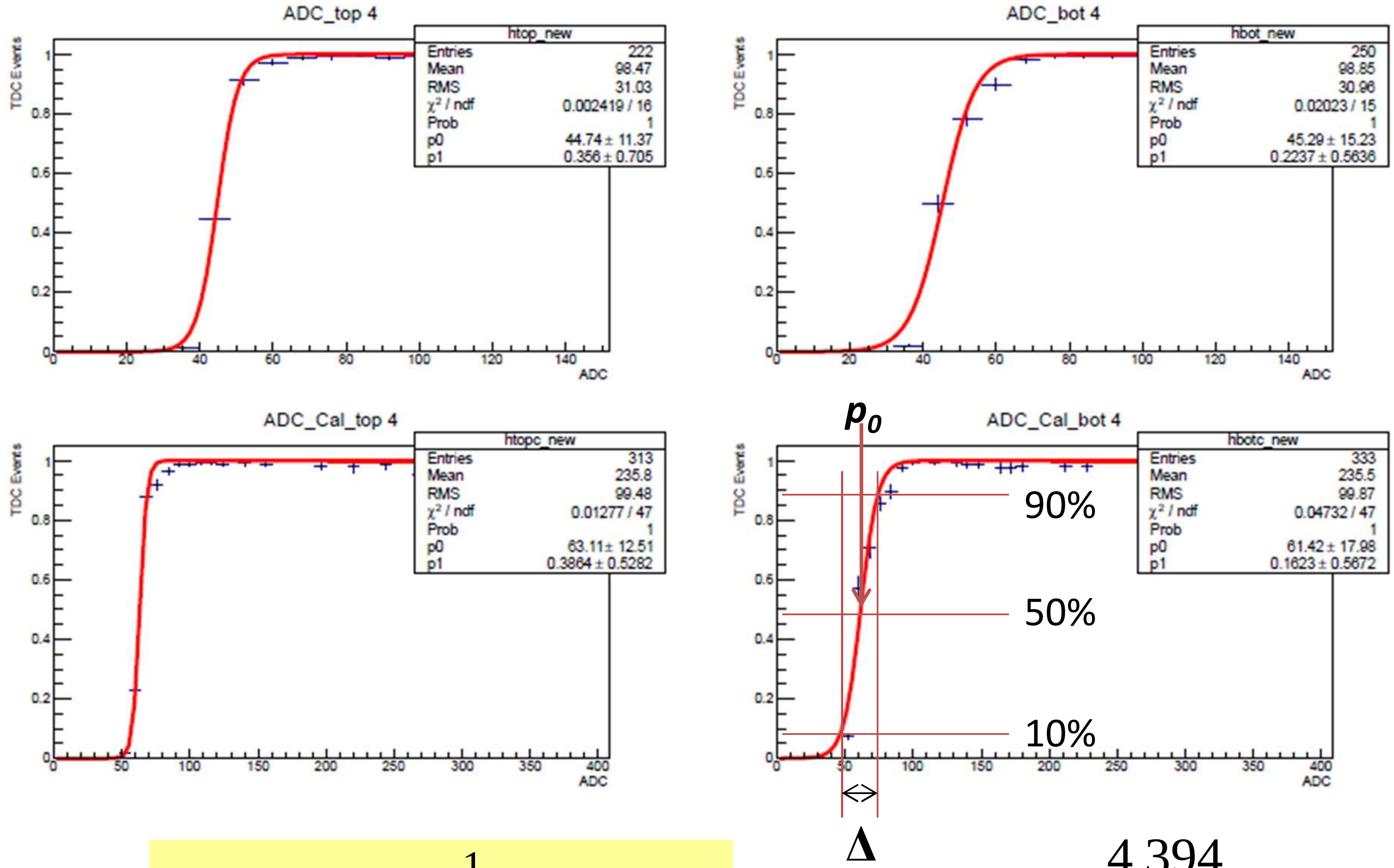
TOF
Energy thresholds for TDCs

V,Monaco, A.Kummali – 19/11/2012

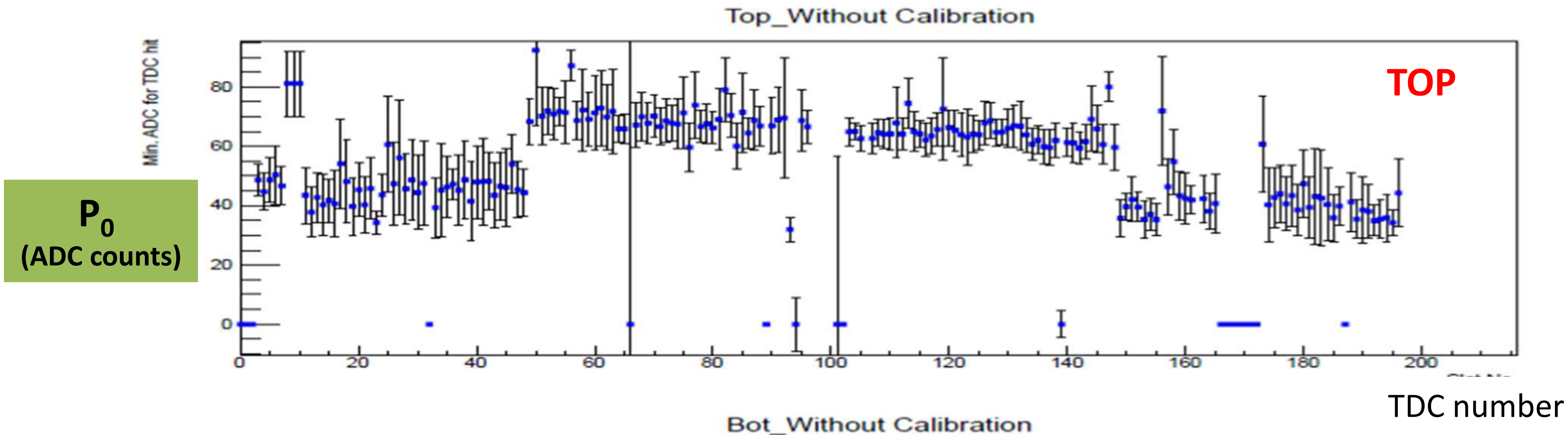
Probability to have a TDC hit as a function of the counts of the corresponding ADC (ADC raw counts with pedestals subtracted)

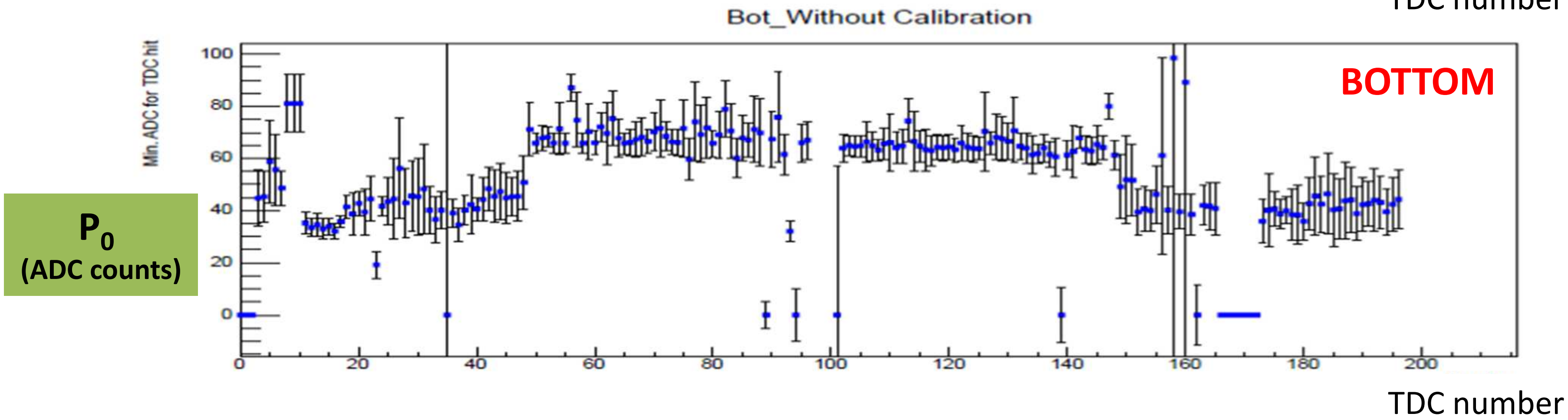


Fitted with: $$\varepsilon = \frac{1}{1+\exp(-p_1 \cdot (ADC_{counts} - p_0))}$$

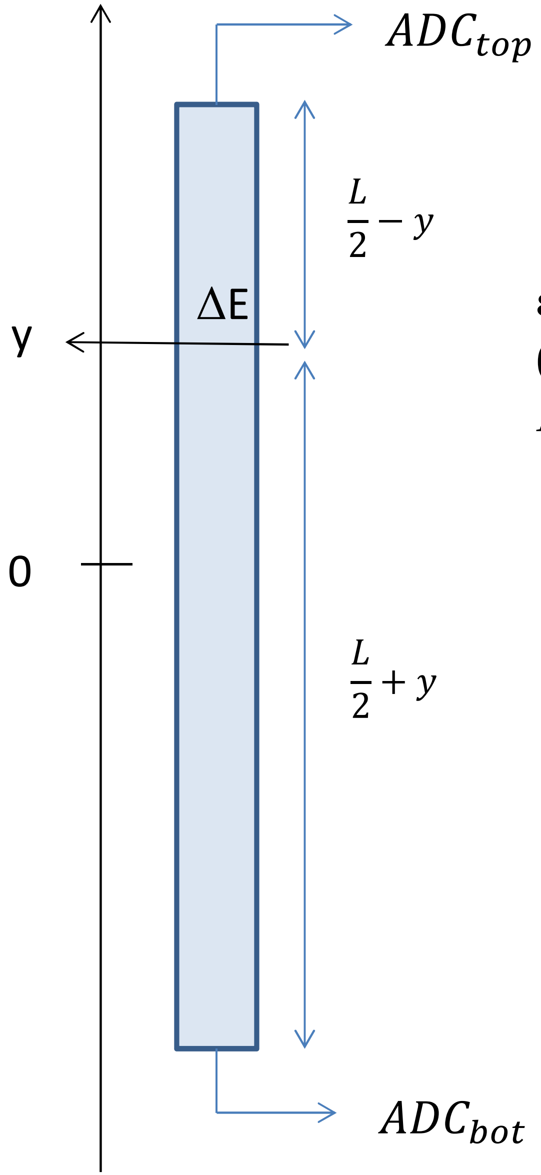
$$\Delta = \frac{4{,}394}{p_1}$$

Minimum detectable energy for each TDC (raw ADC counts with ped. Subtraction)





How to view these results in terms of minimum released energy inside a TOF slat ?



$$ADC_{top} = \varepsilon_t \cdot \Delta E \cdot e^{-\lambda \cdot \left(\frac{L}{2} - y\right)} \qquad ADC_{top} > \min(ADC_{top})$$

$$ADC_{bot} = \varepsilon_b \cdot \Delta E \cdot e^{-\lambda \cdot \left(\frac{L}{2} + y\right)} \qquad ADC_{bot} > \min(ADC_{bot})$$

ε_t and ε_b are related to calibration factors of the individual ADCs (the calibration currently used for the TOF is done on the ADC=sqrt($ADC_{top} \cdot ADC_{bot}$) not on the individual ADCs)

Energy calibration on single ADCs (assuming y=0 in a sweep run and fixed the reconstructed released energy ΔE(rec) = ΔE_o = ΔE(carbon) = 116 MeV)

$$\Delta E_{top}(rec) = k_t \cdot ADC_{top} = \Delta E_o \qquad k_t = \frac{1}{\varepsilon_t} e^{\lambda \frac{L}{2}}$$

$$\Delta E_{bot}(rec) = k_b \cdot ADC_{bot} = \Delta E_o \qquad k_b = \frac{1}{\varepsilon_b} e^{\lambda \frac{L}{2}}$$

Calibration constants k_t and k_b determined long time ago for each slat when we cross-checked the TOF calibration.

Once the calibration constants k_t and k_b are determined in a sweep run, a generic particles releasing a energy ΔE in a point y along the slats gives as reconstructed energies in the two ADCs:

$$\Delta E_{top}(rec) = k_t \cdot ADC_{top} = \Delta E \cdot e^{\lambda y}$$

$$\Delta E_{bot}(rec) = k_b \cdot ADC_{bot} = \Delta E \cdot e^{-\lambda y}$$

The reconstructed energy is $\Delta E(rec)=sqrt(\Delta E_{top}(rec)*\Delta E_{bot}(rec))=E$ and does not depend on the assumption of y fixed to 0 (or to other possible values).

The calibration of individual ADCs provides a independent method to measure the y coordinate (useful to cross check the y measured with the TDCs or to measure it when the information from one or both the TDCs are not available):

$$y = \frac{1}{2\lambda} \cdot ln\left(\frac{\Delta E_{top}(rec)}{\Delta E_{bot}(rec)}\right)$$

The light absorbtion coefficient λ can be determined by studying how the ADC counts scale with the coordinate y measured with the TDCs.

A mean value has been determined and used in the following.
Slat by slat variations to be checked.

If min(ADC_{top}) and min(ADC_{bot}) are the minimum ADC counts for a hit in the top/bottom TDs:

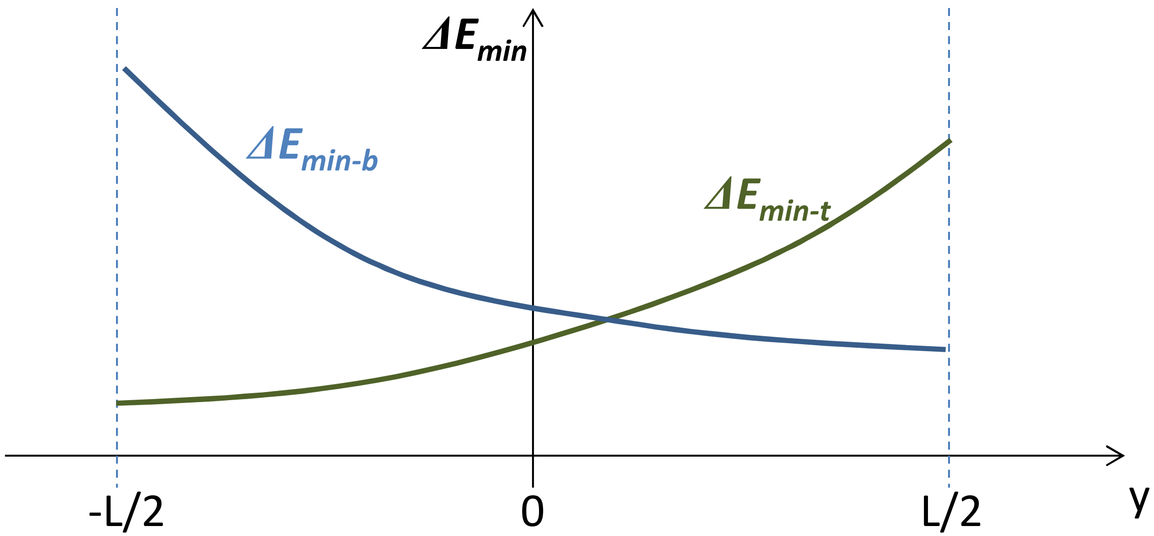
$$\Delta E_{top}(rec) = k_t \cdot ADC_{top} = \Delta E \cdot e^{\lambda y} > k_t \cdot \min(ADC_{top})$$

$$\Delta E_{bot}(rec) = k_b \cdot ADC_{bot} = \Delta E \cdot e^{-\lambda y} > k_b \cdot \min(ADC_{bot})$$

The minimum energy to be released by a particle in the TOF to have a TDC hit are:

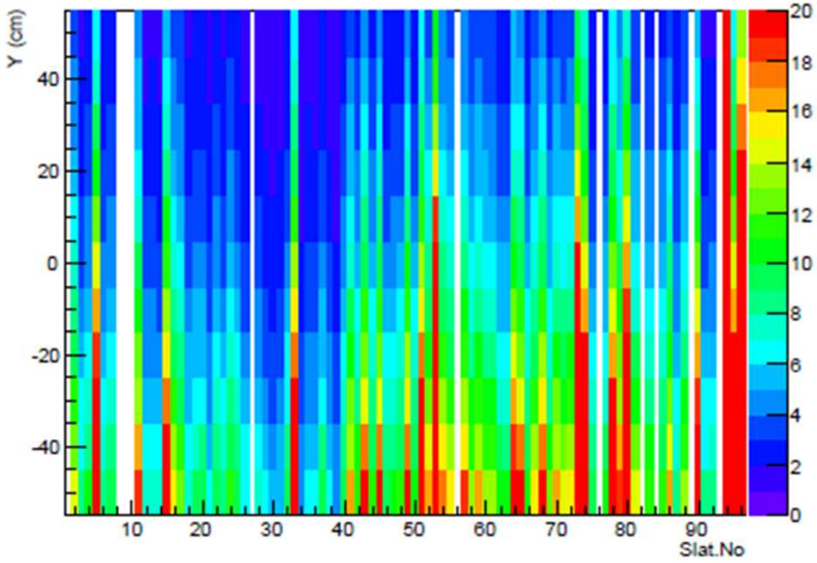
$$\Delta E_{min-t}(y) = k_t \cdot \min(ADC_{top}) \cdot e^{-\lambda y}$$ for the TDC-top

$$\Delta E_{min-b}(y) = k_b \cdot \min(ADC_{bot}) \cdot e^{\lambda y}$$ for the TDC-bottom

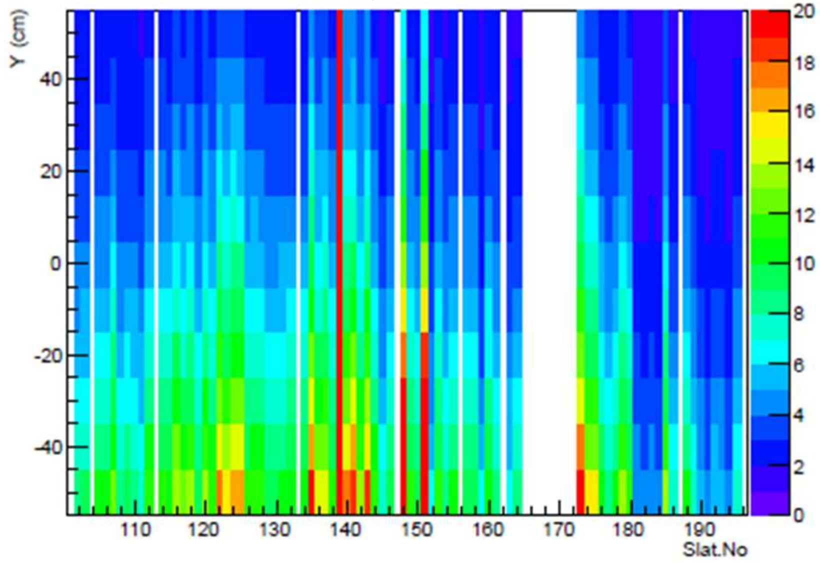


LINEAR ENERGY RESPONSE ASSUMED !!

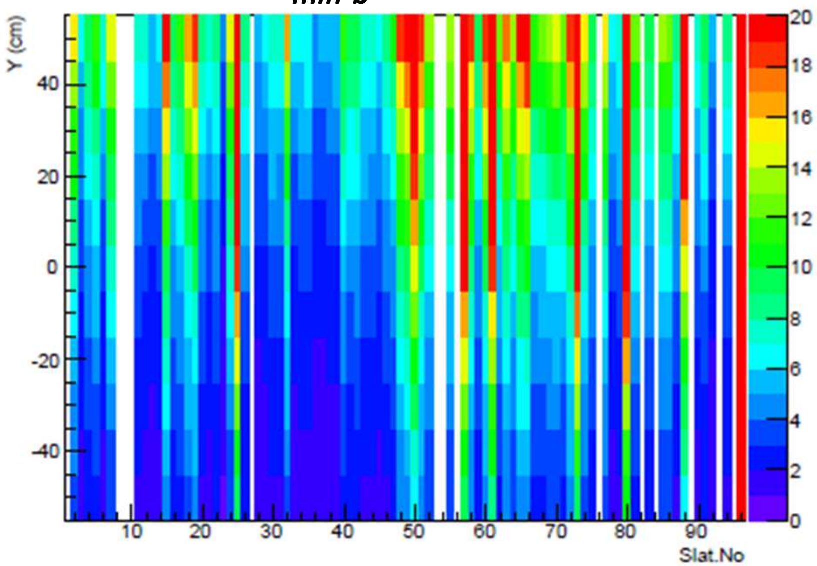
$\Delta E_{min\text{-}t}$ (Front) [MeV]



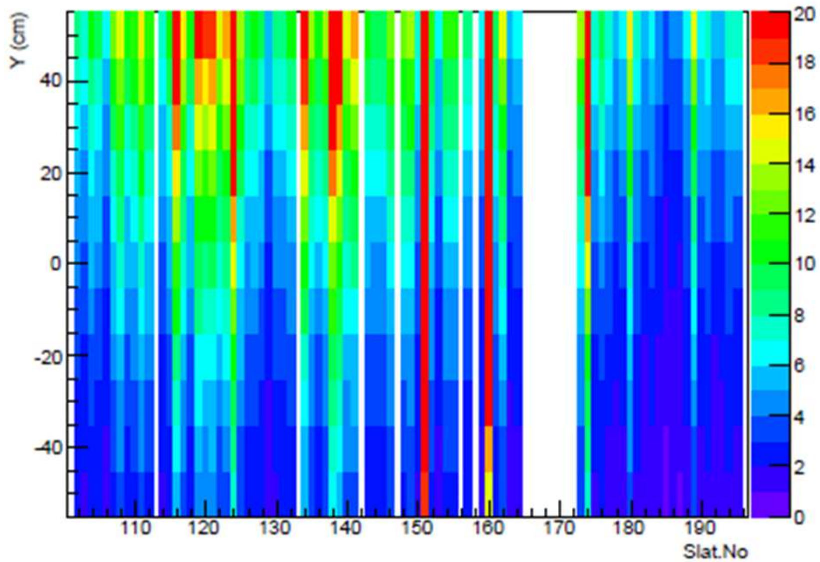
$\Delta E_{min\text{-}t}$ (Rear) [MeV]



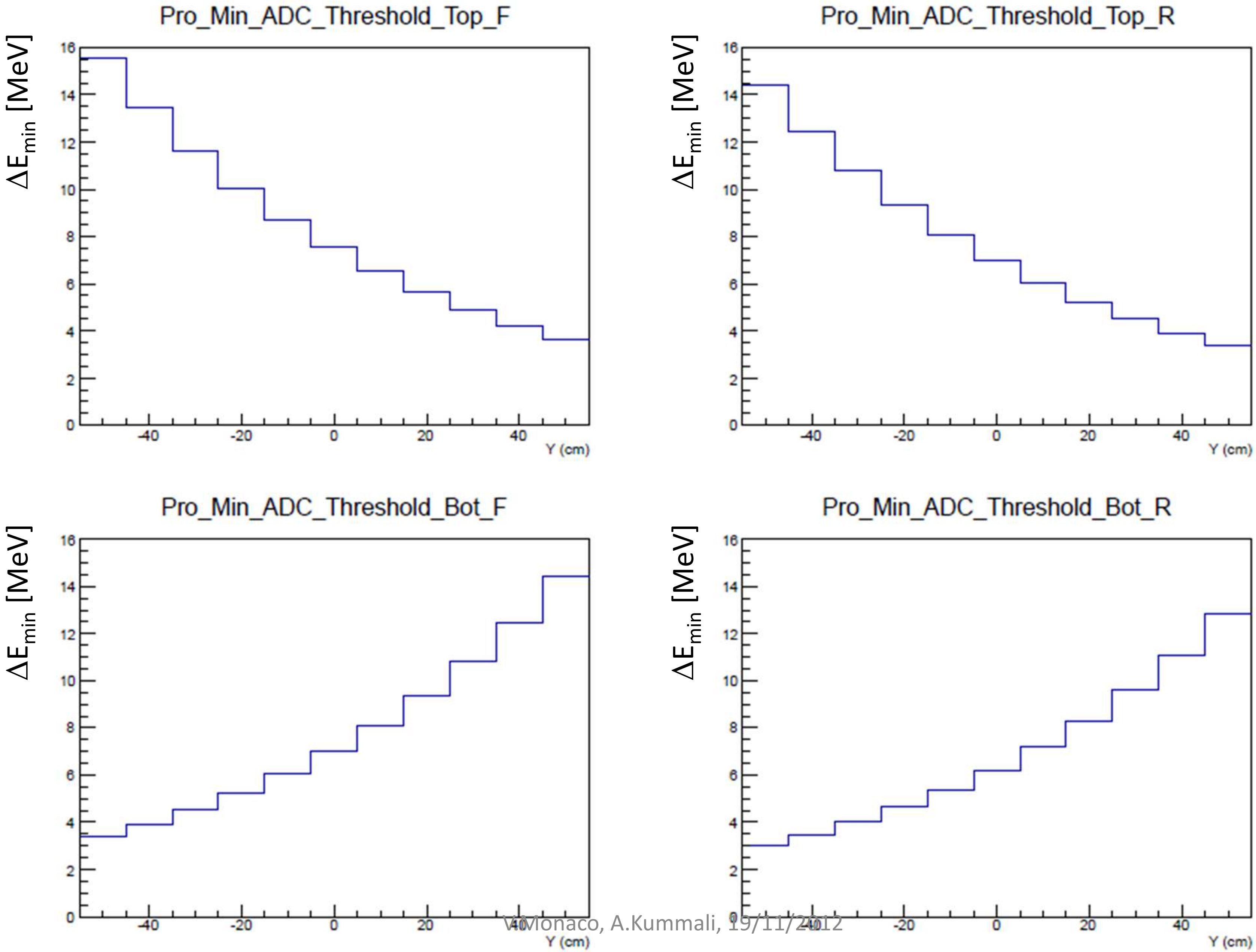
$\Delta E_{min\text{-}b}$ (Front) [MeV]



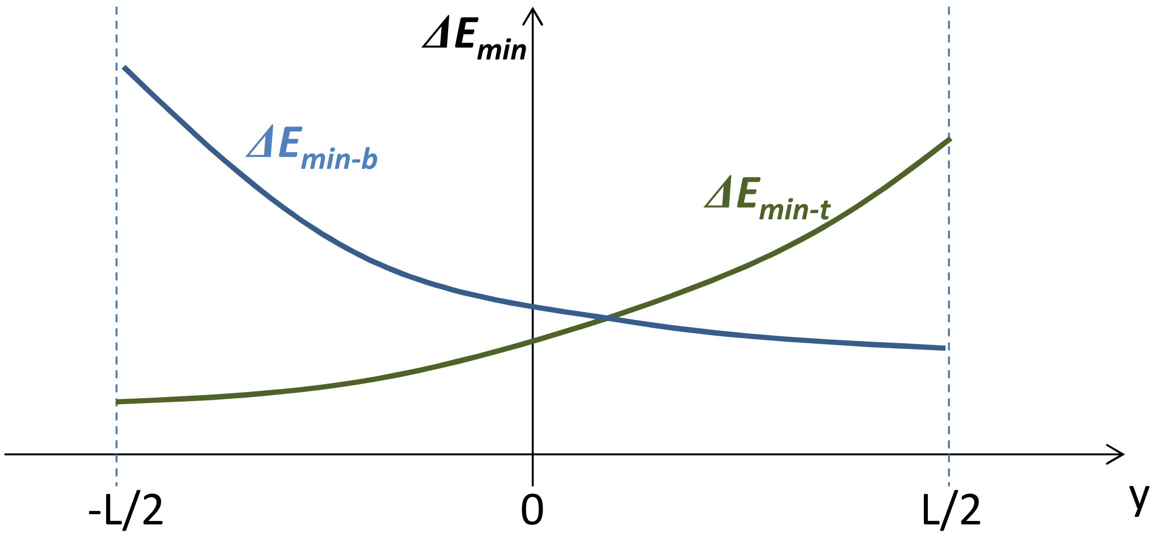
$\Delta E_{min\text{-}b}$ (Rear) [MeV]



Mean ΔE thresholds as a function of y

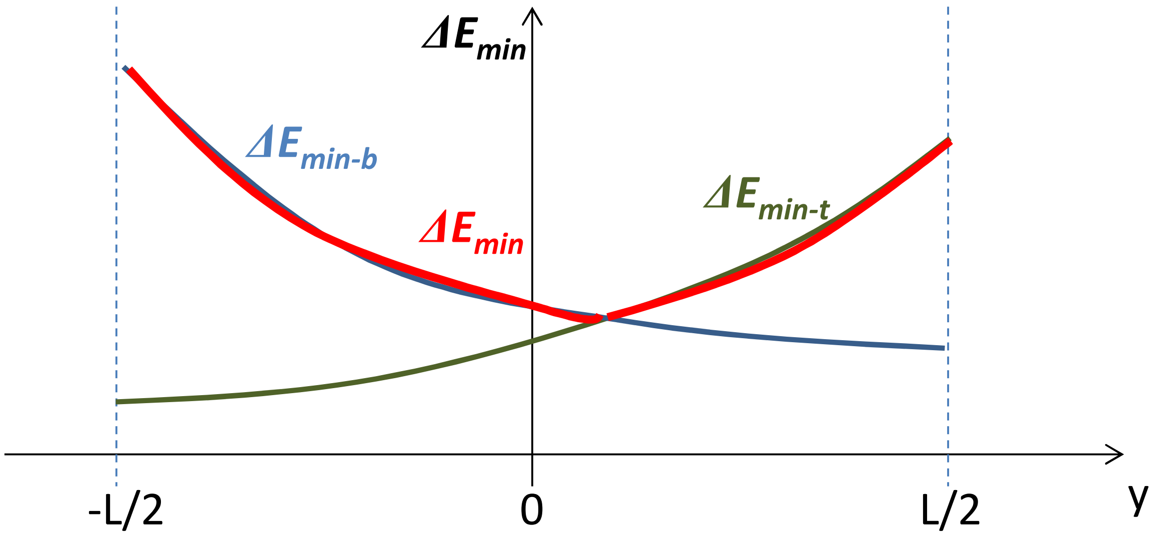


In the current implementation of the TOF calibration and reconstruction, both the TDCs are required to measure the Time Of Flight and the y coordinate.

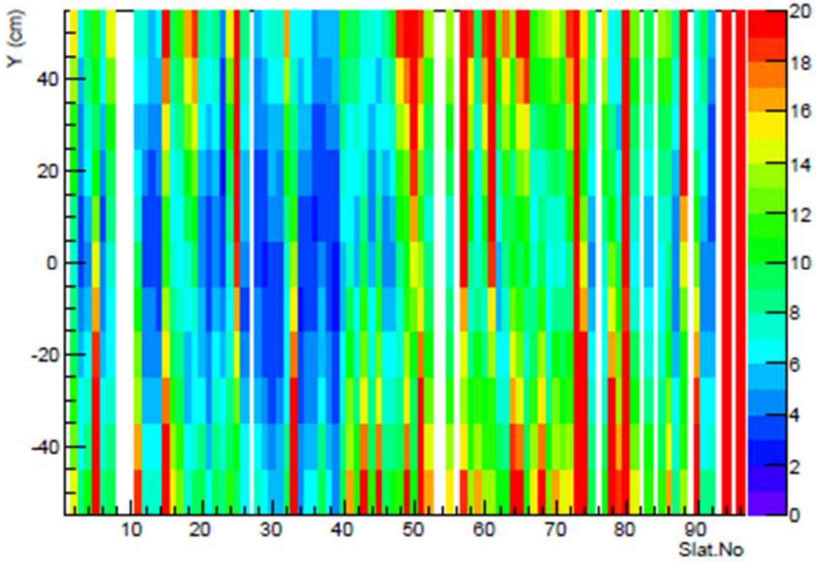


In the current implementation of the TOF calibration and reconstruction,
both the TDCs are required to measure the Time Of Flight and the y coordinate.

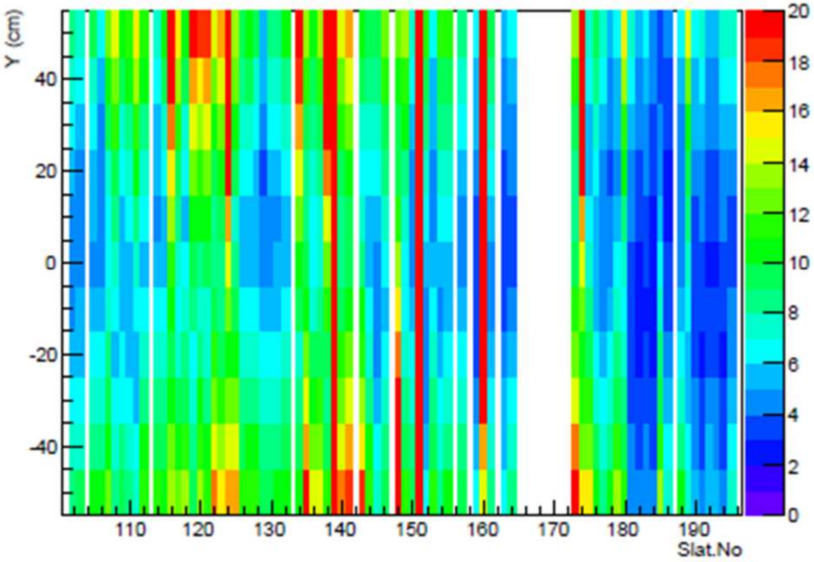
$$\Delta E_{min-AND} = \max(\Delta E_{min-t}, \Delta E_{min-b})$$



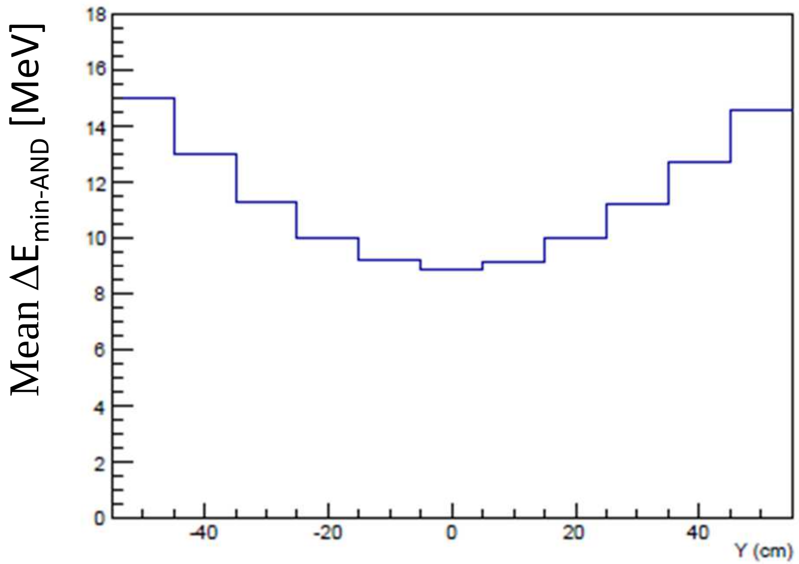
$\Delta E_{min\text{-}AND}$ (Front) [MeV]



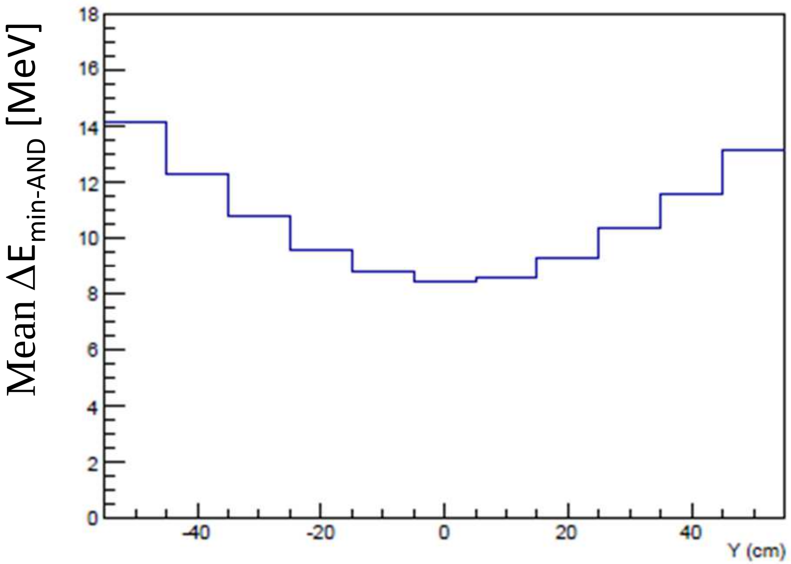
$\Delta E_{min\text{-}AND}$ (Rear) [MeV]



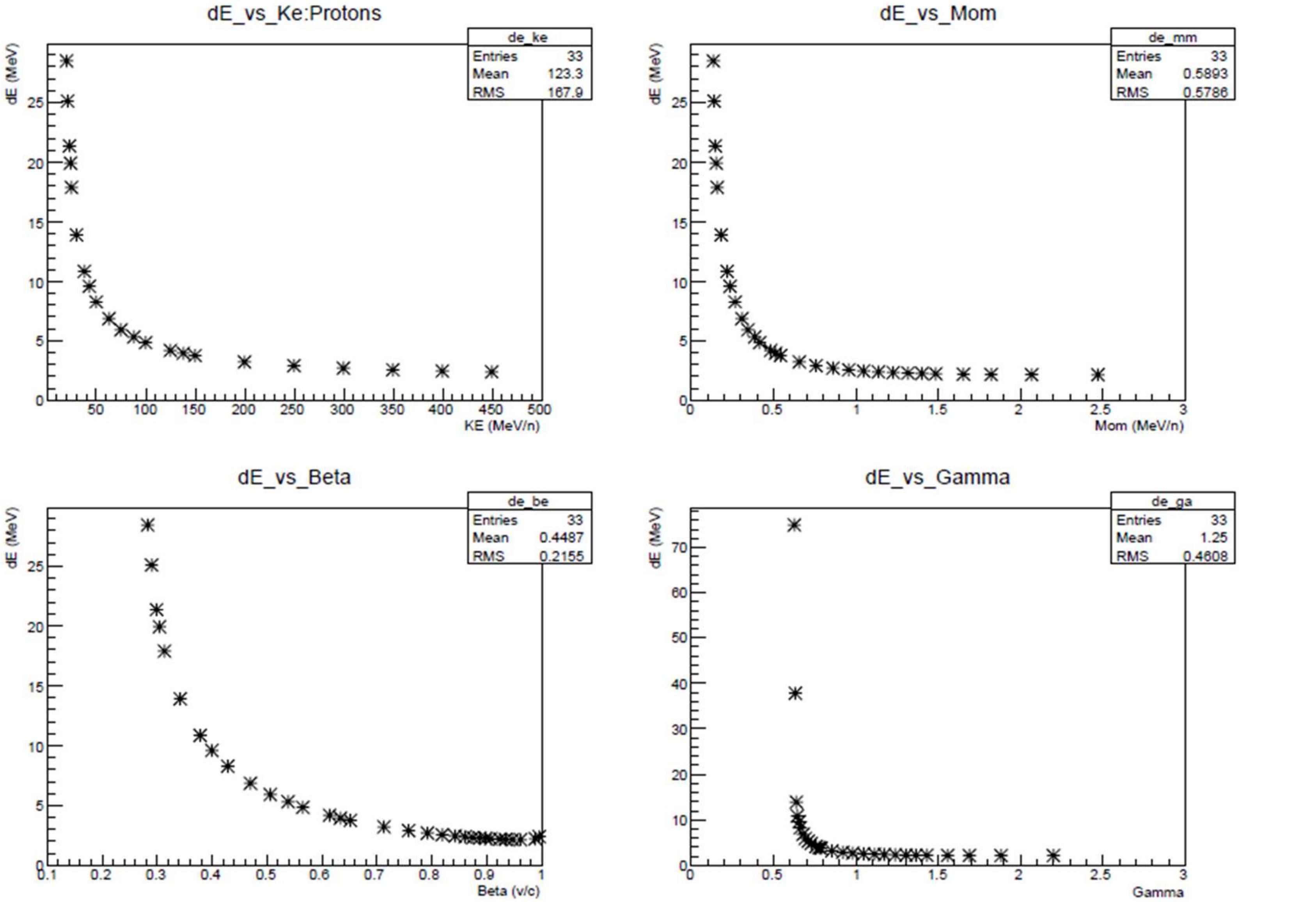
Front



Rear

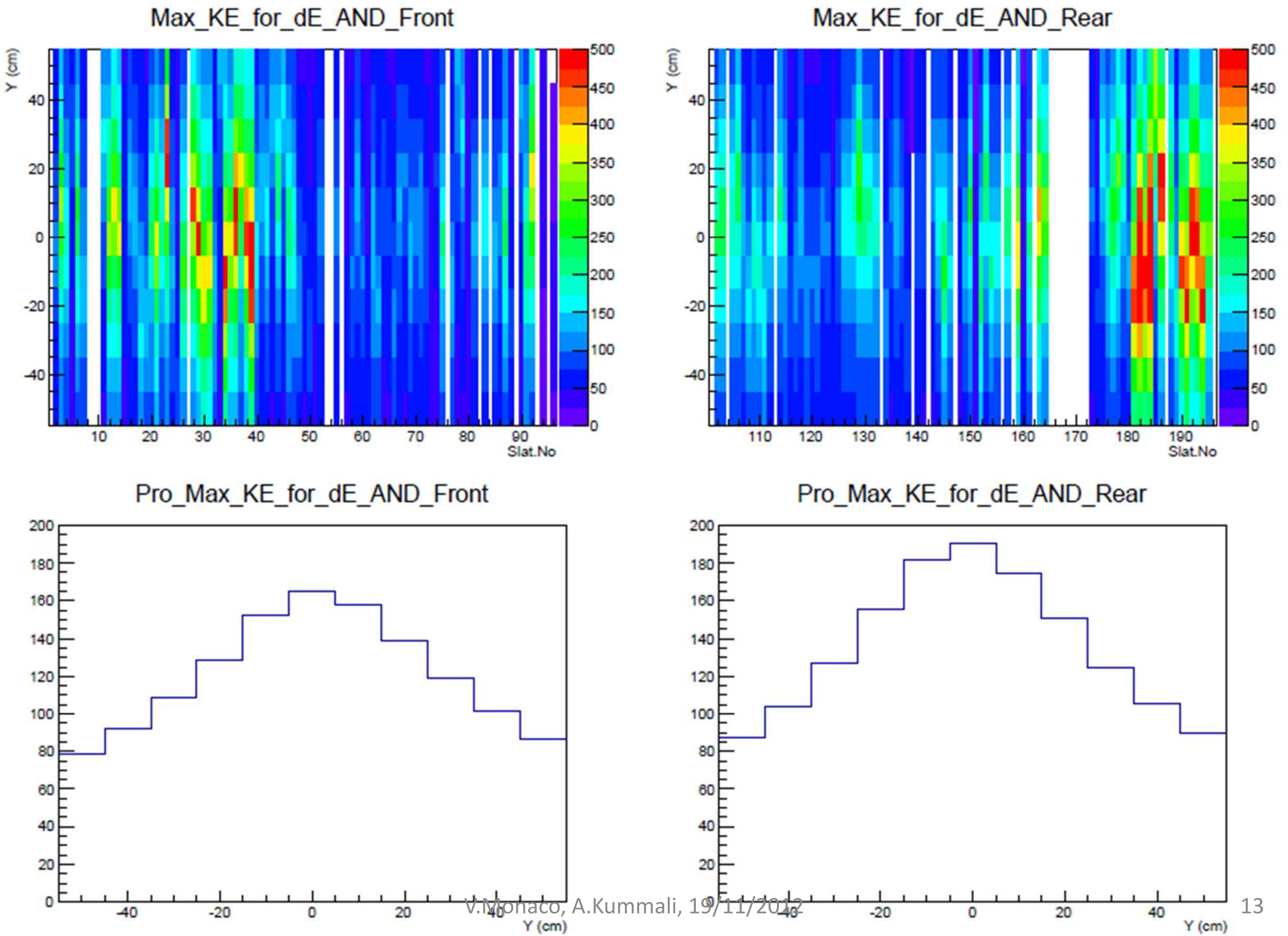


Bethe-Block for protons

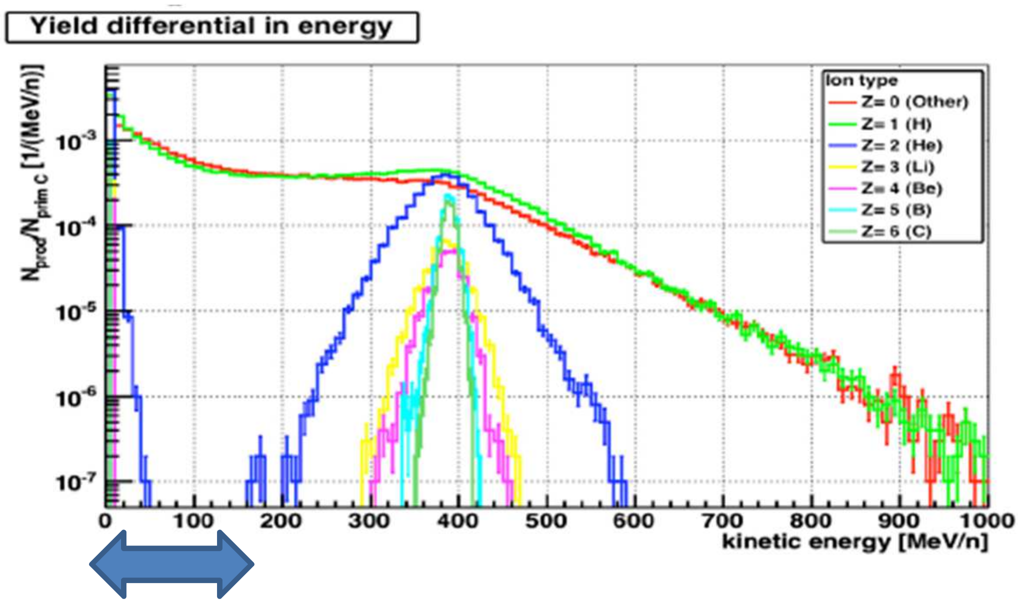


A minimum detectable ΔE means that protons can be reconstructed in the TOF only if their kinetic energy is below a maximum value

Maximum Kinetic energy to detect protons with both the TDCs



The kinetic energy of protons are spread over a broad spectra (to be checked only for protons hitting the TOF and as a function of the x position).



Only low energy protons can be reconstructed if both the TDCs are required.

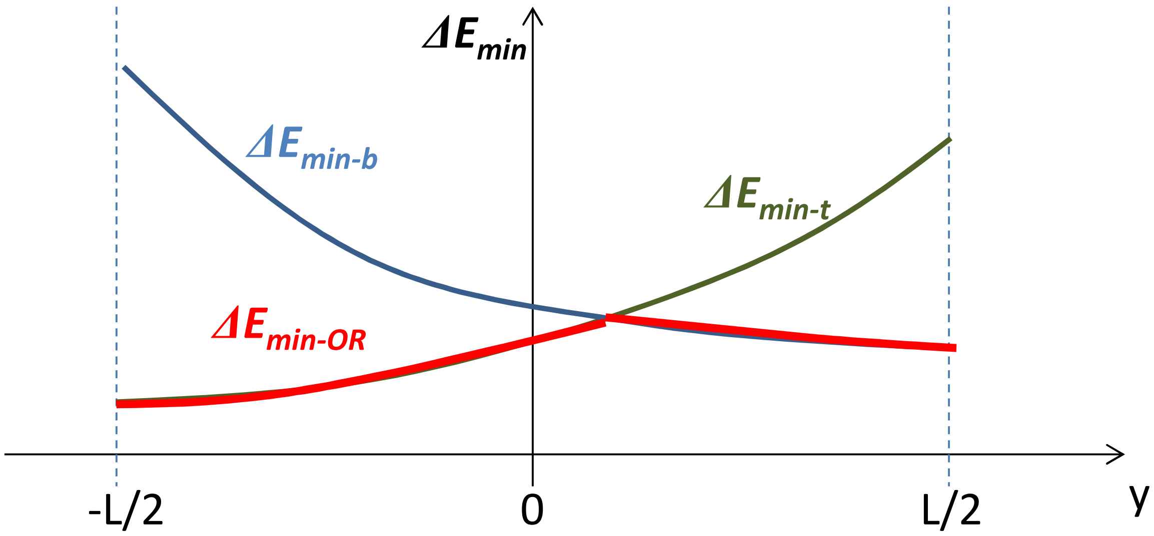
Solution 1: use individual ADCs calibrated measurements to determine the y coordinate. A single TDC measurement allows to calculate the Time of Flight, after a correction based on the y coordinate measured with ADCs)

Solution 2: use only ADC measurements to determine x-y position. No Time of Flight measurement is possible (it must be assumed to be a proton)

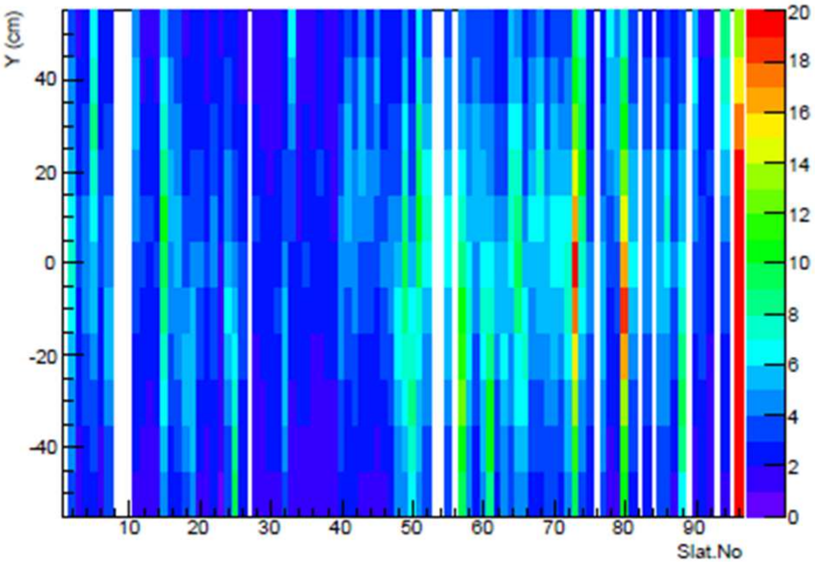
In both the cases several slats where one or both the TDCs are not working could be used.

Inclusion of events with only one TDC hit (OR of bot and top TDCs)

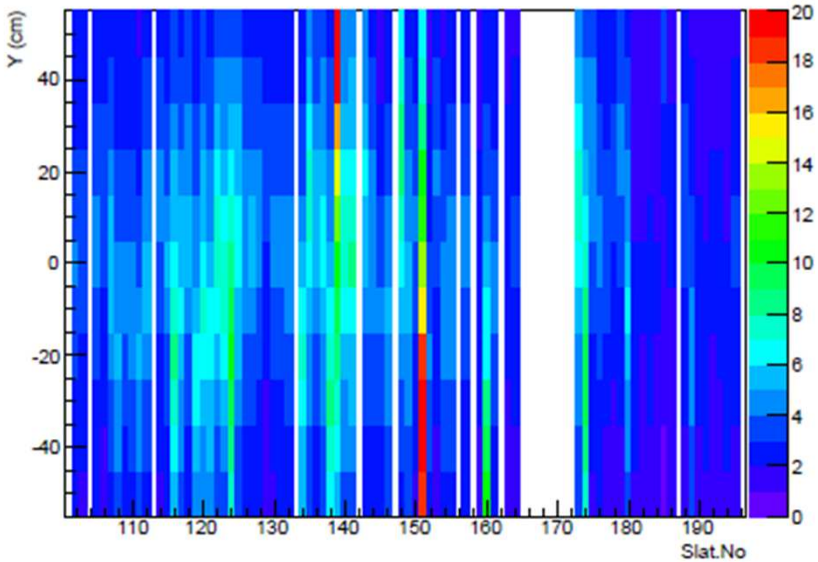
$$\Delta E_{min-OR} = \min(\Delta E_{min-t}, \Delta E_{min-b})$$



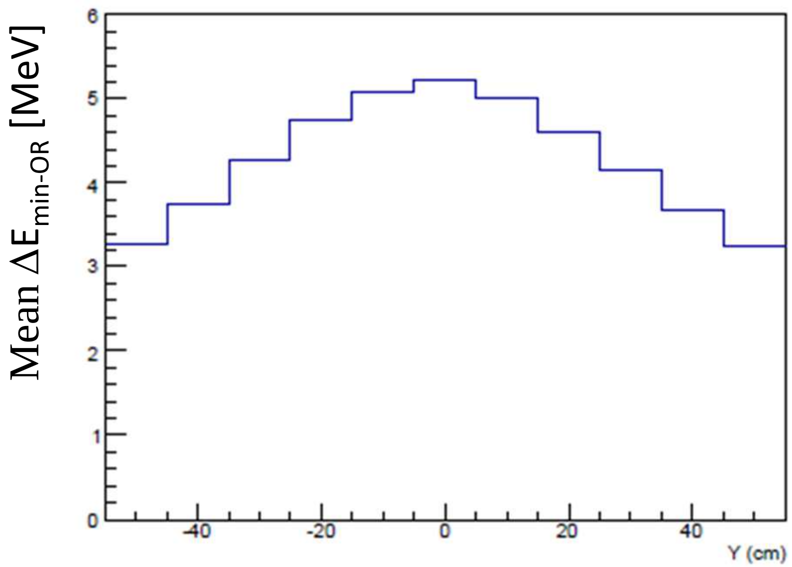
$\Delta E_{min\text{-}OR}$ (Front) [MeV]



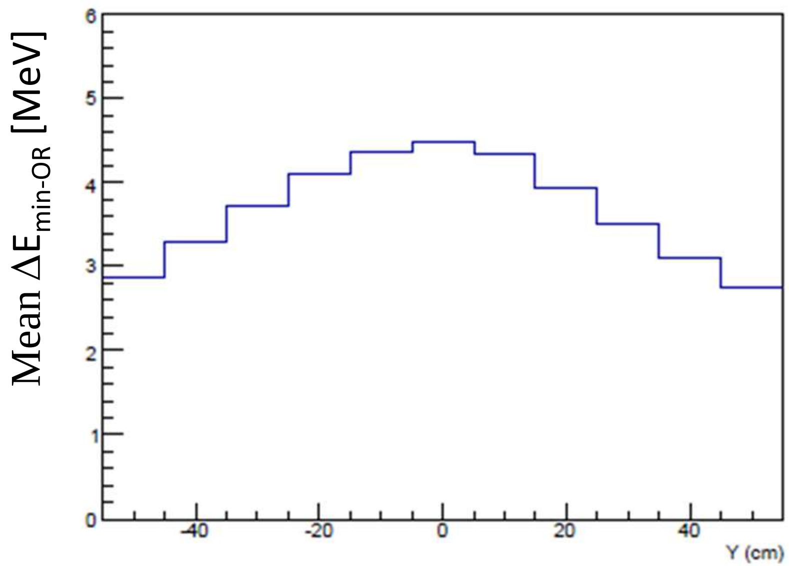
$\Delta E_{min\text{-}OR}$ (Rear) [MeV]

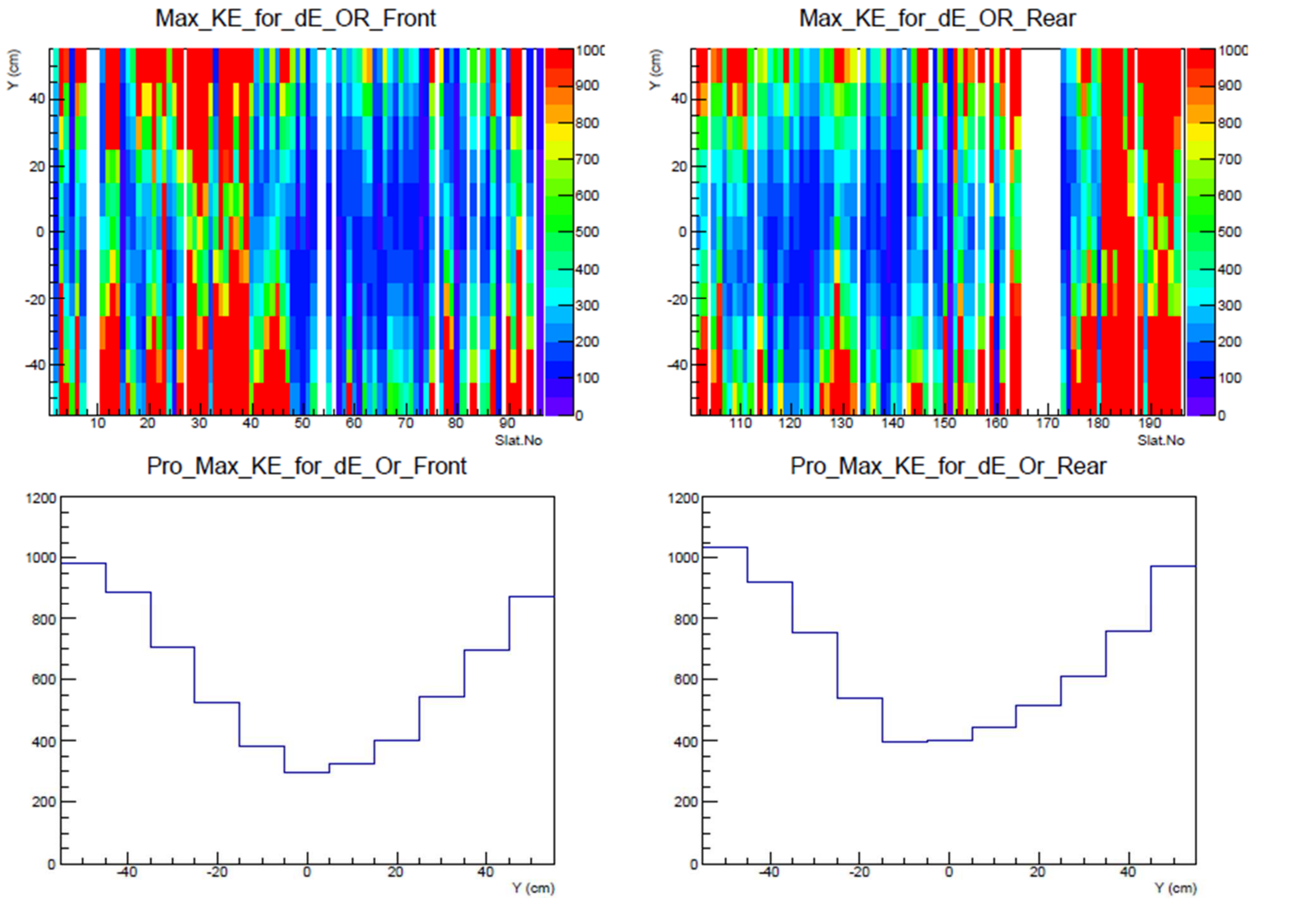


Front



Rear





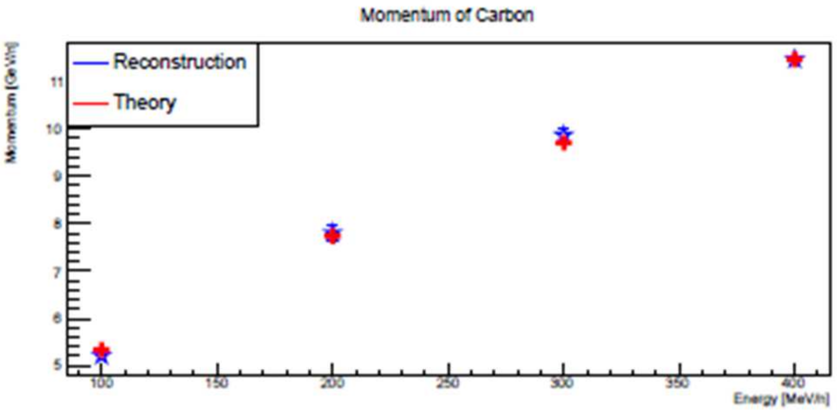
It seems the sensitivity of the Front slats around the C peak is low (only protons of kinetic energy <100-200 MeV can be detected even by using only one TDC).

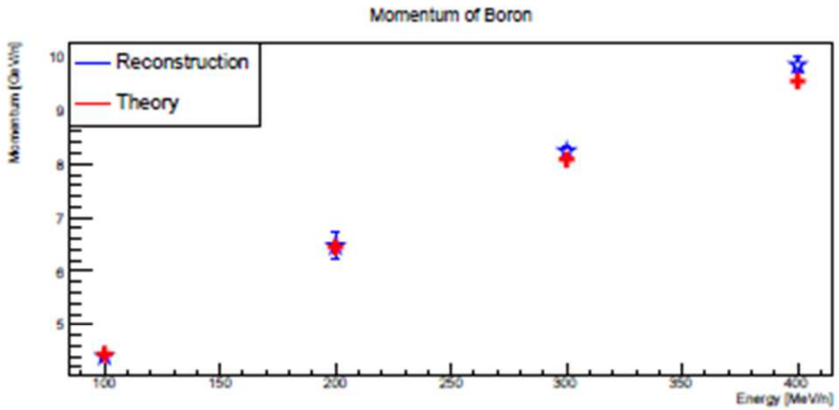
Conclusions

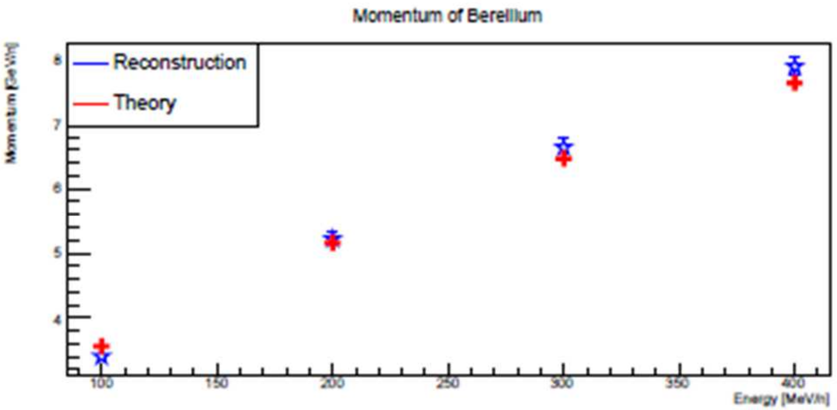
- It seems the TDC thresholds could be not low enough to detect all the protons
- This reduces the efficiency of the reconstruction of the p momentum with the current implementation of the TOF calibration and reconstruction.
- A possible solution is to calibrate the ADCs individually and use the additional information to reconstruct the TOF quantities when one TDC is missing (y and TOF still measurable) or both the TDCs have no hit (y can be still measured from ADCs alone)
- Calibration data already available for single ADCs. To be checked and implemented in the TOF reconstruction.
- With y/TOF measured with only one TDC, many slats now masked for problems in some electronic channel could be recovered.

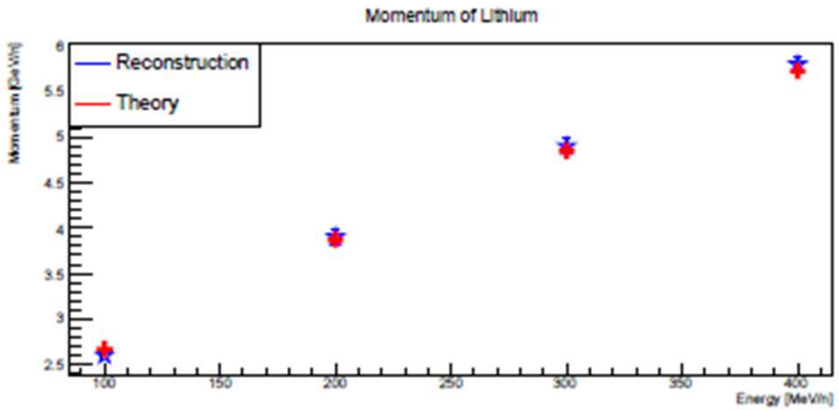
A small test of the reconstruction algorithm

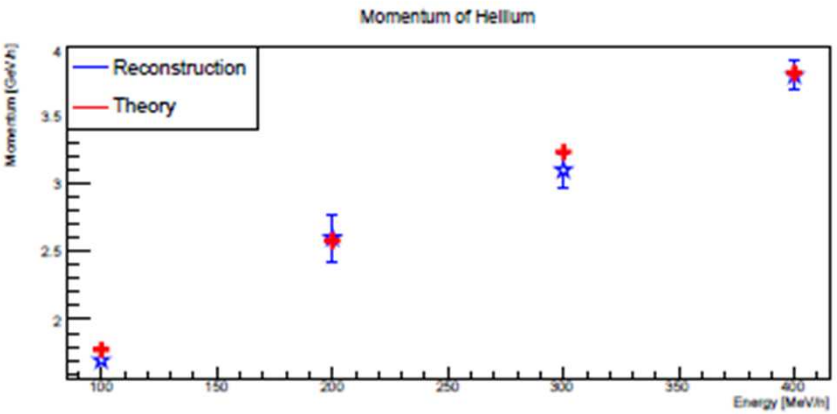
In the simulation primary particles of different kind produced at different energies (no target).
The reconstructed momentum is compared with the momentum of the generated particle.

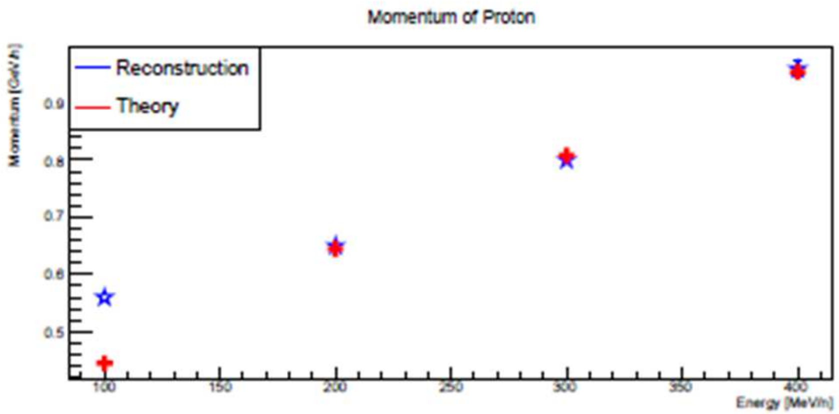

Momentum of Carbon
Reconstruction
Theory
Momentum [GeV/n]
Energy [MeV/n]

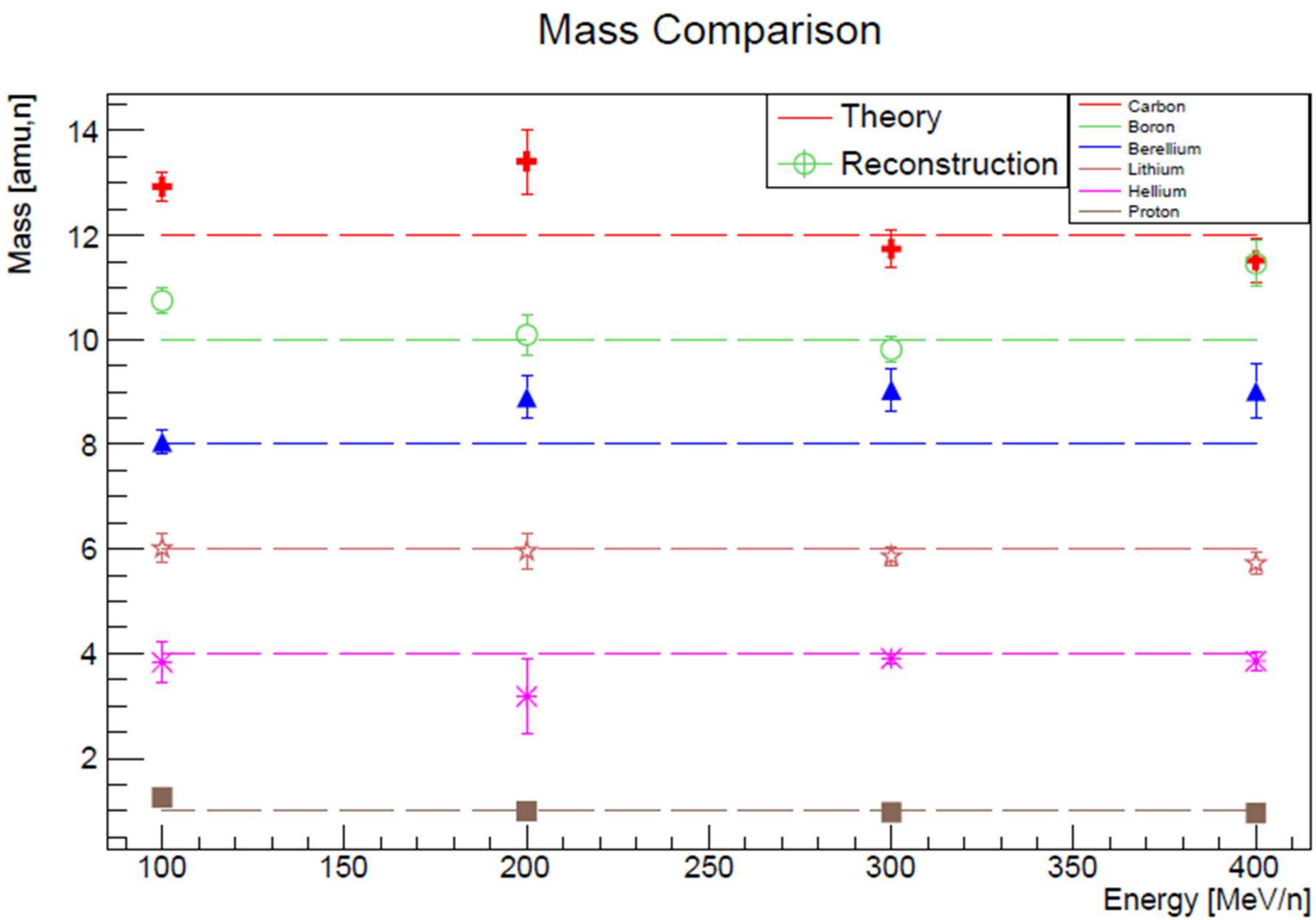

Momentum of Boron
Reconstruction
Theory
Momentum [GeV/n]
Energy [MeV/n]


Momentum of Berelium
Reconstruction
Theory
Momentum [GeV/n]
Energy [MeV/n]


Momentum of Lithium
Reconstruction
Theory
Momentum [GeV/n]
Energy [MeV/n]


Momentum of Helium
Reconstruction
Theory
Momentum [GeV/n]
Energy [MeV/n]


Momentum of Proton
Reconstruction
Theory
Momentum [GeV/n]
Energy [MeV/n]


Mass Comparison
Mass [amu,n]
Energy [MeV/n]
Theory
Reconstruction
Carbon
Boron
Berellium
Lithium
Hellium
Proton
14
12
10
8
6
4
2
100
150
200
250
300
350
400