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Measurement of dE/dx resolution with resistive Micromegas

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Introduction

dE/dx essential in detailed Higgs and top analysis (PID for B and charm reconstruction, b charge tagging)

So far used successfully in the T2K ND280 TPC for e/μ separation

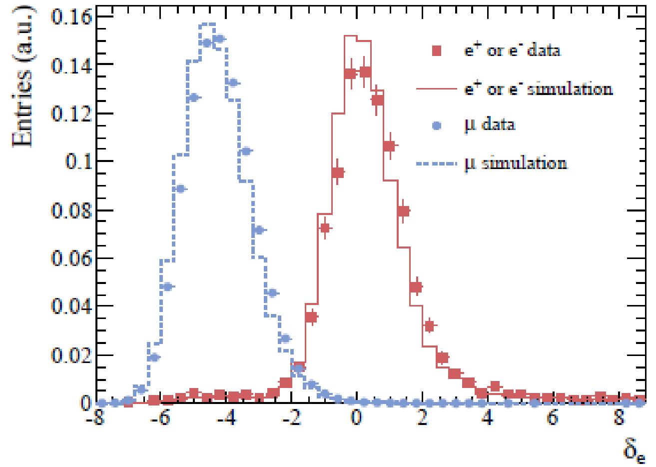
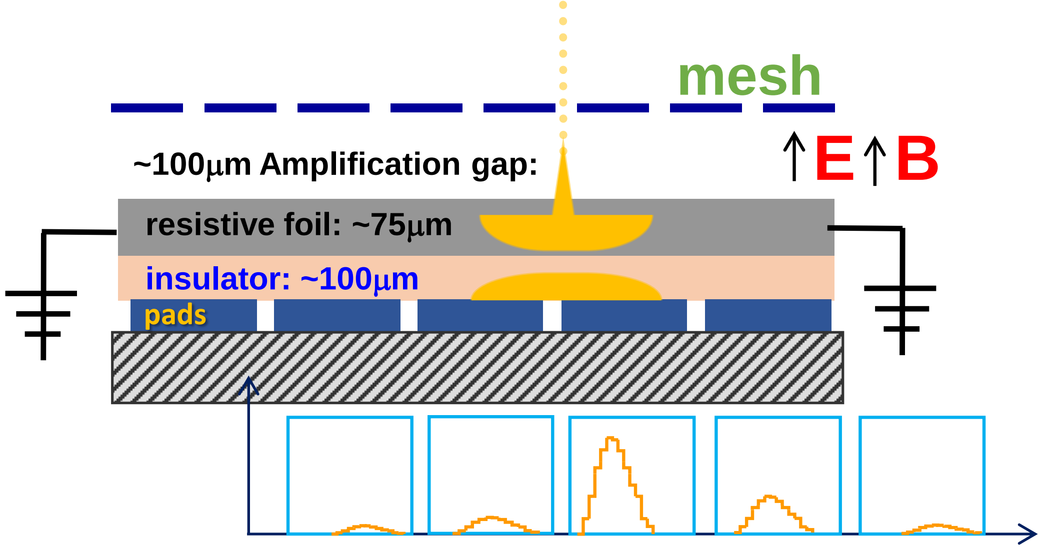
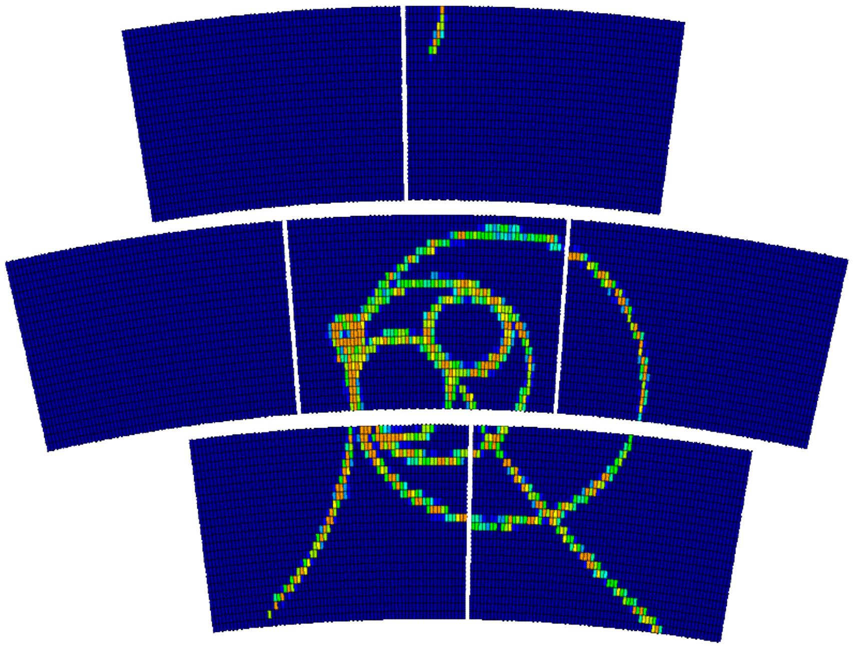


FIG. 5. TPC PID pulls in the electron hypothesis (δ_e) for electrons or positrons coming from photon conversions and for muons in data (points) and in the simulation (lines).

K. Abe et al., *'Measurement of the intrinsic electron neutrino component in the T2K neutrino beam with the ND280 detector'*, Phys.Rev. D89 (2014) 092003

But this was a standard anode TPC, with no charge sharing. We have to investigate the effect of charge sharing on dE/dx resolution, using DESY test beam data.



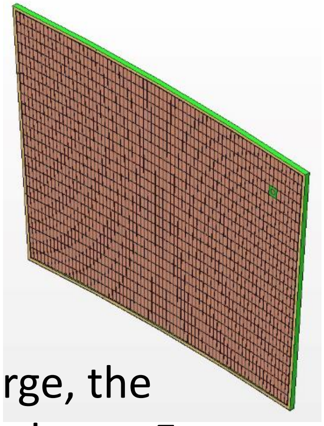


Data 2014

middle module (mod 3) is extremely stable
other modules show 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



Used 2014 and 2015 campaigns to estimate dE/dx resolution.

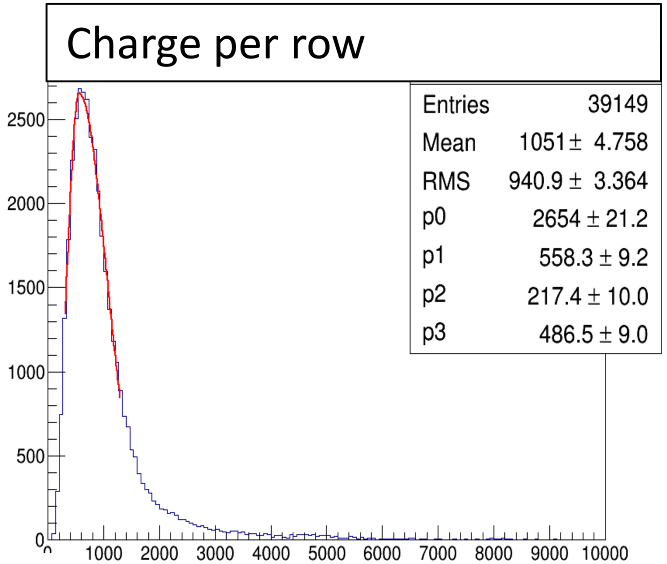
5 GeV/c electron beam along the pad columns

24 rows (the 1st and 24th receive 50% of the charge, the other 50% are lost in the crack between modules due to E-field distortion)

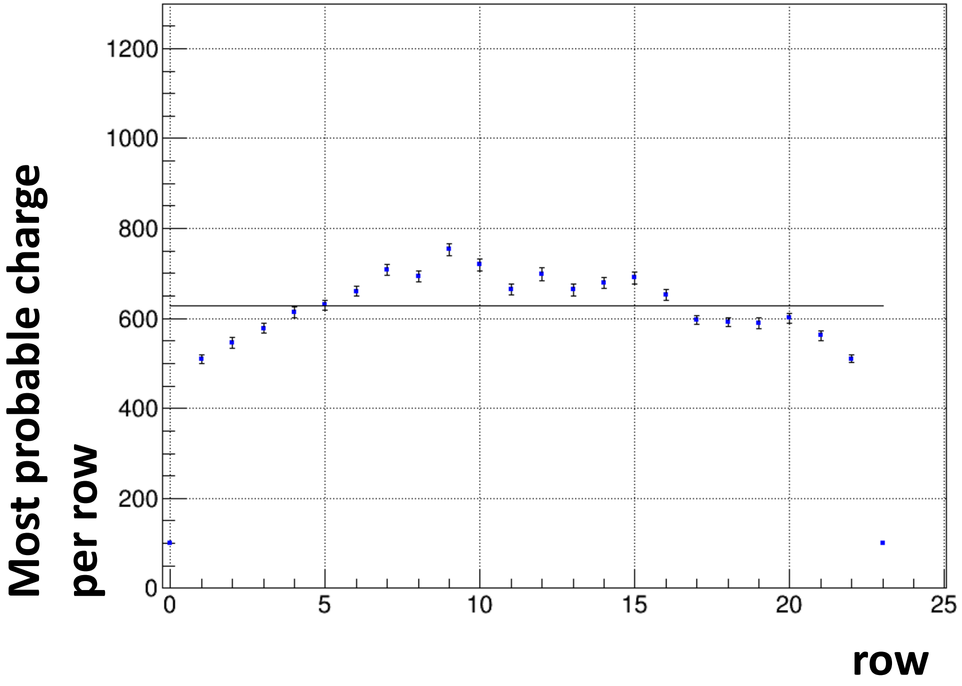
Method:

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

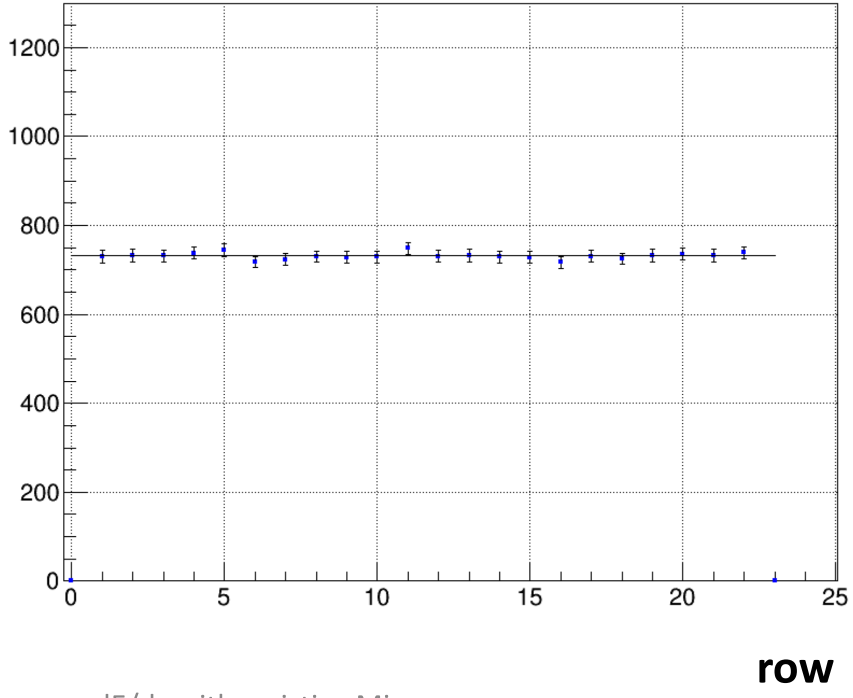
Calibration: equalize row-charge most probable values
Do not use 1st and 24th line (they receive only part of the charge), but count them as inefficient, to be conservative.



w/o calibration



w/ calibration

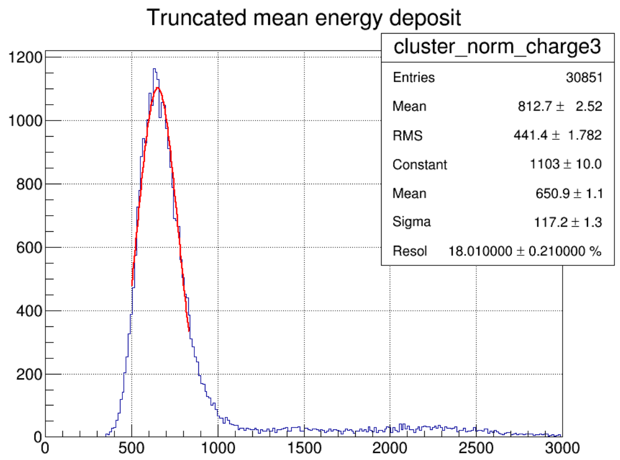


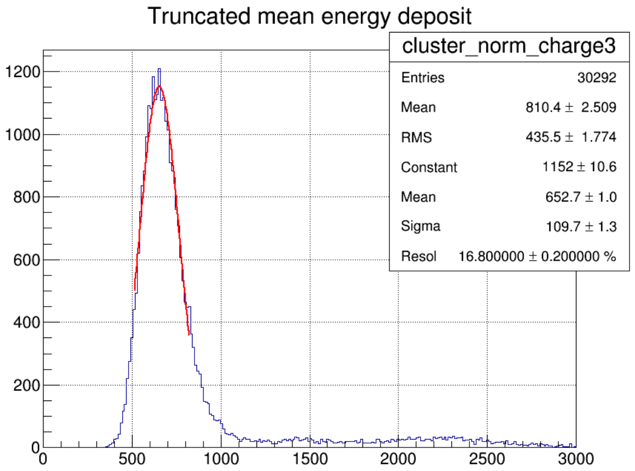
- First check: 1 module 22 rows x 7 mm

B = 0

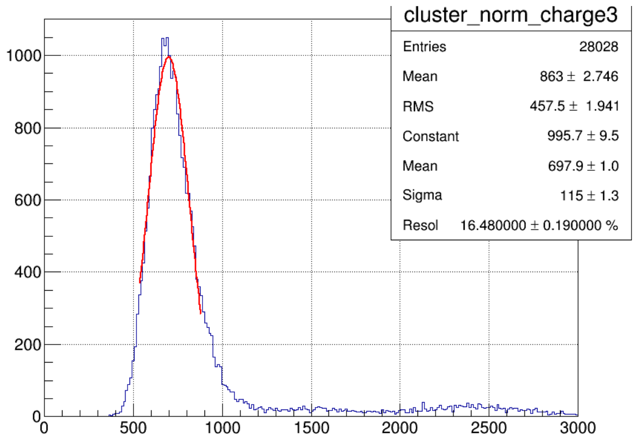
w/o calibration

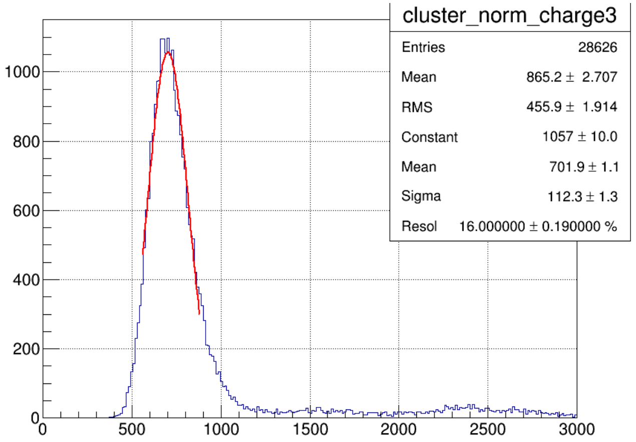
w/ calibration





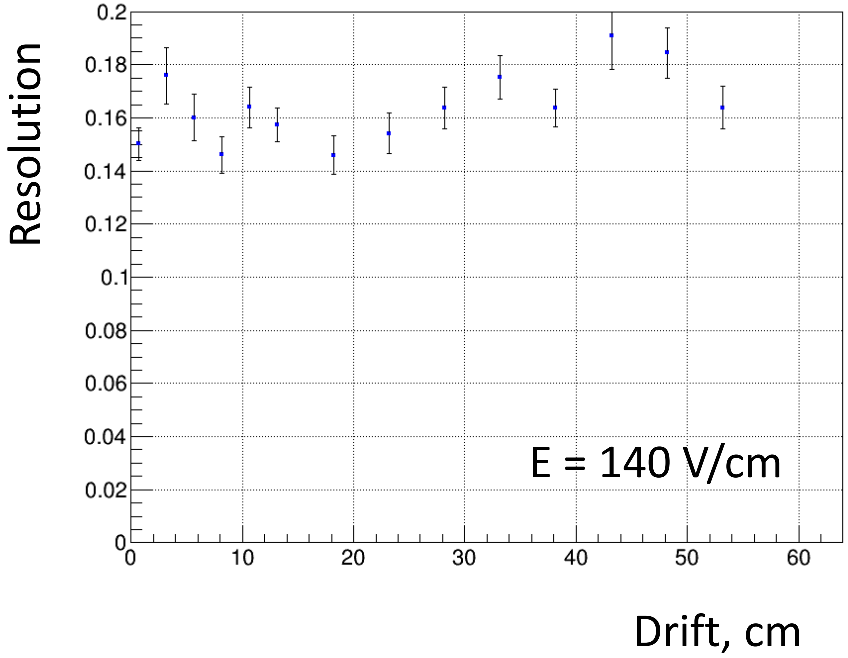
E = 140 V/cm

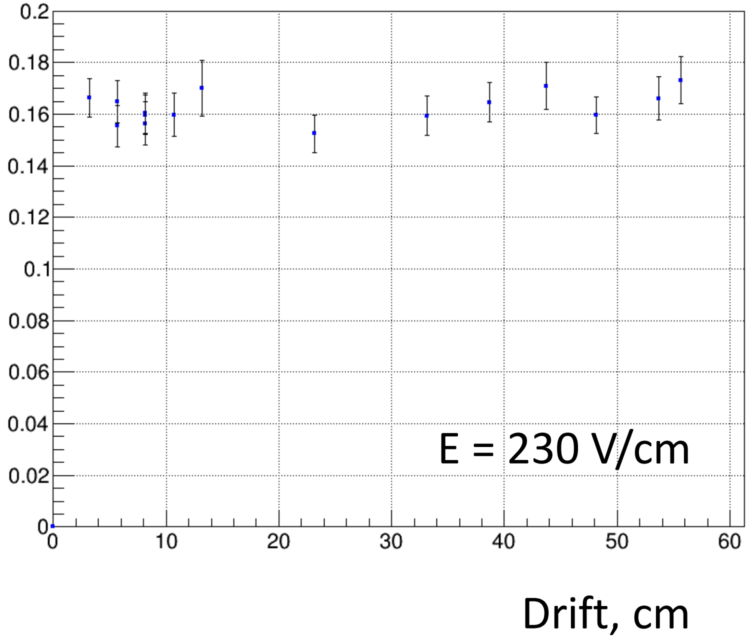




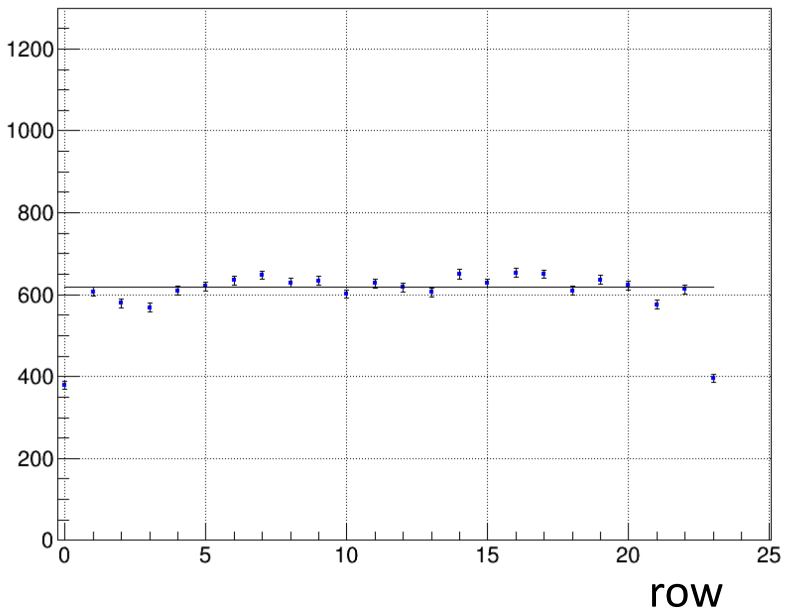
E = 230 V/cm

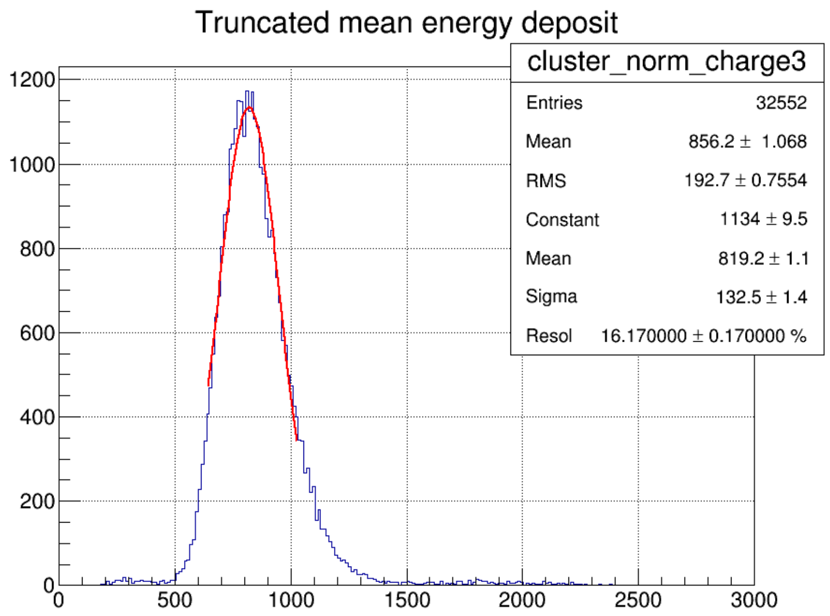
- No significant dependence on drift distance observed (B=0 data)

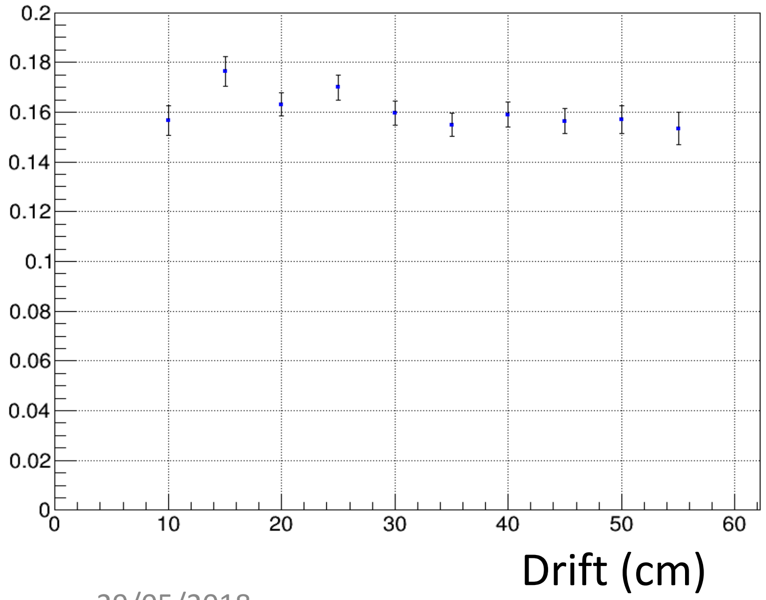




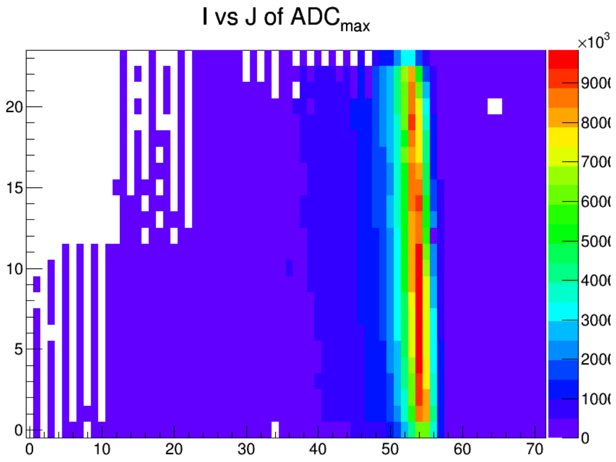
B= 1T Data





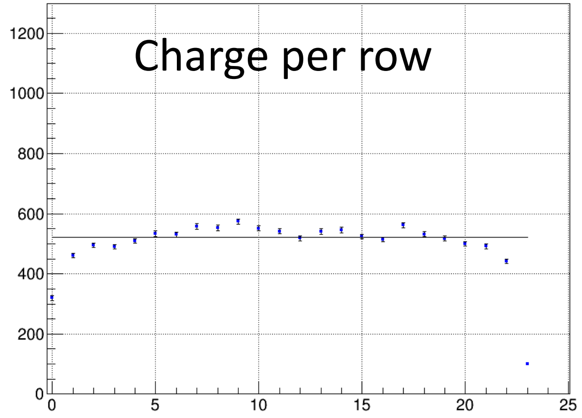


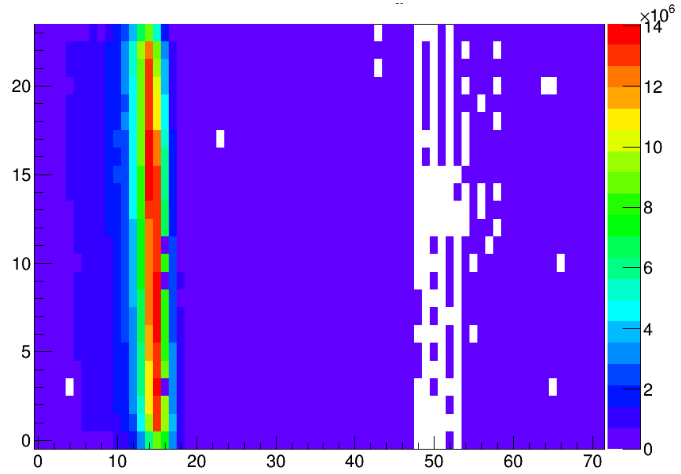
No dependence on drift distance observed

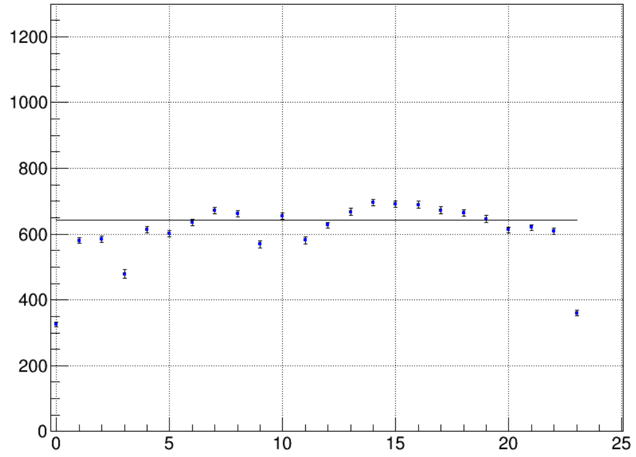


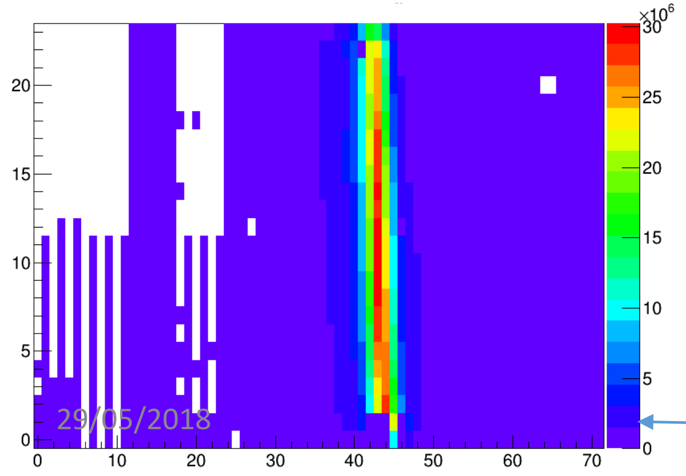
Data samples taken in 2015

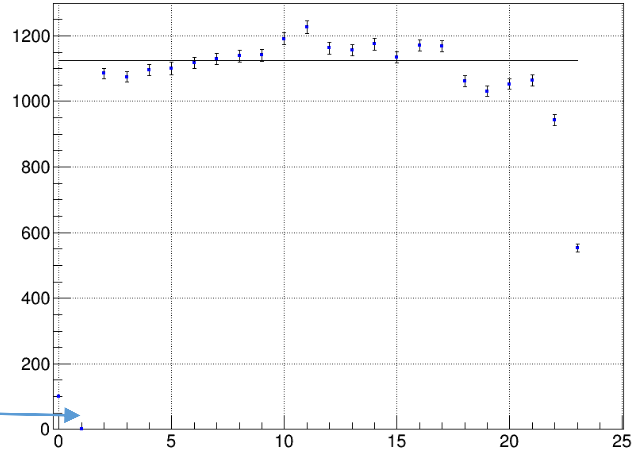
Some pads were disconnected → exclude them from PID study

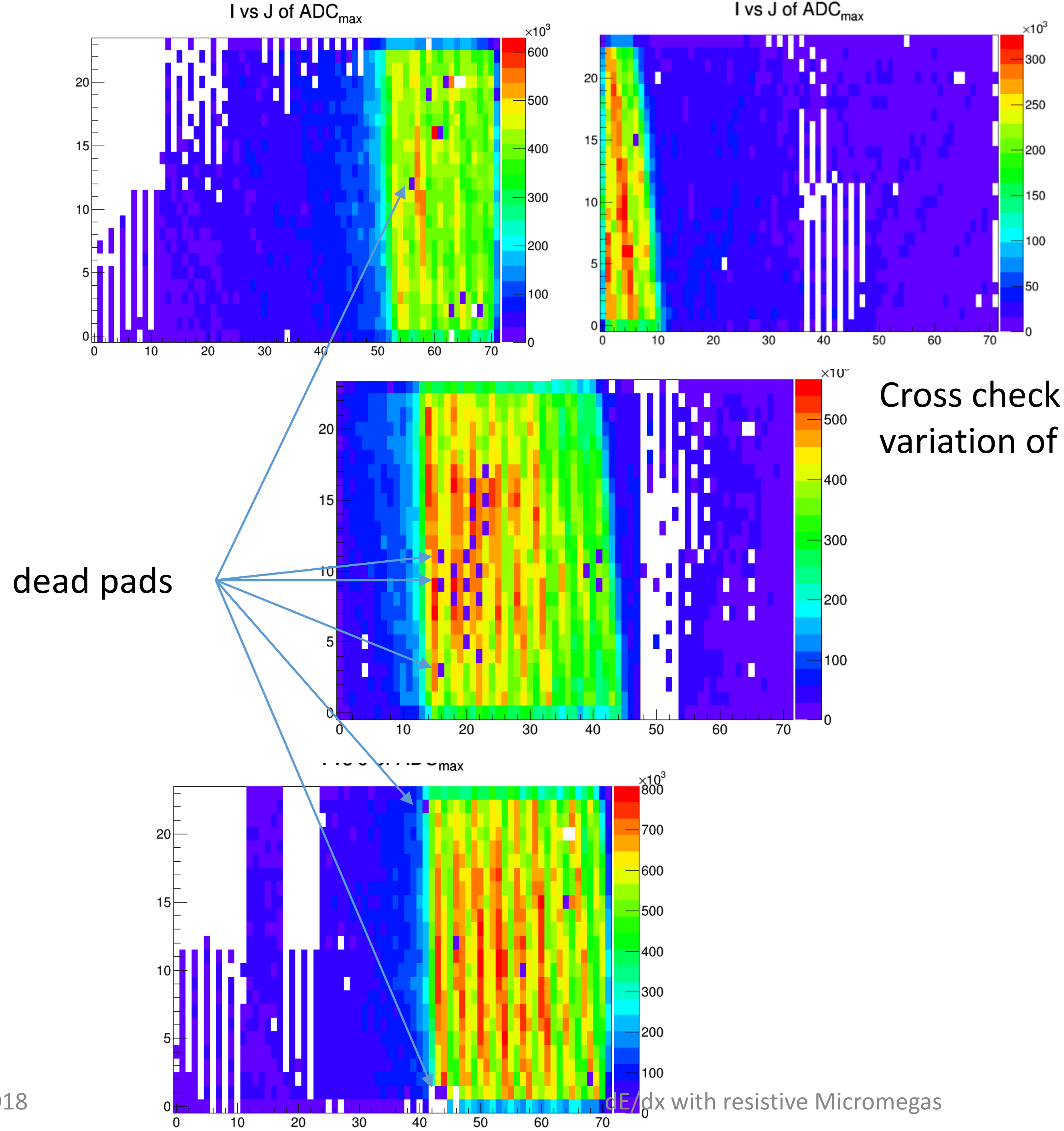








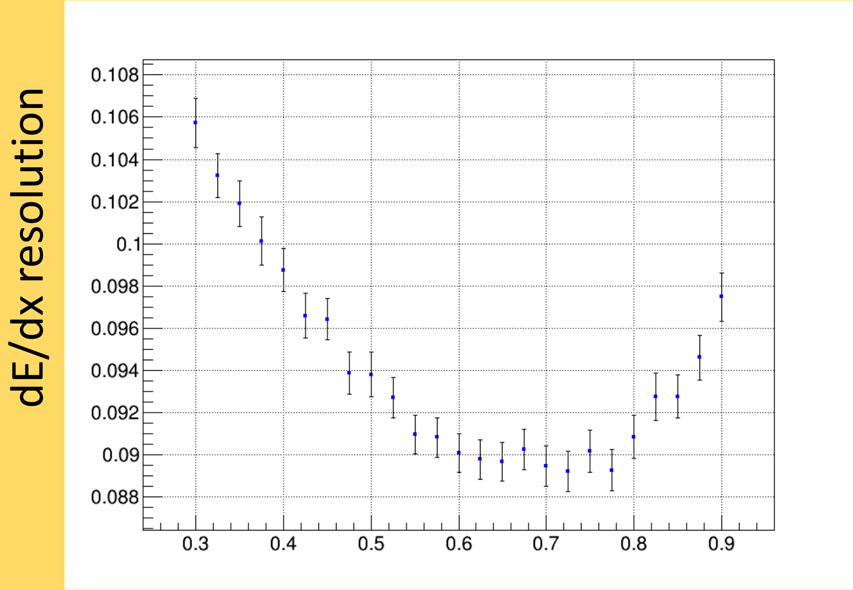




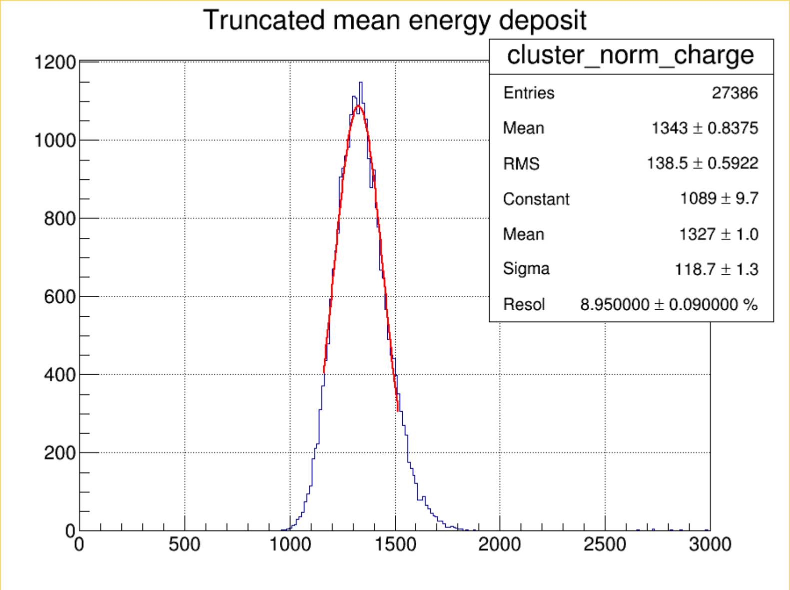
Cross check of the dead pads with the variation of the beam position

RESULTS

- Apply multi-module selection (one long track across 3 modules)
- Vary α to reach the best resolution : α =0.7
- Use 20+19+21=60 rows, 42.5 cm 8.95 ± 0.09 %, which corresponds to 5.00 ± 0.05 %, for the full length (8 modules)



α (truncation parameter)



CONCLUSIONS

The dE/dx resolution for the ILD TPC track length (8 modules of 24 rows) is **5.0 %**

-> **no significant degradation by the resistive foil**

Study the dependence of the resolution on the drift distance, energy, peaking time, was performed:

no dependence is observed

230 V/cm field is slightly better than 140 V/cm

To be studied: correlation between rows (due to transverse diffusion or charge spreading) might increase the dE/dx uncertainty and affect the $L^{-0.5}$ track length dependence of the resolution.