

The elusive gluon at the LHC

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The quest for naturalness

Two main contenders

Supersymmetry



- Weakly dynamics
- Light stops
 $m_{\tilde{t}} \gtrsim 700 \text{ GeV}$

Composite Higgs



- Strong dynamics
- Light top partners
 $m_T \gtrsim 800 \text{ GeV}$

The composite Higgs

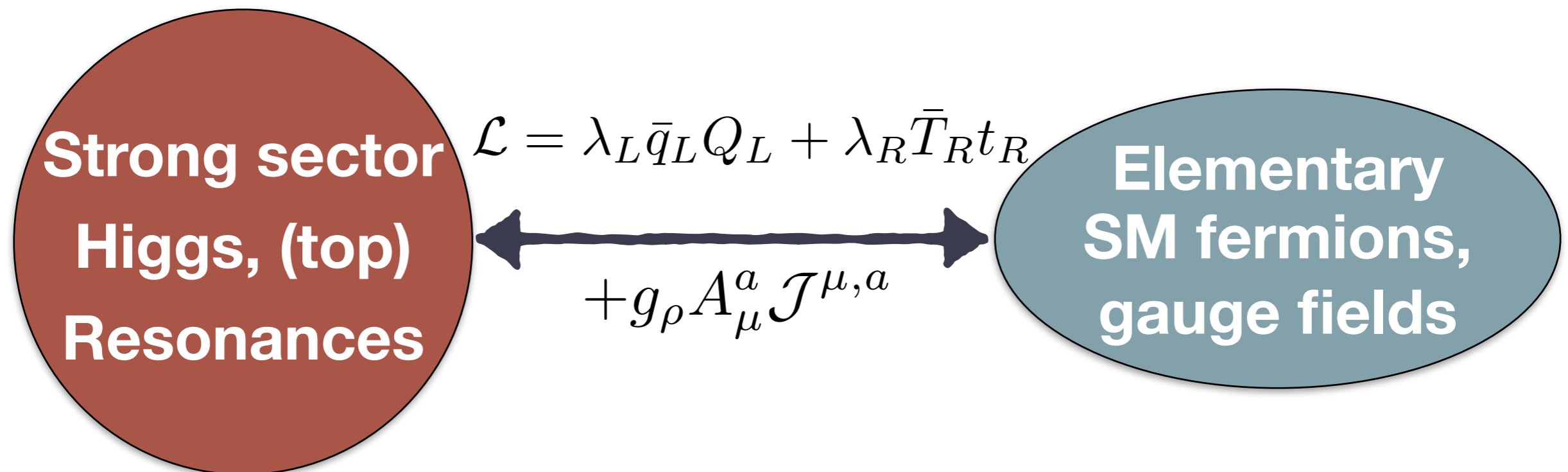


Higgs as a pseudo Nambu-Goldstone boson

$$G \rightarrow H \supset SU(2)_L \times SU(2)_R$$

Simplest realization: Minimal composite Higgs model (MCHM)
based on $SO(5)/SO(4)$.

Agashe, Contino, Pomarol '04



Partial compositeness: quarks and leptons get a mass by mixing with composite fermions

Kaplan '91; Agashe, Contino, Pomarol '05

An effective approach

Useful to capture the relevant collider phenomenology

De Simone, Matsedonsyi, Rattazzi & Wulzer, JHEP(13)

M4₅

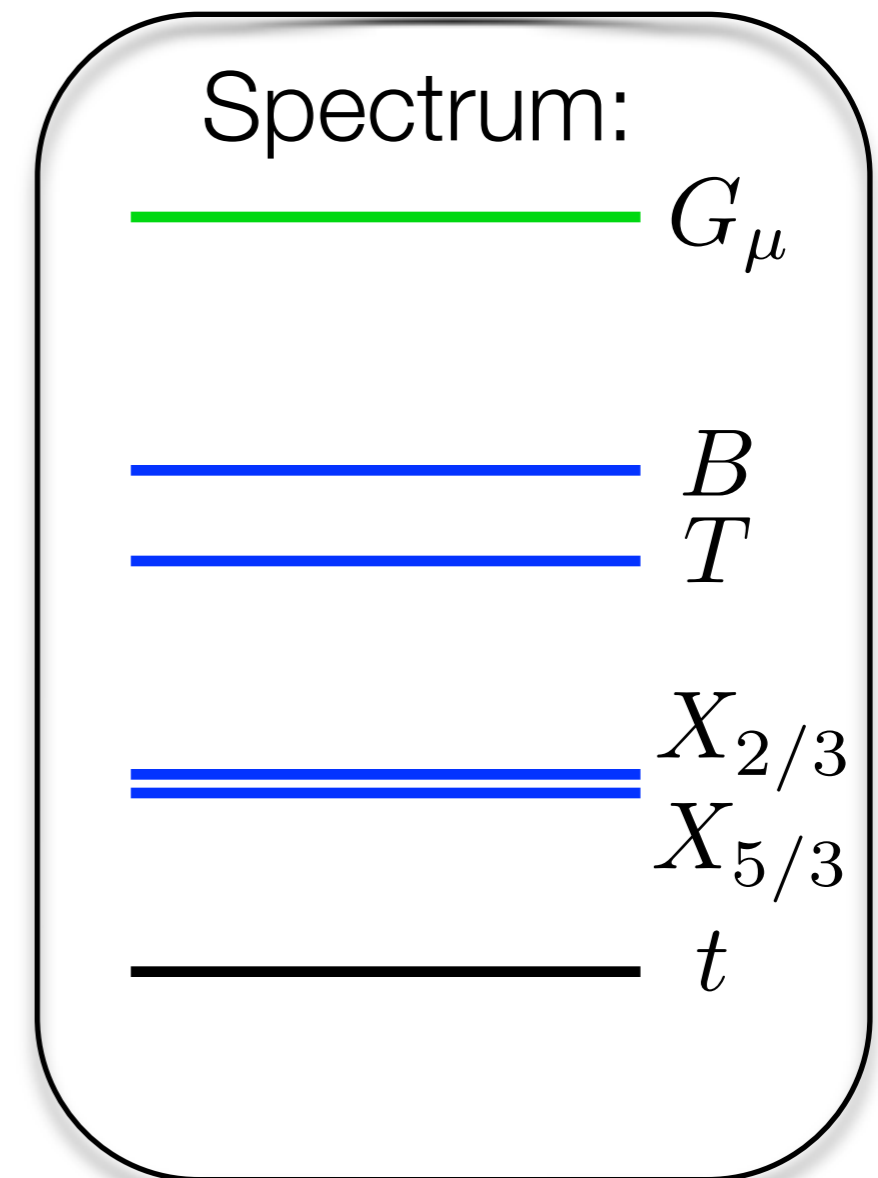
- ▶ Minimal coset: $SO(5) \rightarrow SO(4)$
- ▶ Fully composite t_R
- ▶ Top partners in a **4** of $SO(4)$
+ heavy gluon

$$\Psi = \begin{pmatrix} T & X_{5/3} \\ B & X_{2/3} \end{pmatrix}$$

$$\text{Br}(X_{5/3} \rightarrow tW^+) = \text{Br}(B \rightarrow tW^-) = 1$$

$$\text{Br}(X_{2/3} \rightarrow th) \approx \text{Br}(X_{2/3} \rightarrow tZ) \approx 0.5$$

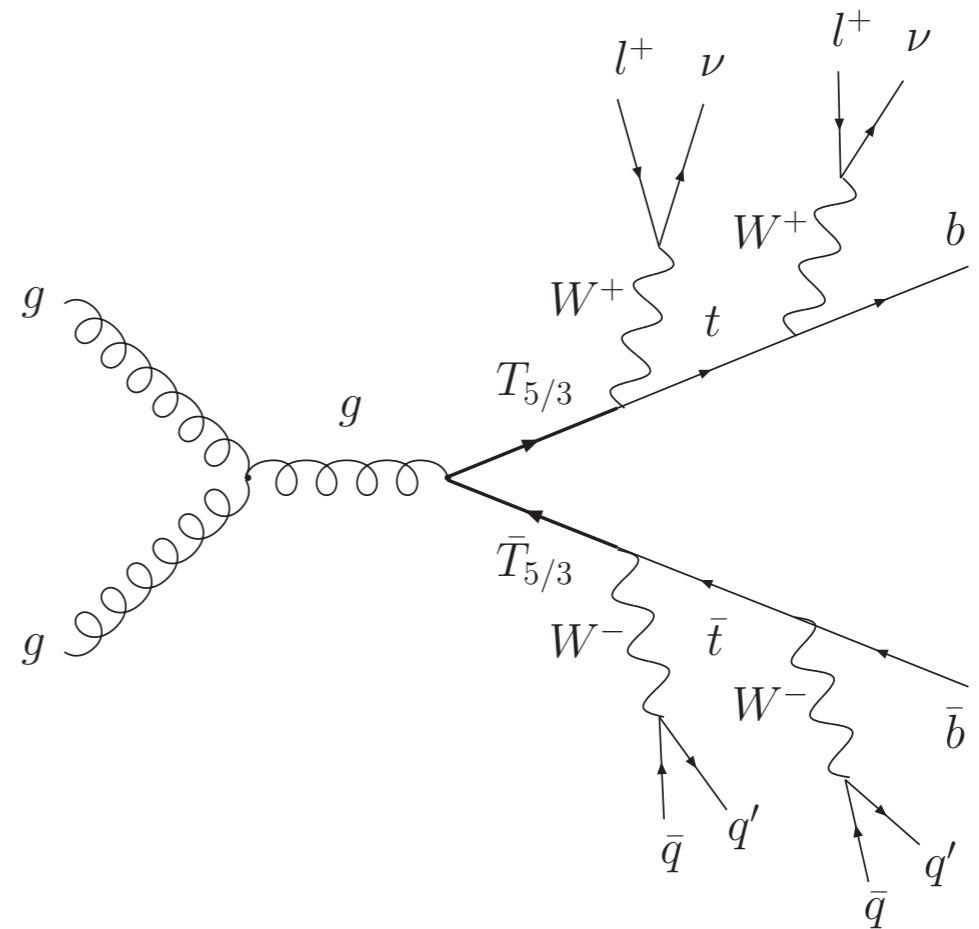
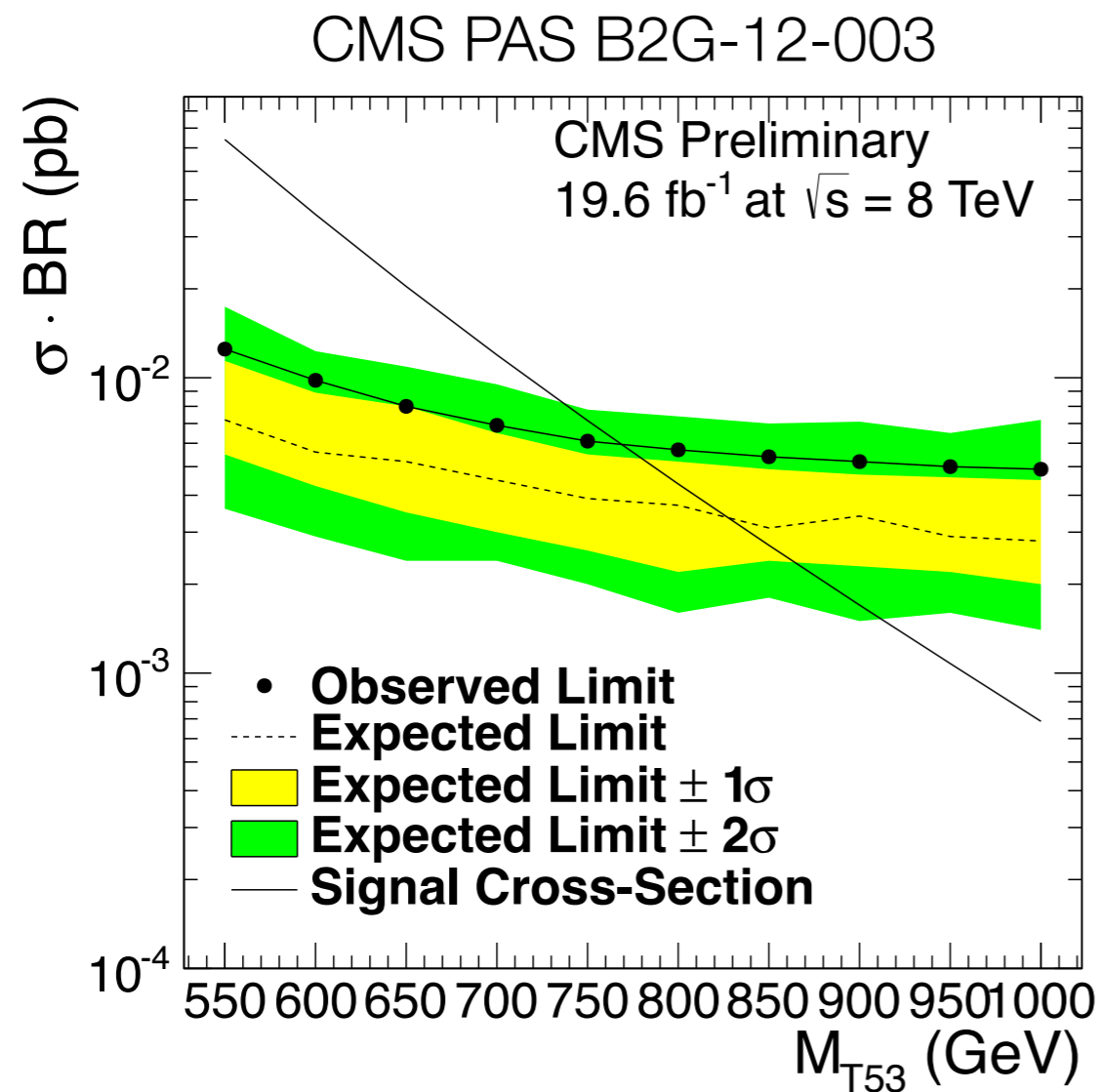
$$\text{Br}(T \rightarrow th) \approx \text{Br}(T \rightarrow tZ) \approx 0.5$$



Direct searches of resonances

The exotic state $X_{5/3}$

- Limits from same-sign dilepton processes

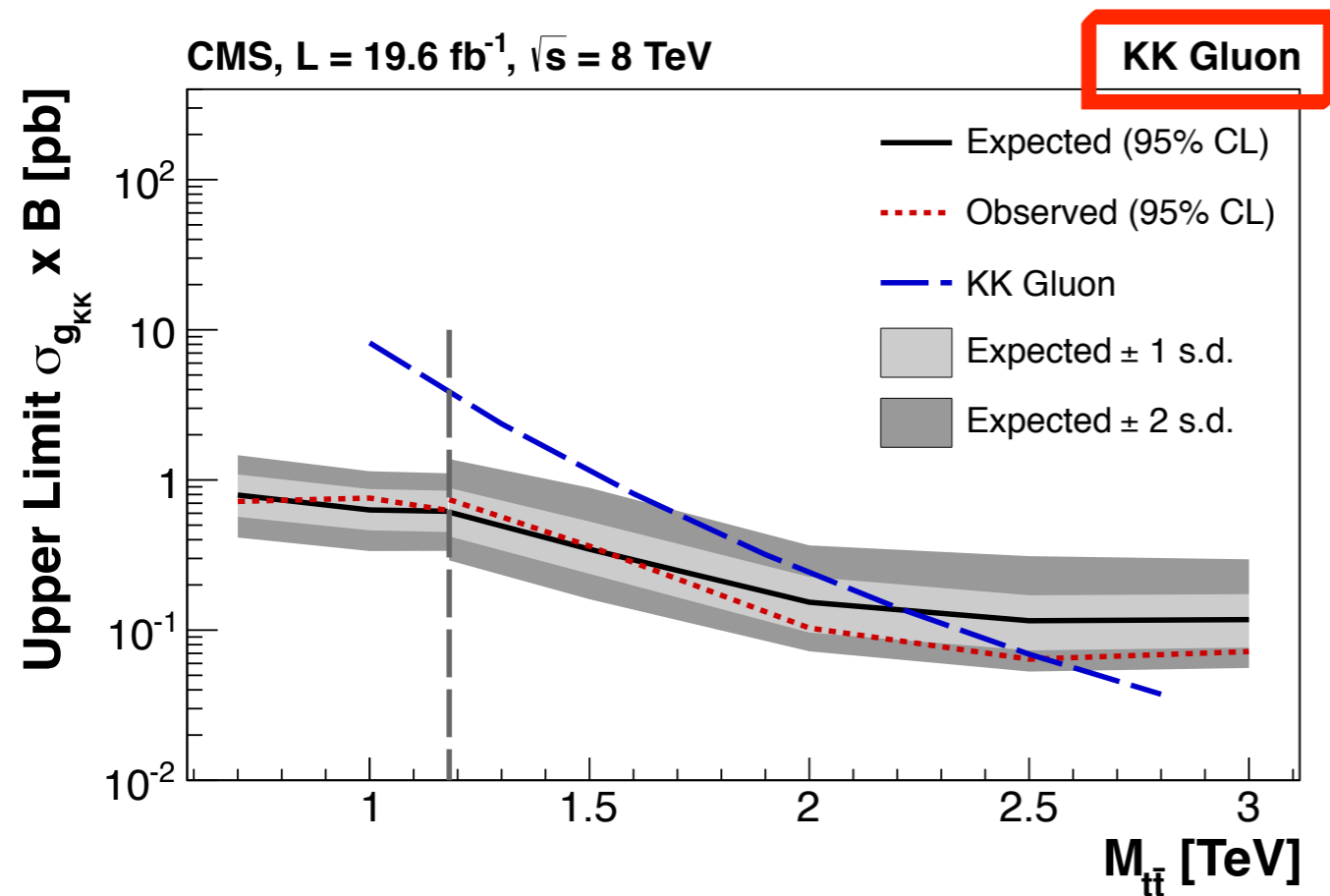


Direct searches of resonances

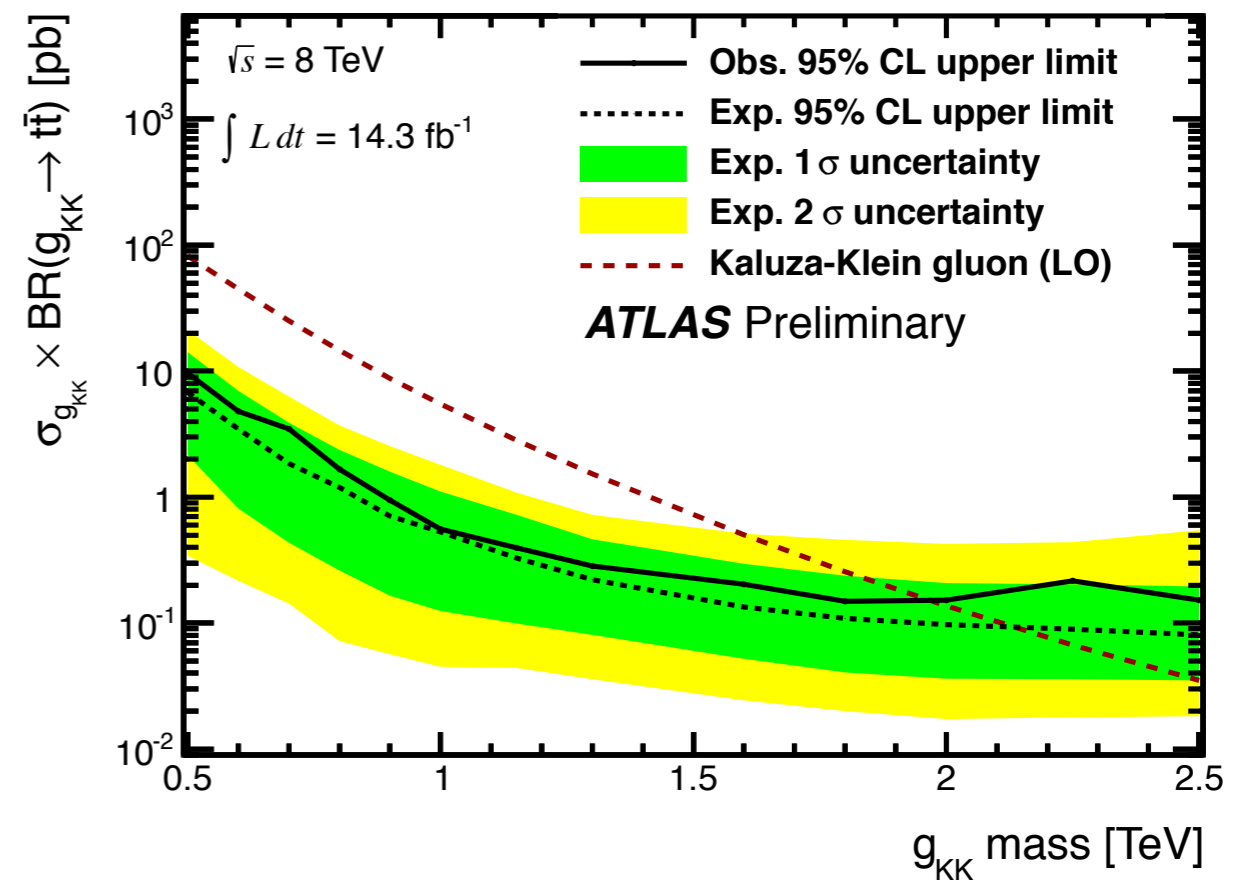
Heavy gluon

- Searches for top-pair resonances in lepton+jets channel

CMS-B2G-13-001



ATLAS-CONF-2013-052



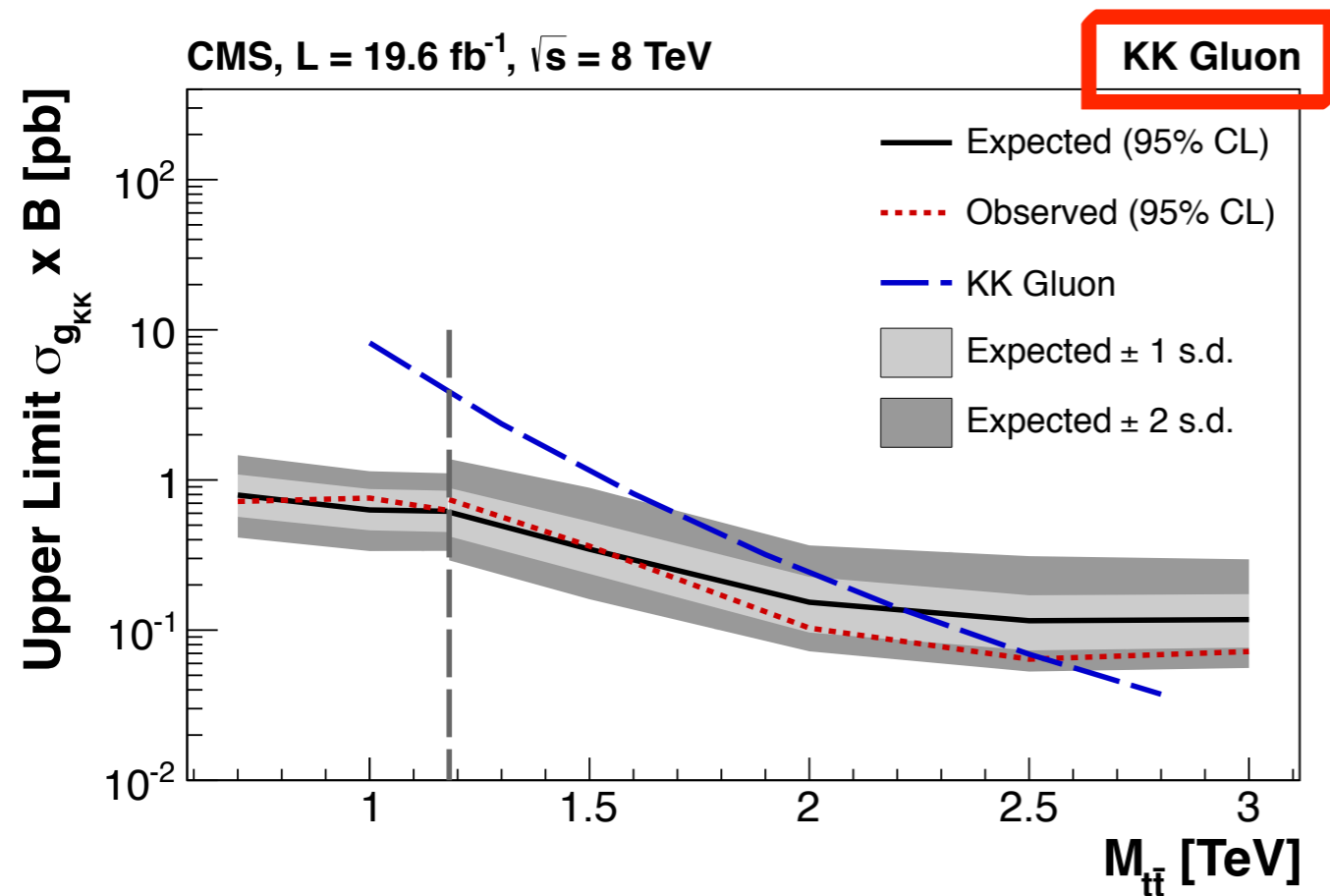
Randall-Sundrum KK gluons excluded up to 2.5 TeV

Direct searches of resonances

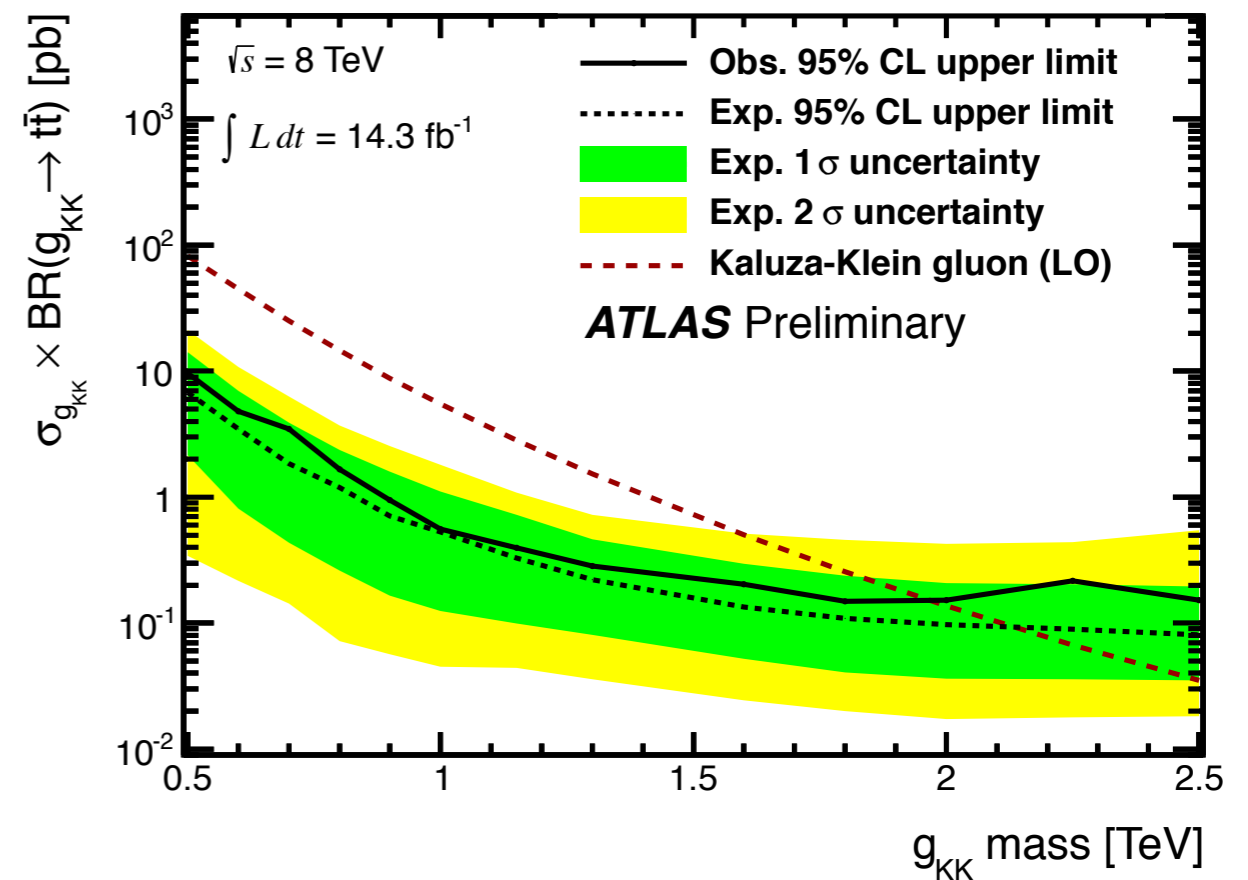
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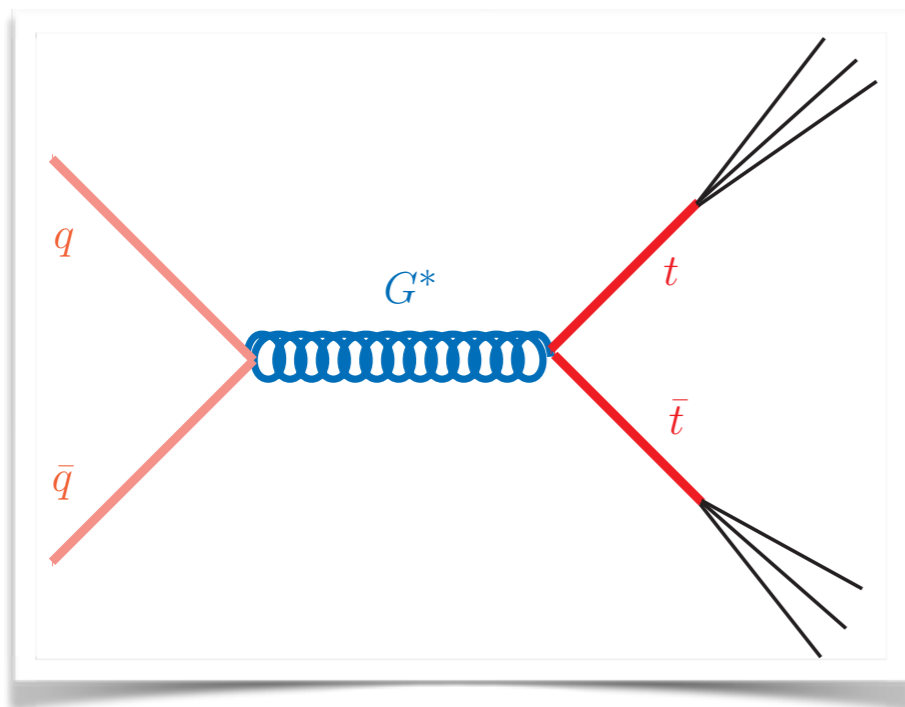
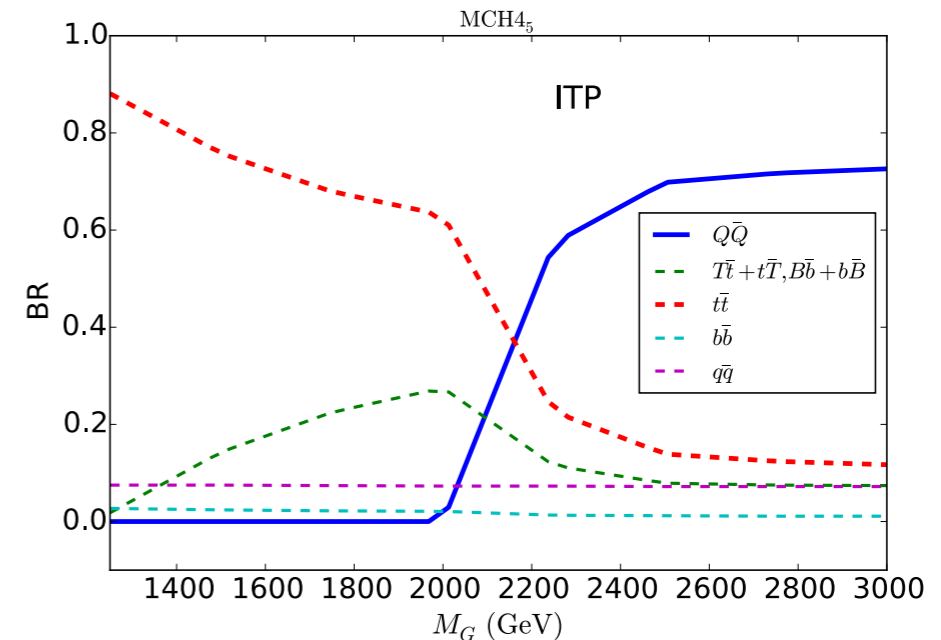
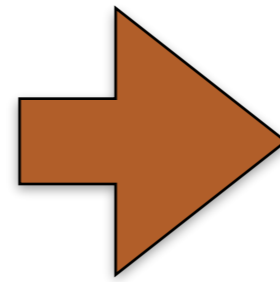
Randall-Sundrum KK gluons excluded up to 2.5 TeV

What effects do top partners have
on searches for heavy gluon?

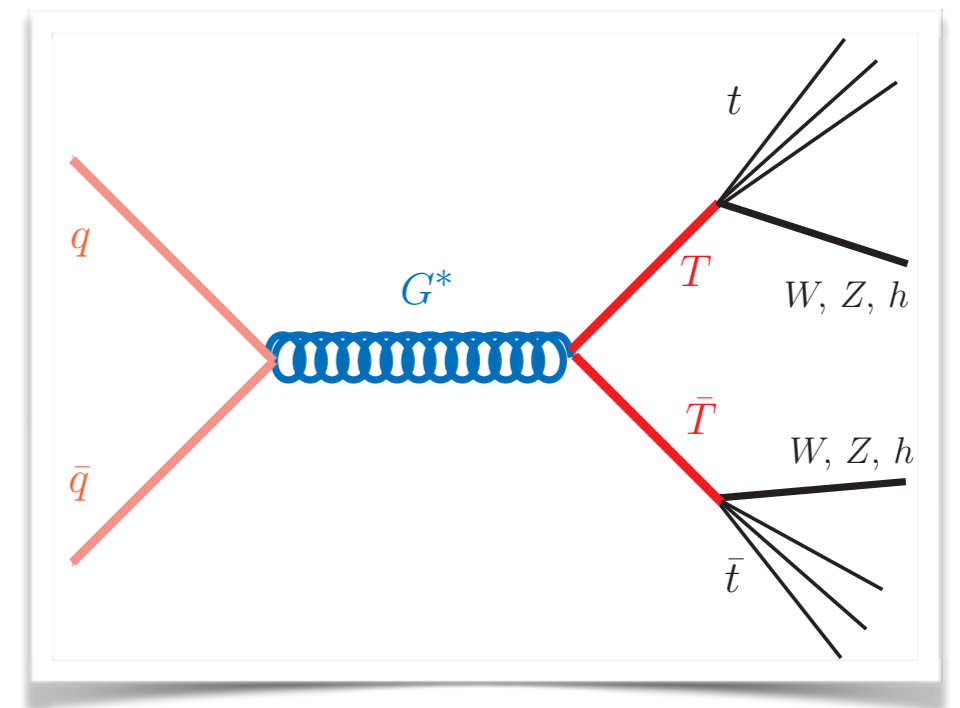
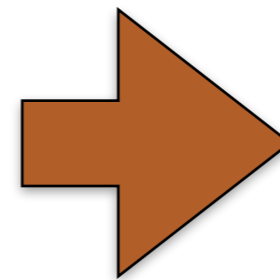
Do we search for the right thing?

The heavy gluon is part of the composite sector

- It decays dominantly to the most composite fermions (t, T) allowed by kinematics



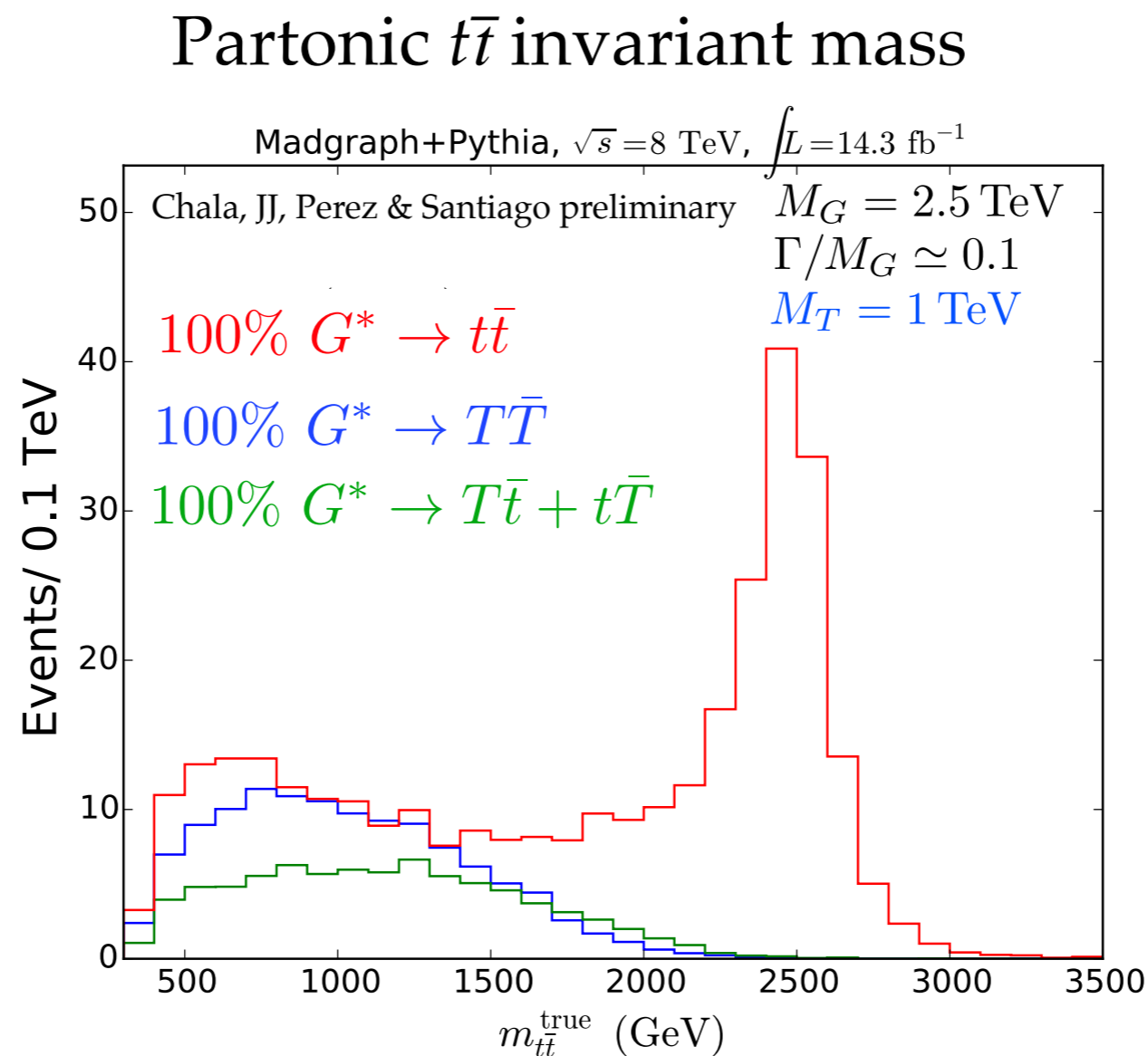
$$m_{G^*} > 2m_T$$



Do we search for the right thing?

Heavy gluon searches designed for the RS KK gluon

- $T \rightarrow t + W/Z/h \Rightarrow$ the observed spectrum becomes softer

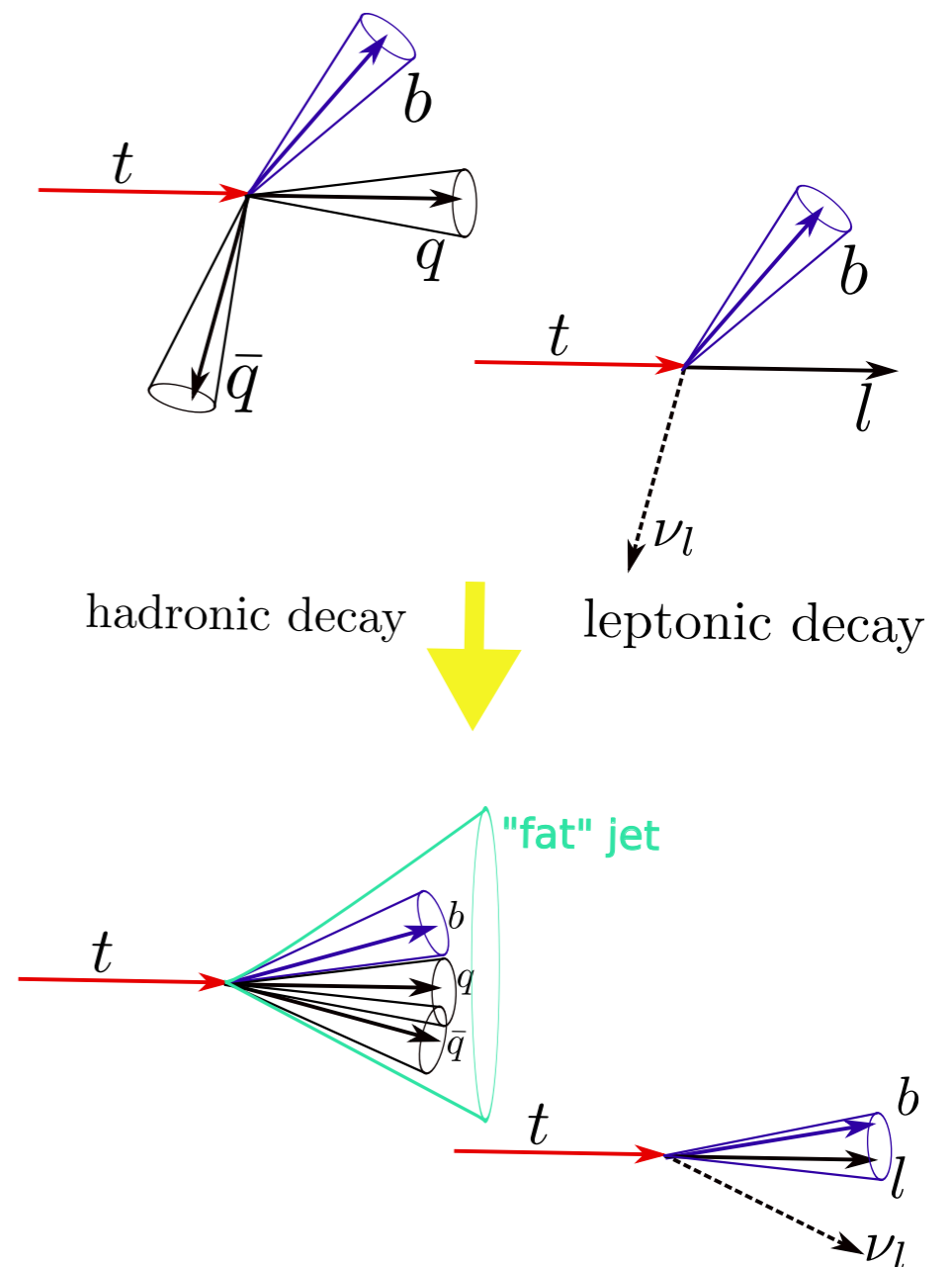


Note: ttbar reconstruction @ ATLAS

(ATLAS-CONF-2013-052)

Analysis performed in the lepton+jets channel

- One lepton with $mini-ISO > 0.95$
- High missing transverse energy
- **Resolved topology**
 - ≥ 4 jets, $p_T > 25$ GeV
 - ≥ 1 b-jet
- **Boosted topology**
 - ≥ 1 large- R jet, $p_T > 350$ GeV
 - ≥ 1 jet, $p_T > 25$ GeV
 - jet close to lepton
 - jet substructure: $\sqrt{d_{12}} > 40$ GeV, $m_J > 100$ GeV



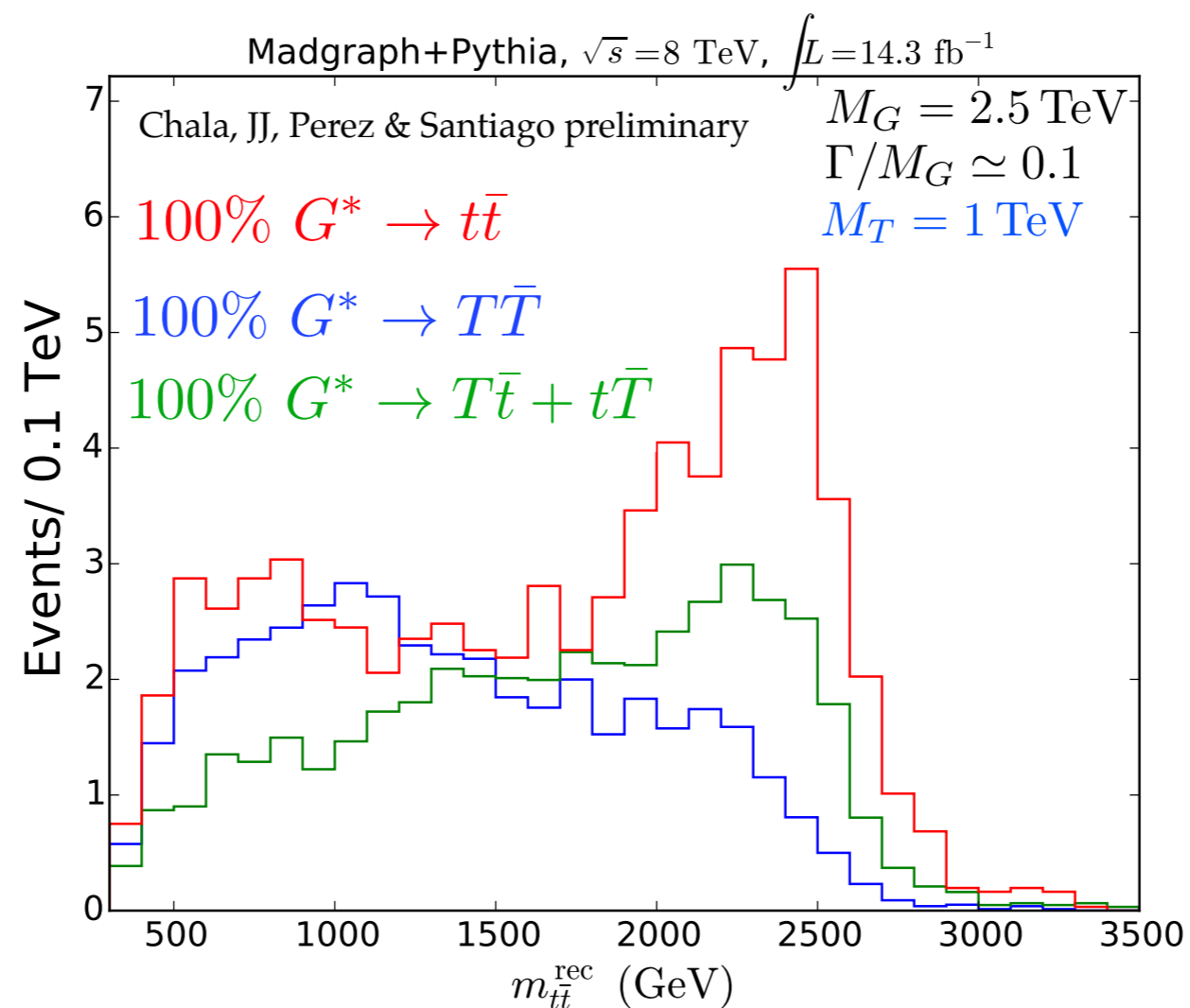
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Reconstructed $t\bar{t}$ invariant mass

ATLAS reconstruction
ATLAS-CONF-2013-052

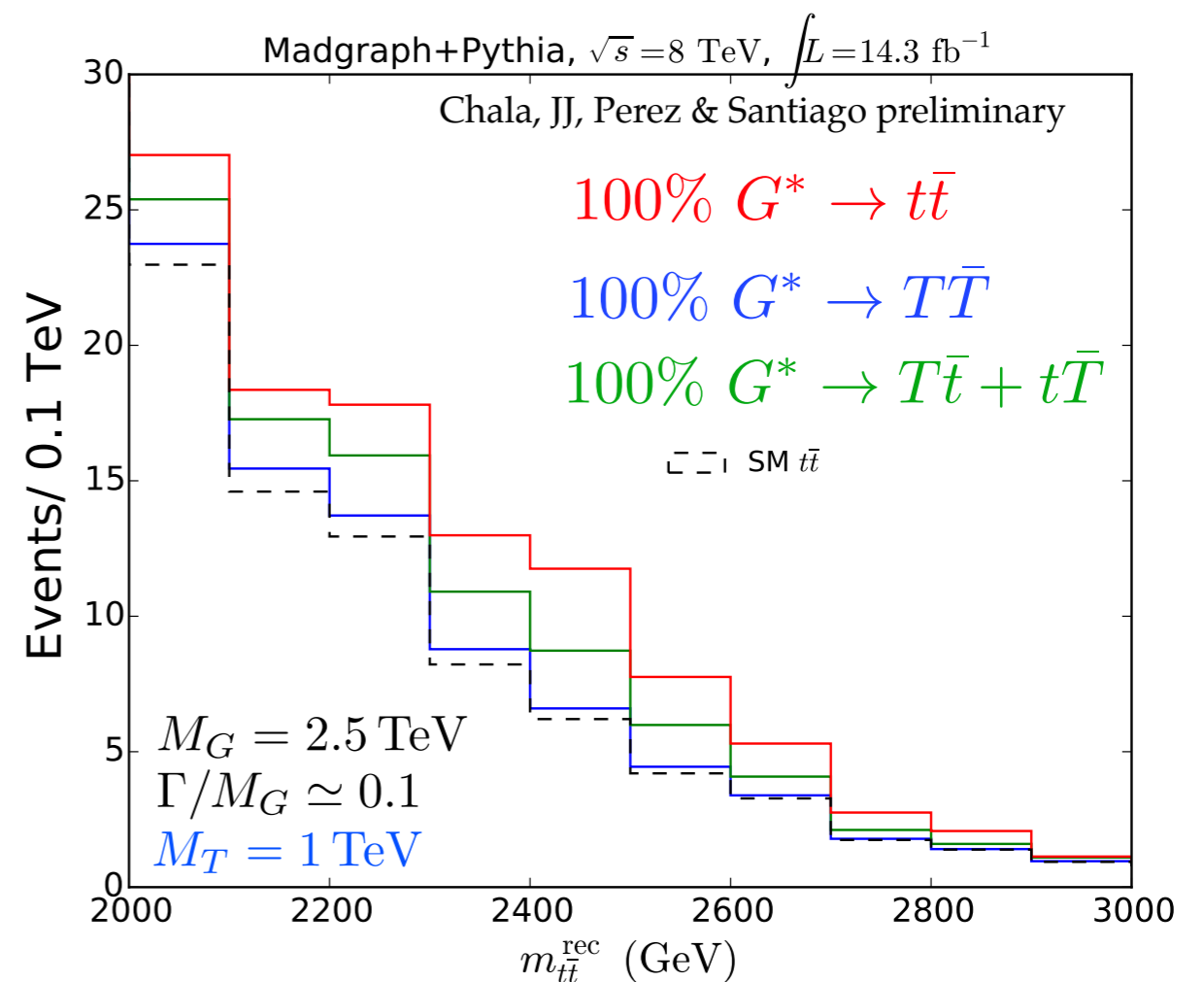
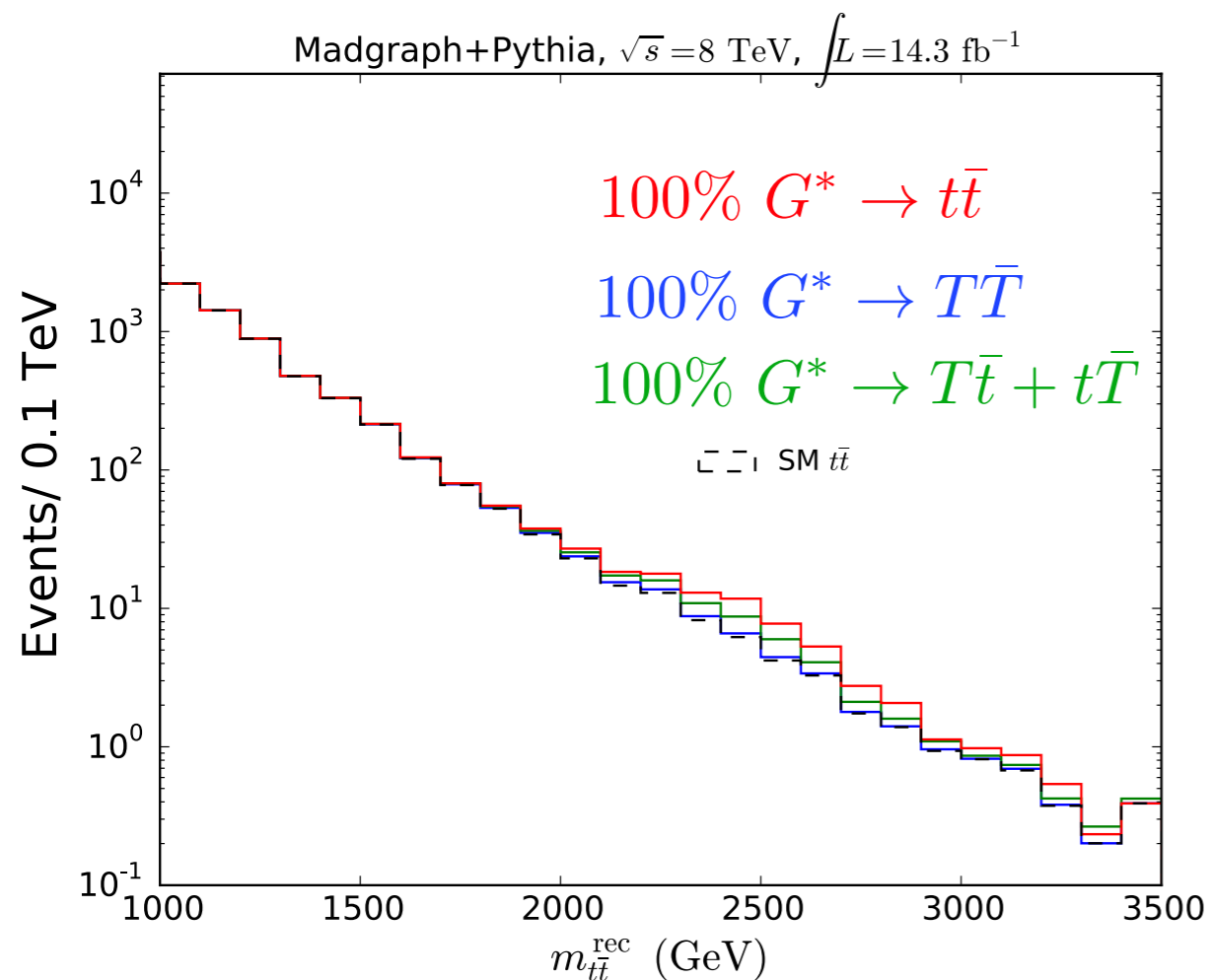


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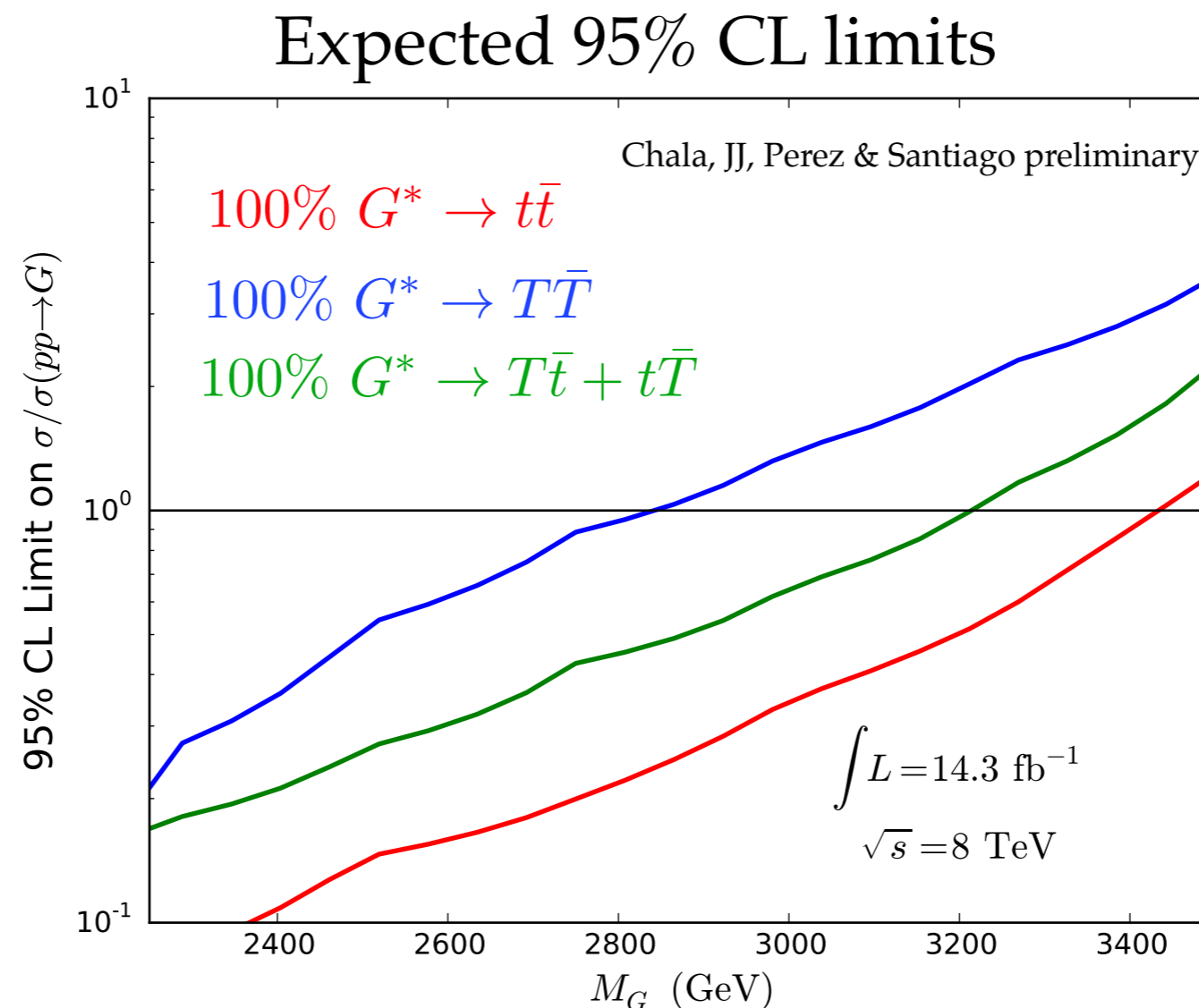
adding SM $t\bar{t}$ reconstructed invariant mass



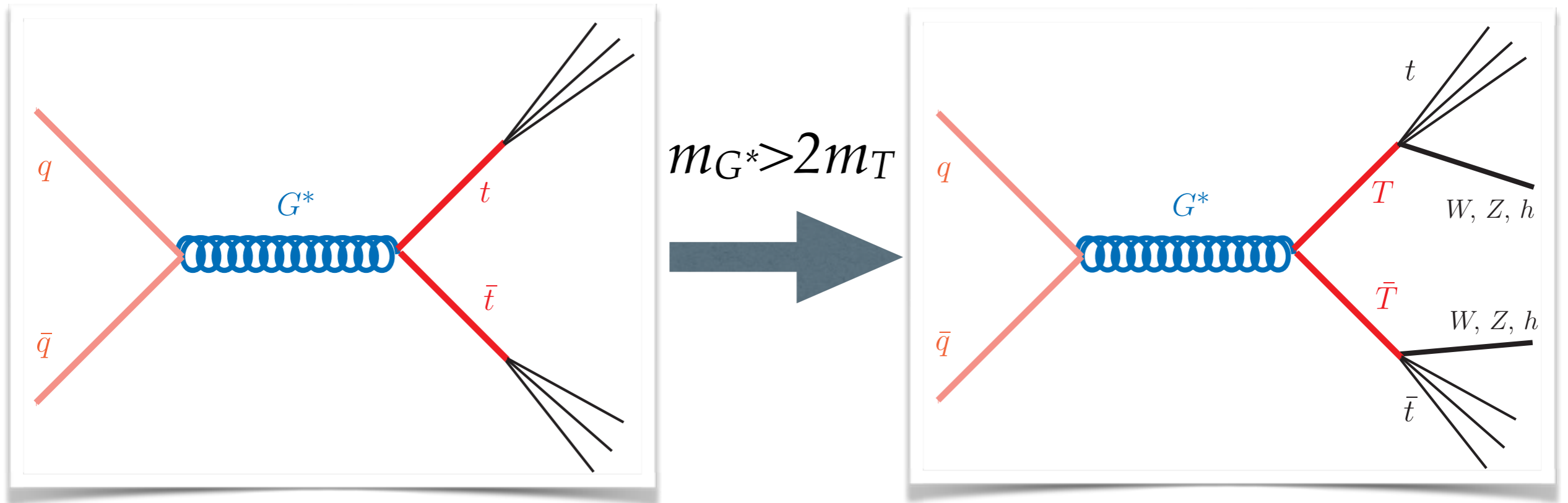
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The elusive gluon



Asks for new kind of searches

Summary

- ▶ Natural composite Higgs models provide a viable solution to the hierarchy problem; they generically predict “lightish” top partners.
- ▶ The phenomenology of heavy gluons widely differs from that of the simpler models considered so far.
- ▶ The heavy gluon bounds can be substantially weakened when considering the generic case of a fourplet being present.
- ▶ The complexity of final states asks for a more tailored study.

Thanks for your attention!

The elusive gluon??



The Elusive Gluon

Cape town, South Africa

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Gluons /'glu:ɒnz/ are elementary particles that act as the exchange particles (or gauge bosons) for the strong force between quarks, analogous to the exchange of photons in the electromagnetic force between two charged



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