ToT & Spatial resolution study

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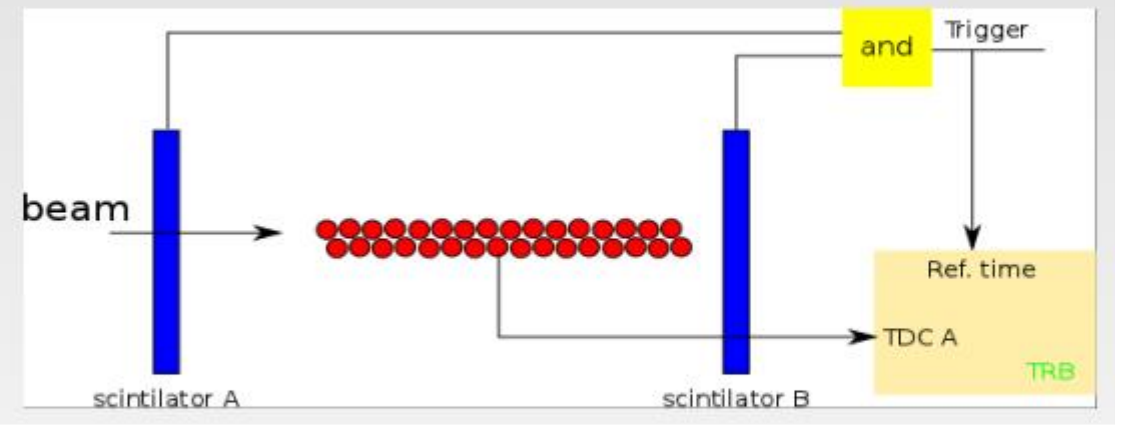
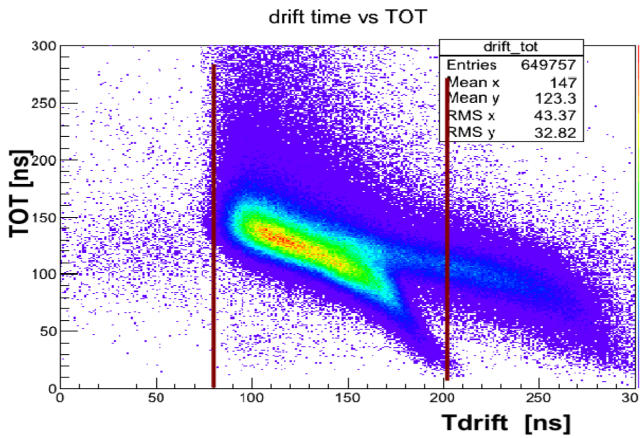
The Data

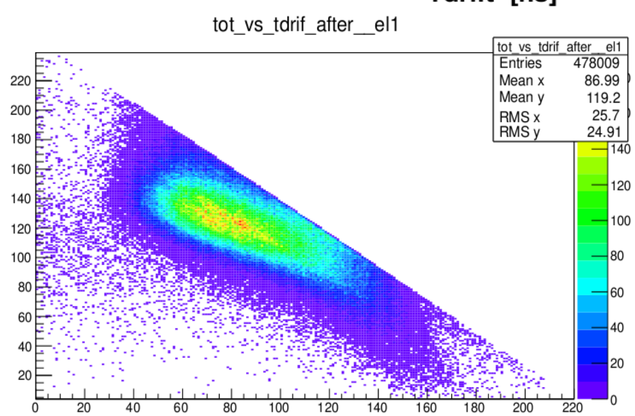
- Momentum – 900 MeV/c
- Intensity – 3 * 10^4 per second
- HV setting – 1700V up to1900 V
- TRB + ASIC setup

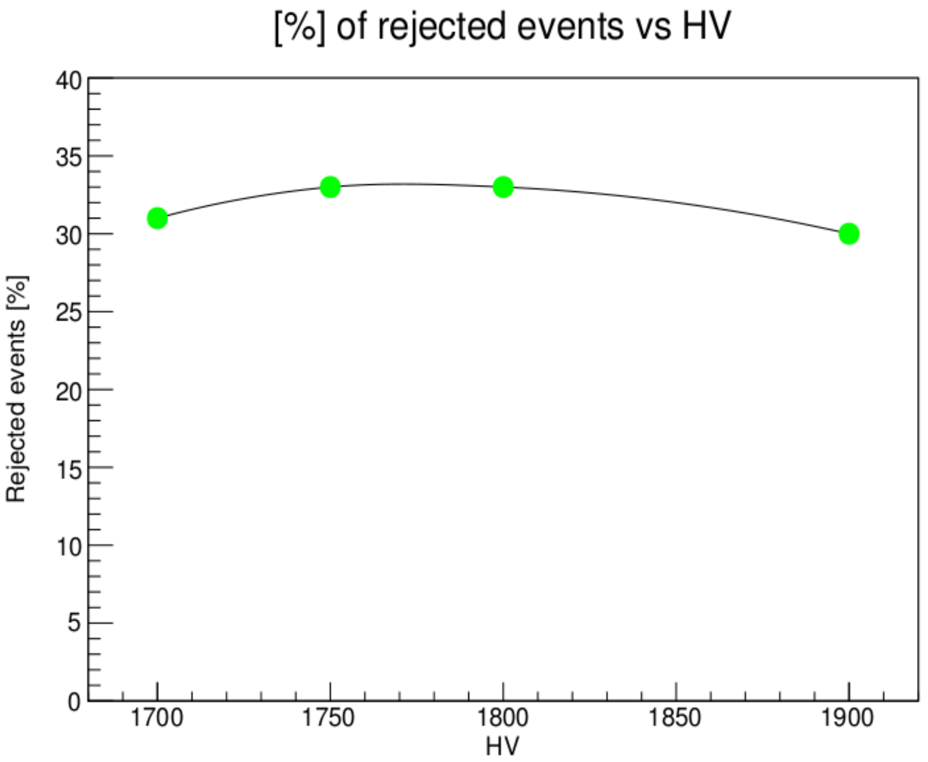


Time over threshold vs drif time

- A background structure is visible above in ToT vs Tdrif spectra ~ 120ns
- A cut was applied to remove the background
- 30% of events rejected







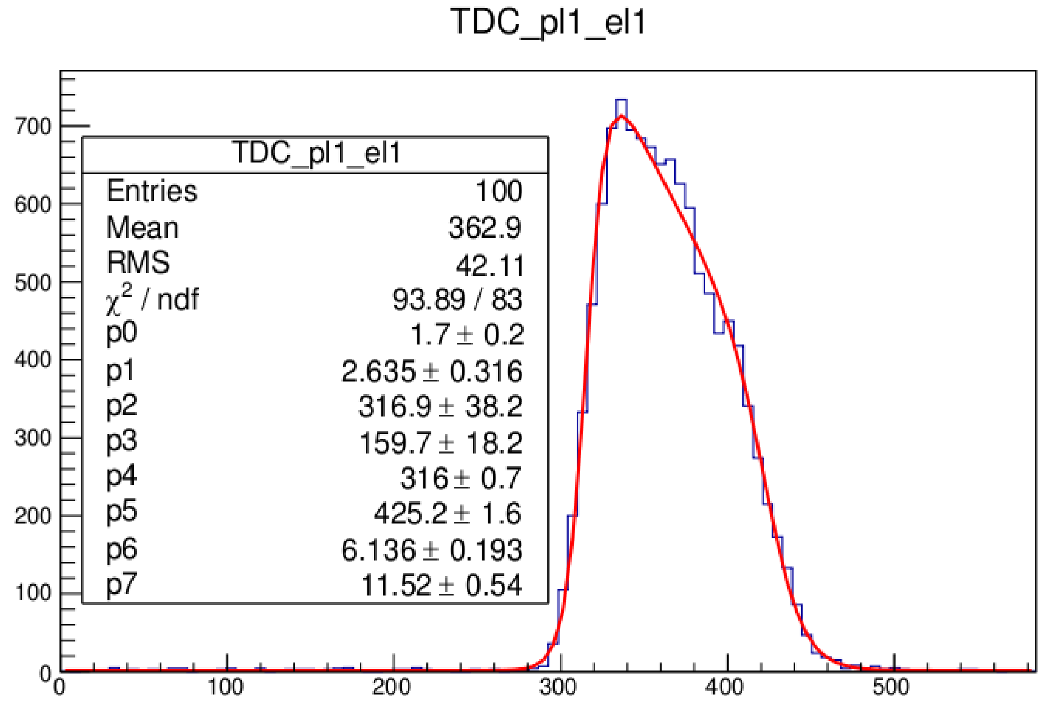
Preparing Data

- Electron drift spectra were calculated for all channels (after the graphical cut)
- Each channel was fitted with a 8 parameter function to calculate the rise time of the spectrum (later referred as „walk”), the function was not used to calibrate the detector (values of start and „end” time of the spectrum was selected manually)
- Spectra from all channels were aligned to start at time 0 (to compensate the error in threshold setting of each channel)

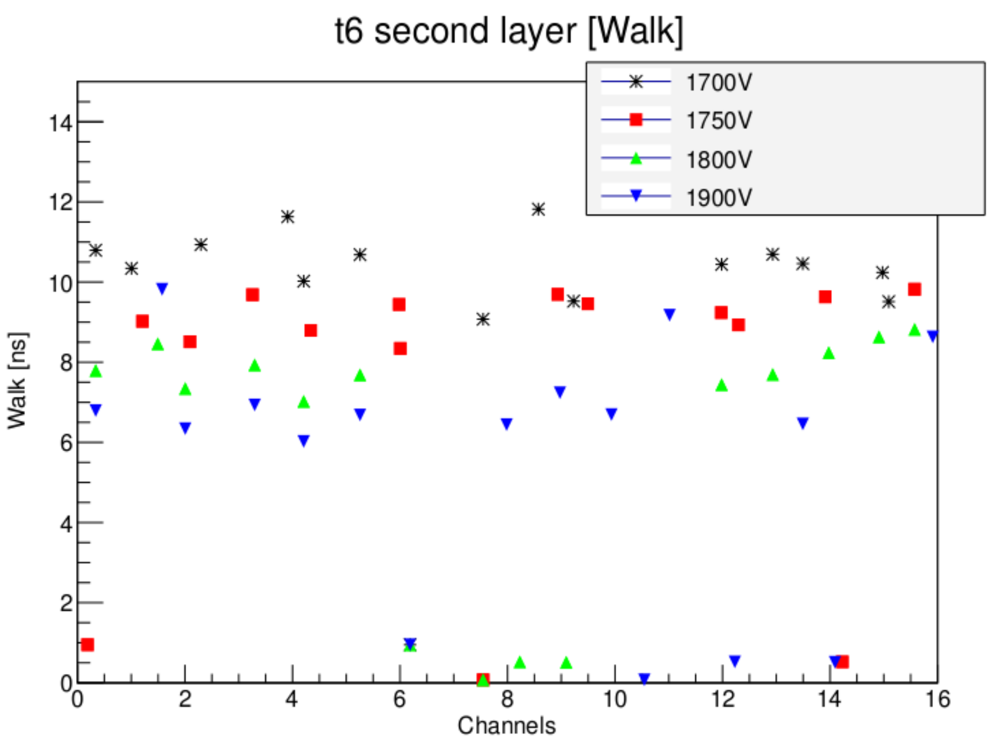
The 8 parameter Fermi like function

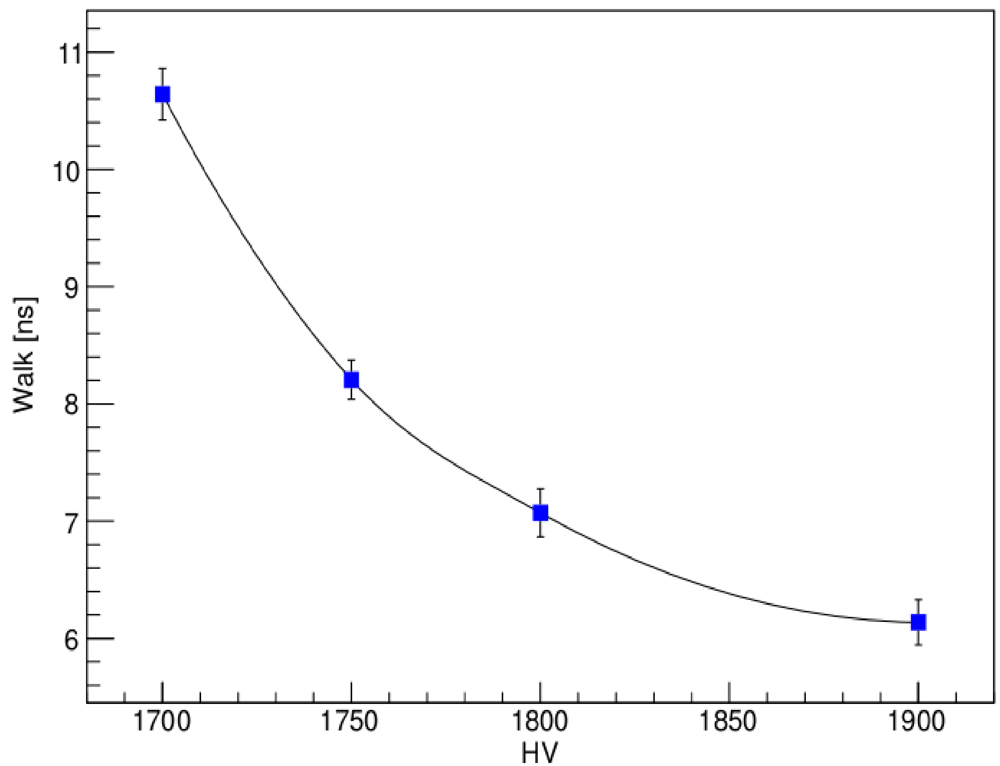
$$\frac{dn}{dt} = P_1 + \frac{P_2\left[1 + P_3 \exp((P_5 - t)/P_4)\right]}{\left[1 + \exp((P_5 - t)/P_7)\right]\left[1 + \exp((t - P_6)/P_8)\right]},$$

- P1- noise
- P2- normalization factor
- P3-related to the shape
- P4- related to the shape
- P5- t0
- P6- t max
- P7- leading edge raise time
- P8- trail time



- „Walk” was calculated for all HV settings
- This parameter affects the calibration, spatial resolution and in as a resoult the track reconstruction efficiency (tracks near the anode wire)
- „Walk” is related to the level of the threshold, high threshold will increase the rise time of the spectrum





2^{nd} step, preforming the D(t) calibration

- A D(t) curve was obtained using the uniform irradiation method, as it is described by the formula below:

$$D(t) = R_{wire} + (R_{tube} - R_{wire}) \cdot \frac{\int_0^t n(t)dt}{\int_0^{T_{max}} n(t')dt'}$$

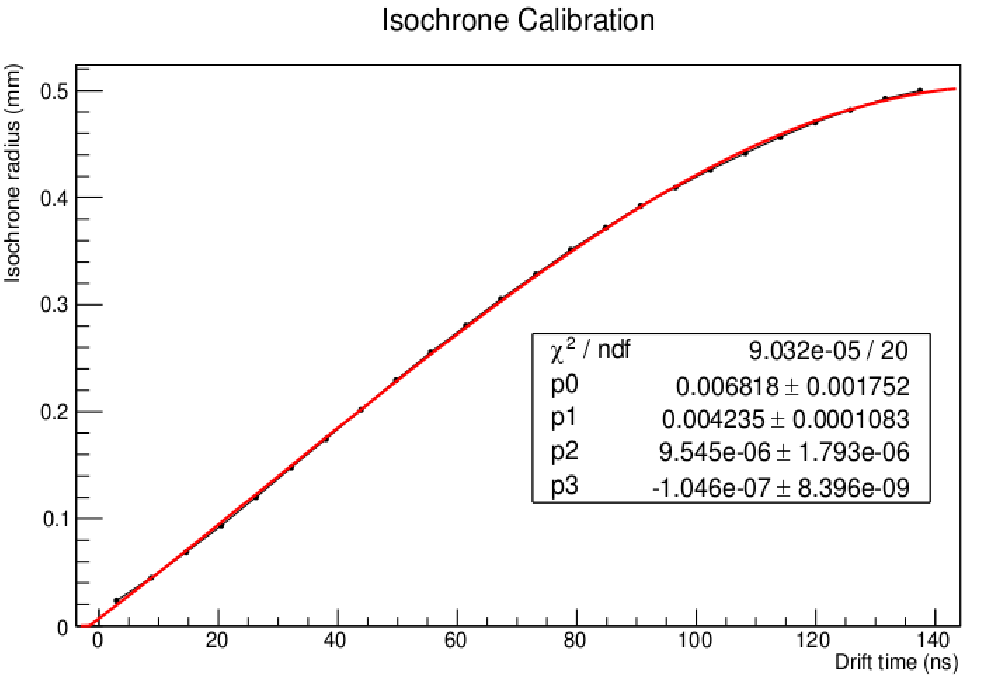
R_{wire} - anode diameter

R_{tube} – tube diameter.

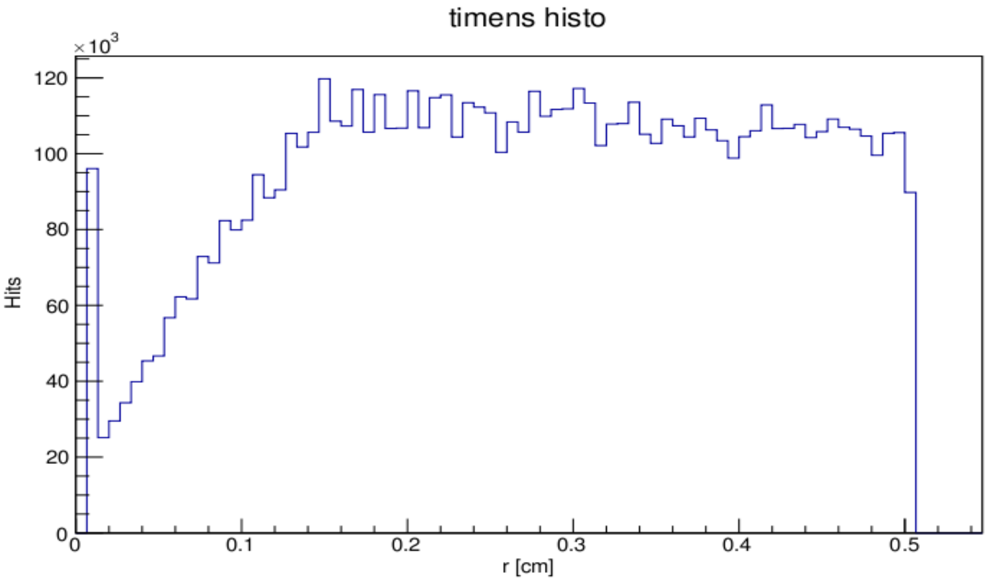
t – time in with the spectrum was measured

n(t) – number of events registered at time t.

T_{max} – maximum drift time.

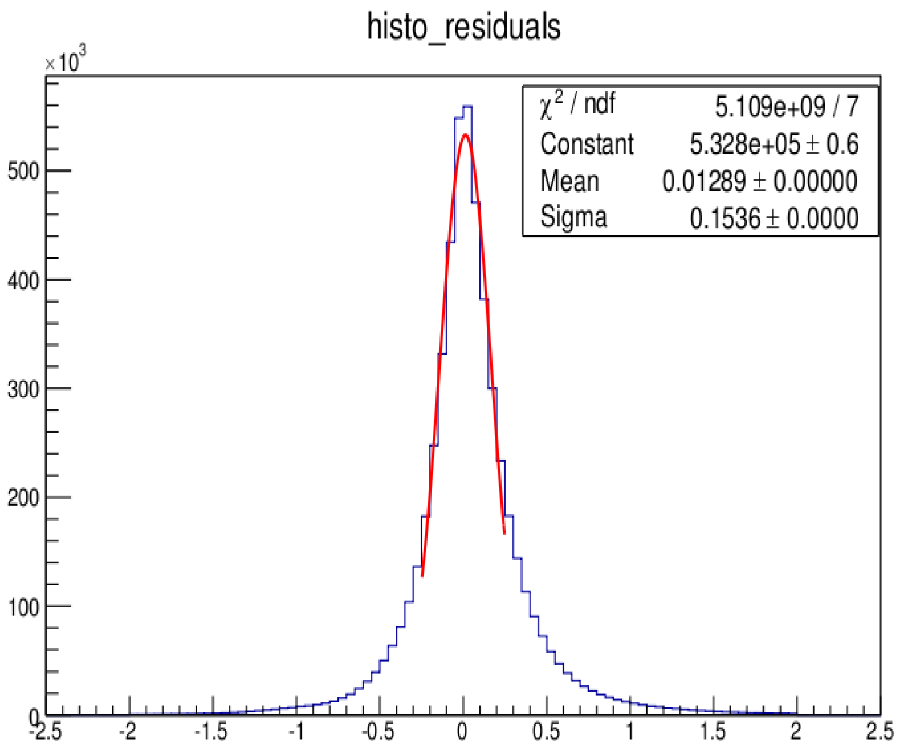


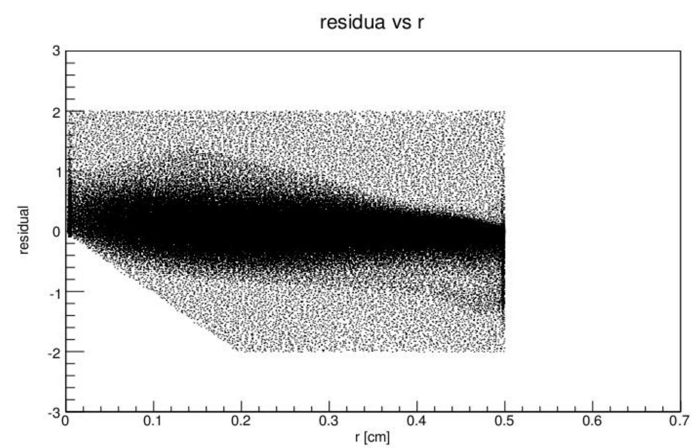
- A distribution of Hits in a function of the drift radius was calculated to check the method
- For hits close to the anode wire one can see a decrees, it is related to the „walk” effect with affects the calibration curve (tracks near the center of the tube are lost due to high threshold setting)

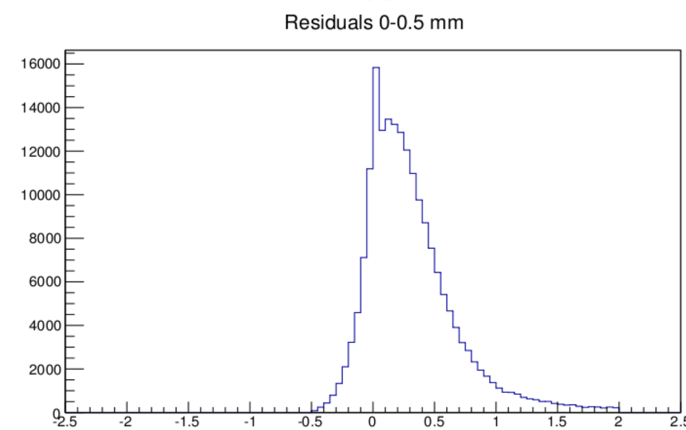


- To calculate the spatial resolution a distribution of residua is calculated, secondly it is fitted withe a Gaussian function, the sigma will be the value of the spatial resolution (153 um)

- In distributions calculated for low drift radius values one can see a asymmetric behavior, it`s a effect of a bias calibration (related to the so called „walk” caused by high threshold setting)

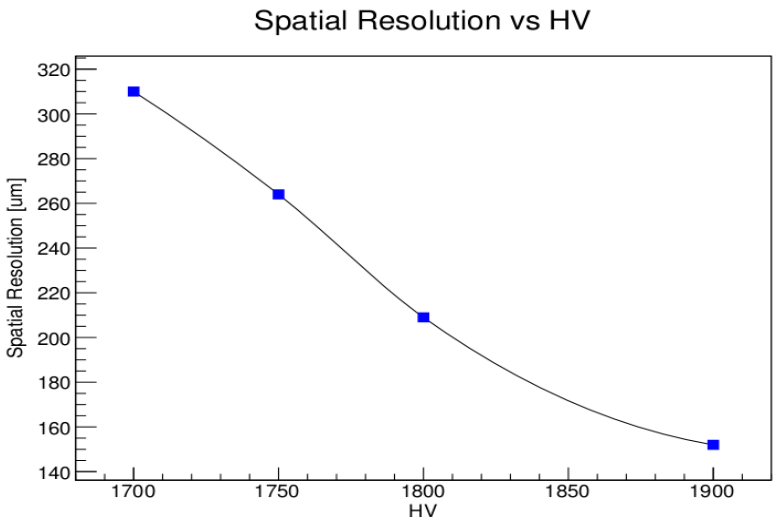


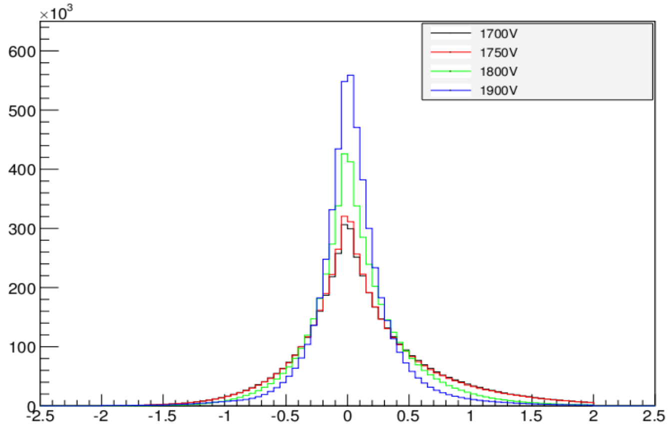


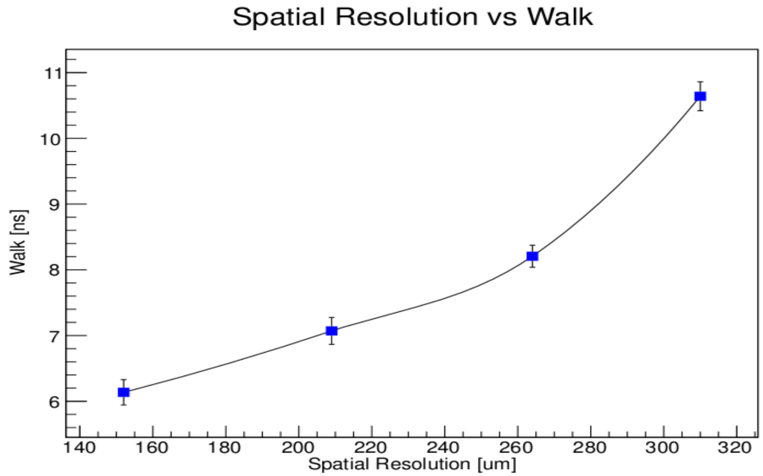


Spatial resolutions for different HV

- Spatial resolution is better for higher HV [expected]
- Poor spatial resolution for low HV [1700 – 1750]
- Spatial resolution related to so called „walk” effect [expected]



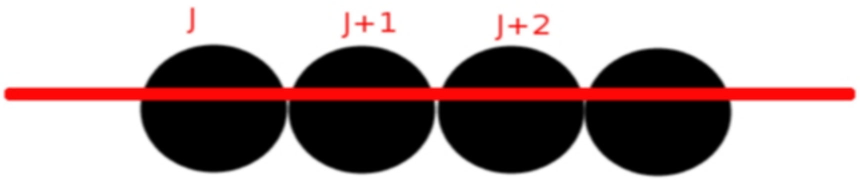


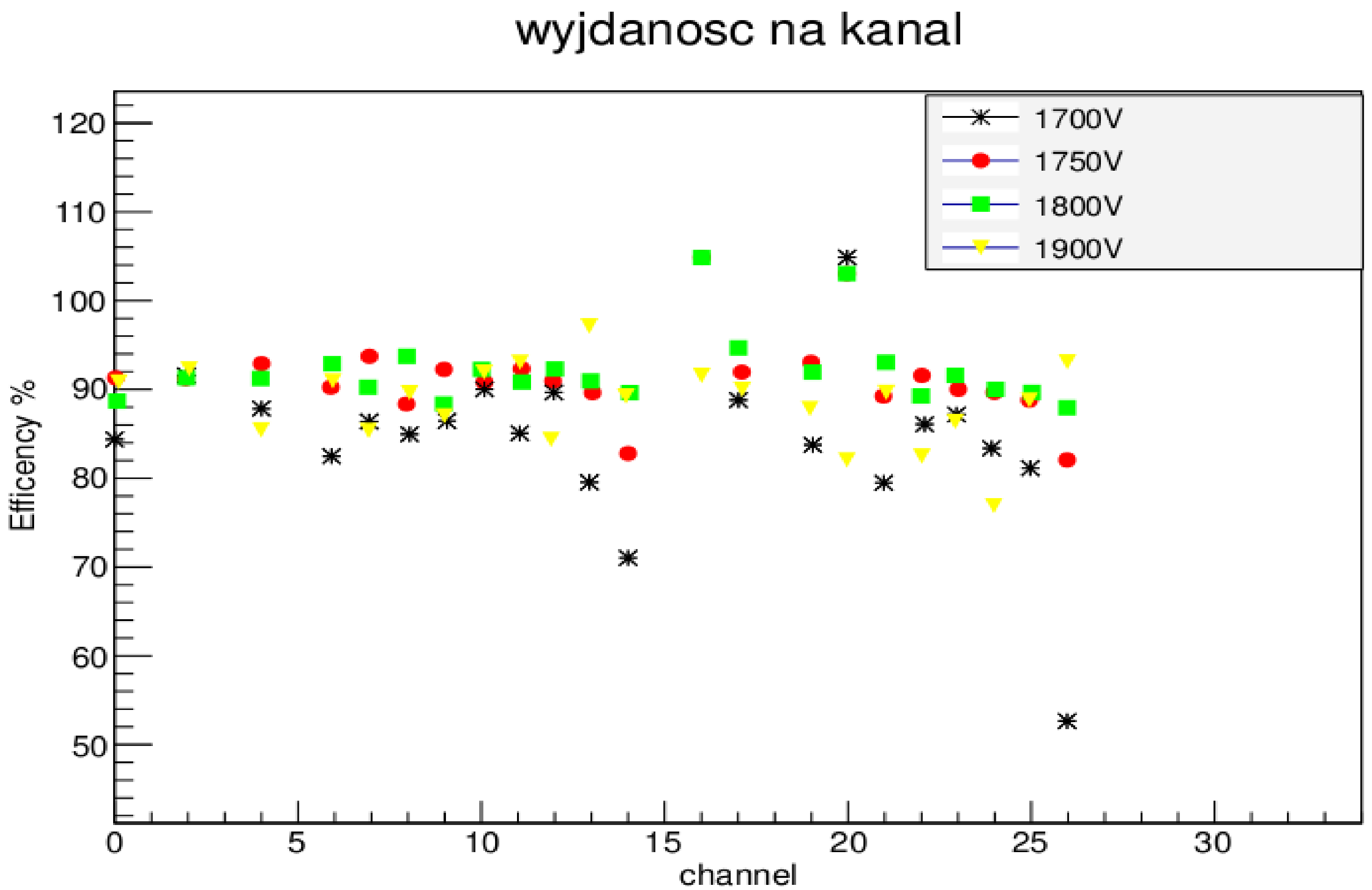


- 80% of track were reconstructed (10 straw track taken in to consideration),tracks are lost due to high threshold setting (signals coming form particles crossing the tube close the anode wire are lost)
- A new calibration improved the spatial resolution ~150 um

Efficiency Study

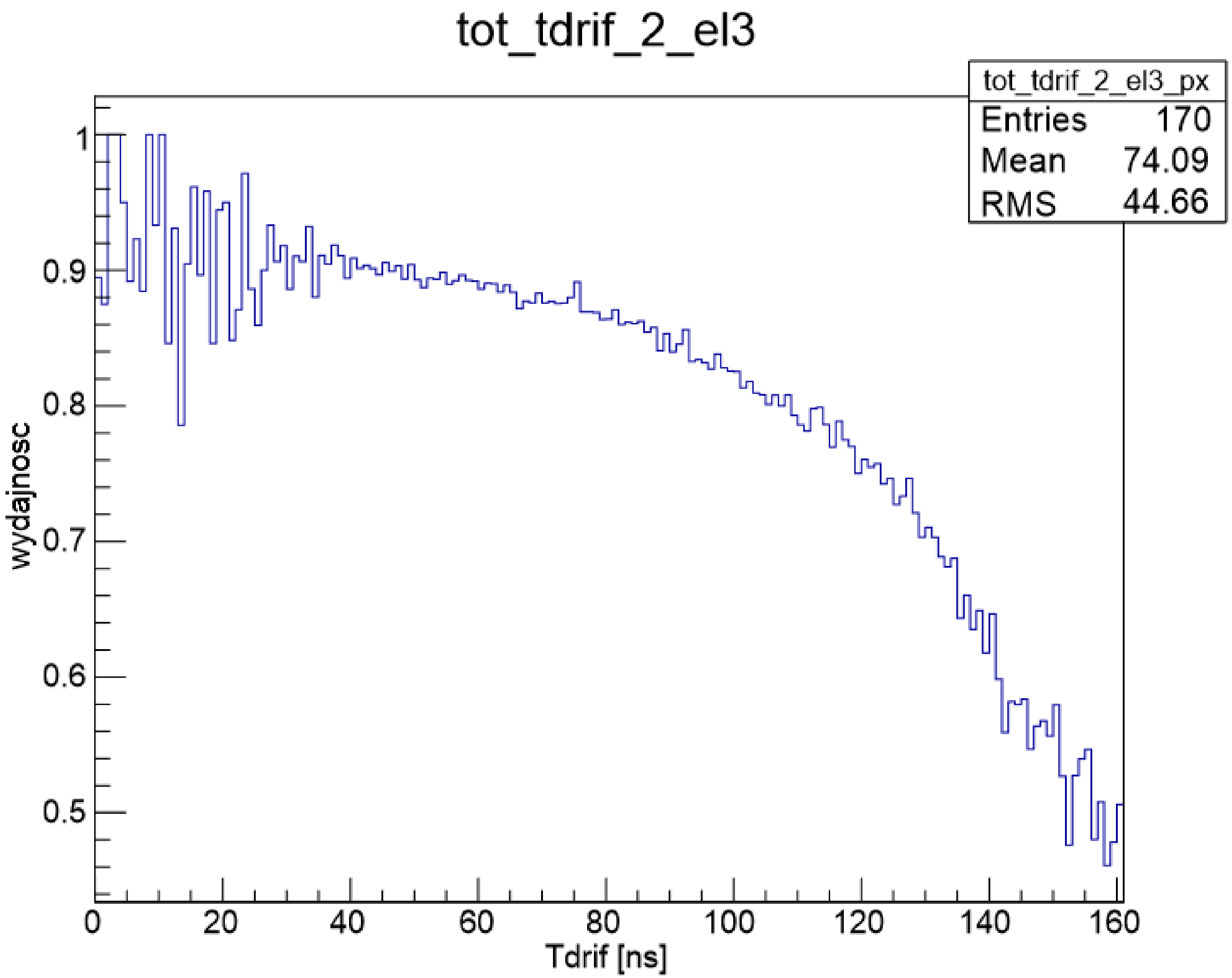
- ToT vs. Drift time spectra were made for j and j + 4 straws (the number of entries were obtained)
- The same was done for straw j + 2
- (Number of entries) [j + 2]/[j & j + 4] * 100%





Efficiency per channels

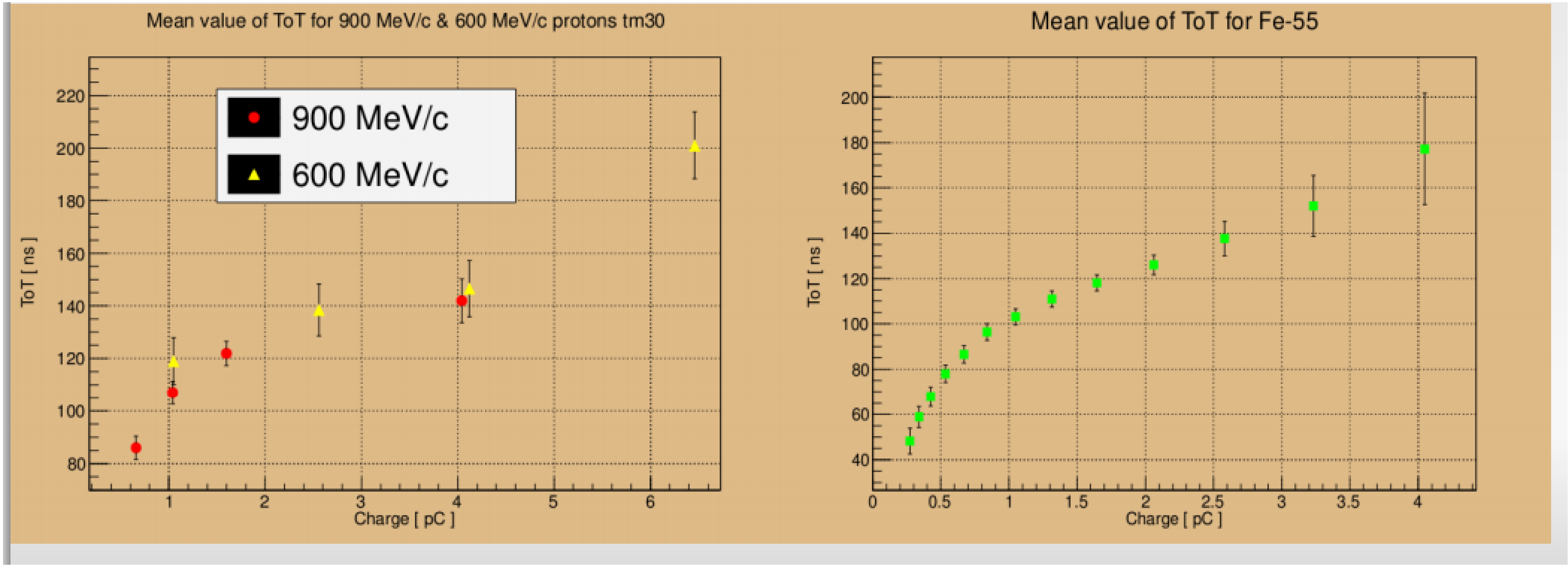
- For each channel the efficiency in a function of the radius was calculated.



ToT & Energy resolution

Reminder: ToT vs Energy Loss distributions (dE with the Bethe- Bloh formula)

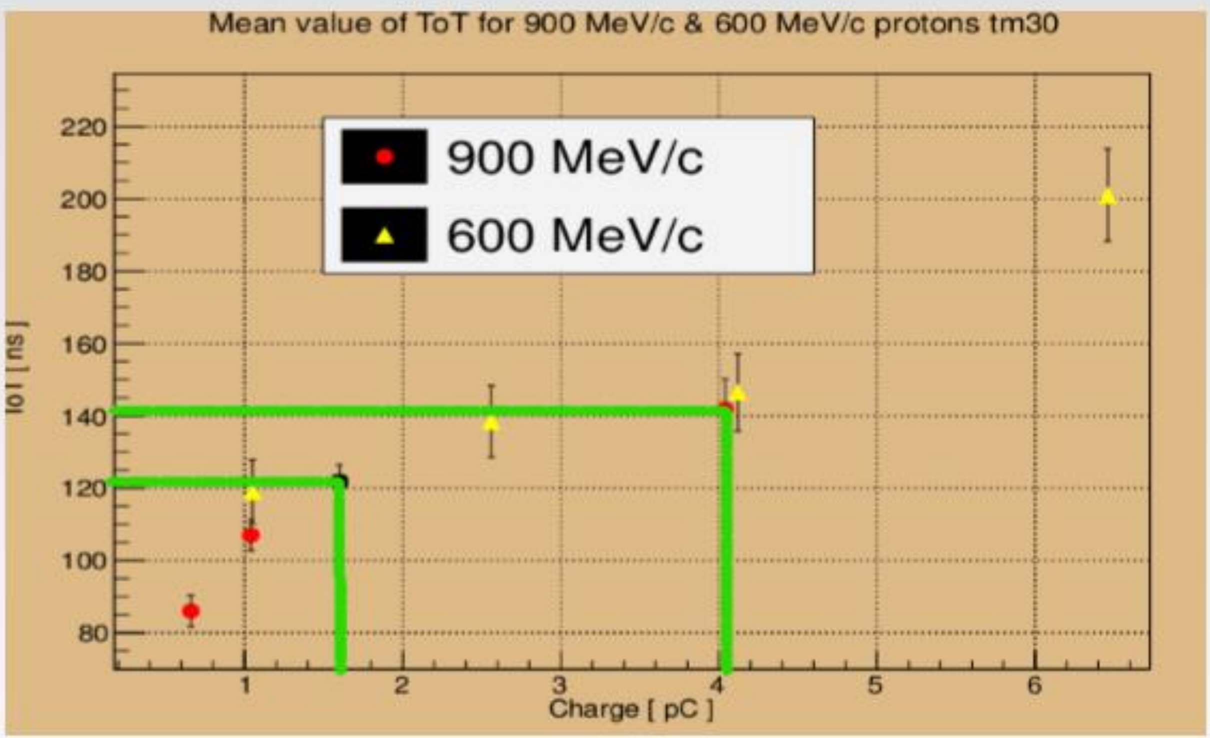
on the left data from the proton beam and on the right data coming form the Fe-55 source



Reminder II

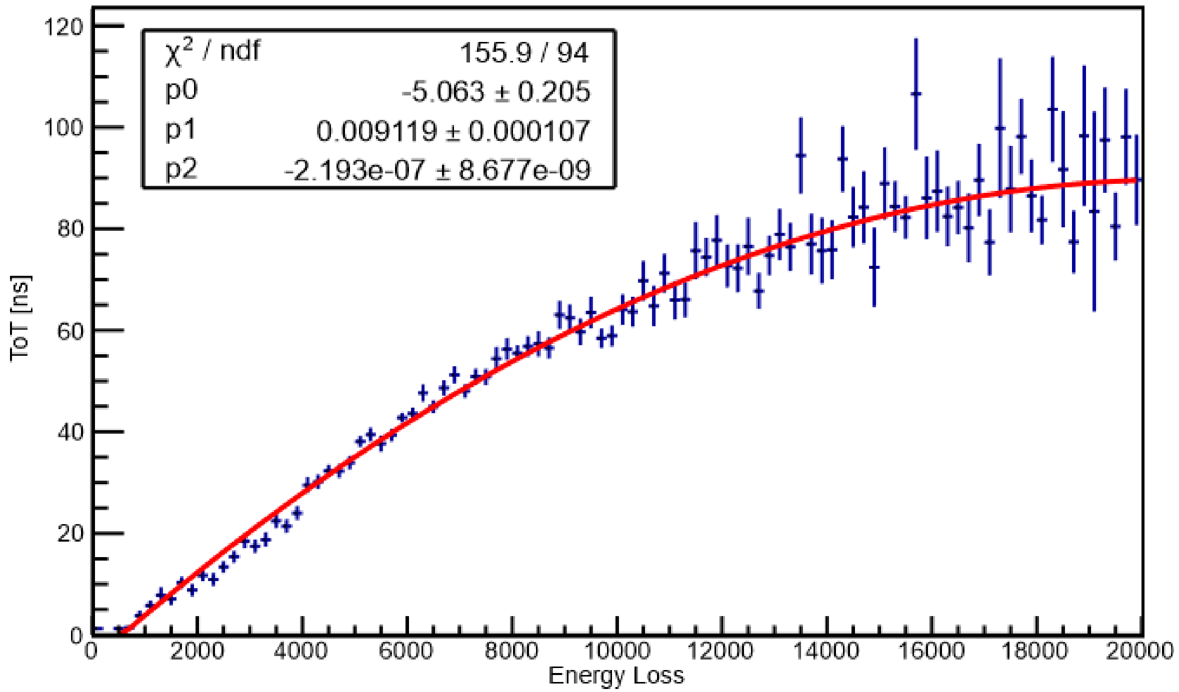
- The Energy Resolution calculations shown previously (Cracow meeting) for the ToT (R = 9.8% for Fe-55 and 11% for 900 MeV/c protons)

$$\frac{\delta E}{E} = \frac{\sigma ToT_1}{ToT_2 - ToT_1} * \left(\frac{Q_2 - Q_1}{Q_1}\right)$$

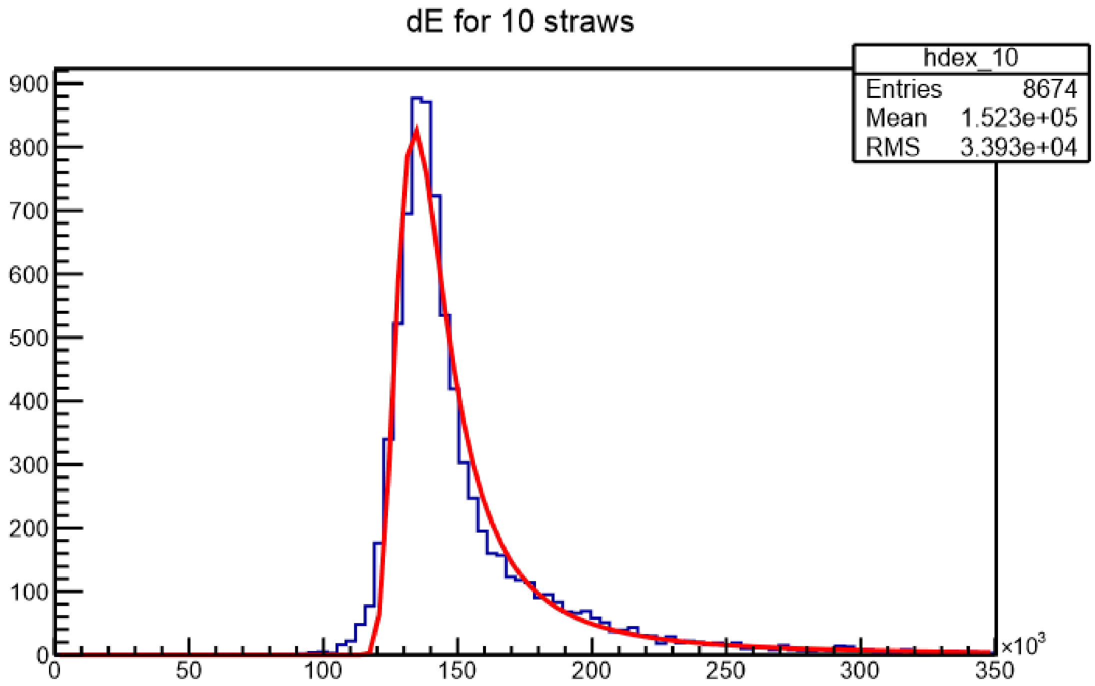


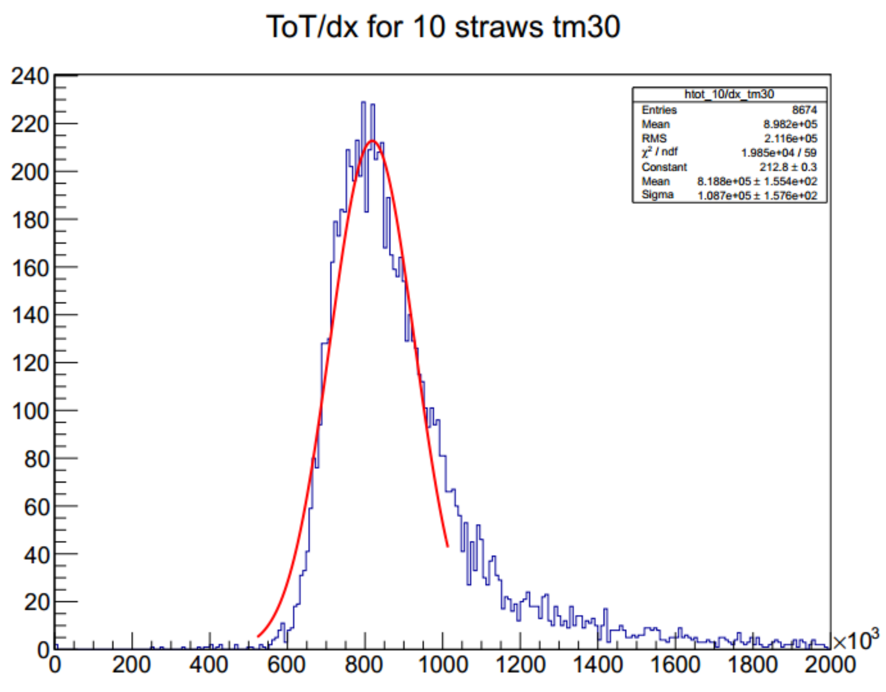
Data coming from the Flash ADC, ToT (done by software) vs Energy Loss distributions were made for each channel.

The plot was fitted with a second degree polynomial to obtain the calibration function



- dE/dx distributions were made for the TRB + ASIC data with the use of the obtained function
- The distribution follows the expected Landau shape
- Truncated mean was preformed (30% „cut off”)
- R = 12% (for 10 straw tracks)

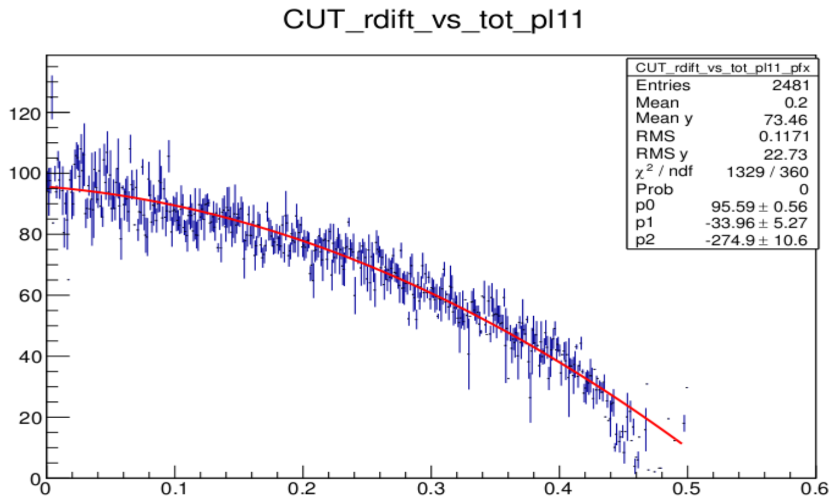


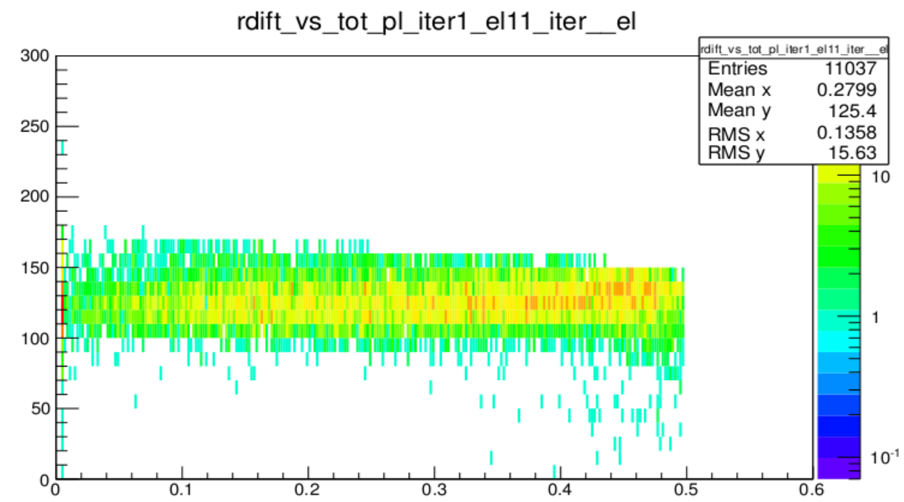


- After tracking one can calculate the ToT vs drift radius distributions (as shown below)
- To lose the dependency of ToT to the distance from the anode wire one can calibrate via 2nd degree polynomial

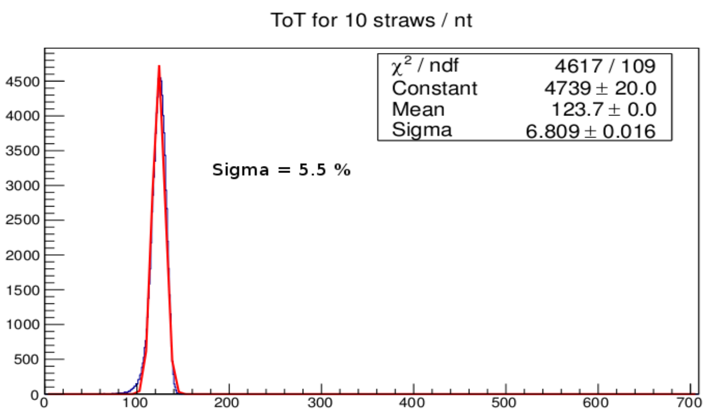
By fitting a 2[nd] degree poly to the ToT vs. rdrift plot one obtains a function of ToT(tdrif) with is used to calibrate the ToT and in effect one drops the dependence of ToT from the center of the tube

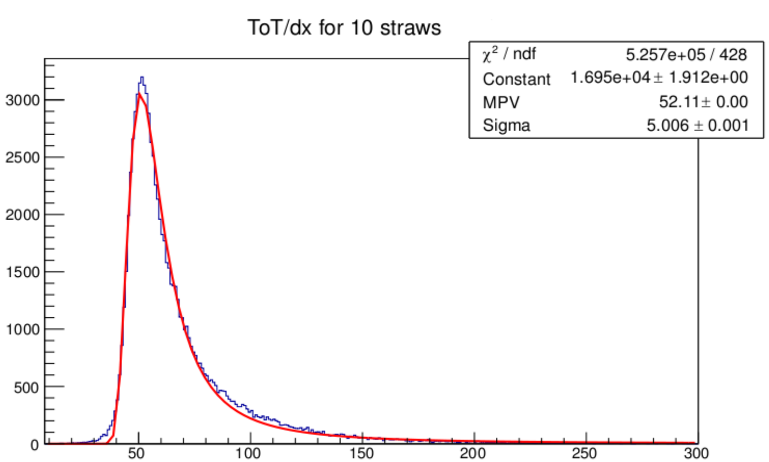
- As a result one obtains a distribution shown on the second figure

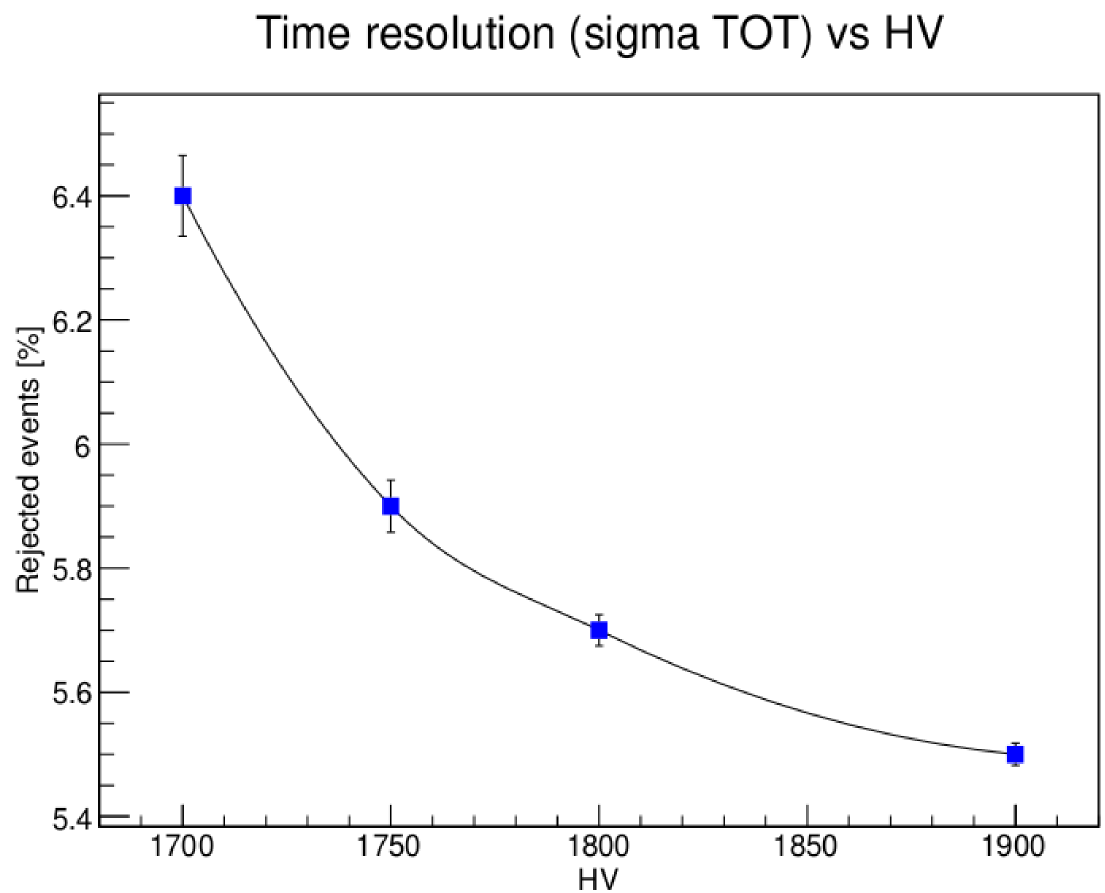




- Spectra for 10 straw tracks were calculated
- ToT/dx and ToT distributions were made
- Landau like shape of ToT/dx (expected due to the fact of linear relation between ToT vs dE at 1900V (4 pC for 900 MeV/c protons)) shows that dx is calculated as it should be







Summary

- Energy resolution calculated (10 straw tracks) for the calibration curve (Flash ADC data) is almost the same as the calculations done for the TRB setup (R =10%/11% for TRB & 12% for Flash ADC)
- ToT (10 straw tracks) time resolution at 5%, ToT/dx follows Landau distribution (expected)
- A dE/dx analysis for ASIC & fADC data is coming soon!

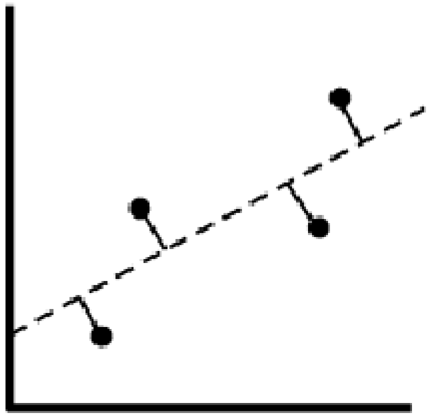
Thank You!

Backup Slides

- Pre-prefit
- Prefit
- Intersection finder
- Refit

- Finding the first track hypothesis

$$R_{\perp} = \sum_{i=1}^{N} d_i \qquad d_i = \frac{|y_i - (a + bx_i)|}{\sqrt{1+b^2}}.$$



- Where ”d” is the distance from the center of the
- firing tube to the fitted line
- The obtained a and b are used to call Minuit class and preform the prefit
- If the mean value of ”d” is above 0.5 cm the procedure is repeated

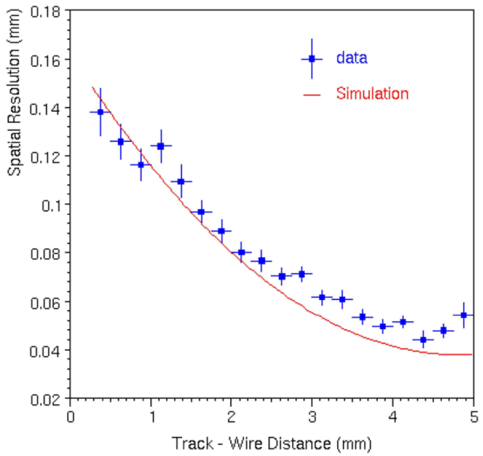
- A ROOT Minuit class is called to preform a prefit
- The next function with is going to optimized:

$$\chi^2 = \frac{1}{N-2}\sum_{i=1}^{N}\left(\frac{\Delta r_i(a,b)}{\sigma_{r_{i,raw}}}\right)^2,$$

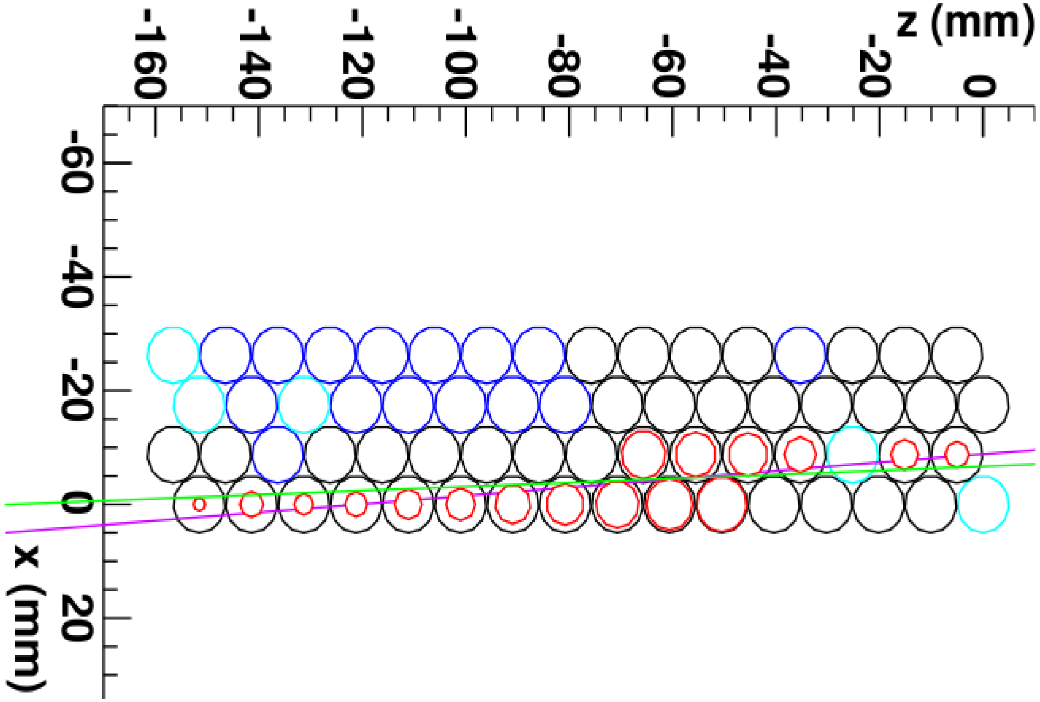
- $\sigma_{ri,raw-}$ is obtained by fitting a six degree polynomial
- First set of residuals is being calculated.

$$\Delta r_i = r_{i,fit}(a,b) - r_{i,raw} = \frac{|y_i - (a+bx_i)|}{\sqrt{1+b^2}} - r_{i,raw}.$$

- $\Delta_{ri} > 0.2$ cm the track is rejected



Finding the intersections between the obtained track and the calculated drift circles



The procedure starts with using Minuit calls and minimalizing the function below:

$$\chi^2 = \sum_{i=1}^{N_{hits}} \frac{d_i^2}{\sigma_{d_i,tot}^2}, \quad d_i^2 = \left[\frac{y_i - (a + bx_i)}{\sqrt{1+b^2}}\right]^2$$

Where the sigma is related to (x,y) with are the coordinates of the intersection with the drift circle:

$$\sigma_{d_i,tot}^2 = \frac{\sigma_{i,y}^2}{1+b^2} + \frac{b^2\sigma_{i,x}^2}{1+b^2}.$$

Another set of residuals is calculated (same way as in prefit) and a cut is applied (above 0.2 cm) to eliminate the influence form delta electrons

As a result of previous calculations one obtains a finale track with is represented by the blue line