Status report on Tau L1 trigger with pixels for phase 2

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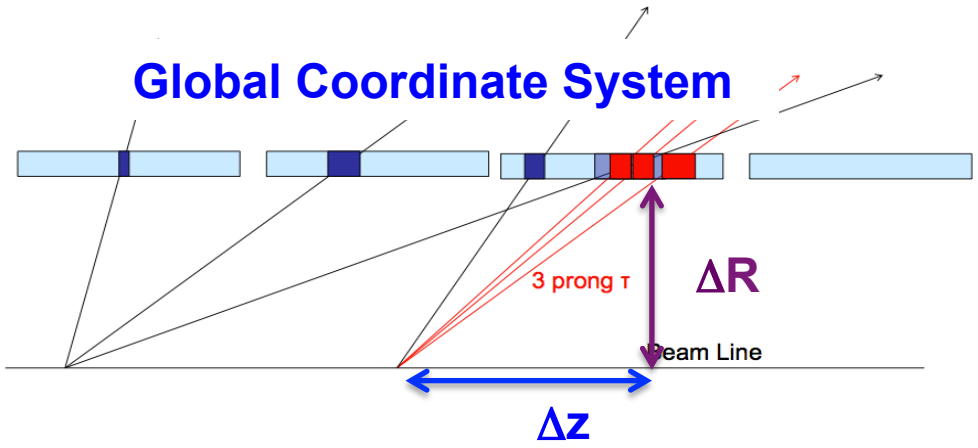
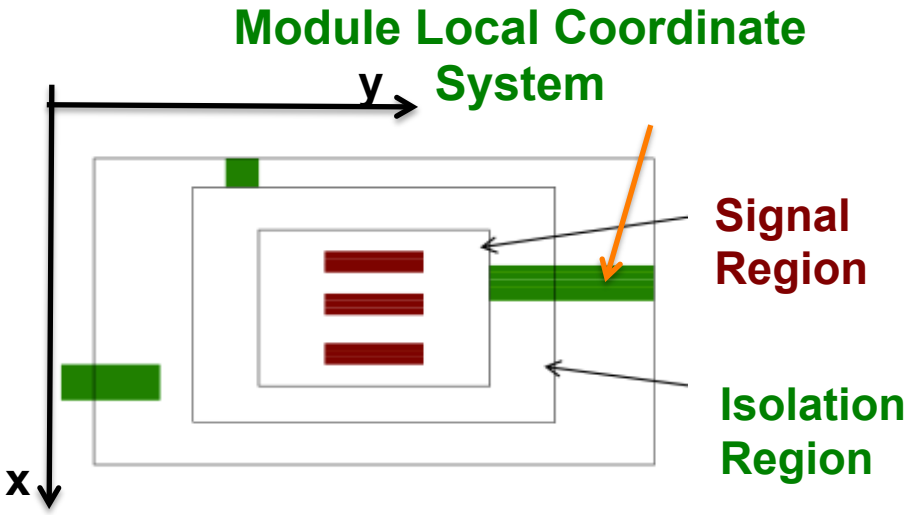
Motivation

- **Possible Tau Pixel Trigger at L1 for τ decaying into 3-prongs**
  - Make use of the dependence of the cluster size along the beam to discriminate tracks coming from different vertices.
    - Possible to reach potentially low p_T taus
  - Average decay angle of 40 GeV p_T tau in the transverse plane (r-phi) is ~1.7/40 ~0.04 radians which corresponds to ~1.2 mm (~O(10) pixels) aperture at Layer 1 radius
  - Clusters along beam axis have very similar shape
  - τ to 3 prongs identifiable as a triplet of clusters with similar size and isolated

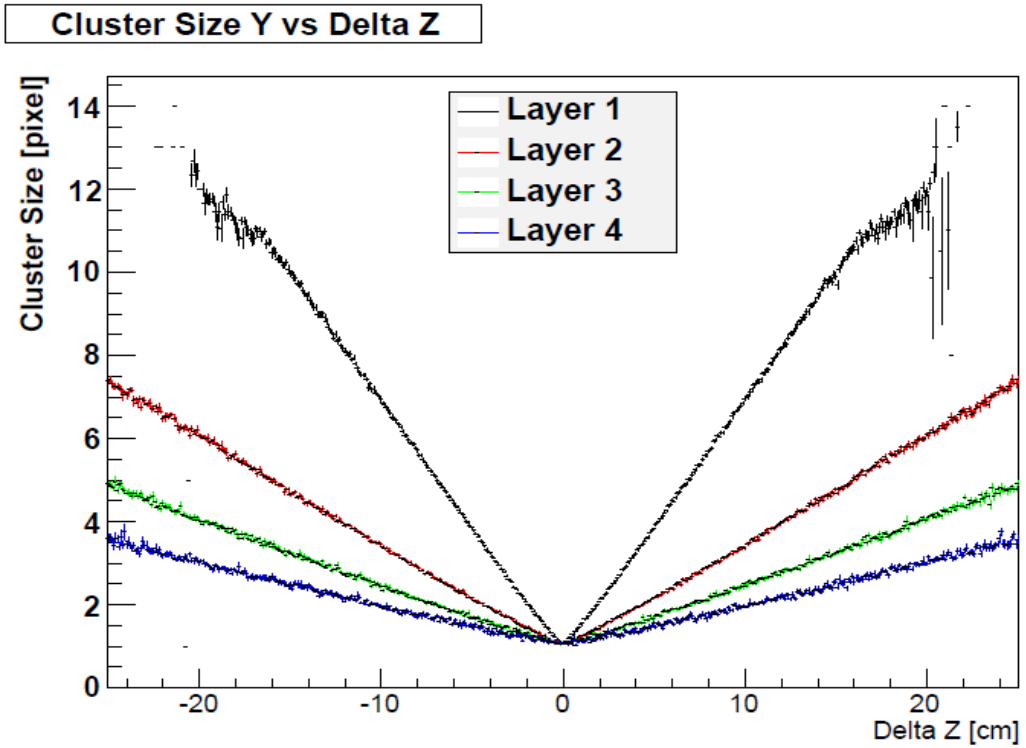


Δz = cluster_barycenter-τ_z_production_Vertex

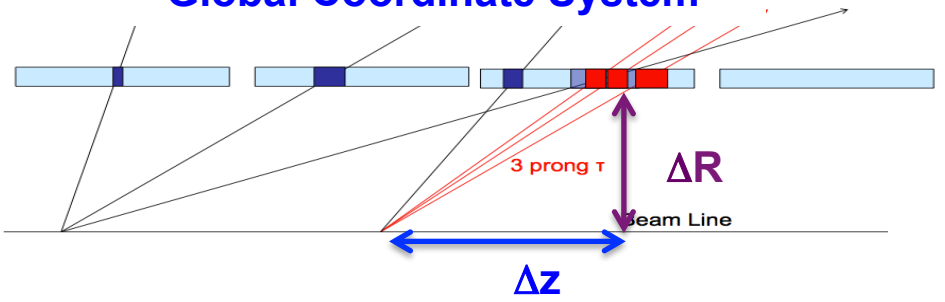


Cluster width

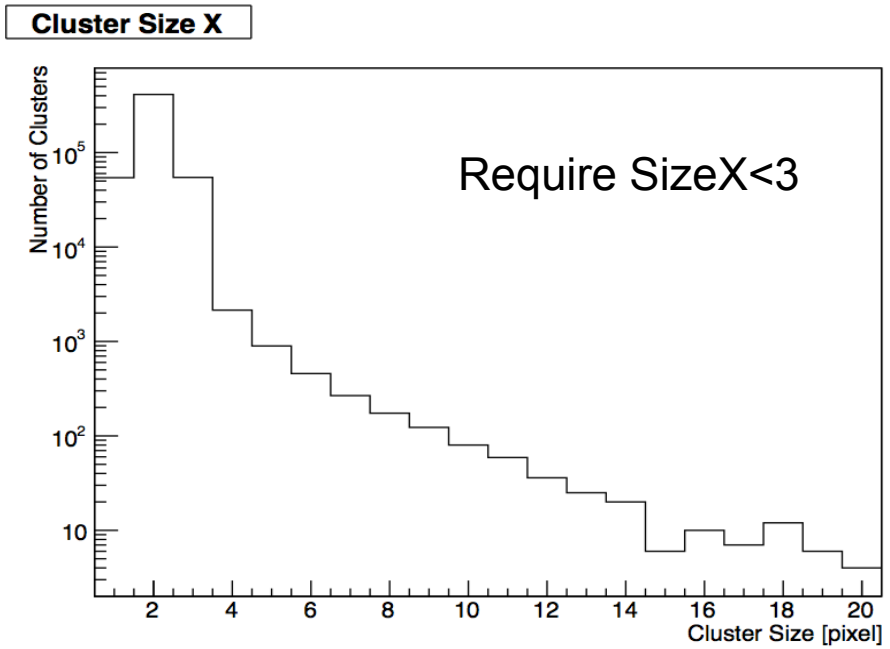
- **Average cluster Y-width as a function of the tau-to-Cluster distance along beam axis**



Global Coordinate System

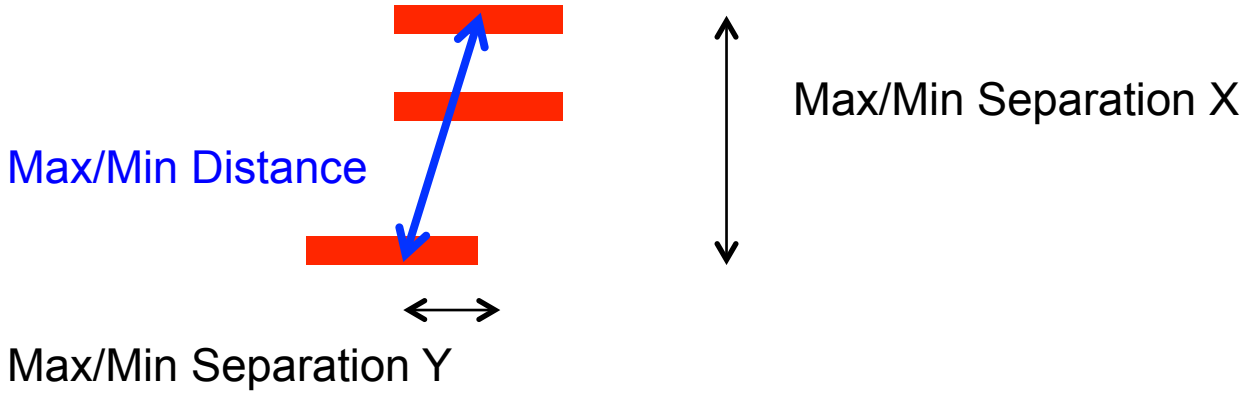


Δz = cluster_barycenter - τ_z_production_Vertex



MC Samples

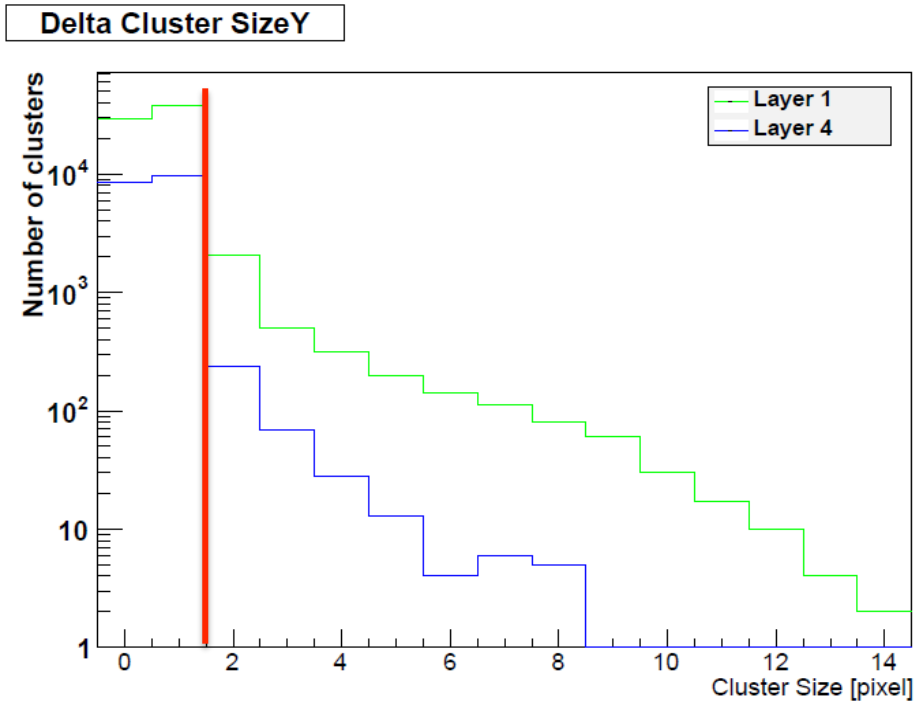
- **CMSSW_6_1_1_SLHCphase1tk1 with Extended 2017 geometry for private production and CMSSW_6_1_2_SLHC2 for official one**
  - **Default clusterization algorithm from standard RECO**
- **Signal Tau events w/o pileup**
  - **Private production of SingleTau with 3 prongs decays**
    - **Particle gun production: flat P_T range = [20, 100] GeV, flat $|\eta| < 2.5$ and default Gaussian Beam Spot**
    - **To study characteristics of Signal Region, only $\tau \rightarrow 3$ prongs are accepted :**
      - **Required 3 not merging clusters in a Single Module in the Pixel Barrel from 3 different prongs**
      - **No clusters from secondary processes in the same module (from GEANT truth)**
- **In addition use VBF H->tau tau private production events w/o pileup**
- **Minimum bias and Tau->3 prongs events with 140 pileup from official production**



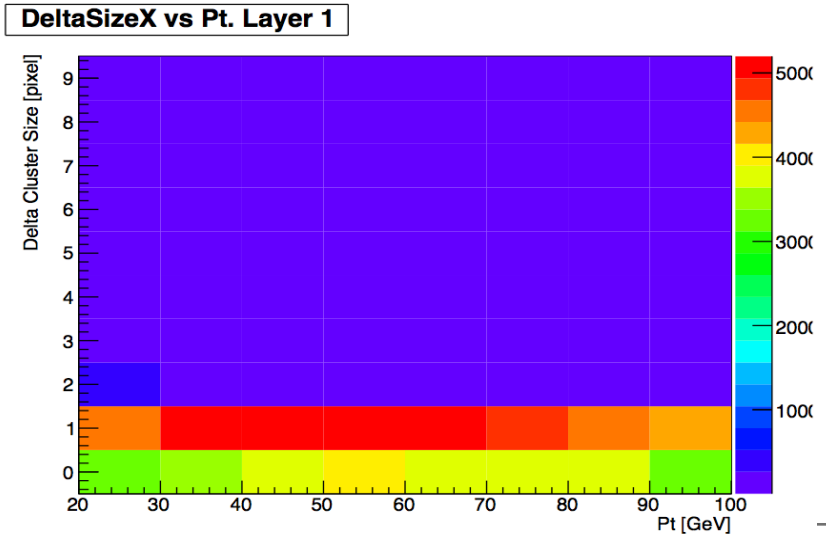
SIGNAL REGION CHARACTERIZATION

Done for each layer and each Tau p_T separately

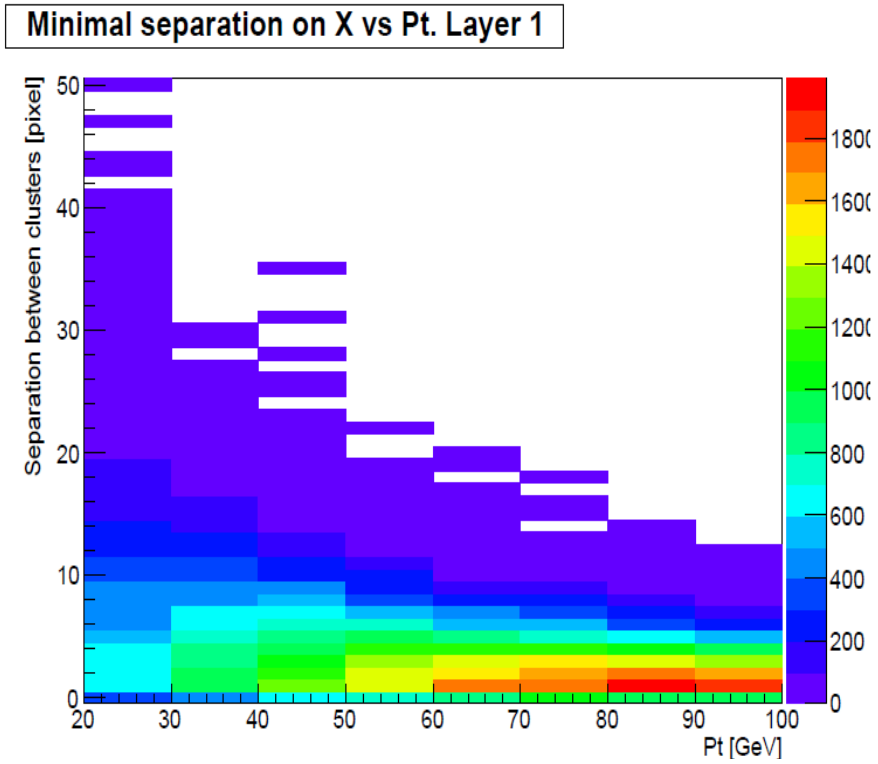
Difference between cluster size for clusters from the same τ

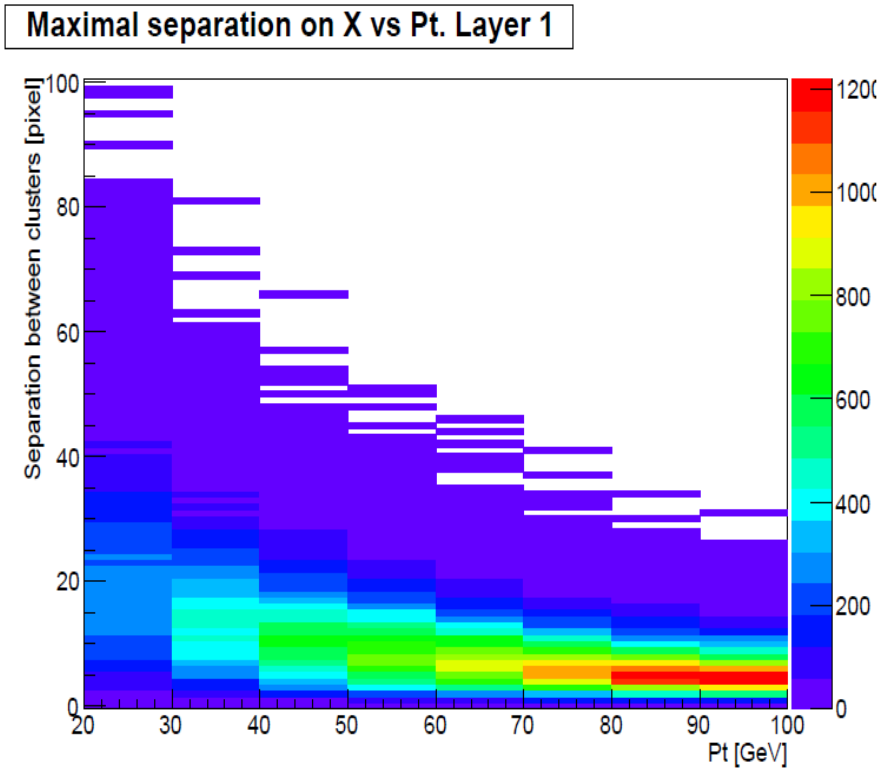


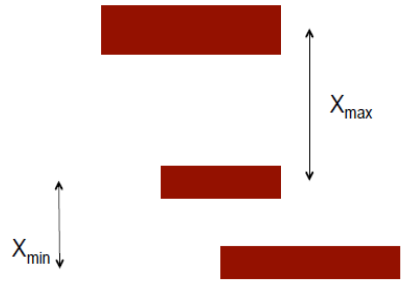
- Clusters produced by same τ→3 prongs generally have comparable width on local Y.
- Events with Delta Cluster Size Y < 2 →
  - 95.7% of all Events for Layer 1;
  - 97.4% of all Events for Layer 4.
- Delta Cluster Size X<2
- Reject clusters made of just 1 pixel



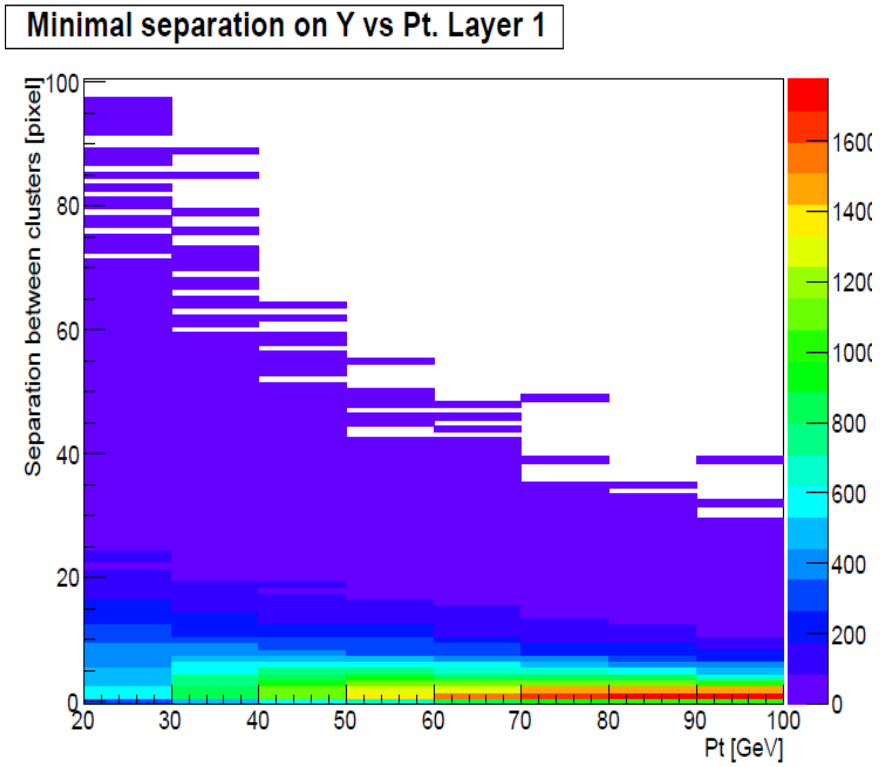
Minimal/Maximal Cluster Separation on X between the two nearest clusters in X

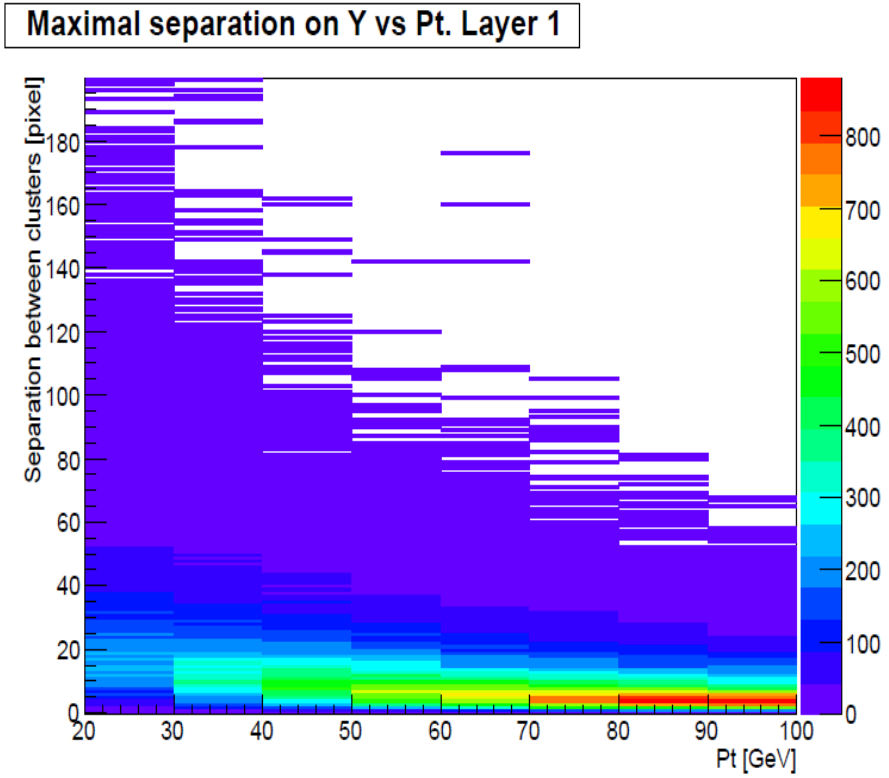




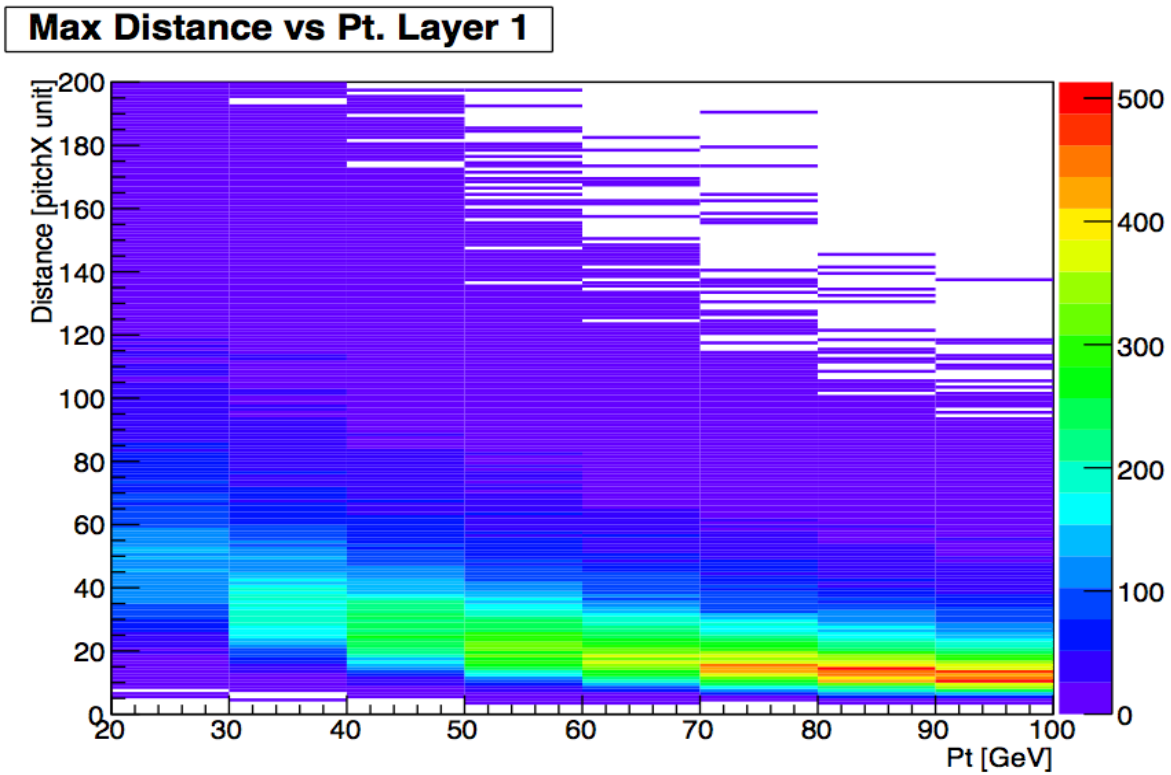


Minimal/Maximal Cluster Separation on Y between the two nearest clusters in Y



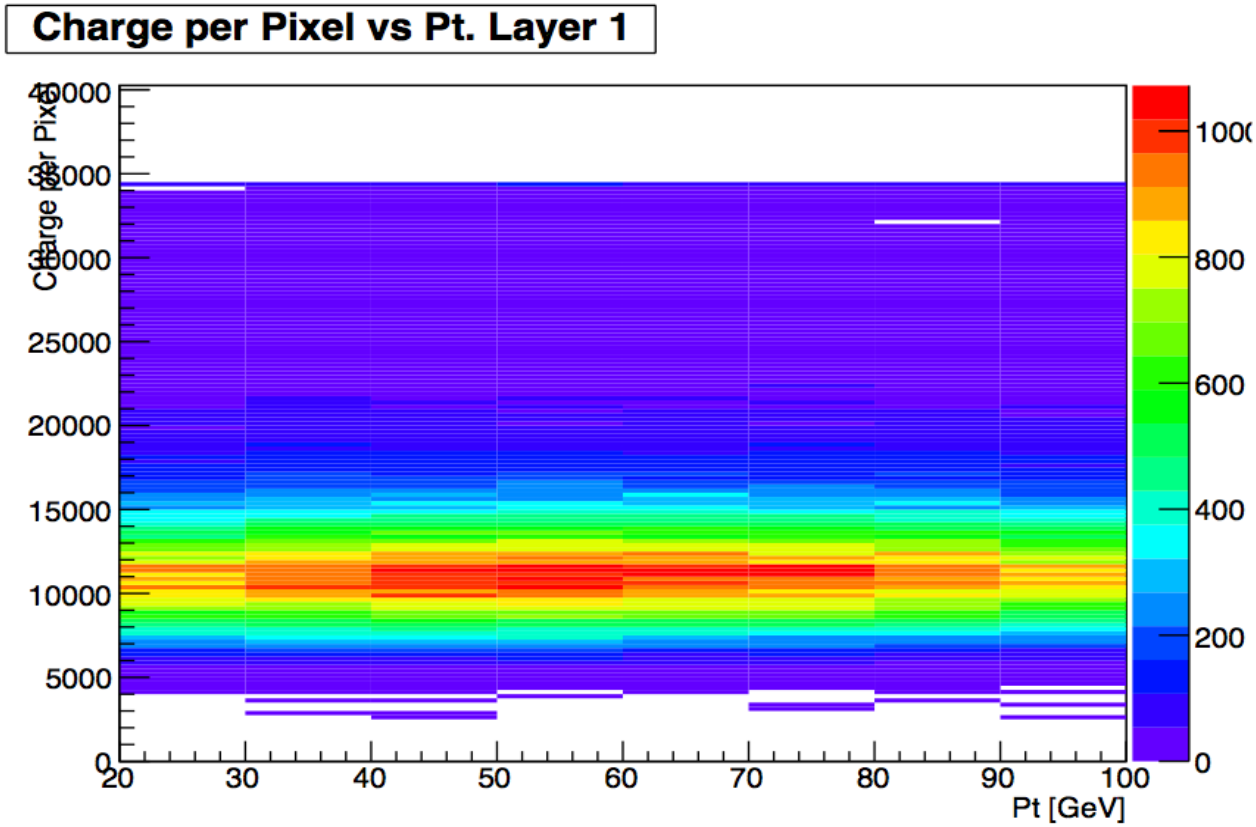


Distance between clusters



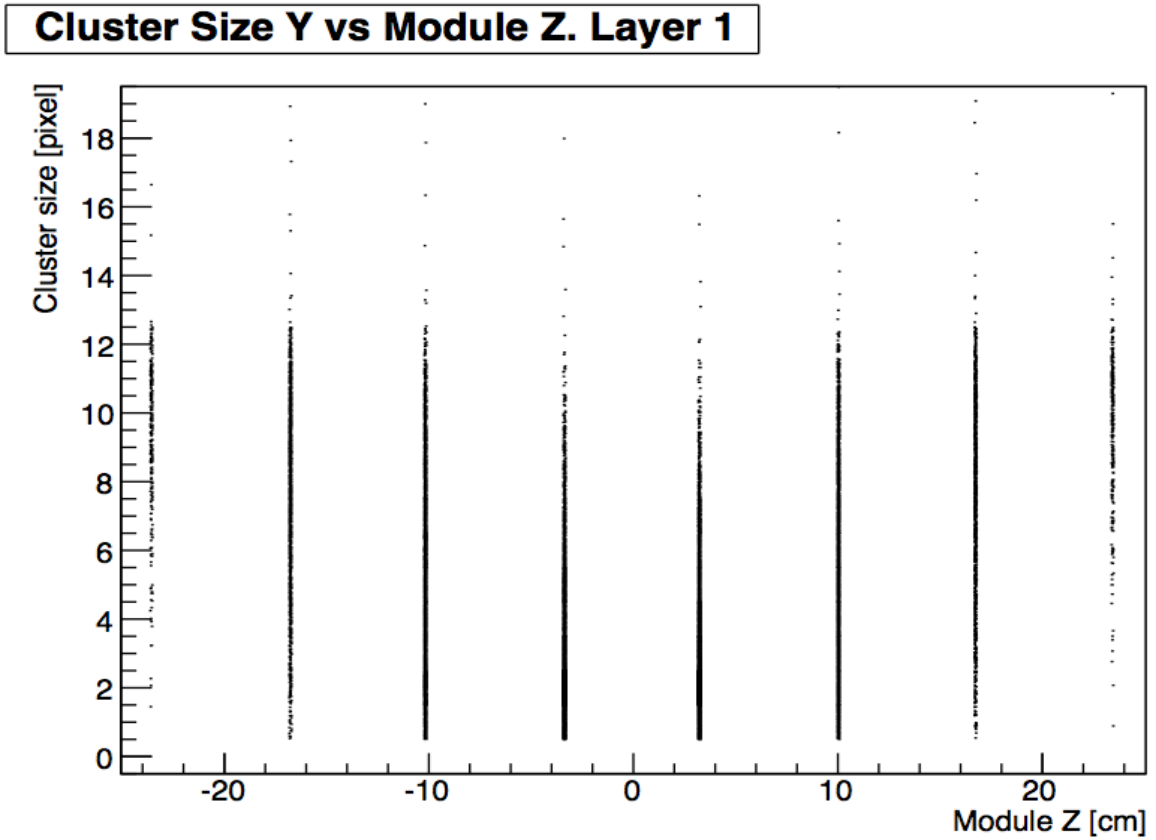
Minimal distance between clusters
Always required > 5 pitch X units

Charge per pixel



Require charge per pixel > ~6500 and a maximum (17-20K)

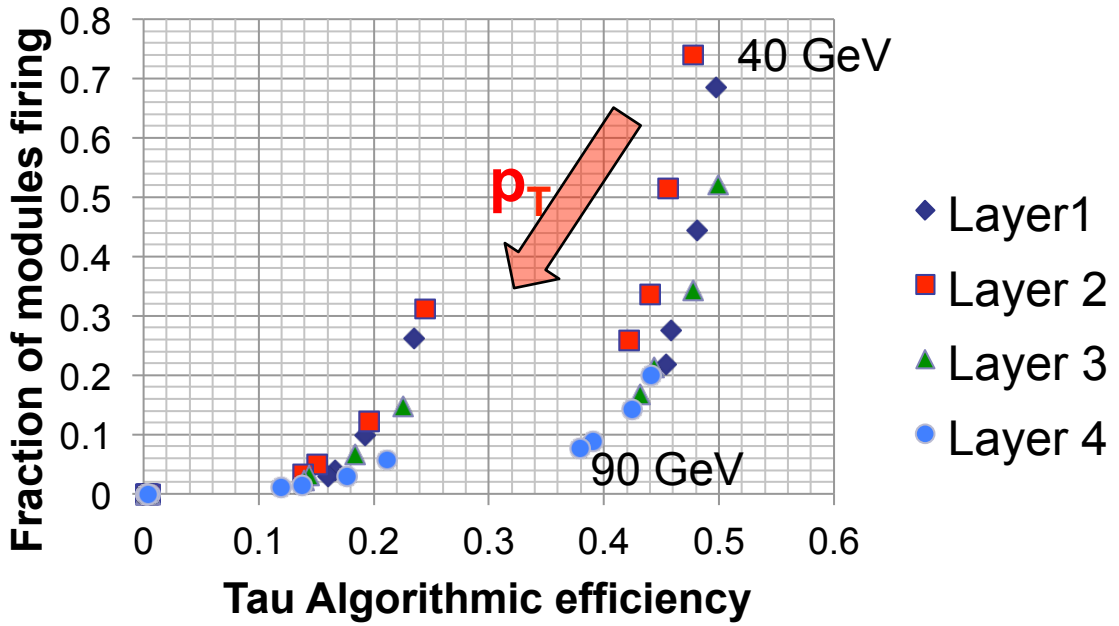
Minimal Size Y vs module



Require Cluster Size Y compatible with expected
(reject small-Y clusters in the high Z modules)

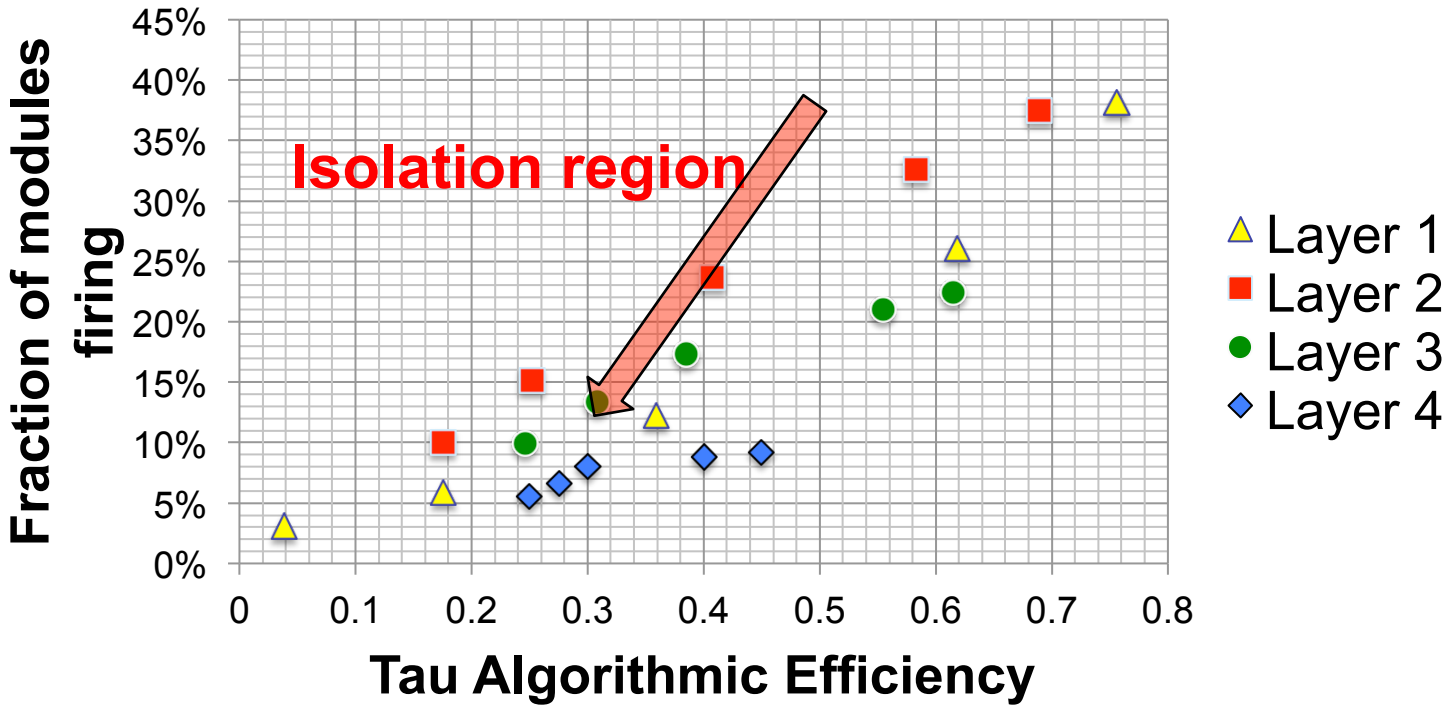
Results: MinBias (140 PU) and Tau (no-PU)

- **Several signal "phase space" regions tried**
  - **With fixed Isolation region 20 (r-phi) x 40 (r-z) pixels**
  - **Minimum bias events always fire (there is at least one module with isolated triplet in each event)**
    - **What fraction of the modules "fire" with two different signal regions**
      - ➨**Scan in p_T for different settings of signal regions**



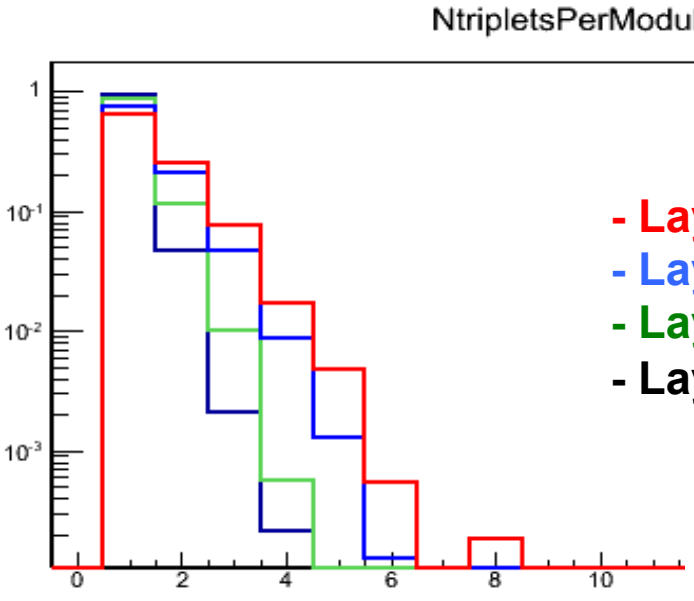
Results on Tau+PU (140)

- **Signal region optimized for 80 GeV.**
  - **Vary the isolation region from 10x20 to 50x100 pixels**



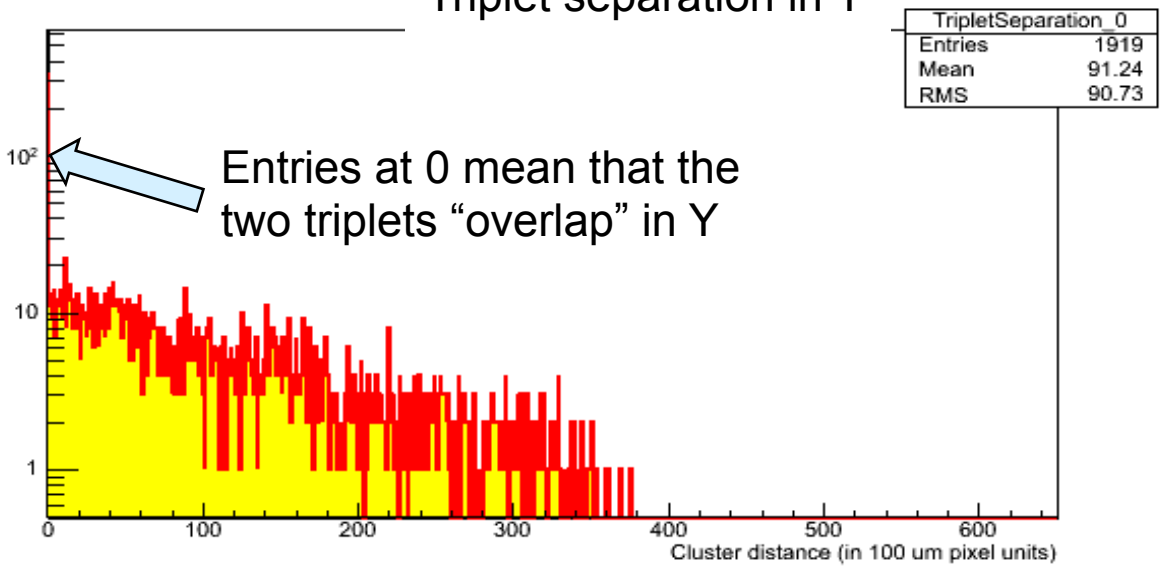
Why do we trigger much on MB?

- **Many isolated triplets in MinBias events and close each other**



- Layer 1
- Layer 2
- Layer 3
- Layer 4

Triplet separation in Y



Entries at 0 mean that the two triplets “overlap” in Y

Try to see what's up in real data

- **Use PixelTree dataset (Thanks to Morris Swartz for let us know)**
  - **https://twiki.cern.ch/twiki/bin/viewauth/CMS/PixelTree**
  - **MinBias with on average 10 pileup/event (run 208392)**
  - **Average number of triplets per module look similar to MC**
  - **However, 95% of those triplets have no (RECO) tracks attached to, so we don't know what these clusters are**
  - **Having ~8 clusters/cm^2 this would give on average 1 clusters in a 20x40 pixels region, and the probability that 1 fluctuates to 3 is 6%.**
  - **This is in agreement with the expected number of triplets from tracks. Hence those clusters are not evenly distributed in the module or should come from other sources.**
- **Investigating origin is under way using MC truth. Possible explanations:**
  1. **Loopers: a track which spiralizes. Could give small similar clusters if it enters "tangent" to the surface and generate "splitted" clusters.**
  2. **Nuclear interactions occurring either in the layer (either passive or active material) or in the beam pipe. Probable**
  3. **Bremsstrahlung from electrons - but also higher than average cluster charge, which is not the case**
  4. **Split clusters from primary tracks? Should see other clusterizers?**
  5. **Real tracks in "bunches" of 3? Probably unlikely.**

Conclusions and next steps

- **Given the large rates for MinBias events, we cannot use triplets in the pixels for a stand-alone trigger on Tau->3 prongs.**
  - **A different approach is needed, to match this information with some other existing one – either Calorimeter or Tracker objects**
    - **(ROI or processing in parallel)**
  - **We have found regions of the parameter space where the occurrence of triplets per layer vary from 5 to 10 % of the total.**
  - **For a pixel chip of 4 cm^2 that corresponds to an output rate of 1.25 to 2.5 MHz, which is "doable" at the chip level (the foreseen output rate is ~3 Gbps)**
    - **Need to develop a logic on chip which provides triplets of similar size at 40 MHz input, correlating several "pixel regions" together. Started interaction with Chip Designers.**
      - **➨ Work in conjunction with the Pixel-Jet algorithm (see Andrea's talk)**
- **Next: study the correlation of triplets with L1Calo Jets or L1 tracks**