ATLAS SUSY & Exotics searches

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IHEP, Protvino, on behalf of ATLAS collaboration

Last news from LHC

-- new peak lumi record: :

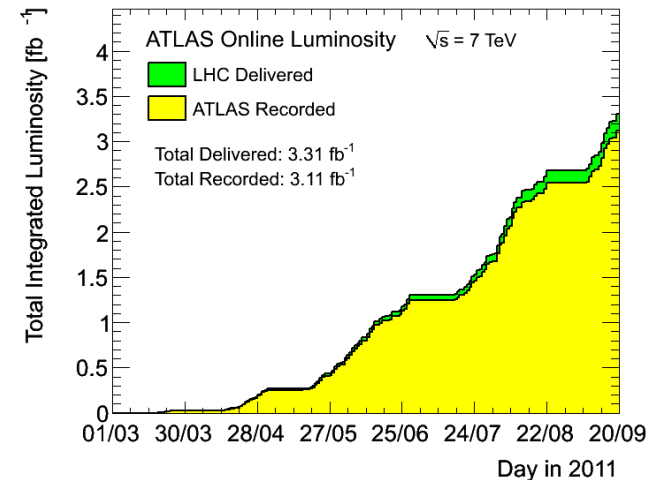$$3.3 10^{33} \ \text{s}^{-1}\text{cm}^{-2}$$

bunch charge up to $1.39 \ 10^{11} \ \text{s}^{-1}\text{cm}^{-2}$

- emittance ~ 2μm)
-- stored beam energy: ~ 107 MJ
-- total recorded luminosity: ~ 3.1 fb^{-1}
 (~ 0.350 fb^{-1} last week)
-- average pile-up: ~ 12 evts/xing (up
to ~ 20)

Detector components ...

4 super-conducting magnets: solenoid + 3 toroids

Solenoid field 2T in inner detector region
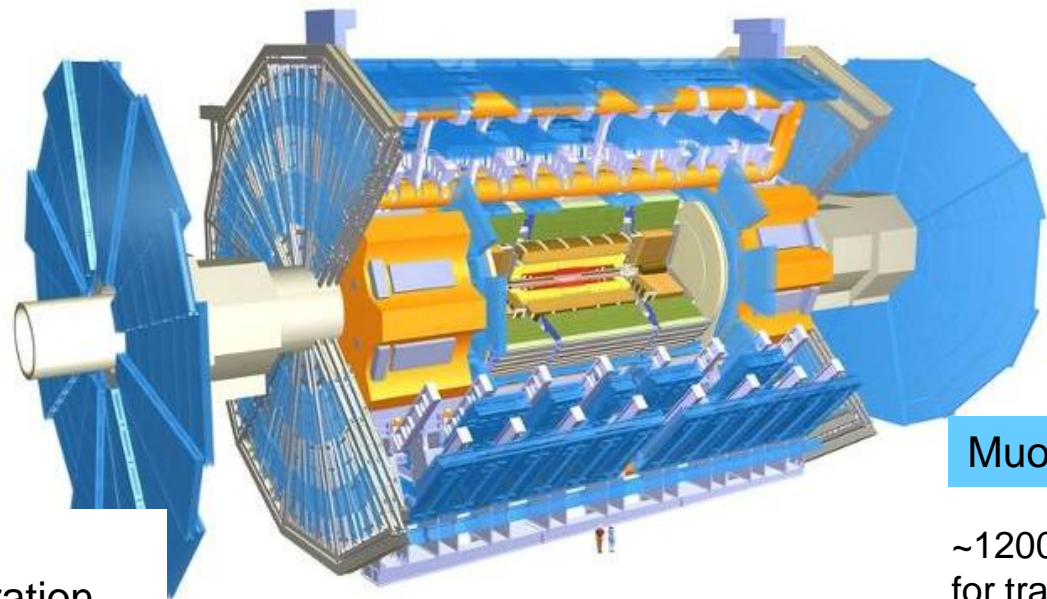
toroid field peak strength 4T

Silicon Pixel detector

80 M channels, intrinsic

resolution 10 x 110 μm

TileCal hadronic calorimeter

Sandwich structure: iron absorber + scintillator tiles

~ 10000 channels

Silicon tracker

~ 6 ·10^6 channels

80 μm wide strips

Transition Radiation Tracker

Xe field straw tubes, electron – pion separation

~ 35 hits/track for track reconstruction

Muon spectrometer

~1200 precision chambers for track reconstruction

~600 RPC and ~3600 TGC trigger chambers

Stand-alone momentum re-solution Δpt/pt < 10% up to 1 TeV

LAr calorimeters (EMC, HC)

~ 160000 + 10000 channels (EMC,HC)

10%/√E energy resolution for e,γ

Trigger for electrons, photons and jets

SUSY phenomenology

- **Very rich and diverse phenomenology in general**
- **–if R-parity is conserved**
  - **•Lightest Supersymmetric Particle (LSP) is stable**
- **–large missing transverse energy (MET)**
- **–dark matter candidate**
- **–if q or g masses are not very large**
  - **•dominant production via strong force at LHC**
  - **•decay chain to LSP (possibly long)**
- **–multiple jets**
- **–can have leptons and/or photons**
- **popular model: CMSSM/MSUGRA**
- **–if 3rdgeneration is lighter (to stabilize Higgs mass) enhanced b-jet production**
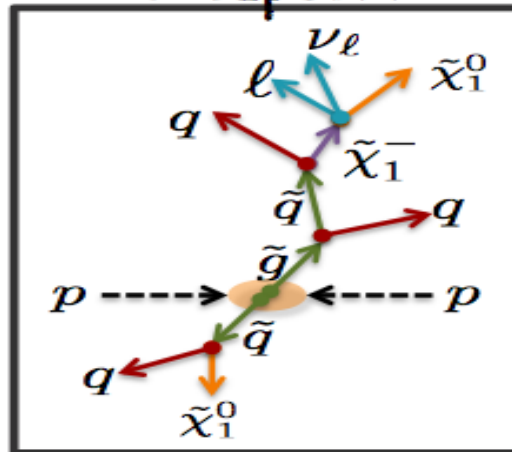
SUSY searches in ATLAS

- MET + jets + 0 lepton (squarks and gluino)

- MET + jets + 1 lepton (chargino)

- MET + 2 leptons (chargino, neutralino)

- MET + 2 photons (bino-like lighest neutralino)

- MET + b-jet + 0/1 lepton (sbottom)

- e+ μ resonance

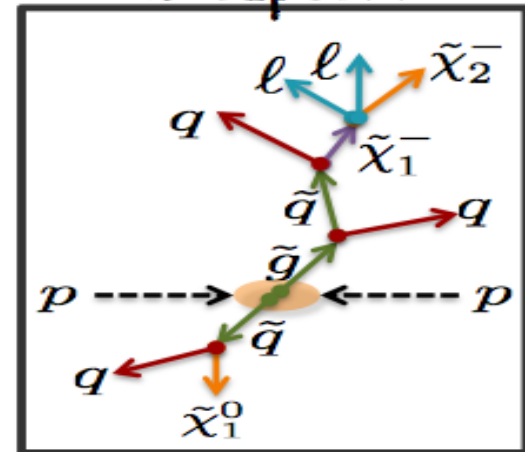- slow colored hadron (squarks and gluino as LLP)
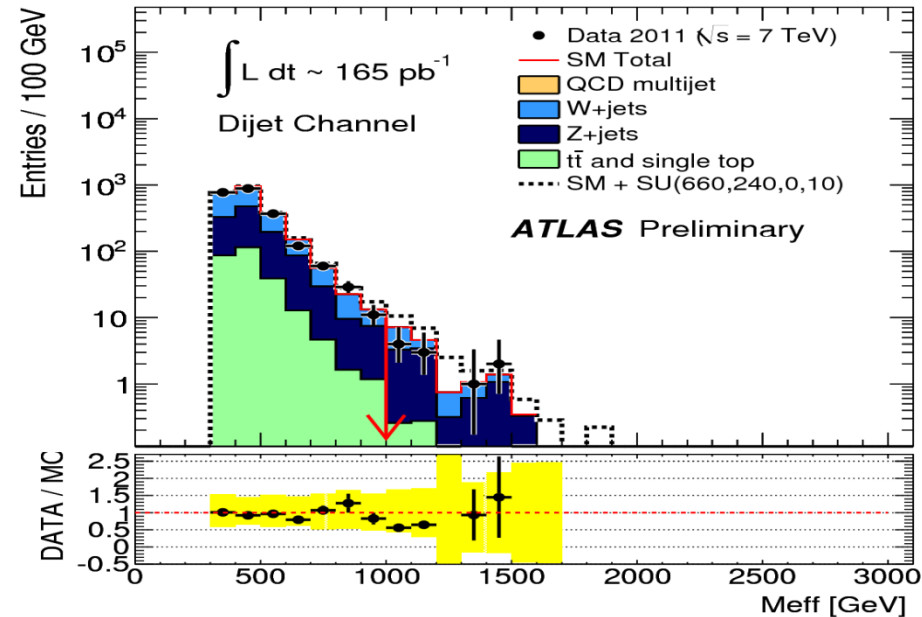
- slow muon-like particle (stau)
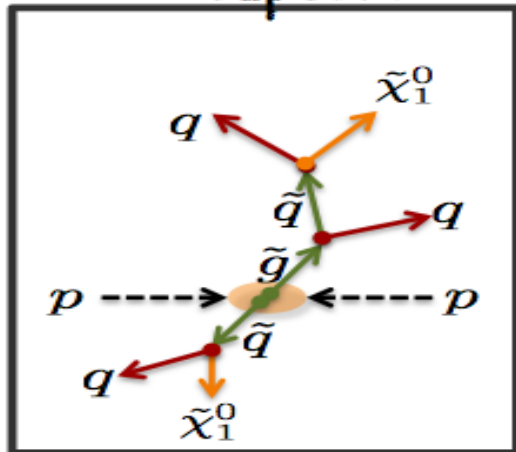
MET + jets + 0 lepton
ATLAS-CONF-2011-086

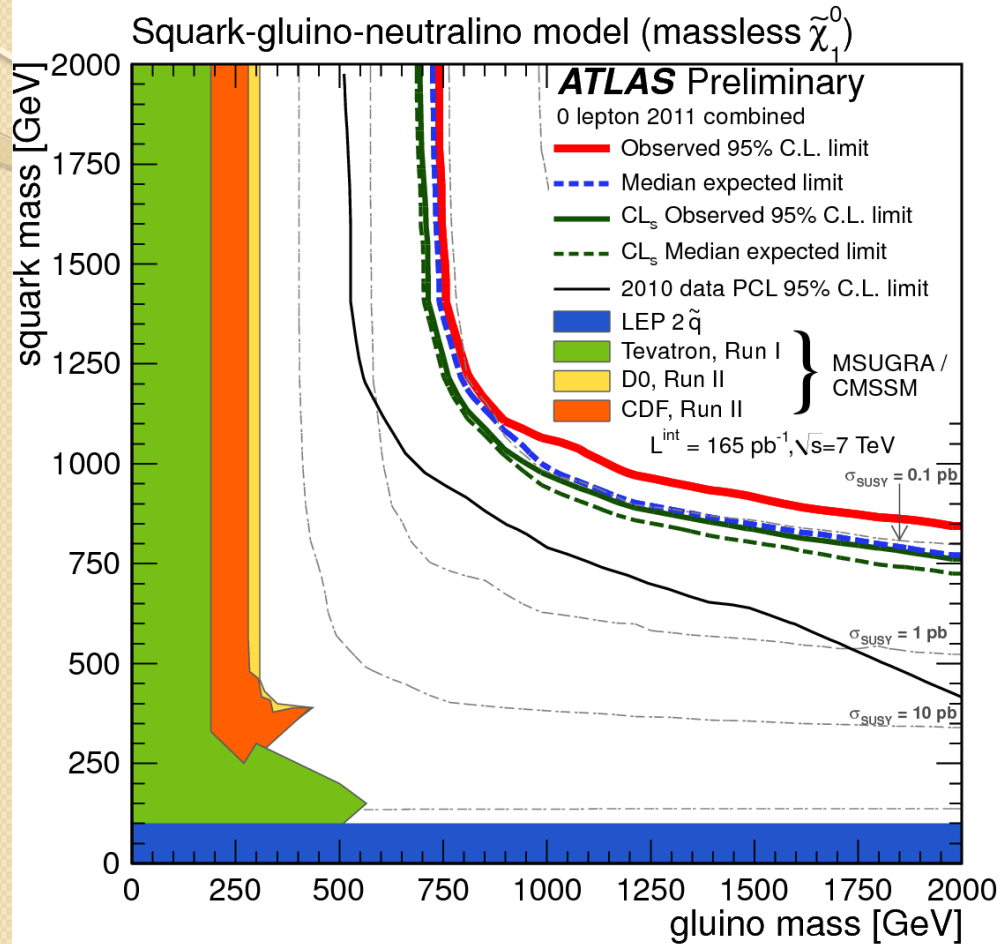| Signal Region	A	B	C	D
observed:	87	11	66	2
expected:	118	10	88	2,5

σεB A (pb)   < 1.1 < 0.11   <0.35   <1.3

The observed distributions of meff for the >=2 jet channel. These plots also show the expected SM contributions after application of all selection criteria obtained from MC simulated samples prior to normalisation using the data-driven likelihood method

Main backgrounds: W+jets,Z_jets,top pair.multi-jet and single top

Combined exclusion limits

Squark-gluino-neutralino model (massless $\tilde{\chi}_1^0$)

ATLAS Preliminary
0 lepton 2011 combined
— Observed 95% C.L. limit
- - - Median expected limit
— CL_s Observed 95% C.L. limit
- - - CL_s Median expected limit
— 2010 data PCL 95% C.L. limit
▮ LEP 2 $\tilde{q}$
▮ Tevatron, Run I
▮ D0, Run II } MSUGRA / CMSSM
▮ CDF, Run II
$L^{int} = 165\ pb^{-1}, \sqrt{s} = 7\ TeV$

$\sigma_{SUSY} = 0.1\ pb$
$\sigma_{SUSY} = 1\ pb$
$\sigma_{SUSY} = 10\ pb$

squark mass [GeV] (y-axis: 0 to 2000)
gluino mass [GeV] (x-axis: 0 to 2000)

Combined exclusion limits (solid red line) in the (m_gluino ; m_squark) plane for the simplified squark--gluino model with massless χ_1, taking the signal region with the best expected limit per point

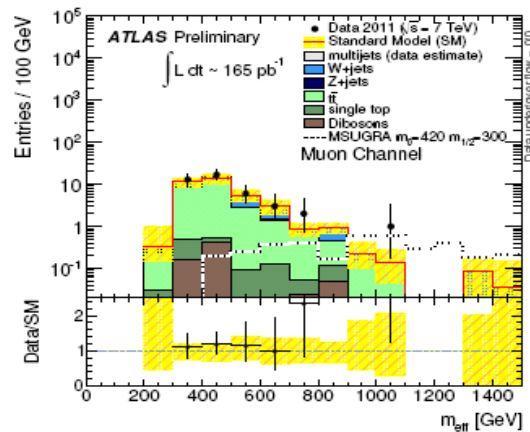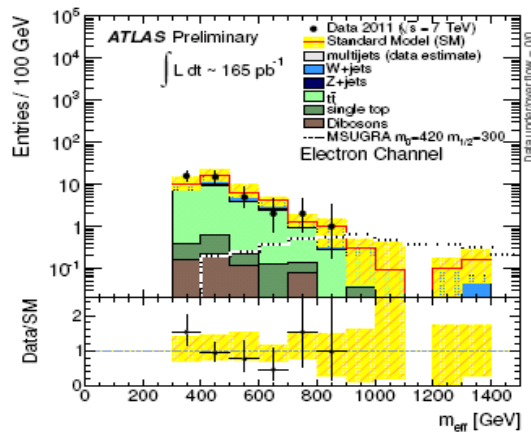Gluino masses below 725 GeV are excluded at 95% CL in simplified model

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MET + 1 lepton

$$m_T = \sqrt{2 p_T^l E_T^{miss} (1 - \cos(\Delta\phi(\vec{l}, E_T^{miss}))}$$
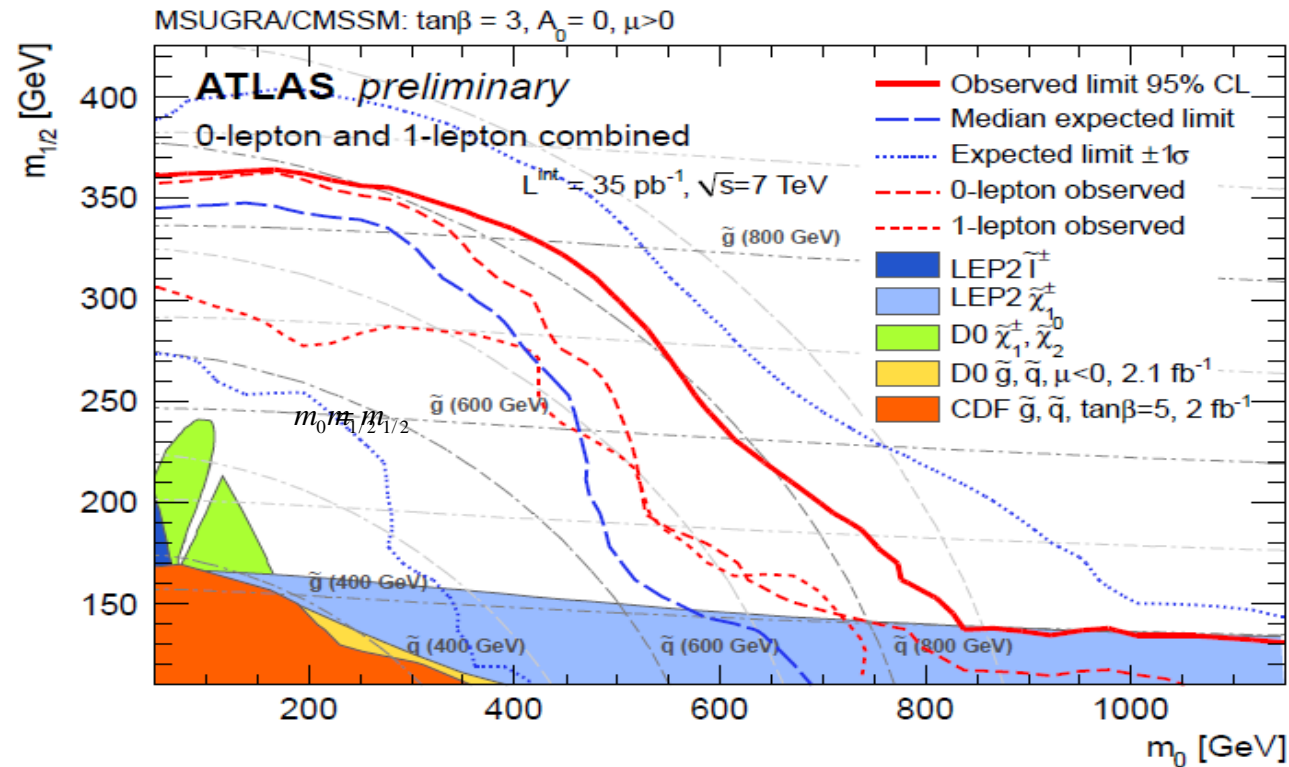
$$H_T = p_T^l + \sum_{i=1}^{3} p_T^{jet}$$

$$m_{eff} = H_T + E_T^{miss}$$

Signal region: $E_T^{miss} / m_{eff} > 0.25 \quad m_{eff} > 500 GeV$

**Phys. Rev. Lett. 106, 131802
(2011)"Viewpoint" Physics 4, 27 (2011)**

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0+1 lepton combination

MSUGRA/CMSSM: $\tan\beta = 3$, $A_0 = 0$, $\mu > 0$

ATLAS *preliminary*

0-lepton and 1-lepton combined

$L^{Int} = 35\ pb^{-1}$, $\sqrt{s} = 7$ TeV

- Observed limit 95% CL
- Median expected limit
- Expected limit $\pm 1\sigma$
- 0-lepton observed
- 1-lepton observed
- LEP2 $\tilde{l}^{\pm}$
- LEP2 $\tilde{\chi}_1^{\pm}$
- D0 $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_2^0$
- D0 $\tilde{g}$, $\tilde{q}$, $\mu < 0$, 2.1 fb^{-1}
- CDF $\tilde{g}$, $\tilde{q}$, $\tan\beta = 5$, 2 fb^{-1}

Exclude $m_0 = m_{1/2}$ **< 815 GeV for tan β=3, A0=0,   μ>0**
More stringent limits than previous ones from Tevatron and LEP
Sensitivity is dominated by 0-lepton, except at low $m_{1/2}$

MET + 2 leptons

Analysis steps (published in 2 papers):
EPJC 71 (2011) 1682, EPJC 71 (2011) 1647

1) count same-sign (SS) and opposite-sign (OS) events
2) flavor subtraction for OS:

$$\mathcal{S} = \frac{N(e^{\pm}e^{\mp})}{\beta(1-(1-\tau_e)^2)} - \frac{N(e^{\pm}\mu^{\mp})}{1-(1-\tau_e)(1-\tau_\mu)} + \frac{\beta N(\mu^{\pm}\mu^{\mp})}{1-(1-\tau_\mu)^2}$$
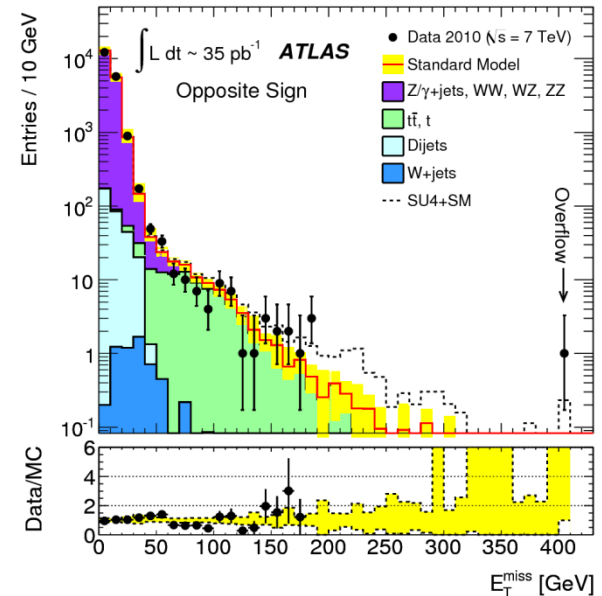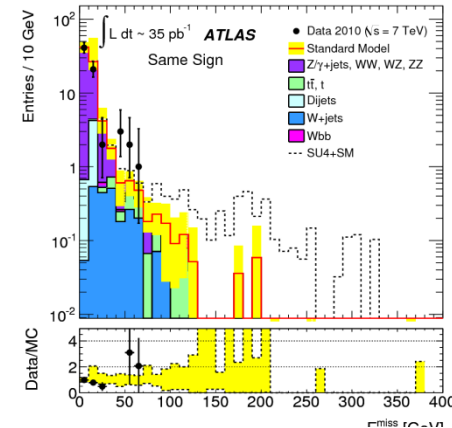
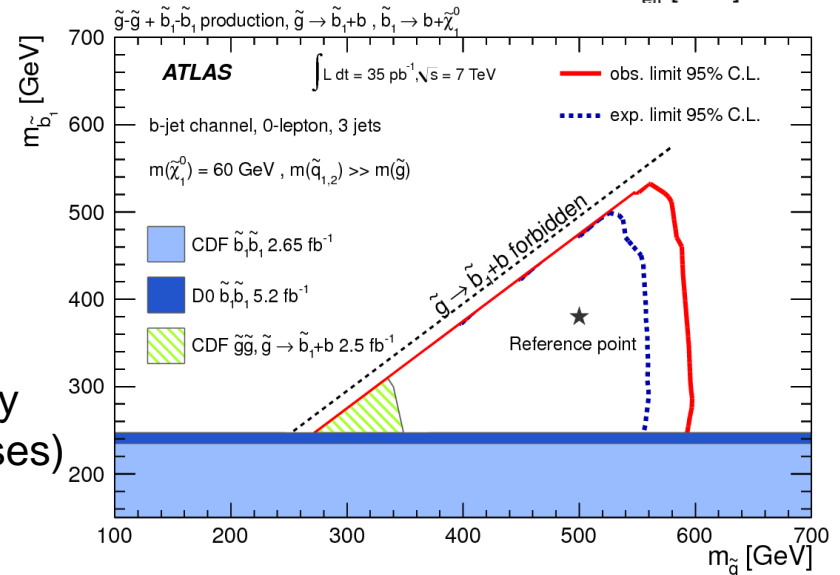# MET + b-jet + 0/1 lepton
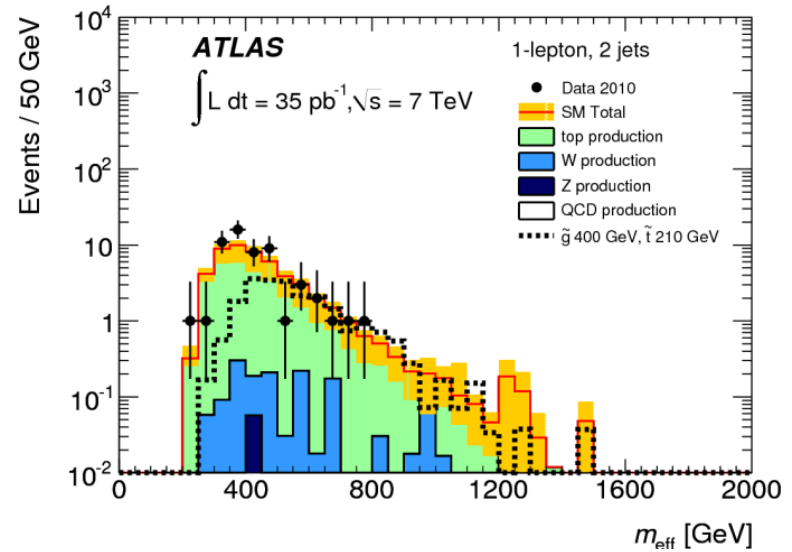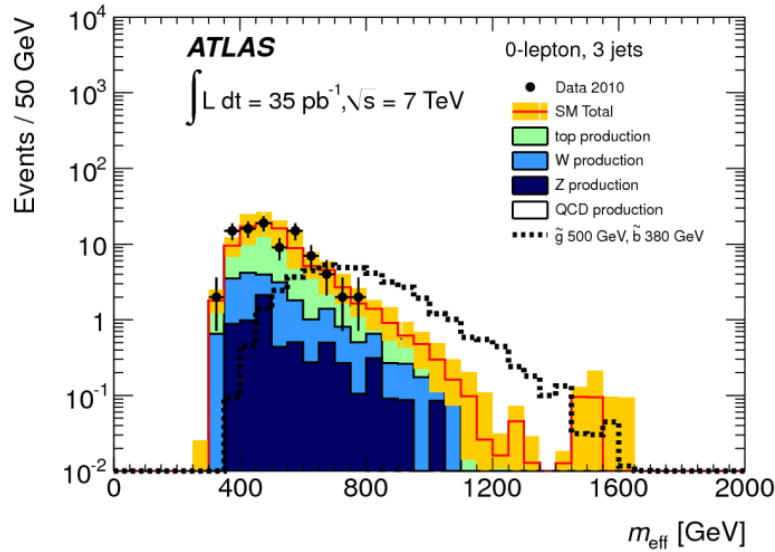
Results

σεB A $<$ 0.32 pb (0 leptons)
$<$ 0.13 pb (1 lepton)

Gluino masses below 720 GeV excluded
for sbottom masses below 600 GeV
(limits insensitive to neutralino mass and only weakly
dependent on 1st and 2nd generation squarks masses)

Search for Diphoton Events with Large Missing Transverse Energy (arXiv: 1107.0561)

Some new physics models predict much larger γγ+E_T_miss yields, than SM processes.

The results are interpreted in the context of a general model of gauge-mediated supersymmetry breaking (GGM) as well as a model positing one universal extra dimension (UED)

In GMSB LLP is gravitino, NLSP for most GGM - χ_1

Expected and observed 95 % CL lower limits on the gluino mass as a function of the neutralino mass in the GGM model with a bino-like lightest neutralino as NLSP
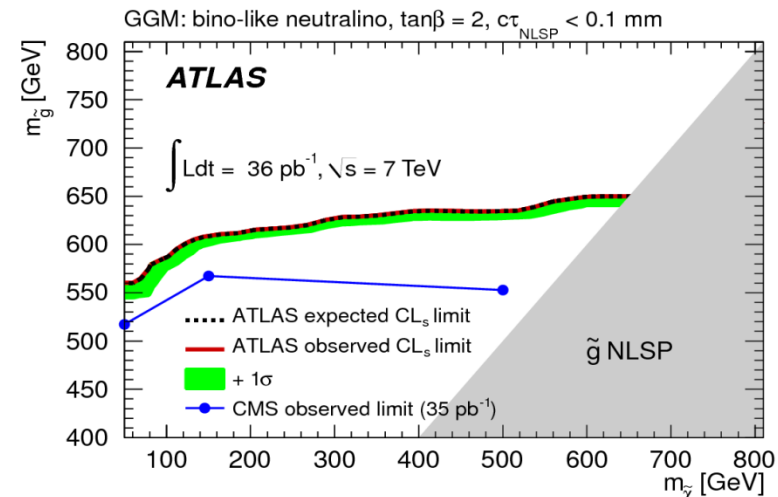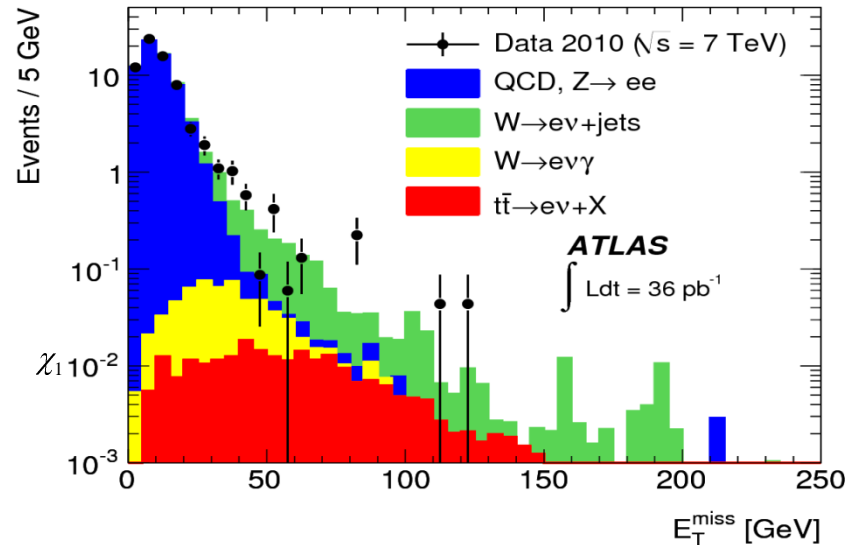
eµ Resonance Search (ATLAS-CONF-2011-109)

Select events with exactly one e, one µ   with opposite signs.

Search in eµ   invariant mass spectrum.

Results consistent with Standard Model backgrounds.

Limits set on lepton-flavour violating Z' and sneutrino models.
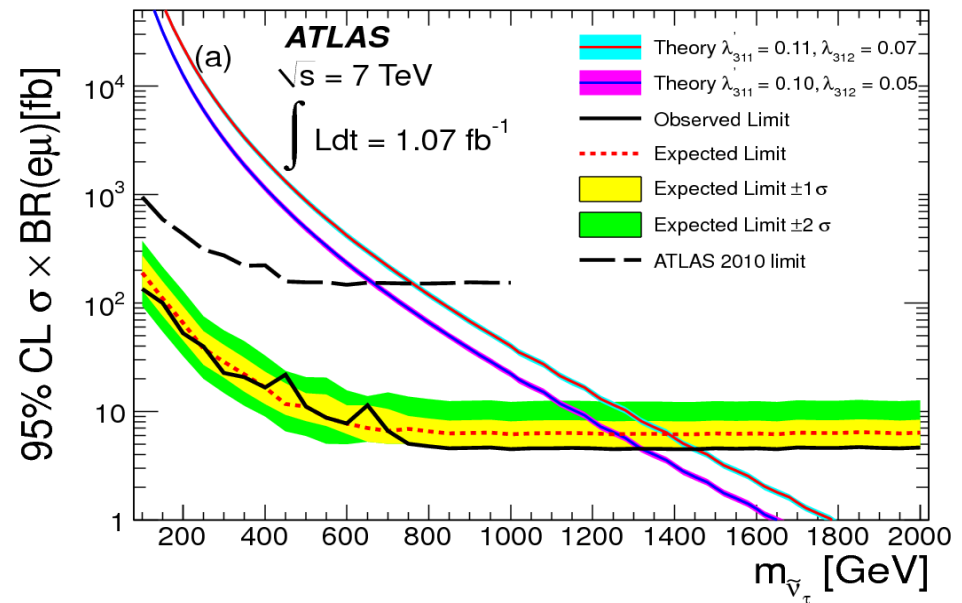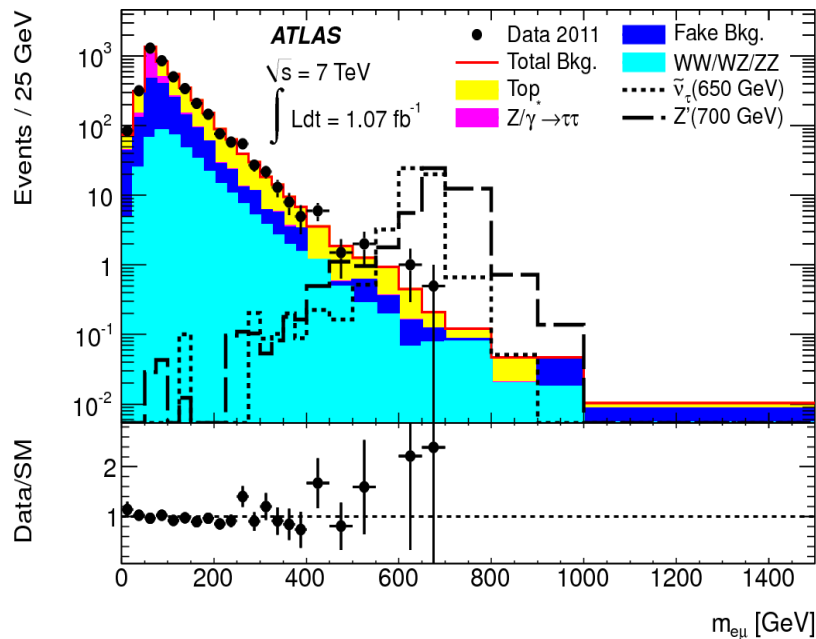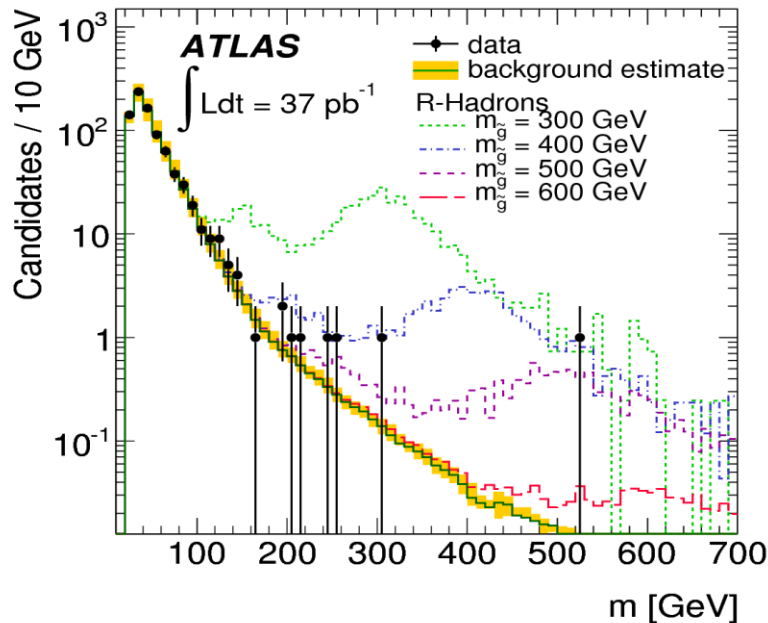

Observed and predicted emu invariant mass distributions. Signal simulations are shown for m_snutau = 650 GeV and m_Z' = 700 GeV.

The observed 95% C.L. upper limits on sigma(pp -> snutau) times BR(snutau -> emu) as a function of m_snutau.

Slow meta-stable particles

- Slow, Massive and Long Lived Particles (SMP, LLP) are predicted in several SUSY models and in other BSM scenarios.


Candidate estimated mass distribution for data, expected background including systematic uncertainty, with simulated signals added, in the R-hadron search.
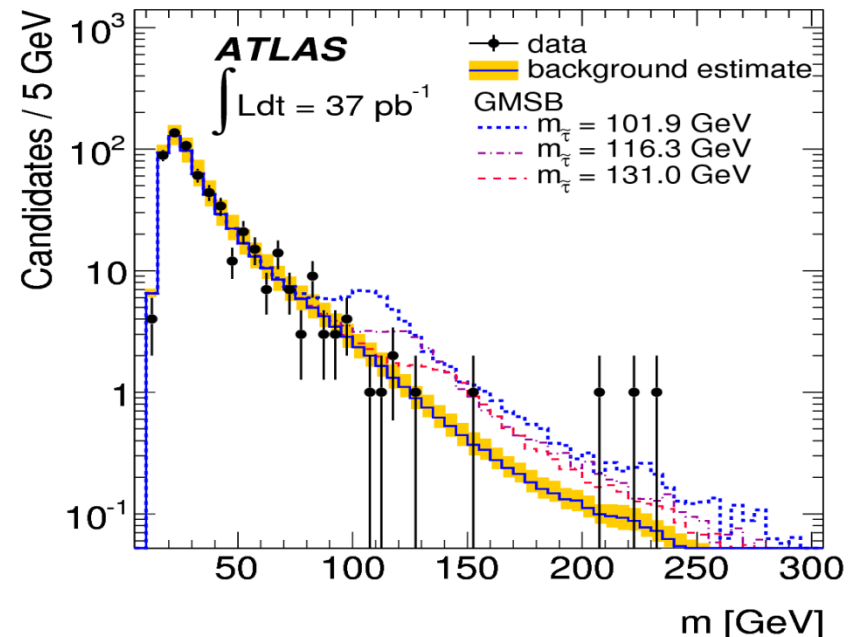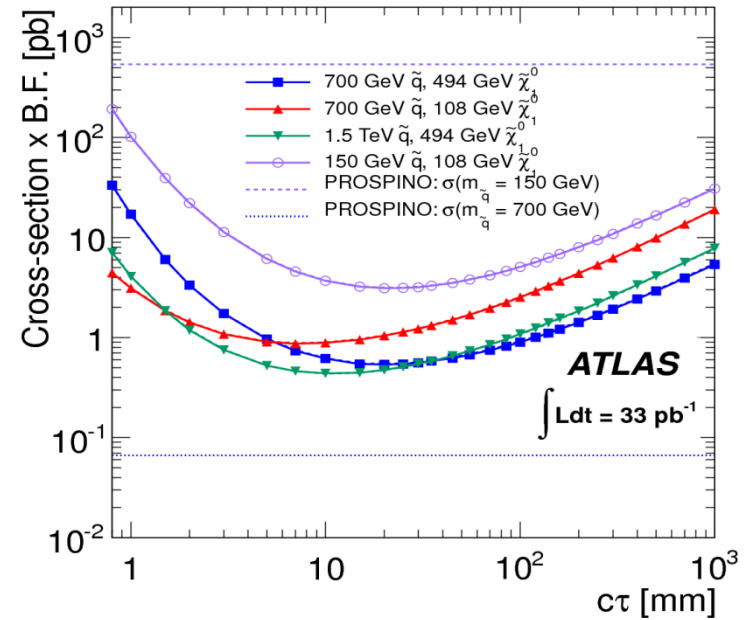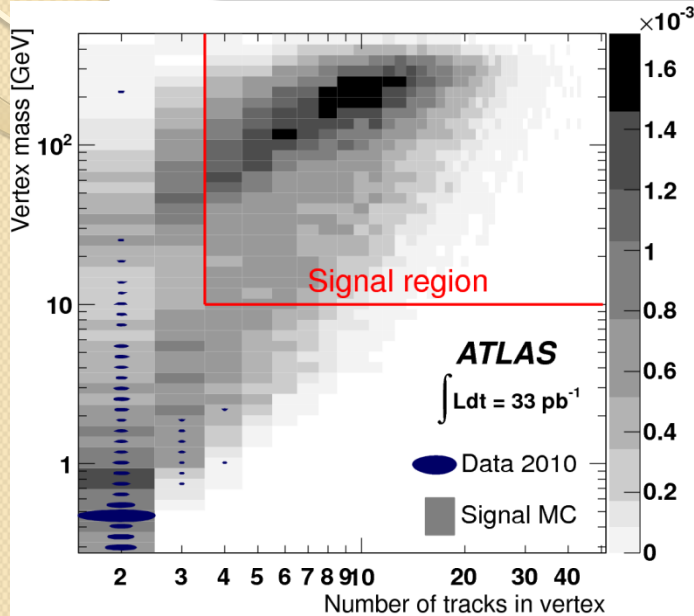
Candidate estimated mass distribution for data, expected background including systematic uncertainty, with simulated signals added, in the slepton search.

Search for Displaced Vertices Arising from Decays of New Heavy Particles
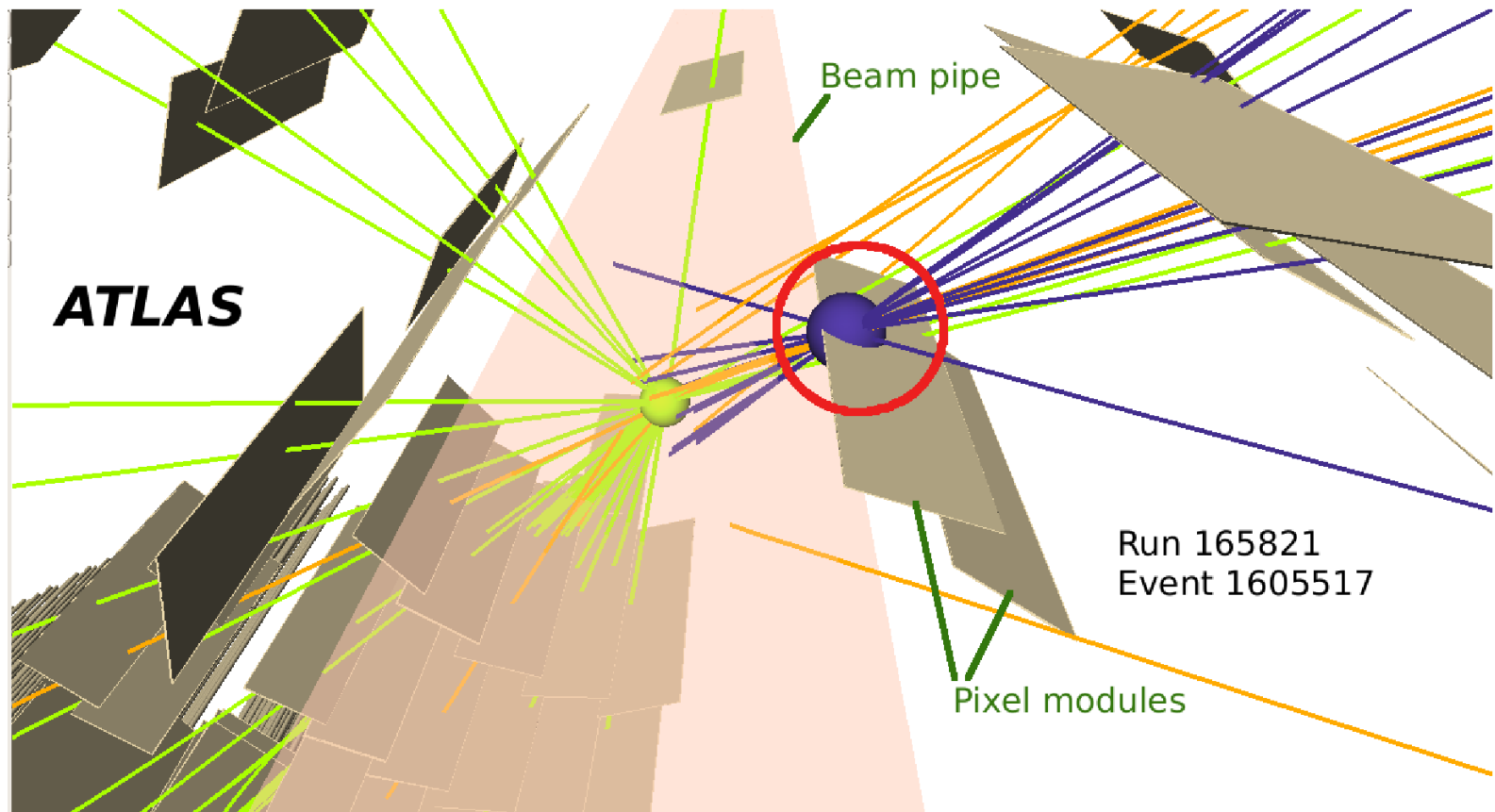
Search for Displaced Vertices Arising from Decays of New Heavy Particles
## arXiv:1109.2242

Vertex mass vs. vertex track multiplicity for displaced vertices that pass the event selection requirements

In GMSB, the NLSP may be long lived due to suppression of the decay by large SUSY-breaking scale.

Upper limits at 95% C.L. on the production cross-section times branching fraction vs. the neutralino lifetime times the speed of light for different combinations of squark and neutralino masses, based on the observation of zero event
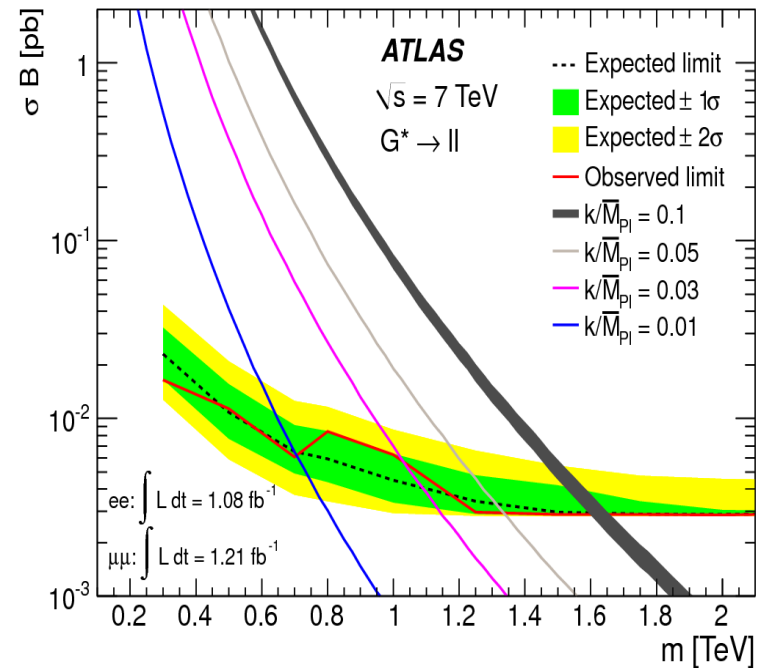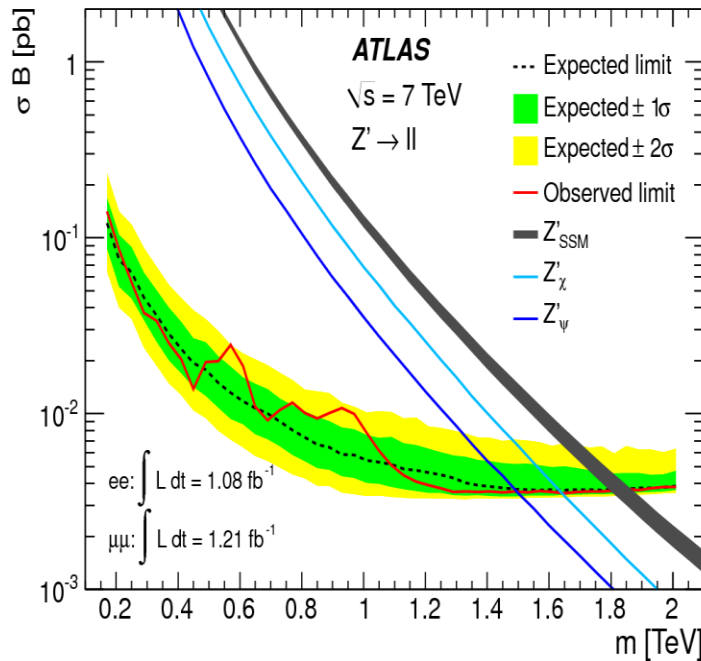
Search for resonances in $l^{\pm}l^{\mp}$
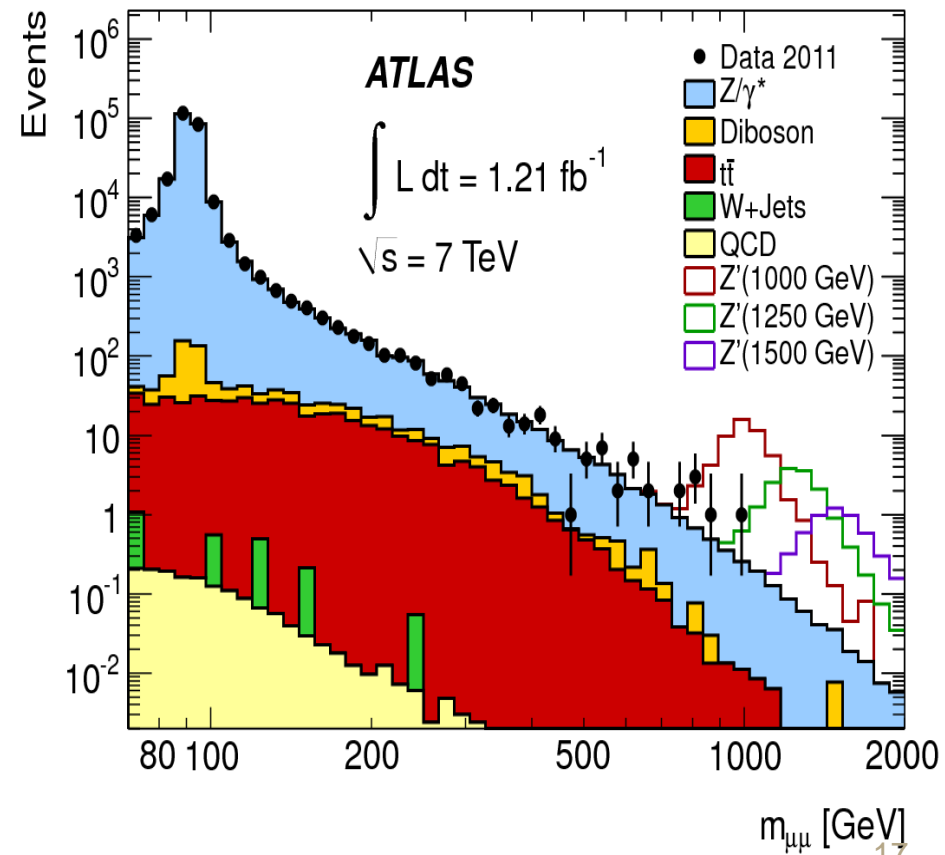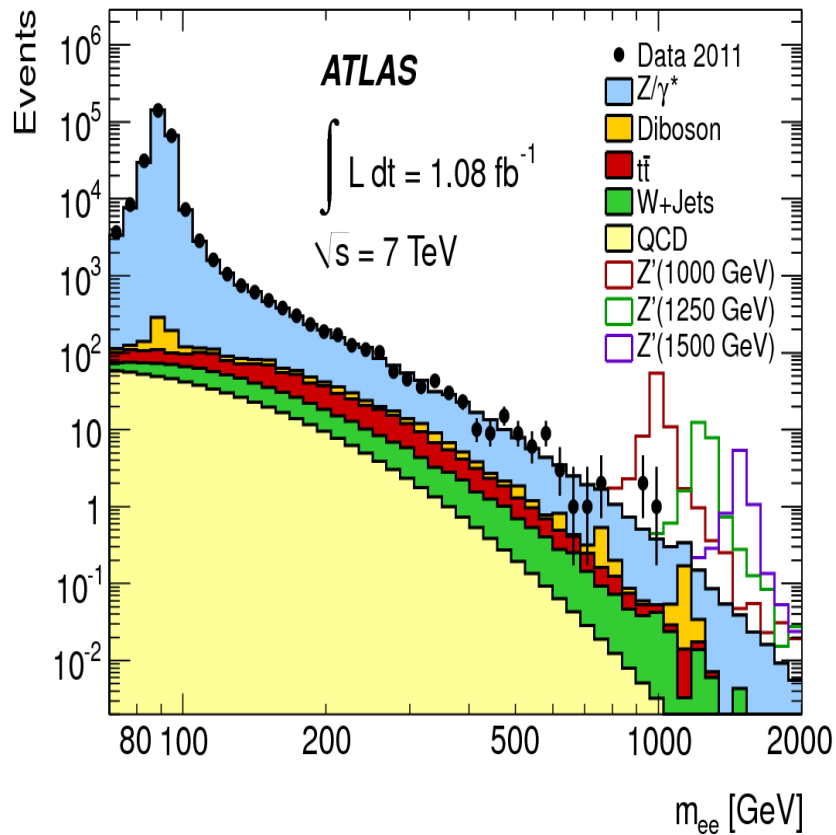
Limits on the Z' and RS graviton masses

Latest limits exclude:

->1.83 TeV on m(Z') in the Sequential Standard Model.

->1.63 TeV for a Randall-Sundrum graviton (k=mPl = 0:1).

Model/Coupling	E_6 Z' Models						RS Graviton			
	Z'_ψ	Z'_N	Z'_η	Z'_I	Z'_S	Z'_χ	0.01	0.03	0.05	0.1
Mass limit [TeV]	1.49	1.52	1.54	1.56	1.60	1.64	0.71	1.03	1.33	1.63

Search for technihadrons ATLAS-CONF-2011-125

Search for the technicolor vector mesons ρ_T/ω_T with their subsequent decay to $l^{\pm}l^{+}$

Since the ρ_T and ω_T are narrow, spin 1 resonances, the search methodology will be identical to that developed for the ATLAS search for the Z'

No evidence for a technihadron signal is observed. Within the context of the low-scale technicolor model, masses of the ρ_T and ω _T from 130−480GeV are excluded at 95% CL for π_T masses from 50−480GeV
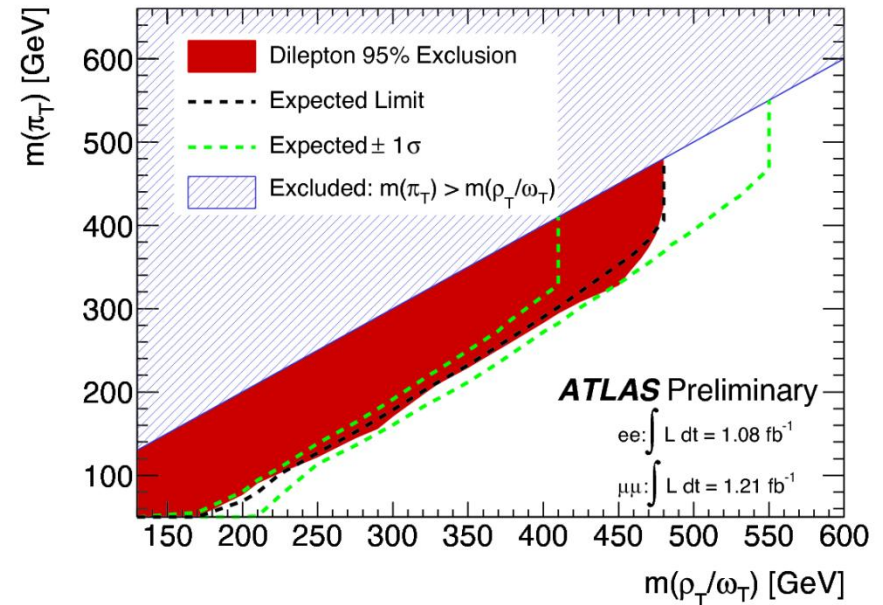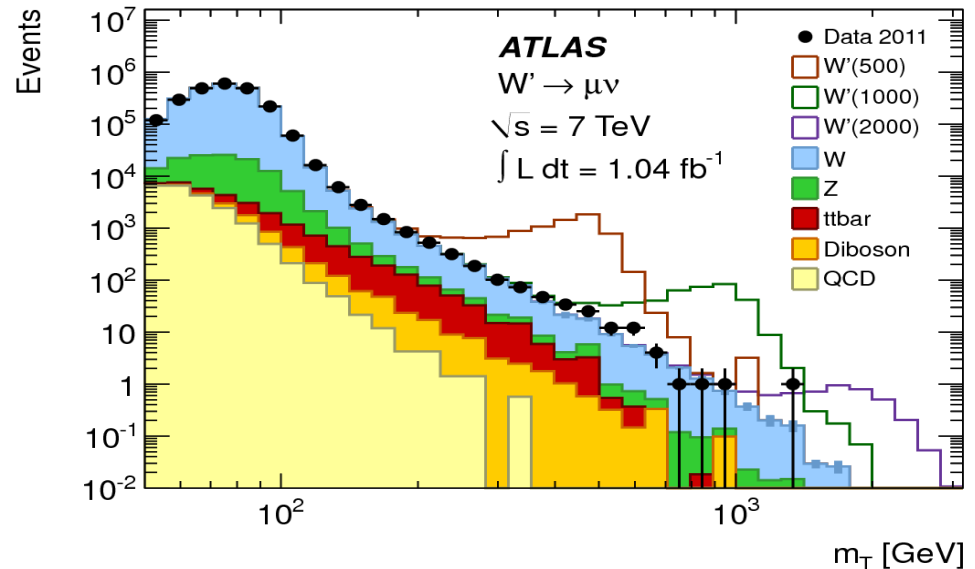

The 95% CL excluded region as a function of the assumed π_T and ρ_T/ω_T masses
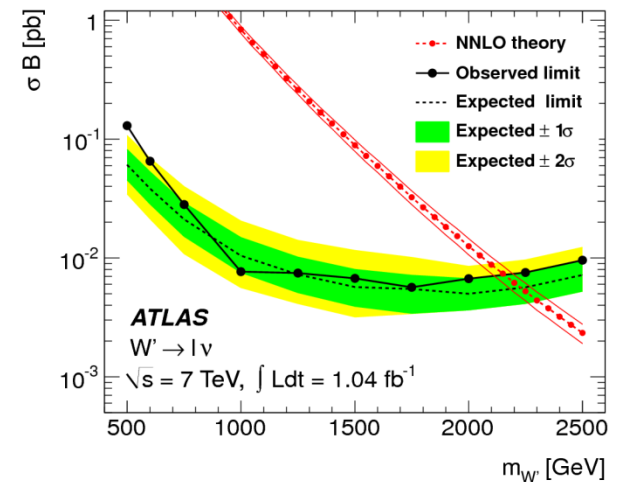
W' search (arXiv:1108.1316)
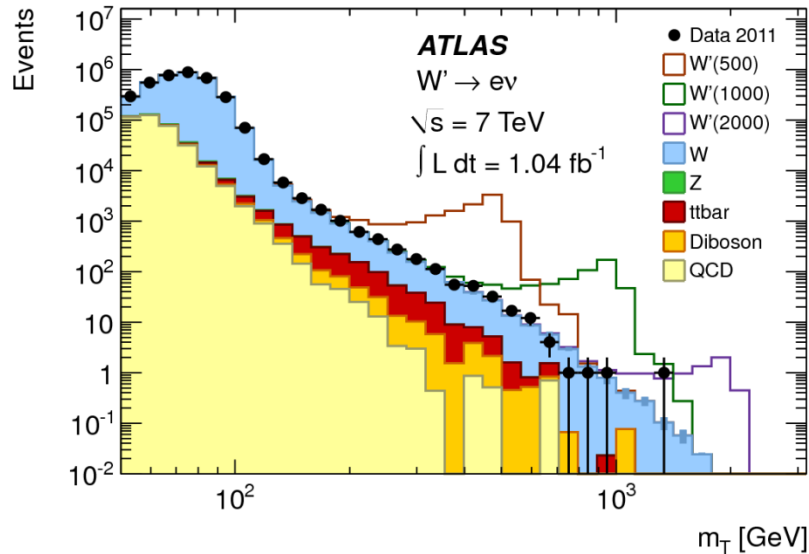
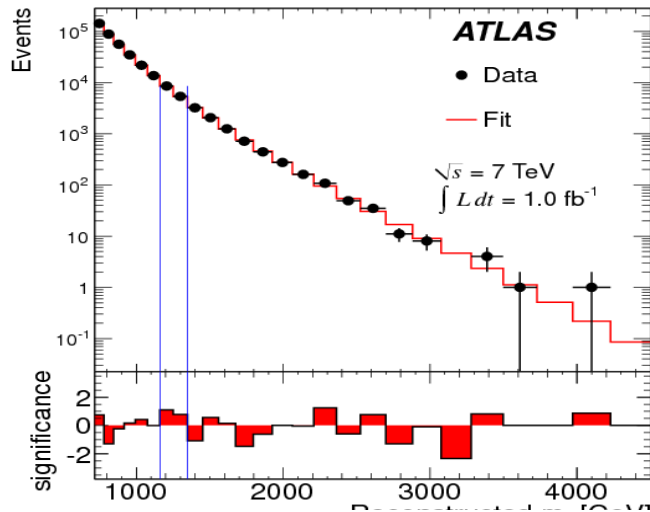Spectrum of mT for the electron channel after event selection

Spectrum of mT for the muon channel after event selection

No excess beyond Standard Model expectations is observed. A W′ with Sequential Standard Model couplings is excluded at the 95% confidence level for masses up to 2.15 TeV.
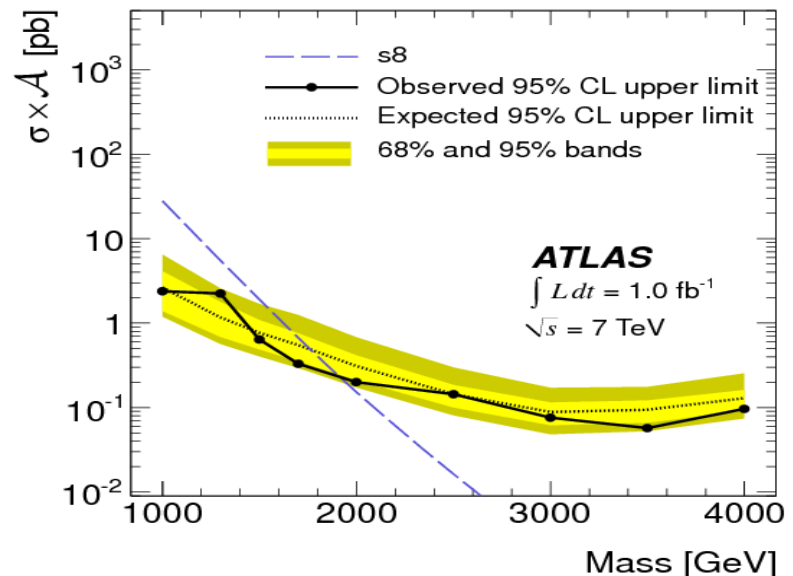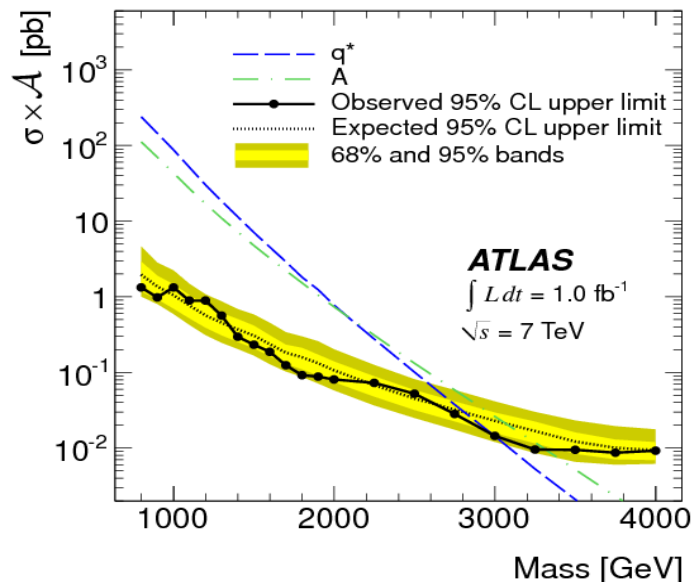
Search for New Physics in the Dijet Mass Distribution (arXiv:1108.6311)

Limits are set at 95% CL for several new physics hypotheses:
-excited quarks are excluded for masses below 2.99 TeV,
-axigluons are excluded for masses below 3.32 TeV, and
-colour octet scalar resonances are excluded for masses below 1.92 TeV.
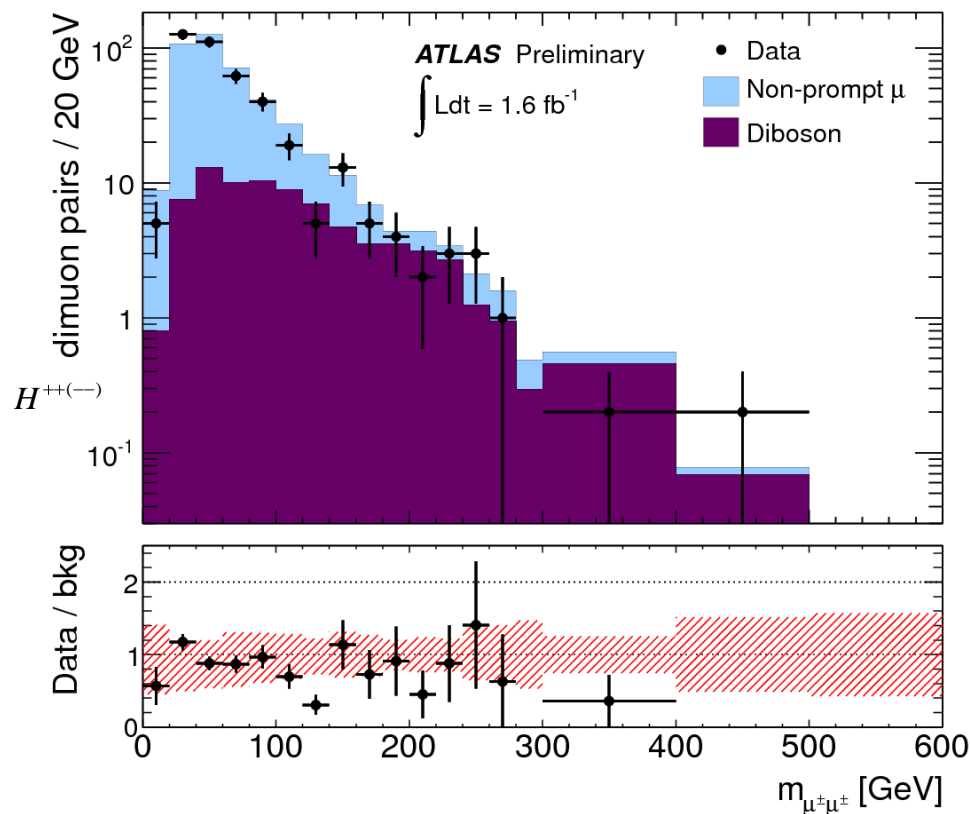
Search for Anomalous Production of Prompt Like-sign Muon Pairs (ATLAS-CONF-2011-126)

In some models Higgs sector contains $H^{++(--)}$

Like-sign dimuon events are selected by requiring two isolated muons with pT>20 GeV for the leading and pT>10 GeV for the subleading muon.

The 95 % confidence level upper limit ranges from 303 fb for M(μμ)>15 GeV to 8 fb for M(μμ)>300 GeV

Search for New Phenomena in Monojet plus Missing Transverse Momentum Final States(ATLAS-CONF-2011-096)

MC simulated samples for the ADD LED model with different number of extra dimensions varying from 2 to 6 are generated

The results are also interpreted in terms of the ADD LED scenario for which *MD* values between 3.2 TeV and 2.0 TeV are excluded at the 95% confidence level for a number of extra dimensions varying from 2 to 6, respectively. These results significantly improve previous limits on models with Large Extra Dimensions.
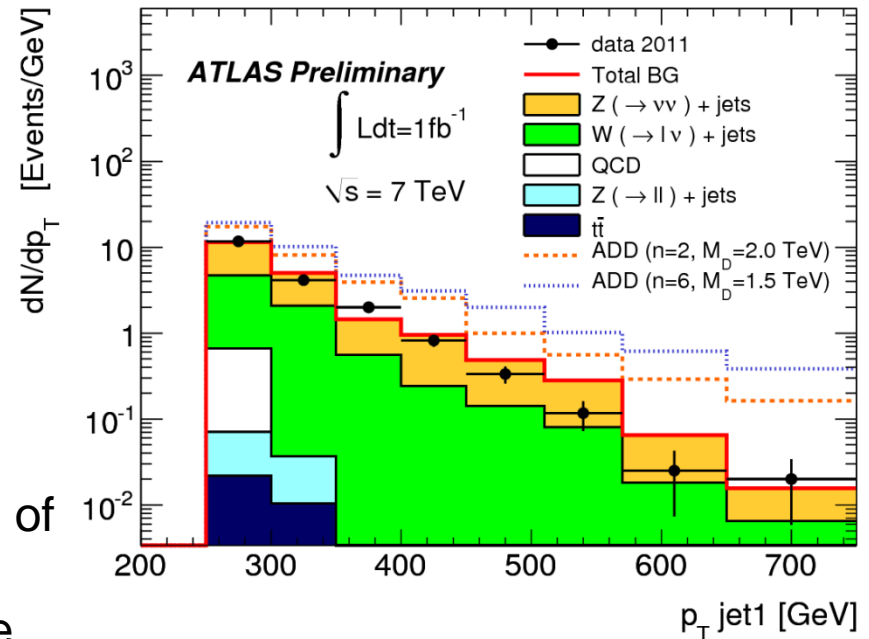
A Search for ttbar Resonances in the Dilepton Channel (ATLAS-CONF-2011-123)
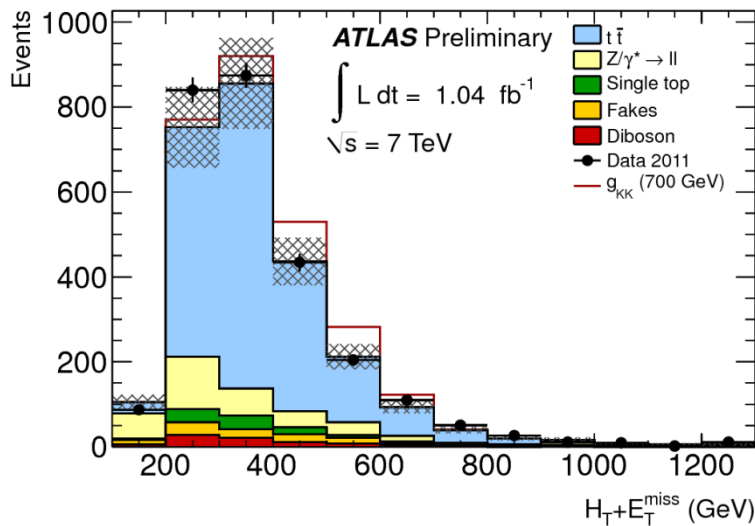
Data - Monte Carlo comparison for the $H_T + E_T^{miss}$ distribution together with a KK-gluon signal with a mass of 700 GeV for illustration
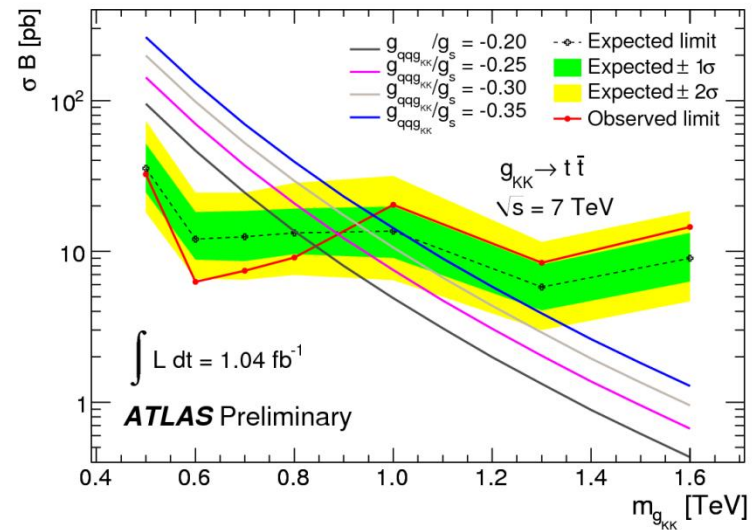
Expected and observed limits on cross section times branching ratio at 95% C.L. and expected cross section for a Randall-Sundrum KK-gluon gKK.

A lower mass limit of 0.84 TeV is set for the case of a KK gluon resonance in the Randall-Sundrum Mode

Event display of an event with high $H_T + E_T^{miss}$. The highest energy electron has an E_T of 104 GeV, the subleading electron an E_T of 35 GeV. The highest energy jet has an E_T of 526 GeV, the subleading jet an E_T of 339 GeV. The $H_T + E_T^{miss}$ is 1226 GeV of which 222 GeV originates from E_T^{miss}.
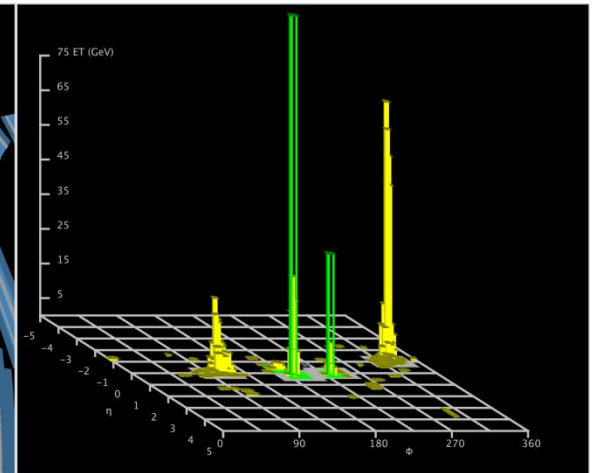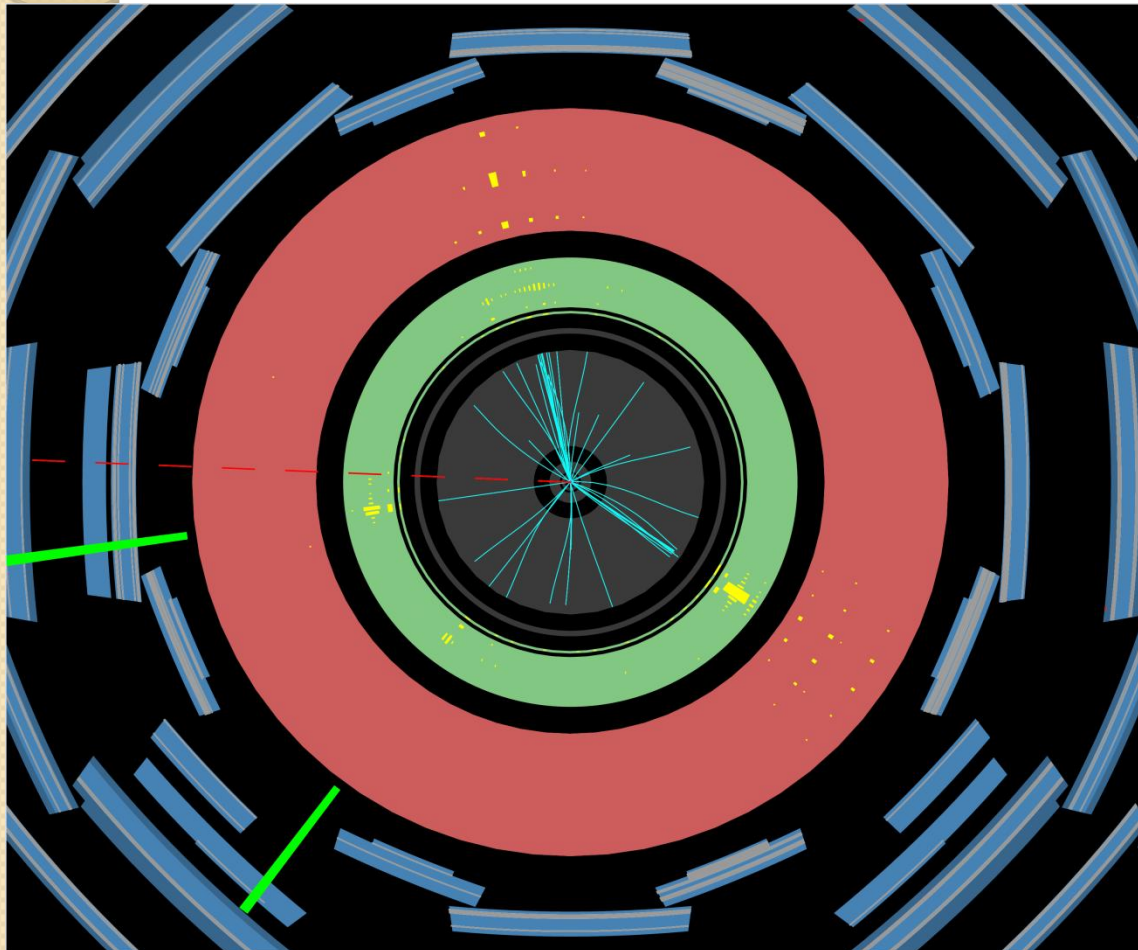
A Search for ttbar Resonances in the Lepton Plus Jets Channel (ATLAS-CONF-2011-087)

Event selection : e or μ, Etmiss, at least 4 jets, where at least 1 jet must be tagged as b-jet

To reconstruct $t\bar{t}$ mass the neutrino's longitudinal momentum is determined by imposing W-boson mass constrain.

For narrow Z' models, the observed 95% C.L. limits range from approximately 38 pb to 3.2 pb for masses going from m(Z') = 500 GeV to m(Z') = 1300 GeV.
In Randall-Sundrum models, Kaluza-Klein gluons with masses below 650 GeV are excluded at 95% C.L.
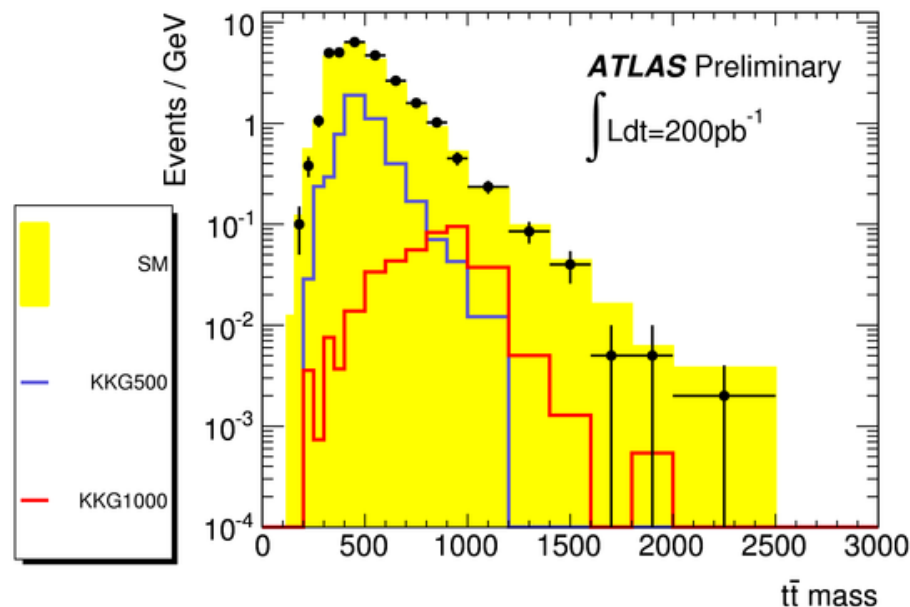
Event display for a high-mass event (m_{tt} = 1602 GeV).
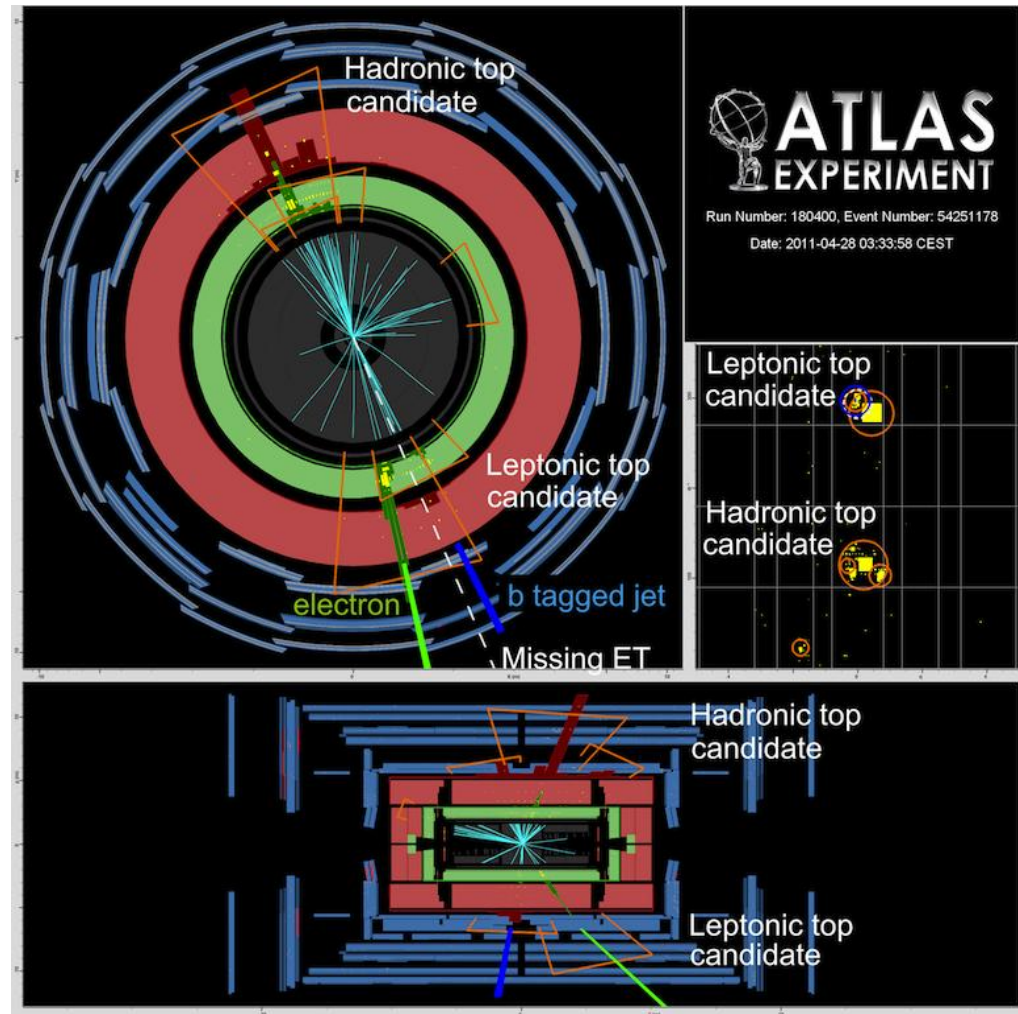
Invariant mass distribution of jet pairs produced in association with a leptonically decaying W boson (ATLAS-CONF-2011-097)

Event selection criteria as close as possible to those used by CDF. Events are selected with two jets produced in association with an electron or muon and missing transverse energy. The distribution of dijet mass, mjj, is compared to a combination of Monte Carlo simulation and data-driven background estimates.
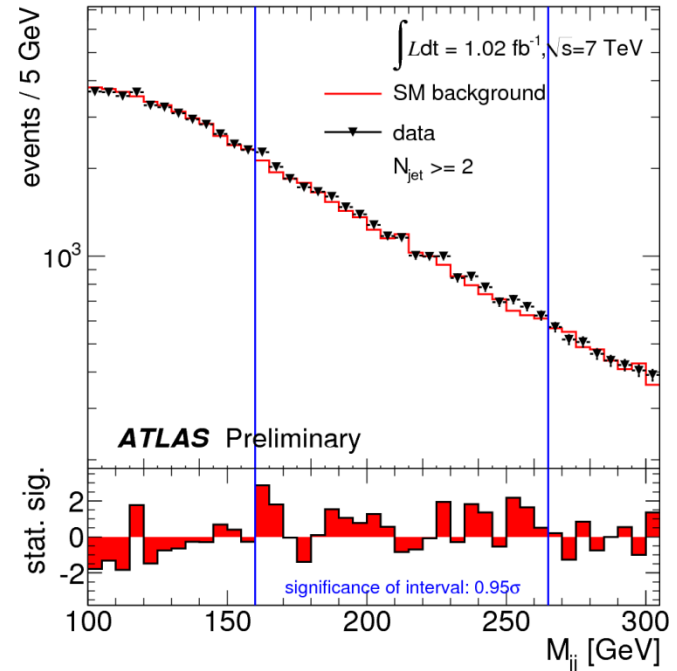
The measured dijet mass spectrum shows no significant excess over the Standard Model expectation.

Conclusion

- A lot of searches were done, no signals of new physics (yet…)
- Will wait and work on significantly bigger statistics