INNOWACYJNA GOSPODARKA
NARODOWA STRATEGIA SPÓJNOŚCI
UNIWERSYTET JAGIELLOŃSKI W KRAKOWIE
FNP Fundacja na rzecz Nauki Polskiej
UNIA EUROPEJSKA
EUROPEJSKI FUNDUSZ ROZWOJU REGIONALNEGO

INTERNATIONAL PHD PROJECTS IN APPLIED NUCLEAR PHYSICS AND INNOVATIVE TECHNOLOGIES

This project is supported by the Foundation for Polish Science – MPD program, co-financed by the European Union within the European Regional Development Fund

Simulation of Time-Over-Threshold with GARFIELD

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PANDA Collaboration Meeting, GSI, Germany, 5-9 September 2011

Outline

- Setting input parameters for GARFIELD
- Signal analysis
- PID methods and their separation power
- Corrections
- Plans for future

Introduction

- GARFIELD: a computer program for the detailed simulation of two- and three-dimensional gas detectors.

- Garfield input is subdivided in sections:
  - CELL
  - FIELD
  - MAGNETIC
  - GAS
  - OPTIMISE
  - DRIFT
  - SIGNAL

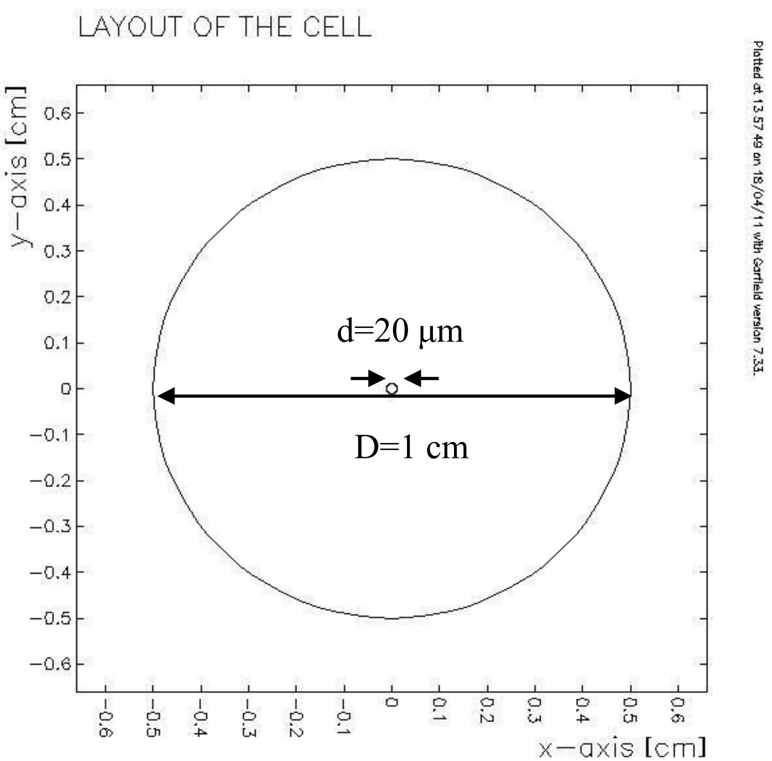
Cell & Field

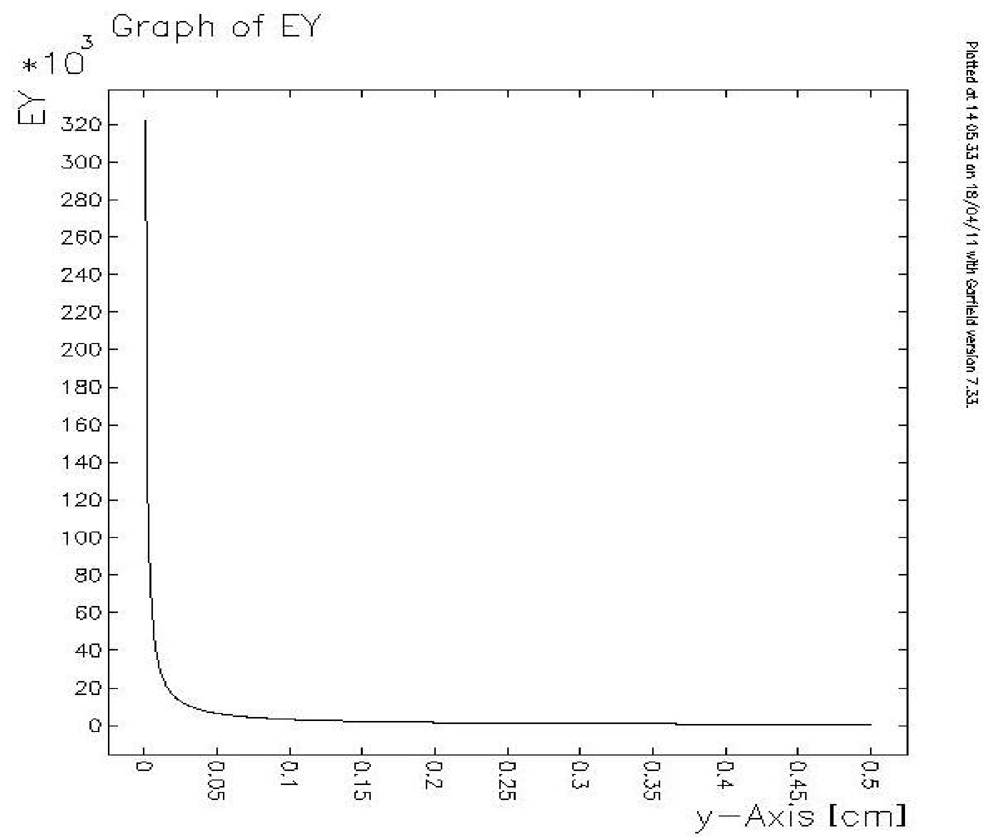
Tube radius= 0.5 cm

Wire radius= 10 µm

Wire voltage=+1800 V

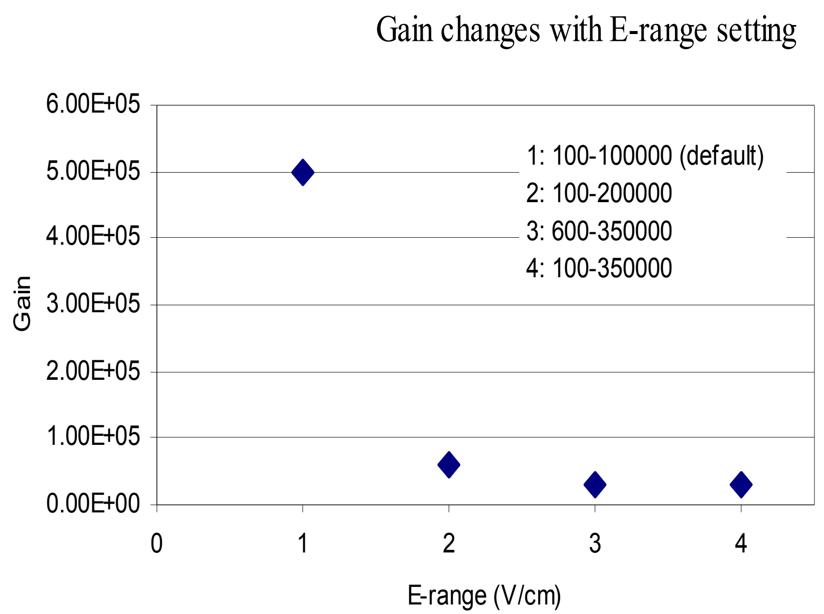
B=0

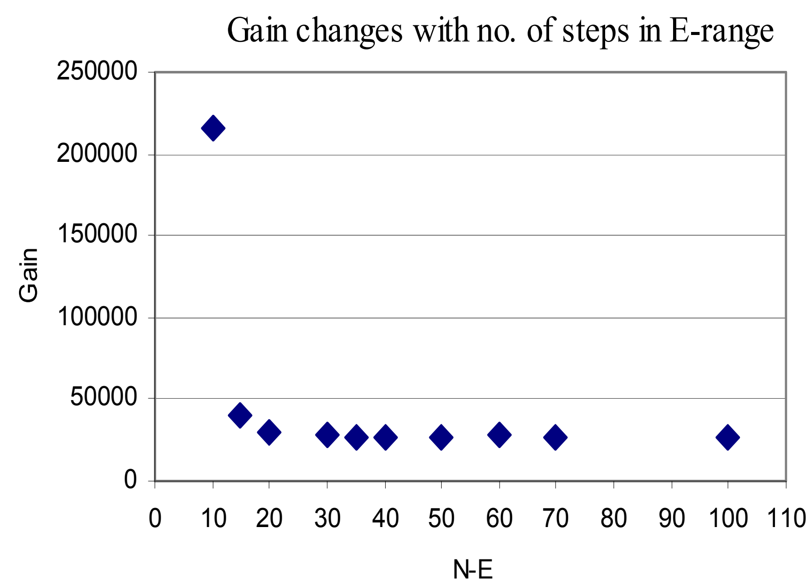




Gas file

- Make a gas file with Magboltz 7
  - 90% Ar, 10% CO_2, Temperature 300 K, Pressure 2 atm
- Importance of different parameters:
  - Electric-field-range
  - The number of points with N-E
  - The number of collisions in MONTE-CARLO integration





Gas gain & Penning effect

- Diethorn formula

$$\ln G = K_1 \frac{V}{\ln(\frac{b}{a})} \ln(\frac{V}{pa\ln(\frac{b}{a})}) + K_2 \frac{V}{\ln(\frac{b}{a})}$$

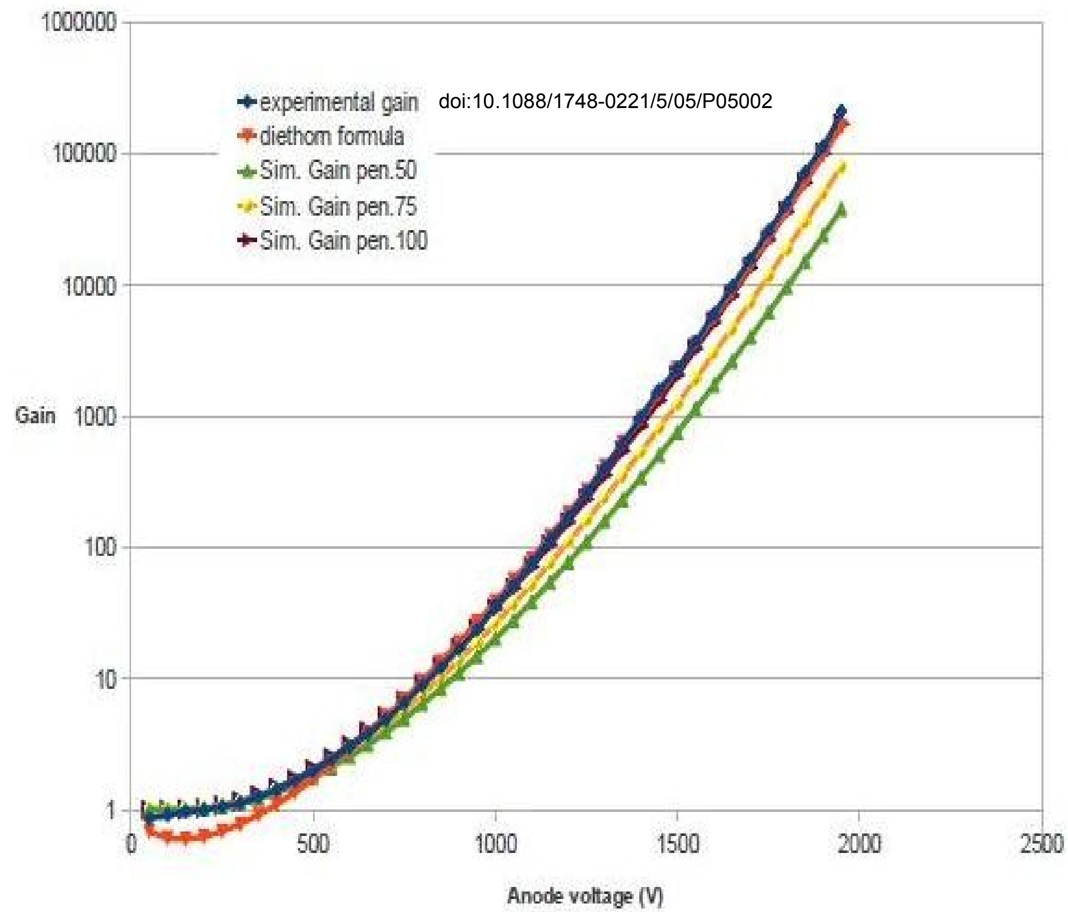
- Penning transfer rate

$$G = \exp\int_{tube}^{anode} dr\alpha(E(r)) \frac{\sum v_i^{ion}(E(r)) + \sum r_i v_i^{exc}(E(r))}{\sum v_i^{ion}(E(r))}$$

- In Ar-CO_2 gas mixtures:
  - Penning rate is about 50%

  doi:10.1088/1748-0221/5/05/P05002

- New version of Magboltz
  - Ar cross section is updated



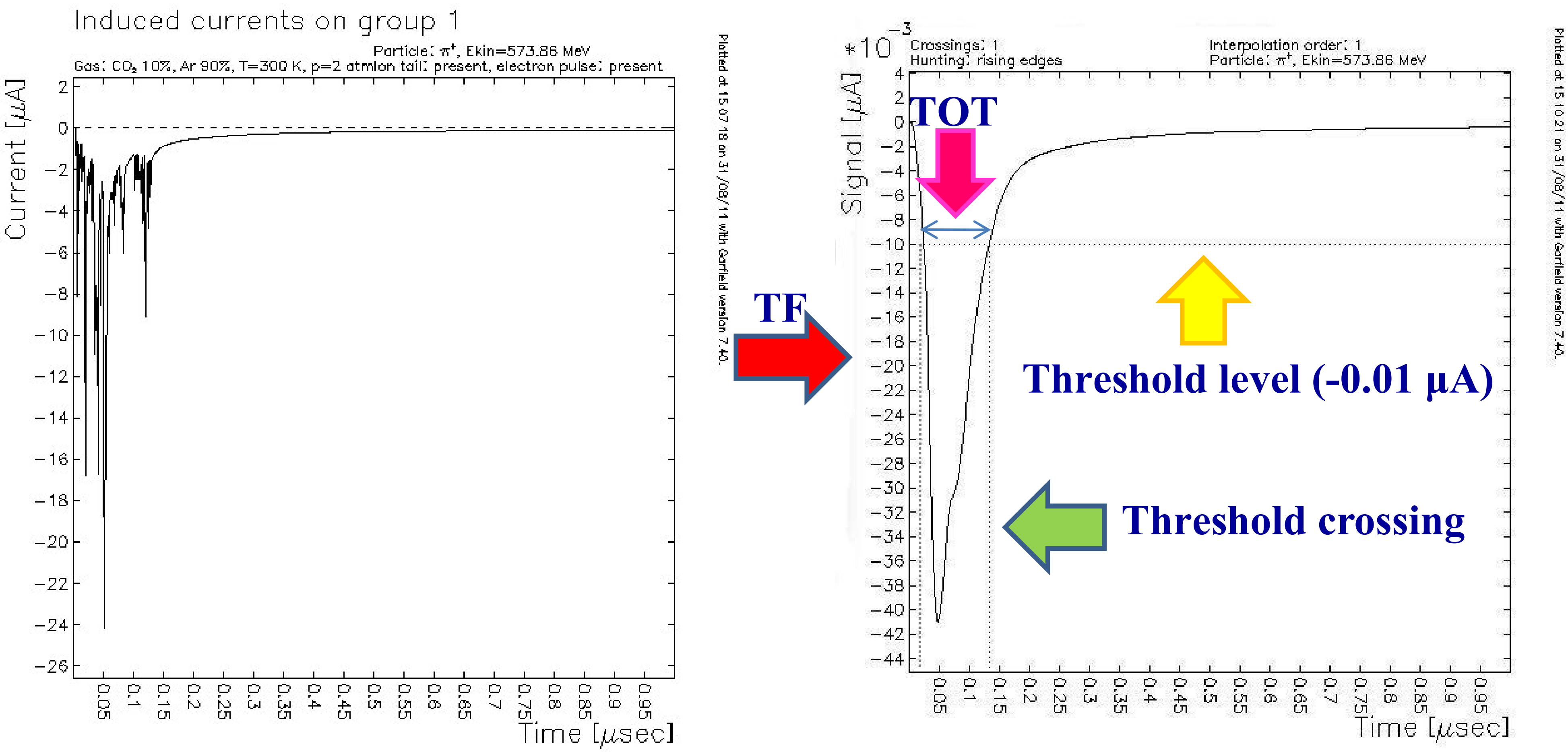
Signal & Transfer Function

- Transfer Function: relation between the Laplace transform of the output and input pulse $H(s) = \dfrac{u_{out}(s)}{I_{in}(s)}$

- Preamplifier response:
  - Shaping $$f(s) = \frac{n!\tau}{(1+s\tau)^{n+1}}$$
    n: number of integrations
    τ: time constant of one integration stage
    - n=2 , τ=10 nsec (peaking time=2*τ=20nsec)
  - Tail cancelation $$f(s) = \frac{(s\tau_1+1).(s\tau_2+1)}{(\frac{s(\tau_1 R_2+\tau_2 R_1)}{R_1+R_2}+1)}$$
    Not implemented yet!

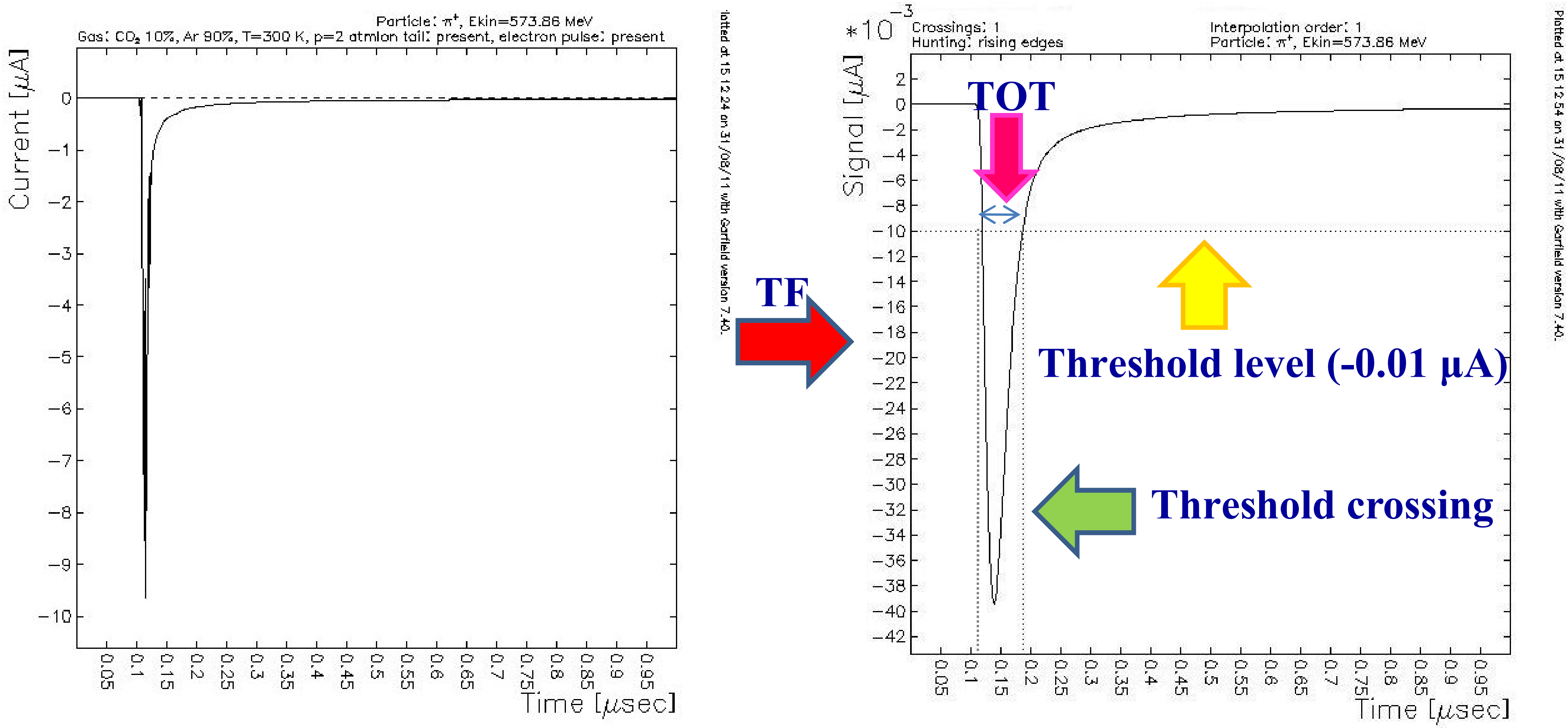
Signal for 0.7 GeV/c pions

- Near to the detector wire



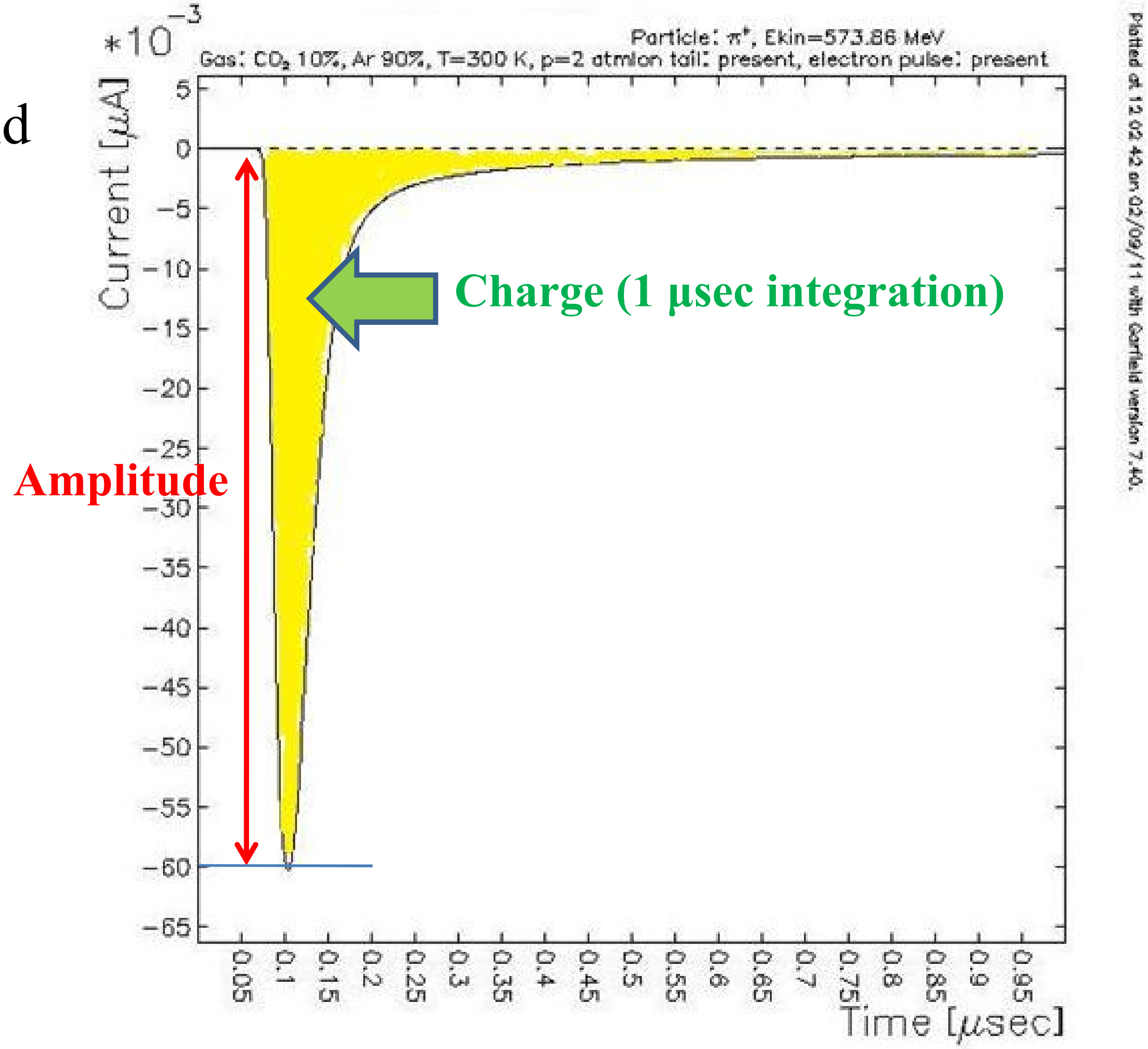
Signal for 0.7 GeV/c pions

- Far from the detector wire



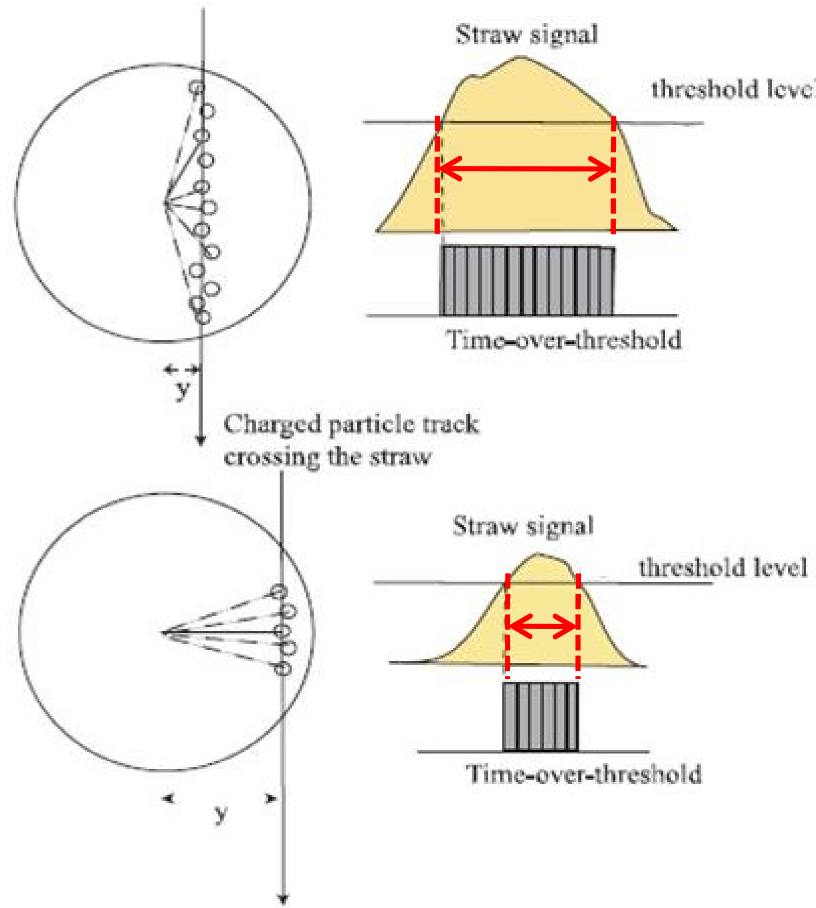
Particle Identification Methods

- Time Over Threshold
- Amplitude
- Charge



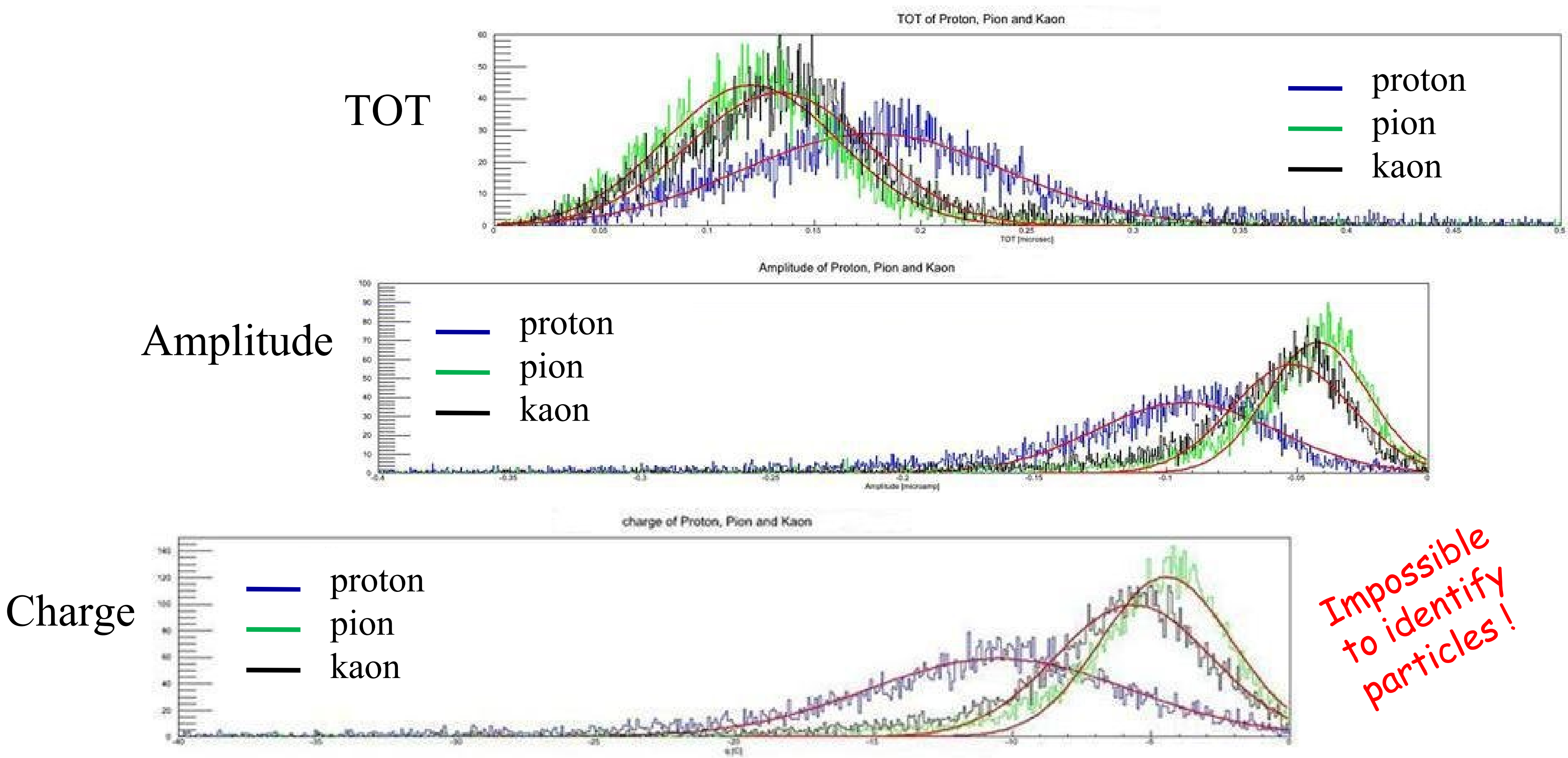
Time Over Threshold

- TOT: the width of signal at the threshold level
- Time over threshold depends on
  - particle's energy loss
  - track distance to wire
- Have to be corrected for distance



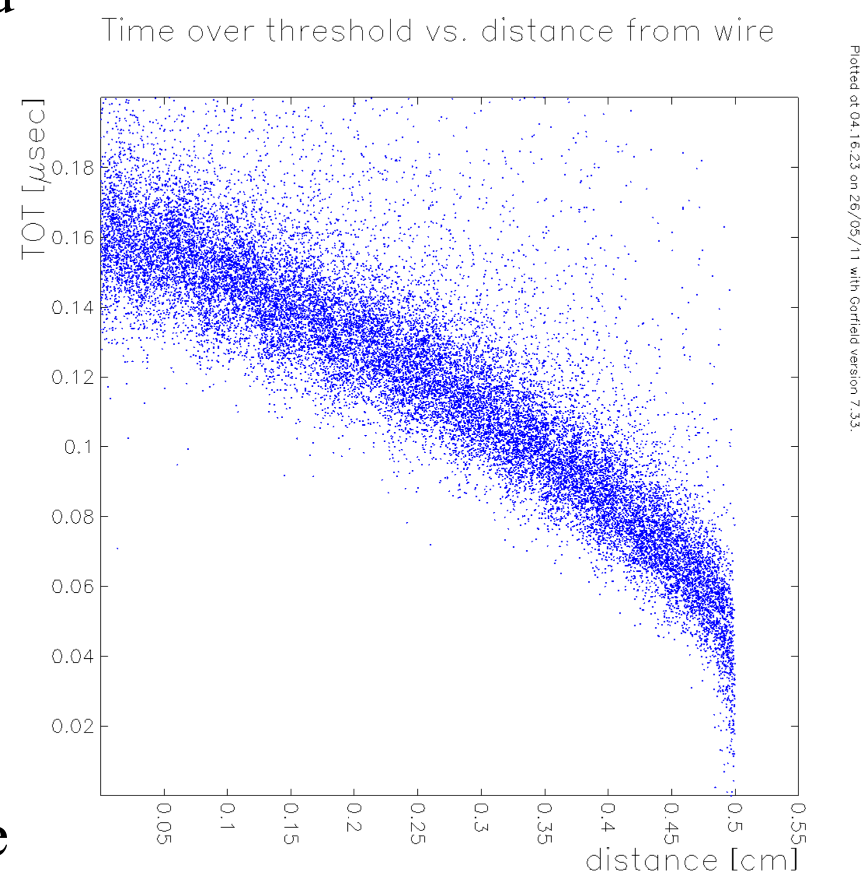
Straw Response Before Distance Correction

0.7 GeV/c protons, pions and kaons



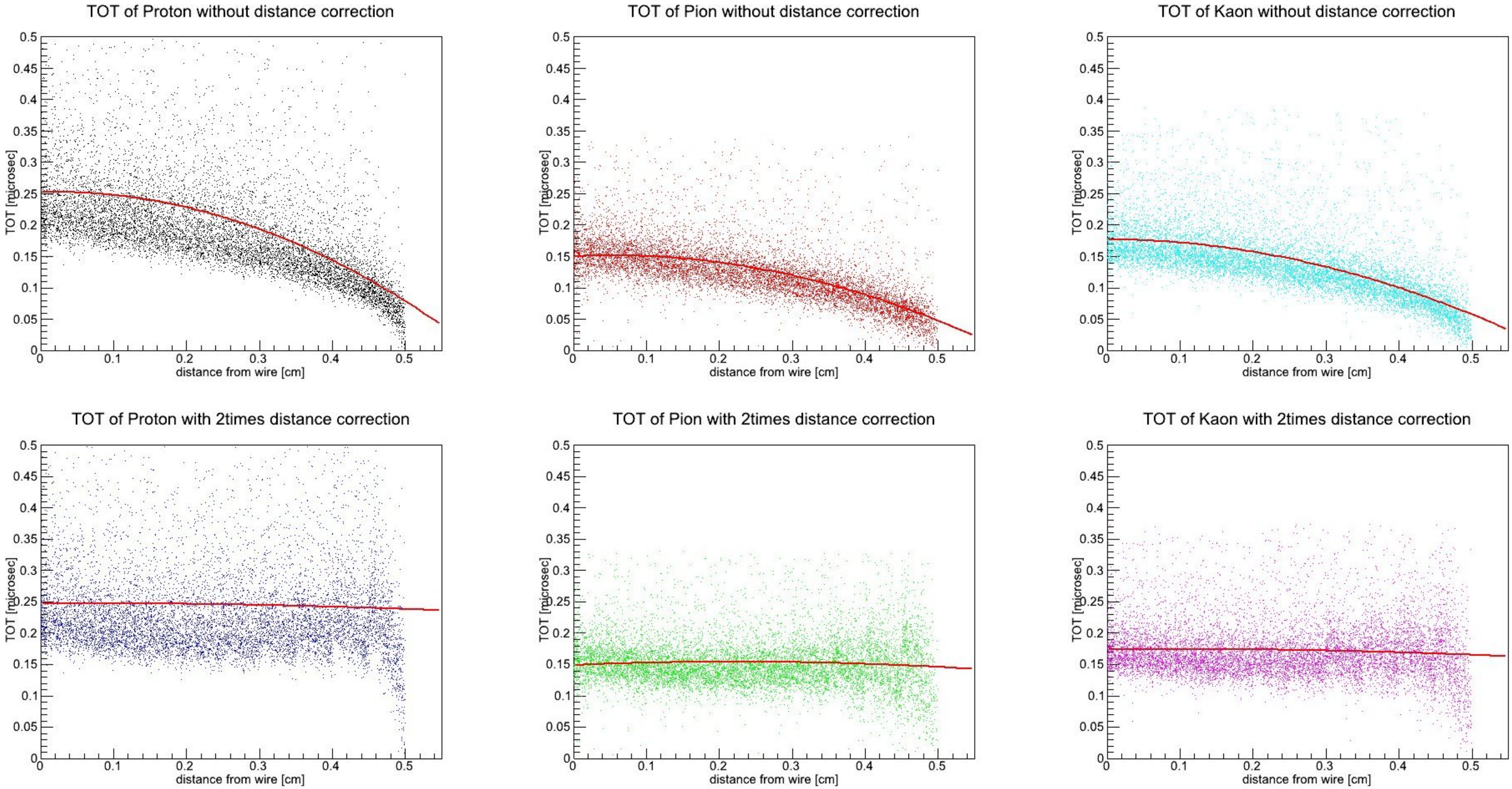
Distance Correction

- Parameterization done for proton, pion and kaon for momentum range 0.3 to 1 GeV/c
- Straw radius divided into 0.5 mm bins
- Average in first bin
- Removing data greater than 2*average for best fitting parameterization
- 2nd order polynomial fit
- Correction factor =yfit(0)/yfit(i) for each bins
- Corrected y(x)=y(x)*correction value
- This corrected y(x) dose not depend on the distance form wire



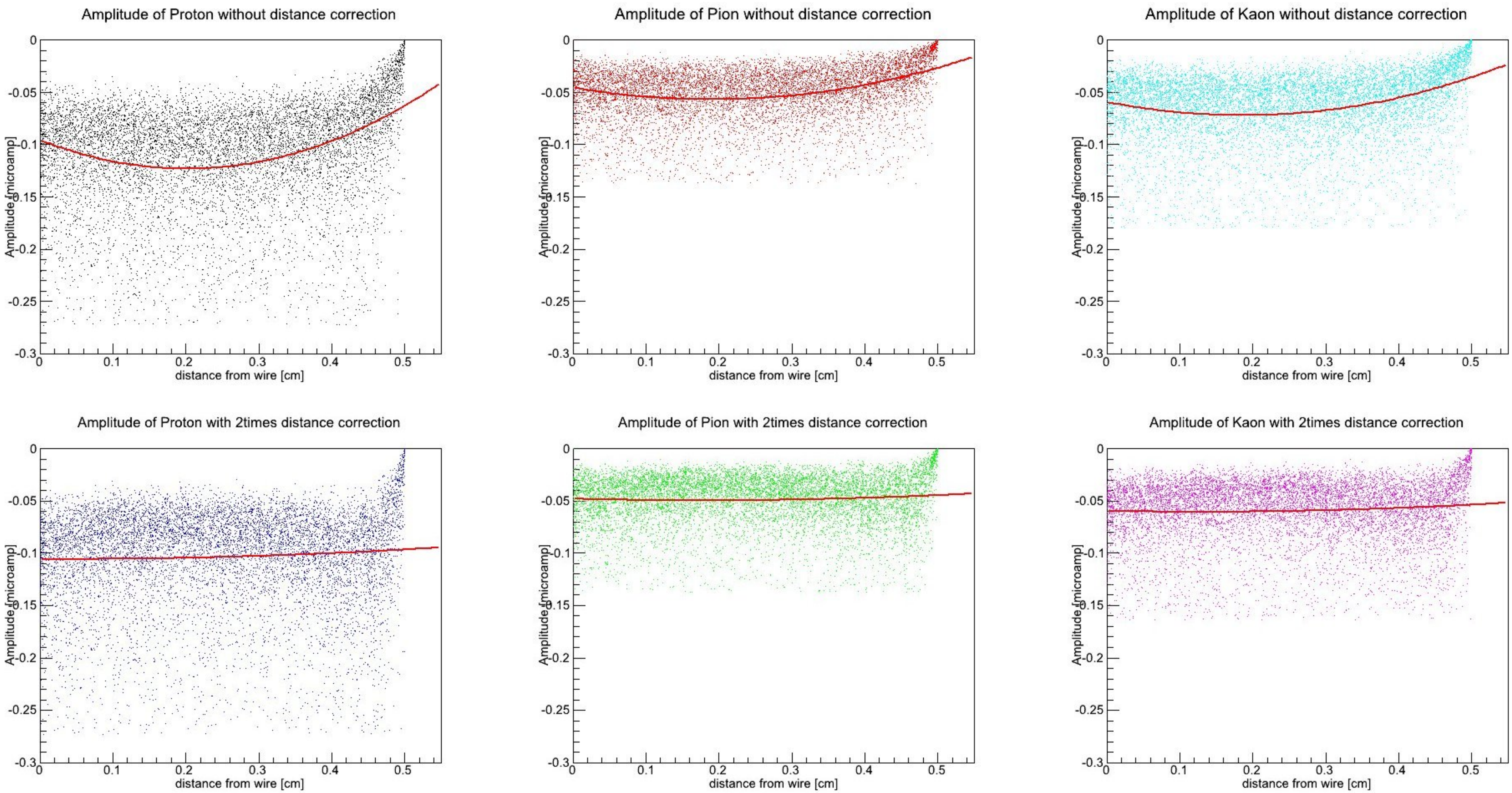
Distance Corrected Data of TOT

0.7 GeV/c proton, pion and kaon



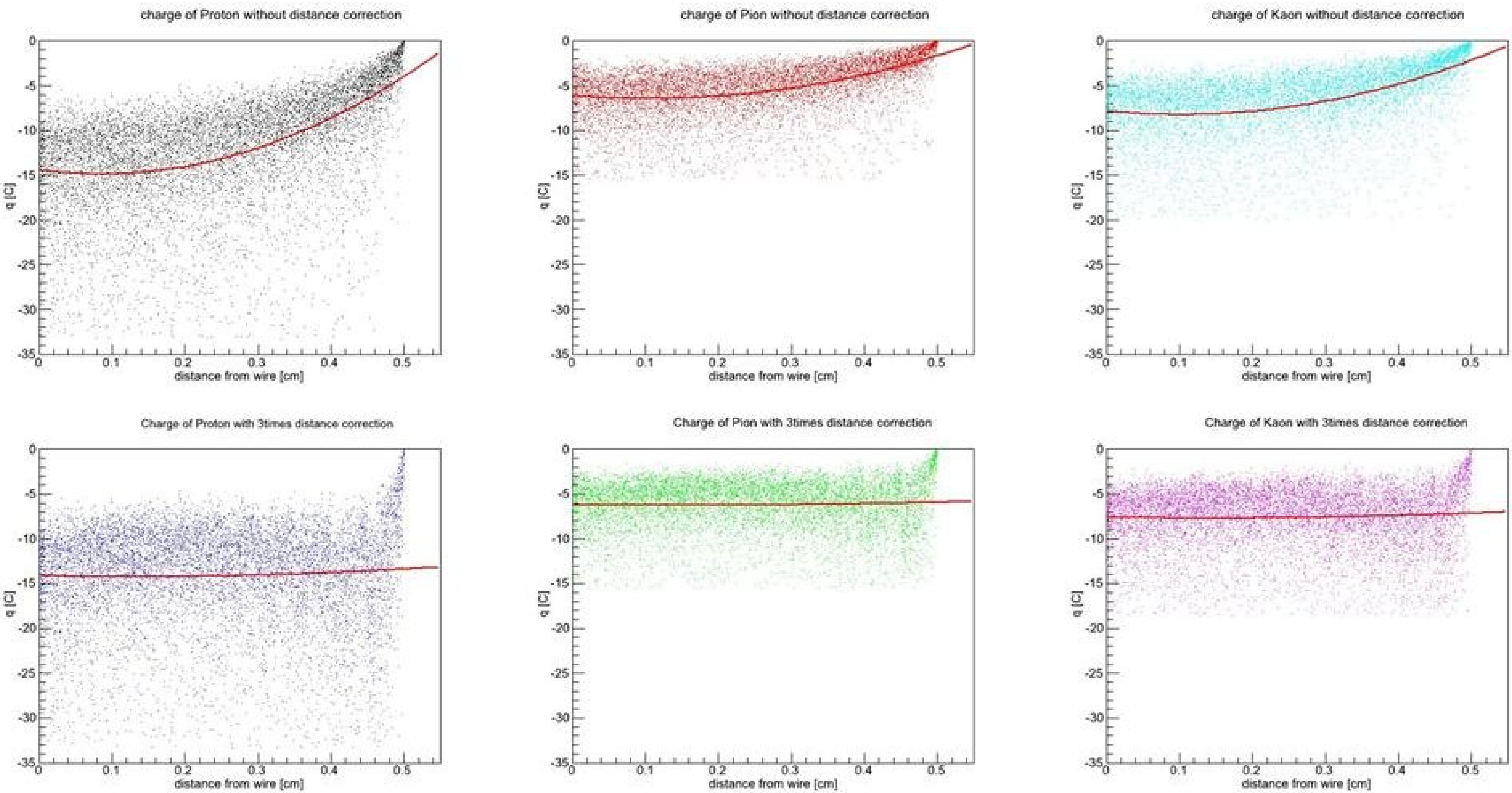
Distance Corrected Data of Amplitude

0.7 GeV/c proton, pion and kaon



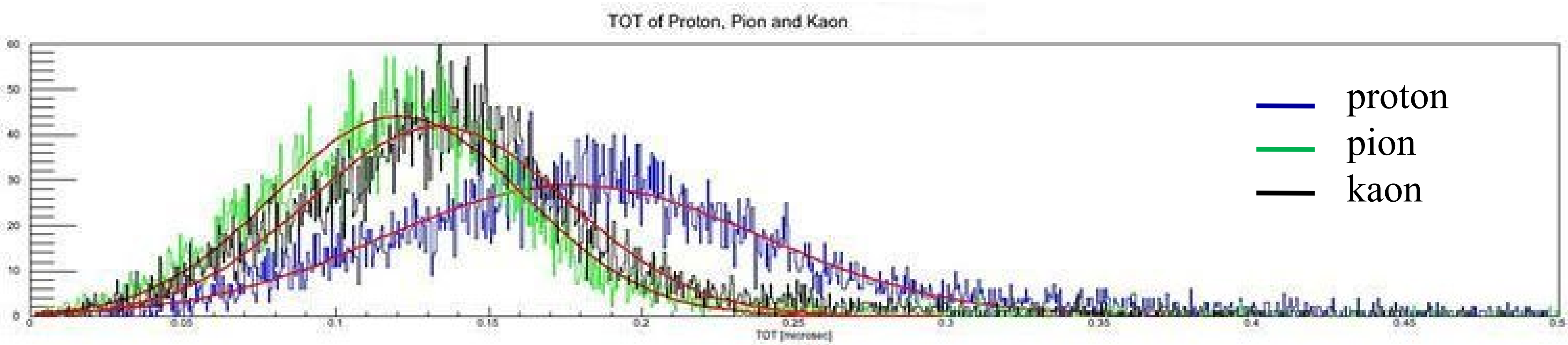
Distance Corrected Data of Charge

0.7 GeV/c proton, pion and kaon

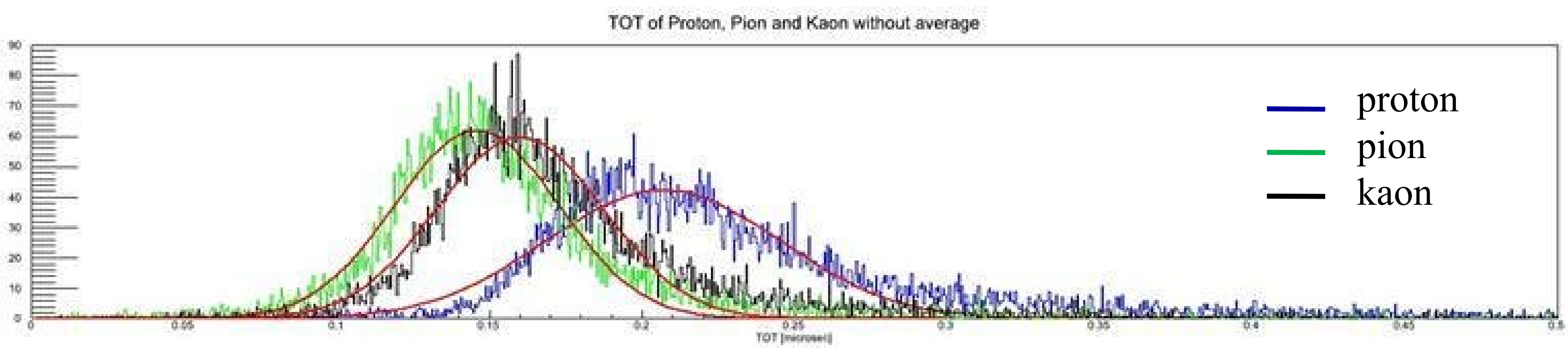


Distance Correction to TOT

- Before

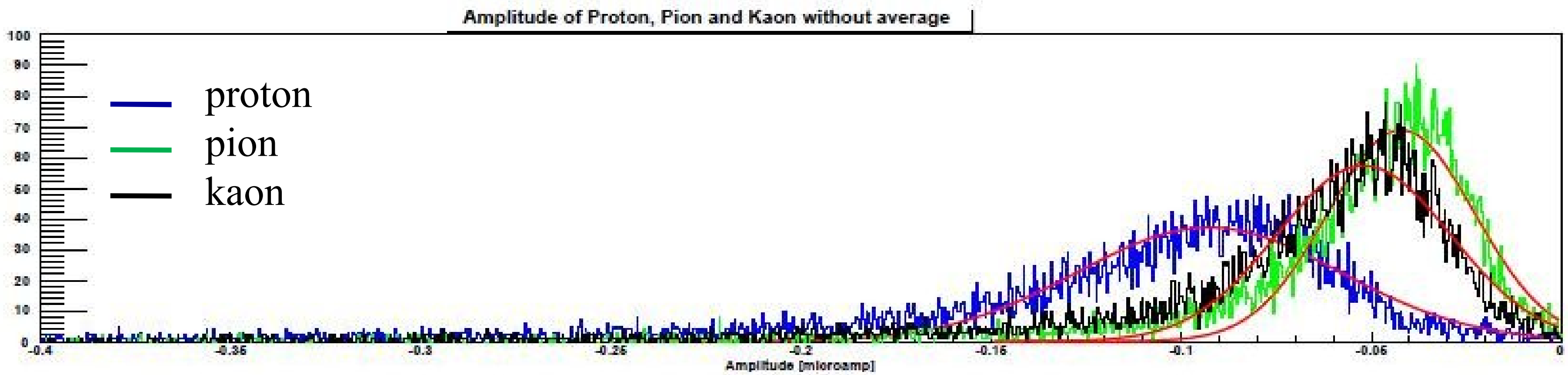


- After

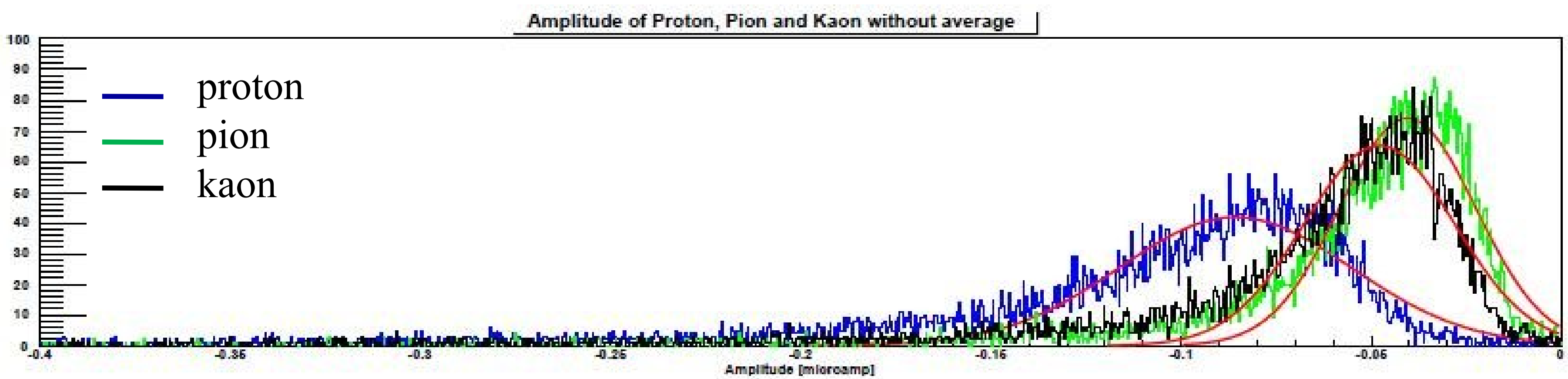


Distance Correction to Amplitude

- Before

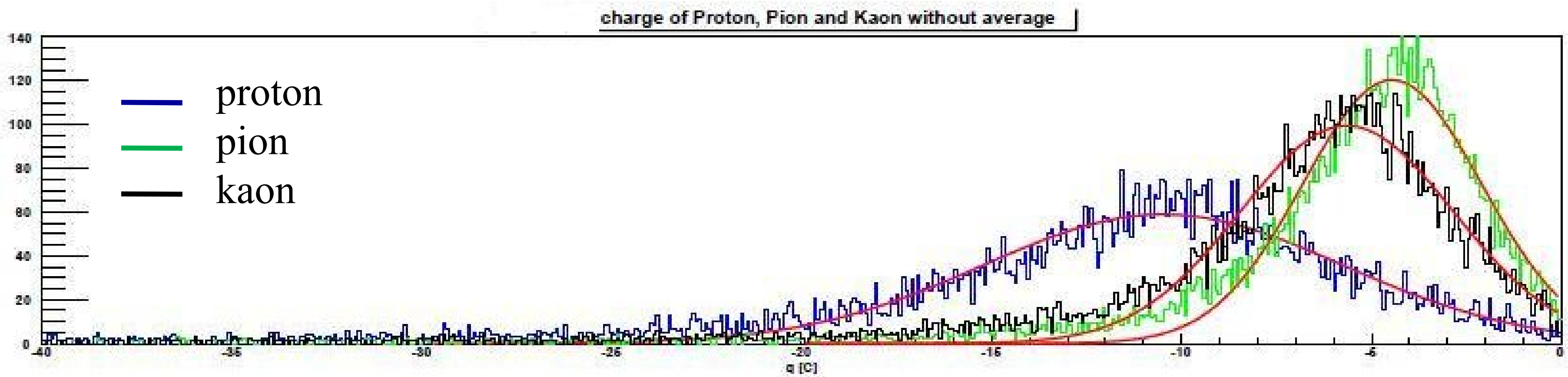


- After

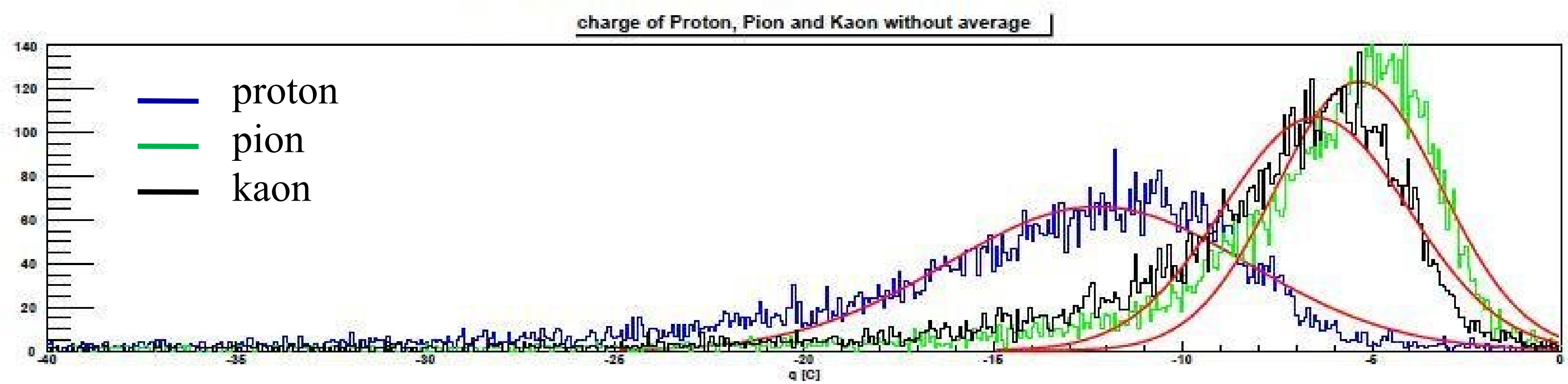


Distance Correction to Charge

- Before



- After



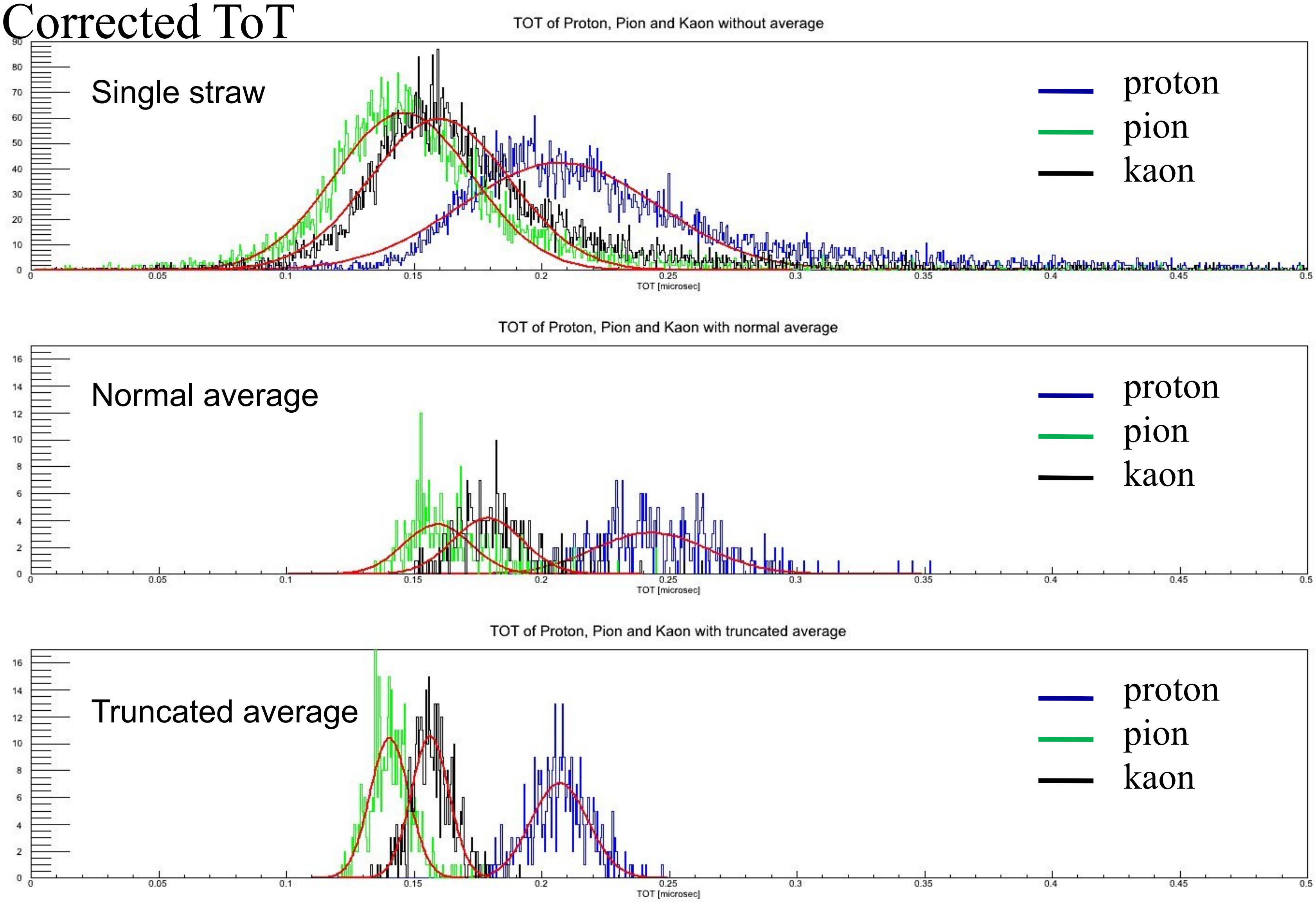
Truncated Average Correction

- Response of 24 single straws to each track
- Distance of each track to wire simulated by uniform random distribution
- Normal Average for 24 straw layers
- Truncated Average for 24 straw layers by removing about 20% of the highest numbers

Results

0.7 GeV/c proton, pion and kaon

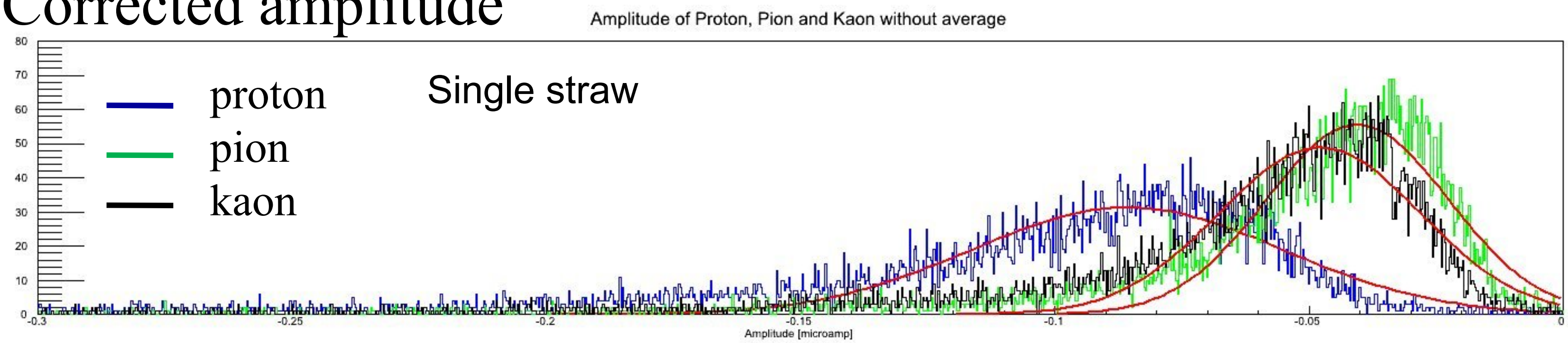
- Corrected ToT

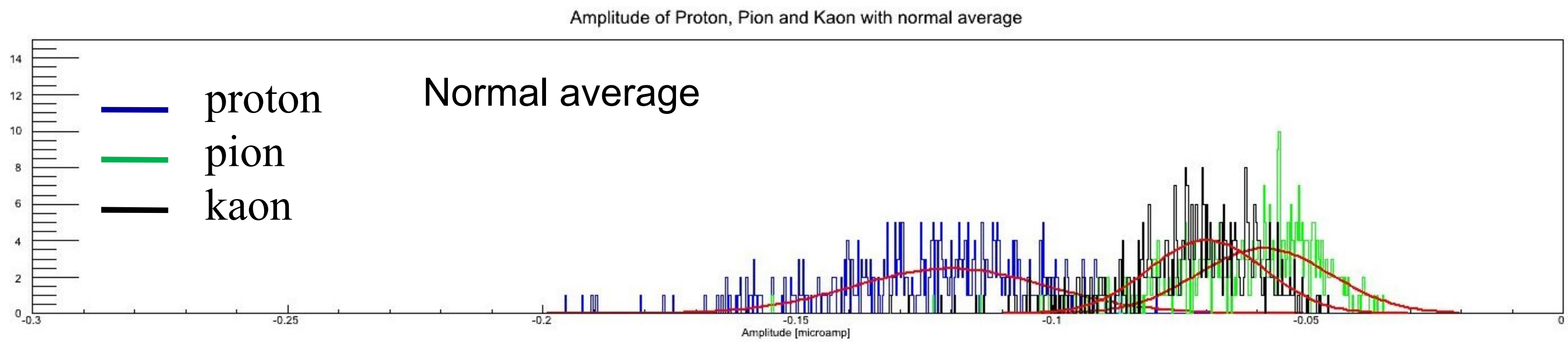


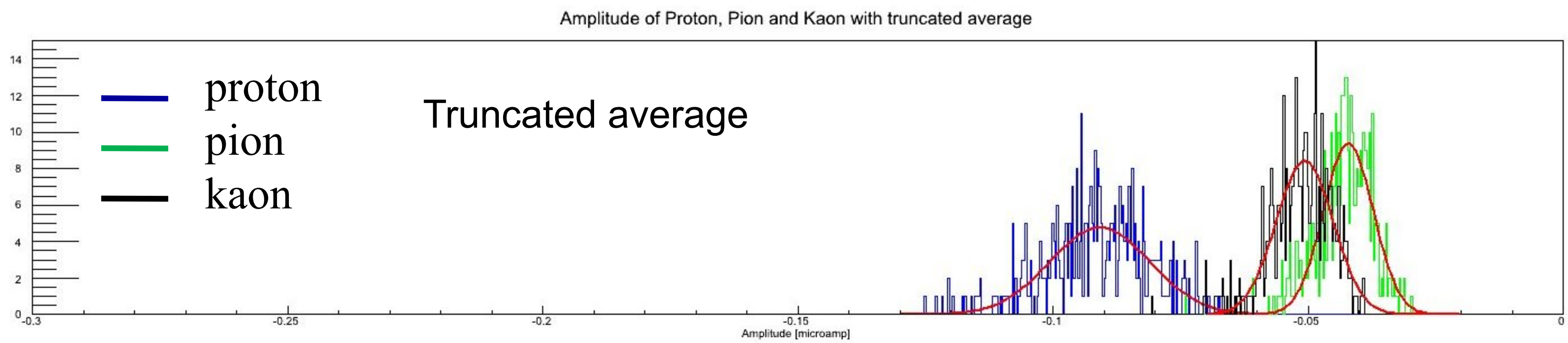
Results

0.7 GeV/c proton, pion and kaon

- Corrected amplitude



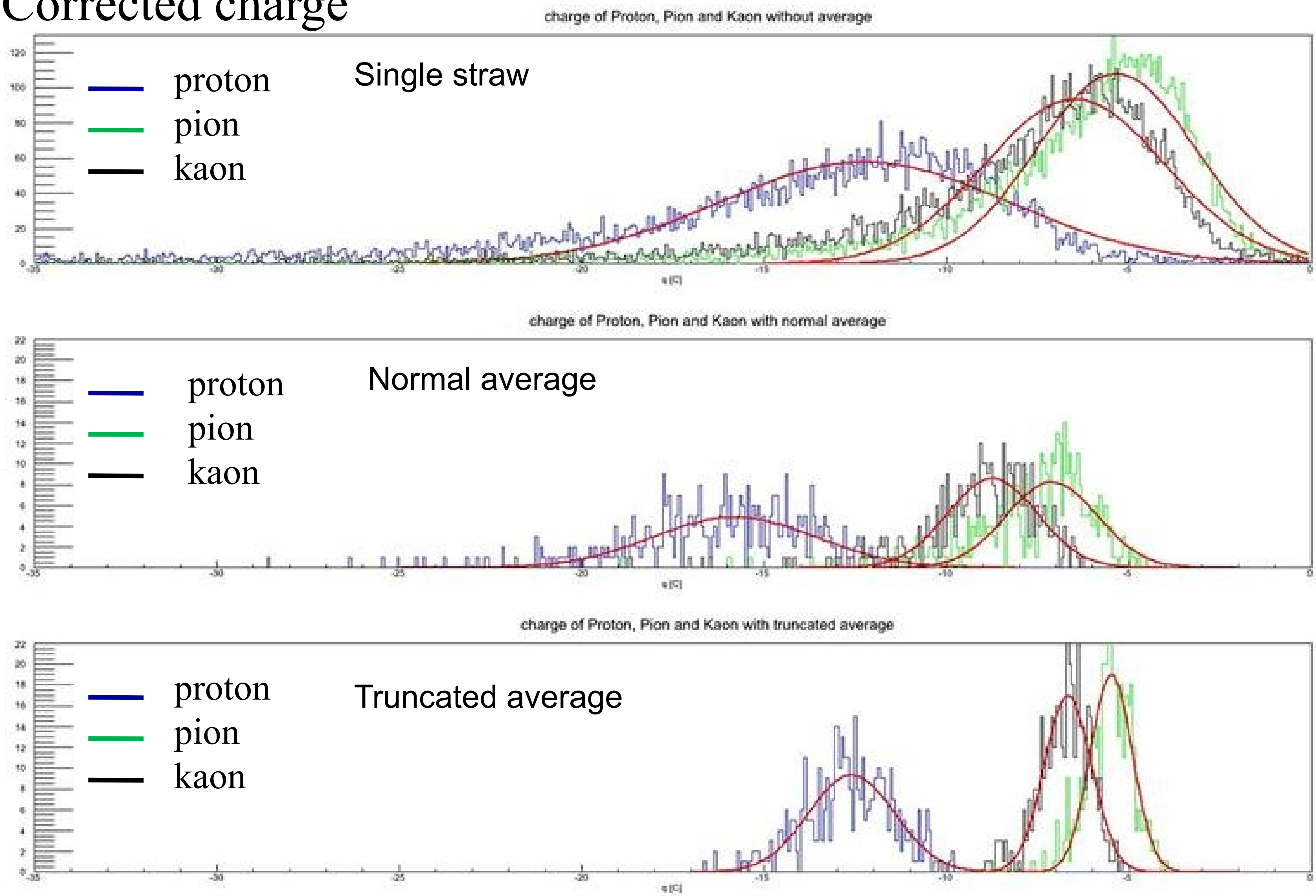




Results

0.7 GeV/c proton, pion and kaon

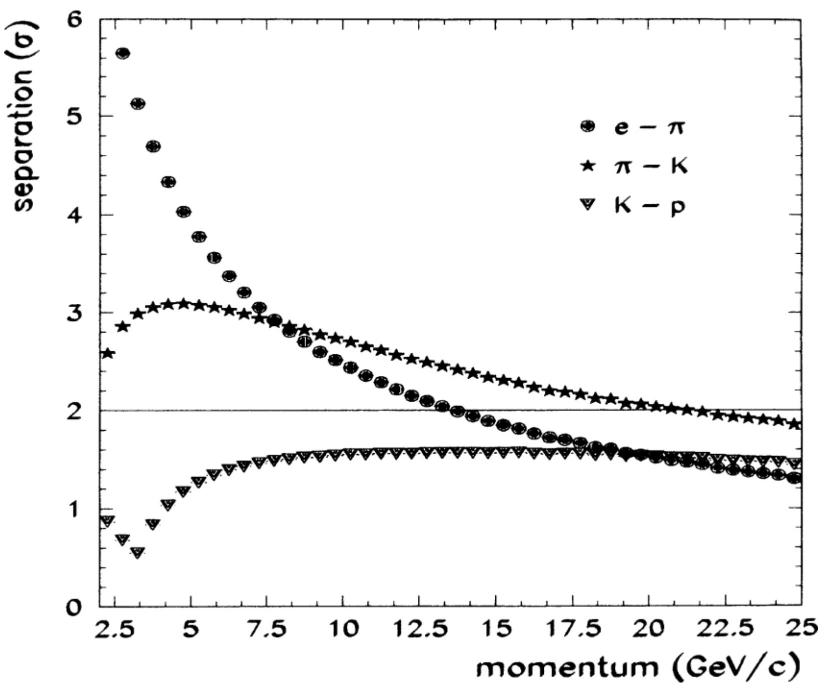
- Corrected charge



Separation Power

- The general way to quantify the separation power between particles A and B is to consider the difference in energy loss compared to standard deviation.

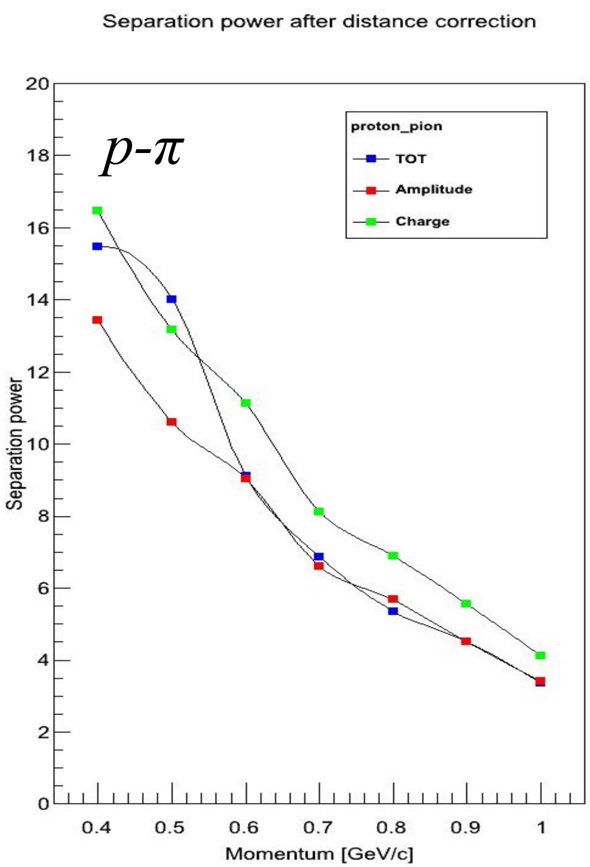
$$N\sigma_{A,B} = \frac{\left| < dE/dx >_A - < dE/dx >_B \right|}{(\sigma_A + \sigma_B)/2}$$

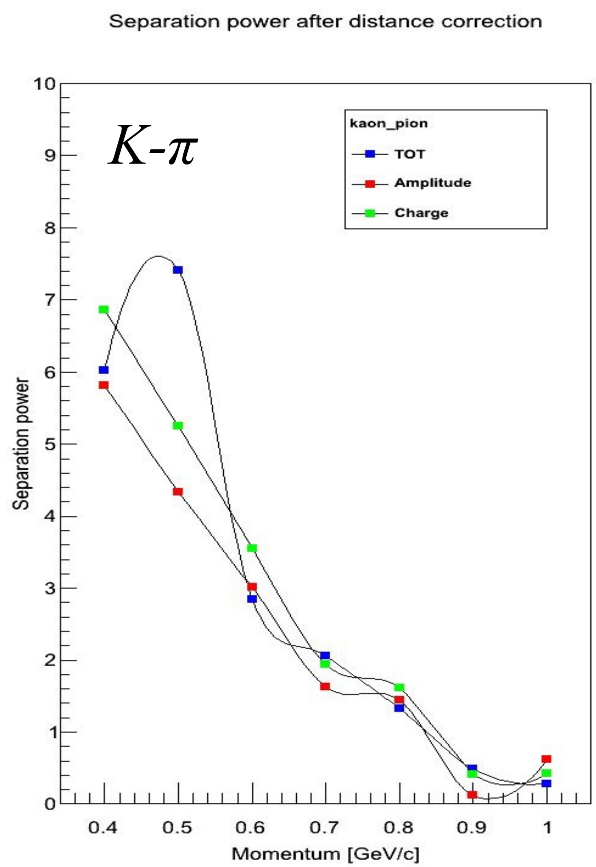


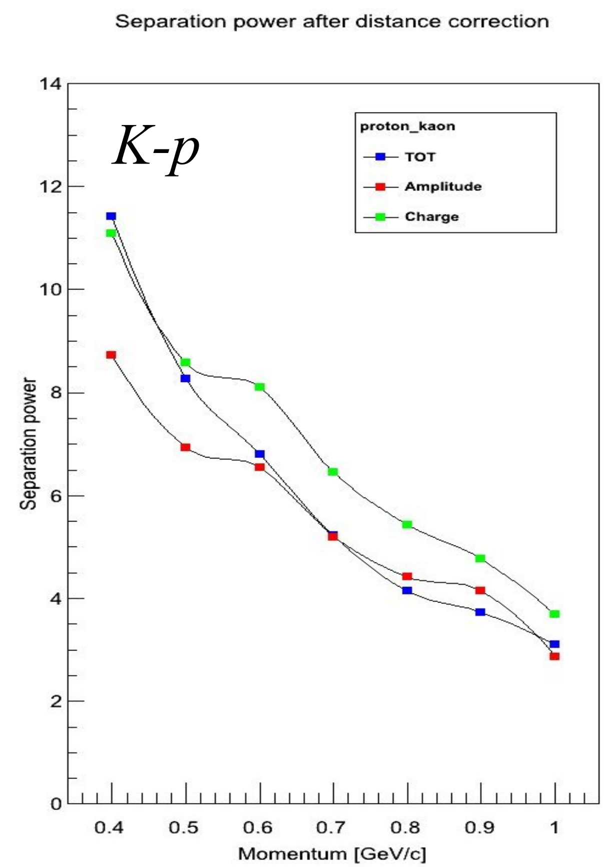
Particle detection with drift chambers, Blum W. et al. (2008) p.366

Typical examples of separation power as a function of momentum

Separation Powers Comparison







Results show:

- TOT method shows similar separation power as the amplitude

Conclusions

- Distance correction improves resolution
- TOT method shows similar separation power as the amplitude

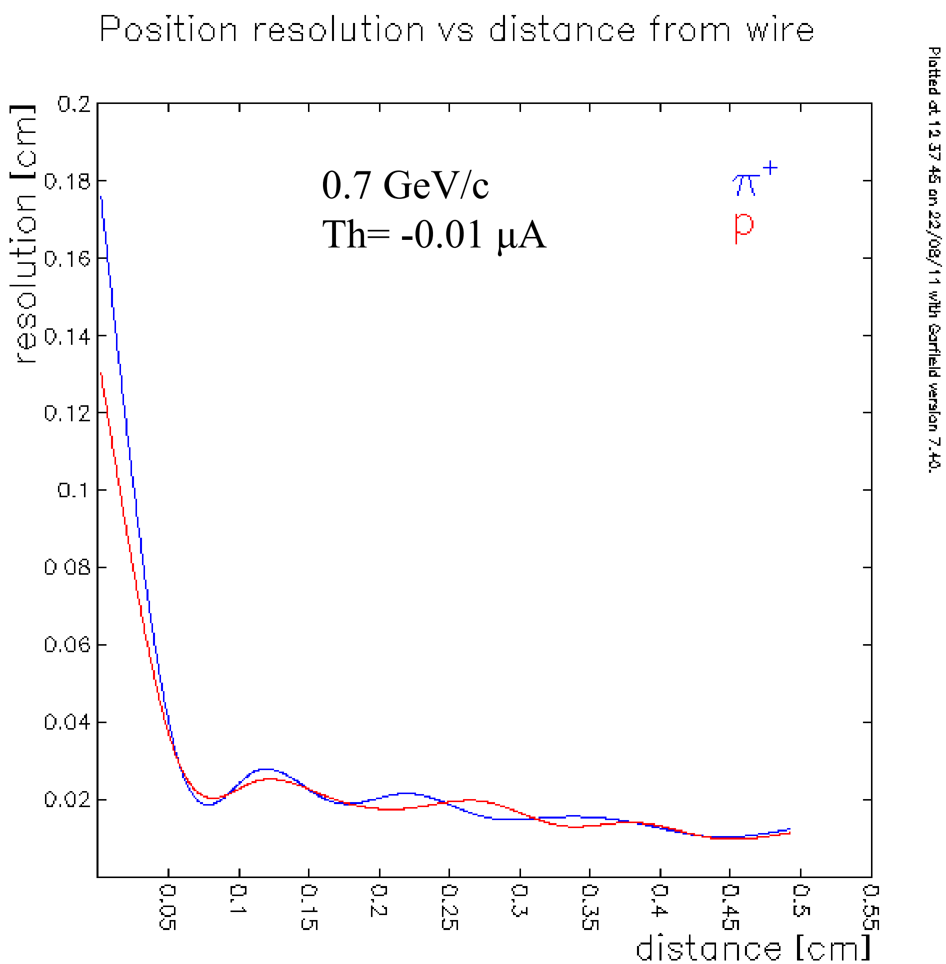
Following Works

- Calculation of gas gain by the new version of Magboltz 8.9
- Adding tail cancelation transfer function
- Adding noise function
- Compare the simulation with experiment

Thanks For Attention!

Position Resolution

- Position resolution
- Signals for distances from 0.002-0.49cm in steps of 0.5mm were created
- Sending them through the electronics
- The threshold crossing time was histogramed
- Fitted with a Gaussian function
- Position resolution=sigma of time distribution * drift velocity



Energy Loss dE/dx in Straw