What the Hell is Matching?

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Basic Idea

Two ways to deal with ISR (initial state radiation):

- **Matrix Element**: calculate the matrix element directly with extra jets, using something like **Madgraph**. This is **less accurate when the particles are soft or collinear**.
- **Parton Shower**: generate only the simplest event, then make extra partons, using something like **Pythia**. This is **more accurate when the particles are soft or collinear**.

To get the best of both worlds, we generate the events in **Madgraph** and decay in **Pythia**.

- But this will double count! Madgraph and Pythia both assign the correct number of jets; using both will give too many jets on average!
- **Matching is the attempt to avoid this double counting.**

XQCUT

XQCUT is a setting in the run card

- Remember Madgraph is less accurate when things are soft or collinear.
- So we should tell Madgraph not to even try things that are too soft or too collinear.
- If Madgraph produces 2 partons, we define the k_T between them as follows:

$$k_T = \sqrt{2\ \min(p_{Ti}, p_{Tj})[\cosh(\eta_i - \eta_j) - cos(\phi_i - \phi_j)]}$$

- If k_T < XQCUT, we do not generate the event.
- So, **XQCUT is the measure of required parton separation at Madgraph Level**
  - For t t~, Madgraph recommends a value of 20
  - For more interesting processes (with more going on), we normally need something like 40
- The events are then passed to Pythia

QCUT

QCUT is a setting for Pythia

- Pythia calculates kT between every final state object as follows:

$$d_{ij} = \min(k_{ti}^{2p}, k_{tj}^{2p}) \frac{\Delta_{ij}^2}{R^2},$$
$$d_{iB} = k_{ti}^{2p},$$

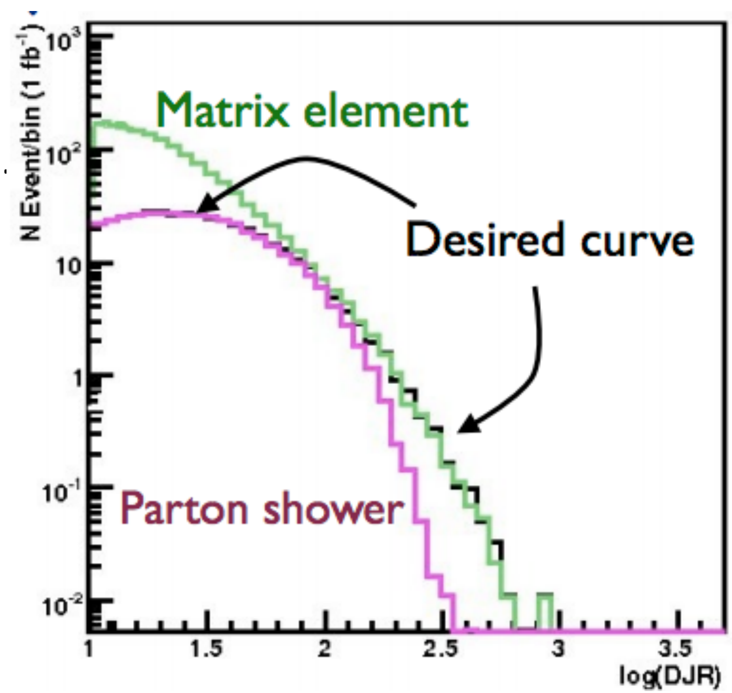
  - R is given and p = 1 for k_T algorithm
- Final-state particles are then combined until all kT values are larger than the QCUT
- The events are then ordered in kT. Throw away events that could lead do double-counting. This is called **matching**.
  - If making up to N jets and event has less than M < N jets, then there can be only M jets above the QCUT, and these must be made with Madgraph.
  - If making up to N jets and event has N jets, then no QCUT requirement, but leading N jets must be made with Madgraph.
  - In all cases, must have Madgraph jets must have small ΔR with generated partons.
- So, **QCUT is a measure of minimum kT for a clustered jet in Pythia**
  - If too high, event will be rejected because not enough jets. This is good, because it would allow Pythia to make high-pT jets.
  - If too low, event will be rejected because too many jets. This is good, because it would not allow Pythia to make low-pT jets
  - Certainly QCUT ≥ XQCUT; otherwise a region of phase space would not be covered at all
  - The exact QCUT value is normally chosen to keep the DJR plot stable

XQCUT & QCUT: Differential Jet Rates

How often will an Nth jet be produced?

- Madgraph and Pythia give different answers
- At low kT, trust Pythia (purple), at high kT, trust Madgraph (green)

- XQCUT and QCUT key here
  - XQCUT is set to split border between Madgraph and Pythia
  - QCUT is in principle the same as XQCUT, but chosen to keep the DJR continuous



Other Settings

PTJ and PTB are the minimum pT of jets and bs

- Set to XQCUT; no point generating objects that can't possibly pass the XQCUT requirement

DRJJ, DRBJ, DRBB are the minimum distances for jet-jet, b-jet, and b-b.

- Set to 0; the XQCUT will take care of the collinearity