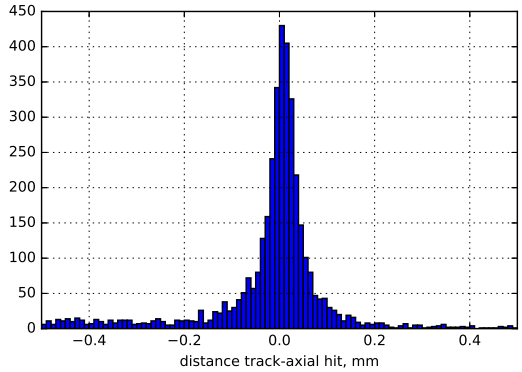
CDC track-reconstruction studies

S. Glazov, 27 Jan 2017, Belle tracking group meeting

Improving track resolution by adding missed hits

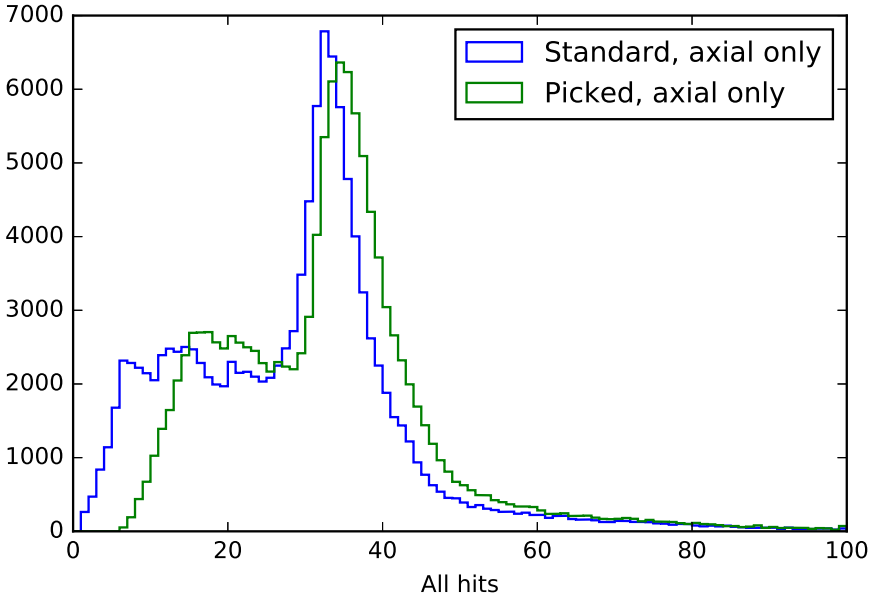
- Track finding follows certain patterns and some of the genuine hits may be discarded during this process.
- It is useful to try to re-assign the hits to the found tracks, in an iterative way, which may recover the missed hits.
- Given that a single hit should belong to a single track global optimisation methods can be used for that (will discuss at the end of the talk)
- For now simple “proof of principle” implementation, also served as a testing ground to understand the Belle CDC tracking.

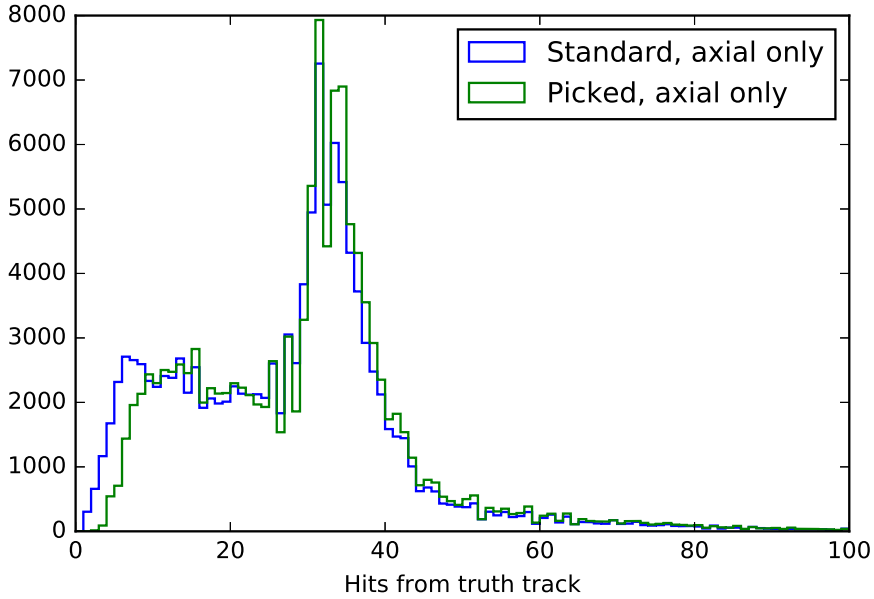
Circle fit to axial hits in CDC



- Run standard `cdc_track_finding` on generic B events
- In a test module:
  - For each CDC track, select accociated axial hits, build a new tracjectory based on them (reference).
  - For each CDC track, loop over all axial hits. Build a new trajectory using all hits which are within 0.2 mm vs the seed track (test).
  - Fit both trajectories using `CDCRiemannFitter`, cirular track hypothesis, weights for all hits set to unity.
  - Do hit-based truth matching, associate the truth-track based on maximal number of hits. Discard pairs of tracks with different truth-match.
  - Compare fitted and truth P_t.

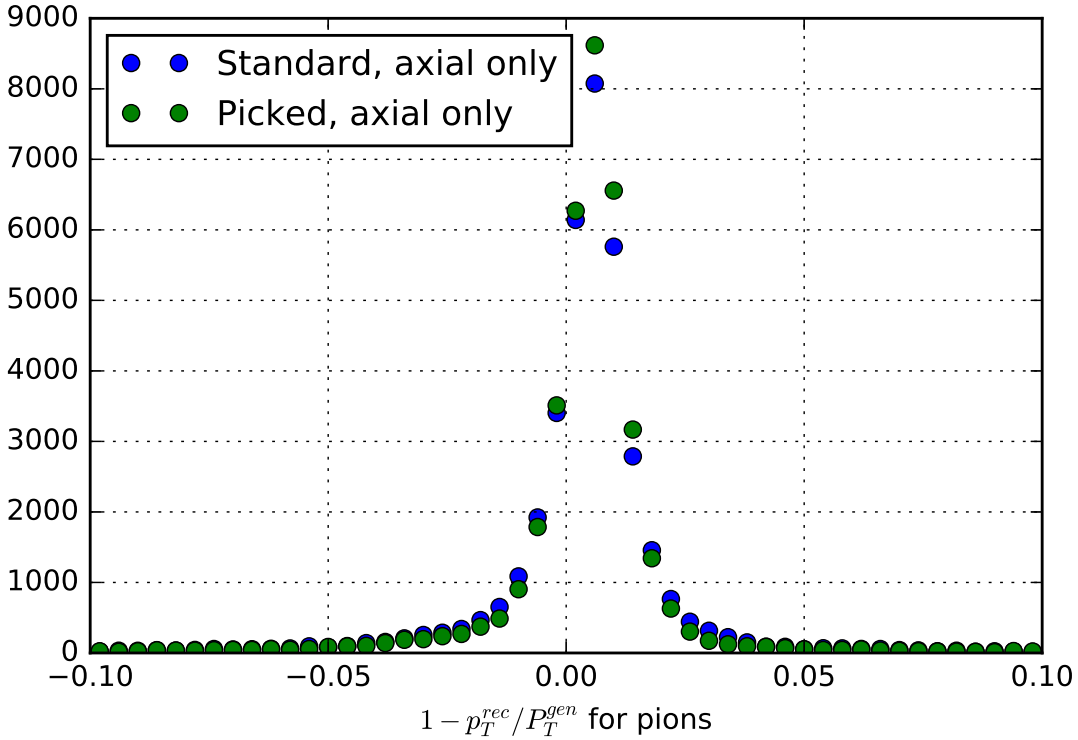
Results: number of linked hits and purity





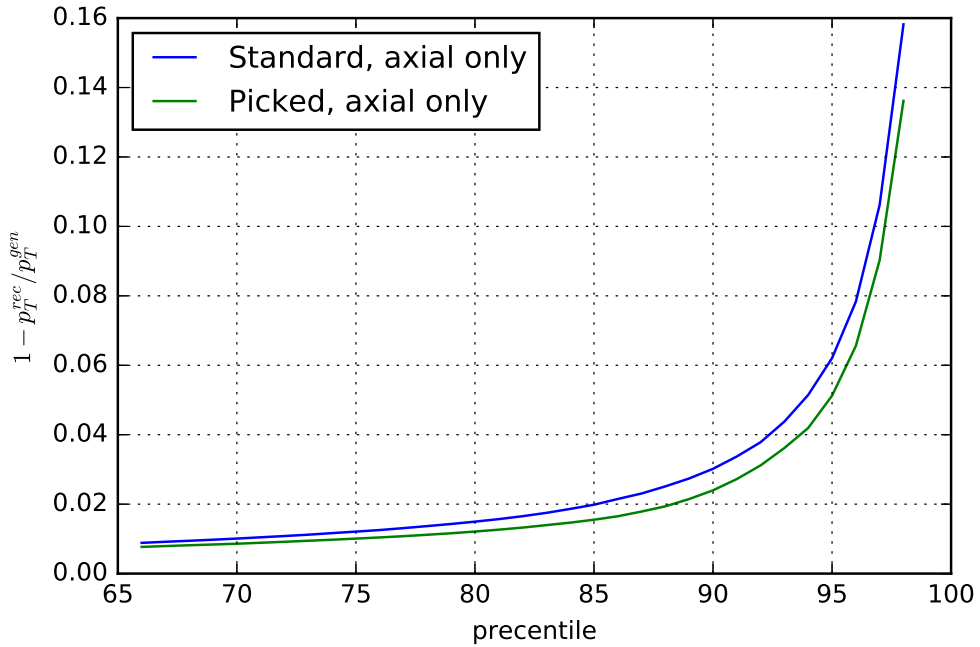
- A few more extra hits are picked vs the standard reconstruction.
- However the purity is reduced, only a handful of extra hits accociated with the truth track are picked.

P_t resolution for pions



- Select pions with $p_T^{\text{rec}} > 300$ MeV.
- Some $\sim 0.5\%$ bias of the median/peak position.
- Despite lower purity, trajectories based on"picked" hits show slightly better resolution and smaller tails.

P_t resolution for pions

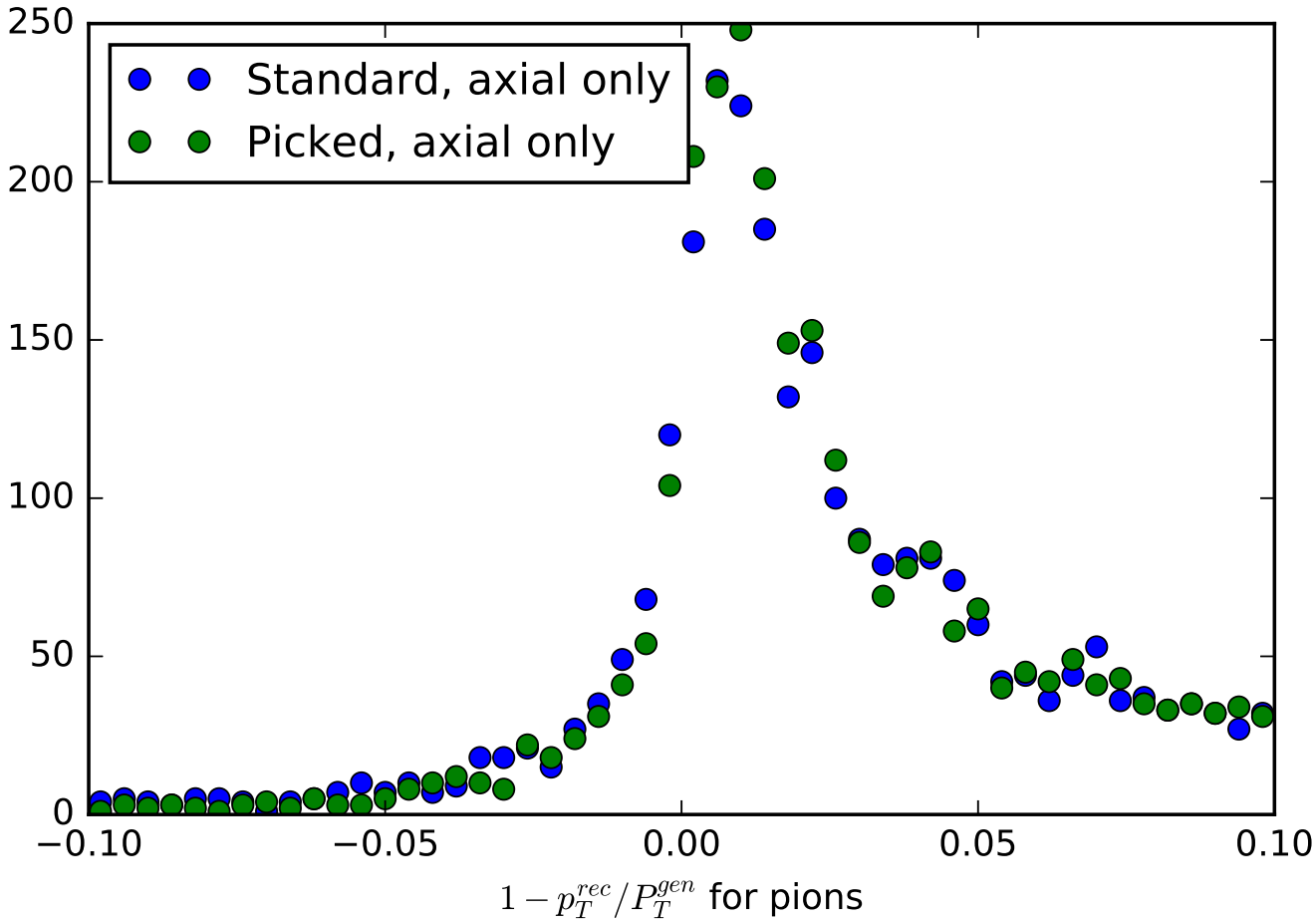


To characterise width of non-gaussian distribution, use percentile around the median:

```
def cov68(a,cl=68):
    b = percentile(abs(a - median(a)), cl)
    return b
```

E.g. for 90% coverage, the cut around median on $p_T^{\text{rec}}/P_T^{\text{gen}} - 1$ would be at 3.0% and 2.4% for the standard and picked fits, respectively.

P_t resolution for protons



Clear bias for both trajectories due to larger energy loss.

Pattern recognition for multiple tracks/hits

$$E = \sum_{i=1}^{N_{\text{track}}} \sum_{j=1}^{N_{\text{hit}}} D_{i,j}^2 S_{ij} + \sum_{j=1}^{\mathrm{N_{hit}}} \lambda (1 - \|S_{ij}\|)^2, \quad D_{i,j} = 1/\sigma_j \left\| T_{i,j} - X_j \right\| .$$

where $T_{i,j}$ is extrapolated trajectory i to the hit j, X_j are the hit coordinates (may depend on $T_{i,j}$), measure $\| \, \|$ includes resolution σ_j.

S_{ij} is a spinor such that for each hit j only for one track i $S_{ij} = 1$ (hit j linked to track i) while for all other i' $S_{i'j} = 0$, or for all i $S_{ij} = 0$ (noise hit).

Find minimum by e.g. simulated annealing: place in a hit bath at temparature T, $E \to F$,

$$S_{ij} \to W_{ij} = \frac{\exp\left(-\frac{D_{i,j}^2}{T}\right)}{\sum_{k,l} \exp\left(-\frac{D_{k,l}^2}{T}\right) + \exp\left(-\frac{\lambda}{T}\right)}, \quad \lambda \to \lambda(T) = \gamma T + \lambda_0$$

Start with temperature $T \sim \sigma^2_{\text{track}}/\sigma^2_{\text{hit}}$, iterate down until W_{ij} are resolved.

Can be added to `genfit`, but perhaps tested first using fast CDC fitting routines.

Summary

- Tests that CDC track resolution might be improved by repeating hit-matching.
- Can be extended to stereo/silicon hits.
- Better performance is expected for an iterative procedure involving all hits/tracks in the event.
- Can be tested using fast circular fits, but requires proper energy loss corrections, using `genfit`.