Matching samples when hard photons are produced: The photon isolation (hep-ph/9801442)

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The problem

- Several background/signal processes with γ:
  1. $t\,\bar{t}\,\gamma$
  2. $t\,\bar{t}\,\gamma\,\gamma$
  3. $t\,\gamma$
- Two ways of producing photons in scattering phenomena:
  - ⇨ **Direct production:**
    - large energy scale,
    - computable in perturbative QCD,
    - well isolated,
    - well described by matrix element Monte Carlo generators.
  - ⇨ **Fragmentation of a QCD parton (quark or gluon):**
    - low energy scale,
    - non-perturbative QCD,
    - extracted from data,
    - collinear with the original parton,
    - Only described by parton shower algorithms.

⇨ How to distinguish between these photons?

The solutions, pt2

- One can use the isolation of the photon as a way to distinguish between the two cases.

No hadronic activity

Draw a cone around the photon axis

impose no quark/gluon

fragmentation process $\equiv 0$

infrared sick

A little of hadronic activity

Draw a cone around the photon axis

allow for a small hadronic activity

fragmentation process $\neq 0$

infrared sick

⇨ Frixione suggests to try a mix.

Frixione's idea (implemented in MadGraph)

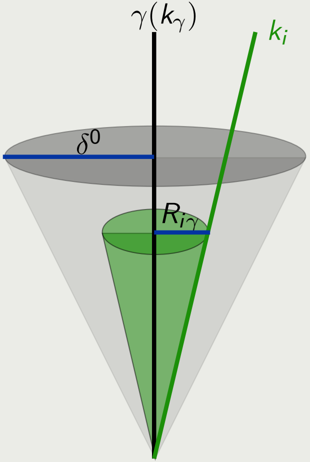
1. define:
   k_γ the 4-momentum of the photon;
   k_i the 4-momentum of the parton i;
   $R_{i\gamma} = \sqrt{(\eta_i - \eta_\gamma)^2 + (\phi_i - \phi_\gamma)^2}$.
2. Keep the event if for all $\delta \leqslant \delta^0$

   $$\Sigma_i E_{iT}\theta(\delta - R_{i\gamma}) \leqslant \mathcal{X}(\delta)$$

   where

   E_{iT} transverse energy of parton i

   $\mathcal{X}(\delta) \xrightarrow{\delta\to 0} 0$
3. Apply a jet finding algorithm to the hadrons of the event;
4. Apply any additional cut to the objects.



What is implemented in MadGraph

- In MadGraph, the formula above is implemented with

$$\mathcal{X}(\delta) = E_\gamma \epsilon_\gamma \left(\frac{1-\cos\delta}{1-\cos\delta_0}\right)^n$$

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#*********************************************************************
# Photon-isolation cuts, according to hep-ph/9801442                 *
# When ptgmin=0, all the other parameters are ignored                *
# When ptgmin>0, pta and draj are not going to be used               *
#*********************************************************************
   0 = ptgmin ! Min photon transverse momentum
 0.0 = R0gamma ! Radius of isolation code
 1.0 = xn ! n parameter of eq.(3.4) in hep-ph/9801442
 1.0 = epsgamma ! epsilon_gamma parameter of eq.(3.4) in hep-ph/9801442
 .true. = isoEM ! isolate photons from EM energy (photons and leptons)
#*********************************************************************
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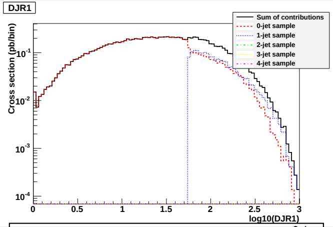
- Frixione argues that a "good" configuration is

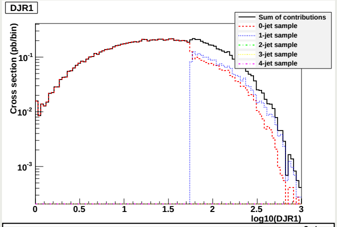
$$\epsilon_\gamma = 1, \quad n = 1$$

- What about R0gamma ?

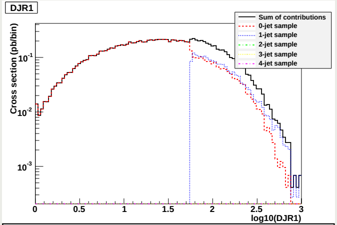
Varying R0gamma for $p\,p \to t\,\bar{t}\,\gamma\,(j)$



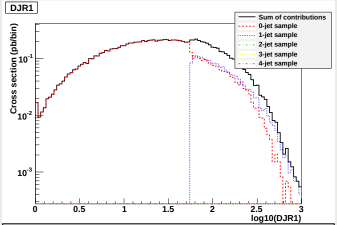
R0gamma = 0, eff. = 80.31%



R0gamma = 0.4, eff. = 80.12%

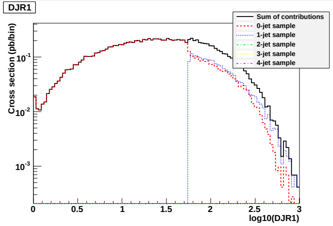


R0gamma = 0.6, eff. = 80.51%



R0gamma = 0.8, eff. = 80.45%

Varying R0gamma for $p\,p \to t\,\bar{t}\,\gamma\,(j)$



R0gamma = 1, eff. = 80.35%