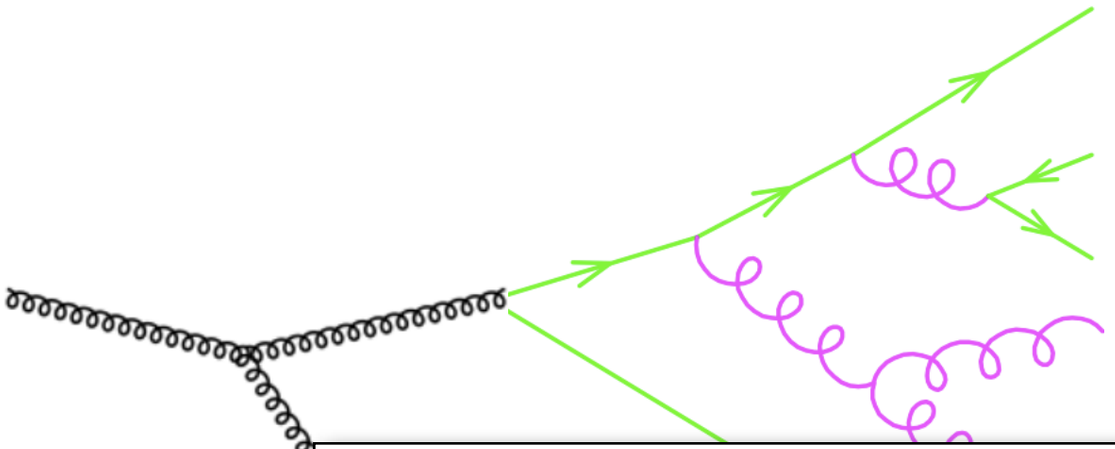

QCD radiation in the production of heavy colored particles at the LHC

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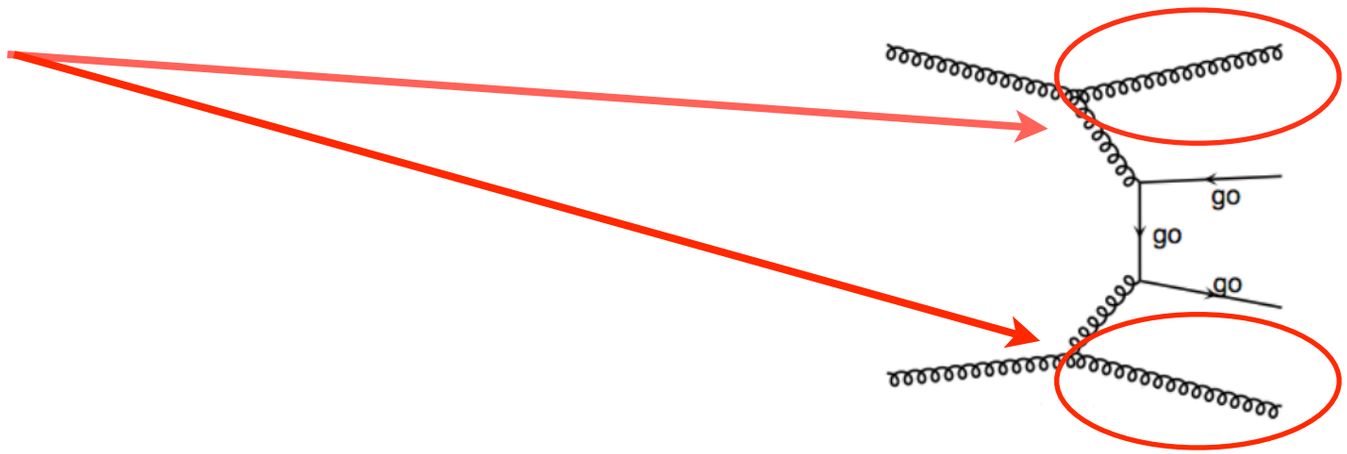
26/03/09 - NIKHEF - TH seminar

Outline

- Introduction
- Jet matching/merging
- Detailed study of matching impact

Heavy particles and QCD radiations

- LHC: a QCD machine!
  - Radiation: not part of the "main" process but could be important
    - additional jets
    - transverse boost
  - ⇨ Trustable MC simulation is crucial for shape prediction, final state definitions, ...
    - SM: ttbar+jets, W/Z+jets,...
    - Beyond the SM: new strongly interacting particles?



Matrix Element vs Parton Showers for multi-jets events

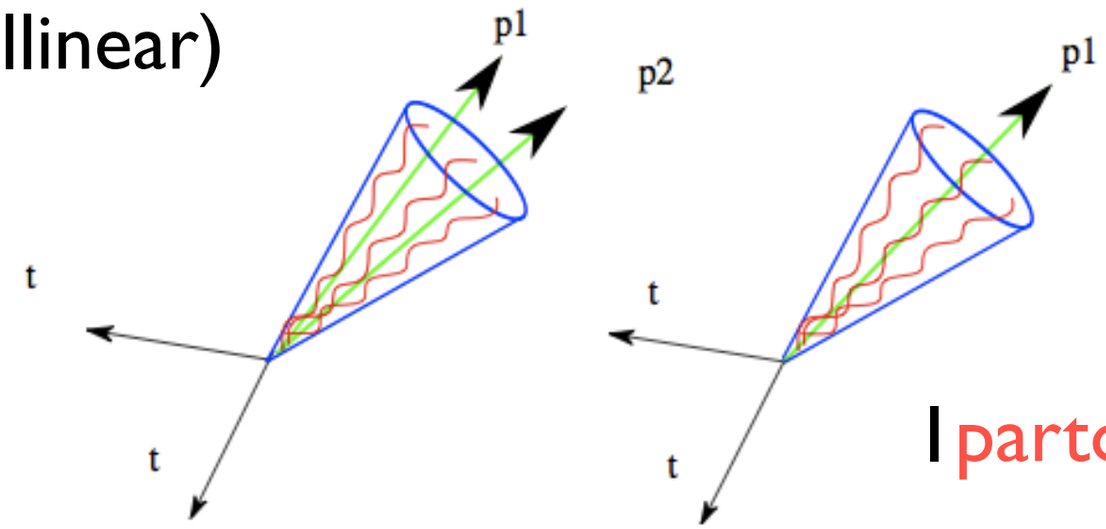
- Matrix-Element
  - Needed for multi-jet description
  - A limited number of partons
  - Valid when partons are well separated in the phase-space

- Parton Showers
  - Needed for realistic studies
  - Any number of partons
  - Valid when partons are collinear/softs

- We need both approaches to simulate physics from high scale down to hadronization scale (~1 GeV)

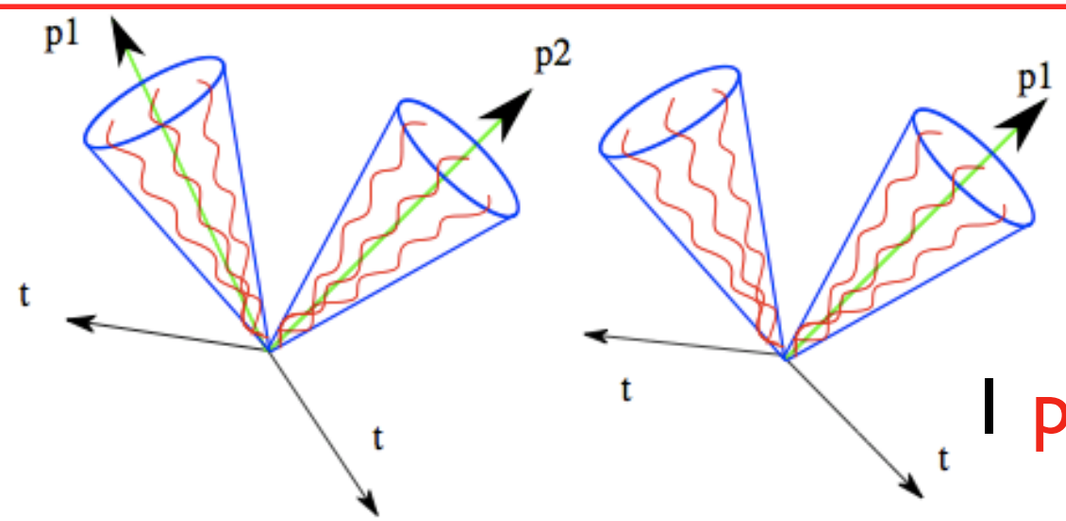
- What happens if ME and PS are used without control?
  - Example: tt + 2 partons vs tt + 1 partons

2 partons (collinear)



1 parton + no hard radiation

2 partons



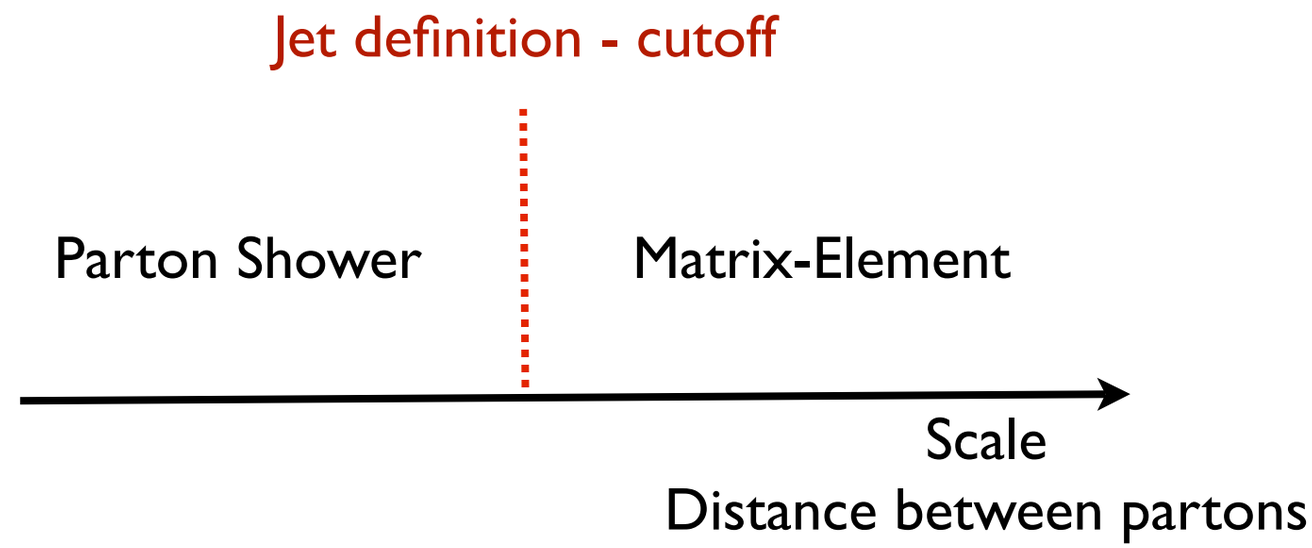
1 parton + 1 hard radiation

ME and PS overlap

➪ If you add all multiplicities: wrong cross-section.

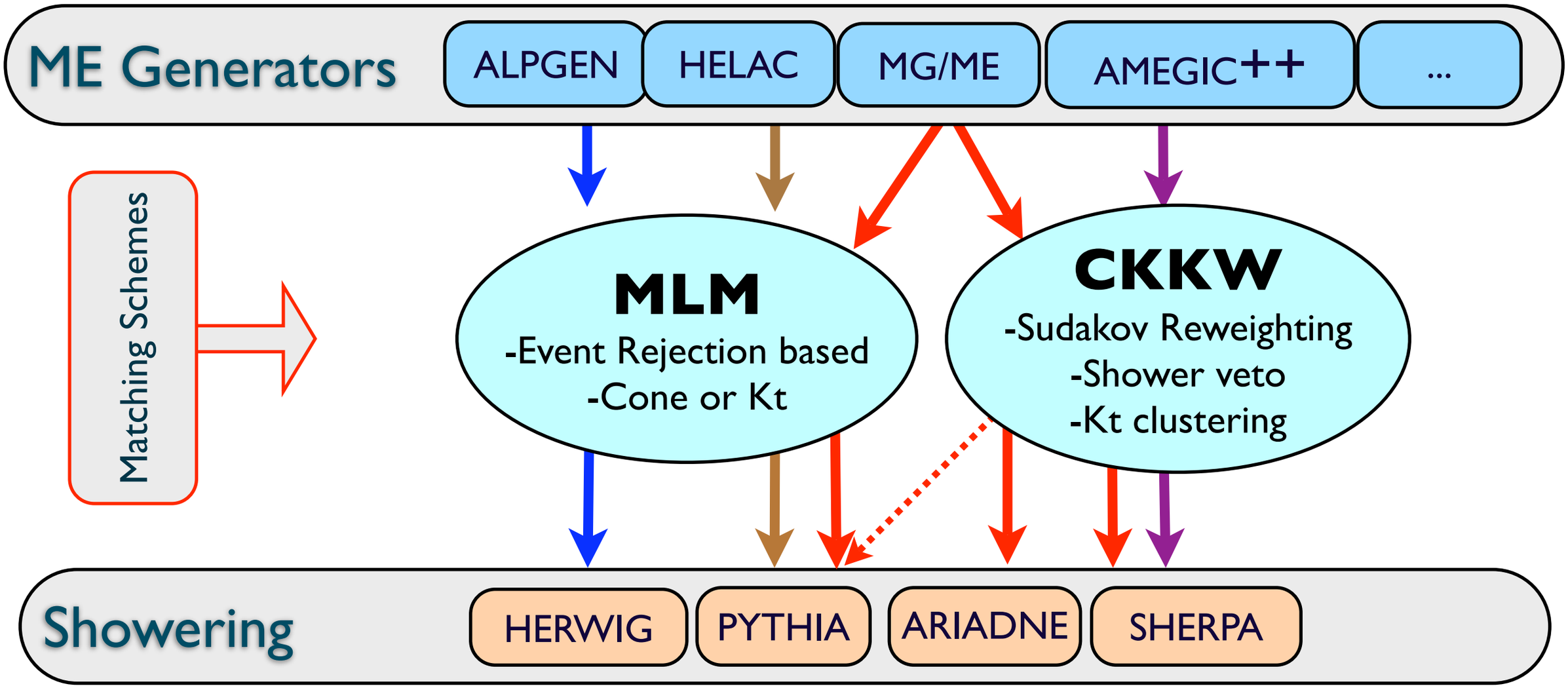
The principle of the jet matching

- To avoid overlap: one parton ⇔ one jet (except for highest multiplicity sample)
  - ME: scale>jet definition
  - PS: scale<jet definition



- ➪ define a cutoff (different definitions are possible) to separate ME and PS phase-spaces and use a matching technique

What is available on the market?



CKKW and MLM

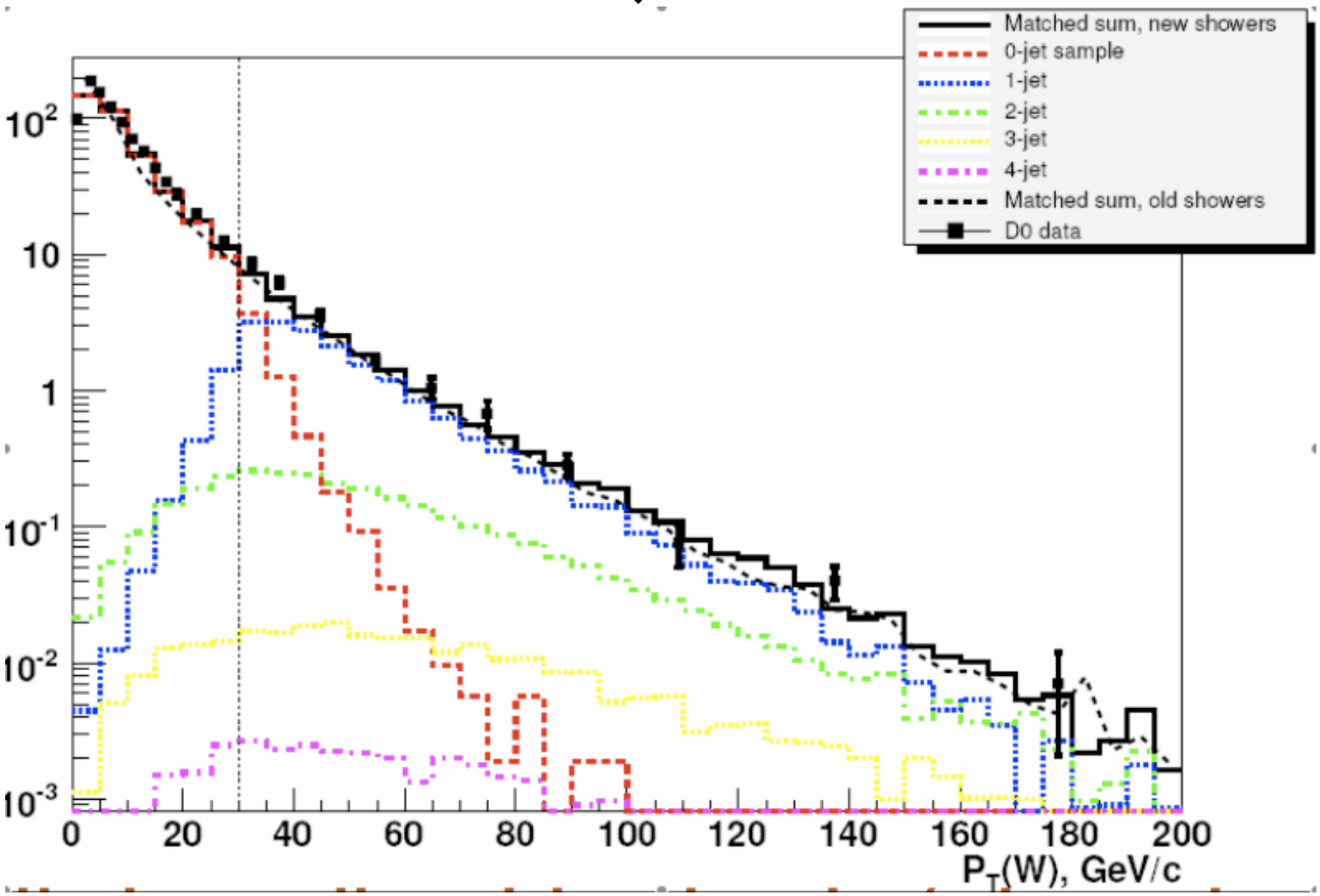
- CKKW (reweighting method) [Catani,Krauss,Kuhn,Webber]
  - Control the showers: no additionnal resolvable radiation
    ⇒ 1 parton gives 1 jet (no double counting)

    ⇒ reweight event/event by the probability of having no resolvable emission (Sudakov form factor)

- MLM (not reweight, but reject) [Mangano]
  - No control of the showers, but match jets (PS level) with partons (ME level): rejection method
  - Three versions: MLM (Mangano), Kt MLM (Mrenna, Alwall), Shower-kt (Alwall).

Does it work?

- A real test of Kt MLM: W+ jets at Tevatron



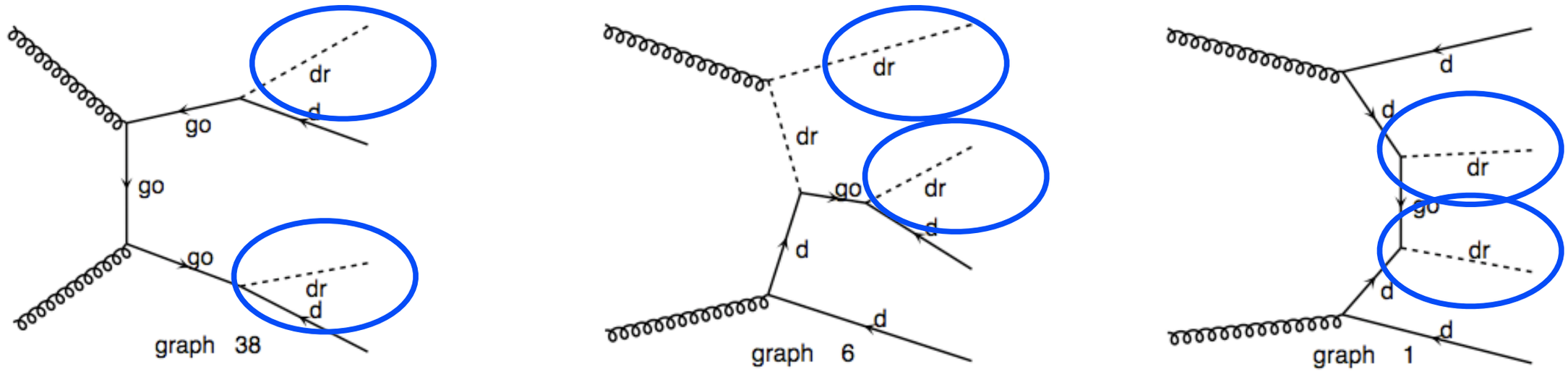
- Possibility of a theoretical validation for most of SM processes:ttbar, W/Z, photon+jets,... we come to that in a while...

[MG Team]

Matching in BSM? One step forward...

- Additional difficulty: double counting due to resonances

Example: $\tilde{q}\tilde{q}jj$



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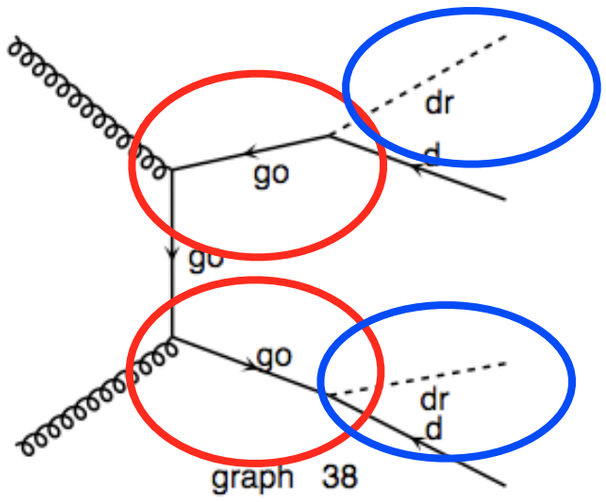
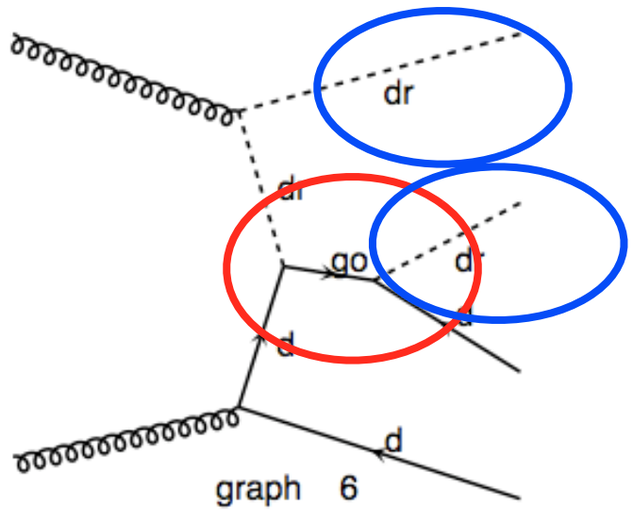
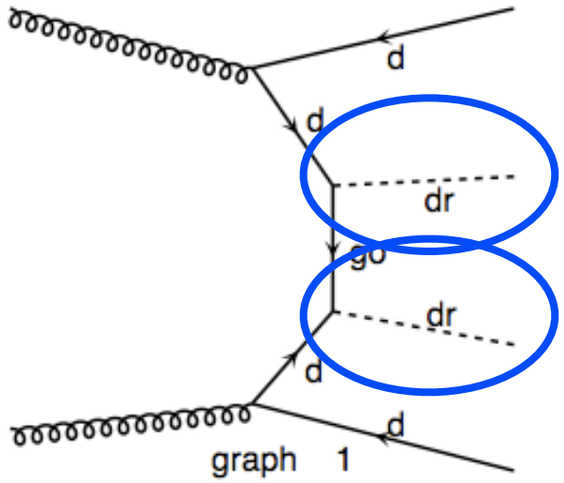
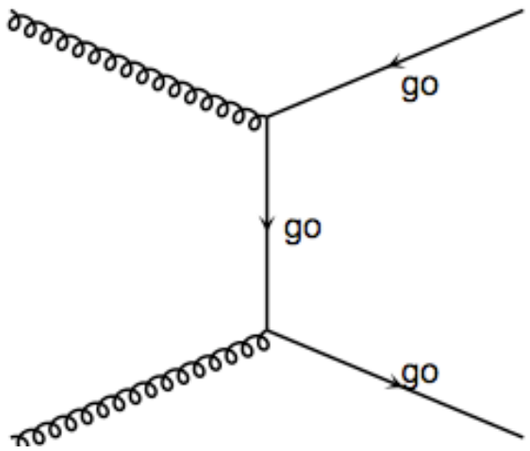
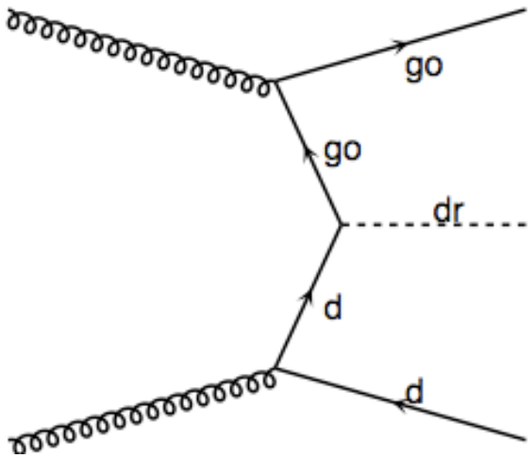






If Go's on resonance:
double counting with



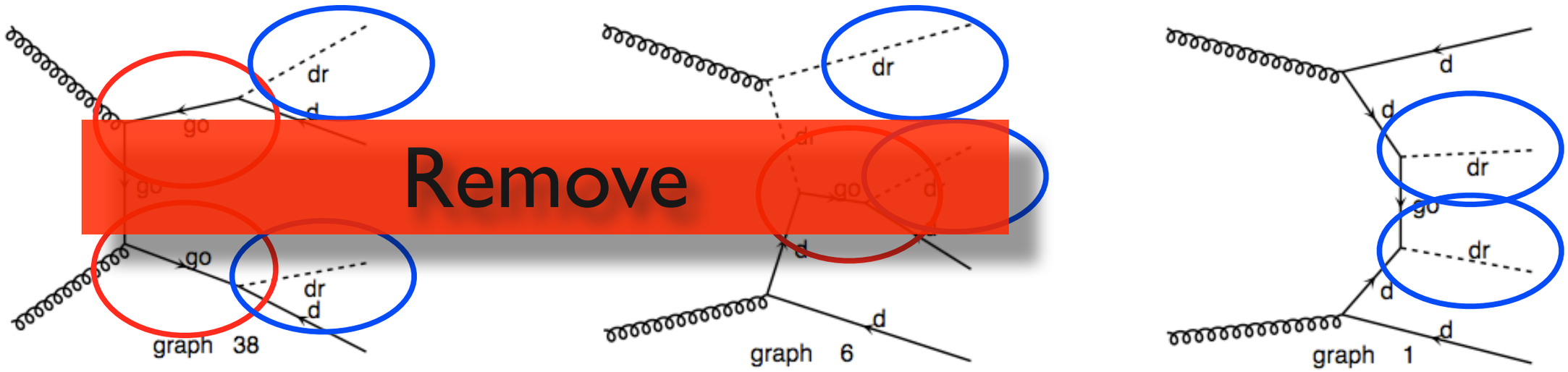


with go→dr+q in pythia

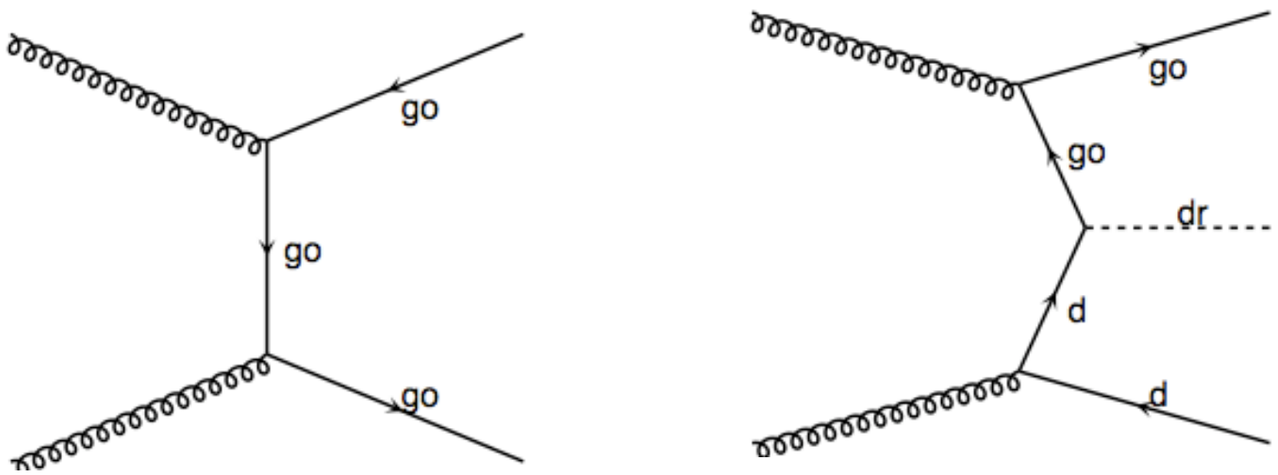
Matching in BSM? One step forward...

- Additional difficulty: double counting due to resonances

Example: $\tilde{q}\tilde{q}jj$



If Go's on resonance:
double counting with



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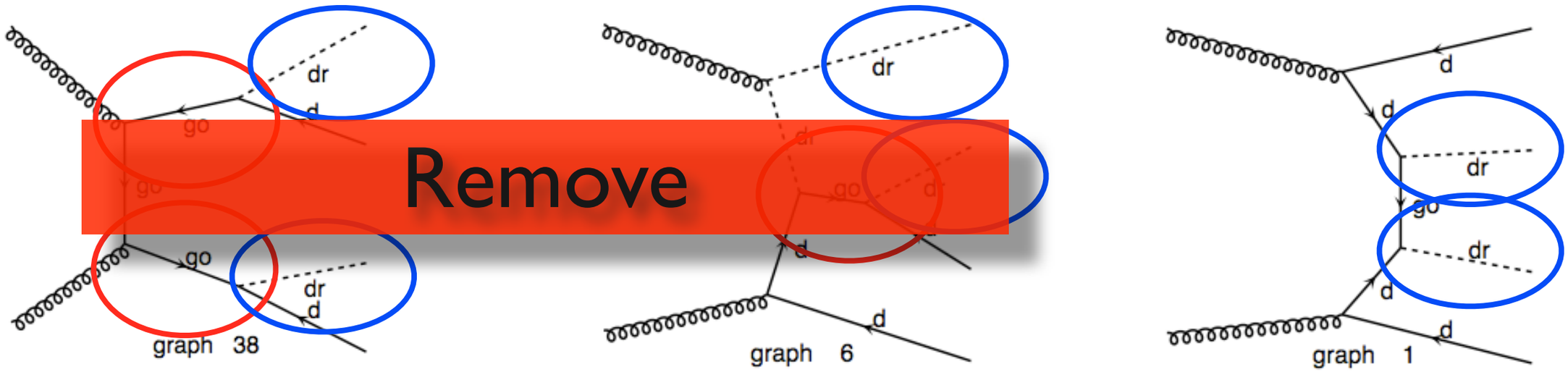

If Go's on resonance:
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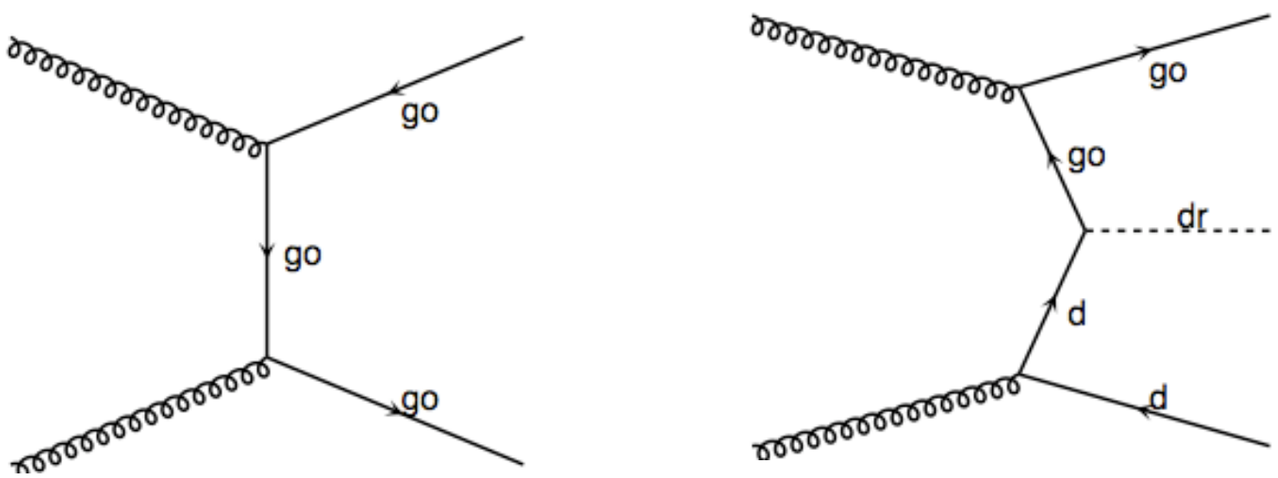

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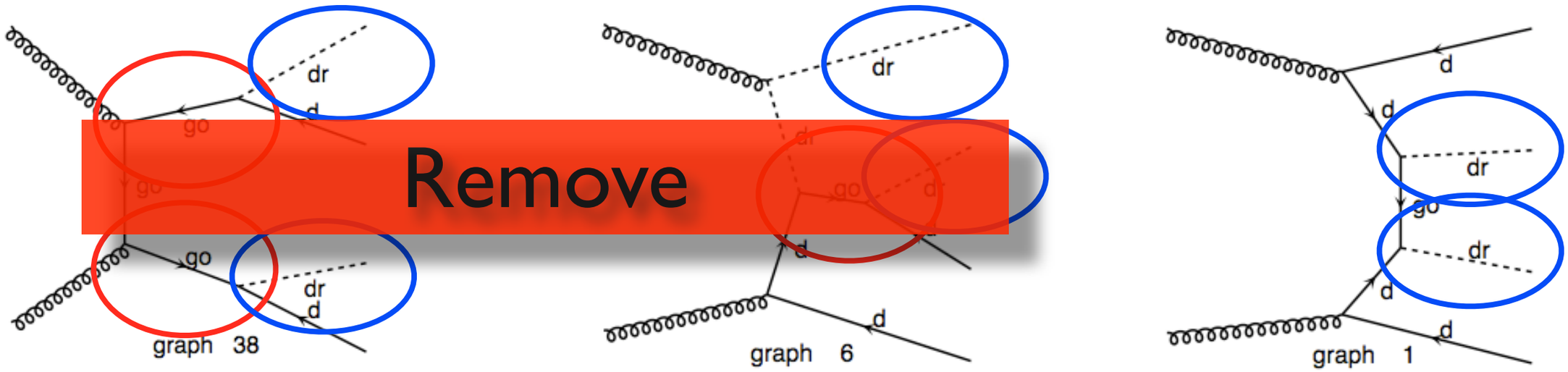
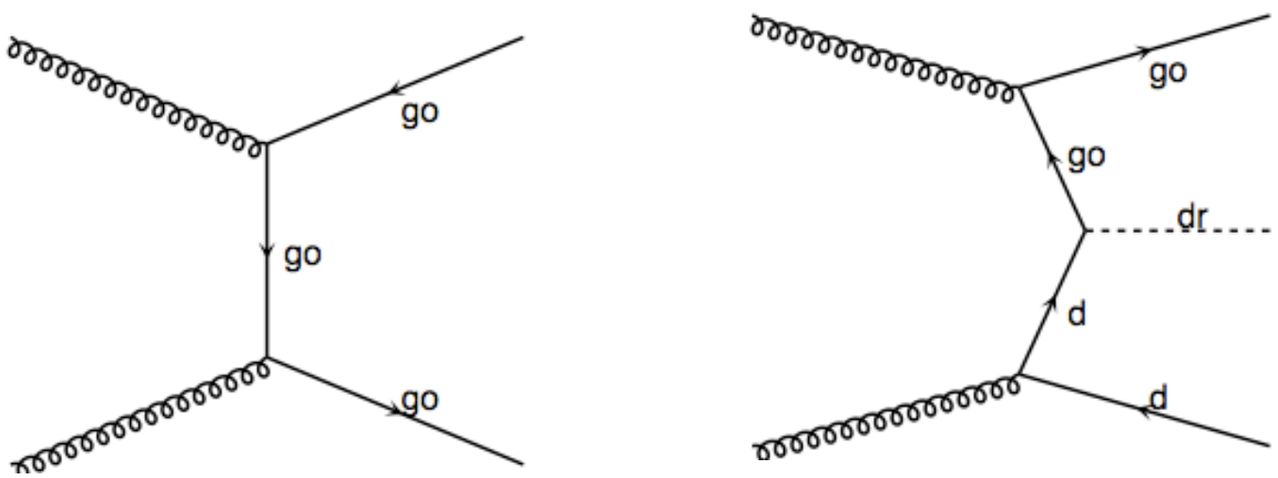


If Go's on resonance:
double counting with

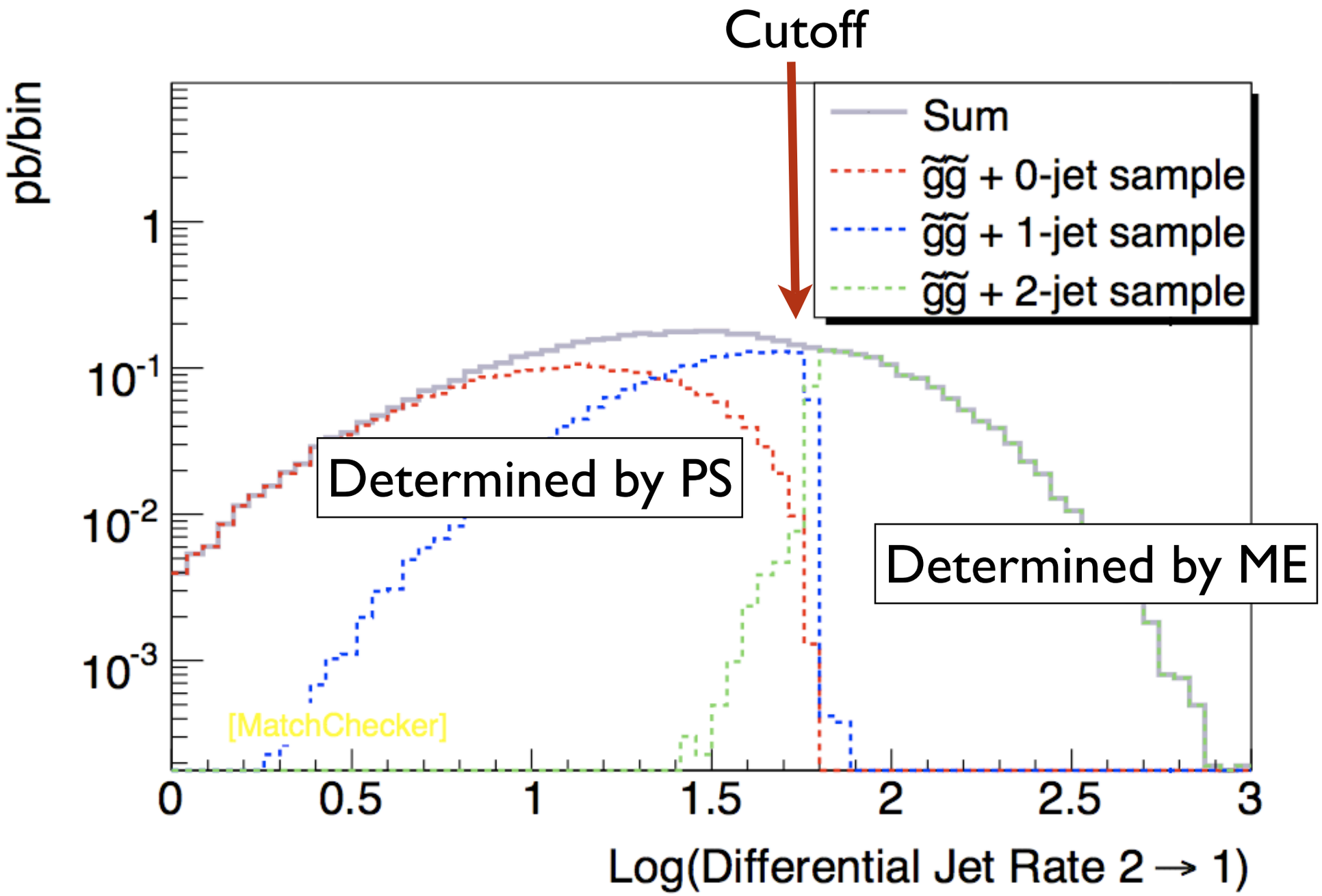


with go→dr+q in pythia

OK!
First time this is possible!

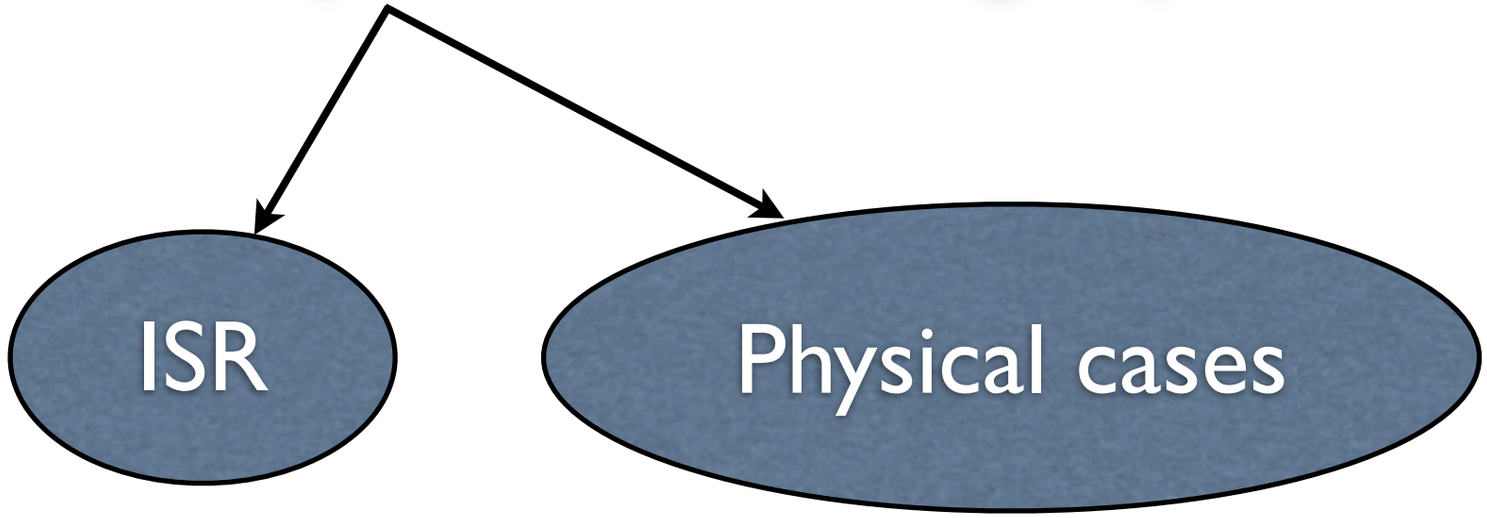
How to control the matched simulation?

- Differential jet rates (N+1→N): scale at which and events passes from a N+1 to a N jet configuration while clustered



-Transition from PS to ME regime is smooth

Detailed study of the matching impact



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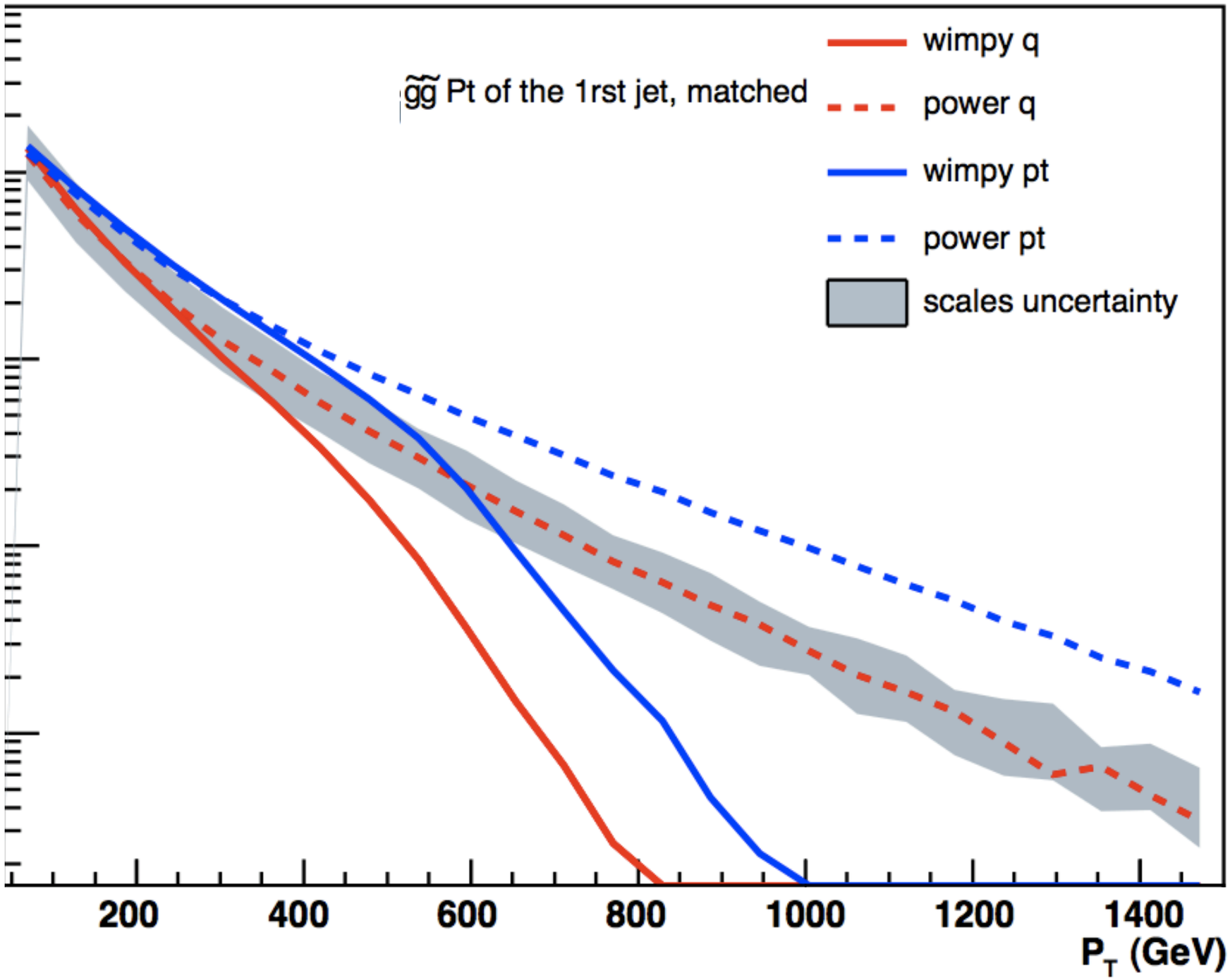
Sensitivity to showers

First study (without matching): Plehn, Rainwater and Skands, *Phys.Lett. B645 (2007) 217-221*

- Matching implies that jets kinematics are ruled by ME calculations above the cutoff
  - ⇒ physical distributions at large Pt should be less sensitive to shower parametrization:
    - Shower evolution variable: Q^2, P_T^2 ,...
    - Starting scales: from low values (“wimpy”) to high values (“power”) showers...
    - additional tunes...

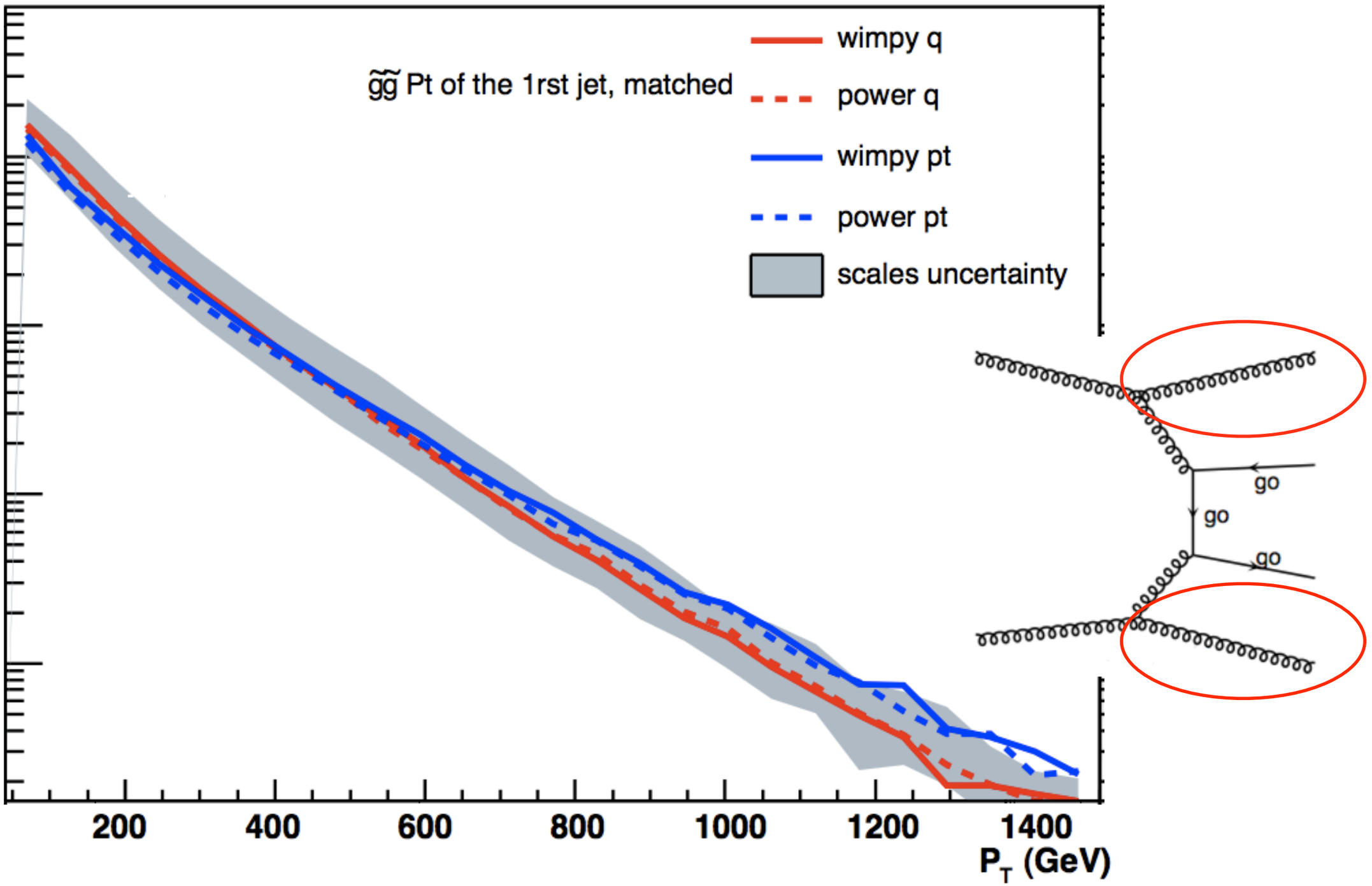
The IS radiation in Pythia only

- Case of gluino production done "a la Pythia "(2→2): Pt distribution of extra-jets



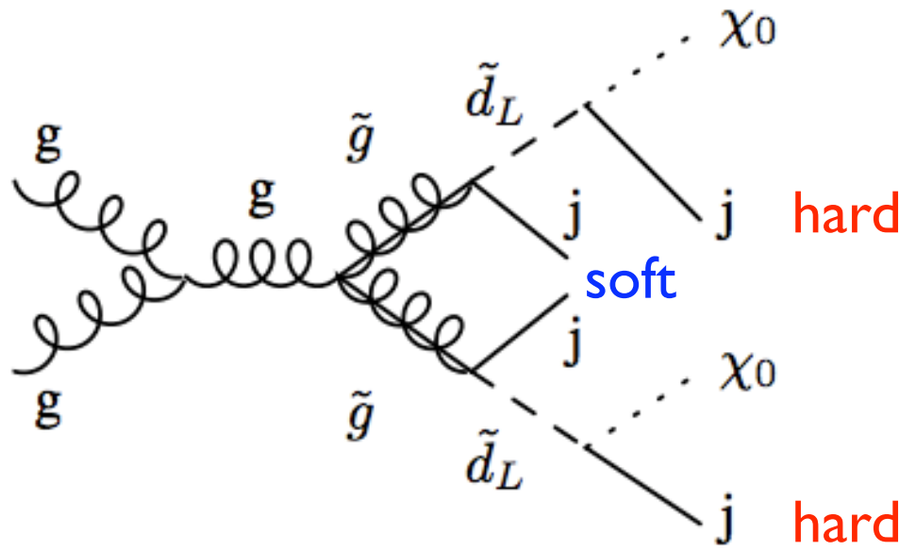
The IS radiation with ME + Pythia

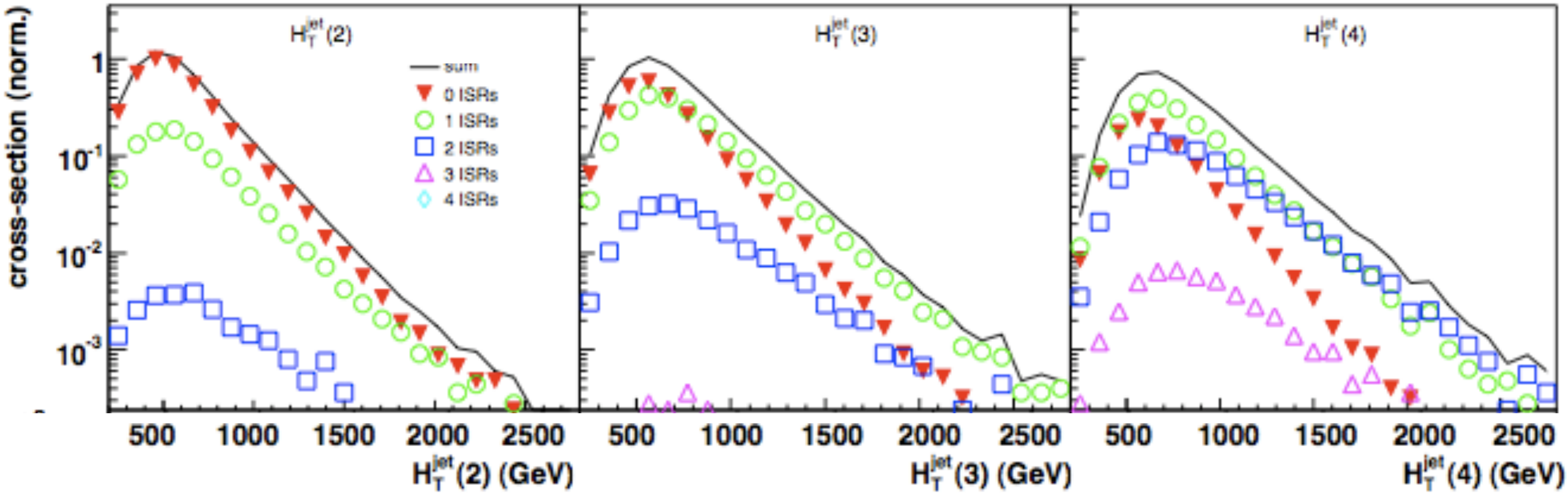
- Case where gluinos are produced with ME calculation with up to 2 jets with MG/ME (2→2,3,4)



Shape prediction

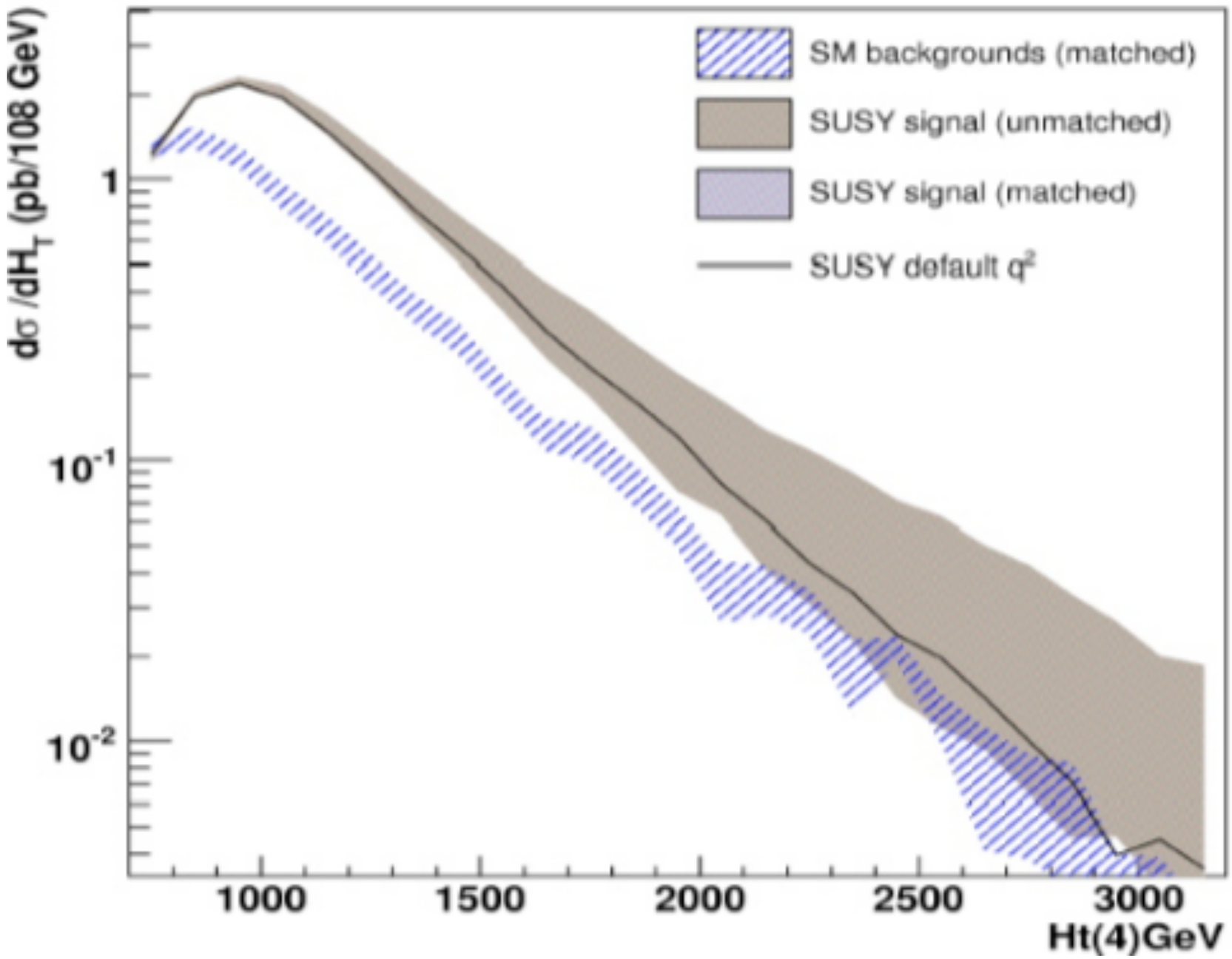
~SPS1a→ gluinos~600 GeV
squarks~560 GeV
neutralino~100 GeV





A classical case: SUSY vs SM

- The classical case illustrated @ SPS1a: (2→2)



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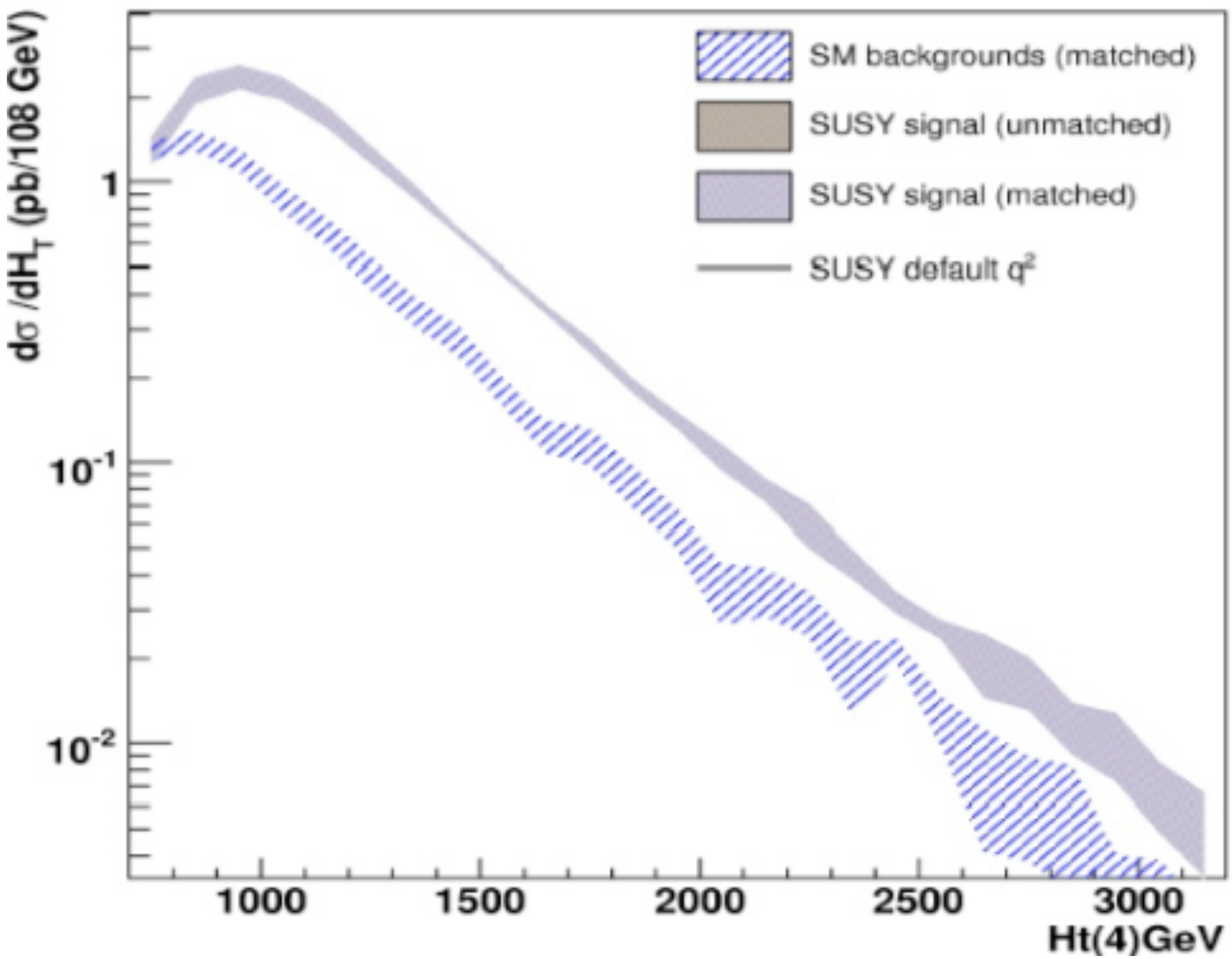
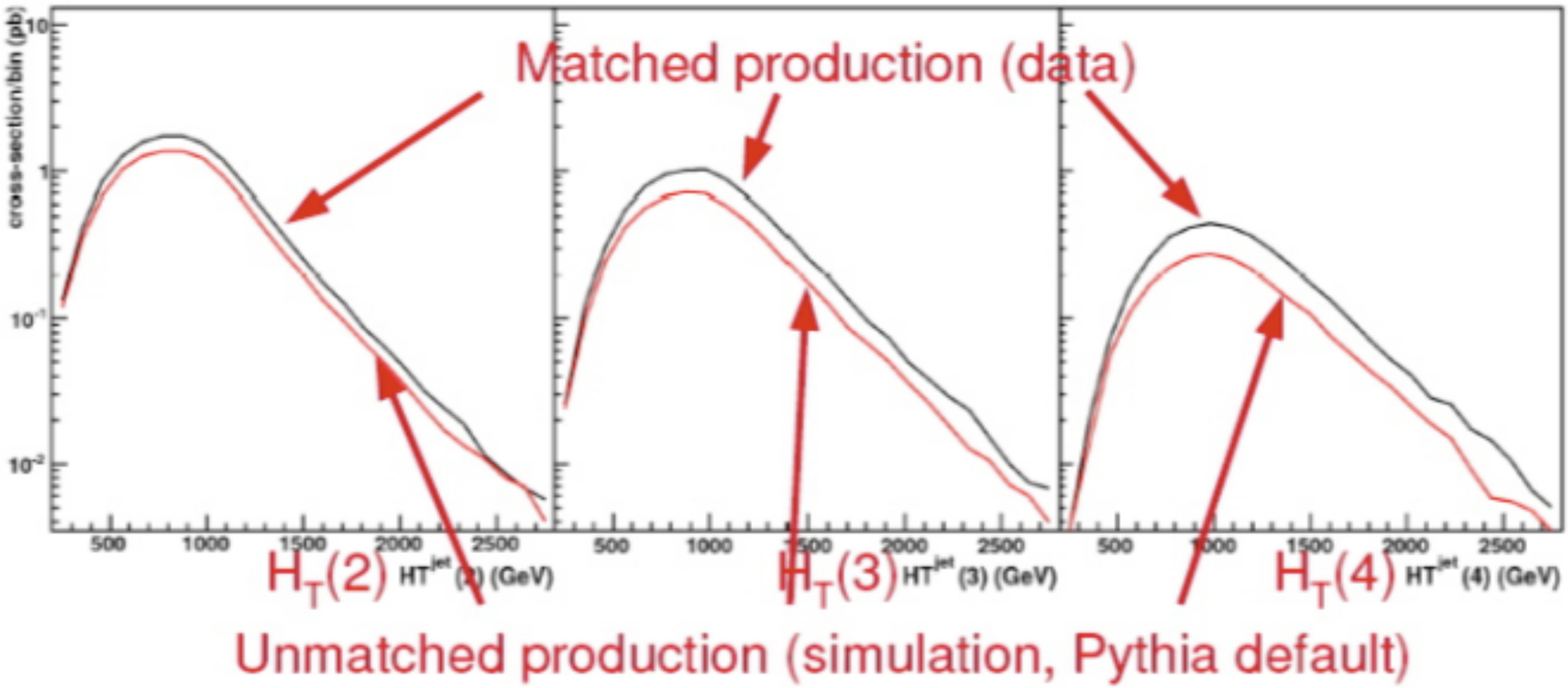


The false gluino case

- Let's say nature produces squark pairs at 600 GeV



- Conclusion: we don't have only squarks!

The false gluino case

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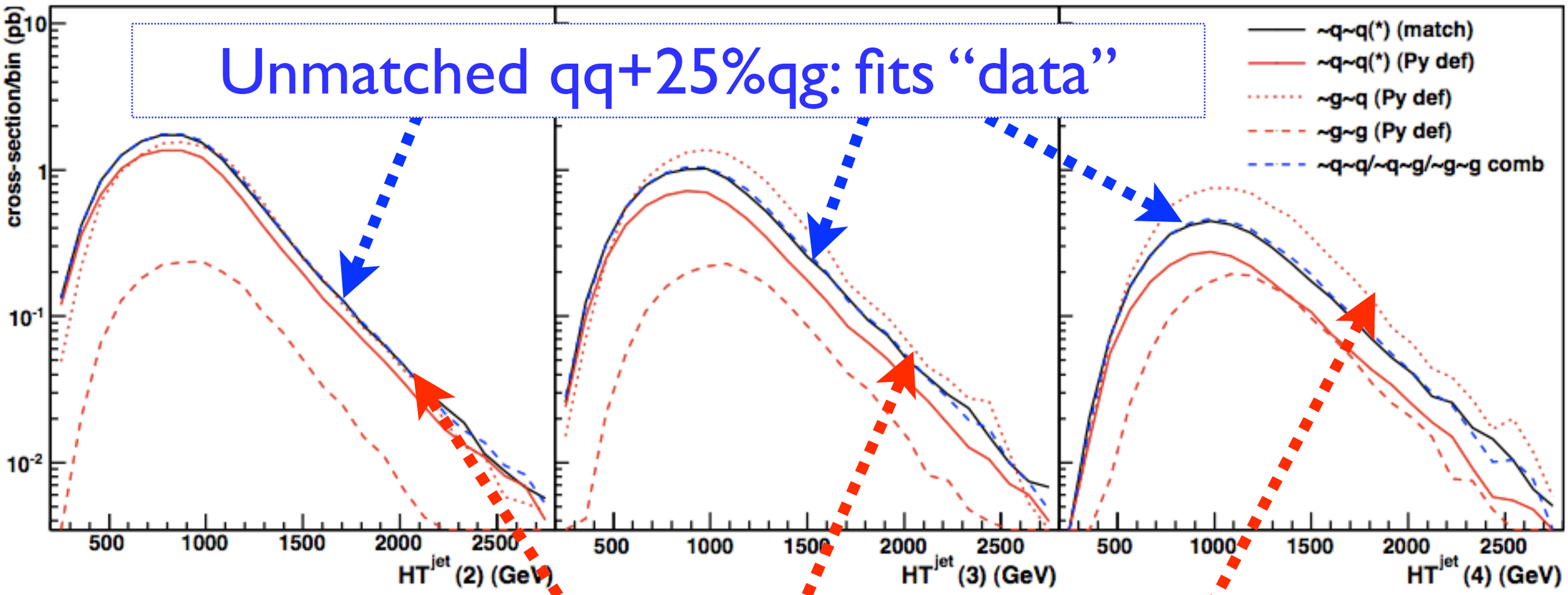
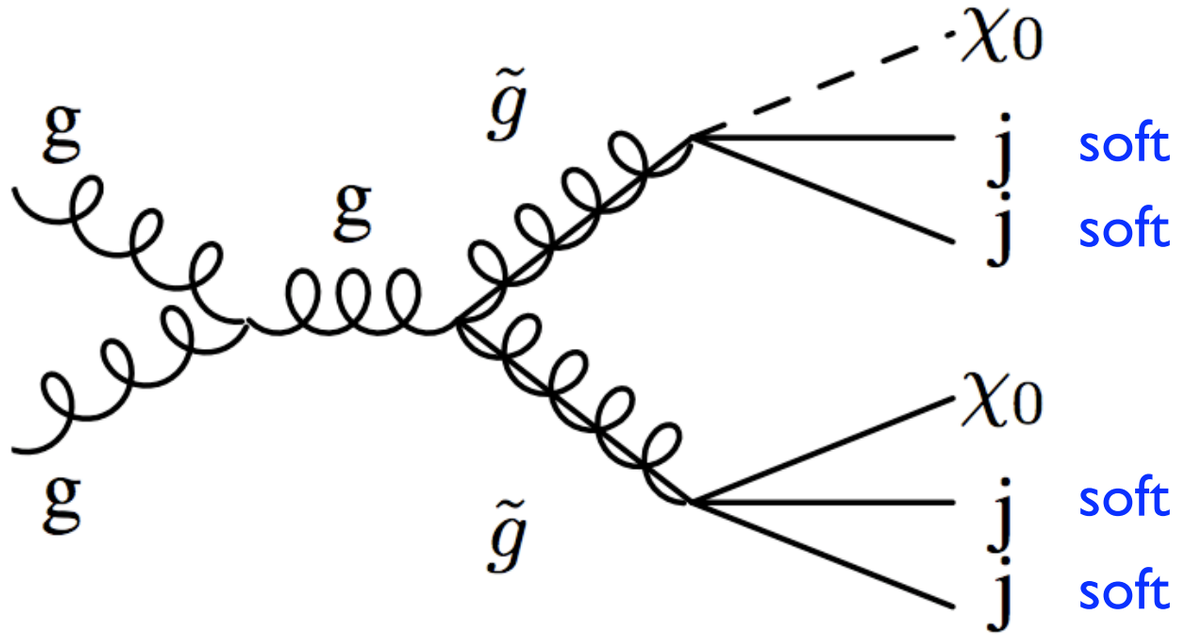


Unmatched qg, Mg=700 GeV

- Mis-interpretation: presence of gluinos!

The degenerate case

- If $m_{\tilde{g}} \sim m_{LSP}$:
  - Jets from gluinos are soft
  - small MET
    - ⇒ gluinos “disappear”!
    - impact of matching is huge since jets are almost exclusively ISR



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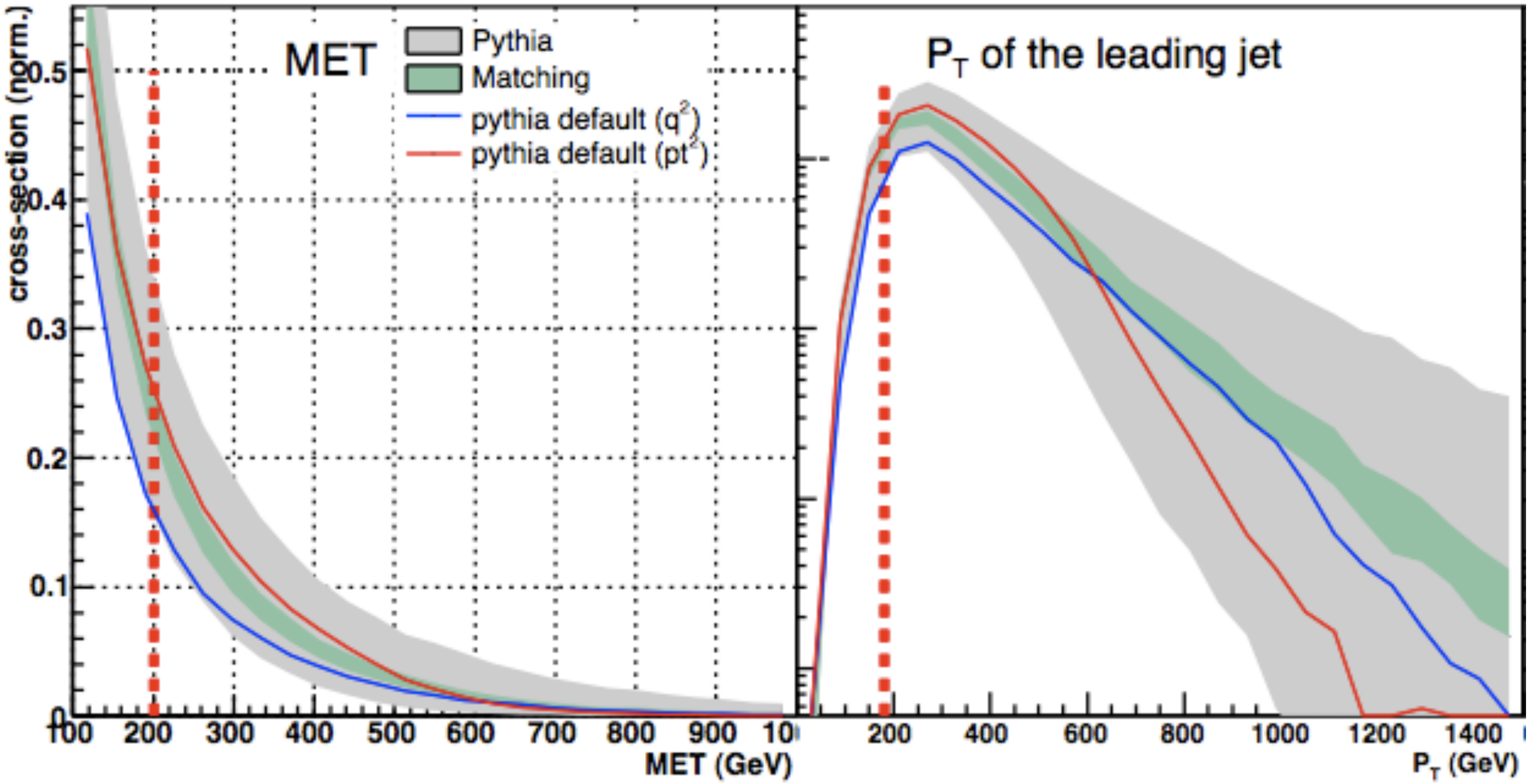

- impact of matching is huge since jets are almost exclusively ISR

Summary

- To simulate multi-jets events inclusive samples, need a matching technique
- Matching in SUSY possible after solving double counting arising from the presence of resonances
- Sensitivity of extra-jet kinematics to showers parametrization is strongly reduced
- Eliminates some major problems for critical cases

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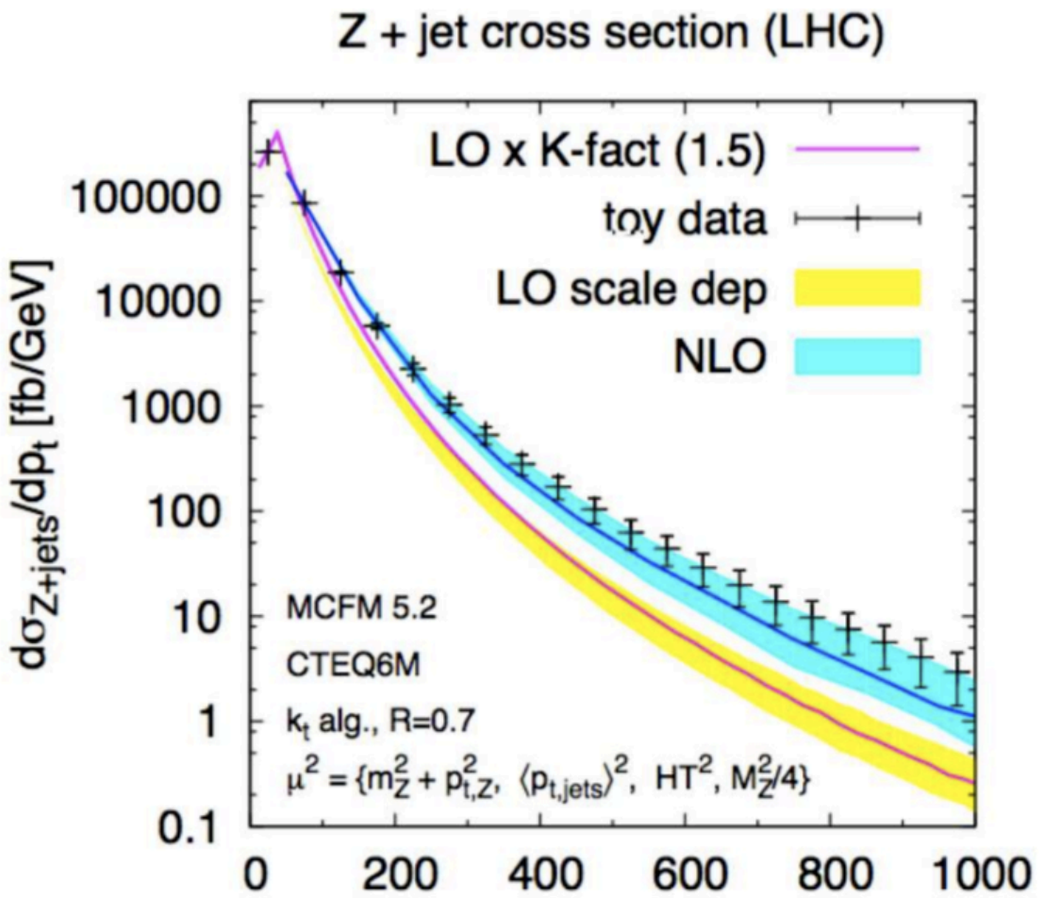
UCL

Thanks for you attention! ☺

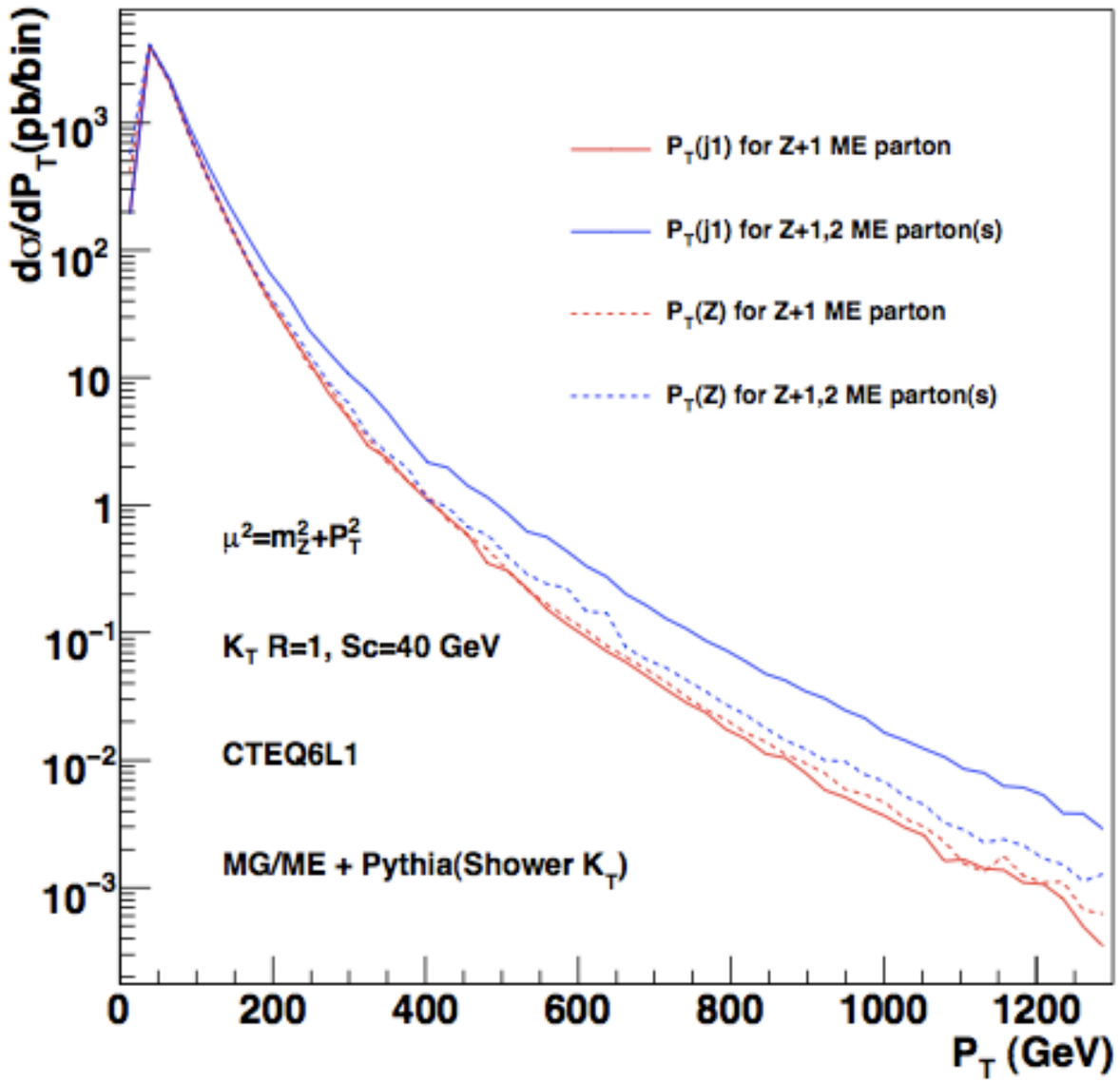
Back-up slides

Tree-level+PS vs NLO calculations



G.Salam, M.Rubin

SDV, F.Maltoni



Kt-MLM in more details

- Main steps are
  - With MadEvent: generate events with a minimal distance in the phase-space between the partons
  - Perform showering using Pythia
  - Match each jet with a parton using the cutoff as maximal distance (except for highest multiplicity events)
    - if N(jet)≠N(parton)→ reject
    - For clustering algos, the distance definition is Kt instead of Cone (MLM [Mangano])

Validation [SdV, P.Demin]

- MatchChecker: http://cp3wks05.fynu.ucl.ac.be/twiki/bin/view/Software/MatchChecker
  - Draw differential jet rates, kinematic, MET, Ht
    - with detailed contribution of each multiplicity
    - in comparison plots if more than one production
  - Produces a rootfile with all global histos for further use
  - Produces a complete report with everything inside