SPD Physics and MC meeting
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Status of track reconstruction for SPD

V. Andreev (LPI, Moscow)

Introduction

Track reconstruction is usually divided on two separate sub-tasks:

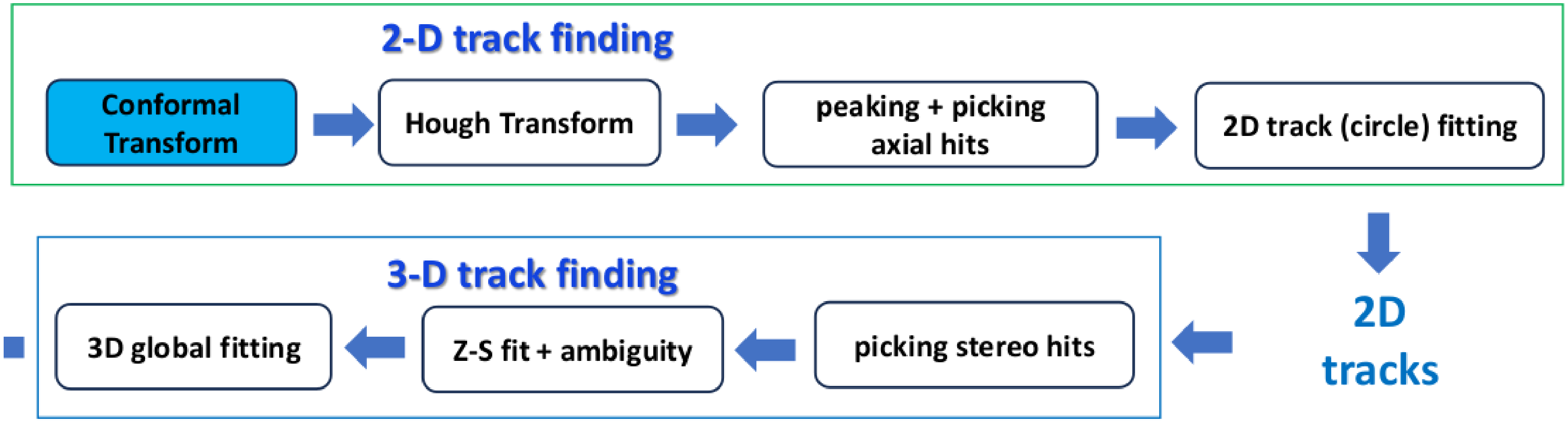
a) track finding (or pattern recognition);
b) track fitting (in general on the base of Kalman filter method).

Track finding:

a) division set of measurements in the tracking detectors (vertex and tracker) into subsets;
b) each subset contains measurements believed to originate from the same particle.

Track fitting - starts with the measurements inside one subset as was provided by the track finder.

General approach



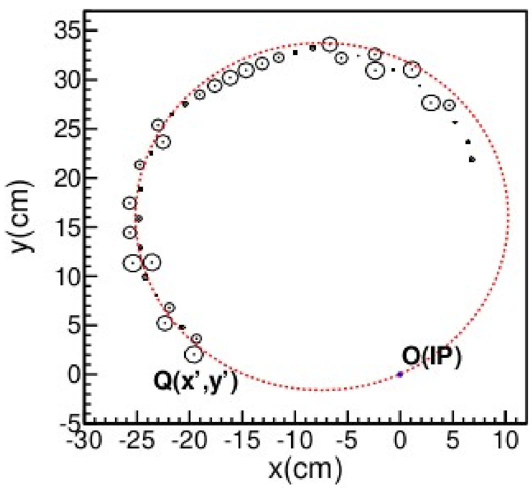
1. Track finding algorithm starts from 2D (x-y plane) :

- use the wire position of fired straw tubes as input;
- apply conformal and Hough transformations;
- consider z-axial straw tubes and find peaks;
- provide 2D circle fitting;
- picking stereo hits (hits from tilted straw tubes);
- estimation of z and phi of track candidate;
- finally apply 3D Kalman fitting.

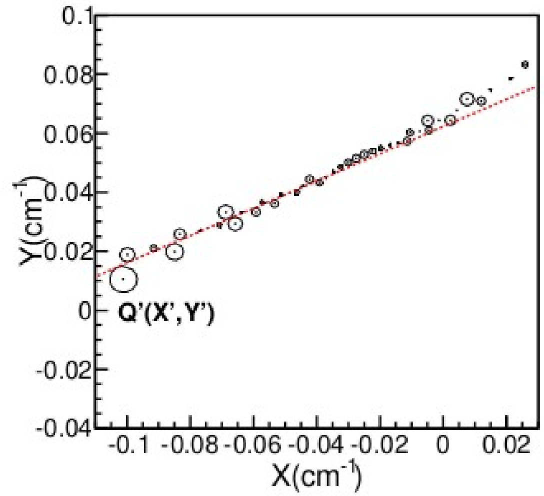
Hough Transformation

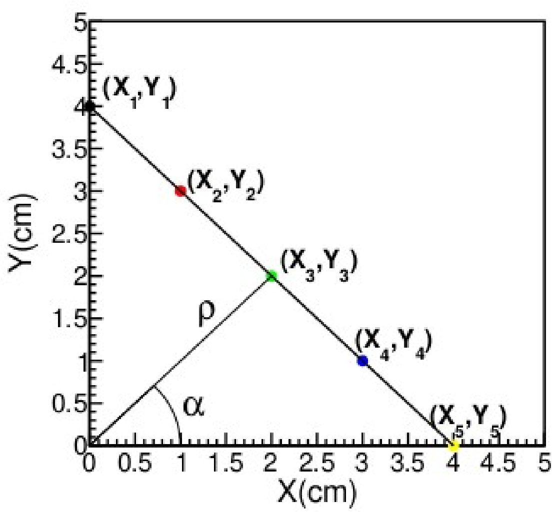
2-D track finding

Conformal Transform → **Hough Transform** → **peaking + picking axial hits** → **2D track (circle) fitting**



$$X = \frac{2x}{x^2 + y^2}, Y = \frac{2y}{x^2 + y^2}$$

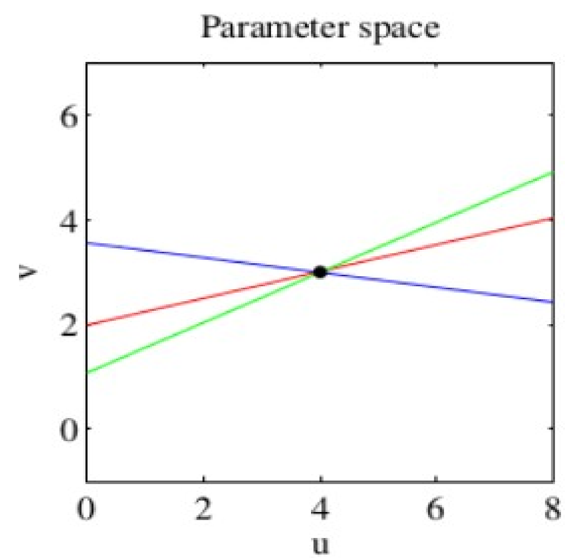




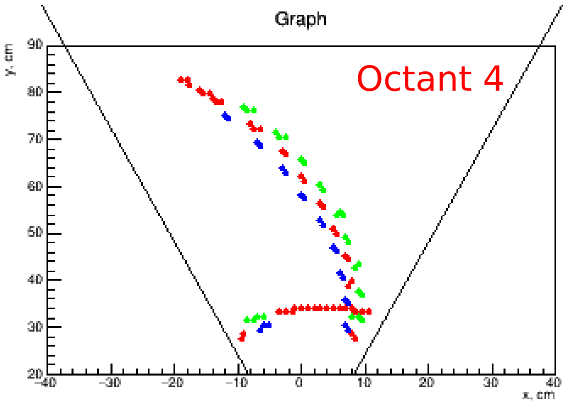
Hough transformation

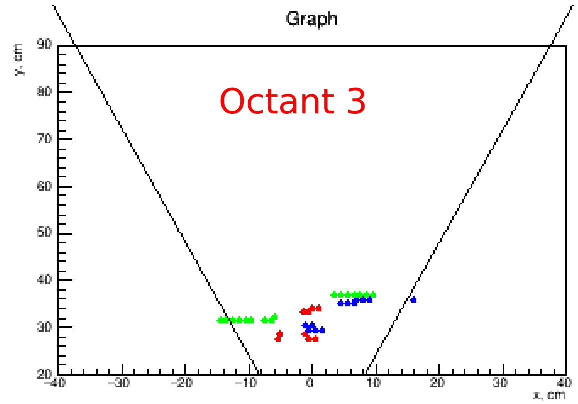
(each point is line in parameter space)

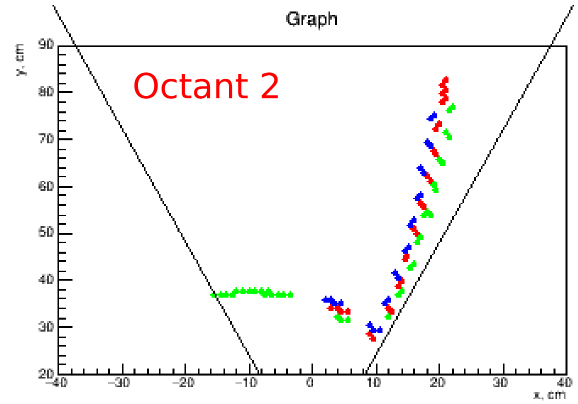
$v = a * u + b$



Event example



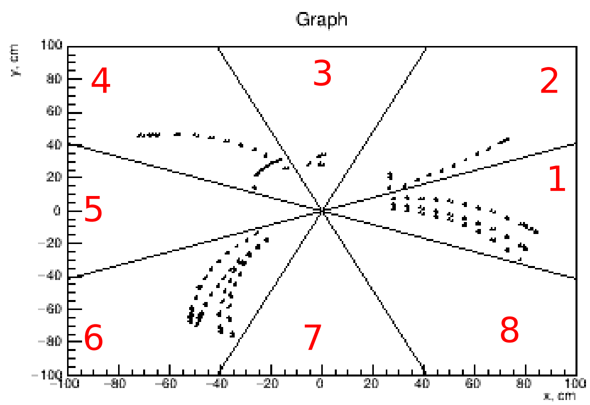


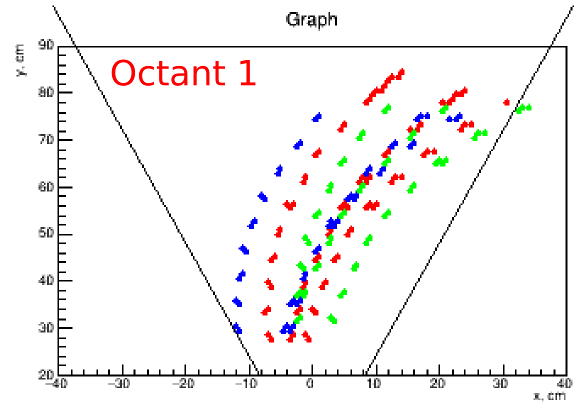


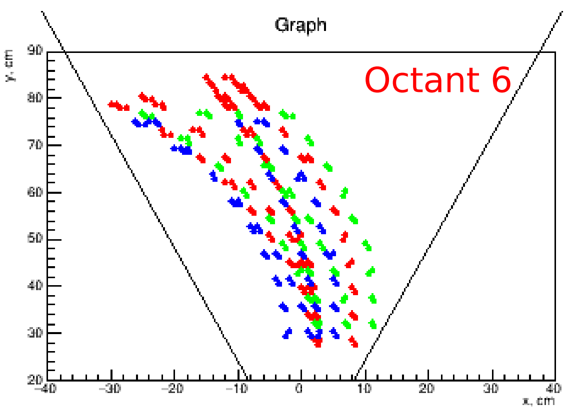
Red points – hits in straw parallel to z-axis

Green points – hits in straw tilted on +3^0

Blue points – hits in straw tilted on -3^0

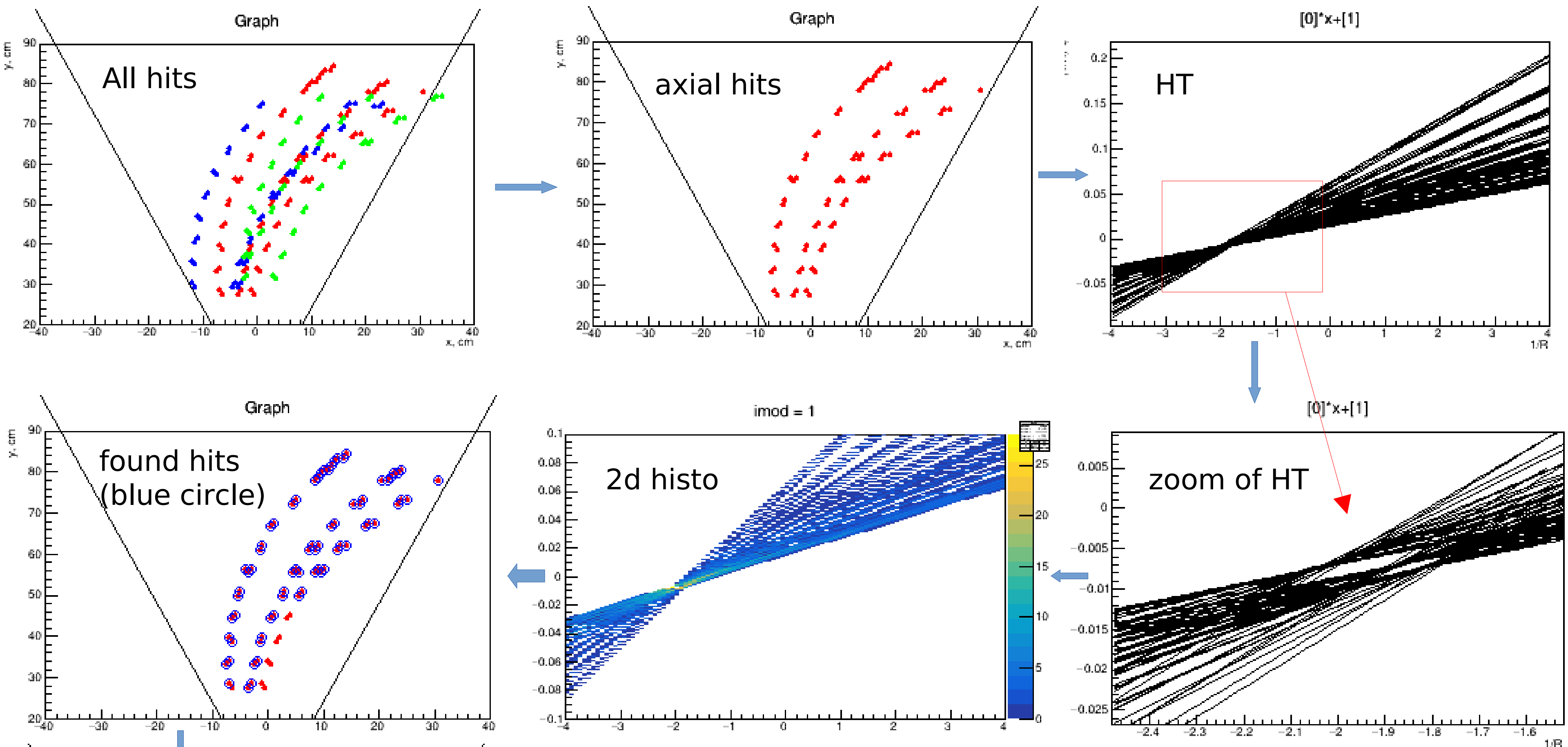


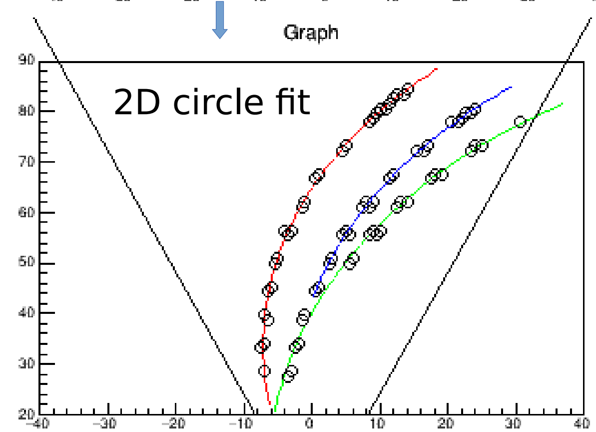




1. Use PYTHIA8 with open charm production option at $\sqrt{s}$ = 27 GeV as testing event sample
2. Middle plot presents fired z-axial straw tubes in XY - projection
3. Transform (only rotate) global coordinate of straw tubes to the local coordinates system (or coordinates which coincide with system of Octant 3)
4. All further consideration will be done in local coordinate

2D track finding (Octant 1)

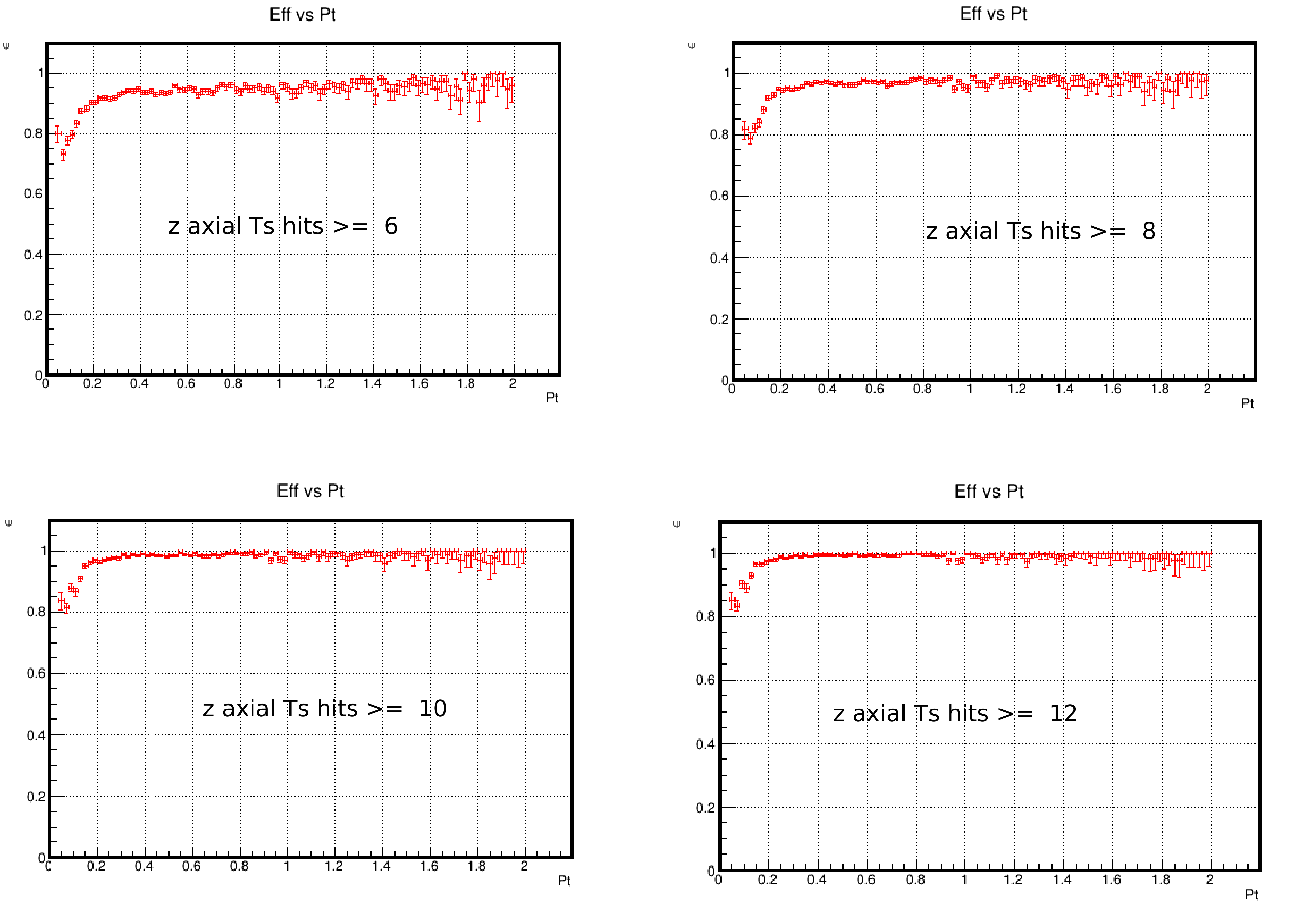




Track finding algorithm starts from 2D (x-y plane) :

1) go from global coordinate system to local system (module = 3);
2) use hits in straw trackers as input (or fired straw tubes);
3) use only z-axial hits (straw which are parallel to z-axis);
4) apply Hough Transformation;
4) construct 2D histogram
5) find peaks on 2D histogram and select axial hits;
4) 2D circle fitting;

2D finding efficiency

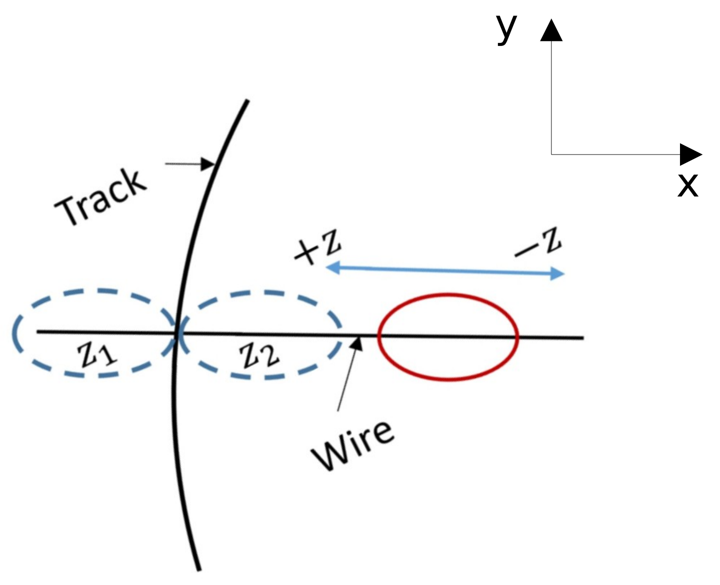


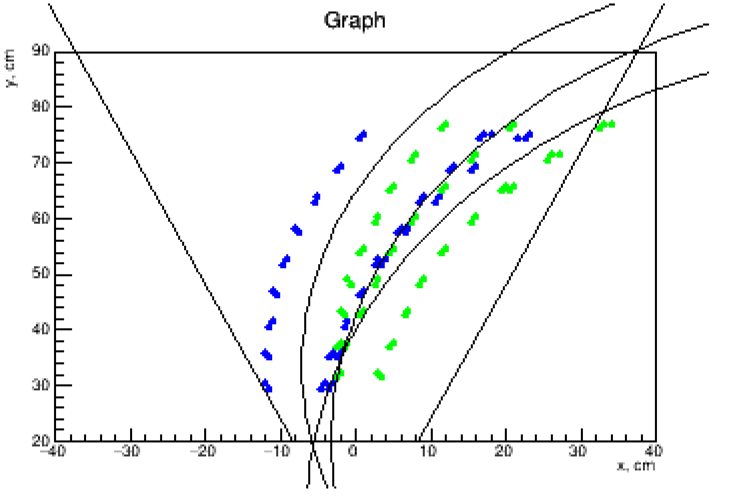
Longitudinal track reconstruction

1. Charge particle trajectory in constant magnetic field is helix which can be described:

   a) in XY plane as circle with radius $R = PT / 0.3 \cdot B$;

   b) z-coordinate is the function of arc length (s), $z(s) = z0 + s \cdot \tan\lambda$, where $s = (\Phi - \Phi 0) \cdot R \cdot q$,
   Φ – azimuthal angle, λ – dip angle, z0 and $\Phi 0$ – track parameters in starting point or in primary vertex





Blue and green points are straw tubes position of tilted tubes in XY-plane

2. The z-position for each hit in a tilted straw tube is extracted through an alignment procedure as illustrated below. The track radius is determined before by the pattern recognition procedure in XY-plane.

   Since these tubes are tilted, the projection of the drift radius onto the XY-plane becomes an ellipse. The drift ellipse is aligned such way that its center position lies along x-axis of layer and is tangential to the particle trajectory.

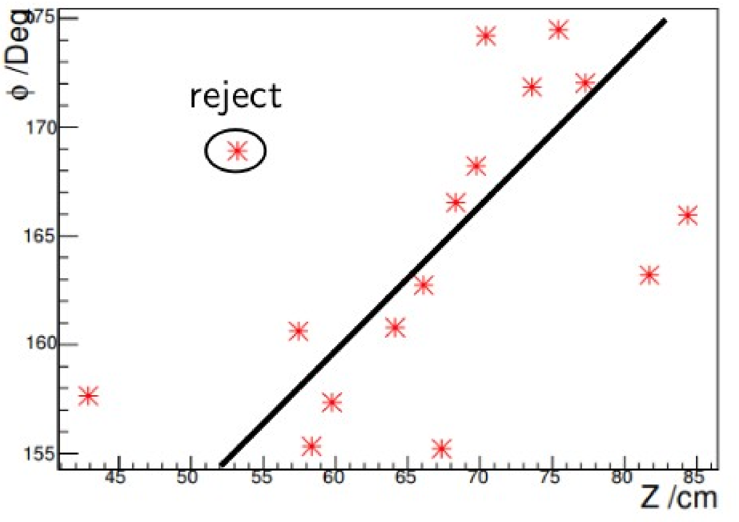
   This alignment provides two solutions, introducing a left/right ambiguity with one solution on each side of the trajectory

Longitudinal track reconstruction (2)

Recursive annealing fit:

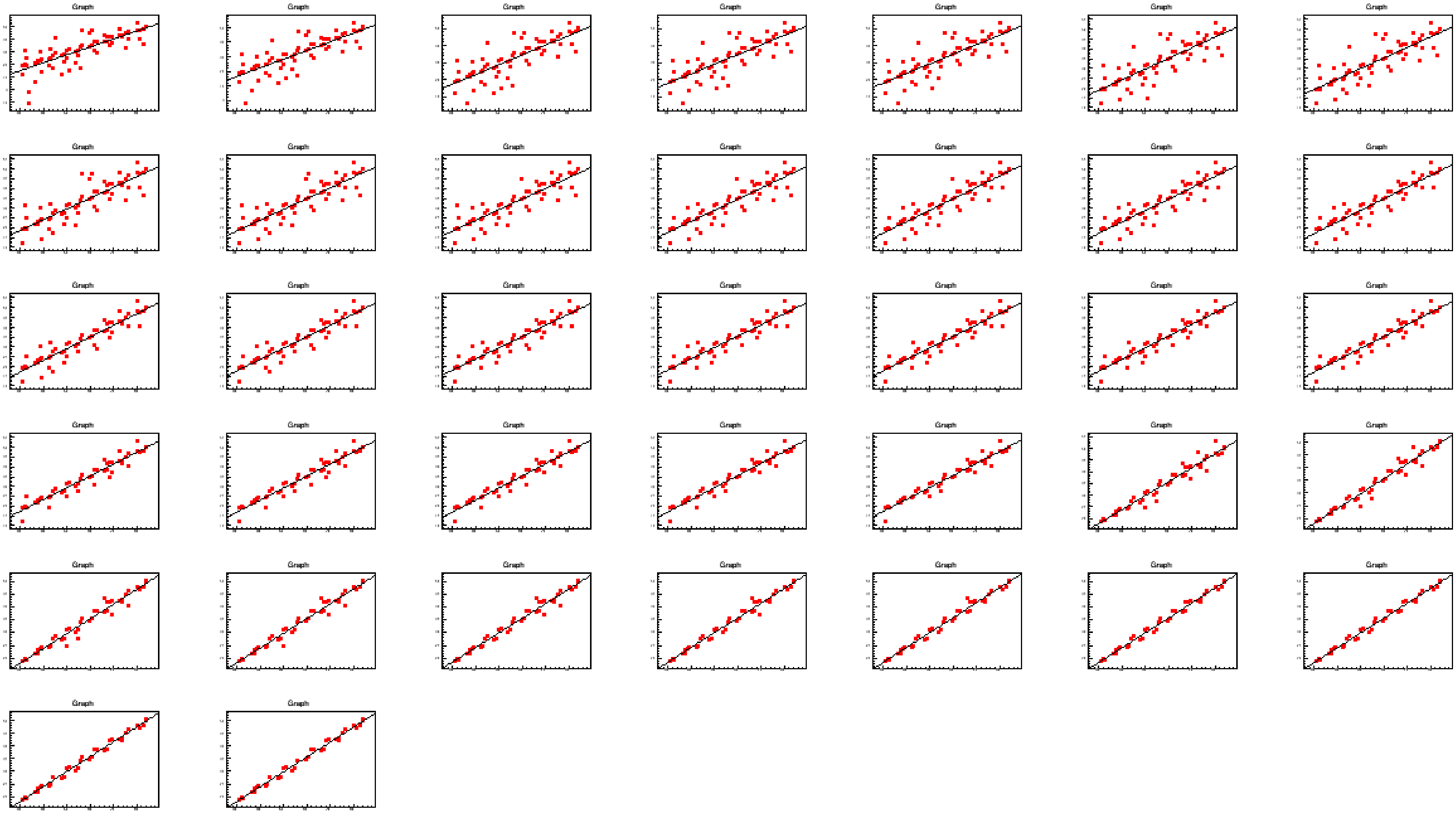
a) fit by line to all points;
b) remove point with largest residual;
c) calculate new line fit;
d) repeat until one point has been rejected for each straw tube;
e) do final line fit.

$$\chi^2 = \sum_i^n \frac{(z_i - kS_i - z_0)}{\sigma_i^2},$$

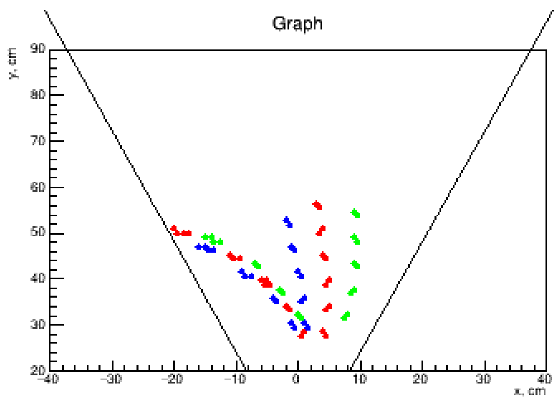


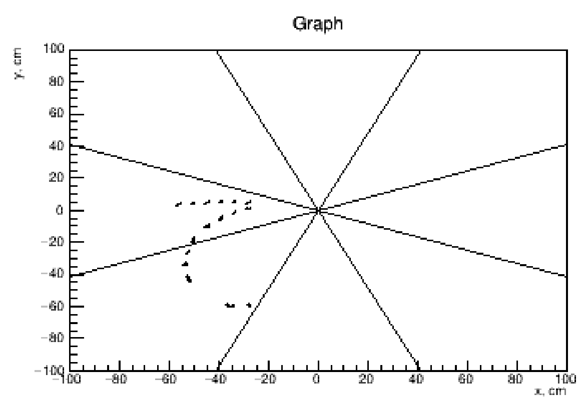
Recursive annealing fit is used in our case.

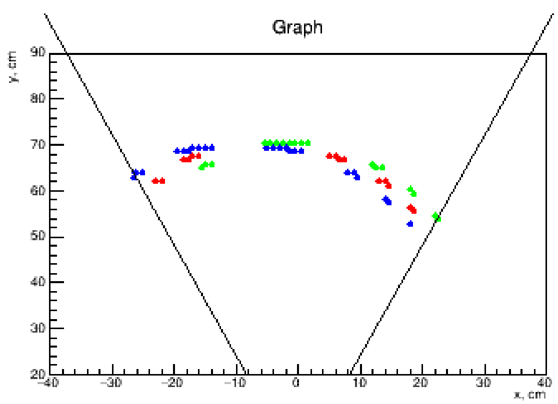
Example of recursive fit



Another event example
(only 1-st generation tracks)







Another event example
(all generation tracks)

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Green points – hits in straw tilted on +3^0

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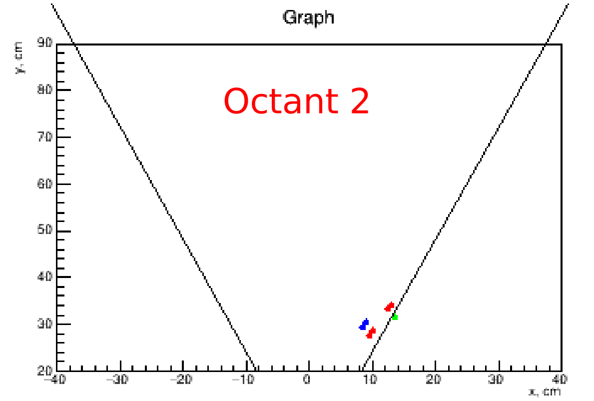
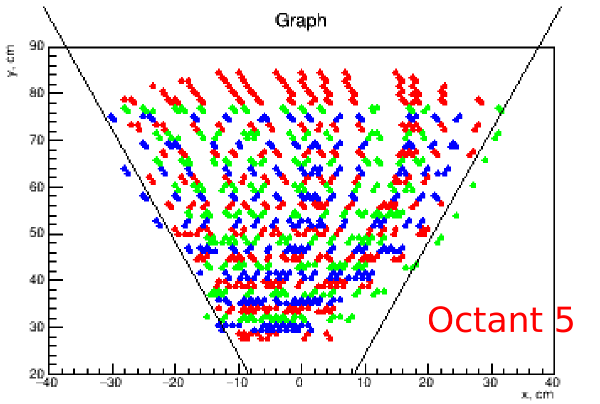
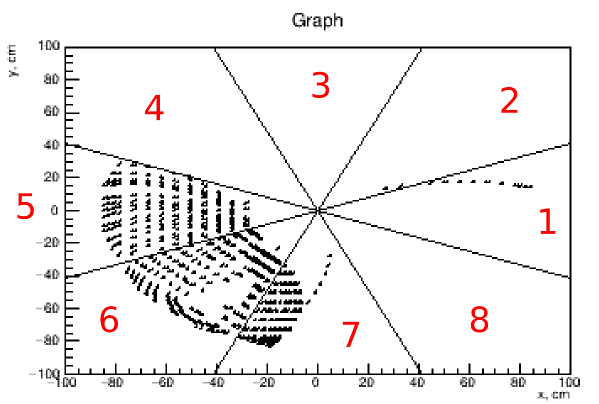
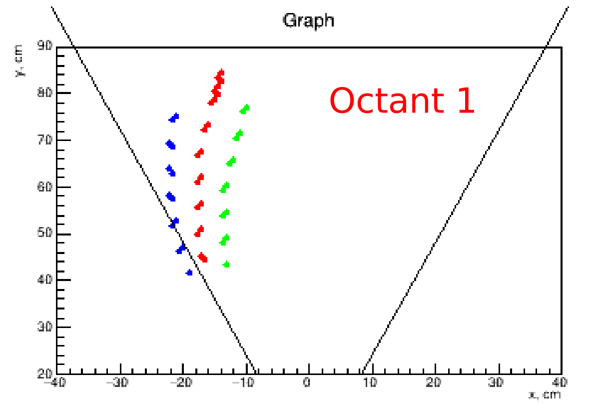
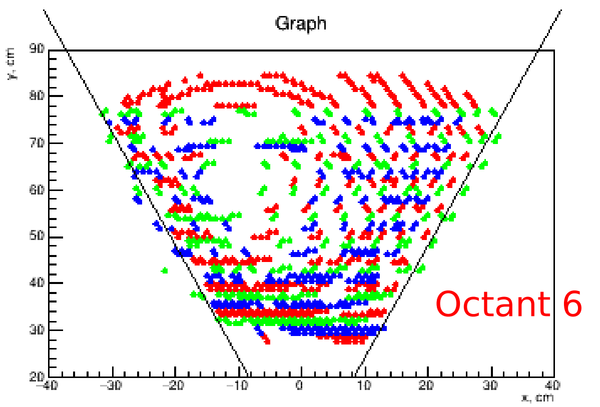
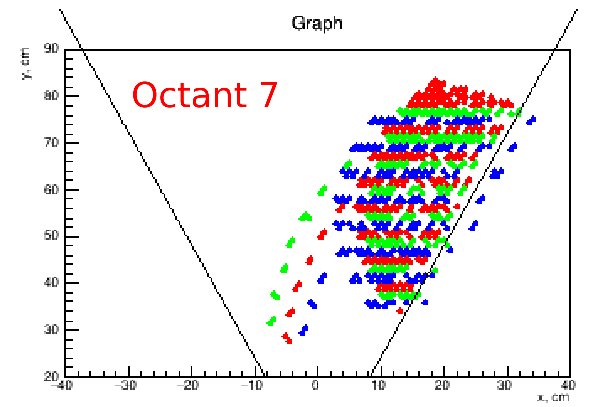




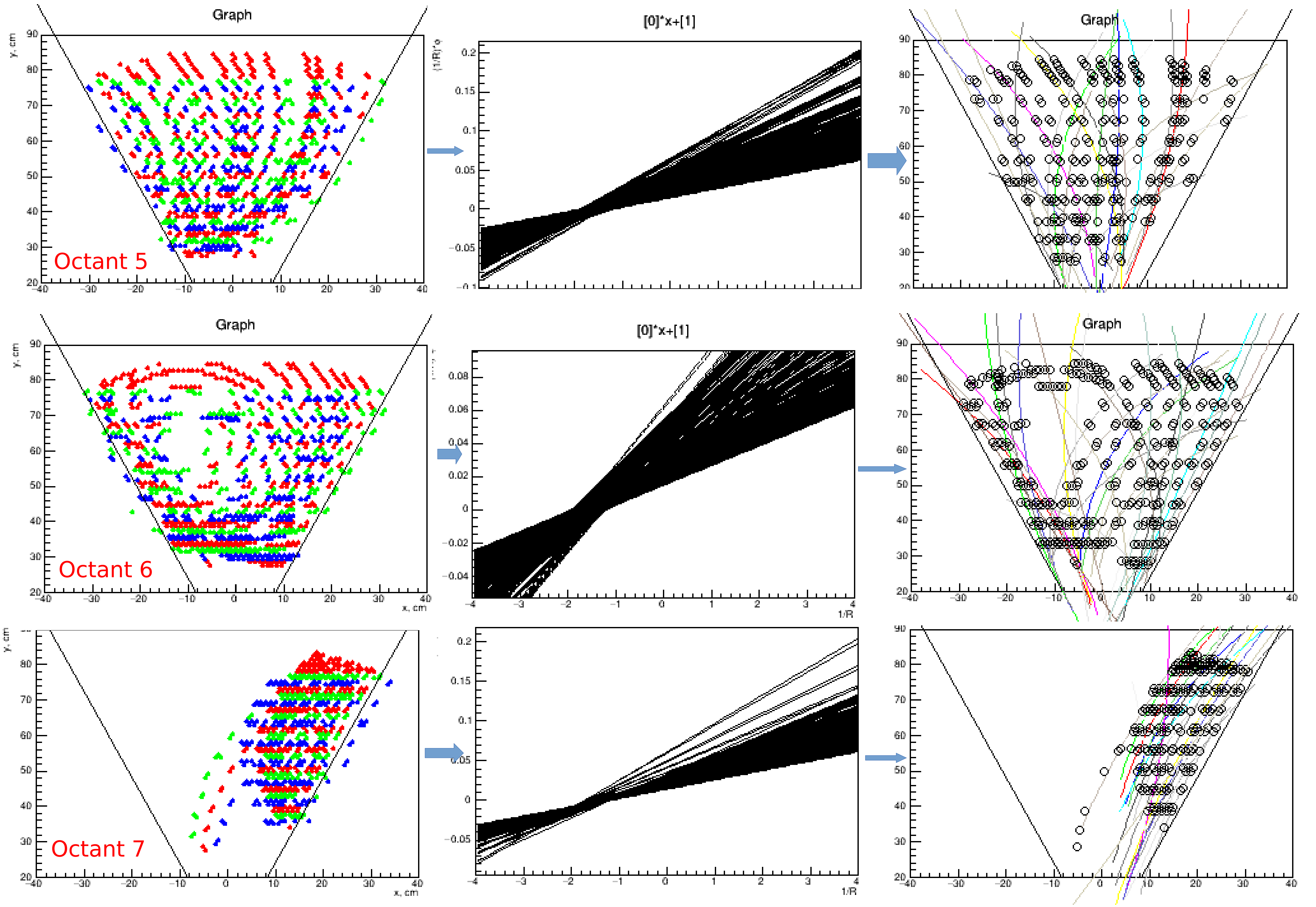




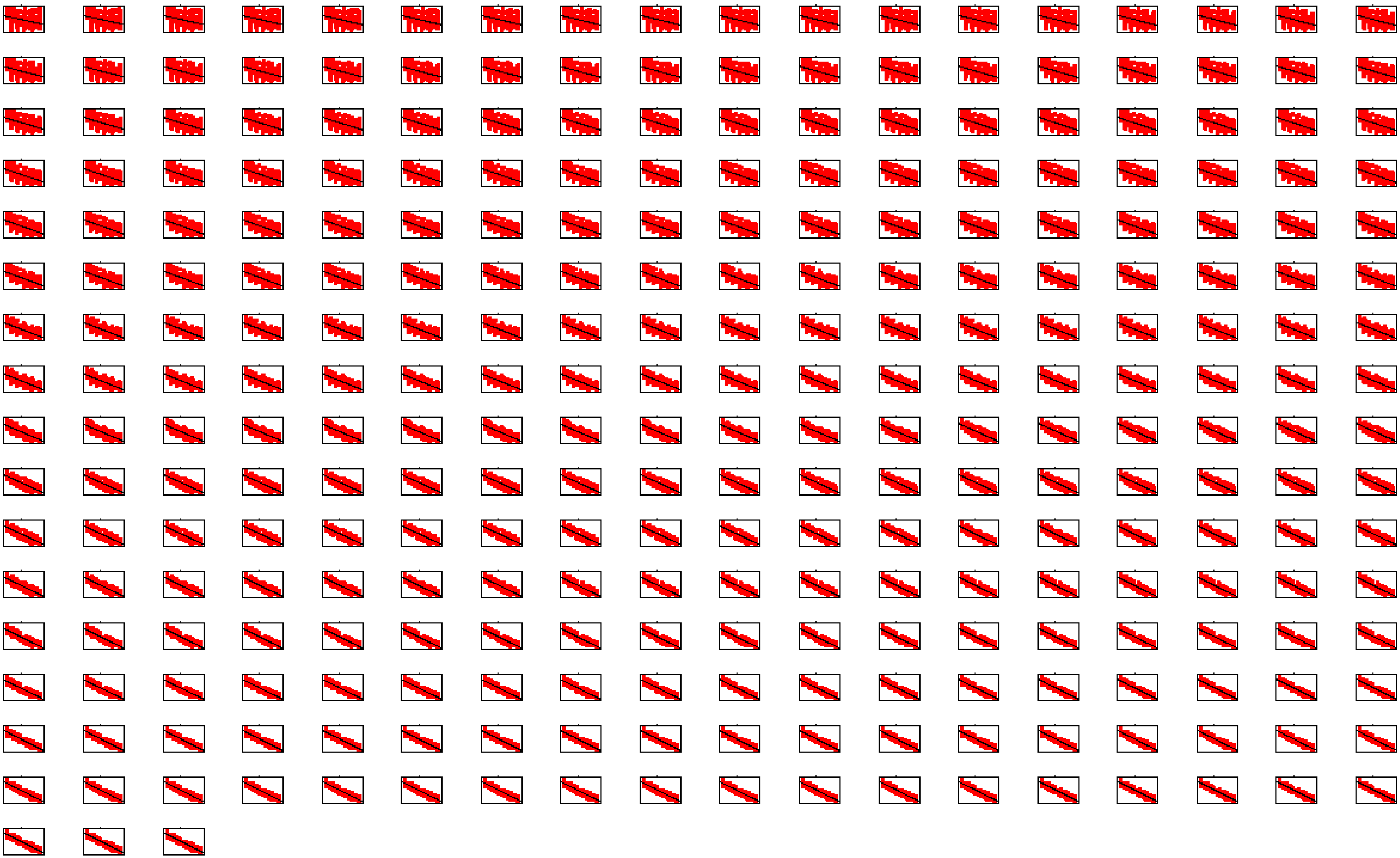




Another event example (2)



Another event example (longitudinal track finding)



3D global fitting

This longitudinal hits finding procedure provides the next track candidate parameters:

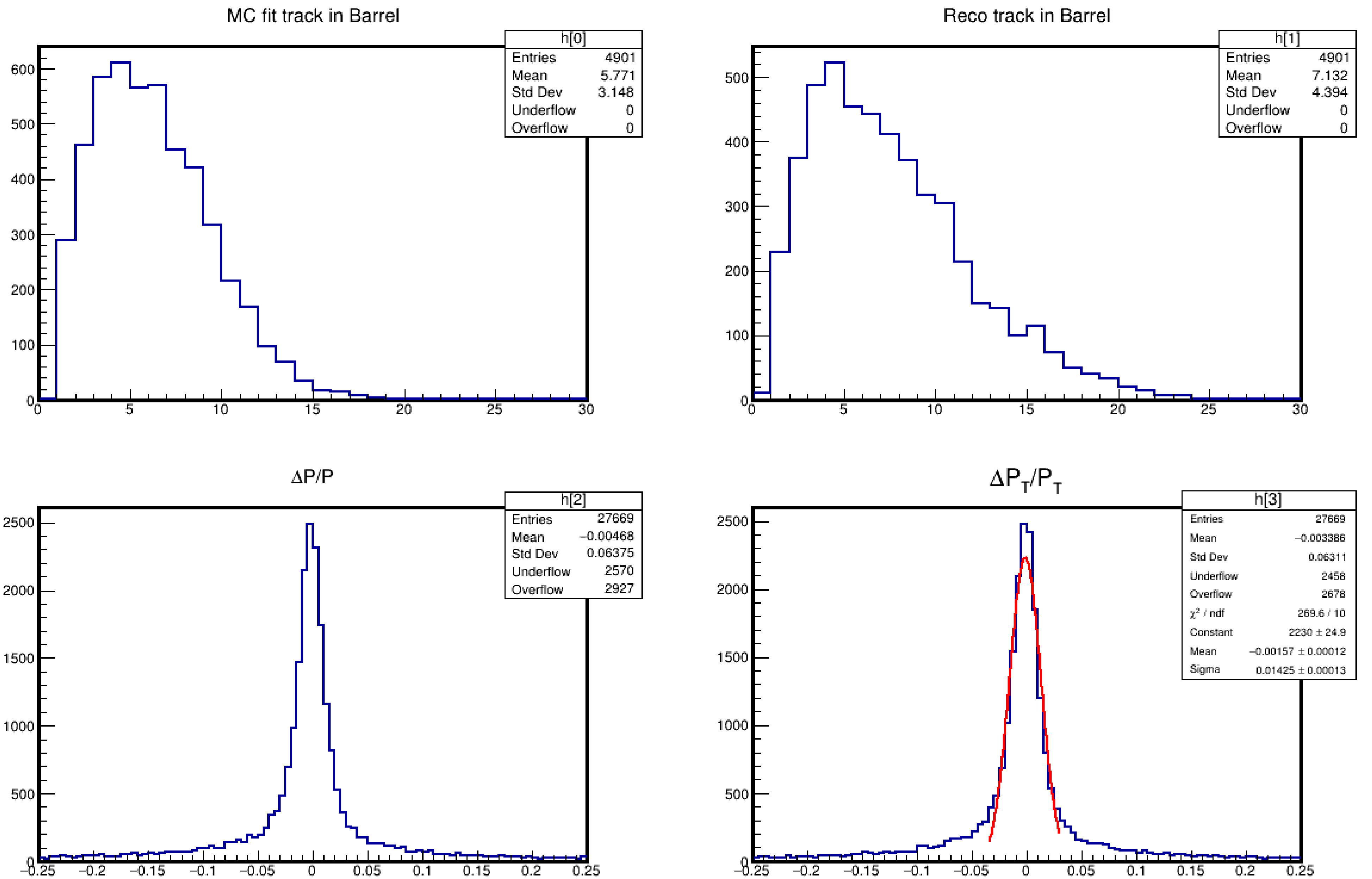
a) tilted hits which are belong to the considered track candidate;
b) estimation of theta and phi angles;
c) estimation of primary vertex position or track position at the first point.

Last step of reconstruction is the fitting procedure of track candidates:

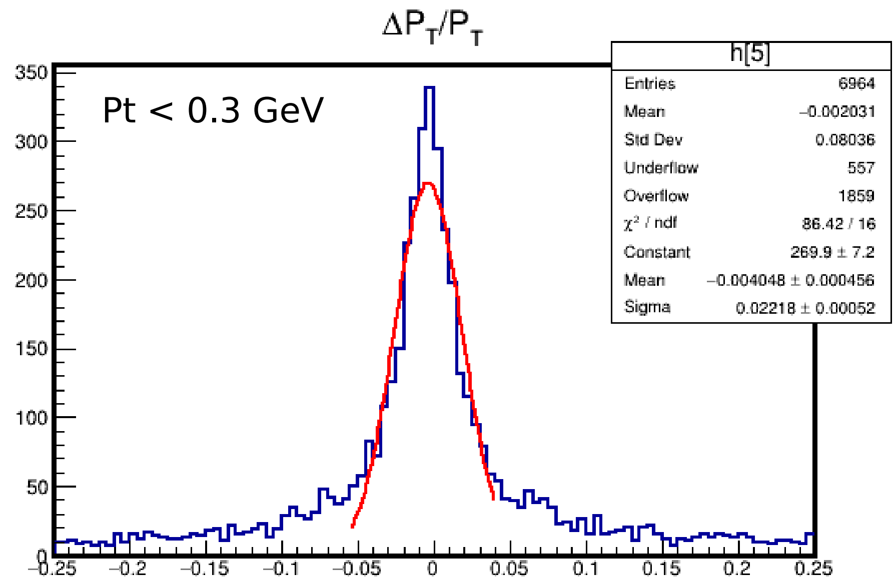
a) we have set of straw tubes (or hits) which are belonged to the track candidate;
b) estimated position of 1-st track point;
c) estimation of track momentum (Px, Py, Pz) at the 1-st track point (or in the primary vertex);
d) then standard SPD fitting procedure (on the base Kalman filter from Genfit2) can be applied.

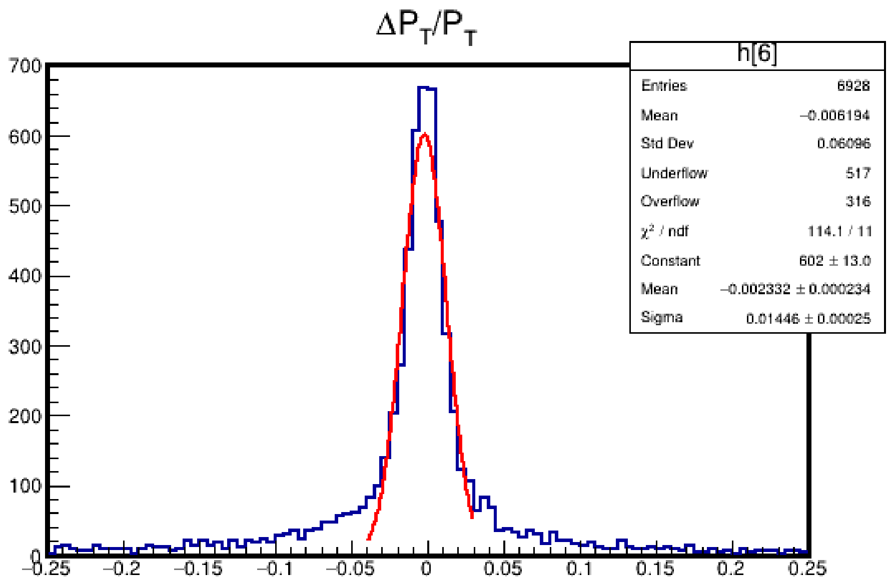
Conclusion – track reconstruction procedure using the only straw detector works.

Track reconstruction
(only 1-st generation, Ts hits > 6)

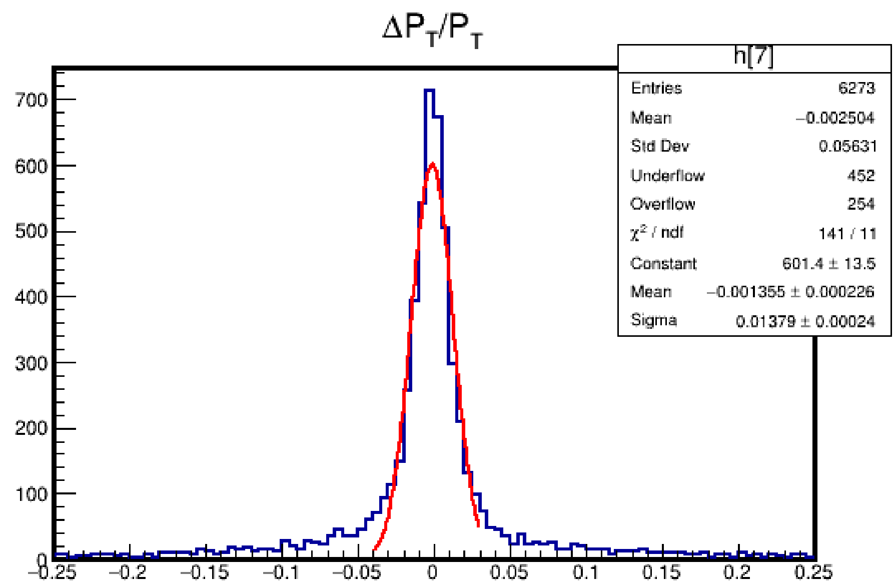


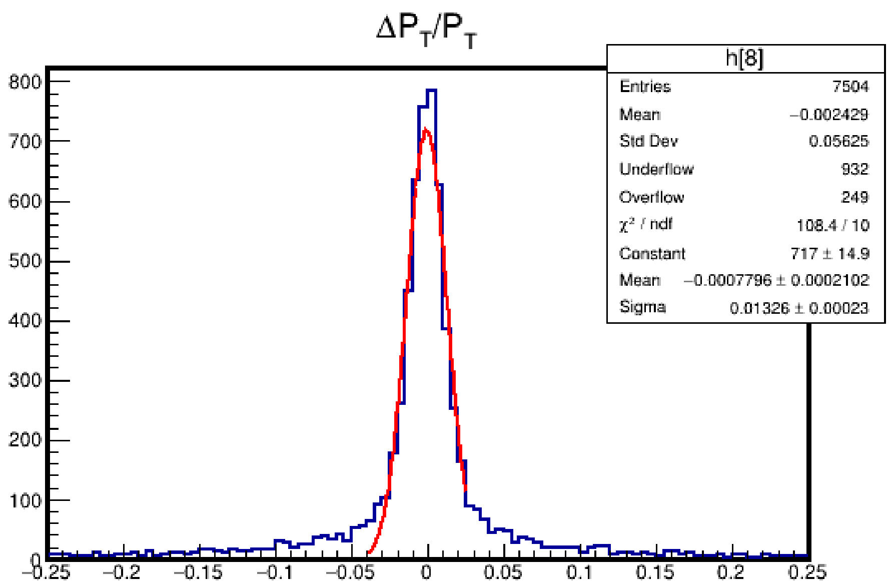
Reconstruction track
(only 1-st generation)





0.3 GeV < Pt < 0.45 GeV

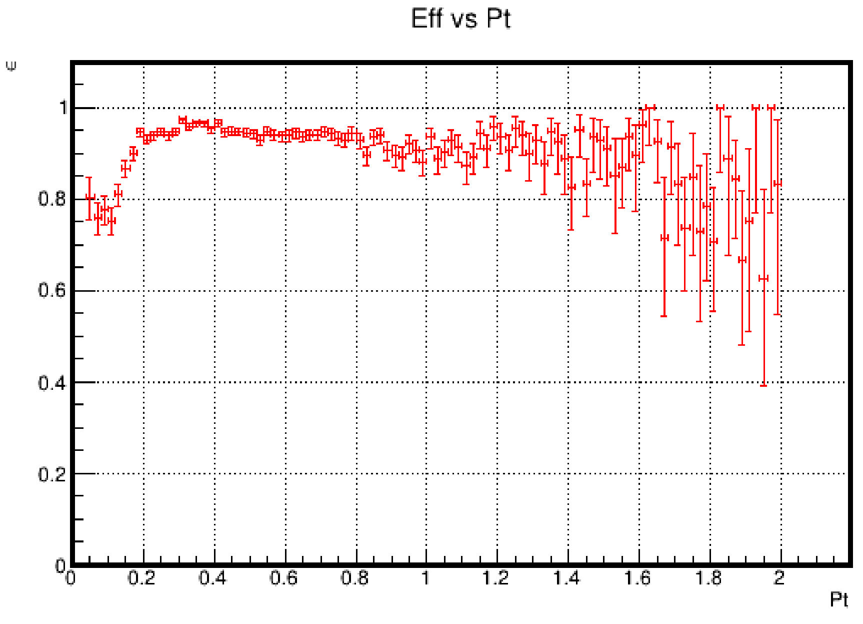


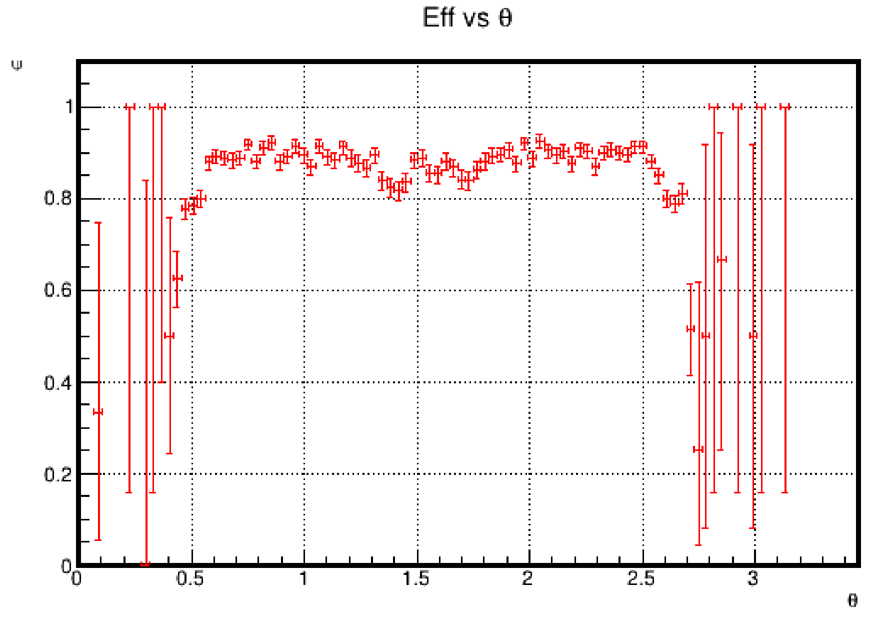


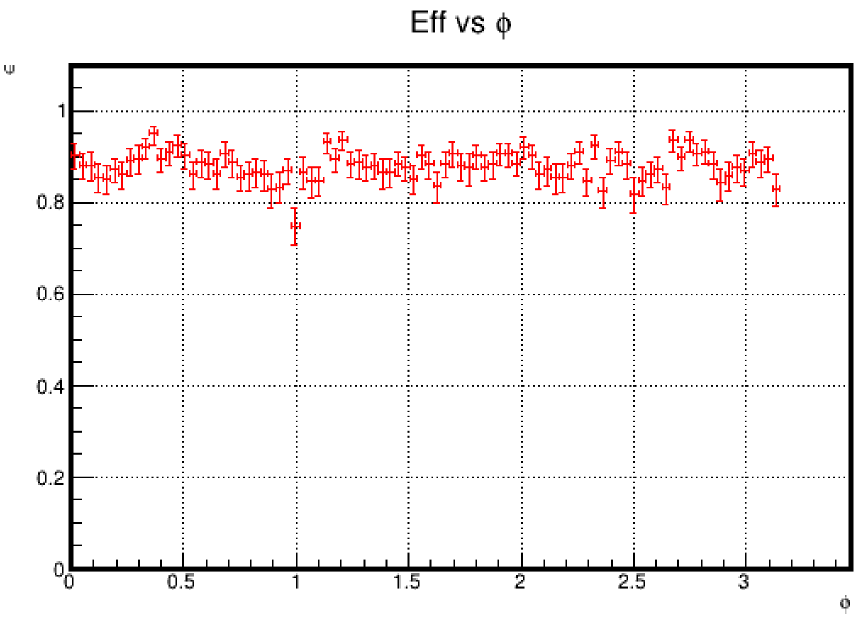
0.45 GeV < Pt < 0.65 GeV

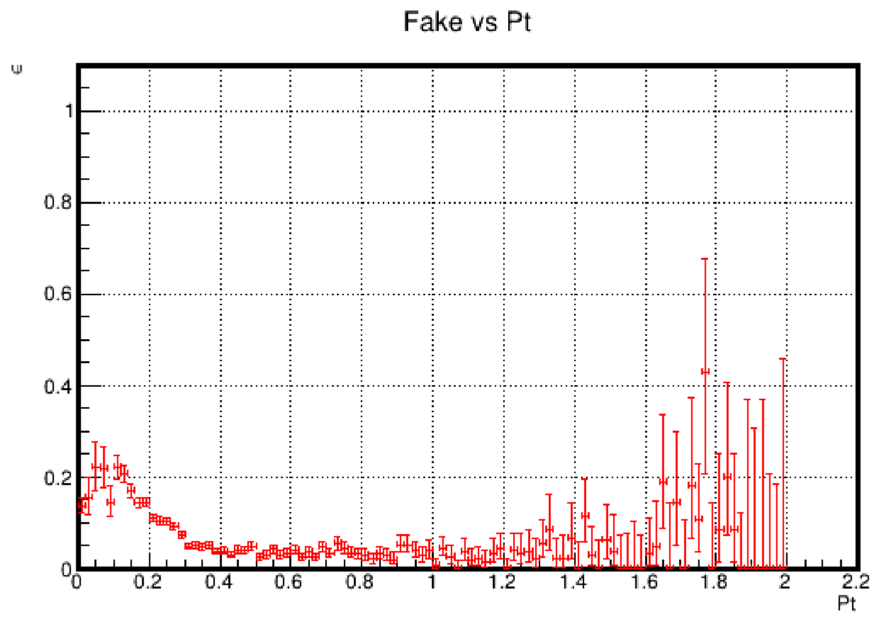
Pt > 0.65 GeV

Reconstruction efficiency
(only 1-st generation)

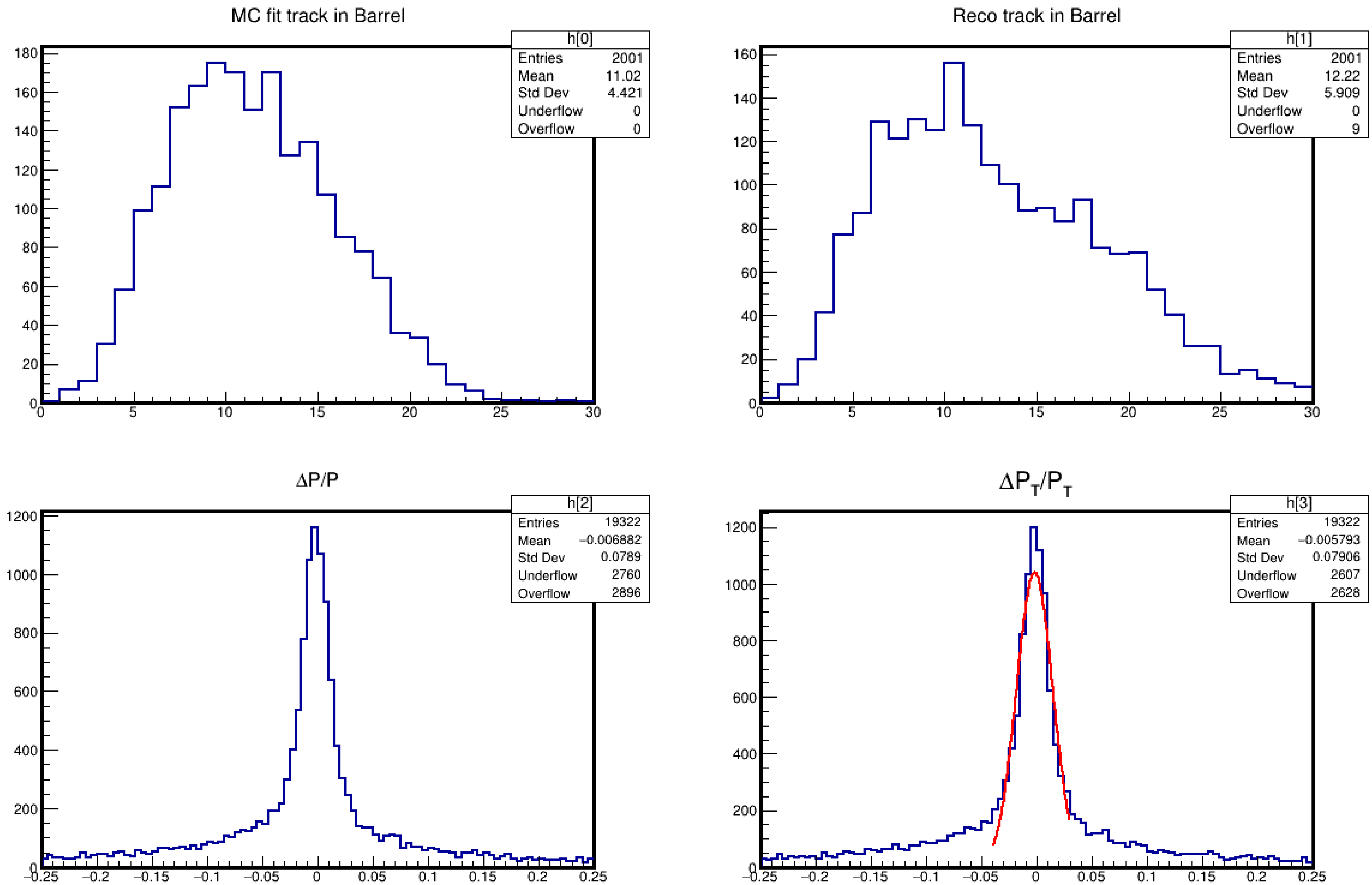




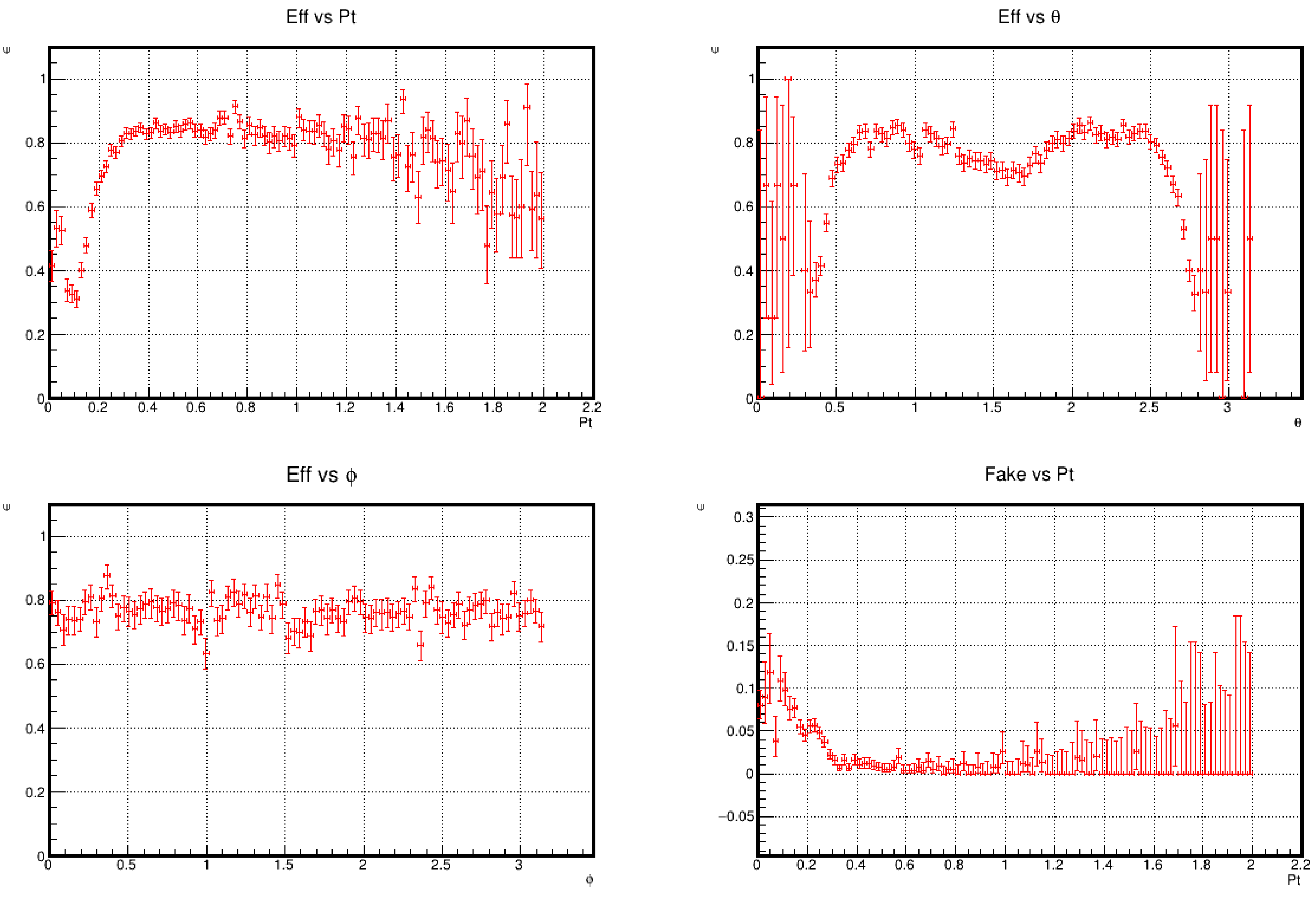




Track reconstruction (all generation)



Reconstruction efficiency (all generations)



Summary

1. General schema for track reconstruction works.

2. It provides relatively good track reconstruction efficiency.

3. Need to check some points and tune the reconstruction procedure.

4. Preliminary conclusion - present tracker geometry is “acceptable” for the track reconstruction using only straw tracker.