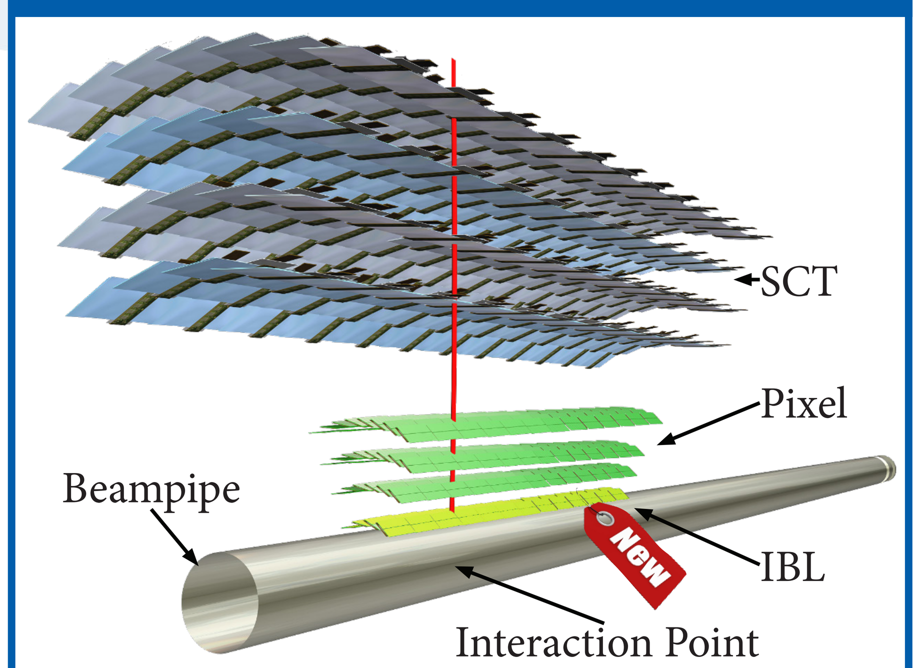
LHCC Poster Session - CERN, 4 March 2015

Novel methods and expected Run II performance of ATLAS track reconstruction in dense environments

ATLAS Pixel & SCT Detector

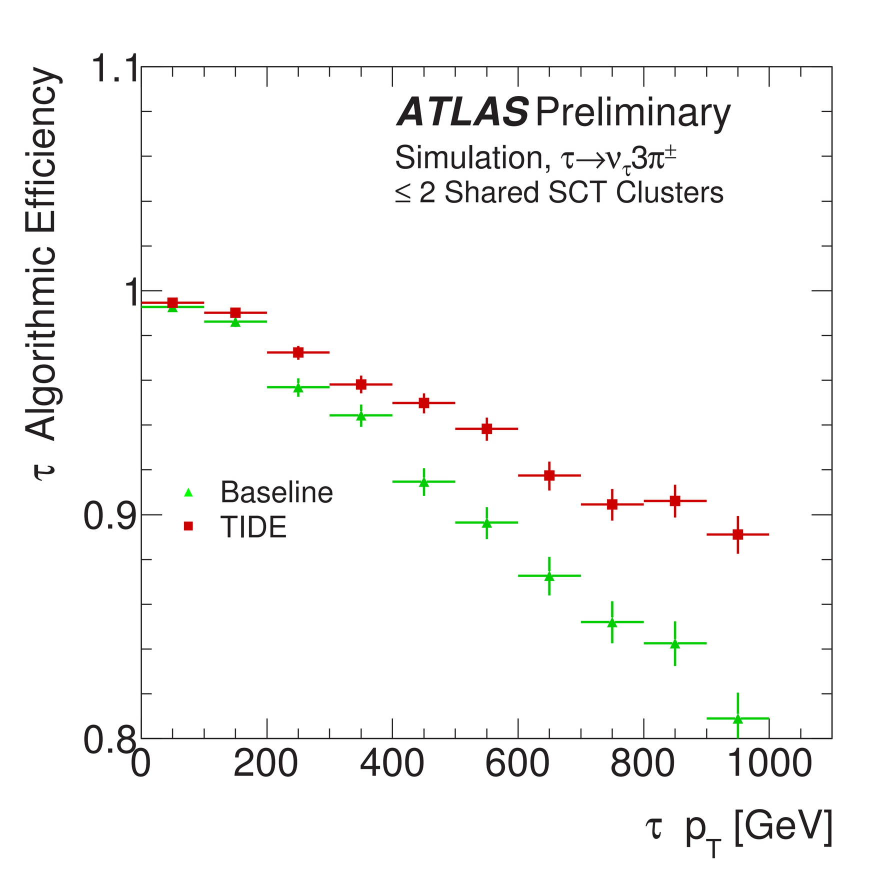


Barrel of the three silicon based inner detectors.

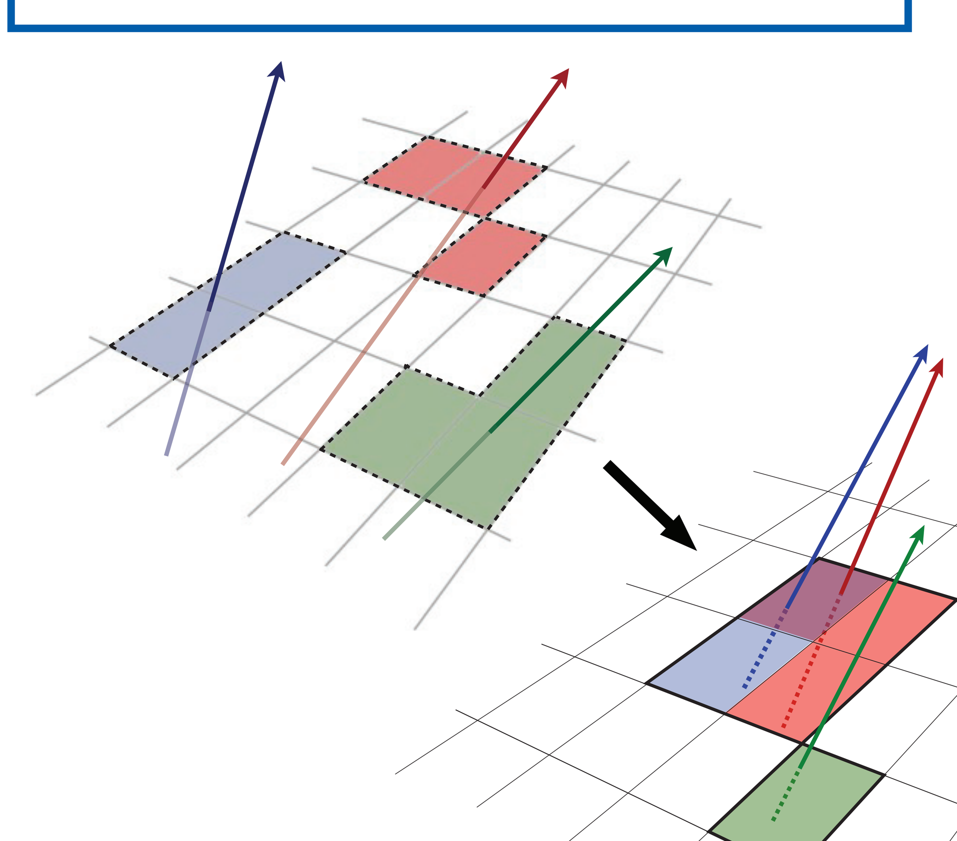
- Immersed in a solenoid field of 2 T.
- Provides precision tracking within $|\eta| < 2.5$.
- Precise primary/secondary vertex reconstruction.

	IBL	Pixel	SCT
Barrel Layers:	1	3	4
Endcap Layers:	0	2 × 3	2 × 9
#Channels:	6M+	80M+	6.3M
Sensor Size:	50μm × 250μm	50μm × 400μm	80 μm × 12cm
Resolution (Rϕ/z):	~10μm/ 50μm	~10μm/ 100μm	~17μm/ 580μm

Tau Reconstruction Performance



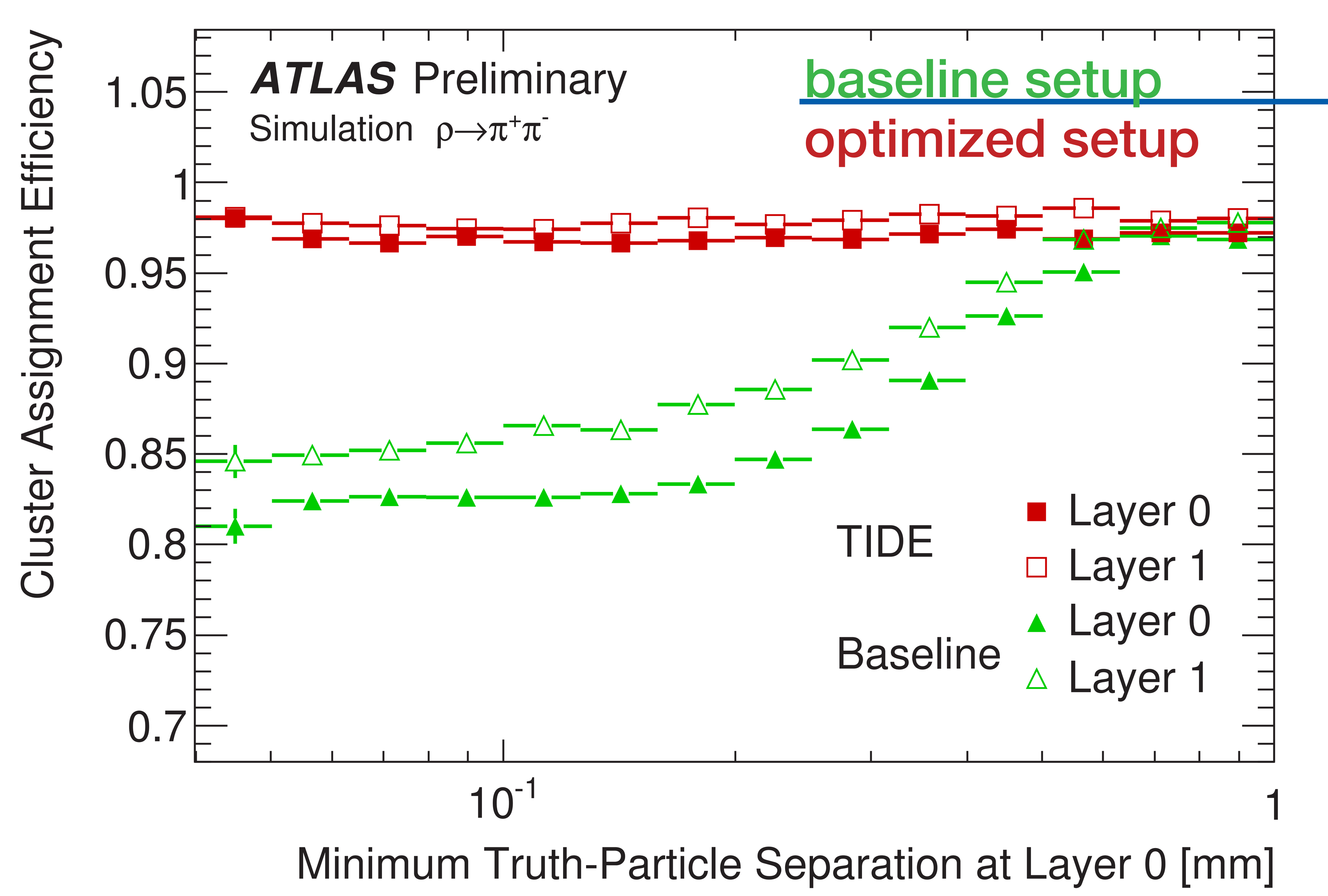
The efficiency to reconstruct all charged decay products of a 3-prong hadronic tau decay is shown as function of the parent truth particle p_T. Only events are considered where simulation requires all tracks to be reconstructable and not to share more than two SCT clusters. A clear improvement in efficiency can be observed for the TIDE setup, especially at high p_T.



Sketch of pixel clusters for isolated tracks as well as for tracks in dense environements.

Tracking in Dense Environments

- **Clusters** are formed when charged particles deposit charge in multiple neighboring pixels.
- **Merged clusters** are created when average spatial separation of particles reaches ~ single pixel size.
  - → Happens in **dense environments!**
- **Shared clusters** (clusters used by >1 track), are penalized during track reconstruction to guarantee high quality tracks.
  - → But common for merged clusters
  - → **Degrades performance** in dense environments!
- Employ an **artificial neural network (NN)** to identify merged clusters & not penalize them.
- During run I **performance in these environments was known to be suboptimal**.
- But crucial in many areas:
  - » b-tagging (esp. at high momenta)
  - » jet calibration
  - » 3-prong τ identification
  - » numerous physics signals, e.g. H→bb, SUSY,...



The efficiency at which reconstructed clusters are properly assigned to a track is shown for the first two pixel layers as a function of the minimum truth particle separation at the innermost pixel layer for the $\rho\rightarrow\pi^+\pi^-$ sample. The different performance between the baseline (green triangle) and TIDE (red boxes) algorithm is striking: while the baseline steeply drops for smaller separations the improved setup provides a constant performance.

Basic Run I chain to reconstruct a track:

1. Create clusters & use NN to duplicate merged ones.
2. Do pattern recognition & create track candidates.
3. Let ambiguity solver select best tracks and clean them up.
4. Use track fitter to create particle trajectories.

This has several disadvantages:

- **Incident angle** of track candidate not available as input to NN at cluster creation stage.
  - → But, **would improve NN performance!**
- **NN evaluated for all cluster**, even for those which are not shared.
- Pattern recognition needs to consider more clusters and it creates more track candidates.
  - → Quite **CPU intensive** approach!

Updates to Algorithms

Moved NN evaluation to ambiguity solver:

- → **Incident angle** is available as NN input.
- Calls NN only if cluster gets shared.
- Does not duplicate clusters.
  - → Therefore **resources are saved!**
- Also identifies cluster as merged if next cluster on track is identified as merged by NN.
  - → **Recovers incorrect NN predictions!**

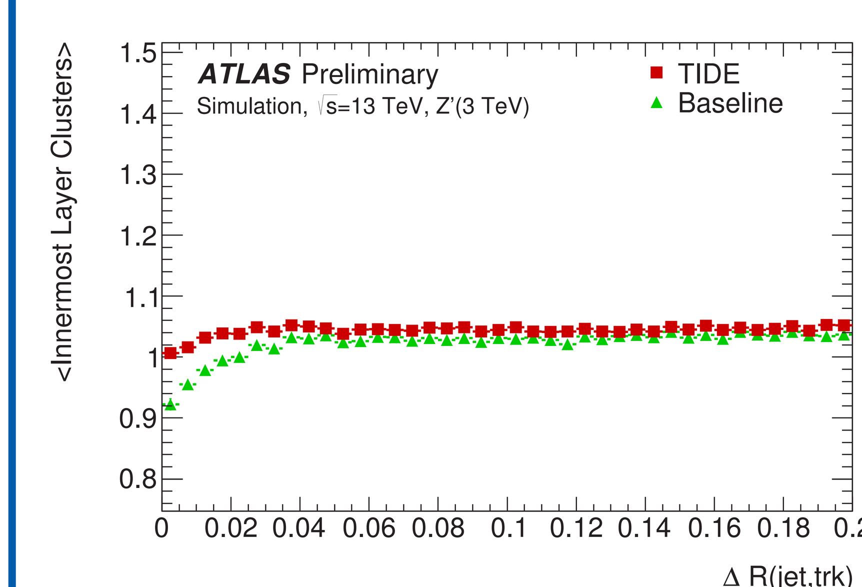
Additional smaller adjustments:

- » Merged clusters can now be shared.
- » Require four unique SCT hits.
- » At least 9 silicon hits on track to share one of its clusters.
- » 1 GeV minimum track p_T for cluster to be marked as merged.
- » Tuning of threshold on NN output to mark a cluster as merged.

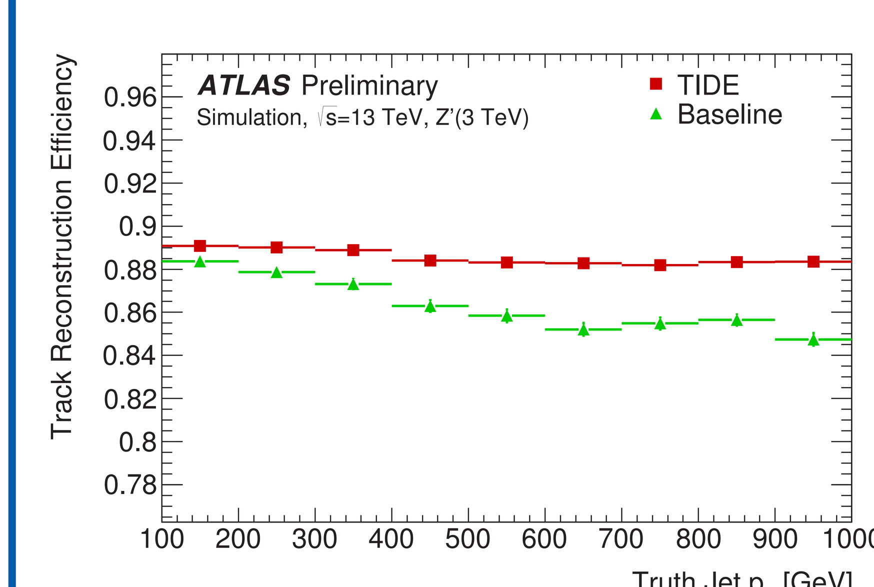
Used Monte Carlo Samples

- ρ(10GeV-1TeV)$\rightarrow\pi^+\pi^-$
  - → To study performance in close-by tracks.
- τ(10GeV-1TeV)$\rightarrow\nu_\tau 3\pi^\pm$
  - → To determine reconstruction efficiency of a 3-prong tau decay.
- Z'(3TeV)$\rightarrow t\bar{t}$
  - → To study track reconstruction performance in the core of jets, and b-tagging efficiency.

Performance in Z'(3TeV)$\rightarrow t\bar{t}$

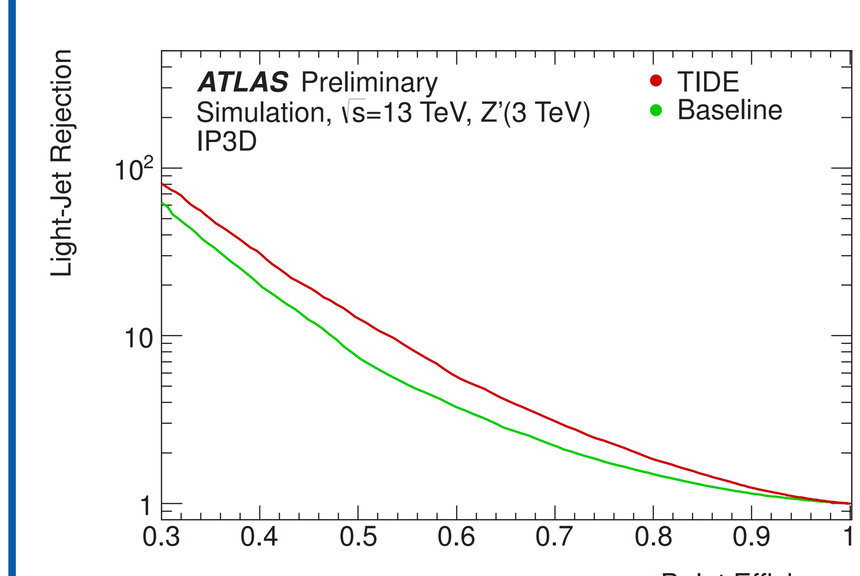


The average number of innermost pixel layer clusters on track is shown as a function of the angular distance of the track from the axis of jets with p_T > 100 GeV. More clusters are found on track with the optimized TIDE setup.



The efficiency to reconstruct tracks in jets as a function of the truth jet's p_T is shown. The TIDE configuration has a higher efficiency, most notable at high jet momenta.

Improvement for b-Tagging



The performance of the impact parameter based tagger IP3D is shown with the updated TIDE setup as well as the baseline. At the 60% efficiency working point 10% efficiency is gained for the same light-jet rejection.

Roland Jansky, for the ATLAS Collaboration

ATLAS EXPERIMENT