Physics with 4 generations

Gökhan Ünel (UCI)

17 August 2009 - TH institute

week3 kick-off meeting

Introduction

- The reports of the death of the 4th generation have been greatly exaggerated.
  - ➡The field is, in fact, active and thriving

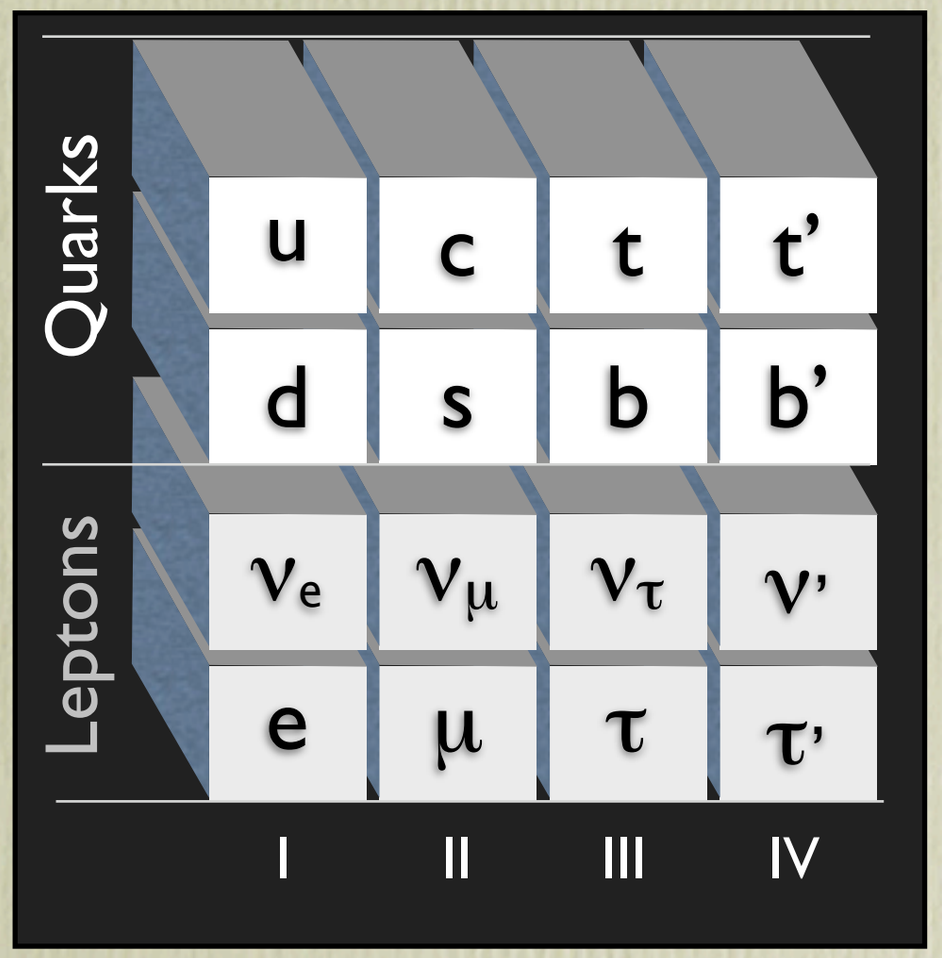
- Recent workshop @ cern to review the different aspects of 4 generations
  - ➡viable?
  - ➡desirable?
  - ➡discoverable?

arXiv:0904.4698v1

B. Holdom, W.S. Hou, T.Hurth, M.Mangano, S. Sultansoy, G. Ünel

What is it?

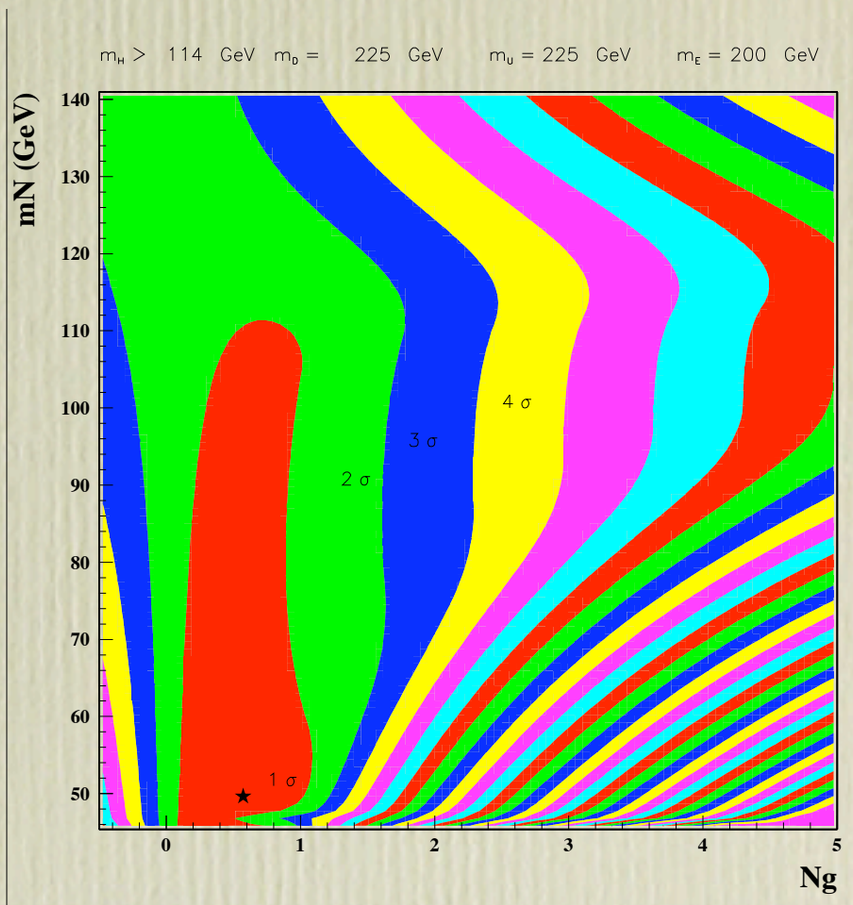
- Fourth generation is the simplest "modification" to SM as we know it today
  - ➡SM does not give #families => not a true modification
  - ➡predicts 4 new heavy fermions with 1TeV > m >100GeV



Viable?

- What about the 6σ evidence reported by PDG against 4th generation from the "S parameter alone"?
  - ➡Valid only if total mass degeneracy, e.g.

$$\delta S = \frac{2}{3\pi} - \frac{1}{3\pi}\left[\log\frac{m_{t'}}{m_{b'}} - \log\frac{m_{\nu'_\tau}}{m_{\tau'}}\right]$$



- What about EW fits?
  - ➡SM3 & SM4 have same χ^2 from fits,
  - ➡SM4 can accommodate heavier Higgs

- What about CKM?
  - ➡There is enough uncertainty for a 4x4 unitary matrix

$$|V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 = 0.9999 \pm 0.0011 = 1 - |V_{ub'}|^2$$

$$|V_{ub'}| < 0.04$$

Desirable?

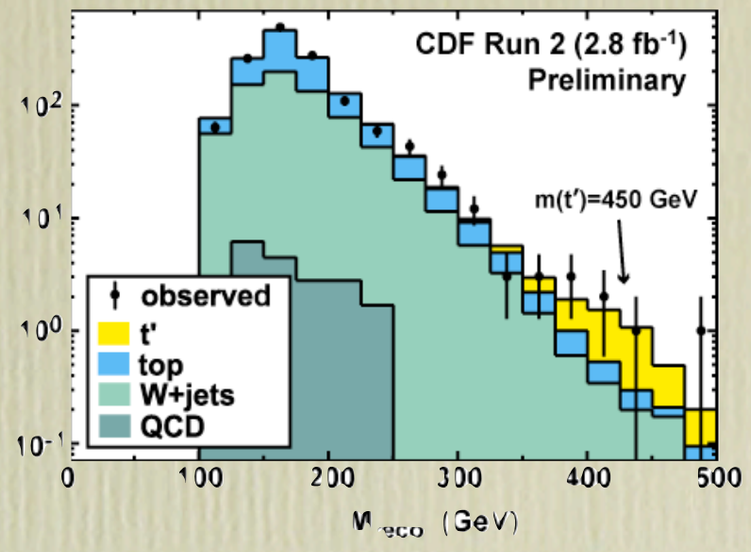
- CPV source (for BAU)
  - ➡3x3 CKM is 10^{10} too short to match WMAP data
  - ➡new quarks of (300) 600 GeV would give (10^{13}) 10^{15} more CPV

- Alternative EW symmetry breaking
  - ➡4th generation fermion condensate can play the Higgs role
  - ➡5D AdS, K.K. excitations of gauge bosons interacting w/ 4th generation fermions => Yukawa couplings & mass hierarchy

- Fermion mass hierarchy
  - ➡observed masses of fermions in the first 3 families arise from perturbations to a flavour-blind 4x4 mass matrix.

- Dark Matter candidates
  - ➡hadrons from stable t′, ν′, additional fermions of spin-charge unification models

Discoverable?



- Tevatron prospects: ongoing...
  - ➡direct t′ search from Wj channel
  - ➡indirect search via Higgs enhancement
  - ➡indirect search via mixing-dependent CPV in B_s->J/Ψ Φ

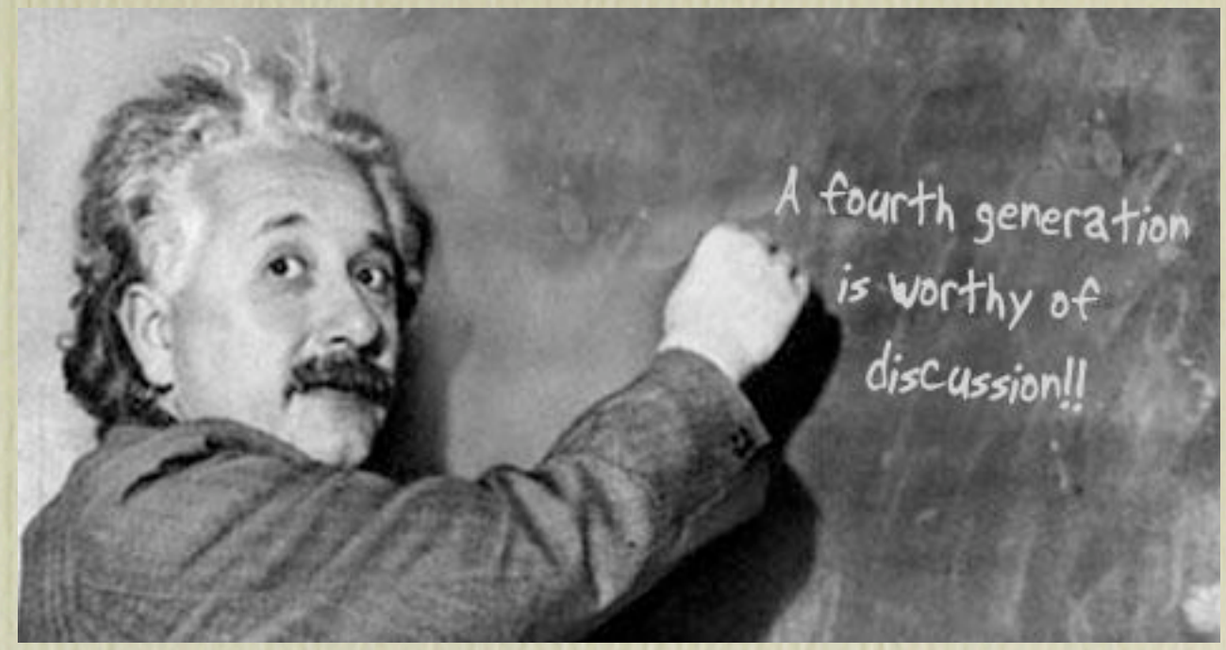
- LHC prospects (discover or exclude the 4th generation)
  - ➡Quarks as the main target
    - Pair production: ATLAS (1999 TDR and post-TDR) & CMS (post TDR) from early data : 0.1fb^{-1} Lumi reaches 300GeV.
    - Single and/or anomalous production => could measure 4x4 CKM.
  - ➡Leptons ==> Do we need to wait for the Linear Colliders?

- Indirectly from B-factories
  - ➡Direct CPV difference in $B^+ \to K^+\pi^0$ & $B^0 \to K^+\pi^-$

$\Delta A_{K\pi} = A_{cp}(K^+\pi^-) - A_{cp}(K^+\pi^0)$
$= -0.147 \pm 0.028$ @ 5.3σ

Discussion

Friday 21st @ 10:30am



Name	*Duration*	*Title*
G. Burdman	20+5	4th generation in models of dynamical electroweak symmetry breaking
S. Sultansoy	15+5	Naturalness of the fourth generation
R. Frederix F. Maltoni	15+5	Predictions for EW production of single top and fourth generation quarks at NLO QCD
E. Ozcan	15+5	Fourth generation leptons at the LHC
O. Cakir	15+5	Single and anomalous productions of fourth family up type quarks at the LHC
K.F. Chen	15+5	Searching for 4th Generation Quarks at CMS