Simulation of Physics Background for Luminosity Measurement at ILC

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In order to exploit the full ILC potential for precise measurements and having in mind that uncertainty of luminosity is affecting them as a systematic effect, the precision goal for luminosity measurement is set to be of order of 10^{-4}. To achieve such a precision, very good understanding of physics background is essential. A study of four-lepton and W-pair processes has been initiated, not only as a possible background for luminosity measurement, but in terms of design optimization of the Very Forward Calorimetry as well. At the same time it is a test if the existing fast simulation tools (SIMDET) can be used for physics studies in the region below 5 degrees in polar angle or one should rely on a more detailed detector description such as BRAHMS.

1. INTRODUCTION

Precise measurements from the Z line-shape (GigaZ program) set the precision goal that uncertainty of luminosity must be as small as 10^{-4}. The Luminosity Calorimeter (LumiCal) will provide such a precise luminosity measurement from counting of the reconstructed Bhabha events in the range of polar angle between 26 and 82 mrad. Due to the fact that Bhabha cross section falls steeply as a function of the polar angle, the most of Bhabha events will be produced in the region covered by the Beam Calorimeter (BeamCal), that is between 4 and 28 mrad. This is illustrated on Figure 1, with Bhabha cross section distributions (in pb) over the BeamCal and Lumi Cal acceptance region. Bhabha scattering events are generated with BHWIDE [1] simulation package.

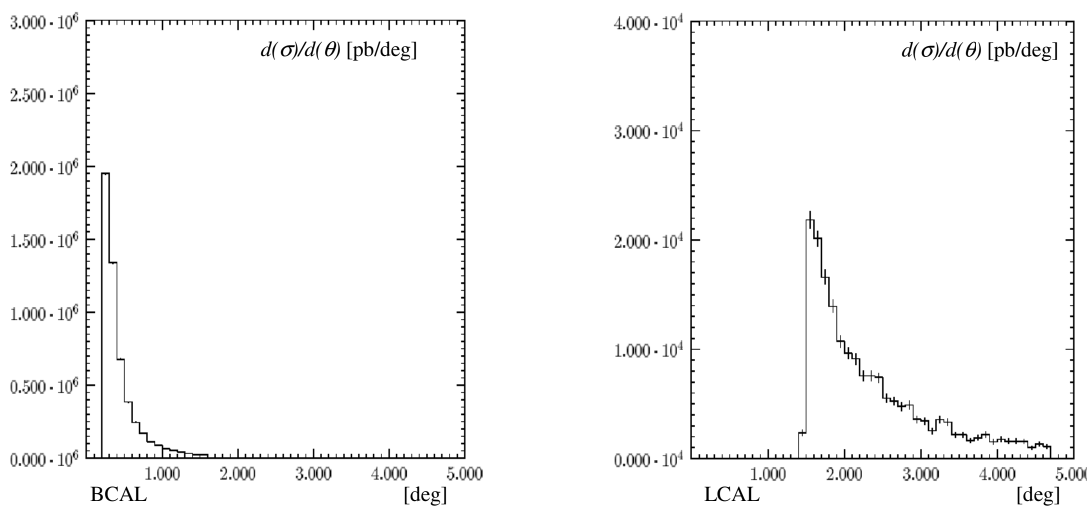

Figure 1: Cross section distributions of Bhabha events generated in the BeamCal and LumiCal acceptance region

Similar distributions have been studied at the generator level (PYTHIA [2], WHIZARD [3]) for potential background processes: W-pair and four-lepton production, at 500 GeV center of mass energy. Both processes are known to be strongly peaked forward, with cross sections that scale like *1/s* and $ln^2(s)$ respectively. At this stage, comparison between signal and background is going to be discussed at the generator level only.

2. W-PAIR AND FOUR-LEPTON PROCESSES

2.1. Event samples

With PYTHIAwe have generated 10^5 W pairs and allow them to decay leptonicaly.

In order to generate leptons from the process $e^+e^- \rightarrow e^+e^-l^+l^-$ ($l=\mu$) we used WHIZARD event generator, assuming event generation through the all contributions from neutral current processes. The sample of 10^4 events has been generated with the cross section of (4.107 ± 0.001) pb, where the main contribution to the cross section comes from the multiperipheral two-photon exchange.

The sample of 10^5 Bhabha events has been used as a signal for luminosity measurement.

All the comparisons have been made without any assumptions on detector or reconstruction efficiencies.

2.2. Comparison to the signal

Distributions of energy to be deposited in the Beam and Luminosity Calorimeter are given on Figure 2 for both sources of background and on Figure 3 for the signal. All distributions have been properly normalized with respect to the cross sections.

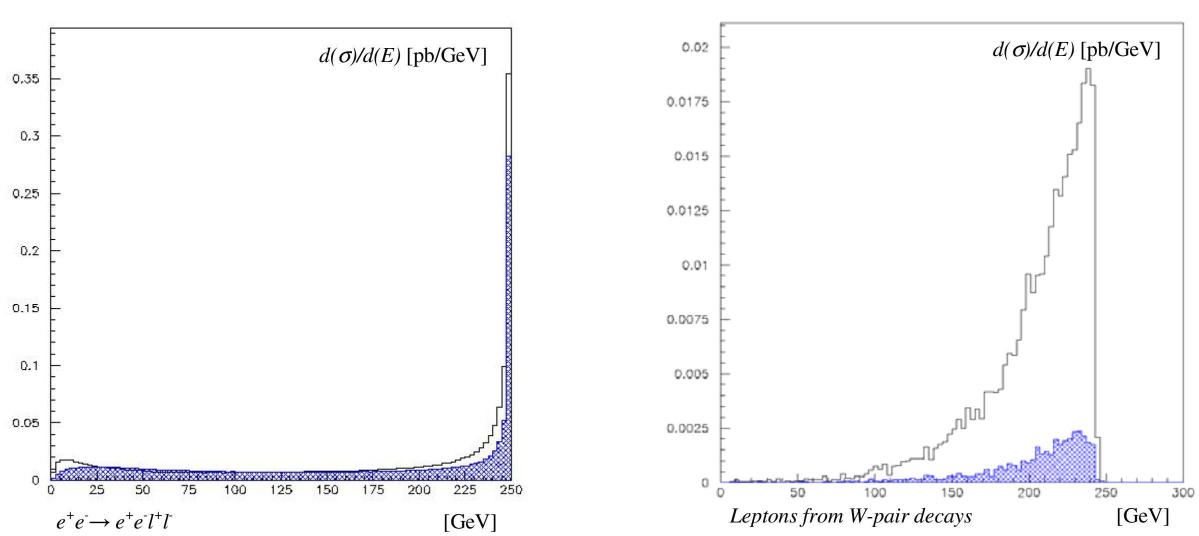

Figure 2: Lepton energy depositions in the BeamCal (hatched) and LumiCal from four-lepton and W-pair processes.

It has been found that, if no cuts applied, signal to background ratio would be $5{\cdot}10^3$ in the LumiCal region and $2{\cdot}10^5$ in the BeamCal, for four-lepton processes, while leptons from W decays would interfere the signal less then one in 10^4 in both calorimeters, due to the fact that their polar angle distribution is shifted to higher angles with respect to Bhabha electrons. Having in mind other properties of the signal and background (i.e. acolinearity or energy distributions) these ratios can be improved further, without significant loss of efficiency.

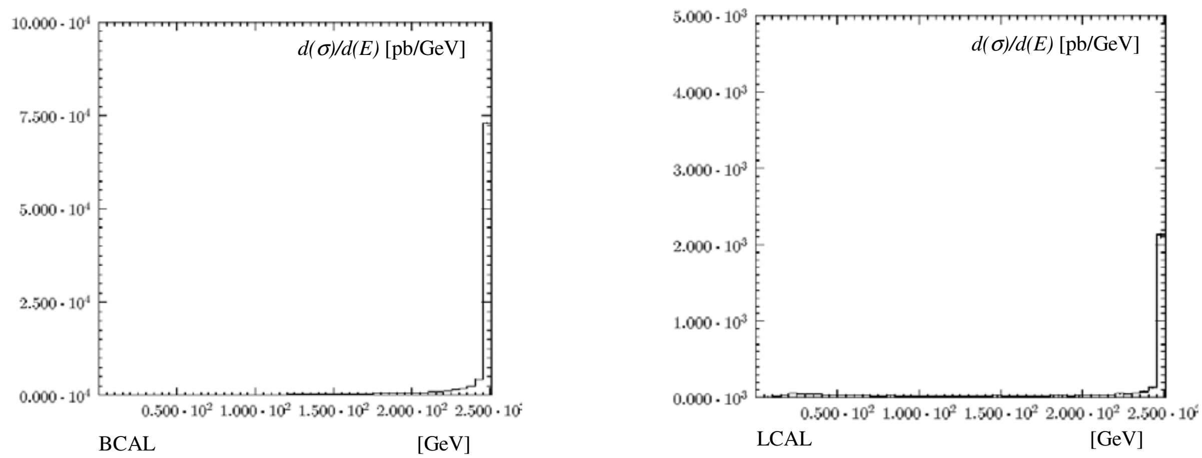

Figure 3: Energy depositions from Bhabha electrons (and positrons) in the BeamCal and LumiCal

2.3. Detector simulation

We have tried to simulate the response of the very forward detectors using the fast detector simulation package SIMDET[4], that has been widely and successfully used for physics studies at ILC, though this package has not be primarily dedicated to this purpose. It turned out that the current version 4, that includes forward calorimeters as proposed in Tesla TDR [5], can not be used for the proper description of the very forward detectors due to an artificial access of Energy Flow objects that has been observed at the LumiCal acceptance limit (around 4.5 degrees), for different event samples and different generators used. Since this is software that performed excellently in the past as a fast detector simulation, we do hope that new versions will include an updated description of the very forward region.

3. CONCLUSIONS

At the generator level, it has been shown that physics background from leptons originating from four-lepton processes via neutral current is of order of 10^{-4} in the LumiCal acceptance region and less in the BeamCal. Contribution from leptons from W-pair decays is even smaller despite the high cross-section for this process, due to the fact that they are not dominantly produced in the very forward region. Physics properties of signal and background are such to allow this ratio to be improved further by applying appropriate cuts. However, in order to make any conclusion final, detector simulation has to be introduced as well as reconstruction efficiencies for both signal and background. At that stage it would be clear if physics background from these processes could influence requirements from the design of the Very Forward Calorimeters and the required precision of luminosity measurement.

References

[1] S. Jadach, W. Placzek, B. F. L. Ward, BHWIDE A Monte Carlo Event Generator for Bhabha Scattering at Large Angles with O(alpha) YFS Exponentiation, Version 1.04.

[2] T. Sjostrand, L. Lonnblad, PYTHIA Version 6.2 (PYTHIA Physics and Manual V6.1, hep-ph/0108264).

[3] W. Kilian, WHIZARD 1.40 A generic Monte Carlo integration and event generation package for multi-particle processes (LC-tool 2002-039).

[4] M. Pohl, J. Schreiber, SIMDET Version 4 A parametric Monte Carlo for a TESLA Detector, DESY 02-061, May 2002.

[5] T. Behnke, S. Bertolucci, R.-D. Heuer, R. Settles (editors), TESLA Technical Design Report, Part IV: A Detector for TESLA, DESY 2001-011, ECFA 2001-209, March 2001.