Multi-jet process generation for LHC

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Context

- There could be a need of reference samples available for theorists, phenomenologists and experimentalists.
- Multi-jet process (all SM backgrounds + ...) generation is not an easy task.
- Simulation uncertainties should be under control

We propose MadGraph/MadEvent to be one of the generators in this game!
Outline

1. Multi-jet process generation

2. Validation of the samples

3. Summary
Plan

1 Multi-jet process generation

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3 Summary
Sensitivity to shower choice

With the generation of multi-jets processes with only PS generators, some choices can affect the physical distributions:

- Choice of showering scheme \((Q^2, P_T^2, \sim E^2 \theta^2, \ldots)\)
- Choice of shower scale (wimpy, power,\ldots)

A global tune of a PS to mimic physical distributions is the opposite methodology for BSM physics discoveries. An elegant solution for the problems evoked is to use a jet-parton matching/merging method.
The example of $\tilde{g}\tilde{g}$ produced "a la pythia"

$\tilde{g}\tilde{g}$ - SP1a
$P_T$ of the 2-nd jet

Graph showing the distribution of $P_T$ for the 2-nd jet with different models:
- pythia-$Q^2$ (wimpy)
- pythia-$Q^2$ (power)
- pythia-$P_T^2$ (wimpy-parp(67)=1)
- pythia-$P_T^2$ (power-parp(67)=1)

Publication to come, F. Maltoni, J. Alwall, SDV.
The remedy

Use one of the available jet-parton matching techniques to manage the problems.

**ME**
- parton-level description
- valid when partons are hard and well separated
- needed for multi-jets description

**PS**
- down to hadron-level description
- valid when partons are collinear and/or soft
- needed for realistic studies

Double counting problem:
Need to cut the phase-space into two parts: one accessible by Matrix-Element (high $Q^2$) and the rest by PS (low $Q^2$).

Jet-Parton matching/merging
What does exist?

There are different combinations of Matrix-Element Generator + Matching Scheme + PS

In MG/ME: Modified MLM (MLM scheme (M. Mangano) using $K_T$ instead of Cone) and CKKW. MMLM designed by S. Mrenna, implemented by J. Alwall and tested by J. Alwall and SDV
Production "a la pythia"

ME: $\tilde{g}\tilde{g}$

$\tilde{g}\tilde{g}$ - SP1a
$P_T$ of the 2-nd jet
Production with Matching

ME: $\tilde{g}\tilde{g} + 0, 1, 2 \text{ GeV}$ Cutoff used: 60 GeV

$\tilde{g}\tilde{g} - \text{SP1a}$

$P_T$ of the 2-nd jet

Matched-$Q^2$ (wimpy)

Matched-$Q^2$ (power)

Matched-$P_T^2$ (wimpy-parp(67)=1)

Matched-$P_T^2$ (power-parp(67)=1)
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What do we provide?

- for each process+multiplicity: one single code suitable for grid production:
  - Each sample is weighted differently.
  - Possibility of merging (events removing depending of xsec)
  - matching + shower choice set up to the user
- A set of small \((O(100k))\) samples: matrix-element + MMLM matching with Pythia showers. Evaluation of the efficiency of the matching procedure (usefull for large scale productions).
- Those provided sample are validated: at matching point of view, we use a set of control distributions (differential jet rate).
MatchChecker (S de Visscher, P.Demin)

Package useful to

- to validate a choice of matching parameters (via the control plots)
- to compare matching impact with different choices of
  - matching parameters
  - shower scales
  - shower ordering scheme
  - ME+matching schemes+PS combinations.

Example:
MG-ME+Pythia(MMLM) vs Sherpa(CKKW) vs ALPGEN+Herwig(MLM)

Those kind of checks/comparisons should be mandatory in order to estimate simulation uncertainties!
How it works?

- Input: STDHEP files
- Ultra-simple to use: fill a card and run 
  `./MatchChecker.sh`
  - Differential jet rates
  - Kinematic plots of X in a ”X+n jet” production
  - Kinematic plots of jets \((P_T, \eta)\) with jet definition up to the user, and with minimal user’s \(P_T\) cut
  - \(H_T(2, ...)\)
  - MET
- A Postscript report is done with everything organised (ToC, possibility of adding banners, sections...)
- Each plot is produced in .eps and C format
- A root file is produced containing all physical histograms for more flexibility

Available soon on the MG wiki
Let's see an example!
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To conclude

- The generation with PS generator is not sufficient for reliable production of multi-jet samples
- Jet-parton matching techniques permits to avoid PS problems
- MadGraph/MadEvent is suitable for those productions: small samples and frozen codes will be available
- Productions can be validated/compared with MatchChecker: systematics estimations.
Back-up slide(s)
Validation of matching parameters: use the differential jet rate distributions to control the matching.

- Invariance of the global shape with respect to the choice of the cutoff
- Smooth transition from one region of the phase-space to the other.
Other examples of plots

Comparison of differential jet rates:

In this example, comparison of the DJR (1→0) for the production of $W+0,1,2,3$ jets at different cutoff (15,20 and 30 GeV) and for wimpy and power $Q^2$ ordered shower schemes.
This is by default in the Report.