New Physics, Where Art Thou

Tilman Plehn

Universität Heidelberg

Dresden 03/2013

Data driven era

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$\Rightarrow$ experimentalists talk, speaker quietly leaves the stage

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Motivation for new physics

Field theory and the Higgs

– Higgs discovery is a triumph of experimental ingenuity

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Road to new physics, depending on attitude...

- WIMP dark matter: Z_2 symmetry?
- quark flavor: symmetry against FCNC?
- lepton flavor: see-saw neutrino masses?
- baryon asymmetry: sphaleron solutions?
- gauge coupling unification: GUT gauge group?
- cosmological constant: strings or fixed points?

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$\Rightarrow$ without a Higgs unrelated

Message from the Higgs

Fundamental Higgs

– single, narrow, light: fundamental

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- strongly interacting sectors very unlikely [e-w precision data]
- Goldstone-protection of composite Higgs losing battle
- working UV model: little Higgs with T parity [Cheng and Low]

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	ΔhVV	$\Delta h\bar{t}t$	$\Delta h\bar{b}b$
Mixed-in Singlet	6%	6%	6%
Composite Higgs	8%	tens of %	tens of %
Minimal Supersymmetry	$< 1\%$	3%	$10\%^{(\text{large } \tan\beta)}$, $100\%^{(\text{small } \tan\beta)}$

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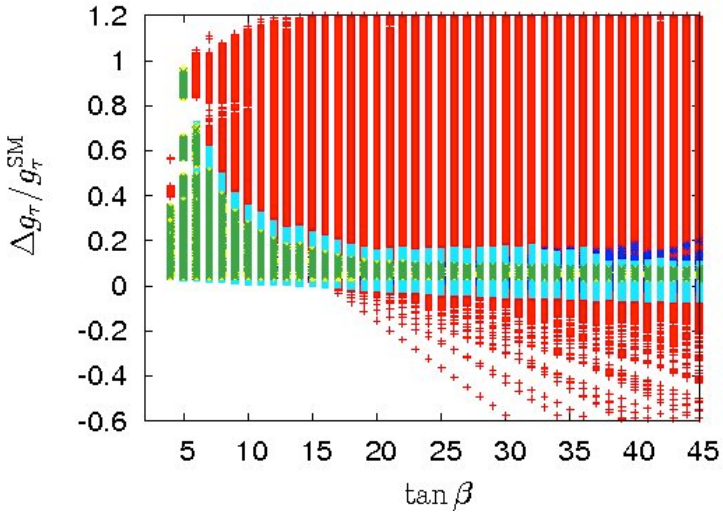
- correlation of Δ_τ and heavy Higgs states
- if you consider $H \to \gamma\gamma$ BSM hint even better!



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$\Rightarrow$ race for BSM physics still on

Signatures

Instead of BSM model sing-along

- models had their chance [depressing details later]
- signatures for upcoming run [simplified models or else]
- experimental questions

  WIMP dark matter: missing energy
  quark flavor: rare processes, warped KK excitations [Higgs?]
  lepton flavor: Majorana searches?

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  gauge structure: new gauge bosons
  electroweak symmetry breaking: extended Higgs sector

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Model-signature matrix [Morrissey, TP, Tait]

	missing energy (p.89)	cascade decays (p.91)	mono-γ/jet/photon (p.15)	lepton resnce (p.109)	di-jet resnce (p.109)	top resnce (p.120)	WW/ZZ resnce (p.15)	W resnce (p.93)	top partner (p.116)	charged tracks (p.123)	displ. vertex (p.123)	multi-photons (p.29)	spherical events (p.47,76)
SUSY (heavy gray.) (p.17,26)	✓	✓	✓						✓				
SUSY (light gray.) (p.17,27)	✓	✓	✓						✓	✓	✓		
large extra dim (p.39)	✓		✓										✓
universal extra dim (p.47)	✓	✓		✓	✓	✓	✓	✓	✓				
technicolor (vanilla) (p.51)				✓	✓	✓	✓	✓✓					
topcolor/top seesaw (p.53,54)					✓	✓✓	✓						
little Higgs (w/o T) (p.55,58)				✓	✓	✓	✓	✓					
little Higgs (w T) (p.55,58)	✓✓	✓✓	✓	✓	✓	✓	✓	✓	✓				
warped extra dim (IR SM) (p.61,63)				✓	✓	✓	✓						
warped extra dim (bulk SM) (p.61,64)				✓	✓	✓✓	✓	✓					
Higgsless/comp. Higgs (p.69,73)				✓	✓	✓✓	✓✓						
hidden valleys (p.75)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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$\Rightarrow$ time to re-think our lyrics

Jets plus missing energy

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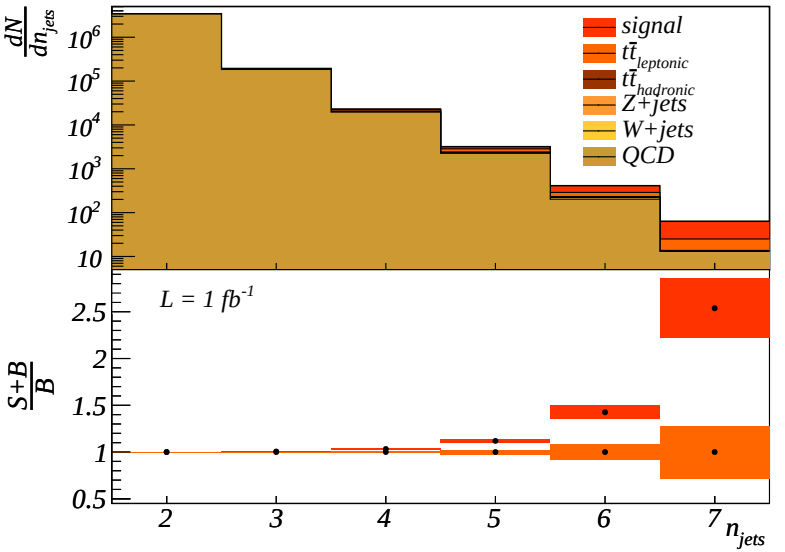

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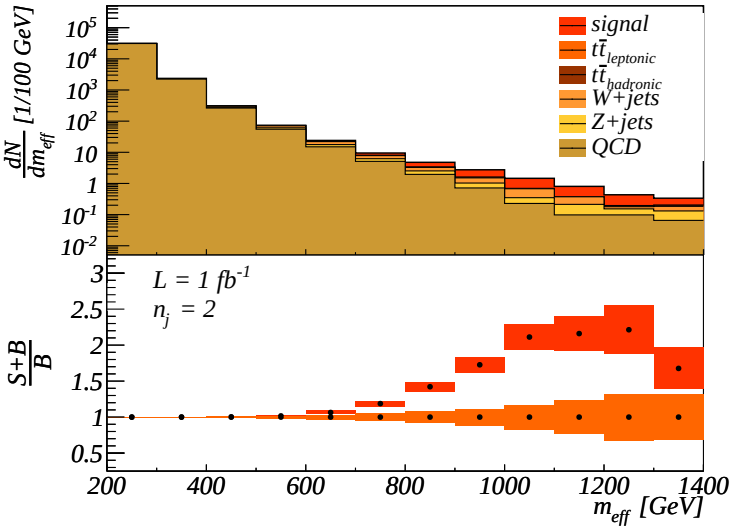

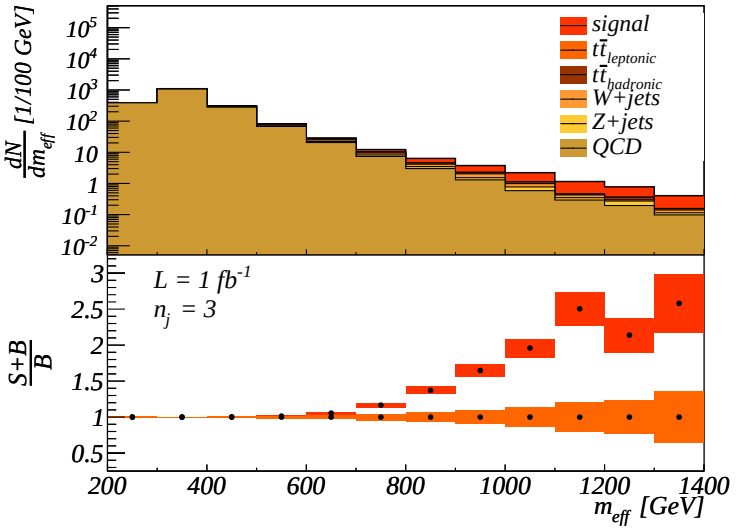

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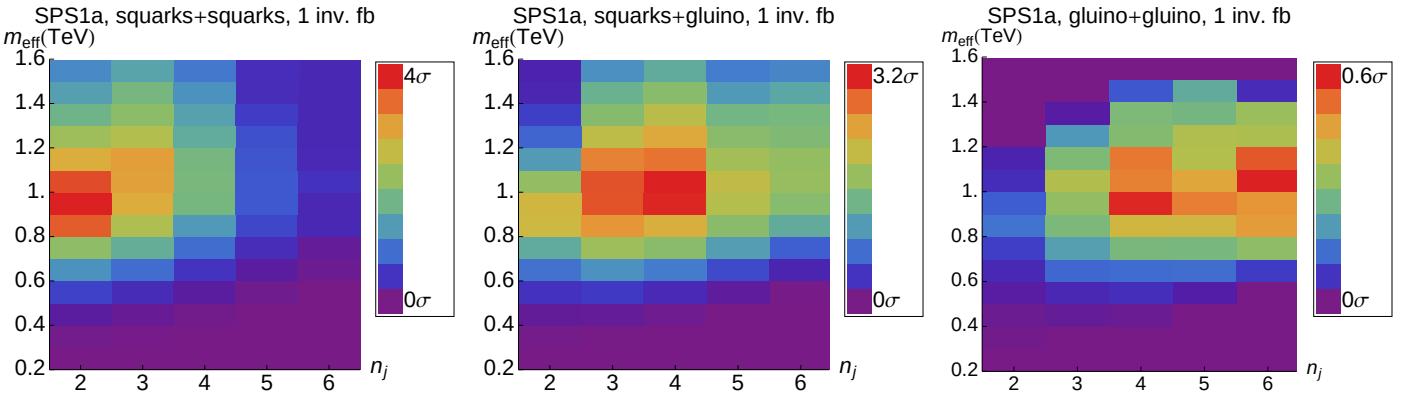

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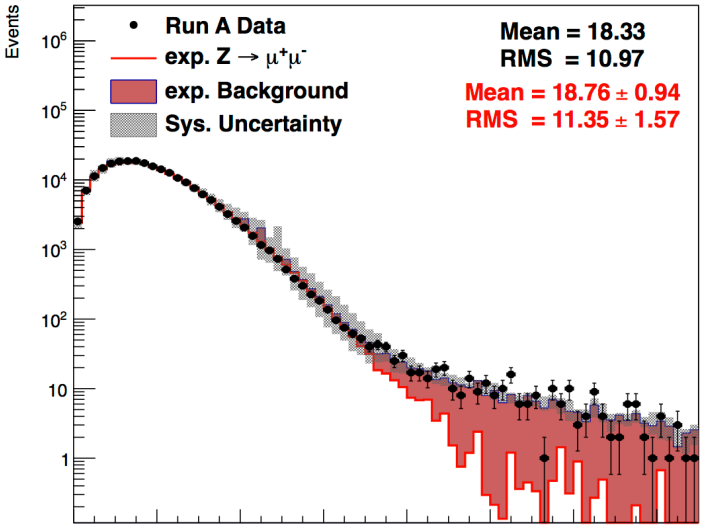

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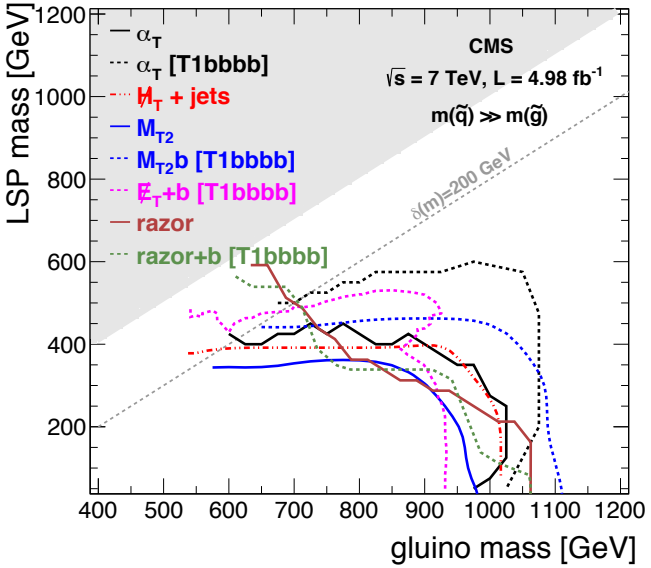

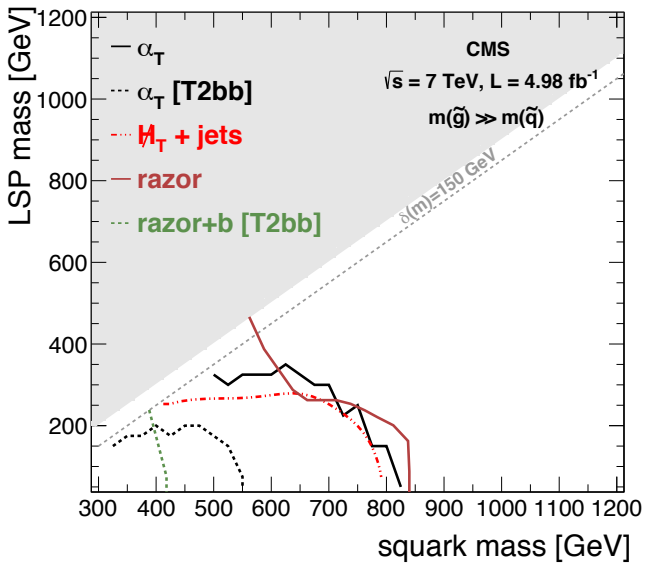

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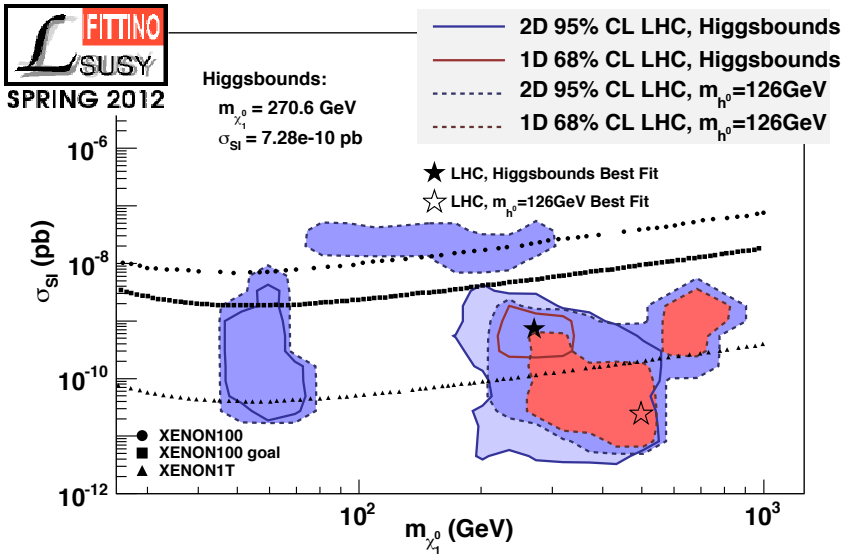

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- hierarchy problem: top main problem
- top partners: cancellation in loop
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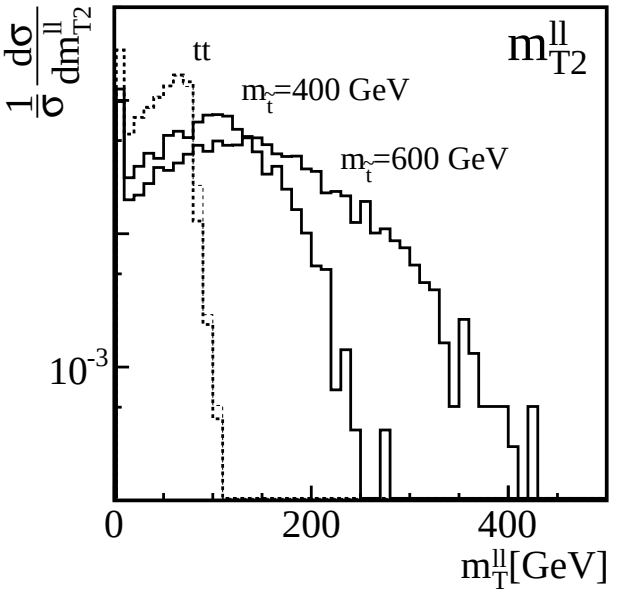

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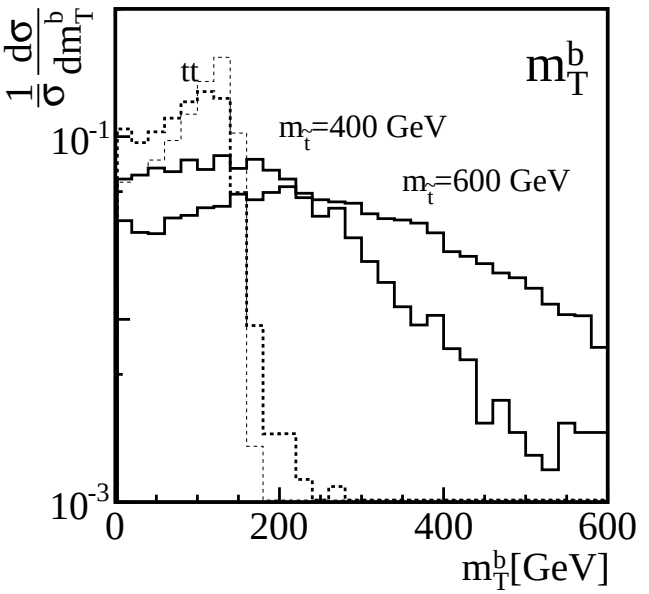

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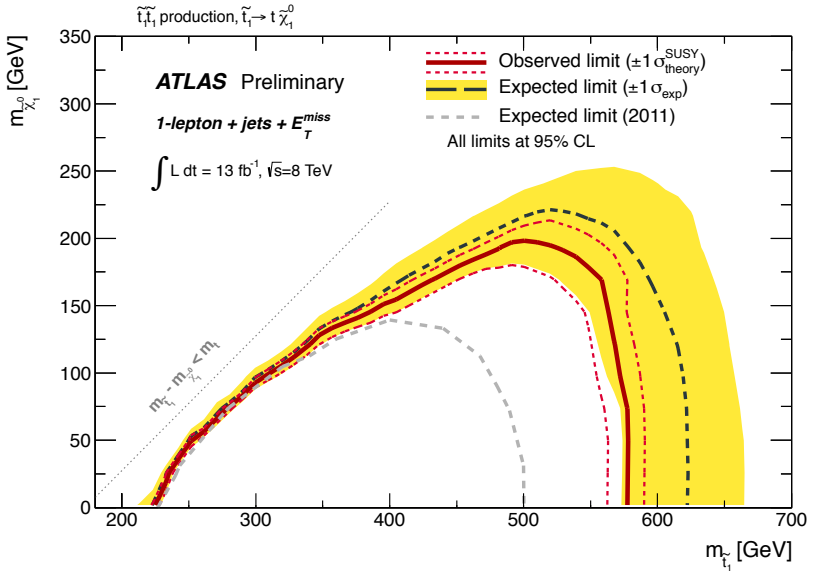

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Resonances

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- gauge extensions: extra $U(1)$ gauge bosons
- warped extra dimensions: KK gravitons, KK gluon
- flavor arguments etc: decay to top pair [weirder resonances lepton-jet: leptogluons in MadGolem]
- current mass range 0.6–3 TeV
- difference in width [KK gluon: $\Gamma/m \sim 15\%$, friendly Z': $\Gamma/m \sim 2\%$]

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Interlude: top tagging [HEPTopTagger: TP, Salam, Spannowsky, Takeuchi; CERN-PH-EP-2012-291]

- identification/reconstruction of boosted hadronic decays [only good news in my talk]
- application of jet algorithm [Seymour 1994]
  hadronic Higgs tagger [BDRS 2008]
  Hopkins tagger and HEPTopTagger [review: Spannowsky & TP]
  coverage down to $p_{T,t} \sim 200$ GeV

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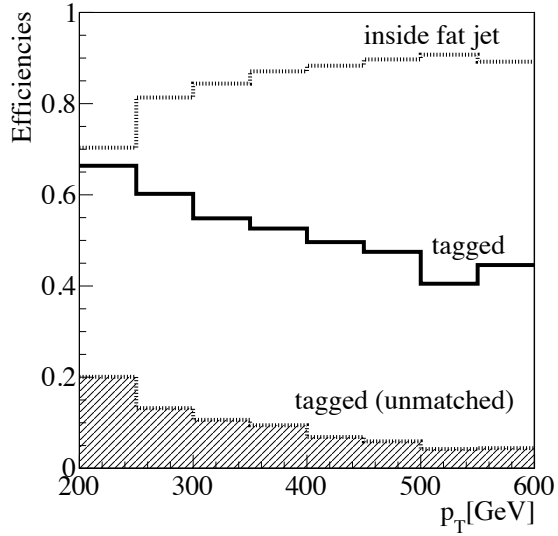


Resonances

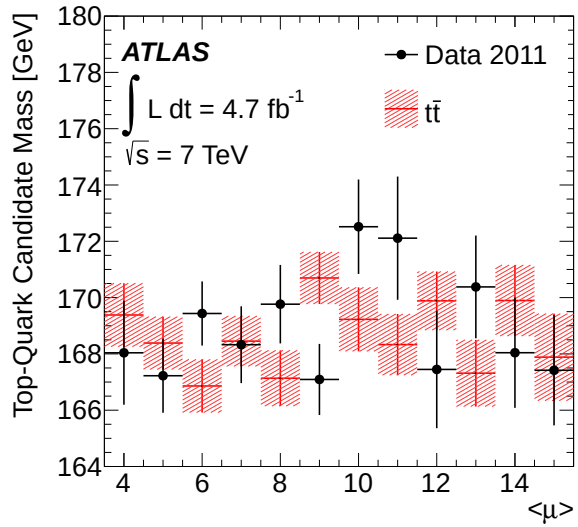
Trust us, it makes sense

- gauge extensions: extra $U(1)$ gauge bosons
- warped extra dimensions: KK gravitons, KK gluon
- flavor arguments etc: decay to top pair [weirder resonances lepton-jet: leptogluons in MadGolem]
- current mass range 0.6–3 TeV
- difference in width [KK gluon: $\Gamma/m \sim 15\%$, friendly Z': $\Gamma/m \sim 2\%$]

Interlude: top tagging [HEPTopTagger: TP, Salam, Spannowsky, Takeuchi; CERN-PH-EP-2012-291]

- identification/reconstruction of boosted hadronic decays [only good news in my talk]
- application of jet algorithm [Seymour 1994]
  hadronic Higgs tagger [BDRS 2008]
  Hopkins tagger and HEPTopTagger [review: Spannowsky & TP]
  coverage down to $p_{T,t} \sim 200$ GeV
- established by ATLAS-HD [Kasieczka & Schätzel]

$\Rightarrow$ substructure methods work!



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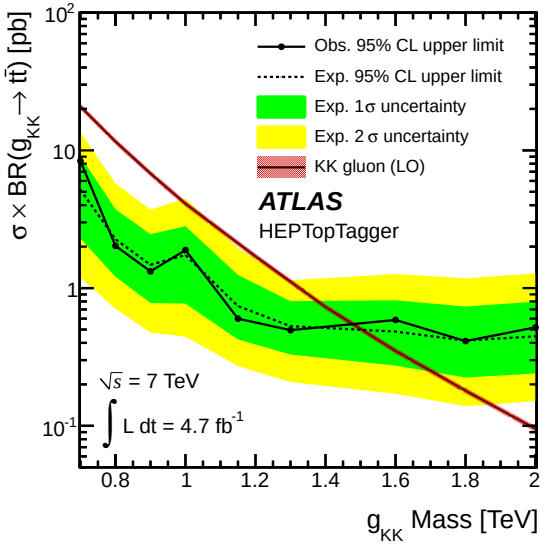

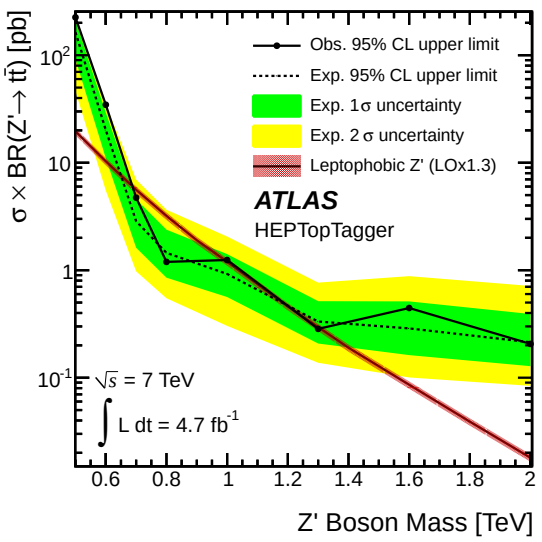

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- searches usually in semi-leptonic top pairs
- top tagging with similar reach in hadronic tops
- ATLAS search using HEPTopTagger and templates
- main issue b-tags at high p_T [sort out for Higgs tagging]

$\Rightarrow$ possibly tools more interesting than searches

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- way past: black hole searches
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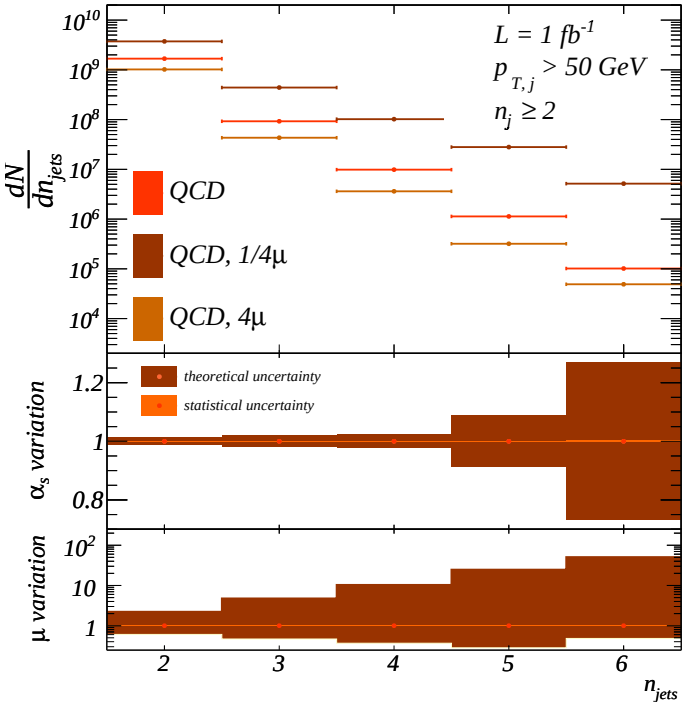

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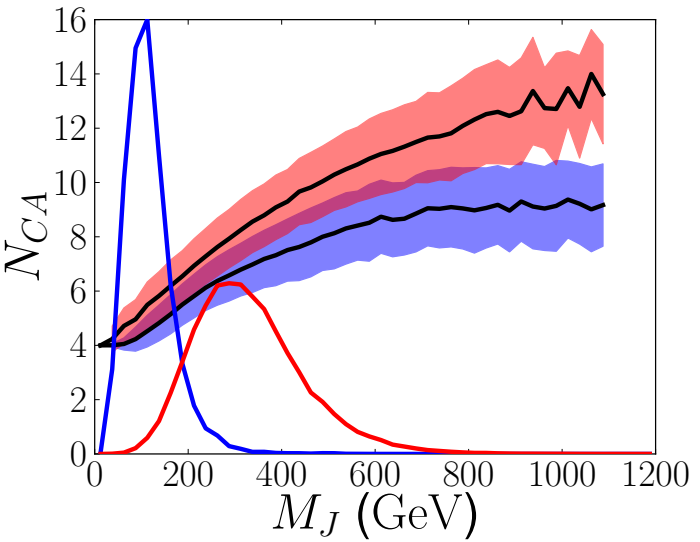

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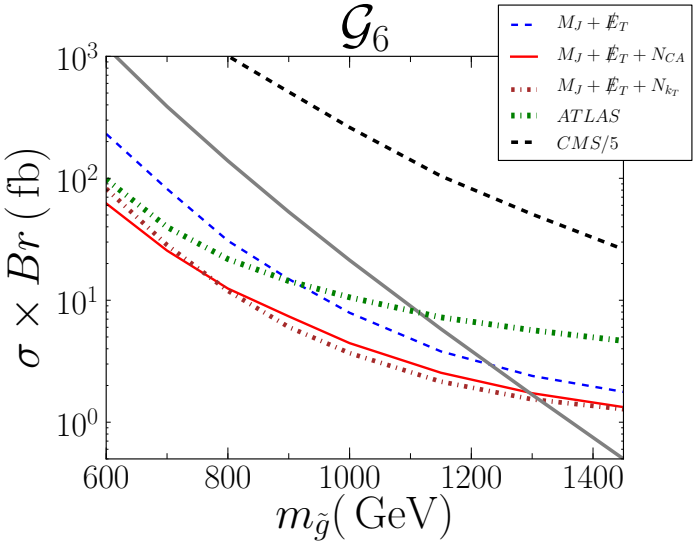
Opening the box [El Hedri, Hook, Jankowiak, Wacker]

- gluino pair production with RPV decays [10-20 decay partons]
- special case $\tilde{q} \to q\bar{q}\tilde{\chi}_2^0$ with RPV decay of LSP

$\Rightarrow$ final (experimental) verdict missing



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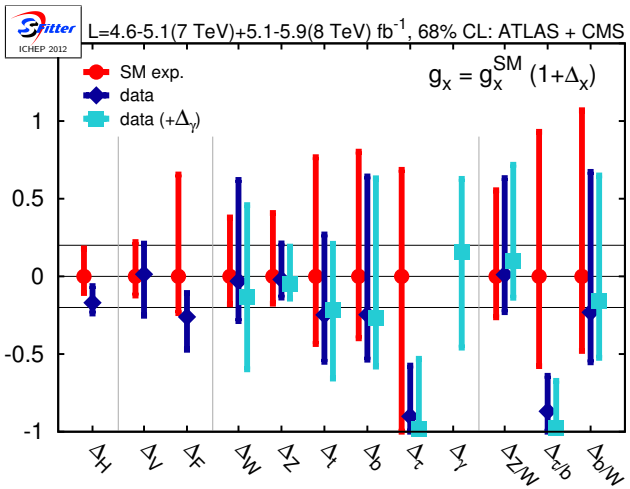

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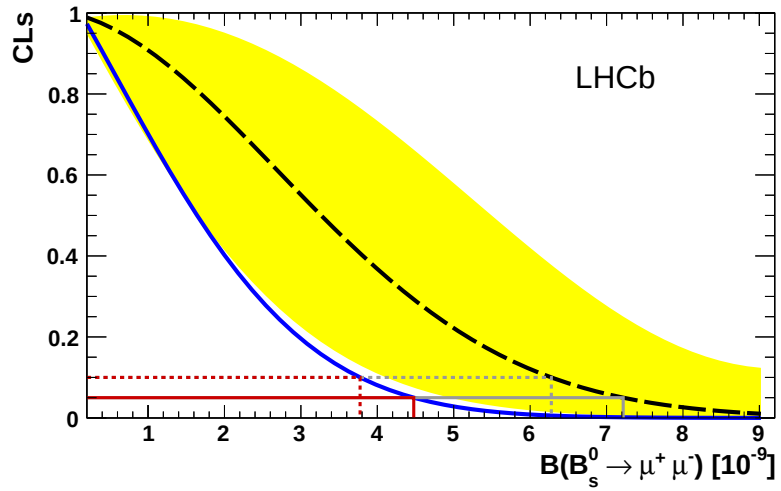

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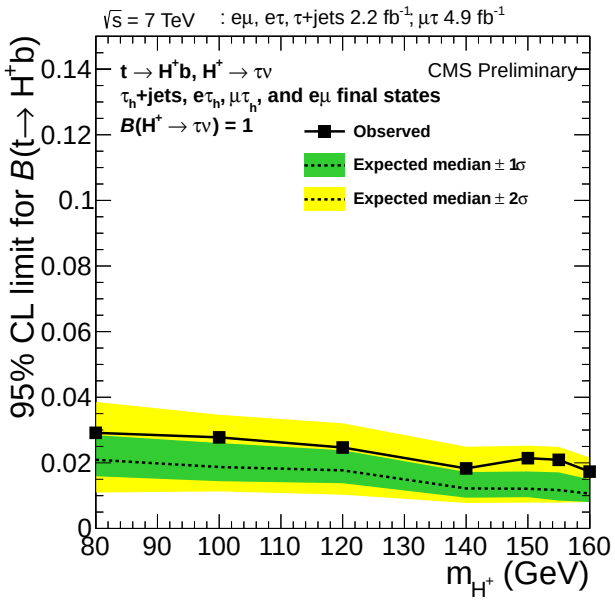

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- precision coupling analyses coming
  searches for tH^- soon

$\Rightarrow$ Higgs sector only just touched

Looking forward to BSM physics

All hope not lost

- motivation strengthened by Higgs
- signatures central:

  jets plus missing energy
  top partners
  resonances
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Some of this work was funded by the BMBF Theorie-Verbund which is great for QCD phenomenology

Bundesministerium
für Bildung
und Forschung

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