Pattern Recognition in PXD: Slow Pions against Electrons

Dual purpose:

1. Stand-alone rescue in case of ROI turn-on
2. Support for low momentum track finding
   (+ pattern recognition in SVD)

PXD Standalone Rescue Project

Motivation:

- Slow pions from D* decays are low momentum (< 250 MeV)
- Only very few make it into the CDC
- Reconstructed mainly by the SVD
- Slow (charged) pions serve as flavor taggers for neutral B mesons, but also crucial for various important physics channels (-> see talks on Monday)

General idea:

- try to identify PXD clusters from slow pions against electron bg (QED or machine bg) without any external detector (no ROIs from SVD needed)
- form clusters and calculate cluster parameters (at the DHH-Level), apply pattern recognition algorithm (e.g. neural nets)

In case of ROIs selection being turned on:

- Cluster algorithm and preprocessing on DHH, „pion“ clusters -> ONSEN

Option PCIe DAQ upgrade: direct transfer of clusters to HLT with the possibility for „6 layer tracking“ with selected PXD / SVD clusters (beat combinatorics)

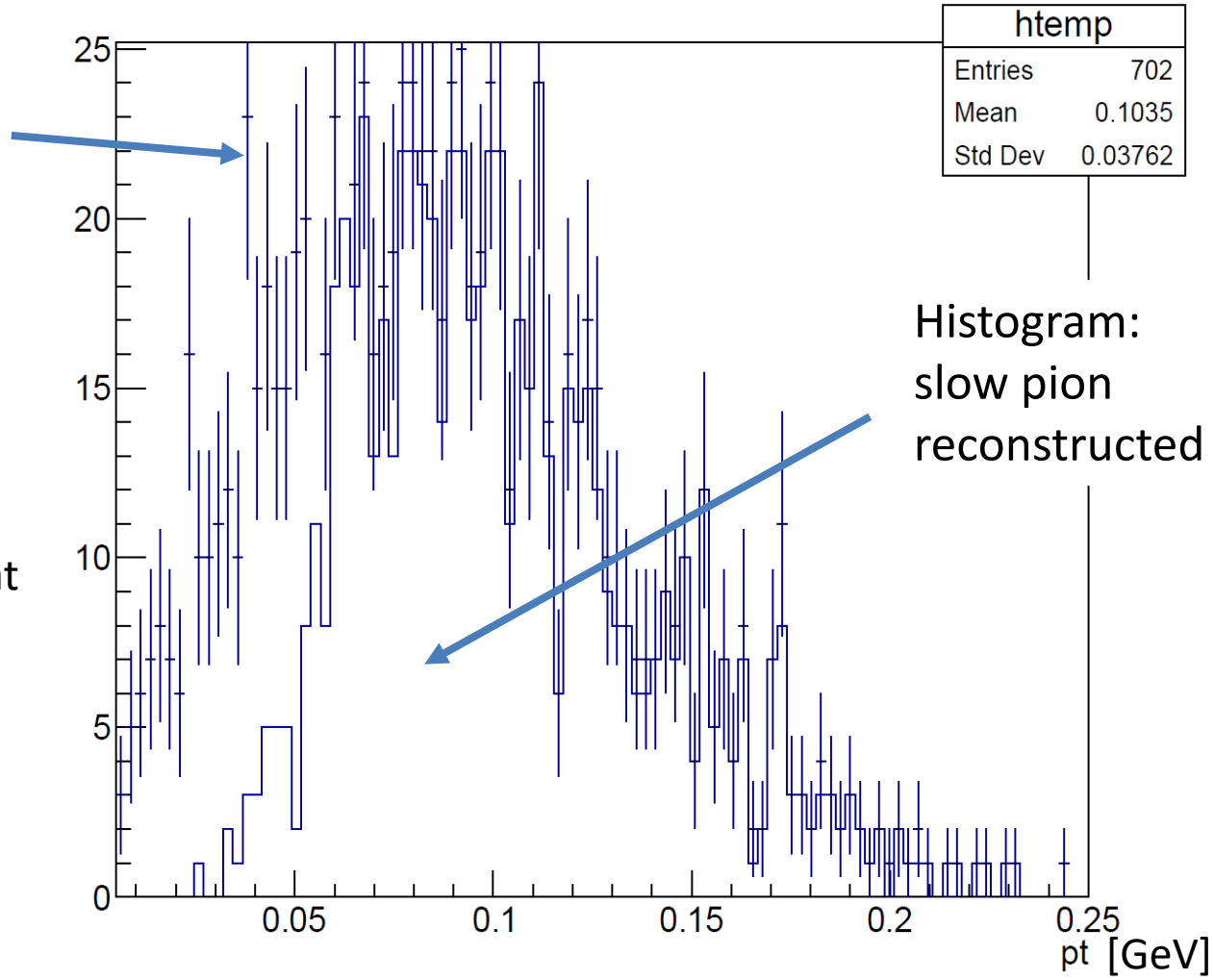
Pt Spectrum of Slow Pions

MC productions: Slow Pions from $B^0 \rightarrow D^* e^- \nu$, $D^* \rightarrow D \pi^-$, $D \rightarrow K^+\pi^-$ (+ $B^0 \rightarrow \nu \nu$)
electrons: QED process $e^+ e^- \rightarrow e^+ e^- e^+ e^-$

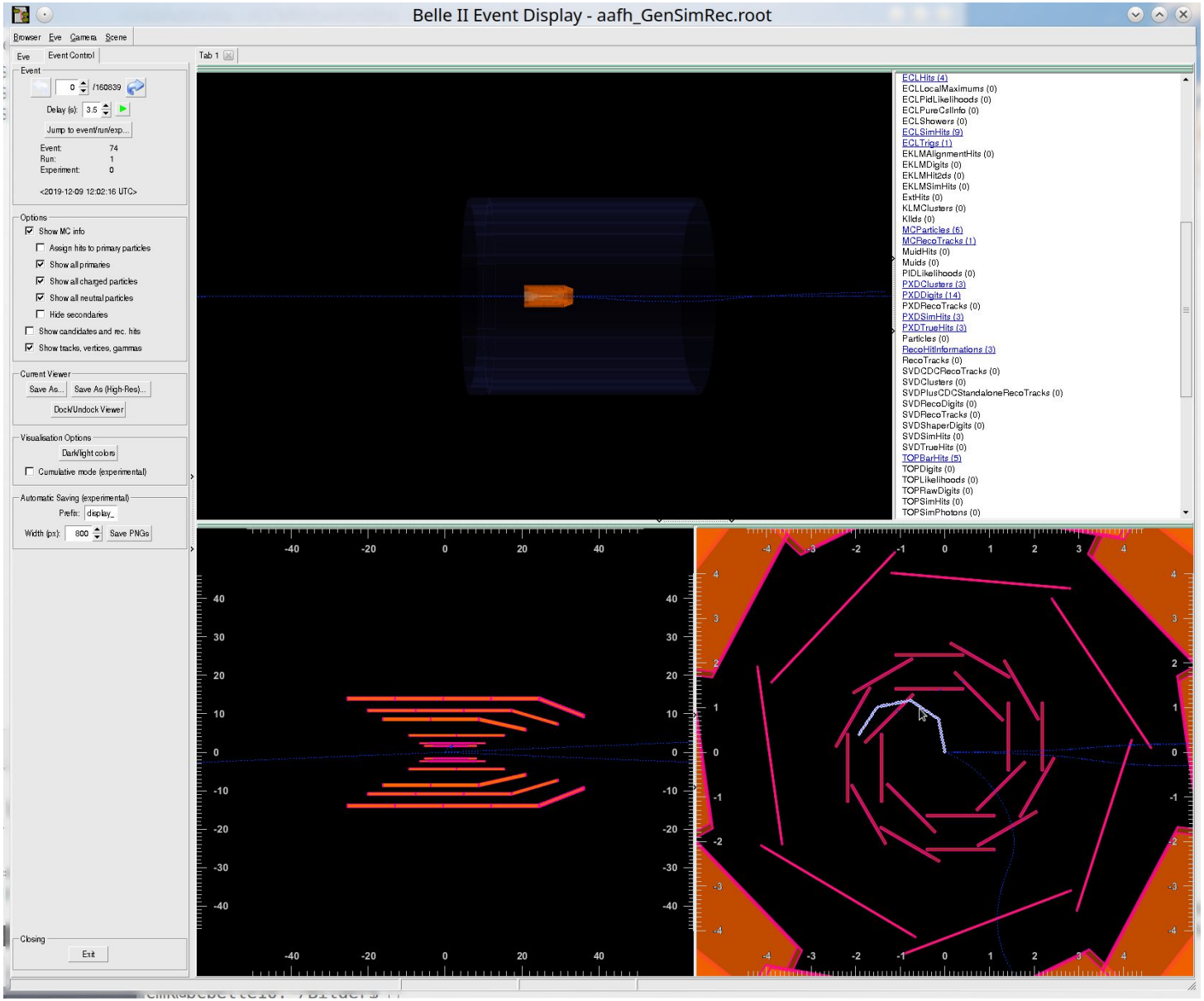
Histogram with error bars:

Slow pions generated

~30% are not reconstructed, predominantly at very low transverse momentum



Dominant PXD Clusters from QED Events

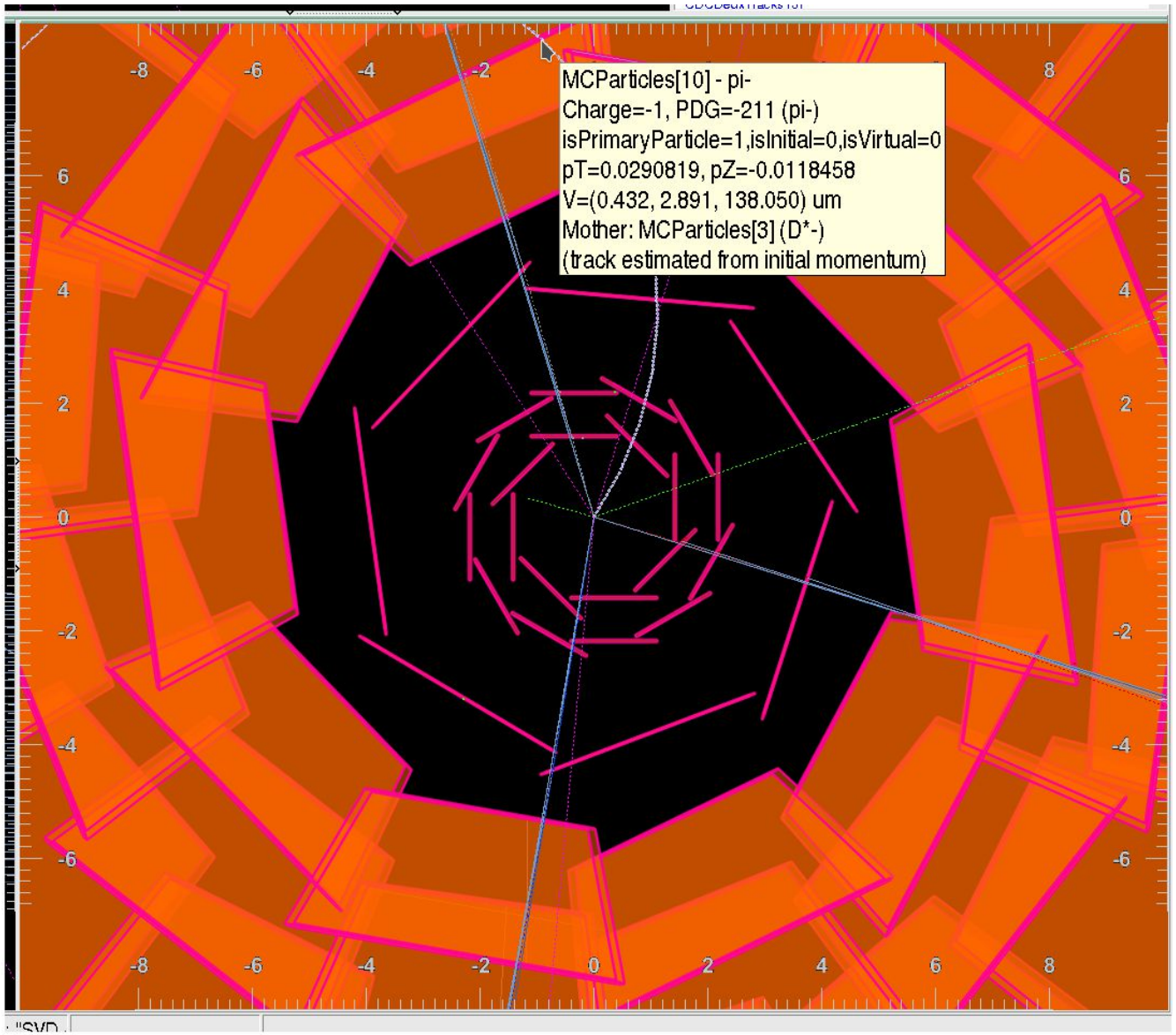


QED events generate the known large background when the luminosity is high

PXD clusters predominantly on layer 1

MC simulation

PXD Clusters in B Meson Events



Slow pions may not traverse all 4 SVD layers, so are lost at the moment

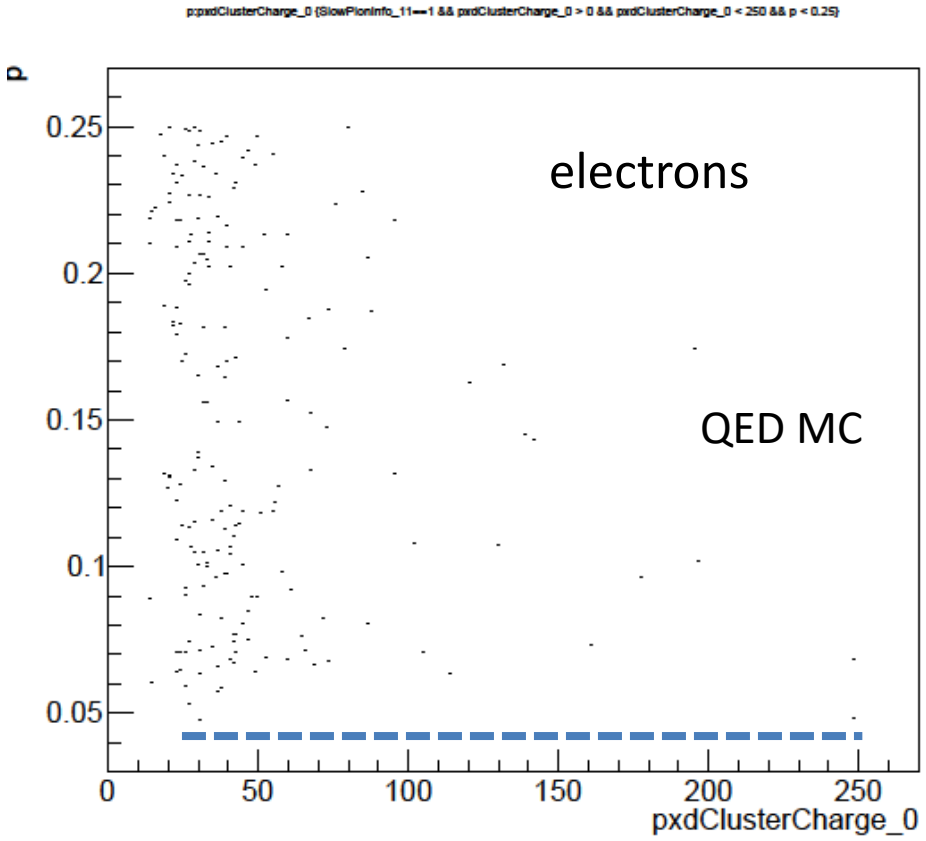
BUT:
Slow Pion **could** be nicely reconstructed (with a NEW algorithm to be written) …..

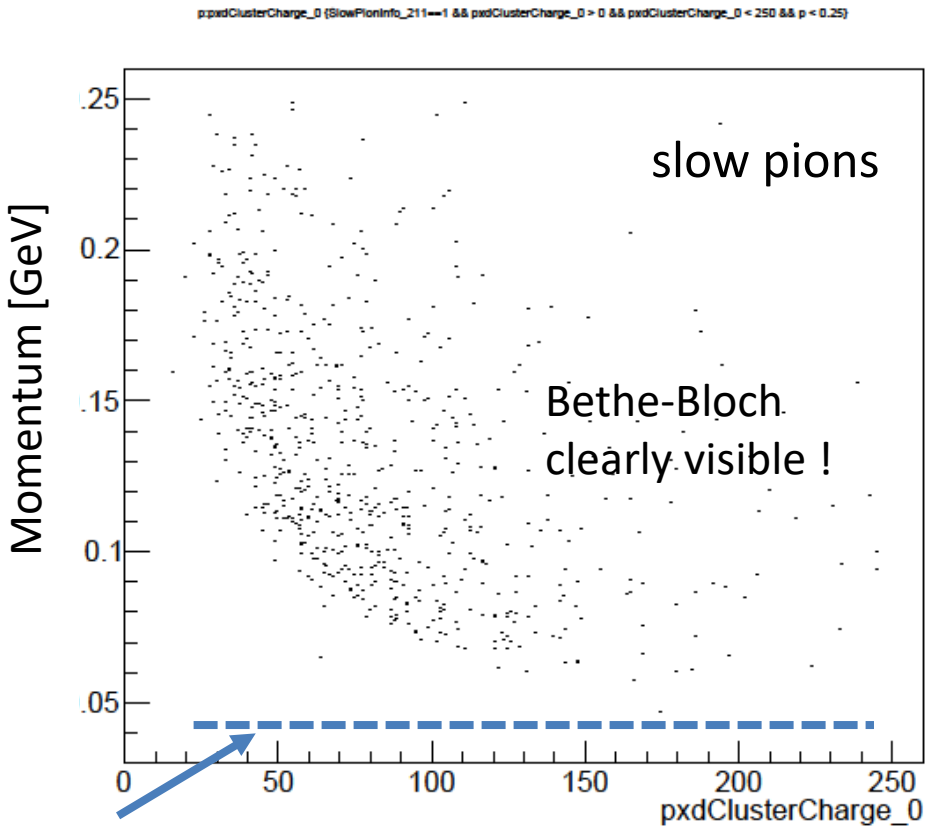
… IF selected PXD hits would be combined with a few (<=4)SVD hits

„6 layer“ ALL SILICON tracking at the HLT

PXD Clusters, pions vs QED electrons

MC productions: Slow Pion from $B^0 \rightarrow D^* e^- \nu$, $D^* \rightarrow D \pi^-$, $D \rightarrow K^+\pi^-$ (+ $B^0 \rightarrow \nu \nu$)
-> Ntuple with MC, reco and associated clusters





The clusters show (hopefully) different patterns between electrons and (slow) pions

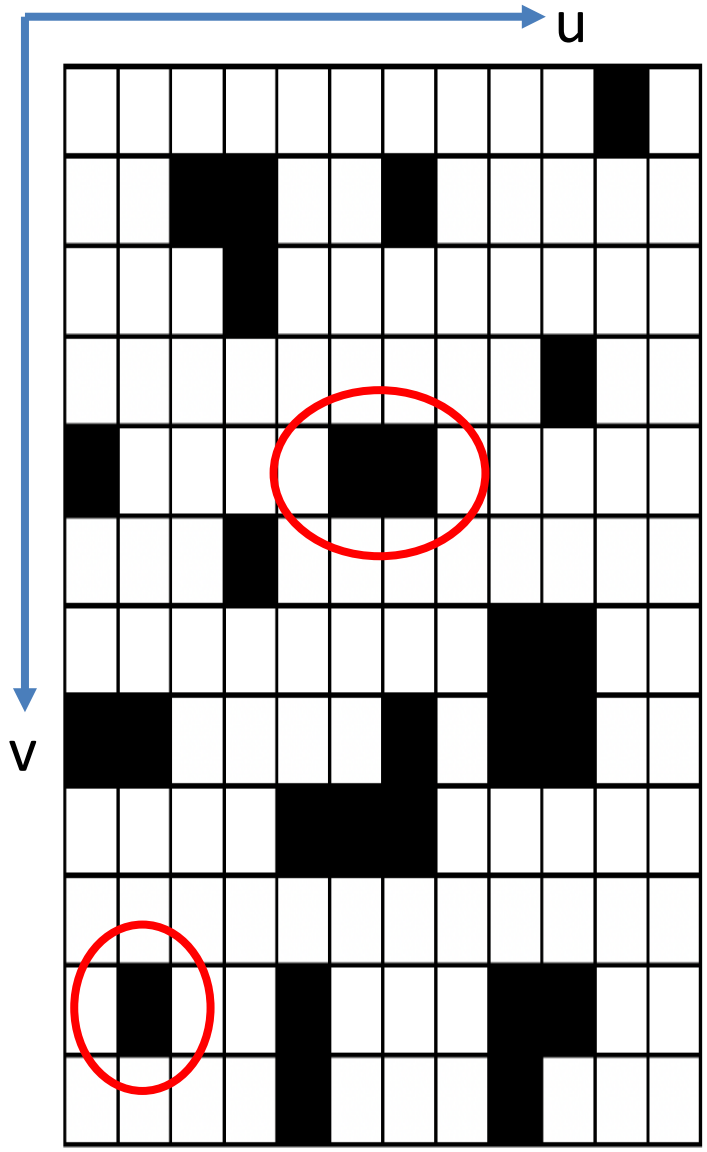
Program Chain

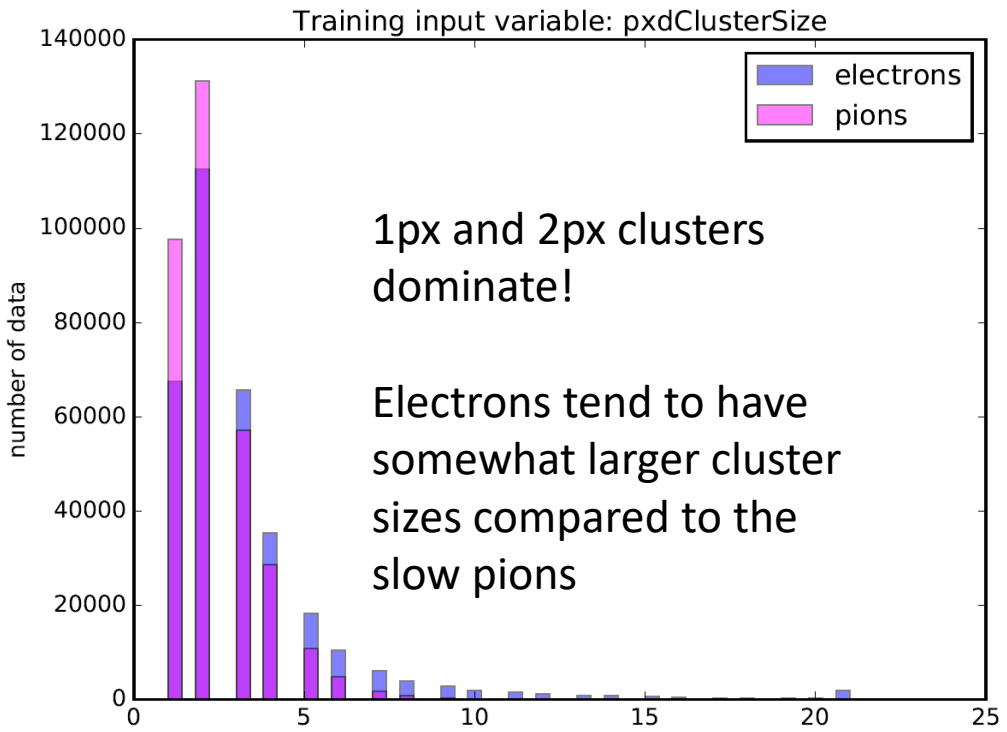
Program chain to generate PXD clusters (DST Format) under control:

- Constructing Ntuples for input data sets from DSTs
- Multivariate algorithm using program FANN (feed-forward neural network)
- Single-hidden-layer network chosen with variable number of hidden nodes, should be well suited for fast execution in FPGA (on DHH)
- Training is done with about 150 000 events (+ 2 independent samples for convergence and test)
- Output of network is a classifier. First tries with FANN (artificial neural net) to separate slow pion from electron clusters have been done
  some of the results shown (see next slides).

PXD is being used as Paricle Identifier

Cluster Variables

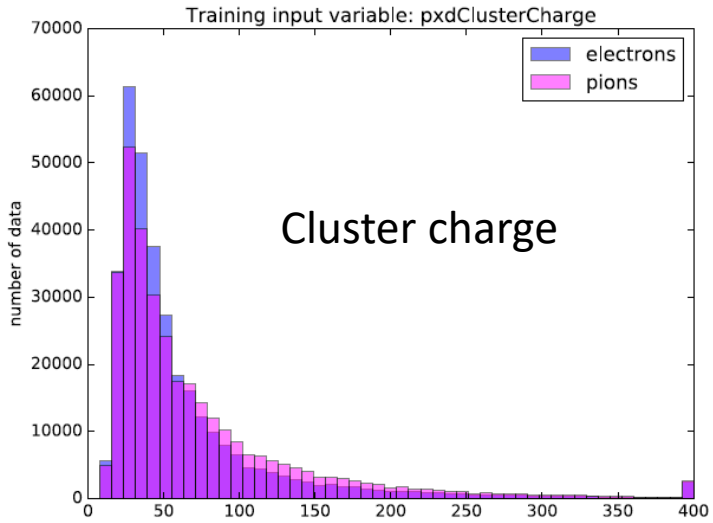


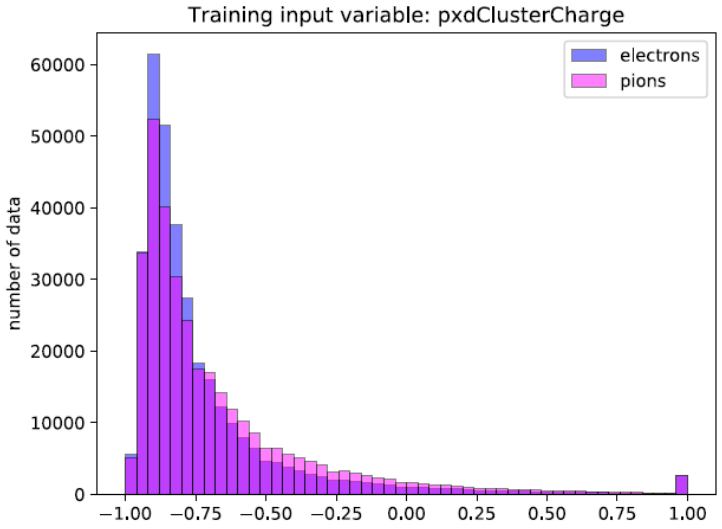


Cluster quantities used:

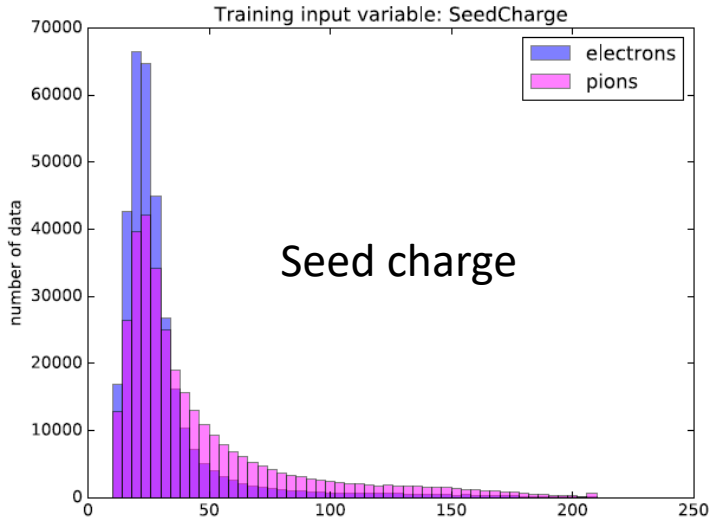
cluster charge, seed charge, size, length in u and v, sigmas u and v, u-v correlation, position in u and v, layer number

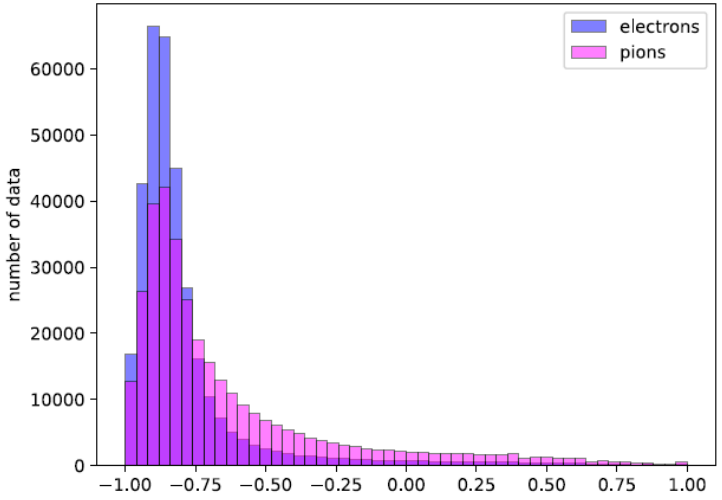
Some Sample Quantities



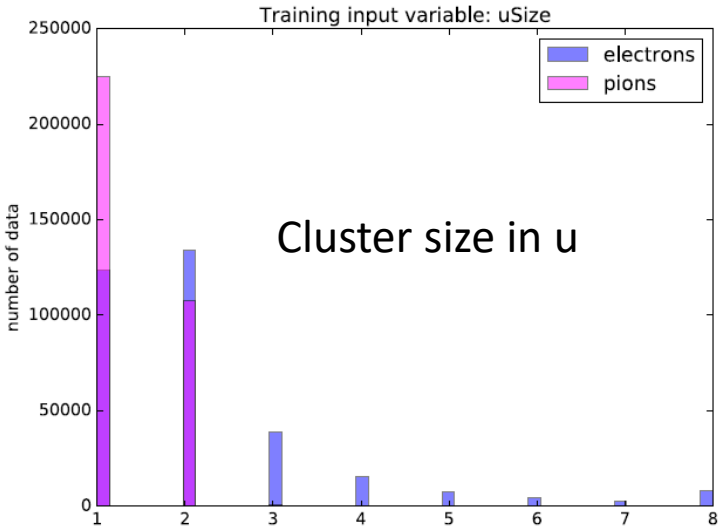


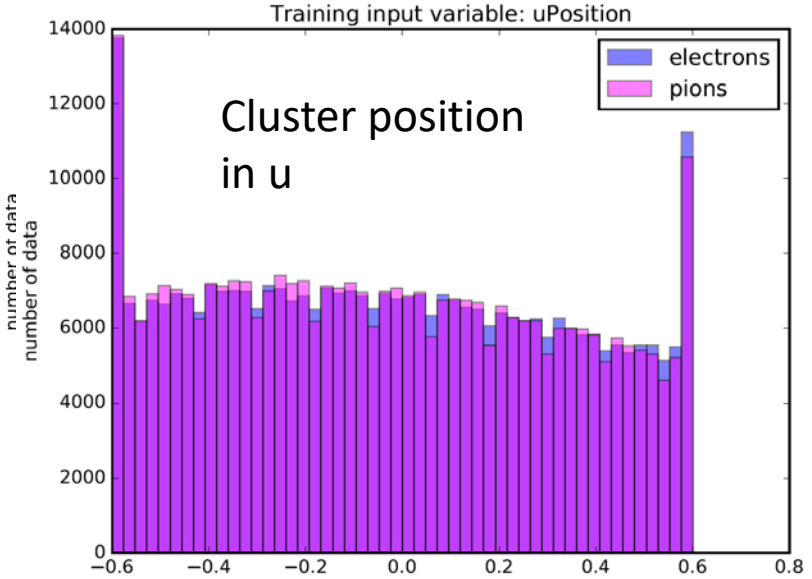
mapping to unit interval

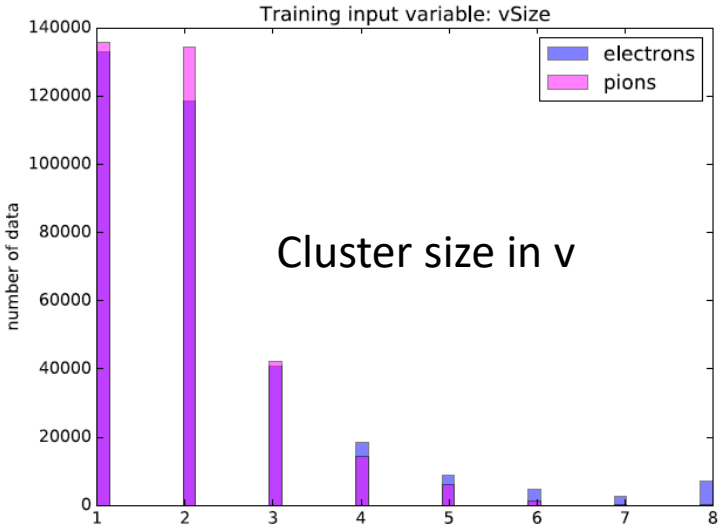


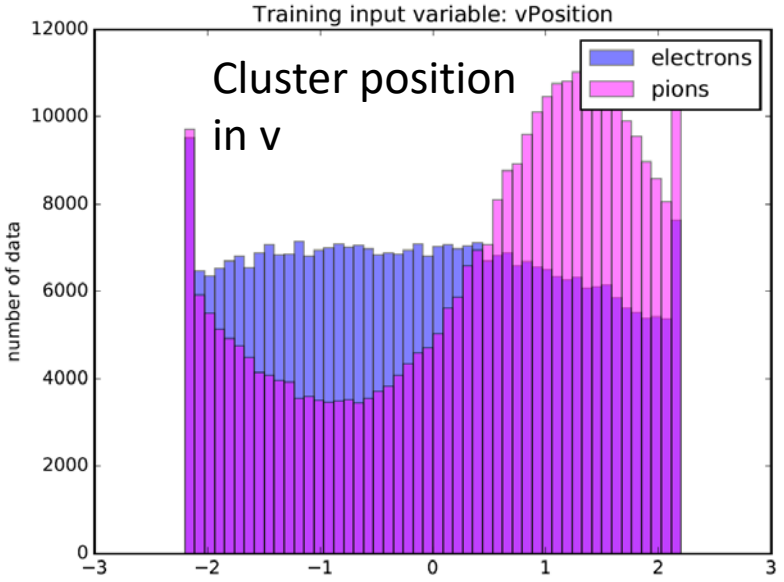


Some Sample Quantities

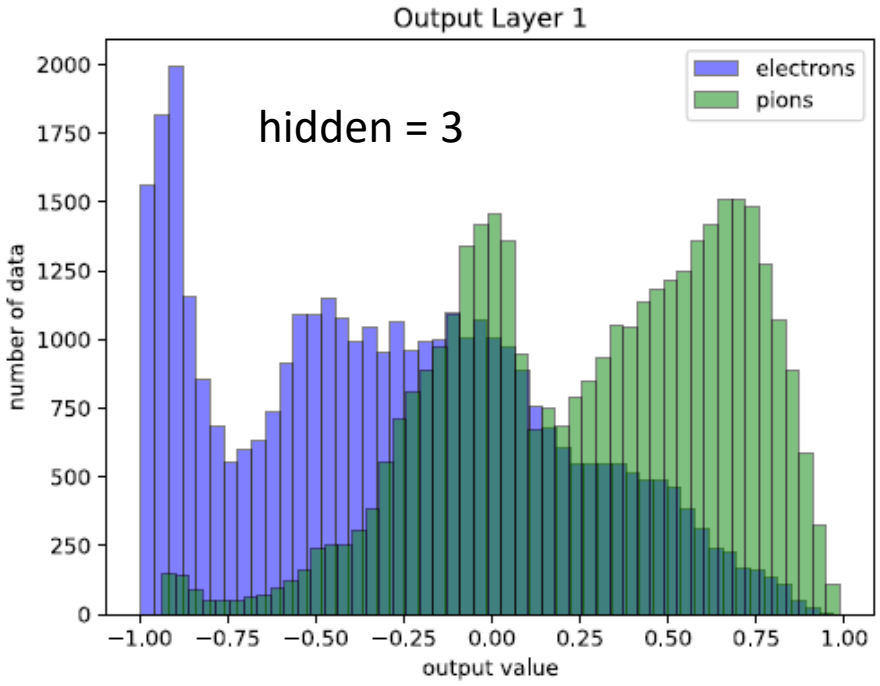








Results from Training

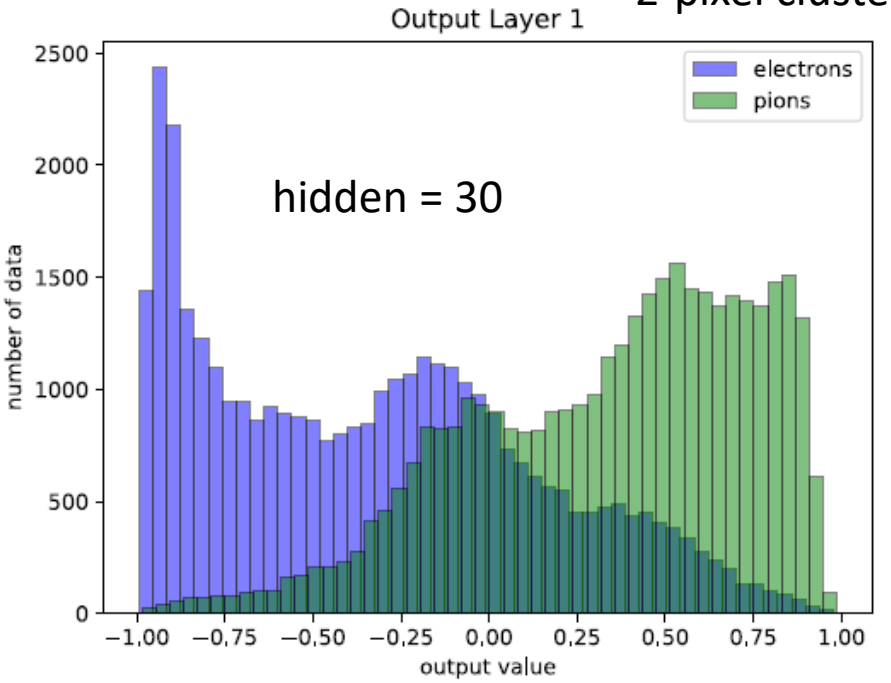


2-pixel clusters

Several numbers of hidden nodes have been tried: Already with 30 nodes there is separability

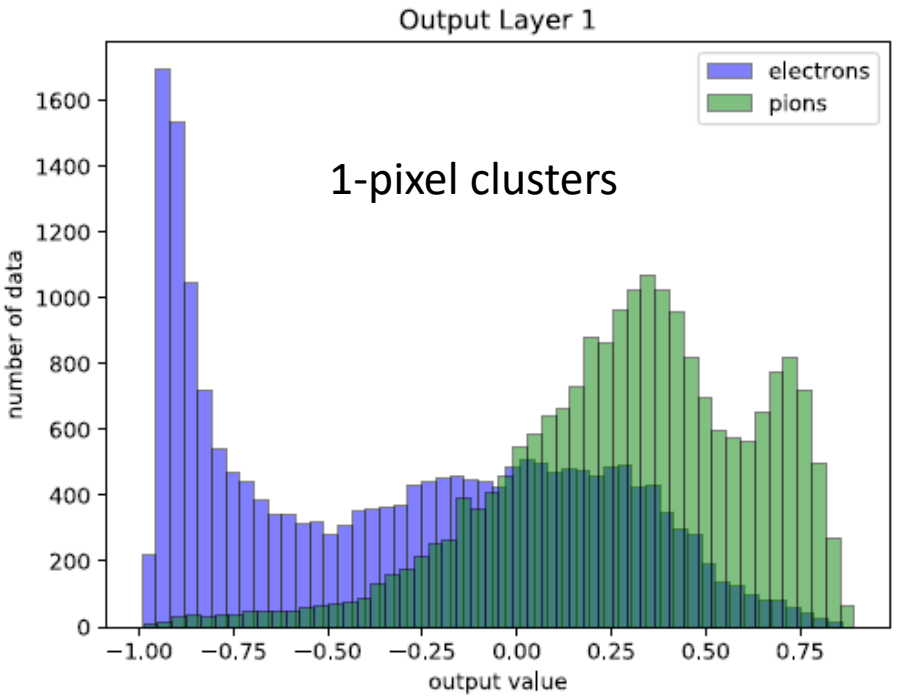
Here: Example of Clusters with 2 pixels

2-pixel clusters



separation with more hidden layers yields better results
(beyond 30 hidden nodes the improvement is marginal)

First Results from Training (master th. Erwin Do)



Separation for 3 or more pixels in the cluster looks very promising!

Typical efficiencies (90% rej.) :

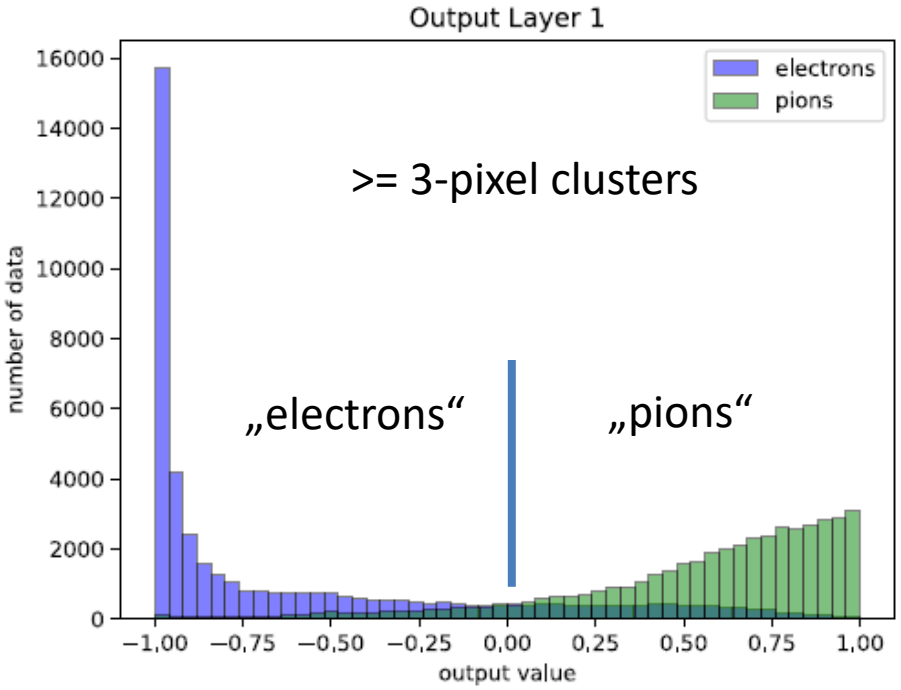
1-pixel: 51%

2-pixel: 54%

>= 3-pixel: 82%

Clusters with different sizes have been trained individually:

Separation for Single Pixel Cluster seem marginal, but still ….



Summary and Next Steps

First tries indicate that indeed the PXD clusters can be used (to some extent) for the identification of slow pions vs electrons

looks promising, we will „restart“

- Even single clusters show some separability, clusters with 3 or more pixels are perfect
- Complexity of network is limited (10-30-1 architecture seems adequate)
- Network cut: goal of required reduction should be defined (factor 10?)

Plan:

- resume training networks to efficiently mark slow pion clusters
- check performance with real data

- Online rescue: consider implementation on DHH level

- Offline tracking: „6 layer tracking“ with selected clusters from PXD and SVD (similar pattern recognition algorithm for SVD should be tried)