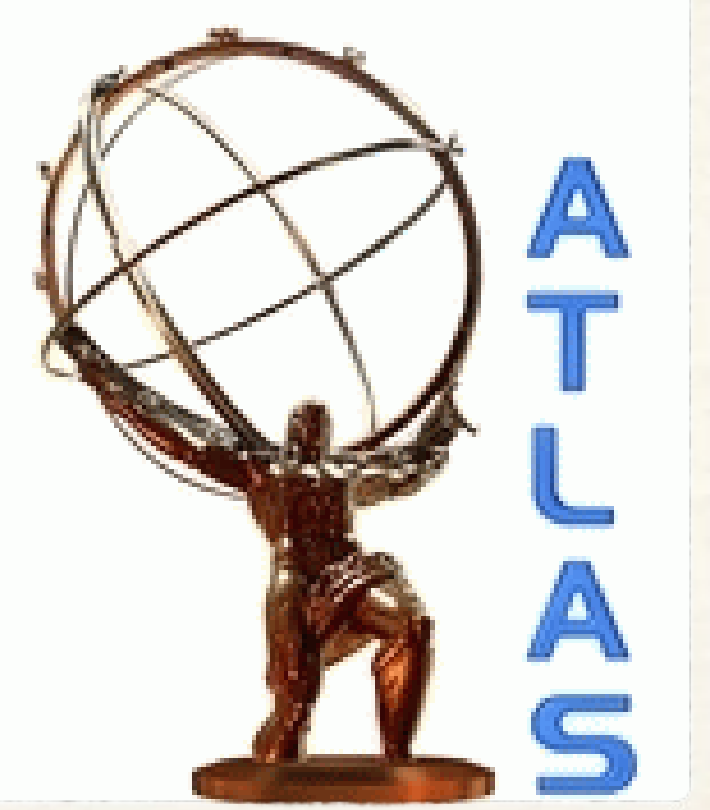




University of Victoria

Search for Contact Interaction in dilepton events from pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector

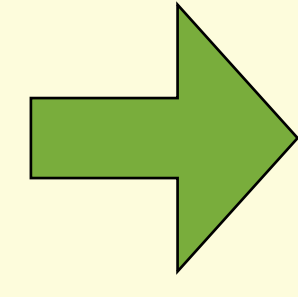
Physics at the LHC - Vancouver 2012



Introduction

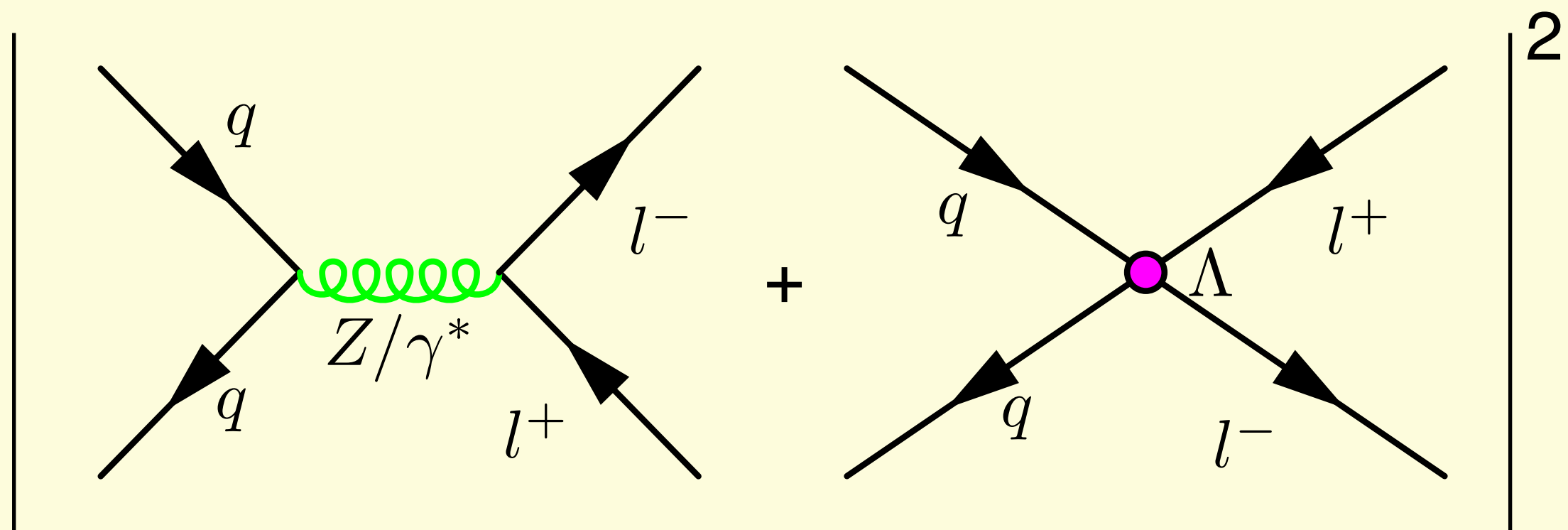
Contact Interaction (CI) can describe large extra dimensions in the ADD model¹ or quark/lepton compositeness²

- Λ - Contact Interaction scale
- Fermions bound below Λ
- Effective lagrangian³ in neutral current interaction

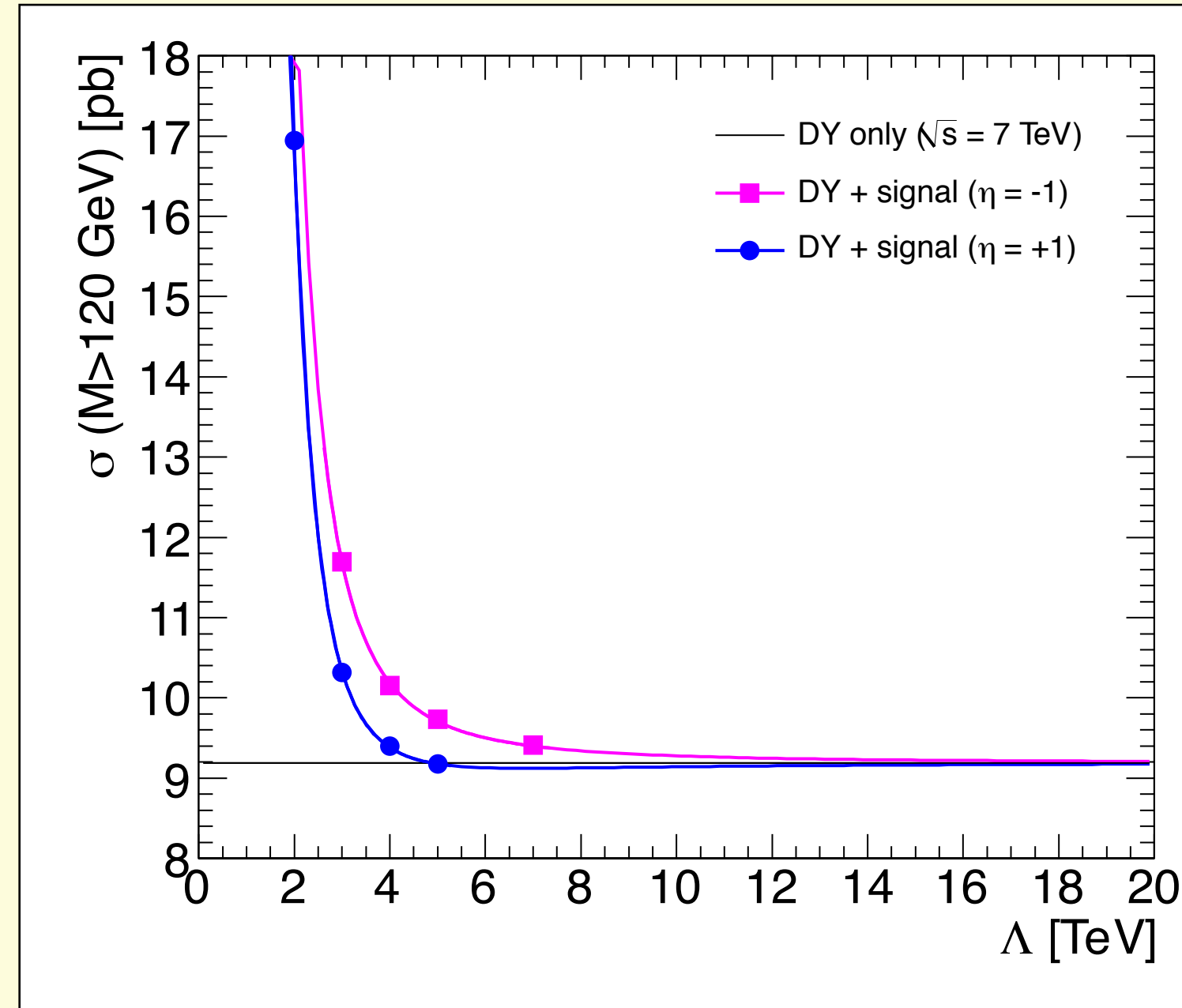


$$\mathcal{L} = \frac{g^2}{2\Lambda^2} \left[\eta_{LL} \bar{\psi}_L \gamma_\mu \psi_L \bar{\psi}_L \gamma^\mu \psi_L + \eta_{RR} \bar{\psi}_R \gamma_\mu \psi_R \bar{\psi}_R \gamma^\mu \psi_R + 2\eta_{LR} \bar{\psi}_L \gamma_\mu \psi_L \bar{\psi}_R \gamma^\mu \psi_R \right]$$

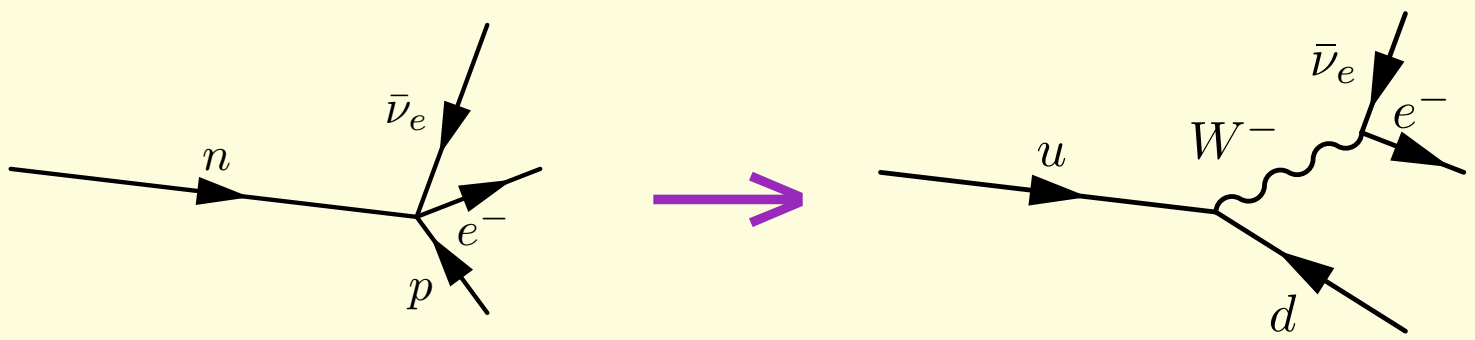
- $2 \rightarrow 2$ scattering cross-section with CI term in dilepton final states
- Assuming left-left isoscalar model ($|\eta_{LL}| = 1, \eta_{RR} = \eta_{LR} = \eta_{RL} = 0$)



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



- Constructive/destructive interference - sign of η_{LL}
- As $\Lambda \rightarrow \infty, \sigma \rightarrow$ the Standard Model
- In invariant mass, interference is most prominent when DY/CI amplitudes are same



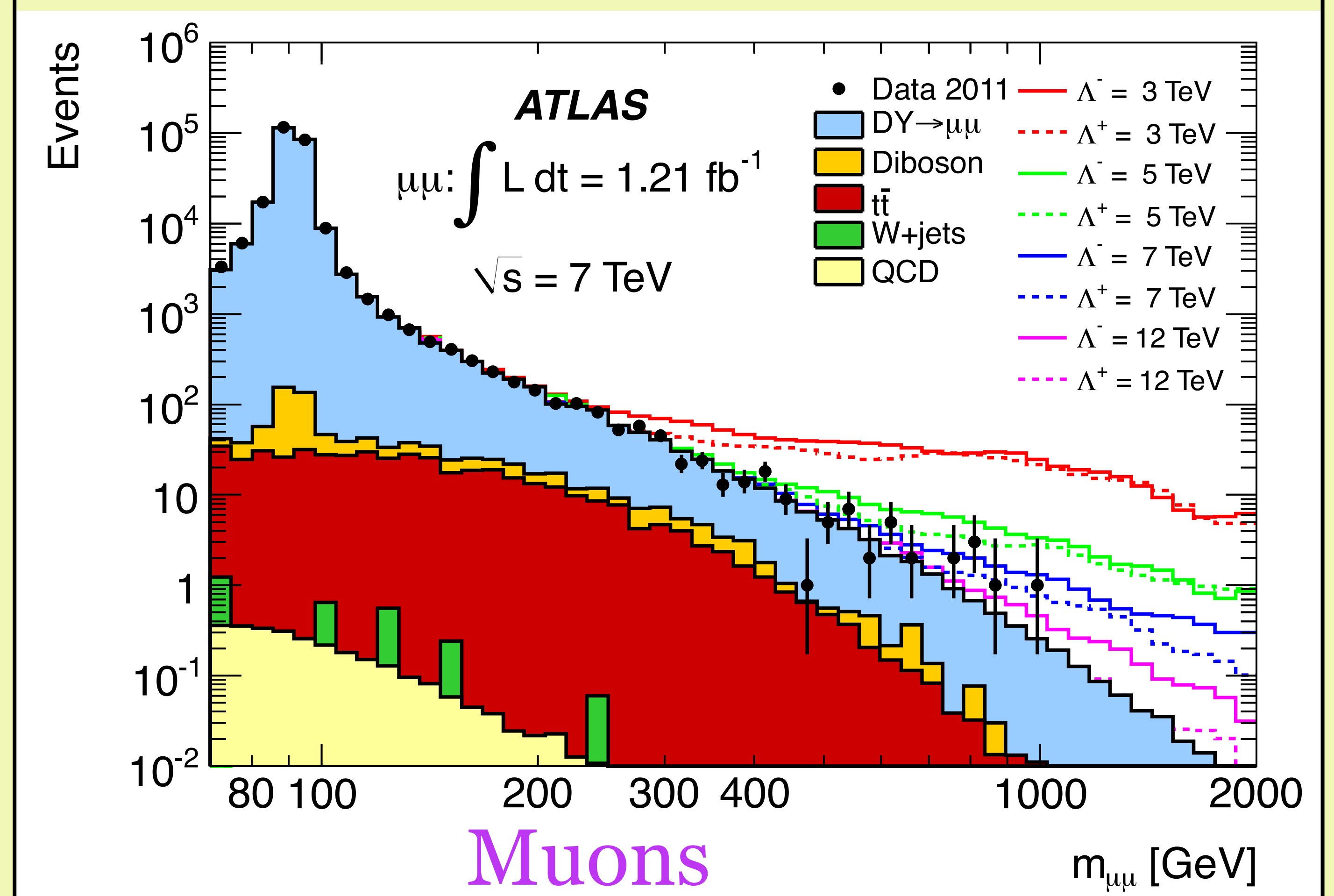
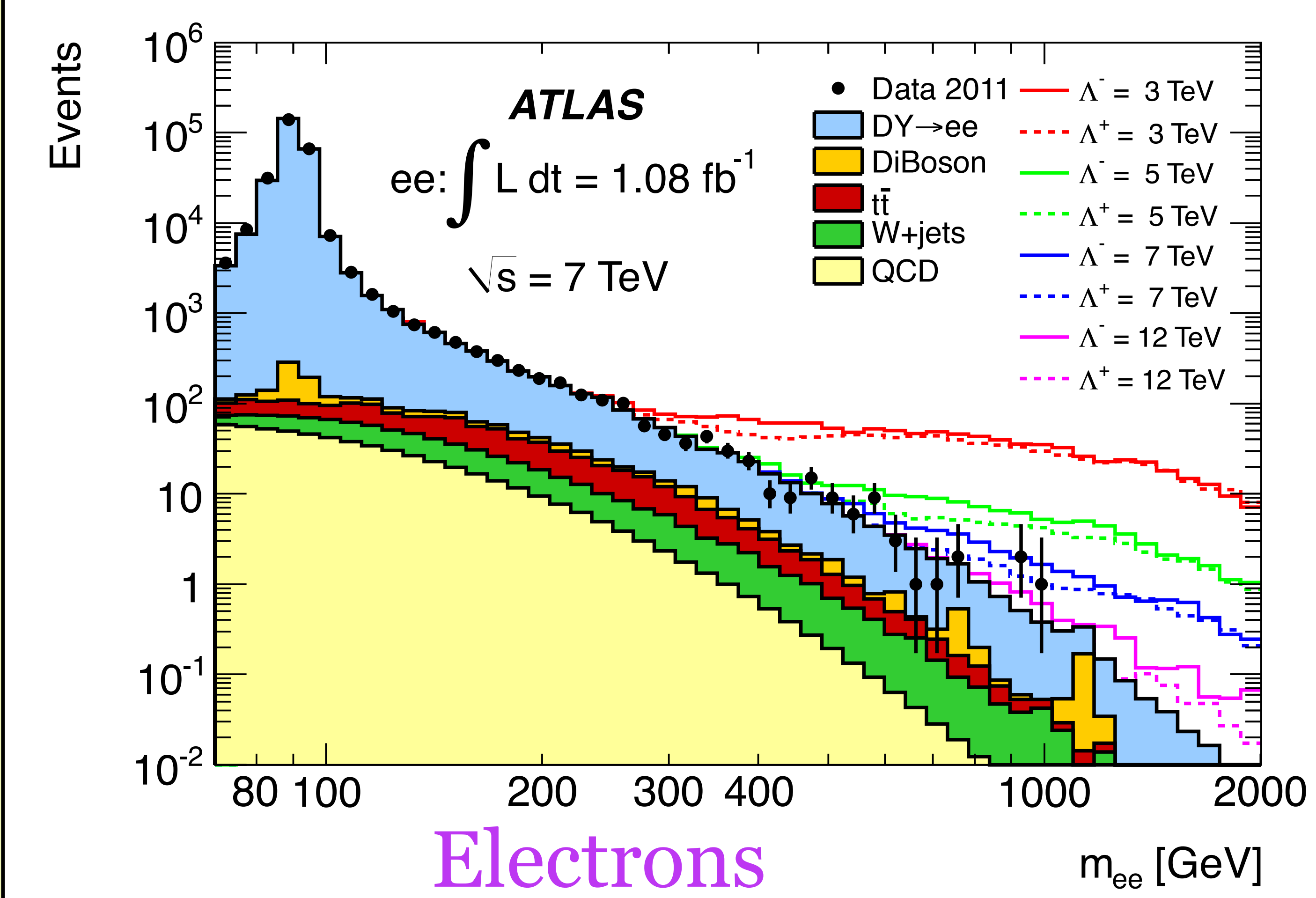
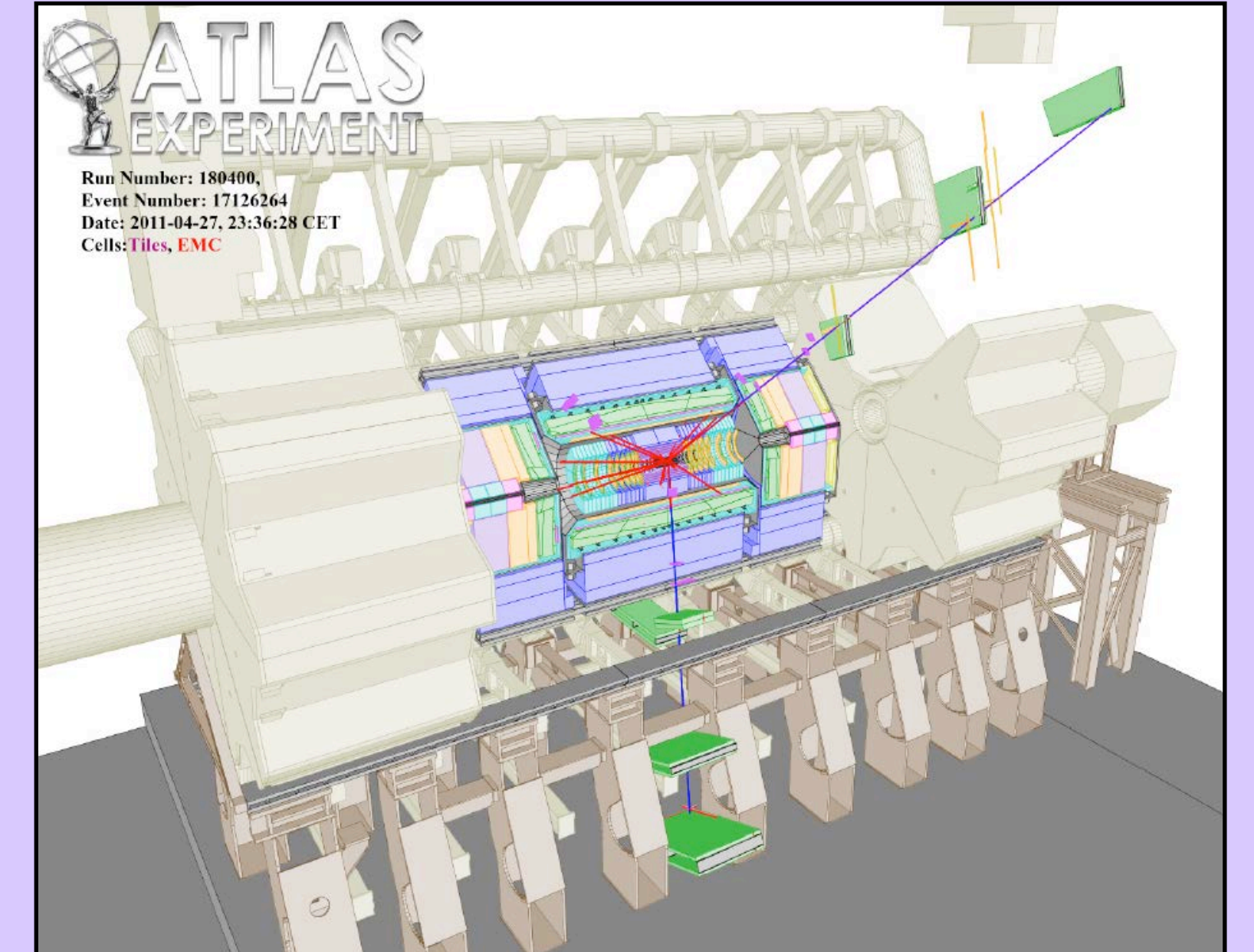
Neutron beta decay, a classic example of CI

[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 $Z/\gamma^* \sigma$
 - 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 - BAT⁴

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

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

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

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

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

RESULT⁵

Λ : 95% CL Lower Limits

Channel	Prior	Expected limit (TeV)		Observed limit (TeV)	
		Constr.	Destr.	Constr.	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)