aTOPe, IFIC, 28 July 2009

Marcel Vos, IFIC Valencia

Les Houches…

The BSM session of the Les Houches workshop “physics at TeV colliders

Define BSM benchmark points:

http://www.lpthe.jussieu.fr/LesHouches09Wiki/index.php/BSM_benchmark_points

Tt resonances (broad and narrow)
Compositeness (Lukas)

Define a signature-to-model map:

http://www.lpthe.jussieu.fr/LesHouches09Wiki/index.php/Signatures/models_map

The KK gluon samples

Our benchmark for a broad tt resonance

MadGraph/MadEvent (Maltoni/Stelzer, hep-ph/0208156)
TopBSM model (R. Frederix and F. Maltoni, 0712.2355)
with some modifications (thanks to R. Frederix)

Full Matrix Element calculation of pp → g* → tt → bb lν qq

g* is represented by a generic colour octet labelled o1

Couplings to light quarks, b_L, b_R, t_L, t_R set according to basic RS setup

(Lillie, Randall, Wang, the bulk RS KK gluon, JHEP 0709:074 (2007))

Three masses 1, 1.5, 2 TeV for early physics

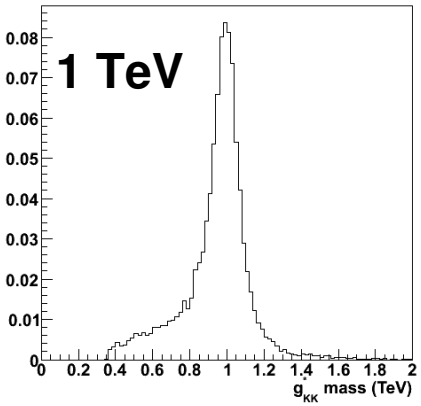
(other masses, setups, decays can be made on demand)

Pythia with MSTP(81)=1

Alternative: Sherpa model by Joe Virzi (LBL)

Being validated right now (M.V.)

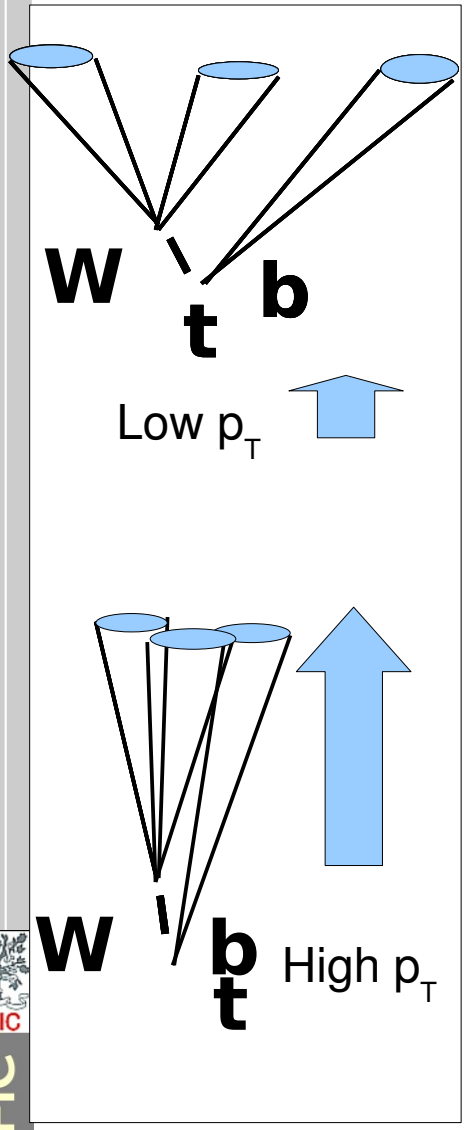
Mass distribution: Convolution of broad Breit-Wigner and luminosity function



Les Houches...

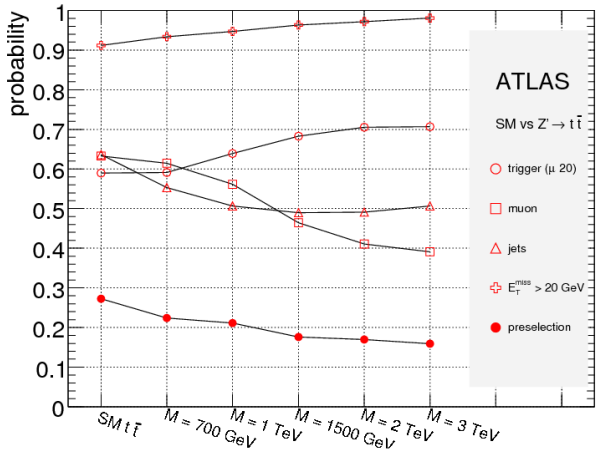
Jet substructure investigated by all types of physics analysis. In two sessions there was discussion of how to use this to improve Higgs searches (WH->jjbb), SUSY searches, di-gauge boson resonances (W'->ZW), and, of course, tops. Many groups (theorists and experimentalists) are developing tools.

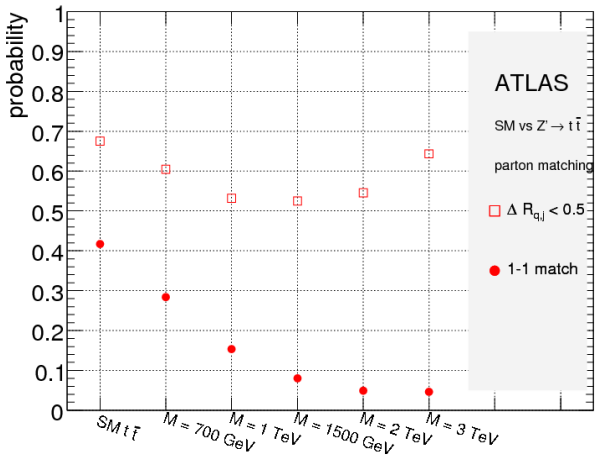
Selection and reconstruction



High pT top quarks are a challenge to the standard tt **selection and reconstruction** scheme:

- Lepton isolation
- Jet multiplicity
- B-tagging





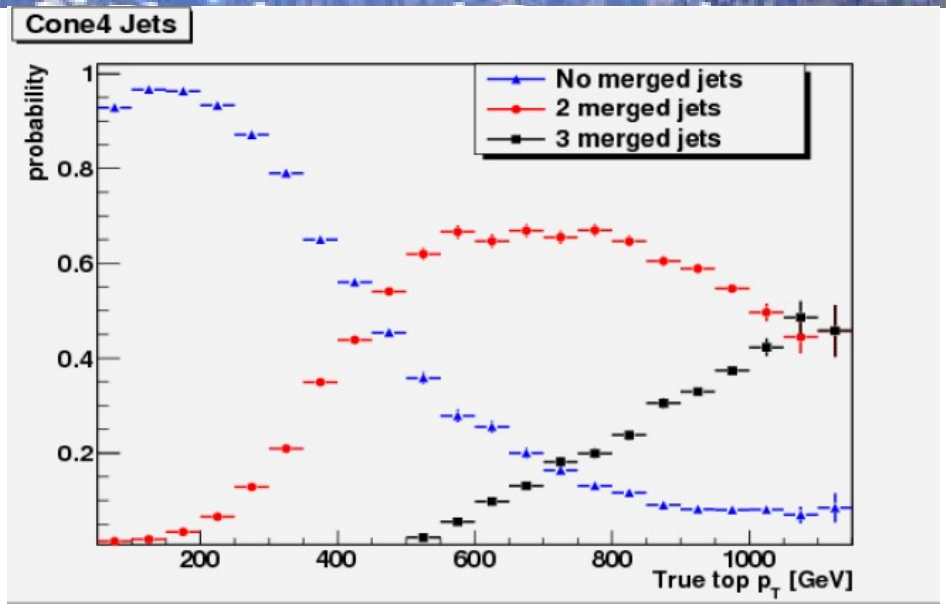
Several reconstruction methods are being explored, using features of the mono-jet to reduce the QCD/W+jets background

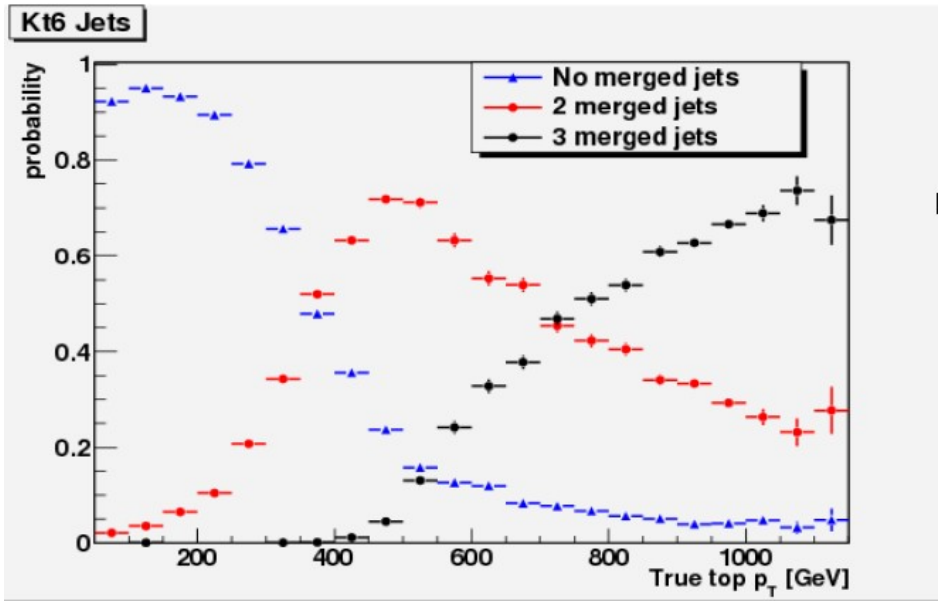
Jet substructure ATL-PHYS-CONF-2008-008, COM-PHYS-2008-184

Life-time ATL-PHYS-CONF-2008-016

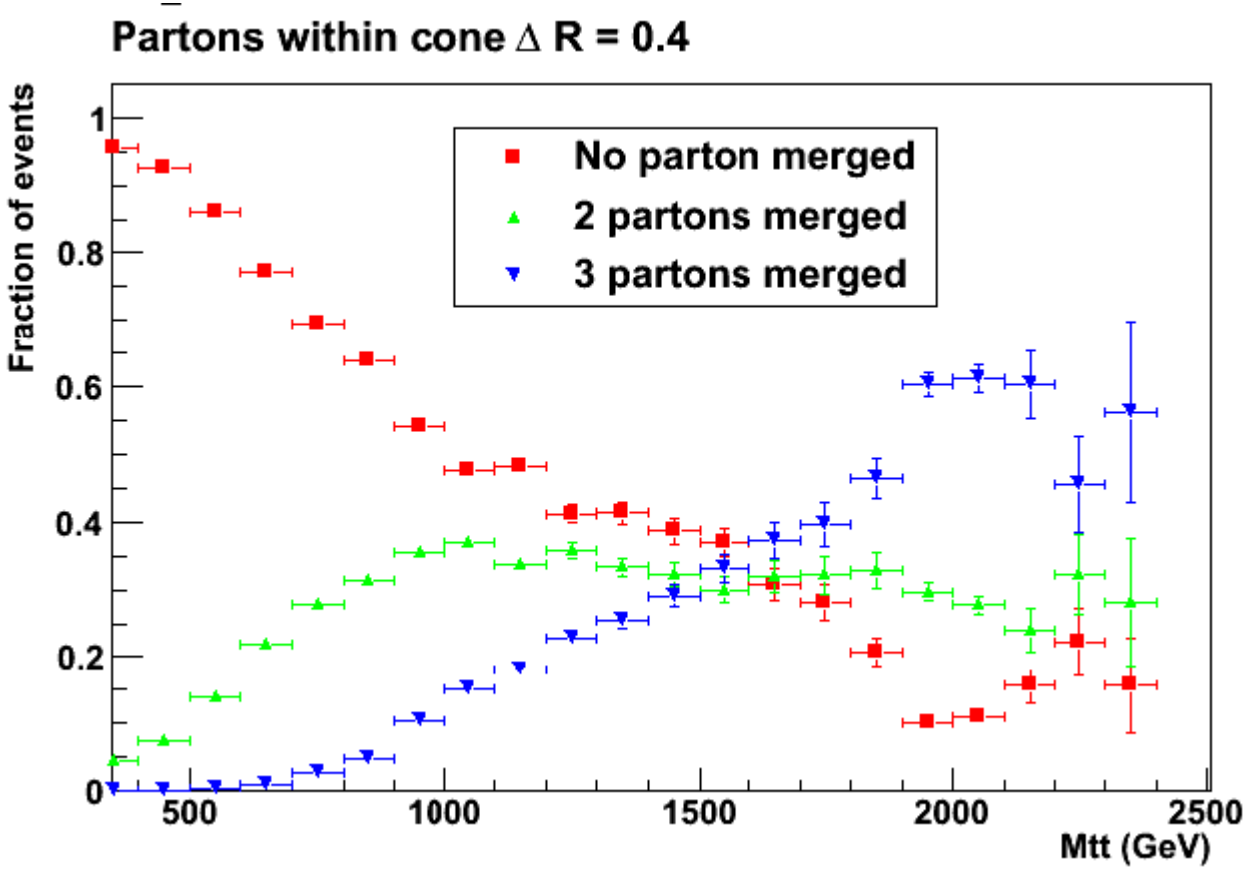
Merging probability

Probability for N jets to "merge" as a function of top p_T.





Merging jets vs Mtt



Les Houches…

Rare top decays t->Hc reach 10^{-4} level (SM prediction ~ 10^{-16}) in model where Higgs couplings are flavour violating….. (K. Agashe and others http://arXiv.org/pdf/0906.1542)

Similarly, gc → tH production would be possible.

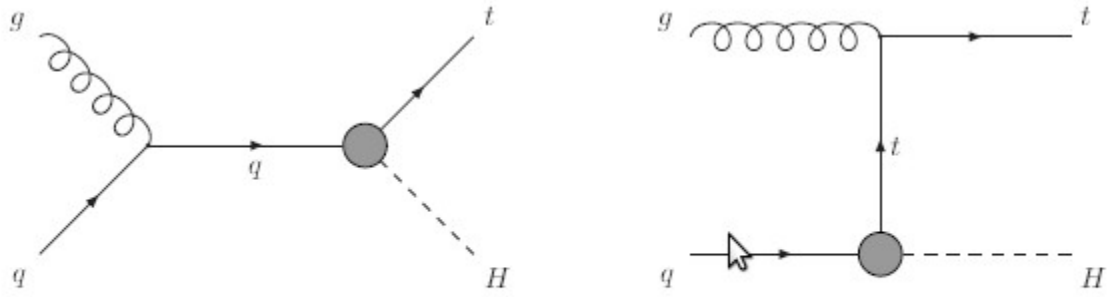


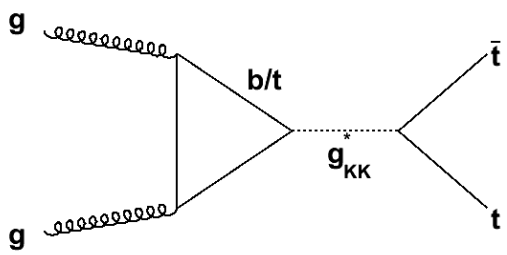
Fig. 9. Feynman diagrams for $gq \to Ht$ via FCN couplings.

Aguilar-Saavedra, Branco,
http://arxiv.org/pdf/hpe-ph/0004190

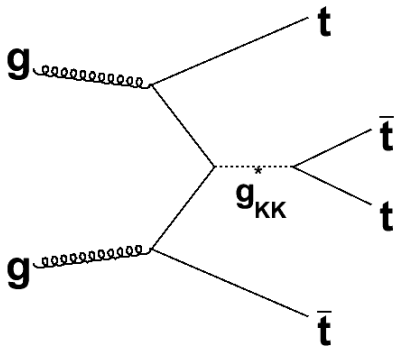
Effort to understand tt+X backgrounds: ttW, tt+N jets

Frank Krauss (Durham, Sherpa) et al. To generate background samples

What if the new physics only couples to top quarks?



- Modest effect on (Tevatron) tt cross-section
- Tt resonance production through loop-diagram
- Resonant signal in 4-top events
  tighly links to top compositeness searches



Potential of same-sign signature?

Same sign lepton is a key signature:

top partner searches look for ttWW

Four top selection

Fully leptonic tt events can be isolated (ATLAS cross-section paper, ATLAS fully leptonic resonance search)

Events with same-sign tops (tt or anti-t anti-t) are produced by Randall/Meade black holes...

Tt resonances are present in many extensions of the Standard Model

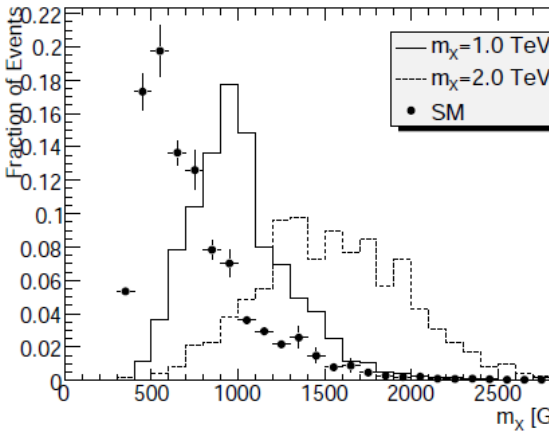
Lively discussions among theorists
Large body of literature from Tevatron searches
ATLAS studies in CSC book + several notes
New paper in preparation: ATLAS Exotics skeleton paper

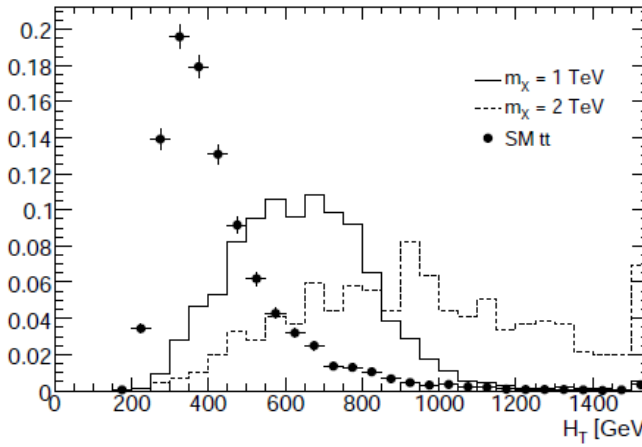
Most analyses concentrate on semi-leptonic events
Reach is limited both in invariant mass (sharply falling parton luminosity at Tevatron and LHC) and σxBR sensitivity (irreducible tt background)

ATLFAST study: H. Gray, B. Heinemann, E. Hughes, A. Korn, M. Scherzer, Search for X->tt using the di-lepton decay signature, ATL-PHYS-INT-2009-004

Reducible SM Backgrounds: tt (400 pb semi-leptonic) , Z+jets (3000 pb), WW+jets (9.9 pb), single top (300 pb) taken care of by a series of simple selection criteria, keeping 20-30 % of signal events
Irreducible SM tt production with di-lepton decay (40 pb) dominant

Distinguish a “narrow” (30%) peak on top of a continuum background Resonance mass (solving for the two neutrinos using W and top mass constraints, or using effective mass) peak





Conclusion: Sensitivity is inferior to a search in semi-leptonic decay mode

Large SM backgrounds (and in particular the dominant irreducible tt background) satisfy the opposite-charge lepton criterion. Backgrounds with same-sign leptons are much less abundant

Example: CDF collaboration, Inclusive search for new physics with like-sign dilepton events in p anti-p collisions at s**(1/2) = 1.96-TeV. Phys.Rev.Lett.98:221803,2007. (for applications to tt+X at the LHC see for instance tttt papers by Dobrescu et al., or Pomarol and Serra)

The following LO numbers are taken from G. Servant, R. Contino, Discovering the top partners at the LHC using same-sign dilepton final states, JHEP 0806:026,2008:

$$t\bar{t}W^+W^- + \text{jets} \rightarrow l^+l^+/l^-l^-: 5.1 \text{ fb}$$

$$ttW+\text{jets} \rightarrow l^+l^+/l^-l^-: 18.7 \text{ fb}$$

$$W^+W^-W^\pm+ \text{jets} \rightarrow l^+l^+/l^-l^-: 18.7 \text{ fb}$$

$$W^\pm W^\pm+ \text{jets} \rightarrow l^+l^+/l^-l^-: 16.0 \text{ fb}$$

Experimentally, a top-top or anti-top anti-top signal would stand out very early (Yang Bai, Zhenya Han reach the same conclusion in arXiv:0809.4487)

What would we learn by studying this signature? What models would be ruled out (confirmed) by non-observation (discovery)?

In “Black Holes and Quantum Gravity at the LHC” (JHEP 0805:003,2008), Randall and Meade argue that on a scale significantly lower than that requiered to produced fully “thermal” black holes (with sufficient entropy to decay into many-object final states), deviations from Standard Model behaviour would be observed in di-object final states. In particular they suggest compositeness-like signatures in di-jet events.

Lower scale + rapidly falling parton luminosity = earlier!

Run BlackMax with “choose_a_case=4 (Lisa_two_particles_final_state)”
3 extra dimensions of size $10/M_{pl}$
Black holes with masses 3-15 TeV Parameters suggested by Cigdem Issever (thanks)
Cross-section: 0.94 nb (16 pb for 5 TeV)
30% of events contains at least one top quark
2% of black holes yields top top final state
0.04 % has top anti-top