$\sqrt{s}$ and Beam Energy Precision with Dimuons and Bhabhas at ILC

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Abstract

We evaluate $\sqrt{s}$ precision and beam energy precision at the International Linear Collider (ILC) at 250 GeV. We use difermion final states of $\mu^+\mu^-$ (dimuon), and e^+e^- (Bhabha). Beam dynamics are simulated using GuineaPig++ and event generation by KKMC and WHIZARD for dimuons and BHWIDE and WHIZARD for Bhabhas. A new Monte Carlo, GP2X, is written to convolve the beam dynamics with event generator output and detector resolution as approximated with the ILD detector concept.

1) Objectives

Determine the energy precision of the beams and $\sqrt{s}$ using detector measurements.

2) Methods

Event generators KKMC [1] , BHWIDE [2] and WHIZARD [3] were used to generate dimuons and Bhabhas. We applied a cut of $|\cos(\theta)| < 0.996$. Beam dynamics were done using GuineaPig++ [4] while beam energy spread and detector smearing was done using GP2X [5]. An algorithm flow diagram for GP2X is shown in Fig1.). Detector smearing was implemented with the ILD tracker for dimuons and an ECAL with 18% stochastic energy resolution for Bhabhas.

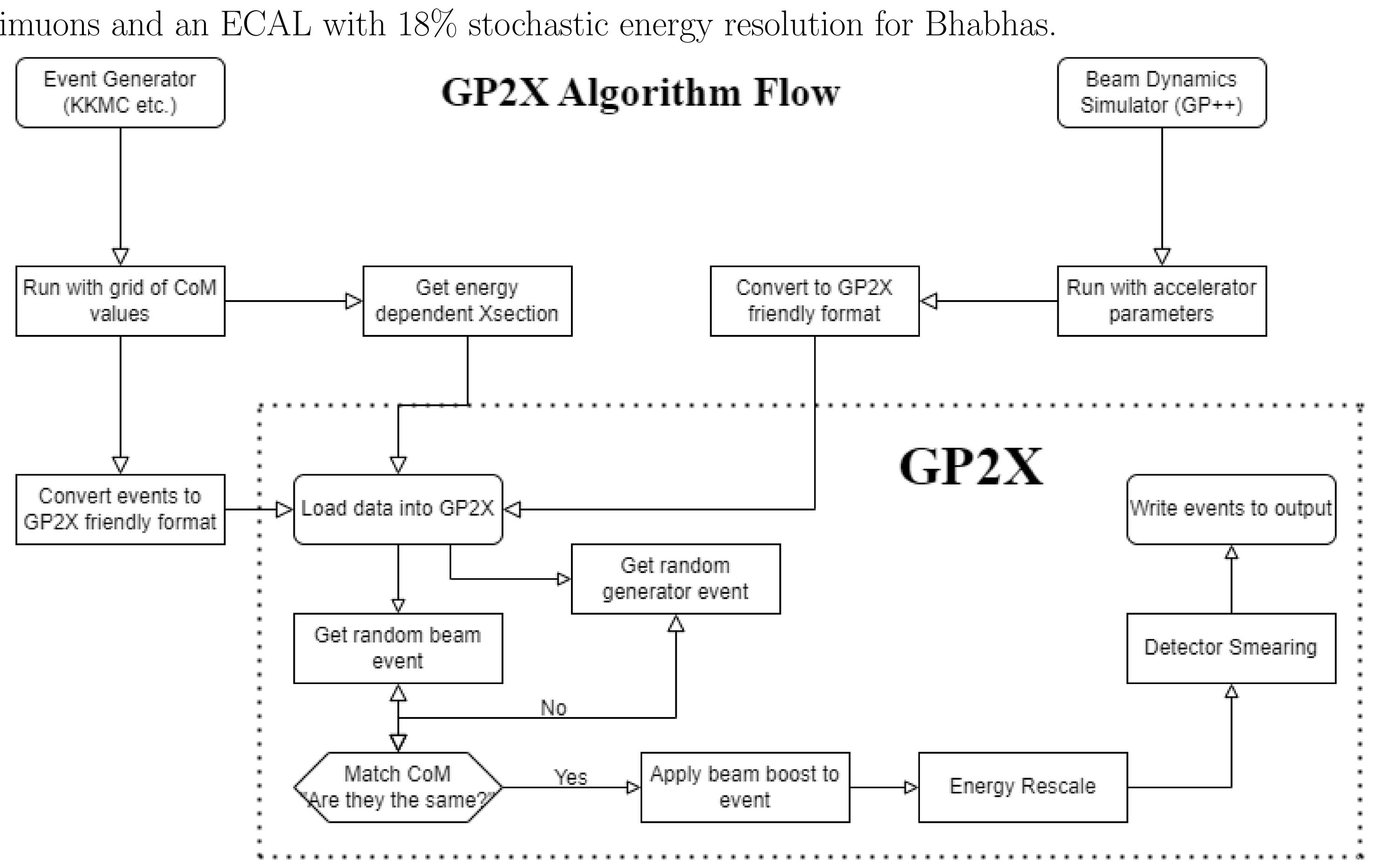

Figure 1: Algorithm diagram for GP2X.

3) Analysis Approach

We use the final state dilepton to estimate the center of mass energy

$$\sqrt{s_p} = E_{ll} + \sqrt{E_{ll}^2 - M_{ll}^2} \tag{1}$$

(more detail at [6]) which is correct in the limit of 2-body and 3-body with massless third body and no crossing angle. In the same limit we can infer that

$$E_i^- = \frac{1}{2}(E_{ll} + p_{ll}^z) \tag{2}$$

$$E_i^+ = \frac{1}{2}(E_{ll} - p_{ll}^z) \tag{3}$$

are the beam energy for the e^- beam and e^+ beam respectively. For fitting at MC level we follow the estimator of CIRCE [7] and use

$$F(x, \alpha, \beta, \sigma) = \int x^{\beta-1}(1-x)^{\alpha-1} G(x-1, \sigma) dx \tag{4}$$

which uses a beta distribution convolved with a gaussian. It features

$$x = \frac{\sqrt{s}}{E_0} \tag{5}$$

which is center of mass rescaled to a mean energy. Including the fraction that is gaussian, f_{peak}, we have five parameters namely $\alpha, \beta, E_0, \sigma, f_{peak}$.

4) Results

We find $\sqrt{s_p}$, E_i^- and E_i^+ can all be fit well at MC level. Beyond MC level further modeling needs to be done. The detector level performance is ≈ 2 times worse for tracker and ≈ 10 times worse for ECAL measurements. Future work will need to address detector level fitting and precision calibration for the tracker and ECAL.

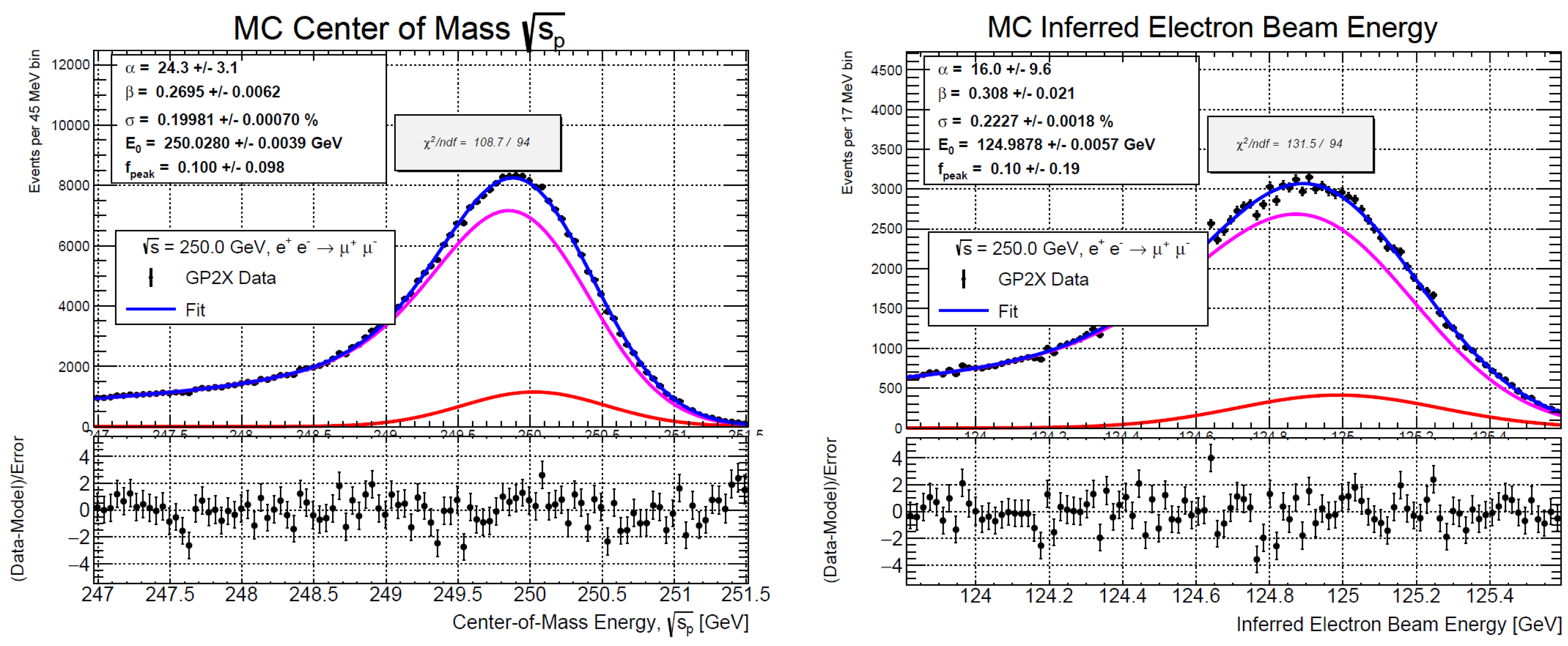

Figure 2: Fit of $\sqrt{s_p}$ and E_i^- using beta and gaussian convolution with data from GP2X using KKMC.

Results using ILC250 and ILD at MC level and 1M Samples				
Metric	E_0 at 100 fb^{-1} (2 ab^{-1}) [GeV]	Fit, True σ [GeV]	XSection (pb)	Pol. (e^- , e^+)
KKMC $\sqrt{s_p}$	250.028 ± 0.004 (0.001)	0.498 , 0.303	5.28 ± 0.05	No
KKMC E_{i-}	124.982 ± 0.002 (0.0004)	0.281 , 0.238	—	—
KKMC E_{i+}	124.953 ± 0.002 (0.0003)	0.234 , 0.188	—	—
BHWIDE $\sqrt{s_p}$	250.063 ± 0.0001 (0.00003)	0.413 , 0.303	2313 ± 15	No
BHWIDE E_i^-	125.002 ± 0.0001 (0.00002)	0.237 , 0.238	—	—
BHWIDE E_i^+	124.999 ± 0.0001 (0.00002)	0.188 , 0.188	—	—
WHIZARD $\mu\mu$ $\sqrt{s_p}$	250.093 ± 0.007 (0.002)	0.415 , 0.303	5.54 ± 0.02	(-0.8,+0.3)
WHIZARD $\mu\mu$ E_i^-	125.012 ± 0.001 (0.0003)	0.235 , 0.238	—	—
WHIZARD $\mu\mu$ E_i^+	124.998 ± 0.003 (0.0006)	0.188 , 0.188	—	—
WHIZARD ee $\sqrt{s_p}$	250.087 ± 0.0001 (0.00003)	0.407 , 0.303	2270 ± 20	(-0.8,+0.3)
WHIZARD ee E_i^-	125.001 ± 0.00007 (0.00001)	0.235, 0.238	—	—
WHIZARD ee E_i^+	124.999 ± 0.0001 (0.00004)	0.188 , 0.188	—	—

Figure 3: Results summary that only includes MC level results.

5) Acknowledgements

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