

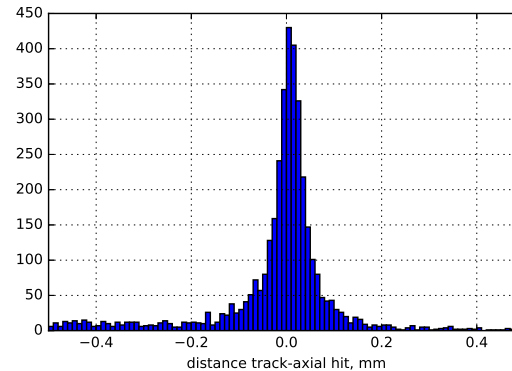
# CDC track-reconstruction studies (update)

S. Glazov, Belle tracking group meeting, Feb 24

## Improving track resolution by adding missed hits

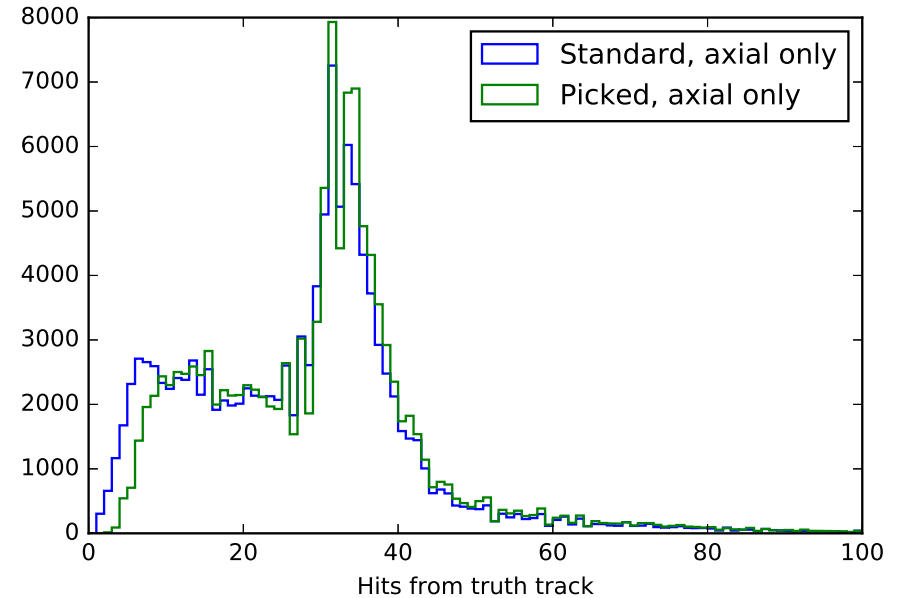
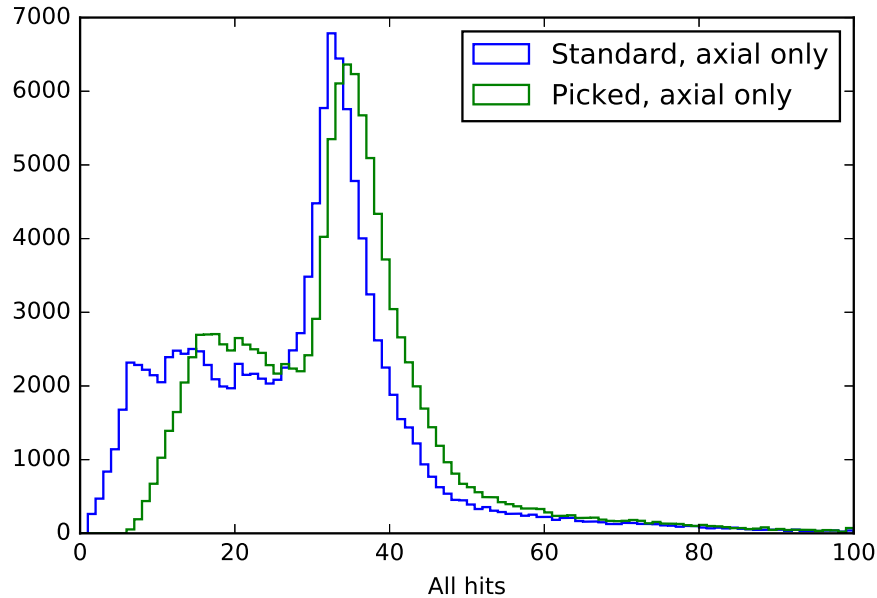
- Track finding follows certain patterns and some of the genuine hits may be discarded during this process.
- It is useful to try to re-assign the hits to the found tracks, in an iterative way, which may recover the missed hits.
- Given that a single hit should belong to a single track global optimisation 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



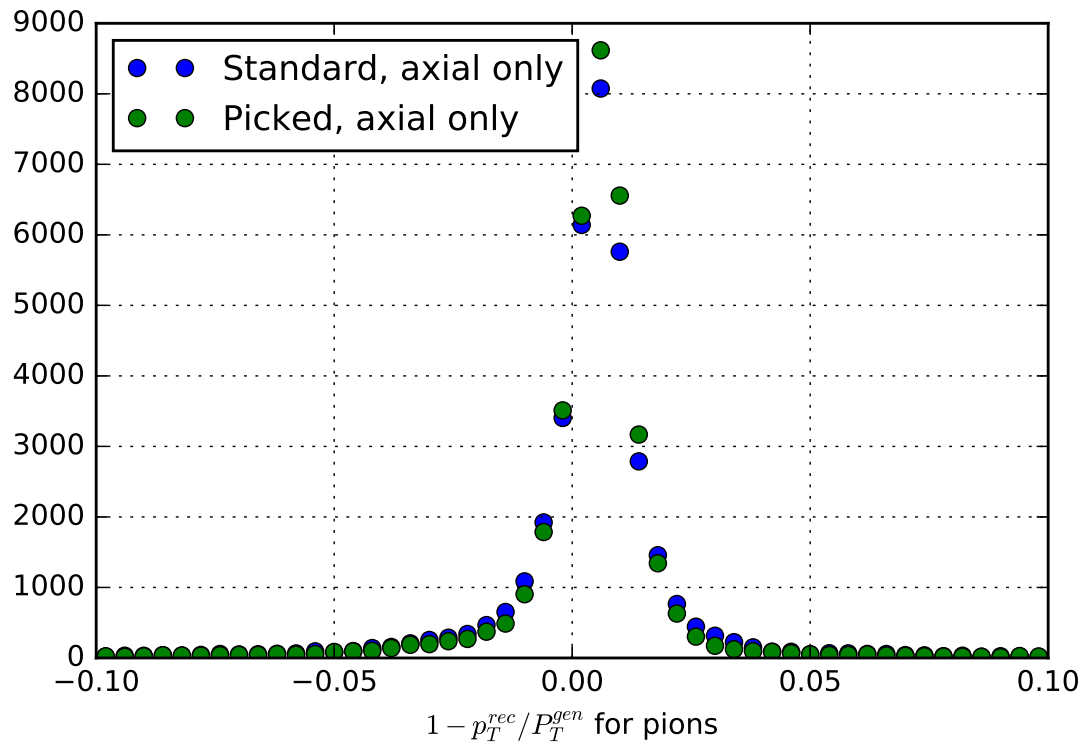
- Run standard `cdc_track_finding` on generic B events
- In a test module:
  - For each CDC track, select associated axial hits, build a new trajectory based on them (reference).
  - For each CDC track, loop over all axial hits. Build a new trajectory using all hits which are within 0.2 mm vs the seed track (test).
  - Fit both trajectories using `CDCRiemannFitter`, circular 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



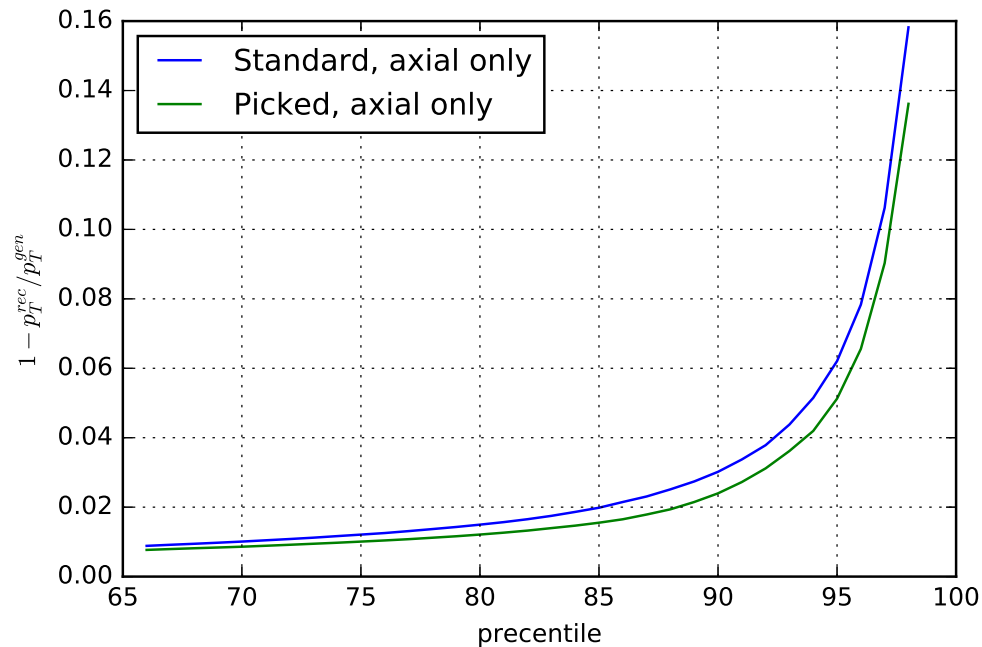
- A few more extra hits are picked vs the standard reconstruction.
- However the purity is reduced, only a handful of extra hits accociated with the truth track are picked.

## $P_t$ 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

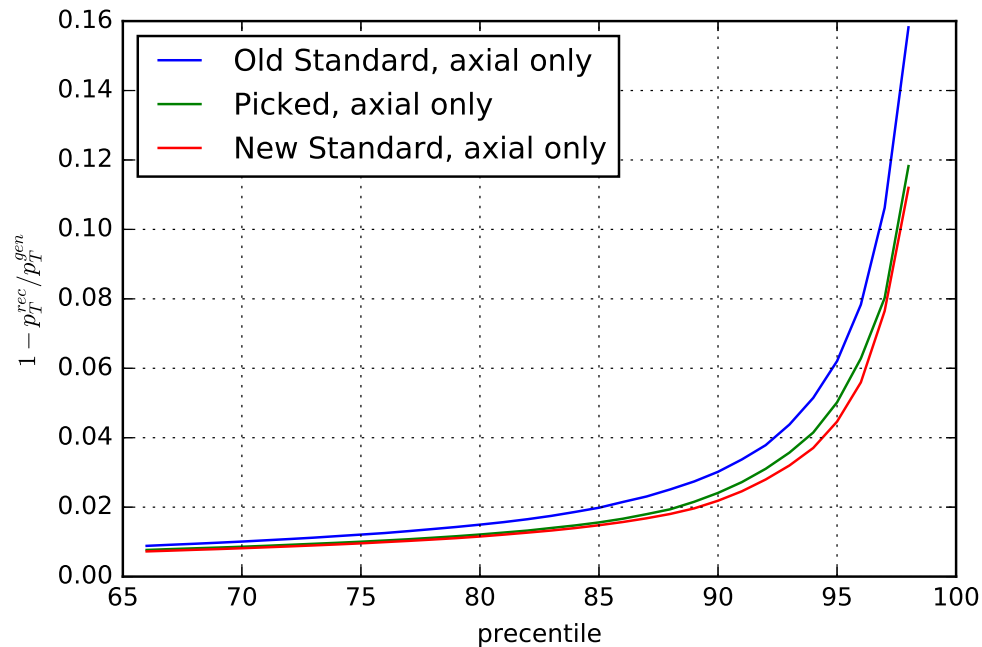


To characterise width of non-gaussian distribution, use percentile around the median:

```
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 pions: master from 23 Feb 2017

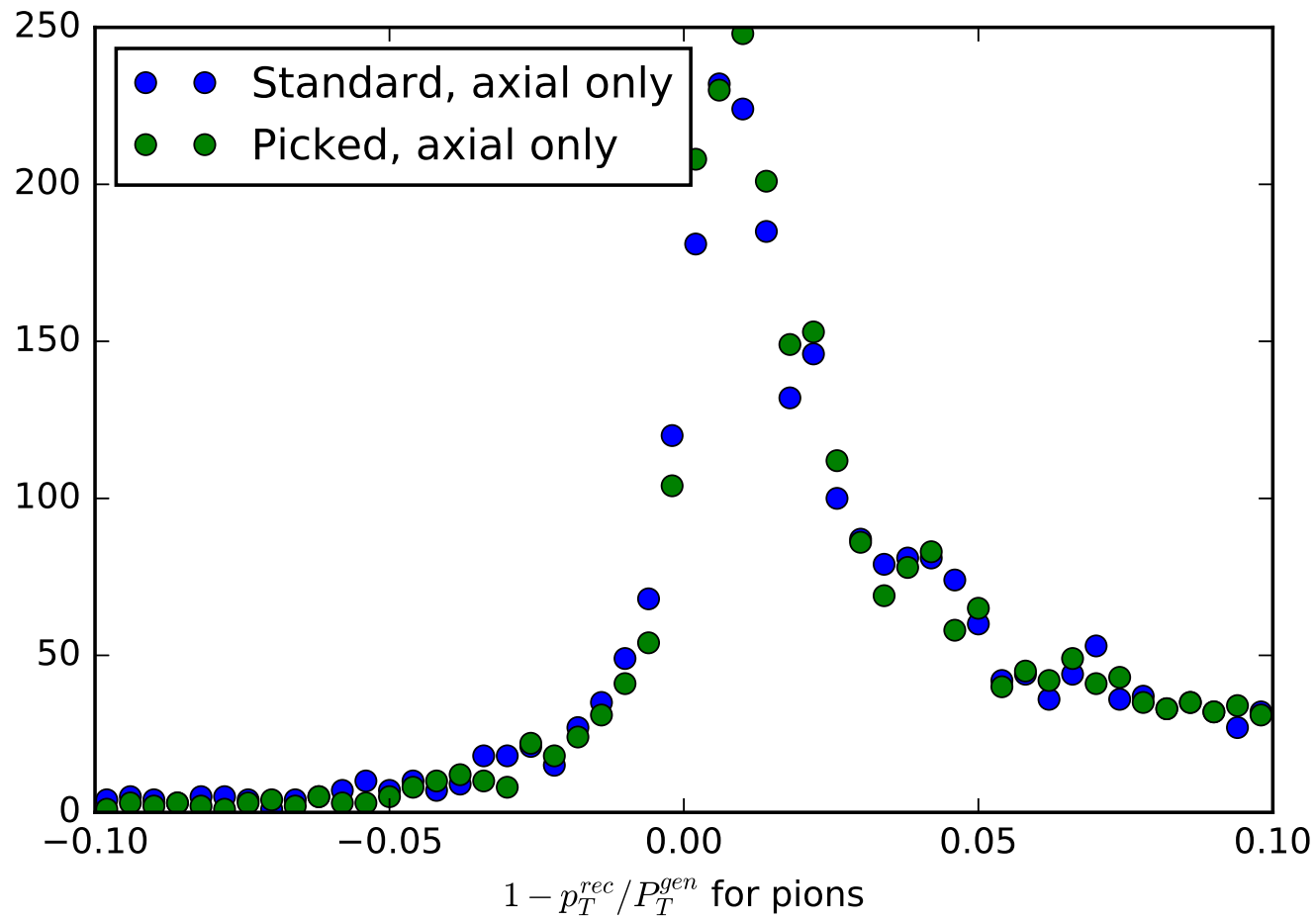


To characterise width of non-gaussian distribution, use percentile around the median:

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

After recent updates from Oliver and Victor of CDC tracking, there is a significant improvement and picking extra hits has no advantage.

## $P_t$ resolution for protons



Clear bias for both trajectories due to larger energy loss.



# Pattern recognition for multiple tracks/hits

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

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  $\| \cdot \|$  includes resolution  $\sigma_j$ .

$S_{ij}$  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 temperature  $T$ ,  $E \rightarrow F$ ,

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

Start with temperature  $T \sim \sigma_{\text{track}}^2 / \sigma_{\text{hit}}^2$ , 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`.