RECAST Workshop
UC-Davis 8-9 April

Albert De Roeck (CERN/UCD)
Jack Gunion (UCD)

High Energy Frontier Theory Initiative

Program

Abstract:

SUSY Recast will focus on using the analyses that are currently available for limits (assuming no discovery by the time of the workshop) on supersymmetric models and on recasting/reusing these limits to place limits on models that have not been analyzed by the experimental community. The idea is to develop a procedure for a theorist to propose a model, send new physics events generated in this model to the experimental collaborations at the LHC, and have the experimental collaborations come back quickly with the limits on the new model.

To contact the organizers, please send email to susy-recast@particle.physics.ucdavis.edu.

~40-50 participants
~ 10 talks+ short contributions

Friday

- 8:30-9:00 **Coffee**
- 9:00-9:15 **Welcome**
- 9:15-9:45 **David Stuart** CMS SUSY Results
- 9:45-10:30 **Discussion**
- 10:30-10:45 **Coffee break**
- 10:45-11:15 **Bruce Schumm** ATLAS SUSY Results
- 11:15-12:00 **Discussion**
- 12:00-1:30 **Lunch**
- 1:30-2:00 **Philip Schuster** The Topologies Approach
- 2:00-2:15 **Myeonghun Park** Topological Approach to New physics
- 2:15-2:45 **Discussion**
- 2:45-3:00 **Coffee break**
- 3:00-3:30 **JoAnne Hewett** SUSY without prejudice
- 3:30-4:15 **Discussion**
- 4:15-4:30 **Coffee break**
- 4:30-6:00 **Baer, Essig, Haber, Kane, Mrenna, Rizzo, Su, Tait (discussion leaders)** Discussion: Expanding SUSY and Low-Scale SUSY Models that evade LHC limits
- 7:00 **Dinner**

Saturday

- 8:30-9:00 **Coffee**
- 9:00-9:30 **Daniel Whiteson** Simplified Models
- 9:30-10:00 **Discussion**
- 10:00-10:15 **Coffee break**
- 10:15-10:45 **Kyle Cranmer** Recast, Closure tests, and a roadmap for simplified models
- 10:45-11:45 **Discussion**
- 11:45-1:30 **Lunch**
- 2:00-2:30 **Jay Wacker** Recasting SUSY
- 2:30-2:45 **Gaurab Sarangi** Recast and Like-Sign Di-Leptons
- 2:45-3:00 **Discussion**
- 3:00-3:15 **Coffee break**
- 3:15-4:15 **Itay Yavin (moderator)** Extended Recast Discussion
- 4:15-4:30 **Coffee break**
- 4:30-5:30 **Michael Peskin** Summary Remarks

http://particle.physics.ucdavis.edu/workshops/doku.php?id=2011:susy-recast

Saturday

Main Themes

- Take stock of the present LHC limits on SUSY
- Are there holes in our present analysis coverage?
- Does fine tuning become an issue?
- How to exchange/maximize the information of a study?
- The RECAST project.

Model considerations in light of the LHC data

J. Gunion et al.

- Constraints on the CMSSM are already remarkably strong and will quickly become much stronger.

- Most constraining channel is jets plus $\not{E}_T$.

  Limits are roughly characterized by $m_{\tilde{g}} \sim m_{\tilde{q}} \lesssim 650$ GeV.

- Is the MSSM becoming finely tuned?

  – Studies by Graham Ross and collaborators suggest that this is not yet the case in the CMSSM context.
    Lowest FT consistent with latest CMS/ATLAS limits is $\Delta \sim 15$ for $m_{h^0} \sim 114$ GeV. (See Haber summary.)
  – Studies on SUSY without prejudice (Hewett talk), in which the CMSSM universality is broken and fine tuning can often be reduced relative to CMSSM, find the same result — many models with low FT still pass current ($35\ \mathrm{pb}^{-1}$, $\sqrt{s} = 7$ TeV) LHC limits.

– Both studies agree that if $m_h > 120$ GeV and/or limits on $m_{\tilde{g}}, m_{\tilde{q}}$ increase to 1 TeV, then large FT will be hard to avoid.

- If you are concerned about FT, then it is best to keep sparticle masses as low as possible.

  To do this, the easiest way to escape LHC limits is to have a rather degenerate mass spectrum in which $m_{\tilde{g}} \sim m_{\tilde{q}}$ is not far above $m_{\tilde{\chi}_1^0}$ — not possible in the CMSSM.

  This reduces the number of jets produced, esp. in strong QCD production processes ($\widetilde{g}\widetilde{g}$, $\widetilde{g}\widetilde{q}$, $\widetilde{q}\widetilde{q}$) — in the extreme limit, one would have to rely on ISR jets + $\not{E}_T$.

- Kane presented a model with extremely large squark masses and gluino masses above 1 TeV that he claimed was nonetheless not fine-tuned because of special boundary conditions / string considerations.

- Su and Mrenna also discussed scenarios in which approximate mass degeneracies made detection of SUSY much harder than in the CMSSM.

Implications

As LHC CMSSM limits increase, to avoid domains of large FT for the MSSM one must move beyond the CMSSM.

This will require developing the means to explore a much larger class of models.

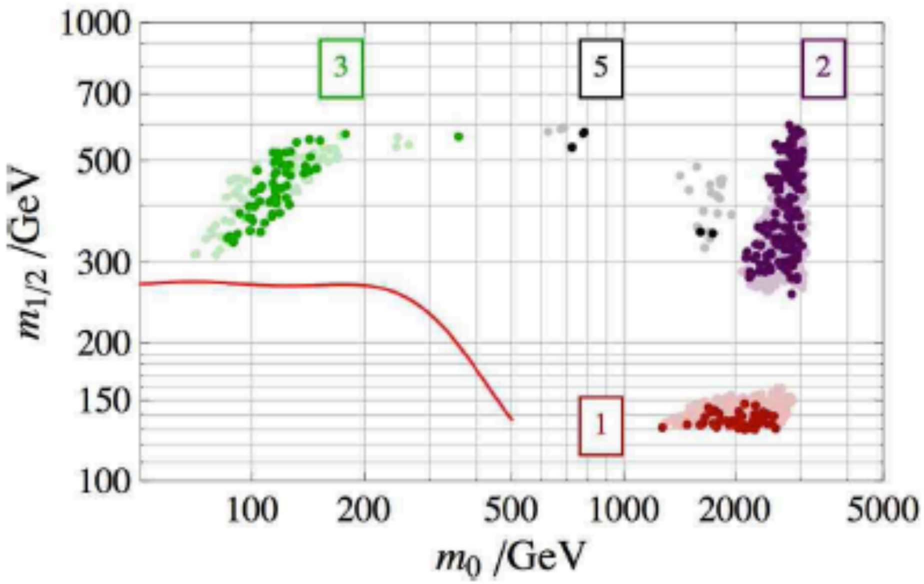
The big question: will the experimental community be able to perform all the needed analyses?

Theorists tend to think that they should have better access to the analyses/data so that they can work on searches and limits for a given model of their choice = open access.

In the following section we review the options discussed at the meeting and one other one not discussed but currently "on the table".

Fine Tuning

H. Haber



May get uncomfortable with 1 fb^{-1} if no signal observed

Regions of low fine-tuning ($\Delta < 100$) in the m_0 versus $m_{1/2}$ plane, summed over $\tan\beta$ and A_0. All points satisfy the SUSY and Higgs mass limits, $\Omega h^2 < 0.1285$ (dark points having $0.0913 < \Omega h^2 < 0.1285$), the B-physics and δa_μ constraints, and the CDMS-II bound on the dark matter detection cross section. The area below the red line shows the CMSSM exclusion (for $\tan\beta = 3$ and $A_0 = 0$) from the CMS dijet+$E_T^{\rm miss}$ analysis.

A few figures and table taken from a paper by S. Cassel, D.M. Ghilencea, S. Kraml, A. Lessa and G.G. Ross, arXiv:1101.4664, may be instructive.

Massive Scalars

G. Kane

CLAIM: compactified string theories with stabilized moduli *that could describe our world* generically have spectrum:

Scalars≈$M_{3/2}$ ☒ 30 TeV; gluinos ☒ TeV; LSP(wino-like)☒200 GeV

Gordy Kane Davis, April 2011

→At LHC can only see gluinos, N1, N2, C1, h (h is SM-like)

→Gluinos decay dominantly to 3rd family so gluino pair decays mainly to bbbb, bbtt, tbtb, tttt (plus two of N1, N2, C1)

[studied backgrounds, easy to find signals; ☒ 1 events pass 35pb^{-1} ATLAS, CMS cuts]

- could describe world: 4D; TeV scale emerges; deS; CC~0; BBN; N=1 susy; susy breaking; supergravity framework, etc – expect many solutions that ***can*** describe our world***,*** and many that cannot – don't care about latter
- First derived in series of papers for M-theory compactified on G2 manifold [Acharya, Kane, Bobkov, Kumar, Shao, Kuflik, Lu, Watson, Feldman, Wang, Nelson, Suruliz Kadota, Velasco]
- **Also showed for M-theory model that TeV scale emerges; potential in metastable deS minimum; universe has non-thermal cosmological history, non-thermal wimp miracle; soft-breaking terms real; all CPV from phases of Yukawas; EDMs ok and predicted; strong CPV explained; no flavor problems; wino-like LSP good DM candidate; first string-based solution of μ problem, predicts ☒$_{SI}$ ☒ $10^{-45}cm^2$**
- ***Then realized that some results, including spectrum and signatures, seems valid for any compactified string theory***
- *Note – some guessed scalars decoupled – here masses derived, not decoupled*

Massive Scalars

- **Key point – study full moduli-like mass matrix – assume (at least one) moduli stabilized by susy-breaking interaction – then showed that smallest moduli mass ~ M3/2 → *moduli and gravitino masses related!***

  (NEW, Acharya, GK, Kuflik, **arXiv:1006.3272**)

- Cosmology (BBN, or energy density) → moduli masses ⌧ 30 TeV →M3/2 ⌧ 30 TeV
- Then supergravity implies scalars (squarks etc) and trilinears ⌧ 30 TeV
- Gauginos too? No in M theory, probably no generically
- Known that if only usual moduli in the theory get AdS minima, not deS
- Generically also have chiral matter at conical singularities on G2, CY manifolds, submanifolds – cannot neglect – condense to mesons, meson F terms positive, raise potential so metastable deS minimum, so these F terms are main contribution to susy-breaking
- Mesons not in gauge kinetic function so do not contribute to leading term for gaugino masses → gaugino masses suppressed ⌧ 50 in M-theory (at low scale)
- True in M-theory/G2 – some such additional susy-breaking contribution must occur in any string theory to have deS minimum → gaugino mass suppression may be generic in string theories

- Run down from ~ 30 TeV, like REWSB, 3rd family runs fastest, stops and sbottoms lighter, dominate gluino decay, get mainly bbbb , ttbb, tttt each plus N1N1 or N2N2 or C1N1 or C1C1 etc for gluino pairs

- EWSB?? Large little hierarchy?? – Fine Tuning an effective theory concept – there are solutions with EWSB, small μ, scalars ~ tens of TeV – have found one analytically, several numerically – need to show boundary conditions for those solutions inevitable in underlying theory

Are there holes?

- Rizzo, Hewett et al. : pMSSM studies
- Schuster et al: Studies with simplified models
  - Also discussed in several other contributions
- Round table discussion
- Emphasize:
  - Searches without MET or high HT (long cascades, stable NLSP, degeneracies, decaying LSP…)
  - Have specific searches for sbottoms and stops
  - Exotica signatures interpreted for SUSY (monojets…)
  - Low mass SUSY scenarios still possible
  - Can we (exp) keep coverage with increasing luminosity?

Supersymmetry Without Prejudice

J. Hewett

Conley, Gainer, JLH, Le, Rizzo , 1103.xxxx,1009.2539

Studying $> 10^7$ models

19 SUSY parameters...

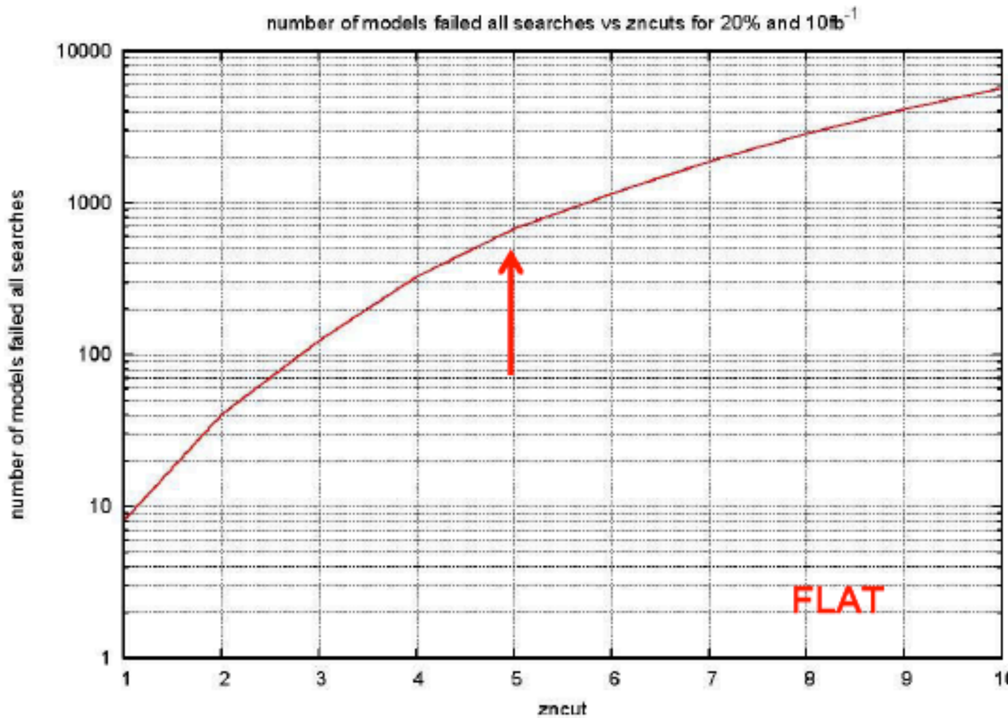
ATLAS pMSSM Model Coverage
RIGHT NOW for ~35 pb $^{-1}$ @ 7 TeV

δB :	100%	50%	20%
FLAT:	16%	29%	39%
LOG :	11%	20%	27%

Wow! This is actually quite impressive as these LHC SUSY searches are just beginning !

Models that fail (10 fb^{-1})

Aside: How many models remain missing in the 'best' case as the minimum requirements of 'S=5' for all searches is weakened?



New analysis strategies needed?

Summary & Conclusions

- ATLAS searches at both 7 &14 TeV (& any value in between) with ~10 fb^{-1} will do quite well at 'discovering' most of the Flat pMSSM models & not at all badly with the Log prior set
- With ~35 pb^{-1} , a reasonable fraction of this model space has already been 'covered' !
- Reducing SM background uncertainties is crucial to enhancing model coverage..
- Models 'missed' primarily due to either compressed spectra *or* because of low MET cascades ending in 'stable' charginos *or*…
- Small spectrum changes CAN be very important !

Avoiding the present limits

H. Baer

Mixed moduli-AMSB models (mirage unification)

Aspects

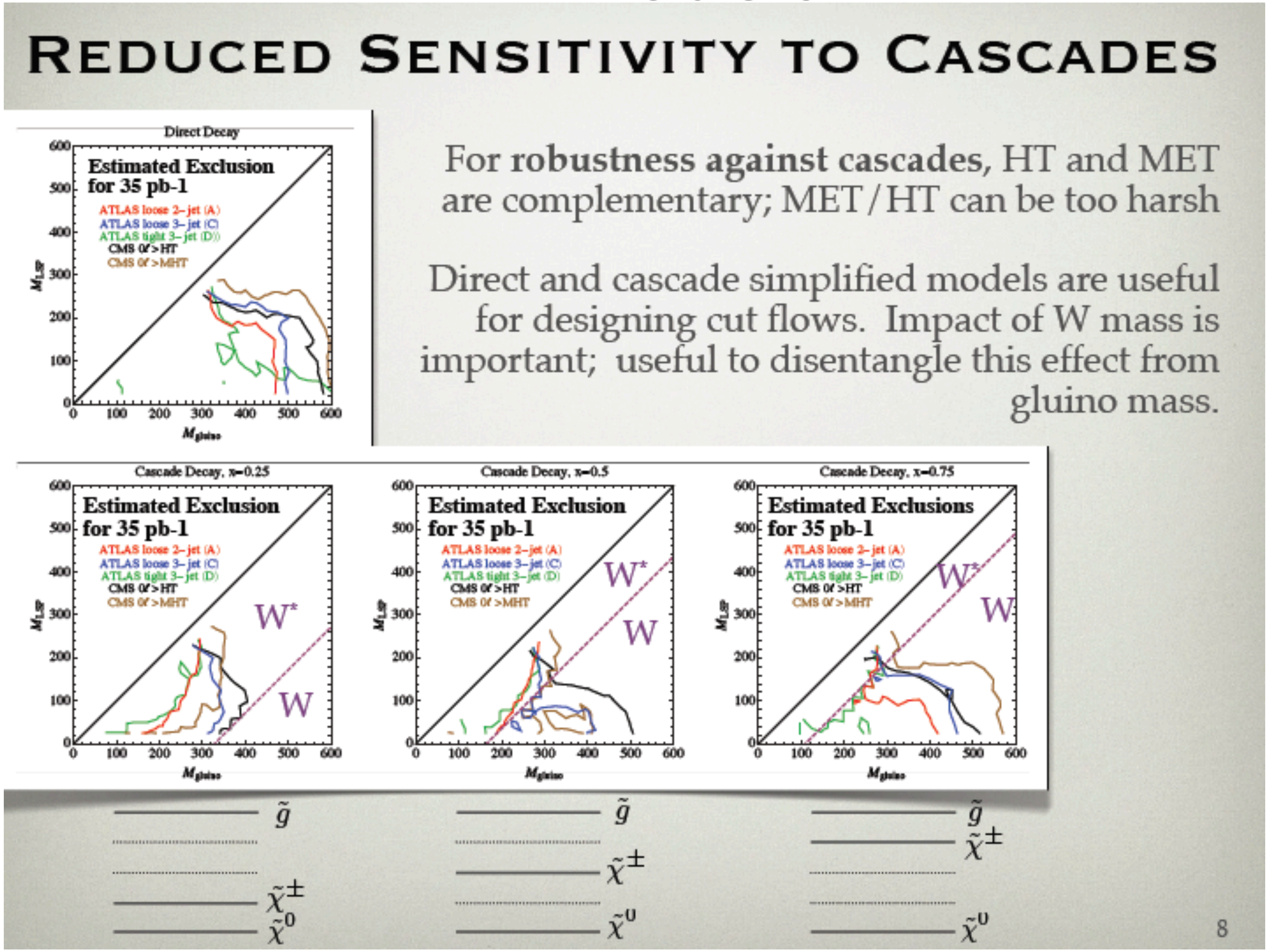
- ★ Inspired by KKLT moduli stabilization and uplifting in string models
- ★ Soft SUSY breaking terms from mixed gravity/anomaly mediation (mix parameter α, Choi et al.)
- ★ Gauge couplings unify at M_{GUT} but soft terms unify at intermediate scale (hence, mirage unification)
- ★ Spectra compressed; for given $m_{\tilde{g}}$, harder to see than mSUGRA/CMSSM at LHC
- ★ Model is pre-programmed in Isasugra/Isajet (model #9)
- ★ Allows solution of gravitino problem, high $T_R > 2 \times 10^9$ GeV allowed, allows for $f_a \sim M_{GUT}$ when mixed axion/LSP dark matter
- ★ See *e.g.* HB, E. Park, X. Tata and T. Wang, JHEP 0608:041,2006 and JHEP 0706:033,2007; HB, A. Lessa, S. Kraml and S. Sekmen, JCAP 1011:040,2010.

Avoiding the present limits

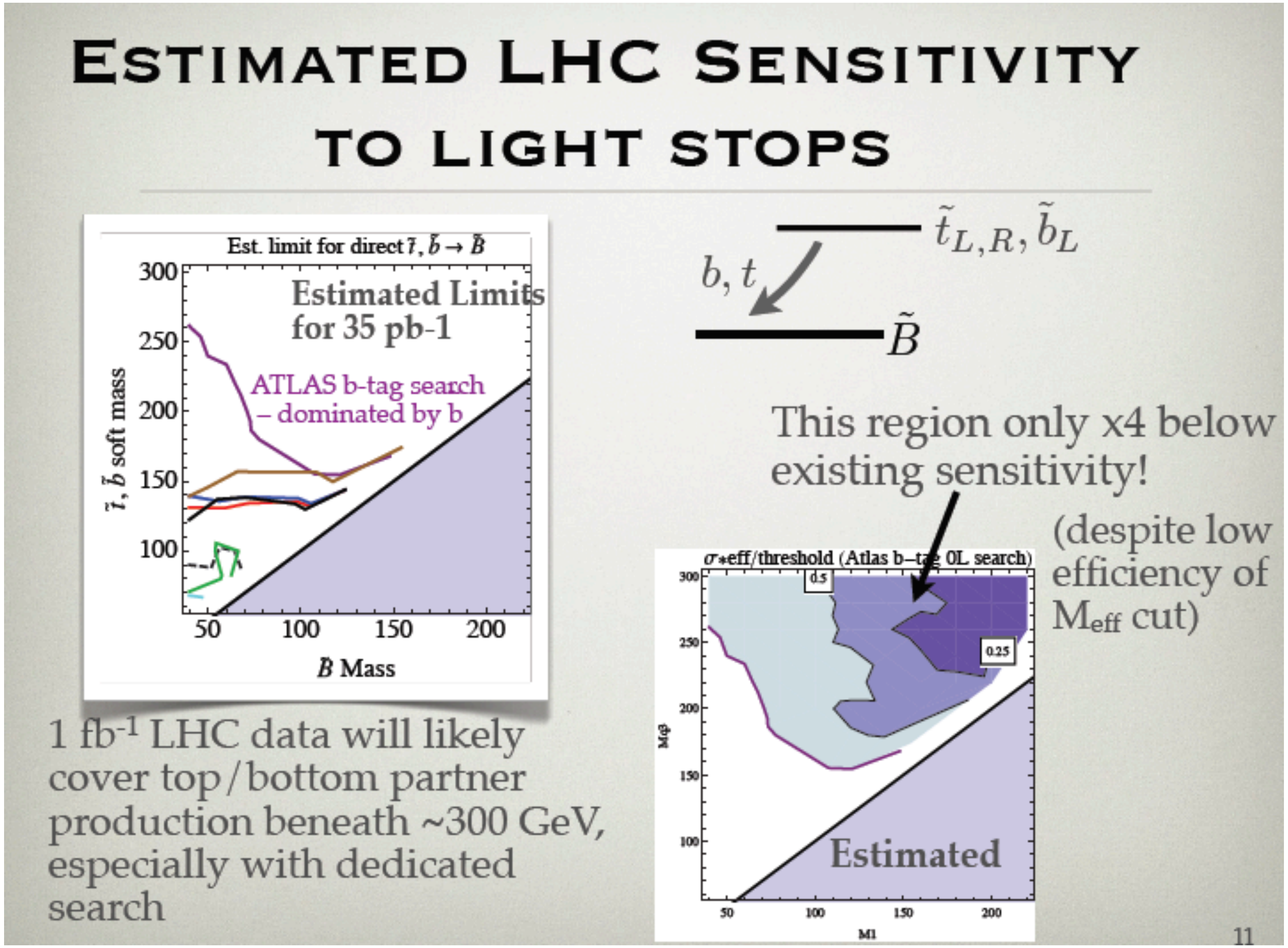
```
ENTER alpha, M_(3/2), tan(beta), sgn(mu), M_t:
4,21000,10,1,173.3
ENTER moduli weights nQ, nD, nU, nL, nE, nHd, nHu [/ for all 0]:
.5,.5,.5,.5,.5,1,1
ENTER moduli parameters L1, L2, L3 [/ for all 1]:
/
Run Isatools? Choose 2=all, 1=some, 0=none:
M_1      = 433.33   M_2       = 494.08  M_3      = 785.15
mu(Q)    = 441.47   B(Q)      =  37.08  Q        = 611.17
M_Hd^2   = 0.244E+05  M_Hu^2  =-0.195E+06 TANBQ  =  14.591

ISAJET masses (with signs):
M(GL) =  820.27
M(UL) =  735.01  M(UR) =  716.75  M(DL) =  739.71  M(DR) =  717.84
M(B1) =  679.88  M(B2) =  714.98  M(T1) =  538.27  M(T2) =  749.67
M(SN) =  443.24  M(EL) =  450.95  M(ER) =  410.52
M(NTAU)=  439.37  M(TAU1)=  400.14  M(TAU2)=  452.30
M(Z1) = -389.53  M(Z2) = -443.91  M(Z3) =  445.47  M(Z4) = -537.28
M(W1) = -408.44  M(W2) = -527.44
M(HL) =  114.60  M(HH) =  472.09  M(HA) =  468.96  M(H+) =  478.79

theta_t=  0.9924  theta_b=  0.4300  theta_l=  1.2674  alpha_h=  0.0715

NEUTRALINO MASSES (SIGNED) = -389.532  -443.910  445.467  -537.279
EIGENVECTOR 1    = -0.49030  0.54897  0.37278 -0.56505
EIGENVECTOR 2    =  0.28127 -0.27972 -0.43961 -0.80585
EIGENVECTOR 3    = -0.70852 -0.70288  0.05374 -0.03263
EIGENVECTOR 4    = -0.42248  0.35545 -0.81541  0.17398
```

Some examples using simplified models

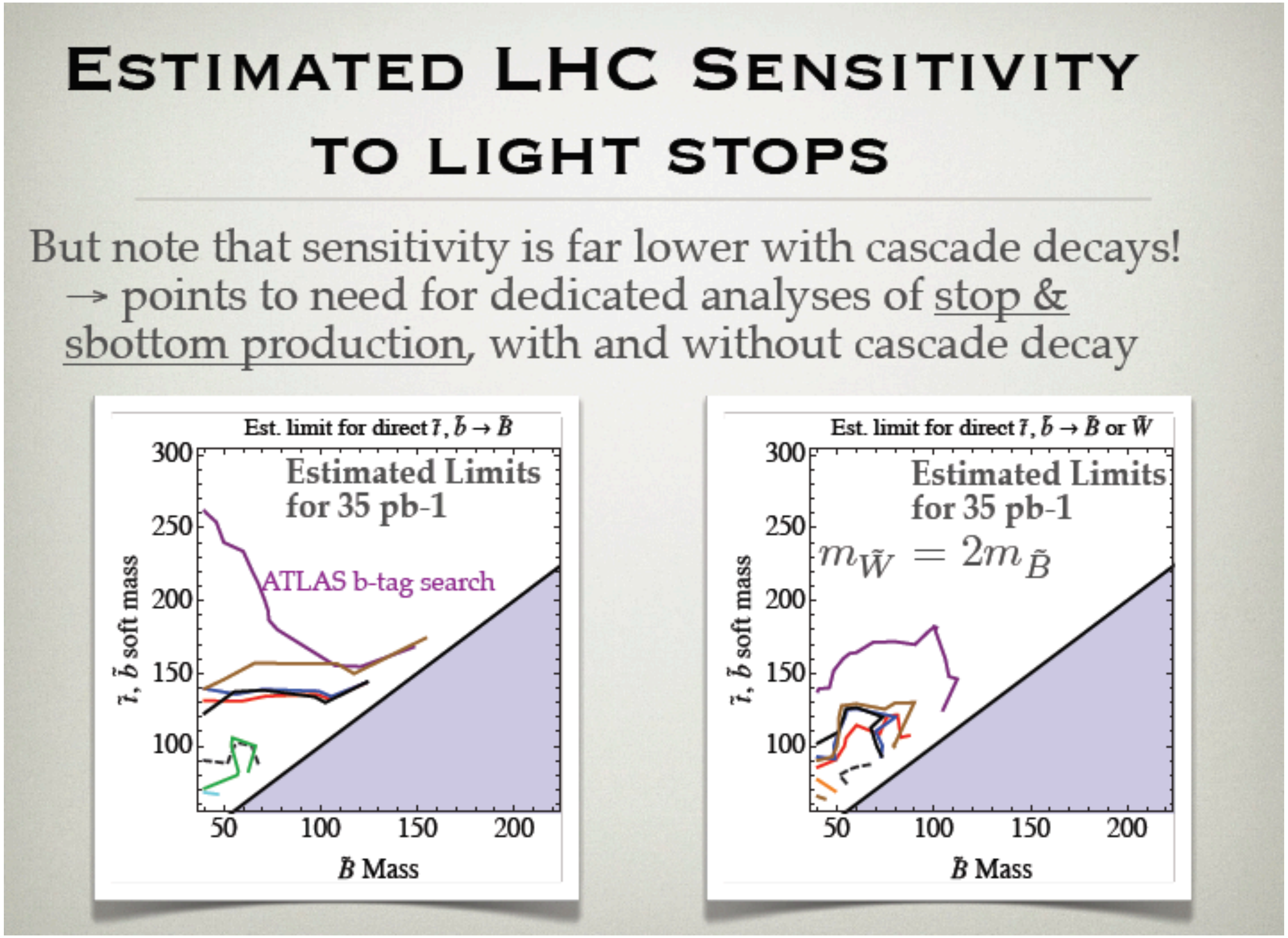
See N. Toro's talk today



Some Examples

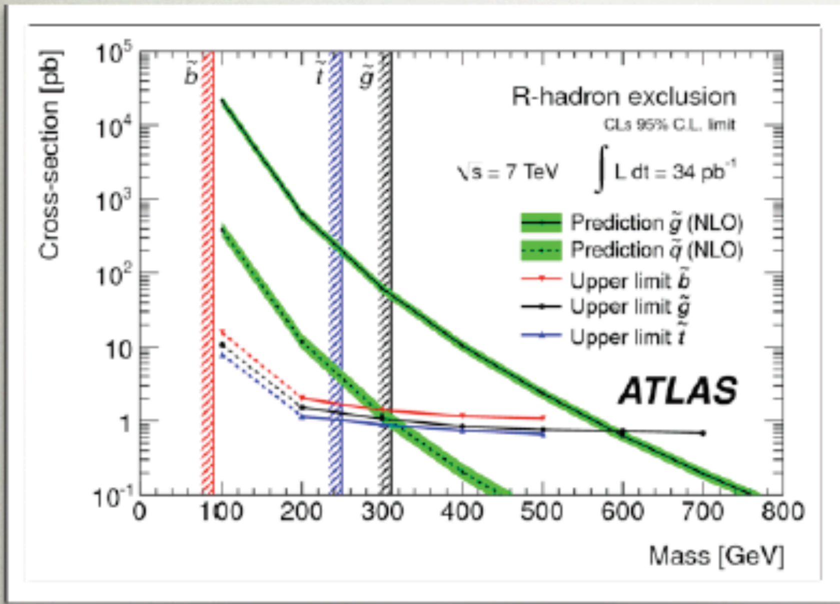


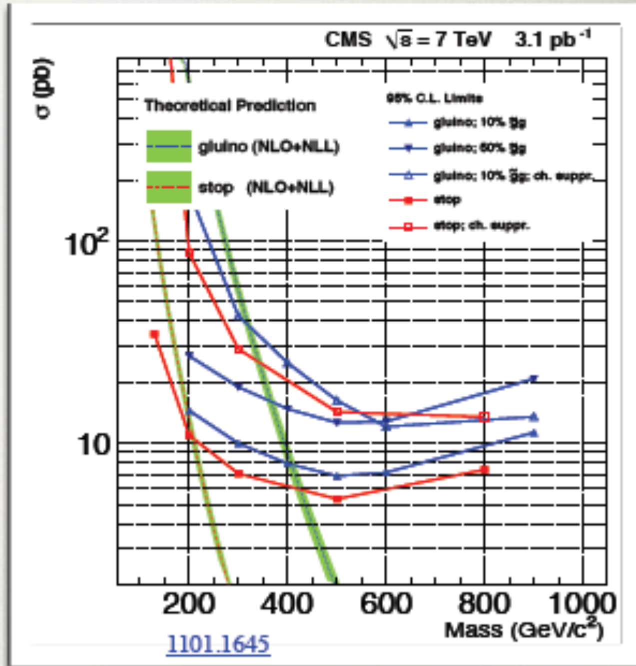
Some Examples



Some Examples

Stable Stop





Sensitivity to βγ<1.5 ⇒ Probably significant constraints on

gluino → top + (stable stop)

from same analysis — is such a study something the R-hadron search groups could look into for next round?

Inverse Problem Studies

Topological Approach to New physics

Myeonghun Park
with P. Konar, K.T. Matchev and G. K. Sarangi

1. How to look for supersymmetry under the lamppost at the LHC. with P. Konar, K. T. Matchev, G. K. Sarangi, Phys.Rev.Lett.105:221801,2010. (arXiv:1008.2483[hep-ph])
2. Follow up paper with P. Konar, K. T. Matchev, G. K. Sarangi

Topological approach

- Model with 9 particles motivated by Supersymmetry
  - UED looks same. (H.Cheng, K.T. Matchev, M. Schmaltz, 2002)
  - We ignore the mass splitting within a multiplet.

$\tilde{u}_L, \tilde{d}_L$	$\tilde{u}_R$	$\tilde{d}_R$	$\tilde{e}_L, \tilde{\nu}_L$	$\tilde{e}_R$	$\tilde{h}^{\pm}, \tilde{h}_u^0, \tilde{h}_d^0$	$\tilde{b}^0$	$\tilde{w}^{\pm}, \tilde{w}^0$	$\tilde{g}$
Q	U	D	L	E	H	B	W	G
M_Q	M_U	M_D	M_L	M_E	M_H	M_B	M_W	M_G

- There are 9! = 362,880 possible permutations.

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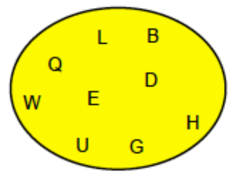


Inverse Problem Studies

Analyzing hierarchies

- First: who is the **LSP** (lightest stable particle)
  - –CHAMP (8!=40,320) if LSP=E
  - –R-hadron (4x8!=161,280) if LSP=G, Q, U or D
  - –Missing energy (4x8!=**161,280**) if LSP=L, H, W or B
- Second: who is the **LCP** (lightest colored particle): G,Q,U, or D
  - –most abundantly produced at hadron colliders
- Total number of distinct hierarchies, starting from LC
  ($x_1x_2x_3$ **C $y_1y_2y_3y_4$ L**) Possible cases = **1,040**.
- For a given hierarchy, how does the LCP decay into LSP?

- By focusing on the finite structure of parameter space, we can cover all possible scenarios.
- We found the inverse map from the signature space to the theory space.
  - We identify the unique solutions.
  - We identify duplicated solutions.
- We provide the relevant topologies to the "simplified model approach" systematically.

How can Theorists work with the present results?

- Use their own simulation (a la PGS) to get the acceptances for their own channels
- (Use ATOM)
- Use acceptance curves for particular analyses
- Use simplified models with corresponding acceptances given by the experiments (now starting)
- Use RECAST (in future)
- Note: publishing of (detector corrected) corrected control distributions is useful as is publishing of likelihoods of the limits.

Traditional phenomenologist approach

- Experimentalists present cross section $\times$ branching ratio limits for a selection of channels using certain cuts.

- Theorists take their model and compute σB at parton level and use PGS to model detector realities and compare.

  After combining channels, limits on $m_{\tilde{g}}, \ldots$ are obtained.

- Considerable work and cross checking is needed to be certain that the PGS being used is really reflective of the fuller GEANT or similar analysis.

  Such checks usually involve reproducing the CMSSM constraints for the channels analyzed by the experiments.

  This approach has a long history and was that employed in SUSY without prejudice for example.

How does a theorist rule out a model?

1. Ask experimentalist friends to redo their analysis for for Model A and tell the answer.

   No work! Easy, more accurate, full simulation.

   Issue: Have to depend on someone else who is really busy.

2. Run a detector simulation, like PGS

   -Get the cuts the experimentalists use

   -Apply the cuts to model

   -Compare expectations to observed number of events (get number of background events from paper)

   Don't have to rely on someone else.

   Issue: PGS has not been validated by ATLAS or CMS

How does a theorist rule out a model?

3. Emulation: Prescribed by the CMS collaboration.

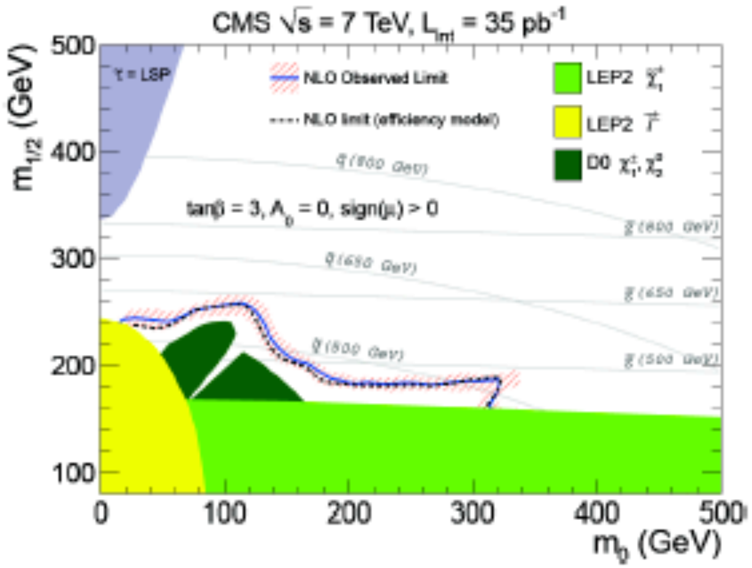
   -Theorist only needs to compute σ.BR

   -Impose cuts at parton level

   -Don't have to worry about Hadronization, Fragmentation or Underlying Event

   Issue: Only given for same sign dilepton channel.

   Must be supplied for each signature → must depend on someone else



Validated PGS approach

- Experimentalists provide a state-of-the-art PGS at frequent intervals that they guarantee reproduces the limits obtained by their analyses for the cuts and so forth quoted.

- Experimentalists provide a comprehensive, easy to use summary of said analyzes, cuts and so forth for use by theorists.

The advantage to the theorists of this approach is that they do not have to spend time validating the PGS that they are using. It, the cuts, the channels employed and so forth would be "certified" by the experimental community.

Theorists would still have to generate the MC parton-level events and then pass them through the appropriate PGS-based analyses.

So far no "validated PGS" (not in the plans right now)

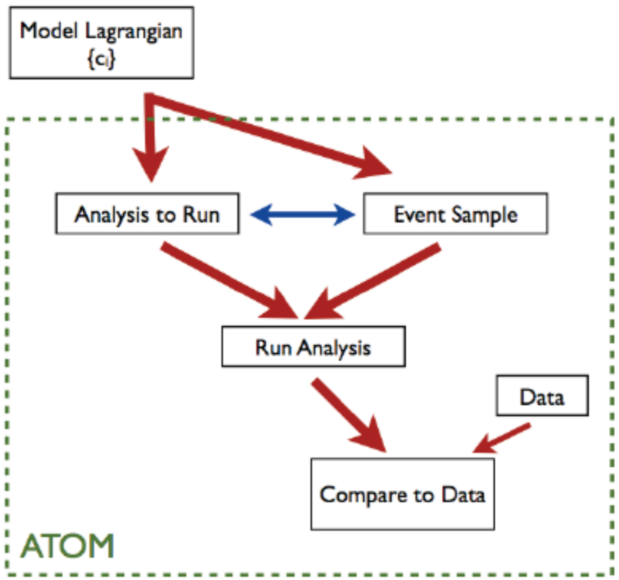
ATOM

See the talk by Chris Vermilion at the LPC:

https://indico.cern.ch/conferenceDisplay.py?confId=135053

In a nutshell the idea is to back up one step and for experimentalists to produce "particle level" (particle = parton) data.

In this approach the raw data is corrected for experimental resolutions, ... and theorists can directly compare their parton-level MC results to data for all available parton-level channels.



- Basic idea: use existing (and growing Rivet library) to automatically test a new model against all available analyses.

Rivet's design emphasises the separation between HepMC records and where they came from, allowing it to be a completely cross-generator validation platform.

Also emphasised is the avoidance of hard-coding reference data or histogram binnings in the analysis code: Rivet provides functions to extract this information from bundled data files, meaning that it is much easier to keep reference and generated data synchronised.

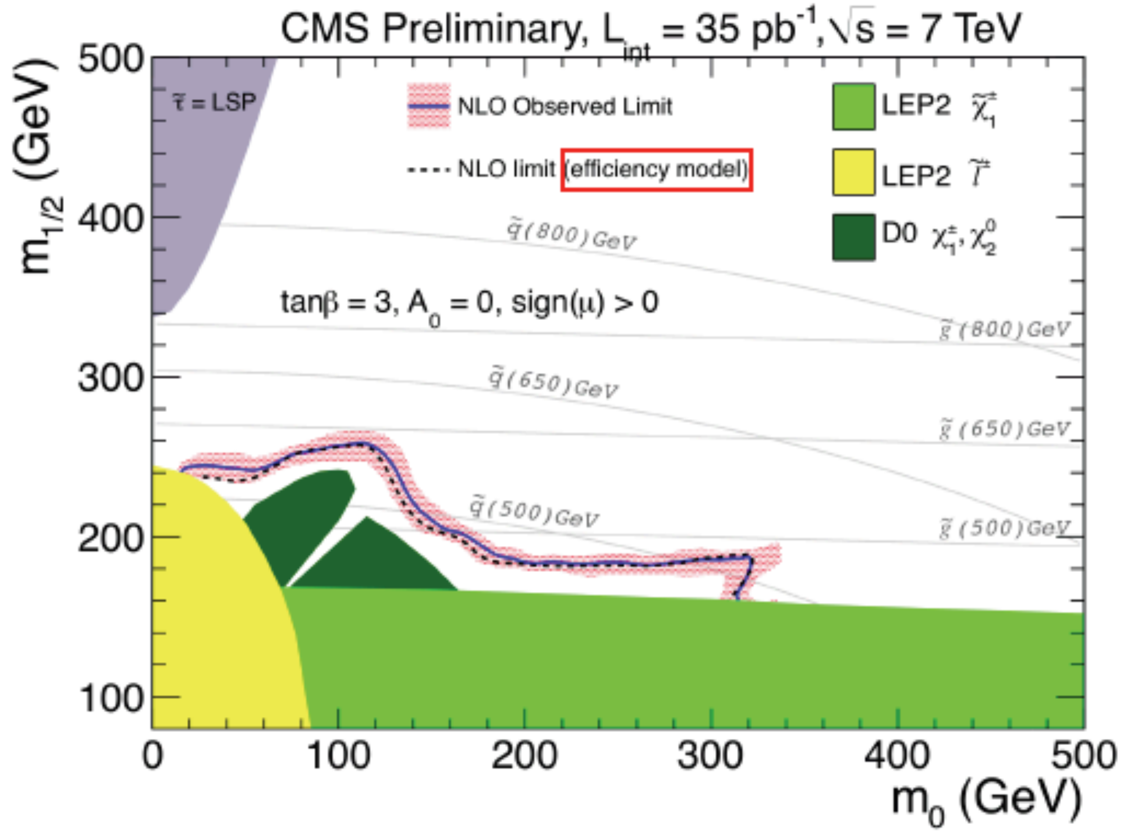
Rivet is summarized by Vermilion as a "framework for creating, collecting analyses".

Ingredients are

- Common set of tools (FastJet jets, lepton isolation, MET, etc.).
- Efficiently re-uses measurements ("Projections").
- Simple way to store an analysis with metadata, experimental results.

Example: Efficiency model for a published analysis

Same sign di-lepton + jets + MET search



Paper includes a simple efficiency model (i.e. for PGS calibrations) and compares full limit to limit with simple model.

Simplified Models

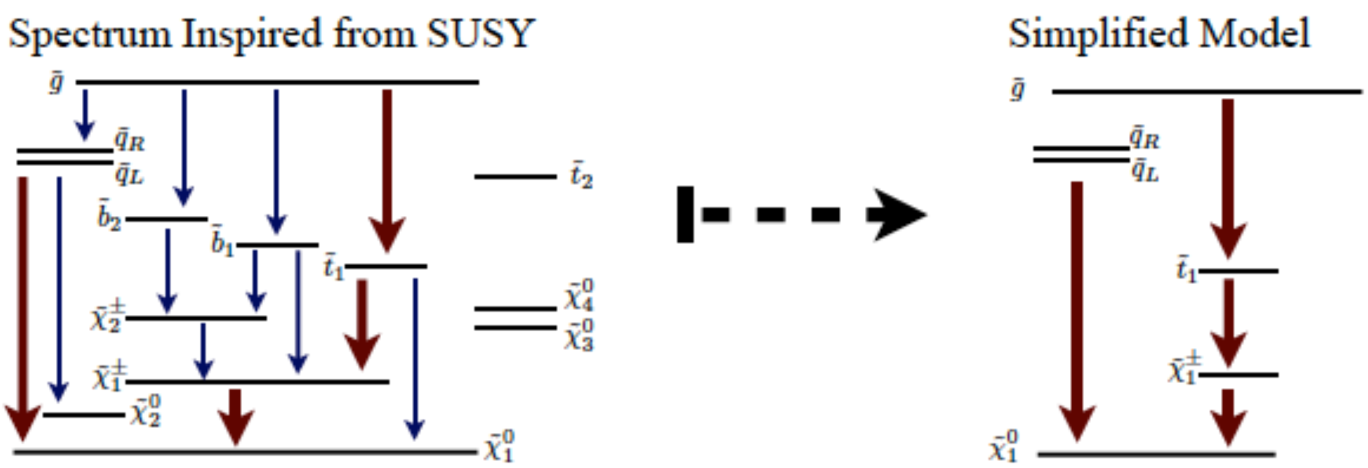
P. Schuster

Simplified Models **For** Collider Physics

Most **Simplified Models** are perfectly valid models, but they are not built to illustrate theoretical mechanisms

SMS are built to emphasize features of an underlying spectrum that matter in a collider search, or in characterizing signals.

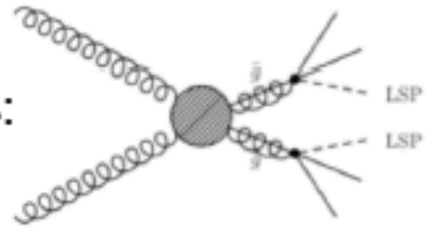
Example

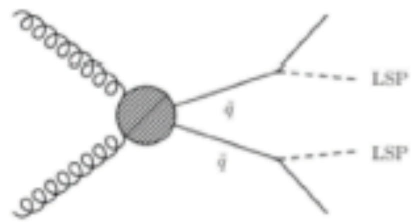


What set of SMS represent SUSY topologies?

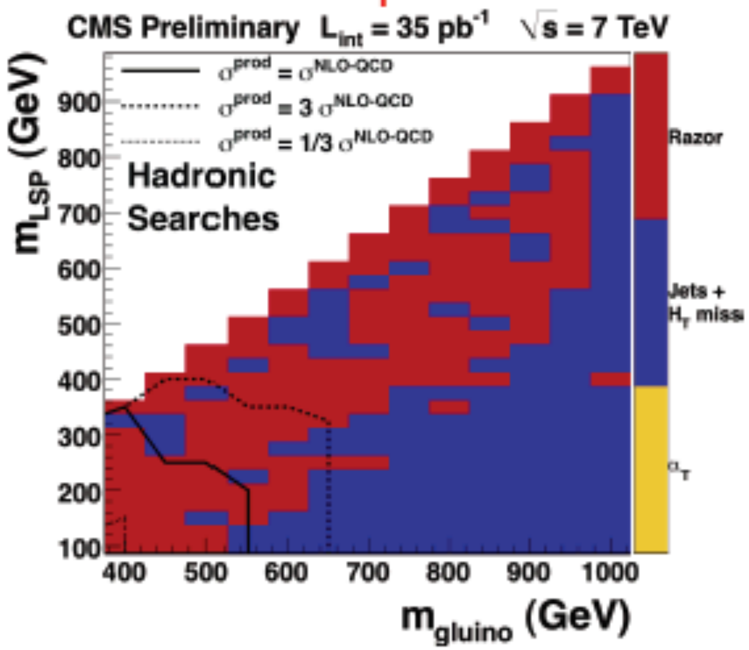
Simplified models

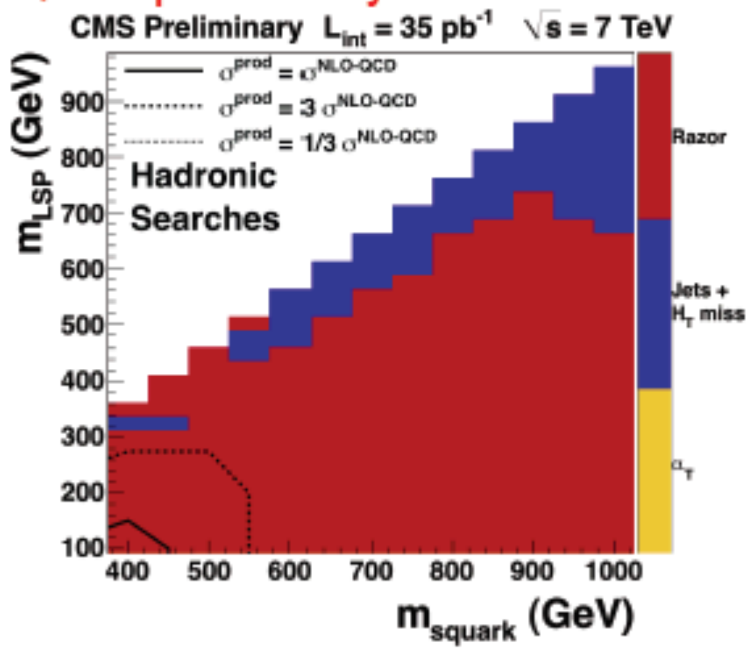
Interpreted hadronic searches
in two simple reference topologies:
gluino & squark pair production
http://www.lhcnewphysics.org





Compared hadronic limits; complementary.





Simplified Models

Baseline interpretations using simplified models have provided clear snapshots of how the searches are performing

Along with kinematic and control region distributions, this is making it much easier to asses search coverage

Please provide plots of control regions and as much in the way of kinematic information about the Standard Model as possible

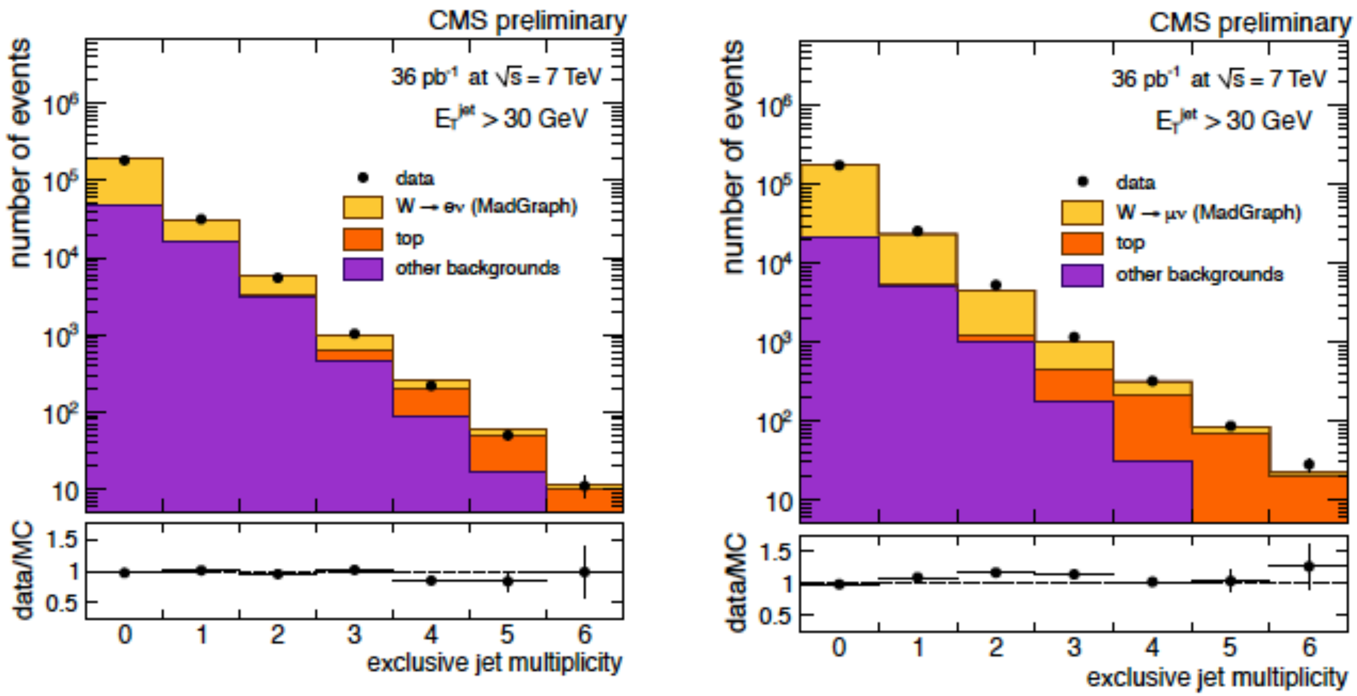
We all know that MET and HT sensitivity is reduced by squeezing the new physics spectrum, increasing the fraction of events that undergo cascade decays, or letting the LSP decay further (or entirely)

Some of this behaviour is evident in the simplified model results

Control plots

Improving Search Robustness and Sensitivity

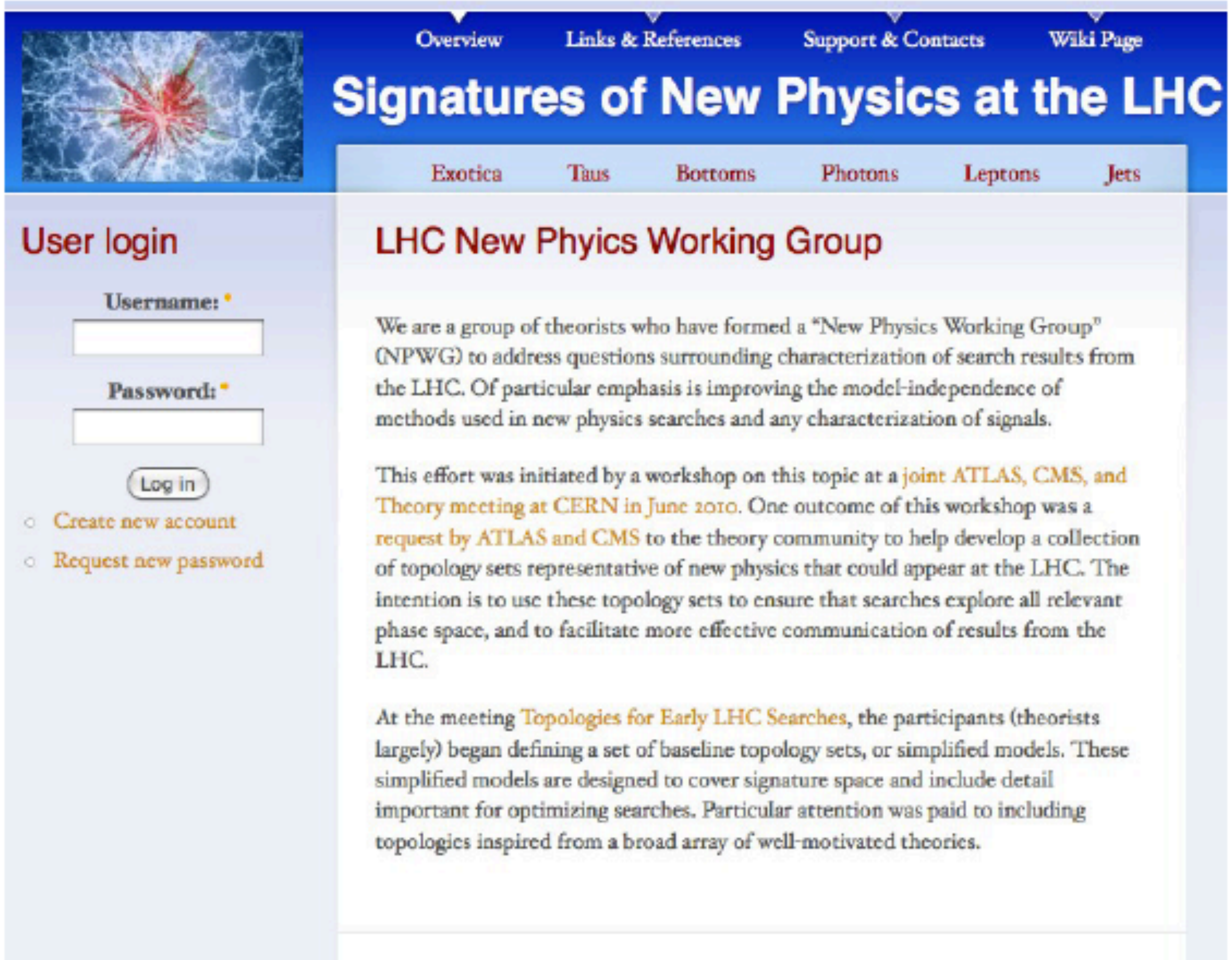
Example: CMS W+ jets measurement
"1-lepton region"



We can tell that 6 jets (certainly fewer with b-tags) above 30 GeV looks like a boundary

Simplified Models

www.lhcnewphysics.org



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Signatures of New Physics at the LHC

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LHC New Phyics Working Group

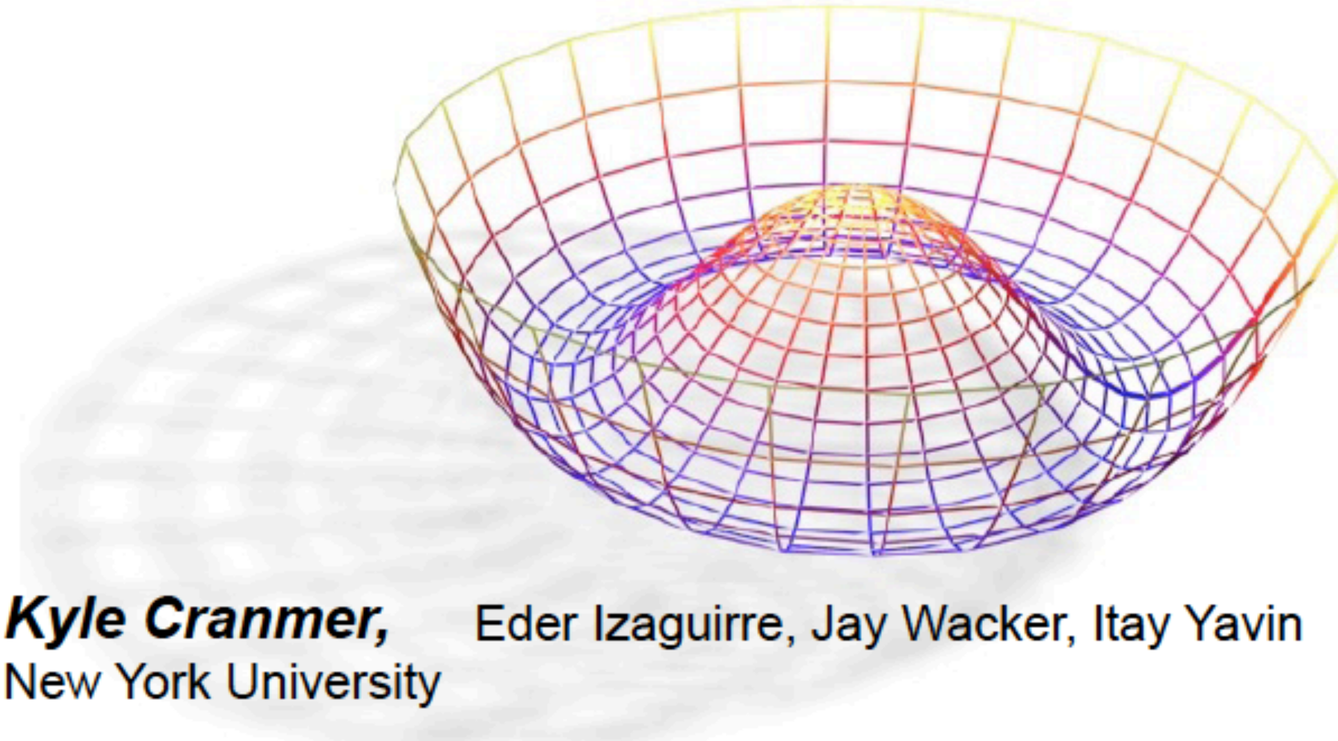
We are a group of theorists who have formed a "New Physics Working Group" (NPWG) to address questions surrounding characterization of search results from the LHC. Of particular emphasis is improving the model-independence of methods used in new physics searches and any characterization of signals.

This effort was initiated by a workshop on this topic at a joint ATLAS, CMS, and Theory meeting at CERN in June 2010. One outcome of this workshop was a request by ATLAS and CMS to the theory community to help develop a collection of topology sets representative of new physics that could appear at the LHC. The intention is to use these topology sets to ensure that searches explore all relevant phase space, and to facilitate more effective communication of results from the LHC.

At the meeting Topologies for Early LHC Searches, the participants (theorists largely) began defining a set of baseline topology sets, or simplified models. These simplified models are designed to cover signature space and include detail important for optimizing searches. Particular attention was paid to including topologies inspired from a broad array of well-motivated theories.

RECAST

RECAST, Closure tests, and a Roadmap for Efficient use of Simplified Models

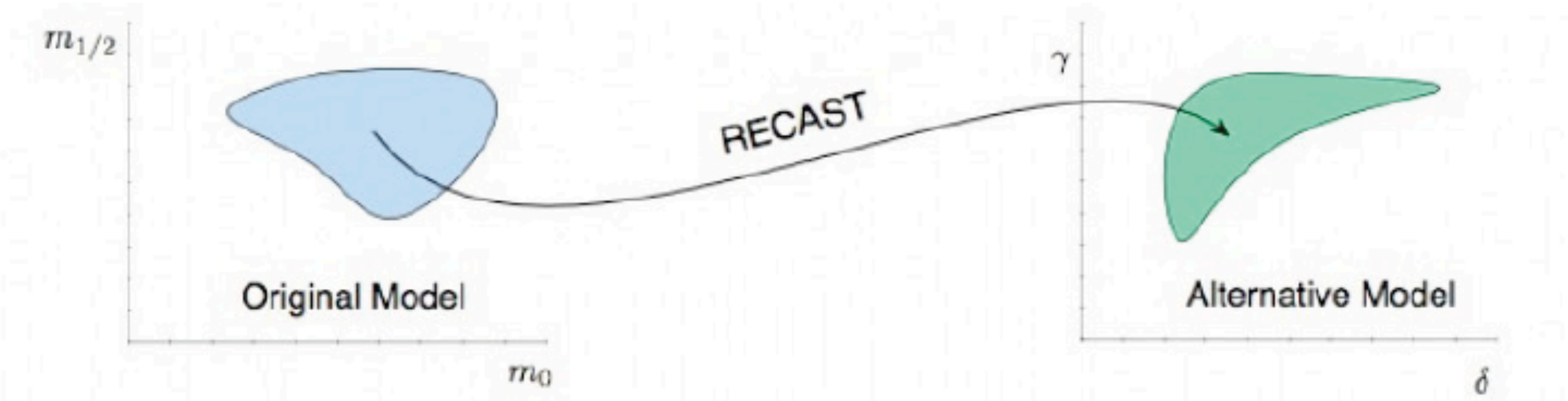


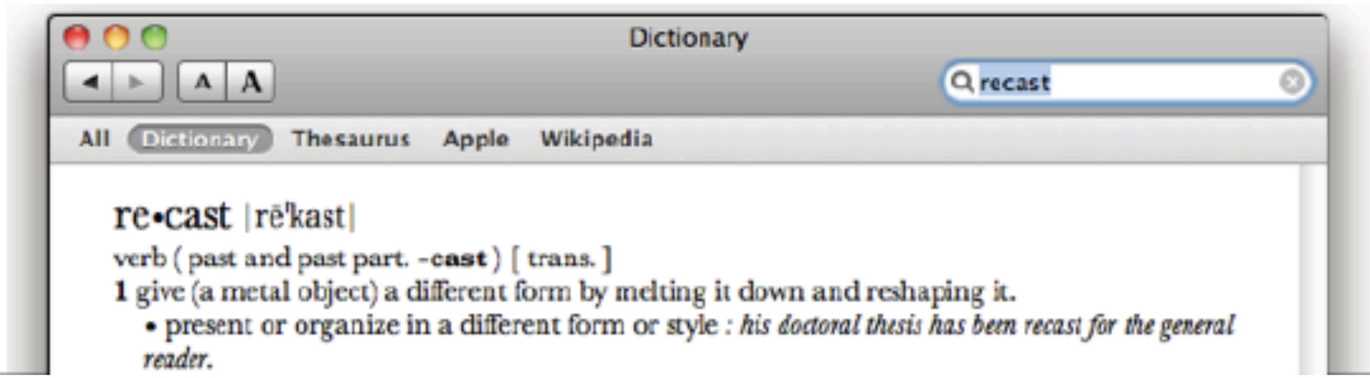
Kyle Cranmer, Eder Izaguirre, Jay Wacker, Itay Yavin
New York University

The recasting technique

Often searches are sensitive to a broader class of models than they were originally designed to test, thus it is natural to ask

What impact does an existing analysis have on an alternative signal?





Examples

Recasting

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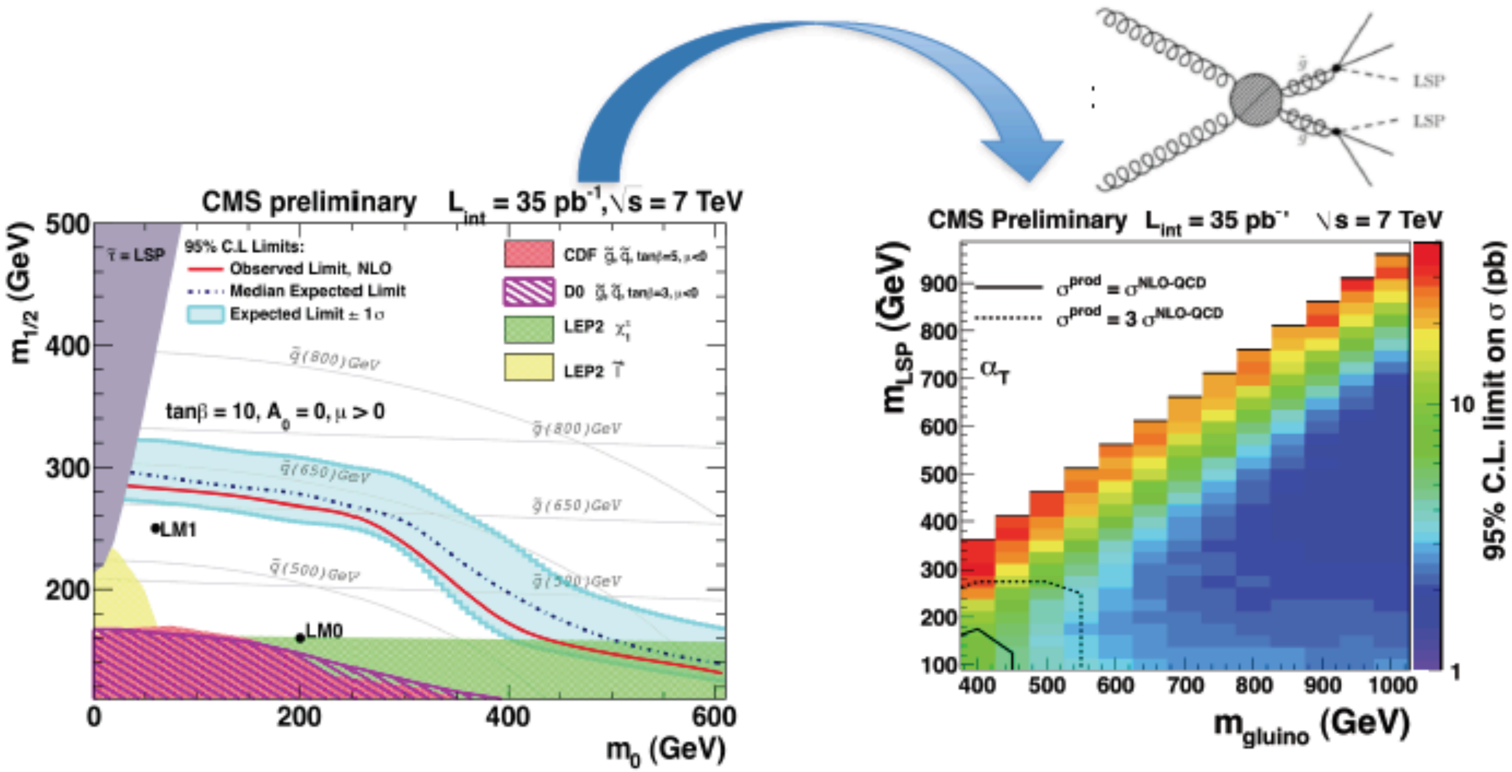
One can, of course, re-interpret the same search (without changing selection) for alternative signal models:

this requires estimate of signal efficiency for alternative model



Examples

OPAL Higgs Searches

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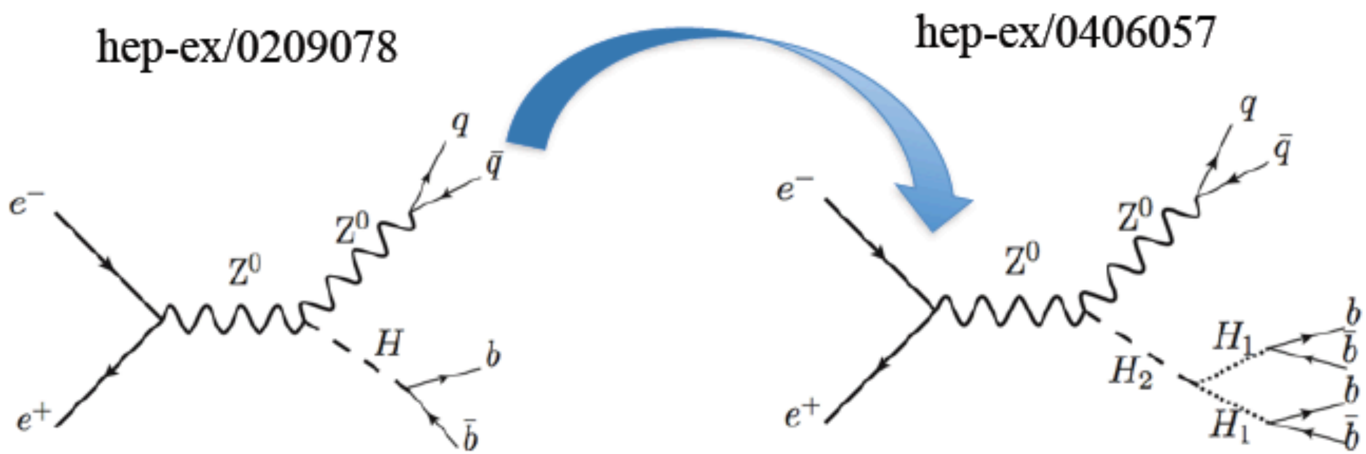
In hep-ex/0406057 OPAL recasted a previous search for Standard Model Higgs to place constraints on MSSM Higgs scenarios Text



Efficient recasting

$m_{\mathcal{H}_2}$ (GeV)	$m_{\mathcal{H}_1}$ (GeV)	Efficiency for the process $\mathcal{H}_2 Z \to b\bar{b}b\bar{b}q\bar{q}$ at $\sqrt{s}$ 192 GeV	196 GeV	200 GeV	202 GeV	206 GeV
100.	12.	0.689	0.684	0.717	0.733	0.693
100.	20.	0.651	0.639	0.653	0.659	0.586
100.	30.	0.460	0.461	0.461	0.470	0.480
100.	40.	0.270	0.260	0.283	0.315	0.323
100.	48.	0.328	0.325	0.361	0.392	0.400

Examples

DELPHI Higgs Searches

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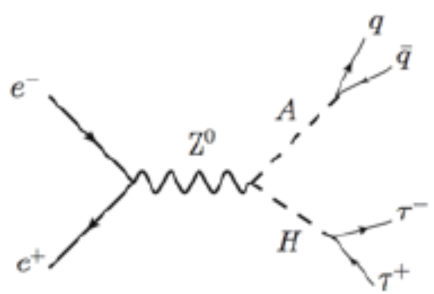
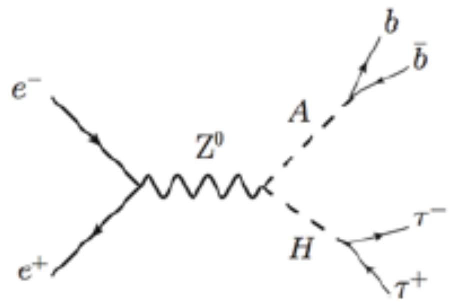
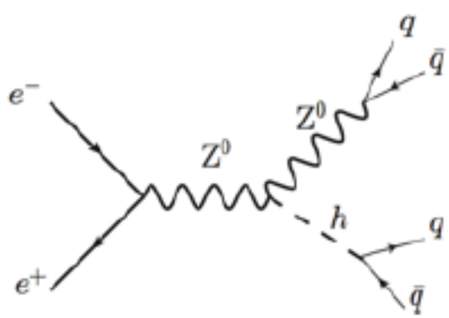
Similar recasting of previous SM Higgs searches was done at DELPHI



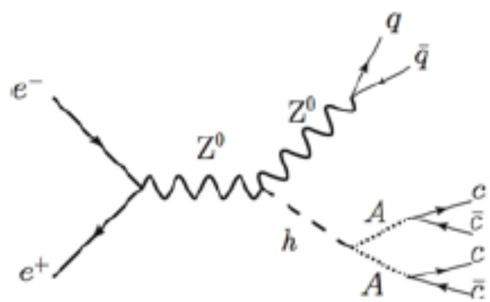
DELPHI Col., Eur. Phys. J. C38 (2004)



DELPHI Col., Eur.Phys.J. C54 (2008)



DELPHI Col., Eur. Phys. J. C23 (2002)



DELPHI Col., Eur.Phys.J. C54 (2008)

The CDF M_{jj} bump in lvjj

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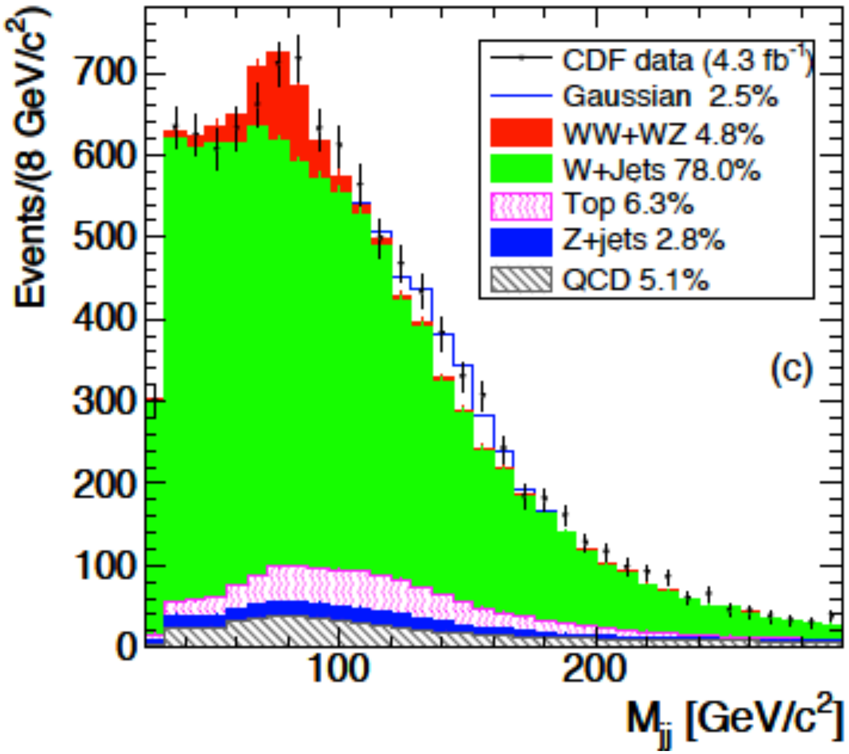
It would be nice to be able to properly recast the myriad of models that are about to be proposed for this bump with the actual detector simulation and reconstruction.



The recasting technique

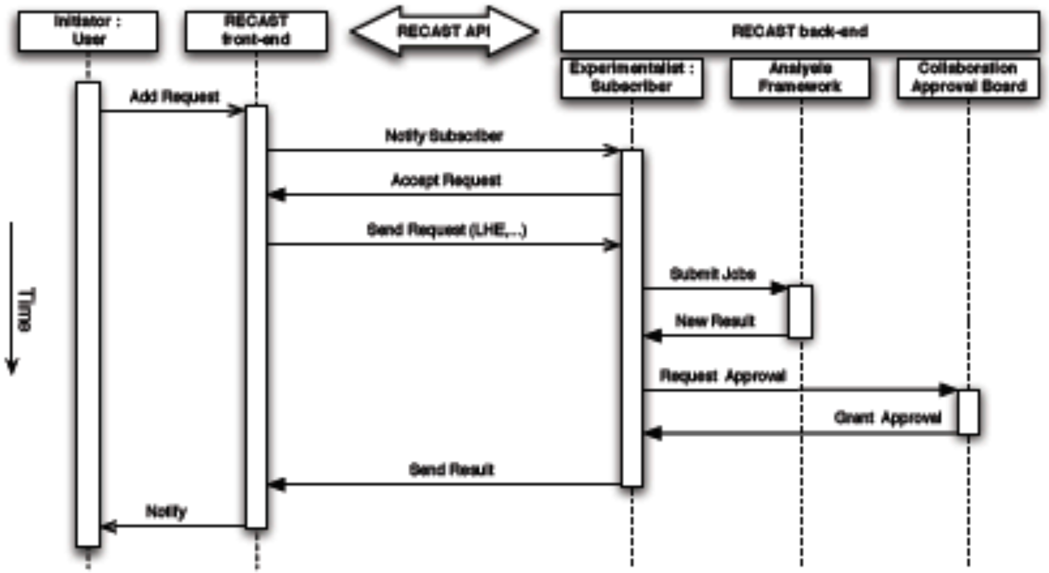
- Does not require access to or reprocessing of the data
- Does not involve design of new event selection criteria
- Does not require additional estimates of background rates or systematic uncertainties

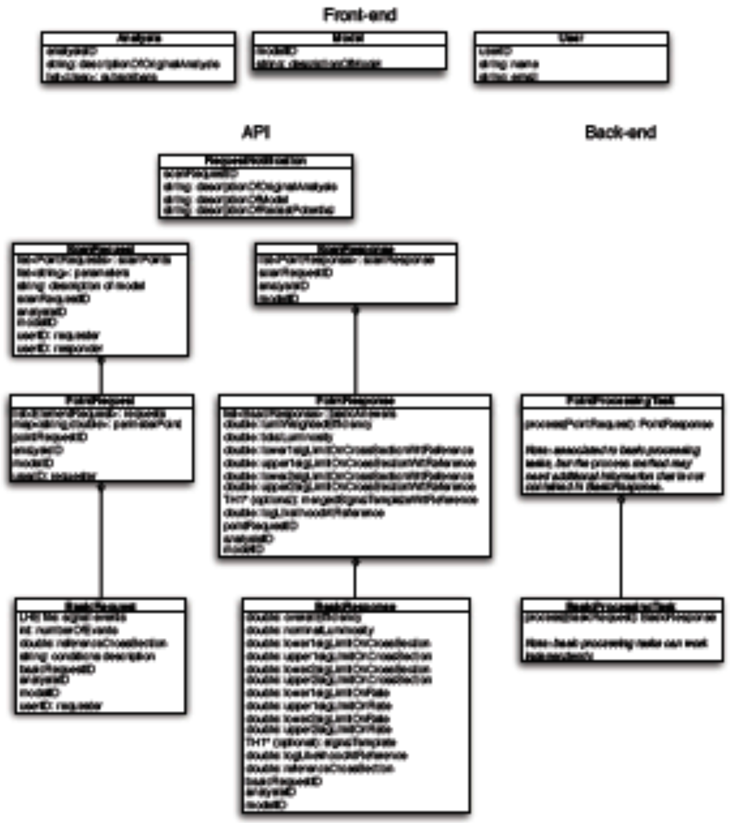
- Extends the impact of existing experimental searches
- Targets physics scenarios of interest to the community
- Provides accurate interpretation of model-independent and signature-based searches in the context of a specific model
- Facilitates the consideration of new models even after the analysis is done
- Allows collaborations to control the approval of new results
- Complements data archival efforts

High Level Design

A first iteration on the high-level design is complete

- identified someone from ATLAS MC production system to start implementing, but this is a side project.
- verbal offer from CERN to provide person to link API with INSPIRE





Details to be worked out

RECAST

In the "full" RECAST approach, implementing analyses is up to the experimentalists and submission of requests by theorists would be standardized.

Basically, RECAST is a framework for theorists to ask experimentalists to re-do analyses with a new signal.

The theorist supplies events, requests specific analysis/analyses, which experimentalists perform, including full detector simulation.

Or, as Mrenna pointed out, if the model is implemented in Pythia or similar, then the theorist need only supply a Pythia card (or cards) which the experimentalists could then use to generate events which they would then process.

A propos

Publishing LEP Higgs as Likelihoods

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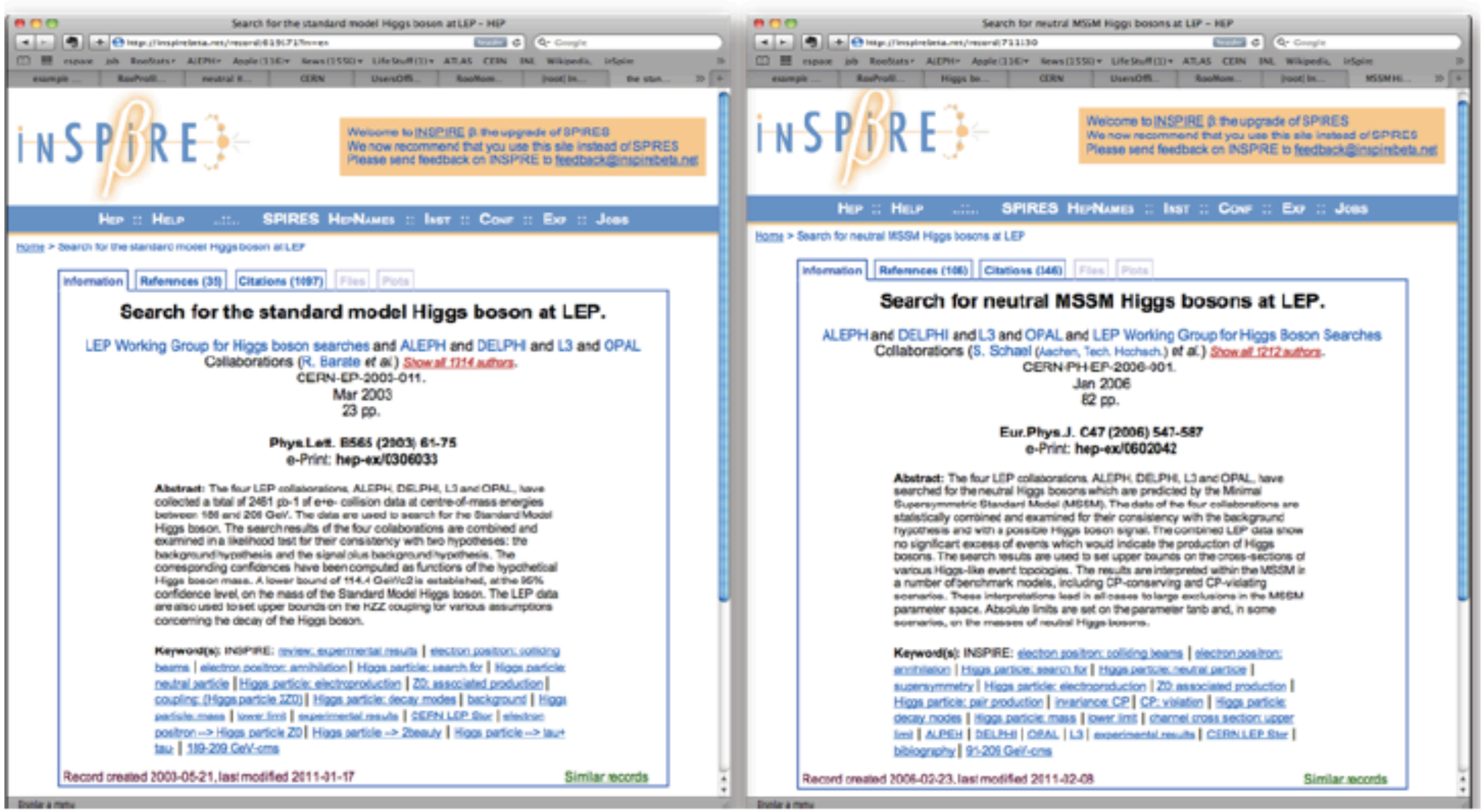
Agreement from all LEP collaborations to convert LEP Higgs searches into RooStats format and publish them (combination?)



RECAST and Simplified Models

1. Theorists propose a variety of simplified models (SMs) and topologies that encapsulate the main production and decay channels needed to adequately represent (see later) all SUSY models.

2. Each such SM is processed through the full experimental analysis and limits are placed on σB for the channels to which a given SM contributes.

3. Theorists can then compare their model predictions directly to these limits for the subprocesses (*specified by production mechanism, chain decays, and final states*) that are present in their model.

The issues are then:

1. A given model concocted by a theorists may have a huge plethora of subprocesses so that it is likely that the SM library will be incomplete.

2. So, the obvious question is how many SMs will need to be processed in order that an arbitrary theoretical model can be tested to a high level of approximation?

Statement of the Closure Test

One of the nagging complaints about the Simplified Model approach is that it hasn't been demonstrated that one can make equivalent statements about a "full model" by bringing together results from simplified models

Closure Test:

Vague statement: show that you can make equivalent statements about the full model based on simplified models

Weak form: limits on the full model parameters based on results from testing the simplified models are always **weaker** than the equivalent statement made directly from the full model (eg. not optimal, but not wrong)

- seems pretty obvious, unless you made a mistake

Strong form: limits on the full model parameters based on results from testing the simplified models are equivalent to the equivalent statement made directly from the full model

- clearly, you would need to cover all the topologies in the full model to expect this could work

Complications from multiple search regions

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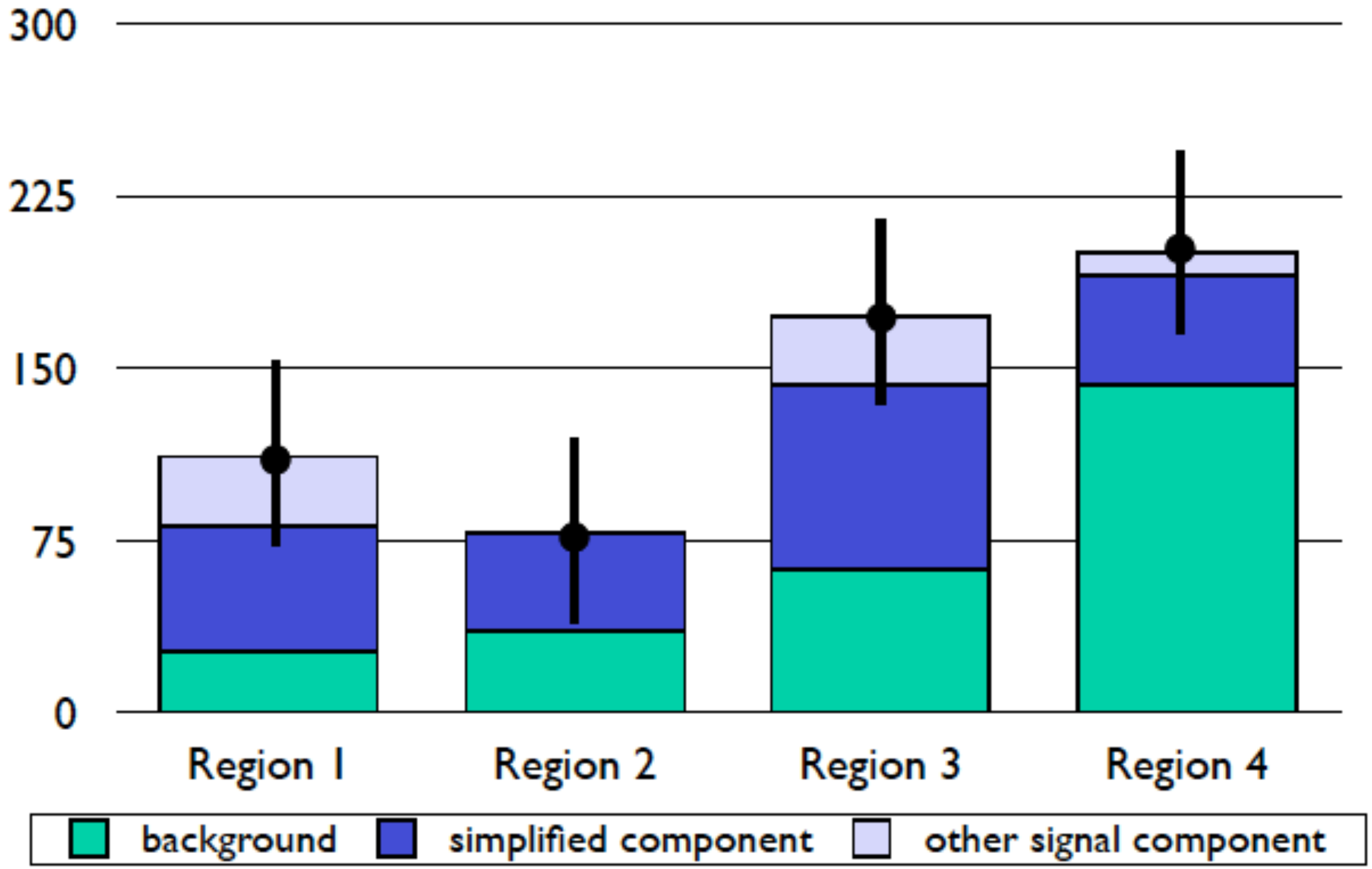
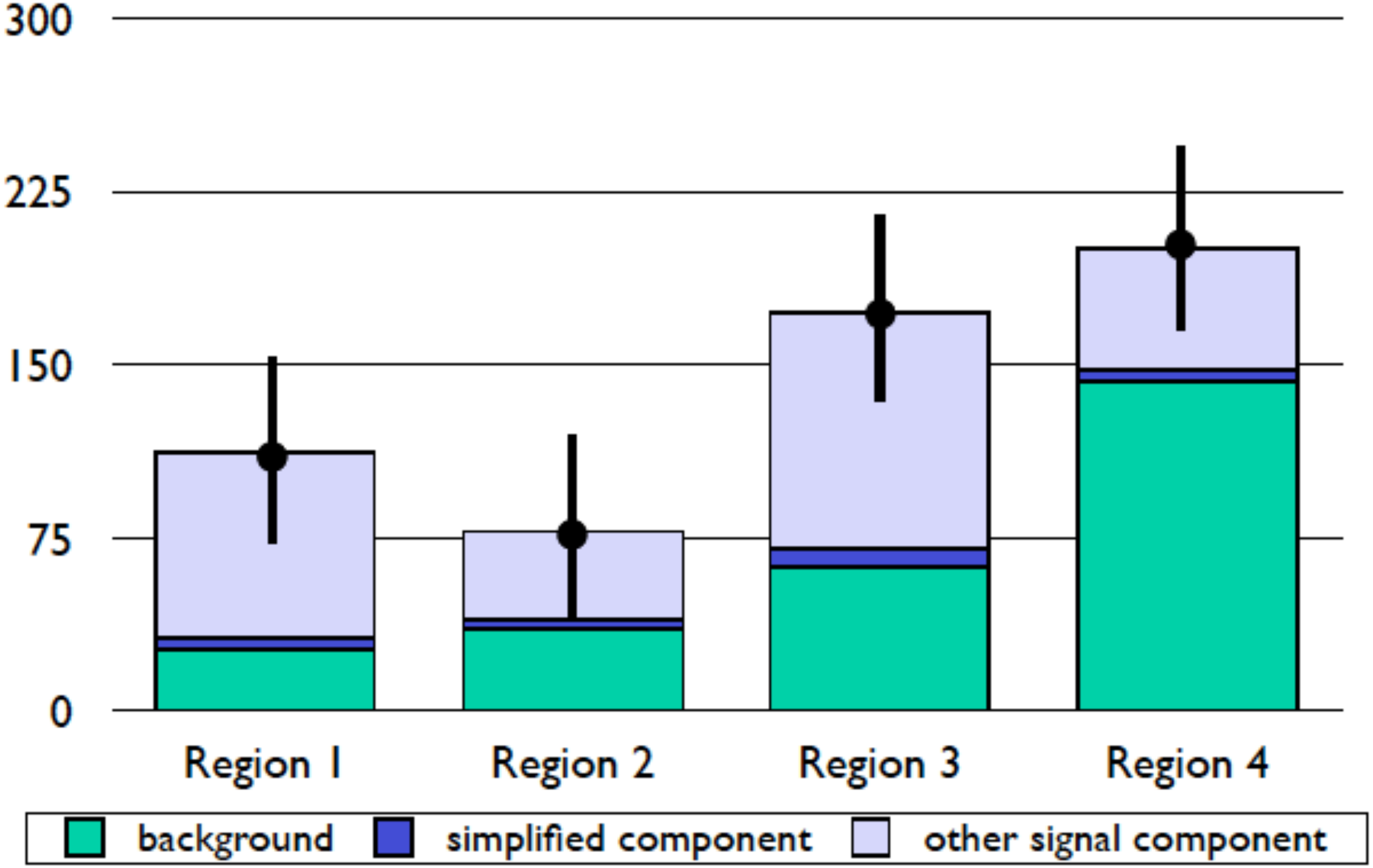
With multiple search regions, one region (2) will be constraining first.



Complications from multiple search regions

No constraint from too few events from simplified model, b/c can always make up the difference with unknown contribution from other signal components.



Weak Closure

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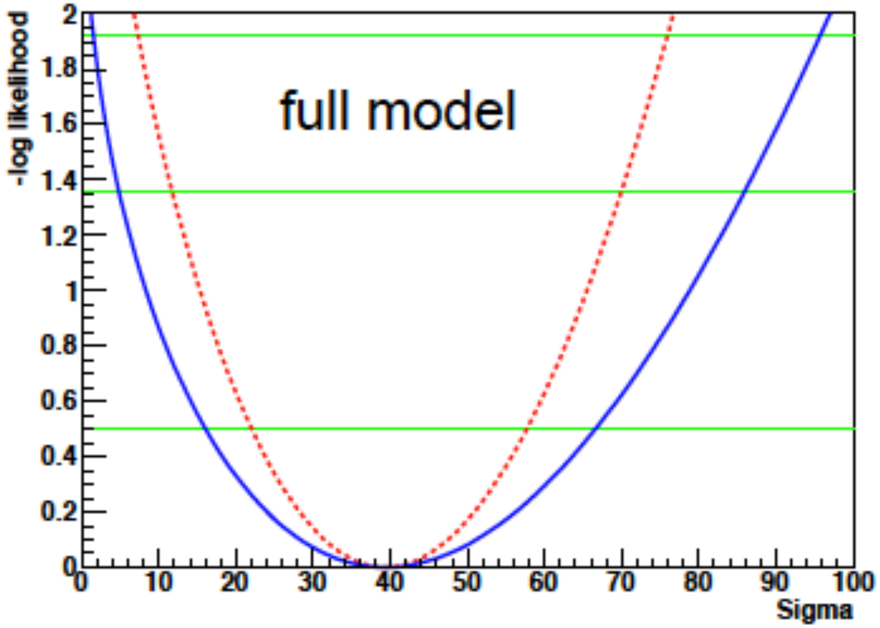
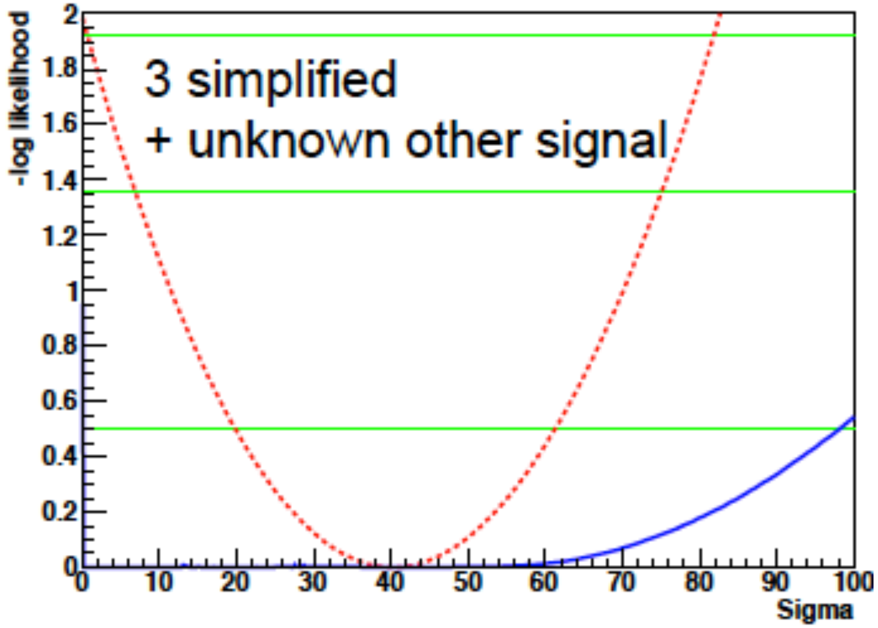
bin-by-bin w/ unknown acceptance from other topologies

- no lower-limit on x-sec b/c other topologies can be responsible for observed excess
- upper limit has at least one search channel contributing (eg. presence of other topologies is 0), but multiple channels might contribute





Conclusions

Existing analyses are sensitive to signals other than the ones they were originally designed to test.

- Recasting those searches for alternative signal models extends the impact of those analyses
- Efficient use of resources

Running simplified models through the existing searches is an example of recasting. The infrastructure developed can be seen as an early form of a RECAST backend for the experiments.

To test full models in the simplified model approach, we need to be able to:

- aggregate signal efficiencies (shapes, yields) for multiple simplified models
  - cross-section limits from individual models ok for “weak closure”, but is not sufficient for “strong closure”
- may need to extend the “grid” scans in the mass parameters of the simplified models

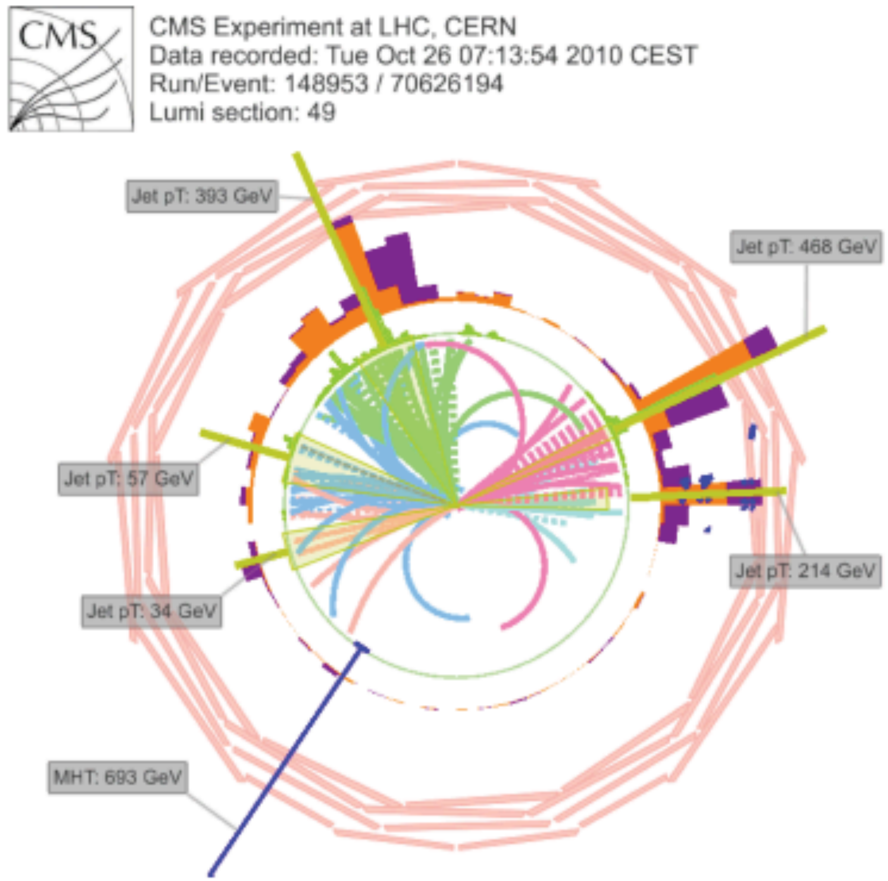
All of these considerations are relevant after discovery when we are trying to figure out what the new physics is.

Conclusion

Accelerator well tuned, back with high luminosity. Expect > 1 fb^{-1} by summer.

…and hopefully more of these…

High MHT candidate event from Jets+MHT search



Peskin's summary

What are we trying to achieve ?

Before discovery, exploratory theoretical studies:

Is my model still alive ? Will my model be constrained by current searches, or does it require study of a new signature ?

After discovery, evaluating models:

Does my model give the correct pattern of observed anomalies ? How do I improve its agreement with the data ?

Archiving of published experimental analyses:

If, in the future, a new model becomes highly motivated, will the experiments be able to test this model against LHC data ?

Levels of analysis for the computation of signals from models:

Run PGS.

Run the fast detector model validated by the collaboration.

With full simulation, compute efficiencies for simplified models over a relevant parameter grid. Use these efficiencies to estimate efficiencies in a more general model. (RECAST might automate the process of generating these.)

Use full simulation to do a complete efficiency calculation for the full model. (Systematize the process with RECAST.)

Experimenters make Ntuples and analysis tools public.

We should be clear on what simplified modes are useful for.

explorations in model space, evaluating search strategies, basis for progressive refinement in relation to data

Simplified models are not meant for obtaining the best limits on full models! The "closure test" is a tautology, but only in complex combinations of models.

It is good to have a single-minded focus on efficiencies.

Experimenters choose search regions and binning in relation to background systematics (esp. data driven). Changing these parameters of an analysis is hard. Theorists should live with these choices.

In this context, it is interesting to ask: What is the efficiency for a model to produce signal in each bin of each final histogram? These efficiencies can be evaluated systematically at least for simplified models. This approaches reduces "shape analyses" to "counting experiments".

There is a connection between model exploration with data and the archiving and publishing of large databases.

We should exploit this connection to build support for systematic approaches to opening the LHC data. Governments and the CERN directorate have declared support for "open access" publishing. Large experimental collaborations -- especially those that are disappearing -- see the importance of long-term data archiving with needed analysis tools.

We need a solution to this problem for the complex LHC data sets. RECAST is a solution -- and, today, the only one on the table.