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Radiative Corrections on CC03

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Abstract

This note reports on a study at generator level about the effects that the improved knowledge of electroweak radiative corrections have on CC03 physics at LEP2. This study was possible thanks to the new $\mathcal{O}(\alpha)$ generators in DPA that came out from the 2000 LEP2 Montecarlo workshop, allowing new, important insights of the effects full radiative corrections have on W physics observables.
The results presented in this note should explain why it is mandatory to take into account the new $\mathcal{O}(\alpha)$ codes in a MC generation for precision LEP2 physics and should give indications about a different way to determine a systematic error due to radiation.

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1 Introduction

The high accuracy reached by LEP in the CC03 cross section measurement during the years 1996-1999 (roughly 1%) has imposed new levels of precision to the theory. Most part of the theoretical uncertainty on σ_{CC03} before the 1999 LEP2 Montecarlo Workshop (LEP2MCWS [1]) was due to the contribution of non leading radiative corrections. This led to a big effort from the theoretical community in order to reduce this error; even though the full calculation of $\mathcal{O}(\alpha)$ electroweak corrections to 4-fermion processes was (and still is) beyond any possibility, the approach of the so-called Double-Pole Approximation (DPA) allowed a substantial improvement of the theoretical accuracy on total and differential cross-sections. This approach consists of an expansion of the 4-fermion matrix elements around the W poles, keeping only the first term. The number of contributing diagrams is thus enormously reduced, and it is possible to calculate the full radiative corrections for this subset only. This procedure has the big advantage of being gauge invariant, but it is exact only at the resonances. The codes that were realized account for DPA and their main features are summarized here:

- **RacoonWW** [2]. A massless 4-fermion generator with full virtual factorisable and non-factorisable $\mathcal{O}(\alpha)$ electroweak corrections in DPA. In figure 1 a few diagrams contributing to these corrections are shown. Real corrections (process $e^+e^- \to 4f\gamma$) are included with correct matrix elements of the CC11 class, i.e. including part of the CC03 background. The matching between real and virtual corrections is done in such a way to exactly cancel all infrared divergencies. Higher order ISR $\mathcal{O}(\alpha^3)$ is implemented via structure functions. Spin correlations are fully taken into account. QCD corrections and Coulomb corrections (DPA or full) are in. RacoonWW has become an unweighted event generator only recently.

- **YFSWW** [3] This is a massive $e^+e^- \to W^+W^- \to 4f$ generator (CC03 diagrams only), therefore it does not deal with full 4-fermion matrix elements. Only $\mathcal{O}(\alpha)$ factorisable electroweak corrections are included (on shell). Non-factorisable corrections are implemented via the so-called Khoze-Chapovsky ansatz [5], which is an analytical approximation via a β_W-dependent correction to the cross-section. ISR $\mathcal{O}(\alpha^3)$ is implemented with YFS exponentiation (p_t photon emission from initial state or Ws), FSR $\mathcal{O}(\alpha^2)$ can be included with PHOTOS. QCD corrections are included.

- **GENTLE 2.10** [6] This is an updated version of GENTLE 2.0. This is a semi-analytical computation of $e^+e^- \to 4f$ cross sections and distributions. With respect to version 2.0, a suppression factor of the Coulomb corrections was introduced in order to emulate the correct DPA calculation.

- **BBC** [7] This is a semi-analytical calculation for 4-fermion processes, to be used as a benchmark for Montecarlo programs. All virtual and real radiative corrections are stricly in DPA (phase space and real photon emission in DPA as well). W spin correlations are correctly taken into account.

For this study only the first two codes were considered, the reason being that the new version of GENTLE is not rigorously taking into account the effect of radiative corrections and that BBC is not an event generator.

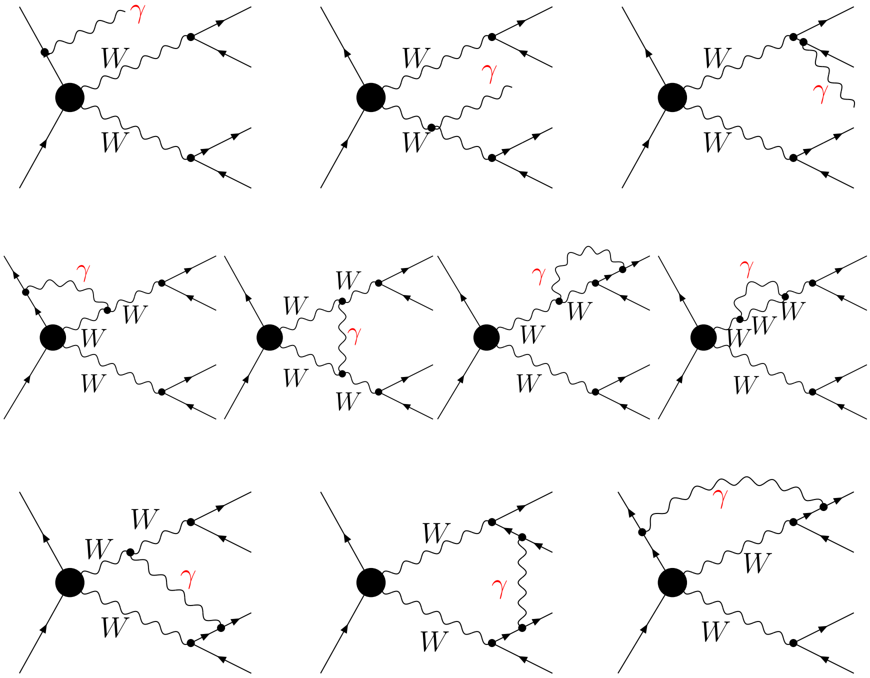

Figure 1: Feynman diagrams contributing to real corrections (first row), virtual non-factorisable corrections (second row) and to both factorisable and non-factorisable corrections (third row).

From the conclusions of the LEP2MCWS Yellow Report [1] it turned out that the CC03 total cross-section was about 2% below the predictions by GENTLE [6] run in the chosen configuration. The new cross-section was found to be in better agreement with the experimental data. In order to safely define a theoretical error on these new predictions, big emphasis was put on a detailed comparison between DPA codes on total cross-sections and comparing the improved calculations with Born differential distribution. This allowed to give 0.4% as an upper limit for a theoretical relative error on σ_{CC03} at 200 GeV. This value goes to 0.7% at 172 GeV; at the WW production threshold any calculation in DPA looses predictive power. No evaluation of the errors on distributions was made.
The missing information, of utmost importance from the experimental point of view, is to understand what is the effect of having introduced DPA with respect to the way radiative corrections were implemented in other 4-fermion generators: this includes Coulomb Corrections (CC), ISR via structure functions (SF), parton shower (PS) or Yennie-Frautschi-Suura exponentiation (YFS) and FSR, usually implemented via PHOTOS [8]. In what follows we present the first study, at generator level, that tried to answer to this fundamental question.

2 Input settings and checks on total cross-sections

In this work the generator used were WPHACT1.9 [9], KoralW [10] with the inclusion of ISR, FSR, CC and YFSWW (1.14 and later) [3], RacoonWW [2] as calculations in DPA.

In order to make tuned comparisons, the generators were run in different configurations that will be explained when relevant. The ISR in KoralW is implemented through the YFS exponentiation approach, whereas in WPHACT the parton shower as implemented in QEDPS [4] is used. For the FSR in YFSWW and KoralW, the same version of PHOTOS is used, which also allows radiation off quarks. The reference final state chosen is $u\bar{d}\mu\bar{\nu}_\mu$, with only CC03 diagrams included. The center of mass energy in which the calculations are performed is 189 GeV, and the G_μ scheme is used. All the programs have the same input parameter settings: namely they have the same input constants, the running width scheme is chosen for the W and Z boson propagators, naive QCD corrections are included, and the CKM matrix is set as diagonal.

Table 1 shows the relevant information concerning the precision of our comparisons; the number of generated events and the typical relative uncertainty on total cross-section and differential distributions at the double pole are indicated. To check the correctness of the input parameter settings and the reproducibility of the results in the LEP2 MC yellow report, technical checks on the values of the total cross-sections were performed. In table 2 the CC03 cross-sections (for the $u\bar{d}\mu\bar{\nu}_\mu$ channel) obtained by running the generators are shown for different configurations; the Born cross-sections, Born with ISR and Coulomb corrections, DPA a la YFSWW and full DPA[1], implementing the same cuts at fermion level to avoid IR singularities. Table 2 confirms the consistency of the input parameters settings, since the Born cross-section computation is consistent within the integration errors. Distributions also were checked to be in perfect agreement. When turning on the "usual" radiative corrections (but FSR) a relative difference of 0.8% on the total cross-sections appears, basically given by the different implementations of the radiation (see also next section). The numbers with DPA confirm a relative decrease of the cross-section of about -1.5%, in perfect agreement with the results of the LEP2MCWS. From the

Generator	Generated events	$\delta\sigma/\sigma$	δm/m$\|_{m_W}$
WPHACT	10^8 unweighted	$8\ 10^{-5}$	$4\ 10^{-4}$
KoralW	10^8 unwweighted	$6\ 10^{-5}$	$3\ 10^{-4}$
YFSWW	10^7 unweighted	$2\ 10^{-4}$	10^{-3}
RacoonWW	$5\ 10^7$ weighted	$2\ 10^{-4}$	10^{-3}

Table 1: Number of generated events and achieved precision, in our set-up, on total cross-section and differential cross-section in mass.

	WPHACT	KoralW/YFSWW	RacoonWW
Born (pb)	0.66762(3)	0.66763(2)	
ISR+CC (pb)	0.60234(5)	0.60687(3)	
LPA (pb)		0.59625(7)	
DPA (pb)		0.5696(1)	0.5684(1)

Table 2: Cross-section values for the process $u\bar{d}\mu\nu_\mu$ in different settings and for the different codes. In brackets the error from the integrator is indicated.

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[1] It includes a 10 degrees cut to the polar angle of the final charged fermions to maintain observables IR safe

comparison of the DPA numbers with the same cuts it is also confirmed that RacoonWW and YFSWW agree at the 0.2% level, as expected and within the associated theoretical error.

3 Tests on ISR

The present way used at LEP to assess a systematic error due to radiation from the initial state is to compare calculations implementing it in different ways, or by comparing calculations done at different orders. The typical results obtained range, for the W mass, from 0 to 15 MeV [11], basically dominated by statistics. Using our tuned comparison of generators we determined the discrepancies, on a distribution basis, driven by the different implementation of ISR in KoralW and WPHACT. FSR was explicitly turned off. The high statistics allows a precision at the MeV scale on the resulting W mass distributions.

Figure 2 shows the ratio KoralW/WPHACT as a function of the total ISR energy and its transverse momentum. The difference on the average emitted ISR energy between the two codes is at the level of 2 MeV. As expected, maximum discrepancies are found in the very soft part of the radiation and in the high p_T region. The distributions are fitted with constants, whose value is equal to the ratio of the total cross-sections. For the left-hand plot also the first bin is included in the fit and the 0.8% relative difference in cross-sections is driven basically by events where there is no radiation. The relevance of a different ISR radiator in terms of the distributions of several observables at generator level can be seen in figure 3. As shown in the figure, the reconstructed W mass or the polar angle distributions are not distorted by a different ISR. The same is true for the W momenta. Therefore the systematic effect on the measurements due to the missing

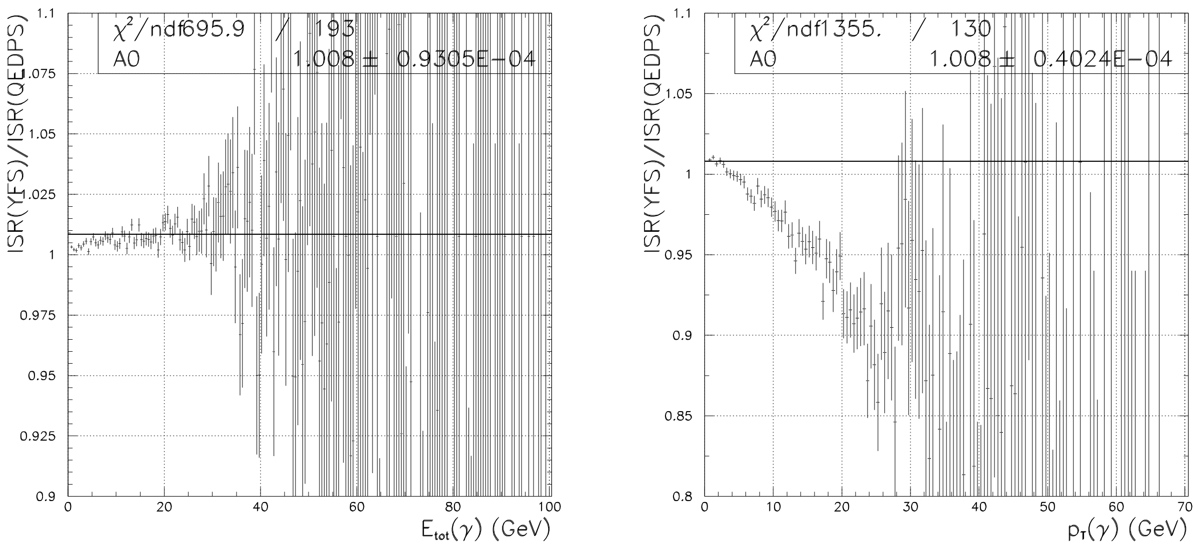

Figure 2: Ratio of the total radiated energy (left) and the total transverse momentum of the event (right) between generators implementing YFS and QEDPS as radiators. The plots are fitted with straight lines.

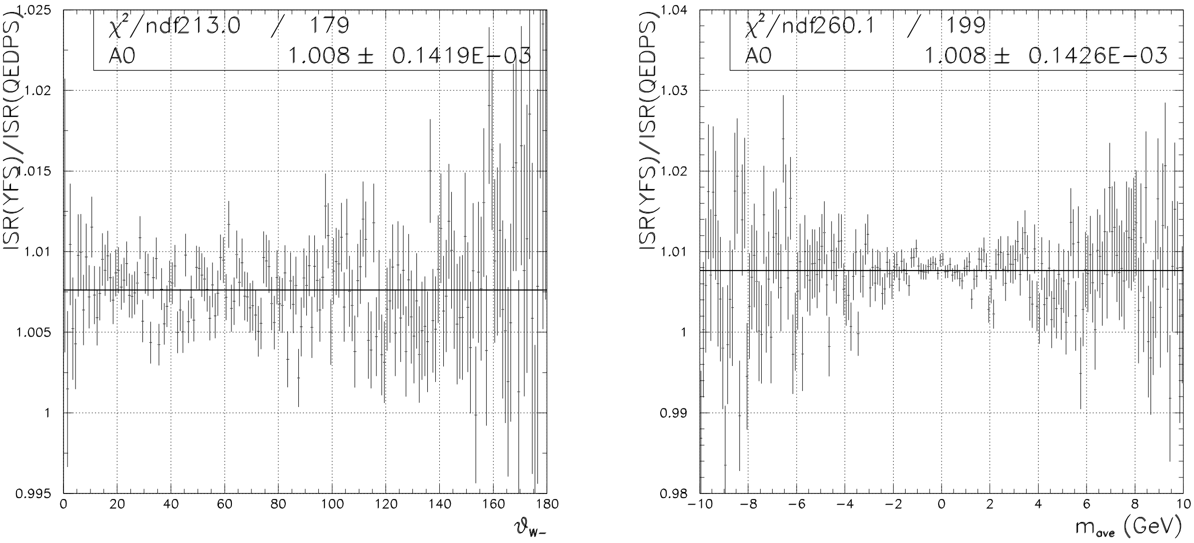

Figure 3: Ratio of W polar angle distributions (left) and difference between nominal and average W mass in the event (right) between generators implementing YFS and QEDPS as radiator. The plots are fitted with straight lines.

knowledge of the ISR shape does not enter directly in the distributions, but can only enter via the non perfect reproduction of the event boost in the kinematic reconstruction of the event (for instance through a constrained fit). Therefore it is not surprising to find small systematic errors on the measurements when changing ISR calculation, which in any case are related to the description of only part of the radiation.

4 The effects of DPA on distributions

Distortions in differential distributions induced by $\mathcal{O}(\alpha)$ corrections are investigated by comparing KoralW and YFSWW in their best settings. The two codes basically differ for the inclusion of the non leading part of the ISR (i.e. photons radiated from Ws) and for the approximate inclusion of the non factorisable corrections, correlating initial and final state and the decay of the two W bosons. The results obtained in this way can be confirmed by the comparison between two different DPA codes; this further check will be described with more details in section 6. The differential distributions chosen for the comparison are the W mass and momentum (or boost) and its polar angle. These observables are the most sensitive to radiation and are of fundamental importance for the characterisation of a WW event. The comparison also deals with quantities related to the radiation in the event. The statistics used for the distribution and the precision achieved in these comparisons are the one already reported in table 1.

- **Radiation**: given the inclusion of extra corrections in YFSWW, a different behaviour of the radiation in the two codes is to be expected. Figure 4 shows the distributions of KoralW, YFSWW and their ratio of the total photon energy radiated below two degrees from the beam pipe (ISR energy) and the total photon

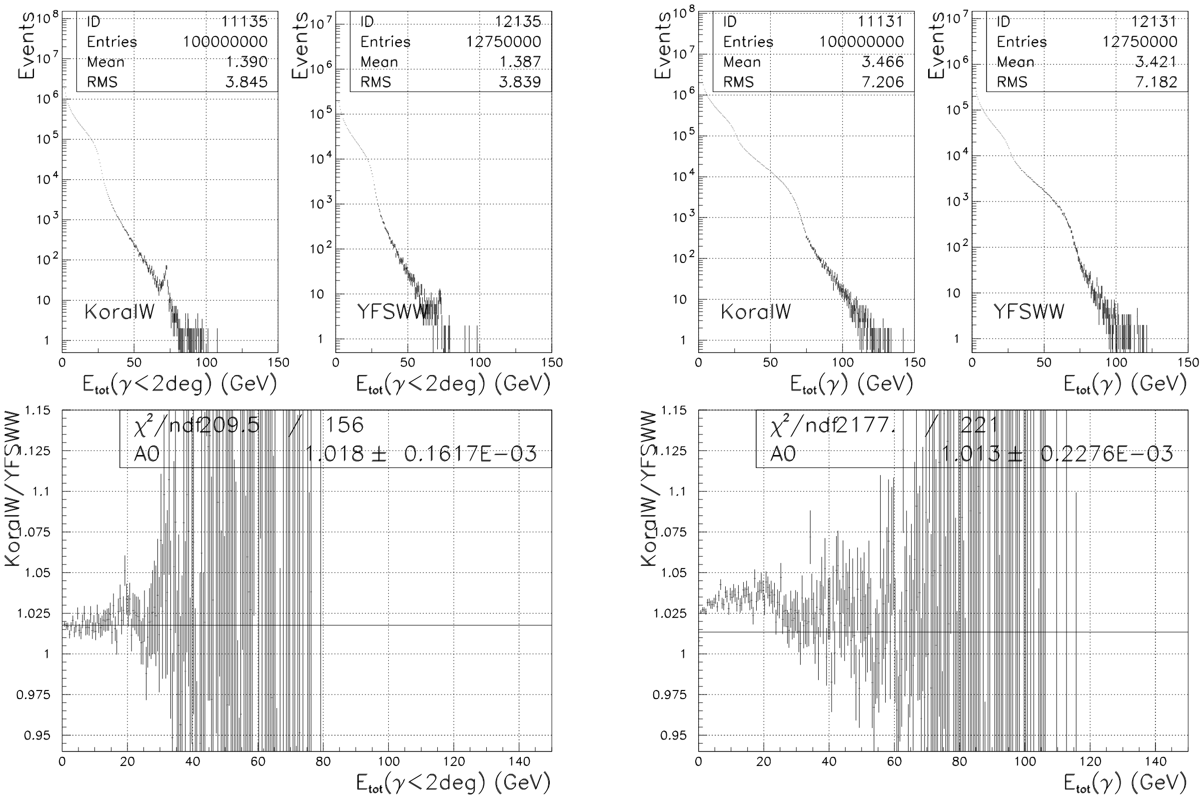

Figure 4: KoralW and YFSWW comparison for ISR-like radiated energy (left) and total radiated energy (right). The lower plots show the ratio between the two distributions, fitted with a straight line.

energy radiated in the event. The ratios are fitted with a constant term, whose value represent then the ratio between the total cross-sections. As expected, the collinear part is compatible since the radiator is the same, the ratio varying only for the overall cross-section scale. On the contrary differences arise at small energies where KoralW underestimates the total radiated energy; this discrepancy is anyway limited since the averages of the two spectra only differ by 40 MeV. The important question is to verify if these differences have also effects directly on the observables to be experimentally measured.

- **W mass**: Radiative corrections could have an impact on the reconstructed fermion masses as well. Figure 5 shows the distribution of the difference between the average event mass, determined from the fermion masses from a W decay, and the nominal W mass. In the figures the distributions from KoralW, YFSWW and the ratio are shown, for different ranges of the mass. The ratio clearly indicates a change of the trend at the double pole, which is a tipical signature of an interference effect. From the right-hand plot it can be seen that the difference in the average of the distributions in the 10 GeV range around the pole is 20.0 ± 0.7 MeV. This is not simply a shift in the W mass, since a fit of a relativistic Breit-Wigner to the histogram gives a W mass value which differs from the nominal one by 5 MeV only.

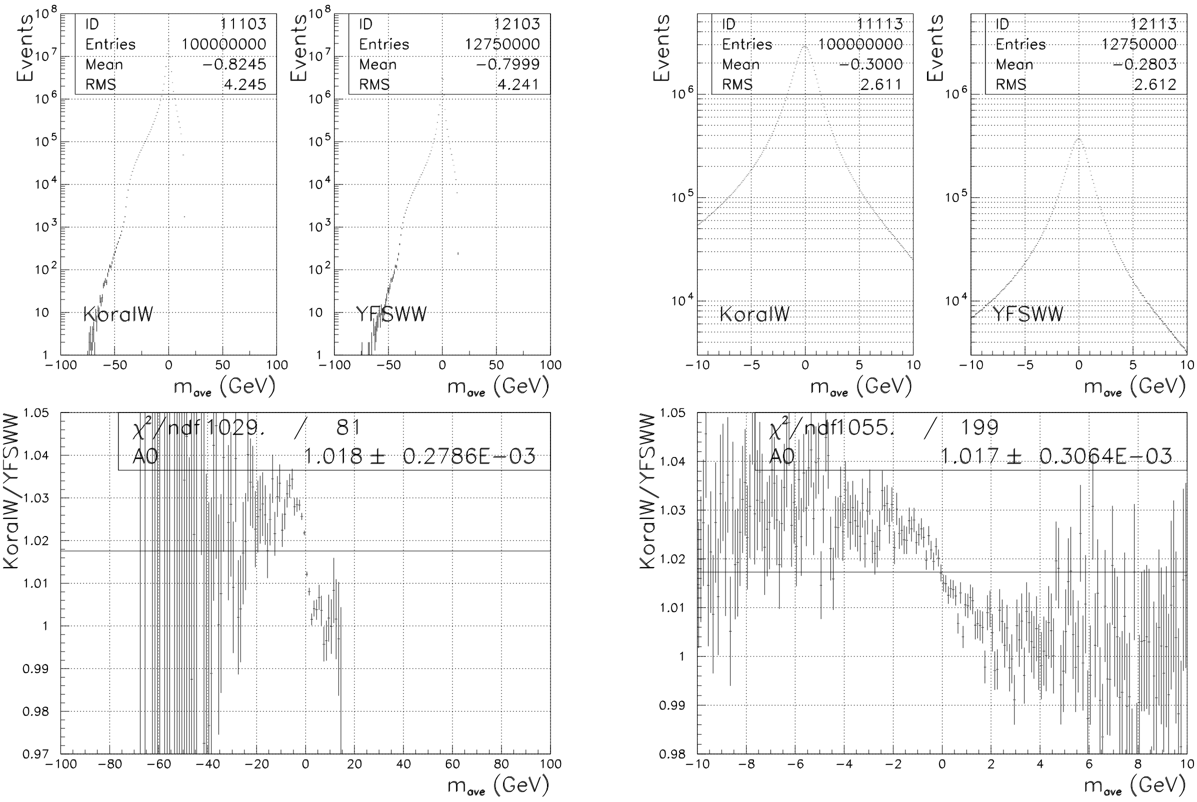

Figure 5: KoralW and YFSWW comparison for the difference between the nominal W mass and the average difermion invariant mass in the event for two different mass ranges. The lower plots show the ratio between the two distributions, fitted with a straight line.

Therefore the introduction of more complete radiative correction distorts the whole mass spectrum towards higher mass values, having an effect on the width of the W as well. We will investigate in the next section with more details what is the cause for this relevant distortion of the mass spectra.

- **W boost**: given the distortion of the mass spectra, a change in the distribution of the W momenta is to be expected as well. In figure 6 the comparison between the generators with and without DPA is shown for the W boost, defined as p_W/E_W. The relative difference between the two codes is of the order of 1% and DPA induces a narrowing of the momentum distribution of about 0.5%.

- **W polar angle**: this is the variable which is affected by DPA in the most spectacular -and dangerous- way. The big difference shown in figure 7 corresponds to a net 2% tilt in the angular distribution, basically due to hard photon emission from the Ws, radiation which has never been taken into account in LEP generators before. This effect can cause significant changes in the analysis performance and introduces big systematic shifts to those measurements which are very sensitive to the W production polar angle, like the anomalous triple gauge couplings measurements.

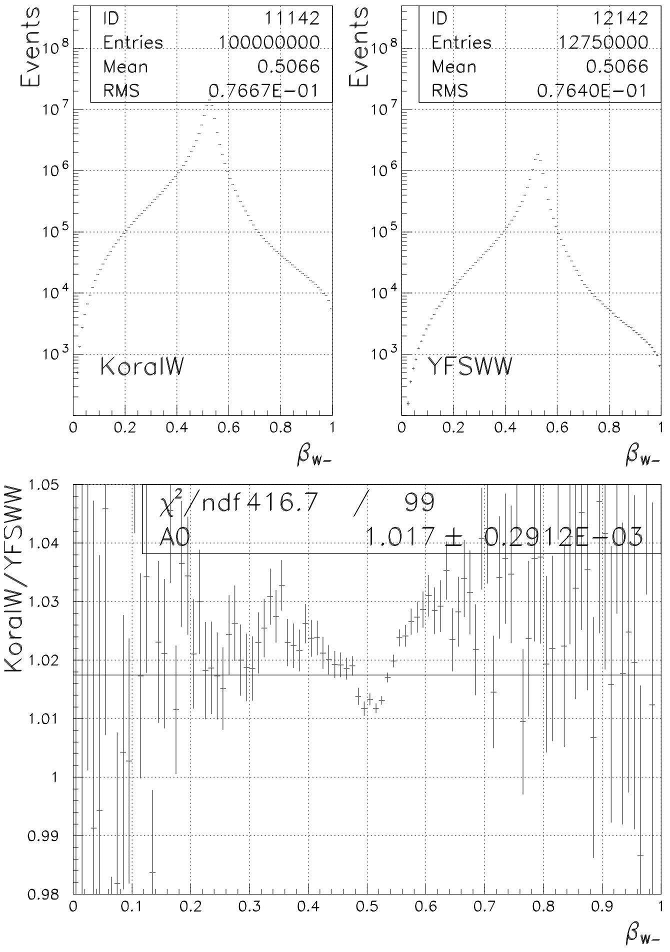

Figure 6: KoralW and YFSWW comparison for the W boost. The lower plot shows the ratio between the two distributions, fitted with a straight line.

5 The effect of non factorisable radiative corrections

One of the advantages of using YFSWW for our comparisons with non-DPA calculations is that it is possible to separately investigate the effects, on distributions, of different parts of the $\mathcal{O}(\alpha)$ corrections. In order to understand whether the distortions in the mass distributions are simply due to the non factorisable corrections, which link the two W systems, the same implementation of the Khoze-Chapovsky Coulomb screening was plugged inside the WPHACT program and the comparison on distributions repeated. Hints of possible spectra distortions or mass shifts due to this kind of screening are already suggested in [5]. Figure 8 shows the new comparison between YFSWW and the modified version of WPHACT. It is possible to notice that the distortion in mass is completely disappeared, the spectra being now compatible within the -small- statistical errors. On the other hand the effect on the momenta is increased, resulting now in a relative increase of the W boosts of 0.08%, corresponding to a 25 MeV momentum shift at a constant typical energy. Basically unchanged is the situation of the polar angle distributions. This

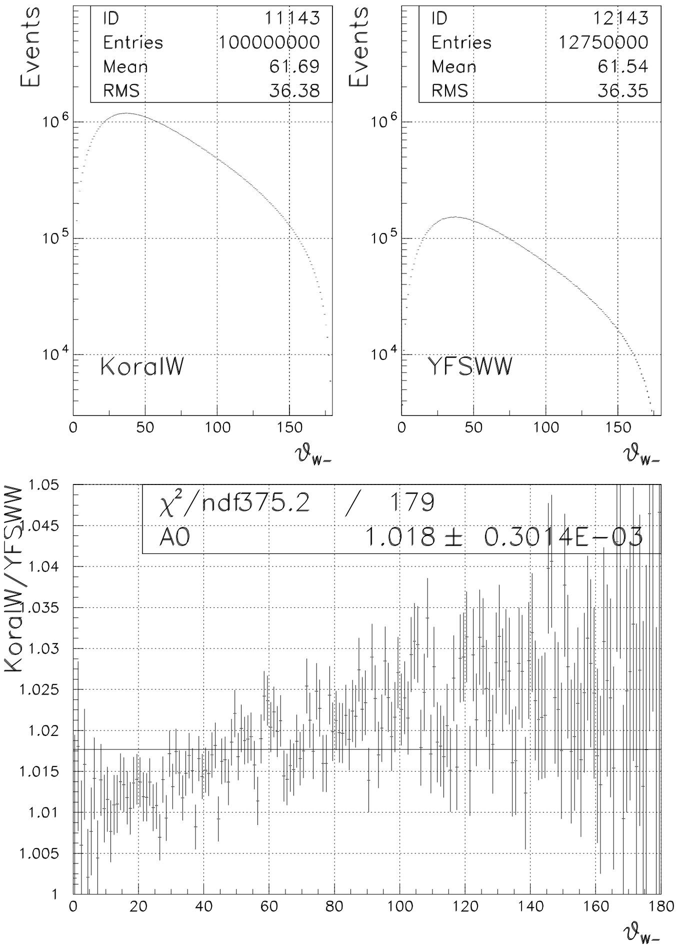

Figure 7: KoralW and YFSWW comparison for the W polar angle distribution. The lower plot shows the ratio between the two distributions, fitted with a straight line.

result leads to the important -and expected- conclusion that the main effect on the mass distributions is induced by those corrections involving photons which connect the two W systems, representing a momentum transfer between the two. This is a sort of electroweak reconnection never accounted for in the LEP2 analyses. The W angular distribution are, on the contrary, more influenced by hard real photon emission from the W themselves.

6 RacoonWW and YFSWW

The distributions obtained up to now are based on the comparisons between the "standard" LEP2 codes and YFSWW. It is very important to confirm with another code like RacoonWW, where the DPA approach is more rigorous, the same conclusions. In order to realize a tuned comparison between the two generators it was necessary to set the W width fixed in YFSWW, given that, for reasons of gauge invariance, the width cannot be s-dependent in DPA calculations. Also the same angular cuts on final charged fermions

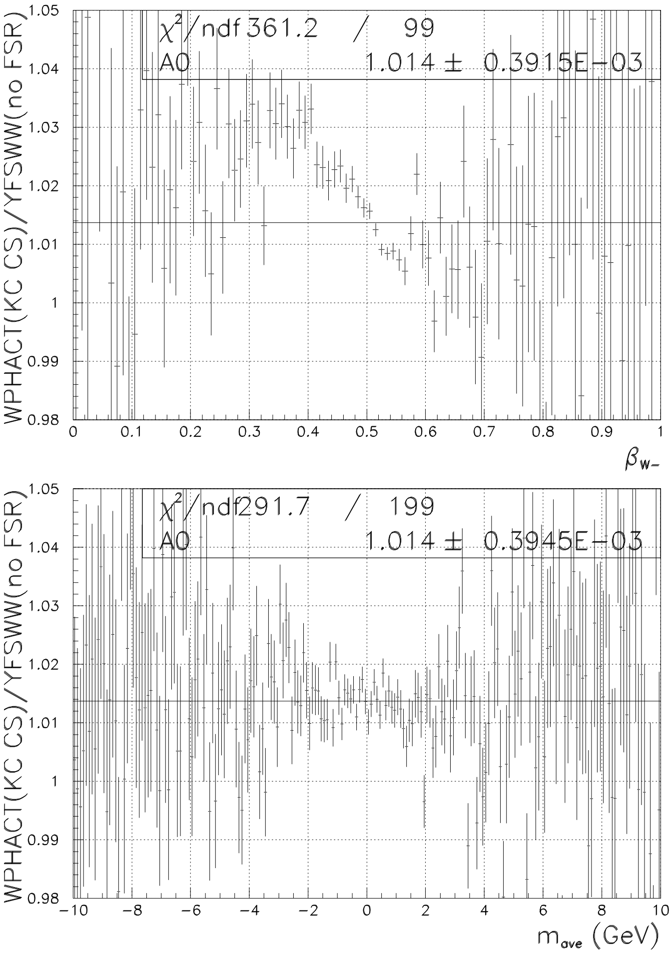

Figure 8: Ratio of the distributions of the W boost (upper plot) and the average W mass (lower plot) computed with WPHACT with the non-factorisable virtual corrections implemented via the Khoze-Chapovsky screening and YFSWW without FSR. The plots are fitted with straight lines.

were applied and the same bare photon recombination scheme used. This scheme consists in considering the emitted photons visible only if their polar angle is at least 2 degrees away from the beam pipe direction and to recombine the photon four-momentum to the closest fermion whenever its energy is below 300 MeV or the mass with the fermion below 5 GeV. The average invariant mass distributions from YFSWW and RacoonWW are shown in figure 9. The ratio is compatible with unity within the theoretical error of DPA; a small structure around the pole could still be justified by the approximate implementation of the non-factorisable corrections inside YFSWW. Anyhow in the right-hand plot the fit of the distributions to relativistic Breit-Wigners shows an excellent agreement of the fitted masses (within 1 MeV) and a very reduced effect on the fitted value of the W width (order of 10 MeV). Also the boost distributions, shown in figure 10, are in reasonable agreement between the two codes. Figures 11 show the polar angles of the Ws with respect to the same charge initial fermion and a remarkable agreement in the

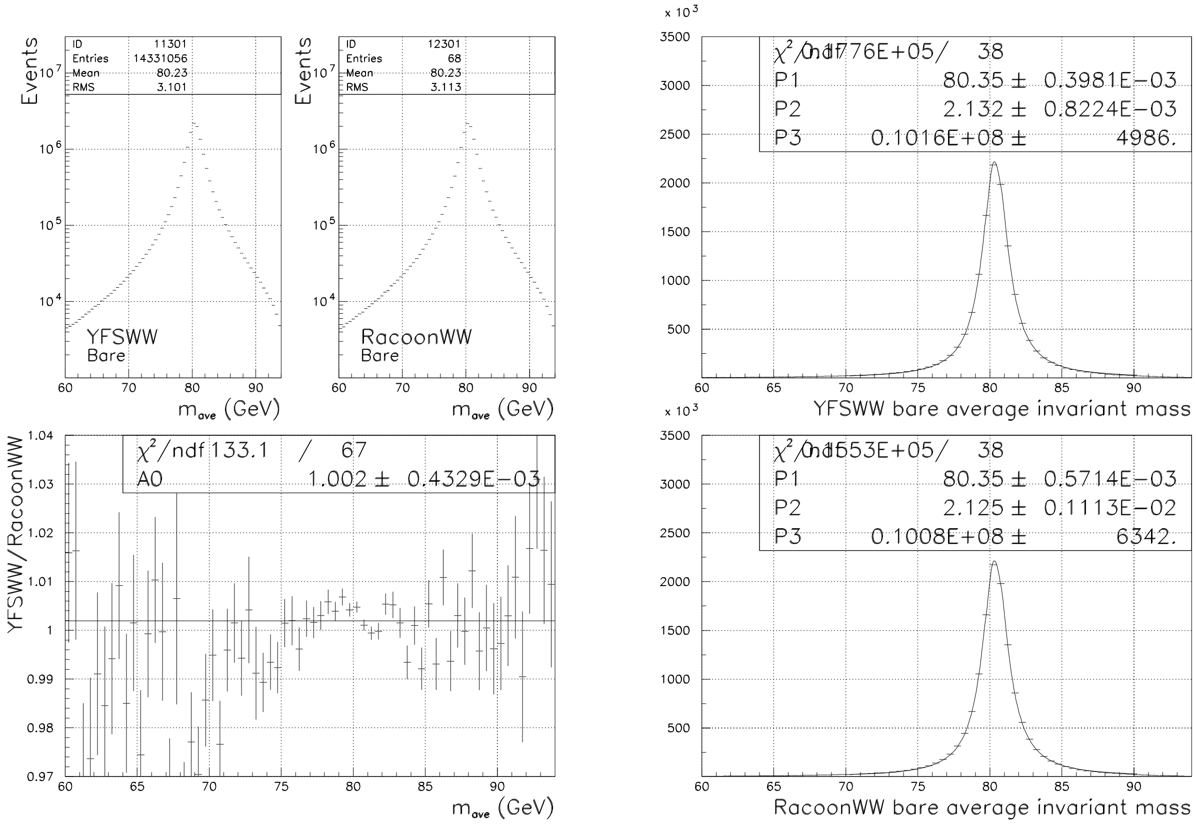

Figure 9: Comparison between YFSWW and RacoonWW average W mass distributions (left) anf fit of the distributions with a relativistic Breit-Wigner (rigt).

whole angular region is visible. This essentially confirms the distortions with respect to non-DPA calculations.

The last important things to be compared are the properties of the real emitted photon(s) in the event. The plots in figure 12 show the comparison between the two codes for the energy and the polar angle of the visible photons -after the photon recombination-, correctly normalised to the total number of photons in the event (since RacoonWW has always only one photon whereas YFSWW has a variable number). As one could expect, major differences (up to 20%) can be seen in the hard part of the spectrum and for collinear photons. This is explained by the different implementation of the extra radiative correction by the two codes: for RacoonWW the exact $\mathcal{O}(\alpha)$ in the production and decay phase is taken into account, extended to $\mathcal{O}(\alpha^3)$ for collinear ISR via SF. KoralW, on the contrary, includes ISR LL $\mathcal{O}(\alpha^3)$ via YFS and FSR LL $\mathcal{O}(\alpha^2)$ via PHOTOS. Therefore one can expect the two calculations to be more trustable in different regions of the photon phase space: RacoonWW is for sure more reliable in the hard, high p_T, regions, where matrix elements are known to be correct, whereas YFSWW might give a better description of the (collinear) multiphoton radiation at low p_T.

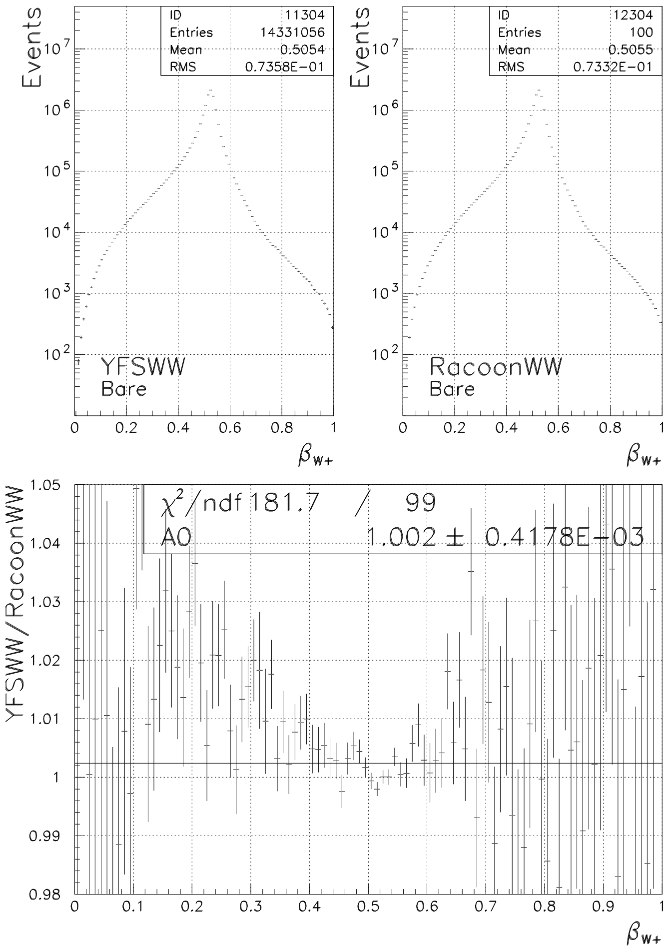

Figure 10: YFSWW and RacoonWW comparison for the W boost. The lower plot shows the ratio between the two distributions, fitted with a straight line.

7 ADLO cuts and photon recombination

To study possible interplays between the effect of the new DPA approach on distributions and experimental cuts (including the recombination of photons to fermions, mandatory when in presence of jets, for instance), the same comparisons were done when in presence of ADLO like cuts. They are summarised here:

- jets (quarks) are visible everywhere, if their energy is greater than 5 GeV
- charged leptons are required to have an angle of at least 10 degrees from the beams and an energy greater than 5 GeV
- the invariant mass of a lepton and any quark is required to be above 10 GeV
- the invariant mass of any couple of quarks is required to be above 30 GeV
- photons are visible if they have energy above 300 MeV and polar angle between 2 and 178 degrees

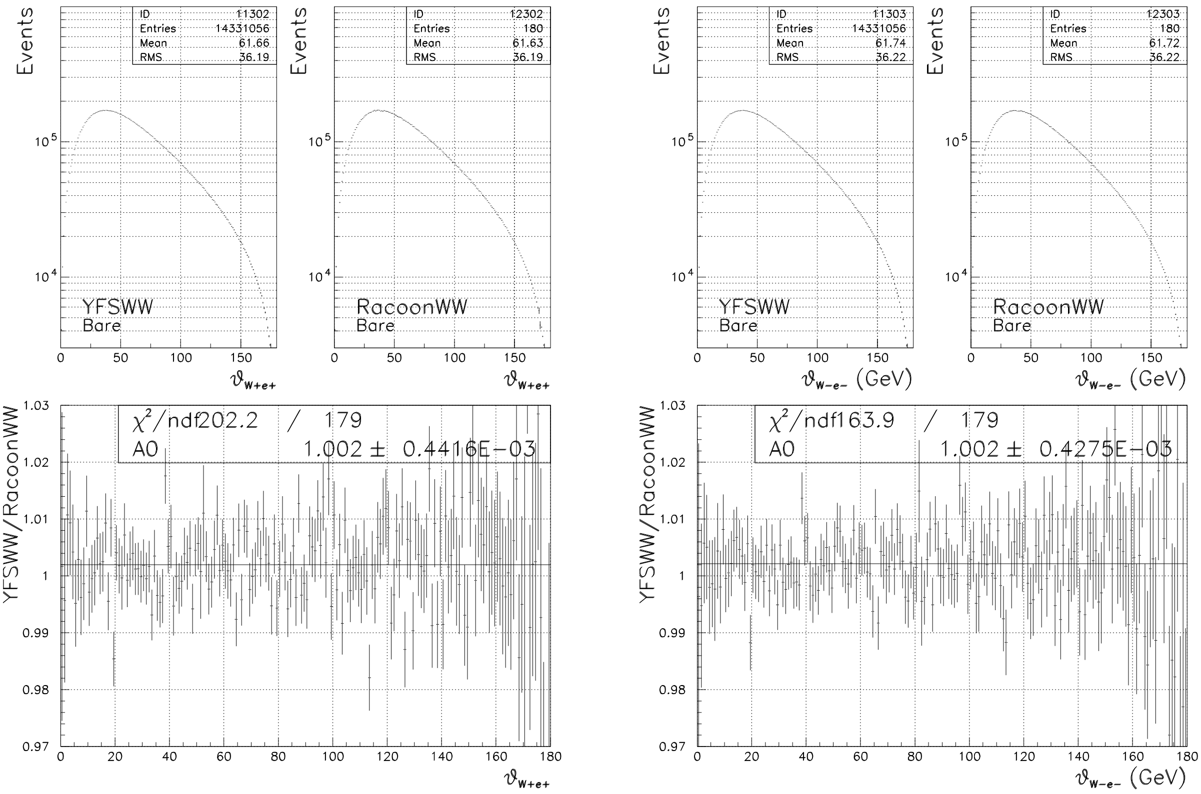

Figure 11: YFSWW and RacoonWW comparisons for the W polar angles with respect to the same charge initial fermion. The lower plots show the ratio between the two distributions, fitted with a straight line.

- photons are non-distinguishable from a quark if their invariant mass is below 10 GeV and non-distinguishable from an electron if they form an angle lower than 5 degrees. In these cases the photon four-momentum is reassociated to the fermion.

The application of the ADLO cuts and the photon reassociation brings a negligible effect on the W angular and momentum distribution, whereas the invariant mass reconstruction is affected. Figure 13 shows the comparison between KoralW and YFSWW for the leptonic and hadronic invariant masses in generated $u\bar{d}\mu\bar{\nu}_\mu$ events, with and without the experimental cuts. What can be noticed is that, where the photon recombination takes place (in the hadronic part), the difference in the reconstructed W mass is decreased by almost 50%. This is of course to be expected since the photons become indistinguishable from the quark and are reassociated to it. In this respect it is clear that it is very hard to reach any conclusion, in the invariant mass reconstruction effect of DPA, from a pure generator study and that a more detailed analysis at full reconstruction level is mandatory. These preliminary studies also tend to point towards an effect of radiation which is different in hadronic and leptonic events. The resulting systematic uncertainties could then be channel dependent.

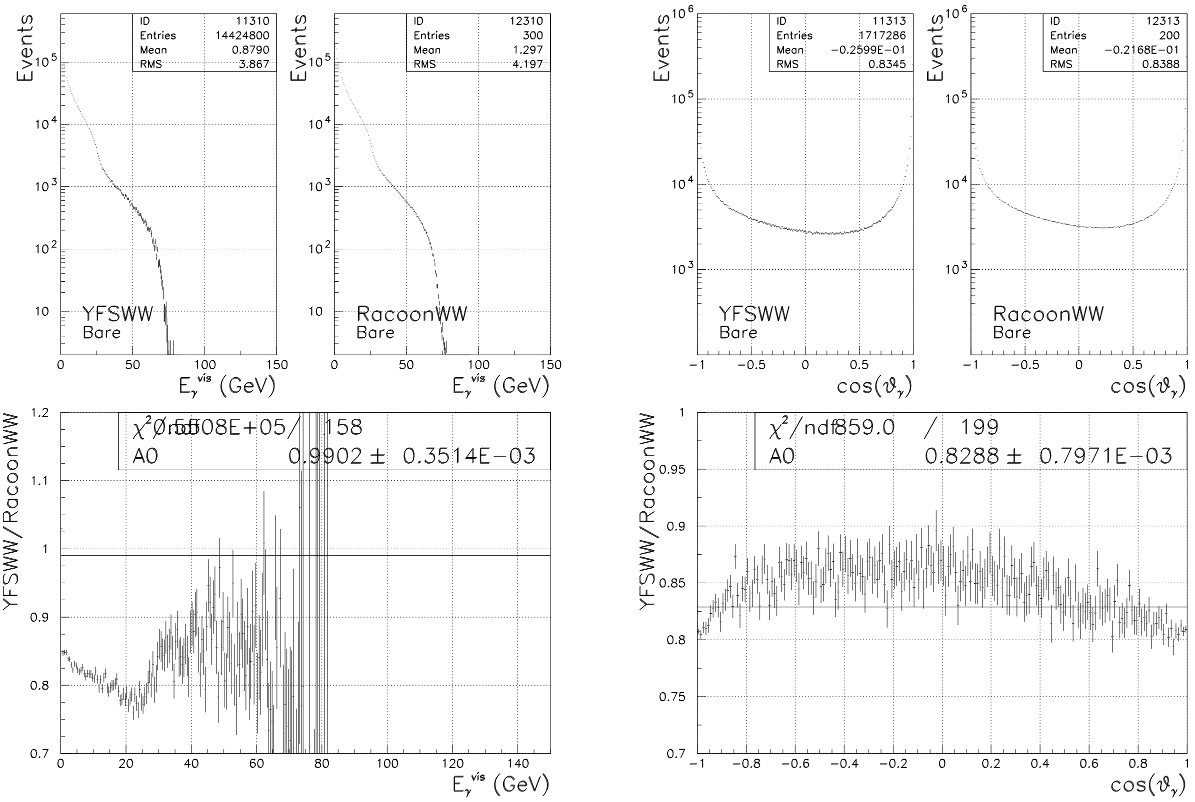

Figure 12: YFSWW and RacoonWW comparison for the energy (left) and the cosine of the polar angle (right) of the visible photons. The lower plots show the ratio between the two distributions, fitted with a straight line.

8 Systematic errors

These comparisons at generator level put in a new light the systematic errors due to EW radiation. The more precise knowledge of radiative corrections tells us that the real effect of not having the exact $\mathcal{O}(\alpha)$ in our CC03 generators was basically unknown before and not even correctly estimated. The results presented here should convince ourselves that it is necessary to use these new codes for a sound Montecarlo generation that aims to precision measurements, but still it leaves open the problem of how to assess the new systematic error due to it. This problem is also enhanced by the fact that now the theoretical uncertainties on the radiative corrections are expected to be very much dependent upon the region of the phase space one is looking at; therefore the systematic effects will also have to be considered at differential distribution level. The new systematic sources can be divided basically into two categories:

- **implementation of DPA**: the corrections $\mathcal{O}(\alpha)$ in DPA are implemented in the codes in widely different ways, including certain approximations as we have seen. The effect, on differential distributions, of different technical realisations of DPA have already been studied by the RacoonWW group [1], bringing an effect well within a few permill. However, from the experimental point of view, it is safer to

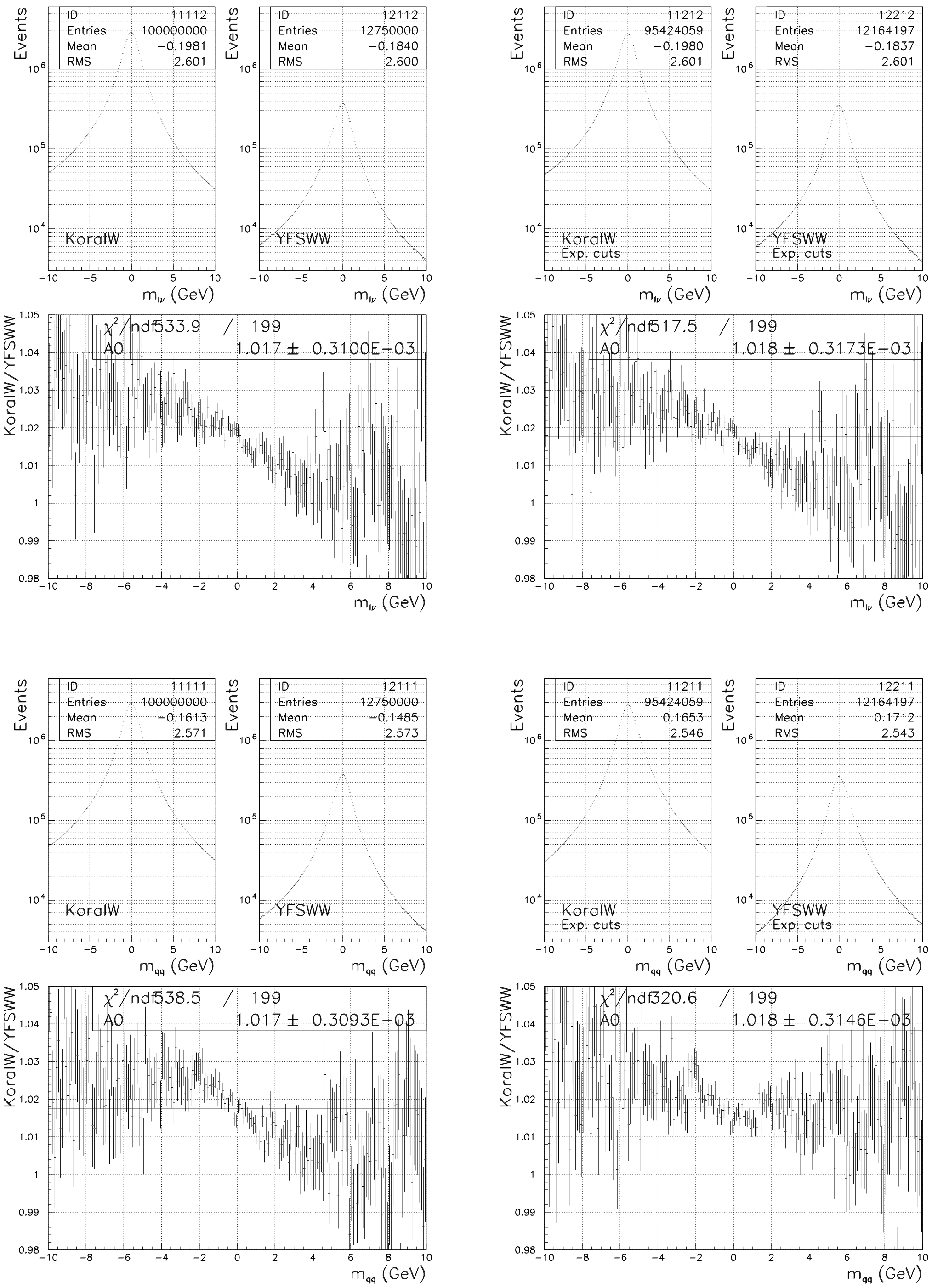

Figure 13: KoralW and YFSWW comparison for the $\mu\bar{\nu_\mu}$ invariant mass (upper figures) and $u\bar{d}$ invariant mass (lower figures) in $u\bar{d}\mu\bar{\nu_\mu}$ events. The first column is the bare comparison, whereas the second is with the ADLO cuts and the recombination of photons to fermions applied as described in the text. The lower plots in each of the figures show the ratio between the two distributions, fitted with a straight line.

estimate this kind of systematics by comparing the results obtained with YFSWW with the ones from RacoonWW.

- **missing corrections**: the real systematics due to lack of knowledge, driven by the approximate treatment of $\mathcal{O}(\alpha)$ in 4-fermion physics and by the absence of complete corrections at higher orders. This is the proper theoretical uncertainty that the theory community has already provided for the total cross-section as a function of $\sqrt{s}$ and that we would like to have also for the most relevant differential distributions.

9 Conclusions and outlook

In this work we have studied in detail what are the effects to be expected due to the introduction of $\mathcal{O}(\alpha)$ corrections to WW physics in terms of distributions at generator level. This work completes what has been done with the LEP2MCWS and has the main aim of answering to the question whether the introduction of DPA in our generators is needed or not. DPA, known to change the total cross-section by a relative amount of almost 2%, has also very important effect on distributions. In particular DPA influences the W distributions in two ways: real photon emission from the Ws significantly changes the shape of the angular distributions, with effects up to 1.5%, whereas non-factorisable virtual corrections, especially the one linking the decay phase of the two W systems, distort the reconstructed mass distributions, shifting it towards higher mass by $\mathcal{O}(10\ \mathrm{MeV})$. In particular the first of the two effect seems independent upon the implementation of experimental cuts or photon recombination to fermions. Another important aspect of the better knowledge of radiative corrections on CC03 is the more correct treatment of real radiation, of special relevance for the correct mass reconstruction and the study of CC03 physics when in presence of hard photons (for instance in the QGC measurements). The results obtained in this work, which in part were unexpected even after the end of the LEP2MCWS, point out that neglecting higher order corrections introduces new systematic effects on our LEP2 physics precision observables, which can be in principle very relevant. This, in turn, tells us that the old way to look at systematics due to radiation simply by different implementation of ISR or FSR, is not adequate to precision CC03 physics and that a new way to consider RC systematics is needed.

10 Acknowledgements

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References

[1] E. Accomando et al., *Four-Fermion Production in Electron-Positron Collisions*, in Report of the Working Groups on precision calculations for LEP2 physics (ed. S. Jadach et al.) CERN 2000-009 (2000).

[2] A. Denner et al., Phys. Lett. **B475** (2000) 127.

[3] S. Jadach et al., **hep-ph/0007012**;
S. Jadach et al., **hep-ph/0103163**.

[4] Y. Kurihara et al., Progress of Theoretical Physics, **96** (1996), 1223

[5] A.P. Chapovsky and V.A. Khoze, Eur. Phys. J. **C9** (1999), 449.

[6] D. Bardin et al., DESY 95-167 (1995).

[7] W. Beenakker, F.A. Berends and A.P. Chapovsky, Nucl. Phys. **B548** (1999) 3.

[8] E. Barberio et al., Comput. Phys. Commun. **67** (1991), 115.

[9] E. Accomando and A. Ballestrero, Comput. Phys. Commun. **99** (1997), 270.

[10] M. Skrzypek, S. Jadach, W. Placzek and Z. Was, Comput. Phys. Commun. **94** (1996), 216.

[11] ALEPH Collaboration, EPJ **C17** (2000) 241,
DELPHI Collaboration, CERN-EP/2001-029, accepted by Phys. Lett. B,
L3 Collaboration, Phys. Lett. **B454** (1999) 386,
OPAL Collaboration, CERN-EP/2000-099, accepted by Phys. Lett. B.