SiD, Main Tracker Pixel Studies

Comparing the tracking performance of a pixel implementation to the current main tracker model with strip sensors.

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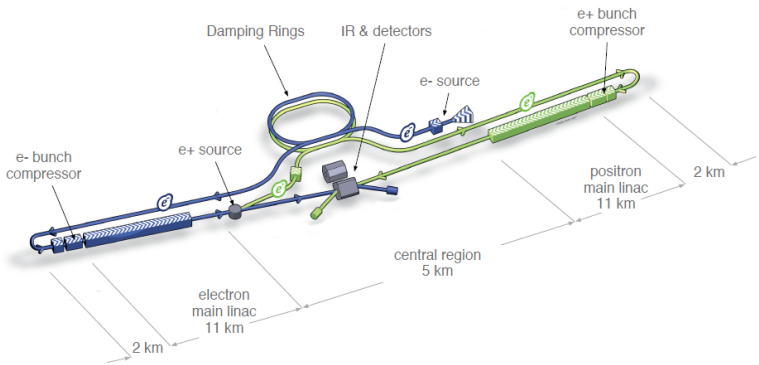
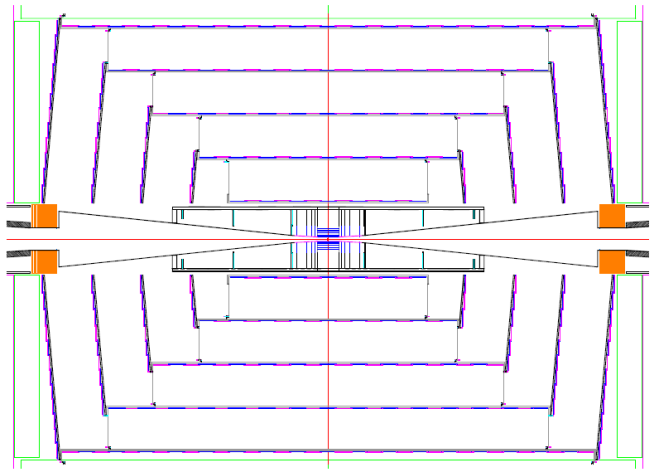


Current SiD Main Tracker Design

- 5 layers of silicon strip sensors.
- Width $25\mu\mathrm{m}$ (sense pitch) with a $50\mu\mathrm{m}$ (readout pitch).
- Provides the required momentum resolution, $\sigma(p_T)/p_T^2 = 5 \times 10^{-5}(GeV/c)^{-1}$ for high momentum tracks.



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Software Used

All simulation and reconstruction was done through ILCDIRAC using,

- SLIC, v3r0p3.
- lcsim, HEAD on ILCDIRAC. Digitisation, tracking and truth linking drivers.

Analysis performed via python based scripts utilising the pyLCIO and pyROOT bindings.

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Pixel Implementation

- Detector geometry is changed so that the silicon sensing layer in the main tracker is the same as that is the vertex detector, $0.02\mathrm{mm}$. Therefore, charge depositions are similar.
- Sensor configuration is defined at digitisation. Pixels defined smaller than $\sim 80 \times 80\mu\mathrm{m}^2$ cause a "Duplicate Channel Number" error.
- Final implementation keeps the $25\mu\mathrm{m}$ size in bending plane of magnetic field. Other dimension is defined to be $400\mu\mathrm{m}$. Note that pixels are only implemented within the barrel.

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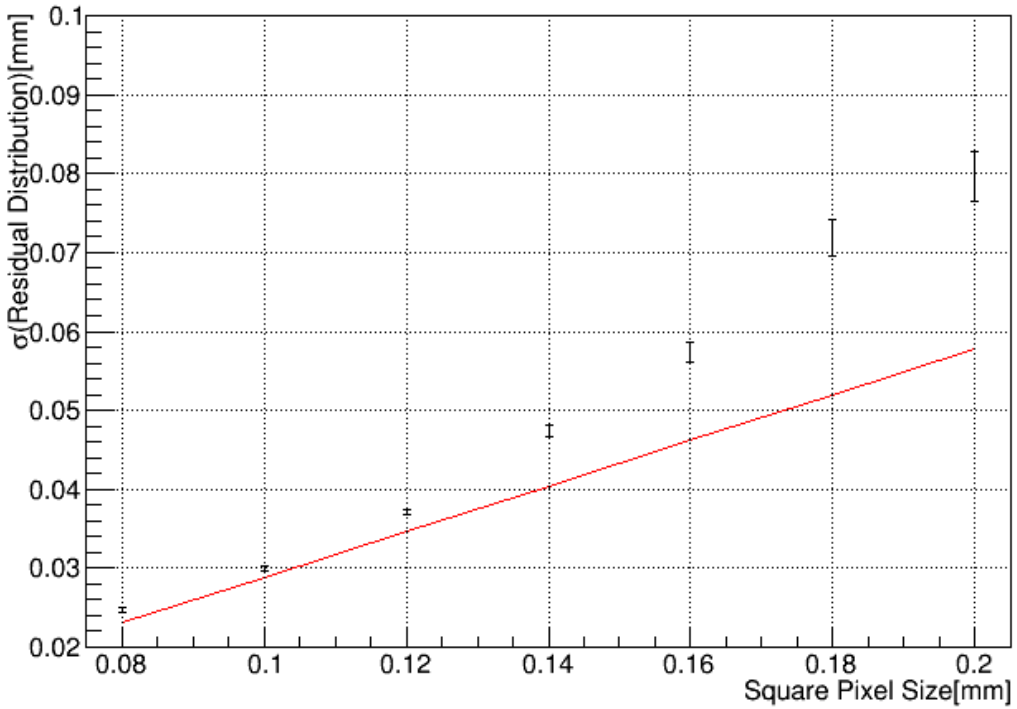
Pixel Validation

An approximation to the tracking residual is made with single muons of $100\mathrm{GeV}$, at 60° to the beam line. Graph shows tracking residual σ against pixel size (square).

ftp : *//ftp − lcd.slac.stanford.edu/lcd/ILC/singleParticle/stdhep/*



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Tracking Performance

- To compare the tracking performance of the "sidloi3" model with the pixel implementation, 5000 $t\bar{t}$ events at a centre-of-mass energy of 500GeV are used. These contain many charged pions as tracking candidates.
  /ILC/ILC500/ttbar/stdhep/pandorapythia/panpyttbar.stdhep.
- These are simulated within both models and then reconstructed (digitisation, tracking, truthlinking only).
- The "McTruthLinker" lcsim driver creates relations between the simulated monte carlo particles and the reconstructed tracks, Each track is related to a Monte Carlo particle via a weight defined as the fraction of hits used to create the track created by the Monte Carlo particle.

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Tracking Rates

Define three rates to study,

- Efficiency = Fraction of Monte Carlo charged pions found to have 1 associated track with a weight of 1.
- Partial Rate = Fraction of Monte Carlo charged pions found to have 1 associated track with a weight less than 1.
- MultiRate = Fraction of tracks for which there are additional tracks associated with the same Monte Carlo charge pion.

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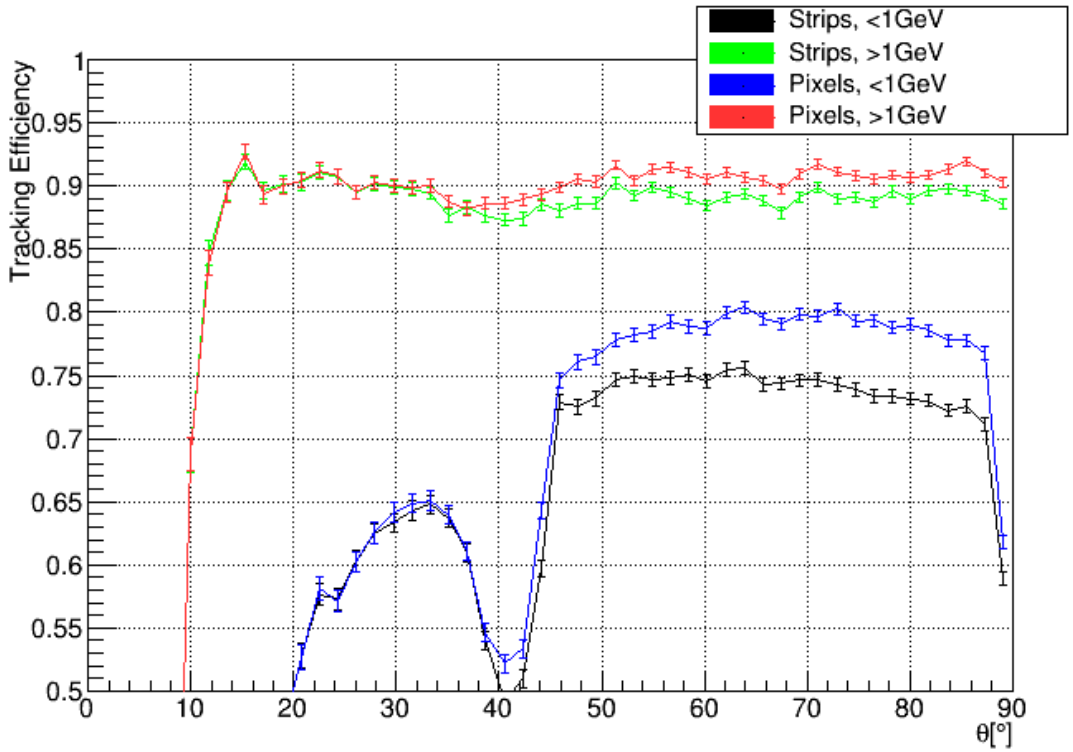
No Overlay

Tracking efficiency for both the "sidloi3" model and the pixel implementation as a function of θ (angle from beamline). Cut at $1\mathrm{GeV}$.



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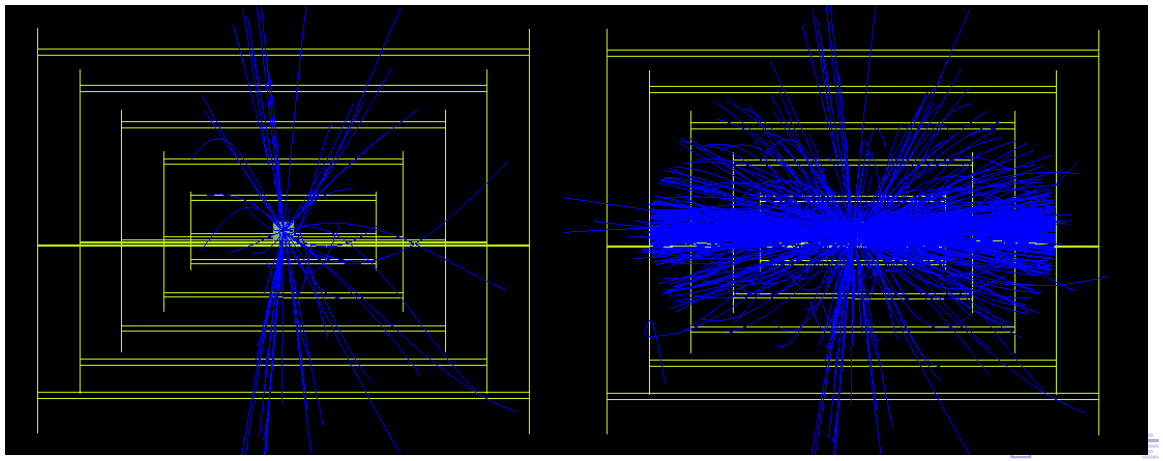
Overlay

- Overlay equivalent to 1,5,10,20,50 bunch crossings worth was added to the simulated events. Only gamma-gamma to hadron overlay was used with 4.1 hadrons per bunch crossing.
  $/ilc/prod/ilc/mc-dbd/generated/500-TDRws$
- This was due to software limitation, which caused any greater overlay to stall the tracking process. With the addition of eepairs this reduced to only 10 bunches being able to run.
- The three rates are found at each level of overlay for the region between 50° and 85° from the beamline. This is within the barrel and excludes the spiralling behavoir.



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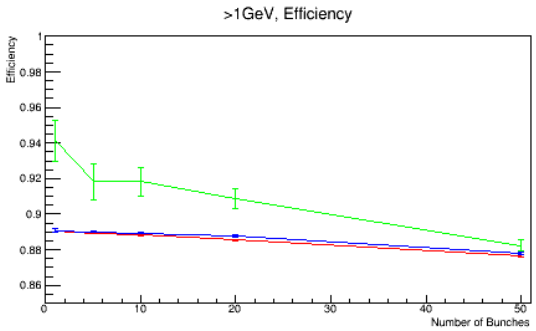
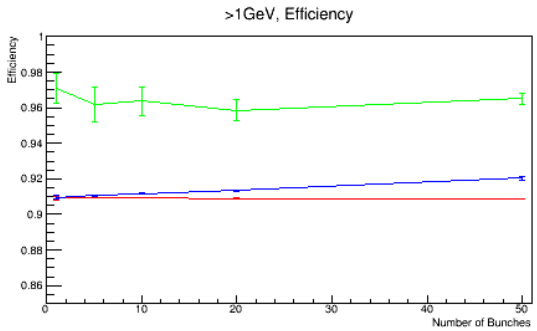
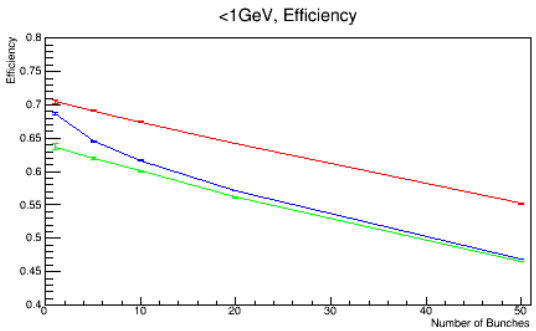
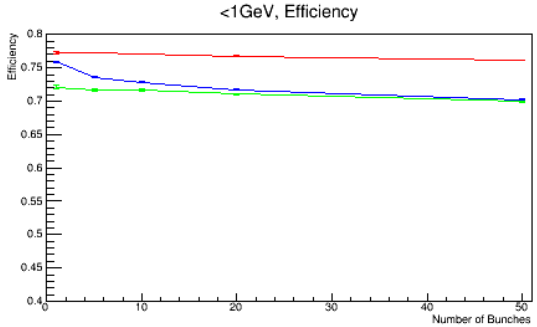
Efficiency with Overlay

Efficiency vs bunches overlayed, for both the “sidloi3” (left) and pixel implementation(right). Signal(red), overlay(green) and total(blue).



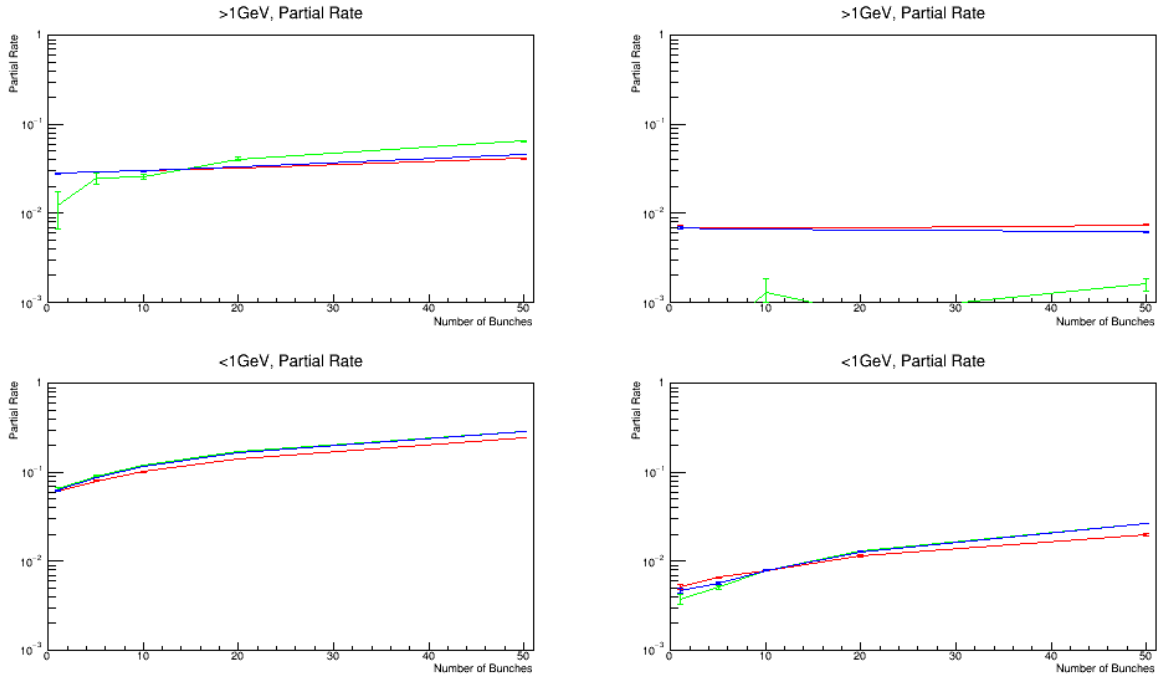






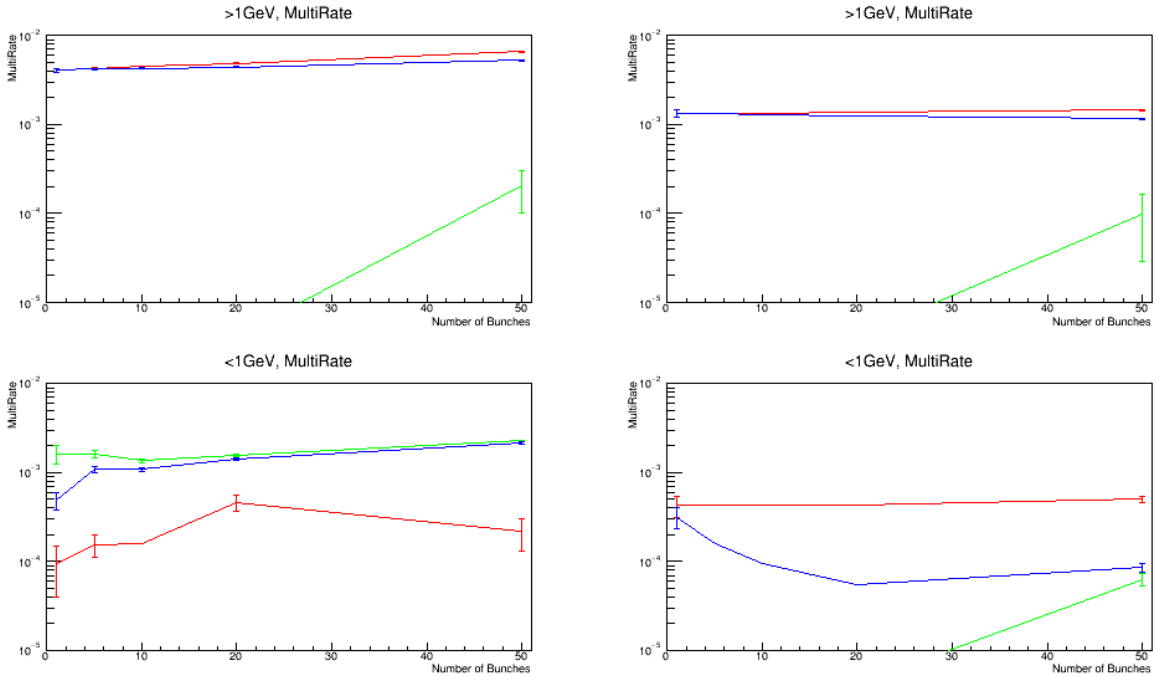
Partial Rate with Overlay

Partial Rate vs bunches overlayed, for both the "sidloi3" (left) and pixel implementation(right). Signal(red), overlay(green) and total(blue).



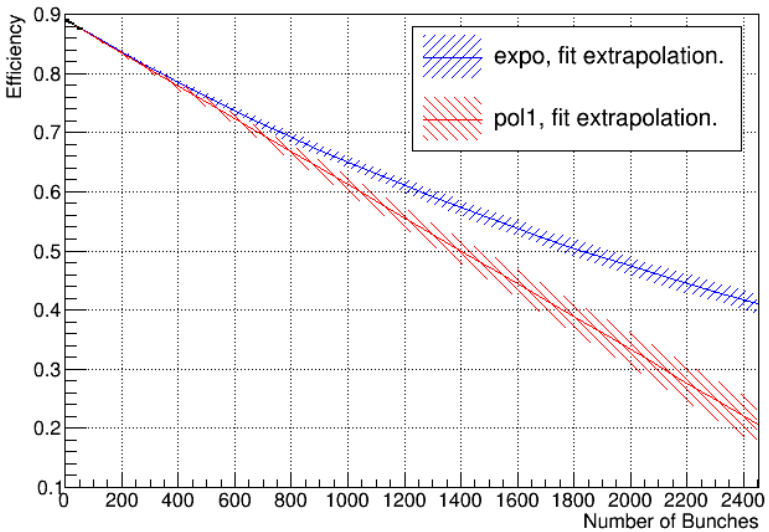
MultiRate with Overlay

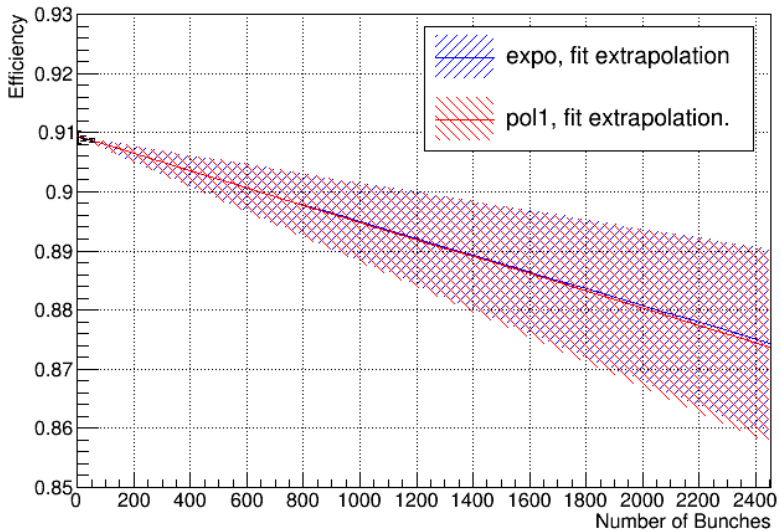
Fake Rate vs bunches overlayed, for both the "sidloi3" (left) and pixel implementation(right). Signal(red), overlay(green) and total(blue).



Extrapolations

Straight line and exponential fit extrapolations of tracking efficiency as a function of the number of bunches overlayed. "sidloi3" (left), pixel implementation(right).





Summary and Future work.

- The pixel implementation leads to clear improvements in the tracking performance and its response to backgrounds.
- Using the improved software framework to remove/reduce the limitations mentioned would allow for a more detailed and thorough analysis, including more confident extrapolations.

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Momentum Resolution

Momentum resolution for $t\bar{t}$ pions. sidloi3(red), pixels(blue).