

Using top quarks to probe the Randall-Sundrum model

Ben Lillie

Argonne / University of Chicago

Outline

B. Lillie, L. Randall, L. Wang hep-ph/0701166

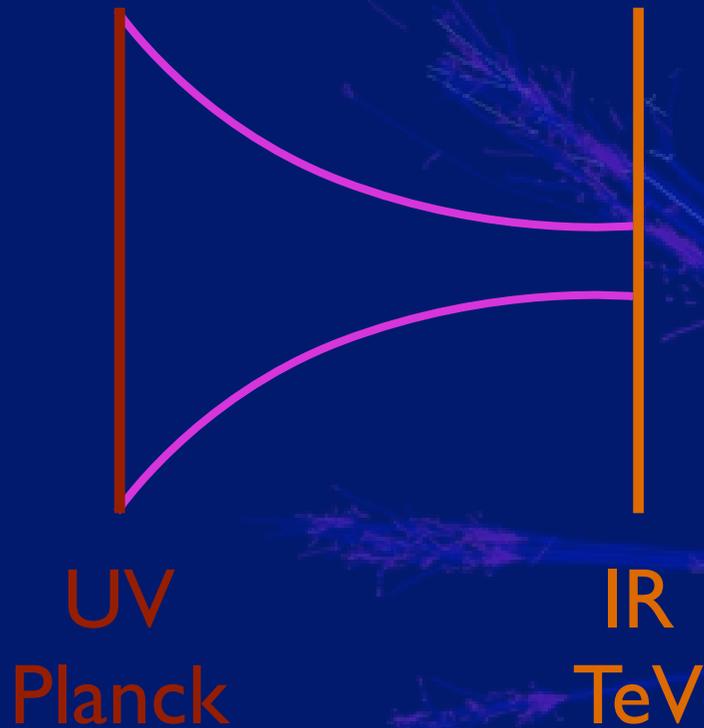
- Description of the RS model
- Importance of top quarks
- Top jets
- ILC channels?
- Outlook

See also: Agashe, Belyaev, Krupovnickas,
Perez, Virzi hep-ph/0612015



The Randall-Sundrum model

L. Randall, R. Sundrum hep-ph/9905221



$$M \rightarrow e^{-\pi k r_c}$$

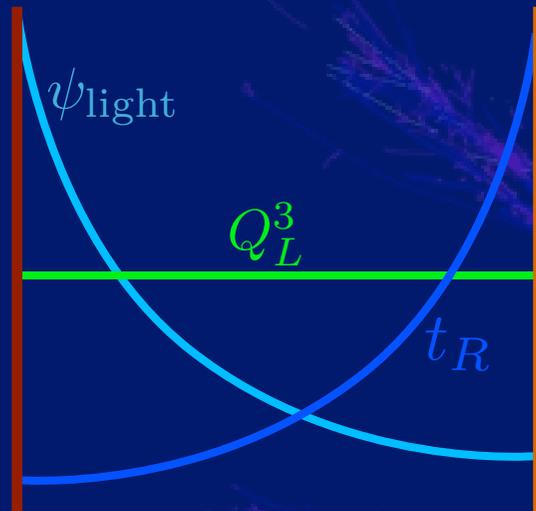
- Five dimensions
- Extra dimension is “warped”
- Warping scales masses, solving the hierarchy problem
- Parameters are natural

W. Goldberger and M. Wise hep-ph/9907447



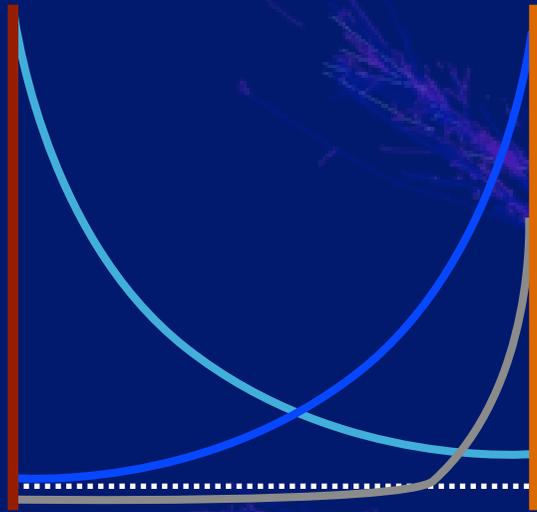
Standard Model fields

H. Davoudiasl, J. Hewett, T. Rizzo hep-ph/9911262
A. Pomarol hep-ph/9911294



- SM fields in bulk to suppress dangerous operators
 - Gauge fields must be in bulk
- Provides explanation of flavor hierarchy
- Structure constrained by SM precision observables
 - $Z \rightarrow b\bar{b}$ dominant constraint

Kaluza-Klein states



- KK states are IR localized
- Universal couplings to light fermions
- Large coupling to top

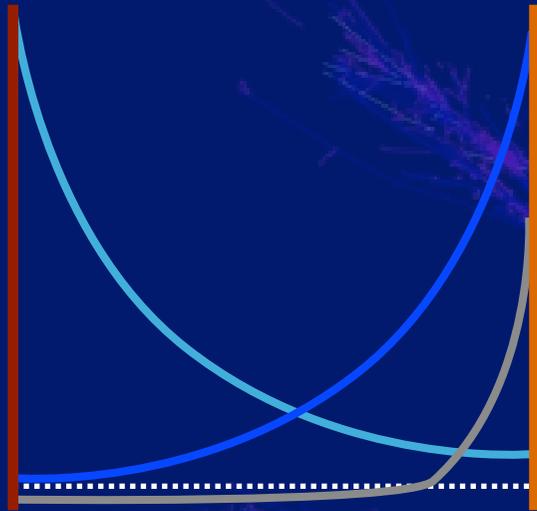
$$g_{f\bar{f}g^{(1)}} \sim 0.2g_s$$

$$g_{Q^3\bar{Q}^3g^{(1)}} \sim g_s$$

$$g_{t_R\bar{t}_Rg^{(1)}} \sim 4g_s$$



Kaluza-Klein states



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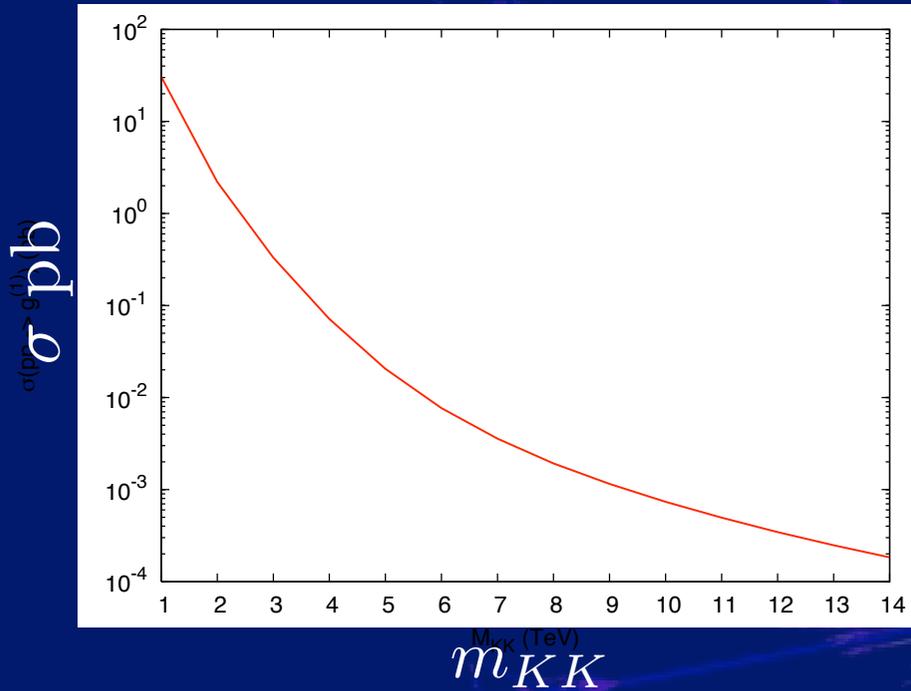
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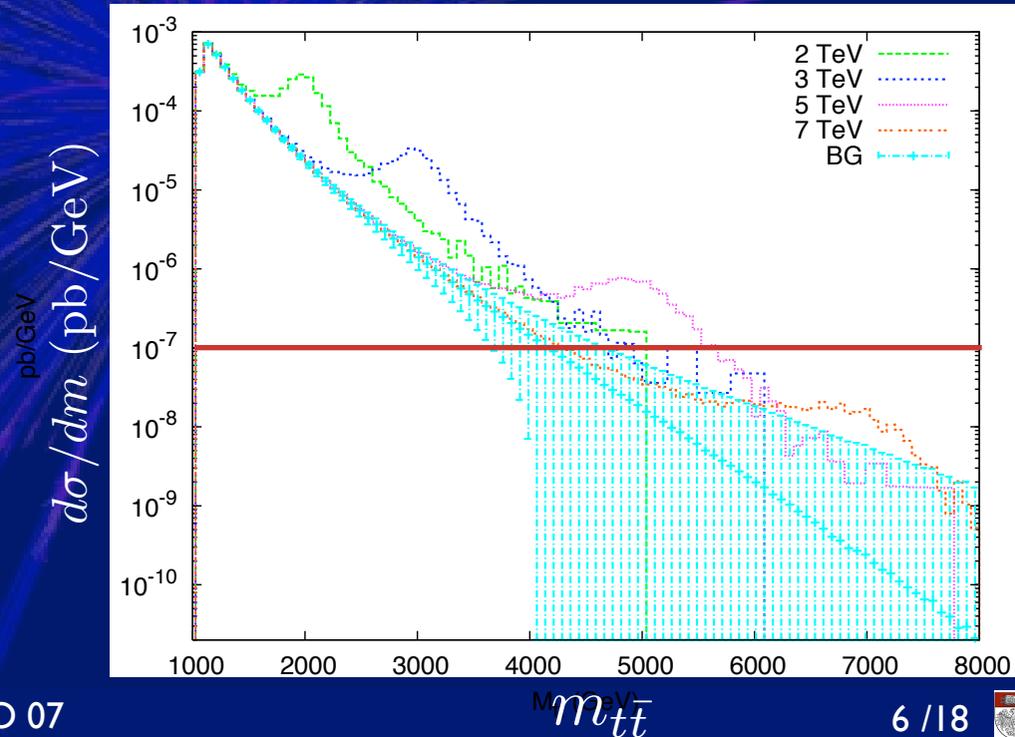
All gauge KK states decay predominantly to top pairs!

Top pairs from KK gluons

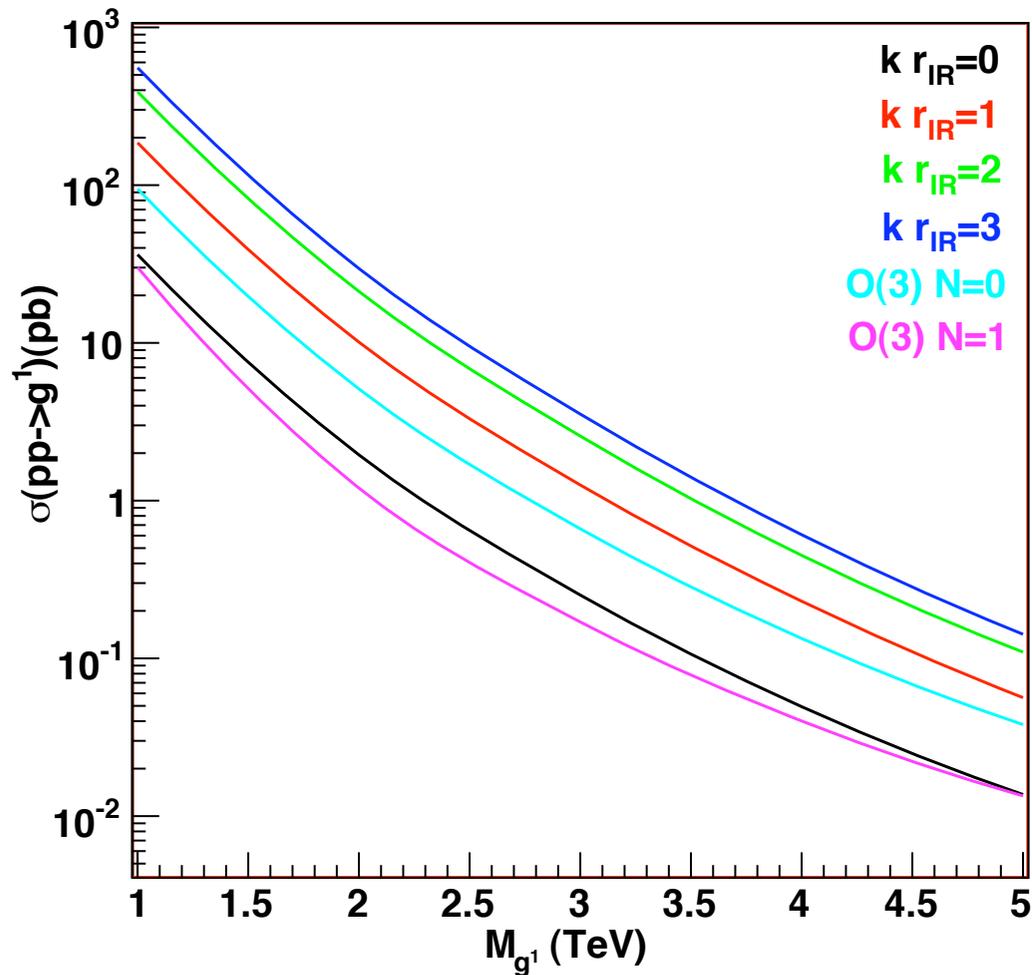


Cross-section at LHC reasonable, limited by small coupling to light fermions, and lack of glue-gluon coupling

- Nice signal above SM top production
- PDF and stat. errors shown, assuming $100 fb^{-1}$
- Width/Mass $\sim 17\%$

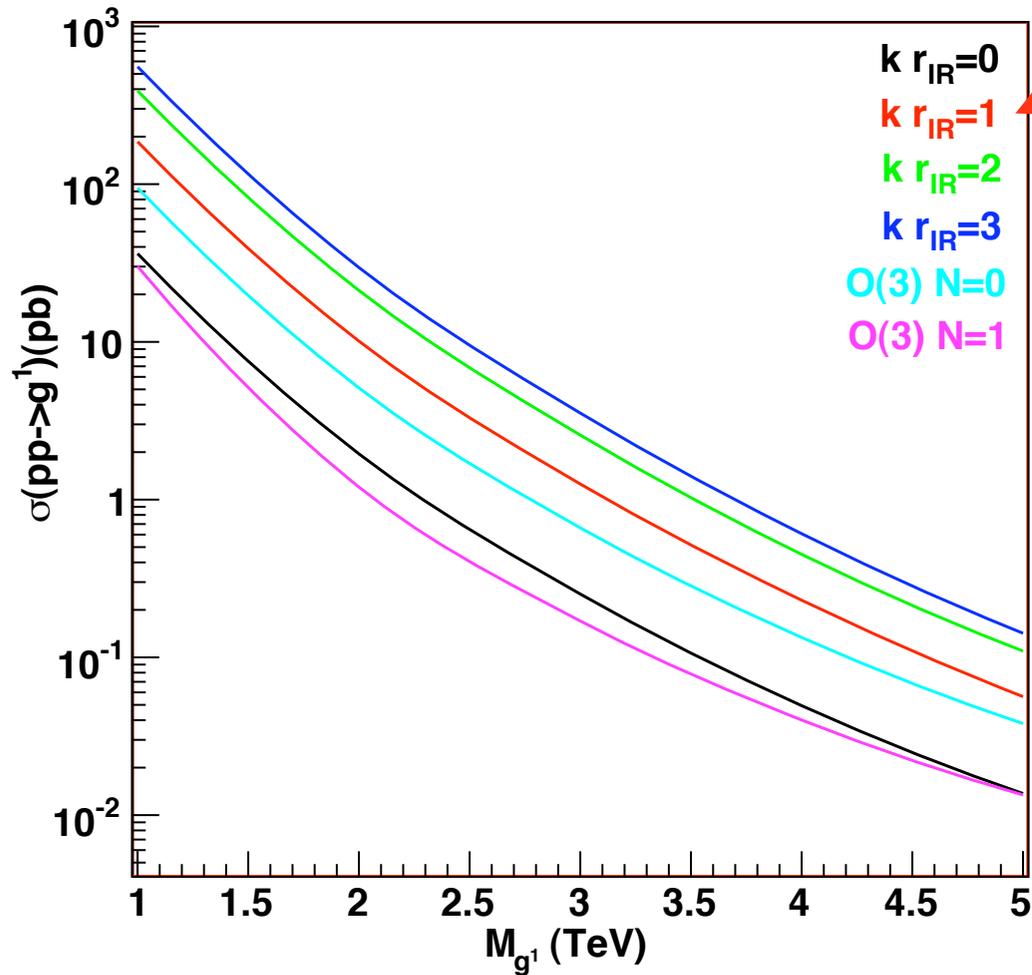


Other model variants



Davoudiasl, Hewett, Rizzo hep-ph/0212279
Carena, Ponton, Tait, Wagner, hep-ph/0212307

Other model variants

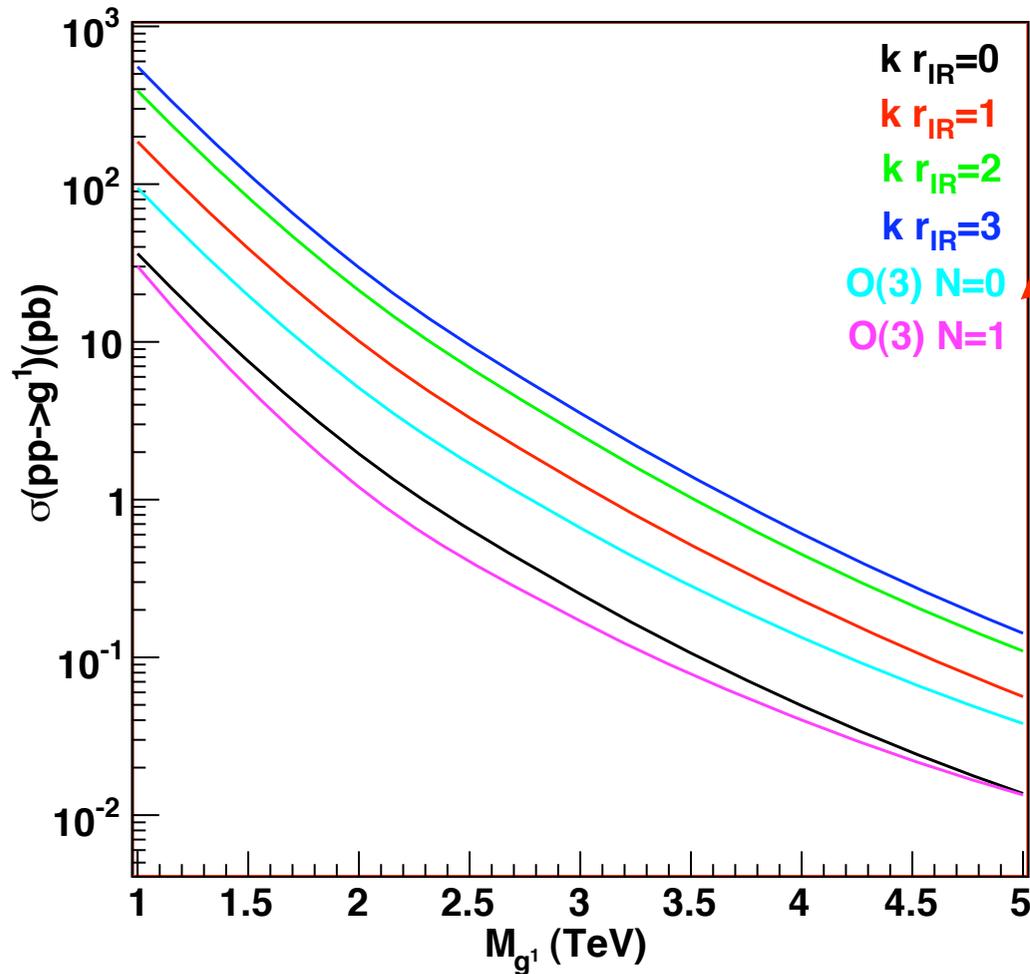


IR brane terms

$$2\delta(y - \pi r_c) r_{IR} F_{\mu\nu} F^{\mu\nu}$$

Davoudiasl, Hewett, Rizzo hep-ph/0212279
 Carena, Ponton, Tait, Wagner, hep-ph/0212307

Other model variants

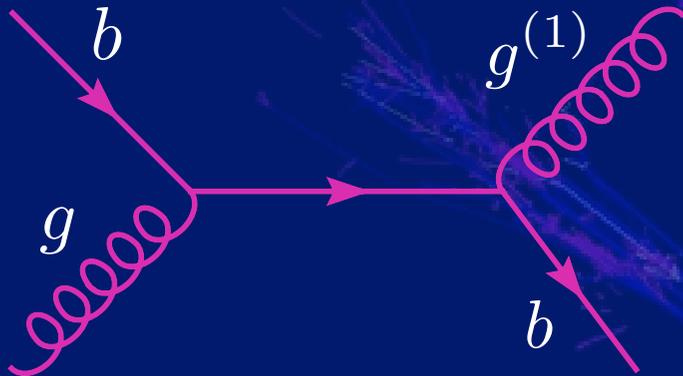


Custodial symmetry
for $Z \rightarrow b\bar{b}$

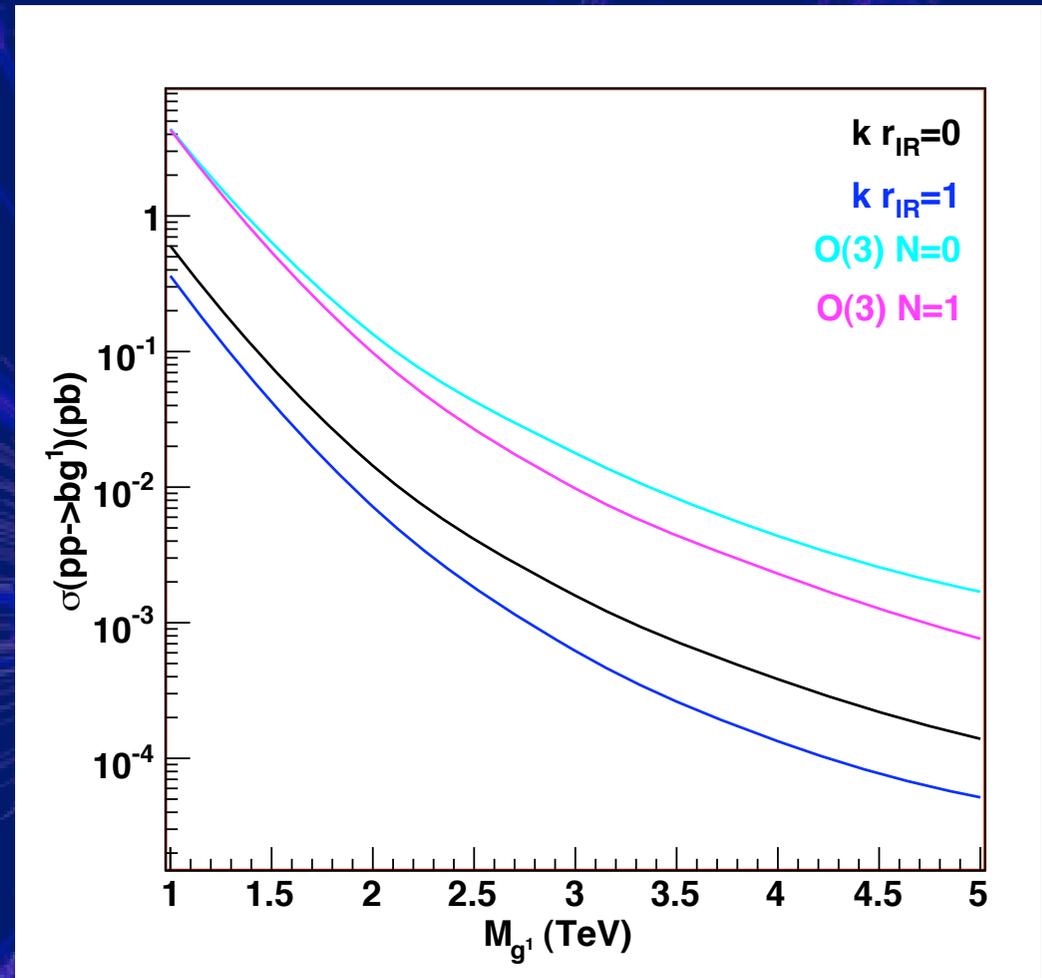
- Produces new light fermions
- KK gluon can decay into N new states

Agashe, Contino, Da Rold, Pomarol, hep-ph/0605341

bottom quark coupling

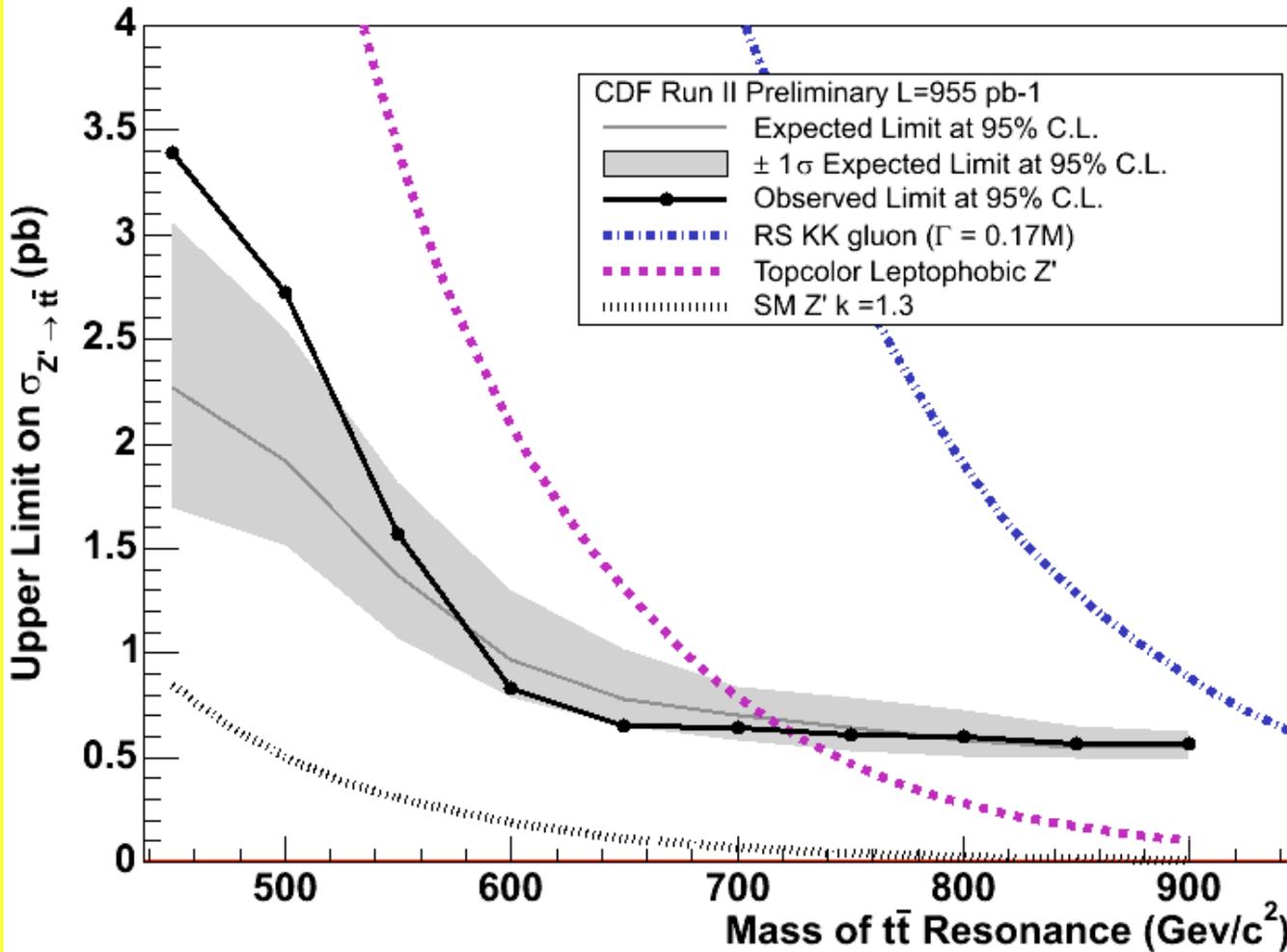


- Measure b associated production
- Probe of b localization



Tevatron constraints

Upper Limit on Resonant $t\bar{t}$ Production at CDF

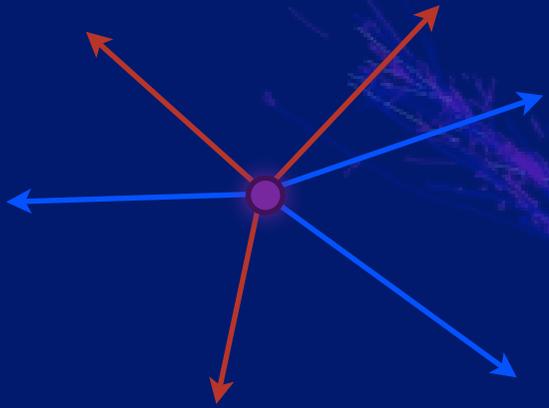


~ 950 GeV

Used narrow-width approximation, so constraint is qualitative, but probably improves with proper treatment

M. Kagan, D. Amidei, C. Cully, T. Schwarz, M. Soderberg (Michigan)
http://www-cdf.fnal.gov/physics/new/top/2006/mass/mttb/pub_page.html

Top collimation

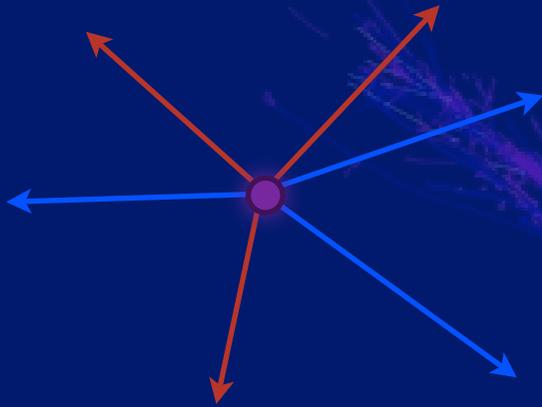


Threshold production

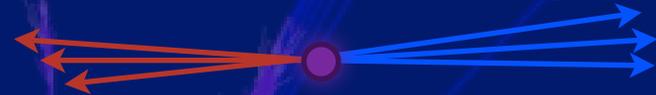


High mass production

Top collimation



Threshold production



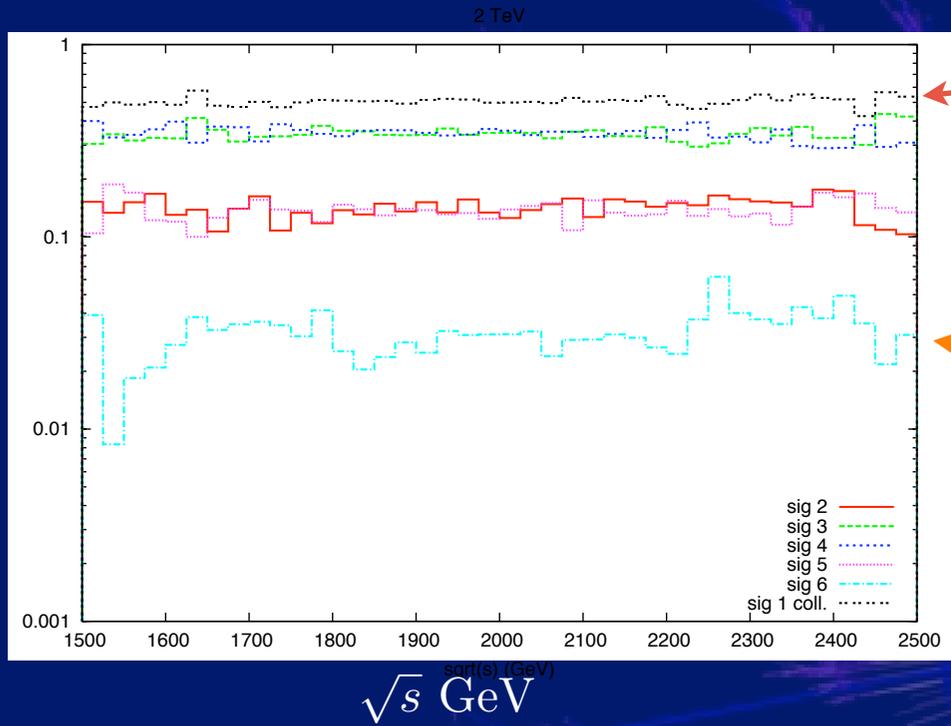
High mass production

- Tops can be highly boosted
- Can they be resolved into separate objects for top ID and reconstruction?

Top collimation (cont.)

2 TeV resonance

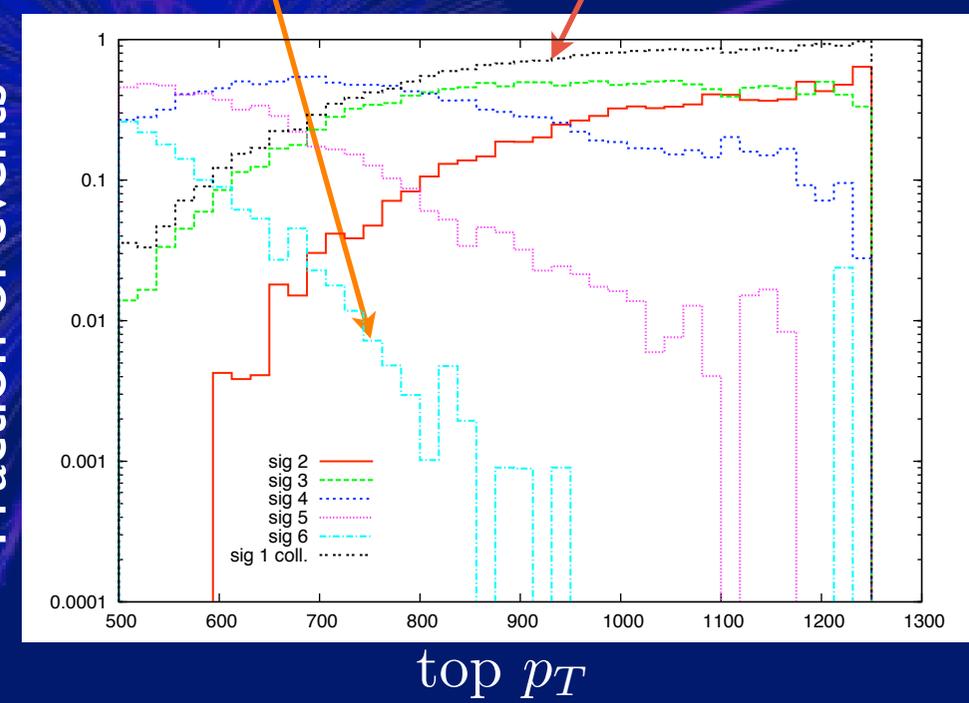
Fraction of events



One top completely collimated

6 isolated decay products

Fraction of events

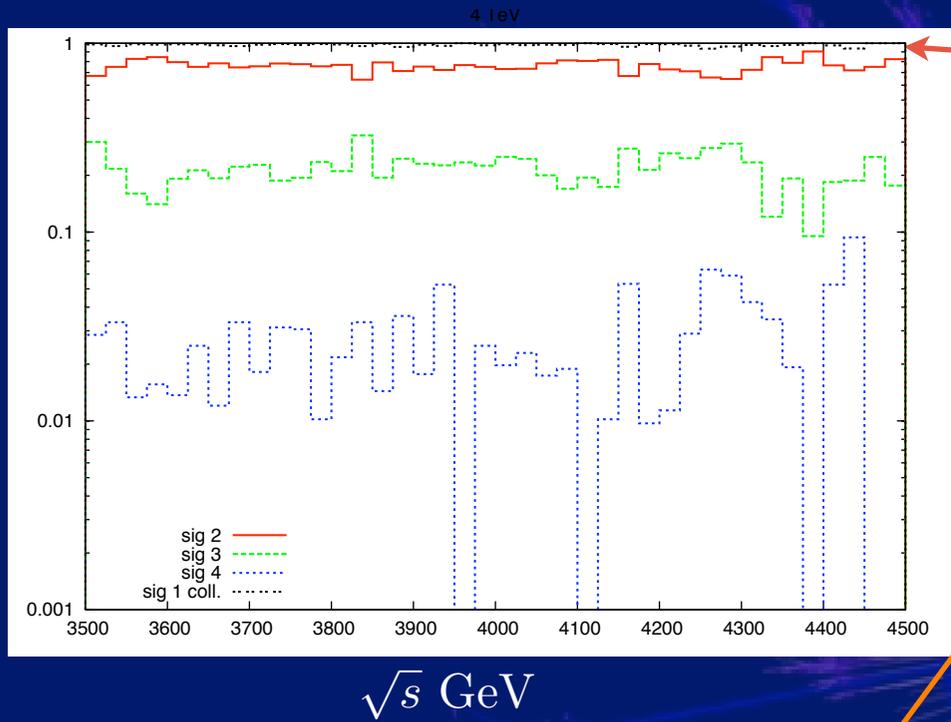


Separation: $\Delta R > 0.4$

Top collimation (cont.)

4 TeV resonance

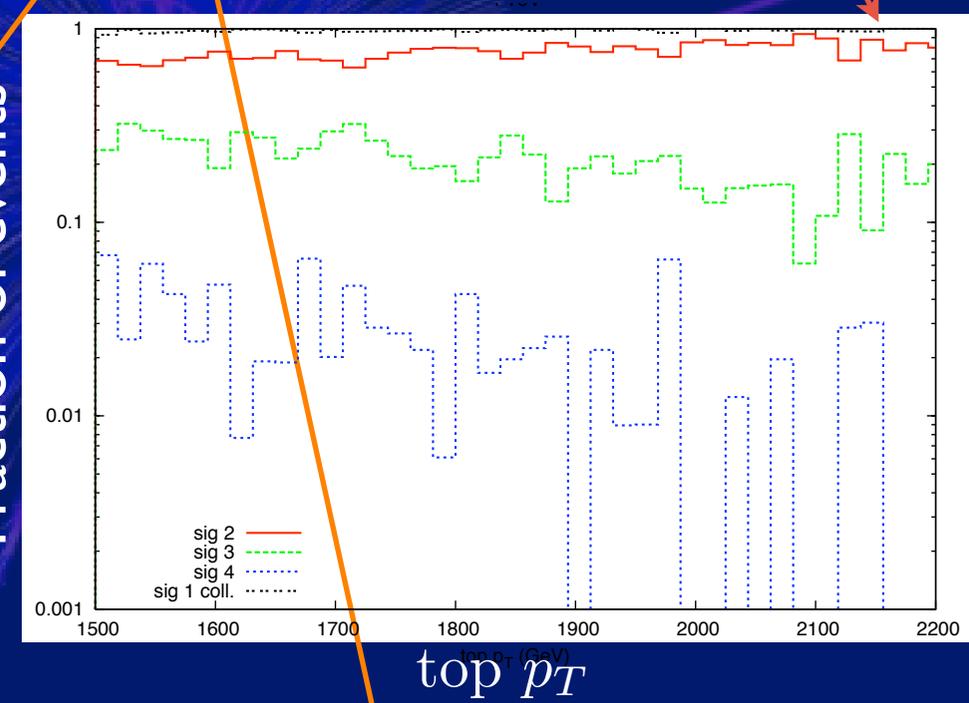
Fraction of events



One top completely collimated

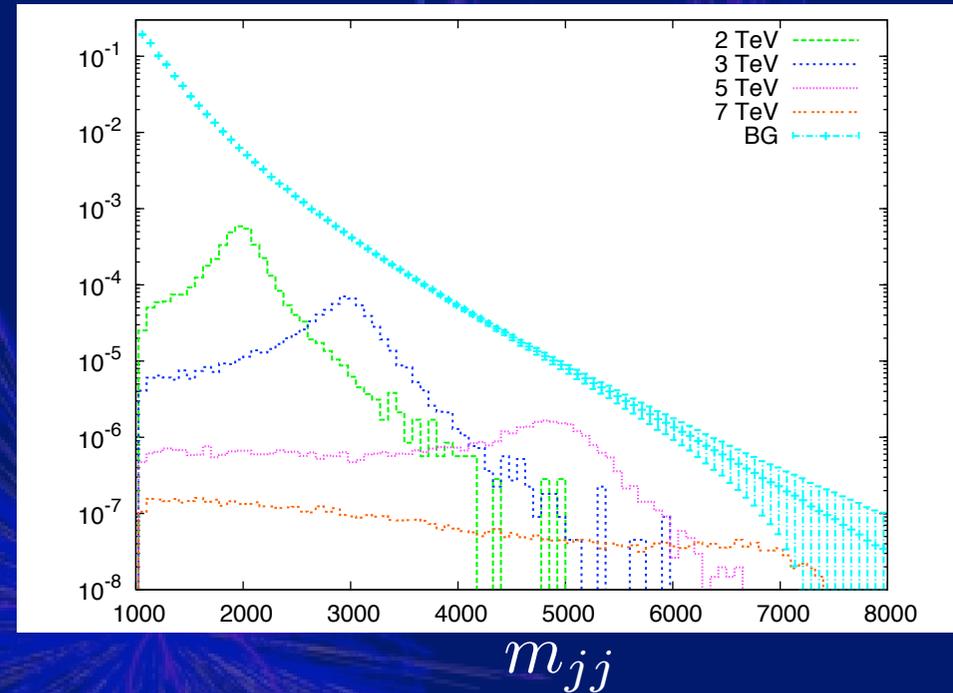
6 isolated decay products

Fraction of events



Compare to dijets?

- Possibly significant at lower masses
- Still very challenging
- Would like a way to identify tops, even if collimated
- In some models may be the discovery mode



Finding collimated $t\bar{t}$

First demonstration

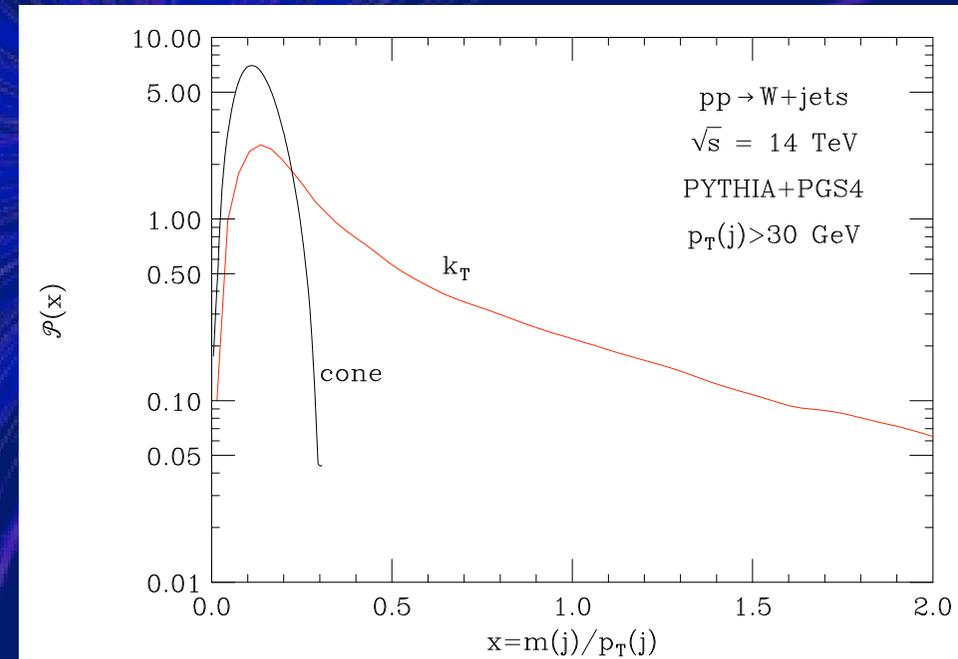
Agashe, Belyaev, Krupovnickas, Perez, Virzi hep-ph/0612015

found leptons inside jets

See Virzi, this session

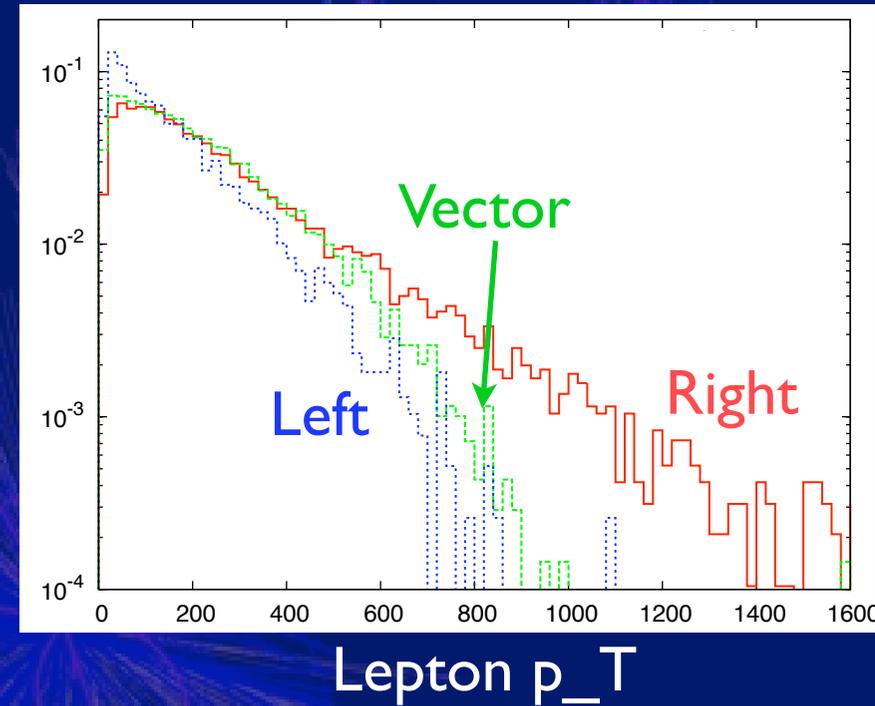
See also: U. Baur - PHENO 07 talk

- Used isolated leptons
- jet mass cut
 - note long tail for k_T algorithm

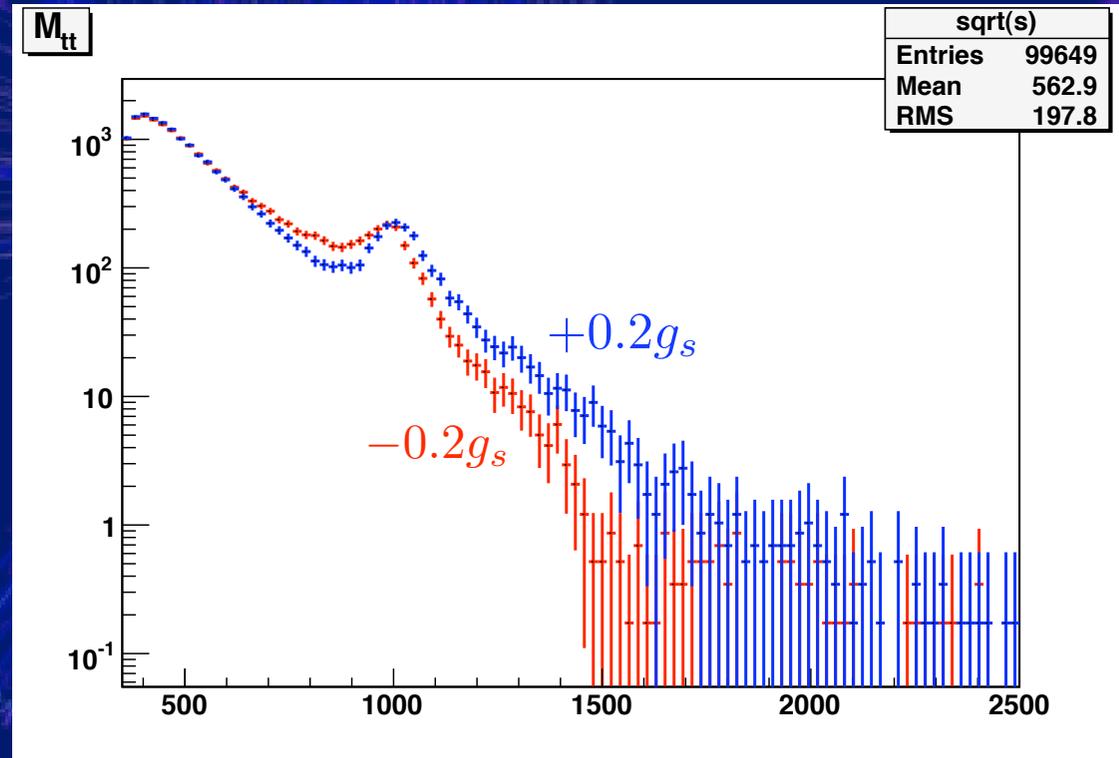
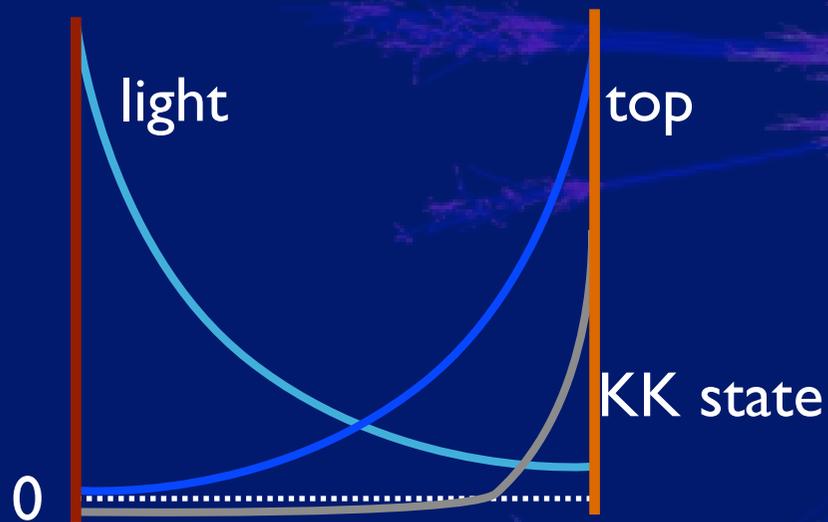
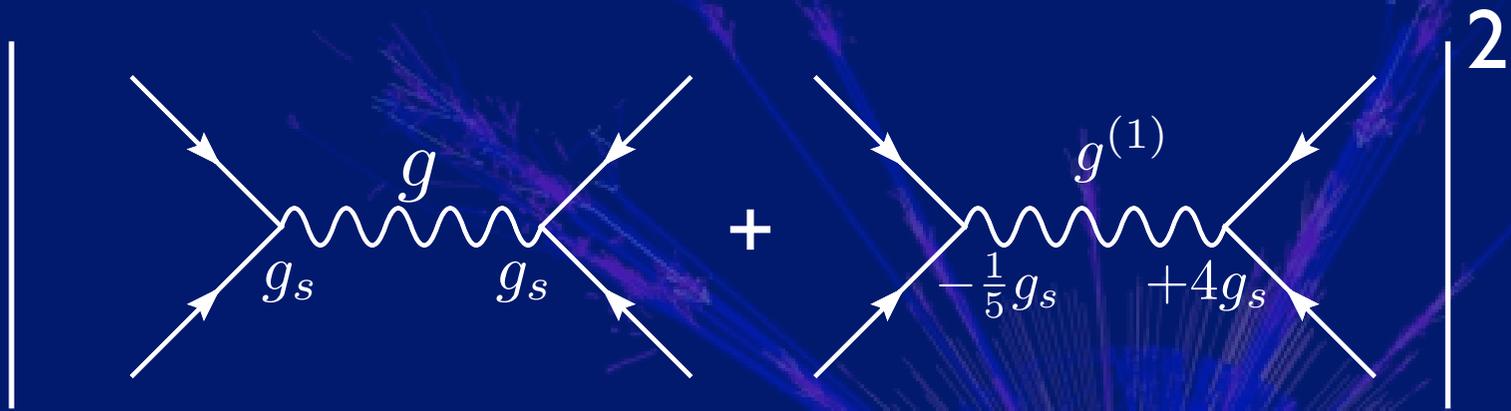


Top helicity

- Tops from KK decays are right-polarized
- Other models where they are left-polarized
 - e.g. Carena *et. al.* hep-ph/0607106
 - Agashe, Contino, Da Rold, Pomarol, hep-ph/0605341



Sign of the couplings



Possibilities at the ILC

- No s-channel gluon production. Gives direct access to EW KK states
 - Disentangle KK gluons from EW bosons
- Unlikely to have on-shell production, but not necessarily problematic
 - See, e.g. TESLA TDR
- Better top helicity measurement?

Outlook

- Another reminder that large resonances can occur in models that solve the hierarchy problem
- Example of a model where almost all new physics appears in hadronic channels
- Possible to extract interesting, qualitative features that probe the model structure.
 - Couplings to top and bottom
 - Light fermion coupling sign