Status of new pixel clustering

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On behalf of the pixel clusterization TF group
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Outline

- Motivation
- Clustering algorithms
- NN-based algorithm :
  - Output
  - Impact on b-tagging performance
- Conclusion

Motivation

- ATLAS current clustering algorithm not optimized for tracking in high p_T jets (dense environment → merged clustered (shared hits) → low efficiency in the core of the jets)

- Pixel Clusterization TF set up to improve clustering algorithm and tracking in these jets

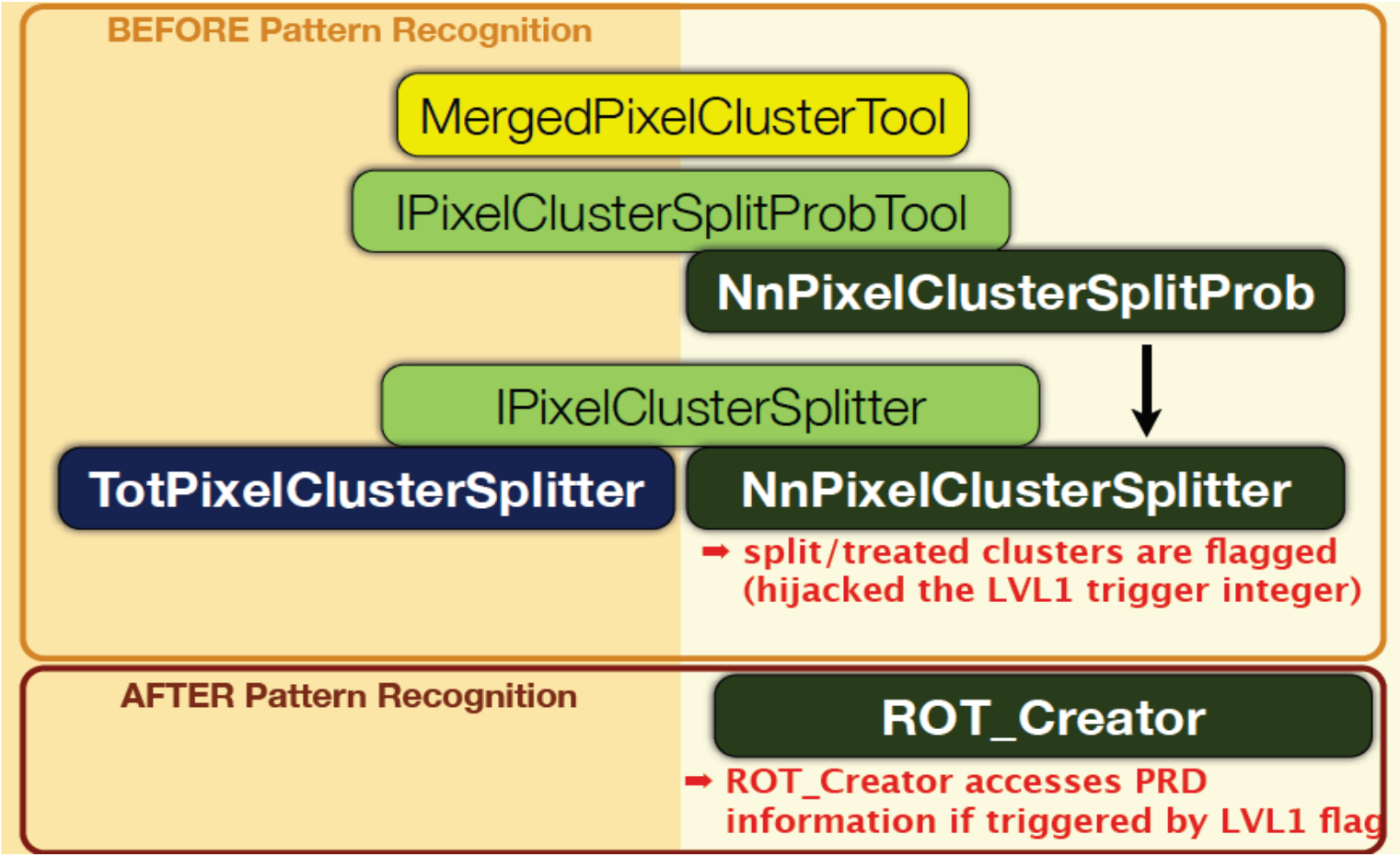
- Huge impact on b-tagging performance at high p_T (useful for H→ bb, SUSY, Z'→bb,..)

Andi

Clustering algorithms

2 new clustering algorithms :

- **NnSplitter** : NN trained with truth input, corrects single clusters & splits
- **TotSplitter**: based on charge information (ToT), searches for split signatures (minimum ToT between 2 maxima) & splits



NN-based algorithm

Giacinto

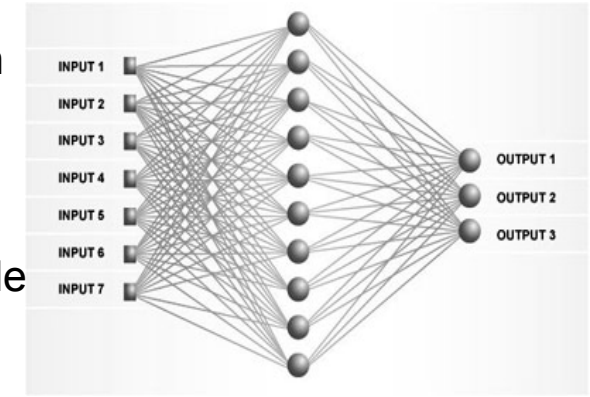
INPUT nodes

7x7 pixel matrix with calibrated charges

vector of z pitches
(normal or long pixel)

track incidence angle
(after pattern recognition)

layer number



OUTPUT nodes

How many subclusters?

What is their position?

What is their associated distribution? → (error)

- Applied **before** and **after pattern recognition** (different training)
- Output : Number of sub-clusters with associated probability
  → Performance according to cut (working point, next slide)
  → Associated position (slide 7)
- After splitting, 1 given pixel is no more associated to 1 given cluster

NN based alg. : performance

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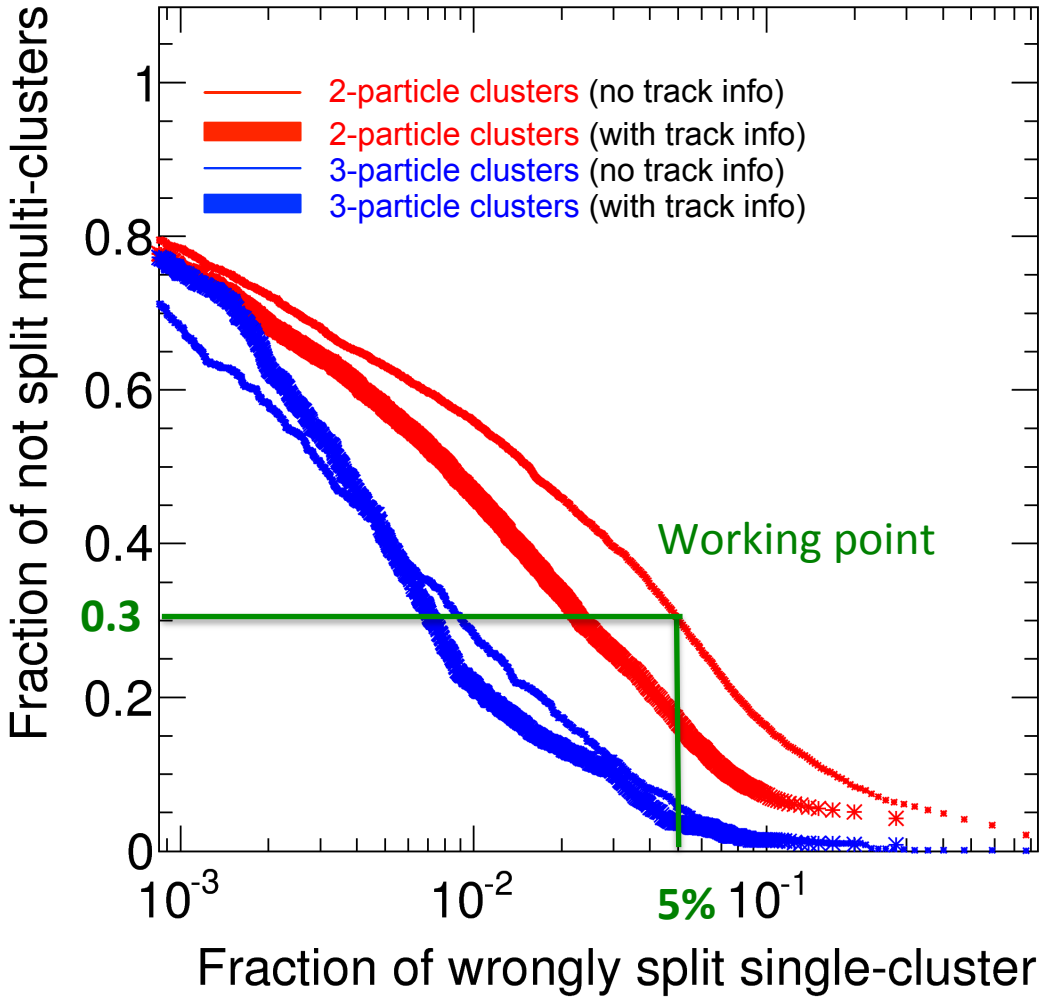


- 1-particle vs. 2-particle case :
- 5% wrongly split 1-particle :
  - 15 % not split 2-particle (with track info = after pattern recognition)
  - 30 % not split 2-particle (without track info = before pattern recognition)

ATLAS W/O IBL

NN based alg. : residuals

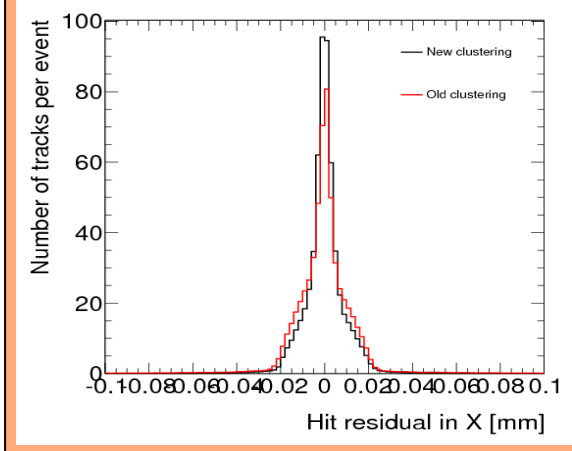
Giacinto

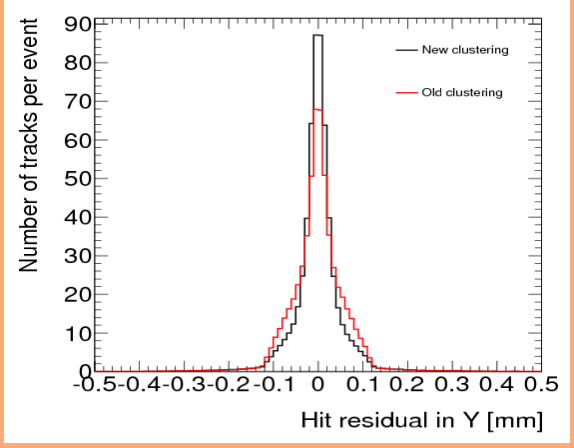
ATLAS + IBL

Distance in X and Y between track and cluster

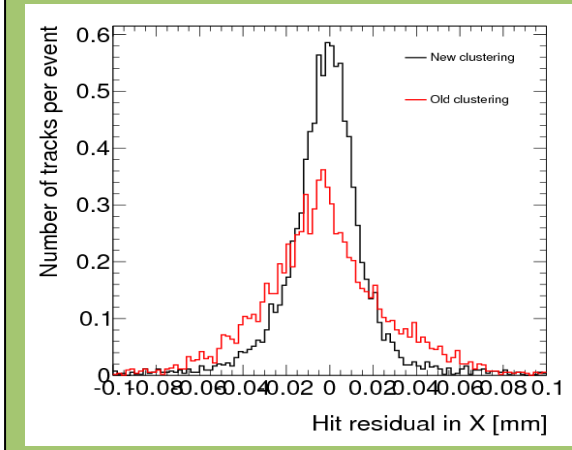
- Better position even for 1-particle clusters (better treatment of **delta-rays**)

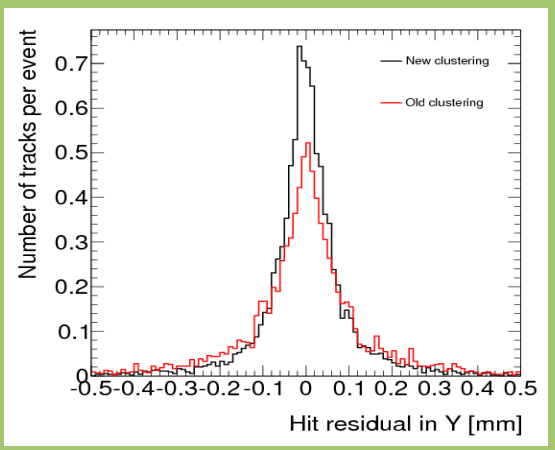
- Residuals of 1-particle clusters:





- Residuals of 2-particle clusters:





- Resolution **2 times better** in **X** and significantly better in Y

Tracking performance : resolution

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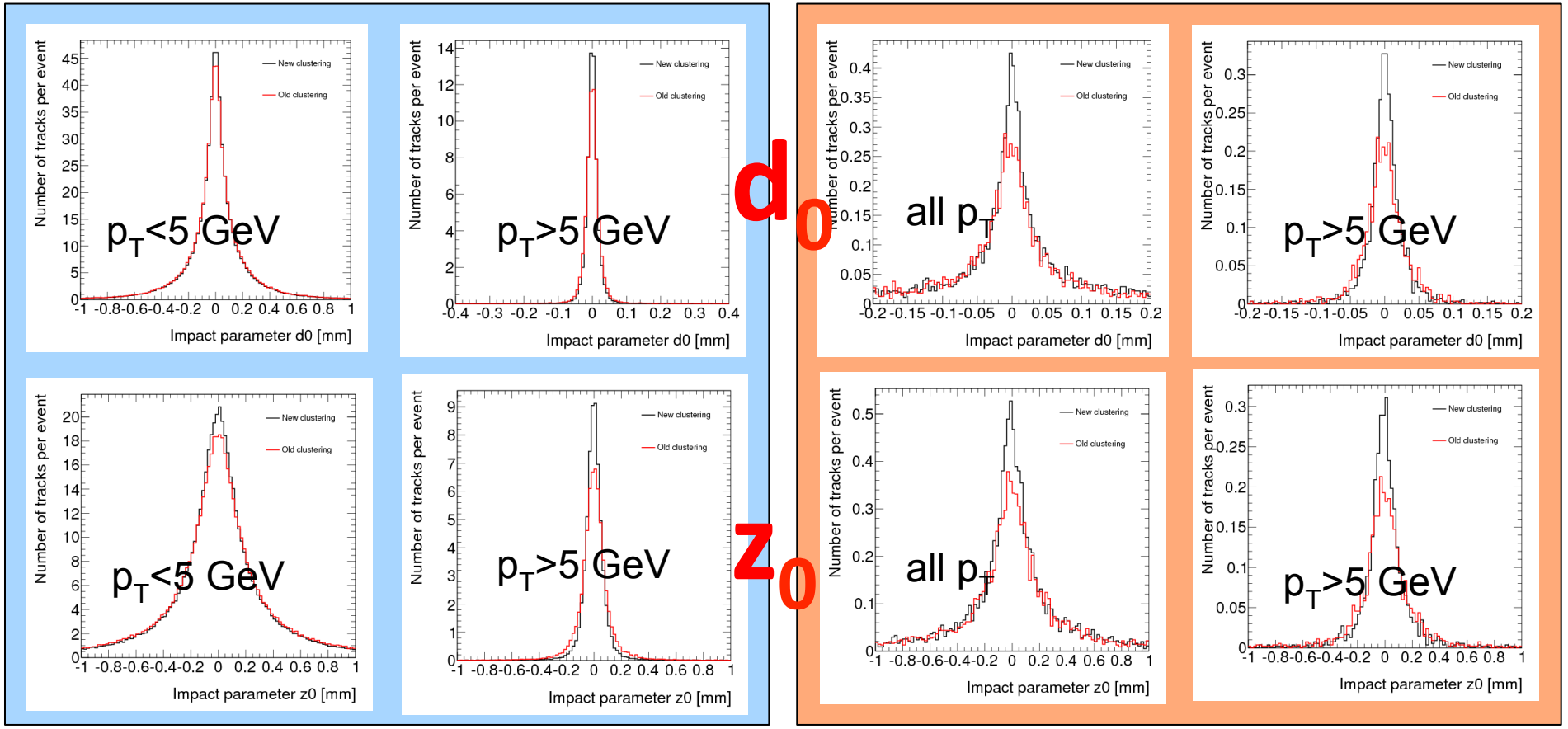
ATLAS + IBL

NN-based alg.

Track with isolated (“1-particle”) IBL cluster

Track with “2-particle” IBL cluster



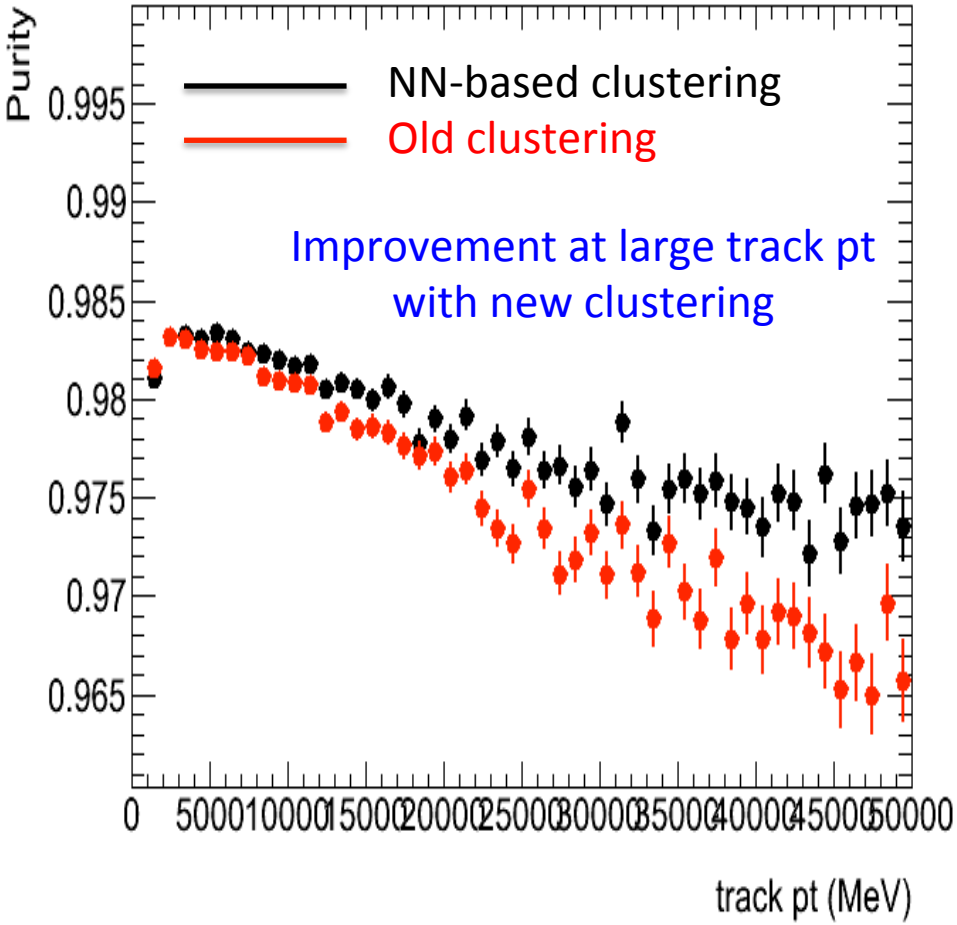
- **Improvement in “isolated” clusters** most likely due to better treatment of **delta rays**
- **Splitting merged clusters** clearly **improves** the **resolution** and the **reconstruction efficiency**

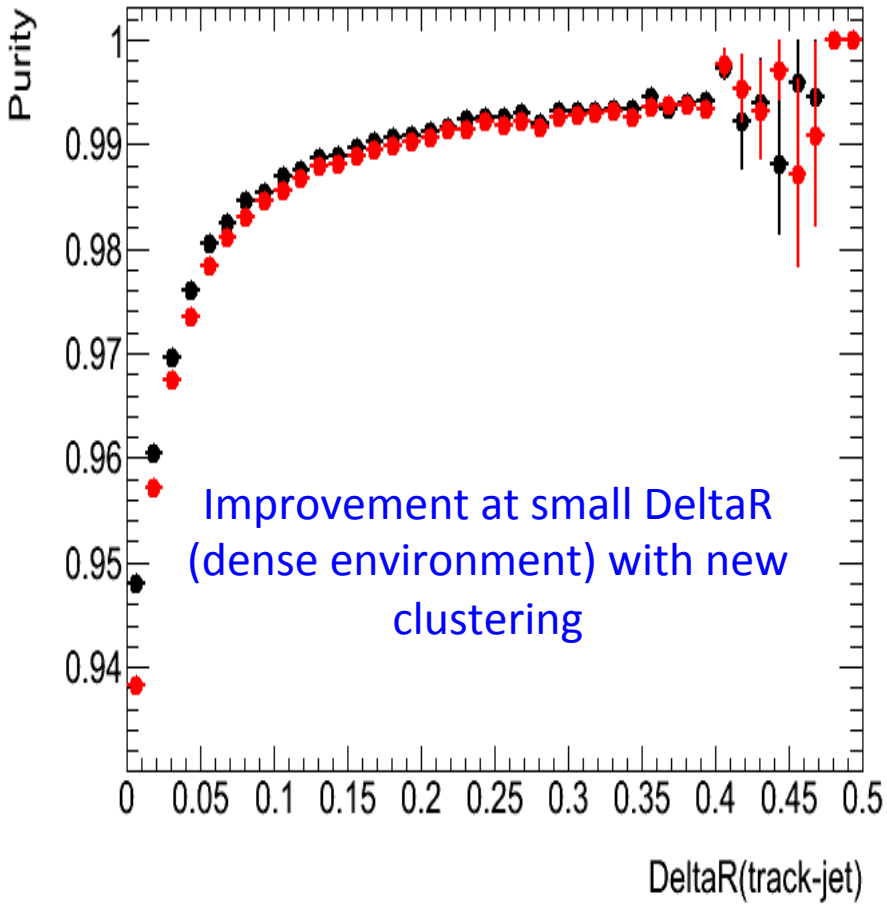
Tracking performance : purity

NN-based alg.

- Tracks passing IP b-tagging cuts in jets with p_T>30 GeV
- High p_T dijet events
- **Track in jets purity vs track p_T and DeltaR (track-jet)**
  - Purity = # reco tracks matching to true track / # reco tracks

ATLAS W/O IBL

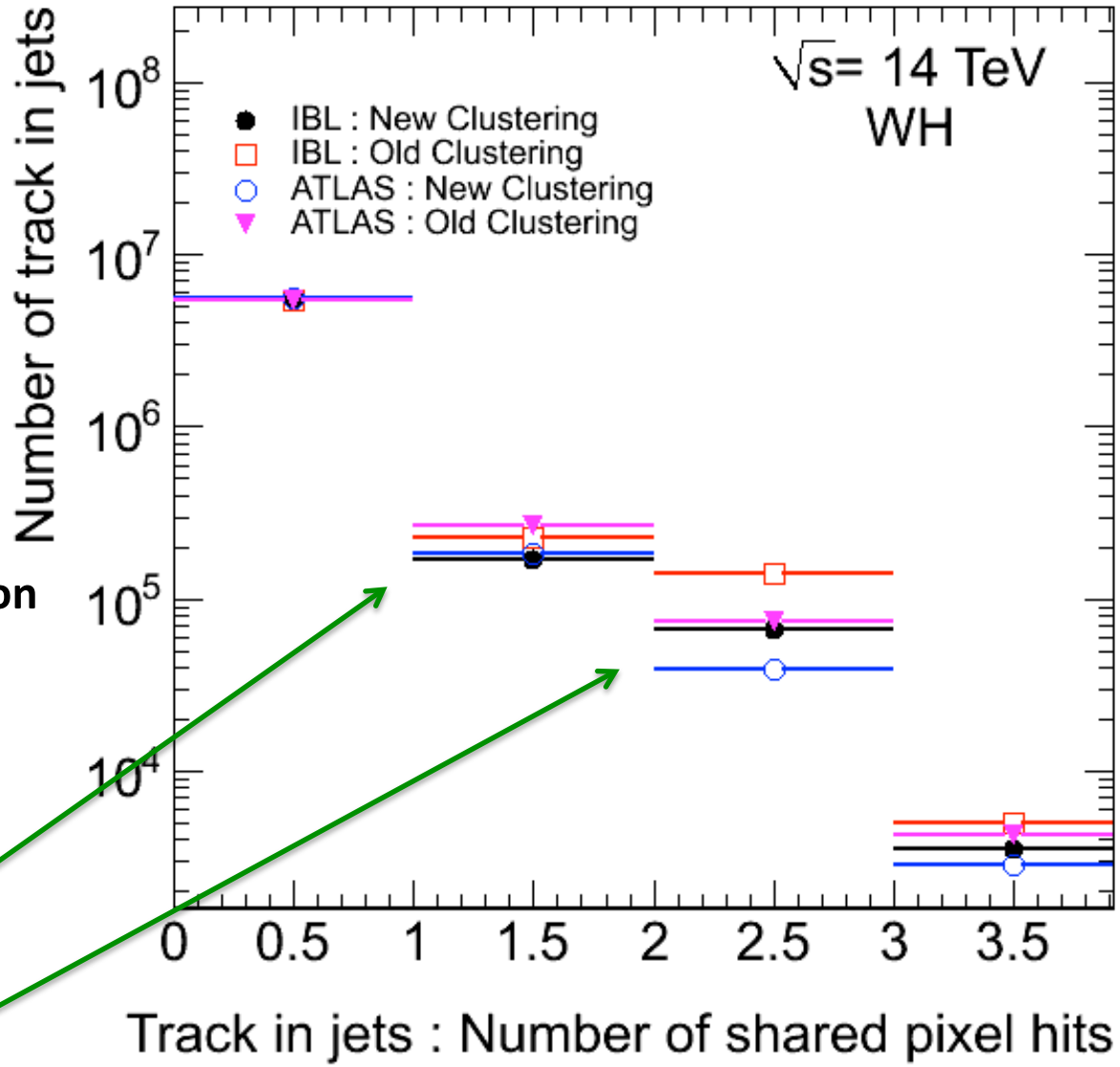




Shared pixel hits

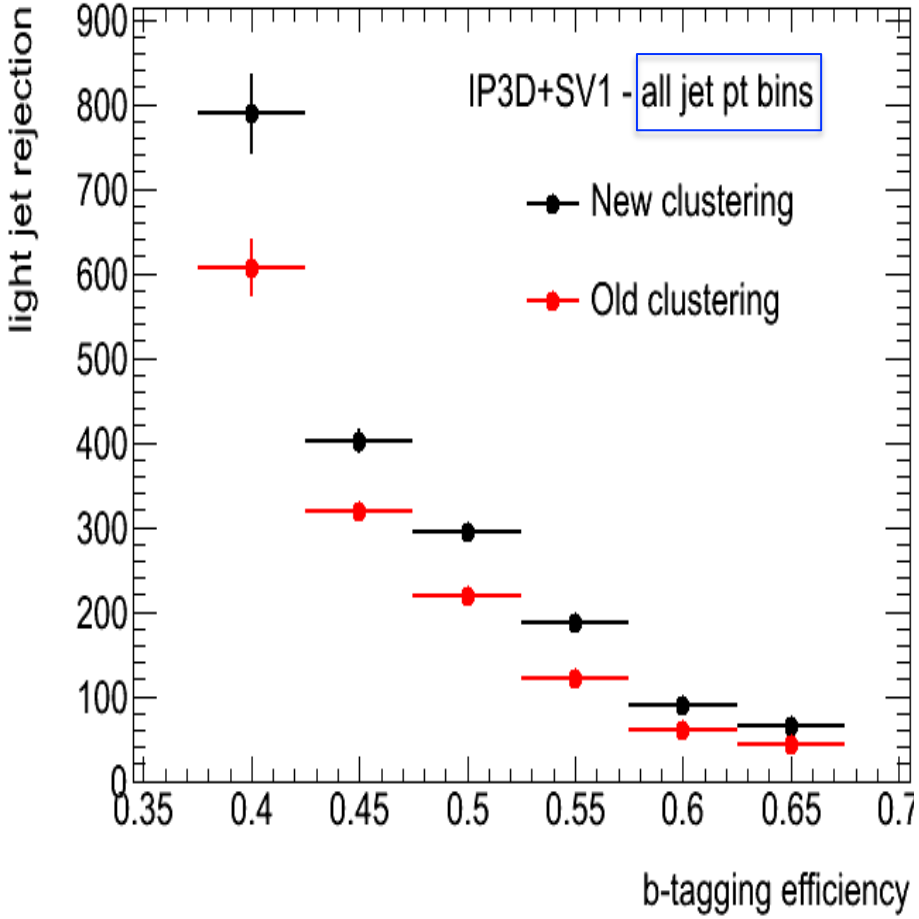
New Clustering = NN-based alg.

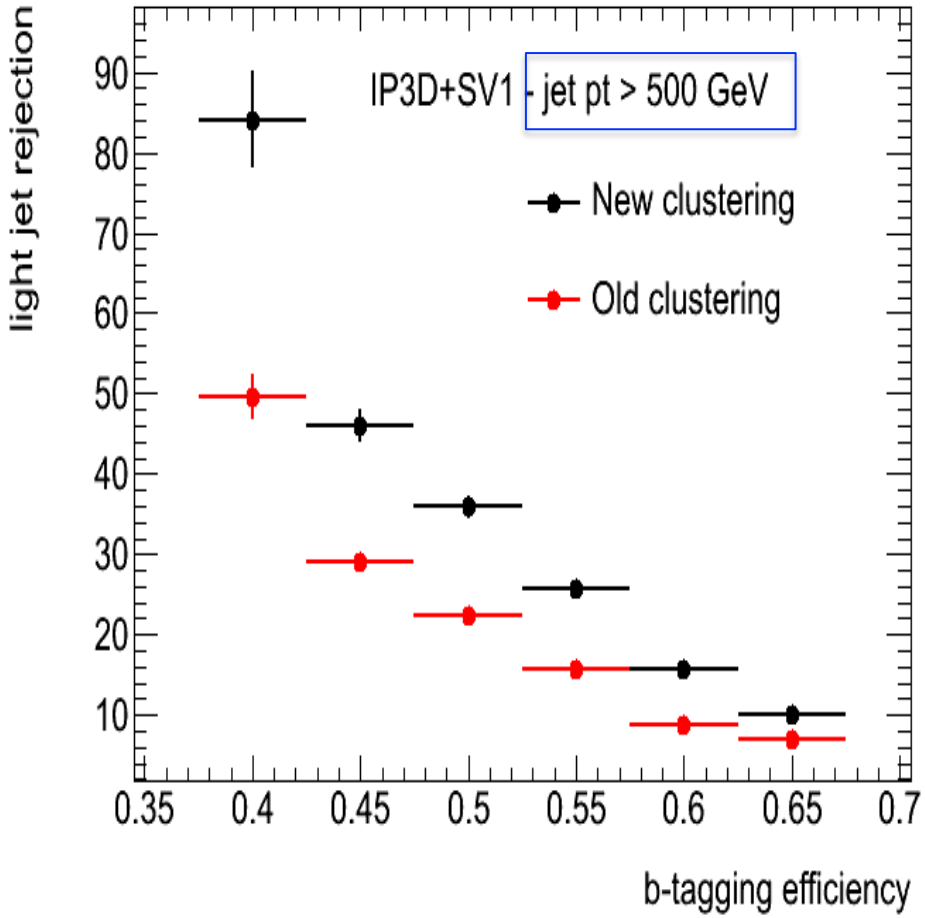
- **Number of shared pixel hits on tracks in jets**
- Without IBL, with NN clustering :
  - **~30% less tracks with 1 shared hits**
  - **~50% less tracks with 2 shared hits**



Impact on b-tagging perf.

ATLAS W/O IBL





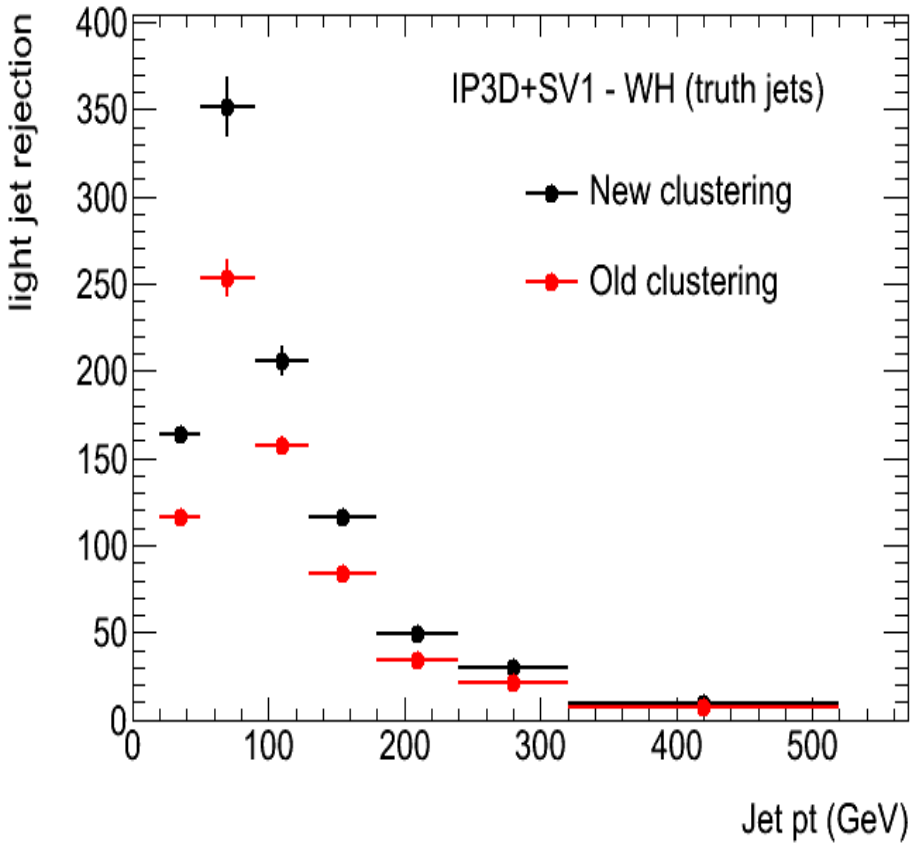
B-tagging efficiency : # of tagged true b-jets/# of true b-jets
Light jet rejection : # of true light jets/# of tagged true light jets

Perf. multiplied by ~1.5 for high p_T jets with NN-based clustering

Impact on b-tagging perf. (with IBL)

ATLAS + IBL

- **Light jet rejection vs jet p_T for a 70% b-tagging efficiency**
- **Using truth jet and IP3D+SV1 algorithm**



Performance improvement : **~40%**

Conclusion

Status

- **Significant improvement** of **cluster resolution**, **track reconstruction efficiency**, **b-tagging perf.** using the **NN-based clustering** (in both the ATLAS and ATLAS+IBL configuration)
- Another algorithm developed – performance ready to be studied

Release migration

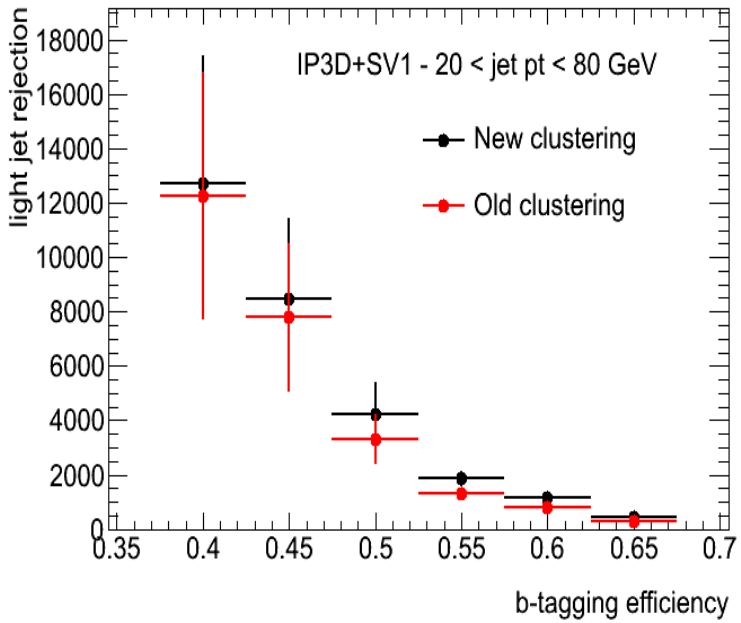
- TAGProd release **branched off from 16.6.0.1** used/in use for studies and grid deployment
- NnClusterSplitter fully integrated in TAGProd,16.6.0.1.1
  - 16.6.0.1.2 should have the first version of the TotClusterSplitter
- AmbiguitySolver being currently updated to handle these new cluster ambiguities
- Currently re-integrating the code into trunk to **devval to match the release 17.0.0 deadline** (MIG release requested)

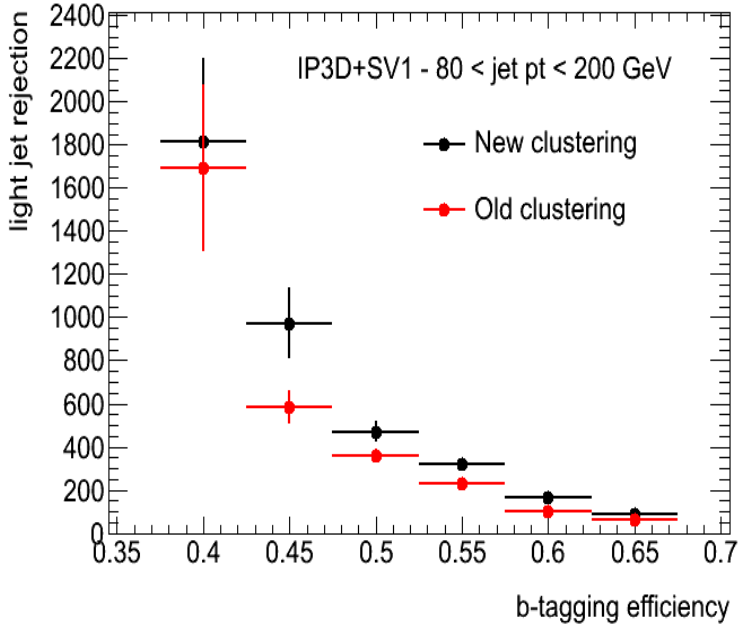
To-do

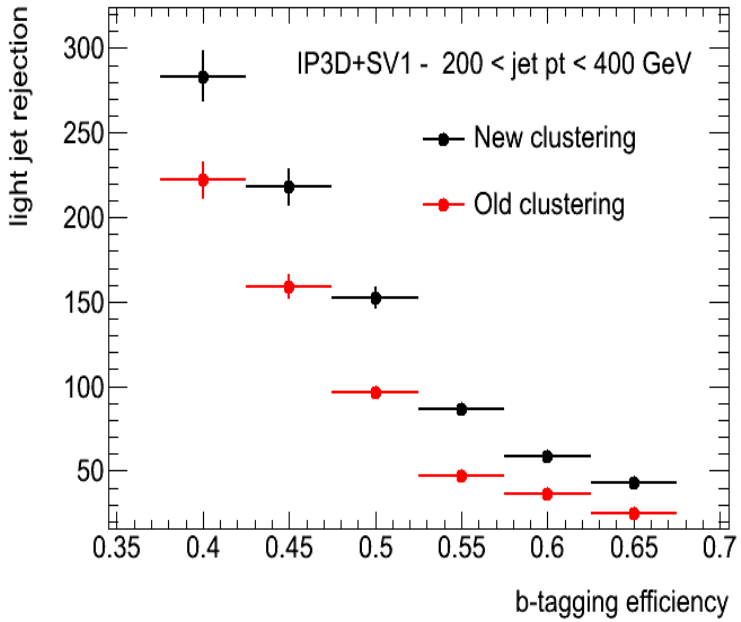
- Finish the AmbiguitySolver behavior in case of splitting
- Solve the ambiguities in truth association after splitting
- Refine implementation of NnClusterSplitter
- Test with data and specific selected events beam halo/beam splash/cosmics
- Write final report
- Full integration into 17.X.0 and correct binding to COOL for the input of the NnClusterSplitter and TotClusterSplitter

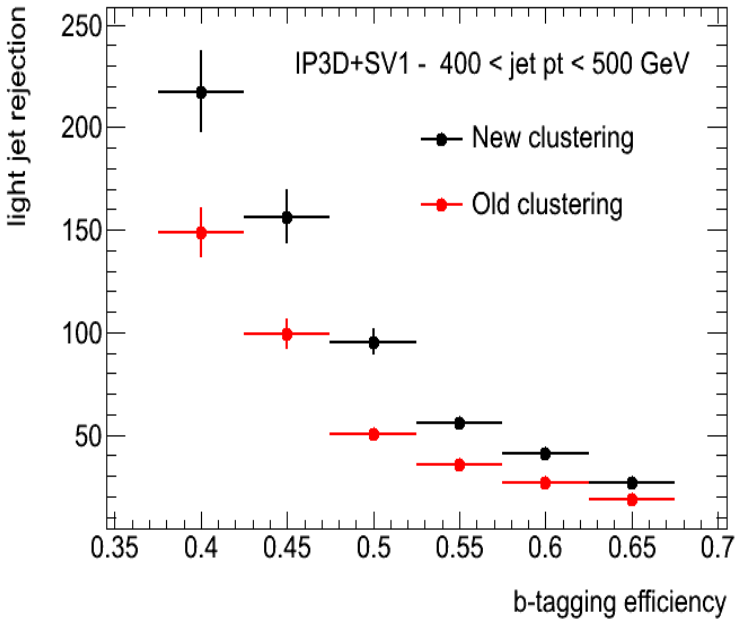
BACK-UP

Impact on b-tagging perf.









NN-based alg. : ToT map example

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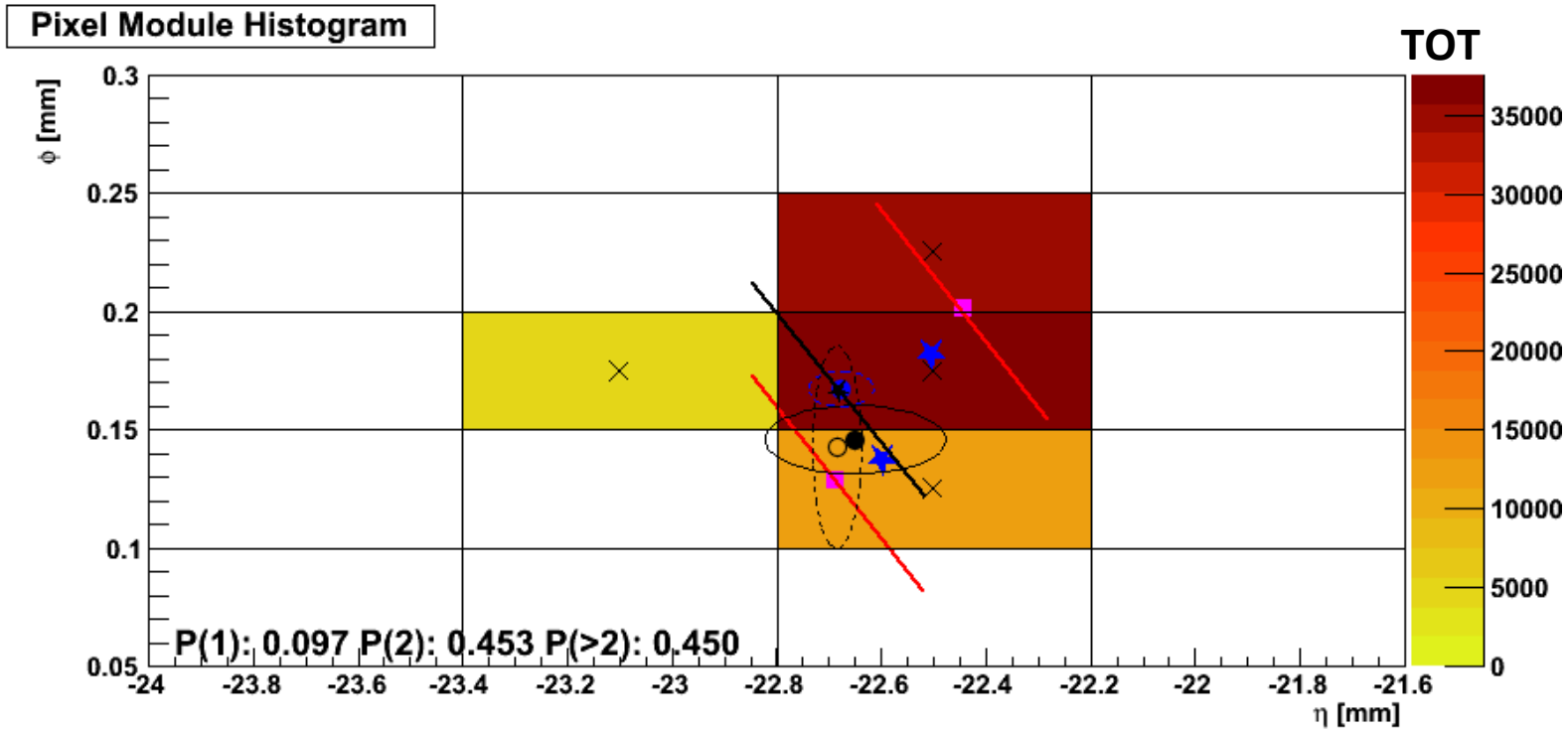

pred. truth impact (2 tracks)

pred. track impact (with path)

PRD with error

ROT with error

Reconstruction with old algorithm (1 cluster)

extrapolated track

Reconstruction with new algorithm (2 clusters)