

Status report on L1 Tau Trigger using Silicon Pixel detector for Phase 2

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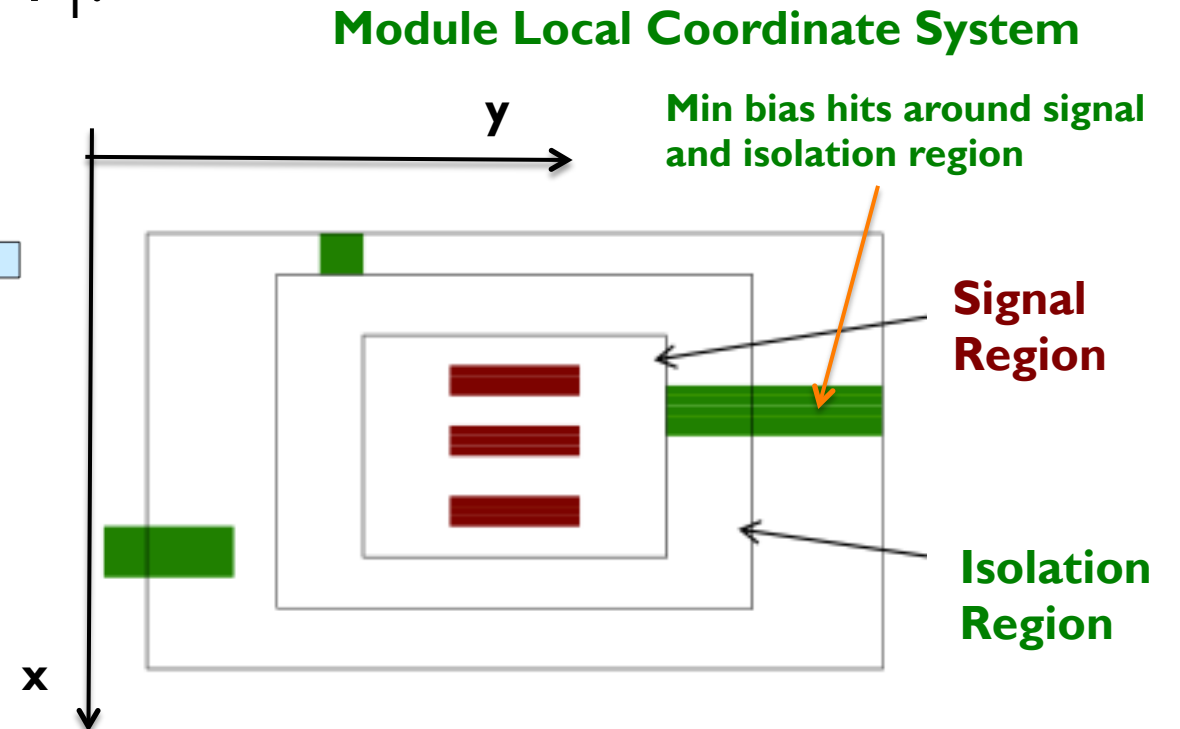
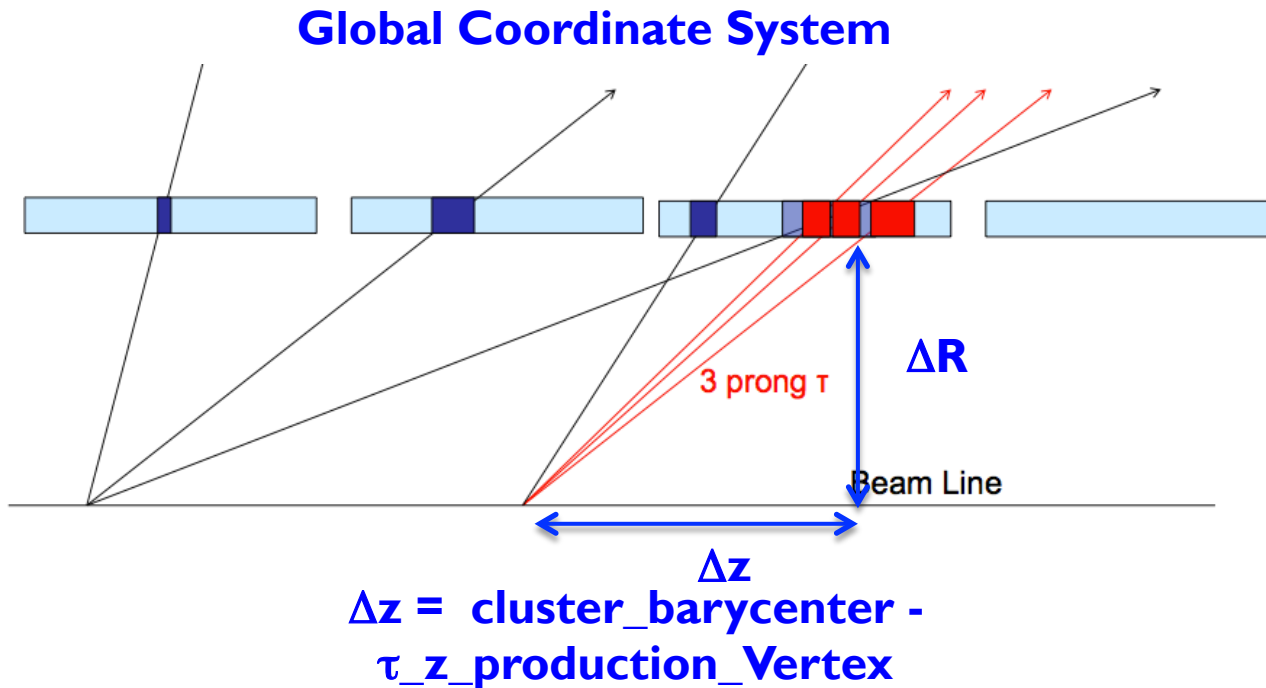
Pixel Trigger at L1 for Phase 2 for τ

- ▶ Studying the feasibility of a possible **Single Tau Pixel Trigger** at Level 1 for τ decaying into 3-prongs
 - ▶ Used MC simulation to analyse signal from τ to **3-prongs decays** to define a **Signal Region**
 - ▶ See dependence of clusters properties on Layer number and P_T of the τ with the new Pixel Tracker geometry
 - ▶ **Define Isolation Region with MinimumBias events and jet backgrounds, from $H \rightarrow \tau\tau$ and $Z \rightarrow \tau\tau$**
 - ▶ Feasibility of implementing trigger algorithm on single chip using cluster shape information

- ▶ Idea described in presentation made by F. Palla 19th February 2013
<https://indico.cern.ch/getFile.py/accesscontribId=9&sessionId=0&resId=0&materialId=slides&confId=235529>

Topology of $\tau \rightarrow 3$ prongs decay

- ▶ Expected similar cluster size along the beam line for the prongs originated from the same vertex
- ▶ Expect 3 clusters within the same module (or chip) above a given P_T threshold. Eventually merging for higher P_T .

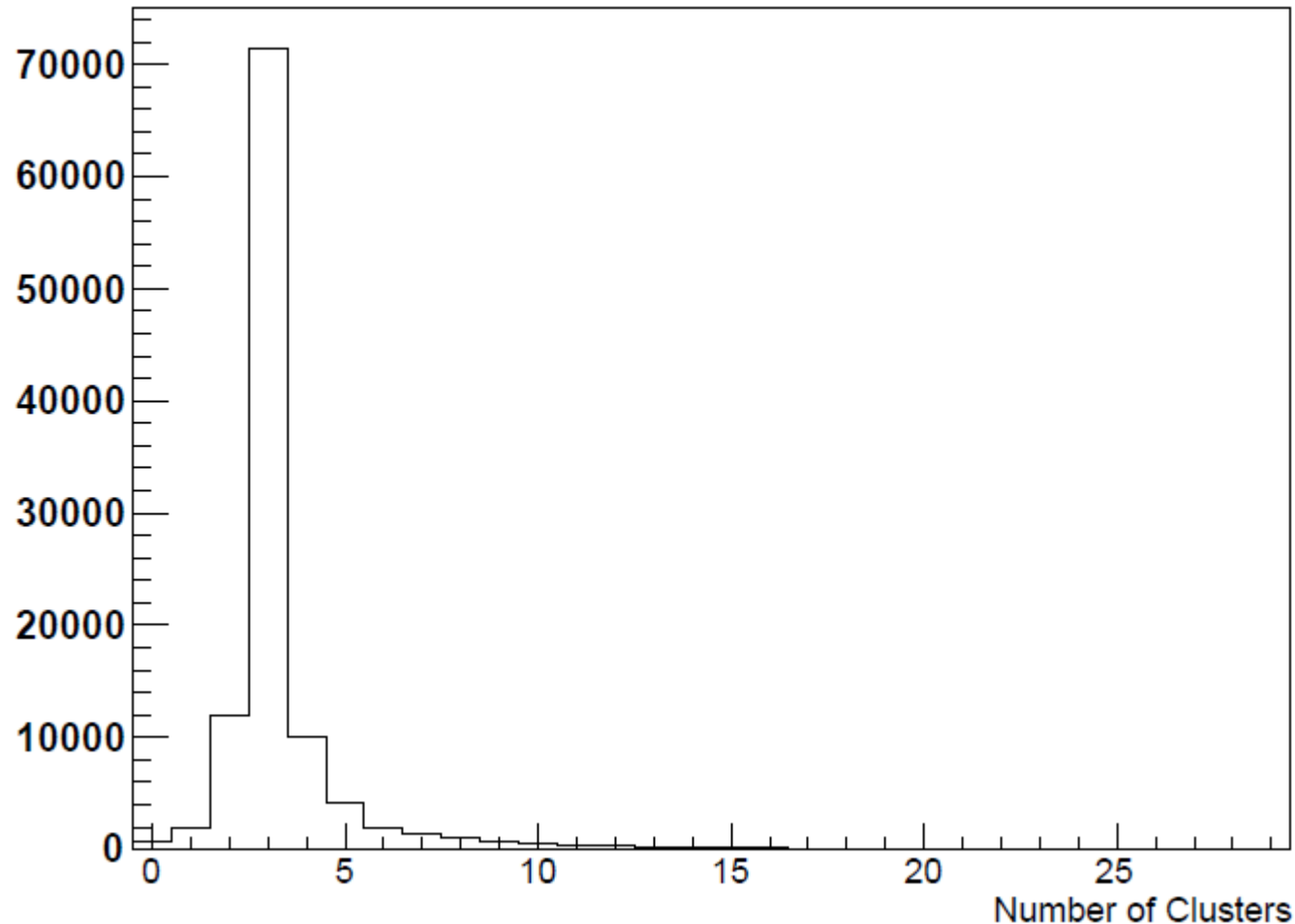


MC Sample

- ▶ CMSSW_6_1_1_SLHCphaseI tk1 with Extended 2017 geometry
- ▶ Private production of **SingleTau** with about 108k three prong decays
 - ▶ Particle gun production: flat P_T range = [20, 100] GeV, flat $|\eta| < 2.5$ and default Gaussian Beam Spot
- ▶ Default clusterization algorithm from standard RECO sequence

Number of clusters per event

Number of Clusters per event for Layer 1



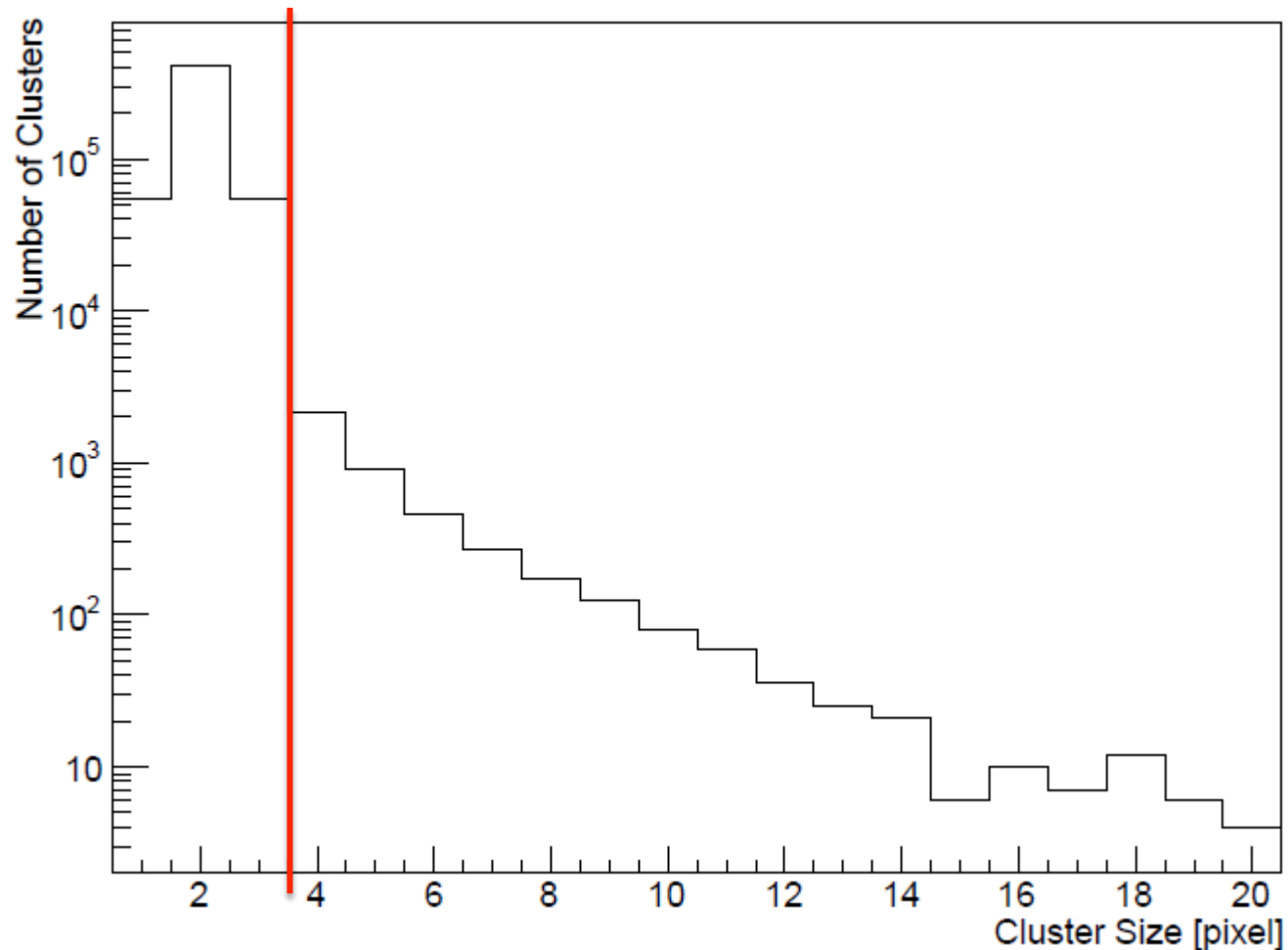
- ▶ Less than 3 clusters =>
 - ▶ merging
 - ▶ Detector and geometrical inefficiencies
- ▶ More than 3 clusters=>
 - ▶ Secondary tracks
- ▶ Events with number of Clusters = 3 → 66 % of all Events, excluding the events without clusters

Genuine $\tau \rightarrow 3$ prongs

- ▶ To study characteristics of **Signal Region**, only **$\tau \rightarrow 3$ prongs** in an “ideal conditions” are accepted :
 - ▶ Required 3 not merging clusters in a **Single Module** in the Pixel Barrel from 3 different prongs
 - ▶ No clusters from secondary process in the same module (from GEANT truth)

Cluster size X for all layers and all P_T

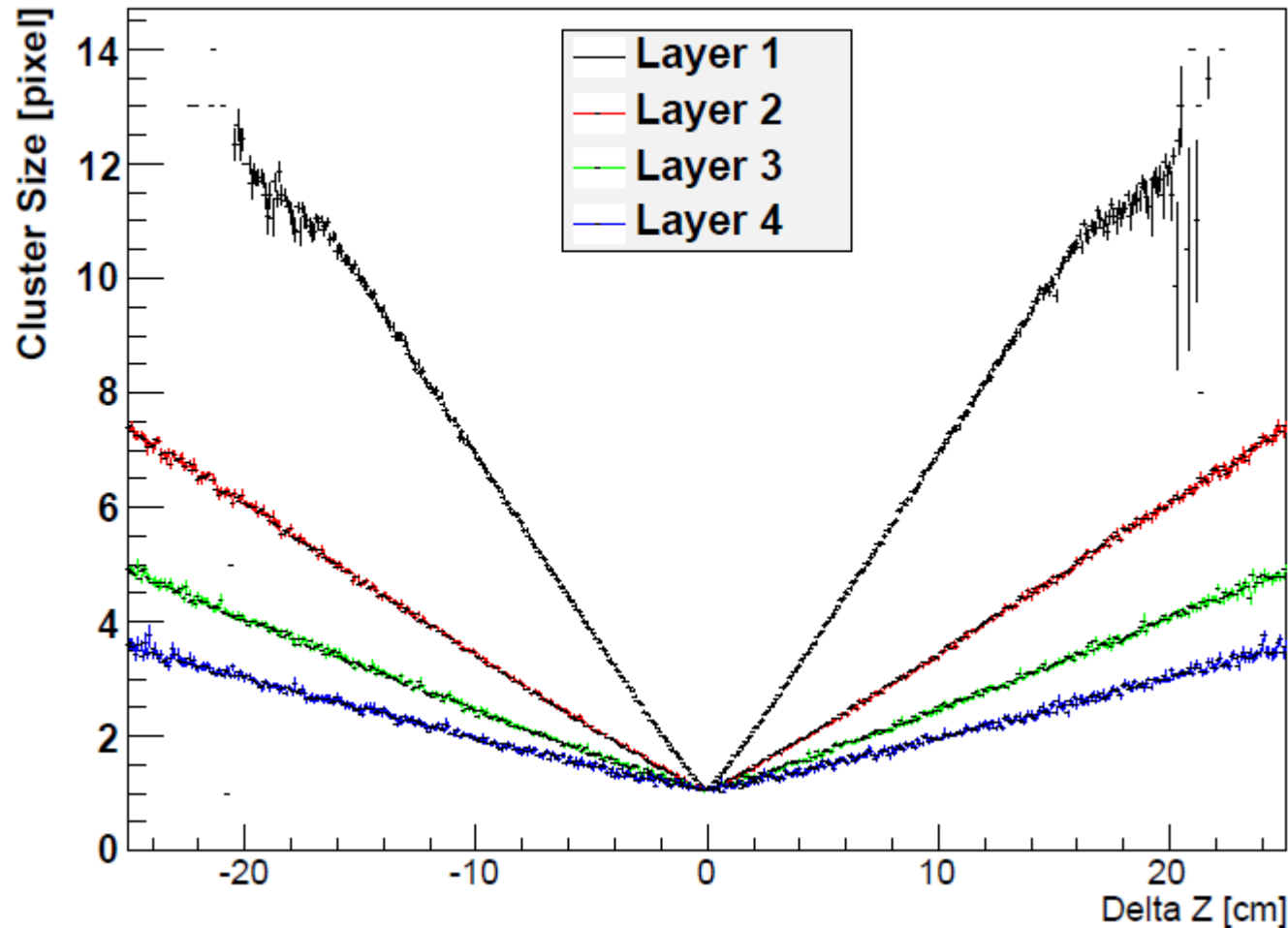
Cluster Size X



- ▶ Most part of clusters from $\tau \rightarrow 3$ prongs have **size on X less than 4**
- ▶ Events with Cluster Size $X < 4 \rightarrow 99.2\%$ of all Events

Dependency on cluster size Y vs. delta Z

Cluster Size Y vs Delta Z

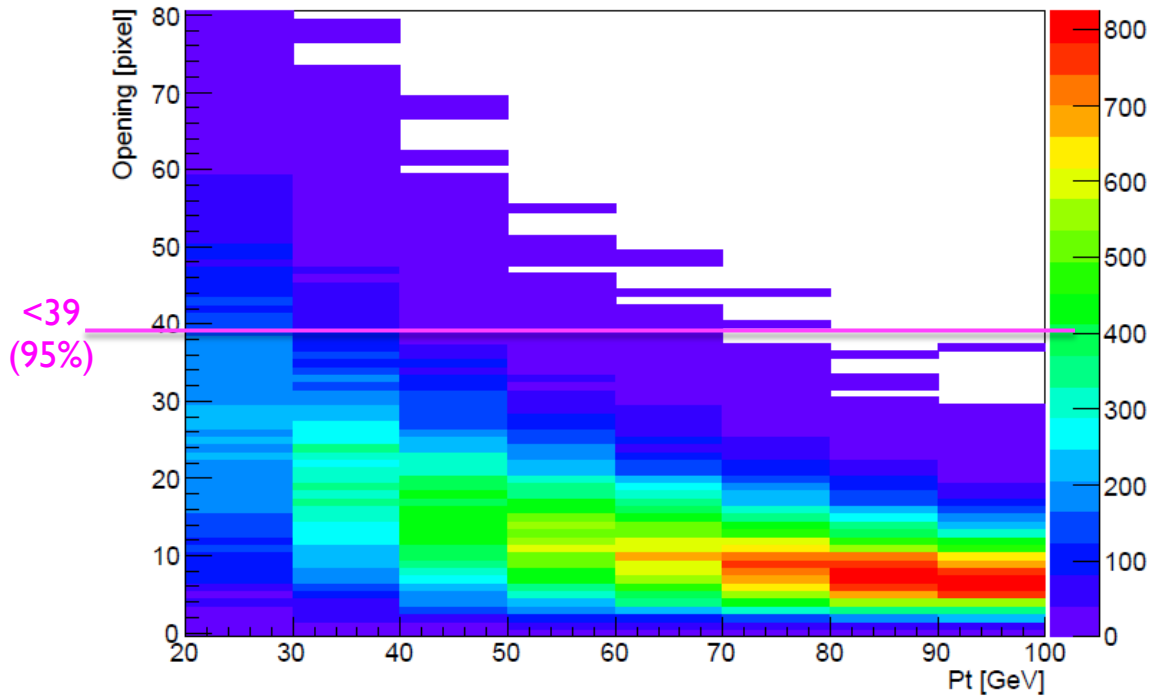


- ▶ Dependency trend corresponds to the expected linear estimation:

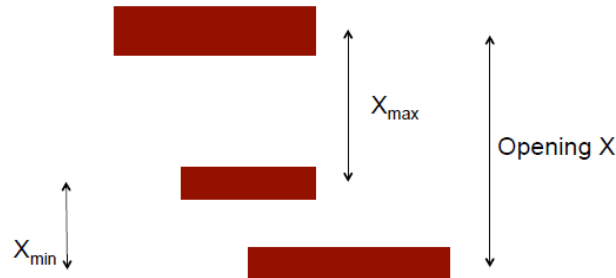
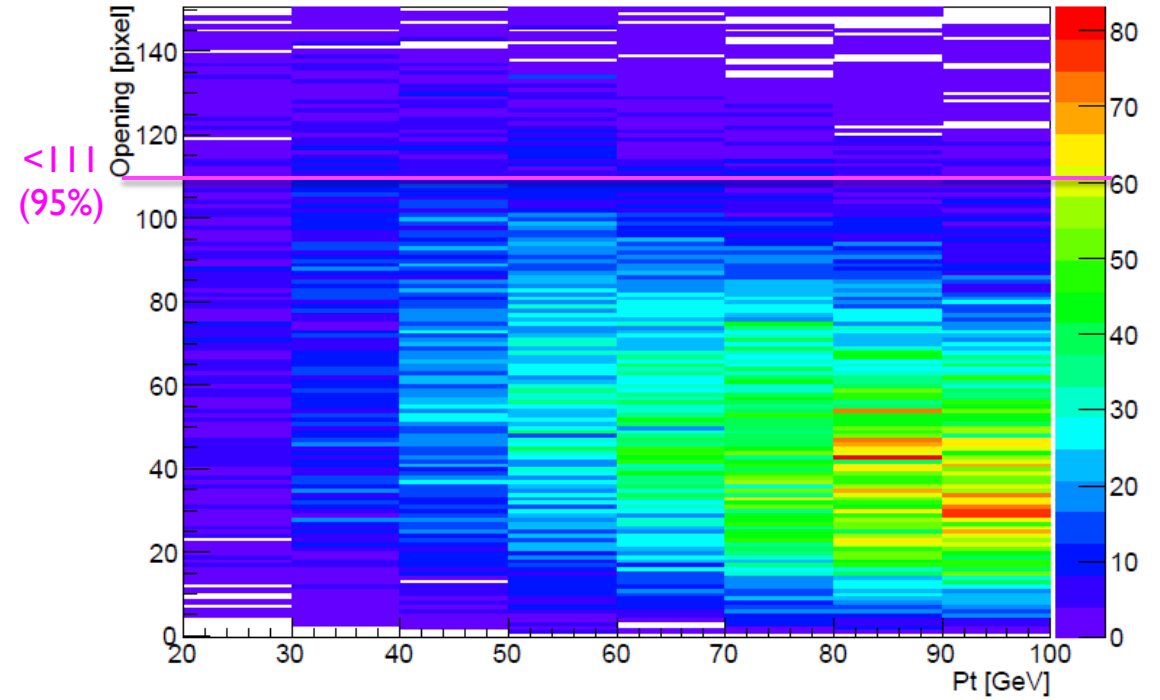
$$Size_{Y \downarrow cluster} \propto Thickness_{\downarrow module} \cdot (z_{\downarrow cluster} - z_{\downarrow \tau_vertex}) / R_{\downarrow Layer}$$

3 Prongs Opening X vs Pt of τ

Opening X vs Pt. Layer 1

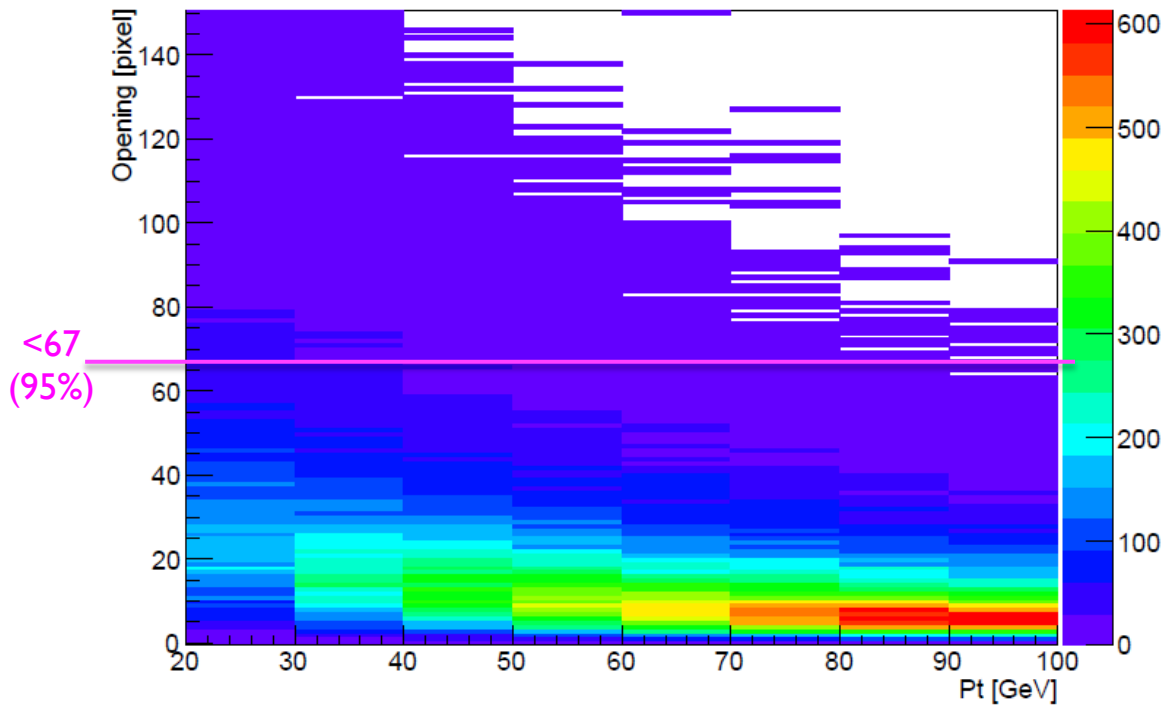


Opening X vs Pt. Layer 4

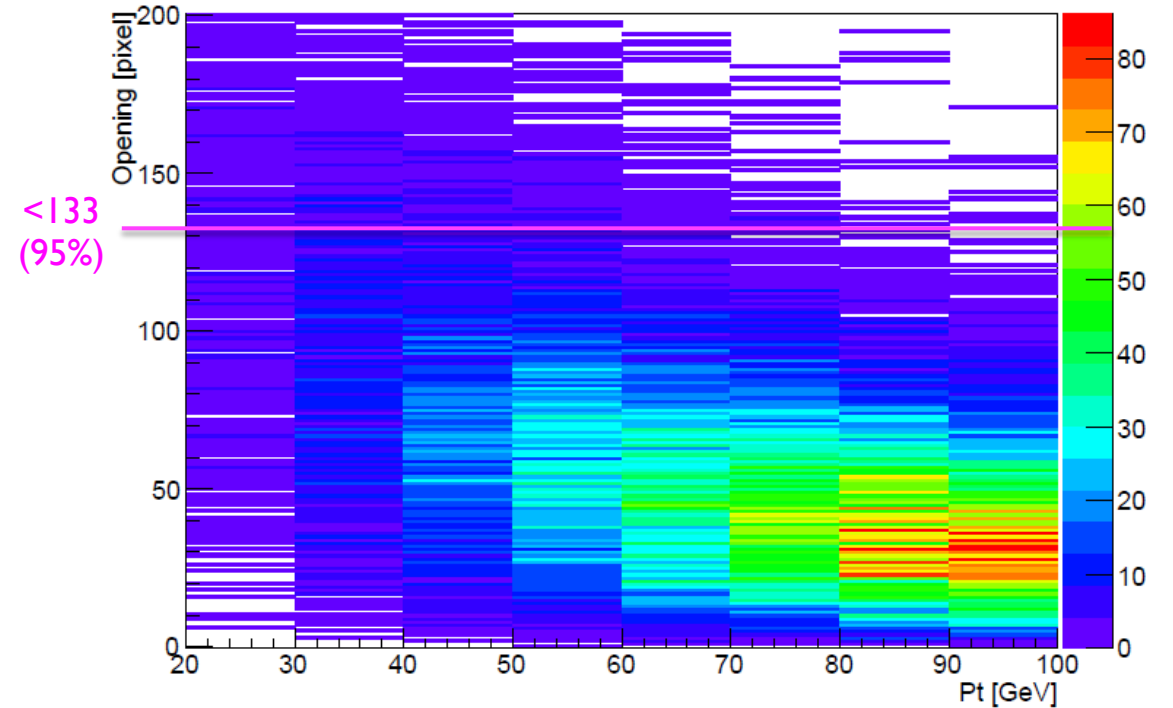


3 Prongs Opening Y vs Pt of τ

Opening Y vs Pt. Layer 1

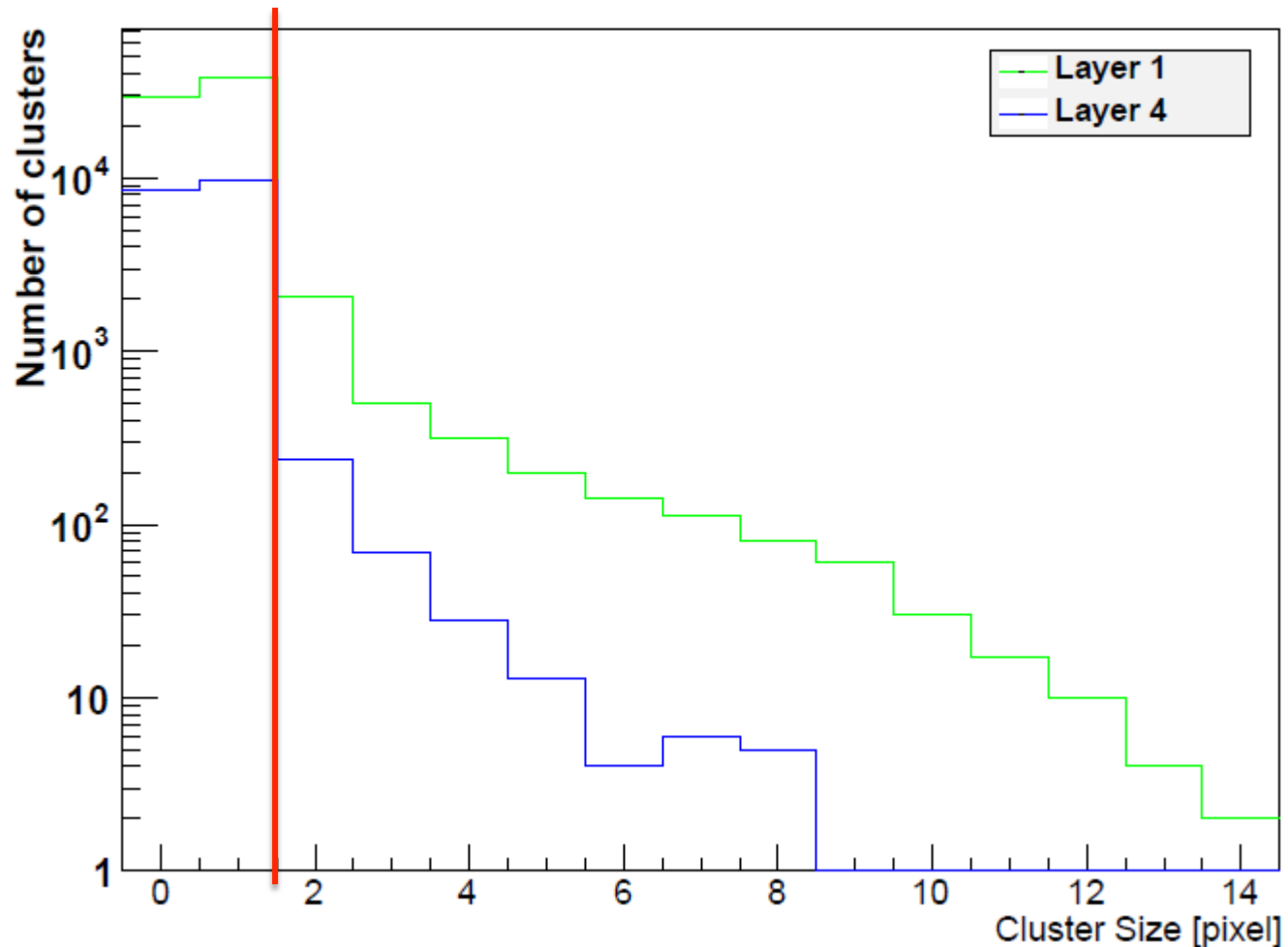


Opening Y vs Pt. Layer 4



Difference between cluster size on Y for clusters from the same τ

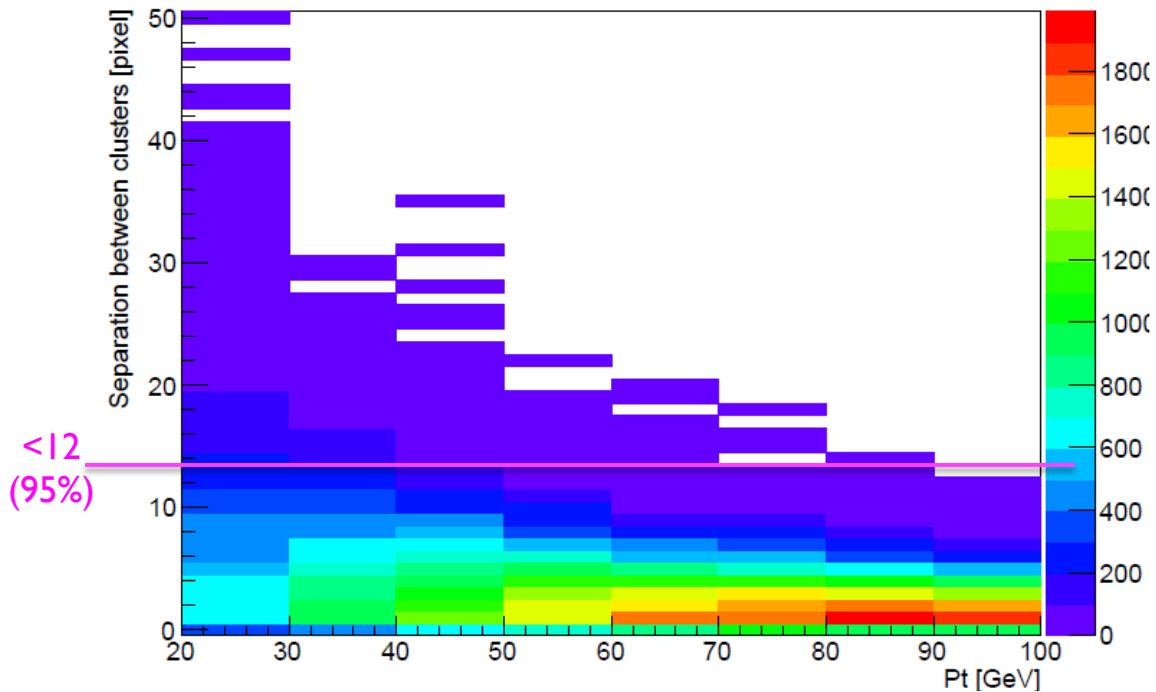
Delta Cluster Size Y



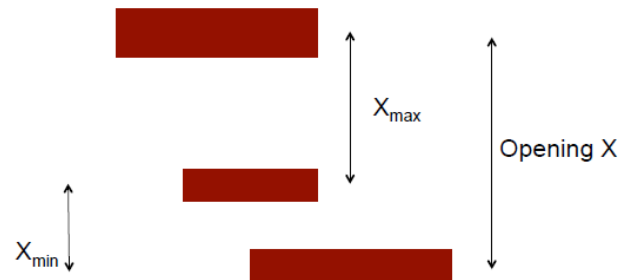
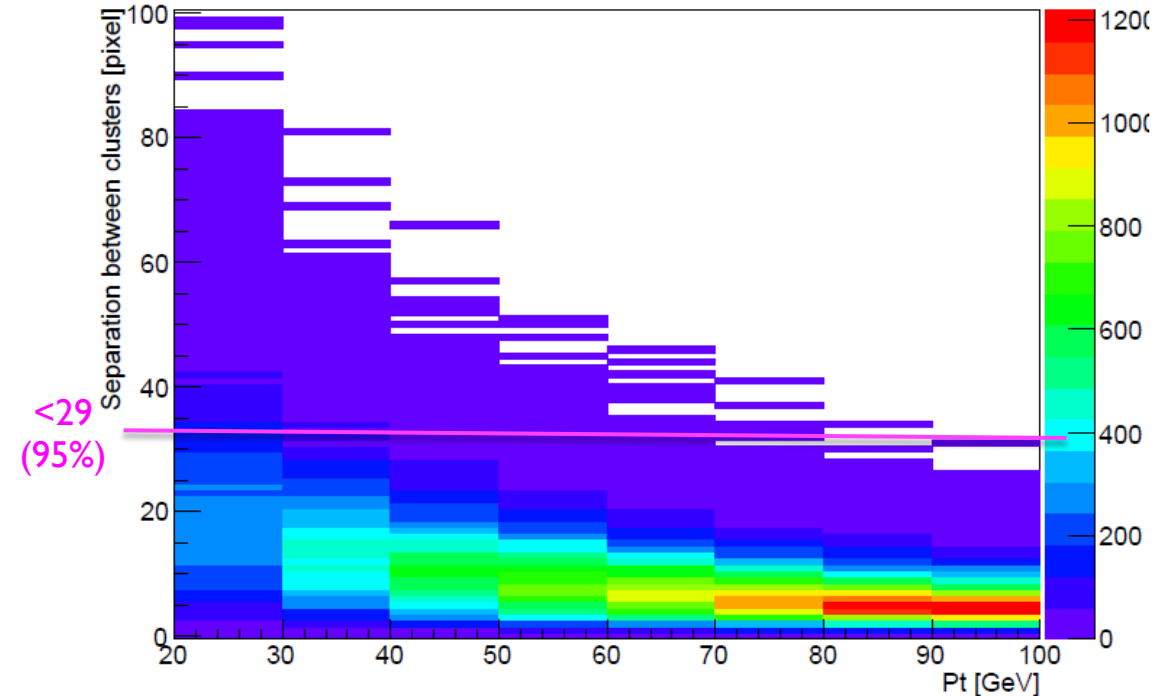
- ▶ Clusters produced by same $\tau \rightarrow 3$ prongs generally have comparable width on local Y.
- ▶ Events with Delta Cluster Size Y < 2 →
 - ▶ 95.7% of all Events for Layer 1;
 - ▶ 97.4% of all Events for Layer 4.

Minimal/Maximal Cluster Separation on X between the two nearest clusters in X

Minimal separation on X vs Pt. Layer 1

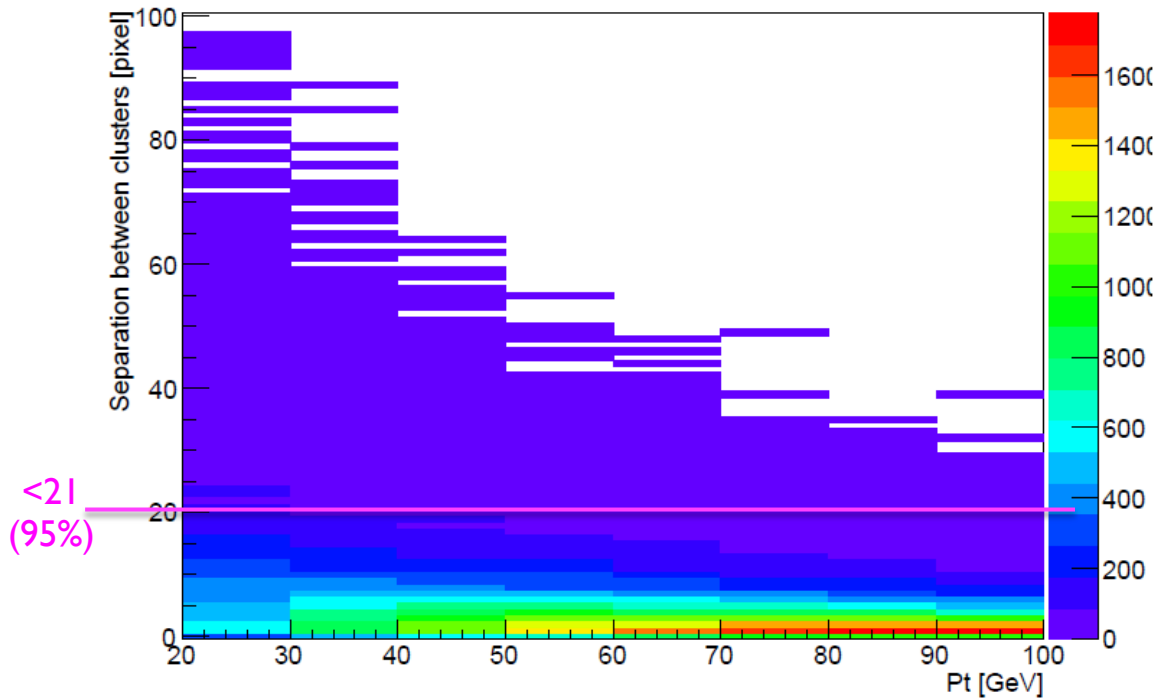


Maximal separation on X vs Pt. Layer 1

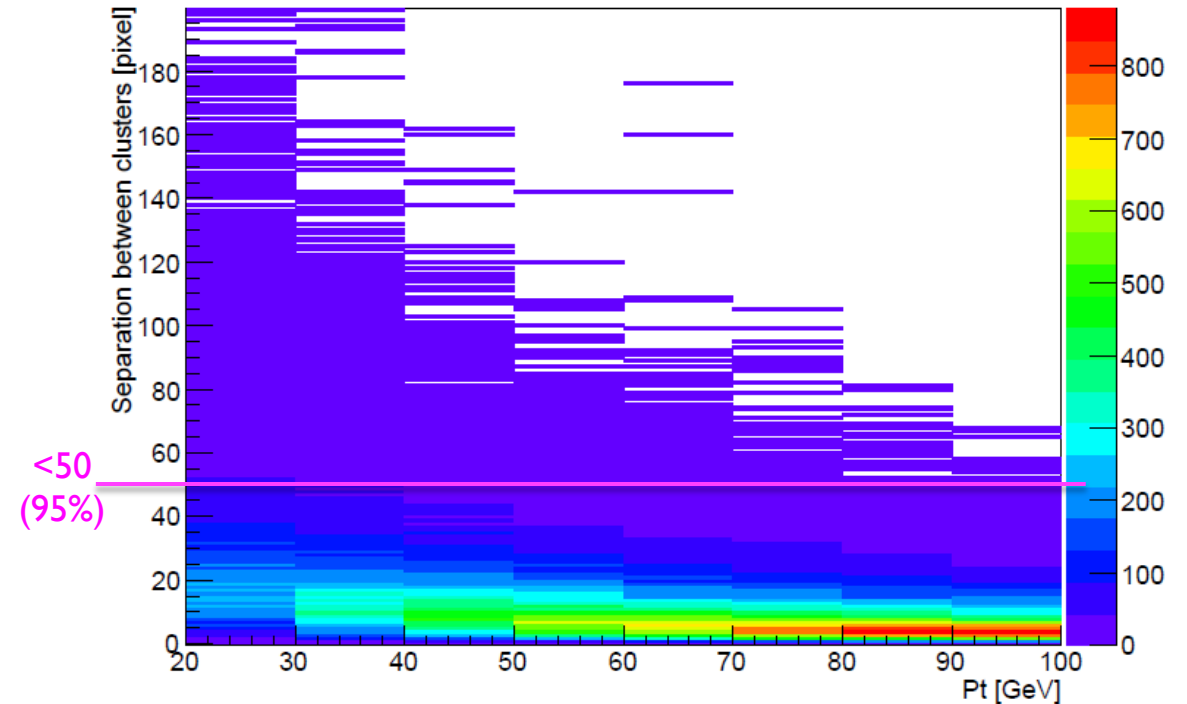


Minimal/Maximal Cluster Separation on Y between the two nearest clusters in Y

Minimal separation on Y vs Pt. Layer 1

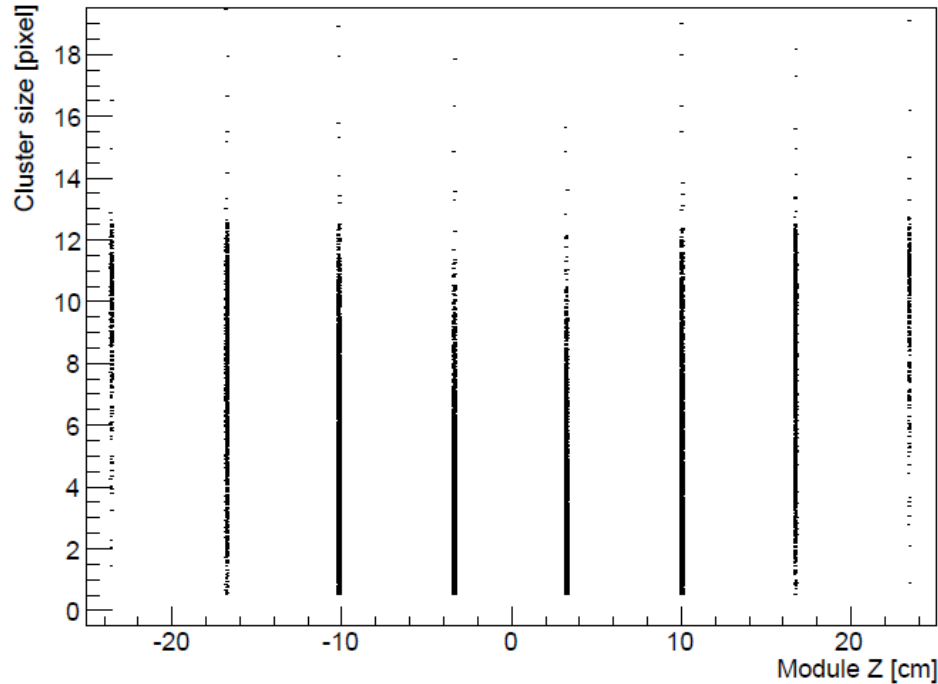


Maximal separation on Y vs Pt. Layer 1

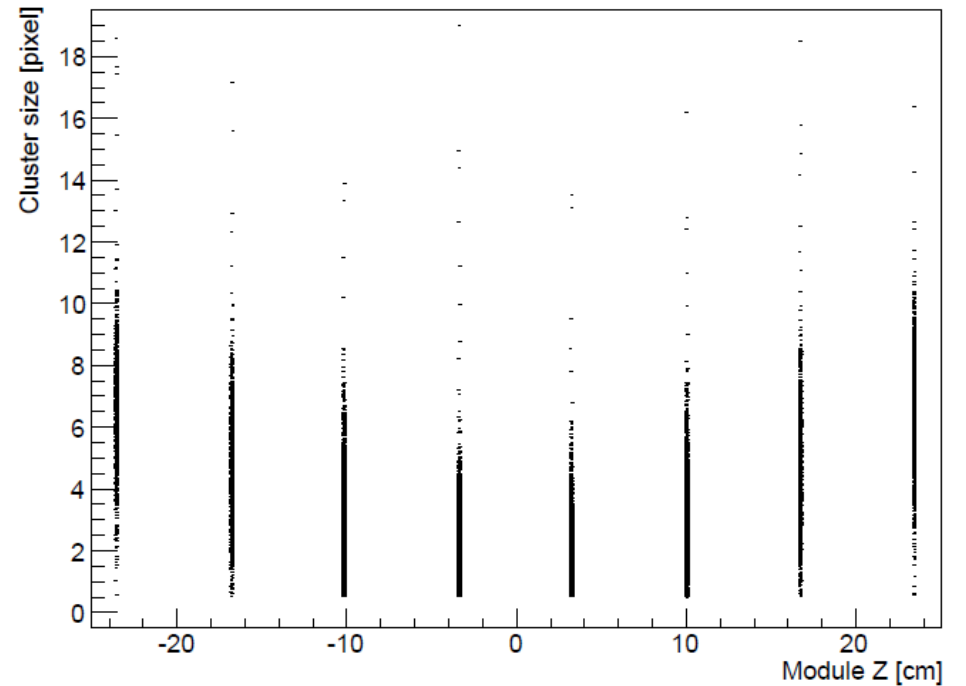


Cluster Size Y vs Module Z

Cluster Size Y vs Module Z. Layer 1



Cluster Size Y vs Module Z. Layer 2



- ▶ For forward barrel modules on first two layers, a cut for small cluster size on Y can be applied

Preliminary conclusions and plans

- ▶ **Analysis of the $\tau \rightarrow 3$ prongs signal shows:**
 - ▶ We have studied the general properties of clusters shapes, their relationships (minimal/maximal separation, similarity) vs. layer number, P_T and eta. This will be used to implement an algorithm to define a signal region.
 - ▶ Increasing P_T , clusters from 3 prongs start merging; however up to 100 GeV the fraction of not merged clusters is still significant
 - ▶ Opening area in first layer is small enough to implement (may be) an algorithm in a single chip
- ▶ **Plans**
 - ▶ Definition of signal region (SingleTau events) and isolation region (MinBias events)
 - ▶ Definition and implementation of the trigger algorithm
 - ▶ Test on $H \rightarrow \tau\tau$ and $Z \rightarrow \tau\tau$ at 14 TeV
 - ▶ Feasibility studies to match pixel trigger output with calorimeter trigger