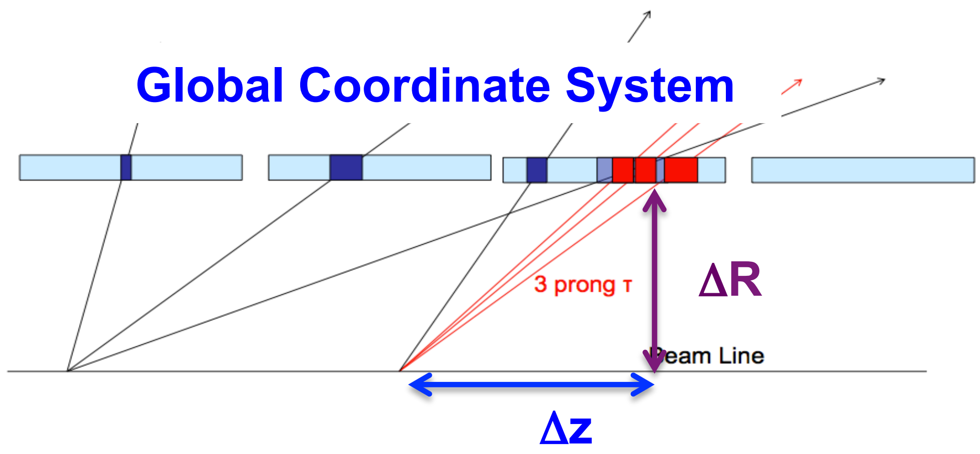
Status report on Tau L1 trigger with pixels for phase 2

K. Androsov, M. T. Grippo, M. A. Ciocci, G. Bagliesi, F. Palla

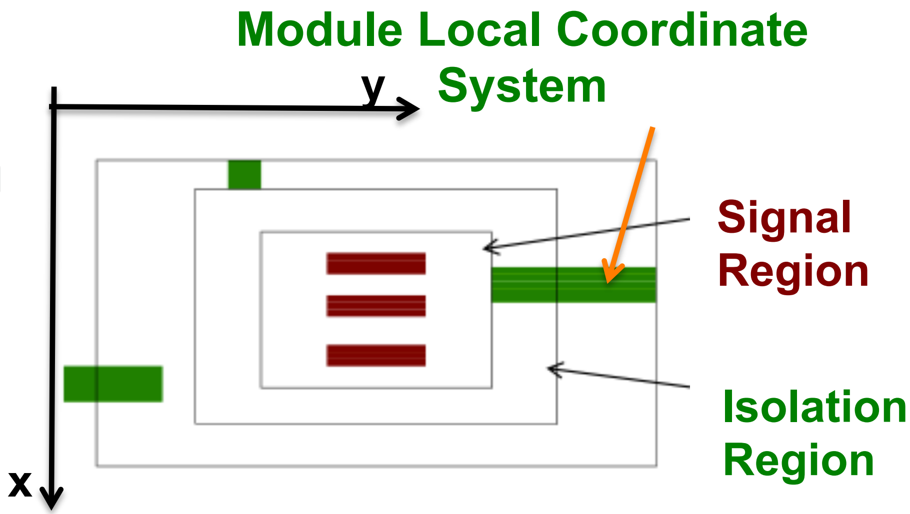
INFN Pisa and University of Siena

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**

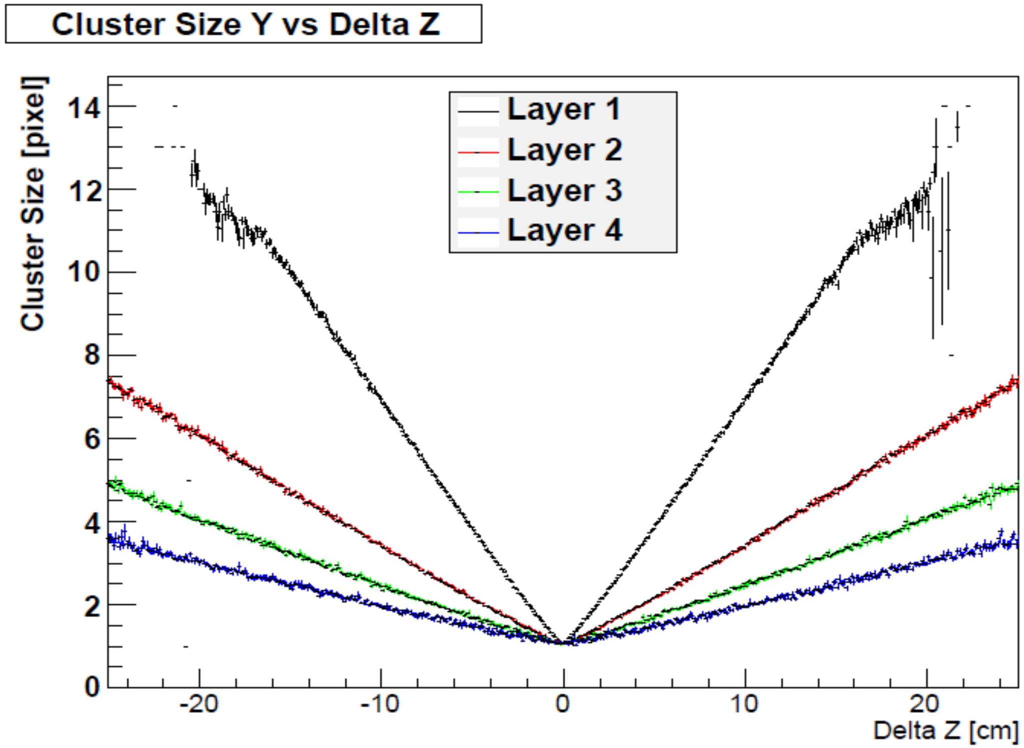


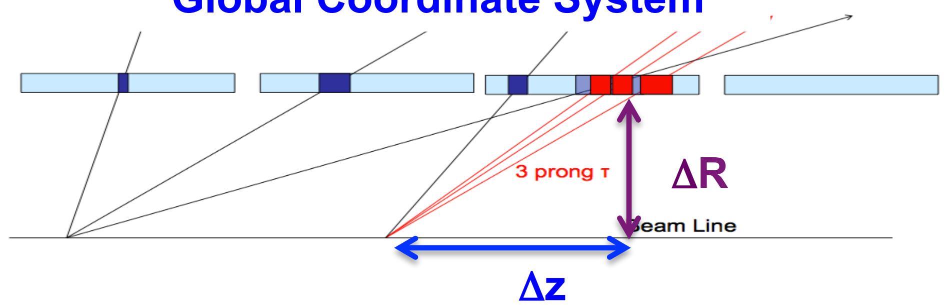
Δz = cluster_barycenter-τ_z_production_Vertex



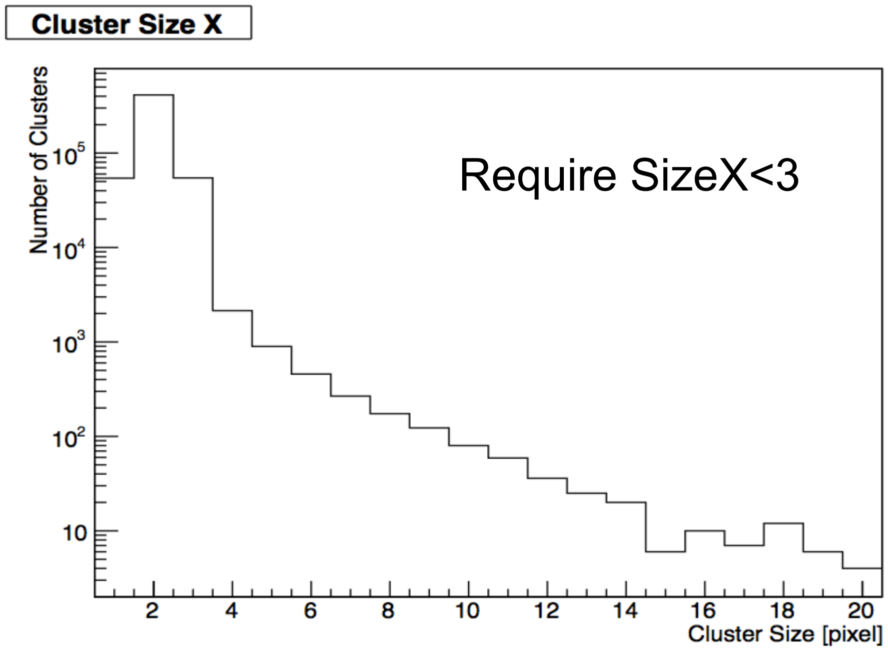
Cluster width

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



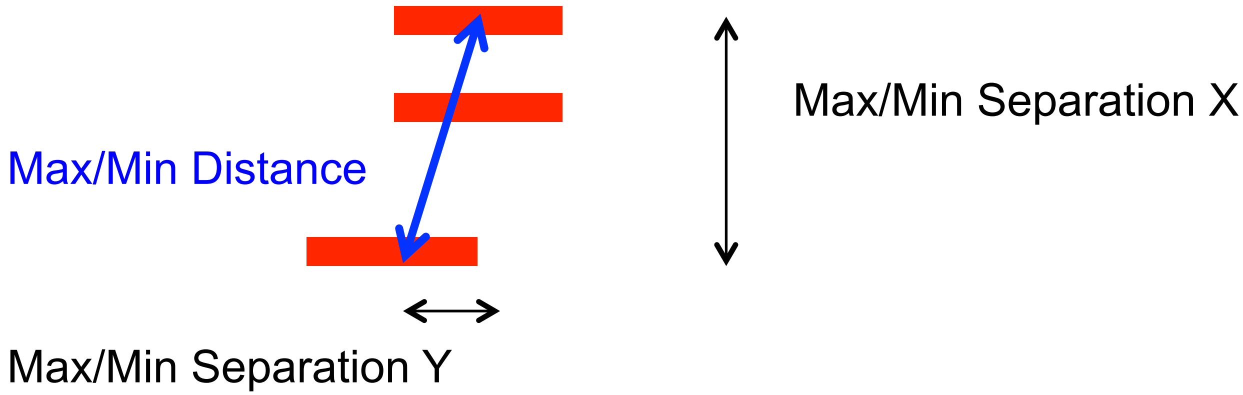


Δz = cluster_barycenter - τ_z_production_Vertex



MC Samples

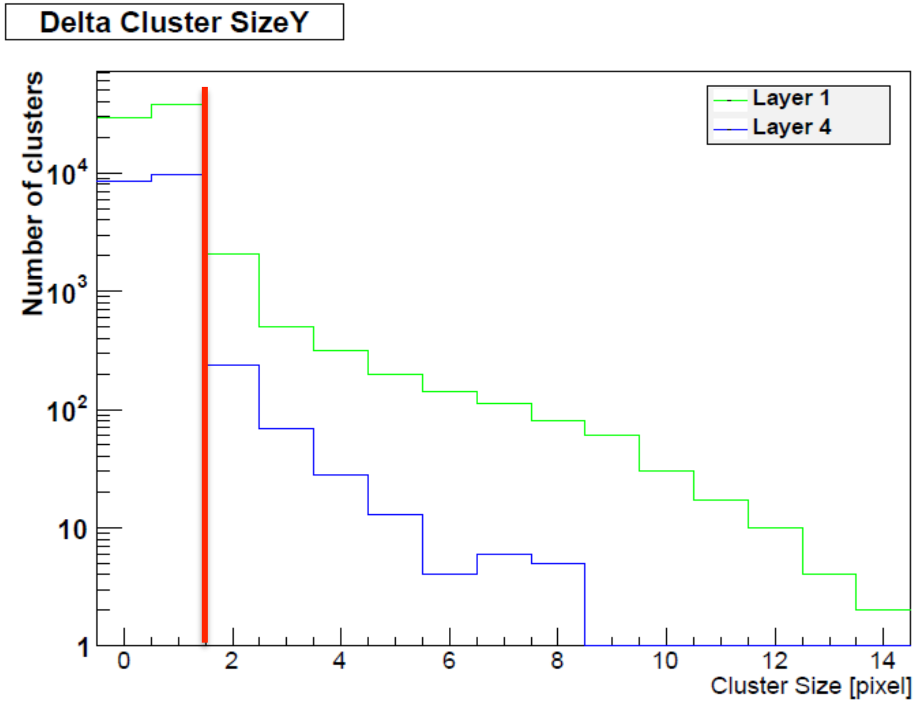
- CMSSW_6_1_1_SLHCphase1tk1 with Extended 2017 geometry for private production and CMSSW_6_1_2_SLHC2 for official one
  - Default clusterization algorithm from standard RECO
- Signal Tau events w/o pileup
  - Private production of SingleTau with 3 prongs decays
    - Particle gun production: flat P_T range = [20, 100] GeV, flat $|\eta| < 2.5$ and default Gaussian Beam Spot
    - To study characteristics of Signal Region, only $\tau \to 3$ 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



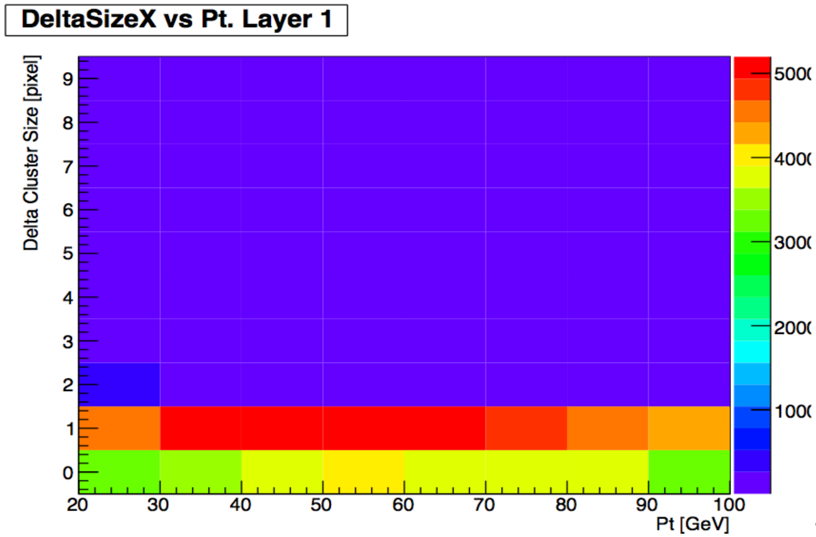
SIGNAL REGION CHARACTERIZATION

Done for each layer and each Tau p_T separately

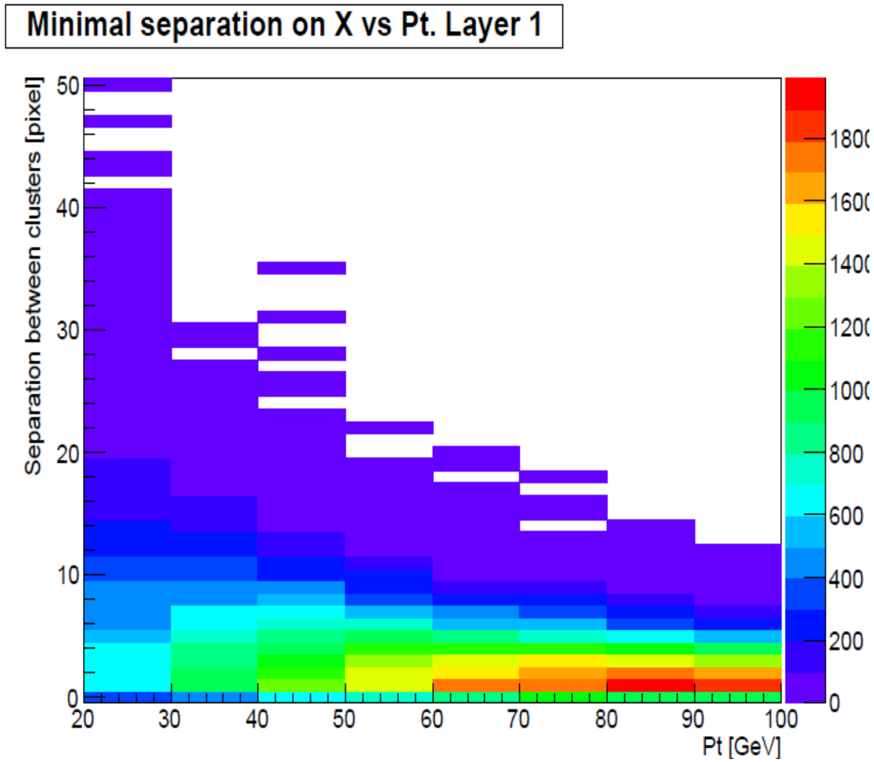
Difference between cluster size for clusters from the same τ

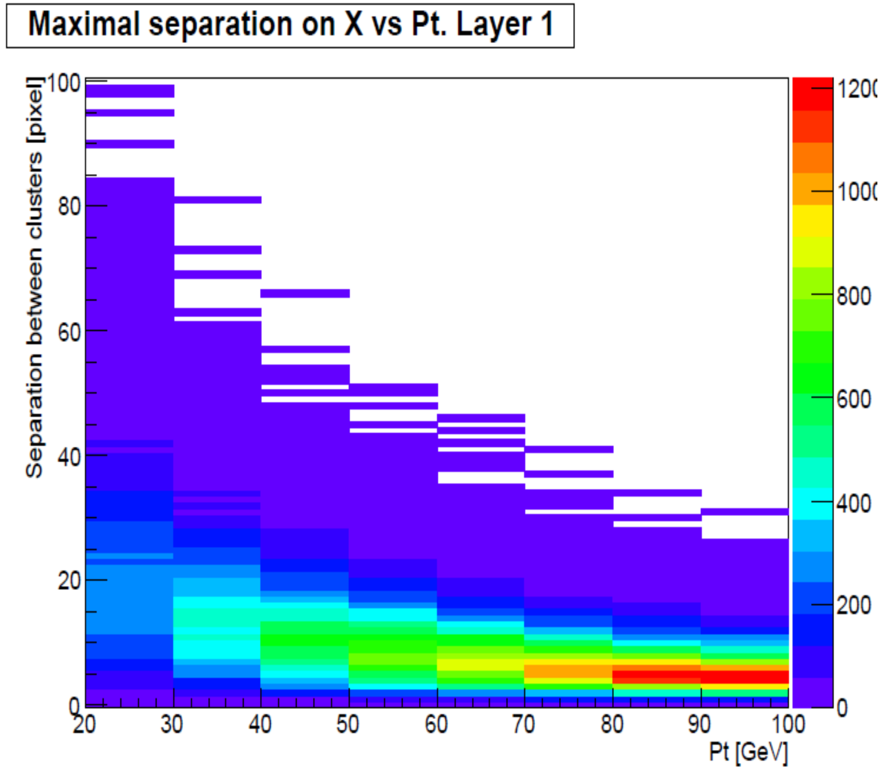


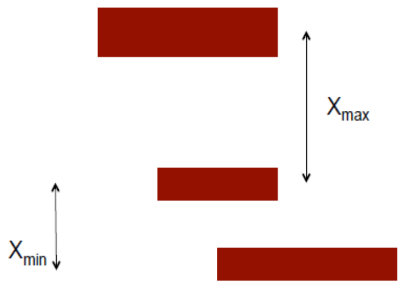
- **Clusters produced by same $\tau \to 3$ prongs generally have comparable width on local Y.**
- **Events with Delta Cluster Size Y < 2 →**
  - **95.7% of all Events for Layer 1;**
  - **97.4% of all Events for Layer 4.**
- **Delta Cluster Size X<2**
- **Reject clusters made of just 1 pixel**



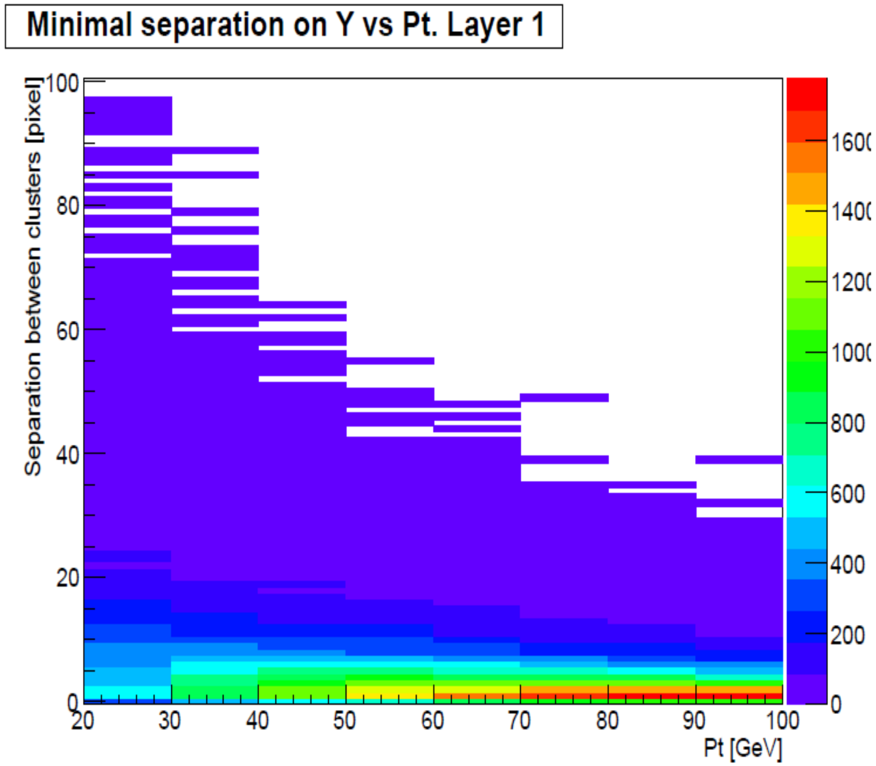
Minimal/Maximal Cluster Separation on X between the two nearest clusters in X

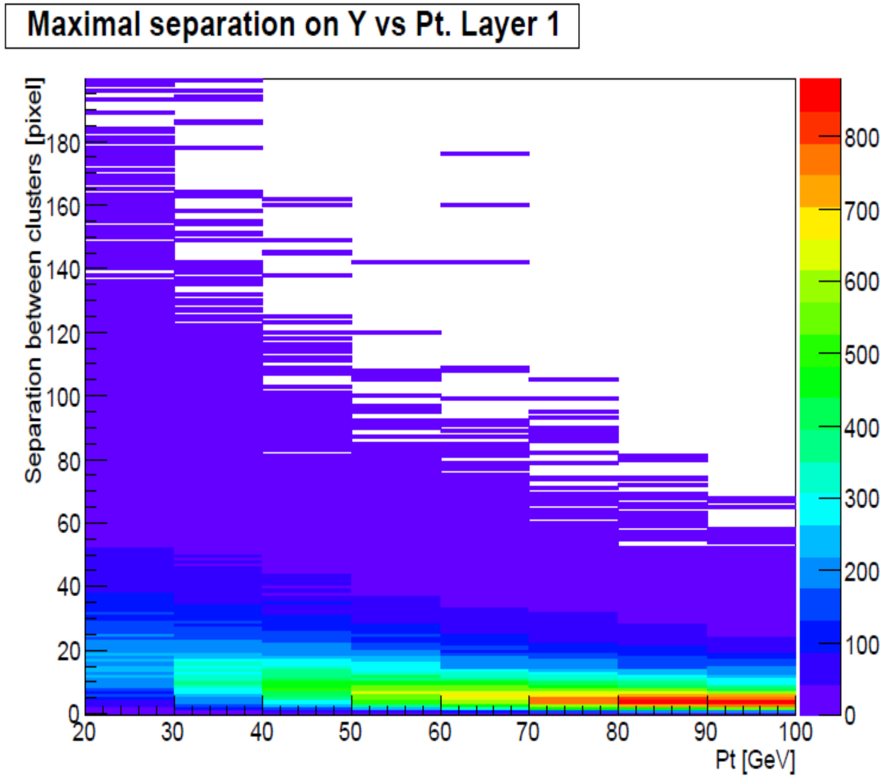




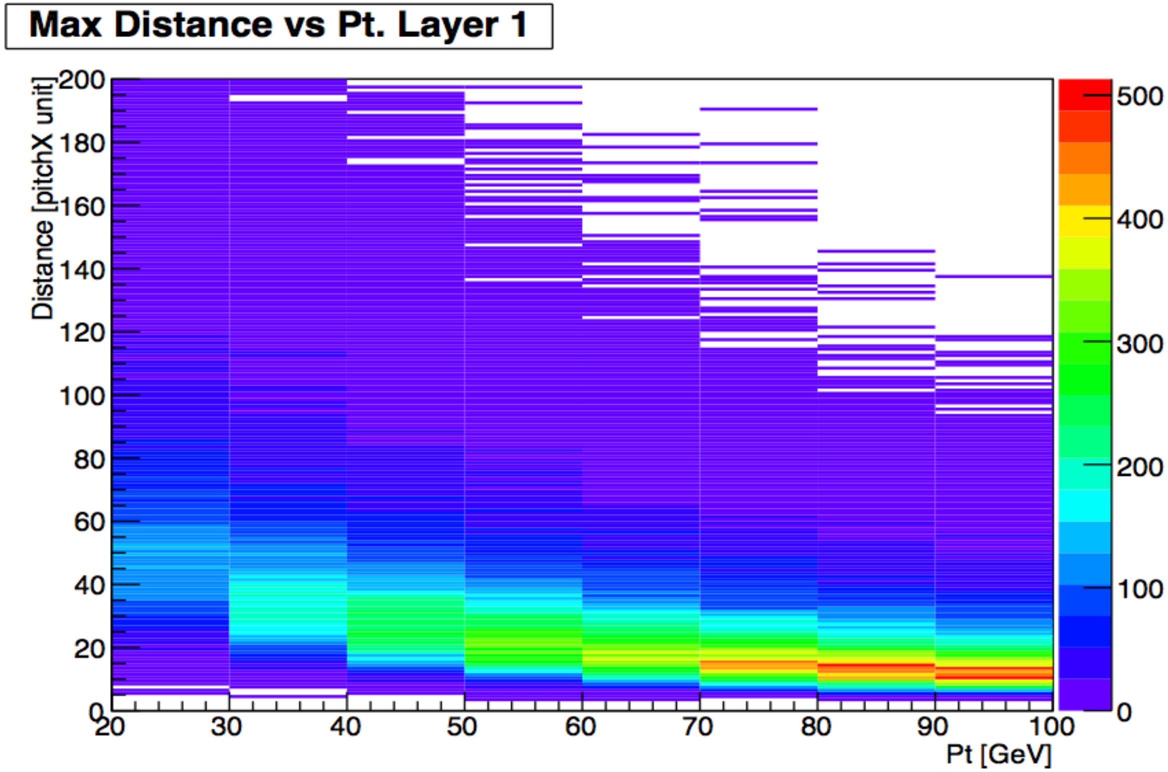


Minimal/Maximal Cluster Separation on Y between the two nearest clusters in Y



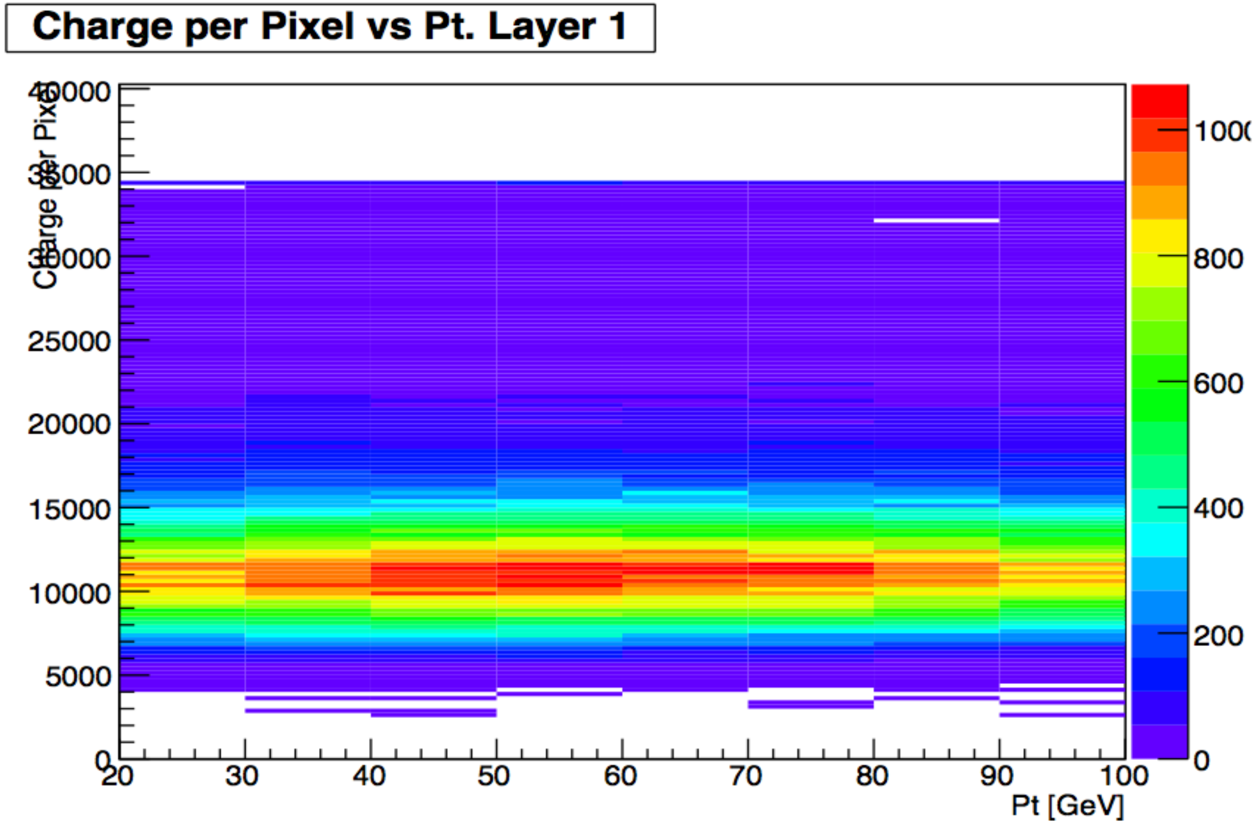


Distance between clusters



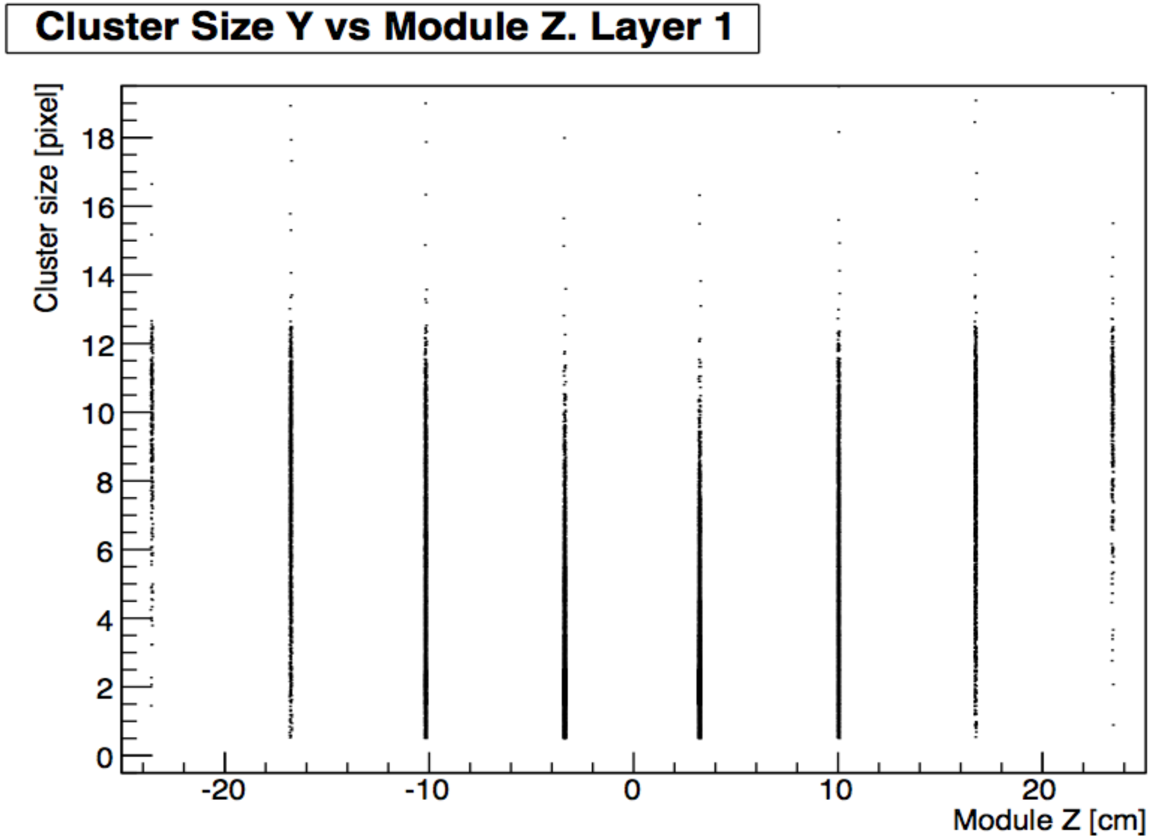
Minimal distance between clusters
Always required > 5 pitch X units

Charge per pixel



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

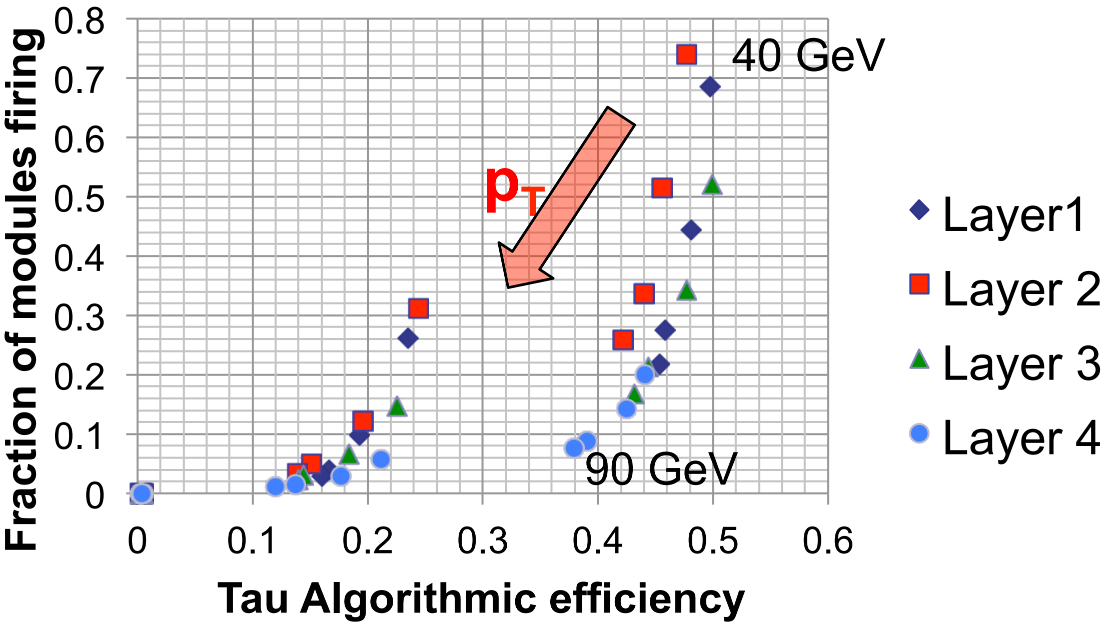
Minimal Size Y vs module



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

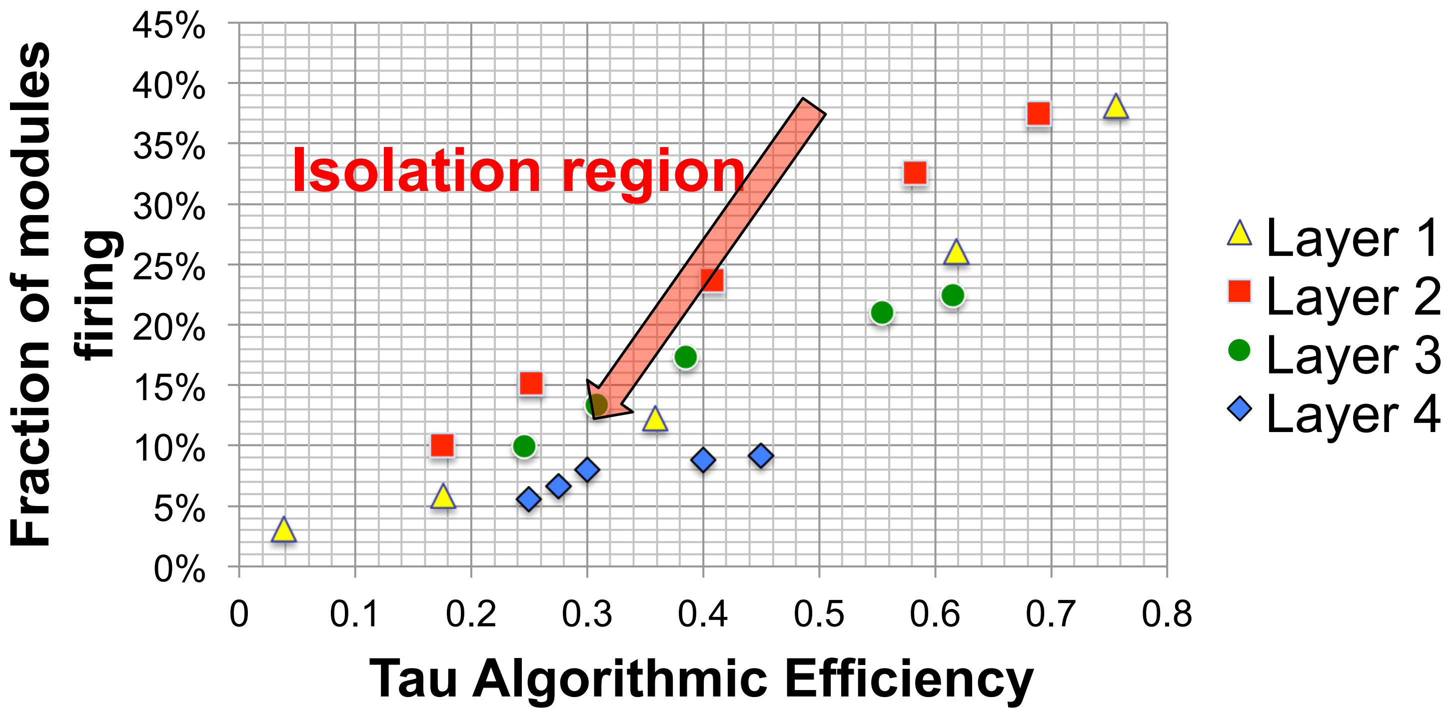
Results: MinBias (140 PU) and Tau (no-PU)

- **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



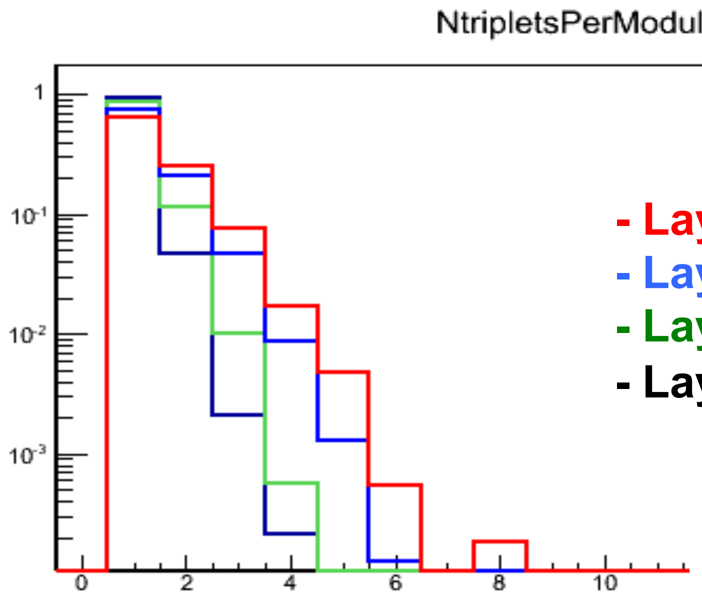
Results on Tau+PU (140)

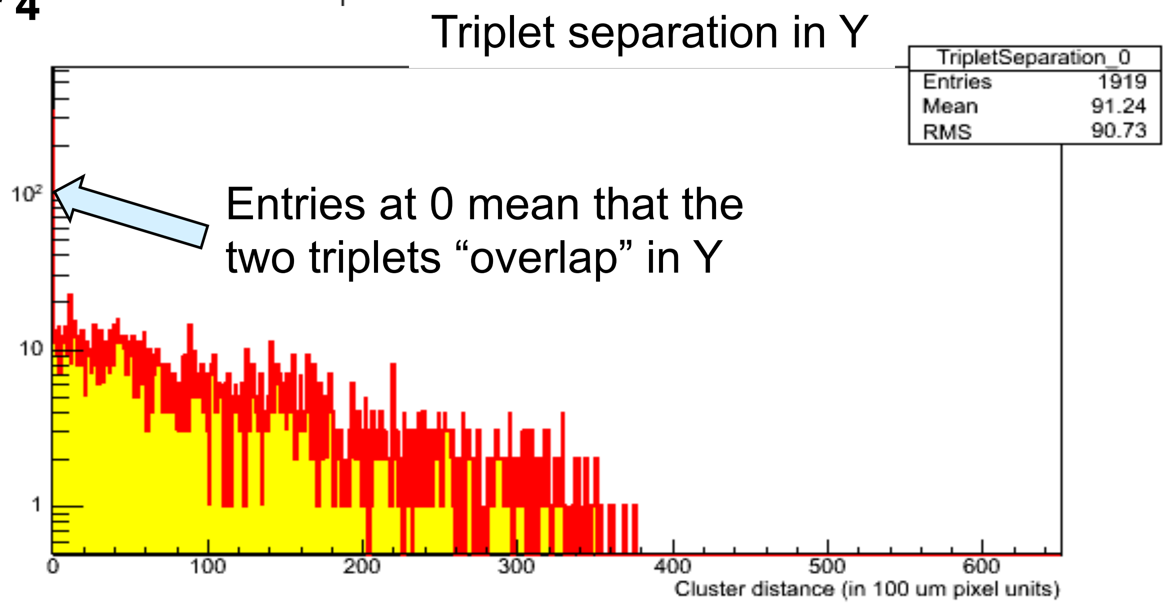
- **Signal region optimized for 80 GeV.**
  - **Vary the isolation region from 10x20 to 50x100 pixels**



Why do we trigger much on MB?

- Many isolated triplets in MinBias events and close each other





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**