



Single Track Selection Update

October 22th Update



SuperFGD Prototype Analysis Meeting

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PCA: Overview

- Calculate the centroid for a distribution of points
- Calculate the covariance matrix with the centroid

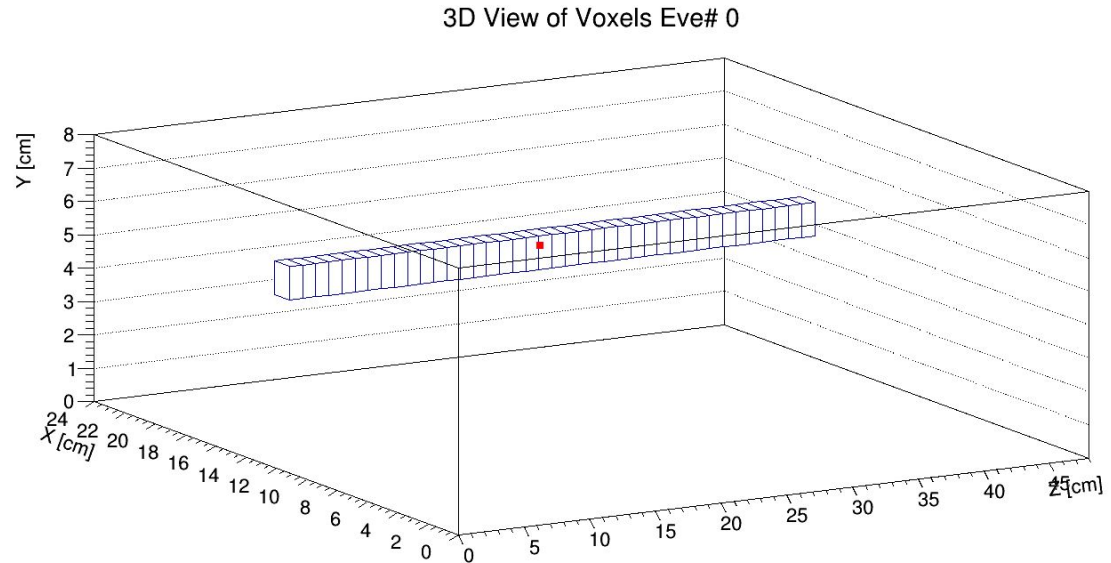
$$[Cov]_{ij} = \frac{\sum_{l=1}^N (A_i - \bar{A}_i) \cdot (A_j - \bar{A}_j)}{N}$$

- Perform eigen decomposition on the covariance matrix to obtain the eigenvalues of the covariance matrix
- Sort the obtained eigenvalues by $\lambda_1 \geq \lambda_2 \geq \lambda_3 \geq 0$
- Evaluate the linearity, planarity and sphericity of the distribution of points

Linearity	$(\lambda_1 - \lambda_2)/\lambda_1$
Planarity	$(\lambda_2 - \lambda_3)/\lambda_1$
Sphericity	λ_3/λ_1

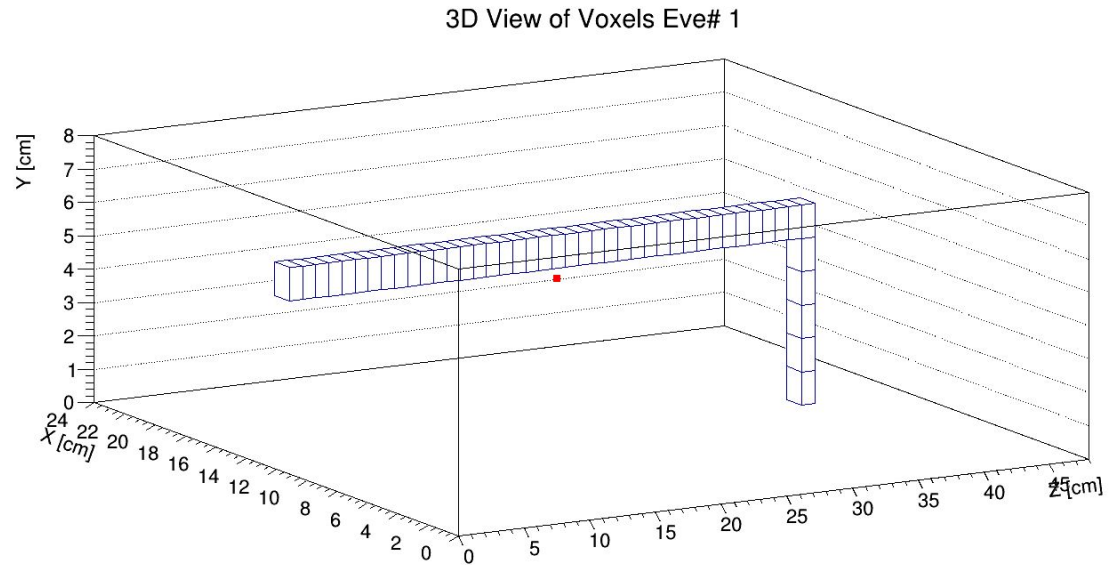
PCA: Tests

- Tested on 3 different toy samples of clusters:
- Eigenvalues: 133.25, 0, 0
- Linearity: 1



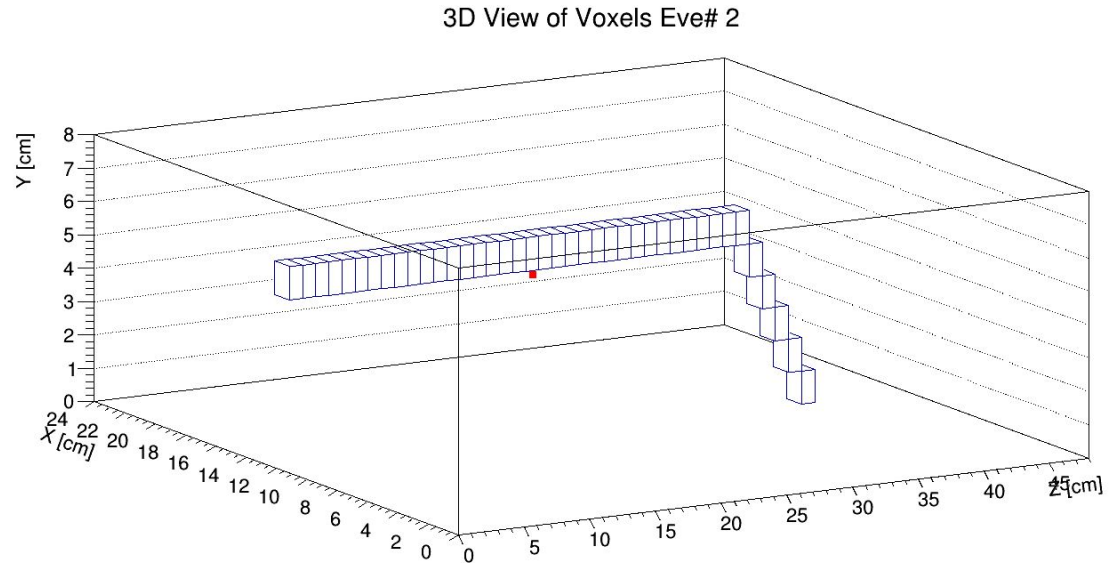
PCA: Tests

- Tested on 3 different toy samples of clusters:
- Eigenvalues: 156.215, 0.895883, 0
- Linearity: 0.994265

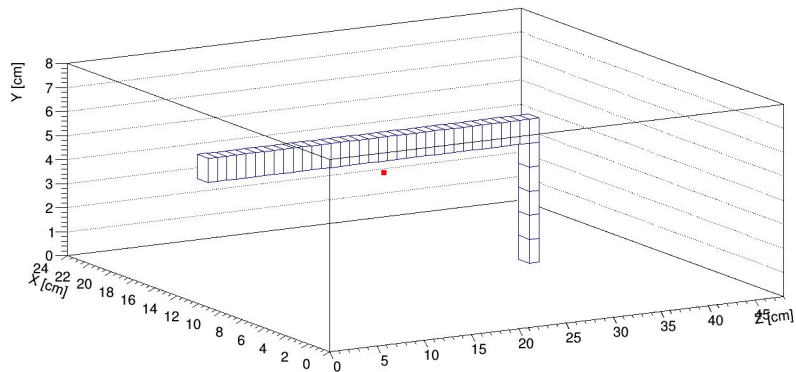


PCA: Tests

- Tested on 3 different toy samples of clusters:
- Eigenvalues: 133.601, 0.883756, 0
- Linearity: 0.993385

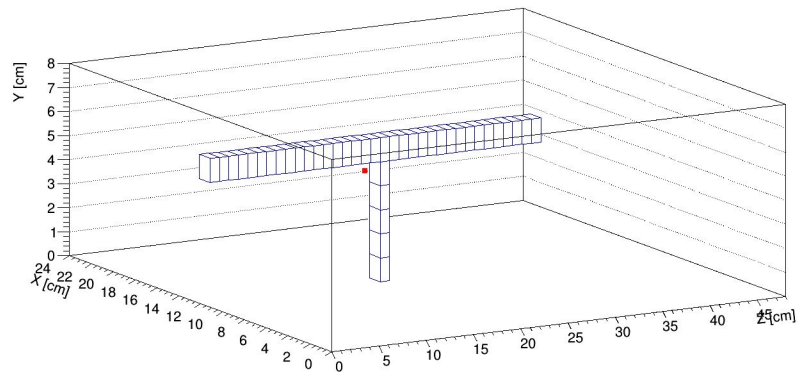


3D View of Voxels Eve# 1



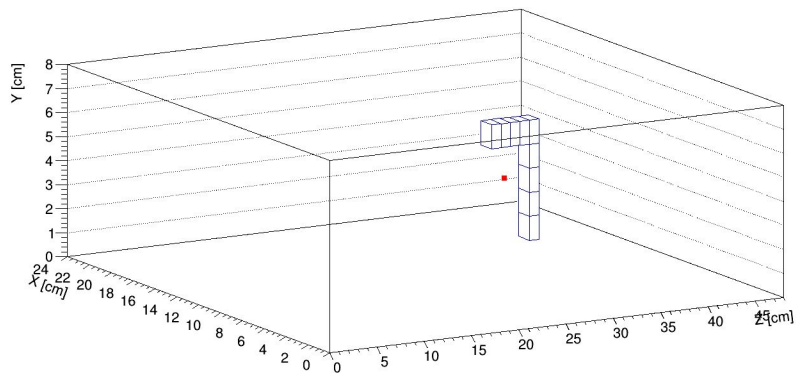
Eigenvalues: 121.119, 0.97483, 0 ; Linearity: 0.991951

3D View of Voxels Eve# 1



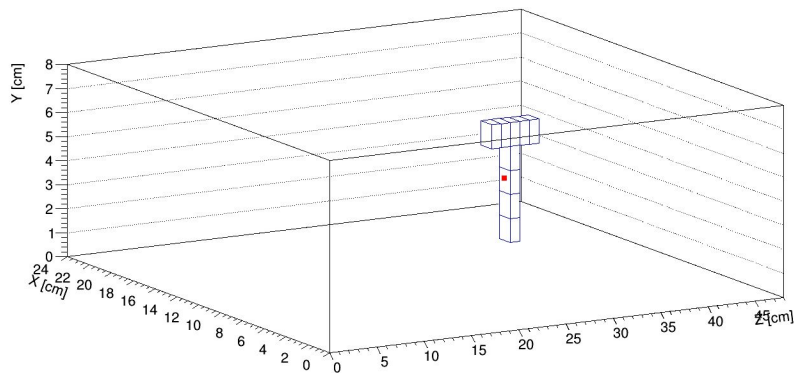
Eigenvalues: 89.3606, 1.23315, 0 ; Linearity: 0.9862

3D View of Voxels Eve# 1



Eigenvalues: 3.333, 0.864198, 0 ; Linearity: 0.740741

3D View of Voxels Eve# 1

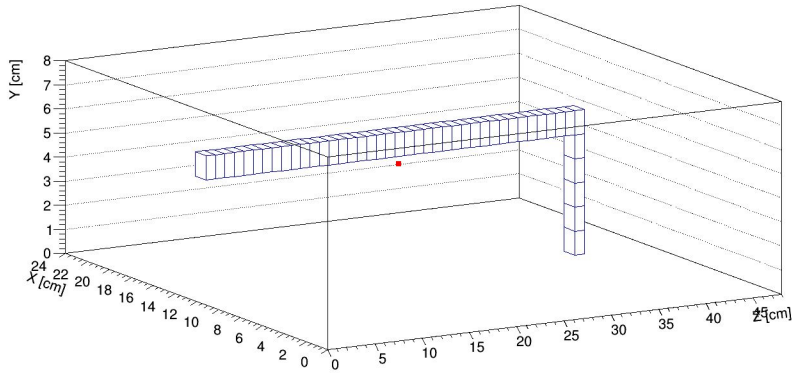


Eigenvalues: 2.09877, 1.111, 0 ; Linearity: 0.470588 6

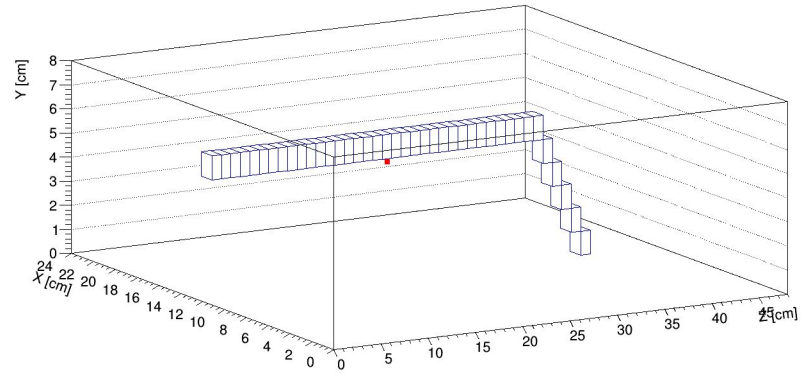
PCA: Possible Solution

- Give different weights for the X, Y and Z coordinates
 - Size of prototype detector: 24x8x48
 - Corresponding weights: 1/24 for X, 1/8 for Y and 1/48 for Z

3D View of Voxels Eve# 1



3D View of Voxels Eve# 2



Eigenvalues: 0.07186, 0.01320, 0 ; Linearity: 0.816215 Eigenvalues: 0.06475, 0.01236, 0 ; Linearity: 0.809052

- Helped in reducing linearity of these tracks

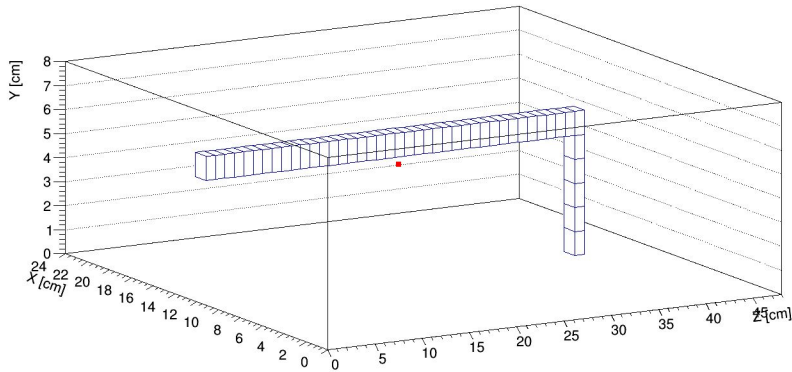
PCA: Possible Solution

- Not a pleasing solution:
 - Giving special directions
 - Should work on symmetric detector as well

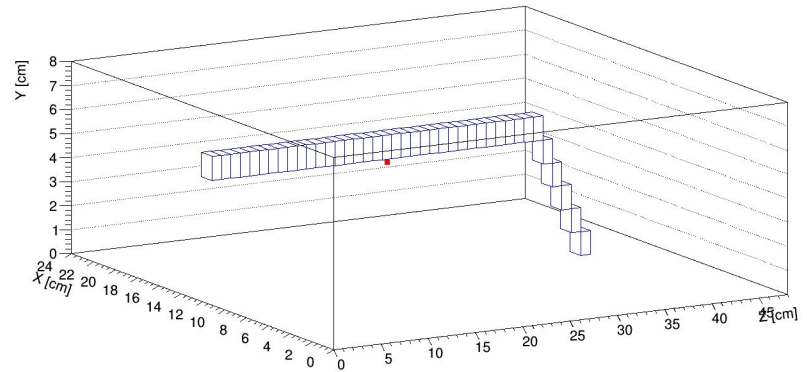
PCA: Possible Solution

- Give different weights for the X, Y and Z coordinates corresponding to the spread of voxels in the X, Y and Z directions (1/standard deviation)

3D View of Voxels Eve# 1



3D View of Voxels Eve# 2



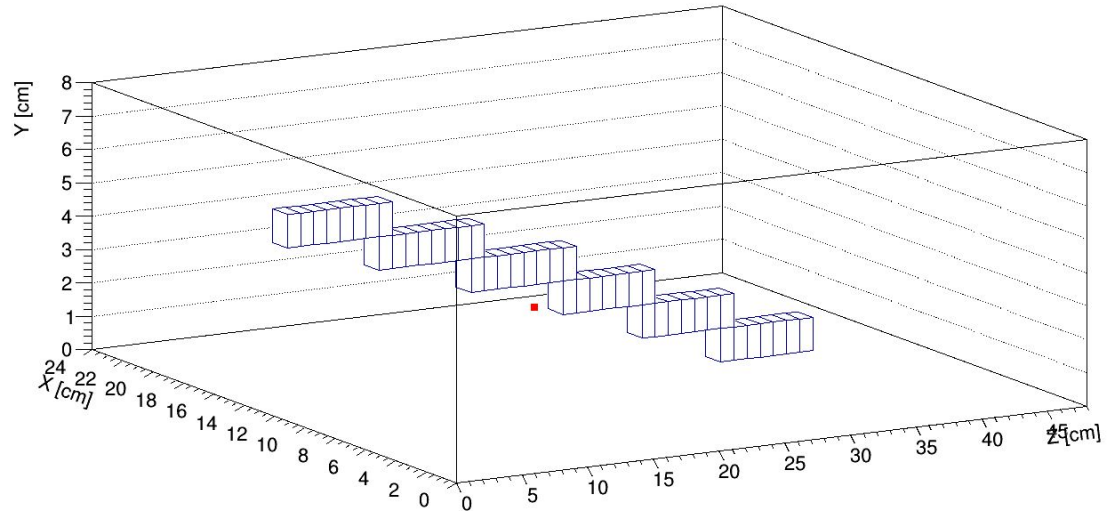
Eigenvalues: 1.40688, 0.54867, 0 ; Linearity: 0.610005 Eigenvalues: 1.49291, 0.45709, 0 ; Linearity: 0.693826

- Helped in reducing linearity of these tracks

PCA: Possible Solution

- Eigenvalues: 1.93691, 0.0186481, 0
- Linearity: 0.990372
- Diagonal tracks still have high linearity with this kind of scaling

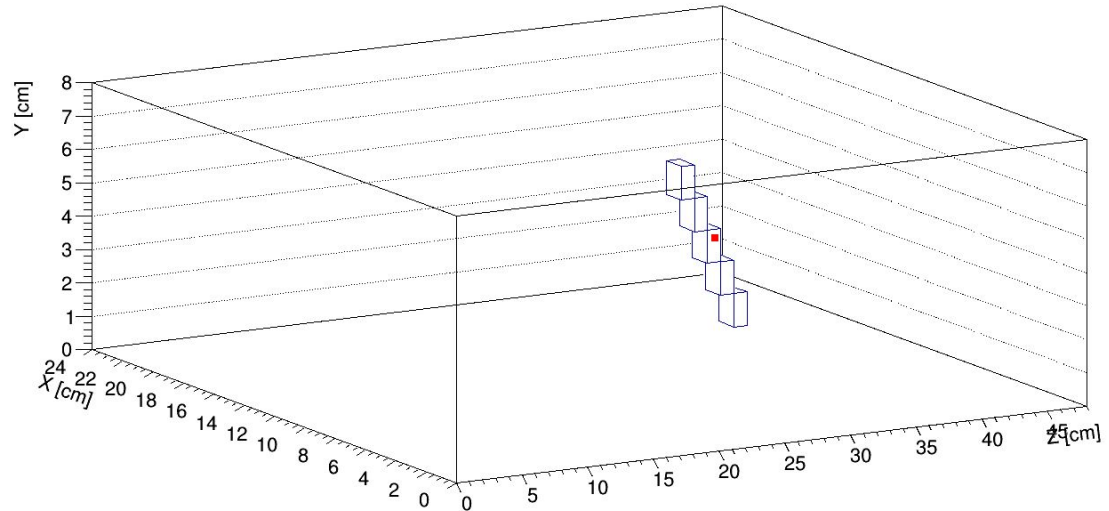
3D View of Voxels Eve# 3



PCA: Possible Solution

- Eigenvalues: 1.6, 0, 0
- Linearity: 1
- Diagonal tracks still have high linearity with this kind of scaling

3D View of Voxels Eve# 4



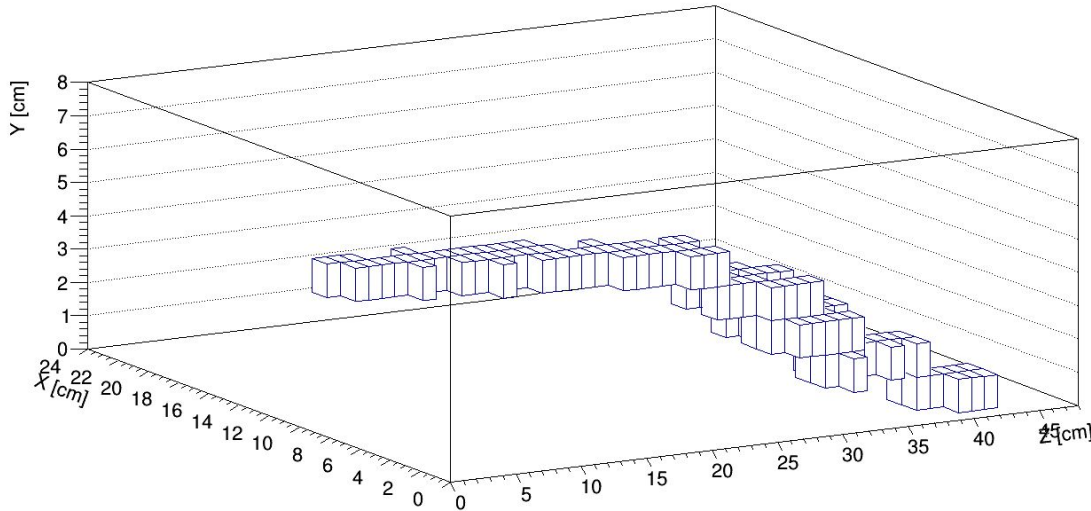
PCA: Possible Solution

Previous event display from data

Linearity: 0.9922 (not cut out with linearity of 0.99)

New linearity: 0.9287

3D View of Voxels



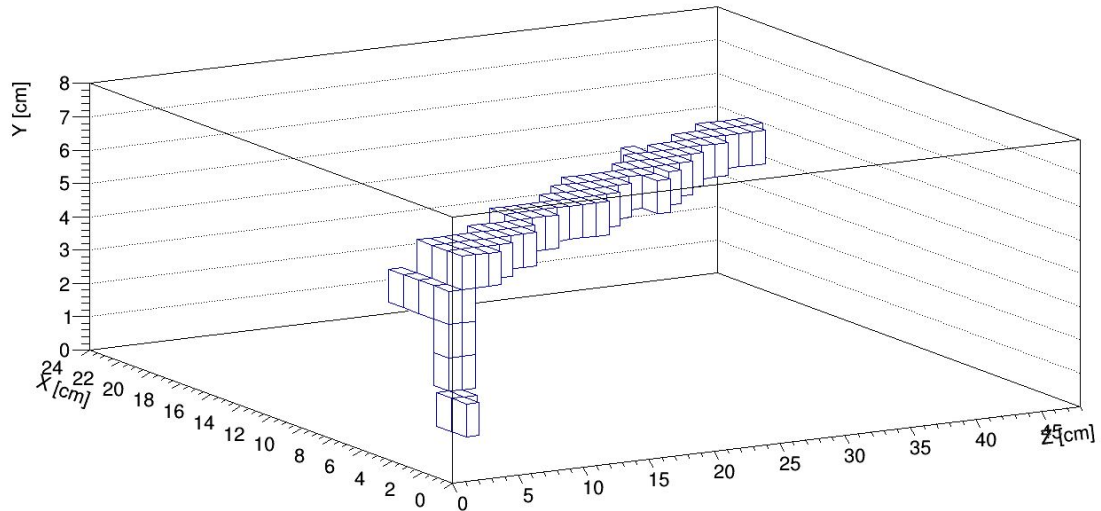
PCA: Possible Solution

Previous event display from data

Linearity: 0.9955 (not cut out with linearity of 0.99)

New linearity: 0.7574

3D View of Voxels



PCA: Possible Solution

- Eye scanned 200 selected events with linearity > 0.96 in data
- All of them are straight tracks (Purity is 100%)
- Purity with neutron MC sample is 95% with linearity > 0.96
- However, after eye scanning the remaining 5%, only 7% of those are topologically not straight tracks
- Overall impurity is $5\% \times 7\% = 3.5\%$ from the neutron MC sample

Straight Track Selection: Alternatives

- Set a threshold for the greatest distance between the voxel and fitted track / eigenvector with the highest eigenvalue
- Single maximum in Hough space
- Other suggestion?

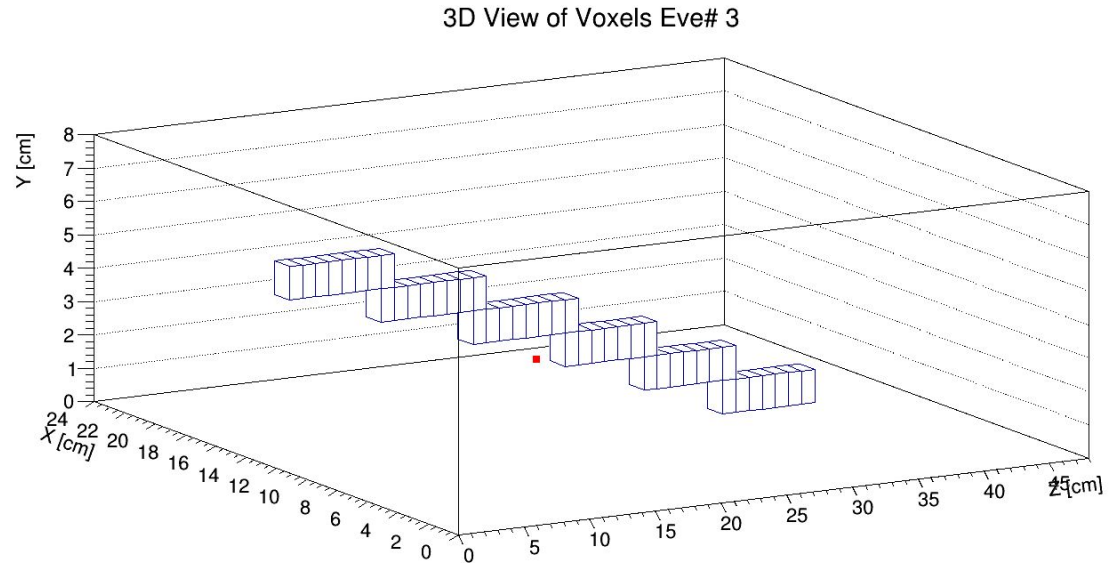


Backup Slides



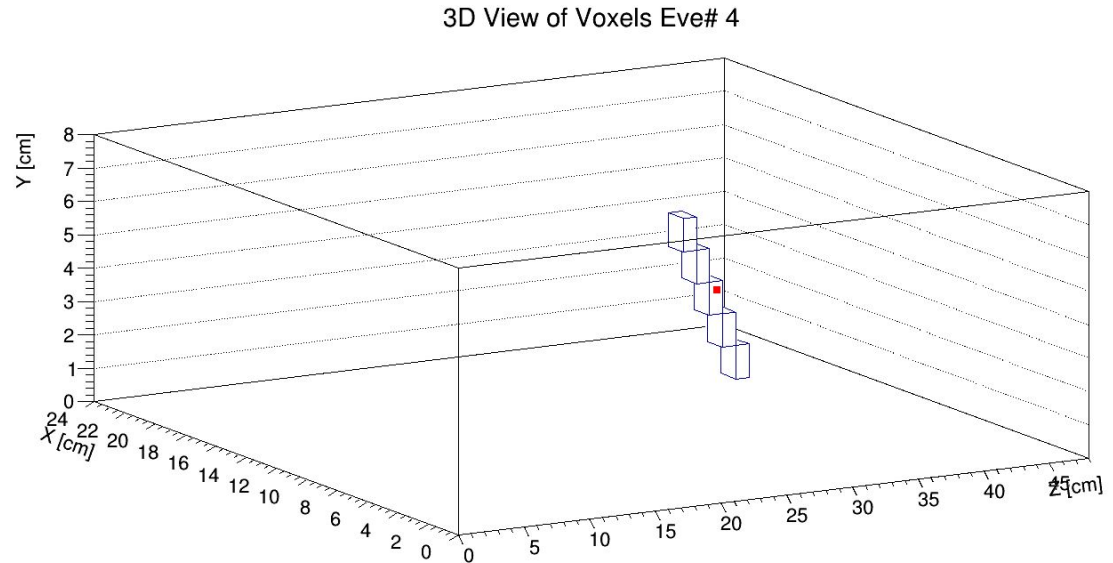
PCA: Tests

- Previous PCA calculation:
- Eigenvalues: 130.728, 0.107463, 0
- Linearity: 0.999178



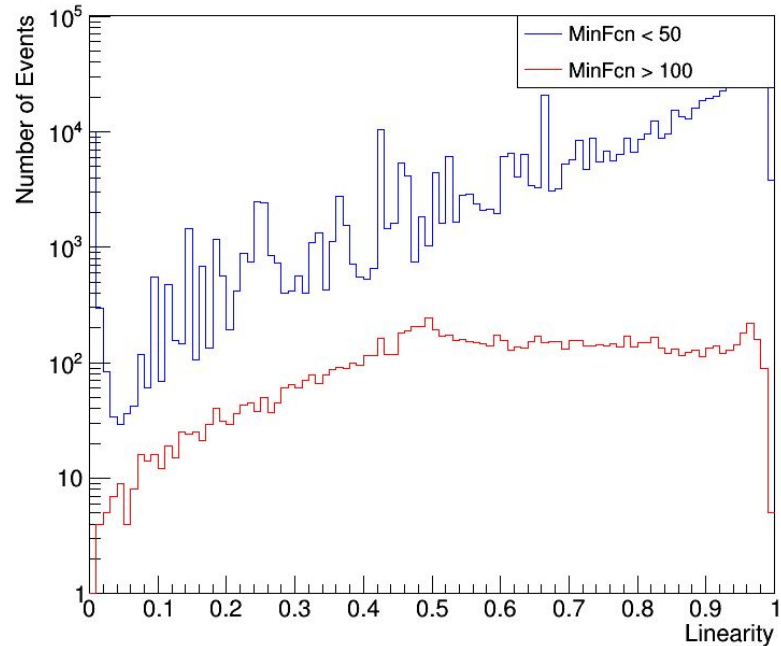
PCA: Tests

- Previous PCA calculation:
- Eigenvalues: 4, 0, 0
- Linearity: 1



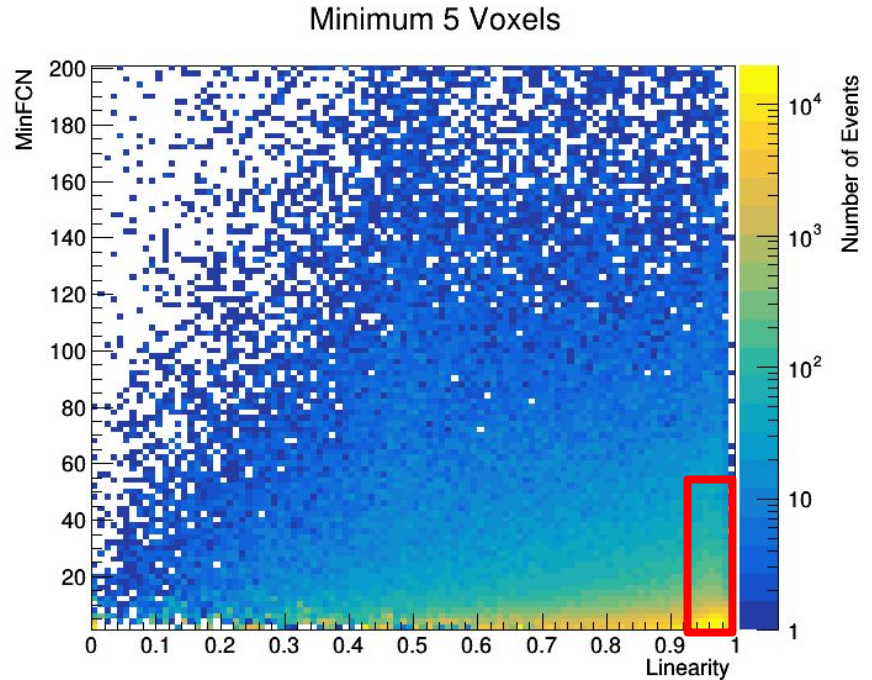
Linearity and MinFcn: Data

- MinFcn is total distance square between voxels and fitted track
- Checked the low linearity end of MinFcn < 50: Planar clusters
- Checked the high linearity end of MinFcn > 100: Straight clusters
- MinFcn by itself is not a good metric for selecting straight tracks

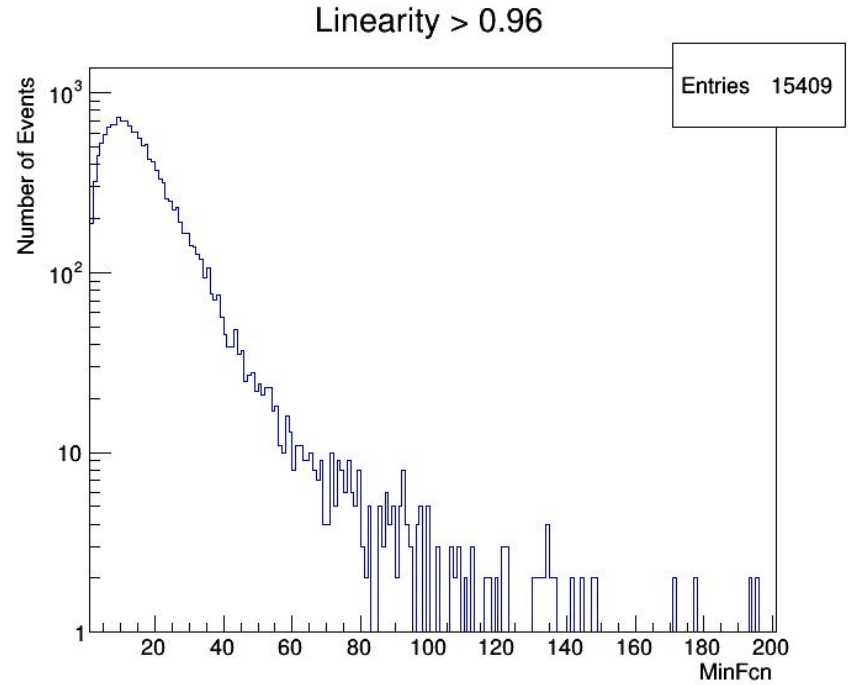
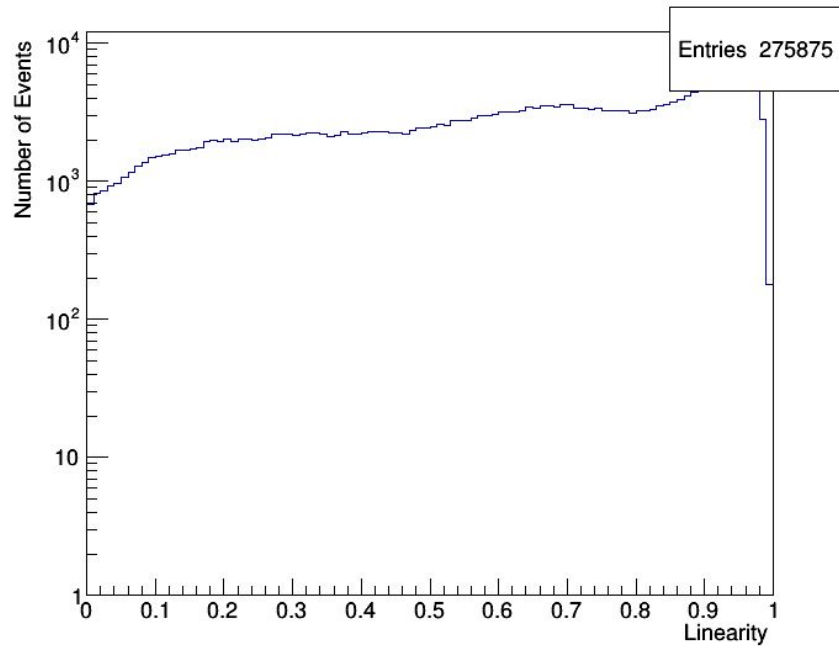


Linearity and MinFcn: Data

- Need to check (by eye scan) if the events in the red box are straight tracks



Linearity and MinFcn: Data



Linearity and MinFcn: Data

- Looked at the combination of linearity from updated PCA and MinFcn
- Eye scanned 200 selected events with linearity > 0.96 and MinFcn < 50 in data
- All of them are straight tracks