Comparison of ZGRAD2 with MCSANC and POWHEG_ew: An update

Doreen Wackeroth
dw24@buffalo.edu

University at Buffalo
The State University of New York

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MCSANC and POWHEG_ew results as presented at the April 21, 2020 meeting.

ZGRAD2 (as implemented in WZGRAD) results have been obtained with the agreed setup.

Change since the talk given at the February 26, 2020 meeting: mstw2008nlo.00.dat → MSTW2008nlo68cl_0000.dat (LHAPDF)
Setup

(masses, width in GeV)

\[ \alpha(0) = 0.007297353; \ G_f = 1.1663787 \cdot 10^{-5}; \ \alpha_s(m_Z^2) = 0.1201789; \conhc = 389379323 \]

pole masses:

\[ m_w = 80.35797; \ m_z = 91.15348; \ m_h = 125 \]

pole width:

\[ \Gamma_z = 2.494266 \]

fermion masses:

\[ m_e = 5.1099907d - 4; \ m_\mu = 0.1056583; \ m_\tau = 1.77705; \ m_d = 0.06983; \ m_u = 0.06984; \ m_s = 0.15; \]

\[ m_c = 1.2; \ m_b = 4.7; \ m_t = 173 \]

Masses were chosen to reproduce:

\[ \Delta \alpha (91.153480619182758) = (5.89760567146062550E-002,-1.62163027982058471E-002) \]

(POWHEG\_ew);

\[ 5.8975530055977214E-002 \] (MCSANC); \[ 5.8975530126199806E-002 \] (WZGRAD, no top loop)

\[ 1/\alpha(91.153480619182758) = (128.95414861873800,2.222171242374937) \] (POWHEG\_ew);

\[ 128.95422078992519 \] (MCSANC); \[ 128.95422078030214 \] (WZGRAD, no top loop)

\[ \Delta r = (2.97632672697318683E-002,-2.89767823517196148E-002) \] (POWHEG\_ew);

\[ 2.9762759543028511E-002 \] (MCSANC); \[ 2.9762756119628920E-002 \] (WZGRAD)

Final-state: bare muons; EW-schemes: \( \alpha(0), G_\mu \); fact/ren scale = \( m_\mu \); PDF: MSTW2008nlo68cl, Fixed-width scheme

Cuts: no \( p_T, \eta, \ m_\mu = [60, 150] \) GeV with binsize=1 GeV

Observables: x-section, forward-, backward-x-sections for QED(ISR,IFI), pure weak (PW), higher order (HO)
$m_{\mu^+\mu^-}$ and $A_{FB}(m_{\mu^+\mu^-})$ distributions at leading order (LO)
$m_{\mu^+\mu^-}$ and $A_{FB}(m_{\mu^+\mu^-})$ distributions at LO+pure weak (PW) corrections.
$m_{\mu^+\mu^-}$ and $A_{FB}(m_{\mu^+\mu^-})$ distributions at LO+ISR QED corrections
$m_{\mu^+\mu^-}$ and $A_{FB}(m_{\mu^+\mu^-})$ distributions at LO+IFI QED corrections
σ and $A_{FB}$ at the 8 TeV LHC

Calculated from distributions: $m_{\mu^+\mu^-} = [60 - 120]$ GeV; $G_\mu$ EW scheme

<table>
<thead>
<tr>
<th>x-section [pb]</th>
<th>Ratio</th>
<th>$A_{rmFB}$</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCSANC [LO] 951.76(1)</td>
<td></td>
<td>0.03683(1)</td>
<td></td>
</tr>
<tr>
<td>POWHEG [LO] 951.74(1)</td>
<td>0.99998(1)</td>
<td>0.03682(1)</td>
<td>$1(1) \cdot 10^{-5}$</td>
</tr>
<tr>
<td>WZGRAD [LO] 951.74(1)</td>
<td>0.99998(1)</td>
<td>0.03683(1)</td>
<td>$0(1) \cdot 10^{-5}$</td>
</tr>
<tr>
<td>MCSANC [PW] -5.94(1)</td>
<td></td>
<td>-0.01684(1)</td>
<td></td>
</tr>
<tr>
<td>POWHEG [PW] -6.03(1)</td>
<td>1.02(1)</td>
<td>-0.01733(1)</td>
<td>$-4.9(1) \cdot 10^{-4}$</td>
</tr>
<tr>
<td>WZGRAD [PW] -5.63(1)</td>
<td>0.95(1)</td>
<td>-0.01710(1)</td>
<td>$-2.6(1) \cdot 10^{-4}$</td>
</tr>
<tr>
<td>MCSANC [ISR] 3.53(1)</td>
<td></td>
<td>-0.00005(2)</td>
<td></td>
</tr>
<tr>
<td>WZGRAD [ISR] 3.65(1)</td>
<td>1.03(1)</td>
<td>0.00000(1)</td>
<td>$5(2) \cdot 10^{-5}$</td>
</tr>
<tr>
<td>MCSANC [IFI] 0.18(1)</td>
<td></td>
<td>-0.00031(1)</td>
<td></td>
</tr>
<tr>
<td>WZGRAD [IFI] -0.08(1)</td>
<td>-0.47(1)</td>
<td>-0.00023(1)</td>
<td>$8(1) \cdot 10^{-5}$</td>
</tr>
</tbody>
</table>
Next steps

- Continue to participate in the tuned comparison/benchmarking with POWHEG, MCSANC, RADY and DIZET, and explore reasons for observed differences.
- Implement “new” parametrization of $A_{FB}$ in terms of $\sin^2 \theta_{eff}$ of arXiv:1906.11569 [hep-ph]