Multi-jet process generation for LHC

Simon de Visscher, Michel Herquet
Universite catholique de Louvain
Centre for Particle Physics and Phenomenology (CP^3)

$\star\star\star$

CERN - 06/02/07

Context

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

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

Simon de Visscher

Outline

Simon de Visscher

Plan

Sensitivity to shower choice

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

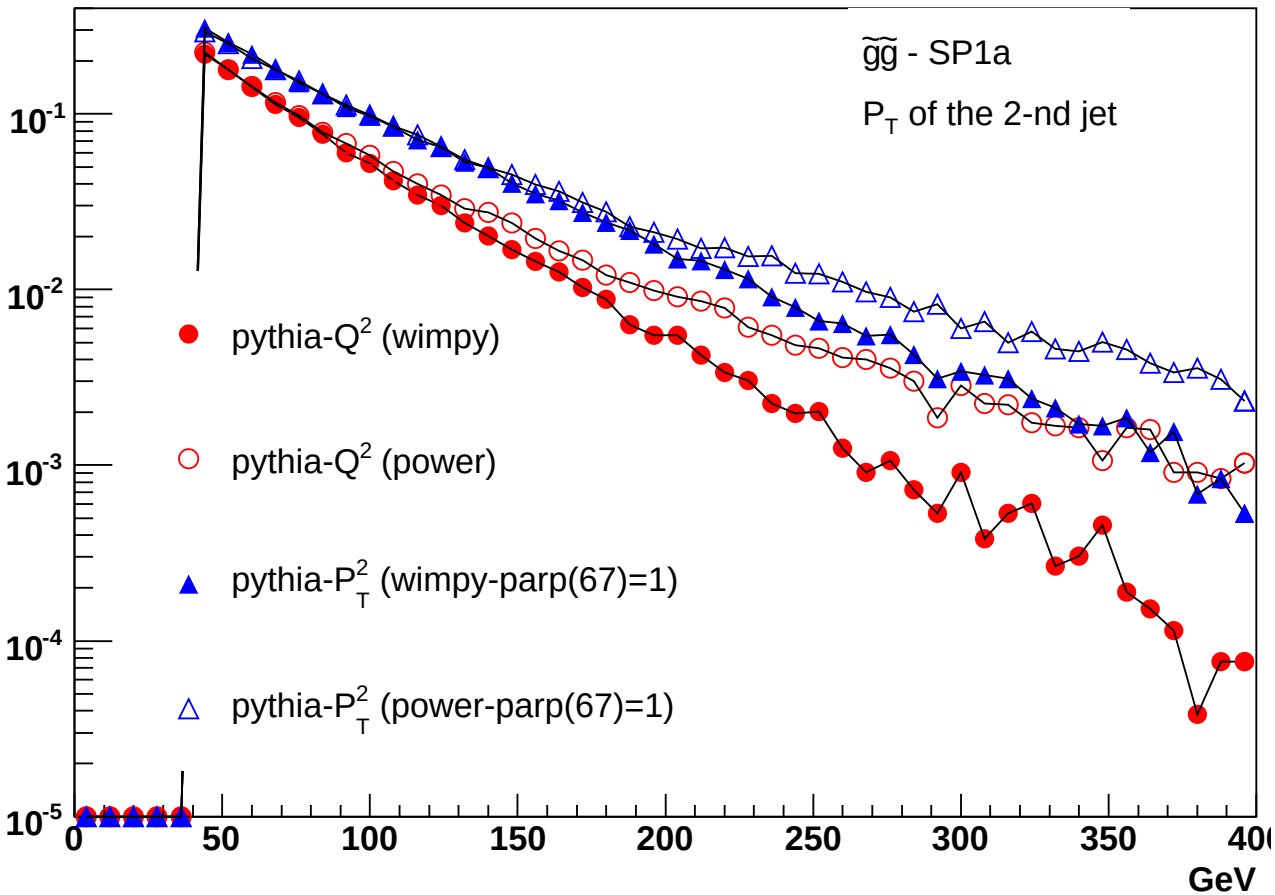
- Choice of showering scheme (Q^2, P_T^2, $E^2\theta^2$,...)
- Choice of shower scale (wimpy, power,...)

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 $\tilde{g}\tilde{g}$

Simon de Visscher

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:

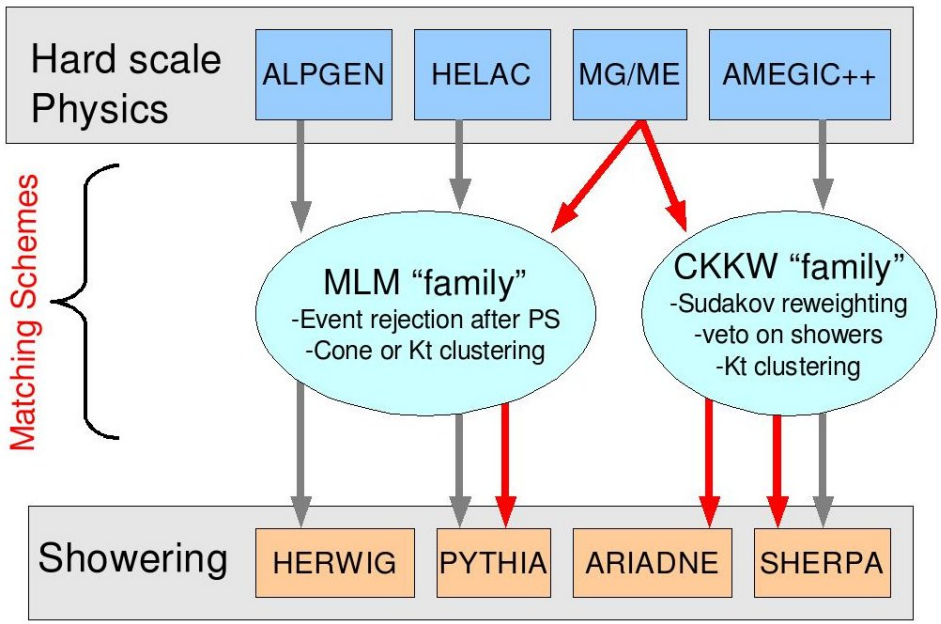
Need to cut the phase-space into two parts: one accessible by Matrix-Element (high Q^2) and the rest by PS (low Q^2).

Jet-Parton matching/merging

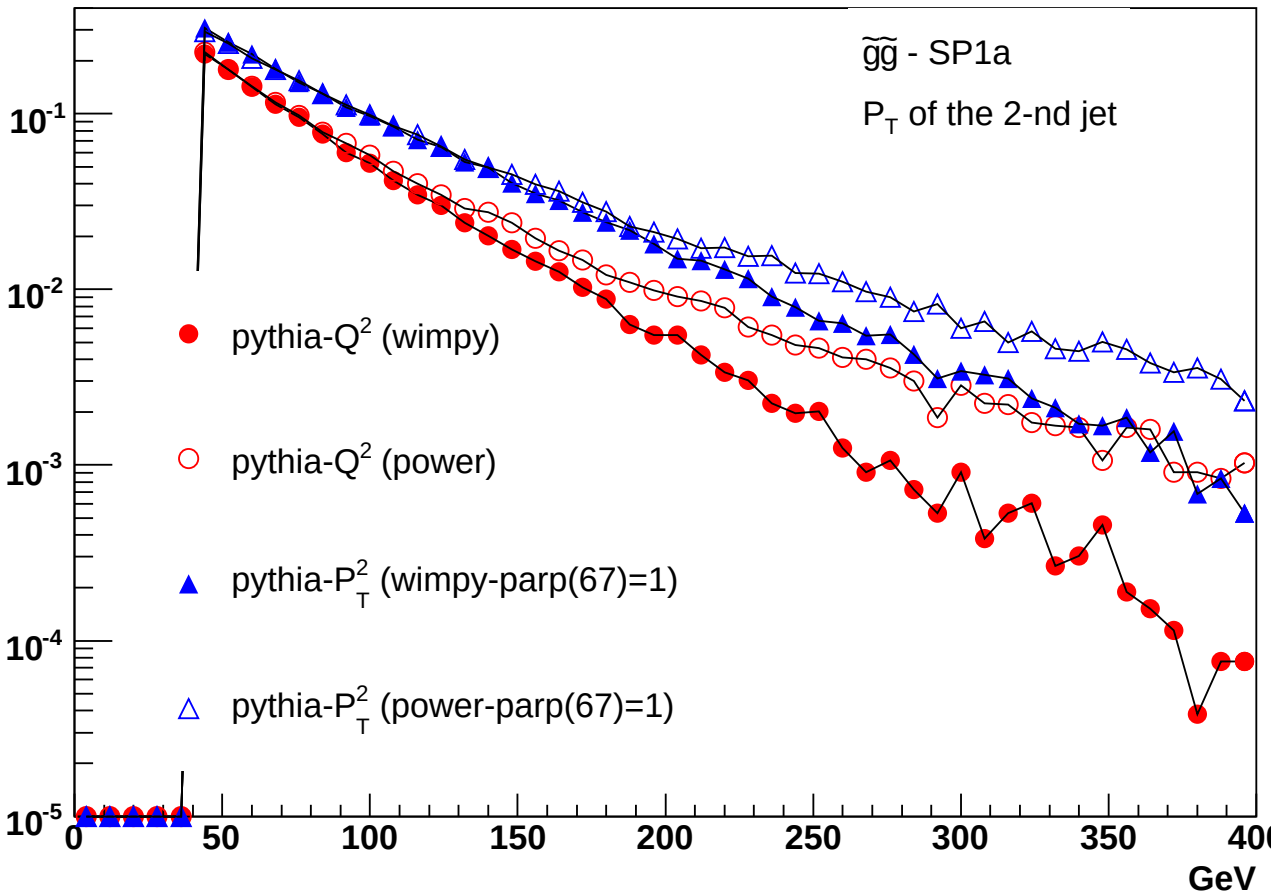
What does exist?

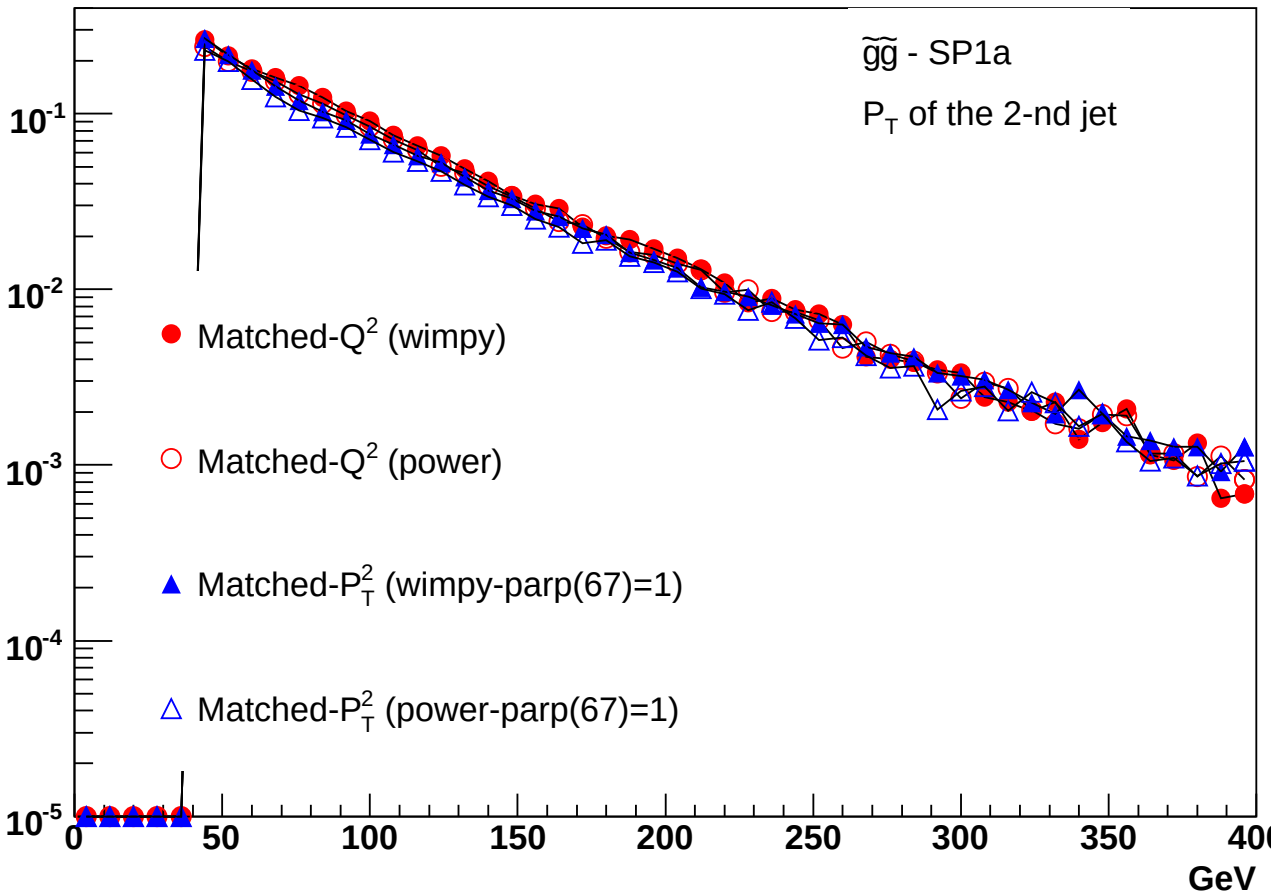
There are different combinations of

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


$\tilde{g}\tilde{g}$ - SP1a
P_T of the 2-nd jet
pythia-Q^2 (wimpy)
pythia-Q^2 (power)
pythia-P_T^2 (wimpy-parp(67)=1)
pythia-P_T^2 (power-parp(67)=1)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
50
100
150
200
250
300
350
GeV


$\tilde{g}\tilde{g}$ - 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)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
50
100
150
200
250
300
350
GeV

Simon de Visscher

Plan

What do we provide?

- A set of small (O(100k)) validated samples: matrix-element + MMLM matching with Pythia showers . Evaluation of the efficiency of the matching procedure (usefull for large scale productions).
- 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

MatchChecker (S de Visscher, P.Demin)

Package usefull to

- to validate a choice of matching parameters
- to compair 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!

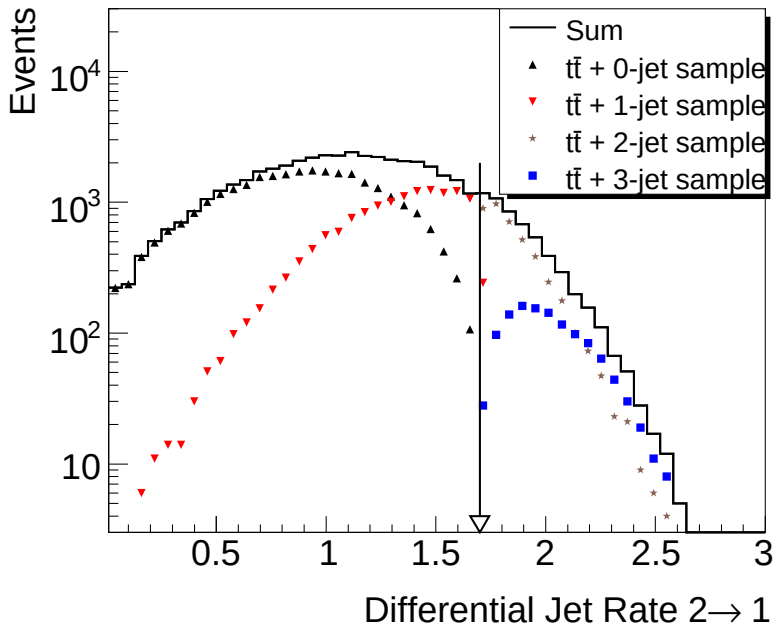
how it works?

- Input: STDHEP files
- Ultra-simple to use: fill a card and run ./MatchChecker.sh
  - Differential jet rates: $4 \to 3$, $3 \to 2$, $2 \to 1$, $1 \to 0$
  - $P_T(X)$, $\Delta(X_1, X_2)$, $M_{inv}(X)$, $\eta(X)$,...
  - $P_T(j_1, ..., j_4)$, $\eta(j_1, ..., j_4)$ 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 everyting 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

Validation of matching parameters

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.

Simon de Visscher

Plan

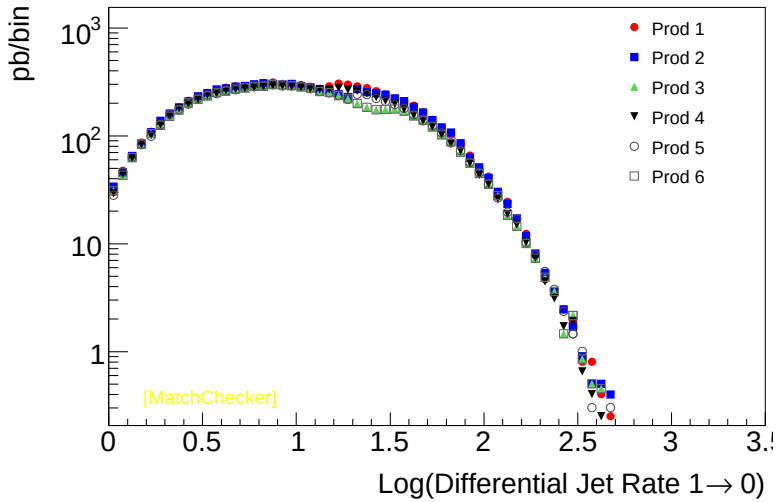
To conclude

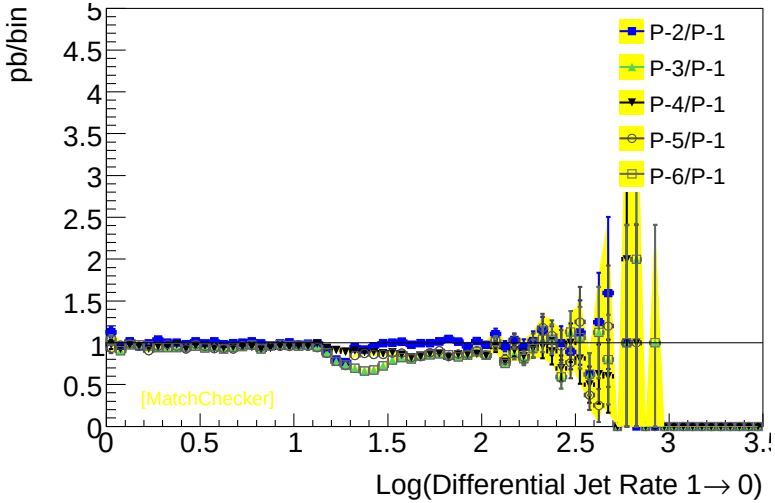
- The generation with PS generator is not sufficient for reliable production of multi-jet samples
- Jet-parton matching techniques permits to avoid PS problems
- MadGraph/MadEvent is suitable for those productions: small samples and frozen codes will be available
- Productions can be validated/compared with MatchChecker: systematics estimations.

Back-up slide(s)

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.