Z boson decay to photon plus Kaluza-Klein graviton in large extra dimensions

Jordan P. Skittrall
J.P.Skittrall@damtp.cam.ac.uk

Department of Applied Mathematics and Theoretical Physics,
University of Cambridge, UK

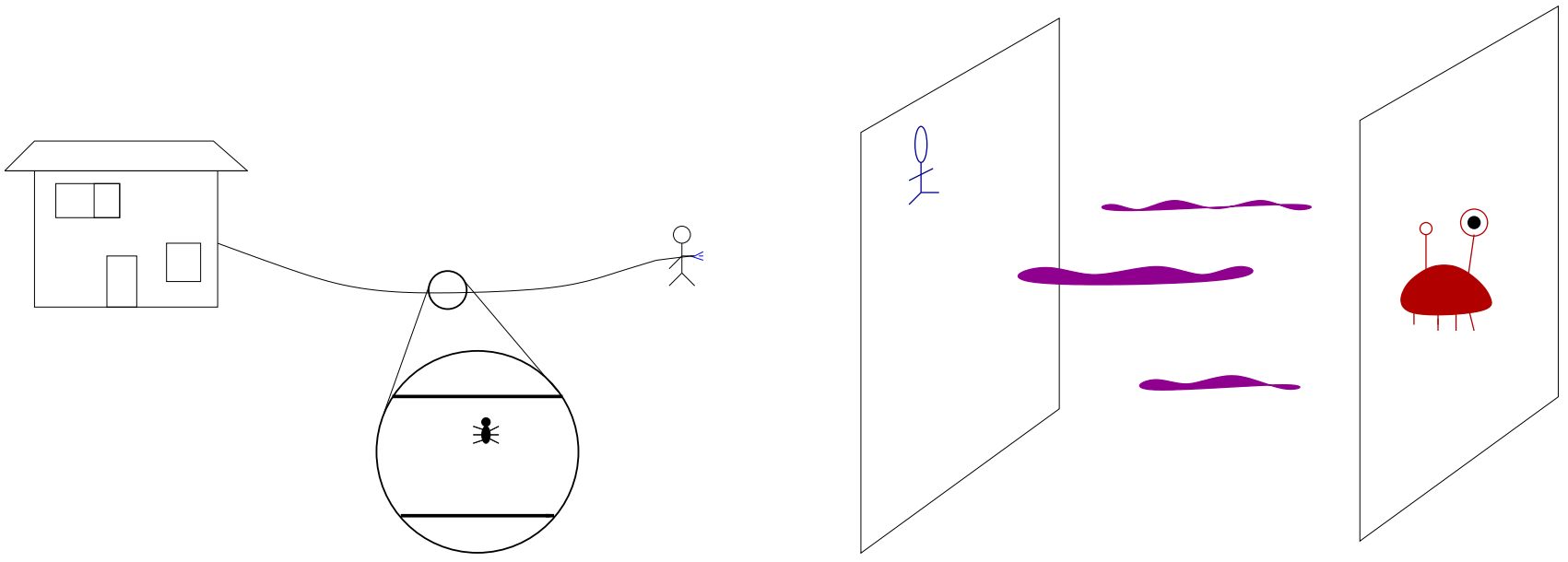
IOP HEPP meeting: Lancaster
2nd April 2008

Work in collaboration with Ben Allanach and K. Sridhar:
JHEP11(2007)089 (arXiv:0705.1953),
and EPJC, to appear (arXiv:0709.2929)

Take-home messages

- $Z \to \gamma \mathcal{G}$ does not beat other bounds on the size of extra dimensions in a toroidally compactified ADD model.
- Other bounds constrain $\Gamma_{Z \to \gamma \mathcal{G}}$. We should not expect to see this event even using a 'Giga-Z' ILC option ($\mathrm{BR}(Z \to \gamma \mathcal{G}) \lesssim 10^{-11}$). It would not be seen at the LHC. A signal in this channel may exclude ADD/a signal of ADD may suggest a consistency check in this channel.

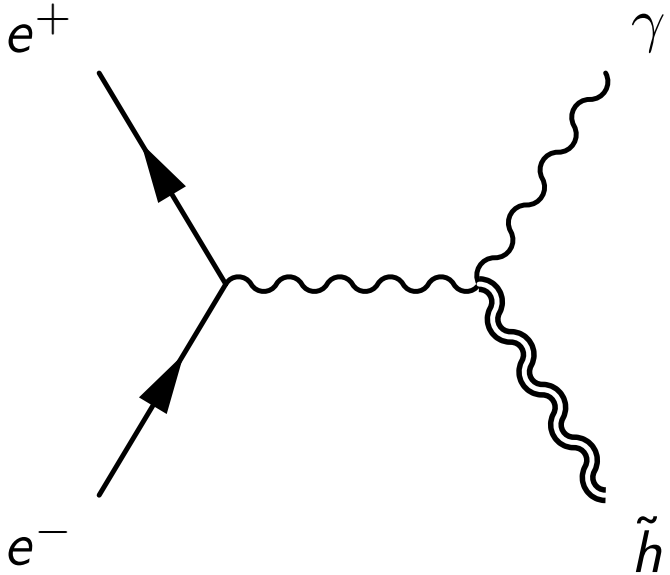
The ADD scenario

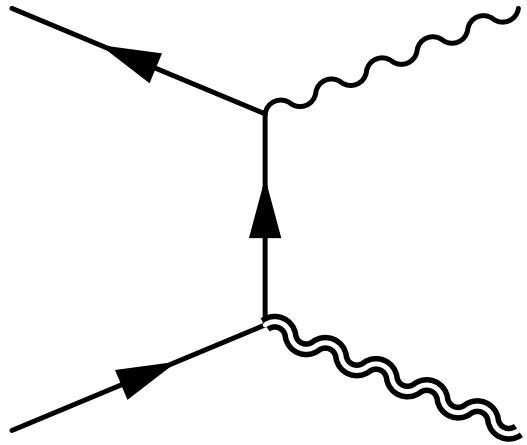


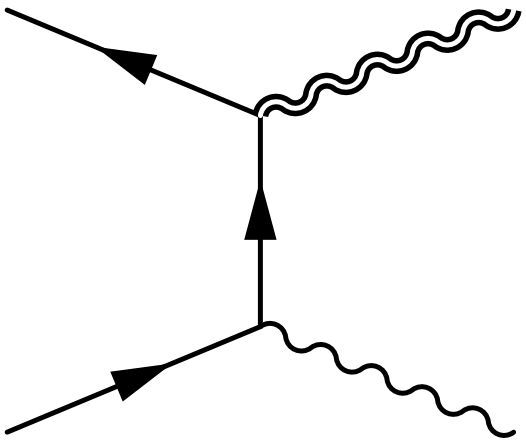
The ADD scenario

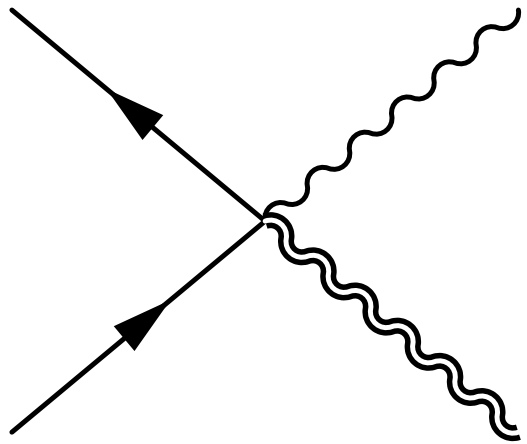
- Only gravity in extra dimensions
- Massive gravitons in 4D
- Spin-2 at tree level
- Spin-0 at one loop

Bounds on ADD: $e^+e^- \longrightarrow \gamma\mathcal{G}$

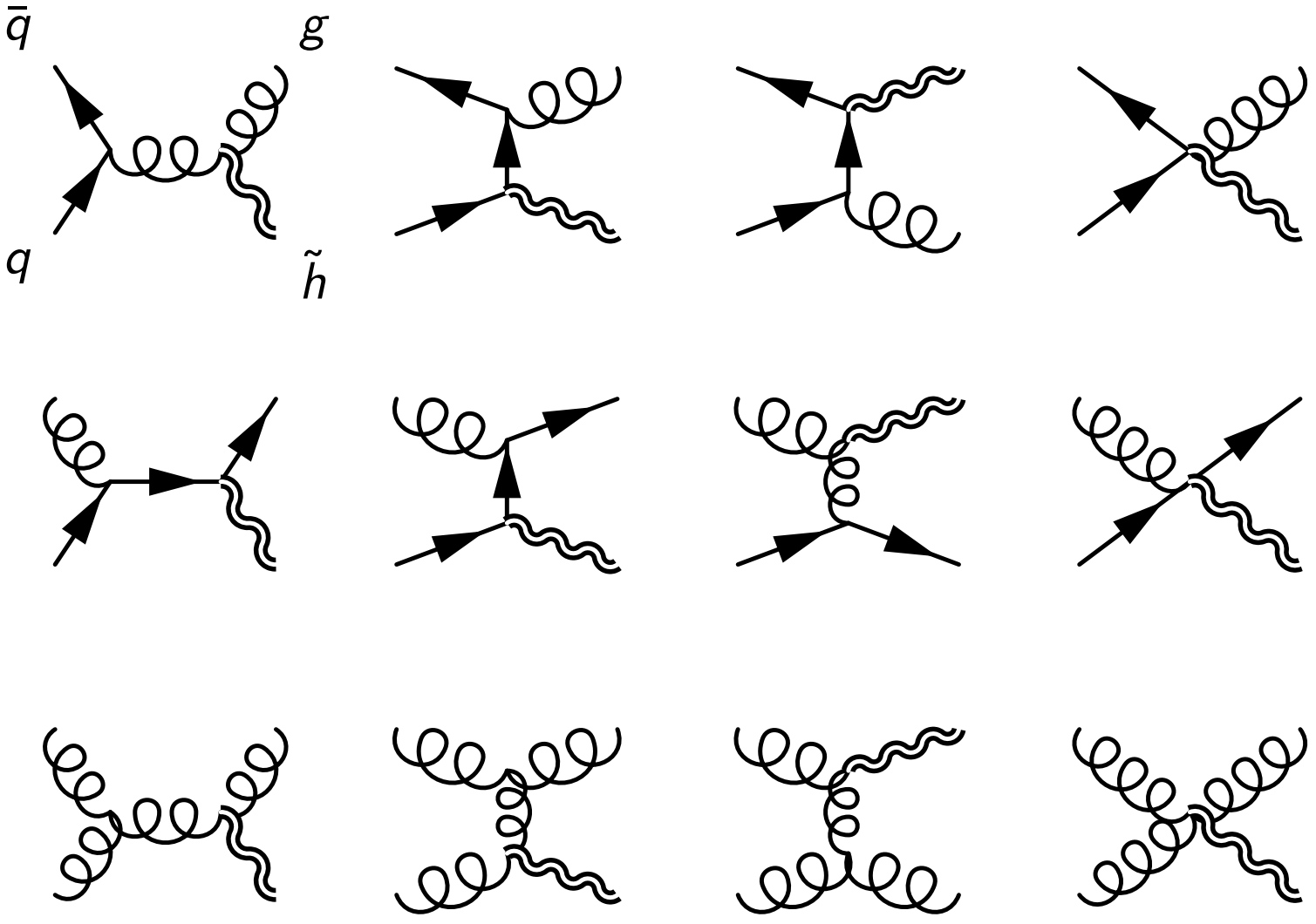








Bounds on ADD: $p\bar{p} \longrightarrow$ jet $\mathcal{G}$



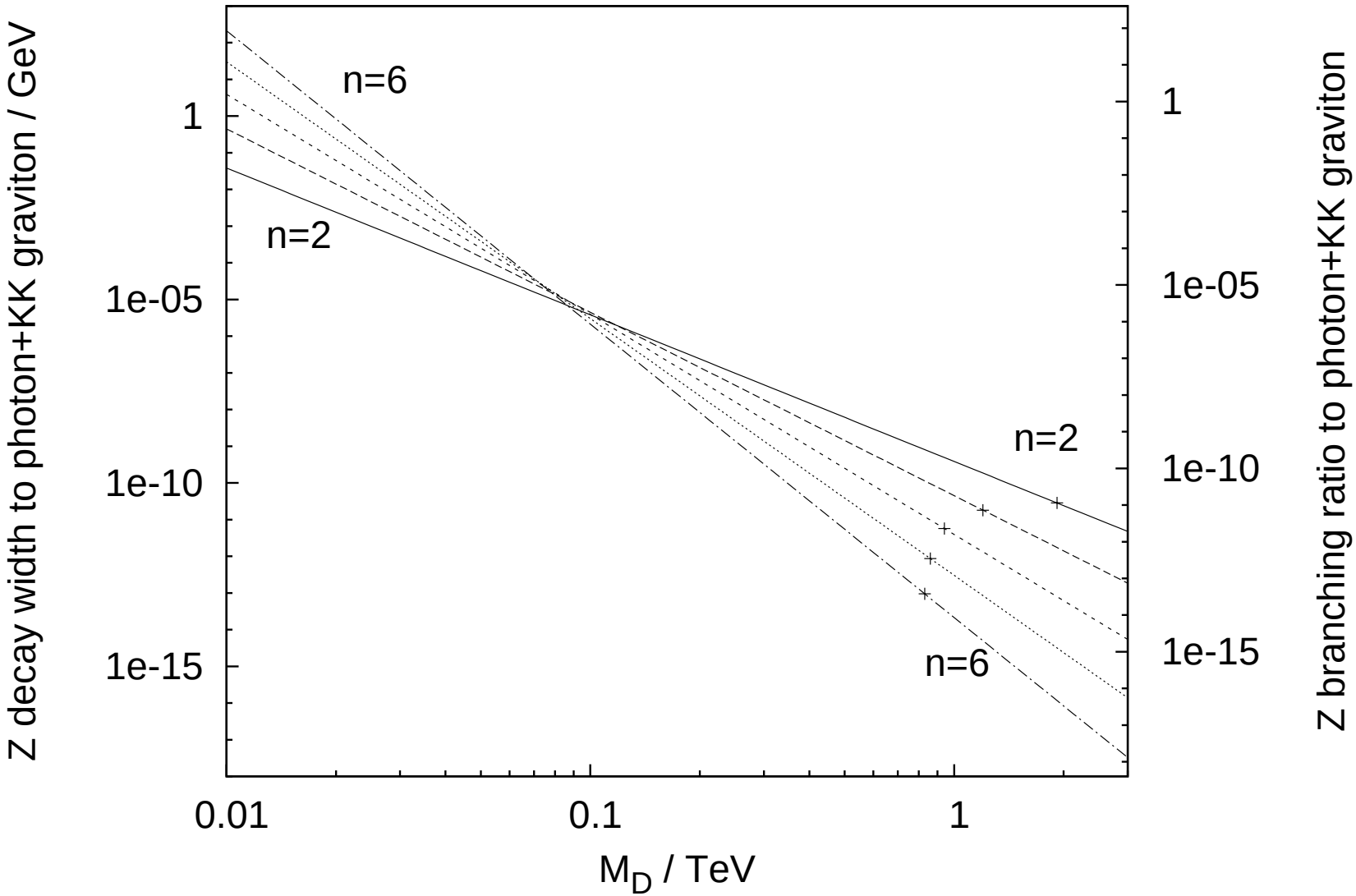
Bounds on ADD: $Z \to \gamma \mathcal{G}$

- One-loop process.
- Dominated by spin-0 gravi-scalar decays ($Z \to \gamma \phi$).
- Many Z decays at LEP1.
- Standard Model background $e^+ e^- \to \gamma \nu \bar{\nu}$.

Bounds on ADD: comparison (95% confidence levels)

n	L3 Z decay bound ($Z \to \gamma\mathcal{G}$)		Combined LEP $e^+e^- \to \gamma\mathcal{G}$ bound		CDF Run II $p\bar{p} \to \mathcal{G}$ + jet bound		Inverse square law experiment bound	
	M_D (TeV) $>$	R (mm) $<$	M_D (TeV) $>$	R (mm) $<$	M_D (TeV) $>$	R (mm) $<$	M_D (TeV) $>$	R (mm) $<$
2	0.18	15	1.6	0.19	1.18	0.35	**1.9**	**0.13**
3	0.16	7.4×10^{-5}	**1.2**	$\mathbf{2.6 \times 10^{-6}}$	0.99	3.6×10^{-6}	—	—
4	0.14	1.8×10^{-7}	**0.94**	$\mathbf{1.1 \times 10^{-8}}$	0.91	1.1×10^{-8}	—	—
5	0.13	5.0×10^{-9}	0.77	4.1×10^{-10}	**0.86**	$\mathbf{3.5 \times 10^{-10}}$	—	—
6	0.12	4.6×10^{-10}	0.66	4.6×10^{-11}	**0.83**	$\mathbf{3.4 \times 10^{-11}}$	—	—

Use of other ADD bounds to constrain $\Gamma_{Z\to\gamma\mathcal{G}}$



Take-home messages

- $Z \to \gamma \mathcal{G}$ does not beat other bounds on the size of extra dimensions in a toroidally compactified ADD model.
- Other bounds constrain $\Gamma_{Z \to \gamma \mathcal{G}}$. We should not expect to see this event even using a 'Giga-Z' ILC option ($\mathrm{BR}(Z \to \gamma \mathcal{G}) \lesssim 10^{-11}$). It would not be seen at the LHC. A signal in this channel may exclude ADD/a signal of ADD may suggest a consistency check in this channel.