Reworking the CES Cluster Reconstruction Algorithm

By: Steve Fedele
Advisor: Pavel Murat

Overview

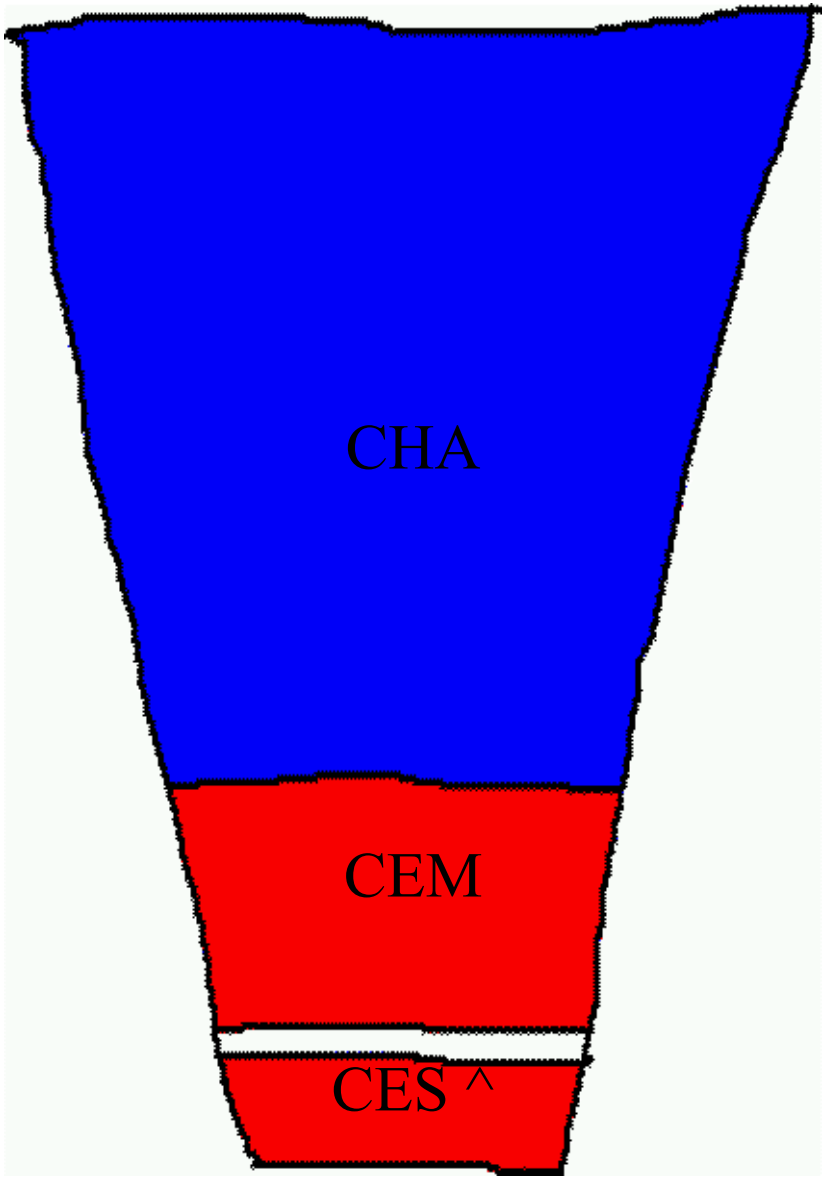
- Tau reconstruction description
- Shortcomings of old reconstruction algorithm
- Description of new algorithm
- Preliminary results
- The future

Tau reconstruction

- Tau leptons decayeither leptonically or hadronically
  - Leptonic: T -> e vv
  - Hadronic: T -> Pi v
- Leptonic decay is difficult to identify
  - W -> e v
  - W -> T v -> e v vv
- Hadronic decay via 2 primary channels
  - "1 prong" : T -> Pi+ Pi0 v
  - "3 prong": T -> Pi+ Pi+ Pi – Pi0 ... v
- Pi0 decay into 2 photons
- Thus reconstruction of photons allow reconstruction of taus
- Photon reconstruction occurs in CES / Calorimeter

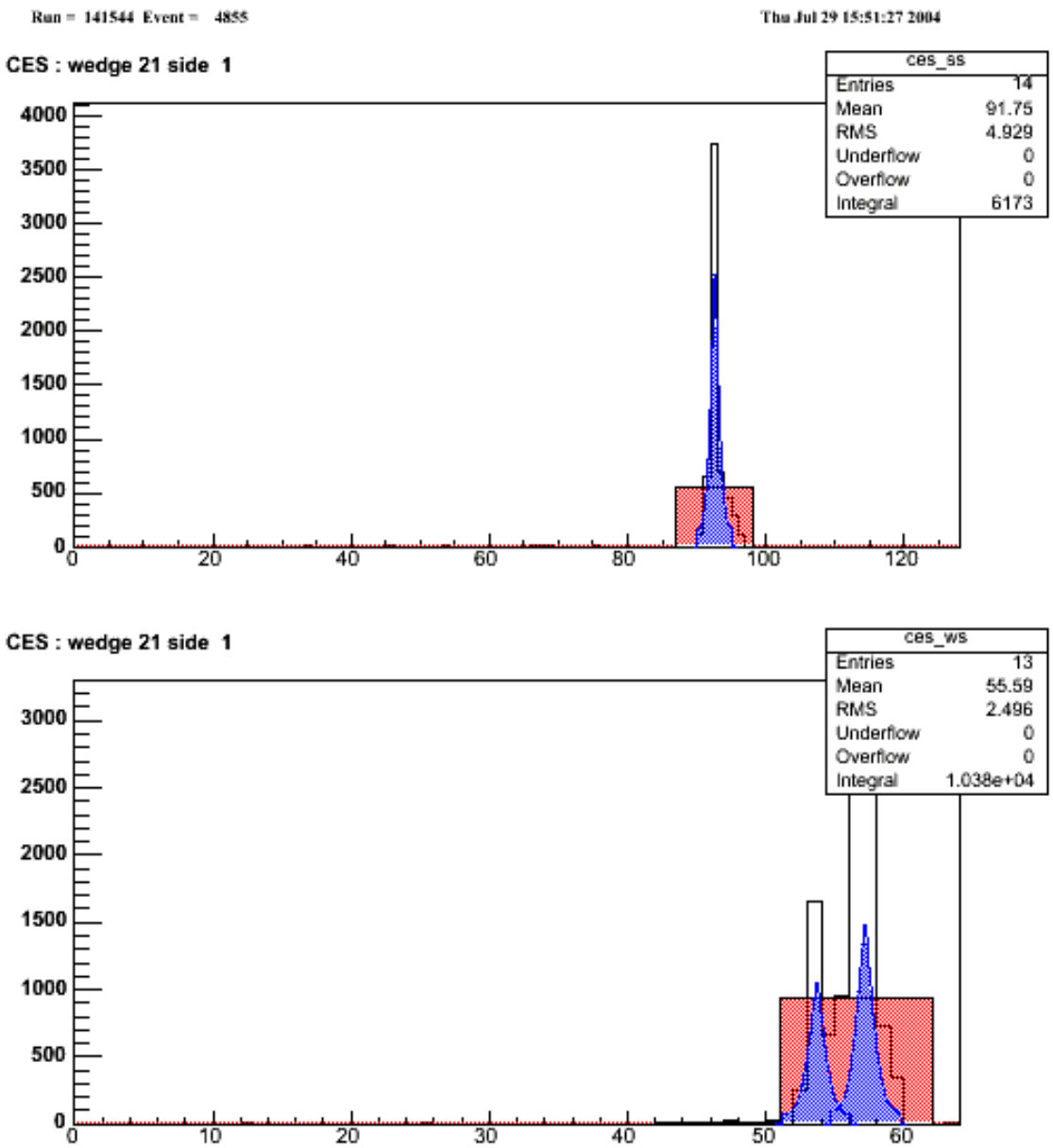
CES Overview

- CEM : (Electromagnetic Calorimeter) before CHA (Hadronic Calorimeter)
- CES = Strip Chamber located inside CEM
- Read out from X side (Wire) and Z side (Strip)
- Each channel reads out total ADC counts (charge) deposited on that channel.



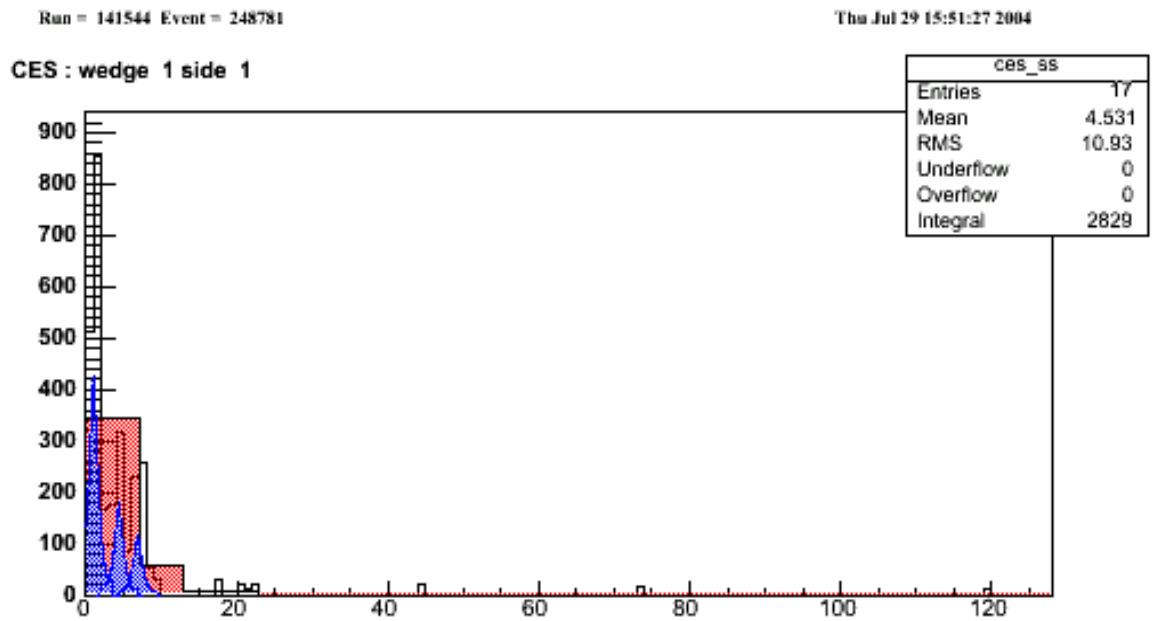
CES Readout Example

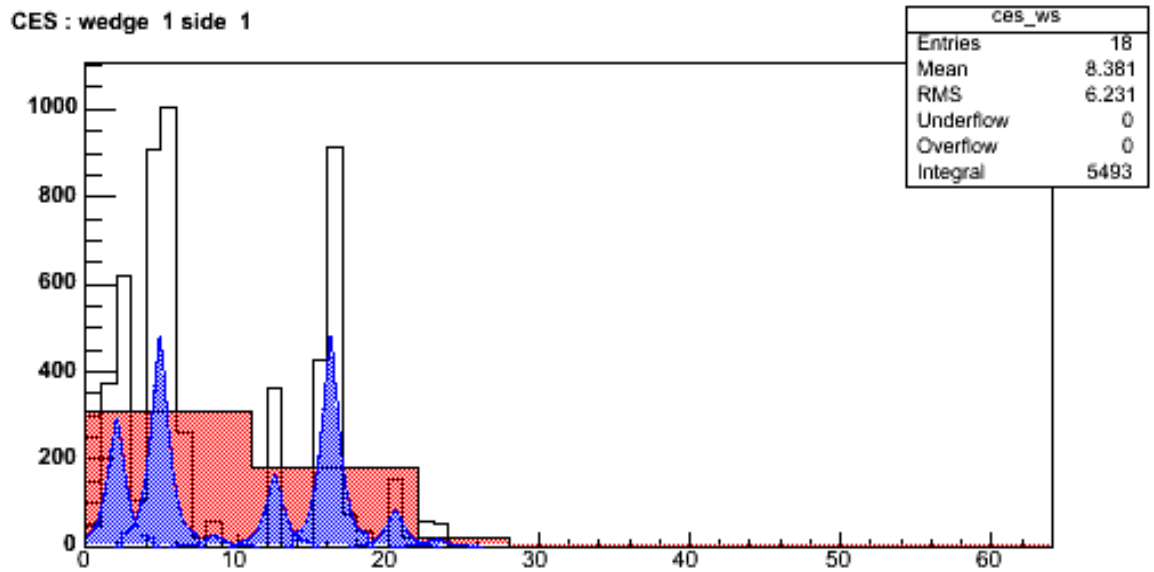
- Reconstruction Goals:
  - Identify "clusters" on wire and strip side
  - Match clusters on wire and strip side
- From this one can tell
  - Energy of shower
  - Location of shower in 2D CES plane



Old Reconstruction Algorithm

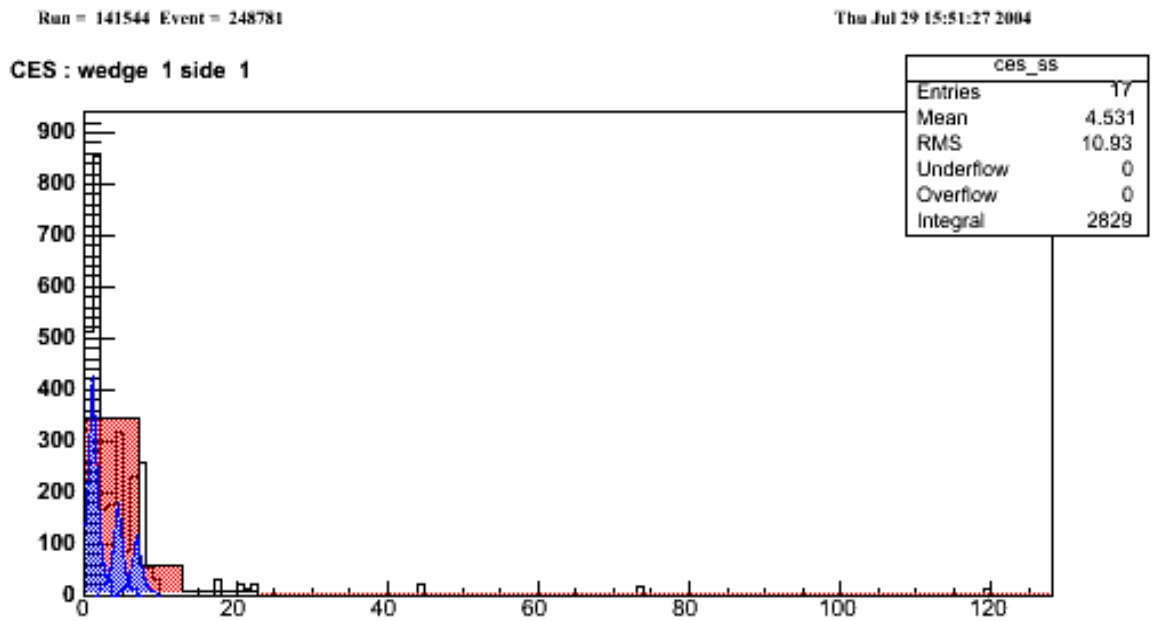
- Fixed window algorithm
- Track/Seed based reconstruction
- Fit to standard shower profile obtained from 1985 test beam
- For more details see Riveline's CDF note number 5863

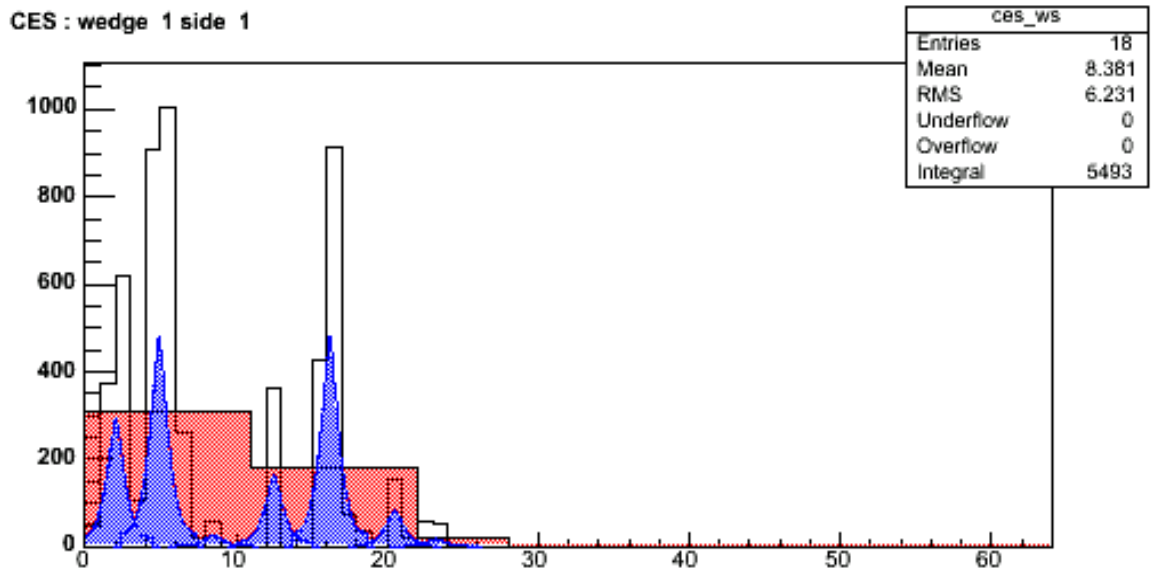




Old Algorithm: Issues

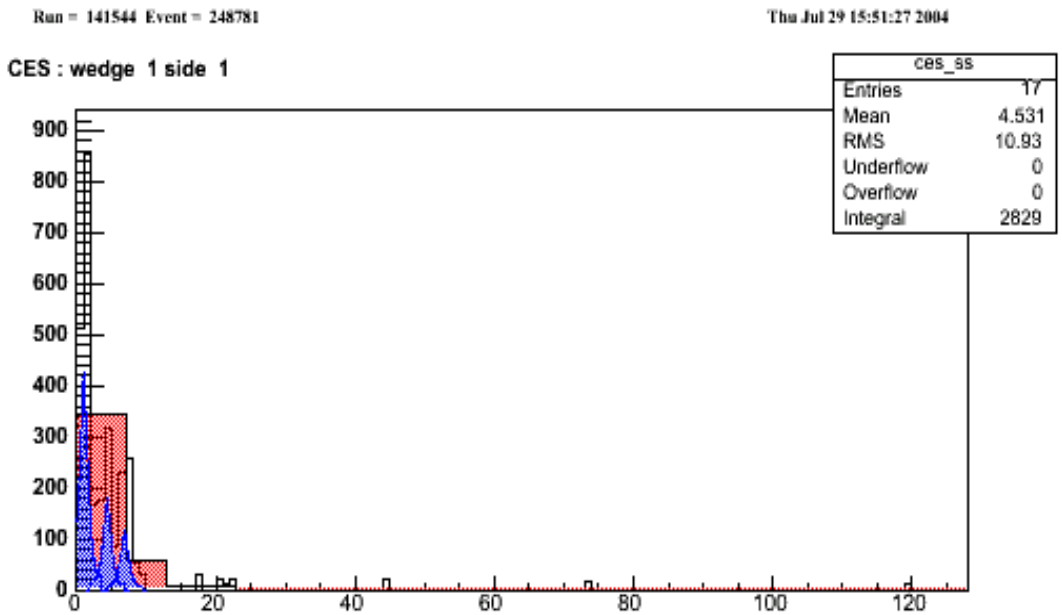
- Windowing method can group two distinct clusters into one
  - Reduces the ability to resolve close or merged clusters
  - Such merged clusters occur often in the case of high PT pi0 decay
- Track based methods fail on neutral particles, e.g. Pi0s.
- Standard E/P < 2 cut implicitly supresses photon emission

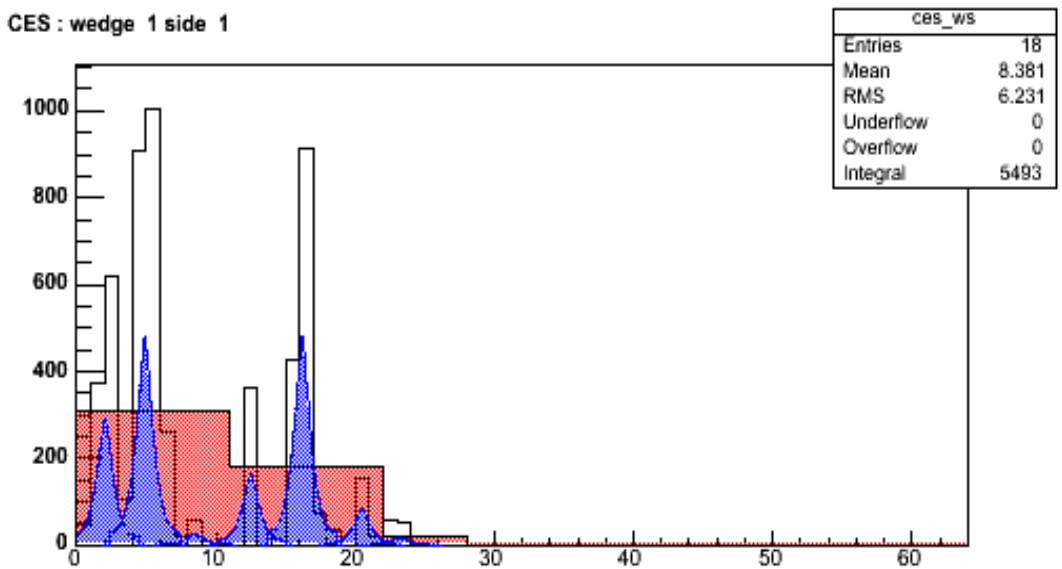




New Algorithm: Description

- The Algorithm
  - Identify continuous regions of charge
  - Identify local maxima within regions
  - Fit to standard cluster shape by varyin
    - Charge Q on individual cluster
    - Offset DX from maxima position
- Note:
  - Total charge of clusters in region must remain normalized
  - -0.5 channel < DX < 0.5 channel
- Assumptions:
  - All particles produce same shower profile
  - Number of clusters = Number of maxin



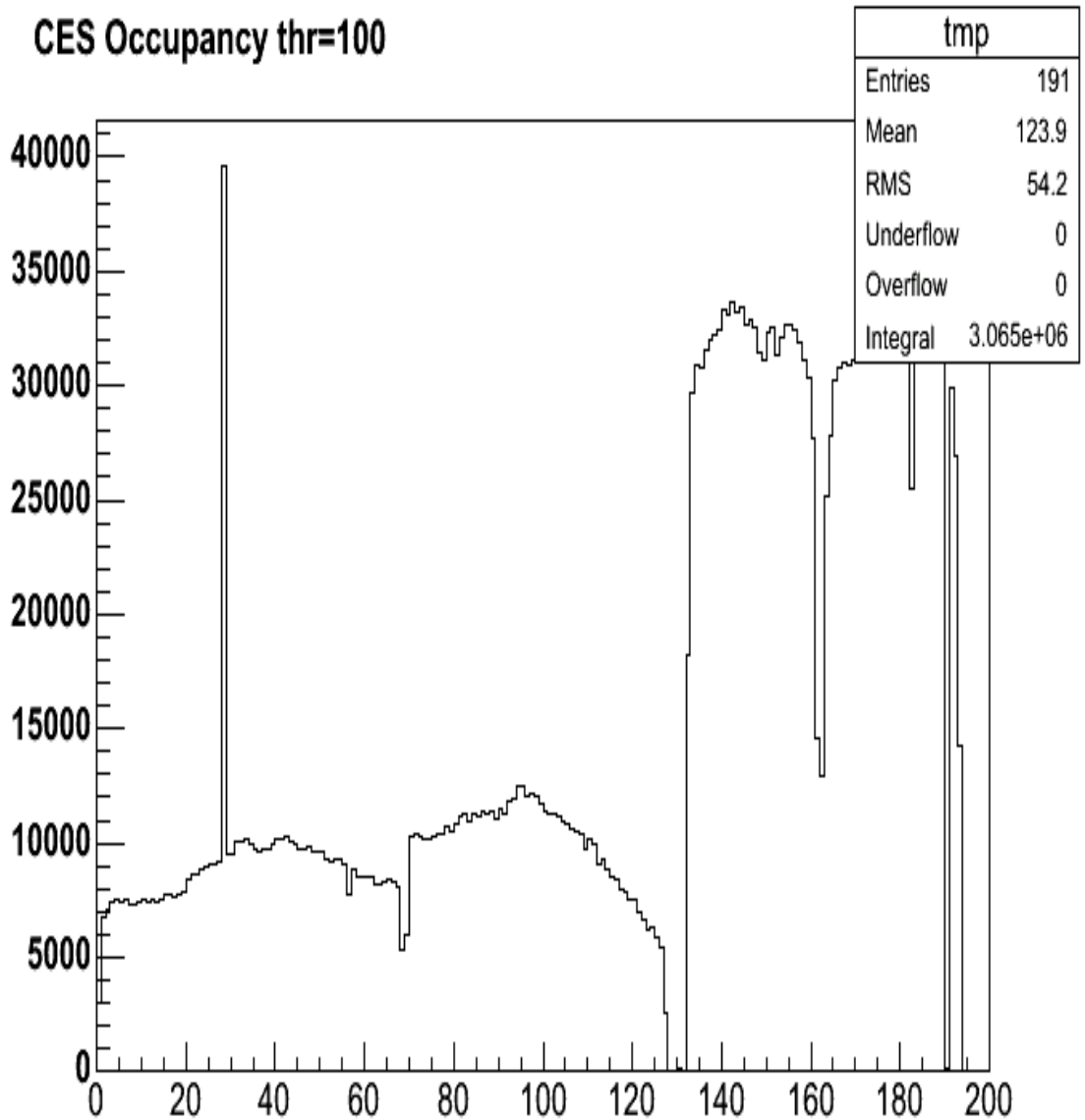


New Algorithm: Questions

- Is assumption on cluster shape valid?
- What is cluster shape?
- Can we use old Run I cluster shape?
- How do bad channels in CES affect results?
- How to correct for this?

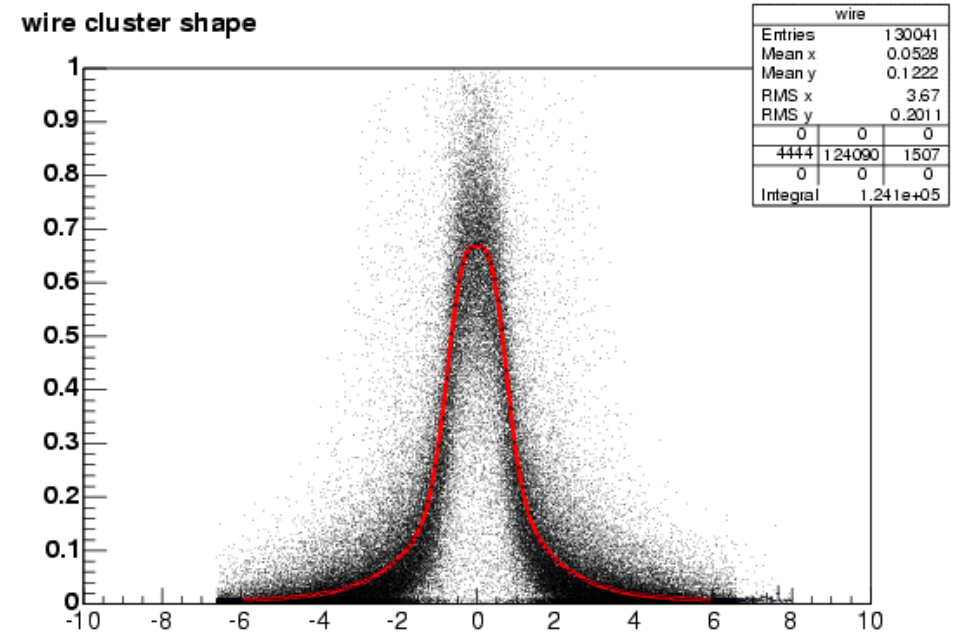
Readout Corrections

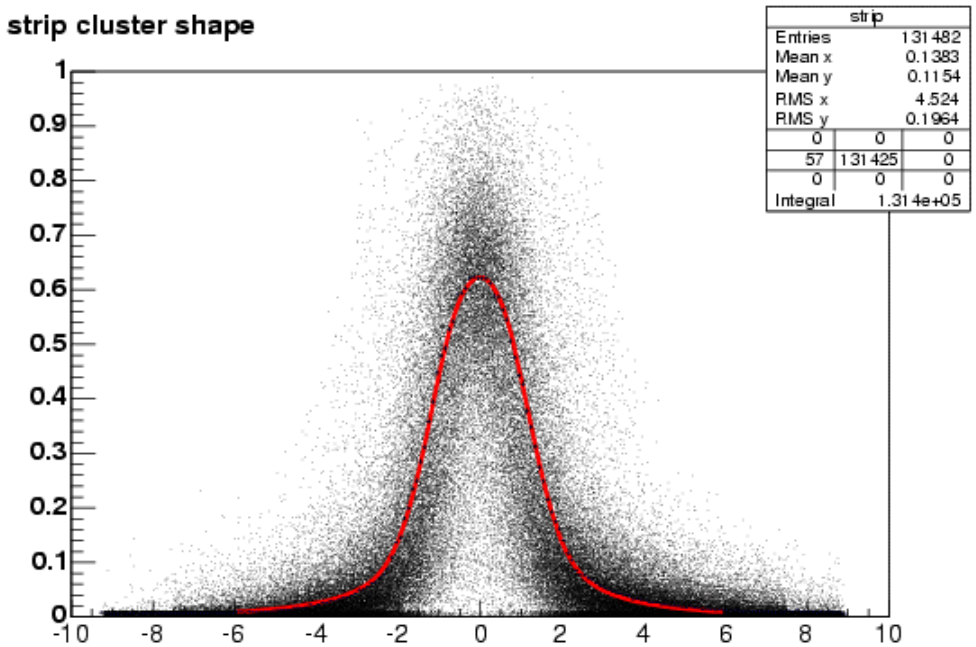
- Two types
  - Global : effects of chamber warping – continuous
  - Channel specific due to wiring, electror etc.
- Correct global effects by looking at Wire/Strip charge vs position
- Gives continuous correction factor
- Different types of bad channels
  - Dead
  - Noisy
- Identify by obtaining energy spectrum histogram for each channel and comparin to its neighbor's (factor out continuous problems)
- Details, see CDF Note 7097 (in theaters soon)



Cluster Shape

- Assume tracks point to "correct" location of cluster
- Cut based on:
  - Residual dx/dz < 5cm
  - Number merged clusters = 1
  - No bad channels in cluster
  - Cluster energy > 1GeV
- Plot charge fraction versus offset from track extrapolation point
- Obtain most likely charge vs offset graph (cluster shape graph)
- Details, see CDF Note 7097



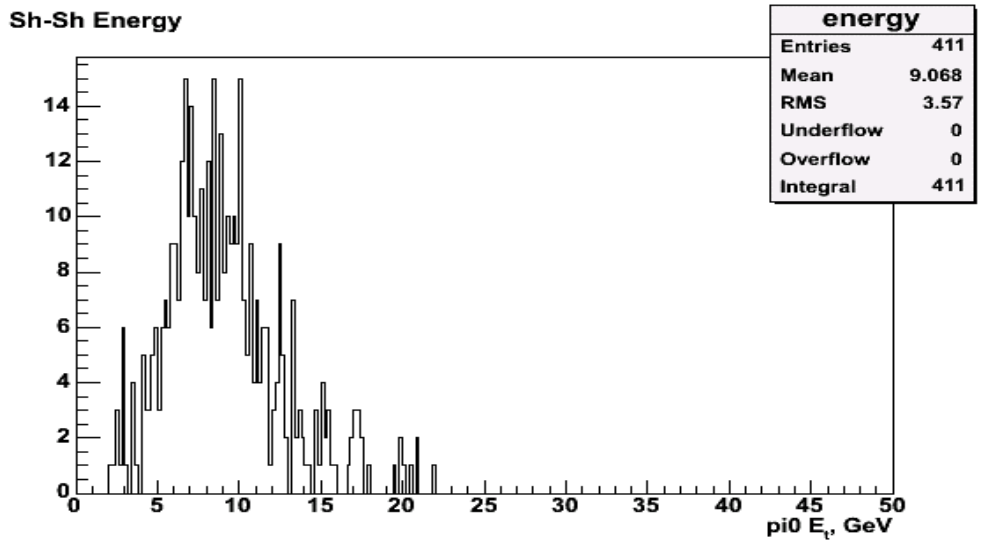


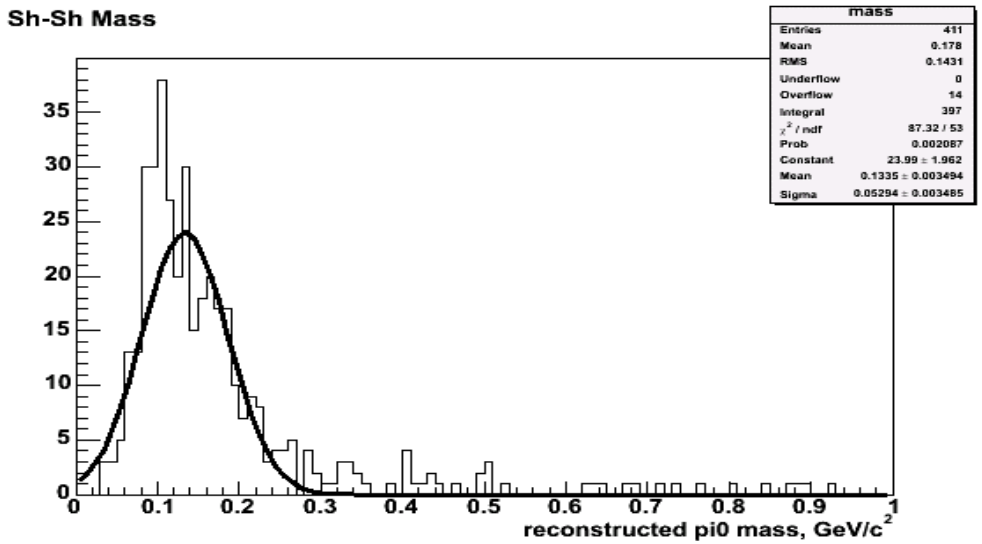
Cluster Shape: Details

- Cluster shape depends on
  - Channel width
  - Z location (geometry of detector)
- Result: wires and strips have different cluster shape
- Strip shape is scaled by a factor of $1 - \cos(\theta)/2$
  - $\cos(\theta)$ motivated by geometry
  - $\frac{1}{2}$ is experimentally determined

New Algorithm: In Action

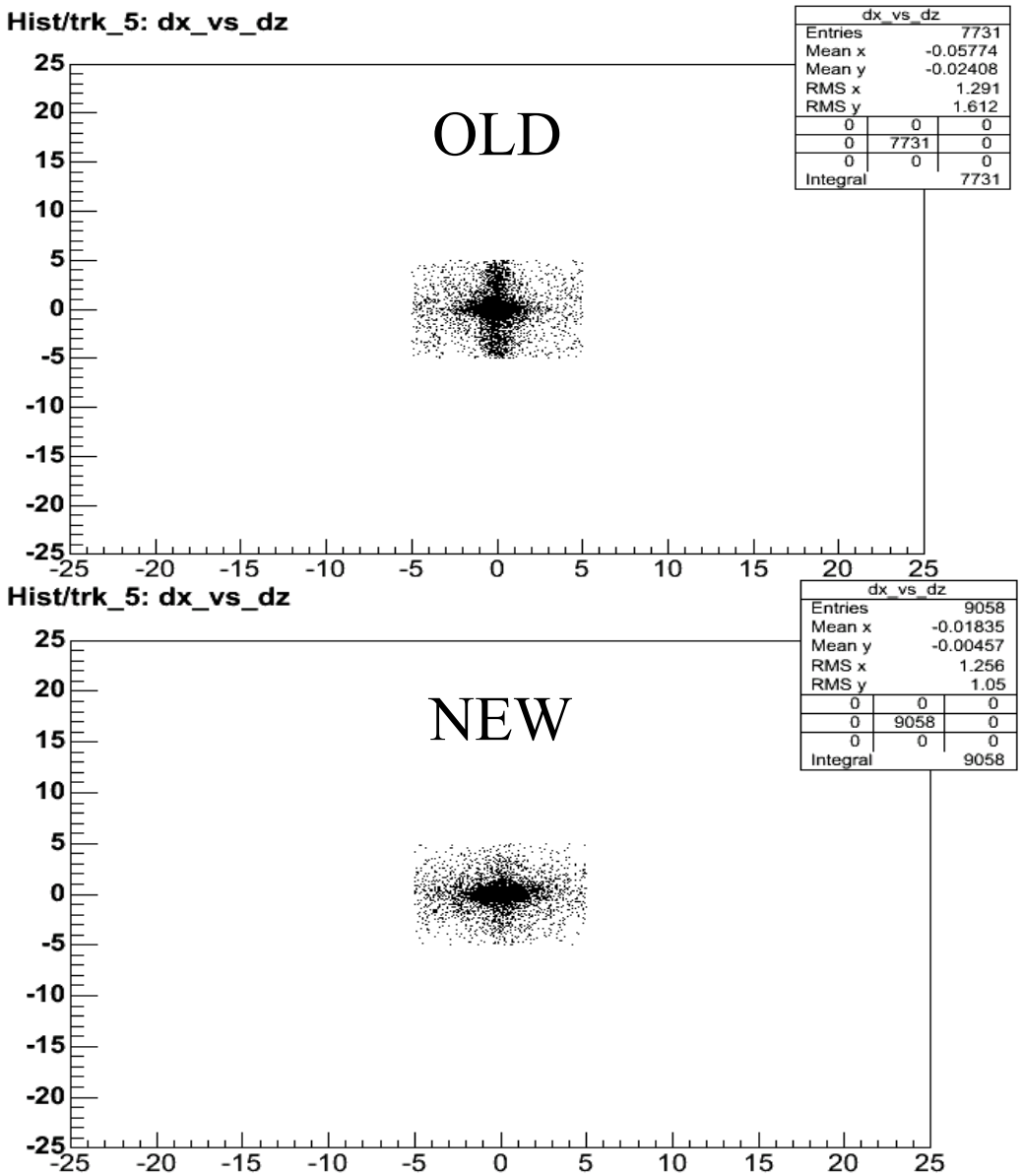
- Correctly resolves merged clusters
- Track based residuals:
  - ~15% more events pass cuts
  - More events closer to 0 dx
- MC Pi0 Mass Plot promising





Comparison: Residuals

- Old Residuals:
  - Number Events: 7731
  - Z RMS: 1.291
  - X RMS: 1.612
- New Residuals:
  - Number Events: 9058
  - Z RMS: 1.256
  - X RMS: 1.050



Cluster Matching

- Associate wire clusters and strip clusters
- Obtain 2D location of shower in CES plane
- Old Algorithm does not do this
- Algorithm is efficient
  - Match 1 cluster on one side with 1 or more clusters on other
  - Make total energies as close as possible
  - Account for wire/strip gains and dead channels when matching
- Method
  - Match strip and wire clusters 1:1 to form showers
  - Attempt to add remaining clusters to existing showers
  - Proceed in order of decreasing energy
- Allows one to obtain position of non track-based particles
- Needs more testing but early results promising

Immediate Benefits

- Single pass as opposed to 3
- Reconstruction of clusters is done only within CES
- Allows for tighter cuts
- No radiation supression by E/p < 2 cut
- Instead cut on E/(p + ???)
- Better reconstruction of high PT pi0
- More, cleaner statstics for events that involve decay into neutral particles (LOTS!)
- Makes measurements more accurate, e.g. better measurement of tau mass

To Do

- Suitable Chi2 function for cluster fitting
- Pi0 and Tau reconstruction code
  - Reimplementation
  - Debugging
- More tests must be done to eliminate bugs and obtain estimate of algorithm's performance
- Obtain accurate results using reconstruction algorithm to generateinterest

Summary

- Taus decay into pi0s which decay into photons
- Photon reconstruction essential in tau reconstruction
- Old cluster reconstruction algorithm insufficient for this
- New algorithm resolves merged clusters efficiently and appropriately
- Early results positive
  - MC pi0 mass
  - Track based residuals
- Still more to do for testing