Background for SUSY searches in ATLAS

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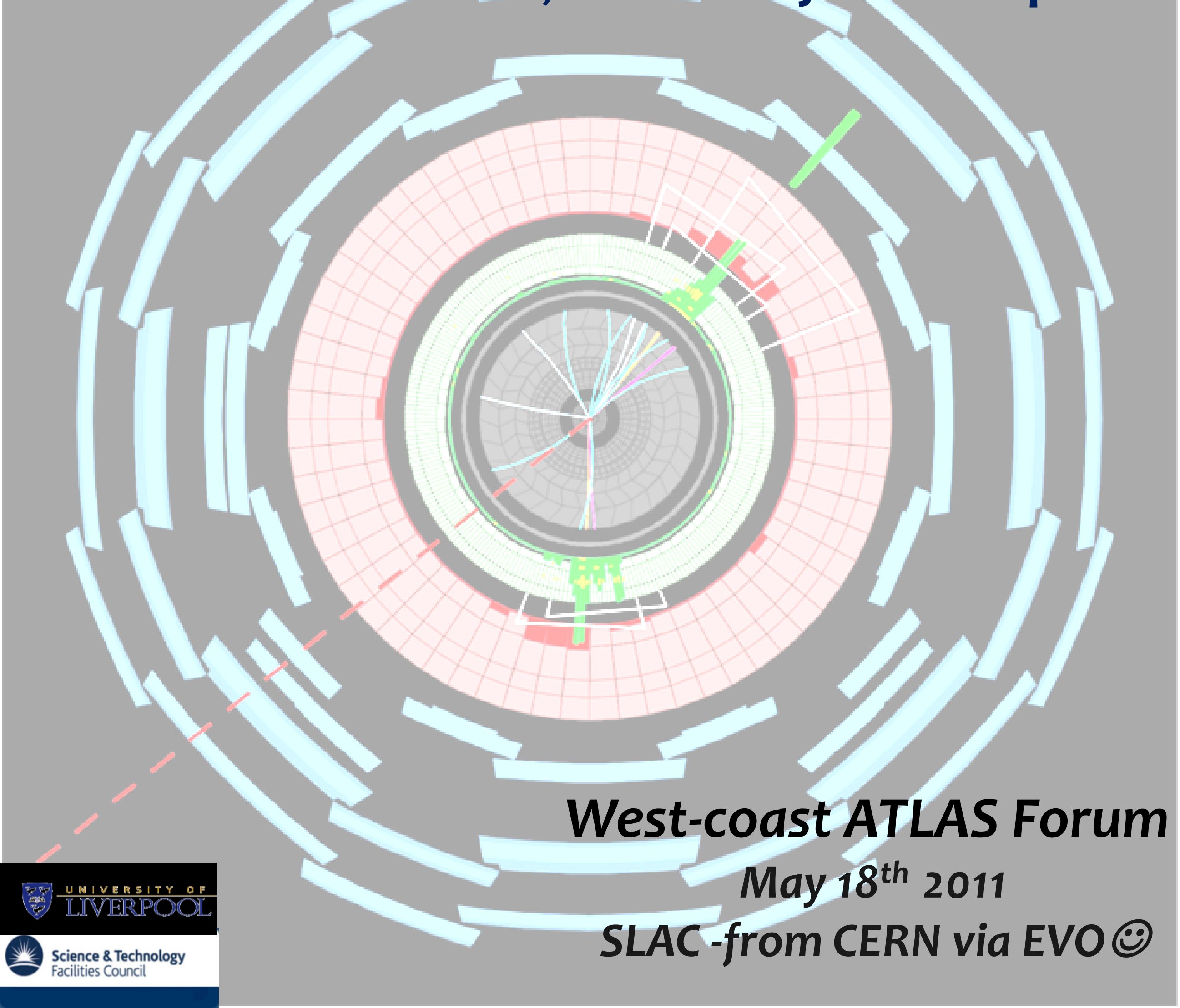

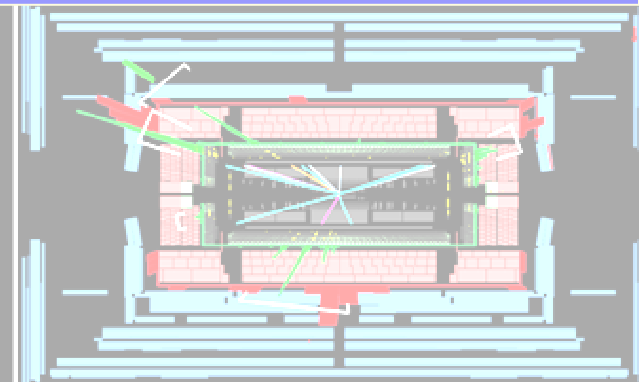

West-coast ATLAS Forum

May 18th 2011

SLAC -from CERN via EVO☺

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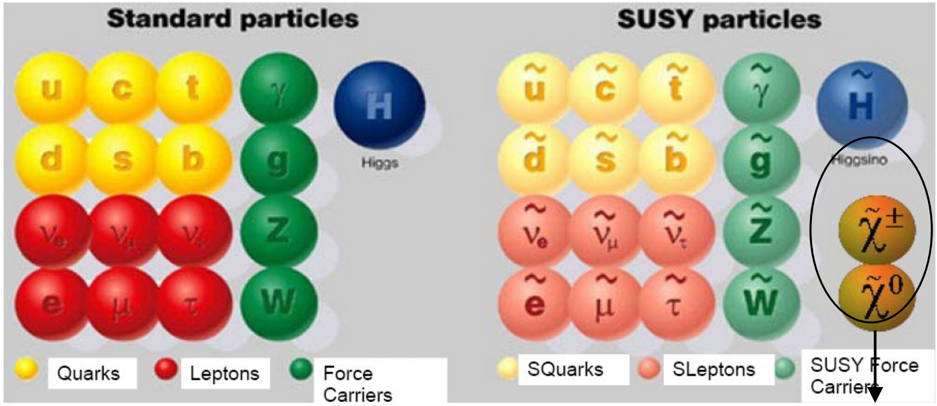
Supersymmetry

New spin-based symmetry relating fermions and bosons

Q|Boson> = Fermion

Q|Fermion> = Boson



gaugino/higgsino mixing

- Minimal SuperSymmetric SM (MSSM):
  - Mirror spectrum of particles
  - Enlarged Higgs sector: two doublets with 5 physical states

$$H_U, H_D \longrightarrow h,\ H,\ A,\ H^{\pm}$$

Naturally solve the hierarchy problem

- Unification of forces possible
- Define R-parity = $(-1)^{3(B-L)+2s}$
  - R = 1 for SM particles
  - R = -1 for MSSM partners

No SUSY particles found yet!

→ SUSY must be broken

$$L = L_{SUSY} + L_{Soft}$$

If conserved, provides Dark Matter Candidate

(Lightest Supersymmetric Particle)

SUSY phenomenology

Breaking mechanism and R-parity determines
phenomenology and the **search strategy**

In R-parity conserving scenarios, $\tilde{\chi}_1^0$(or $\tilde{\nu}$) is LSP.
Signatures:
Missing E_T + jets (+ leptons)

Generic MSSM

MSUGRA/CMSSM

GMSB, GGM

AMSB

Split-SUSY

RPV-scenarios

….

Exploit unbalanced momentum from LSP

Gravitino very light (<< MeV) → is the LSP. Neutralino can be NLSP:

$$\tilde{\chi}_1^0 \rightarrow \tilde{G}\,\gamma$$

Signatures (R-parity cons.):
Missing E_T+2γ (+lepton/jets)

Depending on the mass spectrum if small $\tilde{\chi}^{\pm} - \tilde{\chi}_1^0$ mass difference, long-lived charginos expected
Signatures:
displaced vertex kinked tracks

Dedicated techniques

squarks/gluinos heavy
Typical signatures:
Long-Lived / quasi stable particles (R-hadrons)

If R-parity not conserved, search for resonances

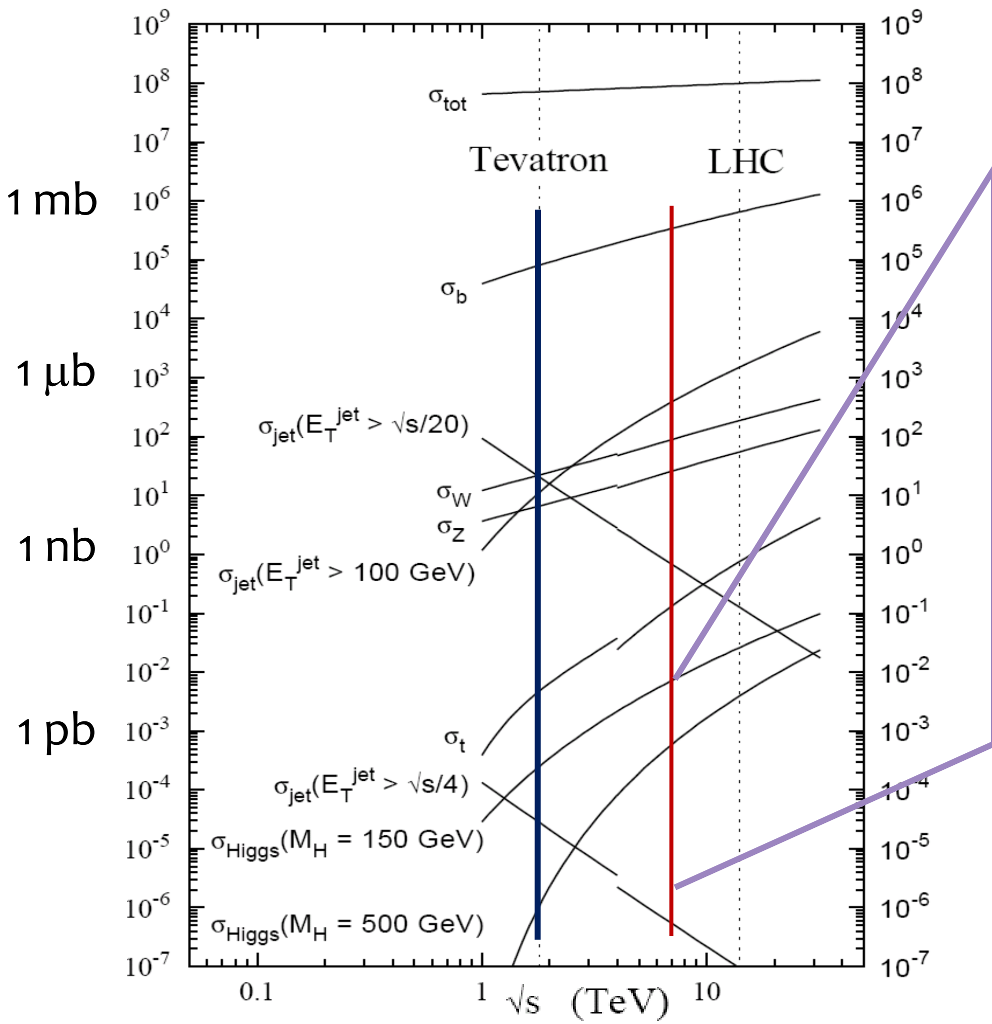
Outline

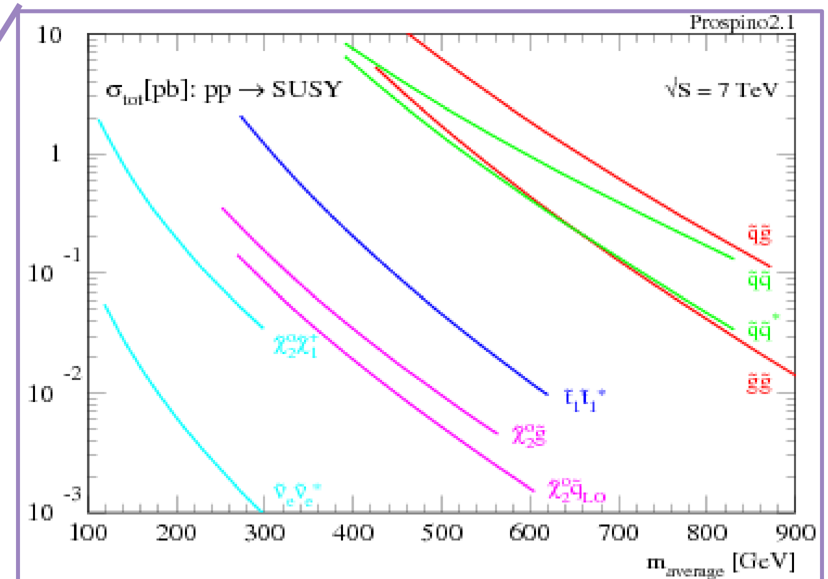
Focus on searches for R-parity conserving SUSY:

- Searches for SUSY in final state events with large E_T^{Miss}, high p_T jets (including b-jets) with and without leptons
  - Data-driven or partially data-driven techniques for:
    - QCD-multijet background
    - W/Z+jets processes
    - Top production
- Summary and conclusions

Note: will show only publicly available material with the 2010 dataset (35 pb^{-1}). On-going update of analysis for PLHC (~170 pb^{-1}) and EPS (up to 500 pb^{-1} ?)

Production cross sections

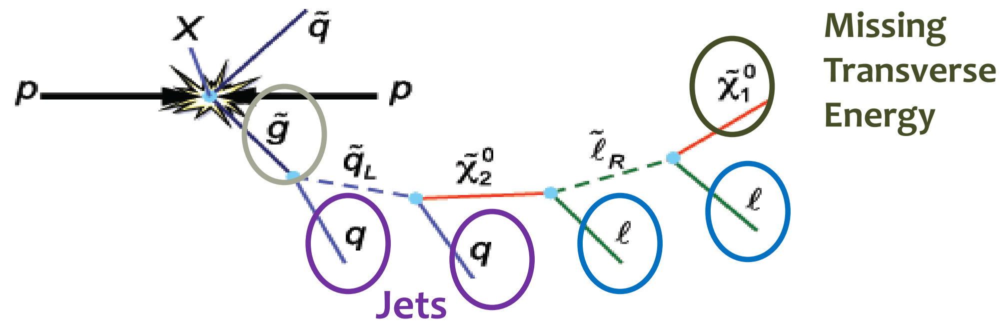




SUSY σ are several order of magnitude lower than SM processes

SUSY Event Topology

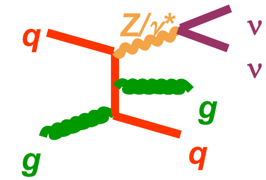
- Complex (and model-dependent) squark/gluino cascades



- Focus on signatures covering large classes of models while strongly rejecting SM background
  - large Missing E_T
  - High transverse momentum jets
  - Leptons
    - Perform separate analyses with and without lepton veto (0-lepton / 1-lepton / 2-leptons)
  - B-jets: to enhance sensitivity to third generation squarks

SM processes as background

- SUSY events present same signature as:
  - QCD events with mismeasured jets/semileptonic HF decay
  - Z → $\nu\nu$ + jets (MET+jets, irreducible background)
  - W → $\ell\nu$ + jets (MET+jets(+leptons) where $\ell = e,\mu,\tau$)
  - Top production processes



f.i.: Z+jets

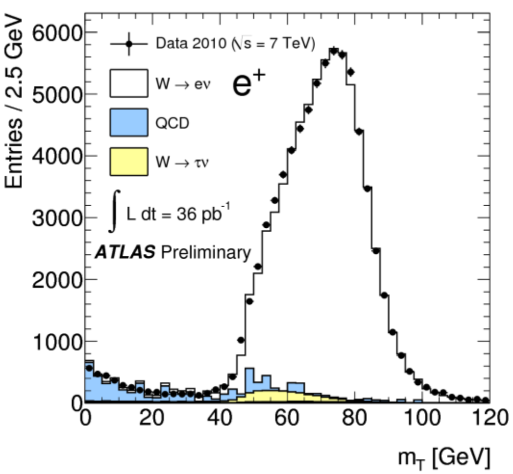
- Different approaches have been followed, depending on the analysis, with some common features:
  - Whenever possible, use of data-driven techniques
    - to estimate absolute normalization and/or shapes
    - defining 'control' samples and making closure tests

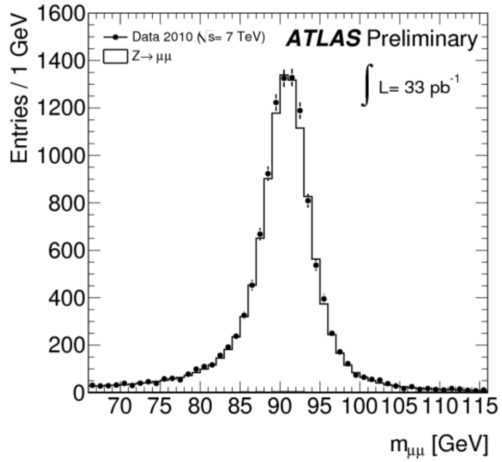
With 35 pb^{-1} in several cases use Monte Carlo tools to model observable shapes

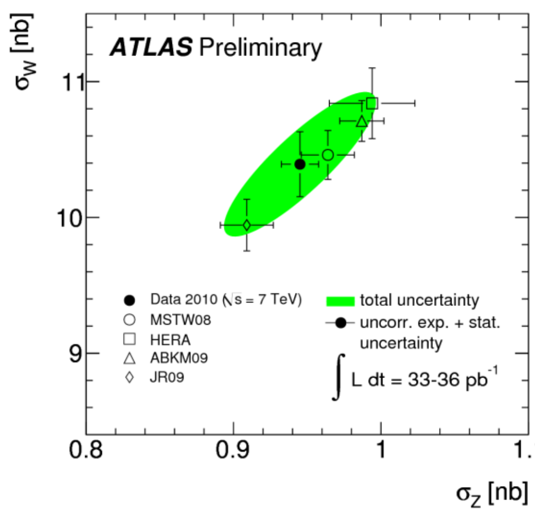
- *Data-driven methods sometimes affected by large statistical uncertainties*
- *Goodness of Monte Carlo tools extensively tested!*

Knowledge of SM processes (I)

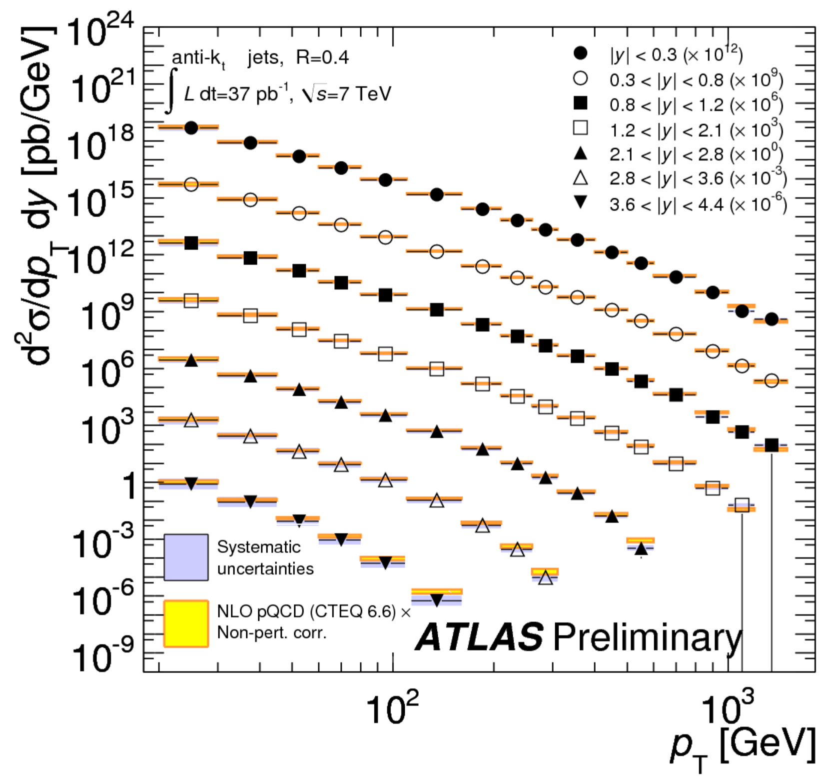
- W/Z (in e/μ) cross sections with very first data
- Excellent reconstruction and identification of e and μ







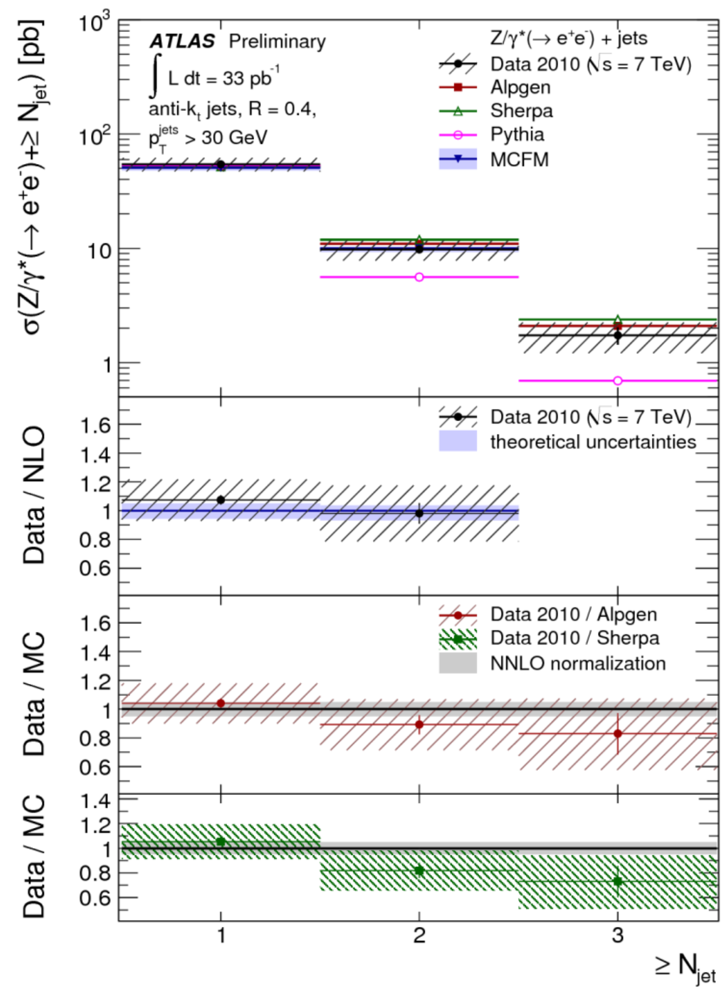
- Inclusive jet (and dijet) cross sections
  - good understanding of jets and Jet Energy Scale

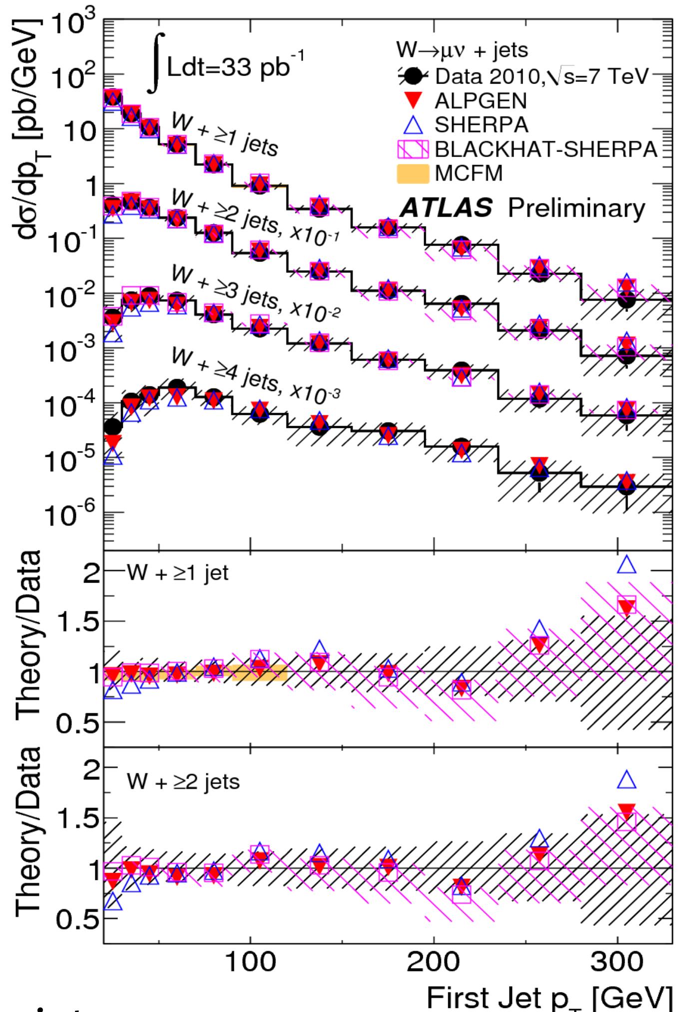


Knowledge of SM processes (II)

- W / Z + jets cross sections

Z→ee + jets

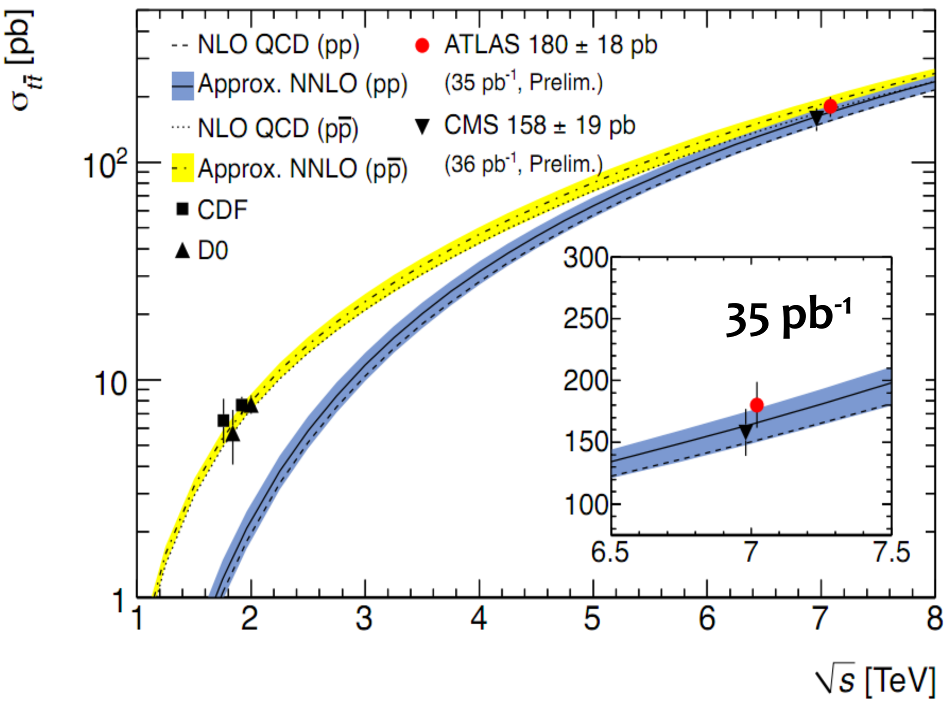




W→μν + jets

Knowledge of SM processes (III)

- Measured in e/μ+jets (with b-tag) and dilepton channels (combined)



ATLAS-CONF-2011-023
ATLAS-CONF-2011-025
ATLAS-CONF-2011-034
ATLAS-CONF-2011-040

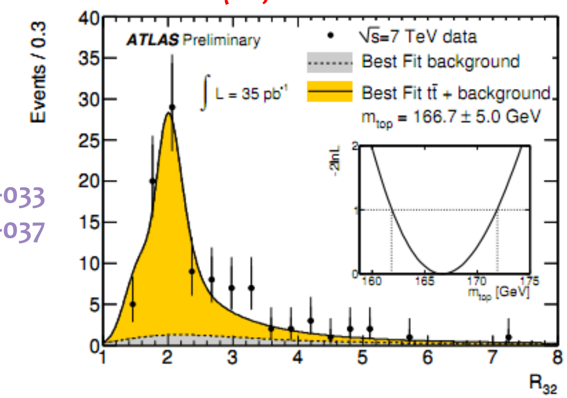
σ(tt) = 180 ± 9± 15 ± 6 pb
[10% total uncertainty]

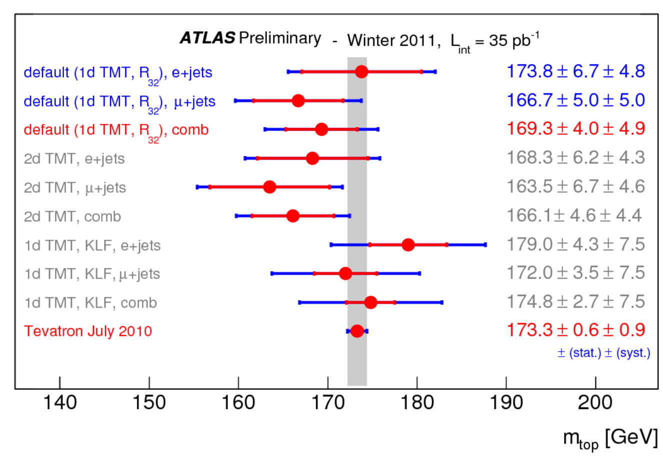
- Measured in e/μ+jets channel
- Dominant uncertainty due to JES
- Employ the ratio of reconstructed top to W mass (R_{32})

m(t) = 169.3 ± 4.0 ± 4.9 GeV

μ+jets channel

ATLAS-CONF-2011-033
ATLAS-CONF-2011-037





Searches for SUSY

Object identifications

Common tools and requirements for 'good events' are used

Primary vertex
- At least 1 good vertex with N_{tracks}>4

Jets
- anti-k_T, R=0.4
- p_T > 20 or 30 GeV, $|\eta|$ up to 2.8
- Reject events compatible with noise or cosmics

B-Jets
- Exploit Secondary vertex reconstruction algorithm

Electrons
- p_T > 20 GeV, $|\eta|$<2.47
- reject events if electron candidates are in transition region ($1.37<|\eta|<1.52$)

Muons
- p_T > 20 GeV, $|\eta|$<2.4
- combined/extrapolated info from ID and Muon spectrometer
- Sum p_T of tracks <1.8 GeV in $\Delta R<0.2$

Missing E_T
- Calculated from objects and clusters

Remove overlapping objects

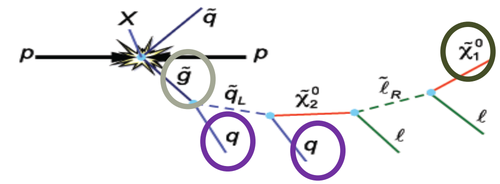
- If $\Delta R(jet,e)<0.2$, remove jet
- If $0.2<\Delta R(jet,e)<0.4$, veto electron, if $\Delta R(jet,\mu)<0.4$, veto muon

arXiv:1102.5290 (Sub. PLB)

Search in no-lepton final states

- Select events with jets, missing E_T and no lepton (e/μ veto)
- Signal regions definition on the basis of jet multiplicity

(n ≥2 jets or n≥3 jets), jet p_T and E_T^{Miss} thresholds and:



Phys.Lett.B463:99-103,1999
J.Phys.G29:2343-2363,2003

Scalar sum of objects p_T
Effective mass (m_{eff})

$$m_{eff} \equiv \sum_{i-1}^{n} | p_T^{(i)} | + E_T^{miss}$$

Stransverse mass (m_{T2})

$$m_{T2}(\vec{p}_T^{(1)}, \vec{p}_T^{(2)}, \vec{\not p}_T) \equiv \min_{\vec{q}_T^{(1)}+\vec{q}_T^{(2)}=E_T^{miss}} \{\max(\ m_T(\vec{p}_T^{(1)}, \vec{q}_T^{(1)}), m_T(\vec{p}_T^{(2)}, \vec{q}_T^{(2)}))\}$$

$$m_T^2(\vec{p}_T^{(i)}, \vec{q}_T^{(i)}) \equiv 2 | \vec{p}_T^{(i)} \| \vec{q}_T^{(i)} | - 2 \vec{p}_T^{(i)} \cdot \vec{q}_T^{(i)}$$

		A	B	C	D
Pre-selection	Number of required jets	≥ 2	≥ 2	≥ 3	≥ 3
	Leading jet p_T [GeV]	> 120	> 120	> 120	> 120
	Other jet(s) p_T [GeV]	> 40	> 40	> 40	> 40
	E_T^{miss} [GeV]	> 100	> 100	> 100	> 100
Final selection	$\Delta\phi(\text{jet}, \vec{P}_T^{miss})_{min}$	> 0.4	> 0.4	> 0.4	> 0.4
	E_T^{miss}/m_{eff}	> 0.3	–	> 0.25	> 0.25
	m_{eff} [GeV]	> 500	–	> 500	> 1000
	m_{T2} [GeV]	–	> 300	–	–

4 signal regions

Due to trigger requirements

QCD-multijet rejection

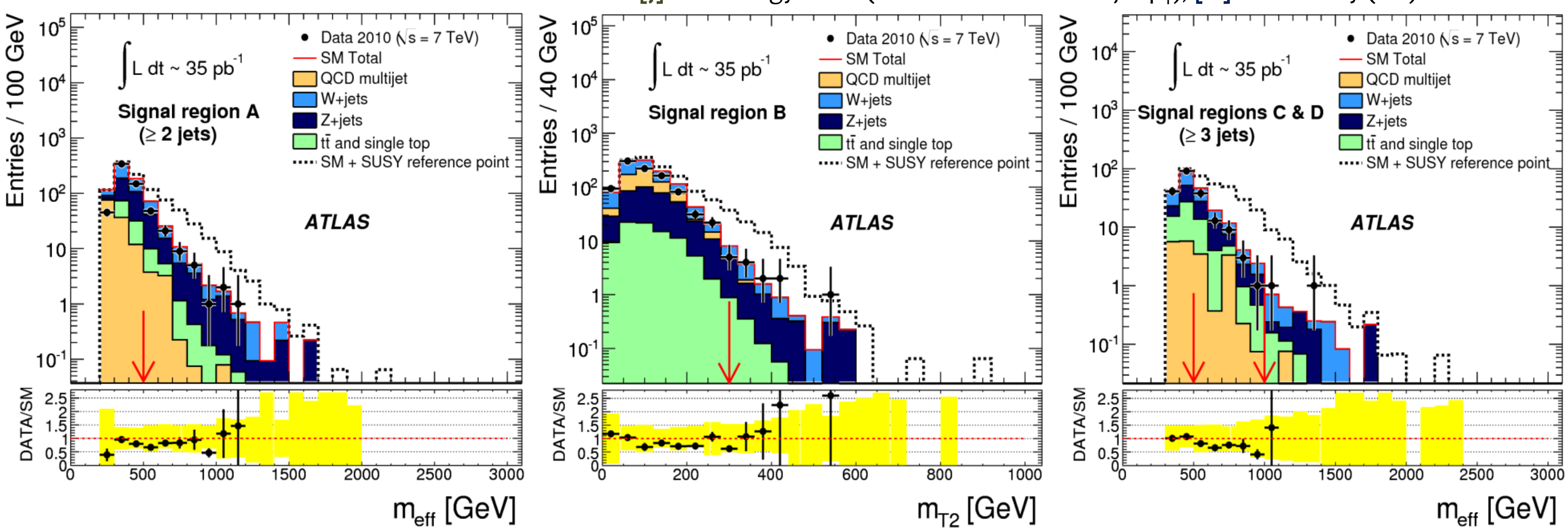
Enhance sensitivity to SUSY

Results for SUSY in jets+MET

	Signal region A	Signal region B	Signal region C	Signal region D
QCD	7^{+8}[u]	$0.6^{+0.7}$[u]	9^{+10}[u]	$0.2^{+0.4}$[u]
$t\bar{t}$ and t	10 ± 0[u] [illegible][j] $\pm 1[\mathcal{L}]$	0.9 ± 0.1[u] $^{[illegible]}_{-0.2}$[j] $\pm 0.1[\mathcal{L}]$	17 ± 1[u] [illegible][j] $\pm 2[\mathcal{L}]$	0.3 ± 0.1[u] $^{[illegible]}_{-0.1}$[j] $\pm 0.0[\mathcal{L}]$
Total SM	118 ± 25[u] $^{+23}_{-19}$[j] $\pm 12[\mathcal{L}]$	10.0 ± 4.3[u] $^{+2.9}_{-1.7}$[j] $\pm 1.0[\mathcal{L}]$	88 ± 18[u] $^{+18}_{-15}$[j] $\pm 9[\mathcal{L}]$	2.5 ± 1.0[u] $^{+0.6}_{-0.4}$[j] $\pm 0.2[\mathcal{L}]$
Data	87	11	66	2

W/Z+jets bkg dominates

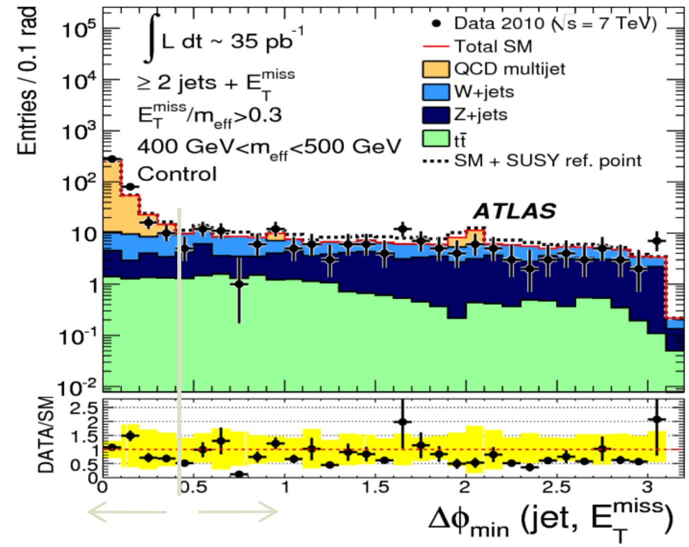
[u]=uncorrelated uncertainties (MC statistics, acceptance, jet energy resolutions..)
[j]=Jet Energy Scale (6%-10% as function of jet p_T), [$\mathcal{L}$]=luminosity (11%)

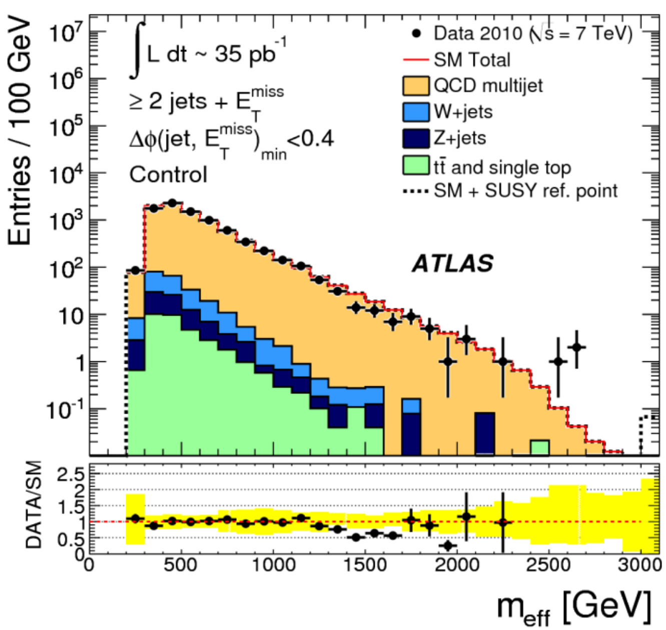


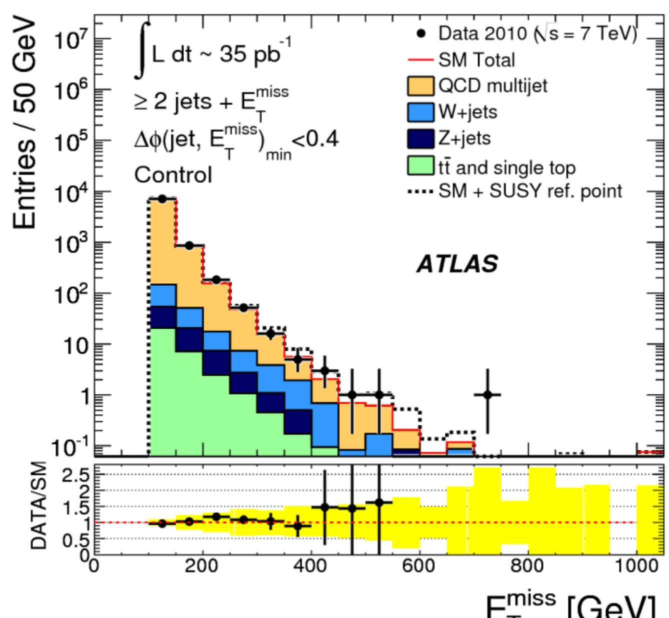
Good agreement between data and SM predictions

QCD for 0-lepton

- QCD-multijet background due to mis-reconstructed jets and neutrinos from HF leptonic decays
  - E_T^{Miss} expected to be aligned to one of the jets
- Use partially data-driven estimate:
  - Rescale MC samples (PYTHIA and ALPGEN) in control region → **$\Delta\phi$(jet, E_T^{Miss}) < 0.4**







After rejection:
QCD ~5% of TOT Bkg

Cross-checked with
→ fully data-driven techniques (Jet smearing)
→ Use control region based on reversed E_T^{Miss}/m_{eff} for rescaling

QCD for 0-lepton: cross checks

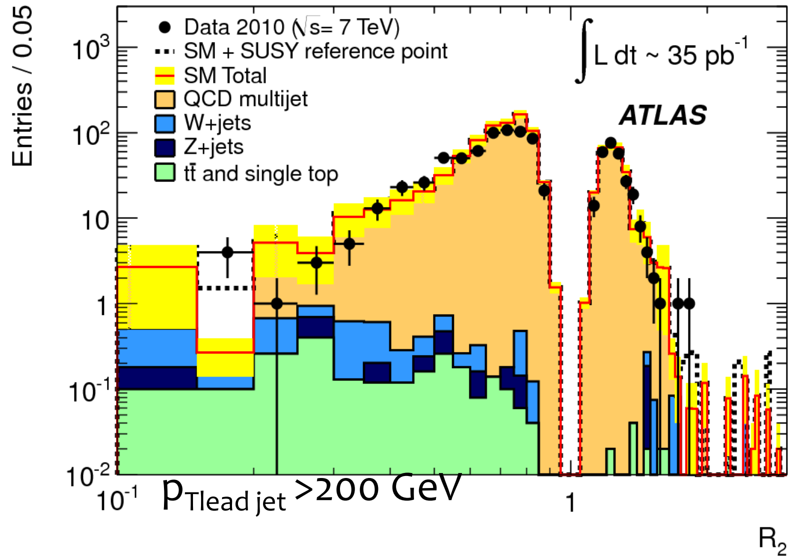
- Baseline QCD estimation consistent with fully data-driven technique:
  - High MET events 'generated' from data, smearing down low MET events on a jet-by-jet basis with measured jet energy resolution functions

(1)

$$R_2 = \frac{(\vec{p}_T \cdot (\vec{p}_T + \vec{p}_{T,Miss}))}{|\vec{p}_T + \vec{p}_{T,Miss}|}$$

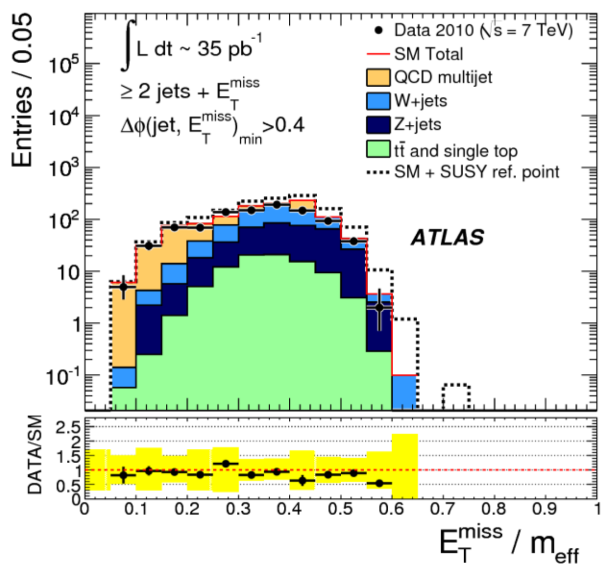
  - Assume source of E_T^{Miss} associated with jets only

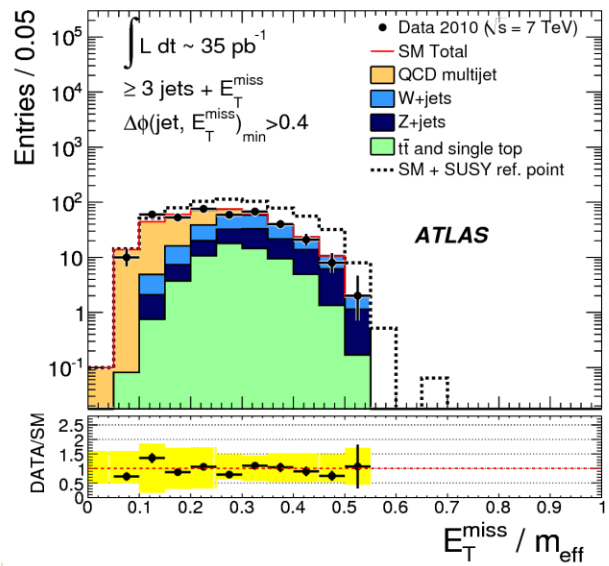
Non-Gaussian tail of jet response function



(2)

-- Use additional control regions reversing E_T^{Miss}/m_{eff} requirements

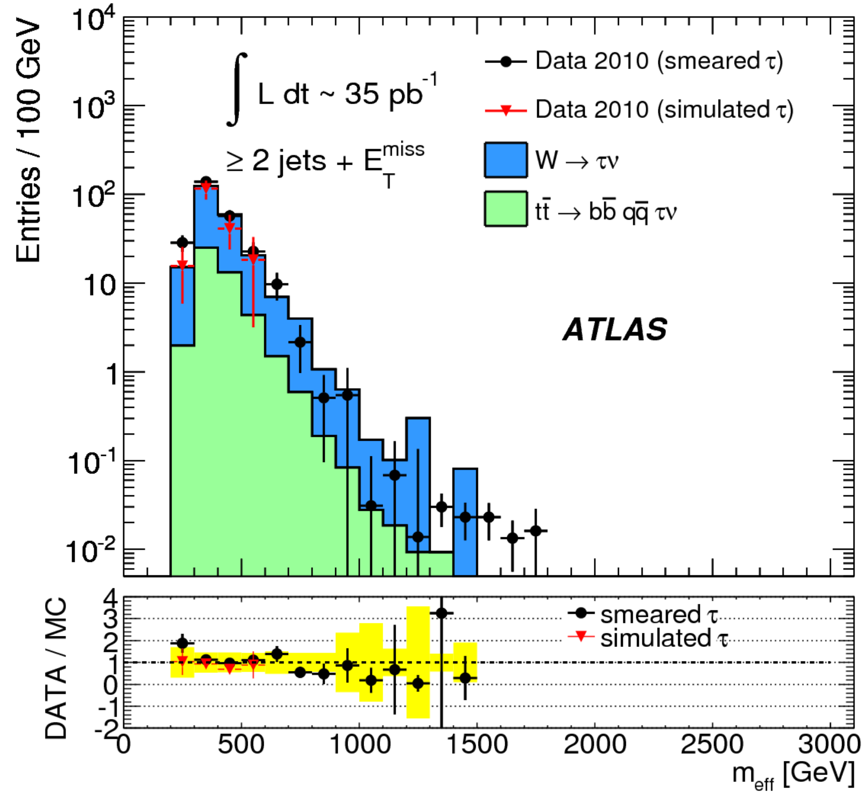




W+jets (and top background)

- Non-QCD bkg dominated by
  - $W \rightarrow \tau\nu$, $W \rightarrow$(missed)e/μ
  - Top pair production ($t \rightarrow \tau$+jets)
- Central value derived from MC:
  - **W+jets:** ALPGEN normalized to NNLO
  - **Top:** MC@NLO (+HERWIG and JIMMY), CTEQ6.6 PDF

Finally use MC → theoretical/modeling uncertainties comparable to statistical uncertainty from data-driven estimates

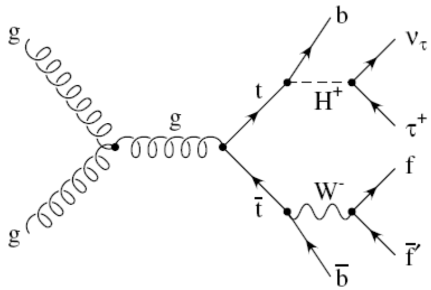


Cross checks on data:

- Control regions with leptons removed from W data
  - In-situ checks for τ background, derived from $W \rightarrow \mu\nu$ events
  - 2 'replacement' methods:
    - smeared resolution function: hadronic τ decay products considered as a single additional τ-jet → τ-jet smearing function calculated from $W \rightarrow \tau\nu$ MC
    - full simulation (embedding)

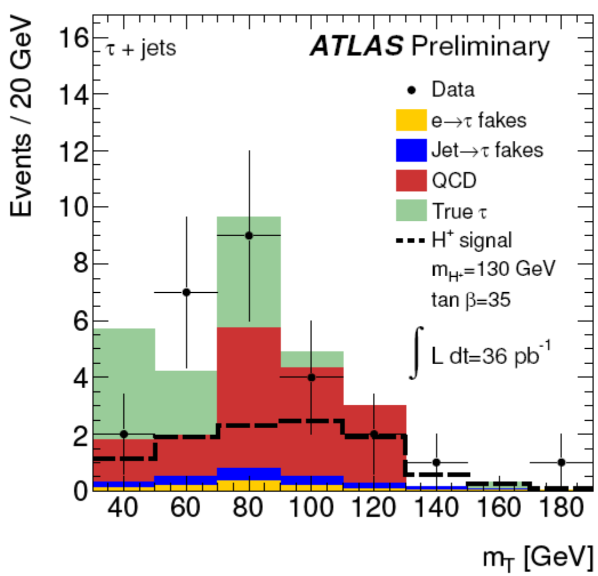
Embedding method for tau: an example

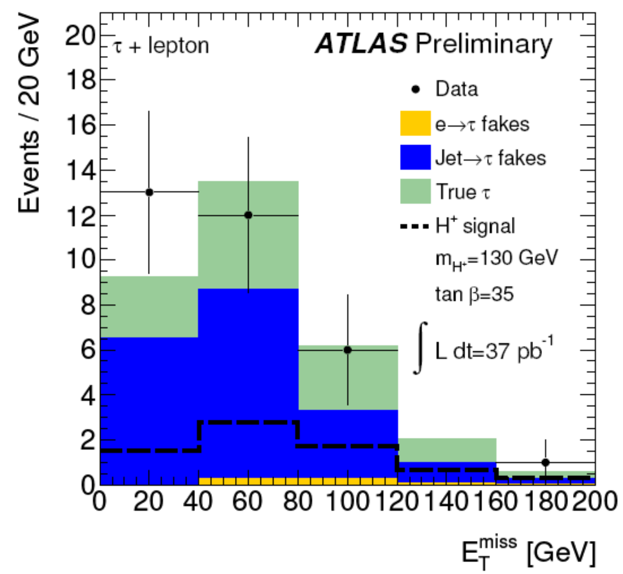
- Method used for data-driven estimates in searches for charged Higgs in τ-hadronic final states:
  - τ+jets and τ+leptons



ATLAS-CONF-2011-051

- SM background estimated with data-driven techniques:
  - Fake τ: e,μ or jets misidentified as τ jets → rate from data
    - e,μ: matrix method; Jets: in γ+jet samples
  - QCD-multijets: in control samples with loose-no-tight τ candidates
  - Real τ (relevant for τ+jets): from top and W+jets with *embedding method*





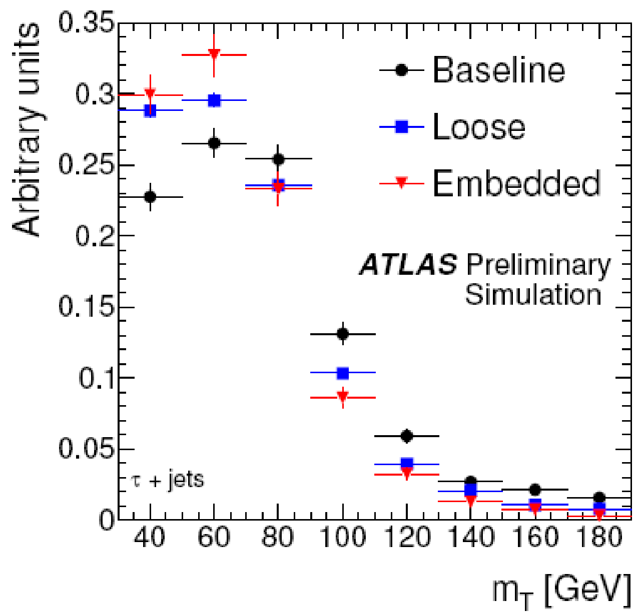
Estimate of true-τ background

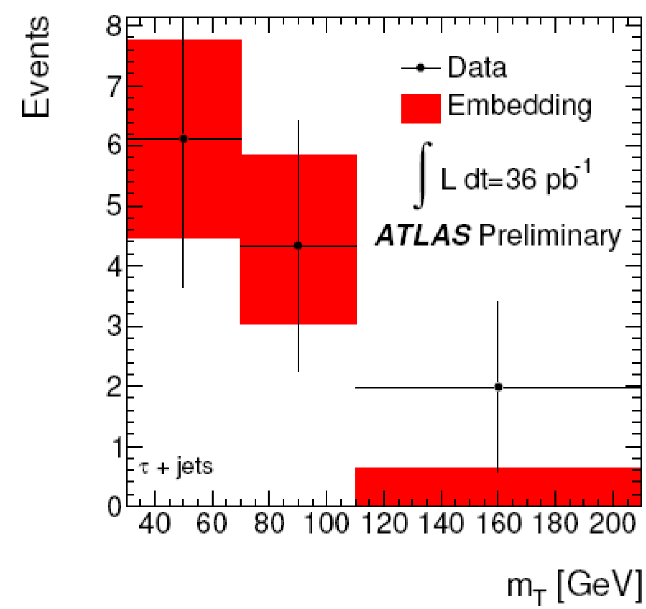
- Control samples with single and top pair production and W+jets events with muons:
  - Replace muon with simulated τ lepton
  - Re-reconstruct new hybrid events
  - Use these events instead of simulation:

    → *Advantage:* whole event is taken from data including pile-up, HF jets etc.

μ+jets sample:
- one isolated m, pT>20 GeV
- at least 3 jets, pT>20 GeV
- at least 1 b-tagged jet
- m(jj) in [M_W± 20 GeV]
- MET>30 GeV, Σ ET > 200 GeV

Method is statistically limited at the moment:
→ Use loose selection with respect to baseline





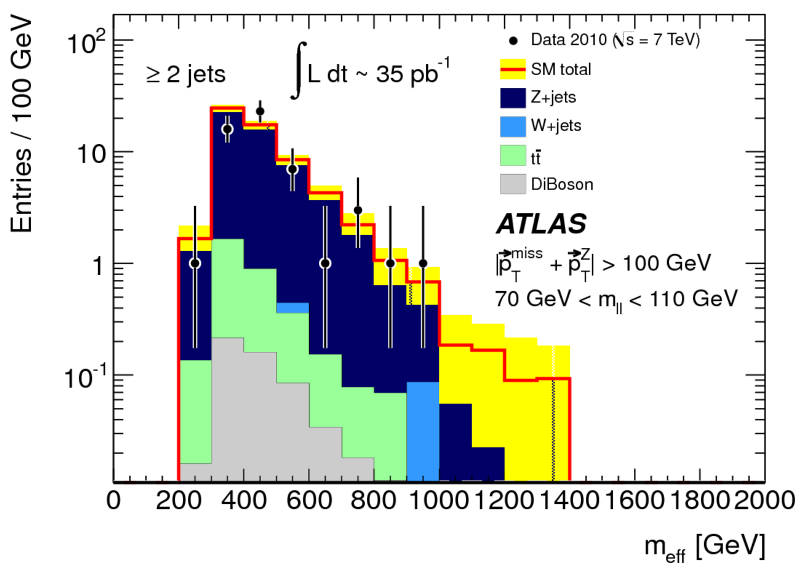
Z + jets in SUSY jets+MET

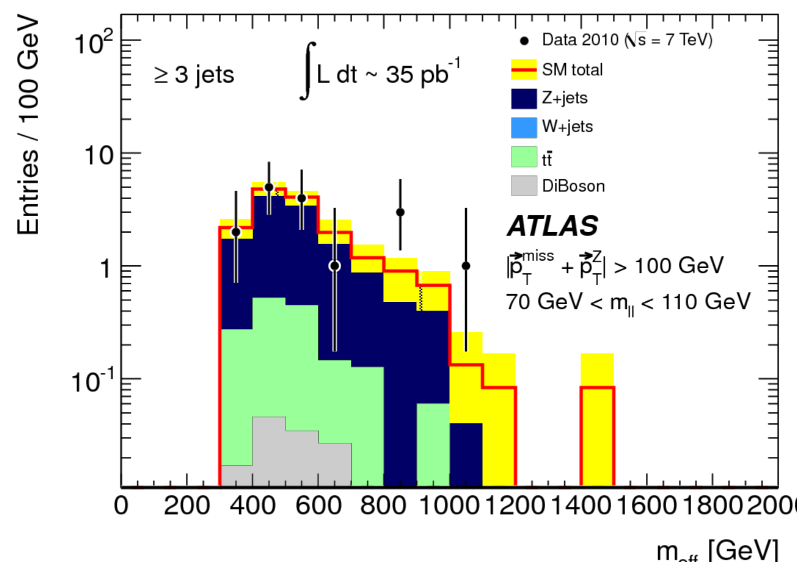
- Z+jets background is dominated by the irreducible Z→νν + jets
- Central value derived from MC:
  - **Z+jets:** ALPGEN normalized to NNLO
- Control regions with leptons removed from Z data

Z+jets control sample

MET recalculated for each event artificially removing the leptons from Z-decay.

Corrections for μ vs ν coverage done with MC





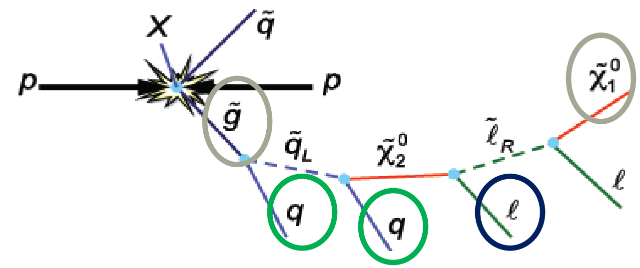
Additional cross checks also performed in γ+jets samples:

→ generally poor statistics at medium/high MET, to be further investigated

Phys. Rev. Lett. 106, 131802 (2011)

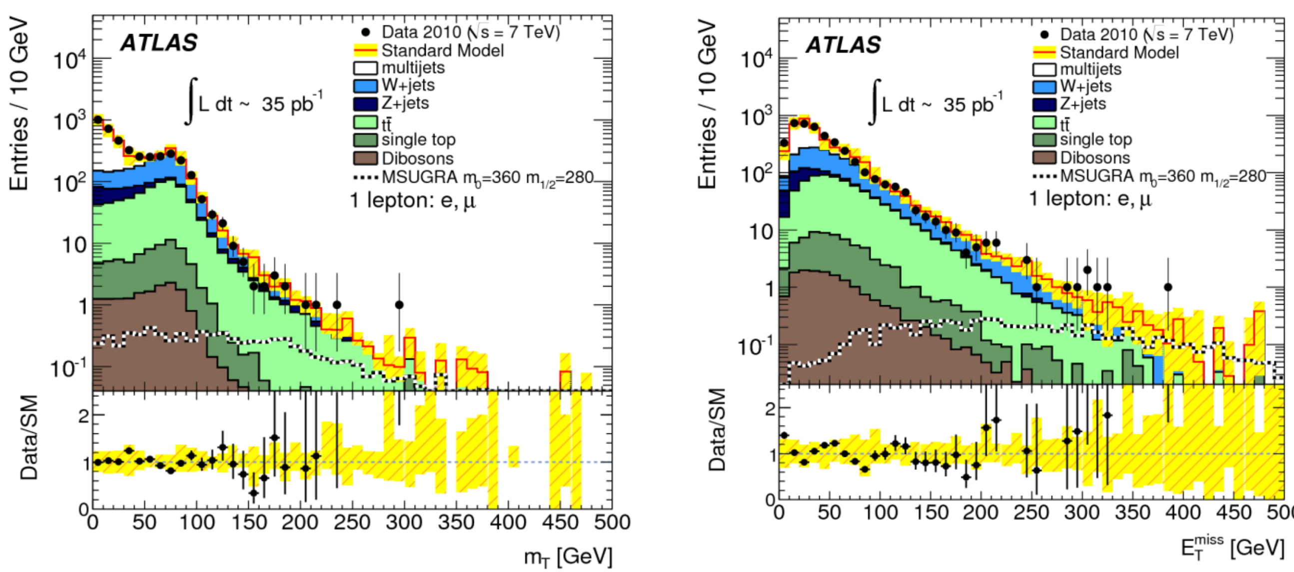
Search in 1-lepton final states

- Require exactly 1 lepton (e or μ, p_T>20 GeV) + ≥3 jets [p_T> 60,30,30 GeV]
  - Privilege signatures from gluino/squark cascade decays with intermediate steps
  - Isolated lepton suppresses QCD multijet background and facilitates triggering



- Use m_T as additional discriminating variable, Missing E_T and jets and leptons p_T

$$m_T \equiv \sqrt{2 \cdot p_T^l \cdot E_T^{Miss} \cdot (1 - \cos(\Delta\varphi(l, E_T^{Miss})))}$$

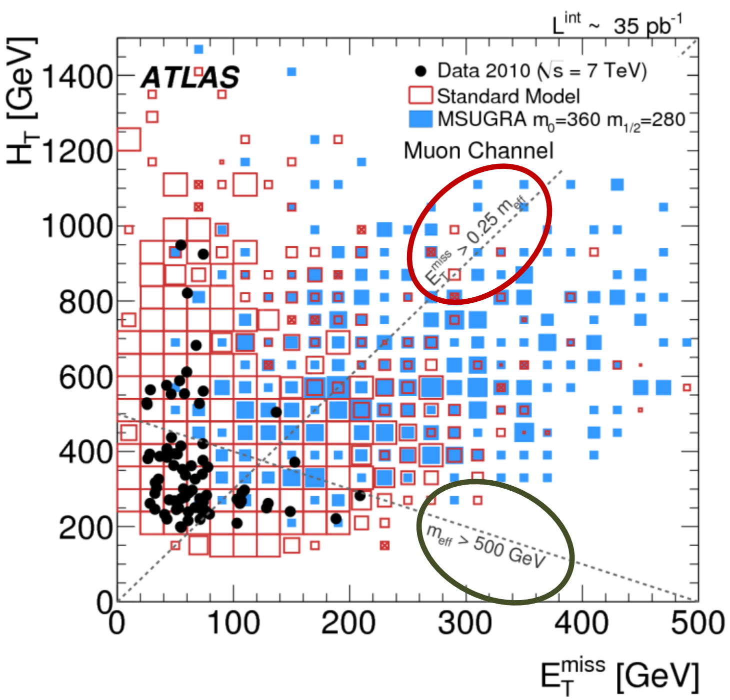


Signal region and results

- Signal region:
  - m_T>100 GeV → to suppress W+jets and top pair production
  - MET/m_{eff} > 0.25 → to suppress QCD background
  - m_{eff}>500 GeV → to enhance sensitivity to SUSY particles

+ $\Delta\phi$(jet, E_T^{Miss}) > 0.2 for QCD rejection

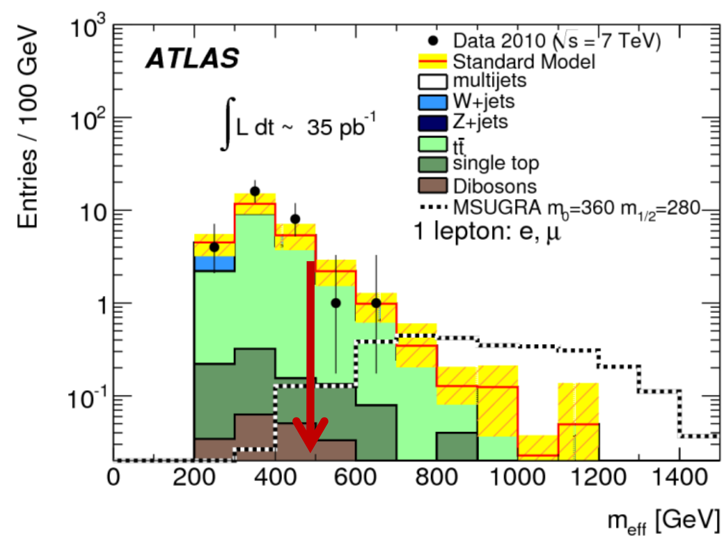
$$H_T = p_T^l + \sum_{i=1}^{3} p_T^{jet_i}$$
$$m_{eff} = H_T + E_T^{Miss}$$



(similar for the electron channel)

After all cuts:

- **One event observed in each channel**
- Main background: top ~ 70%, rest = W+jets
- Estimated with partially data-driven methods



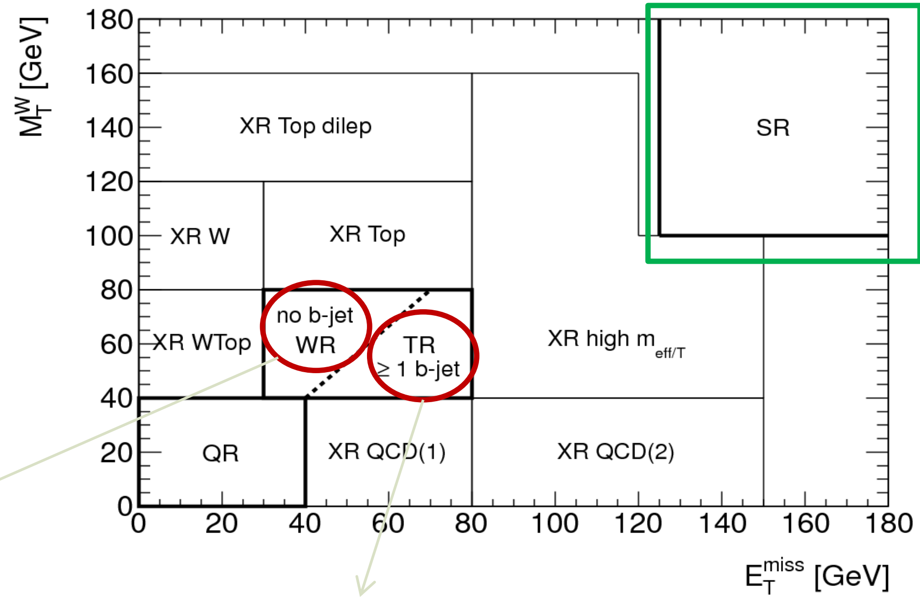
SM background estimation (I)

Exploit use of control regions:

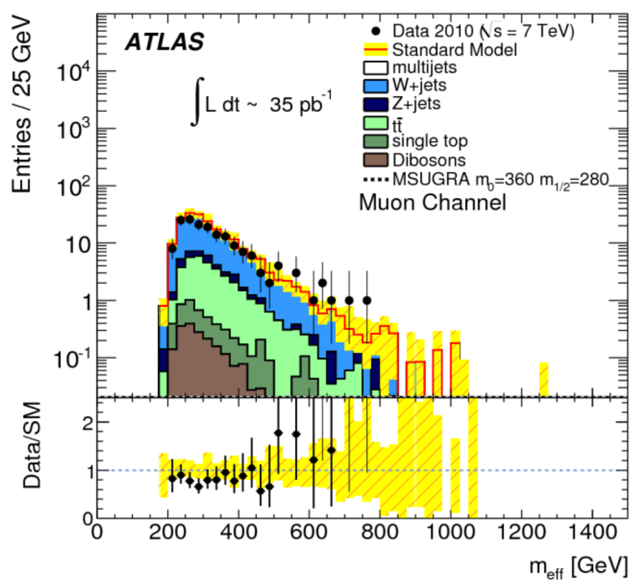
- Based on E_T^{Miss} VS M_T
- Define samples enriched in a given process
- Constrain MC predictions to data in that region *(rely on MC shapes)*
- Extrapolate to other regions (with MC). *Ex.:*

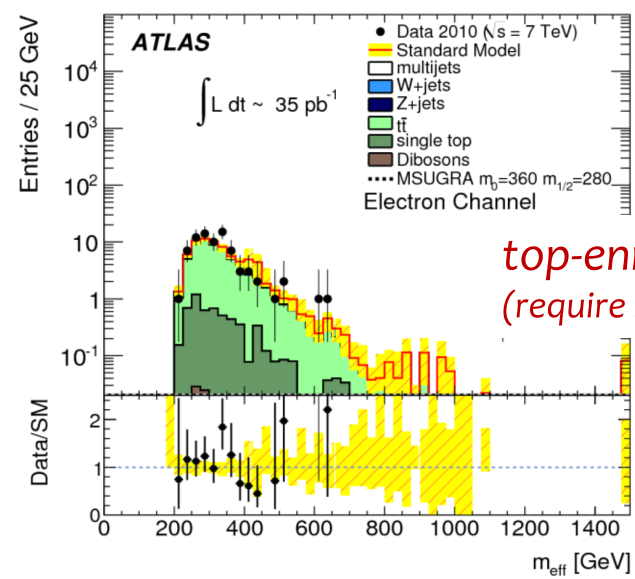
$N^{tt}_{SR}\,(pred) = (N^{data}_{CR} - N^{BkgMC}_{CR}) \times (N^{tt}_{SR,MC} / N^{tt}_{CR,MC})$

- Systematic uncertainties on extrapolation factors



W-enriched sample (require < 1 b-tagged jet)





top-enriched sample (require ≥ 1 b-tagged jet)

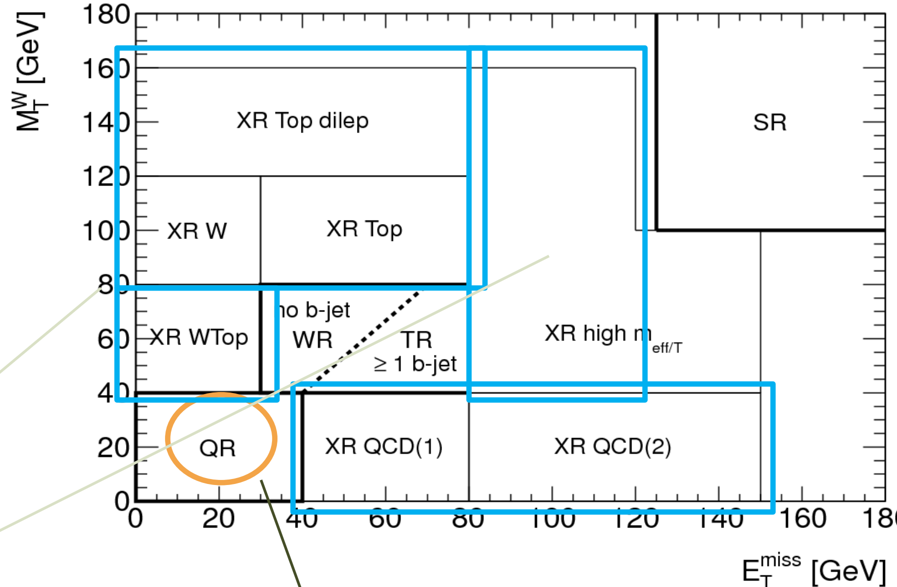
SM background estimation (II)

Exploit use of control regions:

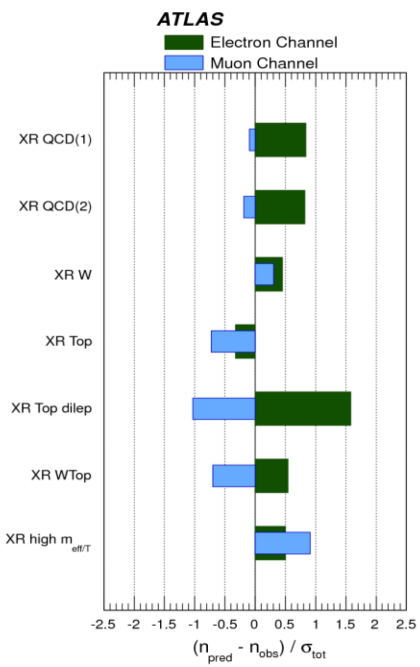
- Based on E_T^{Miss} VS M_T
- Define samples enriched in a given process
- Constrain MC predictions to data in that region *(rely on MC shapes)*
- Extrapolate to other regions (with MC). *Ex.:*

$N^{tt}_{SR}(pred) = (N^{data}_{CR} - N^{BkgMC}_{CR}) \times (N^{tt}_{SR,MC} / N^{tt}_{CR,MC})$

- Systematic uncertainties on extrapolation factors



Used to estimate QCD in other CR



Additional control regions at low M_T or low Missing E_T used to validate the assumption on MC shape.

Pull: $\frac{N_{pred} - N_{obs}}{\sigma_{TOT}}$

Main uncertainties:

1. **Theory/modeling: 50% W+jets** (uncertainty on m_{eff} NLO shape), 25% top (comparison between generators)
2. B-tagging: ~ [10-25]%

Likelihood method (1-lepton)

- Fill all useful information into a likelihood => minimize to estimate bkgs

$$L(n|\mu, b, \theta) \;=\; P_{\mathrm{SR}} \times P_{\mathrm{WR}} \times P_{\mathrm{TR}} \times P_{\mathrm{QR}} \times C_{\mathrm{Syst}}$$

  - One poisson for signal region and for each control region
    → **simultaneous fit of all regions (signal and control)**
  - Systematic uncertainties treated as nuisance parameters

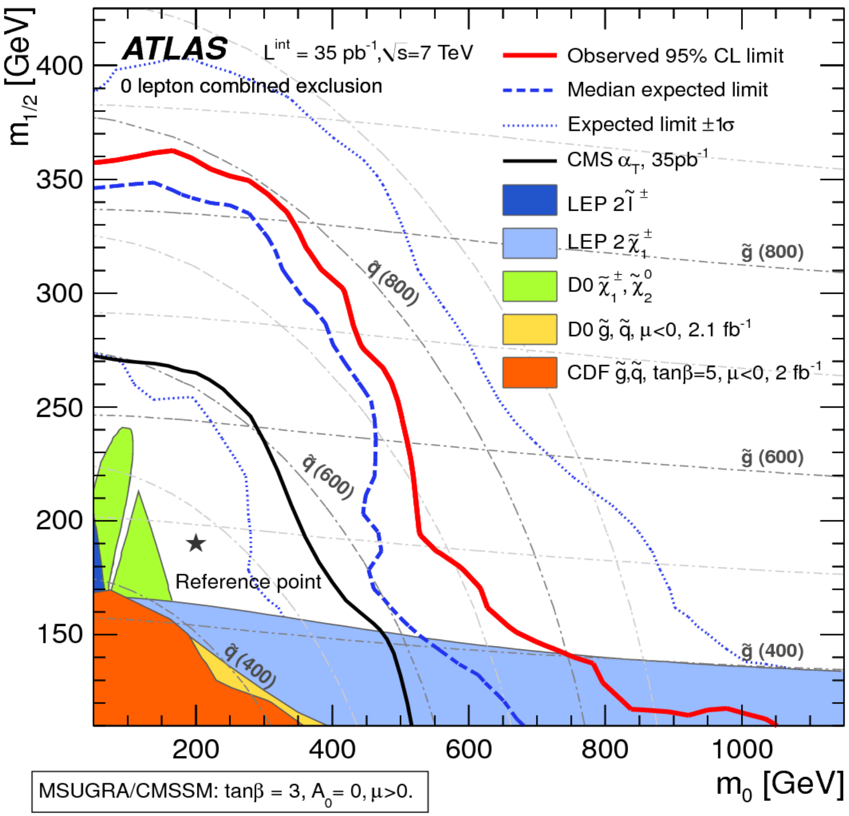
Electron channel	Signal region	Top region	W region	QCD region
Observed events	1	80	202	1464
Fitted top events	1.34 ± 0.52 (1.29)	65.0 ± 12.3 (62.9)	31.8 ± 15.8 (31.0)	40.1 ± 11.3
Fitted W/Z events	0.47 ± 0.40 (0.46)	11.2 ± 4.6 (10.2)	161 ± 27 (146)	170 ± 34
Fitted QCD events	$0.0^{+0.3}_{-0.0}$	3.7 ± 7.6	9.4 ± 19.6	1254 ± 51
Fitted sum of background events	1.81 ± 0.75	80 ± 9	202 ± 14	1464 ± 38

Muon channel	Signal region	Top region	W region	QCD region
Observed events	1	93	165	346
Fitted top events	1.76 ± 0.67 (1.39)	85.0 ± 10.5 (67.1)	41.8 ± 18.6 (33.0)	49.7 ± 10.2
Fitted W/Z events	0.49 ± 0.36 (0.71)	7.7 ± 3.3 (11.6)	120 ± 26 (166)	71.4 ± 16.4
Fitted QCD events	$0.0^{+0.5}_{-0.0}$	0.3 ± 1.2	3.4 ± 12.1	225 ± 22
Fitted sum of background events	2.25 ± 0.94	93 ± 10	165 ± 13	346 ± 19

Fitted predictions in agreement with observation

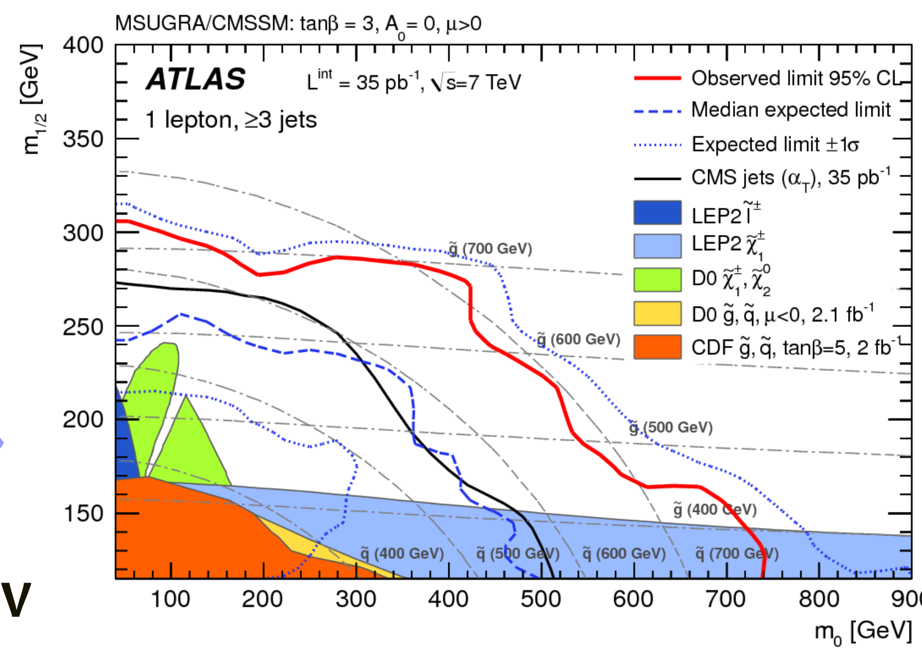
0 and 1-lepton results

Limit in mSUGRA



0-lepton

If $m_{squark}=m_{gluino}$ exclude < 775 GeV



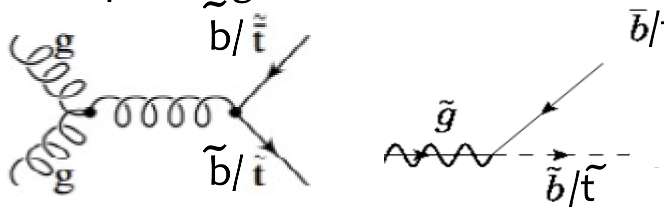
1-lepton

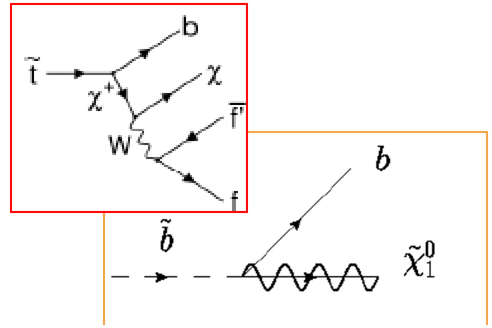
If $m_{squark}=m_{gluino}$ exclude < 700 GeV

Searches in E_T^{Miss}+b-jets

arXiv:1103.4344
Submitted to PLB

- Third generation squarks might be lighter than 1st, 2nd generation → possibly high cross sections:
  - direct pair or gluino-mediated production





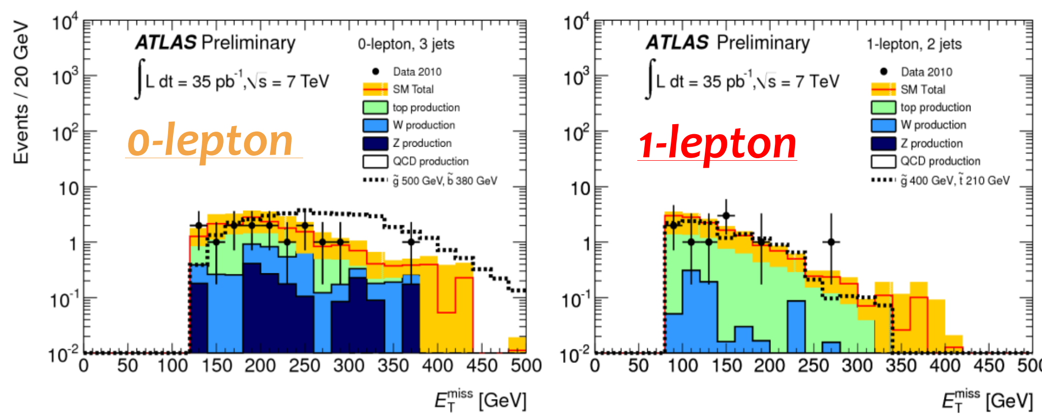
Final state enriched in b-jets → **search in events with jets (≥1 b-jet) +E_T^{Miss} (+ 0/ ≥ 1) leptons**

Event selection

0-lepton	1-lepton
no-lepton ($p_T > 20$ GeV)	≥ 1 lepton ($p_T > 20$ GeV)
jet $p_T > 120, 30, 30$ GeV, $\lvert\eta\rvert < 2.5$	jet $p_T > 60, 30$ GeV, $\lvert\eta\rvert < 2.5$
$E_T^{miss} > 100$ GeV	$E_T^{miss} > 80$ GeV
$E_T^{miss}/m_{eff} > 0.2$	–
At least 1 b-tagged jet (SV0, $L/\sigma(L) > 5.72$, $p_T > 30$GeV, $\lvert\eta\rvert < 2.5$)	
$\Delta\phi_{min} > 0.4$ rad	$m_T > 100$ GeV

	0-lepton	1-lepton Monte Carlo	1-lepton data-driven
$t\bar{t}$ and single top	12.2 ± 5.0	12.3 ± 4.0	14.7 ± 3.7
W and Z	6.0 ± 2.0	0.8 ± 0.4	-
QCD	1.4 ± 1.0	0.4 ± 0.4	$0^{+0.4}_{-0.0}$
Total SM	19.6 ± 6.9	13.5 ± 4.1	14.7 ± 3.7
Data	15	9	9

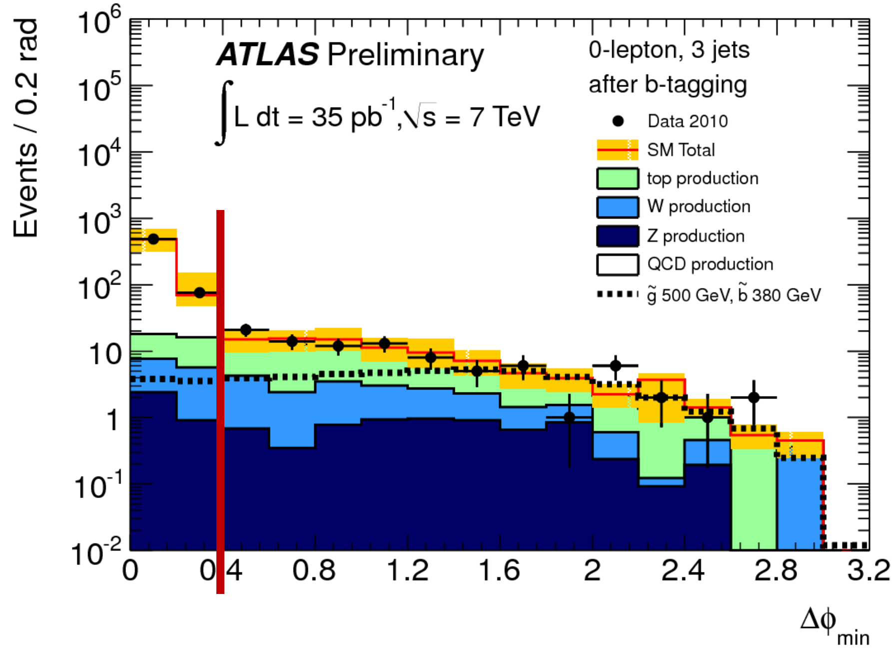
Signal regions:
0-lepton: M_{eff} > 600 GeV
1-lepton: M_{eff} > 500 GeV



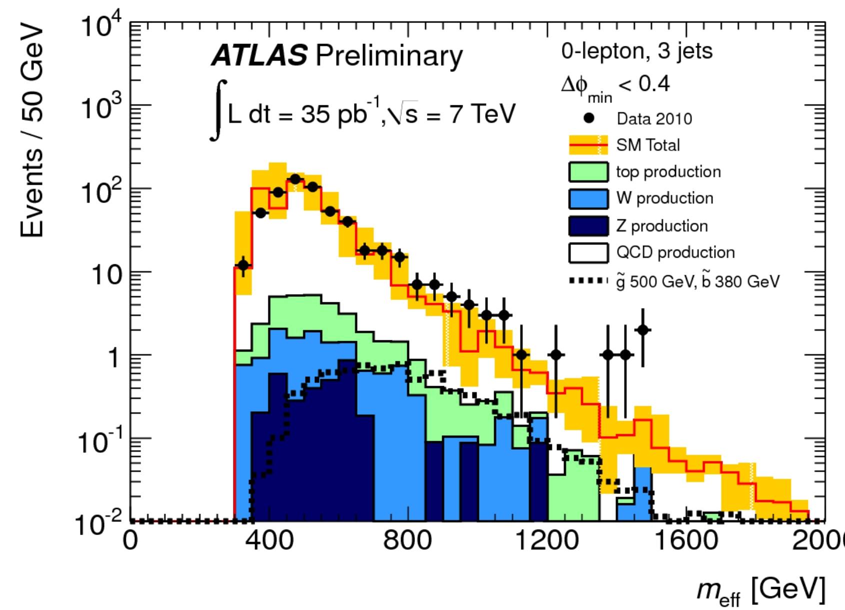
SM Background: 0-lepton

- →**QCD:** Partially data-driven
- →**Top/Boson+jets:** MC estimate

Revert $\Delta\phi_{min}$<0.4



Take Meff shape from $\Delta\phi_{min}$ <0.4 Uncertainties (~60%) driven by statistics



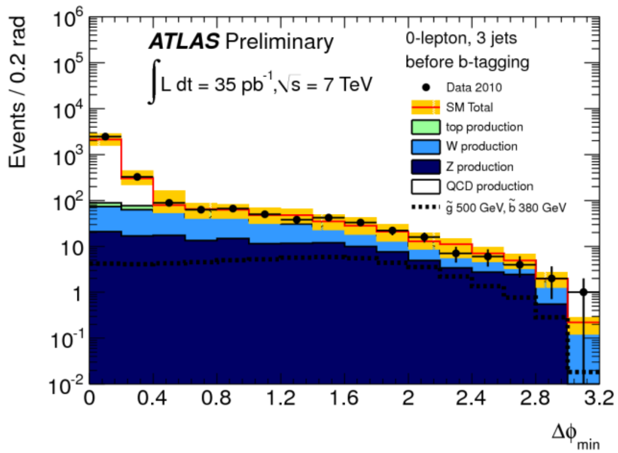
From MC: take fraction of QCD events passing $\Delta\phi_{min}$ >0.4

0-lepton bkg details (b-jets)

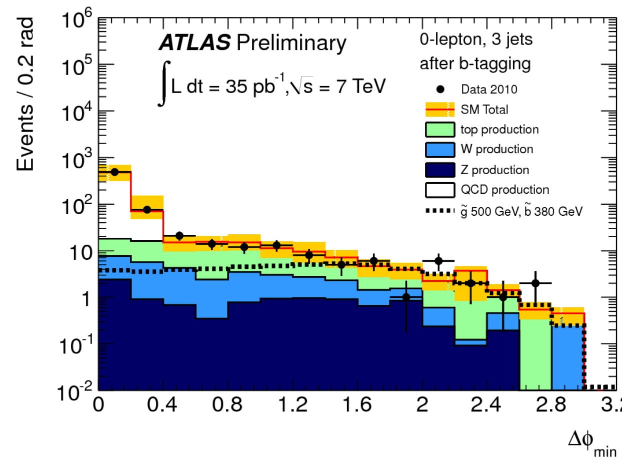
- Breakdown of non-QCD SM-background contributions (from MC) for 0-lepton analysis at each stage of the selection (per pb^{-1})

Cut	$t\bar{t}$	W+ jets	Wbb	Z + jets	Zbb	single top
$E_T^{miss} > 100$ GeV	3.55 ± 0.02	9.29 ± 0.15	0.1 ± 0.01	4.66 ± 0.14	0.054 ± 0.002	0.30 ± 0.02
$E_T^{miss}/m_{eff} > 0.2$	3.05 ± 0.02	8.36 ± 0.14	0.09 ± 0.01	4.28 ± 0.14	0.047 ± 0.001	0.26 ± 0.02
1 b-tagged jet	2.15 ± 0.02	0.69 ± 0.04	0.06 ± 0.01	0.28 ± 0.03	0.022 ± 0.001	0.16 ± 0.01
$\Delta\phi_{min} > 0.4$	1.60 ± 0.02	0.42 ± 0.03	0.05 ± 0.01	0.19 ± 0.03	0.016 ± 0.001	0.11 ± 0.01
$m_{eff} > 600$ GeV	0.33 ± 0.01	0.11 ± 0.02	0.006 ± 0.002	0.05 ± 0.01	0.0031 ± 0.0003	0.02 ± 0.01

Selection	Expected events	Observed Events
$E_T^{miss} > 100$ GeV	4800 ± 1600	5834
$E_T^{miss}/m_{eff} > 0.2$	2800 ± 900	3221
b-tag	620 ± 200	656
$\Delta\phi_{min} > 0.4$	90 ± 30	91
$m_{eff} > 600$ GeV	20 ± 7	15



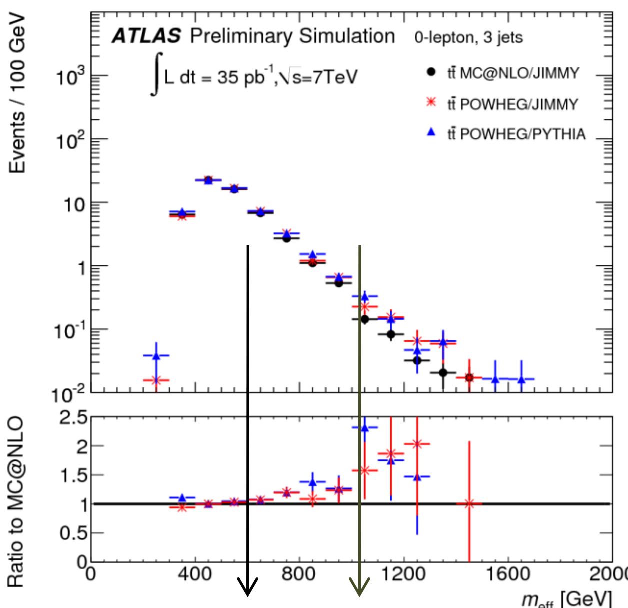
b-tagging



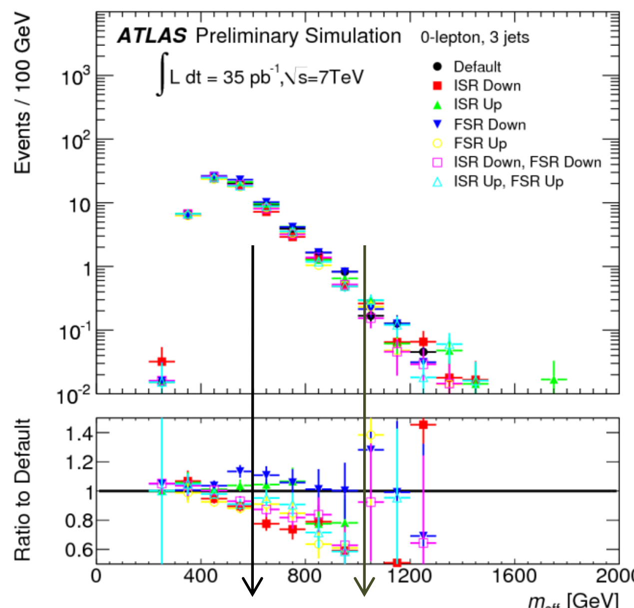
Systematic uncertainties

- 0-lepton analysis: theoretical uncertainties larger than JES at high meff values

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



Meff: 600 GeV → 1 TeV



Meff: 600 GeV → 1 TeV

Tails of relevant distributions for SUSY event selection affected by large theoretical uncertainties.

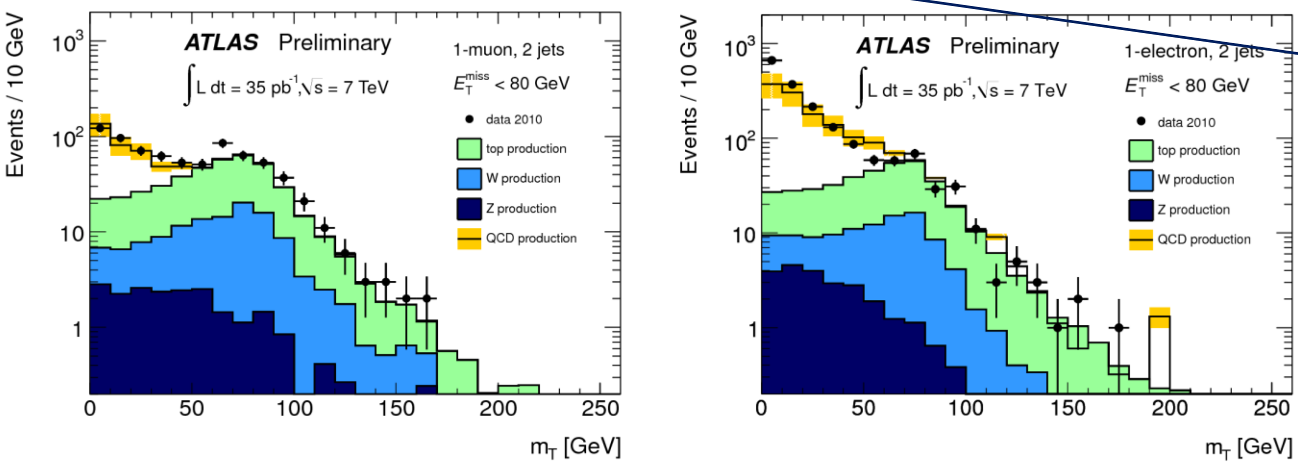
1 lepton bkg details (b-jets)

- QCD estimation from a Matrix method relying on 2 data sets differing only in the lepton ID criteria: tight (standard) and loose (relaxed):

$$N^{tight}_{fake} = \frac{\varepsilon_{fake}}{\varepsilon_{real} - \varepsilon_{fake}} (N^{loose} \varepsilon_{real} - N^{tight})$$

ε_{real}=measured in Z-samples

ε_{fake}=measured QCD-enriched sample



QCD yield consistent with 0 in the signal region

- Breakdown of non-QCD SM-background contributions for 1-lepton analysis at each stage of the selection

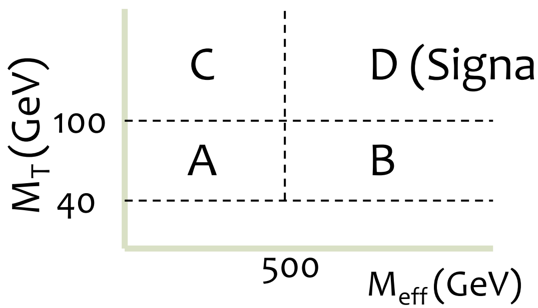
Cut	Top	W	Z	QCD	Di–boson production
1 electron with $p_T > 20$ GeV	24.4	3760	631.4	16865	6.2
2 jets ($p_T > 60, 30$ GeV)	17.2	59.6	21.2	590	1.0
$E_T^{miss} > 80$ GeV	4.6	10.4	0.3	6.6	0.2
$m_T > 100$ GeV	1.0	0.38	0.025	0.08	0.0021
1 b-tag	0.70	0.016	3×10^{-4}	0.06	0.0013
$m_{eff} > 500$ GeV	0.18	0.011	–	–	–

Cut	Top	W	Z	QCD	Di–boson production
1 muon with $p_T > 20$ GeV	24.4	4700	770	4880	6.8
2 jets ($p_T > 60, 30$ GeV)	17.3	70	15.5	65	1.0
$E_T^{miss} > 80$ GeV	4.7	12	0.63	0.02	0.21
$m_T > 100$ GeV	1.0	0.57	0.037	1×10^{-4}	0.02
1 b-tag	0.67	0.03	0.002	–	0.002
$m_{eff} > 500$ GeV	0.17	0.013	–	–	–

SM Background: 1-lepton (II)

→**Data-driven techniques** for all bkg

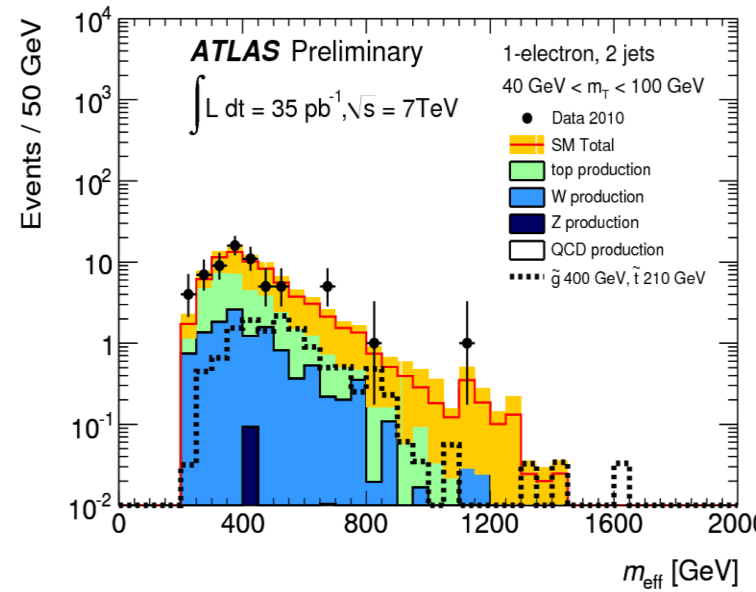
- →QCD: "matrix-method" as in previous analyses
- →Top/Boson+jets: exploit low correlation between M_T and M_{eff}

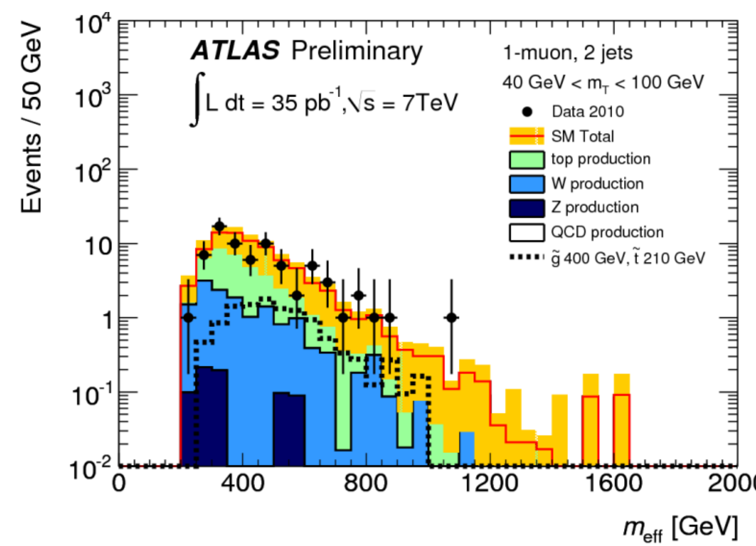


$$N_D^{SM} = N_C / N_A \times N_B$$

Region	Data	Monte Carlo
A: $40 < m_T < 100$ GeV and $m_{eff} < 500$ GeV	103	105.1 ± 1.5
B: $m_T > 100$ GeV and $m_{eff} < 500$ GeV	46	35.9 ± 0.5
C: $40 < m_T < 100$ GeV and $m_{eff} > 500$ GeV	33	40.1 ± 0.8
D: $m_T > 100$ GeV and $m_{eff} > 500$ GeV	9	13.5 ± 0.4
Estimation	14.7 ± 3.7	13.7 ± 0.4
Ratio	(164 ± 41) %	(101.2 ± 2.9)%

"Closure-test" with MC → good agreement with data

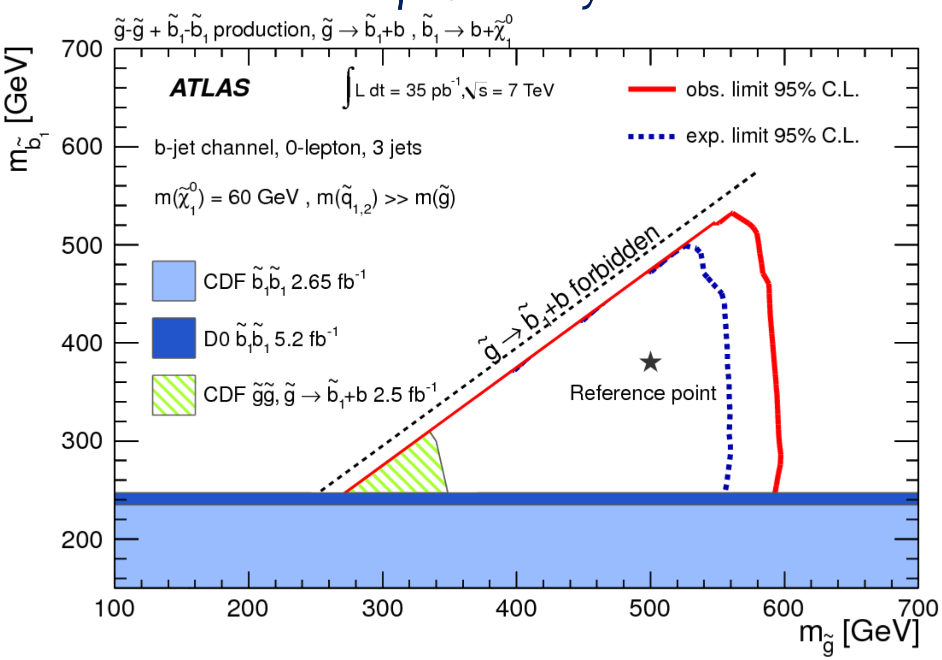




Interpretation in pheno-MSSM

- Assume gluino decays in $\tilde{b}_1 b$ (BR=100%) and $\tilde{b}_1 \rightarrow b\tilde{\chi}^0_1$ (BR=100%)
- $m(\tilde{\chi}^0_1)$=60 GeV

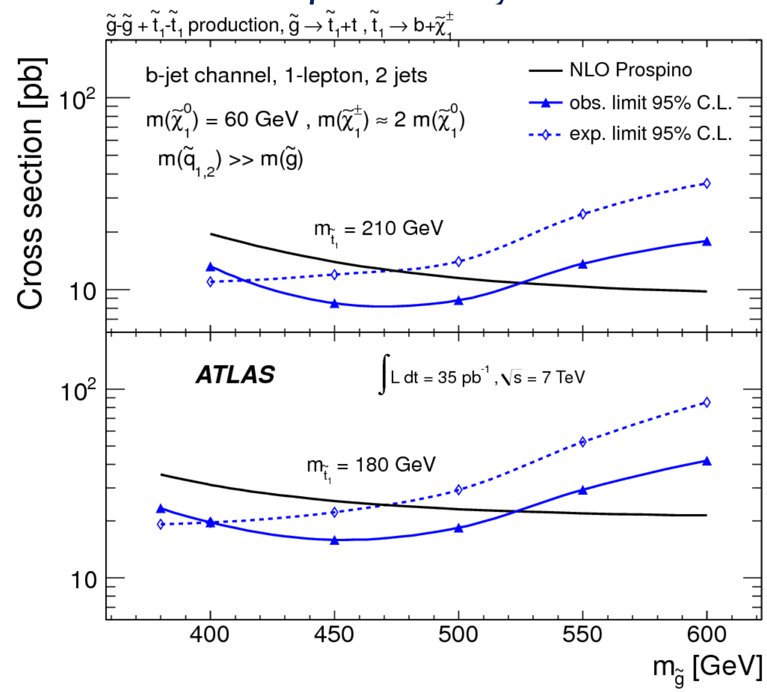
0-lepton analysis



Gluino masses below 590 GeV excluded for sbottom masses below 500 GeV

- Assume gluino decays in $\tilde{t}_1 t$ (BR=100%) and $\tilde{t}_1 \rightarrow b\tilde{\chi}^+_1$ (BR=100%), $\tilde{\chi}^+_1 \rightarrow W^*\chi^0_1$
- $m(\tilde{\chi}^0_1)$=60 GeV , $m(\chi_1) \approx 2 \times m(\chi^0_1)$

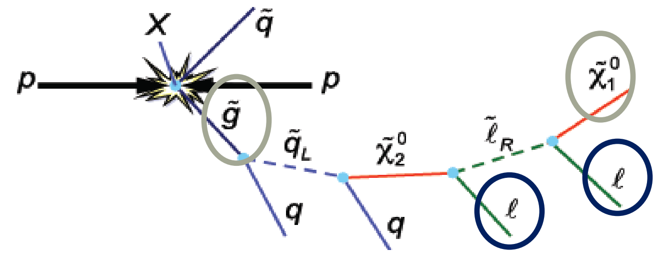
1-lepton analysis



Gluino masses below 520 GeV excluded for stop masses below 300 GeV

2-leptons analysis

- Search for dilepton (e,μ) pairs from neutralino/chargino decays
- Two search strategies, requiring opposite-sign (OS) and same-sign (SS) dileptons events



Event selection

- exactly two leptons
- M(ll) > 5 GeV

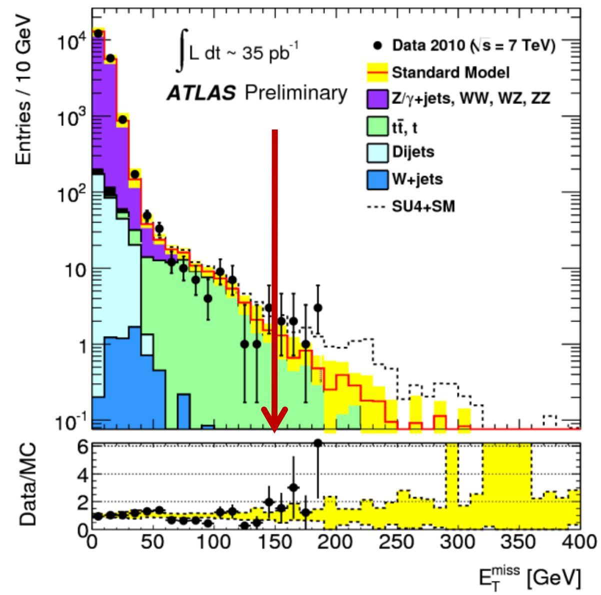
Signal regions

- OS: $E_T^{Miss} > 150$ GeV
- SS: $E_T^{Miss} > 100$ GeV

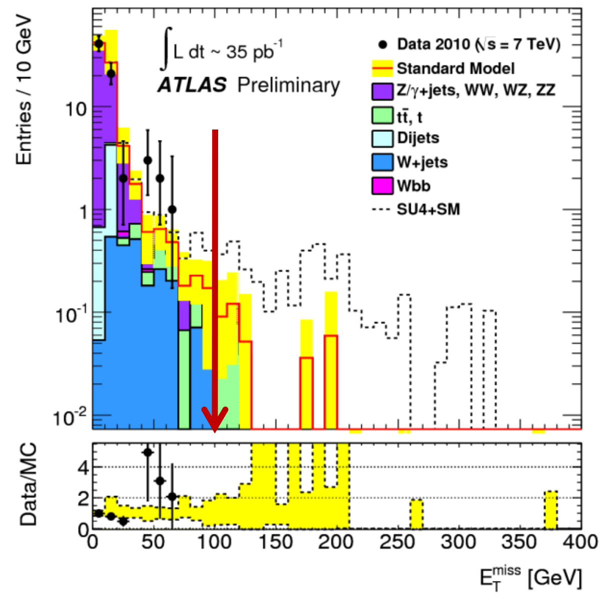
Main SM Background

- OS: **top pair** (estimate in CR)
- SS: misidentified leptons (fakes) → data-driven as in previous analyses

Opposite-Sign



Same-Sign

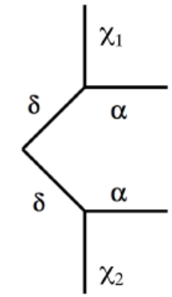


Top background for OS

Dileptonic top decays $tt \rightarrow l^+ \nu b\, l^- \nu b$

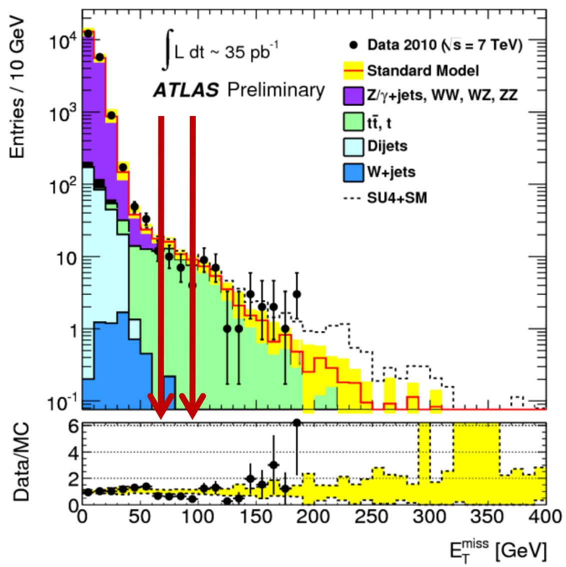
- **"Top tagging" algorithm** based on contransverse mass (m_{CT})

$$m_{CT}^2(\chi_1,\chi_2) = [E_T(\chi_1)+E_T(\chi_2)]^2 - [\mathbf{p_T}(\chi_1) - \mathbf{p_T}(\chi_2)]^2$$



Control Sample

- E_T^{Miss} [60,80] GeV, ≥2 jets with p_T>20 GeV
- Calculate m_{CT} from 4-vectors of leptons and jets → must be consistent with $t\bar{t}$ bounds
- m(jet,l1) and m(jet,l2) consistent with top decays



Data CR: 15 top-tagged events
MC CR: 21.3±3.8 (18.8 from ttbar)

Estimation in Signal Region →

$$(N_{tt})_{SRch} = \left((N^{tag}_{data})_{CR} - (N^{tag}_{non-tt,MC})_{CR}\right) f^{CR\rightarrow SR}_{MC}$$

$$f^{CR\rightarrow SR}_{MC} = (N_{top,MC})_{SRch} / (N^{tag}_{top,MC})_{CR}$$

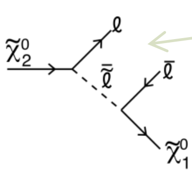
2.8+1.4-1.3

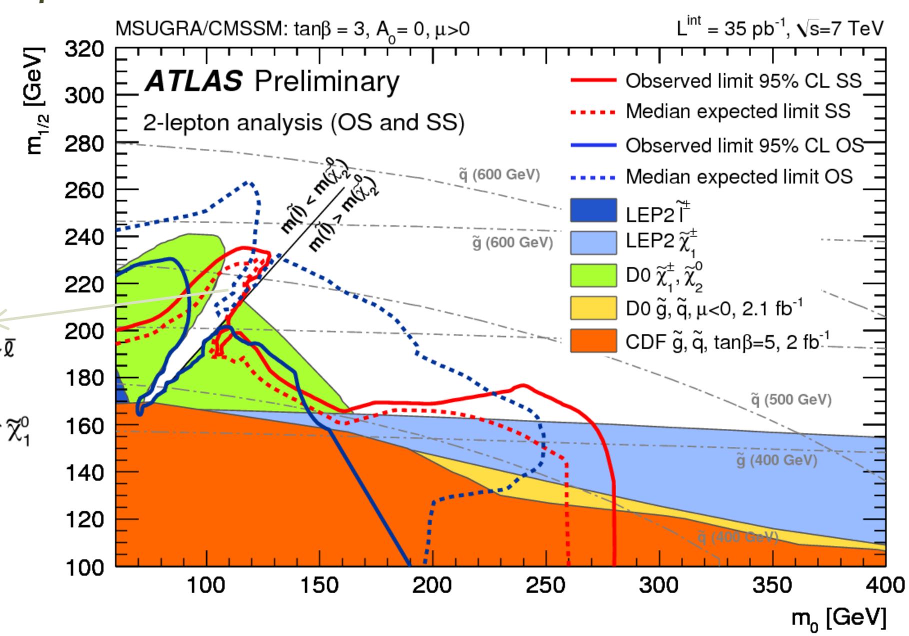
Results

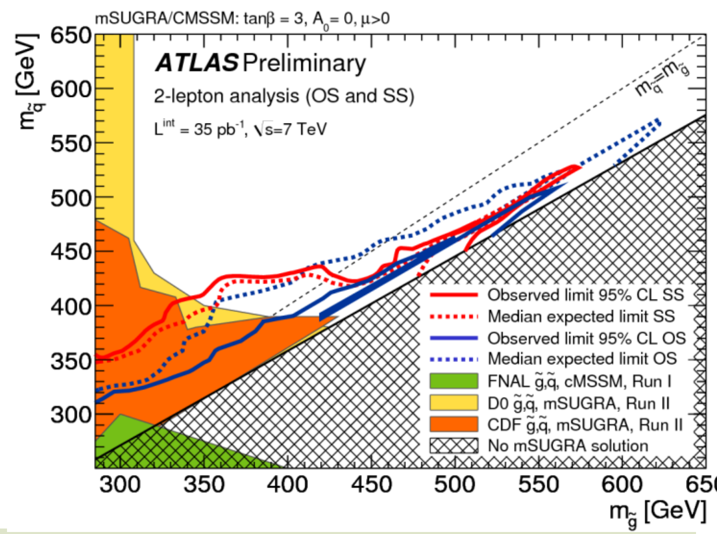
- Agreement between data and SM expectations within uncertainties:
- Use sum of ee,μμ,eμ channel for SS, combination of the three channels for OS
- 95% C.L. upper limits on effective cross section σ · A·BR from new physics:
  - SS: σ<0.07 pb
  - ee: 0.09 pb, μμ: 0.21 pb, eμ: 0.22 pb

	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	0.03±0.026	0.014±0.01
Di-bosons	0.015±0.005	0.021 ±0.009	0.035 ±0.012
Charge-flip	0.019+0.008	0.026 +0.011	-
Cosmic	-	$0^{+1.32}_{-0}$	-
Total	0.14 + 0.13	$0.08^{+1.32}_{-0.03}$	0.05 +0.01
	Opposite Sign, $E_T^{miss} > 150$ GeV		
	$e^\pm e^\mp$	$e^\pm \mu^\mp$	$\mu^\pm \mu^\mp$
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	$0.03^{-0.05}_{-0.03}$	$0.06^{+0.08}_{-0.06}$	0.10 ± 0.07
Di-bosons	0.09 ± 0.03	0.06 ± 0.03	0.15 ± 0.07
Cosmics	-	$0^{+1.32}_{-0}$	$0^{+1.32}_{-0}$
Total	$0.92^{+0.42}_{-0.40}$	$1.43^{+1.58}_{-0.59}$	$1.39^{+1.53}_{-0.53}$

Interpretation in mSUGRA







Bkg estimate methods

Difficult to summarize, but let's try …

- **MC based approach:** MC based estimate where both the shape and the rate in the signal region (SR) are estimated from MC

- **Mixed data and MC based via overall corrections :** estimate where the MC rate is constrained by data in a control sample (CS), but the MC is used to extrapolate from the control sample to the signal region

$$N^{V}_{SR,est.} = \frac{N^{V}_{SR,MC}}{N^{V}_{CS,MC}} \times (N_{CS,data} - N_{CS,bkg})$$

→***Pros:*** remove uncertainties on Lumi and total σ, factorize part of detector and theoretical uncertainties (if Control Sample CS ~ similar topology)

→***Cons:*** central value possibly affected by large statistical fluctuation in CS. Theoretical uncertainties might be quite large.

- **Event based correction on data:** A quasi data-driven approach, where both the number of events and the shape are taken from a data CS. In case correction factors must be applied to account for the acceptance and ID efficiency of the events in the CS → taken from data when possible, otherwise from Monte Carlo.

Conclusions

- Several approaches followed to estimate SM background contributions in SUSY searches, depending on the analysis variables (jet multiplicity, explicit lepton requirement, with/without b-tagging)
  - Common features:
    - define control regions orthogonal to signal samples
    - use MC tools to estimate shapes, data-driven techniques for normalization

  Only a few examples shown here
- Larger use of data-driven techniques with more data:
  - Analyzing already 170 pb^{-1} of 2011 data
  - in most cases, use of MC samples unavoidable (acceptance corrections, control sample-to-signal region corrections).
    → *Reducing theoretical uncertainties might be the key-issue for kinematic regimes interesting for searches*

Back-up slides

The ATLAS detector

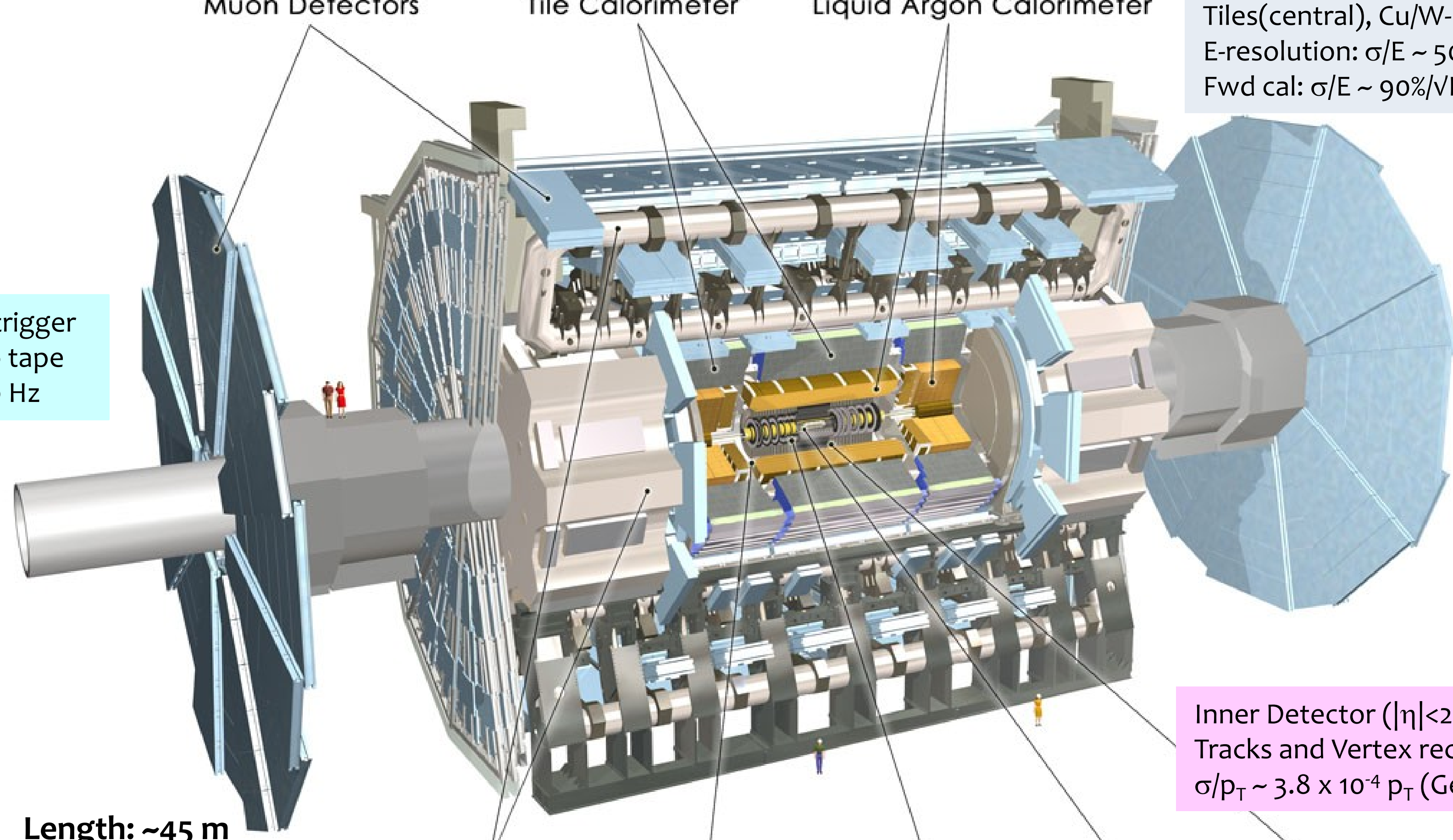
Spectrometer coverage up to $|\eta|<2.7$
Trigger and measurement for μ with momentum resolution < 10% up to $E_\mu \sim 1$ TeV

EM calorimeter, e/γ trigger, ID, measurement
Resolution: $\sigma/E \sim 10\%/\sqrt{E} \oplus 0.007$

Coverage up to $|\eta|=4.9$

HAD calorimeter (jets, MET)
Tiles(central), Cu/W-Lar (fwd)
E-resolution: $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$
Fwd cal: $\sigma/E \sim 90\%/\sqrt{E} \oplus 0.07$

3-level trigger
rate to tape
~200 Hz



Inner Detector ($|\eta|<2.5$)
Tracks and Vertex reconstructions
$\sigma/p_T \sim 3.8 \times 10^{-4}\, p_T\,(\text{GeV}) \oplus 0.015$

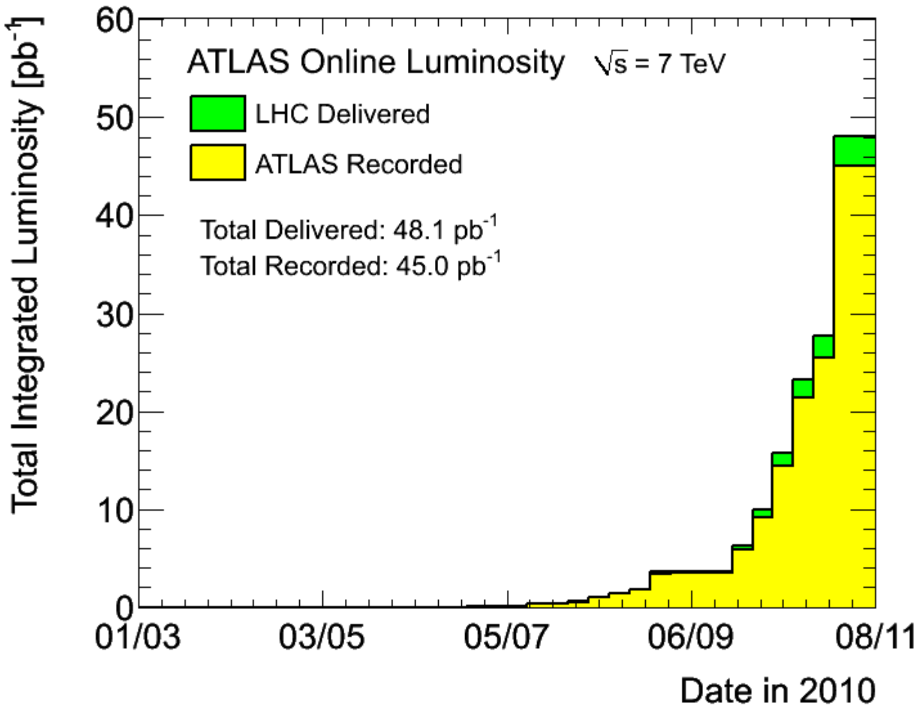
Length: ~45 m
Radius: ~12 m
Weight: ~7000 tons

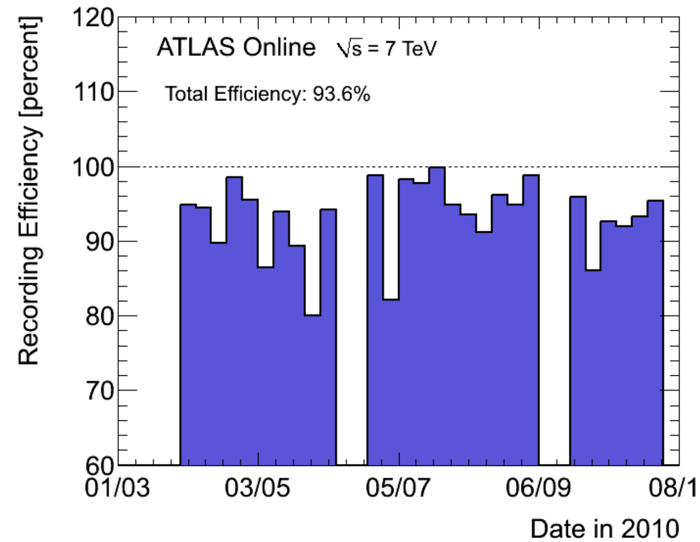
2 T magnetic field

The 2010 ATLAS pp data

- Profiting at best from the excellent LHC performance:
  - Maximum values of 6 pb^{-1} luminosity per day
  - Instantaneous luminosity values up to 2 × 10^{32} cm^{-2} s^{-1}
- Detector efficiency above 90%

~ 35 pb-1 of data used in the analyses presented here

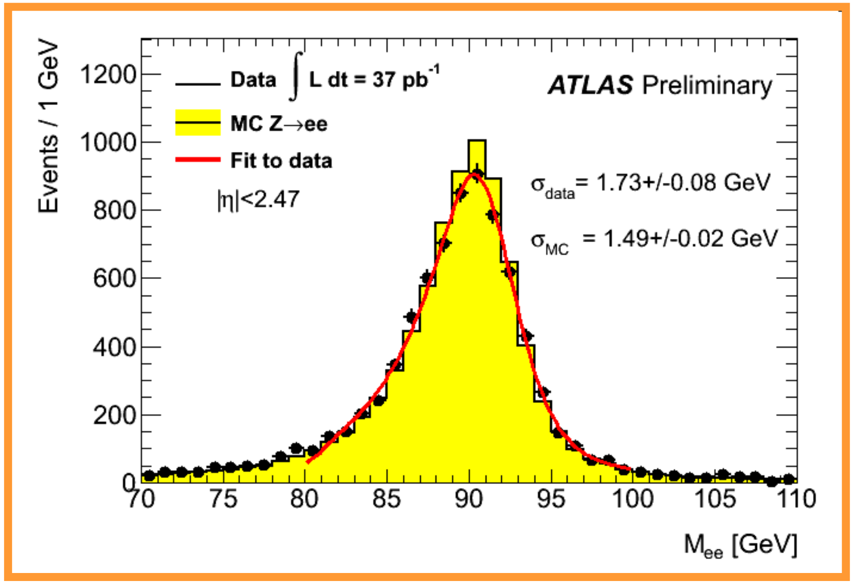


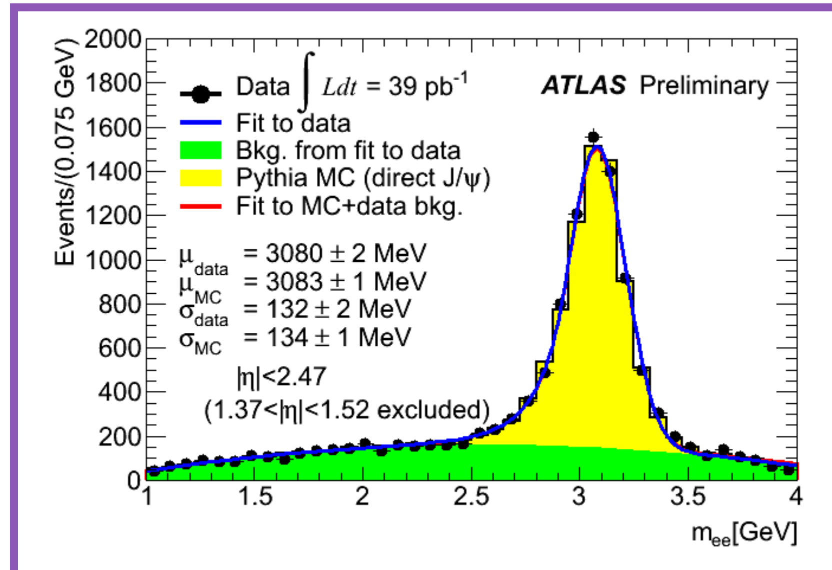


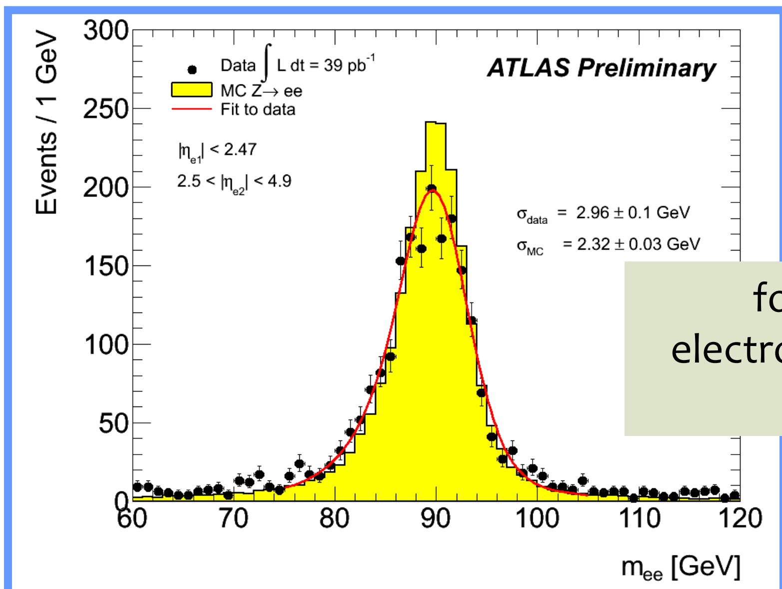
Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.1	99.9	100	90.7	96.6	97.8	100	99.9	99.8	96.2	99.8

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.

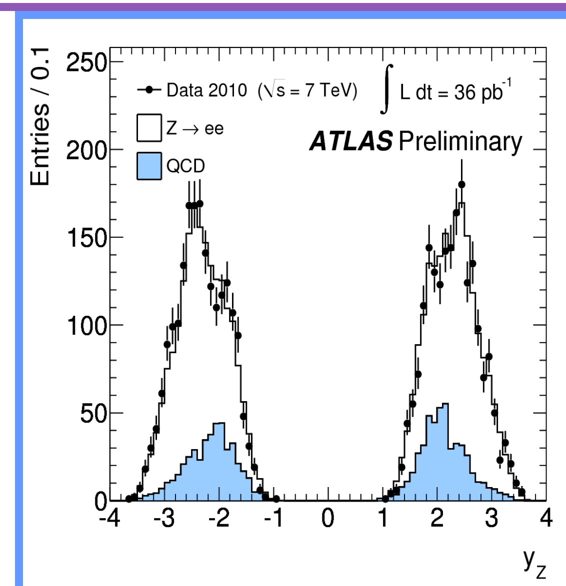
Electron Performance Results







forward-central Zs
electrons above the tracker
acceptance

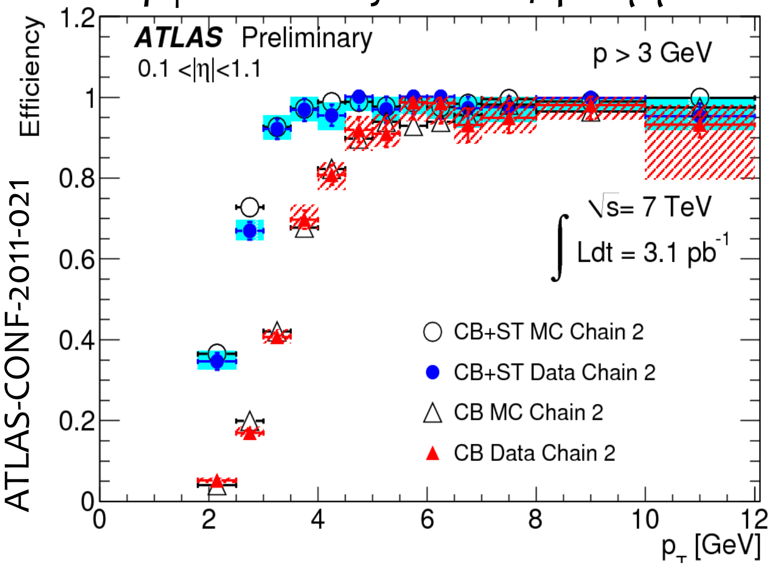


ATLAS-CONF-2011-041

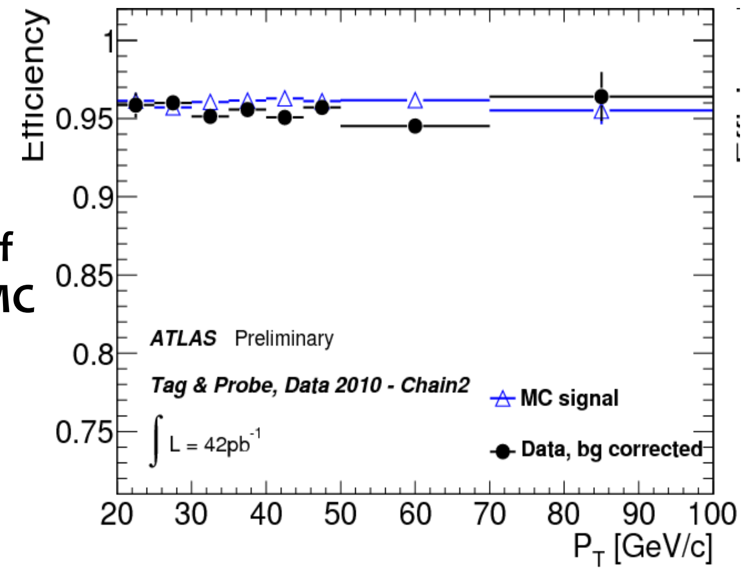
ID and Muon Combined Performance

Low p_T efficiency from $J/\psi \rightarrow \mu\mu$ decays

ATLAS-CONF-2011-021



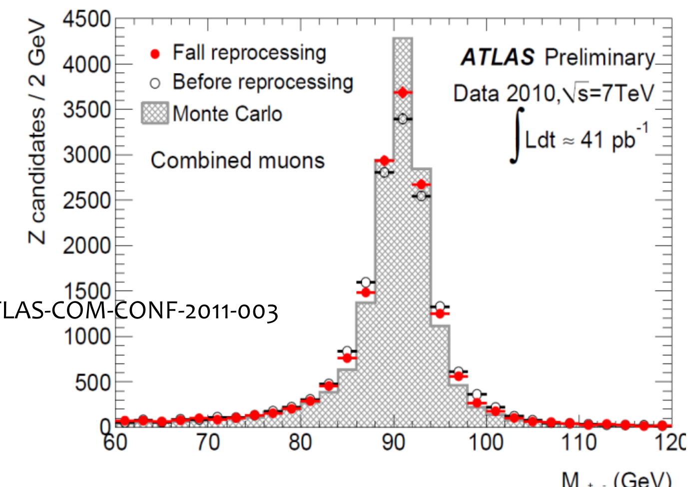
High p_T efficiency from $Z \rightarrow \mu\mu$ decays



ATLAS-CONF-2011-046

Very good description of alignment in MC

Efficiency understood down to very low p_T



ATLAS-COM-CONF-2011-003

Present understanding of ID alignment

Detector type	coordinate	Barrel	End-caps
		c [μm]	
Pixel	local x	4	7
	local y	18	35
SCT	local x	10	11
TRT		0	0

Smear MC hit uncertainties

$$\sigma = a * \sigma \oplus c$$

$$a = 1$$

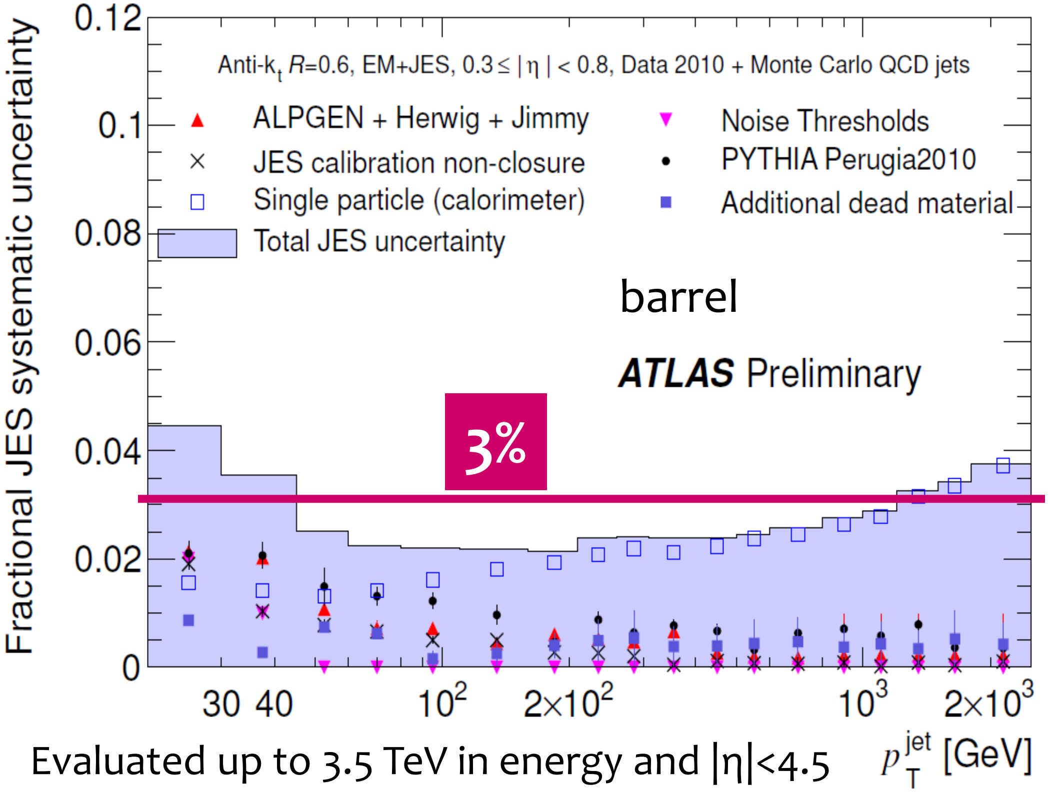
Improved momentum scale and resolution

muon scale uncertainty is < 1%

dimuon mass resolution 1.8% barrel and 3% end-cap

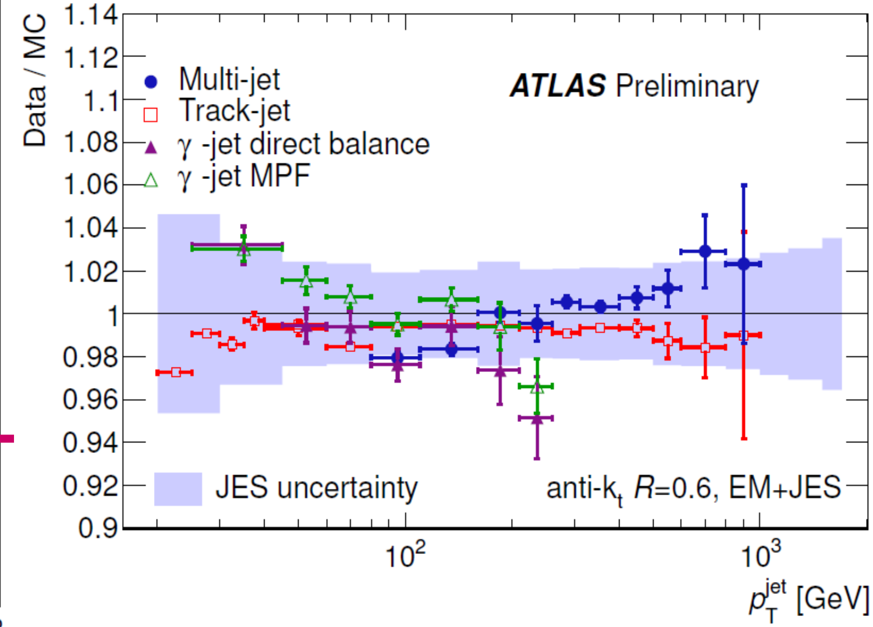
Jet Energy Scale

ATLAS-CONF-2011-032



Evaluated up to 3.5 TeV in energy and |η|<4.5

In-situ calibrations

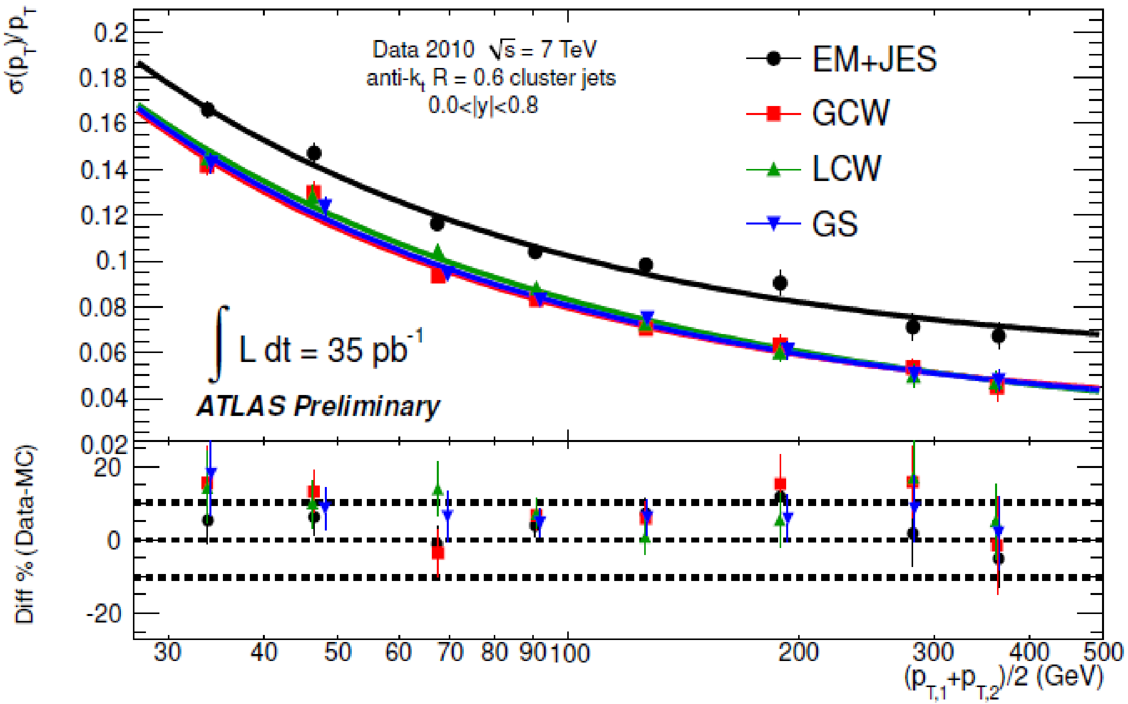


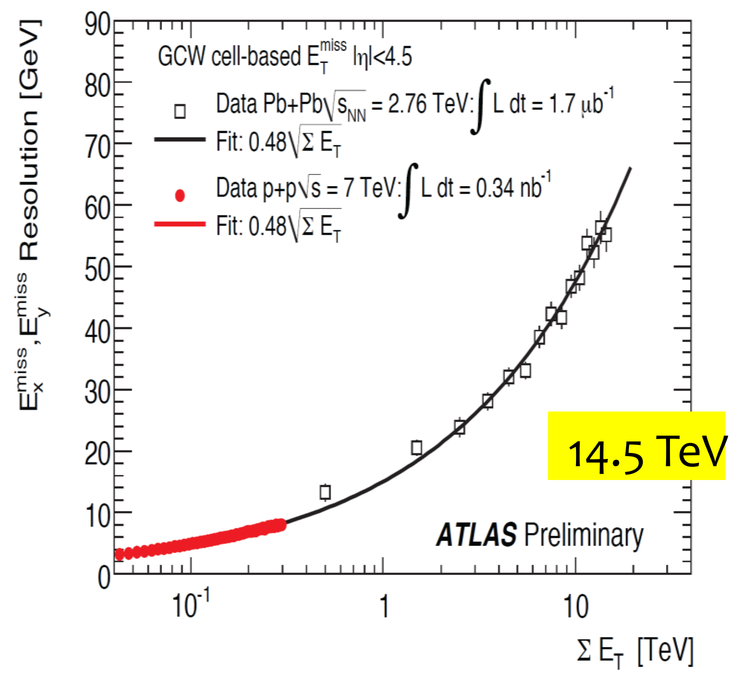
Improved by factor of 2 with respect to previous version

η region	Maximal relative JES uncertainty		
	P_T^{jet} = 20 GeV	P_T^{jet} = 200 GeV	P_T^{jet} = 1.5 TeV
|η|<0.3	4.6%	2.3%	3.1%
2.1<|η|<2.8	7.1%	2.5%	
3.6<|η|<4.5	12.6%	2.9%	

Jet Energy and Etmiss Resolutions

PbPb data only sample reaching this high in $\sum E_T$





Advanced calibrations → improve resolution by 10-30%

Monte Carlo agrees with data within 10%

Interpretation of the results

Use profile likelihood ratio: $\Lambda(\mu) = -2(\ln L(n \mid \mu, \hat{\hat{b}}, \hat{\hat{\theta}}) - \ln L(n \mid \hat{\mu}, \hat{b}, \hat{\theta}))$

- include correlations of uncertainties where appropriate

→ Estimate upper limits at 95% C.L. on N signal events and effective cross sections **independently** of new physics models (background-only hypothesis)

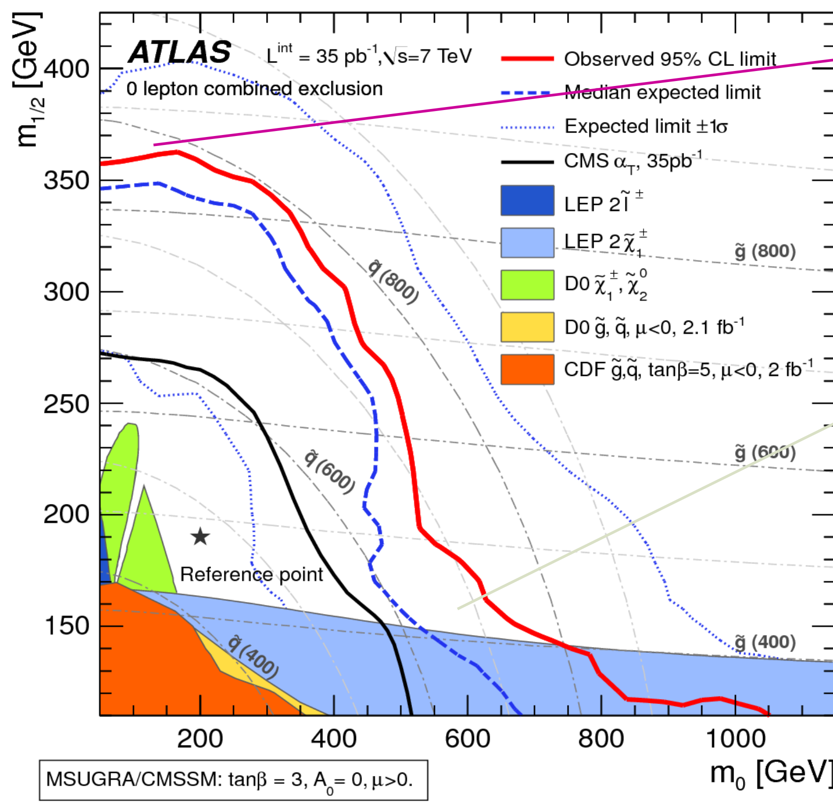
Exclude non-SM: N events 43.9(A), 11.9(B), 37.6(C), 3.5(D)
σ of 1.3(A), 0.35(B), 1.1(C), 0.11 (D) pb

Translate results in limits on **MSUGRA/CMSSM** $(m_0, m_{1/2})$-plane

parameters at GUT scale

1. Unified gaugino(scalar) mass $m_{1/2}(m_0)$
3. Ratio of H_1, H_2 vevs $\tan\beta$
4. Trilinear coupling A_0
5. Higgs mass term $\mathrm{sgn}(\mu)$

Theoretical uncertainties on SUSY NLO cross sections included in limit calculation



Best sensitivity
Region D
(3j, m_{eff} > 1 TeV)

Best sensitivity
Region C
(3j, m_{eff} > 500 GeV)

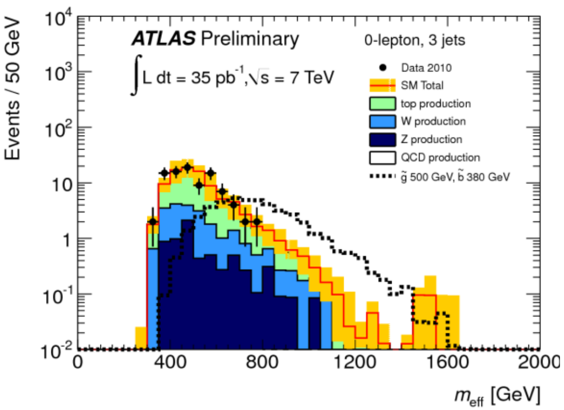
If m_{squark}=m_{gluino} exclude < 775 GeV

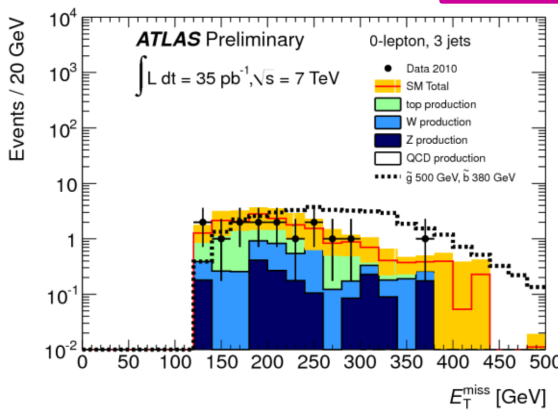
Results (b-jets)

Good agreement between data and SM predictions within systematic uncertainties in both channels

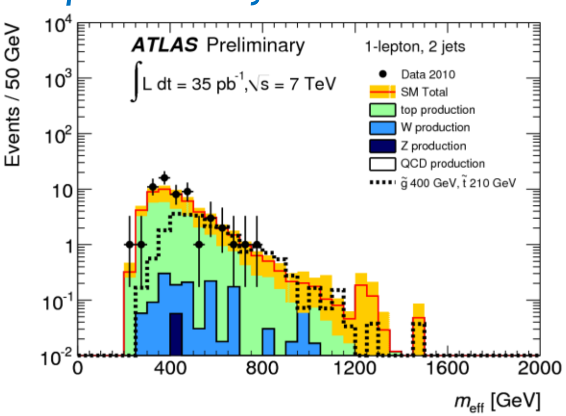
	0-lepton	1-lepton Monte Carlo	1-lepton data-driven
$t\bar{t}$ and single top	12.2 ± 5.0	12.3 ± 4.0	14.7 ± 3.7
W and Z	6.0 ± 2.0	0.8 ± 0.4	-
QCD	1.4 ± 1.0	0.4 ± 0.4	$0^{+0.4}_{-0.0}$
Total SM	19.6 ± 6.9	13.5 ± 4.1	14.7 ± 3.7
Data	15	9	9

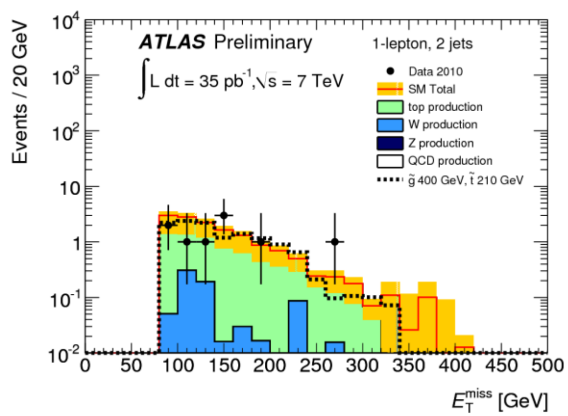
0-lepton analysis





1-lepton analysis





Interpret the results as 95%C.L. upper limits on N signal events independently of new physics models:

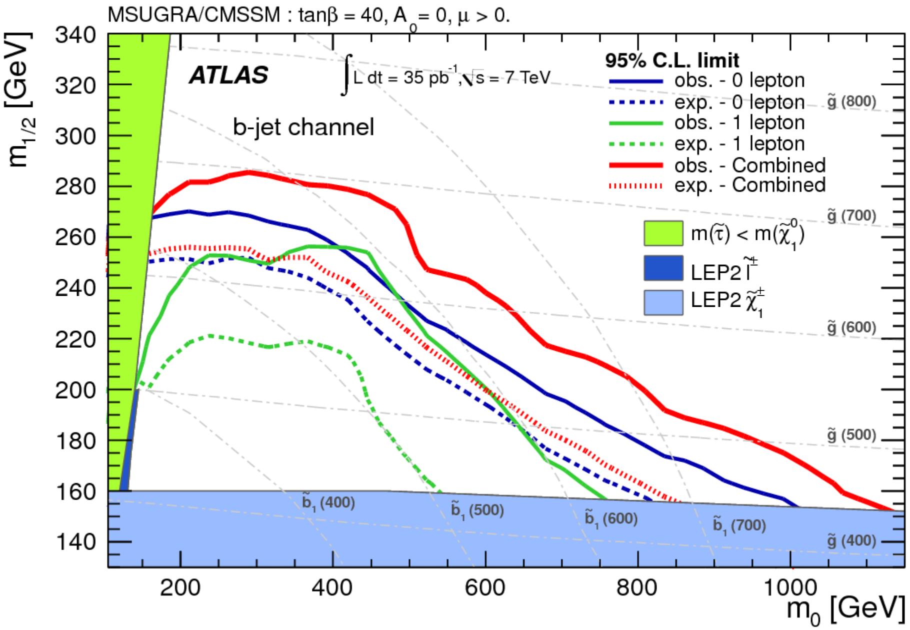
N(0-lepton) > 10.5
N(1-lepton)>4.7

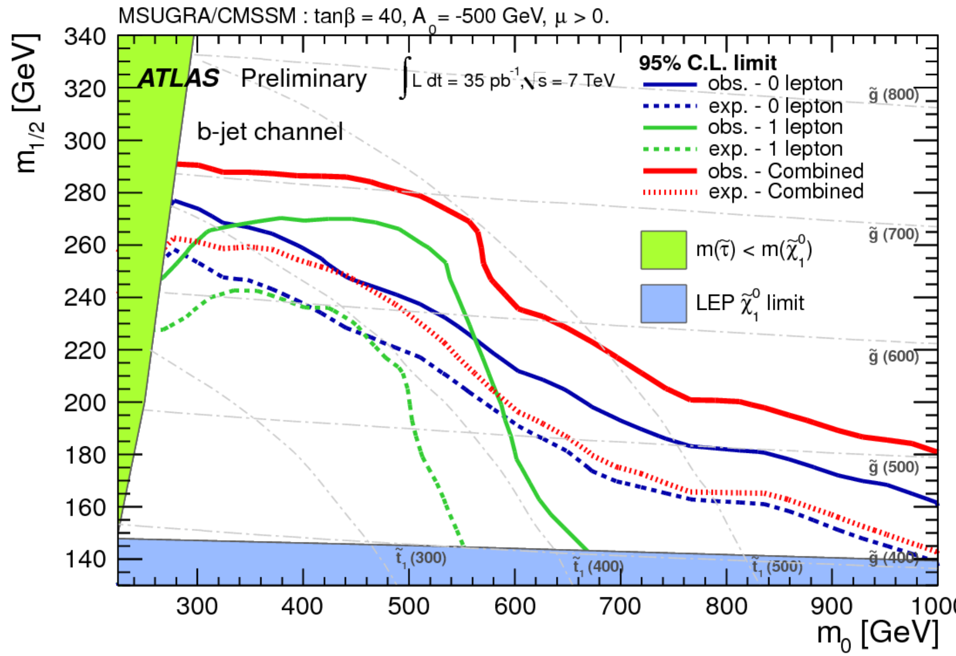
Effective cross sections:

σ (0-lepton) > 0.32 pb
σ (1-lepton) > 0.13 pb

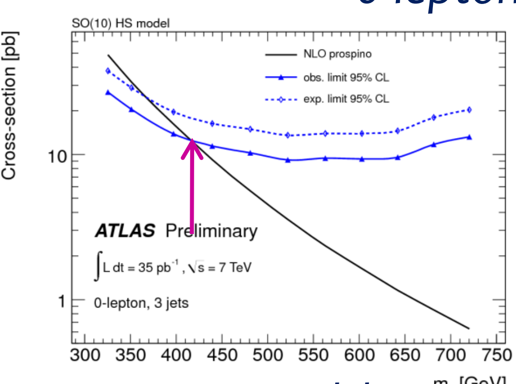
Specific SUSY models

0- and 1-lepton analyses

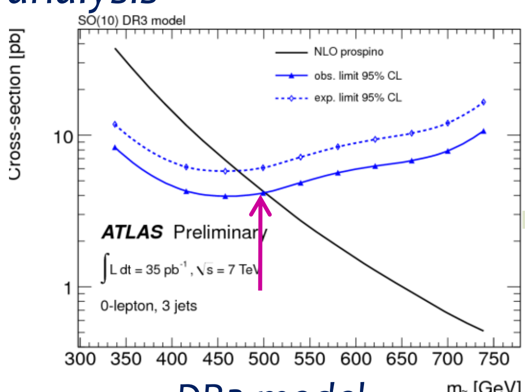




0-lepton analysis



HS-model



DR3-model

- **mSUGRA:** large tan β or low A_0 values:
  - For each (m_0,$m_{1/2}$) sbottom/stop masses lower than in low tan β scenarios
  - **Exclude gluino masses up to 500 GeV for m_0 < 1 TeV**
- **SO(10) models:** gluino pair production one of the dominant processes:
  - Gluino → $bb\chi^0_1$ (DR3) or $bb\chi^0_2$ (HS)
  - **Exclude masses up to 500(420) GeV**

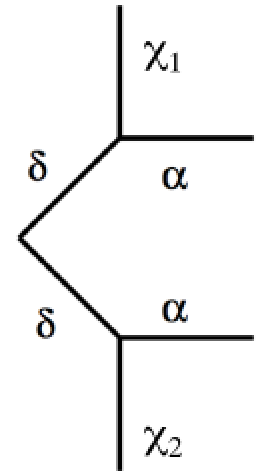
Top-tagger: m_{CT}

Tovey, JHEP 0804 (2008) 034
Polesello, Tovey, JHEP 1003 (2010) 030

- In the decay of a two pair-produced heavy states which decay via $\delta \rightarrow \alpha\chi_i$

$$m_{CT}^2(\chi_1,\chi_2) = [E_T(\chi_1) + E_T(\chi_2)]^2 - [\mathbf{p_T}(\chi_1) - \mathbf{p_T}(\chi_2)]^2$$

- m_{CT} distributions have endpoints defined by $m(\delta)$, $m(\alpha)$ and the vector sum of transverse momenta of the visible particles upstream of the system for which the contransverse mass is calculated (p_b)
- For the top-pair system m_{CT} (ll), m_{CT} (jj), m_{CT} (j l, jl) can be constructed



Contransverse mass tagger

1. Event with least 2 jets with $p_T > 20$ GeV
2. Consider all 2 jet permutations j_1, j_2, such that the two jets have $p_T > 20$ GeV and $p_T(j_1) + p_T(j_2) + p_T(\ell_1) + p_T(\ell_2) > 100$ GeV
3. $m_{CT}(\ell_1, \ell_2)$ in the allowed area of the $(m_{CT}(\ell_1, \ell_2), p_b(\ell\ell))$ plane
4. Build all pairs $((j_i\ell_1)(j_j\ell)_2)$ such that $m(j_i\ell_1) < 155$ GeV and $m(j_j\ell_2) < 155$ GeV
5. One combination with $m_{CT}(jj)$ in the allowed area of the $m_{CT}(jj)$, $p_b(jj)$ plane
6. $m_{CT}(j\ell, j\ell)$ should be compatible with $t\bar{t}$

- Efficiency m_{CT} tagger = 85%
- control region for ttbar:
  - m_{CT}-tagged events
  - $60 < E_T^{Miss} < 80$ GeV

Other backgrounds for 2-lepton

- **Electron charge-flip:**
  - Relevant for Same-Sign dilepton final states
  - Background from dilepton top events:
    - Hard bremsstrahlumng process

$$e^{\mp}_{\mathrm{hard}} \to \gamma_{\mathrm{hard}}\, e^{\mp}_{\mathrm{soft}} \to e^{\mp}_{\mathrm{soft}}\, e^{\mp}_{\mathrm{soft}}\, e^{\pm}_{\mathrm{hard}}$$

    - Charge mis-identified rate taken from Zee MC samples as a function of $|\eta|$
    - Validated in Z→ee data
- **Z+jets:**
  - Z→eμ from MC (low statistics in data)
  - Semi-data driven estimation for Z→ee,μμ
  - Control region:
    - 81<m(ll)<101 GeV
    - E_T^{Miss} < 20 GeV

$$N^{\mathrm{est,SR}}_{Z/\gamma^*} = \beta \cdot N^{\mathrm{data,CR}}_{Z/\gamma^*} \qquad \beta = \frac{N^{\mathrm{MC,SR}}_{Z/\gamma^*}}{N^{\mathrm{MC,CR}}_{Z/\gamma^*}}$$

  - Corrected for predicted number of W and top in control region
- **Cosmics:**
  - 2 methods considered →
    - matrix method based on impact parameter
    - Trigger Lifetime
  - Both consistent to zero
  - Define an upper bound: Ncos < 1.32 at 68% CL, Ncos < 3.45 at 95% CL

Monte Carlo samples used

- Analyses generally employ MC samples generated with:
  - Alpgen associated with HERWIG (not ++) and JIMMY for W+jets and Z+jets (including Wbb, Zbb)
    - MLM matching scheme to combine samples with different final state parton multiplicities (up to 5 for inclusive, up to 3 for Wbb/Zbb)
  - PYTHIA used for low DY region and Z→ττ (τ-decays with TAUOLA)
  - SHERPA samples used for cross check in some cases
    - Large "production" on-going for 2011 analyses
- V+jets predictions normalized to NNLO cross sections (FEWZ)
  - CTEQ6L1 for ALPGEN and SHERPA samples
  - MRST2007lomod (LO modified) for PYTHIA samples (for low mass DY)

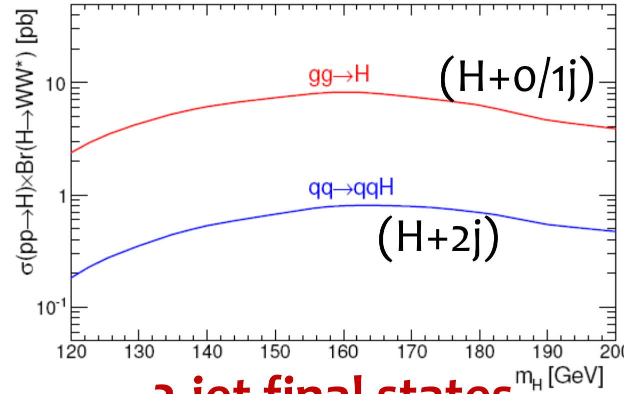
Example from H →WW analysis*

Inclusive $W \to \ell\nu$	ALPGEN	10.5×10^3 [34,35]
Inclusive $W \to \tau\nu$	PYTHIA	10.5×10^3 [34,35]
Inclusive $Z/\gamma^* \to \ell\ell$ ($M_{\ell\ell} > 40$ GeV)	ALPGEN	10.7×10^2 [35,36]
Inclusive $Z/\gamma^* \to \tau\tau$ ($M_{\tau\tau} > 60$ GeV)	PYTHIA	9.9×10^2 [35,36]
Inclusive $Z/\gamma^* \to \ell\ell$ ($10 < M_{\ell\ell} < 40$ GeV)	ALPGEN	3.9×10^3 [36]
Inclusive $Z/\gamma^* \to \tau\tau$ ($10 < M_{\ell\ell} < 60$ GeV)	PYTHIA	4.0×10^3 [36]

Search on SM Higgs
H→ W*W

SM Higgs → W W* → lν lν (l = e, μ)

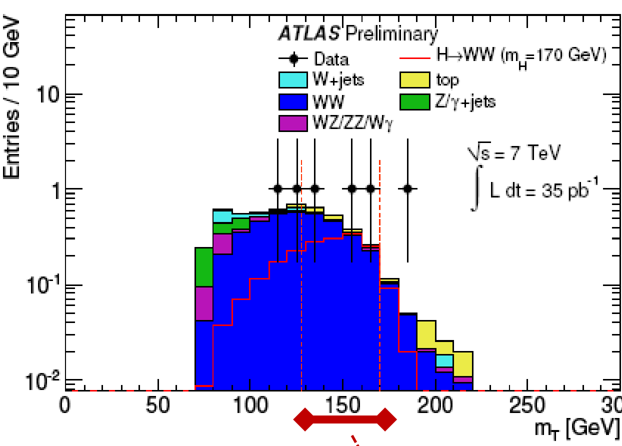
- Strong sensitivity in $120 < m(H_{SM}) < 200$ GeV
- Cut-based analysis
  - combine H + 0 jet, H + 1 jet and H + 2 jet
- Dominant backgrounds: DiBoson, tt,V+jets



0-jet final states

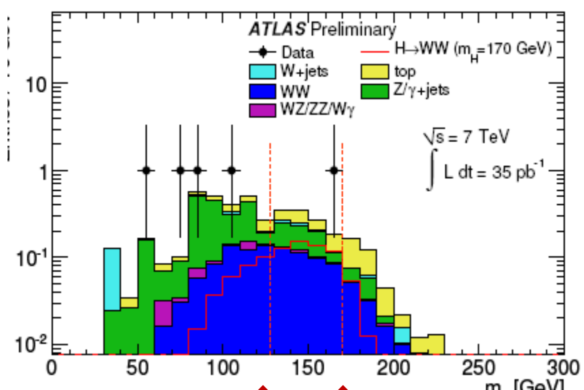
- 2 leptons, m(ll)<50(65) GeV
- $p_T(ll) > 30$ GeV
- $0.75\times m_H < m_T < m_H$

$$m_T = \sqrt{(E_T^{\ell\ell} + E_T^{miss})^2 - (\mathbf{P}_T^{\ell\ell} + \mathbf{P}_T^{miss})^2}$$



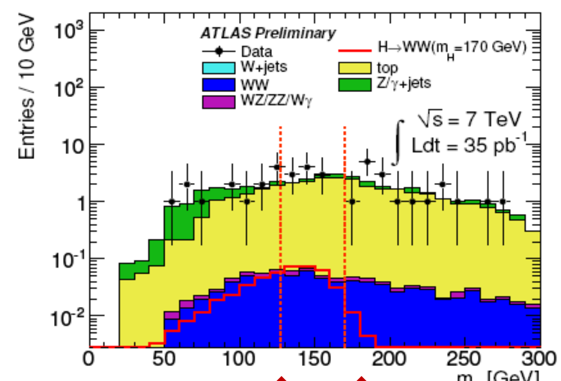
1-jet final states

- 2 leptons and exactly 1 jet
- same as H+0j selection
- p_T(jet)>25 GeV, |η|<2.5
- B-jet veto (anti-tag)
- $|P_T^{TOT}| < 30$ GeV (l1,l2,j,MET)
- Z→ττ suppression



2-jet final states

- 2 leptons and 2 jets
- $\eta_{j1} * \eta_{j2} < 0$, $\Delta\eta_{jj}>3.8$, $m_{jj}>500$ GeV
- m(ll)<80 GeV, $p_T(ll) > 30$ GeV
- $0.75\times m_H < m_T < m_H$
- B-jet veto and Z→ττ suppression
- $|P_T^{TOT}| < 30$ GeV (l1,l2,j1,j2MET)



Signal region

W+jets background

- Define control sample enriched in W+jets:
  - One lepton must satisfy ID and isolation cuts of the analysis
  - Require second lepton to satisfy loose set of cuts (*fakeable*)

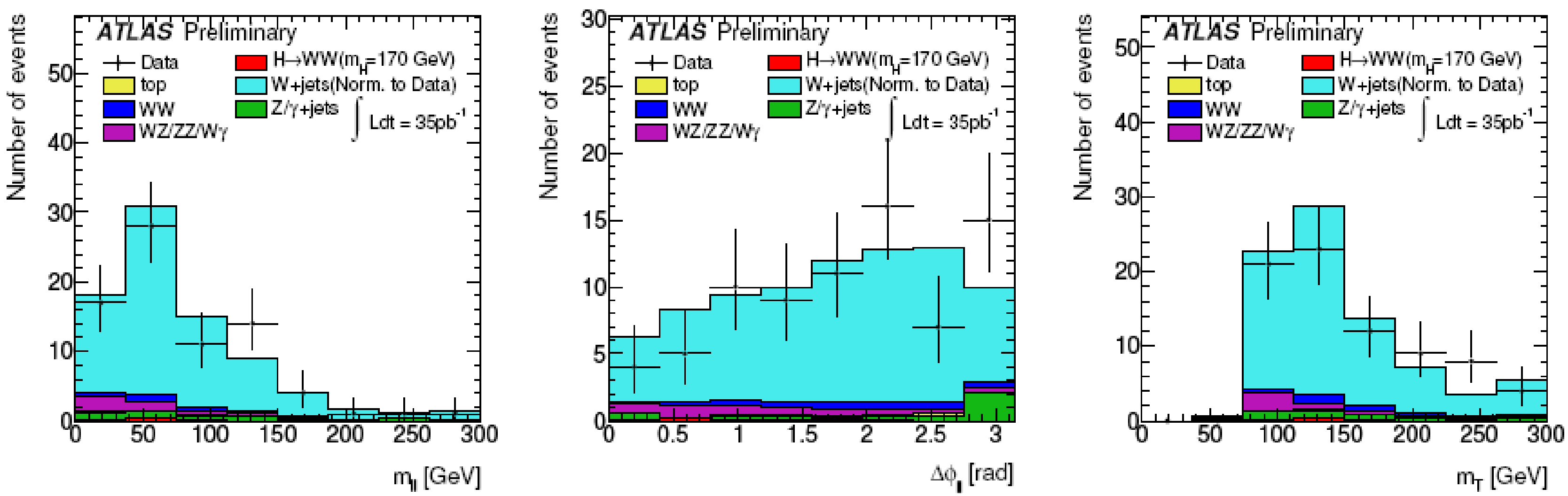
Fakeable (loose) electron	Fakeable (loose) muon
$\Sigma(p_T^{calo})/p_T < 0.3$	$\Sigma(p_T^{calo})/p_T < 0.3$
$N^{hits}_{Pixel} \geq 1$	No TRT Requirement
$N^{hits}_{SCT} \geq 1$	No χ^2 cut
No Impact Parameter Requirement	No Impact Parameter Requirement
	No $(p_{MS}^{extrapol.} - p_{ID})$ Requirement

→ W+jets expectations in signal region (SR):

$d\sigma/dX\,(SR) = d\sigma/dX\,(CR) \times f_l$

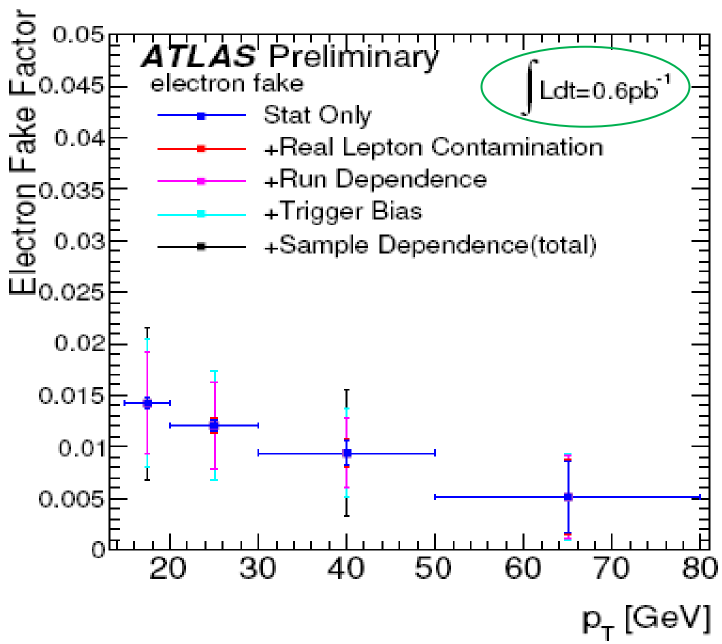
f_l = fake factor = Prob(loose → ID)

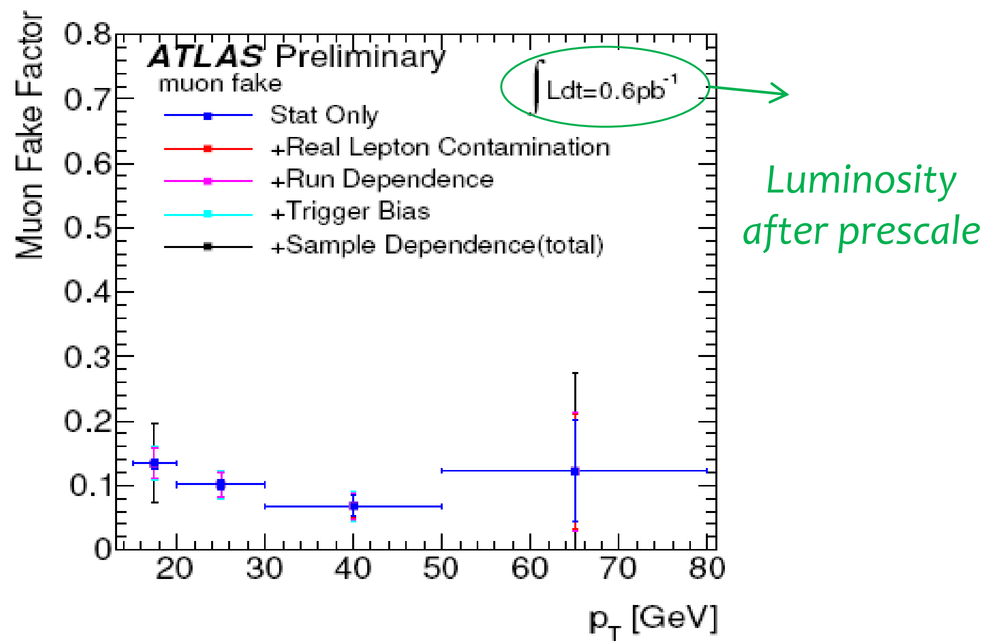
Good agreement data/MC in shape for kinematic distributions



Fake factor

- Control sample defined in multi-jets events with at least a fakeable lepton.
- Real lepton contamination (from W,Z) removed
- ~ 50% uncertainties, mostly dominated by sample and trigger selection dependence





W+jets estimates in H→WW*

- H+0j

	ee-channel	$\mu\mu$-channel	$e\mu$-channel
Before topological selection			
Expected events (excluding W+jets)	3.77	1.29	8.03
Observed one identified+one fakeable leptons	30	6	41
Estimated W+jets in the control region	26.2±5.6	4.7±2.5	33.0±6.4
Estimated W+jets in the signal region	0.2±0.0±0.1	0.5±0.3±0.2	0.5±0.2±0.2
After all selection (m_H = 170 GeV)			
Expected events (excluding W+jets)	0.3	0.1	0.6
Observed one identified+one fakeable leptons	3	0	2
Estimated W+jets in the control region	2.7±1.7	0.0	1.4±1.4
Estimated W+jets in the signal region	0.02±0.01±0.01	0.0 ± 0.1 ± 0.1	0.01±0.01±0.02

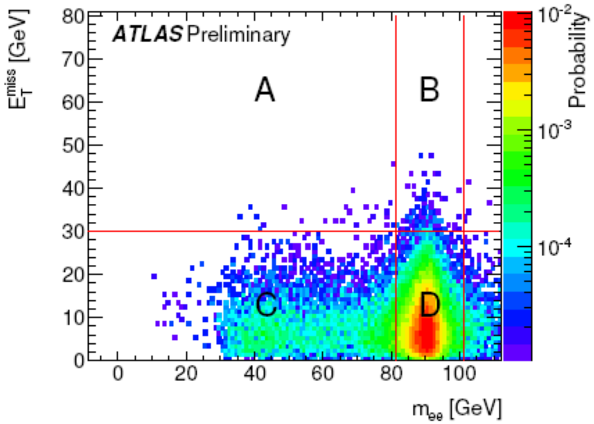
- H+1j

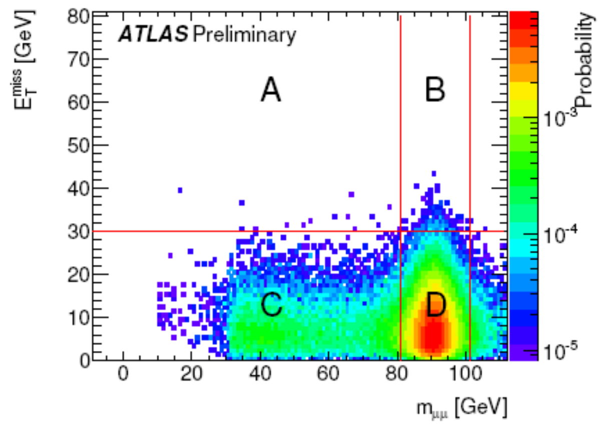
	ee-channel	$\mu\mu$-channel	$e\mu$-channel
Before topological selection			
Expected events (excluding W+jets)	3.0	2.3	4.7
Observed one identified+one fakeable leptons	18	3	36
Estimated W+jets in the control region	15.0±4.2	0.7±1.7	31.3±6.0
Estimated W+jets in the signal region	0.1±0.0±0.1	0.2±0.2±0.1	0.5±0.2±0.2
After all selection (m_H=170 GeV)			
Expected events (excluding W+jets)	0.2	0.1	0.4
Observed one identified+one fakeable leptons	3	0	2
Estimated W+jets in the control region	2.8±1.7	0.0	1.6±1.4
Estimated W+jets in the signal region	0.03 ± 0.02 ± 0.01	0.0 ± 0.1 ± 0.1	0.02 ± 0.02 ± 0.01

- H+2j: negligible

Z+jets (and low DY) background

- Scaling the yield in MC by a E_T^{Miss} mis-modeling factor using control regions





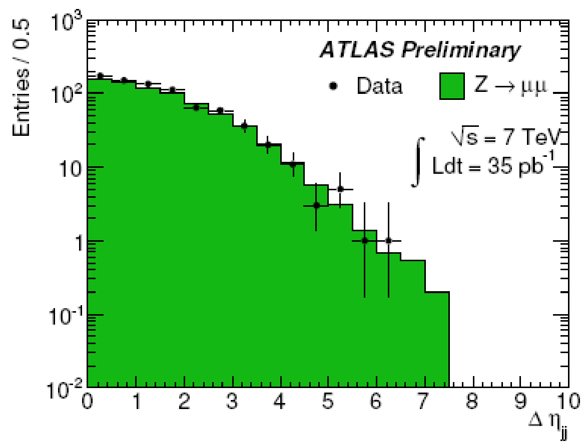
$$A_{\rm MC}^{\rm corrected} = A_{\rm MC} \times \frac{B_{\rm data}}{D_{\rm data}} \frac{D_{\rm MC}}{B_{\rm MC}}$$

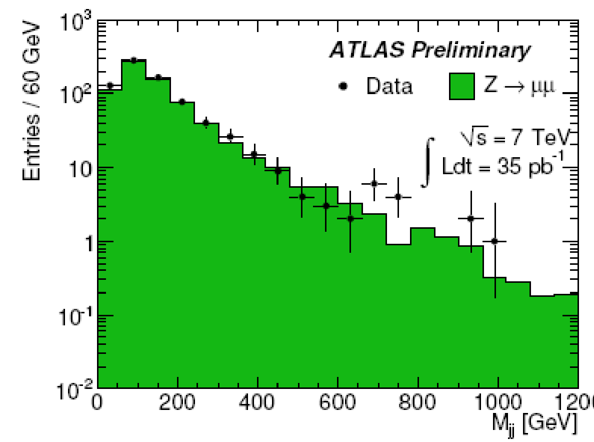
Same method used independently on jet multiplicity

In H+2j selection, Z-->ll+jets expected to be dominant before m(ll) selection → checks on pre-selection events for several kinematic distributions:

- E_T and η jets (1,2,3)
- m(jj), Δη(jj), Δϕ(jj)

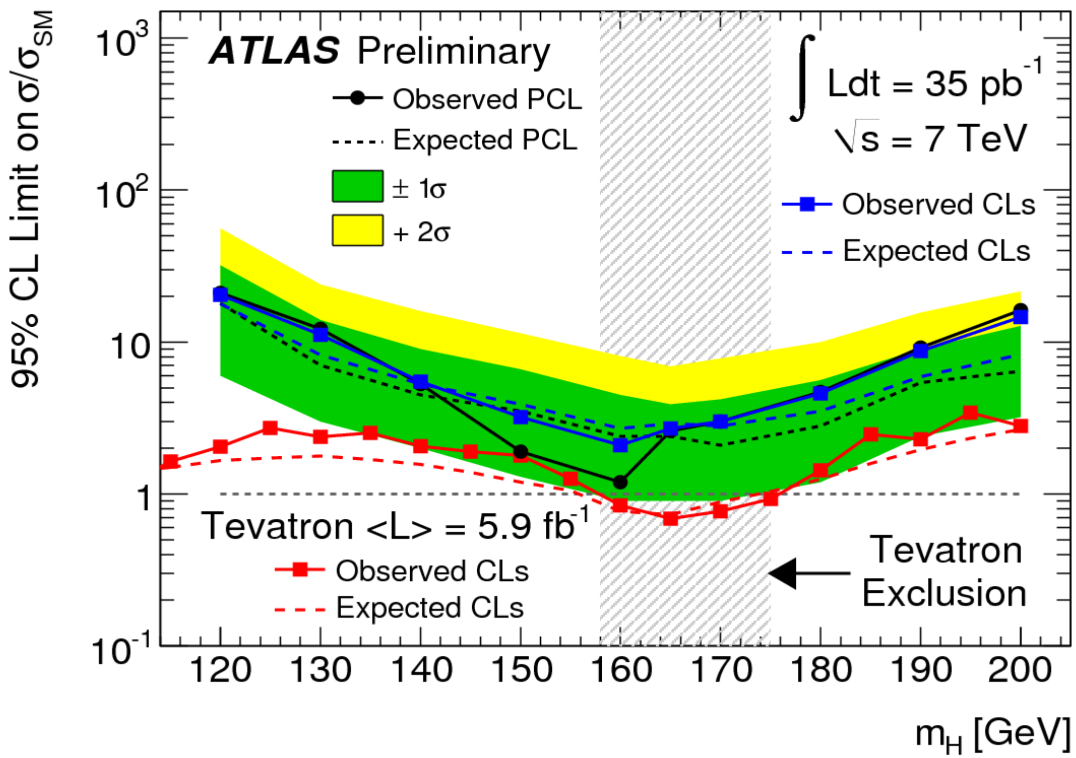
- Good agreement in shape and in absolute normalization (within 10%)





Results for SM Higgs → W W*

Channel	Signal	top	WW	$WZ/ZZ/W\gamma$	Z+jets	W+jets	Total Bkg.	Observed
				$H+0j$				
$e\mu$	$0.62 \pm 0.01 \pm 0.18$	0.09	0.71	0.02	0.00	0.01	$0.83 \pm 0.07 \pm 0.13$	1
ee	$0.20 \pm 0.01 \pm 0.07$	0.03	0.20	0.00	0.00	0.02	$0.25 \pm 0.08 \pm 0.04$	1
$\mu\mu$	$0.44 \pm 0.01 \pm 0.12$	0.08	0.53	0.01	0.00	0.00	$0.62 \pm 0.05 \pm 0.10$	1
				$H+1j$				
$e\mu$	$0.31 \pm 0.01 \pm 0.09$	0.26	0.18	0.01	0.00	0.02	$0.47 \pm 0.08 \pm 0.16$	0
ee	$0.08 \pm 0.01 \pm 0.03$	0.10	0.05	0.00	0.05	0.03	$0.23 \pm 0.04 \pm 0.06$	0
$\mu\mu$	$0.21 \pm 0.01 \pm 0.06$	0.15	0.16	0.00	0.25	0.00	$0.56 \pm 0.09 \pm 0.14$	1
				$H+2j$				
$e\mu$	$0.03 \pm 0.01 \pm 0.01$	0.01	0.00	0.00	0.00	0.00	$0.01 \pm 0.01 \pm 0.01$	0
ee	$0.01 \pm 0.01 \pm 0.01$	0.00	0.00	0.00	0.00	0.00	0.00	0
$\mu\mu$	$0.02 \pm 0.01 \pm 0.01$	0.00	0.01	0.00	0.00	0.00	$0.01 \pm 0.01 \pm 0.01$	0



Upper limit on σxBR(H→WW*)

- m_H=120 GeV : 54 pb
- m_H=160 GeV : 11 pb
- m_H=200 GeV : 71 pb