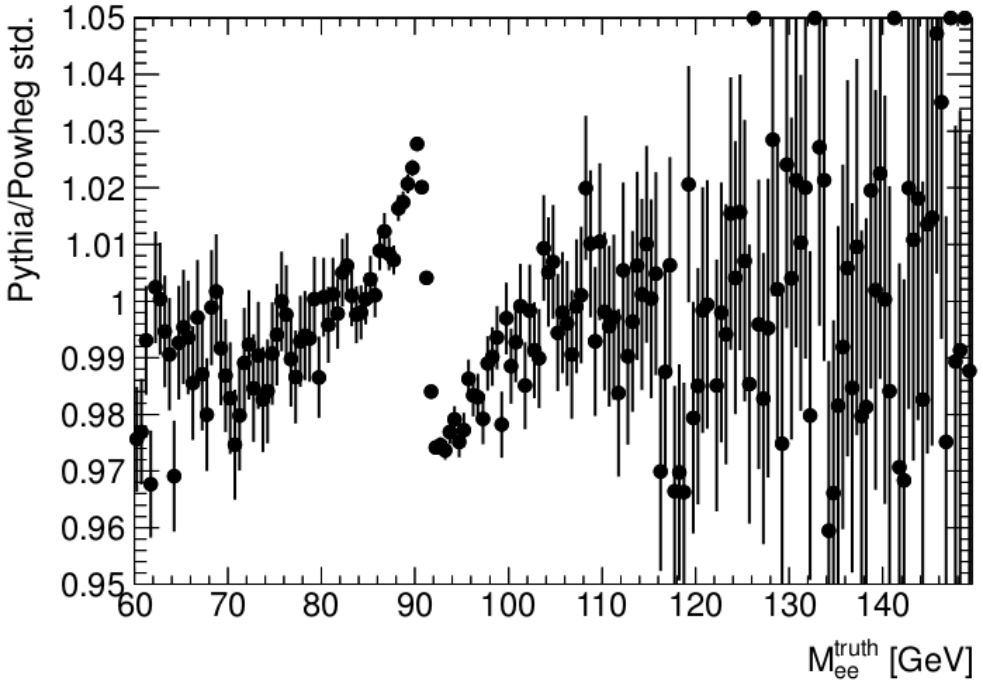
A few comments on EW settings in QCD generators

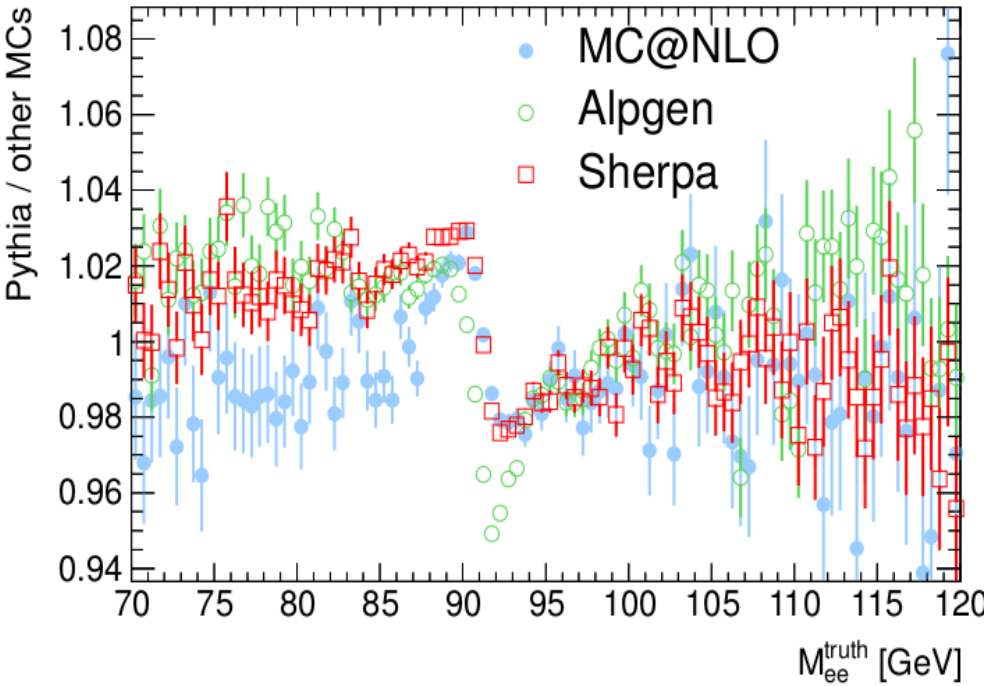
M.Boonekamp, IRFU

- Review of generator choices and related discrepancies
- Issues at the experimental level
- Requests

Generator-level dilepton mass distributions

- In ATLAS, we try to have consistent parameter definitions across our generators
  - Couplings, masses and widths set to reference values (PDG), passed to all generators
- Comparing generator distributions nevertheless reveals discrepancies. Taking Pythia as a reference, compare to NLO+PS and Multileg generators:





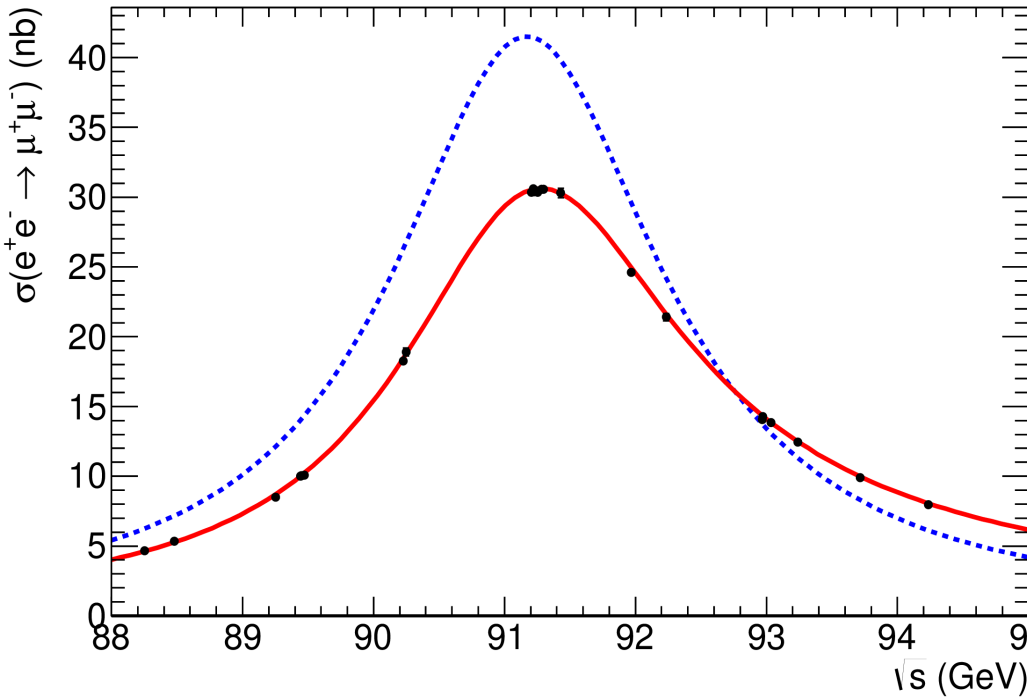
Comparison of EW input parameters

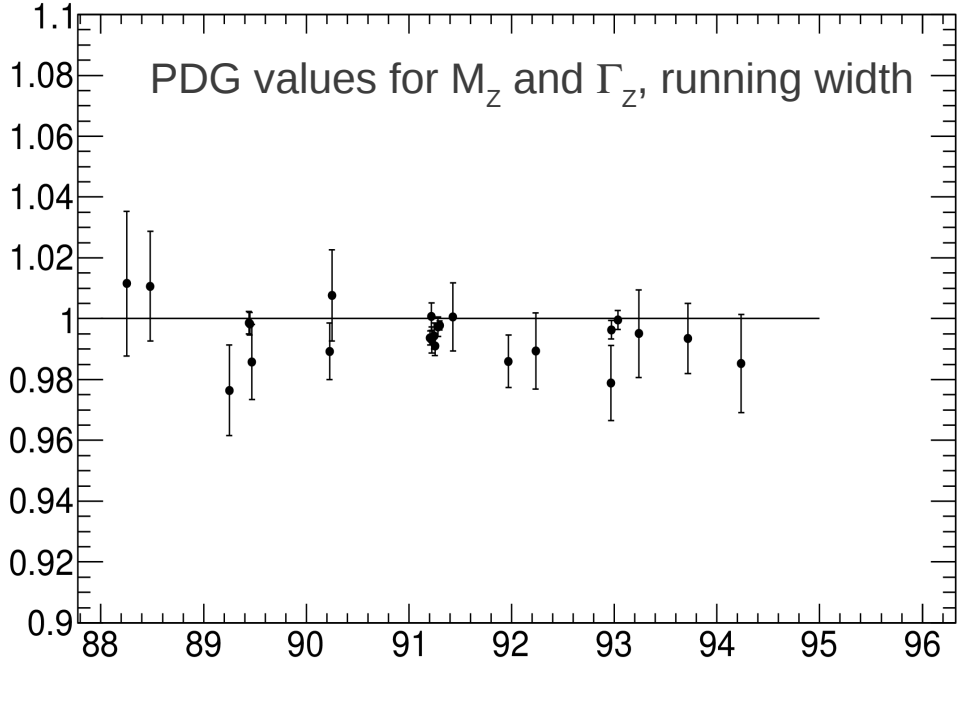
- Study of generator documentation and code displays a rich variety of default choices
- Assuming we want to stick to PDG values for masses and widths, the colors below are assigned comparing to what is needed to make the dilepton mass distributions consistent with the Z lineshape measurement at LEP1:

Generator	alphaEM	Gmu	Mz	Γz	Mw	Γw	BW form
Pythia	Running	Running	91.1876	2.4812	80.399	2.072	Running-width
Powheg	1/127.9	$1.166\ 10^{-5}$	91.1876	2.4952	80.399	2.085	Fixed-width
Alpgen	1/132.3	$1.166\ 10^{-5}$	91.1880	2.4409	80.419	2.047	Fixed-width
Sherpa	1/128.8	$1.166\ 10^{-5}$	91.1876	2.4952	80.399	2.085	Fixed-width
MC@NLO	Running	$1.166\ 10^{-5}$	91.1876	2.4952	80.399	2.085	Fixed-width

Running width vs Fixed width, for physical M_Z, Γ_Z

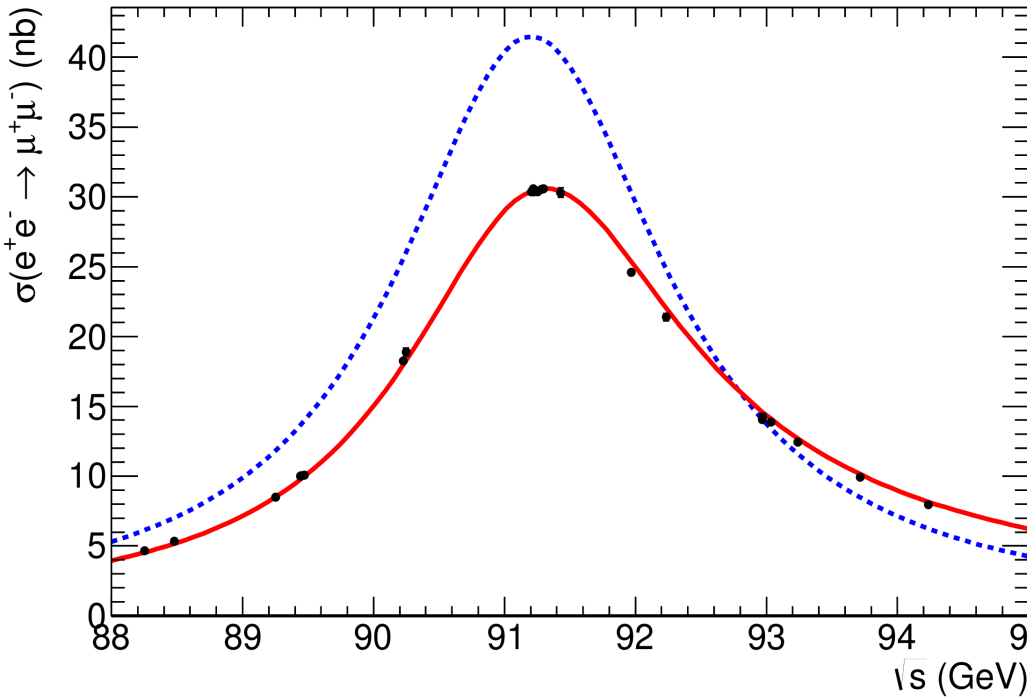
- LHC → LEP : PDFs → QED ISR
- Semi-analytical calculation assuming the LEP1-recommended Improved Born Approximation ("IBA", precise to ~0.2%) :
  - Either [running width, M_Z, Γ_Z]; or [fixed width, M_Z/γ, Γ_Z/γ, $\gamma == (1+\Gamma_Z^2/M_Z^2)^{1/2}$]
  - W,Z couplings ~ G_μ, photon coupling ~ $\alpha_{QED}(M_Z^2)$

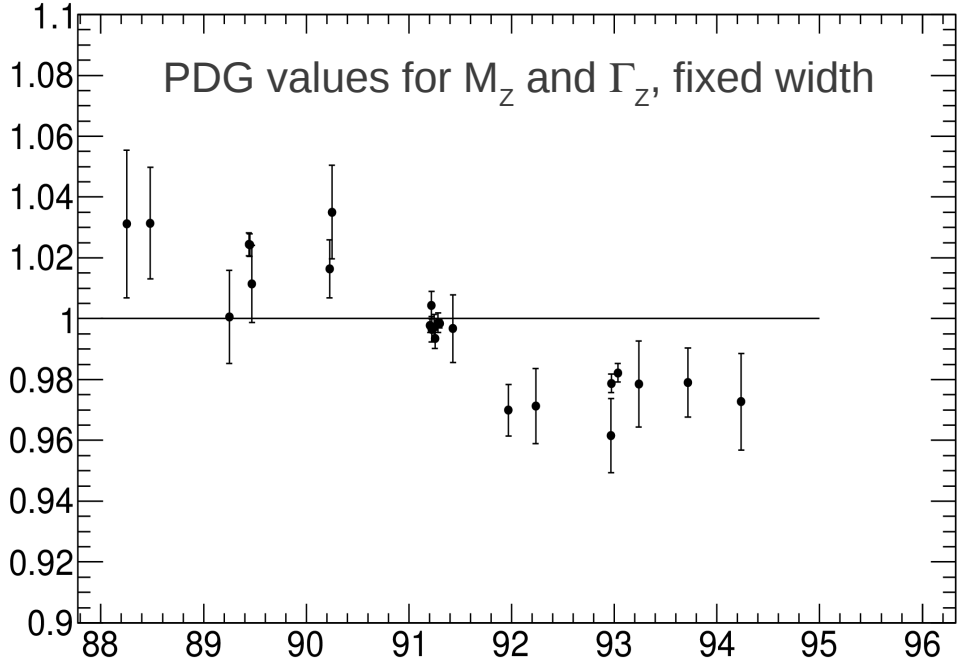




Running width vs Fixed width, for physical M_Z, Γ_Z

- LHC → LEP : PDFs → QED ISR
- Semi-analytical calculation assuming the LEP1-recommended Improved Born Approximation ("IBA", claimed precision ~0.2% at LEP) :
  - Either [running width, M_Z, Γ_Z]; or [fixed width, M_Z/γ, Γ_Z/γ, $\gamma == (1+\Gamma_Z^2/M_Z^2)^{1/2}$]
  - W,Z couplings ~ G_μ, photon coupling ~ $\alpha_{QED}(M_Z^2)$



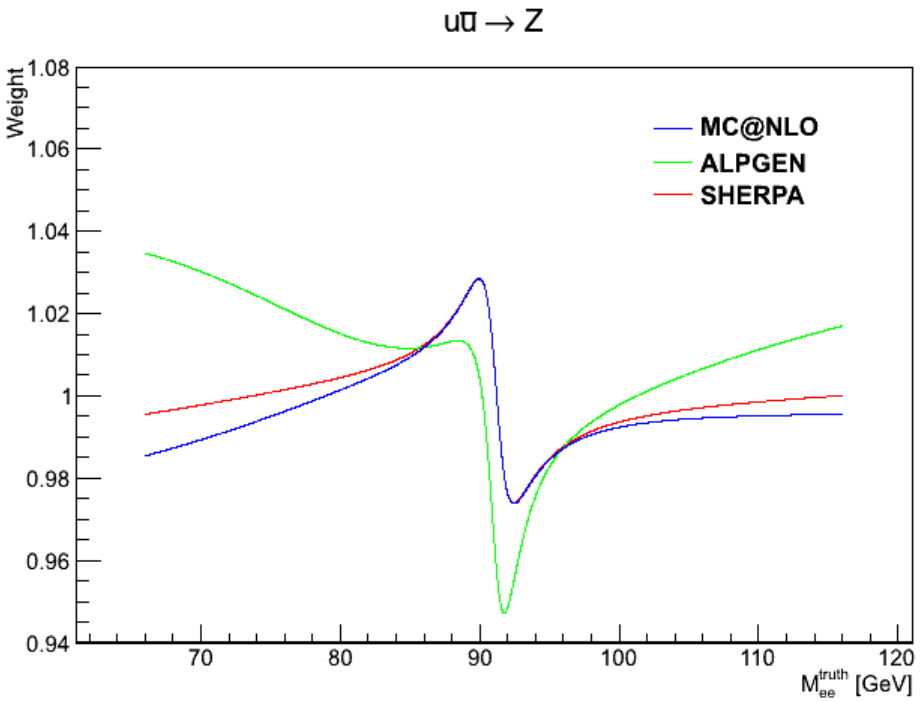


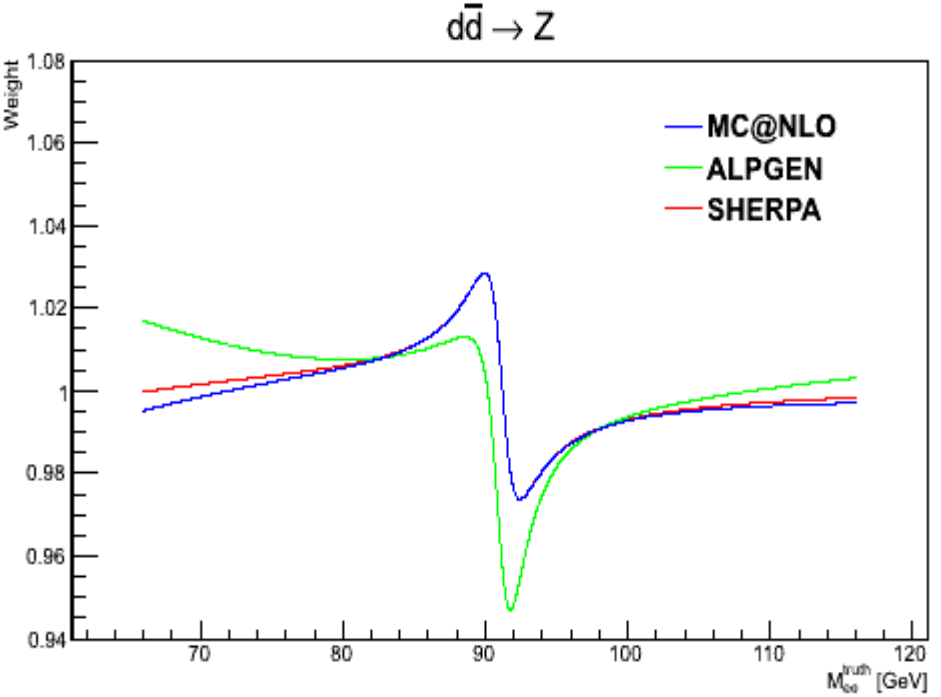
Experimental issues

- Makes detector calibration (energy and momentum scales, resolution corrections to the simulation) generator dependent – the Z is the primary standard candle
  - Effect ~0.05% - small for most applications except M_W
- We are permanently comparing the available generators in many different contexts and distributions. Data/MC comparisons of basic kinematic distributions are polluted by these underlying differences
  - Local effects up to 5% in ratios
- These discrepancies are not reflecting a real uncertainty, so could we remove them?

Temporary / poor man's solution

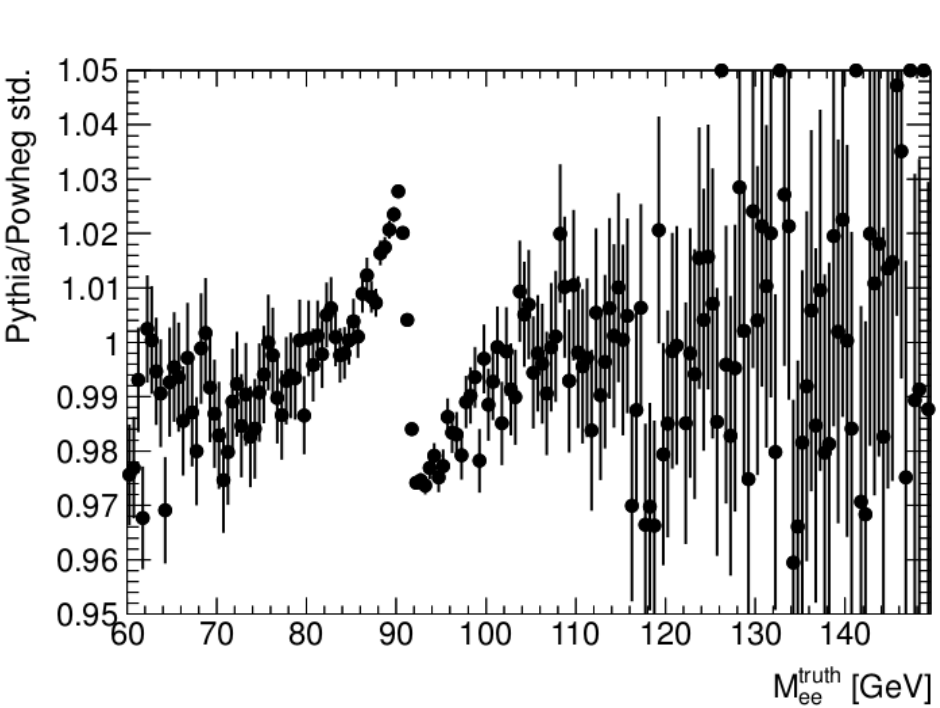
- Analytically reweighting the various predictions to a common “IBA”, defined for the moment as on slides 4-5
- Plots below : ratios are Generator / IBA (following slide 2 quite closely)
- Only lineshape addressed – does not include any corrections to the couplings
- W & Z processes

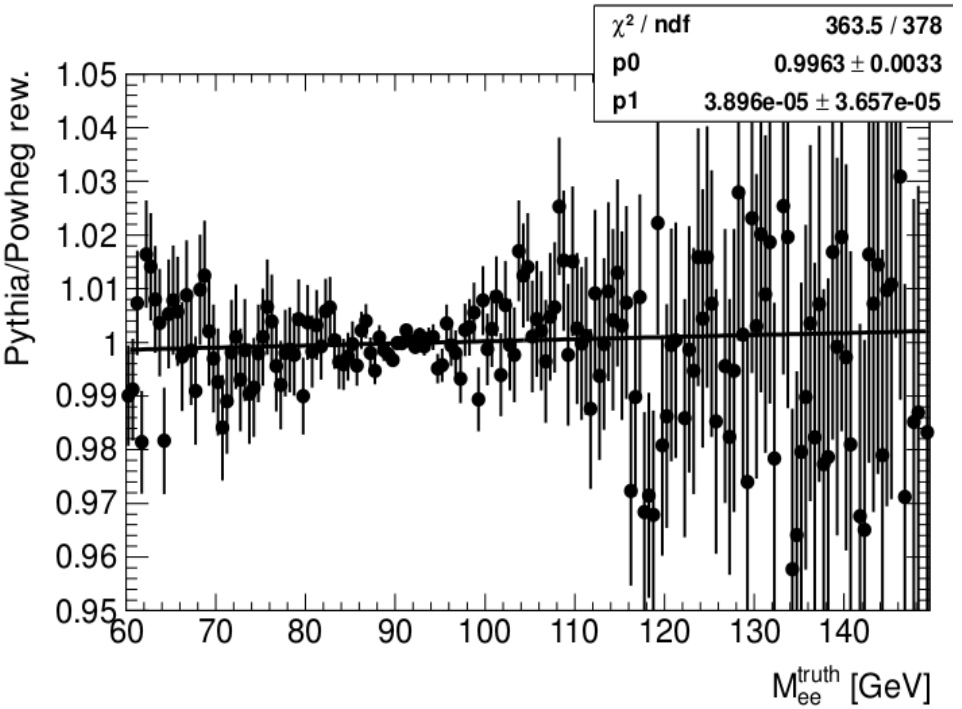




Temporary / poor man's solution

- Performance of lineshape reweighting on Pythia / Powheg comparison





Summary

- In the era of N(N)LO QCD + NLO EW event generators, leading order and multi-leg generators will remain relevant for a long time
  - The more mature generators are precisely tuned to data, allowing for accurate description of many features (underlying event, isolation, …) that are very relevant in event selections, and hence for efficiency determination, etc. Newer generators will need time to catch up
  - Multi-leg generators are complementary to the NLO generators in the high parton multiplicity regime
  - Many ongoing analyses will stay with current state-of-the-art tools
- However, large diversity in EW settings lead to unnatural discrepancies in some key kinematic distributions.
- Kind request to the theory community:
  - Define a sensible IBA, that mimics the full NLO EW correction to sub-percent accuracy. Was successfully done at LEP times. Precision tag to be re-evaluated in LHC context
  - Harmonize the QCD generators EW settings according to this
- Thanks to all MC authors for discussions in the last months!