

MCSANC update for $pp \rightarrow \mu^+ \mu^-$ @ 8 TeV

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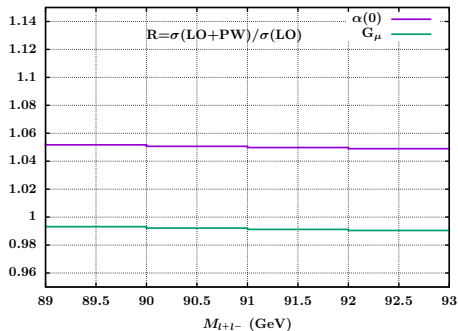
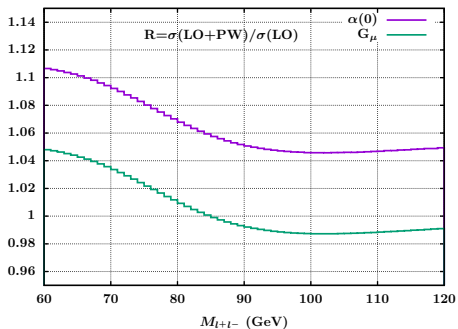
LHC EW Precision sub-group meeting, CERN, December 16, 2019

- LO QCD – no QCD corrections
- Fixed-width scheme: $\text{prop}(s, M_Z) = 1/(s - [M_Z^2 - iM_Z w_Z])$
- MSTW2008nlo68cl PDF-function (dynamical scale)
- Physical parameters:
 $\alpha_0 = 1/137.0360$, $\alpha(G_\mu) = 1/132.2332$, $g_{\text{Fermi}} = 1.166389 \cdot 10^{-5}$,
 $M_W = 80.35797$ GeV, $M_Z = 91.15348$ GeV, $\Gamma_Z = 2.494266$ GeV
- Pure weak (PW) virtual corrections (self-energies, vertices, ZA and ZZ-boxes) and high-order (HO) corrections (α_{fer}^2 and $\alpha\alpha_s(s)$ terms to $\Delta\rho$ parameter)
- Initial-State-Radiation (ISR) and Initial-Final-Interference (IFI) QED corrections: virtual (vertices, AA-boxes), soft and hard real photon radiation
- No p_T and η cuts, only $m_{ll} = [60-120]$ GeV for total, forward and backward (A_{FB}) cross sections with bin width is equal to 1 GeV

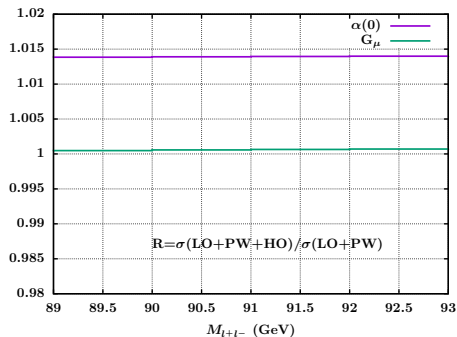
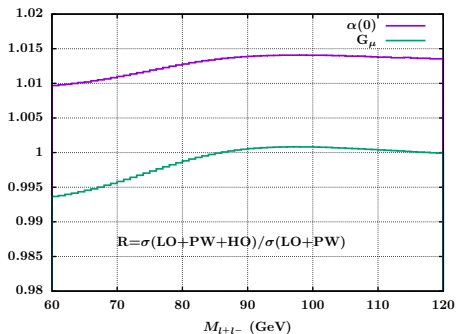
PW and HO corrections: $m_{ll}=[60-120],[89-93]$ GeVIntegrated cross-section σ (pb) and ratio $\sigma(G_\mu)/\sigma(\alpha(0))$

m_{ll}		60-120	89-93
$\alpha(0)$	LO	887.86(1)	571.41(1)
G_μ	LO	951.76(1)	612.53(1)
$G_\mu/\alpha(0)$	LO	1.07196(1)	1.07196(1)
$G_\mu/\alpha(0)$	LO,%	7.196(1)	7.196(1)
$\alpha(0)$	LO+PW	934.29(1)	600.09(1)
G_μ	LO+PW	945.81(1)	607.42(1)
$G_\mu/\alpha(0)$	LO+PW	1.01233(1)	1.01221(1)
$G_\mu/\alpha(0)$	LO+PW,%	1.233(1)	1.221(1)
$\alpha(0)$	LO+PW+HO	947.16(1)	608.45(1)
G_μ	LO+PW+HO	946.14(1)	607.79(1)
$G_\mu/\alpha(0)$	LO+PW+HO	0.99893(1)	0.99891(1)
$G_\mu/\alpha(0)$	LO+PW+HO,%	-0.107(1)	-0.109(1)

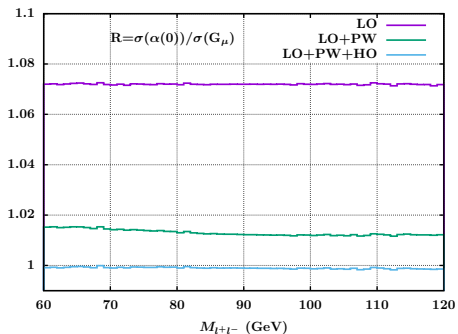
Distributions of the ratio $\sigma/\sigma(\text{LO})$ and $\sigma/\sigma(\text{LO} + \text{PW})$ on $m_{\mu^+\mu^-}$



Distributions of the ratio $\sigma/\sigma(\text{LO} + \text{PW})$ on $m_{\mu^+\mu^-}$



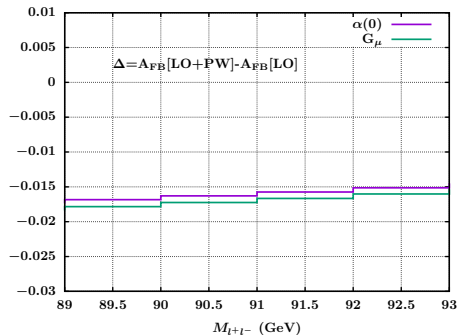
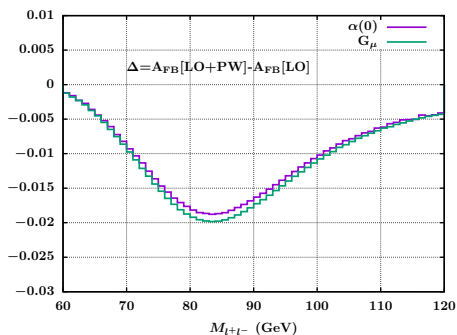
Distribution of the ratio $\sigma(G_\mu)/\sigma(\alpha(0))$ on $m_{\mu^+\mu^-}$



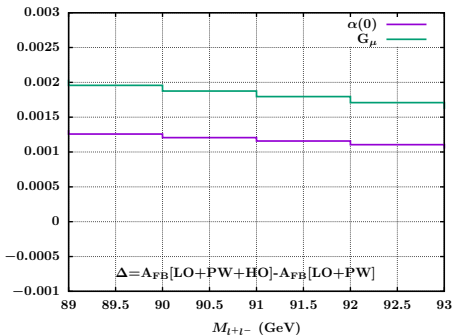
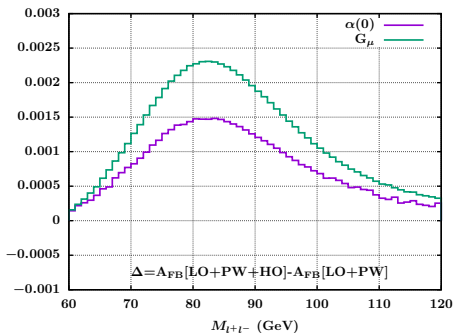
Integrated A_{FB} , differences $\Delta_A = [A_{\text{FB}} - A_{\text{FB}}(\text{LO})]$ and
 $\Delta_{\text{EW}} = [A_{\text{FB}}(\alpha(0)) - A_{\text{FB}}(G_\mu)]$

m_{ll}			60-120	89-93
$\alpha(0)$	A_{FB}	[LO]	0.03684(1)	0.04655(1)
G_μ	A_{FB}	[LO]	0.03683(1)	0.04655(1)
$\alpha(0) - G_\mu$	A_{FB}	[LO]	0.00001(1)	0.00001(1)
$\alpha(0)$	A_{FB}	[LO+PW]	0.02091(1)	0.03058(1)
G_μ	A_{FB}	[LO+PW]	0.01997(1)	0.02964(1)
$\alpha(0)$	Δ_A	[LO+PW]-[LO]	-0.01593(1)	-0.01597(1)
G_μ	Δ_A	[LO+PW]-[LO]	-0.01686(1)	-0.01691(1)
$\alpha(0) - G_\mu$	Δ_{EW}	[LO+PW]	0.00094(1)	0.00095(1)
$\alpha(0)$	A_{FB}	[LO+PW+HO]	0.02209(1)	0.03176(1)
G_μ	A_{FB}	[LO+PW+HO]	0.02180(1)	0.03147(1)
$\alpha(0)$	Δ_A	[LO+PW+HO]-[LO]	-0.01475(1)	-0.01479(1)
G_μ	Δ_A	[LO+PW+HO]-[LO]	-0.01503(1)	-0.01508(1)
$\alpha(0) - G_\mu$	Δ_{EW}	[LO+PW+HO]	0.00029(1)	0.00029(1)

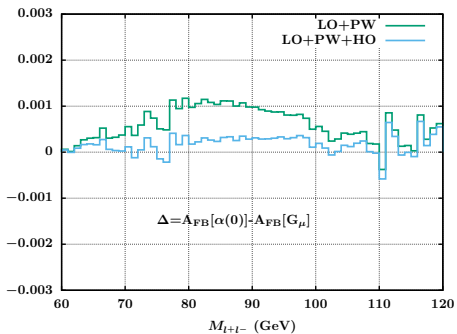
Distribution of the difference $\Delta = [A_{\text{FB}} - A_{\text{FB}}(\text{LO})]$ on $m_{\mu^+ \mu^-}$



Distribution of the difference $\Delta = [A_{\text{FB}} - A_{\text{FB}}(\text{LO+PW})]$ on $m_{\mu^+ \mu^-}$



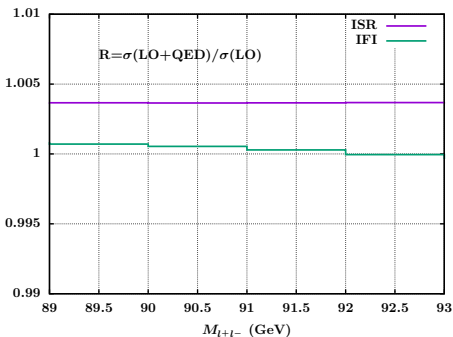
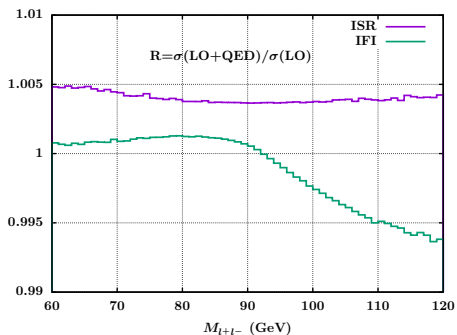
Distribution of the difference $\Delta = [A_{\text{FB}}(\alpha(0)) - A_{\text{FB}}(G_\mu)]$ on $m_{\mu^+ \mu^-}$



ISR and IFI QED corrections: $m_{ll}=[60-120],[89-93]$ GeV

Integrated cross-section σ (pb) and ratio $\sigma/\sigma(\text{LO})$

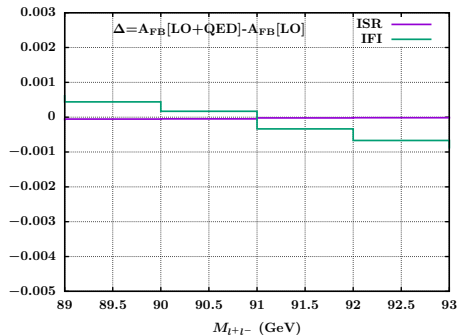
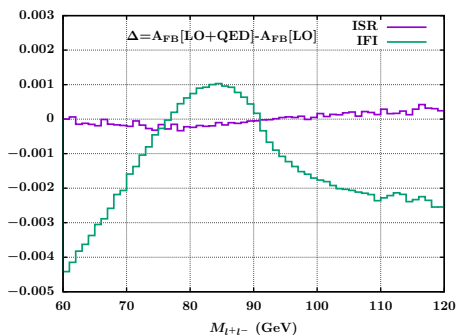
m_{ll}	60-120	89-93
LO+ISR	955.23(1)	614.77(1)
1+ISR/LO	1.00371(1)	1.00366(1)
ISR/LO,%	0.371(1)	0.366(1)
LO+IFI	951.93(1)	612.76(1)
1+IFI/LO	1.00018(1)	1.00037(1)
IFI/LO,%	0.018(1)	0.037(1)

Distribution of the ratio $\sigma/\sigma(\text{LO})$ on $m_{\mu^+ \mu^-}$ 

Integrated A_{FB} and difference $\Delta_A = [A_{\text{FB}} - A_{\text{FB}}(\text{LO})]$

m_H		60-120	89-93
[LO+ISR]	A_{FB}	0.03678(1)	0.00465(1)
[LO+ISR]-[LO]	Δ_A	-0.00004(1)	-0.00003(1)
[LO+IFI]	A_{FB}	0.03652(1)	0.00464(1)
[LO+IFI]-[LO]	Δ_A	-0.00031(1)	-0.00013(1)

Distribution of the difference $\Delta = [A_{\text{FB}} - A_{\text{FB}}(\text{LO})]$ on $m_{\mu^+ \mu^-}$



SUMMARY

In Oct-Nov, 2019 we restarted pure weak/high-order and QED (ISR, IFI) calculations for $m_{ll}=[60-120]$ GeV with bin width is equal to 1 GeV with slightly refined parameters.

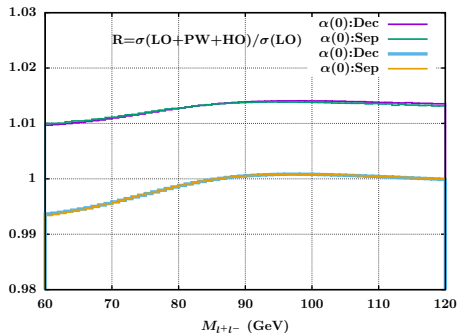
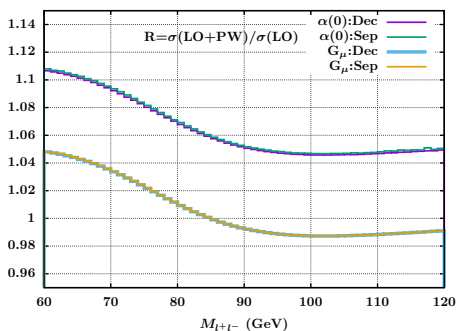
We have rather good agreement for PW corrections with POWHEG_{ew} results but not for HO results in opposite to Sep, 2019 time where we had agreement both for PW/HO corrections (see [Elzbieta report on 10/09/2019, p.8](#)).

One the other hand we see the PW/HO MCSANC Dec, 2019 results are compatible with MCSANC Sep, 2019 results.

OUTLOOK

- need to finish comparison and justification (validation) of the pure weak and high-order correction results (POWHEG_{ew} team)
- need to justify the QED results
- waiting for the Alessandro report to restart photon-induced calculations to compare and justify (HORACE team)

BACKUP SLIDES

Distribution of the ratio $\sigma/\sigma(\text{LO})$ 

Distribution of the difference $\Delta = [A_{\text{FB}} - A_{\text{FB}}(\text{LO}, \text{LO} + \text{PW})]$ on $m_{\mu^+ \mu^-}$

