IFT

Simulation of Vectorial Bosons + Jets Production: Comparisons Between LO and NLO Calculations

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Outline

- Motivation / Objectives
- Monte Carlo generators
- Tevatron data comparison
- LHC energy (7 TeV) simulation features
- Conclusions

Z boson production

- Background for new physics searches
  - Supersymmetry
  - Heavy gauge bosons (W', Z')
  - Extra dimensional excitations
- Important tests of Standard Model
  - Tests of perturbative QCD

    Strong coupling constant, renormalization and factorization scales, PDFs
- Detector commissioning
  - Absolute electromagnetic energy scale from $Z \longrightarrow e^+e^-$
  - Tracker alignment and momentum resolution from $Z \longrightarrow \mu^+\mu^-$

Objectives

- Preparatory MC study of major Standard Model background for new physics searches
- Next-to-Leading Order (NLO) contributions
- Matrix Element (ME) corrections to the Parton-Shower (PS) formalism
  - Validation of Monte Carlo (MC) data against Tevatron data
  - Determination of optimized MC parameters for LHC energy simulation
  - Identification of features from generators in LHC energy

Monte Carlo Simulations

- Understand experimental conditions and performance
- General purpose Monte Carlo (MC):
  - Terms up to Leading Order (LO)
  - Parton Shower (PS) formalism
  - Matrix Element (ME) corrections
  - Generators examples:

    HERWIG++ (M. Bahr et al., Eur. Phys. J. C 58:639-707, 2008)

    SHERPA (T. Gleisberg et al., JHEP 0902:007, 2009)

    PYTHIA (T. Sjostrand et al., JHEP 0605:026, 2006)

    ALPGEN (M.L. Mangano et al., JHEP 0307:001, 2003)

Generators features summary

- Herwig++
  - LO hard process
  - Parton Shower + ME corrections
  - Z production

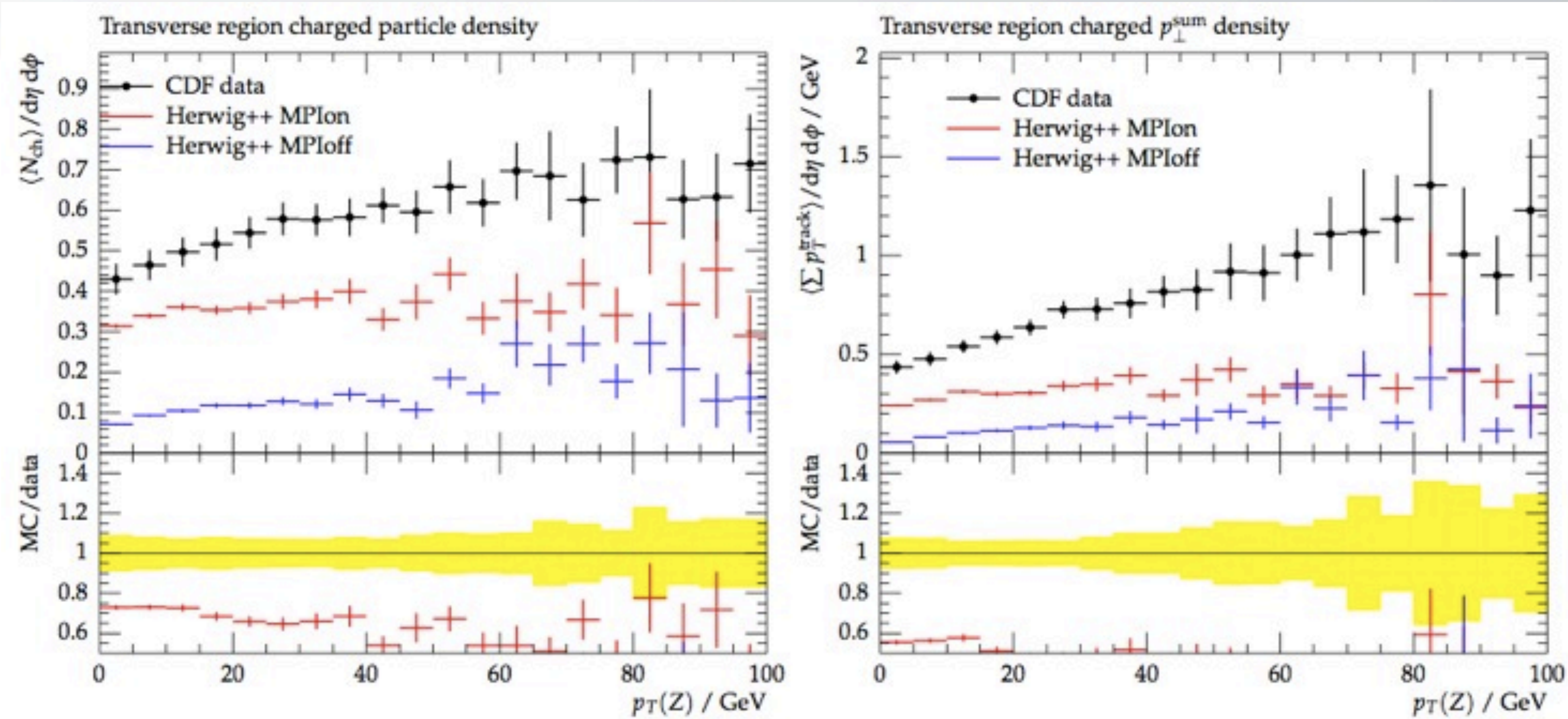
- Sherpa
  - LO hard process
  - Parton Shower + ME merging (improved CKKW)
  - Z + n jets production

- POWHEG (Herwig++)
  - NLO hard process
  - LO showering (pT ordered)
  - Z production

Tevatron data comparisons

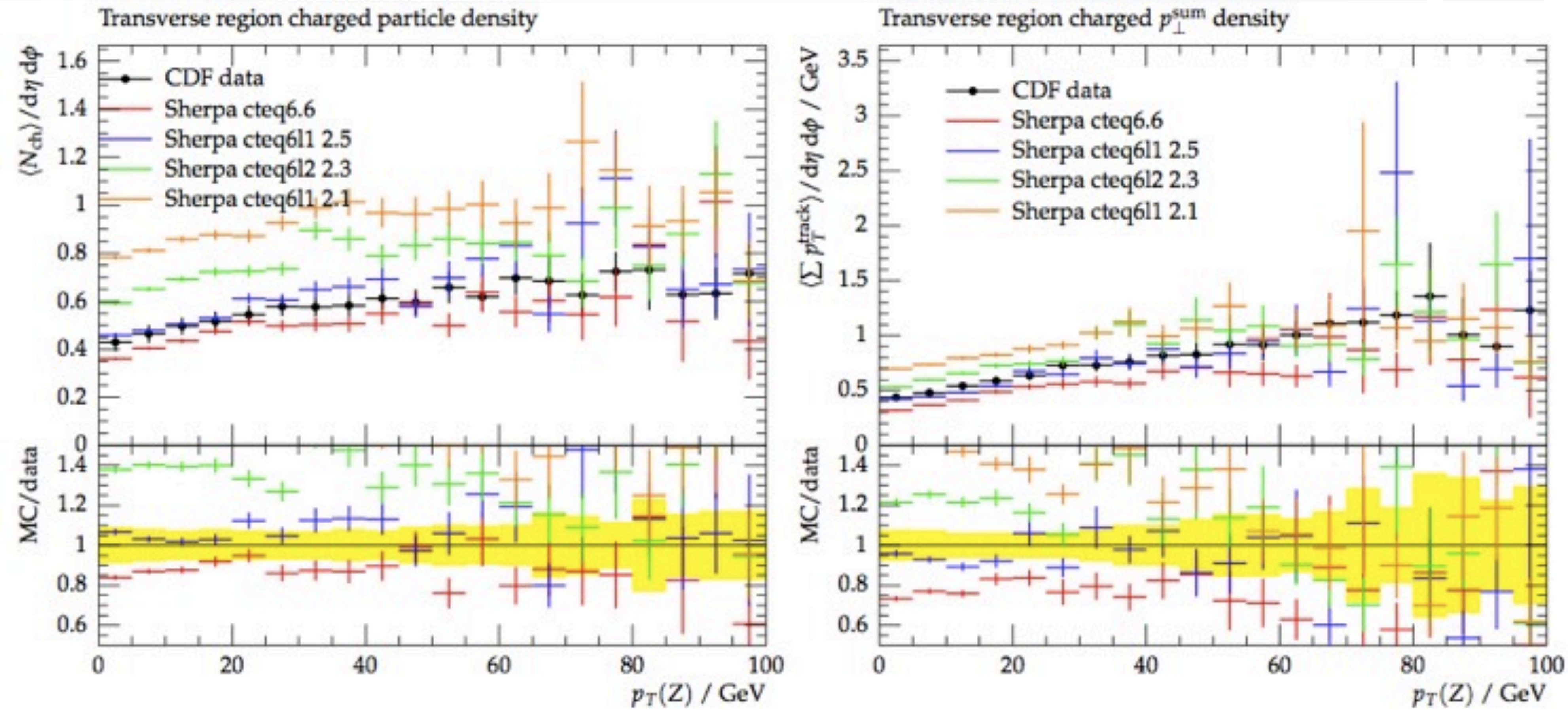
- Choice of generator parameters for best agreement with CDF and D0 data
- Parameters:
  - Multiple Parton Interaction (MPI)
  - Parton Distribution Function (PDF)
  - Intrinsic p_T of the beams (K_PERP)

MPI model - Herwig++



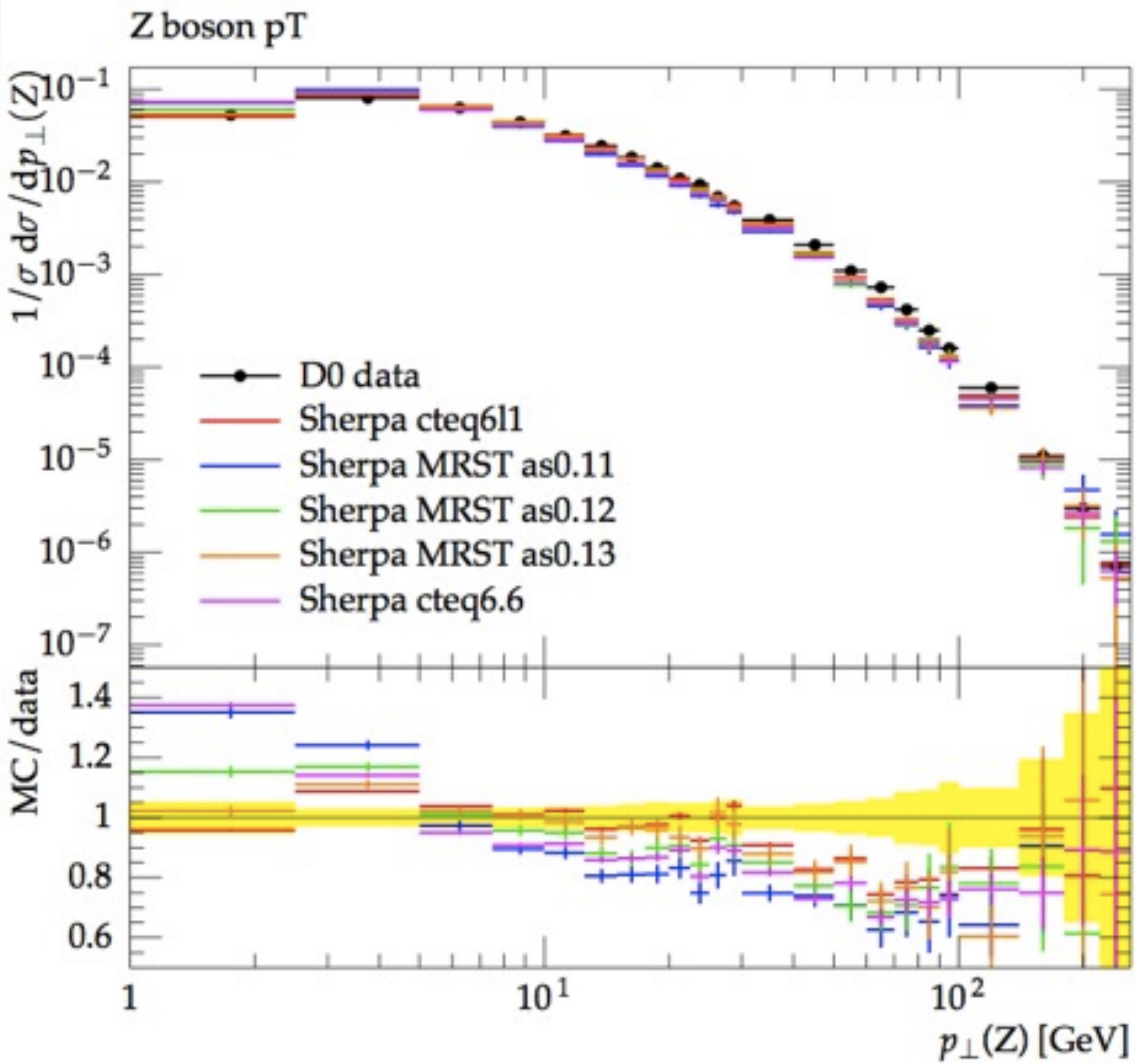
Underlying Event analysis for Herwig + + Z NLO

MPI model - Sherpa

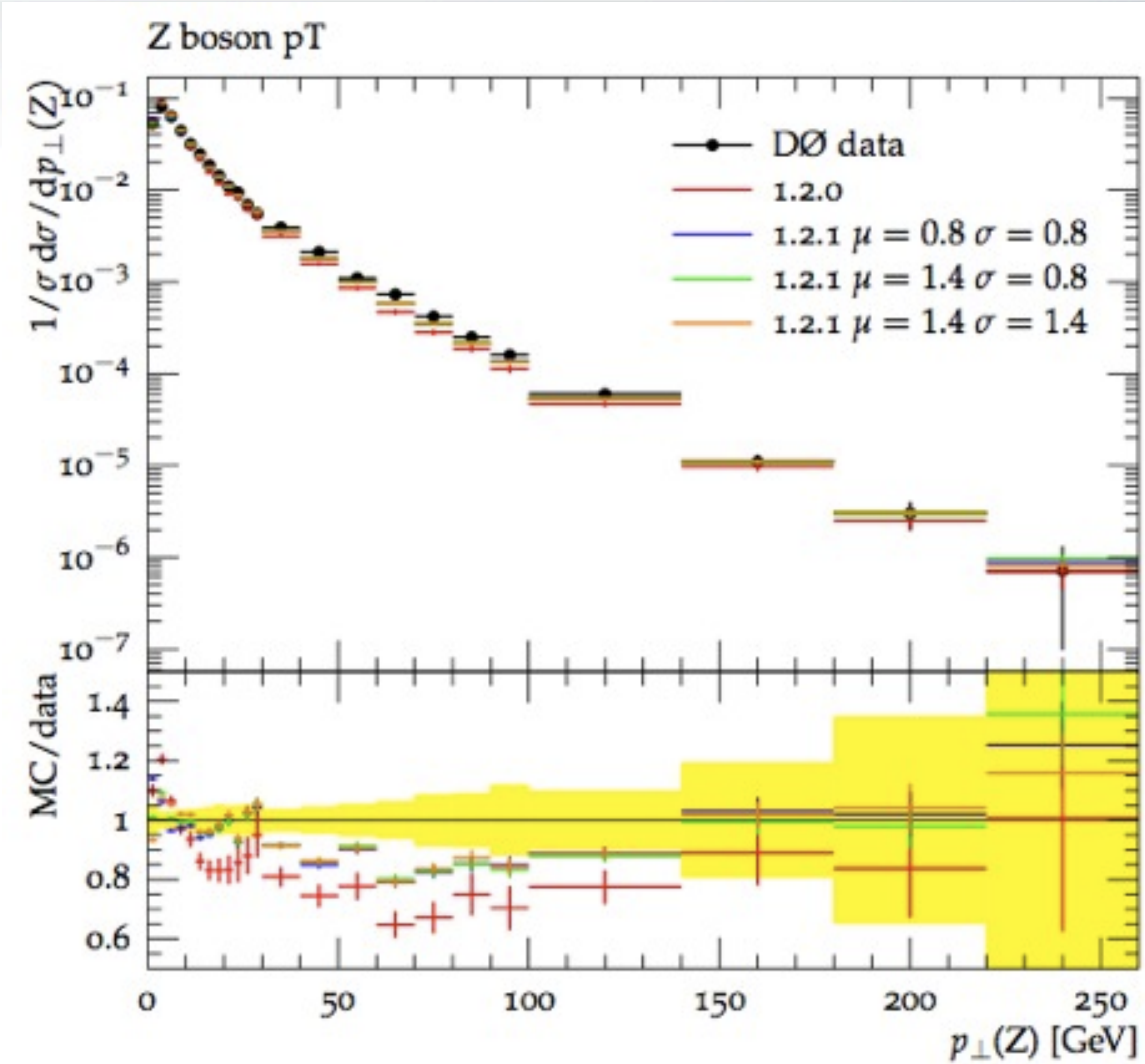


Underlying Event analysis for SHERPA Z + 3 jets

PDF choice - Sherpa



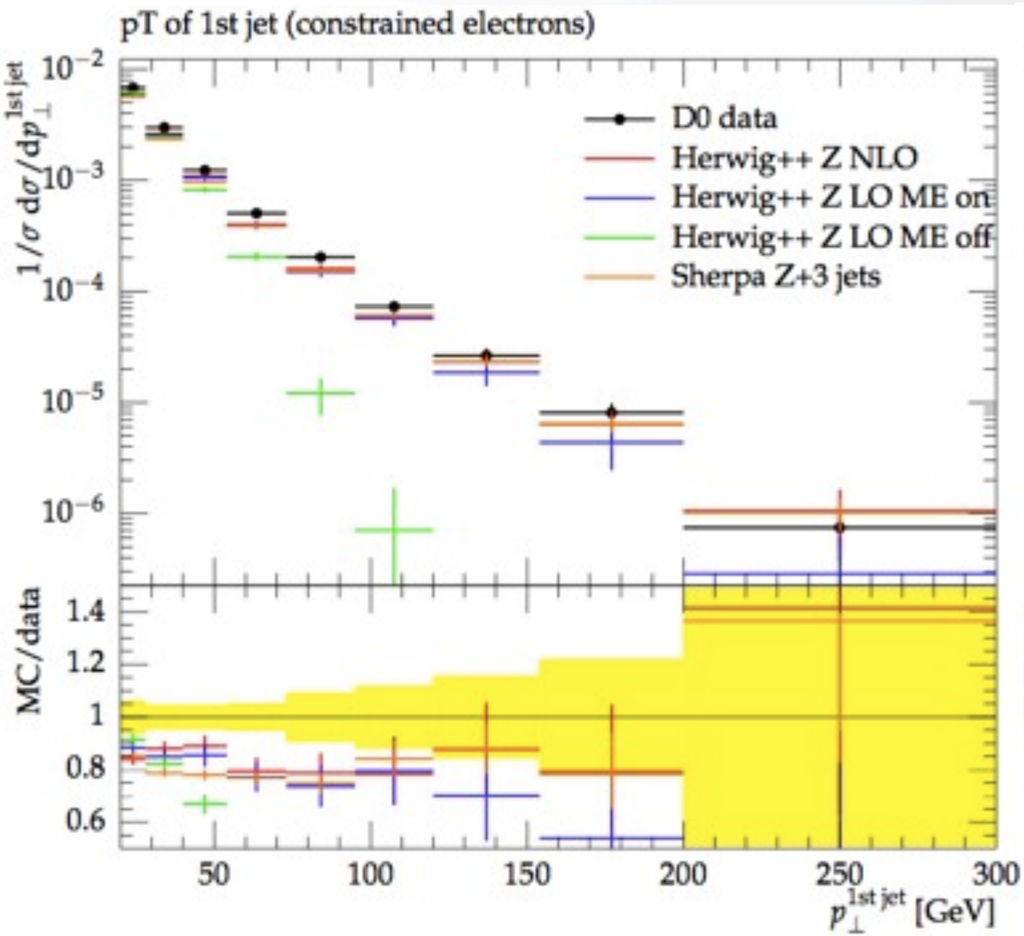
K_PERP choice - Sherpa

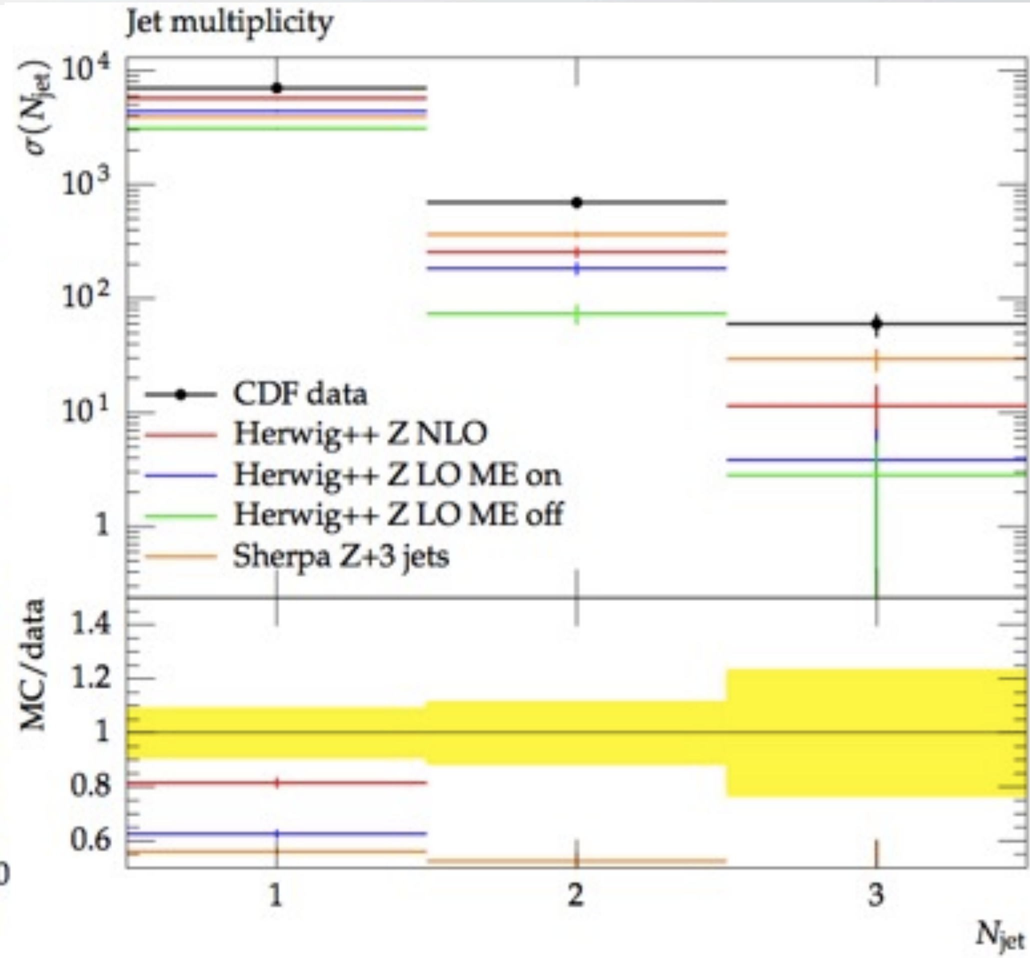


LO vs NLO comparisons

ME correction on LO - high p_T region
NLO - better description of high p_T

NLO - better cross section description
Z+3 jets LO - better on higher multiplicities

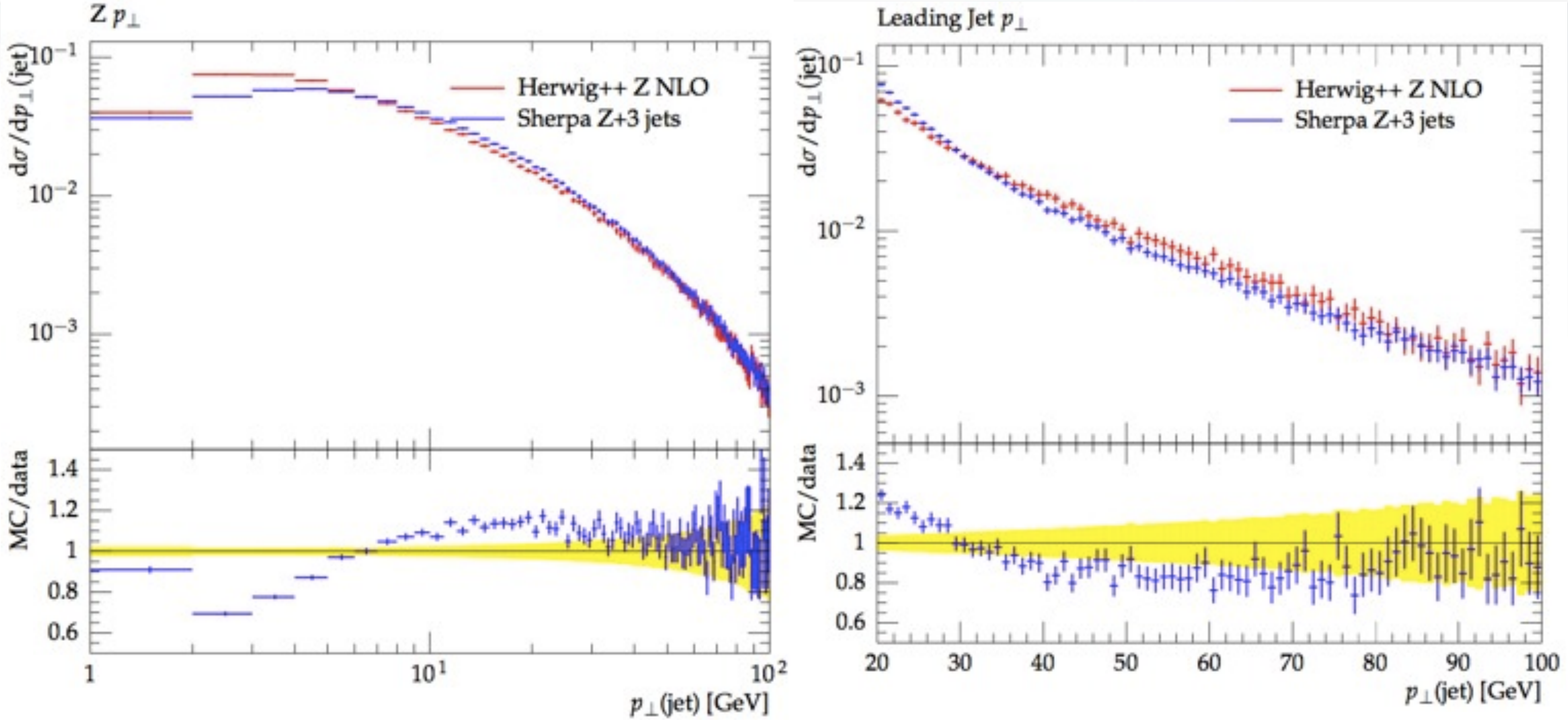




LHC simulation features

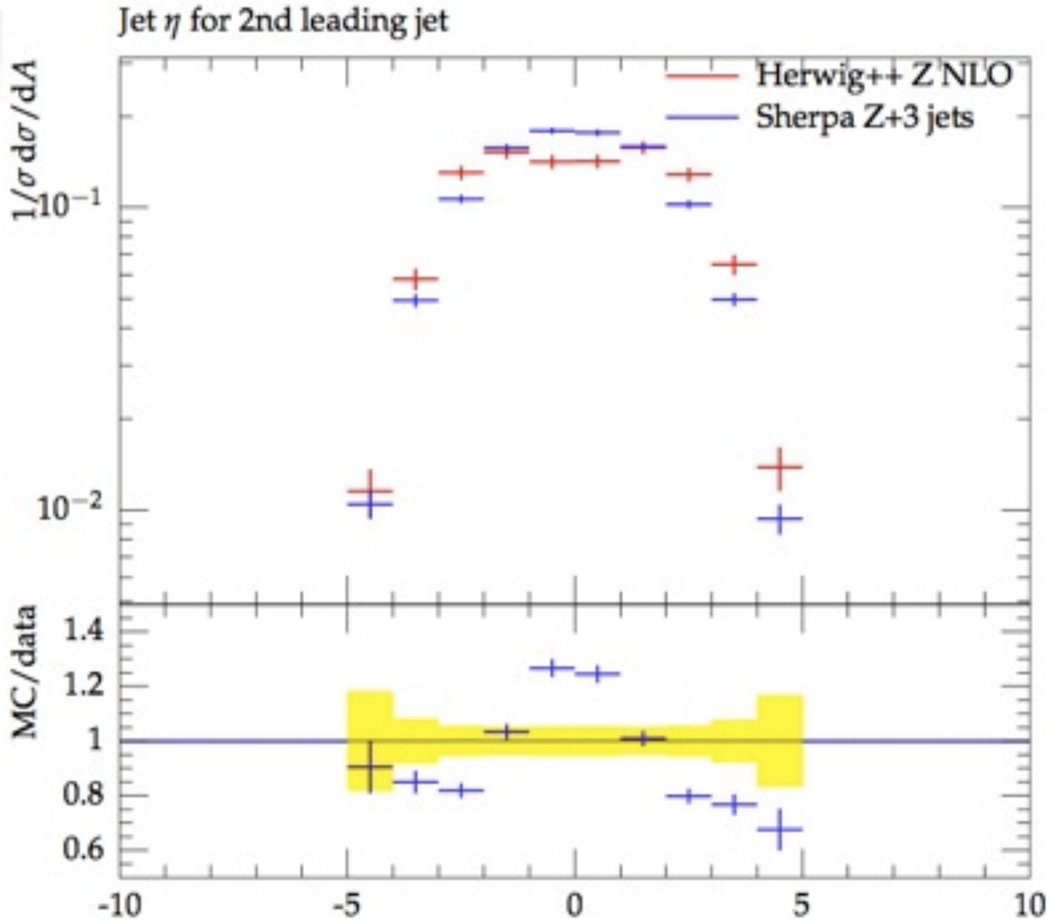
- Analysis cuts:
  - p_T (lepton) > 15 GeV;
  - $|\eta$ (lepton)$|$ < 2.4;
  - p_T (jet) > 20 GeV;
  - $|\eta$ (jet)$|$ < 4.5;
  - Lepton isolation criteria: $\Delta R_{ll} > 0.2;\ \Delta R_{lj} > 0.4;$
  - Jet algorithm: midpoint, radius R=0.7;
  - Mass cut (photon singularity): M_{ll} > 15 GeV.

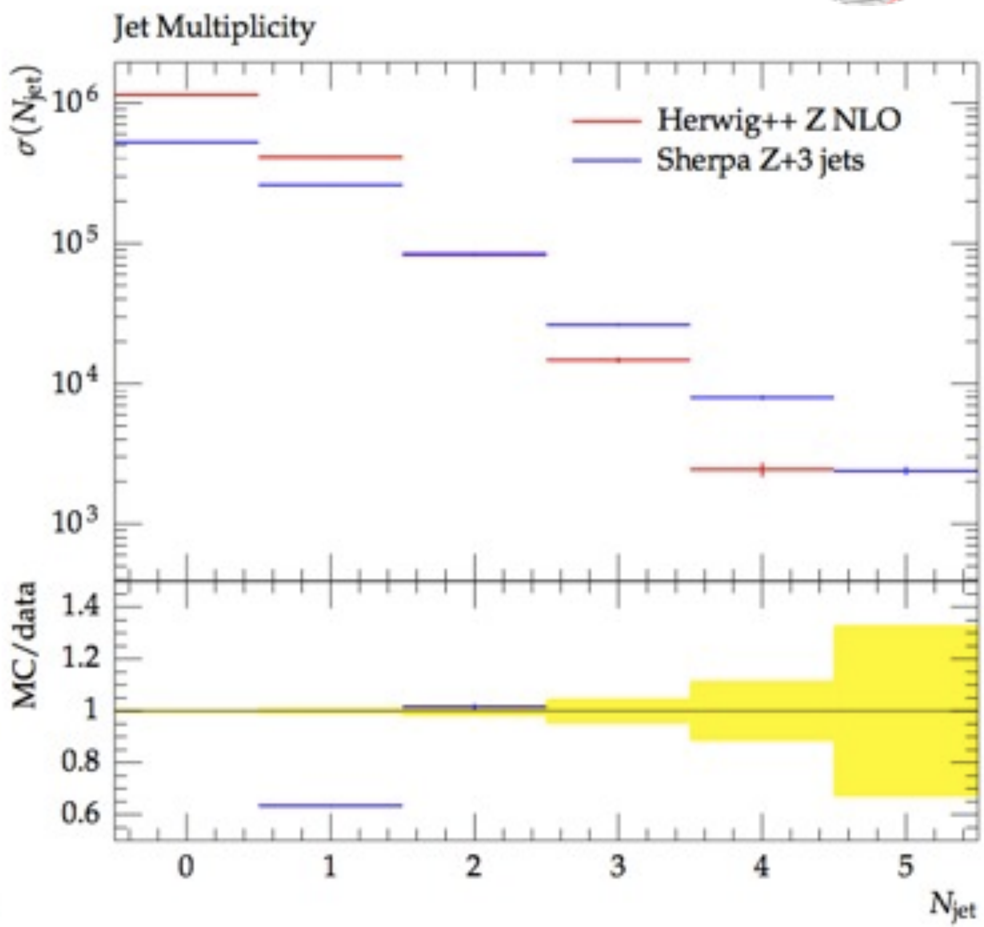
LHC simulation features



Differences in transverse momentum of Z p_T and leading jet p_T.

LHC simulation features





Differences in transverse momentum of Z p_T and leading jet p_T.

Conclusions

- LO PS+ME describes better the high p_T region;
- NLO improves cross section predictions, besides high p_T region;
- The simulation input parameters influence in the observables;
- Generators show different features in LHC energy, even agreeing in Tevatron energy.
- LHC data needed for further MC tunings.

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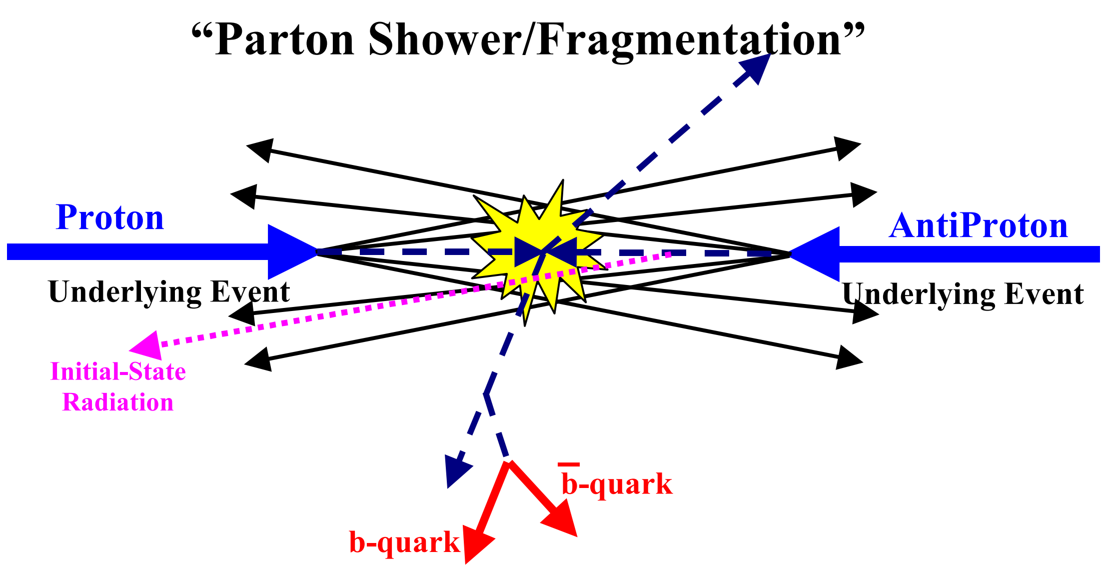
- Prof. Peter Richardson

EXTRA SLIDES

Parton Shower

- Collinear approximation;
- Low transverse momentum (p_T) description;
- High p_T distribution not filled.



Matrix Element Corrections

- Improvement of PS description
- Sherpa - Improved CKKW merging:
  - Separation of phase space in two regions;
  - Sudakov weighting;
  - Generator automatization of inclusive samples.
- Herwig++ - Soft and hard ME corrections:
  - Corrections in low p_T;
  - ME distribution in high p_T.

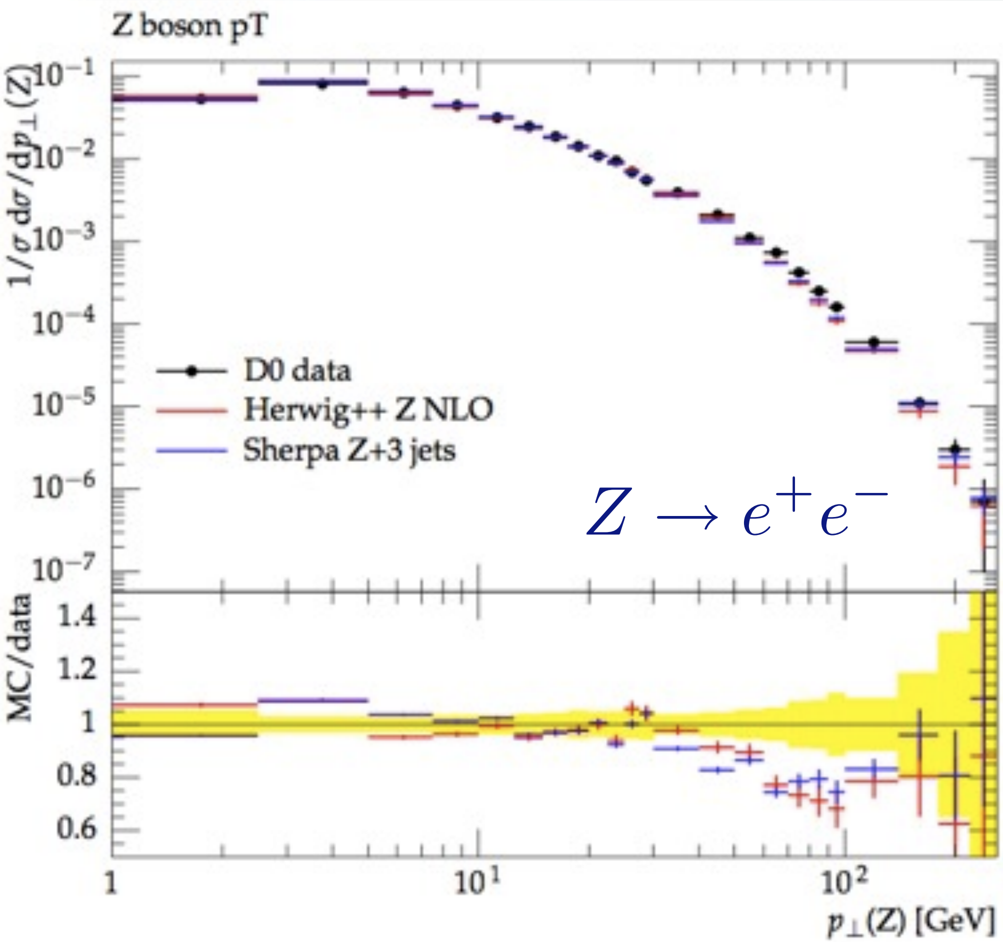
Next-to-Leading Order methods

- LO for showering, hard process in NLO;
  - Improvement of precision, without NLO showering.

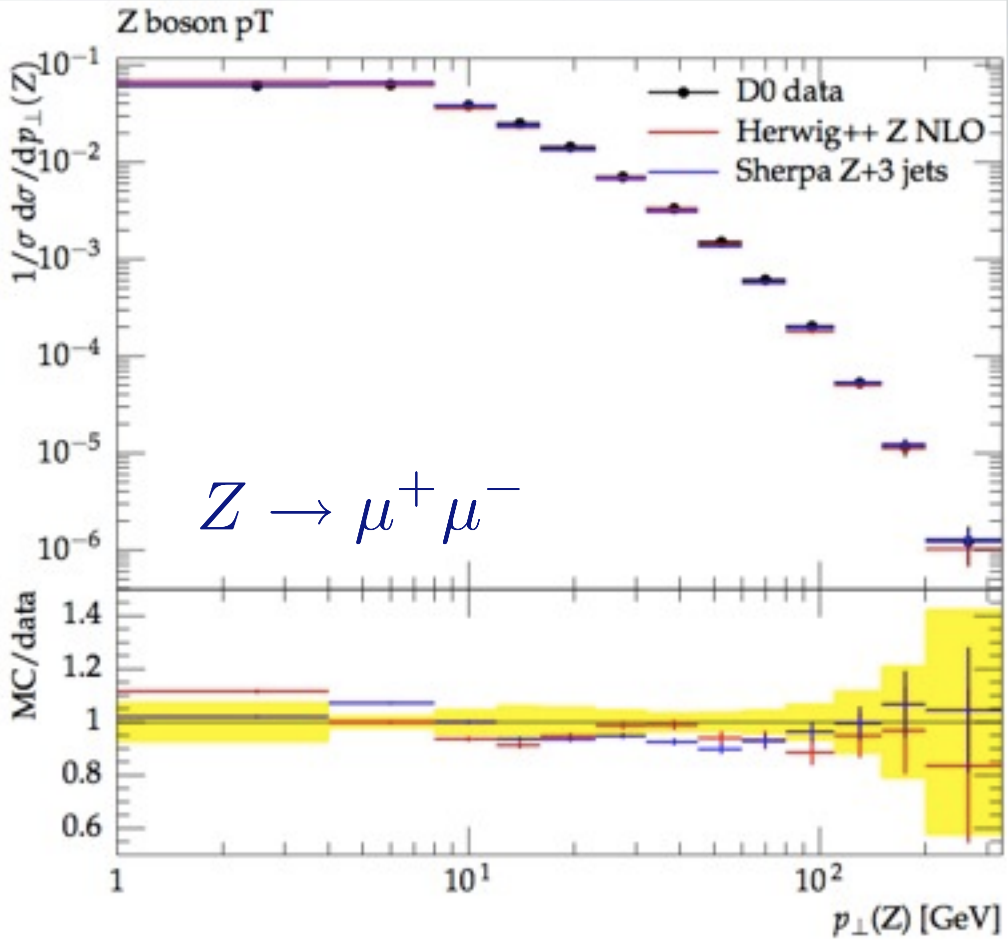
- POWHEG (Positive Weight Hardest Emission Generator):
  - Hard process in NLO;
  - Showering MC for following radiation;
  - POWHEG formula as input parameter to any p_T ordered showering general purpose MC generator.

Z p_T features

Theoretical Corrections



Without Theoretical Corrections



Theoretical corrections: undetected final state radiation, full lepton coverage to .