Z+b bbar in Herwig and Herwig++, in Cascade

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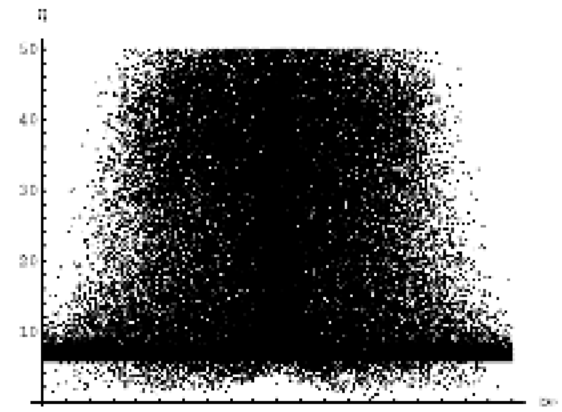
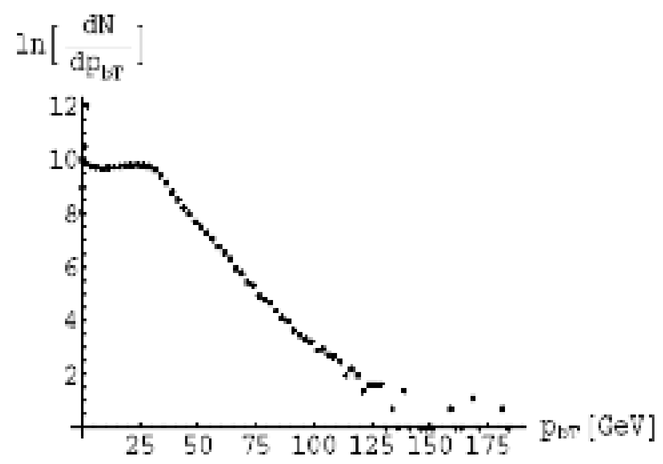
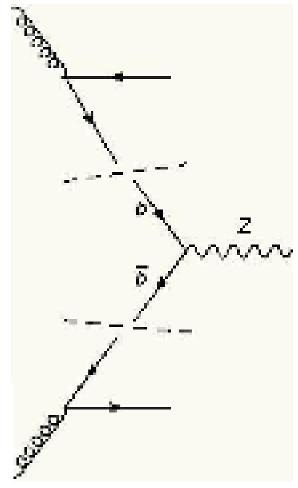
Z+b bbar in Herwig

- b-quarks naturally appear in initial state parton showers in Drell-Yan production in pp collisions
- strange pt distribution
- massless b-quarks
- cut on radiated parton pt to simulate the dead cone effect
- NO dead cone effect in $g \to b\bar{b}$
- NO coherence effect $g \to b\bar{b}$
- angular ordering inappropriate
- forced non-perturbative splitting







- similar problems in Herwig++
  - no problem with forced b-quarks
  - mass effects included in the final state parton showers

Motivation – FOPT vs. VFNS

- heavy quark mass – a new scale in the hard process
- potentially large logarithmic terms $\left[\alpha_S \ln\left(m_b^2 / \mu^2\right)\right]^n$ which should be resummed – really?
- two solutions:

FOPT – Fixed Order Perturbation Theory

- allows for the heavy flavours only in the final state
- doesn't resum logarithms

VFNS – Variable Flavour Number Scheme

- the flavours appear in the initial state
- treats heavy flavours as massless – unable to describe threshold effects

can we have an interpolation in Monte Carlo?

Quazi-collinear approximation

- by calculating the splitting functions (SF) not only $q_\perp \to 0$
  but also $m \to 0$ by keeping $m \sim q_\perp$
- the SFs factorize and include additional terms

$$P_{Qg}\left(z, m_Q^2 / q_{Q\perp}^2\right) = T_R\left(\frac{2m_Q^2}{m_Q^2 + q_{Q\perp}^2} z(1-z) + z^2 + (1-z)^2\right)$$

$$P_{gQ}\left(z, m_Q^2 / q_{Q\perp}^2\right) = C_F\left(-\frac{2m_Q^2}{z^2 m_Q^2 + p_{Q\perp}^2} z(1-z) + \frac{1+(1-z)^2}{z}\right)$$

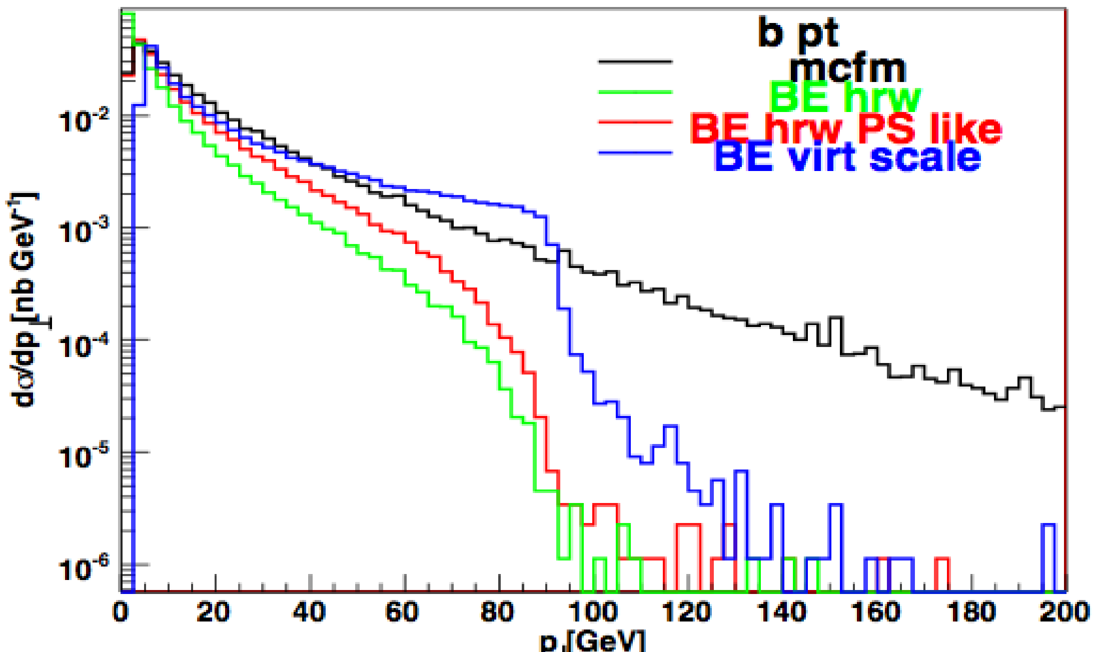
$$P_{QQ}\left(z, m_Q^2 / q_{Q\perp}^2\right) = C_F\left(-\frac{2m_Q^2}{(1-z)^2 m_Q^2 + p_{Q\perp}^2} z(1-z) + \frac{1+z^2}{1-z}\right)$$

- the most important SF is the P_{Qg}
- the changes also affect the Sudakov formfactor

B-quark transverse momentum distribution

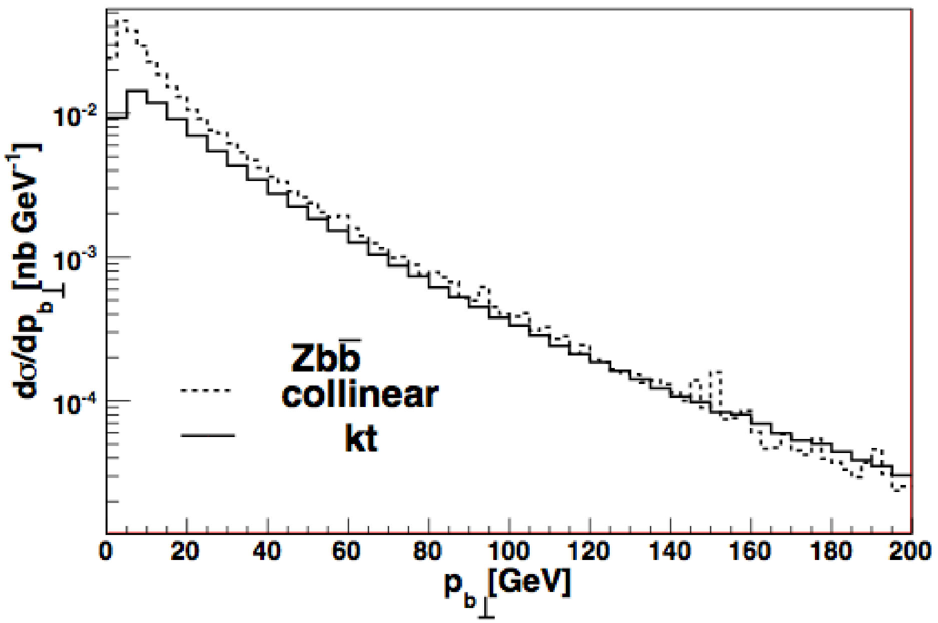
- the angular ordering – the evolution scale $E_i\theta_i$ – is not appropriate
- the choice of the evolution scale is not obviously clear

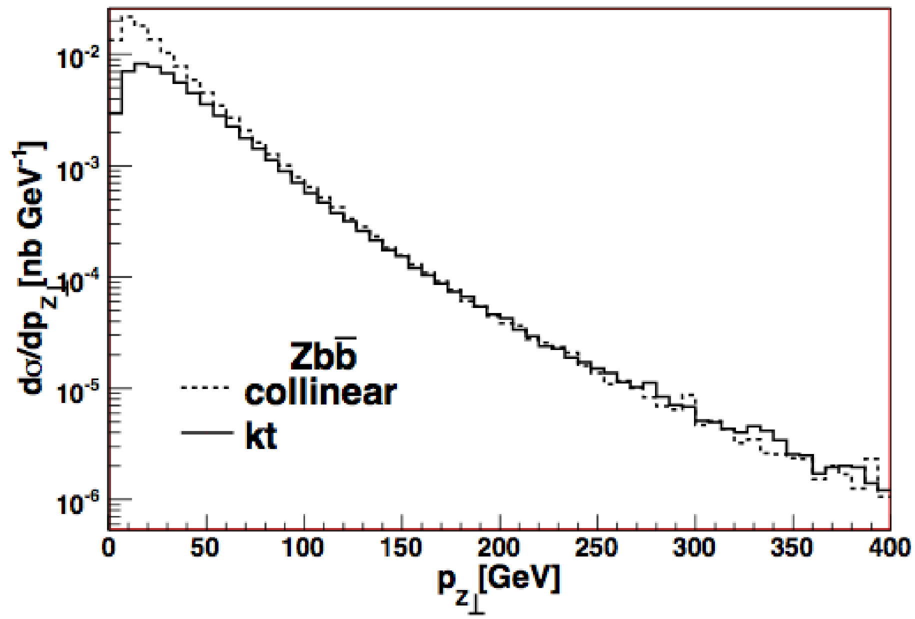
- transversal momentum of the emitted heavy Q
- virtuality of the evolved heavy Q
- the angular scale from Herwig++



Z+b bbar in Cascade

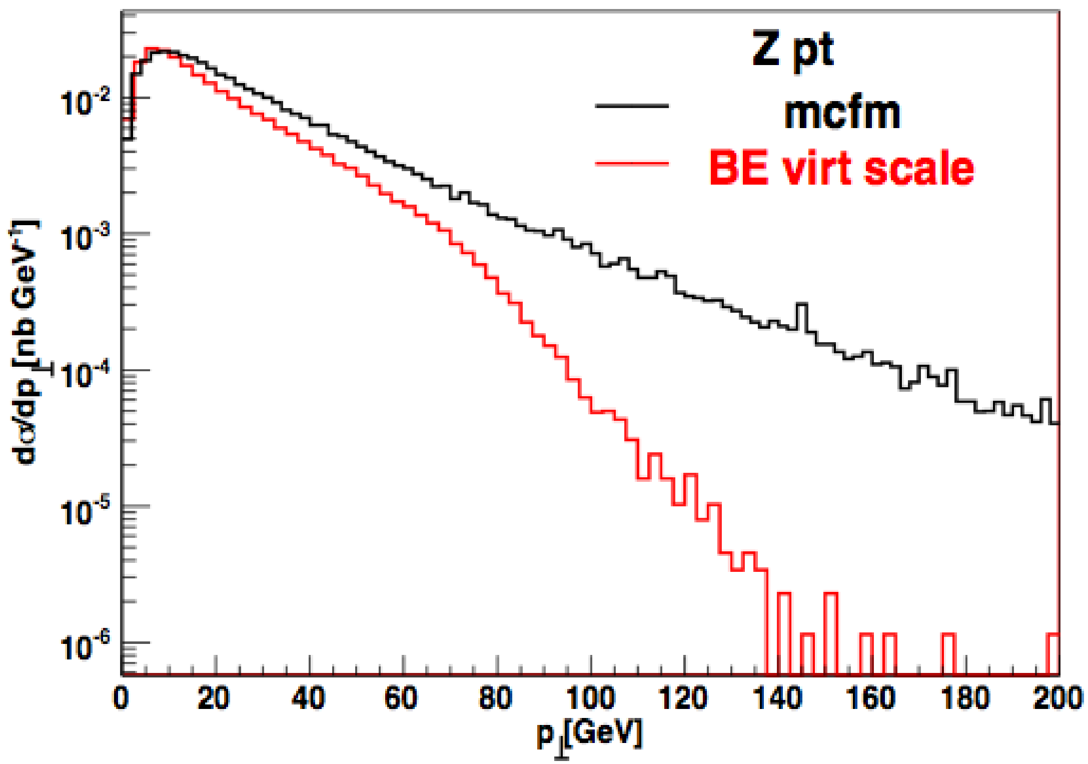
- Initial state evolution in Cascade by CCFM equation – interpolation between BFKL and DGLAP – includes low-x dynamics – resums logarithms ln(1/x)
- Full matrix element $g^*g^* \rightarrow Z+b\bar{b}$ with off-shell initial state gluons, each with polarisation sum $(k_T^\mu k_T^\nu)/k_T^2$
- Exact kinematics with/without parton showers





Summary and conclusions

- Need to improve parton showers for heavy quarks in Herwig and Herwig++ motivated
- Splitting functions in quasi-collinear approximation
- Results for Z+b bbar with new model
- Different approach in Cascade and results for Z+b bbar
- Difference at low transverss]e momenta of the final state particles


Z pt
mcfm
BE virt scale
dσ/dp⊥[nb GeV-1]
p⊥[GeV]
10-2
10-3
10-4
10-5
10-6
0
20
40
60
80
100
120
140
160
180
200