Study of Drell-Yan processes in SANC

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Motivation

Drell-Yan processes (DY) have a clear signature, large cross-section and contribute to the background in many searches for the new physics. Precision studies of DY will be used for luminocity monitoring, detector calibration and to refine the values of $\Gamma_{W,Z}$, $\sin^2\theta^{\rm eff}$ and M_W.

- Neutral currend DY processes (single-Z production)
  $p\bar{p} \to \gamma, Z \to \ell^+\ell^-(\gamma)X, \qquad pp \to \gamma, Z \to \ell^+\ell^-(\gamma)X$
- Charged currend DY processes (single-W production)
  $p\bar{p} \to W^+ \to \ell^+\nu_\ell(\gamma)X, \qquad p\bar{p} \to W^- \to \ell^-\bar{\nu}_\ell(\gamma)X,$
  $pp \to W^+ \to \ell^+\nu_\ell(\gamma)X, \qquad pp \to W^- \to \ell^-\bar{\nu}_\ell(\gamma)X$
  $\ell = e, \mu, \quad X = \text{hadrons}.$

Required theoretical precision is about 1 %. To achieve this accuracy we should take into account EW and QCD corrections at least at NLO and their interplay.

Particular features of calculation

- The total one-loop EW cross-section consists of the following terms:

$$\sigma^{1-loop} = \sigma^{Born} + \sigma^{virt}(\lambda) + \sigma^{soft}(\bar{\omega}, \lambda) + \sigma^{hard}(\bar{\omega}).$$

  The auxiliary parameters $\bar{\omega}$ and λ cancel out after summation.
- The calculation of the complete set of Feynman diagrams is realized within SANC environment.
- The Passarino–Veltman reduction is applied.
- For virtual corrections we use SANC and LoopTools libraries.
- *On-shell* singularities are regularized by the W-width:
  $\log(s' - M_W^2 + i\epsilon) \to \log(s' - M_W^2 + iM_W\Gamma_W)$.

Quark mass singularities

One-loop QED RC to the partonic DY processes contain terms proportional to logarithms of quark masses $\log\frac{s}{m_q^2}$. But this terms are also effectively taken into account in QED evolution of PDF's. To avoid double-counting we should subtract them either from the cross-section or from PDF's.

- Subtraction from the cross-section:

$$\sigma \to \sigma - \sum_{i=1,2}\int_0^1 {\rm d}x\ \sigma_0(x)\frac{\alpha}{2\pi}Q_i^2\left[\frac{1+x^2}{1-x}\left(\log\frac{M^2}{m_i^2} - 1 - 2\log(1-x)\right)\right]_+ .$$

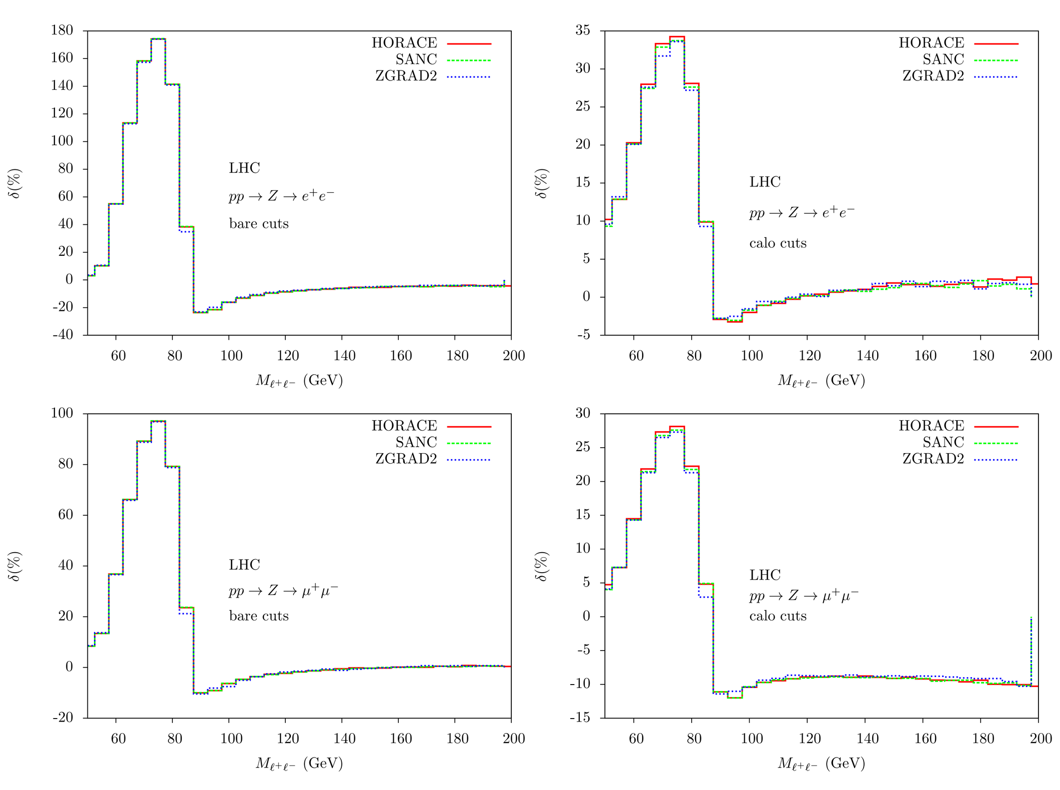
- Subtraction from PDF:

$$q_i(x, M^2) \to q_i(x, M^2) - \int_x^1 \frac{{\rm d}z}{z}\ q_i\left(\frac{x}{z}, M^2\right)\frac{\alpha}{2\pi}Q_i^2\left[\frac{1+z^2}{1-z}\left(\log\frac{M^2}{m_i^2} - 1 - 2\log(1-z)\right)\right]_+ .$$

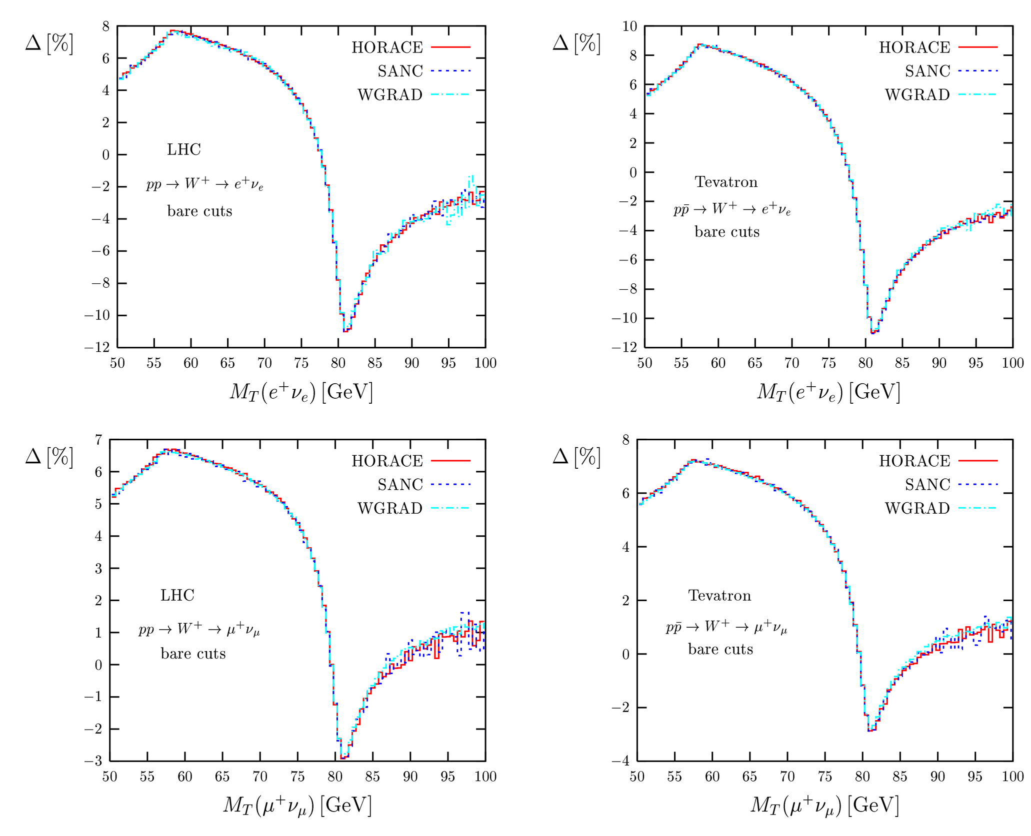
Application of parton showers

- To combine EW corrections with the effect of QCD parton showers we use our Monte-Carlo generator of unweighted events.
- The generator is based on the FOAM program written in C++, which allows to generate unweighted events as well as to compute the inclusive cross-section of the process under study. The generator uses the standard SANC Fortran modules (SSFM) for the different components of differential cross section at partonic level.
- The transfer of information between SANC Monte Carlo generator and general purpose event generators PYTHIA and HERWIG is organized via data files containing the event information in the standard Les Houches Accord format.

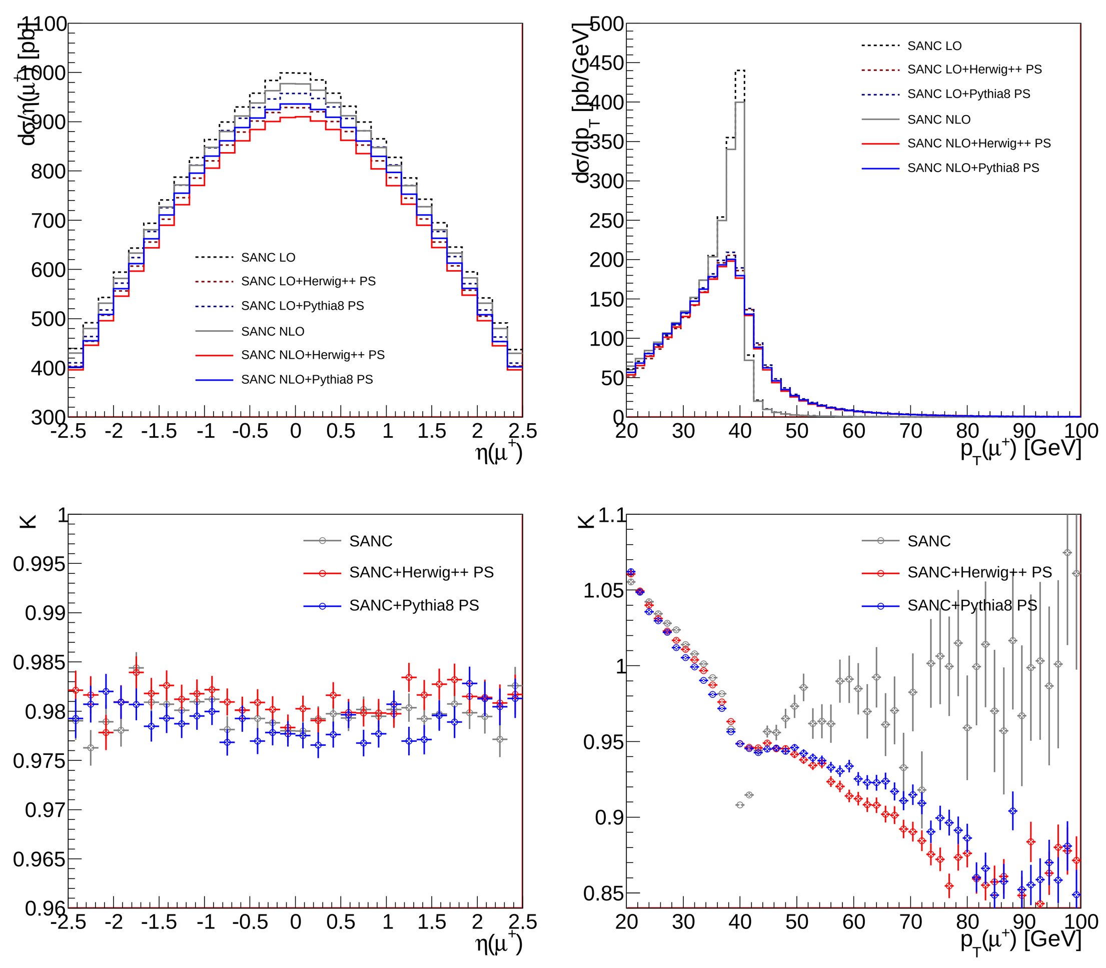
Results



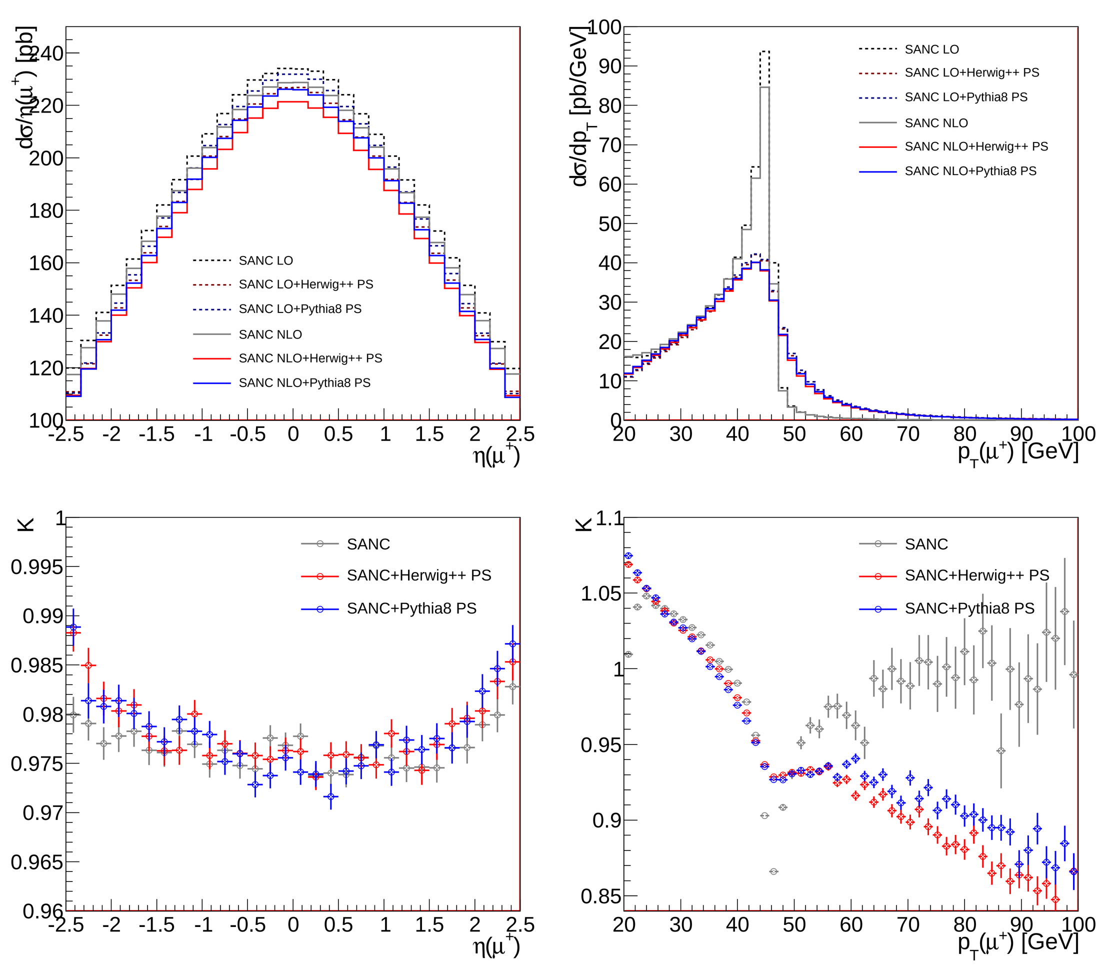
a) The relative correction δ due to electroweak $\mathcal{O}(\alpha)$ corrections to the $M(\ell^+\ell)$ distribution for Z production with bare and calo cuts at the LHC.



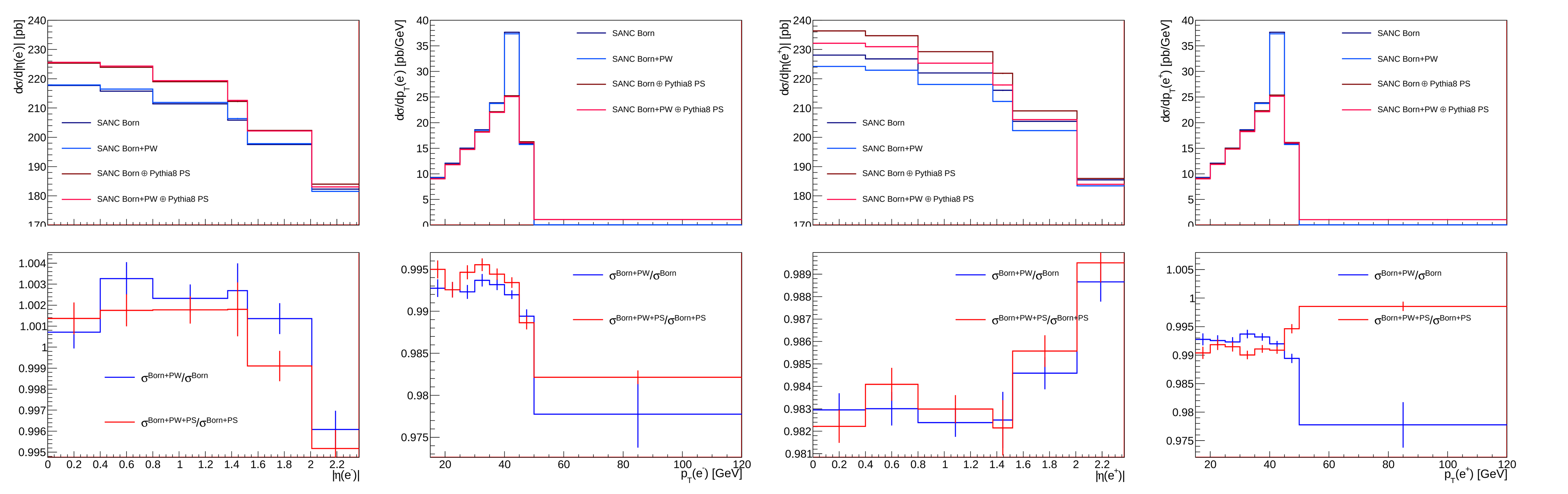
b) The relative correction Δ due to electroweak $\mathcal{O}(\alpha)$ corrections to the $M_T(\ell\nu)$ distribution for single W^+ production with bare cuts at the Tevatron and the LHC.



c) Distributions of pseudorapidity (*left*) and transverse momentum (*right*) of μ^+ for CC DY with the effect of parton showers from Pythia8 and Herwig++.



d) Distributions of pseudorapidity (*left*) and transverse momentum (*right*) of μ^+ for NC DY with the effect of parton showers from Pythia8 and Herwig++.



e) The results of SANC Born + pure weak (PW) corrections combined with parton showers for NC DY.

Conclusions

- The tuned comparison between Monte Carlo tools HORACE, SANC and (W)ZGRAD2 for EW corrections to DY shows a good agreement between these programs.
- Preliminary studies show that the effect of pure weak corrections which are not included to the standard LHC software may be not-negligible.
- Standard SANC Fortran Modules (SSFM) for EW corrections to CC DY were implemented into the WINHAC generator. The implementation of SSFM in existing MC event generators is the main priority of the development of SANC as a HEP tool.
- We have a self-consistent simultaneous treatment of QCD and EW radiative corrections to the DY processes in the environment of SANC system. Our results for QCD are in a good agreement with the ones of MCFM for both CC and NC channels.

References

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