PXD Digitizer Studies: Clusters and Dynamic Range

Martin Ritter

7th International Workshop on DEPFET Detectors and Applications
May 9, 2011

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

DEPFET
Active Pixel Detector

Introduction

PXD has to perform a data reduction due to high data volume

➡ Use fast tracking in SVD to find regions of interest in PXD

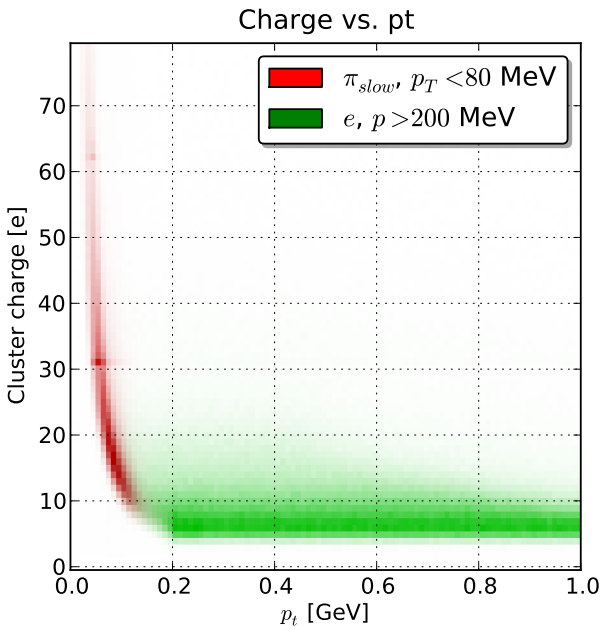
Studies indicate this should work well for high energy tracks but might have efficiency problems for tracks with $p_T \leq 80\,\text{MeV}$

Slow pions from $D^*(2010)^{\pm} \rightarrow D^0\pi^{\pm}$ have very low momentum but are important for B-tagging

- Their momentum is mostly below minimum ionizing

➡ Find pixels/clusters with very high energy deposition and keep them in addition to the regions of interest

- In addition, there might be a way to veto photon pixels/clusters



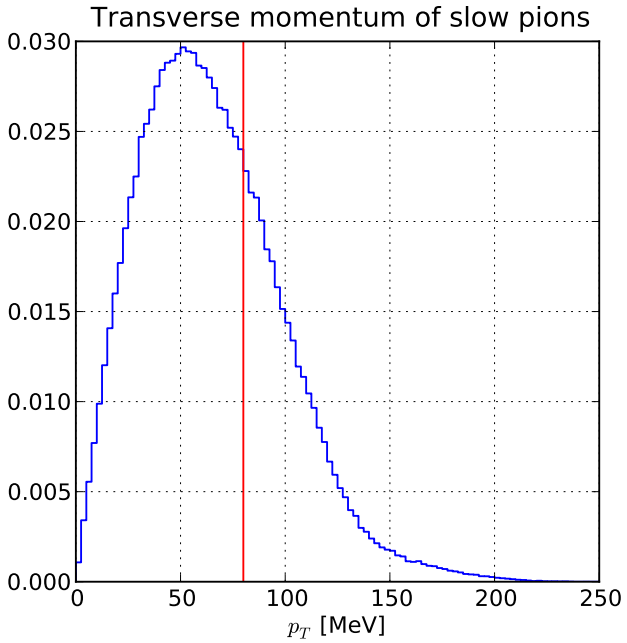
Purity requirement

- Data reduction requirement is to keep at most 10% of PXD data
- pixels kept by slow pion search + pixels kept by tracking $\leq$ 10%

Setup

Simulated particles

- electrons between 200 MeV and 1.5 GeV
- fast pions between 200 MeV and 1.5 GeV
- slow pions from $D^*(2010)^{\pm} \rightarrow D^0\pi^{\pm}$
- photons between 5 keV and 50 keV



- fast pions behave very similar to electrons, so only electrons will be shown
- electrons, fast pions and photons not yet according to expected distributions

Software

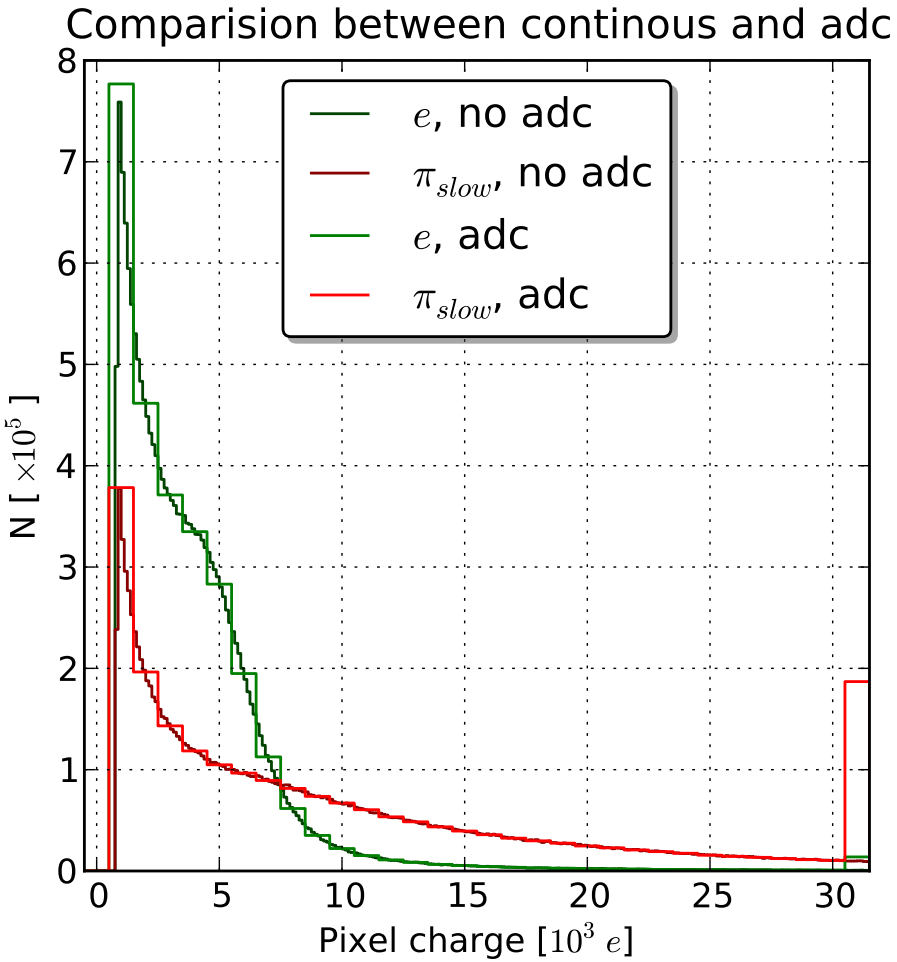
- Belle2 Analysis Framework (basf2)
- digitization and clustering based on Peter Kvasnickas work
- drift model from Benjamin Schwenker

Dynamic Range

Assumption: effective 5 bits available for pixel signal.

- MIP Particle expected to produce a charge of 6000e, landau distributed
- for good position reconstruction we also need the tail
- slow particles deposit more energy, but precise position reconstruction is not essential

Simulation suggests a signal range up to ~30000e
All studies were performed simulating a 5bit ADC, dynamic range 0-31000 electrons

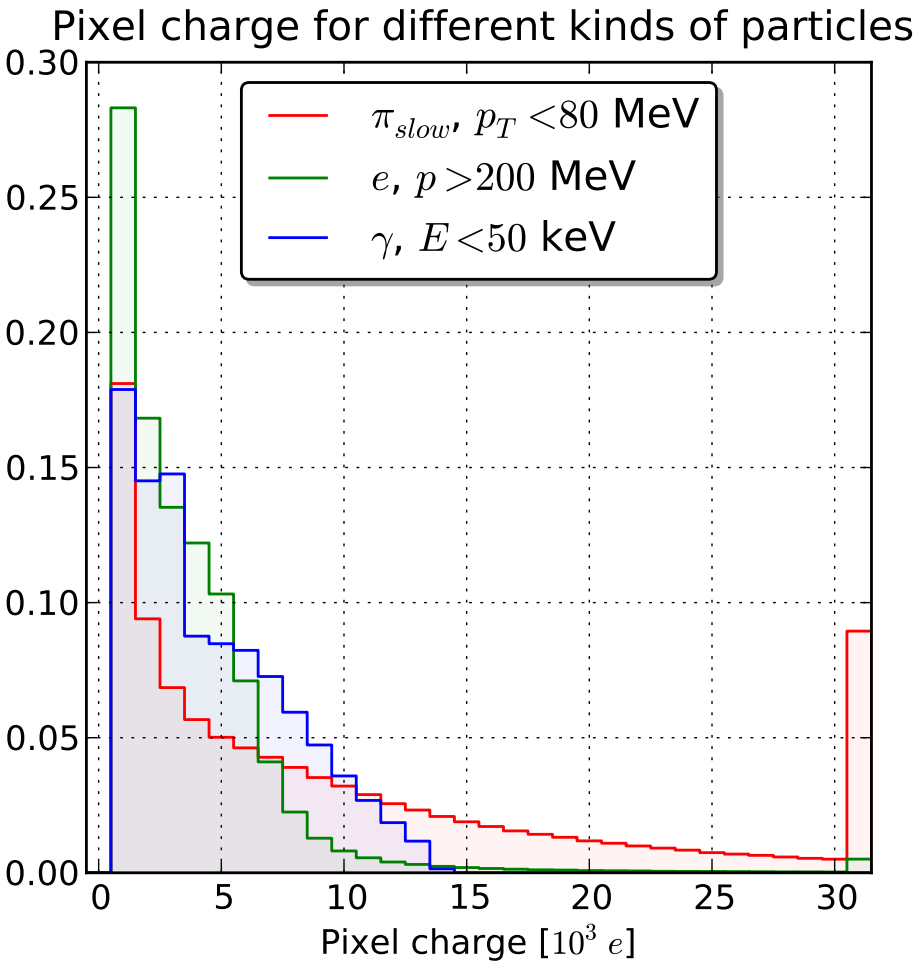


Pixel Energies

Cut on the pixel signal height is always possible

But: also slow pions have high fractions of low energy pixels due to charge sharing

➡ efficiency of $\sim$ 30% with purity of $\sim$ 95%



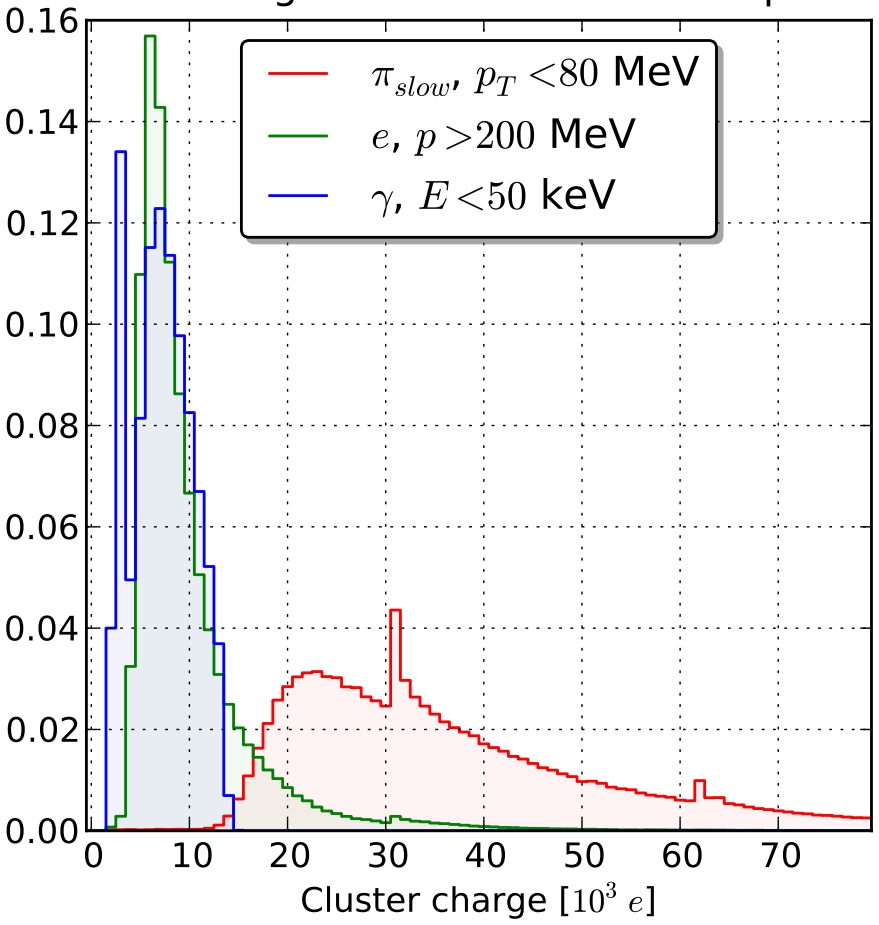
Cluster Energies

Cut on the cluster charge requires online clustering but yields much better separation

➡ efficiency of $\sim$ 80% with purity of $\sim$ 95%

- Cluster charge of photons depends very strongly on the spectrum since all of the photon energy is deposited in the sensor
- dip at low charge caused by gold in beampipe

Cluster charge for different kinds of particles



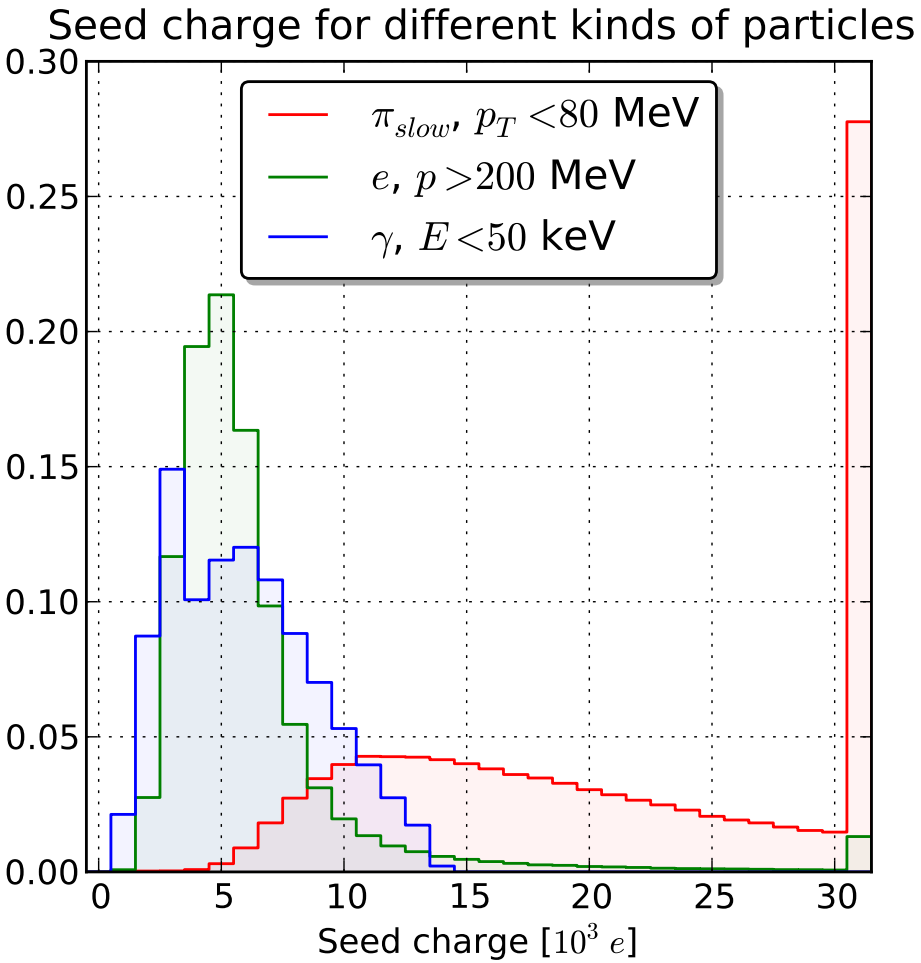
Seed Charge

Perfect position reconstruction not essential for slow pions: Their contribution to the vertex reconstruction is small.

- try to keep at least one pixel per slow pion, or
- keep all clusters with minimal seed charge

➡ efficiency of $\sim$ 95% with purity of $\sim$ 95% when only keeping pixels

➡ efficiency of $\sim$ 75% with purity of $\sim$ 95% when keeping clusters

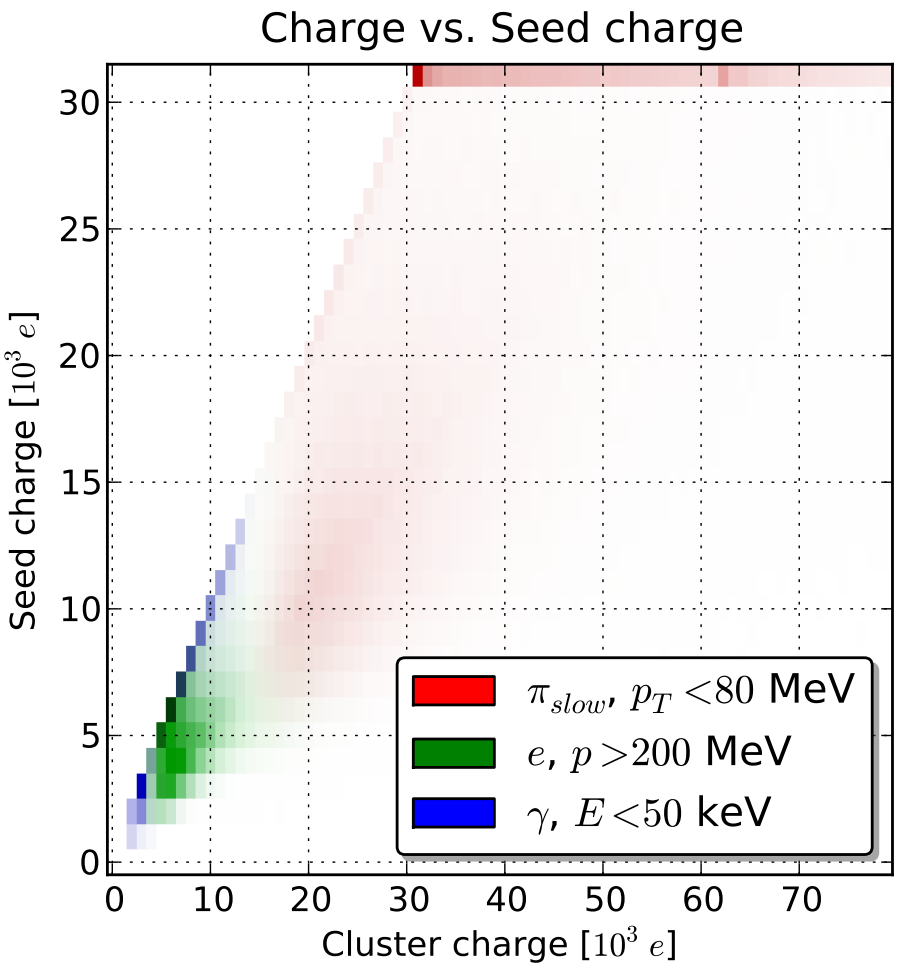


Multivariate

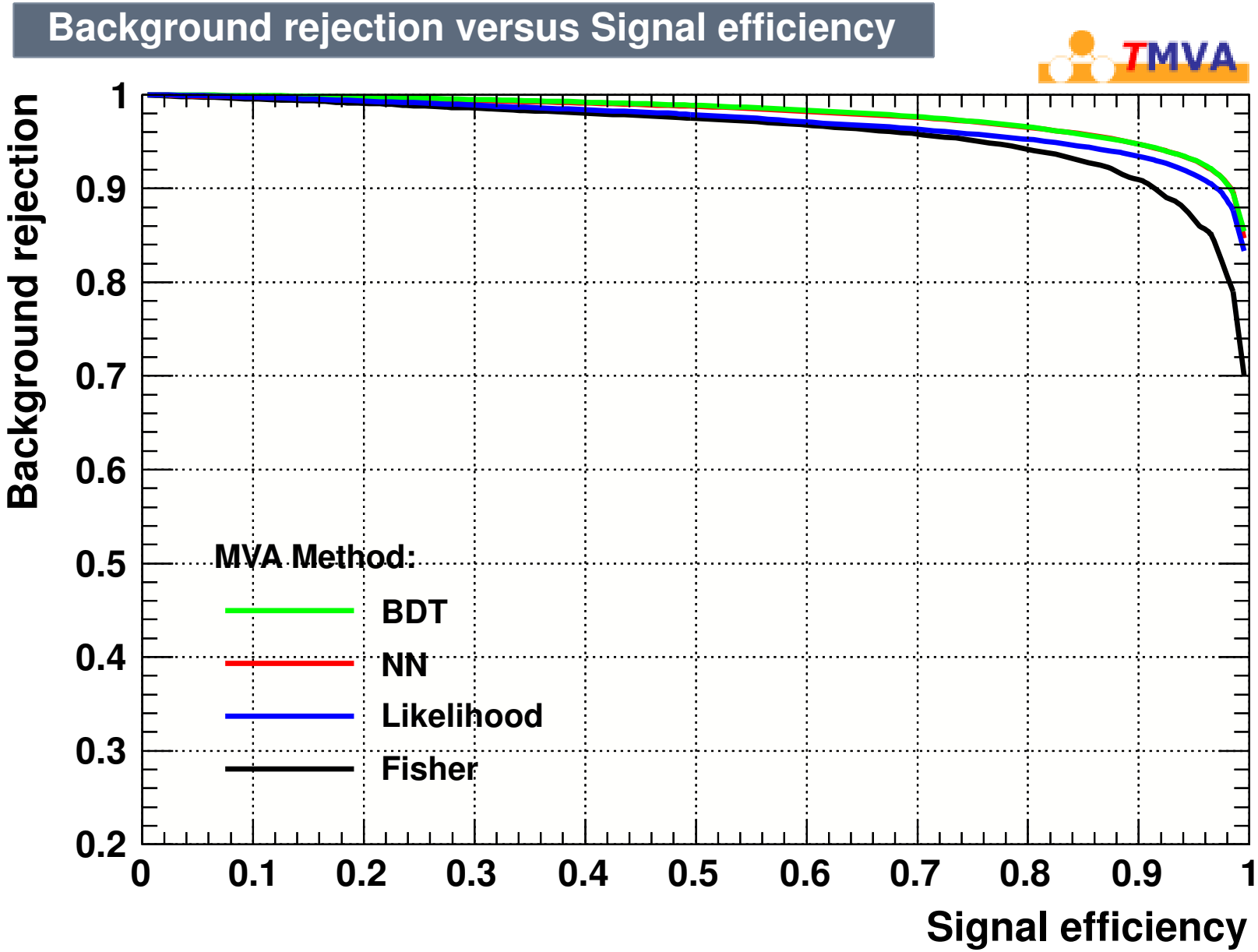
Best precision and high purity could be reached by combining all possible variables of a cluster to do a multidimensional analysis.
For a inital test, TMVA was used. Input variables were

- cluster charge
- seed charge
- total size
- size in rphi
- size in z

efficiency of $\sim$ 95% with purity of $\sim$ 95% seems feasible for clusters



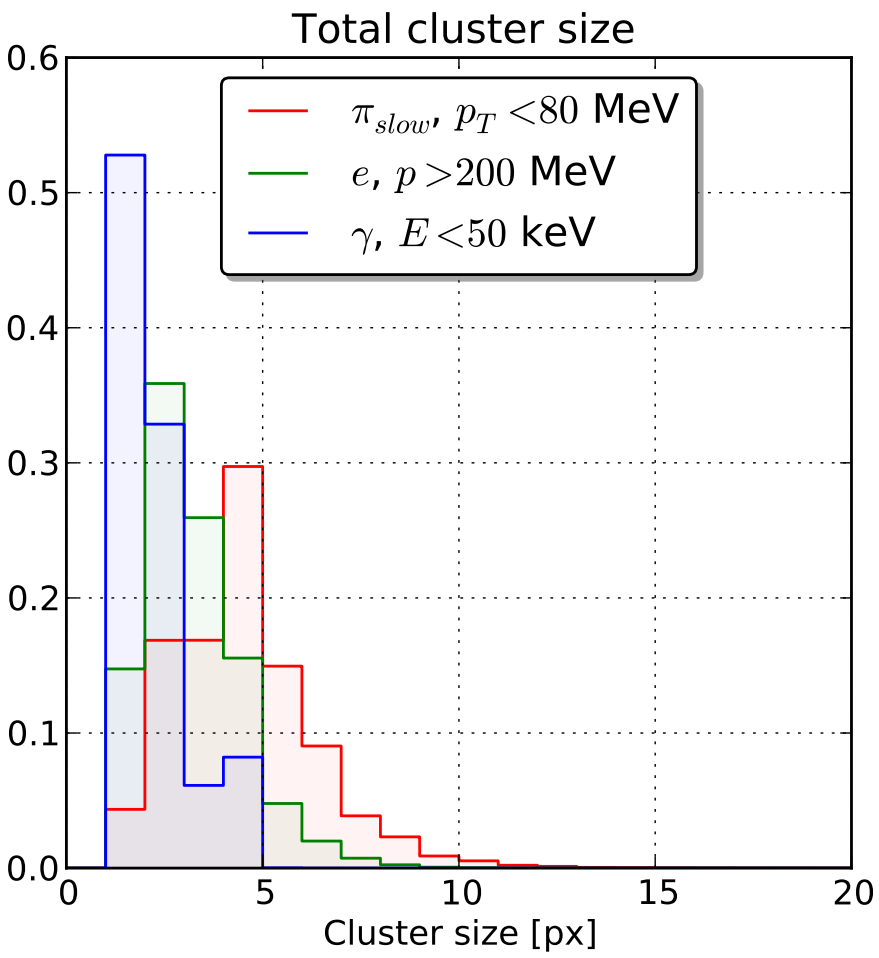
Multivariate



Cluster size

Idea: Cut single pixels cluster because this should cut away most photons whithout hurting physics, but:

- about 15% of electron clusters seems to be just a single pixel
- due to charge sharing only $\sim$ 50% of photons produce single pixel clusters



➡ Might still be possible to get rid of photons, but not as easy as we hoped.

➡ depends very strong on the actual photon spectrum, waiting for input from BG group

Conclusions

- work is still preliminary
- effective 5bit ADC seems to be sufficient
- depending on the data reduction achieved by the tracking group, we should be able to salvage most clusters from slow pions

method	eff @ 5% purity	eff @ 1% purity
pixel charge	35%	15%
cluster charge	80%	35%
seed pixels	95%	45%
seed pixel clusters	75%	25%
tmva	95%	45%

Further plans

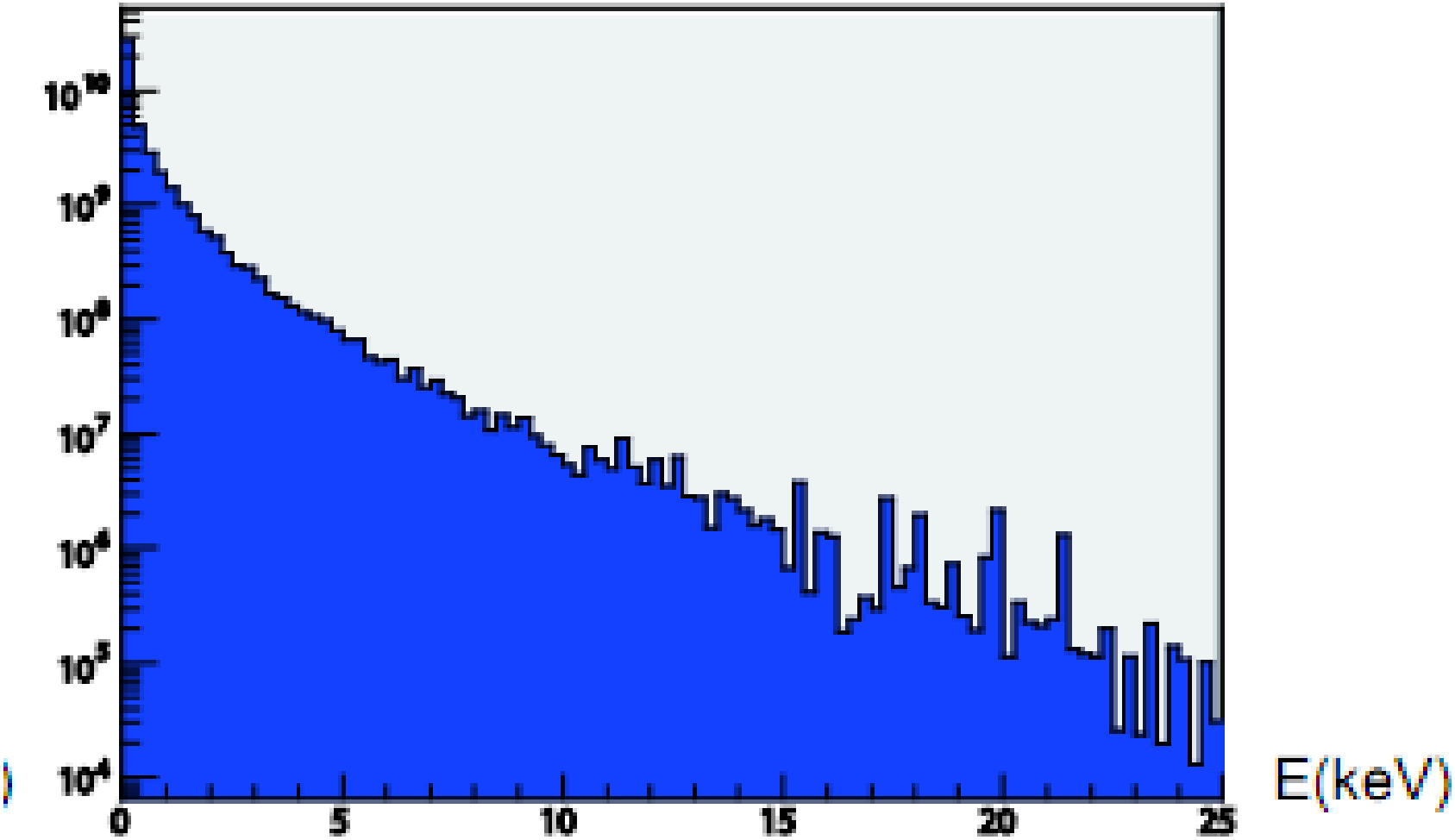
- use real spectra for fast particles and photons
- determine if photon cut is feasible

Everything is now in place to simulate PXD-Events for interested groups. Please tell (again) me what is needed.

Thank you
for your attention

Preliminary SR spectrum

SR energy (keV)



Cluster charge vs p_T