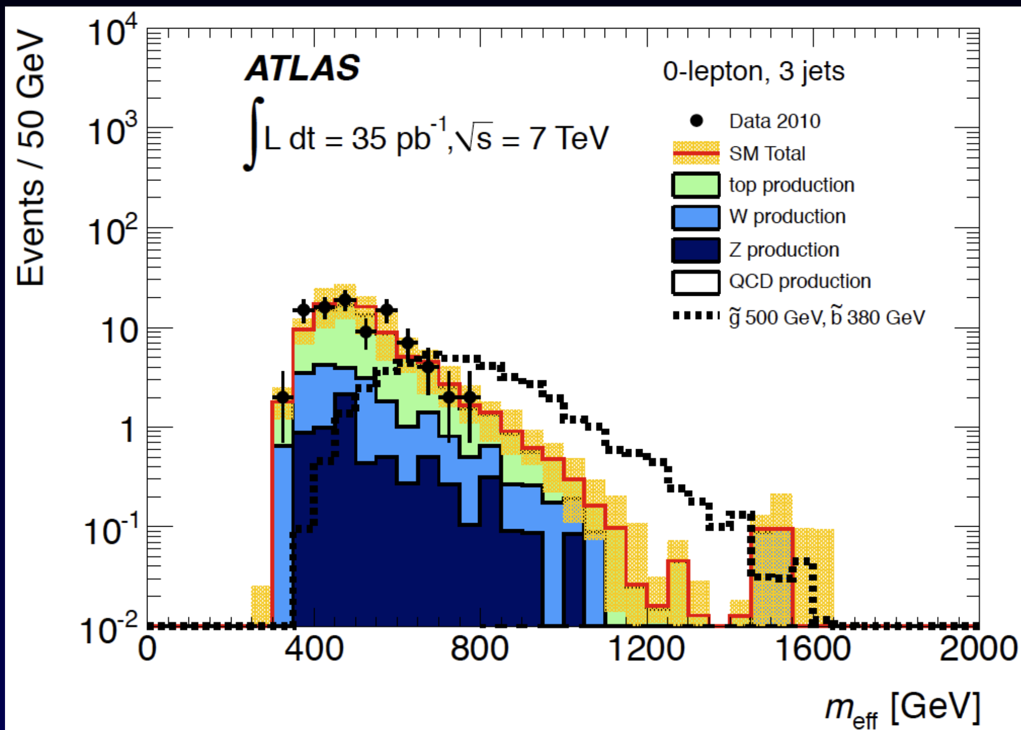
A: $\sigma_{fid} < 1.3$ pb
B: $\sigma_{fid} < 0.35$ pb
C: $\sigma_{fid} < 1.1$ pb
D: $\sigma_{fid} < 0.11$ pb

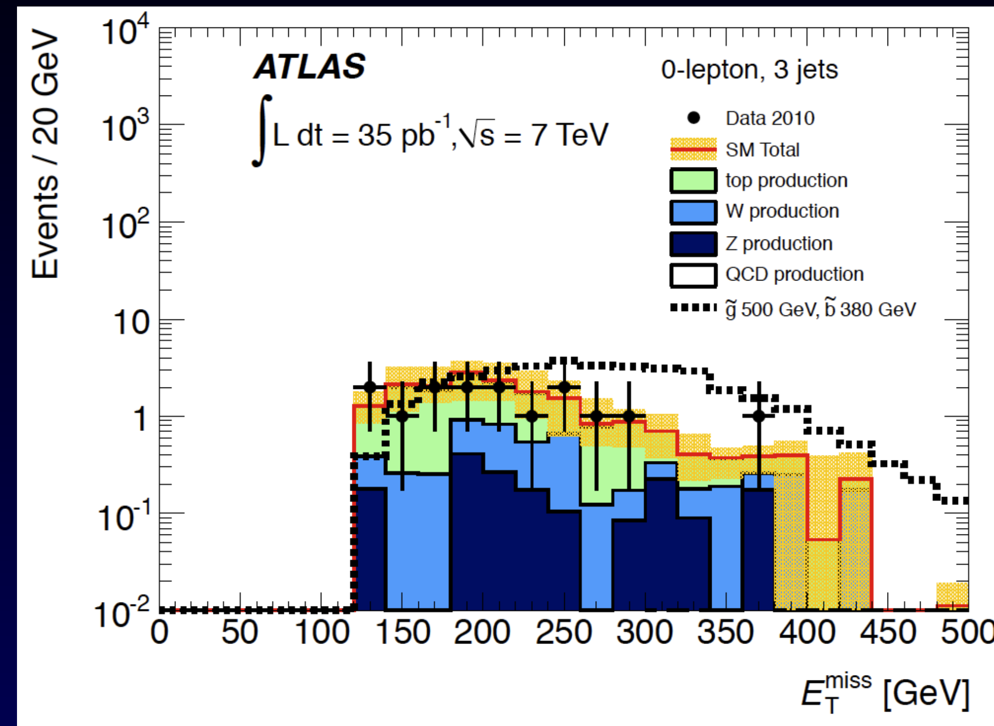
| | Signal region A | Signal region B | Signal region C | Signal region D |
|---|---|---|---|---|
| QCD | $7\ ^{+8}_{-7}[u]$ | $0.6\ ^{+0.7}_{-0.6}[u]$ | $9\ ^{+10}_{-9}[u]$ | $0.2\ ^{+0.4}_{-0.2}[u]$ |
| $W$+jets | $50 \pm 11[u]\ ^{+14}_{-10}[j] \pm 5[\mathcal{L}]$ | $4.4 \pm 3.2[u]\ ^{+1.5}_{-0.8}[j] \pm 0.5[\mathcal{L}]$ | $35 \pm 9[u]\ ^{+10}_{-8}[j] \pm 4[\mathcal{L}]$ | $1.1 \pm 0.7[u]\ ^{+0.2}_{-0.3}[j] \pm 0.1[\mathcal{L}]$ |
| $Z$+jets | $52 \pm 21[u]\ ^{+15}_{-11}[j] \pm 6[\mathcal{L}]$ | $4.1 \pm 2.9[u]\ ^{+2.1}_{-0.8}[j] \pm 0.5[\mathcal{L}]$ | $27 \pm 12[u]\ ^{+10}_{-6}[j] \pm 3[\mathcal{L}]$ | $0.8 \pm 0.7[u]\ ^{+0.6}_{-0.0}[j] \pm 0.1[\mathcal{L}]$ |
| $t\bar{t}$ and $t$ | $10 \pm 0[u]\ ^{+3}_{-2}[j] \pm 1[\mathcal{L}]$ | $0.9 \pm 0.1[u]\ ^{+0.4}_{-0.3}[j] \pm 0.1[\mathcal{L}]$ | $17 \pm 1[u]\ ^{+6}_{-4}[j] \pm 2[\mathcal{L}]$ | $0.3 \pm 0.1[u]\ ^{+0.2}_{-0.1}[j] \pm 0.0[\mathcal{L}]$ |
| Total SM | $118 \pm 25[u]\ ^{+32}_{-23}[j] \pm 12[\mathcal{L}]$ | $10.0 \pm 4.3[u]\ ^{+4.0}_{-1.9}[j] \pm 1.0[\mathcal{L}]$ | $88 \pm 18[u]\ ^{+26}_{-18}[j] \pm 9[\mathcal{L}]$ | $2.5 \pm 1.0[u]\ ^{+1.0}_{-0.4}[j] \pm 0.2[\mathcal{L}]$ |
| Data | 87 | 11 | 66 | 2 |

# b-jets + MET results

b-jets+MET

Example SUSY point:
$m_{\tilde{b}_1} = 380$ GeV, $m_{\tilde{g}} = 500$ GeV



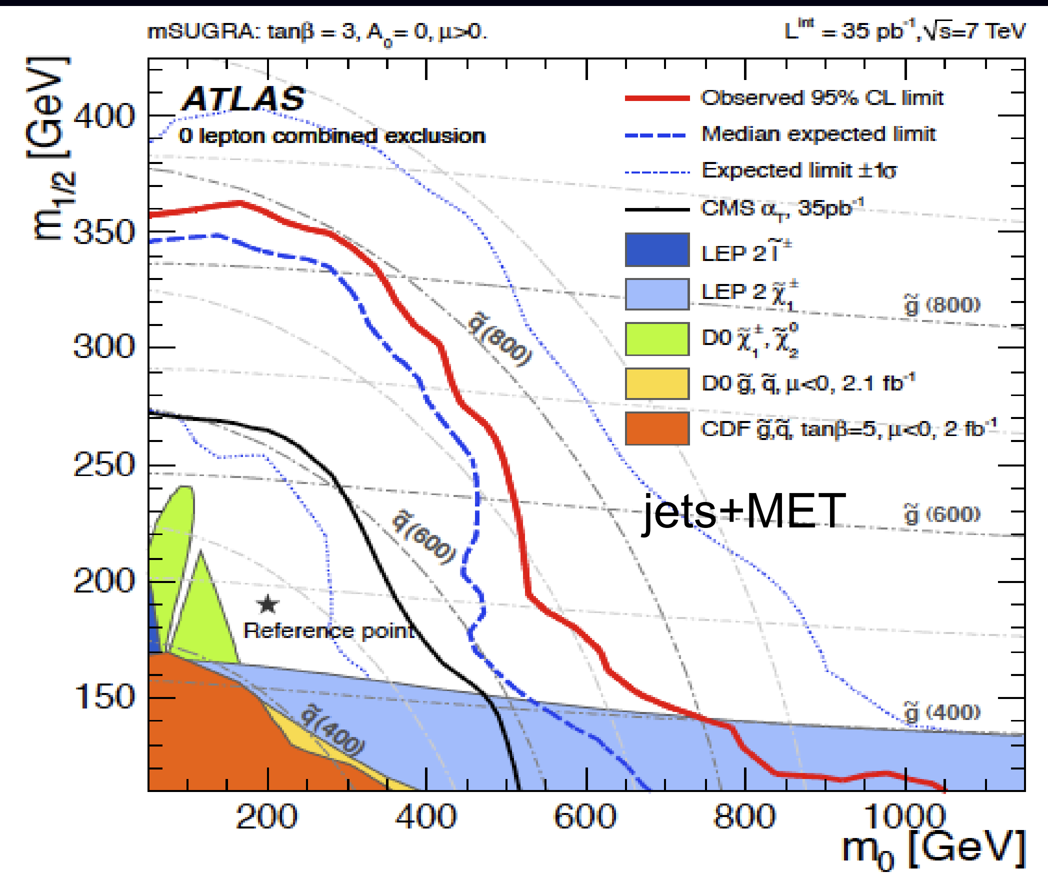




- Main systematic uncertainties:
  - Jet energy scale
  - b-tag efficiency
  - Theoretical uncertainty
  - Luminosity

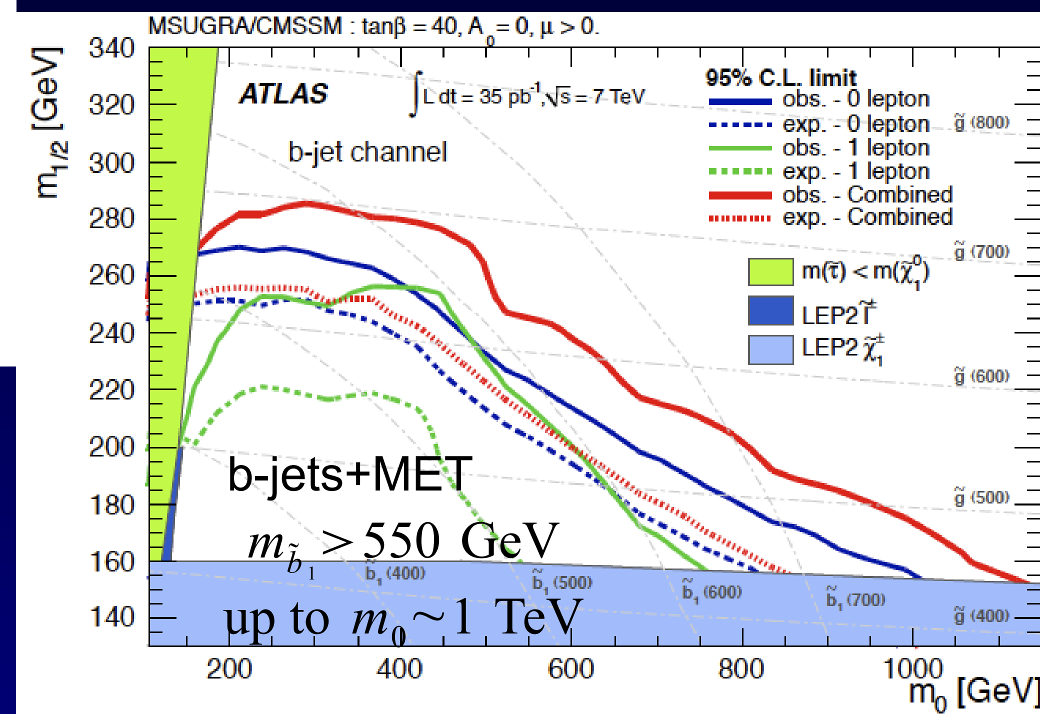
Model-independent limit:
$\sigma_{fid} < 0.32$ pb

| | 0-lepton |
|---|---|
| $t\bar{t}$ and single top | $12.2 \pm 5.0$ |
| W and Z | $6.0 \pm 2.0$ |
| QCD | $1.4 \pm 1.0$ |
| Total SM | $19.6 \pm 6.9$ |
| Data | 15 |

# Exclusion limits: mSUGRA/CMSSM




- Benchmark plane with tan β = 3 (jets+MET) or 40 (b-jets+MET), $A_0 = 0$, μ > 0 @ unification scale
- Useful for comparison with LEP, Tevatron and CMS

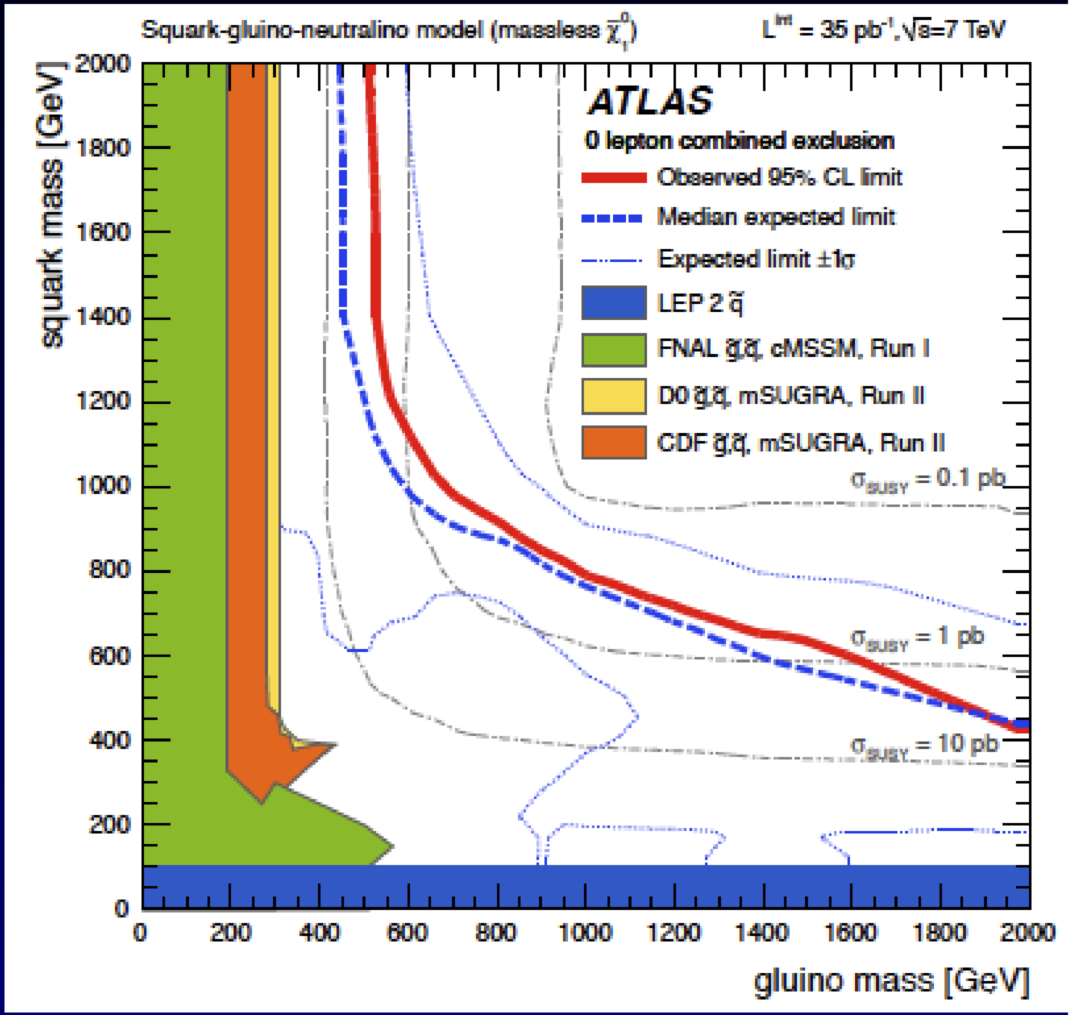



- Jets+MET: Combination of 4 signal regions – select one with best **expected** significance for each model point

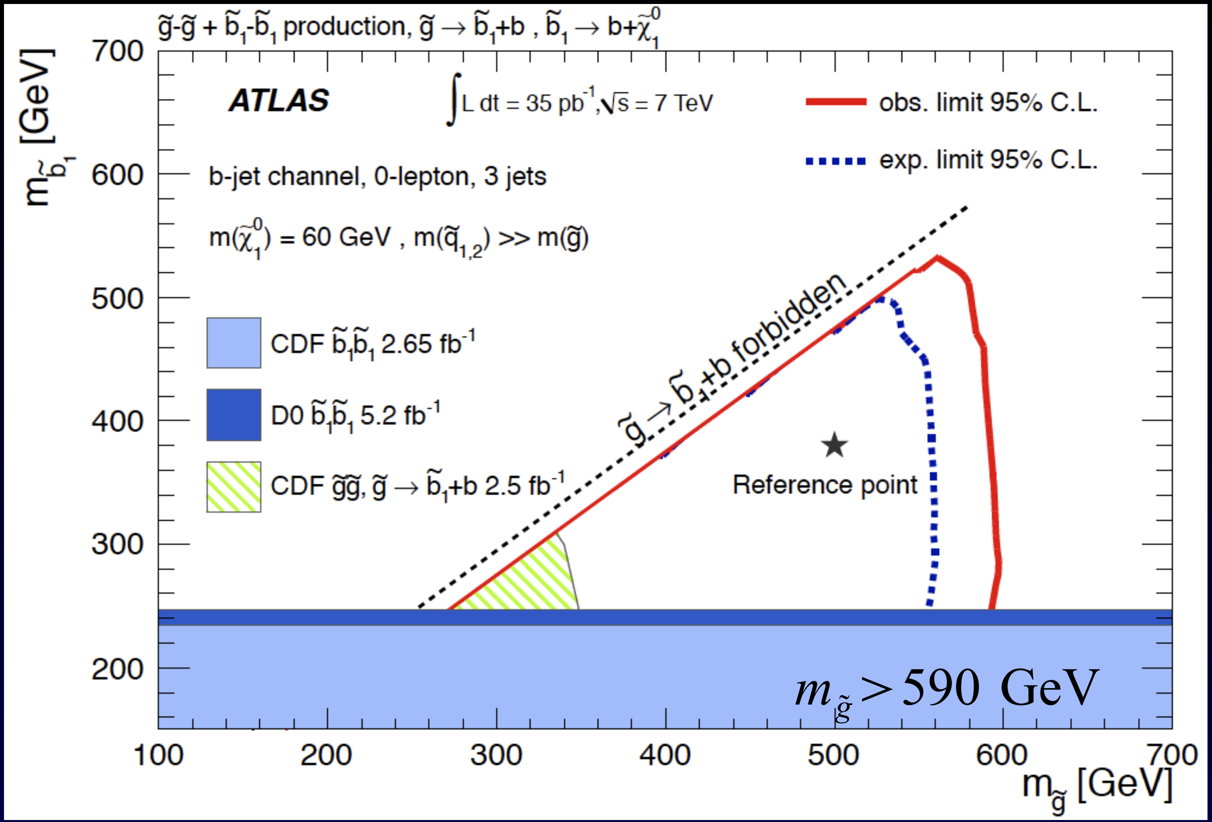
# Exclusion limits: squark/gluino plane

Jets+MET

- Used for more general, less assumption-heavy, limits
  - And analysis optimisation
- Equal masses for first and second generation squarks
- m(LSP) = 0, Bino couplings
- All other particles (except gluino) set to 5 TeV
- Gluino mass below 500 GeV excluded



# Limits: sbottom production




- Simple hierarchy for direct or gluino-mediated sbottom production:

$$m_{\tilde{g}} > m_{\tilde{b}_1} > m_{\tilde{\chi}_1^0}$$

$m_{\tilde{\chi}_1^0}$ assumed 60 GeV

$$\mathrm{BR}(\tilde{g} \to \tilde{b}_1 b) = 100\%$$

$$\mathrm{BR}(\tilde{b}_1 \to b \tilde{\chi}_1^0) = 100\%$$

- Optimisation model for b-jets+MET analysis
- Selection efficiency ~7-50%, dependent on $m_{\tilde{g}} - m_{\tilde{b}_1}$
- Some dependence of limit on LSP mass if $m_{\tilde{g}} - m_{\tilde{\chi}_1^0} < 250 - 300$ GeV
- Weak dependence on $m_{\tilde{q}_{1,2}}$
  - 20 GeV variation for $2m_{\tilde{g}} < m_{\tilde{q}_{1,2}} < 3$ TeV

b-jets+MET

# SO(10) GUT model

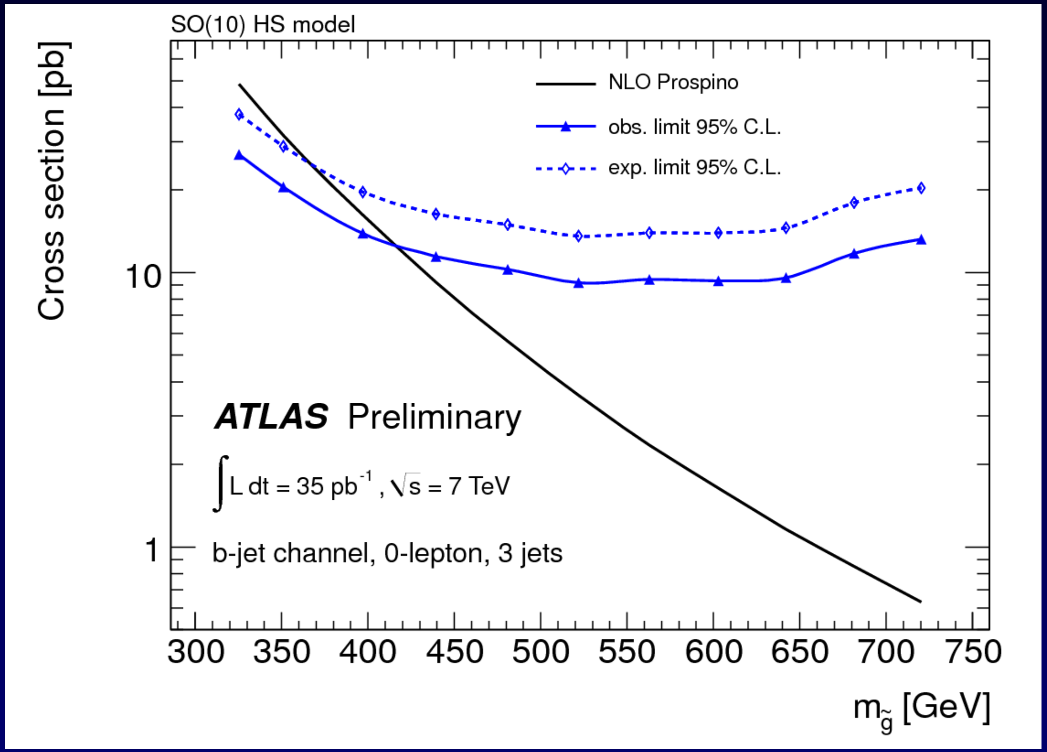
SO(10) models:
Baer et al, JHEP **1002** (2010) 055

b-jets+MET

- Exclusion also calculated for SO(10) GUT model using b-jet+MET results

$$m_{\tilde{\chi}^0} \sim 50-90\ \text{GeV},\ m_{\tilde{\chi}^\pm} \sim 100-180\ \text{GeV},\ m_{\tilde{g}} \sim 300-600\ \text{GeV}$$

  - m(scalar) > TeV
  - Chargino-neutralino or gluino pair production with $\tilde{g} \to b\bar{b}\tilde{\chi}^0_{1,2}$
  - Selection efficiency ~7-20%




Higgs Splitting (HS) model

$$m^2_{H_{u,d}} = m^2_{10} \mp 2M^2_D$$

$$m_{\tilde{g}} > 420\ \text{GeV}$$

D-term splitting (DR3) model

Mass splitting in Higgs and scalars

$+\nu_R$ Yukawa couplings

$+3^{rd}$ generation mass splitting

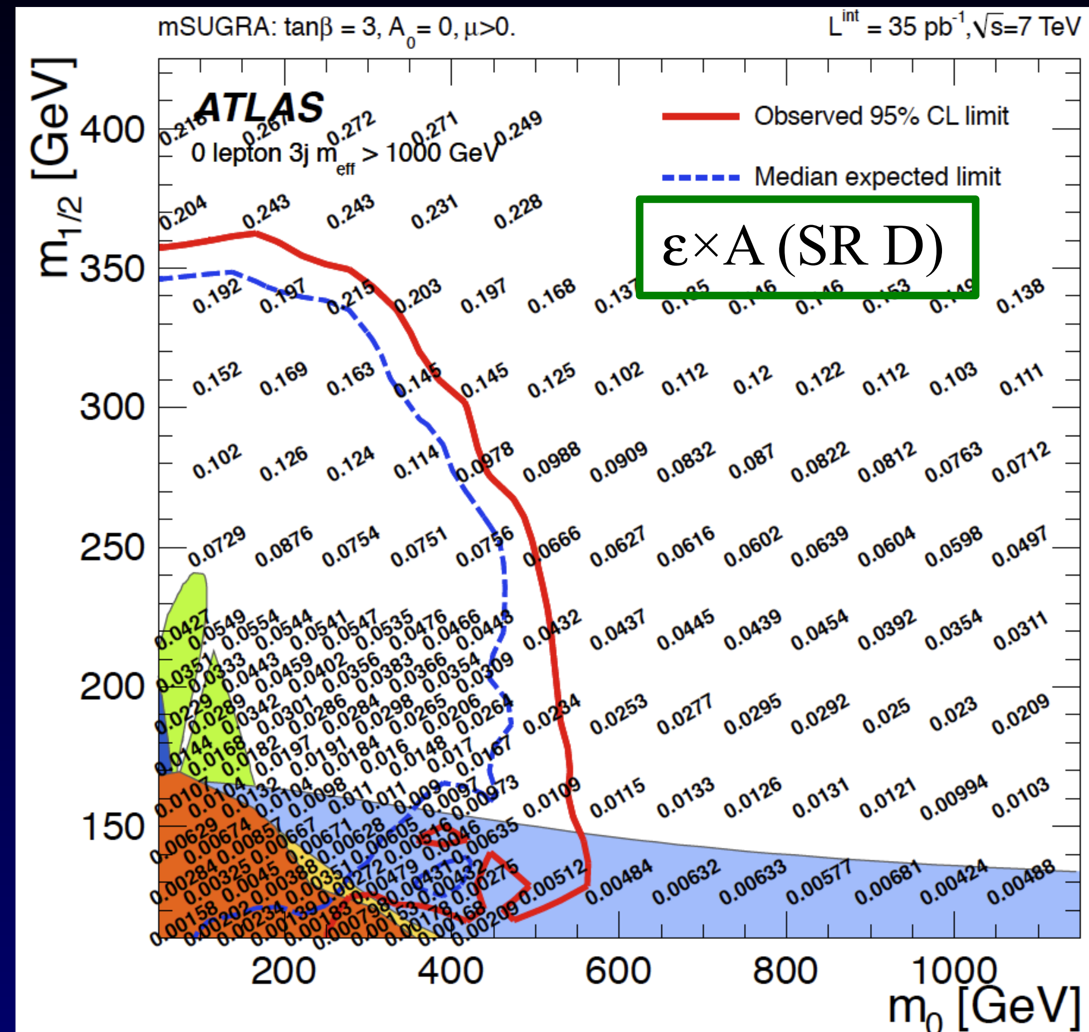
$$m_{\tilde{g}} > 500\ \text{GeV}$$

# Other models

- We search for SUSY, not mSUGRA
  - But we can't test everything
- So, you have some other model:

1 Validate your local setup
  - Acceptance * efficiency provided for each point
  - Les Houches format files too, on hepdata

2 Test your model!




- cf: SUSY Recast workshop report (2pm today)

# Summary and outlook

- Supersymmetry may be found as an excess of events with jets + MET
  - … but not yet
- Two analyses: inclusive and ≥1 b-jet
  - m(gluino) > 500 GeV in phenomenological gluino-squark-LSP model
  - m(gluino) > 590 GeV with b-jets if $m_{\tilde{g}} > m_{\tilde{b}_1} > m_{\tilde{\chi}_1^0}$
  - Strong mSUGRA and SO(10) model limits
  - Possible to extend interpretations to arbitrary theoretical models
- Bright prospects for 2011
  - Vastly more luminosity => "factory-mode" analysis
  - Refined experimental techniques (eg data-driven background estimation)
  - Experience and feedback from 2010
  - Sensitivity beyond m ~ 1 TeV

# *Backup*

# Monte Carlo samples

- QCD jets (Jn): PYTHIA v6.4.21
  - Binned in $p_T$
  - ALPGEN for systematics
- Top (single and double): MC@NLO v3.41, CTEQ6.6
  - $m_t$ = 172.5 GeV
  - POWHEG and ACERMC for systematic uncertainties
- W/Z+jets (incl. b jets): ALPGEN v2.13
- W/Z+γ: MADGRAPH 4
- Dibosons: HERWIG or ALPGEN
- Drell-Yan: PYTHIA or ALPGEN
- LO pdf: MRST2007LO*
- MC09 parameter tune + GEANT4

- SUSY signal models:
  - HERWIG++ v2.4.2
  - Jets+MET MSSM grids: HERWIG
- SUSY cross sections: NLO PROSPINO v2.1
- Mass spectra and decay modes
  - ISASUSY (from ISAJET) v7.80
  - SUSYHIT v1.3 (b-jet+MET MSSM scenarios)

- NLO pdf: CTEQ6.6M
  - Scale = mean sparticle mass
- Showering: HERWIG v6.510
- UE: JIMMY v4.31

# What is $m_{T2}$?

- It is a generalisation of the transverse mass, used for W physics

$$m_{\mathrm{T}}^{2}\left(\mathbf{p}_{\mathrm{T}}^{(i)}, \not{\mathbf{q}}_{\mathrm{T}}^{(i)}\right) \equiv 2|\mathbf{p}_{\mathrm{T}}^{(i)}||\not{\mathbf{q}}_{\mathrm{T}}^{(i)}| - 2\mathbf{p}_{\mathrm{T}}^{(i)} \cdot \not{\mathbf{q}}_{\mathrm{T}}^{(i)},$$

- With two jets plus MET, $m_{T2}$ is calculated like this:

$$m_{\mathrm{T2}}\left(\mathbf{p}_{\mathrm{T}}^{(1)}, \mathbf{p}_{\mathrm{T}}^{(2)}, \not{\mathbf{p}}_{\mathrm{T}}\right) \equiv \min_{\not{\mathbf{q}}_{\mathrm{T}}^{(1)}+\not{\mathbf{q}}_{\mathrm{T}}^{(2)}=\vec{E}_{\mathrm{T}}^{\mathrm{miss}}} \left\{\max\left(m_{\mathrm{T}}\left(\mathbf{p}_{\mathrm{T}}^{(1)}, \not{\mathbf{q}}_{\mathrm{T}}^{(1)}\right), m_{\mathrm{T}}\left(\mathbf{p}_{\mathrm{T}}^{(2)}, \not{\mathbf{q}}_{\mathrm{T}}^{(2)}\right)\right)\right\}$$

- It is most sensitive to processes like this:

$$\tilde{q}+\tilde{\bar{q}} \rightarrow q+\bar{q}+2\chi_1^0$$

- It is a continuous variable, displaying a kinematic endpoint at $m_{T2} \simeq m_{\tilde{q}}$

# Hypothesis testing

- Signal and background hypotheses test statistics
  - $P_{\chi^2}$ = one-sided p-value for a given $\chi^2$
  - Models with p-values < 0.05 are excluded at 95% CL

$$q_\mu \equiv \begin{cases} P_{\chi 2}(\Lambda(\hat{\mu})) & \hat{\mu} \geq \mu \\ 1 - P_{\chi 2}(\Lambda(\hat{\mu})) & \hat{\mu} < \mu. \end{cases}$$

$$q_0 \equiv \begin{cases} P_{\chi 2}(\Lambda(\hat{\mu})) & \hat{\mu} < 0 \\ 1 - P_{\chi 2}(\Lambda(\hat{\mu})) & \hat{\mu} \geq 0. \end{cases}$$

$\mu$ = signal strength ($0 \leq \mu \leq 1$)

- Signal and background control region expectation values:

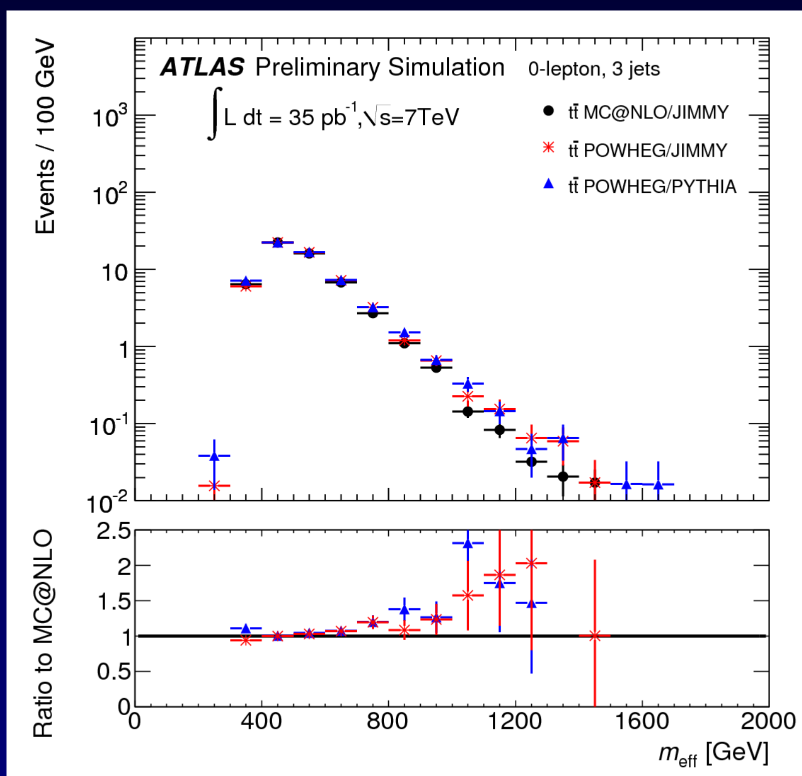
$$\begin{aligned} \lambda_S(\mu, \mathbf{b}, \boldsymbol{\theta}) &= \mu \cdot c_{s,\mathrm{SR}}(\boldsymbol{\theta}) \cdot s + \sum_j c_{j,\mathrm{SR}}(\boldsymbol{\theta}) \cdot b_j , \\ \lambda_i(\mu, \mathbf{b}, \boldsymbol{\theta}) &= \mu \cdot c_{s,i}(\boldsymbol{\theta}) \cdot s + \sum_j c_{j,i}(\boldsymbol{\theta}) \cdot b_j . \end{aligned}$$

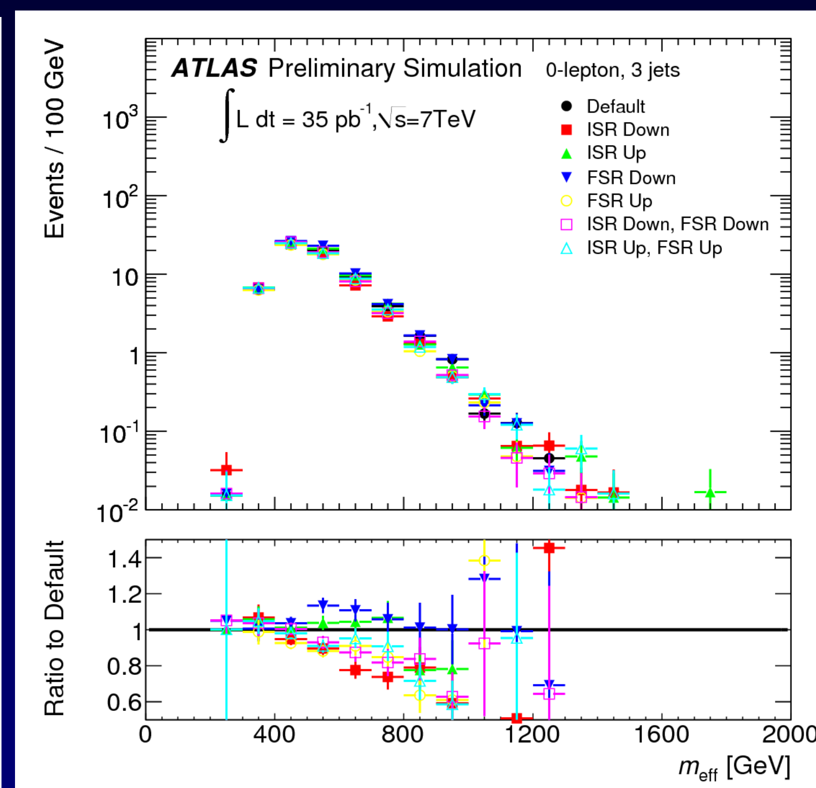
- **Background fit:** $\mu = 0$, signal region excluded, nuisance parameters for signal strength and theoretical extrapolation uncertainties turned off
- **Discovery fit:** $\mu = 1$, signal contamination in control regions = 0, nuisance parameters for signal strength turned off
- **Exclusion fit:** $\mu$ fitted, all features turned on

b-jets+MET

# *W, Z, top background estimation*

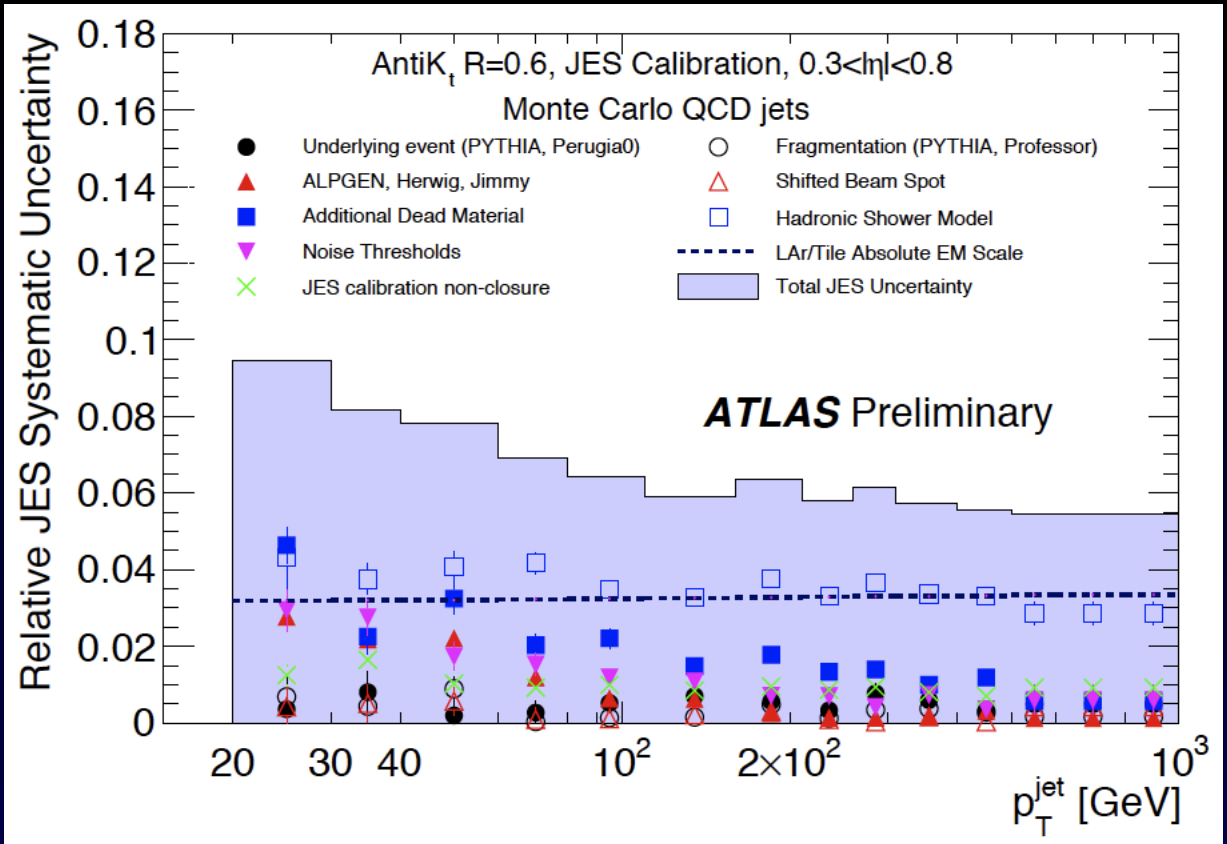
| Process | MC stat | JES | $b$-tagging | Lum. | Theor. | Pileup | other (lepton, trigger) | Total |
|---|---|---|---|---|---|---|---|---|
| $W$ | $\pm 15\%$ | $\pm 24\%$ | $\pm 24\%$ | $\pm 11\%$ | $\pm 27\%$ | $\pm 5\%$ | $\pm 3.5\%$ | $\pm 43\%$ |
| $Z$ | $\pm 27\%$ | $\pm 20\%$ | $\pm 25\%$ | $\pm 11\%$ | $\pm 27\%$ | $\pm 5\%$ | $\pm 3.5\%$ | $\pm 45\%$ |
| Top | $\pm 2.5\%$ | $^{+30\%}_{-23\%}$ | $^{+12\%}_{-15\%}$ | $\pm 11\%$ | $^{+20\%}_{-27\%}$ | $\pm 5\%$ | $\pm 3.5\%$ | $\pm 40\%$ |



# *Jet energy scale*

ATLAS-CONF-2010-056

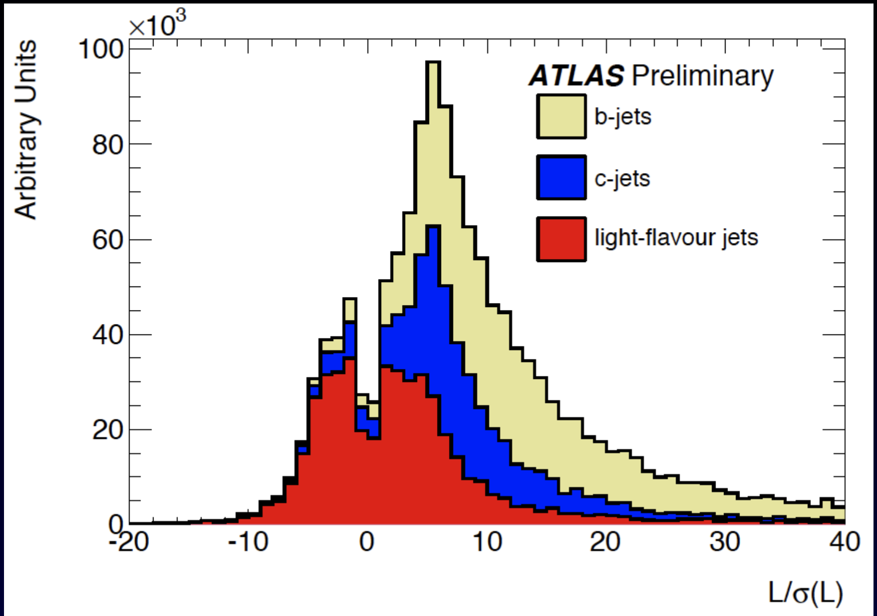


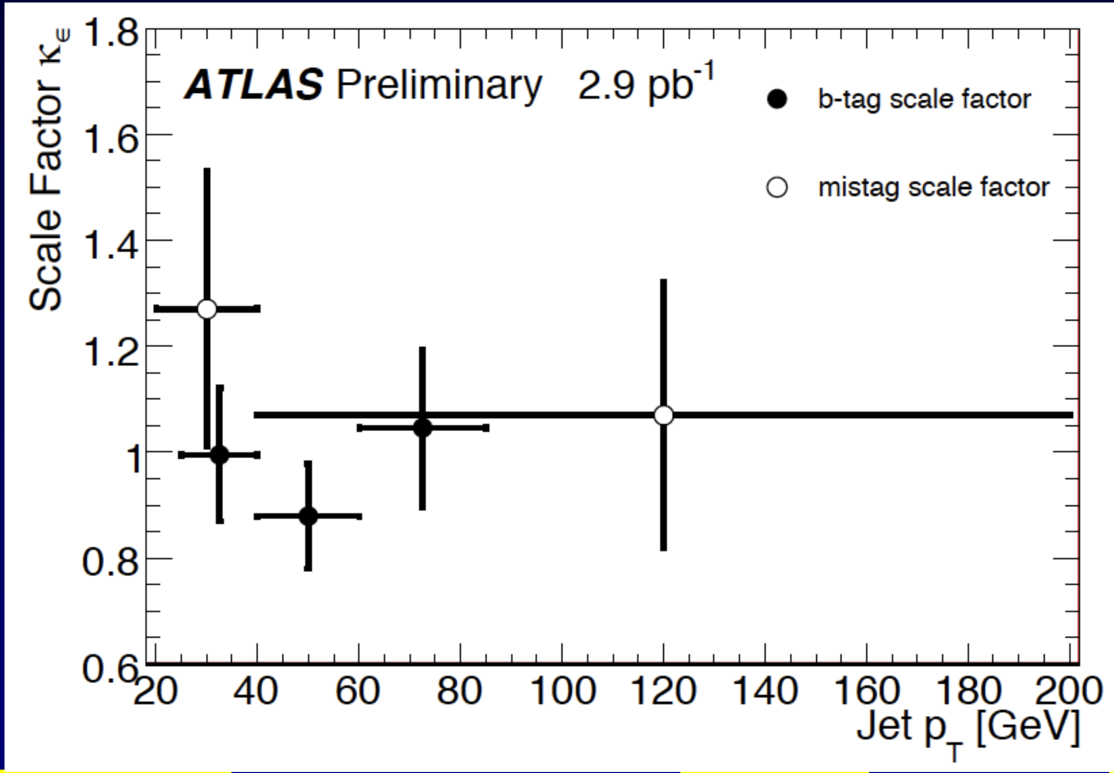

- Energy scale factors determined using Monte Carlo
  - Non-compensation, leakage, inefficiencies etc
- Tested with different physics and detector models, and relative response measurements in data
- Uncertainty < 10% for jets with $p_T$ > 20 GeV, |η| < 2.8
- Already improved for 2011 analyses

# *b-jet reconstruction*

ATLAS-CONF-2010-099

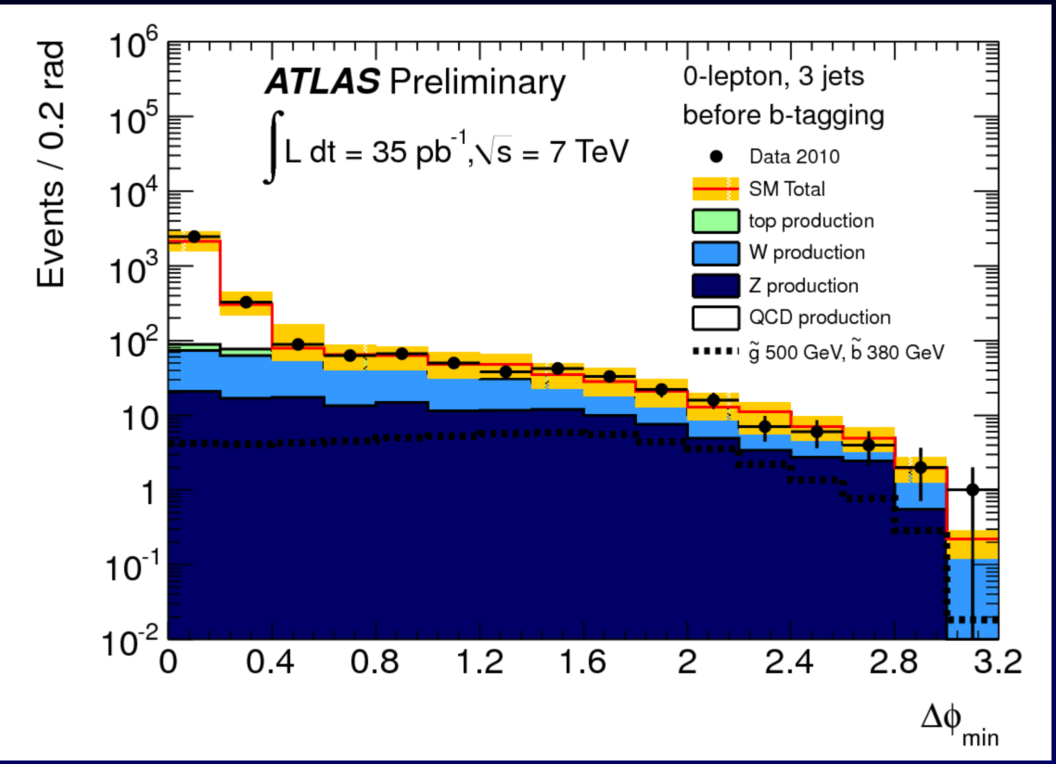
- SV0 algorithm: a secondary vertex is reconstructed, and the decay length L computed
  - Vertices consistent with material interactions are vetoed
- Cut at L = 5.72σ(L) gives 50% efficiency and 1% fake rate on MC (ttbar)
  - Varies with jet $p_T$ and η
  - Data/MC scale factors consistent with 1



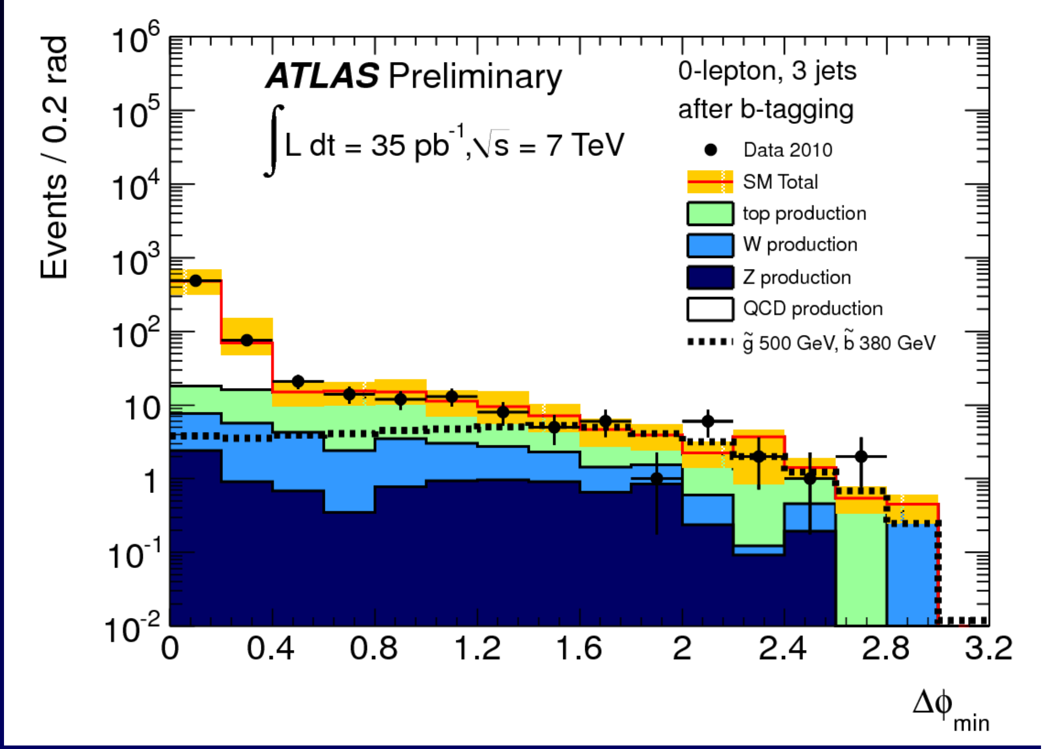



# Effect of b-jet selection

BEFORE



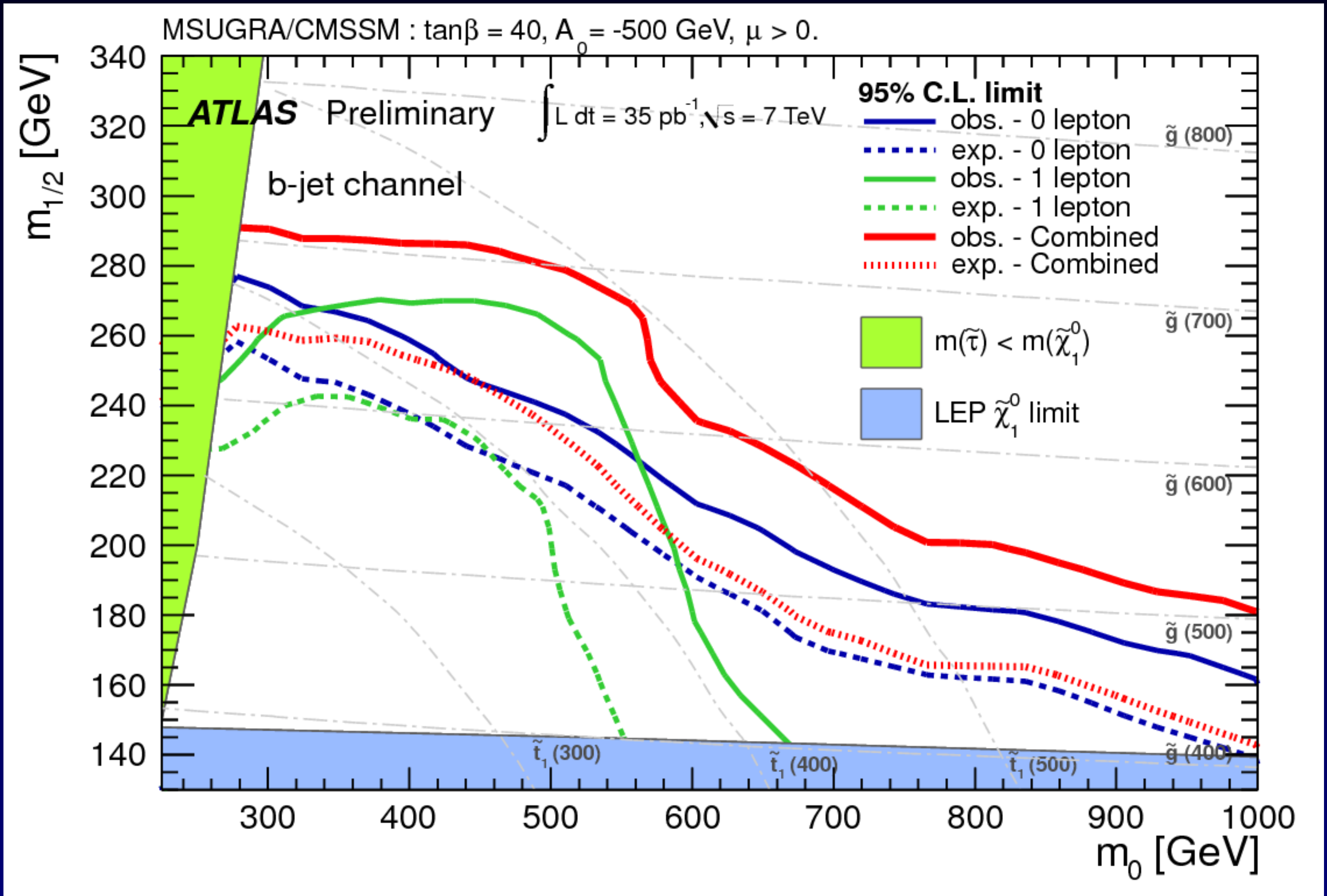

AFTER




- W, Z + jets dominates background before b-jet selection
- Top dominates after it

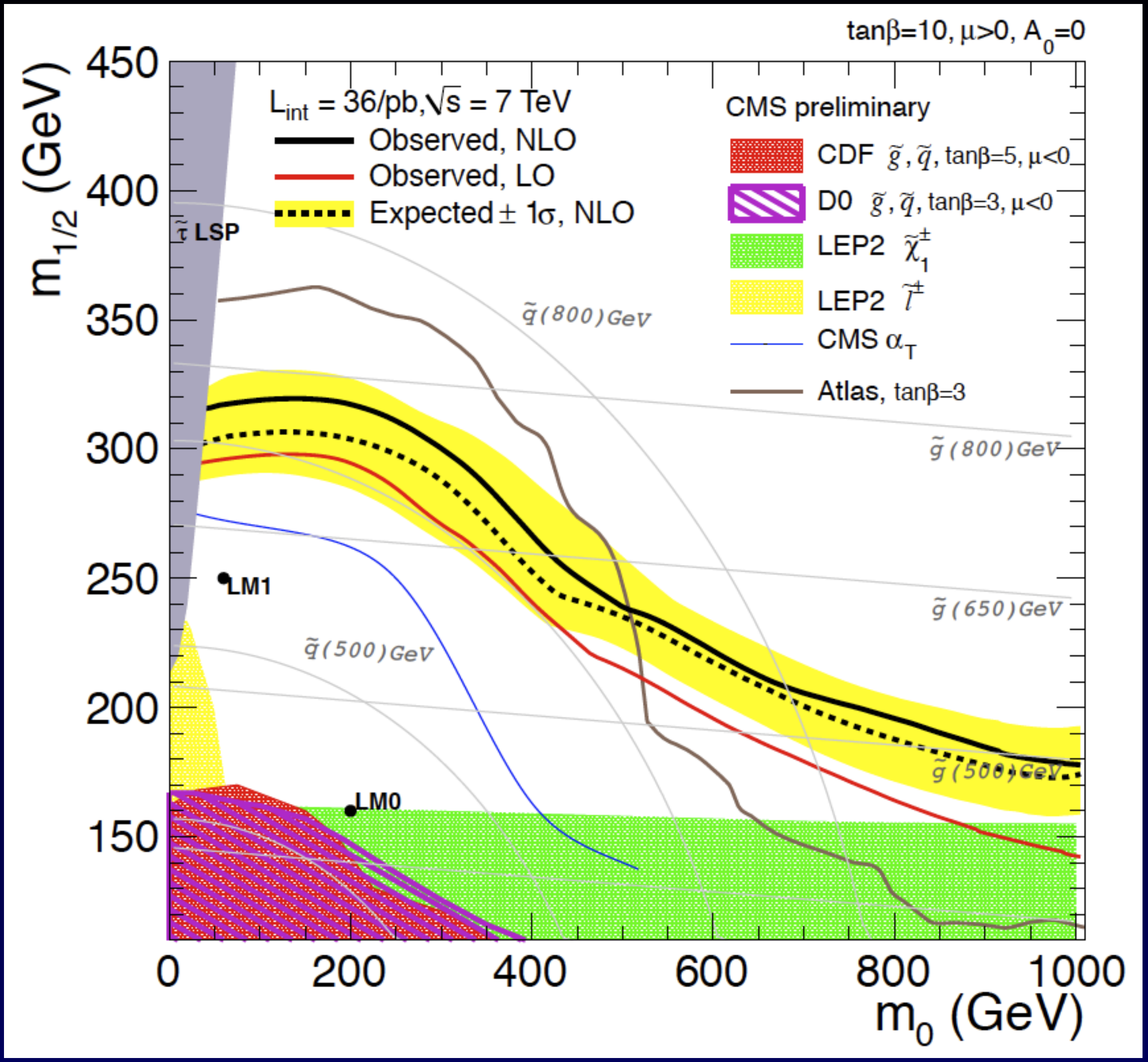
# MSUGRA with $A_0$ = -500 GeV

b-jets+MET



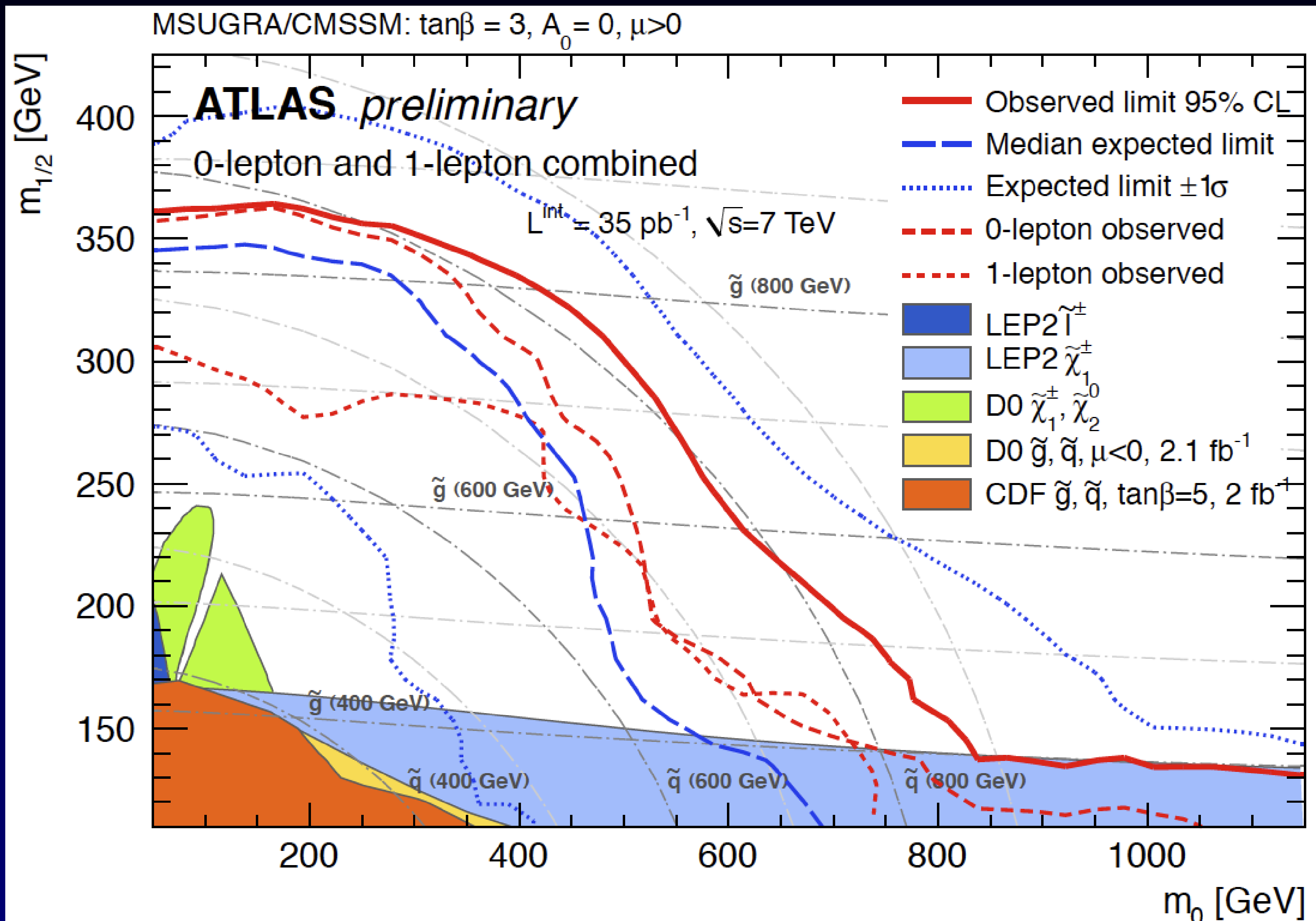
# CMS new results

CMS-PAS-SUS-10-005




- New CMS analysis, different discriminating variables
  - "MHT", ie MET only from jets, rather than $\alpha_T$ ("QCD killer")
- Reach similar to ATLAS overall, different in the details

# 0+1 lepton combination



# SUSY object preselection (rel 15)

Jet cleaning:
Reject events with "bad" jet of $p_T$ > 20 GeV

Vertex: > 4 tracks

Jet selection:
AntiKt4TopoJets, calibrated with EMJES
$p_T$ > 20 GeV
$|\eta| < 2.5$

MET:
MET = "Simplified" RefFinal (+ specific e/μ corrections)

Electron selection:
ElectronMedium
AuthorElectron
$p_T$ > 10/20 GeV
$|\eta_{s2}| < 2.47$
Dead OTX removed

Muon selection:
Combined or segment-tagged staco muons
MCP recommended cuts
$p_T$ > 10/20 GeV
$|\eta| < 2.4$
$p_T$ cone 20 < 1.8 GeV

Overlap removal:
Jets with $\Delta R < 0.2$ from medium electron removed
Electrons/muons with $\Delta R < 0.4$ from jet removed

Crack veto:
Remove events with electron in crack ($1.37<|\eta|<1.52$, no iso cut)

b-jets+MET