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Request to ILD & SiD to specify their needs for Z pole calibration

ILC Parameters Joint Working Group

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Abstract

The ILC Technical Design Report documents the design for the construction of a 500 GeV linear collider, including beam parameters for its operation at centre-of-mass energies from 200 to 500 GeV, as well as for the energy upgrade to 1 TeV. The detector concepts proposed in the TDR however assume that operation at lower energies, in particular at the Z pole, will be possible for calibration purposes. However, the accelerator as proposed in the TDR is not easily operated at energies that low and would probaby need some modifications depending on the amount of Z pole data required and on the frequency of such calibrations runs. We therefore request the ILC detector concepts to quantify and justify more precisely their need for Z pole calibration runs.

1 Introduction

The ILC Technical Design Report documents the design for the construction of a 500 GeV linear collider [1], including beam parameters for centre-of-mass energies from 200 to 500 GeV as well as for the energy upgrade to 1 TeV. The detector concepts proposed in the TDR [2], however, assume that operation at lower energies, in particular at the Z pole, will be possible for calibration purposes.

However, the accelerator as proposed in the TDR is not easily operated at energies that low and would probaby need some modifications depending on the amount of Z pole data required and on the frequency of such calibrations runs. We therefore request the ILC detector concepts to quantify and justify more precisely their need for Z pole calibration runs. This request relates only to the question of Z pole calibration runs interleaved with high-energy data-taking. It is explicitely not concerned with a dedicated Z pole run for physics, aka "GigaZ". The prospects for ILC physics operation at the Z pole and the WW threshold have recently been discussed in [3].

This document is structured as follows: In the next section, we will summarize the current status of particle-based detector calibration and alignment. This will be contrasted with the challenges on the machine side in section 3, before summarizing our request.

2 Detector Calibration

For the precision physics programme of the ILC [4, 5], detectors with precisions resolutions are required. Technologies matching the resolutions requirements have been successfully developed over many years, and two detector concepts based on these technologies have been described in detail in the TDR [2].

The exquisite resolution of the ILC detectors can only be fully exploited if calibration and alignment match this precision over the whole time of ILC operation. Most subdetectors foresee a multi-layered approach, which combines pre-installation measures with in-situ techniques, e.g. based on laser-systems. These are discussed in more detail in [2]. The ultimate level of calibration and alignment can only be achieved based on particle physics quantities, e.g. by gauging energy and momentum scales against known particle masses, like Z, J/Ψ etc, or by exploiting specific kinematically over-constrained types of events, e.g. radiative Bhabhas or muon pairs. In the following, we summarize the existing ideas about for calibration samples as specified by the various subdetectors of ILD and SiD in the TDR. Similar information has already been provided in the Letter of Intents [6, 7] and their supporting notes.

2.1 Tracking

SiD expects that from normal luminosity operation, at least $\mathcal{O}(10^4)$ tracks per month could be collected even for the outer layers of the tracking system, which they expect to be suffient to do track-based alignment between push-pull moves [8]. In case of ILD, the tacking system expects to exploit frequent calibration runs on the Z pole, assuming a luminosity of about $10^{32}\,\mathrm{cm}^{-2}\mathrm{s}^{-}1$ [9], or $1\,\mathrm{pb}^{-1}$ within a few hours [10]. In particular several thousands of muon pairs in a day [11] are assumed for the pixel detector while the TPC expects $10\,\mathrm{pb}^{-1}$ on the Z pole during commissioning, plus shorter runs of $1\,\mathrm{pb}^{-}1$ during the year depending on operation conditions [9].

2.2 Calorimetry

For the MIP scale calibration, the scintillator-based ECAL expects to use muon pairs from Z pole running, which would deliver about 50 hits per cell per day, thus a couple of days would be needed [12]. For the endcaps, halo muons could be used in addition. The absolute scale of the ECAL is supposed to be determined using electrons and photons from kinematically constraint Bhabhas or radiative returns to the Z, no Z pole running required [13]. Concerning the hadronic calorimeter, the calibration procedure has been studied for the scintillator HCAL, however the gaseous options are expected to have similar requirements. In order to reach a MIP scale calibration of 3%, 1000 tracks segments identified as "MIP-like" [14] are needed per layer module. These could be obtained most efficiently at the Z pole, where $1\,\mathrm{pb}^{-1}$ would give sufficient statistics up to layer 20, while the outermost layers would need $10-20\,\mathrm{pb}^{-1}$. At 500 GeV, comparable precision requires $2\,\mathrm{fb}^{-1}$ up to layer 20 and correspondingly more for the outer layers [15].

2.3 Jet Energy Scale

In particle flow detectors like ILD and SiD, the jet energy scale depends on the calibration of basically all subdetectors plus the particle flow reconstruction algorithm itself. SiD expect to calibrate the jet energy scale from di-jet and WW events from normal physics running, of which 2800 and 1900, respectively, could be collected in $1\,\mathrm{fb}^{-1}$ [16].

3 Operating the ILC at 90 GeV

- positron production? unpolarised source?
- BDS changes?
- low energy transport?

How much to write here before citing [3]?

4 Conclusions

Given the discrepancy between the assumptions of some subdetector systems and the actual TDR accelerator design, the Joint Working Group on ILC Beam Parameters asks the detector concepts to revisit their needs for calibration data and address the following points:

- For which subdetectors is Z pole calibration essential and why? Which precision could be achieved without Z pole running?
- If Z pole running is required, specify how often (once for commissioning, every year, every push-pull?) they are needed and with which integrated luminosity.

We are aware that person power very limited, but since these questions have potential impact on key accelerator specifications, they should be addressed with priority. (Too strong?)

Acknowledgement

References

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