A stringy top resonance from warped geometry

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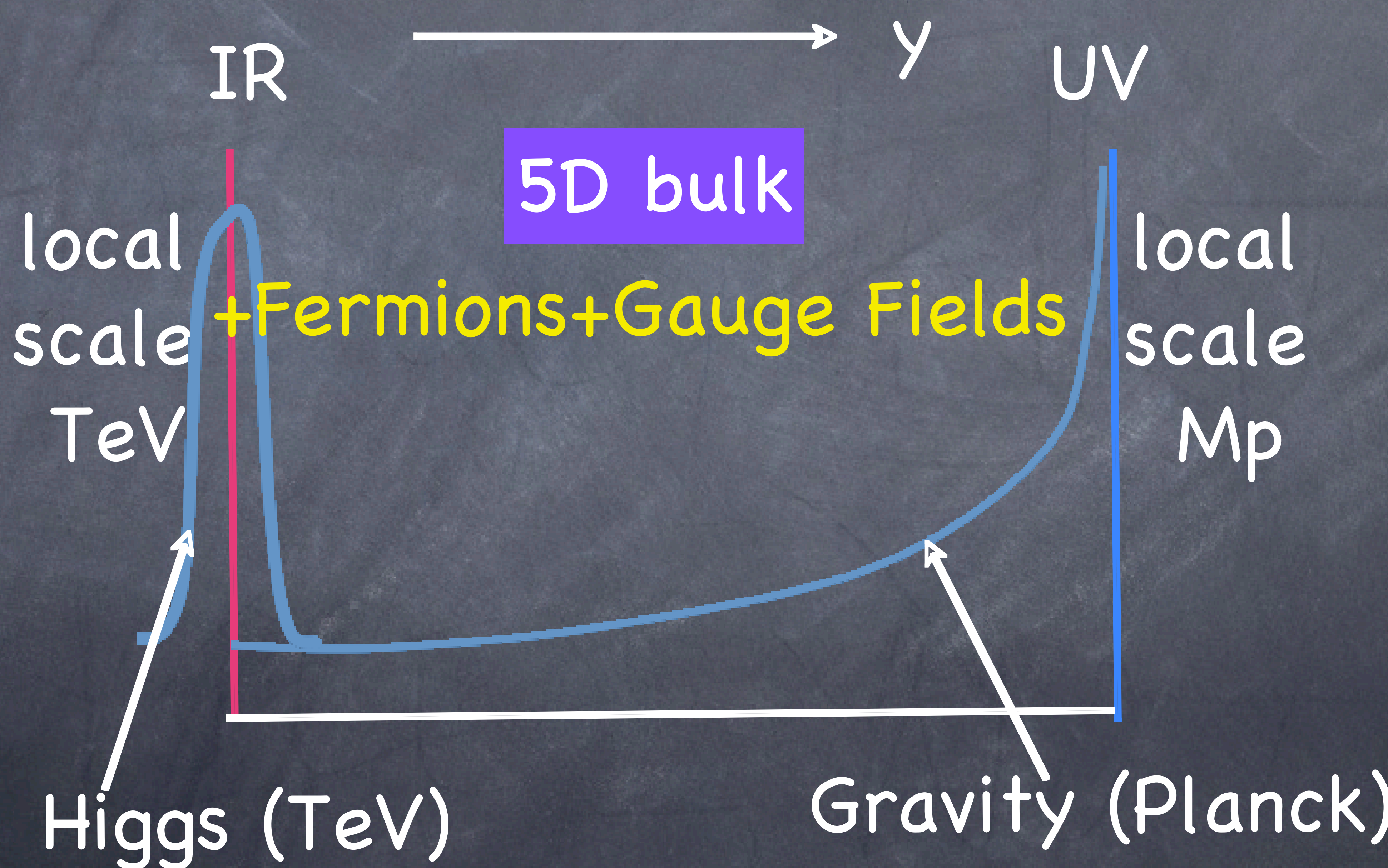
JHEP 0907:077,2009

Motivation

- We hope that the Standard Model can be realized in String Theory.
- Consequence is: Standard Model particles have string-oscillator excitations (Reggeons).
- Most string theory vacua have curved regions of spacetime (throats), because of flux stabilizing moduli (extra-dimensions).
- Warping may solve hierarchy problem (Randall & Sundrum), if throat long enough.
- Important to study the phenomenology of SM excitations in warped throats.

RSI model

The very simplest throat geometry (constant -ve curvature) is the Randall-Sundrum solution.



Long throat -> TeV/Planck hierarchy

String Excitations in Randall-Sundrum

- Expect a proper string realization of RS (intersecting D3/D7 branes) to yield Regge excitations of all the SM fields.

- In flat space ([Cullen, Perelstein, Peskin], [Friess,Han,Hooper], [Anchordoqui,Goldberg,Lust,Nawata,Taylor,Steiberger]) we only have interesting pheno if $M_s \sim TeV$

- Difficult (currently) to obtain top-down description of these Reggeons in curved space.

- Use Effective Field Theory. Assume that we have SM fields in the 5D bulk (fermions + gauge fields) with Higgs on the I.R. brane.

Fermion Excitations

- Consider the excitations of the fermions (u,d,....,t), which are in 5D bulk of the space.
- They have 5D mass parameters $M_u \cdots M_t$.
- Each SM fermion has 5D string resonance (copy) with identical quantum numbers, BUT spin = 3/2 and 5D mass $M_q^* = M_q + M_s$.
- $M_u \neq M_d \neq M_t$ to obtain correct SM 4D masses.
- String mass M_s is flavour-blind. Depends on the precise way in which fermions are obtained (flavour branes wrapping cycles....).

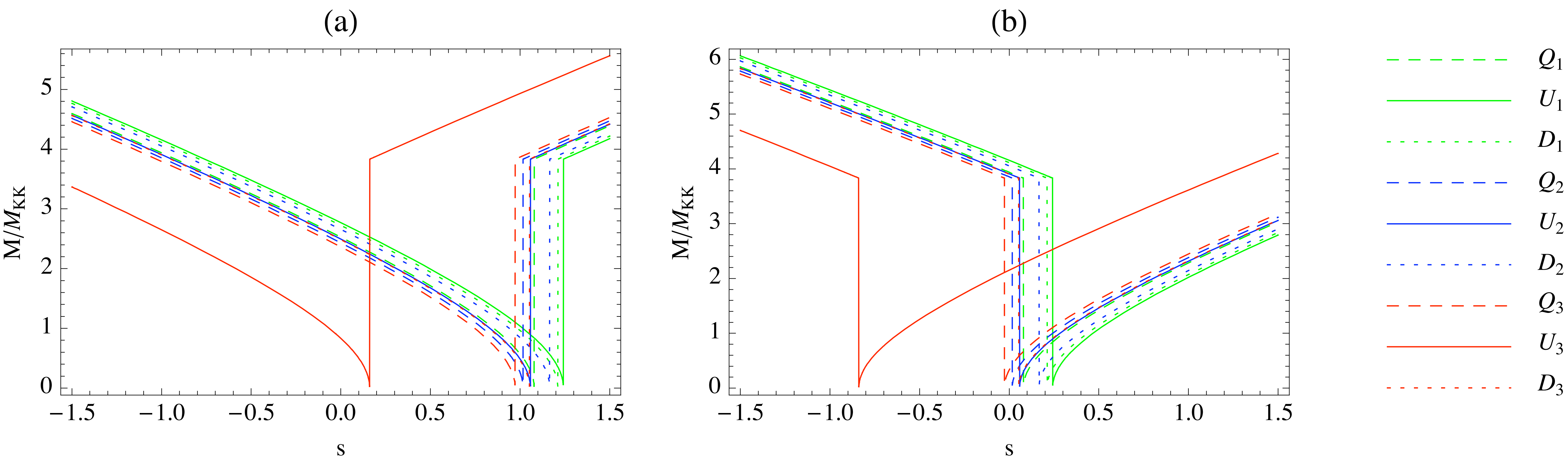
- For 4D pheno, to get masses of 4D SM fermions m_q and their 4D resonances m_q^*, must solve the 5D equations of motion.

$$\Gamma^{\alpha\beta\gamma}\left(D_\beta + \frac{1}{3} M_q^* \Gamma_\beta\right)\Psi_\gamma = 0$$

- The results depend on the mass scales: $k =$ curvature scale, $M_s =$ String scale.
- Naively $M_s/k \sim (g_s N)^{1/4}$ -> $m_q^* > M_{KK}$ = mass of spin-1/2 KK modes.
- But this is too naive: $M_s = s\,k$, $s \sim \mathcal{O}(1)$ and really it is a parameter of the model.
- Focus on right-handed spin-3/2 top t_R^*.

mass of t^*_R in 4D

Mass of resonances m^*_q vs s

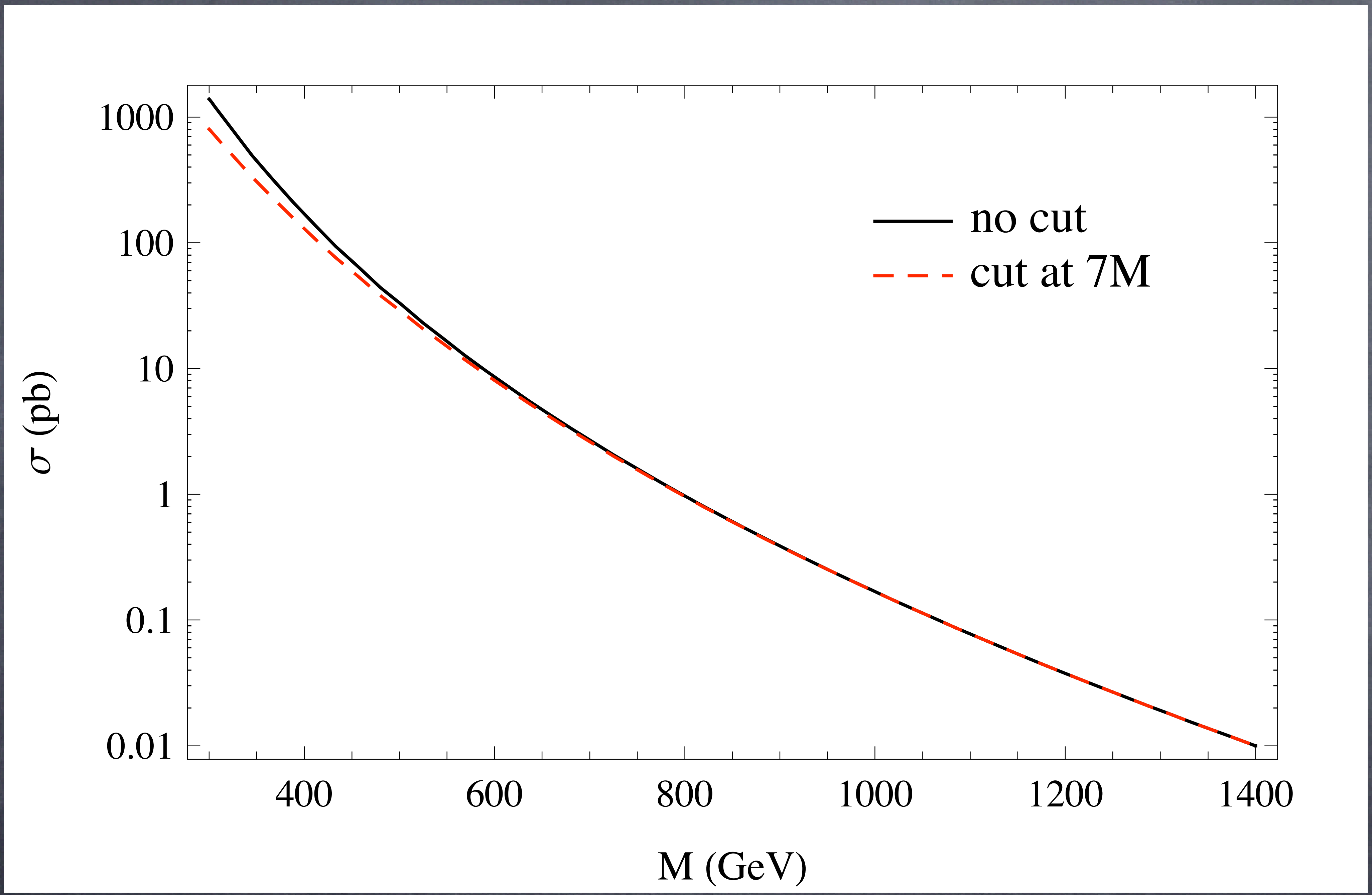


All masses warped down from Planck -> TeV. Top-3/2 is lighter than all others for much of parameter space, and lighter than KK modes for some of it (if we want 4D SM fermion masses).

Top-3/2 phenomenology

- Mass of Top-3/2 can be low O(TeV).
- Decay channels: $t^*_R \to tg,\ W^+b,\ tZ,\ tH$
- top-gluon channel is a dimension-5 operator, very interesting signal. W b channel due to mixing of t^*_R and t_R .
- Top-3/2 is SU(3) colour triplet, so can be pair-produced at LHC. Model-independent process, so theoretically clean.

Pair Production



Higher spin theories violate unitarity. Here violation above $\sqrt{s} \simeq 7M$, so we set partonic cross-section to zero above this scale.

Results

- For W b decay channel, assuming top-3/2 production has same K-factor as top production, Tevatron direct detection bound is
- $$m_t^* \geq 350\, GeV$$
- For observability at LHC, again under same assumptions, we require
- $$m_t^* \leq 1.35\, TeV$$

Conclusions

- String Resonances in throats WARPED DOWN TO TEV, even for $M_s \sim$ Planck.
- In flat space, only accessible if $M_s \sim$O(TeV).
- t^*_R good place to start as generically lightest + can be lighter than spin-1/2 KK modes.
- At LHC pair-production is promising & model-independent. Study top-gluon decay channel.
- Single production more model-dependent, but also interesting (Stringy Dim(5) operators).
- Work on other stringy aspects of throats (Perelstein and Spray, Reece and Wang)

Single production of top3/2