TPC Status

Outlook

- Simulation updates
- Reconstruction
- Calibration
- Quality assurance

Simulation

- Bug fix – mismatch between ideal geometry in the TgeoManager and AliTPCParam
  - Z offset
- Simulation of the Krypton source
- The application of calibration coefficients
  - Time 0 offsets, V drift, ExB in drift region, not yet used in the simulation
  - The situation not so straightforward than in the reconstruction
    - The sequence – Effect ->Random process ->Effect random process ->Effect
  - To be committed after the verification of the full chain (Overdue task currently)

Gain calibration using Krypton

- Simulation of the krypton source (Marek Kowalski)
- Some problems in (3D) Cluster finder to be solved
  - The peaks not yet well visible (Unclear, either simulation || && reconstruction problems)
- Difference between Alice TPC and NA49 TPC
  - Shorter pads 1cm (Alice)– 4cm (NA49)
  - Wider pads 0.6 cm
  - Bigger influence of threshold effect

Reconstruction - Update

- Adding additional (slower – n^2 loop) function to remove the splitted tracks
  - In addition to the fast, not so performant n loop method
- Possibility to disable cluster sharing
  - Highly not recommended, implemented only because somebody requested it
  - Possibility to switch in on-off in the AliTPCRecoParam
- Bug fix – Problem with one high pt track reconstruction

Reconstruction - Update

- Investigated possibility to remove curling tracks
  - In high flux environment problems with signal (curling tracks) to background ratio
  - The CPU time too big in comparison with ESD size factor (~10 % of the tracks)
  - Code anyway kept in the AliTPCtrackerMI
- Possibility to use cluster shape as the criteria to remove overlapped events
  - Using the mean cluster shape the z coordinate of the track can be estimated (from diffusion coefficient) with precision on the level of 40 cm
  - The precision is dominated by angular effect
  - Still space for improvement – e.g better treatment of angular effect, usage of the calibrated shape parameterization instead of the analytical formula (+-5 % systematic error)

Calibration tasks:

1. Pedestal and noise calibration.
    a. Pedestal per time bin and pad
    b. Pedestal per pad

   Electronic calibration
    c. Electronics gain calibration (pulser)
    d. Time 0 calibration - Electronic calibration (pulser/data)
    e. Time response function width (pulser/data)
2. Gain calibration
    a. Krypton gain calibration
    b. Gain calibration using cosmic (parameterization)
    c. Gain calibration using laser – central electrode plane (pad –by-pad fluctuation)
    d. Attenuation loss (cosmic)
3. Drift velocity calibration. –in relation with 3 c
    a. Laser system – tracks +CE signals (local drift velocity parameterization)
4. DCS values in OCDB.
    a. Corrections(p, T)
    b. Goofy (drift velocity, attenuation loss)
    c. Temperature map.
5. Space point resolution parameterization and cluster shape parameterization
6. Space point correction
    a. E distortions (laser) algorithm to be defined.
    b. ExB (B map + laser) algorithm to be defined.
    c. Drift velocity map – parameterization algorithm to be defined.
7. Data quality monitoring based on calibration parameters –strongly related with points (1-6)
    a. Noise calibration – Detection of outliers (alarms), FFT spectra for outliers
    b. Electronic gain calibration – Detection of outliers (alarms)
    c. Time 0 calibration - Detection of outliers (alarms)
    d. Gain calibration using cosmic – Detection of outliers (alarms)
    e. Space point resolution parameterization and cluster shape parameterization – Pulls for sectors, pad-rows, detection of outliers (alarms)
8. Central electrode plane (Unisochronity correction)
9. Ion tail characteristics and optimization of filter parameters (laser, cosmic)
10. Alignment

AliTPCcalibTracks analysis

- Input for the analysis are `AliTPCseed` and `AliESDtrack` for a given track
  - **`Process`**`(seed, track)` function applies the cuts and calls following analysis functions:
    - **`FillResolutionHistoLocal`**`(seed)`
      - » Tracks are refitted cluster by cluster and resolution histograms are filled (see following slides)
    - **`AlignUpDown`**`(seed, esdTrack)`
      - » For alignment calibration, not discussed in this presentation

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AliTPCcalibTracks analysis

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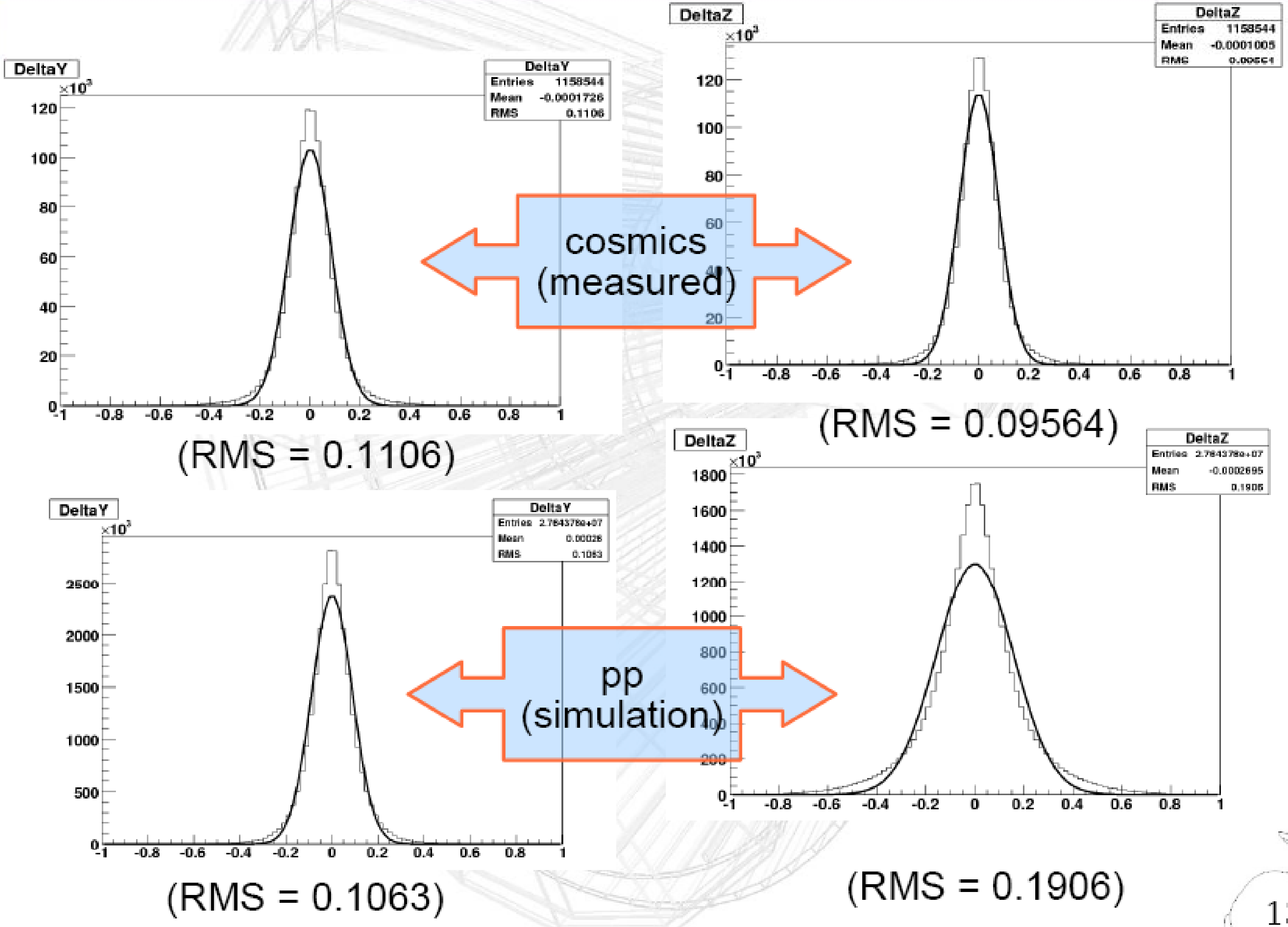
FillResolutionHistoLocal(seed):

- The tracklet is also fitted with a polynomial 2nd order in Y and Z direction
  - The difference between cluster and polynomial is stored as *delta* (σ) in one of the resolution histograms
  - Results of this analysis will be shown later on

σ Histograms



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Error parametrization

- The error can be parametrized like

$$\sigma^2_{COG} = p_0^2 + p_1^2 \cdot \frac{L_{Drift}}{A_{charge}} + p_2^2 \cdot \frac{\tan^2 \alpha}{A_{charge}}$$

  - Three fit parameters:
    - p_0: Noise offset
    - p_1: Diffusion and gain fluctuation
    - p_2: Secondary ionization fluctuation
  - Variables:
    - L_{drift}: Drift length (from cluster to pad plane)
    - A_{charge}: Charge in one cluster
    - α: Angle between track and CE for time direction (Z), angle between track and pad row for pad direction (Y)

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Error parametrization

$$\sigma^2_{COG} = p_0^2 + p_1^2 \cdot \frac{L_{Drift}}{A_{charge}} + p_2^2 \cdot \frac{\tan^2 \alpha}{A_{charge}}$$

- Behavior:

Given variables	Error (σ) proportional to
charge A_{charge}, angle α	$\sqrt{L_{Drift}}$
charge A_{charge}, drift length L_{Drift}	tan α
drift length L_{Drift}, angle α	$1/\sqrt{A_{charge}}$

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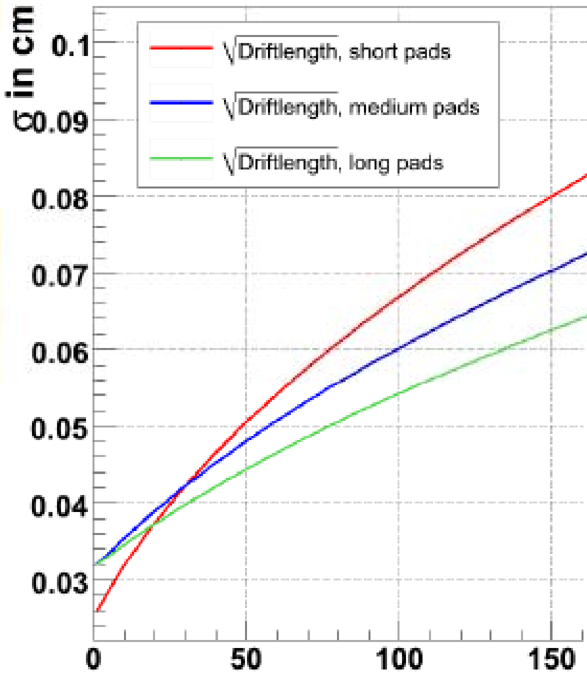
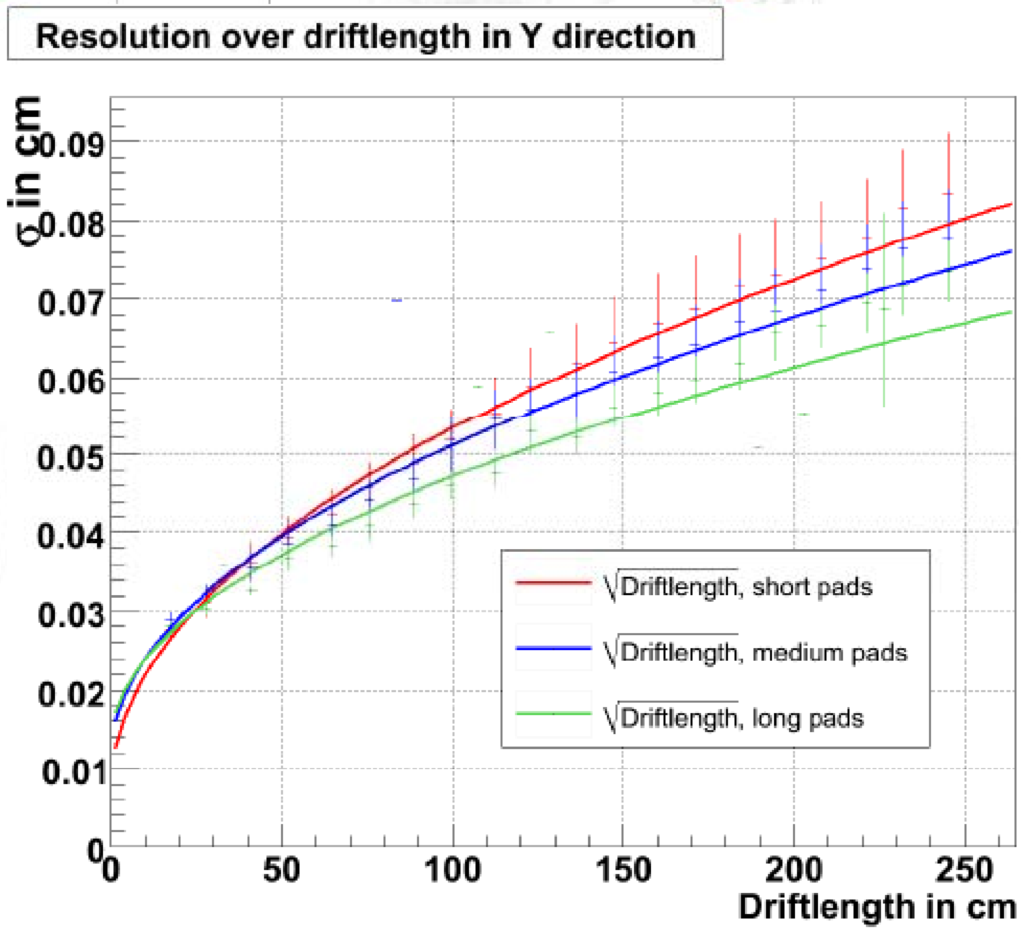
σ vs. Driftlength



parametrization (theory)

measurement (pp)



(|AngleM|<0.04 && QMean>0)

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σ vs. deposited charge

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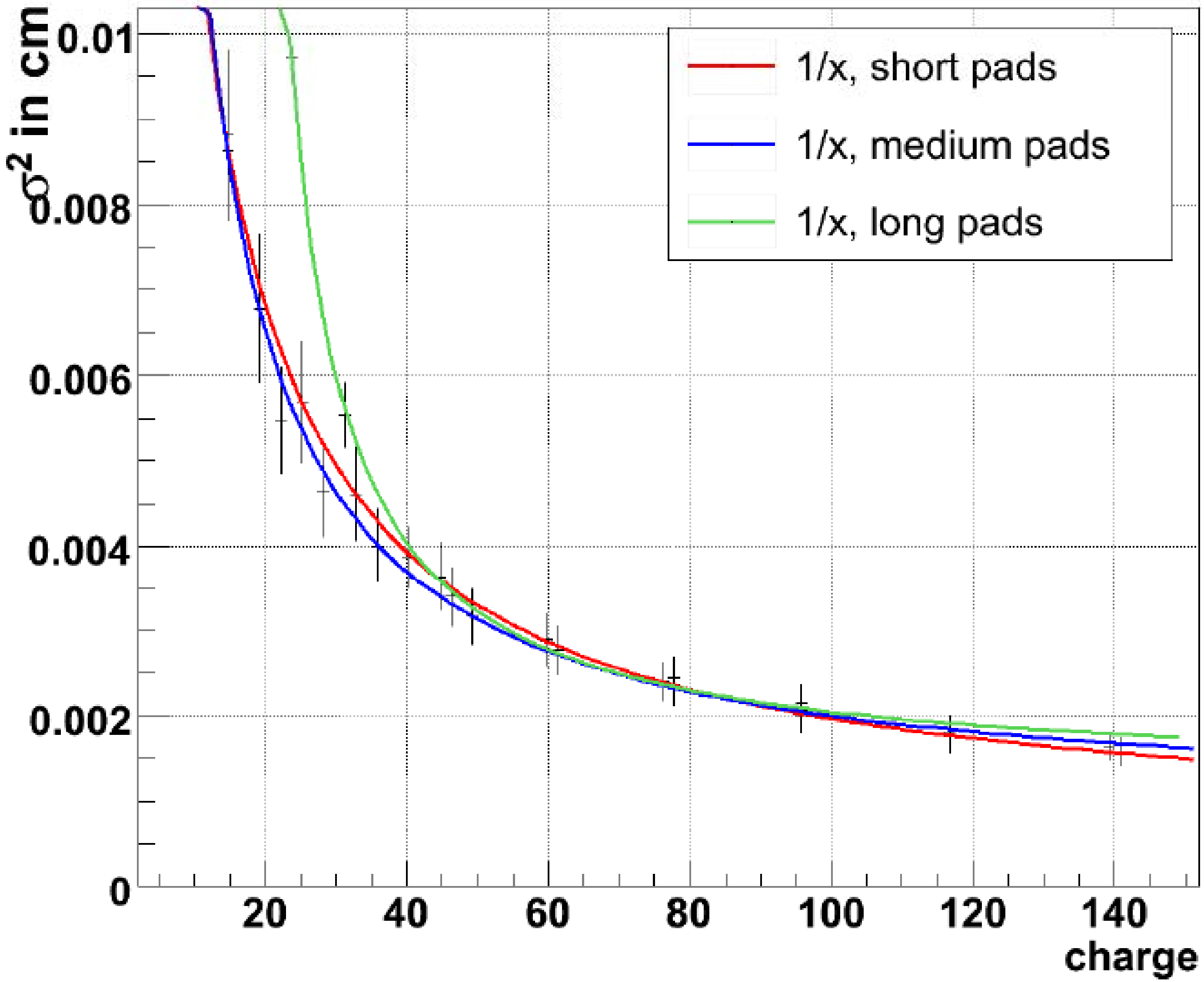
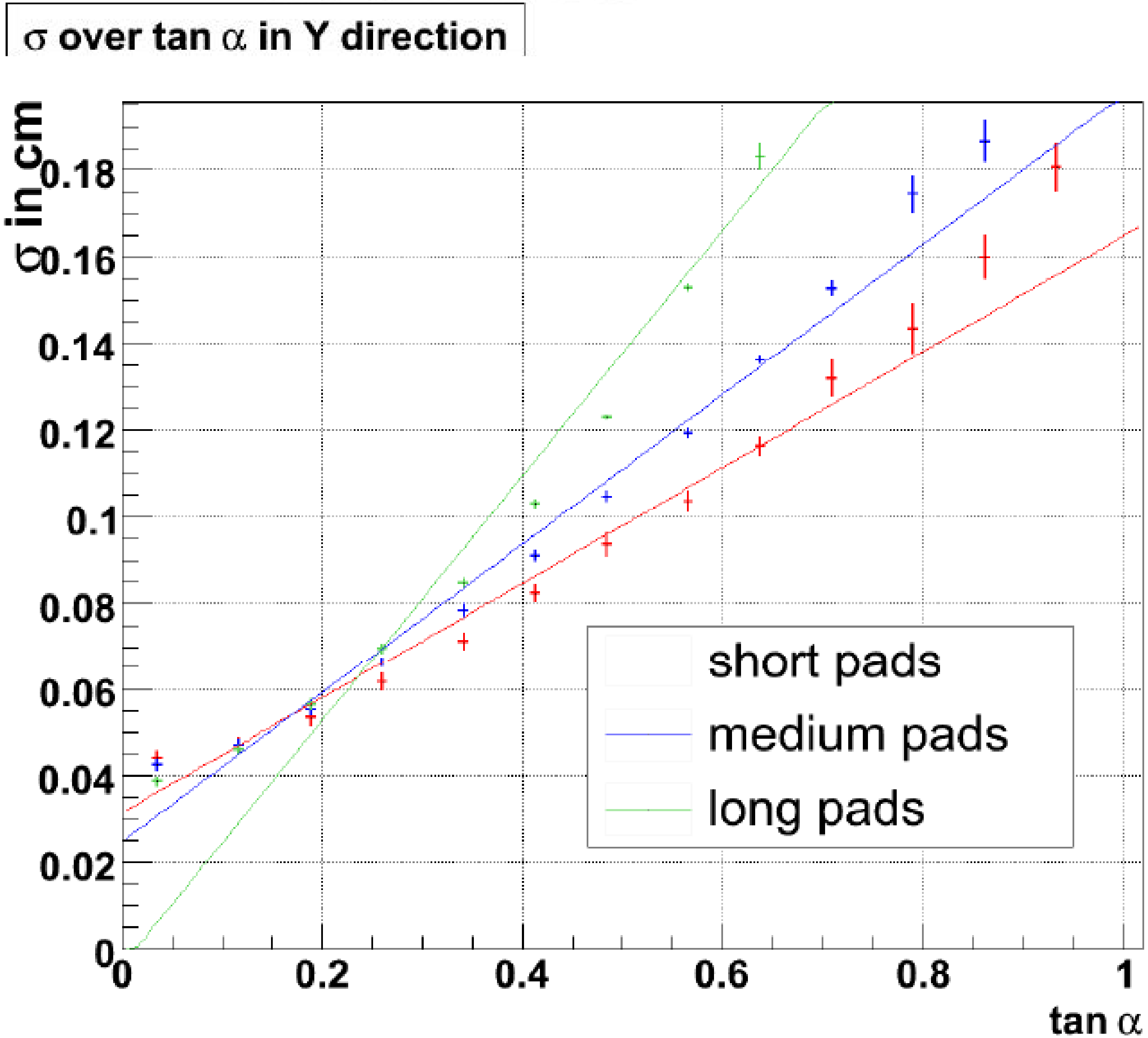
σ² over charge in Y direction



(|AngleC|;0.1 && QMean>0)

σ vs. tan α



(|Qmean|<0 && AngleC>1 && Zm>50 && Zm<80)

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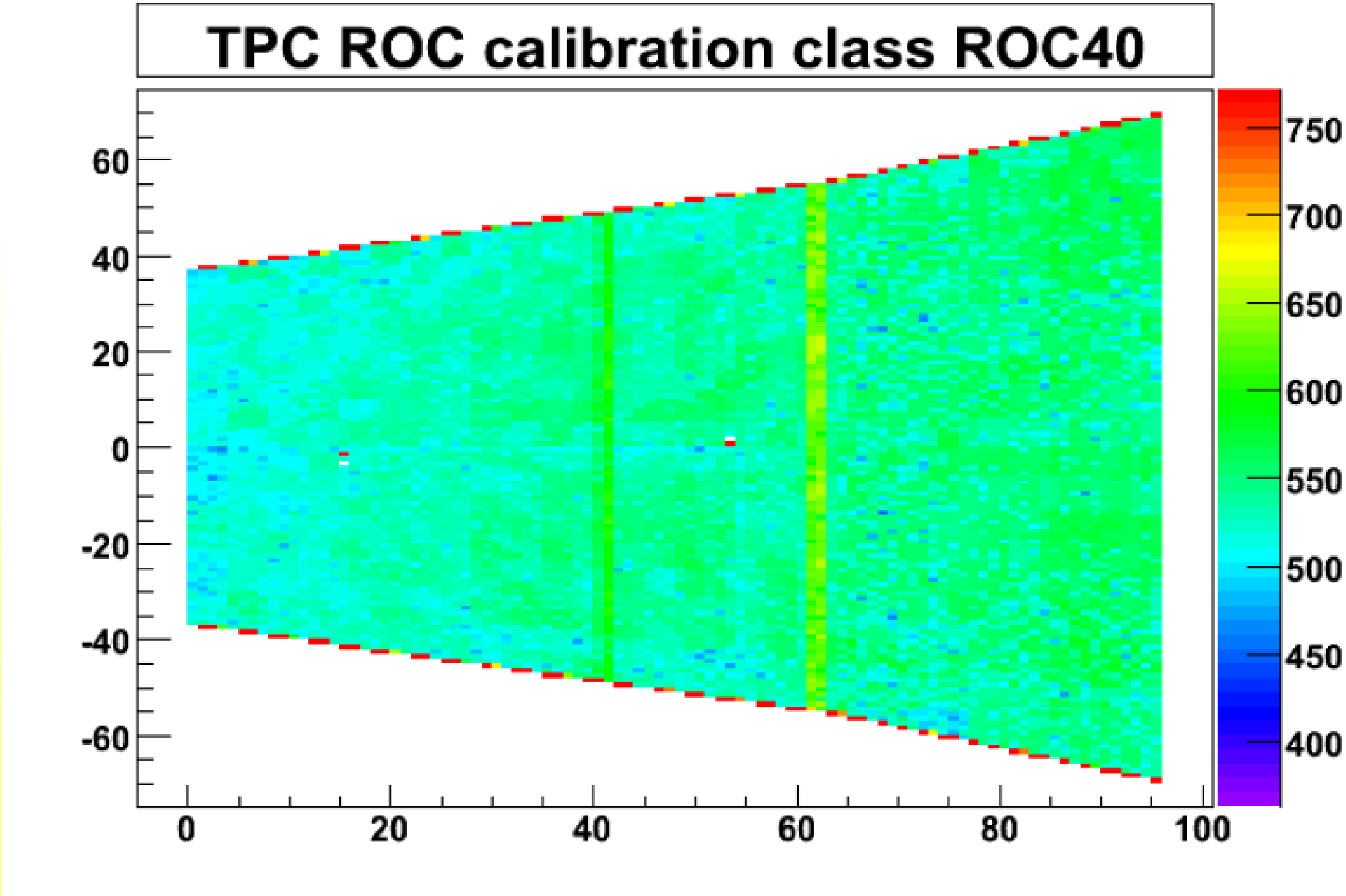
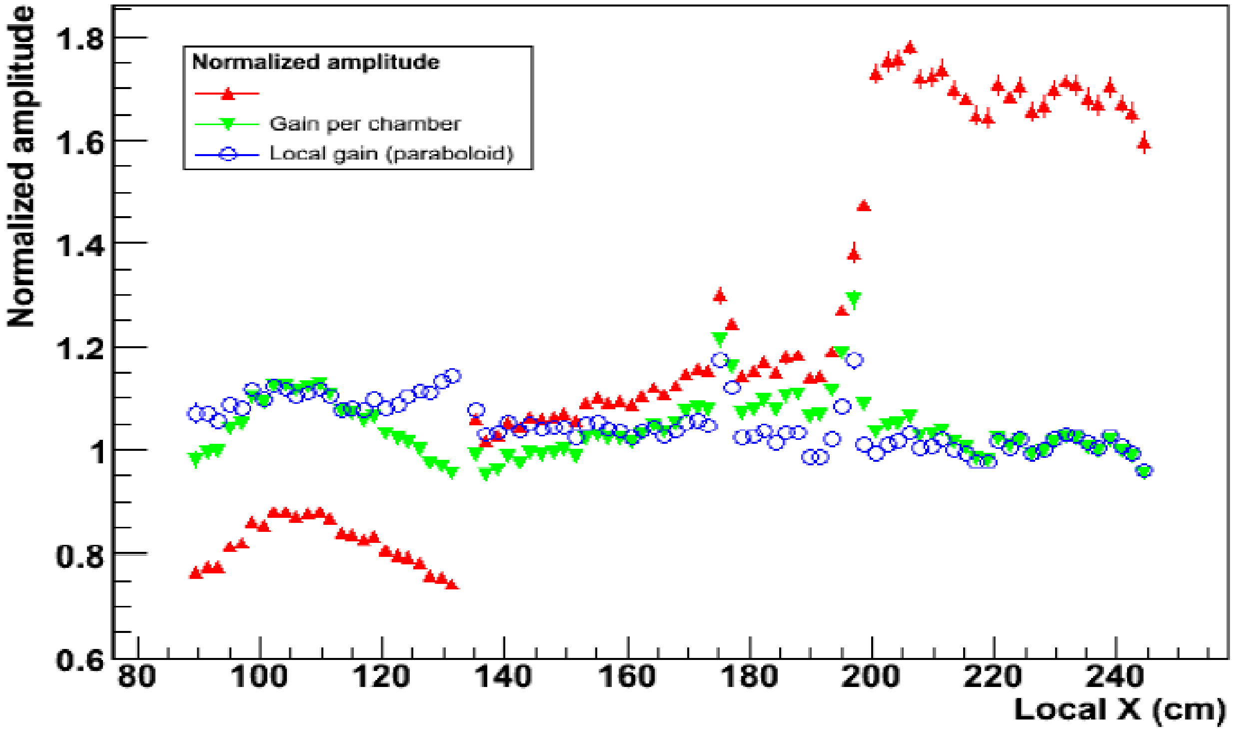
Gain Calibration

Gain calibration strategy

- Use three components for the gain - dE/dx calibration
  - Calibration Pulser measurements (effect from electronics, pad sizes)
    - no smooth variations
    - manufacturing tolerances of the chips
    - calibration channel by channel
  - Cosmic measurements
    - smooth variations within one sector
    - remove outliers
  - cross-check and improve using krypton calibration
  - V0s
    - use gamma conversions to identify e+ and e-
    - use K^0 to identify π+ and π-
    - -> determine dE/dx calibration factors for all sectors


TPC ROC calibration class ROC40
60
40
20
0
-20
-40
-60
0
20
40
60
80
100
750
700
650
600
550
500
450
400



- Essential to make a good outlier map
  - High noise channels
  - floating wire channels
  - dead channels

dE/dx calibration using V^0 decays

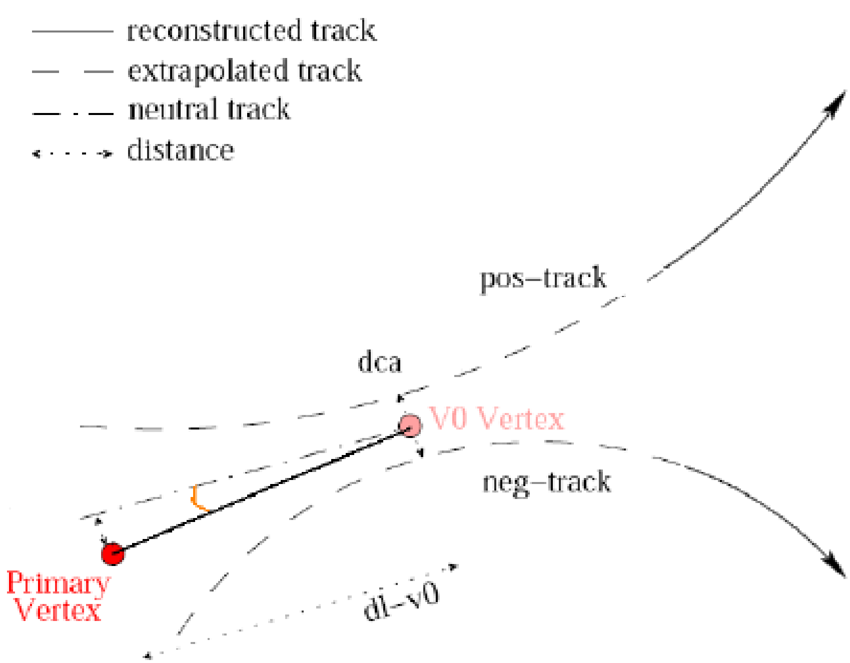
the basic idea

We want to obtain a pure sample of pions, electrons and protons via the decays

$$K_s^0 \rightarrow \pi^+ \pi^-$$

$$\gamma \rightarrow e^+ e^-$$

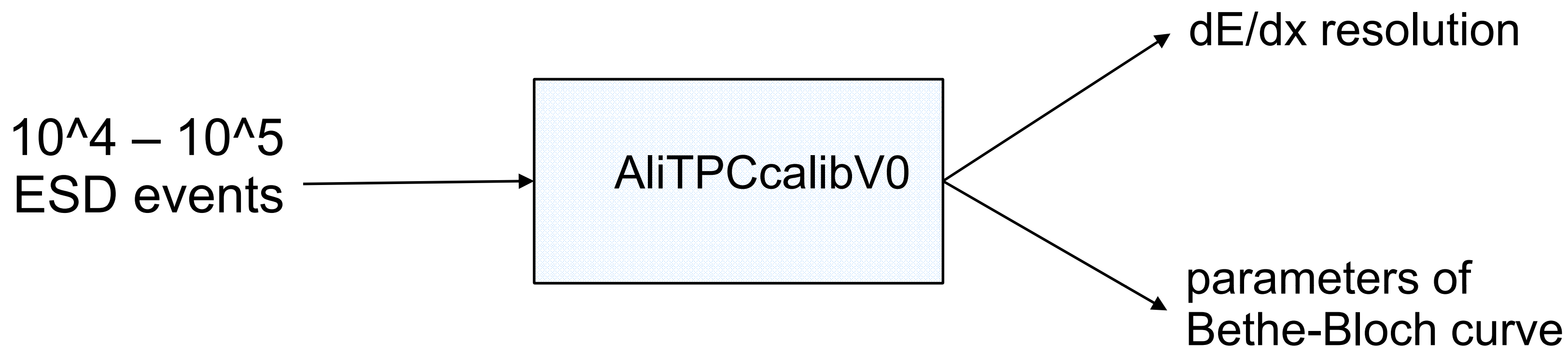
$$\Lambda \rightarrow p^+ \pi^-$$



several cm flight path:

V0			$c\tau$ (cm)
Λ	$p + \pi^-$	63.9%	7, 89
$\bar{\Lambda}$	$\bar{p} + \pi^+$	63.9%	7, 89
K_S^0	$\pi^- + \pi^+$	68.6%	2.68

basic idea (2)



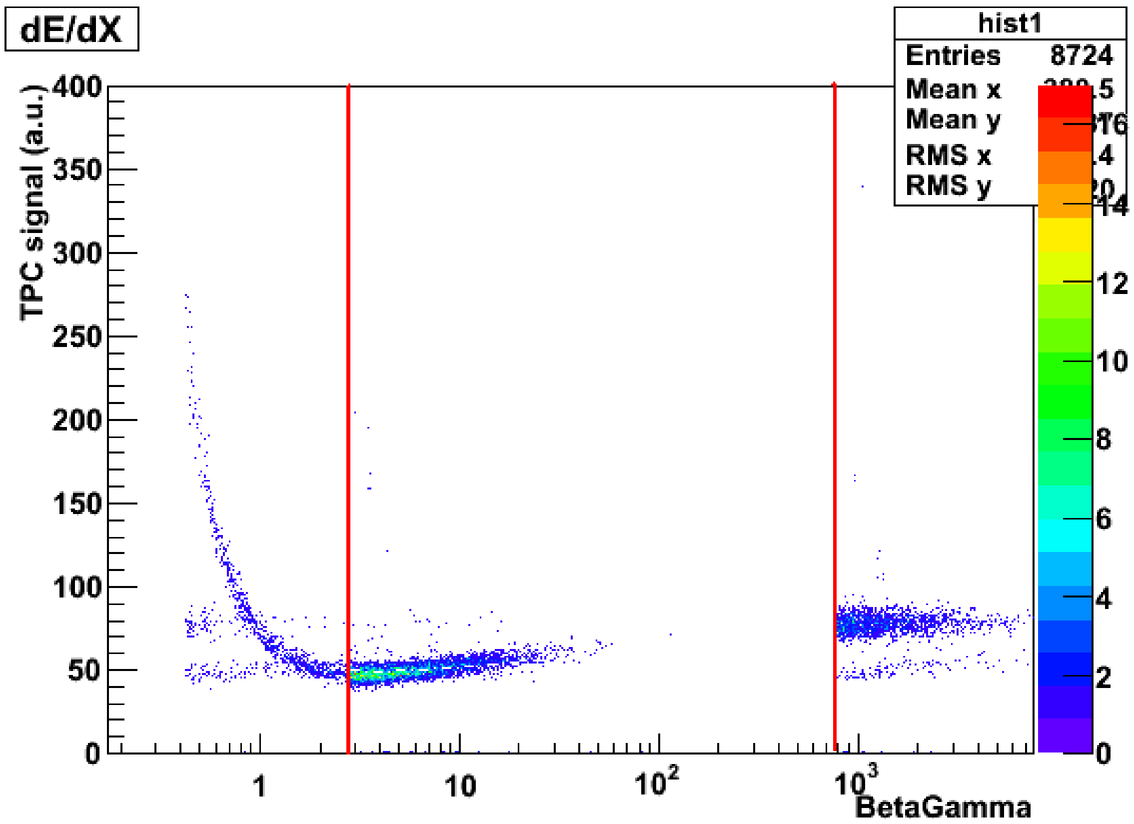
$$f(\beta\gamma) = \frac{P_1}{\beta^{P_4}} \cdot \left\{ P_2 - \beta^{P_4} - \ln\left[P_3 + \frac{1}{(\beta\gamma)^{P_5}} \right] \right\},$$

(Aleph parametrization)

mass independent formulation

p = m·βγ

protons, pions and electrons cover different regions of βγ



$\chi 2 < 4$ with constrained mass / pt > 400 MeV

Bethe-Bloch fit → preprocessing

fit this distribution with Bethe-Bloch-curve

currently based on Aleph parametrization (MC input)

$$f(\beta\gamma) = \frac{P_1}{\beta^{P_4}} \cdot \left\{ P_2 - \beta^{P_4} - \ln\left[P_3 + \frac{1}{(\beta\gamma)^{P_5}} \right] \right\},$$

problem I: outliers in the spectrum → **robust fitting**

problem II: this parametrization shows strong parameter correlation

→ primary goal is a proper fit/calibration and not decorrelating the function

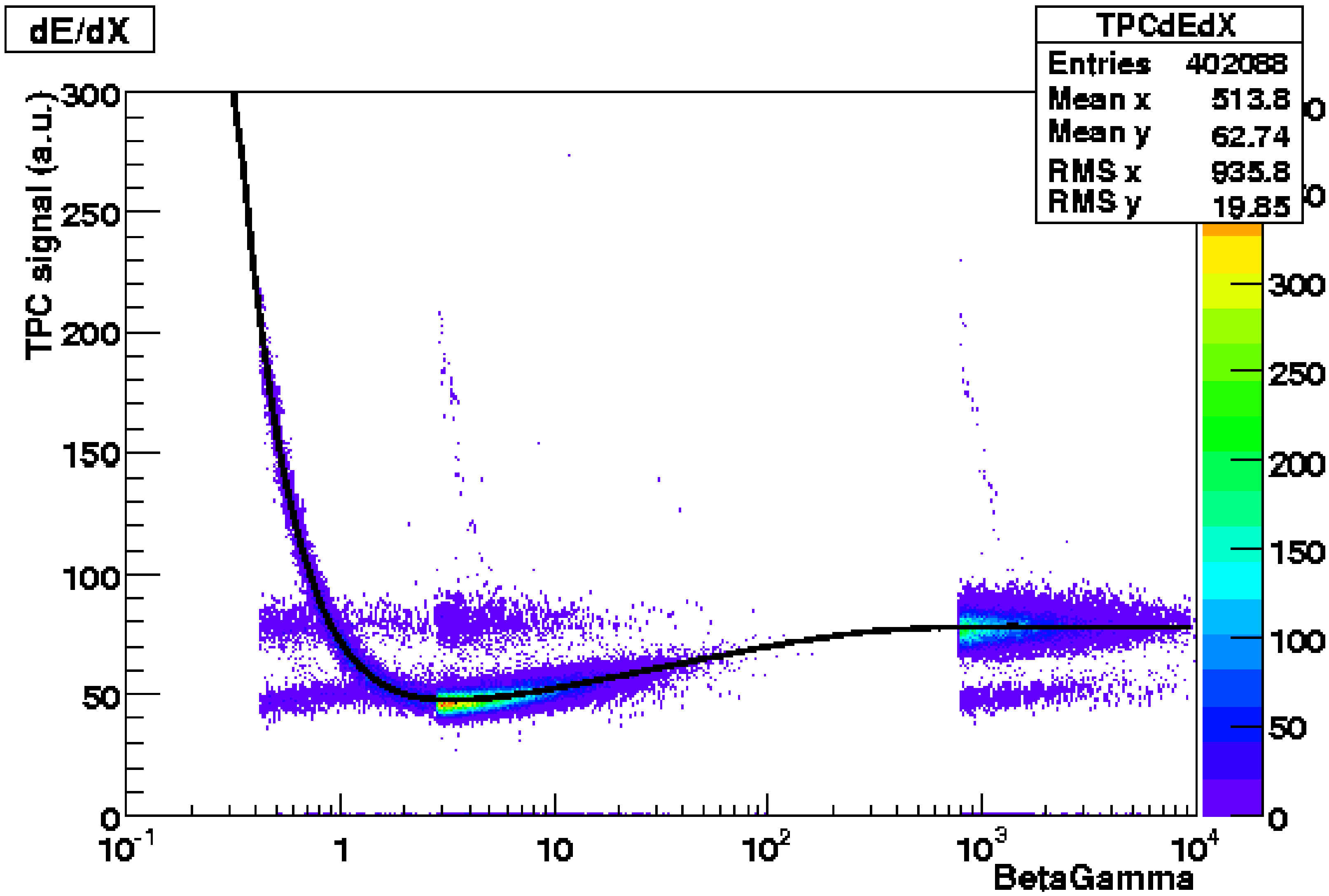
robust fitting

calculate distance to the curve for every point

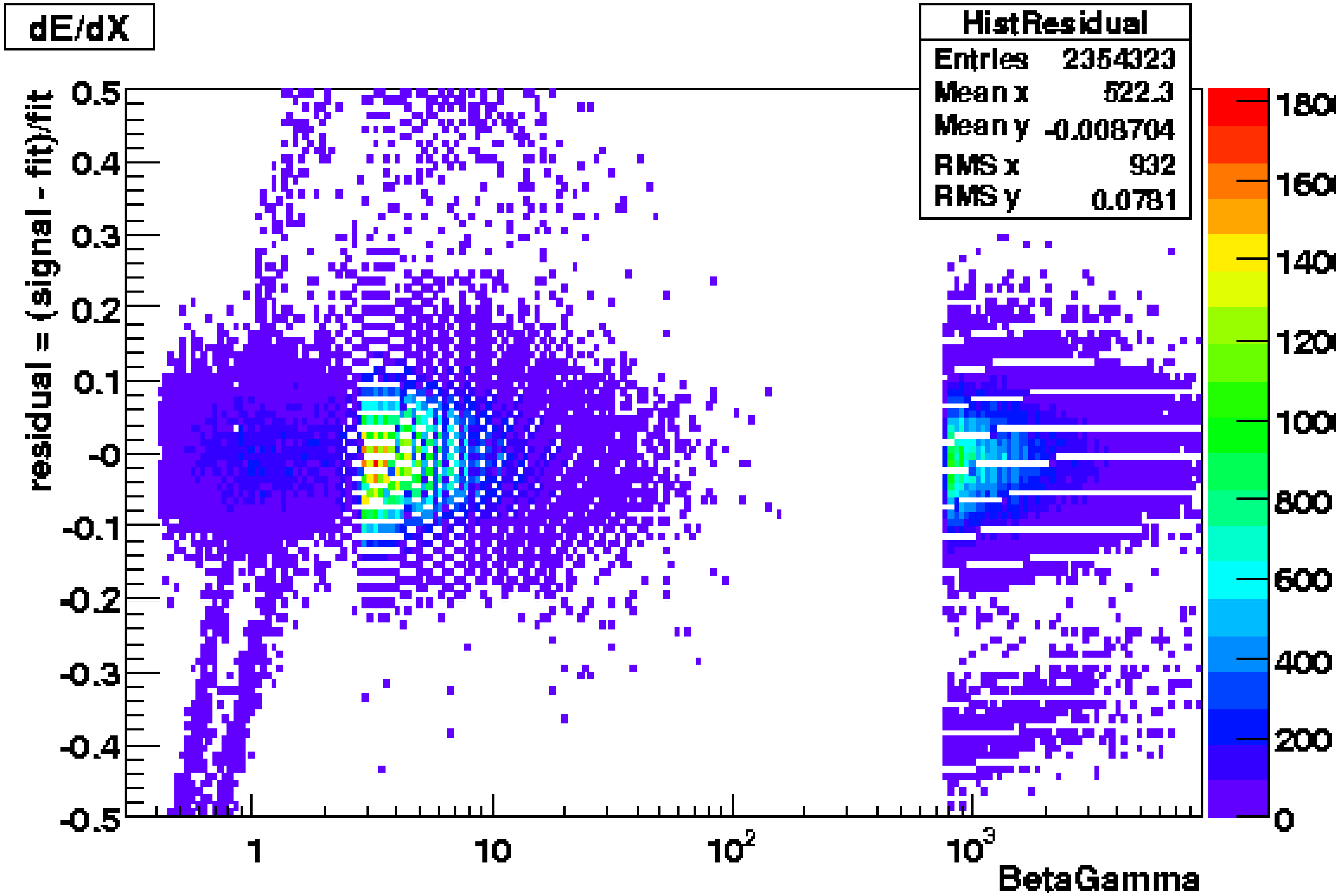
assign a weight to this point as function of its distance
(e.g. exponential decay, gaussian, box)

simplex fit algorithm for stability reasons

final fit and residuals



$\chi2 < 3$ with constrained mass / pt > 400 MeV / 8*10^5 events



dE/dX
HistResidual
Entries 2354323
Mean x 522.3
Mean y -0.008704
RMS x 932
RMS y 0.0781
residual = (signal - fit)/fit
BetaGamma
0.5
0.4
0.3
0.2
0.1
-0
-0.1
-0.2
-0.3
-0.4
-0.5
1
10
10^2
10^3
0
200
400
600
800

Gain Calibration Using Tracks

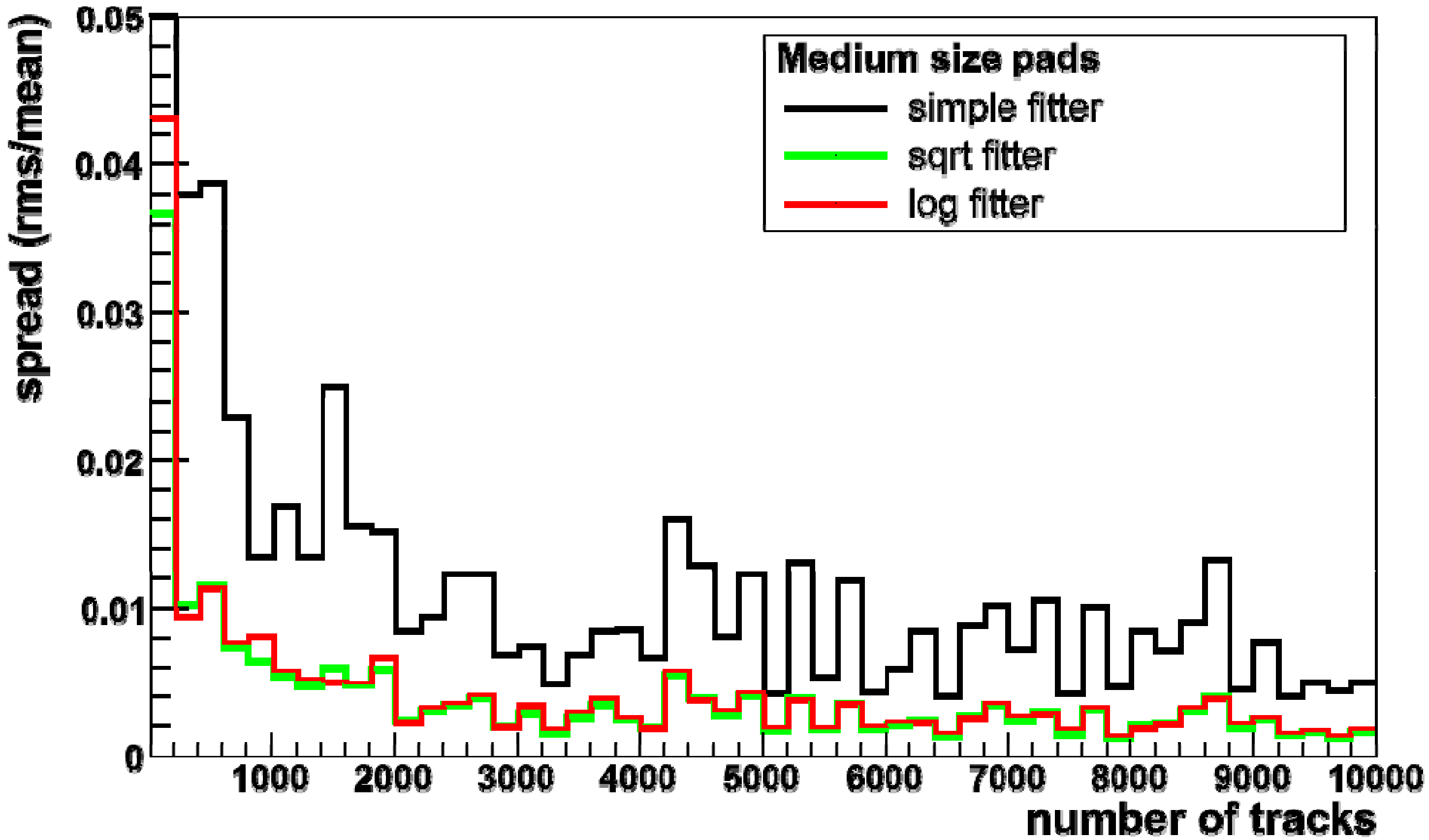
Interface, Tests and Outlook

Calibration Strategy

- strategy:
  - fitting of a parabolic function for each ROC (actually for each pad size) for recovering the gain G(x, y)
  - $G(x, y) = p_0 + p_1 x + p_2 y + p_3 x^2 + p_4 y^2 + p_5 x \cdot y$
  - coordinate origin at center of area of same pad size
  - problem: outliers due to Landau distribution
  - solution: transformation of the input data to minimize effect of the long Landau tail

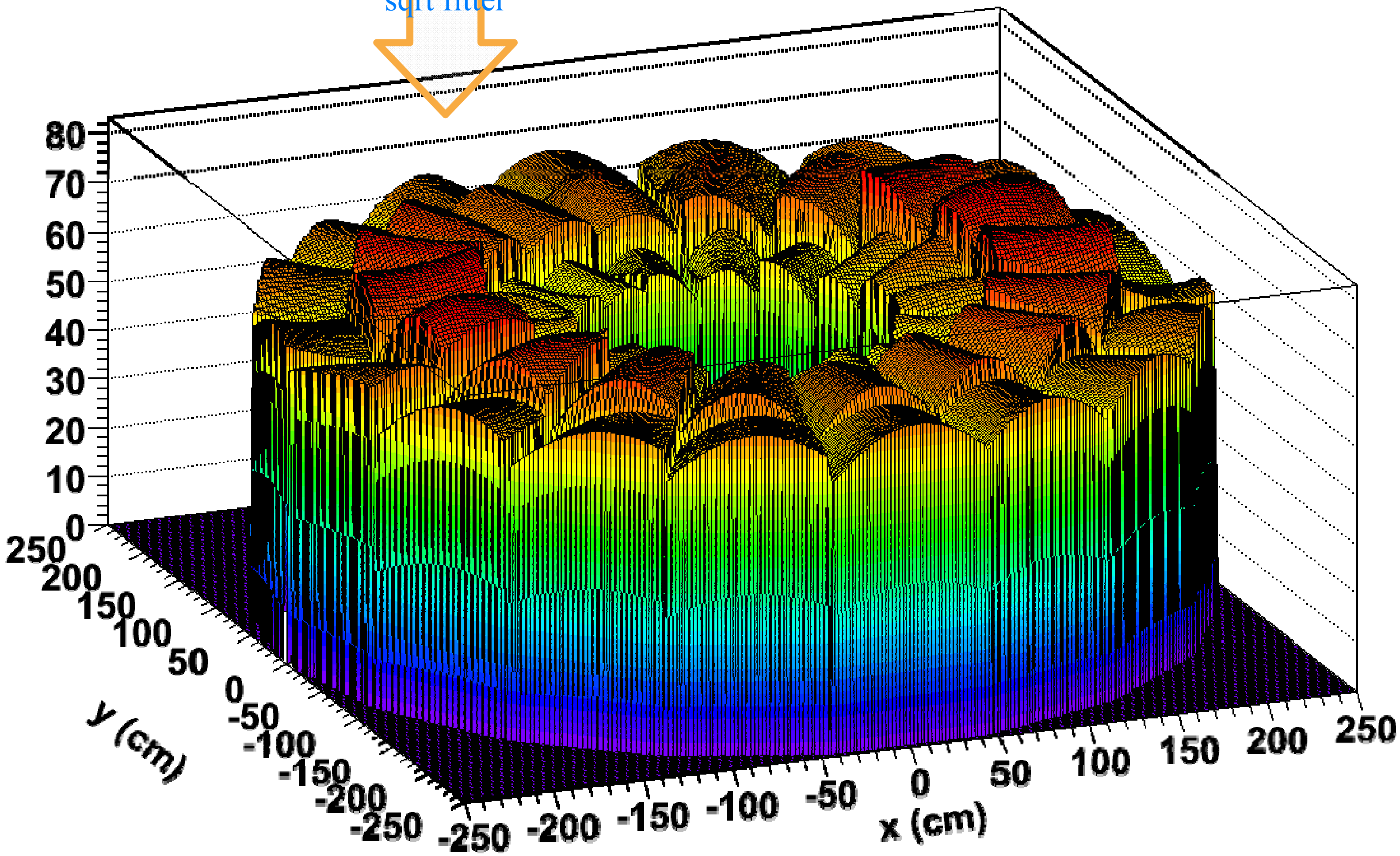
Tests and Comparison

- a simple and fast standalone track simulator was used for testing the AliTPCcalibTracksGain object



Visualization

obtained by using MC cosmics data with 84 files and fitting with sqrt fitter



Problems

- Test of the calibration algorithm with Monte Carlo simulated tracks
  - should give flat fit functions
  - but: they are not
  - probably due to not yet corrected effects
    - need for angular correction
    - correlation between clusters for non-MIPs

1 Alice TPC gain calibration

The detector response (A(x,t)) to the particle deposit is a random variable. This variable is position and time dependent. The response can be written as product of the energy deposit (E_d) and gain function (G(x,t)).

Averaging the detector response over the many particles we can get the mean gain function at given position at some time interval. The systematic uncertainty of such estimate is given by the uncertanty of energy deposit function. The importance of the energy deposit influence can be demonstrated in figure 1.

$$A(x,t) = E_d(x)G(x,t) \quad (1)$$

$$< A(x,t) >=< E_d(x) >< G(x,t) > \quad (2)$$

$$< G(x,t) >= \frac{< A(x,t) >}{< E_d(x) >} \quad (3)$$

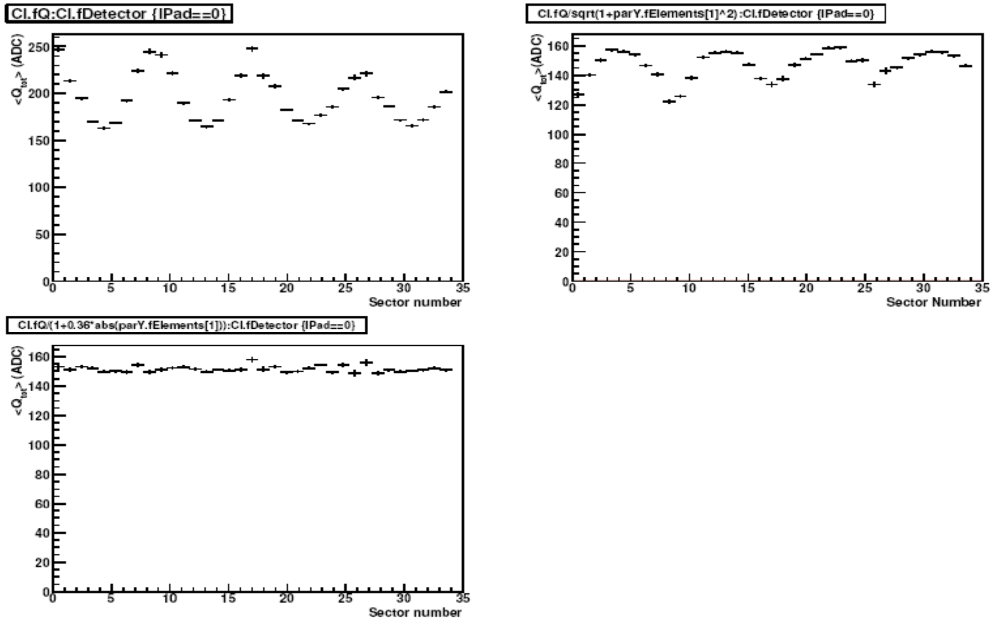


Fig. 1. Cosmic simulation. The mean amplitude at different sectors of the TPC. The gain factor is the same in all sectors. a.) Raw mean amplitude b.) Amplitude normalized to the tracke length c.) Amplitude normalized to the angle (simple linear parameterization)

The mean amplitude at different x,y,z position is not proportional to the gain

The unknown energy deposit make a big influence

The influence doucmented on the cosmic MC data

The gain function is product of the gas gain function (G_g(x,t)), coupling function (Pad Response function (PRF)), electronic gain (G_{chip}) and attenuation

loss (A_{att}).

$$G(x,t) = A_{att}(x,t)G_g(x,t)G_{coupling}(x)G_{chip}(x) \quad (4)$$

In the ALICE TPC, the gas gain function $G_g(x,t)$ and coupling function ($G_{coupling}$) are usually smooth function of the position which are given mainly by distance between the pads and wires. The time dependence of $G_g(x,t)$ is given mainly by the time variation of the pressure. The other variables will be controlled on the level $\leq 1\%$.

The attenuation function is given mainly be electron attachment, it is drift length dependent - exponential decay. The decay length depends on the admixture of the electronegative molecules in the gas. The concentration of these admixtures is time dependent, therefore it decay length should be regularly controlled.

The electronic gain (G_{chip}) is determined by the tolerance (...). In ALICE TPC the variation is on the level of $\sigma \approx 1\%$. The grouping on the chip level is obsereved. (need picture 1D and 2D).

The energy deposit (E_d) is given by the type of the particle (mass), their local properties :momenta, pad length, tracklet orientation (ϕ and θ).

$$E_d(x) = E_d(m, p(x), l(x)) \approx k\frac{dE}{dx}(\beta\gamma)L(padlength, \phi, \theta) \quad (5)$$

The mean energy deposit $< E_d(x) >$ can strongly differ for different physical cases (cosmic, beam-beam interaction).

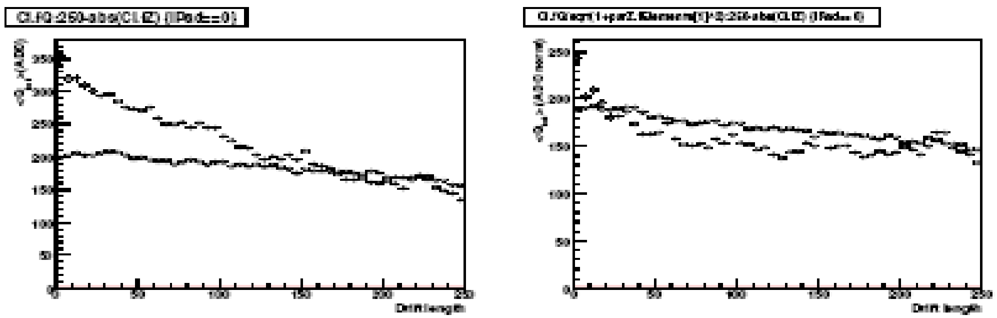


Fig. 2. Mean total charge as function of z for cosmic topology and for pp events. Before and after normalization to the local inclination angle.

The energy deposit is particle and angular dependent

Example, mean aplitude as function of z - comparison of the pp event and cosmic (MC) data

The gainfunction is given as ratio of the mean detector response (A(x,t)) and mean energy deposit $E_d(x)$. The $E_d(x)$ can be eleminated, under assumption

that the track properties (momenta, angle) are constant along the track.

$$\frac{A(x,t)}{< A(x,t) >_{track}} = \frac{E_d(x)}{< E_d(x) >_{track}} \frac{G(x,t)}{< G(x,t) >_{track}} \qquad (6)$$

Having the analytical model of the gain as function of position the mean gain along the track trajectory can be calculated. In case of the Alice TPC we will assume that the gain can be approximated by parabola (x,y,z cordinates). The mean gain than can be calculated integrating the parabola over track trajectory.

The influence on the energy deposit Ed, can be removed making doing statistic on the ratios of amplitudes over the mean amplitude for track

- Cluster - Gaussian shape

$$f(t,p) = K_{Max}.exp\left(-\frac{(t-t_0)^2}{2\sigma_t^2} - \frac{(p-p_0)^2}{2\sigma_p^2}\right) \quad (7)$$

K_{Max} - normalization factor and maximal value of cluster charge
t, p - time and pad bins
t_0, p_0 - center of cluster
σ_t, σ_p - sigma of time and pad cluster distribution

- Total charge N_{ch} in cluster :

$$N_{ch} = \int_{-\infty}^{\infty} f(t,p)dtdp = K2\pi\sigma_t\sigma_p \quad (8)$$

$$K_{Max} = \frac{N_{ch}}{2\pi\sigma_t\sigma_p} \quad (9)$$

- Effective area s_{eff} of cluster : area of elipsa given by threshold th

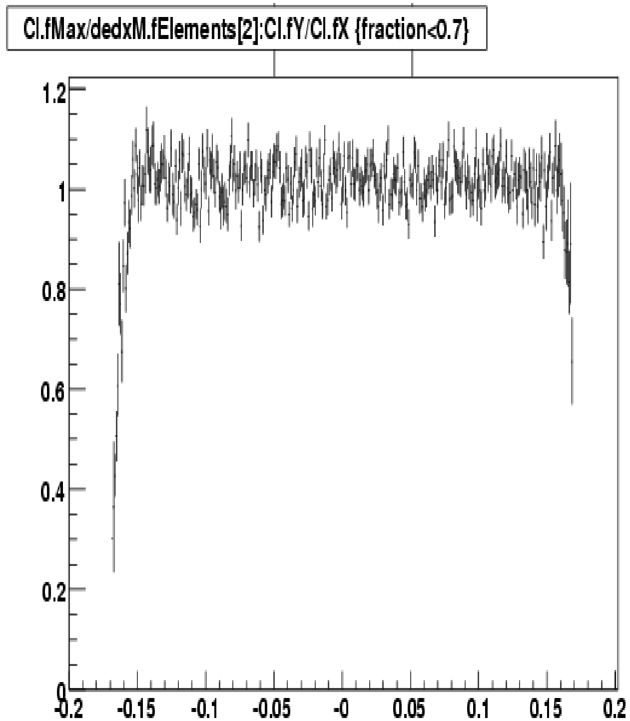
$$s_{eff} = 2\pi\sigma_t\sigma_p ln\left(\frac{K_{Max}}{th}\right) \quad (10)$$

The dependence of the mean total mplitude of the cluster and mean maximal charge amplitude depends on the cluster shape

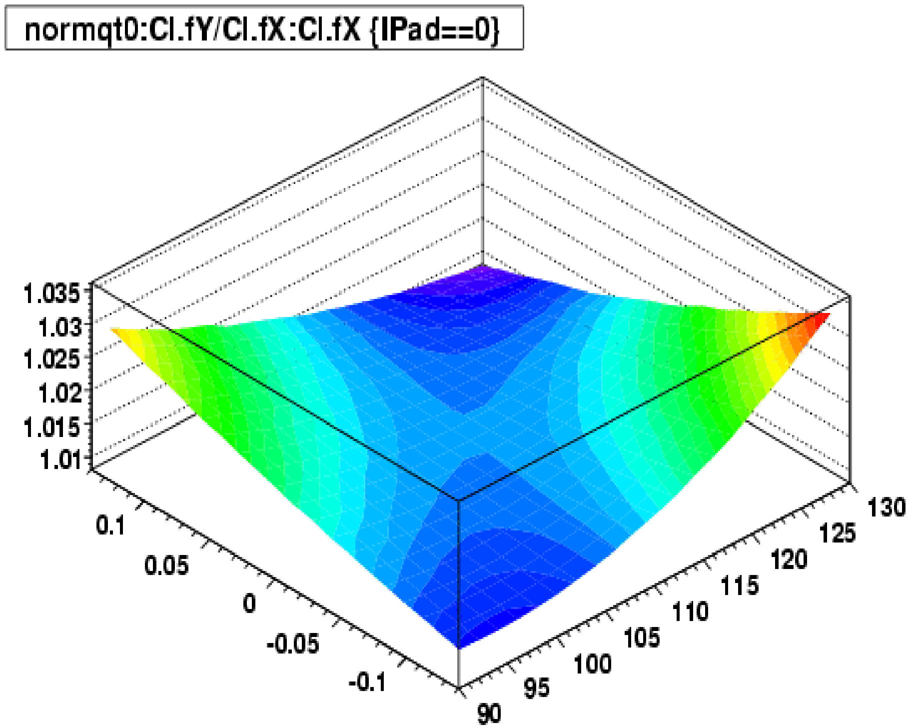
The shape is determined by the cluster z position and 2 track inclination angles

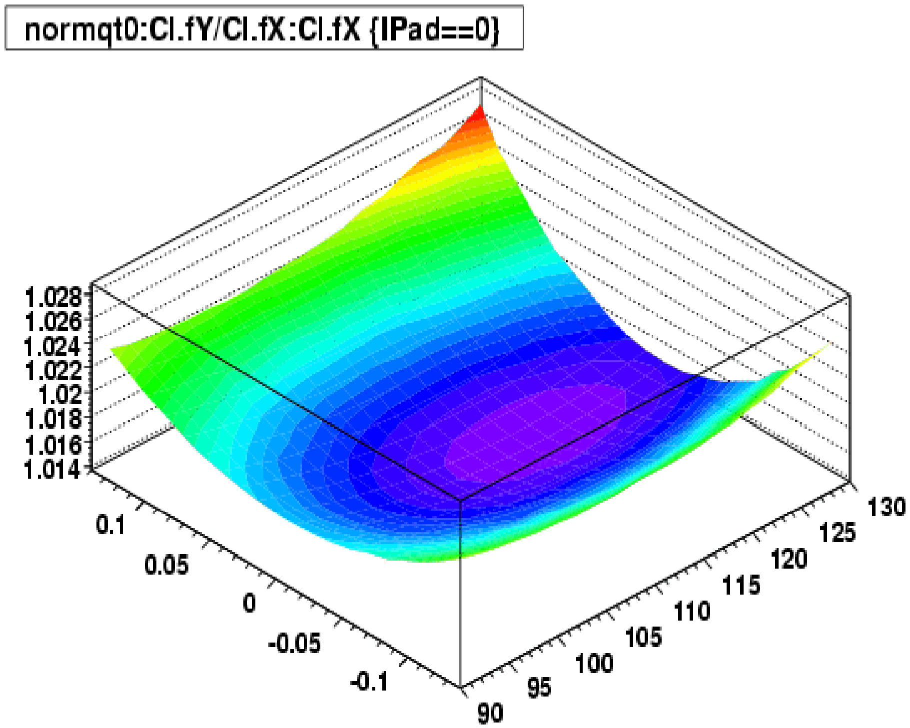
(Complex) gain calibration (0)

- Remove edge effect
- Normalize signal to the mean signal over track segment
- Perform 3 D parabolic fit



(Complex) gain calibration (1)

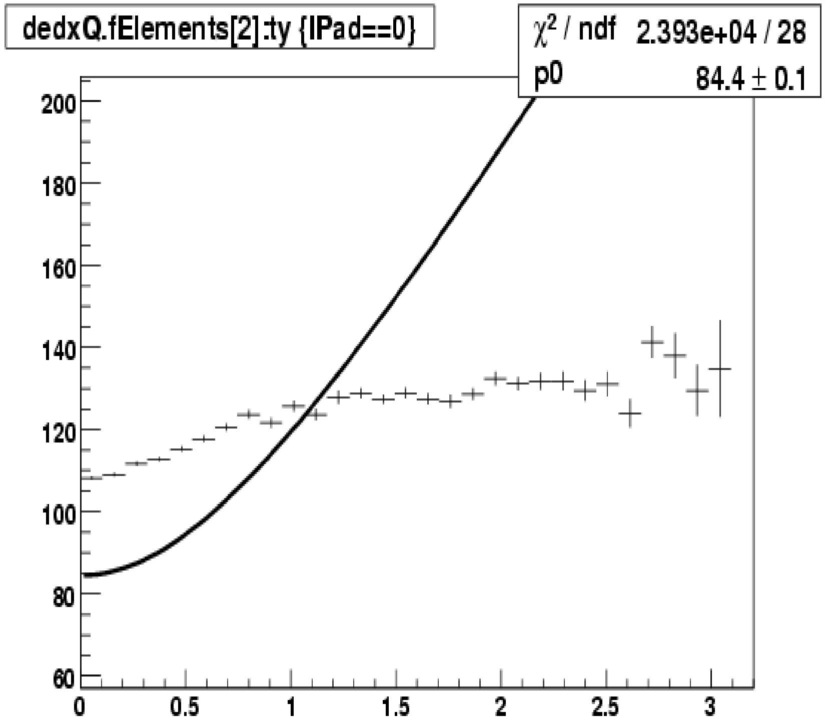




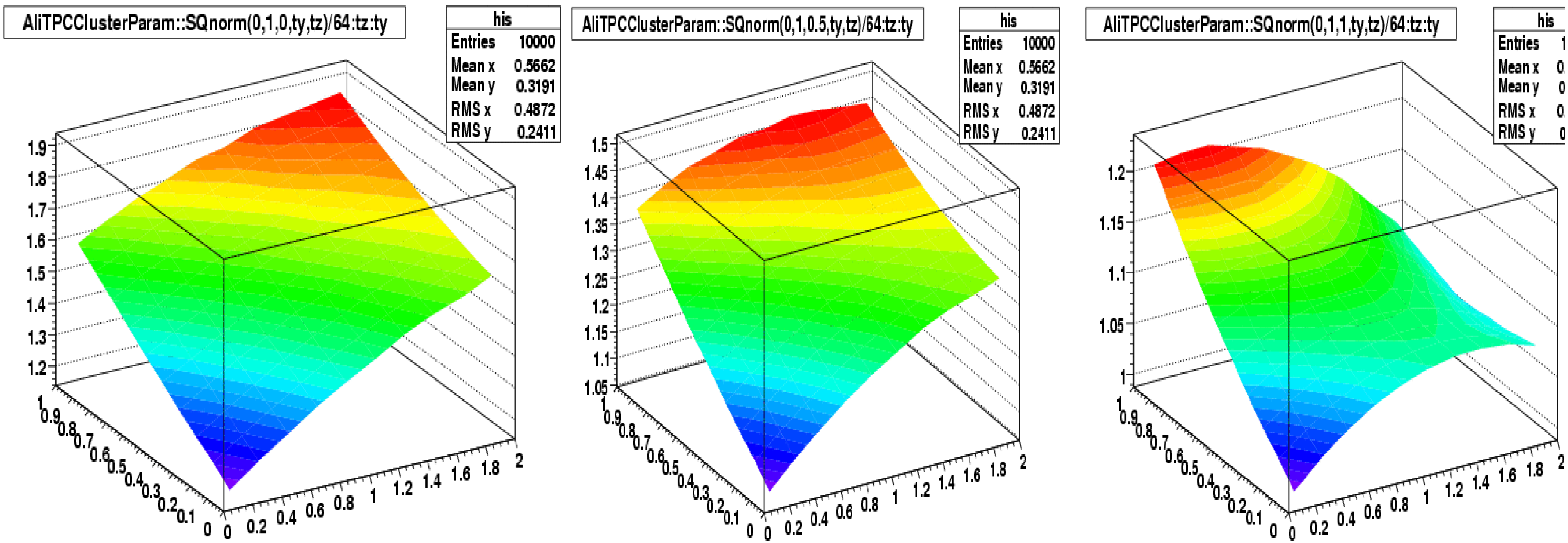
- Obtained gain function
  - Left side statistic - ntracks ~ 500 (2 % min-max difference)
  - Right side statistic – ntracks ~2000 (1% min-max difference)

Energy deposit calibration (0)

- The energy deposit (Qtot, Qmax) do not scale with tracklet length
  - sqrt(1+tan(angle)^2)
- The dependence is different for Qmax and Qtot
- The charge integration influenced by threshold effect
- 2 possible solution
  - make a 2-dim fit of cluster (needs track angles as input parameters)
  - Correct for effect in 3D (tany, tanz, z)

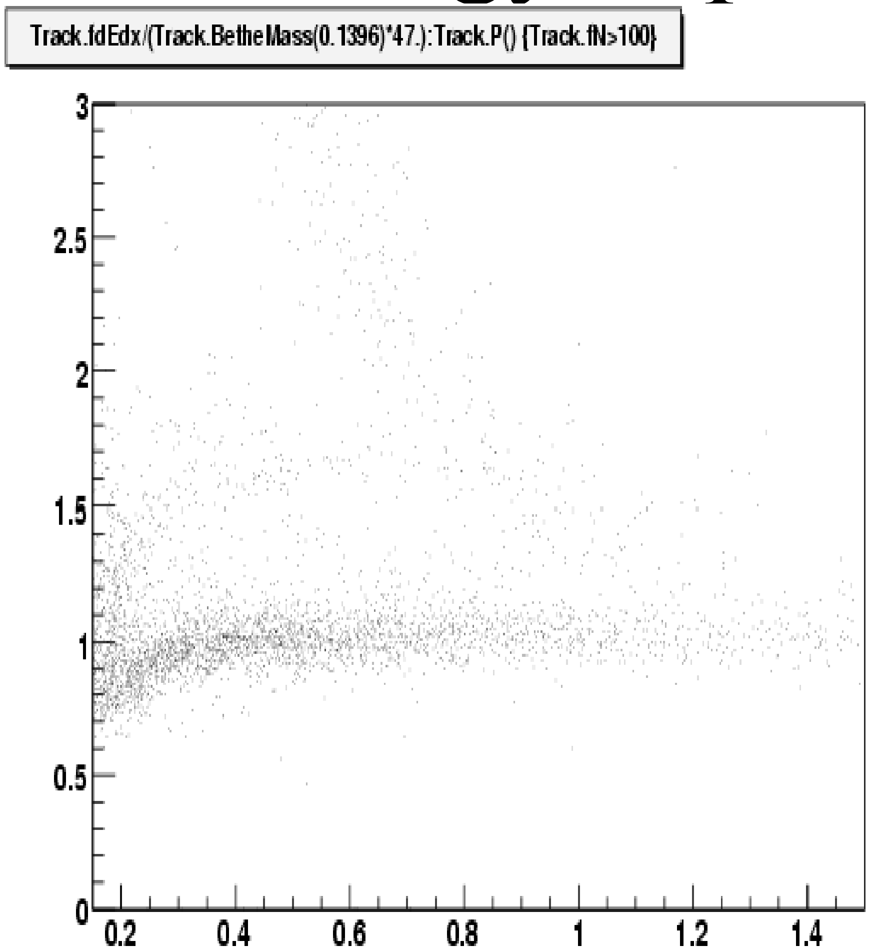


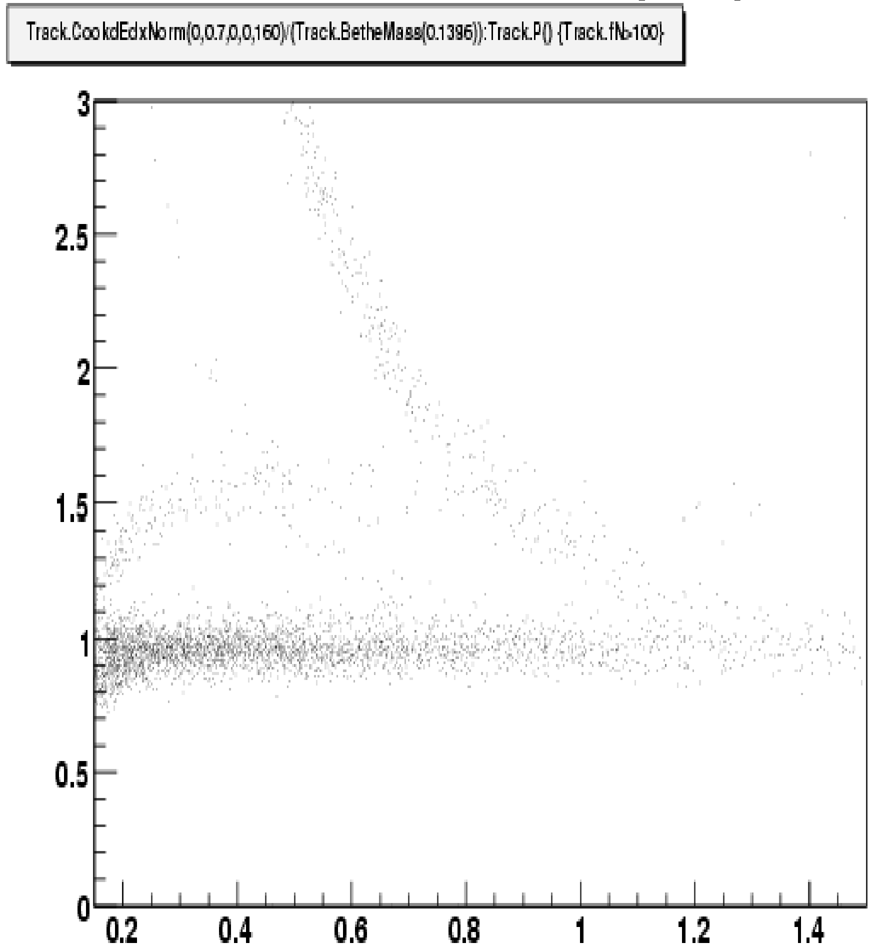
Energy deposit calibration (1)



- The energy deposit as function of the inclination angle at 3 different z position

Energy deposit calibration (2)





- The dEdx /dEdx theoretical(pi mass) as function of particle momenta (Qmax used)
  - Left side – Using sqrt(1+tany^2) correction (current aliroot)
  - Right side – Using fitted correction (to be committed)

Quality assurance (0)

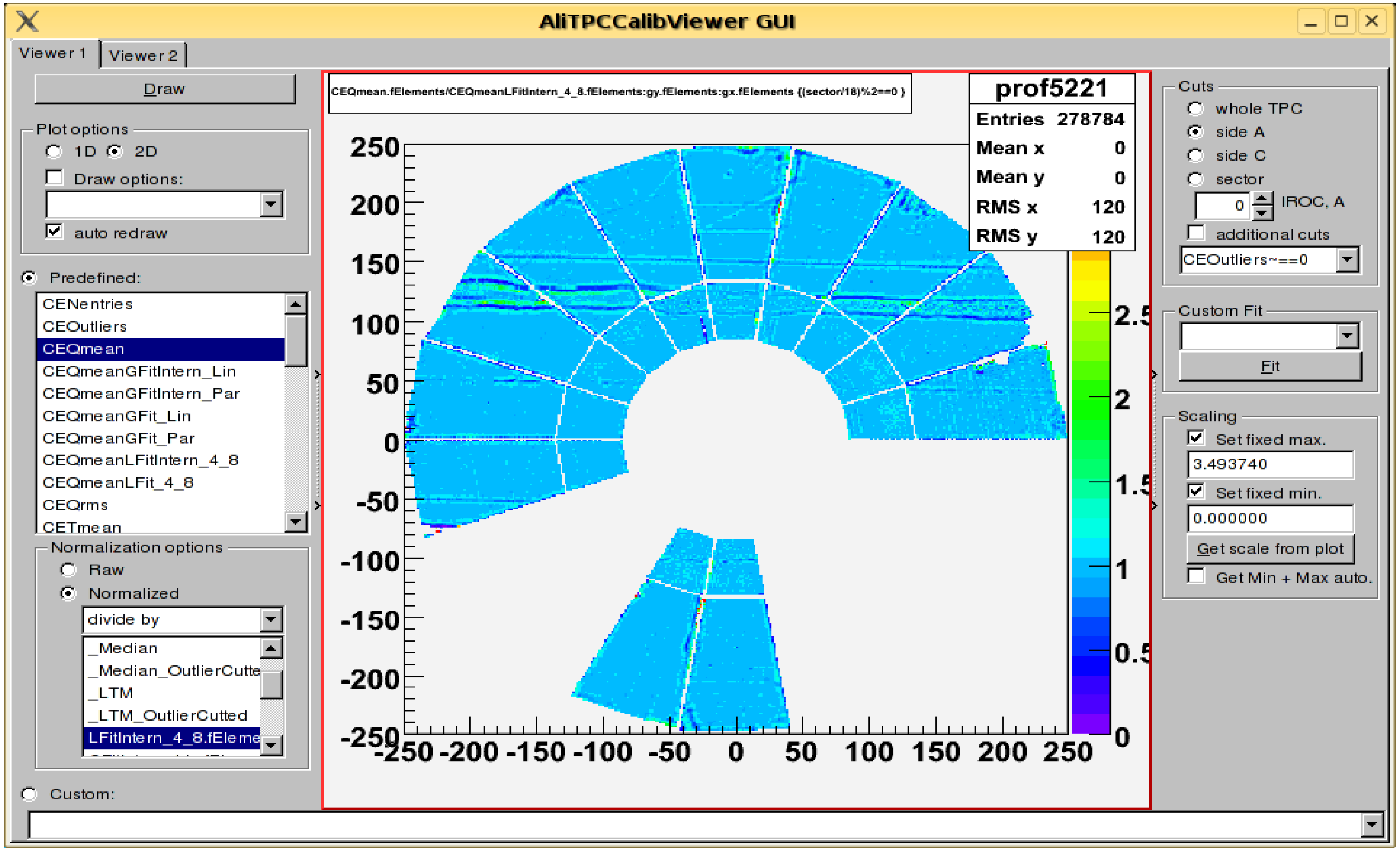
1) Quality assurance based on the statistical properties of the data
    1) Using data from calibration algorithm
    2) Calibration viewer adopted to the AliEve
2) Comparison of the MC data with the reconstructed data
    1) Code in PWG1
    2) Implemented as components
    3) Usage in the AliAnalysis not yet tested-implemented (Work in progress)
3) Low level monitoring – e.g counters to be implemented
4) Some low level histograms – e.g. mean amplitude vs z, vs x only qualitative information – something is terribly wrong

Quality assurance (1)

- Data quality monitoring based on calibration parameters –strongly related with points (1-6)
- Noise calibration – Detection of outliers (alarms), FFT spectra for outliers
- Electronic gain calibration – Detection of outliers (alarms)
- Time 0 calibration - Detection of outliers (alarms)
- Gain calibration using cosmic – Detection of outliers (alarms)
- Space point resolution parameterization and cluster shape parameterization – Pulls for sectors, pad-rows, detection of outliers (alarms)

TPC Calibration Viewer GUI

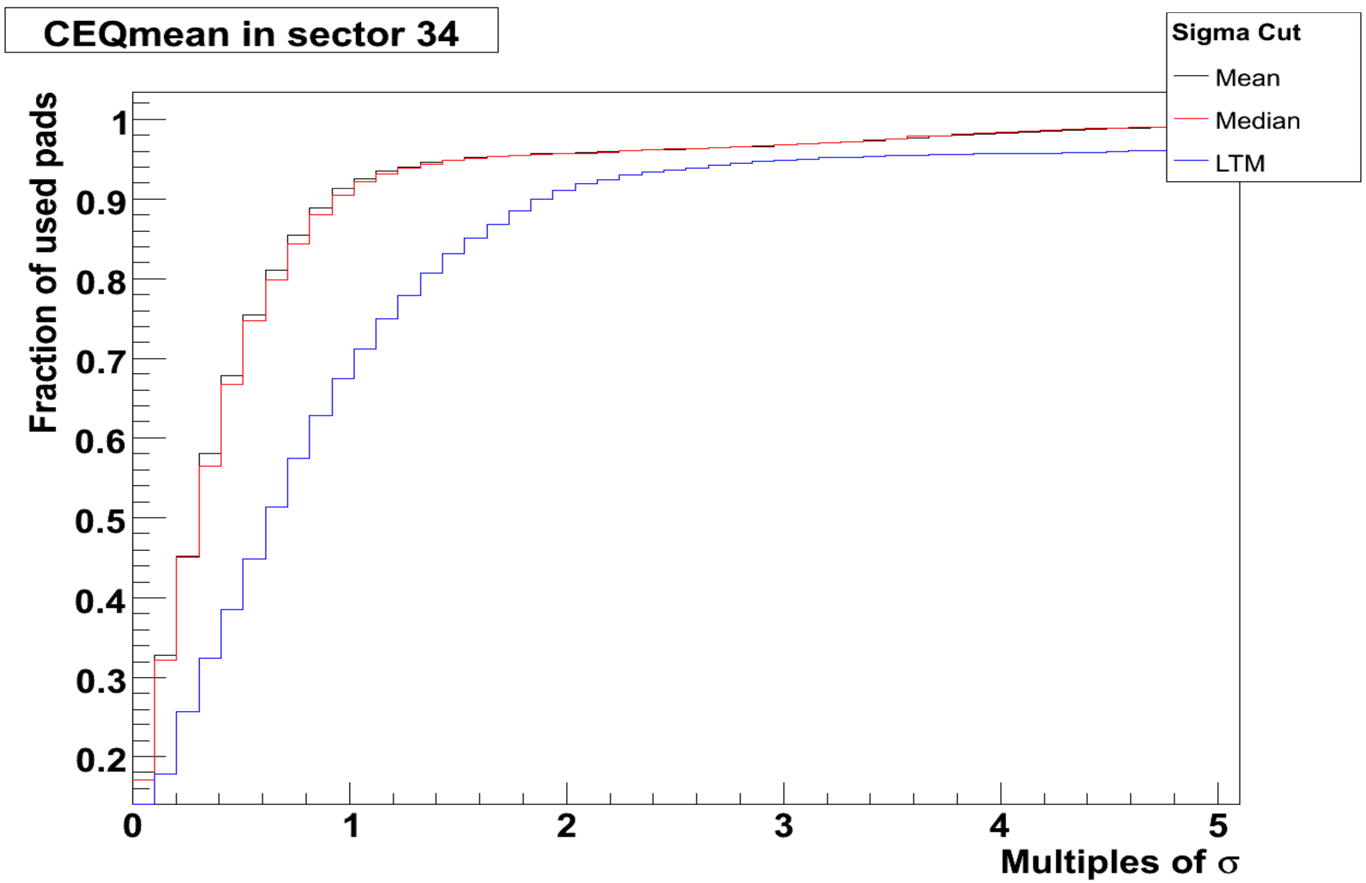
`AliTPCCalibViewerGUI` provides a graphical interface for visualization of calibration information. It utilises the `AliTPCCalibViewer` class for generating the diagrams.



CalibViewer Functionality: SigmaCut

`SigmaCut:` Shows fraction of rejected pads for different σ cuts

- **`SigmaCut(char* type, Int_t sector, Float_t sigmaMax, Float_t sigmaStep)`**
- `SigmaCut("CEQmean", 34, 5, 0.05)`



CalibViewer Functionality: DrawHisto1D

`DrawHisto1D:` Draws histogram for given sector with mean and different σ intervals

- **`DrawHisto1D(char* type, Int_t sector, TVectorF& nsigma)`**
- **`TvectorF vec(3); vec[0]=1; ...`**
- `DrawHisto1D("CEQmean", 34, vec)`