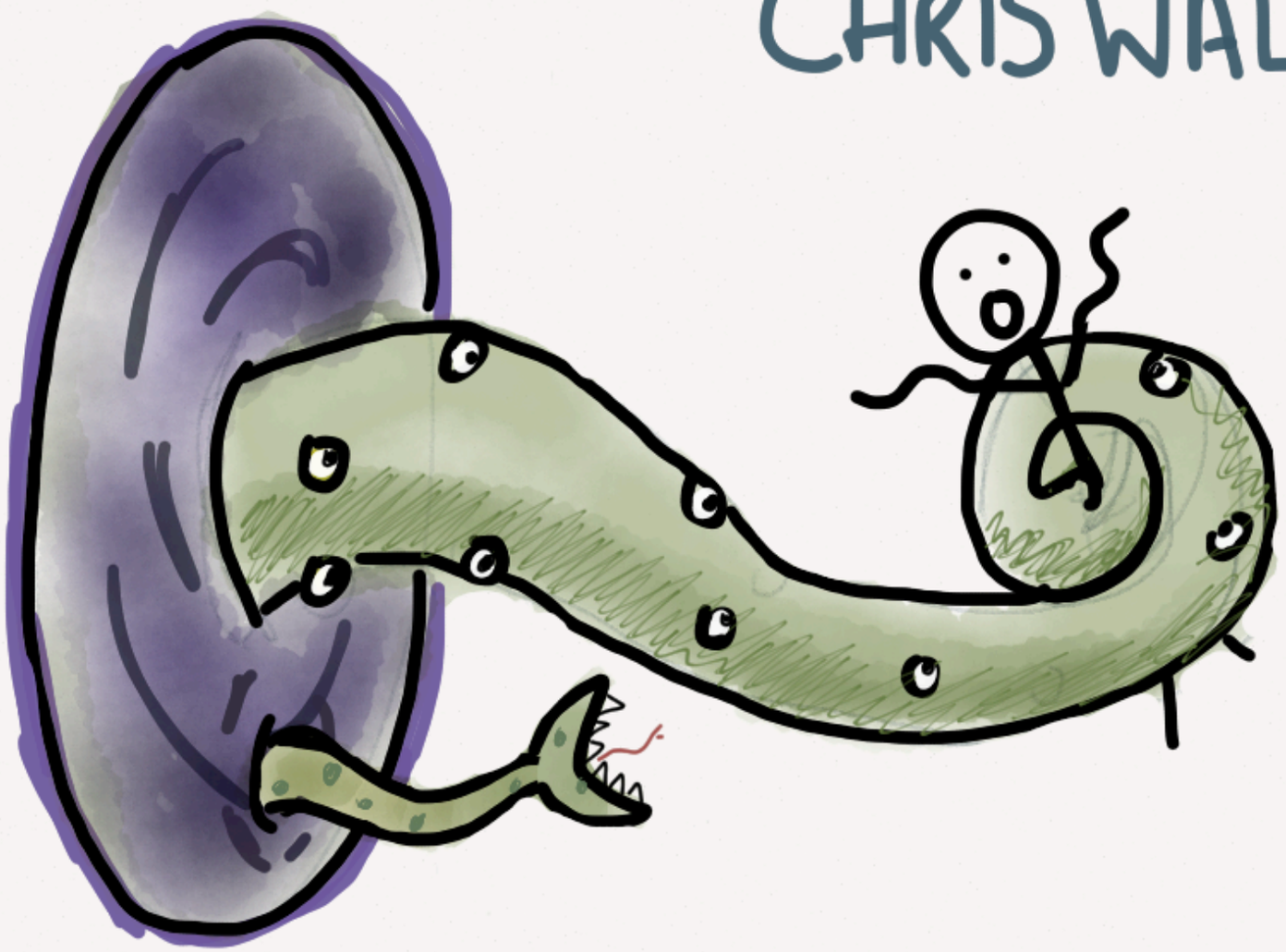
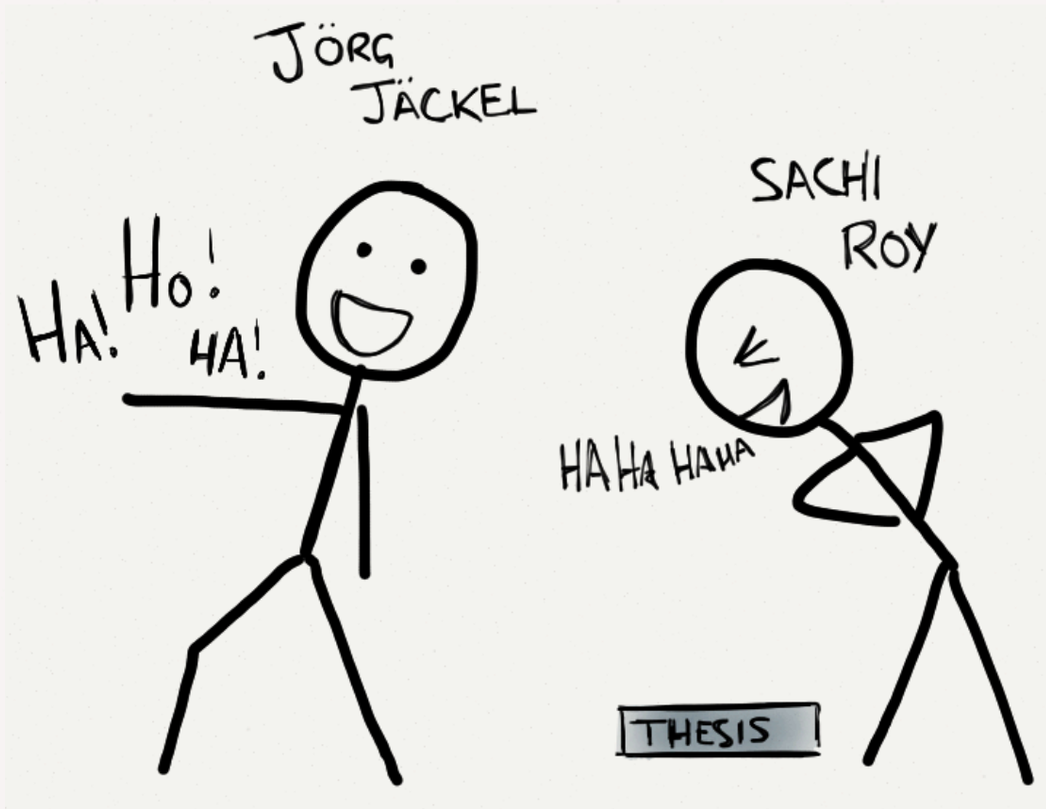
Hidden Photons in

EXTRA DIMENSIONS

Chris Wallace





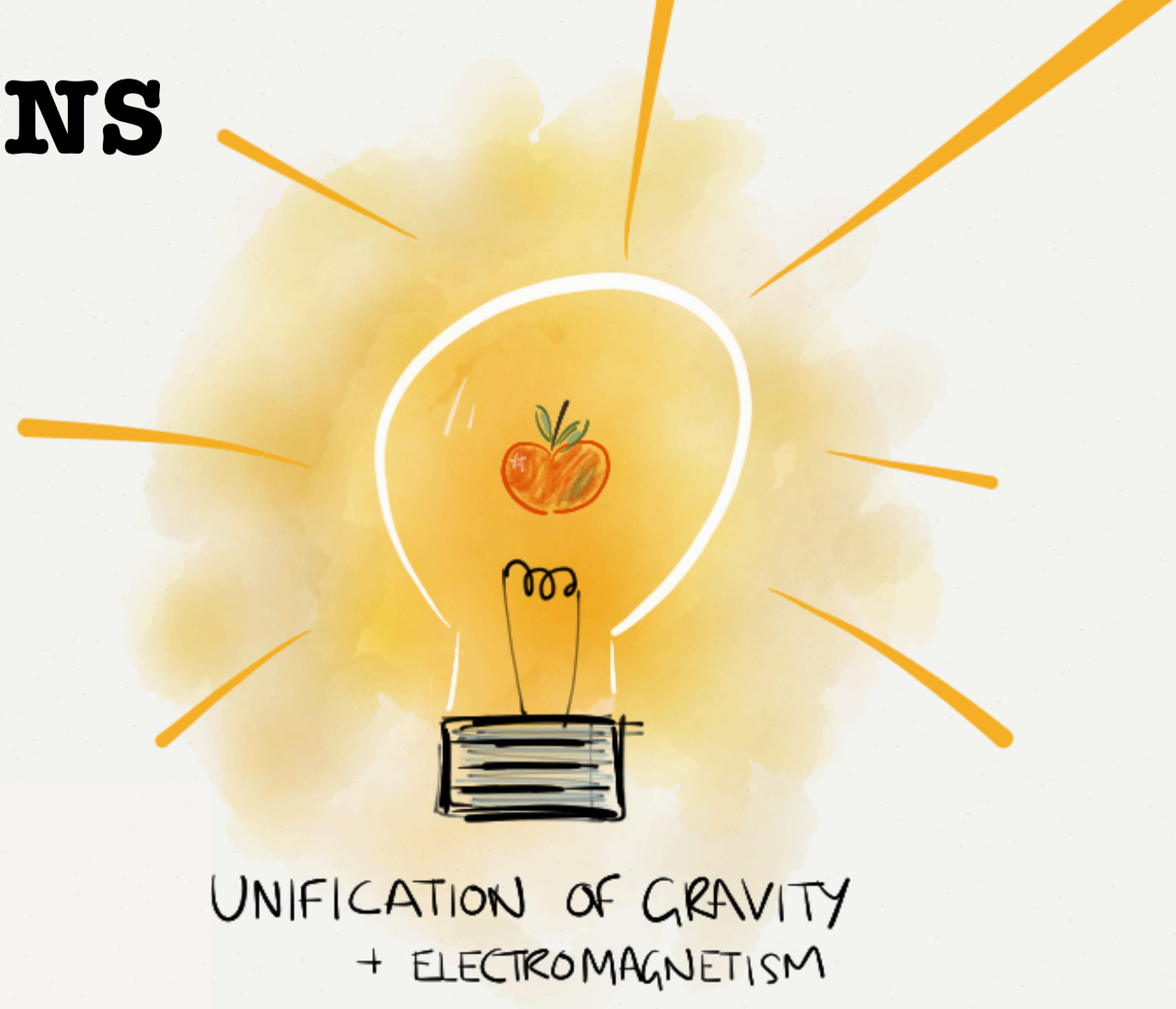
IP3 University of Durham
Durham University

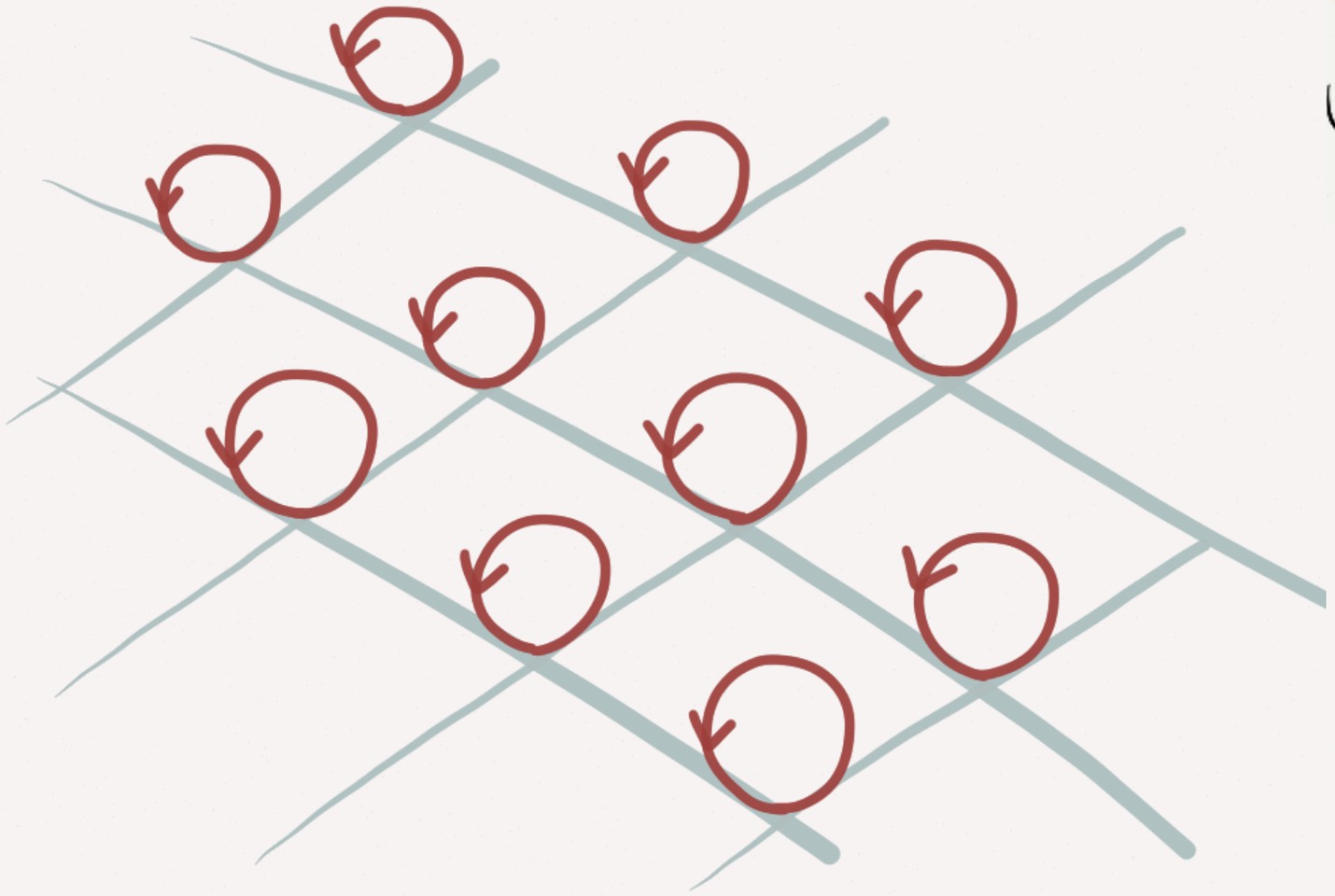
Outline

- Extra dimensions?
- Mass generation.
- Virtual constraints.
- Real constraints.

Extra Dimensions

- Can unify gauge + gravity.
- Solution to hierarchy problem.
- Quantum gravity.
- Generate massive states.





Compactification:

Symmetry of manifold

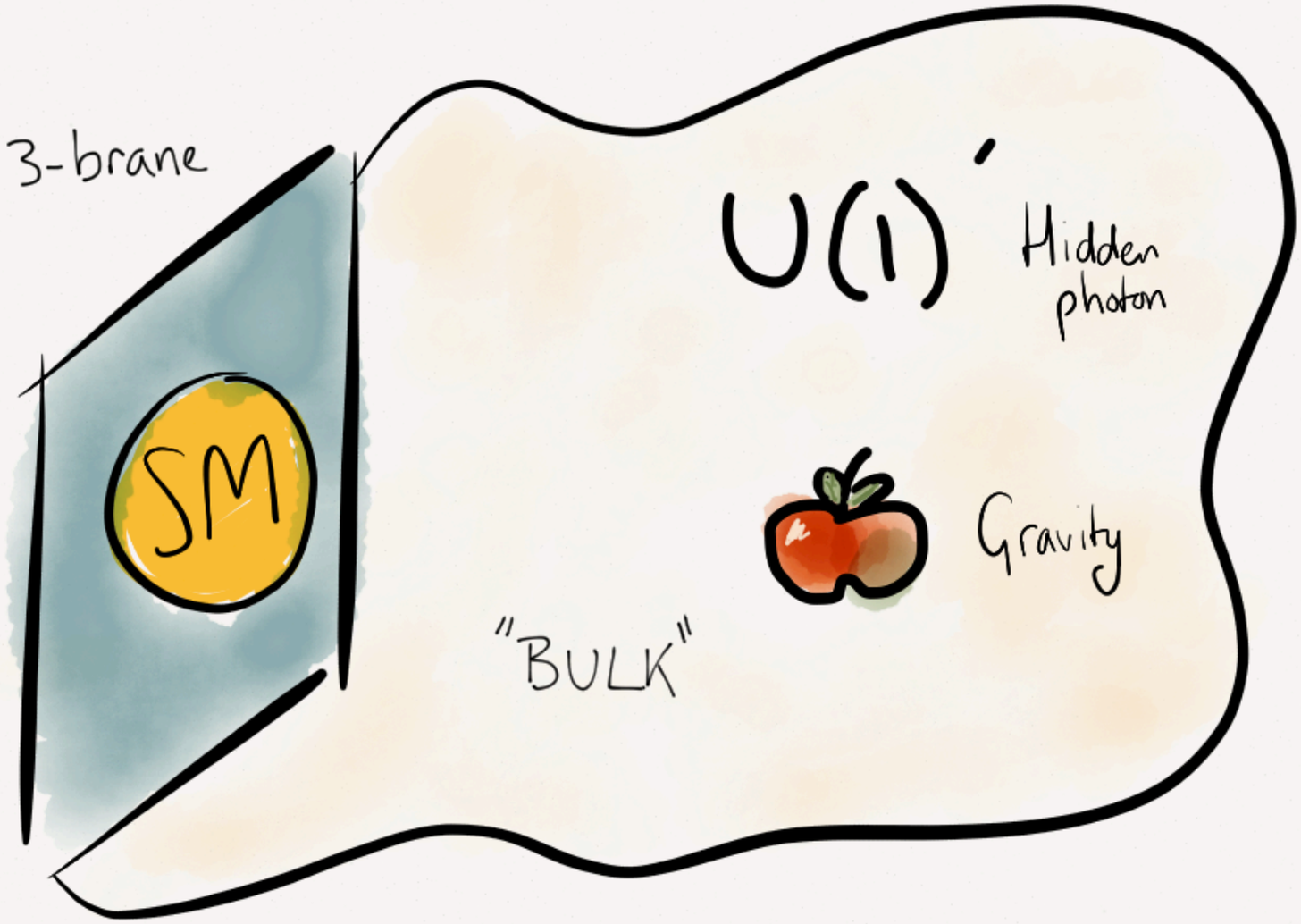
↕

Internal symmetry

Toy Model

$$\mathcal{L} = -\frac{1}{4}F^{MN}F_{MN}\delta_{\rm SM} - \frac{1}{4}B^{MN}B_{MN} - \frac{\chi}{2}F^{MN}B_{MN}\delta_{\rm SM}$$

- Low energy effective theory.
- SM confined to 3-brane - pheno unaffected.
- FLAT extra dimensions. ADD/LED scenario.



Size constrained by precision tests of gravity.

n	m	M_*
1	> 10 meV	$> 2 \times 10^5$ TeV
2	> 10 meV	> 2 TeV
3	> 0.35 keV	> 1 TeV
4	> 0.13 MeV	> 1 TeV
5	> 4.4 MeV	> 1 TeV
6	> 47 MeV	> 1 TeV

Generating mass

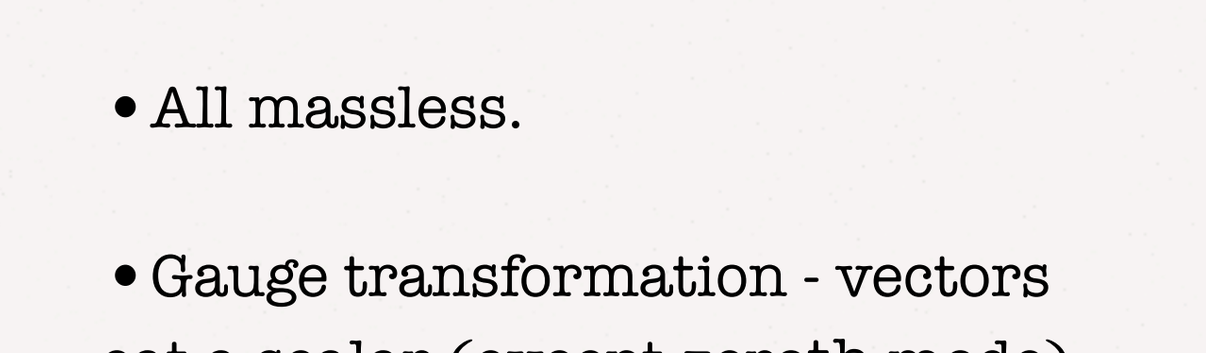
- Fourier expansion splits D-dim field into 4D vector + n scalars.

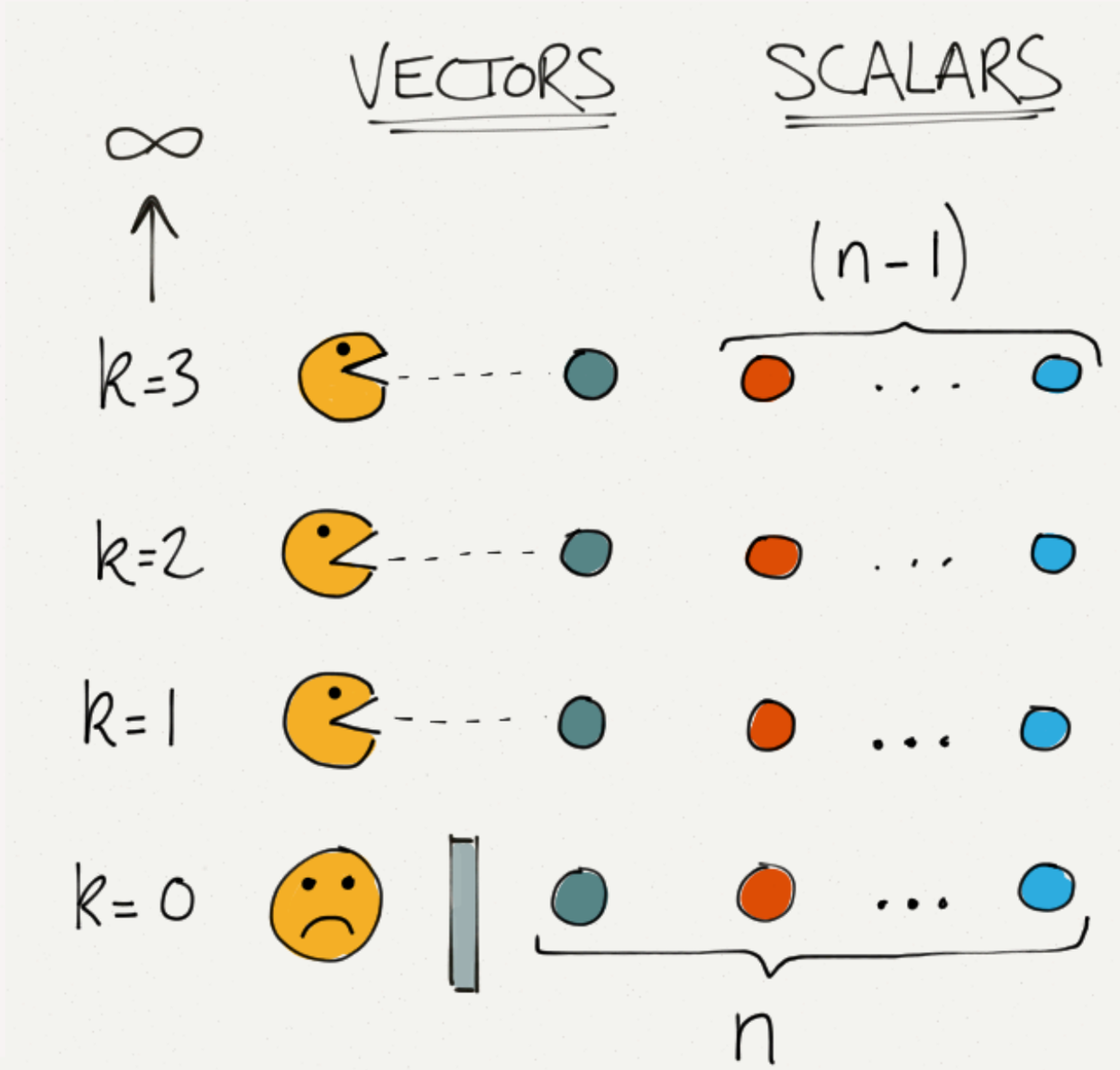
- All massless.

- Gauge transformation - vectors eat a scalar (except zeroth mode).

$$A^{\mu}_{(k)} \to A^{\mu}_{(k)} - i\frac{1}{k/R}\partial^{\mu}A^{5}_{(k)}$$

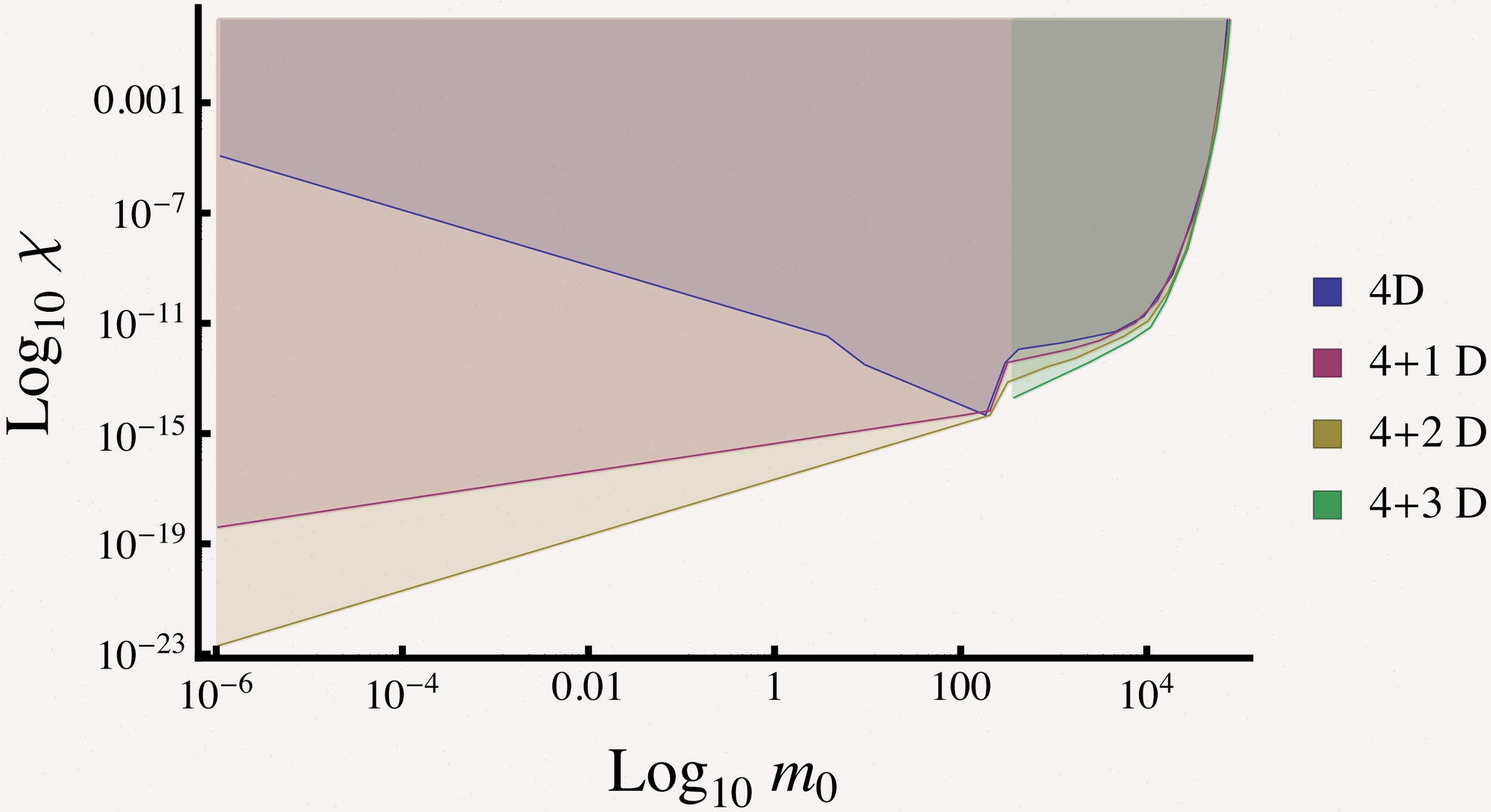
- k × Higgs mechanism!



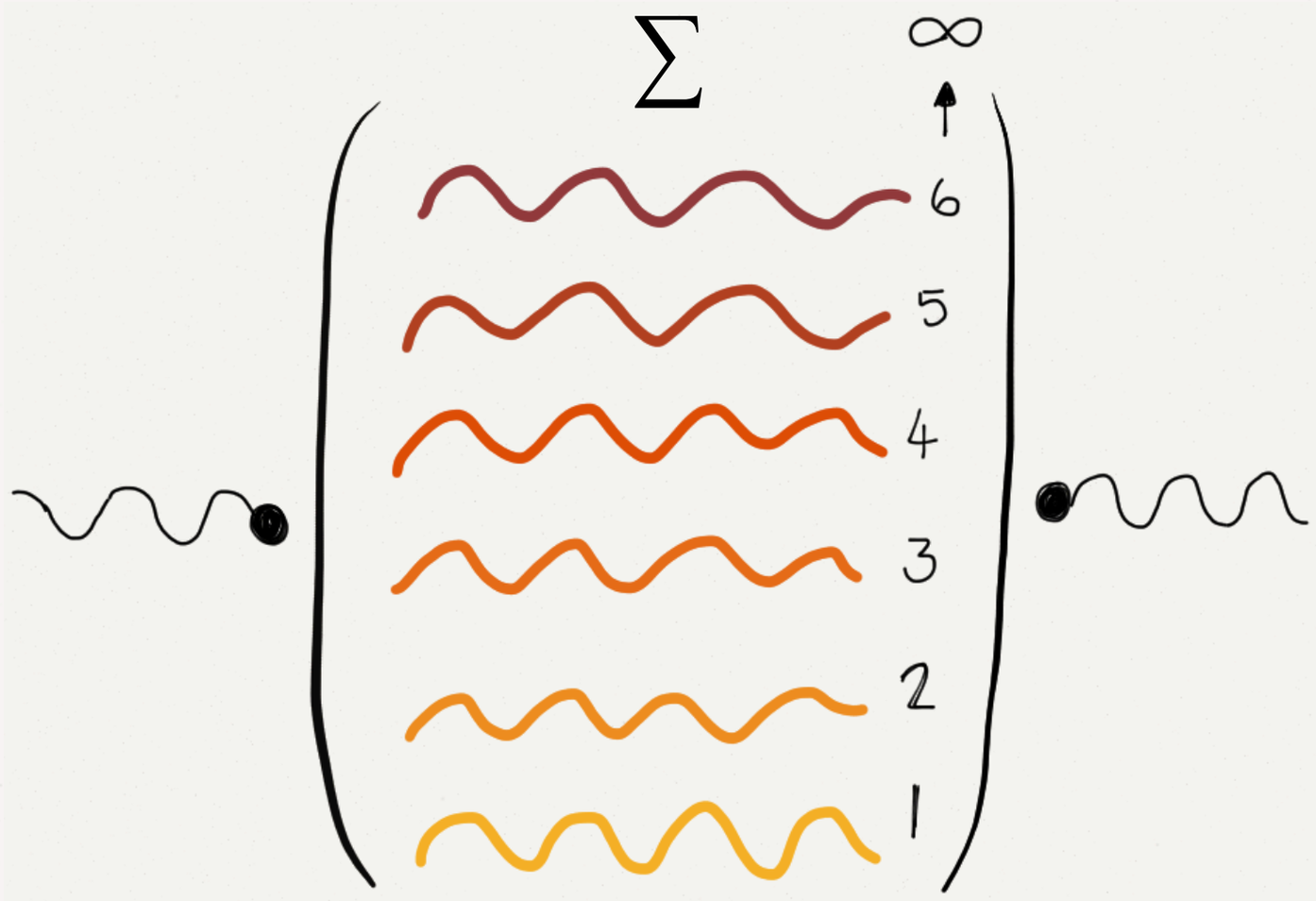


$$A^{M} = (A^{0}, A^{1}, A^{2}, A^{3}, A^{5}, \ldots, A^{D})$$

E.G. Solar Lifetime



Virtual Constraints



- If hidden photon virtual, no momentum cut off.
- Must sum over ∞ modes.
- Effectively resolves extra dimension.

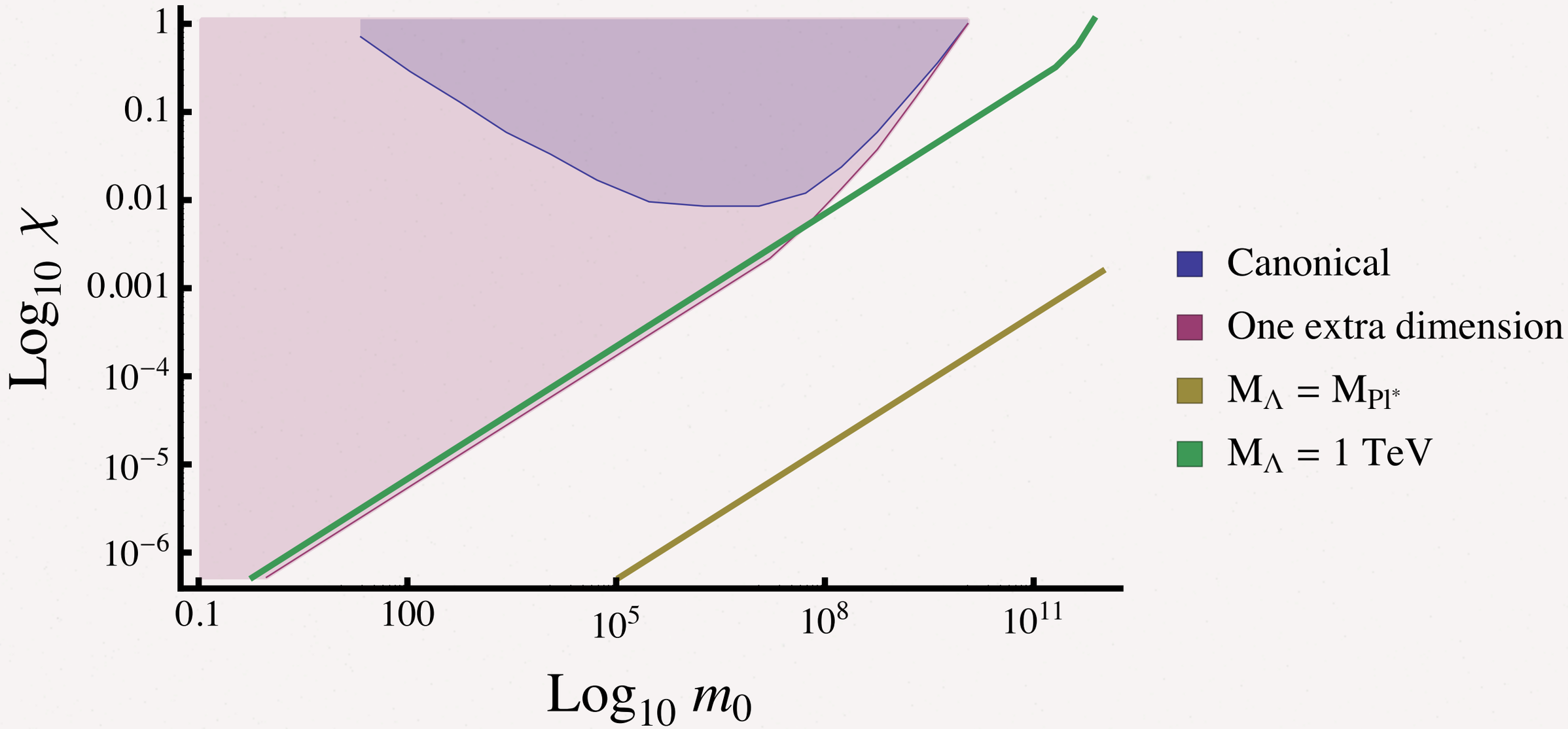
Perturbativity:

$$\chi^2 \to \chi^2_{\text{pert.}} = \chi^2 \times \int_1^{\frac{\Lambda}{m_0}} d^n k$$

modes.

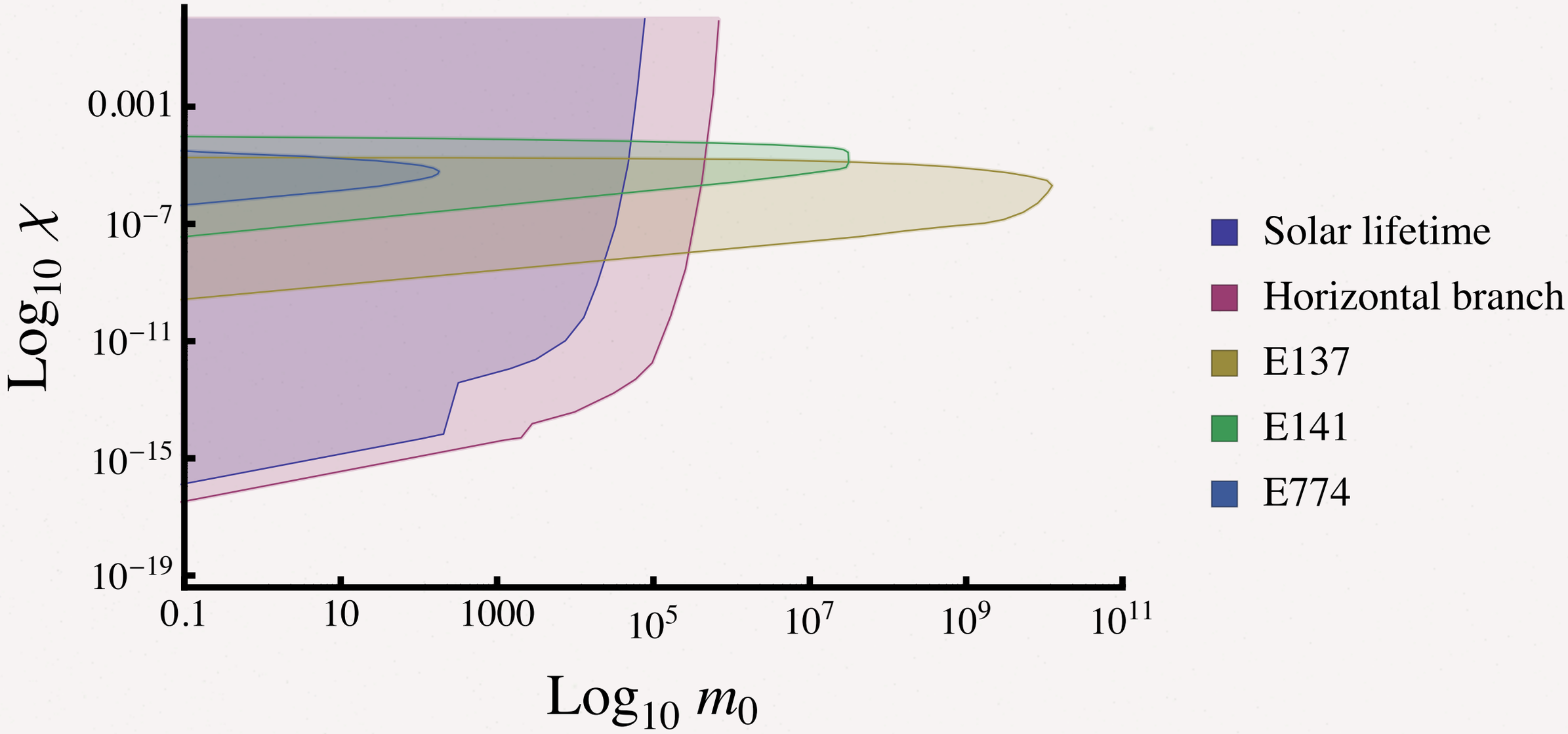
Chris Wallace. Patras 2013, Mainz.

Virtual Constraints

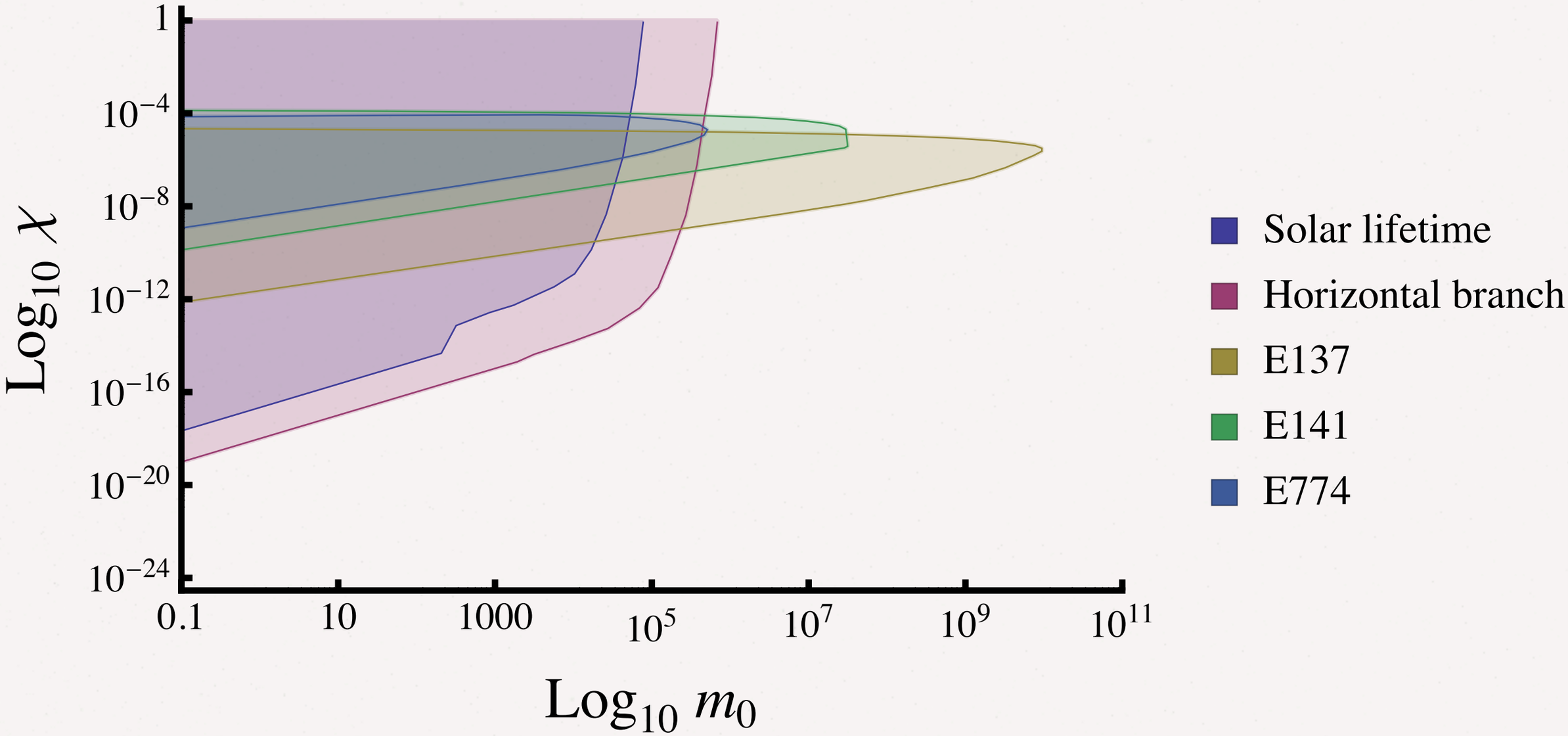


- Electron + muon g-2 constraint.
- Not in region of perturbative treatment.

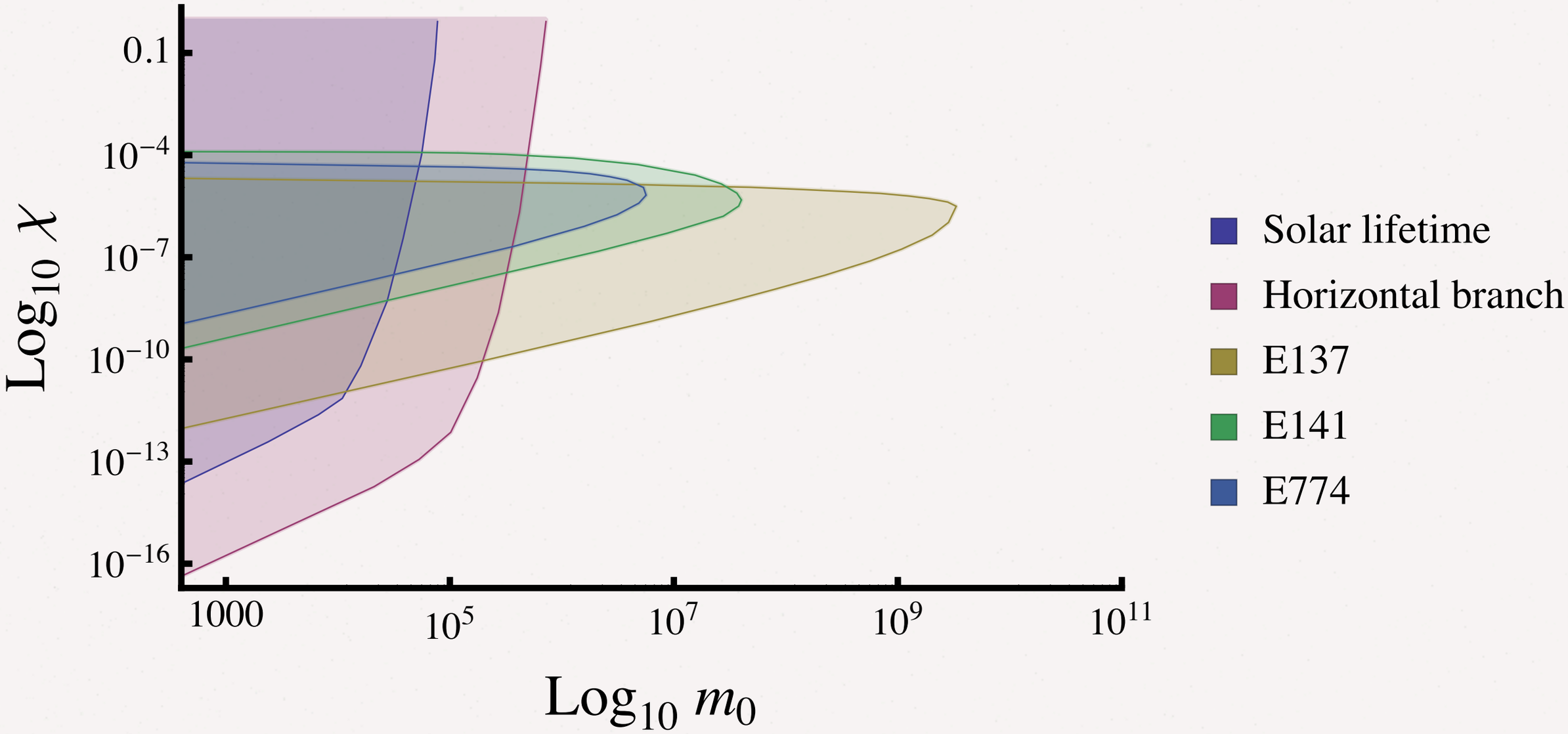
One Extra Dimension



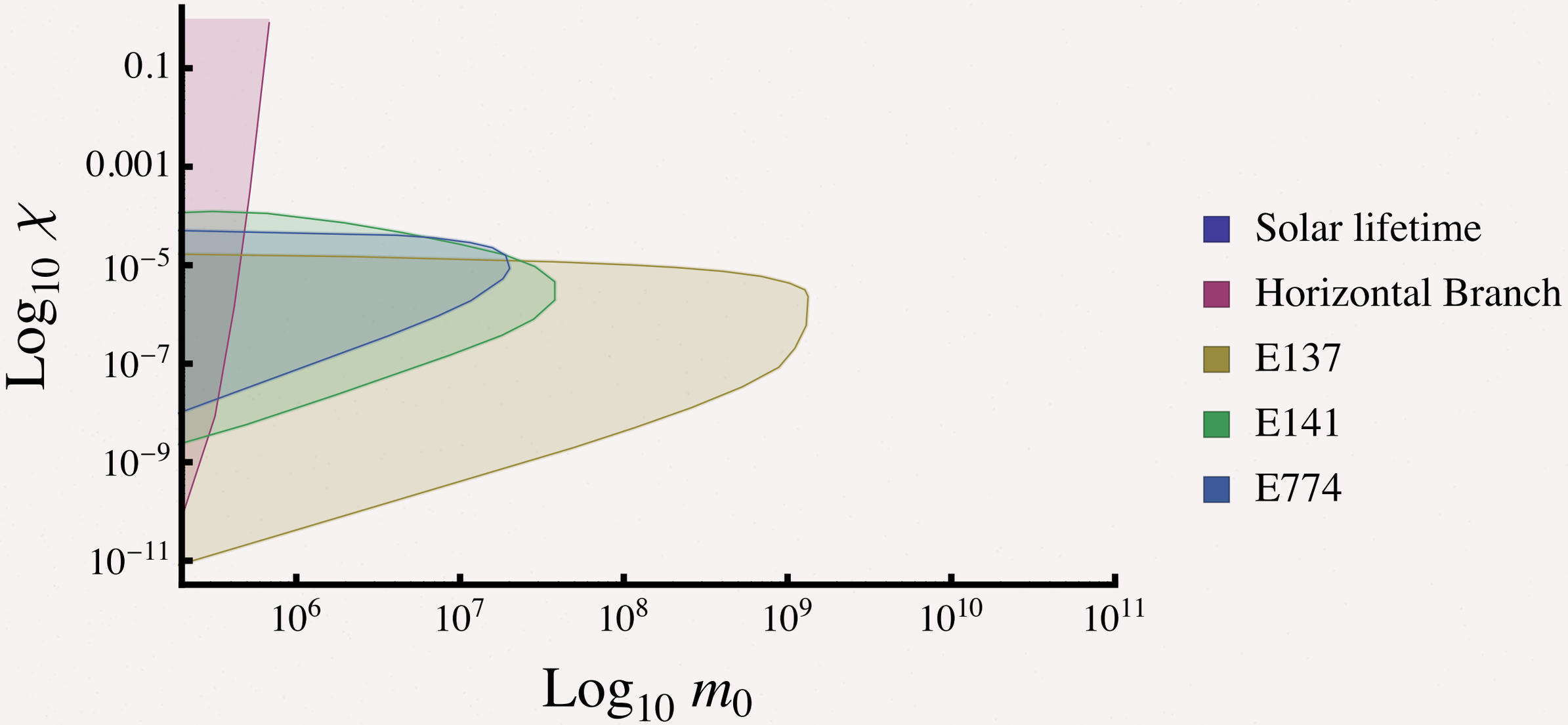
Two Extra Dimensions



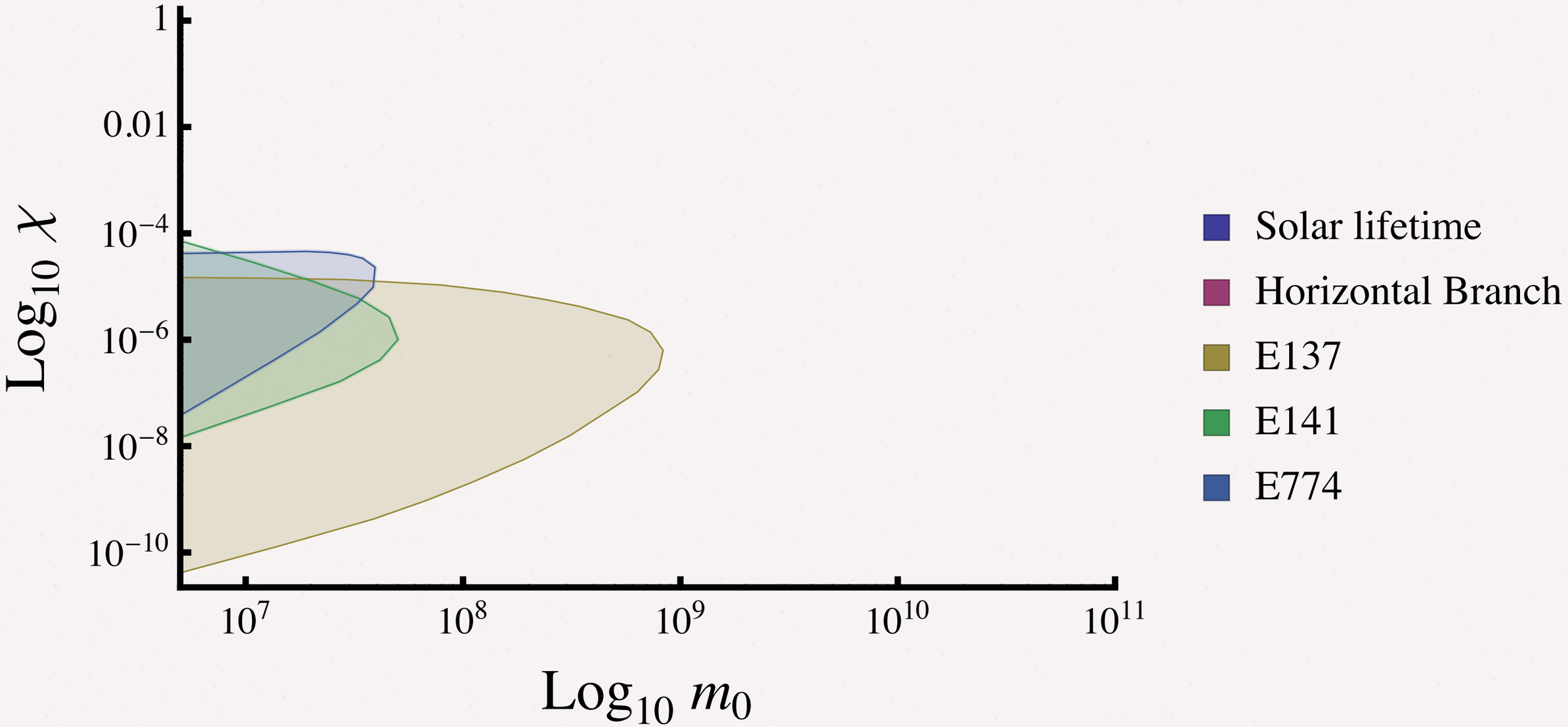
Three Extra Dimensions



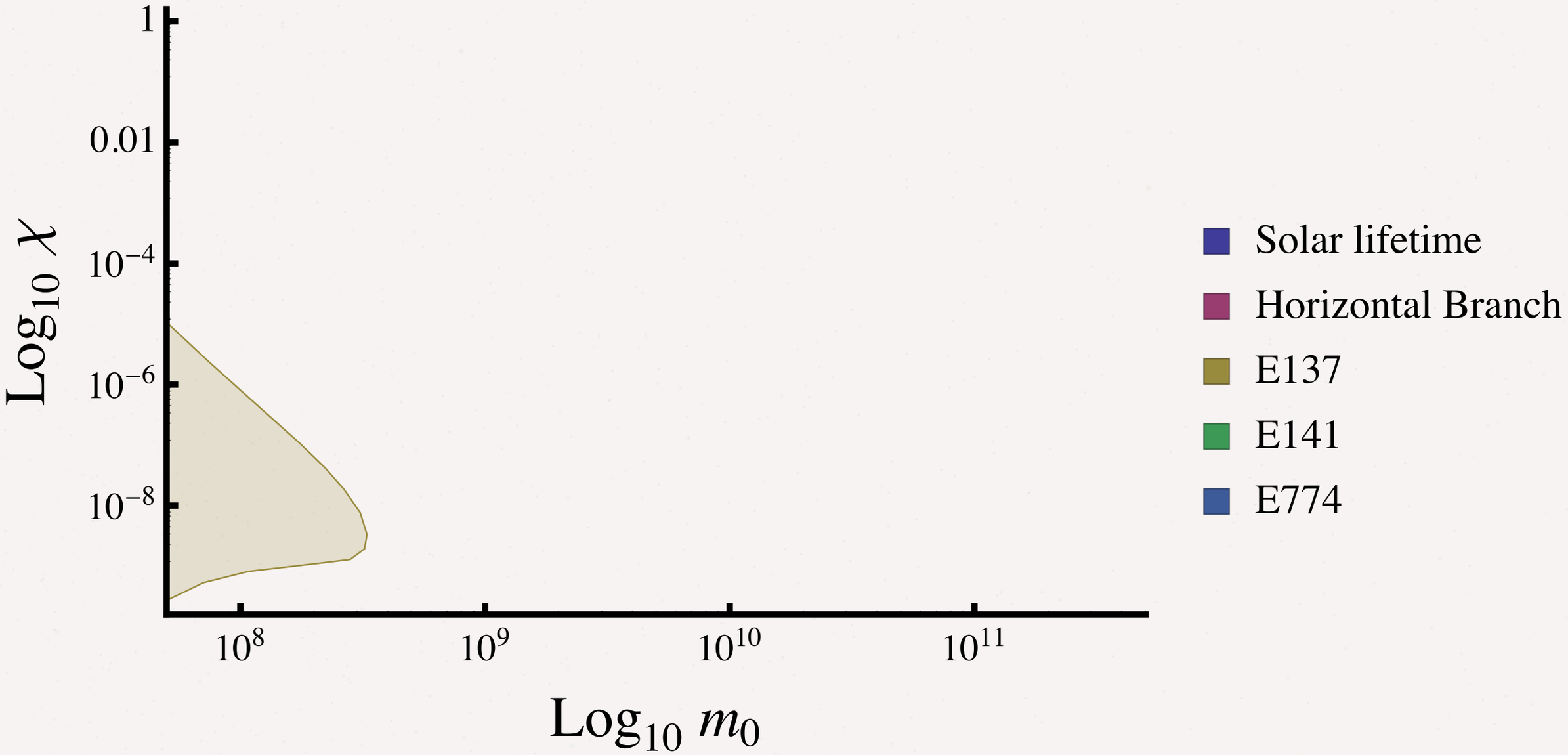
Four Extra Dimensions



Five Extra Dimensions



Six Extra Dimensions



Conclusions:

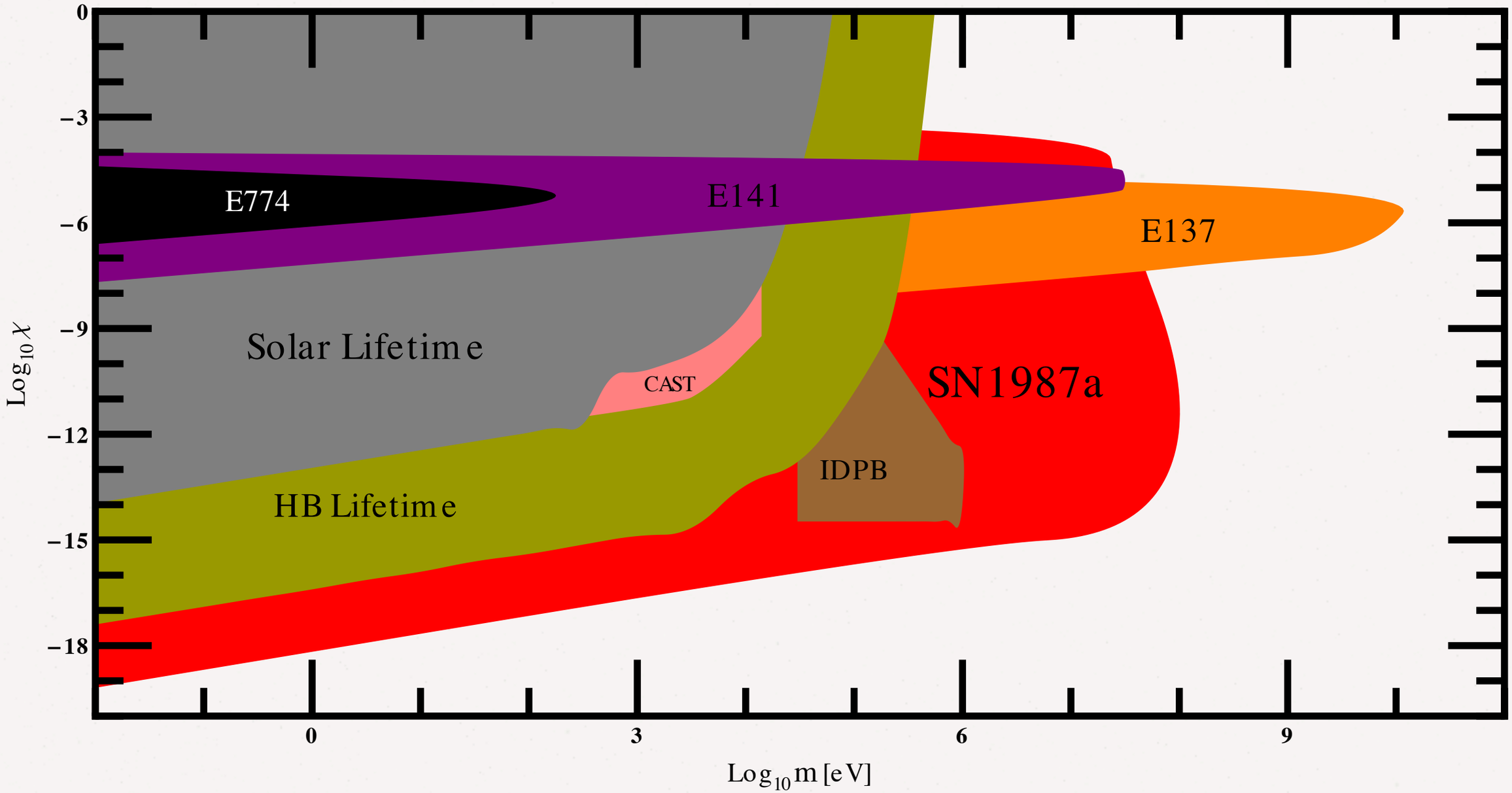
- Extra dimensions can generate hidden photon mass.
- Modified phenomenology.
- Connect with string theory?
- Next up, do (4d!) SN1987A in full.

With thanks to

THANKS!

CAST, IDPB, SN1987A

(ONE EXTRA DIM.)



Chris Wallace. Patras 2013, Mainz.