Impact Parameter Resolutions for CLICdet

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Introduction

- The transverse impact parameter, d_0, is the distance of closest approach between a reconstructed track and the IP in the xy-plane.
- Excellent resolution is needed for flavour tagging and constraining the track fit.
- The impact parameter resolution, specifically the transverse impact parameter resolution is the figure of merit for the vertex detector.
- The resolution can be parametrised by $\sigma(d_0) = \sqrt{a^2 + b^2/(p^2 \sin(\theta)^3)}$
- a depends on the point resolution of the vertex detector
- b represents multiple scattering and therefore depends on the material budget of the detector.
- The minimal requirements of CLICdet, for its physics goals, are $a \approx 5\ \mu$m and $b \approx 15\ \mu\text{m} \cdot$ GeV.

Method

- The 2017-07-12 version of the ILC software was used.
- The *CLIC_o3_v11* detector model was used.
- Muons were fired with a particle gun at 1 GeV, 10 GeV and 100 GeV.
- The polar angle θ of the muons was varied and the azimuthal angle ϕ was uniform in 2π.
- 2000 muons were fired for each angle in θ.
- Events were reconstructed using truth tracking.
- Secondary particles generated by the muons are excluded.
- Events with $recoP < 0.9\ trueP$ were excluded. This primarily affects very forward events.
- $\sigma(d_0)$ for a given angle and energy was found by fitting a histogram of $\Delta d_0 = d_{0_{reco}} - d_{0_{truth}}$ with a Gaussian.

Example of Δd_0

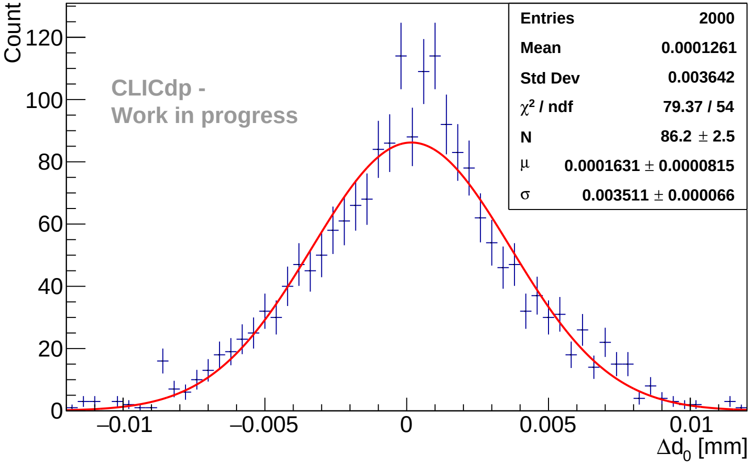
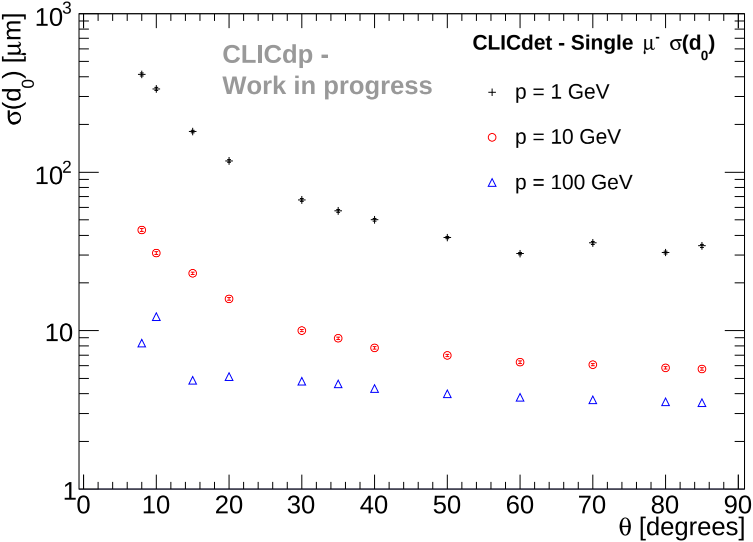
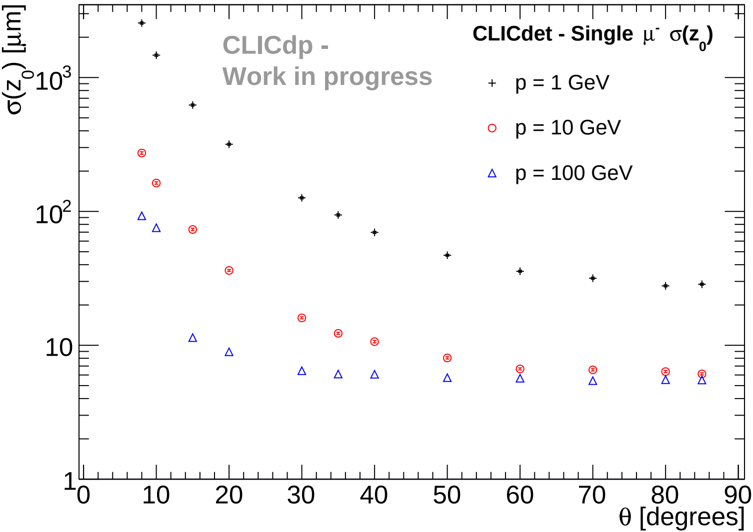


Figure: 100 GeV μ^- with $\theta = 85°$

$\sigma(d_0)$ for CLICdet - Old Fit



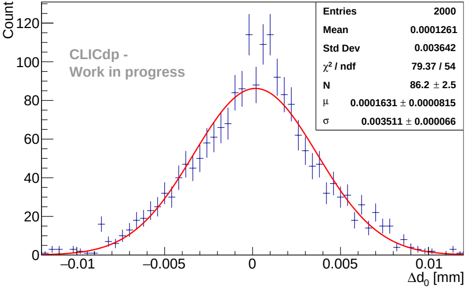
$\sigma(z_0)$ for CLICdet - Old Fit



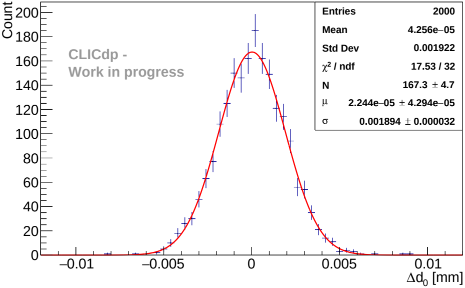
Improvements to the Track Fit

- Truth tracking uses the Monte Carlo hits of a particle to make the tracks.
- It starts by making a prefit of the track based on the first, middle and last hit.
- Then it fits the track using the prefit to get starting parameters.
- These initial parameters result in a bad track.
- The prefit now uses all track hits for the new truth tracking.
- The parameters from this fit are used as starting parameters for a refit.
- The new starting parameters result in a better fit which improves $\sigma(d_0)$.

Δd_0 Without and With Refit



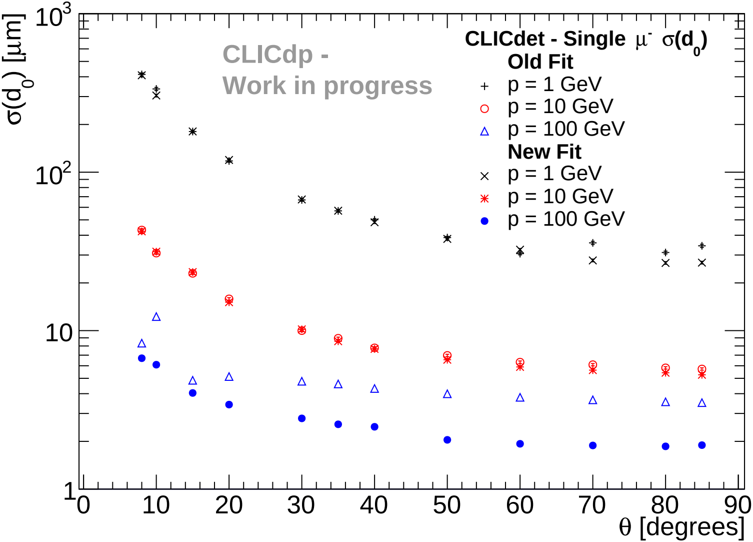
(a) Old truth tracking



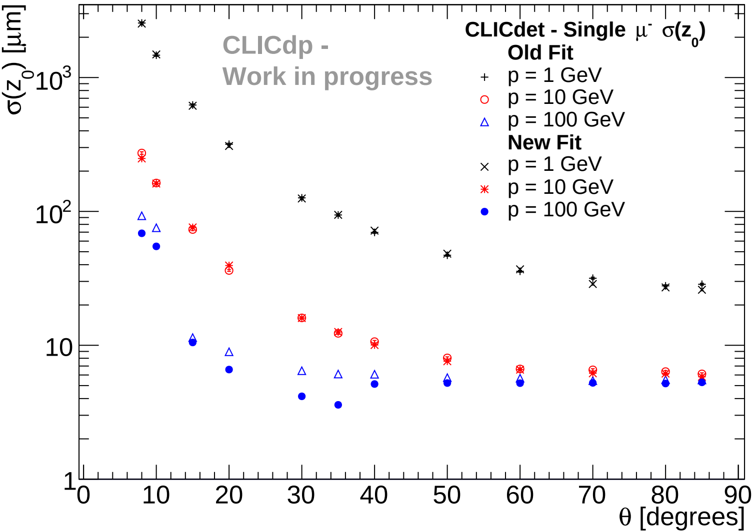
(b) Truth tracking with refit

Figure: 100 GeV μ^- with $\theta = 85^\circ$

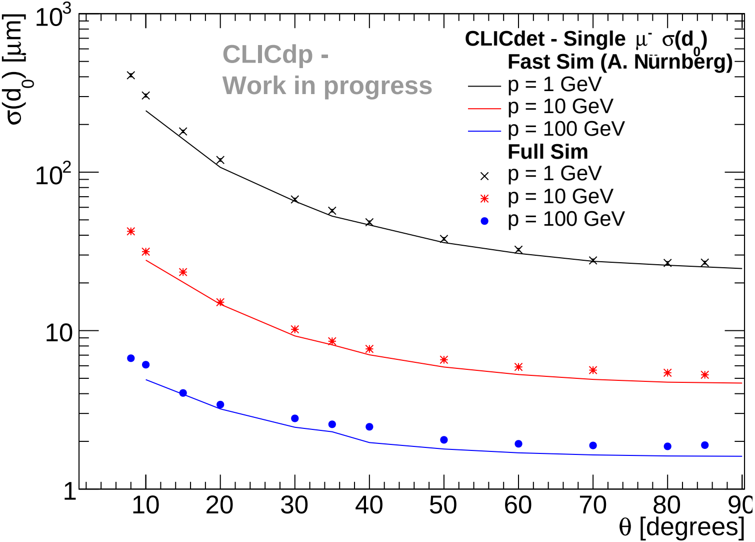
$\sigma(d_0)$ for CLICdet - New Fit



$\sigma(z_0)$ for CLICdet - New Fit



$\sigma(d_0)$ Full vs. Fast Simulation



Conclusion

- The current reconstruction is not biased depending on the charge track which was the case for CLIC_SiD.
- The refit improves the track reconstruction.
- The refit drastically improves the $\sigma(d_0)$ at high energies.
- The full simulation is consistent with the fast simulation.
- The $\sigma(d_0)$ is compatible with the physics goal of CLIC.
- The $\sigma(d_0)$ provides a strong validation of the CLICdet design.