Returning to Z-peak in Bhabha with a visible photon

Andrej Arbuzov[ab*]

2nd LEP2 MC workshop,
25 —26 June 1999, CERN

[a] *Dipartimento di Fisica, Università di Torino, and INFN group; via Guiria 1, I-10125 Torino, Italy*

[b] *BLTPh, Joint Institute for Nuclear Research, 141980 Dubna, Russia*

Abstract

The effect of radiative return to the Z-peak in Bhabha scattering is studied by means of a new Monte Carlo event generator `LABSMC`. Events with a visible initial state radiation photon are considered. The results are compared with other theoretical predictions and preliminary experimental data.

1 Motivation

At the first LEP2 Monte Carlo workshop a comparison (see Table 1) of the preliminary experimental data and theoretical prediction obtained by means of the `BHWIDE` [1] event generator was presented [2]. The process under consideration is Bhabha scattering with detection of a radiated hard photon:

$$e^+ \ + \ e^- \ \longrightarrow \ e^+ \ + \ e^- \ + \ \gamma \ + \ (n\gamma). \tag{1}$$

For definition of cuts and event selection conditions see Sect. 3 below.

Table 1: Comparison of data with `BHWIDE` prediction.

Cuts	all data	all `BHWIDE`	Z-peak data	Z-peak `BHWIDE`
1+2	231	227.1	25	11.29
1+2+3	47	50.4	14	3.21

In spite of the pure present statistics, the disagreement seems to be too large to be explained by fluctuations. Meanwhile, the analysis of events with radiative returning to the

*e-mail: arbuzov@to.infn.it

Z-peak (especially with a visible hard photon) is relevant for searches for new physics and anomalous gauge boson couplings, in particular.

The aim of our small study is to perform an independent analysis of the events and to estimate the contribution of radiative corrections (RC) to the measured cross section. For this purpose we used a new Monte Carlo event generator `LABSMC`.

2 LABSMC Monte Carlo

Initially the `LABSMC` event generator [3] was developed to simulate large–angle Bhabha scattering at energies of about a few GeV's at electron positron colliders like VEPP–2M, DAΦNE, *etc.* The code included the Born level matrix element, the complete set of $\mathcal{O}(\alpha)$ QED RC, and the higher order leading logarithmic RC by means of the electron structure functions. The relevant set of formulae can be found in Ref. [4]. The generation of events is performed using an original algorithm, which combines advantages of semi–analytical programs and Monte Carlo generators.

In order to consider higher energies a set of electroweak effects was included [5, 6, 7]. The Born level cross section in the program contains now both the photon and Z-boson exchange contributions (it is used also as a kernel cross section for higher order leading log RC). The first order virtual and soft EW RC were taken directly from the semi-analytical code `ALIBABA` [6]. The EW matrix element for radiative Bhabha is taken from Ref. [7]. A comparison of the Bhabha cross-section integrated over photons is in a reasonably good agreement (see Table 2) with the published numbers of other codes [8], including `BHWIDE` [1].

Table 2: A shortened comparison with Fig. 21 from Ref. [8]

E_{cm}, GeV	`BHWIDE`	`TOPAZ0`	`BHAGENE3`	`UNIBAB`	`SABSPV`	`BHAGEN95`	`LABSMC`
175	35.3	35.5	34.7	34.5	35.7	35.8	35.7
190	29.9	30.0	28.8	29.2	30.3	30.4	30.2
205	25.6	25.7	24.7	25.0	26.0	26.0	25.8

The pure tree level matrix element for radiative process (1) was supplemented by radiative corrections due to initial state soft and hard collinear radiation by means of the structure function approach [9] (the corresponding result is in the last column). The reason, why the ISR corrections decrease the ratio is clear: they decrease the peak with M_{ee} close to E_{cm} and do not affect so much on the Z-peak region. The effect of vacuum polarization to the virtual photon propagator is also taken into account. It gives a positive shift to the ratio, because it increases the contribution of the t-channel photon exchange and does not affect on the contribution with s-channel Z-exchange, which is responsible for the returning to the peak.

3 Results

The event generator was run at the centre–of–mass energy 184 GeV. Events were selected according to the following criteria. Two high energy e-γ clusters were assumed to be separated, when the opening angle is greater than 5°. In the event selection described below, any e-e or e-γ pair is required to be separated by more than 25.8° (cos(opening angle) < 0.90). The events in the Z-peak region are defined as ones with the invariant mass of electron–positron pair in the range

$$85 \; < \; M_{ee} \; < \; 95 \text{ GeV}. \tag{2}$$

Cut 1. Final state with two identified electrons and one photon. The two electrons must each have a transverse momentum greater that 1.0 GeV, and the photon must have an energy greater than 1.0 GeV. Each electron must satisfy $|\cos\theta| < 0.90$, and the photon must satisfy $|\cos\theta| < 0.95$.

Cut 2. The sum of the energies of the two electrons and the photon must be greater than $0.8E_{cm}$.

Cut 3. The photon must satisfy $|\cos\theta| < 0.70$, and at least one of the two electrons must satisfy $|\cos\theta| < 0.70$

In Table 3 we present the ratio R of the total number of events, satisfying the conditions, to the part of it, lying in the Z-peak region (2).

Table 3: R values for different cut selections.

	data	`BHWIDE`	`LABSMC`		
Cuts			w/o RC	vac. pol.	vac. pol. + ISR
1+2	9.24	20.1	14.6	16.5	15.2
1+2+3	3.36	15.6	9.4	10.5	9.9

Note, that we supposed that processing of events through a detector simulator does not change the distribution in the ee mass considerably. But one can see from the figures [2], that the experimental point in the region of M_{ee} close to E_{cm} are not stable, they seemed to be affected by detector efficiencies, misinterpretations, etc. So, we are going to process the events generated by `LABSMC` through the detector simulation program.

4 Conclusions

- There is a new **L**arge–**A**ngle **B**habha **S**cattering **M**onte **C**arlo event generator.
- Checks of the code and comparisons are in progress.
- Returning to the Z-peak in radiative and inclusive Bhabha scattering should be considered separately.
- The process with a visible photon requires further experimental and theoretical investigation.
- *New physica* could contribute to the process, but, probably not so much, to explain the present disagreement.

- Radiative processes with tagged photons are very attractive, but more difficult to study.

References

[1] S. Jadach, W. Placzek, B.F.L. Ward, Phys. Lett. **B 390** (1997) 298;
W. Placzek et al., preprint CERN-TH/99-07, Geneva, 1997; hep-ph/9903381.

[2] see the copy of transparencies of P. Bambade at www.dft.unito.it/ giampier/lep2.html

[3] A.B. Arbuzov, `LABSMC` code, write–up in preparation.

[4] A.B. Arbuzov *et al.*, JHEP 10 (1997) 001.

[5] M. Böhm, A. Denner, and W. Hollik, Nucl. Phys. **B 304** (1988) 687.

[6] W. Beenakker, F.A. Berends, S.C. van der Marck, Nucl. Phys. **B349** (1991) 323;

[7] F.A. Berends, R. Kleiss, W. Hollik, Nucl. Phys. **B 304** (1988) 712.

[8] H. Anlauf *et al.*, S. Jadach, O. Nicrosini (convenors), CERN Yellow Report 96-01, vol. 2, 1996, p.229.

[9] E.A. Kuraev, V.S. Fadin, Sov. J. Nucl. Phys. **41** (1985) 466.