Monte Carlo Overview

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thinkshop^2
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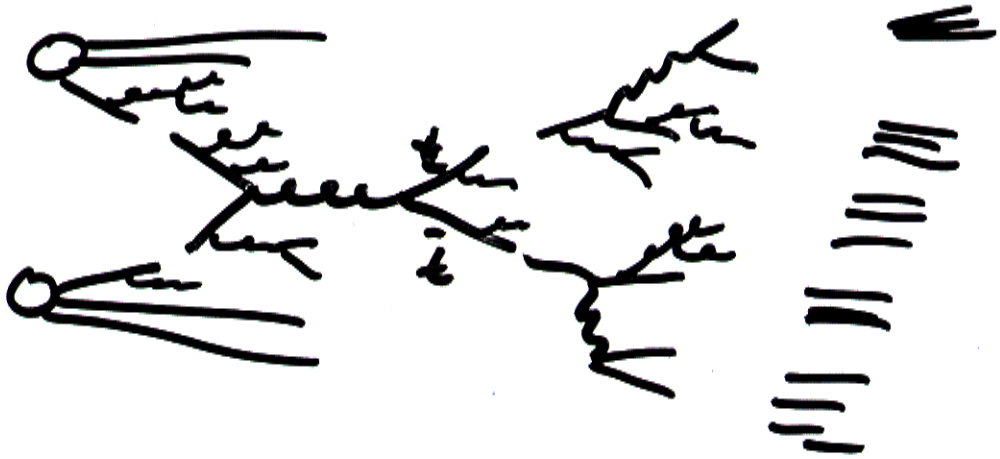
<u>Outline</u>

1. "Full-service" MC's (for $t\bar{t}$ prod.)
   - HERWIG
   - Pythia
   - Isajet

2. Backgrounds
   - VECBOS
   - ResBos

3. Parton-level (automatic generation)
   - CompHEP
   - FeynArts/FormCalc
   - GRACE
   - MadGraph

"Full-Service" Monte Carlos



ISR, FSR : QCD showers

Hard subprocess:

production + decay (on-shell)

Hadronization, underlying evt.

- <u>HERWIG</u> Webber, Marchesini, Corcella et al.

  ISR/FSR : shower approx (collinear/soft)

  QCD coherence via angular ordering

  virtual corr's via Sudakov form fact.

- Hard subprocess
  - all color structure
  - exact ME for prod., decay
  - no spin corr. (but in progress)

  Gluon radiation
    - hard corr (exact ME) for top decay
    - hard corr. for production <u>in progress</u>

- Hadronization
  - cluster had. model
- Underlying evt / spectator effects incl.

- Bckgrnd:
  - W + 1 jet exact
  - extra jets come fr/ showers

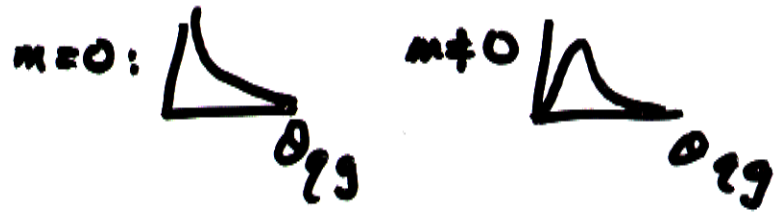
- Other comments
  - non-SM processes : Z', SUSY
  - new processes can be imported

    provide 4-mom, masses, identity/status codes, color/flavor structure

- <u>PYTHIA</u> Sjöstrand et al.

- ISR/FSR: showers (A-P parton splitting, as Herwig)
  all color str. included
  Sudakov form factors

- Hard subprocess
  exact ME for prod., decay
  no spin corr.
  inclusion of top width in progress
  Gluon radiation
  <u>new</u>: mass correction for showers



  top: increases radiation in production
  decreases rad. in decay
  ⇒ net decrease

- Hadronization: Lund string model
- Underlying evt.
- Other comments Bckgrnd: exact W+1jet
  - non-SM: SUSY, TC, many other
  - new processes can be used to feed into showering/hadronization ⇒ give color struc

• **ISAJET** Paige, Protopopescu, Baer, Tata

• ISR/FSR
  - cascade (AP splitting) down to cutoff scale
  - color coherence not included

• Hard subprocess
  - exact ME for top prod., decay
    + W width in decay
  - no higher order exact QCD

• Hadronization
  independent fragmentation

• underlying evt

• Background
  W + 1 jet exact ME
  plus

$$\frac{1}{q_t^2} \rightarrow \frac{1}{\sqrt{q_t^4 + q_{t0}^4}} \qquad q_{t0}^2 = (0.2\,\mathrm{GeV})\,M$$

  gives approx resummed q_t dep.

• Other comments
  - non-SM : SUSY, TC...
  - tie in new processes?

Backgrounds (W+jets)

- Herwig, Pythia, Isajet
- VECBOS Berends, Kuijf, Tausk, Giele
  - exact ME for $W + \leq 4$ jets
    ($Z + \leq 3$ jets)
  - includes decay correlations
- ResBos Balazs, Yuan
  - boson prod + decay w/ soft gluon resummation
  - γ, W, Z : leptonic decay
  - g : $t\bar{t}$
  - includes boson width, spin corr.

"Self-service" programs

- multipurpose ; often w/automatic generation of diagrams, amplitudes
- showering, hadronization, underlying evt. <u>not</u> included (phase space int. not incl. for MadGraph
- <u>CompHEP</u> Boos, Dubinin, Ilyin, Pukhov, Savrin
  - tree-level
    collisions : 2 → 2, 3, 4 or decays 1 → 2, 3, 4, 5
  - SM or user-provided model
    ↑ Lagrangian level
  - includes phase space int., allows Kin cuts
- <u>FeynArts/FORMCalc/LoopTools</u> Eck, Küblbleck, Hahn
  - generates diagrams, amplitudes
    tree level
    some one-loop
  - provides tools for integration
  - SM ; MSSM in prep.

- <u>GRACE</u> Fujimoto et al.
  - tree level SM + MSSM
  - generates diagrams, evaluates + integrates amplitudes, gives unweighted evts
  - some EW one-loop corr's avail.

- <u>MadGraph</u> Stelzer, Long, Rainwater
  - tree level helicity amplitudes using HELAS
  - up to 7 external particles (more to come)
  - SM; SUSY to come