Exotic physics with tops

Introduction:

A background for many...

...and a signal for some

Early physics with third generation quarks

Organization:

Interaction with the top group

News:

Validation of MC samples

Marcel Vos, IFIC Valencia

for the exotics group

tt: A background to many...

Many possible (non-SUSY) extensions of the Standard Model: Extra Dimensions, technicolour, Little Higgs and related models.

Generic searches (by final state) to be performed in Exotics group. Some examples from CSC paper:

Z' and W' searches, di-lepton resonance, lepton+MET channel:

SM tt is the principal irreducible background.

Search for scalar lepto-quarks and right-handed W-bosons and neutrinos in di-lepton+jets final states:

tt the dominant background for LRSM searches, second for lepto-quark

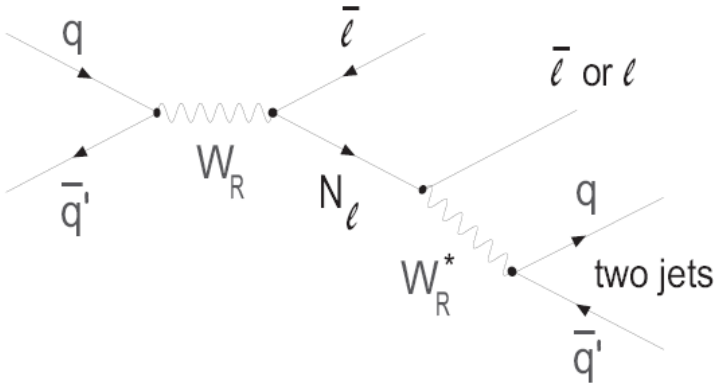
Vector-boson scattering:

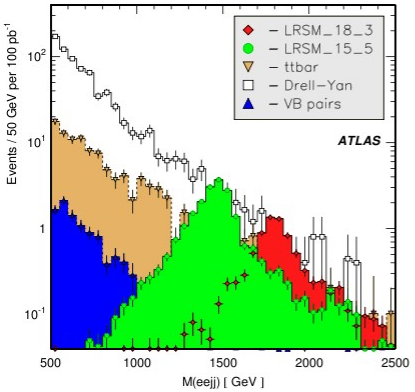
tt and tW events form an important background to WW signals

Black holes:

Standard Model tt among important backgrounds

A background to many... LRSM searches





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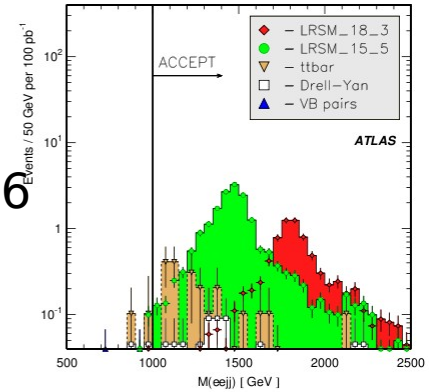


Physics sample	Before selection	Baseline selection	m_{ejj} $\geq$ 100 GeV	m_{eejj} $\geq$ 1000 GeV	m_{ee} $\geq$ 300 GeV	S_T $\geq$ 700 GeV
LRSM_18_3	0.248	0.0882	0.0882	0.0861	0.0828	0.0786
LRSM_15_5	0.470	0.220	0.220	0.215	0.196	0.184
$Z/\gamma^*, m \geq 60$ GeV	1808.	49.77	43.36	0.801	0.0132	0.0064
$t\bar{t}$	450.	3.23	3.13	0.215	0.0422	0.0165
VB pairs	60.94	0.610	0.522	0.0160	0.0016	0.0002
Multijet	10^8	20.51	19.67	0.0490	0.0444	0.0444

Table 5: LRSM dielectron analysis. Partial cross-sections (pb) that survive the selection criteria.

From Exotics CSC (Stroehmer, Savinov)

Only very special tt events pass the selection cuts: fully leptonic (2 leptons, 2 jets), with significant jet activity (S_T). How well will we know this corner of phase space.

Tevatron searches

Important program at the Tevatron ~ 20 papers since 2000.

(narrow) tt resonances

D0, FERMILAB-PUB-08-097E, arXiv:0804.3664

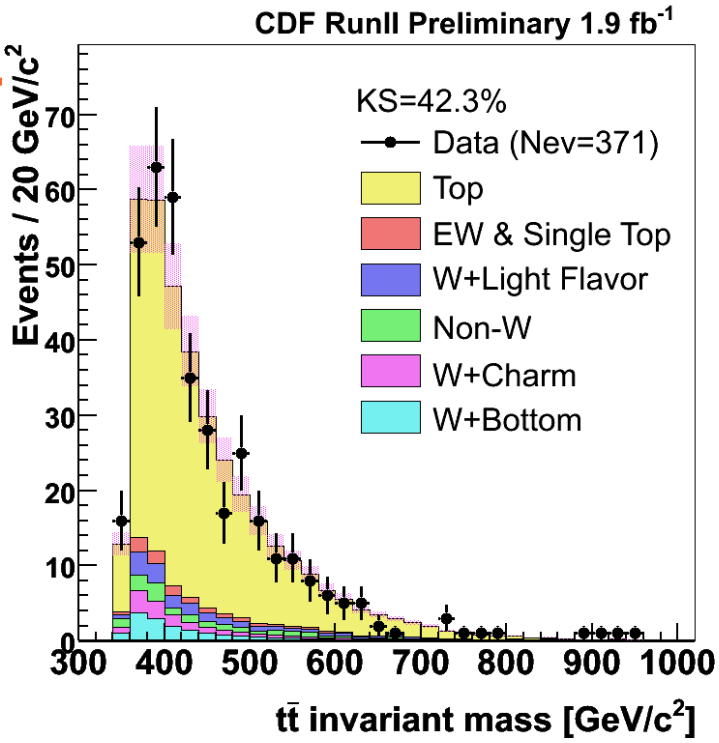
CDF, Phys.Rev.Lett.85 (2000), arXiv:0710.5335v1

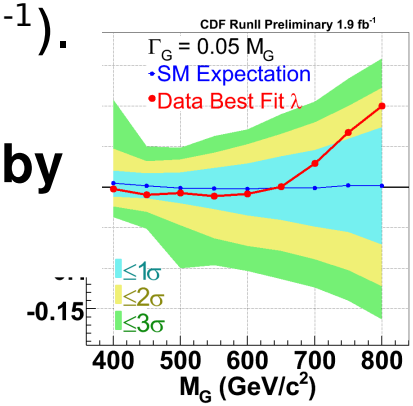
W'-> tb search @ D0:

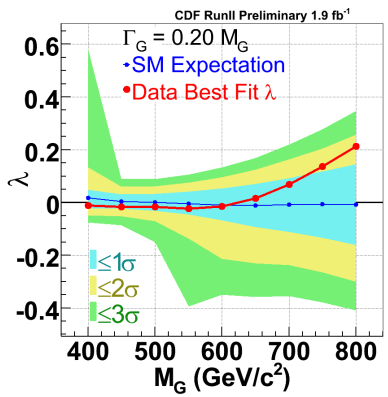
Phys.Rev.Lett.100 (2008) 21180

Few tt events at large invariant mass (CDF totals 347 evts. In 1 fb^{-1}).

Exclusion limits are modest, limited by the Tevatron center-of-mass energy







CDF note 9164: massive gluon search in 1.9 fb^{-1}: data compatible with SM within 1.7 σ

...and a signal to some.

Exotics Jet + X group covers those searches for Beyond the Standard Model physics where one or several jets are the “principal” signature.

Third generation quarks play a special role
At the experimental level:

- high p_T b-tagging
- High p_T top reconstruction/tagging

In many models:

- tt resonance search
- searches for Little / Twin Higgs W_H
- ...

Early exotic physics

Considering that:

Heavy partners to electro-weak gauge bosons (W', Z') tend to be produced with moderate cross-section

Very complex final states are inaccessible to early studies

We chose:

The search for KK gluons decaying to tt

as our candidate for early ATLAS analysis

With only 10 pb^{-1} at 10 TeV(*), but with a rather involved understanding of many aspects of the detector, we expect to improve on the Tevatron limit

(*) is this the relevant center-of-mass energy until we show that the machine will work at 14 TeV? Or should we revise the whole MC strategy?

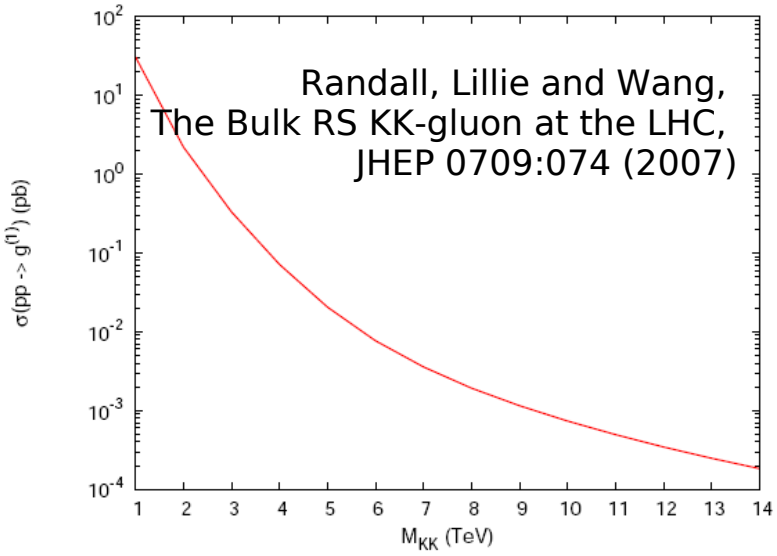
Properties of the KK gluon

Kaluza Klein excited state of the gluon, expected to be present in Large Extra Dimensions models where gauge bosons propagate into the bulk

It's a massive gluon, with strong coupling to quarks (typically does not couple to SM gluon):

enormous cross-section ------->:

$\sigma(G_{KK}^{1\ TeV} \rightarrow tt) = 30$ pb
in the LHC @ 14 TeV
Taking 10 pb^{-1} :
1000s of signal events



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The KK gluon is particularly interesting as it may couple preferentially to third generation quarks (Randall, Lillie and Wang, The Bulk RS KK-gluon at the LHC, JHEP 0709:074 (2007))

$$BR (G_{KK} \rightarrow tt) = 90\ \%$$

tt resonance searches complement di-jet studies

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experimentally it reveals itself as a not-so-narrow resonance in tt.

$$\Gamma = 0.18\ M$$

generator level mass distribution
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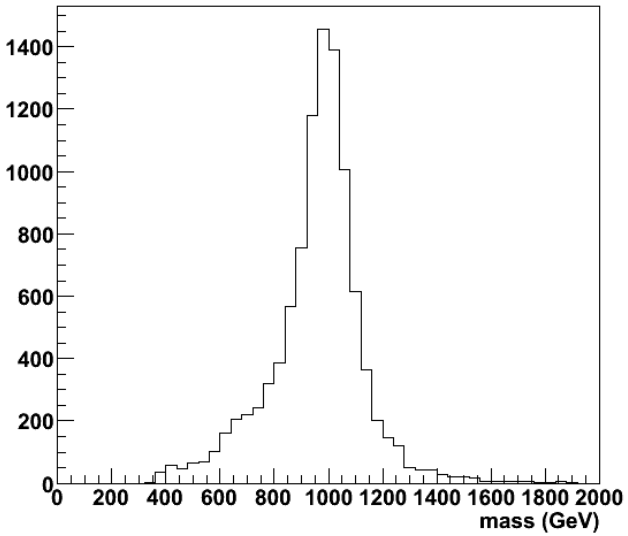

Generally, we cannot assume that heavy resonances with very large cross-section at the LHC (large couplings to light quarks) are narrow (Compared to the experimental resolution)

Properties of the KK gluon

Kaluza Klein excitated state of the gluon, expected to be present in Large Extra Dimensions models where gauge bosons propagate into the bulk

It's a massive gluon with strong coupling to quarks (typically

Low mass tail due to convolution of relatively broad Breit-Wigner with rapidly falling quark PDFs at high x

$\Gamma = 0.18\ M$

generator level mass distribution

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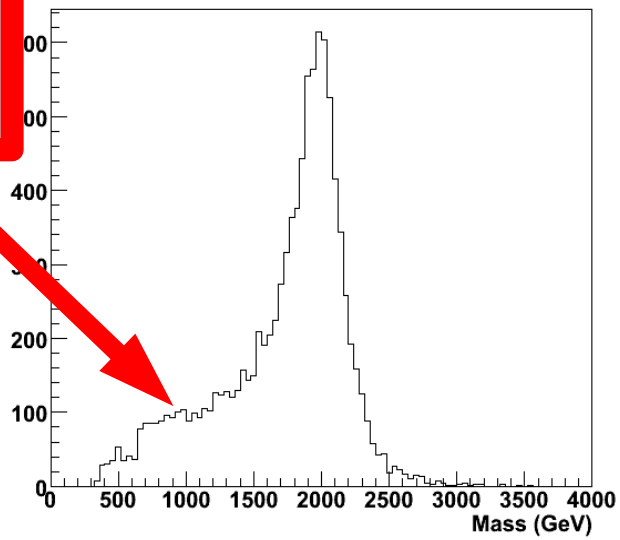

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Organization: Interaction with the top group

Jet+X is a small group compared to i.e. lepton+X.
Still, we have three papers in the proposed early physics list.

In case of third generation quarks, work closely together with top group:

Reconstruction and tagging of high pT top "jets"
(top reconstruction, led by G. Brooijmans and I. Van Vulpen)
Understanding of SM tt spectrum in terms of top p_T, or invariant mass of the pair
(top cross-section group, led by S. Bentvelsen and M. Cobal)

News: meetings

Those involved in high p_T top physics should follow:

- these meetings
- top reconstruction (phone) meetings
- the top workshop (Grenoble, 23-25 oct.)

News: DPD discussion

Events where the leading jet E_T is 70 GeV are not very useful to us.
Generally, many exotic searches have rather exotic signatures.

A very efficient skim with large rejection can be made on the basis of missing transverse energy, number of leptons or jet E_T.
Slimming and thinning, on the other hand, is not very promising for semi-leptonic tt events (need everything).
We can use prescaled performance DPDs to understand jets, b-tagging, leptons, etc.
Can/should we define a Jet+X physics DPD? No pre-scale!!!
Run dedicated reconstruction only on preselected streams/events?

News: validation of MC samples

Work in progress (high priority):

GKK -> tt (Luis March, Marcel Vos)
Z' -> tt (Luis March, Marcel Vos)
W' -> tb (Manouk Rijpstra, see talk)

Expected next year:
high p_T SM tt (p_T > 500 GeV, on top quota)

Conclusions

There's a lot of work to be done:

On Monte Carlo events:

- realistic reconstruction of high p_T tops
- inventory of relevant models
- validation MC samples
- develop tools to take into account the width of the resonance
- full MC study into sensitivity for resonances in range 0.7 – 1.5 TeV

AND soon also on data:

- understand di-jets, W+jets, SM tt
- Understand jet and E_T^{miss} resolution
- make sure selection of high p_T b- and top works

Before we do the measurement of $d\sigma/dM$ and derive limits on models. Don't wait for this to be done by others (there are no others)