

CALLI

Calorimeter for **ILC**

*Selecting MIPs with  
the Hough Transform*

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## DHCAL

- alignment of detector layers
- MIP/energy calibration

## ECAL

- clean the em showers from eventual MIP contamination
- facilitate the study of the hadronic showers

*Method proposed by Hough in 1962 to clean the bubble chamber events by selecting straight line tracks*

## Principle :

- under-constrain a system
- create a digitised phase-space for the parameters
- find the parameters by looking for maxima In 2D plan, each point is transformed into a curve

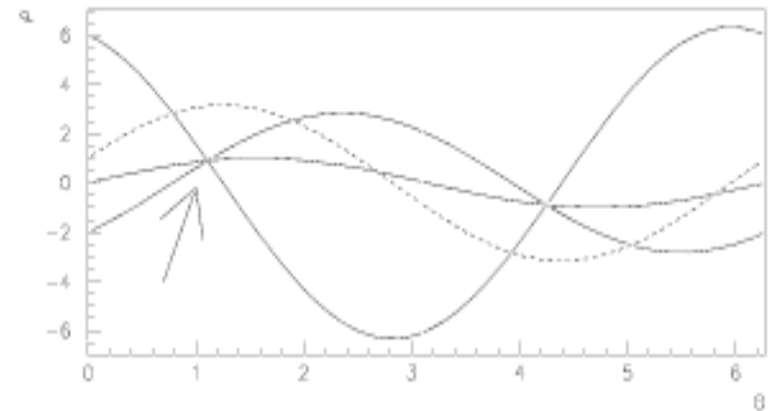
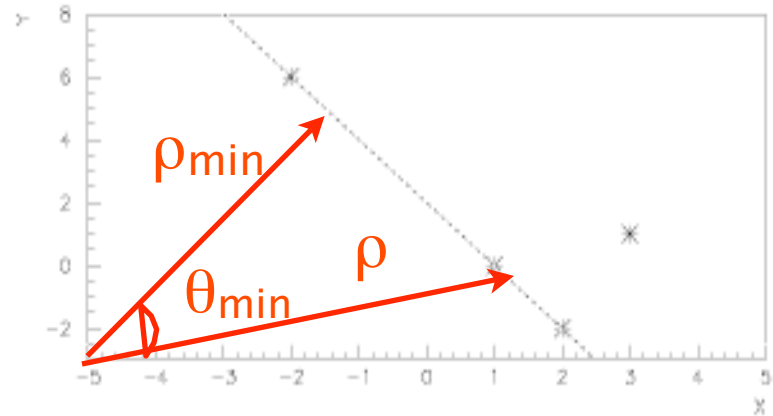
*One of the most popular patents - heavily used for noise reduction in photography and mapping*

*Heavily generalised ....*

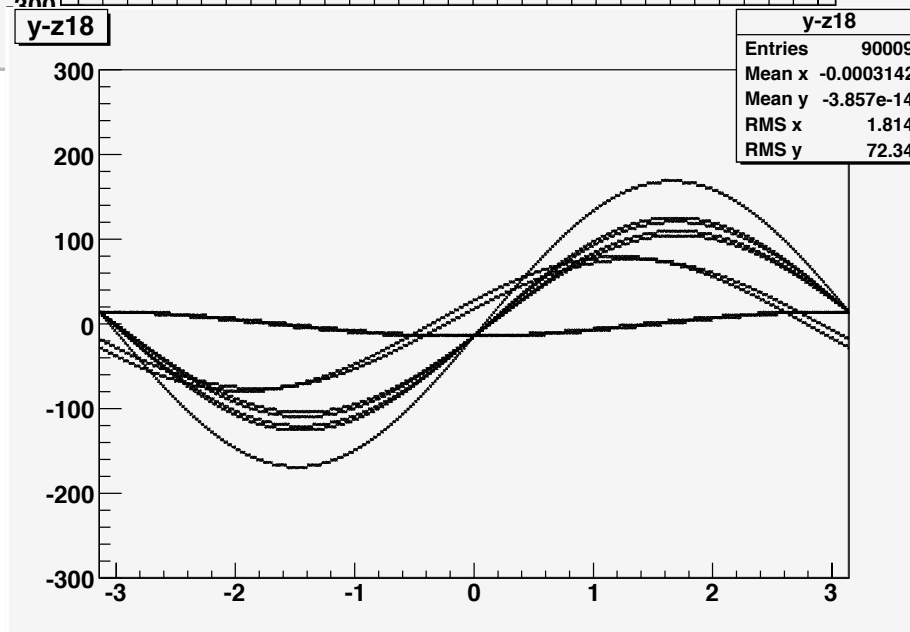
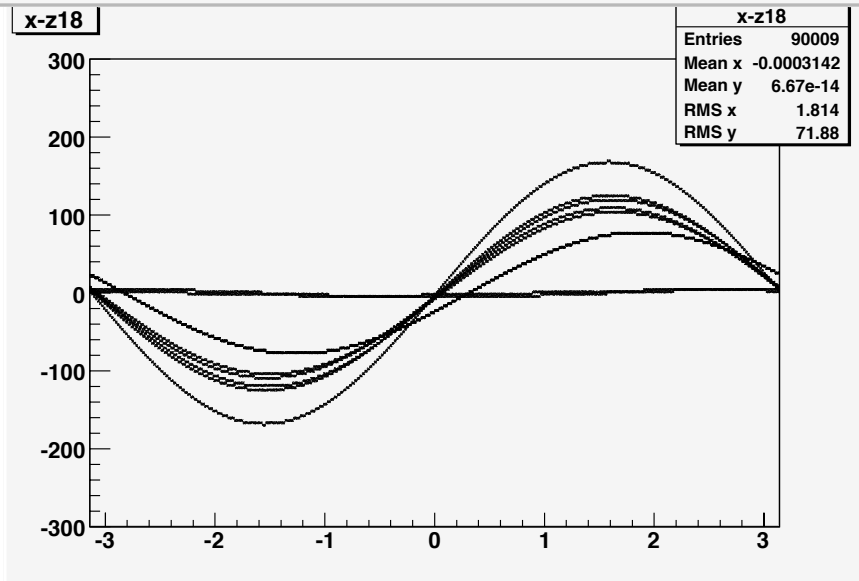
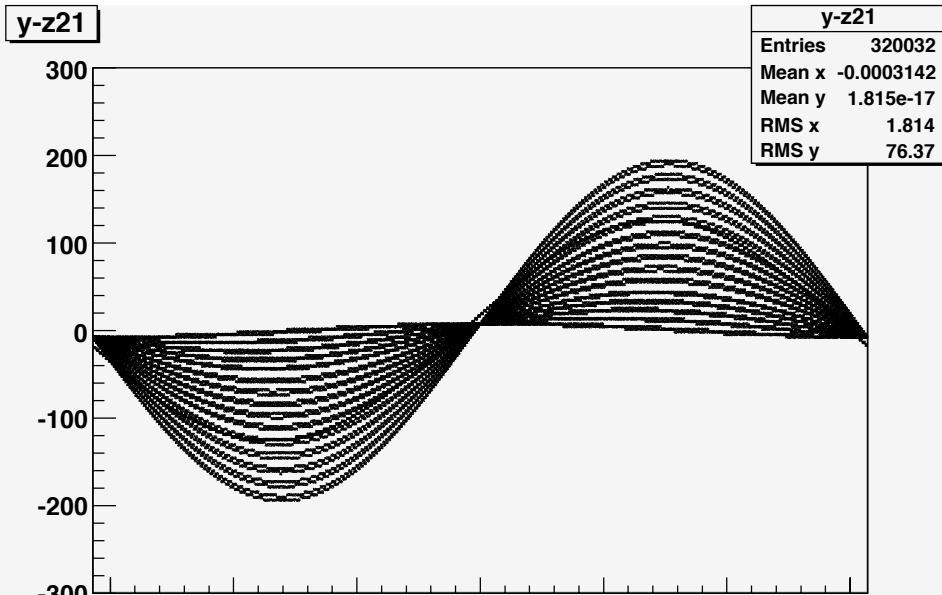
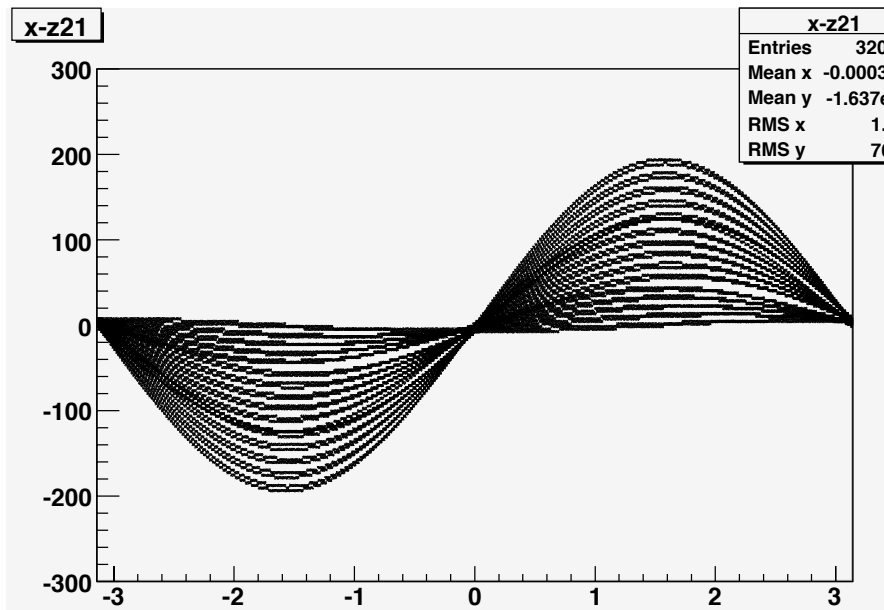
$$\rho = y_i \cos \theta + x_i \sin \theta$$

For each point  $(x_i, y_i)$

- vary  $\theta \in [0, \pi]$
- fill a 2D histogramme with  $(\theta, \rho)$
- find the vertex for the sinusoid
- crossings by locating the maximum
- binning determined by detector segmentation
- keep only hits “voting” for the winner



# 2D-Hough Transform for SiECAL



2 possibilities :

- 3D line can be projected into two 2D-lines -> 2D Hough transform in the (X,Z) and (Y,Z) planes and keep only hits selected by both.
- treat directly the 3D case:

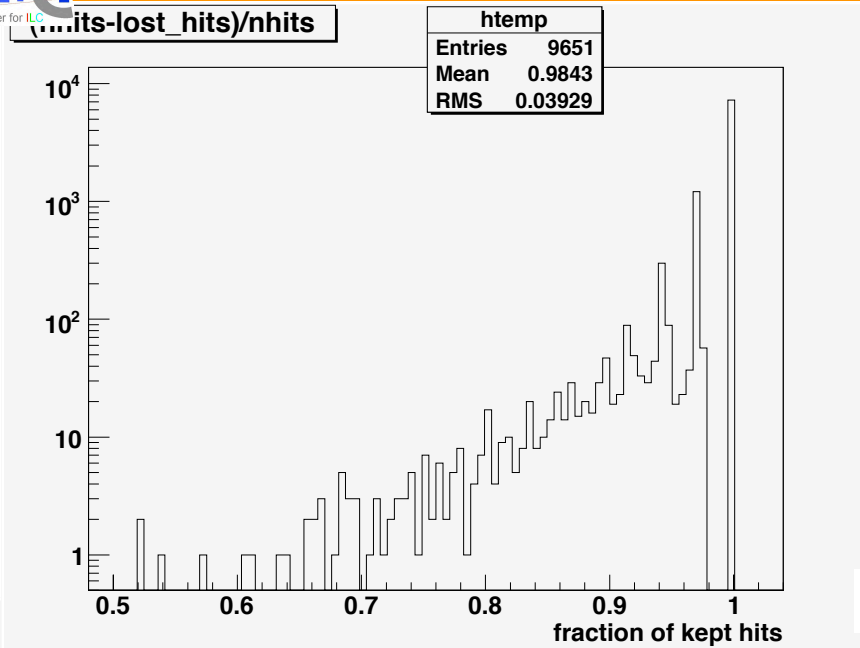
$$\rho = x_i \sin \theta \cos \phi + y_i \sin \theta \sin \phi + z_i \cos \theta$$

with  $\phi \in [0, 2\pi]$ ,  $\theta \in [0, \pi]$

build a 3D histo and find the maximum...

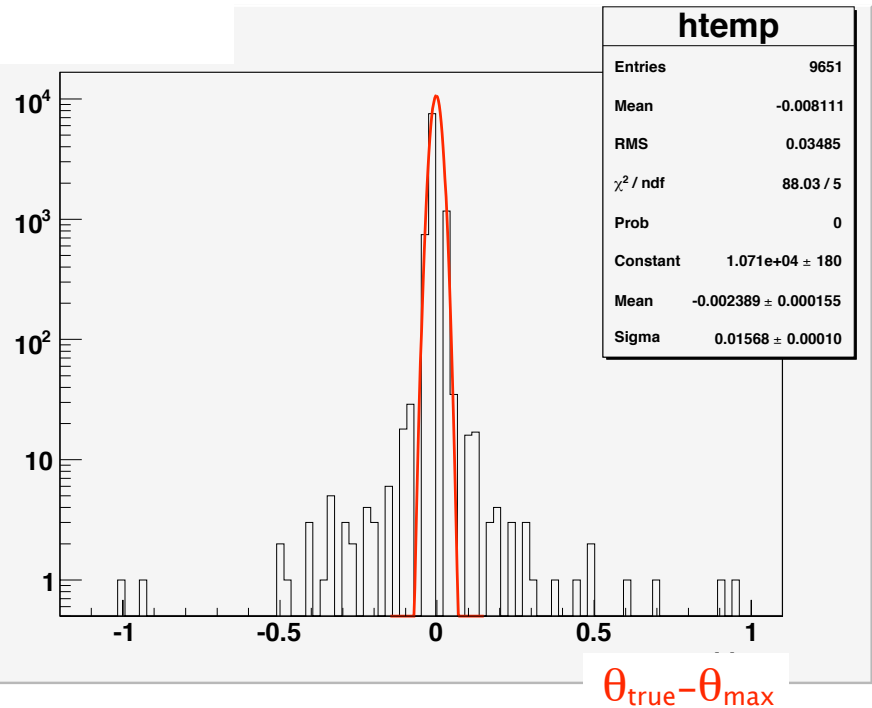
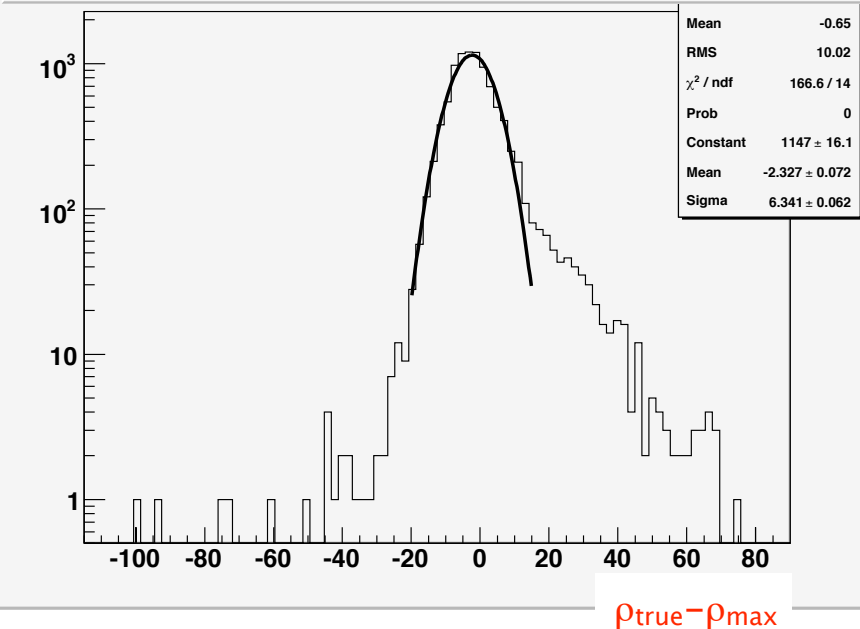
Accidental alignment can be reduced by considering the distances between the selected hits or/and the number of aligned hits

# 3D Hough Transform for Single Mu's

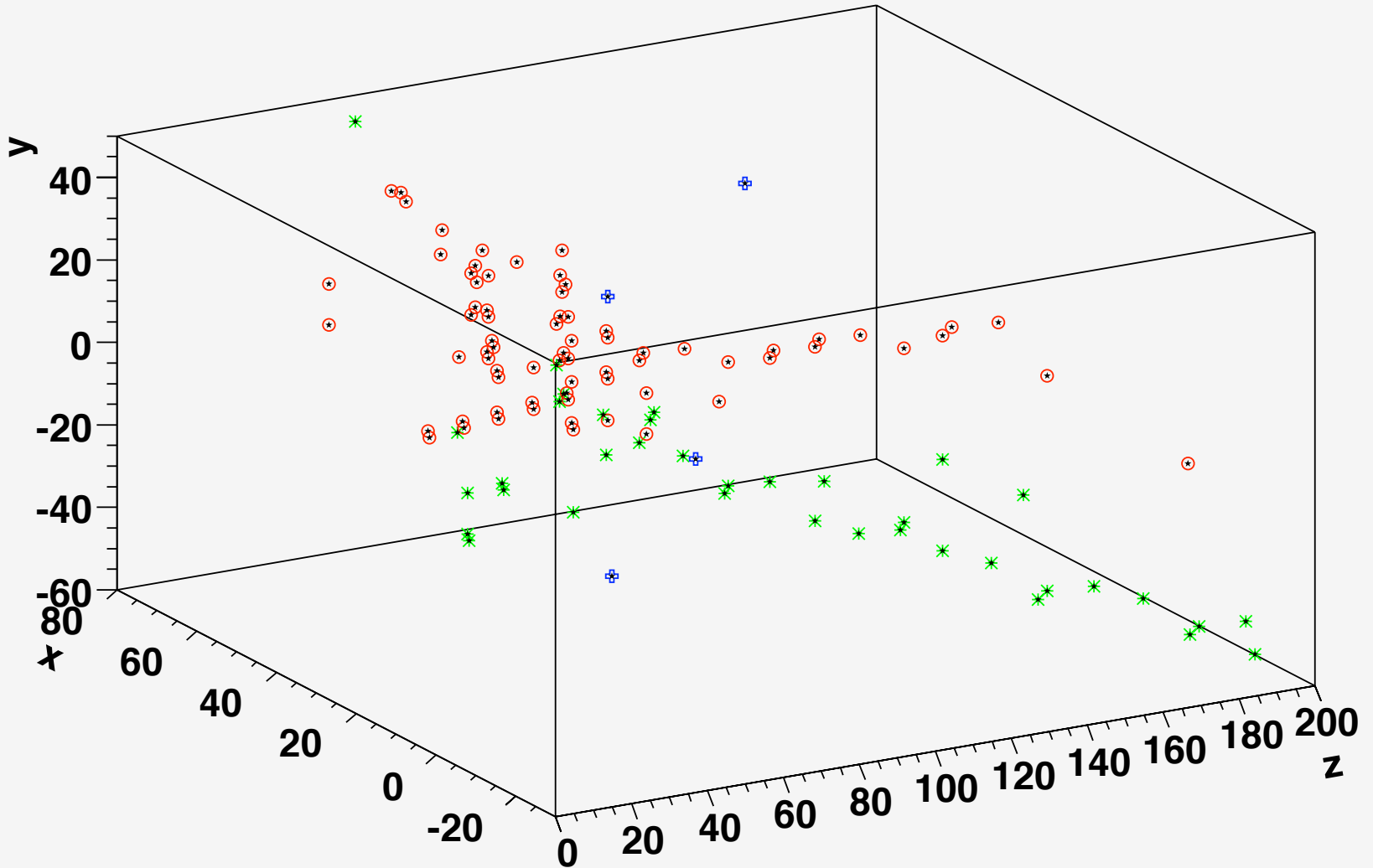


$\rho_{\max}$  binning: 10 mm

keep all hits within +/- 10 mm of  $\rho_{\max}$



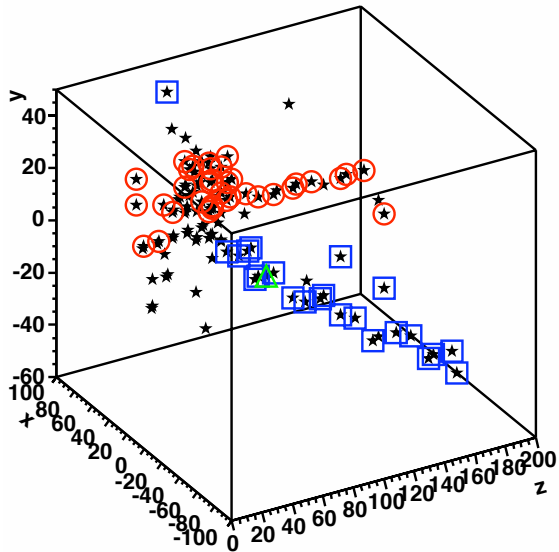
**y:x:z {evtid==10 && used ==1}**



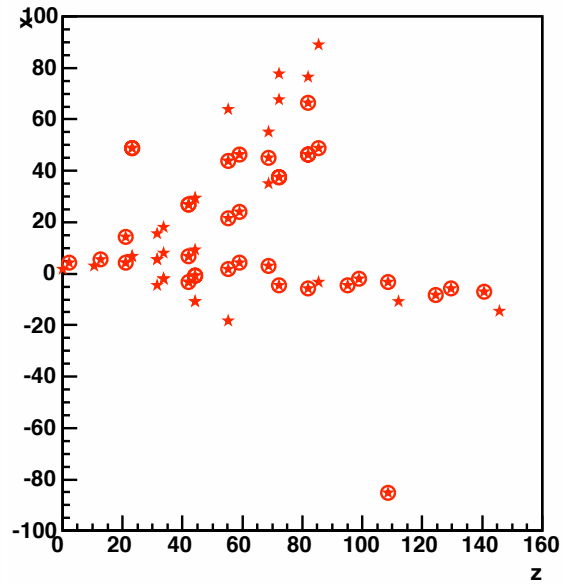


# Closer look to the event

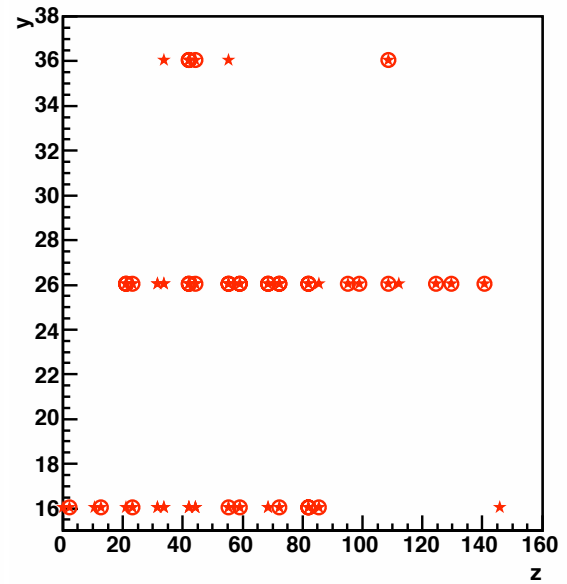
y:x {evtid==10}



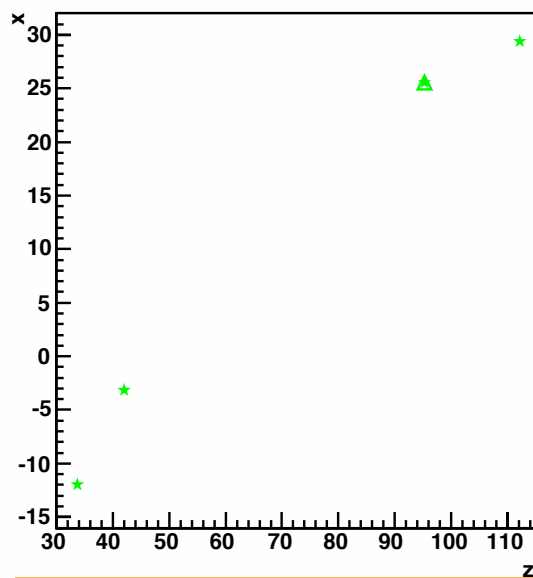
x:z {(used==0)&&(evtid==10)}



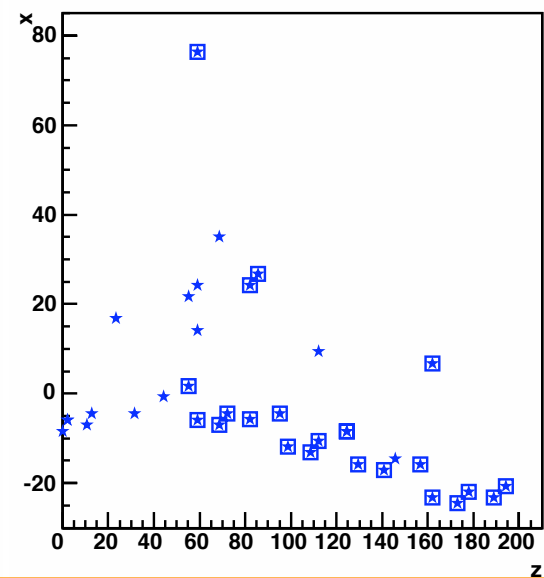
y:z {(used==0)&&(evtid==10)}



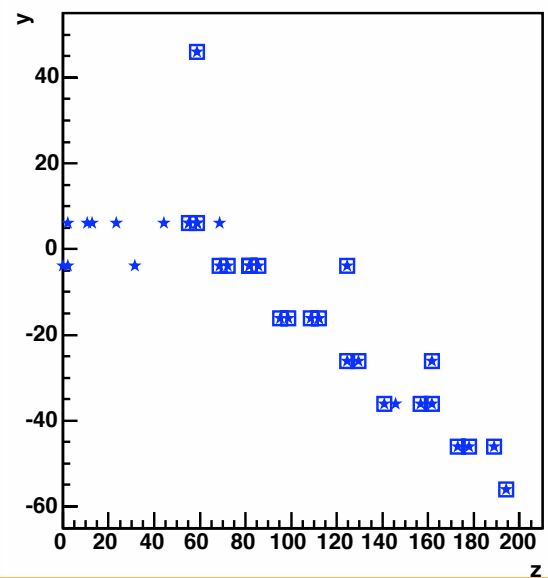
x:z {(used==2)&&(evtid==10)}



x:z {(used==1)&&(evtid==10)}

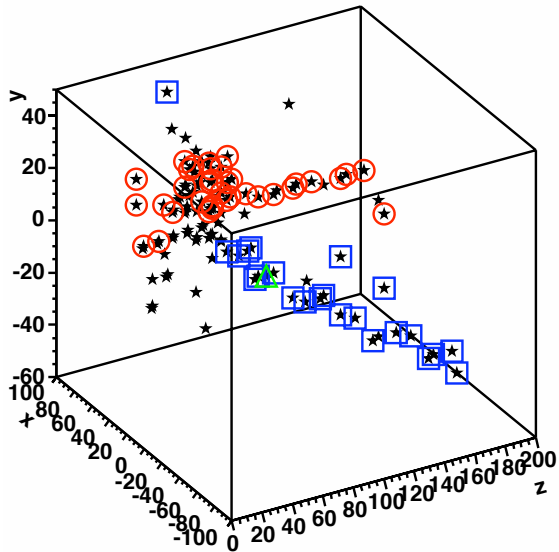


y:z {(used==1)&&(evtid==10)}

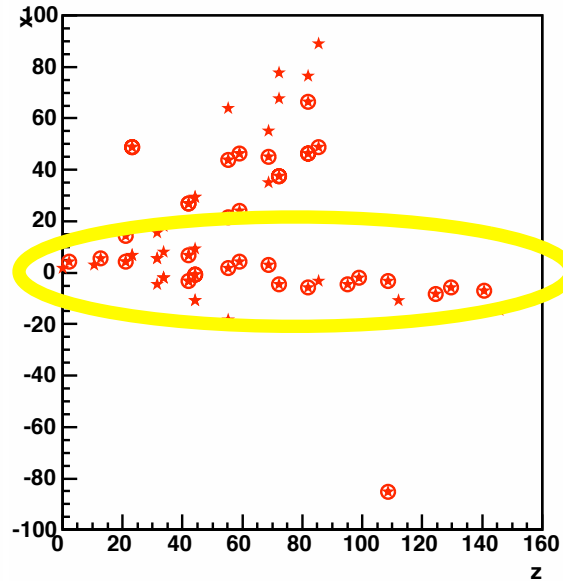


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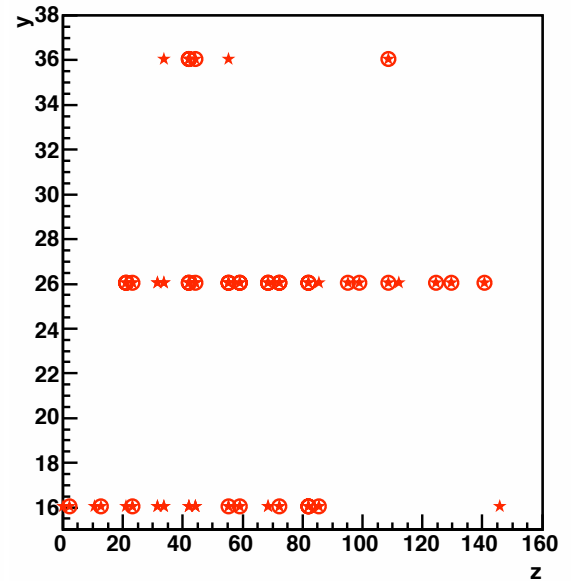
y:x {evtid==10}



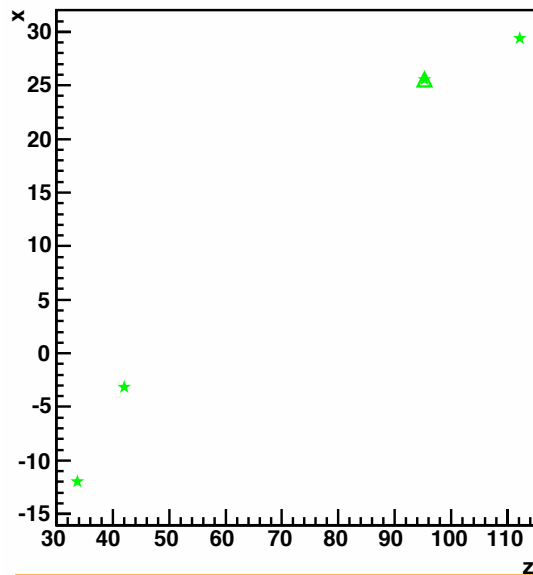
x:z {(used==0)&&(evtid==10)}



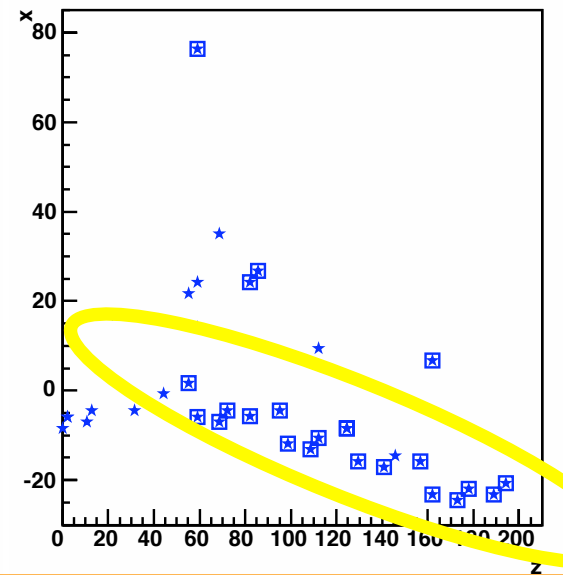
y:z {(used==0)&&(evtid==10)}



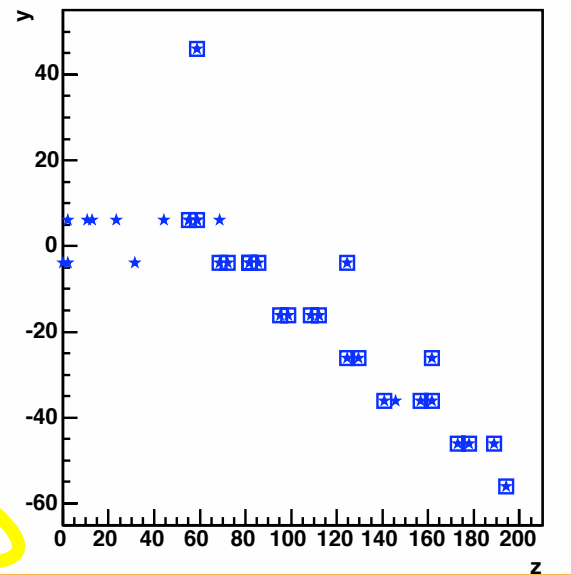
x:z {(used==2)&&(evtid==10)}



x:z {(used==1)&&(evtid==10)}

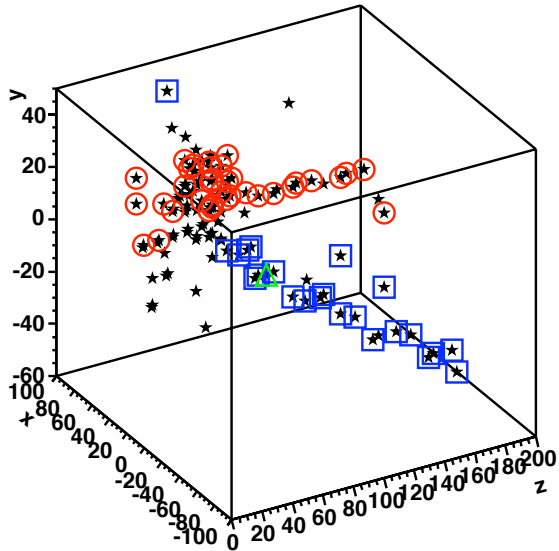


y:z {(used==1)&&(evtid==10)}

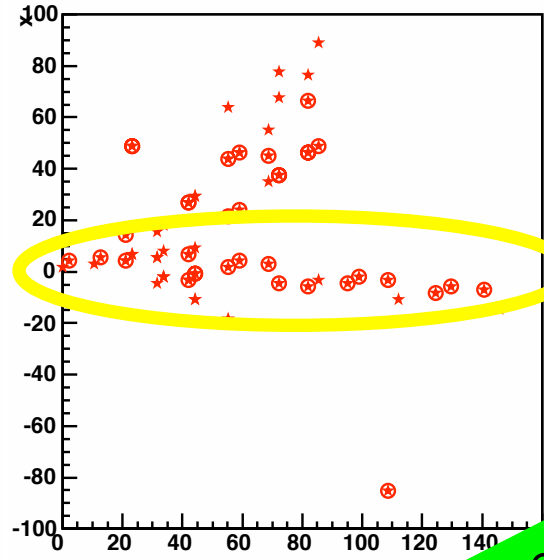


# Closer look to the event

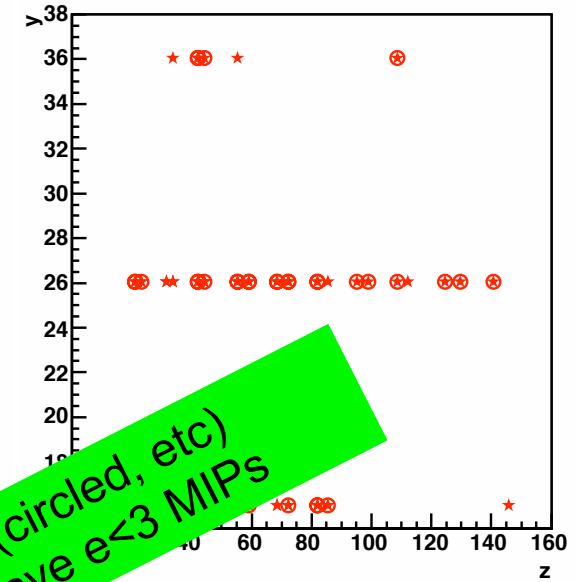
y:x {evtid==10}



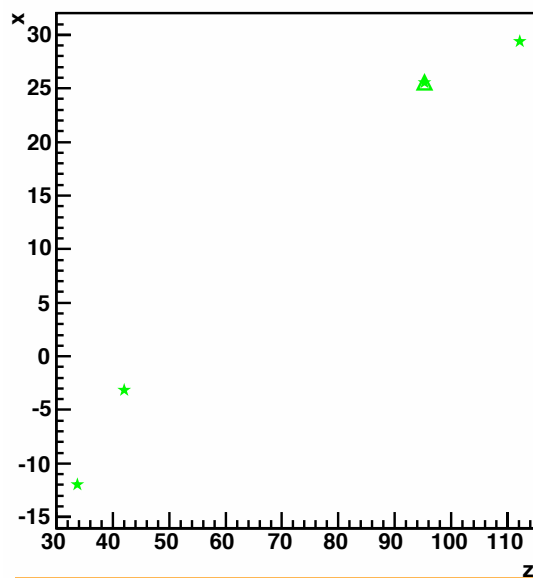
x:z {(used==0)&&(evtid==10)}



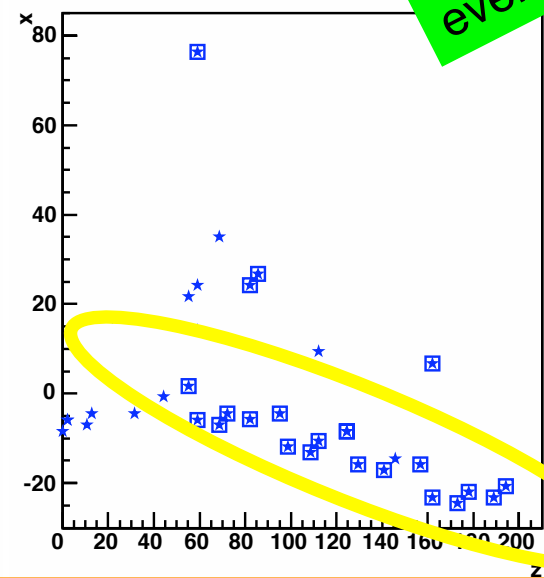
y:z {(used==0)&&(evtid==10)}



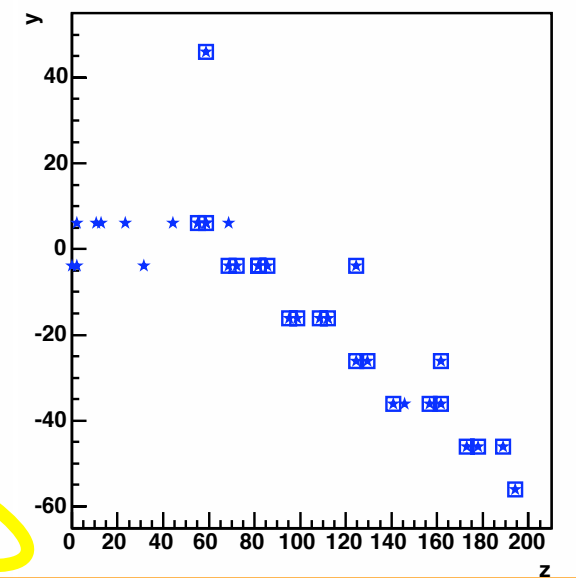
x:z {(used==2)&&(evtid==10)}



x:z {(used==1)&&(evtid==10)}



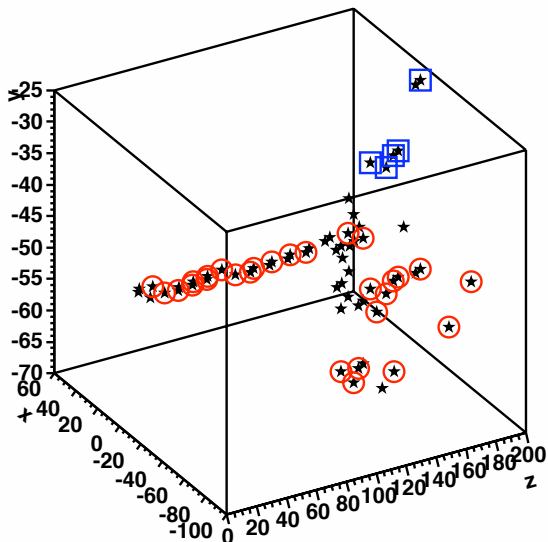
y:z {(used==1)&&(evtid==10)}



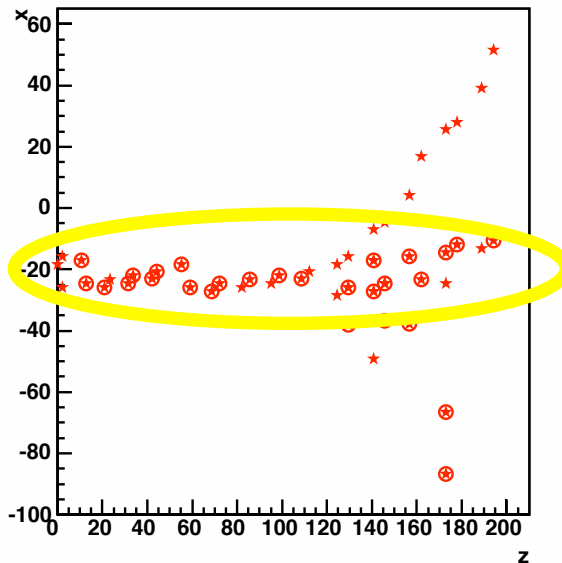
Squared (circled, etc) events have  $e < 3$  MIPS

# The Next Pion Event in the File

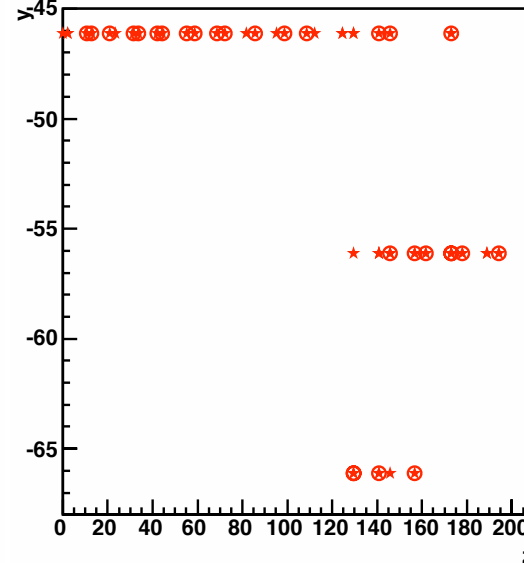
y:x:z {evtid==15}



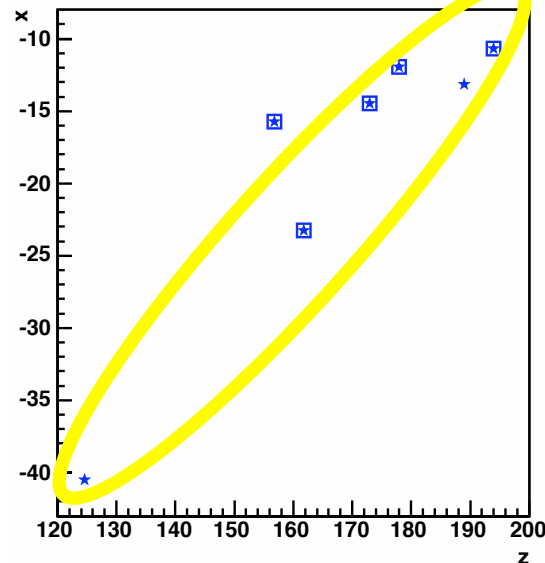
x:z {(used==0)&&(evtid==15)}



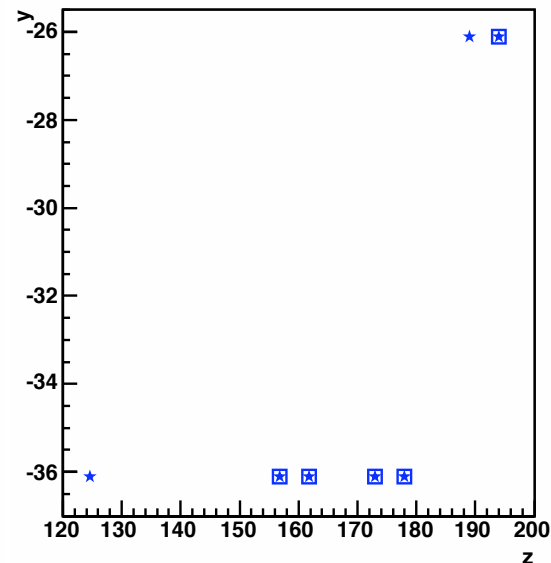
y:z {(used==0)&&(evtid==15)}



x:z {(used==1)&&(evtid==15)}

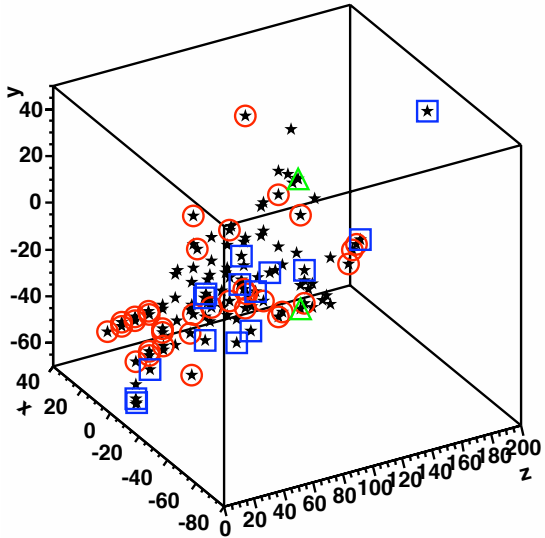


y:z {(used==1)&&(evtid==15)}

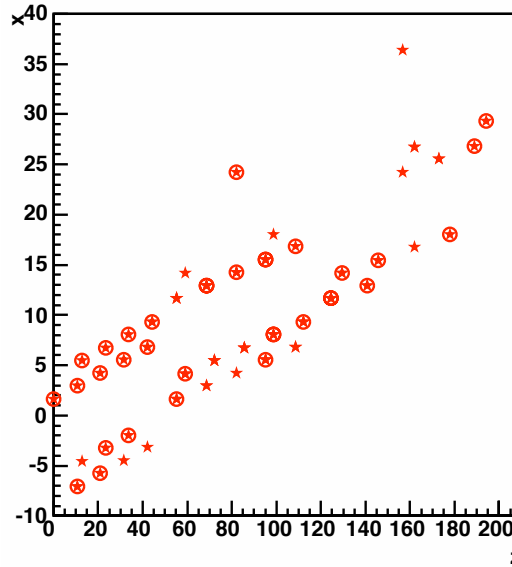


# A not so nice event...

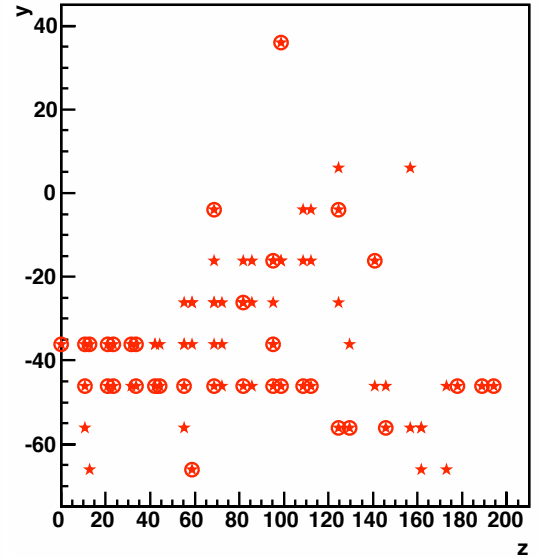
y:x:z {evtid==18}



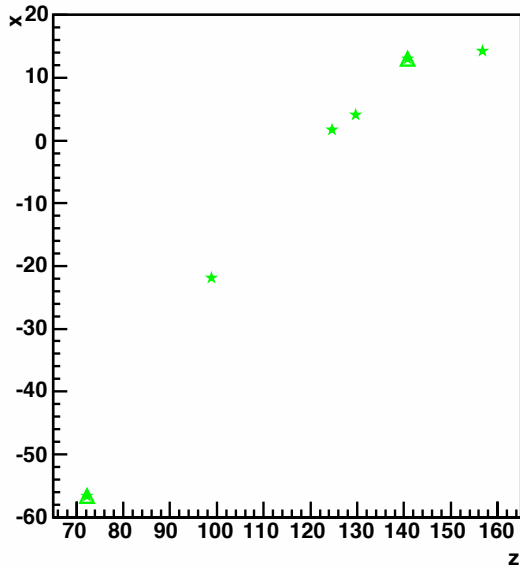
x:z {(used==0)&&(evtid==18)}



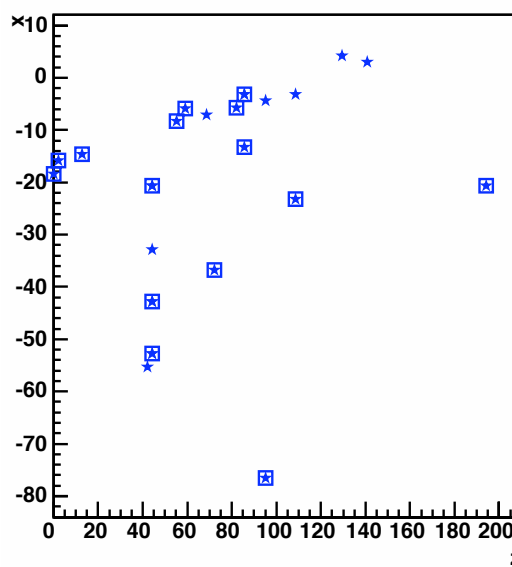
y:z {(used==0)&&(evtid==18)}



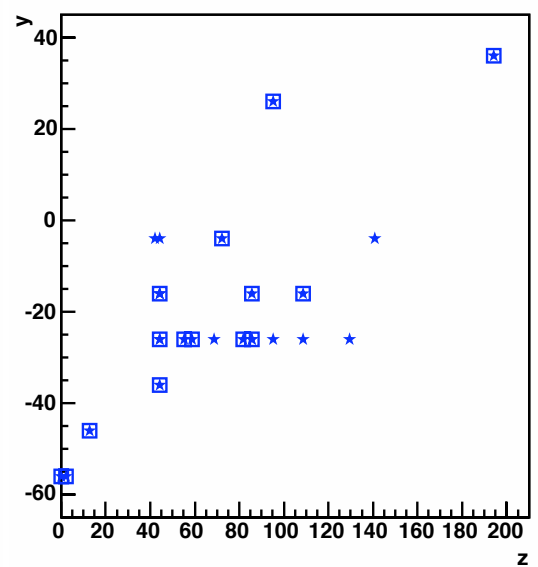
x:z {(used==2)&&(evtid==18)}



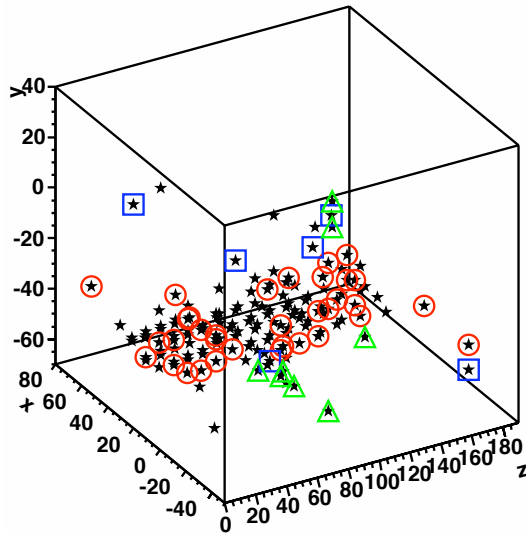
x:z {(used==1)&&(evtid==18)}



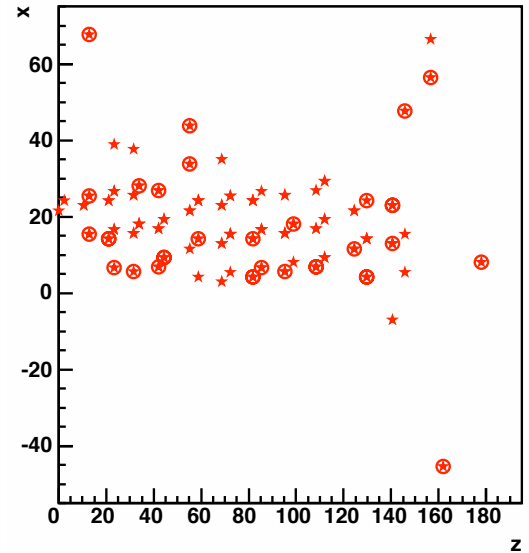
y:z {(used==1)&&(evtid==18)}



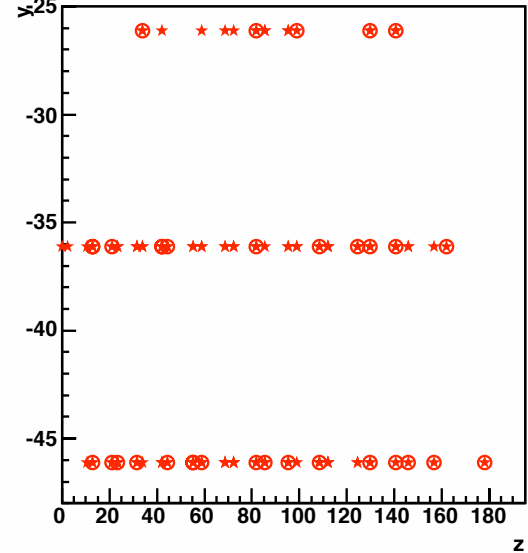
y:x:z {evtid==25}



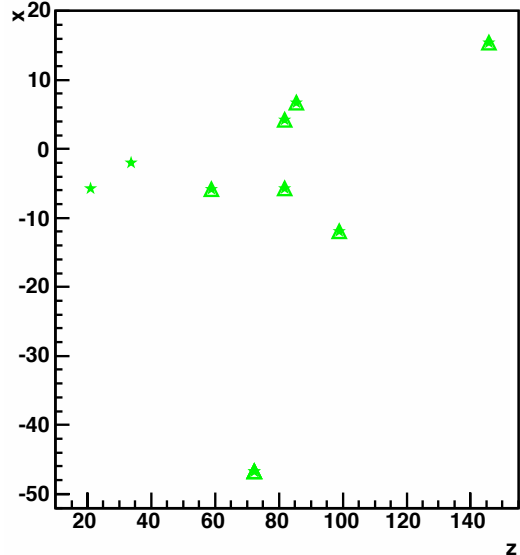
x:z {(used==0)&&(evtid==25)}



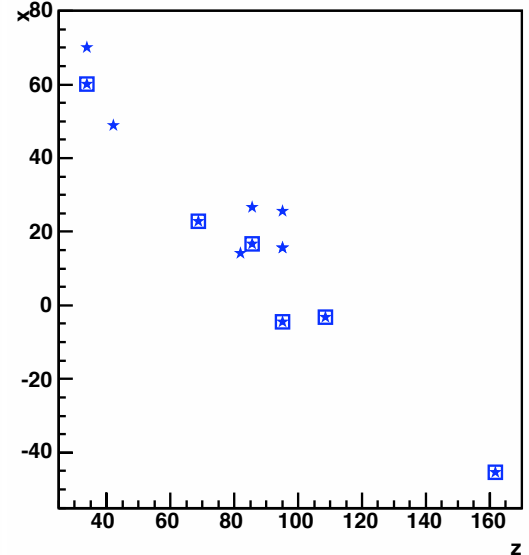
y:z {(used==0)&&(evtid==25)}



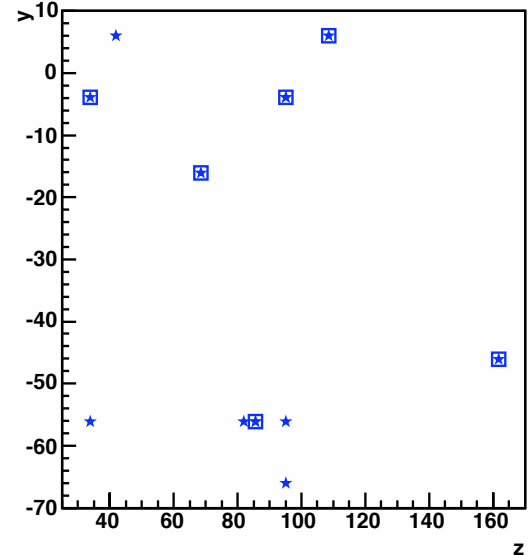
x:z {(used==2)&&(evtid==25)}



x:z {(used==1)&&(evtid==25)}



y:z {(used==1)&&(evtid==25)}



Encouraging but further work necessary ...