Searching for the Kaluza-Klein Graviton in Bulk RS Models

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Motivation and Outline

- KK Graviton is a General Signature of RS
- Bulk SM, Graviton Couples to Composites
- Produced through Gluon Annihilation
- Dominantly decays to tops – reconstruction issues
- Can we measure the spin?
- Conclusion – Very difficult to discover

Specific Model: Agashe, Delgado, May, Sundrum, hep-ph/0308036

Parametric Production

Production will be dominated by PDF effects.

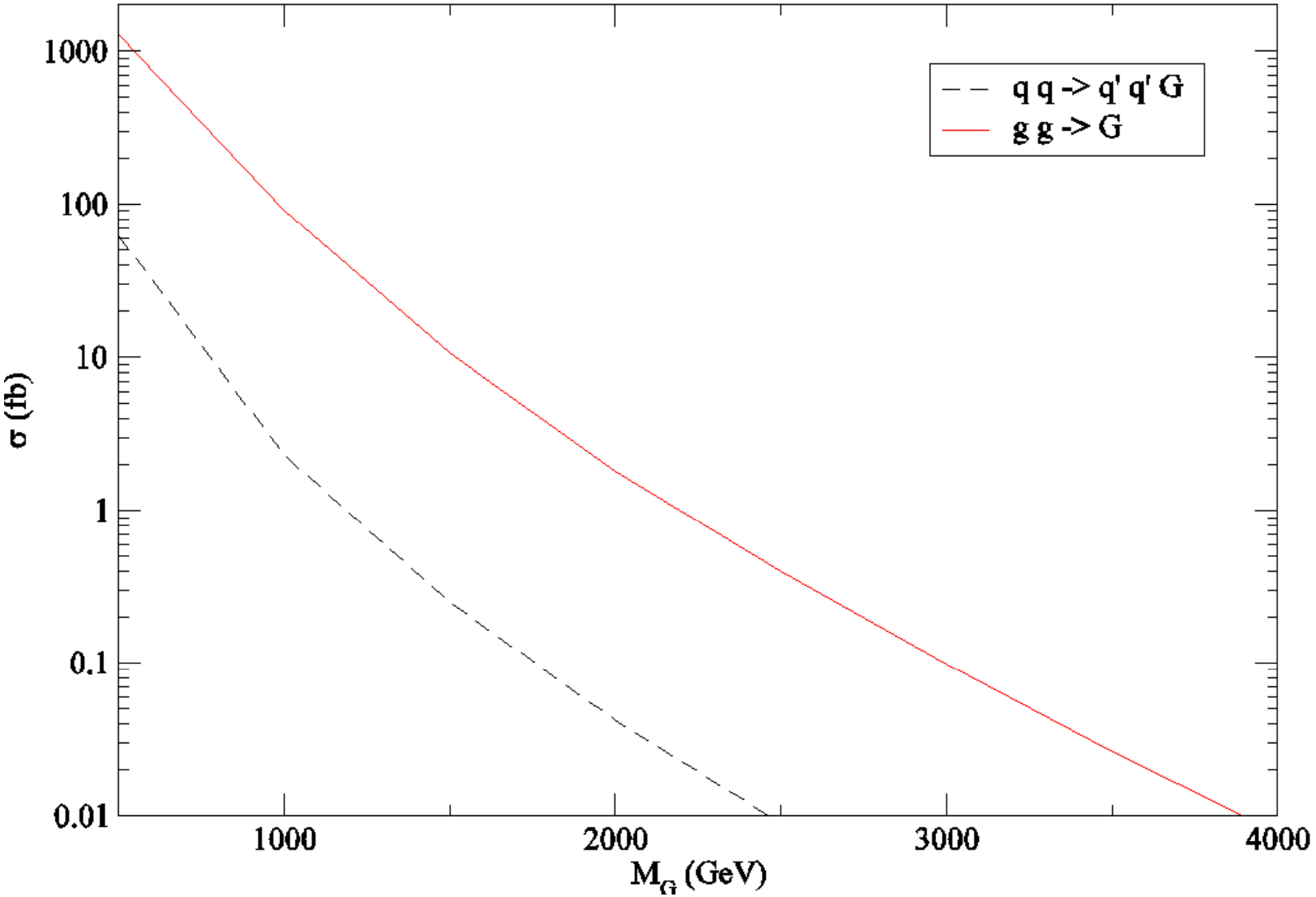
$$\sigma_{gg \to G} \approx \frac{1}{(\pi k r_c)^2} \frac{1}{(M_4 L)^2} \frac{1}{m_G^2}$$

Possibility of production through W boson fusion since coupling to longitudinal component enhanced?

Also get quark PDFs – larger at large x. We will see from the plot that this is not good enough…

Makes sense, since we are effectively using the ‘W PDF’

Production with $M_4L = 2.5$



Parametric Decay

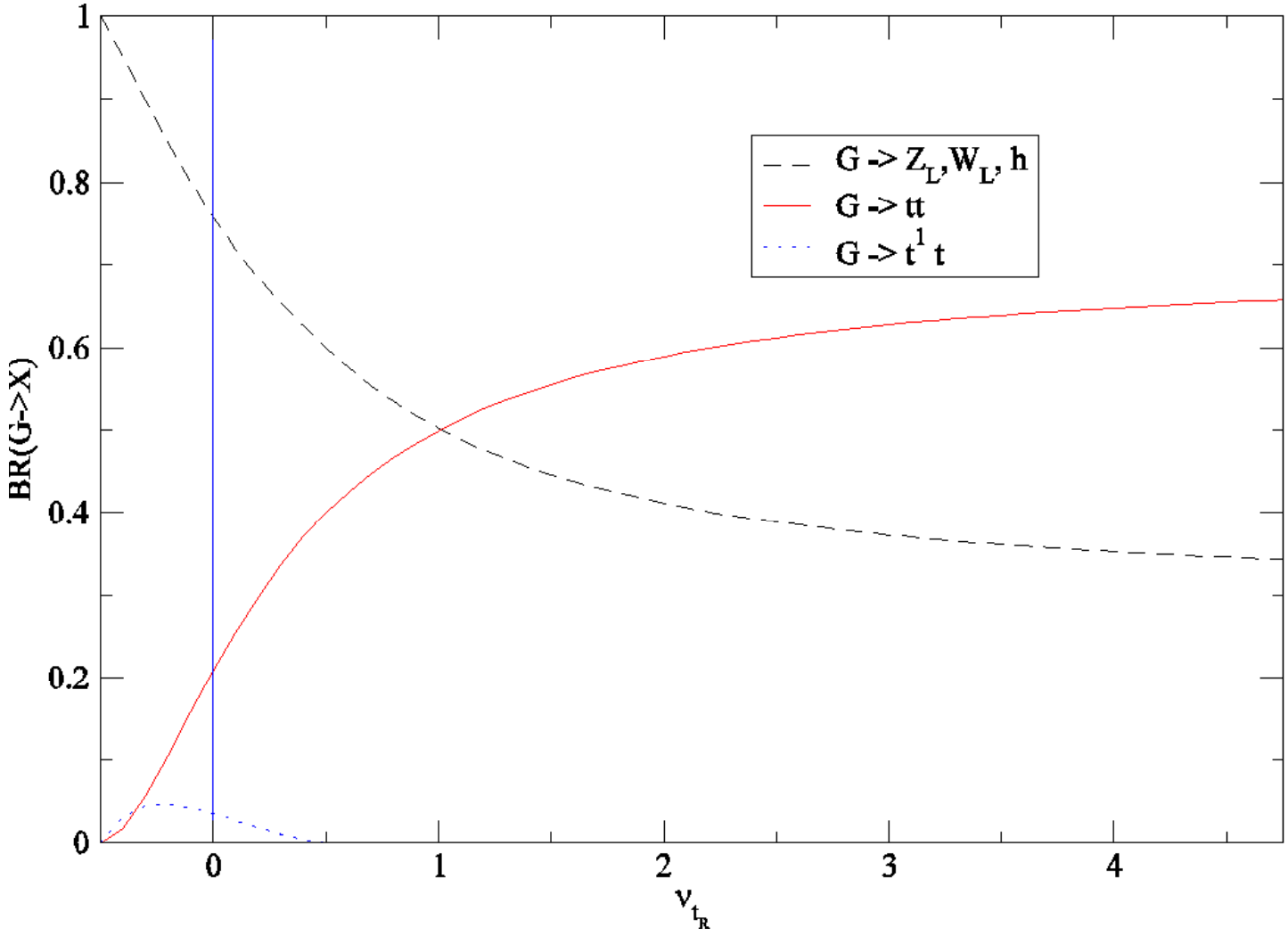
Decays to Tops, H, Z, W (goldstone bosons); precise branching ratios differ for fermion vs scalar, bulk mass…

$$\Gamma_{1s} = \frac{1}{(M_4 L)^2 \mu_{\mathrm{TeV}}^2} \frac{m_G^3}{960\pi}$$

$$\Gamma_{t\bar{t}} = \frac{1}{(M_4 L)^2 \mu_{\mathrm{TeV}}^2} \mathrm{F}[v_t] \frac{3m_G^3}{320\pi}$$

Width smaller than experimental invariant mass uncertainty!

Graviton Branching Ratio



Reach (using Tops)

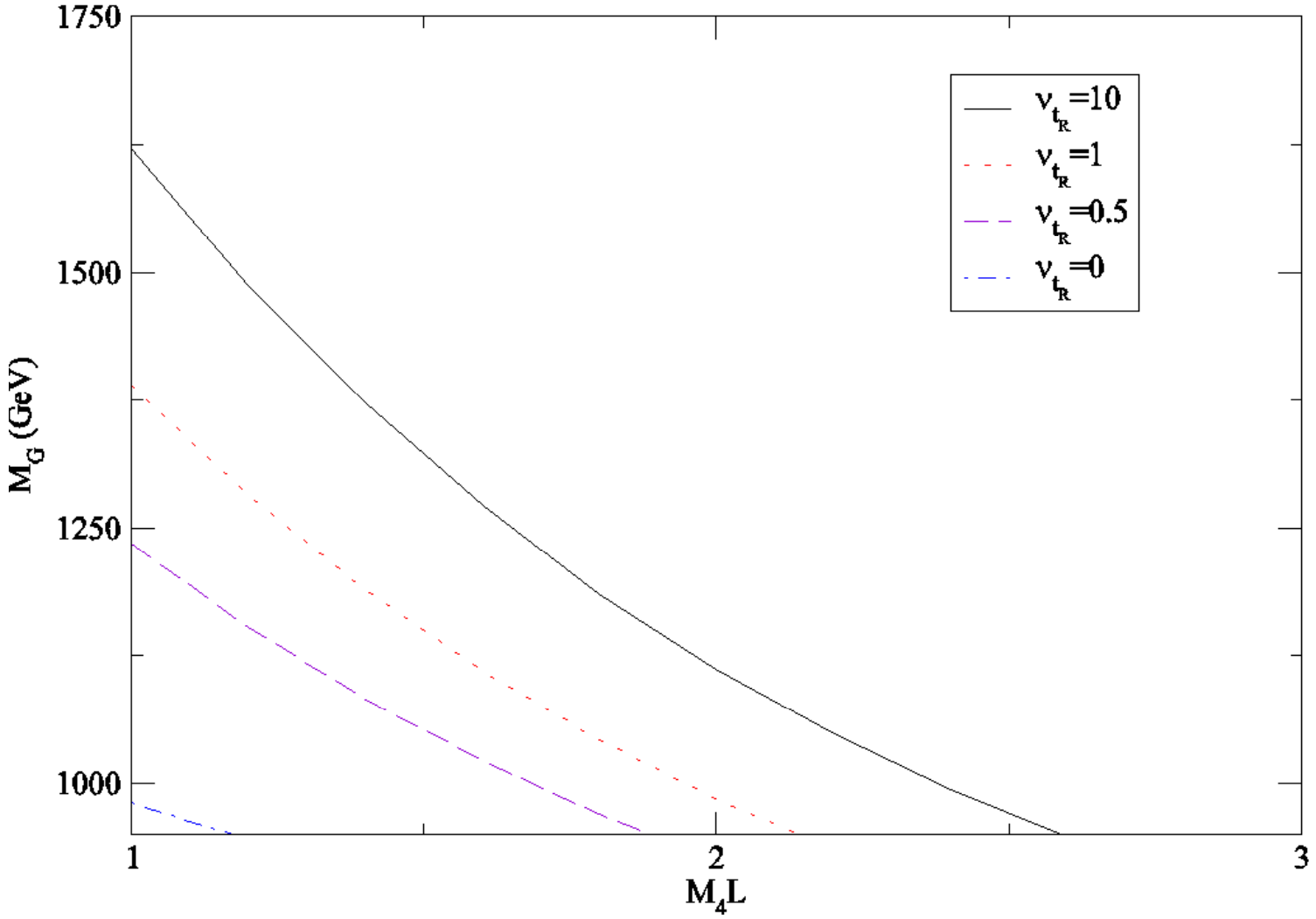
Given:

- the production cross section
- branching ratio to tops = 70%
- top finding/reconstruction efficiency = 3% ?
- invariant mass uncertainty = 3% > graviton width
  → background estimate

we can compare to the (tt-bar) background to find the reach.

We will discuss top finding in a moment, but first…

Reach (5σ, 3% top efficiency)

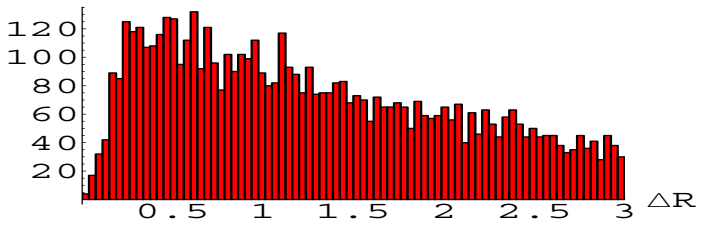


Top Finding

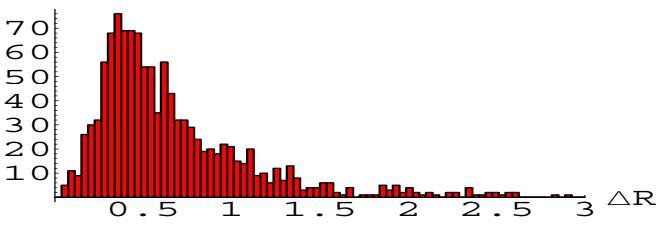
- Studies near threshold show efficiency ~ 1%,
  but we are far from threshold
- Simplest to construct Inv Mass from well-separated decay products using ΔR (figure)
- Possibility of using fat jets, though background greater
- For discovery, only need to identify resonance,
  no need to fully identify top decay products

ATLAS Study: Hubaut et. al., hep/ex-0508061

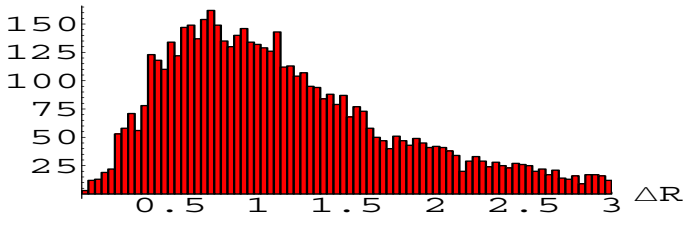
Counts, m_{grav}=500GeV



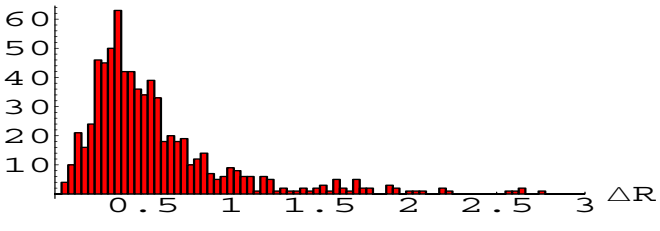
Counts, m_{grav}=2500GeV



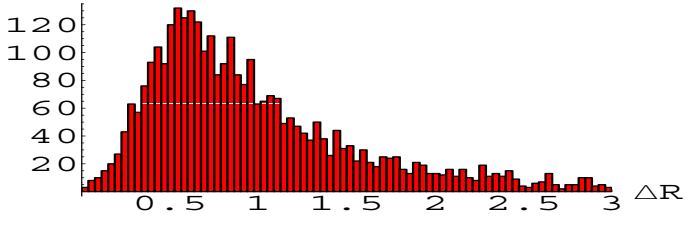
Counts, m_{grav}=1000GeV



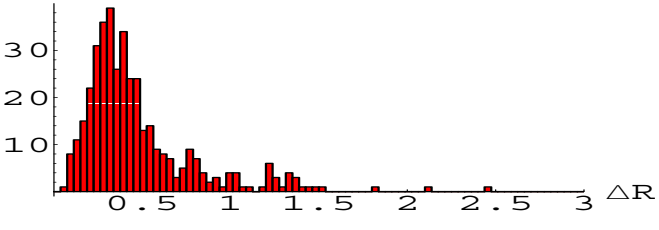
Counts, m_{grav}=3000GeV



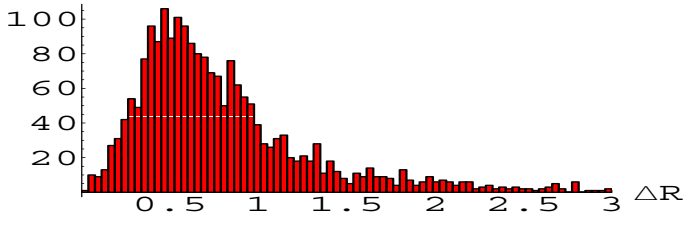
Counts, m_{grav}=1500GeV



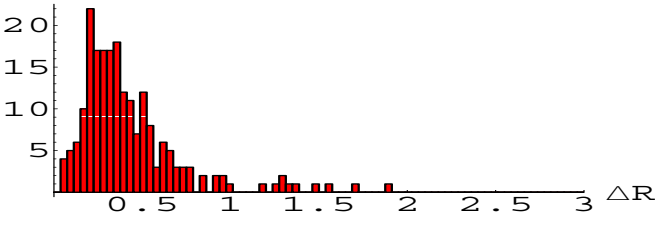
Counts, m_{grav}=3500GeV



Counts, m_{grav}=2000GeV



Counts, m_{grav}=4000GeV

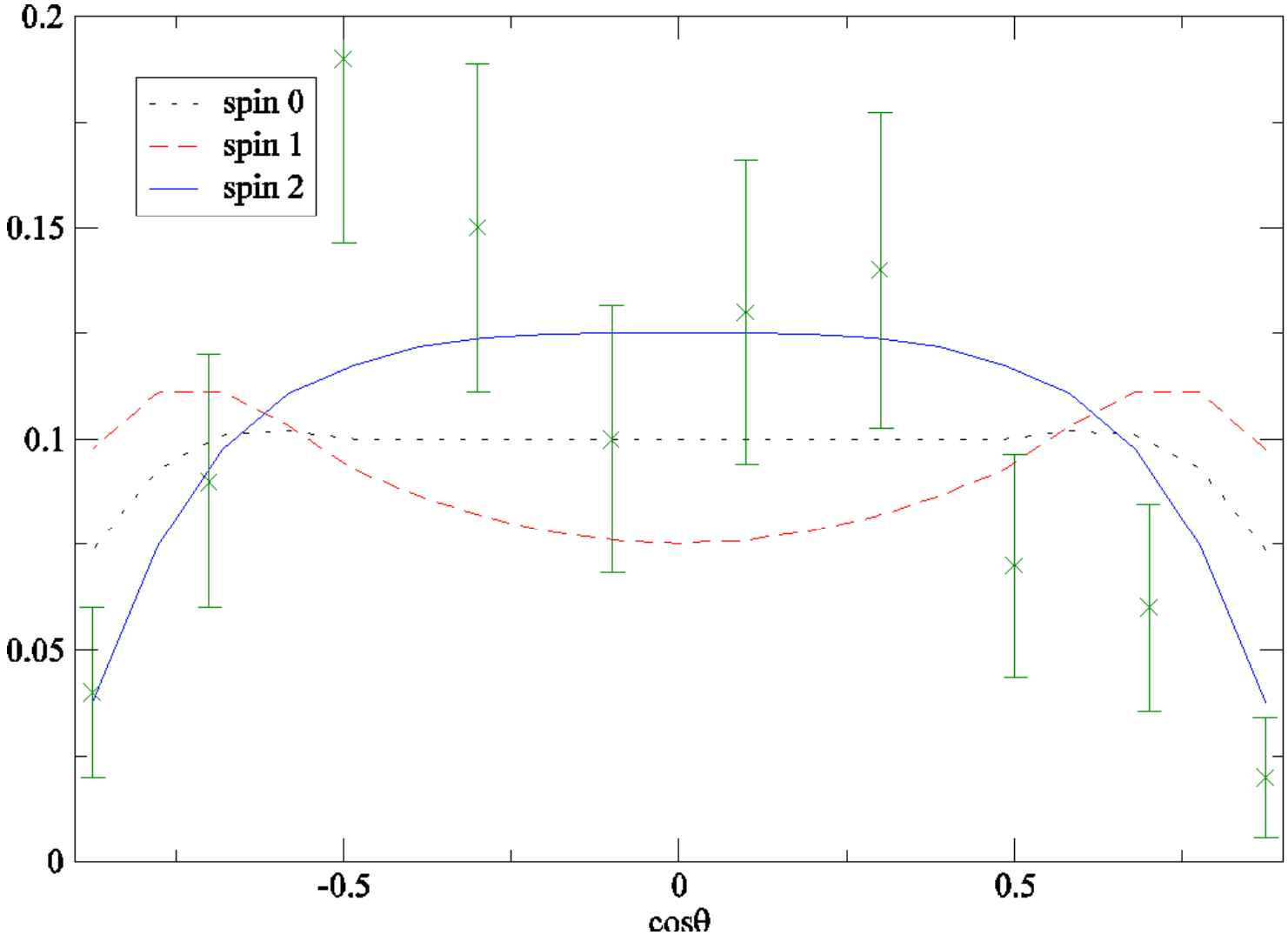


Spin Measurement

- qq → V → tt has distribution $1+\cos^2(\theta)$
- qq → G → tt has distribution $1-\cos^4(\theta)$
- Vanishes on z-axis due to angular momentum conservation!
- Fewer events for all spins near z-axis due to η cut

Thus with an adequate number of events, spin measurement could be possible.

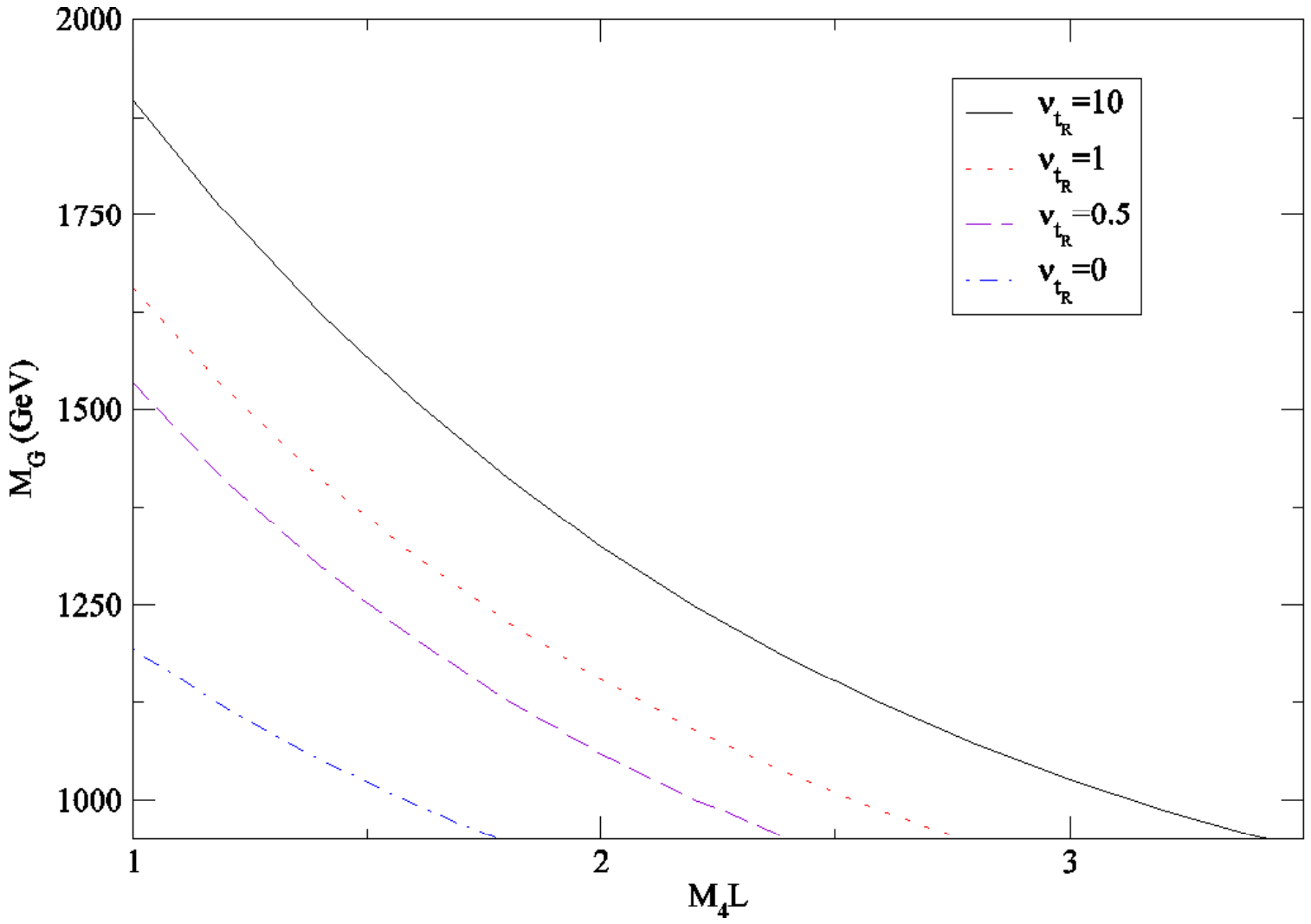
Spin Measurement (100 events)



Conclusion

- Discovering a KK Graviton will be challenging in most optimistic scenarios, but key to identifying RS models
- Spin 2 (relatively) easy to distinguish from vector boson
- Further progress requires better understanding of highly boosted Top ID

Reach (5σ, 10% efficiency)



Reach (5σ, 100% efficiency)