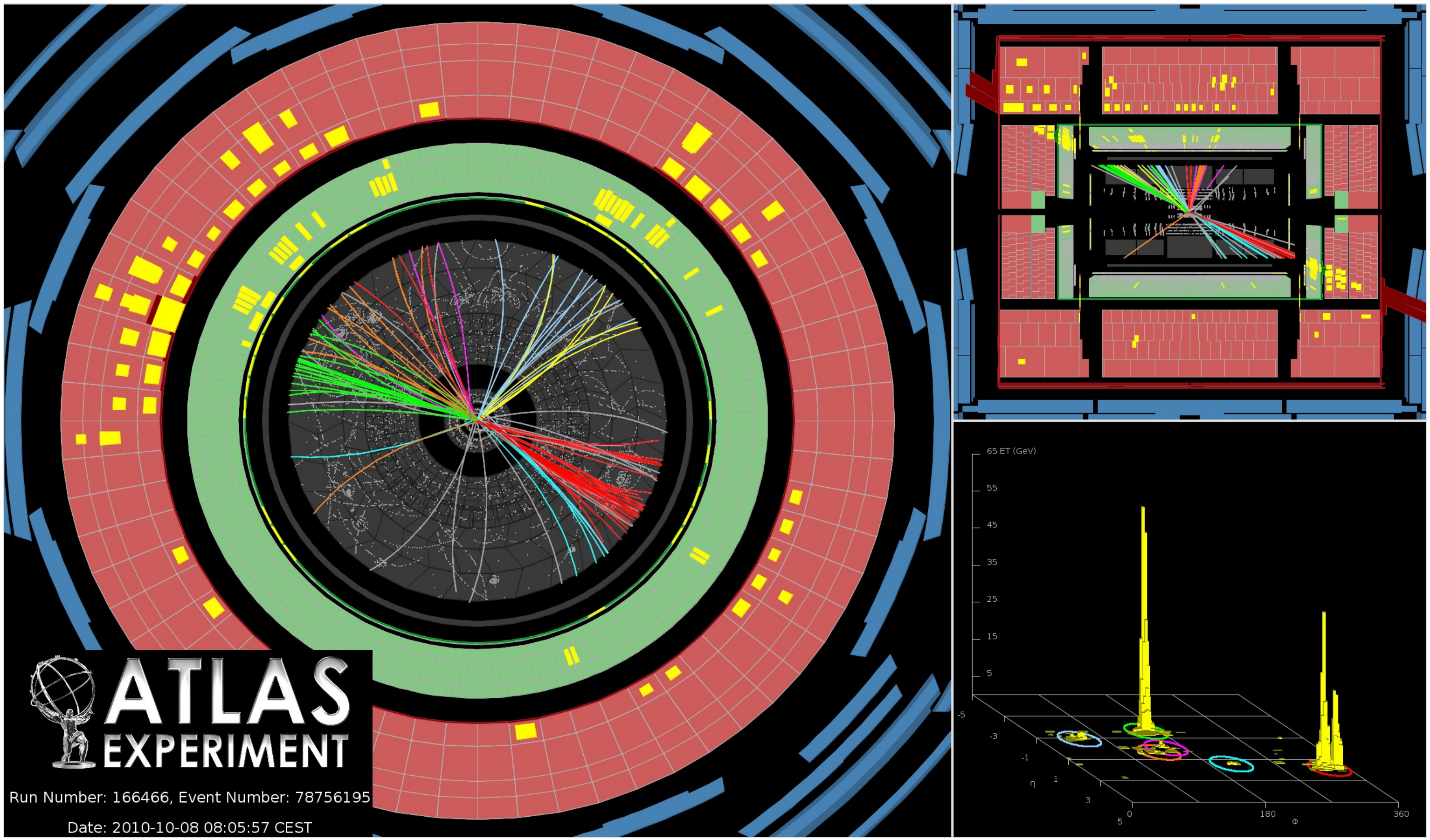
Searches for supersymmetry in Jets+MET channel



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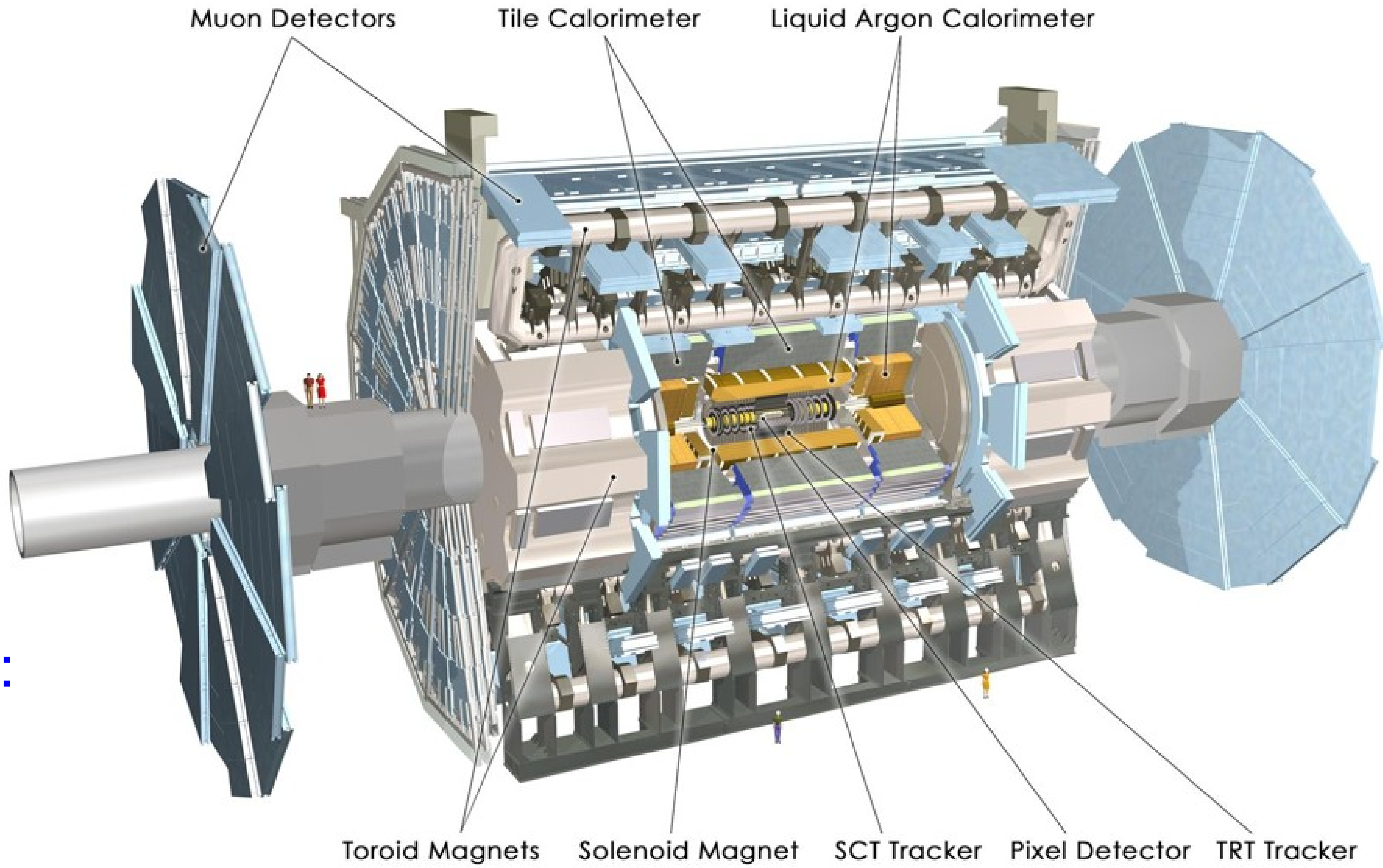
Outline

- Atlas detector in 2010
- SUSY analyses, the 0-lepton channel.
- Signal selection
- Background estimation
- Results
- Interpretation
- Summary and outlook

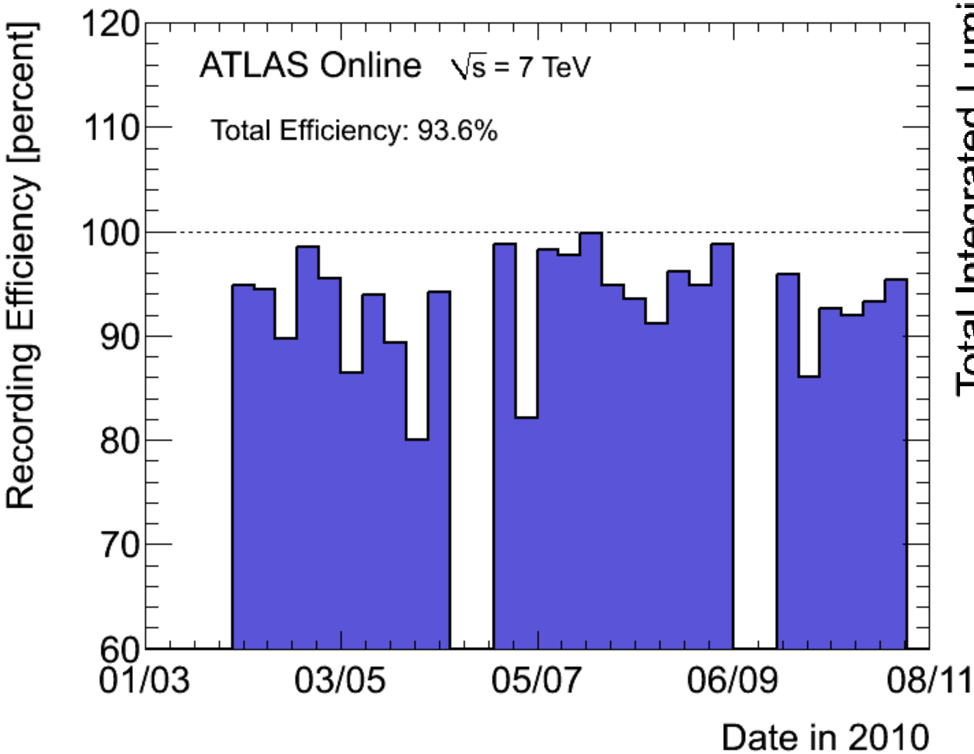
The ATLAS detector

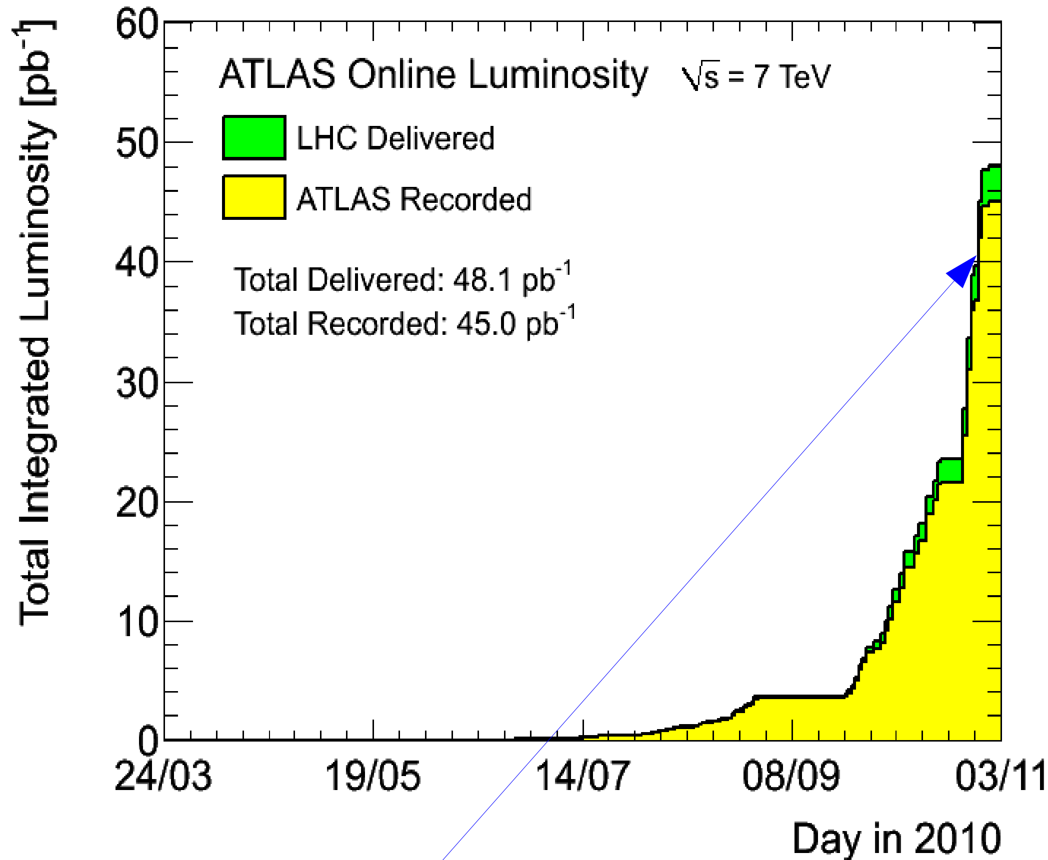
Inner detector :
Charged particle tracks and vertices, 2T solenoidal magnetic field.
Liquid argon and Tile calorimeters :
Electromagnetic and hadronic showers
Muon spectrometer :
Muon tracks, 0.5 to 1T toroidal magnetic field.



Largest LHC detector (7000 tons, 45m length, 22m diameter).

Atlas 2010 data collection





Half of the data taken during the last two weeks.
Already double the luminosity with 2011 data.

- About 45pb^{-1} recorded pp collisions (48pb^{-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 channel

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

arXiv:1102.5290

- Lepton veto ensures orthogonality with other searches
  - Leptons + MET
  - Leptons/γ* + jets + MET

- However, jets+MET analysis does not veto b-jets.

- 4 signal regions, to target $\tilde{q}\tilde{q}$ $\tilde{g}\tilde{g}$ & $\tilde{q}\tilde{g}$ signatures :

		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	–	–

$$m_{eff} \equiv \sum_{i=1}^{n} |\mathbf{p}_T^{(i)}| + E_T^{miss}$$

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

with

$$m_T^2\left(\mathbf{p}_T^{(i)}, \not{\mathbf{q}}_T^{(i)}\right) \equiv 2|\mathbf{p}_T^{(i)}||\not{\mathbf{q}}_T^{(i)}| - 2\mathbf{p}_T^{(i)} \cdot \not{\mathbf{q}}_T^{(i)}$$

SUSY object selection

Trigger: ε> 97% in signal region
Vertex: > 4 tracks

Jet selection:
AntiKt jets, R=0.4
MC-based calibration
pT>20 GeV
|η|<2.5

Electron selection:
pT> 20 GeV
|η|<2.47

Muon selection:
pT> 20 GeV
|η|<2.4

MET= calorimetric MET + corrections for electrons and muons.

Overlap removal: Jets with ΔR<0.2 from electron removed. Electrons/muons with ΔR<0.4 from jet removed.

Event veto:
"Fake" jet (pT > 20 GeV).
Isolated reconstructed electron or muon.

After selection : 35 pb^{-1} of good data quality luminosity.

with $\eta = -\ln\left[\tan\left(\theta/2\right)\right]$ and $\Delta R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$

QCD background estimation

Fake MET includes mis-reconstruction and b/c → νX

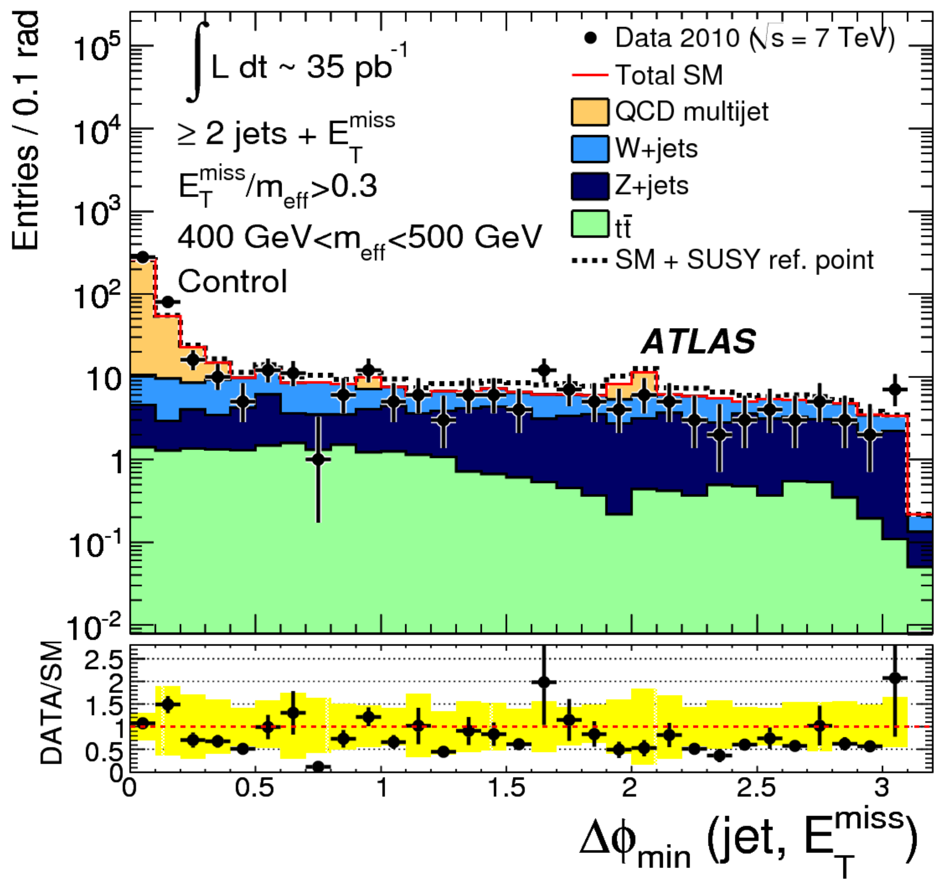
- MET associated with a jet

Monte Carlo prediction normalized using $\Delta\Phi<0.4$ control region

- Large MC statistical uncertainties
- ± ~ 100% stat. + syst.
- Alternative: MET/Meff cut inverted

Data driven approach :

- Gaussian and non-Gaussian jet response measured from low MET control sample.
- Event 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 mis identified e,μ

Data-driven methods:

Remove leptons from Z→ll,W→lν (→ Z→νν and lost leptons)

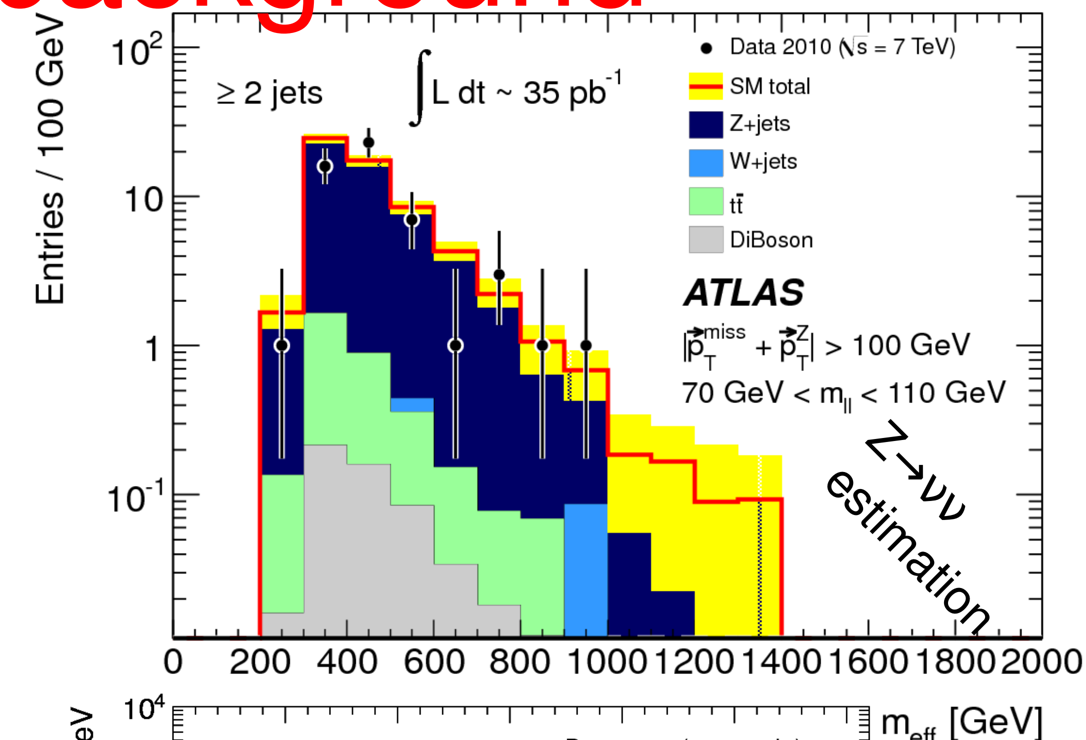
τ "replacement" from W→μν seed events

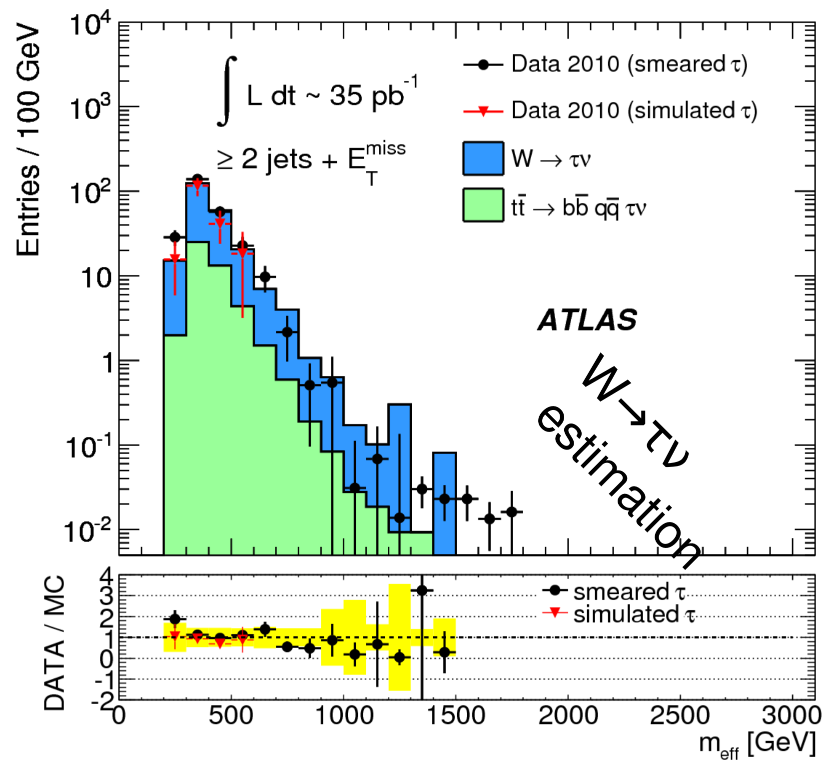
Statistical limitations → Use MC predictions

ALPGEN (W,Z)

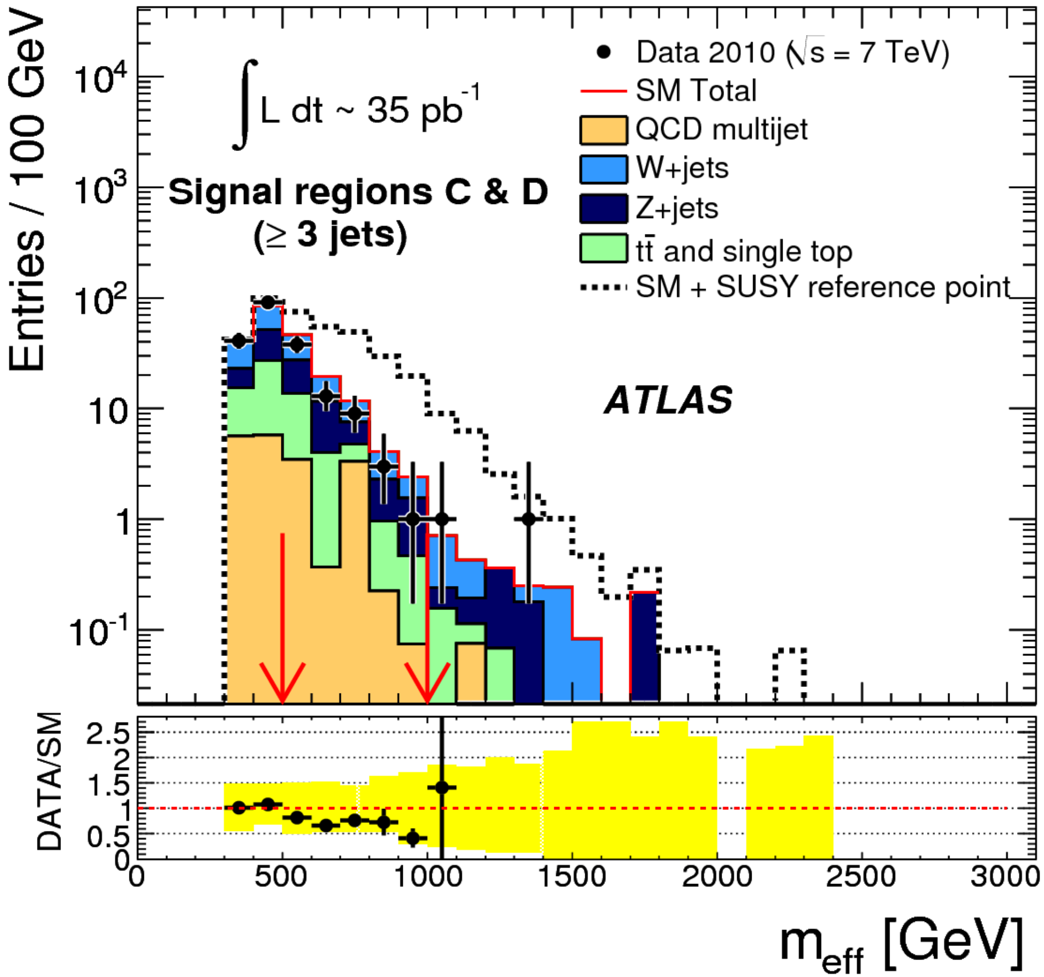
MC@NLO (ttbar)

Uncertainty from control region checks





Jets+MET results



Example mSUGRA point:

m_0=200GeV

$m_{1/2}$=190GeV

A_0=0, tanβ=3, μ>0

Main systematic uncertainties:

Uncorrelated background uncertainties [u]

Jet energy scale [j]

Luminosity [L]

Model independent limits:

A: σ_{fid} <1.3pb

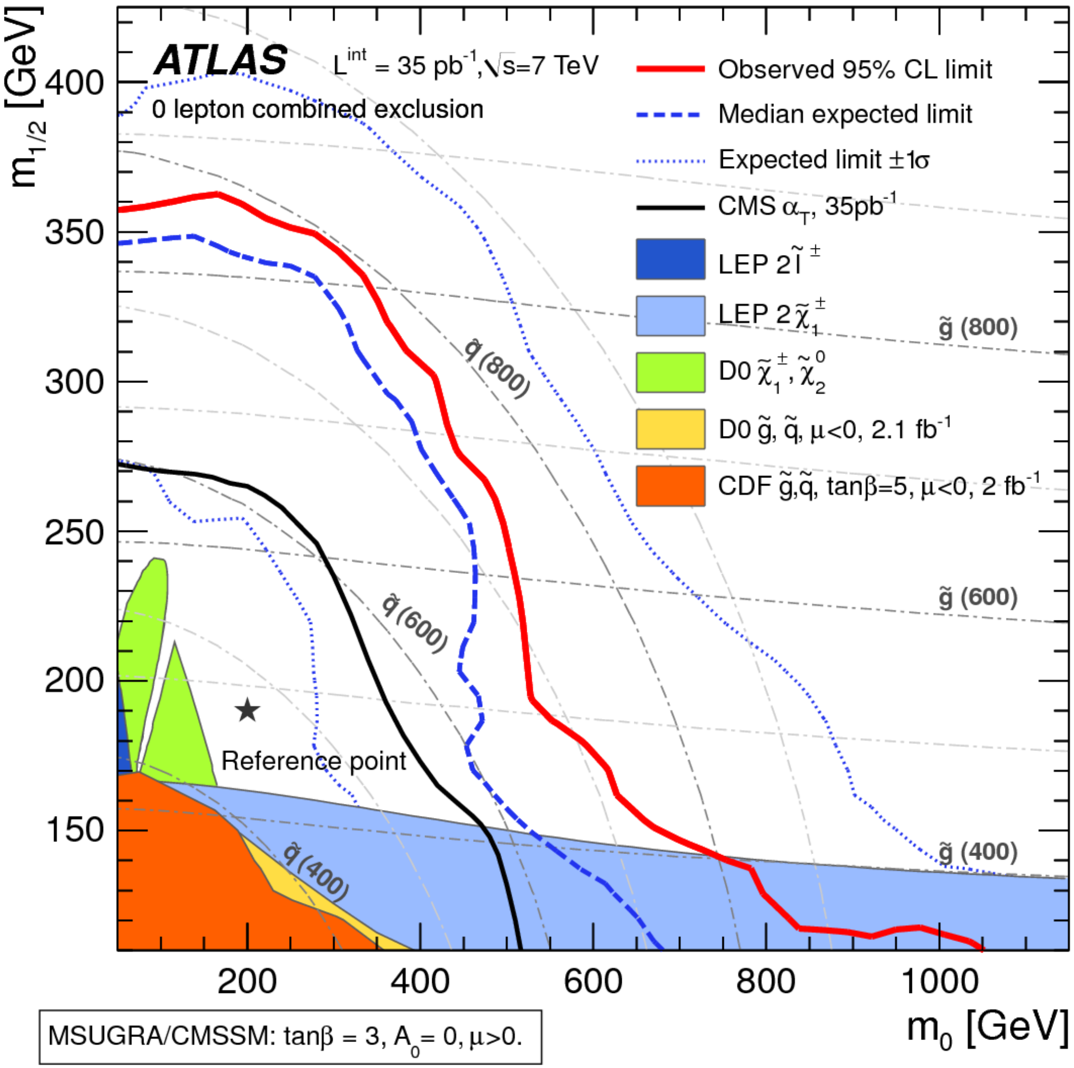
B: σ_{fid} <0.35pb

C: σ_{fid} <1.1pb

D: σ_{fid} <0.11pb

	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

Exclusion limits:mSUGRA



Benchmark plane with tan β = 3, 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 : squark/gluino plane

Used for more general, less assumption-heavy, limits

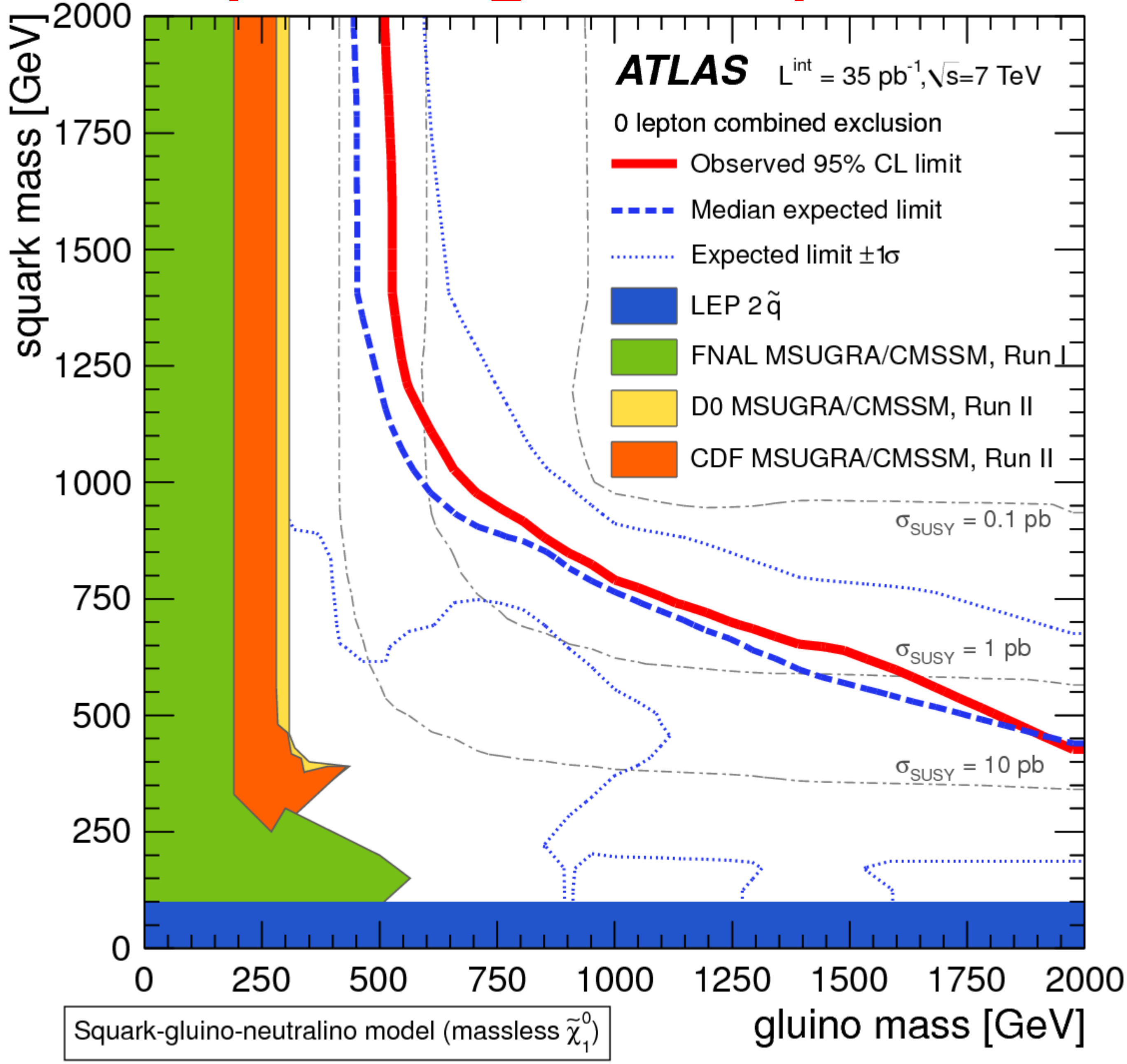
And analysis optimisation

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.



Summary and outlook

Supersymmetry may be found as an excess of events with jets + MET
… but not yet

Inclusive analysis :
- m(gluino)>500 GeV in phenomenological gluino-squark-LSP model
- Strong mSUGRA and SO(10) model limits
- Possible to extend interpretations to arbitrary theoretical models

Bright perspectives for 2011:
- Vastly more luminosity (up to $3fb^{-1}$) but more pile-up...
- Refined experimental techniques (data-driven bkgd estimation)
- Experience and feedback from 2010
- Sensitivity beyond m ~ 1 TeV