Three-generation baryon and lepton number violation at the LHC

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Moriond EW
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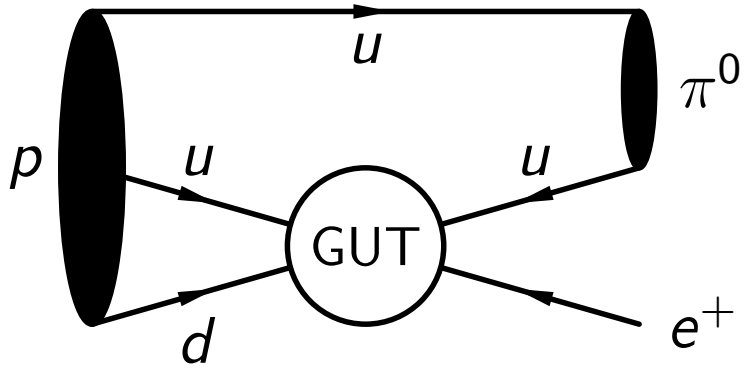
Three-generation BLV at the LHC

Baryon and lepton number violation (BLV) is expected:

- Theoretically: B and L are accidental and anomalous in the SM.
- Experimentally: BLV is required for baryogenesis and, Majorana neutrinos.

Low-energy constraints on BLV seem amazingly strong...



but this violates flavour symmetries present in the SM
which favour $\epsilon_{abc}\psi^a\psi^b\psi^c$ structures

$\Longrightarrow$
- at least six fermions
- all three generations

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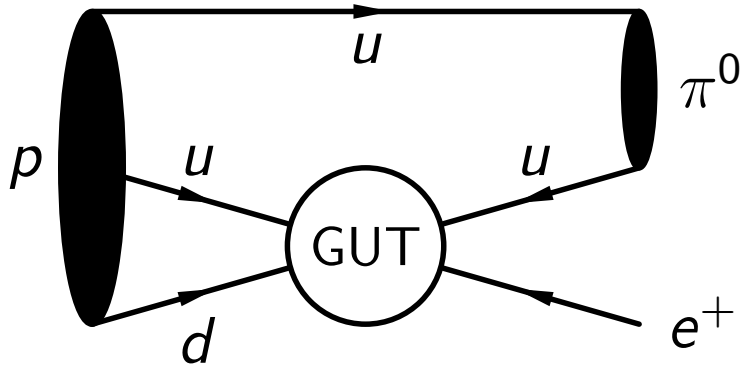

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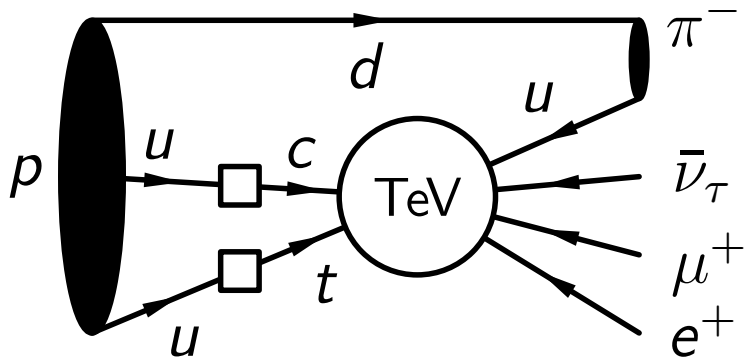
Yet, we found they are not!



$\Longrightarrow$
- dimensional suppression
- flavour suppressions

and BLV allowed at the TeV!

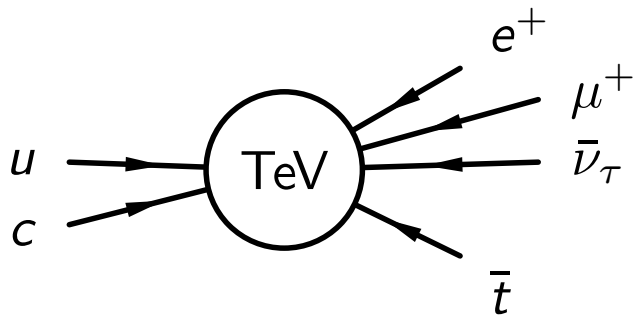
Three-generation BLV at the LHC

Resonant and unsuppressed BLV expected at the LHC!

A model-independent classification of allowed processes
based on overall symmetries conservation.

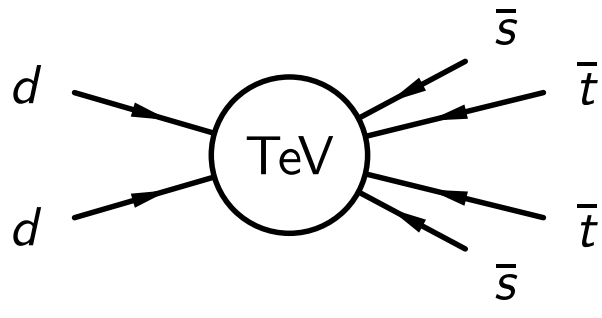
$\longrightarrow$ striking three-generation signatures

e.g.



$(\Delta B;\, \Delta L) = \pm(1;\, 3)$

positively charged
same-sign dileptons



$(\Delta B;\, \Delta L) = \pm(2;\, 0)$

negatively charged
same-sign dileptons

Special!

... more in 1210.6598

Backup

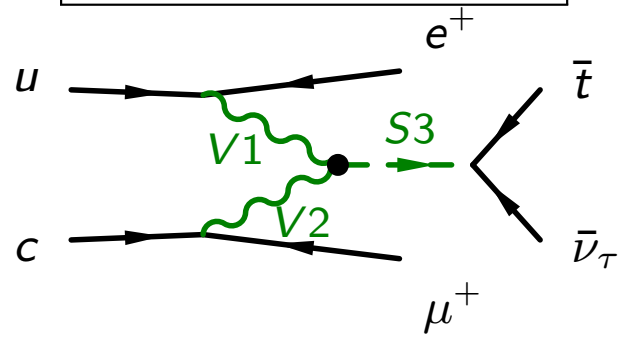
- Master table
- Simplified models
- Charge asymmetries and rates
- Strategy

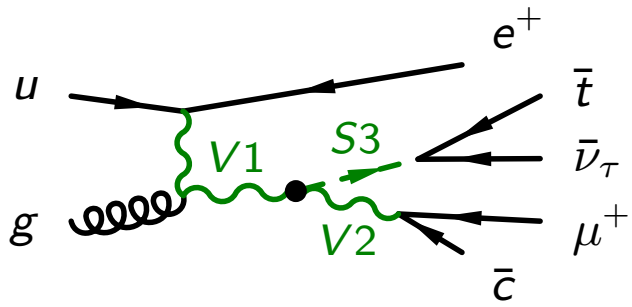
Master table

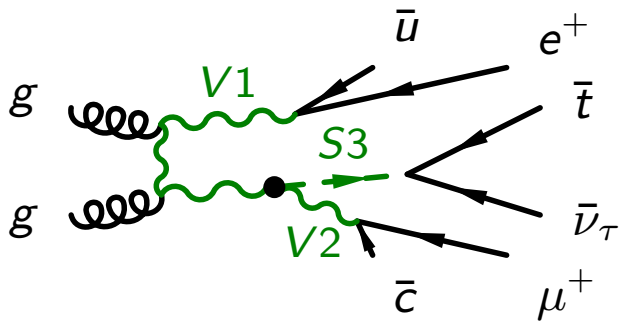
ΔB	ΔL	Fermionic cores	Examples	Promising LHC processes	$A_{e\mu}$
0	± 6	NNN NNN	$\nu_e\,\nu_\mu\,\nu_\tau \otimes \nu_e\,\nu_\mu\,\nu_\tau$	$u\,\bar{u} \to e^-\,\mu^-\,\nu_\tau\,\nu_e\,\nu_\mu\,\nu_\tau \quad W^+W^+$	0
± 1	± 3	UUU EEN	$\boldsymbol{t\,c\,u \otimes e^-\,\mu^-\,\nu_\tau}$	$\boldsymbol{u\,c \to \bar{t}\quad e^+\,\mu^+\,\bar{\nu}_\tau}$	$\boldsymbol{+}$
				$\boldsymbol{u\,g \to \bar{t}\,\bar{c}\quad e^+\,\mu^+\,\bar{\nu}_\tau}$	$\boldsymbol{+}$
				$\boldsymbol{g\,g \to \bar{t}\,\bar{c}\,\bar{u}\quad e^+\,\mu^+\,\bar{\nu}_\tau}$	$\boldsymbol{0}$
				$u\,c \to \bar{t}\quad e^+\,\mu^+\,\tau^+\quad W^-$	$+$
		UUD ENN	$t\,c\,d \otimes e^-\,\nu_\mu\,\nu_\tau$	$d\,c \to \bar{t}\quad e^+\,\mu^+\,\bar{\nu}_\tau\quad W^-$	$+$
		UDD NNN	$t\,s\,d \otimes \nu_e\,\nu_\mu\,\nu_\tau$	$d\,s \to \bar{t}\quad e^+\,\mu^+\,\bar{\nu}_\tau\quad W^-W^-$	$+$
± 1	∓ 3	UDD $\bar{\text{N}}\bar{\text{N}}\bar{\text{N}}$	$t\,s\,d \otimes \bar{\nu}_e\,\bar{\nu}_\mu\,\bar{\nu}_\tau$	$d\,s \to \bar{t}\quad e^-\,\mu^-\,\nu_\tau\quad W^+W^+$	$-$
		DDD $\bar{\text{E}}\bar{\text{N}}\bar{\text{N}}$	$b\,s\,d \otimes e^+\,\bar{\nu}_\mu\,\bar{\nu}_\tau$	$d\,s \to \bar{t}\quad e^-\,\mu^-\,\nu_\tau\quad W^+W^+$	$-$
± 2	0	UDD UDD	$\boldsymbol{t\,s\,d \otimes t\,s\,d}$	$\boldsymbol{d\,d \to \bar{t}\,\bar{t}\quad \bar{s}\,\bar{s}}$	$\boldsymbol{-}$
				$\boldsymbol{d\,g \to \bar{t}\,\bar{t}\quad \bar{s}\,\bar{s}\quad \bar{d}}$	$\boldsymbol{-}$
				$\boldsymbol{g\,g \to \bar{t}\,\bar{t}\quad \bar{s}\,\bar{s}\quad \bar{d}\,\bar{d}}$	$\boldsymbol{0}$
			$t\,c\,d \otimes b\,s\,d$	$d\,u \to \bar{t}\,\bar{t}\quad \bar{s}\,\bar{s}\quad W^+$	$-$
				$d\,d \to \bar{t}\,\bar{t}\quad \bar{c}\,\bar{s}\quad W^+$	$-$

Simplified models

$(\Delta B; \Delta L) = (\pm 1; \pm 3)$

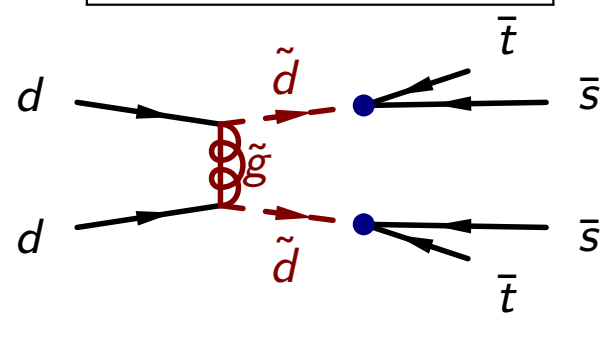


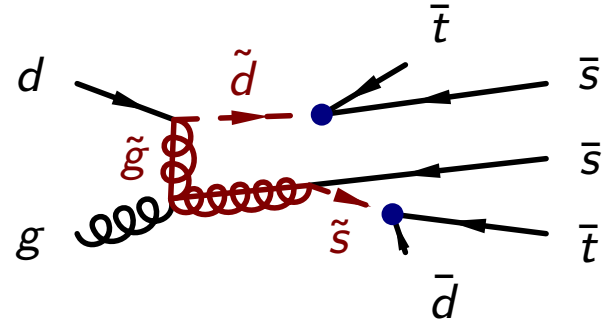


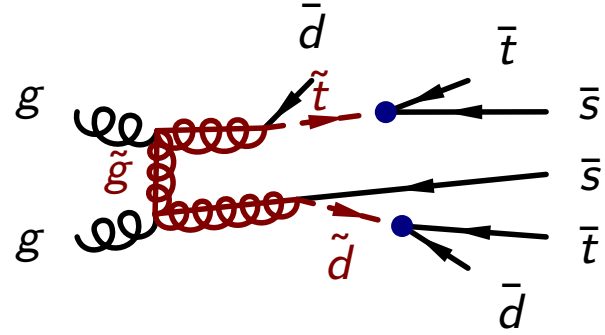


With **leptoquarks**: vectors (eu, μc, τt), scalars ($\nu_e u$, $\nu_\mu c$, $\nu_\tau t$ chiral couplings)

$(\Delta B; \Delta L) = (\pm 2; 0)$







With **RPV**: superQCD, λ''_{tds} only (from $\lambda''_{abc}\,\overline{\mathcal{U}}_a\,\overline{\mathcal{D}}_b\,\overline{\mathcal{D}}_c$)

Charge asymmetries and rates

LQ LHC@8 TeV	$c_i = 0.6$ $m_{V_i} = 1$ TeV $m_{S_i} = 500$ GeV	**RPV** LHC@8 TeV	$\lambda''_{tds} = 0.1$, $m_{\tilde{q}} = 600$, $m_{\tilde{g}} = 750$,	0.1 800 GeV 650 GeV
$u\,c \to \bar{t}\,e^+\,\mu^+\,\bar{\nu}_\tau$:	0.0029 fb	$d\,d \to \bar{t}\,\bar{t}\,\bar{s}\,\bar{s}$:	30 fb	0.012 fb
$A_{ll}^{\rm LQ} =$	$+0.93$	$A_{ll}^{\rm RPV} =$	-0.95	-0.98
$u\,g \to \bar{t}\,\bar{c}\,e^+\,\mu^+\,\bar{\nu}_\tau$:	0.018 fb	$g\,d \to \bar{t}\,\bar{t}\,\bar{s}\,\bar{s}\,d$:	16 fb	1.2 fb
$A_{ll}^{\rm LQ} =$	$+0.96$	$A_{ll}^{\rm RPV} =$	-0.80	-0.81
$g\,g \to \bar{t}\,\bar{c}\,\bar{u}\,e^+\,\mu^+\bar{\nu}_\tau$:	0.0019 fb	$g\,g \to \bar{t}\,\bar{t}\,\bar{s}\,\bar{s}\,\bar{d}\,\bar{d}$:	1.7 fb	38 fb
$A_{ll}^{\rm LQ} =$	0	$A_{ll}^{\rm RPV} =$	0	0
$p\,p \to \bar{t}\,e^+\,\mu^+ + X$:	0.023 fb	$p\,p \to \bar{t}\,\bar{t} + X$:	48 fb	39 fb
$A_{ll}^{\rm LQ\ TOT} =$	$+0.88$	$A_{ll}^{\rm RPV\ TOT} =$	-0.87	-0.025

[FeynRules-MadGraph 5, no cuts]

Strategy

– inclusive search for same-sign (flavour-different) dileptons

– compute the charge asymmetry in NP rates: $A_{ll}^{\rm NP} \equiv \dfrac{\langle ++ \rangle - \langle -- \rangle}{\langle ++ \rangle + \langle -- \rangle}$

Note $A_{ll}^{\rm NP} < 0$ **points at BLV**
or at very special and constrained scenarios like: