Shower Influences On $t\bar{t}$ Pairs At LHC

A Comparison Of Different Monte Carlo Event Generators

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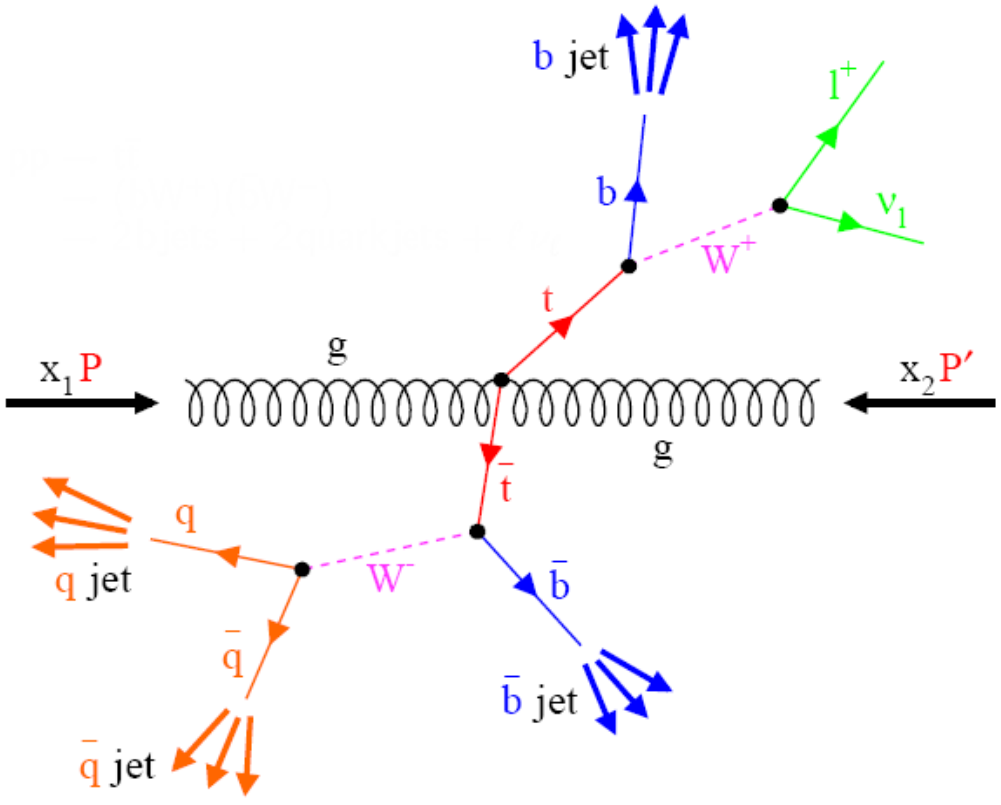
Many Thanks To: Stefano Frixione, Lars Sonnenschein

Monte Carlo Group Meeting, 04/09/2008

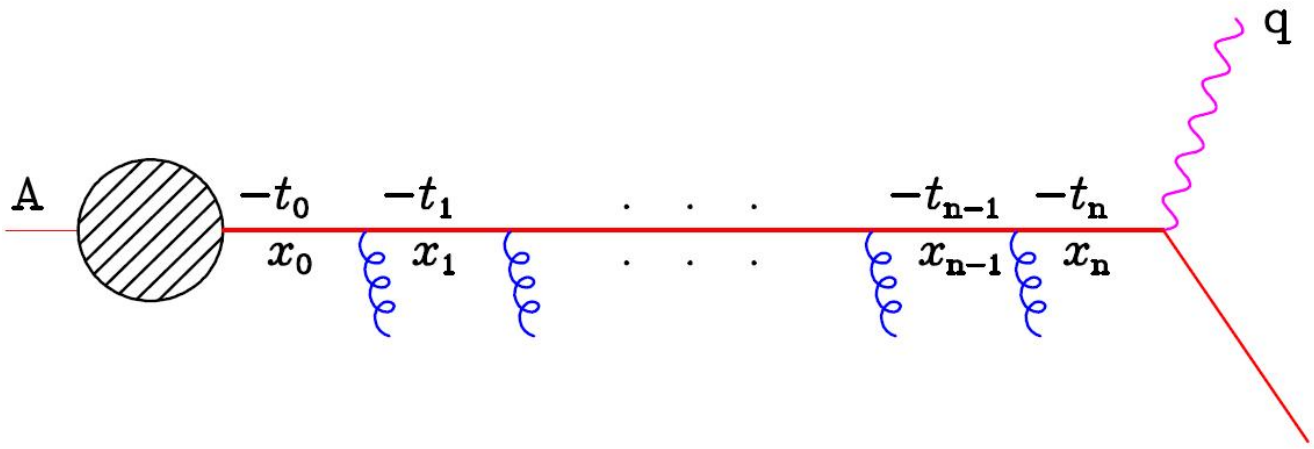
Contents

Top Physics



- LHC: $s = 14\mathrm{TeV}$
- One $t\bar{t}$ pair per second
- $m_t \approx 175\mathrm{GeV}$
- Radiation of high-energetic particles possible
- Understanding of radiation will play a crucial role for $t\bar{t}$

Parton Shower



B. Webber, CERN Training Lecture, Februrary 2008

- Evolution of parton from hadron A to hard process
- t: Virtuality of parton
- x: Parton's momentum fraction of initial hadron momentum
- Parton gets transverse momentum due to radiation

Used Generators

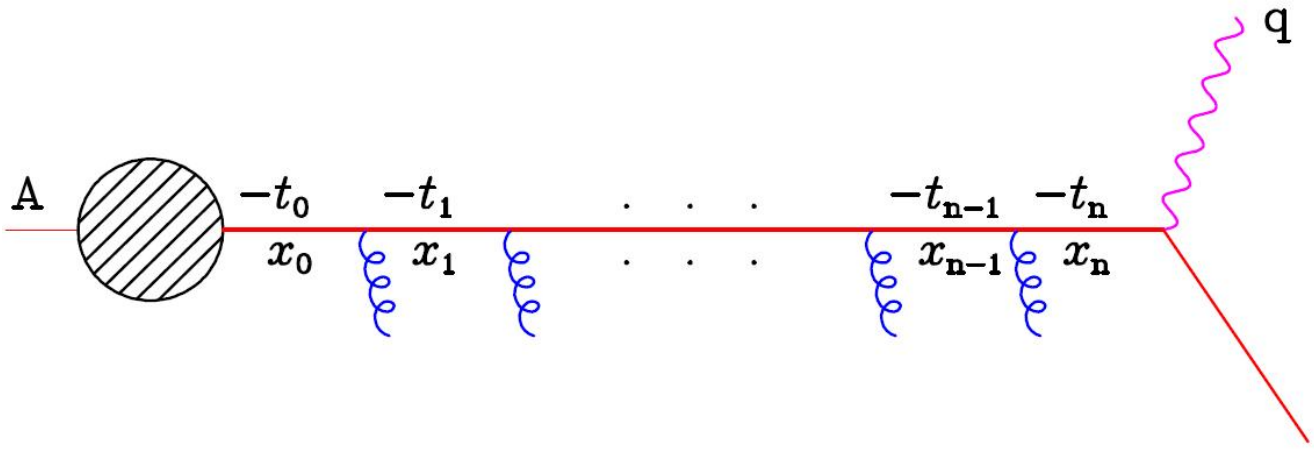
Standalone Event Generators

- Herwig (angular ordered showers)
- Herwig++ (angular ordered showers)
- Pythia 6 (Q^2 and p_T^2 ordered showers)
- Pythia 8 (p_T^2 ordered showers)

Generators Including Higher Order Contributions On ME Level

- MC@NLO (NLO computation on matrix element level)
  - uses Herwig for showering and hadronisation
- Alpgen (accounts for additional hard partons at ME level)
  - uses Herwig or Pythia 6 for showering and hadronisation

Shower Types



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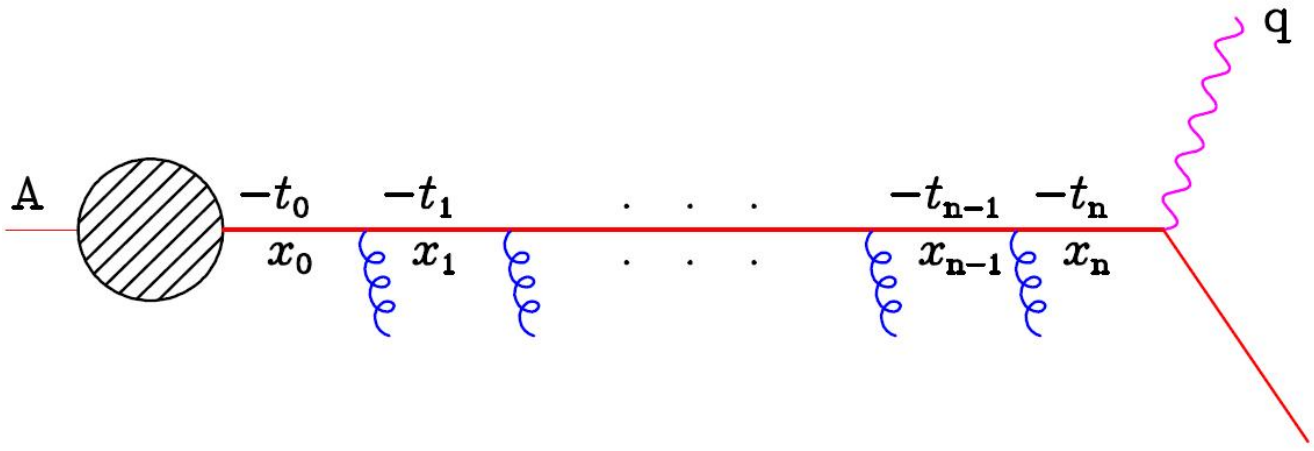

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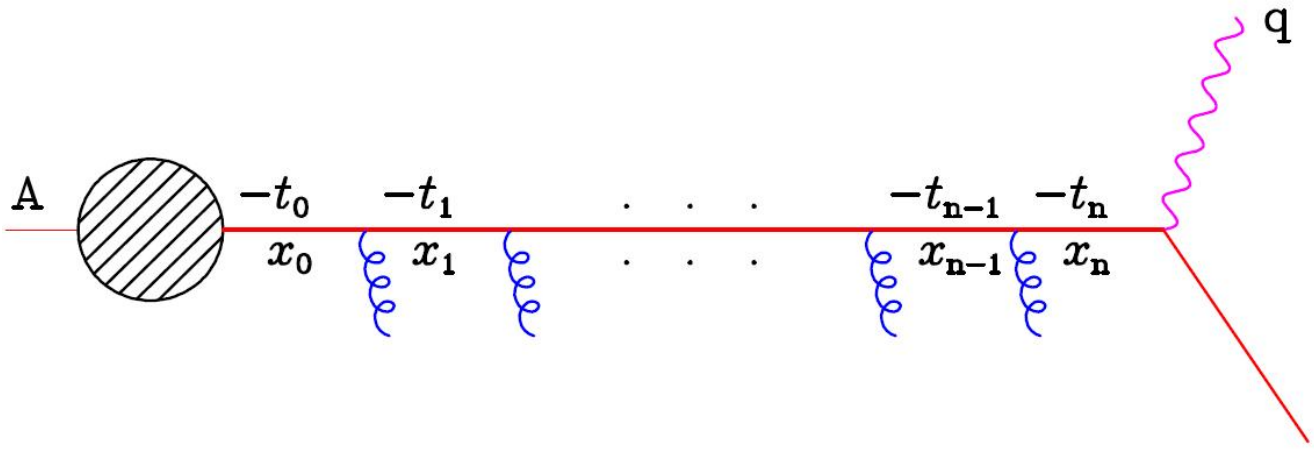
Wimpy Showers

- Maximum virtuality for shower is $t_{max} \sim t_{hard}$
- Cutoff in shower evolution

Shower Types



B. Webber, CERN Training Lecture, Februrary 2008

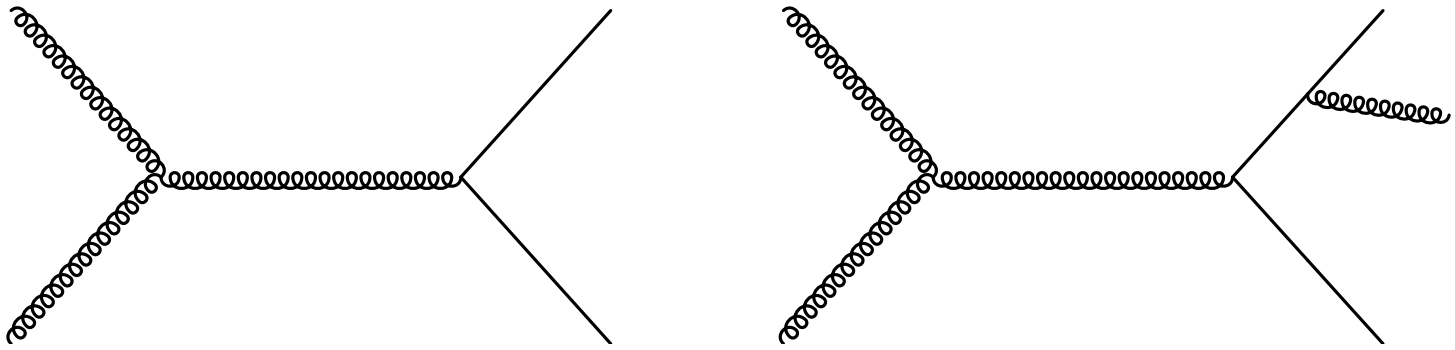
Wimpy Showers

- Maximum virtuality for shower is $t_{max} \sim t_{hard}$
- Cutoff in shower evolution

Power Showers

- Maximum virtuality for shower is $t_{max} = s$
- Whole phase space is used

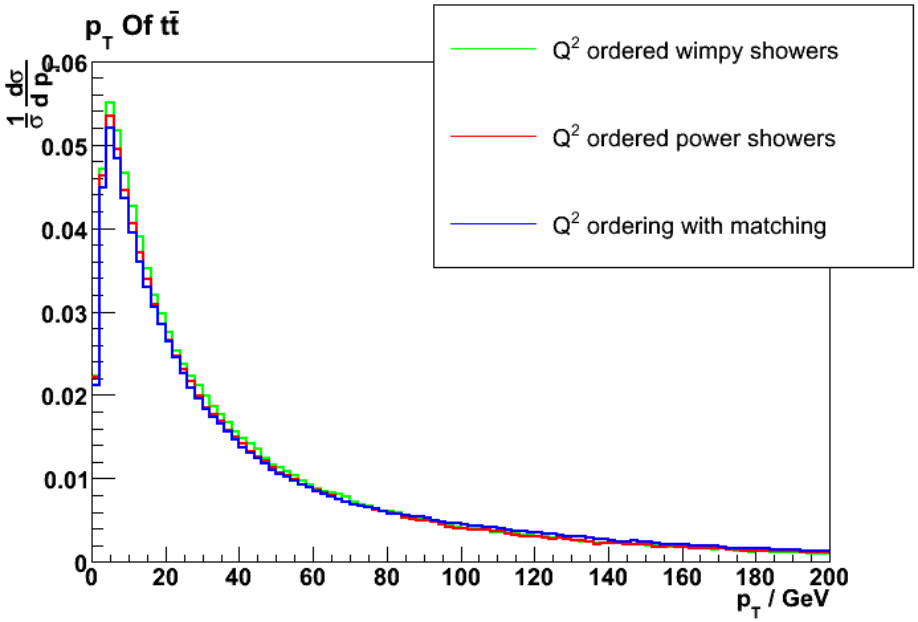
Matching

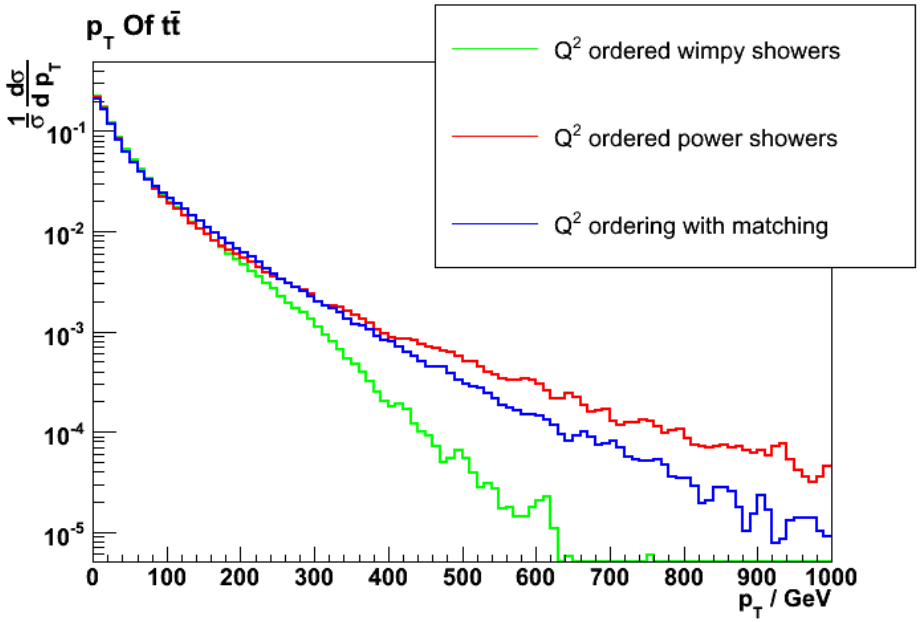


Matched Showers

- Hardest radiation is calculated on tree level (NLO diagrams)
- Parton shower accounts for soft radiation
- Matching with parton shower to avoid double counting
- MC@NLO uses subtraction method internally
- Alpgen uses a veto algorithm to discard events wich suffer from double counting

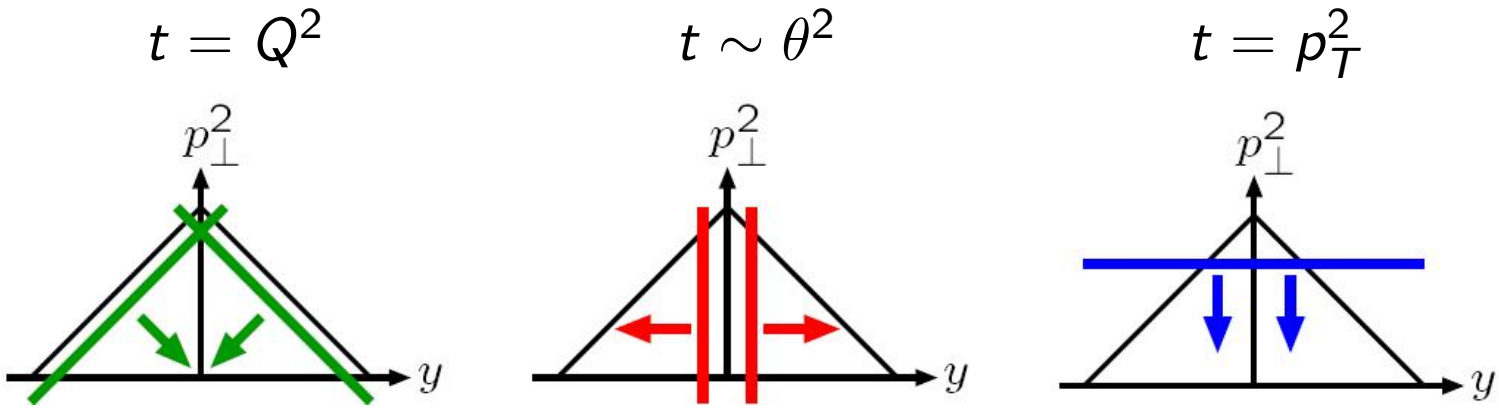
p_T Of The $t\bar{t}$ System





- Peak region of p_T distribution not affected much by choice of shower type
- Tail of p_T distribution determined by shower type

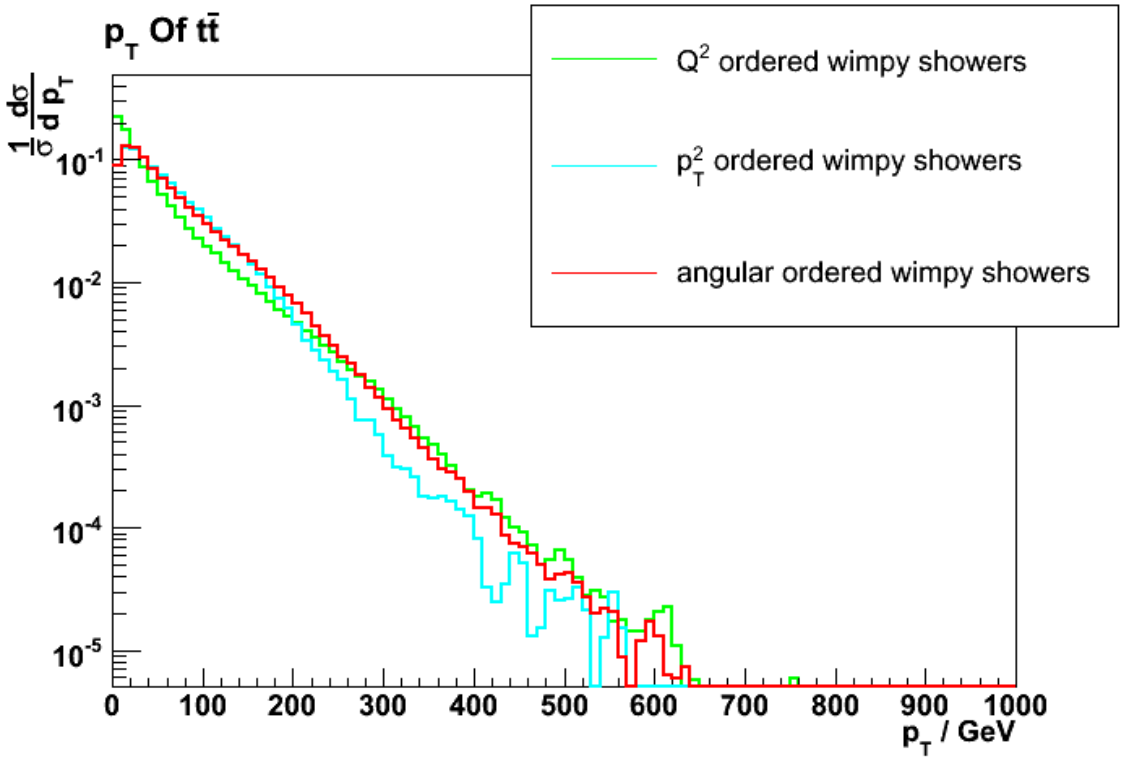
Shower Algorithms



T. Sjöstrand, European School of HEP, June 2006

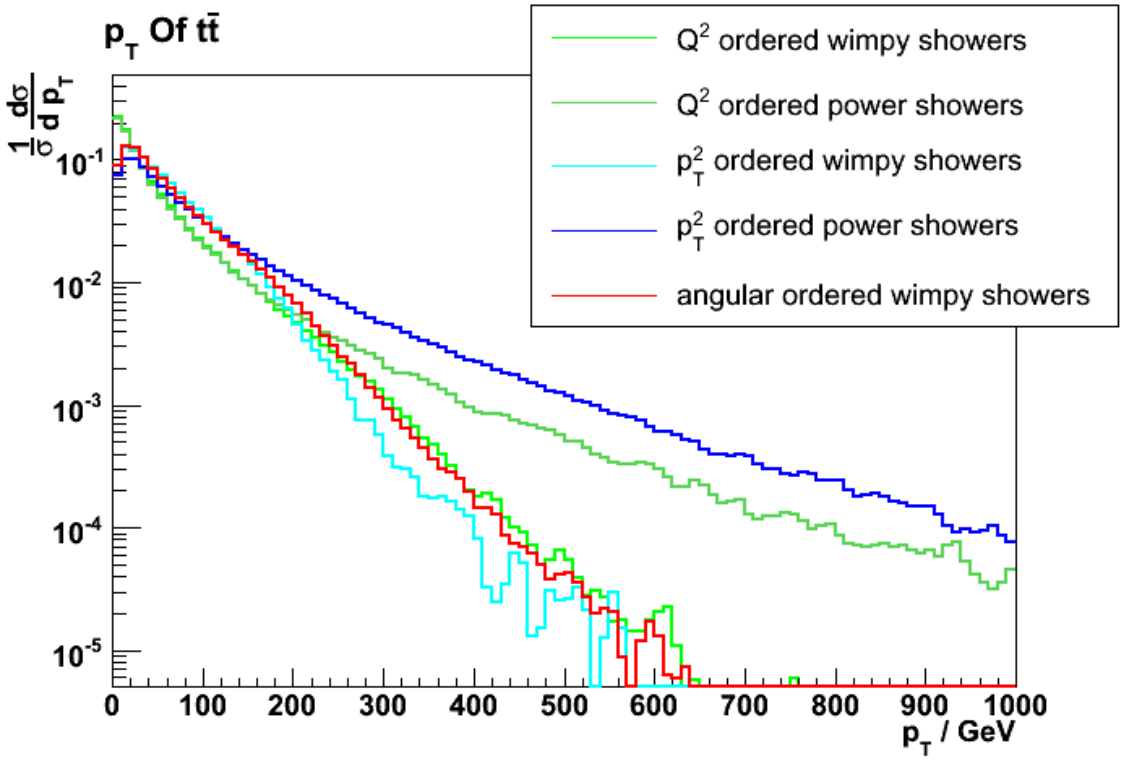
- evolution from the hard interaction (ME) on
- decreasing in Q^2: Pythia 6
- decreasing in p_T^2: Pythia 6 and Pythia 8
- decreasing in angle: Herwig and Herwig++

Shower Algorithms



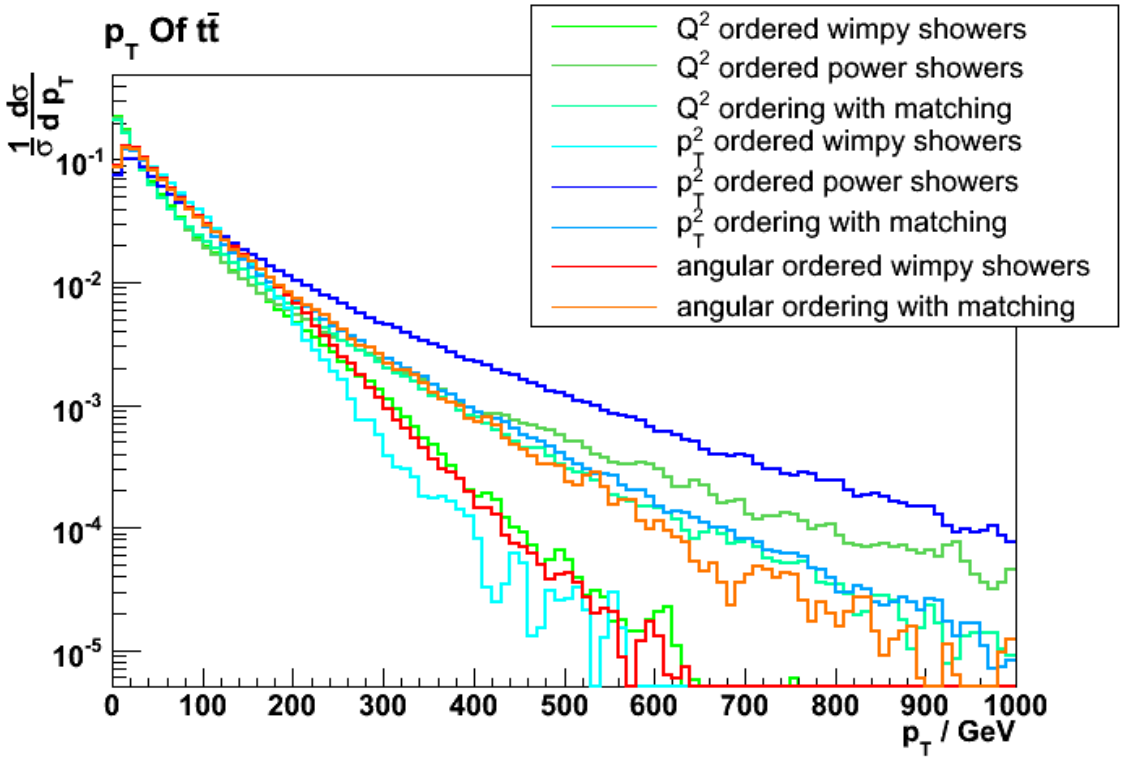
- All wimpy showers show similar behaviour

Shower Algorithms



- All wimpy showers show similar behaviour
- p_T ordered power showers favour high p_T regions

Shower Algorithms



- All wimpy showers show similar behaviour
- p_T ordered power showers favour high p_T regions
- Samples with hardest radiation on ME level agree quite well

Jets

Parton Jets

- Try to understand the kinematics of the radiation
- Build jets on the final parton state

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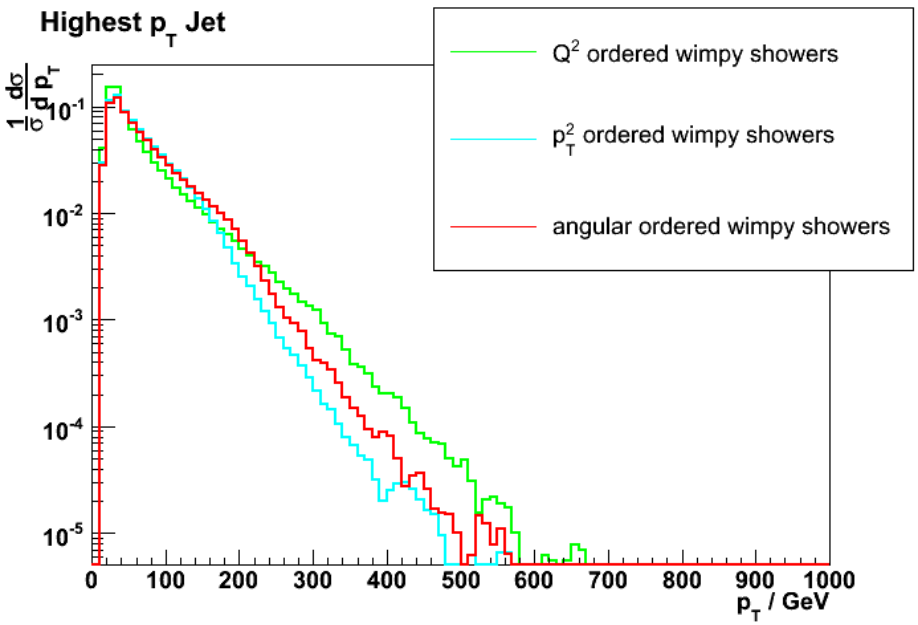
Jet Definition

- Leave tops stable and neglect them
- Switch off hadronisation
- Run jet algorithm on final partons within $|\eta| < 6$
- Results for SISCone 0.5 are presented

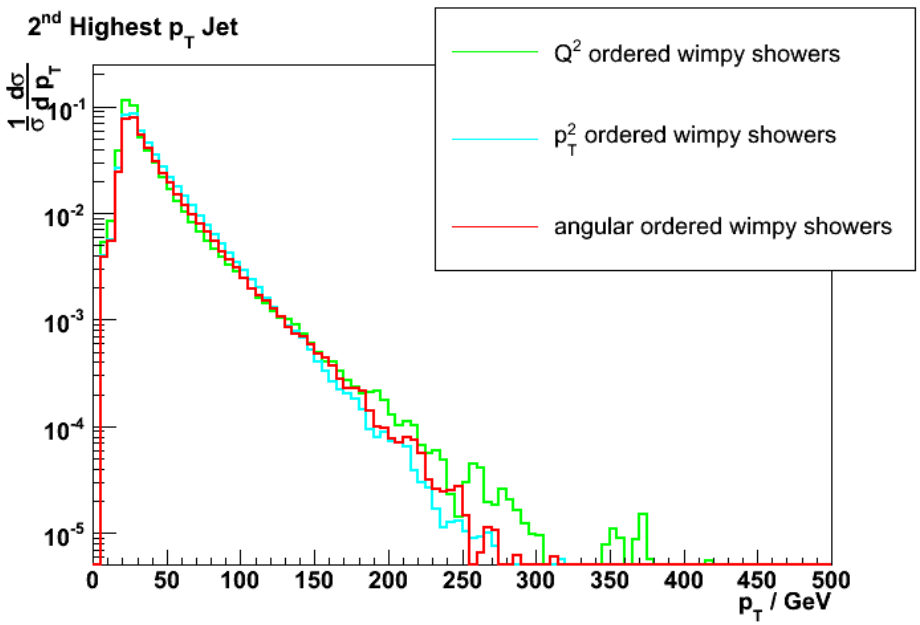
p_T Of Jets

Hardest Jet



- Slight difference due to different t_{max}

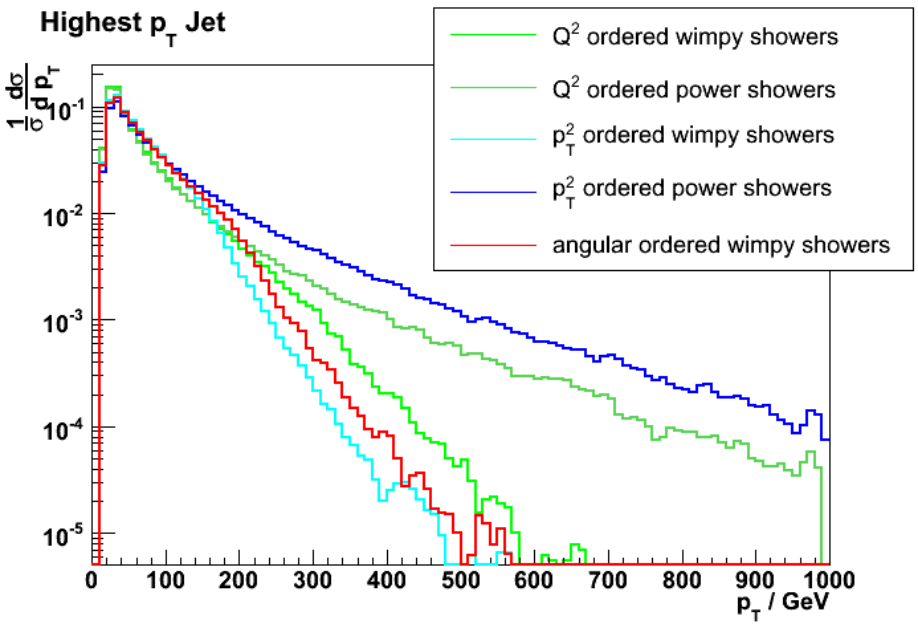
Second Hardest Jet



- Almost identical for all shower types

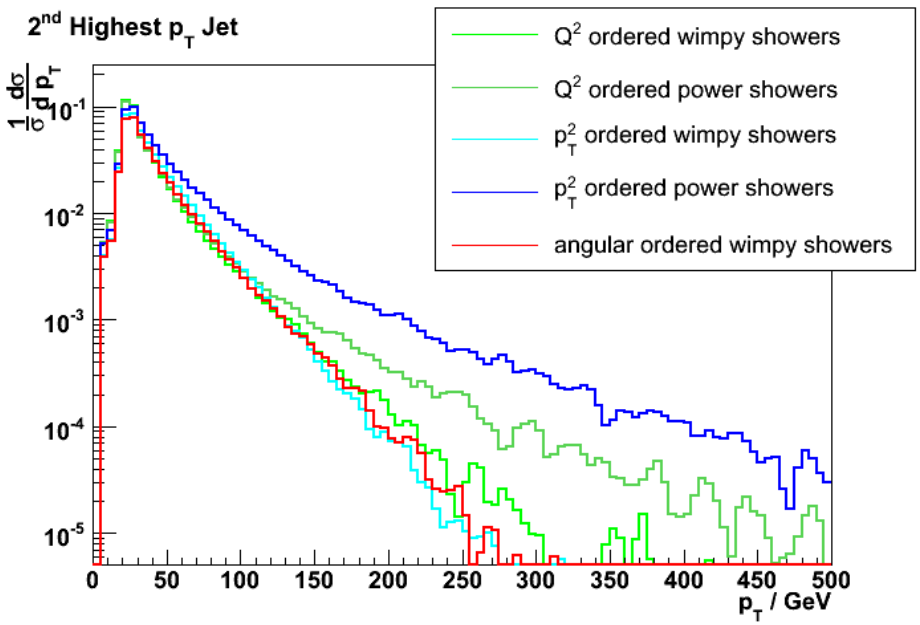
p_T Of Jets

Hardest Jet



- Differences in shower type for power showers

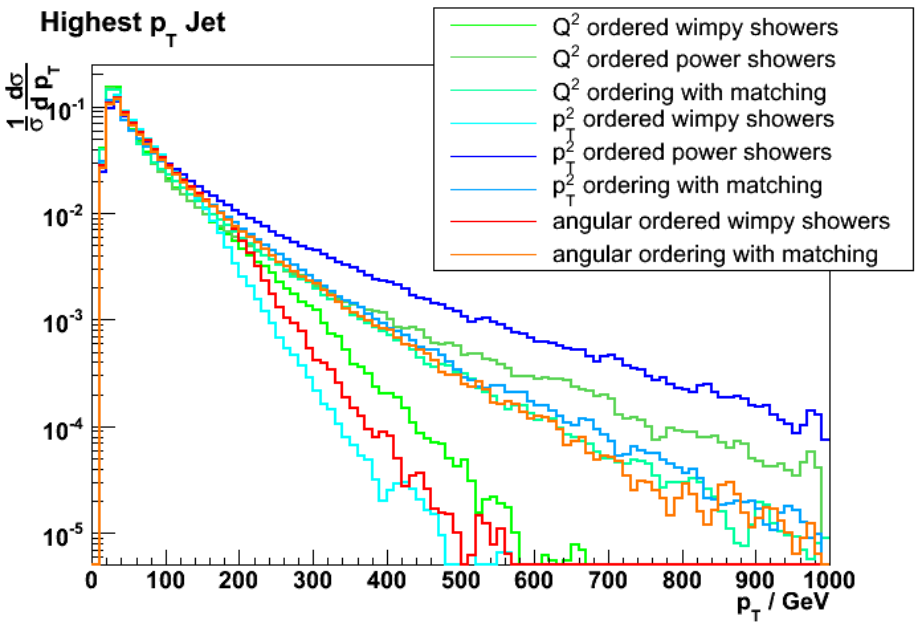
Second Hardest Jet



- Differences in shower type for power showers as well

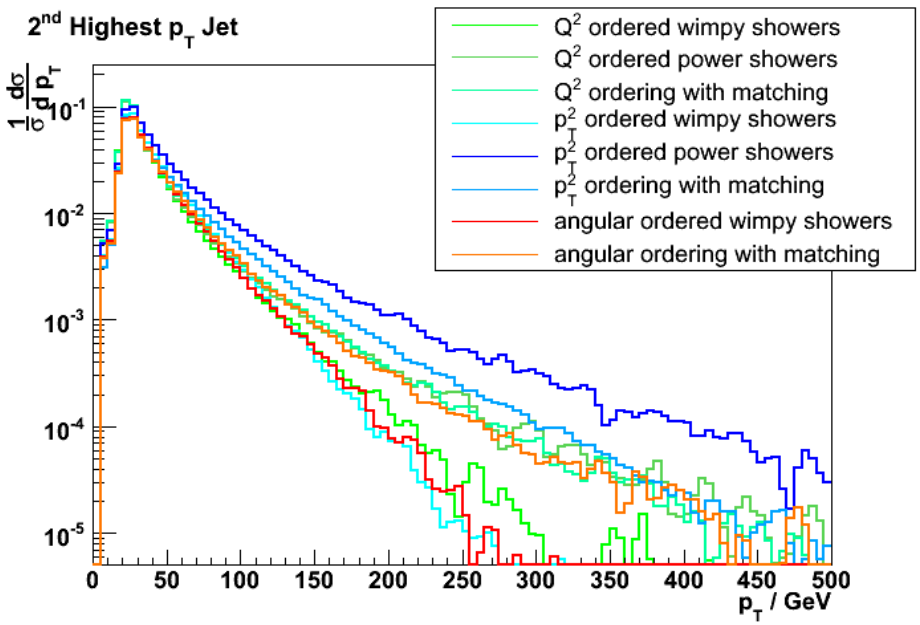
p_T Of Jets

Hardest Jet



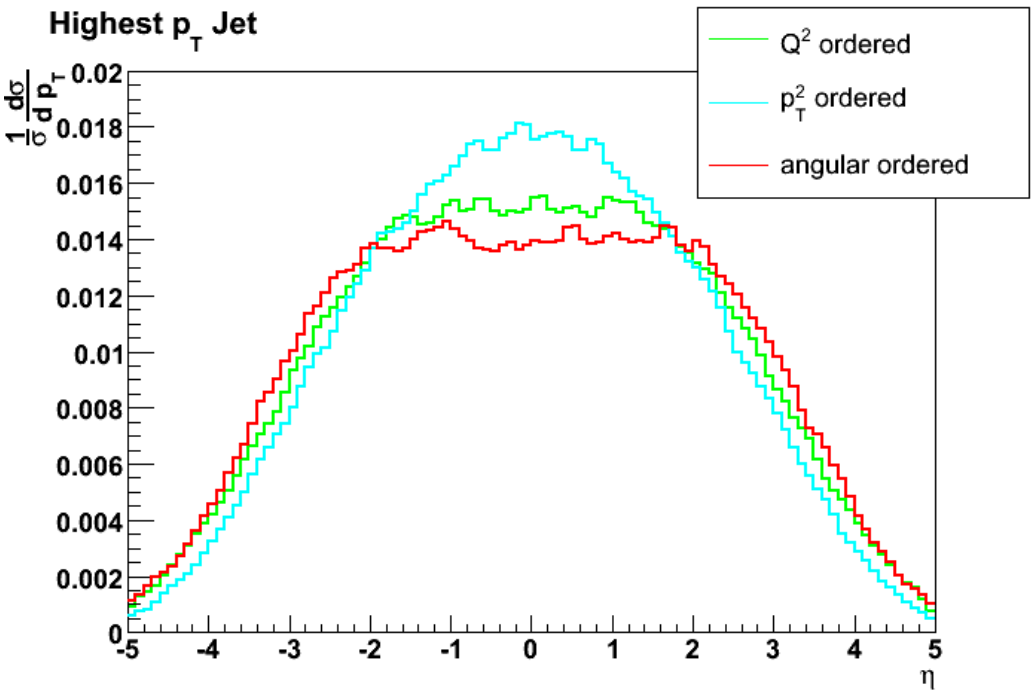
- For matched samples hardest jet mostly originates from ME

Second Hardest Jet



- Matched samples and Q^2 power showers agree

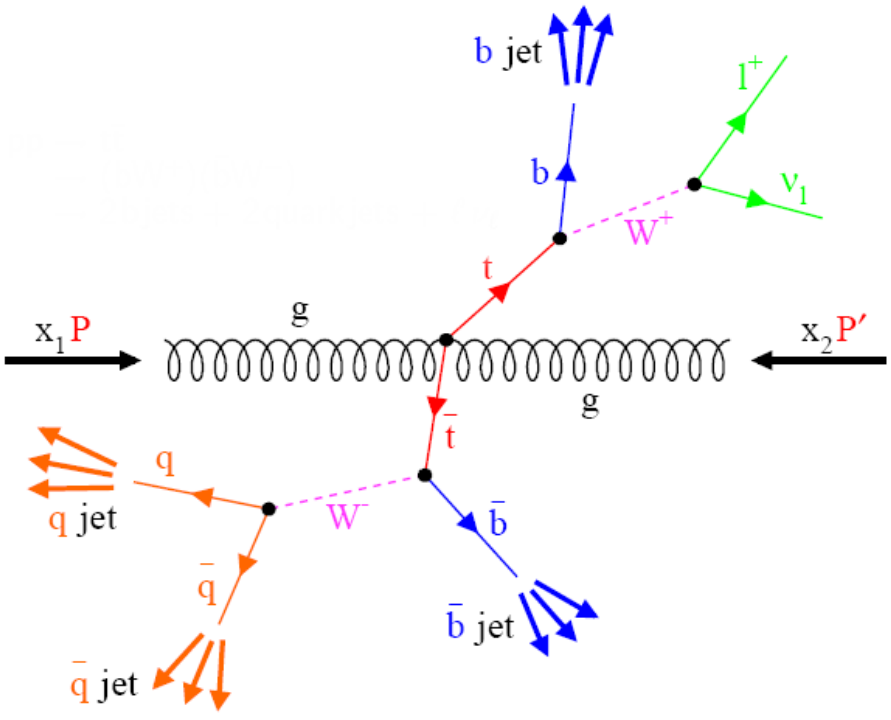
Rapidity Of Jets



- Shower models show different η distribution for hard radiation
- Angular ordering leads to a flatter shape
- Wimpy / power showers give similar results

Top Mass On Generatorlevel

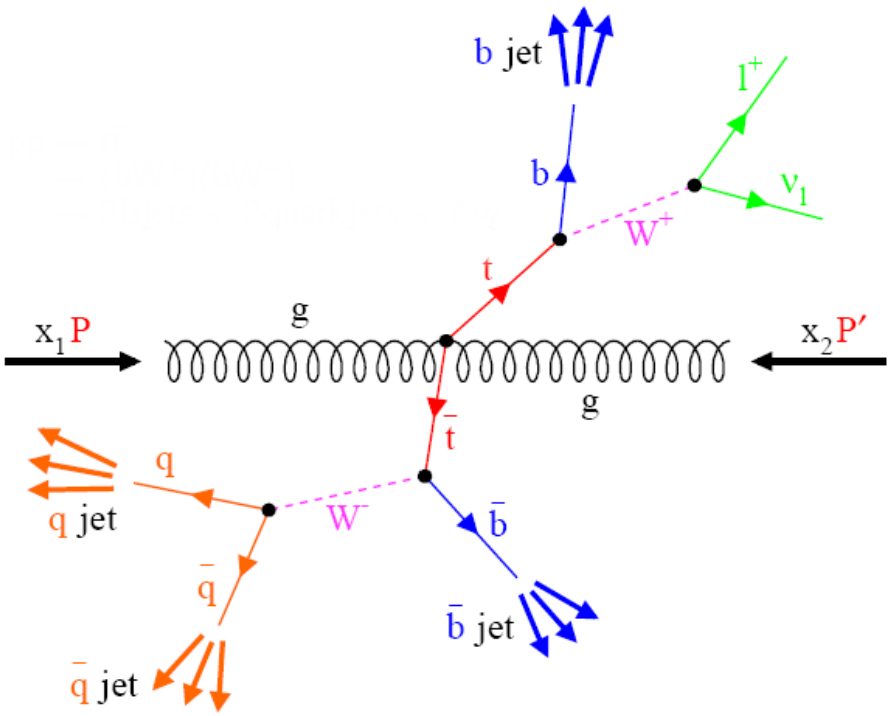
Semileptonic Decay



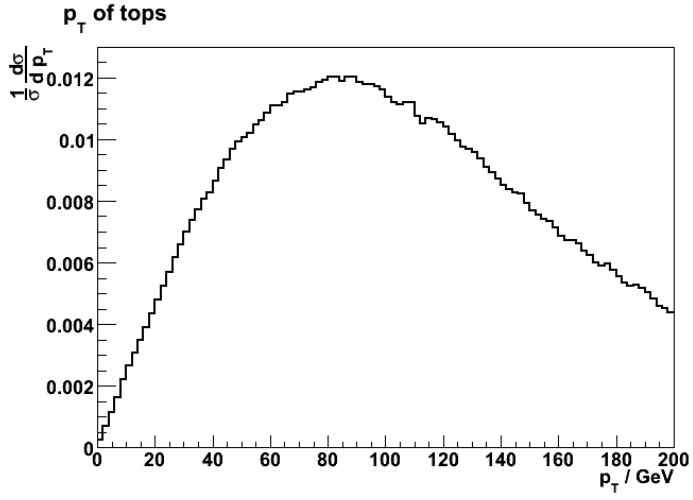
- Top mass measurement of semileptonic $t\bar{t}$ events from final hadrons
- Hard process leads to four quarks (jets), one lepton and one neutrino
- Additional partons from radiation and underlying event

Top Reconstruction

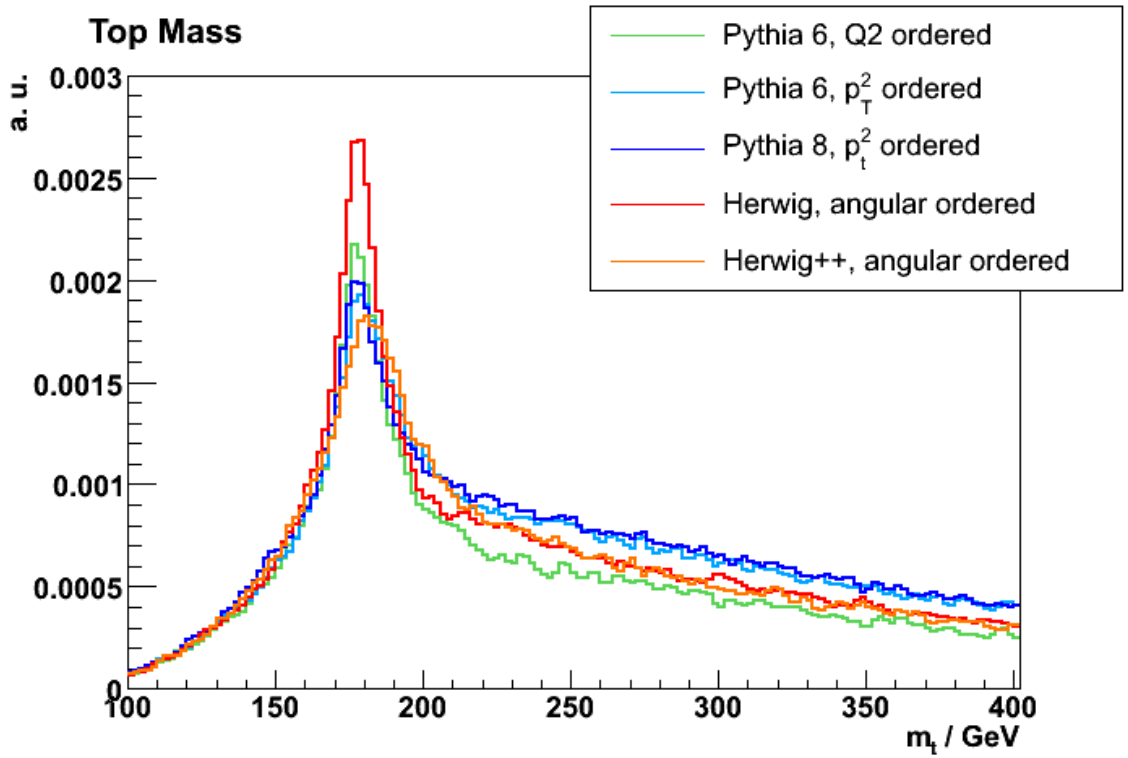
Semileptonic Decay



- Tops often produced with high p_T
- Request for at least four jets with $p_T > 40\mathrm{GeV}$
- Find 3-jet combination with maximum p_T



Top Mass



- Additional jets and wrong combinations both lead to background
- Differences in peak height and combinatorial background
- Showers and underlying event influence combinatorial background

Summary And Outlook

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- Different shower models lead to differences in p_T distributions of $t\bar{t}$ system and jets
- Performing the hardest radiation on ME level and matching the parton shower gives good agreement between the different shower models

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Outlook

- Comparison of different jet algorithms and top reconstruction methods
- Effects still visible after full detector simulation and reconstruction?
- Top Mass
  - Comparison of generator dependent combinatorial background with physical background
  - Check more sophisticated reconstruction methods

Acknowledgements

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