The Beginnings Of A Particle Flow Algorithm

- Quick status update on crystal ECAL
- General comments
- Current state of the code
- Some plots
  - May skip some if pressed for time

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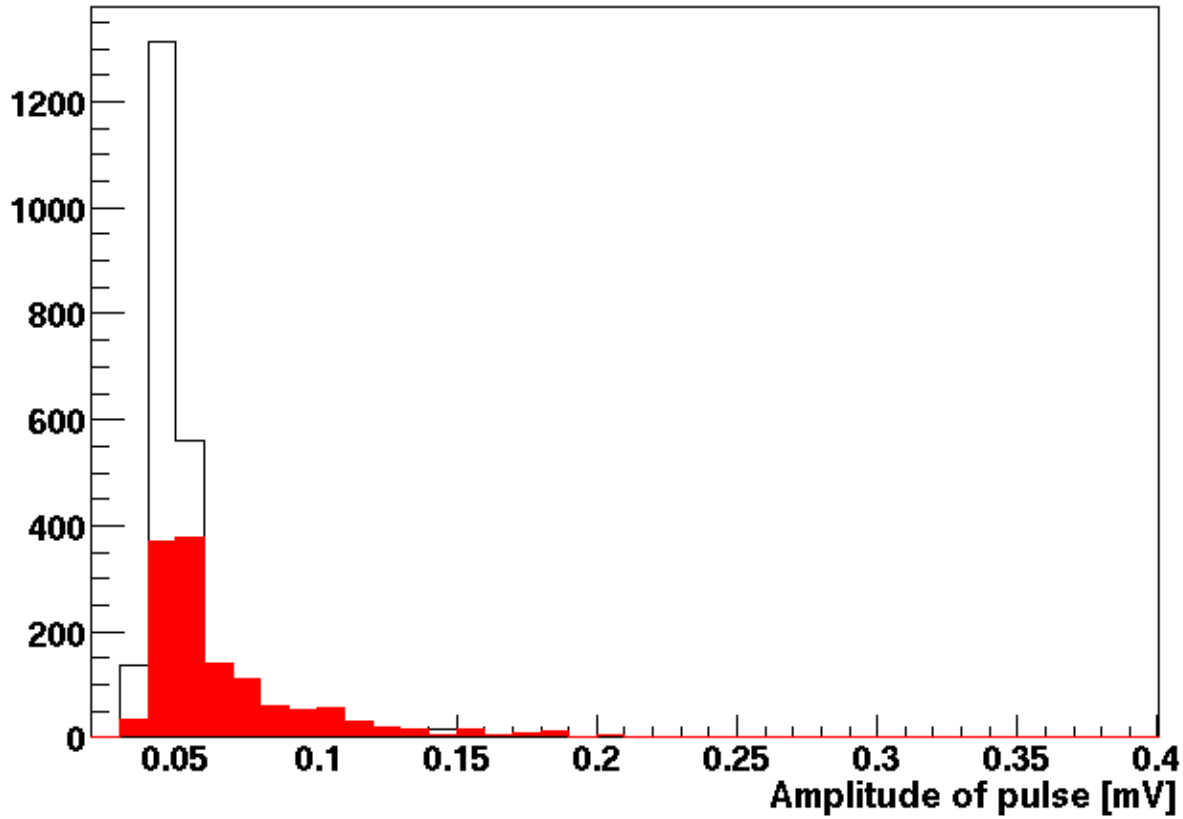
Crystal ECAL hardware study

- **Being done by William Caudy (Uiowa)**
- **Using high-yield $PbWO_4$ crystals, source**
- **Been taking data via oscilloscope (slow)**
- **Finally solved DAQ problem Friday; will start taking data via NIM crate.**

- **Many thanks to Peter Kim.**

Crystal ECAL hardware study

Pulse height distribution
with source (white)
without source (red)
taken over same time interval



Particle flow algorithm

Flow algorithm thoughts

- **Basic process:**
  - **Locate a cluster (possibly seeded)**
  - **“Fit” it with an appropriate shape**
  - **Store results**
  - **Assign energy/hits from the CAL**
  - **Iterate**
- **Optimal use of information:**
  - **Start with most known/predictable clusters**
  - **Move onto those with less seed information**
  - **Move onto those with no seed information**

Where to start

- MIP-like tracks, seeded with position and direction info from tracker
  - charged pions, muons, ...
- Showers with known pos. and dir.
  - electrons
  - charged tracks that shower inside the CAL
- Clusters with some seed information
  - scattered/fragmented tracks
- Others
  - gammas etc.
  - Neutral hadrons

MIPs: What's implemented

- Cheating: Following one track at a time
- Seed using truth information
- Simple track extrapolation algorithm
  - First few layers (until 4 layers already hit) just extend MC seed in a straight line
  - After that, straight line from hits in last few layers (up to 6), done with principal axis (hep.lcd.recon.cluster.util.AbstractCluster)
  - Pick up nearby hits in same layer
  - Will skip gaps of up to n layers (using 2)
- Some plots (e.g. dE/dx)

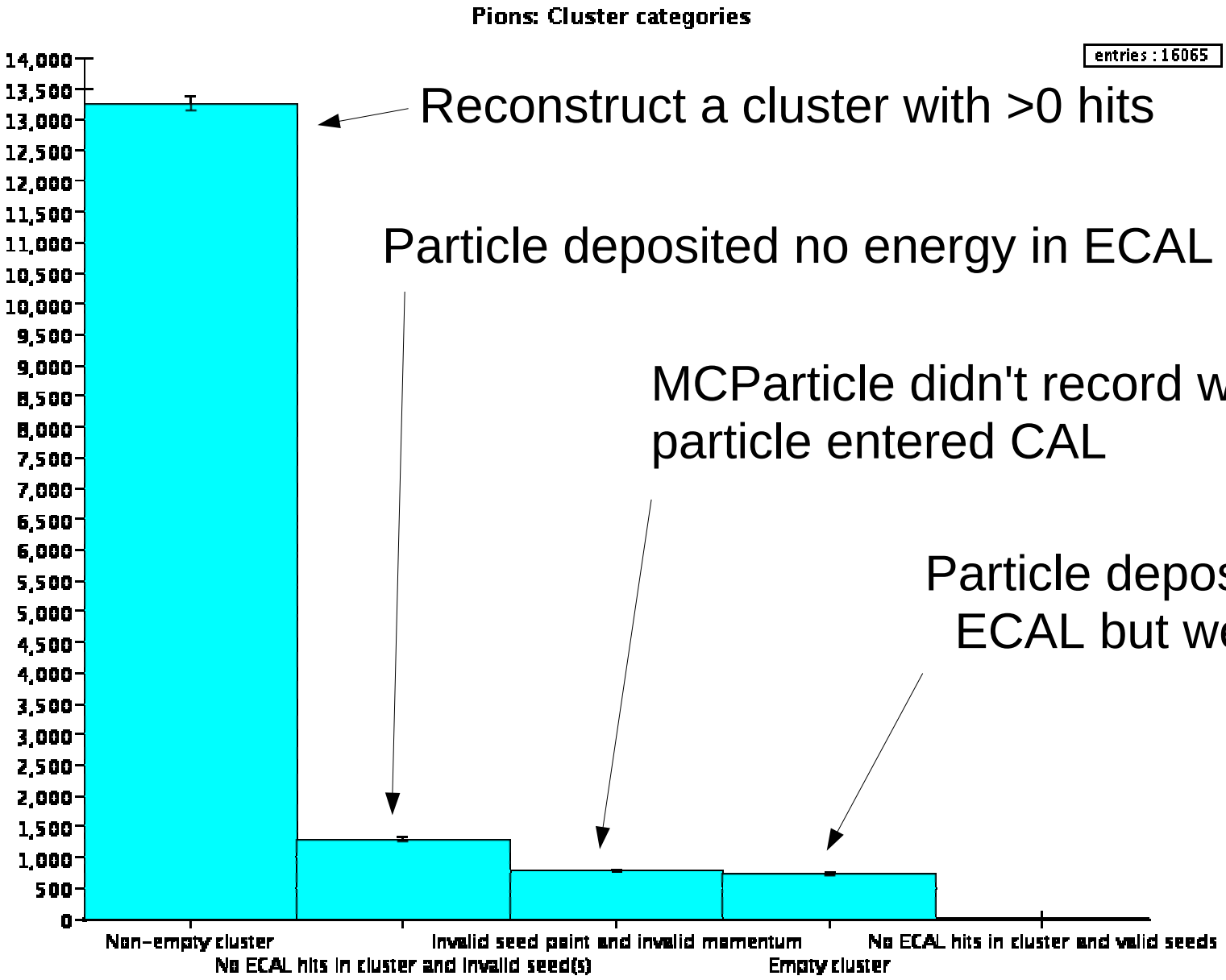
What's not implemented yet

- Total energy deposited by cluster
- Energy subtraction from CAL
  - How much to take? Should be roughly consistent with MIP, but allow for fluctuations.
- Refining (second pass to improve the fit)
- Re-seeding for subsequent clusters
- Reco in the presence of noise, other clusters
  - Need to incorporate ClusterAnalysis first
- Tracks crossing from barrel to/from endcap
- HCAL

What's next

- Understanding why we lose clusters
- Refine/second pass
- Ron's cluster analyzer
- Add noise, rest of event
  - How do threshold cuts affect things?
  - Will we need to allow for larger gaps?
- Pick thresholds
- Energy-subtraction algorithm

Pions



Reconstruct a cluster with >0 hits

Particle deposited no energy in ECAL

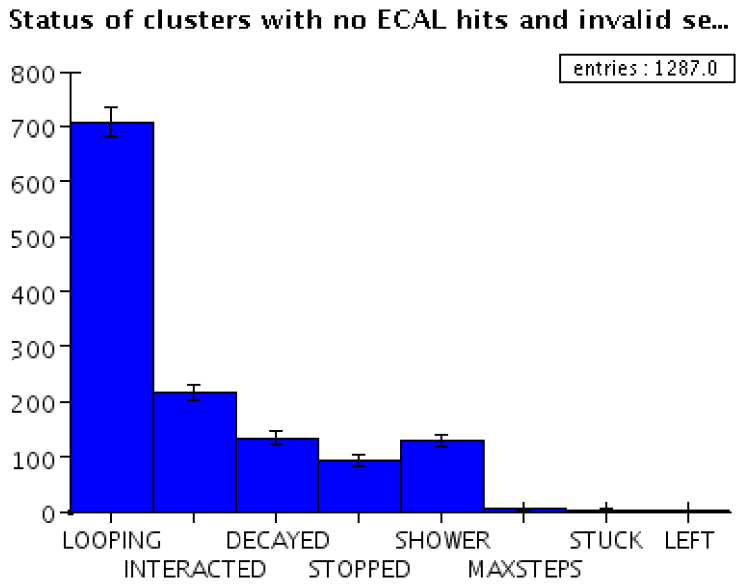
MCParticle didn't record where particle entered CAL

Particle deposited energy in ECAL but we didn't find it

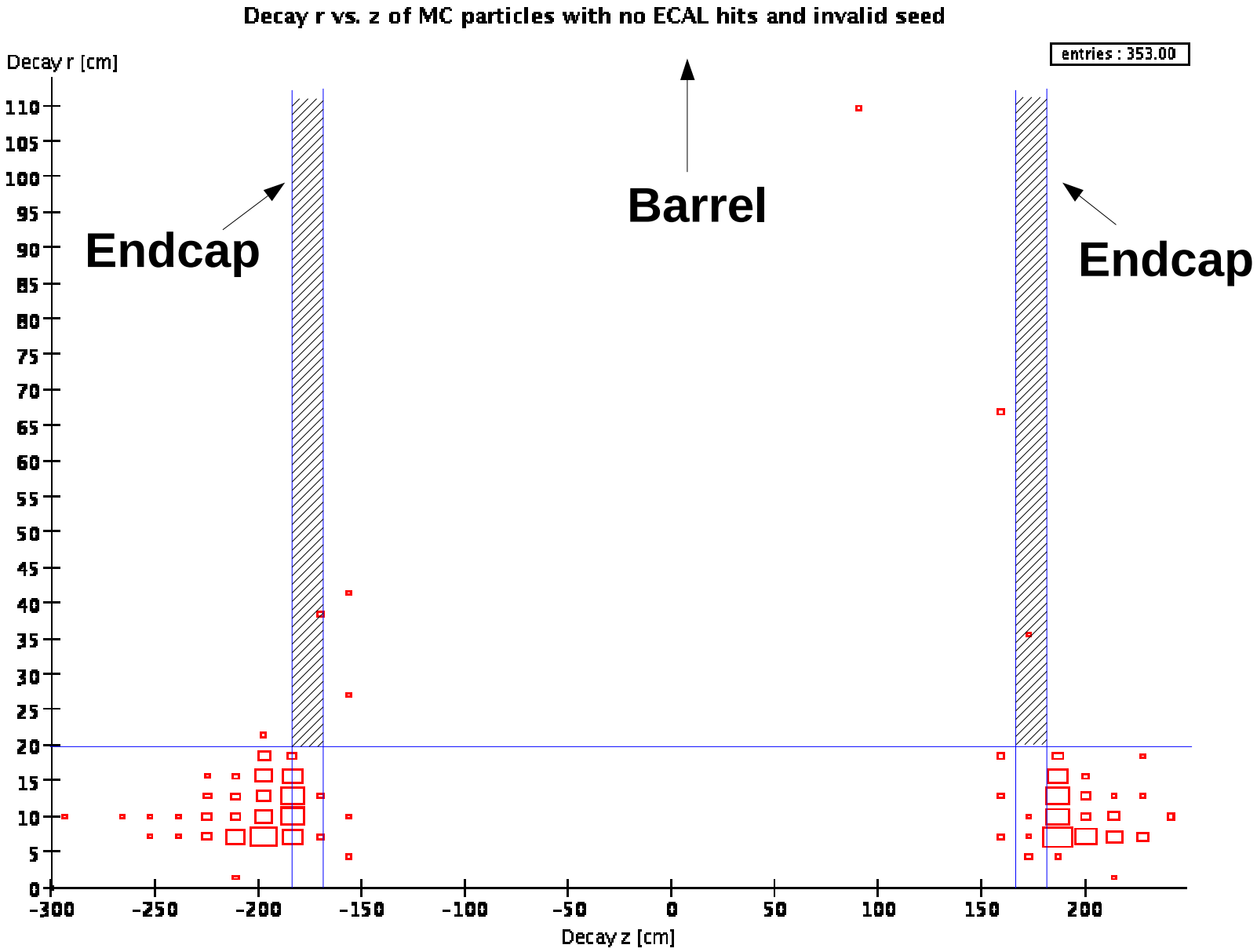
panpyZH120-0-500.sio

Unreconstructable clusters?

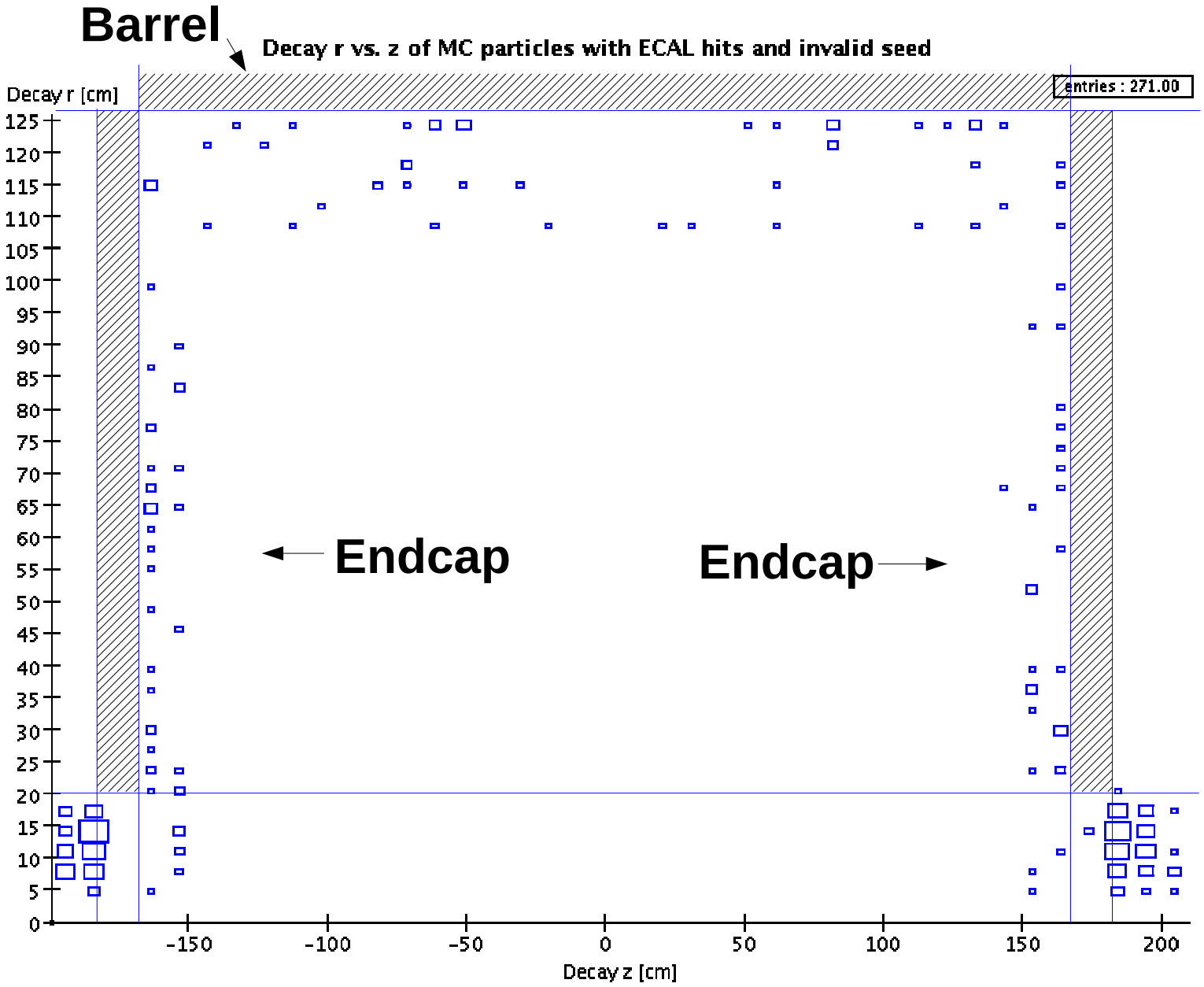
- **Where do the clusters with no ECAL hits come from?**
- **Where do the clusters with ECAL hits but no valid seed point/momentum come from?**



Pions with no ECAL hits: decay point

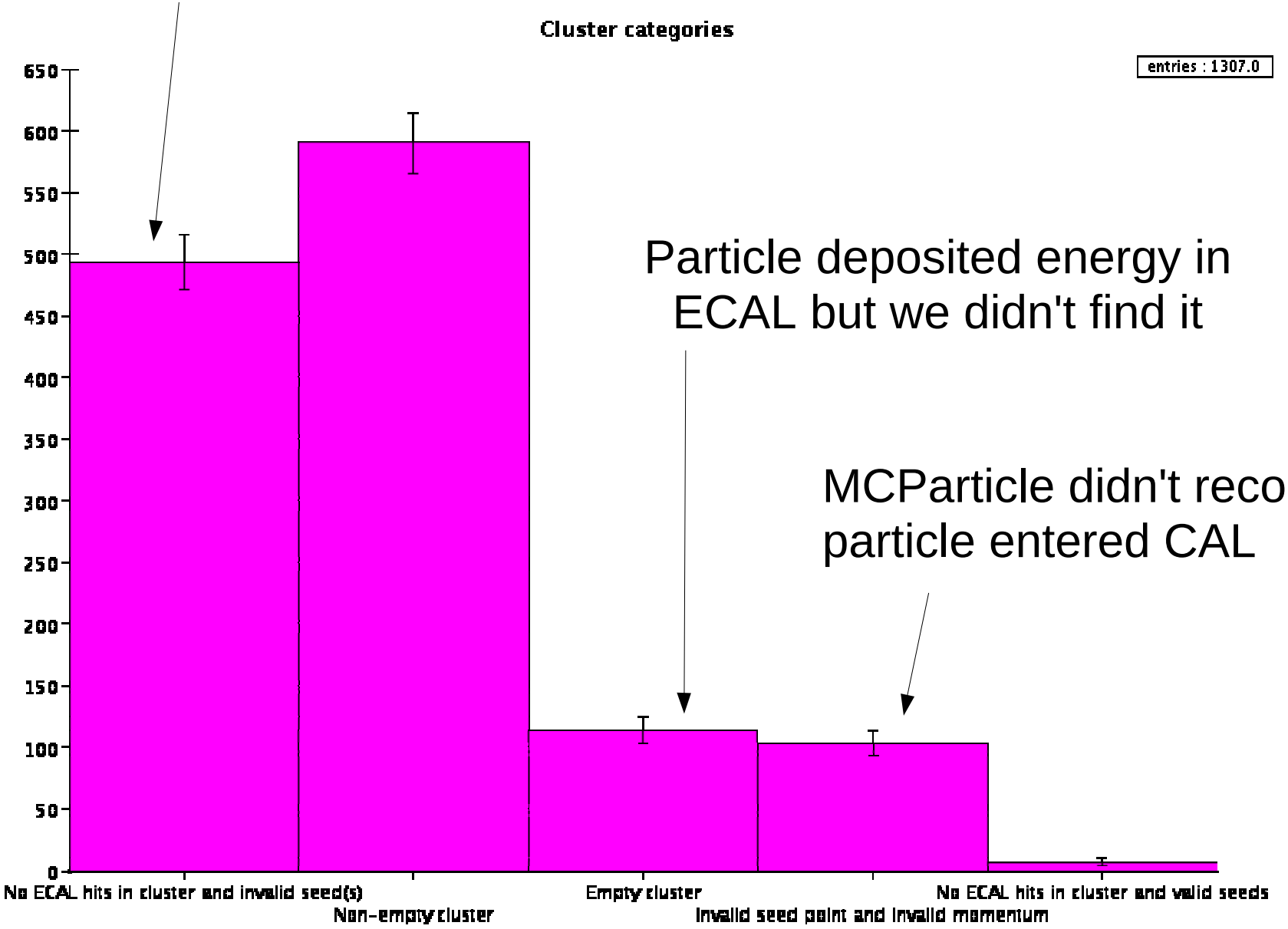


Pions with ECAL hits but no seed point/momentum



Muons

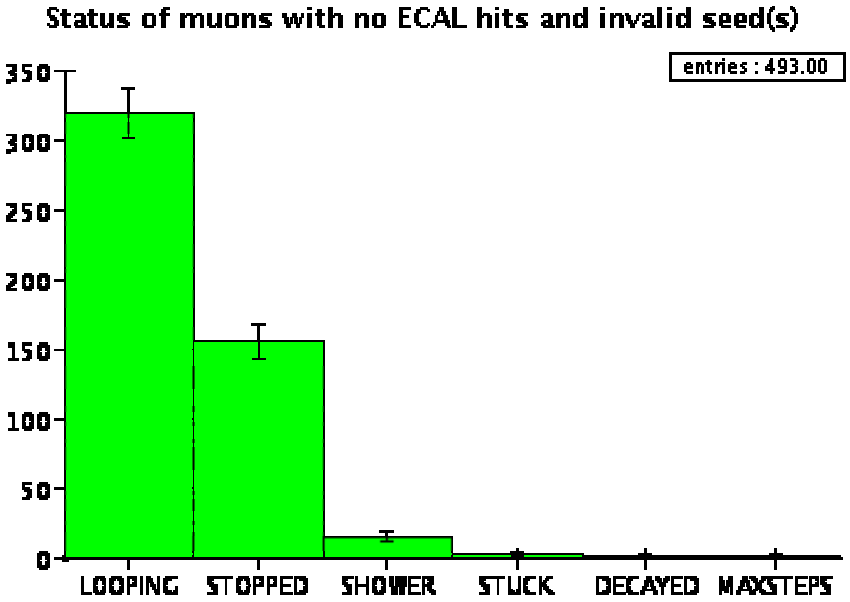
Particle deposited no energy in ECAL

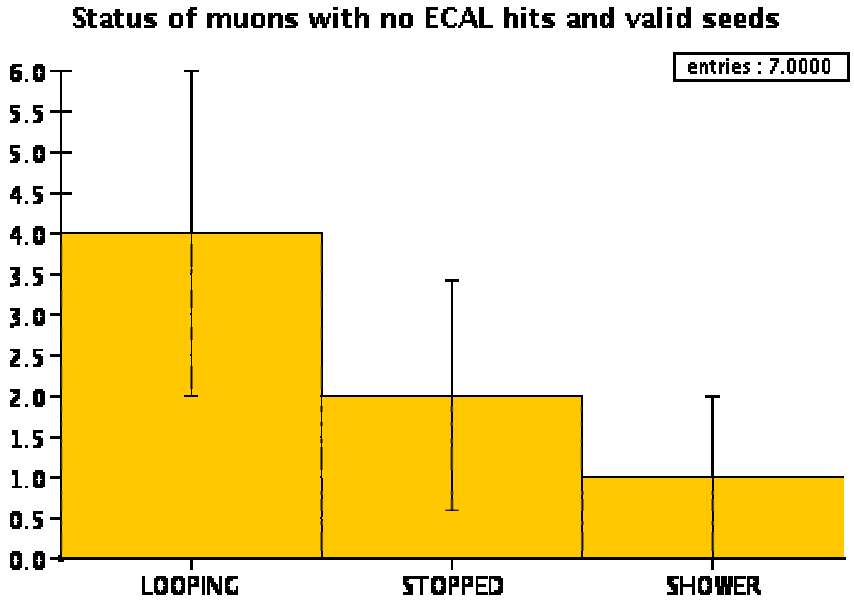


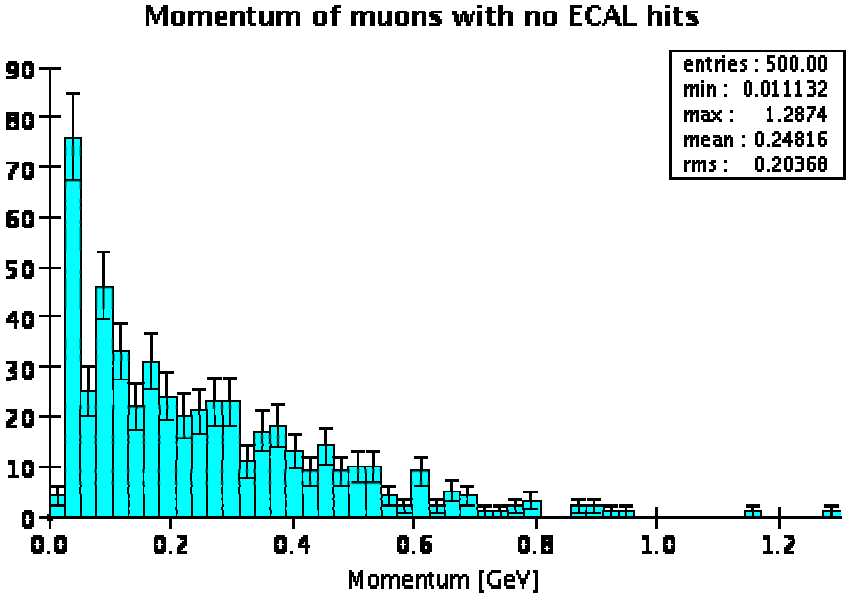
Particle deposited energy in ECAL but we didn't find it

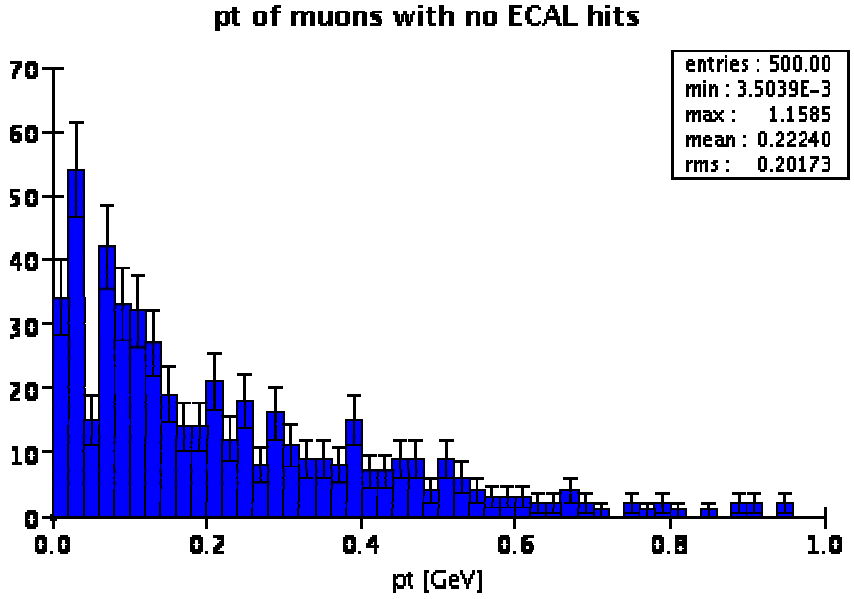
MCParticle didn't record where particle entered CAL

Why so many muons with no hits in the ECAL?

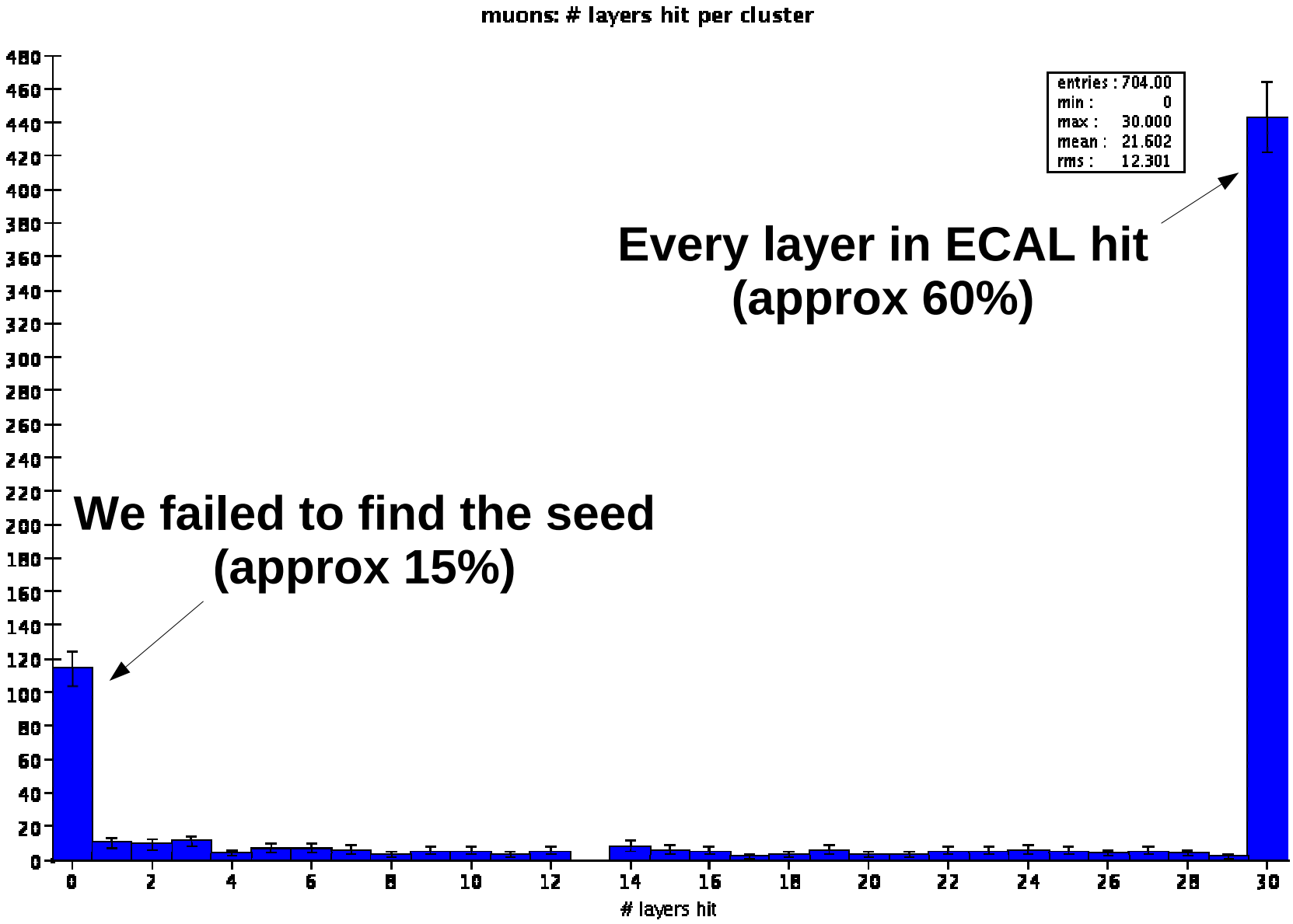








Muons: # layers in reconstructed clusters

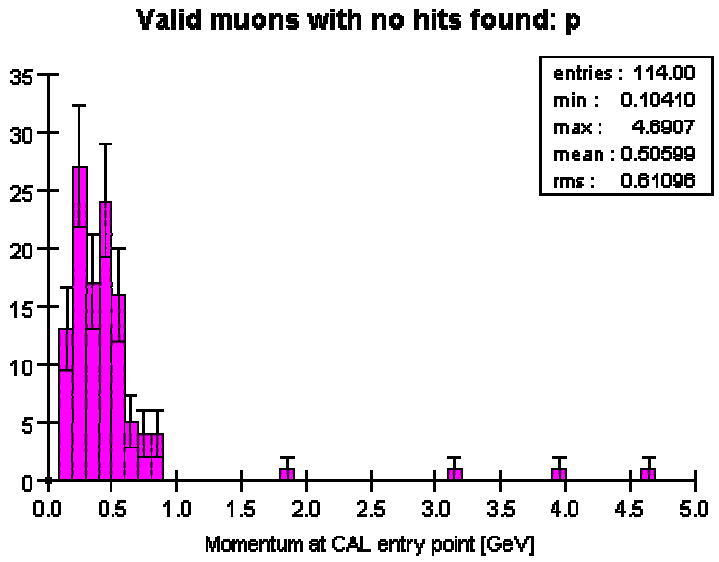


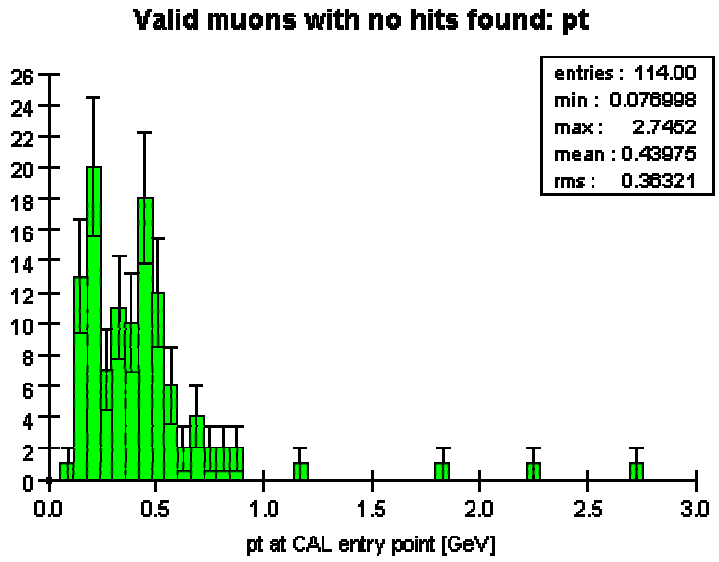
Every layer in ECAL hit (approx 60%)

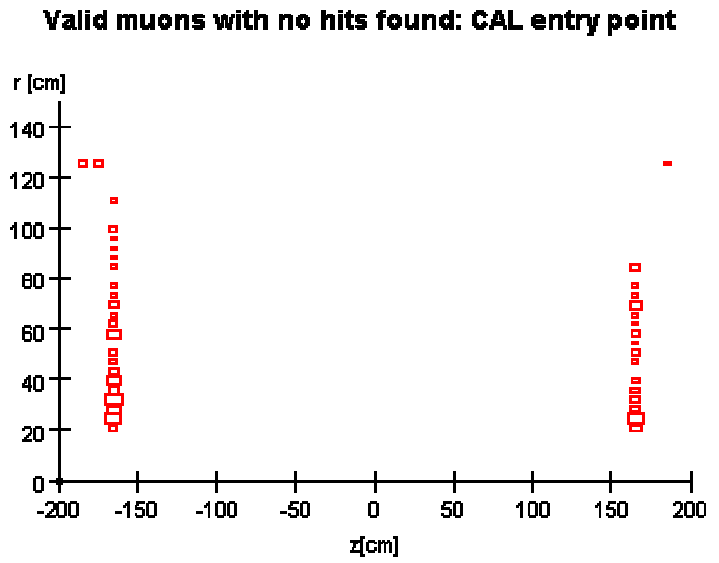
We failed to find the seed (approx 15%)

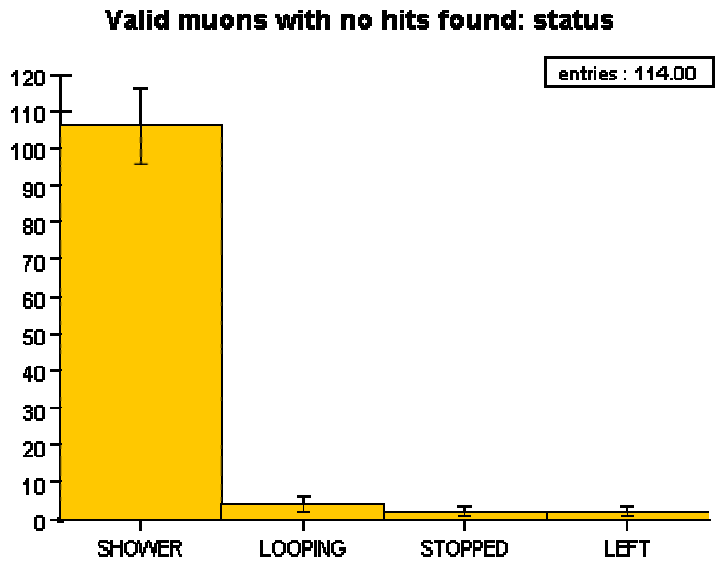
Only plotting results for tracks that deposit energy in ECAL

Why so many muons being missed/dropped?









All low momentum.

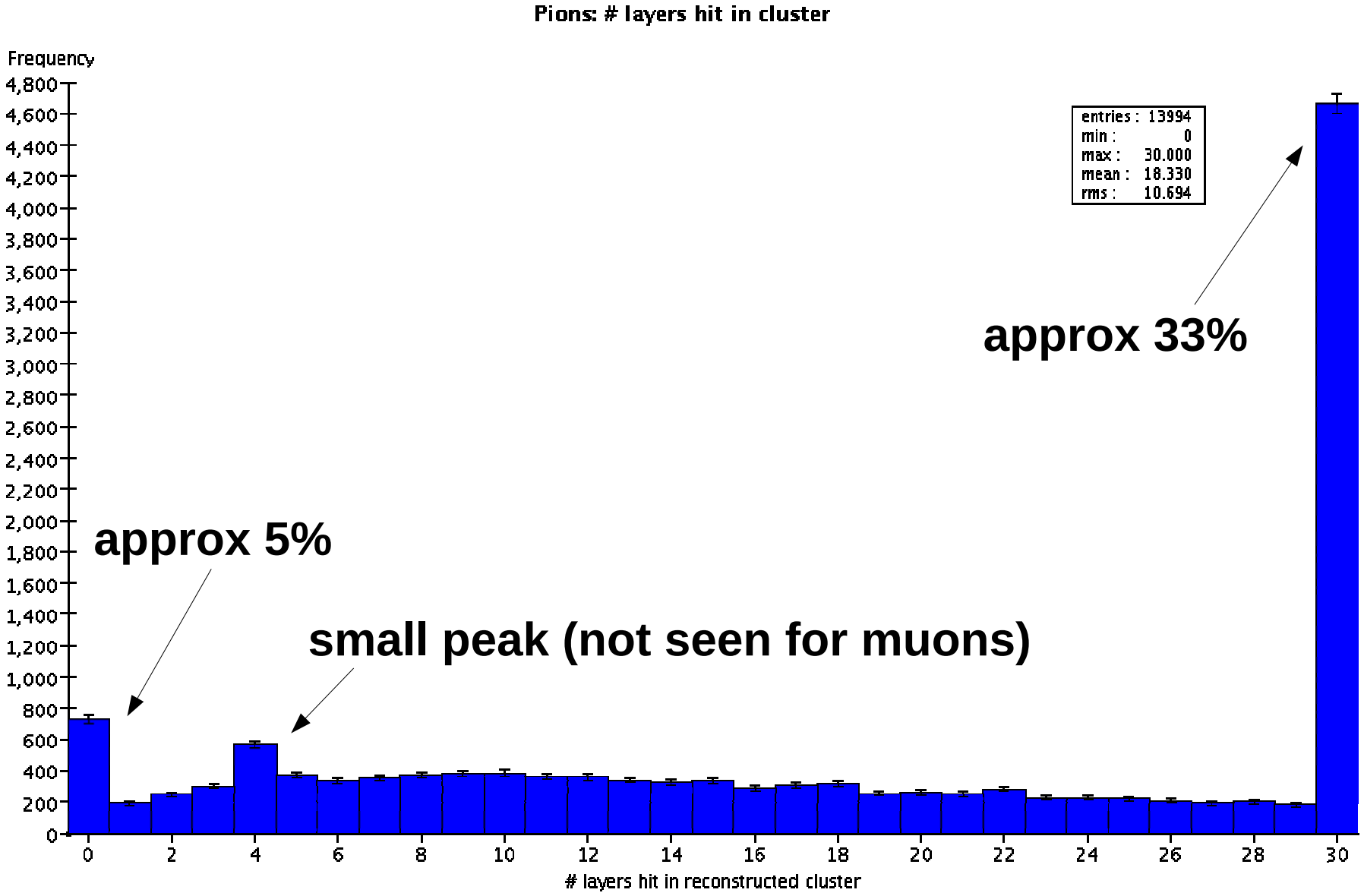
All enter the endcap

Nearly all shower (!)

... so maybe being scattered or showering before first active layer. Not verified yet.

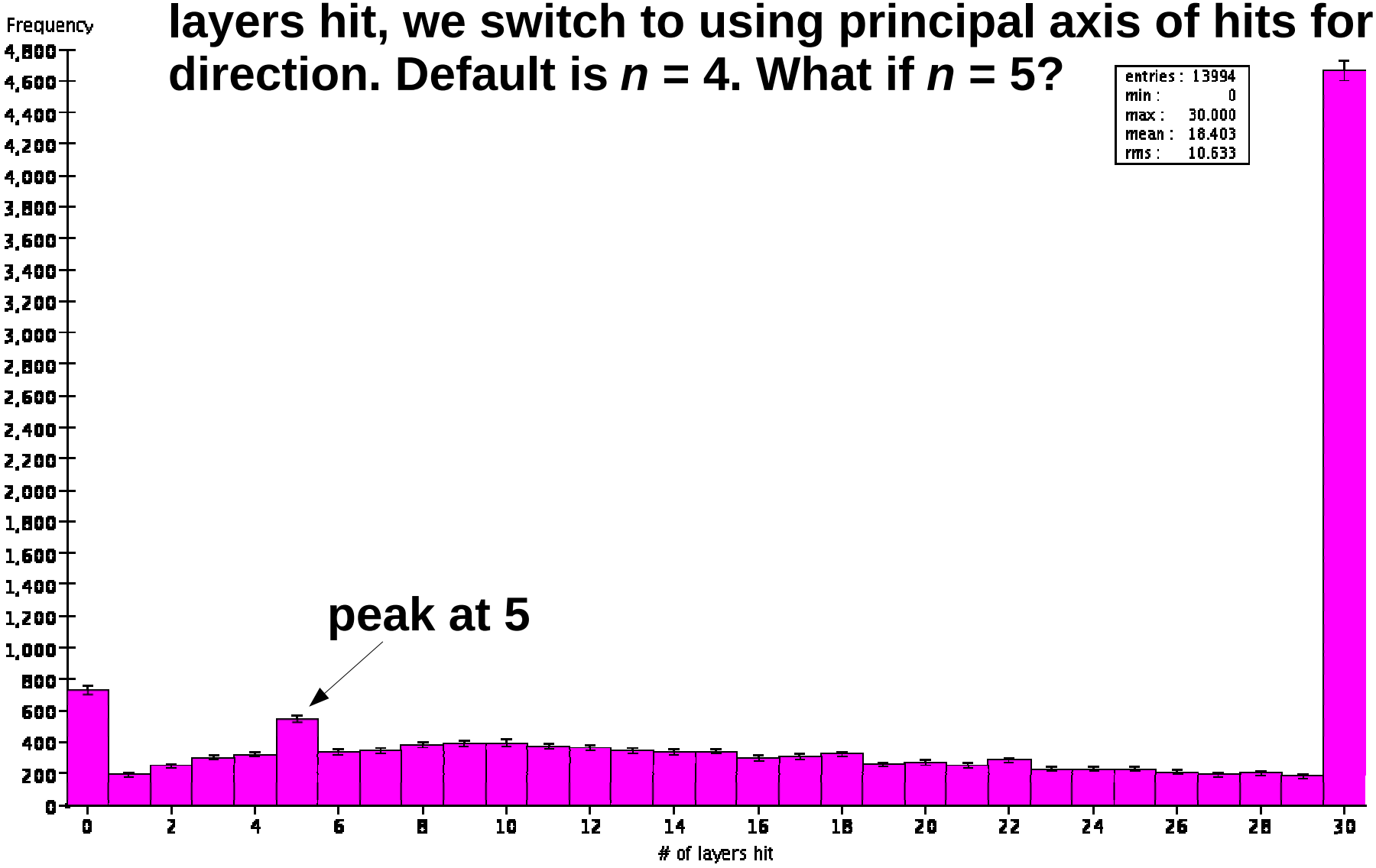
Pions

Only plotting results for tracks that deposit energy in ECAL



Why the peak after 4 layers? (1 / 3)

- When there are < *n* layers hit previously, we extrapolate previous best-guess direction. When there are >=*n* layers hit, we switch to using principal axis of hits for direction. Default is *n* = 4. What if *n* = 5?



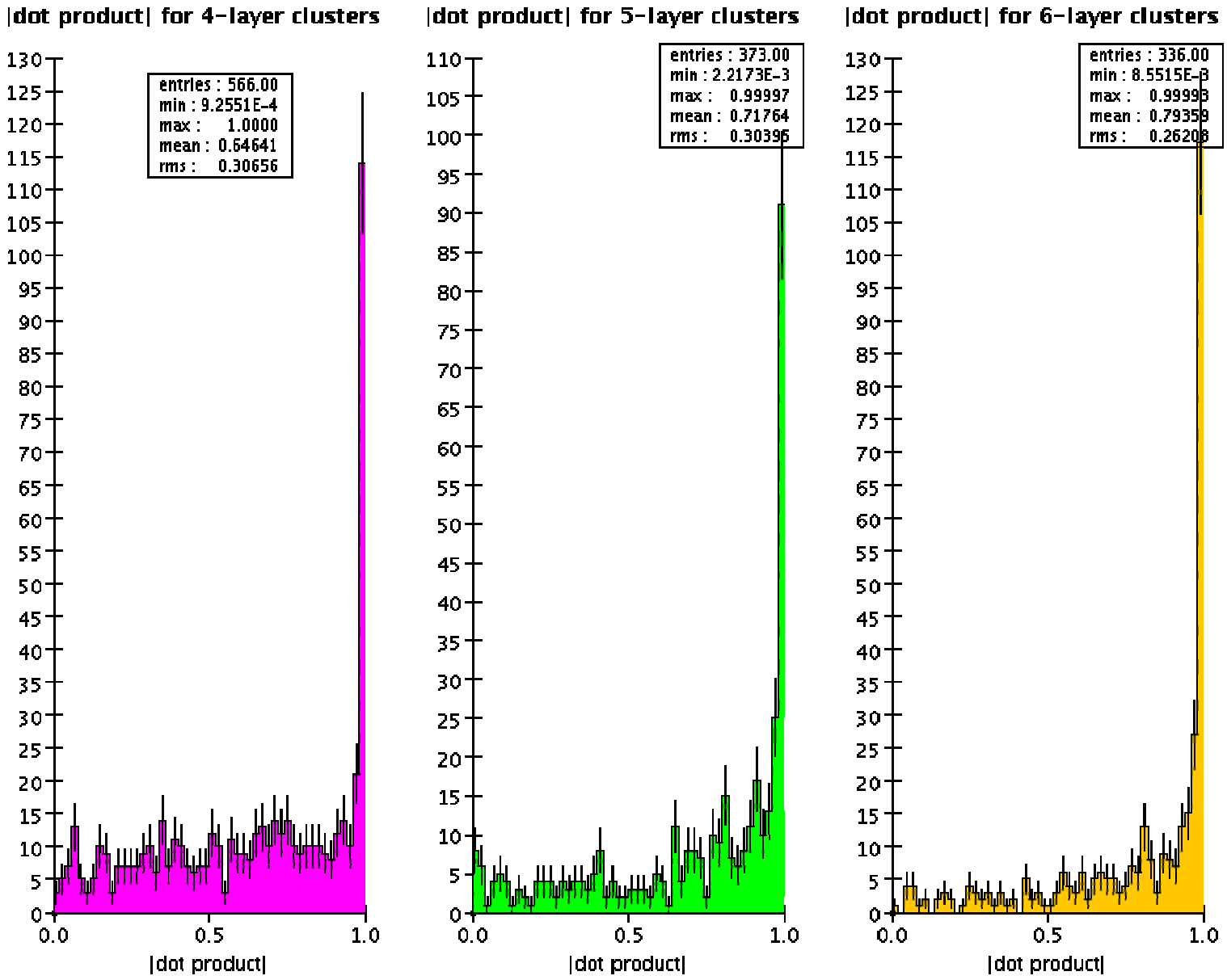
Why the peak after 4 layers? (2 / 3)

- **... so it's algorithmic. Direction estimate fails if the cluster is quite erratic.**
- **Why is it seen in pions and not muons? Because pions are more likely to shower.**
- **Verify by plotting dot product:**

  [initial momentum].[estimated mom]

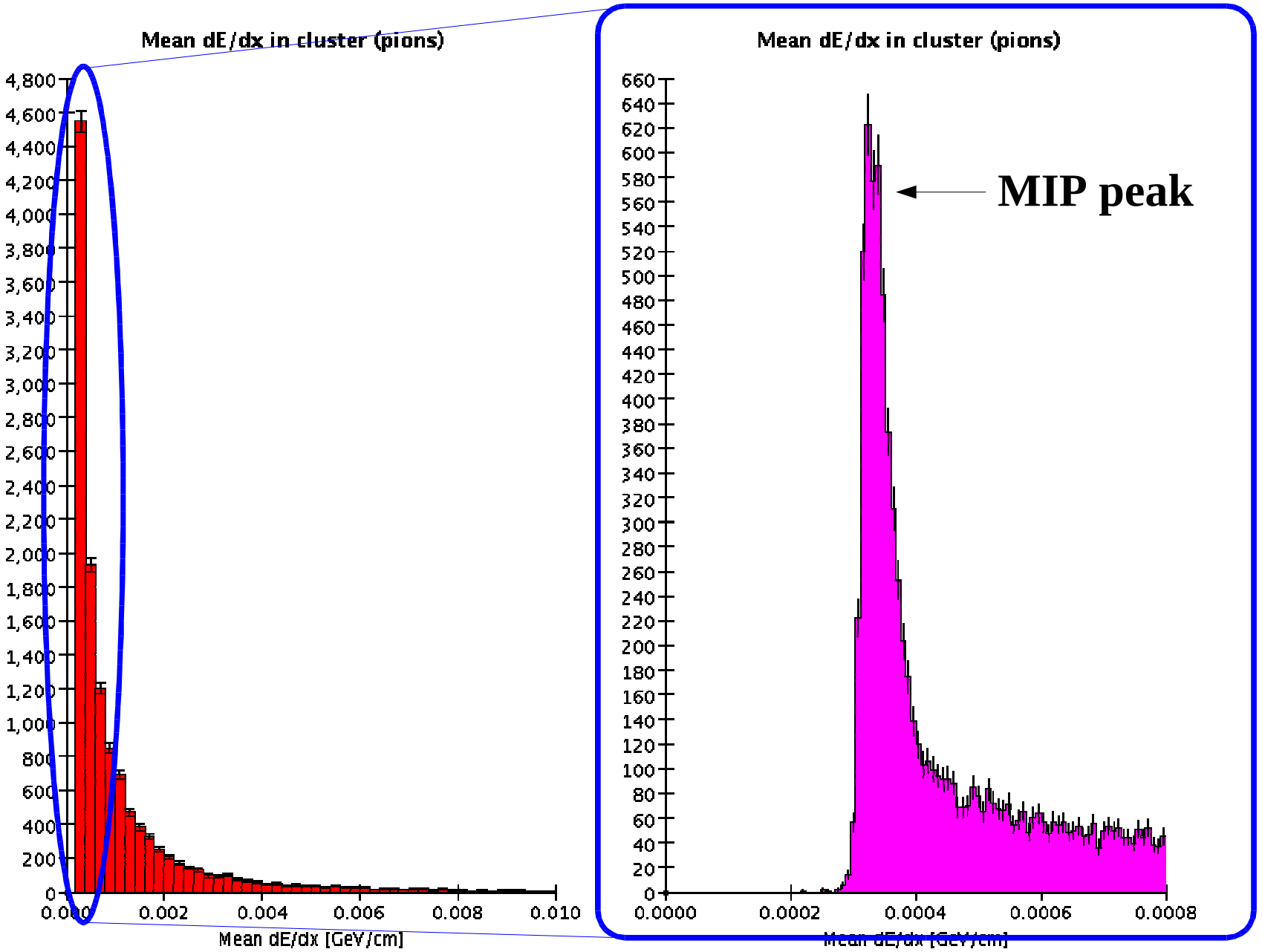
  for particles lost after finding hits in *n* layers, for *n* = 4,5,6...

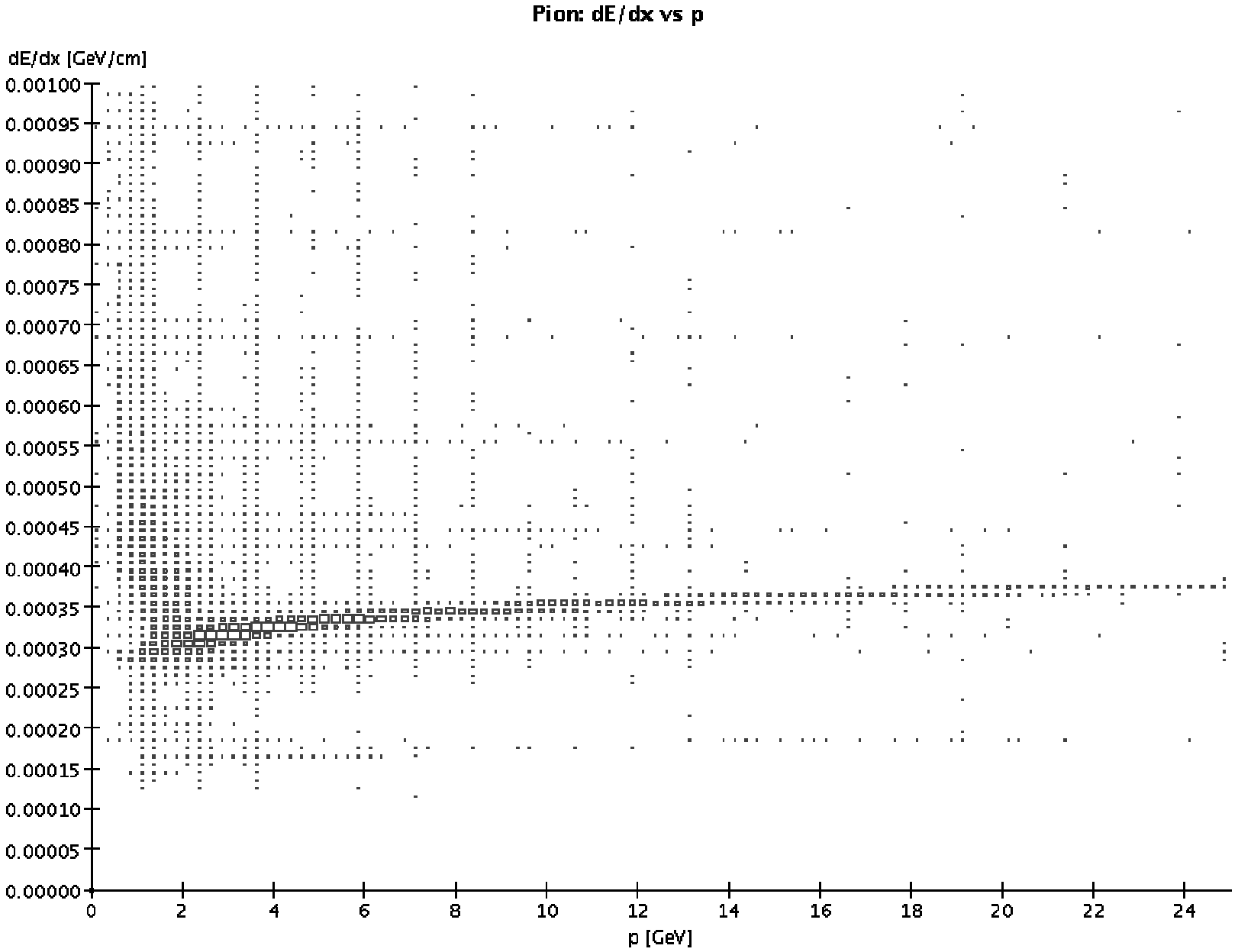
Why the peak after 4 layers? (3 / 3)



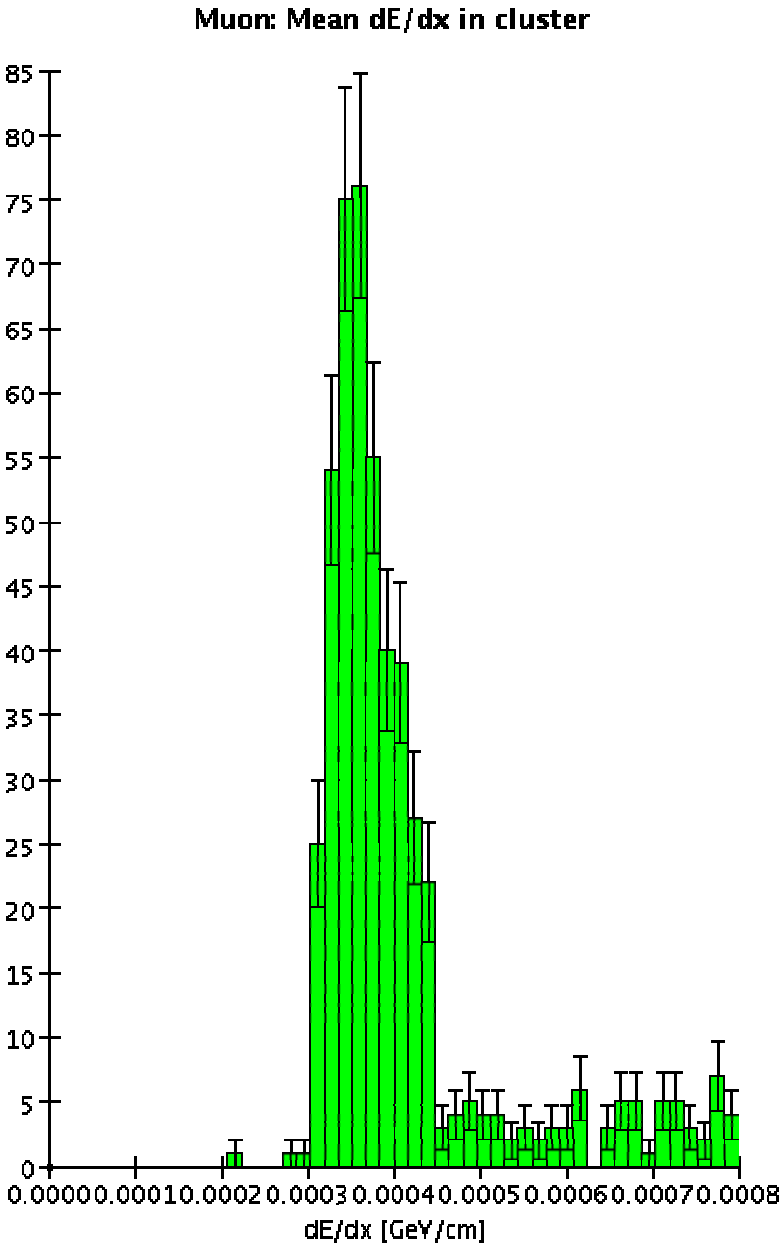
dE/dx

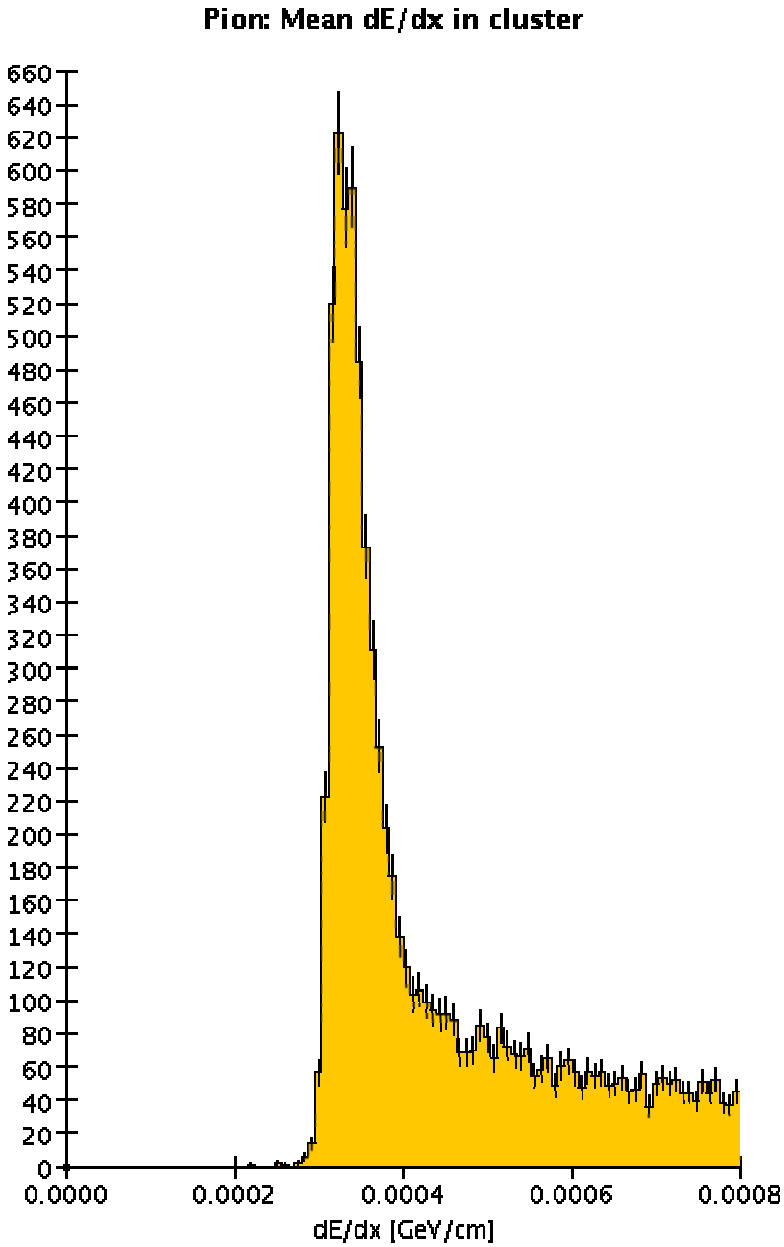
- **Good cross-check**
- **Will be used for a cut on energy deposited in cells**
- **Calculated for core hit in each layer, using best estimate of trajectory.**


Mean dE/dx in cluster (pions)
Mean dE/dx [GeV/cm]
Mean dE/dx in cluster (pions)
MIP peak


Pion: dE/dx vs p
dE/dx [GeV/cm]
0.00100
0.00095
0.00090
0.00085
0.00080
0.00075
0.00070
0.00065
0.00060
0.00055
0.00050
0.00045
0.00040
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
0
2
4
6
8
10
12
14
16
18
20
22
24
p [GeV]

Muons: dE/dx


Muon: Mean dE/dx in cluster
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0.0000 0.0001 0.0002 0.0003 0.0004 0.0005 0.0006 0.0007 0.0008
dE/dx [GeV/cm]


Pion: Mean dE/dx in cluster
660
640
620
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0.0000 0.0002 0.0004 0.0006 0.0008
dE/dx [GeV/cm]