LHCfast: A Method for Including New Physics in Hadronization Event Generators

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Special Thanks: H. Davoudiasl, T. Han and P. Skands

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  LHCfast3 (Converts histogrammed data to plots.)

  LHCfast1 (Calculates matrix element, etc...for the theory du jour)

Why LHCfast?

The New Paradigm for the LHC Era

Conventional Steps:

Model builders construct new theories, calculate precision electroweak parameters (to ensure the theory is not ruled out), and comment on possible LHC signatures. Later a collider physicist, e.g. Tao Han, performs detailed analysis.

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New Paradigm:

With programs like this, model builders should include distinctive collider signatures, in addition to precision electroweak constraints, of their model at the LHC.

Structure of the Talk

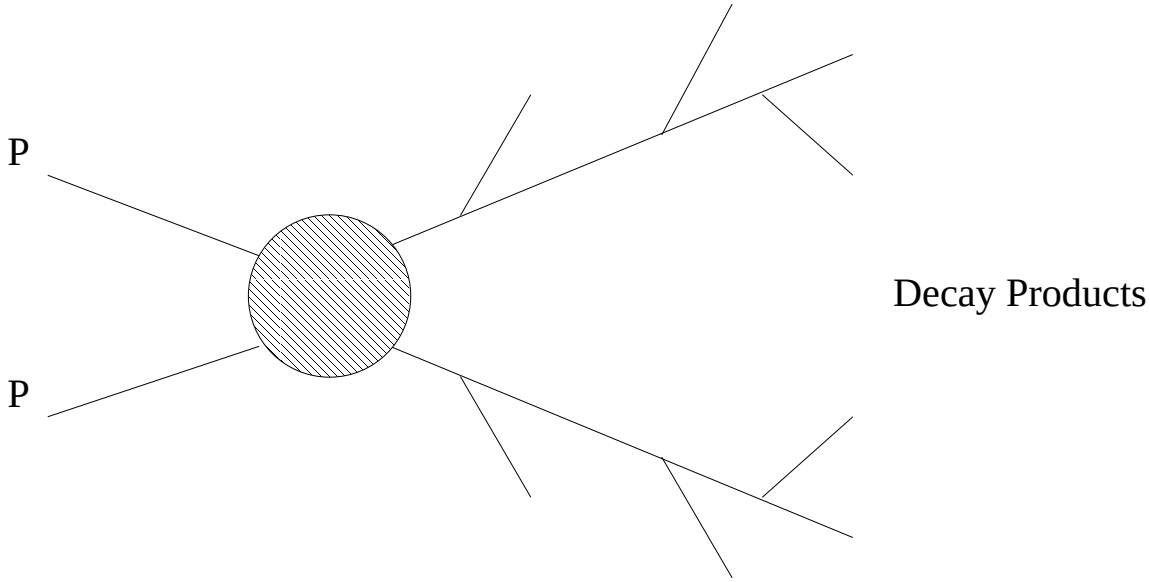
1. Important Details of LHCfast

2. Implementing LHCfast:

   Quick Review of the Little Higgs w/T-Parity
   Movie(s) of typical LHCfast run(s)

3. Outlook

What makes LHCfast fast?



LHCfast1: Production and Decay

- Enough to calculate the particle production matrix matrix elements. The products decay via ordinary phase space decay.

  Get coarse features. (No helicity information)

- Production and Decay processes calculated with CalcHEP batch.

- Links lagrangians to the CalcHEP batch via LanHEP

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CalcHEP Credit/References:

A. Pukhov, et al. Preprint INP MSU 89-41/542, arXiv: hep-ph/9908288 and hep-ph/0412191

CalcHEP contains codes from the CompHEP group:
V. Ilyin, D. Kovalenko, A. Kryukov, V. Edneral and A. Semenov

Default RGE codes written by: A. Djouadi, J.-L. Kneur and G. Moultaka

Phase Space Concerns(Tao's Point)

- CAUTION: With any automatic matrix element calculator, inherent phase space issues.

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- Traditional methods are important!

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- An example read-in text file:

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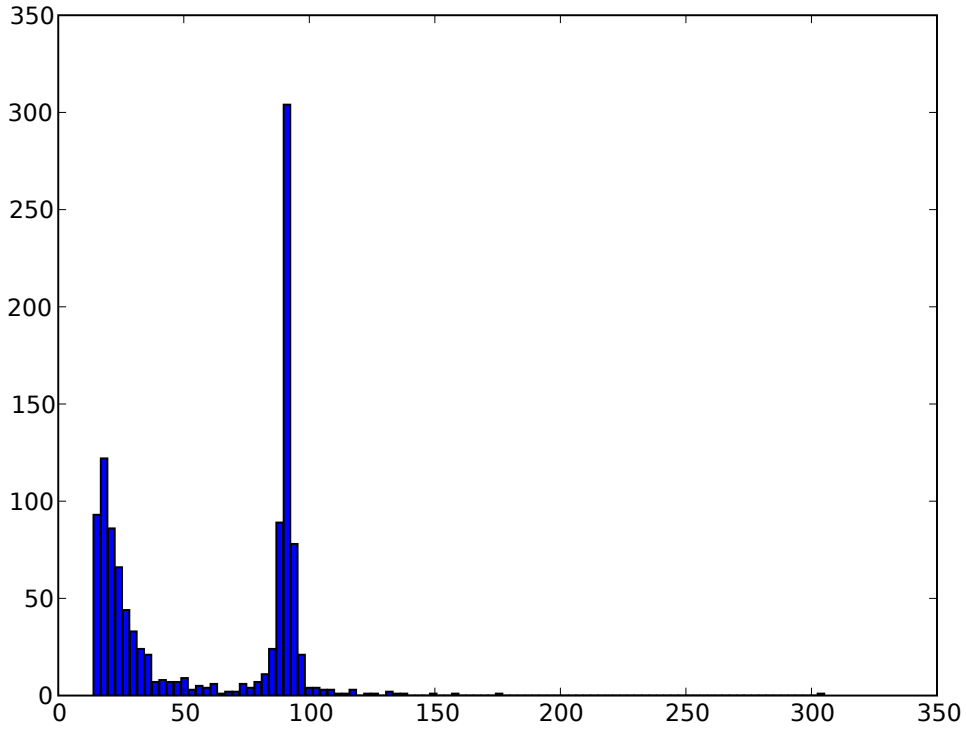
- LHCfast3 uses matplotlib for high quality plots. (http://matplotlib.sourceforge.net/)

- An Example Plot from LHCfast3: Finding the Z by looking at μ^+ μ^- invariant mass.



Muon Invariant mass (GeV) vs. Counts

for $q + \bar{q} \rightarrow Z$ at the LHC.

Additional LHCfast Features

- Interactive: Like mathematica or maple. Not like fortran or C.

  All numerics remain in Fortran.
  LHCfast just synchronizes the programs.

- Can inspect Pythia subroutines live, generate and inspect individual events and change Pythia settings interactively.

- Can build higher level/GUI programs on top of framework.

Does this improve existing packages?

- The numerics stay the same. Functionality/speed increases when going from lagrangians to plots.

- The ability to input, e.g. eight-body final states with full helicity information, into Pythia is novel.

- If the Les Houches Accords are not modfied and the commands to run the CalcHEP batch remain the same, upgrades are not necessary.

Really Brief Comments on the Littlest Higgs with T-Parity

- T-parity is a discrete symmetry applied to "Little Higgs theories."
- The symmetry ameliorates "Little Hierarchy problem"– the discrepancy between the TeV scale and the scale of new physics suggested by precision electroweak measurements.
- Produces viable Dark Matter candidates.
- Similar to R-parity in the MSSM.
- Standard Model is t-even. New t-odd particles transform as:

$$P_{\text{odd}} \to -P_{\text{odd}}$$

- For the simulation, focus on heavy top decays into the heavy photon and top.

$$T_{\text{heavy}} \rightarrow t + A_{\text{heavy}}$$

- A_{heavy} is the Dark Matter candidate.

Some T-parity Authors:

Cheng, Low, Hubisz, Meade, Noble, Perlestein, Wang, Birkedal, Martin, Lee, Paz, ...

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- Movie 3: Running Pythia with LHCfast. Simple case of discovering the Z at the LHC.

Outlook

- LHCfast is a toolkit to efficiently/quickly go from theories to collider observables.

- When the program becomes more battle tested, we will release a version for the public.