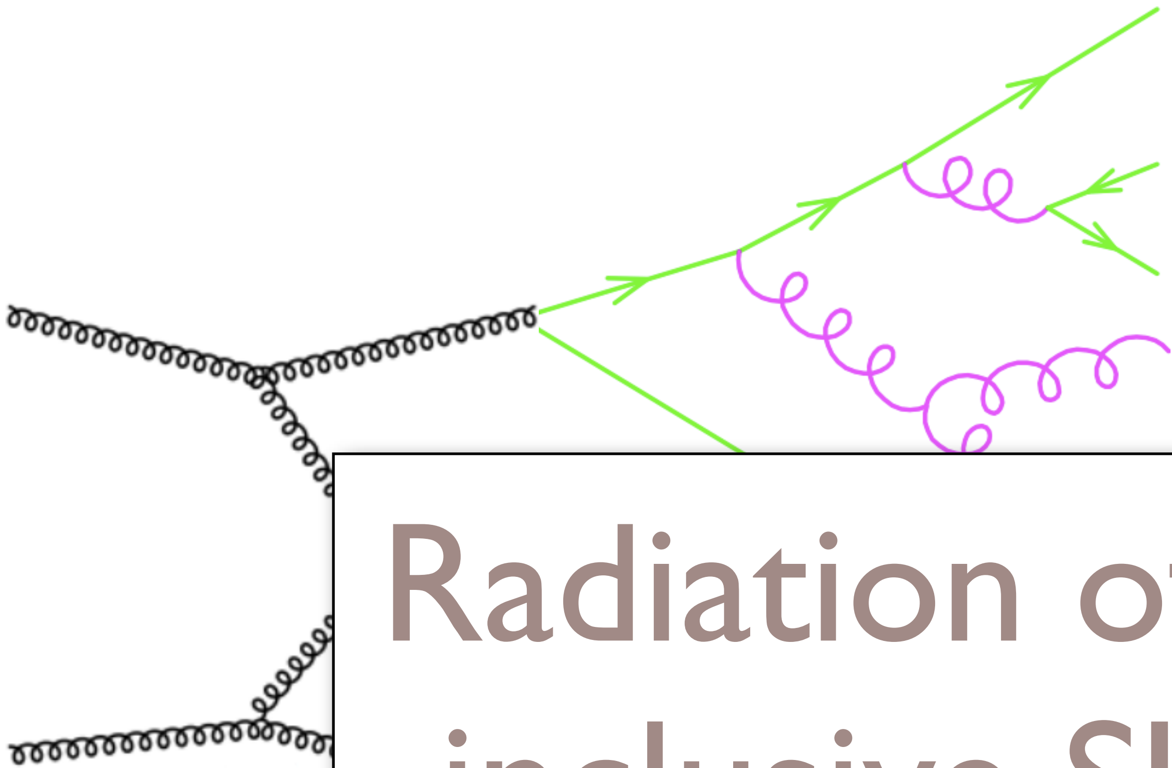

Radiation of extra-jets in inclusive SUSY samples

S.de Visscher

Université catholique de Louvain

J.Alwall (SLAC), F. Maltoni (UCL)

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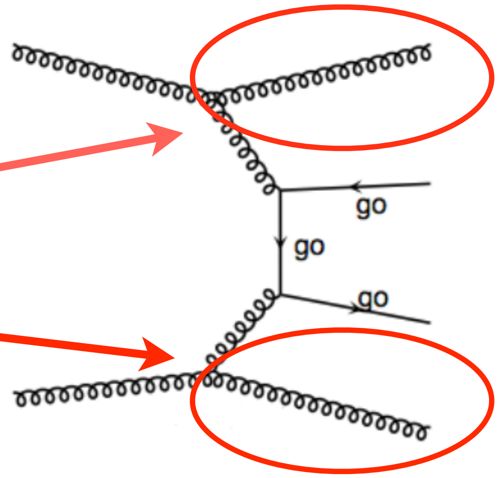
SUSY08 - Seoul - 20/06/08

Heavy particles and QCD radiations

- In many models (SUSY, RS, UED, LH,...) Higgs mass stabilized by introducing new strongly interacting particles

- QCD radiation can be important



  - ➪ crucial to simulate them correctly for shape prediction, final state definitions, ...

- Monte Carlo problem: realistic multi-(extra) jets event generation with full matrix-element calculation is problematic in SM and even more in SUSY.

Outline

- Generation of multi-jet processes
- Jet matching in SM and SUSY
- Impact on physical distributions

Generation of multi-jet processes

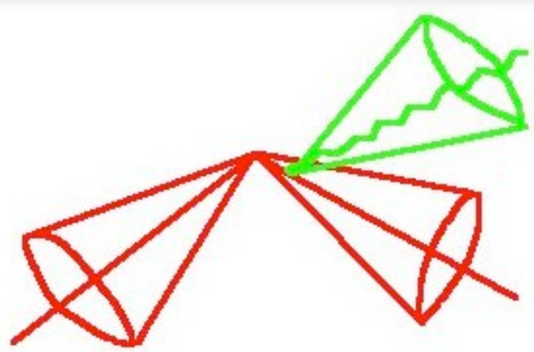
Matrix Element vs Parton Showers

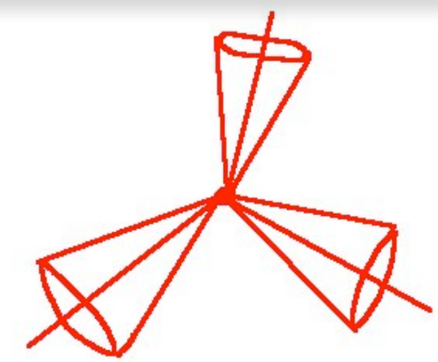
- Matrix-Element
  - A limited number of partons
  - Valid when partons are well separated in the phase-space
  - Needed for multi-jet description

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

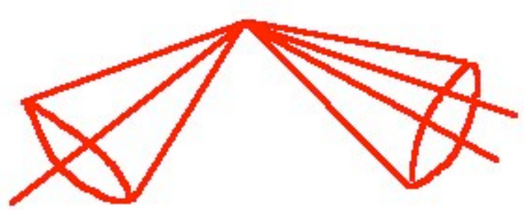
- We need both approaches to simulate physics from hard-scattering scale down to hadronization scale (~1 GeV)

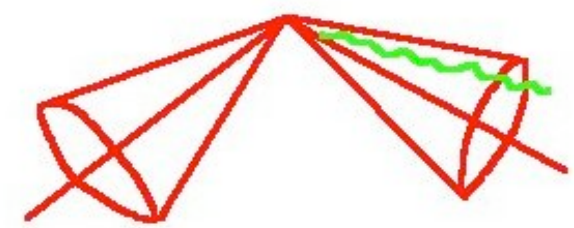
- What happens if ME and PS are used without control?
  - Example: X + 3 partons vs X + 2 partons





2 partons + 1 hard radiation ⟷ 3 partons + no hard radiation





3partons (2 collinear) ⟷ 2 partons + no hard radiation

ME and PS overlap

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

The jet matching in SM and SUSY

The principle of the matching

- To avoid overlap: one parton has to give one jet (except for highest multiplicity sample)

  - ➪ ME has to rule distances between jets (scale>jet definition) and PS only the shower (scale<jet definition)

  - ➪ Use ME calculation for hard scales, and PS for low scales: 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?

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ME Generators: ALPGEN | HELAC | MG/ME | AMEGIC++ | ...

What is available on the market?

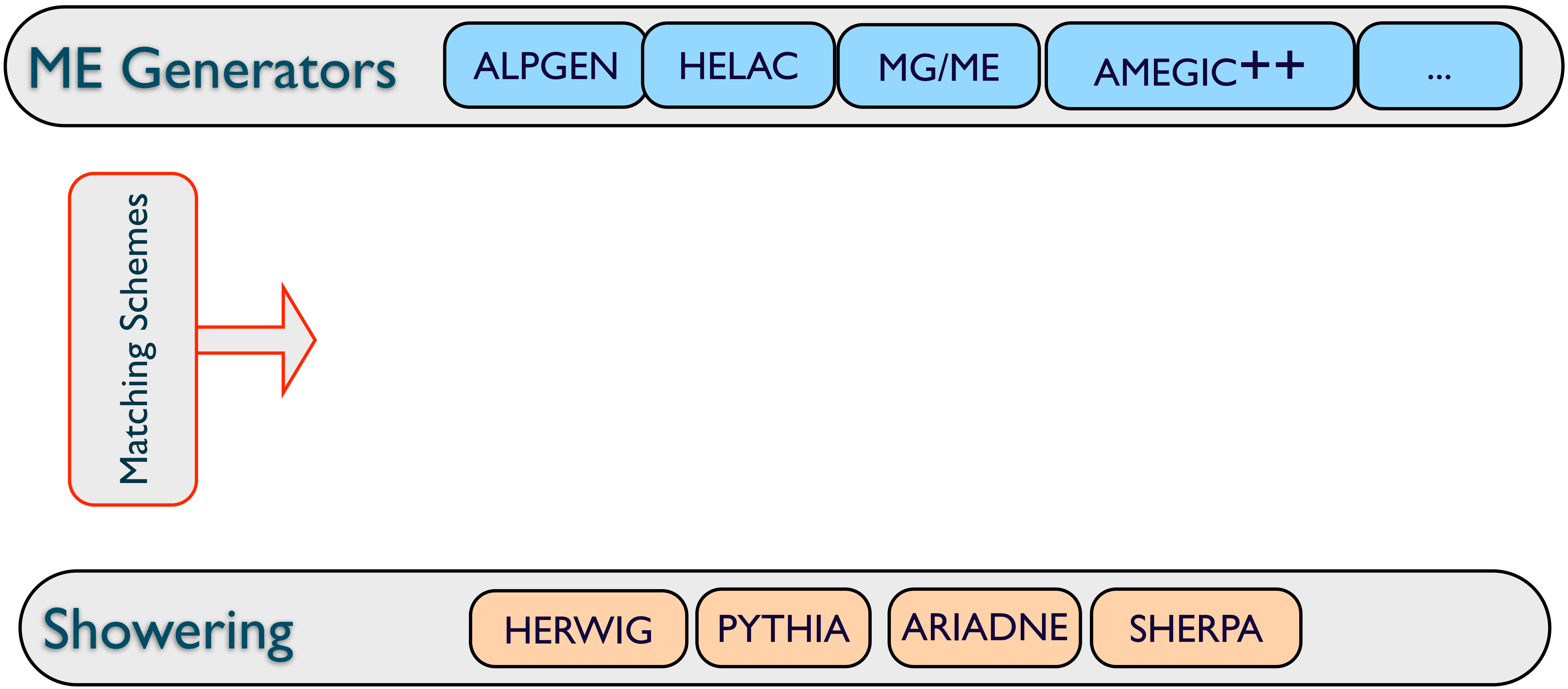
ME Generators

- ALPGEN
- HELAC
- MG/ME
- AMEGIC++
- ...

Showering

- HERWIG
- PYTHIA
- ARIADNE
- SHERPA

What is available on the market?



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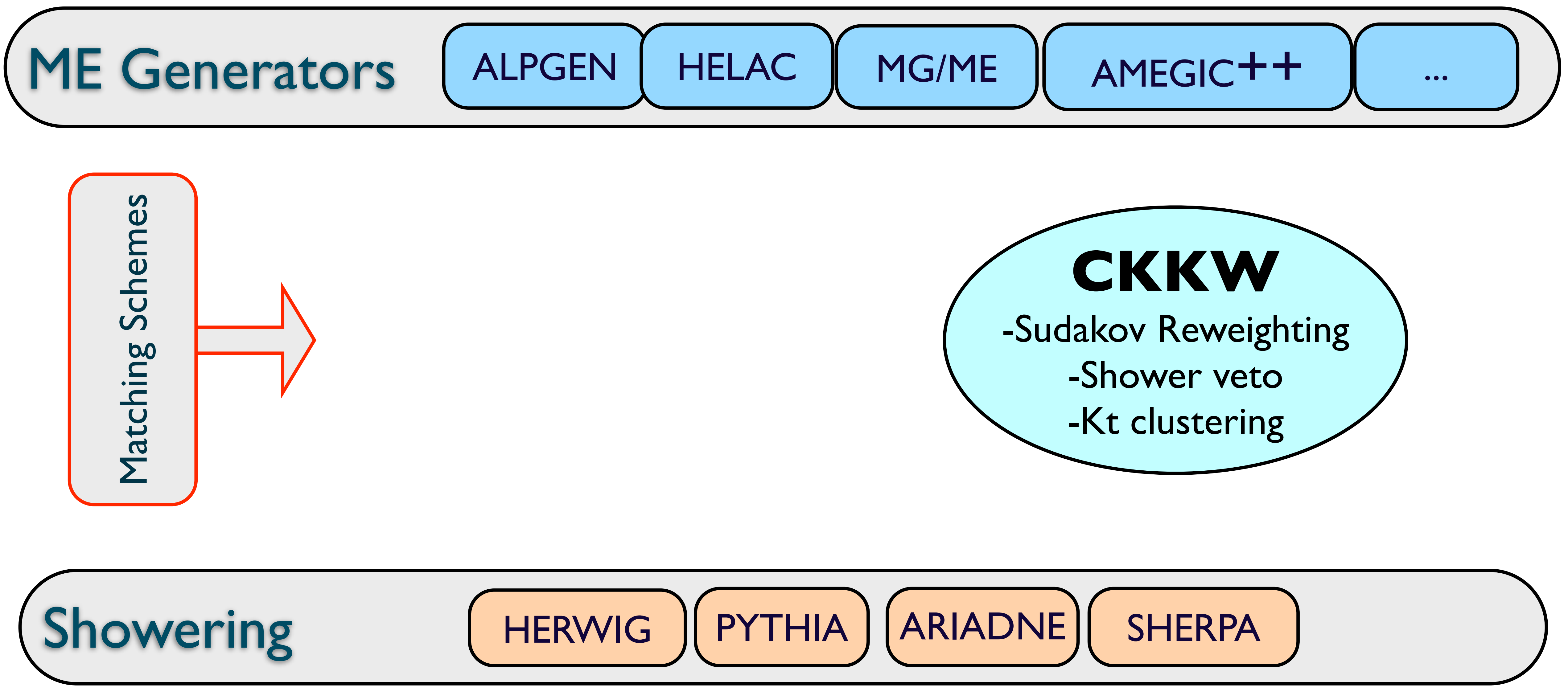


UCL

What is available on the market?

ME Generators: ALPGEN | HELAC | MG/ME | AMEGIC++ | ...

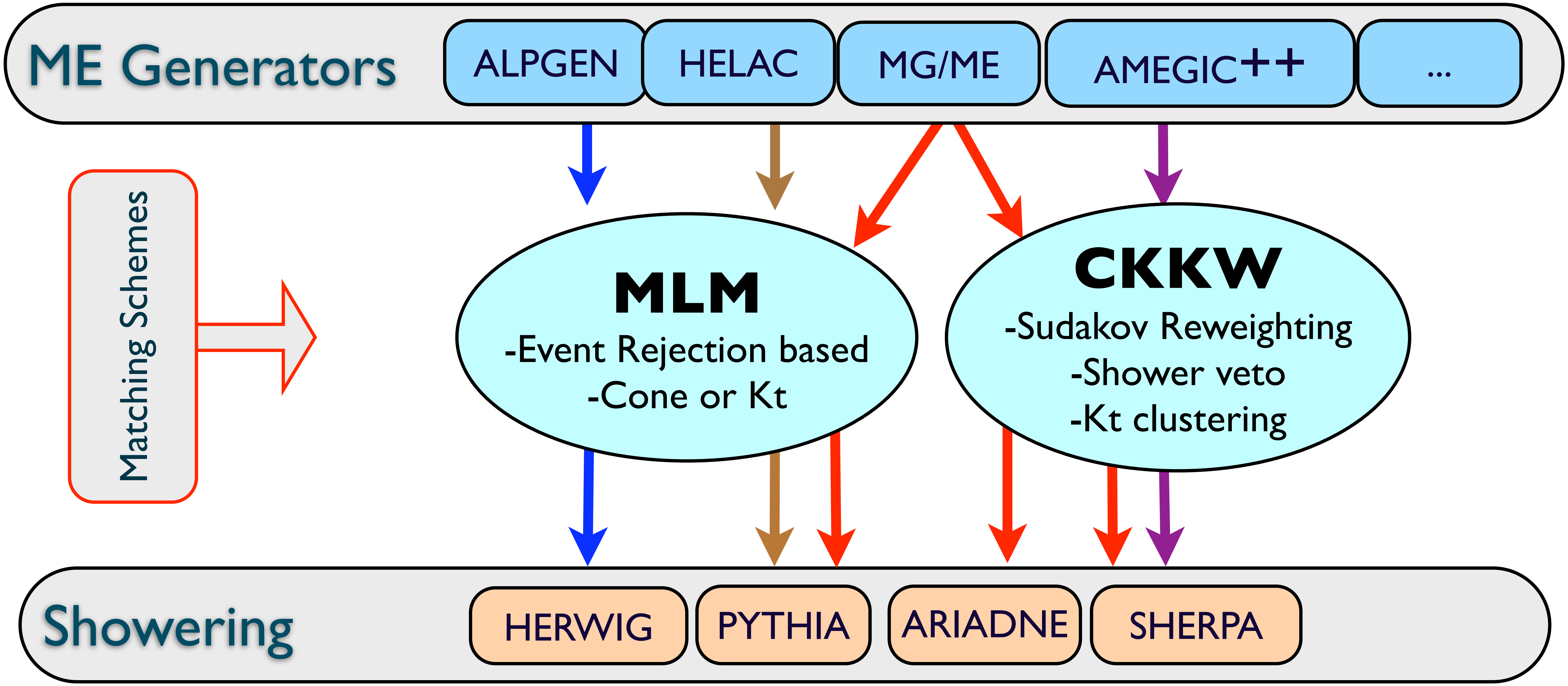
Matching Schemes →

MLM
- Event Rejection based
- Cone or Kt

CKKW
- Sudakov Reweighting
- Shower veto
- Kt clustering

Showering: HERWIG | PYTHIA | ARIADNE | SHERPA

What is available on the market?



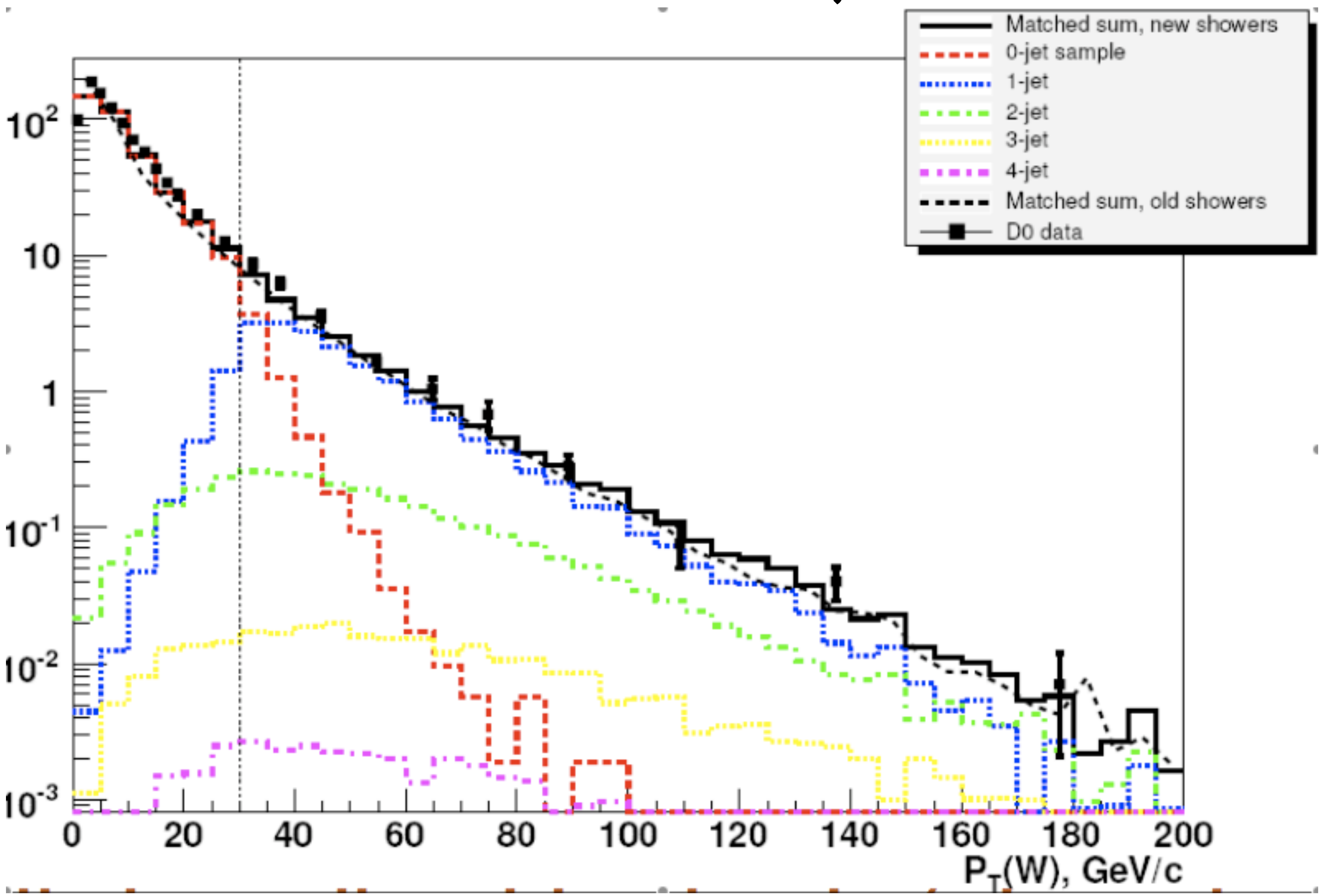
Kt MLM in more details

[Mrenna,Richardson; Alwall]

- Main steps are
  - 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
    - if N(jet)$\neq$N(parton)$\rightarrow$ reject (except if it's the sample with highest multiplicity)
- For clustering algos, the distance definition is Kt instead of Cone (MLM [Mangano])

Does it work?

- A real test of Modified MLM: W,Z+ jets at Tevatron



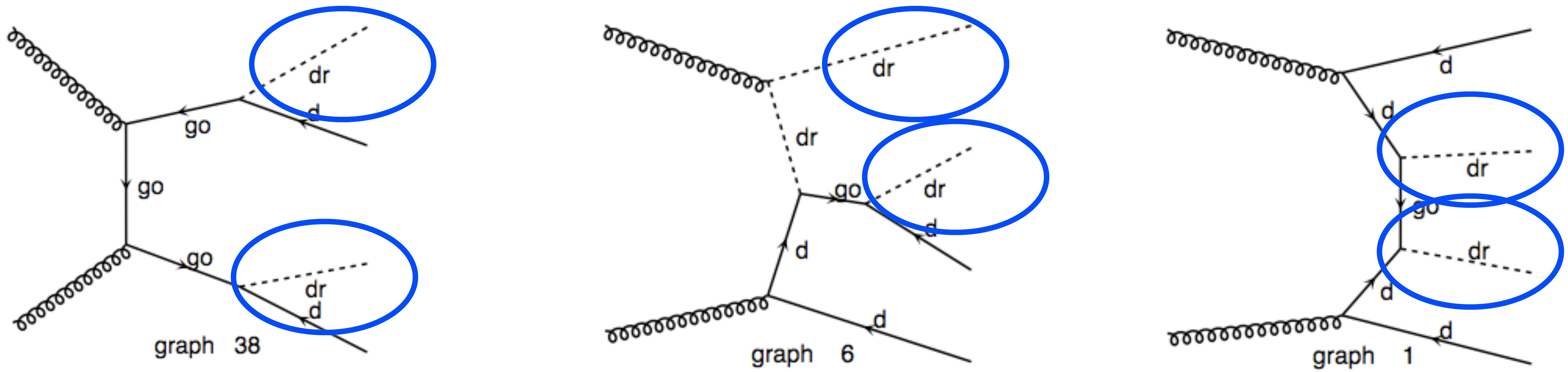
- For other SM processes:
Theoritical validation for ttbar+jets, QCD, bbar+jets,photon +jets, we come to that in a while...

[MG Team]

Matching in SUSY? Again a story of double counting!

- Additional difficulty: double counting due to susy particles

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



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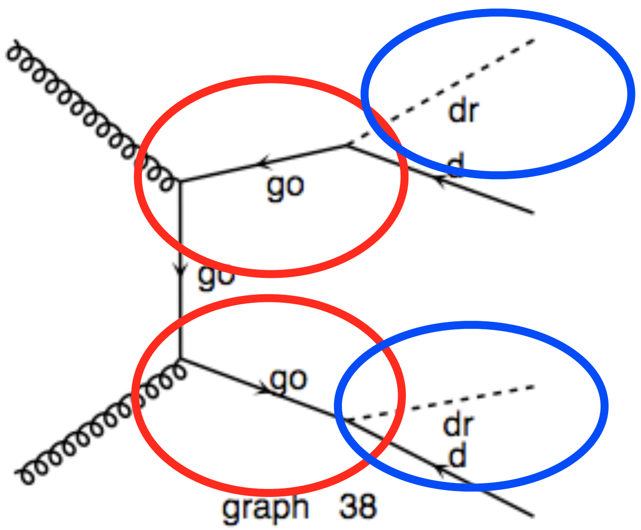
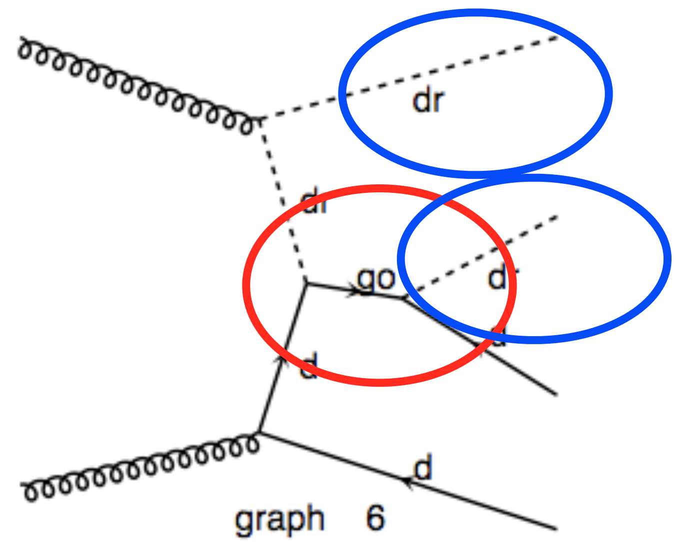
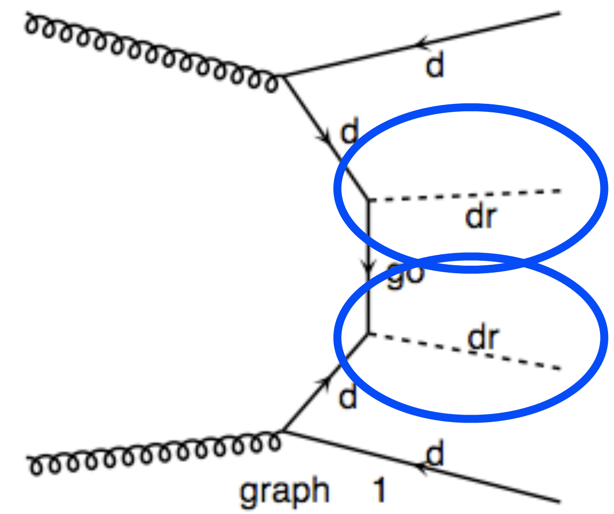
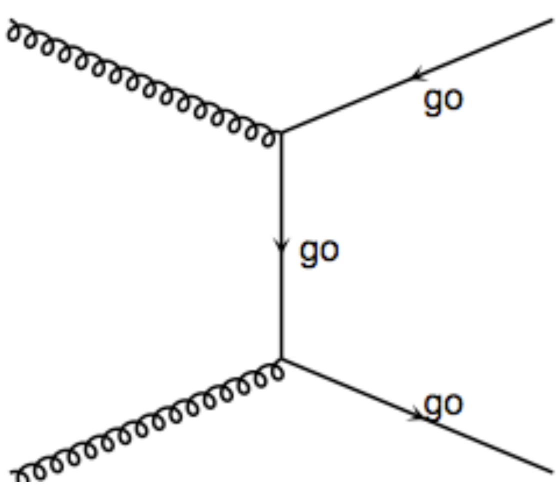
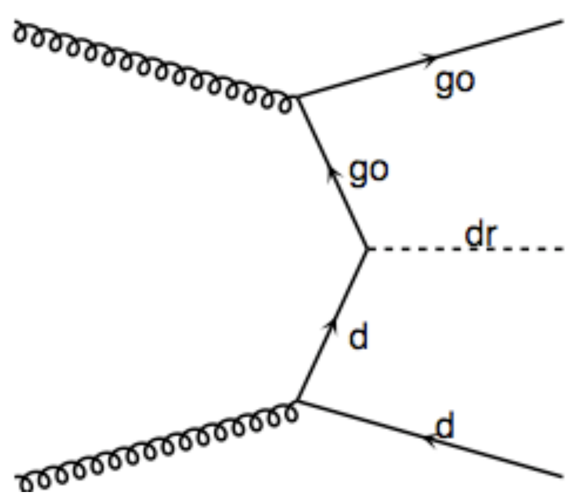






If Go's on resonance:
double counting with





with go→dr+q in pythia

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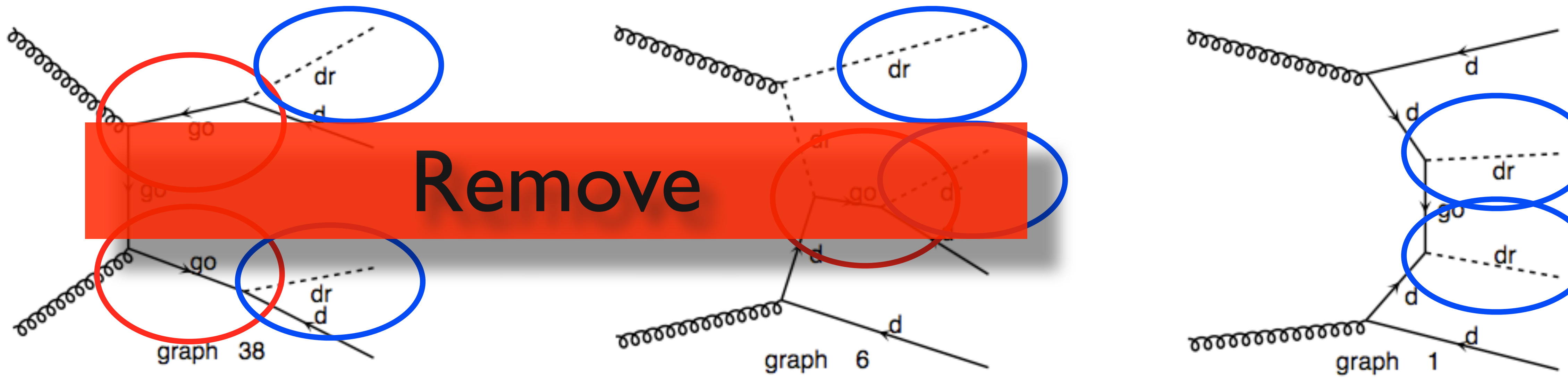

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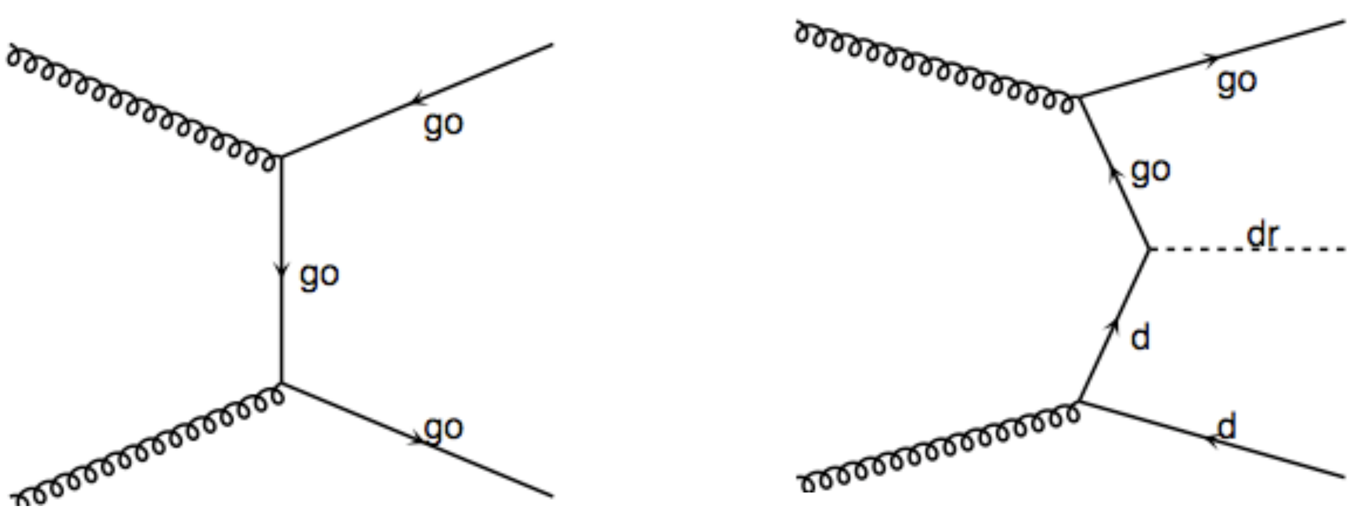

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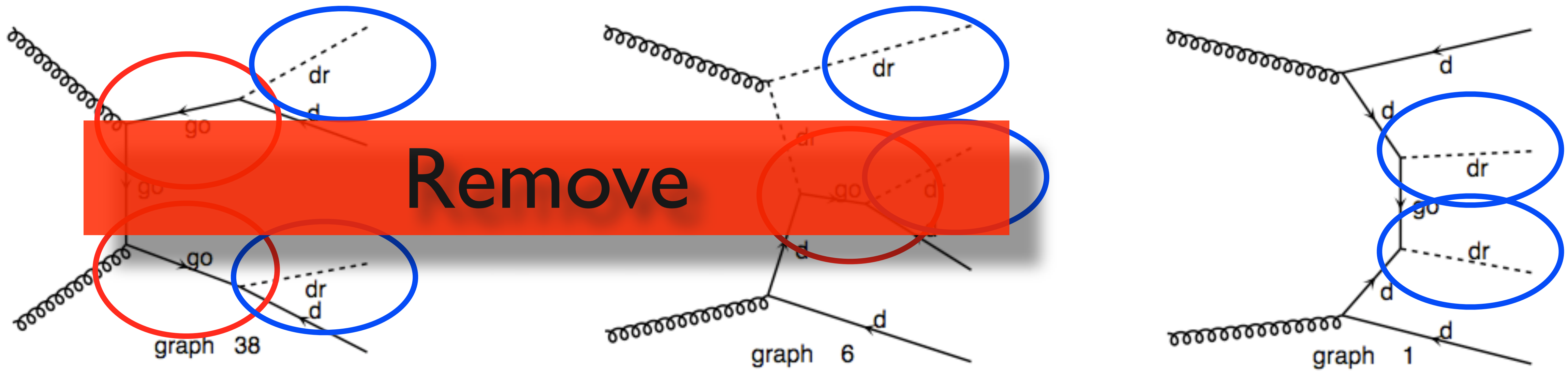

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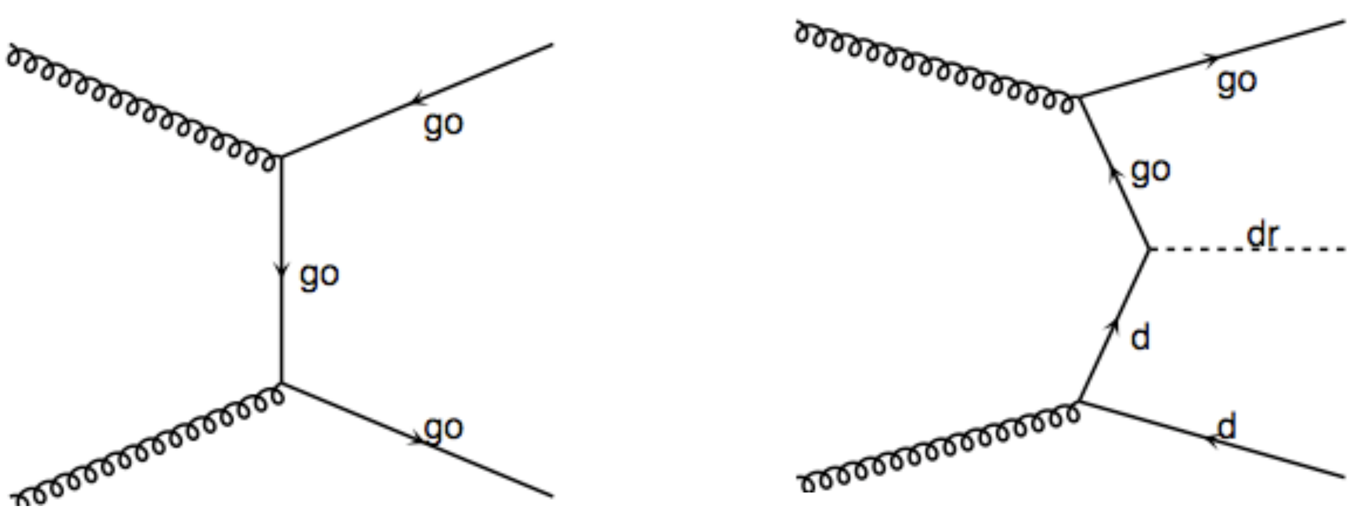
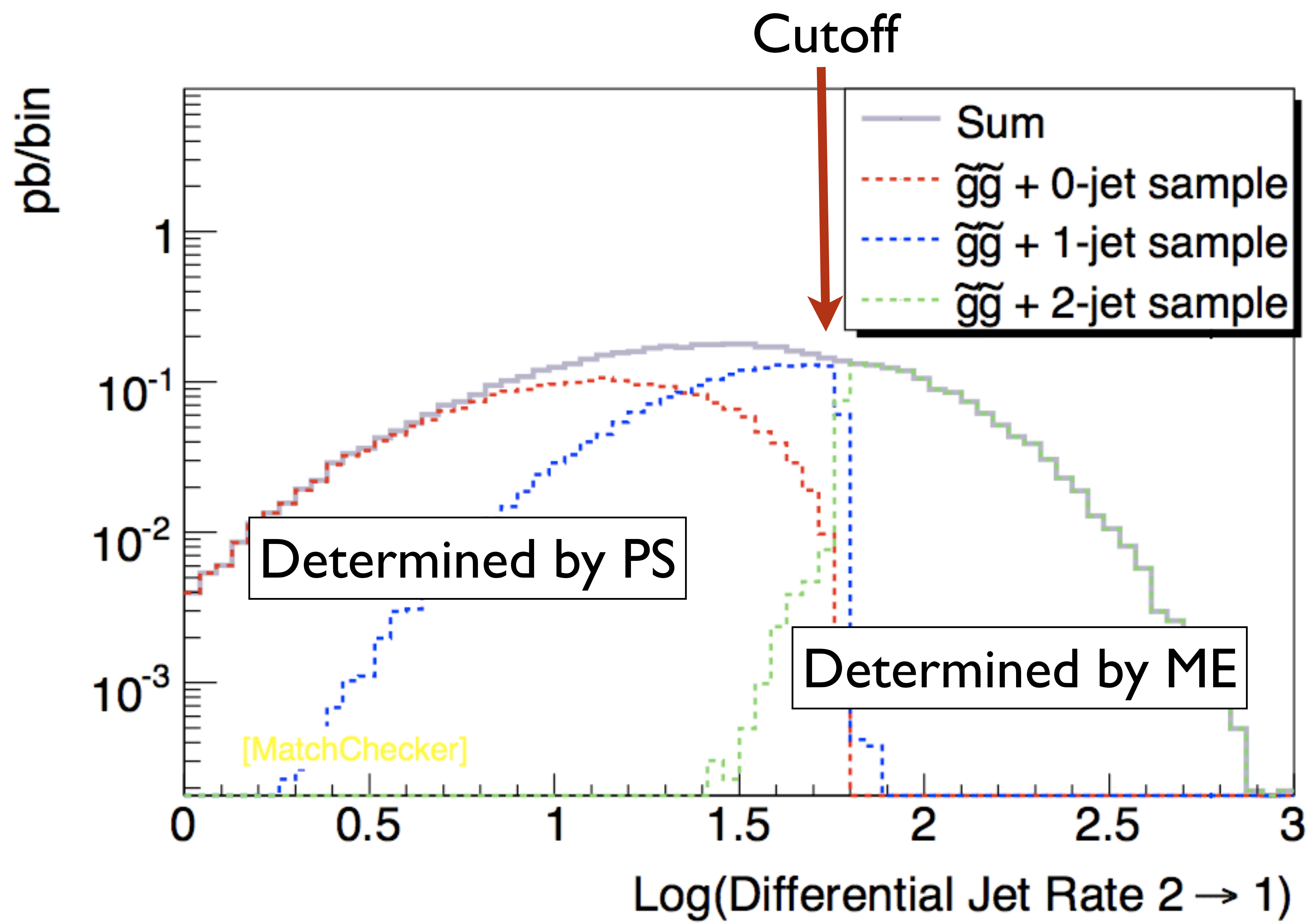


with go→dr+q in pythia

OK!

Validation? Check differential jet rates



-Transition from PS to ME regime is smooth

-Cross section is stabilized

-Global shape remains invariant under cutoff change

Impact of matching

J.Alwall, SdV, F.Maltoni, paper in preparation

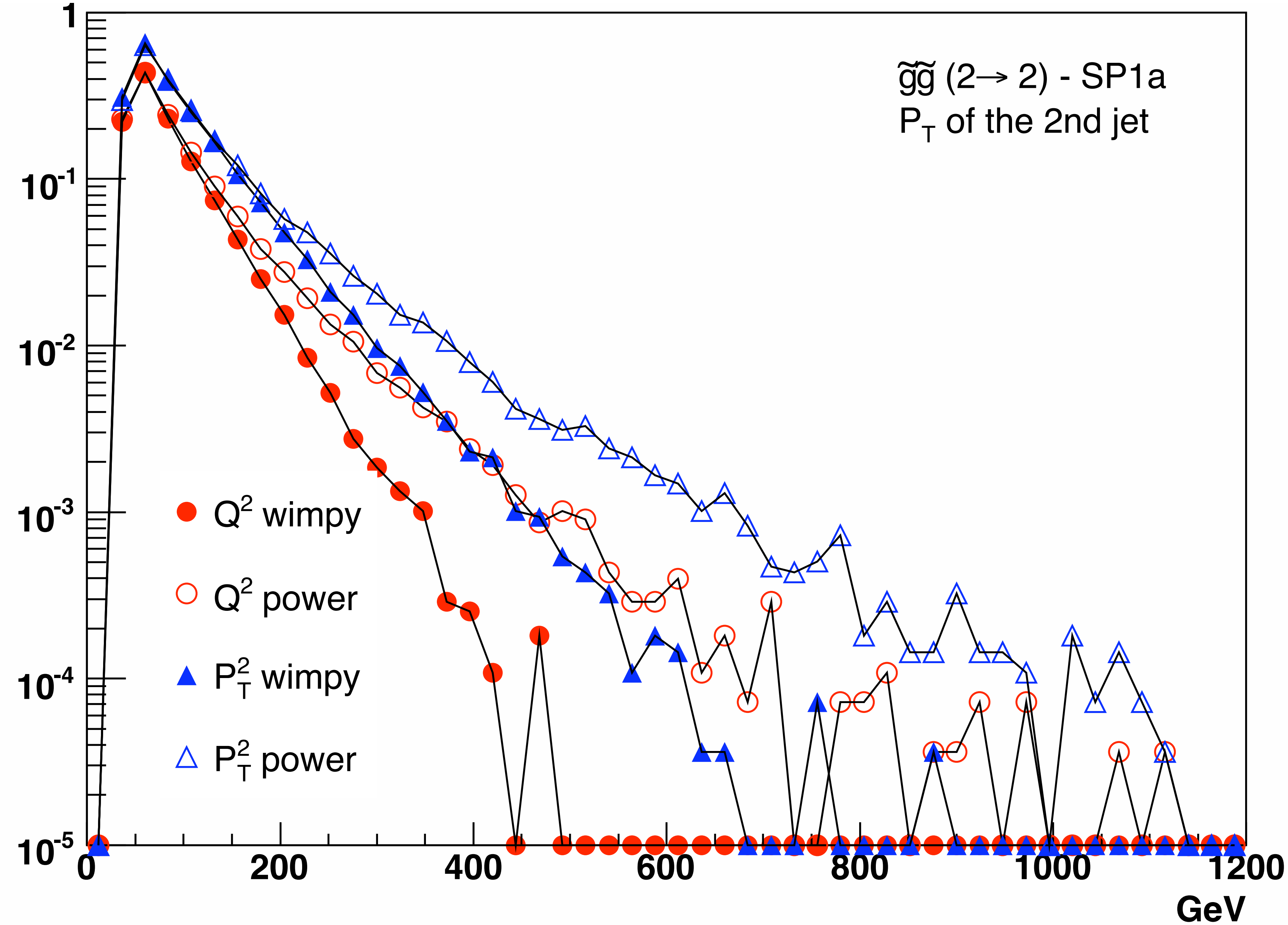
Sensitivity to showers

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
  - $\Rightarrow$ physical distributions at large Pt should be less sensitive to shower parametrization:
    - Shower evolution variable: Q^2, P_T^2 ,...
    - Starting scales: from wimpy to power showers...
    - additional tunes...

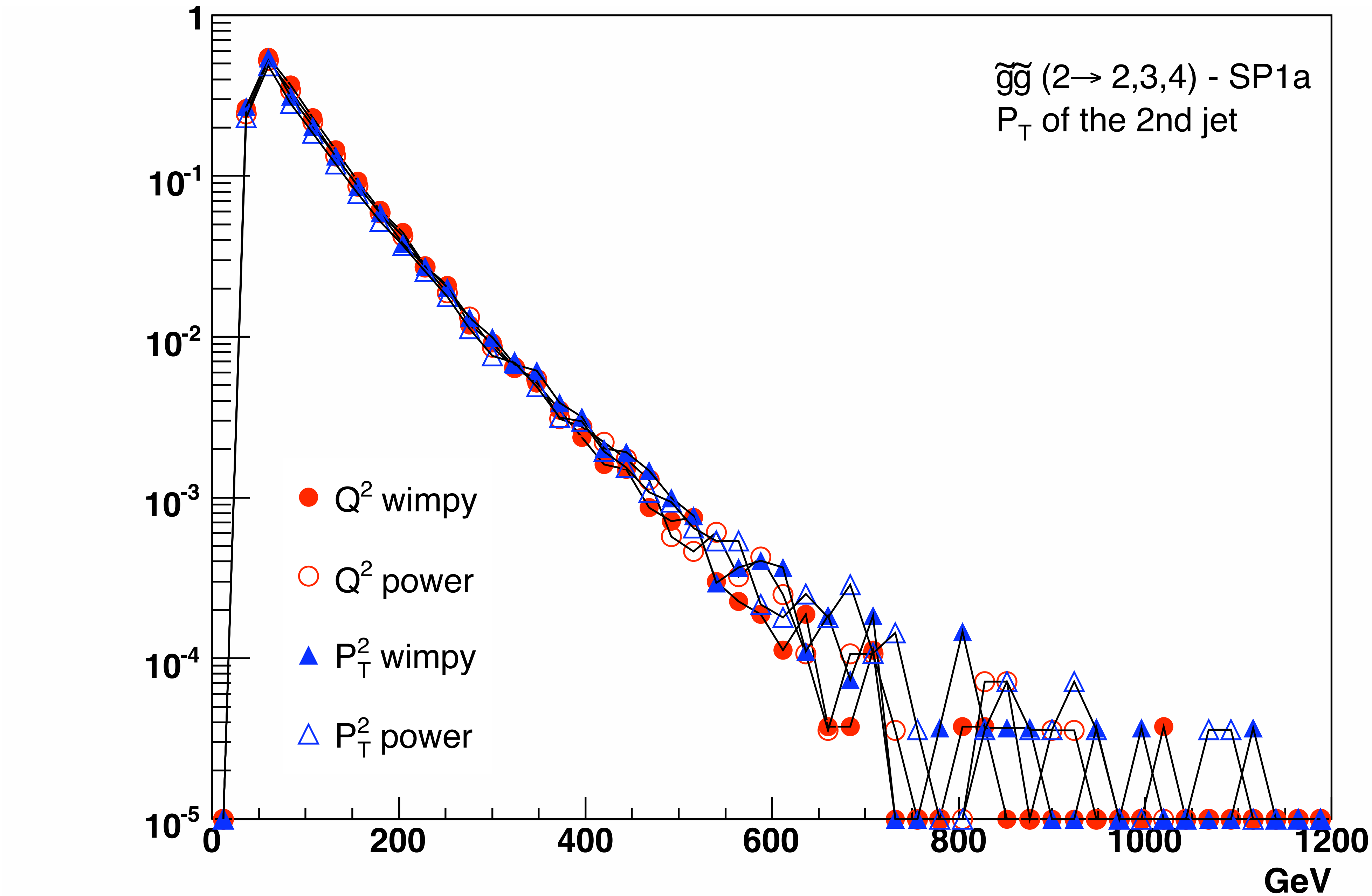
The IS radiation

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



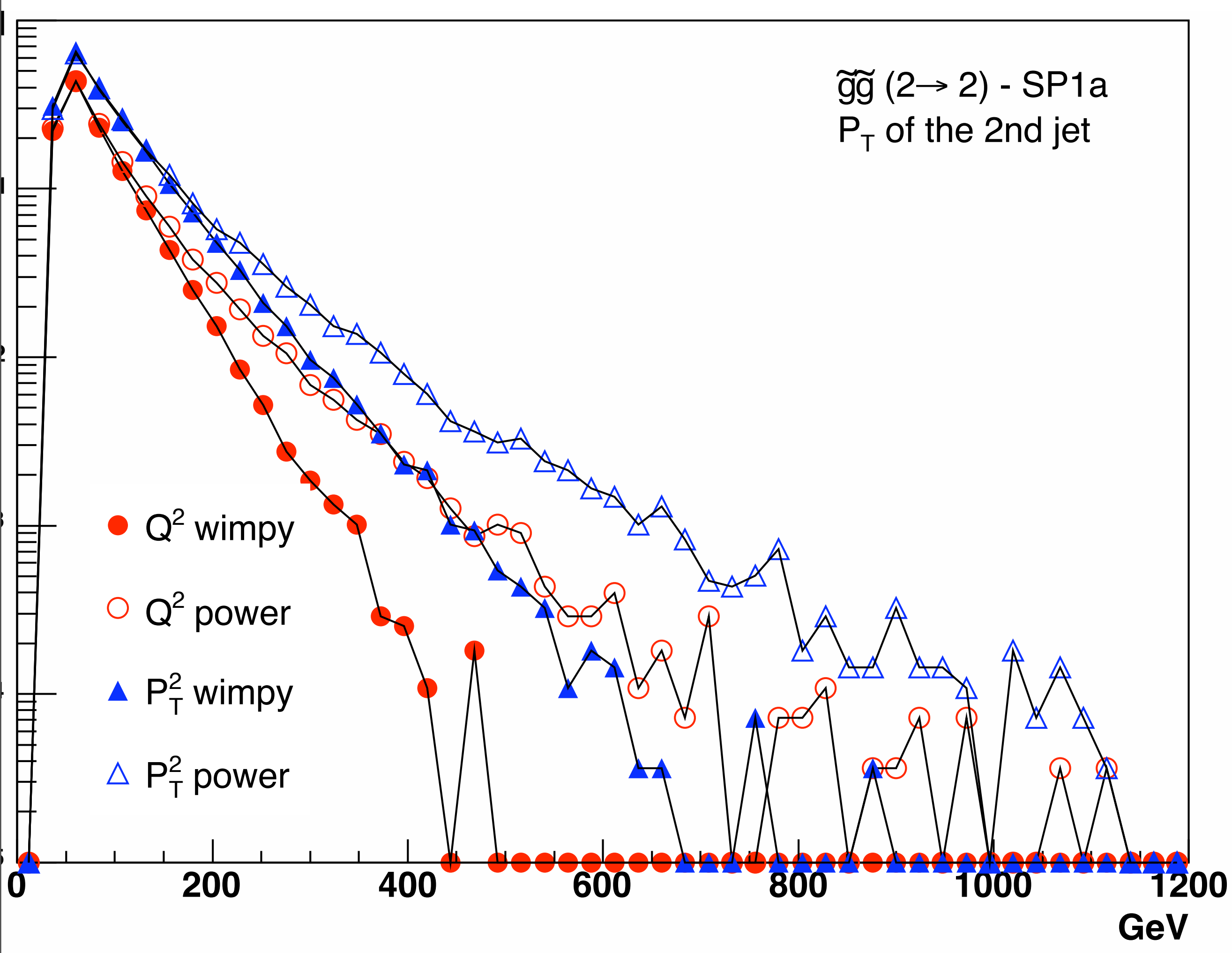
The IS radiation

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

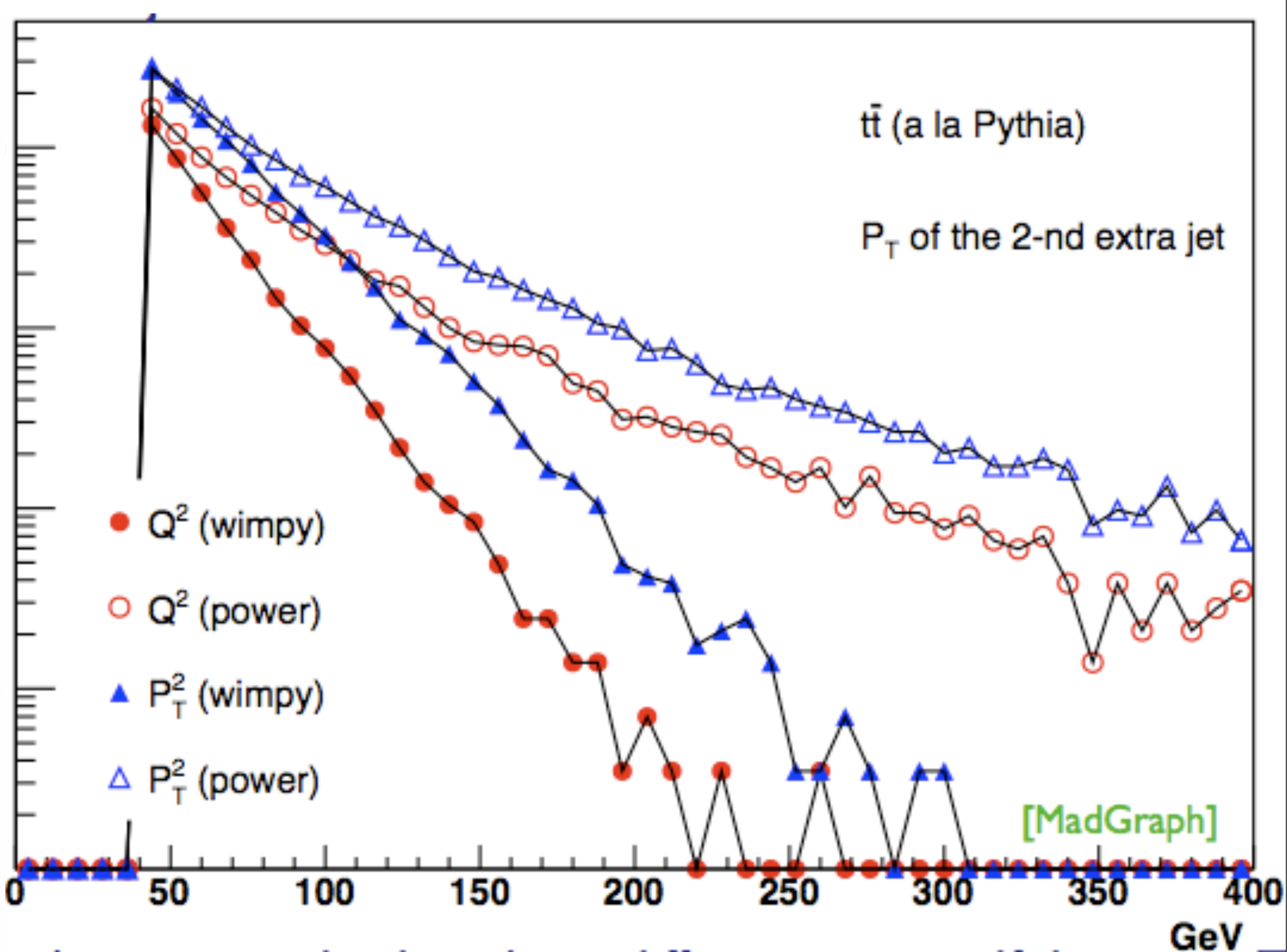


Scale dependance: gluinos @ SP1a vs ttbar

gluino-gluino



ttbar

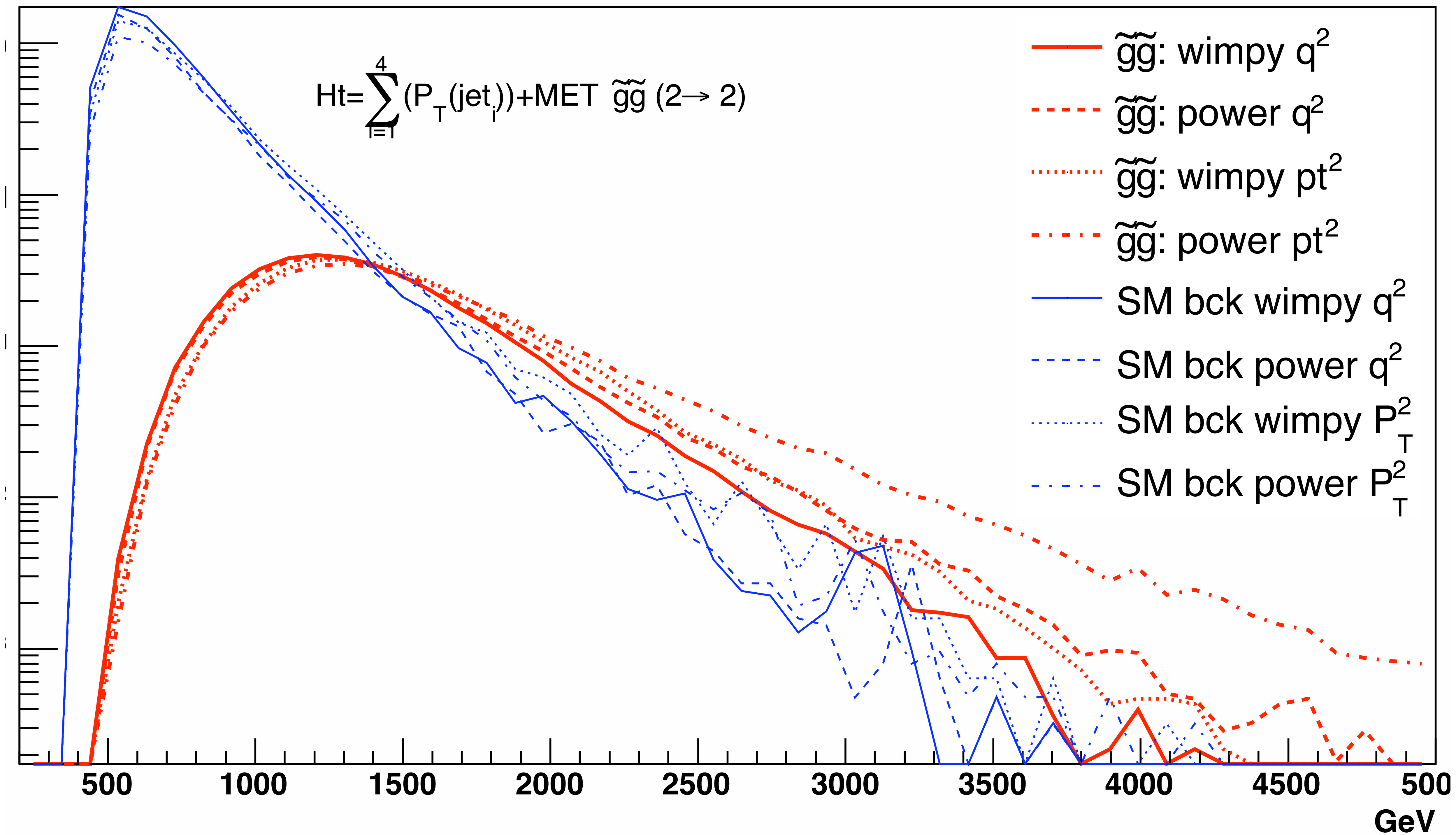


Impact on Ht variable

- Signal: gluino pair at 600 GeV ➪ Final state is at least 4 jets and MET from $\tilde{g} \rightarrow \overline{q}\tilde{q} \rightarrow \overline{q}q\chi_0^1$
- Backgrounds
  - (V to leptons)+4 jets inclusive (cutoff at 15 GeV) are relevant (only matched!)
  - ttbar+0,1,2 jets inclusive
- Use $H_T = \sum_j P_T^j + MET$
- Selection: MET>100 GeV, Pt(jet 1,2)>100, Pt(jet 3,4)>50
- Let's see some preliminary results (no lepton consideration up to now, still have to consider Z, squark-gluino and squark-squark)

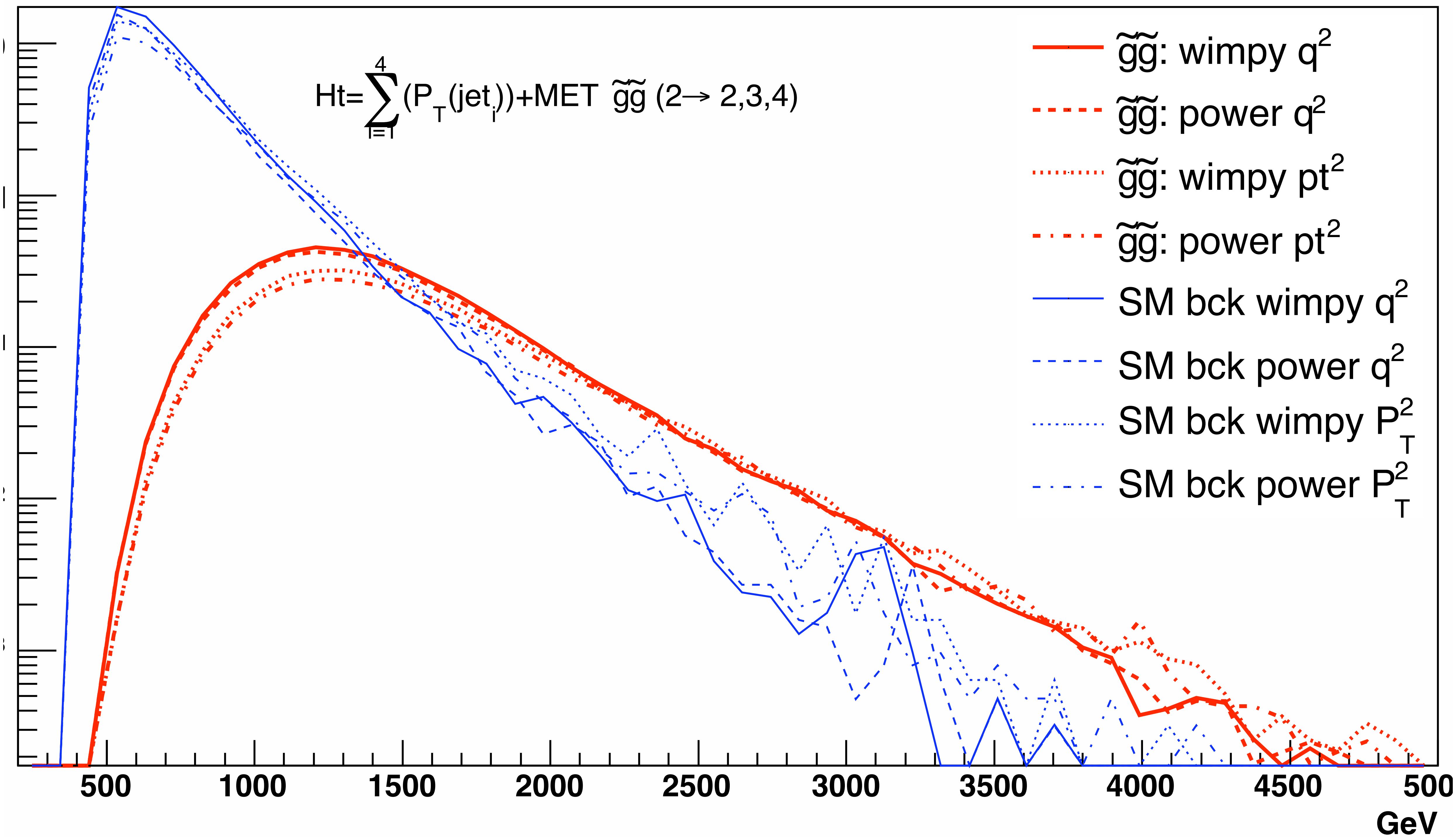
Ht(4) for gluino-gluino @ SP1a and matched SM

Case of gluinos production done "a la Pythia "($2\rightarrow2$) vs SM backgrounds (W+jets, ttbar)



Ht(4) for gluino-gluino @ SP1a and matched SM

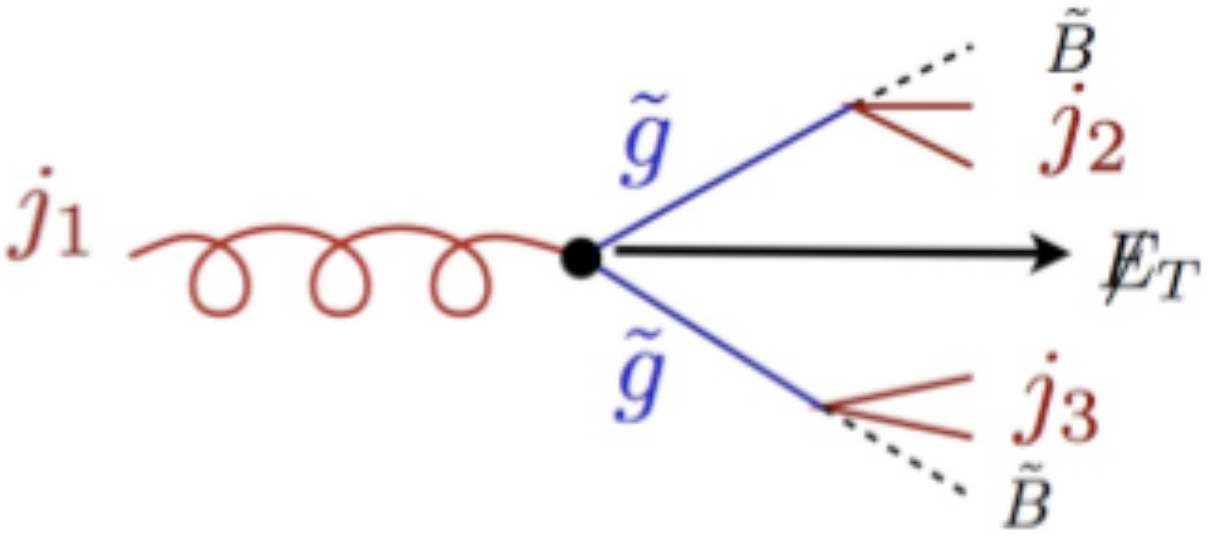
Case where gluinos are produced with ME calculation with up to 2 jets with MG/ME (2→2,3,4) vs SM backgrounds (W+jets, ttbar)



An important special case

[Alwall,Le,Lisanti,Wacker]

- If $m_{\tilde{g}} \sim m_{LSP}$:
  - Jets from gluinos are soft
  - Missing ET
    - $\Rightarrow$ gluinos "disappear"!
    - $\Rightarrow$ Compared to the previous case, where $m_{\tilde{g}} >> m_{LSP}$ impact of matching is huge since jets are almost exclusively ISR (see talk of J.Alwall)



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
- This has an important impact on physical distributions like Ht...and therefore in analyses as well!

Thanks for you attention! ☺

Back-up slides

The matching in a few clicks

- Using MG/ME:
  - proc_card.dat: defines the process(es), the number of QCD and QED vertices (this one has to be the smallest possible), the jets flavour(s).
  - run_card.dat: collider cuts, scales + xqcut (efficiency cut)
  - pythia_card.dat: shower scheme, scales + Qcut (matching cutoff)

What do we want to get?

#partons	#jets	xsec
0	0	exclusive
1	1	exclusive
2	2,3,4,...	inclusive

- With Madgraph/MadEvent we can generate
  - all multiplicities in one sample: one hep file at the end
  - one multiplicity by sample (specificy treatment at PS level for each): 3 hep files at the end

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

MLM and CKKW

- CKKW (reweighting method) [Catani,Krauss,Kuhn,Webber]
  - Control the showers: no additionnal resolvable radiation
    ⇒ I parton gives I 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
  - Two versions: MLM (Mangano), Modified MLM (Mrenna, Alwall)