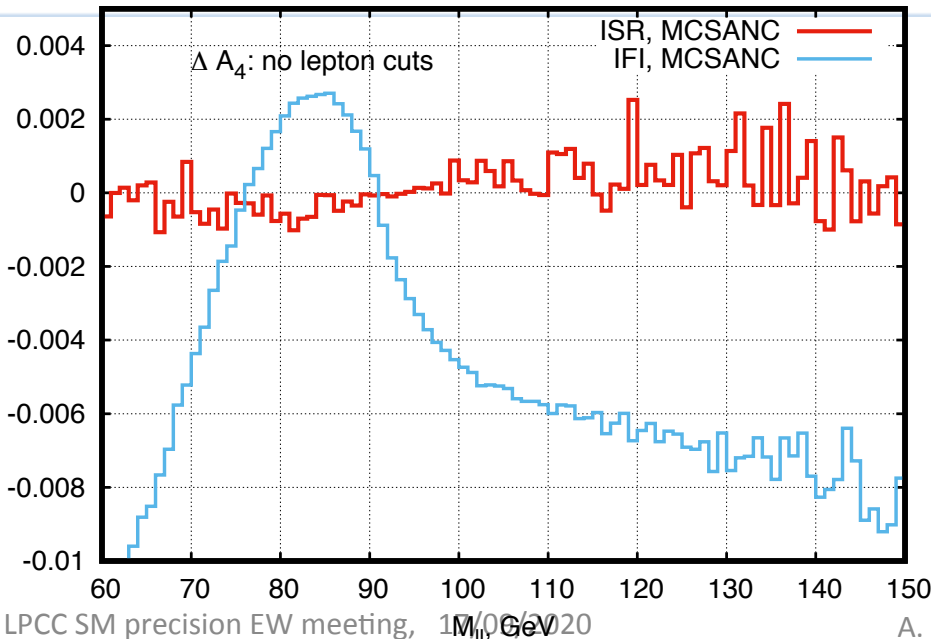
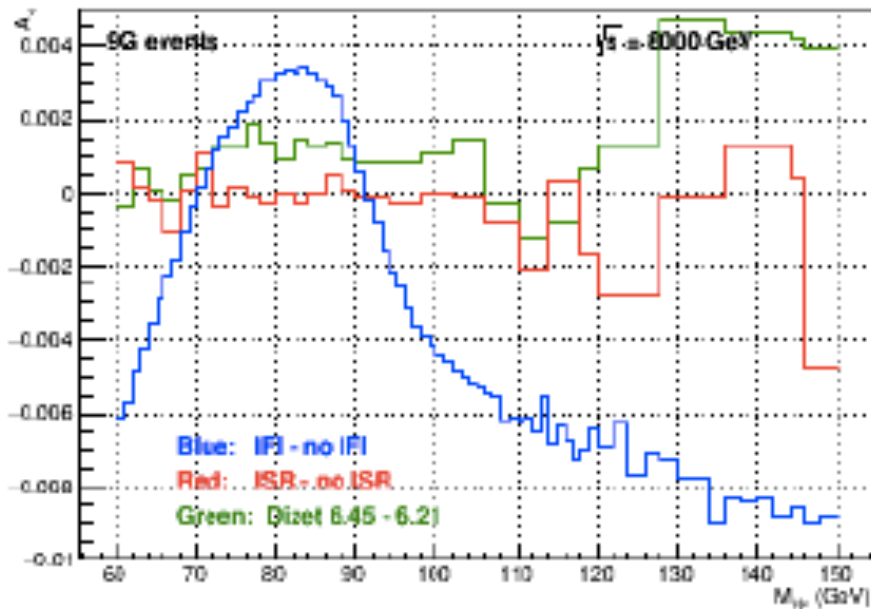


## Summary of status of QED corrections

- Over past six months, focus has been mostly on virtual corrections except for regular updates by Scott (KKMC-hh) and for a few discussions about photon-induced processes by Alessandro and Serge/Lida (HORACE and MC-SANC)
- In this brief summary, recap results as they currently stand from latest KKMC-hh report and from earlier MC-SANC and Powheg\_EW reports
- Setup is the same for all calculations (however KKMC-hh does not rely on collinear PDFs for collinear part of ISR). Both KKMC-hh and MC-SANC include virtual EW corrections in their results (not yet Powheg\_EW if I am not mistaken?), but this is irrelevant since Scott has shown that the IFI and ISR results are numerically unchanged if the virtual EW corrections are included or not
- Will focus here only on A4/AFB since  $d\sigma/dm_{\parallel}$  was never an issue

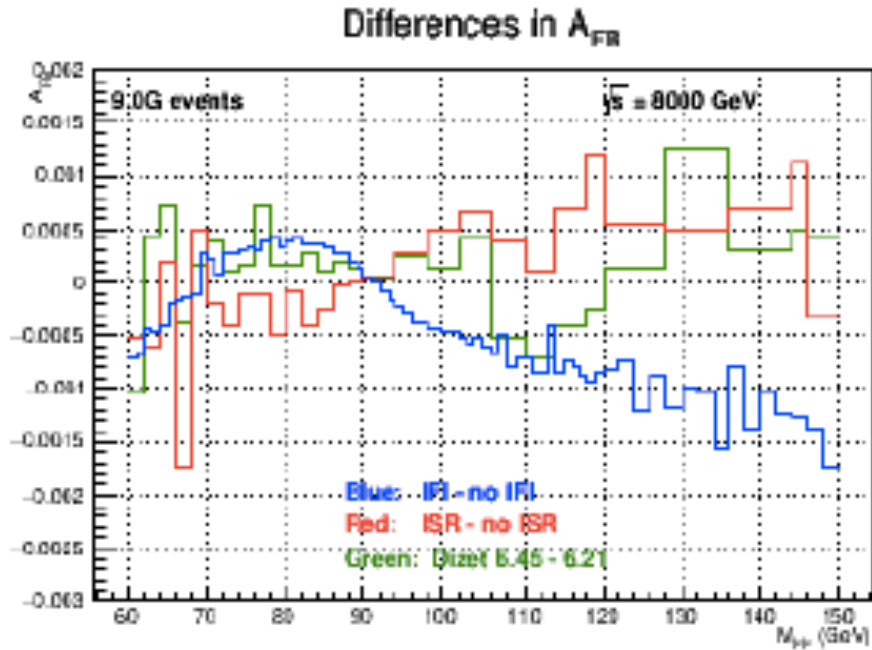
# Shape of QED IFI and ISR corrections to $A_4$

Differences in  $A_4$

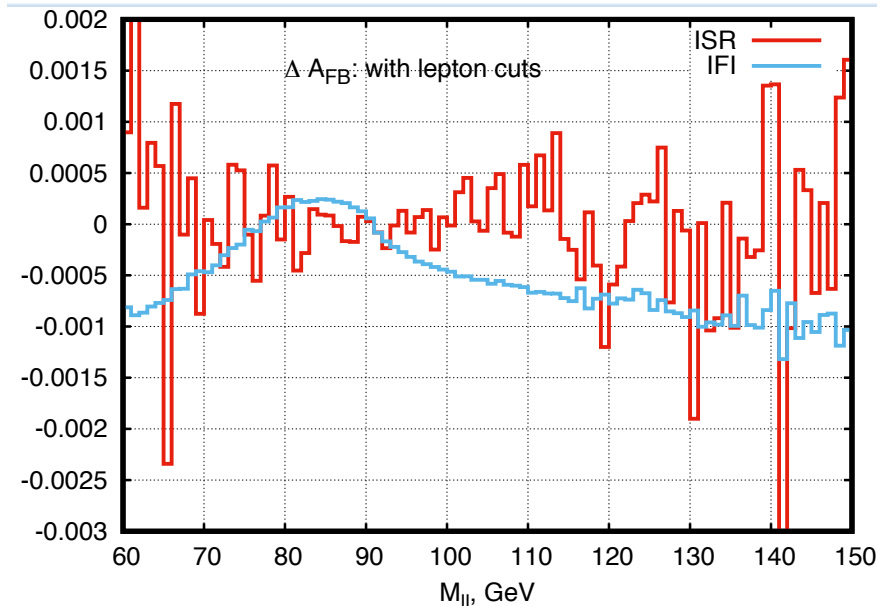


- Shown here from KKMC-hh (top) and MC-SANC (bottom) in full phase space of decay leptons
- Bare muons,  $A_4 = 8/3$  AFB, AFB computed as  $(\sigma_F - \sigma_B) / (\sigma_F + \sigma_B)$
- ISR is small,  $< 1$  in units of  $10^{-4}$  and flat versus  $m_{ll}$
- IFI is small around Z pole. 1-3 in units of  $10^{-4}$ , but has strong shape vs  $m_{ll}$ , with values between -100 and +50 in units of  $10^{-4}$ . It follows roughly shape of asymmetry.
- Note that  $\Delta A_4 = 1 \cdot 10^{-4}$  corresponds to  $\sim 1 \cdot 10^{-5}$  for  $\sin^2 \theta_1^{\text{eff}}$

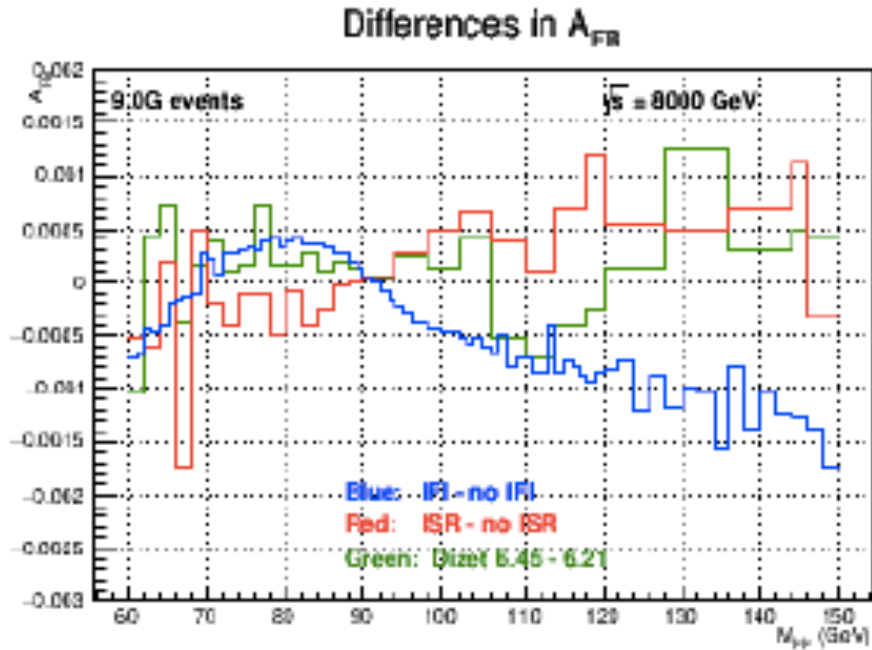
# Shape of QED IFI and ISR corrections to $A_4$



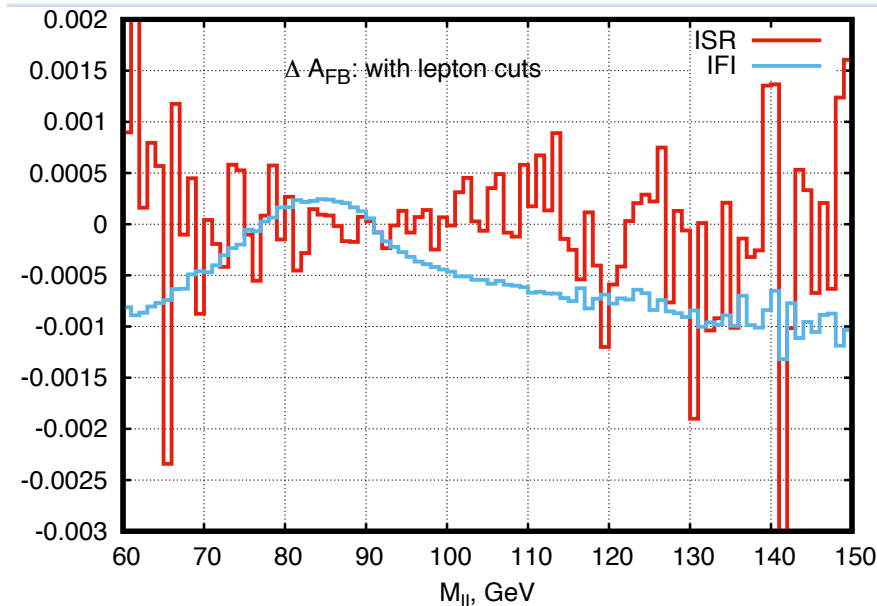
- Shown here from KKMC-hh (top) and MC-SANC (bottom) in fiducial phase space of decay leptons
- IFI peak is smaller than for full phase space of decay leptons
- Note that  $\Delta A_4 = 1 \cdot 10^{-4}$  corresponds to  $\sim 1 \cdot 10^{-5}$  for  $\sin^2\theta_1^{\text{eff}}$



# Shape of QED IFI and ISR corrections to $A_4$



- Shown here from KKMC-hh (top) and MC-SANC (bottom) in fiducial phase space of decay leptons
- IFI peak is smaller than for full phase space of decay leptons
- Note that  $\Delta A_4 = 1 \cdot 10^{-4}$  corresponds to  $\sim 1 \cdot 10^{-5}$  for  $\sin^2\theta_1^{\text{eff}}$



# Tabular comparison between calculations

89-93 GeV

81-101 GeV

Units of $10^{-4}$	KKMC-hh	MC-SANC	Powheg_EW		KKMC-hh	MC-SANC	Powheg_EW
Delta A4 IFI	2.0+-0.3	-3.3+-9.0	1.6+-1.5		3.1+-0.2	-4.5+-0.8	1.2+-1.2
Delta A4 ISR	-1.0+-0.6	-0.6+-1.0	0.4+-0.6		-0.5+-0.5	-0.8+-0.8	0.2+-0.1

60-81 GeV

101-150 GeV

Units of $10^{-4}$	KKMC-hh	MC-SANC	Powheg_EW		KKMC-hh	MC-SANC	Powheg_EW
Delta A4 IFI	3.4+-0.9	-35+-40	-64+-8		-62+-1	-60+-50	-54+-10
Delta A4 ISR	0.2+-1.1	-1.3+-1.0	-5+-4		-8+-2	-23+-20	5+-4

- Quite good agreement in pole region, need more stats to be sure
- Even larger stat- uncertainties outside pole region, effects also larger?

## Next steps, outstanding issues

- As expected (hoped?) , impact of ISR and IFI on interpretation is quite small ( $< 1 \cdot 10^{-5}$ ?) for weak mixing angle. Need  $\sim 10$  times more stats outside pole region for all calculations (if my rendering of the numbers in the table is correct)
- To me, there are two outstanding issues which require further work:
- The first one is that mentioned by Scott concerning the quark mass dependence of KKMC-hh ISR results. However, I would think that this ISR calculation which is independent of how global PDFs “absorb collinear photon radiation” and therefore a useful cross-check, even a necessary one given the sensitivity of precision EW measurements at the LHC to PDFs.
- The second one is the issue of photon-induced processes: should we just mention these in a small chapter or attempt to document a more extensive documented comparison (HORACE vs MC-SANC). Except for NNPDF and its strange features shown by Alessandro, it seems the photon-induced processes have a negligible impact probably (?)