Hough method for pattern recognition
(inspired by Matteo's work)

- characterizing single clean tracks
- two-steps search for track segments in a module
- first trial on beam events

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signature of a single isolated track

$$Z = \frac{\sum q_i z_i}{\sum q_i} \qquad Y = \frac{\sum q_i y_i}{\sum q_i}$$

$$S_{zz} = \frac{\sum q_i (z_i - Z)^2}{\sum q_i} \quad S_{yy} = \frac{\sum q_i (y_i - Y)^2}{\sum q_i} \quad S_{zy} = \frac{\sum q_i (z_i - Z)(y_i - Y)}{\sum q_i}$$

$$\Delta = \sqrt{(S_{zz} - S_{yy})^2 + 4S_{zy}^2}$$

$$A_1 = \sqrt{(S_{zz} + S_{yy} + \Delta)/2} \qquad A_2 = \sqrt{(S_{zz} + S_{yy} - \Delta)/2}$$

A_1 is related to the longitudinal extension (main axis), A_2 to the transverse one

criterion for a single weakly curved track: A_2 is small

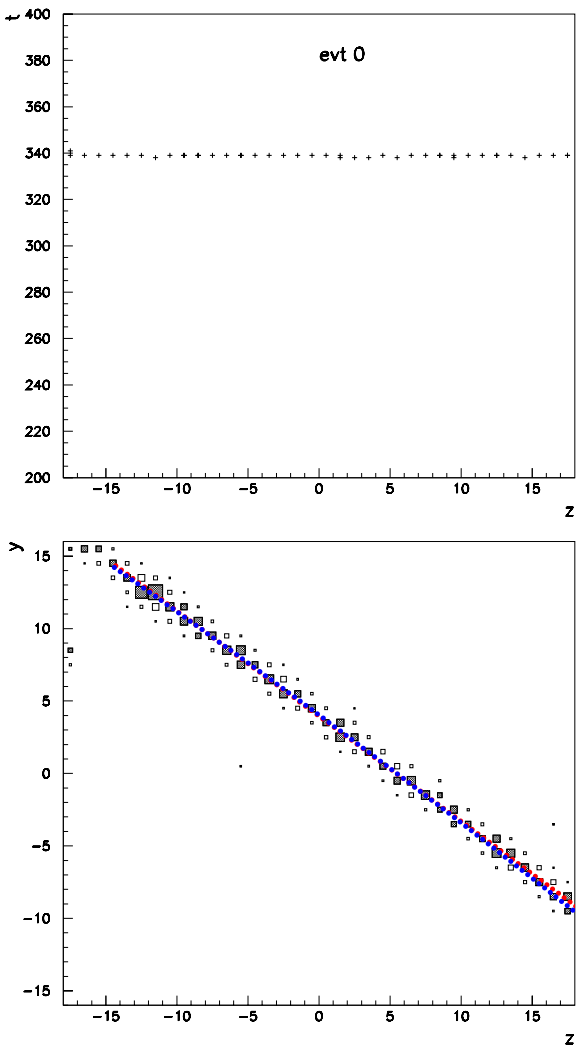
refinements:

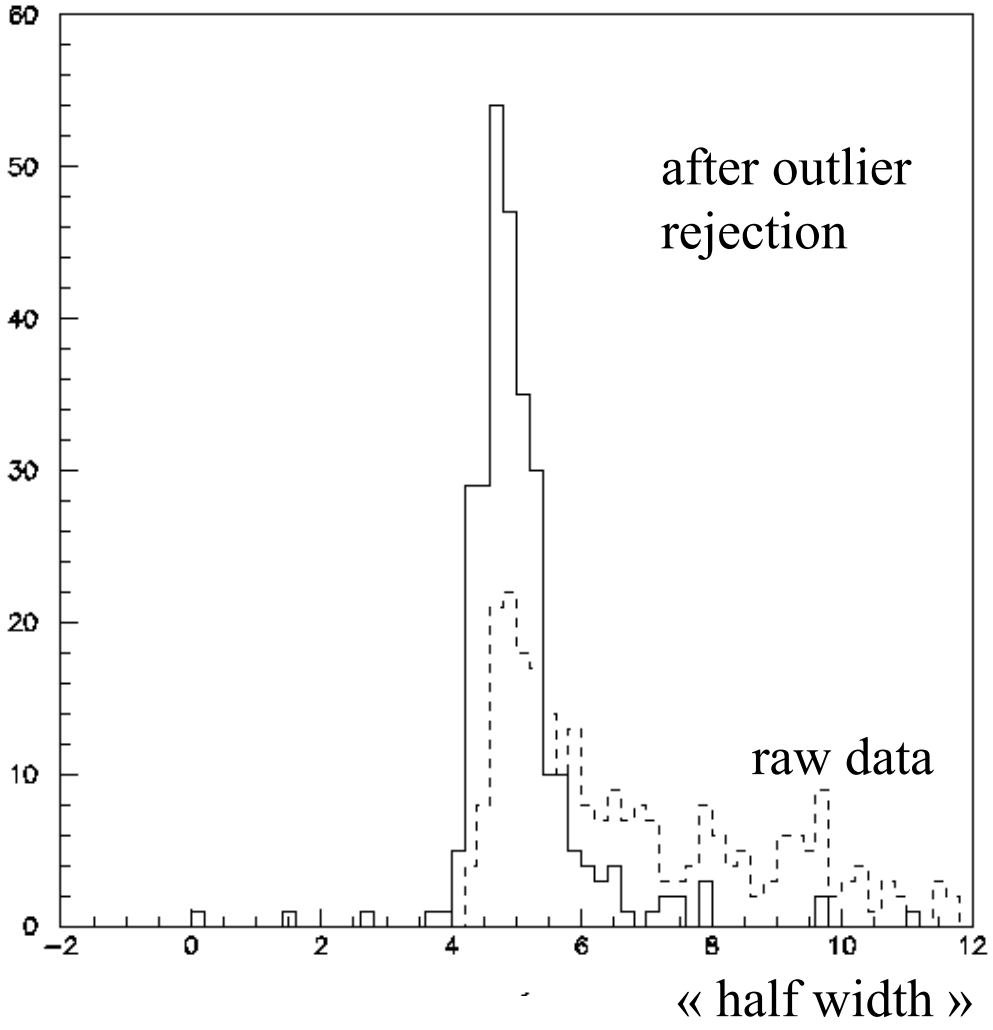
- define a parabolic correction perpendicular to the main axis and recompute the "width"

- remove iteratively outliers (points far from main axis)

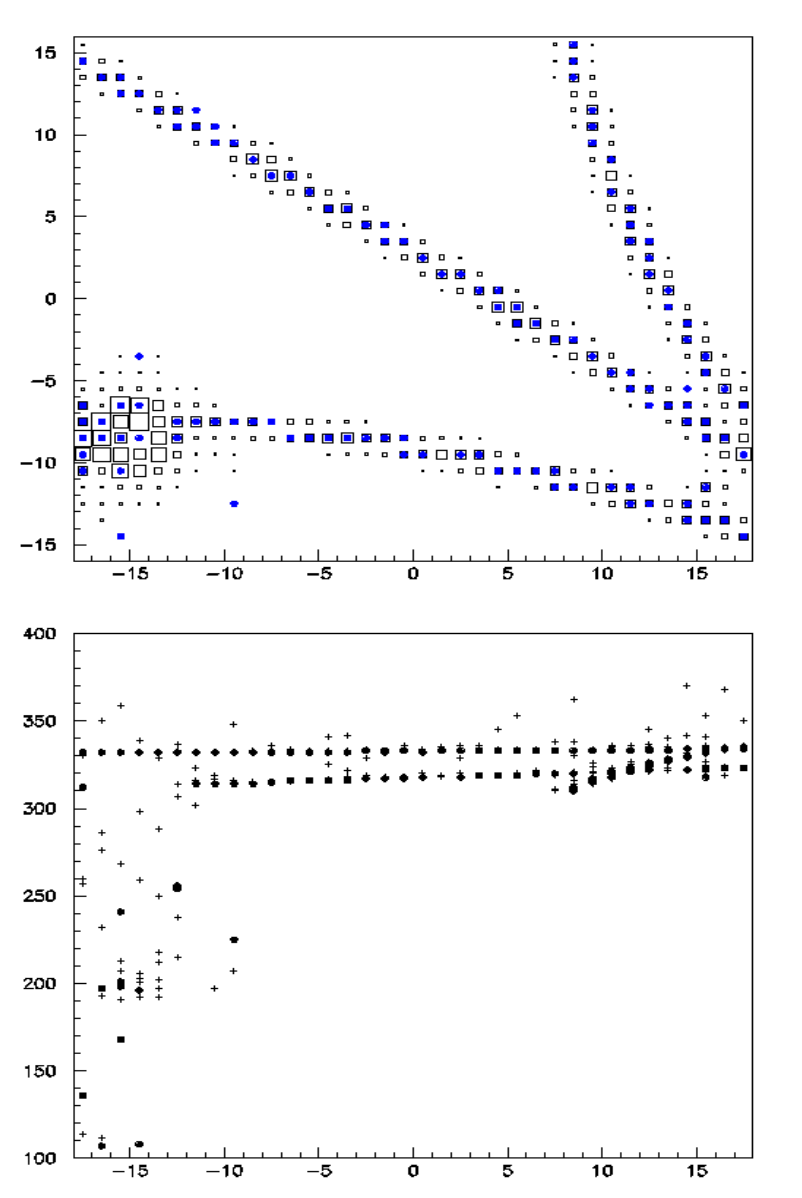
a similar criterion may be defined in the (z,t) or (y,t) plane

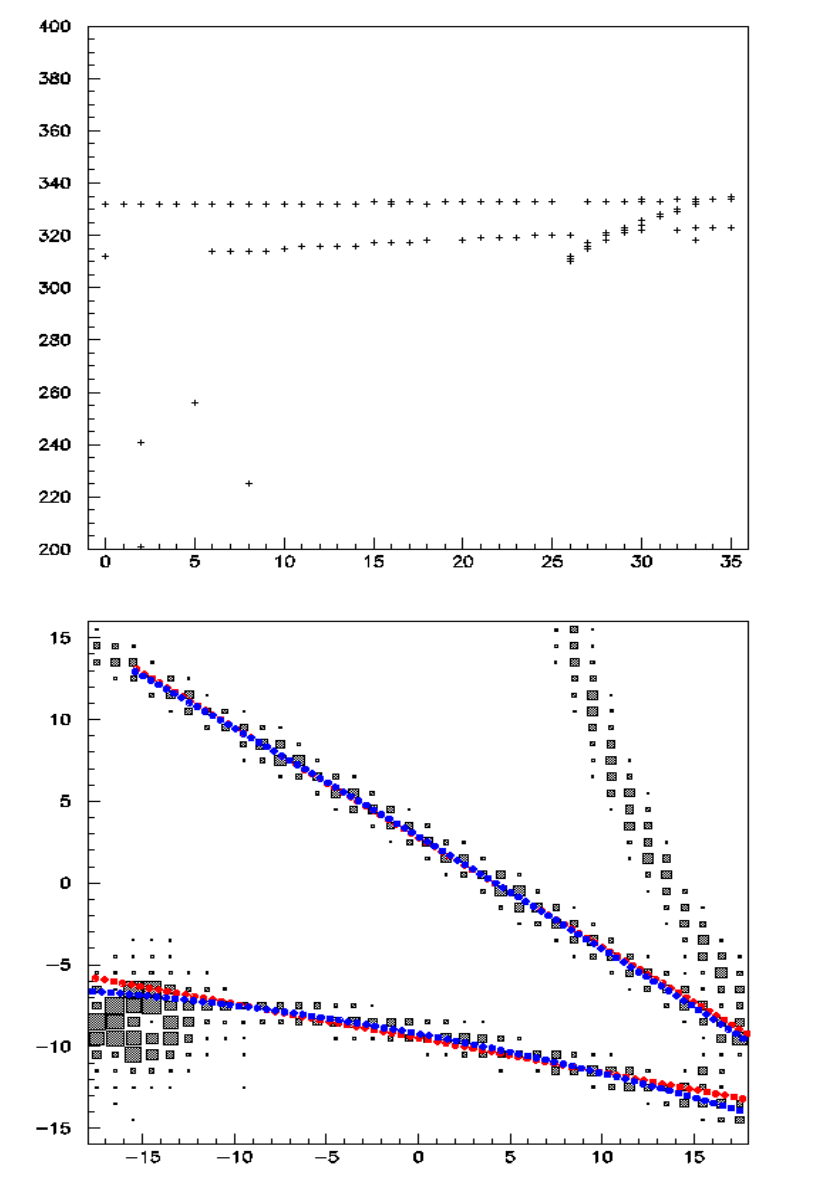
outlier rejection





a useful selection : waveform with an *undershoot* just after the maximum





global strategy

- handle separetely each module to define track segments
- make selections in (z,t) and/or (y/t) based on undershoot criterion
- reject pads with $q < q_{min}$ and set an upper value q_{max} to reduce the effect of background
- for each selection, search for segments in (z,y)

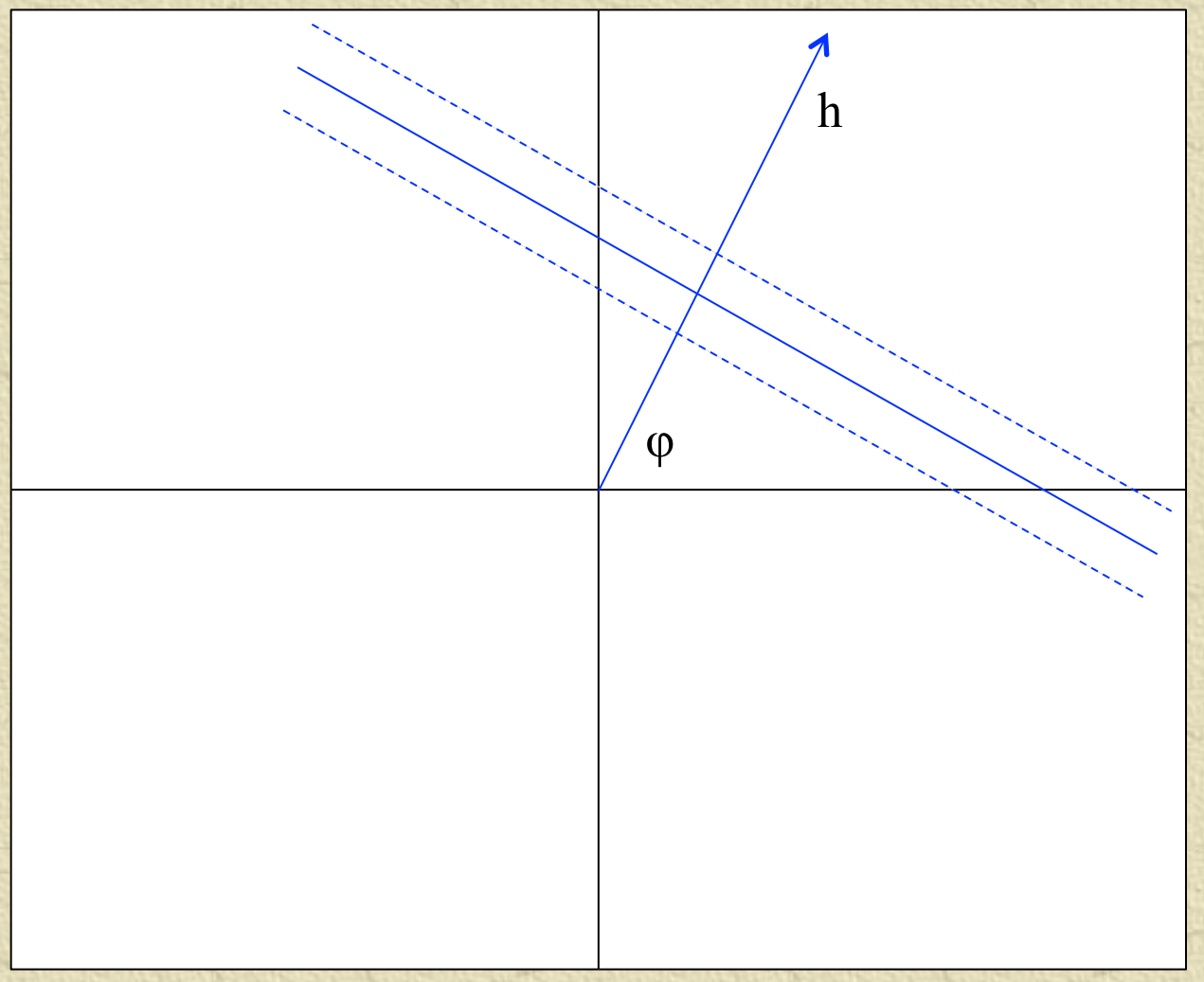
  (rough Hough method for both steps)
- define ambiguous parts (points compatible with two segment candidates)
- refine the segments (finer granularity in y,z + curvature)
- connect the segments between modules (not yet done)

in this study: application to beam events (many of them more or less noisy)

aim: tune the various parameters; try to define a criterion for a « local maximum » corresponding to a physical trajectory of an « interesting » particle

next step: apply the method simulated physical events with specific characteristics (kink, secondary vertex,…)

first and second step
to find curved routes in the (y,z) plane



counting C(φ,h) in a stripe h ± Δh along direction φ

weight:

qmax*gauss(dist to line)

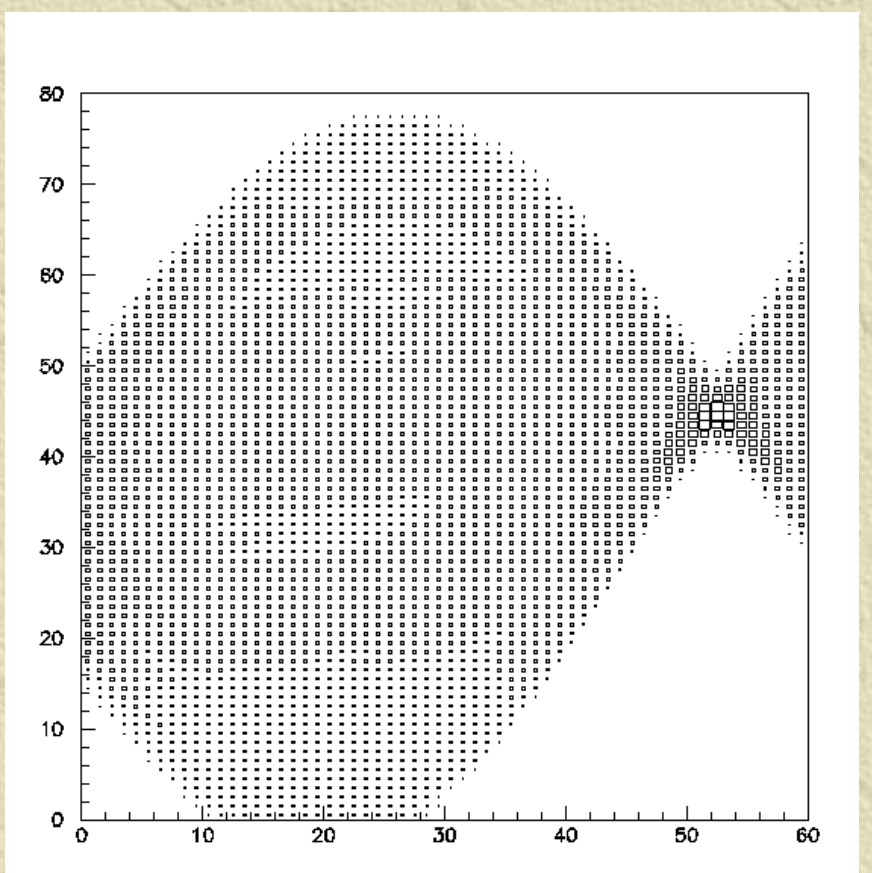
search for local maxima in the (φ,h) plane

➔ local rotated frame

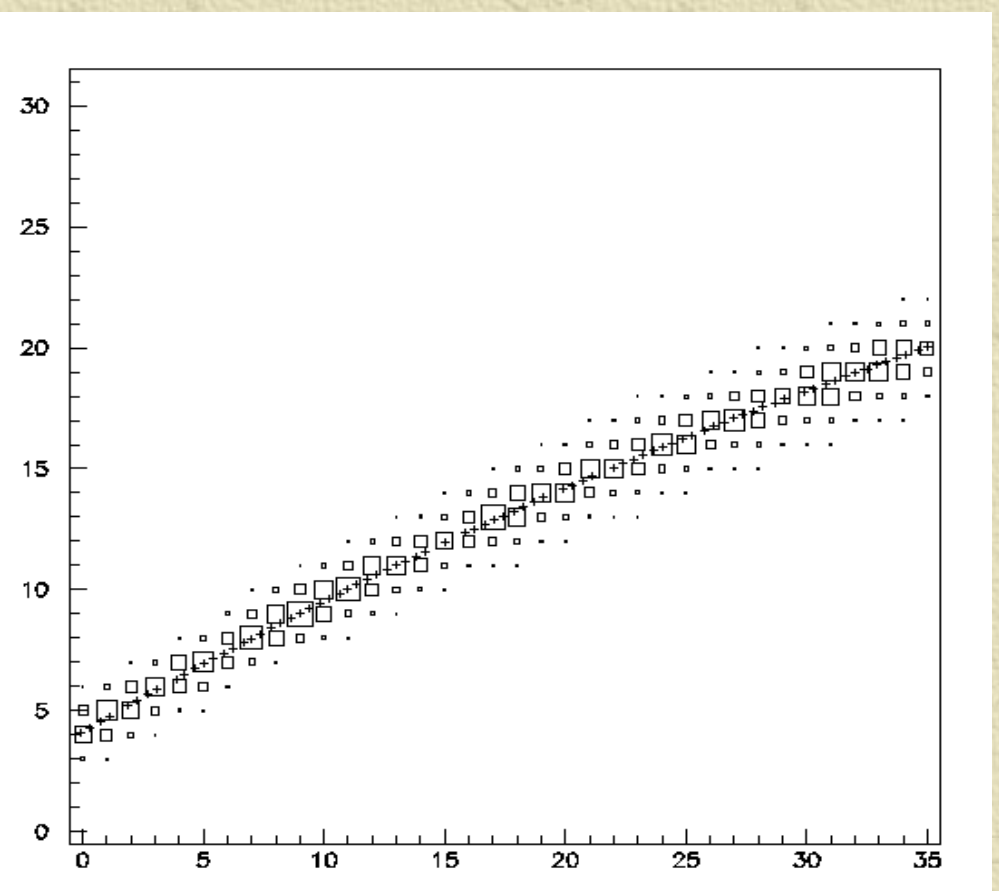
in each local frame around a local maximum: zoomed 3D Hough search for the best parabolic stripe (highest counting)

simulated single track

Hough space (φ,h)

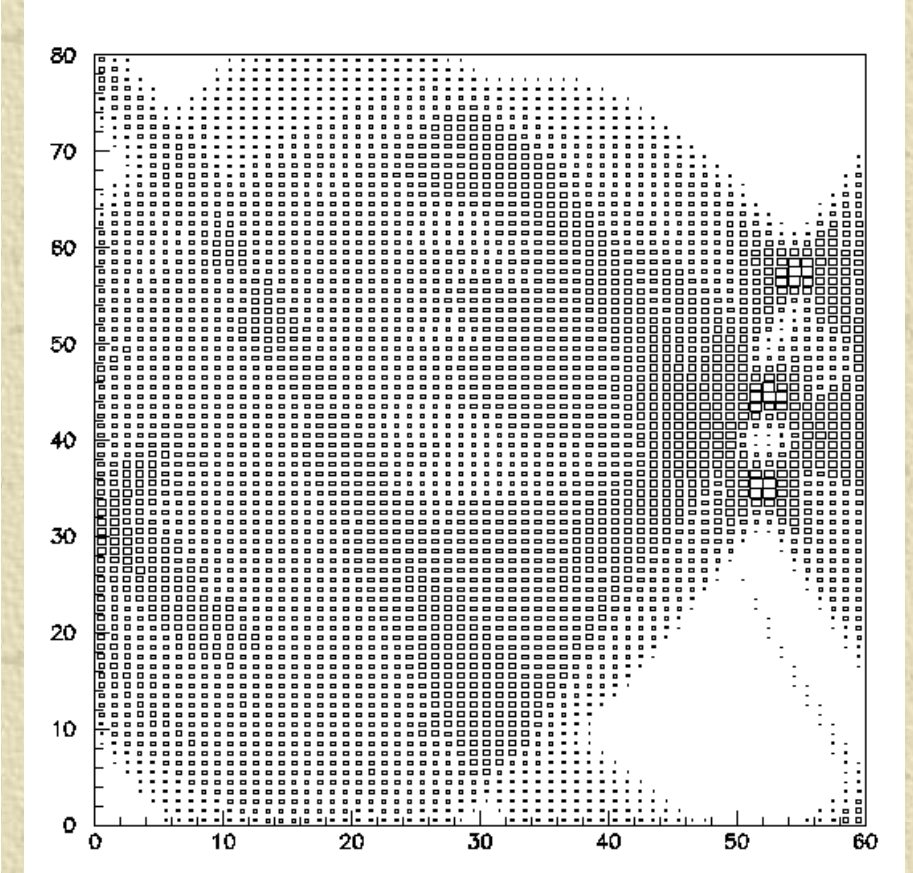


best route found in zy space

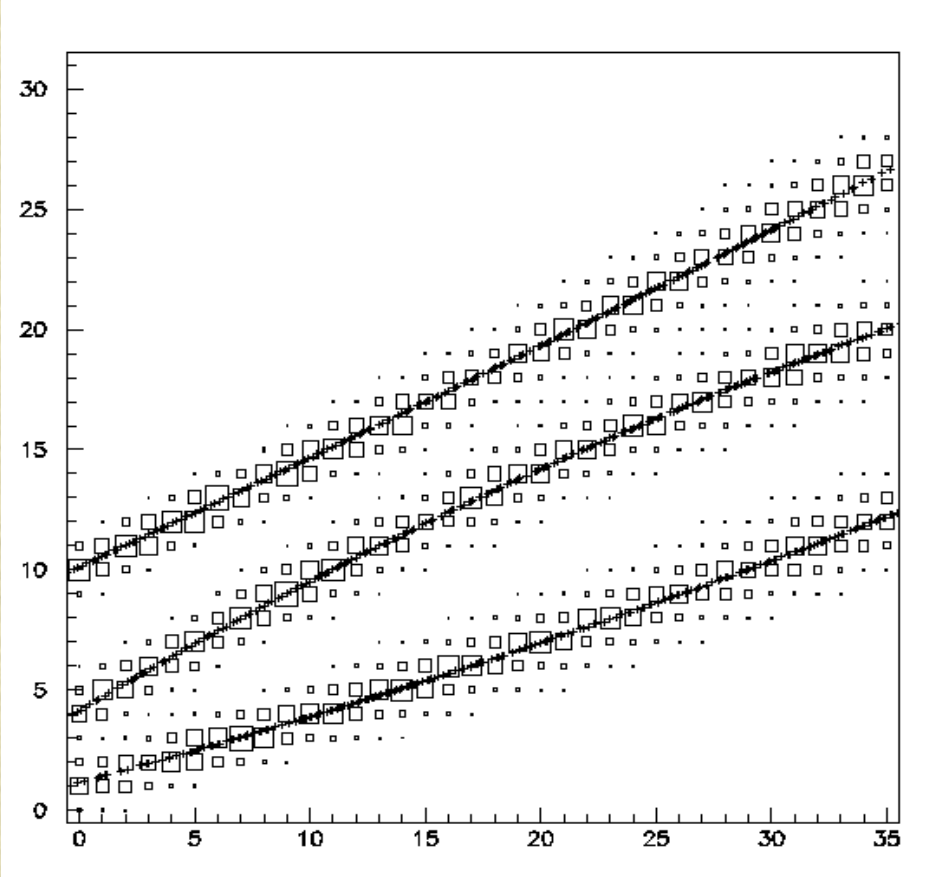


superposition of 3 non overlapping tracks
(simplified simulation)

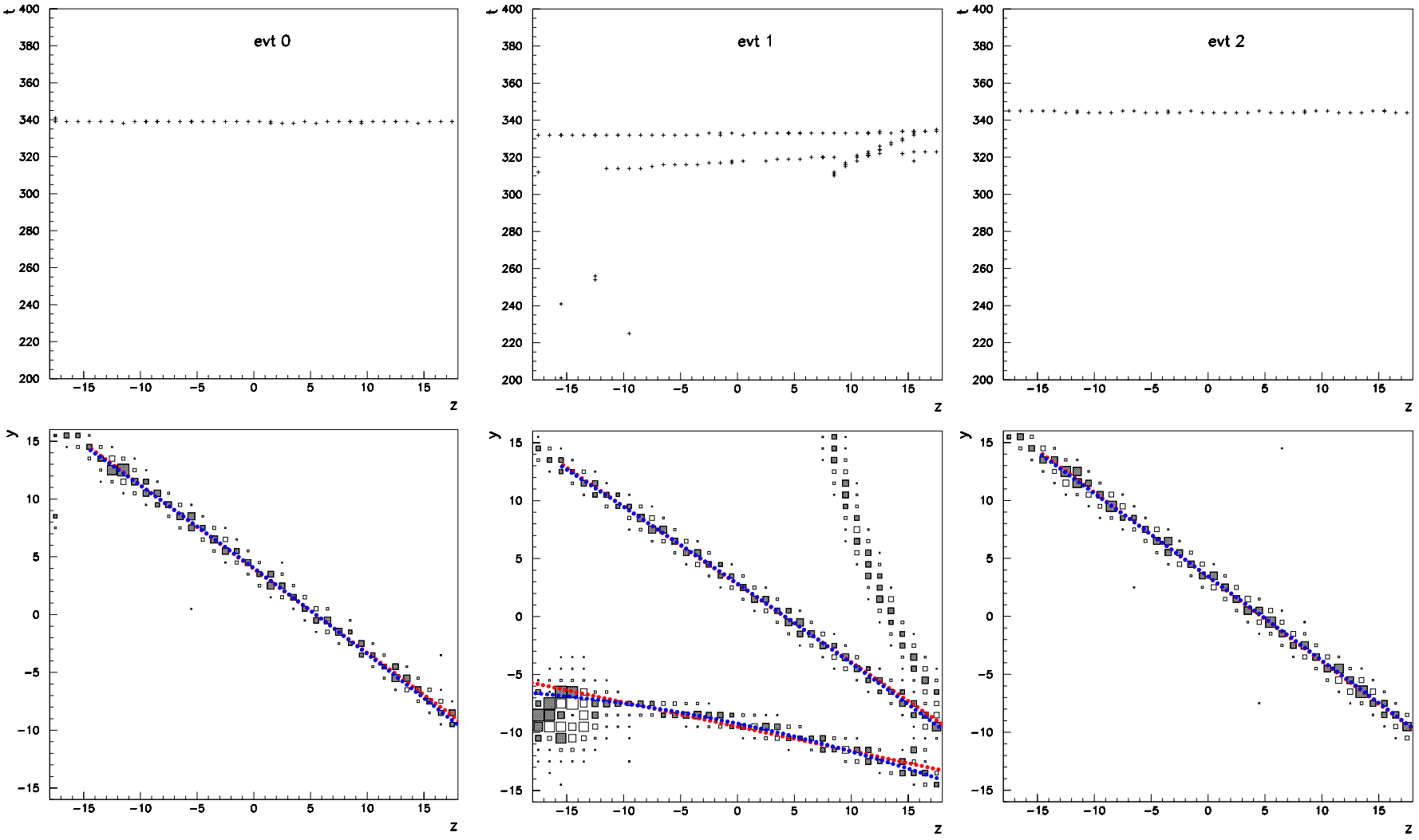
Hough space (φ,h)



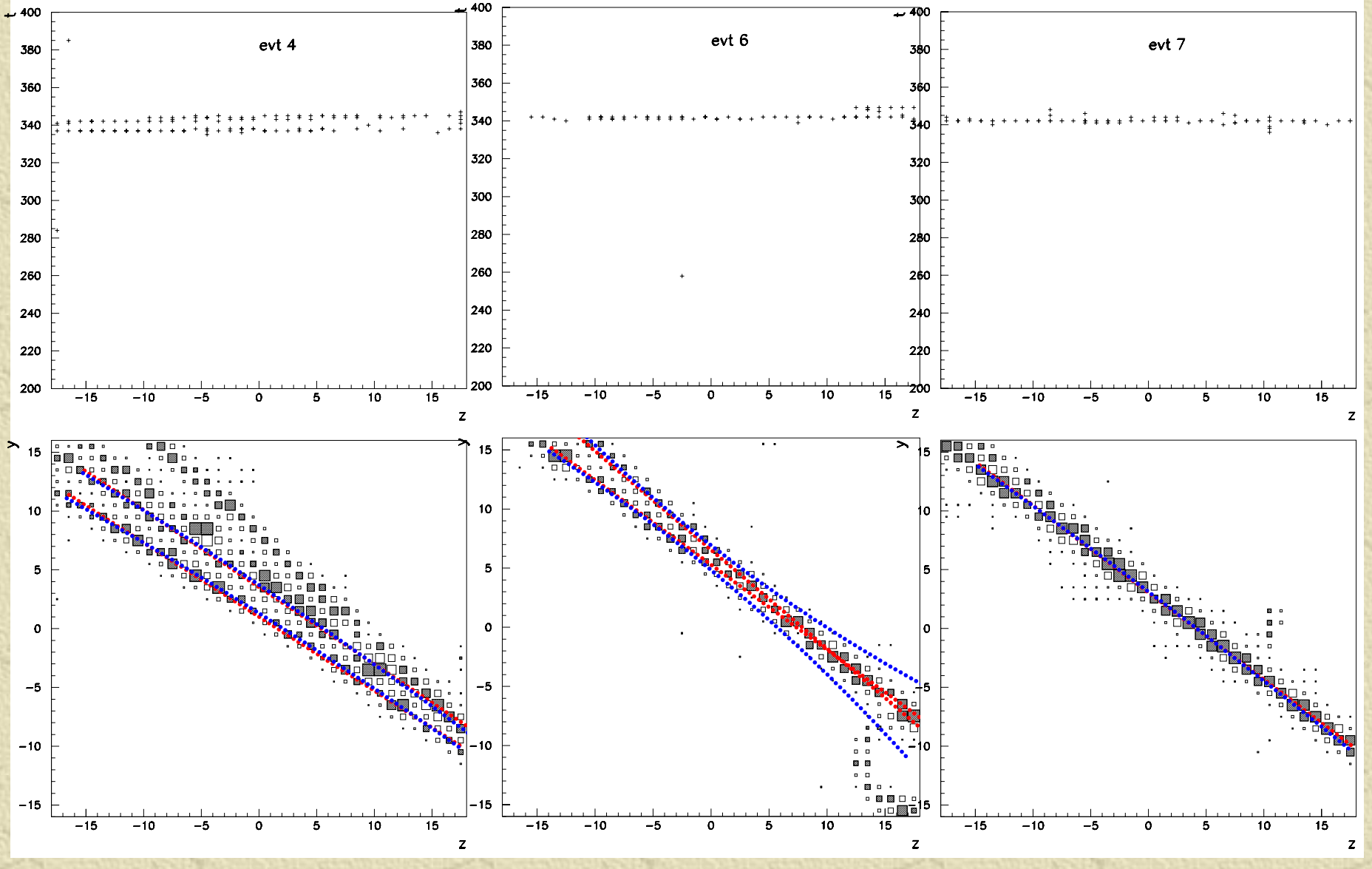
best routes found in zy space



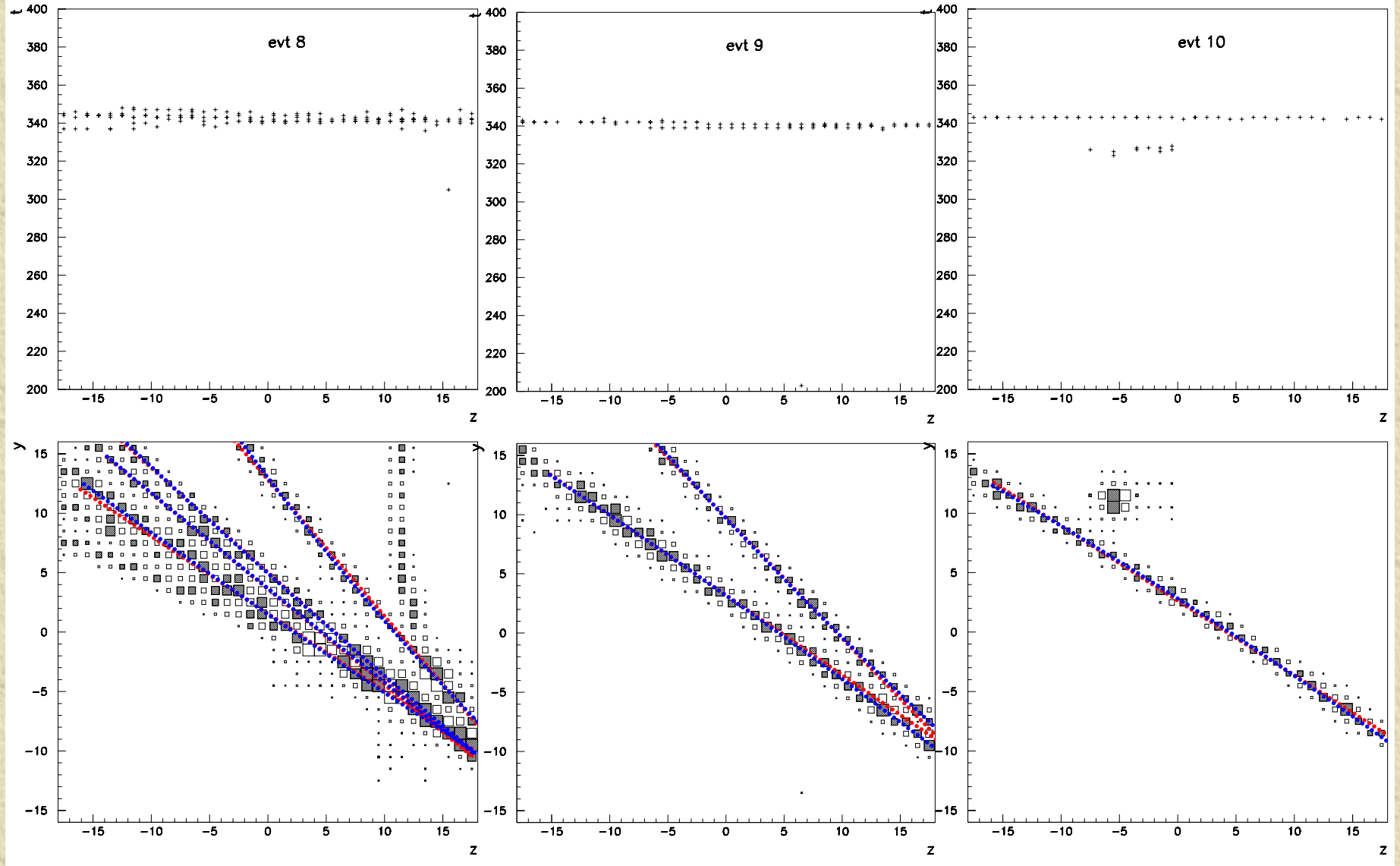
beam tracks



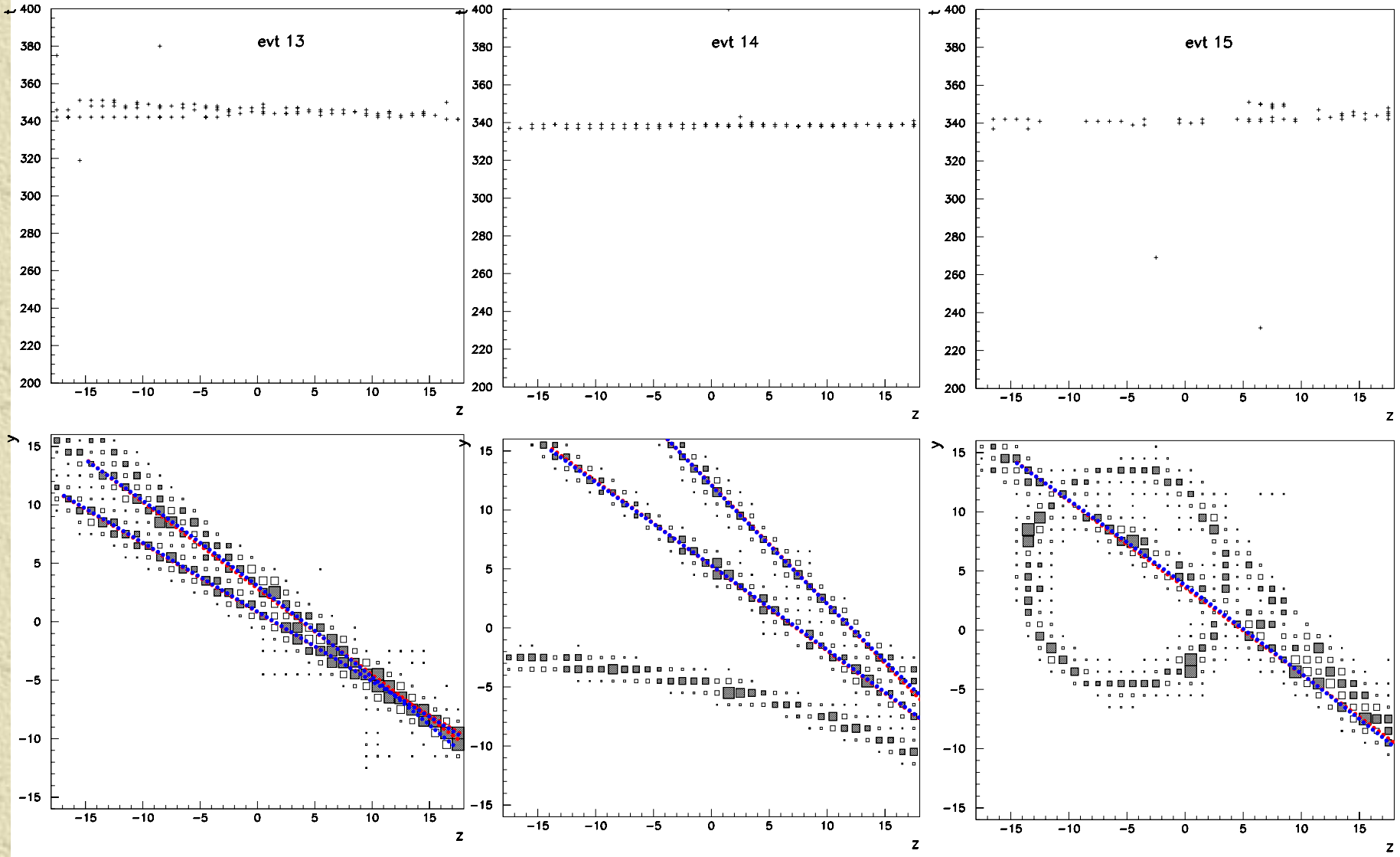
beam tracks



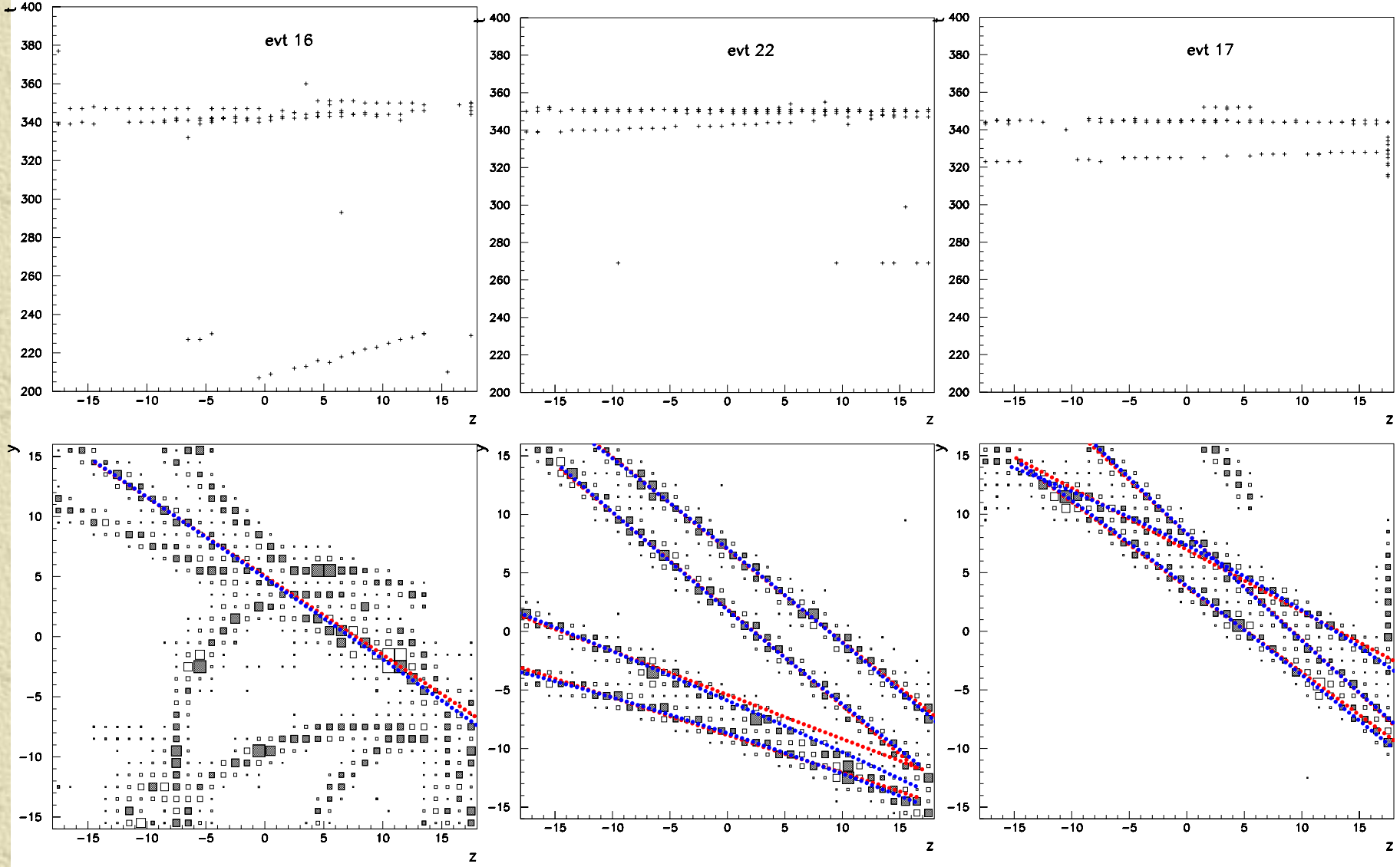
beam tracks



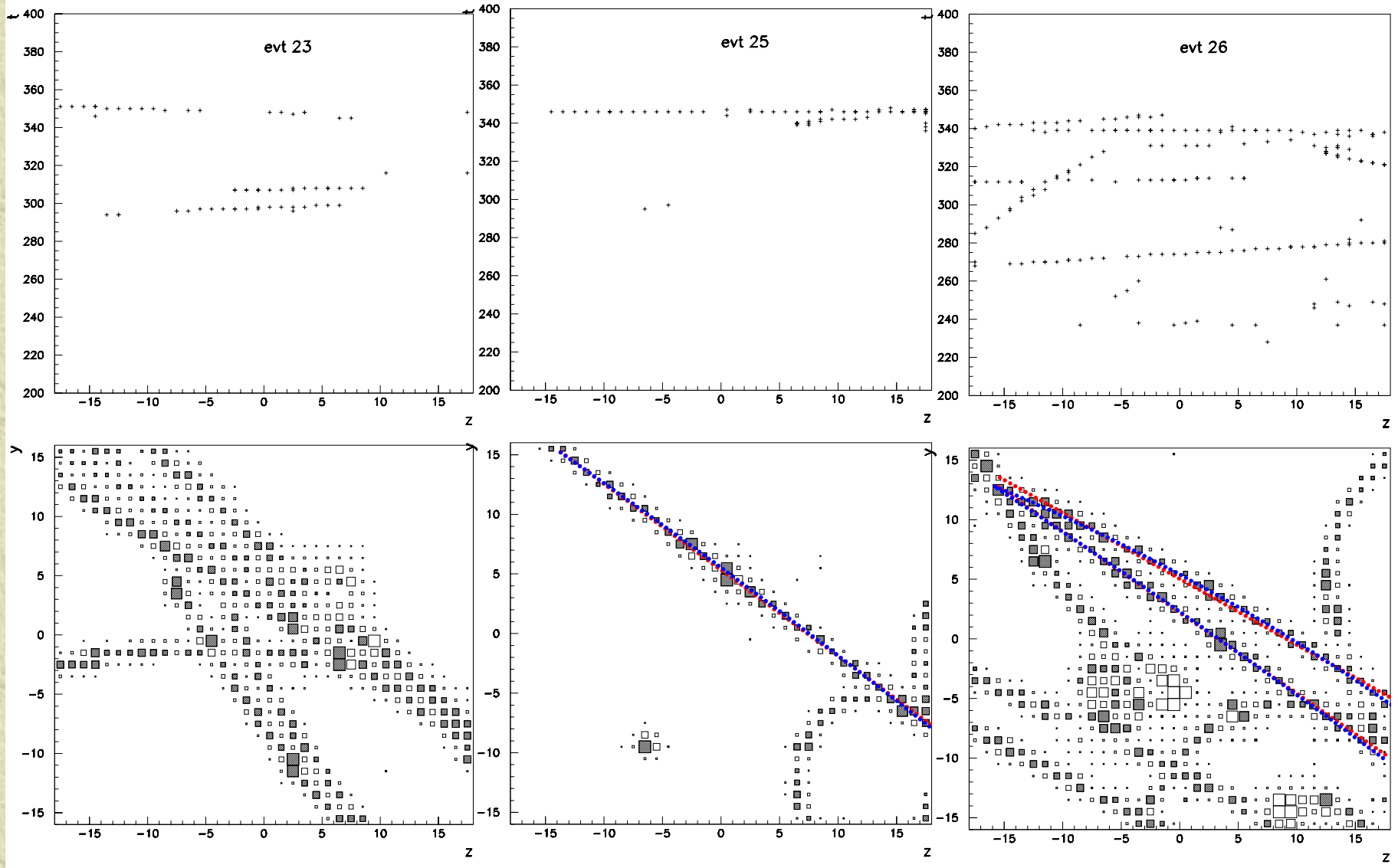
beam tracks



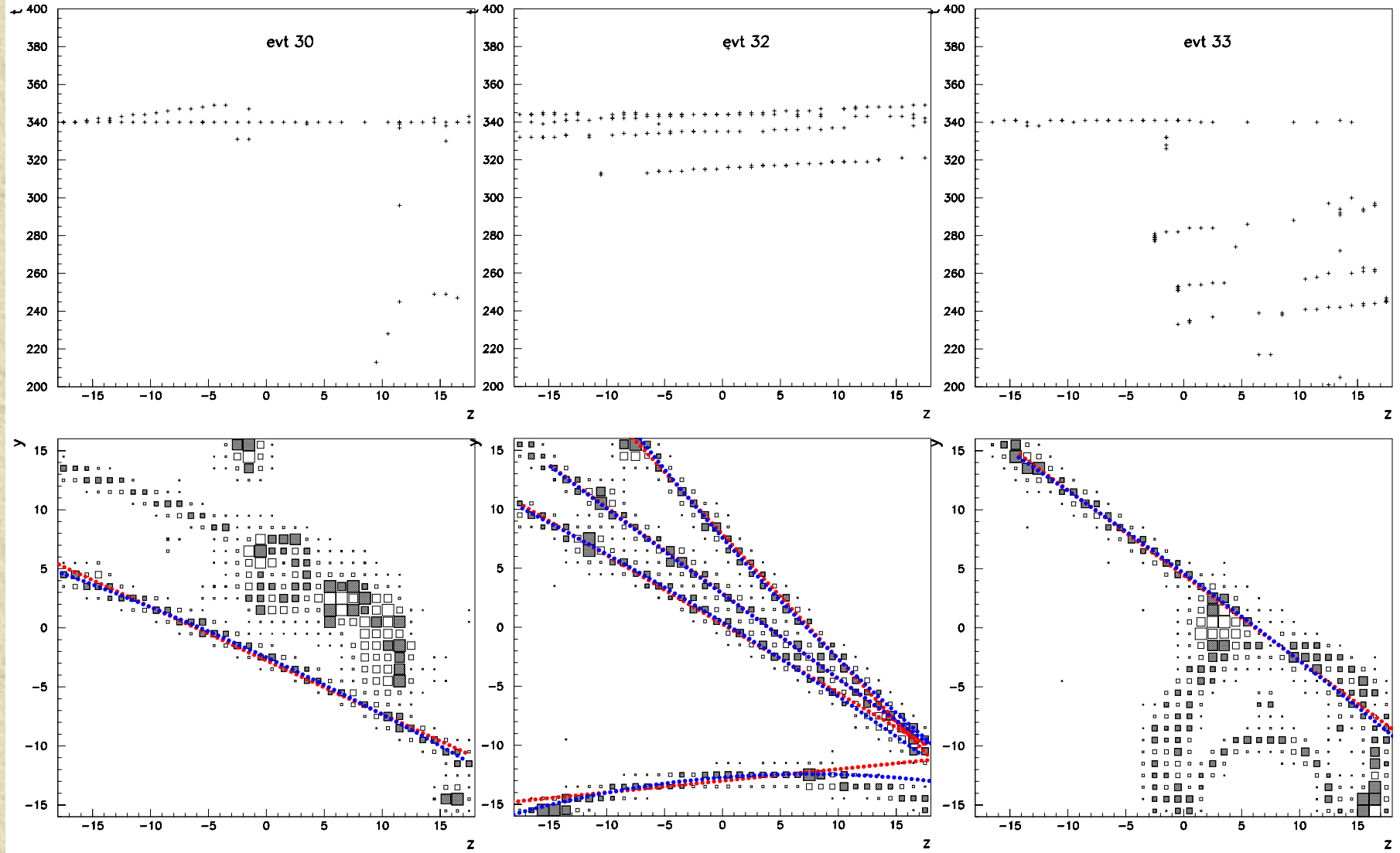
beam tracks



beam tracks



beam tracks



beam tracks

parameters to be tuned

- number of slots in φ,h
- width of the route
- upper bound on Q in a pad (to reduce the effect of background)
- extension of the zooming region (minimal momentum)
- definition of a « local maximum » (threshold, dominance over neighbours)

in this study: work on one module

to go further: make connections between track segments (better than extending the method to the full area ?)

Promising; needs more « human learning »