

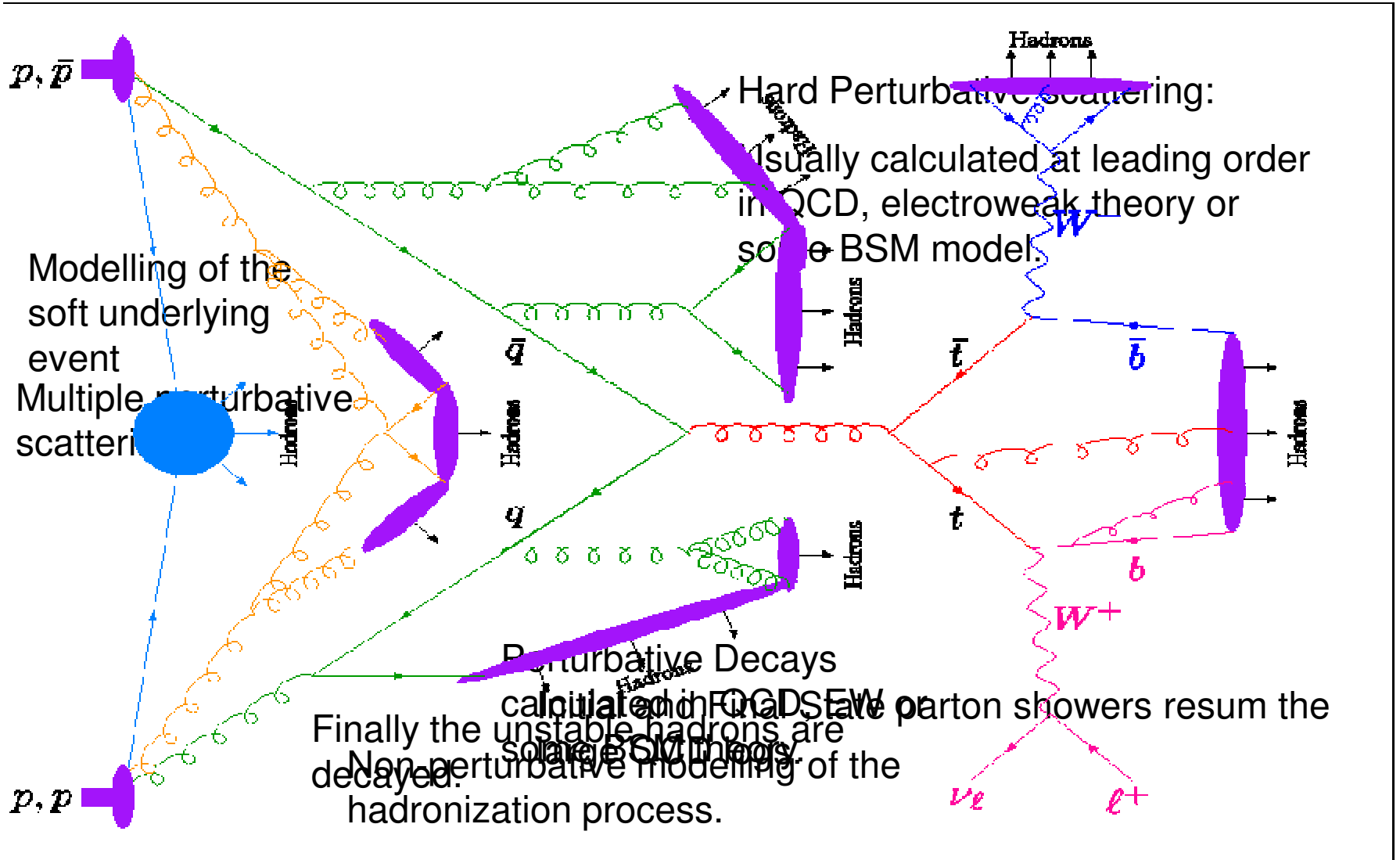
PDF issues for Monte Carlo generators

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Outline

- Introduction
- LO or NLO
- Heavy Quarks
- PDF Errors
- Conclusions

A Monte Carlo Event



Introduction

- Monte Carlo event generators used PDFs for three things:
 - calculation of the hard process;
 - guiding the backward evolution in initial-state radiation;
 - generating additional scatterings in the multiple-parton interaction model.
- There are issues about the PDFs we use for all of these stages.

Hard Process

- The calculation of the hard process is the theoretically cleanest use we make of the PDFs.
- The major question is whether to use leading or next-to-leading order PDFs:
 - Most processes in the event generators are only available at leading order, so to be consistent should use leading order PDFs;
 - An increasing number of processes are now available at NLO, **MUST** use an NLO PDF for the hard process at least.

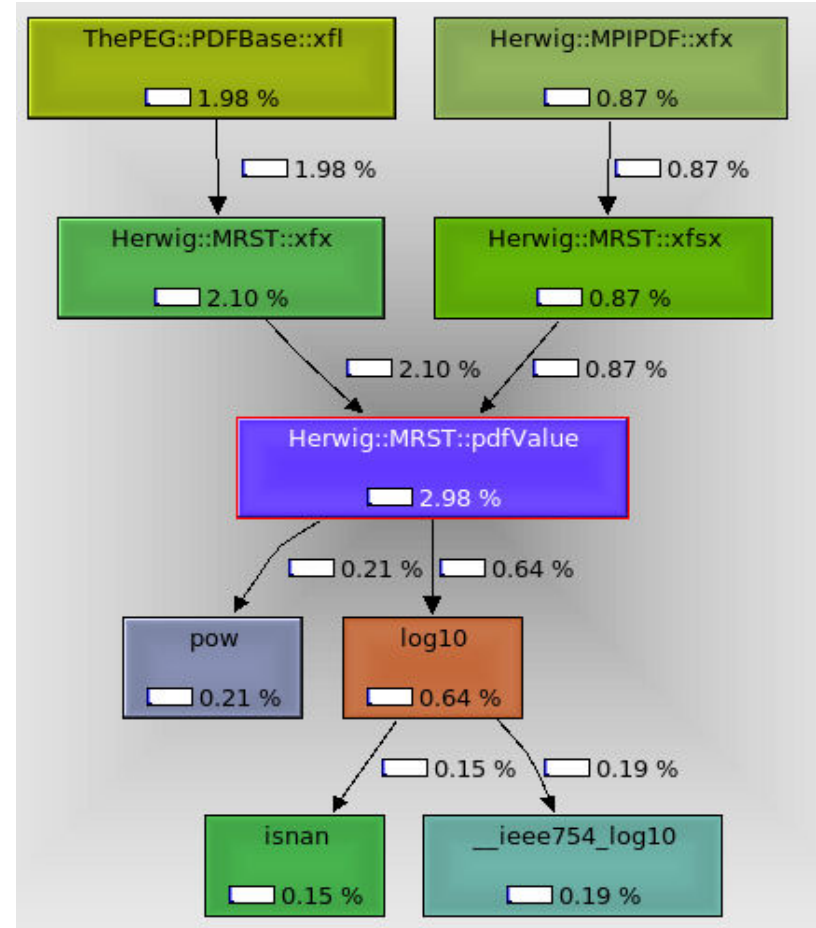
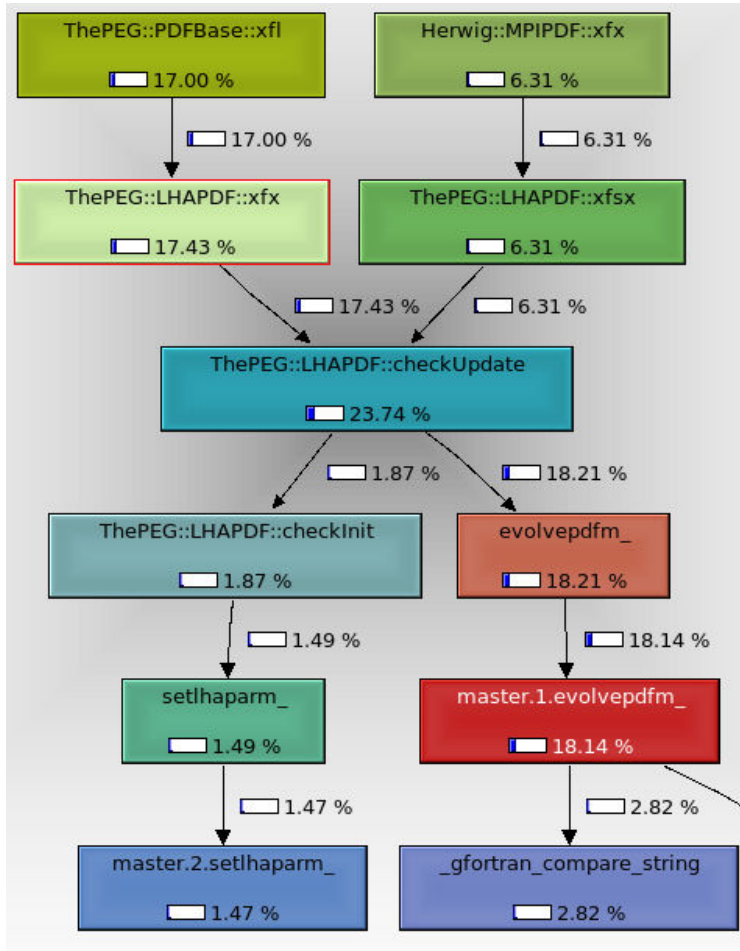
Parton Shower

- Formally the backward shower algorithm is equivalent to starting with the PDF at a low scale and generating the PDF using a forward evolution algorithm.
- However various cut-offs in the parton shower and different mass treatments can lead to inconsistencies.
- A major problem if NLO PDFs are used as the algorithm is LO.
- Need to use LO PDFs.

Multiple Interactions

- In generating additional scatterings we should be using PDFs for extracting two or more partons from the proton.
- As these are not available we are forced to use the inclusive PDF and model the effect of removing more than one parton.
- As the matrix elements we use for the additional scatterings are leading order need to use leading order PDFs.

Speed is important



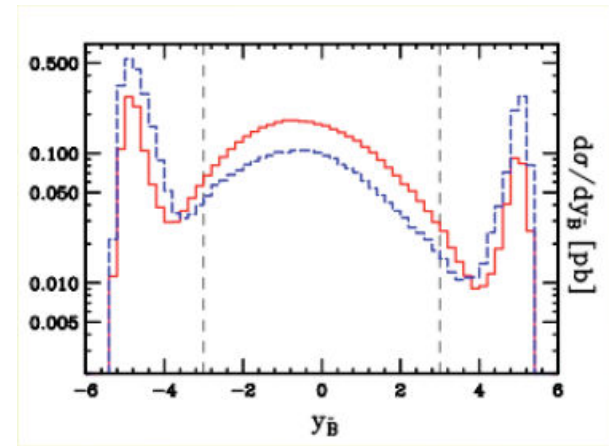
Which PDF to Use?

- The general view in the MC community is that we should use:
 - LO PDFs for LO hard processes, the shower and underlying event;
 - NLO PDFs for NLO hard processes.
- LO* and LO** seem are a good choice at LO accuracy to improve the results and make the PDF and shower evolution similar.
- Issues when we have an NLO hard process about which PDFs to use for the shower.

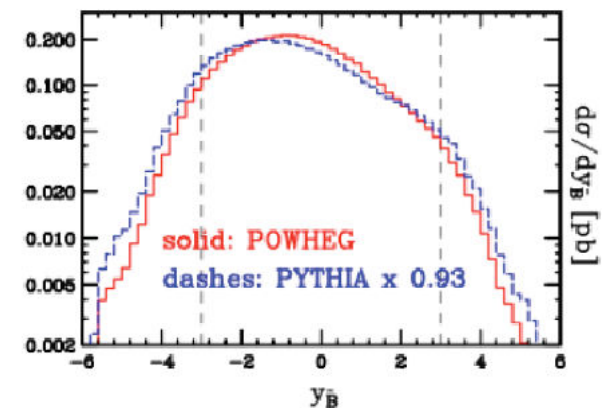
Heavy Quarks

- One area where the differences in the shower and PDF evolutions is largest is for the backward evolution of heavy quarks.
- Expect bottom to backward evolve to a gluon.
- If this doesn't happen perturbatively has to be forced non-perturbatively.

HERWIG



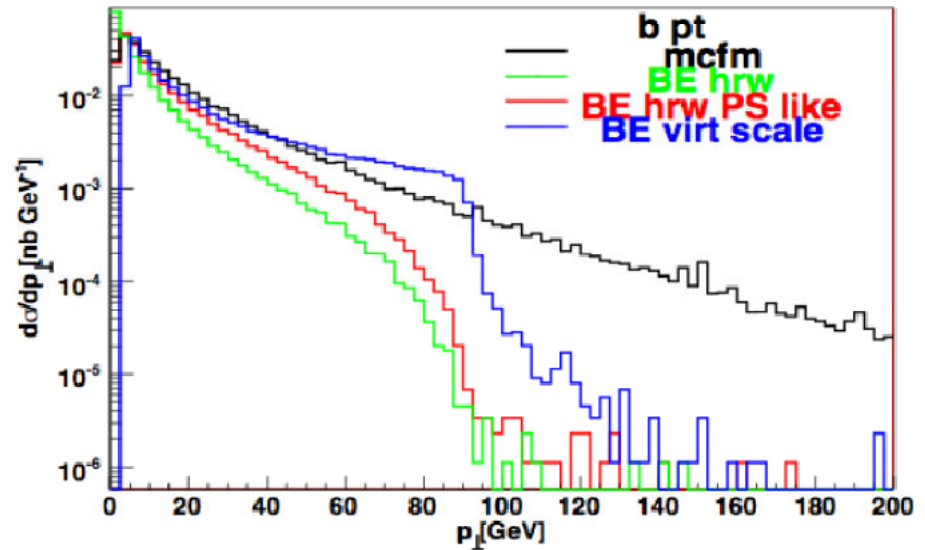
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Heavy Quarks

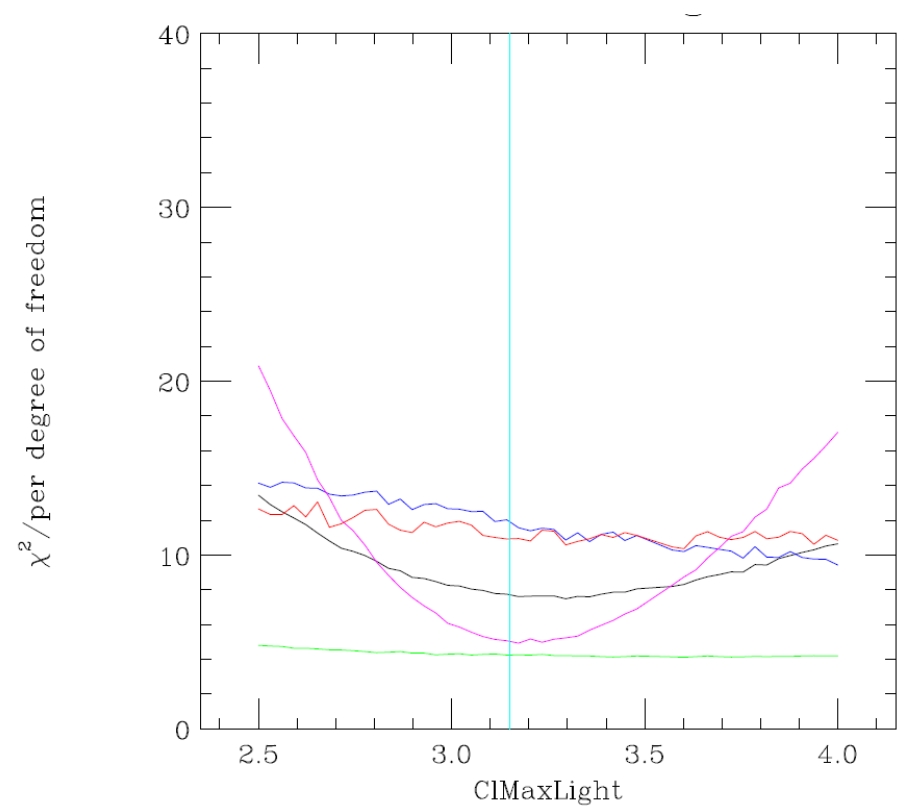
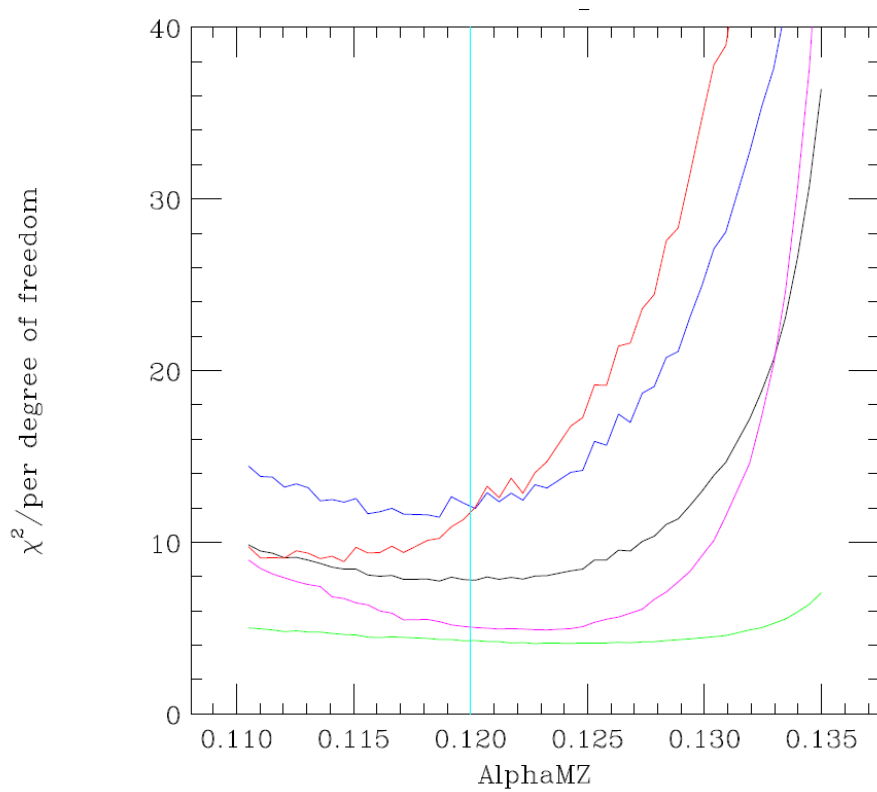
- Look at different treatments by forcing the backward evolution of the bottom quark to a gluon perturbatively.
- Work by Deak and Seymour to use a different evolution variable in Herwig++ for this branching as shouldn't be angular ordered.



PDF Errors

- There is an increasing focus on the PDF uncertainty.
- However when running Monte Carlo event generators there are many other uncertainties from other parameters.
- Its worrying that we hear so much about one source of uncertainty to the exclusion of many others which are probably larger.

Monte Carlo Uncertainties



Summary

- Important that the PDFs are used consistently, LO with LO matrix elements and NLO with NLO matrix elements.
- Some issues for showering if start from an NLO matrix element.
- More work needed to match the backward evolution of heavy quarks to the treatment in the PDFs.
- Shouldn't become too focused on the PDF uncertainty as the only source of errors in the Monte Carlo event generators.