Mighty Tracker – Tracking and Scoping

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FSP LHCb
Erforschung von
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I: Scoping - fibre tracking with high luminosity

- Smaller & less expensive pixel detector → fibre tracker needs to cover larger area.
- High occupancy fibre tracking may limit scoping options.

- Use the Run 3 simulation @ UII luminosity → fibre tracking performance.
- Tracking in the fibres only.

- Currently not accounting for:
  - Differences to a future fibre tracker.
  - Differences in material budget (e.g. support for pixel).
  - Changes to the other detectors.

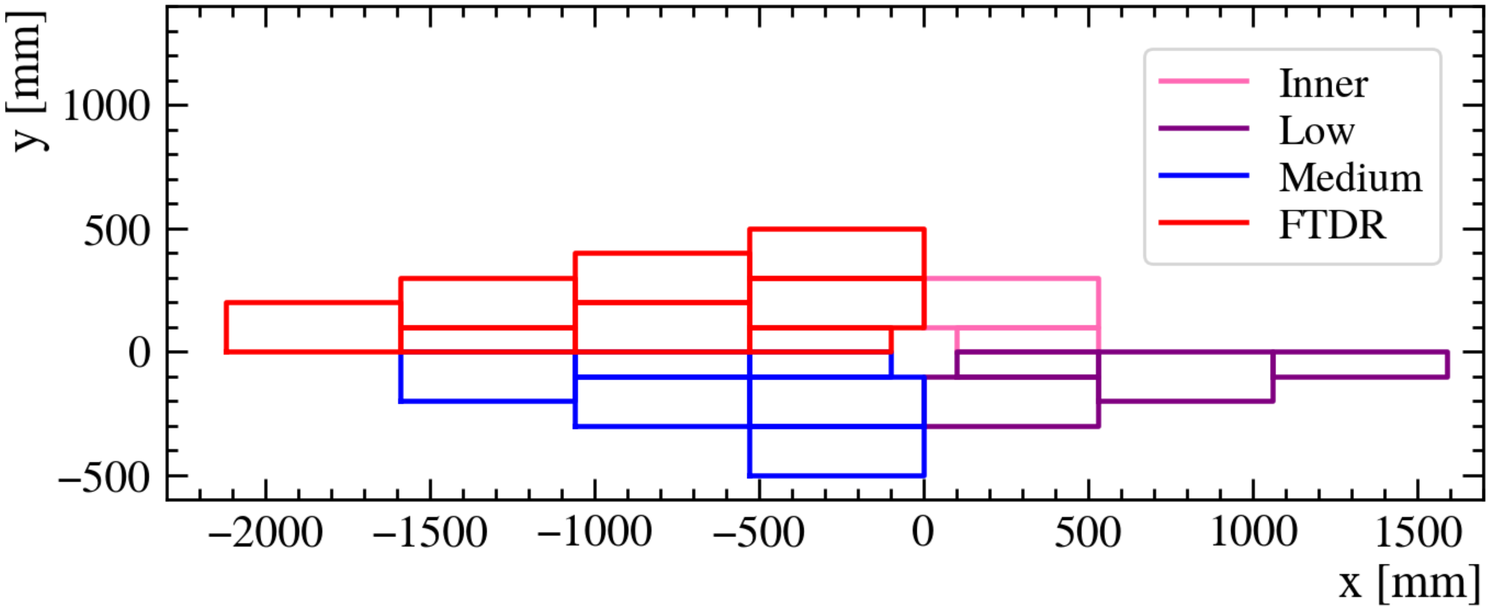
Methodology

- Pipeline: `Gauss` → `Boole` → `Moore`.
- `Gauss`:
  - Generate Bs → J/$\Psi\phi$ events.
  - Use Run 3 detector geometry.
- `Boole`:
  - Remove FT hits in the `MCFTDepositCreator`.
  - Consideration of spillover.
- `Moore`:
  - PrChecker → tracking efficiencies and ghost rates with MCTruth.
  - Correct consideration of removed Tracks/hits in the FT.
  - Removed Global Event Cut.

Scoping options under investigation

- 4 configurations of cut fibres.

- Different luminosities:
  - $1.5 \cdot 10^{34} \frac{1}{\mathrm{cm}^2\mathrm{s}}$
  - $1.3 \cdot 10^{34} \frac{1}{\mathrm{cm}^2\mathrm{s}}$
  - $1.0 \cdot 10^{34} \frac{1}{\mathrm{cm}^2\mathrm{s}}$
  - Run 3 $0.2 \cdot 10^{34} \frac{1}{\mathrm{cm}^2\mathrm{s}}$



Areas of pixel detectors per layer:

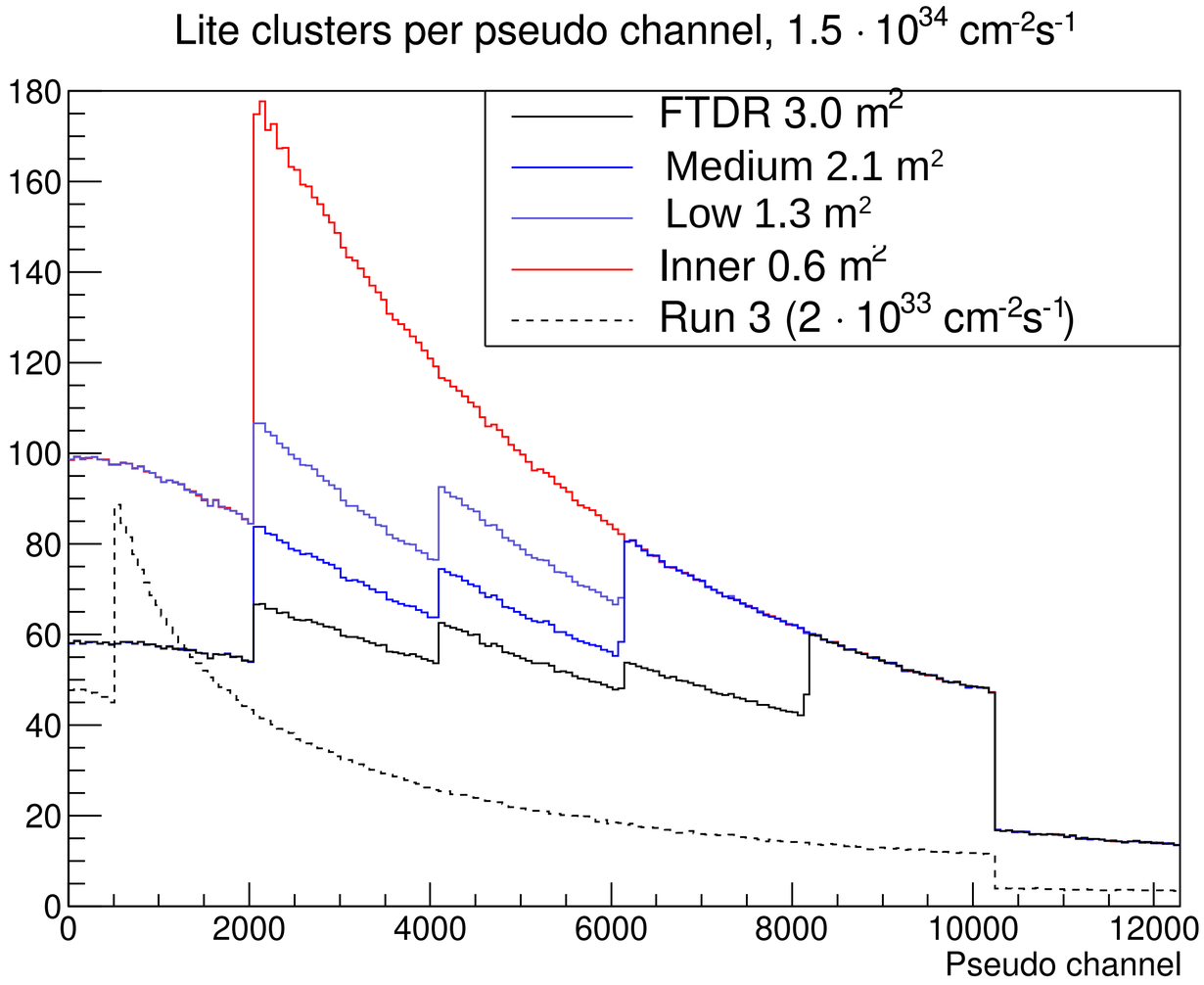
- **Inner** **0.6 m²**
- **Low** **1.3 m²**
- **Medium** **2.1 m²**
- **FTDR** **3.0 m²**

Occupancy

- Looking at LiteCluster
  → proxy occupancy

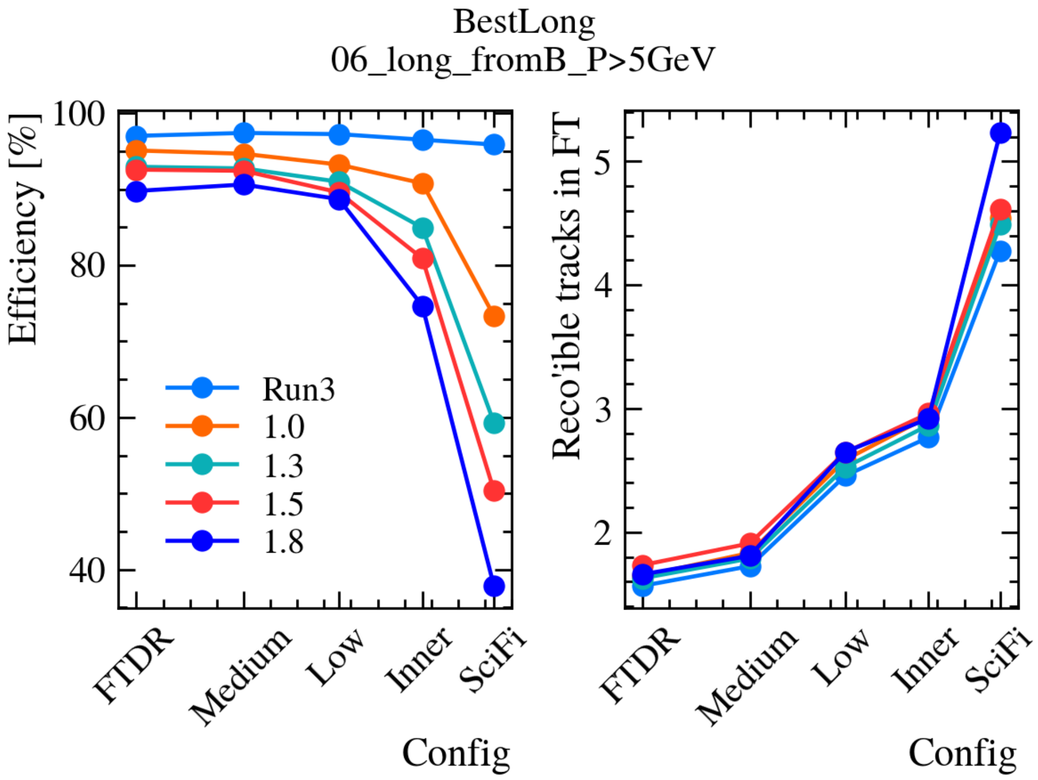
- Overall occupancy will look similar to highest in Run 3.

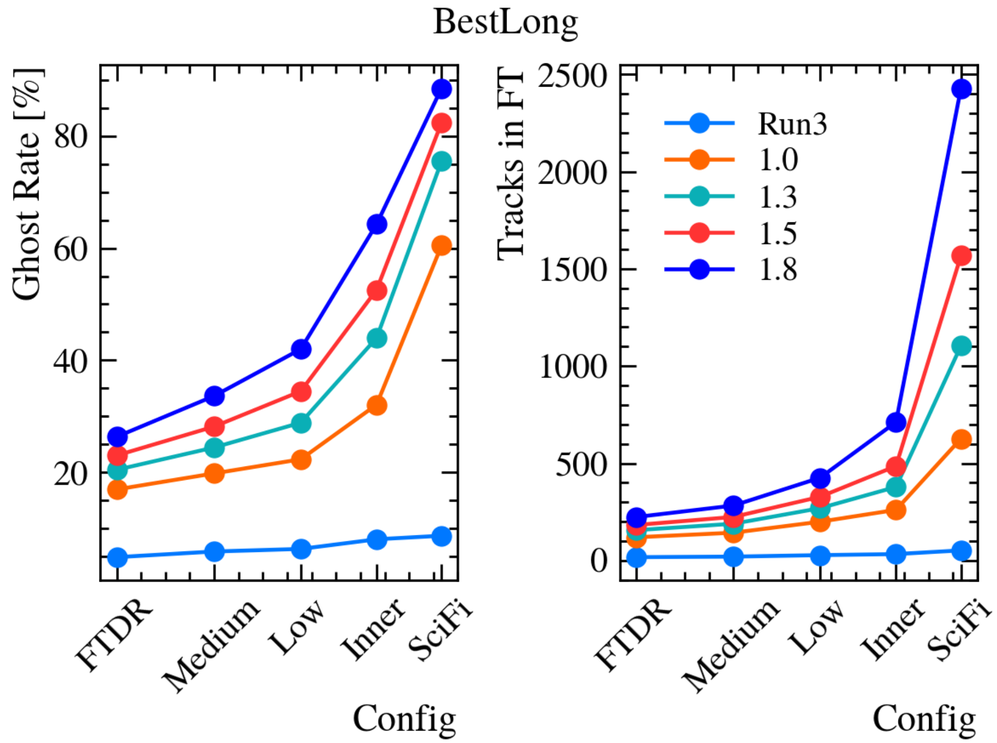
Name	ν	μ
1.5e34	58.0	40.6
1.3e34	50.3	35.2
1.0e34	38.8	27.1
Run 3 2.0e33	8.2	5.6



Fibre tracking efficiencies & ghost rates

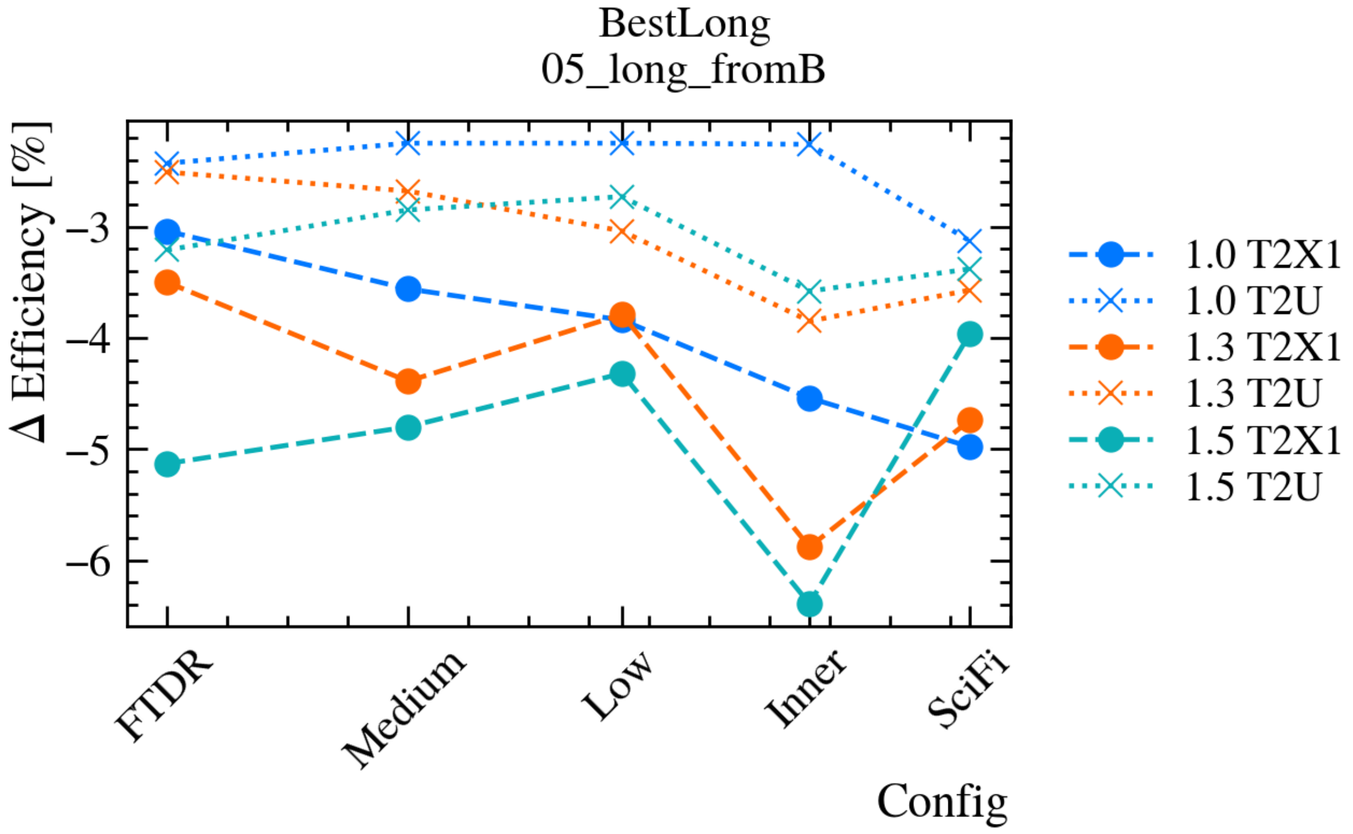
- Tracking efficiencies high momentum track in FT for different scoping scenarios and luminosities.
- Here for **BestLong** tracks, i.e. best from Matching and Forward + Kalmanfilter.
- We observe **efficiencies over 90%** for medium and low, **ghost rates ~ 30%** at 1.5e34.
  - With ~10% ghost rate coming from upstream tracking.





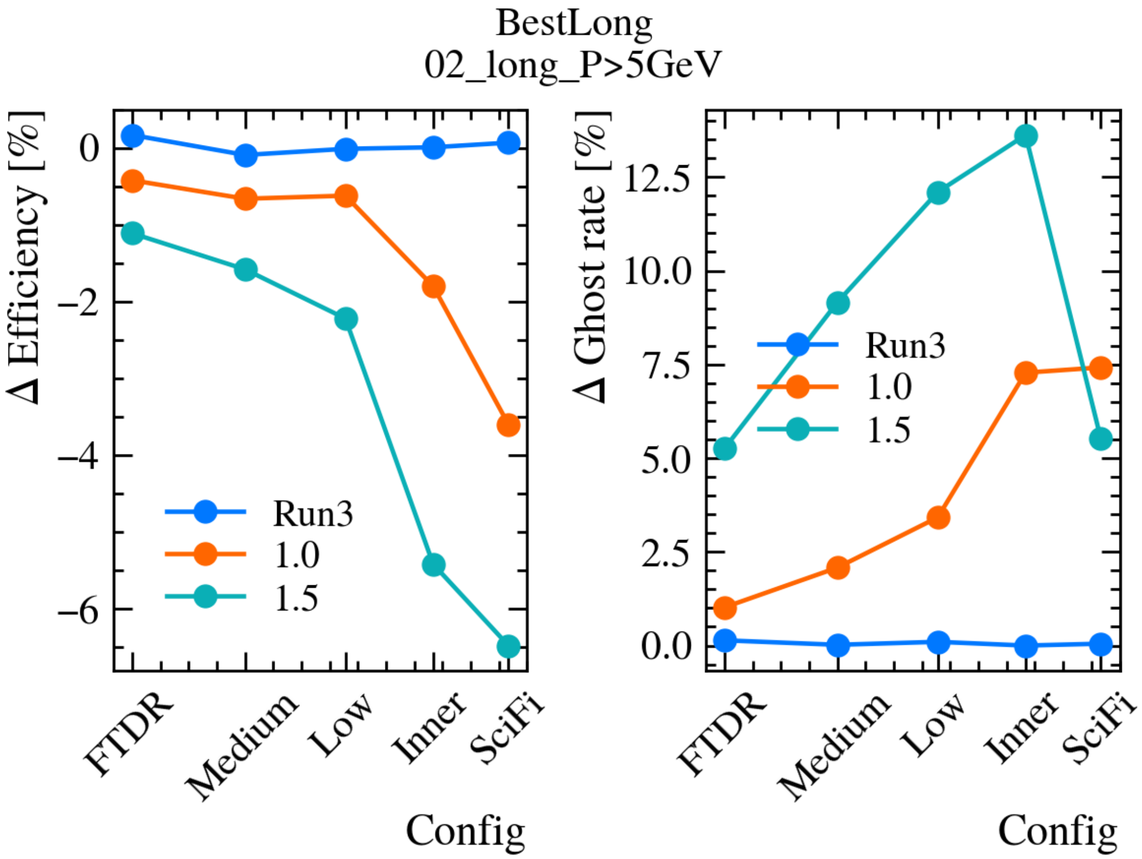
Dropping a fibre layer

- Dropping a FT layer was identified as scoping option.
- Large drop in efficiency.
- Tuned the Hybrid-Seeding for less hits.
- Still very large inefficiency → disfavoured.



Effect of spillover

- Effect of spillover, in **run3 configuration,** on the efficiencies.
- Spillover cannot just be assumed to apply to U2.
- Up to 2% inefficiency for Low.

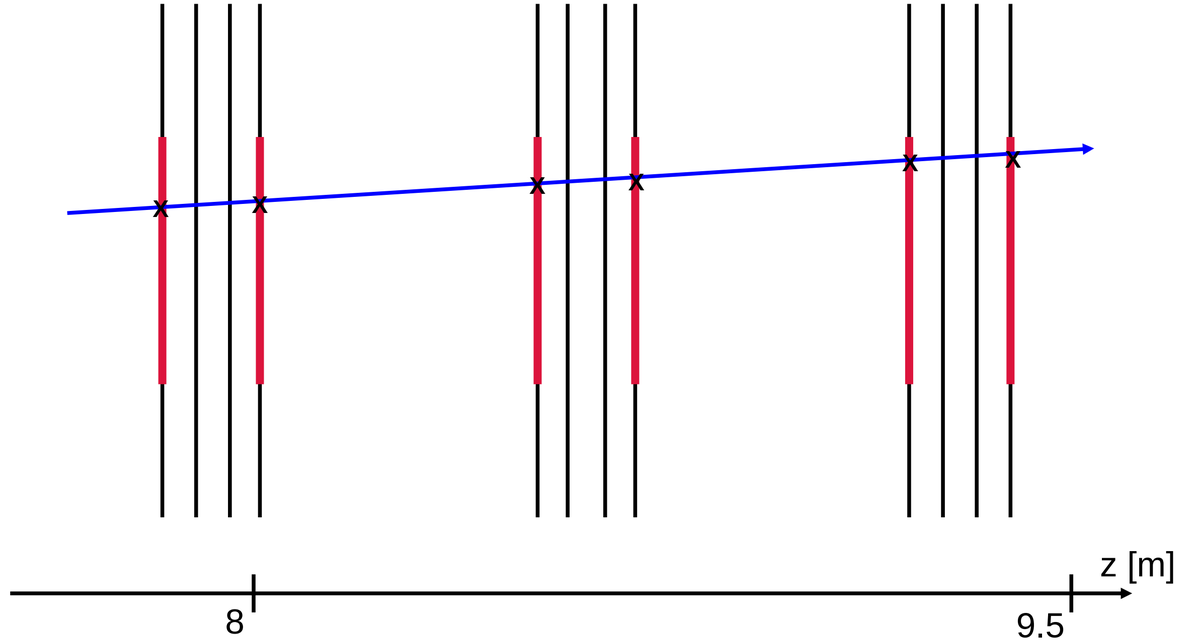


Conclusions for fibre tracker

- The fibre tracker seems to have robust tracking efficiency for higher luminosities in several scoping setups.
- Factors not considered here are:
  - Radiation hardness.
  - Differences to an upgraded fibre tracker.
  - Changed position of mirror for reflected photons.

II: Mighty Tracker – Pixel Tracking

- Use MC FTHits in the pixel area → removed from FT.
- Simplified digitisation with MP resolution.
- Fake LHCbIDs for PrChecker.



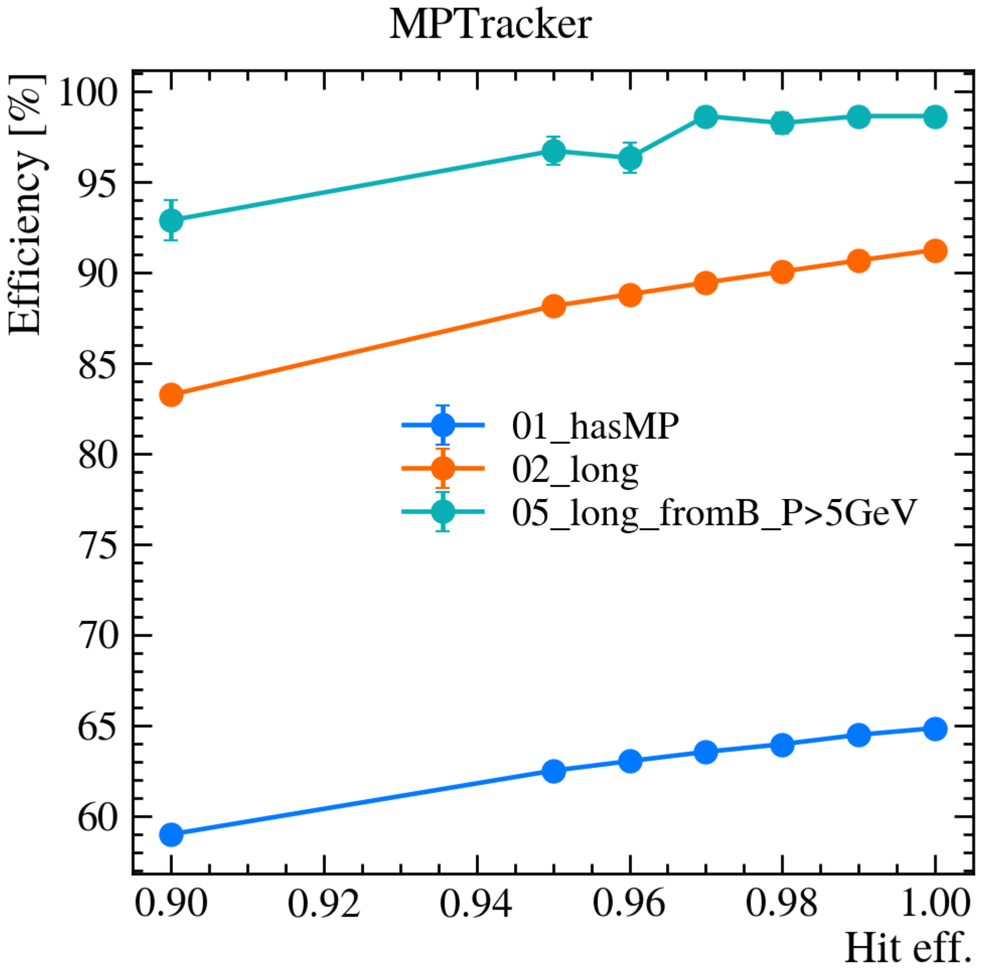
- Standalone pixel tracking.
- Consistent with expectations:
  - High efficiency with low ghost rates:

```
INFO **** MPSeed                  79503 tracks including        95 ghosts [ 0.12 %]
INFO   01_hasMP                :  52818 from    81448 [ 64.85 %]   hitEff: 88.68 %
INFO   02_long                 :  46238 from    50667 [ 91.26 %]   hitEff: 89.01 %
INFO   03_long_P>5GeV          :  41616 from    42950 [ 96.89 %]   hitEff: 90.73 %
INFO   04_long_fromB           :    537 from      557 [ 96.41 %]   hitEff: 92.77 %
INFO   05_long_fromB_P>5GeV    :    514 from      521 [ 98.66 %]   hitEff: 93.65 %
```

Hit efficiency

- Uniform distribution of hit inefficiency.
- Shown here: at $1.5 \times 10^{34}\,cm^{-2}s^{-1}$ with FTDR size.
- Ghost rate ~ 0.1 %

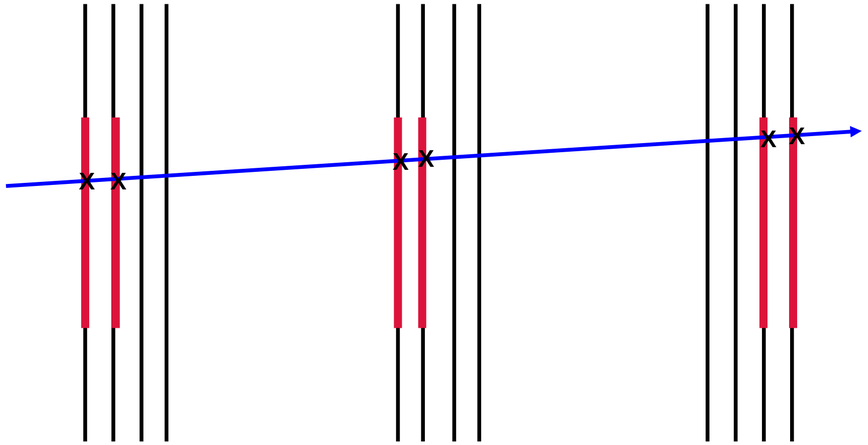
- Optimised for tracks coming from IP.
- Implemented pixel tracking algorithm optimised for 100% hit efficiency.



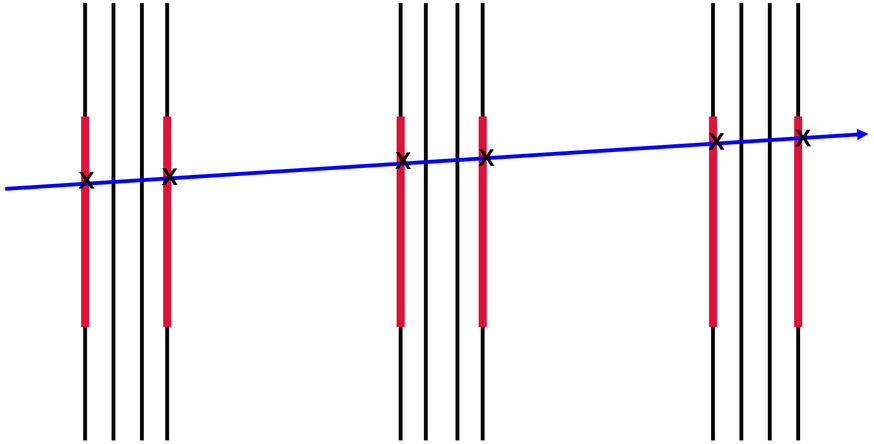
Move layer

- Change in spacing between pixel layers:

```
closer Layers                  40736 tracks including      168 ghosts [ 0.41 %]
  01_hasMP                     26482 from    41926 [ 63.16 %]   hitEff: 90.29 %
  02_long                      23390 from    26023 [ 89.88 %]   hitEff: 90.59 %
  03_long_P>5GeV               20901 from    22048 [ 94.80 %]   hitEff: 92.29 %
  04_long_fromB                  256 from      277 [ 92.42 %]   hitEff: 93.51 %
  05_long_fromB_P>5GeV           245 from      256 [ 95.70 %]   hitEff: 94.43 %
```



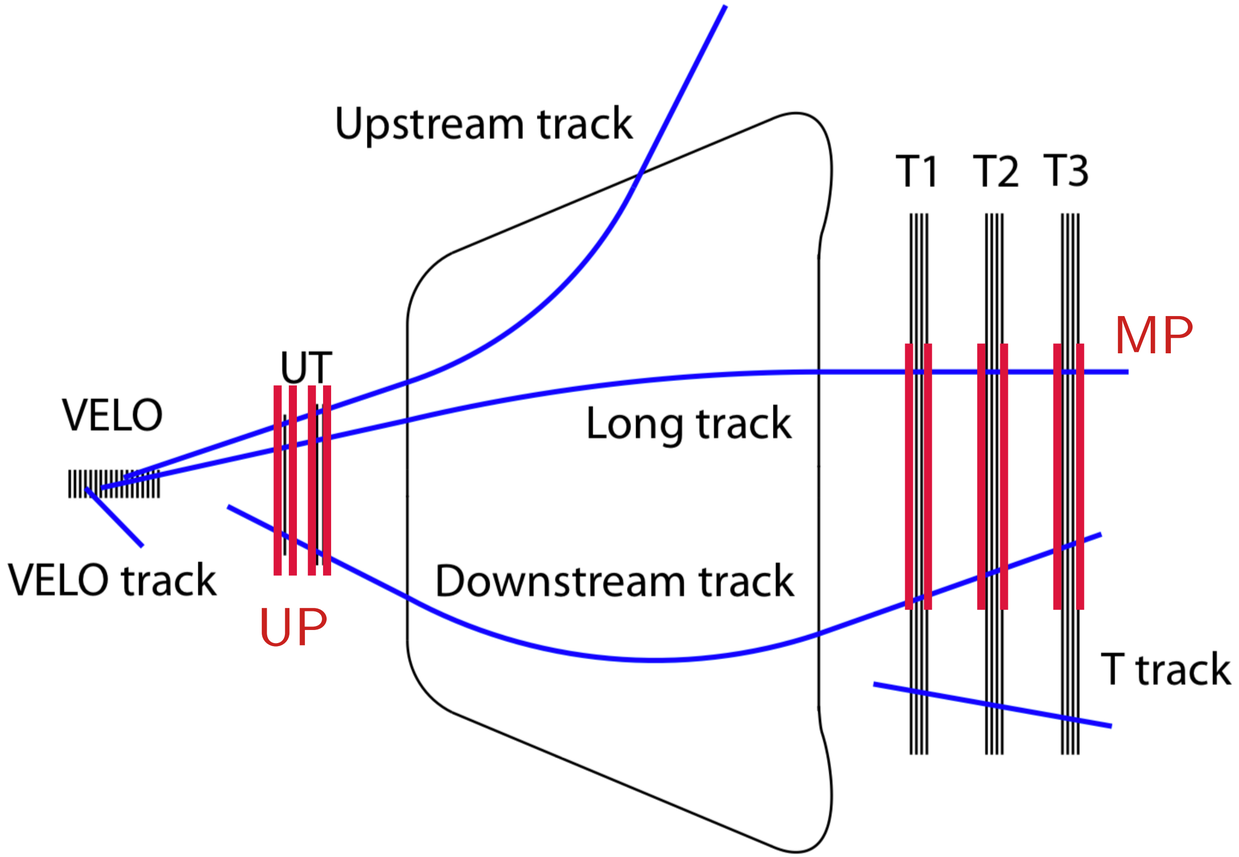
```
evenly spaced                  40900 tracks including       48 ghosts [ 0.12 %]
  01_hasMP                     27166 from    41926 [ 64.80 %]   hitEff: 88.60 %
  02_long                      23701 from    26023 [ 91.08 %]   hitEff: 88.97 %
  03_long_P>5GeV               21354 from    22048 [ 96.85 %]   hitEff: 90.69 %
  04_long_fromB                  268 from      277 [ 96.75 %]   hitEff: 92.21 %
  05_long_fromB_P>5GeV           254 from      256 [ 99.22 %]   hitEff: 93.22 %
```



- Slight loss in tracking efficiency and increase in ghost rate.
- Could possibly be compensated.

III: Long Tracks

Use MatchNN to make long tracks.



Figure

Retraining MatchNN

- Can retrain the Matching NN:
  - A first try was not as successful as hoped
  - Can optimise further:

- Variables used in NN:
  - chi2
  - teta2
  - distX
  - distY
  - dslope
  - dSlopeY

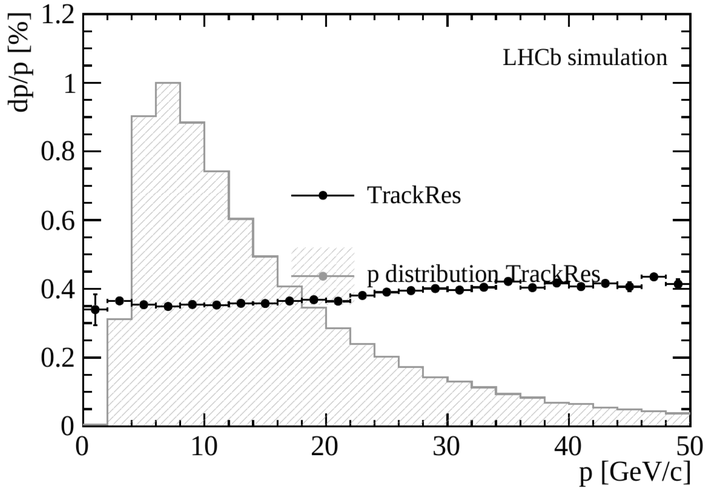
```
Run 3 NN              12711 tracks including          5262 ghosts [41.40 %]
01_long                                    :    6539 from     7545 [ 86.67 %]
02_long_P>5GeV                             :    6046 from     6642 [ 91.03 %]
03_long_strange                            :     262 from      343 [ 76.38 %]
04_long_strange_P>5GeV                     :     226 from      269 [ 84.01 %]
05_long_fromB                              :     116 from      122 [ 95.08 %]
05_long_fromD                              :     121 from      131 [ 92.37 %]
06_long_fromB_P>5GeV                       :     113 from      115 [ 98.26 %]
06_long_fromD_P>5GeV                       :     115 from      117 [ 98.29 %]

Retrained NN          12381 tracks including          4864 ghosts [39.29 %]
01_long                                    :    6577 from     7545 [ 87.17 %]
02_long_P>5GeV                             :    6080 from     6642 [ 91.54 %]
03_long_strange                            :     262 from      343 [ 76.38 %]
04_long_strange_P>5GeV                     :     227 from      269 [ 84.39 %]
05_long_fromB                              :     116 from      122 [ 95.08 %]
05_long_fromD                              :     121 from      131 [ 92.37 %]
06_long_fromB_P>5GeV                       :     113 from      115 [ 98.26 %]
06_long_fromD_P>5GeV                       :     115 from      117 [ 98.29 %]
```

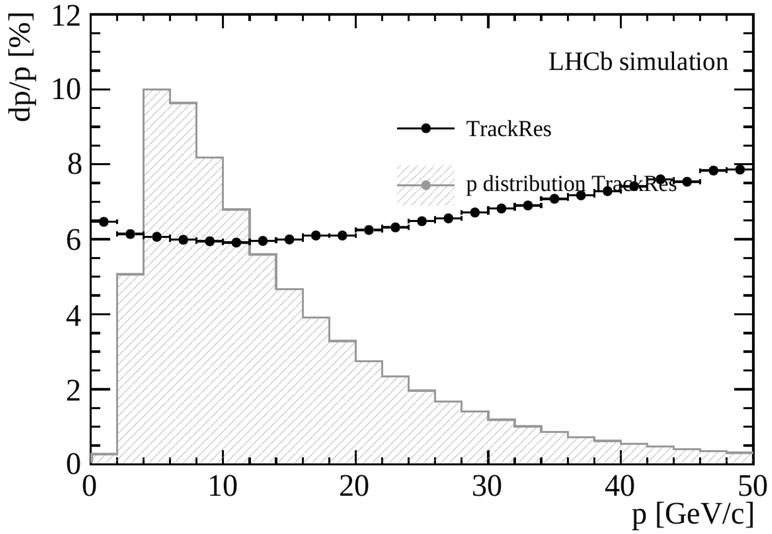
Fitted tracks & momentum resolution

- Use TrackMasterFitter.
- Works with MP (UP) hits, as well as all run3 hits.
- High momentum tracks limited by single hit resolutions.

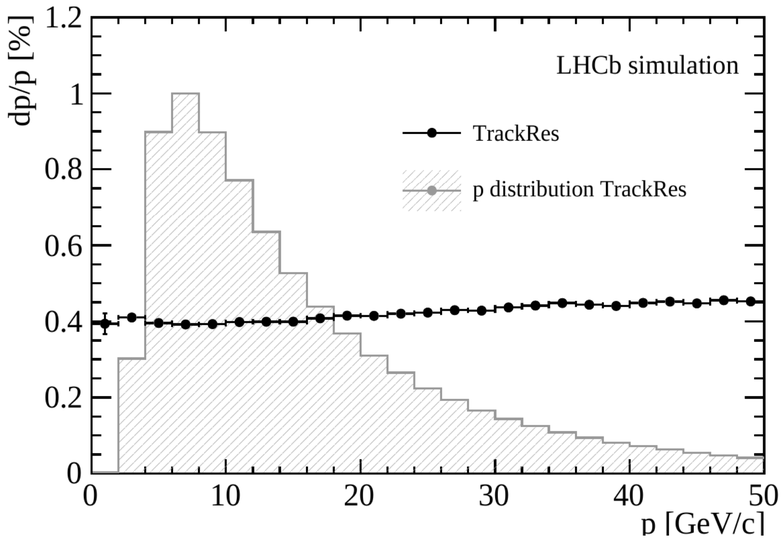
Long Tracks in Mighty Tracker pixel area with UP



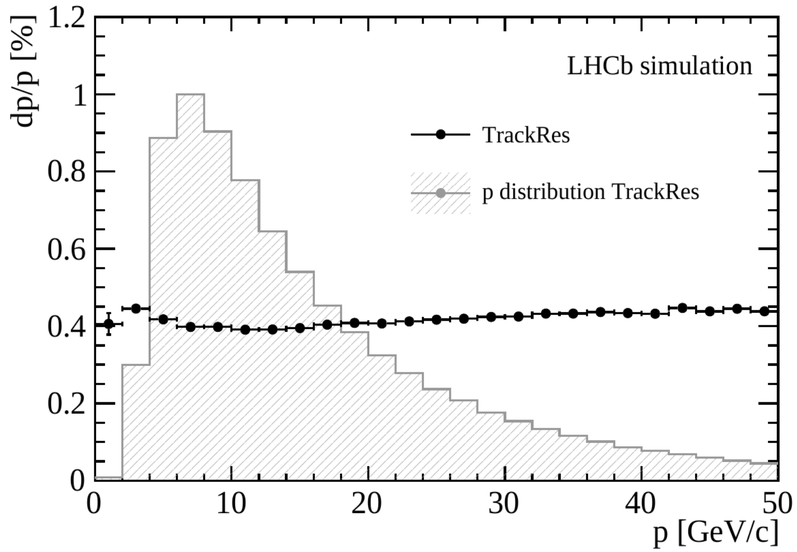
Ttrack in Mighty Tracker pixel area



Long Tracks in Mighty Tracker pixel area



Long Tracks in Mighty Tracker pixel area with UT



Conclusion

- Studied fibre tracking performance for several descoping scenarios.
- Flexible approach using Run 3 simulation @ UII luminosity.
  - profiting from available tools & algorithms.
- Added pixel tracking for MP area showing high efficiency & low ghost rate.
- Obtained fitted long tracks with momentum resolutions.

Backup