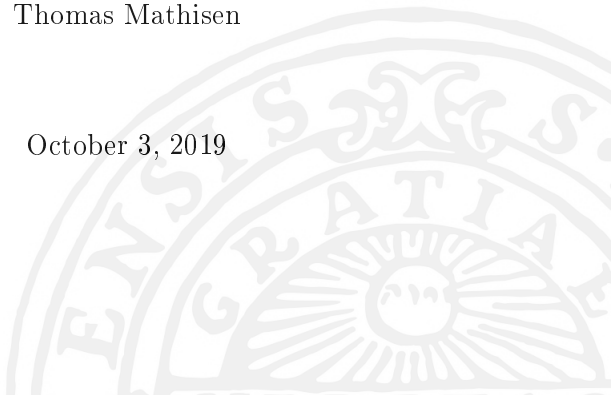


# Non-Standard Decays of Vector-Like Quarks

Teaser Talk for Partikeldagarna 2019

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# What are VLQs?

Fermion that transform the same way under the SM gauge group  
 $SU(3)_c \times SU(2)_L \times U(1)_Y$

Only left handed charge currents for SM quarks

$$J^{\mu+} = J_L^{\mu+} = \bar{u}_L \gamma^\mu d_L = \bar{u}_L \gamma^\mu (1 - \gamma^5) d \rightarrow V - A$$

**BOTH** left- and right-handed charged currents for VLQs:

$$J^{\mu+} = J_L^{\mu+} + J_R^{\mu+} = \bar{u}_L \gamma^\mu d_L + \bar{u}_R \gamma^\mu d_R = \bar{u} \gamma^\mu d \rightarrow V$$

# Models involving VLQs

- ▶ Warped or universal **extra-dimensions**  
Kaluza-Klein excitations of bulk fields
- ▶ **Composite-Higgs** models (CHMs)  
Historical origins in technicolor. Two broad categories of CHM:
  - ▶ Higgs is a bound state of strong dynamics
  - ▶ Higgs is pNGB due to spontaneous symmetry breaking, (for example:  $SO(5) \rightarrow SO(4)$ )
- ▶ **Little Higgs** models  
Partners of SM fermions in larger group reps. ensuring cancellation of divergent loops.
- ▶ **Gauged flavor group** with low scale gauge flavor bosons  
Required to cancel anomalies in the gauge flavor symmetry
- ▶ Non-minimal **SUSY extensions**  
VLQs increase corrections to Higgs mass without affecting EWPT

# Past Search for Top Partners

So far experimental studies are only looking at SM decays of the VLQ.

$$t' \rightarrow Ht, \quad t' \rightarrow W^+b, \quad t' \rightarrow Zt$$

Focusing on the minimal case

(Minimal symmetry breaking pattern)

# Additional States

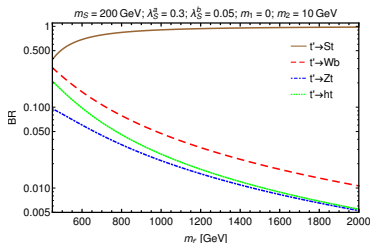
In Composite Higgs Models the Higgs boson arise as a pNGB

If one does not consider the minimal symmetry breaking pattern additional spin-0 states ( $S$ ) arise.

$S$  couples to  $t'$   $\Rightarrow$  new decays form which can affect current bounds

$$t' \rightarrow St$$

Important to consider exotic, non-standard, decays of  $t'$ .



# Phenomenological study

Study the case of exotic decays of the Top Partner

Two cases:

- ▶ Fundamental spin-0 state (2HDM+VLQ)
- ▶ Composite spin-0 state (Composite Higgs Model)

Look into the sensitivity of specific final state at the LHC for run-2 and for future run-3 luminosity

Source:

*Signatures of vector-like top partners decaying into neutral scalar or pseudoscalar bosons,*  
R.Benbrik, E.Bergeaas Kuutmann, D.Buarque Franzosi, V.Ellajosyula, R.Enberg, G.Ferretti,  
M.Isacson, Y.-B.Liu, T.Mandal, T.Mathisen, S.Moretti, L.Panizzi arXiv:1907.05929