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theory retreat, 2014
BSM physics and Cosmology

• Important open questions:

  dark matter

  baryogenesis
recent & current work

• Theoretical understanding of Baryogenesis
  ‣ Finite temperature scattering rates
  ‣ Spectator effects

• Collider dark matter searches
  ‣ Monojet for Higgsinos, Winos

• Non-WIMP dark matter
  ‣ dark QCD
  ‣ Emerging jets
Leptogenesis

- LG: Generates baryon asymmetry from CPV decays of heavy RH neutrinos
  - Consistent with observed neutrino masses → maybe the most convincing baryogenesis scenario we have
  - Solid understanding of LG dynamics desirable

- Finite temperature scattering rates
Spectator effects

- Interactions that are in thermal equilibrium during leptogenesis, but don’t change $L$

- What if they reach equilibrium during LG?

- Spectator DoF “hide” asymmetry from washout

- Up to 50% correction to final asymmetry

Next: Dependence on initial conditions
Mono-jet searches for DM

• One way to observe invisible particles:
  ‣ Sensitive to electroweakly produced states?
  ‣ Close the gap in SUSY searches?

PS, Zurita, JHEP 2014.

Important: Soft leptons
Relax vetoes

Currently: Optimize for 100 TeV
Composite (asymmetric) Dark Matter

- **Dark QCD:** DM is “proton” of QCD like dark sector
  - Explain DM mass, stability
  - Efficient annihilation of symmetric relic density

- **New collider signature of DM:** Emerging Jets

<table>
<thead>
<tr>
<th>Cut Flow</th>
<th>Model A</th>
<th>Model B</th>
<th>QCD 4-jet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree level</td>
<td>14.6</td>
<td>14.6</td>
<td>410,000</td>
</tr>
<tr>
<td>≥ 4 jets,</td>
<td>7.1</td>
<td>9.2</td>
<td>48,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>pT(jet) &gt; 200 GeV</td>
<td>5.9</td>
<td>4.1</td>
<td>41</td>
</tr>
<tr>
<td>H_T &gt; 1000 GeV</td>
<td>2.6</td>
<td>0.7</td>
<td>~ 0.08</td>
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</table>

For the signal we take the mass of the bifundamental M_X = 1 TeV. The two right most columns are different background estimates, the first using the standard PYTHIA tune, while the second uses the modified tune [14]. The tree level cross section for the background is with the generator level cuts discussed in the text.

4.5 Alternative Strategy: p_T Weighting

In this section we present an alternative based on using the p_T fraction of the jet which is emerging rather than counting tracks. As before, this requires reconstruction of displaced charged tracks in order to determine \( L_{xy} \), how far from the origin in the \( xy \) plane they originate. This strategy, however, is more robust to pileup because while a pile up event can produced tracks above the 1 GeV threshold from the previous section, they are much more unlikely to make a substantial contribution to the p_T of a jet.

For this section we define the p_T fraction F(r) for a jet as a function of radius as:

\[
F(r) = \frac{\sum_{\text{charged tracks}} p_T(r > r)}{\sum_{\text{charged tracks}} p_T(8)}
\]

where \( p_T \) is the p_T of charged tracks with \( L_{xy} > r \). This variable goes from 0 to 1 for a given jet. For QCD jets it tends to take values near zero since most of the energy is in prompt tracks. A jet can only have \( F = 1 \) if it is composed entirely of charged tracks which originate further away than the lifetime of the dark pions.

We now analyze this variable more quantitatively. Looking first at the QCD background, in Fig. 8 we plot F for the jet with the highest and second highest value of F in an event. We see that it is indeed peaked at zero and steeply falling. We also see that it is much more steeply falling for \( r = 100 \) mm.
Other stuff/Outlook

• Higgs and BSM (2011-2013)
  ‣ Higgs portal DM
  ‣ Probing Higgs CP violation
  ‣ Vector-like leptons

• Electroweak Baryogenesis

• Aspects of composite DM
  ‣ self interactions
  ‣ bound states
  ‣ model building

• Production of self-interacting sterile neutrinos

• Strong coupling measurements to constrain new physics