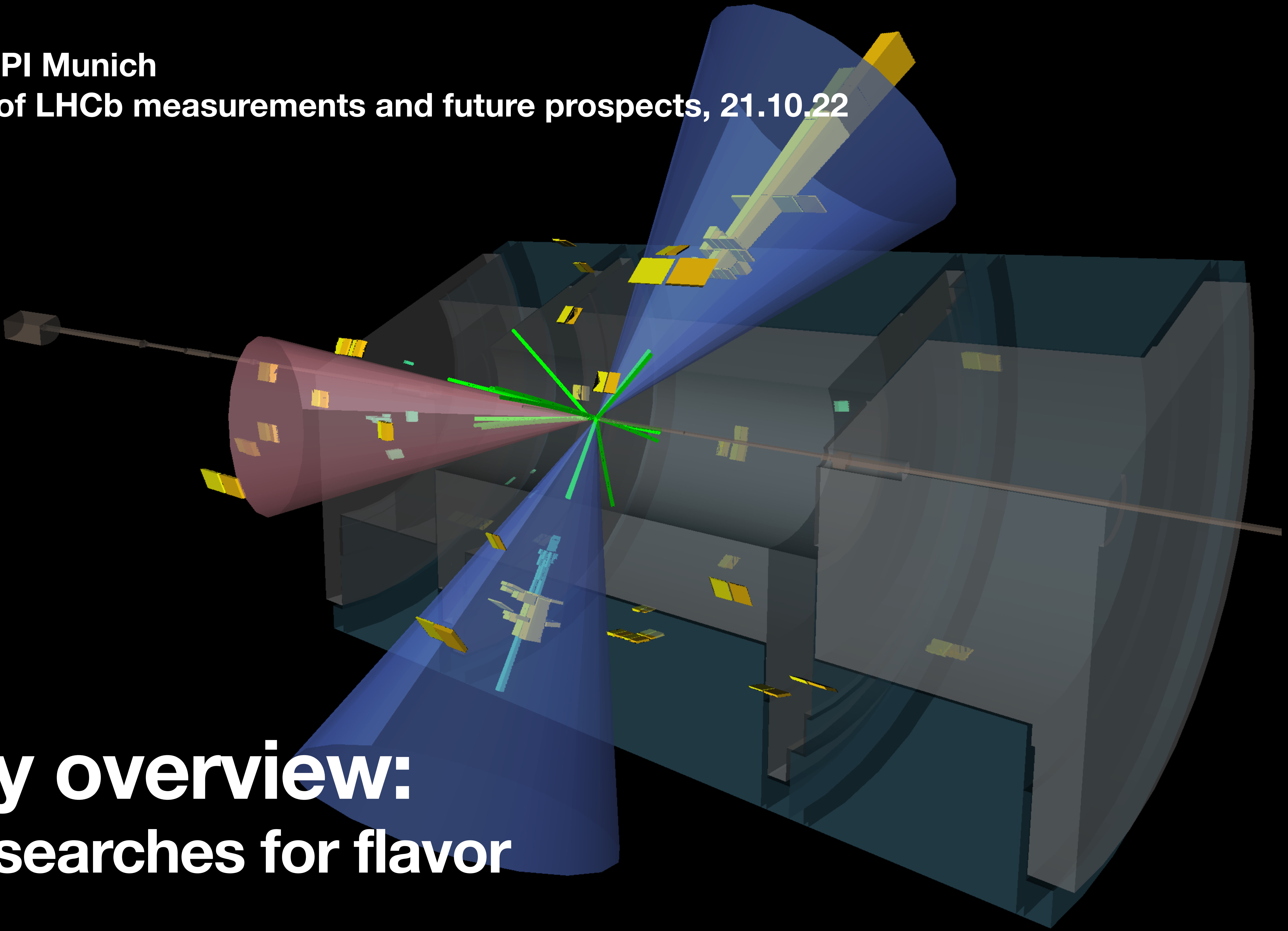
Uli Haisch, MPI Munich
Implications of LHCb measurements and future prospects, 21.10.22



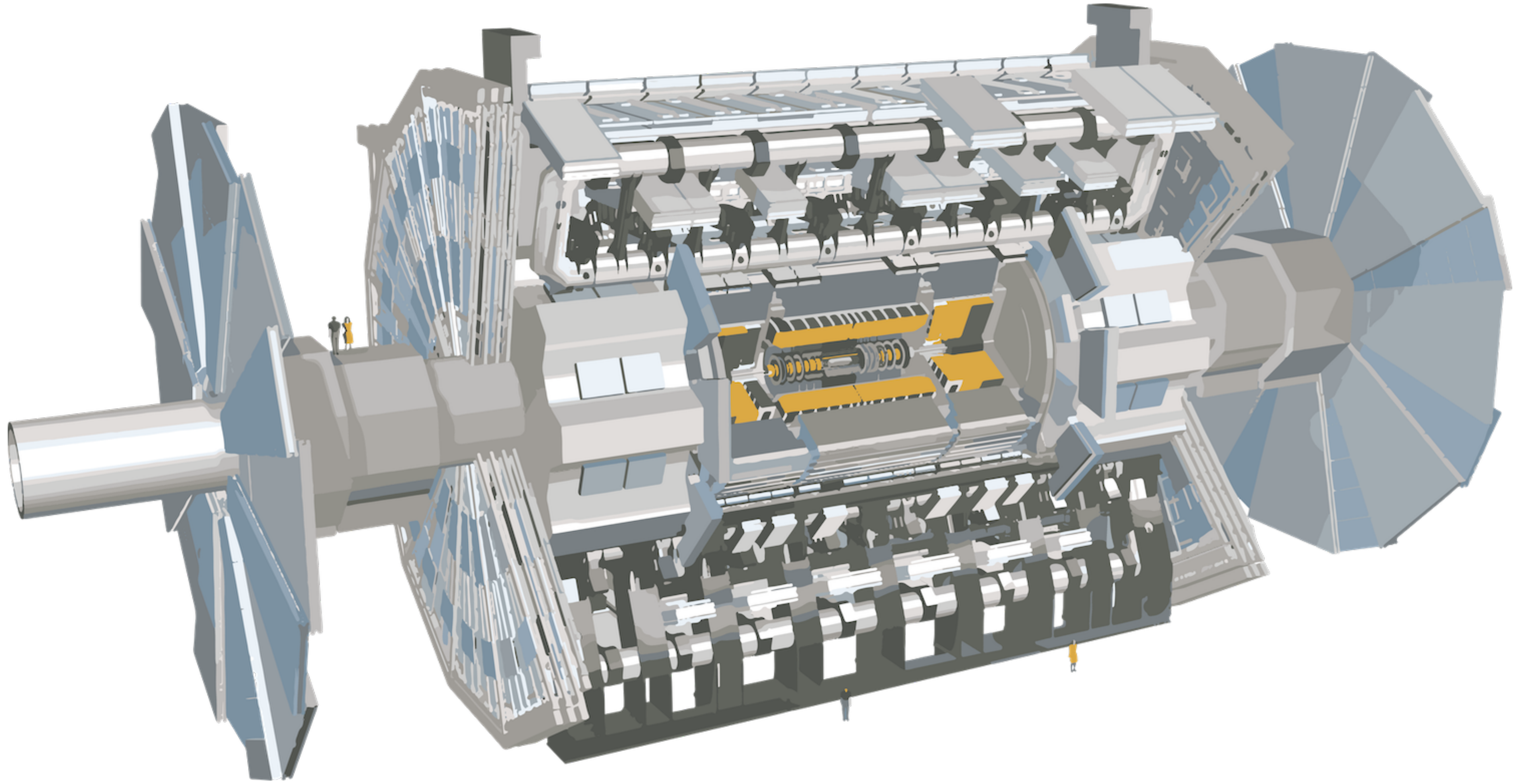
Theory overview:
high-p_T searches for flavor

Plan of this talk

$R_{D^{(*)}}$

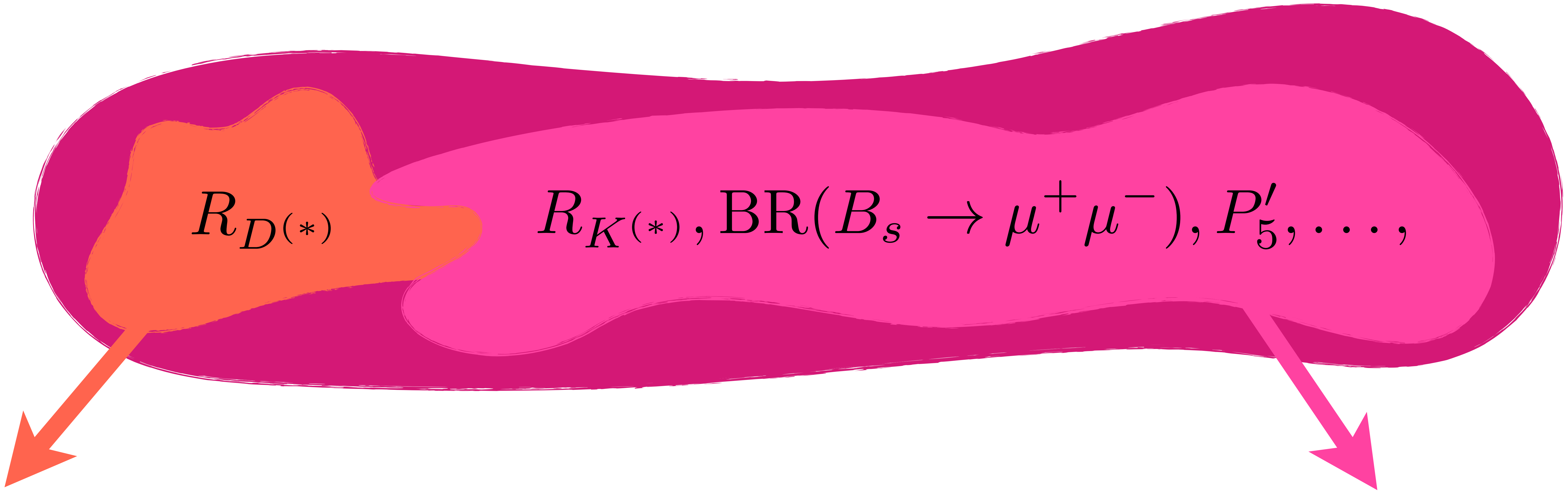
P_5' $R_{K^{(*)}}$

?



Assuming that well-known B anomalies are indeed due to new physics, I will discuss possible implications of these deviations in high-p_T searches @ LHC

B anomalies in a nutshell

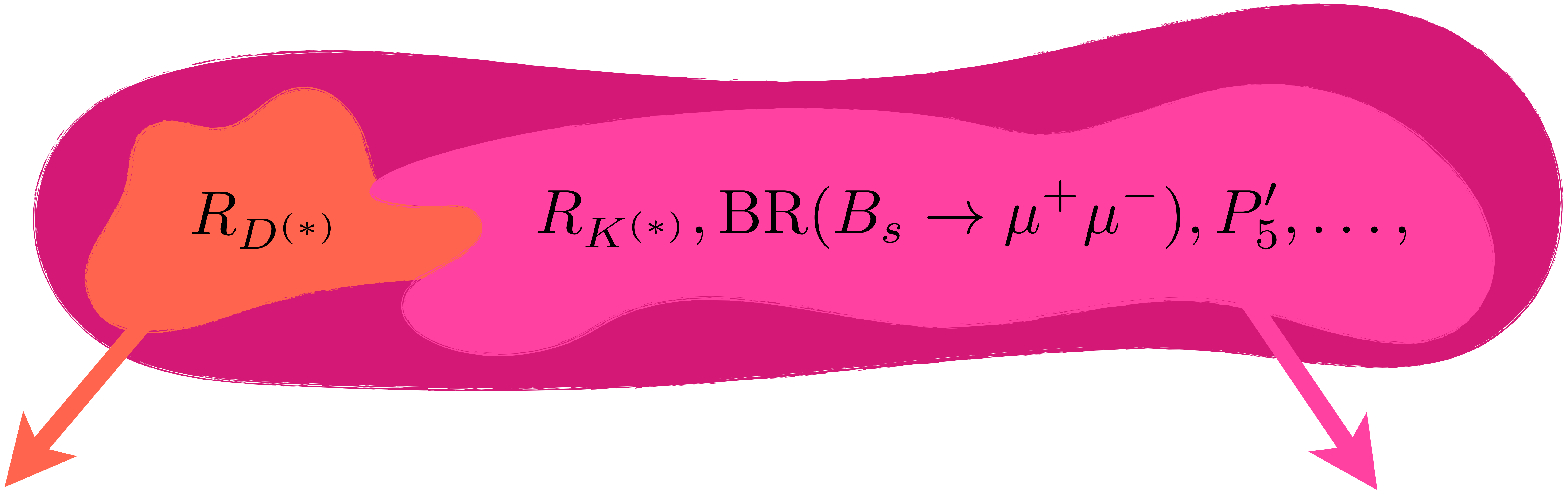


$$\frac{1}{(1.2\,\mathrm{TeV})^2}\,(\bar{c}_L\gamma_\alpha b_L)\,(\bar{\tau}_L\gamma^\alpha\nu_L)$$

$$\frac{1}{(35\,\mathrm{TeV})^2}\,(\bar{s}_L\gamma_\alpha b_L)\,\big(\bar{\mu}_{(L)}\gamma^\alpha\mu_{(L)}\big)$$

Both sets of B anomalies challenge assumption of lepton flavor universality (LFU), which is usually taken for granted in high-energy physics

B anomalies in a nutshell

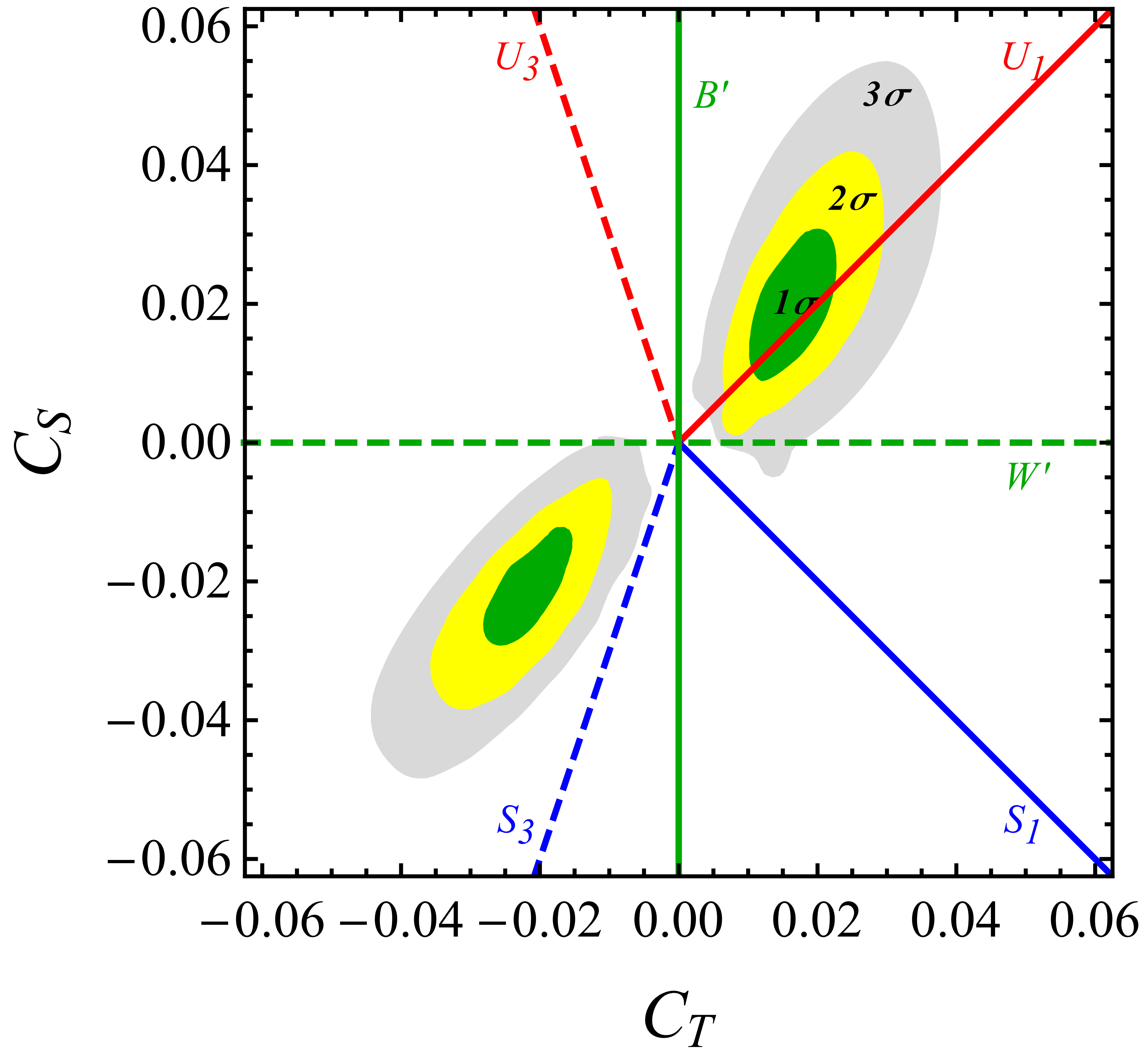


$$\frac{1}{(1.2\,\mathrm{TeV})^2}\,(\bar{c}_L \gamma_\alpha b_L)\,(\bar{\tau}_L \gamma^\alpha \nu_L) \qquad \frac{1}{(35\,\mathrm{TeV})^2}\,(\bar{s}_L \gamma_\alpha b_L)\,\left(\bar{\mu}_{(L)} \gamma^\alpha \mu_{(L)}\right)$$

Mass/scale suppression of effective operators suggests that explanations of b → c anomalies should lead to testable high-p_T signatures, while b → s case looks much less promising

Simplified models for B anomalies

$$\lambda^q_{ij}\lambda^l_{\alpha\beta}\left(C_T\,(\bar{Q}^i_L\gamma_\mu\sigma^a Q^j_L)(\bar{L}^\alpha_L\gamma^\mu\sigma^a L^\beta_L) + C_S\,(\bar{Q}^i_L\gamma_\mu Q^j_L)(\bar{L}^\alpha_L\gamma^\mu L^\beta_L)\right)$$



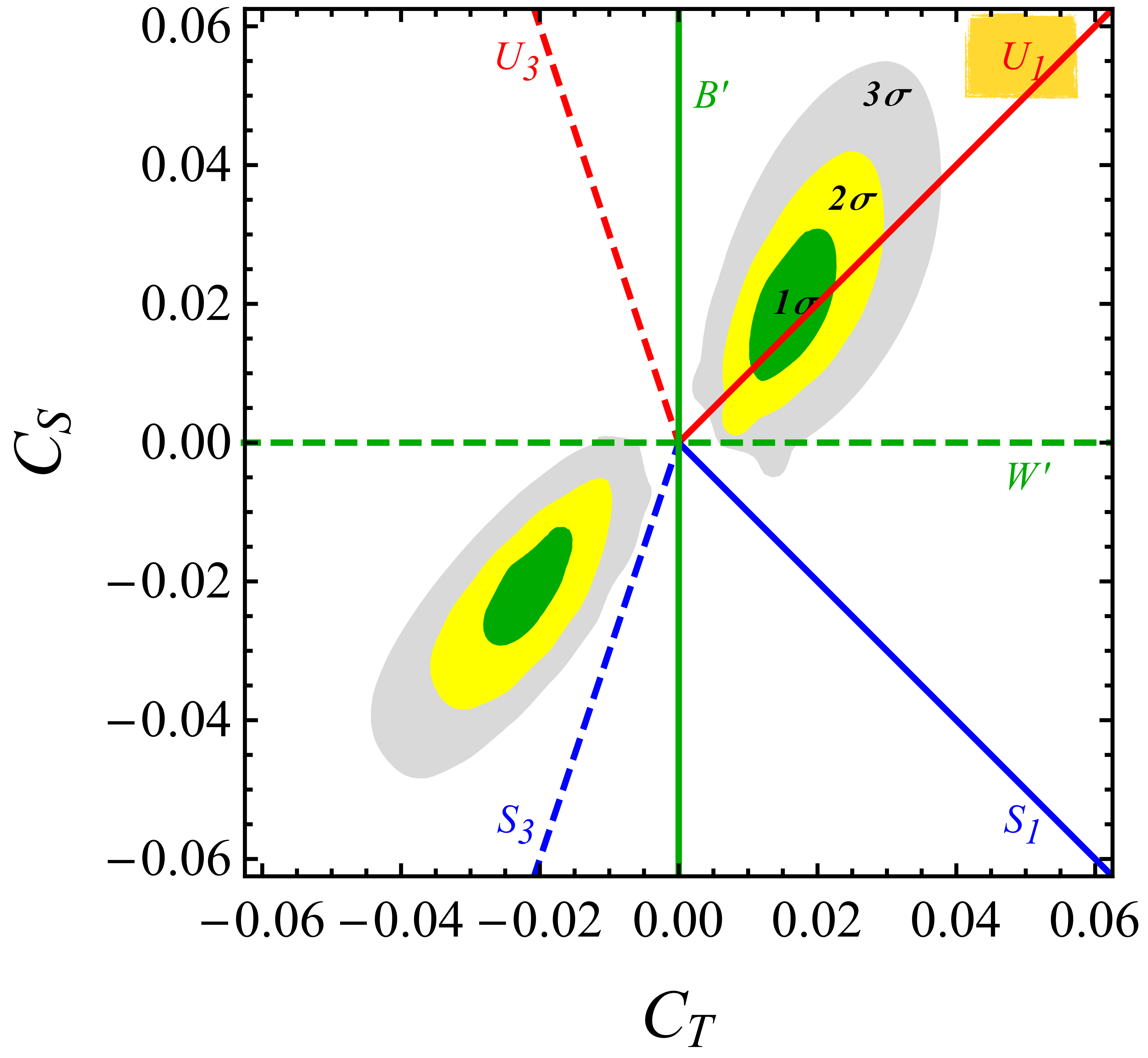
Model	Mediator	$b \to s$	$b \to c$
Colorless vectors	$B' = (1,1,0)$	✓	✗
	$W' = (1,3,0)$	✗	✓
Scalar leptoquarks	$S_1 = (\bar{3},1,1/3)$	✗	✓
	$S_3 = (\bar{3},3,1/3)$	✓	✗
Vector leptoquarks	$U_1 = (3,1,2/3)$	✓	✓
	$U_3 = (3,3,2/3)$	✓	✗

b → s (b → c) anomalies alone can be accommodated by several simple single-mediator models

[see for instance Buttazzo, Greljo, Isidori & Marzocca, 1706.07808]

Simplified models for B anomalies

$$\lambda^q_{ij}\lambda^l_{\alpha\beta}\left(C_T\,(\bar{Q}^i_L\gamma_\mu\sigma^a Q^j_L)(\bar{L}^\alpha_L\gamma^\mu\sigma^a L^\beta_L) + C_S\,(\bar{Q}^i_L\gamma_\mu Q^j_L)(\bar{L}^\alpha_L\gamma^\mu L^\beta_L)\right)$$

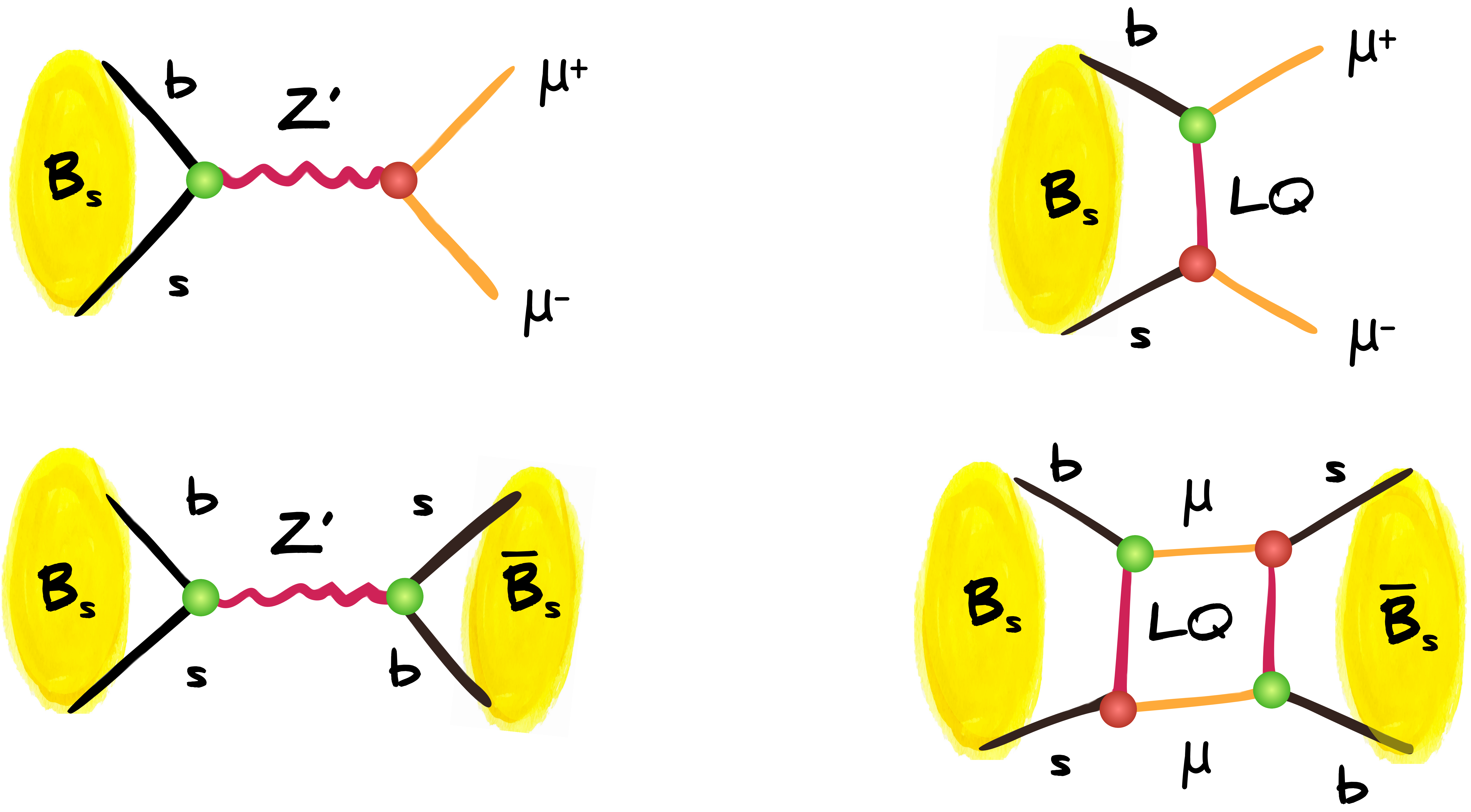


Model	Mediator	$b \to s$	$b \to c$
Colorless vectors	$B' = (1,1,0)$	✓	✗
	$W' = (1,3,0)$	✗	✓
Scalar leptoquarks	$S_1 = (\bar{3},1,1/3)$	✗	✓
	$S_3 = (\bar{3},3,1/3)$	✓	✗
Vector leptoquarks	$U_1 = (3,1,2/3)$	✓	✓
	$U_3 = (3,3,2/3)$	✓	✗

U_1 singlet vector leptoquark (LQ) is only single-mediator model that can explain both sets of anomalies

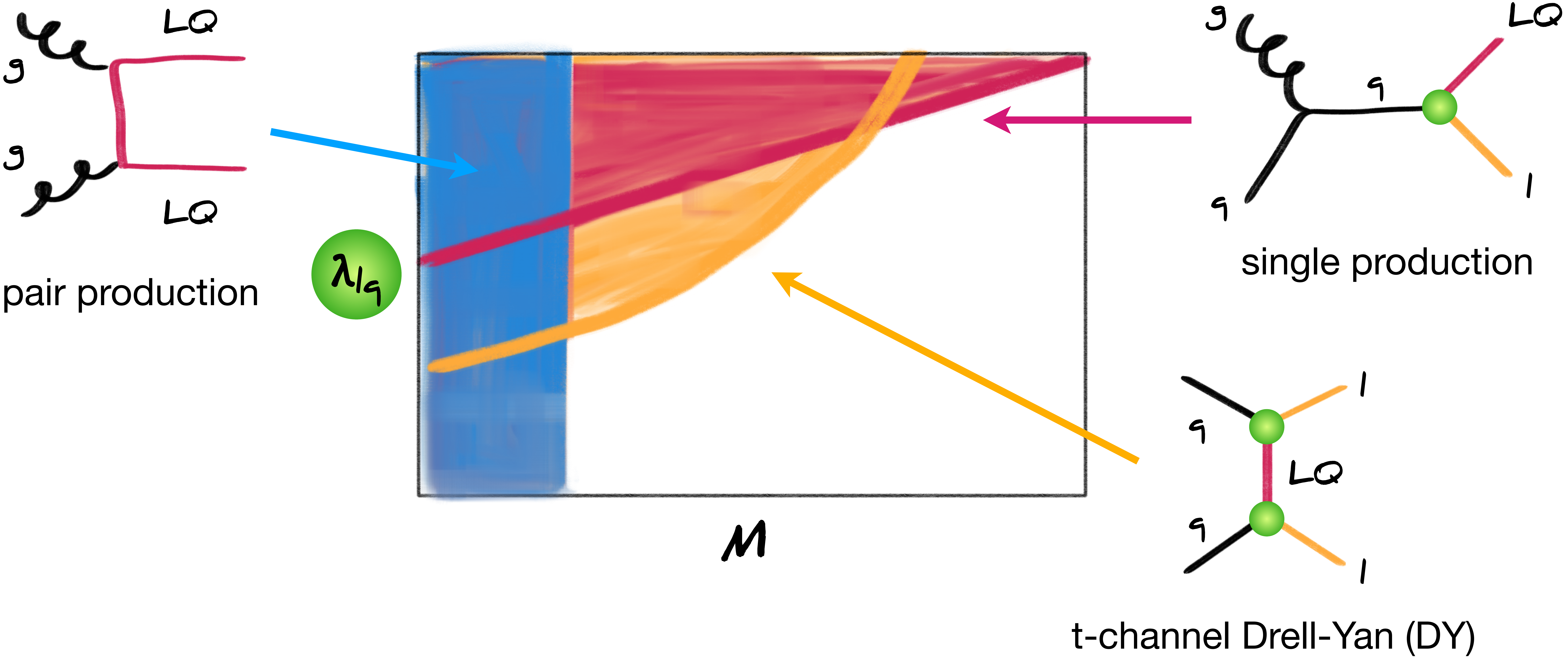
[see for instance Buttazzo, Greljo, Isidori & Marzocca, 1706.07808]

A digression on LQs



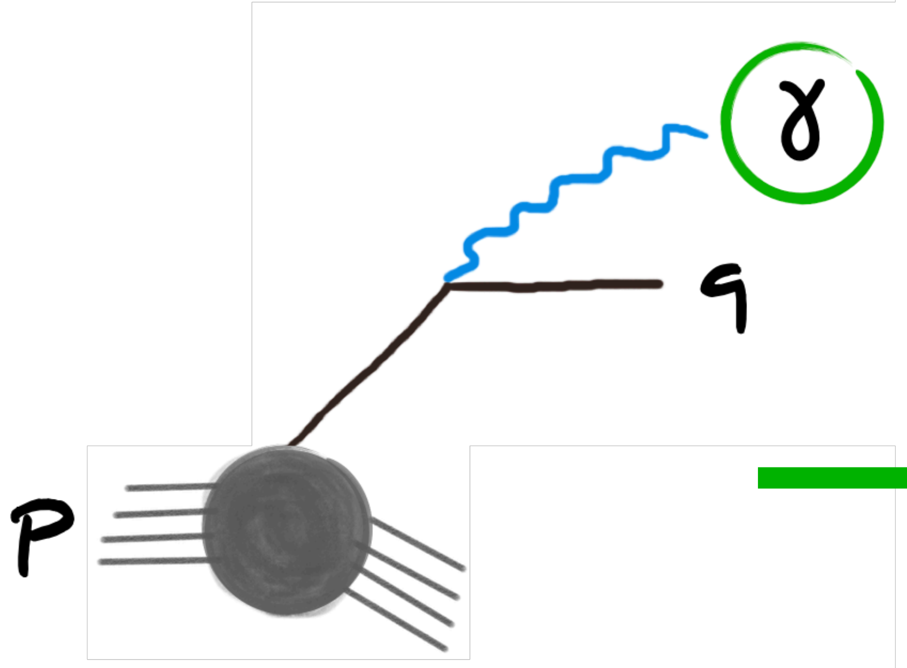
Both scalar & vector LQ have important advantage with respect to other tree-level mediators that they do not induce tree-level contributions to B mixing & $\tau \to \mu\nu\nu$

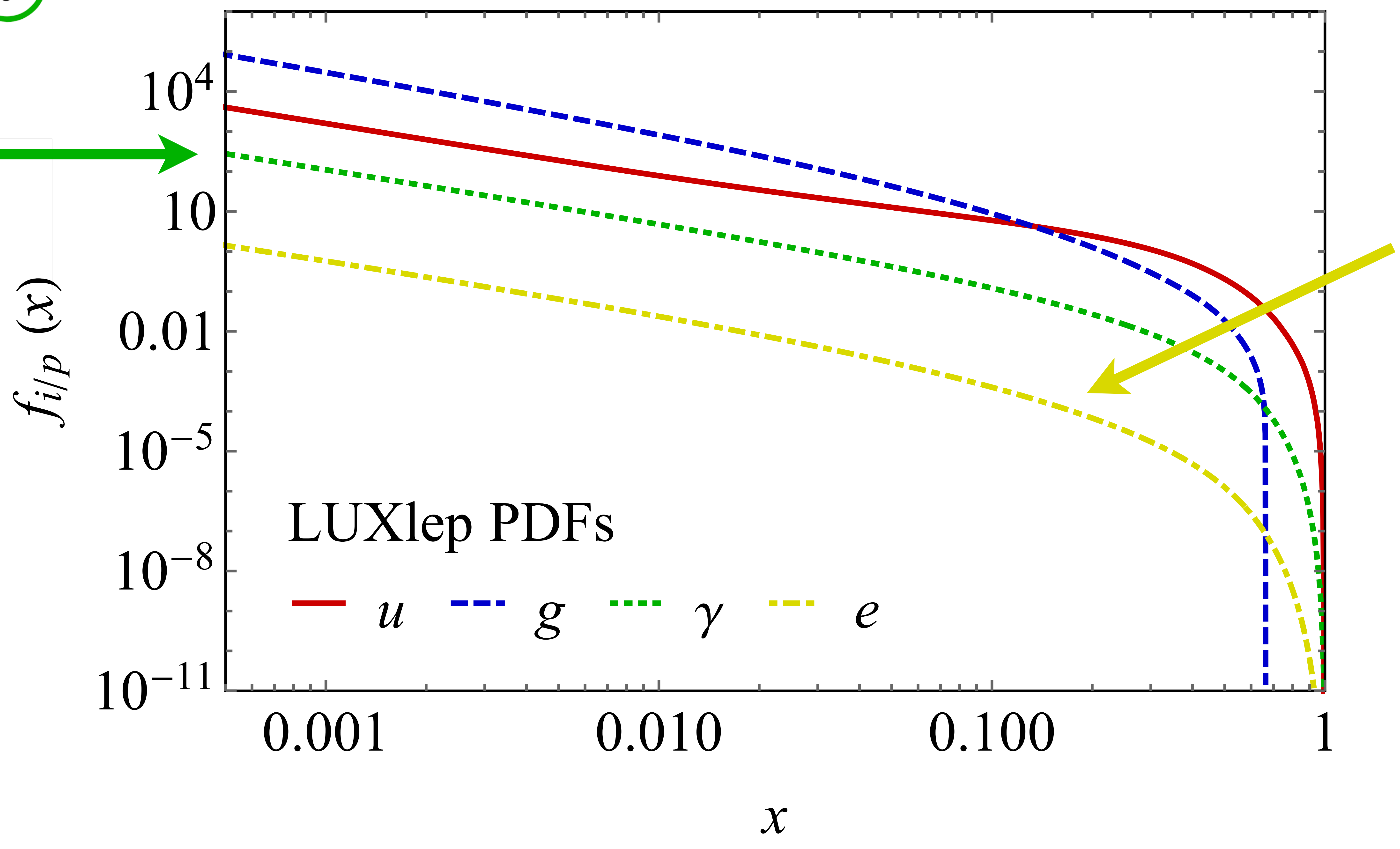
Well-known LQ search strategies @ LHC

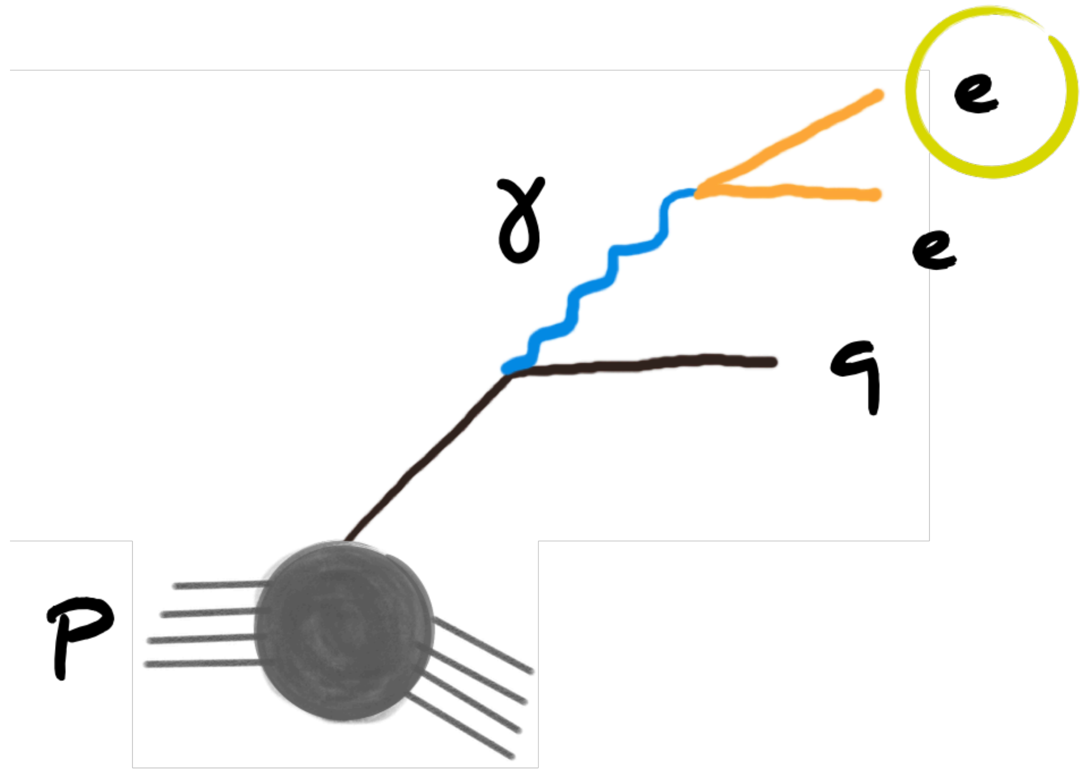


[sketch adopted from Dorsner & Greljo, 1801.07641]

Photon & lepton content of proton

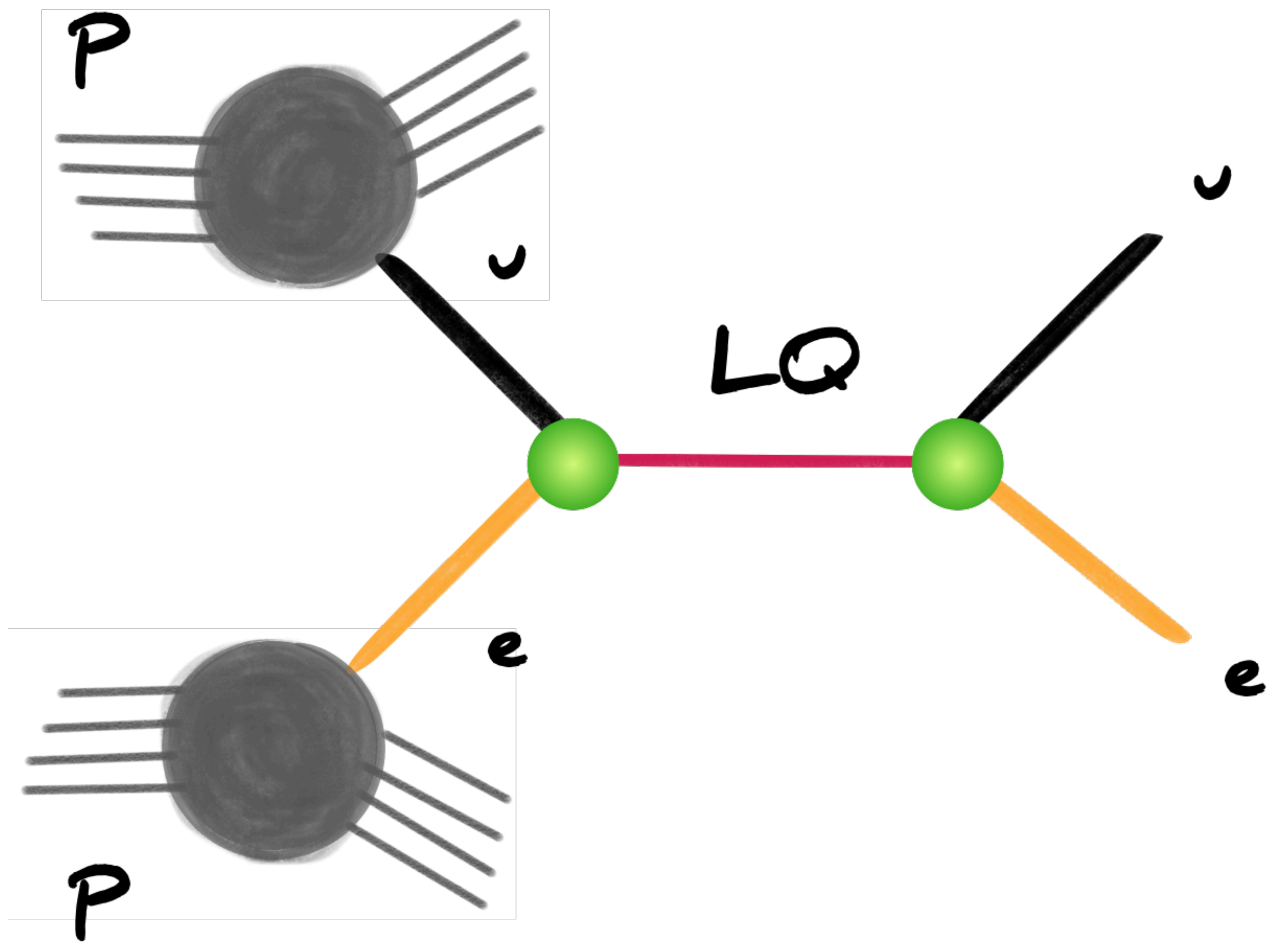


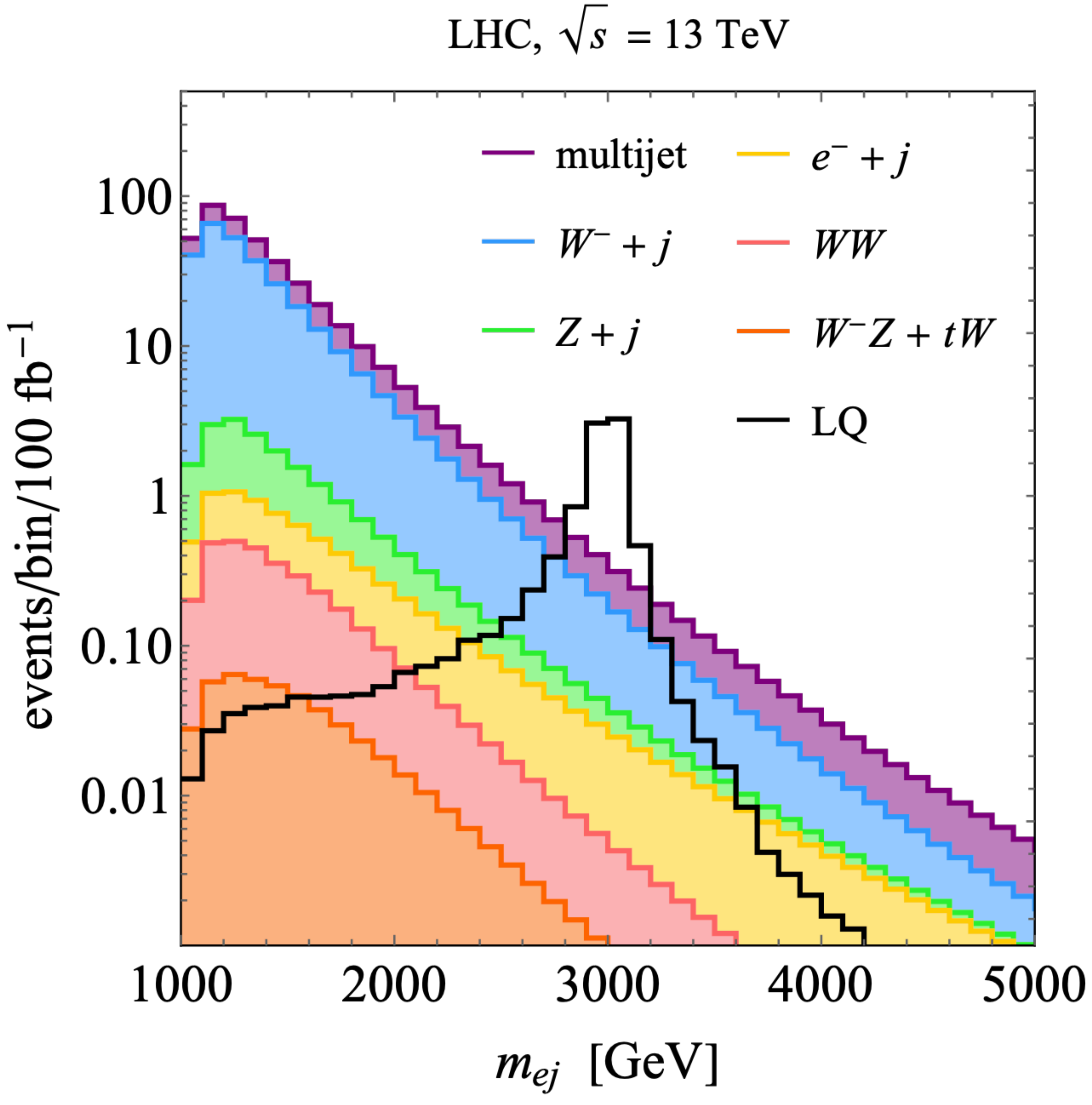




[Manohar et al., 1607.04266, 1708.01256; Buonocore et al., 2005.06477]

Resonant LQ production @ LHC

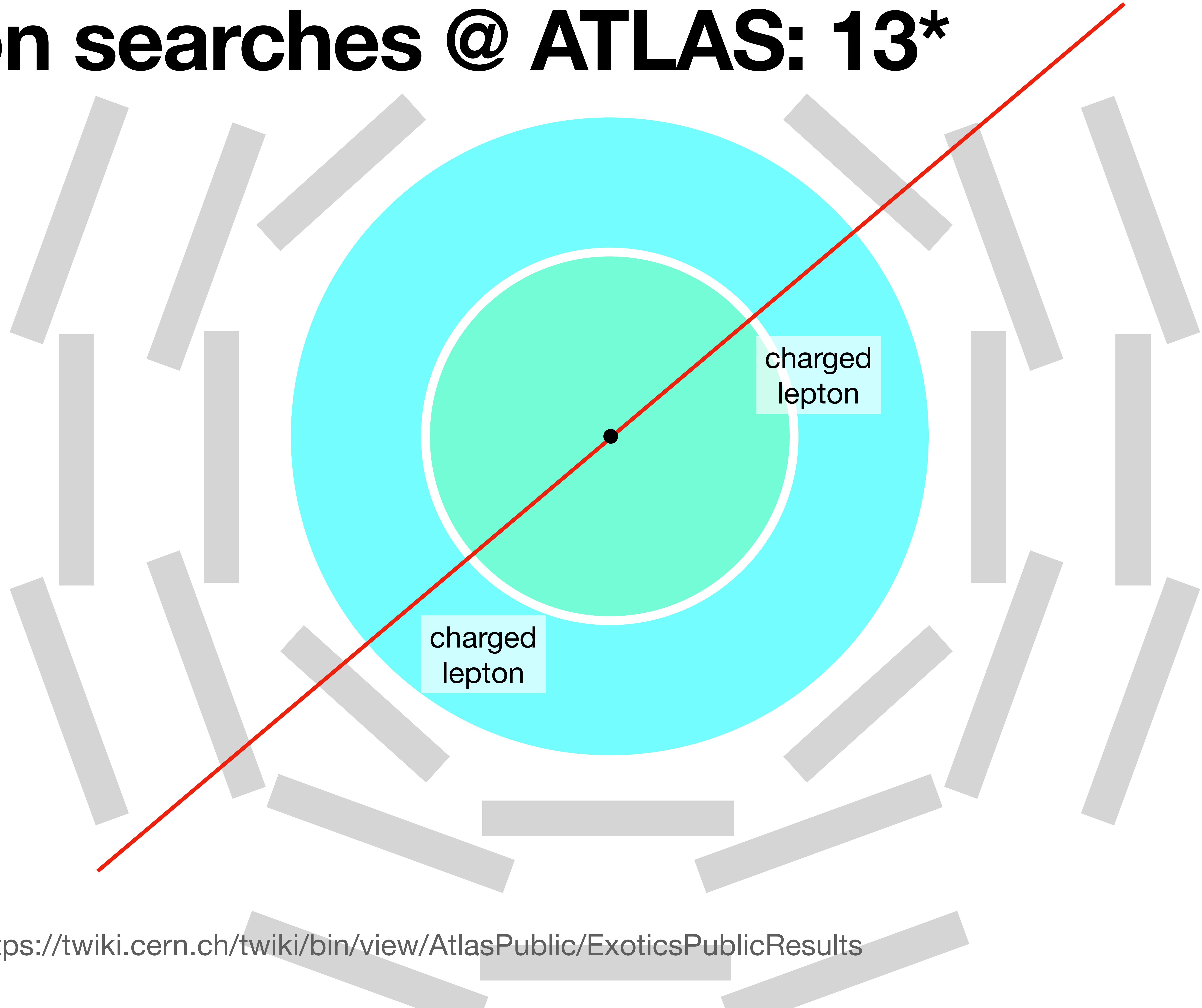




Non-zero lepton parton distribution functions allow for resonant LQ production @ LHC, but single lepton-jet final states are not part of exotics search canon of ATLAS & CMS

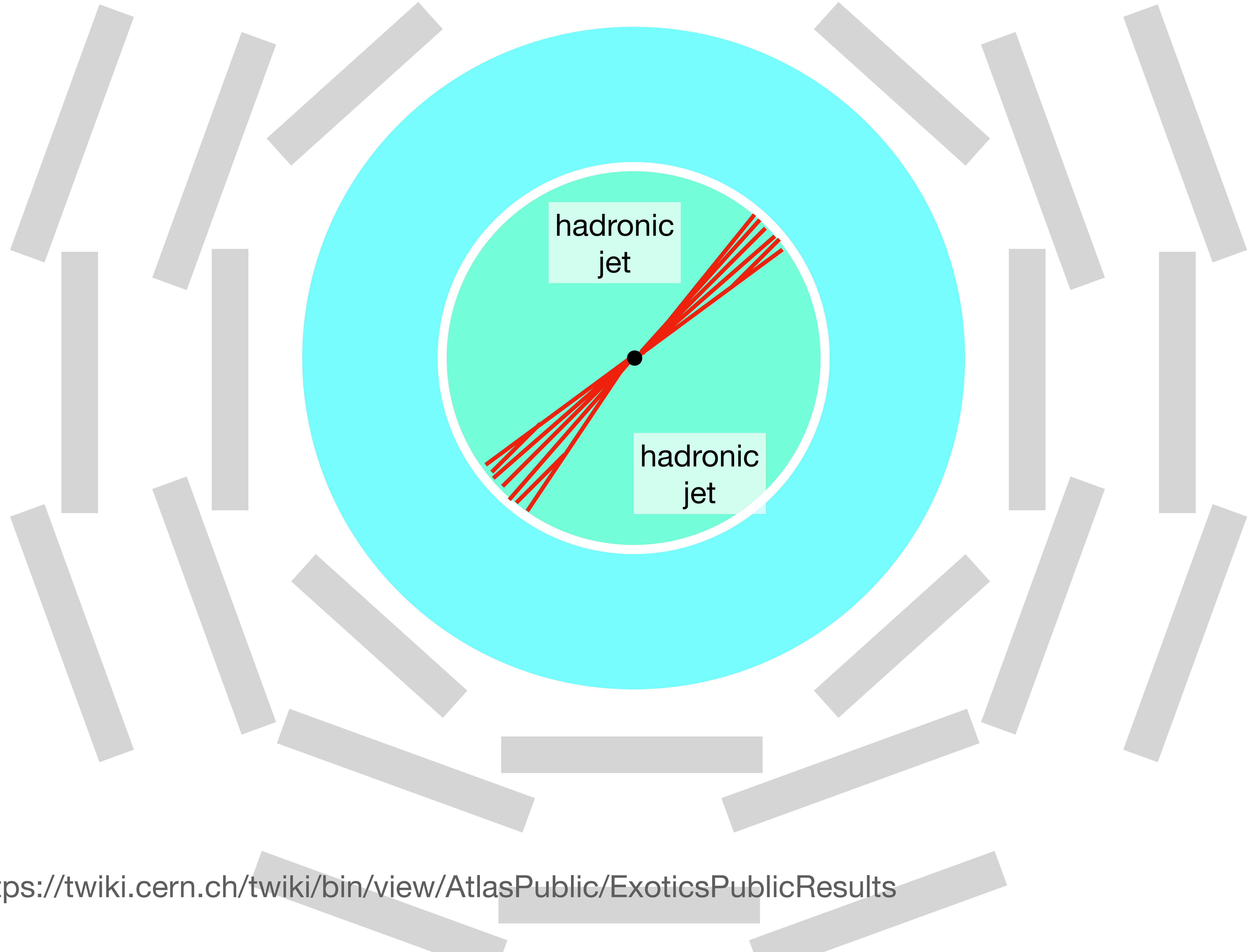
[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475; Greljo & Selimovic, 2012.02092; Buonocore et al., 2209.02599]

Dilepton searches @ ATLAS: 13*



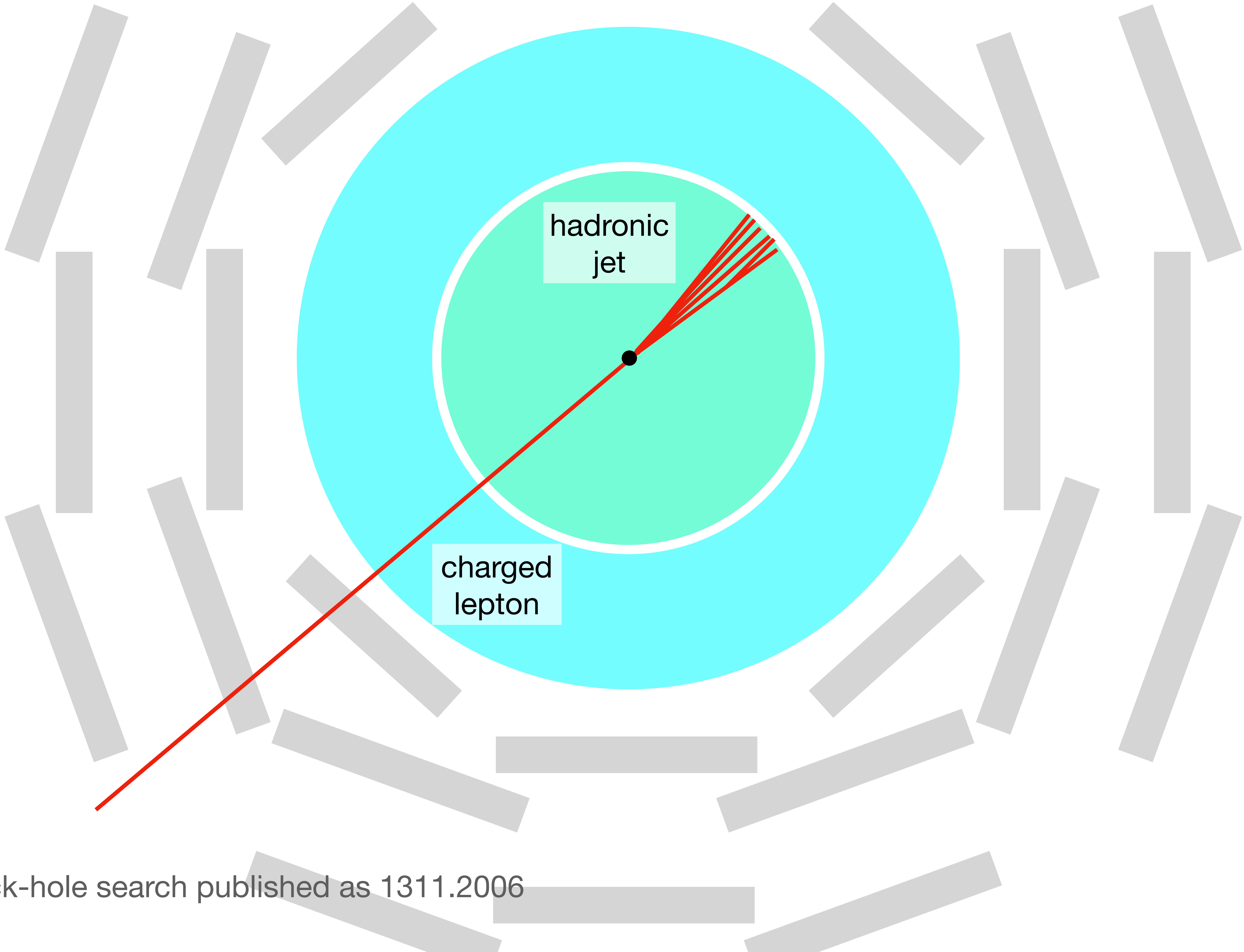
*number based on https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ExoticsPublicResults

Dijet searches @ ATLAS: 12*



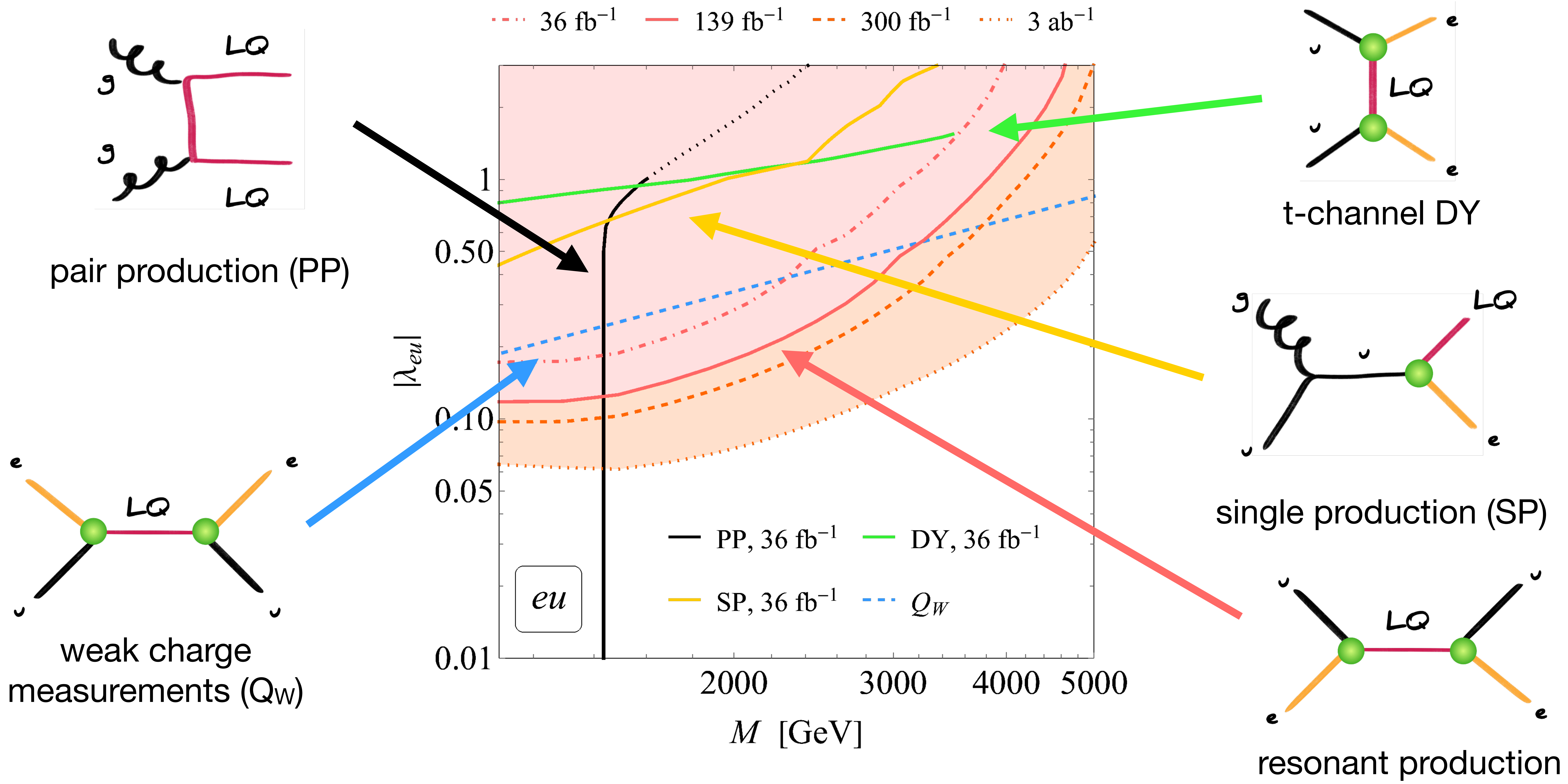
*number based on https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ExoticsPublicResults

Lepton-jet final state searches @ ATLAS: 1*



*i.e. the quantum-black-hole search published as 1311.2006

LHC limits on 1st & 2nd generation LQs



[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

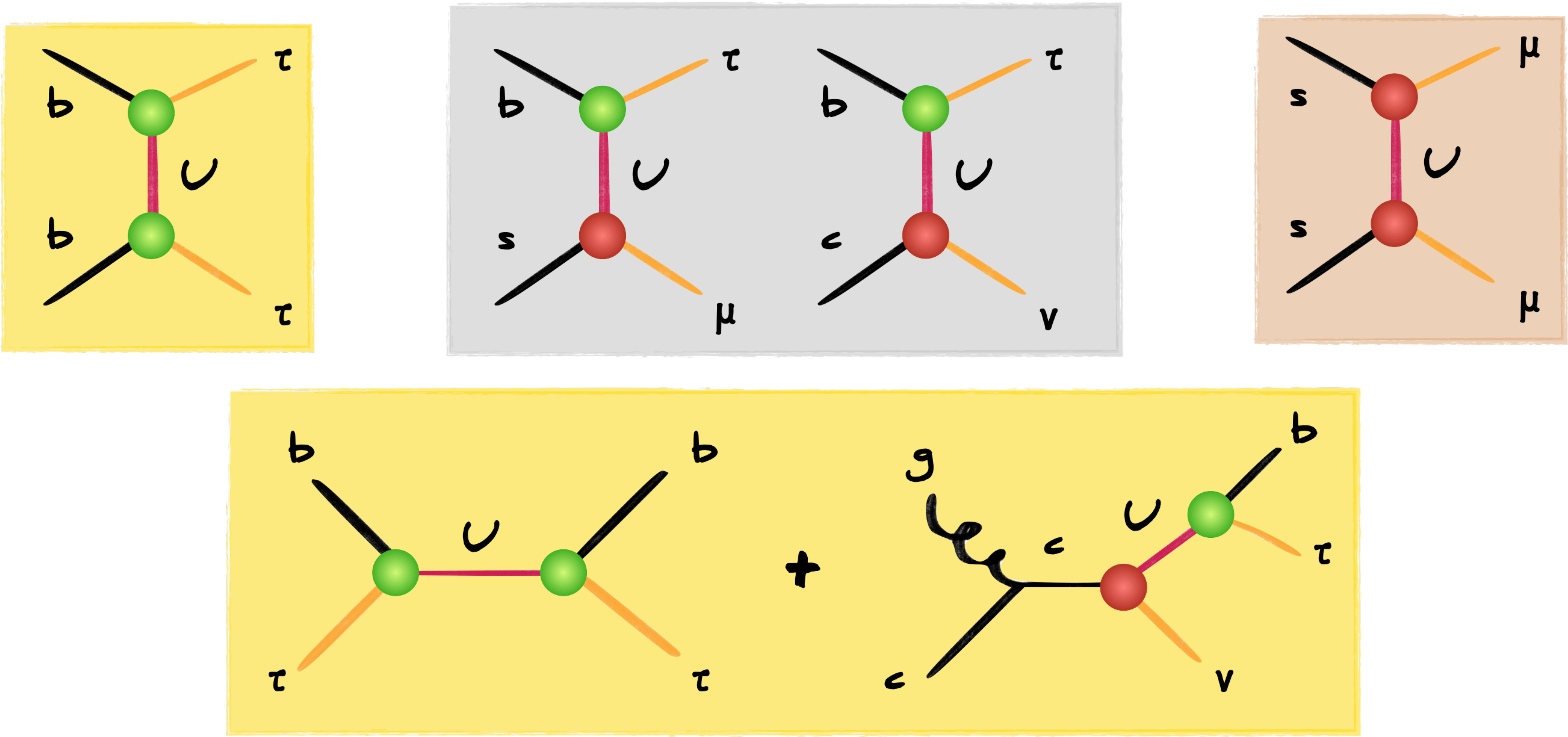
Singlet vector LQ models for B anomalies

$$\mathcal{L} \supset \frac{g_U}{\sqrt{2}} \left[\beta_L^{ij}\, \bar{Q}_L^{i,a} \gamma_\mu L_L^j + \beta_R^{ij}\, \bar{d}_R^{i,a} \gamma_\mu \ell_R^j \right] U^{\mu,a} \; + \text{h.c.}\,,$$

$$|\beta_L^{22}| \lesssim |\beta_L^{32}| \ll |\beta_L^{23}| \lesssim |\beta_L^{33}| = \mathcal{O}(1)$$

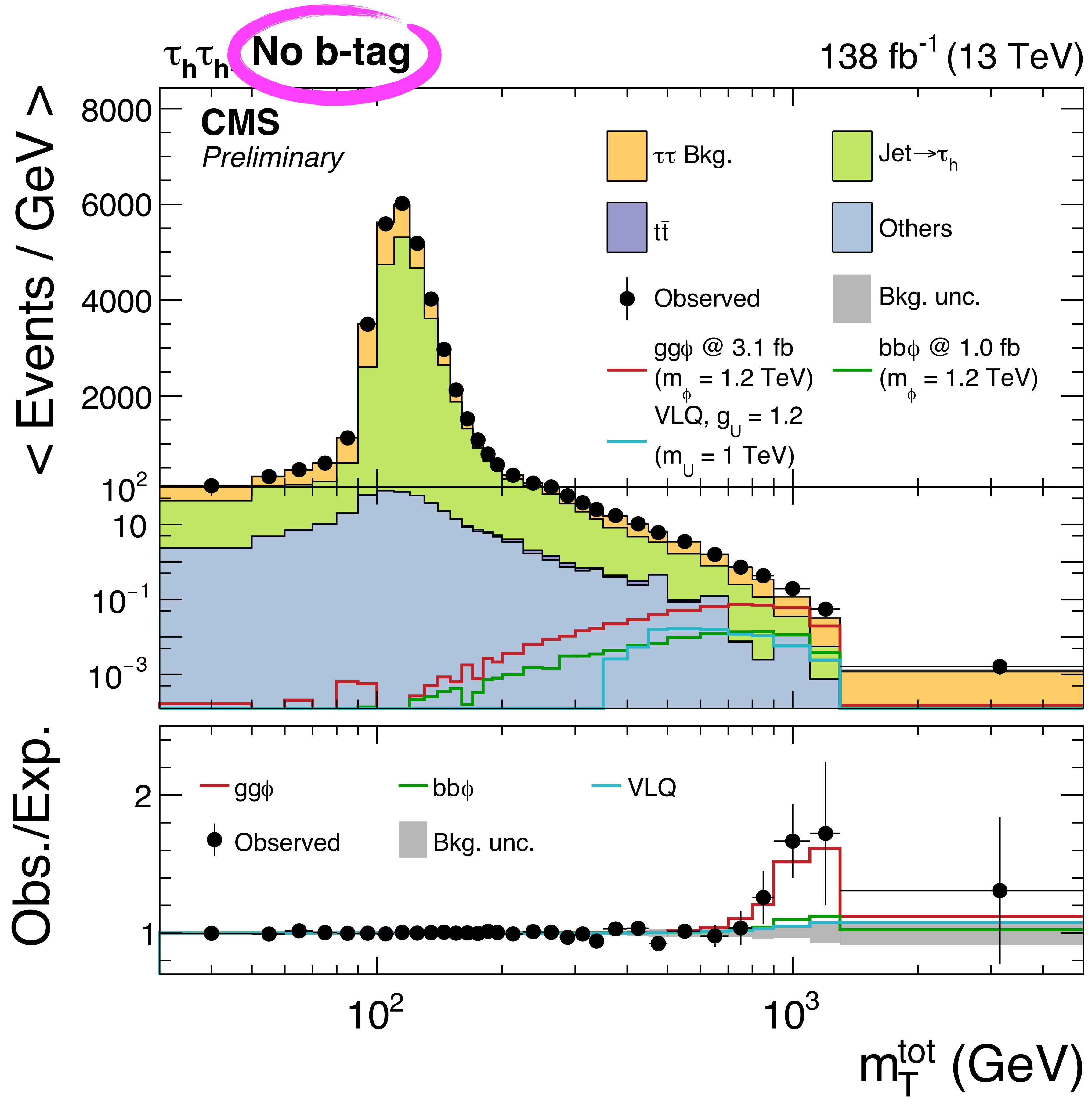
Parameters		Branching ratios			
β_L^{33}	β_L^{23}	$\text{BR}(U \to b\tau^+)$	$\text{BR}(U \to t\bar{\nu}_\tau)$	$\text{BR}(U \to s\tau^+)$	$\text{BR}(U \to c\bar{\nu}_\tau)$
1	0	51%	49%	0%	0%
1	1	25%	22%	25%	27%

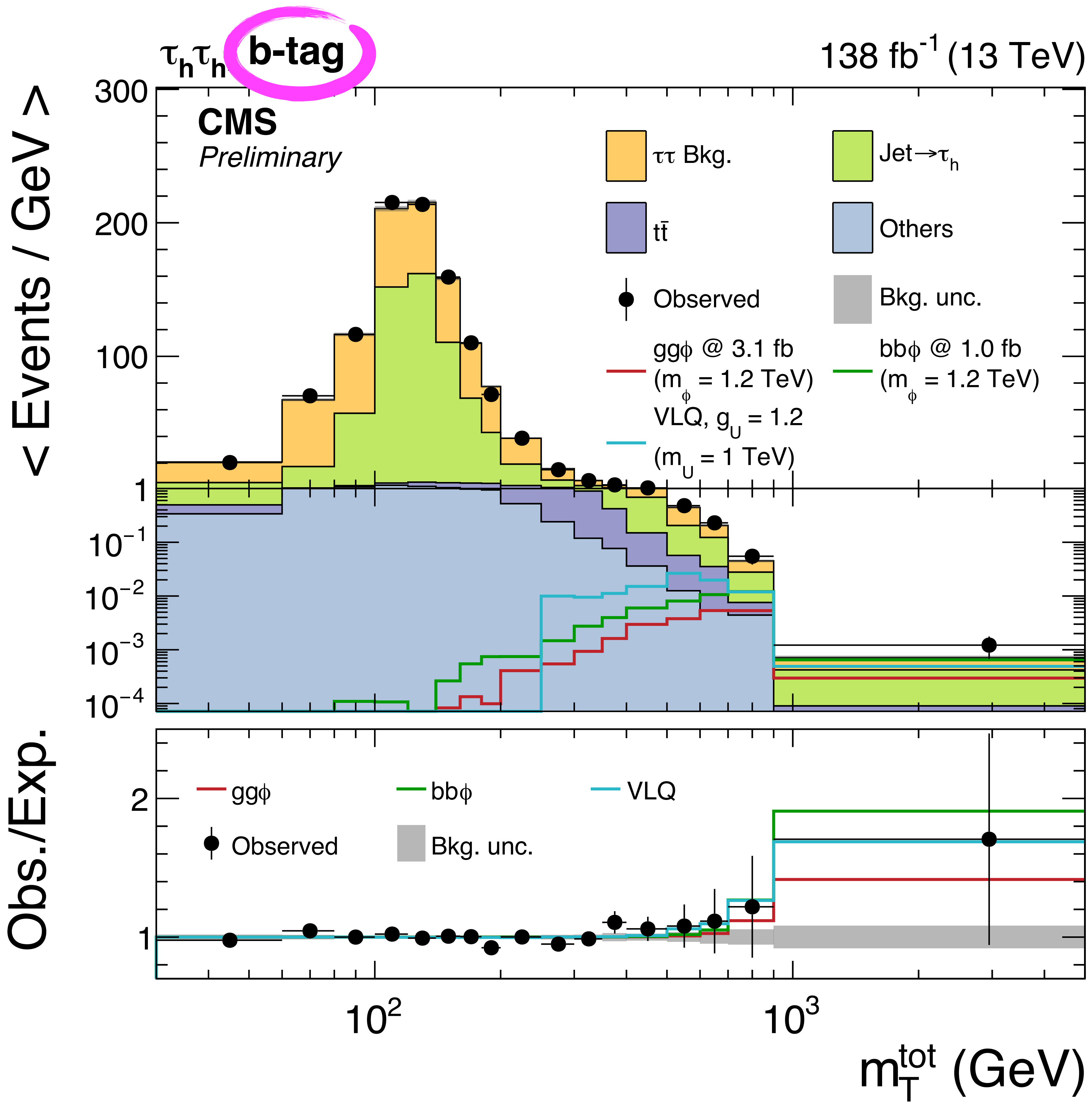
Possible singlet vector LQ signatures



Flavor structure as suggested by $b \to c$ anomalies singles out $pp \to \tau^+\tau^-$, $b\tau$ as most interesting channels — $pp \to \tau\mu$, $\tau\nu$, $\mu^+\mu^-$, $t\nu$, $c\nu$ may be important as well in case of discovery or if $b \to c$ anomalies disappear

Ditau searches @ LHC Run II

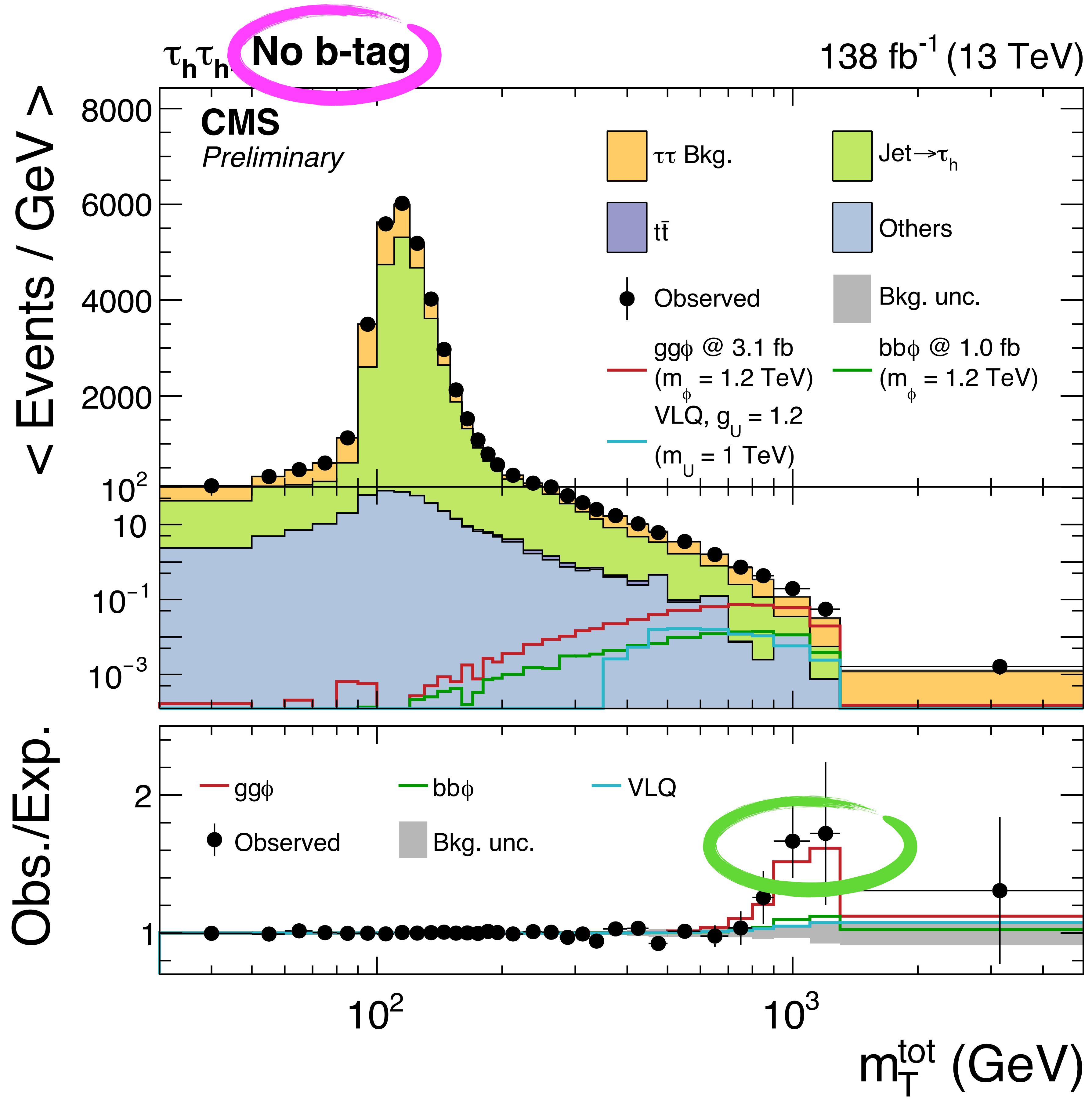


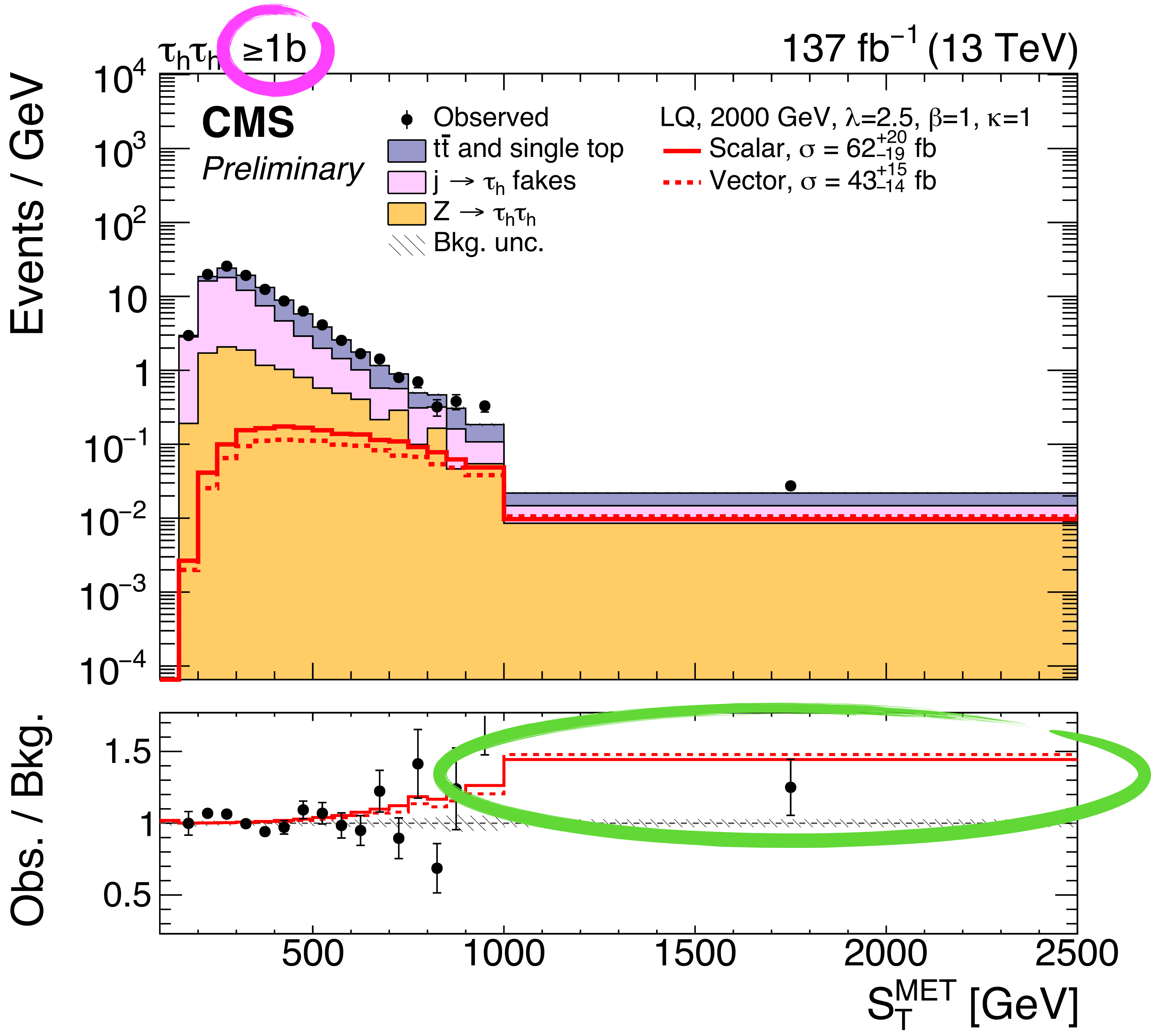


Three different ditau LHC Run II analyses, all considering events without & with an extra b-jet

[ATLAS, 2002.12223; CMS, 2208.02717; CMS PAS HIG-21-001]

Ditau searches @ LHC Run II

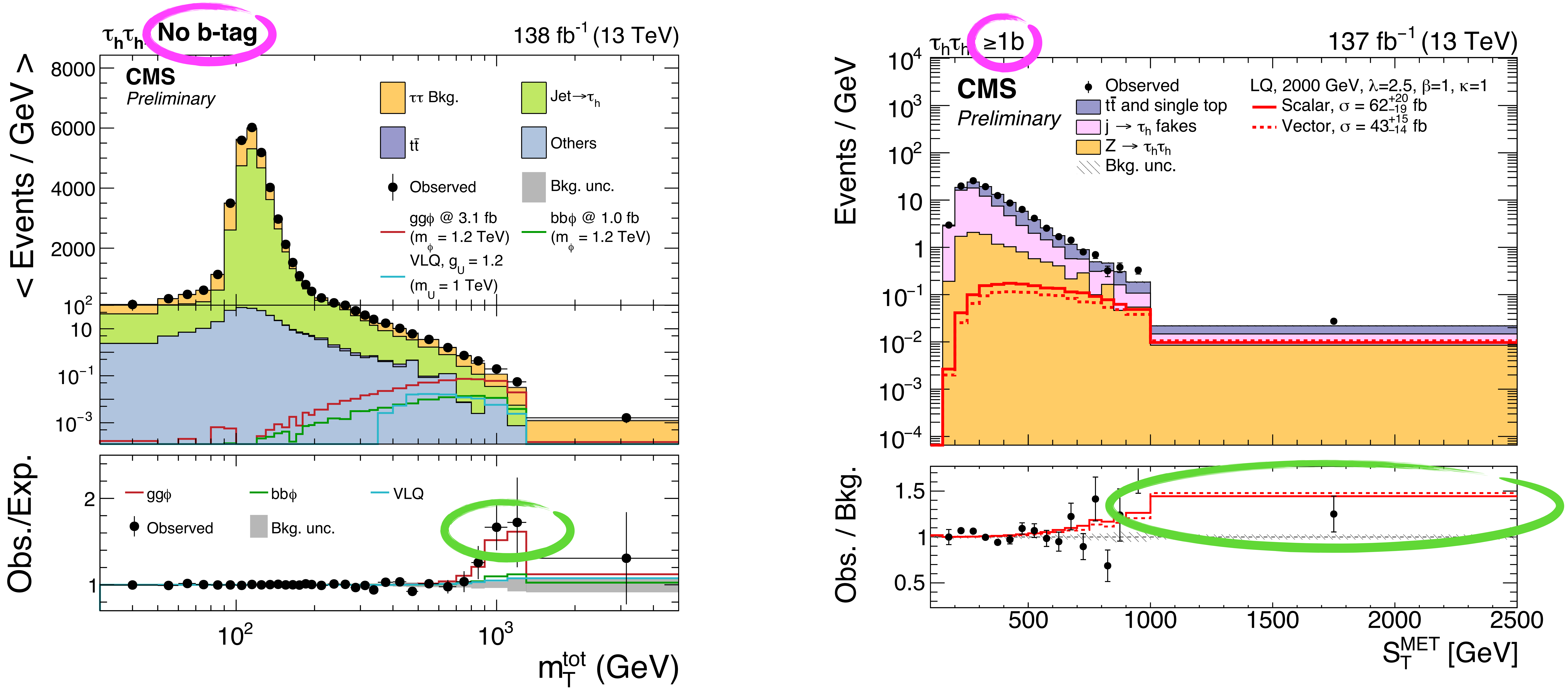




ATLAS data agrees with background predictions but both CMS analyses see a 3σ excess

[ATLAS, 2002.12223; CMS, 2208.02717; CMS PAS HIG-21-001]

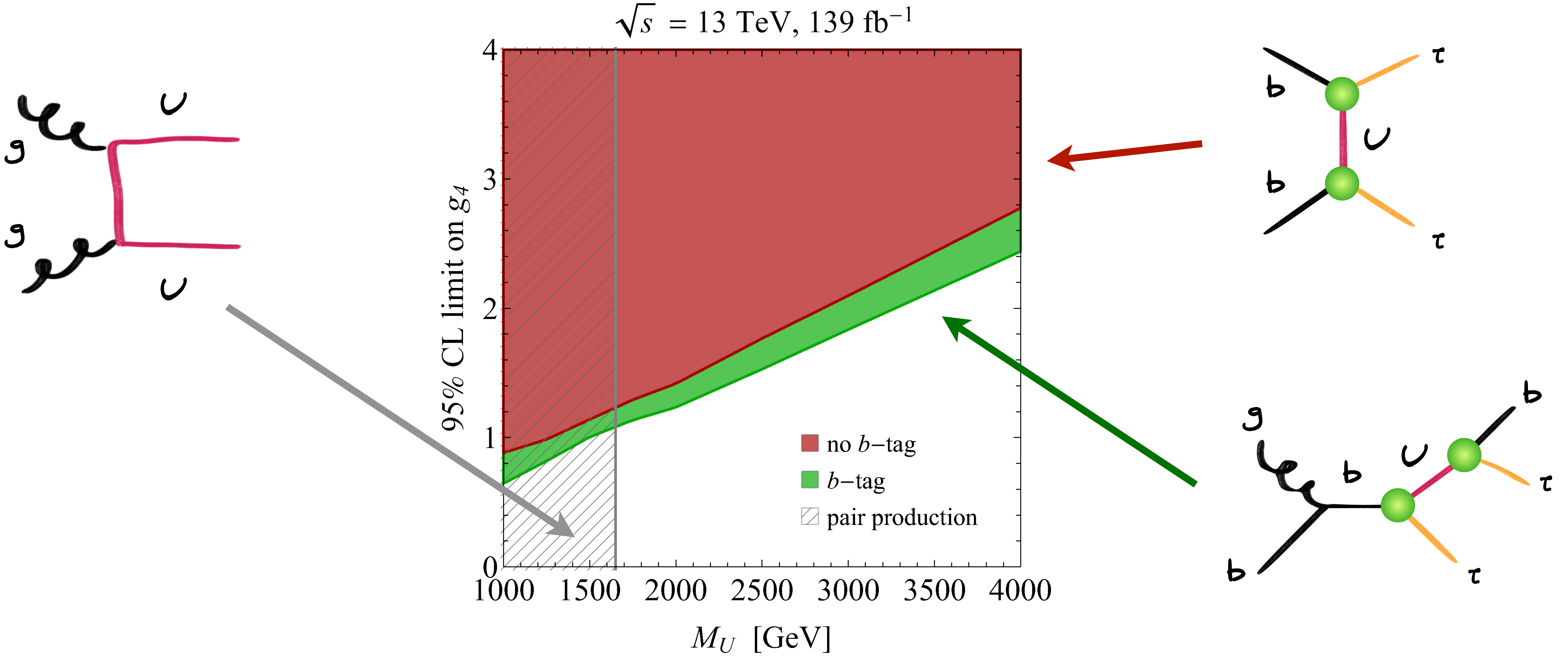
Ditau searches @ LHC Run II



Non-resonant (resonant) excess in b-tag (b-veto) sample fits (does not fit) LQ explanation

[ATLAS, 2002.12223; CMS, 2208.02717; CMS PAS HIG-21-001]

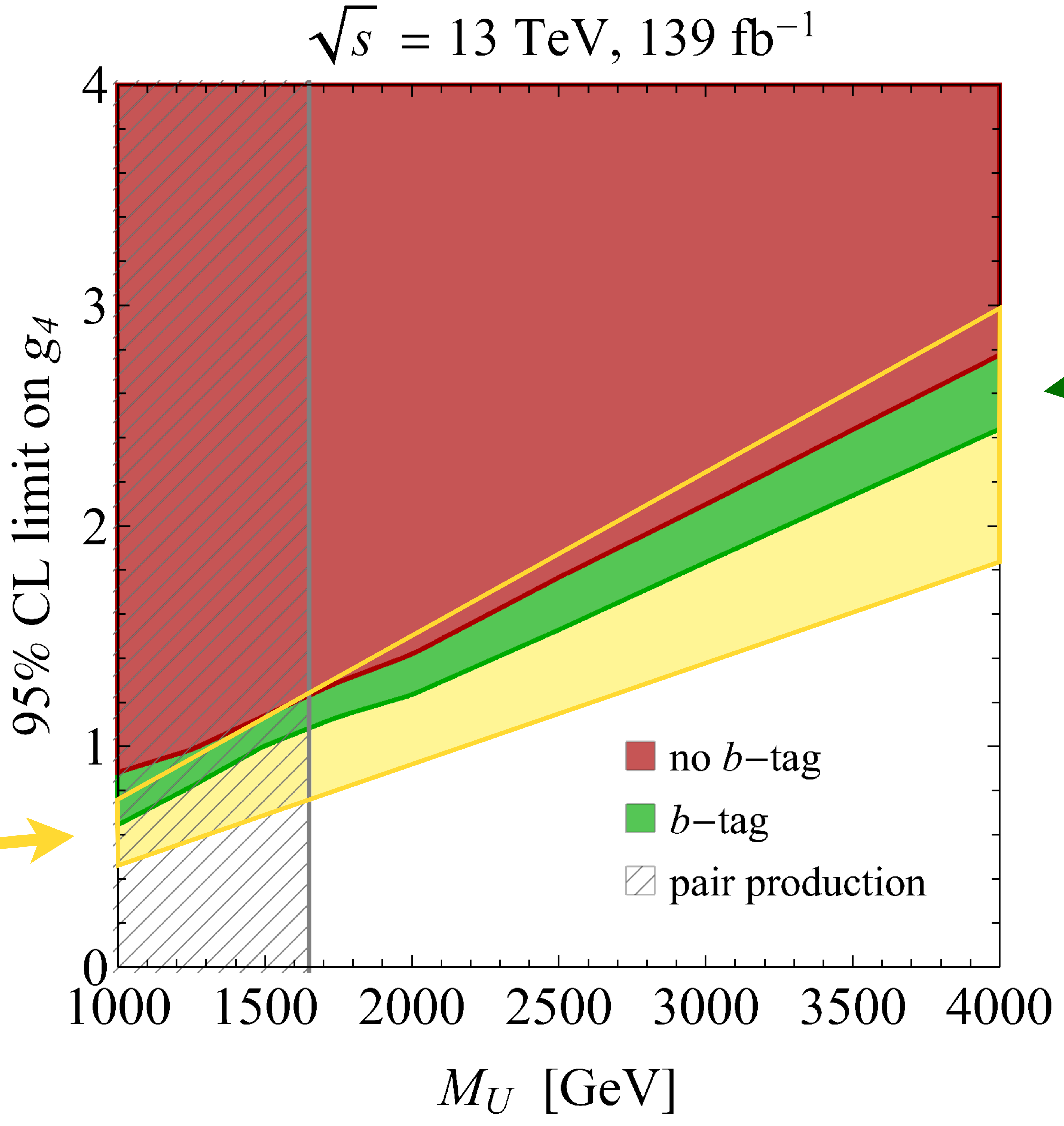
ATLAS ditau limits on singlet vector LQs



[NLO+PS accurate results for t-channel ditau production in LQ models obtained in UH, Schnell & Schulte, 2207.00356; 2209.12780]

ATLAS ditau limits on singlet vector LQs

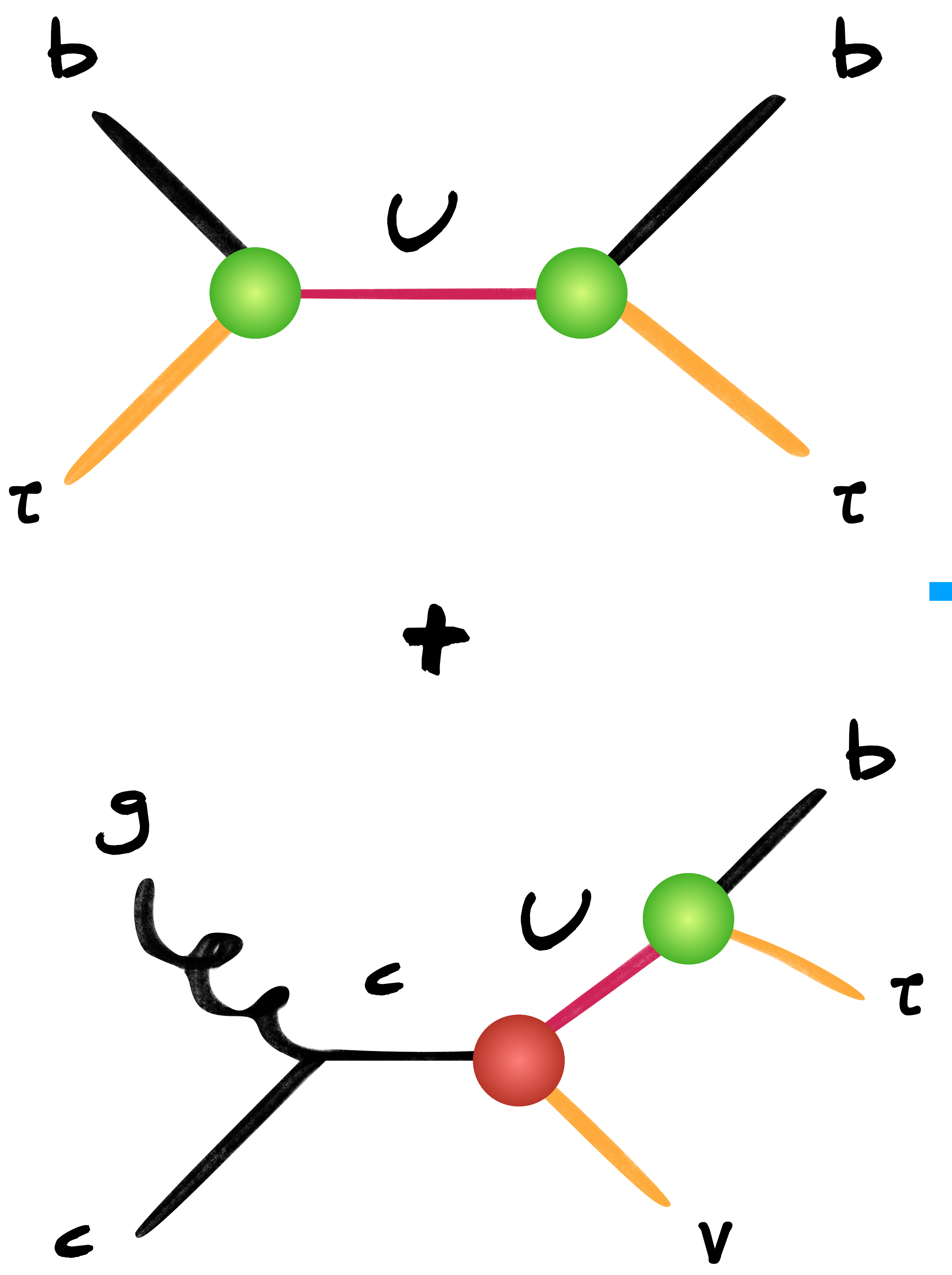
95% CL region favoured by b → c anomalies

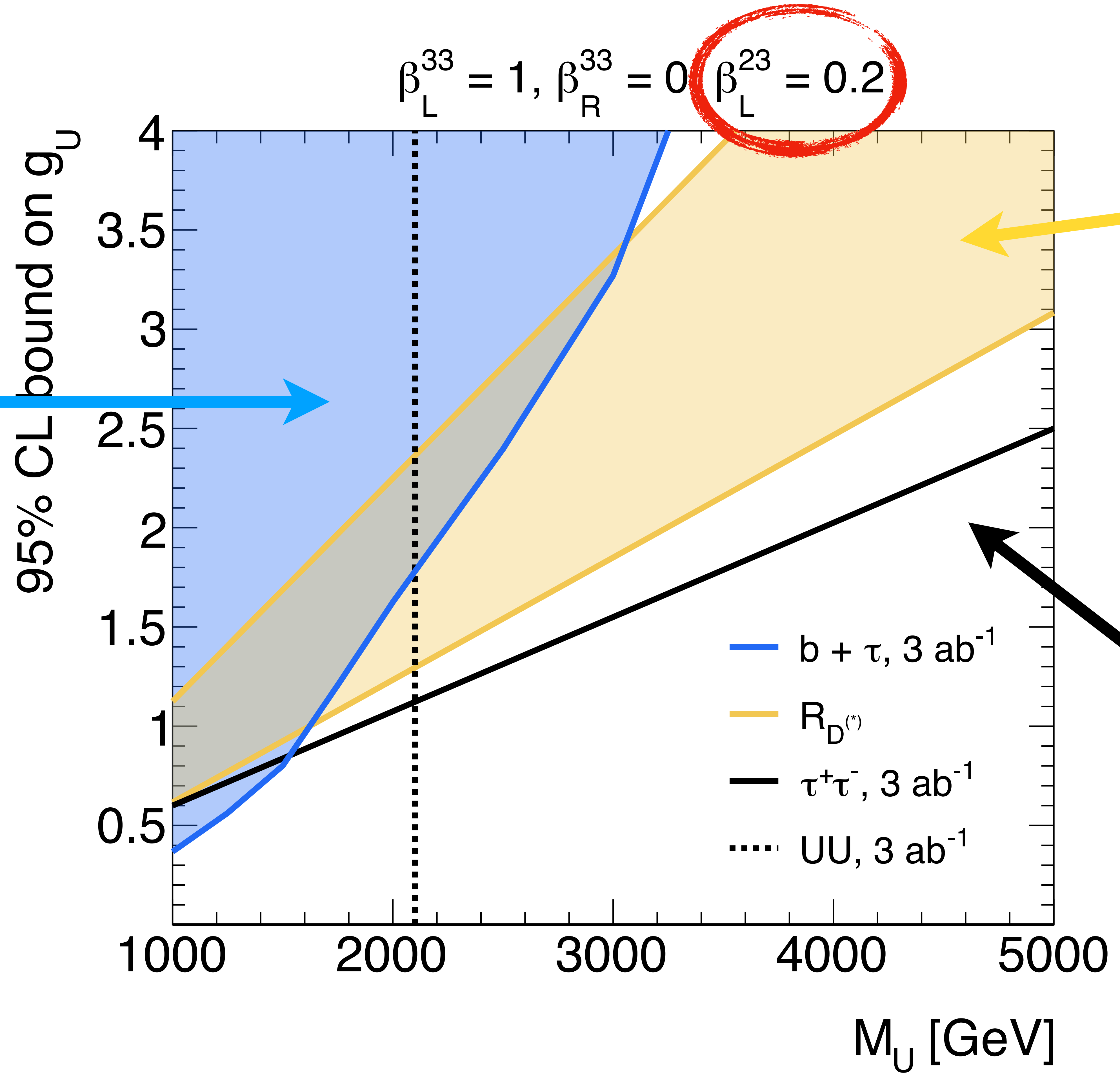


ditau constraints start to test LQ explanations of b → c anomalies — leading limits arise from events with b-jets

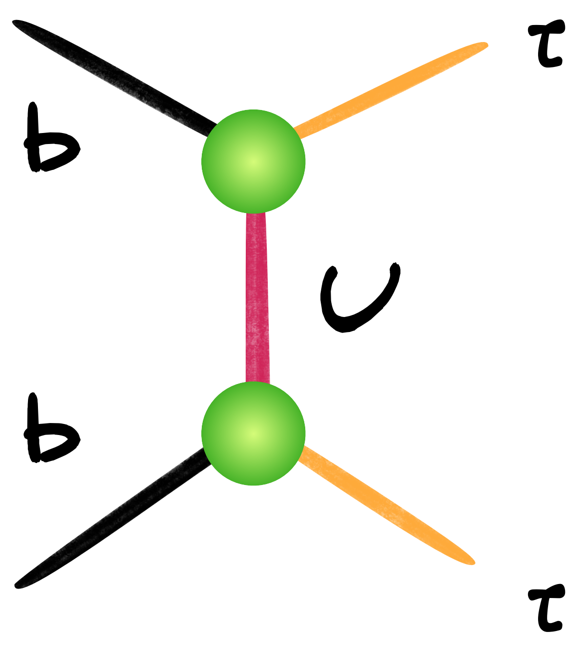
[NLO+PS accurate results for t-channel ditau production in LQ models obtained in UH, Schnell & Schulte, 2207.00356; 2209.12780]

HL-LHC projections for singlet vector LQs





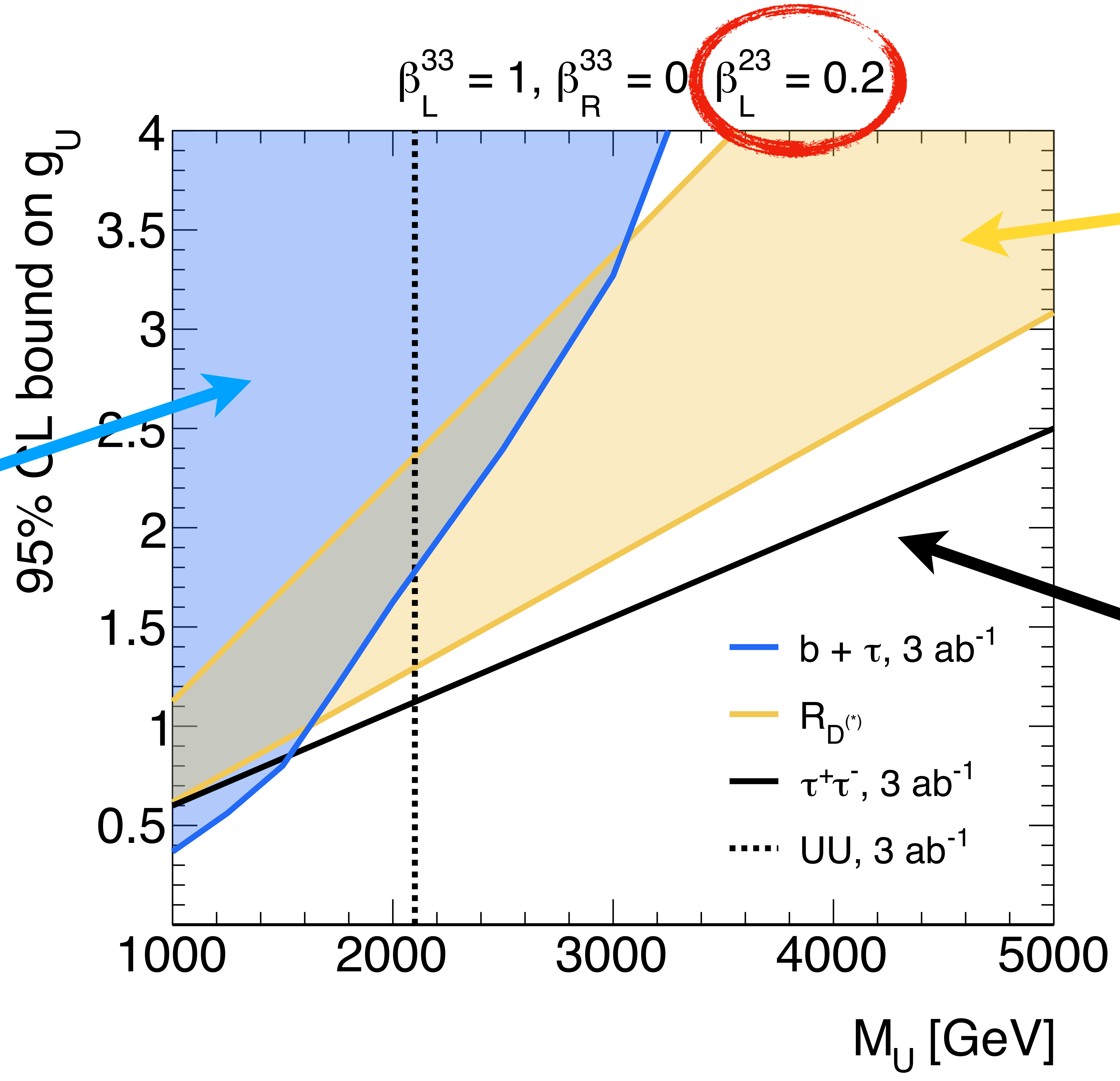
95% CL region favoured by b → c anomalies



[UH & Polesello, 2012.11474; Cornella, Fuentes-Martin, Faroughi, Isidori & Neubert, 2103.16558]

HL-LHC projections for singlet vector LQs

weaker but complementary information provided by searches for resonant 3rd-generation LQ signatures

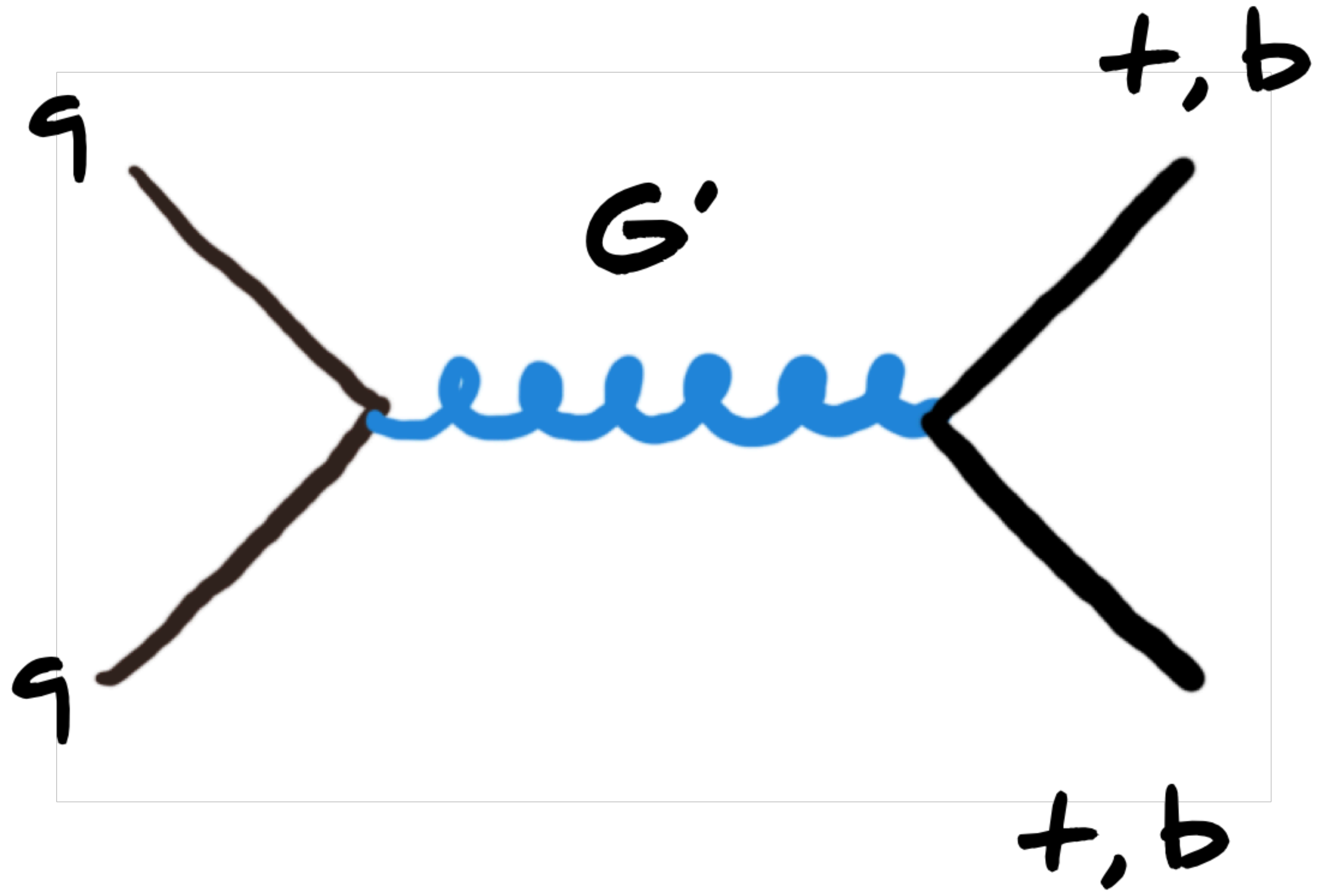


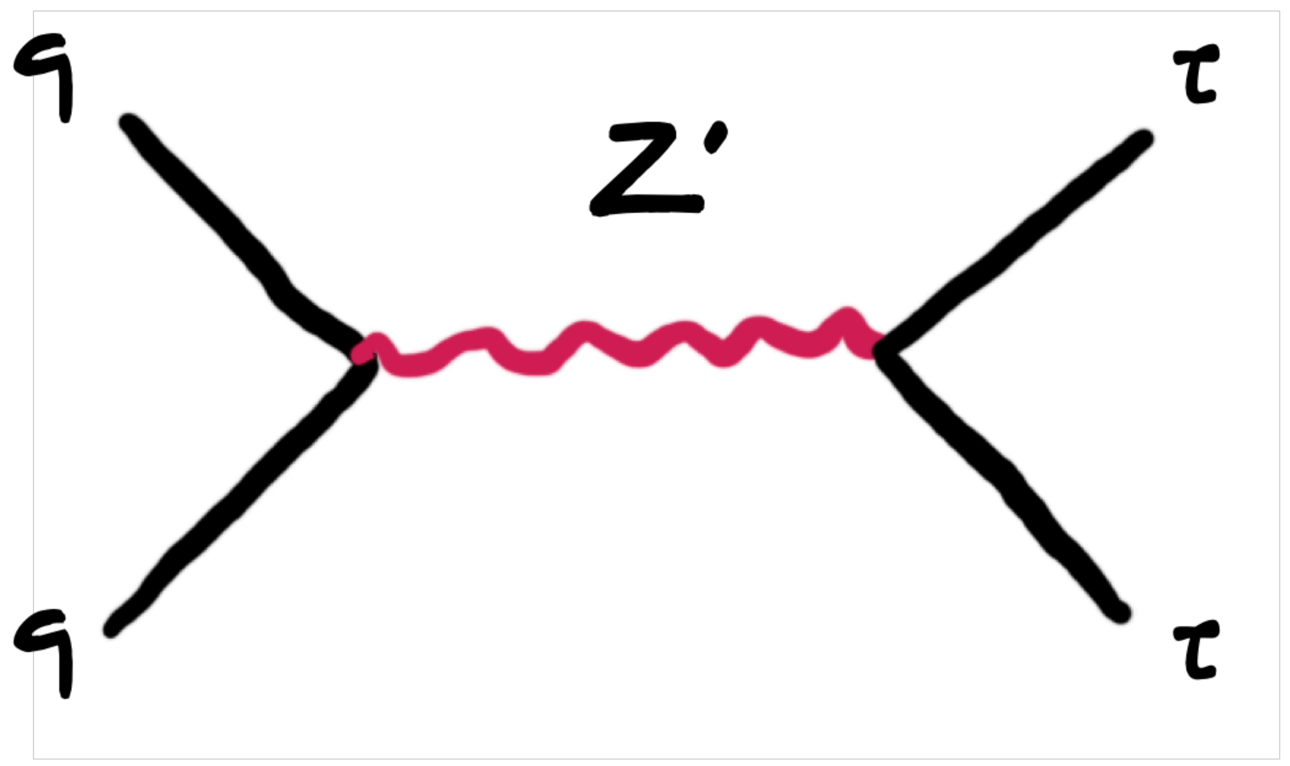
95% CL region favoured by b → c anomalies

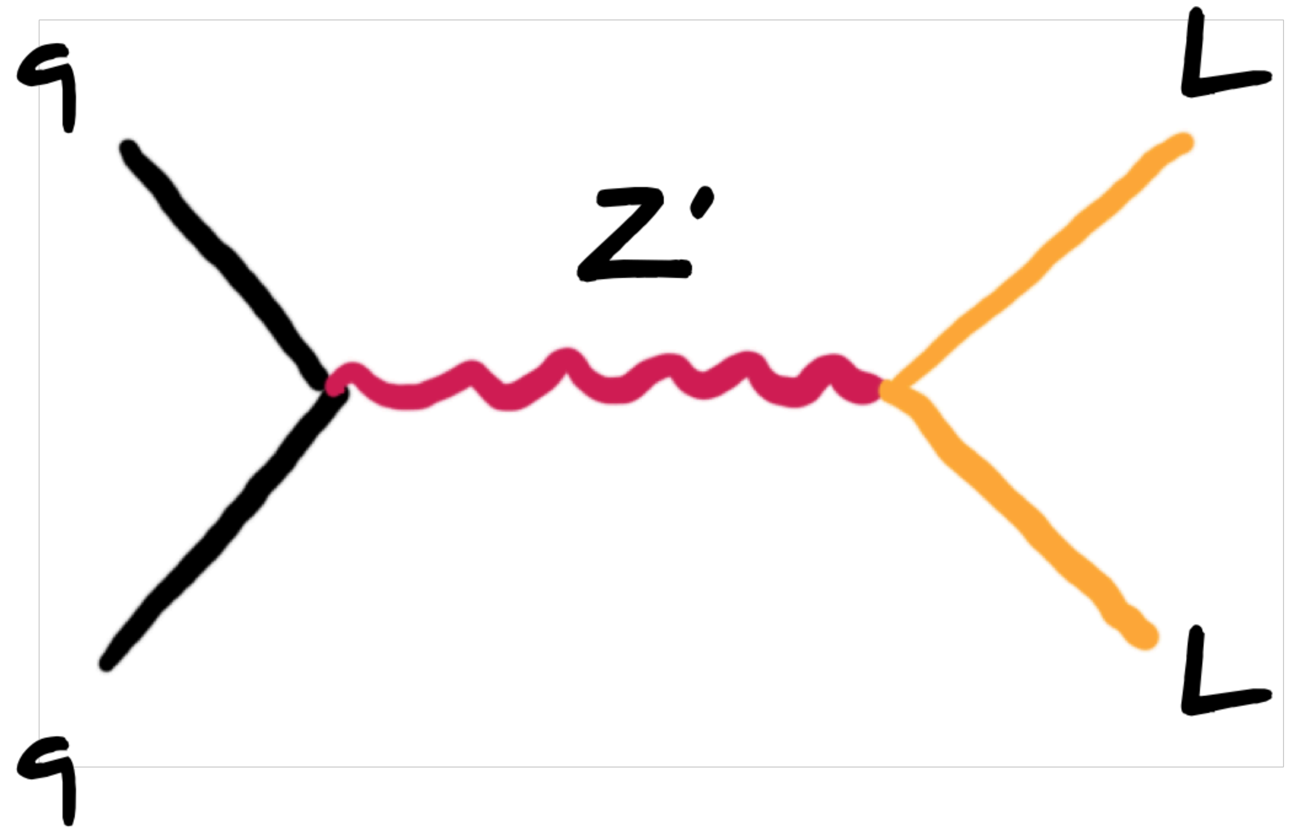
probably all singlet vector LQ explanations of b → c anomalies can be tested via ditau searches @ HL-LHC

[UH & Polesello, 2012.11474; Cornella, Fuentes-Martin, Faroughi, Isidori & Neubert, 2103.16558]

Beyond simplified LQ models

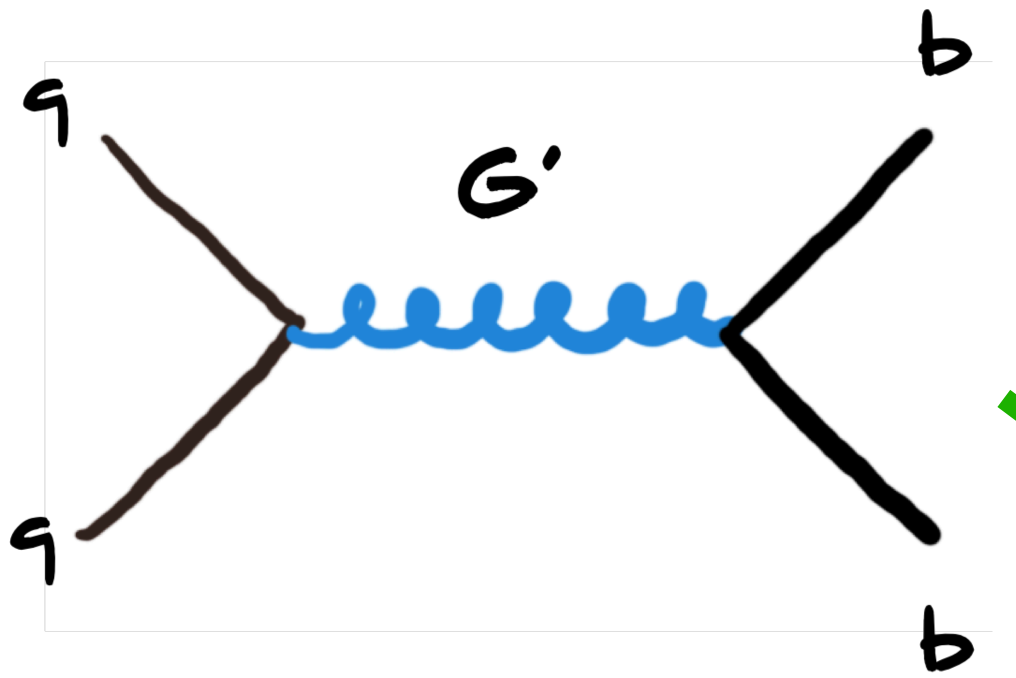




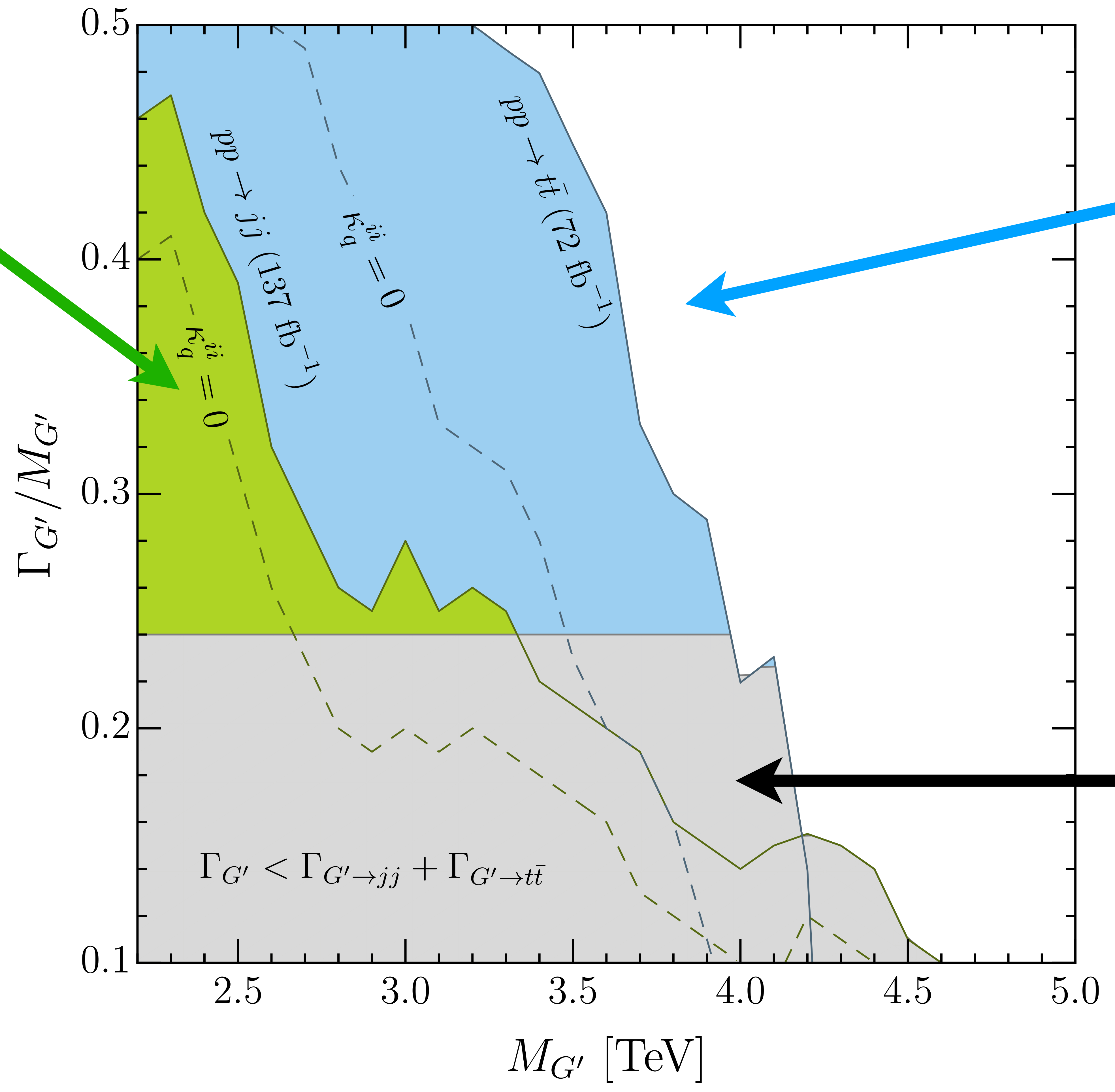


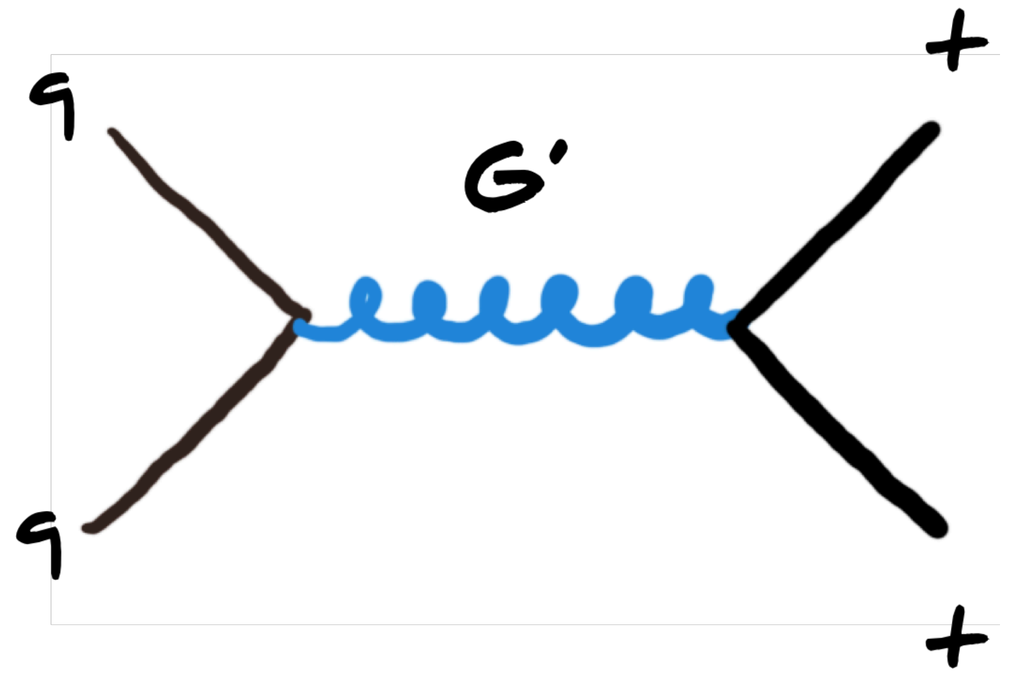
Ultraviolet complete LQ models typically contain new degrees of freedom besides LQ such as a heavy gluon G′, a Z′, vector-like leptons (VLLs) L, additional Higgses, etc. New states cannot be arbitrarily heavy in models that address $b \to c$ anomalies

Bounds on G′ motivated by b → c anomalies



b-pair production



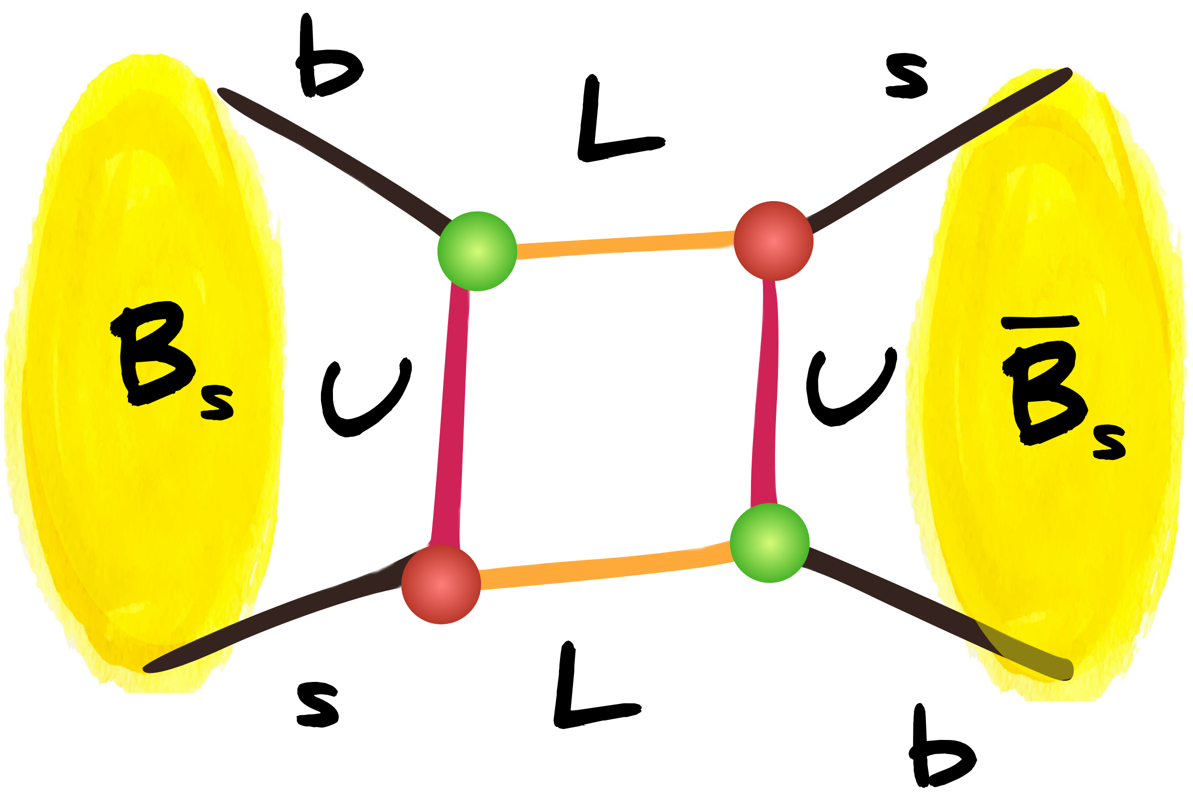


t-pair production

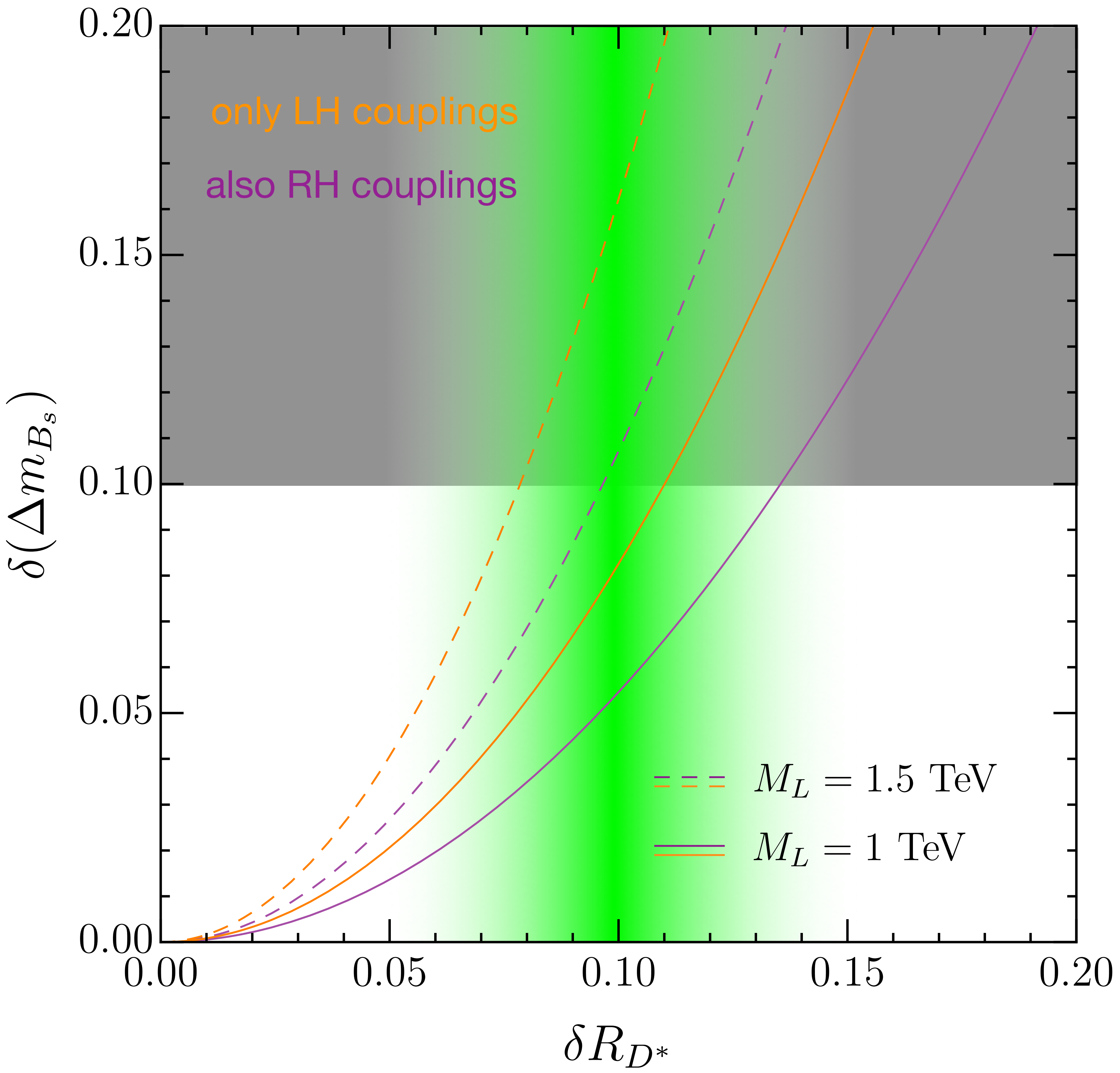
parameter region where G′ decays only to SM quarks

[Cornella, Fuentes-Martin, Faroughi, Isidori & Neubert, 2103.16558]

VLLs in gauged vector LQ models



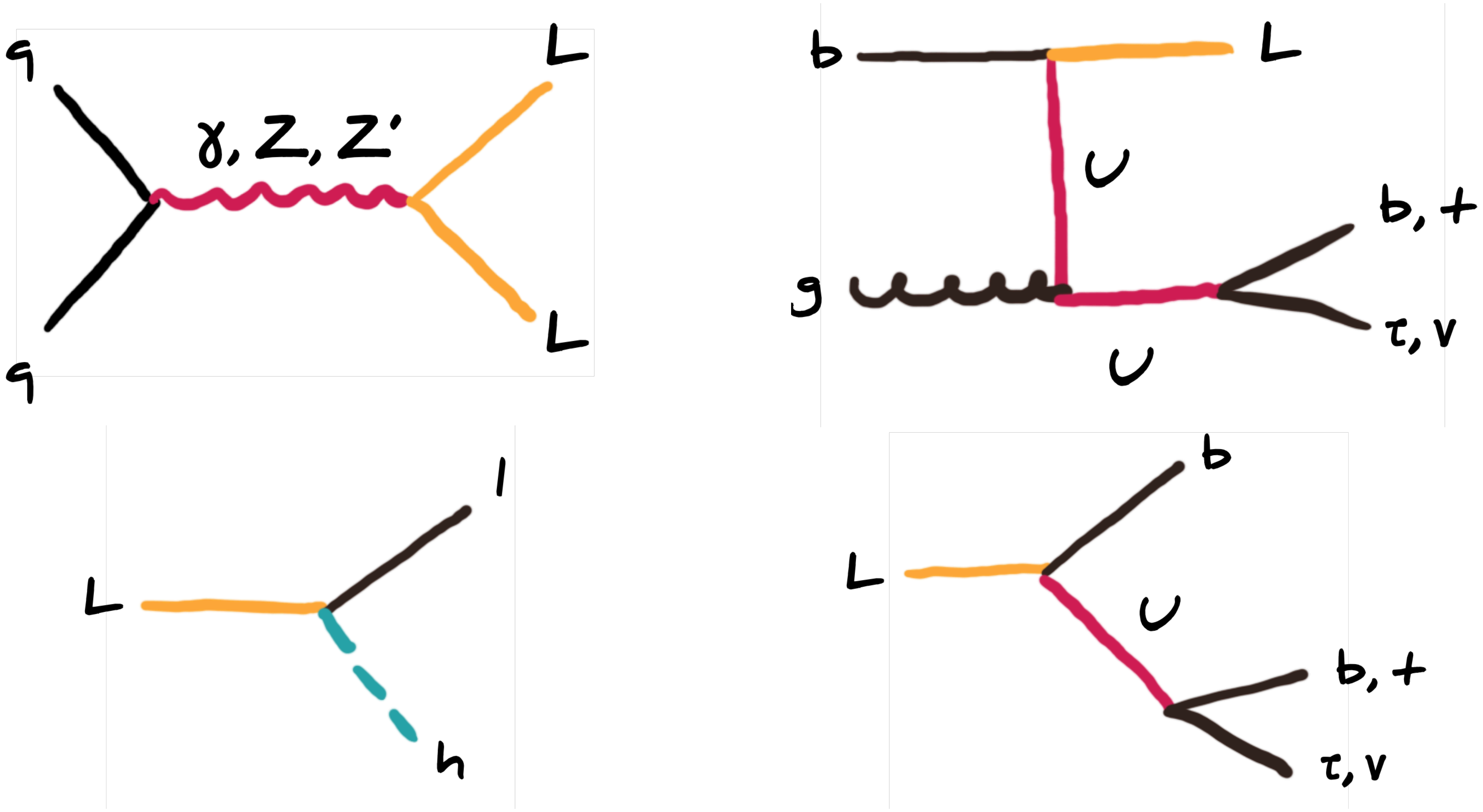
$$\propto \frac{M_L^2}{M_U^2}$$



Curbing LQ contributions to B_s mixing requires VLLs with mass M_L not far from 1 TeV

[Cornella, Fuentes-Martin, Faroughi, Isidori & Neubert, 2103.16558]

VLLs in gauged vector LQ models

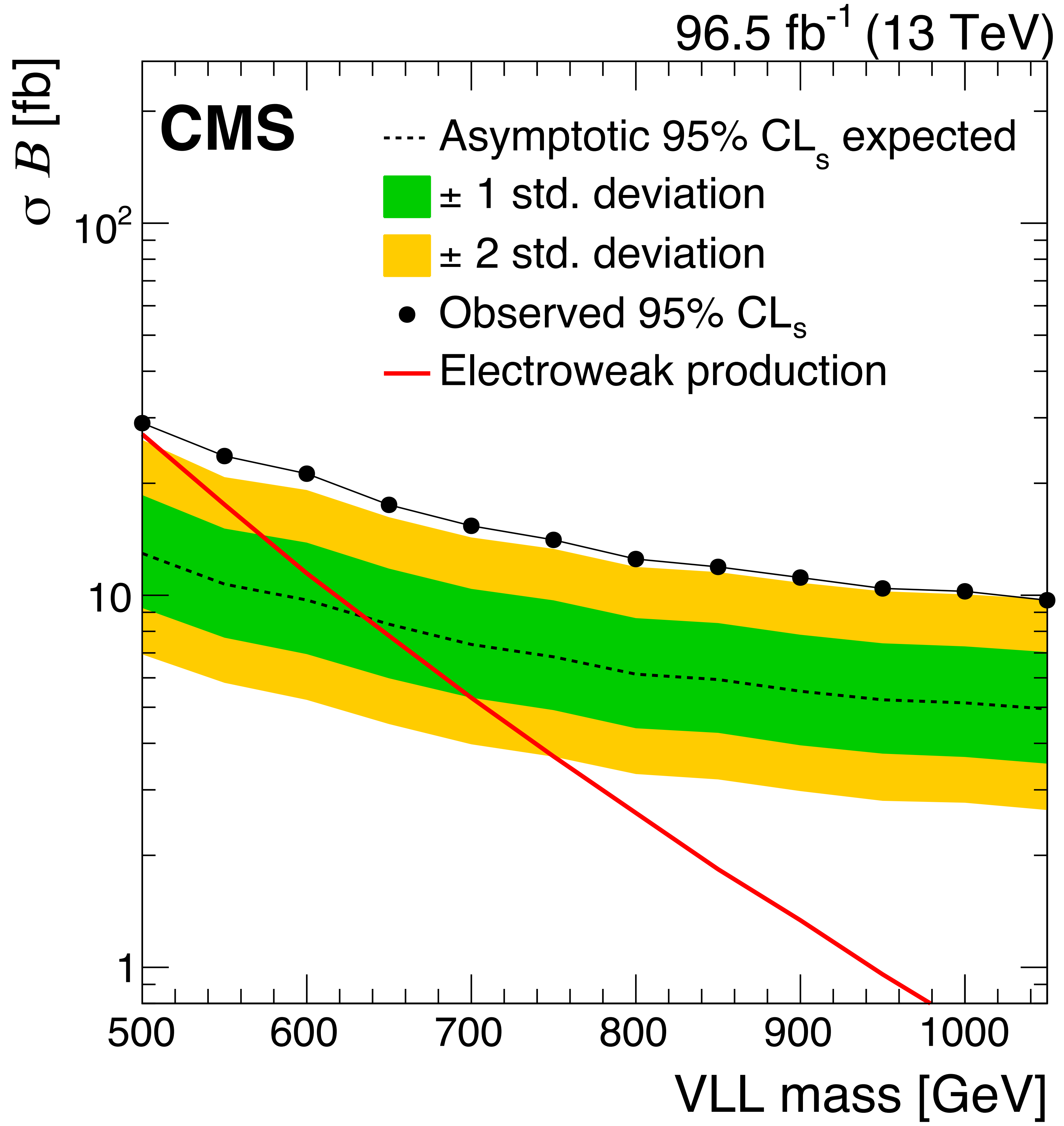


VLL production in context of gauged vector LQ models addressing b → c anomalies is expected to lead to high-multiplicity final states with τ, b, t & $E_{T,miss}$

[see for instance Di Luzio et al., 1808.0094; Cornella, Fuentes-Martin, Faroughi, Isidori & Neubert, 2103.16558]

VLLs searches triggered by B anomalies

Tau multiplicity	VLL production + decay mode	Final state
$0\,\tau$	$\mathrm{EE} \to \mathrm{b}(\mathrm{t}\nu_\tau)\mathrm{b}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+4\mathrm{j}+2\nu_\tau$
	$\mathrm{EN} \to \mathrm{b}(\mathrm{t}\nu_\tau)\mathrm{t}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+6\mathrm{j}+2\nu_\tau$
	$\mathrm{NN} \to \mathrm{t}(\mathrm{t}\nu_\tau)\mathrm{t}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+8\mathrm{j}+2\nu_\tau$
$1\,\tau$	$\mathrm{EE} \to \mathrm{b}(\mathrm{b}\tau)\mathrm{b}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+2\mathrm{j}+\tau+\nu_\tau$
	$\mathrm{EN} \to \mathrm{b}(\mathrm{t}\nu_\tau)\mathrm{t}(\mathrm{b}\tau)$	$4\mathrm{b}+4\mathrm{j}+\tau+\nu_\tau$
	$\mathrm{EN} \to \mathrm{b}(\mathrm{b}\tau)\mathrm{t}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+4\mathrm{j}+\tau+\nu_\tau$
	$\mathrm{NN} \to \mathrm{t}(\mathrm{b}\tau)\mathrm{t}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+6\mathrm{j}+\tau+\nu_\tau$
$2\,\tau$	$\mathrm{EE} \to \mathrm{b}(\mathrm{b}\tau)\mathrm{b}(\mathrm{b}\tau)$	$4\mathrm{b}+2\tau$
	$\mathrm{EN} \to \mathrm{b}(\mathrm{b}\tau)\mathrm{t}(\mathrm{b}\tau)$	$4\mathrm{b}+2\mathrm{j}+2\tau$
	$\mathrm{NN} \to \mathrm{t}(\mathrm{b}\tau)\mathrm{t}(\mathrm{b}\tau)$	$4\mathrm{b}+4\mathrm{j}+2\tau$

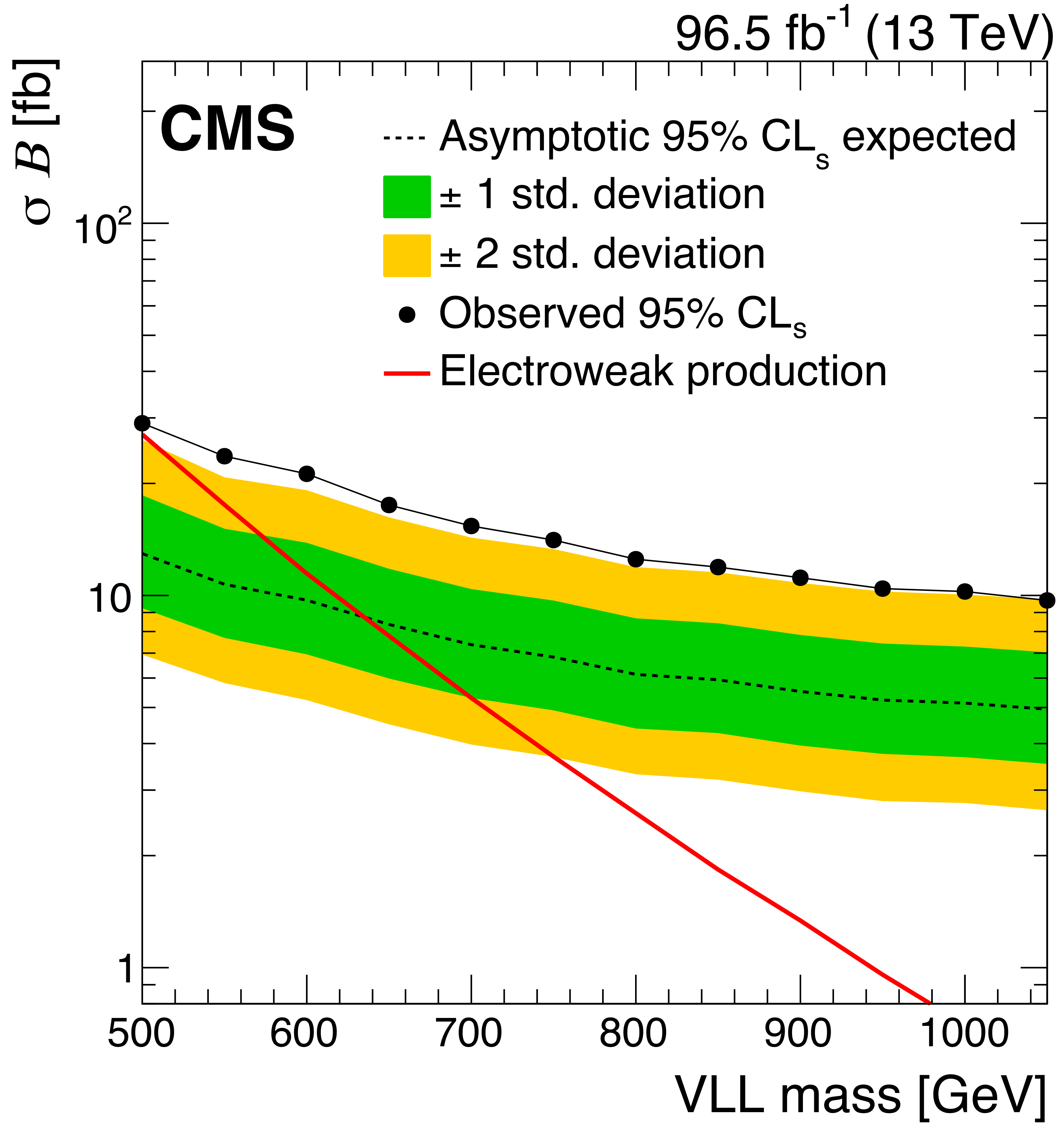


Recently CMS performed first dedicated search for VLLs in gauged vector LQ model, exploring final states with at least three b-jets & two 3rd-generation leptons

[CMS, 2208.09700]

VLLs searches triggered by B anomalies

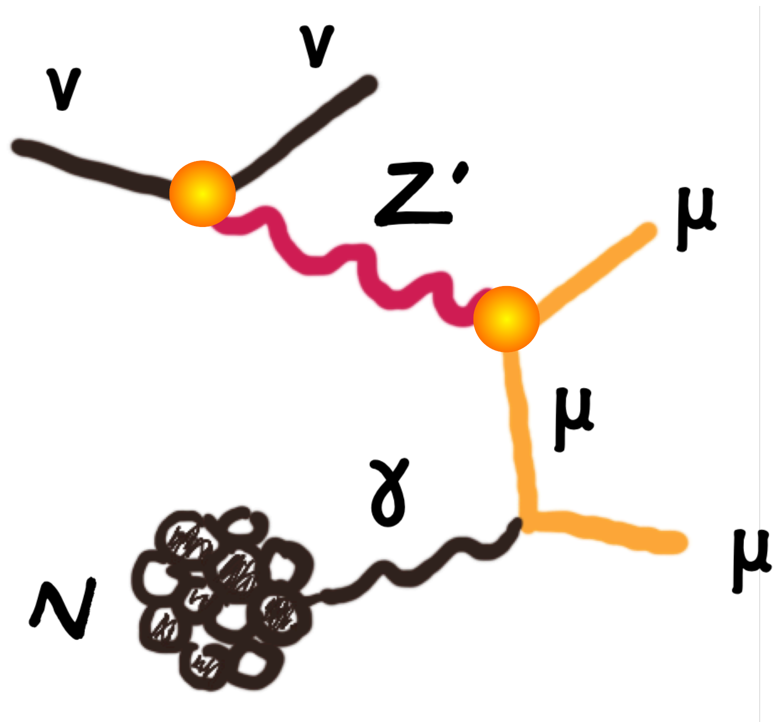
Tau multiplicity	VLL production + decay mode	Final state
$0\,\tau$	$\mathrm{EE} \to \mathrm{b}(\mathrm{t}\nu_\tau)\mathrm{b}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+4\mathrm{j}+2\nu_\tau$
	$\mathrm{EN} \to \mathrm{b}(\mathrm{t}\nu_\tau)\mathrm{t}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+6\mathrm{j}+2\nu_\tau$
	$\mathrm{NN} \to \mathrm{t}(\mathrm{t}\nu_\tau)\mathrm{t}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+8\mathrm{j}+2\nu_\tau$
$1\,\tau$	$\mathrm{EE} \to \mathrm{b}(\mathrm{b}\tau)\mathrm{b}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+2\mathrm{j}+\tau+\nu_\tau$
	$\mathrm{EN} \to \mathrm{b}(\mathrm{t}\nu_\tau)\mathrm{t}(\mathrm{b}\tau)$	$4\mathrm{b}+4\mathrm{j}+\tau+\nu_\tau$
	$\mathrm{EN} \to \mathrm{b}(\mathrm{b}\tau)\mathrm{t}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+4\mathrm{j}+\tau+\nu_\tau$
	$\mathrm{NN} \to \mathrm{t}(\mathrm{b}\tau)\mathrm{t}(\mathrm{t}\nu_\tau)$	$4\mathrm{b}+6\mathrm{j}+\tau+\nu_\tau$
$2\,\tau$	$\mathrm{EE} \to \mathrm{b}(\mathrm{b}\tau)\mathrm{b}(\mathrm{b}\tau)$	$4\mathrm{b}+2\tau$
	$\mathrm{EN} \to \mathrm{b}(\mathrm{b}\tau)\mathrm{t}(\mathrm{b}\tau)$	$4\mathrm{b}+2\mathrm{j}+2\tau$
	$\mathrm{NN} \to \mathrm{t}(\mathrm{b}\tau)\mathrm{t}(\mathrm{b}\tau)$	$4\mathrm{b}+4\mathrm{j}+2\tau$



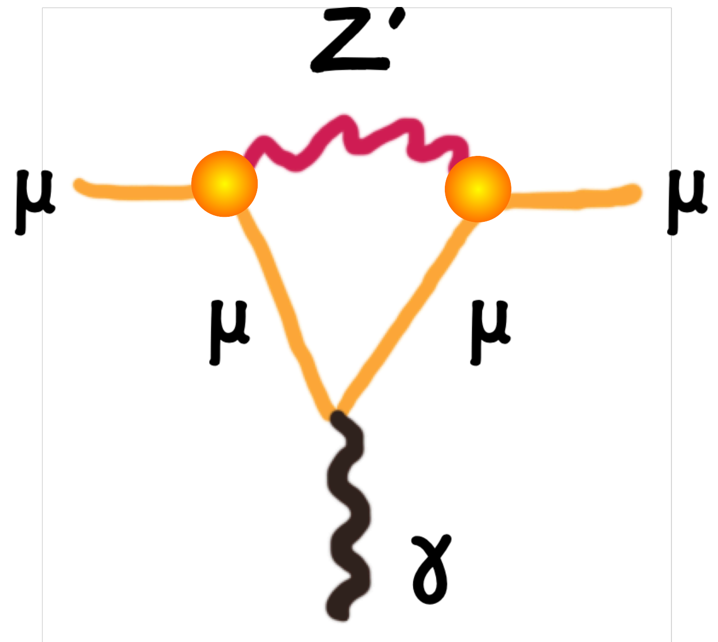
Expected limit on VLL mass of 650 GeV but CMS observes 2.8σ excess for VLL mass hypothesis of 600 GeV & as a result no VLL masses are excluded at 95% CL

[CMS, 2208.09700]

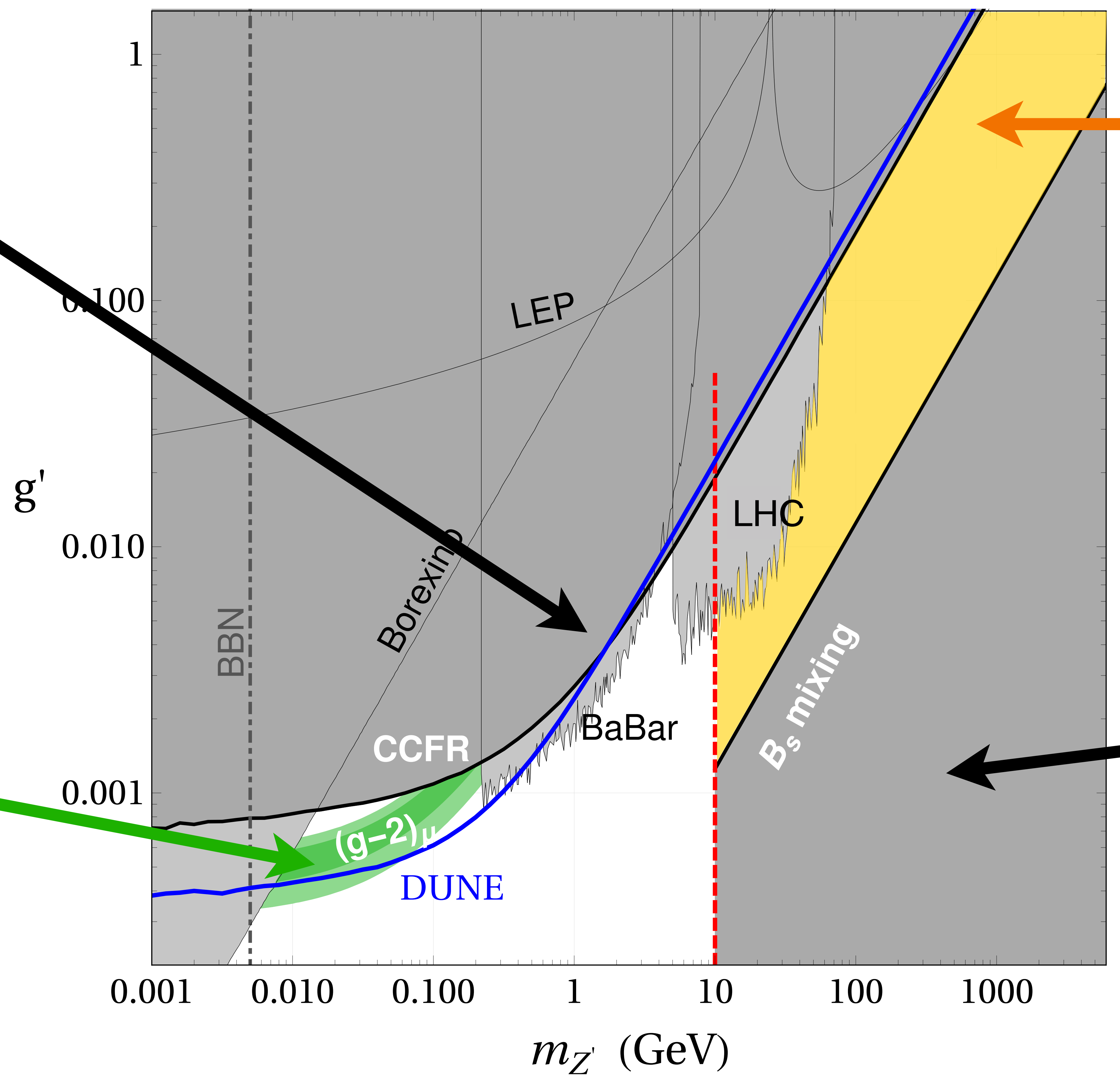
Z′ for b → s anomalies: L_μ-L_τ models

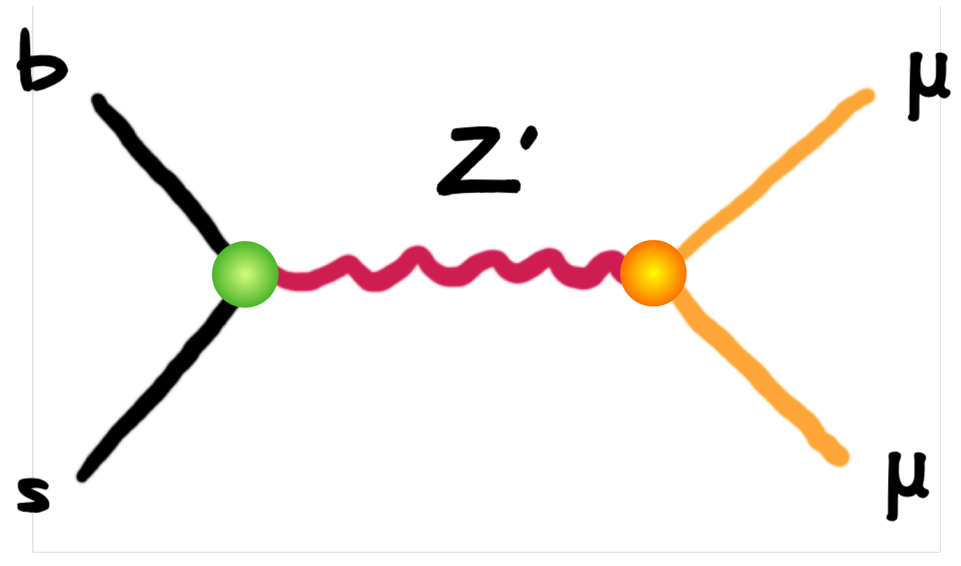


excluded by neutrino trident production

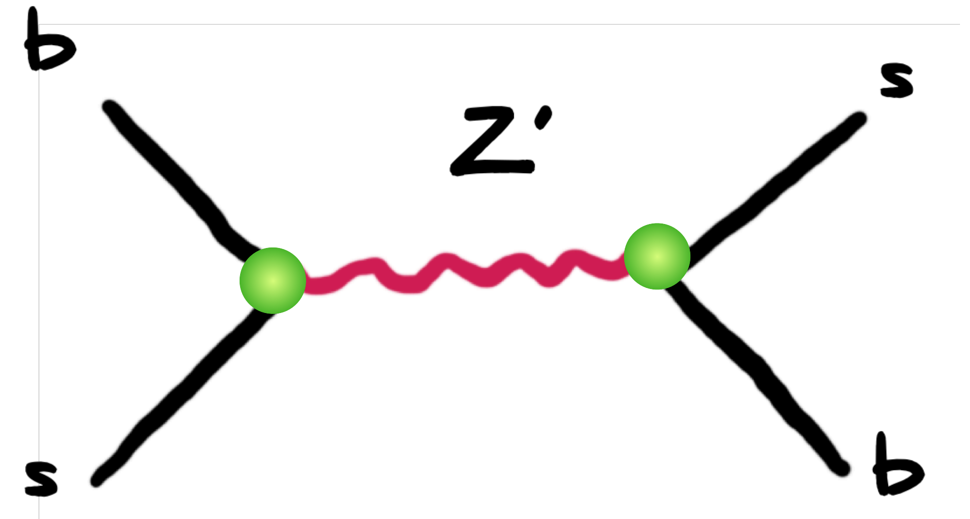


$(g\text{-}2)_\mu$ explained





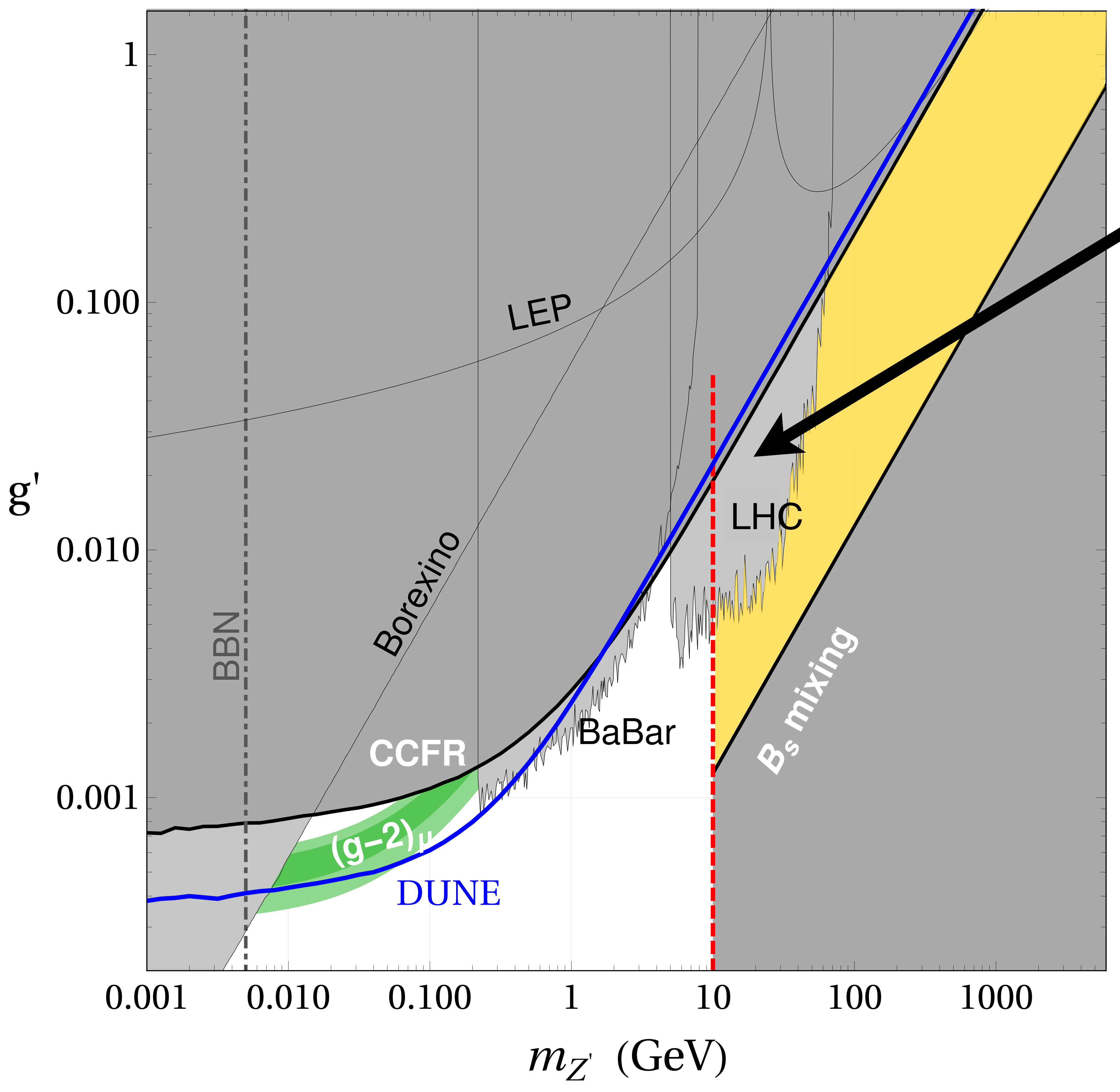
b → s anomalies explained

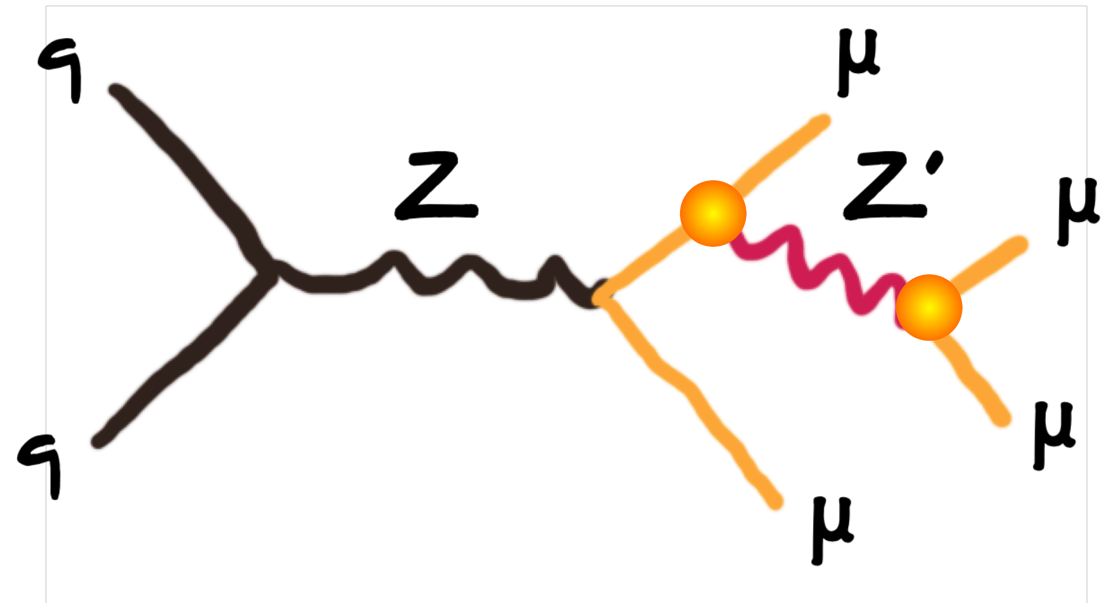


excluded by B_s mixing

[see for instance Altmannshofer et al., 1403.1269, 1508.07009 & 1902.06765]

Z′ for b → s anomalies: L_μ-L_τ models



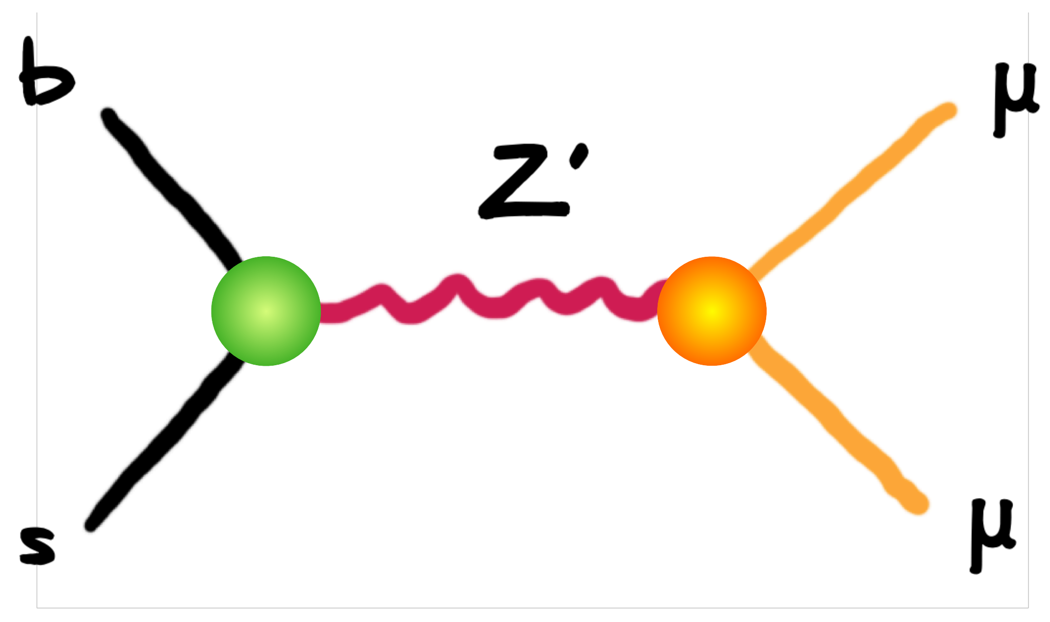


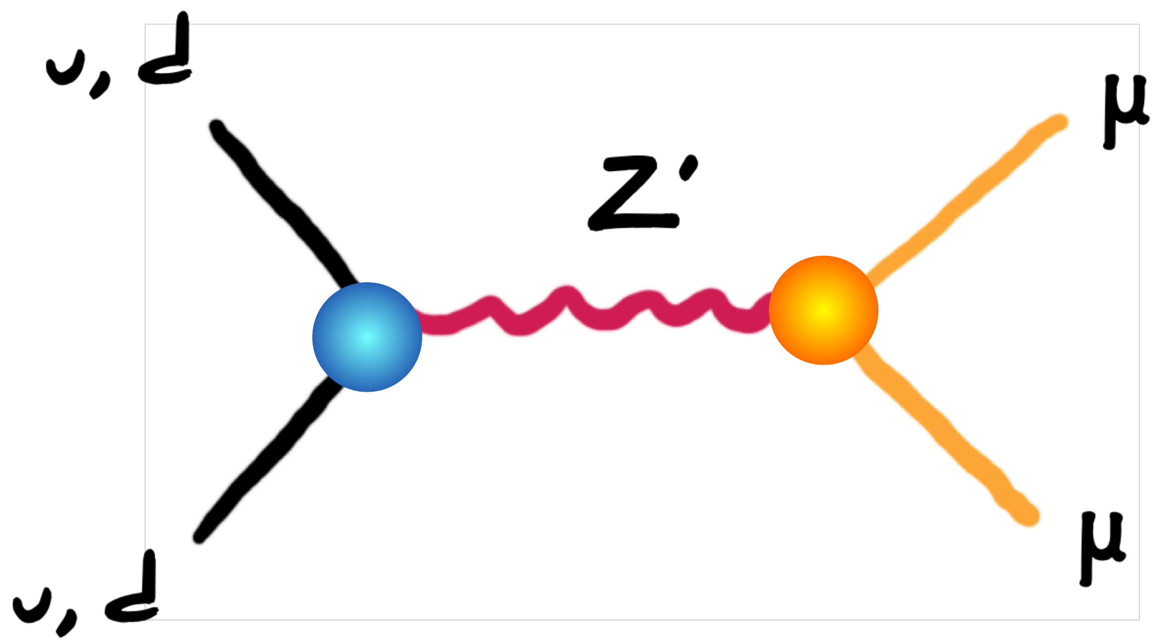
excluded by LHC searches for pp → 4μ

[CMS, 1808.03684]

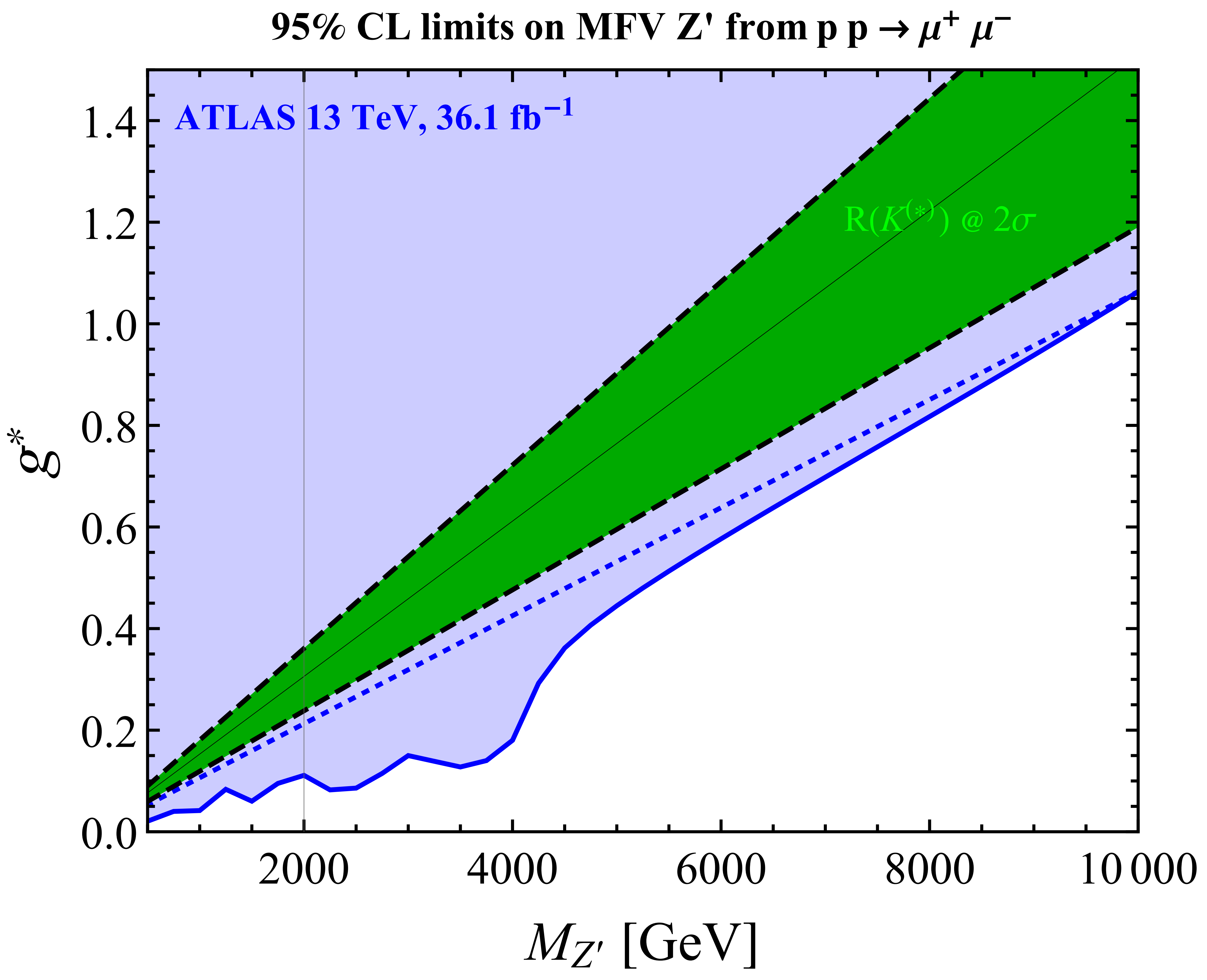
[see for instance Altmannshofer et al., 1403.1269, 1508.07009 & 1902.06765]

Dilepton searches in L_μ-L_τ models





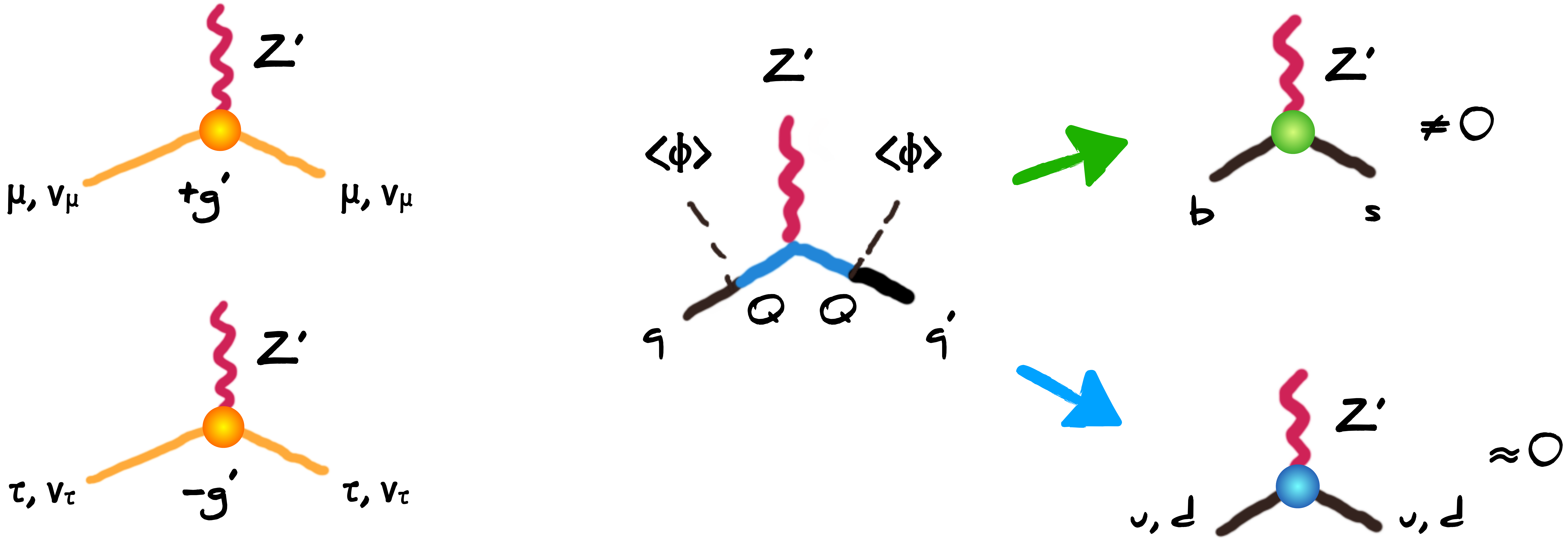
$= |V_{ts}|\, g^* \simeq 0.04\, g^*$ $\qquad$ $= g^*$



Z′ couplings that follow minimal flavor violating (MFV) pattern excluded by dilepton searches

[Greljo & Marzocca, 1704.09015]

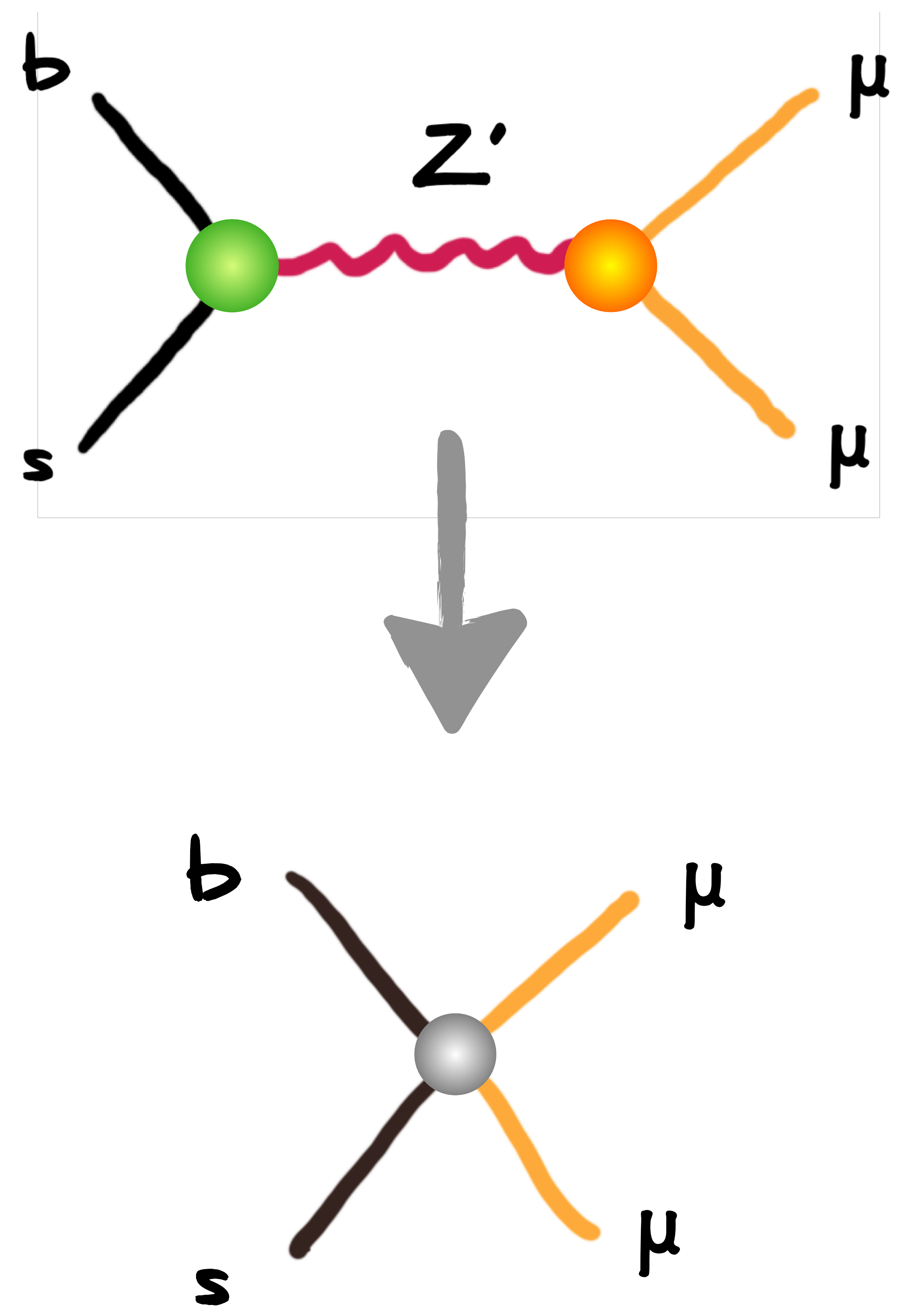
Dilepton searches in L_μ-L_τ models

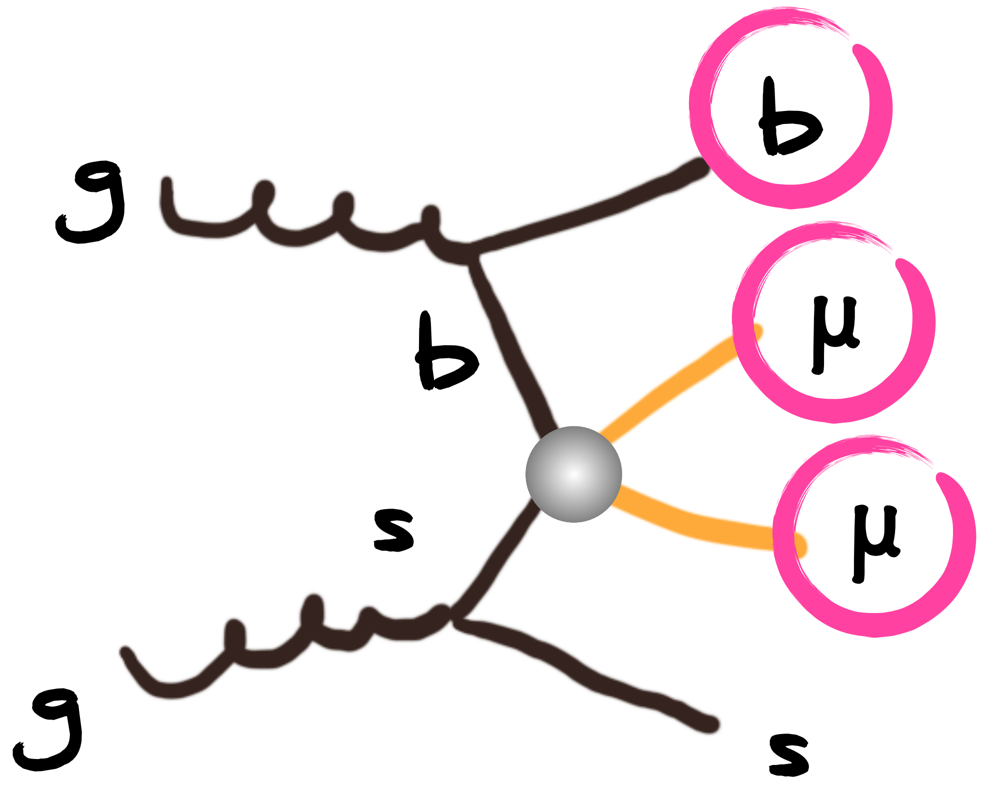


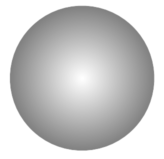
Gauging L_μ-L_τ gives gives Z′ with vectorial couplings to μ, τ & corresponding ν. Introduce vector-like quarks Q to generate bsZ′ coupling & suppress Z′ couplings to light quarks

[see for instance Altmannshofer et al., 1403.1269, 1508.07009 & 1902.06765]

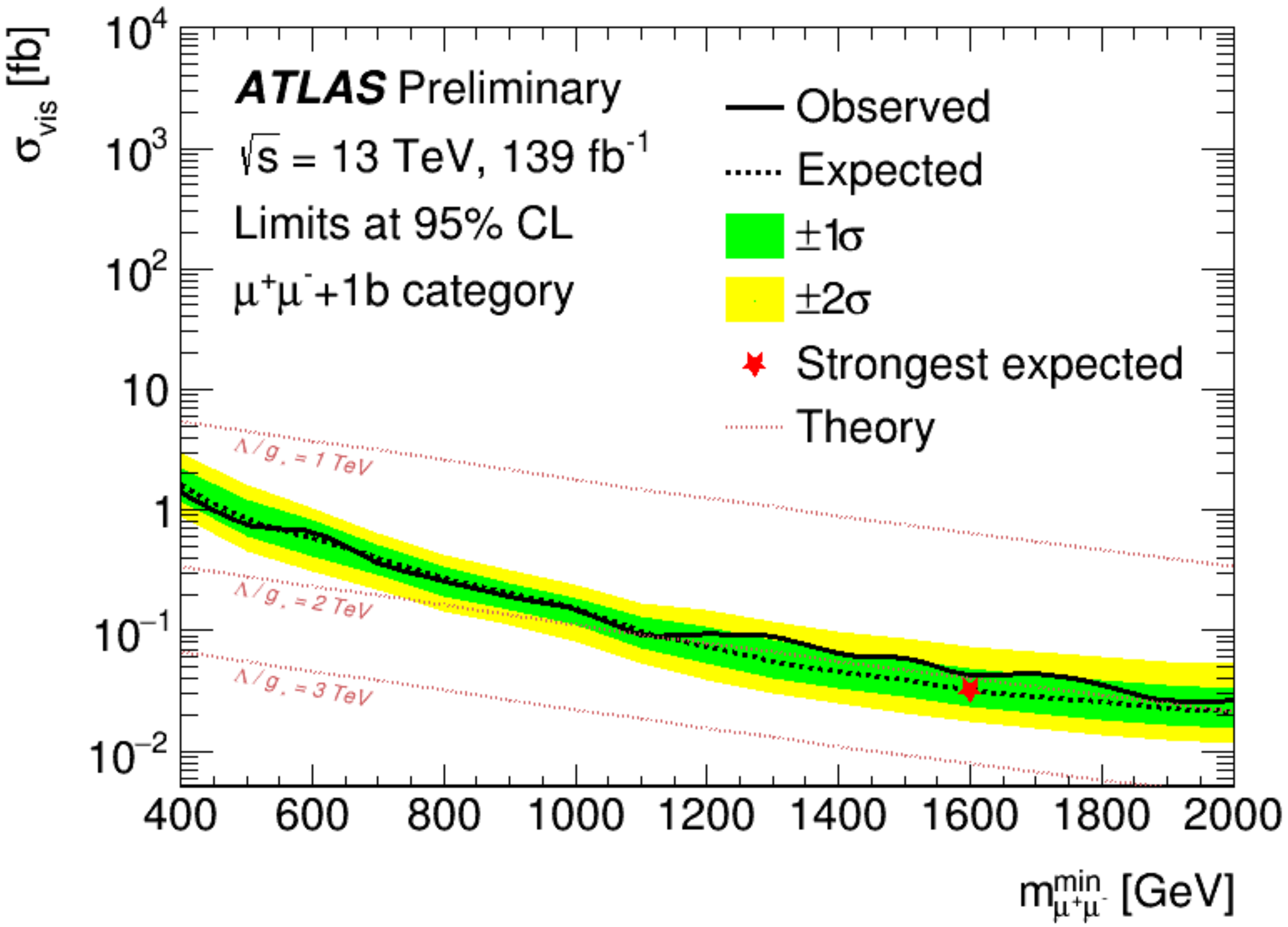
Searches for bsμμ contact interactions





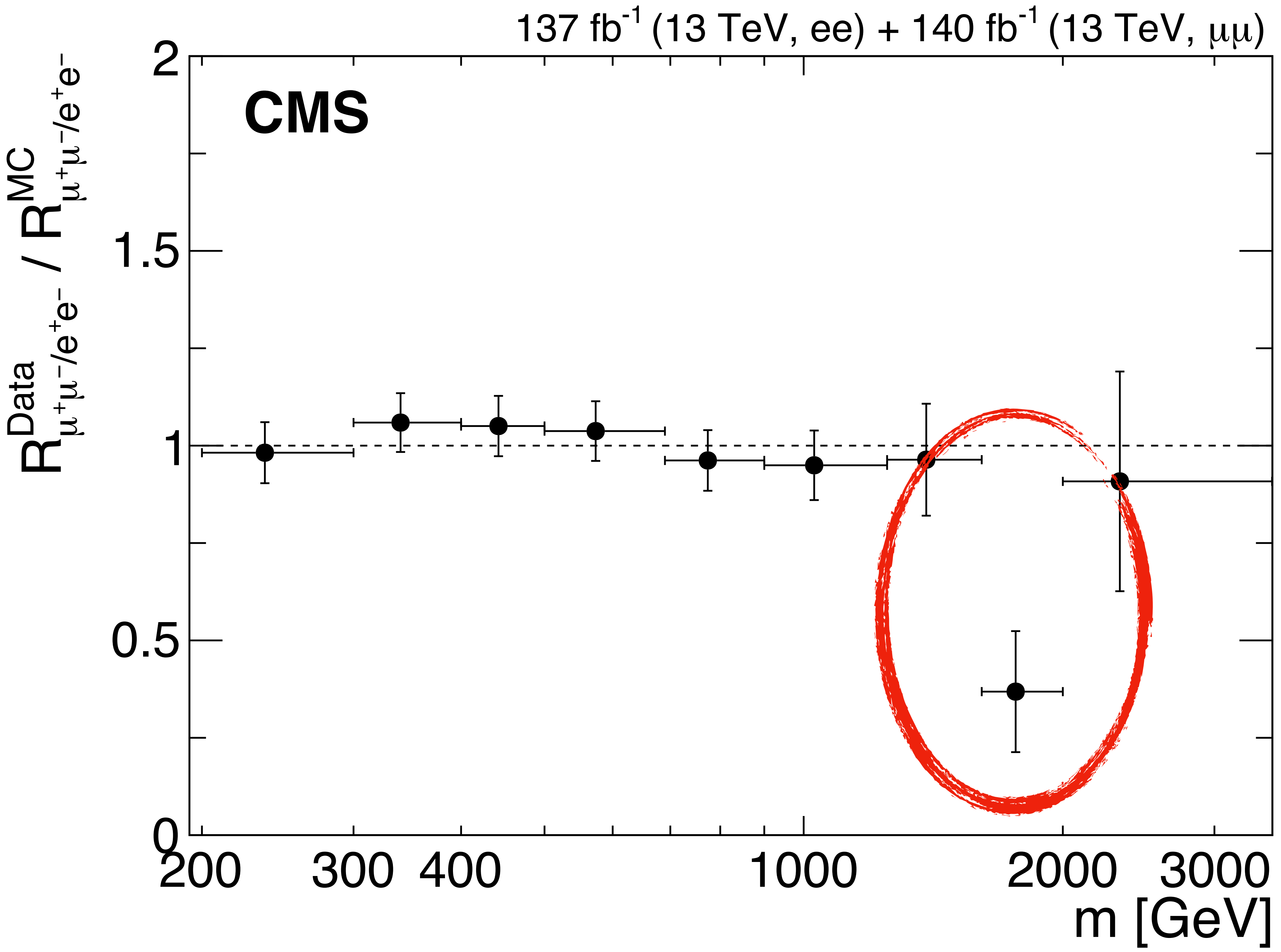
 $= \frac{g_*^2}{\Lambda^2}$

[ATLAS-CONF-2021-012]



First search for bsμμ four-Fermi operator by ATLAS, but bounds on suppression scale are a factor of O(20) below sensitivity needed to test b → s anomalies model independently

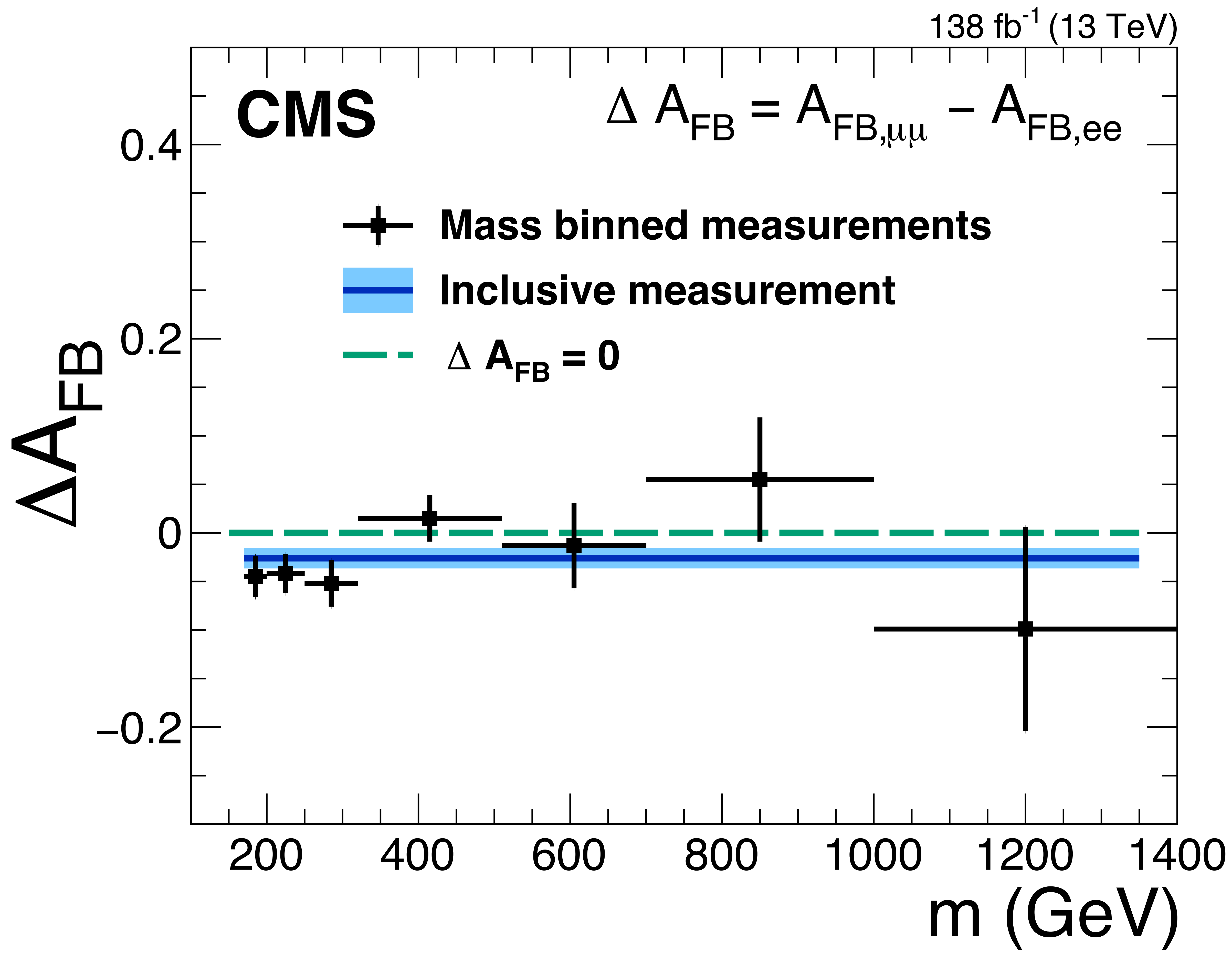
Testing LFU with dilepton events @ LHC



CMS observes good agreement with LFU up to masses of 1.5 TeV, but above 1.8 TeV there is slight excess in dielectron channel leading to a deviation of LFU ratio from 1

[CMS, 2103.02708 & for interpretations see for instance Crivellin et al., 2103.12003, 2104.06417]

Testing LFU with dilepton events @ LHC



CMS recently also measured difference between dimuon & dielectron forward-backward asymmetry (A_{FB}). Result is found to agree with zero within 2.4σ. Like rate measurement, also A_{FB} results show a slight dielectron excess

[CMS, 2202.12327]

Conclusions & outlook

- Beyond SM models that explain all B-physics anomalies generically lead to signatures (e.g. $pp \to \tau^+\tau^-$, $b\tau$, $t\bar{t}$ & high-multiplicity final states with τ, b, t & $E_{T,miss}$) testable @ LHC. If $b \to c$ anomalies persist, IMHO likely that LHC sees something
- BSM models that explain only $b \to s$ anomalies can be easily hidden from leaving imprint on high-p_T LHC physics. Still, searches for $bs\mu\mu$ contact interactions, LFU violation in dilepton production, etc. may shed light on origin of anomalies
- Signals in Higgs & diboson physics connected to anomalies possible (e.g. $h \to \tau\mu$ & exotics decays of heavy Higgses) but model dependent — cf. backup for details

Backup

A digression on LFU

Decay	Precision	Channels	Deviation
Z	0.3%	e, μ, τ	—
W	0.8%	e, μ	—
W	3%	τ	2.8σ
μ, τ	0.15%	e, μ	—
π	0.3%	e, μ	—
K	0.4%	e, μ	—
J/ψ	0.65%	e, μ	—
D_s	6%	μ, τ	—

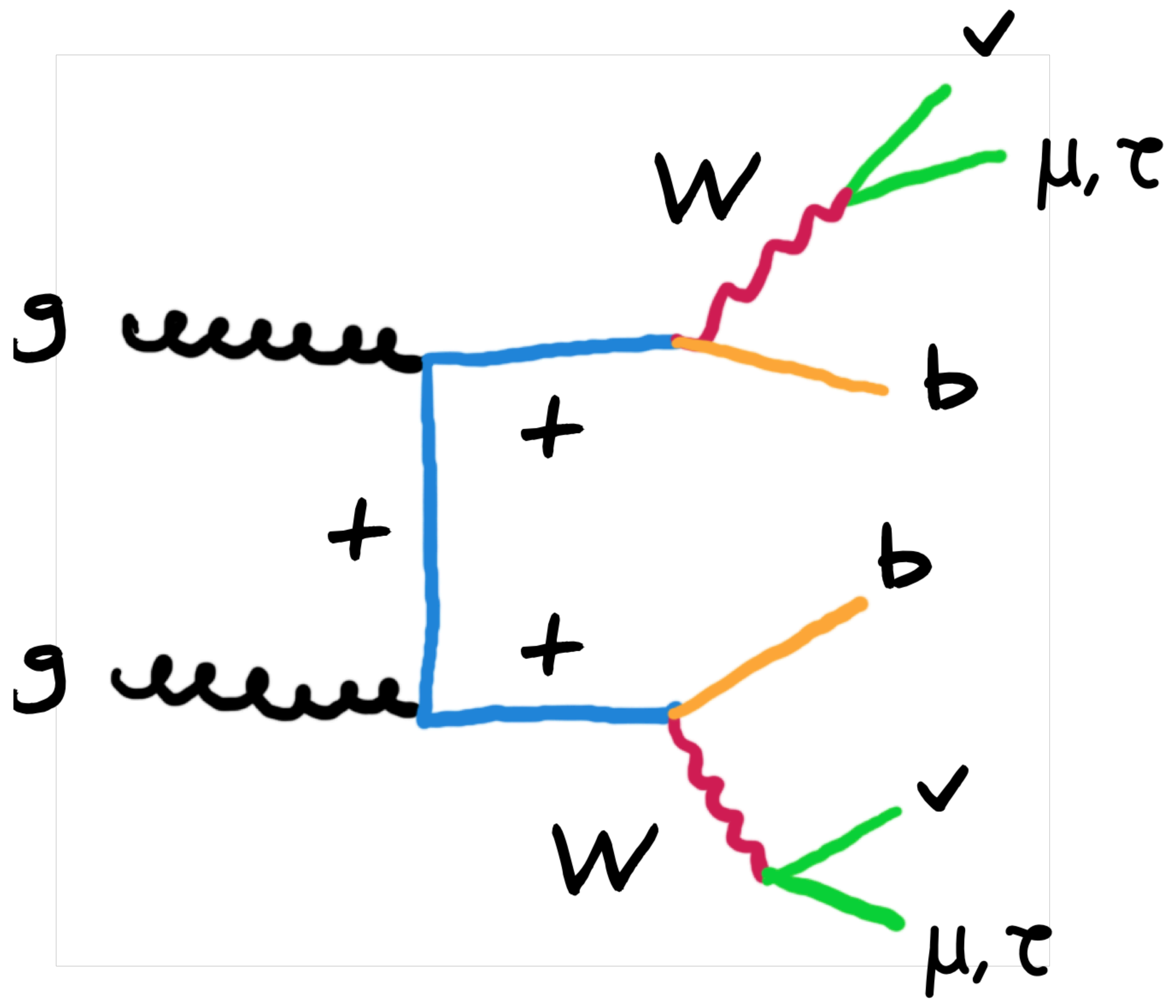
Summer 2011

Before 2012, stringent experimental test of LFU in B-meson decays did not exist

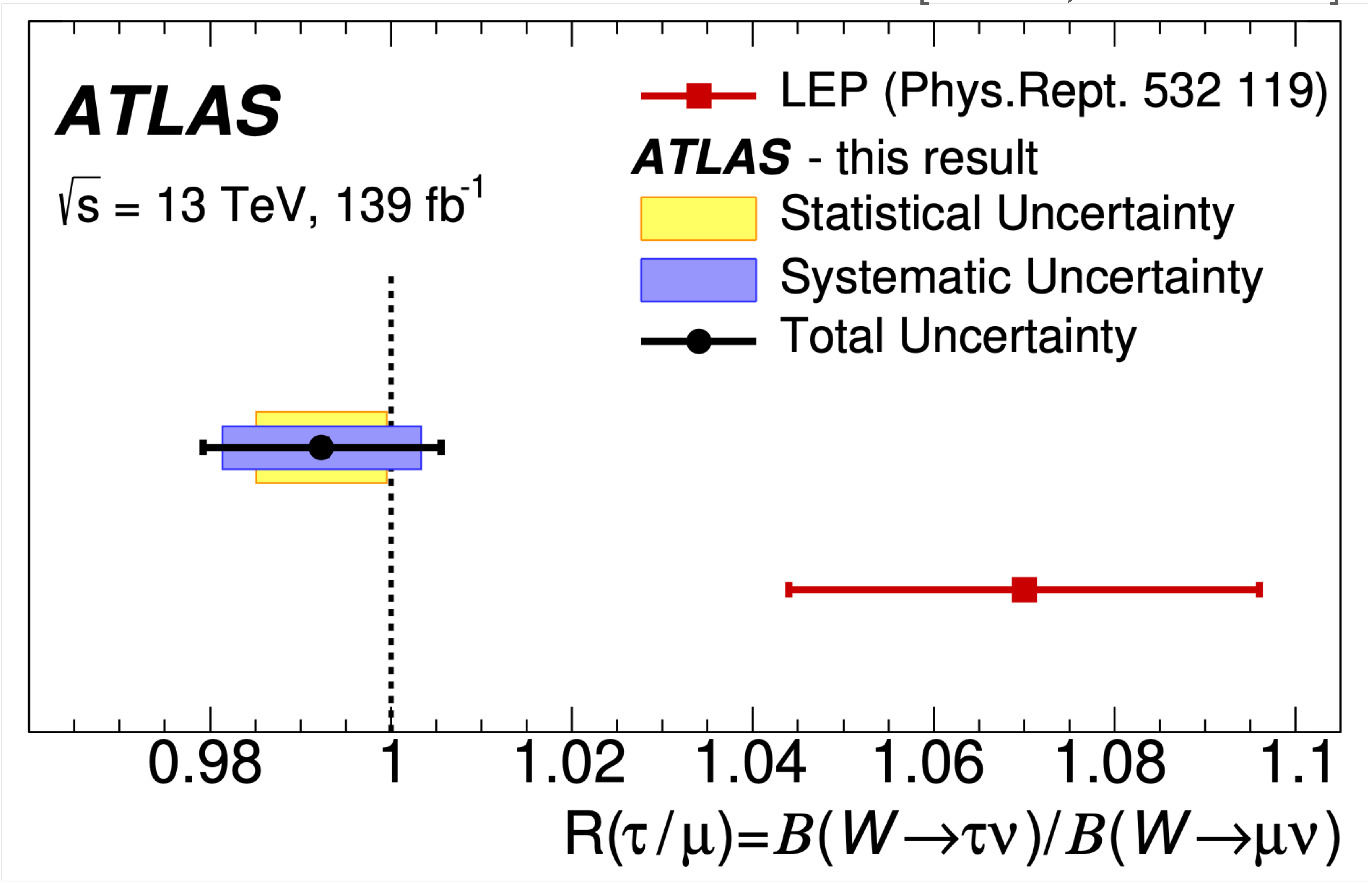
Combined LEP results hint towards LFU violation in W-boson decay with significance of 2.8σ

[LEPEWWG, hep-ex/0511027]

LFU violation in W decays?

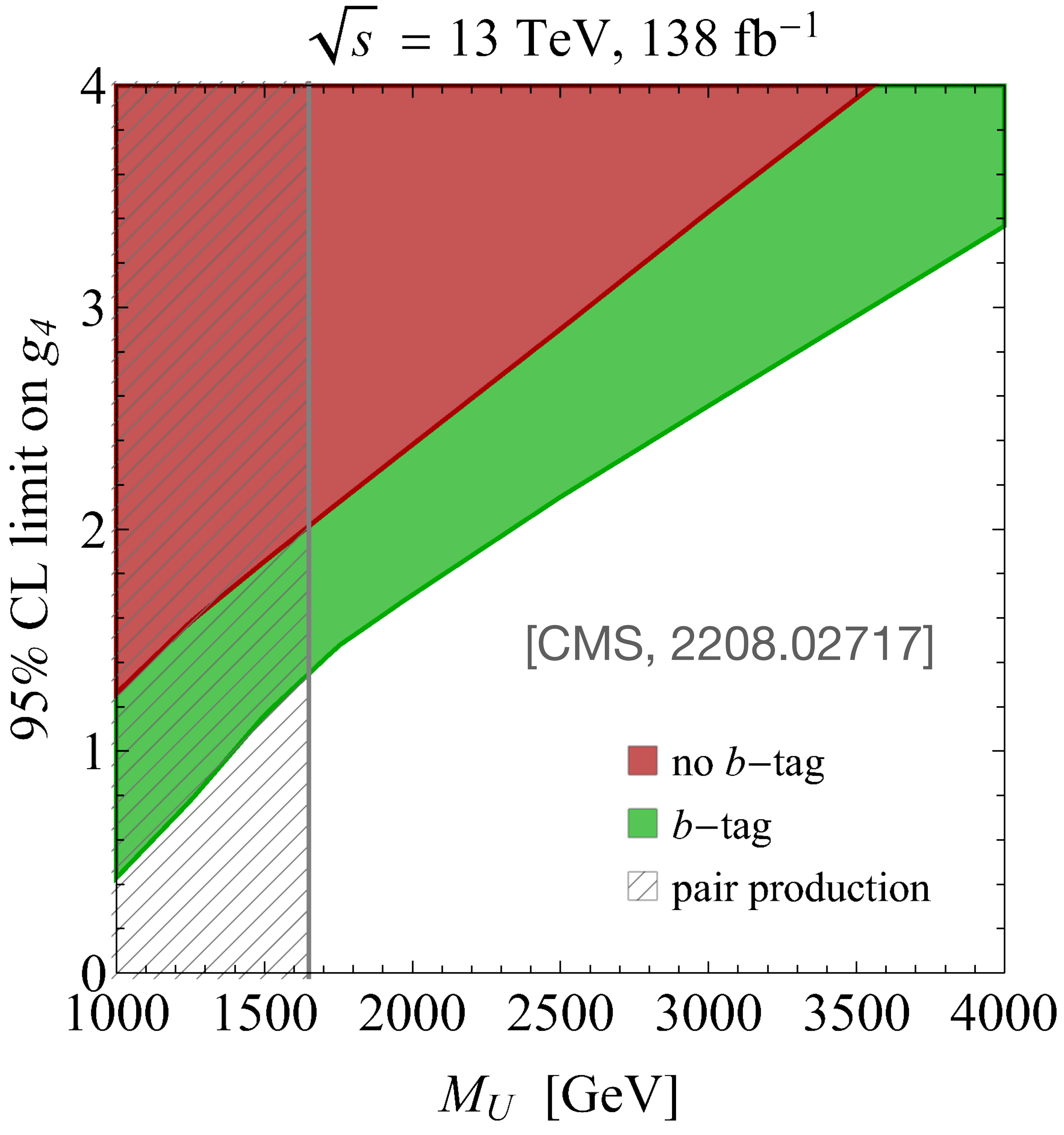


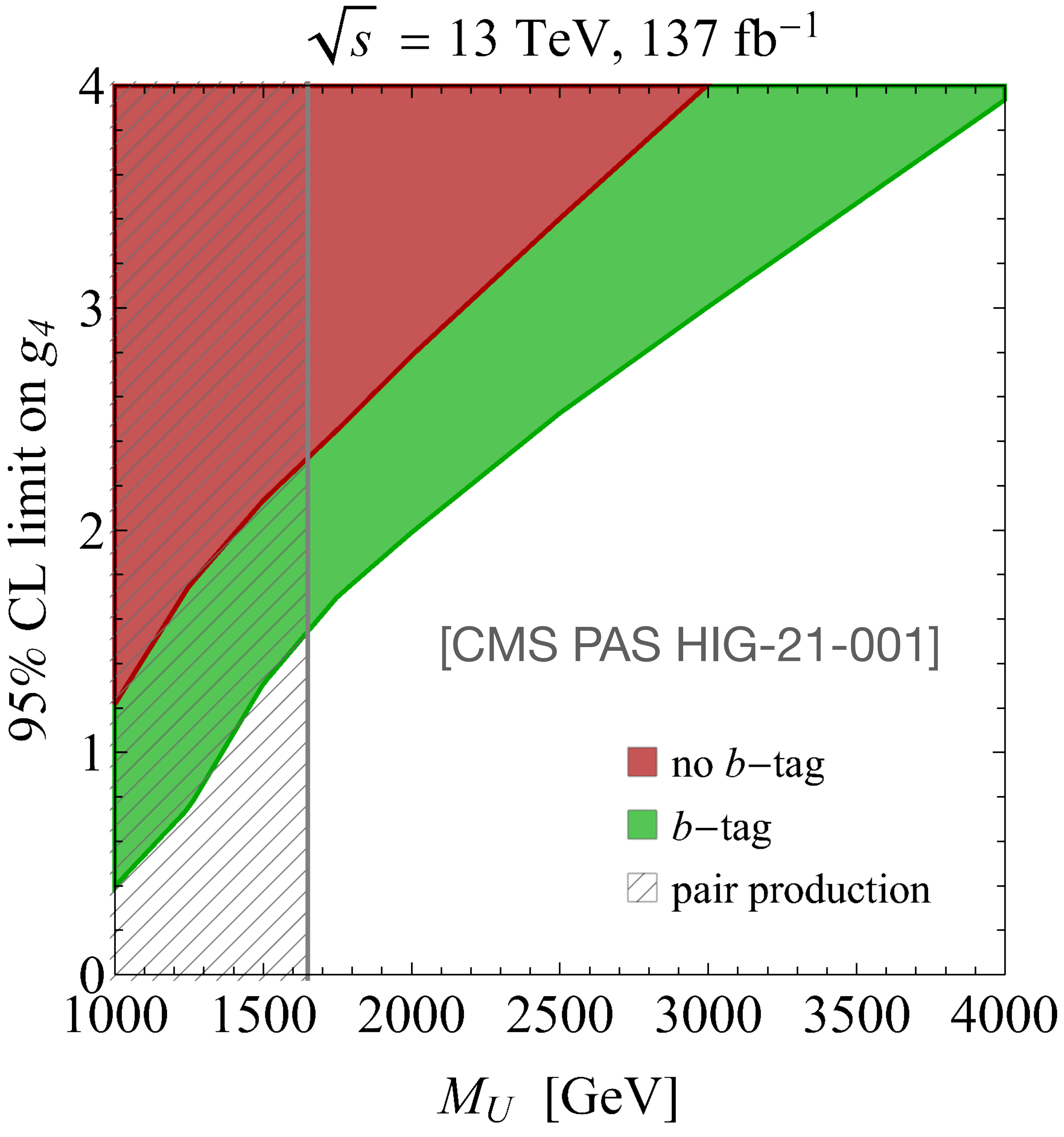
[ATLAS, 2007.14040]



ATLAS LHC Run II measurement in full agreement with LFU as predicted in SM

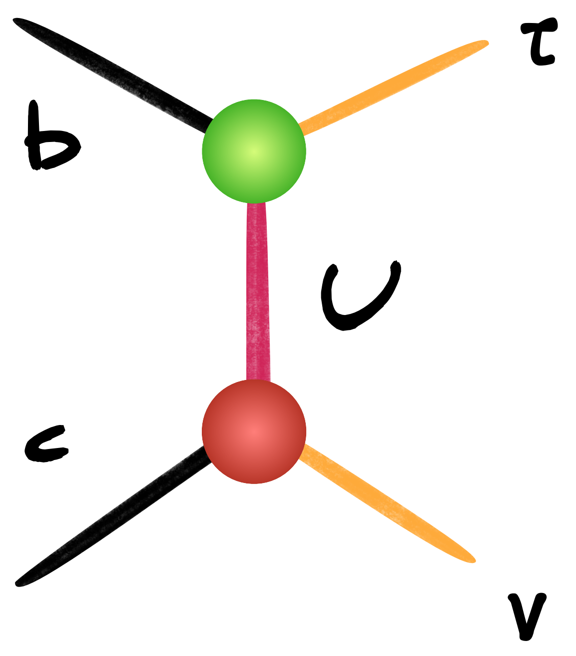
Ditau limits on singlet vector LQs from CMS

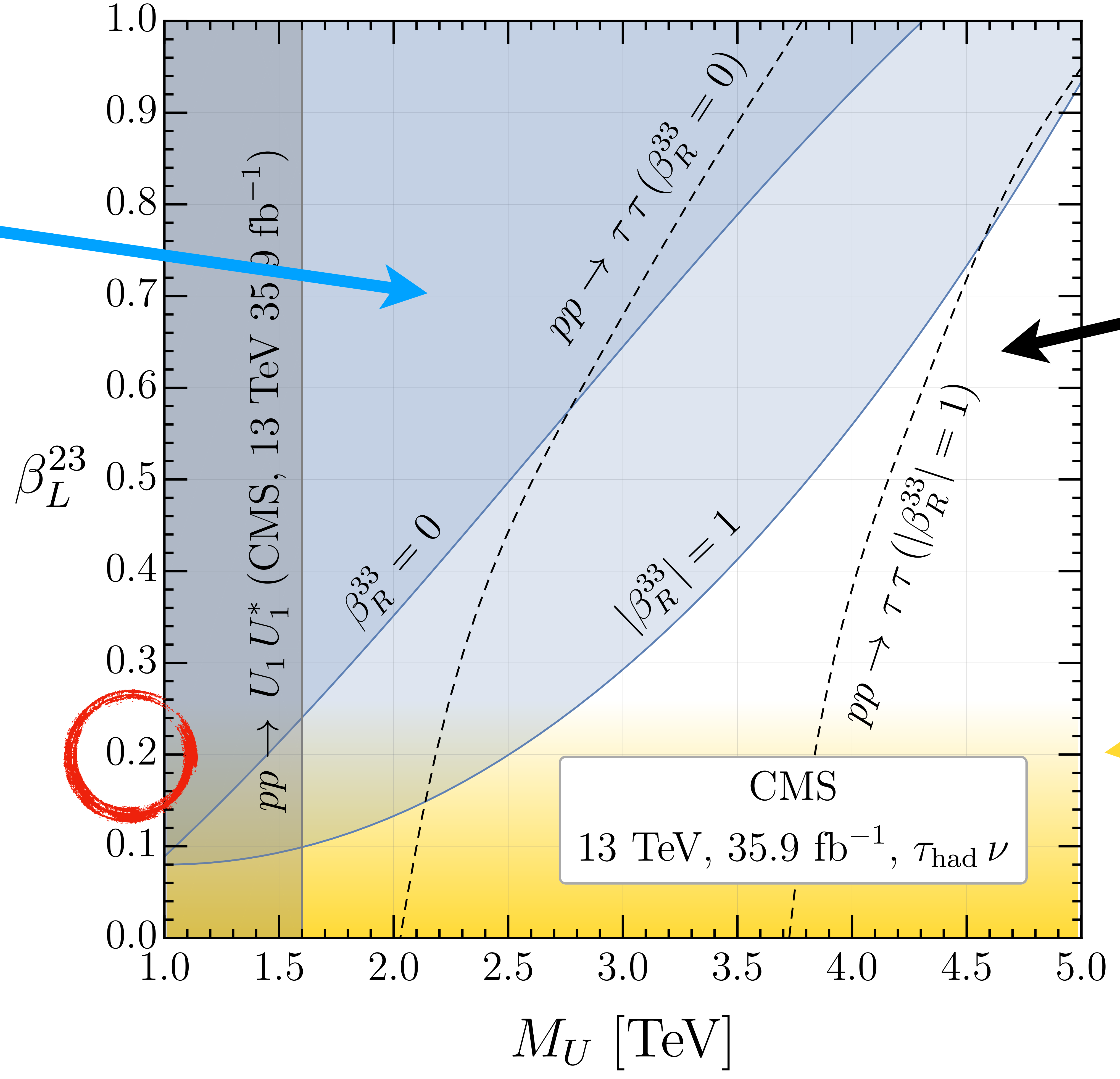


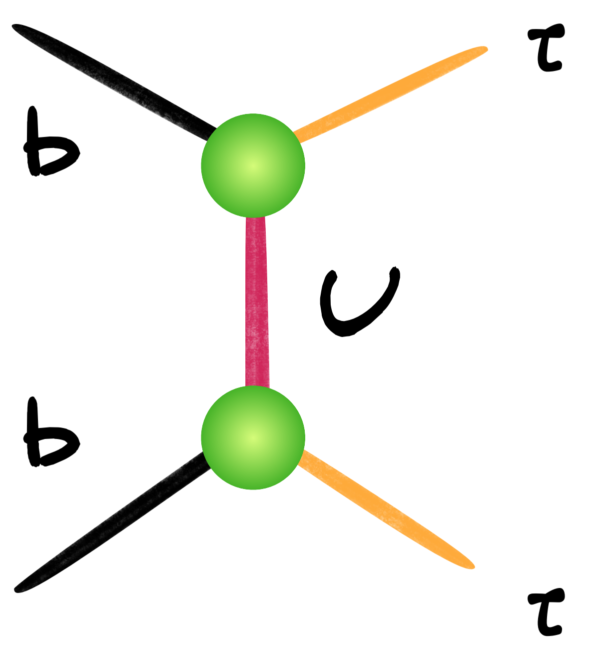


[NLO+PS accurate results for t-channel ditau production in LQ models obtained in UH, Schnell & Schulte, 2207.00356; 2209.12780]

LHC bounds: pp → ττ vs. pp → τν



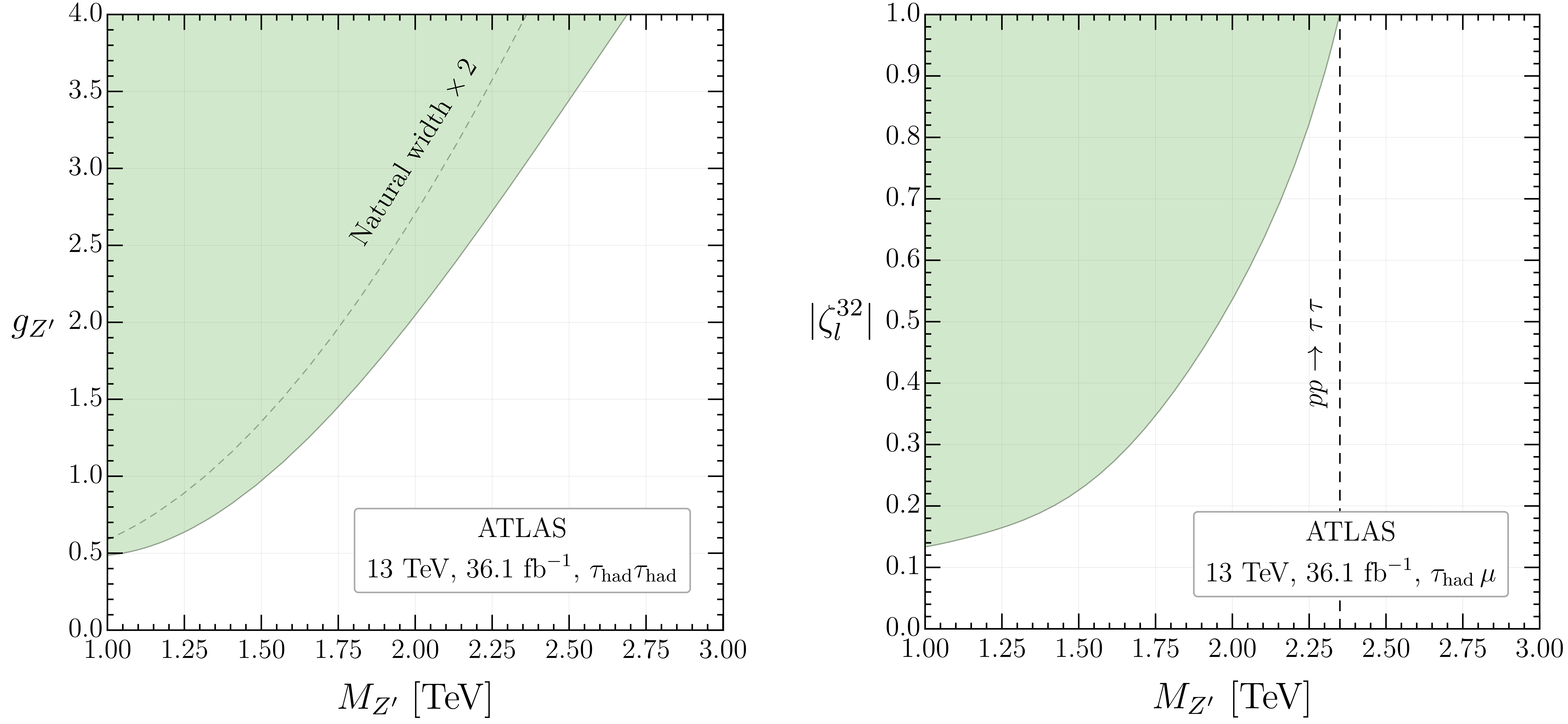




parameter space of singlet vector LQ with natural flavor structure

[Baker, Fuentes-Martin, Isidori & König, 1901.10480]

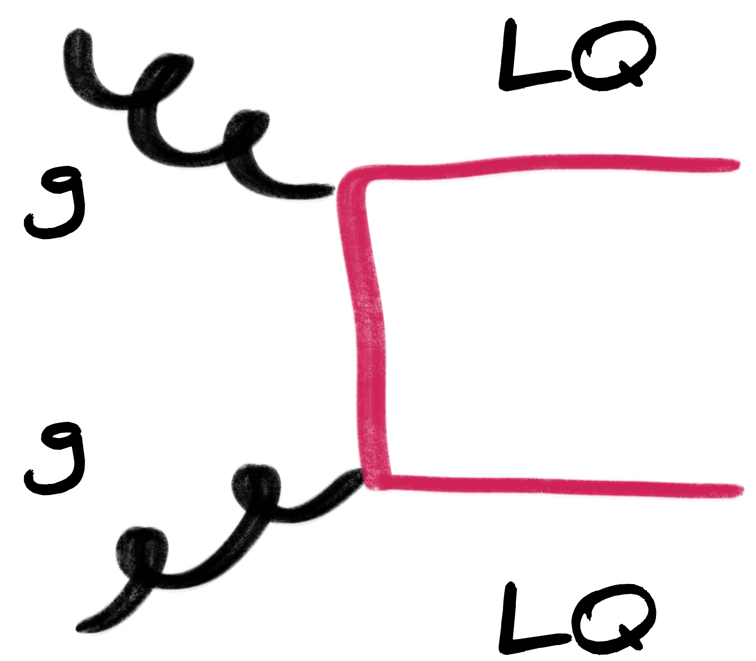
Z′ bounds in singlet vector LQ model

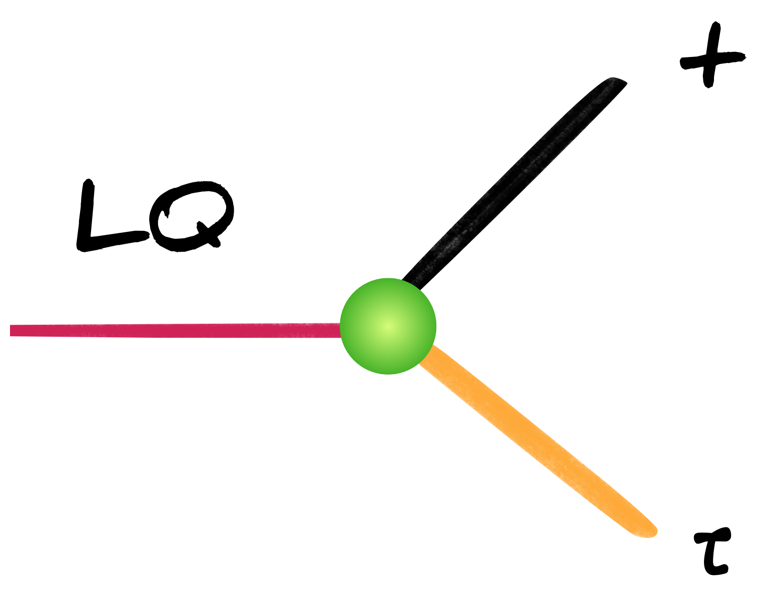


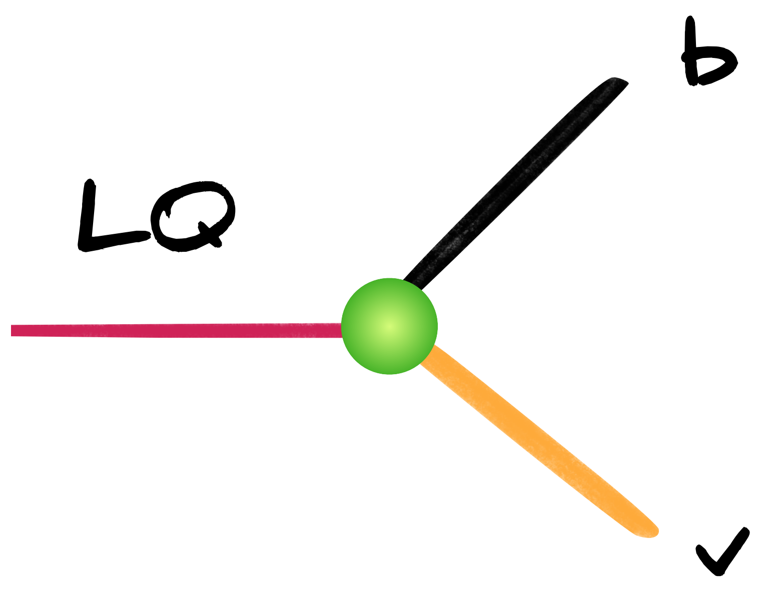
Z′ searches in general not competitive with limits obtained from LQ or G′ searches

[Baker, Fuentes-Martin, Isidori & König, 1901.10480]

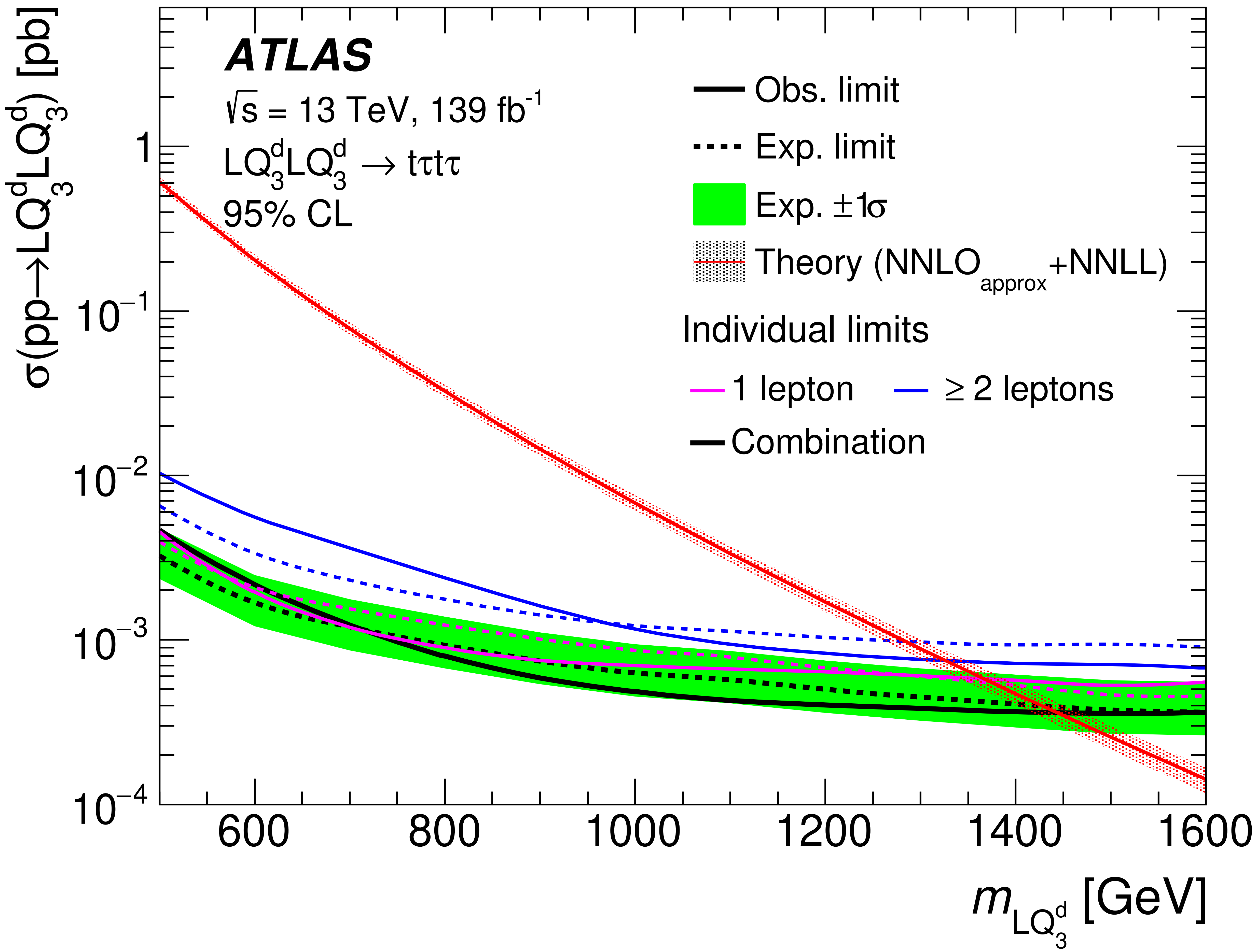
Another LQ search triggered by B anomalies





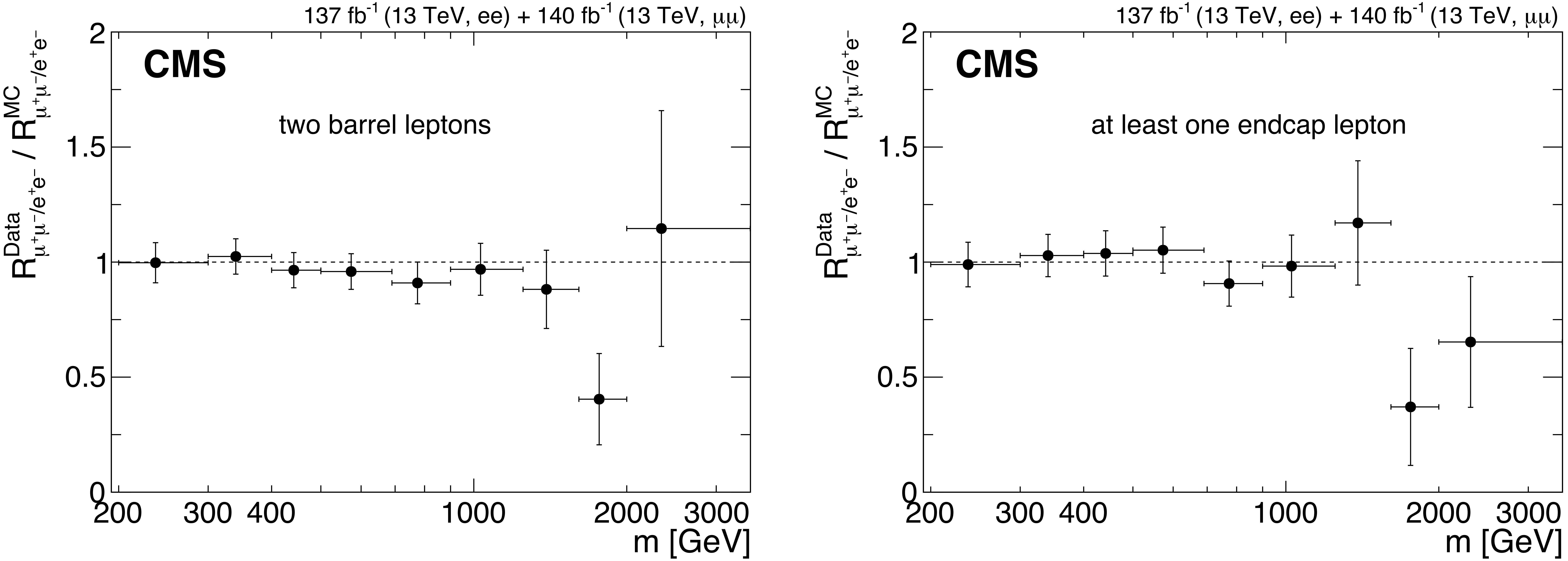


[ATLAS, 2101.11582]



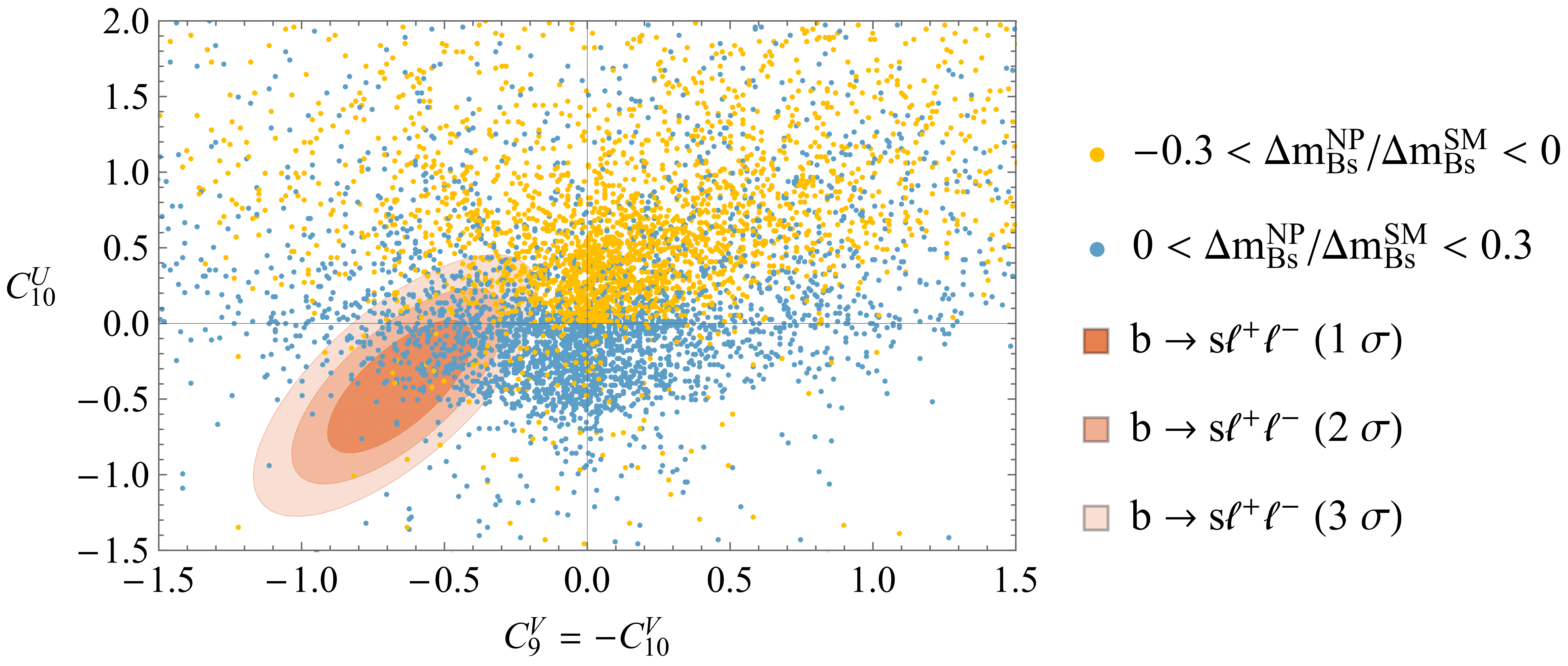
[Bauer & Neubert, 1511.01900]

Testing LFU with dilepton events @ LHC



[CMS, 2103.02708]

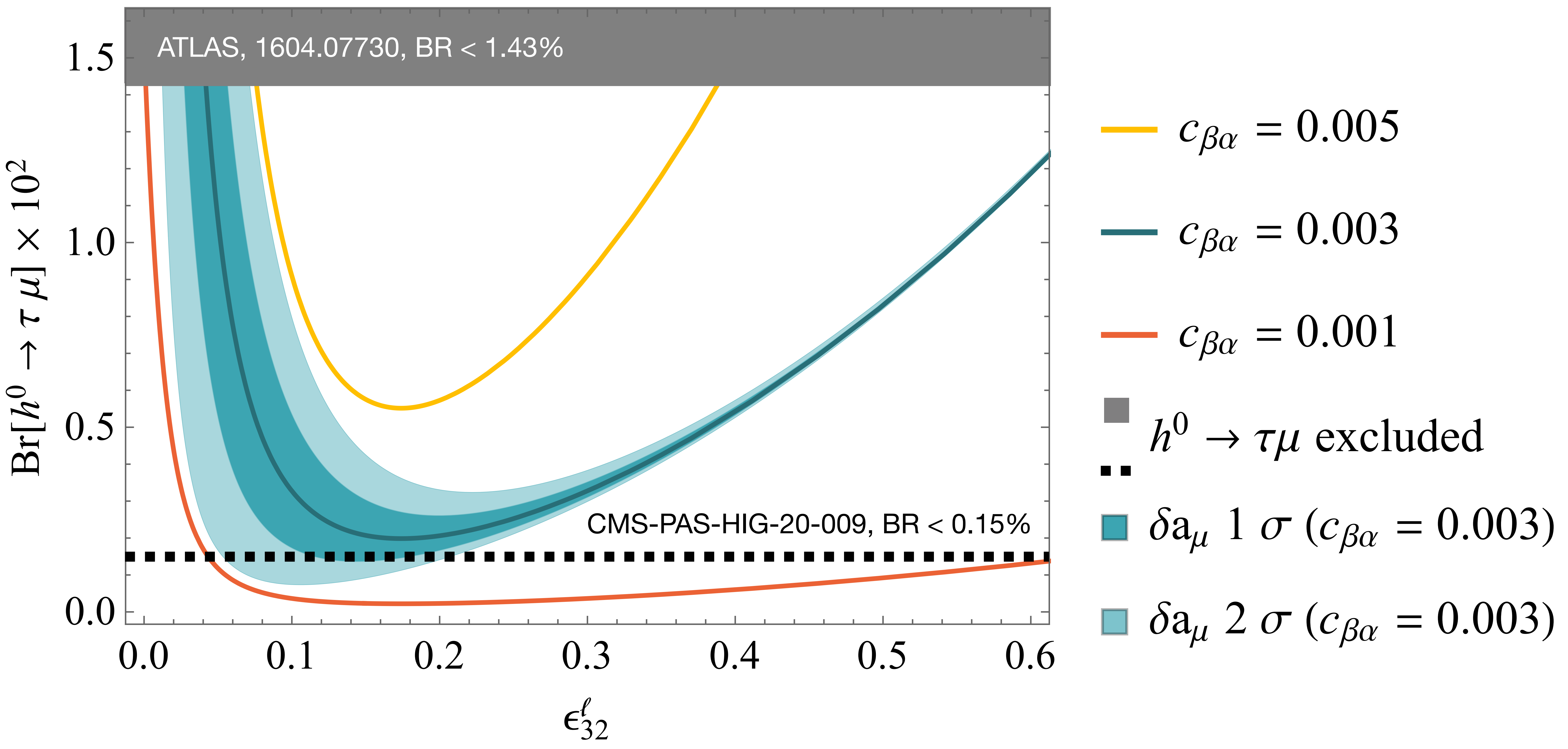
Flavorful 2HDM with right-handed neutrinos



Box diagrams with a charged Higgs boson & a right-handed neutrino are able to generate LFU violating effects needed to explain b → s anomalies

[Crivellin, Müller & Wiegand, 1903.10440]

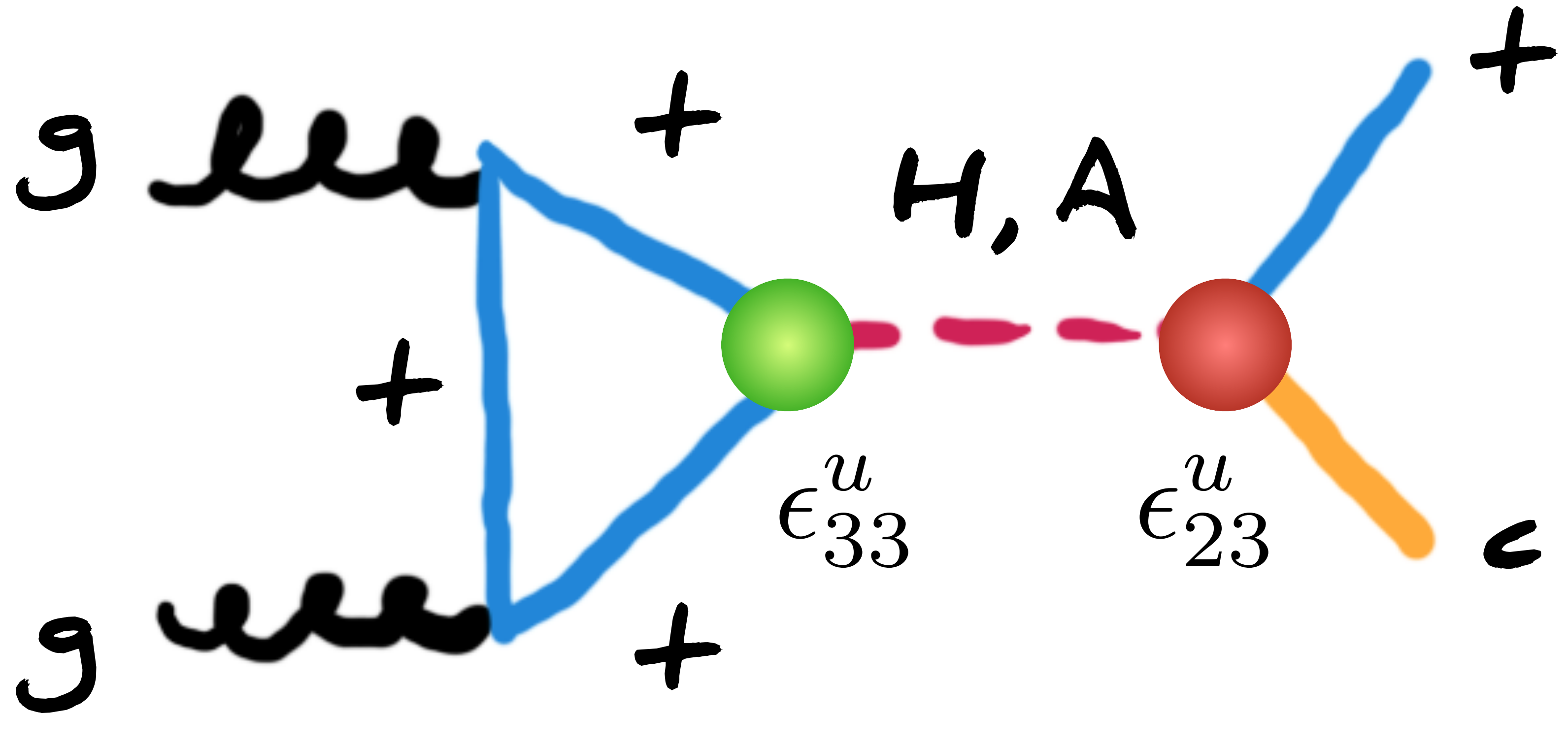
Flavorful 2HDM with right-handed neutrinos

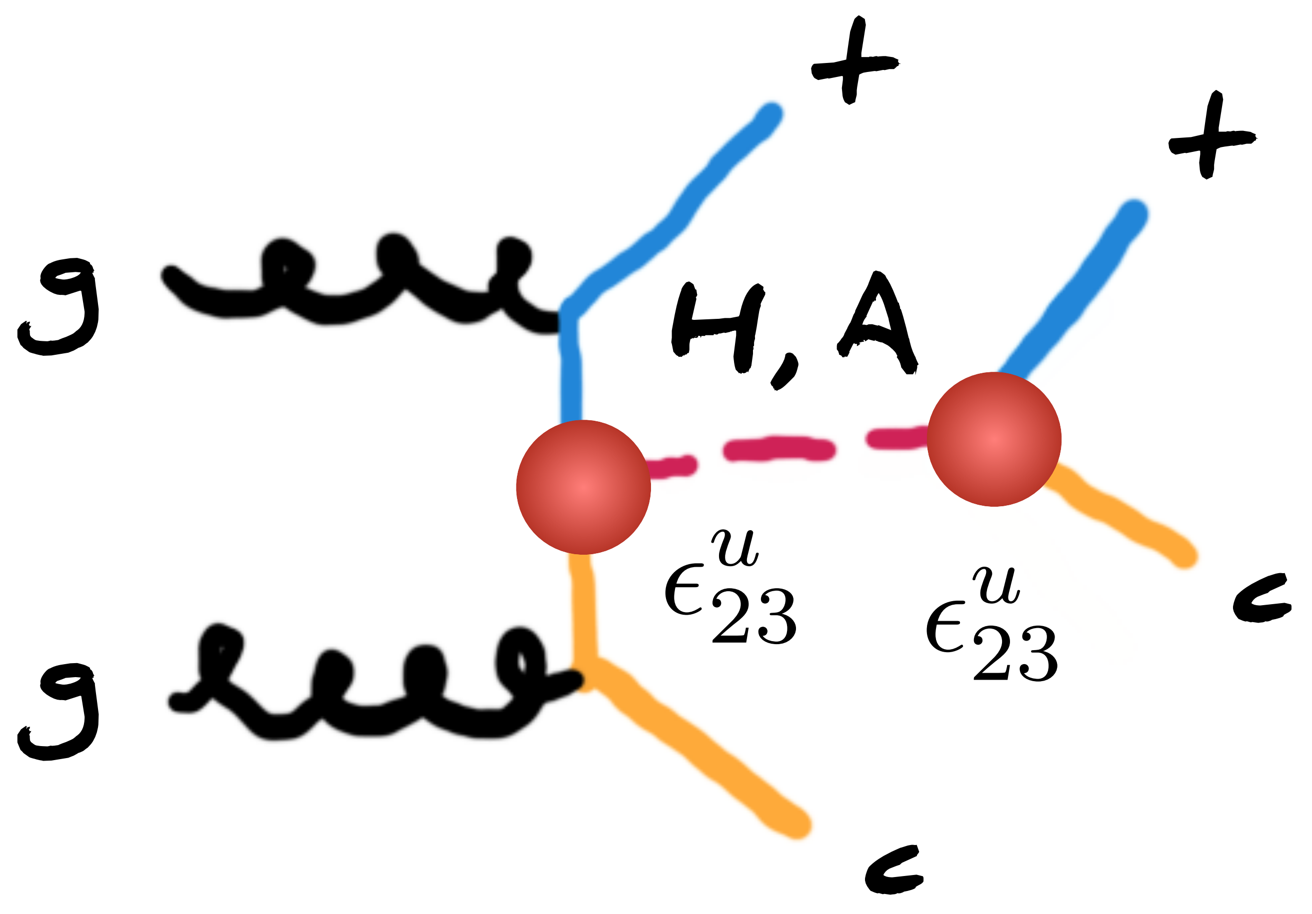


In 2016 explanation of muon anomalous magnetic moment possible without violating h → τμ bound if Higgs sector close to alignment. Now possibility even stronger constrained

[Crivellin, Müller & Wiegand, 1903.10440]

Flavorful 2HDM with right-handed neutrinos

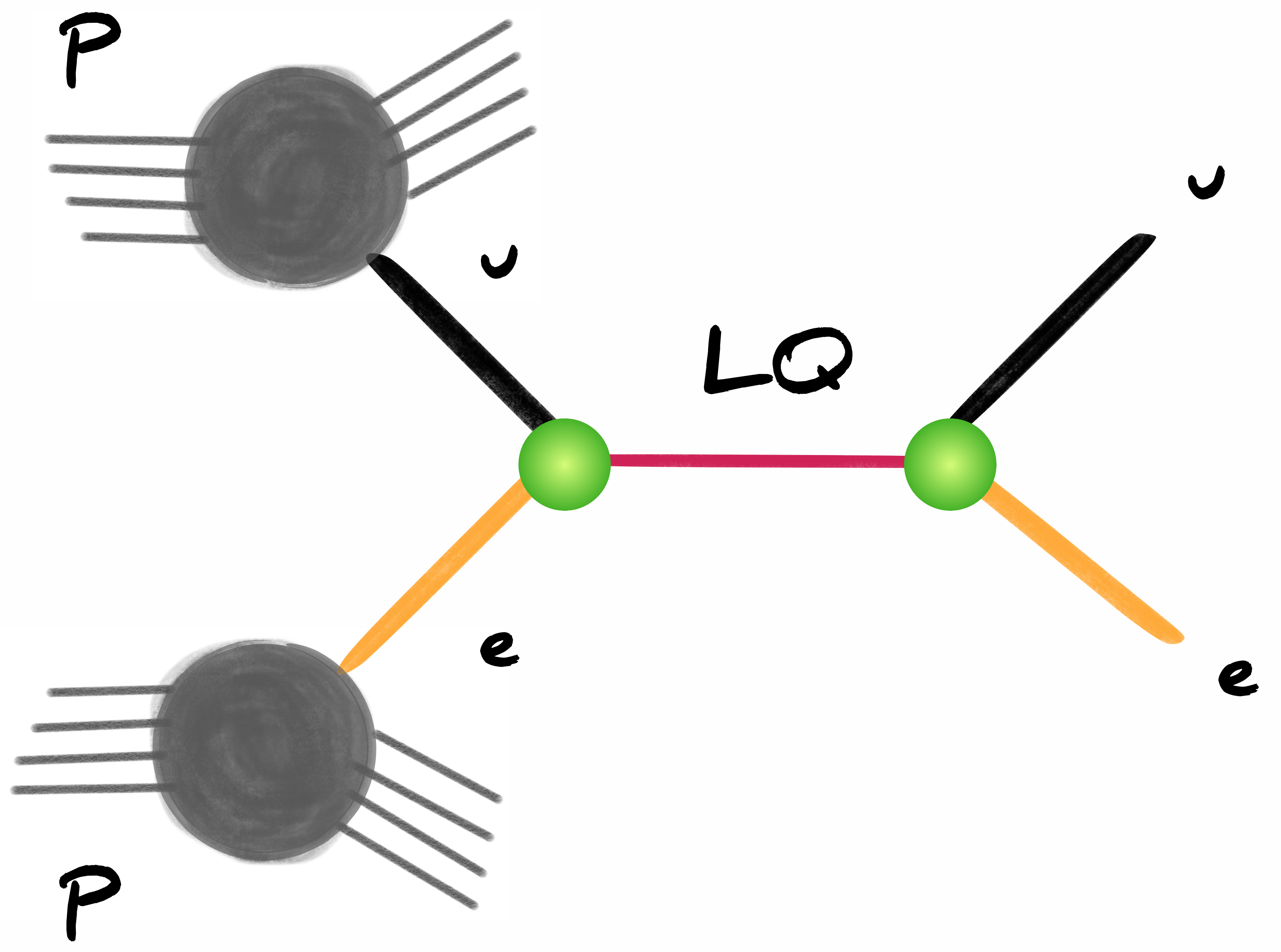


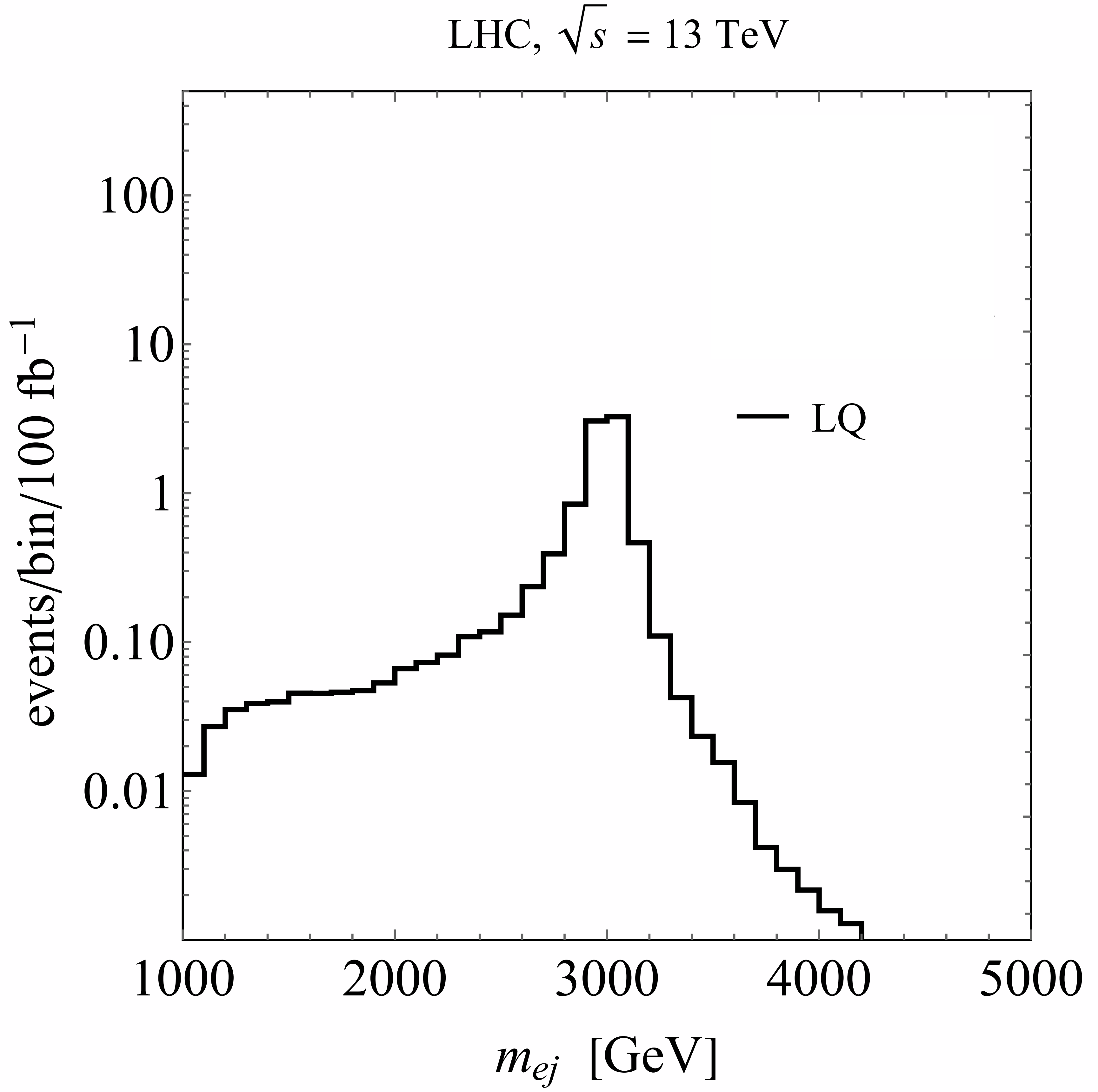


LHC phenomenology of model not worked out, but exotic decays such as H, A → tc (τμ) & $H^{\pm}$ → cb generically expected & wait for interest of community. Challenging searches but may reveal first direct evidence of beyond SM physics & unravel origin of flavor

[see Gori, Grojean, Juste & Paul, 1710.03752 for a related discussion]

Resonant LQ production @ the LHC

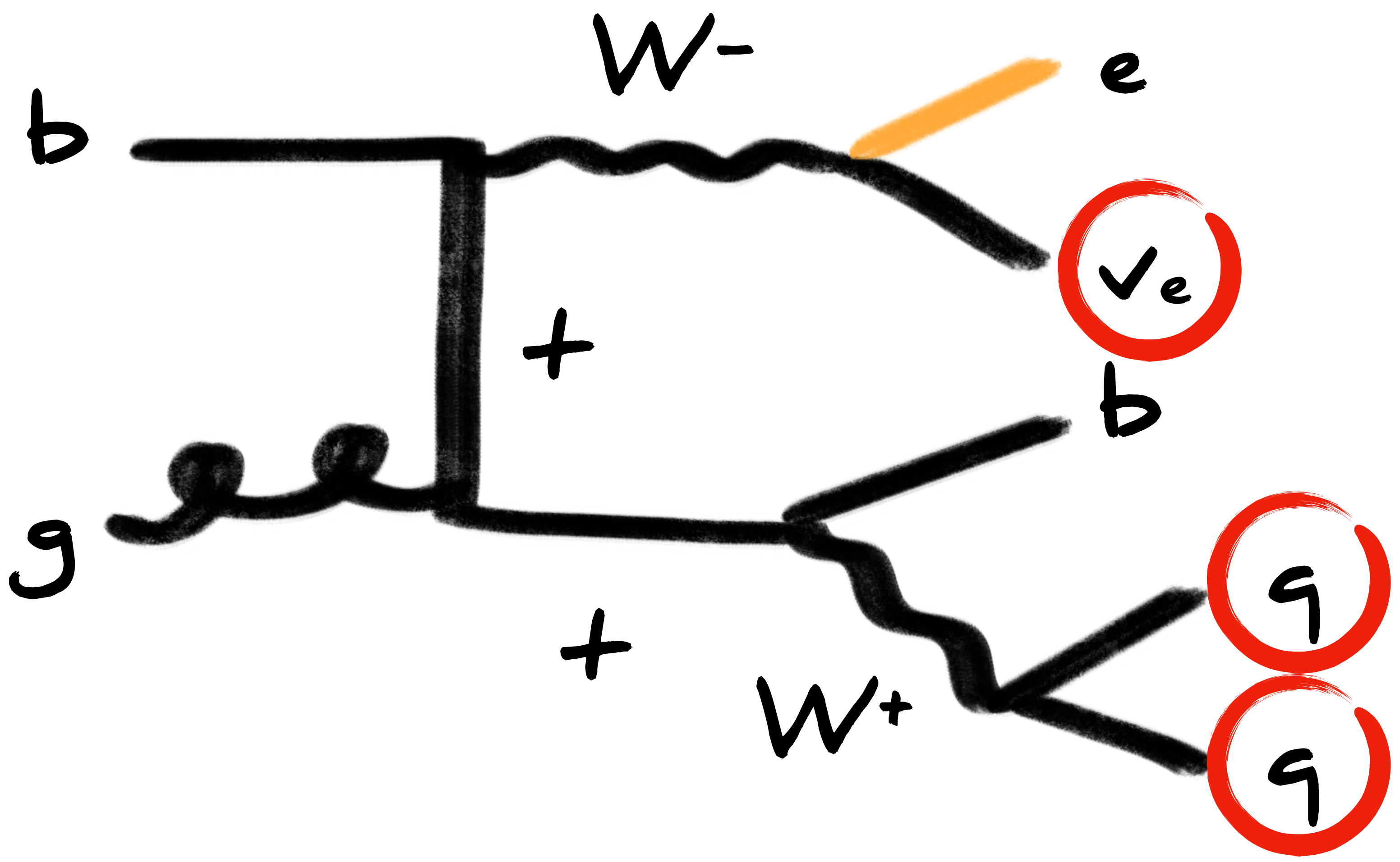


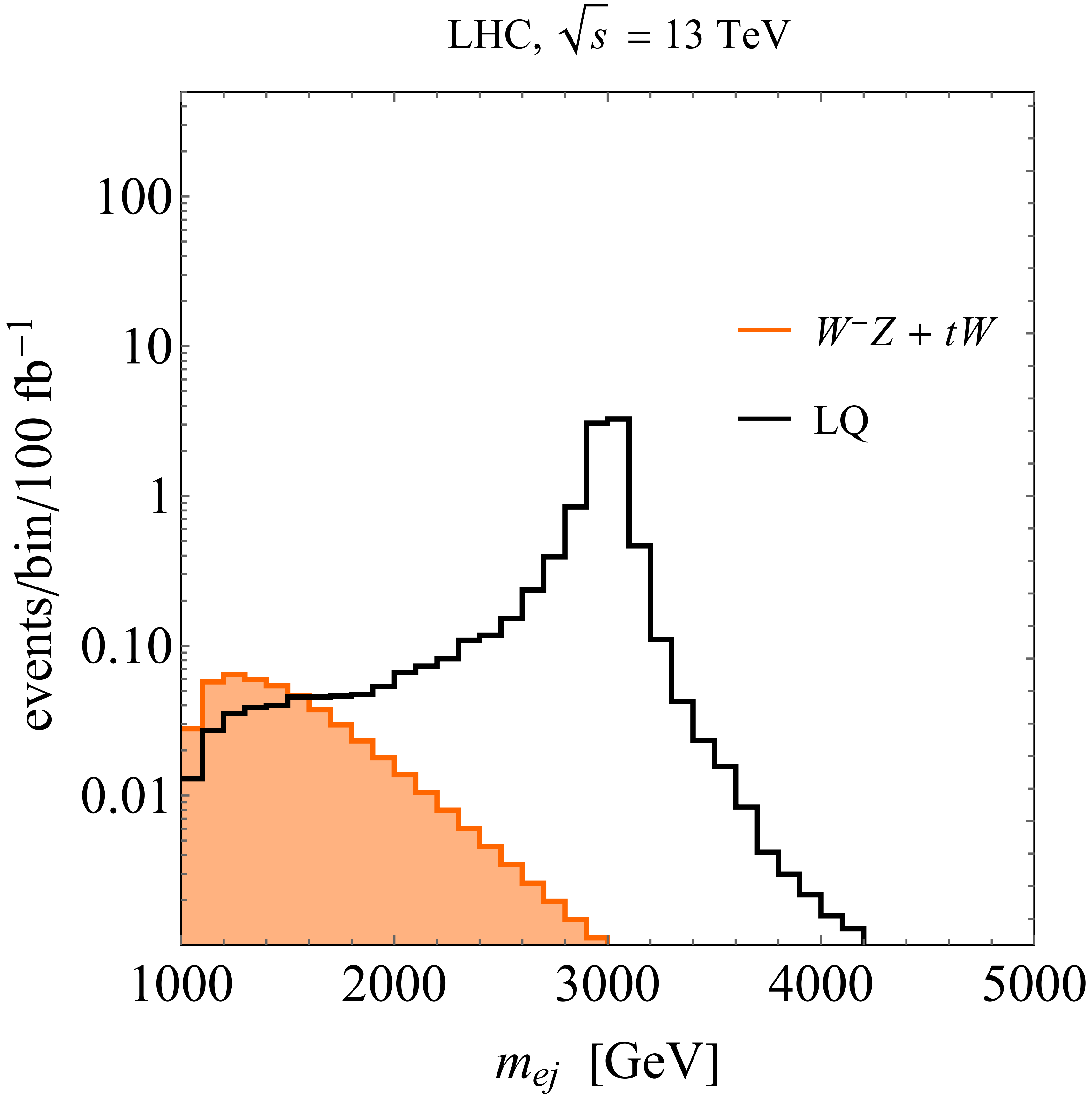


At 13 TeV LHC, 9 events per 100 fb^{-1} for minimal scalar LQ of M = 3 TeV & λ_{eu} = 1

[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

Resonant LQ production @ the LHC

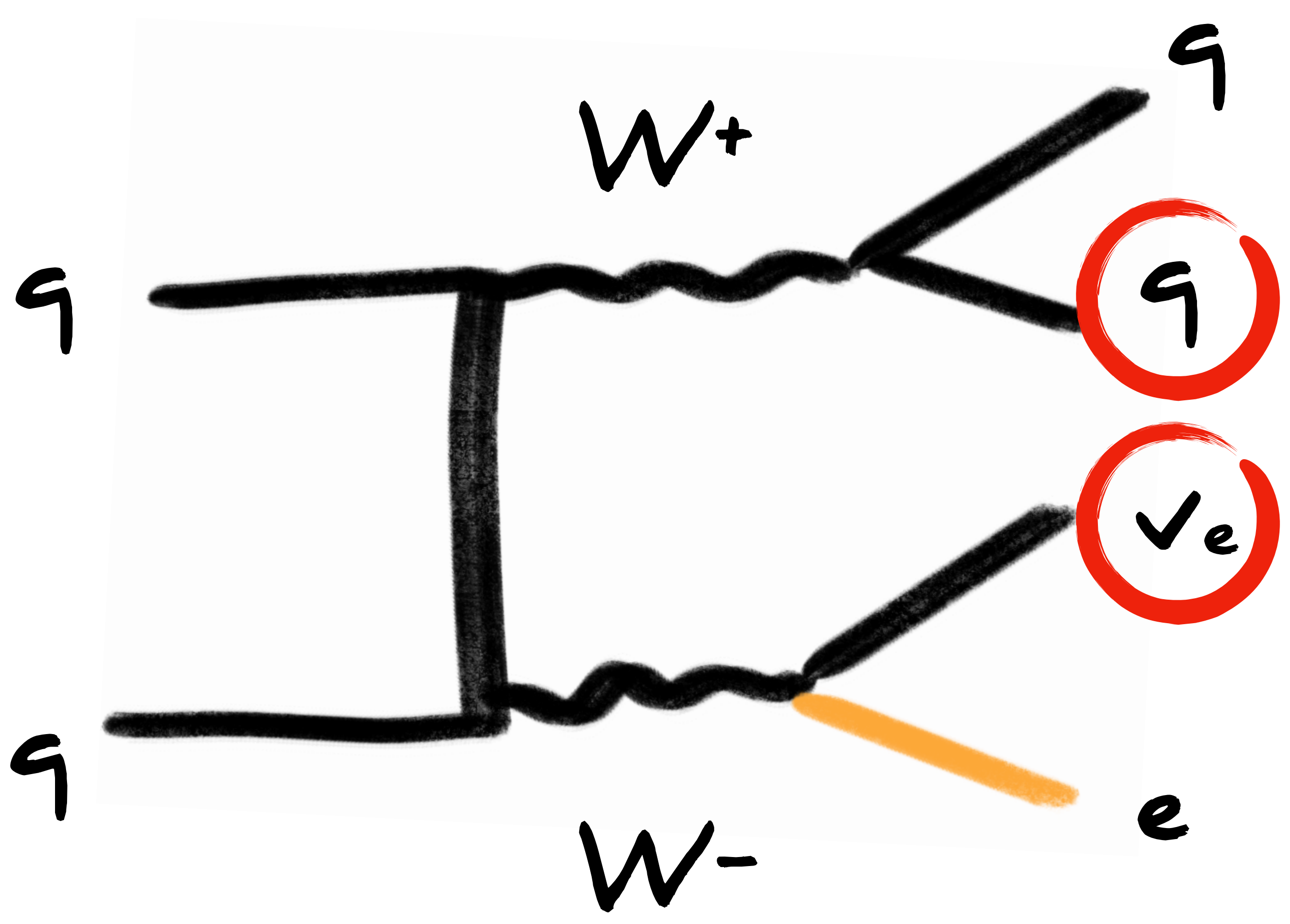




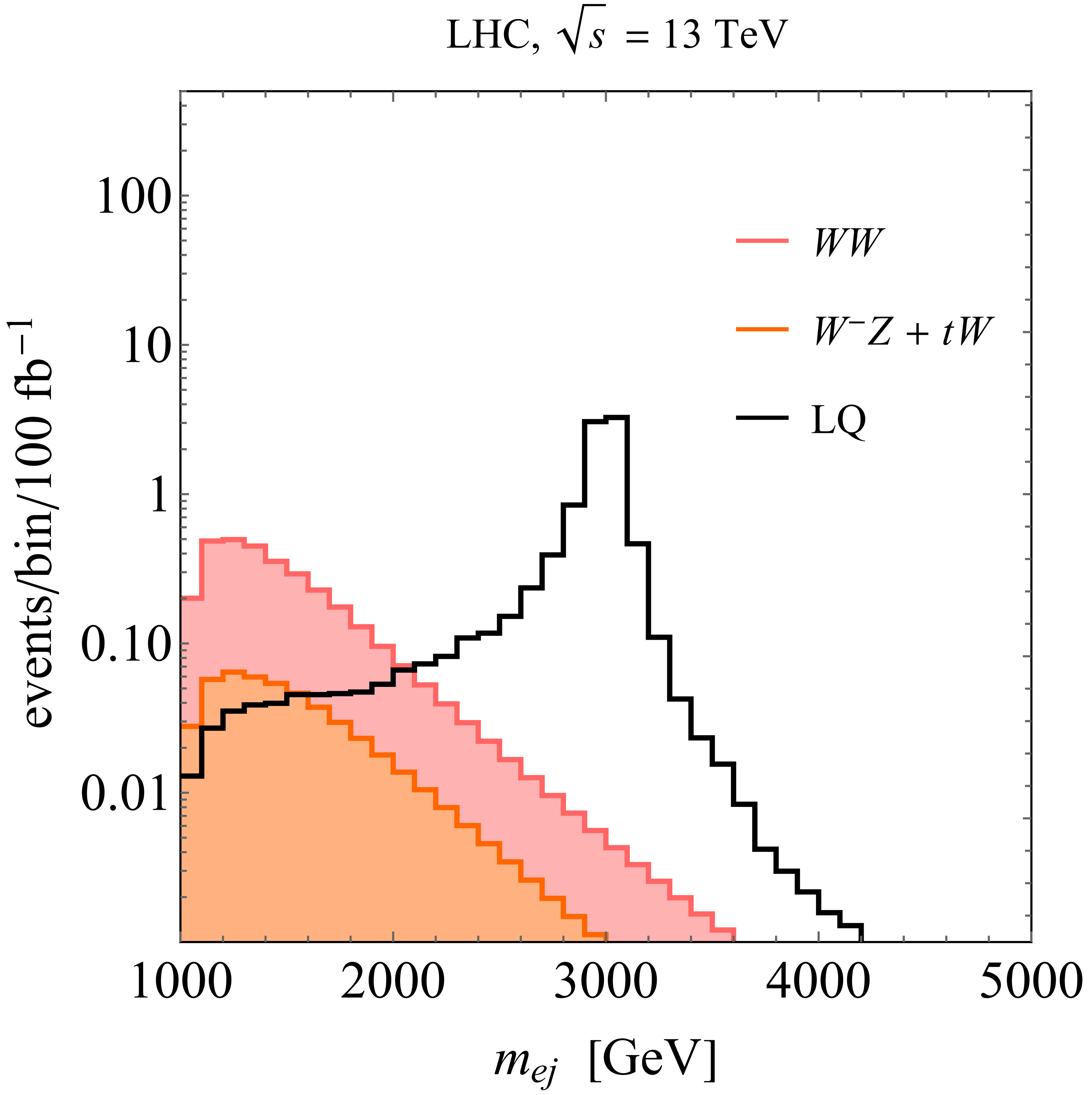
Suppressed by $E_{T,miss}$ requirement & jet veto

[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

Resonant LQ production @ the LHC

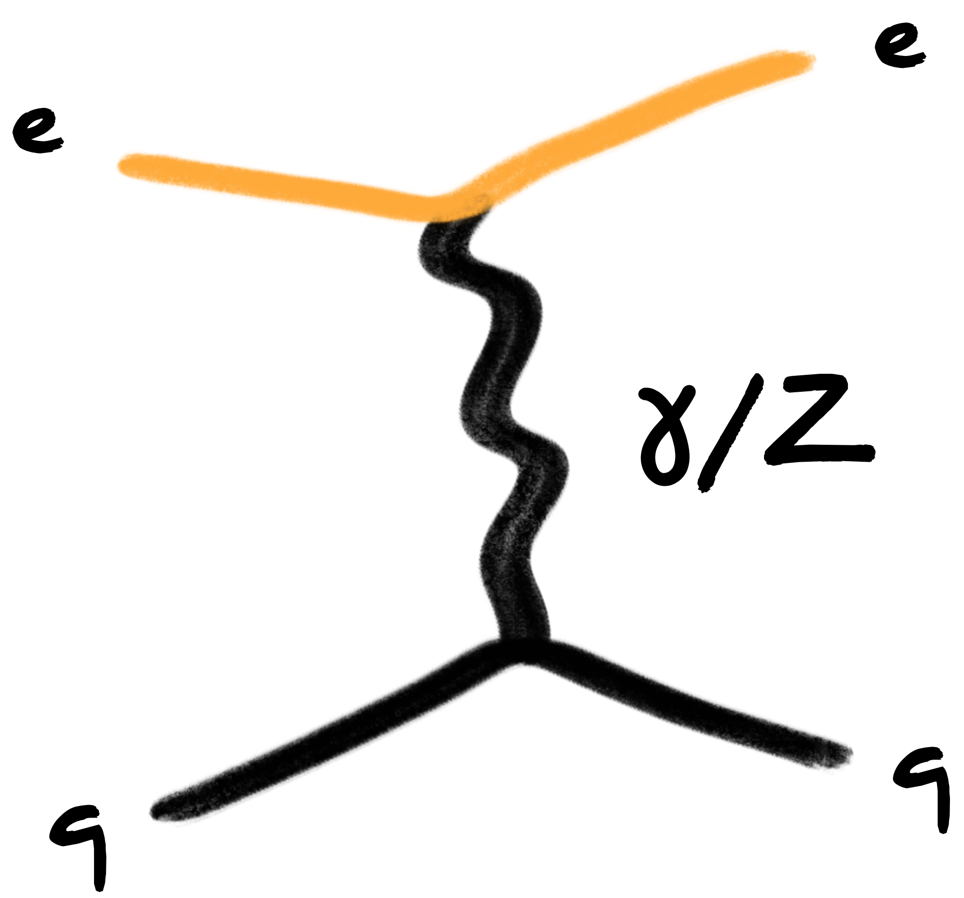


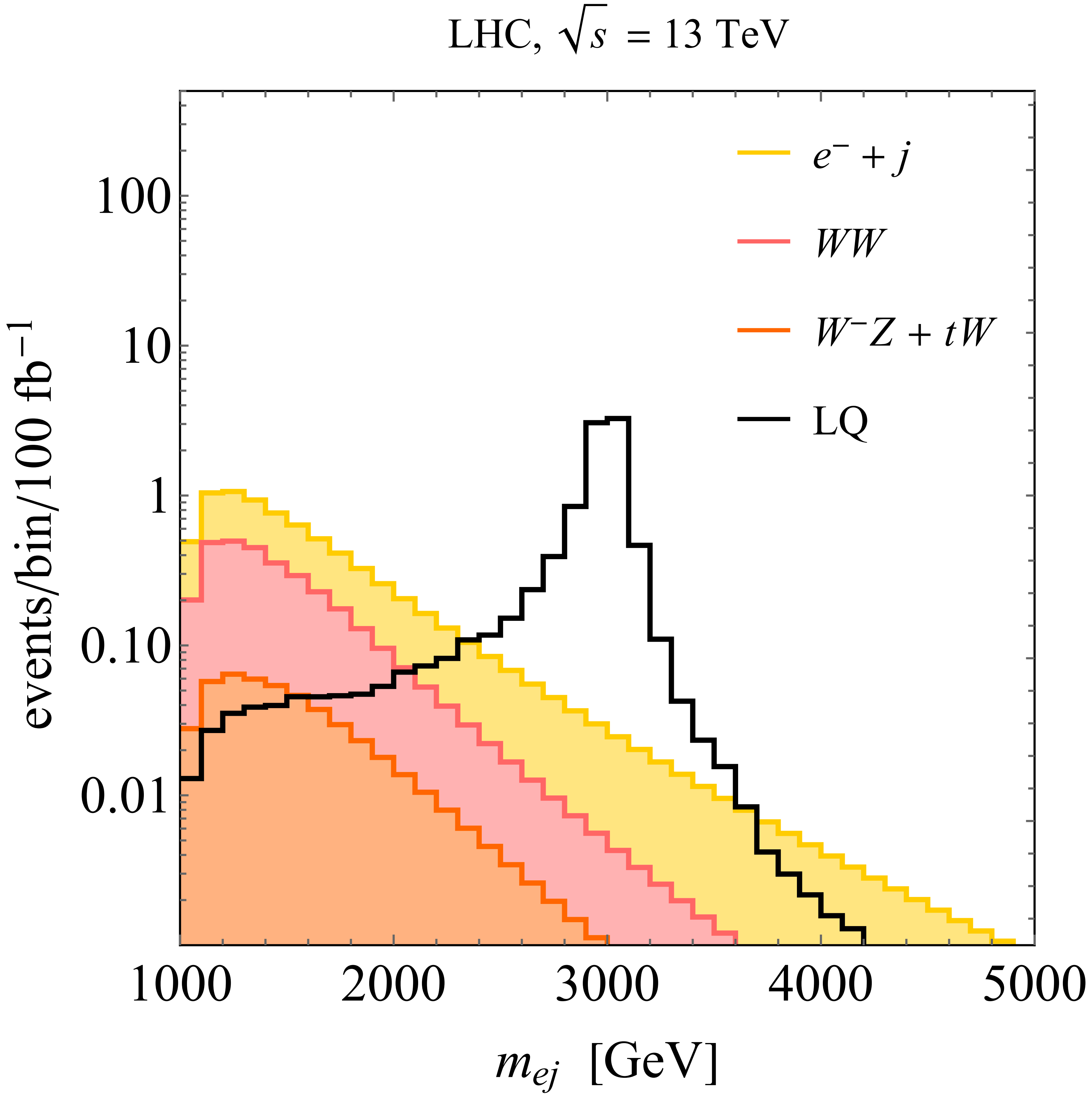
Suppressed by $E_{T,miss}$ requirement & jet veto



[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

Resonant LQ production @ the LHC

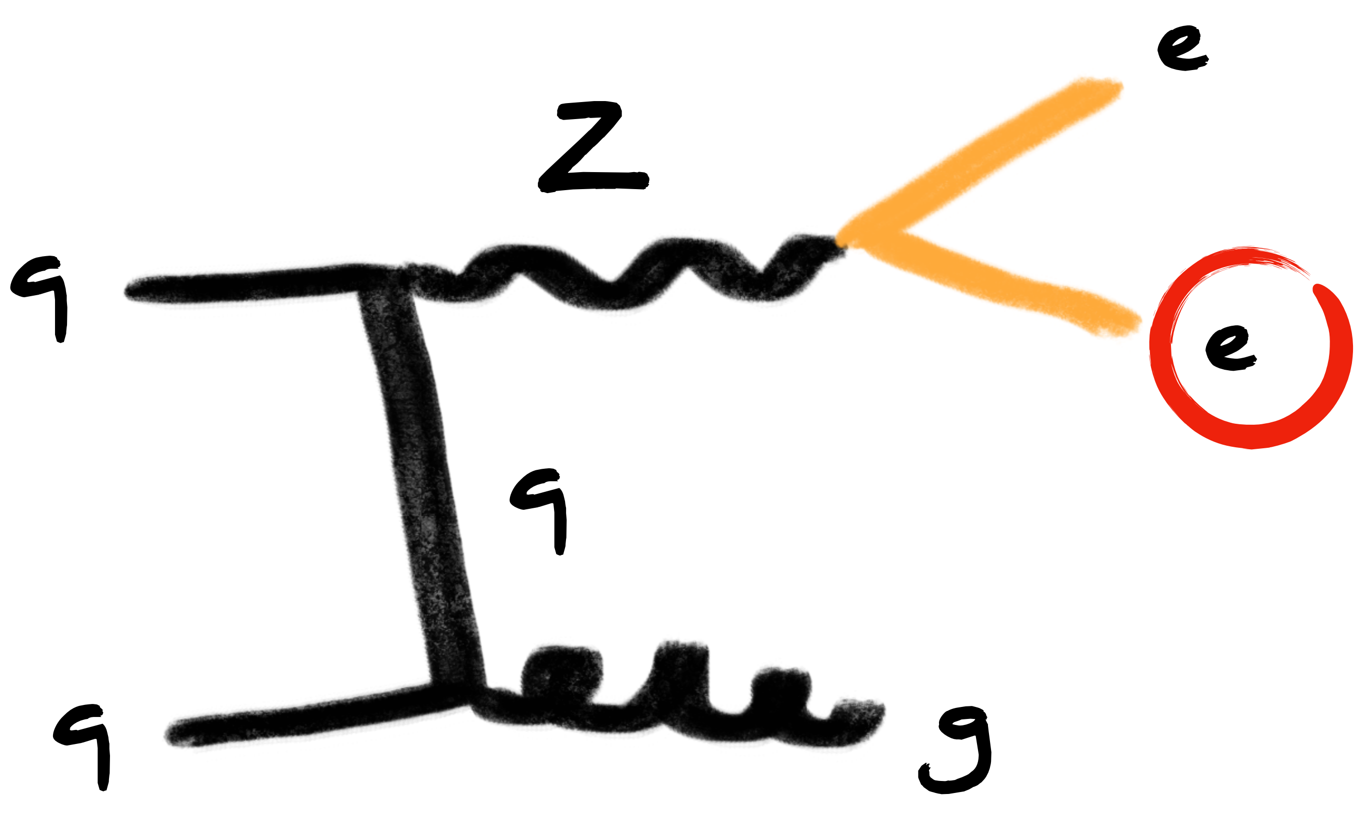




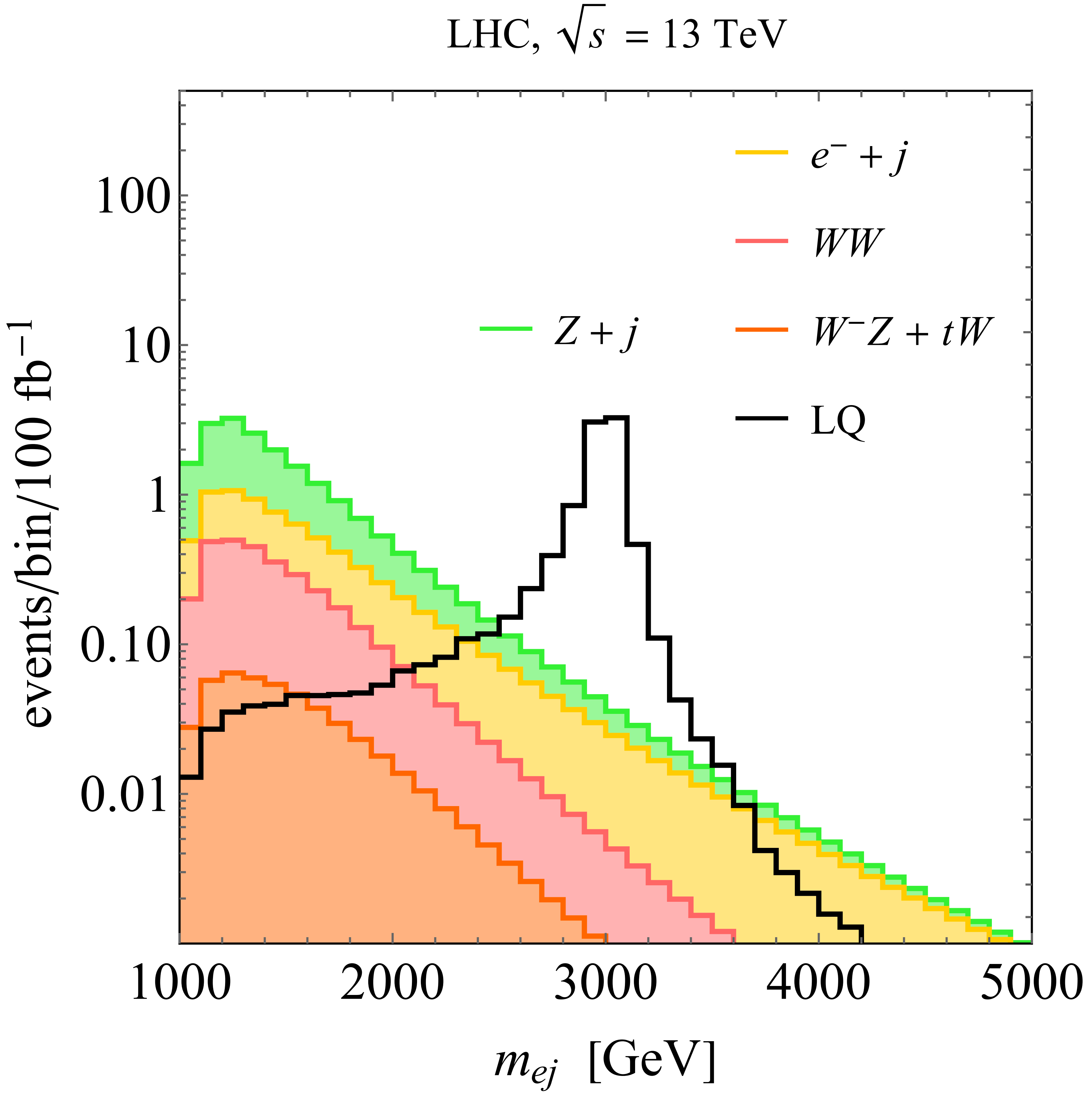
Irreducible background particularly relevant @ high invariant lepton-jet mass

[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

Resonant LQ production @ the LHC

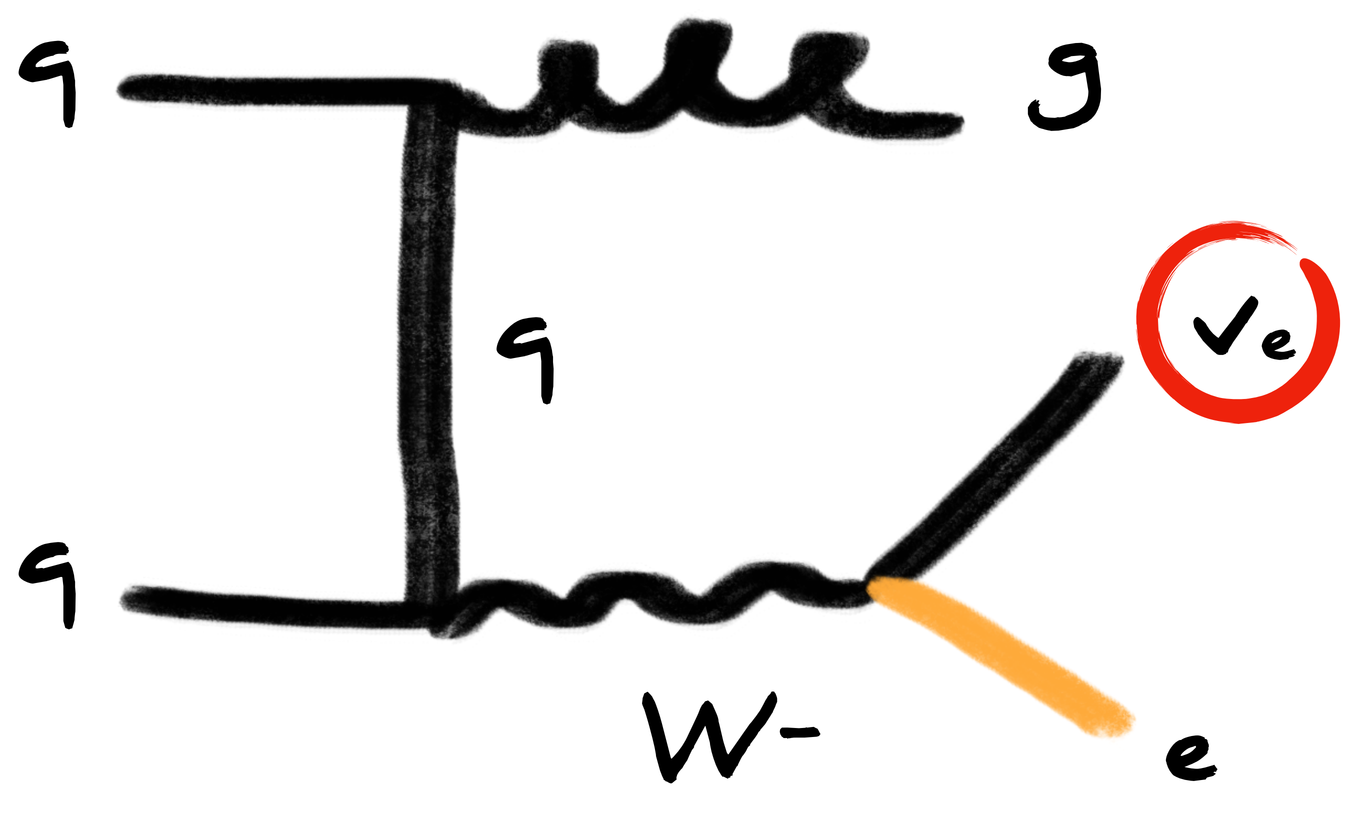


Suppressed by lepton veto

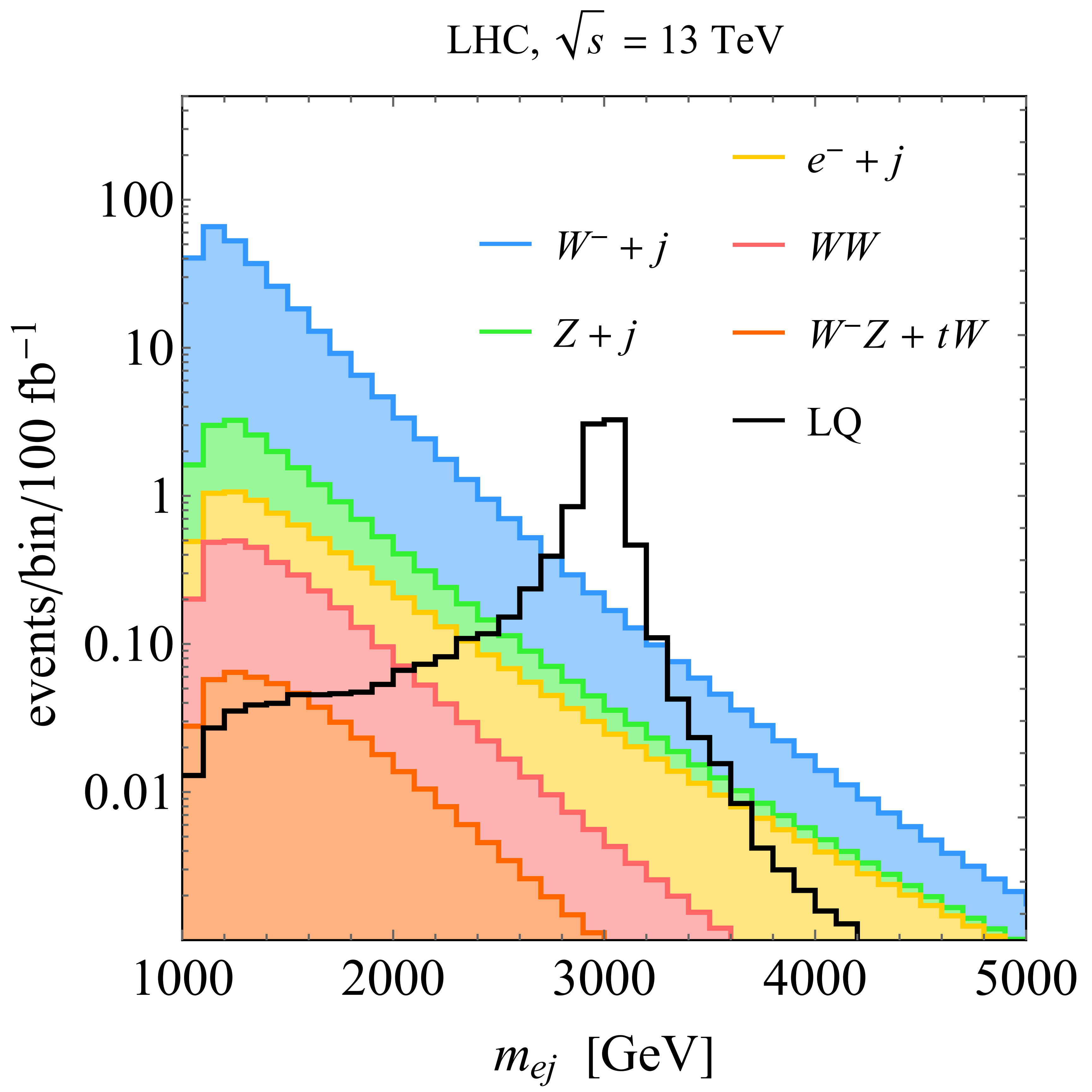


[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

Resonant LQ production @ the LHC

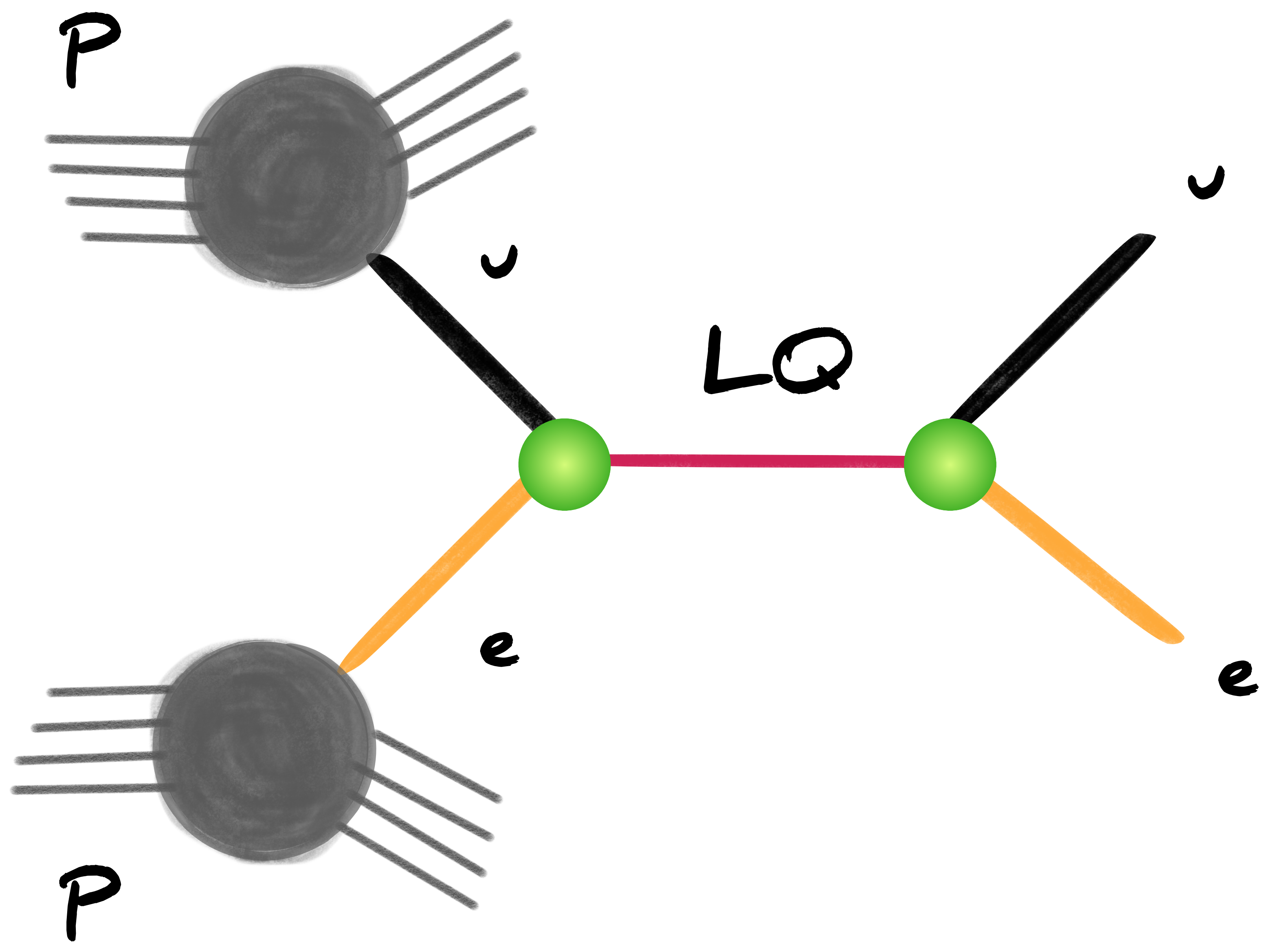


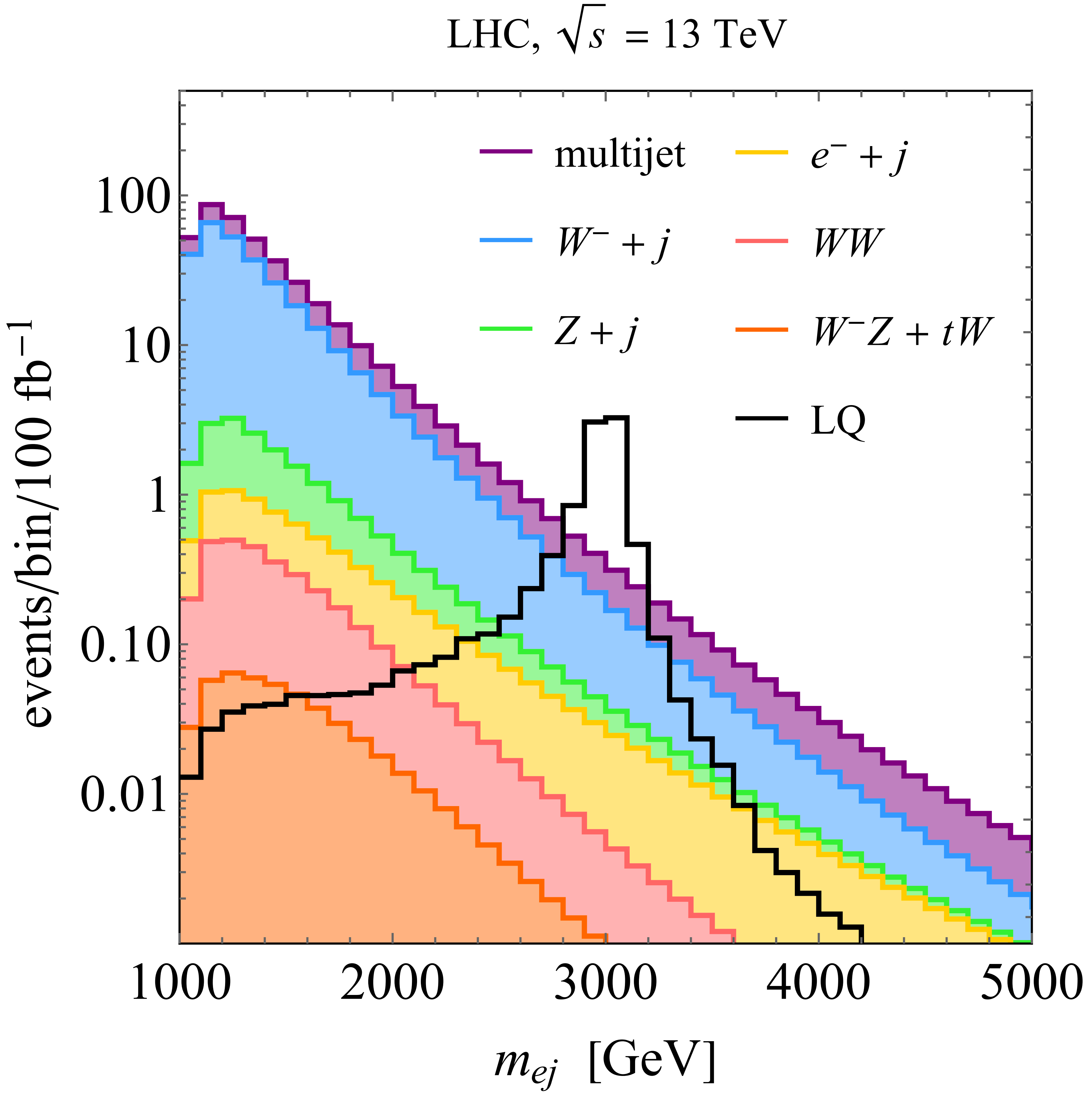
Suppressed by $E_{T,miss}$ requirement



[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

Resonant LQ production @ the LHC

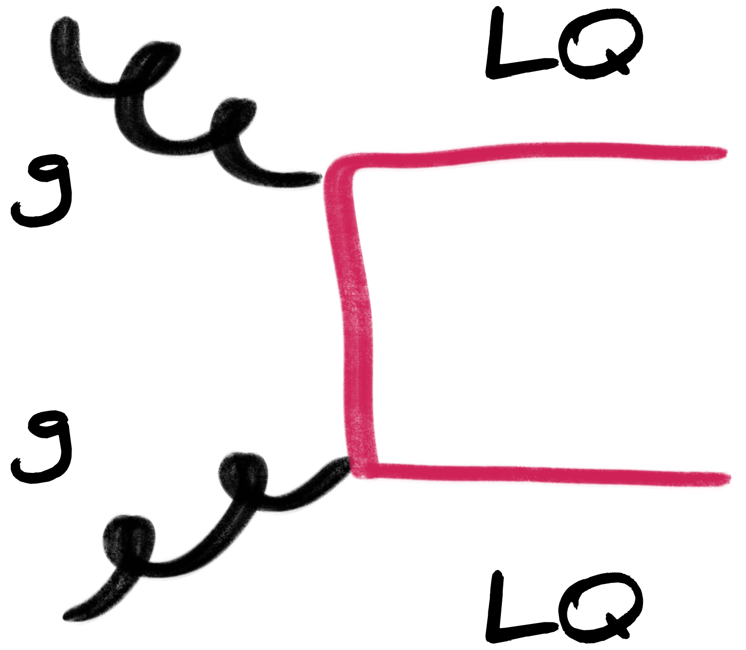




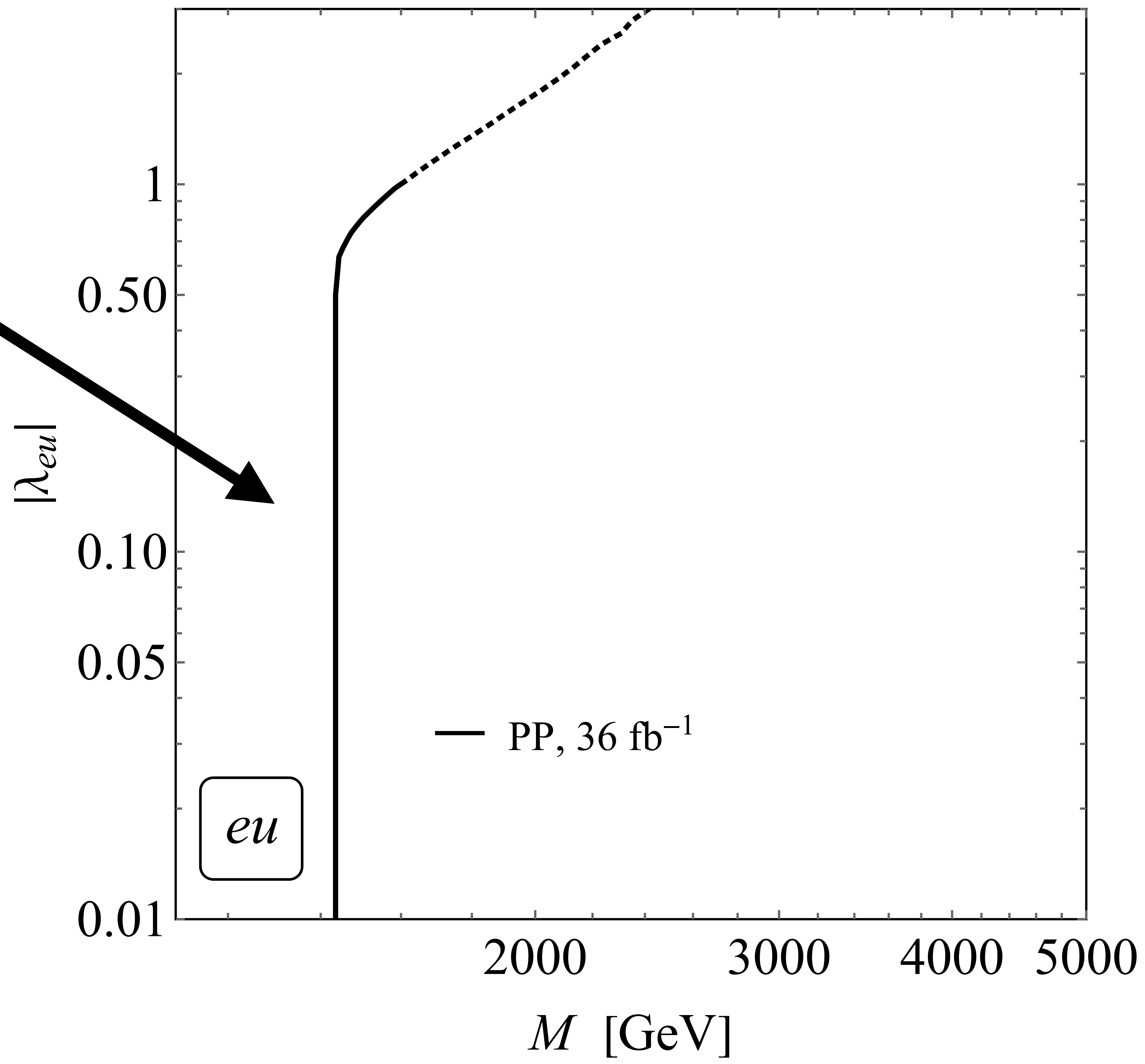
Sum over backgrounds is a steeply falling distribution, while signal exhibits a narrow peak

[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

LHC limits on 1st & 2nd generation LQs

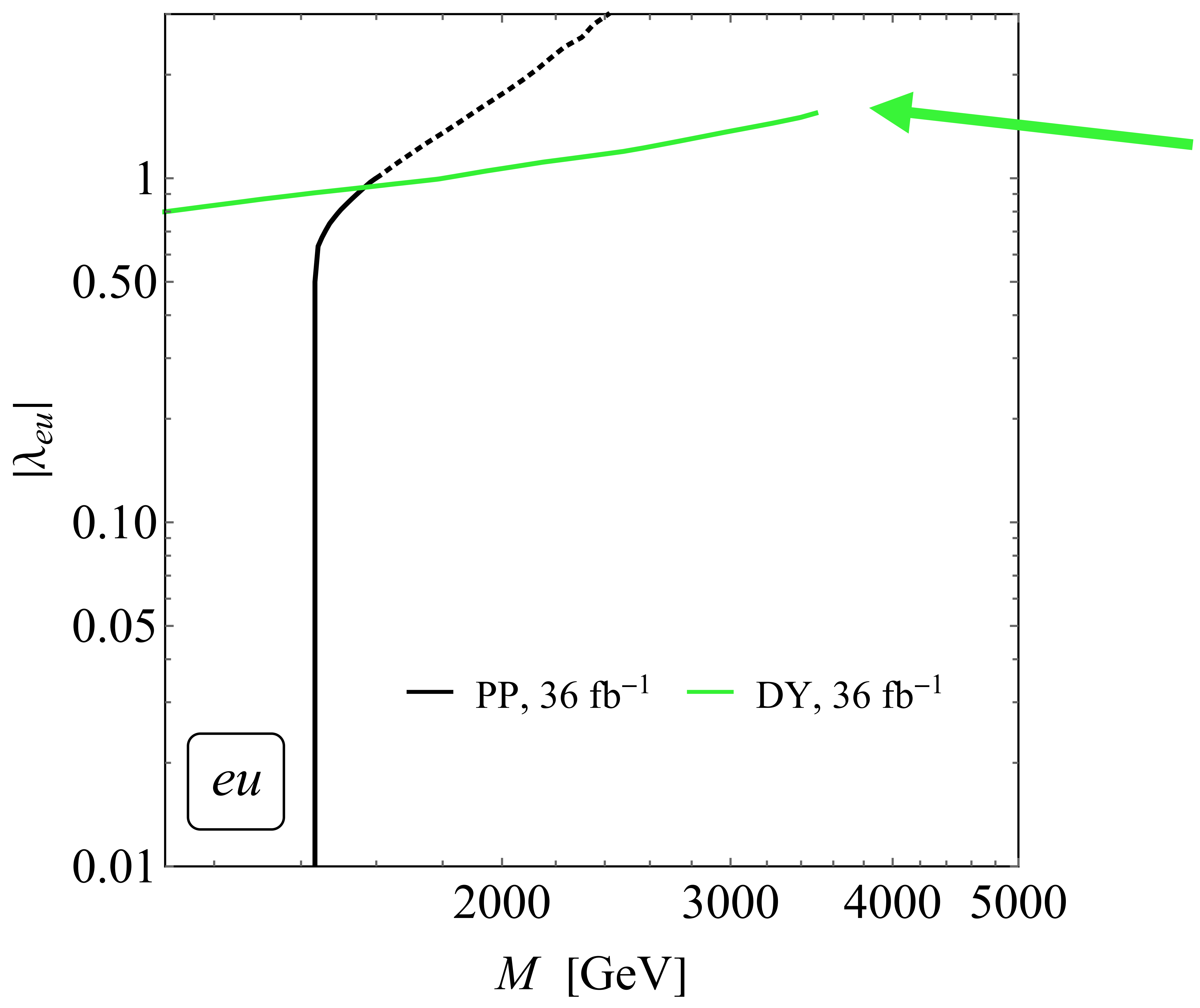


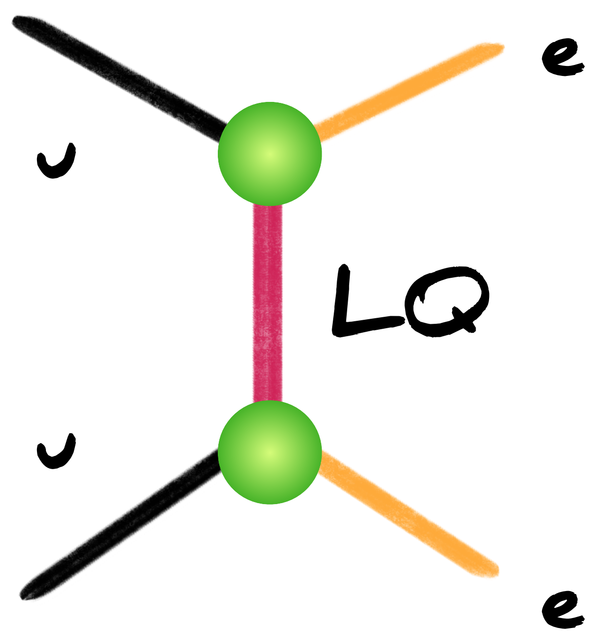
LQ pair production (PP)



[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

LHC limits on 1st & 2nd generation LQs

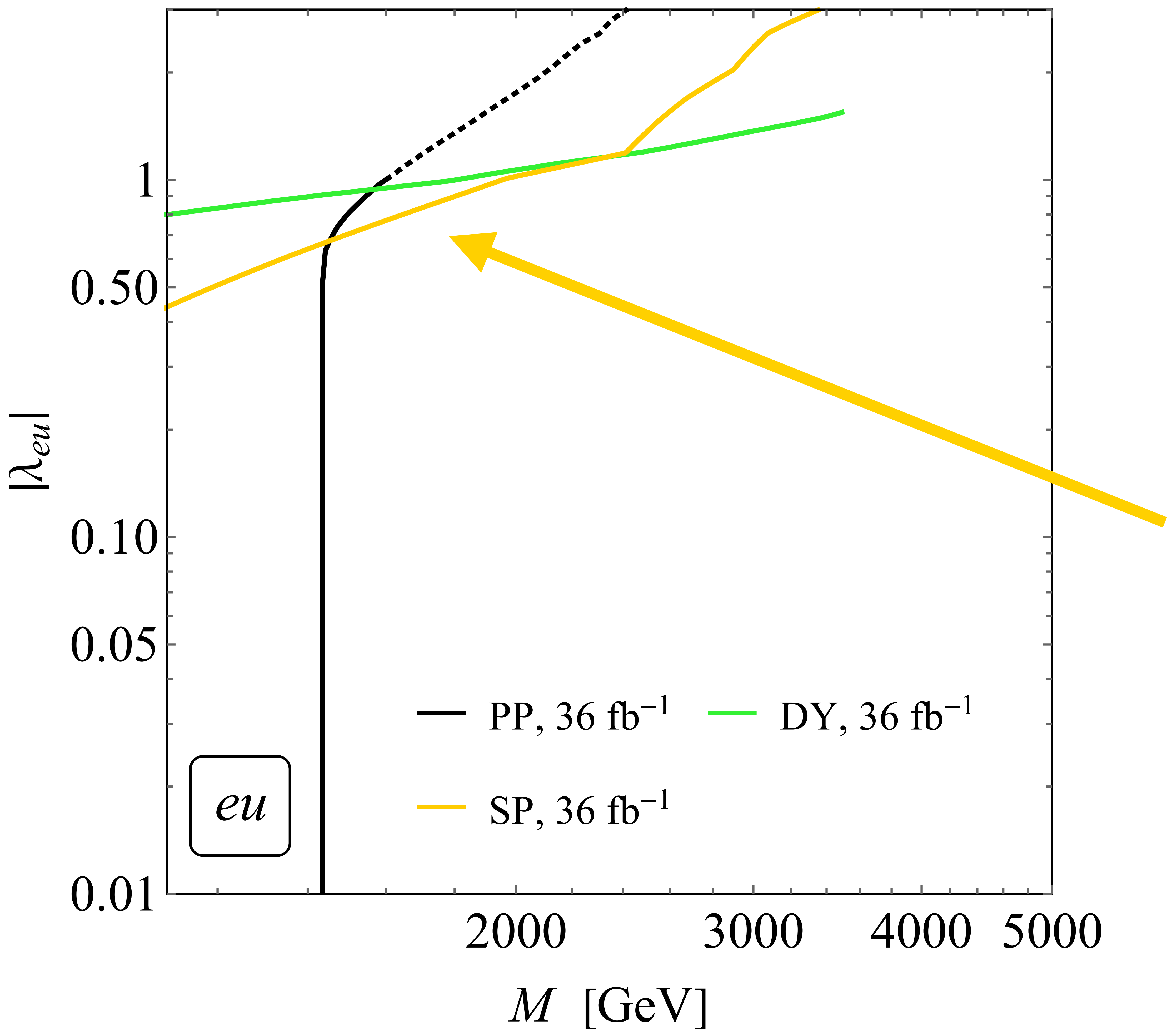


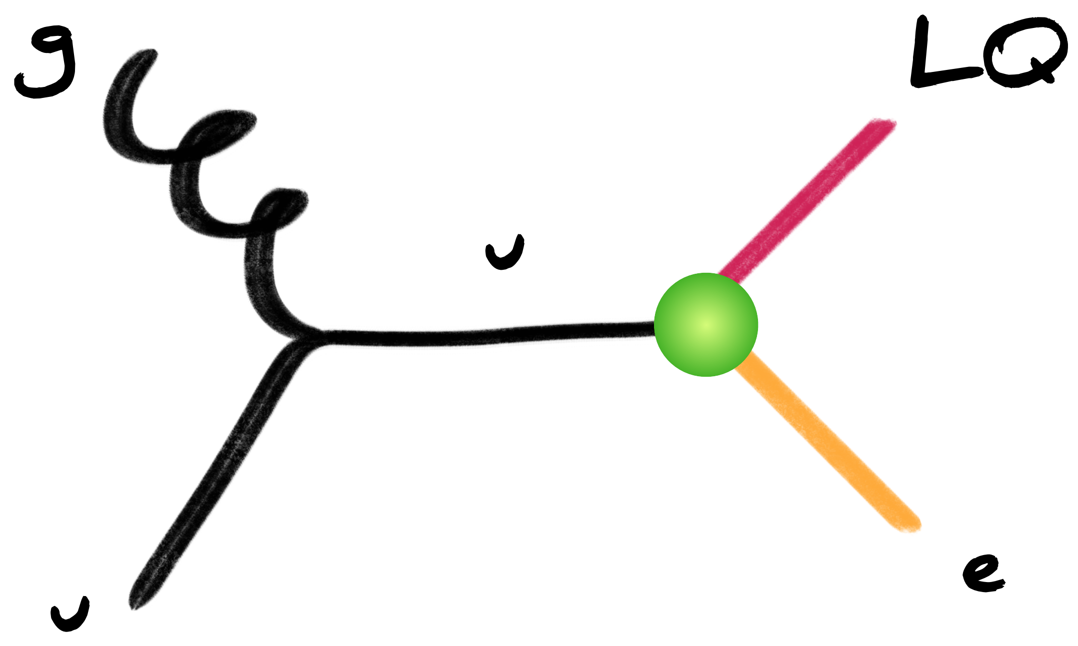


t-channel Drell-Yan (DY)

[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

LHC limits on 1st & 2nd generation LQs

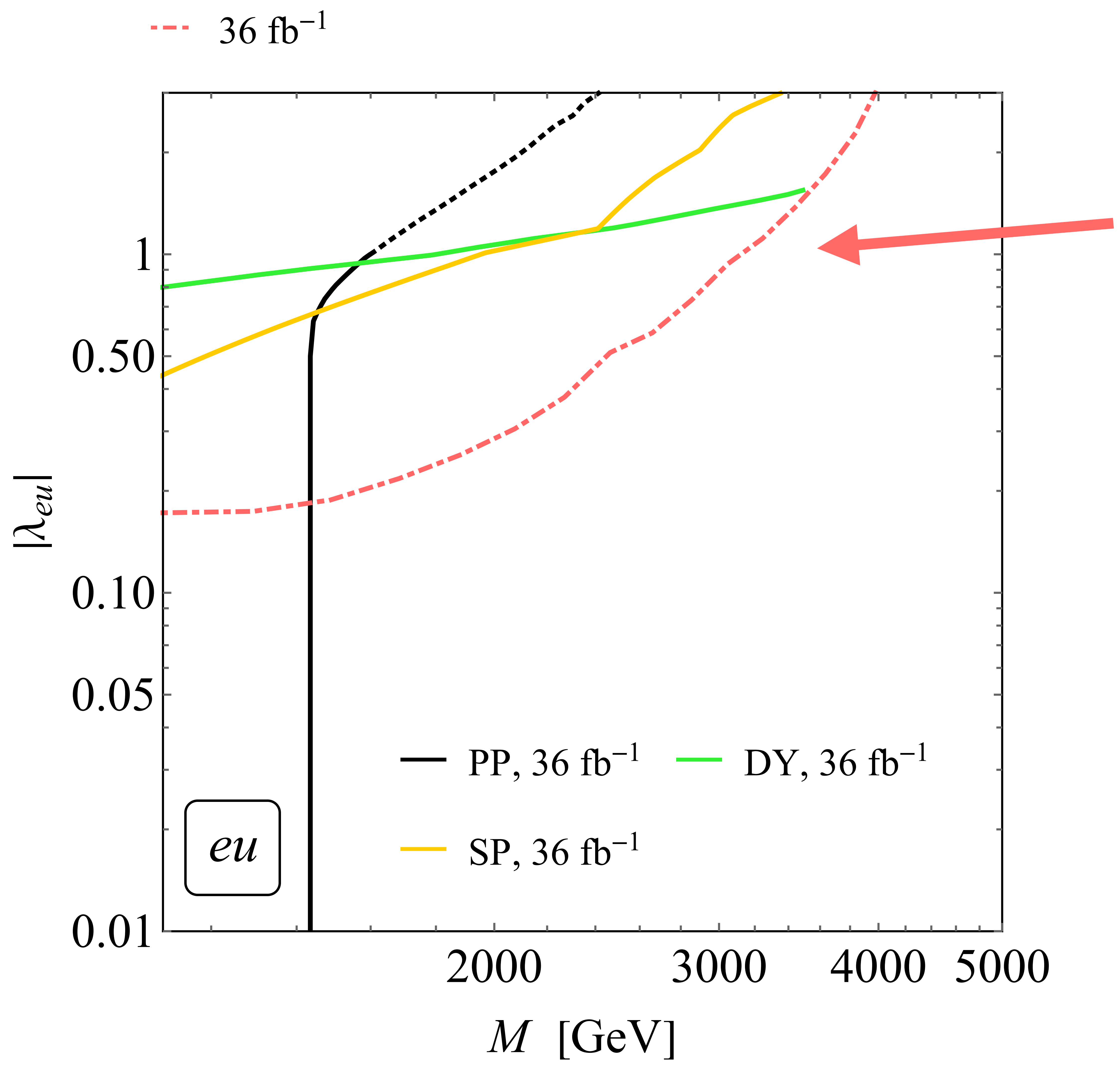


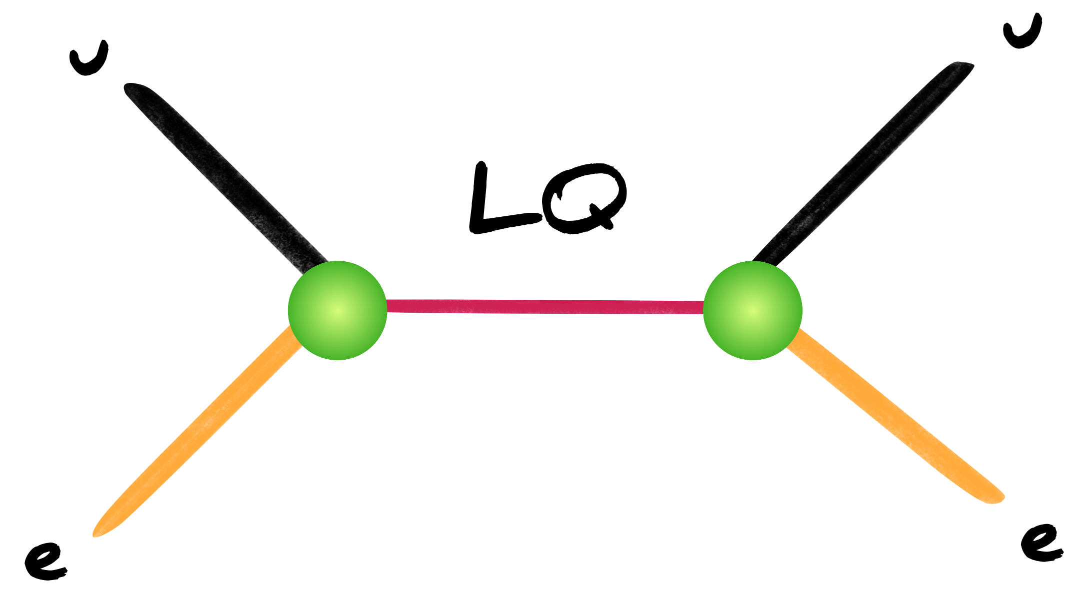


single LQ production (SP)

[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

LHC limits on 1st & 2nd generation LQs

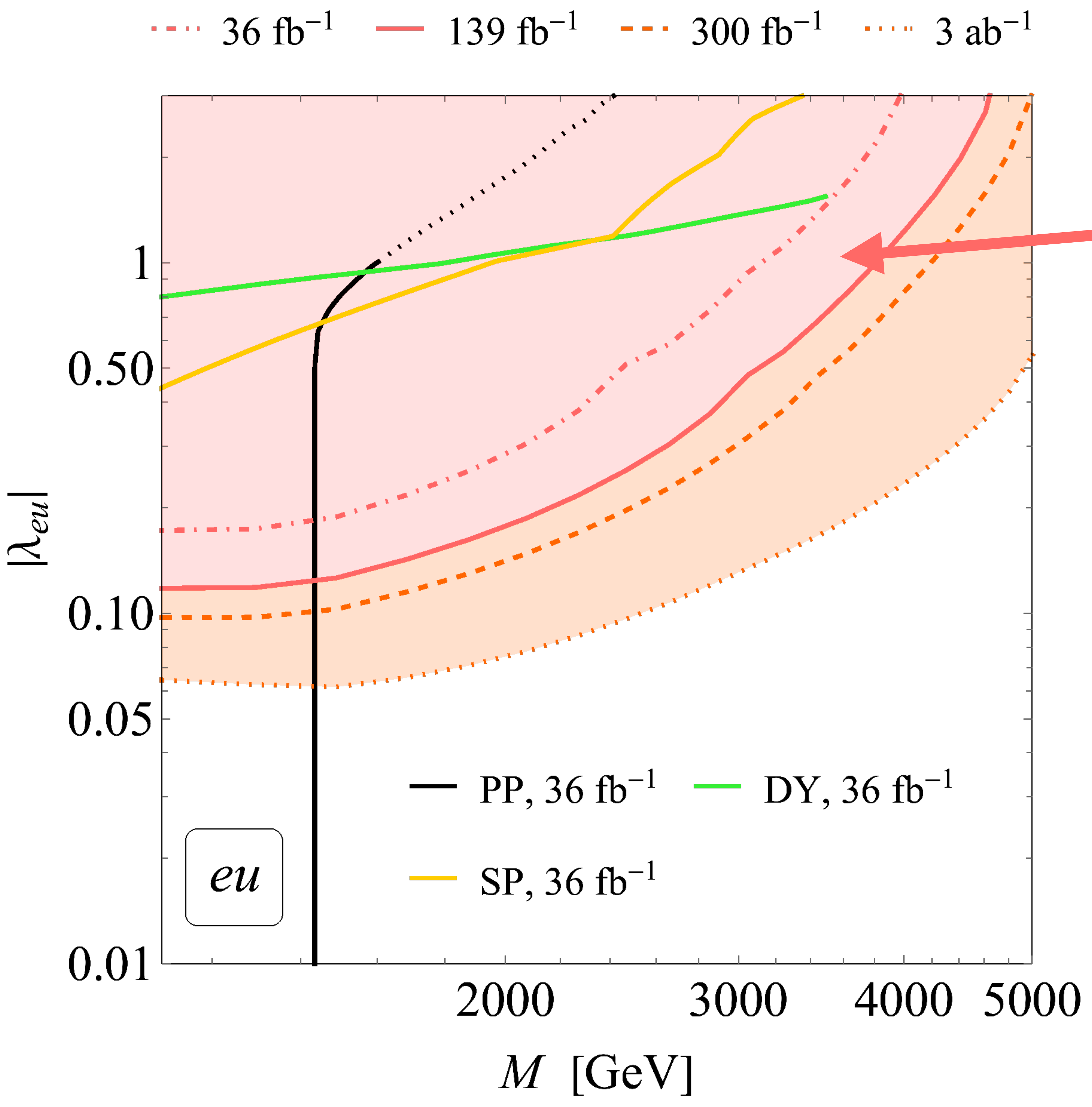


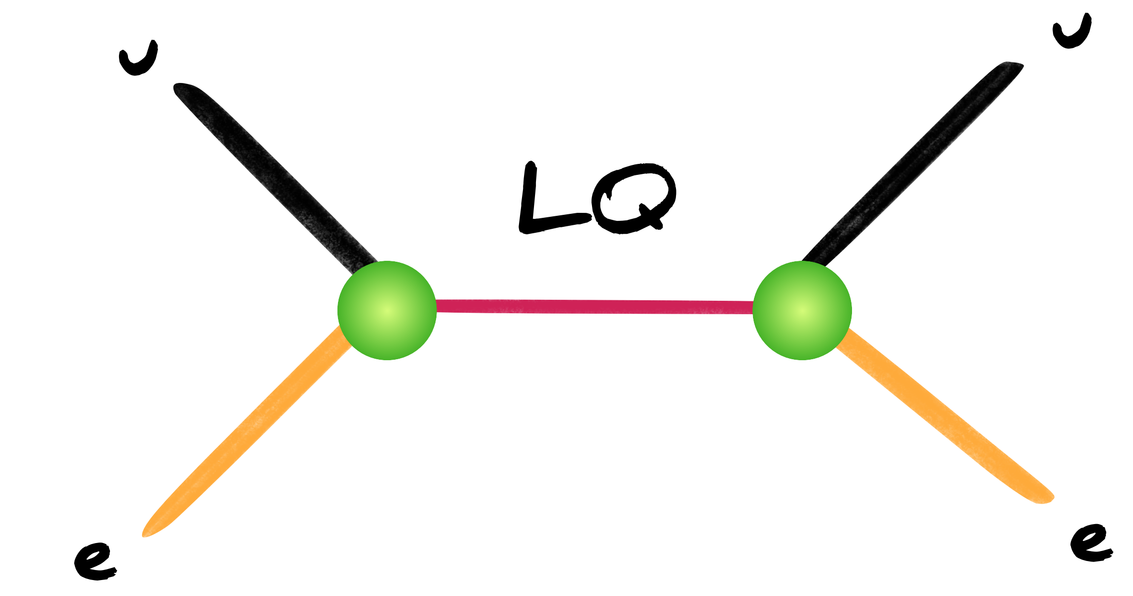


resonant LQ production

[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

LHC limits on 1st & 2nd generation LQs

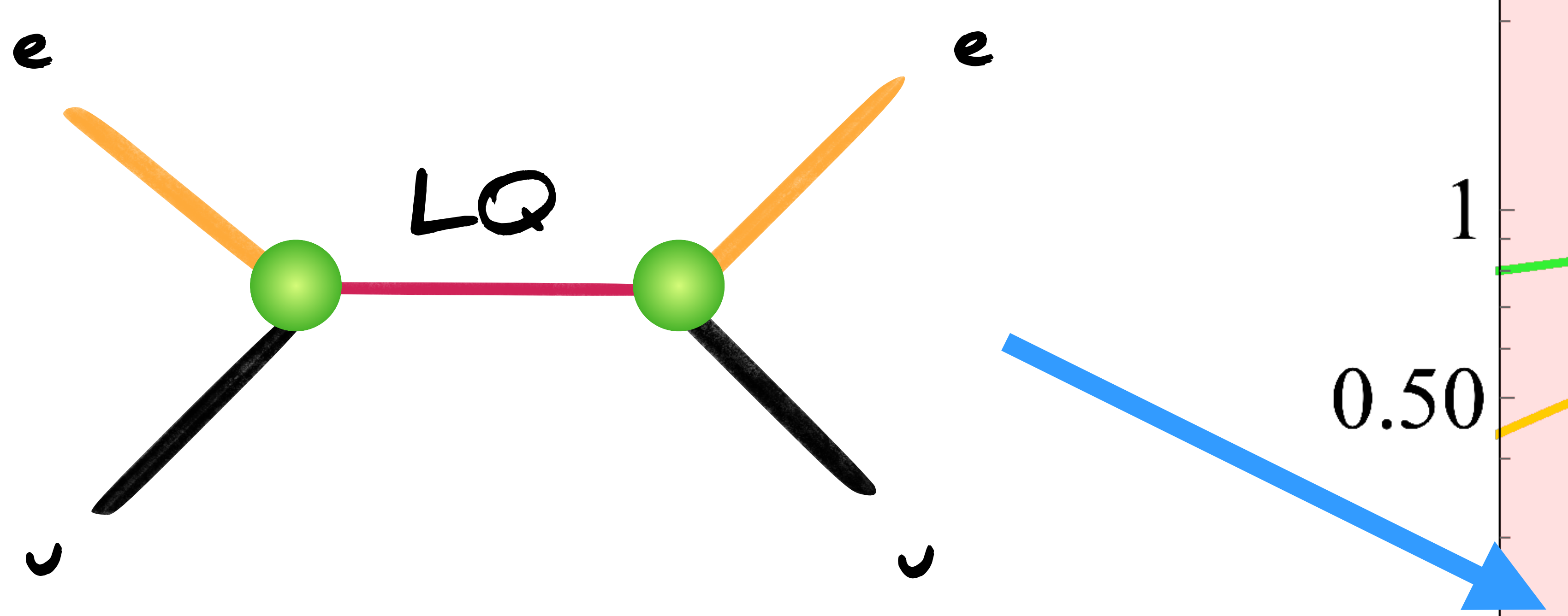




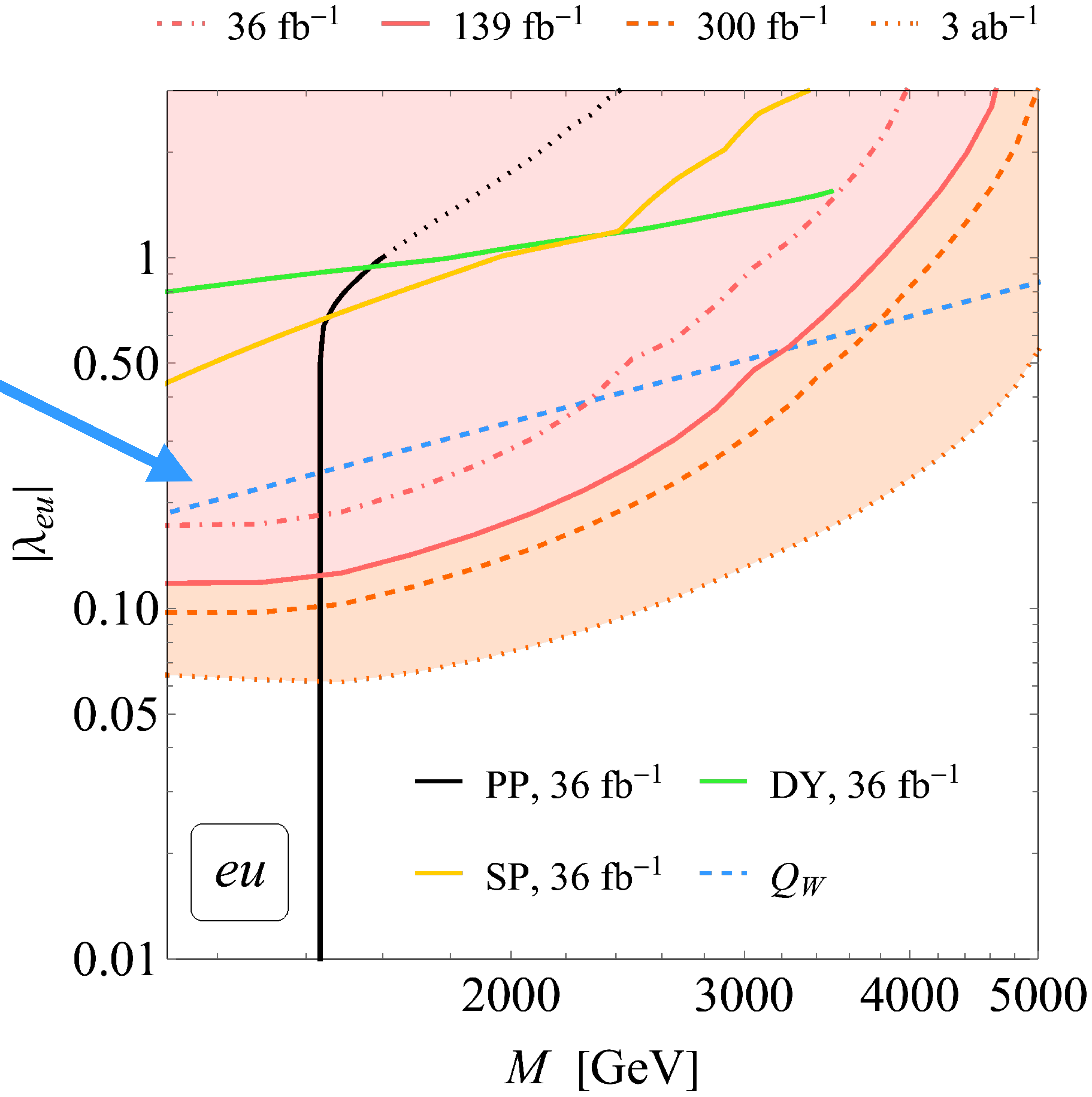
resonant LQ production

[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

LHC limits on 1st & 2nd generation LQs

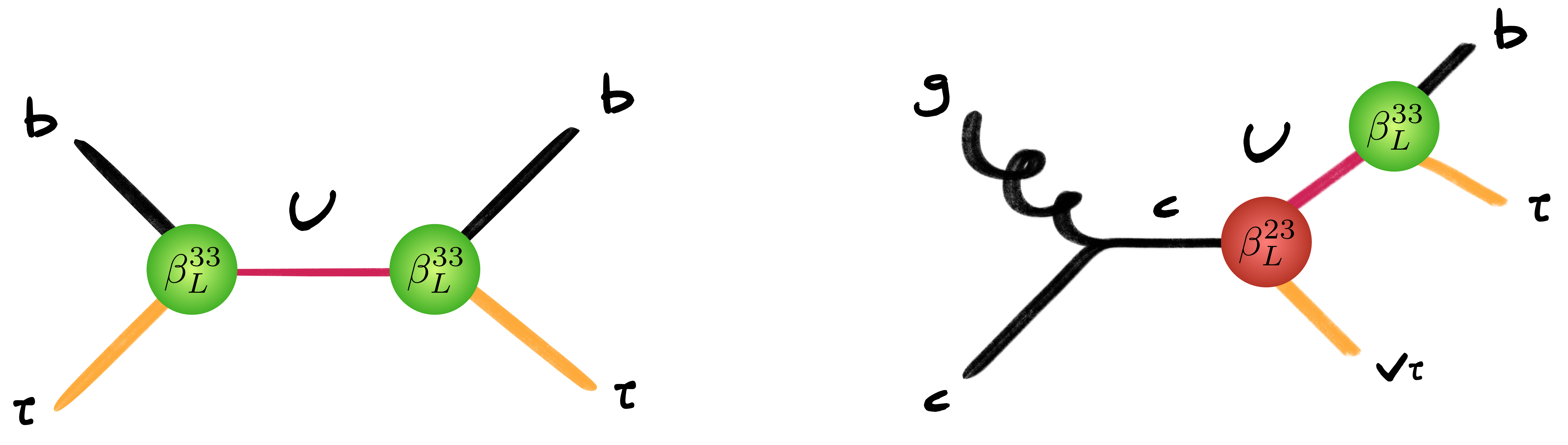


weak charge
measurements (Q_W)



[Buonocore, UH, Nason, Tramontano & Zanderighi, 2005.06475]

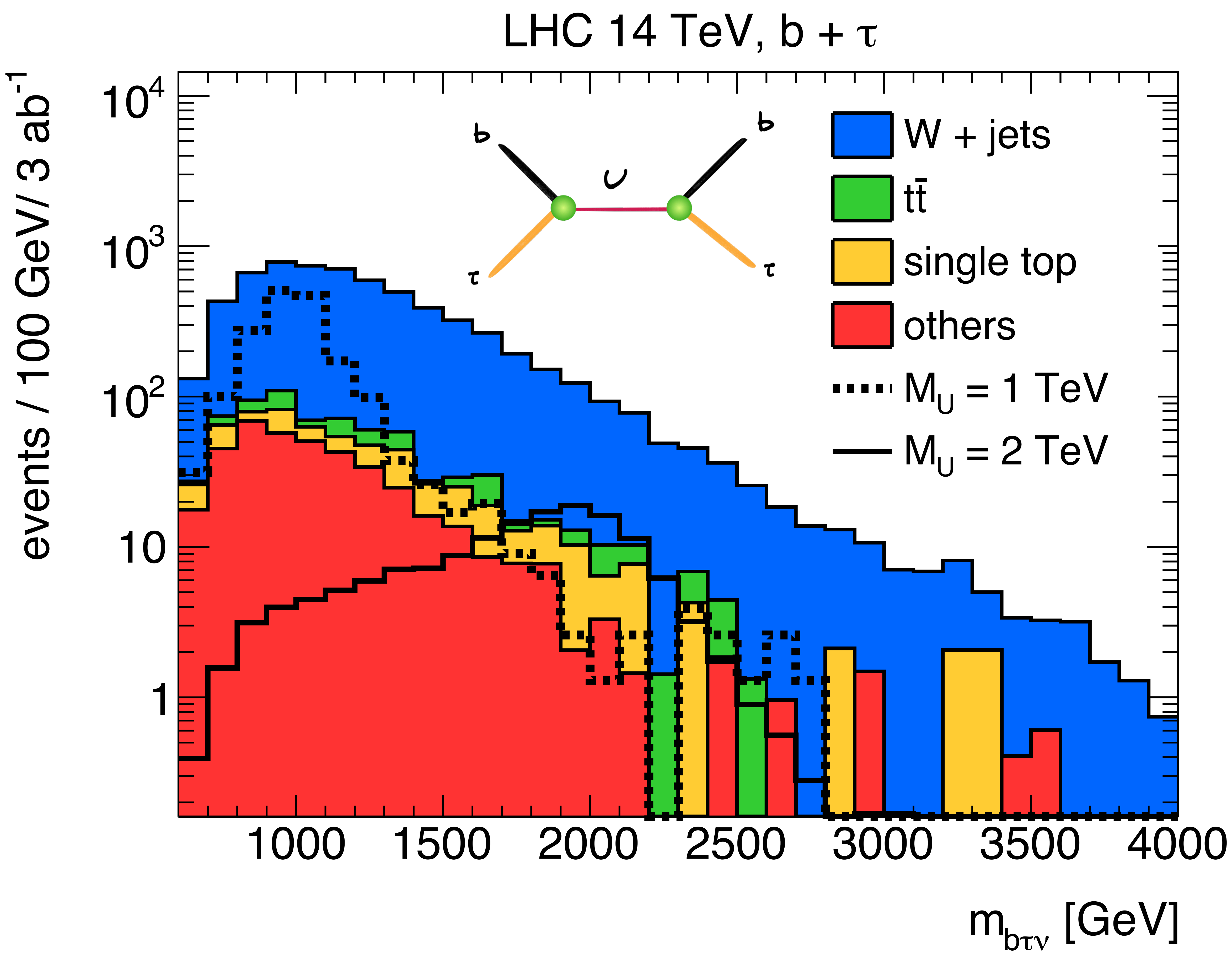
LQ contributions to b + τ signature

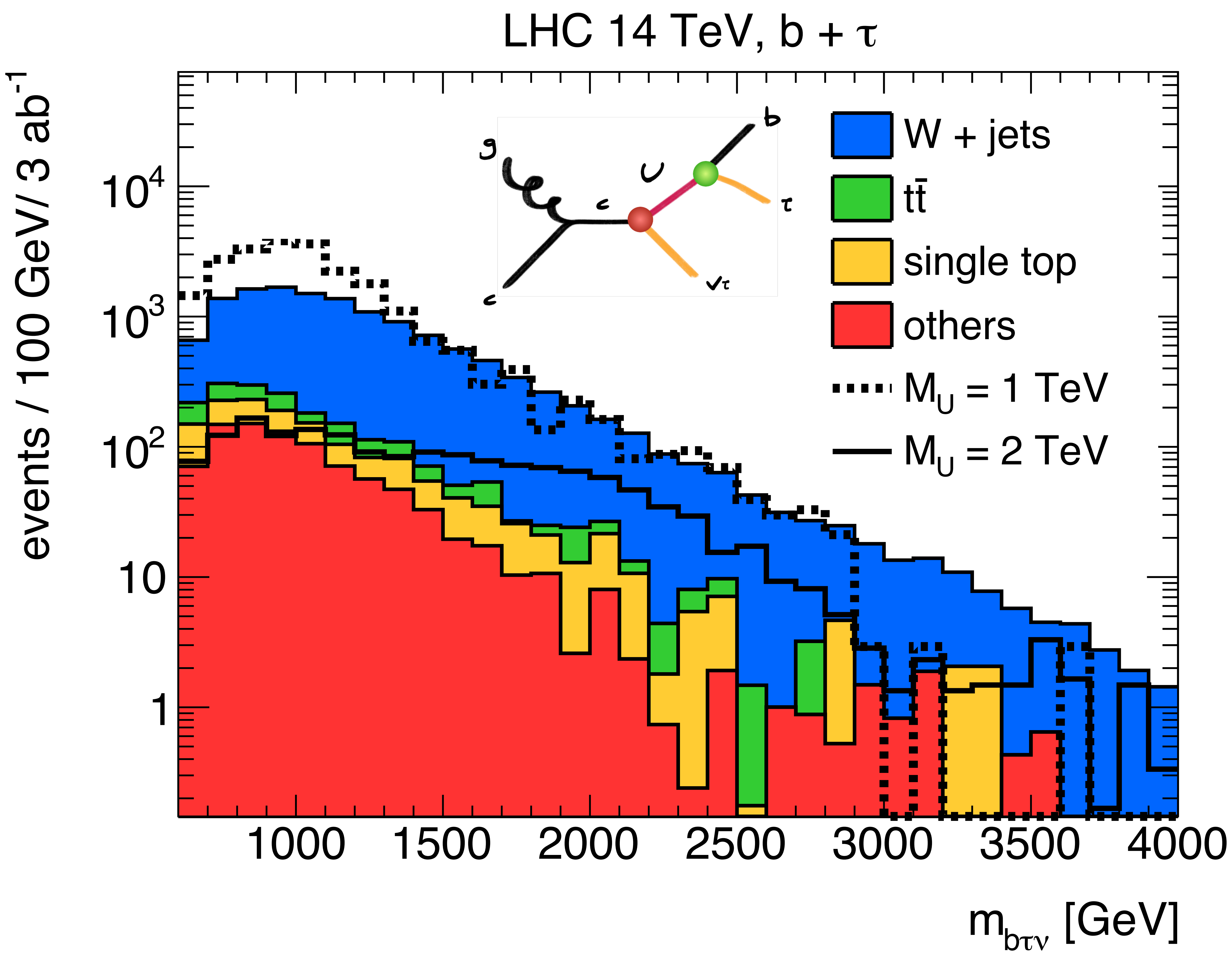


For $\beta_L^{23} = 0$, b + τ signal arises only from 2 → 2 process, while for $\beta_L^{23} \neq 0$ also 2 → 3 scattering is relevant. Since two topologies lead to final states with very different kinematic features, it is essential to develop two separate search strategies for them

[UH & Polesello, 2012.11474]

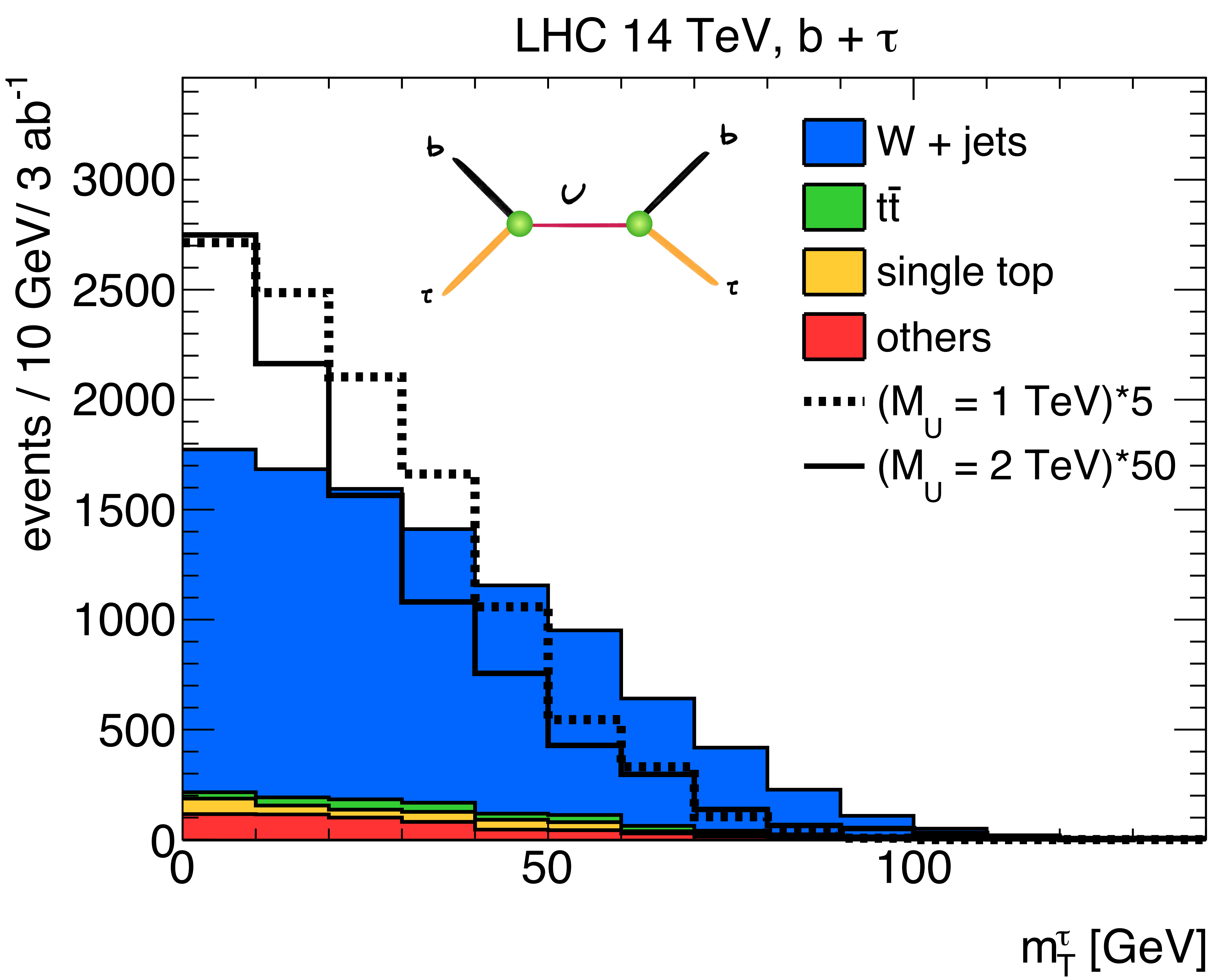
Kinematic distributions of b + τ signal

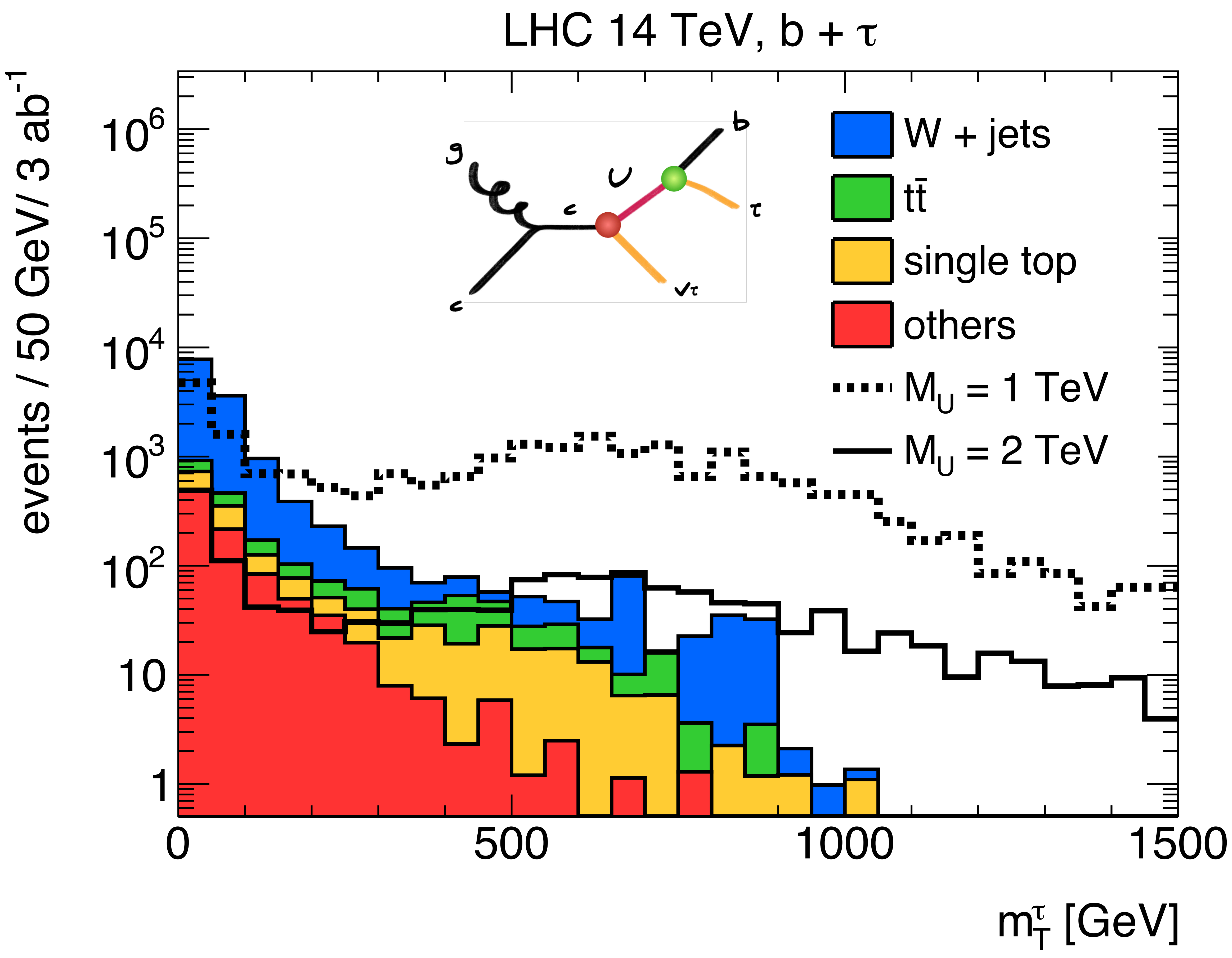




[UH & Polesello, 2012.11474]

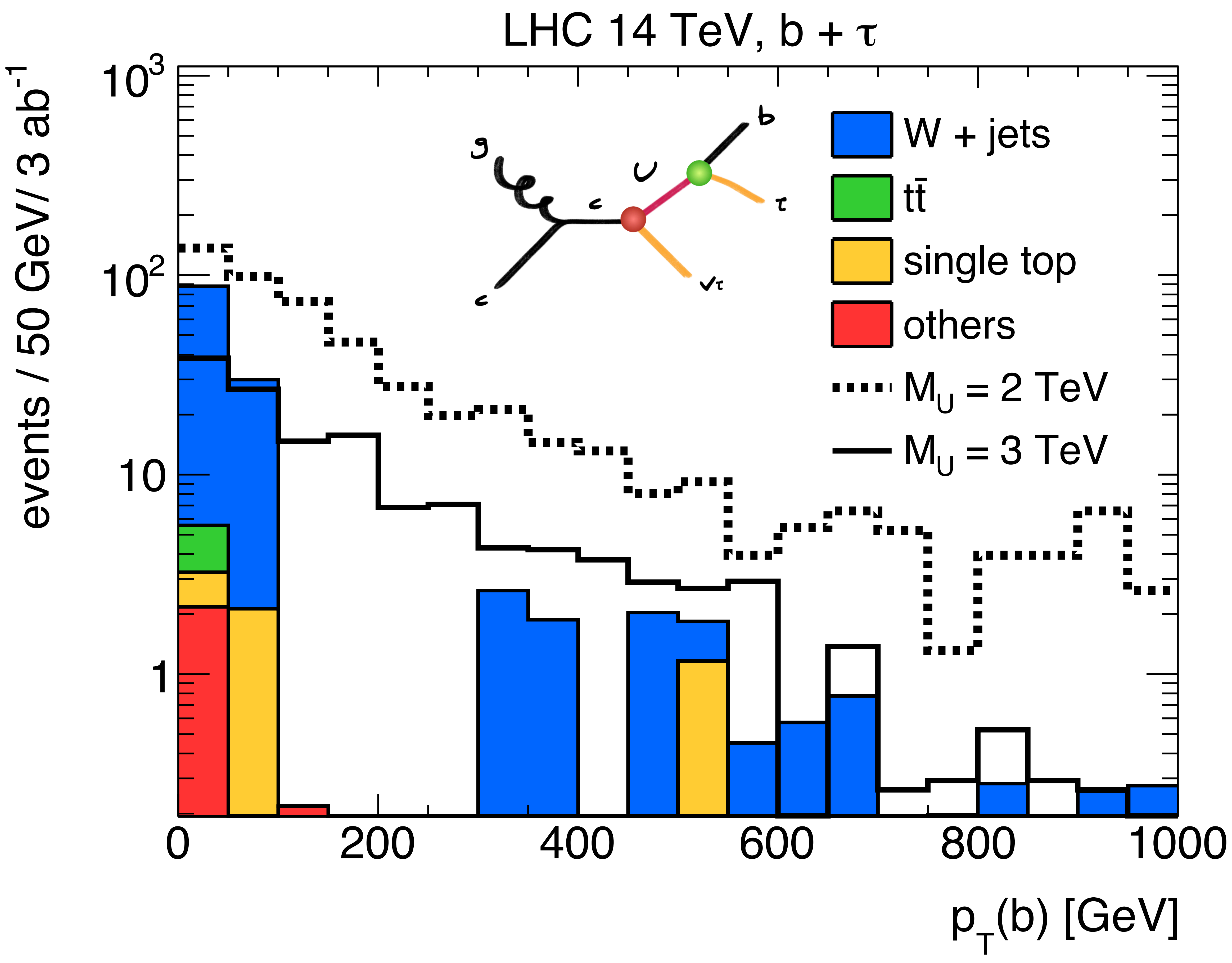
Kinematic distributions of b + τ signal

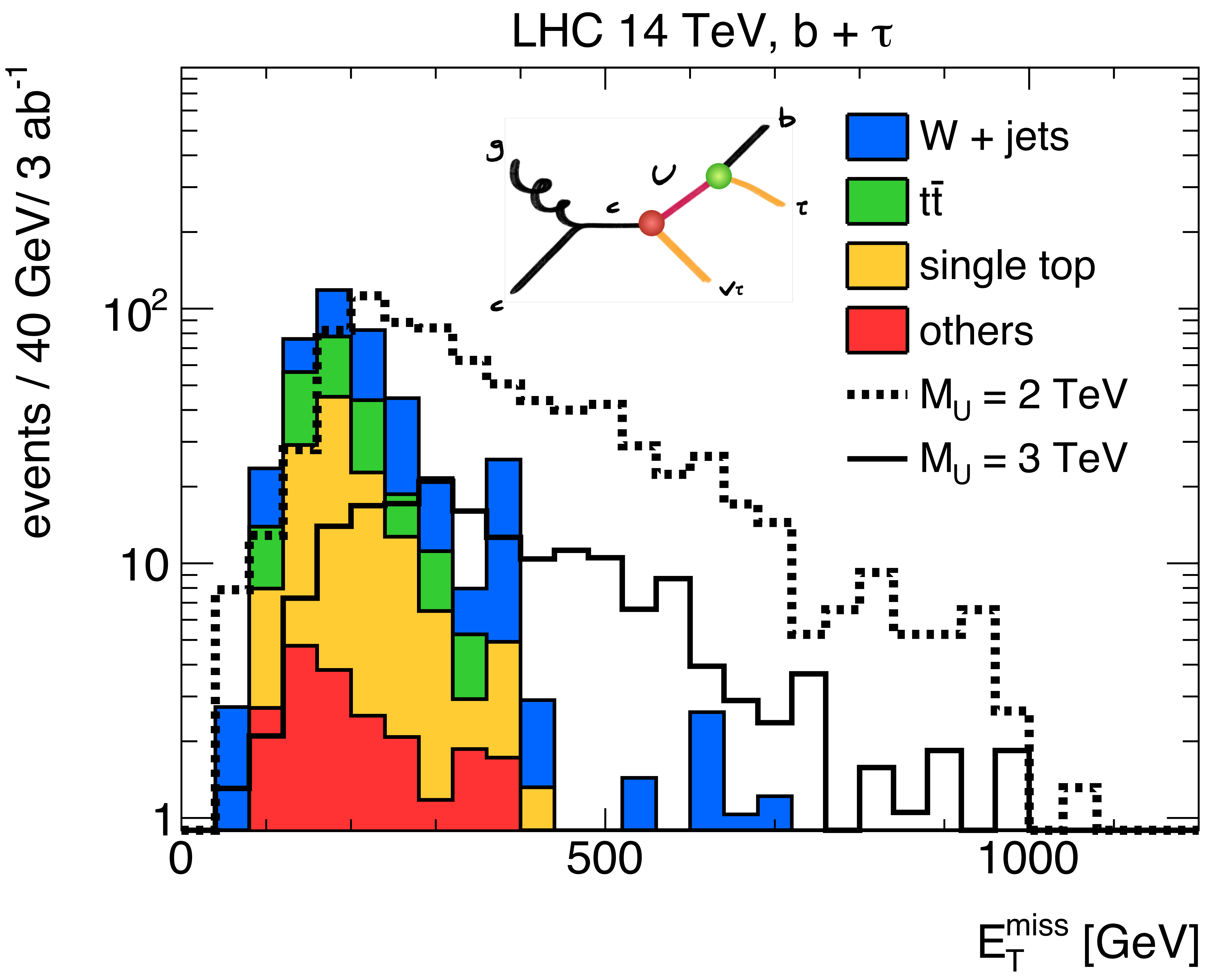




[UH & Polesello, 2012.11474]

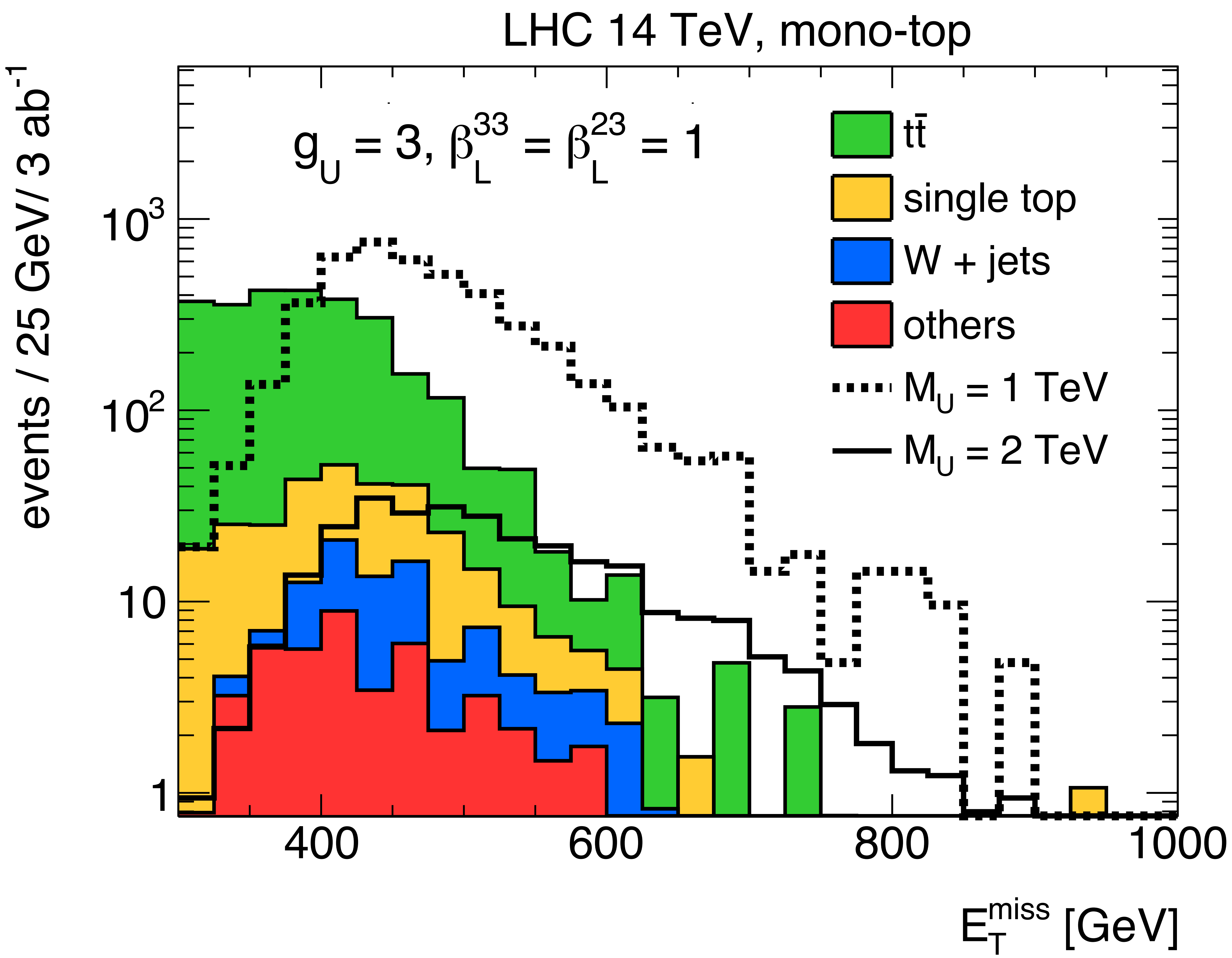
Kinematic distributions of b + τ signal

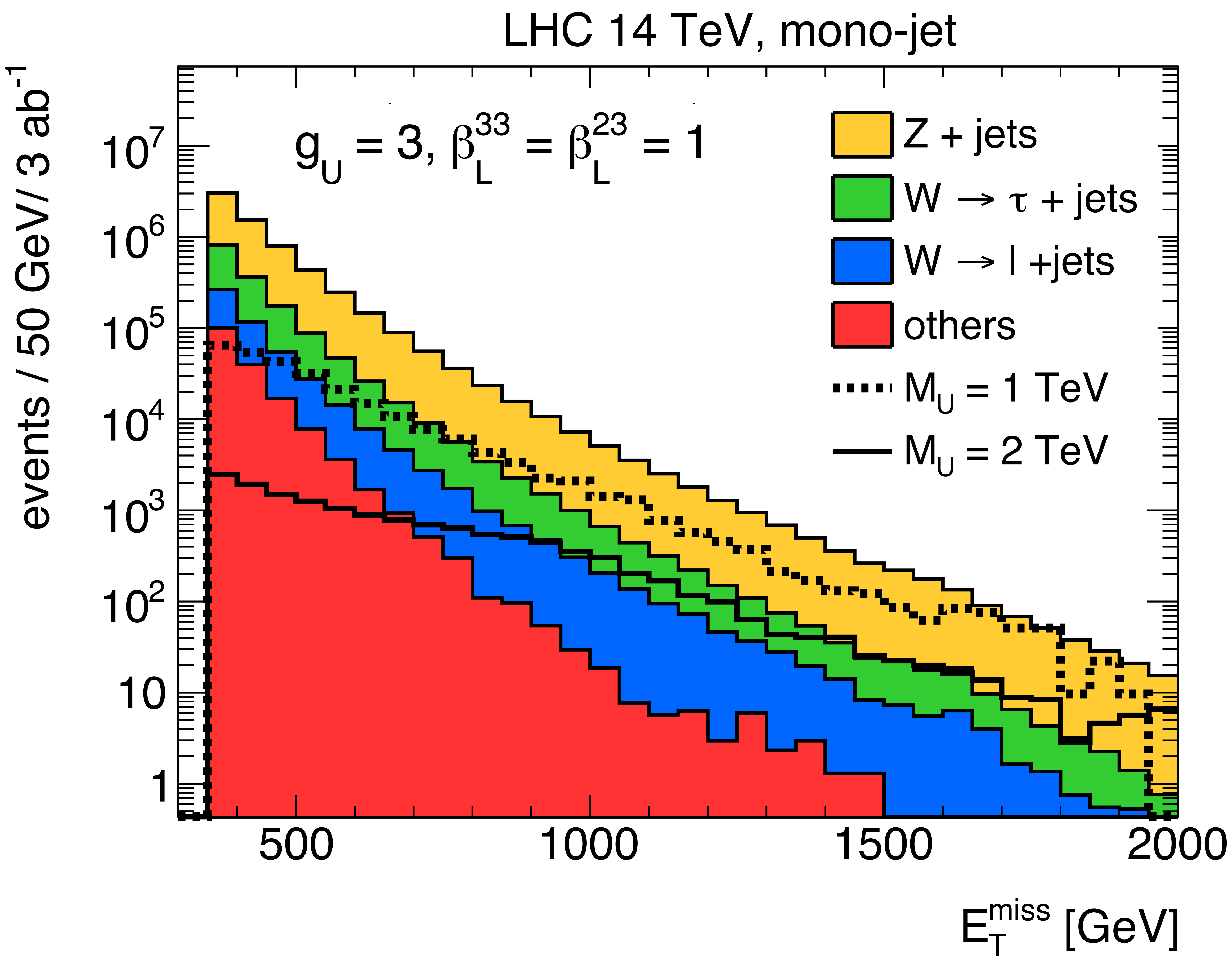




[UH & Polesello, 2012.11474]

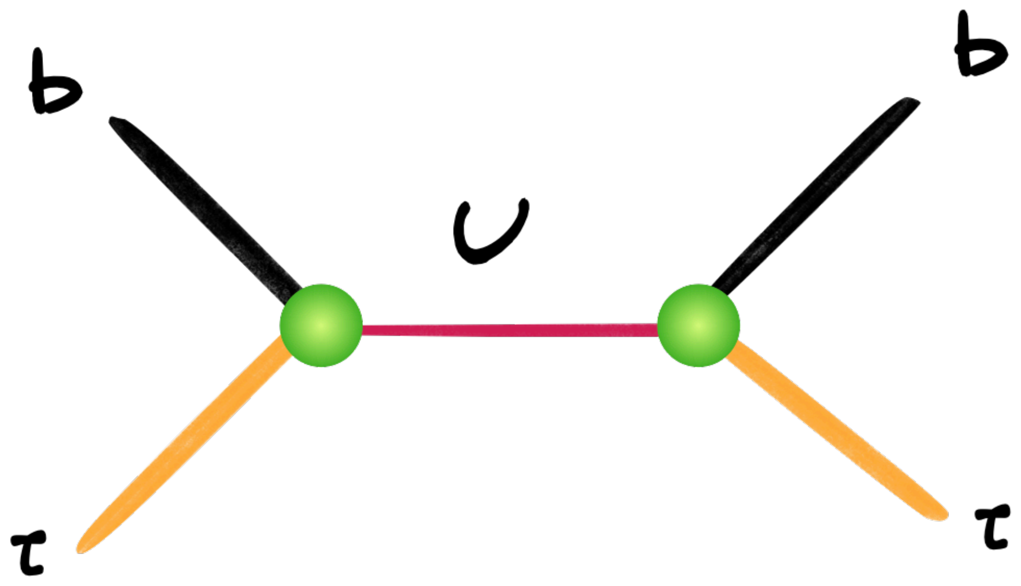
Mono-top & mono-jet distributions

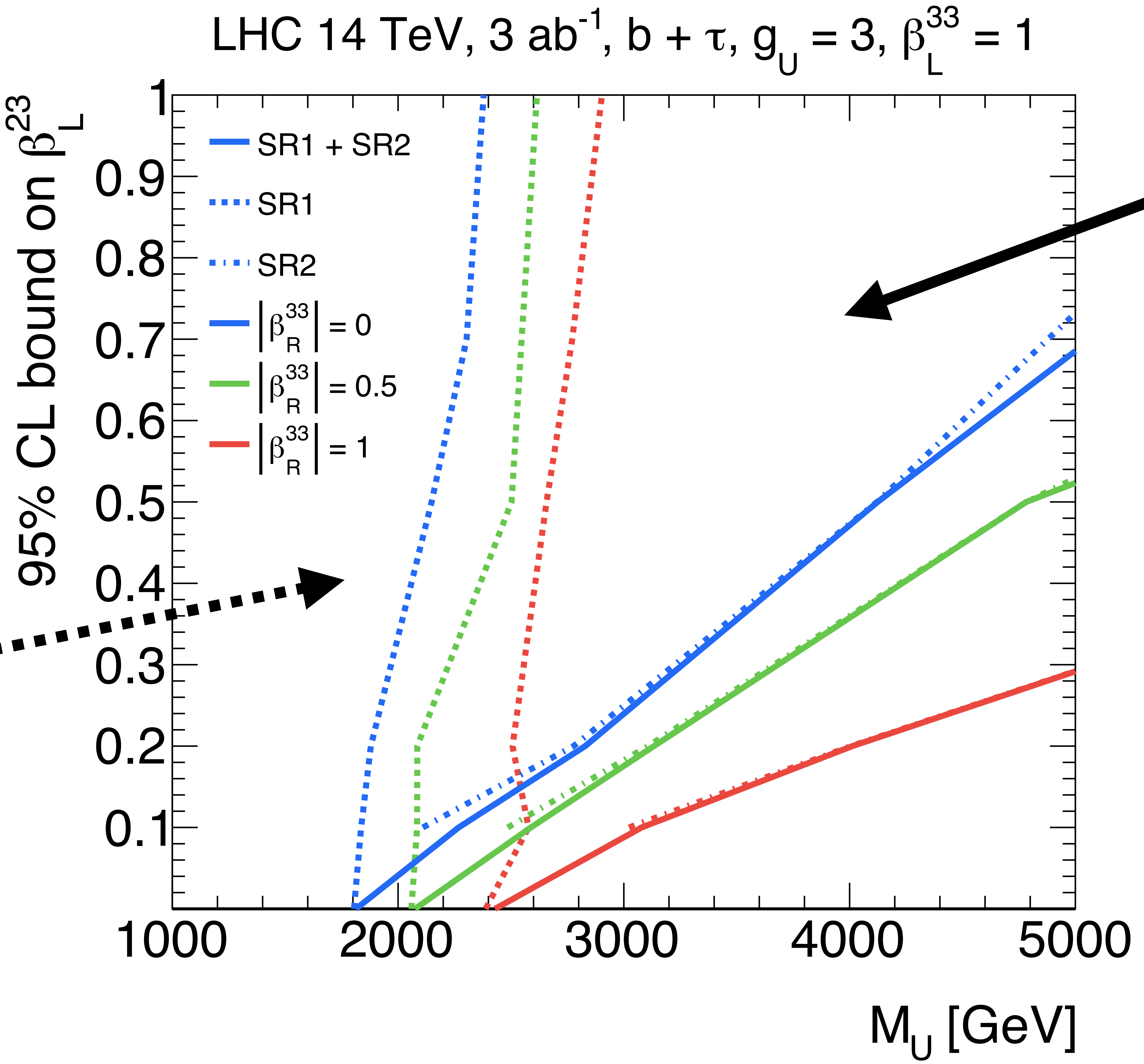


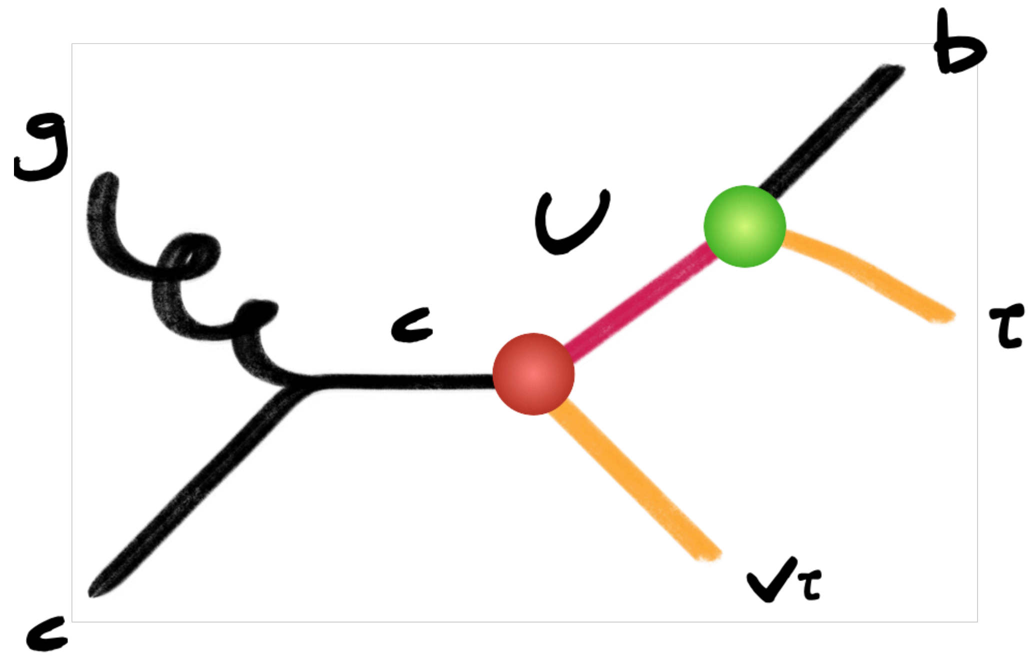


[UH & Polesello, 2012.11474]

b + τ constraints from 2 → 2 & 2 → 3 signal

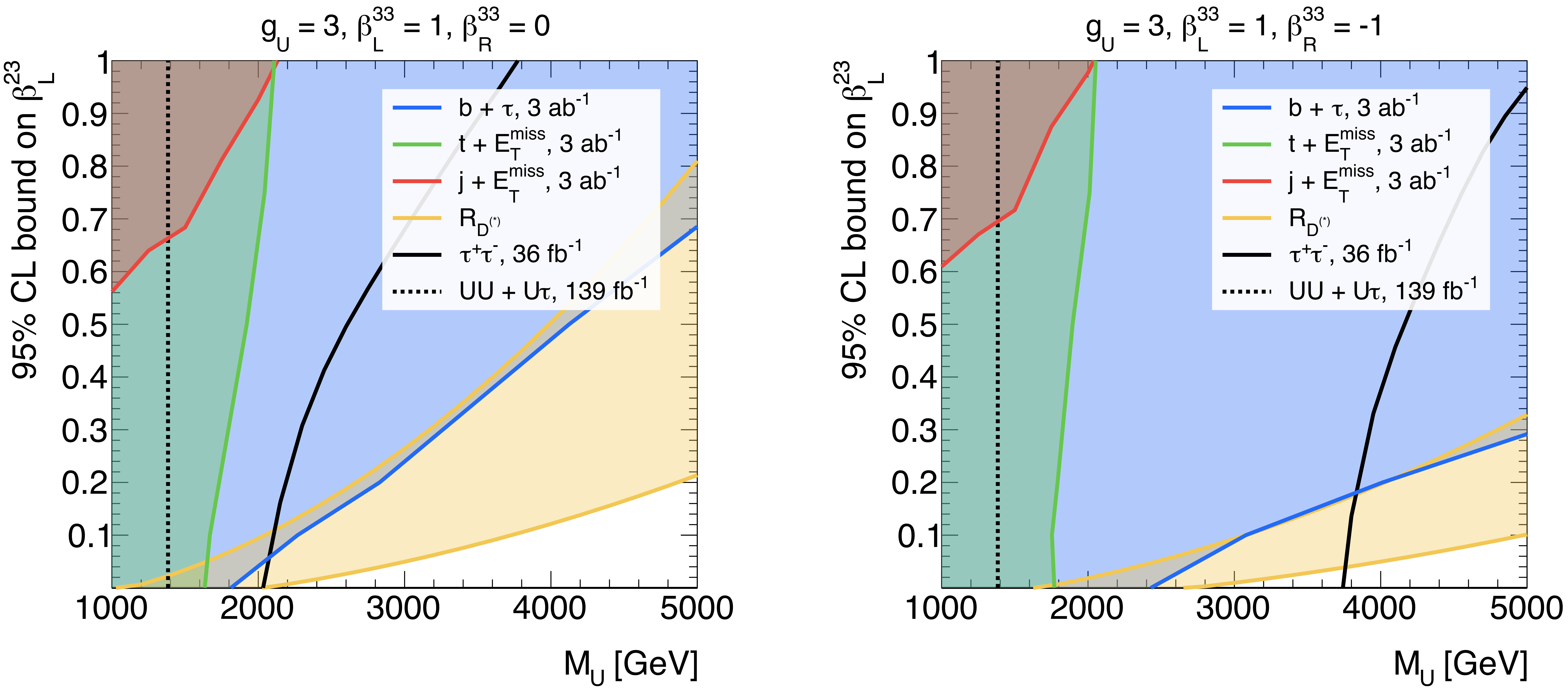






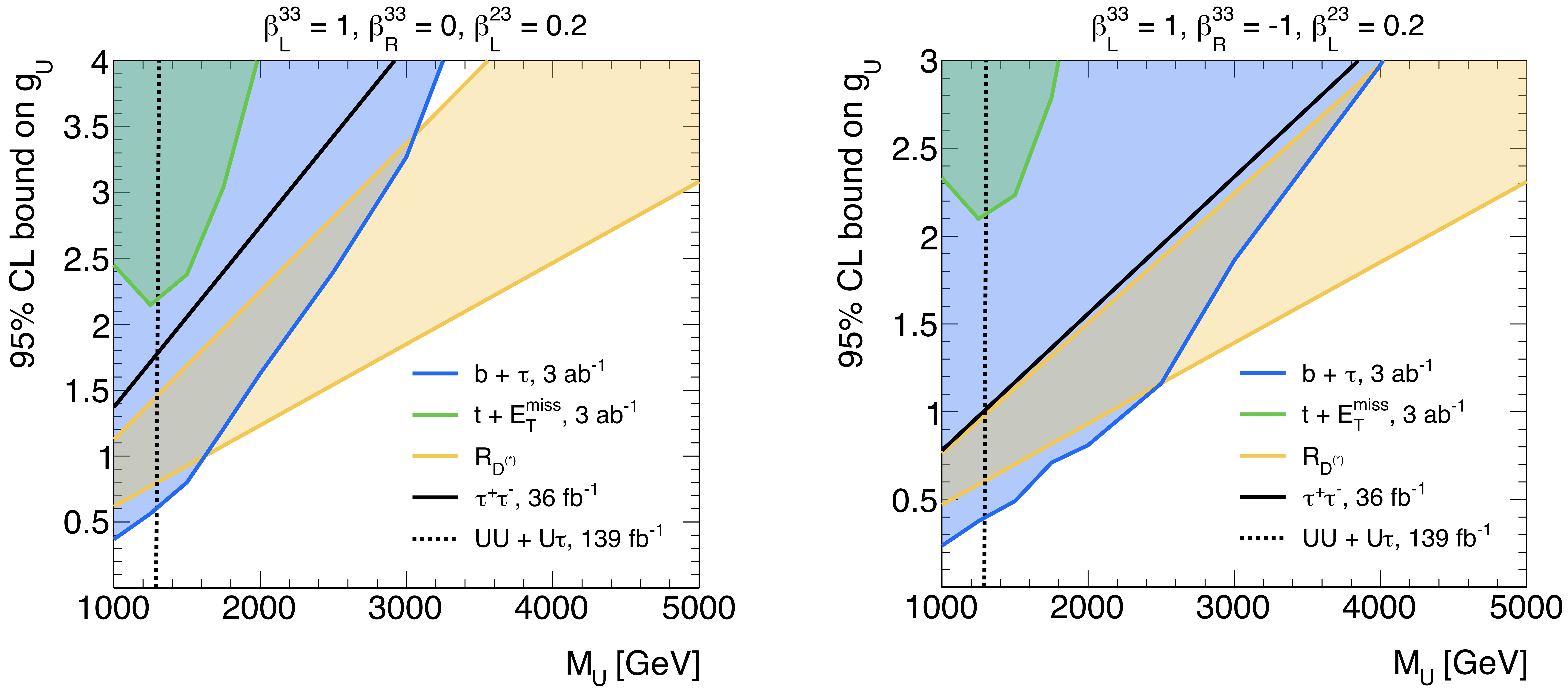
[UH & Polesello, 2012.11474]

Constraints from new LQ search strategies



[UH & Polesello, 2012.11474]

Constraints from new LQ search strategies



[UH & Polesello, 2012.11474]