Search for resonances
in lepton pairs and photon pairs
with the ATLAS detector

ATLAS EXPERIMENT
http://atlas.ch

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On behalf of the ATLAS collaboration

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Outline

■ A large variety of models beyond the SM predicts new signals that could be observed at the LHC through the analysis of final states involving two leptons or two photons
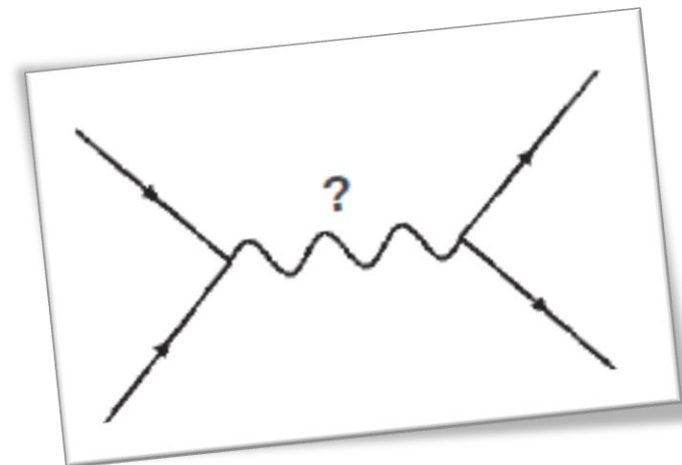

■ A summary of several searches in such channels, with proton-proton data from the LHC at √s=7 TeV collected by the ATLAS detector during 2011 is presented here.

  ▫ Same data can probe various models
  ▫ References for the details on the slides

Searches on the dilepton final state

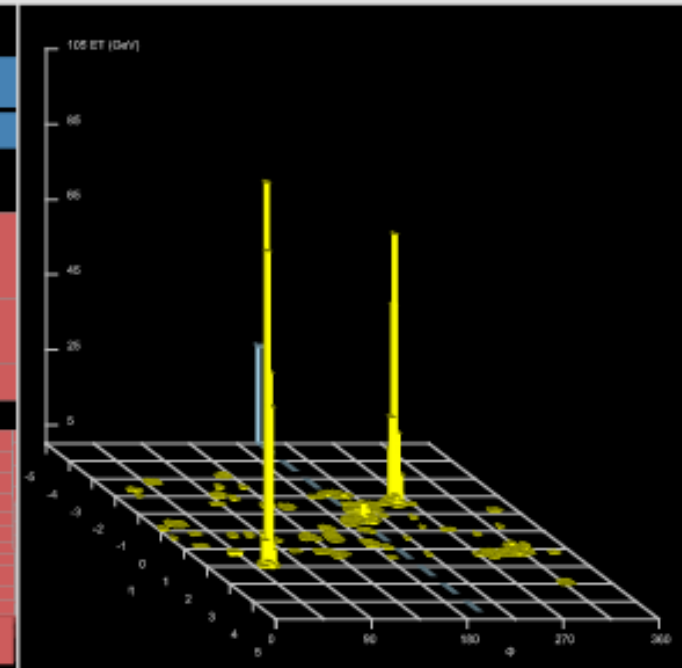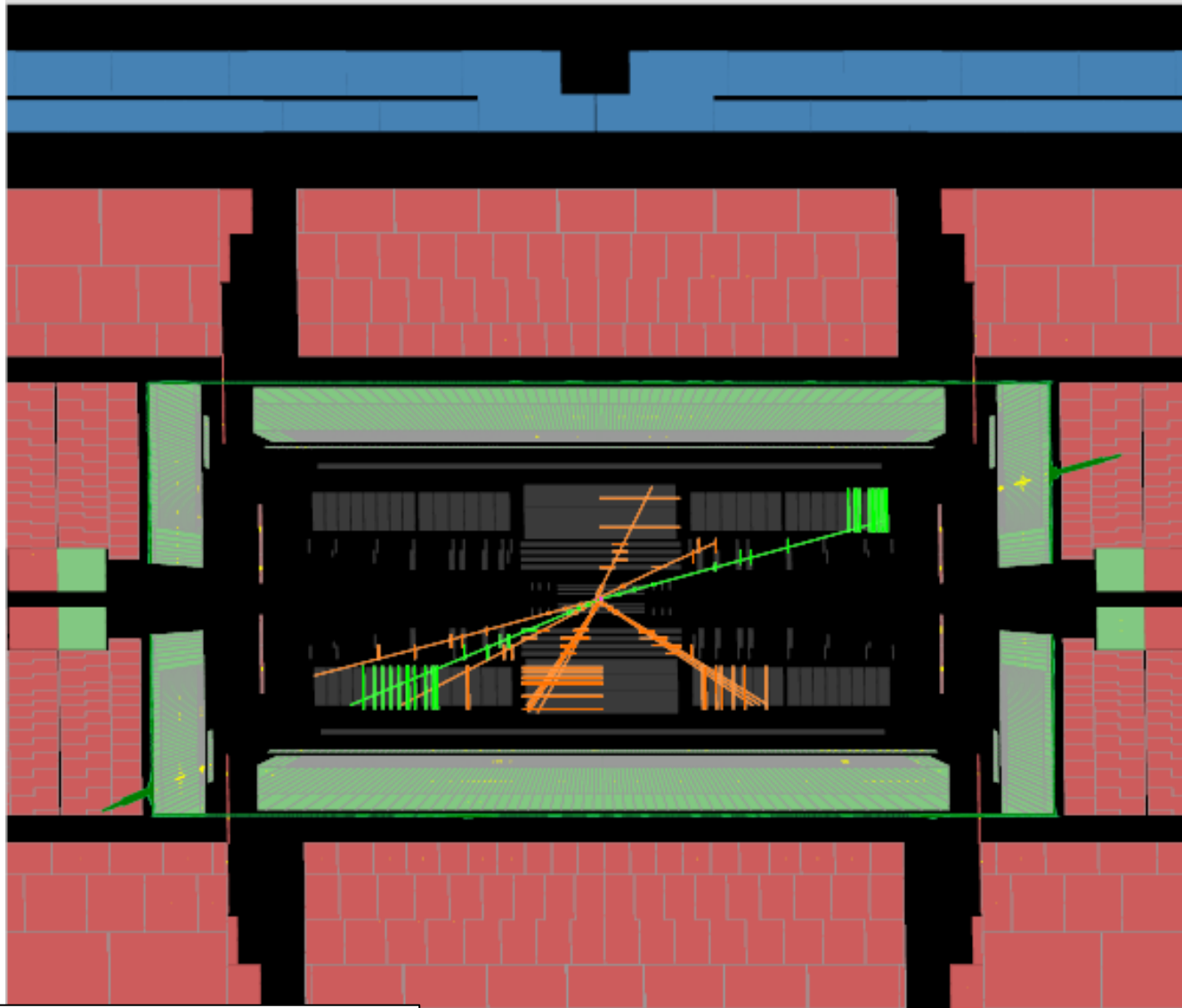| Final State	Model	$\int$ L dt [1/fb]	Topology
ee/$\mu\mu$	Heavy spin-1 neutral gauge bosons (SSM, E6): Z' Spin-2 gravitons (RS) : G*	4.9/5.0 ($\sqrt{s}$=7 TeV)	Resonant
	Technicolor (LSCT): Techni-hadrons	1.08/1.21 ($\sqrt{s}$=7 TeV)	Resonant
	Quark/Lepton compositeness: Contact-Interactions		Non-resonant
eν_e/$\mu\nu_\mu$	Heavy spin-1 charge gauge bosons (SSM): W' Magnetic-type interacting bosons: W*	4.7/4.7 ($\sqrt{s}$=7 TeV)	Resonant

* For $\tau\tau$ final state see presentation by Peter Wagner .

ee/μμ (i)

ee -channel   **Z′ / G***   **μμ -channel**

$p_T^{1,2} > 25$ GeV $p_T^{1,2} > 25$ GeV
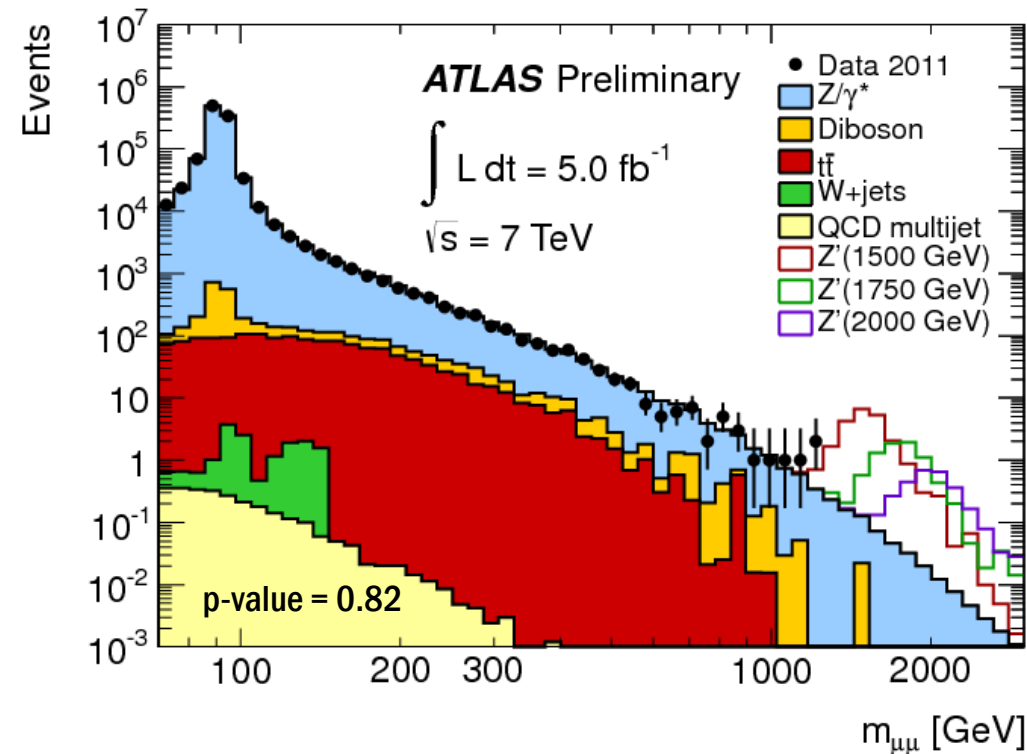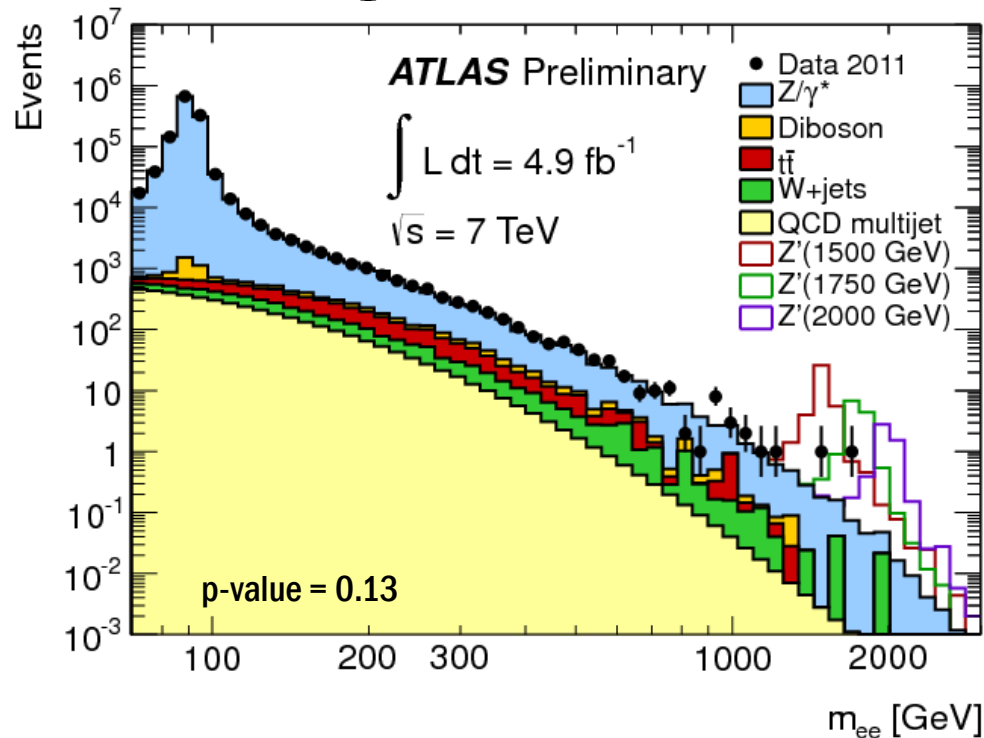
Background Estimate

· **Z/γ*** - **Diboson** - **tt** - **W+jets** : from simulations (**@NNLO** , approx-**NNLO**, **@NLO**)

· QCD : data-driven reverse id technique (negligible contributions in the μμ channel)

  normalization from low mass control region [70-110] GeV

· Dominant systematic uncertainty arise from theory (PDFs & scales ~20 %)

References : ATLAS-CONF-2012-007

Display of dielectron candidate event with largest m_{ee} value

Run Number: 190300, Event Number: 75300042

Date: 2011-10-04 05:39:53 UTC

Run Number: 190975,
Event Number: 26669226
Date: 2011-10-13, 23:34:58 CET
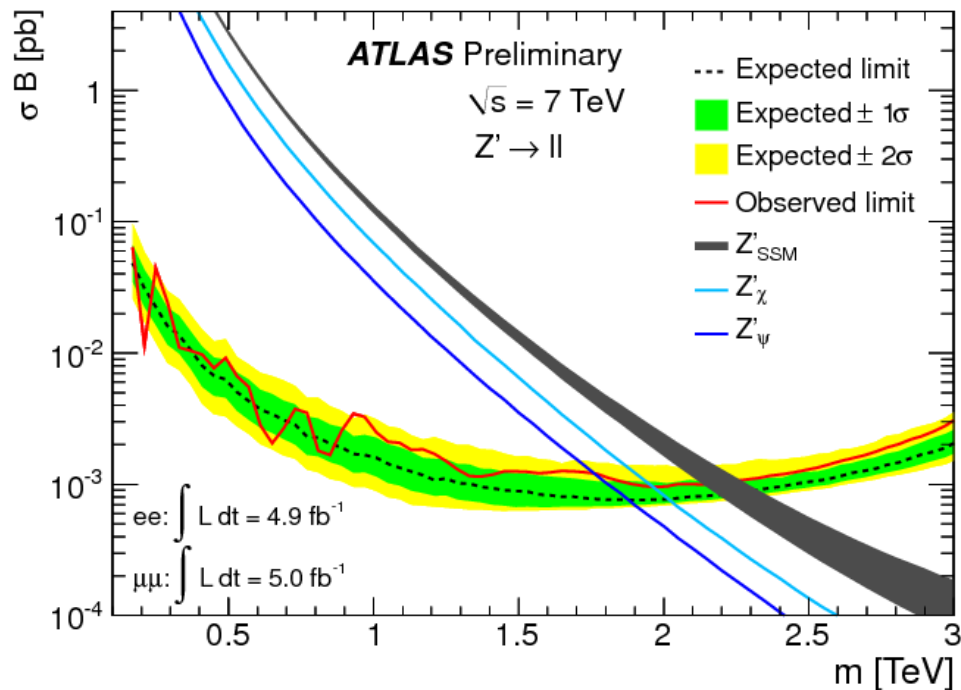
Muon: blue
Electron: black
Cells: Tiles, EMC
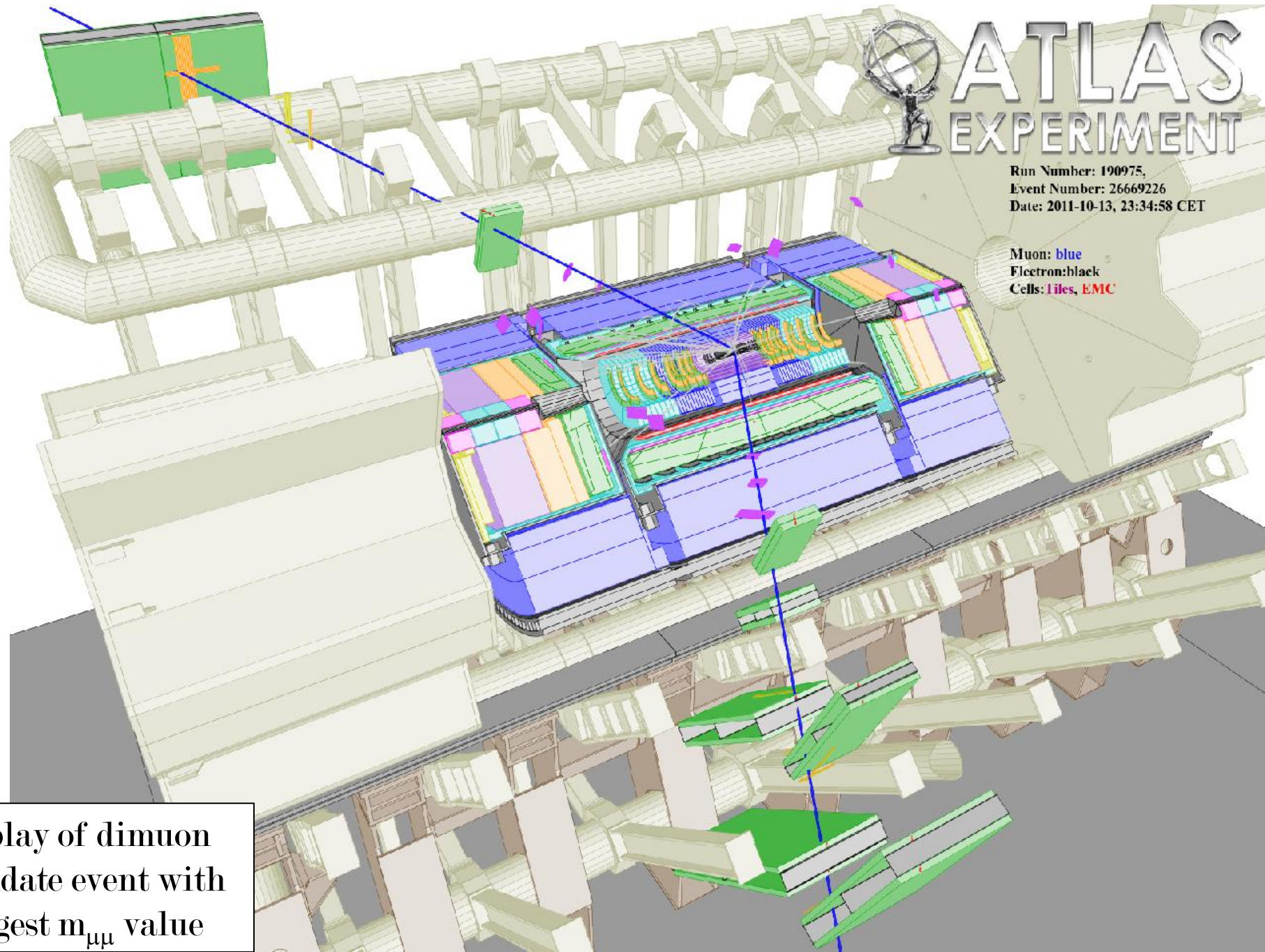
Display of dimuon
candidate event with
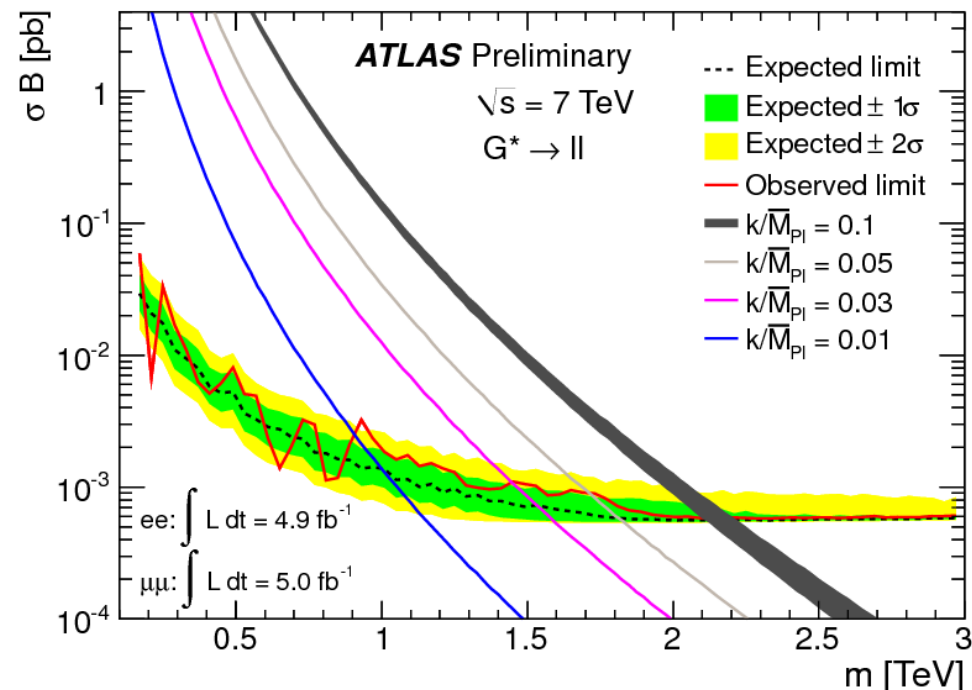largest $m_{\mu\mu}$ value

ee/µµ (ii) 95% CL exclusion limits

Z′
(heavy spin-1 neutral gauge bosons)

G*
(spin-2 gravitons)

Model	Z'_ψ	Z'_N	Z'_η	Z'_I	Z'_S	Z'_χ	Z'_{SSM}
$M_{Z'}$ limit [TeV]	1.76	1.78	1.84	1.84	1.90	1.96	2.21

Signal (k/M=0.1)	M_{G*} limit [TeV]
$G* \rightarrow e^+e^-$	2.03
$G* \rightarrow \mu^+\mu^-$	1.90
$G* \rightarrow l^+l^-$	2.16

ee/μμ (iv)

*Results based on a subsample of the 2011 data (~1/fb)

TechniHadrons/
Contact Interactions

ee -channel

$p_T^{1,2} > 25$ GeV

μμ -channel

$p_T^{1,2} > 25$ GeV
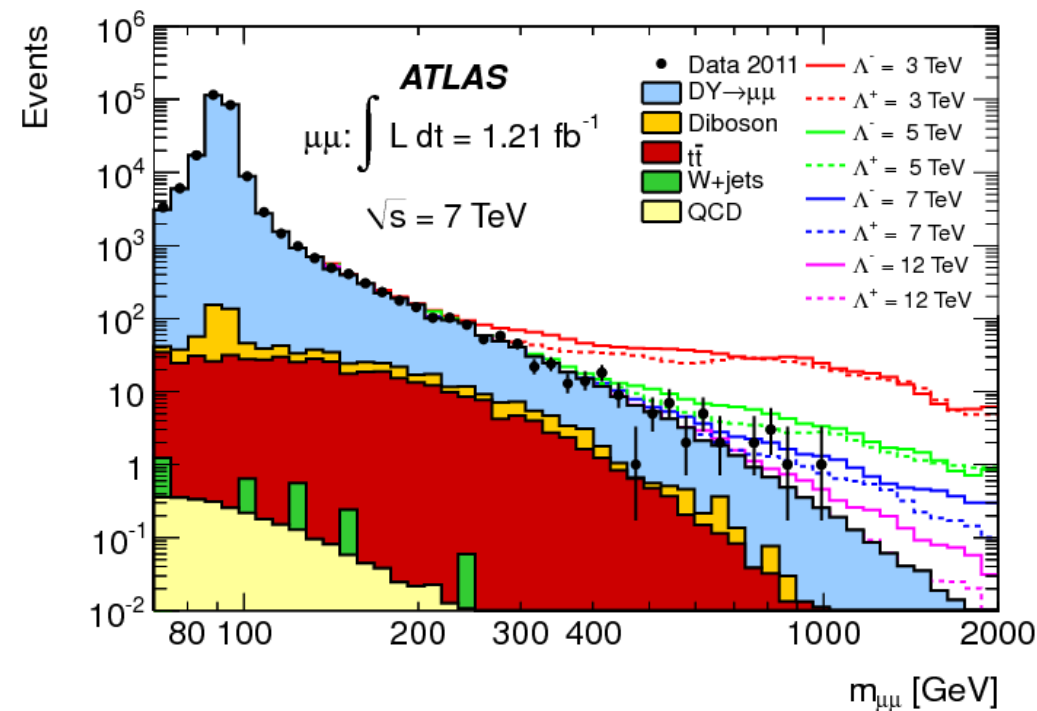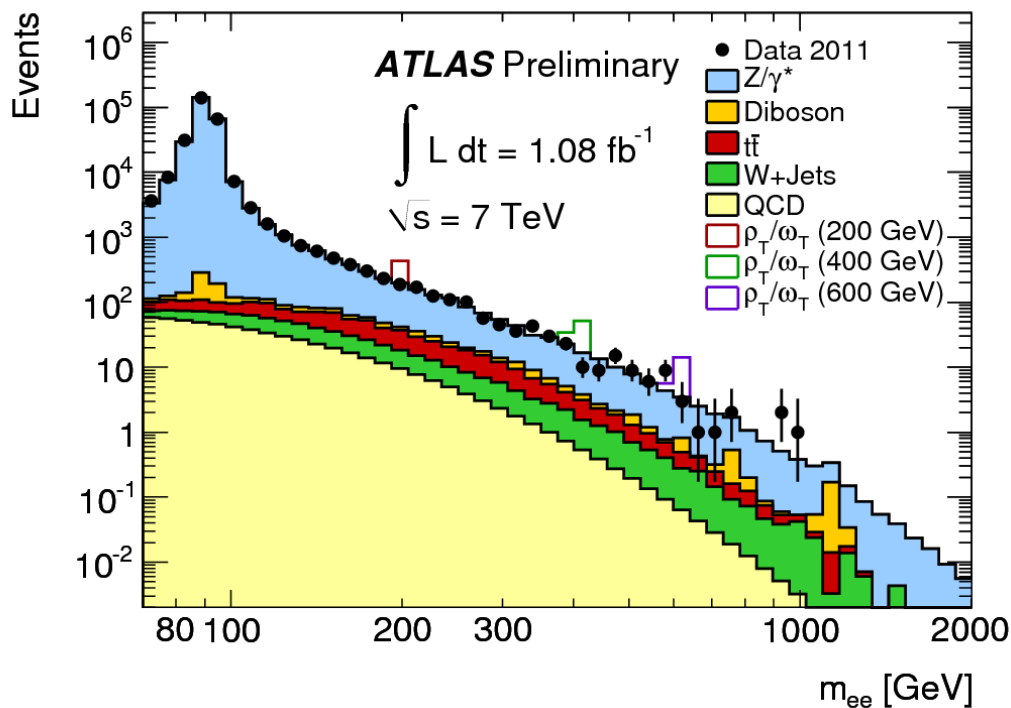
Search methodology identical to Z'/G*
(same event selection criteria, backgrounds, systematics)

References : Phys. Lett. **B712** (2012) 40-58, ATLAS-CONF-2011-125

ee/μμ (v) 95% CL exclusion limits

LSCT
(Low Scale Technicolor)
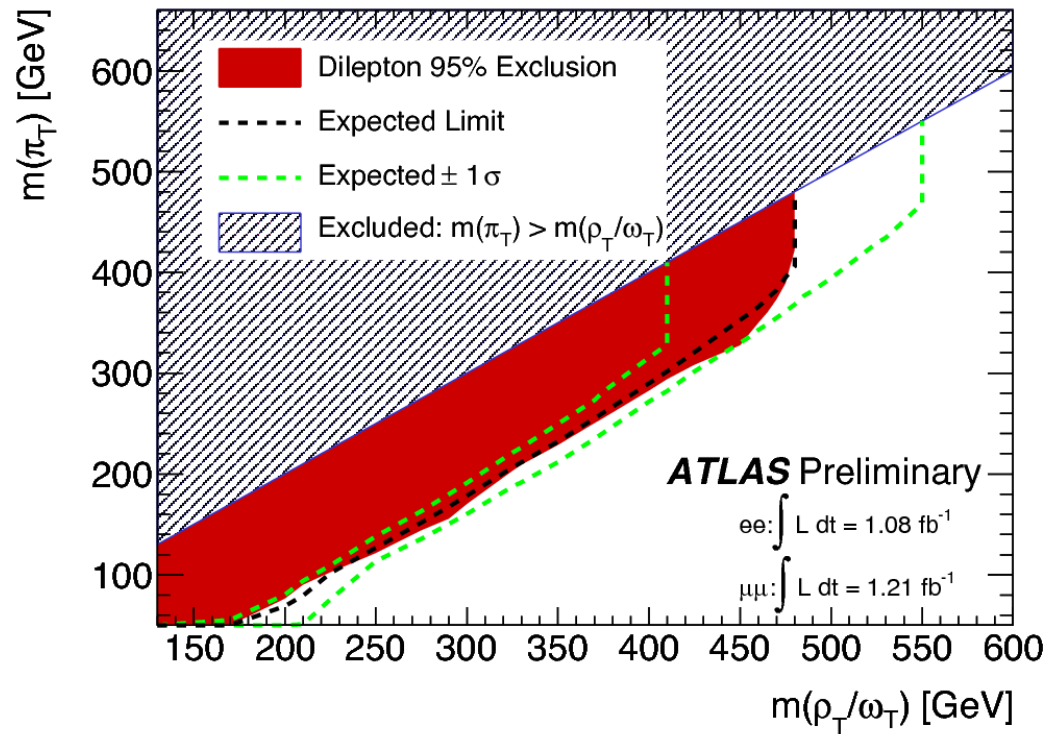
Signal (M(ρ_T) – M(π_T) = 100 GeV)	M_ρ limit [TeV]
$\rho_T/\omega_T \to l^+l^-$	0.47

Contact Interactions

Left-Left Isoscalar Model

$$\eta_{LL}=\pm 1 \quad \eta_{LR}= \eta_{RR}=0$$

$$\frac{d\sigma}{dm_{\ell\ell}} = \frac{d\sigma_{DY}}{dm_{\ell\ell}} - \eta_{LL}\frac{F_I(m_{\ell\ell})}{\Lambda^2} + \frac{F_C(m_{\ell\ell})}{\Lambda^4}$$

Channel	95% CL limits [TeV] on Λ (1/Λ^2 prior)	
	η_{LL}= -1	η_{LL}=1
e^+e^-	10.1	9.4
$\mu^+\mu^-$	8.0	7.0
l^+l^-	10.2	8.8

$e\nu_e/\mu\nu_\mu$ (i)

NEW

$$\text{Observable} \qquad m_T = \sqrt{2p_T E_T^{miss}(1-\cos\theta_{l\nu})}$$

W' / W*

eν -channel

$p_T, E_T^{miss} \rangle 85$ GeV

$\mu\nu$ -channel

$p_T, E_T^{miss} \rangle 25$ GeV
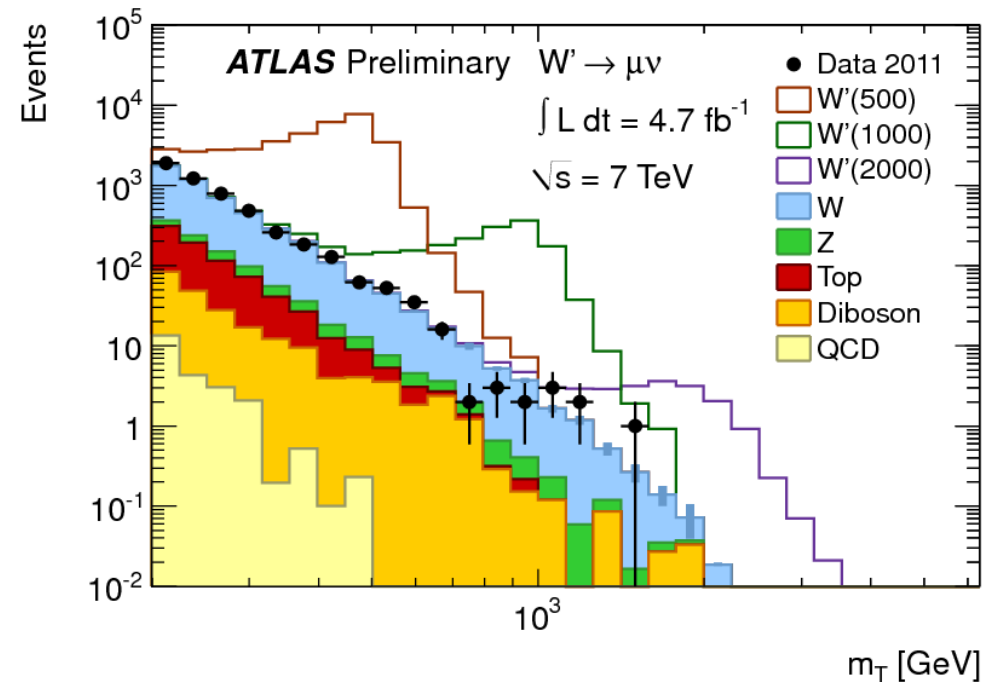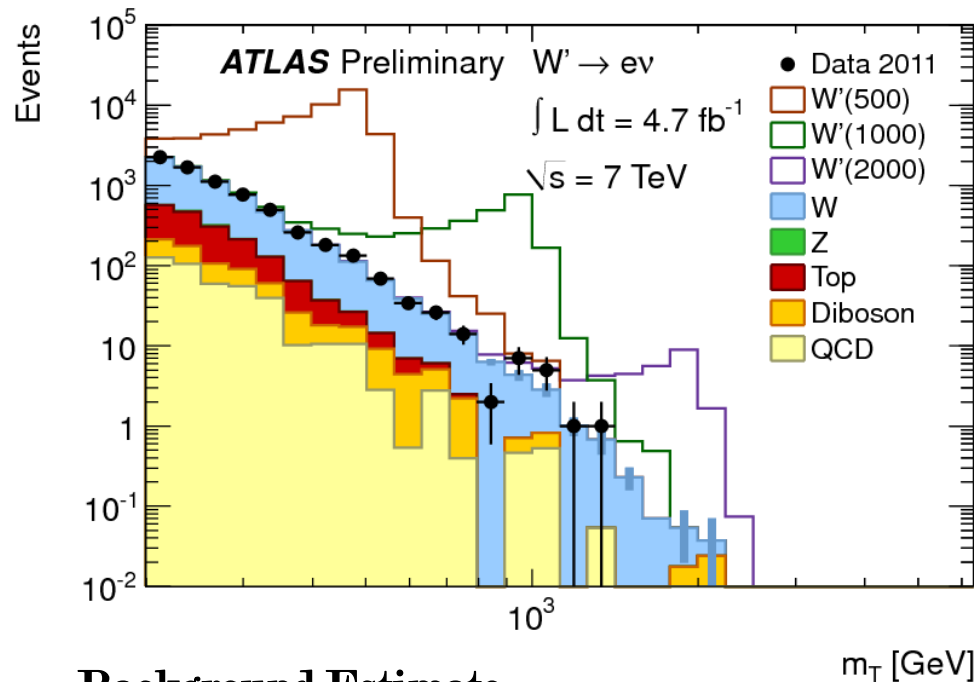
Background Estimate

· **W** - **Z** - **Top** - **Diboson** : from simulations (**@NNLO**, **approx-NNLO**)

· **QCD** : data-driven ABCD technique (negligible contributions in the $\mu\nu$ channel)

· Dominant systematic uncertainty arise from theory (PDFs & scales) ~12% and MC statistics ~10%

References : ATLAS-CONF-2012-086

$e\nu_e/\mu\nu_\mu$ (ii) 95% CL exclusion limits

W '

W *
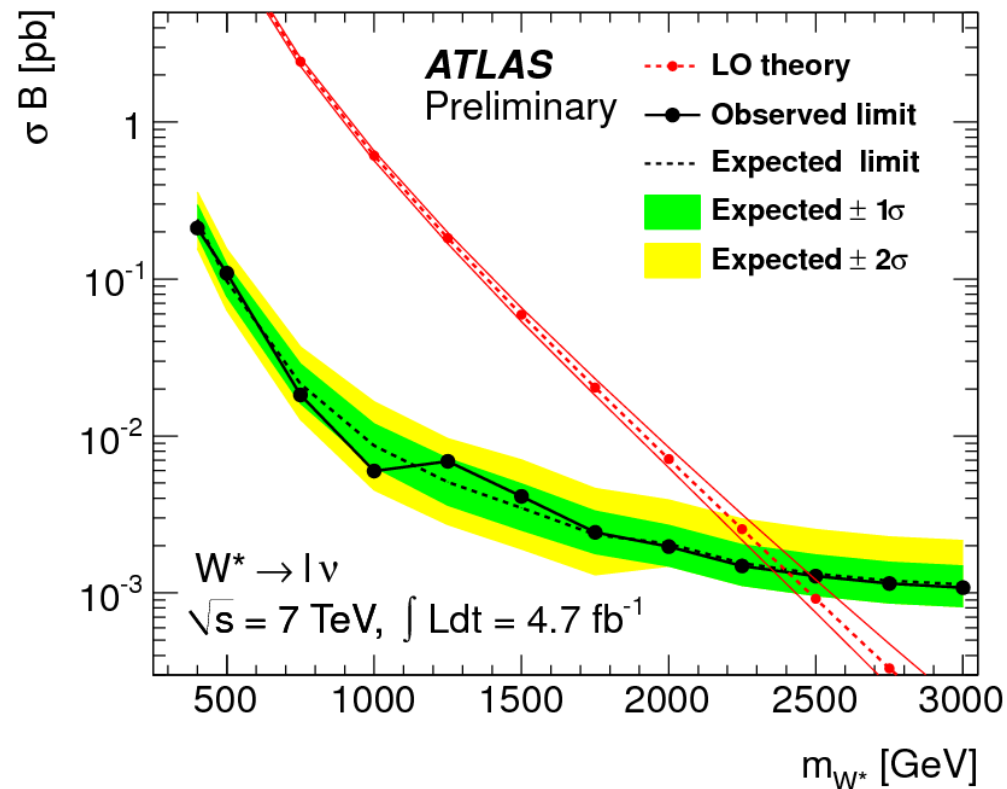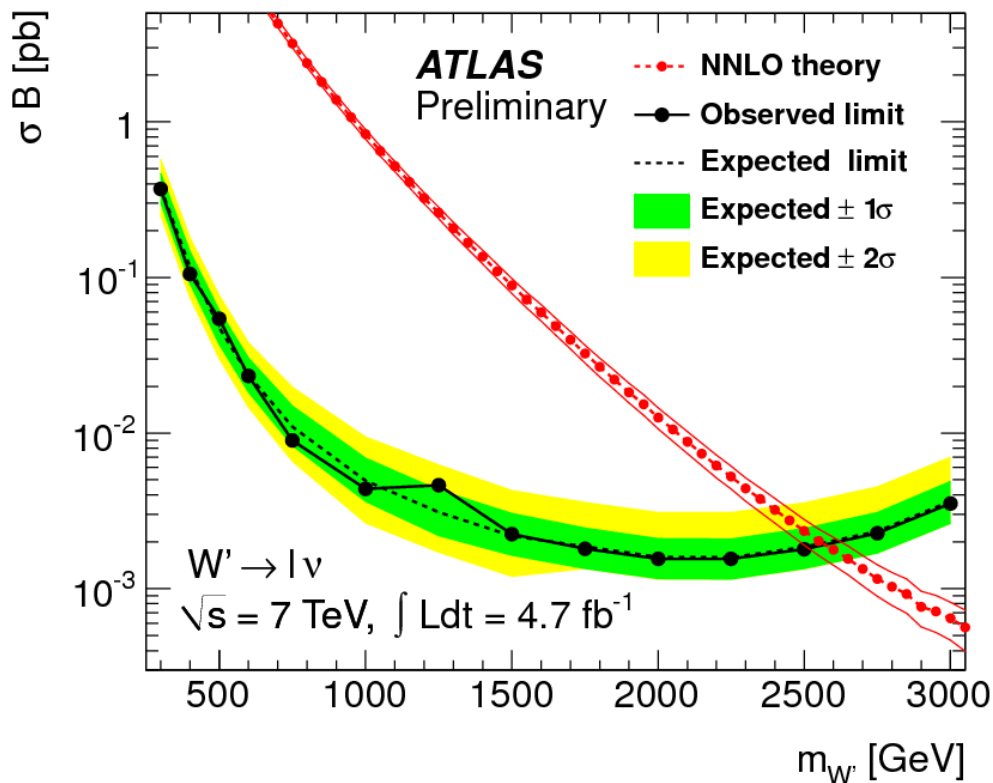
Signal	95% CL limit on mass [TeV]		
W '	eν: 2.50	$\mu\nu$: 2.28	lν: 2.55
W *	eν: 2.35	$\mu\nu$: 2.04	lν: 2.40

Searches on the diphoton final state (i)

Final State	Model	$\int L\ dt\ $ [1/fb]	Topology
$\gamma\gamma$	Spin-2 gravitons (RS) : G*	4.9 ($\sqrt{s}$=7 TeV)	Resonant
	Virtual-graviton exchange : ADD		Non-resonant

*Branching ratio twice the one to any pair of charge leptons

$\gamma\gamma$ (ii)

$p_T^{1,2} > 25$ GeV / $m_{\gamma\gamma} > 140$ GeV
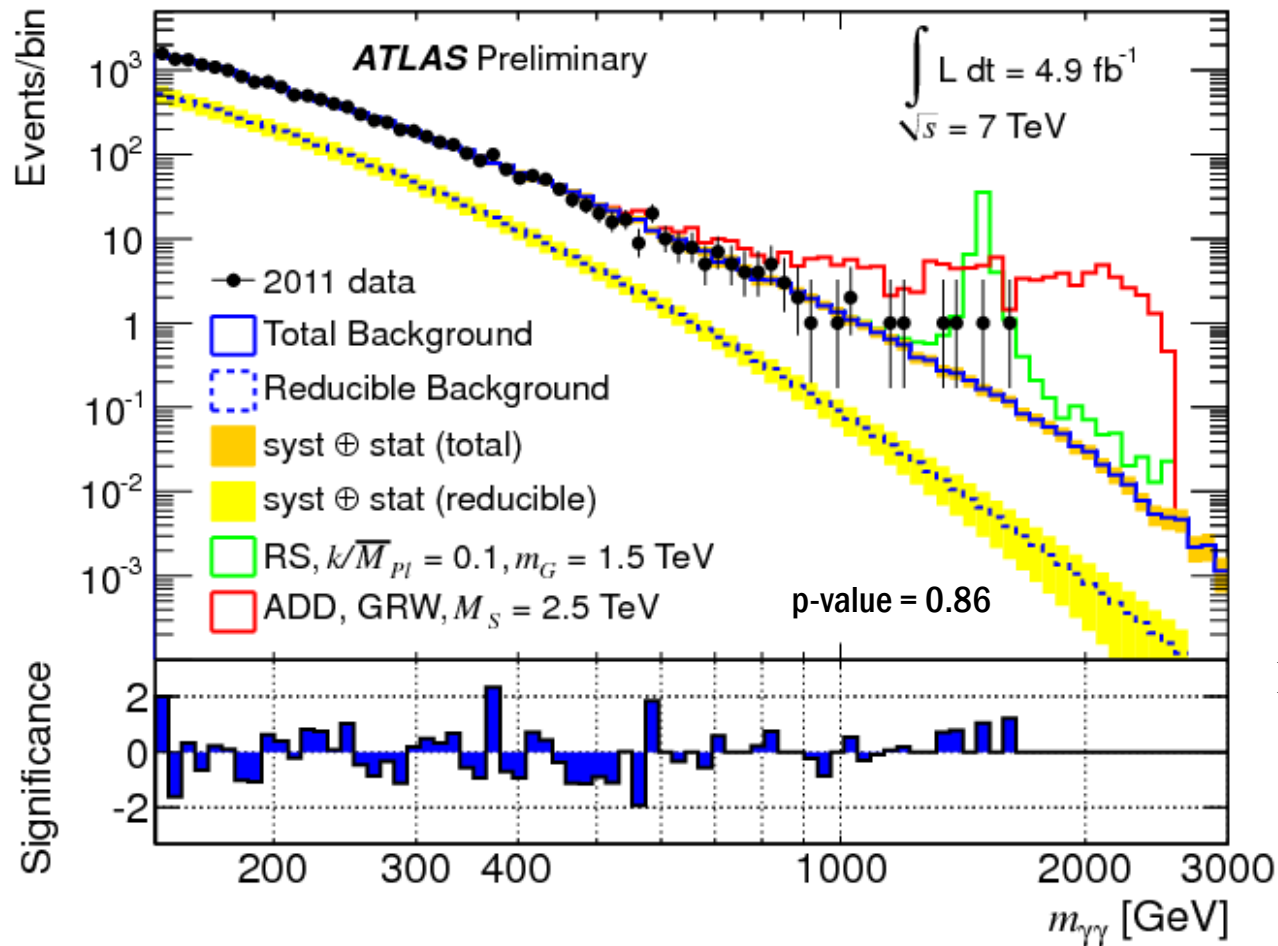
Background Estimate

Irreducible
SM $\gamma\gamma$
(shape from simulation @NLO)

+

Reducible
QCD γ+jet / jet+jet
(shape from data jet enriched samples)

Normalization from low mass control region [142, 409] GeV using isolation templates

References: ATLAS-CONF-2012-087
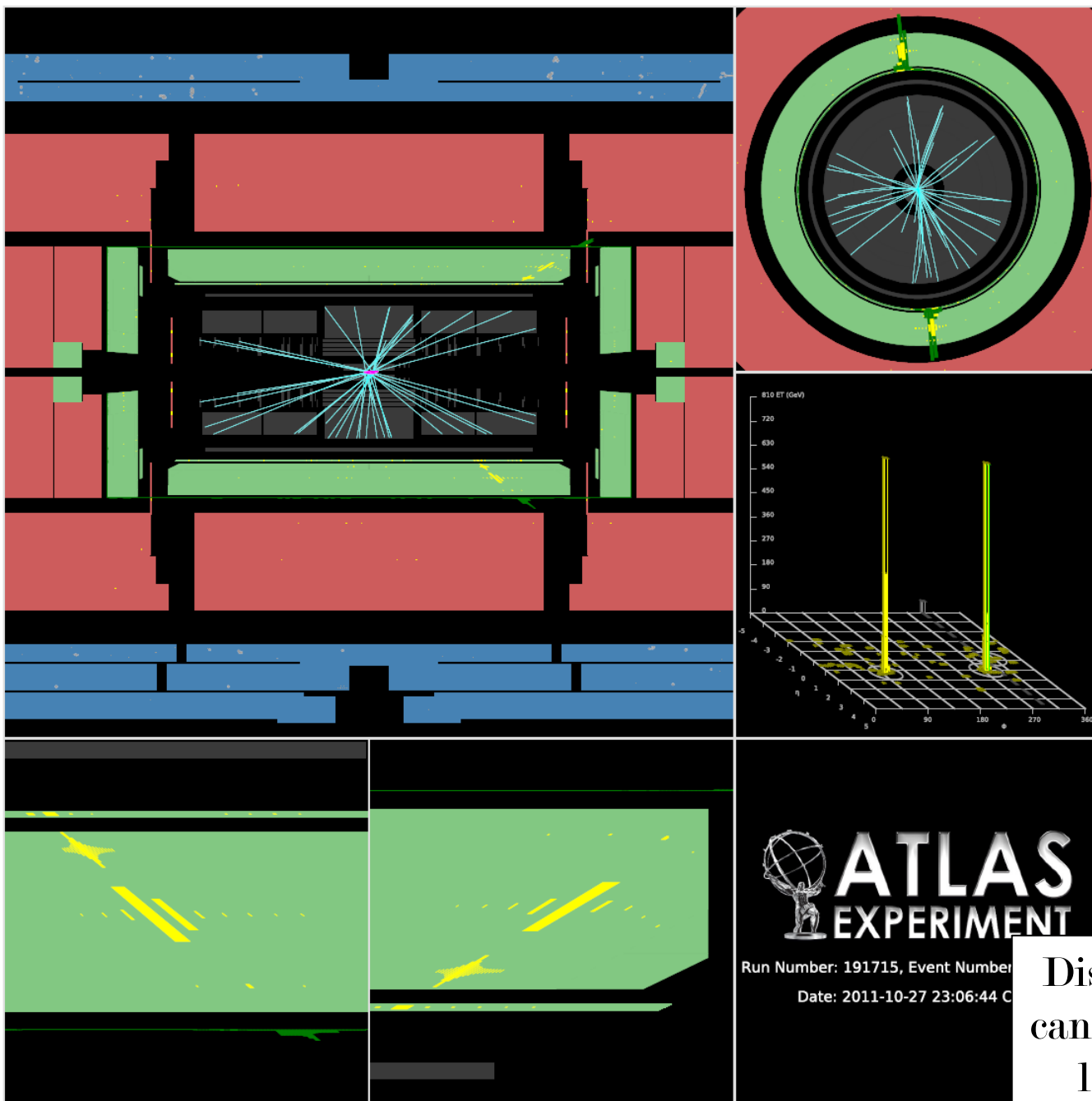
Display of diphoton candidate event with largest $m_{\gamma\gamma}$ value

γγ (iii) 95% CL exclusion limits

G*
(resonant)
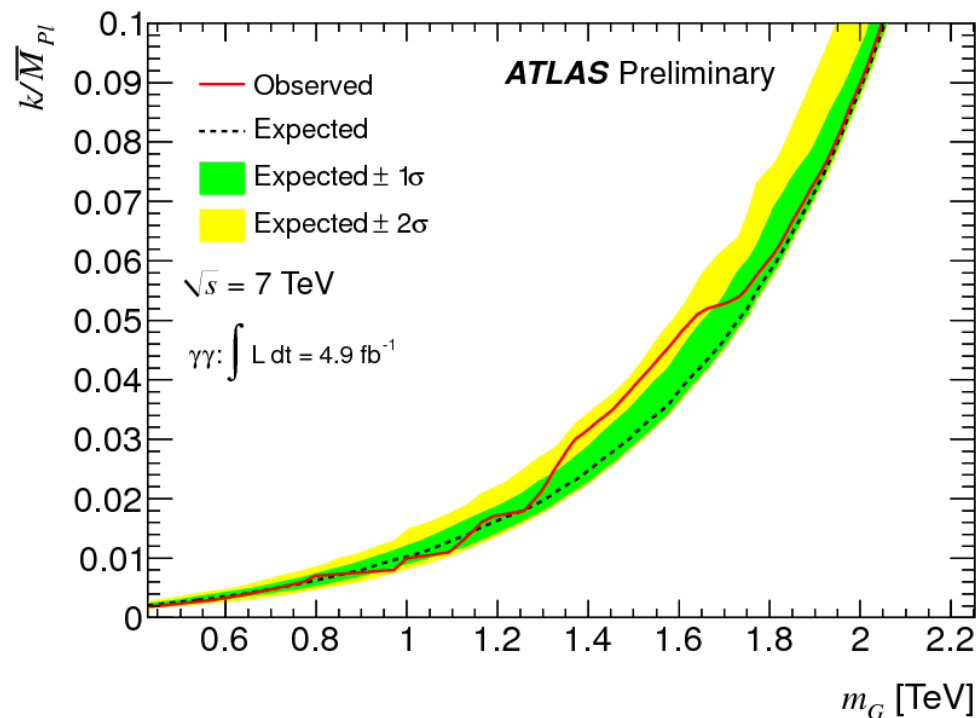
Signal (k/M=0.1)	m_{G*} limit [TeV]
G*→γγ	2.06

Virtual graviton exchange
(non - resonant)
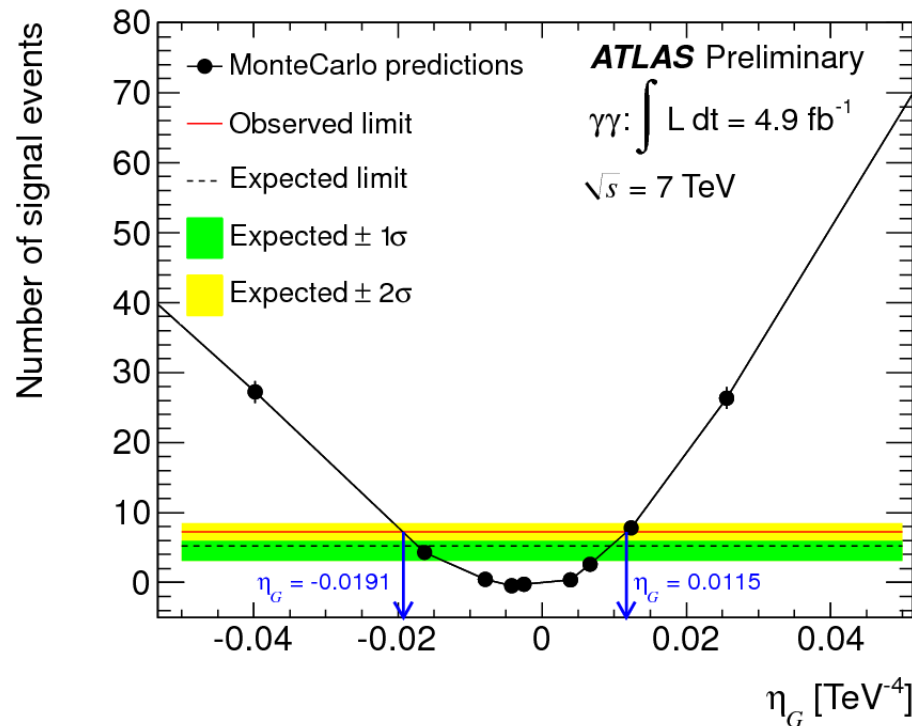
$$\sigma_{\text{total}} = \sigma_{SM} + A\eta\sigma_{\text{int}} + B\eta^2\sigma_{ED}$$

$$\eta = \mathcal{F}/M_S^4$$

Model	GRW	Hewett	HLZ
M_S limit [TeV]	3.29	2.52 – 2.94	3.92 – 2.62

Conclusions

- Searches for new signals in events with a pair of leptons or photons have been made by the ATLAS experiment for several BSM scenarios.
  - Data consistent with SM expectations : No hint of new physics so far.
  - A widely new region of the parameters space of the models has been explored and 95% CL upper/lower limits were set on them.

- 8 TeV 2012 data is coming very fast
  - Data is being analyzed as we speak
  - New physics might come very soon!

ATLAS Exotics Searches* - 95% CL Lower Limits (Status: ICHEP 2012)

* Shown today

Backup

Other references (i)

- **Z'/G***

D. London and J. L. Rosner, *Extra Gauge Bosons in E(6)*, Phys. Rev. **D34** (1986) 1530.

P. Langacker, *The Physics of Heavy Z' Gauge Bosons*, Rev. Mod. Phys. **81** (2009) 1199–1228.

J. Erler, P. Langacker, S. Munir, and E. R. Pena, *Improved constraints on Z' bosons from electroweak precision data*, JHEP **0908** (2009) 017.

L. Randall and R. Sundrum, *A large mass hierarchy from a small extra dimension*, Phys. Rev. Lett. **83** (1999) 3370–3373.

- **Technihadrons (LSCT)**

K. Lane and S. Mrenna, *The Collider phenomenology of technihadrons in the technicolor straw man model*, Phys. Rev. **D67** (2003) 115011, `arXiv:hep-ph/0210299`.

E. Eichten and K. Lane, *Low-scale technicolor at the Tevatron and LHC*, Phys.Lett. **B669** (2008) 235–238, `arXiv:0706.2339 [hep-ph]`.

- **CI (LLIM)**

E. Fermi, Nuovo Cim. **11**, 1 (1934); Z. Phys. **88**, 161 (1934).

E. Eichten, K. Lane, and M. Peskin, Phys. Rev. Lett. **50**, 811 (1983).

K. Nakamura *et al.* (Particle Data Group), J. Phys. G **37**, 075021 (2010).

Other references (ii)

- ## W'/W*

G. Altarelli, B. Mele, M. Ruiz-Altaba, Z. Phys. C 45 (1989) 109.

M. V. Chizhov, V. A. Bednyakov, J. A. Budagov, Phys. At. Nucl. 71 (2008) 2096–2100.

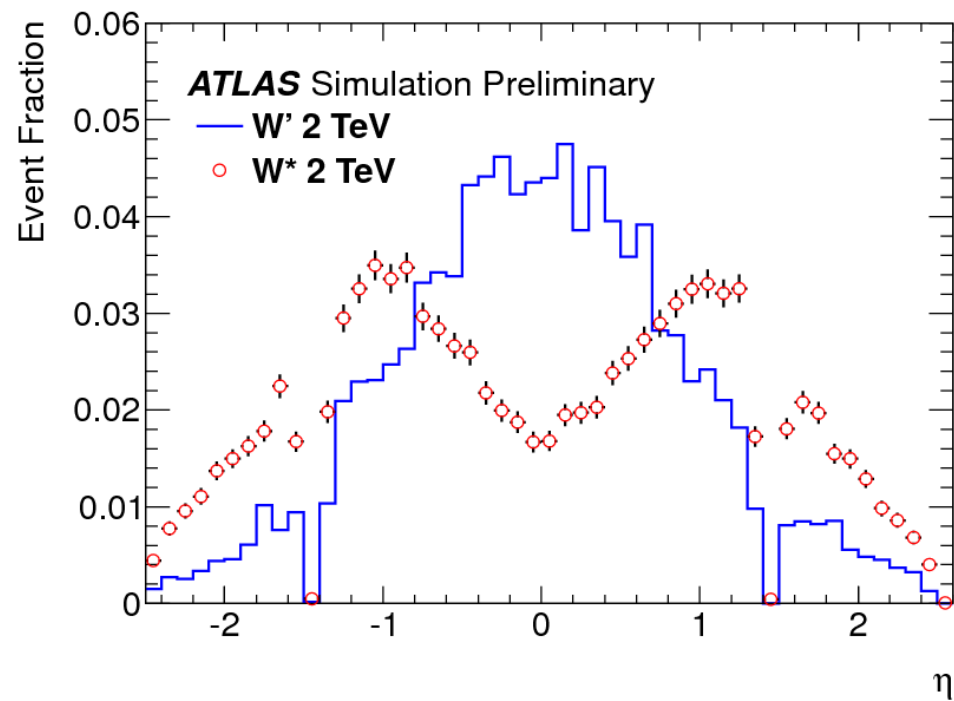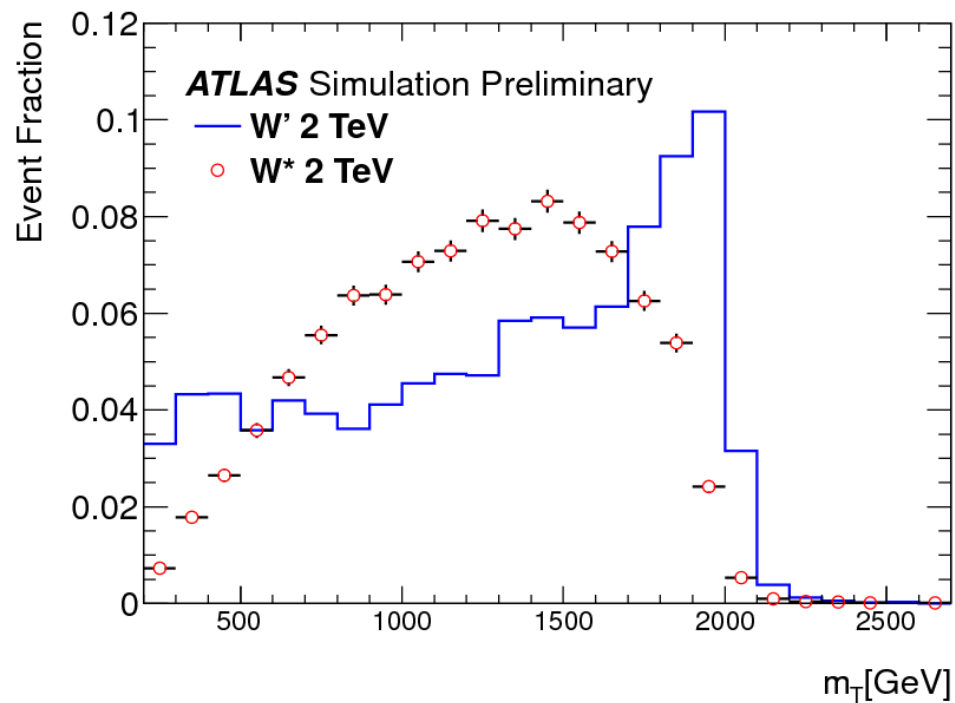M. Chizhov, G. Dvali, Phys Lett. B 703 (2011) 593–598.

- ## ADD

N. Arkani-Hamed, S. Dimopoulos, and G. R. Dvali, Phys. Lett. **B429**, 263 (1998).
G. Giudice, R. Rattazzi, and J. Wells, Nucl. Phys. **B544**, 3 (1999).
T. Han, J. Lykken, and R.-J. Zhang, Phys. Rev. **D59**, 105006 (1999).
J. Hewett, Phys. Rev. Lett. **82**, 4765 (1999).

W'/W* kinematics

Simulated processes : Generators

- **Z':** PYTHIA -› NNLO PHOZPR

- **G*** : PYTHIA -› NLO (from dedicated study)

- **DY:** PYTHIA -› NNLO PHOZPR + HORACE (EW)

- **DIBOSON:** HERWIG -›NLO MCFM

- **tt:** MC@NLO -› approx-NNLO (from dedicated study)

- **W+JETS** : ALPGEN -› NNLO FEWZ

- **DY+CI:** PYTHIA -› NNLO PHOZPR + HORACE (EW)

- **Technihadrons** : PYTHIA -› NNLO PHOZPR

- **W':** PYTHIA -› NNLO FEWZ

- **W*:** COMPHEP

- **W/Z:** PYTHIA -› NNLO FEWZ

- **DIPHOTON:** PYTHIA -› NLO DIPHOX

- **ADD:** SHERPA -› NLO (dedicated study)