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

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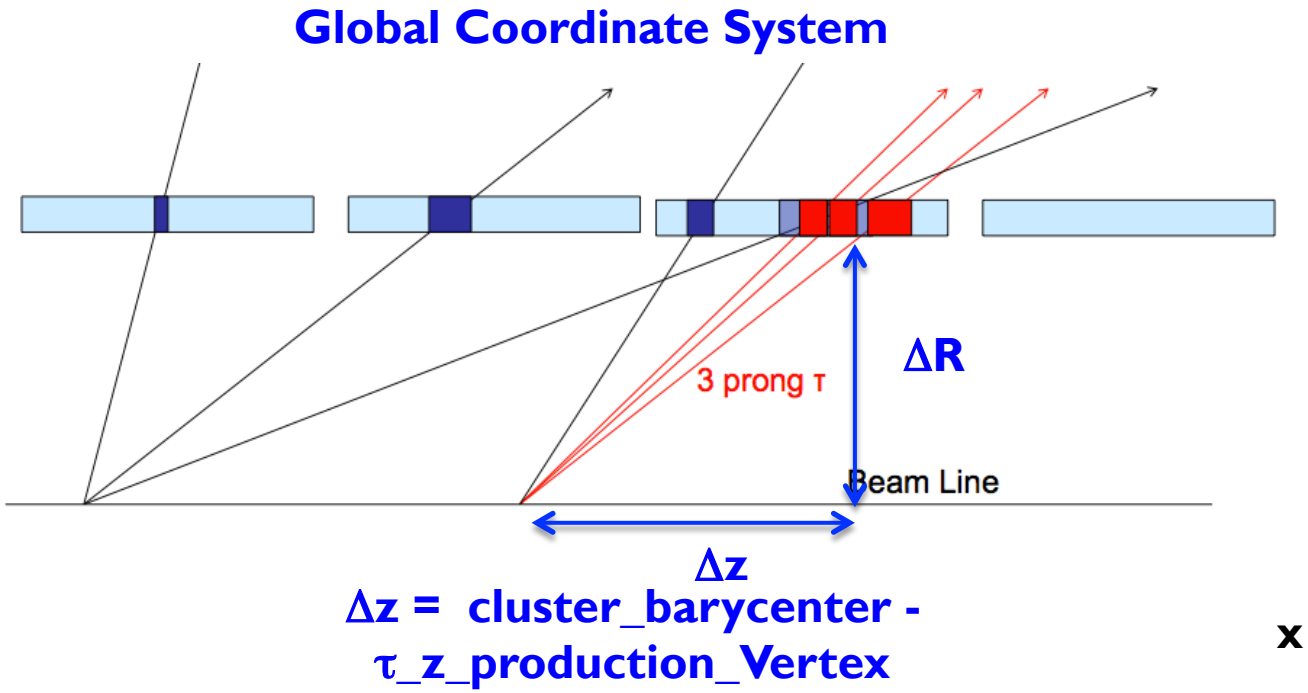
Pixel Trigger at L1 for Phase 2 for τ

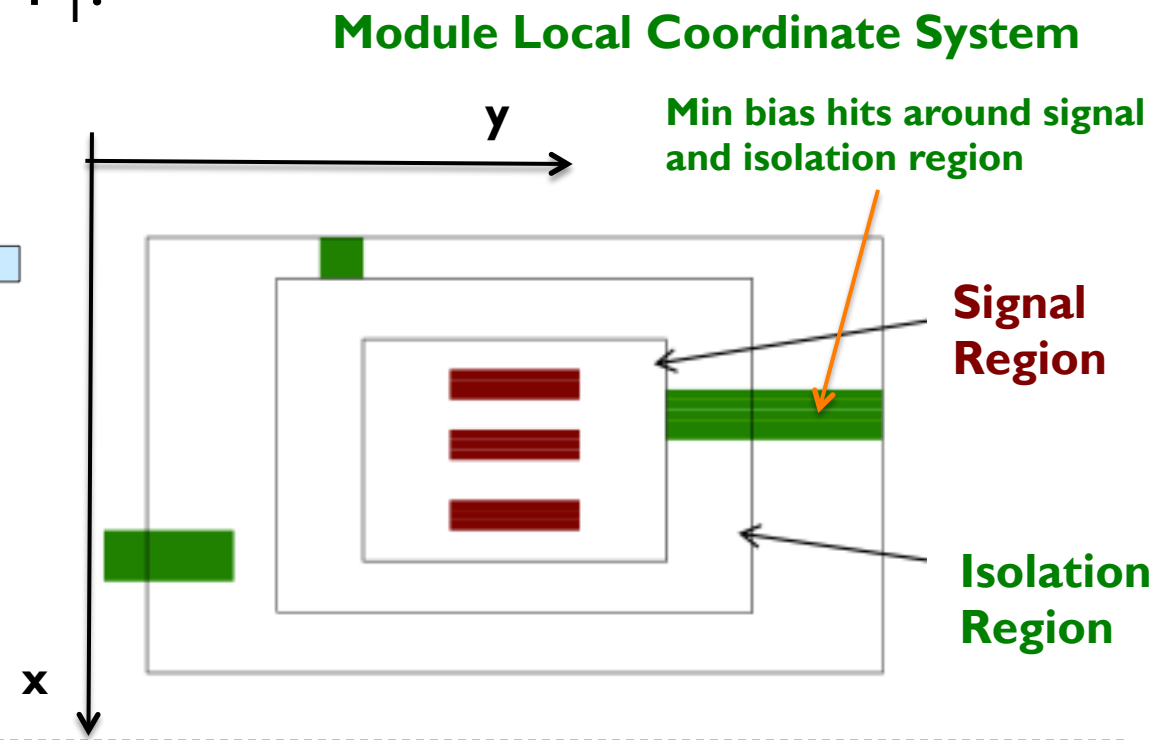
- Studying the feasibility of a possible Single Tau Pixel Trigger at Level 1 for τ decaying into 3-prongs
  - Used MC simulation to analyse signal from τ to **3– prongs decays** to define a Signal Region
  - See dependence of clusters properties on Layer number and P_T of the τ with the new Pixel Tracker geometry
  - Define Isolation Region with MinimumBias events and jet backgrounds, from H→ττ and Z→ττ
  - 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.

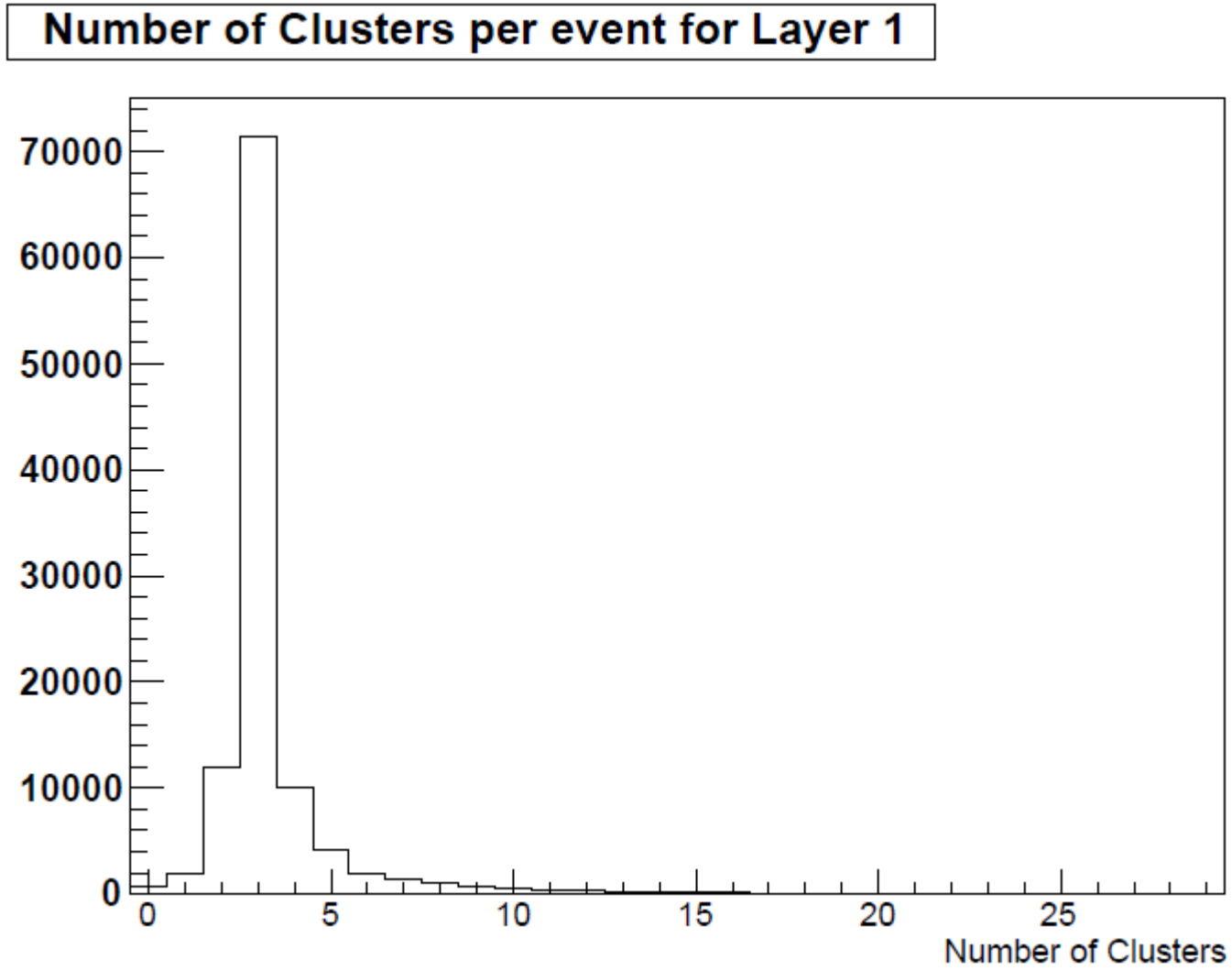




MC Sample

- CMSSW_6_1_1_SLHCphase1tk1 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

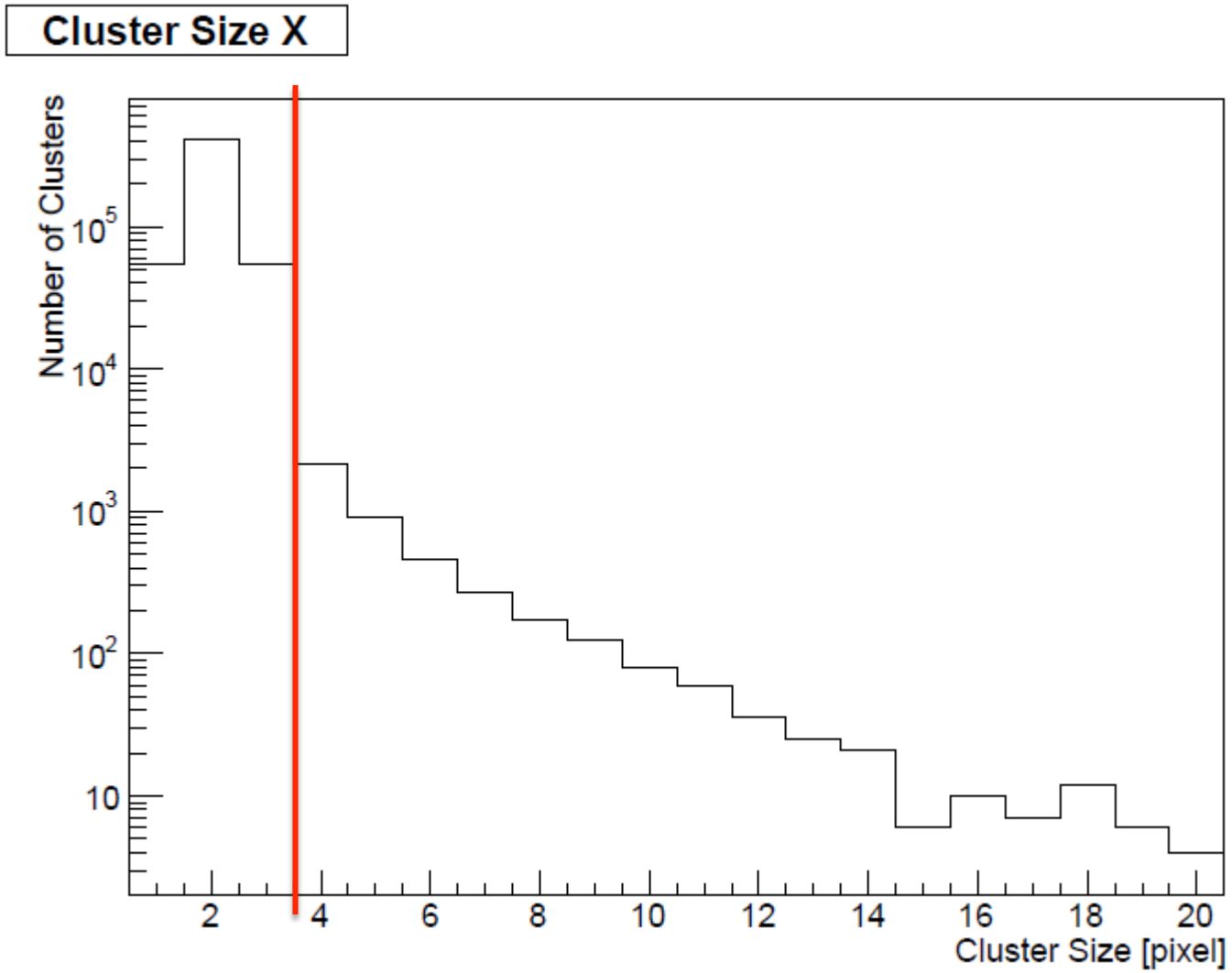


- Less than 3 clusters =>
  - merging
  - Detector and geometrical inefficiencies
- More than 3 clusters=>
  - Secondary tracks
- Events with number of Clusters = 3→ 66 % of all Events, excluding the events without clusters

Genuine $\tau \rightarrow 3$ prongs

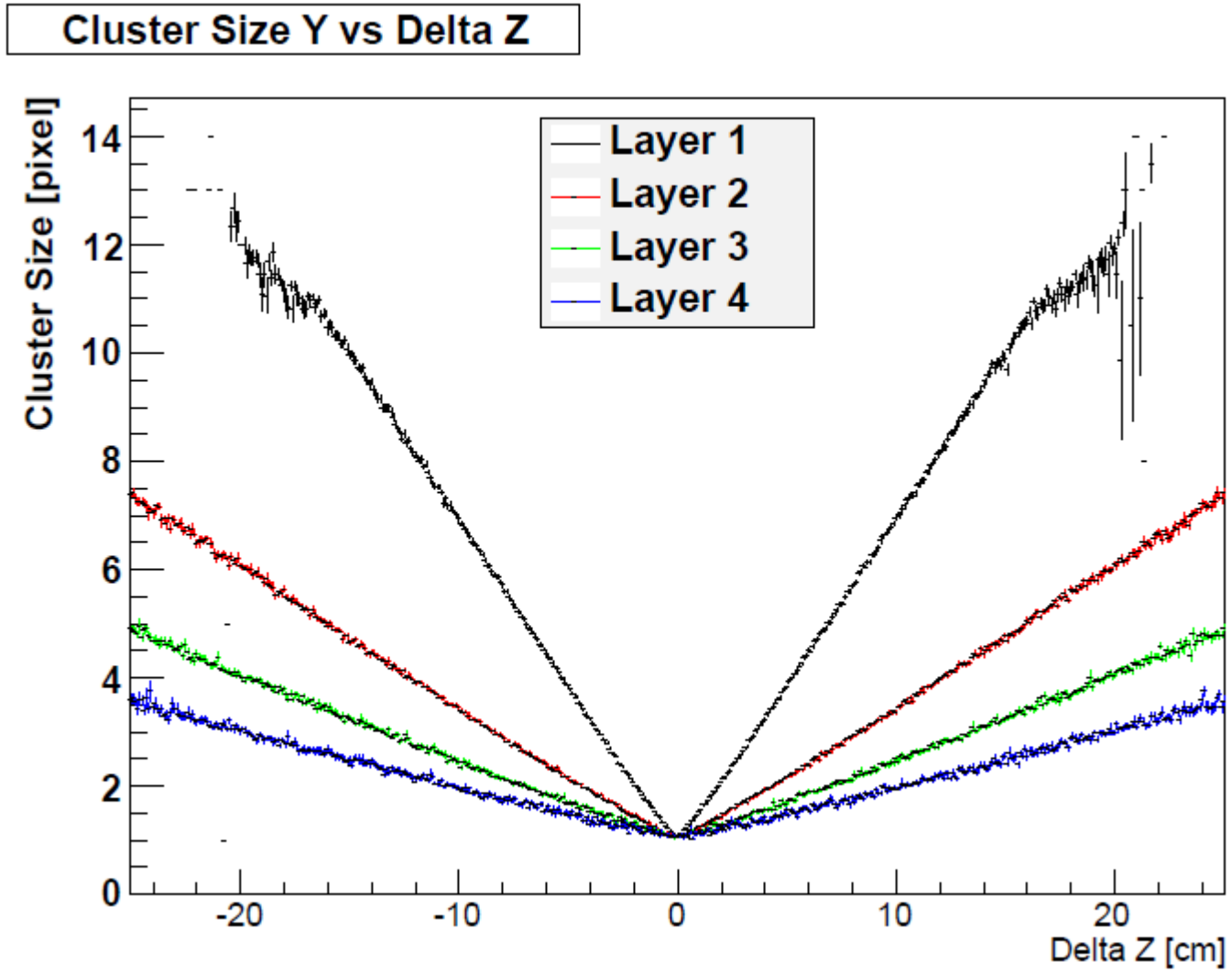
- To study characteristics of Signal Region, only $\tau \rightarrow 3$ prongs in an "ideal conditions" are accepted :
  - Required 3 not merging clusters in a Single Module in the Pixel Barrel from 3 different prongs
  - No clusters from secondary process in the same module (from GEANT truth)

Cluster size X for all layers and all P_T



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

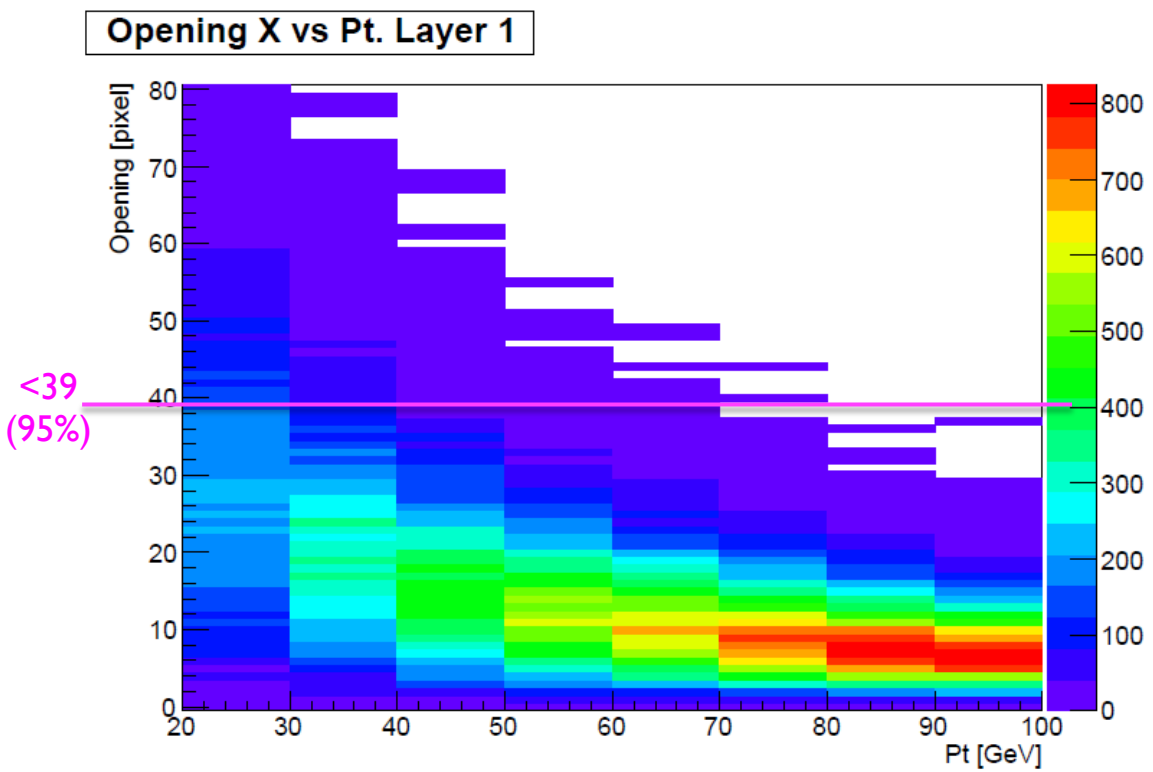
Dependency on cluster size Y vs. delta Z

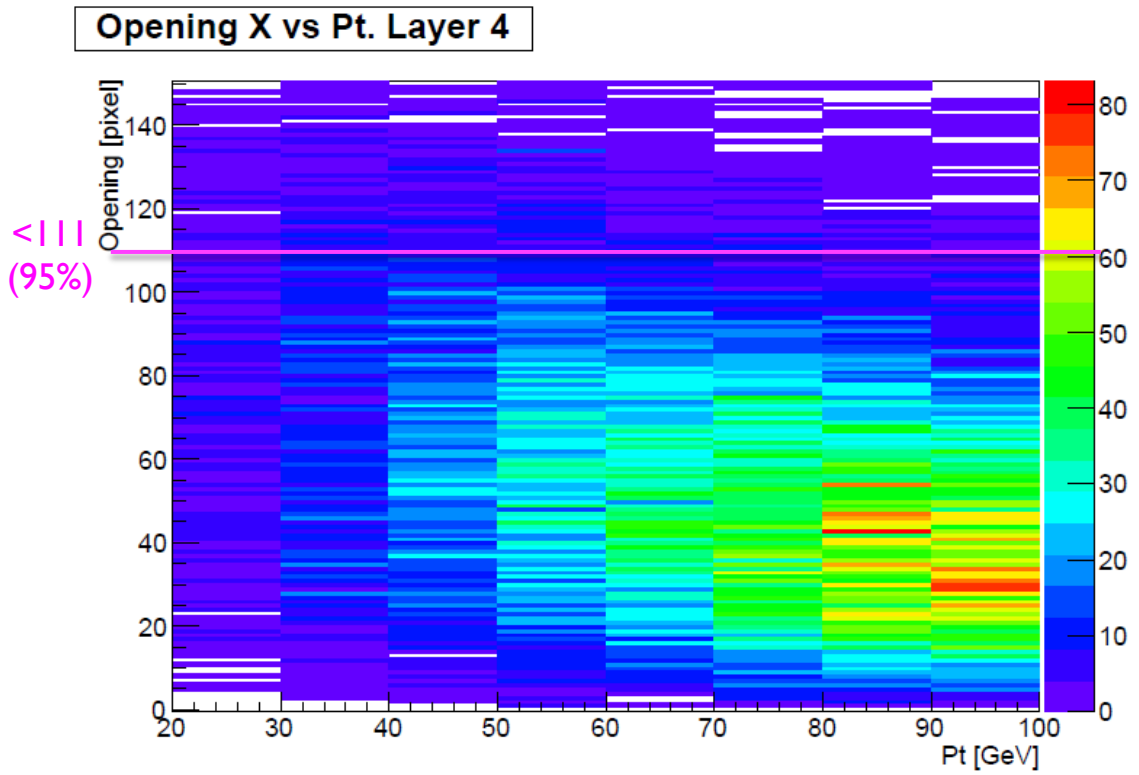


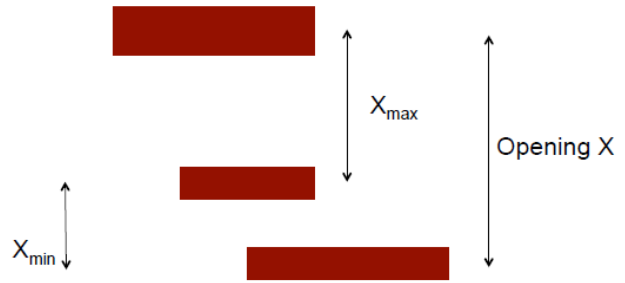
- Dependency trend corresponds to the expected linear estimation:

$$SizeY\downarrow cluster \propto Thickness\downarrow module \cdot (z\downarrow cluster - z\downarrow \tau\_vertex\ ) / R\downarrow Layer$$

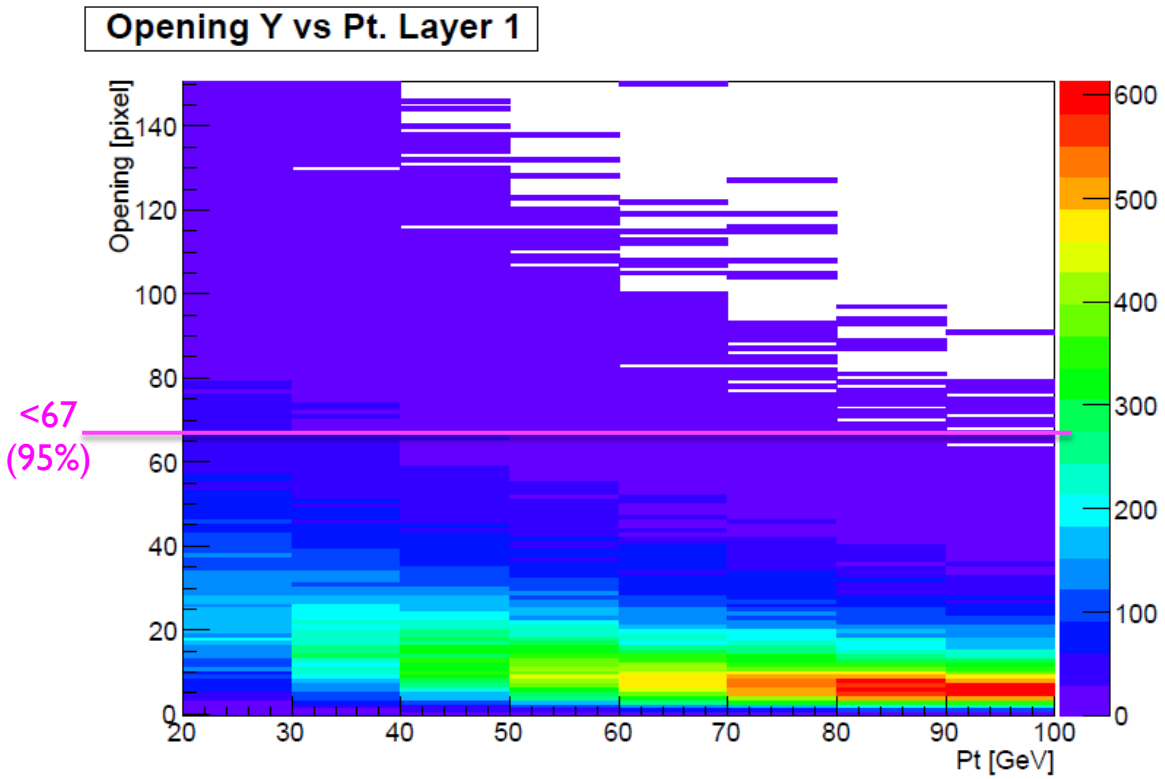
3 Prongs Opening X vs Pt of τ

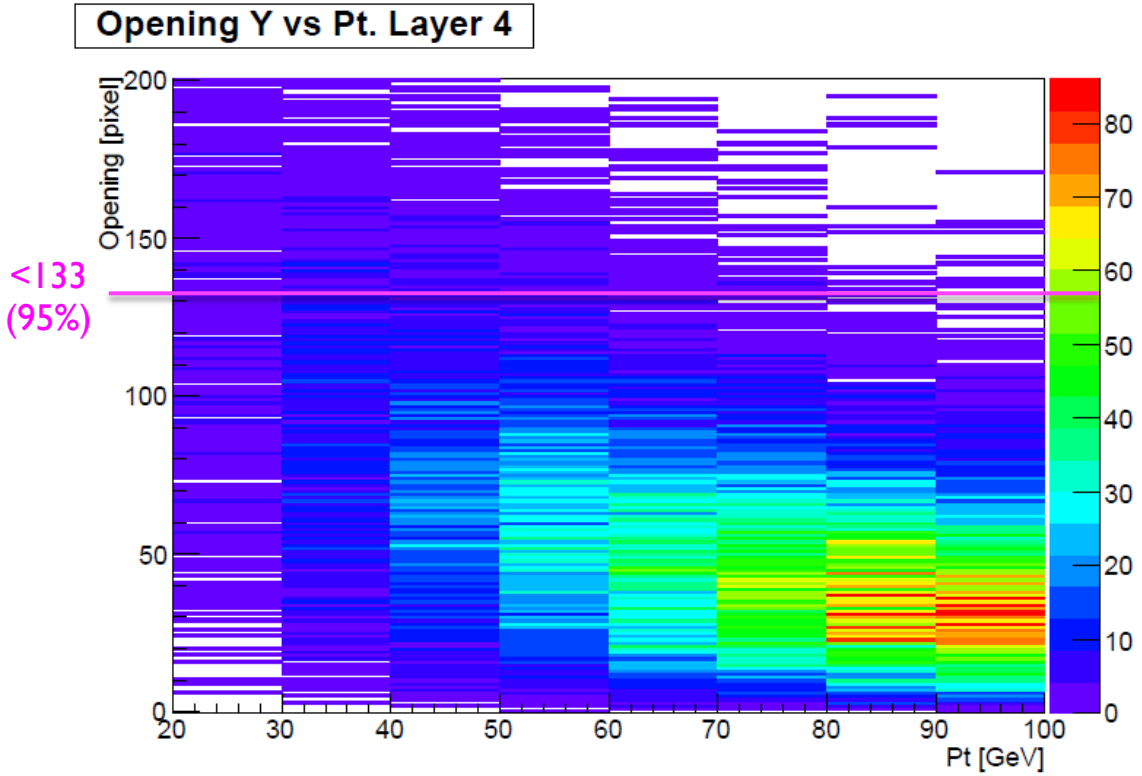




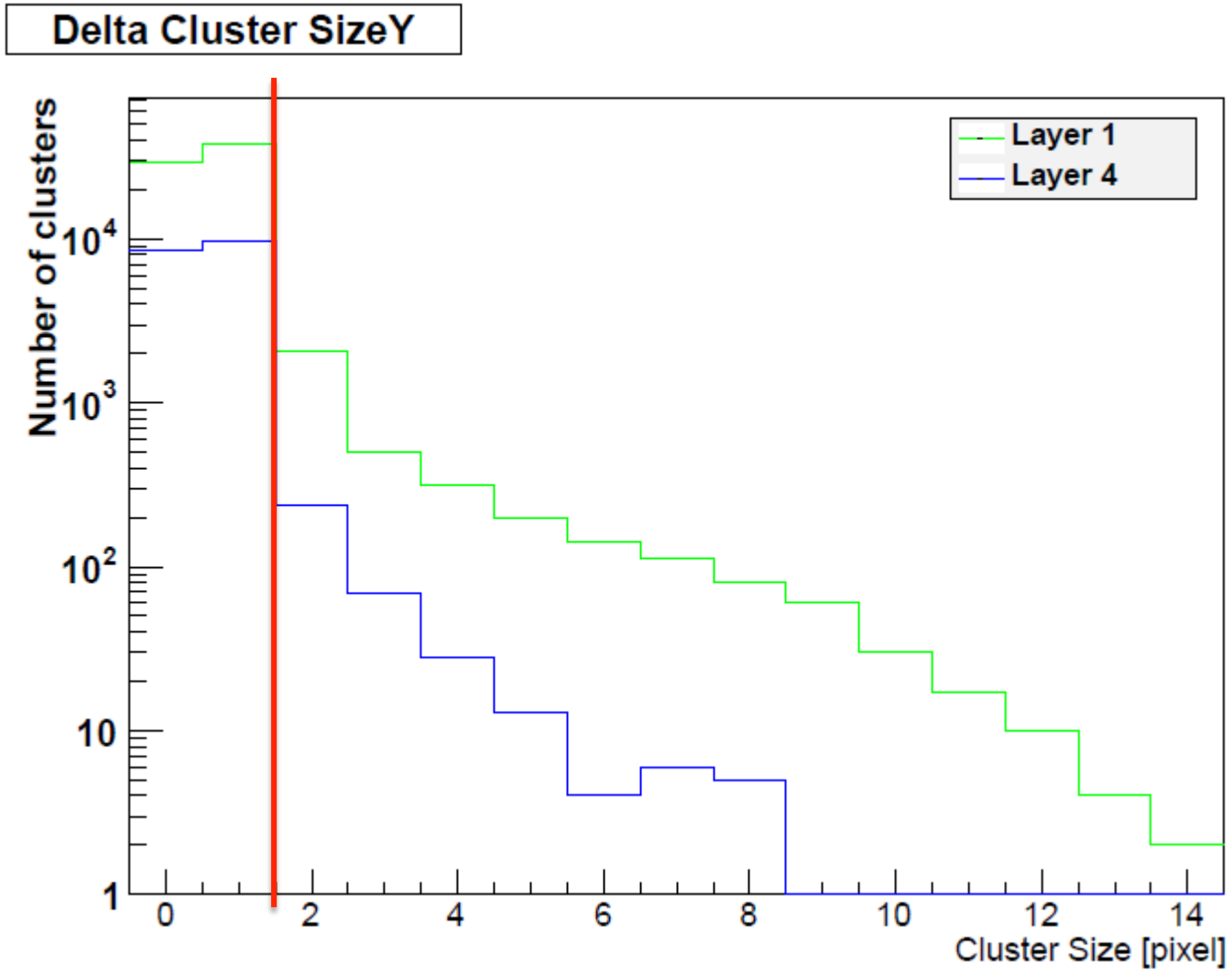


3 Prongs Opening Y vs Pt of τ



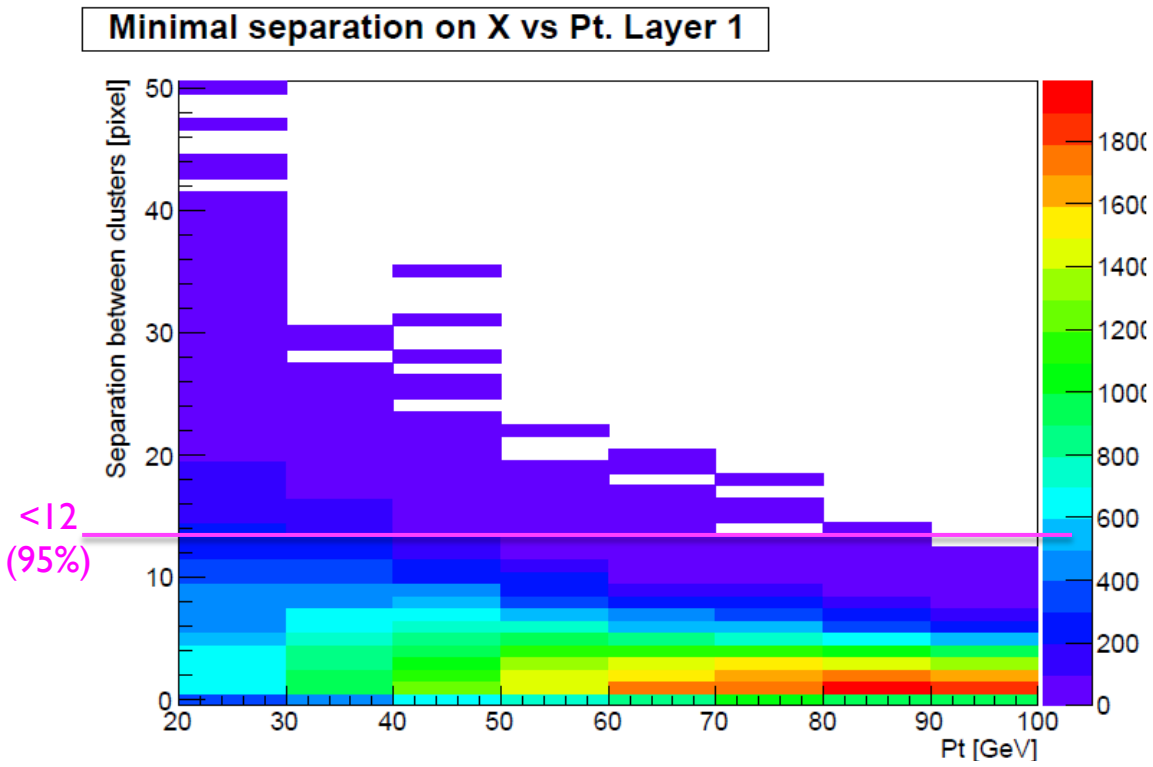


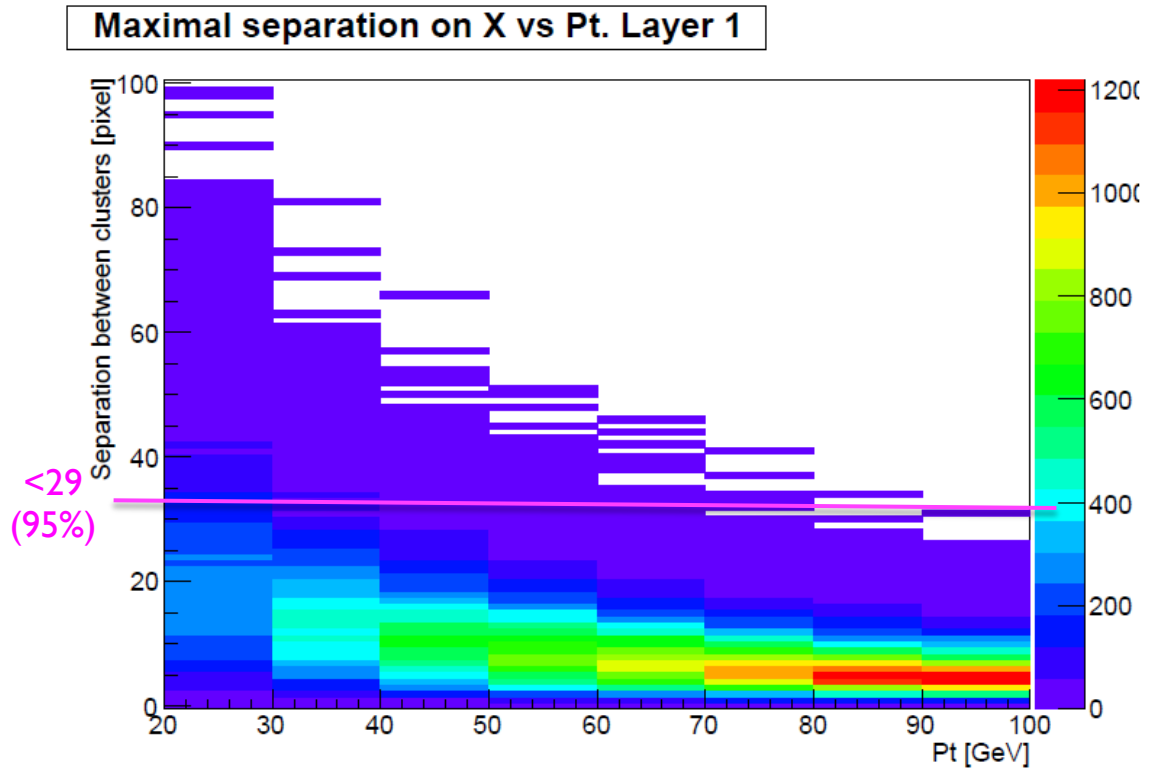
Difference between cluster size on Y for clusters from the same τ

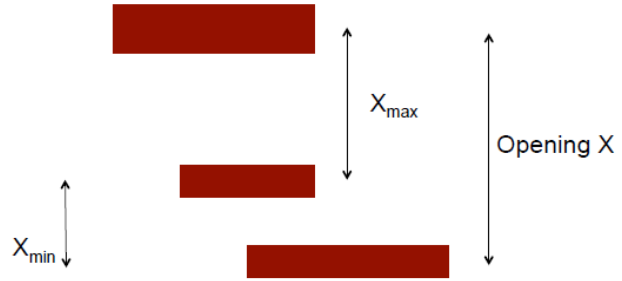


- Clusters produced by same τ→3 prongs generally have comparable width on local Y.
- Events with Delta Cluster Size Y < 2 →
  - 95.7% of all Events for Layer 1;
  - 97.4% of all Events for Layer 4.

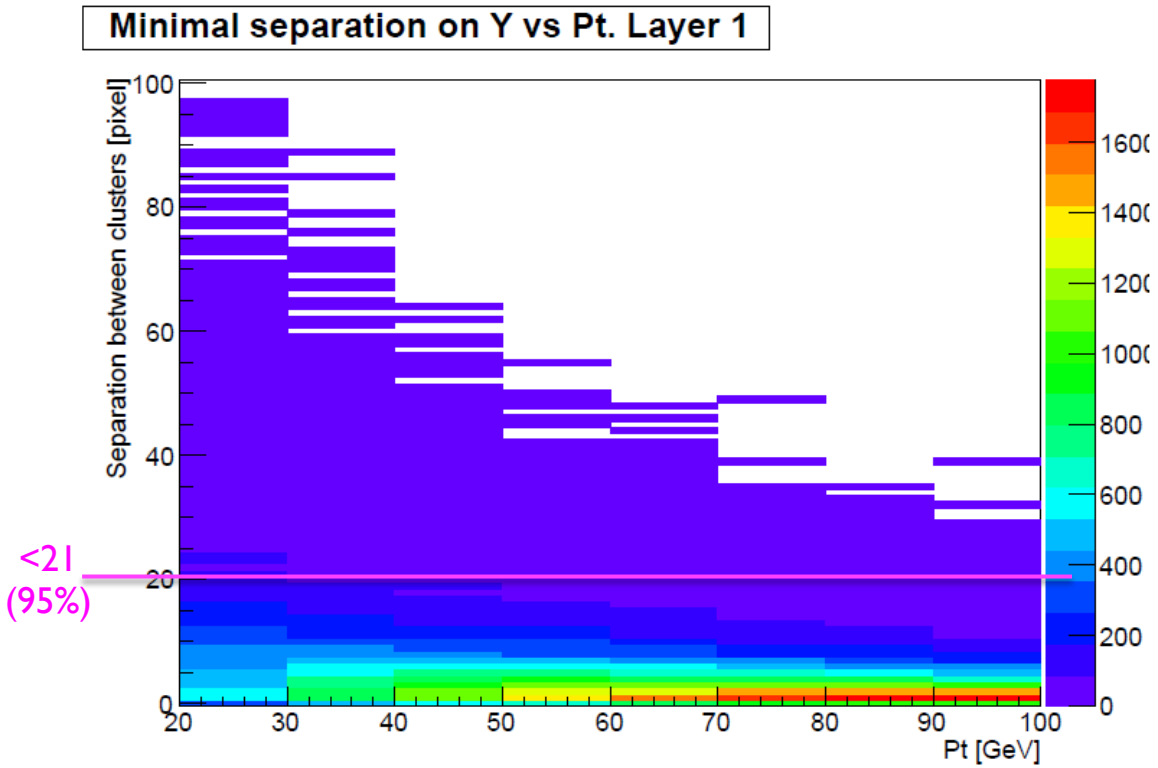
Minimal/Maximal Cluster Separation on X between the two nearest clusters in X

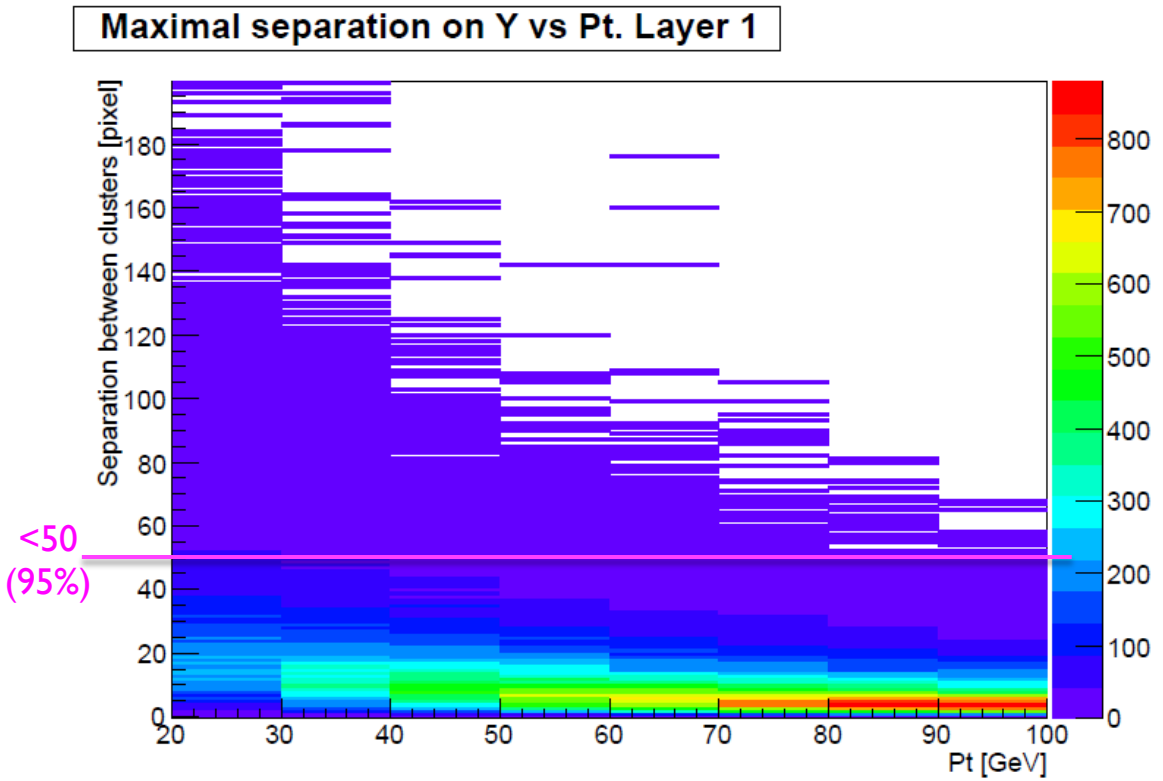




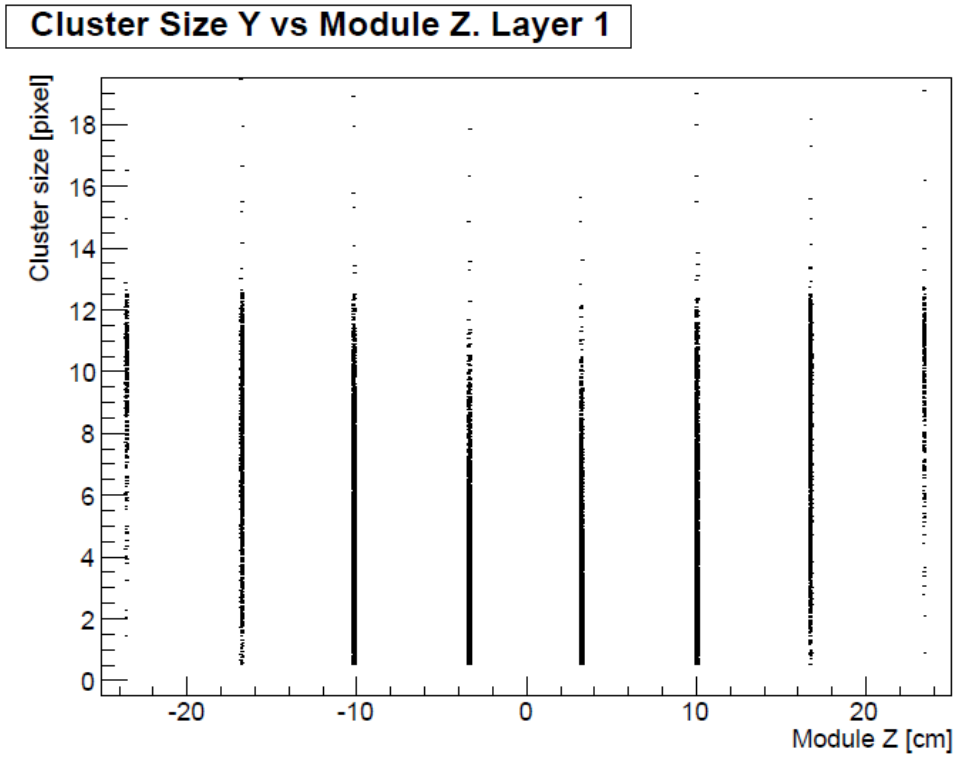


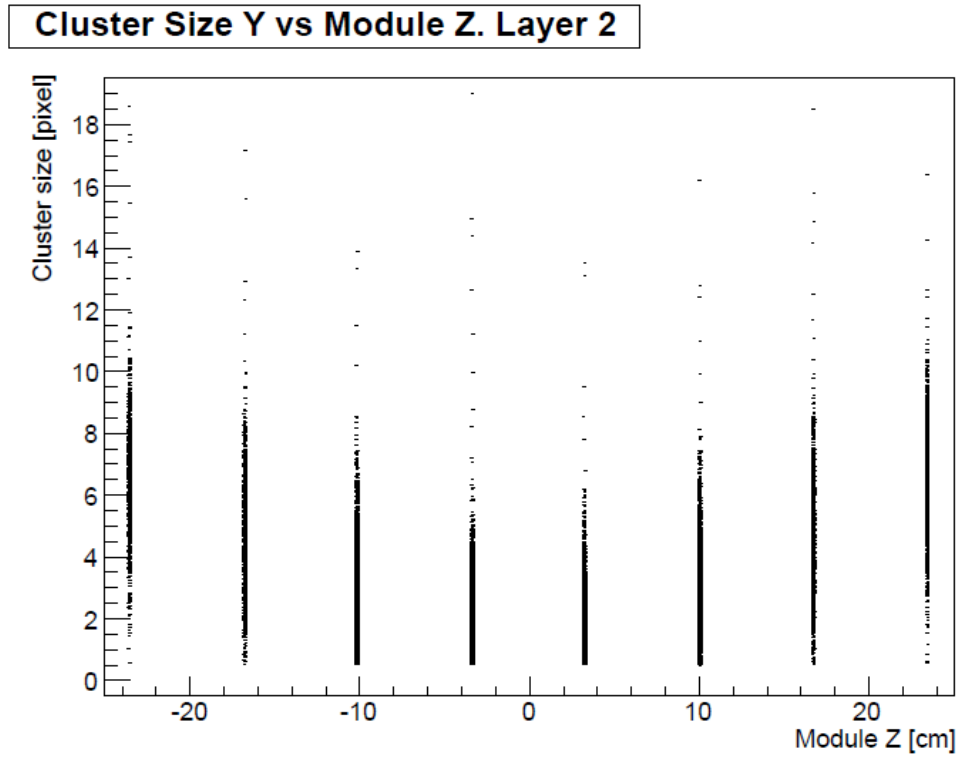
Minimal/Maximal Cluster Separation on Y between the two nearest clusters in Y





Cluster Size Y vs Module Z





- 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