Search for supersymmetry in jets plus missing transverse momentum final states with the ATLAS detector

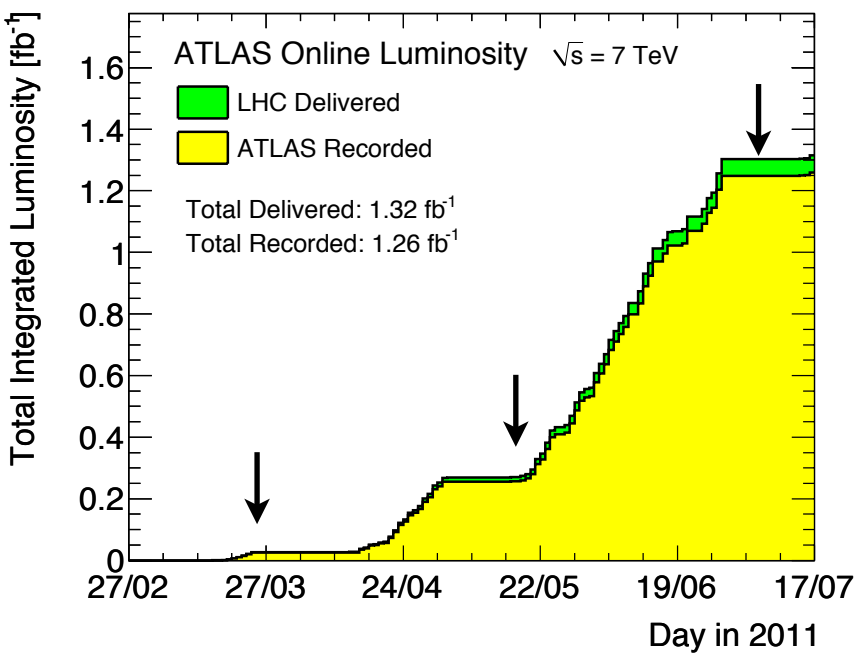
I.Vivarelli - Albert Ludwigs Universität, Freiburg
On behalf of the ATLAS collaboration

International Europhysics Conference on High Energy Physics - Grenoble - July 21st-27th 2011

Introduction

- If accessible, squarks and gluinos will be produced copiously at the LHC
- In R-parity conserving scenarios, the simplest signature is multiple jets and missing E_T from $\tilde{g} \rightarrow qq\tilde{\chi}_1^0$ $\tilde{q} \rightarrow q\tilde{\chi}_1^0$

- Previous results (with 35 pb^{-1}) published in Phys. Lett. B 701 (2011) p186.
- Intermediate result (with 165 pb^{-1}) released in spring: ATLAS-CONF-2011-086
- Analysis improved and updated using 1 fb^{-1}



Object definition

JET PRESELECTION:

- Anti-k_T - $\Delta R = 0.4$
- $P_T > 20$ GeV, $|\eta| < 2.8$

Missing E_T (MET):

- Reconstructed from the vectorial sum of all jets and leptons. Clusters not belonging to any jets are added to the MET

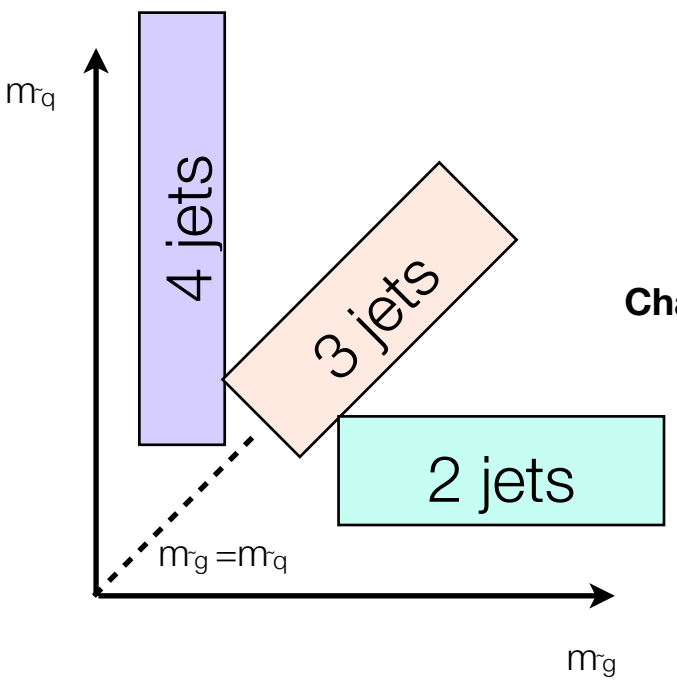
LEPTON VETO:

- **Electrons** Identified using shower shape and track matching criteria; $P_T > 20$ GeV, $|\eta| < 2.47$
- **Muons** identified with a track matching between the ID and muon spectrometer; $P_T > 20$ GeV, $|\eta| < 2.4$

- Events containing one lepton (e or μ) are analysed in a complementary analysis (see talk from H.Hayward, including results with searches with more complex final states)

Event selection

- Depending on the SUSY mass hierarchy, different production processes favoured ($\tilde{g}\tilde{g}, \tilde{g}\tilde{q}, \tilde{q}\tilde{q}$)
  - Signal regions optimised to maximise sensitivity to different production processes



	Signal Region	≥ 2 jets	≥ 3 jets	≥ 4 jets	High mass
Trigger requirements	$E_{\mathrm{T}}^{\mathrm{miss}}$	> 130	> 130	> 130	> 130
	Leading jet p_{T}	> 130	> 130	> 130	> 130
Channel definition	Second jet p_{T}	> 40	> 40	> 40	> 80
	Third jet p_{T}	–	> 40	> 40	> 80
	Fourth jet p_{T}	–	–	> 40	> 80
Reduce QCD	$\Delta\phi(\mathrm{jet}, E_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$	> 0.4	> 0.4	> 0.4	> 0.4
	$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}$	> 0.3	> 0.25	> 0.25	> 0.2
Enhance signal	m_{eff} [GeV]	> 1000	> 1000	> 500/1000	> 1100

$$m_{eff} = \sum_{i=1}^{n} |\vec{p}_T^{\,jet\ i}| + E_T^{miss}$$

Analysis strategy

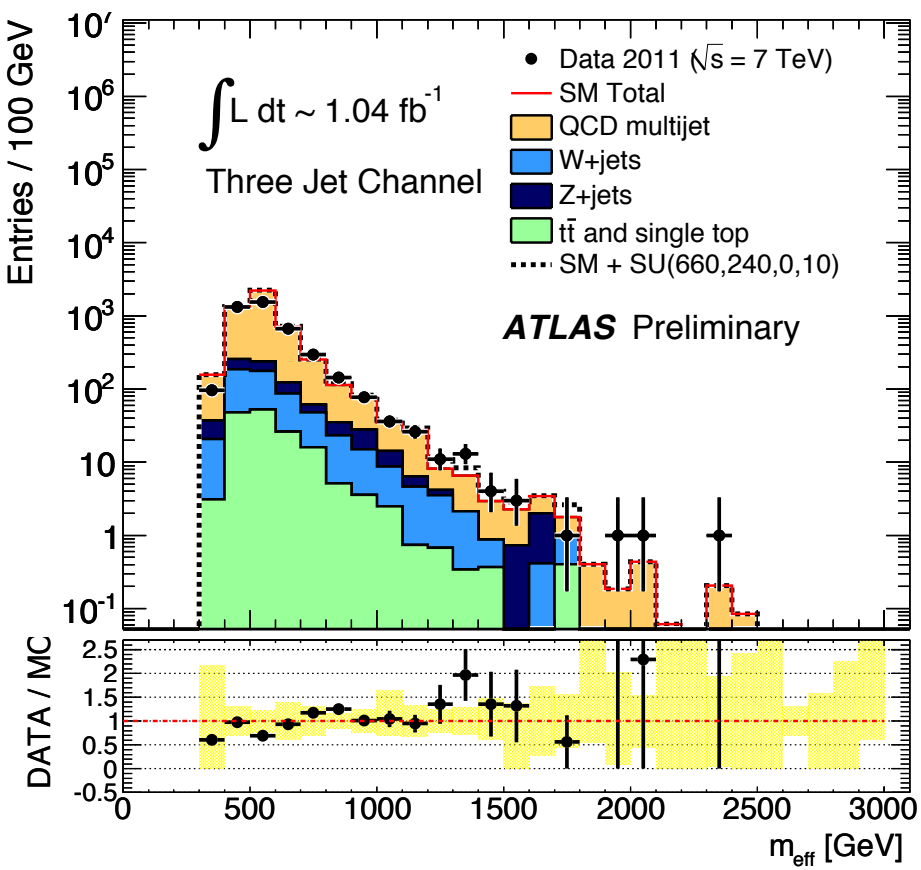
- Main expected SM background: W/Z + jets, top production, QCD multi-jet
- For each background, for each signal region, one or more dedicated control regions (CR)
- Background determination done with a combined fit to all CRs (mutual background contamination in CR and correlations automatically taken into account)
- Transfer factors (TF) from each background process CR to the SR are computed using a mix of data-driven and Monte Carlo driven techniques.

$$N(SR, est, proc) = N(CR, obs, proc) * \left[\frac{N(SR, raw, proc)}{N(CR, raw, proc)} \right]$$

QCD background estimation

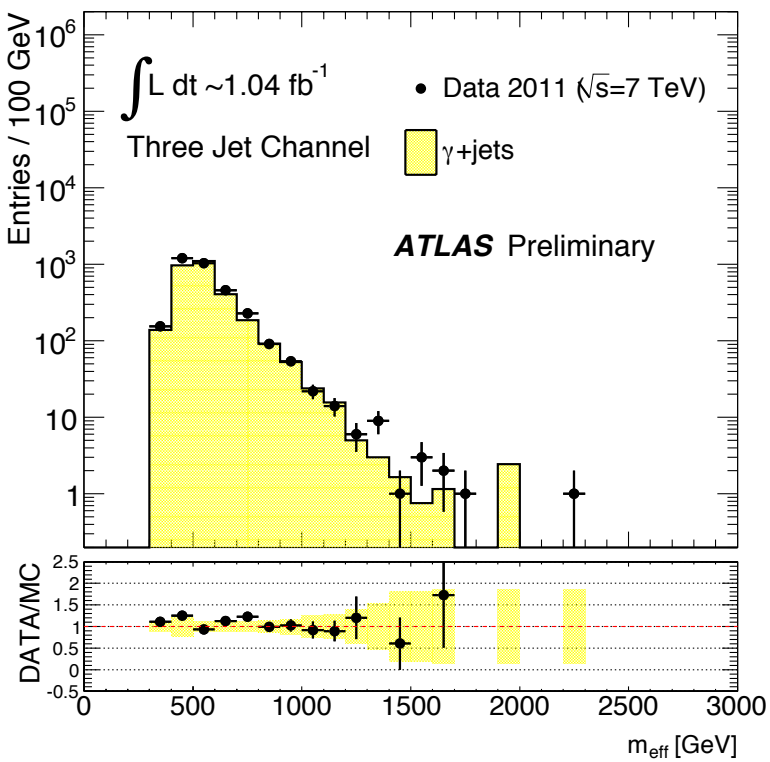
- QCD pseudo-events obtained by smearing low E_T significance events with a jet response function.

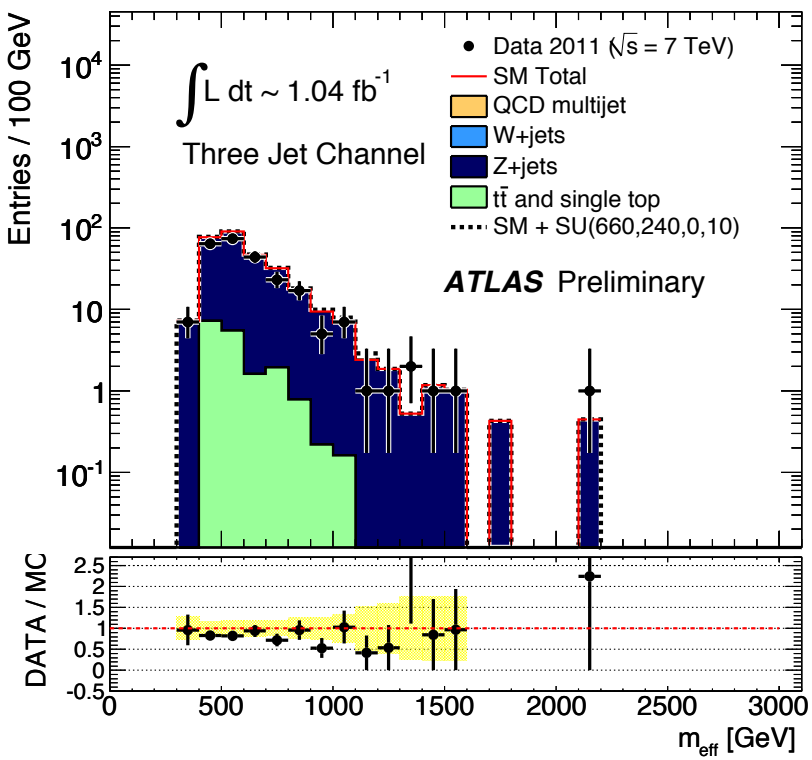
- Validation:
  - QCD prediction from pseudo-events compared to data in events where $\Delta\phi_{min\ (jet,}E_T^{miss}) < 0.4$
  - QCD multi-jet events have large MET because of jet mis-measurement or heavy flavours leptonic decays.
  - In both cases MET tends to align with one of the jets



Z control region

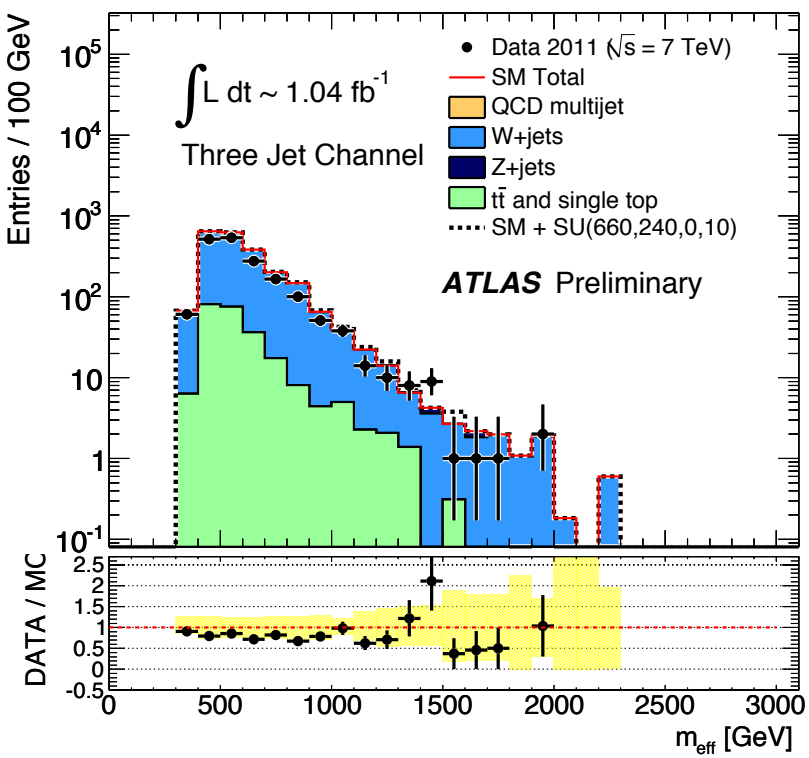
- Z→νν is the dominant component of the total Z background
- Estimation done in 2 CR (in both cases replacing the boson with MET):
  - γ+jets events (use robustness of ratio between photon and Z production cross section)
  - Z (→ee,μμ) + jets

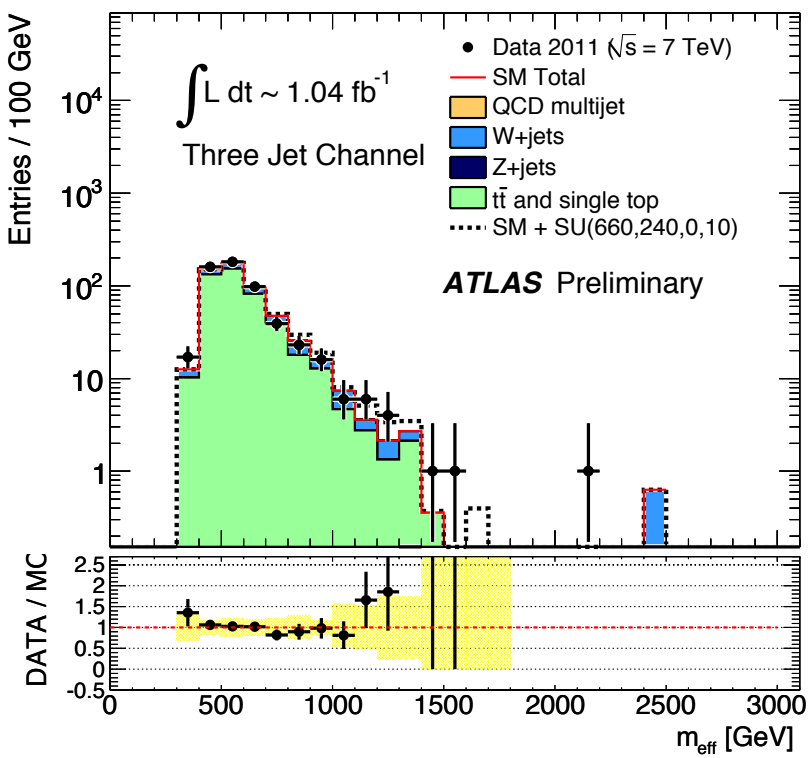




W and top control regions

- Two control regions defined in events containing one additional lepton (additional selection 30 GeV < M_T < 100 GeV):
  - Applying a b-tag veto a W control region is obtained.
  - Applying a b-tag requirement a top control region is obtained.

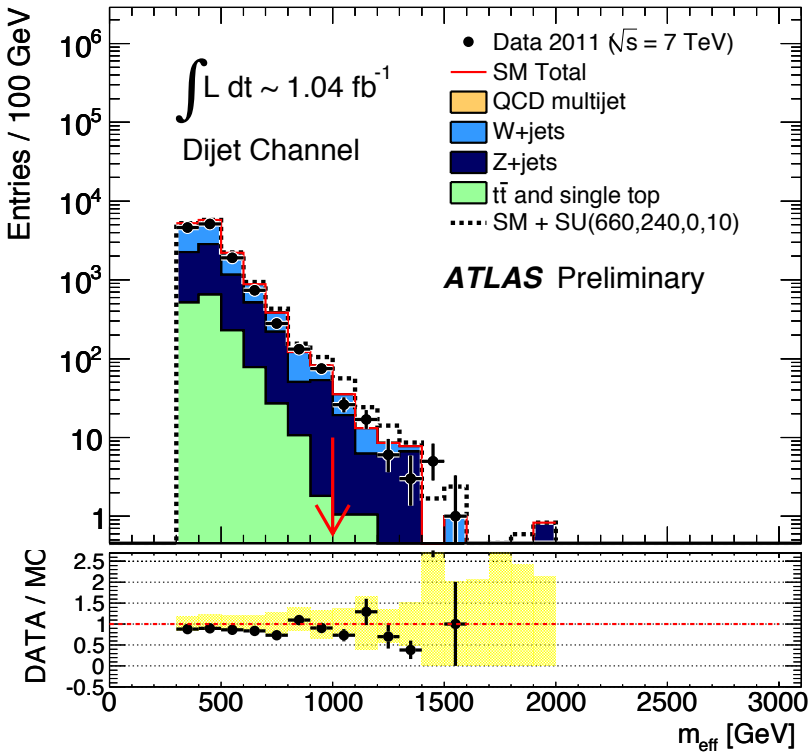


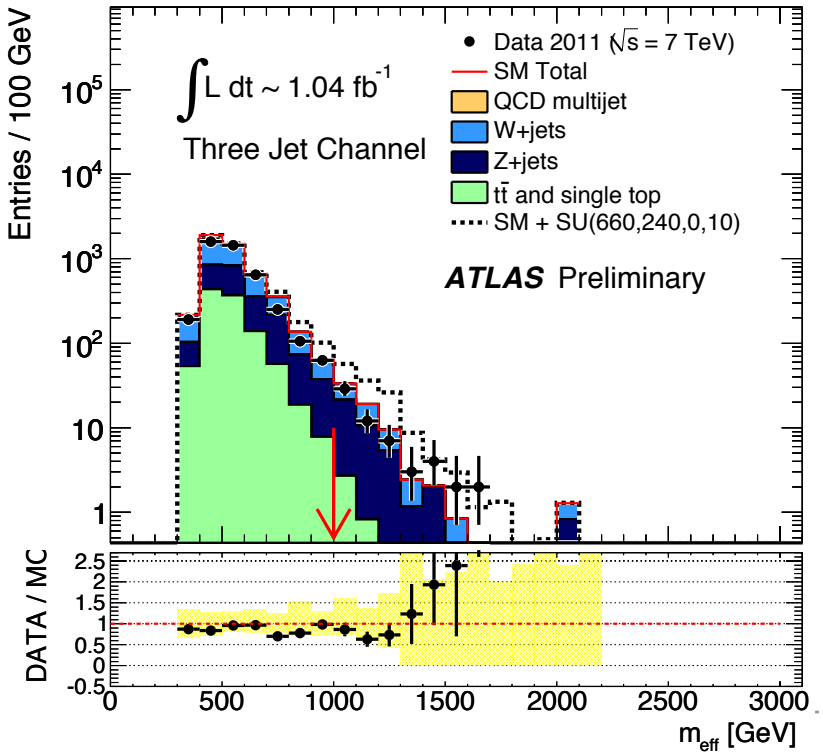


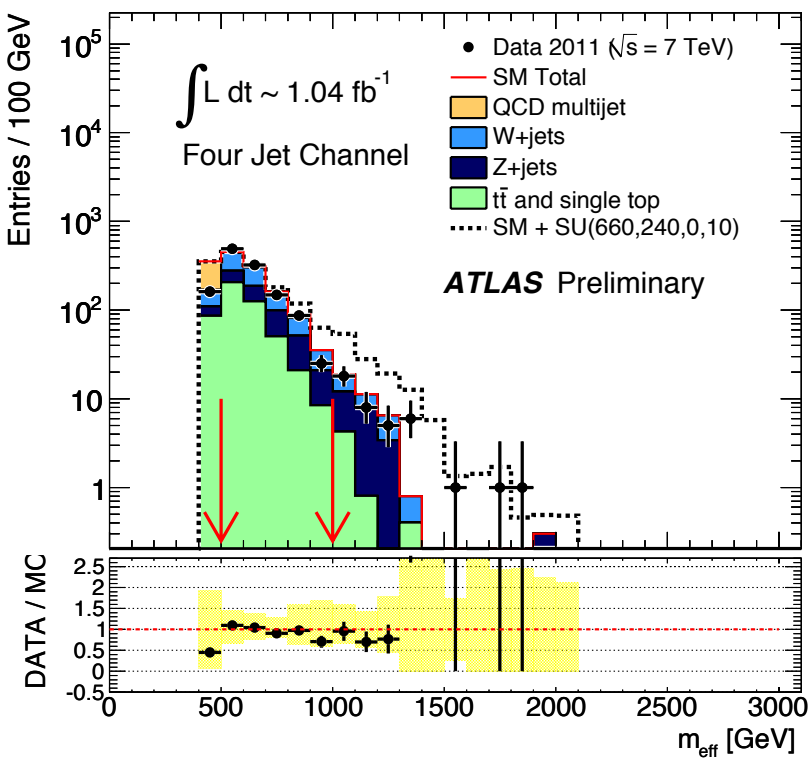
Systematic uncertainties

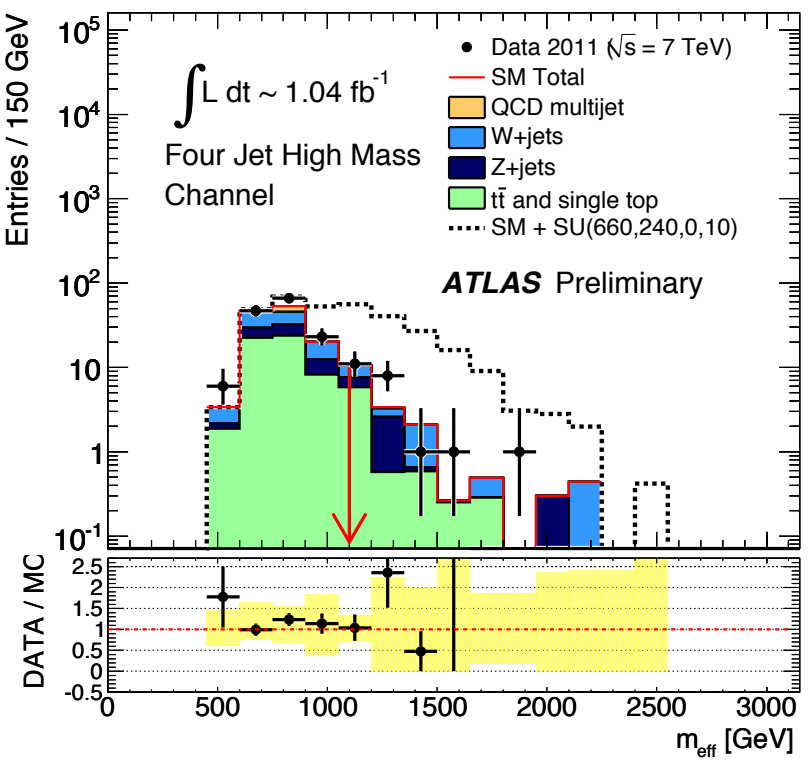
- Systematic uncertainties are reduced by the use of the transfer factors
- Jet energy scale and resolution uncertainties derived using 2010 data
  - Additional, conservative, uncertainties due to pileup considered
  - (typical effect on TF ~15%)
- Monte Carlo modelling uncertainties addressed by comparing transfer factor obtained with, e.g., ALPGEN or MC@NLO and varying renormalisation and factorisation scales (~25%)
- Depending on the CR: CR available statistics, lepton identification, b-tagging, etc. considered, typically with a smaller impact.

Results


Data 2011 (√s = 7 TeV)
SM Total
QCD multijet
W+jets
Z+jets
tt̄ and single top
SM + SU(660,240,0,10)
∫L dt ~ 1.04 fb-1
Dijet Channel
ATLAS Preliminary
Entries / 100 GeV
DATA / MC
meff [GeV]


Data 2011 (√s = 7 TeV)
SM Total
QCD multijet
W+jets
Z+jets
tt̄ and single top
SM + SU(660,240,0,10)
∫L dt ~ 1.04 fb-1
Three Jet Channel
ATLAS Preliminary
Entries / 100 GeV
DATA / MC
meff [GeV]


Data 2011 (√s = 7 TeV)
SM Total
QCD multijet
W+jets
Z+jets
tt̄ and single top
SM + SU(660,240,0,10)
∫L dt ~ 1.04 fb-1
Four Jet Channel
ATLAS Preliminary
Entries / 100 GeV
DATA / MC
meff [GeV]

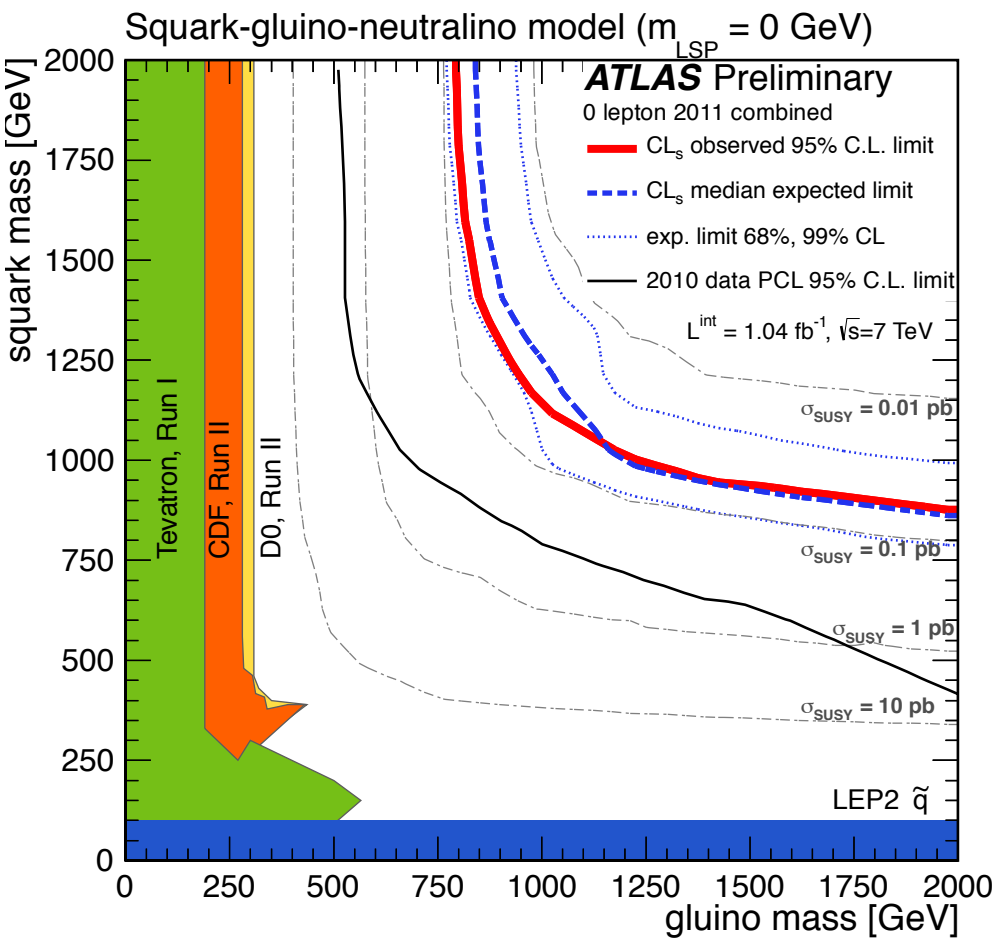

Data 2011 (√s = 7 TeV)
SM Total
QCD multijet
W+jets
Z+jets
tt̄ and single top
SM + SU(660,240,0,10)
∫L dt ~ 1.04 fb-1
Four Jet High Mass Channel
ATLAS Preliminary
Entries / 150 GeV
DATA / MC
meff [GeV]

Results

Process	Signal Region				
	≥ 2-jet	≥ 3-jet	≥ 4-jet, m_{eff} > 500 GeV	≥ 4-jet, m_{eff} > 1000 GeV	High mass
Z/γ+jets	32.5 ± 2.6 ± 6.8	25.8 ± 2.6 ± 4.9	208 ± 9 ± 37	16.2 ± 2.1 ± 3.6	3.3 ± 1.0 ± 1.3
W+jets	26.2 ± 3.9 ± 6.7	22.7 ± 3.5 ± 5.8	367 ± 30 ± 126	12.7 ± 2.1 ± 4.7	2.2 ± 0.9 ± 1.2
$t\bar{t}$+ single top	3.4 ± 1.5 ± 1.6	5.6 ± 2.0 ± 2.2	375 ± 37 ± 74	3.7 ± 1.2 ± 2.0	5.6 ± 1.7 ± 2.1
QCD jets	0.22 ± 0.06 ± 0.24	0.92 ± 0.12 ± 0.46	34 ± 2 ± 29	0.74 ± 0.14 ± 0.51	2.10 ± 0.37 ± 0.83
Total	62.3 ± 4.3 ± 9.2	55 ± 3.8 ± 7.3	984 ± 39 ± 145	33.4 ± 2.9 ± 6.3	13.2 ± 1.9 ± 2.6
Data	58	59	1118	40	18
excluded σx acc (fb)	24	30	477	32	17

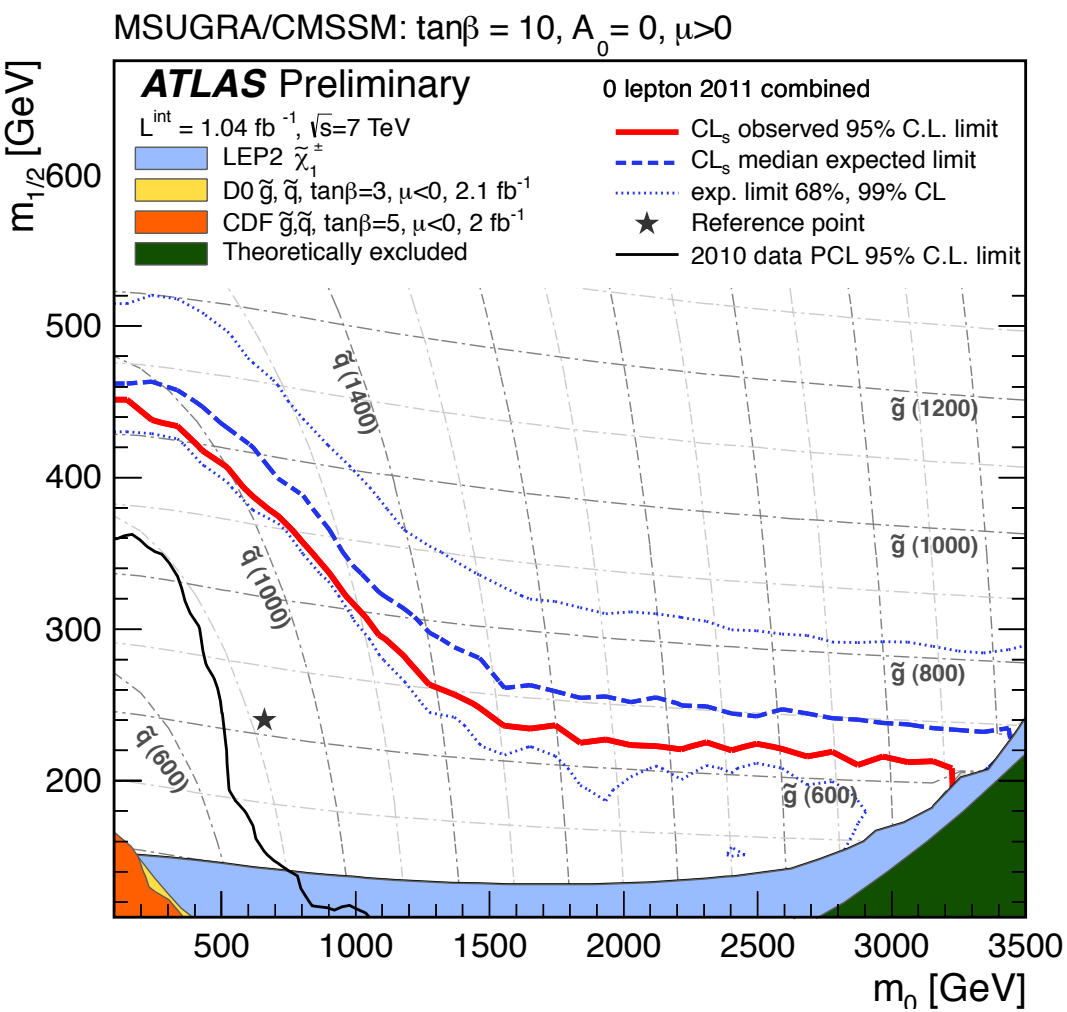
- No discrepancy with respect to SM predictions.
- The result is interpreted as a 95% CL exclusion limit on effective cross sections using a profile likelihood ratio approach following the CLs prescriptions.
- Analysis giving best expected limit used in each point.

Result interpretation (1)



- Simplified model (pheno MSSM) interpretation:
  - LSP mass set to 0, all other sparticle masses set to 5 TeV except a common (1st and 2nd generation) squark mass and the gluino mass (shown in the plot)
  - Up to m ~ 1 TeV excluded for equal gluino-squark masses (2010 limit extended by ~250 GeV).
- Exclusion limit not too sensitive to the neutralino mass up to ~200 GeV

Result interpretation (2)



- Results interpreted in mSUGRA/CMSSM (A_0 = 0, tanβ = 10, μ>0)
- Limit in large m_0 region profits from the introduction of signal regions with large jet multiplicities.
- Equal squark-gluino masses excluded below 980 GeV

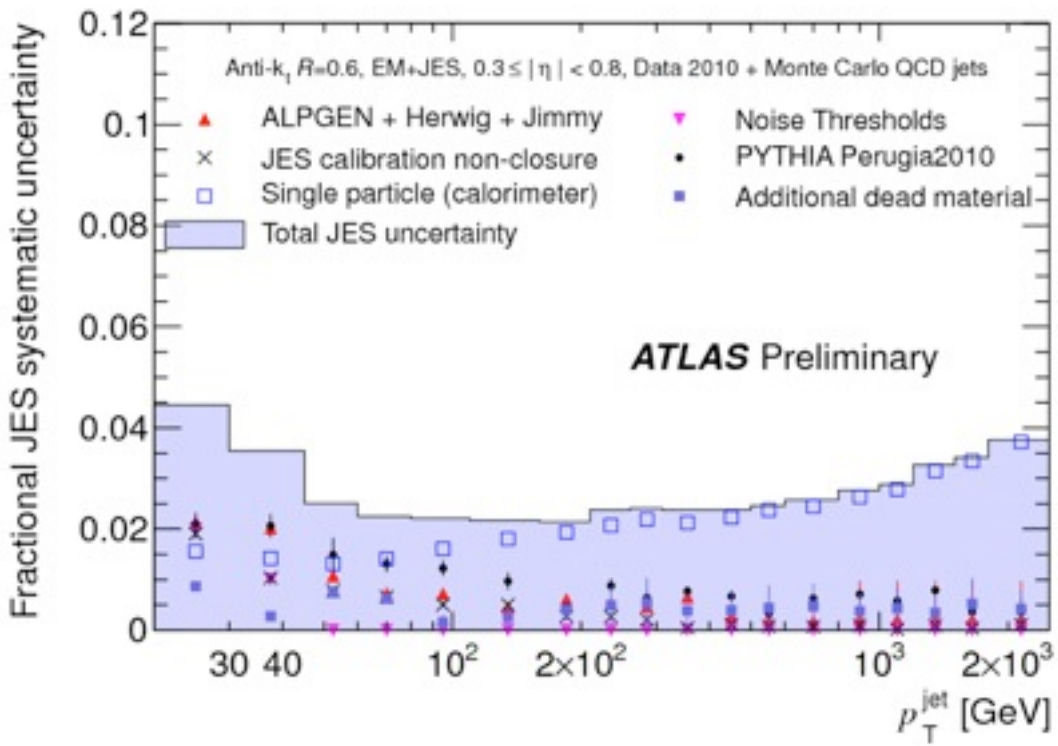
Conclusions

- The ATLAS search for R-parity conserving SUSY in final states with jets and transverse missing momentum has been updated to L = 1 fb^{-1} and the analysis strategy improved.
- Full agreement with SM prediction observed in five signal regions defined based on jet multiplicity and m_{eff} cut.
- The results have been used to derive a 95% CL exclusion limit:
  - In simplified models with only squark (1st and 2nd generation) and gluino accessible, m ~ 1 TeV excluded if $m_g = m_q$.
  - In mSUGRA/CMSSM, equal gluino and squark masses are excluded up to 980 GeV.
  - A paper is in preparation.

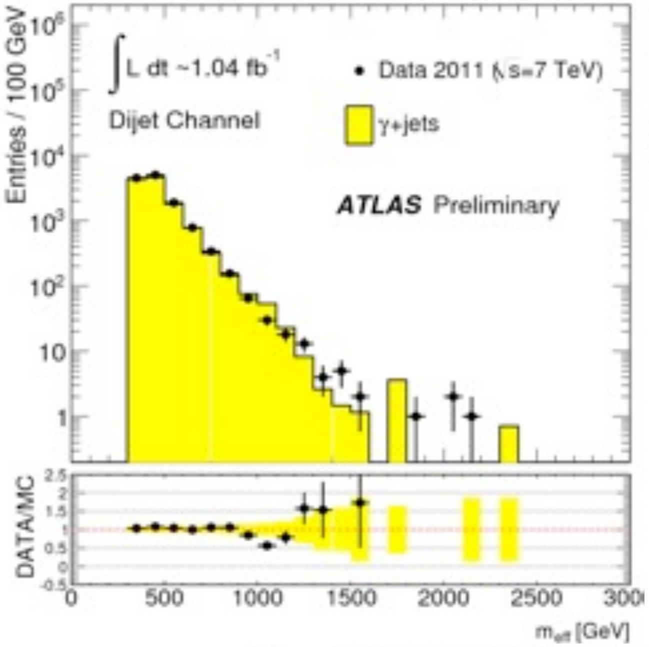
Backup

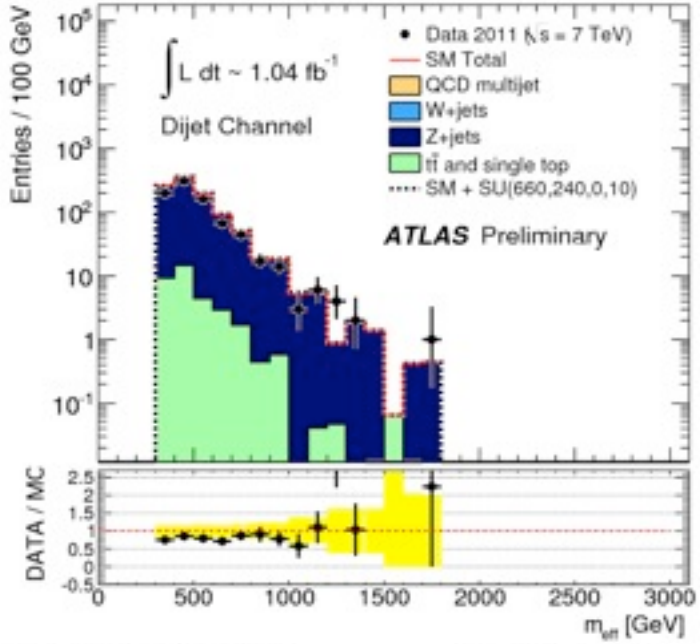
Jet energy scale uncertainties

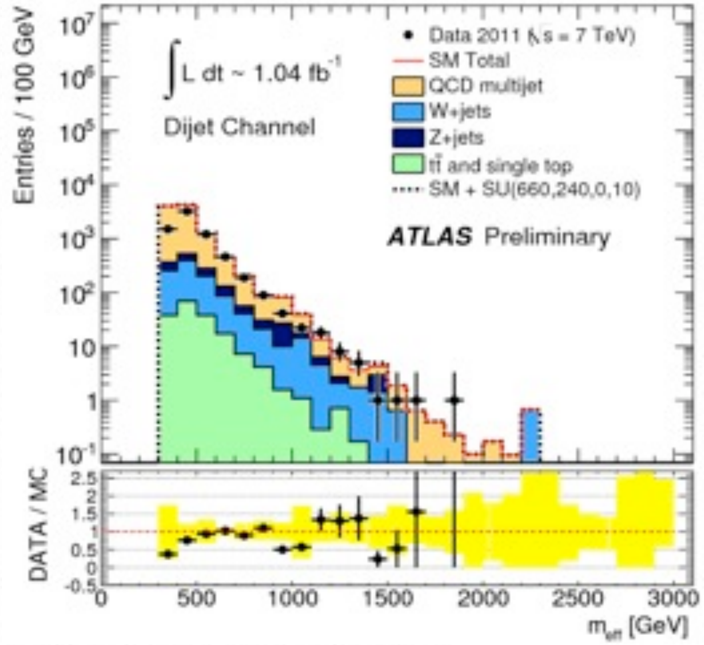
- Derived using 2010 data
- Main component of the uncertainty at high p_T: calorimeter uncertainty
- Additional uncertainties taken into account:
  - 2011 pileup
  - response dependency on the flavour
  - response dependency on jet isolation

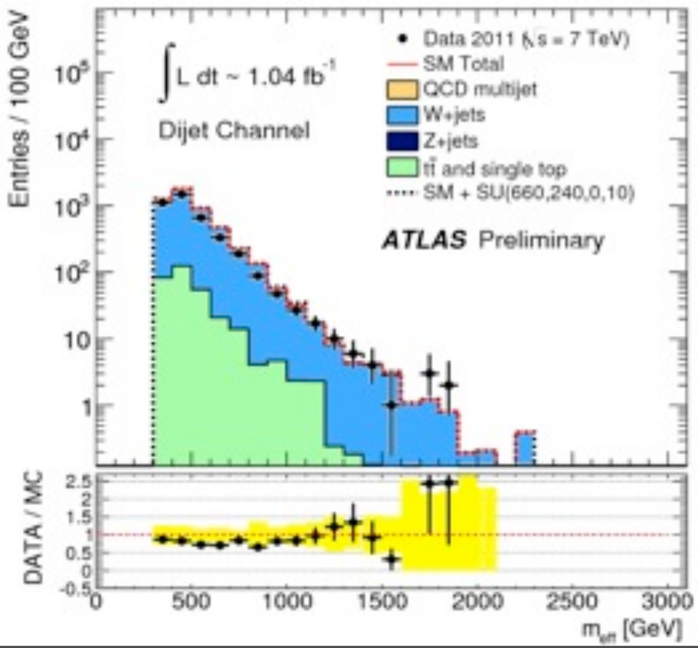


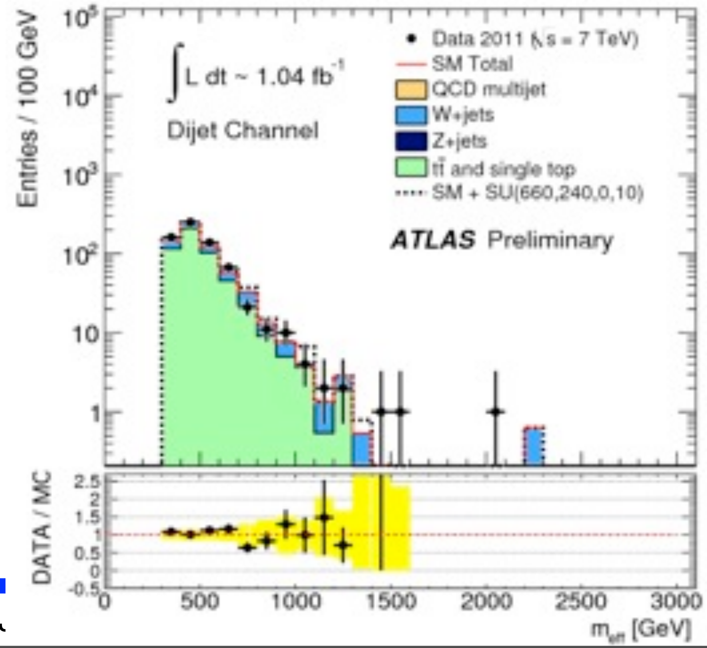
2 jets signal region control plots



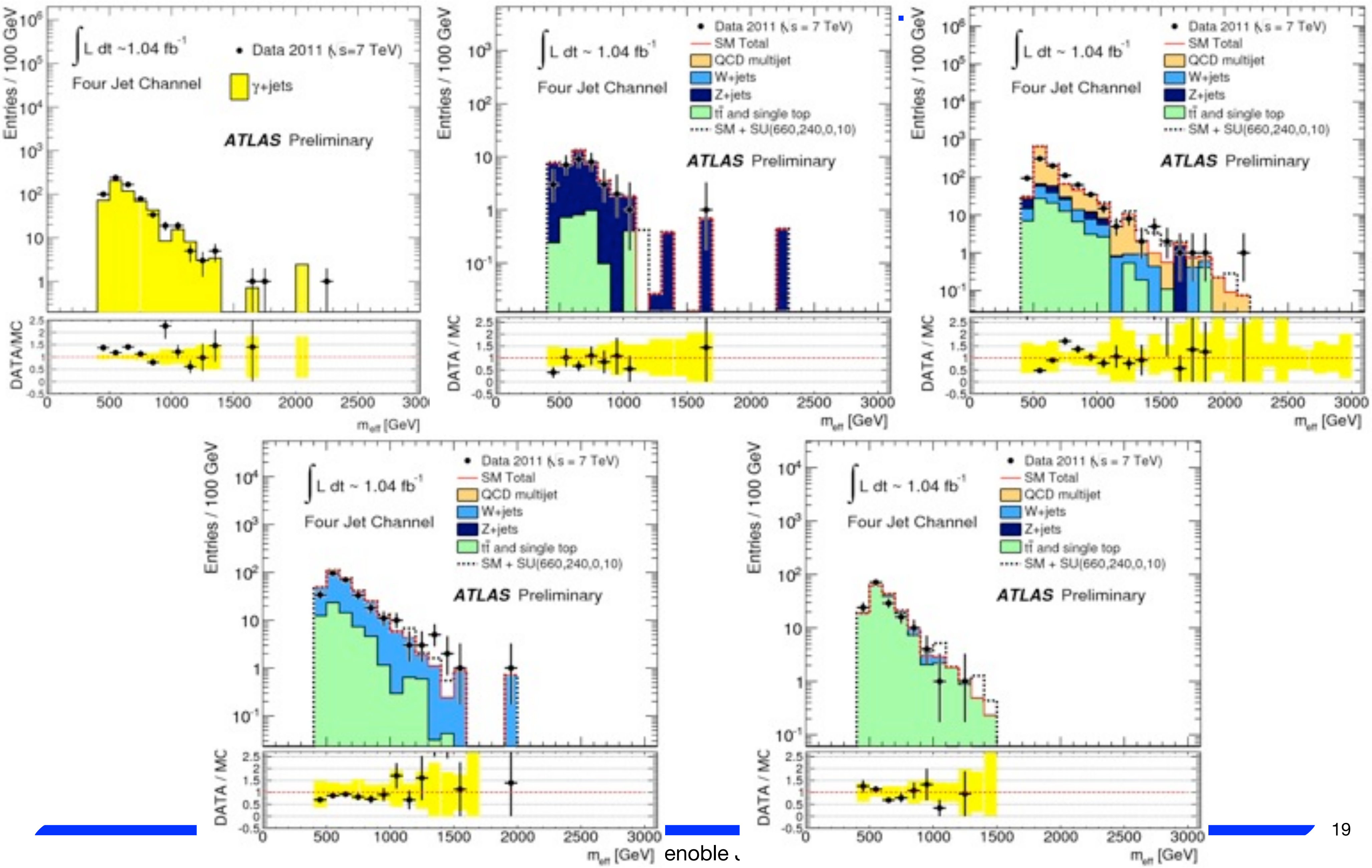








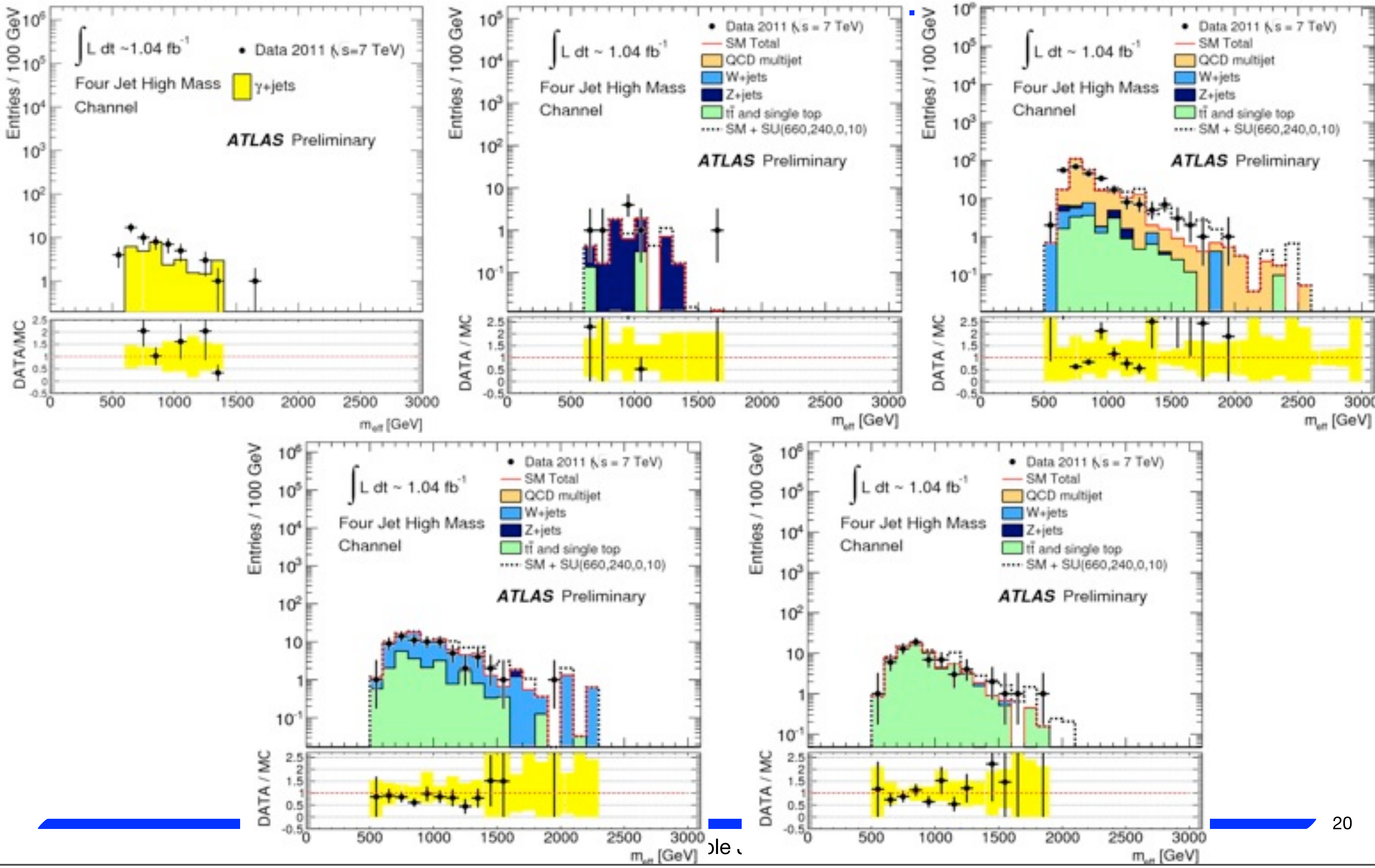
4 jets signal region control plots



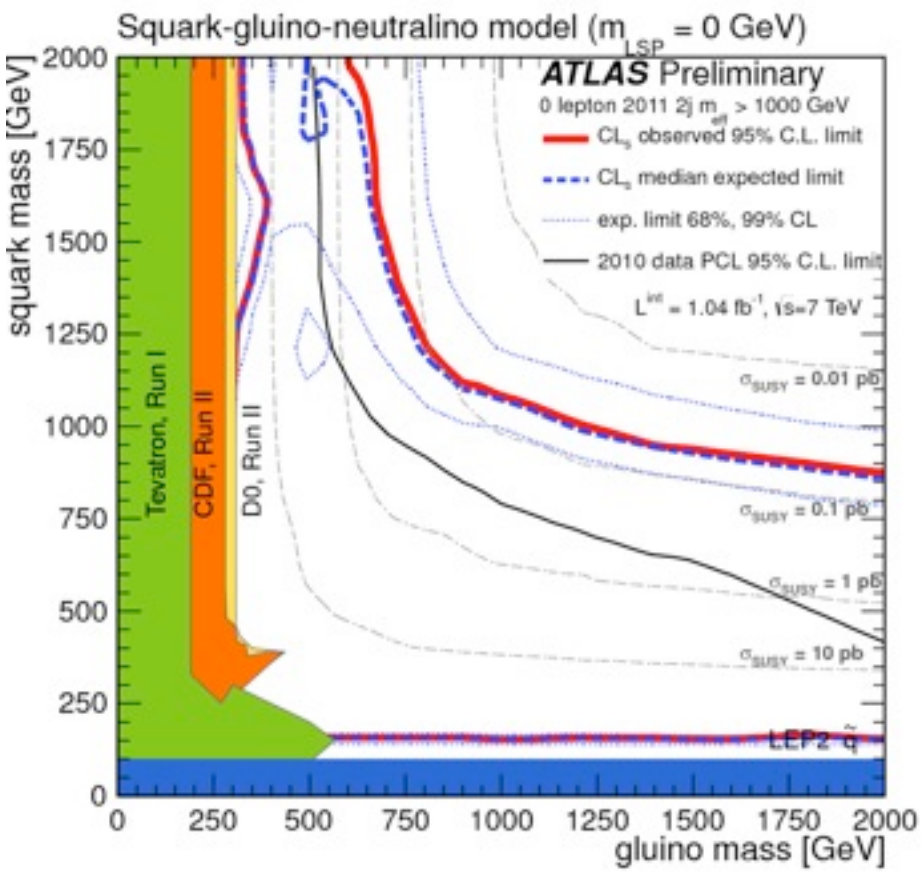
enoble

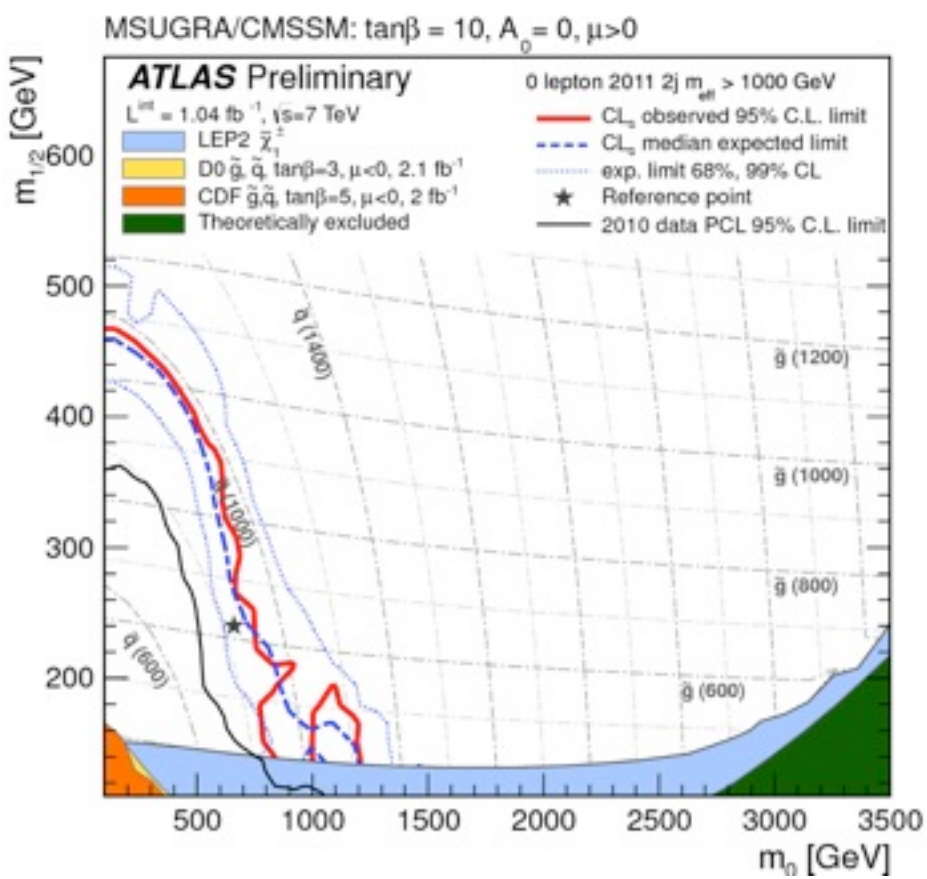
Saturday, July 23, 2011

High mass signal region control plots

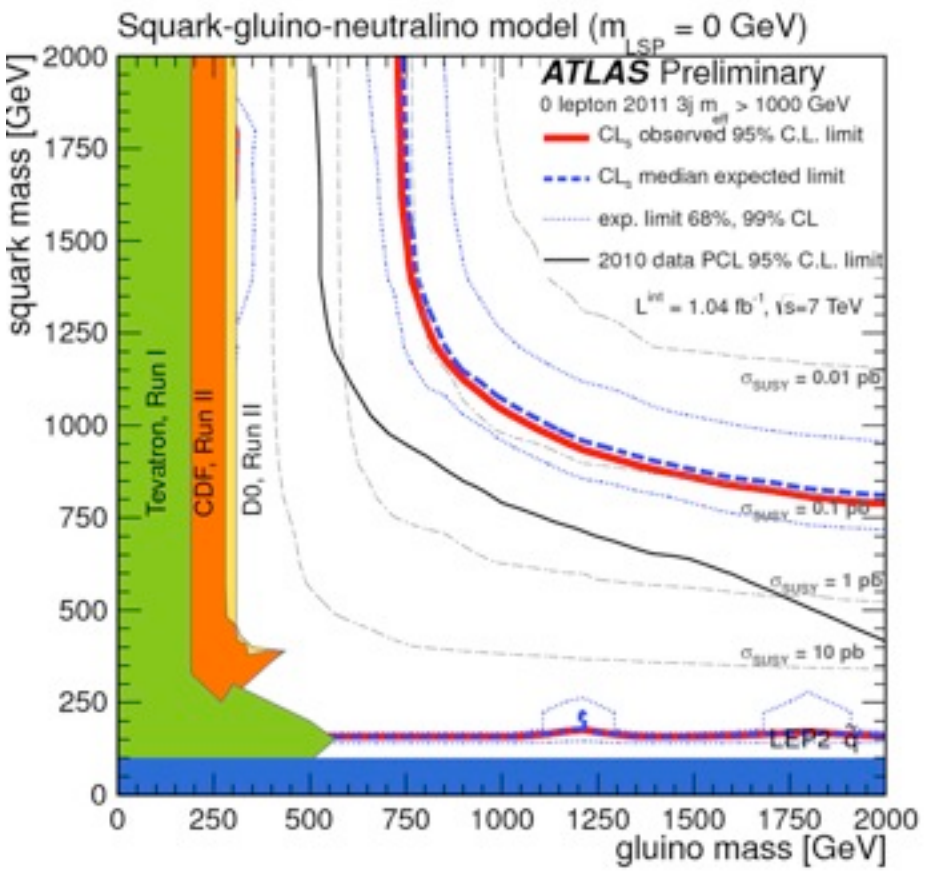


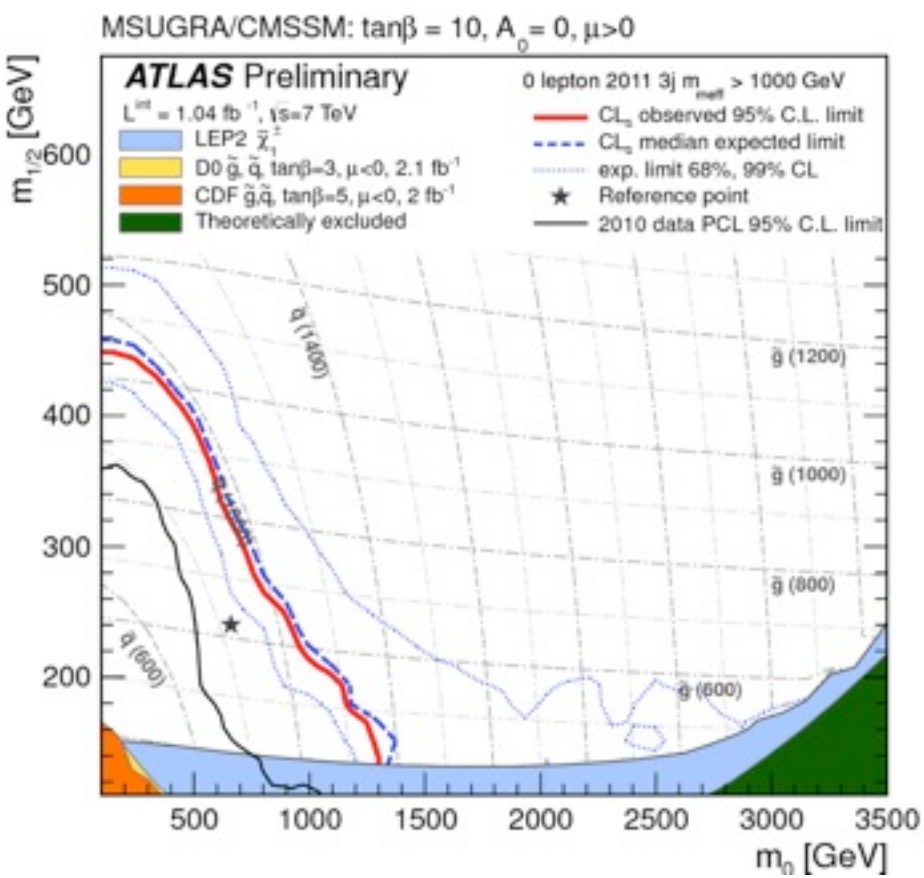
2 jets signal region exclusion limits



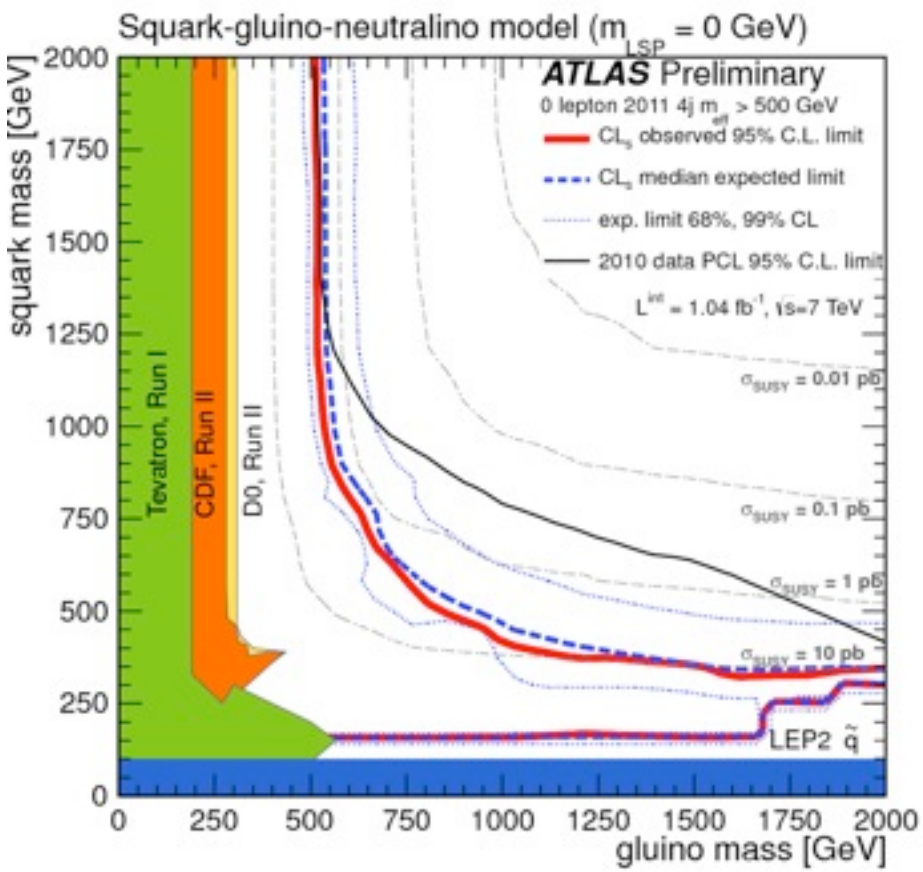


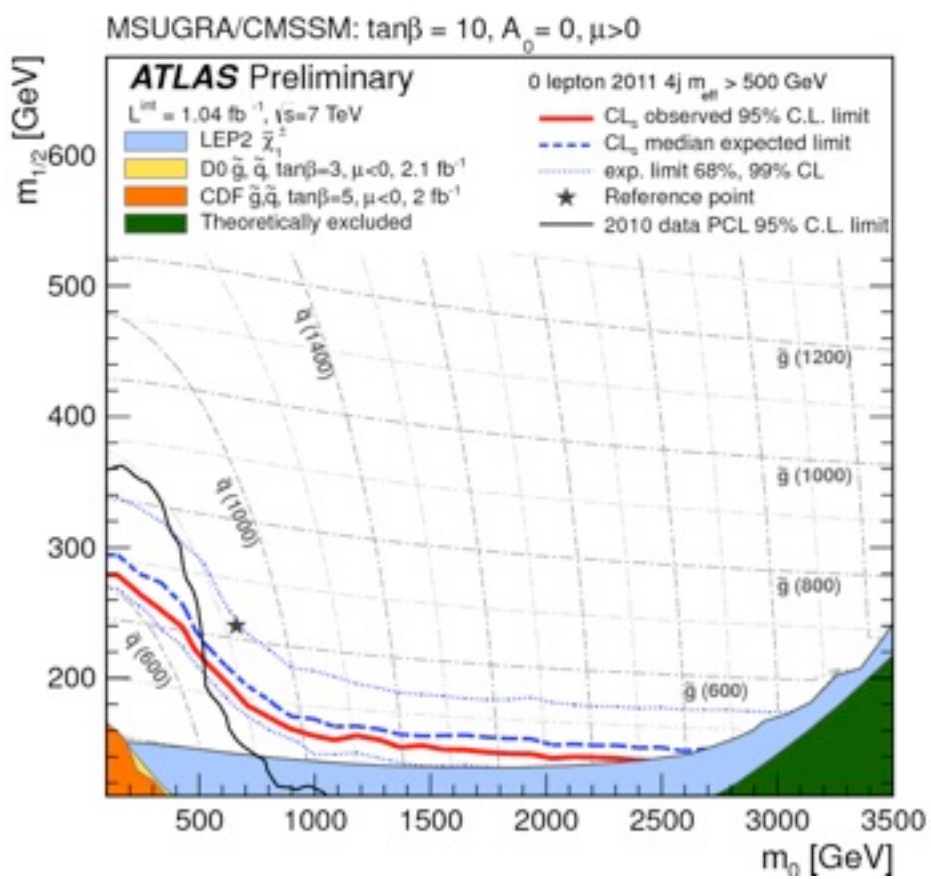
3 jets signal region exclusion limits



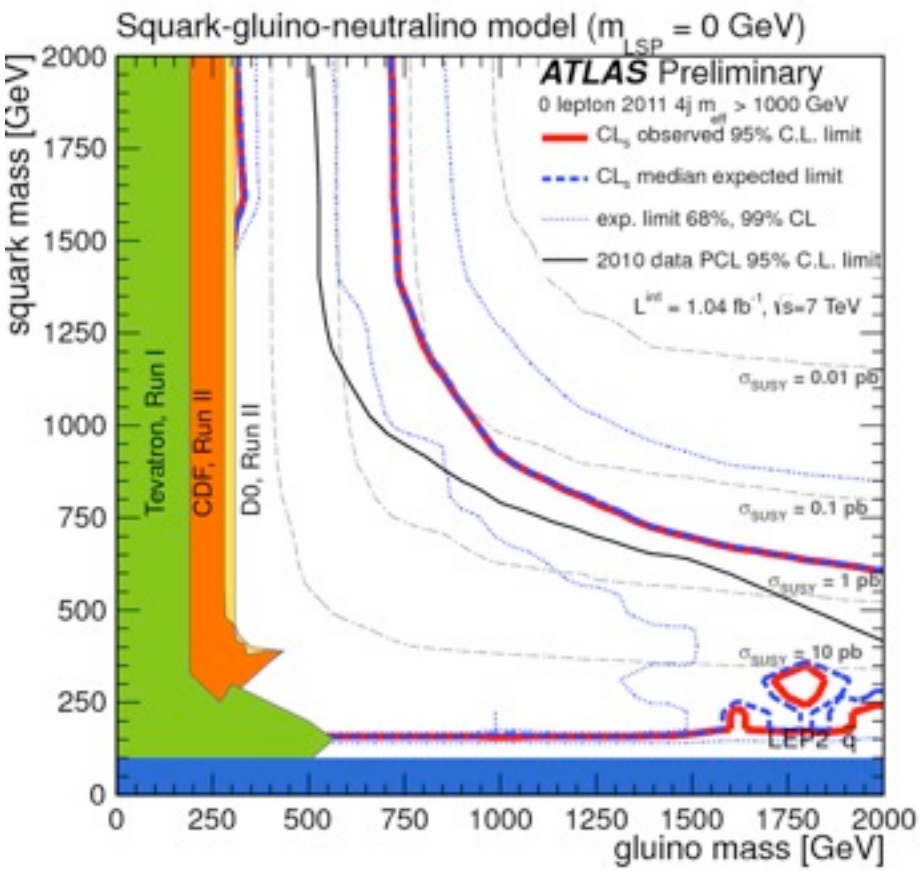


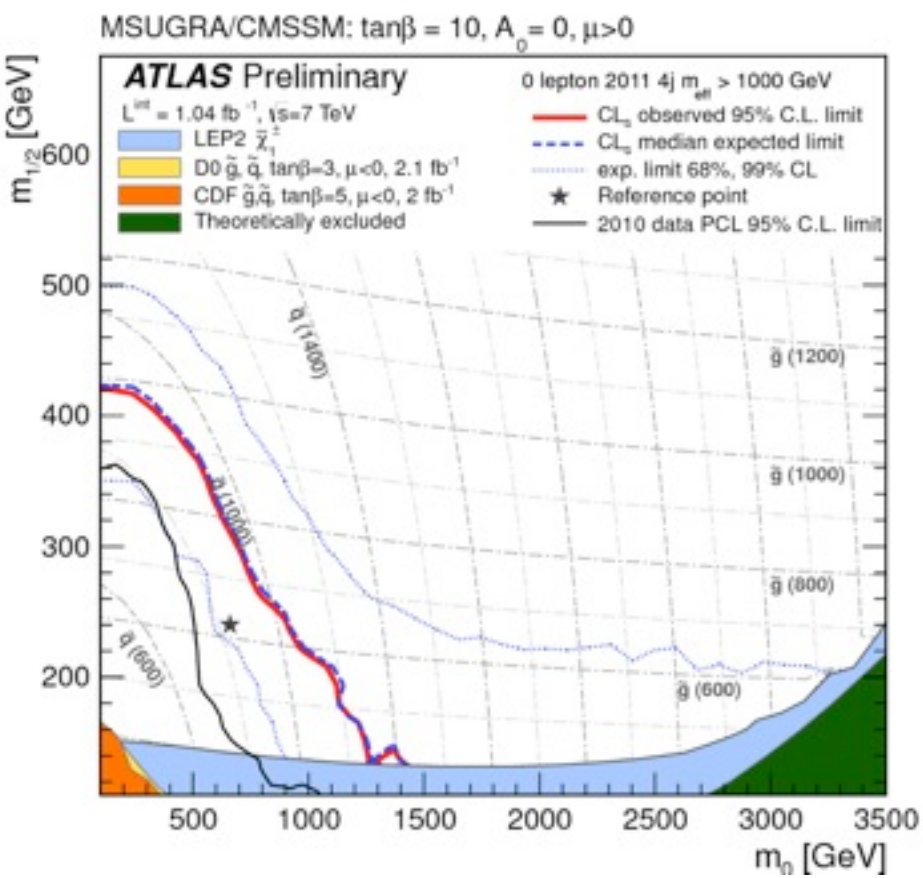
4 jets signal region (m_{eff} > 500 GeV)



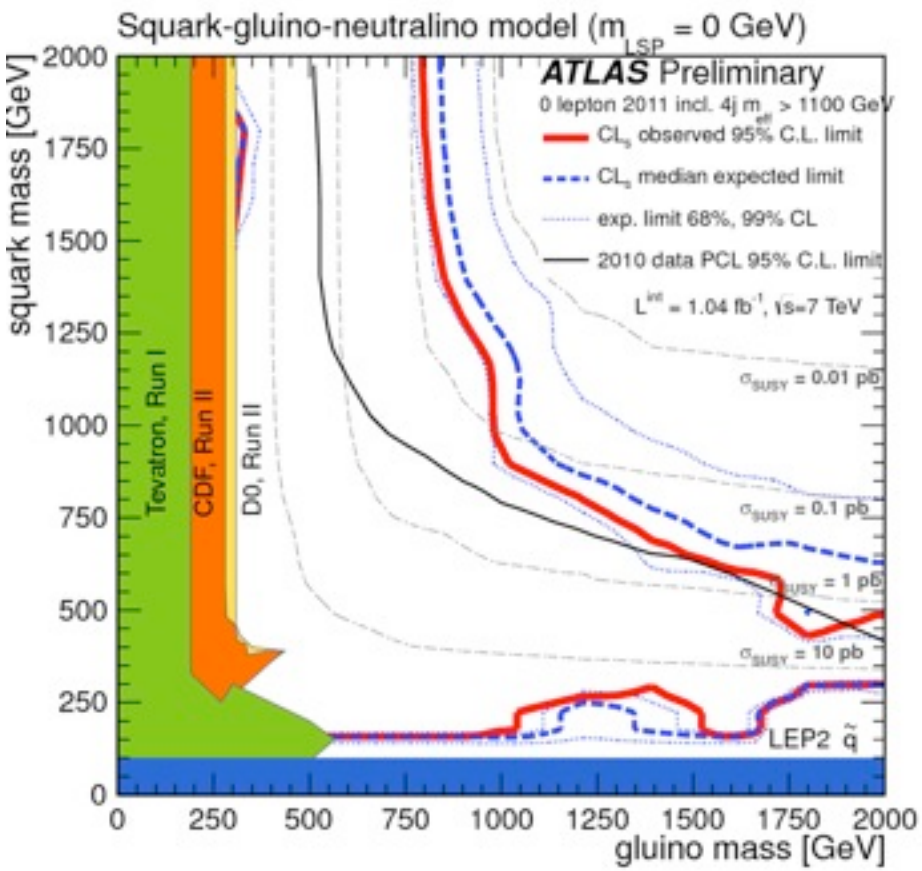


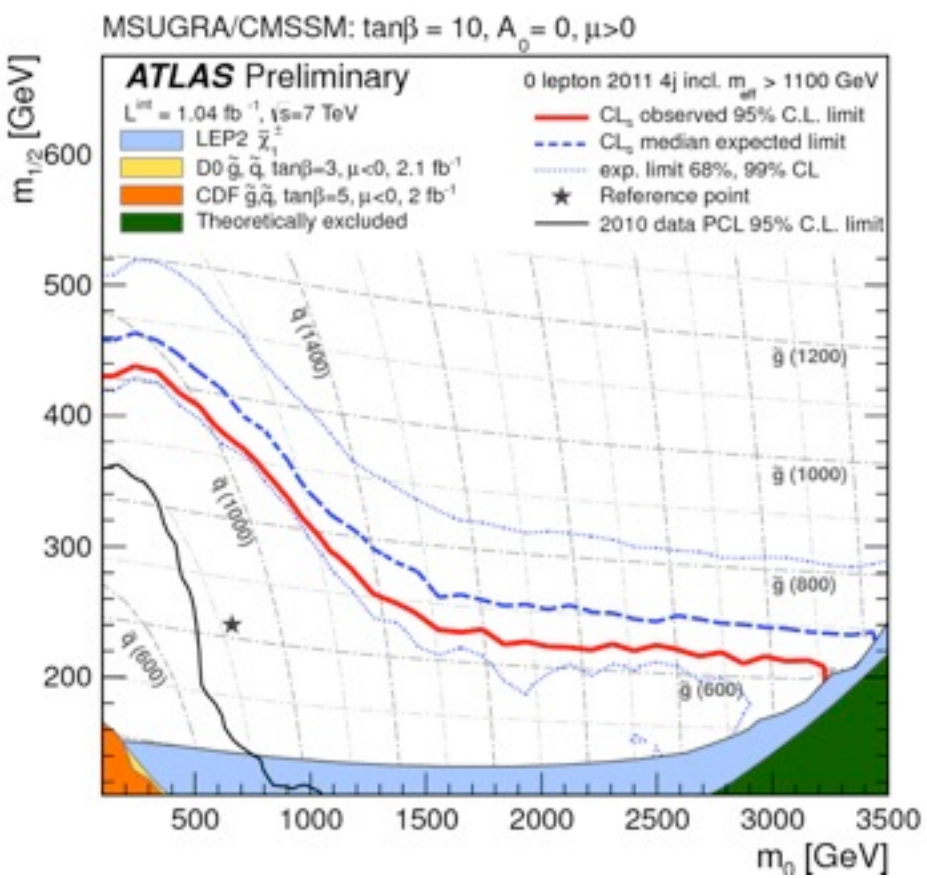
4 jets signal region (m_{eff} > 1 TeV)



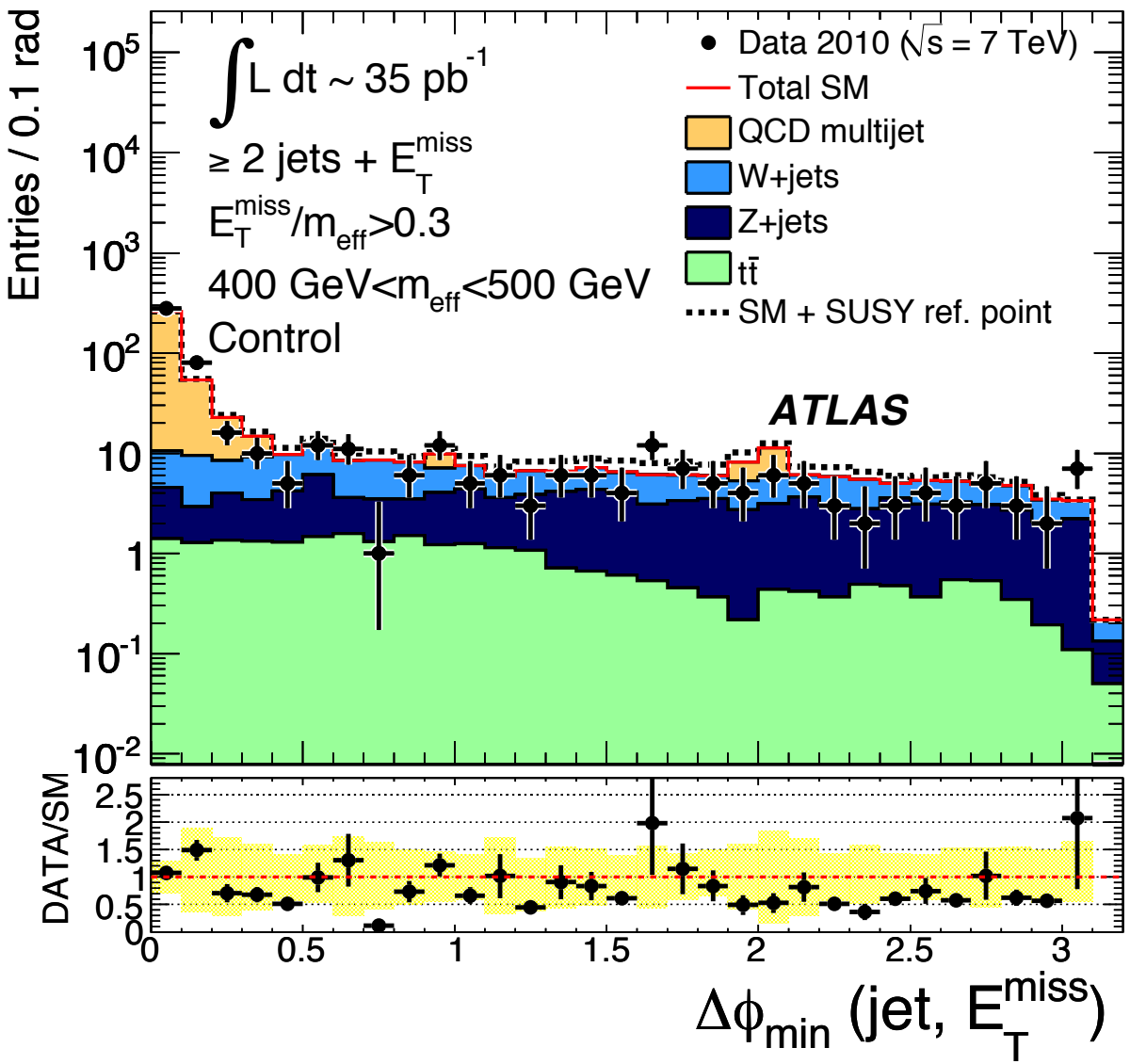


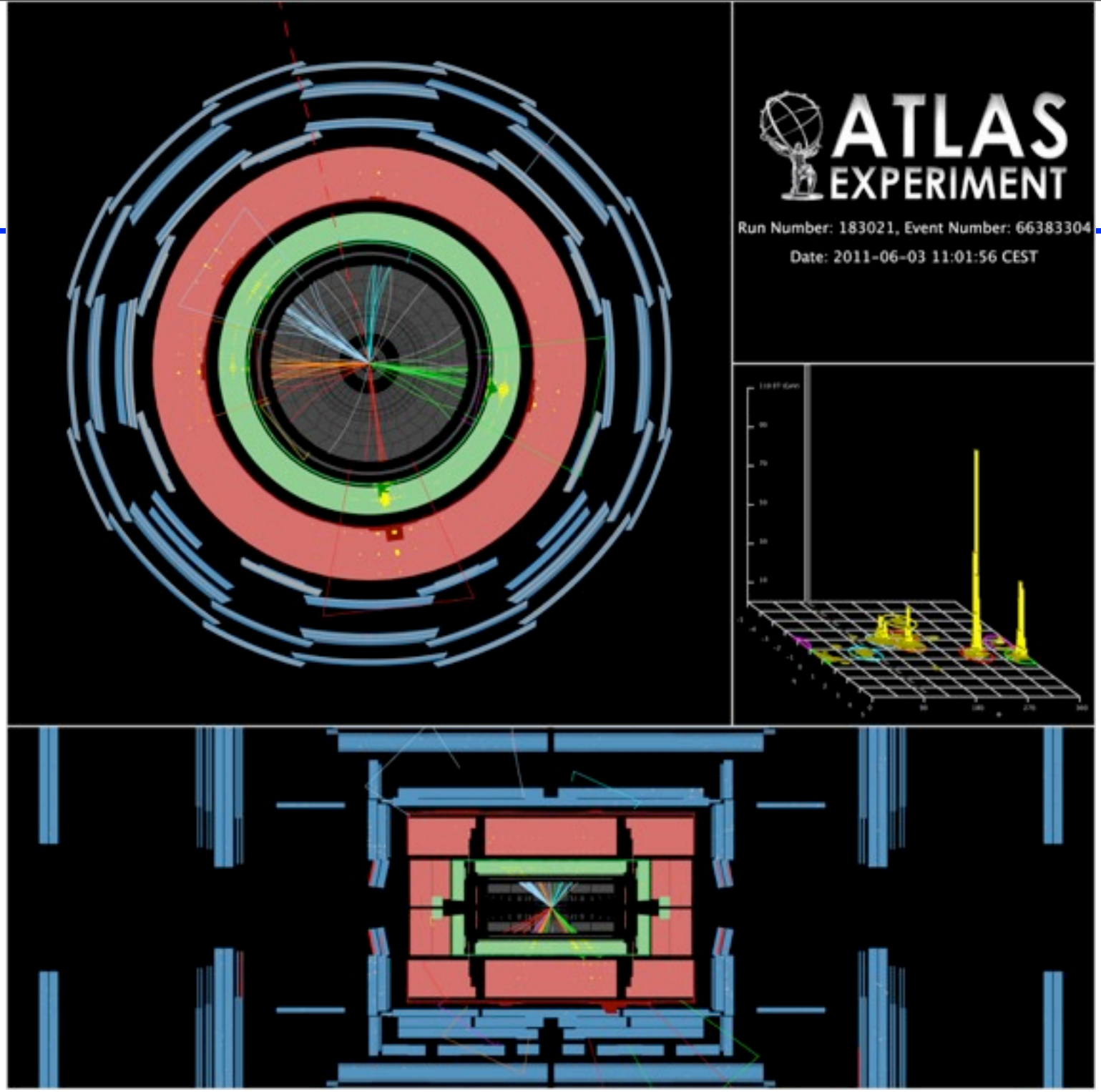
High mass signal region





Delta phi distribution




ATLAS
EXPERIMENT
Run Number: 183021, Event Number: 66383304
Date: 2011-06-03 11:01:56 CEST