Matrix Elements Tools

Conveners:
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Definition of scope

- exact matrix-element computation, at whatever order available (typically, but not exclusively, LO), with emphasis on multi-jet, high-order EW/QCD processes

- allows event generation (at least parton-level momenta available)

- allows processing of final state through a shower code

This includes MC@NLO-like tools

LO Codes available for:

- W/Z/gamma + N jets (N≤6)
- W/Z/gamma + Q Qbar + N jets (N≤4)
- Q Qbar + N jets (N≤4)
- Q Qbar Q' Q'bar + N jets (N≤2)
- Q Qbar H + N jets (N≤3)
- nW + mZ + kH + N jets (n+m+k+N ≤8, N≤2), including weak-boson fusion channels
- N jets (N≤6)
- single top production
- Several new physics processes (e.g. SUSY)

In the case of codes merged with parton shower, flavour state and colour flow (leading 1/Nc) are usually calculated on an event-by-event basis, to allow QCD-coherent shower evolution

Actively maintained and documented LO codes

- Multiprocess, automatic code generators:
  - CompHEP (LHA)
  - MadEvent (LHA)
  - Grace, Omega, Helac/Phegas
- Ready-to-use:
  - Acer (multiprocess, LHA)
  - Alpgen (multiprocess, LHA)
  - Grappa (4b, W/Z+jets, LHA)
  - Toprex (mostly top production)
- New players (to be first released and publicly evaluated during the Workshop):
  - AMEGIC++ (multiprocesses, in its hadronic collisions incarnation, Sherpa)
  - JetI (multijet code)

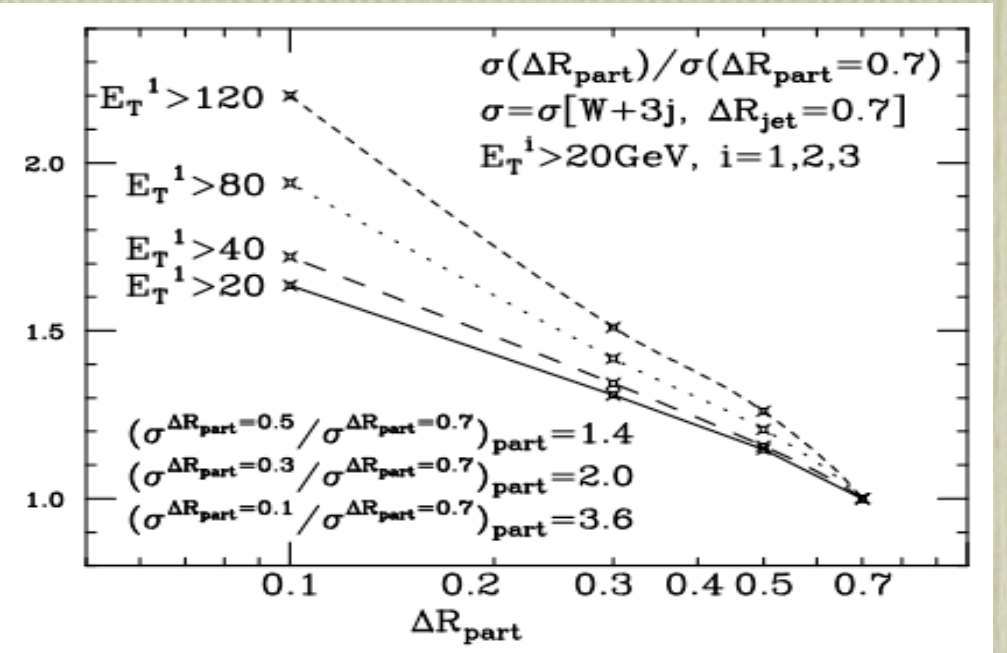
NLO available processes/tools

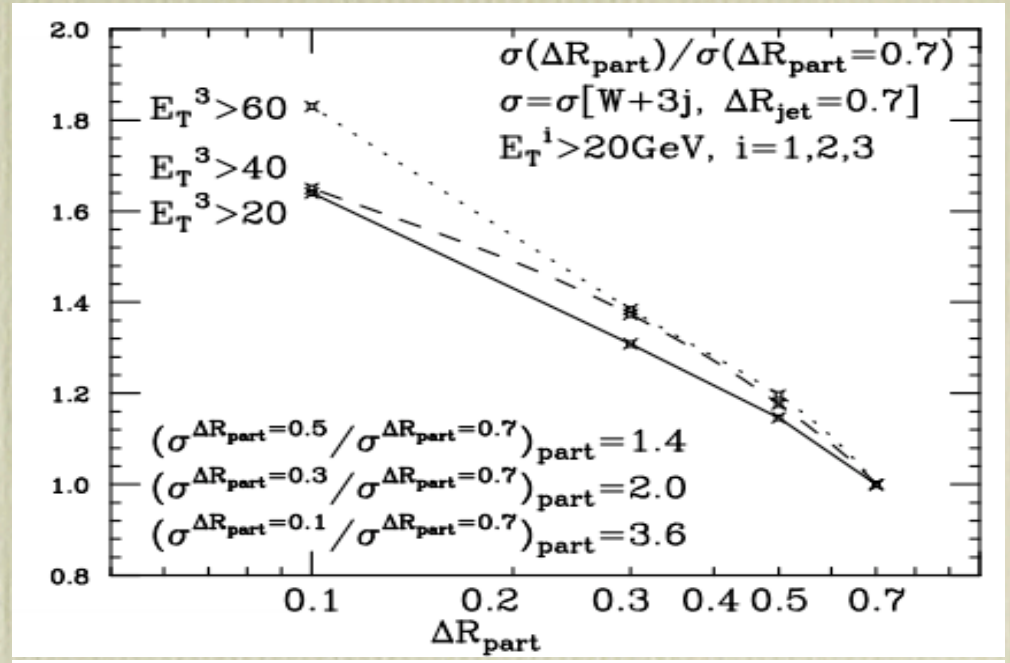
- WW: M.Dobbs, MC@NLO
- DY: Grace
- QQ: MC@NLO
- MCFM: (no shower) VV', W/Z+1,2 jets, W/Zqqbar, W/ZH
- ME corrections to Herwig/Pythia internal hard processes:
  - DY production
  - top decays
  - Z/W hadronic decays
  - Higgs production

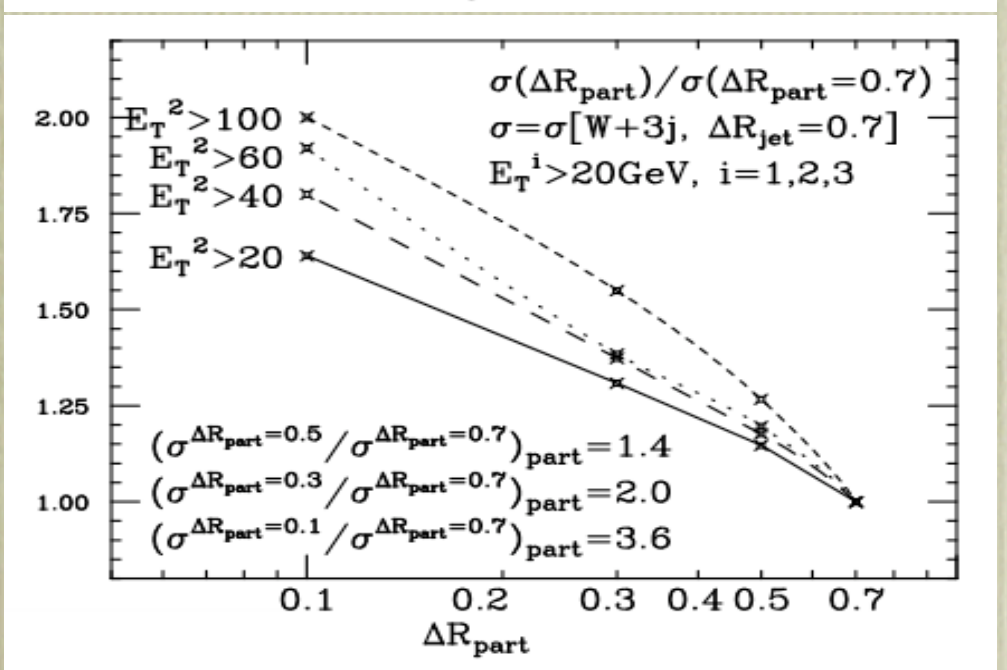
By and large for any bg process you have in mind there is a code dealing with it. So, what's there to discuss?

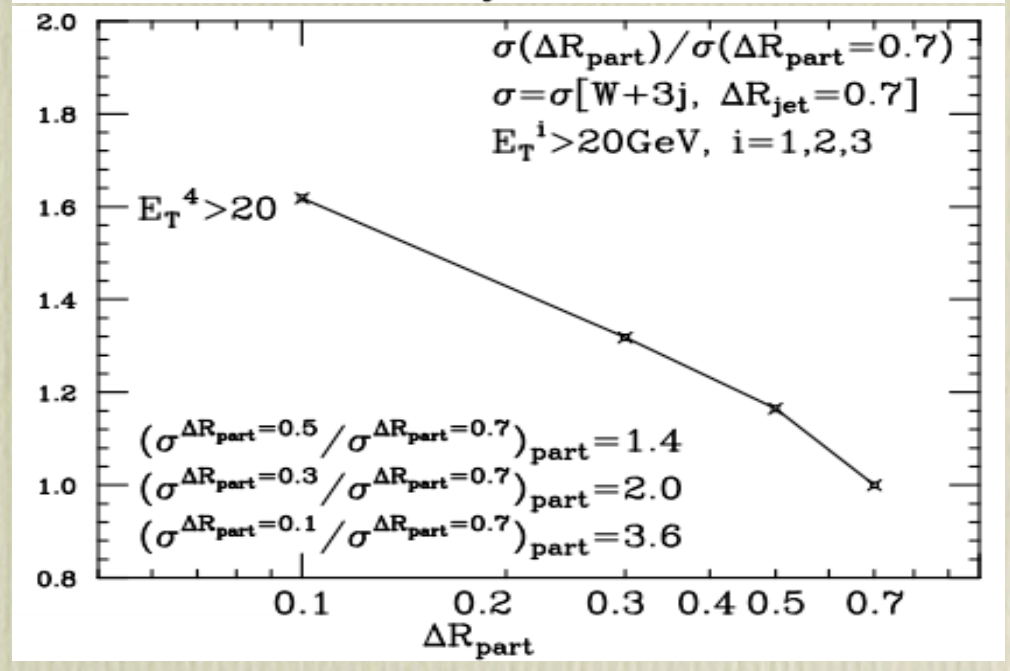
- reliability: need for cross-comparisons
- LO means large impact of intrinsic arbitrariness in the rate calculations (e.g. choice of scales, generation cuts, combination of different multiplicity bins, ...): quantify impact
- merging with shower leads to additional level or arbitrariness ($1/N^2$ terms, colour-flow extraction, merging prescriptions)
- impact of non-resonant channels (e.g. WWbb for tt)
- impact of EW contributions (e.g. vector-boson fusion for WWjj) and EW gauge invariance issues
- impact of spin correlations for final states of massive particles
- efficiency issues (multijet final states typically have large weight spreads => low unweighting efficiencies)
- approximations: comparison of ME-generated vs shower-generated higher orders, approximations to exact ME's

Cut-generation dependence, example

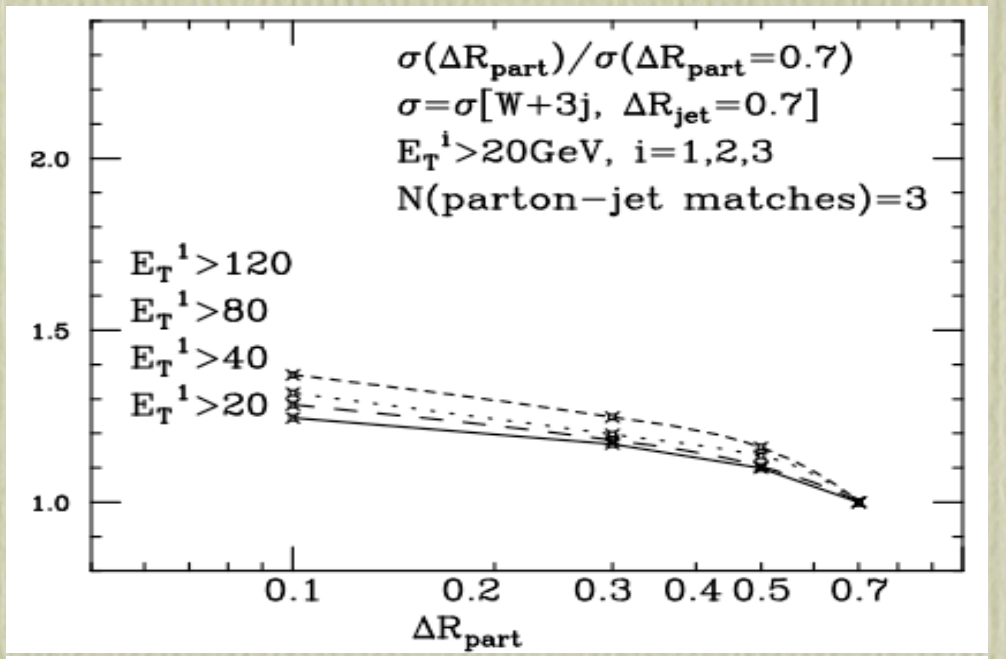


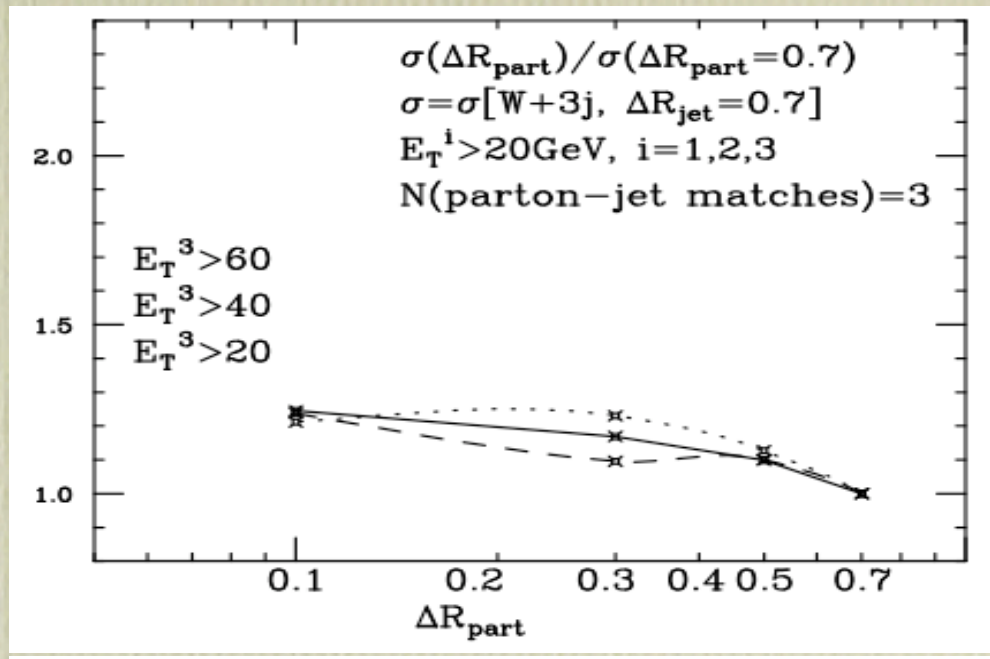


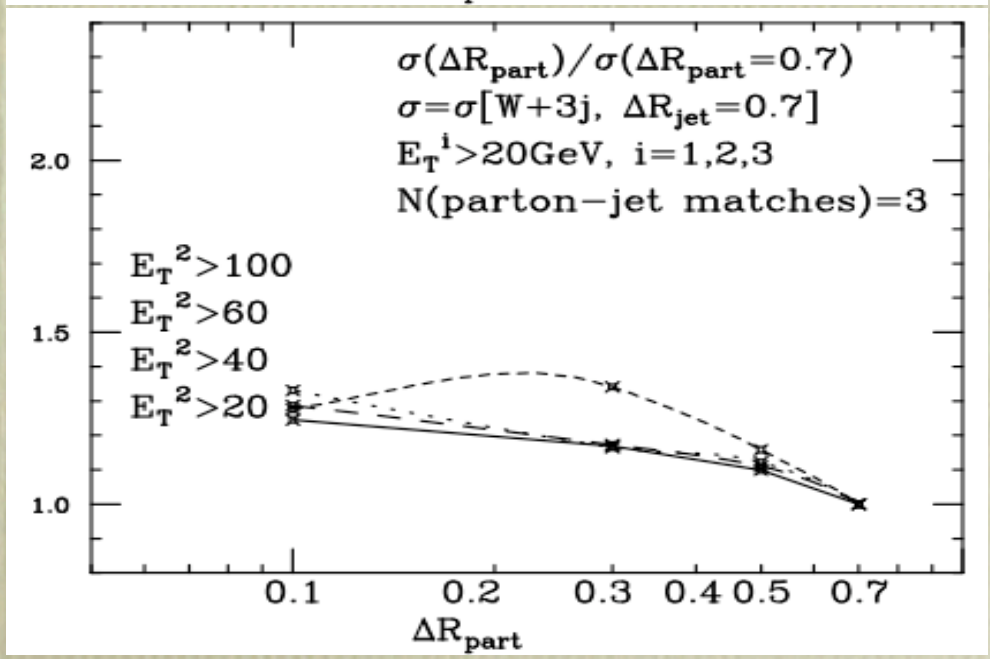


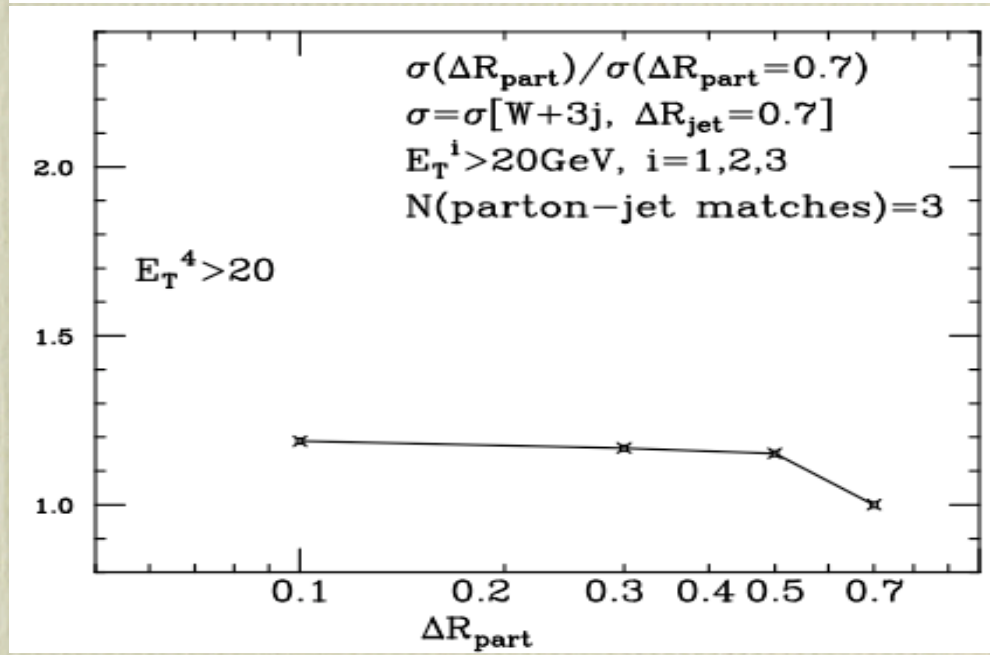


After simple-minded matching









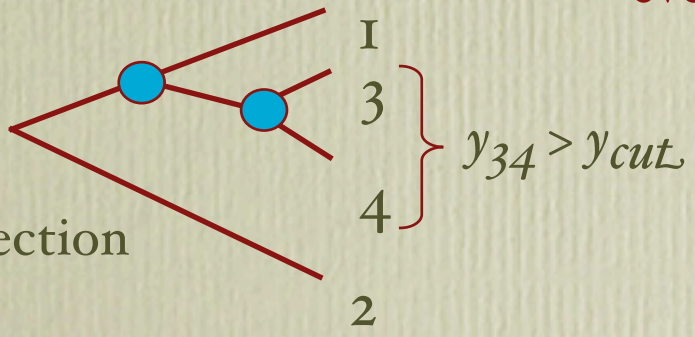
CKKM (Catani, Krauss, Kuhn, Webber) algorithm

- Generate samples of different jet multiplicities according to exact tree-level ME's, with N_{jet} defined using a k_{perp} algorithm

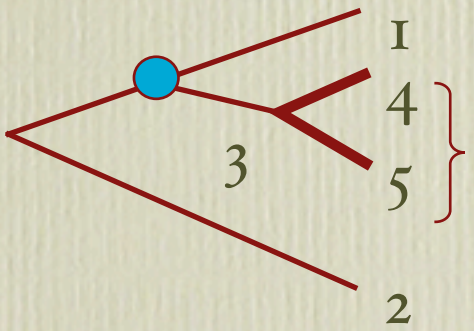
$$y_{ij} = \frac{2\min\left\{E_i^2, E_j^2\right\}\left(1 - \cos\theta_{ij}\right)}{s} \geq y_{cut} = \frac{Q_{cut}^2}{s}$$

- Reweight the matrix elements by vertex Sudakov form factors, assuming jet clustering sequence defines the colour flow
- Remove double counting by vetoing shower histories (i.e. y_{ij} sequences already generated by the matrix elements)
- Fully successfull for e^+e^- collisions, being extended to hadronic collisions (Richardson, Krauss, Mrenna, Alpgen)

From the sample of 4-hard-parton events



From the sample of 3-hard-parton events



(splitting rejected if $y_{45} > y_{cut}$)

: Sudakov correction

Work Plan:

- Comparisons: establish common benchmarks usable for arbitrary processes
  - parameters
  - cuts
- Systematics:
  - quantify impact of spin correlations, gauge preserving prescriptions
  - define efficient ways of studying PDF/scale systematics
- ME/shower merging:
  - extend current studies (W+jets) to more processes (e.g. multijets, WW+jets in VBF, heavy quark final states)
  - explore alternative prescriptions
- Technical issues:
  - review implementation of LH accord
  - dataset issues

Agenda for week 1

- Tuesday 8:45-10:30: Joint opening session with (N)NLO
- Tuesday 15:30-18:00: ME/shower merging: results, problems, work agenda
- Wednesday 13:45-15:30: joint session with NLO, review of automatic codes (MadEvent and Amegic++)
- Wednesday 16:00-18:30: ME code comparisons, selection of processes, parameters, cuts, spin-correlation issues
- Thursday 9:00-10:30: gauge invariance issues
- Thursday 14:00-16:00: MadEvent tutorial
- Friday 9:00-10:30: open discussion

Items for weeks 2-4

- Review of other codes, tutorials
- Gauge invariance issues and EW precision physics
- Approximations to exact LO results
- MC@NLO
- PDF issues (interfacing to LHPDF, PDF systematics, etc)
- Event datasets, formats etc (see CLHEP sessions)
- Discussions of preliminary new results
- ..... work, work, work .....