

# EM Shower Start Point Reconstruction

Dorota Stefan, Robert Sulej  
NCNR Warsaw

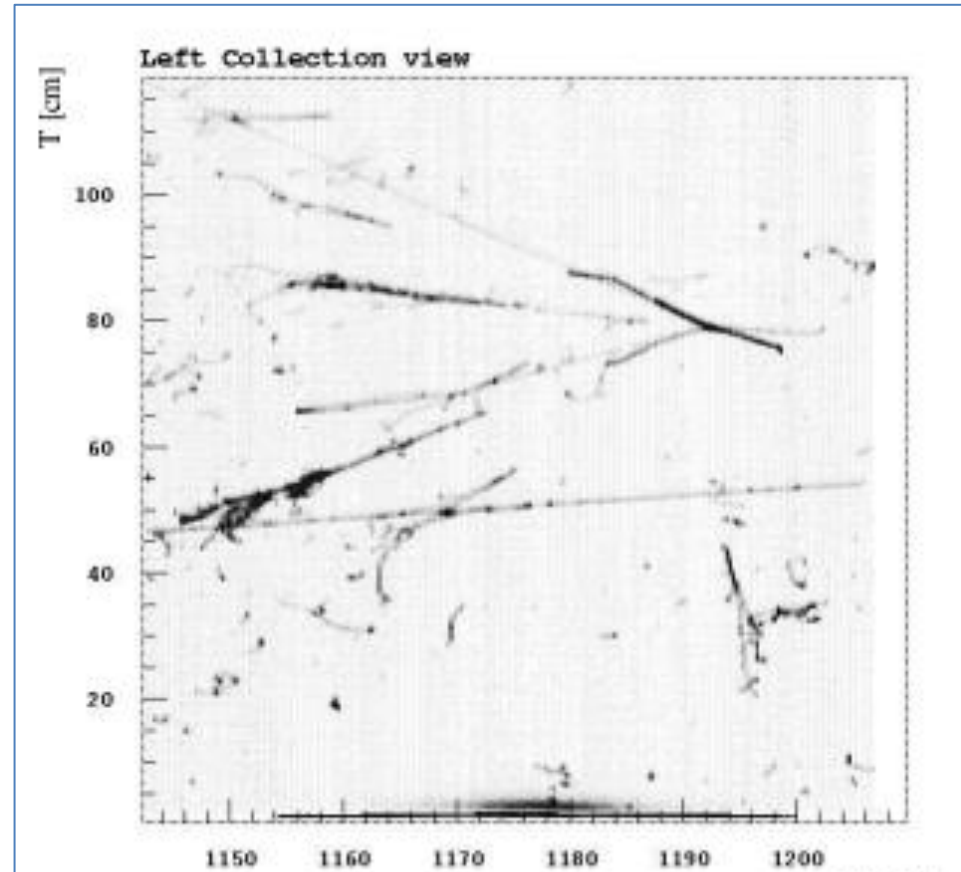
# Introduction

- AIM:  $\pi^0$  reconstruction
- $\pi^0$  from hadronic interactions

$\pi^0$ 's can be reconstructed in the context of the full event topology:

- vertex, if contained, can be used to merge cascade fragments and define cascade directions
- relies on track and vertex reconstruction = full event reco...

**Analysis of cascade features independent from other algorithms can be used in the full reconstruction chain, or used independently if needed – we focus on this approach now.**



3  $\pi^0$  from cosmic rays during ICARUS tests on surface in Pavia.

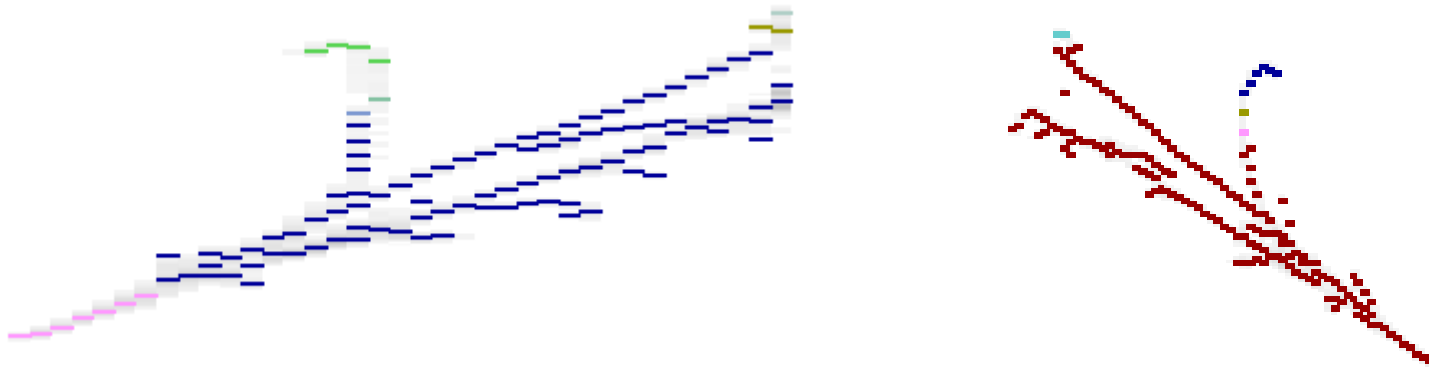
Fig. from Acta Phys.Polon.B41:103-125,2010.  
arXiv:0812.2373

# $\pi^0$ possible reconstruction chain

- Preselect events with showers.
- Apply track-like and shower-like clustering.
- Reconstruct shower start point (this talk).
- Match 2D views and reconstruct 3D direction.
- Search for the pairs of showers that point to the common vertex.

# Simulation and data preparation

- Single photon simulated with momentum 700 MeV.
- Only Collection used.



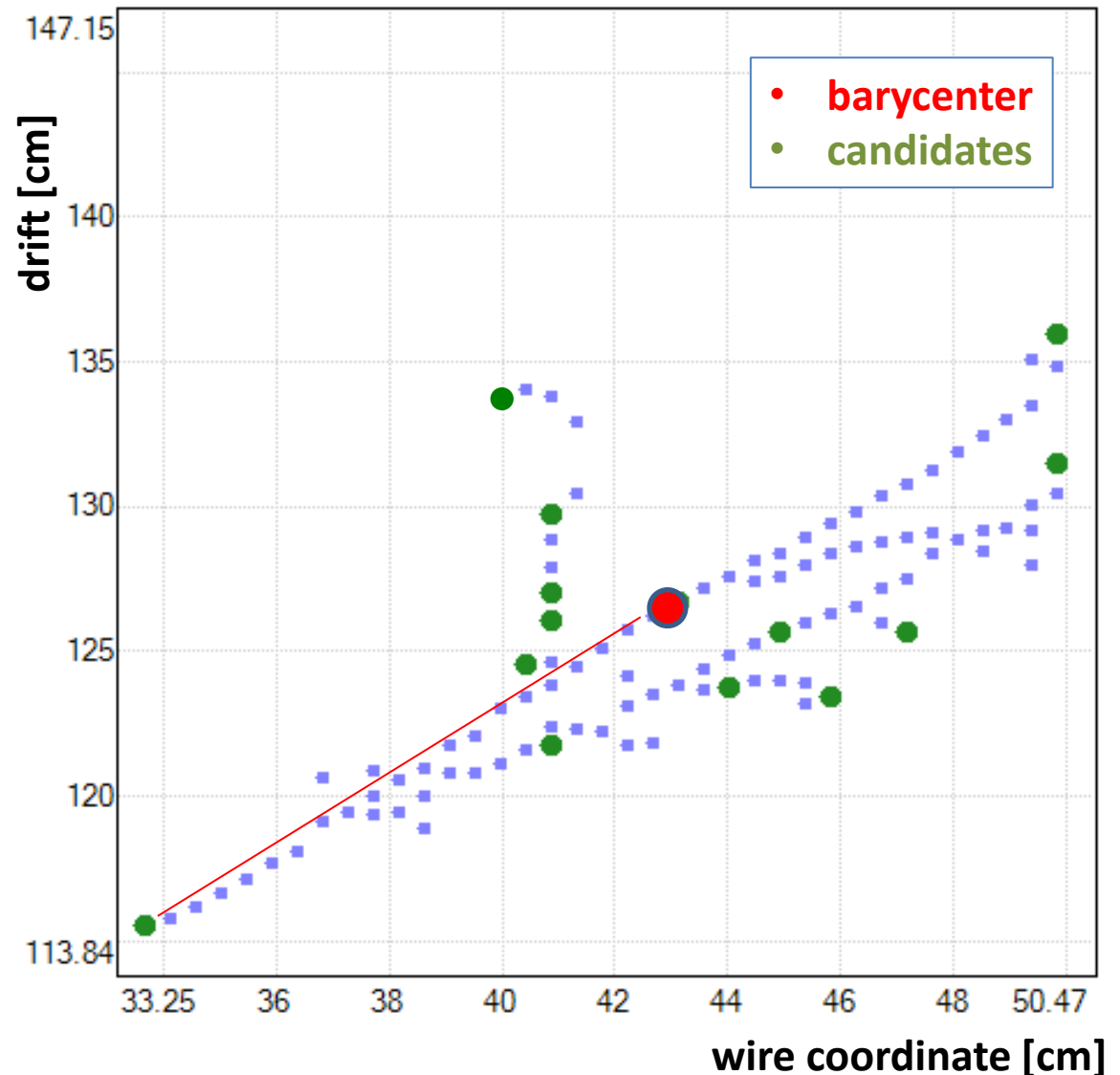
Example: blurred clustering algorithm

## Approach

Algorithm that identifies primary vertex is based on the shape of the cascade and the charge distribution. It also takes into account that we are looking for: double m.i.p. from the primary vertex and a high charge asymmetry in the local angular distribution.

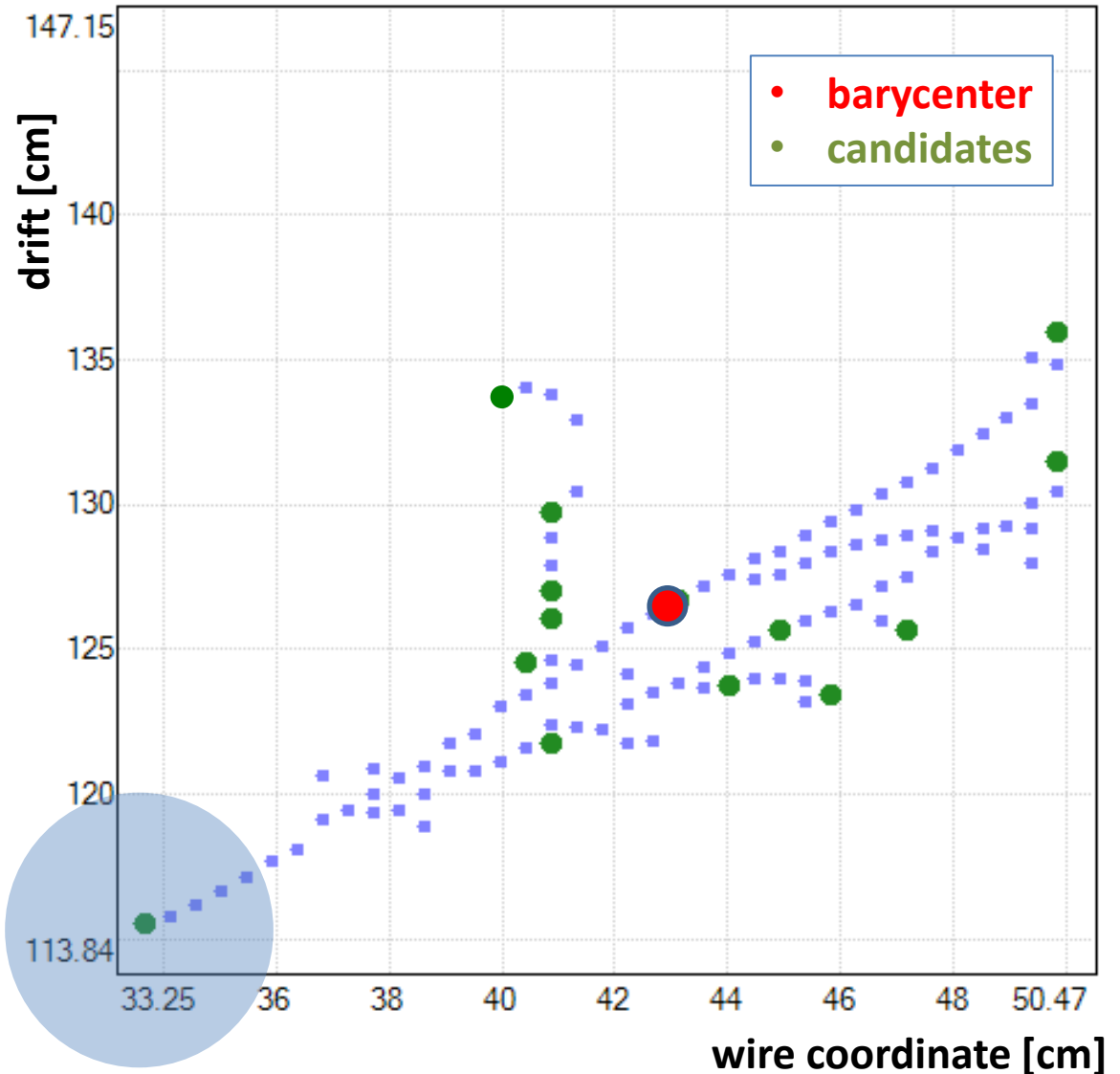
# Algorithm part 1

- Barycenter of the hits positions of the shower.
  - Searching for the most external positions of the shower in the angular bins: „candidates”.
- maximum distance to barycenter defines „the size” of cascade, and normalization of distances.



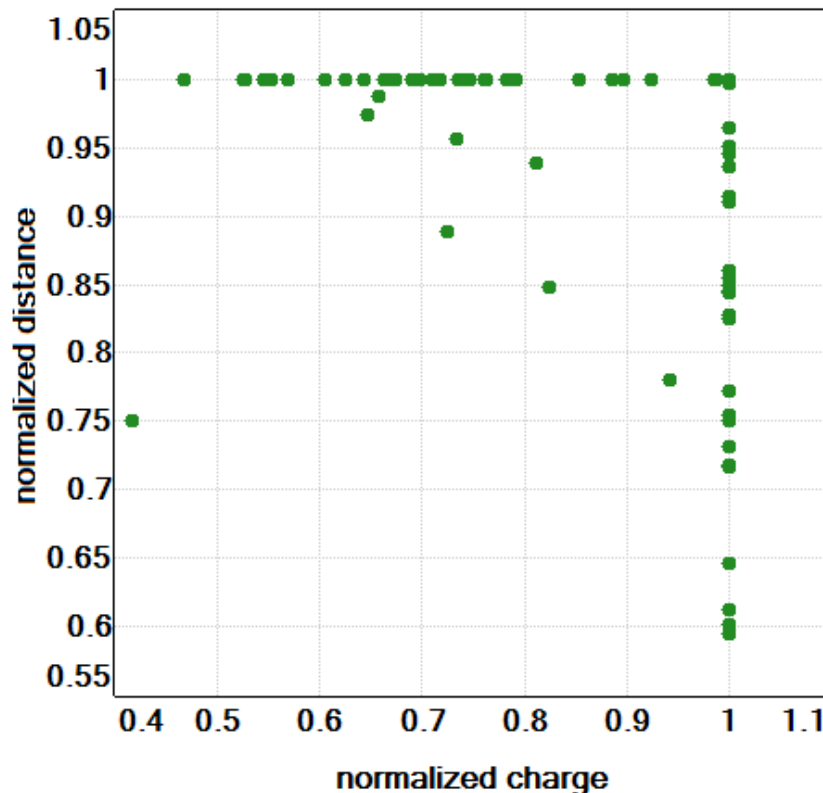
## Algorithm part 2

- Angular charge distribution (48 bins) for each candidate.
- Compute charge asymmetry (max vs. mean of the rest) for each candidate.
- Candidate with the highest max charge defines the charge normalization.



# Algorithm part 3

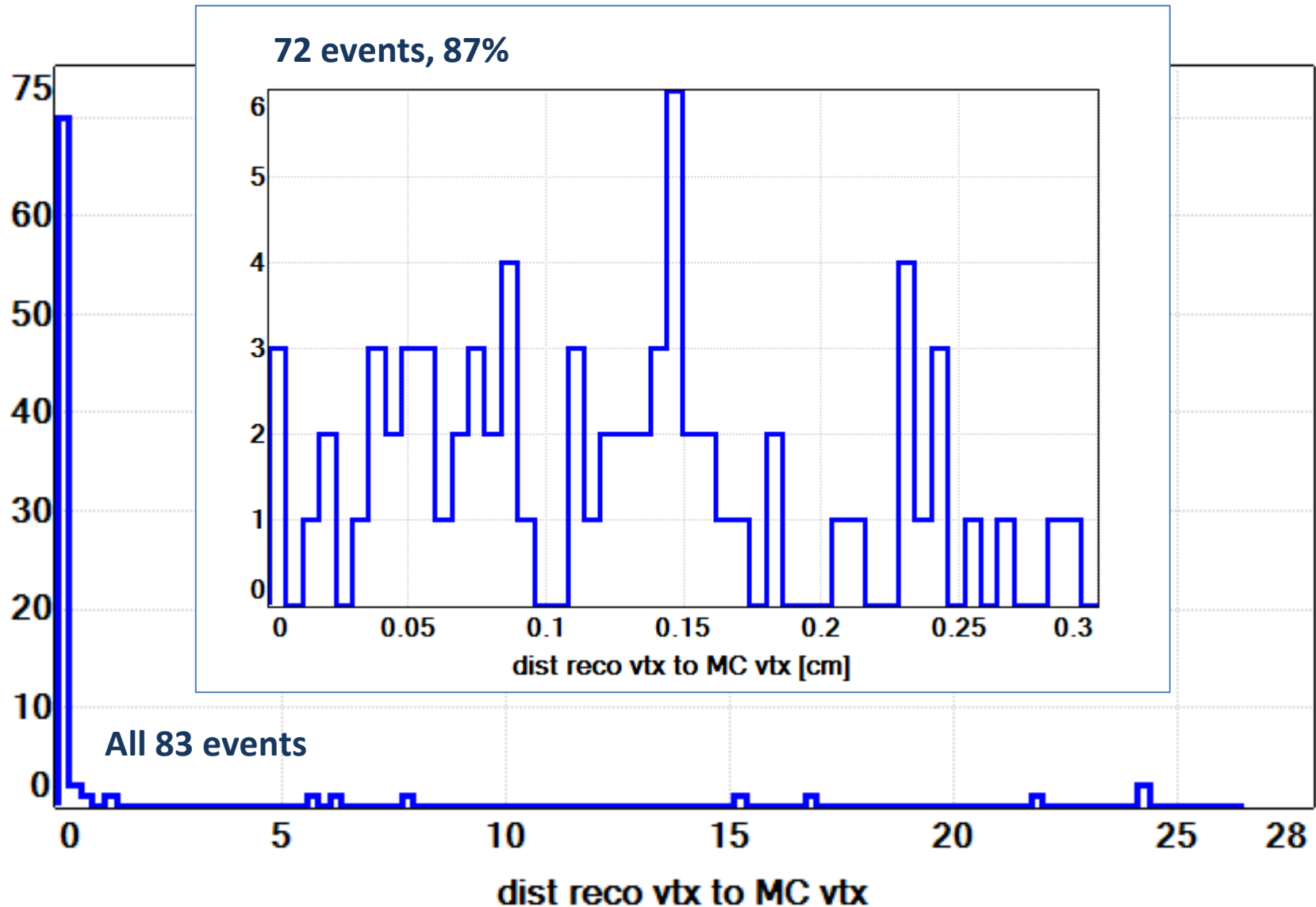
- Parameters which can be tuned: number of bins and radius for which the angular charge distribution is made.
- We consider two points as good candidates for shower start point: the most distant from the barycenter AND with the highest maximum charge. The candidate with the higher charge asymmetry is taken as primary vertex.



Sample generated with the parameters:

point of gen (100, 0, 20), Theta0XZ: 0 and sigma: 0; Theta0YZ: 0 and sigma 180

For reco, for simplicity, we take only photons which converted in TPC 1

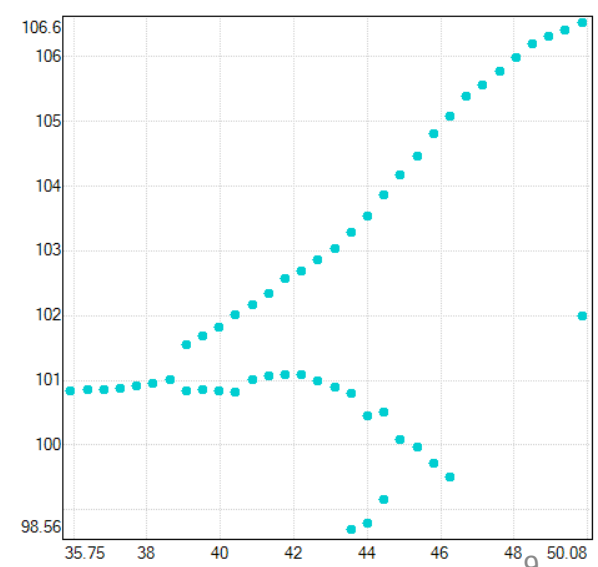
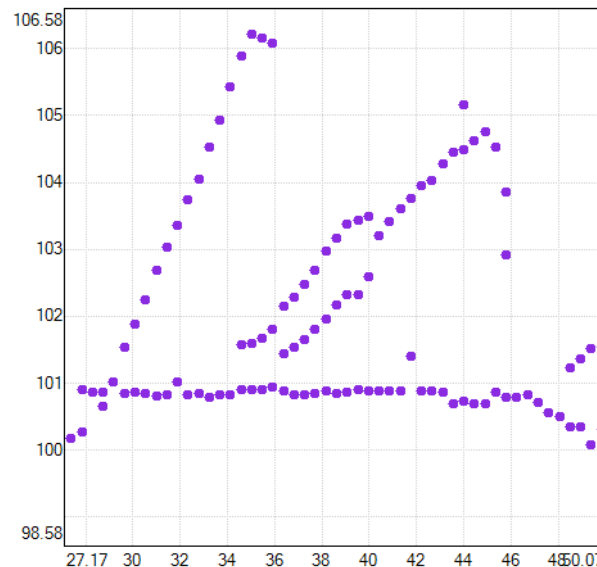
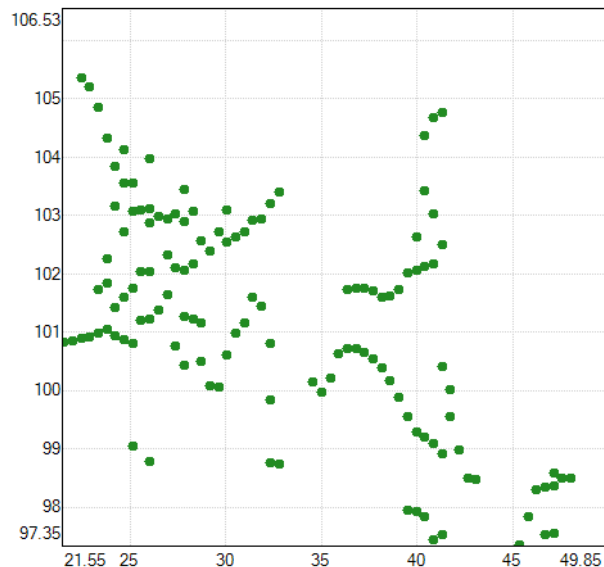
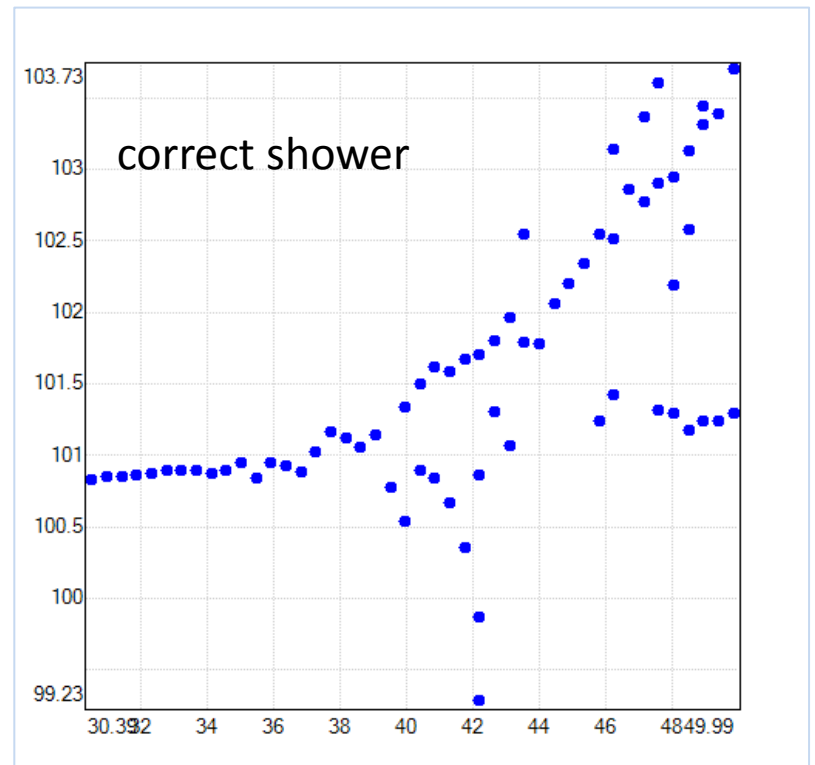




## Reasons for inefficiency.

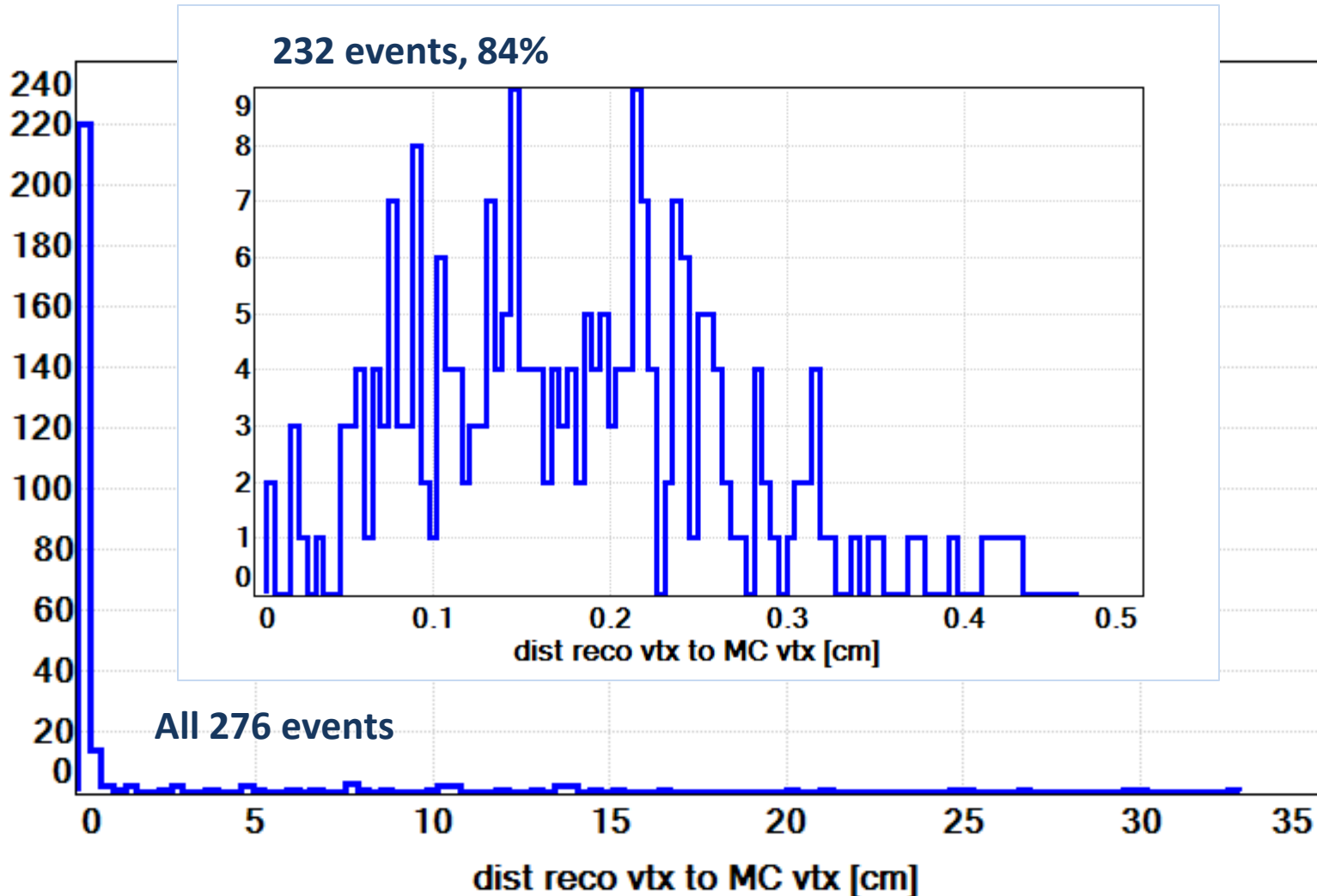
- short projection of the shower
- asymmetric (open) pair production
- long, track like topologies

Some difficult configurations:



Sample generated with the parameters:

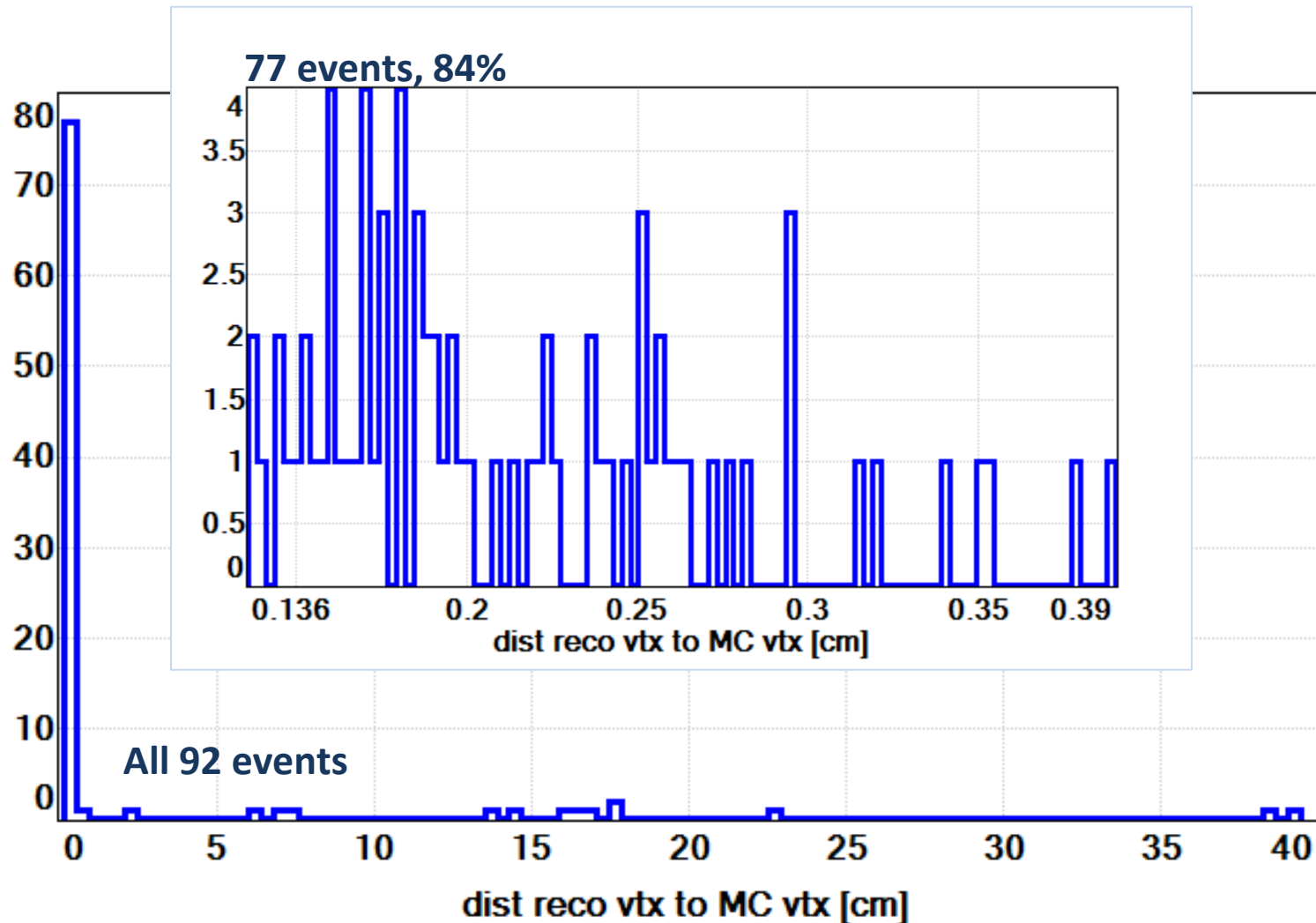
point of gen (100, 0, 20), Theta0XZ: 0 and sigma: 90; Theta0YZ: 0 and sigma 180  
For reco, for simplicity, we take only photons which converted in TPC 1



Sample generated with the parameters:

point of gen (100, -60, 20), Theta0XZ: 45 and sigma: 0; Theta0YZ: 45 and sigma 0

For reco, for simplicity, we take only photons which converted in TPC 1



## Next steps

- The algorithm should include „no answer” possibility, e.g. too low asymmetry – to be investigated.
- Combine all views: select the best projection (highest asymmetry of the selected start point, or length of the cascade); matching of pairs between views.
- 3D reconstruction of the primary vertex and initial direction.
- ...