# Description of Charged Current Drell-Yan process in SANC

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# Outline

- SANC news
- Predictions for Drell-Yan at LHC
- Electroweak corrections to Drell-Yan
- NLO QCD corrections
- Theoretical uncertainties in Drell-Yan
- Conclusions

# Recent SANC news

SANC: a project to Support of Analytic and Numeric calculations for experiments at Colliders


- SANC web-site: `http://sanc.jinr.ru`, `http://pcphsanc.cern.ch`
- A. Andonov et al., *"Standard SANC Modules,"* arXiv:0812.4207
- D. Bardin et al., *"Implementation of SANC EW corrections in WINHAC Monte Carlo generator,"* Acta Phys. Pol. B **40** (2009) 75 [arXiv:0806.3822]
- A. Andonov et al., *"NLO QCD corrections to Drell-Yan processes in the SANC framework,"* arXiv:0901.2785
- D. Bardin et al. *"SANCnews: top decays in QCD and EW sectors,"* arXiv:0903.1533

# Predictions for Drell-Yan at LHC

Aiming at high precision $M_W$ and $\Gamma_W$ determination we need:

- QCD in NLO and NNLO
- Parton shower effects
- EW radiative corrections at one-loop at least
- Most important higher order effects (re-summed where possible)
- Interplay of QCD and EW effects
- Input: coupling constants, hadronic vacuum polarization, and parton density functions for the appropriate energy scale and $x$-values
- All relevant effects to be implemented in a Monte Carlo event generator

# Drell-Yan in SANC

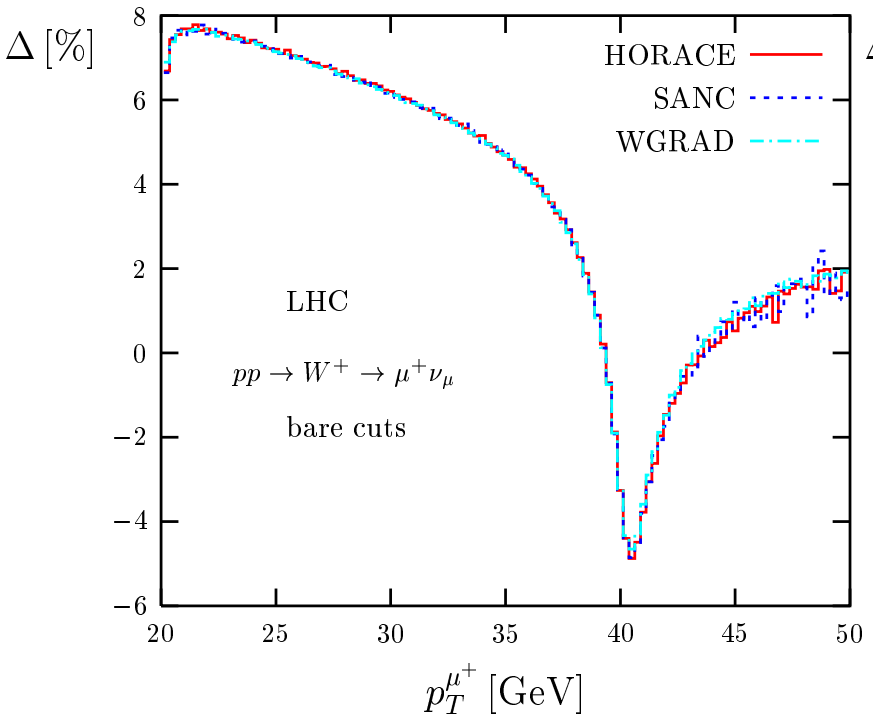
Automatized analytic calculations in SANC provide FORM and FORTRAN modules, which can be downloaded and used in a stand-alone mode (see arXiv:0812.4207, arXiv:0806.3822 and the SANC web-site)

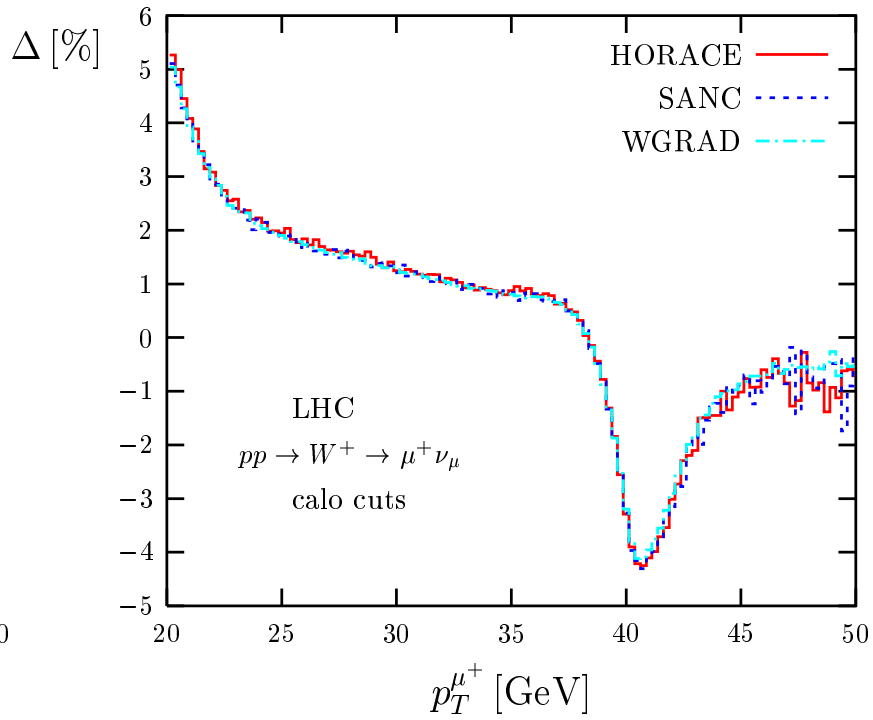
For the charged current Drell-Yan we have:

- Complete one-loop EW RC [A.A. et al., EPJC'06]
- Photon induced DY processes [A.A. et al., JETP'08]
- Complete one-loop (NLO) QCD [A.Andonov et al., arXiv:0901.2785; Phys.Part.Nucl.Lett.'07]
- Interface to parton showers in PYTHIA and HERWIG [P.Richardson, R.Sadykov, M.Seymour, P.Skands, in preparation]
- Higher order photonic FSR in LLA
- MC integrator and MC event generator

# Tuned comparison of EW RC

Tuned comparison with results of HORACE and Z(W)GRADE for EW RC to CC and NC DY were performed within *Les Houches* '05, '07 and *TEV4LHC* '06 workshops



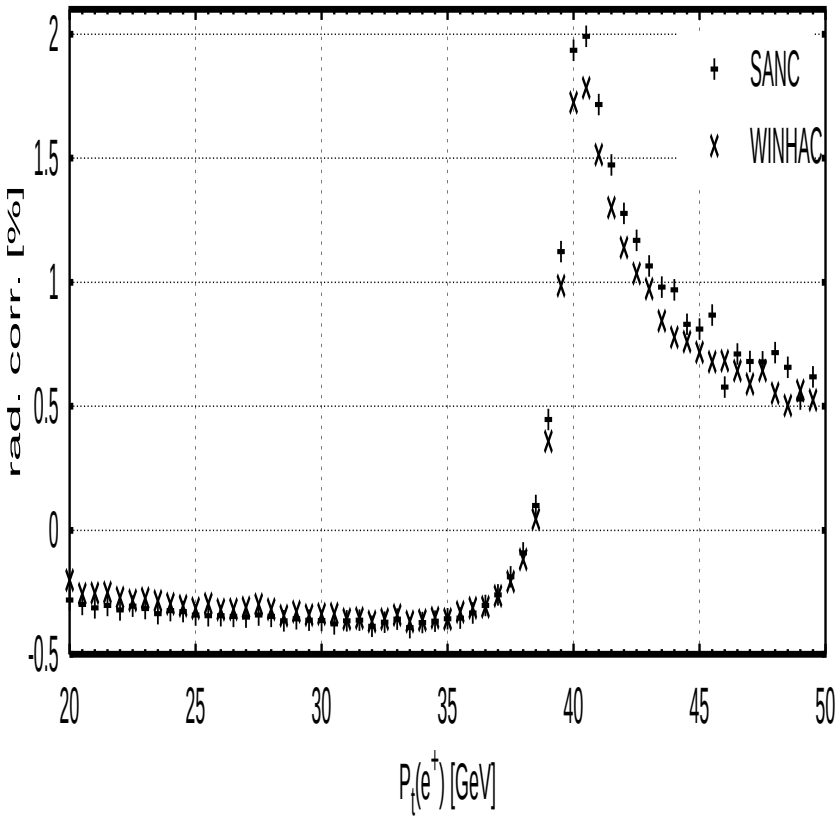



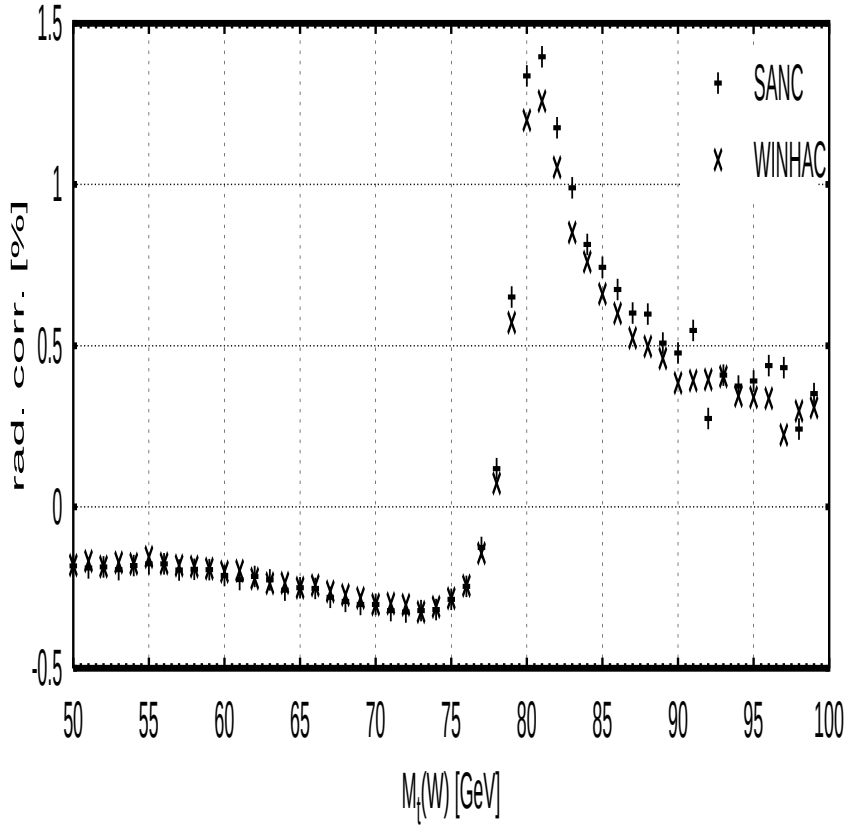

- Set-up: $P_T(l,\nu) > 20$ GeV, $|\eta(l)| < 2.5$; $\alpha(0)$ EW scheme; MRST2004QED; NLO QED DIS subtraction scheme

# Higher order photonic FSR

Multiple FSR photon radiation in LLA
Comparison with WINHAC (BARE $e^+$)

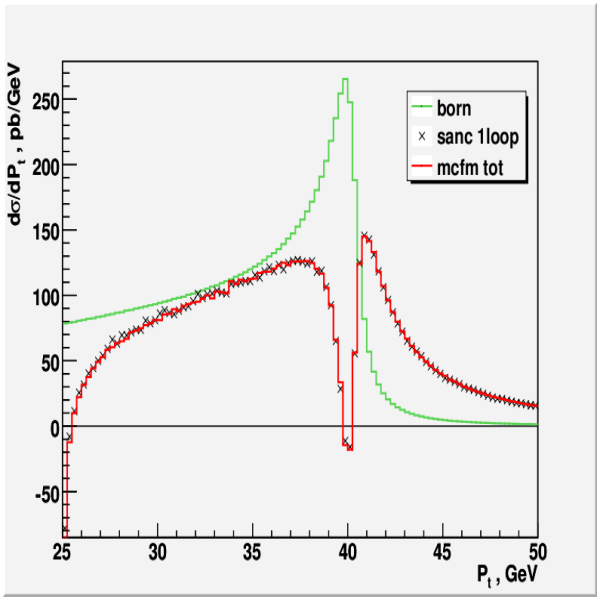
**PRELIMINARY**



# QCD in NLO

- One-loop QCD corrections to Drell-Yan are computed in SANC for CC and NC case, including gluon induced sub-processes
- Comparison with MCFM is performed for CC and NC cases
- Matching of one-loop QCD RC in SANC MC with parton showers in PYTHIA and HERWIG is in progress. POWHEG scheme of matching is applied



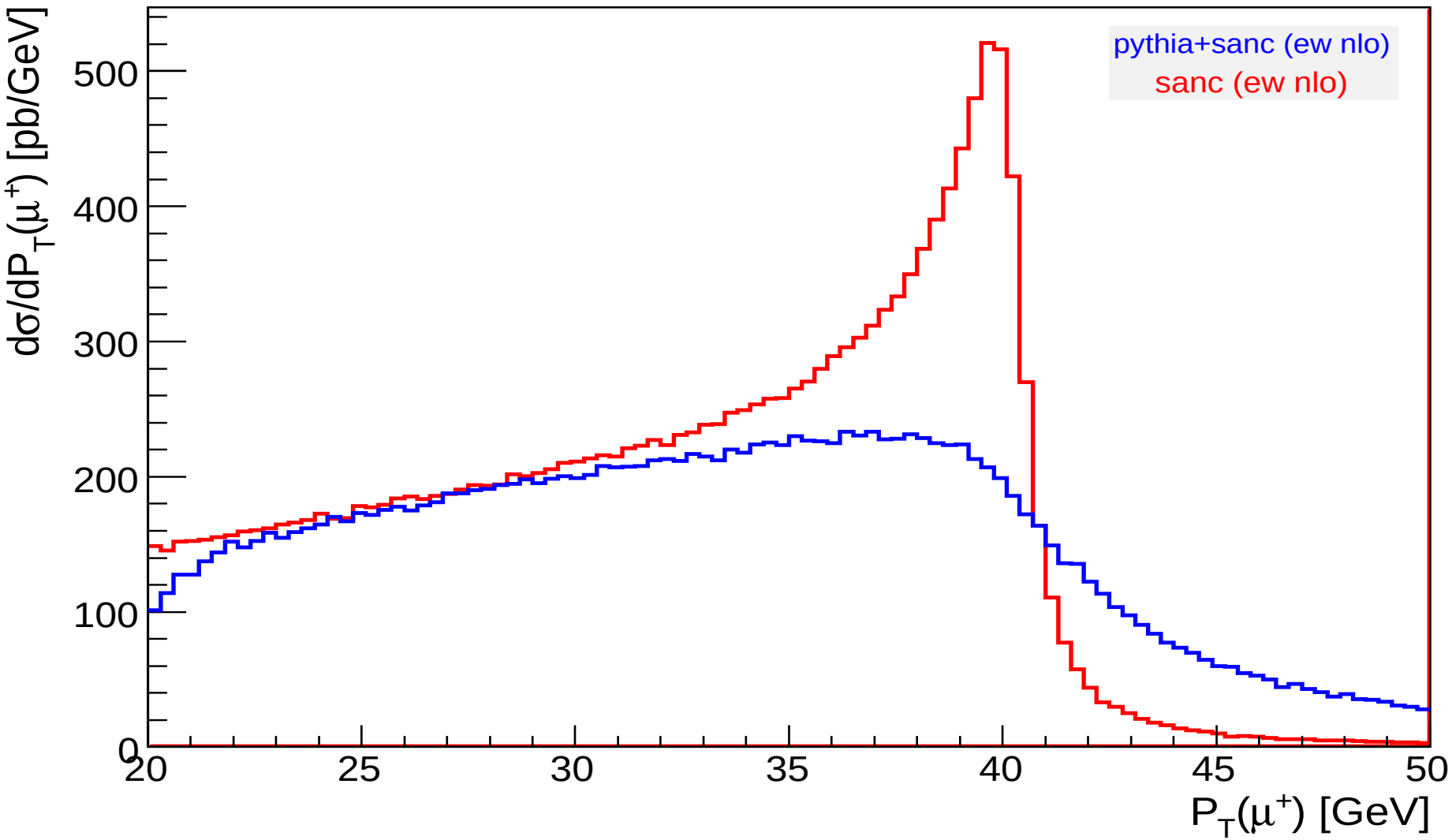

| | Born | NLO | $\delta$ |
|---|---|---|---|
| CC [SANC], $G_F$ | 2058.149(3) | 1906.1(8) | −7.39(4) |
| CC [MCFM], $G_F$ | 2058.1(1) | 1901.9(9) | −7.59(5) |
| NC [SANC], $G_F$ | 233.548(1) | 254.7(2) | 9.1(1) |
| NC [MCFM], $G_F$ | 234.14(4) | 254.8(1) | 8.8(1) |

# Interfacing SANC with PYTHIA and HERWIG

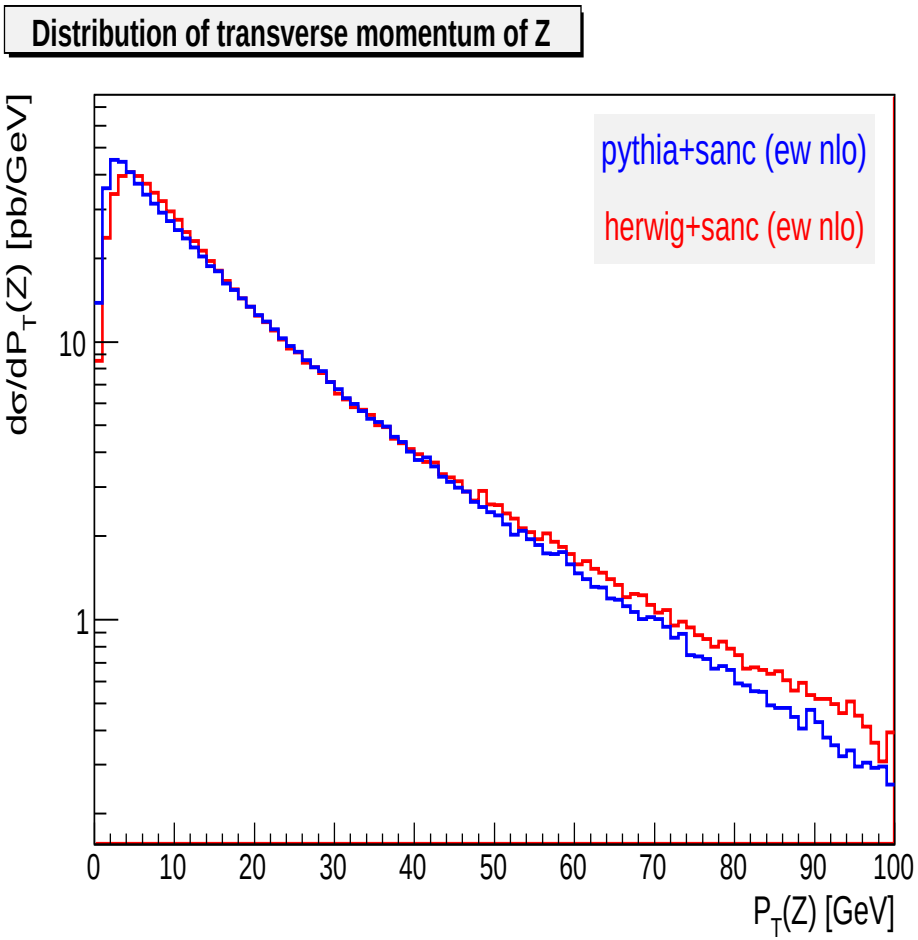
- SANC Monte-Carlo generators for neutral and charged current Drell-Yan processes produce unweighted events with help of FOAM algorithm
- The transfer of information between SANC Monte Carlo generator and the general purpose event generators PYTHIA and HERWIG is organized via data files containing the event information in the standard Les Houches Accord format
- Matching for the Born-level and $\mathcal{O}(\alpha)$ EW contributions with parton showers is *almost* trivial
- Matching of $\mathcal{O}(\alpha_s)$ QCD contributions is scheme dependent

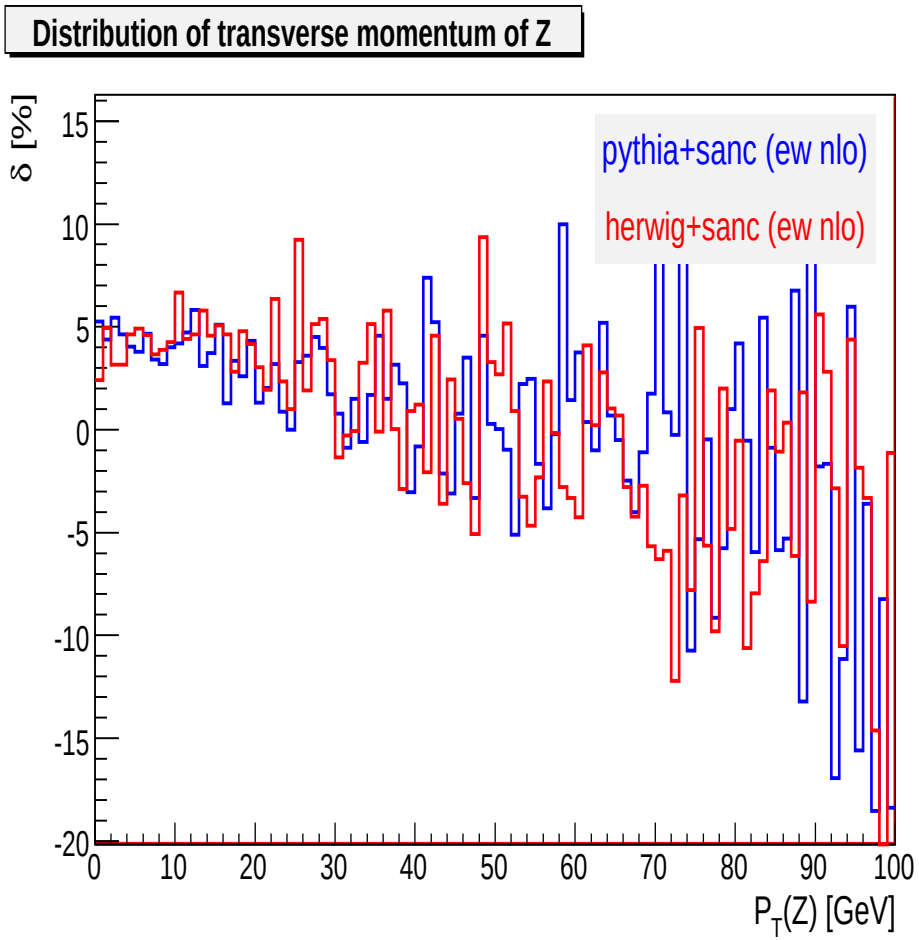
# The effect of parton showers on single-W production

**Distribution of transverse momentum of $\mu^+$**



# Distribution of $Z$ transverse momentum



# Theoretical uncertainty

- Uncertainties in PDF, but after a new fit from LHC data ...
- QCD (and QED) factorization scheme and scale dependence
- pure QCD higher order terms $\Leftarrow$ recent NNLO results by Anastasiou, Melnikov, Petriello *et al.*
- pure EW higher order terms:
  - EW scheme dependence: $\alpha(0)$ *vs.* $G_F$ *vs.* $\alpha(M_Z)$
  - resummation of higher order EW Sudakov logs
  - other unknown EW higher order terms (should be small?)
  - hadronic vacuum polarization
  - top and Higgs mass dependence
- Interplay of EW and QCD effects: multiplicative *vs.* additive treatment
- All this to be quantified within working groups

# Outlook

- SANC provides an advanced description of CC and NC Drell-Yan processes
- Monte Carlo event generators are created, their development is continued
- Packages with MC and partonic level modules are available for download
- SANC modules with EW RC to CC Drell-Yan were implemented in `WINHAC` event generator
- Tuned comparisons with other groups were performed. They should be extended
- But further theoretical studies are still required for better understanding of DY at LHC