Investigating Precision In-Situ $\sqrt{s}$ Determination with $\mu^-\mu^+(\gamma)$ Events

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Abstract

Precision measurements of masses from both threshold scans and using beam energy and momentum constraints rely on knowledge of the absolute center-of-mass energy scale and the luminosity spectrum, $\mathrm{d}\mathcal{L}/\mathrm{d}\sqrt{s}$. These issues are central to some of the proposed measurement techniques for the W mass, the top mass and the Higgs mass at a linear collider. The process $\mathrm{e}^-\mathrm{e}^+ \rightarrow \mu^-\mu^+(\gamma)$ can potentially address both issues with high precision using in-situ measurements.

Previous studies have emphasized the use of the radiative-return to the Z sub-sample and the knowledge of m_{Z} to infer $\sqrt{s}$ using a muon-angle based method. That method is expected to be systematically robust - but is statistically challenged due to the width of the Z and gives uncomfortably poor precision and acceptance at high $\sqrt{s}$.

An alternative method, investigated earlier by T. Barklow, is to directly use the muon momenta measurements. Here, I will present studies using this momenta-based method, taking into account effects from muon momentum resolution, beam energy spread, ISR, FSR and beamstrahlung. I estimate statistical errors on determining the absolute center-of-mass energy scale from these effects as a function of $\sqrt{s}$, illustrate how well the momentum-scale may be determined from Z (γ) events, and discuss prospects for contributing to the determination of the luminosity spectrum. Statistical uncertainties at the 10 ppm level on the effective $\sqrt{s}$ are not out of the question.