ILC-TPC PID RESOLUTION

Sergey Suvorov

INR RAS, CEA Saclay

21 December 2017

INTRODUCTION

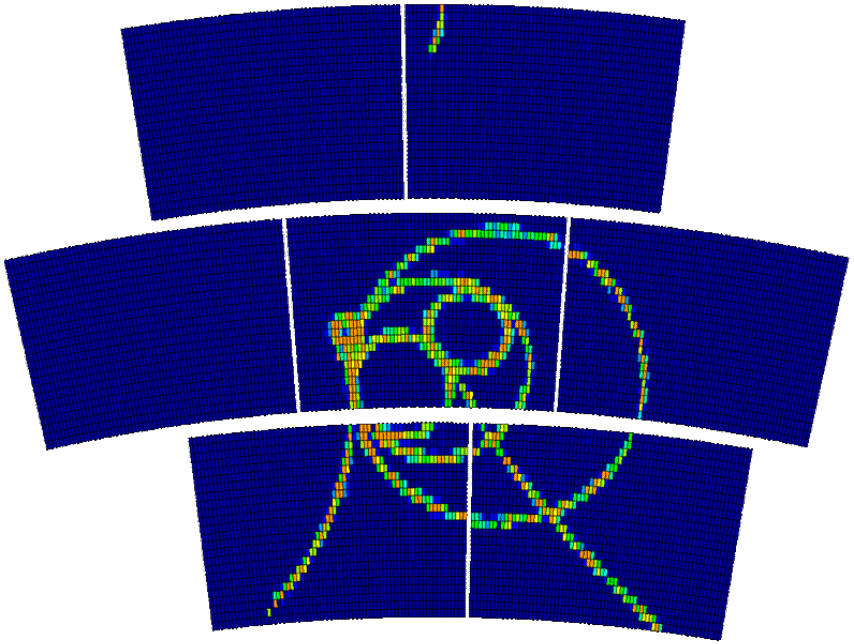
- Motivation:
  - resistive foil affect the charge collection in TPC
  - need to investigate PID resolution

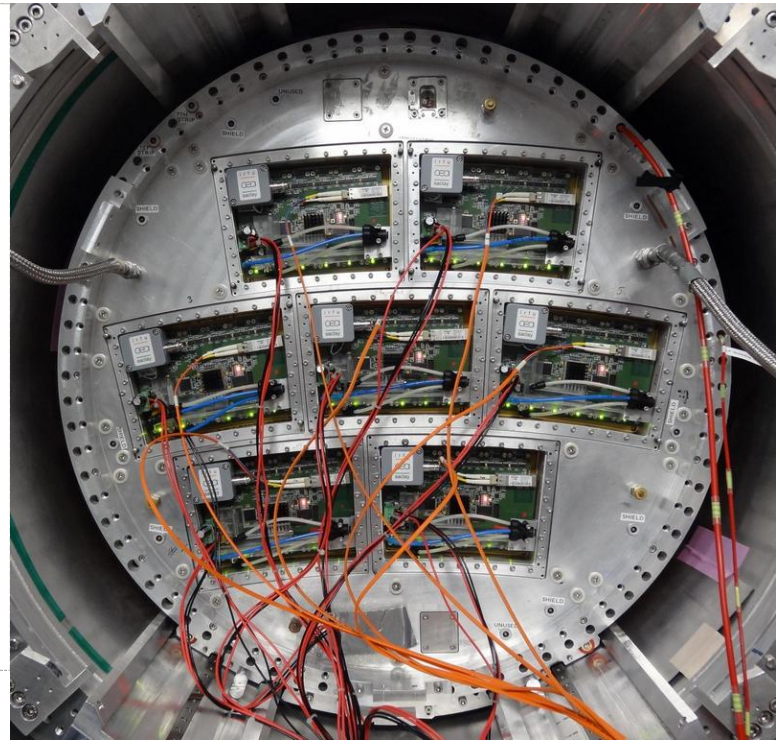
- Samples:
  - ILC-TPC data in DESY with $5\ GeV/c$ electron flux

- Method:
  1. Took ILC-TPC $5\ GeV/c\ e^-$ data
  2. Define the simple selection
  3. Use the same calibration as for T2K TPCs
  4. Extract the PID resolution
  5. Study the influence of different setup params

ILC-TPC OVERVIEW

- 5 FEMs in the cylindrical module
- each FEM 24 rows x 72 columns





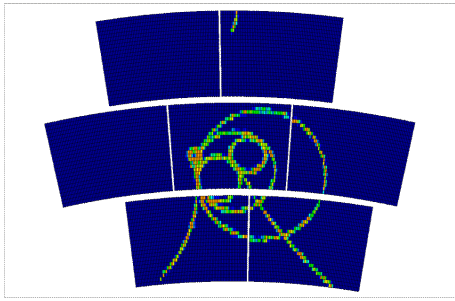
PID STUDY

- Perform the common method of energy truncation:
  - don't use extremely high values of deposited charge
- Method:
  1. For each pad take maximum charge from ADC (C_{pad})
  2. Sum up pads in a row to make a cluster ($C_{cluster}$)
  3. For each track sort $C_{cluster}$ in increasing order
     (N clusters per track)
  4. Take αN first clusters.
     $0.4 < \alpha < 1$
  5. Truncated mean energy per cluster

$$C_T = \frac{1}{\alpha N} \sum_{i}^{\alpha N} C_{cluster,i}$$

  6. Vary α to reach best resolution

ILC-TPC SAMPLES

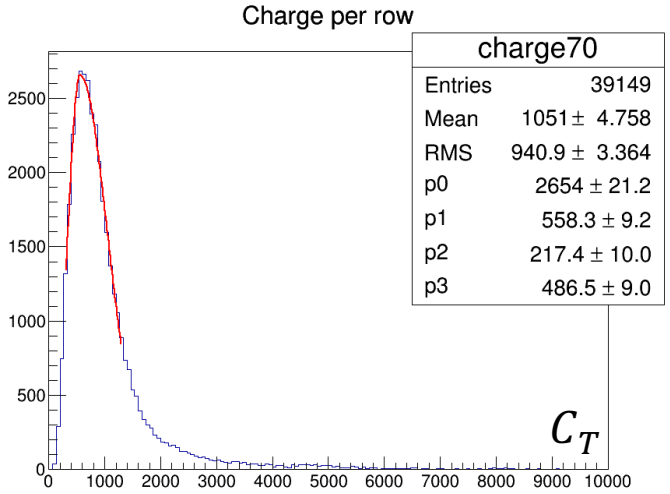


- Data 2014
  - middle module is extremely stable
  - other modules show significant degradation in time
  - *strategy:* make pseudo-long track from 8 different tracks crossing the middle module

- Data 2015
  - long tracks along all three modules can be used
  - not all the pads can be used
  - *strategy:* extract dead pads from the study

ROW BY ROW CALIBRATION

- For scan over Z beam goes over ~same columns
- For every row expect ~same amount of charge
- For each row plot the cluster charge distribution

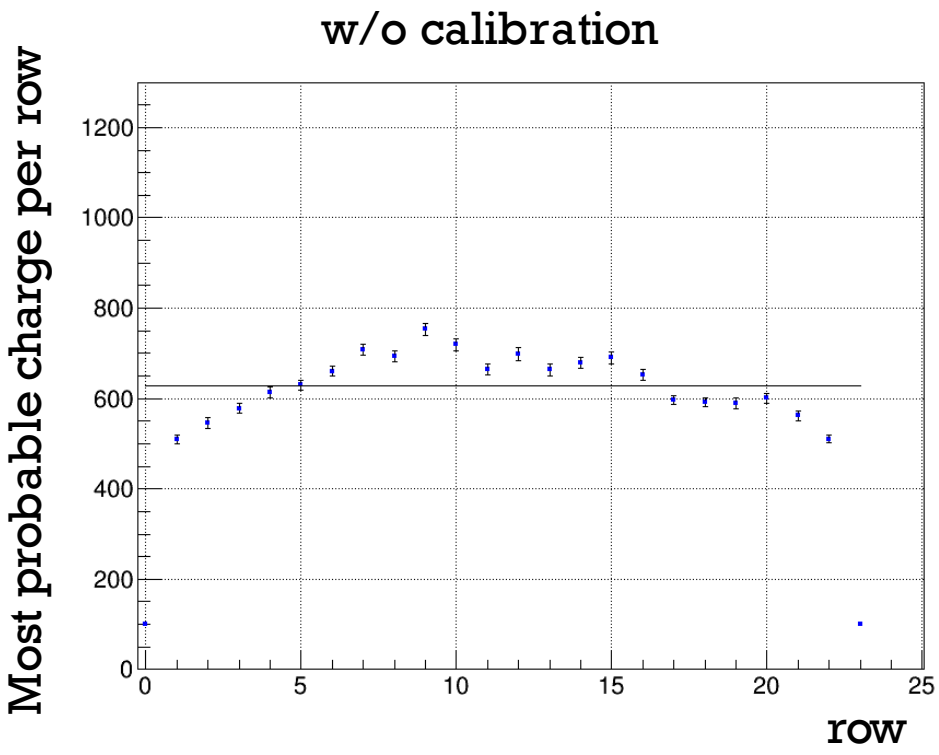


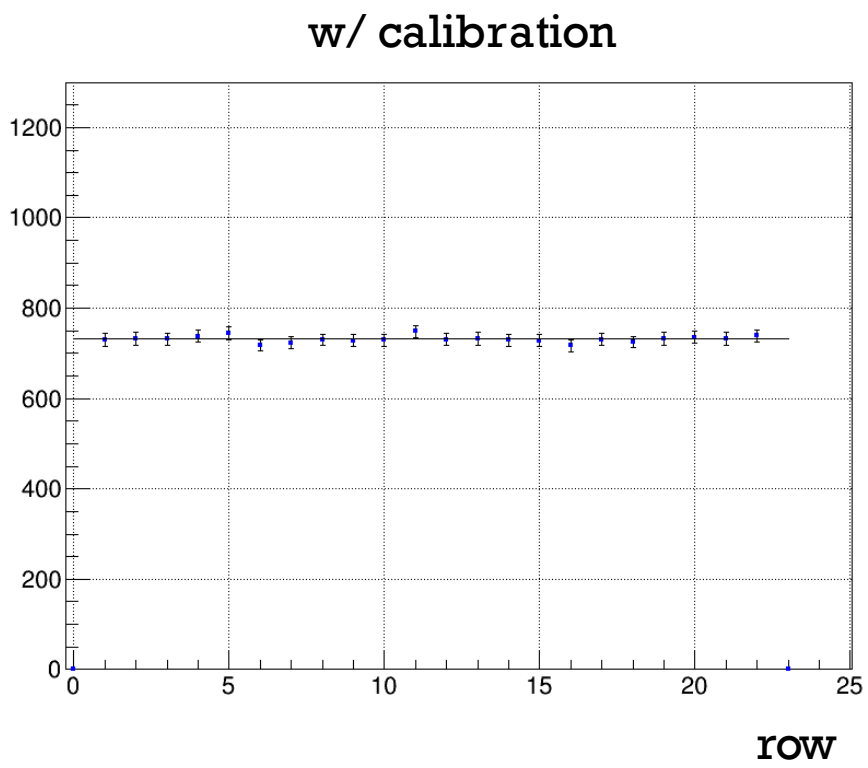
e.g. distribution of C_T for FEM0 row 7

- Fit with asymmetric Gaussian → extract maximum (most probable value)
- Make C_T equal for all rows

ROW BY ROW CALIBRATION

- Example of the 2014 data with B = 0
- 1st and last row are excluded from all PID studies



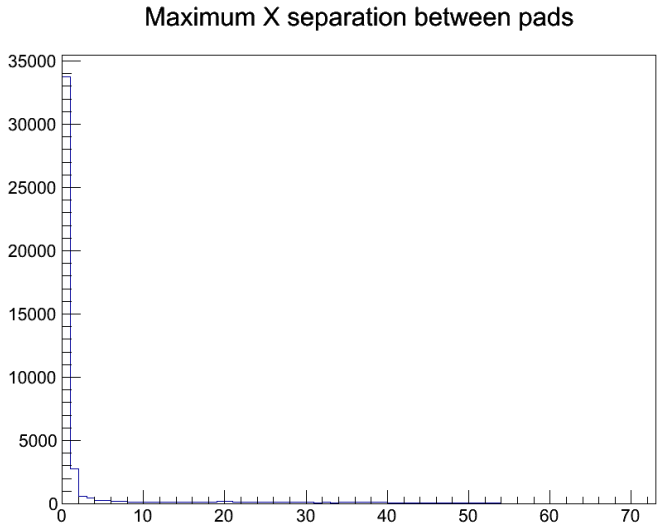


SIMPLE EVENT SELECTION

- Design the simple selection:

- For first look PID study need:
  1. one track per FEM
  2. long enough track

- Selection:
  1. Look at maximum gap between hited pads in a row
  2. All rows except corrupted are hited

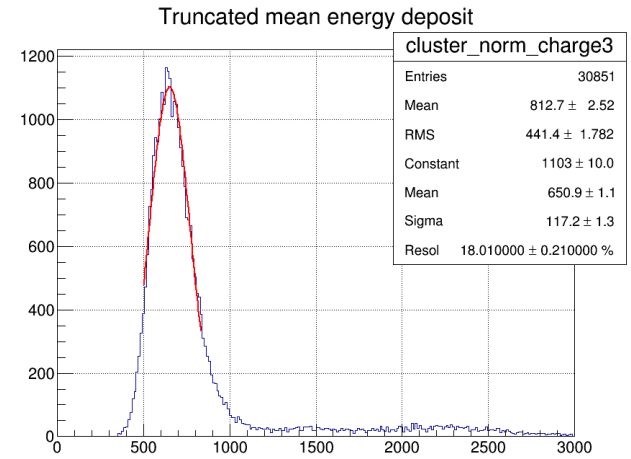


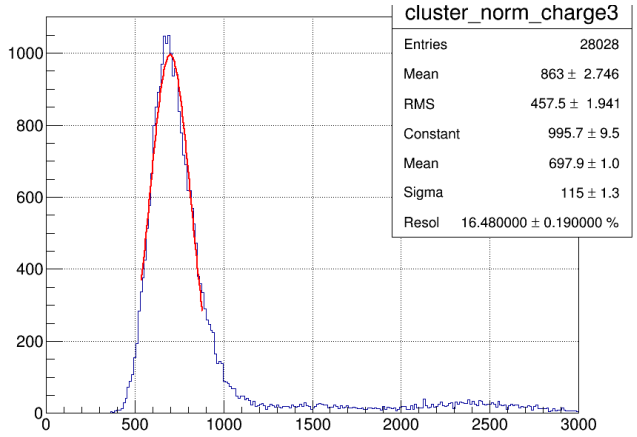
$N_{gap} < 2$

PID RESOLUTION WITH B = 0

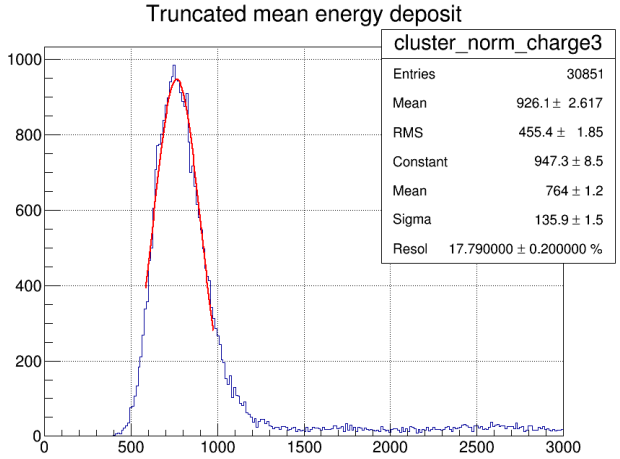
- First check: 1 module 22 rows x 7 mm B = 0

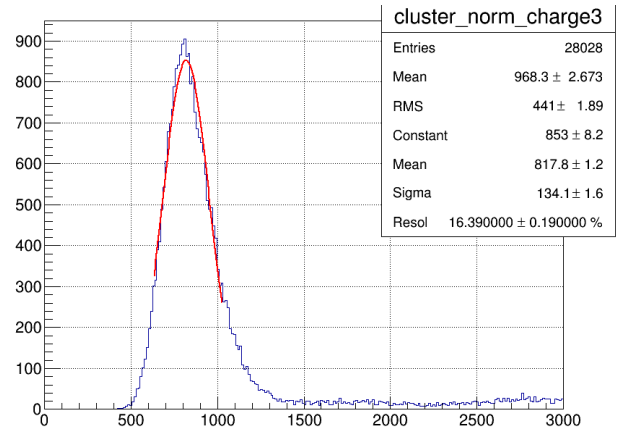
w/o calibration





w/ calibration





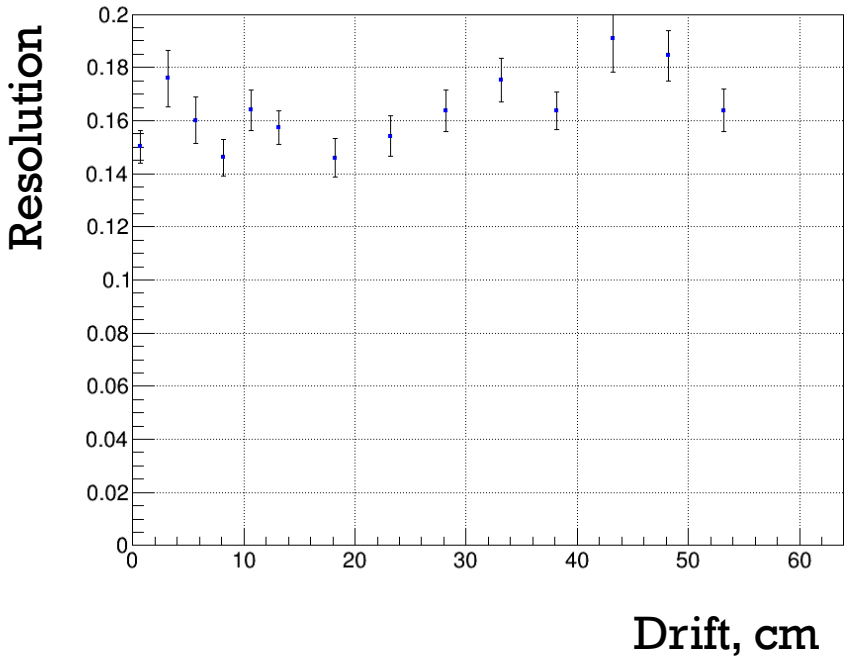
E = 140 V/cm

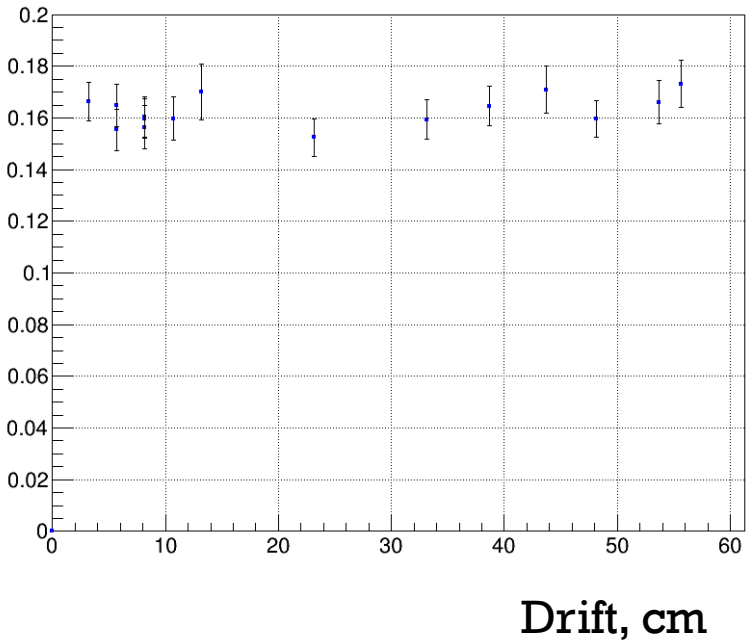
E = 230 V/cm

Fitting only upper 70% of histo, to avoid bias because of the tail

PID RESOLUTION WITH B = 0

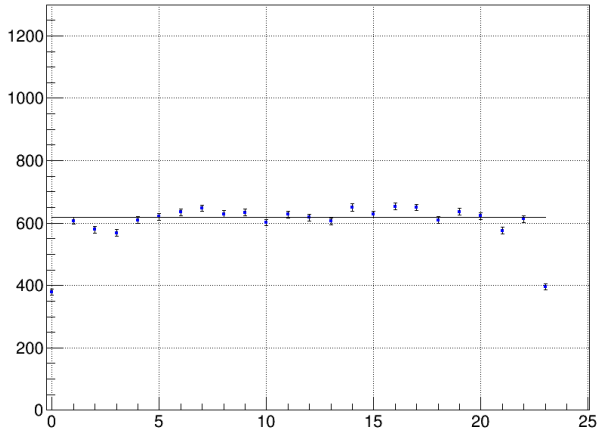
- Dependence on drift distance study
- No significant dependencies observed



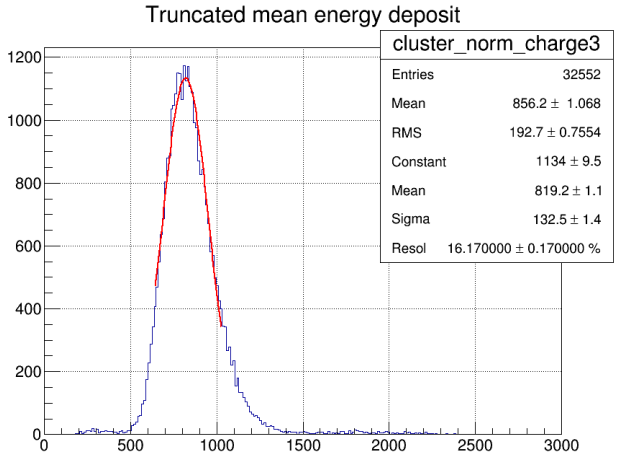


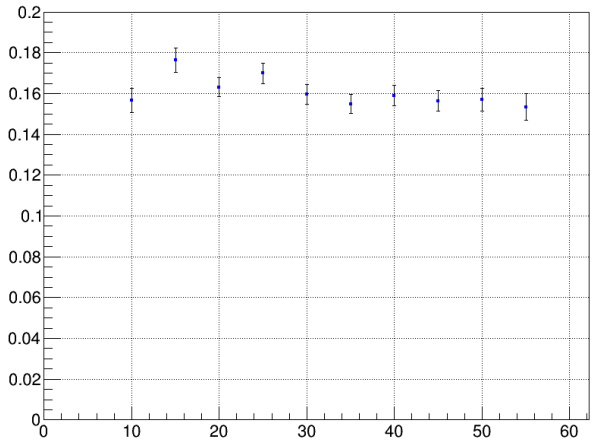
PID RESOLUTION WITH B = 1 T

- With magnetic field charge per row is ~same even w/o callibration
- Magnetic field slightly improve PID resolution (E = 230 V/cm)



row



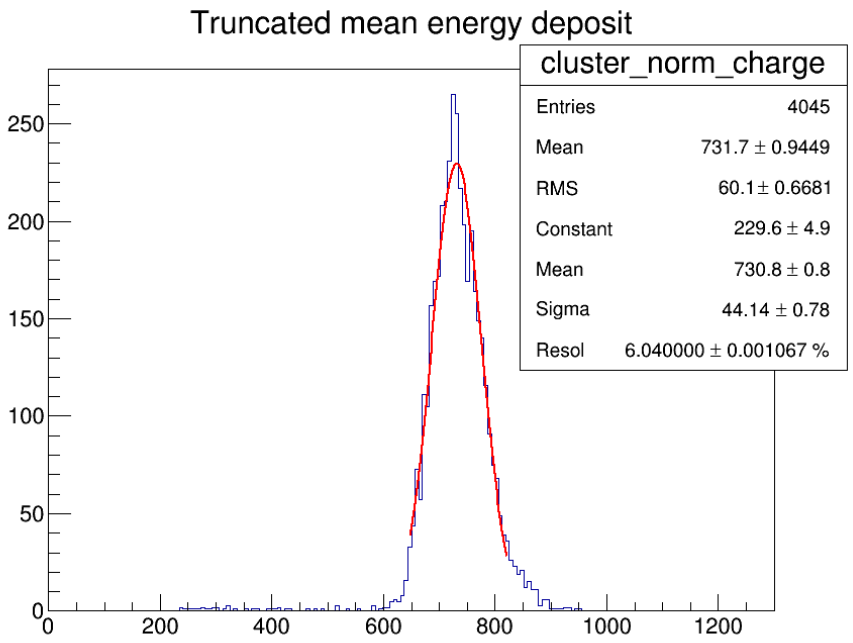


Drift, cm

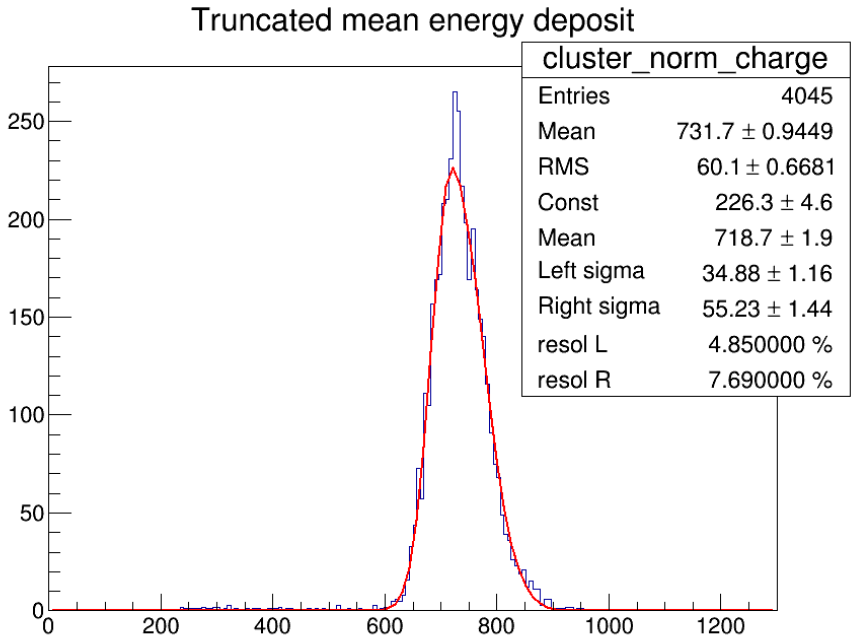
No dependence on drift distance observed

PID RESOLUTION WITH B = 1 T

- Make pseudo-long track with 8 different tracks
- 8 x 22 rows x 7 mm = 1232 mm

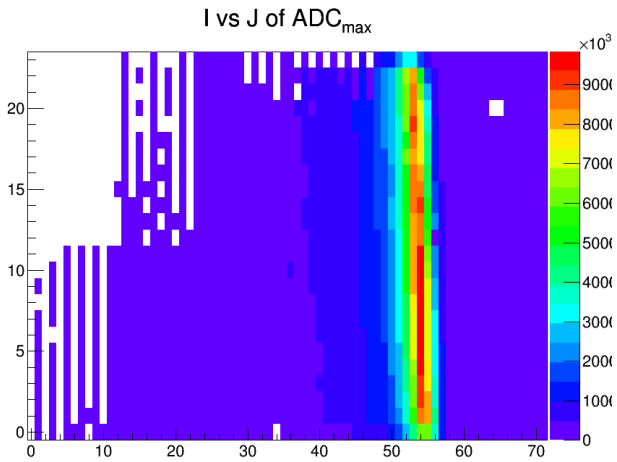


Gaussian fit



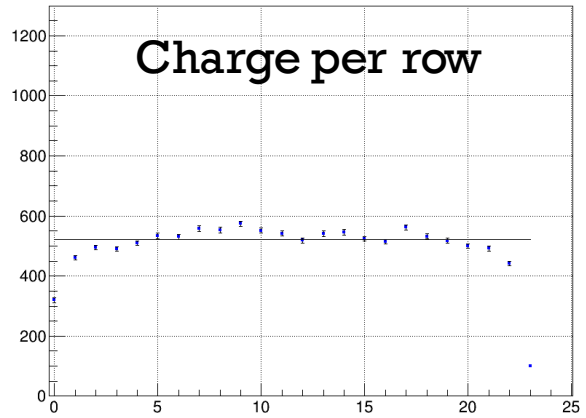
Asymmetrical Gaussian fit

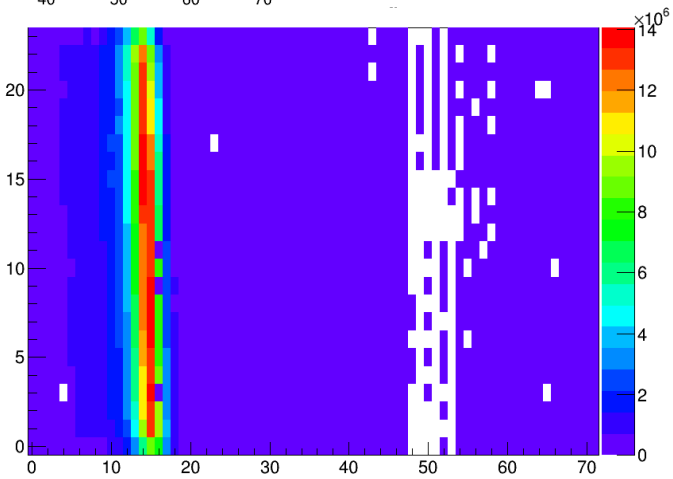
For 1232 mm expect 6% dE/dx resolution

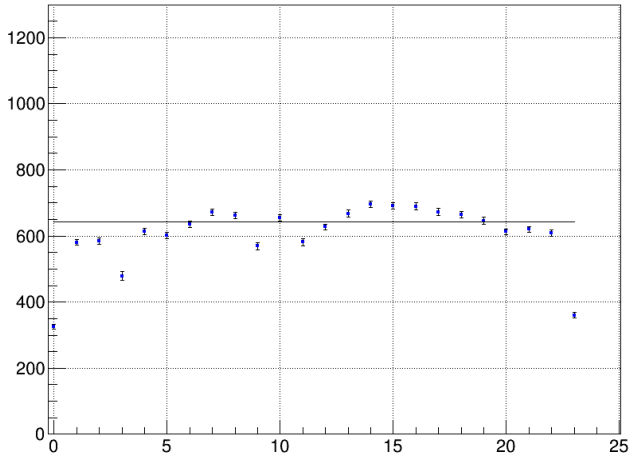


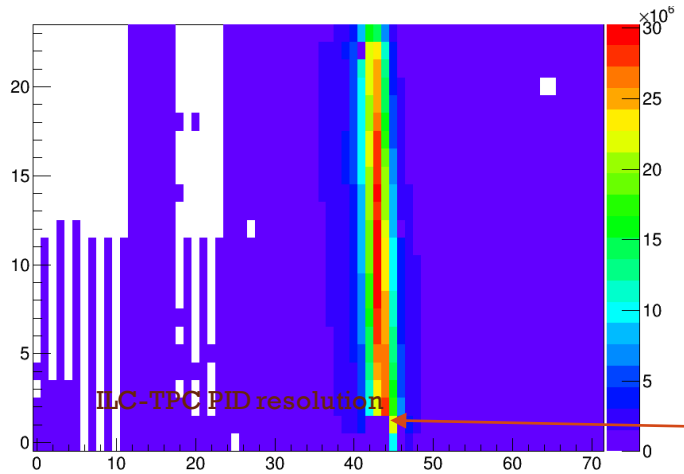
Data samples took during 2015

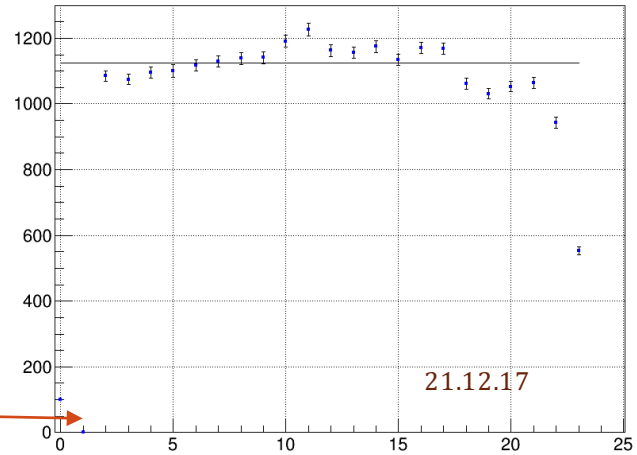
Some corrupted pads were observed → exclude them from PID study

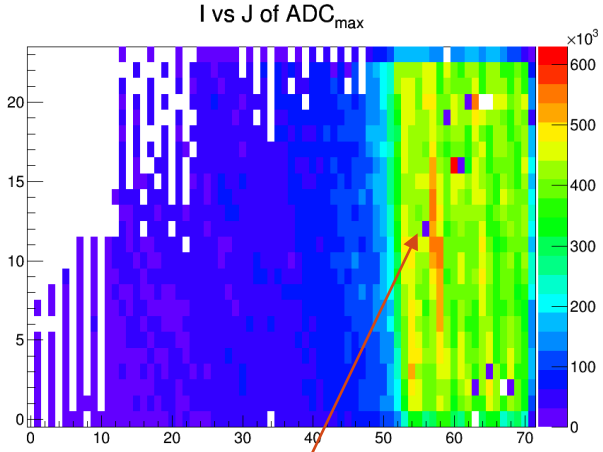


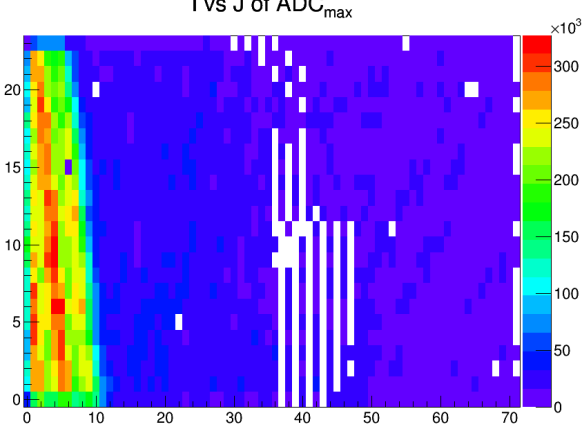


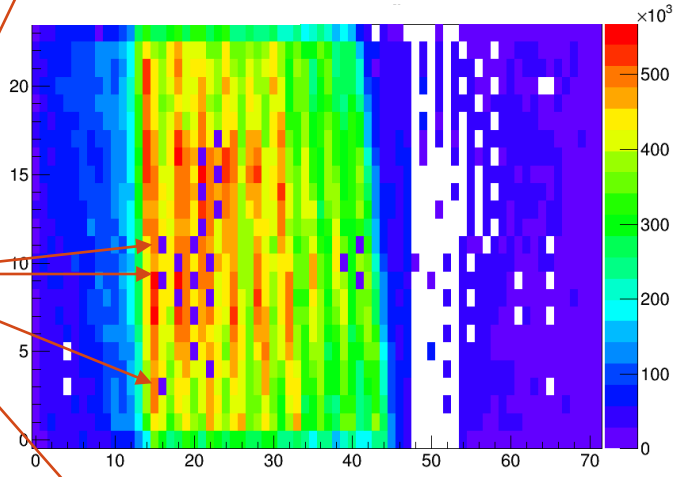




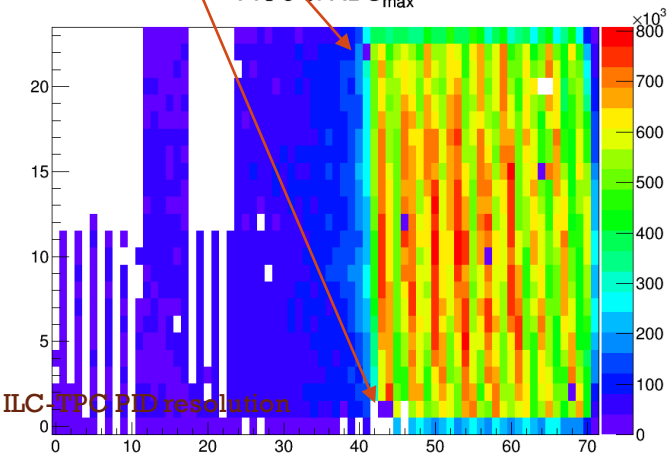








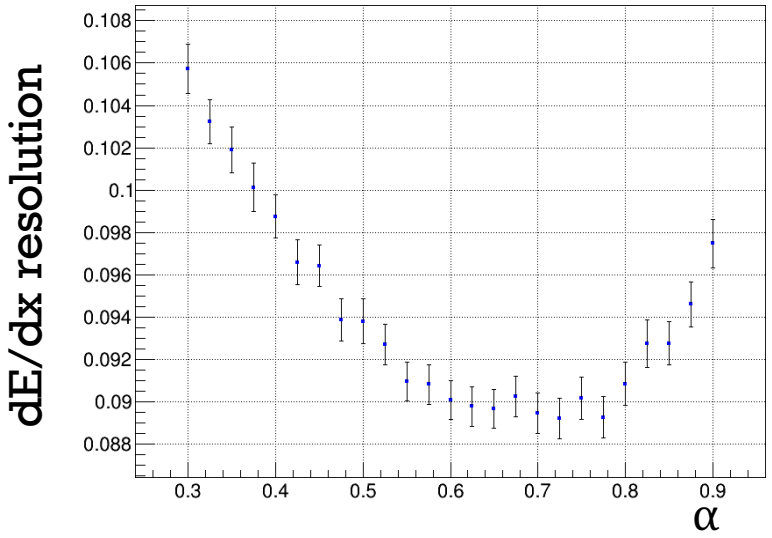
dead pads

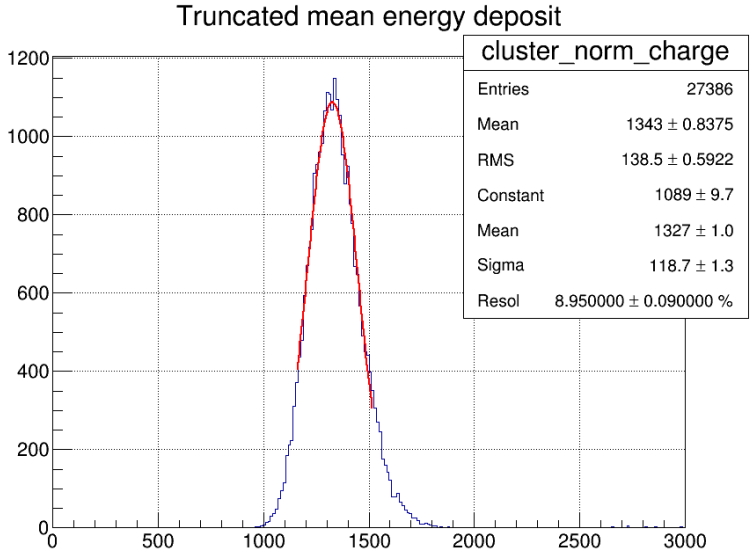


Cross check of the dead pads with the variation of the beam position

ENERGY RESOLUTION

- Apply multi FEM selection (one long track across 3 modules)
- Vary α to reach the best resolution
- Common value is 0.7 → still make sense
- Use 20+19+21=60 clusters, 42.5 cm - 8.95 ± 0.09 %
- Comparing to T2K vertical 72 clusters 80 cm:
  Approximating our result - 6.48 ± 0.07%
  T2K value - 5.6 ± 0.4%





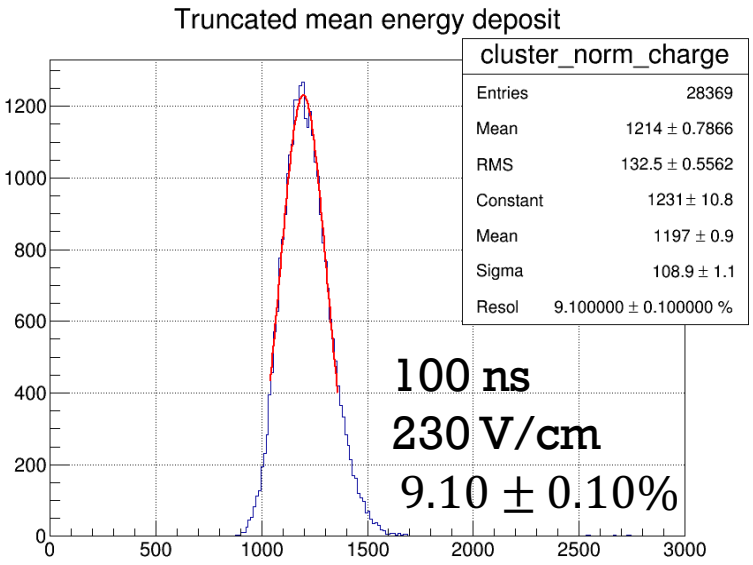
SUMMARY

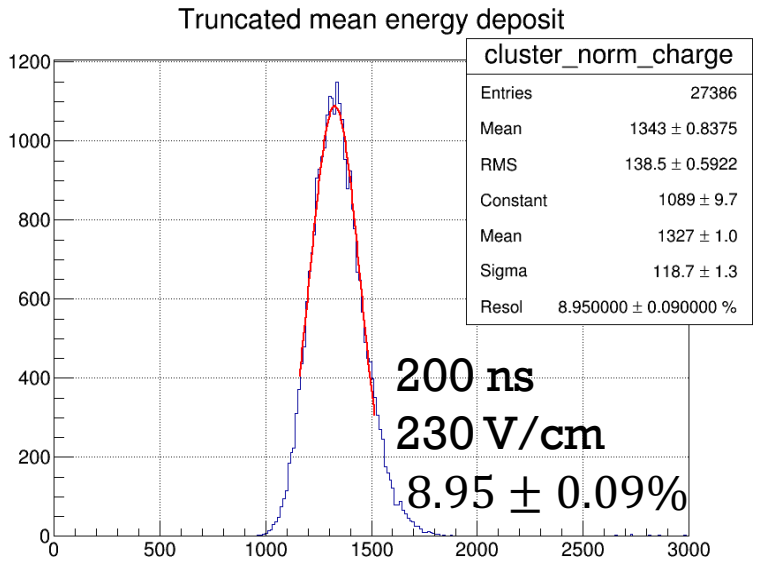
- ILC-TPC $5\ GeV/c\ e^-$ samples were be used for dE/dx estimation (2015 and 2015 samples)
- Charge per row calibration:
  - exclude rows with unreliable pads
  - amount of charge per row set equal with calibration
- Selections for 1 FEM and for multi-FEM track are developed
- The first estimation of the PID resolution was done:
  - for 8 x 22 rows x 7 mm = 1232 mm expect ~6% dE/dx resolution
  - resolution is comparable to T2K TPC w/o resistive foil
- Study the dependence of the resolution on the drift distance, energy, peaking time, field was performed:
  - no dependence on the drift distance is observed
  - 230 V/m field is better to 140 V/m

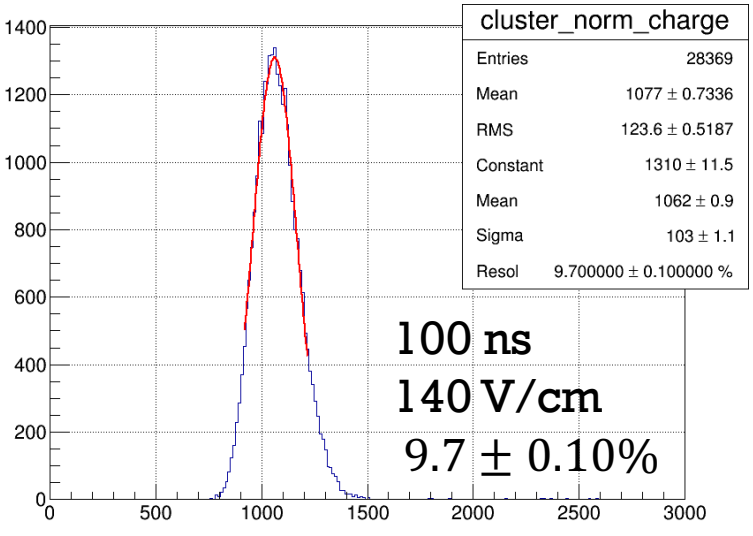
BU

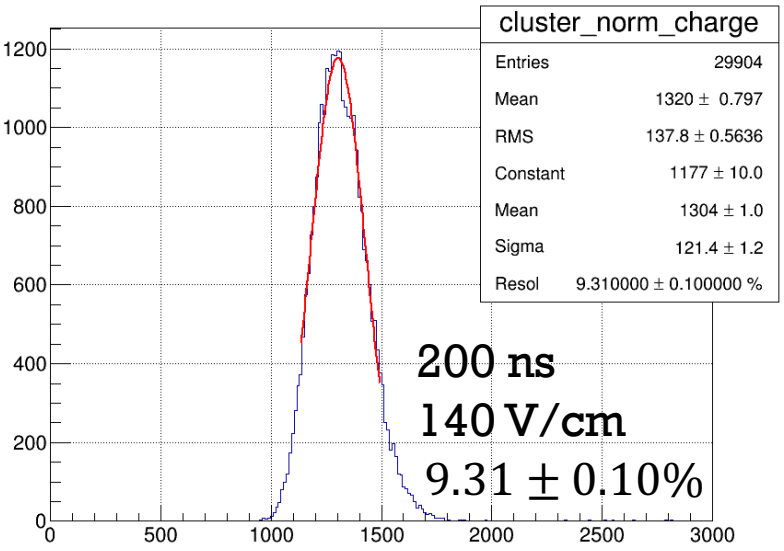
DEPENDENCE ON PEAKING TIME AND E_{field}

60 clusters
42.5 cm



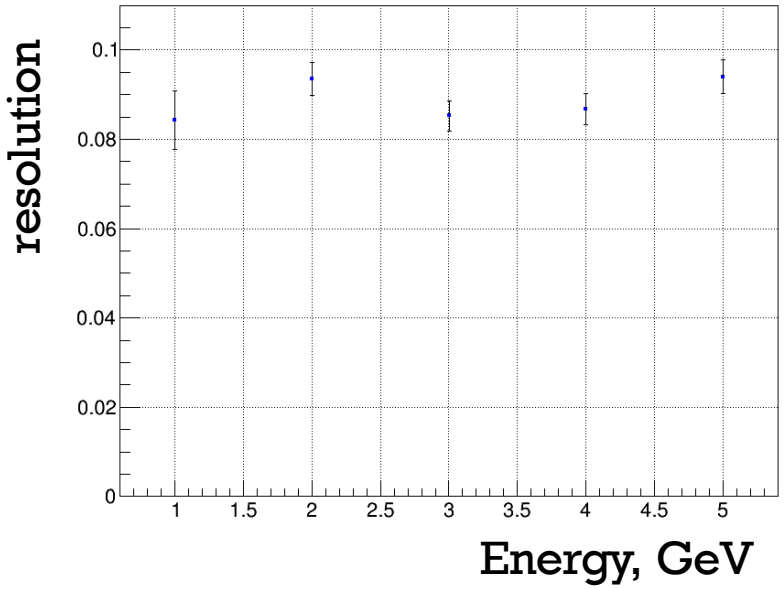


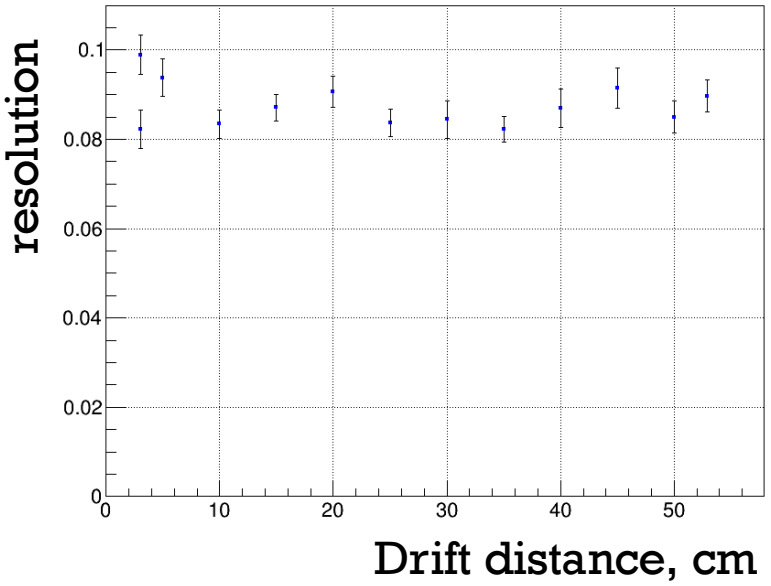




DEPENDENCE ON DRIFT DISTANCE & ENERGY

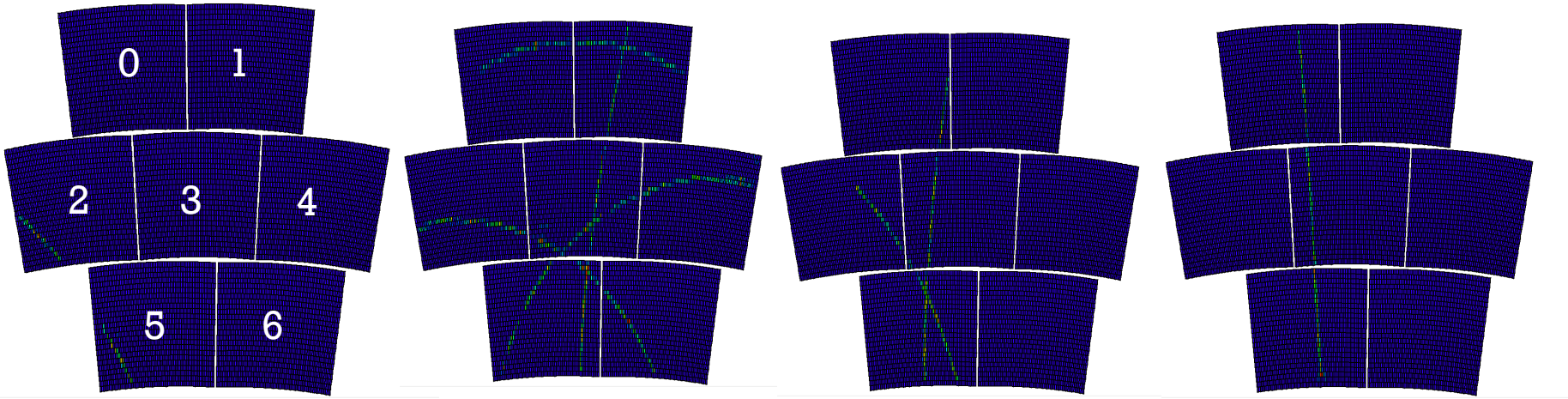
- 2015 samples
- Should study the effect of drift distance and e^- energy
- Almost no significant changes of the dE/dx resolution





MULTI FEM SELECTION

- dE/dx resolution depends on distance → need to study deposited charge in all FEMs
- Simple selection: 49 000 events
  1. FEM5 contain 1 long track ($N_{row} = 21,\ Sep_{max} < 2$) 36074
  2. FEM 3 1 long track, FEM 2 or 4 low activity ($N_{row} < 5$) 32326
  3. 1 long track in FEM0. No activity in FEM1. 30678
  4. Track doesn't touch left/right border of any FEM 30254
  5. Horizontal distance between track start/end at FEMs < 5 mm 27386



NO NO NO OK