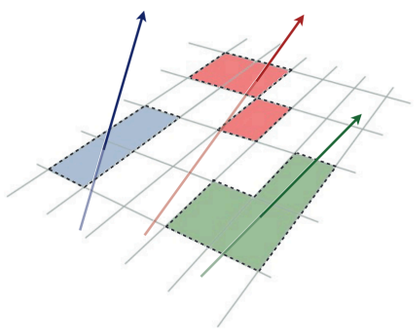
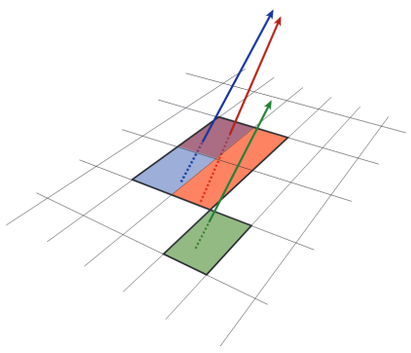
Clustering and tracking in dense hadronic environments with the ATLAS ITk.

Cluster merging

> In environments with a high density of charged particles such as the center of high-p_T jets, silicon clusters can merge



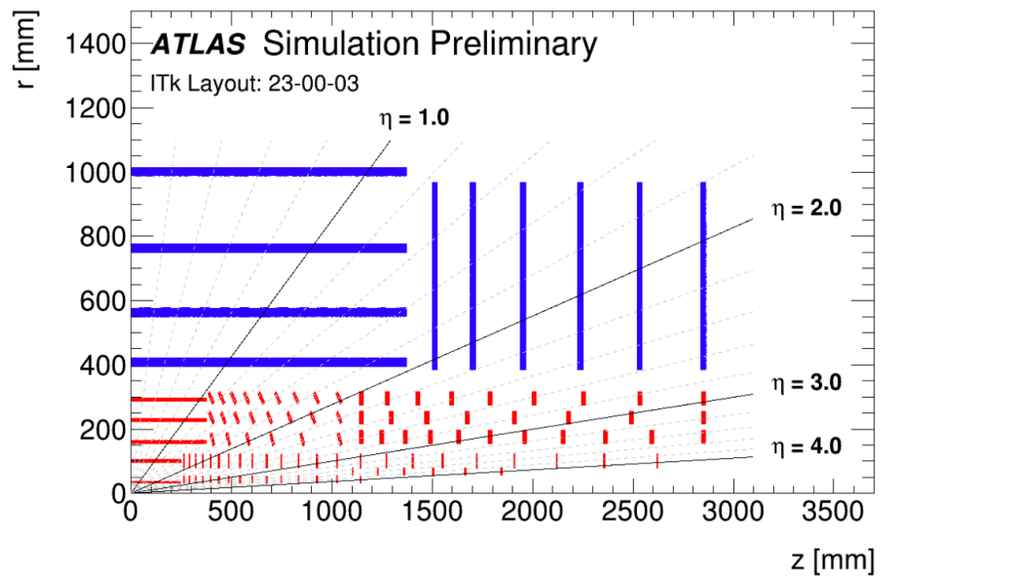


Taken from [1]

> Merged clusters usually end on multiple tracks
  > Tracks sharing clusters are penalised in the reconstruction, hence tracking **efficiency is reduced**
> Merged clusters **reduce the quality of tracking**
  > Track parameter resolution worsens and this affects jet flavour tagging
  > Flavour tagging is crucial for many measurements and searches
> Merged clusters are identified (Number Network) and split (Mixture Density Network) with the current detector
> Expected tracking performance in dense environments with the ITk?

The ITk

> All-silicon ATLAS tracker for High-Luminosity LHC
> Pixel and Strip sub-detectors
> Finer granularity than current ID (but higher occupancy)

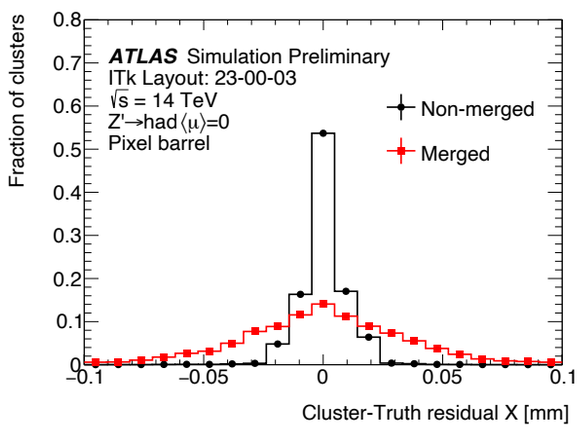


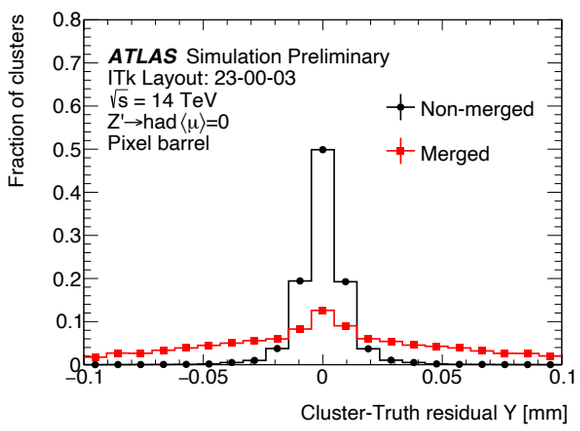
Taken from [2]

Pixel pitch	Innermost layer	Other layers
ITk	25 μm × 100 μm	50 μm × 50 μm
Current ID	50 μm × 250 μm	50 μm × 300 μm

Effects of cluster merging

> **Cluster position residuals** $\left(x_{\text{reco}} - x_{\text{truth}}^{\text{particle}}\right)$
> Reconstructed position of merged clusters is degraded

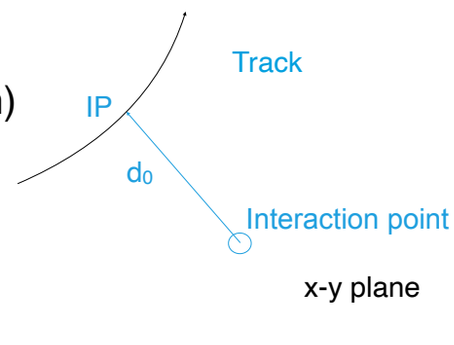


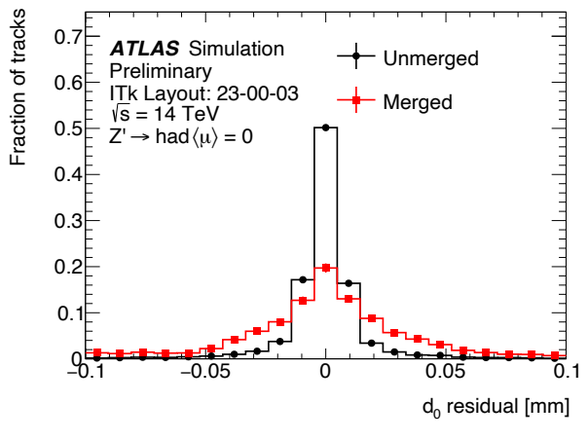


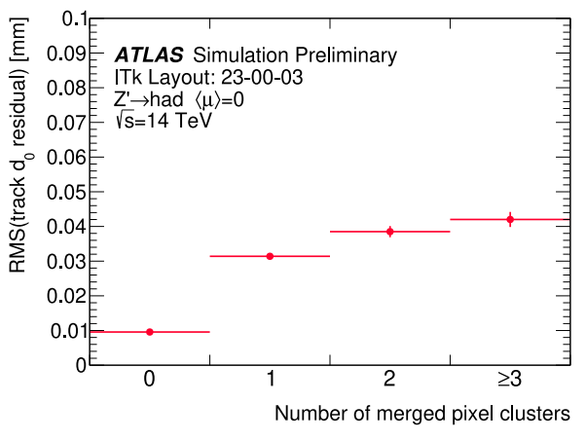
> **Impact parameter** d_0

Width of residual distribution for d_0 (μm)

Process	Not merged	Merged
$t\bar{t}$ $\langle\mu\rangle = 0$	12.4 ± 0.1	34 ± 2
$t\bar{t}$ $\langle\mu\rangle = 200$	12.3 ± 0.1	39 ± 2
$Z' \rightarrow$ had	9.57 ± 0.08	33.4 ± 0.6

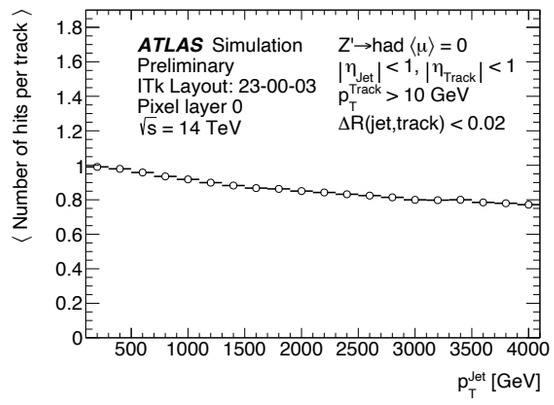




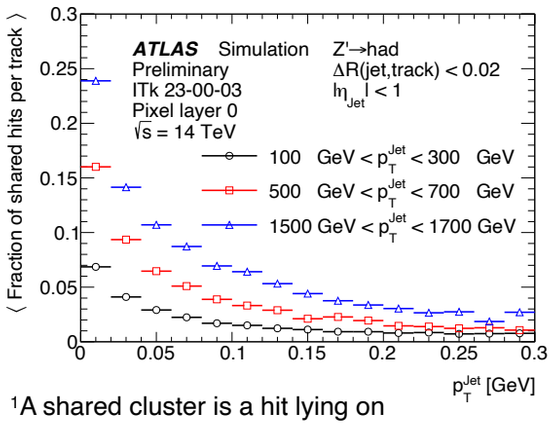


Tracks inside of jets

> Number of clusters in the Pixel detector decreases with jet p_T

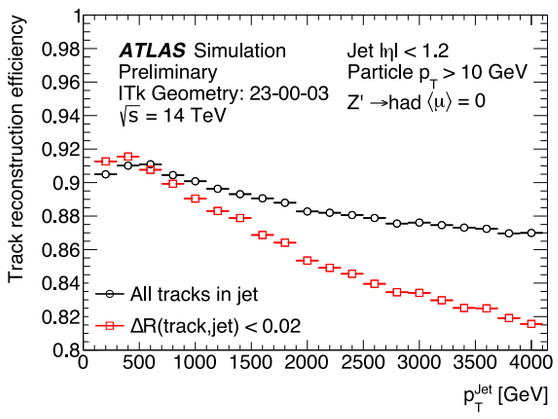


> Fraction of Shared[1] clusters increases in jet core

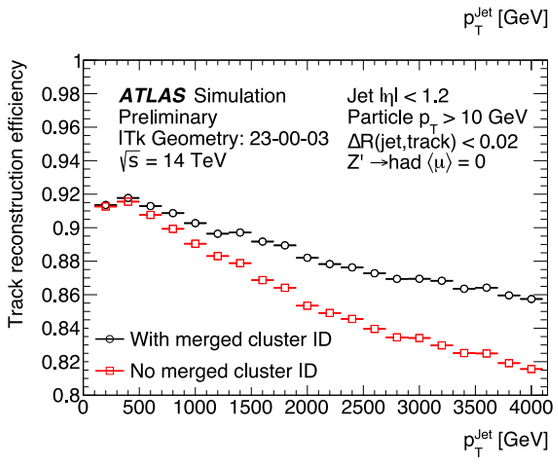


[1]A shared cluster is a hit lying on multiple tracks

> **Efficiency of track reconstruction**



> **No classification of merged clusters**
  > Reconstruction efficiency reduction in jet core
  > Better expected performance than current Inner Detector [3]



> **Perfect vs no classification of merged clusters**
  > **Focus on jet core**
  > No identification of merged clusters leads to efficiency loss in jet core
    > ~1% at 1 TeV

References

> [1] ATLAS Collaboration, *Performance of the ATLAS track reconstruction algorithms in dense environments in LHC Run 2,* Eur. Phys. J. C 77 (2017) 673
> [2] ATLAS Collaboration, *Expected tracking and related performance with the updated ATLAS Inner Tracker layout at the High-Luminosity LHC*, tech. rep. ATL-PHYS-PUB-2021-024
> [3] ATLAS Collaboration, *Modelling of Track Reconstruction Inside Jets with the 2016 ATLAS √s = 13 TeV pp Dataset*, tech. Rep. ATL-PHYS-PUB-2017-016
> [4] ATLAS Collaboration, *Clustering and Tracking in Dense Environments with the ATLAS Inner Tracker for the High-Luminosity LHC,* ATL-PHYS-PUB-2023-022

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Connecting the Dots 2023 poster session