Search for high-mass resonances decaying to dileptons with the ATLAS detector

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SILAFAE 2012 – December 14, 2012

Introduction

> Additional heavy neutral gauge bosons are common to many SM extensions.

> The ATLAS detector is used to search for high-mass resonances decaying to an electron-positron pair or muon-antimuon pair.

> This talk will focus on a set of specific signatures from different models

- Z' gauge boson, from SSM and models based on E_6 symmetry group.
- Z* boson, which interacts with SM fermions via magnetic-type interactions.
- Excited graviton states (G^*), from Randall-Sundrum model
- Torsion resonance from torsion models
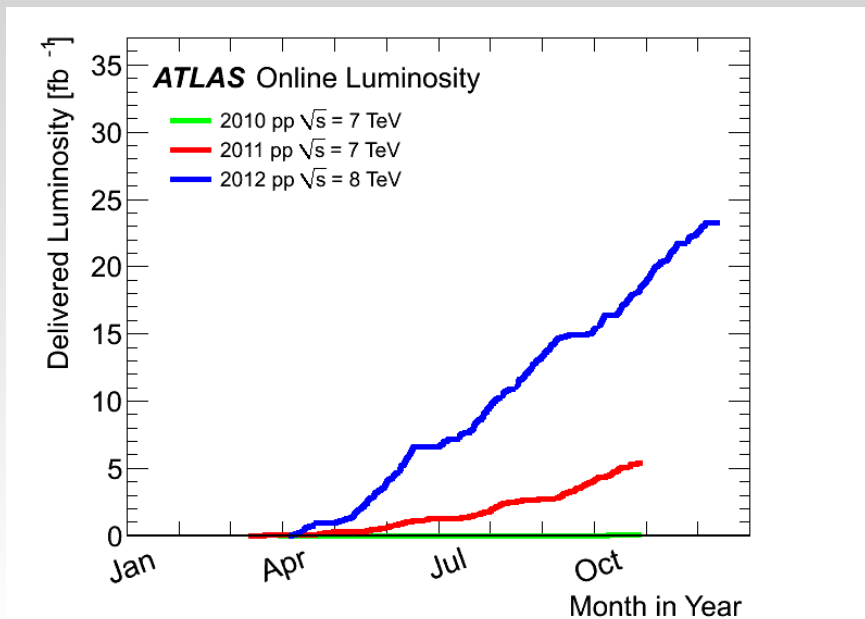- Techni-mesons from Technicolor models.

The results are based on pp collisions data at $\sqrt{s}$ = 7 TeV corresponding to an integrated luminosity of 4.9 fb^{-1} in the electron channel and 5.0 fb^{-1} in the muon channel. For Z', an update for $\sqrt{s}$ = 8 TeV will also be presented.

The ATLAS Detector
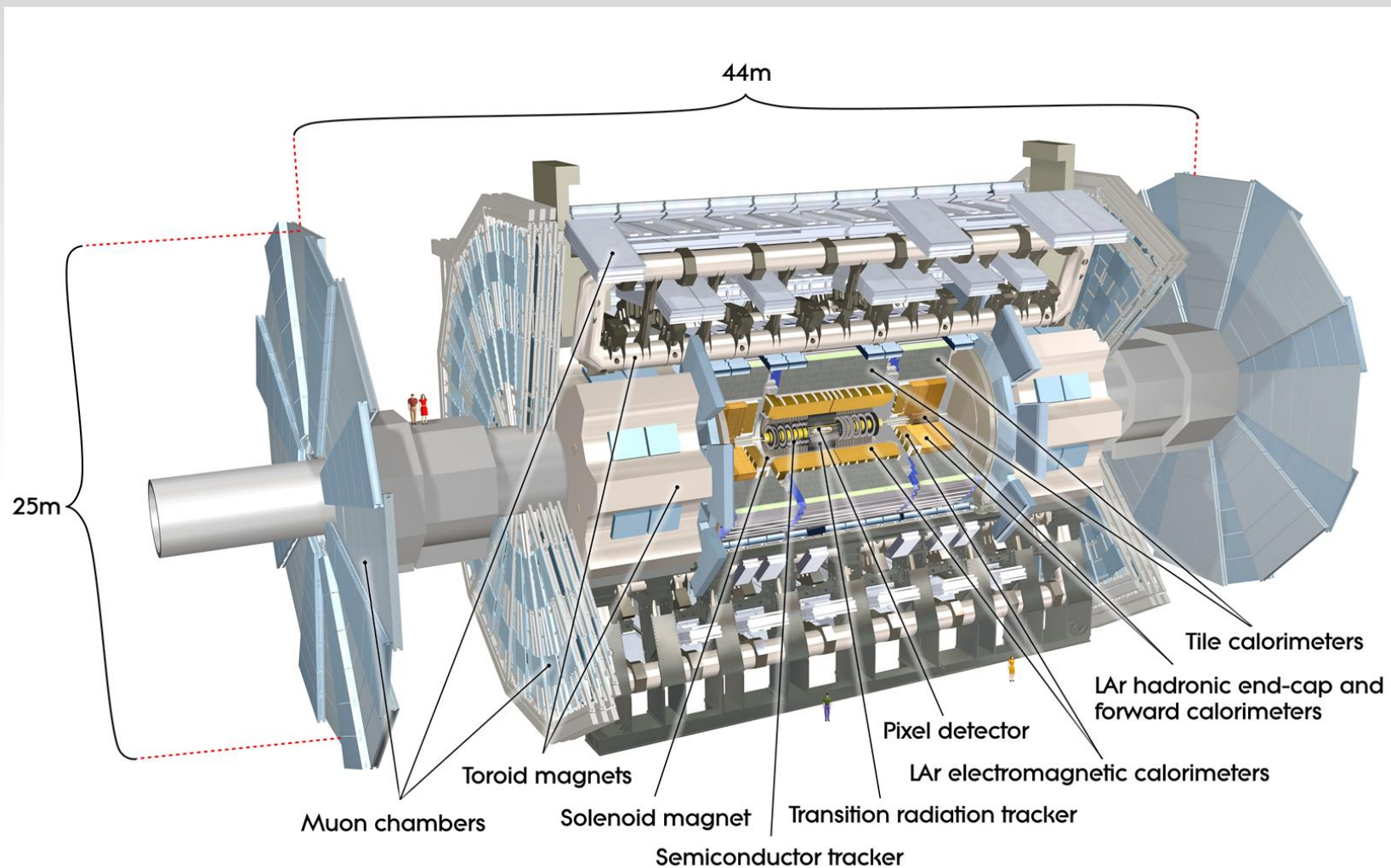
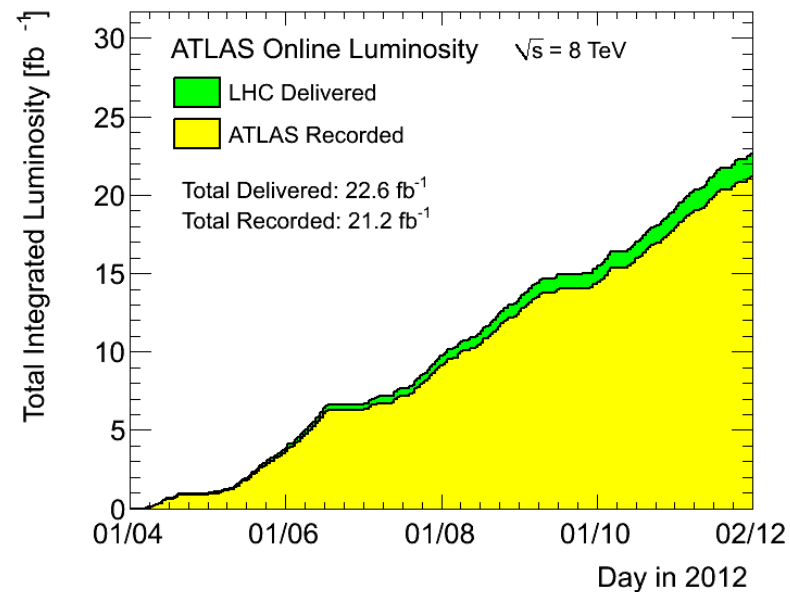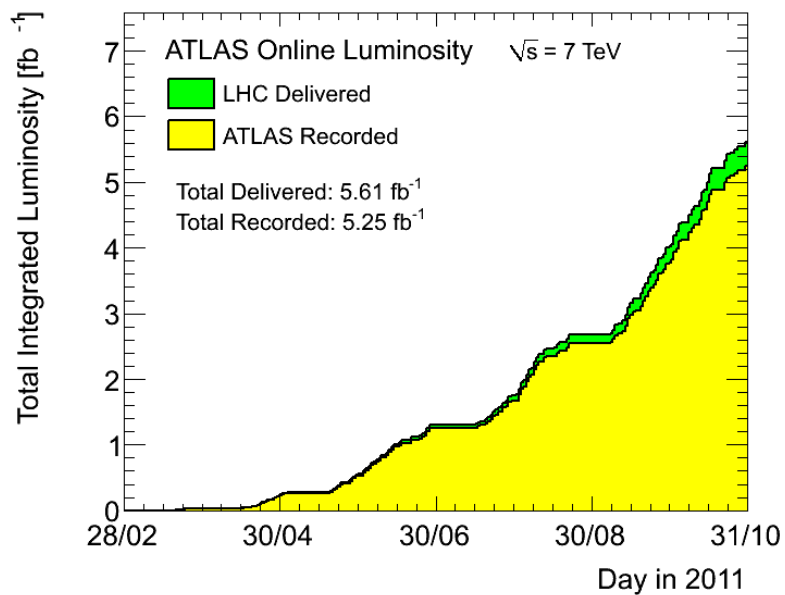
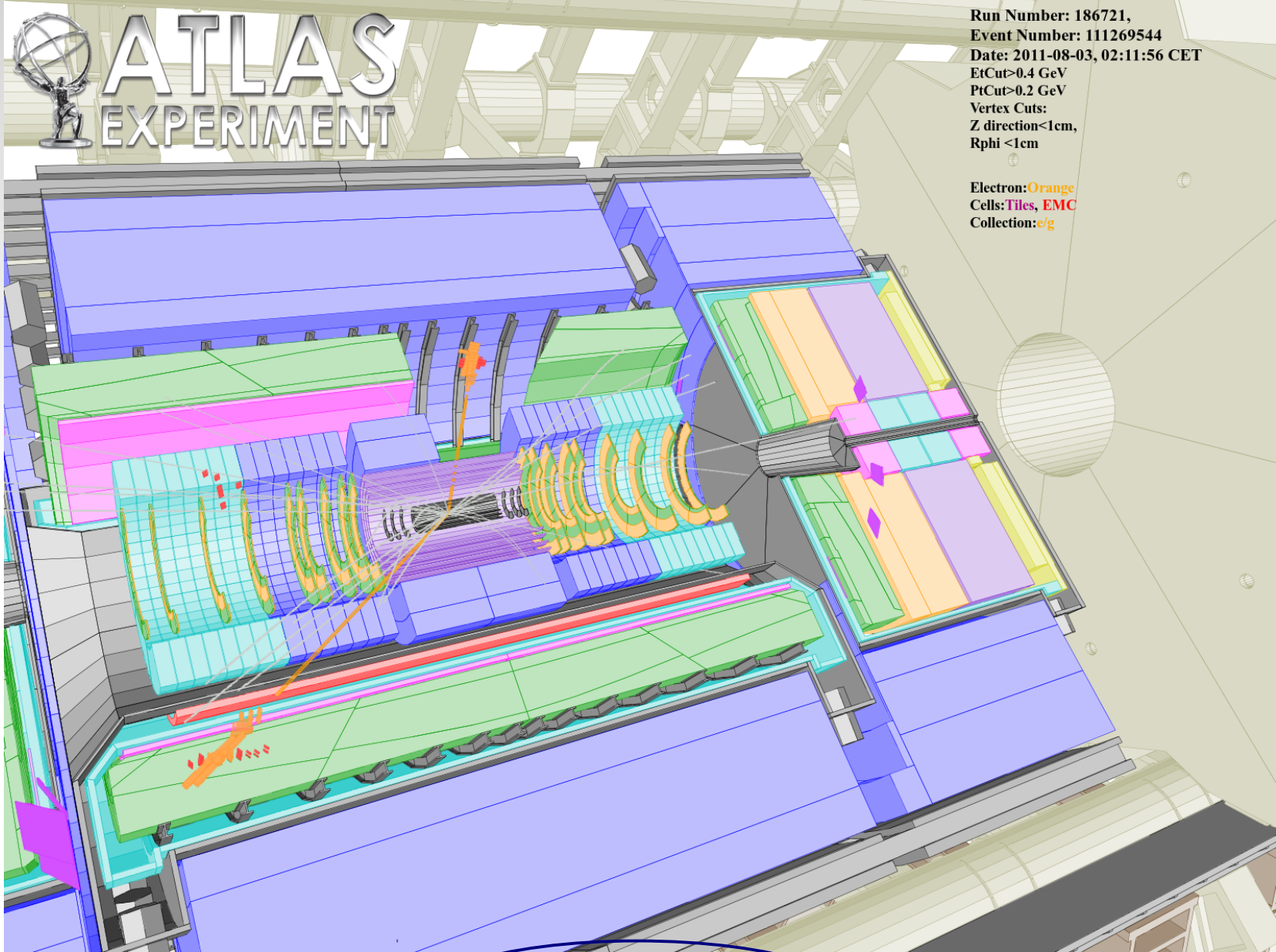Excellent performance over unprecedented energy range: few GeV to few TeV

ATLAS Luminosity

Cumulative luminosity versus day recorded by ATLAS.

$$M_{ee} = 1.21 \text{ TeV/c}^2$$

Event Selection

Dielectron Selection

➢ 2 electrons candidates identified with information based on electromagnetic calorimeter shower shape and tracks

➢ $E_T > 20$ GeV

➢ A hit in the first layer of the pixel detector

➢ $|\eta| < 2.47$

➢ Leading electron isolated

Overall efficiency in the electron channel: ~ 66% for a Z' mass of 2 TeV

Dimuon Selection

➢ 2 opposite charge muons

➢ $p_T > 25$ GeV

➢ $|\eta| < 2.4$

➢ Impact parameter with respect to the PV must be smaller than 0.2 mm in the transverse plane and 1.0 mm along the beam axis.

➢ Different requirements on the number of hits in the inner detector and muon stations.

➢ Each muon must be isolated.

Overall efficiency in the muon channel: ~ 43% for a Z' mass of 2 TeV
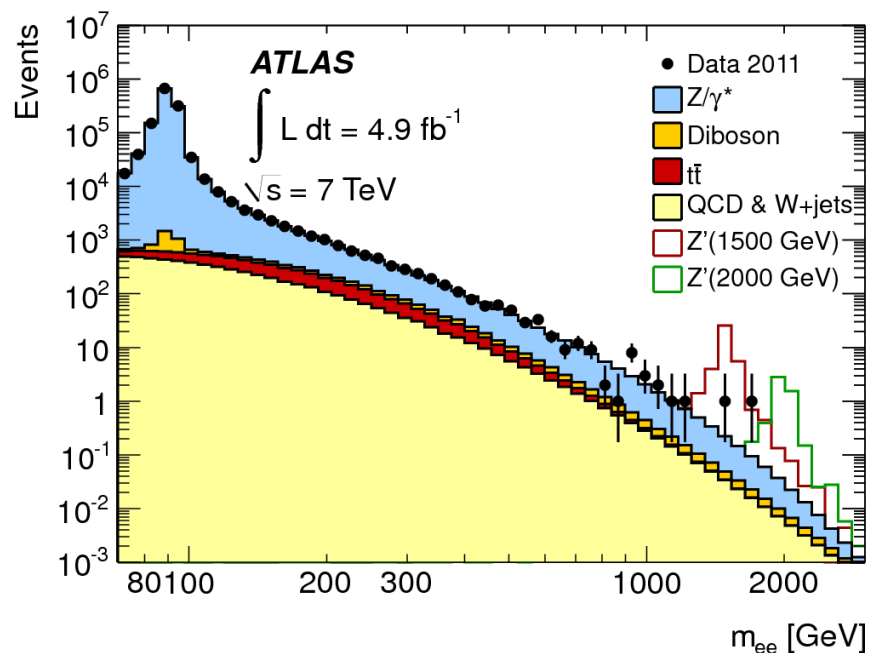
Background

The backgrounds considered in this analysis are

- Drell-Yan
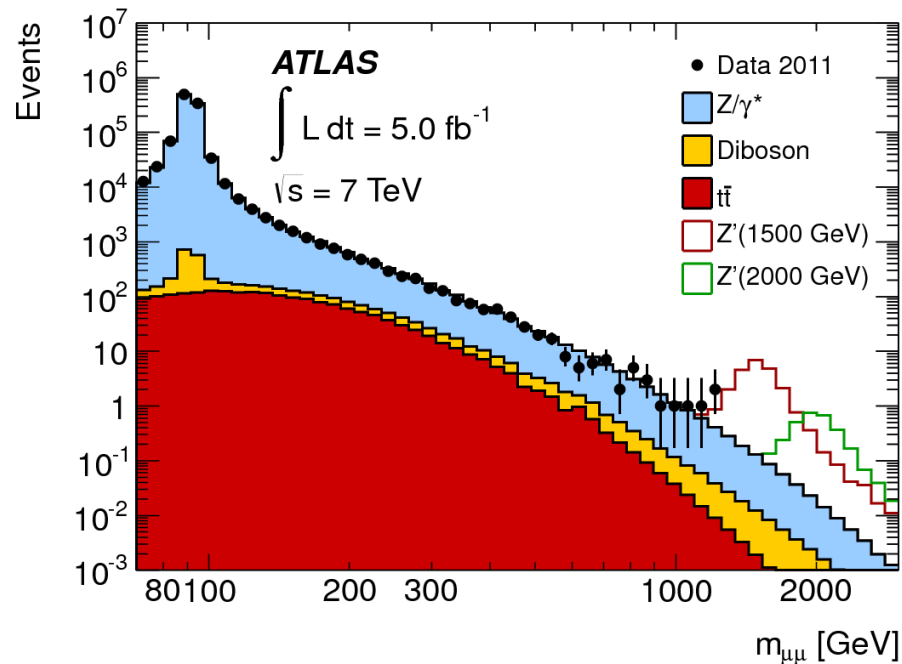
- Diboson

- $t\bar{t}$

- W + jets

- QCD

These backgrounds are estimated using MC, except for QCD and W + jet, that are estimated by data-driven methods.

Looking for a bump

The dilepton invariant mass distribution for selected events is compared to the expected SM background.
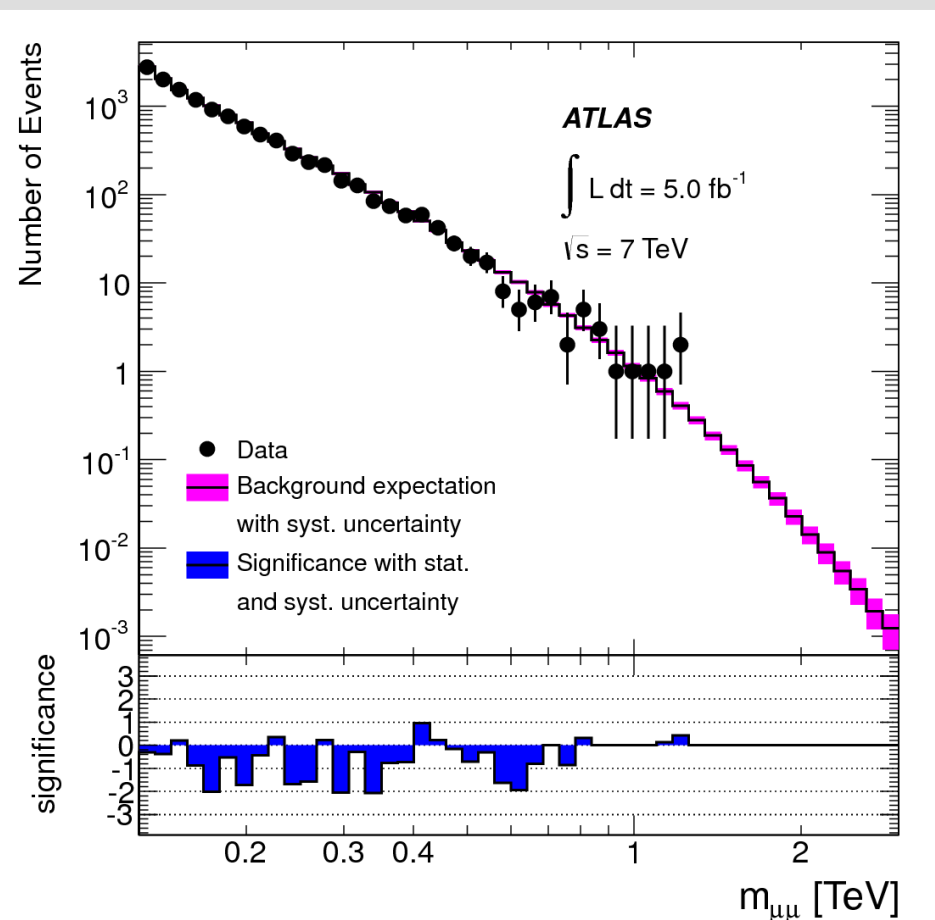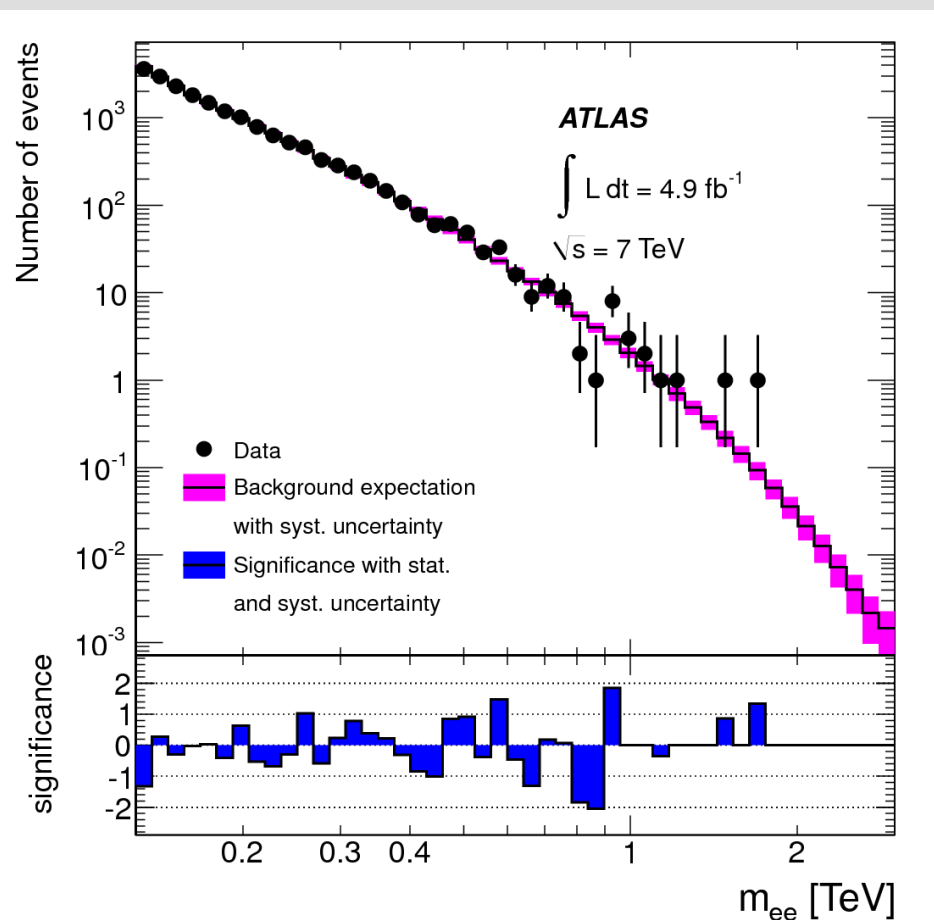

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The dilepton invariant mass distributions are well described by the Standard Model.

Significance

Differences between data and expectation in the dielectron (left) and dimuon (right) channels.

The observed *p*-values (for the full mass scan) for dielectron, dimuon and combined channels are **36%**, **68%** and **40%**, respectively.

No significant deviation from SM found....put limits

Setting Limits

➢ Upper limits on the number of events produced by the decay of a new resonance are determined at 95% of confidence level (CL). This limit can be converted into a limit of the signal cross section times branching-ratio.

➢ The invariant mass distribution of the data is compared to templates of the expected background and signal from different models at varying resonance masses in the 0.13 to 3.0 TeV range.

➢ The Bayesian approach is used, with a flat prior probability distribution for the signal cross section times branching ratio (σB).

➢ Expected exclusion limits are also determined using simulated pseudo-experiments with only SM process and evaluating the 95% CL upper limits for each pseudo-experiment and for each resonance mass hypotheses. The median of the distribution of limits is chosen to represent the expected limit.

➢ Limits are computed for electron channel, muon channel and for the combination. **On the next slides, only the results for the combination are shown.**

Limits on Z' and Z*
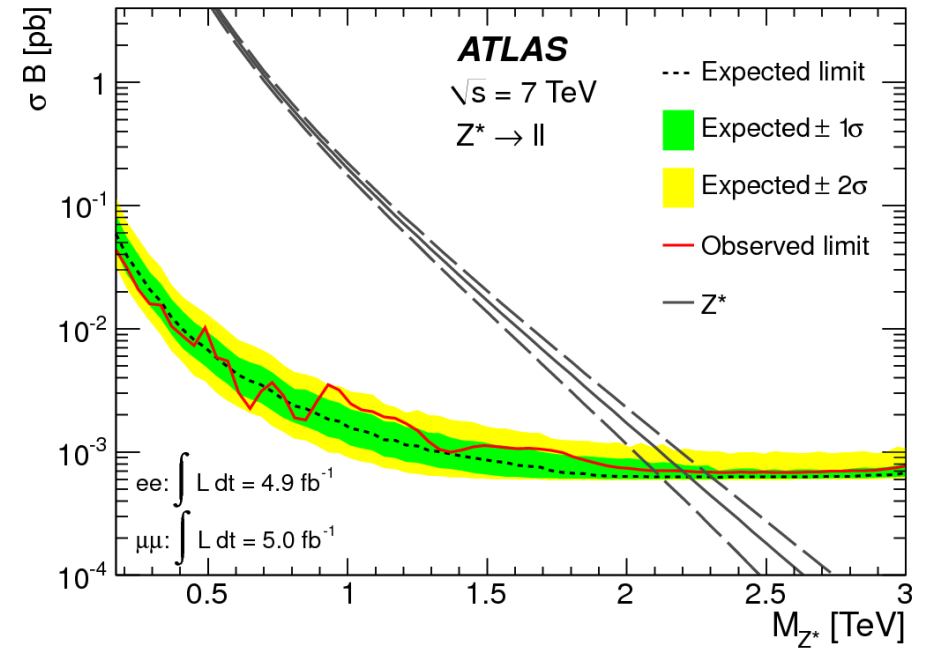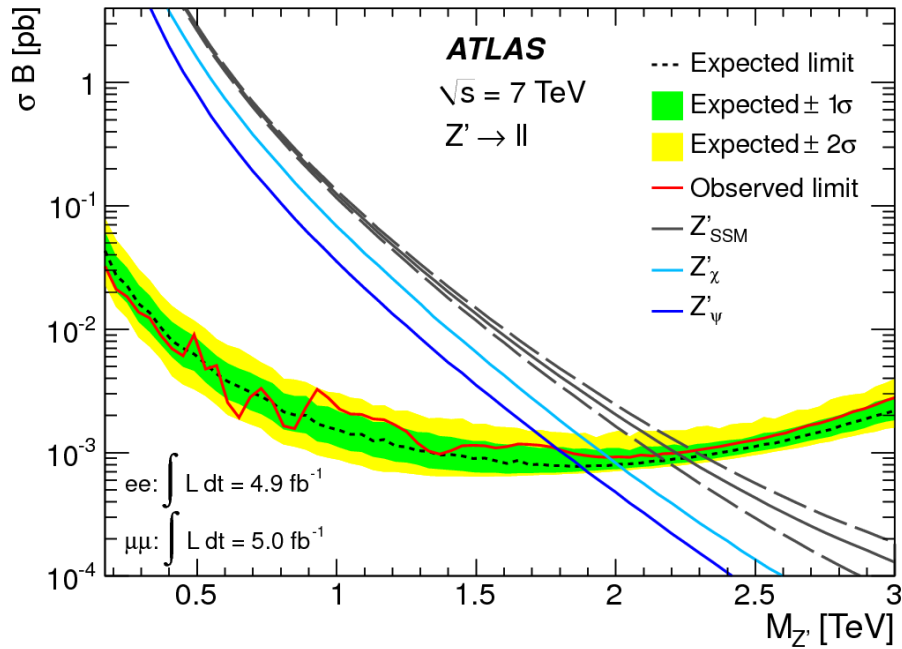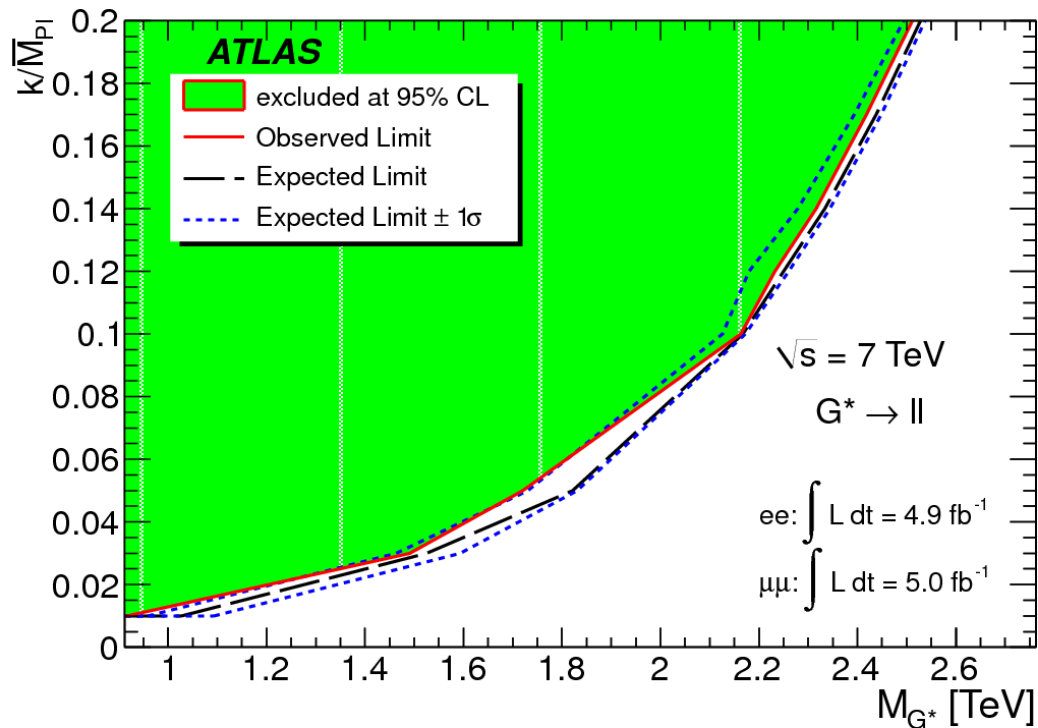

Limits for different Z' Models

Model	Z'$_{\psi}$	Z'$_{N}$	Z'$_{\eta}$	Z'$_{I}$	Z'$_{S}$	Z'$_{\chi}$	Z'$_{SSM}$
Observed limit (TeV)	1.79	1.79	1.87	1.86	1.91	1.97	2.22
Expected limit (TeV)	1.87	1.87	1.92	1.91	1.95	2.00	2.25

Limits for Z*
Observed limit (TeV): 2.20
Expected limit   (TeV): 2.22

QCD K-factor (NNLO) is applied to the signals cross-section.
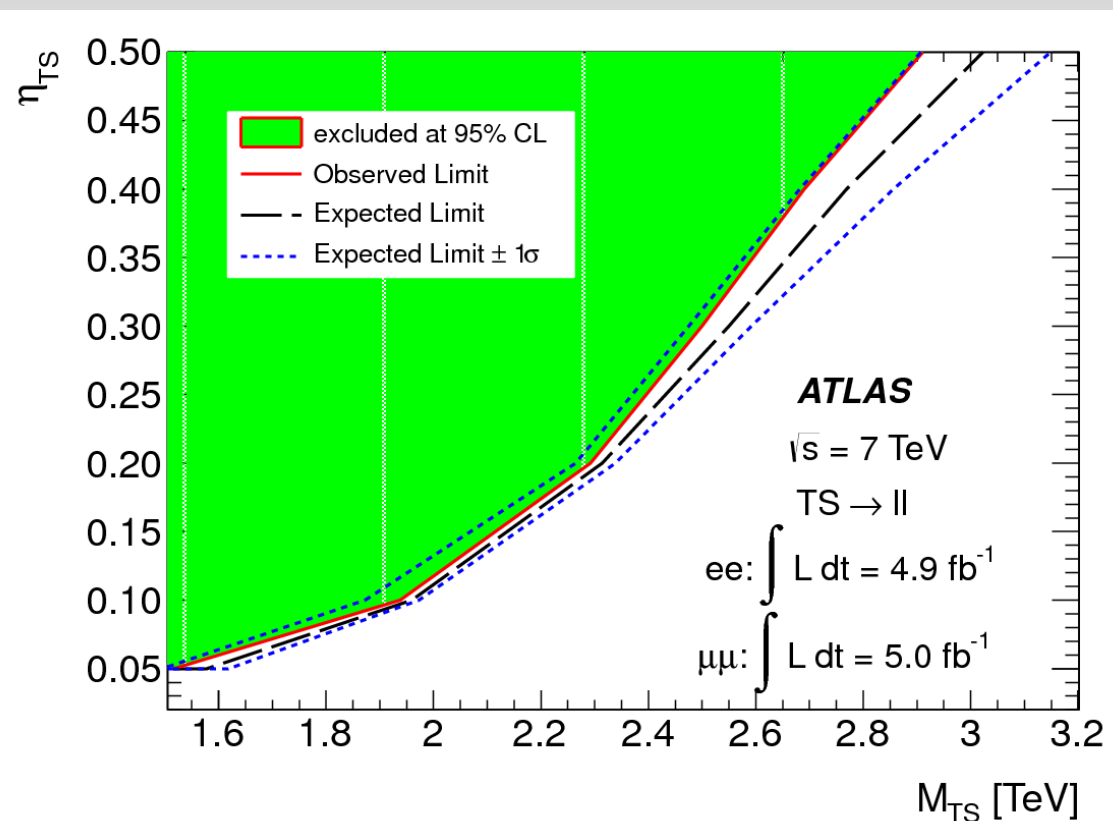
Limits on G*

The phenomenology of RS model is described by the graviton mass and coupling $(k/\overline{M}_{Pl})$ to SM fermions.

Limits for different couplings strength

$k/\overline{M}_{Pl}$	0.01	0.05	0.1	0.2
Observed limit (TeV)	0.92	1.72	2.16	2.51
Expected limit (TeV)	1.02	1.81	2.17	2.53

Limits on Torsion (TS)

Torsion is a propagating field characterized by its mass (M_{TS}) and couplings to fermions (η_{TS}).

Limits for different couplings strength

η_{TS}	0.1	0.2	0.3	0.4	0.5
Observed limit (TeV)	1.94	2.29	2.50	2.69	2.91
Expected limit (TeV)	1.96	2.31	2.55	2.77	3.02

This is the first direct search for Torsion resonance.

Limits on Technicolor

Low-scale Technicolor postulate the existence of vector techni-mesons (ρ_T, ω_T) degenerate in mass, axial techni-mesons (a_T) and light techni-pions (π_T).
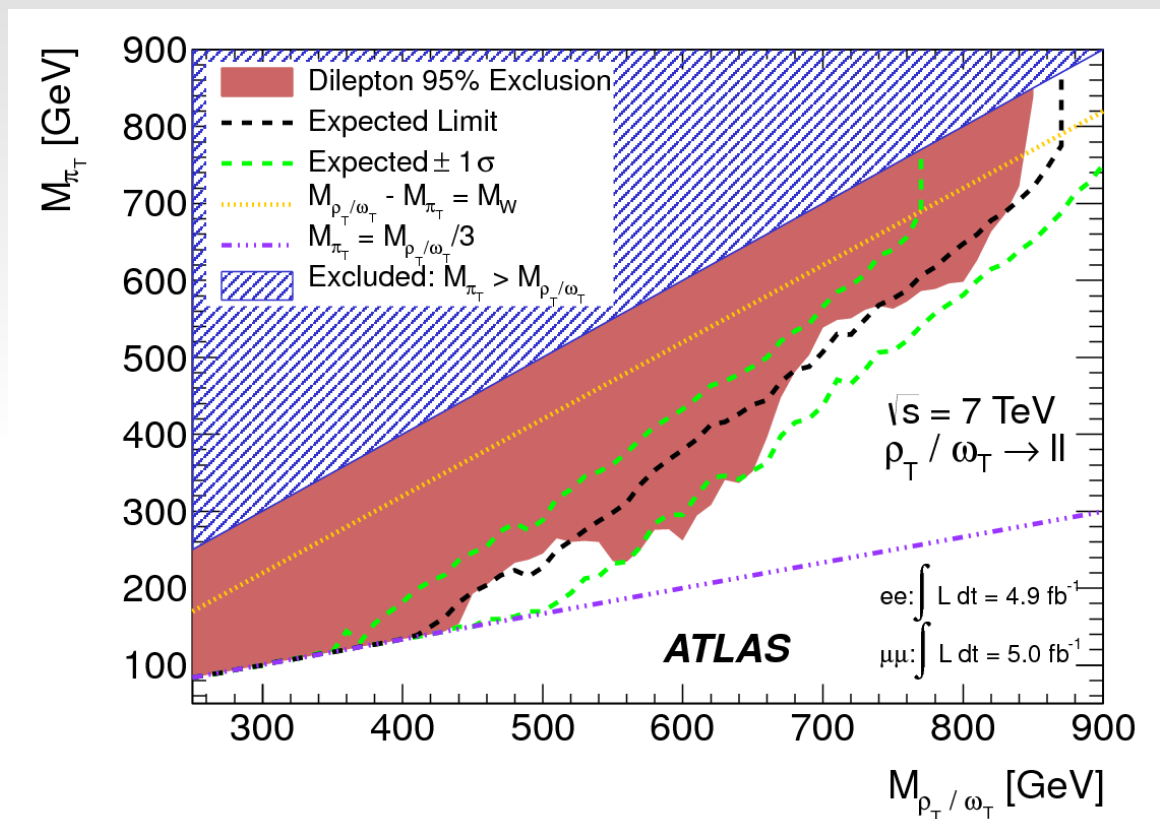
Limits on ρ_T/ω_T assuming $M_{\rho T} - M_{\pi T} = M_W$

Observed limit (TeV): 0.85
Expected limit (TeV): 0.89

Update for 8 TeV

Analysis of 2012 data at 8 TeV corresponding to an integrated luminosity of 6.1 fb^{-1}.
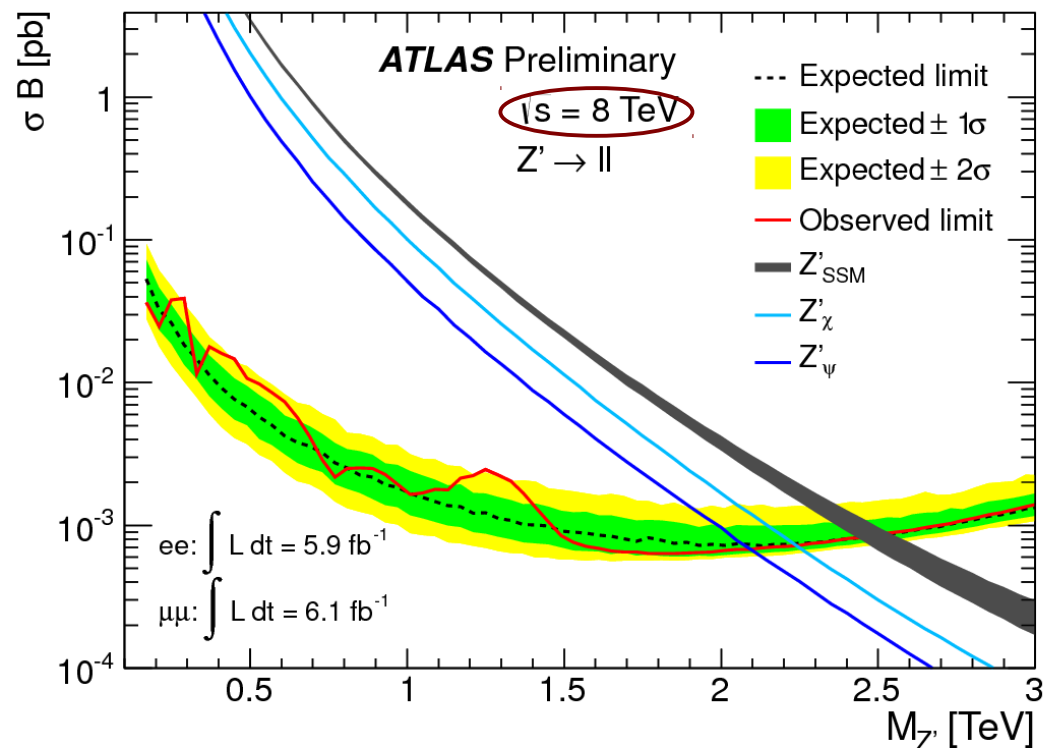
ATLAS-CONF-2012-129

New Z' SSM Limits (2012)
Observed limit (TeV): 2.49
Expected limit (TeV): 2.49

Z' SSM Limits (2011)
Observed limit (TeV): 2.22
Expected limit (TeV): 2.25

See more details on Maria A. B. do Vale poster.

Summary

➢ Searches for heavy resonances predicted by different BSM have been performed using *pp* collision data at center-of-mass energy of 7 TeV and integrated luminosity of 5.0 fb^{-1}.

➢ So far, the data analyzed are consistent with SM expectations.

➢ Limits on the cross sections times branching ration of spin-1 and spin-2 bosons were set.

➢ The resulting mass limits for most of the spin-1 bosons are around 2 TeV.

➢ Limits on *G** mass range from ~ 0.9 to 2.5 TeV

➢ Techni-mesons with masses below 850 GeV are excluded.

➢ See more details and results for other models in: **JHEP11 (2012) 138**
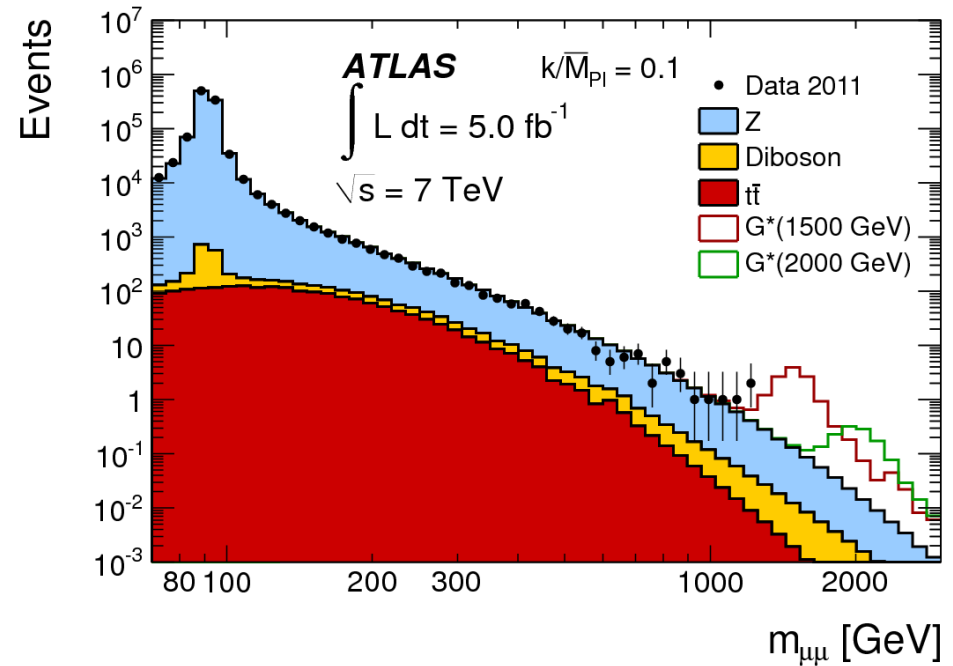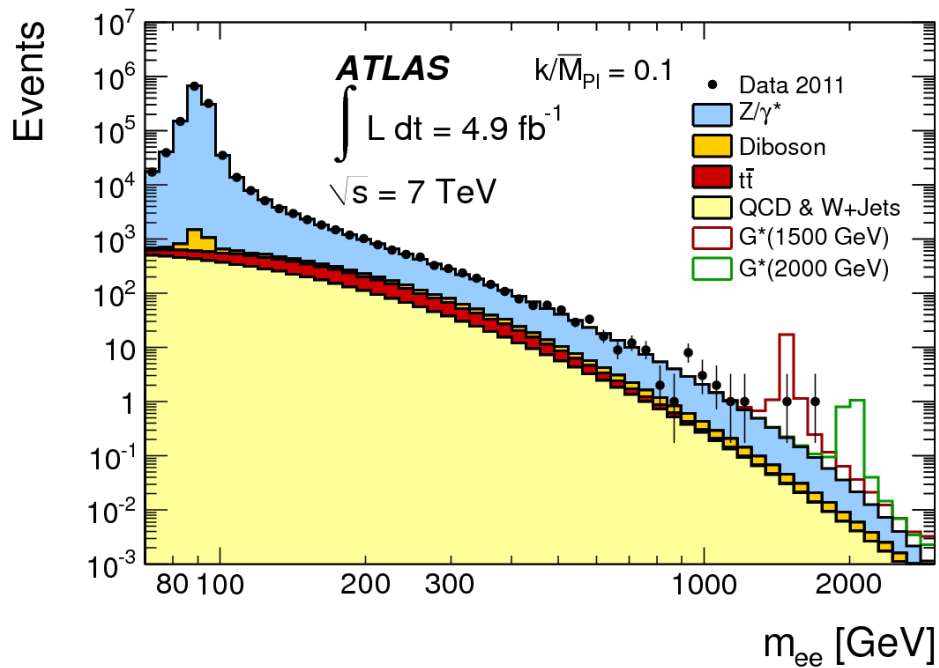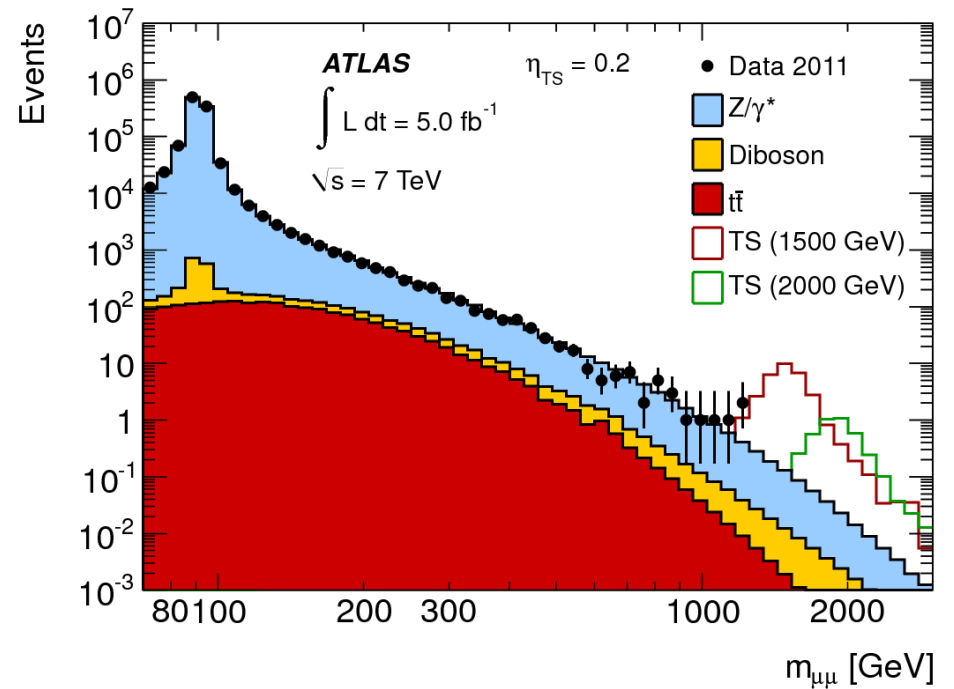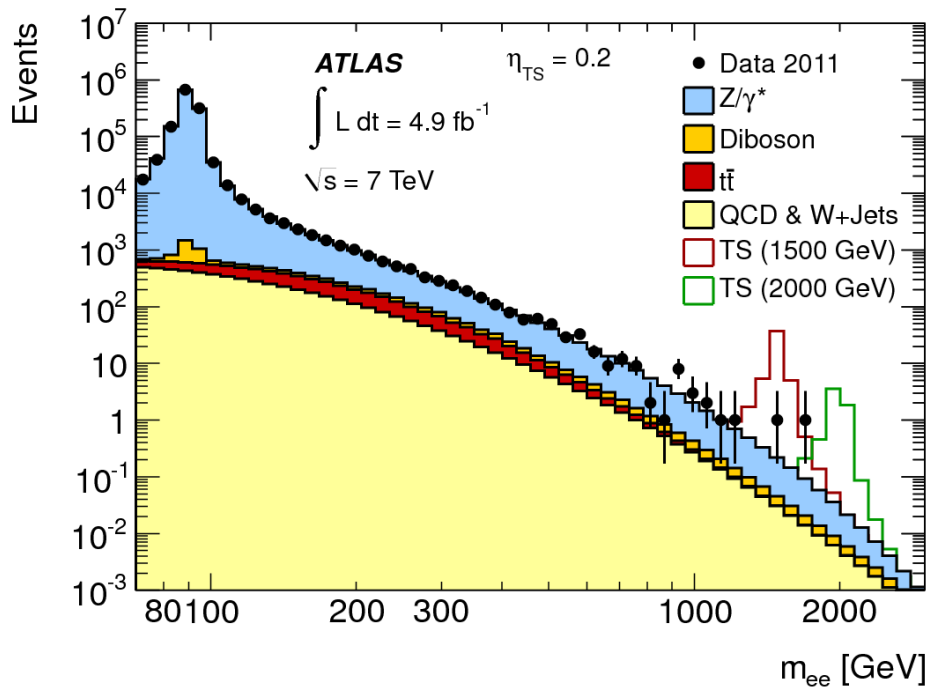
Back-up Slides

Systematic uncertainties

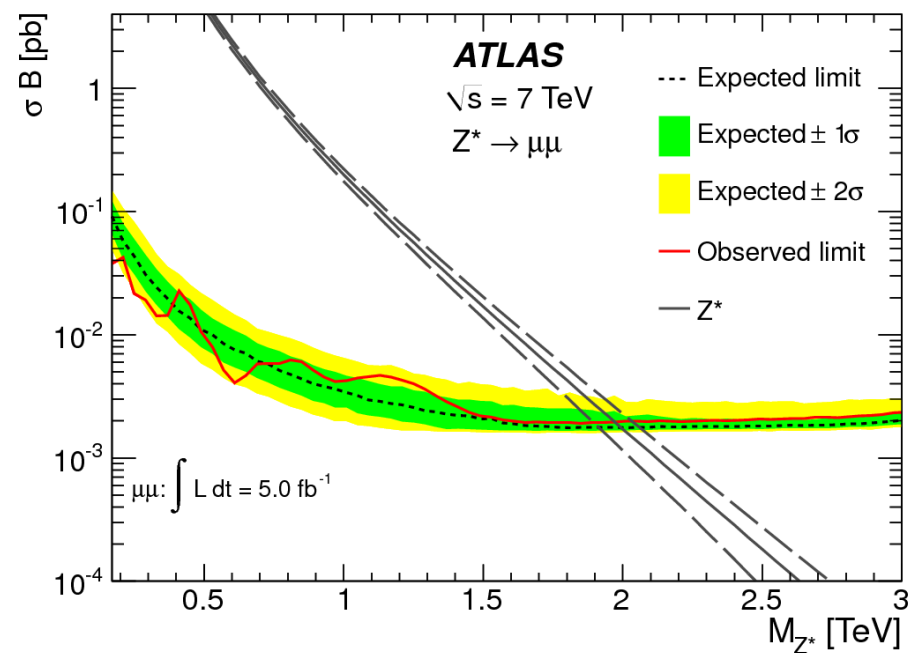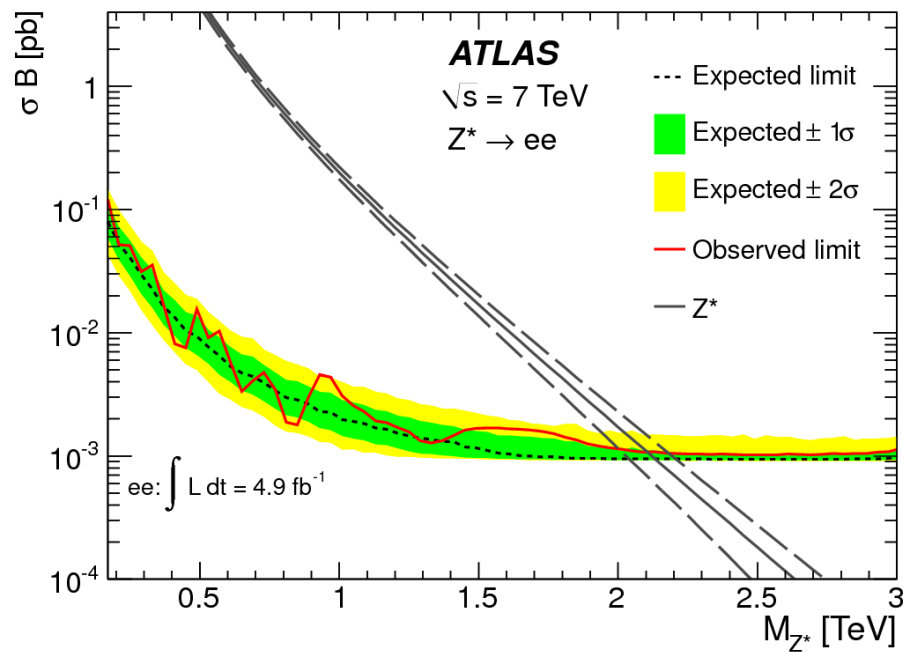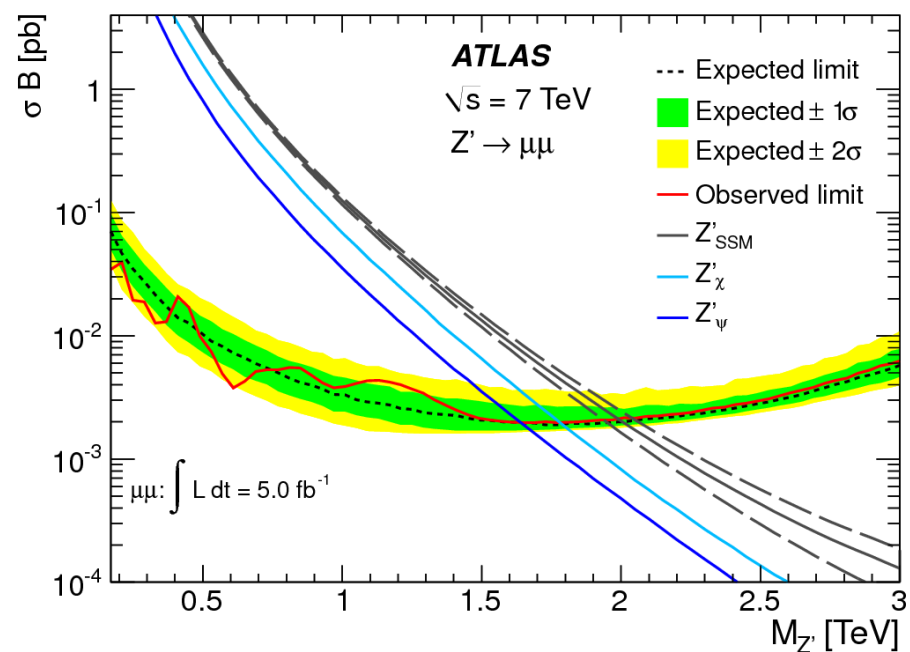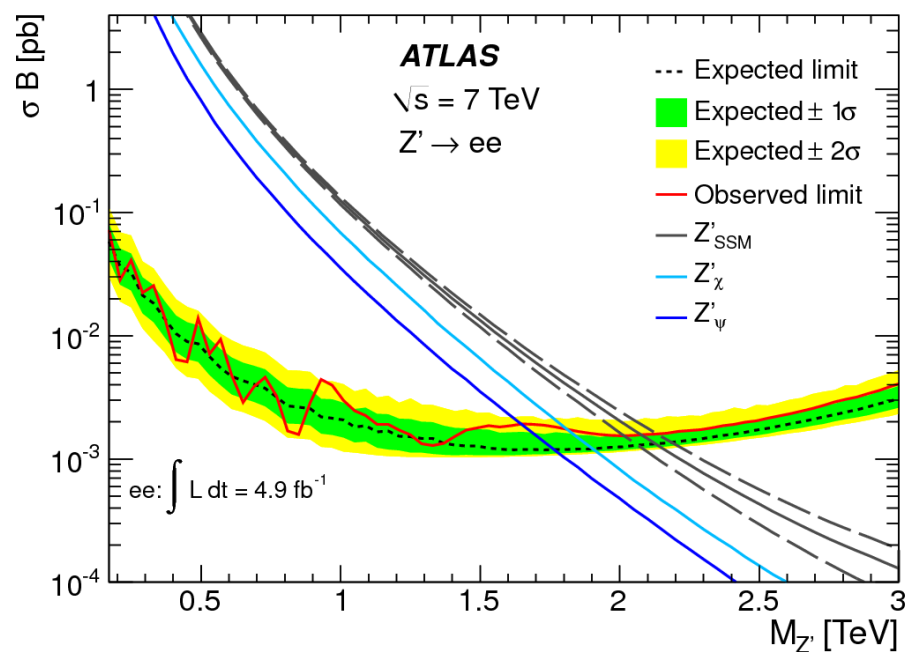| Source	Dielectrons		Dimuons	
	Signal	Background	Signal	Background
Normalization	5%	NA	5%	NA
PDF/α_s /scale	NA	20%	NA	20%
Electroweak corrections	NA	4.5%	NA	4.5%
Efficiency	-	-	6%	6%
W + jets and QCD background	NA	26%	NA	-
Total	5%	34%	8%	21%

Kinematic distributions
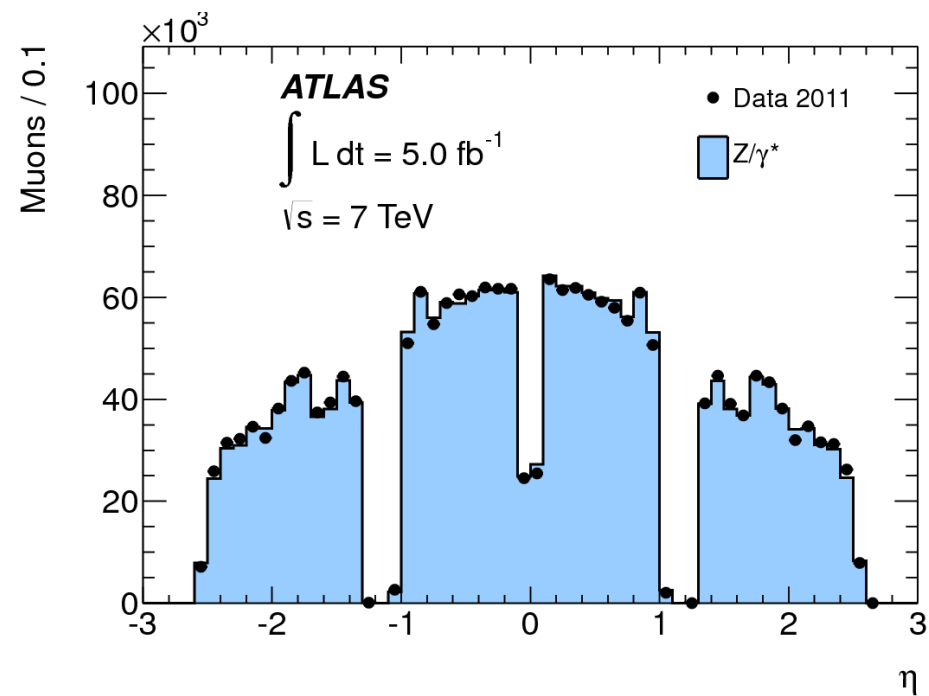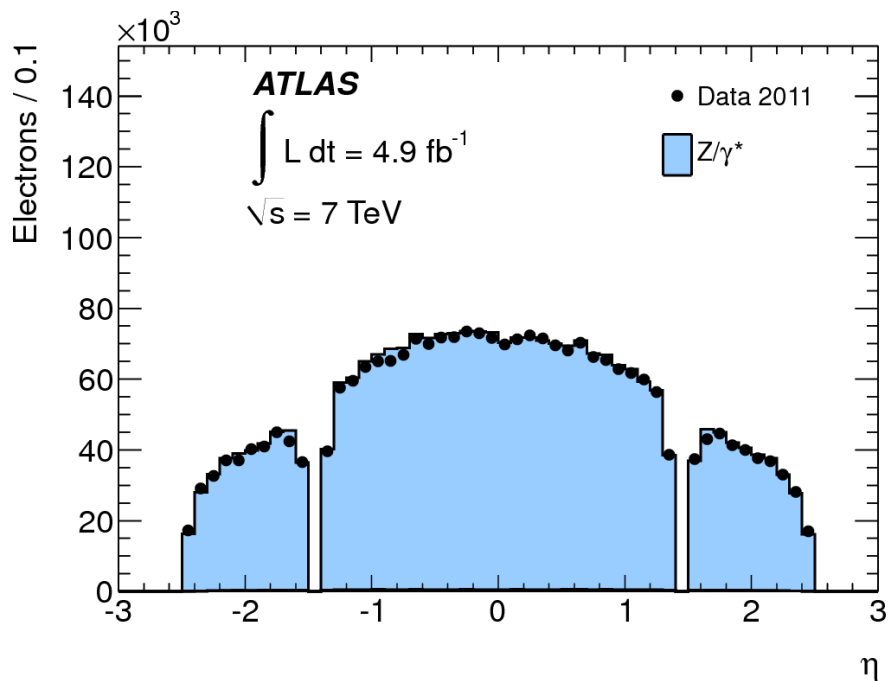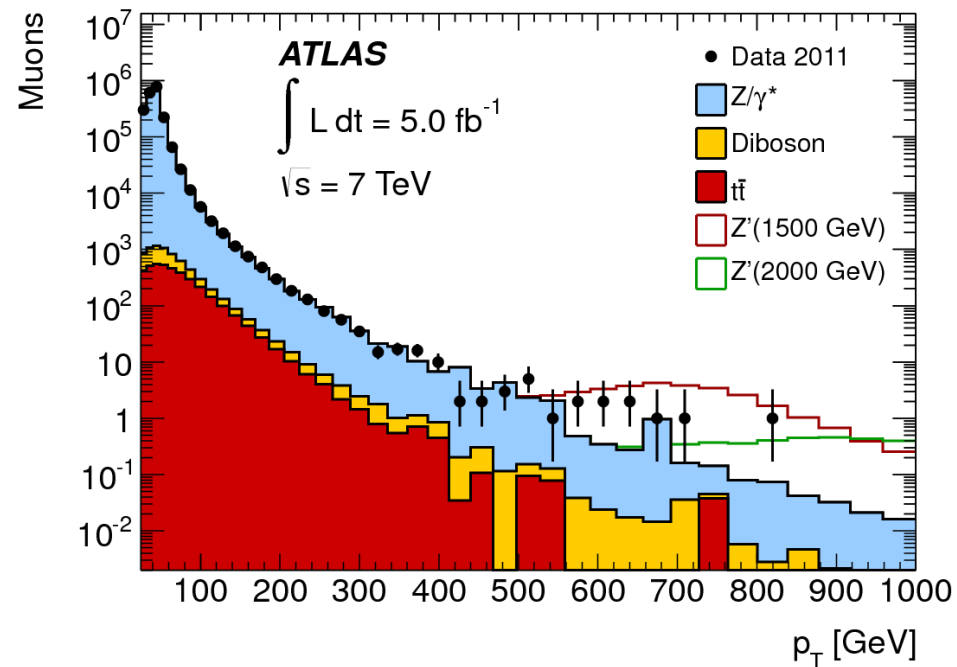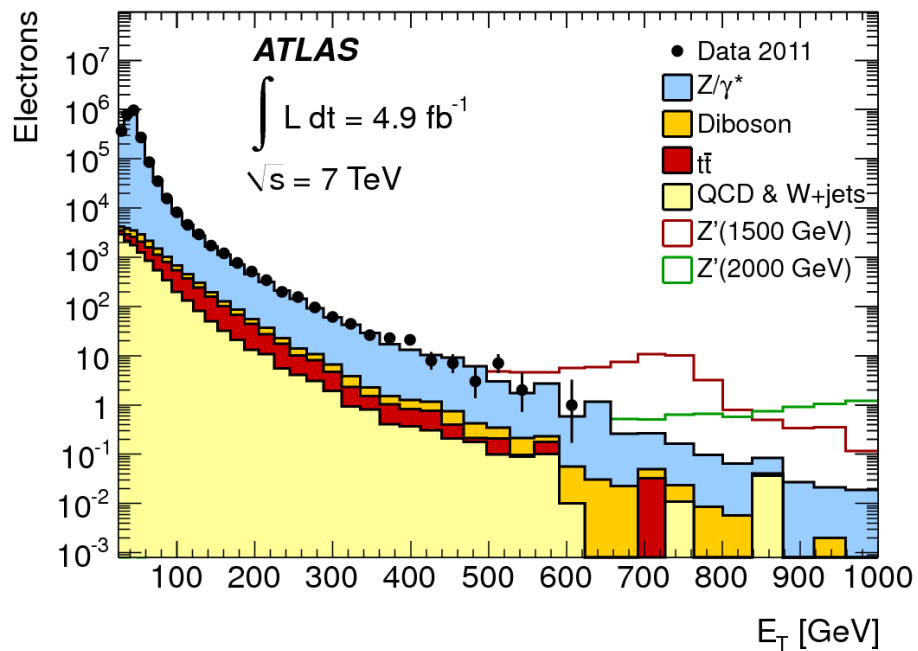
Torsion and *G** invariant mass distributions

Limits on Z' and Z* for individual channels

Limits on Torsion and *G** for individual channels