$t\bar{t}$ asymmetry, axigluons and multijet signals at the LHC

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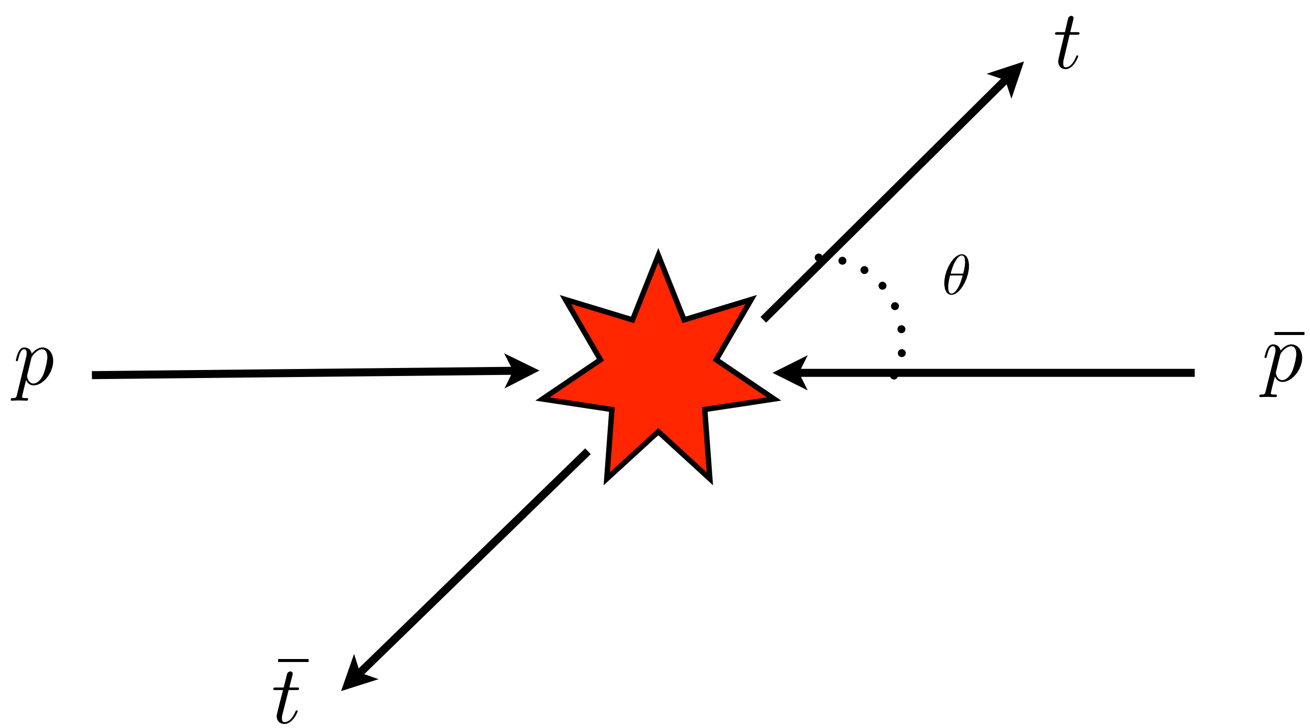
ttbar forward-backward asymmetry



$$A_{FB} = \frac{N_{\theta<\pi/2} - N_{\theta>\pi/2}}{N_{total}}$$

$$\text{SM} \;\; \sim 7\%$$

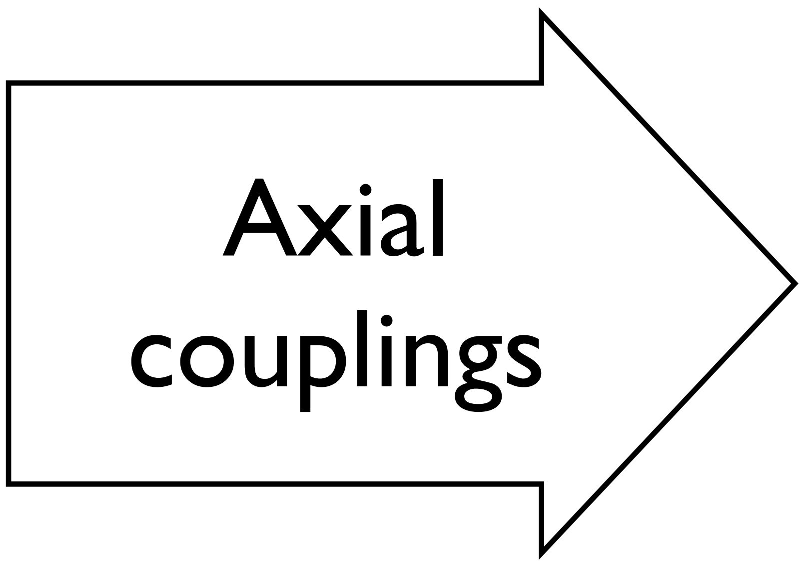
Combining CDF single lepton + dilepton with D0 single lepton measurement

$$A_{FB} = 0.185 \pm 0.037$$

New physics explanations

Few models still viable: Light Axigluon

$$
\begin{aligned}
\frac{d\sigma}{d\cos\theta} &= \frac{\beta}{144\pi s}\left\{\left[g_s^4(1+c^2+\frac{4m_t^2}{s})\right] + \frac{2s(s-m_A^2)}{(s-m_A^2)^2+m_A^2\Gamma_A^2}\left[g_V^q g_V^t g_s^2(1+c^2+\frac{4m_t^2}{s}) + 2g_A^q g_A^t g_s^2\, c\right]\right. \\
&+ \left.\frac{s^2}{(s-m_A^2)^2+m_A^2\Gamma_A^2}\left[((g_V^q)^2+(g_A^q)^2)\{(g_V^t)^2(1+c^2+\frac{4m_t^2}{s})+(g_A^t)^2(1+c^2-\frac{4m_t^2}{s})\}+g_V^q g_A^q g_V^t g_A^t\, 8c\right]\right\}
\end{aligned}
$$



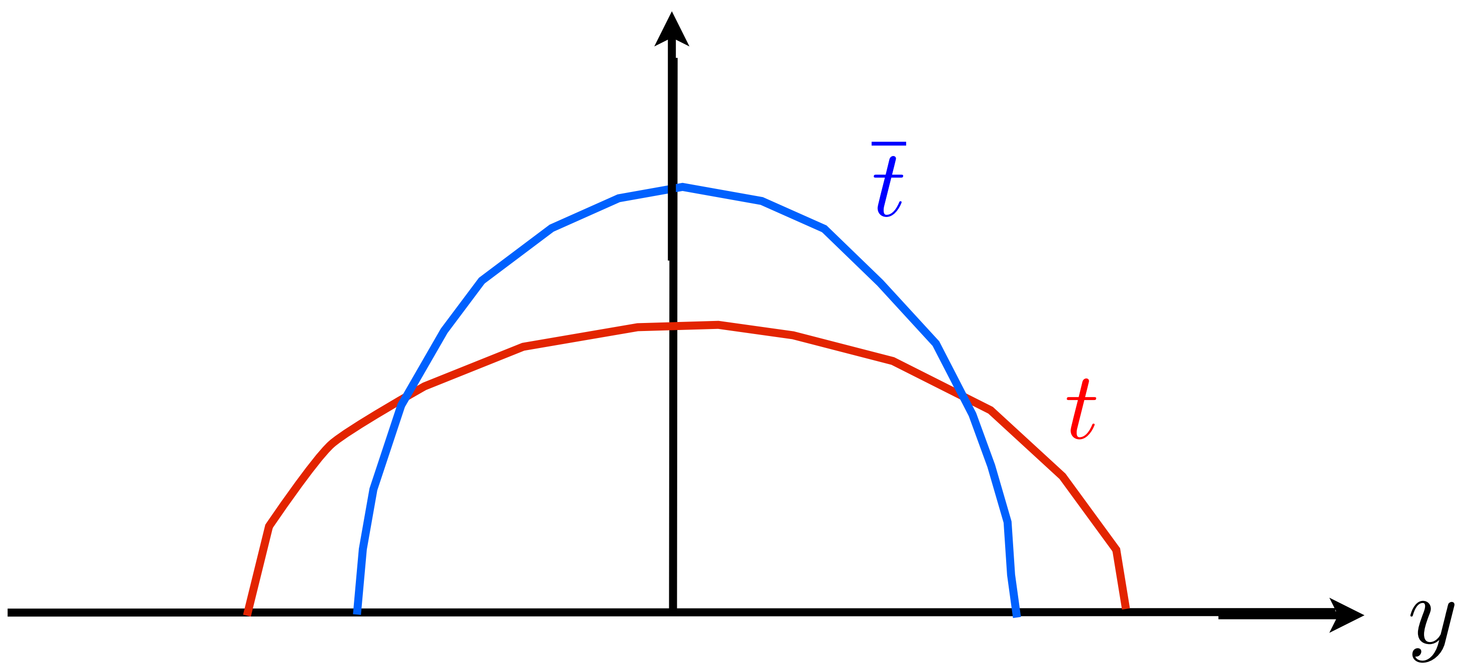
- ➡ Asymmetry ~ $g_A{}^2$
- ➡ Cross-section ~ $g_A{}^4$

Can generate 10% asymmetry with $g_A \sim 0.4$ for masses between 100 GeV to 400 GeV

Tevatron has retired. What does the LHC tell us?

- ➡ It is a proton-proton collider. How to define forward?
- ➡ Can still be sensitive to asymmetry

LHC charge asymmetry

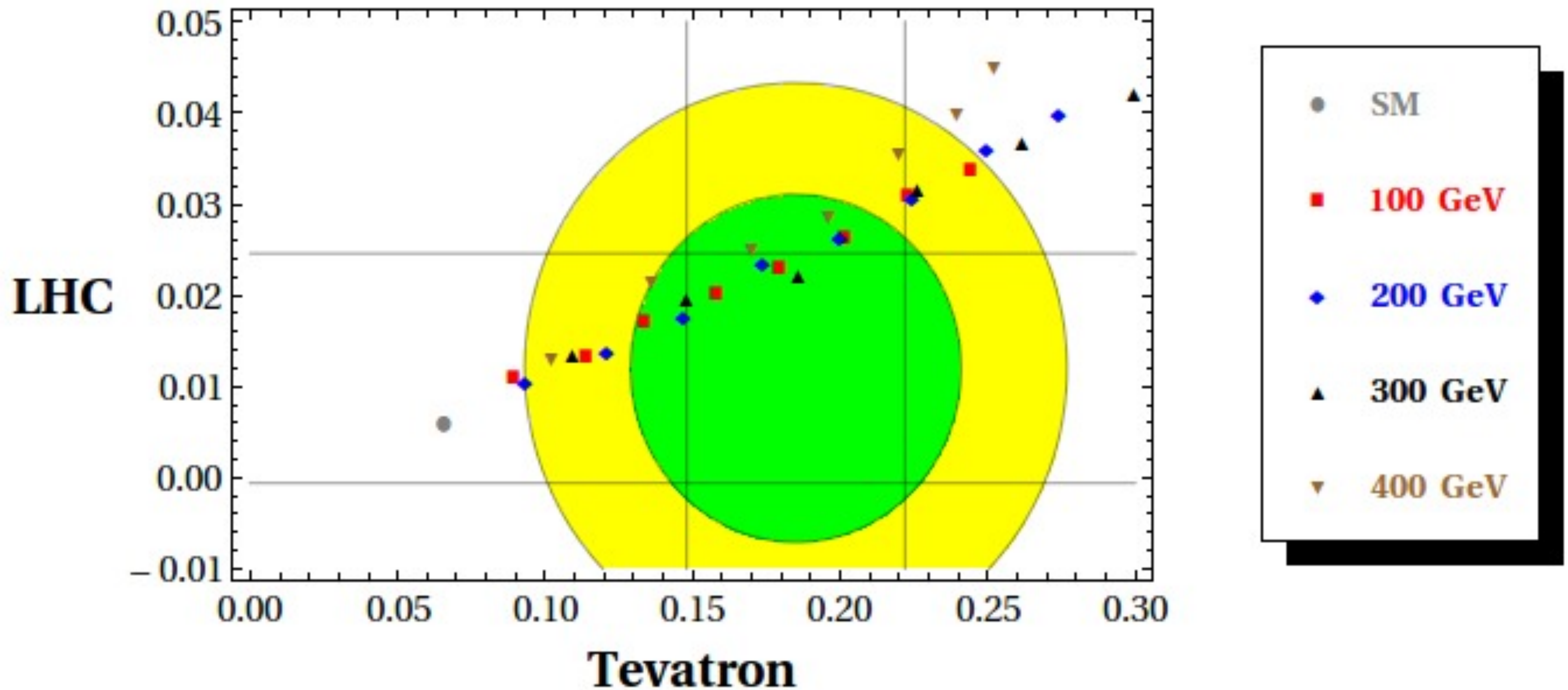


Rapidity distribution of top and anti-top should be different if there is a ttbar asymmetry

$$A_C^{SM} = 0.0115 \pm 0.0006$$

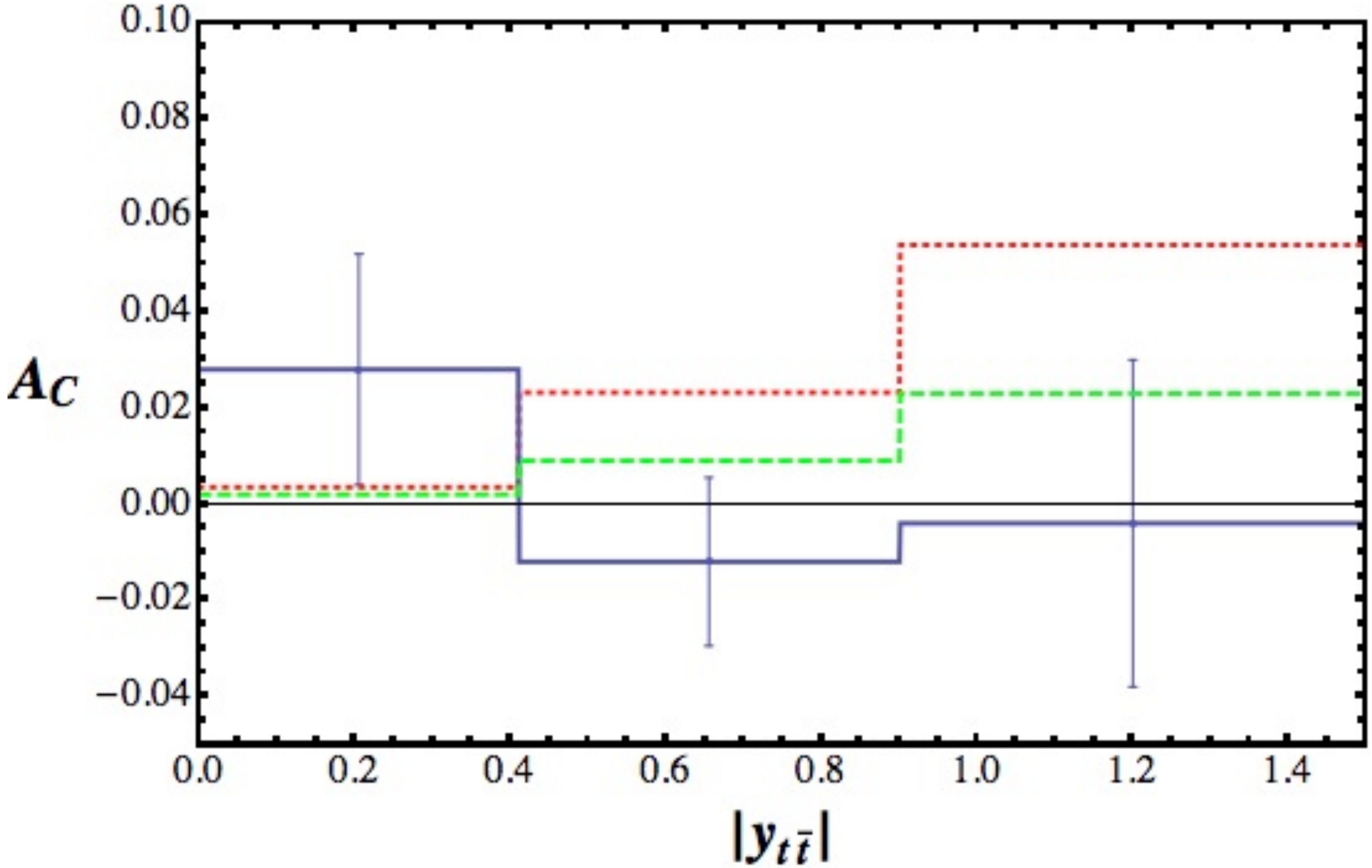
	semi leptonic	dileptonic
CMS	$0.004 \pm 0.010_{stat} \pm 0.011_{sist}$	$0.050 \pm 0.043_{stat} \pm 0.039_{sist}$
ATLAS	$-0.019 \pm 0.028_{stat} \pm 0.024_{sist}$	$0.057 \pm 0.024_{stat} \pm 0.015_{sist}$

Tevatron A_{FB} vs LHC A_C



Assuming flavor universal couplings.

Increase sensitivity to LHC charge asymmetry



CMS 5 fb^{-1}

Partial summary

➡ Interesting anomaly in top data

➡ Light axigluon is a great explanation to this anomaly and has a good fit to other top data.

➡ What about other constrains. Is it still alive?

Direct searches in hadron colliders

- Single production depends on the coupling to light quarks. Strong constrains from dijet searches.

- Since the asymmetry depends only on the product of g^l_A and g^t_A.

★ Decrease coupling to light quarks g^l_A. No constrains from dijet searches.

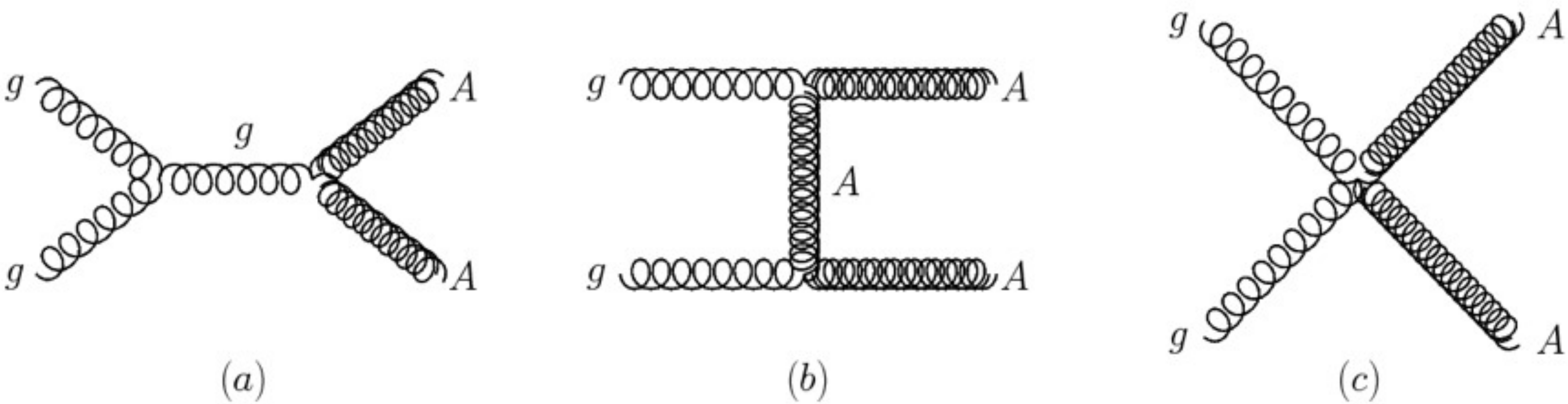
★ Increase coupling to 3rd generation to get large asymmetry.

Axigluon pair production

Pair production from gluon-gluon initial state:

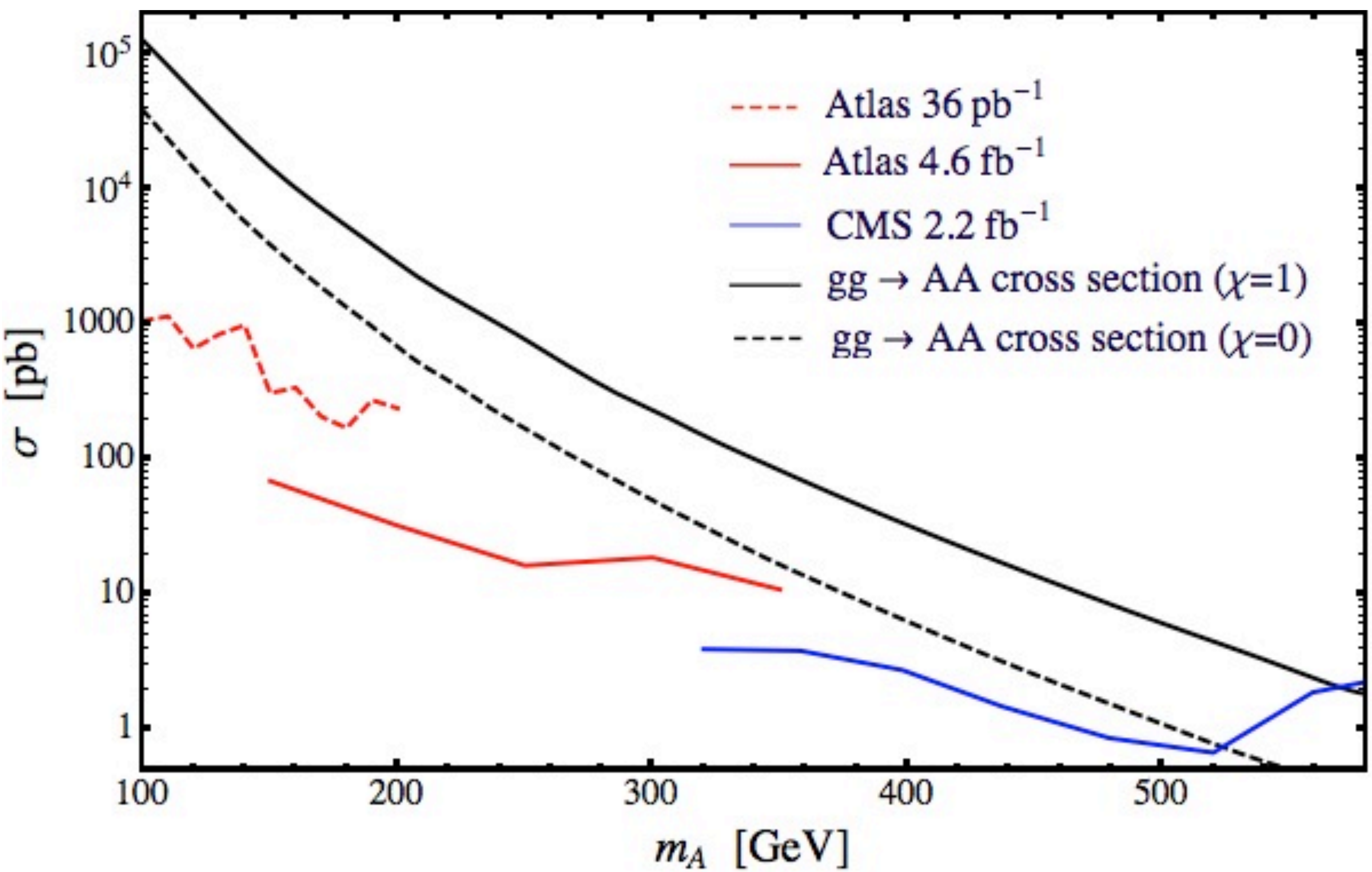
$$\mathcal{L} = -\frac{1}{2}\mathrm{tr}\left(D_\mu A_\nu - D_\nu A_\mu\right)^2 + m_A^2 \mathrm{tr}\left(A_\mu A^\mu\right) + i\chi\ g_s\ \mathrm{tr}\left(G^{\mu\nu}[A_\mu, A_\nu]\right)$$

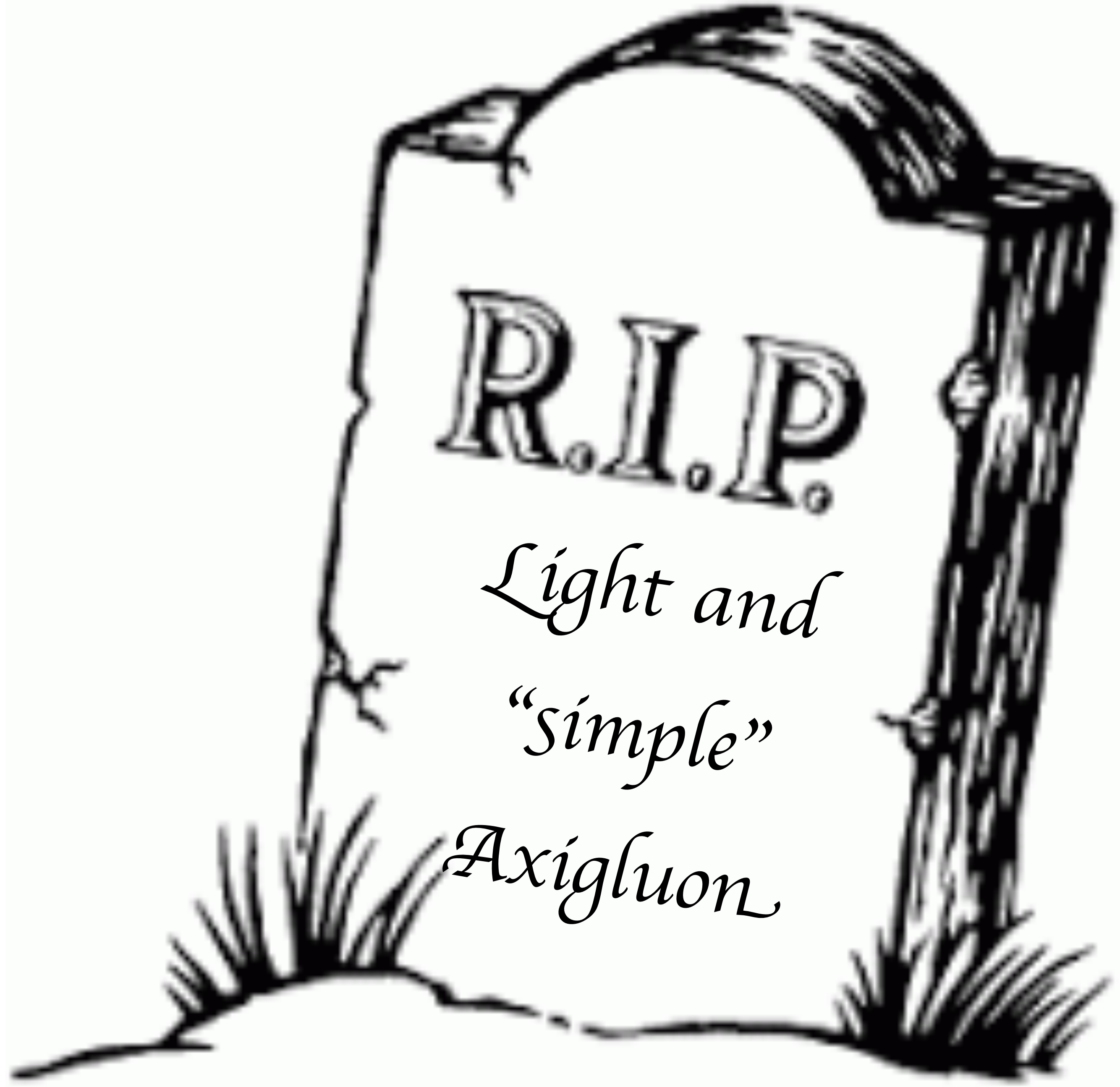
Unitarity of $g\,g \to A\,A$ at LO requires $\chi = 1$



This leads to a very large pair production cross-section of axigluons at the LHC.

Constrains on axigluon decaying to dijets



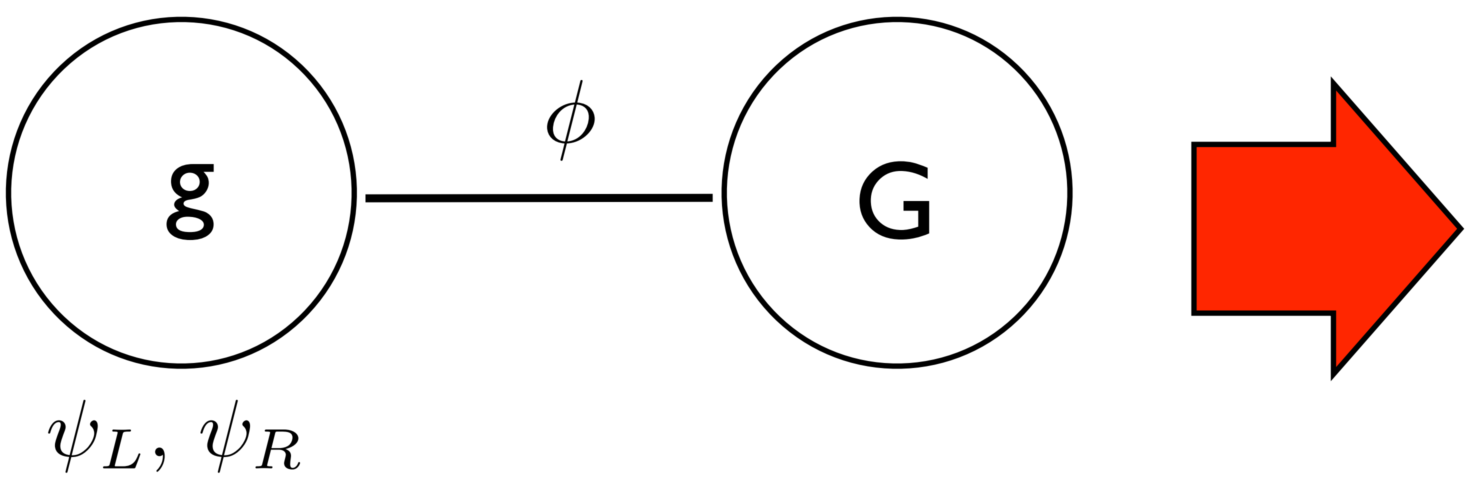


A simple model where the light axigluon decays to dijets has been totally "killed" by LHC data.

Remain optimistic

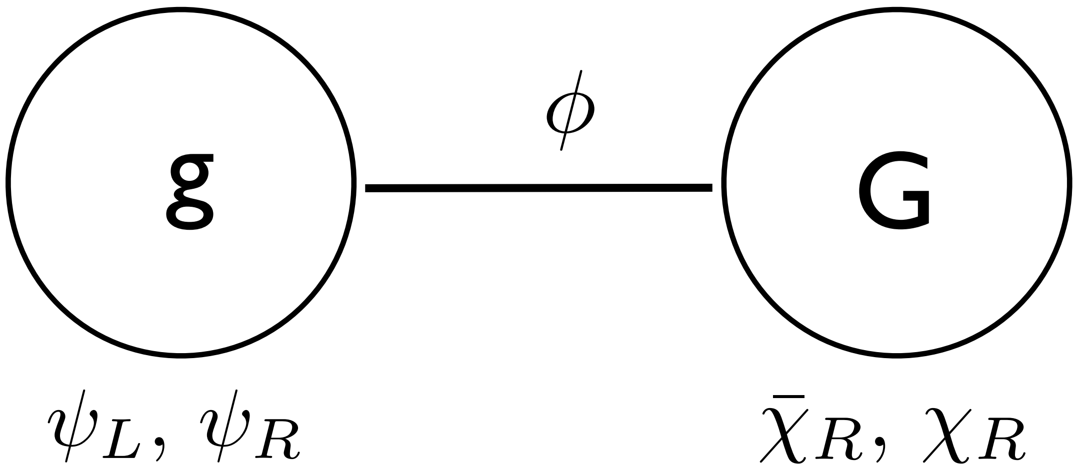
➡ Not unreasonable, since getting axial couplings to quarks that are weaker than g_s + unitarity already requires introducing new particles.

example



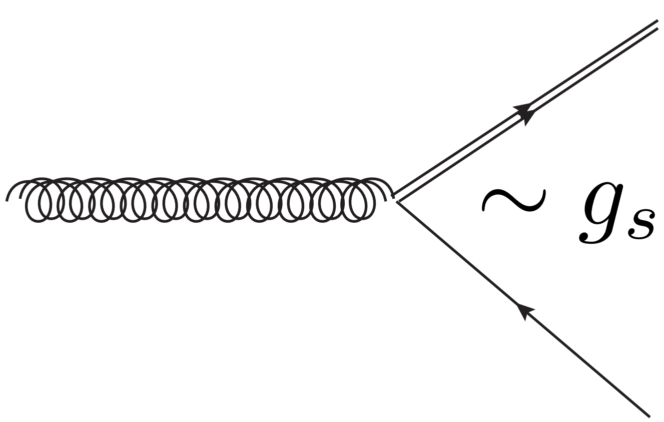
Fermions get vectorial couplings to axigluon suppressed by g/G compared to g_s

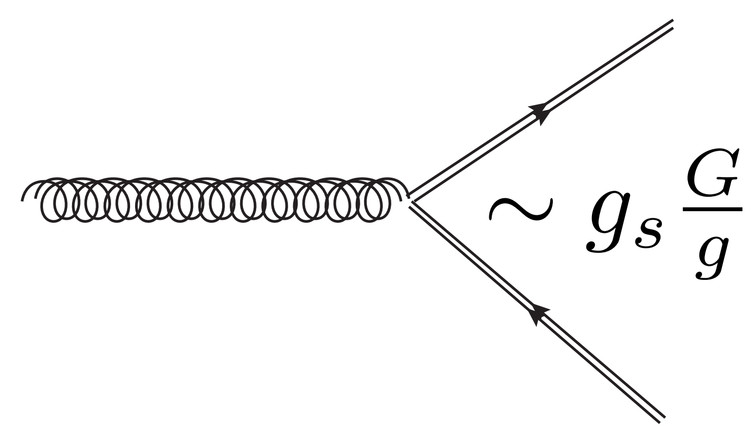
Add extra fermions

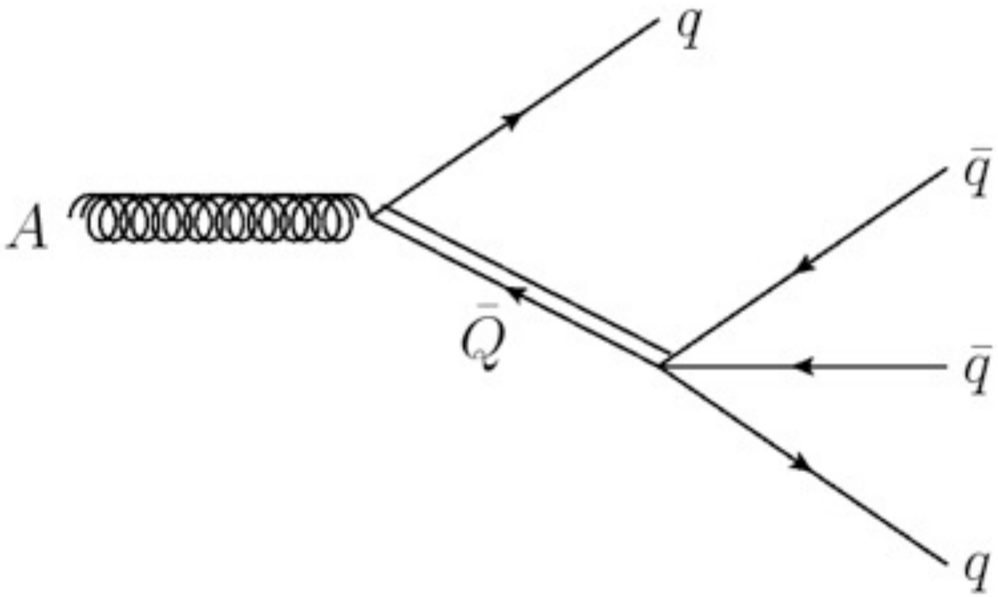


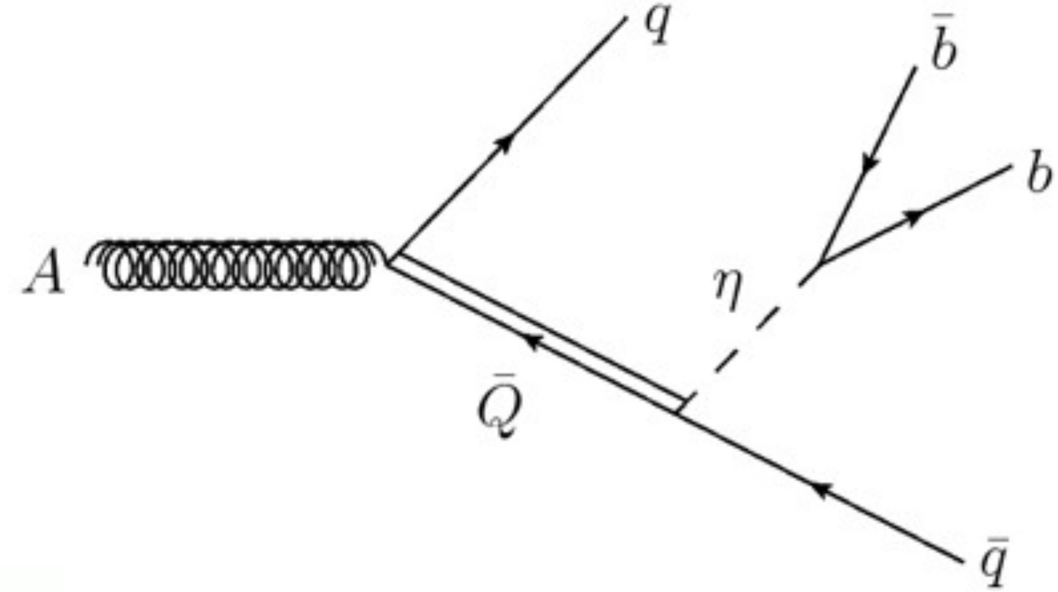
Coupling between new fermions and axigluon is $-g_s \frac{G}{g}$

Introduce small mixing between ψ_R and χ_R such that ψ_R couple axially






A
q
$\bar{Q}$
$\bar{q}$
$\bar{q}$
q


A
q
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η
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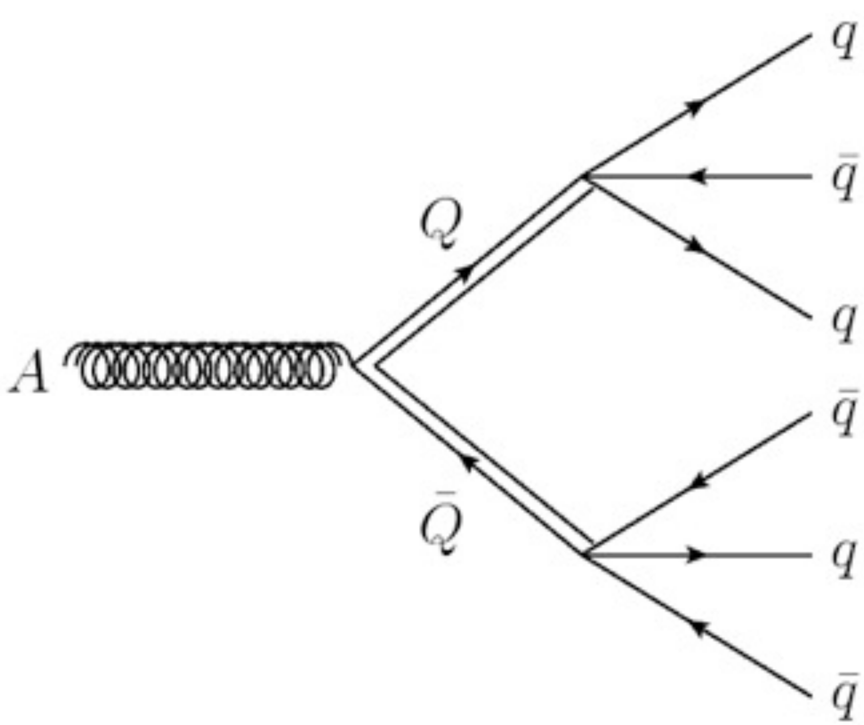
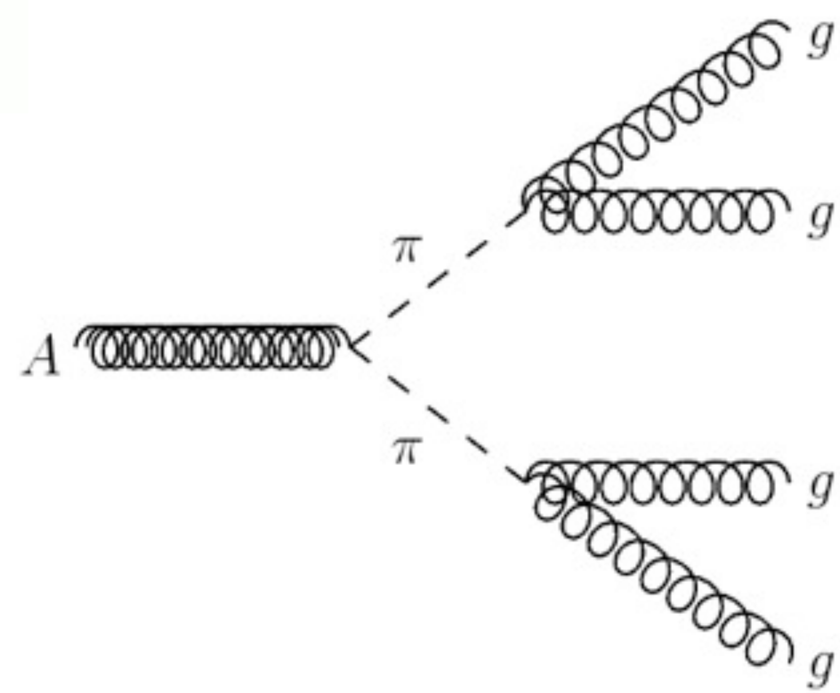
b
$\bar{q}$


A
Q
$\bar{Q}$
q
$\bar{q}$
q
$\bar{q}$
q
$\bar{q}$

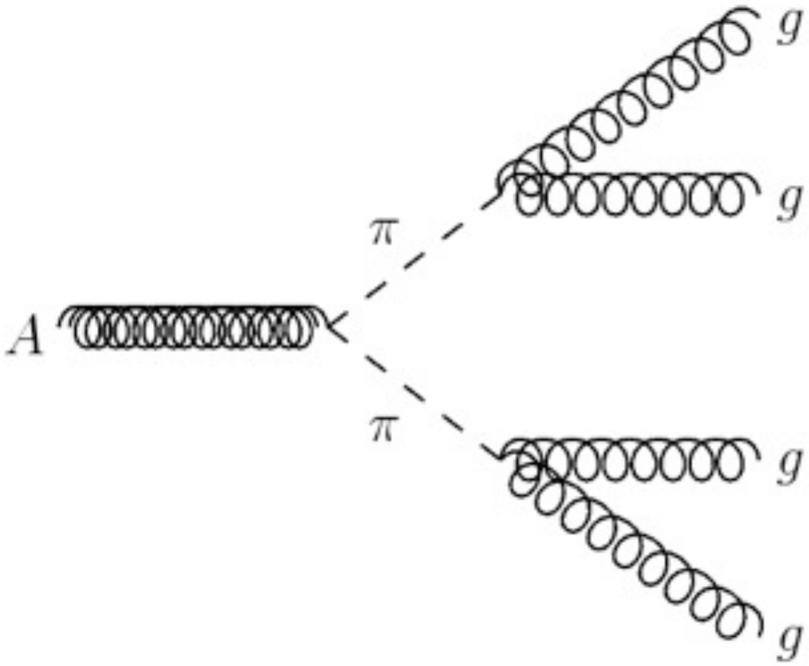

A
π
π
g
g
g
g

Axigluons decaying to multijets

Searching for resonances in events with multiple jets and without leptons or significant missing energy is challenging.

However the axigluon pair production cross-section is very large. For example the cross-section for pair production of 300 GeV axigluons is more than 5x larger than the cross-section for the pair production of gluinos with this mass.

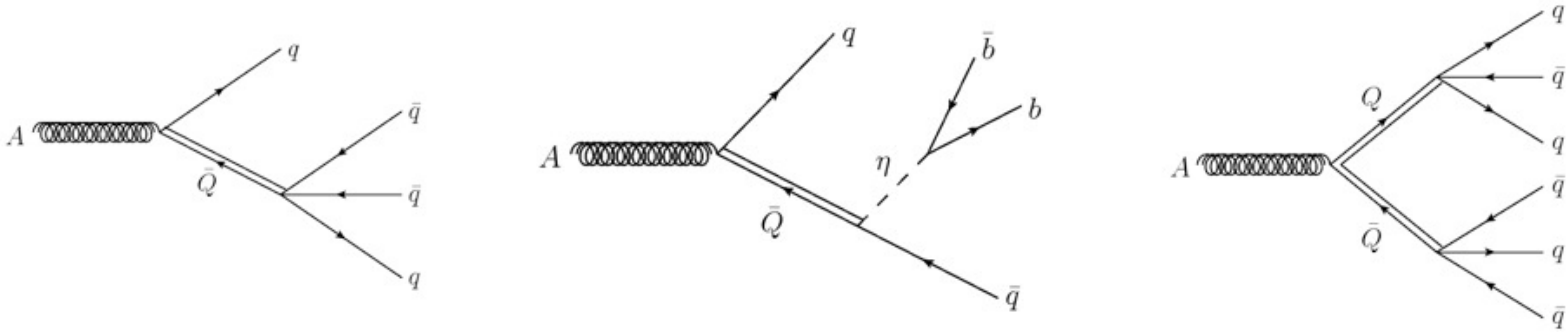
Requires systematically exploring the different decay topologies for the axigluon.



In this case there is a recent CDF analysis (1303.2699) that puts strong bounds on this topology from axigluon single production.

$m_{\rm axi}$	$\sigma_{\rm exp}$	$\sigma_{\rm axi}$
150 GeV	~ 400 pb	5600 pb
300 GeV	~ 5 pb	540 pb

In addition there is a preliminary CMS search for pair production of colored particles decaying with this topology that rules out axigluon/colorons with masses between 400 GeV to 900 GeV.



Remaining topologies still unexplored.

Those scenarios are "more natural" since the intermediate resonances are already required in UV completions of the axigluon model in order to get $g_A < g_S$

Conclusions

- Axigluon still provides a good explanation for ttbar asymmetry
- In order to be in agreement with direct searches must decay to multijets
- There are still scenarios where the axigluon is unconstrained by collider searches