Search for Contact Interaction in dilepton events from pp collisions at √s = 7 TeV with the ATLAS detector

Physics at the LHC - Vancouver 2012

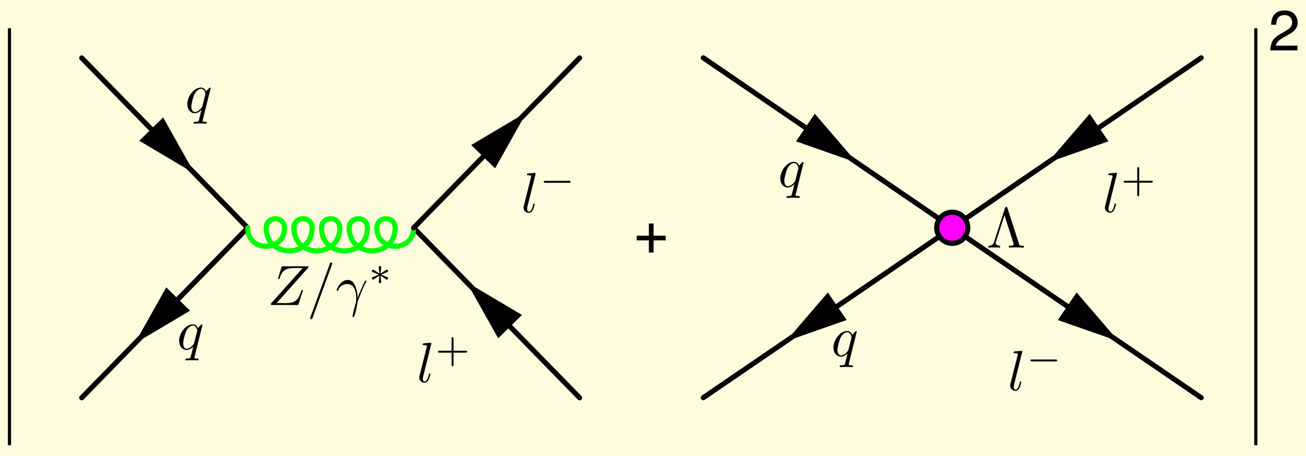
Introduction

Contact Interaction (CI) can describe large extra dimensions in the ADD model[1] or quark/lepton compositeness[2]

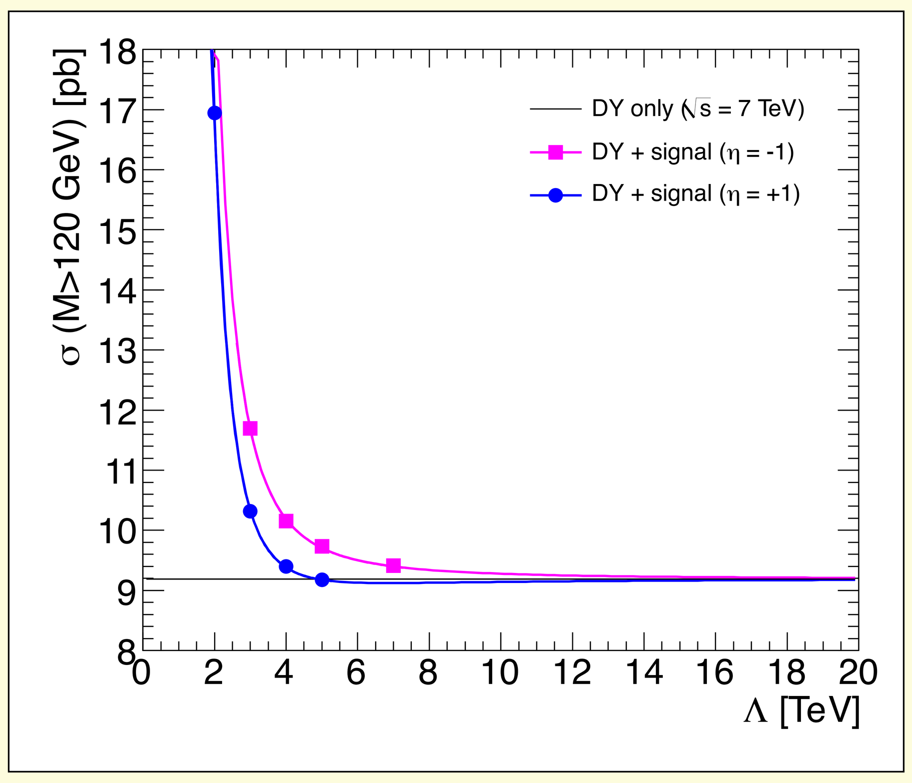
- Λ - Contact Interaction scale
- Fermions bound below Λ
- Effective lagrangian[3] in neutral current interaction

$$\mathcal{L} = \frac{g^2}{2\Lambda^2}\left[\ \eta_{LL}\ \overline{\psi}_L\gamma_\mu\psi_L\,\overline{\psi}_L\gamma^\mu\psi_L + \eta_{RR}\ \overline{\psi}_R\gamma_\mu\psi_R\,\overline{\psi}_R\gamma^\mu\psi_R + 2\eta_{LR}\,\overline{\psi}_L\gamma_\mu\psi_L\,\overline{\psi}_R\gamma^\mu\psi_R\ \right]$$

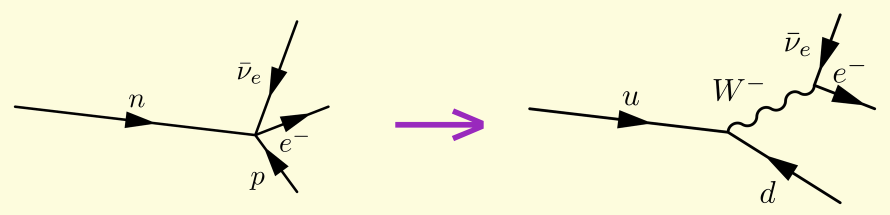
- 2 → 2 scattering cross-section with CI term in dilepton final states
- Assuming left-left isoscalar model ($|\eta_{LL}| = 1$, $\eta_{RR}=\eta_{LR}=\eta_{RL}=0$)



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



- Constructive/destructive interference - sign of η_{LL}
- As Λ → ∝, σ → the Standard Model
- In invariant mass, interference is most prominent when DY/CI amplitudes are same



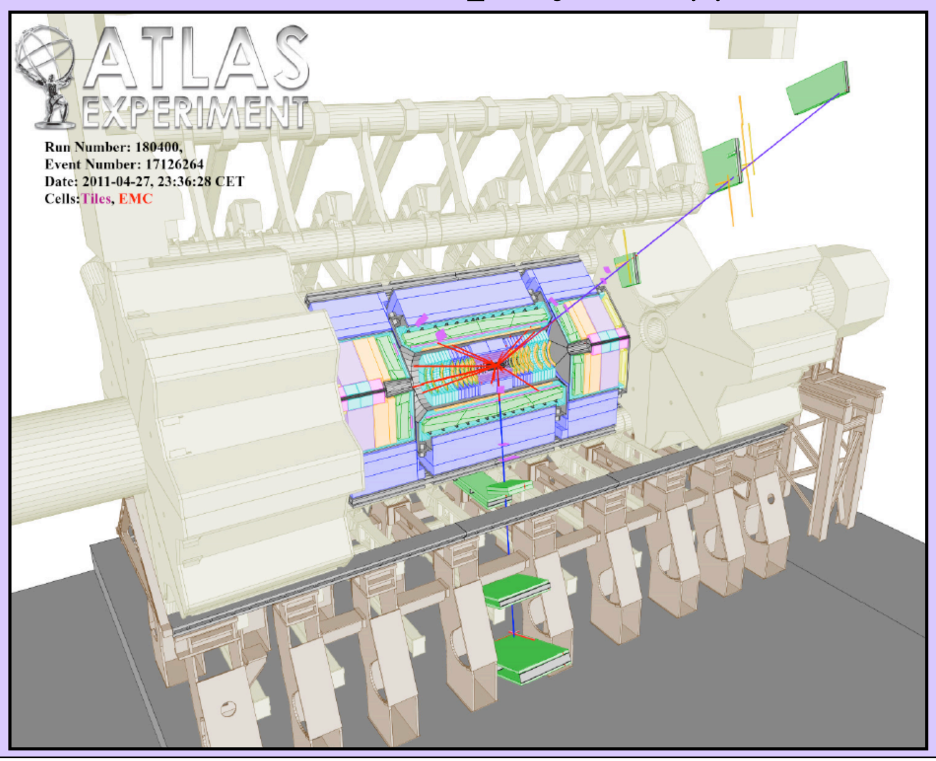
Neutron beta decay, a classic example of CI

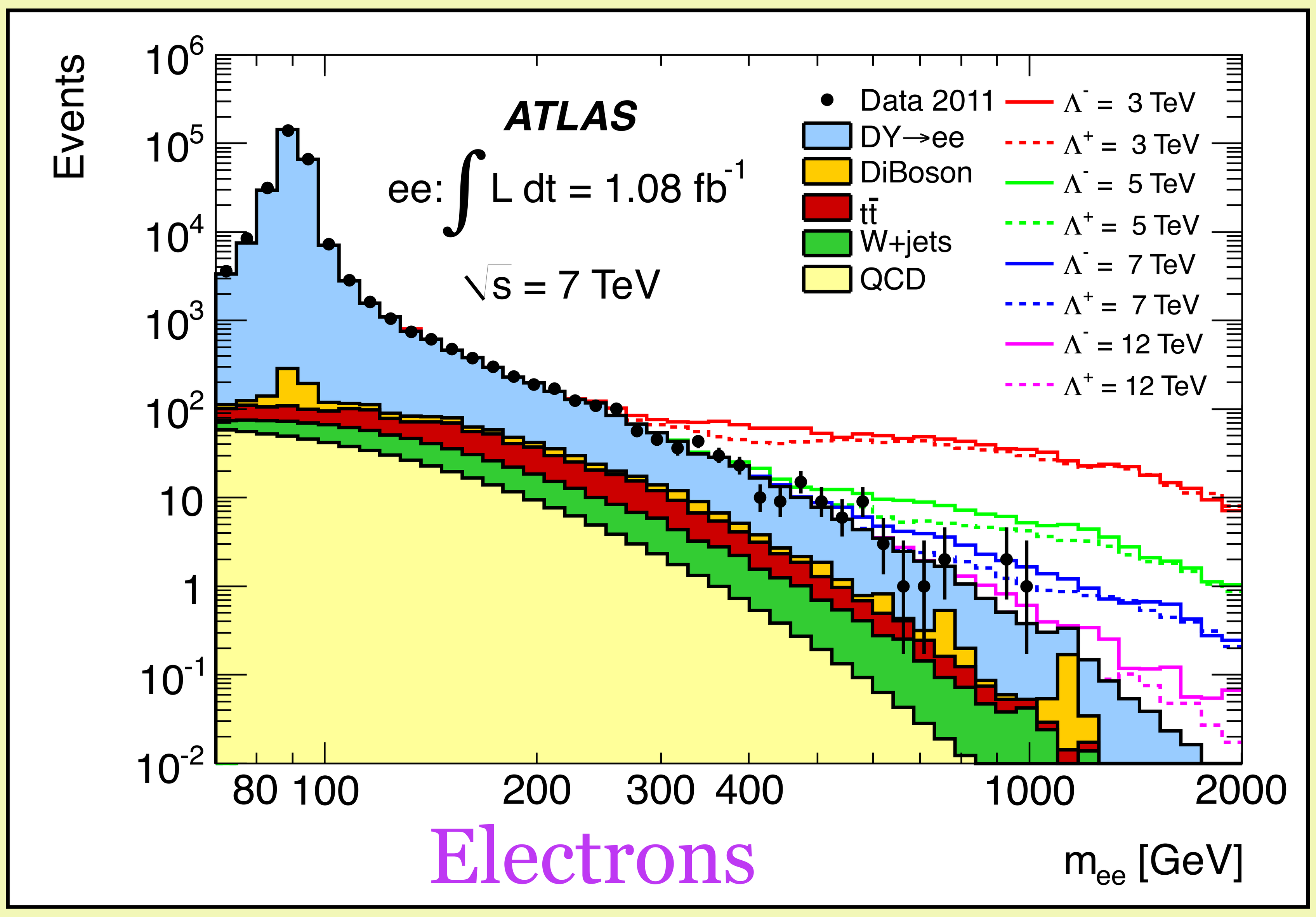
[1] N. Arkani-Hamed, S. Dimopoulos, and G. Dvali. Phys. Lett. B 429, 263 (1998). [2] E. Eichten, K.D. Lane, and M.E. Peskin, Phys Rev. Lett. 50 11 811-814 (1983). [3] E. Eichten, I. Hinchliffe, K. Lane, and C. Quigg, Rev. Mod. Phys. 56 4 579 (1984).

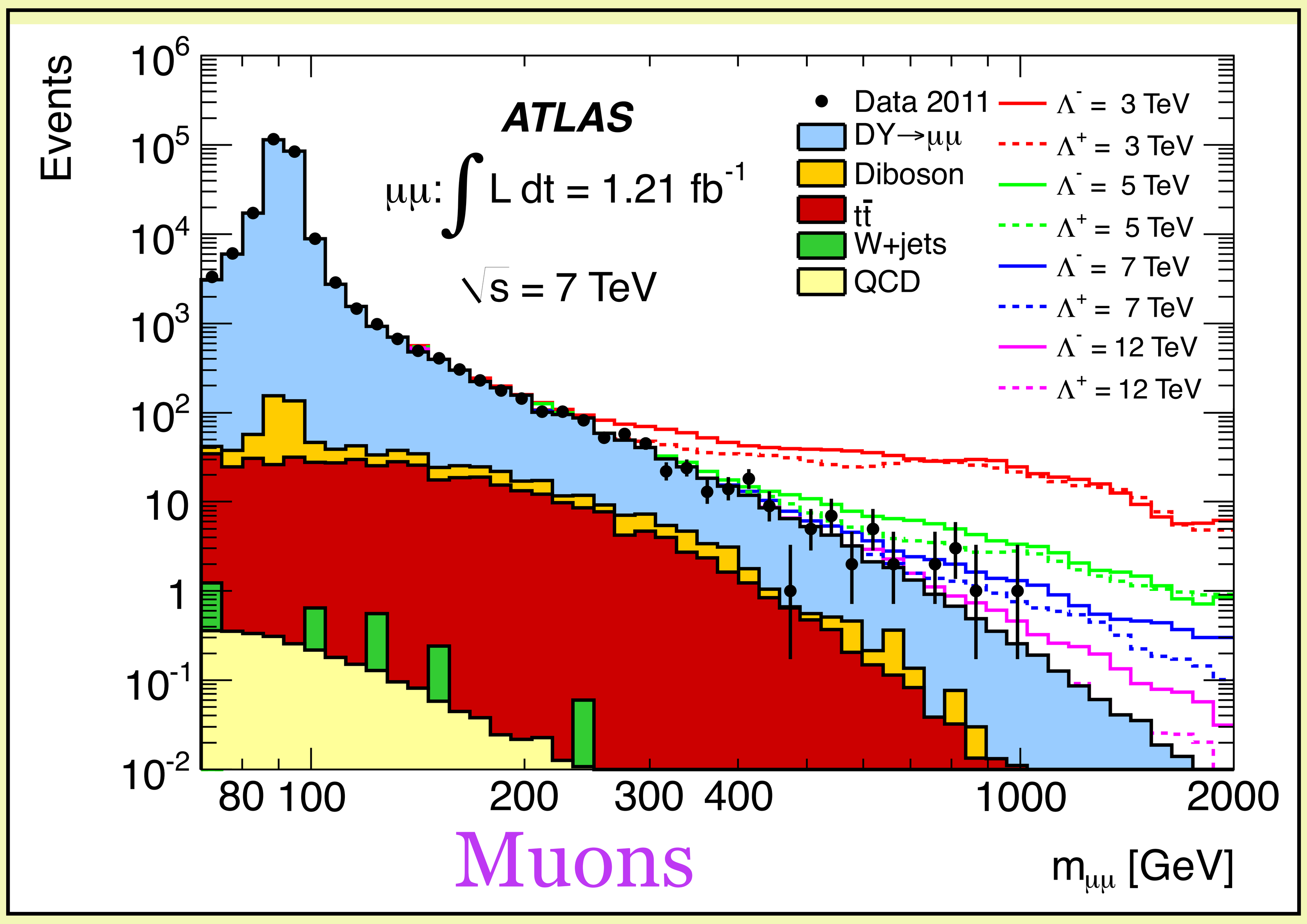
Event Selection

- Events:
  - ➡Single lepton trigger
- Electron candidates:
  - ➡p_T > 25 GeV
  - ➡shower shape and leakage cuts
  - ➡tracking quality cuts
  - ➡calorimeter isolation on leading electron
- Muon candidates:
  - ➡p_T > 25 GeV
  - ➡tracking and spectrometer quality cuts
  - ➡constrained impact parameter
  - ➡isolated muons
  - ➡opposite sign pairs

High Mass Event Display : $m_{\mu\mu}$ = 680 GeV







Background Estimates & Systematics

✦ Backgrounds:

- QCD from data driven method
- Mass dependent QCD & EW K-factors for DY

✦ Systematics:

- Mass independent systematics do not contribute
- Electron identification is 1.5% effect
- Muon reconstruction is up to 4.5% at 1.5 TeV mass
- 5% uncertainty due to Z/γ* σ
- PDF and α_s contribute 10% at 1.5 TeV mass
- QCD & EW K-factors - 3% & 5% at 1.5 TeV

Statistical Analysis

Bayesian Method - BAT[4]

$$\mu = n_{\mathrm{DY+CI}}(\theta,\bar{\nu}) + n_{\mathrm{non-DY\ bg}}(\bar{\nu})$$

$$\mathcal{L}(\bar{n}\mid\theta,\bar{\nu}) = \prod_{k=1}^{N}\frac{\mu_k^{n_k}e^{-\mu_k}}{n_k!}$$

$$\mathcal{P}(\theta\mid\bar{n}) = \frac{1}{\mathcal{Z}}\mathcal{L}_{\mathcal{M}}(\bar{n}\mid\theta)P(\theta)$$

$$Prior:\quad P(\theta) = \frac{1}{\Lambda^2}$$

[4] A. Caldwell, D. Kollar, and K. Kroninger, Computer Phys. Comm. 180 2197 (2009)

RESULT[5]

Λ: 95% CL Lower Limits

Channel	Prior	Expected limit (TeV) Constr.	Expected limit (TeV) Destr.	Observed limit (TeV) Constr.	Observed limit (TeV) Destr.
e^+e^-	$1/\Lambda^2$	9.6	9.3	10.1	9.4
	$1/\Lambda^4$	8.9	8.6	9.2	8.6
$\mu^+\mu^-$	$1/\Lambda^2$	8.9	8.6	8.0	7.0
	$1/\Lambda^4$	8.3	7.9	7.6	6.7
Comb.	$1/\Lambda^2$	10.4	10.1	10.2	8.8
	$1/\Lambda^4$	9.6	9.4	9.4	8.4

[5] ATLAS Collaboration, Phys. Lett. B 712 40-58 (2012)

Vikas Bansal, University of Victoria, British Columbia, on behalf of the ATLAS Collaboration