DHCAL Track Segment Analysis

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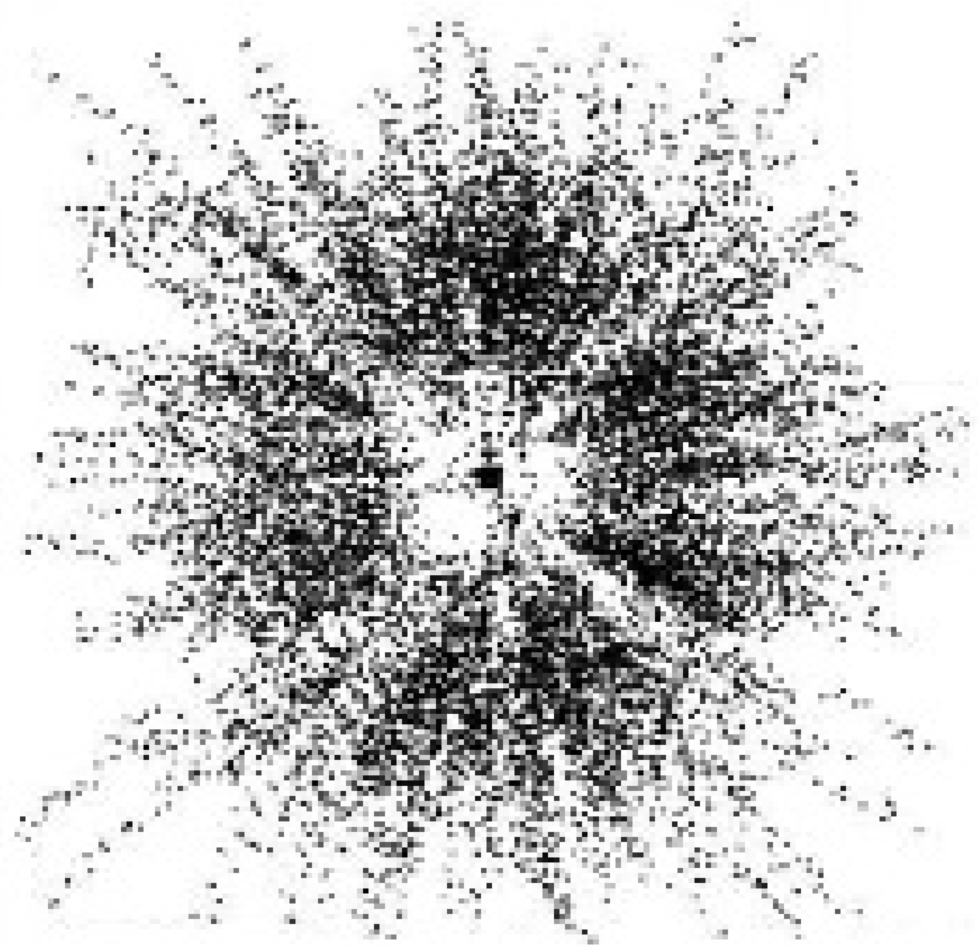
DHCAL Team



Motivation's Report

18 May 2016

AHCAL Paper

Track segments in hadronic showers in a highly granular scintillator-steel hadron calorimeter

CALICE Collaboration

Journal of Instrumentation, Volume 8, September 2013

- Sensitivity to the spatial structure
- Details of secondary particle production in hadronic cascades
- Comparisons with GEANT4 observables
- Possibility for in-situ calibration of highly granular calorimeters

using a seed method

SDHCAL Paper

Tracking within Hadronic Showers in the SDHCAL prototype using Hough Transform Technique

CALICE Collaboration

Paper being finalized

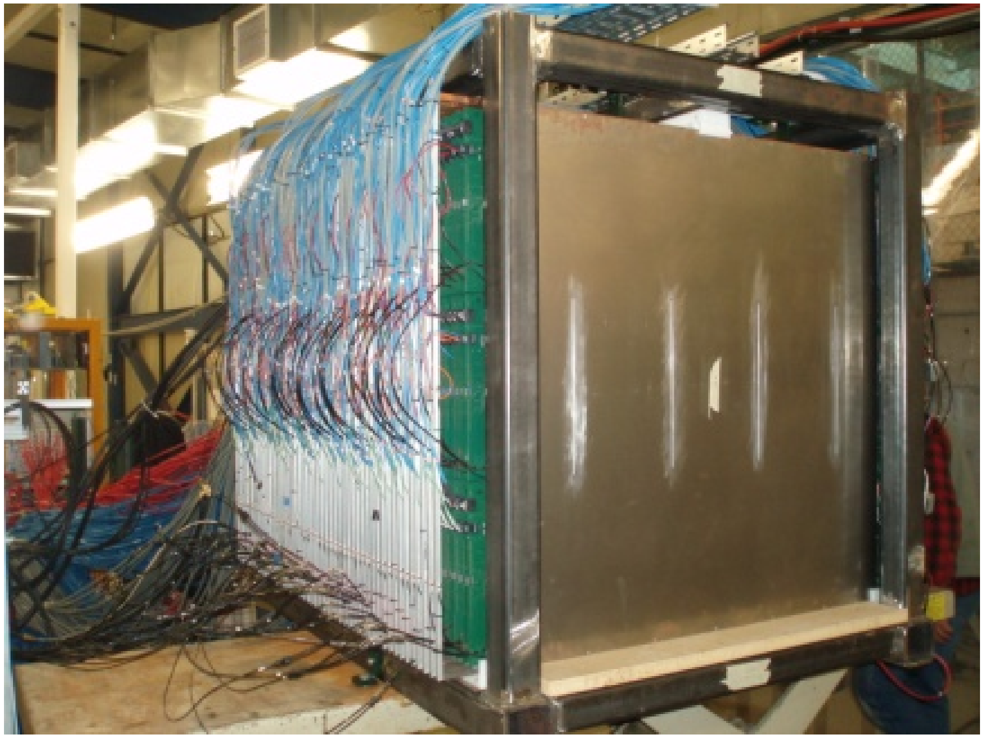
- extract minimum ionising particle tracks using HT method
- determination of the efficiency of the method
- also applied to simulated events, with comparison of results
- tool to probe the behaviour of the SDHCAL active layers in situ

using Hough Transform method

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

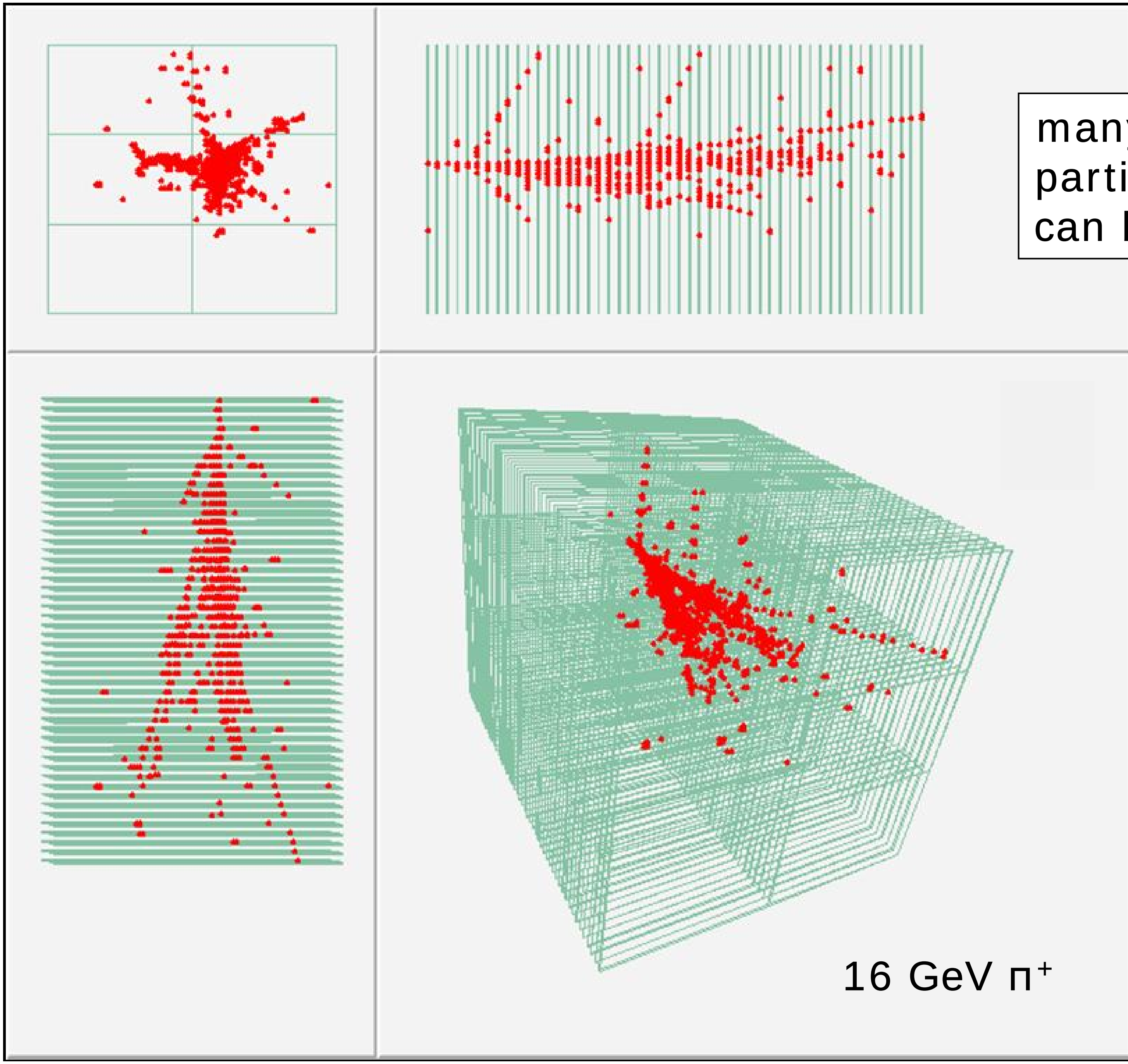
spaced every 25.4 mm

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

High Granularity DHCAL Events



many secondary particle tracks can be identified

Intent

Goal: Use the presence from minimum ionizing tracks from secondary particles to provide an *in situ* calibration of the detector in any part of its volume.

Principle: Each detected particle shower consists of 4 topologic parts:

- incident particle track
- core
- secondary track segments
- outliers

Method: Develop a fast, robust, efficient and reliable algorithm to

- identify those parts from the measured hits
- reject the core and outlier elements
- reconstruct track segments
- use them to determine the calibration

This work: Proof of principle, accuracy estimates to come later.

Connectivity

The Graph Theory approach: (no seed)

Connectivity is defined as the number of hits within some radius of a given hit. Connectivity maps are build: 1st order, 2nd order, etc.. with appropriate weights as function of the radius.

High connectivity points (**core**) and low connectivity points (**outliers**) can be rejected.

Iterative **clustering** is performed with adjacent hits.

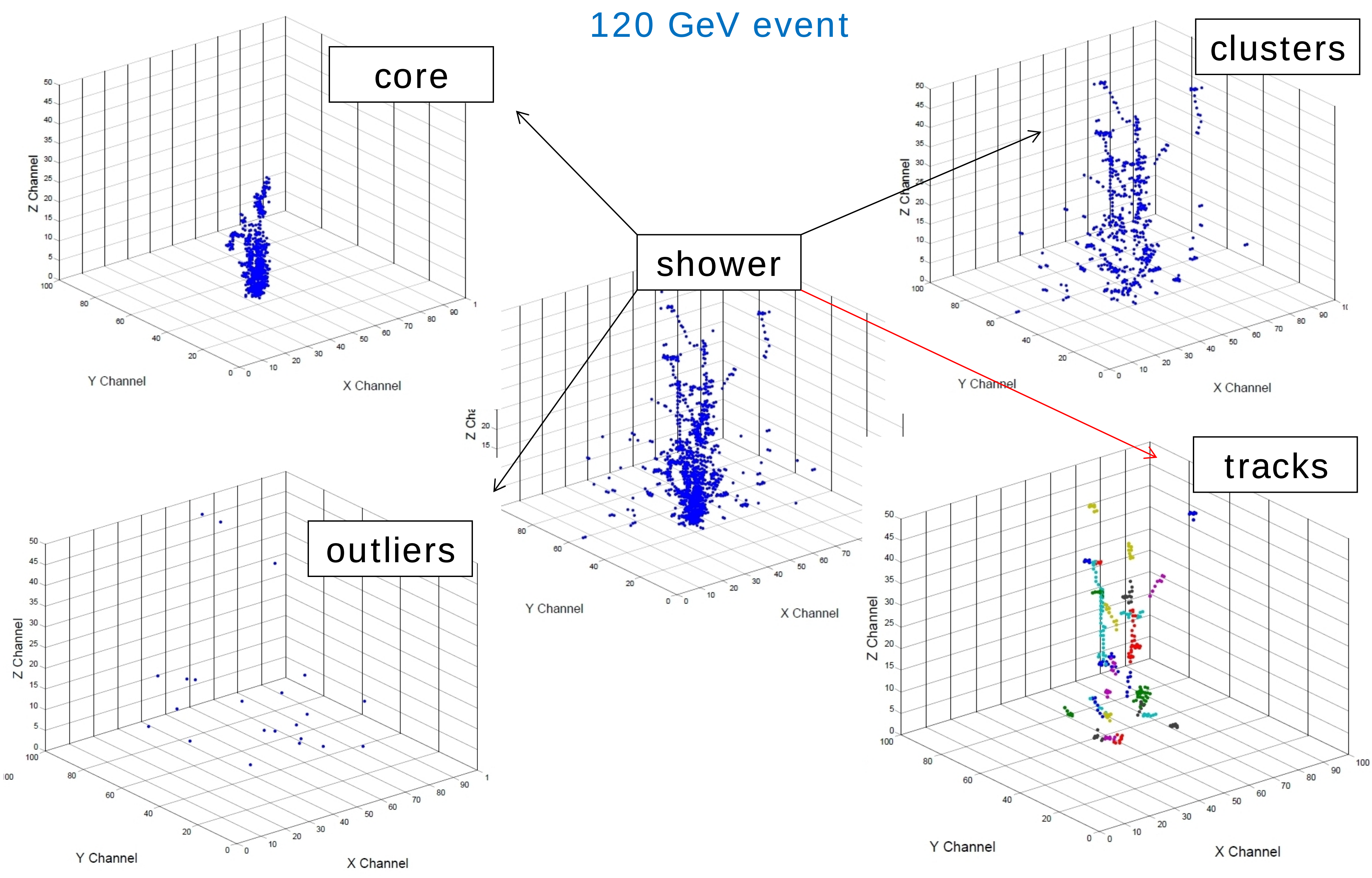
The **inertial tensor** of each cluster is computed:

[as in position and angular resolution analyses (McGill)]

$$I_{xyz} = \begin{pmatrix} \Delta y^2 + \Delta z^2 & -\Delta xy & -\Delta xz \\ -\Delta yx & \Delta x^2 + \Delta z^2 & -\Delta yz \\ -\Delta zx & -\Delta zy & \Delta x^2 + \Delta y^2 \end{pmatrix}$$

Eigenvalues yield direction and "thickness" of each cluster → track

Connectivity - Principles



Connectivity - Calibration

Standard DHCAL muon run calibration is performed first on the data to equalize the response for each RPC *"i"* wrt the whole stack *"0":*

$$c_i = \frac{\mu_i \, \epsilon_i}{\mu_0 \, \epsilon_0}$$

whereby μ is the multiplicity and ε is the efficiency for each RPC.

The connectivity algorithms were enhanced and tuned into the McGill DHCAL event analysis program

.**Variables:** x,y,z = coordinates

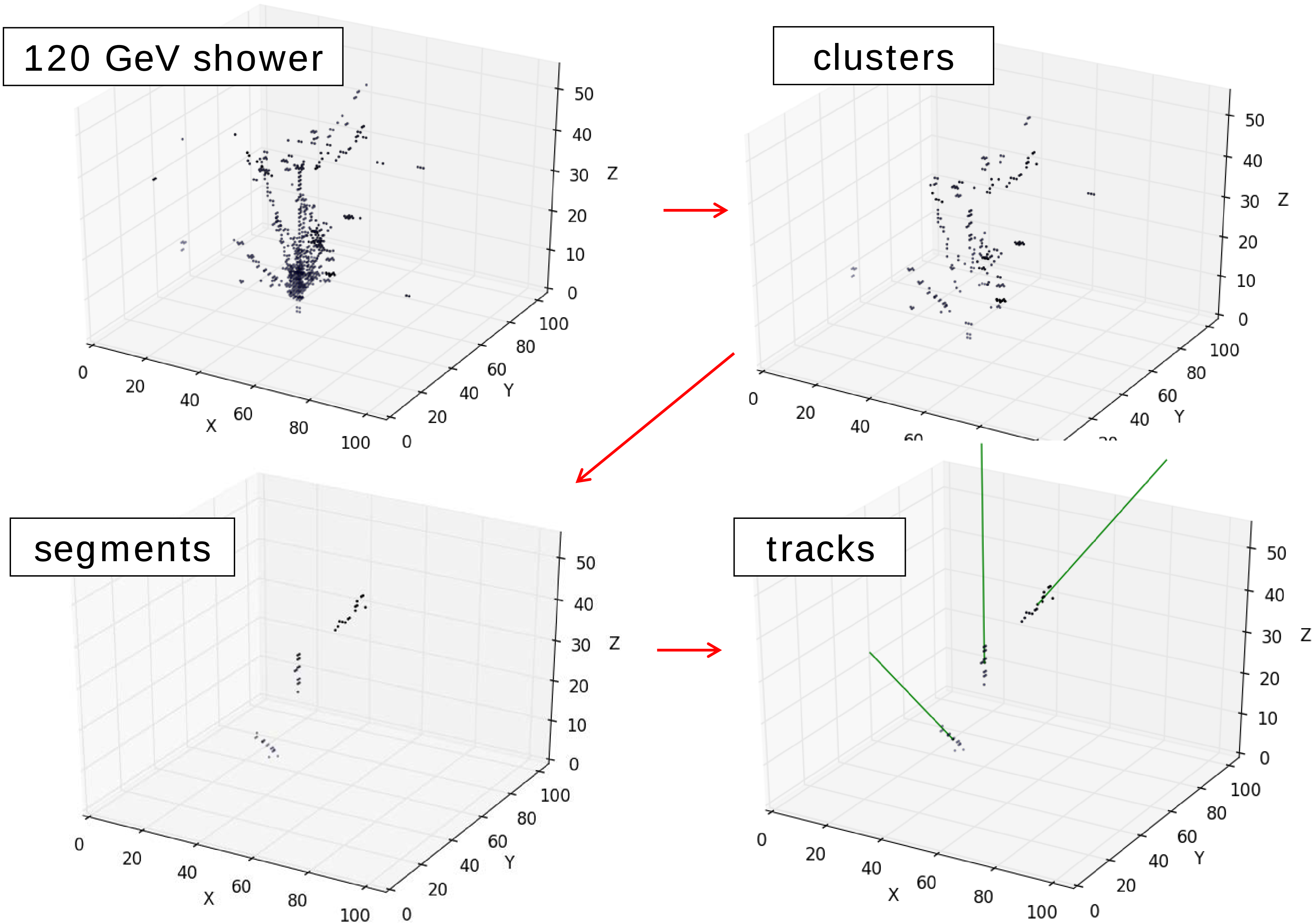
θ = polar angle of segment

φ = azimuthal angle of segment

e_1,e_2,e_3 = eigenvalues of tensor (e_1 smallest: long axis)

e_t = quadratic sum of e_2 and e_3 ("thickness" of segment)

Connectivity - First Results



Status

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

Lots of DHCAL data are available.

Code is being re-written and developped

Angular dependence very important.

The method could be extended to other high granularity detectors.