xFitter interface to cute

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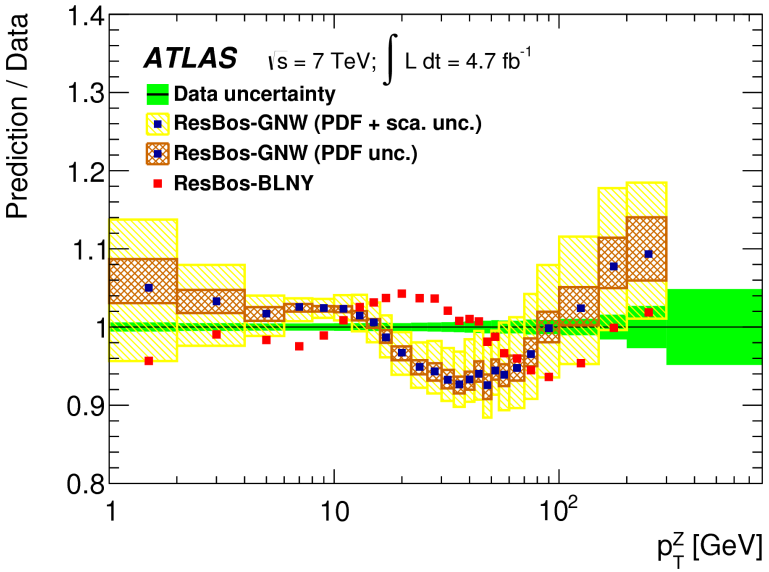
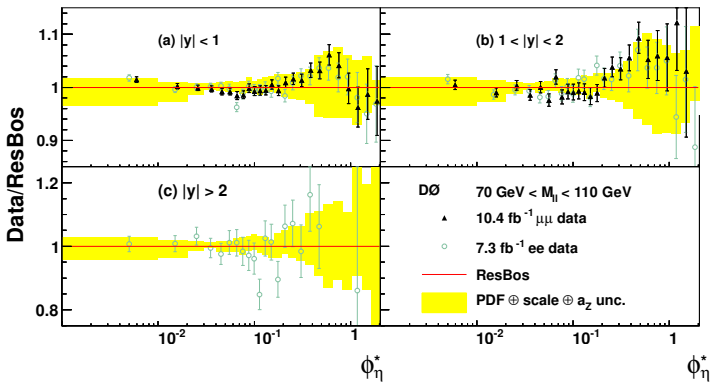
February 19, 2016

Outline

- Motivation: PDF fits to Z p_T data
- CuTe program
- Interface to xFitter

Measurements of Z p_T at hadron colliders





- Measurements of p_T^Z at hadron colliders have reached accuracy below 1% in the low and medium p_T region
- PDF uncertainties are sizeable in the low p_T region, at the level of 5%, indicating sensitivity to PDFs of these data
- Can we use these data in PDF fits? It depends on having the appropriate theoretical predictions

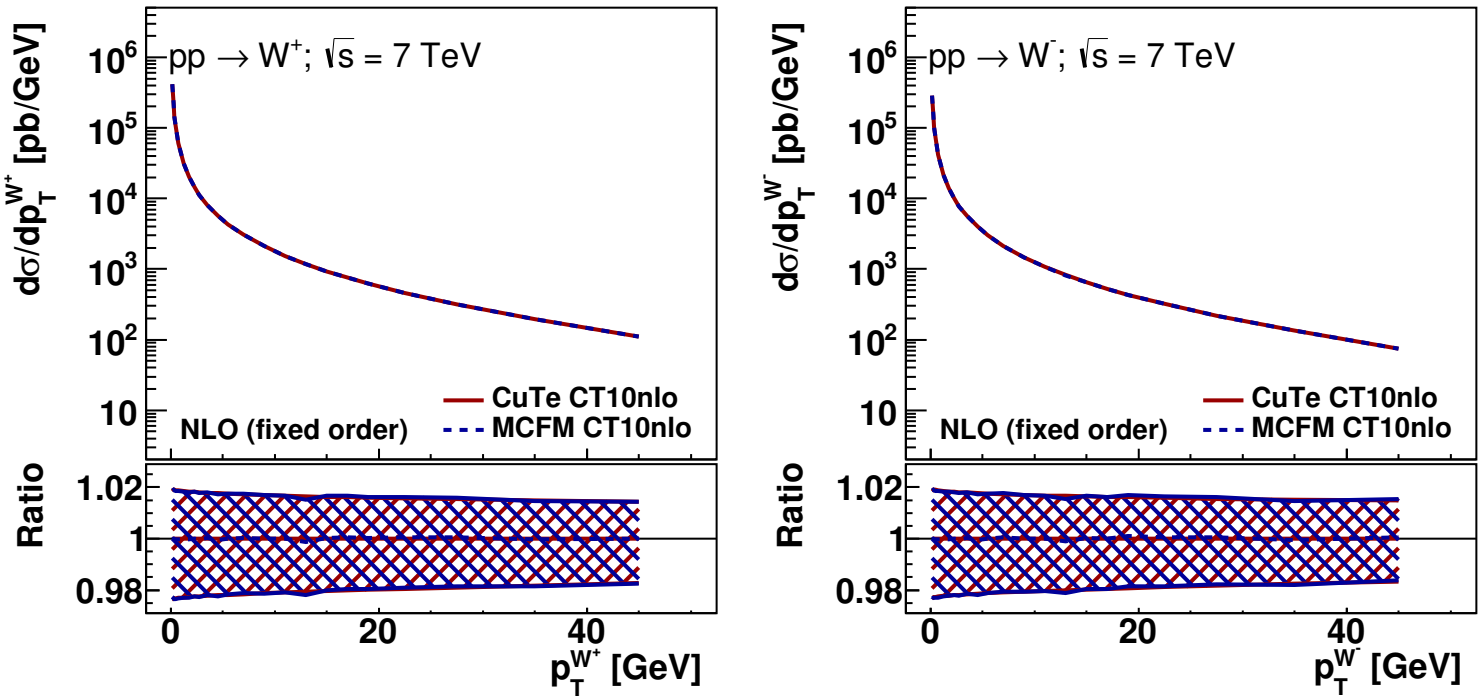
Theoretical predictions for the Z p_T

- As a poor man approach, let's try to use APPLGRID at NLO, with $k-$factors to correct from fixed order to resummation
- Combine MCFM at NLO, and CuTe at NLO+NNLL

CuTe

- Infrared Safety from the Collinear Anomaly [Becher, Neubert, Wilhelm '11]
- The factorisation scale is set to $\mu = q^* + q_T$, with $q^* \sim 1.82$ GeV
- The non-perturbative scale $q^* \sim e^{-C/\alpha_s(m_V)}$ protects the processes from receiving large long-distance hadronic contributions
- Allows to calculate the derivative of $p_T^{W,Z}$ for $p_T \to 0$ with perturbative QCD
- One additional non perturbative parameter $\Lambda_{NP} = 0.6$ GeV introduce a gaussian smearing for hadronic non-pQCD effects
- **Public C++ code, very fast**

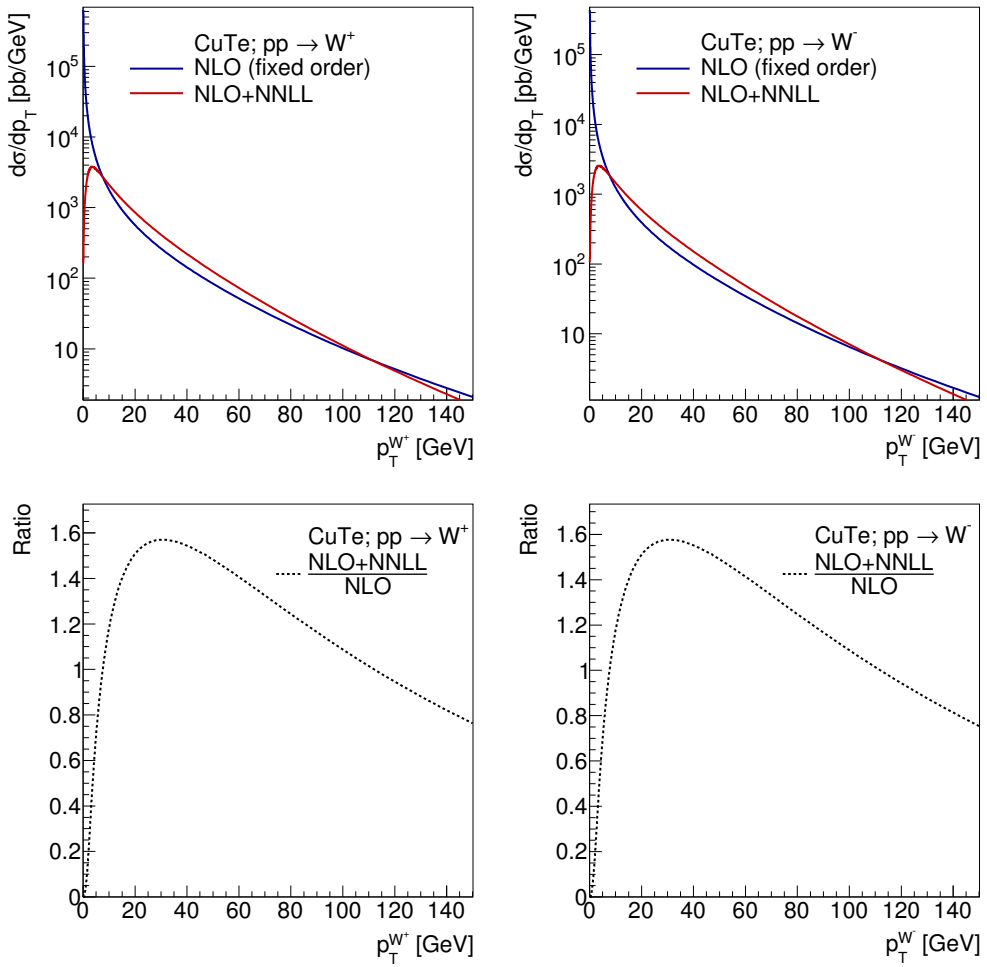
Theory predictions - benchmark



Perfect agreement between the two codes, at fixed order O(α_s), zero width, no decay.

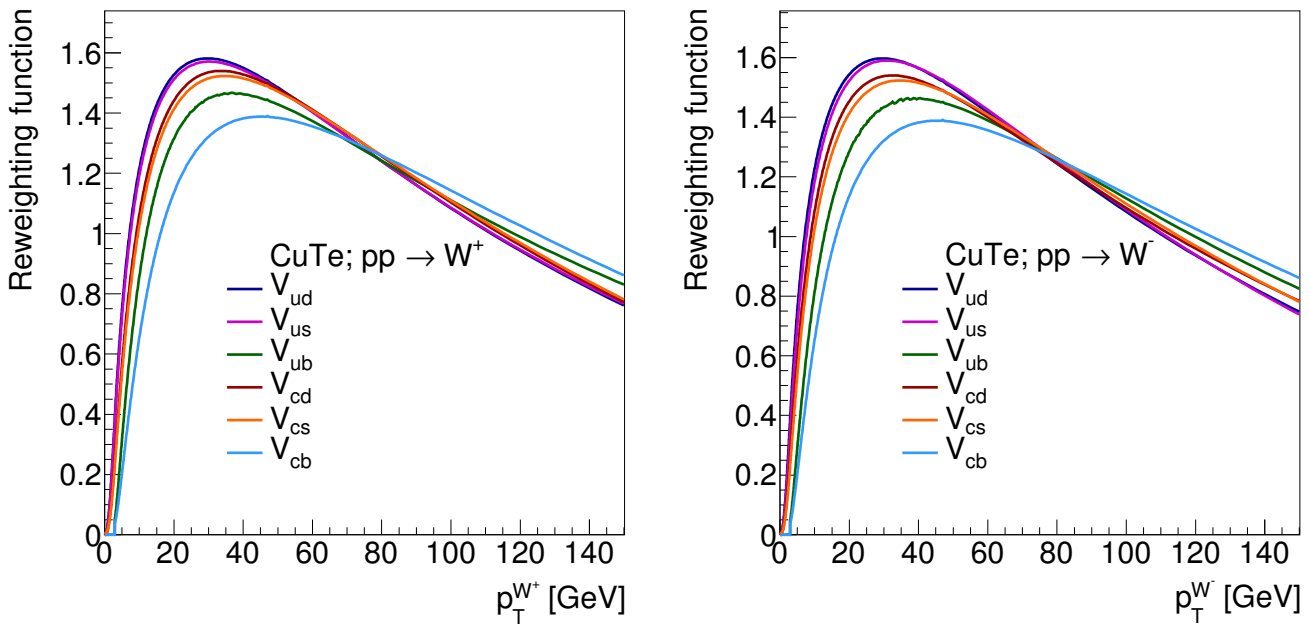
Theory predictions - combination

- Reweighting function defined as $r(p_T) = \frac{\mathrm{NLO+NNLL}}{\mathrm{NLO}}$
- The reweighing is applied, in the range $0.1 < q_T < 150$ GeV, outside this range the weight is set to 0

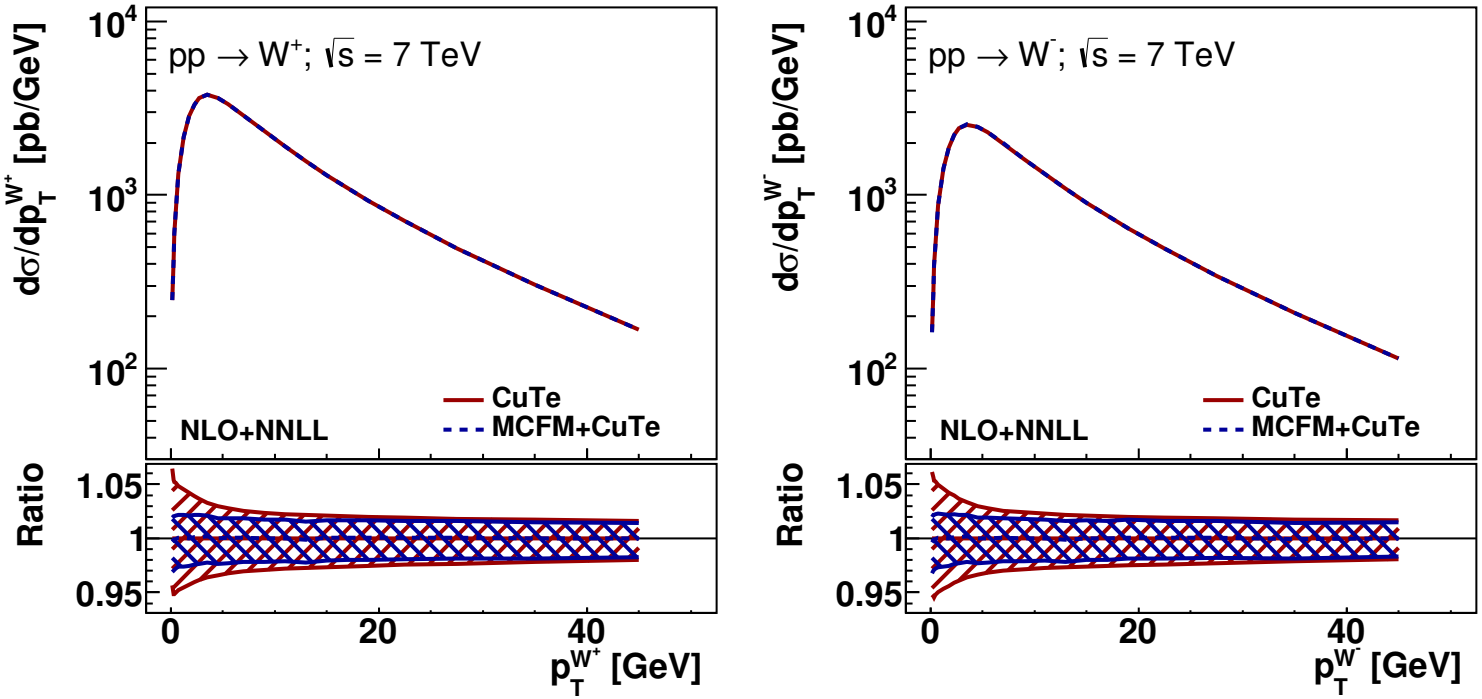


CKM decomposition of the reweighting function

- The NLO+NNLL/NLO ratio has a significant dependence on the flavour of the quarks initiating the W-boson production process: heavy quarks result in a harder p_T^W spectrum and a harder ratio between resummed and fixed order predictions
- The reweighting function is decomposed in terms of the CKM matrix: 6×2 functions are the NLO+NNLL/NLO ratios evaluated by setting to 0 all the CKM matrix except the V_{xy} term, separately for W^+ and W^-



Theory predictions - benchmark

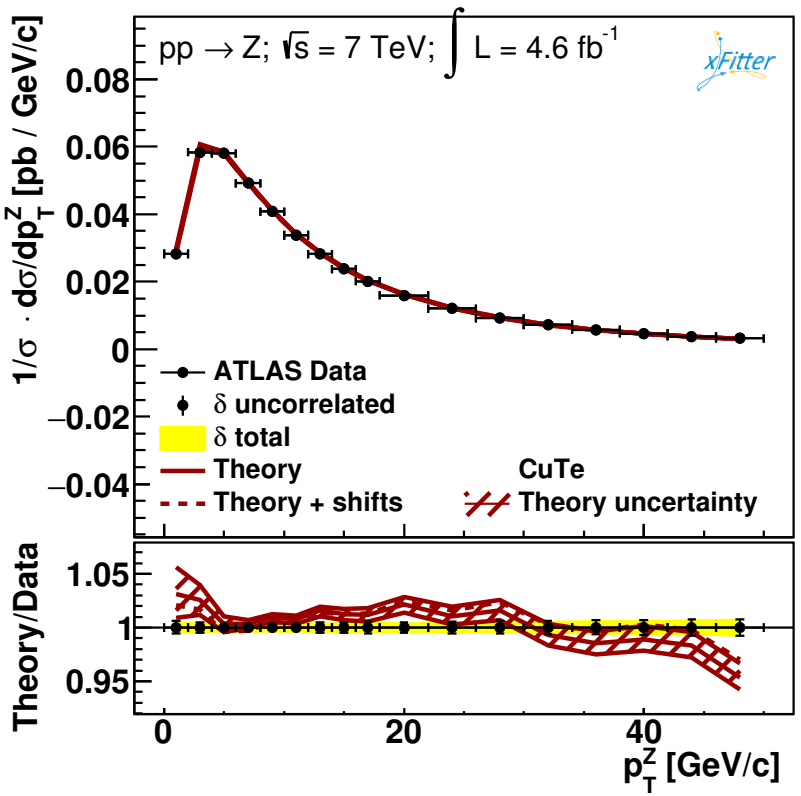


- PDF uncertainties reproduced at high p_T, at low p_T CuTe has larger PDF uncertainties
- PDF uncertainties are not the same at fixed order and after including qt-resummation corrections!
- Sizeable PDF sensitivity in the Sudakov form factor $\rightarrow$ cannot use a APPLGRID + $k-$factor approach to correct from fixed order to resummation

Theoretical predictions for the Z p_T

- Need to reconsider the strategy, and possibly fully implement a direct interface of a resummed calculation to xFitter
- Performed such a test with CuTe 1.1.0, assuming it is fast enough for doing simple PDF analysis
- CuTe 1.1.0 adopts the narrow width approximation, and does not decay the Z boson
- When comparing to fiducial measurements, needs to apply some acceptance corrections, calculated with Pythia in the following plots
- CuTe provides point-like predictions at fixed values of p_T, in the xFitter interface they are integrated in p_T bins by using a simple trapezoidal rule

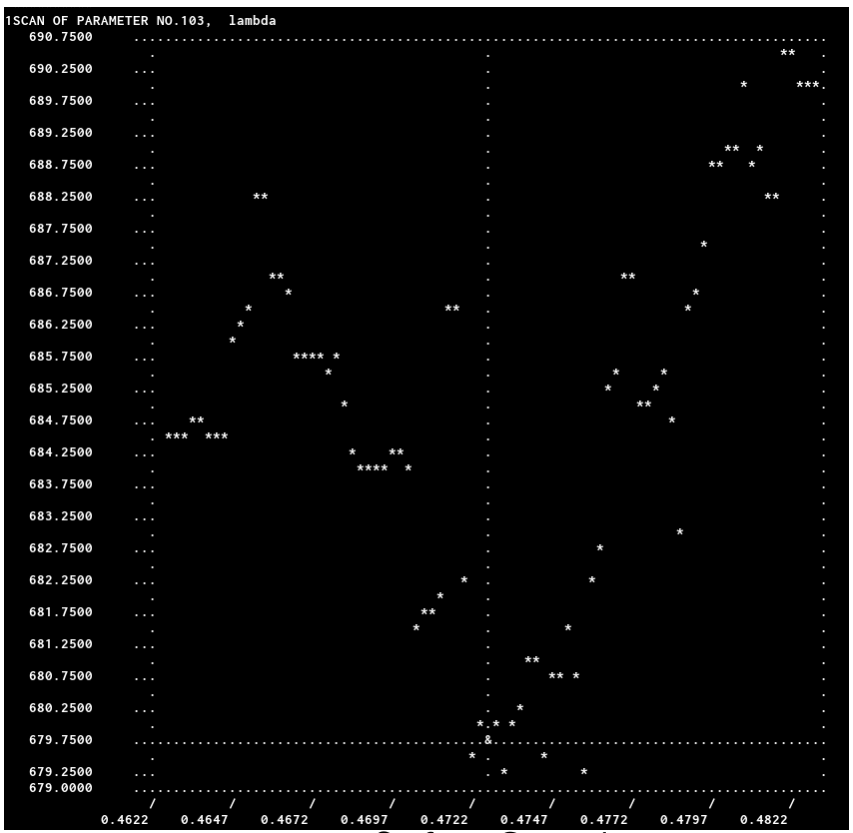
xFitter interface to CuTe



- Direct interface works, and the data is fairly described by CuTe plus Pythia acceptance corrections
- Each PDF convolution requires about 10min, not yet suitable for PDF fits, but in principle usable for fitting a few free parameters, or for PDF profiling

xFitter interface to CuTe

- Added also the possibility to fit the non perturbative form factor, i.e. the λ_{NP} parameter
- The limiting for usage of this interface, is the numerical accuracy of CuTe. There are numerical issue with prevents Minuit to converge, they appear clearly by performing a chi2 scan as a function of λ_{NP}



xFitter interface to CuTe

- For these numerical issues, the CuTe interface was dropped
- However, authors are about to release CuTe version 2 which should solve the numerical issues and implements
  - Higher order corrections (NNLO+N^{3}LL)
  - Z boson decay
- We are in touch with the authors to explore the possibility of interfacing CuTe to xFitter

Summary

- The interface of CuTe 1.1.0 to xFitter looked promising, but is unusable due to numerical precision issues, and limited by the narrow width approximation
- CuTe v2 may be able to solve these issues, stay tuned