LHC Phenomenology of a Strongly Coupled Fourth Generation

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Based on **arXiv:0710.0623** and **arXiv:0812.0368**
with Gustavo Burdman, Leandro Da Rold e Oscar Éboli

Motivation

We are looking for models that:

1. Provide a natural EWSB mechanism

2. Generate the correct fermion mass hierarchy

Motivation

Top Condensation

Nambu `89, Bardeen-Hill-Lindner `89

New interaction at scale Λ, strongly coupled to t

$\langle \bar{t}t \rangle \neq 0$ ⟹ Breaks EWS, gives mass to t

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But, to get $m_t = 170\ \mathrm{GeV}$ ⟹ $\Lambda \simeq 10^{15}\ \mathrm{GeV}$ *(fine tuning)*

To avoid fine tuning:

$\Lambda \simeq 10^{3}\ \mathrm{GeV}$ ⟹ $m_Q = 600 \sim 700\ \mathrm{GeV}$

Strongly Coupled 4^{th} generation

1. Chiral fourth generation.
2. Strong new interaction at O(1) TeV scale.

   ⇒ Realized in a compact AdS_5 gauge theory

3. Zero modes of 1^{st} and 2^{nd} generations are Plack localized, 4^{th} is IR localized, 3^{rd} lies in between.

   ⇒ 4^{th} gen. Couples strongly to KK Gauge Bosons

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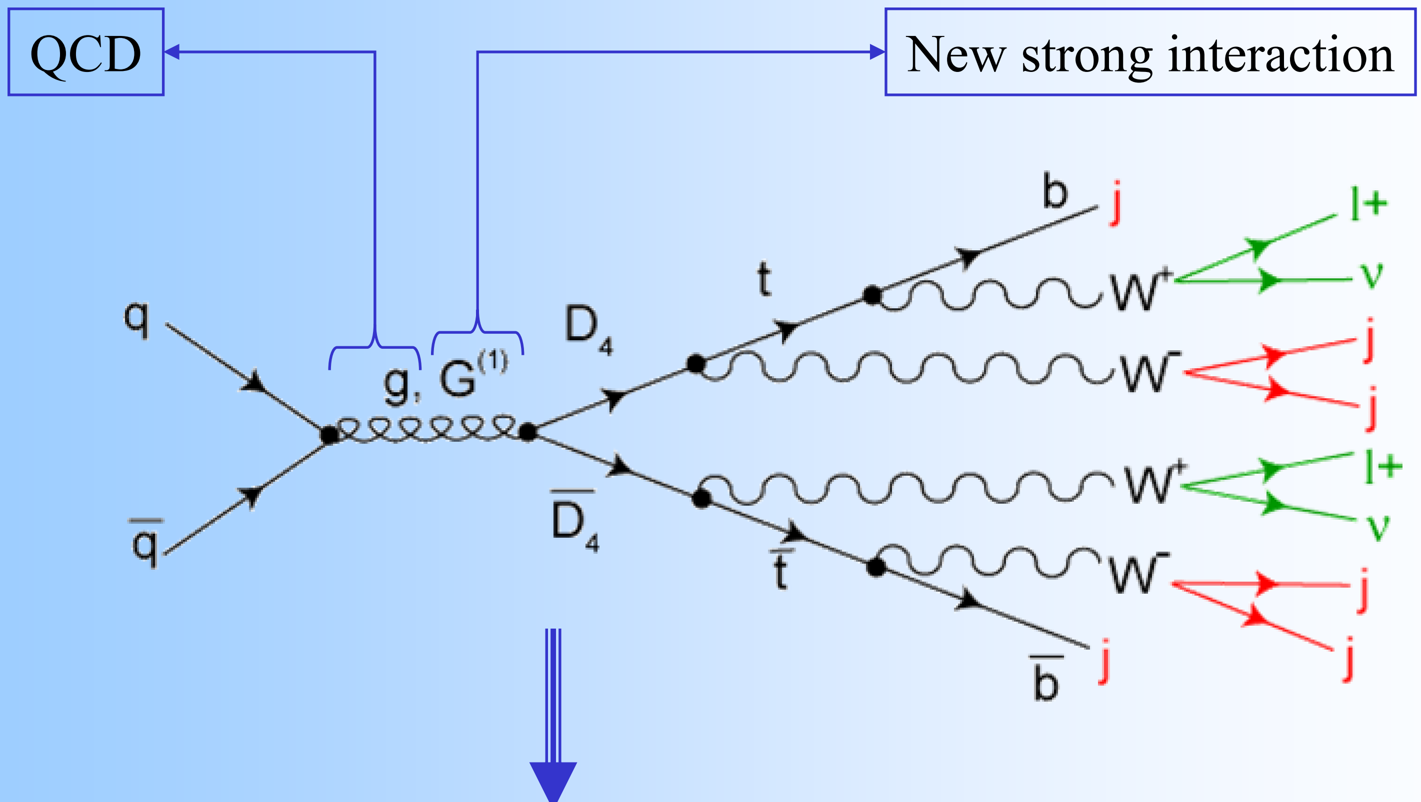
Particular realization

Only the up quark (U_4) condenses: $m_{U4} \sim 700$ GeV

$m_{D4} \sim 300\text{-}600$ GeV

Phenomenology



MadGraph / MadEvent(http://madgraph.hep.uiuc.edu/)

Phenomenology

Backgrounds

- $t\bar{t}$ (b semileptonic decay)
- W^+W^+jj
- W^-W^-jj
- W^+W^+jjj
- W^-W^-jjj
- W^+Zjj
- W^-Zjj
- $W^+t\bar{t}$
- $W^-t\bar{t}$
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- $W^+W^+W^-$
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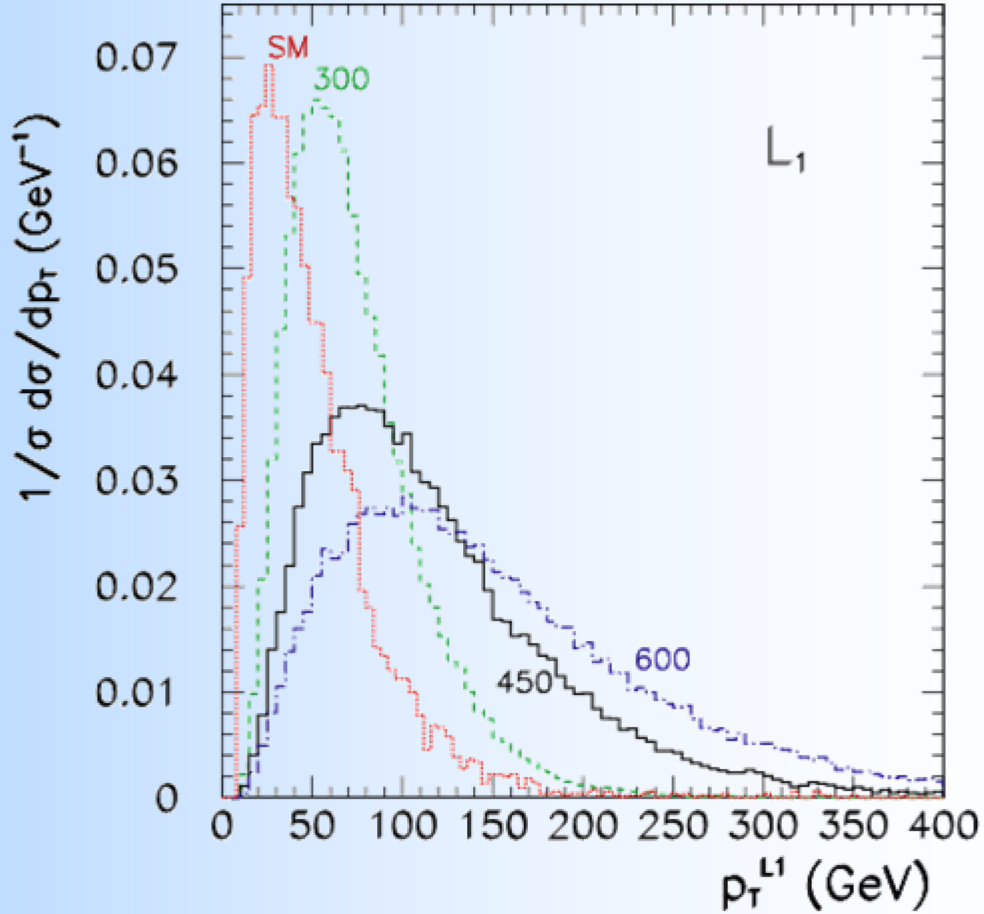
$$p_T^\ell > 10 \text{ GeV} \ , \quad |\eta_\ell| < 2.5 \ ,$$
$$p_T^j > 20 \text{ GeV} \ , \quad |\eta_j| < 3 \ ,$$
$$\Delta R_{\ell\ell} \geq 0.7 \ , \quad \Delta R_{\ell j} \geq 0.7 \ , \quad \Delta R_{jj} \geq 0.7$$



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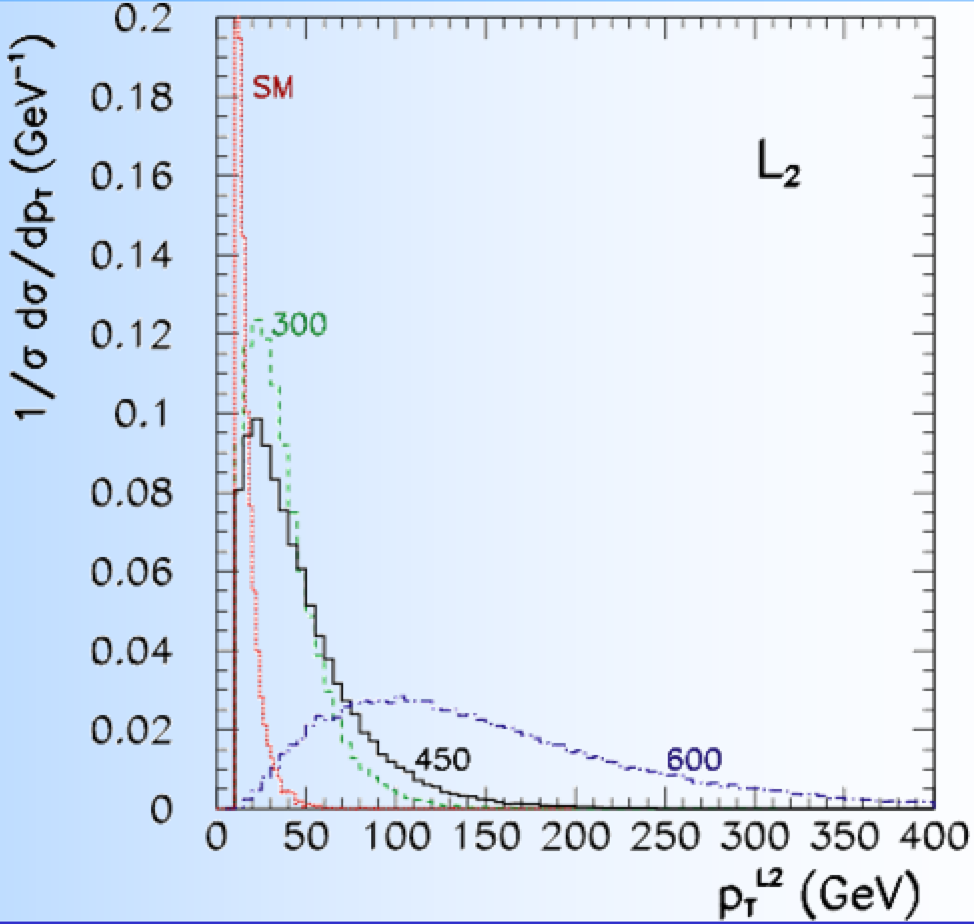

Phenomenology

process/cuts	$\sigma[fb]$		
signal: $m_{D_4} = 300$ GeV	1388	412	87.0
QCD: $m_{D_4} = 300$ GeV	1360	402	83.4
signal: $m_{D_4} = 450$ GeV	222	164	54.2
QCD: $m_{D_4} = 450$ GeV	204	150	48.8
signal: $m_{D_4} = 600$ GeV	48	44	17.8
QCD: $m_{D_4} = 600$ GeV	42	38	15.5
$t\bar{t}$	2060	452	1.2
W^+W^+jj	8.2	4.0	1.0
W^-W^-jj	3.8	1.8	0.6
W^+W^+jjj	8.1	5.0	1.3
W^-W^-jjj	3.4	2.1	0.8
W^+Zjj	9.4	1.2	0.3
W^-Zjj	4.3	0.6	0.2
$W^+t\bar{t}$	8.6	2.3	0.6
$W^-t\bar{t}$	3.5	0.9	0.2
$W^+W^-t\bar{t}$	0.2	0.1	-
$W^+W^+W^-$	0.7	-	-
$W^+W^+W^-j$	1.2	0.3	-

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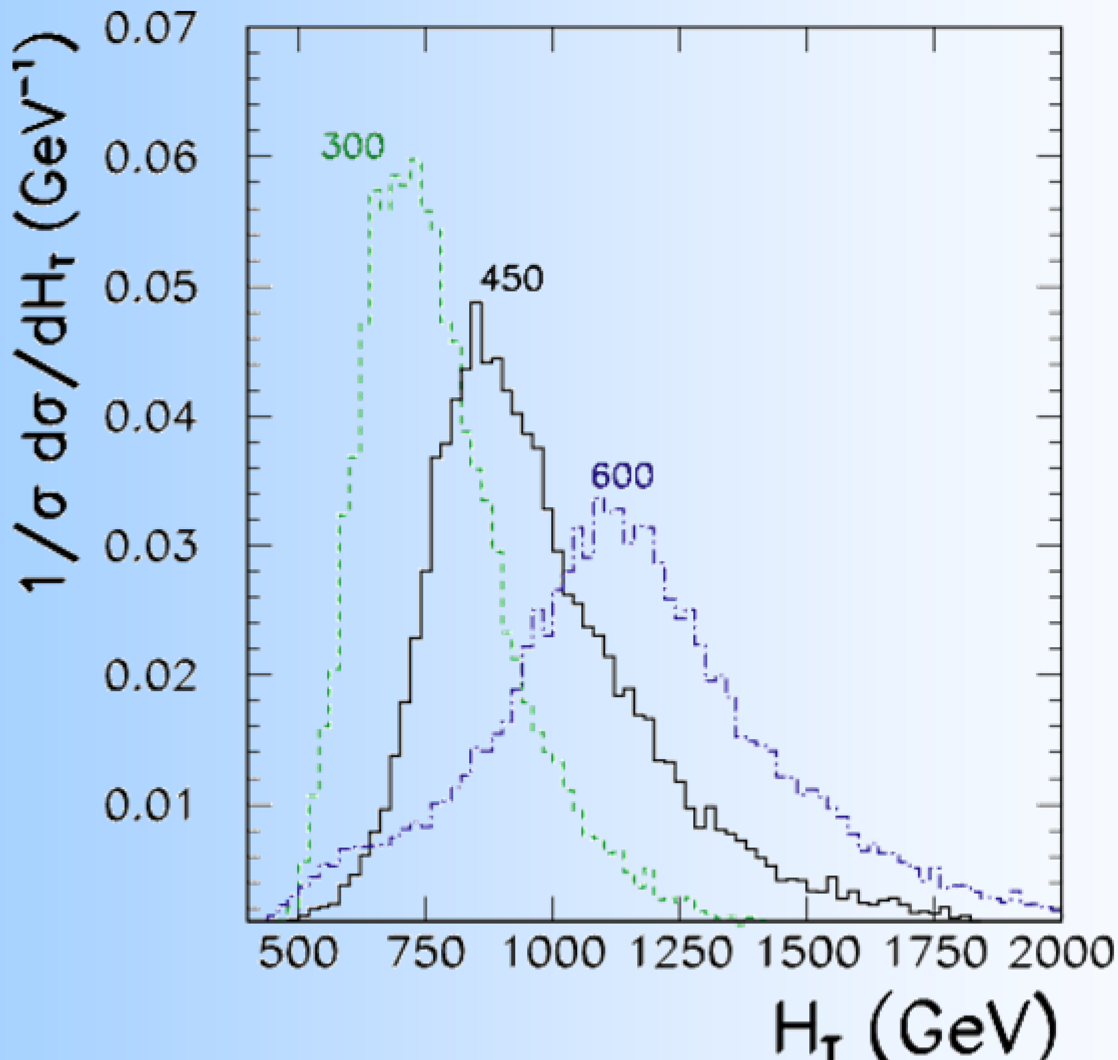
$$p_T^{j_{1,2}} > 100\ \text{GeV}$$

$$p_T^{\ell_{1,2}} > 50\ \text{GeV}$$

m_{D_4}	$\sigma_{\mathcal{S}}$[fb]	$\sigma_{\mathcal{B}}$[fb]	$\mathcal{S}/\mathcal{B}$	$\mathcal{L}_{min}[\text{pb}^{-1}]$
300 GeV	87.0	6.2	14.	44
450 GeV	54.2	6.2	8.7	84
600 GeV	17.8	6.2	2.9	460

Phenomenology

m_{D4} ?



Phenomenology

Trilepton Signal

$$p_T^{j_1} > 80 \text{ GeV}$$
$$p_T^{j_2} > 50 \text{ GeV}$$
$$m_{\ell^+\ell^-} > 100 \text{ GeV}$$

m_{D_4}	$\sigma_{\mathcal{S}}$[fb]	$\sigma_{\mathcal{B}}$[fb]	$\mathcal{L}_{min}$[pb^{-1}]
300 GeV	210	1	24
450 GeV	61.0	1	82
600 GeV	15.4	1	325

Four-lepton Signal

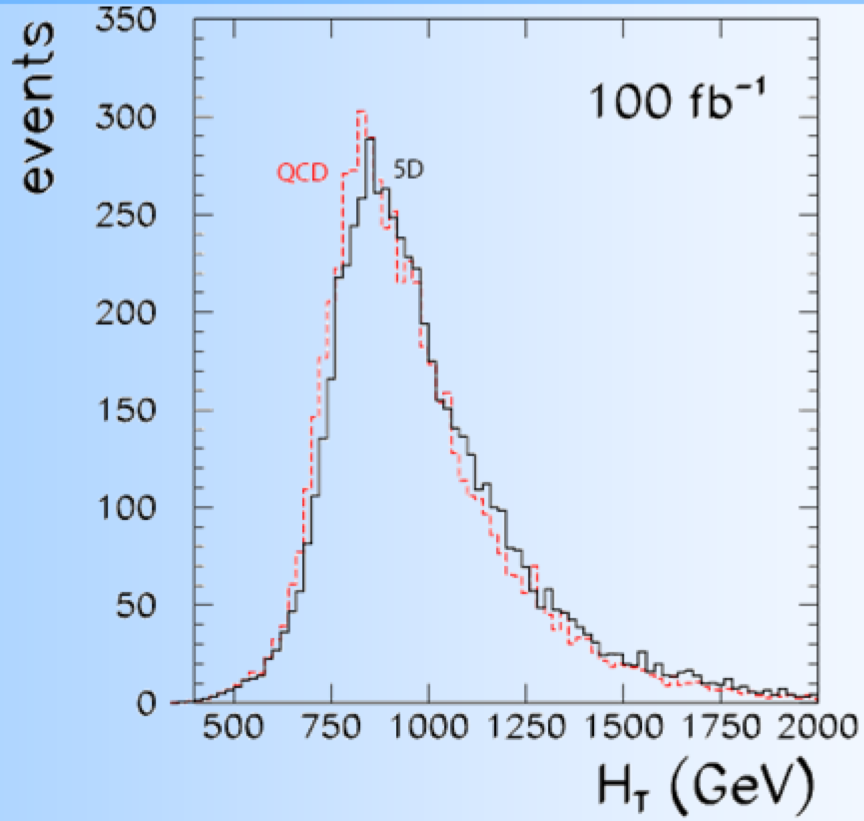
$$p_T^{j_{1,2}} > 50 \text{ GeV}$$
$$m_{\ell^+\ell^-} > 100 \text{ GeV}$$

Minimum luminosity to get 5 events is between 0.6 e 4.9 fb^{-1} (depending on the mass).

EWSB Mechanism

$G^{(1)}$ is broad
(Γ/M ~ 1)
⇒ Only causes a general enhancement of D_4 production

$$\sigma^{5D}(m_{D_4} = 450 \text{ GeV}) \approx \sigma^{QCD}(m_{D_4} = 435 \text{ GeV})$$



Conclusion & Outlook

- The dilepton and trilepton signals should be observable in the LHC with less than 1 fb^{-1} of integrated luminosity.
- To really verify the existence of a 4^{th} generation a lot more data would be needed, so we are able to reconstruct the particle mass.
- The KK-Gluon is too broad to be observed in obtainable luminosities. Other channels have to be studied to observe the new strong interaction.
- The KK resonances of eletroweak gauge bosons are good candidates. They could be seen in the production of 4^{th} generation leptons. This is a work we have in progress.