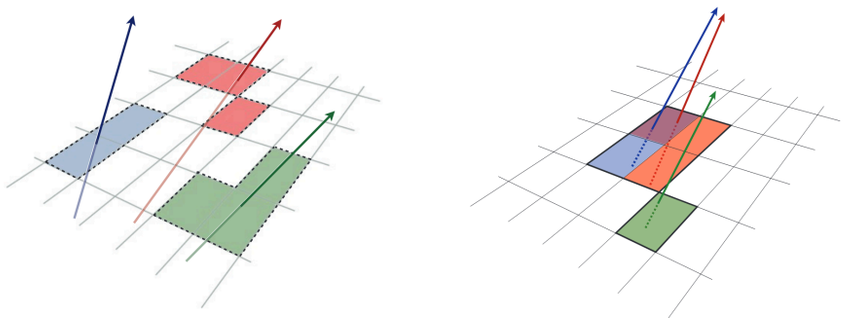
Clustering and tracking in dense hadronic environments with the ATLAS ITk

Cluster merging

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

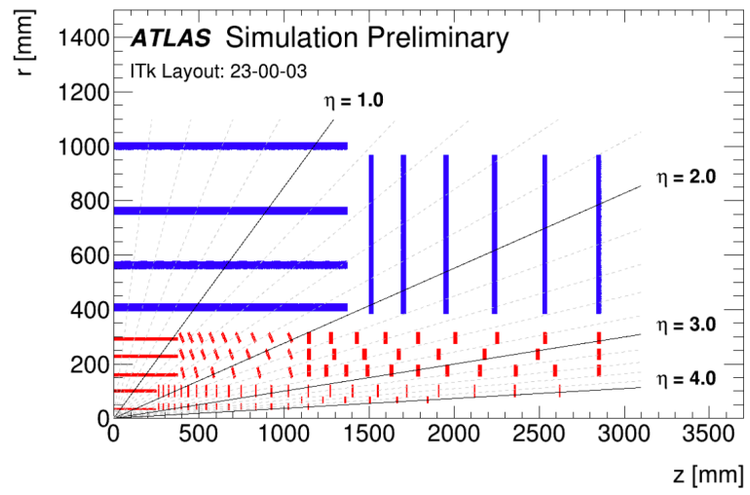


Taken from [1]

> 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
  > Will dedicated handling of merged clusters be needed for ITk?

The ITk

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

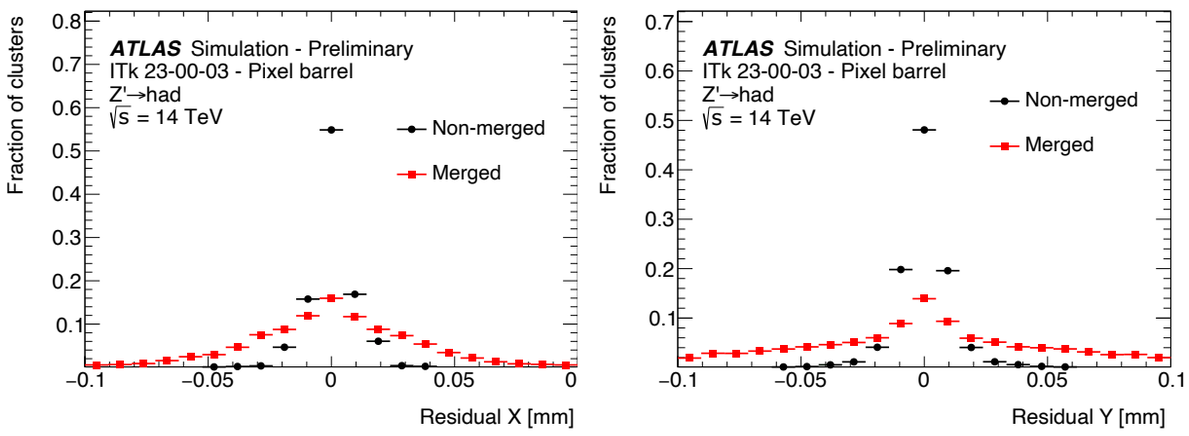


Taken from [2]

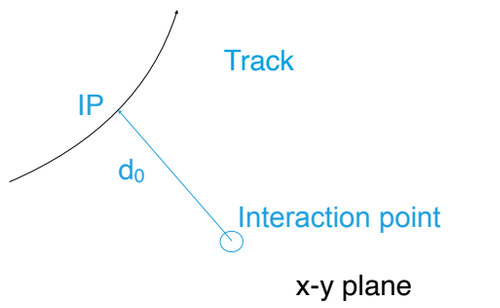
Pixel pitch	Innermost layer	Other layers
ITk	25 μm × 100 μm	50 μm × 50 μm
Current ID	50 μm × 250 μm	50 μm × 300 μm

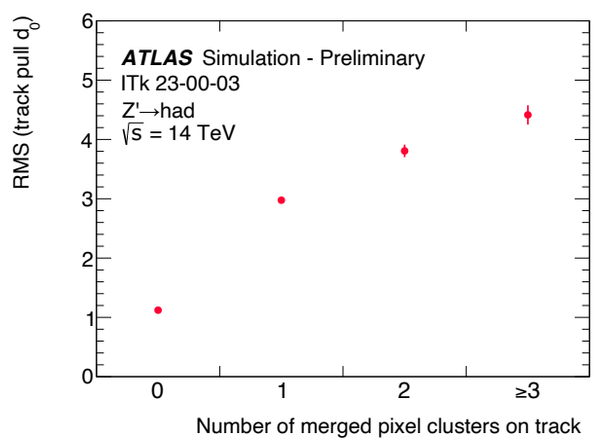
Effects of cluster merging

> **Cluster position residuals**
  > Residual $= x_{\text{reco}} - x^{\text{particle}}_{\text{truth}}$
> Reconstructed position of merged clusters is degraded



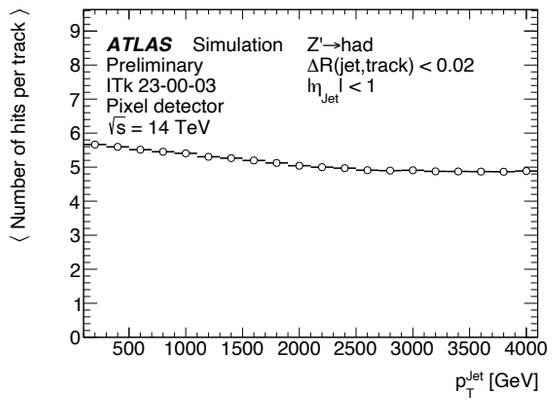
> **Impact parameter** d_0
  > Transverse component of the point of closest approach between the track and the interaction point
> Pull on d_0: $\dfrac{d_0^{\text{truth}} - d_0^{\text{reco}}}{\sigma(d_0)}$
> d_0 resolution degrades with increasing number of merged clusters per track



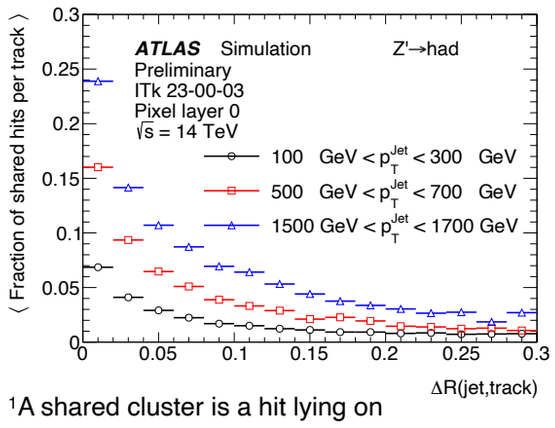


Tracks inside of jets

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

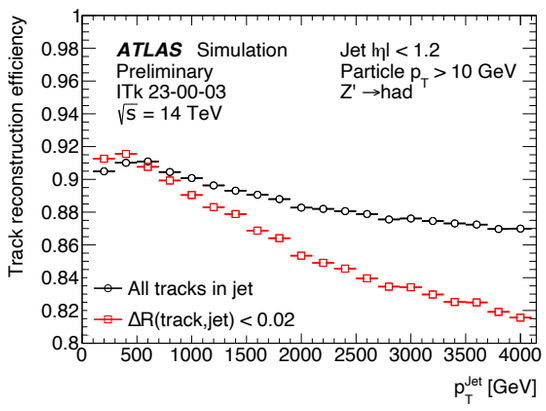


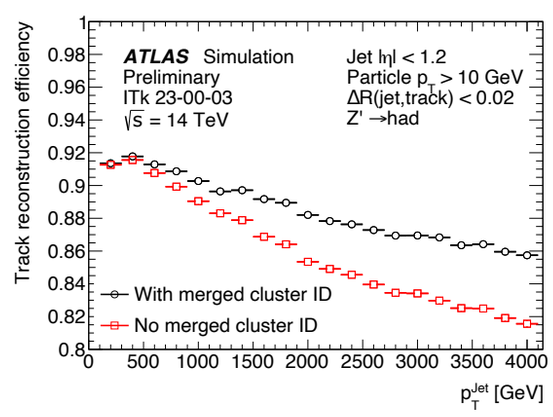
> Fraction of Shared[1] clusters increases in jet core



[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
    > ~3% at 2.5 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

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