Monitoring of physics performance of ILC Software based on Higgs Recoil Mass

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Abstract. We discuss a part of ILC software development, that allow us to make automated testing of ILC results. The testing code consists of automated everyday Higgs recoil mass analysis and compares Higgs recoil mass with one of the previous day result. This code uses the result of generation, Mokka simulation and Marlin reconstruction of ILC events.

1. Introduction
The ILD detector is one of two detectors of the International Linear Collider \cite{1}, that will collide electrons and positrons at energies of initially 500 GeV, upgradeable to 1 TeV. The ILC software will consists of \approx 60 packages, developed by people in different institutes. A key task in software development is the automated testing on different levels of the process: at compile and build time, at runtime and on the results level. The first testing tasks are more technical, while the latter one relies on physics and statistics understanding.

The physics performance will be monitored via the simulation study of the Higgs boson production for processes in which the Higgs is produced together with a well measurable di-muon system using the current proposal of the ILD detector. This part of ILC software can be included in the highly builds, comparing everyday the obtained value of the Higgs recoil mass with the one of the previous day. The higgs recoil mass reconstruction was conducted based on Marlin and Mokka modeling of ILD.

More information about ILC is in \cite{2}.

2. Higgs recoil mass
The relevant process for the present study is the recoil reaction $e^+e^- \rightarrow Hz \rightarrow H\mu^+\mu^-$ (where $f$=leptons and quarks), also called Higgs-strahlung. Higgs recoil mass was reconstructed in the $Hz \rightarrow \mu^+\mu^- X$ process, because the track quality for muons is better and the $Z$-boson mass peak is more clear than for electrons \cite{3}.

All data analysed in this discussion have been produced by the GEANT4 generation ($E_{\text{cms}} = 250$ GeV), Mokka detector simulation and Marlin reconstruction. The generated Higgs boson mass is 120$GeV/c^2$. 500 $fb^{-1}$ have been reconstructed with the use of Marlin software and two different reconstruction algorithms: DBD tracking and cellular automaton \cite{4}. The final program will compare resalts of two parts with 5000 events every day. On development stage the programm reconstructed 2000 events and all interim results were showed for 2000 events.
The first step of analysis was muon tracks selection and recovery of Z-boson from two muons, and the result is shown in figure 1.

![Figure 1](image1.png)

**Figure 1.** Z-boson mass of two data parts: a) for first part of date; b) for second part of date.

The Higgs recoil mass was calculated via the relative kinematic equation:

\[
M^2_{\text{recoil}} = s + M^2_Z - 2E_Z \sqrt{s},
\]  

(1)

Then the selection of one muon pair from each event was included for peak improvement. The idea of selection is to choose a muon pair that has the most close mass to the well known Z-boson mass [5]. The results for Higgs recoil mass with muons selection are shown in figure 2.

![Figure 2](image2.png)

**Figure 2.** Higgs recoil mass with Z-boson select: a) for first part of date; b) for second part of date.

The energy of the incoming beams is smeared with an energy spread of 0.3%, that is a one of the sources of tail. The another one is initial state radiation and beamstrahlung [6].

Fit function for resulting spectra consists of Gaussian for the Peak with Gaussian and Exponent functions for tail.

Then for peak improvement the $70\text{GeV}/c^2 < M_z < 110\text{GeV}/c^2$ cut and rebin was made, and the final result for two parts of 5000 events is represented in figure 3.

This work was conducted in the framework of the DESY summer student program.
3. Conclusion
The testing code of ILC software was created and will be use in automated testing of ILC results via higgs recoil mass analyse of a lot of pairs independent parts, that will consist of 5000 events. The results of the program are shown on table 1, total error = 0.5GeV/c^2, the difference of values = 0.3GeV/c^2.

| Mean       | Err        |
|------------|------------|
| 121.9 GeV/c^2 | ±0.5GeV/c^2 |
| 122.17 GeV/c^2 | ±0.19GeV/c^2 |

The result for parts with 5000 events is shown on table 2, total error = 0.08GeV/c^2.

| Mean       | Err        |
|------------|------------|
| 120.76 GeV/c^2 | ±0.06GeV/c^2 |
| 120.76 GeV/c^2 | ±0.06GeV/c^2 |

The next step is to improve the fitting of the distribution. After that, the presented in the discussion part of ILC software can be included in the ILC software diagnostic tools.

References
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