DHCAL Track Segment Analysis

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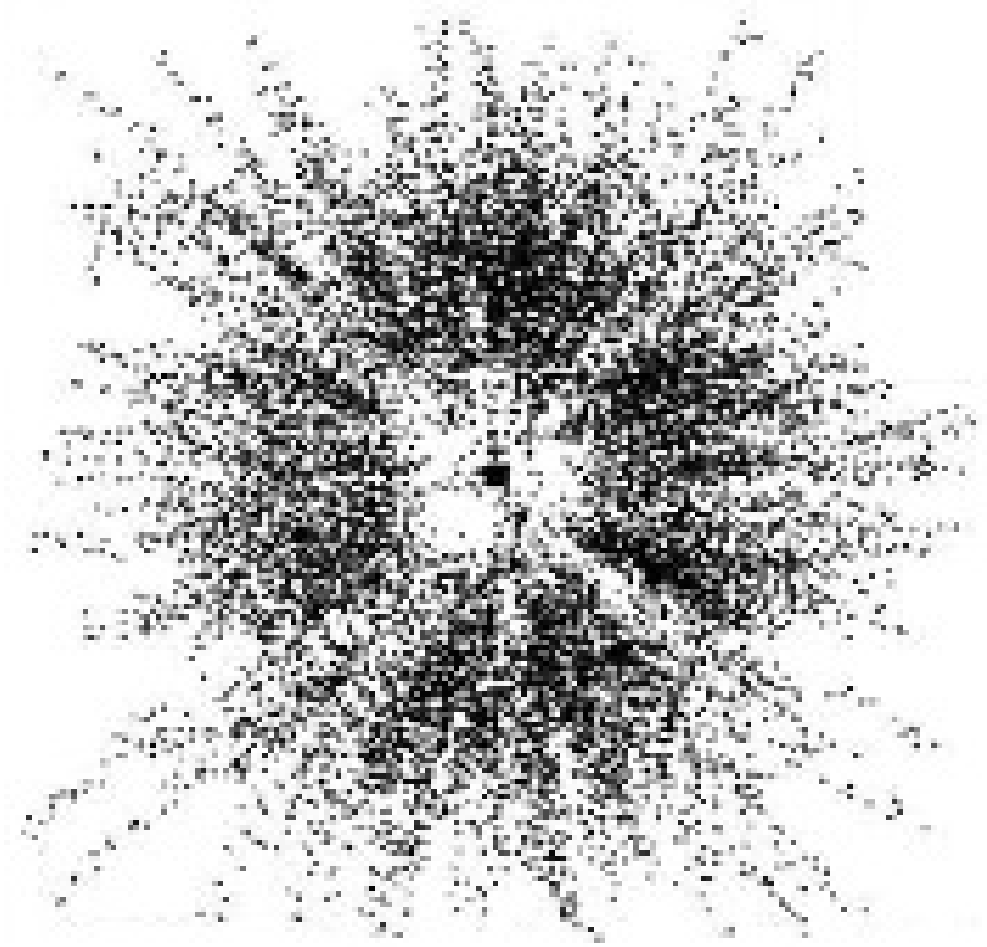


DHCAL Team

Argonne NATIONAL LABORATORY

DAAD

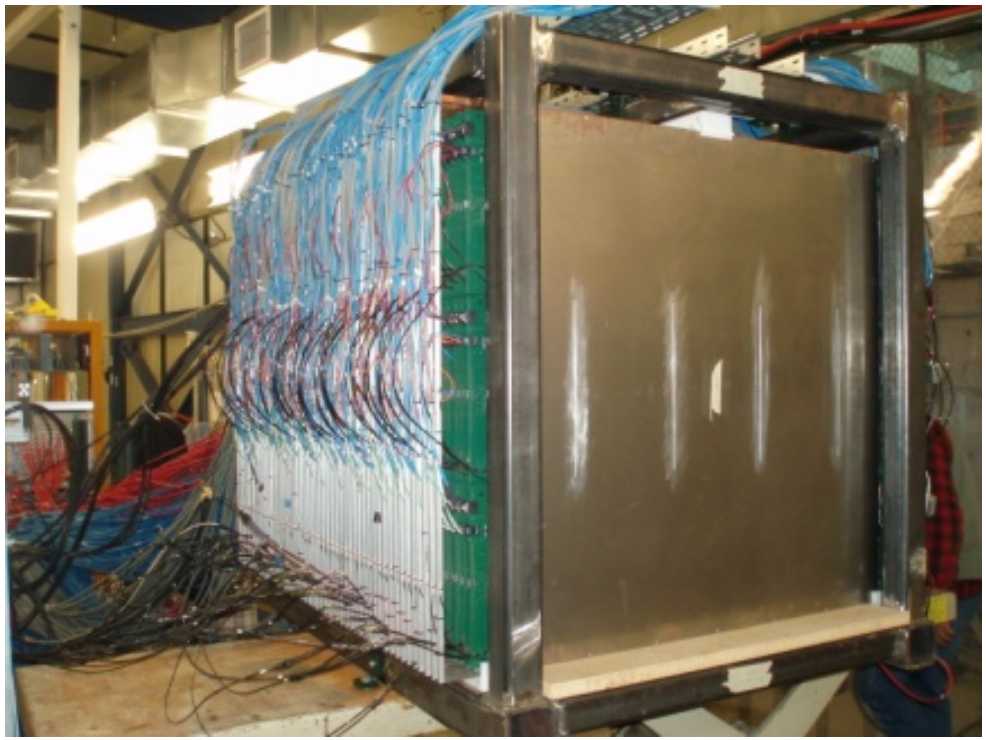
Progress Report

22 June 2016

Digital Hadronic Calorimeter (DHCAL)

1 m^3 prototype
built at Argonne

Based on **Resistive Plate Chamber** (RPC) technology:
2 thin glass plates, 1.15 mm gas gap, readout boards.



up to 52 layers:

× 3 RPCs per layer
× 2 boards per RPC
× 24 chips per board
× 64 channels per chip } 1536 pads

= 460,800 1×1 cm^2 readout channels

Each layer is a **cassette** containing:

2 mm copper front plate
3 RPC's
2 mm steel rear plate } 12.5 mm

spaced every 25.4 mm

Absorber: 38 x 1.75 cm steel
8 x 2.00 cm steel
6 x 10.0 cm steel } tail catcher

Material: ~1.2 X_0 or 0.12 λ_0 per layer

Special configuration available:
Min-DHCAL = Minimal Absorber DHCAL:
the normal absorber plates were removed.
with 0.4 X_0 or 0.04 λ_0 per layer

Data Format

```
6084680 -1 0 -1
6084661 52 73 36
6084661 52 73 34
6084661 52 73 37
6084661 53 73 35
6084661 52 73 35
6084661 52 73 30
6084661 52 72 30
6084661 53 73 33
6084661 52 73 33
6084661 52 72 33
6084661 53 73 32

..

6084661 52 71 5
6084661 52 70 5
6084661 52 70 3
6084661 52 70 4
6084661 52 70 2
6084661 53 70 2
6084661 52 70 0
6084661 52 70 1
6084661 53 74 41
6084661 52 74 38
6084661 53 74 40
6084661 52 74 40
6084661 53 74 39
6084661 52 74 39
6084661 53 75 42
6084661 53 74 42
6084661 52 75 44
6084661 52 75 45
6084661 53 75 46
6084661 52 75 46
6084661 53 76 48
6084661 53 77 50
6084661 53 76 50
```

muon event

Format is deceptively simple:

header line

hit lines ..

Hit lines:

time, x, y, z,

time in units of 100 ns
coordinates of cell which fired

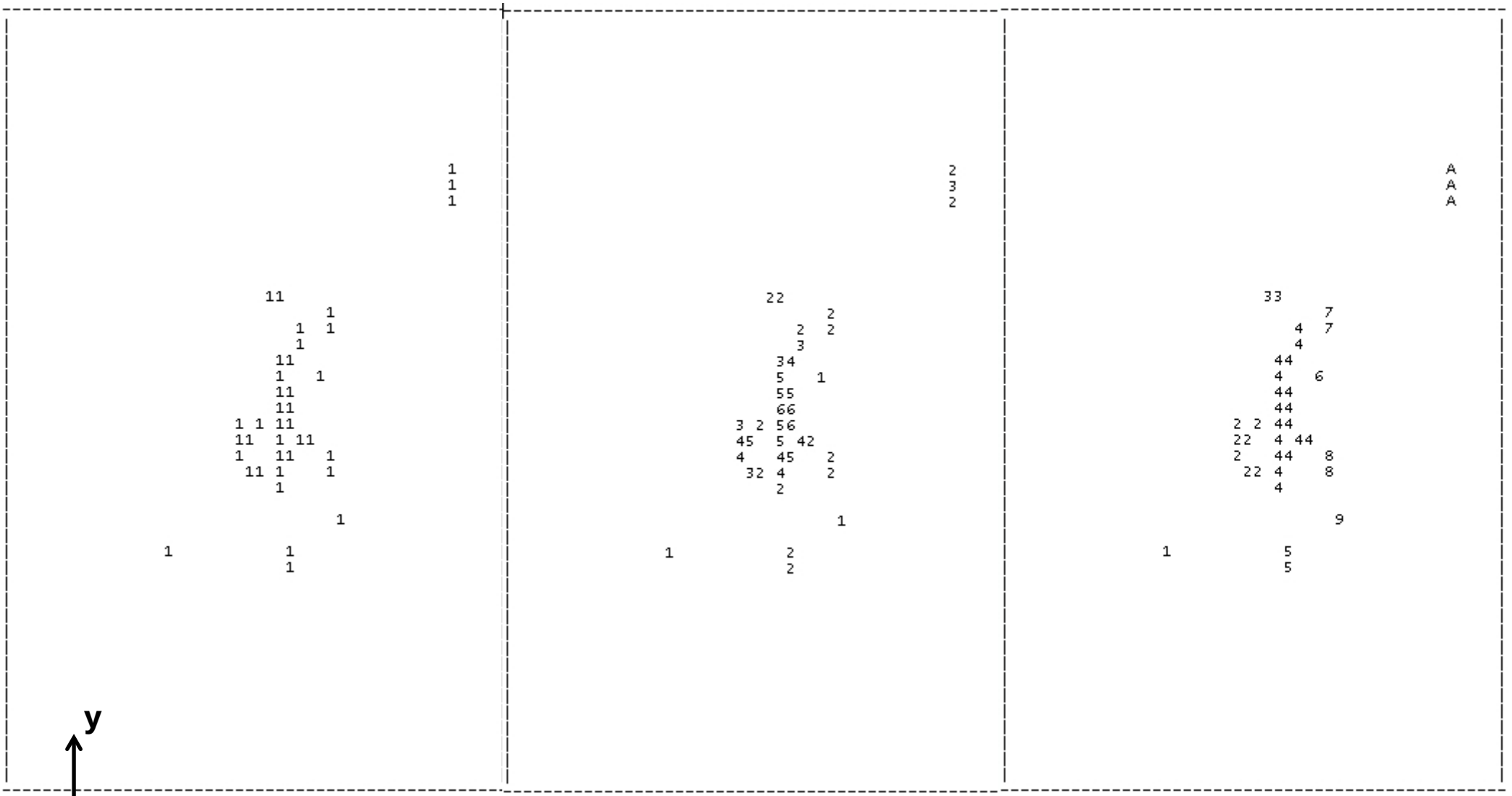
x = horizontal [0-95]
y = vertical [0-95]
z = beam direction [0-51]

2D Clustering - 40 GeV Pion - z-layer 10

Data: hit cells

Connectivities

Clusters



input to clustering algorithm

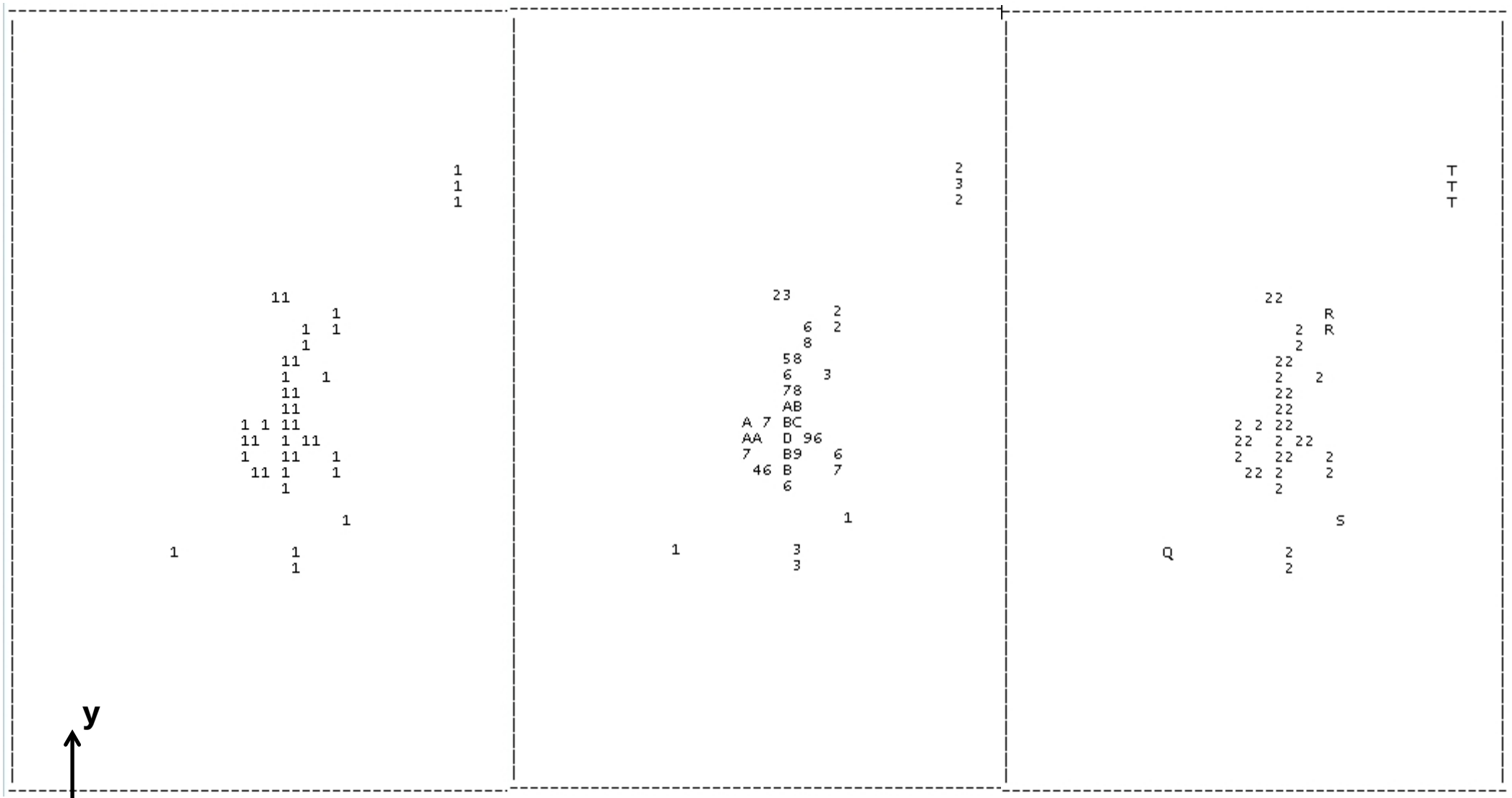
here for connectivity > 0

3D Clustering - 40 GeV Pion - z-layer 10

Data: hit cells

Connectivities

Clusters



same

higher connectivities

less clusters

Apply Clustering to Beam Muons

5 muons

number of hit cells

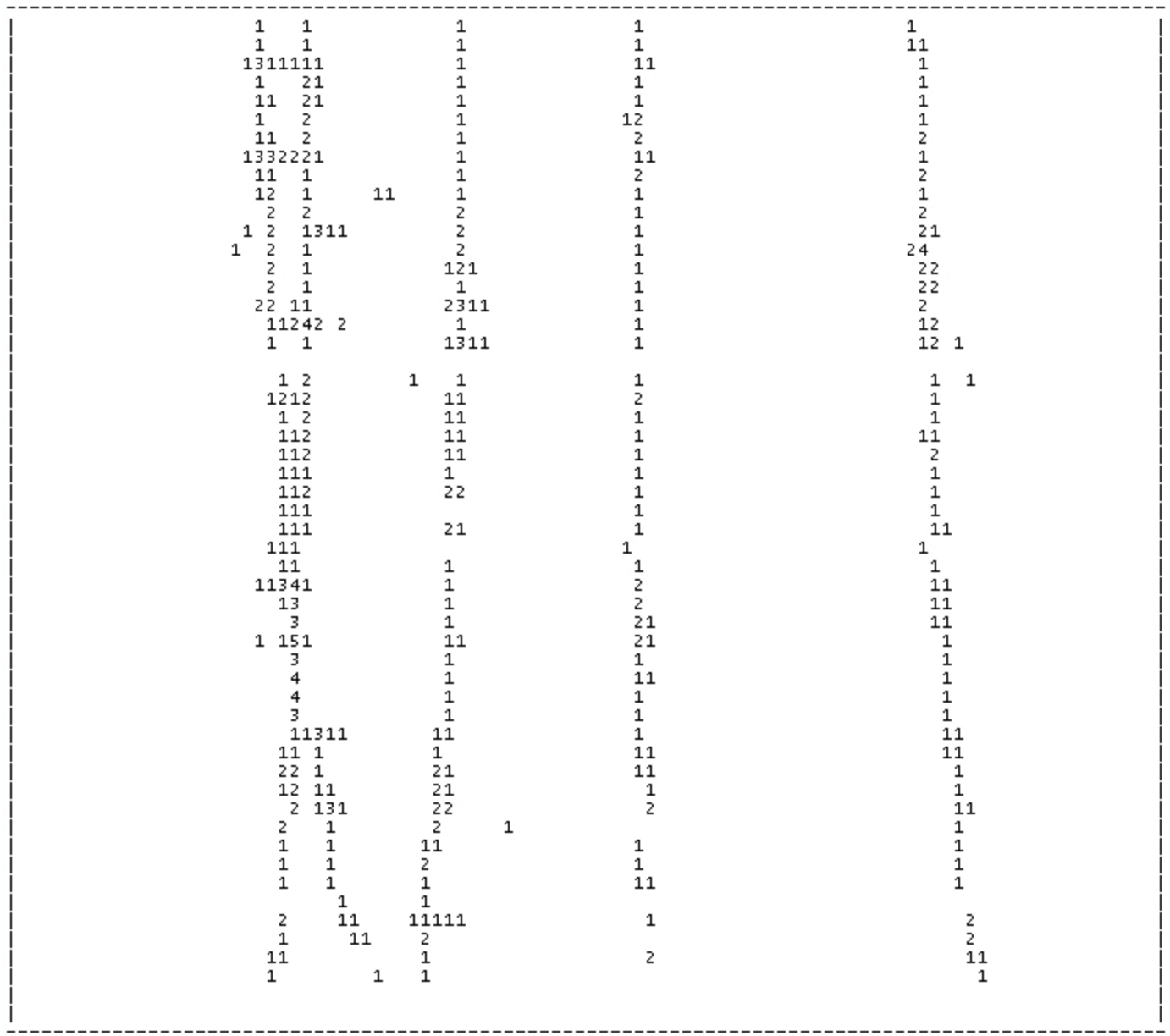
features:

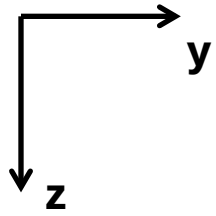
missing layer

individual cells not firing

use this to calculate efficiencies (ε) and multiplicities (μ)

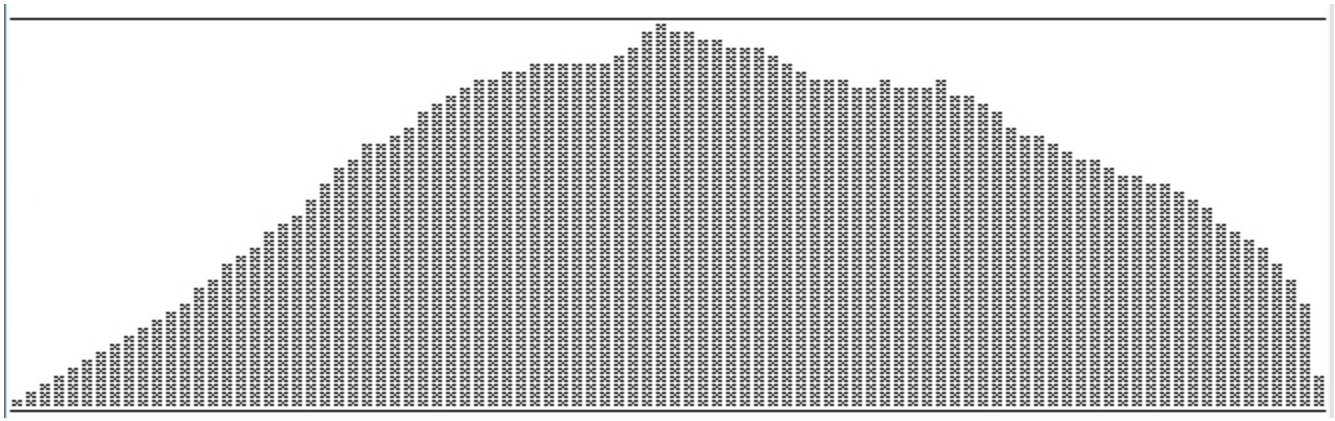
calibration = $\varepsilon \times \mu$



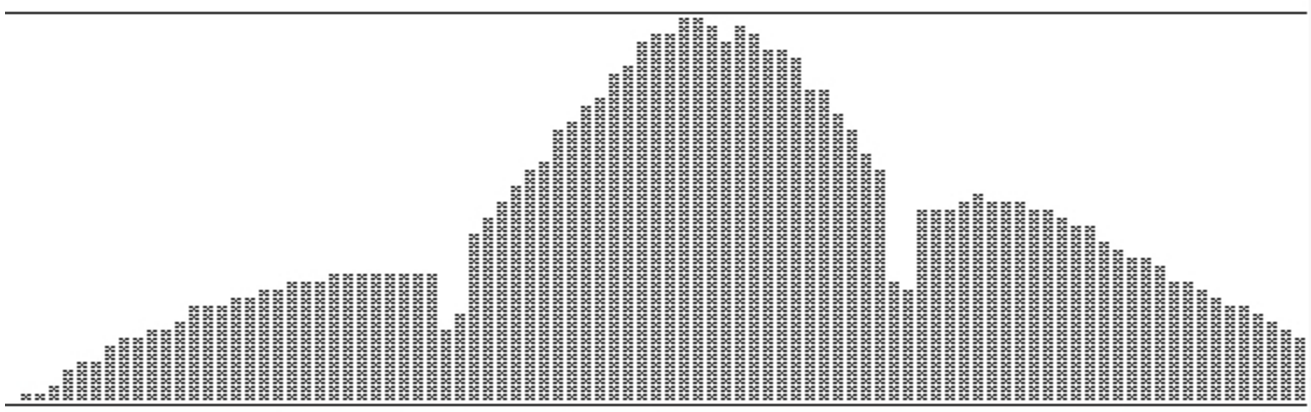


Muons - Spatial Distributions of Hits

Along x

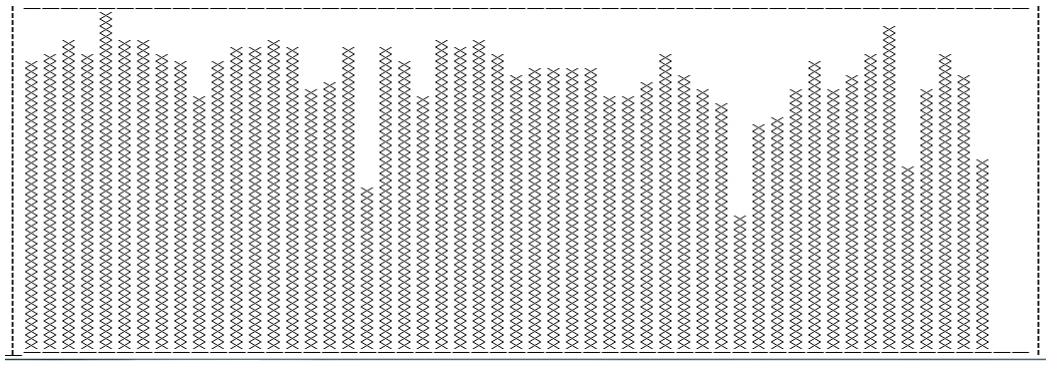


Along y



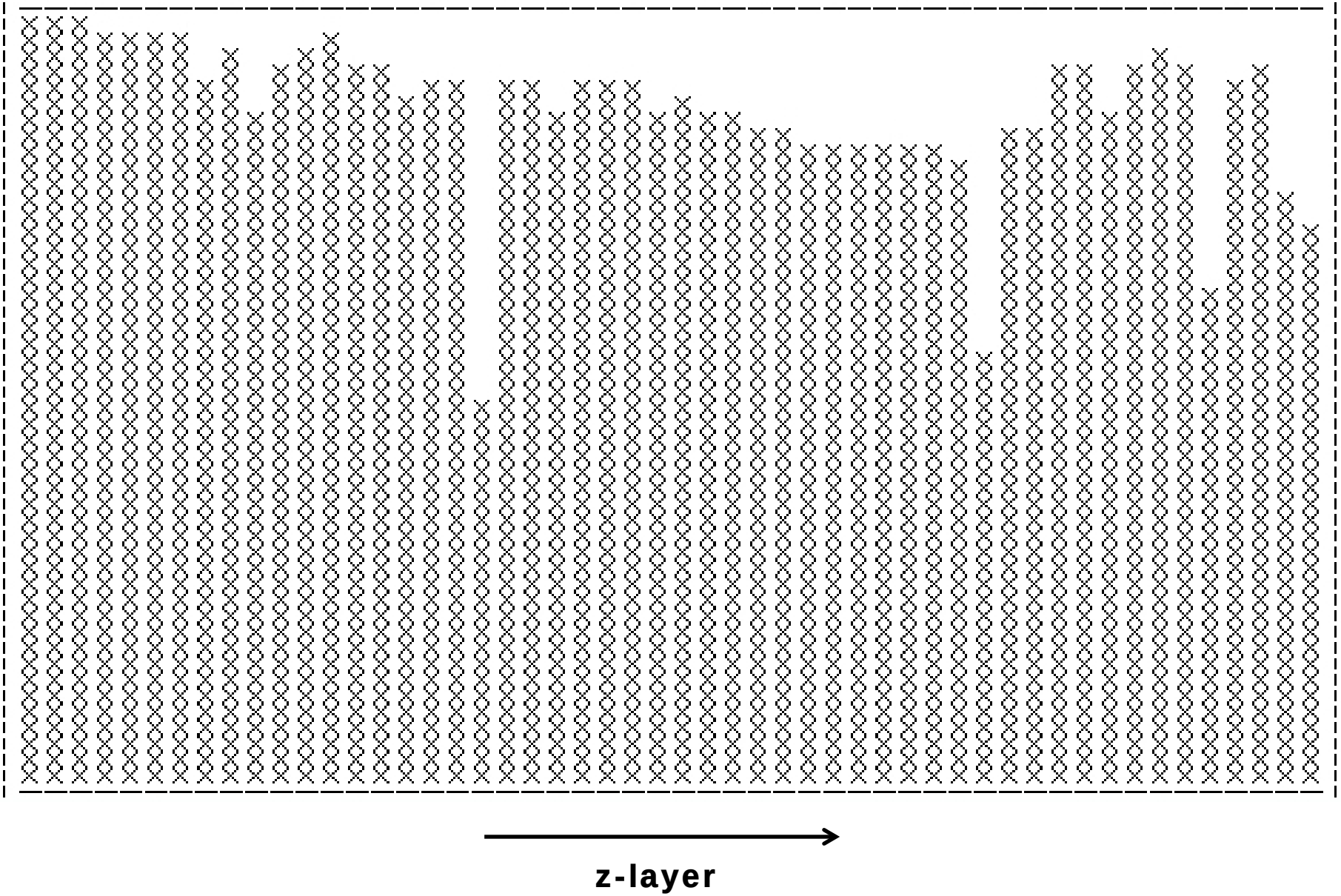
2 RPCs dead in that run (out of 52×3)

Along z



Hint at large disparities in calibration

Muons - #Clusters vs z



Muon Clusters

Examples of 2 muon events:

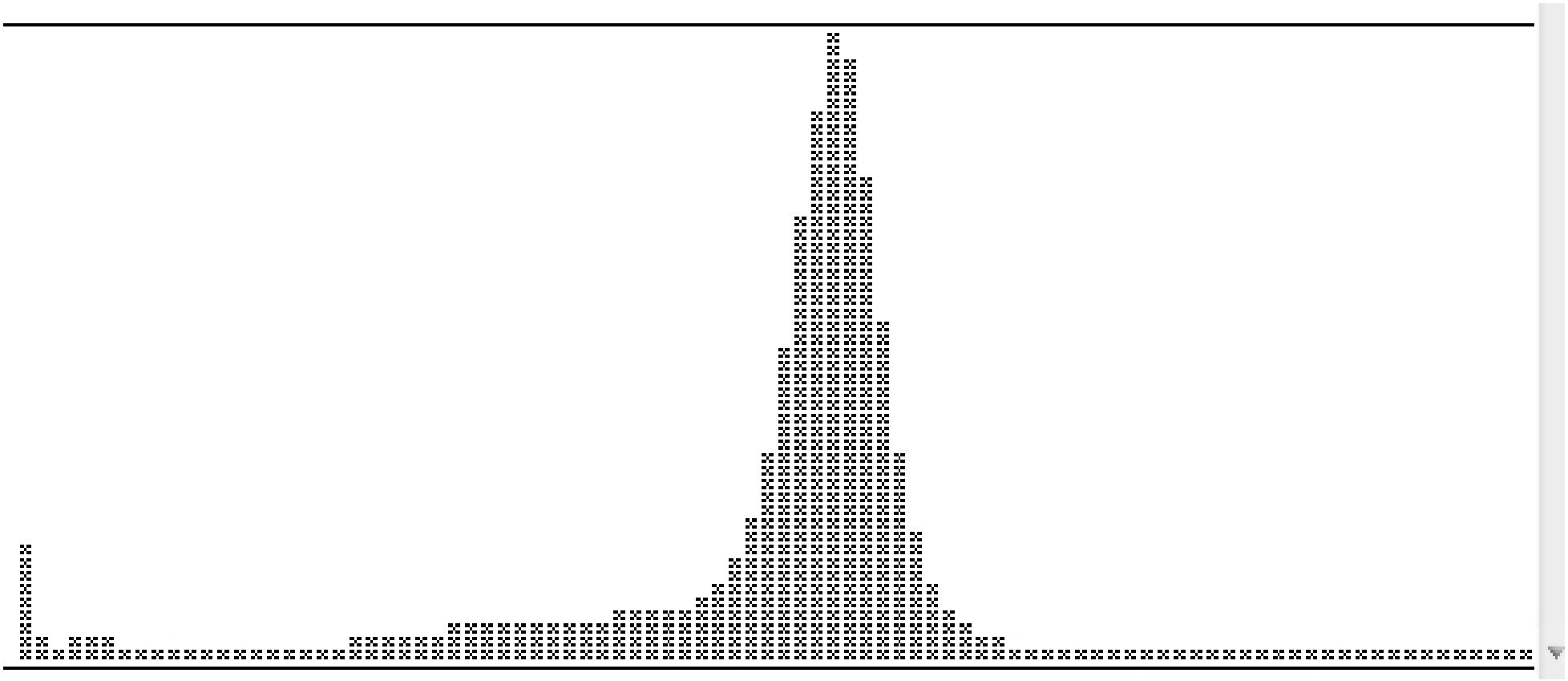
Clusters	#	Hits	Cells	x	y	z	z1	z2
CLP	1	24	24	52.04	70.58	7.75	0	17
CLP	2	35	35	52.20	72.77	31.40	19	42
CLP	3	4	4	52.25	75.00	45.25	44	46
CLP	4	1	1	53.00	76.00	48.00	48	48
CLP	5	2	2	53.00	76.50	50.00	50	50
CLP	5	66	66					

Clusters	#	Hits	Cells	x	y	z	z1	z2
CLP	1	36	36	76.19	86.39	10.39	0	17
CLP	2	4	4	75.50	71.50	12.00	12	12
CLP	3	1	1	79.00	82.00	17.00	17	17
CLP	4	37	37	77.81	86.97	32.27	19	46
CLP	5	1	1	80.00	87.00	19.00	19	19
CLP	6	7	7	80.29	87.71	49.29	48	51
CLP	6	86	86					

Event 1: all clusters can be aligned and merged together according to z-ranges

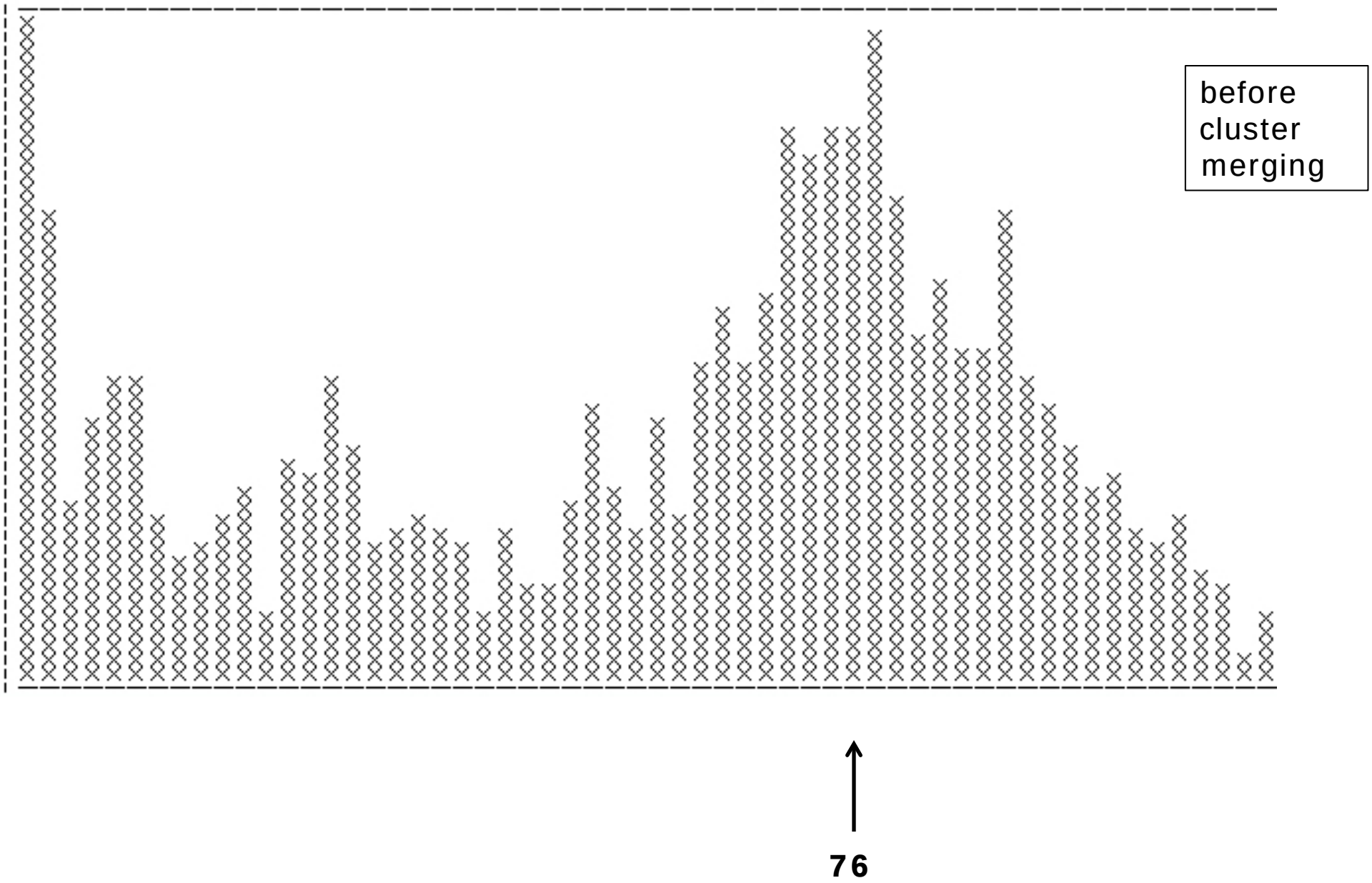
Event 2: cluster #2 and #5 are odd particles not matching a track and are automatically rejected by clustering algorithm

Muons - Number of 2d Clusters per Event

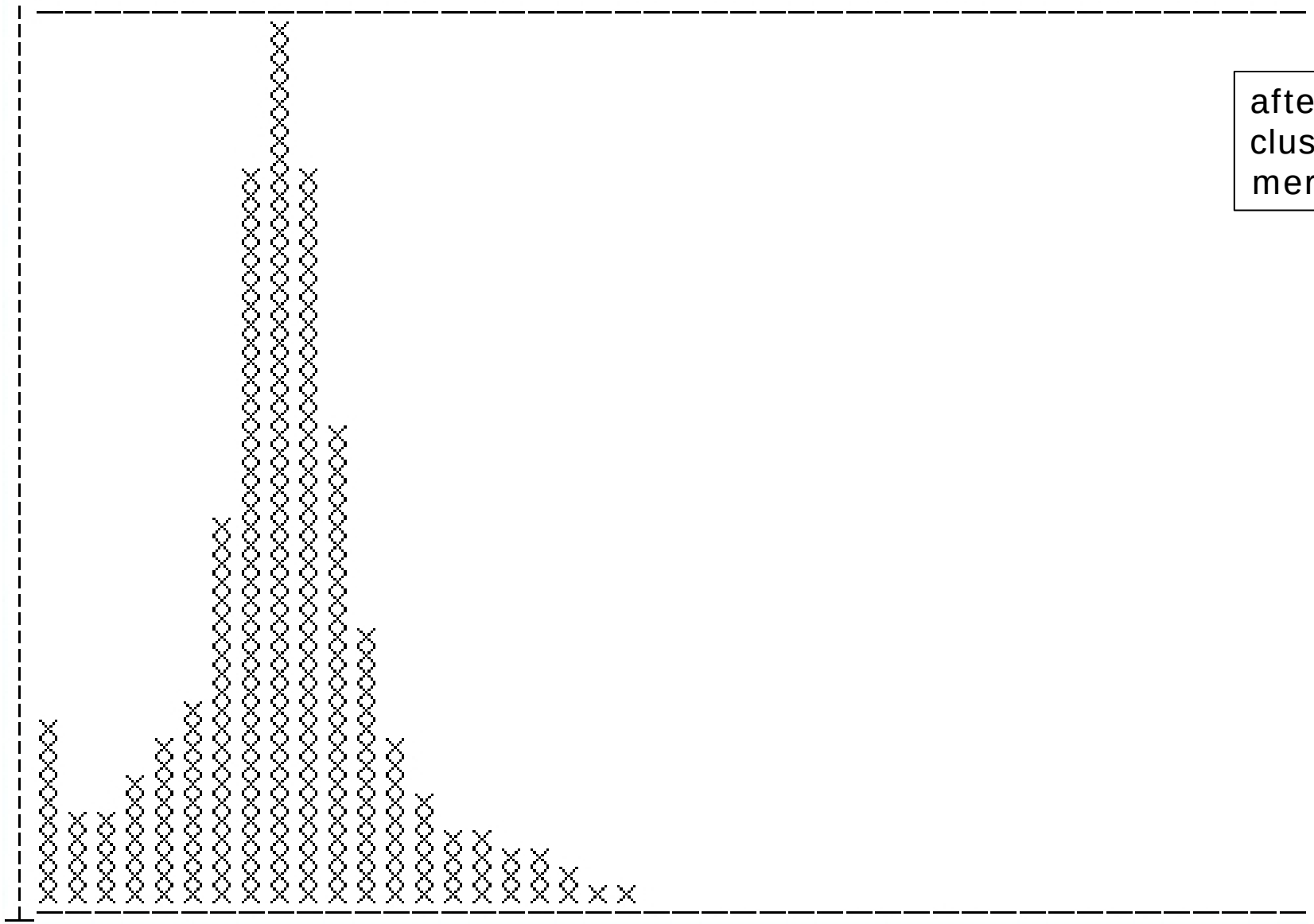


52 z-layers: peak at ~50 per event

Muons - Hits per 3d Segment



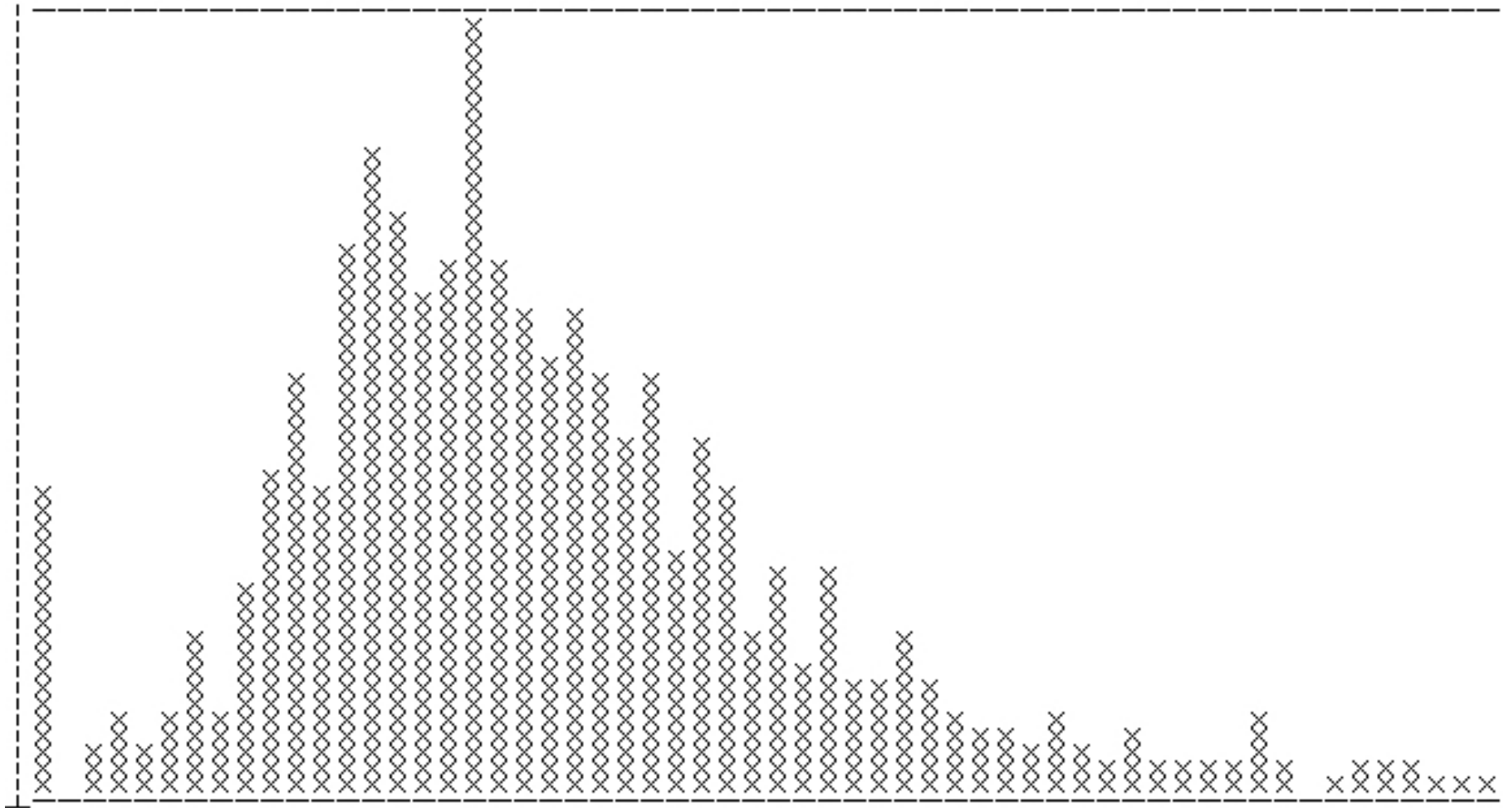
Muons - Number of Hits per Event



peak at ~85

Muons - Reduced χ^2 from Track Fit

Simple 3d linear fit through the hits

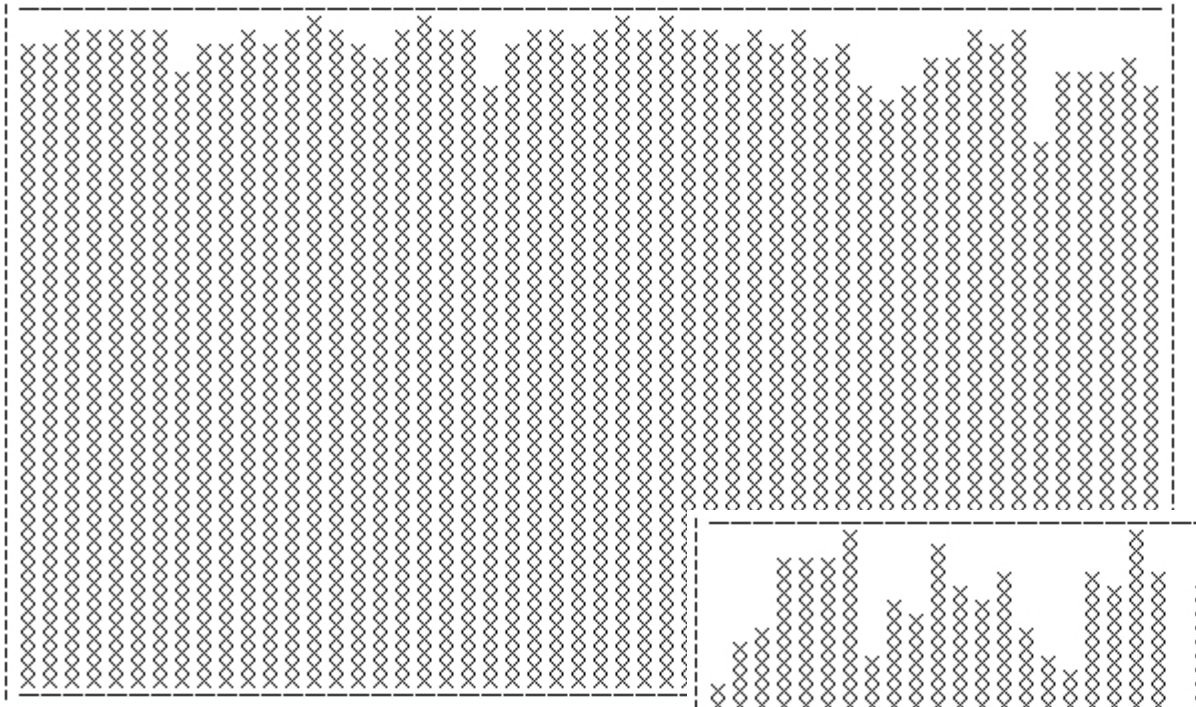


0.43

will be later done with inertial tensor

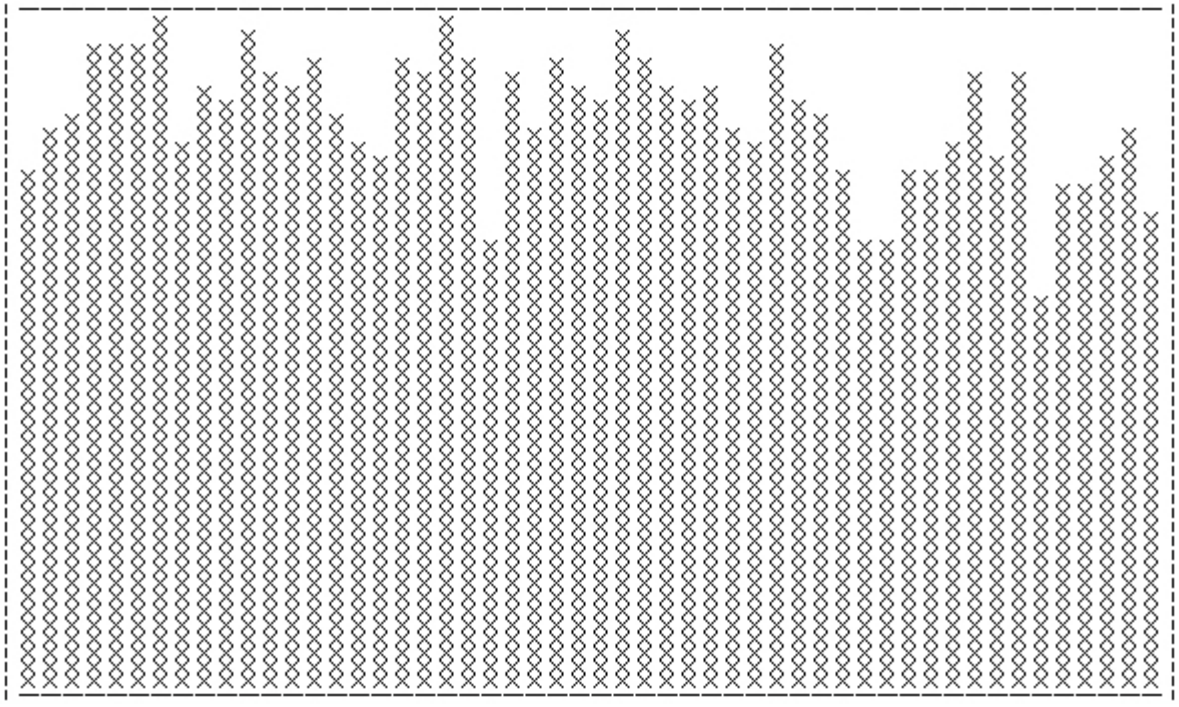
Efficiencies and Multiplicities

Efficiencies ~95%



Middle RPCs

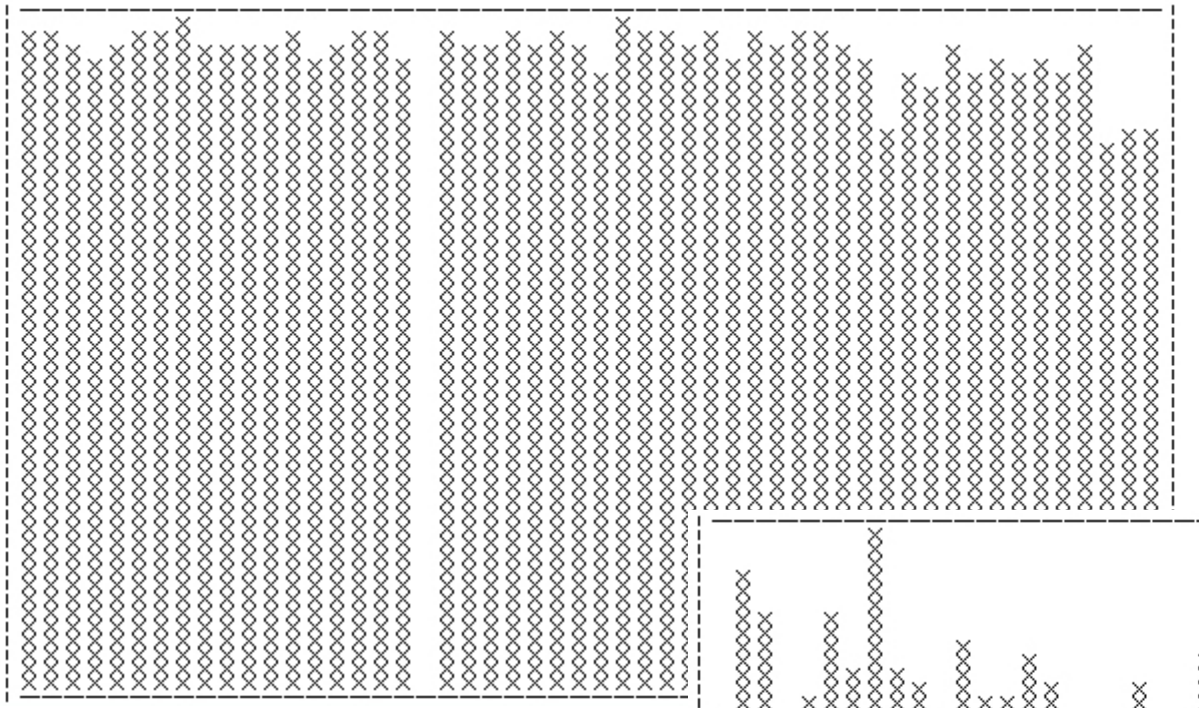
Multiplicities ~1.55



z-layer

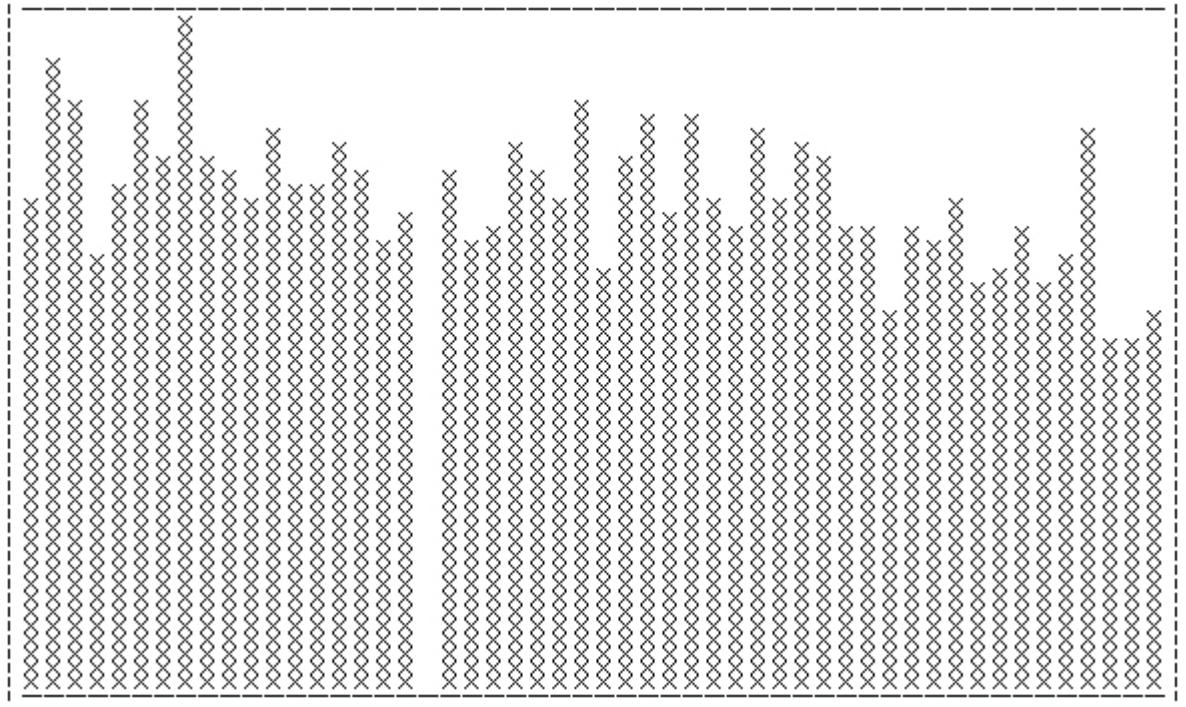
Efficiencies and Multiplicities

Efficiencies ~94%



Bottom RPCs

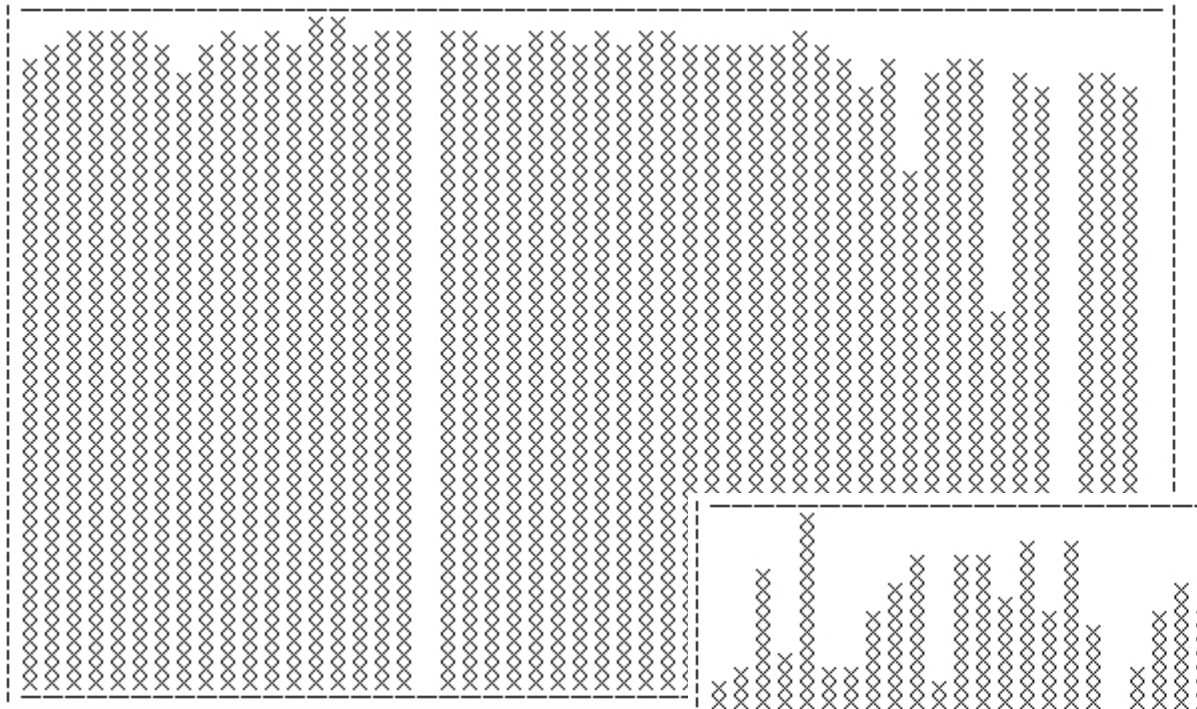
Multiplicities ~1.55



z-layer

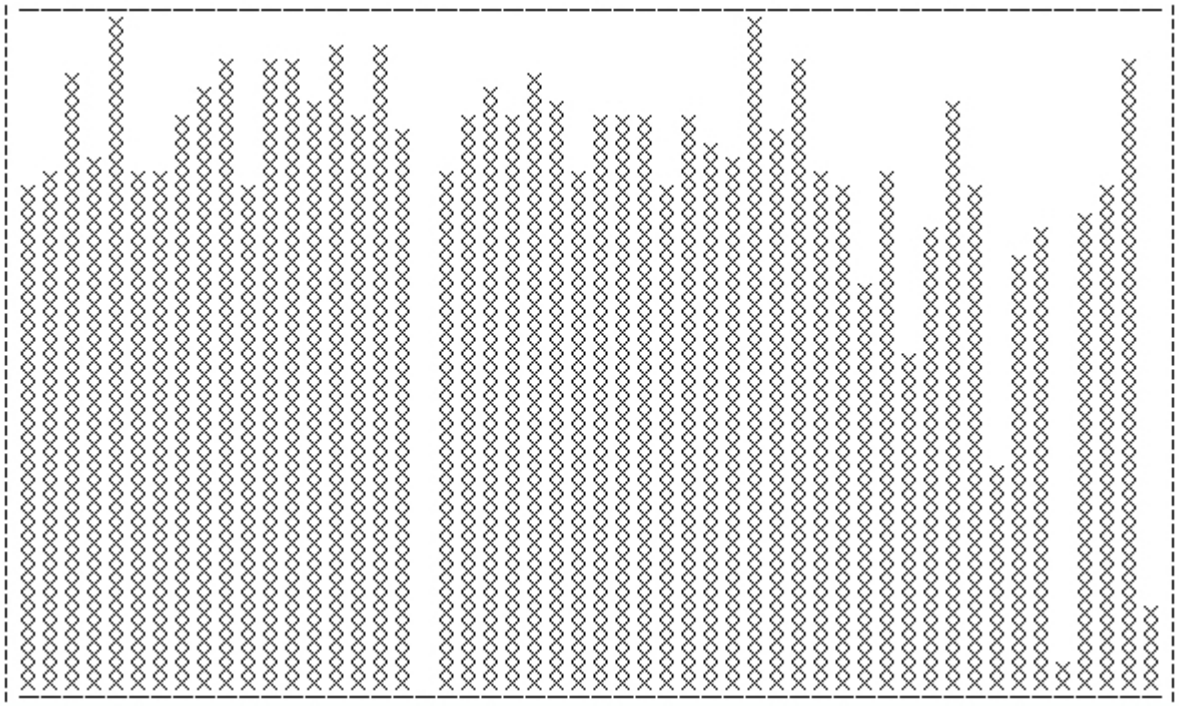
Efficiencies and Multiplicities

Efficiencies ~93%



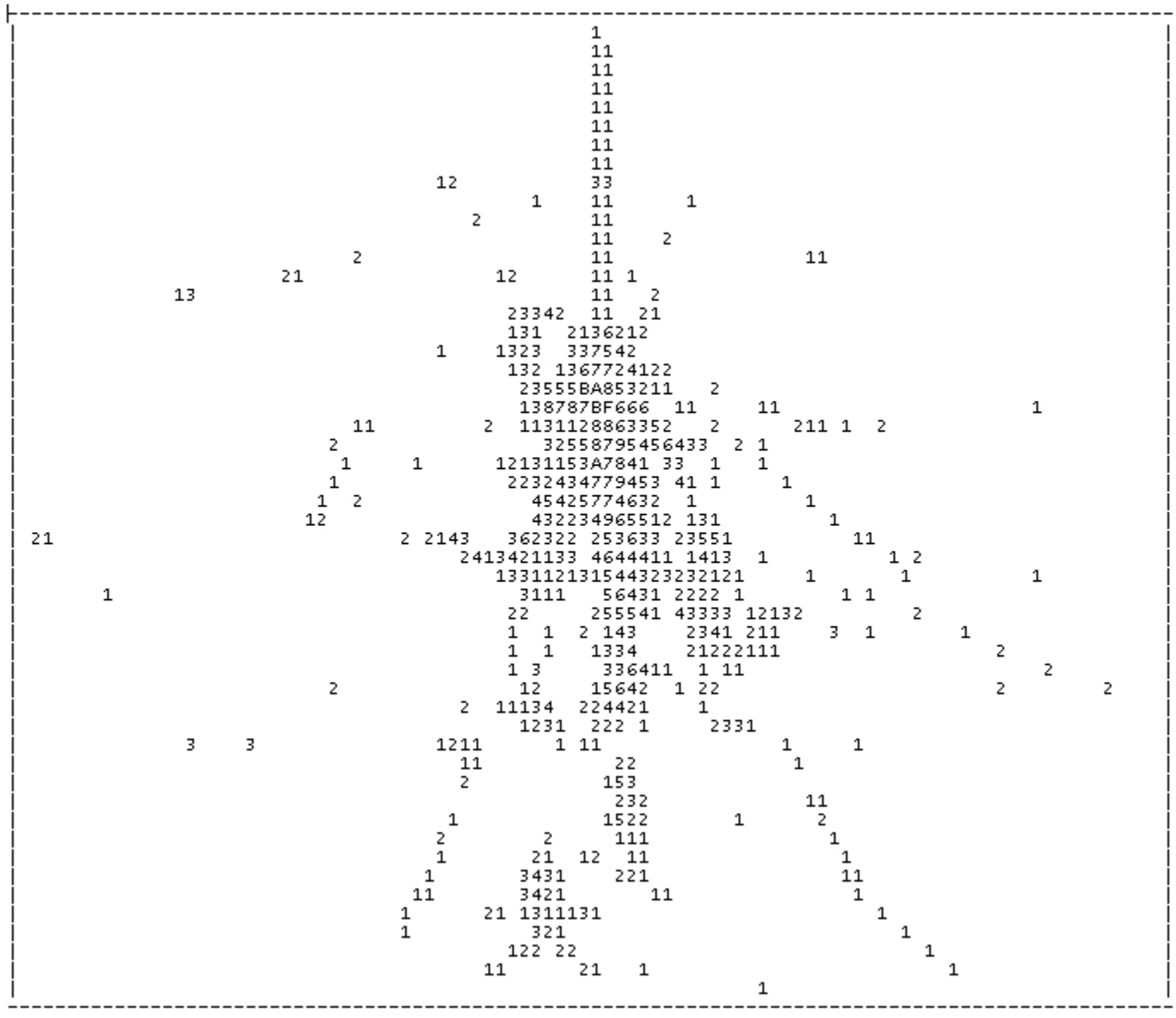
Top RPCs

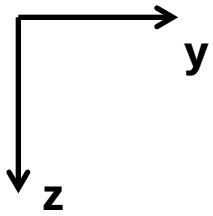
Multiplicities ~1.50



z-layer

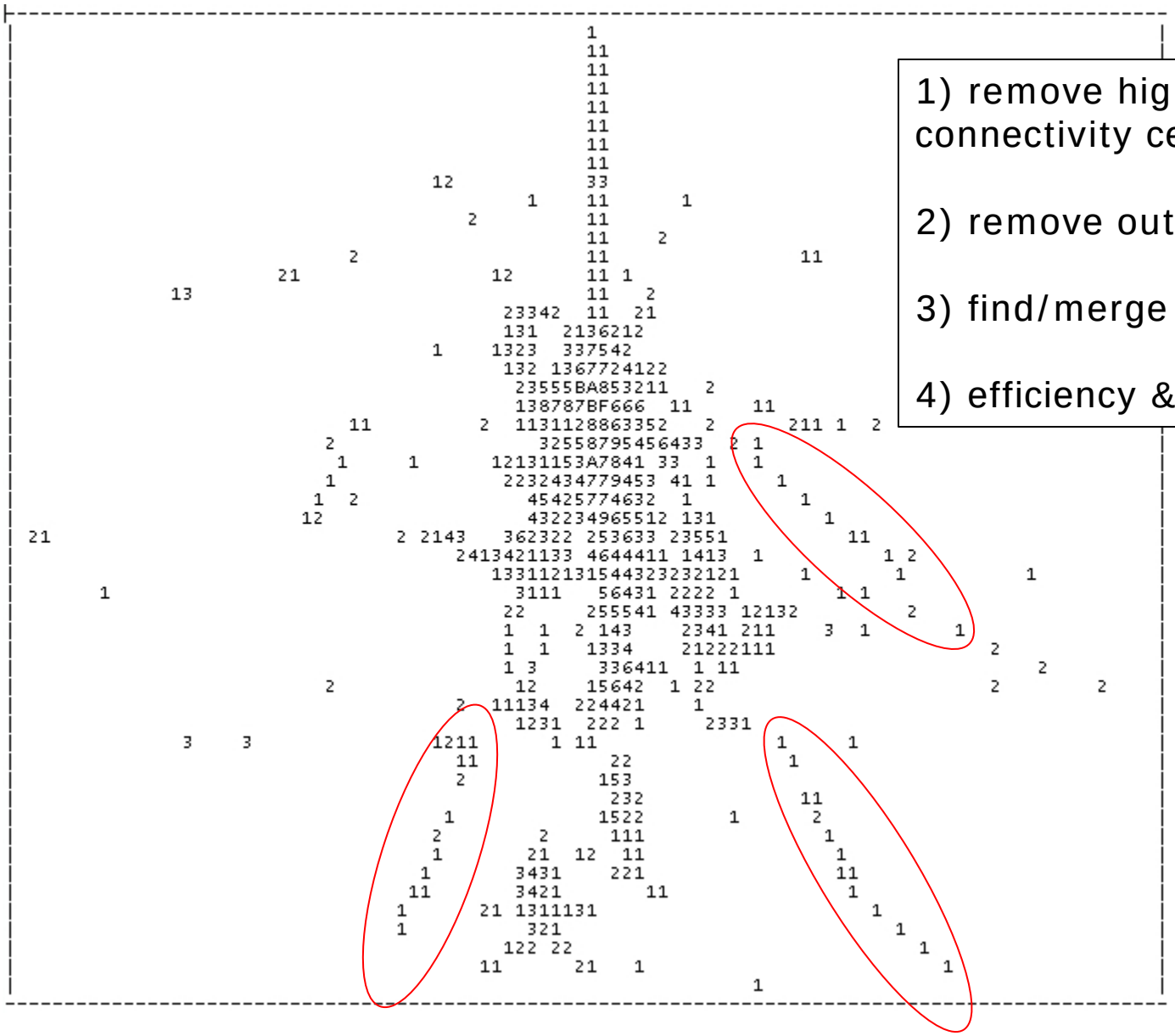
120 GeV Pion





Track segments to be isolated and used for calibration

120 GeV Pion

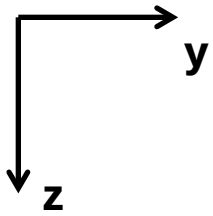


1) remove high connectivity cells

2) remove outliers

3) find/merge segments

4) efficiency & multiplicity



Status

Calorimeter calibration is being studied for particle shower track segments with DHCAL.

- Connectivity used to isolate and define segments.
- Method is first applied to muons.
- Calibration works for them and sets a reference.
- Method is next applied to segments in showers.
- Angular dependence will be the main issue.

?