COORDINATING SIMPLIFIED MODELS

Jay Wacker

LPCC Meeting

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Simplified Models have come a long way in the past few years

They have

Reduced the model dependence of searches

Opened up new regions of parameter space

Made interpreting results easier

However, there still is a long way to go

The coverage is spotty

Requires extensive MC work

Need more tools to facilitate use of results

OUTLINE

1. Review of Simplified Model Motivation
2. The Need for Coordination
3. How to Coordinate
    a. Topologies
    b. Analyses

REVIEW OF SIMPLIFIED MODELS

Specific models have far too many parameters

e.g. RPC pMSSM has 19

Most of the parameters not critical for specific searches

"Motivated" model dependent assumptions to reduce the number of parameters, but at the cost of loss of generality

Experimental searches should be as general as possible

REVIEW OF SIMPLIFIED MODELS

Simplified Models have become the standard way of reducing model dependence in searches

Simplified Models are full Lagrangian models that eliminate additional particles not necessary for specific searches

SIMPLIFIED MODEL EXAMPLE

Gluino with heavy squarks and a single light neutralino

$$\begin{aligned}\mathcal{L} &= \mathcal{L}_{\rm SM} + \bar{\tilde{g}}(i\not{D} - m_{\tilde{g}})\tilde{g} + \bar{\chi}^0(i\not{\partial} - m_{\chi^0})\chi^0 \\ &\quad + \frac{\kappa_{ij}}{\Lambda^2}\tilde{g}^A\bar{q}_i T^A q_j \bar{\chi}^0 + \text{ h.c.}\end{aligned}$$

Single simplified model has lots of diversity

Assume: u,d,c,s indistinguishable

$$\tilde{g} \to \begin{cases} q\bar{q}\chi^0 \\ b\bar{b}\chi^0 \\ t\bar{t}\chi^0 \end{cases}$$

No single decay mode is necessarily 100% Br

TOPOLOGIES

A topology is a specific production and a decay mode

Single Simplified Model has several topologies

$$pp \to \tilde{g}\tilde{g} \to (q\bar{q} \oplus b\bar{b} \oplus t\bar{t})\chi^0 \otimes (q\bar{q} \oplus b\bar{b} \oplus t\bar{t})\chi^0$$

$$pp \to \chi^0\chi^0 \begin{cases} q\bar{q}q\bar{q} \\ q\bar{q}b\bar{b} \\ q\bar{q}t\bar{t} \\ b\bar{b}b\bar{b} \\ b\bar{b}t\bar{t} \\ t\bar{t}t\bar{t} \end{cases}$$

6 topologies

Sizeable amount of work to cover this topology

More if t_L and t_R are separated

TOPOLOGIES

Topologies are what Simplified Model searches study

Production and Decay Modes factorize

Can easily rescale results if a BR is not 100%

Relatively easy to take production cross sections and a decay table and get limits

```
#                              ================
#                              |The decay table|
#                              ================
#
# - The QCD corrections to the decays gluino -> squark  + quark
#                                     squark -> gaugino + quark_prime
#                                     squark -> squark_prime + Higgs
#                                     squark -> gluino  + quark
#   are included.
#
# - The multi-body decays for the inos, stops and sbottoms are included.
#
# - The loop induced decays for the gluino, neutralinos and stops
#   are included.
#
# - The SUSY decays of the top quark are included.
#
#
#          PDG            Width
DECAY         6     1.44086637E+00   # top decays
#           BR         NDA      ID1       ID2
     1.00000000E+00    2          5        24   # BR(t ->  b    W+)
#
#          PDG            Width
DECAY   1000021     4.82210243E-02   # gluino decays
#           BR         NDA      ID1       ID2
     5.04287101E-06    2     1000022        21   # BR(~g -> ~chi_10 g)
     1.69695676E-05    2     1000023        21   # BR(~g -> ~chi_20 g)
#           BR         NDA      ID1       ID2       ID3
     1.58291728E-02    3     1000022         1        -1   # BR(~g -> ~chi_10 d  db)
     5.83772898E-02    3     1000023         1        -1   # BR(~g -> ~chi_20 d  db)
     5.33523326E-02    3     1000022         2        -2   # BR(~g -> ~chi_10 u  ub)
     5.93305605E-02    3     1000023         2        -2   # BR(~g -> ~chi_20 u  ub)
     1.58291728E-02    3     1000022         3        -3   # BR(~g -> ~chi_10 s  sb)
     5.83772898E-02    3     1000023         3        -3   # BR(~g -> ~chi_20 s  sb)
     5.33523326E-02    3     1000022         4        -4   # BR(~g -> ~chi_10 c  cb)
     5.93305605E-02    3     1000023         4        -4   # BR(~g -> ~chi_20 c  cb)
     8.43315358E-03    3     1000022         5        -5   # BR(~g -> ~chi_10 b  bb)
     3.02211594E-02    3     1000023         5        -5   # BR(~g -> ~chi_20 b  bb)
     1.61160823E-02    3     1000022         6        -6   # BR(~g -> ~chi_10 t  tb)
     1.38836179E-02    3     1000023         6        -6   # BR(~g -> ~chi_20 t  tb)
```

USING RESULTS FROM SIMPLIFIED MODELS

Each search has some sensitivity

For a specific Simplified Model topology, each search results

Fraction of events to pass search's cut

$$\epsilon(pp \to X \to y)$$

A full model can be decomposed into topologies and add together

EFFICIENCIES

Efficiencies are more multipurpose

Can compute limit on a specific topology

Can combine several topologies to get a tighter limit on a full model

$$\epsilon\left(\begin{cases} q\bar{q}q\bar{q}\chi^0\chi^0 \\ q\bar{q}b\bar{b}\chi^0\chi^0 \\ q\bar{q}t\bar{t}\chi^0\chi^0 \\ b\bar{b}b\bar{b}\chi^0\chi^0 \\ b\bar{b}t\bar{t}\chi^0\chi^0 \\ t\bar{t}t\bar{t}\chi^0\chi^0 \end{cases}\right) = \begin{cases} 1\% \\ 10\% \\ 15\% \\ 20\% \\ 25\% \\ 30\% \end{cases}$$

$$\mathrm{Br}\left(\tilde{g} \to \begin{cases} q\bar{q}\chi^0 \\ b\bar{b}\chi^0 \\ t\bar{t}\chi^0 \end{cases}\right) = \begin{cases} 60\% \\ 20\% \\ 20\% \end{cases}$$

A little multiplication yields 10.36% efficiency

No single topology more than 3.6%

LIMITS ON CROSS SECTIONS

From the efficiencies limits can be calculated

$$\sum_y \sigma(pp \to X)\,\mathrm{Br}(X \to y)\,\epsilon(pp \to X \to y) \leq \sigma_{95\%}$$

Want limit

Result from theory

Result from reanalysis

Result from search

Even with missing final states, upper bounds are possible, but the more final states, the better

THE SIMPLIFIED MODEL DREAM

Take a full model and decompose it into topologies
and be able to determine if it is excluded
(or in case of discovery, if it fits the anomaly)

Individual groups are getting close for
RPC MSSM with short decay chains

NEED MANY MORE TOPOLOGIES

Some basic topologies have been extensively studied

Squark-Gluino-Neutralino hasn't been fully done

Squark/Gluino → EWino → LSP

RPV hasn't been extensively covered

RS & Little Higgs Models

e.g. Top Partners and Colorons

UED version of these signals hasn't been done

(altering spin might be done by reweighting)

WHY NOT LEAVE IT TO THE COLLABORATIONS?

Performing Simplified Model grid scans requires a lot of signal Monte Carlo work

Doing extensive MC signal scans isn't the best way to spend computing resources.

Experiments often don't use the same definitions across analyses

THE NEED FOR COORDINATION

There are many topologies to cover

Feasible for a single group to cover a dozen topologies

It is a lot of work to:

1. Produce Events for Scans
2. Transcribe & validate analysis cuts
3. Work out statistics for each search

In practice, there are several groups performing similar studies and duplicating effort

Each group wants their work reusable by others

Difficult to work out discrepancies between groups

PROPOSED MODEL

Small groups would be responsible for maintaining a specific topology

When a new experimental analysis becomes available, it will be encoded and validated and then distributed to groups

When new analyses become available, they would produce efficiency and limit results in a timely fashion

AGENDA FOR MEETING

To determine if this is a viable model

Top Level Organization For

Coordination of Topologies & Analyses

Storage of results

Find interested parties for

Topologies, Analyses & Statistics

Standardize:

Notation for topologies

Efficiency Scans

Analysis cuts

SPECIFIC SESSIONS

Go to day

Tuesday, 29 October 2013

10:30 - 11:00	Introduction *30'* Speaker: Jacob Wacker
11:00 - 11:30	Latest Results From ATLAS *30'* Speaker: Christopher Young (CERN)
11:30 - 12:00	Latest Results From CMS *30'* Speaker: Alessandro Gaz (University of Colorado at Boulder (US))
12:00 - 14:00	Lunch break
14:00 - 14:10	Progress Report from Atom/FastLim *10'* Speaker: Kazuki Sakurai (University of Cambridge)
14:10 - 14:20	Progress Report from SModelS and Aachen *10'* Speaker: Dr. Suchita Kulkarni (LPSC Grenoble)
14:20 - 14:30	Progress Report from MadAnalysis *10'* Speaker: Eric Conte (Institut Pluridisciplinaire Hubert Curien (FR))
14:30 - 14:40	Progress report from Sebastian *10'* Speaker: Sebastian Liem (U)
14:40 - 14:55	Non-SUSY simplified models *15'* Speaker: Giuliano Panico
15:00 - 16:20	Discussion: defining simplified models *Which new simplified models are already considered by the experiments?* *Which models are considered by the pheno groups?* *Which new models should we consider?* Conveners: Prof. Jacob Wacker (SLAC), Zachary Louis Marshall (Lawrence Berkeley National Lab. (US)), Dr. Kazuki Sakurai (King's College London), Andreas Weiler (CERN)
16:20 - 16:40	coffee + tea break (4-2-011 - TH common room)
16:40 - 18:00	Discussion: Prioritization of Simplified Models *What are relevant simplified models?* *Can we we prioritize them and assign them to different goups?* *How do we validate?* *Can we define a standard for a naming convention of the models?* Conveners: Andreas Weiler (CERN), Zachary Louis Marshall (Lawrence Berkeley National Lab. (US))
19:00 - 20:30	Reception *Welcome drink at R1 (near the Kiosk/Crêpe station)*

Wednesday, 30 October 2013

09:00 - 09:30	SMS Scans in ATLAS *30'* Speaker: Takashi Yamanaka (University of Tokyo (JP))
09:30 - 10:00	SMS Scans in CMS *30'* Speaker: Nadja Strobbe (Ghent University (BE))
10:00 - 10:10	Systematic NLSP searches *10'* Speaker: Jenny List (Deutsches Elektronen-Synchrotron (DE))
10:10 - 10:20	Simplified Models and g-2 *10'* Speaker: Dr. Andre Lessa (USP Sao Paolo)
10:20 - 10:30	Application of simplified models in exotic SUSY searches *10'* Speaker: Jan Heisig (University of Hamburg)
10:30 - 10:45	Coffee break
10:45 - 12:00	Discussion: Assessment of the current experimental results *- What information is currently provided by the experiments? Can we use it? How can we use it?* *- What can be improved?* *- Discussion on likelihoods* Conveners: Andreas Weiler (CERN), Sabine Kraml (Centre National de la Recherche Scientifique (FR)), Michele Papucci (Lawrence Berkeley National Lab. (US))
12:00 - 14:00	Lunch break
14:00 - 15:00	CERN-TH colloqium *http://indico.cern.ch/conferenceDisplay.py?confId=275416*
15:00 - 15:15	Coffee break
15:15 - 16:30	Discussion: Definitions of Standards for Efficiency Maps and Reinterpretations *We want to define standards for efficiency maps , upper limit maps, and analysis cuts. Also, we would like to establish a standard procedure for analysis reinterpretation.* Convener: Benjamin Fuks (Institut Pluridisciplinaire Hubert Curien (FR))
16:30 - 16:45	Coffee break
16:45 - 17:30	Technical discussion *Task assignment, etc...* Conveners: Andreas Weiler (CERN), Benjamin Fuks (Institut Pluridisciplinaire Hubert Curien (FR)), Prof. Jacob Wacker (SLAC)
17:30 - 18:00	Summary and conclusions *30'*