WG1 Summary

- Top quark physics: N. Castro and G. Burdman
- Sleptons: T. Lari, N. Krasnikov, W.P.
- Squarks: A. Tricomi and M. Klasen
- Non-SUSY models: G. Ünel and J.A. Aguilar-Saavedra
- Tools: F. Moortgat, G. Polesello and F. Krauss

Top quark physics

Contact persons: N. Castro and G. Burdman

Tasks:

- study of top FCNC: production + decays
- anomalous couplings
- consistency with electroweak precision data, K-physics and B-physics

Talks

- E. Kou: anomalous t-couplings
  - additional vector-like states do not lead to large effects (b' due to FCNC, t' due to EWP)
  - 4th SM family can be accommodated more easily, modifies all V_{tq}
- J.A. Aguilar-Saavedra + J. Carvalho: anomalous couplings + t decay asymmetries: challenging, need the W rest frame
- J. D'Hondt: topological searches for like-sign t quark pairs: visible at σ 1 pb for 30 fb^{-1}
- C. Verzegnassi: complete EW correction to single t production; 10% SM contributions, SUSY effects few percent at most

N. Castro status report on top FCNC, first results from combination of ATLAS & CMS

Top FCNC studies @ LHC — Status Report

- Ongoing work:
  - Common framework for ATLAS/CMS limits evaluation
  - ATLAS/CMS results combination
  - Draft of the top FCNC studies section for the yellow report

Study of the LHC sensitivity to FCNC top quark decays

— *Flavour in the era of the LHC* Workshop —
Working Group 1

Top Physics Subgroup

Send comments to: nuno.castro@cern.ch and leonardo.benucci@pi.infn.it

May 9, 2006

Flavour Changing Neutral Currents are strongly suppressed in the SM due to the Glashow-Iliopoulos-Maiani (GIM) mechanism. Although absent at tree level, small FCNC contributions are expected at one loop level, according to the CKM mixing matrix [1]. In the top quark sector of the SM, these contributions limit the FCNC decay branching ratios to the gauge bosons, $BR_{t\to qX}$ $(X = Z, \gamma, g)$, to below 10^{-10}. There are however extensions of the SM, like supersymmetry (SUSY) [2], multi-Higgs doublet models [3] and SM extensions with exotic (vector-like) quarks [4], which predict the presence of FCNC contributions already at tree level and significantly enhance the FCNC decay branching ratios compared to the SM predictions (up to $BR(t \to qg) \sim 10^{-4}$ for some SUSY models [5]).

Due to its large mass, much higher than any other known fermion, the top quark is a very good laboratory to look for physics beyond the SM. If the top quark has FCNC anomalous couplings to the gauge bosons, its decay properties would be affected, and possibly measured at colliders, in addition to the dominant decay mode $t \to bW$. Indeed one of the most prominent signatures of FCNC processes at the Large Hadron Collider (LHC), would be the direct observation of a top quark decaying into a charm or an up quark together with a γ, g or Z boson. In the effective Lagrangian approach [6] the new top quark decay rates to the gauge bosons,

$$\Gamma(t \to qg) = \left(\frac{\kappa^g_{tq}}{\Lambda}\right)^2 \frac{8}{3}\alpha_s m_t^3 \quad , \quad \Gamma(t \to q\gamma) = \left(\frac{\kappa^\gamma_{tq}}{\Lambda}\right)^2 2\alpha m_t^3, \tag{1}$$

$$\Gamma(t \to qZ)_\gamma = (|v^Z_{tq}|^2 + |a^Z_{tq}|^2)\,\alpha m_t^3 \frac{1}{4M_Z^2 \sin^2 2\theta_W}\left(1 - \frac{m_Z^2}{m_t^2}\right)^2\left(1 + 2\frac{m_Z^2}{m_t^2}\right), \tag{2}$$

$$\Gamma(t \to qZ)_\sigma = \left(\frac{\kappa^Z_{tq}}{\Lambda}\right)^2 \alpha\, m_t^3 \frac{1}{\sin^2 2\theta_W}\left(1 - \frac{m_Z^2}{m_t^2}\right)^2\left(2 + \frac{m_Z^2}{m_t^2}\right), \tag{3}$$

can be expressed in terms of the κ^g_{tq}, κ^γ_{tq}, $(|v^Z_{tq}|^2 + |a^Z_{tq}|^2)$ and κ^Z_{tq} anomalous couplings to the g, γ and Z bosons respectively. The energy scale associated with this new physics is represented by Λ, while α_s and α are, respectively, the strong and electromagnetic coupling constants. The electroweak mixing angle is represented by θ_W and the top and Z masses are represented, respectively, by m_t and m_Z.

Although FCNC processes associated with the production [7, 8] and decay [9] of top quarks have been studied at colliders ($BR_{t\to Zu(c)} < 7.8\%$ [7], $BR_{t\to\gamma u(c)} < 2.4\%$ [7] and $BR_{t\to gu(c)} < 13\%$ [8]), the amount of data collected up to now is not comparable with the statistics expected at the LHC. In the LHC low luminosity phase, several millions of top quarks per year and experiment will be produced,

1

9

Sleptons

Contact persons: T. Lari, N. Krasnikov, W.P.

Tasks:

- 'flavour' identification of sleptons and sneutrinos at LHC
- impact of lepton flavour violation on flavour conserving observables, e.g. on the edge variables
- which observables are useful to identify the flavour structure
- lepton number and, thus, R-parity violation
- work out connections to low energy physics, e.g. to $\mu \to e\gamma$

- Can flavour observables be used to discriminate between SUSY and other beyond the SM models ?

No talks this time, but . . .

Start of first LFV study in ATLAS by T. Lari

take modified version of SU3: $M_0 = 100$ GeV, $M_{1/2} = 300$ GeV
$A_0 = -300$ GeV, $\tan\beta = 6$, sign(μ) = 1
add $M^2_{E,12} = 40$ GeV^2, $M^2_{E,13} = M^2_{E,23} = 1000$ GeV^2
$(m_{\tilde{l}_1}, m_{\tilde{l}_2}, m_{\tilde{l}_3}) = (147.7, 155.0, 158.0)$ GeV

	BR($\tilde{\chi}^0_1\, e$)	BR($\tilde{\chi}^0_1\, \mu$)	BR($\tilde{\chi}^0_1\, \tau$)
$\tilde{l}_1$	0.135	0.135	0.73
$\tilde{l}_2$	0.5	0.5	0
$\tilde{l}_3$	0.37	0.37	0.26

BR($\mu \to e\gamma$) $= 4.6 \cdot 10^{-12}$, BR($\tau \to e\gamma$) $\simeq$ BR($\tau \to \mu\gamma$) $= 3.8 \cdot 10^{-9}$

aim: measure mass difference and branching ratios

Similar modification for LM1 (CMS)

SLHA files can be found at webpage starting next week

Squarks

Contact persons: M. Klasen and A. Tricomi

Tasks:

- 'flavour' identification of squarks
- impact of quark flavour violation on flavour conserving observables, e.g. in $\tilde{g} \to b\tilde{b}_1$
- which observables are useful to identify the flavour structure
- R-parity violation
- work out in detail the connections to low energy physics, e.g. to $b \to s\gamma$, $B_s \to \mu^+\mu^-$, ...

- Can flavour observables be used to discriminate between SUSY and other beyond the SM models ?

Talks

- P. Skands: Baryon Number Violation imply new colour structure
  $\Rightarrow$ affects hadronizaton
  leads to slow moving baryons

- B. Fuks: SUSY-CKM matrix determinations in SUSY electroweak processes

- S. Paktinat: SUSY discovery using $t\bar{t}$ + missing energy

Non SUSY models

Contact persons: G. Ünel and J.A. Aguilar-Saavedra

Tasks:

- Are there interesting flavour signals stemming from new states predicted by these models consistent with the bounds from low energy experiments ?

- work out in detail the correlations between these signals to low energy physics, e.g. to $\mu \to e\gamma$, $b \to s\gamma$ ...

- Are there observables related to the flavour sector which help to discriminated between the various models ?

Talks

- J.A. Aguilar-Saavedra: Higgs boson discovery in decays of heavy T singlets: requires only 2 fb^{-1}, independent of mixing with other quarks

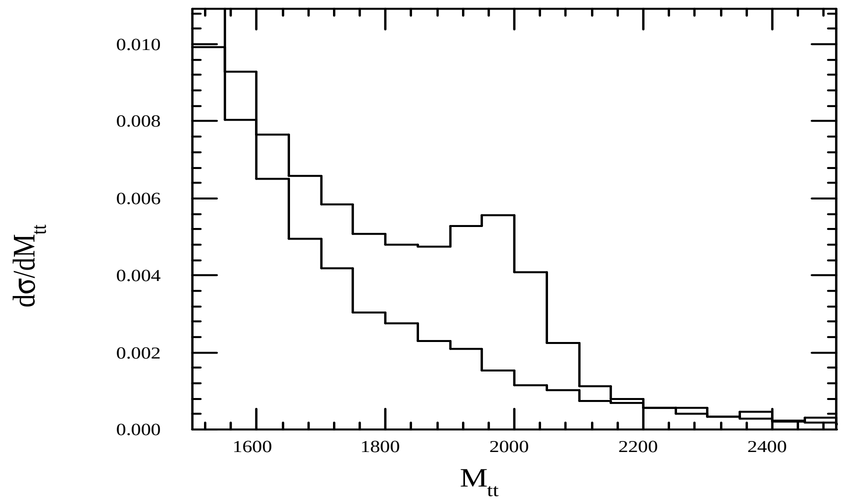
- S. Sultansoy:
  status of 4th SM family + plans for future studies
  - impact of 4th family on Higgs search
  - anomalous production of 4th family fermions
  - identification: u_4 versus Little Higgs t'
  - identification: d_4 versus isosinglet D

- G. Burdman:
  Signals of flavour violation in Warped Extra Dimensions

Signals: KK Gluon as $t\bar{t}$ resonance

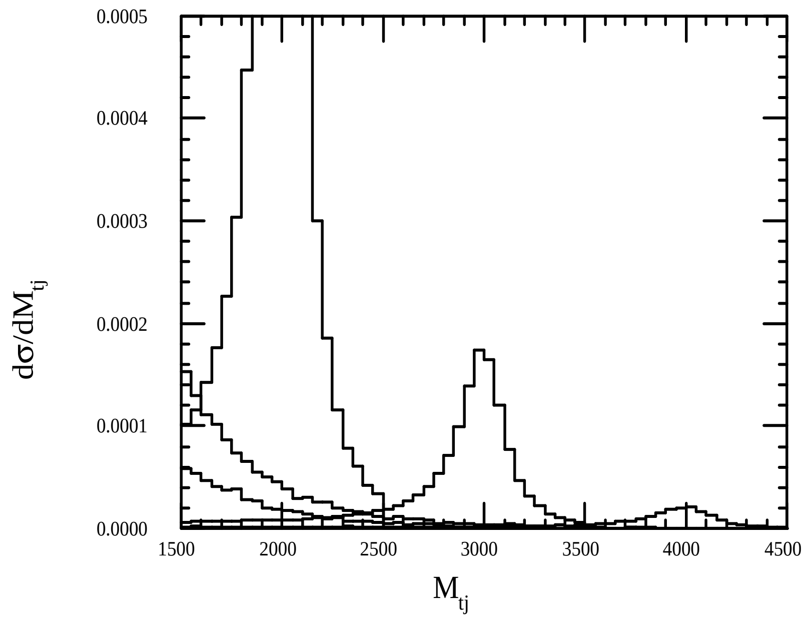
Standard Cuts:

$p_T > 20$ GeV, $|\eta_\ell| < 2.5$, $|\eta_j| < 3.2$, $\Delta R = 0.4$
(MADGRAPH/MADEVENT)



Single Top Production at High Invariant Mass

E.g. For $\Gamma_{\mathrm{min.}}$ and $U_L^{tc} = 0.33$:



But now, even for $\Gamma_{\mathrm{max.}}$ we get lmits.

Tools

F. Krauss, F. Moortgat and G. Polesello

Tasks:

- to which extend can the various tools be used to investigate flavour aspects, e.g. flavour identification and/or flavour violating production/decays
- are there existing plans to extend your tool in this direction
- extension of the SUSY Les Houches Accord (SLHA) to include flavour, CP and R-parity violation
- investigate possibilities to create a SLHA equivalent for other BSM models than SUSY
- needs of experimentalists

Talks + Diskussion sesssions

- S. Peñaranda: Update of FeynArts/Formcalc including NMFV structures + update on $H \to bs$ versus $b \to s\gamma$

- S. Pukhov: Calchep for BSM physics

- Z. Was: Discussion on PHOTOS: inclusion of γs in b-decays, e.g. $B^0 \to \pi^+\pi^-\gamma$, detailed comparison with the SANC package

- P. Skands: Discussion on SLHA2

Some Details on SLHA2

Aim: include FV, CP, RPV and NMSSM

- input: additionl switches for FV, CP, RPV and NMSSM

- work in SuperCKM basis

- def. of blocks for variable names, e.g. `MSQ2`
  for hermitian matrices only upper triangle given

- for complex quantities: preface `IM`, e.g. `IMMSQ2`

- squarks: $\overline{DR}$ mixing matrices

- RP: block names `RVLAMBDAIN`, `RVLAMBDA`

- mixing matrices defined to include mixings between SM- and SUSY particles

- to be done:

  - details for inclusion of lepton flavour violation

  - which sets of input parameters for RP?

What is next

- Update of homepage with a clearer structure of subgroups
- Looking for existing ATLAS/CMS studies is still going on but should be finished in the next weeks
- Requests to specific persons for write-ups will happen in the next weeks
- the style file + definition file for LaTeX abbreviations will be put on the homepage latest at the end of next week