Simulation of BSM Physics (II)

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IPPP/Durham
• Today:
  ➡ Effective Field Theory
  ➡ Width computation
  ➡ Narrow width approximation (decay-chain)
  ➡ Mass Production
  ➡ ReCasting
## Available models

<table>
<thead>
<tr>
<th>Model</th>
<th>Short Description</th>
<th>Contact</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard Model</strong></td>
<td>The SM implementation of FeynRules, included into the distribution of the FeynRules package.</td>
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<td><strong>Supersymmetric Models (5)</strong></td>
<td>Various supersymmetric extensions of the SM, including the MSSM, the NMSSM and many more.</td>
<td></td>
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<tr>
<td>Axigluon model</td>
<td>The SM plus a scalar gluon field.</td>
<td>S. Krastanov</td>
<td>Available</td>
</tr>
<tr>
<td>DY SM extension</td>
<td>The SM plus new spin-0, -1, and -2 bosons that contribute to Drell-Yan production of leptons at the LHC.</td>
<td>N. Christensen</td>
<td>Available</td>
</tr>
<tr>
<td>FCNC Higgs interactions</td>
<td>The SM plus higher-dimensional flavor changing Higgs interactions.</td>
<td>S. Krastanov</td>
<td>Available</td>
</tr>
<tr>
<td>Fourth generation model</td>
<td>A fourth generation model including a t' and a b'.</td>
<td>C. Duhr</td>
<td>Available</td>
</tr>
<tr>
<td>General 2HDM</td>
<td>The most general 2HDM, including all flavor violation and mixing terms.</td>
<td>C. Duhr, M. Herquet</td>
<td>Available</td>
</tr>
<tr>
<td>Hidden Abelian Higgs Model</td>
<td>A Z' model where the Z' interacts with the SM through mixings, leading to very small non-SM like Z' couplings.</td>
<td>C. Duhr</td>
<td>Available</td>
</tr>
<tr>
<td>HiggsCharacterisation</td>
<td>The model file for the spin/parity characterisation of a 125 GeV resonance.</td>
<td>P. de Aquino, K. Mawatari</td>
<td>Available</td>
</tr>
<tr>
<td>Higgs effective theory</td>
<td>An add-on for the SM implementation containing the dimension 5 gluon fusion operator.</td>
<td>C. Duhr</td>
<td>Available</td>
</tr>
<tr>
<td>Higgs Effective Lagrangian</td>
<td>Higgs effective Lagrangian including operators up-to dimension 6.</td>
<td>A. Alloul, B. Fuks and V. Sanz</td>
<td>Available</td>
</tr>
<tr>
<td>Higgs Model</td>
<td>A model with an unusual extension of the SM Higgs sector.</td>
<td>P. de Aquino, C. Duhr</td>
<td>Available</td>
</tr>
<tr>
<td>Inert Doublet Model</td>
<td>A model with an additional complex scalar SU(2)_L doublet and an unbroken 22 symmetry under which all SM particles are even while the extra doublet is odd.</td>
<td>A. Goudelis, B. Herrmann, O. Stal</td>
<td>Available</td>
</tr>
<tr>
<td>Minimal Zp models</td>
<td>The minimal Z' extension of the SM.</td>
<td>L. Basso</td>
<td>Available</td>
</tr>
<tr>
<td>Monotops</td>
<td>The SM plus monopole effective Lagrangian.</td>
<td>B. Fuks</td>
<td>Available</td>
</tr>
<tr>
<td>Sextet diquarks</td>
<td>The SM plus sextet diquark scalars.</td>
<td>J. Alwall, C. Duhr</td>
<td>Available</td>
</tr>
<tr>
<td>Standard model + Scalars</td>
<td>The SM, together with a set of singlet scalar particles coupling only to the SM Higgs, and allowing it to decay invisibly into this new scalar sector.</td>
<td>C. Duhr</td>
<td>Available</td>
</tr>
<tr>
<td>Triplet diquarks</td>
<td>The SM plus triplet diquark scalars.</td>
<td>J. Alwall, C. Duhr</td>
<td>Available</td>
</tr>
<tr>
<td>Type III See-Saw Model</td>
<td>The SM, including neutrino masses coming from a type III See-Saw mechanism.</td>
<td>C. Biggio, F. Bonnet</td>
<td>Available</td>
</tr>
<tr>
<td>Wprime</td>
<td>The SM a new spin-1 W' boson.</td>
<td>J. Donini, B. Fuks</td>
<td>Available</td>
</tr>
<tr>
<td>Available models</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
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<td></td>
</tr>
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<td><strong>Extra-dimensional Models (4)</strong></td>
<td>Extensions of the SM including KK excitations of the SM particles.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Strongly coupled and effective field theories (8)</strong></td>
<td>Including Technicolor, Little Higgs, as well as SM higher-dimensional operators, vector-like quarks.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Miscellaneous (0)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Effective Operator

- New Physics at (too?) High Energy

\[ M_{Z'} \gg \sqrt{\hat{S}} \]

Offshell

\[ \mathcal{L} = \mathcal{L}_{SM} + \frac{1}{\Lambda^2} \mathcal{L}_6 + \frac{1}{\Lambda^4} \mathcal{L}_8 + \ldots \]
Fermi Theory

• The muon decay can (and was) be described by a Dimension 6 operator

\[
\frac{G_F}{\sqrt{2}} (\bar{\nu}_l \gamma_\mu (1 - \gamma_5) l) (\bar{l} \gamma^\mu (1 - \gamma_5) \nu_l)
\]

Dimension 6:

\[
\frac{G_F}{\sqrt{2}} = \frac{c_F}{\Lambda_F^2}
\]

• This corresponds to the first term of the propagator Taylor expansion

\[
\frac{1}{p^2 - M_W^2} = - \frac{1}{M_W^2} - \frac{p^2}{M_W^4} - \cdots
\]

Dimension 8
Effective Field Theory

\[ \mathcal{L} = \mathcal{L}_{SM} + \sum \frac{c_i}{\Lambda^2} O_i \]

<table>
<thead>
<tr>
<th>Type</th>
<th>Name</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bosons</td>
<td>( H, G, W, B )</td>
<td>1</td>
</tr>
<tr>
<td>Fermion</td>
<td>( L, Q, l_R, u_R, d_R )</td>
<td>3/2</td>
</tr>
<tr>
<td>Covariant derivative</td>
<td>( D^\mu )</td>
<td>1</td>
</tr>
<tr>
<td>Strength tensor</td>
<td>( F^{\mu\nu} )</td>
<td>2</td>
</tr>
</tbody>
</table>
Effective Field Theory

\[ \mathcal{L} = \mathcal{L}_{SM} + \sum \frac{c_i}{\Lambda^2} \mathcal{O}_i \]

The number of possible Operators are huge

- 59 Dimension 6 Operators If
  - Preserve the SM gauge symmetries
  - Preserve B-L accidental symmetries
  - We consider only one flavour

- Only One Dimension 5 Operator:
  \[ \frac{1}{\Lambda} \epsilon_{ij} \epsilon_{kl} H^j H^l \bar{L}^c_i L^k_L \]
  Give a mass to the neutrino

\[ \mathcal{L} = \mathcal{L}^{SM} + \sum \frac{c_i}{\Lambda^2} \mathcal{O}_i + \mathcal{O} \left( \frac{1}{\Lambda^4} \right) \]

Th. error
Dimension 8

- Smaller effects or larger errors for higher dimension operators

\[ \mathcal{L} = \mathcal{L}^{SM} + \sum \frac{c_i}{\Lambda^2} \mathcal{O}_i^6 + \sum \frac{d_i}{\Lambda^4} \mathcal{O}_i^8 + \mathcal{O} (\Lambda^{-6}) \]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>10%</th>
<th>1%</th>
<th>0.1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>1</td>
<td>0%</td>
<td>10%</td>
<td>3%</td>
</tr>
</tbody>
</table>

- Extra assumptions if first order does not vanishes
- Less convergence
  - more problem with unitarity
Effective Field Theory

\[ \mathcal{L} = \mathcal{L}_{SM} + \sum \frac{c_i}{\Lambda^2} \mathcal{O}_i \]

- Only few Operators for one process and different effects

**Weak Boson production**

**Conserving CP**

\[ \mathcal{O}_{WWW} = \text{Tr}[W_{\mu\nu} W^{\nu\rho} W_\rho] \]
\[ \mathcal{O}_W = (D_\mu \Phi)^\dagger W^{\mu\nu} (D_\nu \Phi) \]
\[ \mathcal{O}_B = (D_\mu \Phi)^\dagger B^{\mu\nu} (D_\nu \Phi) \]

**Not Conserving CP**

\[ \mathcal{O}_{\tilde{W}WWW} = \text{Tr}[\tilde{W}_{\mu\nu} W^{\nu\rho} W_\rho] \]
\[ \mathcal{O}_{\tilde{W}} = (D_\mu \Phi)^\dagger \tilde{W}^{\mu\nu} (D_\nu \Phi) \]
Benchmark

- After having choose the model of interests you need to choose a benchmark

**SUSY Case**
- Low Energy spectrum is calculable from High energy spectra.
- Based on the RGE
- Example:
  - SoftSUSY
  - FlexibleSUSY

**EFT**
- Free parameter
- Check the constraint on the parameter

**What about the width?**
- Need to be (re-)computed for each phase-space.
- Need partial-width
2-body decay

\[ \Gamma = \frac{1}{2MS} \int d\Phi_2 |M|^2 \]

• By Lorentz Invariance the matrix element is constant over the phase-space.

\[ \Gamma = \frac{\sqrt{\lambda(M^2, m_1^2, m_2^2)} |M|^2}{16\pi SM^3} \]

\[ \lambda(M^2, m_1^2, m_2^2) = (M^2 - m_1^2 - m_2^2)^2 - 4m_1^2m_2^2 \]

• Calculable analytically by FeynRules
  ➞ formula present in the UFO model.
N Body Decay

3(and more)-body Decay

- Analytical Formula too complicated
  - Especially in a spectrum independent way
- Numerical integration
- Need to remove double counting with 2-body
- Typically LO computation
  - Remove radiation diagram

Example of code
- Herwig / Bridge / MadWidth
MadWidth

2-body

• Use FeynRules formula (instataneous)

Fast-Estimation of 3-body

• Only use 2-body decay and PS factor

Channel Generation

• Remove Sequence of 2-body/radiation diagram

Estimation of 3-body

• Based on the diagram. Approx. PS/Matrix-Element

Numerical Integration

DONE

Relevant?

No

Maybe

Yes?

No
### Speed

**Speed comparison**

<table>
<thead>
<tr>
<th>Model</th>
<th>FeynRules Two-body</th>
<th>Bridge Two-body</th>
<th>MadWidth Default</th>
<th>Bridge Three-body</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEFT model</td>
<td>0.6 s</td>
<td>60s</td>
<td>40s</td>
<td>114 s</td>
</tr>
<tr>
<td>SPS1a MSSM scenario</td>
<td>12 s</td>
<td>13 min 43s</td>
<td>84 s</td>
<td>1h47</td>
</tr>
</tbody>
</table>

- 100 times faster for 2body decay
- 3 to 75 times faster for 3body decay

**Input**

```
DECAY 2000011 Auto # wsl4
DECAY 2000013 Auto # wsl5
DECAY 2000015 Auto # wsl6
```

**Output**

```
<table>
<thead>
<tr>
<th>DECAY 25 1.844415e-02</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>7.587771e-01</td>
</tr>
<tr>
<td>1.214531e-01</td>
</tr>
<tr>
<td>9.108578e-02</td>
</tr>
<tr>
<td>5.920576e-03</td>
</tr>
<tr>
<td>5.920576e-03</td>
</tr>
<tr>
<td>4.858342e-03</td>
</tr>
<tr>
<td>4.070016e-03</td>
</tr>
<tr>
<td>4.069040e-03</td>
</tr>
</tbody>
</table>
```
QCD

• Need to be handle in a specific way
  → provide additional information for the shower

• Handling the color algebra to rewrite it in a product of $\delta_{ij}$ (i.e. color flow)

<table>
<thead>
<tr>
<th>color</th>
<th>disponibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>✔️</td>
</tr>
<tr>
<td>3</td>
<td>✔️</td>
</tr>
<tr>
<td>$\epsilon_{ijk}$</td>
<td>✔️</td>
</tr>
<tr>
<td>6</td>
<td>✔️</td>
</tr>
<tr>
<td>8</td>
<td>✔️</td>
</tr>
<tr>
<td>10</td>
<td>Whizard</td>
</tr>
</tbody>
</table>
Type of Interactions

Color sextet and $\varepsilon^{ijk}$ implementations

7 TeV LHC

Diquark cross sections with coupling 0.01

Jet $p_T$:s, fully matched

$pp \rightarrow D + 0, 1, 2$ jets
Decay

Problem

- Process complicated to have the full process
  - Including off-shell contribution

Solution

- Only keep on-shell contribution
Narrow-Width Approx.

Theory

\[
\int dq^2 \left| \frac{1}{q^2 - M^2 - iM\Gamma} \right|^2 \approx \frac{\pi}{M\Gamma} \delta(q^2 - M^2)
\]

\[\sigma_{full} = \sigma_{prod} \ast (BR + \mathcal{O}\left(\frac{\Gamma}{M}\right))\]

Comment

• This is an Approximation!

• This force the particle to be on-shell!
  • Recover by re-introducing the Breit-wigner up-to a cut-off
Spin-correlation

Full Spin correlation

- MadGraph
- MadSpin
- Sherpa
- Herwig

Slow
- Exact Matrix-Element integration
- Re-weighting method
- Full Density Matrix Method
- Diagonal Density Matrix Method

Fast
- Pure Flat Decay

Flat Decay
- BridGe
- Pythia
One Event
- smear the mass
- flat decay

Decay Events
- re-weight by $|M_{LO}^{P+D}|^2/|M_{LO}^P|^2$

Decay Events II
- accept/reject method
- reject the decay not the event

Final Sample

<table>
<thead>
<tr>
<th>offshell</th>
<th>spin</th>
<th>unweighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>YES</td>
</tr>
</tbody>
</table>

[Frixione, Leanen, Motylinski, Webber (2007)]

[Artoisenet, OM et al. 1212.3460]
Figure 5: Next-to-leading-order cross sections differential in $p_T(l^+)$ (left pane) and in $\cos(\phi)$ (right pane) for $t\bar{t}H$ events with or without spin correlation effects. For comparison, also the leading-order results are shown. Events were generated with aMC@NLO, then decayed with MadSpin, and finally passed to Herwig for shower and hadronization.

Figure 6: Next-to-leading-order cross sections differential in $p_T(l^+)$ (left pane) and in $\cos(\phi)$ (right pane) for $t\bar{t}A$ events with or without spin correlation effects. Events were generated with aMC@NLO, then decayed with MadSpin, and finally passed to Herwig for shower and hadronization.

That preserving spin correlations is more important than including NLO corrections for this observable. However, we observe that the inclusion of both, as it is done here, is necessary for an accurate prediction of the distribution of events with respect to $\cos(\phi)$. In general, a scheme including both spin correlation effects and QCD corrections is preferred: it retains the good features of a NLO calculation, i.e. reduced uncertainties due to scale dependence (not shown), while keeping the correlations between the top decay products.

The results for the pseudo-scalar Higgs boson are shown in Figure 6. The effects of the spin correlations on the transverse momentum of the charged lepton are similar as in the case of a scalar Higgs boson: about 10% at small $p_T$, increasing to about 40% at $p_T = 200$ GeV. On the other hand, the $\cos(\phi)$ does not show any significant effect from the spin-correlations. Therefore this observable could possibly help in determining the CP nature of the Higgs boson, underlining the importance of the inclusion of these spin correlations.
BSM simulation

Lagrangian

FeynRules, ...

Feynman rules

UFO, ...

MadGraph, ...

matrix-element

StandAlone, ...

Sherpa, ...

parton events

LHE, ...

Herwig, ...

Showered events

HepMC, ...

Sherpa, ...

Pythia, ...

hadronized events

HepMC

Delphes, ...

FULL SIMULATION

SLOWEST PART

Detector events
Before Discovery

Original Model

After Discovery

Alternative Model

plot from arXiv:1010.2506v1
Idea

- Reuse the sample (Only one Full Sim)
- Change the weight of the events

\[ W_{new} = \frac{|M_{new}|^2}{|M_{old}|^2} \times W_{old} \]
Examples HEFT

\[ p p \rightarrow Z W^+ \text{ with } \mathcal{O}_{3W} \]

- SM
- MG5, \( c=50 \)
- MG5, \( c=500 \)
- RWGT, \( c=50 \)
- RWGT, \( c=500 \)

```
p_{T}^{Z} [\text{GeV}] 1000
```

Mattelaer Olivier

BSM: Sao Paolo 2015
Systematics study

Theoretical Dependance

- the PDF set
- the renormalization/refactorization scale
- the matching scale

50 sets
9 sets
3 sets

Idea

- Reweighting can also be used to study systematic uncertainty.

Implementation:

- Store additional information in the Event File
- Make the re-weighting on the flight
Non Definite positive

Effective Field Theory:

\[ \mathcal{O}(\Lambda^0)^2 + \mathcal{O}(\Lambda) + \mathcal{O}(\Lambda^2) \]

Signal

Equivalent to Dimension 8 contribution

\[ \text{SM Model independent Dominant} \]

\[ \text{BSM Model dependent Sub-Dominant} \]
Interference Plot

$pp \rightarrow e^+e^-$ interference term

$\frac{d\sigma}{dM}$ [pb] vs $M_{e^+e^-}$ [GeV]
Re-Casting

- Same idea but at the analysis level

plot from arXiv:1010.2506v1
Why is it interesting

**Experimentalist**
- Your analysis will be reuse to exclude new model without extra work
- You might gain feedback about the analysis
- You will get cited

**Theorist**
- Want to check your analysis
- Is the BSM model exclude?
- Is the BSM reduces fluctuations?
- The closer they are from your work the better

**What do we need?**
- Simplified way to compare theory/data
- Need to be outside of experimental control area
- Automatic running
Working Flow

Input
- Event File
- LHE
- HEPMC

Detector Simulation
- Rivet Fork or Delphes Fork

Output
- CL
- CutFlow
- Plots

Examples of code
- MadAnalysis 5
- RECAST
- ATOM
- Checkmate
For such cases, the comparison is only reasonable after the cut to which the trigger requirement is subjected. The efficiency or 

<table>
<thead>
<tr>
<th>#</th>
<th>Cut Name</th>
<th>$\varepsilon_{\text{ATLAS}}$</th>
<th>$\varepsilon_{\text{Atom}} \pm \text{Stat}$</th>
<th>$\varepsilon_{\text{Atom}}/\varepsilon_{\text{ATLAS}}$</th>
<th>$(\varepsilon_{\text{Atom}} - \varepsilon_{\text{ATLAS}})/\text{Stat}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No cut</td>
<td>100.</td>
<td>100. ±</td>
<td>1.06</td>
<td>5.23</td>
</tr>
<tr>
<td>2</td>
<td>Muon veto</td>
<td>75.1</td>
<td>79.8 ± 0.89</td>
<td>1.06</td>
<td>5.23</td>
</tr>
<tr>
<td>3</td>
<td>Electron veto</td>
<td>56.1</td>
<td>55.4 ± 0.74</td>
<td>0.99</td>
<td>-0.93</td>
</tr>
<tr>
<td>4</td>
<td>MET &gt; 130</td>
<td>51.9</td>
<td>47.9 ± 0.69</td>
<td>0.92</td>
<td>-5.78</td>
</tr>
<tr>
<td>5</td>
<td>Jet multiplicity and pT</td>
<td>19.3</td>
<td>16.3 ± 0.4</td>
<td>0.84</td>
<td>-7.41</td>
</tr>
<tr>
<td>6</td>
<td>MET_track &gt; 30</td>
<td>19.</td>
<td>16.2 ± 0.4</td>
<td>0.85</td>
<td>-6.99</td>
</tr>
<tr>
<td>7</td>
<td>delPhi(MET, MET_track) &lt; pi/3</td>
<td>17.8</td>
<td>15.9 ± 0.4</td>
<td>0.89</td>
<td>-4.77</td>
</tr>
<tr>
<td>8</td>
<td>delPhi(jet, MET) &gt; pi/5</td>
<td>15.2</td>
<td>14.6 ± 0.38</td>
<td>0.96</td>
<td>-1.5</td>
</tr>
<tr>
<td>9</td>
<td>Tau veto</td>
<td>13.3</td>
<td>13.5 ± 0.37</td>
<td>1.01</td>
<td>0.53</td>
</tr>
<tr>
<td>10</td>
<td>&gt;= 2–bjet</td>
<td>5.8</td>
<td>5.9 ± 0.24</td>
<td>1.02</td>
<td>0.46</td>
</tr>
<tr>
<td>11</td>
<td>mT(bjet, MET) &gt; 175</td>
<td>4.</td>
<td>3.8 ± 0.2</td>
<td>0.97</td>
<td>-0.67</td>
</tr>
<tr>
<td>12</td>
<td>80 &lt; m$^{0}_{jjj}$ &lt; 270</td>
<td>3.5</td>
<td>3.4 ± 0.18</td>
<td>0.96</td>
<td>-0.7</td>
</tr>
<tr>
<td>13</td>
<td>80 &lt; m$^{1}_{jjj}$ &lt; 270</td>
<td>2.1</td>
<td>2.2 ± 0.15</td>
<td>1.02</td>
<td>0.31</td>
</tr>
<tr>
<td>14</td>
<td>SR1: MET &gt; 200</td>
<td>2.</td>
<td>2. ± 0.14</td>
<td>1.</td>
<td>0.05</td>
</tr>
<tr>
<td>15</td>
<td>SR2: MET &gt; 300</td>
<td>1.5</td>
<td>1.6 ± 0.13</td>
<td>1.04</td>
<td>0.54</td>
</tr>
<tr>
<td>16</td>
<td>SR3: MET &gt; 350</td>
<td>1.2</td>
<td>1.3 ± 0.11</td>
<td>1.05</td>
<td>0.55</td>
</tr>
</tbody>
</table>
Non cut based method

**Boosted Decision Tree**

**Matrix-Element method**

- Use the BSM matrix-element to discriminate the signal for the background

$$P(p^{vis} | \alpha) = \frac{1}{\sigma_\alpha} \int d\Phi dx_1 dx_2 |M_\alpha(p)|^2 W(p, p^{vis})$$

- Some study are too specialised to be recast
Types of Technique

- Missing transverse momentum
- $M_{\text{eff}}, H_T$
- $s$ Hat Min
- $M_T$
- $M_{\text{TGEN}}$
- $M_{T2} / M_{CT}$
- $M_{T2}$ (with “kinks”)
- $M_{T2} / M_{CT}$ (parallel / perp)
- $M_{T2} / M_{CT}$ ("sub-system")
- “Polynomial” constraints
- Multi-event polynomial constraints
- Whole dataset variables
- Cross section
- Max Likelihood / Matrix Element

Few assumptions

Many assumptions
Types of Technique

Vague conclusions

- Missing transverse momentum
- M_eff, H_T
- s Hat Min
- M_T
- M_TGEN
- M_T2 / M_CT
- M_T2 (with “kinks”)
- M_T2 / M_CT (parallel / perp)
- M_T2 / M_CT ("sub-system")
- “Polynomial” constraints
- Multi-event polynomial constraints
- Whole dataset variables
- Cross section
- Max Likelihood / Matrix Element

Specific conclusions

Slide from Lester: arXiv:1004.2732
Types of Technique

Robust
- Missing transverse momentum
- M_eff, H_T
- s Hat Min
- M_T
- M_TGEN
- M_T2 / M_CT
- M_T2 (with “kinks”)
- M_T2 / M_CT ( parallel / perp )
- M_T2 / M_CT ( “sub-system” )
- “Polynomial” constraints
- Multi-event polynomial constraints
- Whole dataset variables
- Cross section
- Max Likelihood / Matrix Element

Fragile
• QCD is everywhere!

unmatched

with ME/PS matching

very bad close to deg. region

~ 20% agreement
MadAnalysis 5 implementation of CMS-SUS-13-011: search for stops in the single lepton final state at 8 TeV

Dumont, Beranger (LPSC, Grenoble); Fuks, Benjamin (CERN); Wymant, Chris (Annecy, LAPTH)

Cite as: (2014) authors, http://doi/10.7484/INSPIREHEP.DATA.LR5T.2RR3

Description: This is the MadAnalysis 5 implementation of the CMS search for top-squark pair production in the single lepton final state with 19.5/fb at 8 TeV, to be used for re-interpretation studies. The C++ code contains extensive comments and can thus easily be used as a template for implementing other analyses.

Note: This analysis requires MINUIT libraries. Therefore, the line <LIBFLAGS += -Iminuit> should be added to the Makefile of the Build/ directory before compilation. More information how to use this code as well as a detailed validation summary are available at http://madanalysis.irmp.ucl.ac.be/wiki/PhysicsAnalysisDatabase


This dataset complements the following publication:
Toward a public analysis database for LHC new physics searches using MADANALYSIS 5

Record added 2014-06-19, last modified 2014-07-17
Conclusion

• BSM is now fully automated at LO
  ➔ NLO is starting to be as well
• BSM is very large
  ➔ various kind
  ➔ various need
  ➔ various way to generate
• It is your responsibility to use this wisely
  ➔ You need to know the limitation of the tools