The Interaction Point Collision Feedback System at the International Linear Collider and its Sensitivity to Expected Electromagnetic Backgrounds

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Thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy at the University of Oxford

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Abstract

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An Interaction Point Collision Feedback System is necessary to achieve design luminosity at the future International Linear Collider (ILC). This is proposed to include a stripline beam position monitor (BPM) positioned ∼3 m from the Interaction Point (IP). The BPM is required to be able to measure the position of the outgoing electron or positron beam with a resolution of ∼1 μm.

Prototype feedback systems have been built and tested at the Next Linear Collider Test Accelerator (NLCTA) at the Stanford Linear Accelerator Center in the USA (SLAC) and also at the Accelerator Test Facility (ATF) at the High Energy Research Laboratory in Japan (KEK). The successful correction of position offsets is demonstrated with the lowest latency achieved 24 ns, the best position resolution 4 μm and the best correction ratio 23:1.

To make the feedback system a more powerful tool, a digital processor is added. It raises the total latency of the feedback system to ∼140 ns. Its ability to perform algorithms is demonstrated with charge normalisation. Preliminary results indicate a resolution of ∼8 μm and correction ratio 7:1.

Backgrounds at the ILC comprise mainly electron-positron pairs from the beam-beam interaction. For the high luminosity 1TeV accelerator parameters, 10^5 pairs are produced per bunch crossing. This is the worst case for ILC pair backgrounds. These pairs produce $\sim 5 \times 10^5$ particle hits on a stripline of the IP feedback BPM.

In two experiments at End Station A (ESA) at SLAC, a stripline BPM was exposed to secondary particle backgrounds to determine if the particle hits degraded the ability of the stripline BPM to resolve micron-level position offsets. The experiments agree that the worst ILC pair backgrounds degrade the resolution by less than 8.5 nm (95% confidence level). It is concluded that micron-level resolution will not be affected by the ILC pair backgrounds.

Studies of stripline signals caused by backgrounds led to the development of a GEANT3-based tool that could predict the signals. The prediction tool was tested against one of the experiments at ESA and used to predict the signals on the ILC feedback BPM striplines. The results confirm that the ILC pair backgrounds do not produce micron-level errors in position measurement, indicating that the degradation in resolution by the worst pair backgrounds expected was under 13 nm.

For Clifford E Jones (1915-2007)

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