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

A Comparison Of Different Monte Carlo Event Generators

Alexander Floßdorf

Supervisors: Peter Richardson, Mike Seymour, Peter Skands
Many Thanks To: Stefano Frixione, Lars Sonnenschein

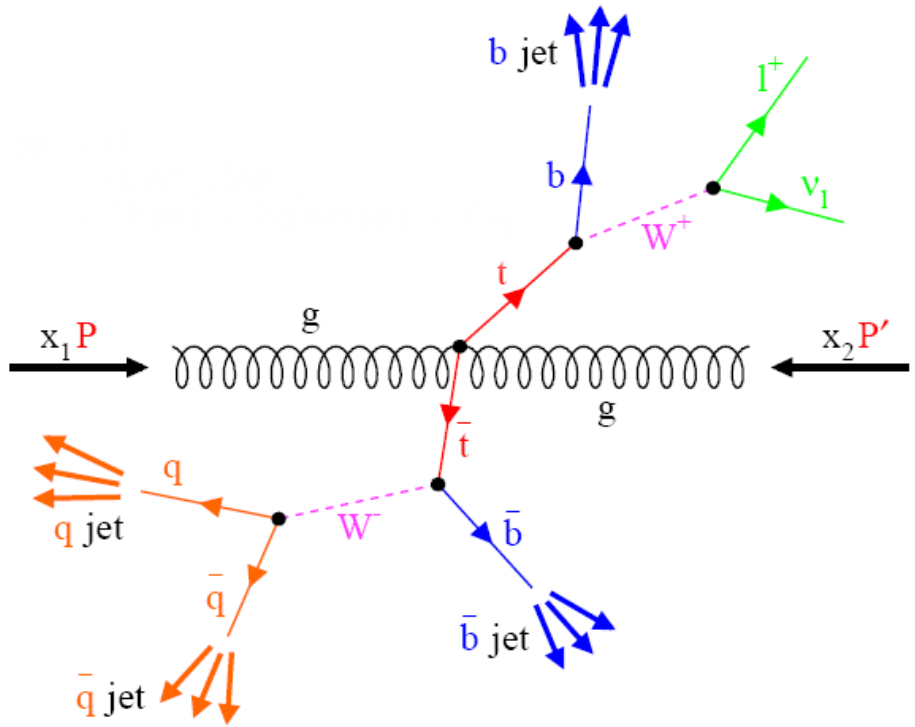
Debrecen, August 2008

Contents

Introduction Of Myself

- PhD student at DESY in Hamburg (Germany)
- Member of the CMS collaboration
- MCnet student at CERN from February to May 2008
- Topic of my thesis: Influence of NLO and shower algorithms on $t\bar{t}$ at LHC, comparison of different MC generators
  $\Rightarrow$ studentship was very helpful to learn basics and get in contact with the experts :)

Top Physics



- High energy radiation is possible
- Understanding of radiation will play a crucial role for $t\bar{t}$

Used Generators

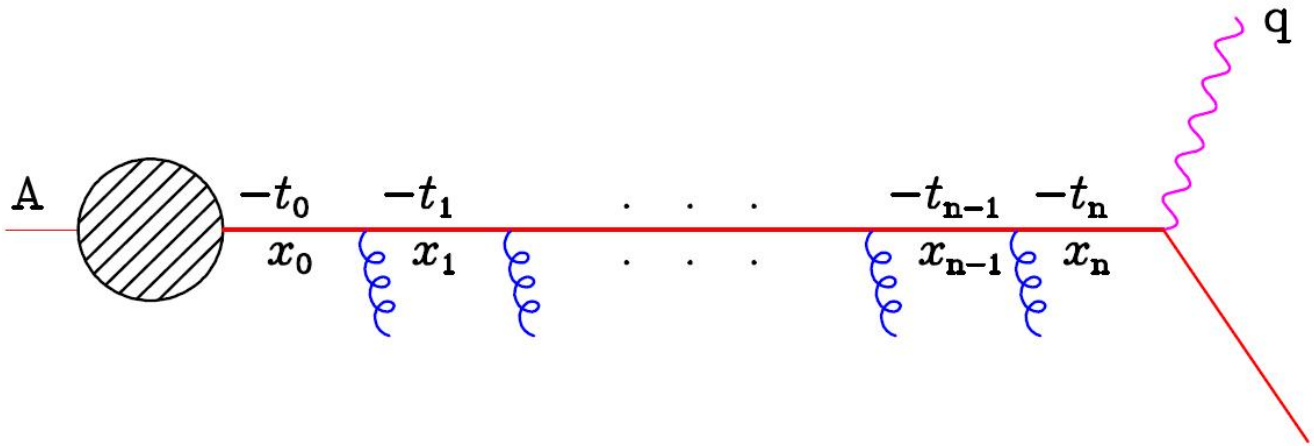
Standalone Event Generators

- Herwig (anglular 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

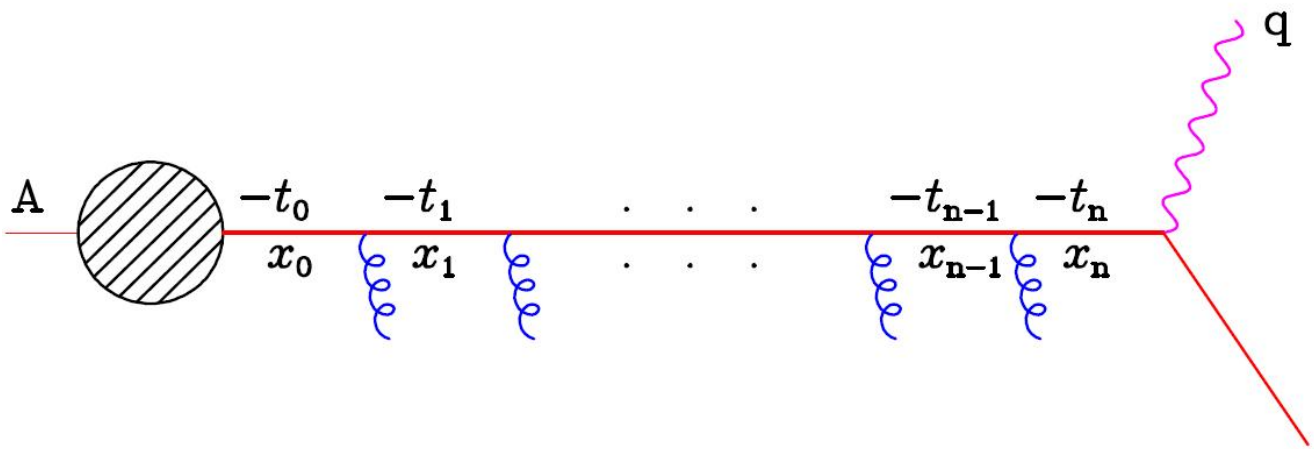
- MC@NLO (NLO computation on ME level)
  - uses Herwig for showering and hadronisation
- Alpgen (acoounts for additional hard partons at ME level)
  - ueses Herwig or Pythia 6 for showering and hadronisation

Shower Types



B. Webber, CERN Training Lecture, Februrary 2008

Shower Types

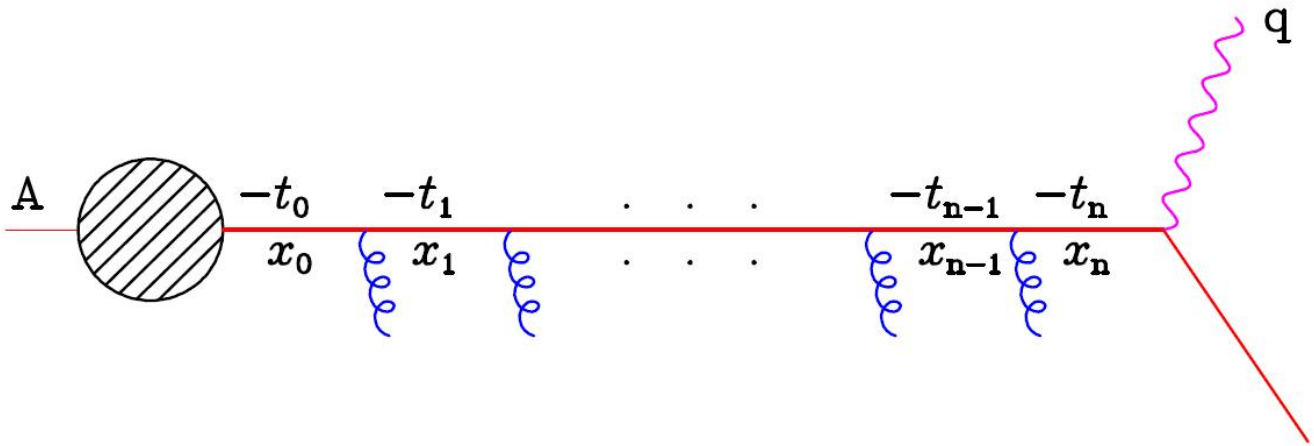


B. Webber, CERN Training Lecture, Februrary 2008

Wimpy Showers

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

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

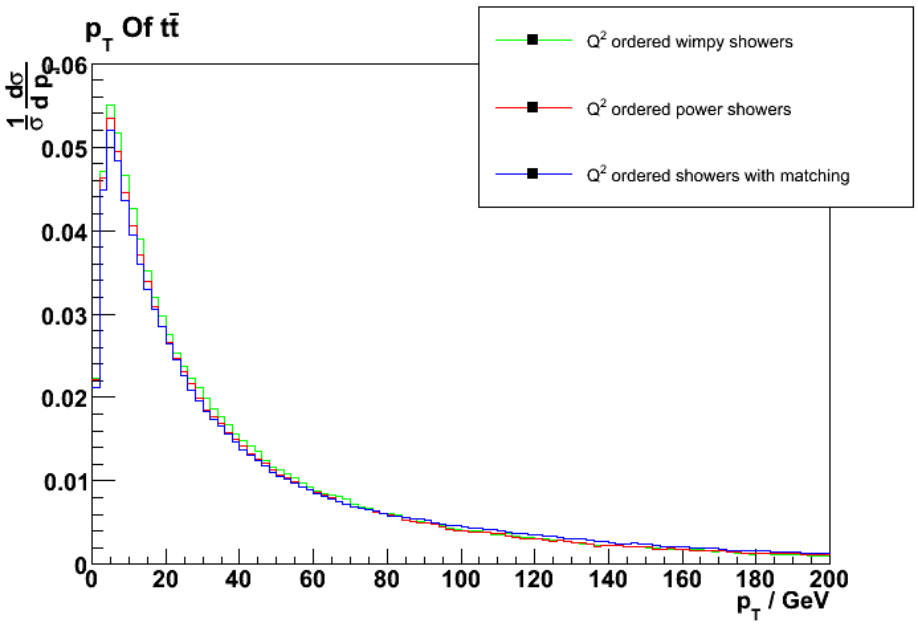
- Maximum virtuality for shower is $t_{max} = s$
- Whole phase space is used

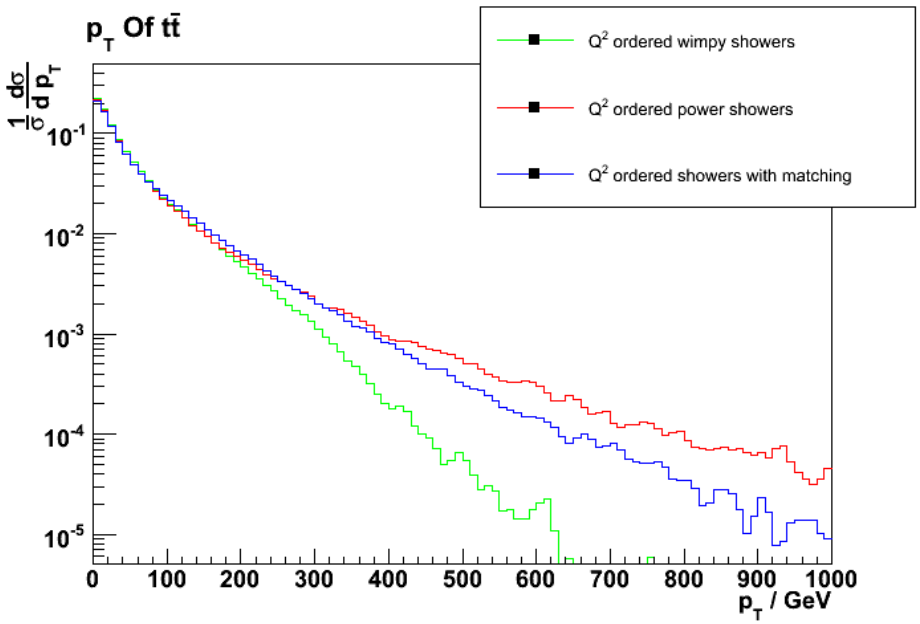
Matching

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

Shower Type Comparison

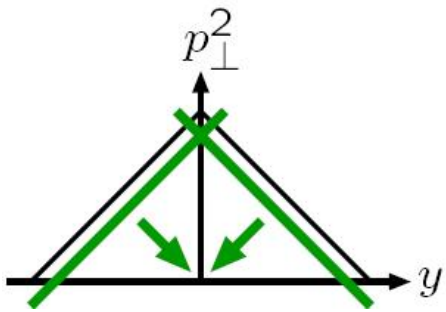




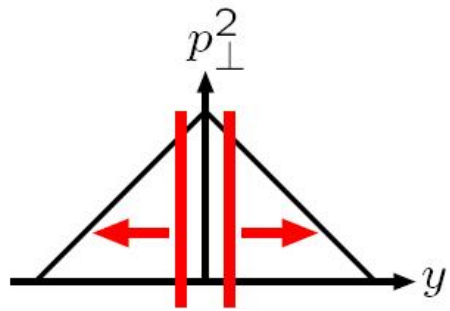
- Peak region of p_T distribution not affected by choice of shower type
- Tail of p_T distribution determined by shower type

Shower Algorithms

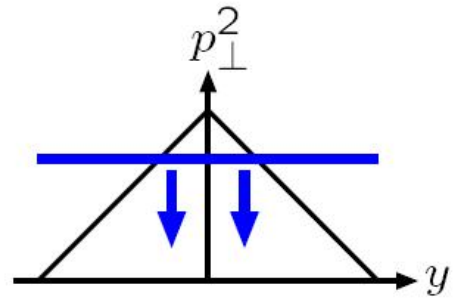
$t = Q^2$



$t \sim \theta^2$

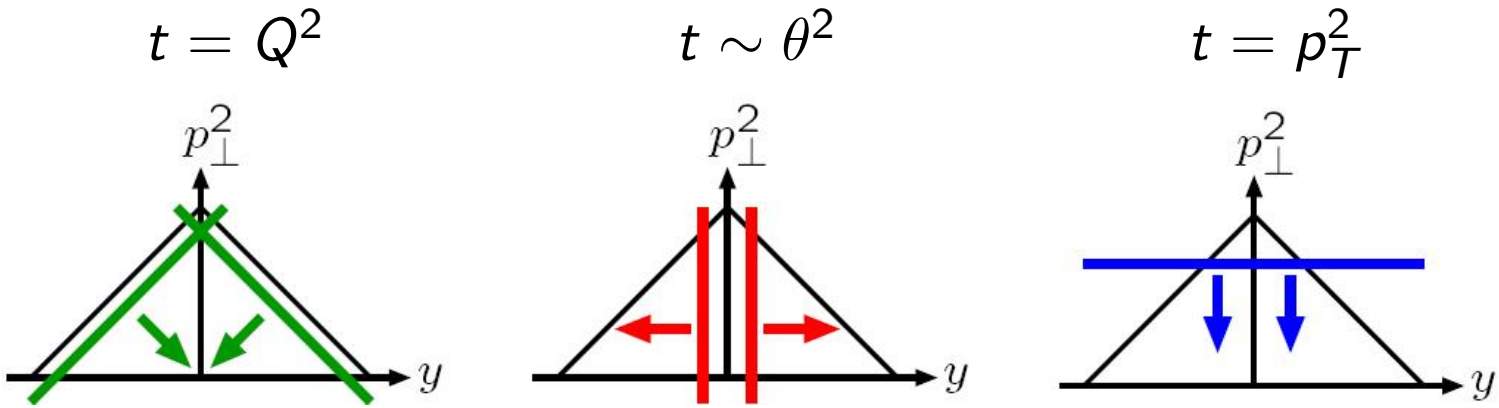


$t = p_T^2$



T. Sjöstrand, European School of HEP, June 2006

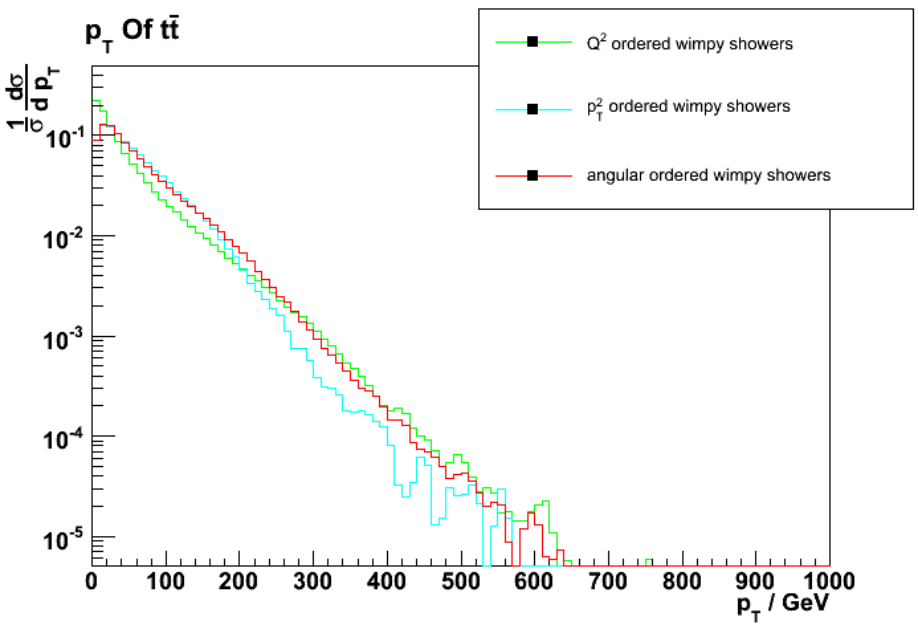
Shower Algorithms



T. Sjöstrand, European School of HEP, June 2006

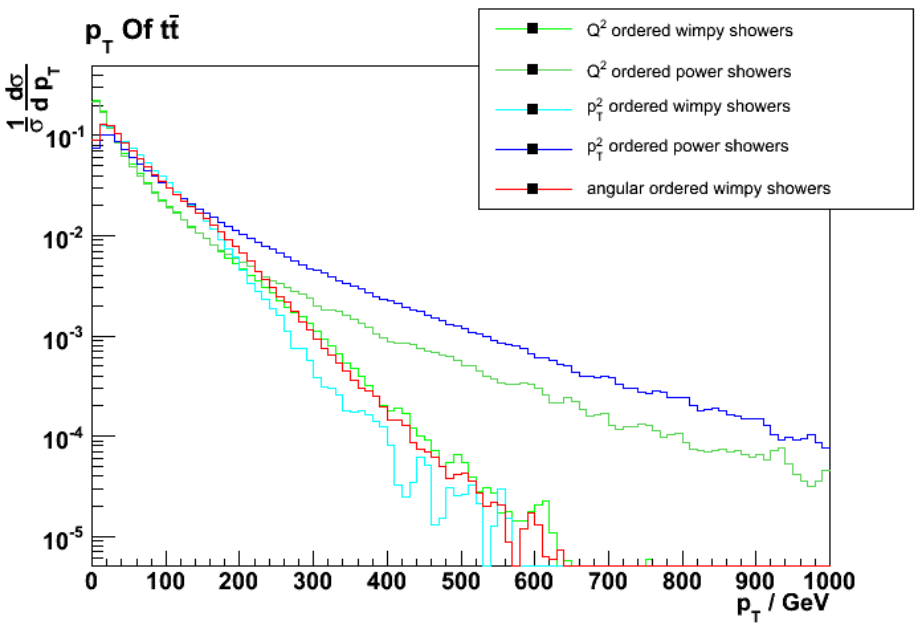
- evolution from the hard interaction (ME) on
- decreasing in Q^2: Pythia 6
- decreasing in p_T^2: Pythia 6 and Pythia 8
- decreasing in angle: Herwig and Herwig++

Shower Algorithms



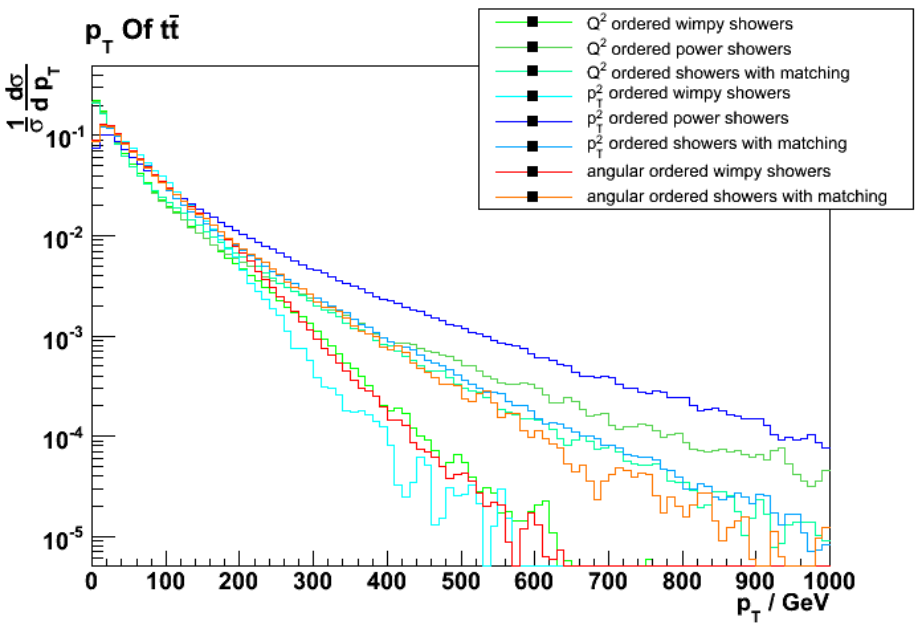
- Angular ordered wimpy showers: Herwig
- Q^2 ordered wimpy showers: Pythia 6
- p_T^2 ordered wimpy showers: Pythia 8

Shower Algorithms



- Angular ordered power showers: not available
- Q^2 ordered power showers: Pythia 6
- p_T^2 ordered power showers: Pythia 8

Shower Algorithms



- Angular ordered showers with matching: MC@NLO
- Q^2 ordered showers with matching: Alpgen + Pythia 6
- p_T^2 ordered showers with matching: Alpgen + Pythia 6

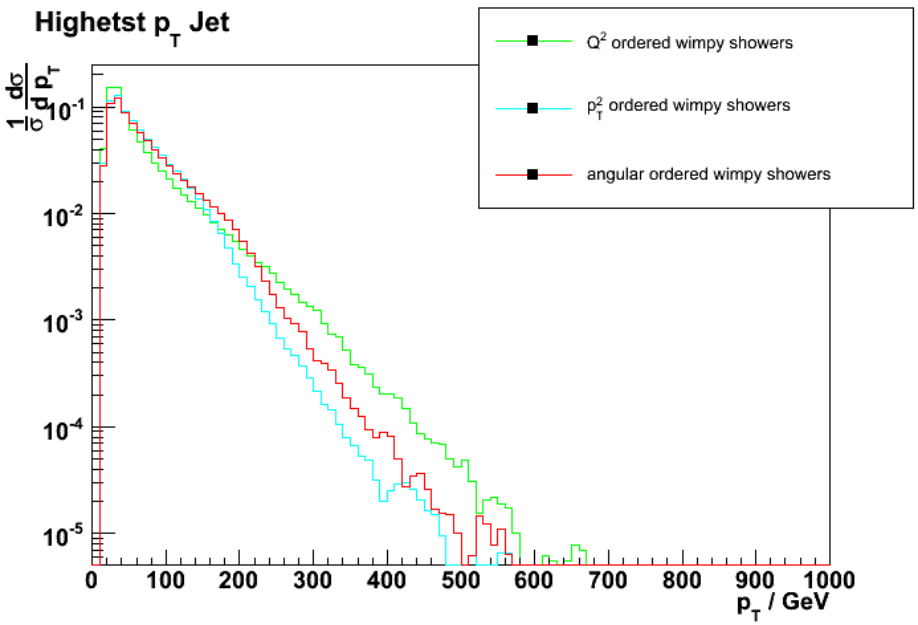
Jets

Jet Definition

- Leave tops stable and neglect them
- Run jet algorithm on remaning particles within $|\eta| < 6$
- Results for SISCone 0.5 are presented

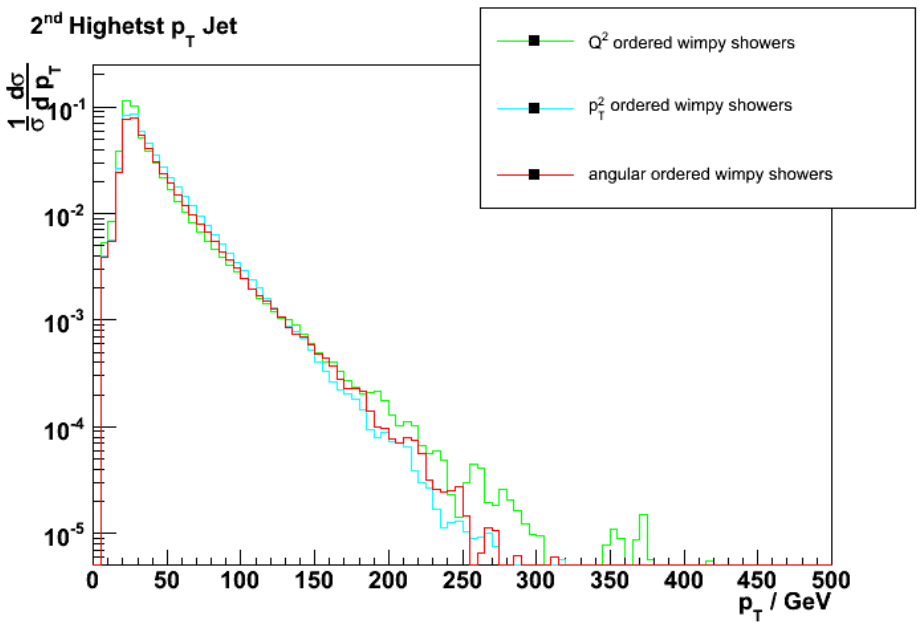
p_T Of Jets

Hardest Jet



- Slight difference in shower type

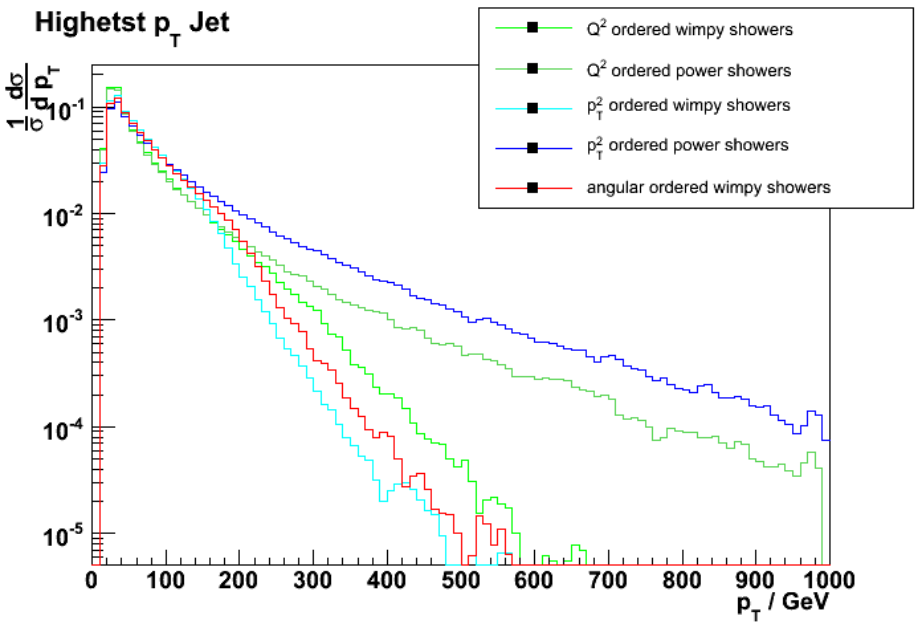
Second Hardest Jet



- Almost identical for all shower types

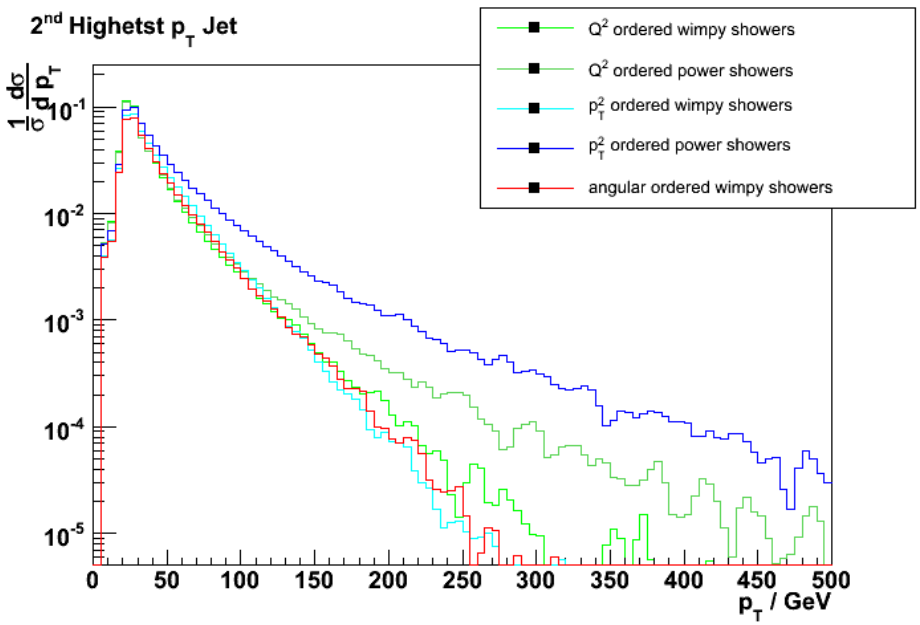
p_T Of Jets

Hardest Jet



- Differences in shower type for power showers

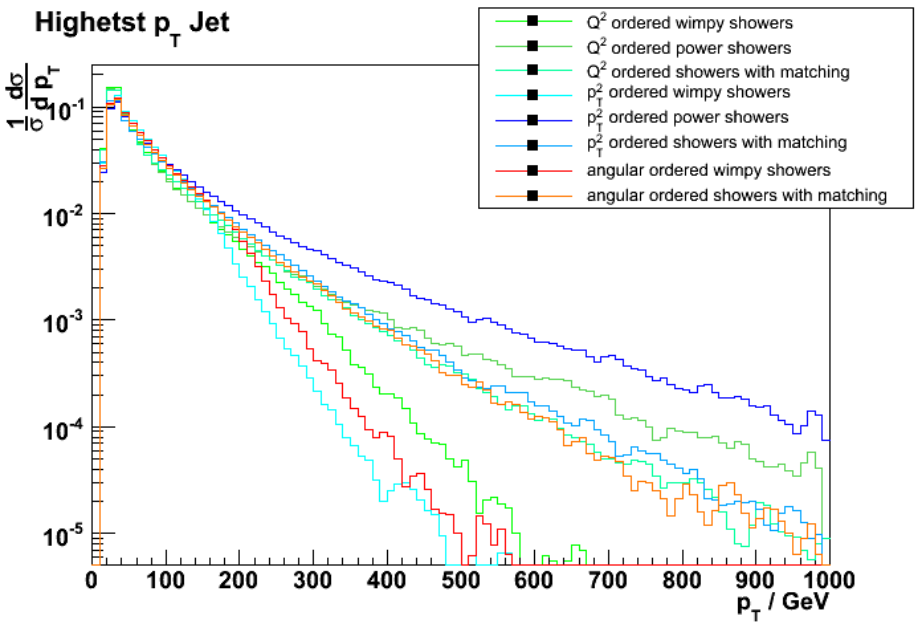
Second Hardest Jet



- Differnces in shower type for power showers as well

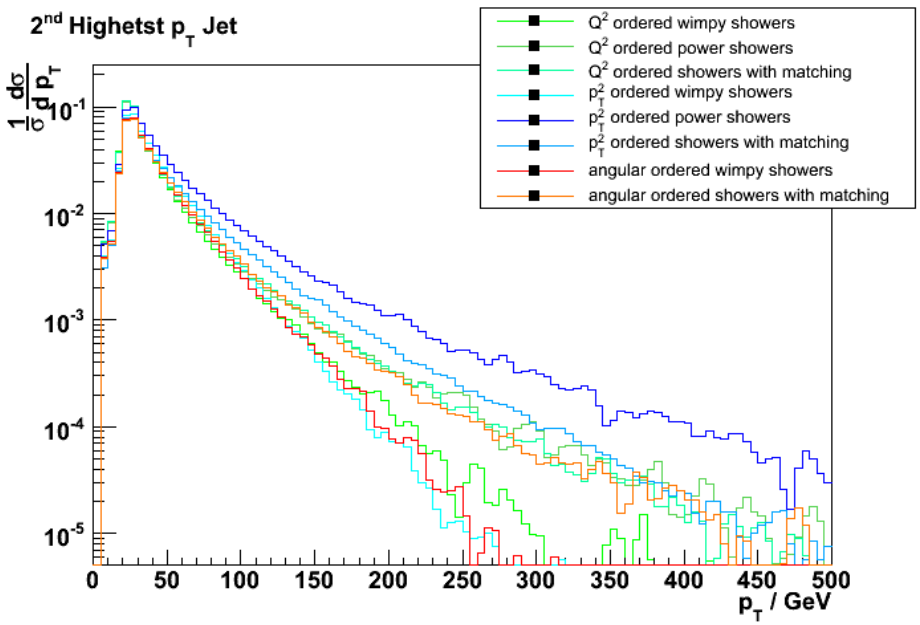
p_T Of Jets

Hardest Jet



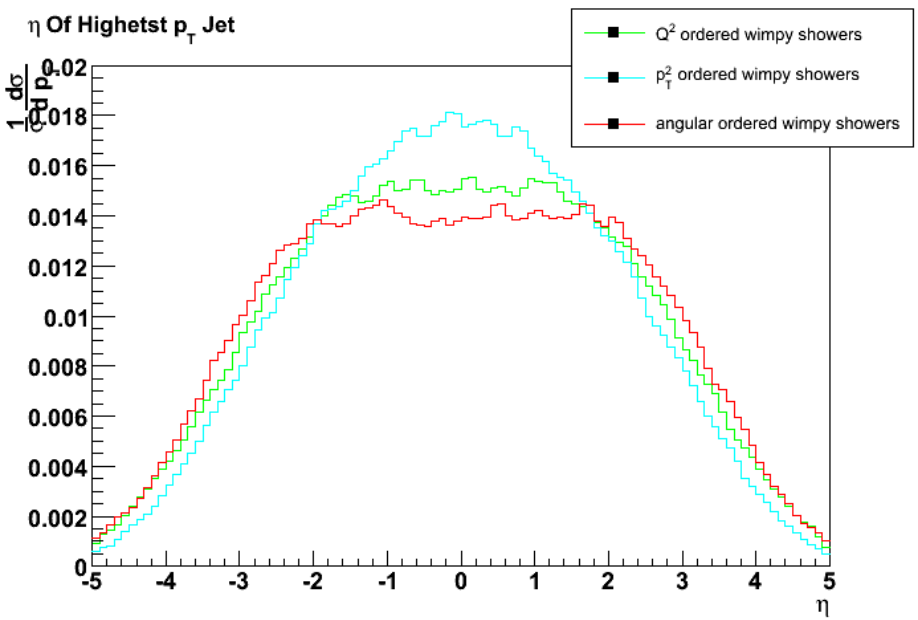
- Matched samples agree

Second Hardest Jet



- Matched samples and Q^2 power showers agree

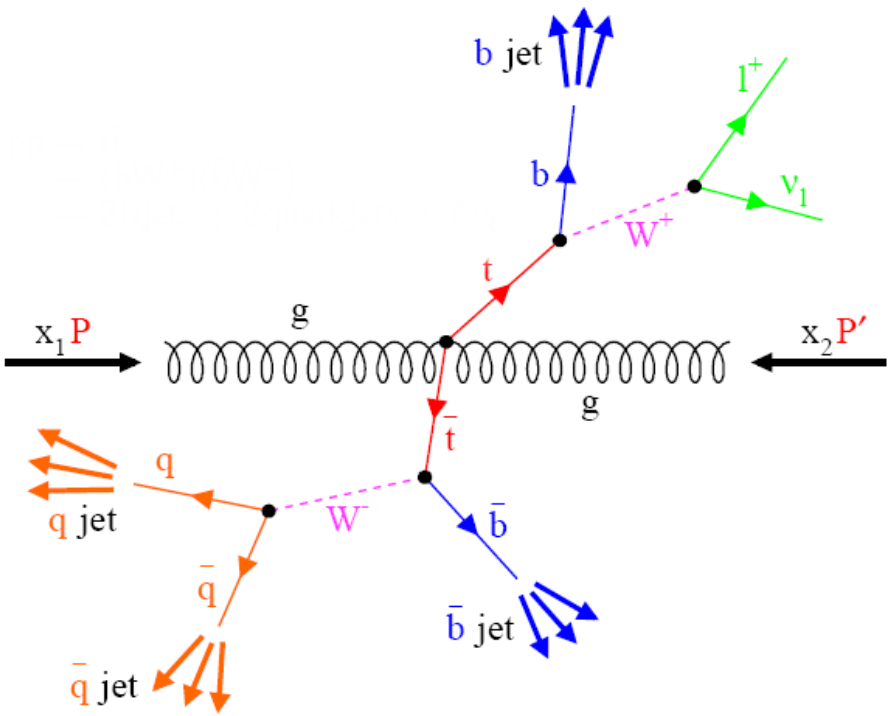
Rapidity Of Jets



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

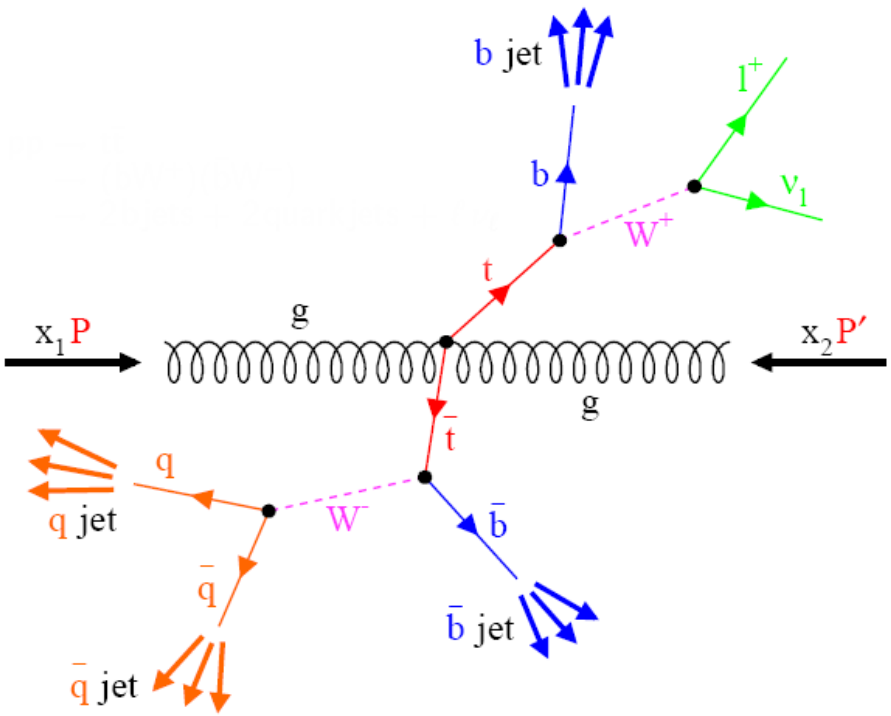
Top Reconstruction

Semileptonic Decay

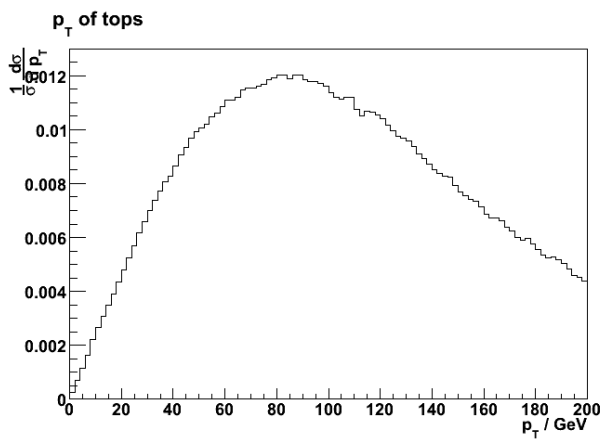


Top Reconstruction

Semileptonic Decay

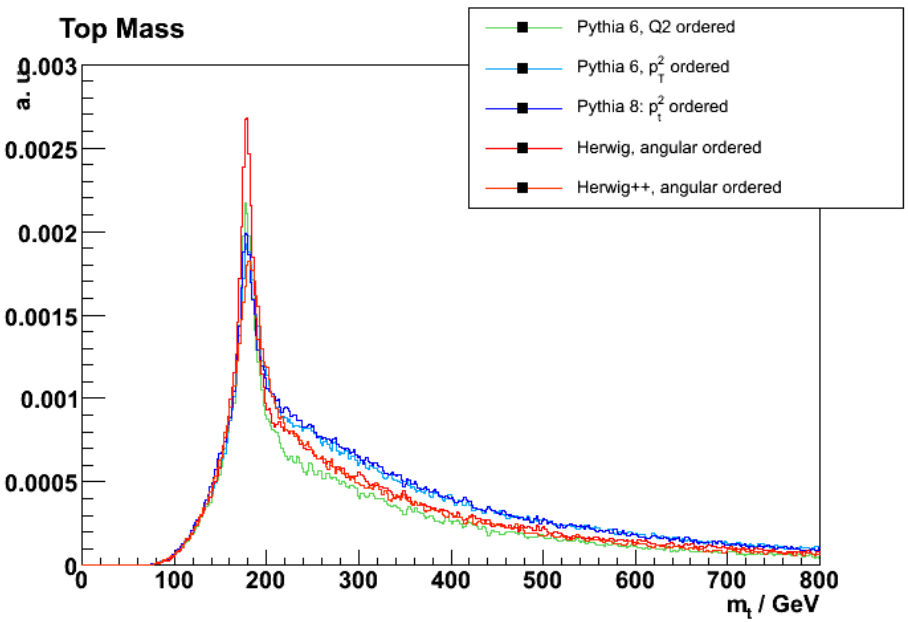


- Tops often produced with high p_T
- Request for at least four jets with $p_T > 40(GeV)$
- Find 3-jet combination with maximum p_T



Top Mass

Top Mass



- Differences in peak height and background
- Showers and underlying event influence combinatorial background
- Reconstruction methods can be sensible to generator effects

Summary And Outlook

p_T *Spectra*

- Different shower implementations lead to differences in p_T distributions of $t\bar{t}$ system and jets

Summary And Outlook

p_T *Spectra*

- Different shower implementations lead to differences in p_T distributions of $t\bar{t}$ system and jets
- Are these still visible after full detector simulation and reconstruction?

Summary And Outlook

p_T Spectra

- Different shower implementations lead to differences in p_T distributions of $t\bar{t}$ system and jets
- Are these still visible after full detector simulation and reconstruction?

Top Mass

- Combinatorial background for top mass distribution depends on generator

Summary And Outlook

p_T Spectra

- Different shower implementations lead to differences in p_T distributions of $t\bar{t}$ system and jets
- Are these still visible after full detector simulation and reconstruction?

Top Mass

- Combinatorial background for top mass distribution depends on generator
- Does that influence the overall efficiency when physical background is taken into account?
- Are more sophisticated methods affected by this as well?

Acknowledgements

This research project has been supported by a Marie Curie Early Stage Research Training of the European Community's Sixth Framework Programme under contract number MRTN-CT-2006-035606.