university of groningen / kvi - center for advanced radiation technology

JÜLICH FORSCHUNGSZENTRUM

Beam test results for the flash ADC- readout

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Outlines

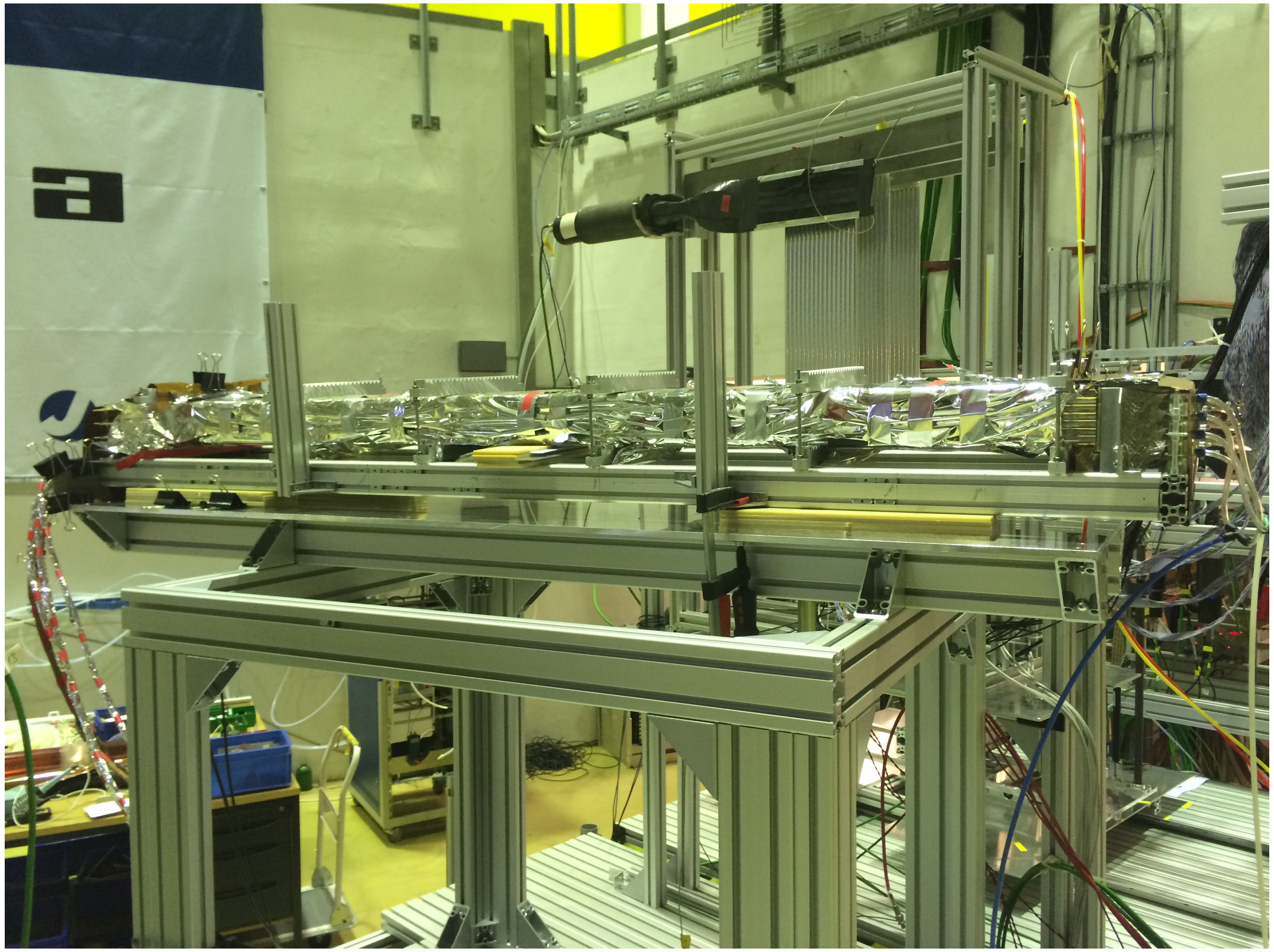
- Beam time setup April 2016
- Analysis method review
- Results of spatial and energy resolution
- Summary and outlook

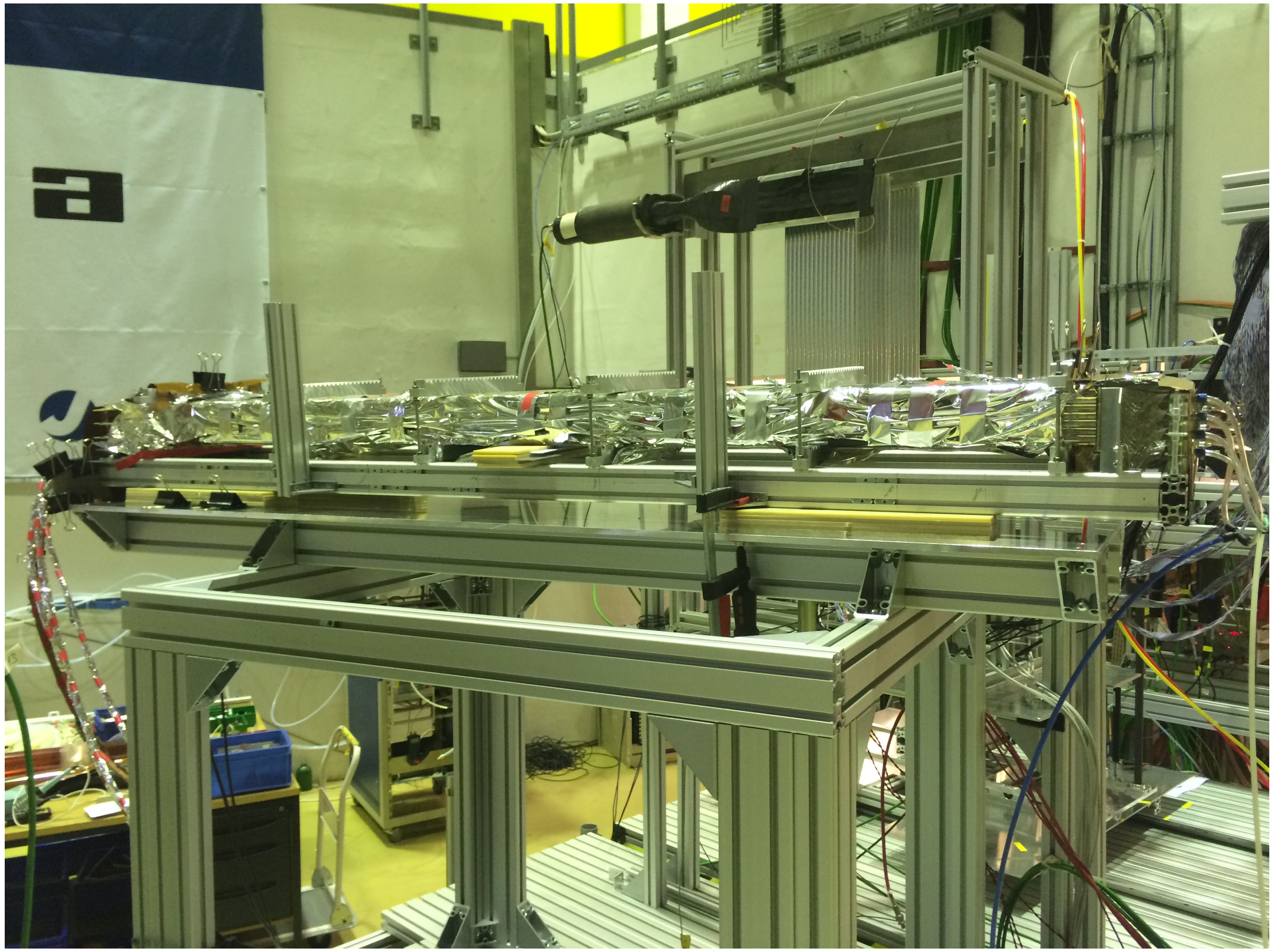
STT beam test in April 2016

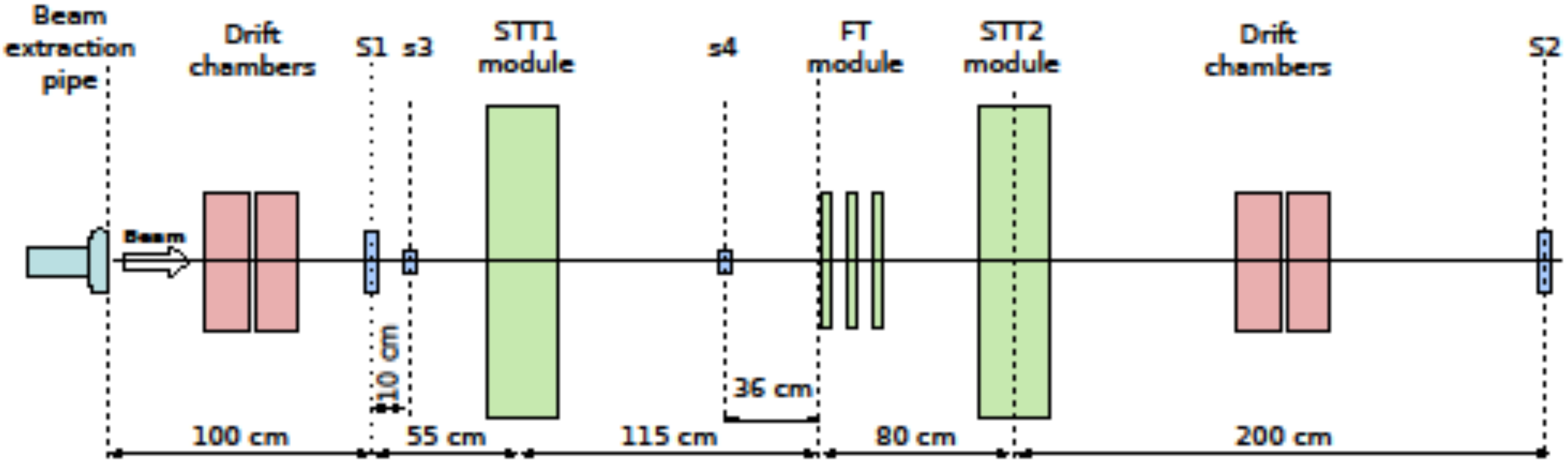
- For the first time in COSY-TOF area, almost 10 days beam with time 3 prototype detectors

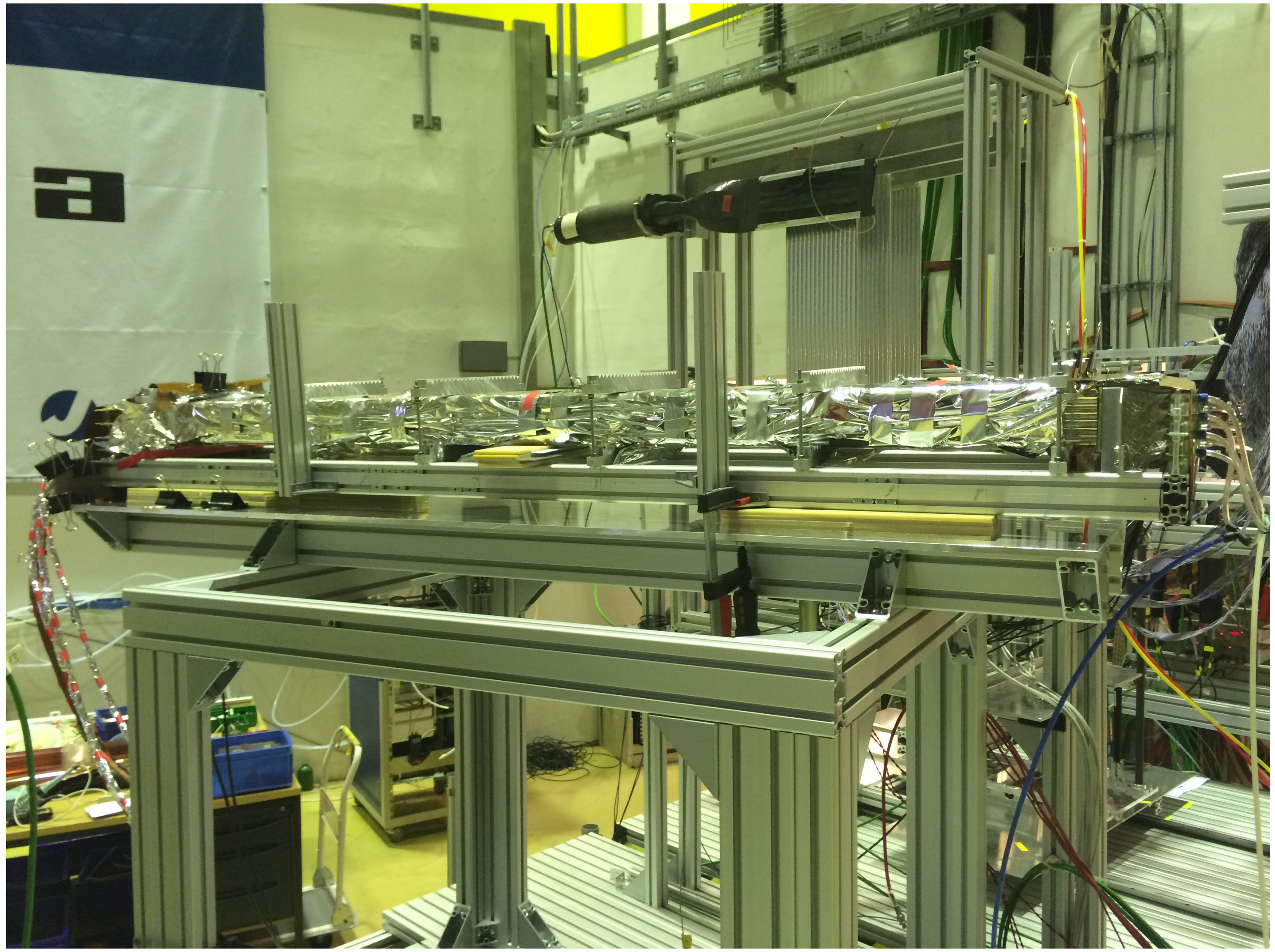
1. STT with flash ADC read out
2. STT with ASIC read out
3. Forward tracker with ASIC readout

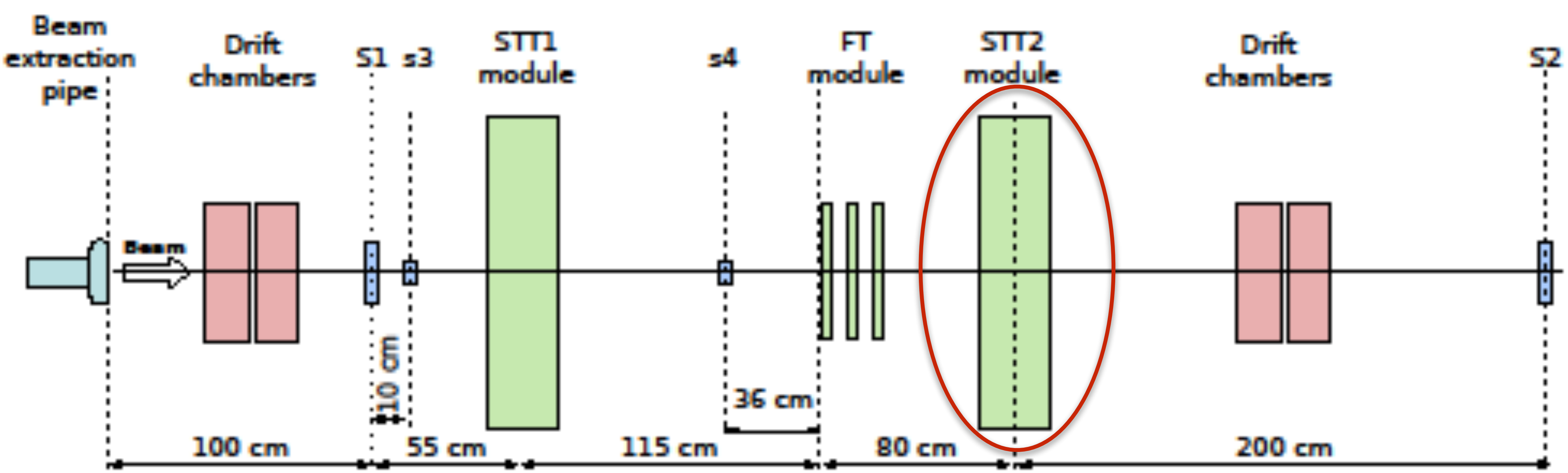
- Proton beam with 4 different momenta (0.55 GeV/c, 0.75 GeV/c, 1.00 GeV/c and 2.95 GeV/c)
- Different high voltages (1750V, 1800V & 1850V)






Beam extraction pipe
Drift chambers
S1
s3
STT1 module
s4
FT module
STT2 module
Drift chambers
S2
Beam
10 cm
36 cm
100 cm
55 cm
115 cm
80 cm
200 cm

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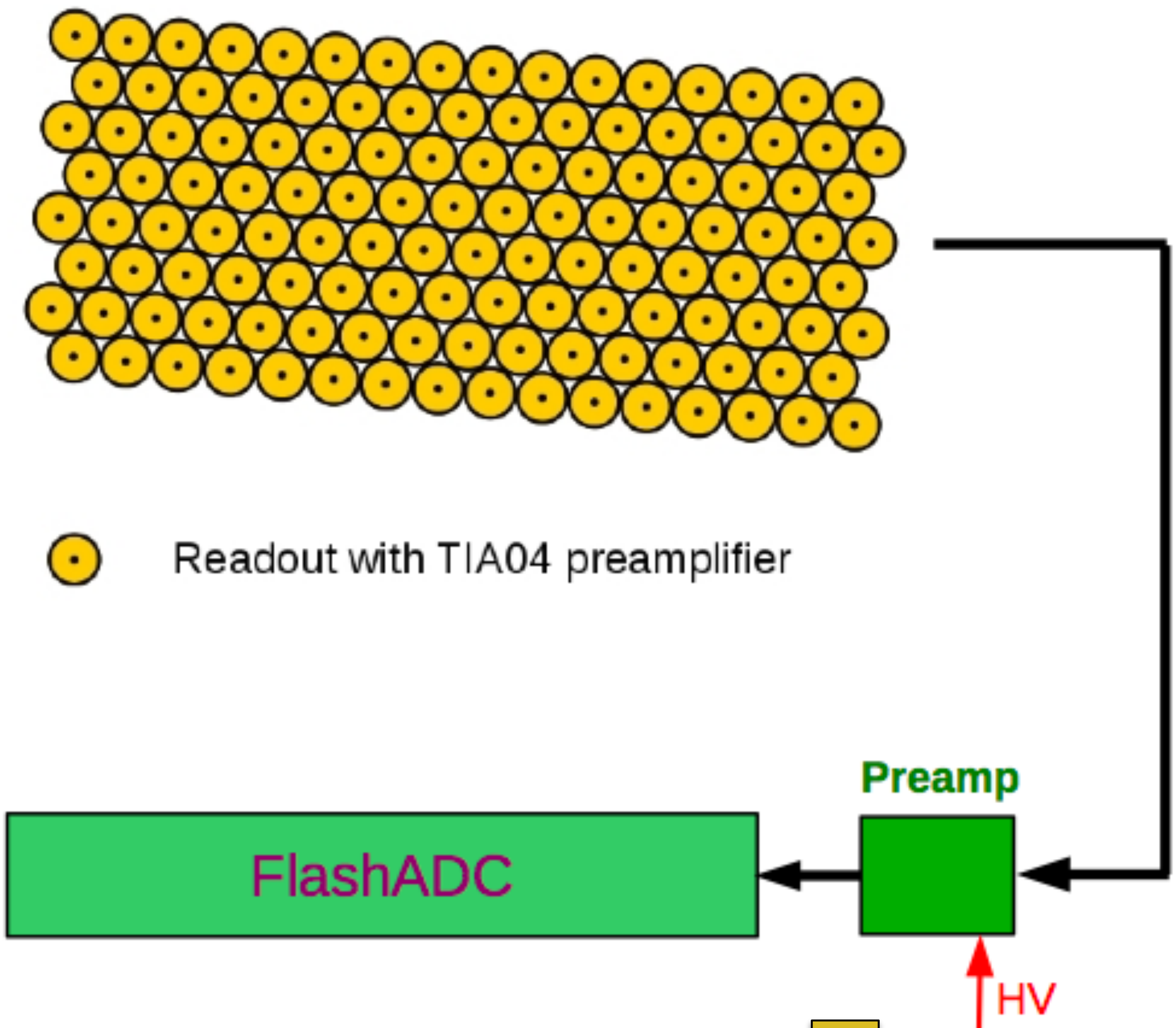
Proton beam



0.55 GeV/c
0.75 GeV/c
1.00 GeV/c
2.95 GeV/c

12 m coax Cable Signal/HV

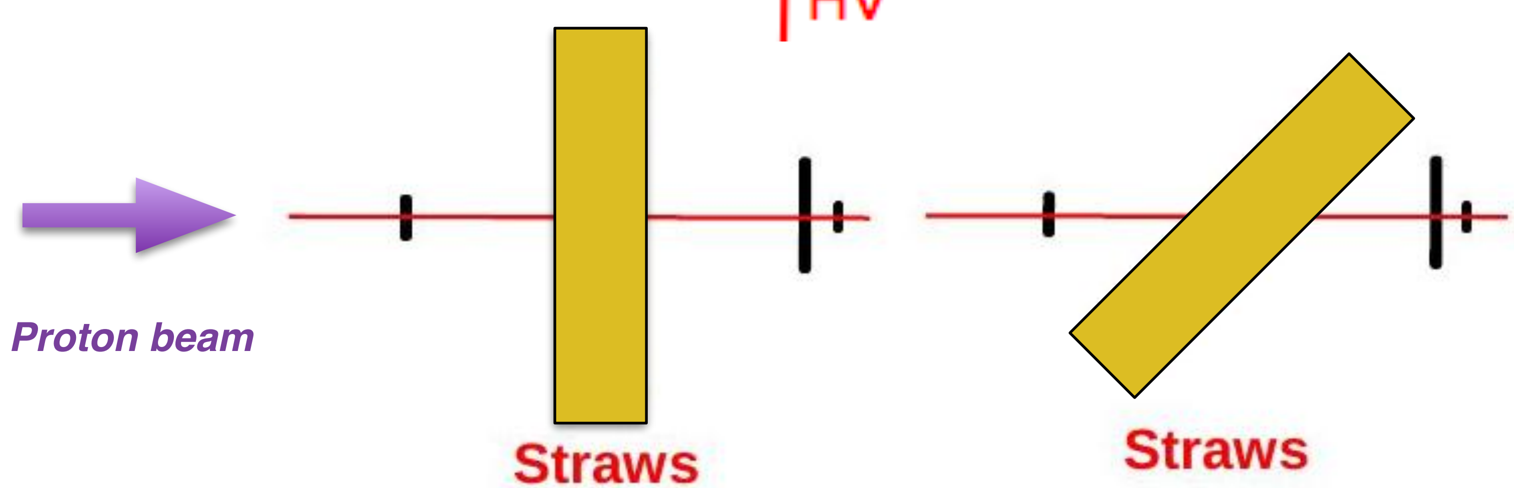
MK7501

75 Ω

Various beam intensities

Different Proton impinging angle:

90deg, 23deg,18deg



Analysis Method

1. Tracking

2. Energy loss measurement

Analysis Method

1. Tracking

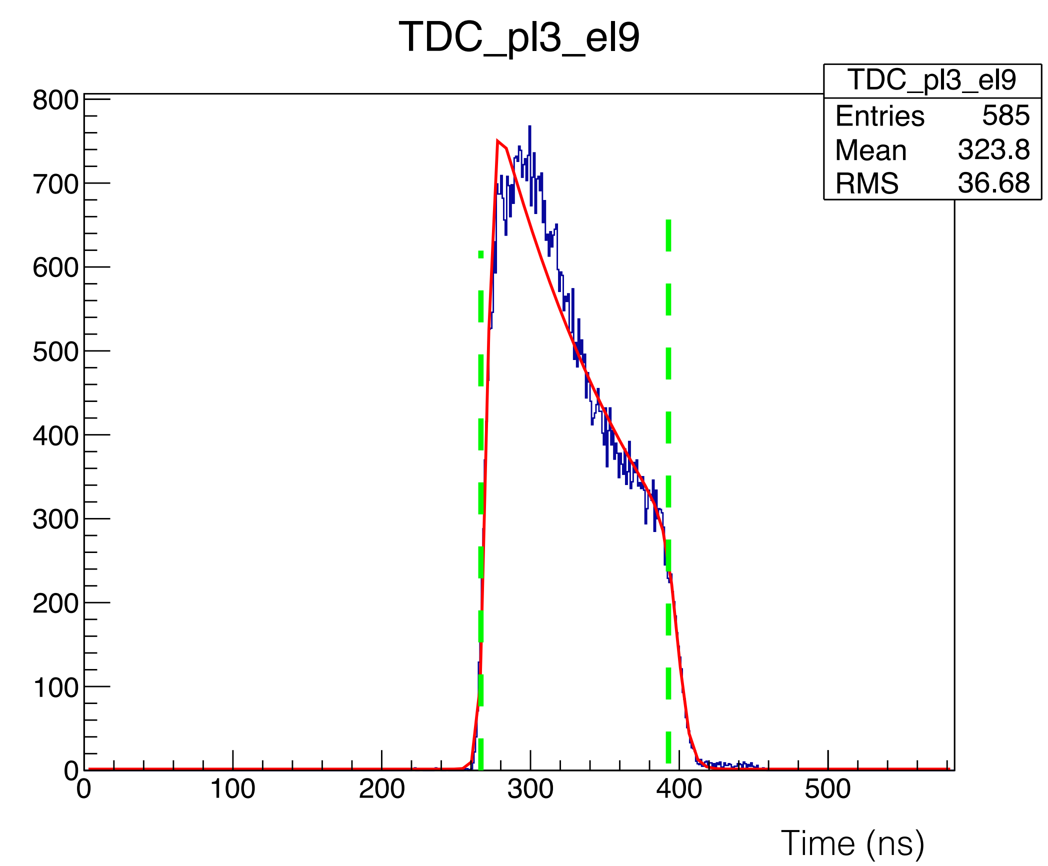
- Drift time spectra
- Calculation of radius-drift time (calibration curve)
- Track reconstruction
- Calculation of the path length

Analysis Method

- For each tube the parameters of the drift time distribution are derived from the fit performed with the following empirical function:

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

- The minimum and maximum drift times, t_0 and t_{max} , corresponds to a track traversing the tube close to the wire and to the cathode wall.
- The value of t_0 , depends on delays of signal cables and front-end electronics, and HV setting.
- $\Delta t = t_{max} - t_0$ depends only on the drift properties of the tubes.



Fitted time spectrum of an illuminated tube

Analysis Method

The primary information from the tubes:

Analysis Method

The primary information from the tubes: → The drift time distribution of the arriving signals, the number of tracks traversing the tubes within a time interval:

Analysis Method

The primary information from the tubes:

$$\frac{\mathrm{d}n}{\mathrm{d}r} = \frac{N_{\mathrm{tot}}}{R_{\mathrm{tube}}}$$

$$\frac{\mathrm{d}n}{\mathrm{d}t} = \frac{\mathrm{d}n}{\mathrm{d}r}\frac{\mathrm{d}r}{\mathrm{d}t} = \frac{N_{\mathrm{tot}}}{R_{\mathrm{tube}}}\frac{\mathrm{d}r}{\mathrm{d}t}.$$

$$r(t) = \frac{R_{\mathrm{tube}}}{N_{\mathrm{tot}}}\int_0^t \frac{\mathrm{d}n}{\mathrm{d}t'}\mathrm{d}t'.$$

n is the number of tracks and r is the wire distance.

The drift time distribution of the arriving signals, the number of tracks traversing the tubes within a time interval:

Analysis Method

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$$r(t_i) = \frac{\sum_{i=1}^{i_t} N_i}{N_{tot}} \cdot (R_{tube} - R_{wire}) + R_{wire}.$$

$$r(t) = p_0 + p_1 t + p_2(2t^2 - 1) + p_3(4t^3 - 3t) + p_4(8t^4 - 8t^2 + 1) + p_5(16t^5 - 20t^3 + 5t)$$

Analysis Method

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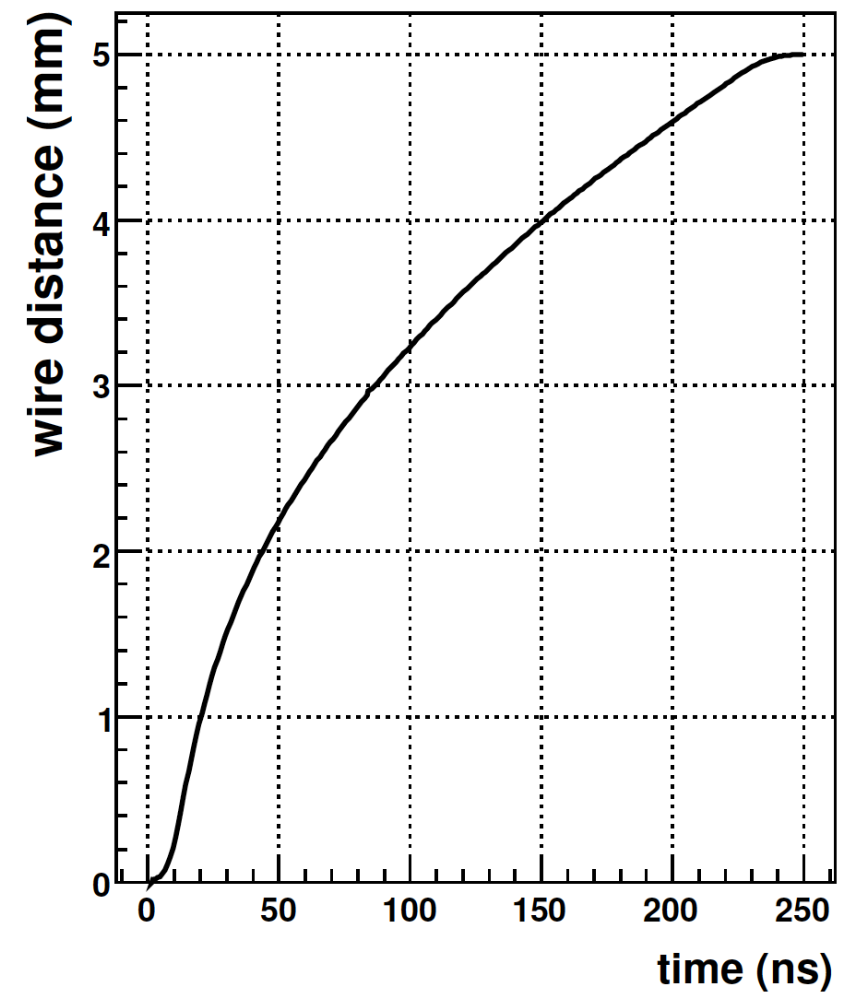
The drift time distribution of the arriving signals, the number of tracks traversing the tubes within a time interval:



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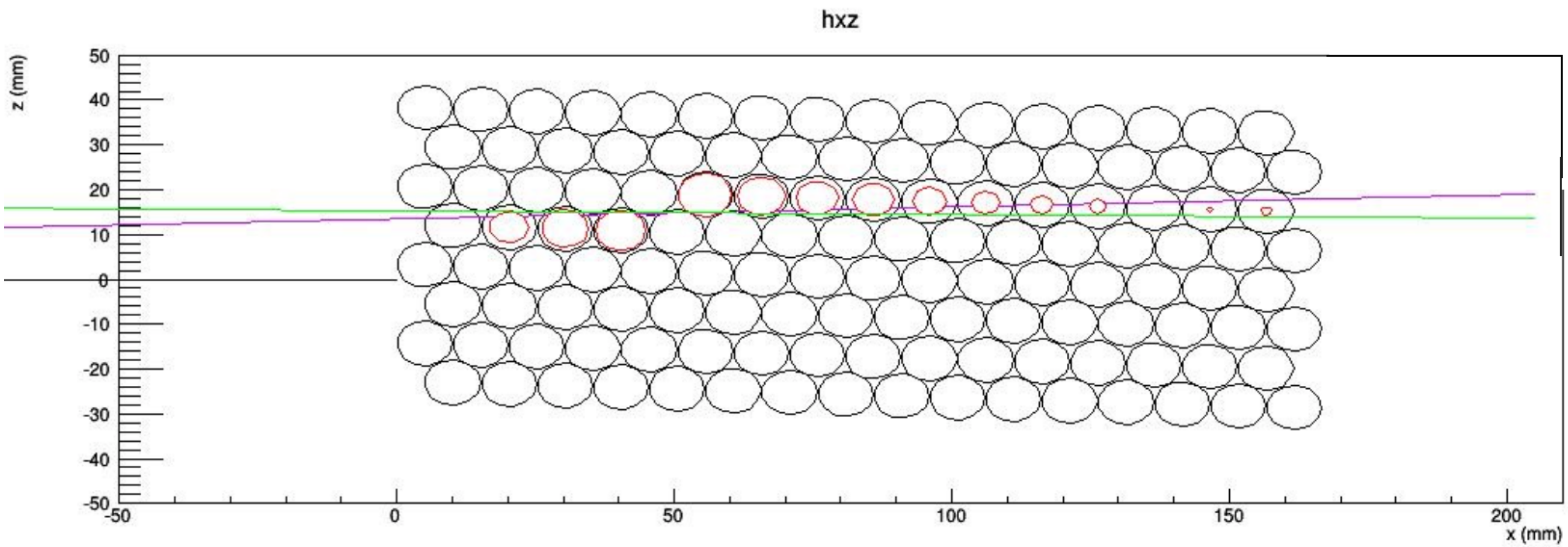
Track reconstruction

1. Pre-prefit
2. Pre-fit using Minuit
3. The Intersection Finder
4. Refit by using Minuit minimization

The observables measured by the straw tubes are not the (x; y) coordinates of the particle hits, but the (x; y) coordinates of the firing wires and the drift times.



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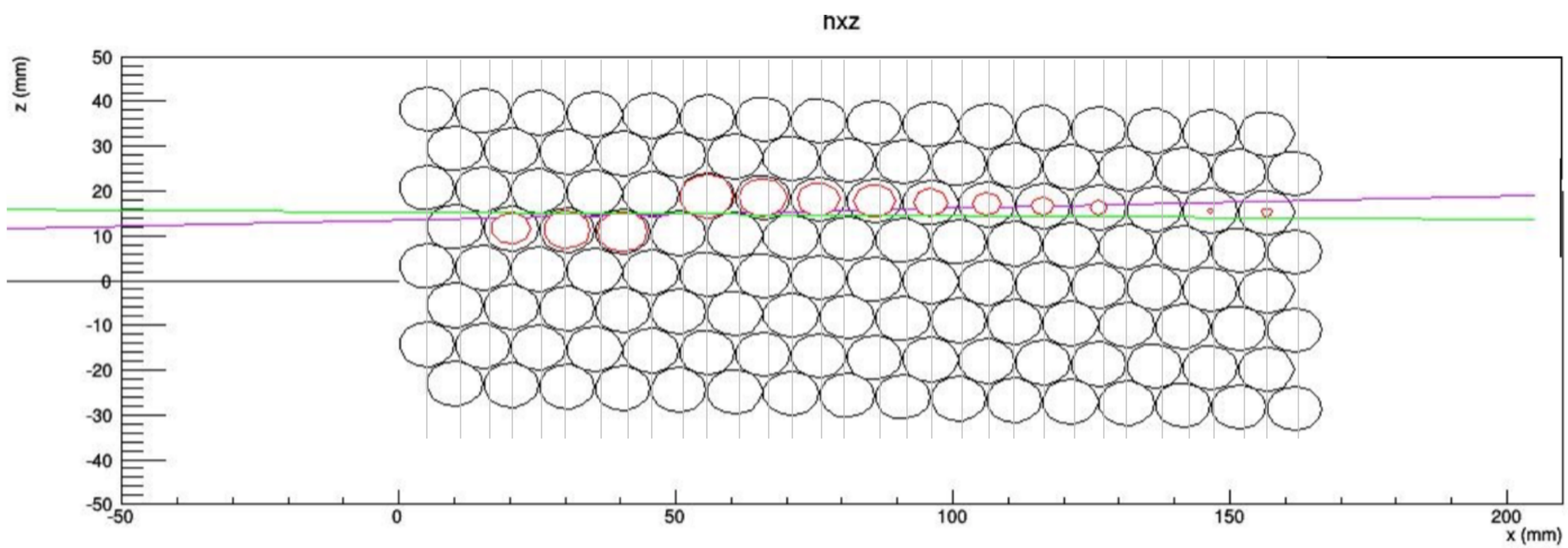
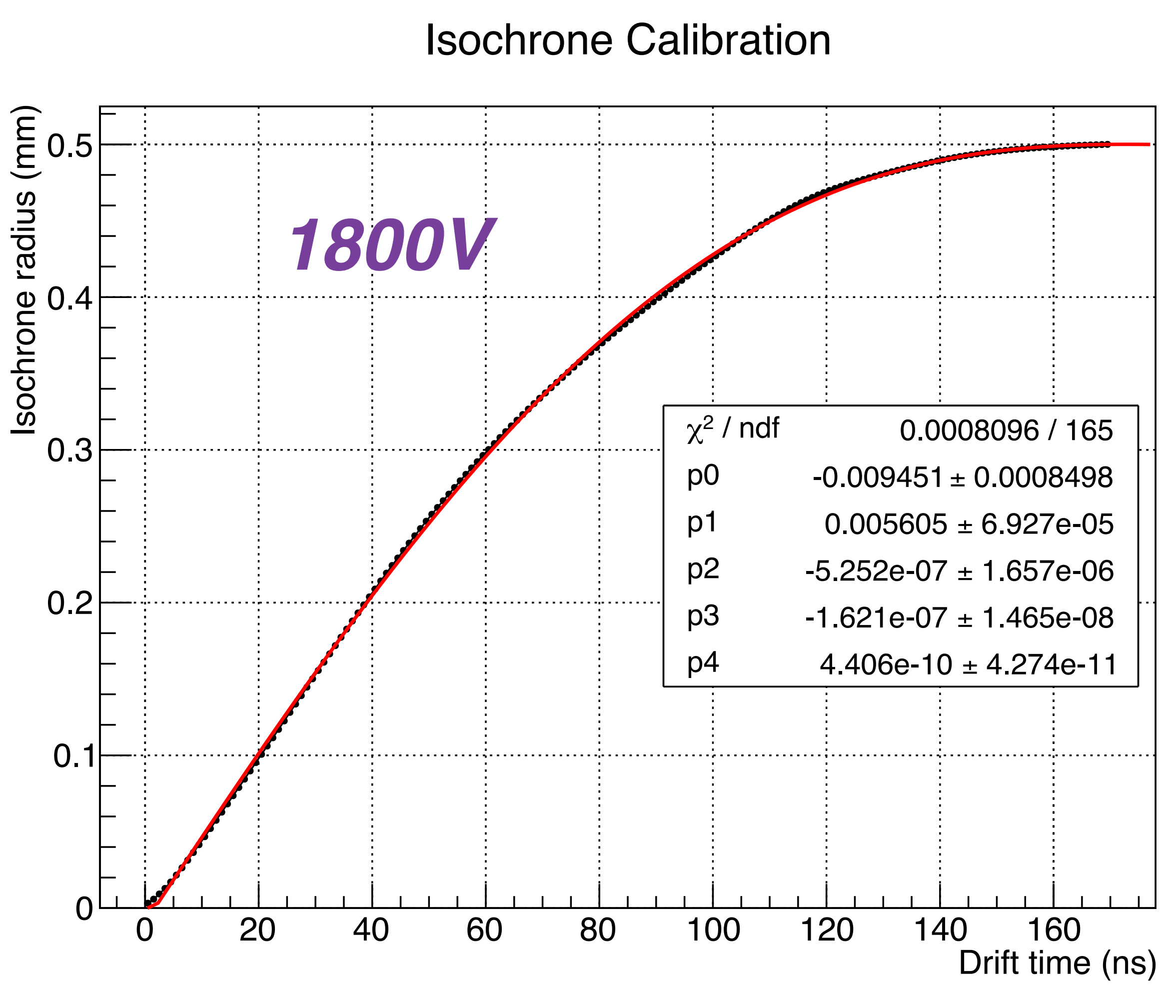
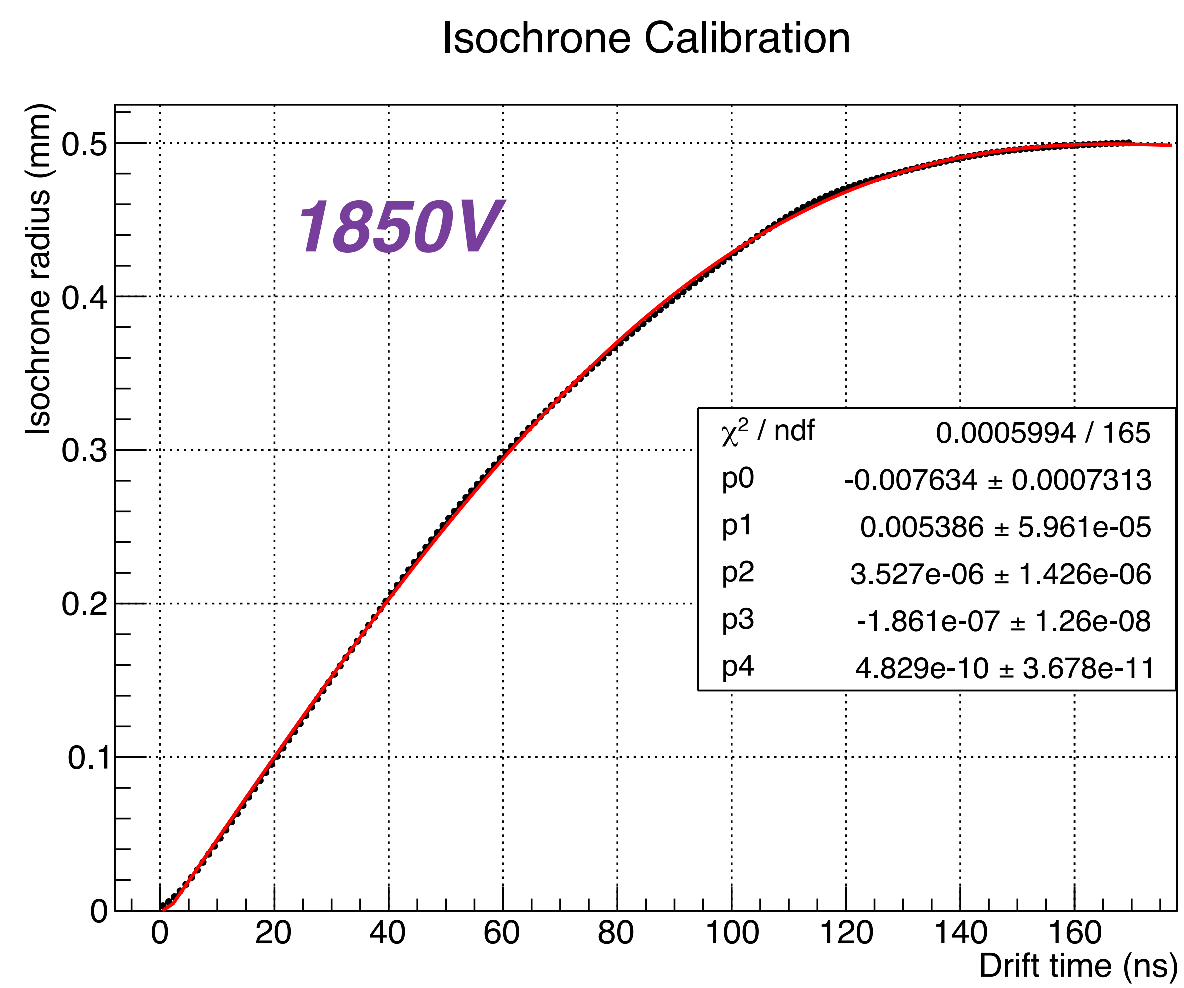


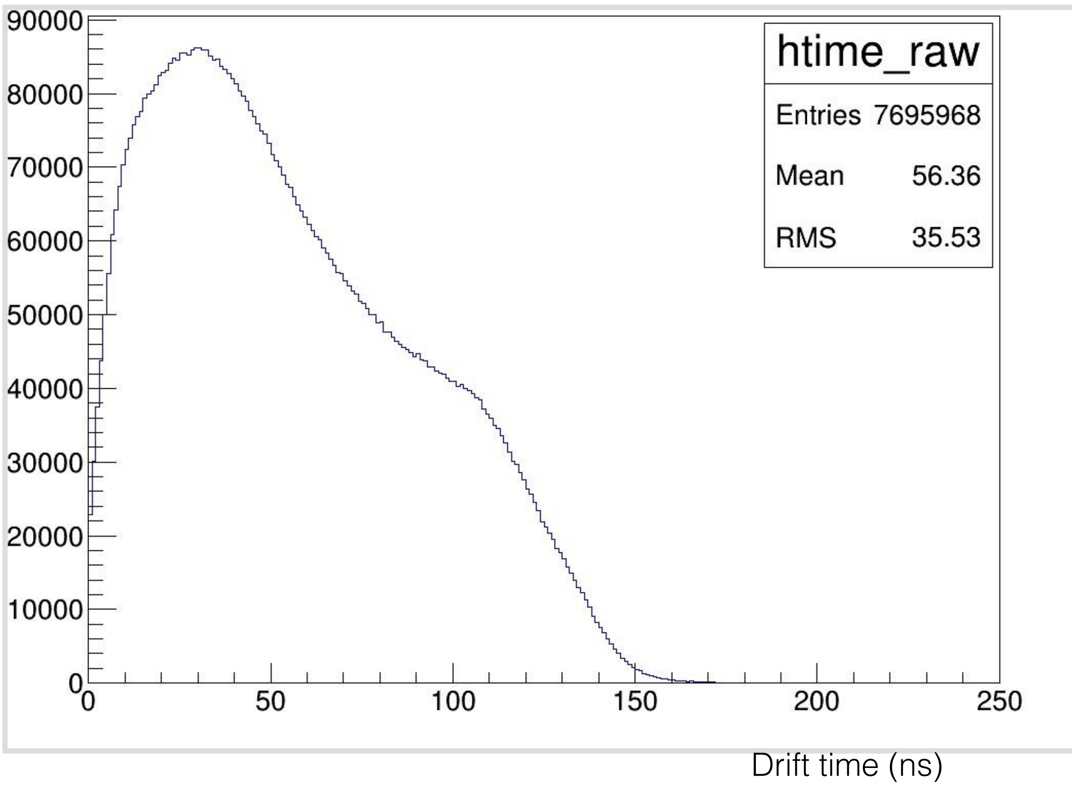
Data from April 2016, Isochrone calibration

- Clean beam condition, data taken for different intensities
- Equal samples of data collected at different momenta
- Obtained calibration curve used for the analysis of data

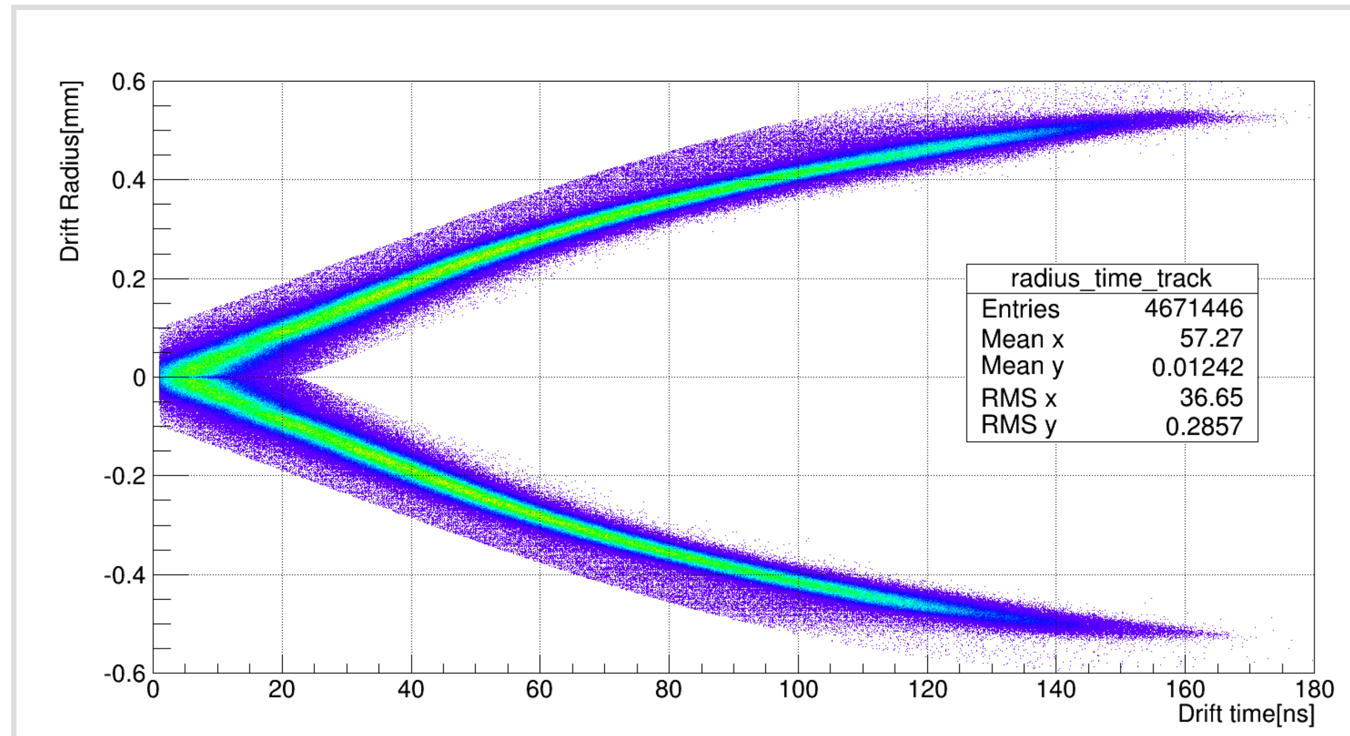




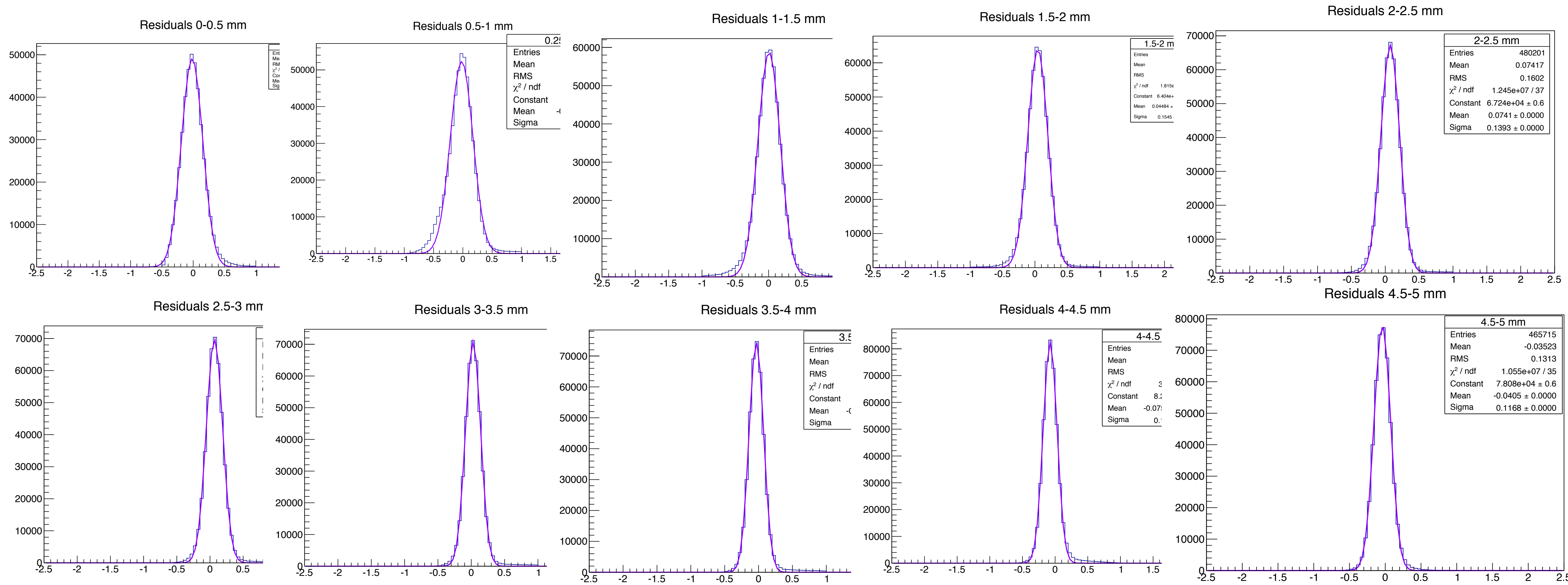
Drift Time



Drift Time - Drift Radius

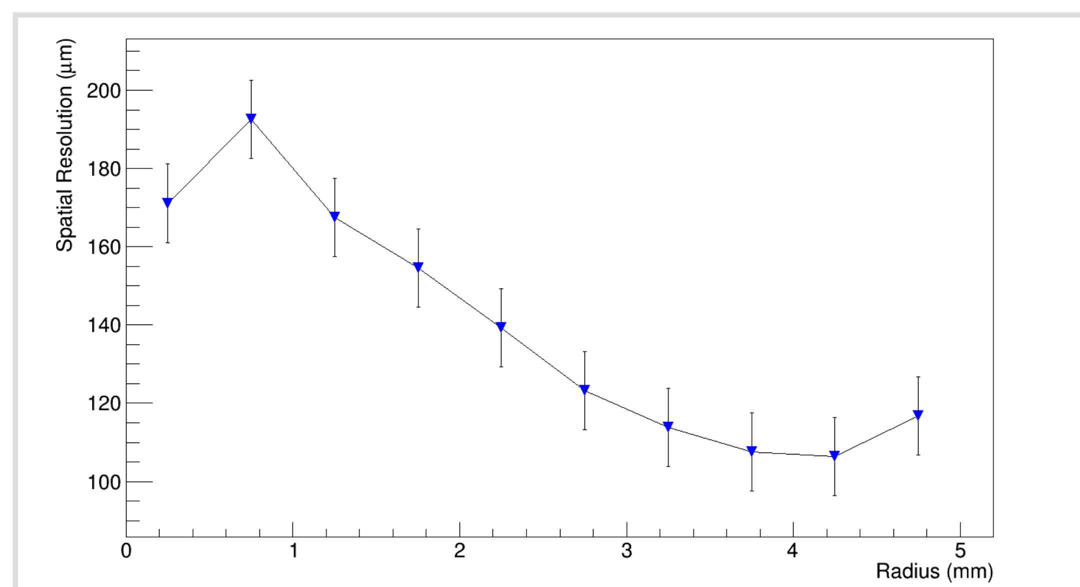


Residual distribution for 0.550 GeV/c, 1800V

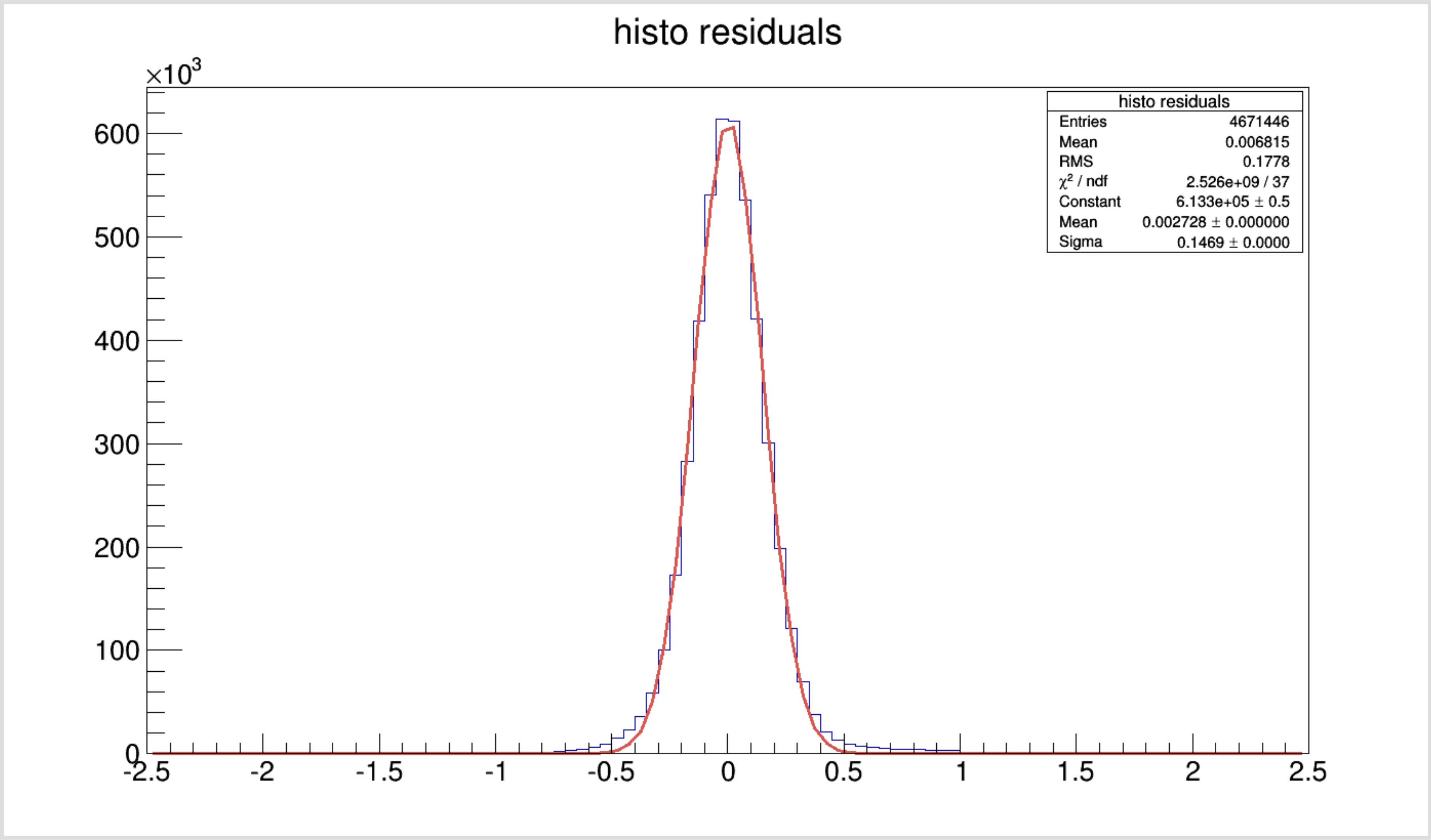


Spatial resolution

for 0.550 GeV/c, 1800V



Residual distribution for 0.550 GeV/c



The best achieved spatial resolution at 0.550 GeV/c proton momentum:

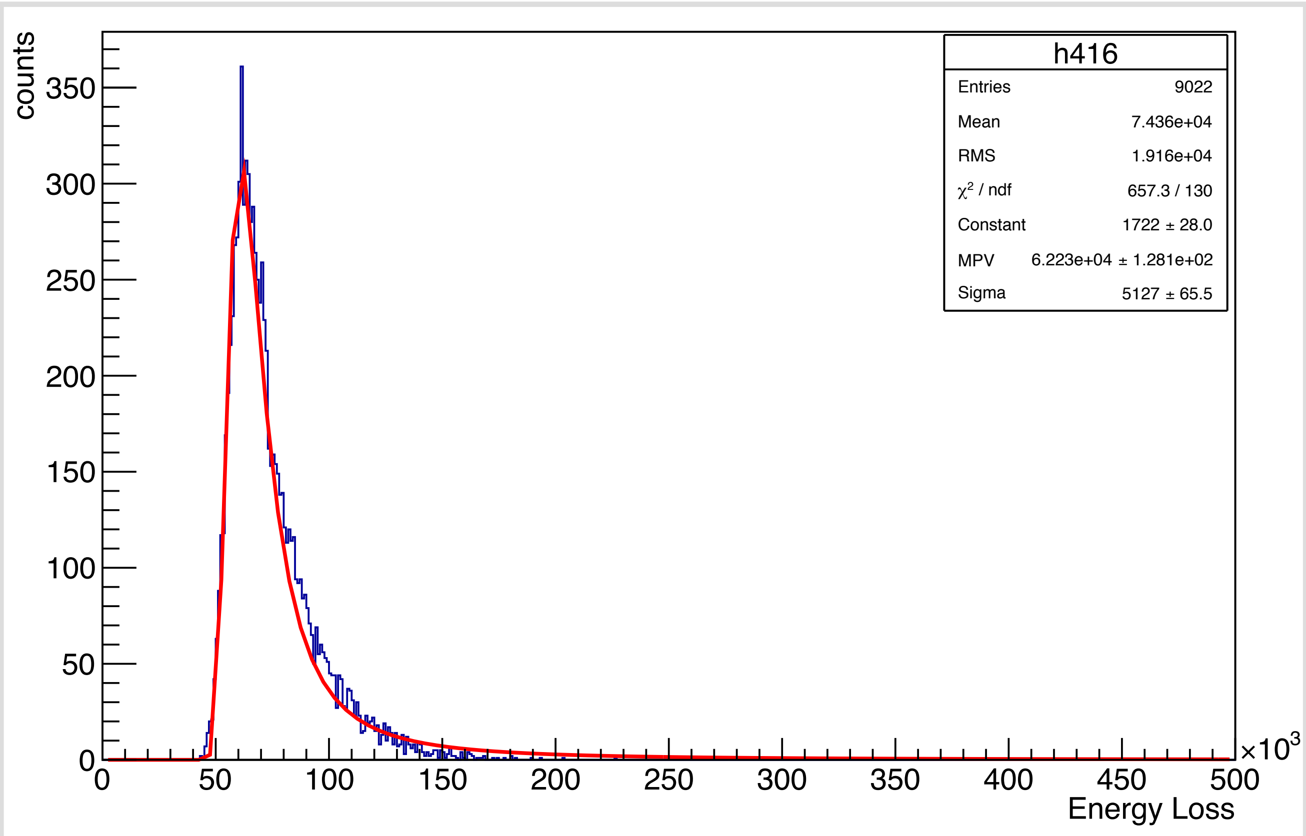
at 1800V is $\sigma_{\text{(spatial resolution)}} =$ 147± 1% (μm)

Analysis Method

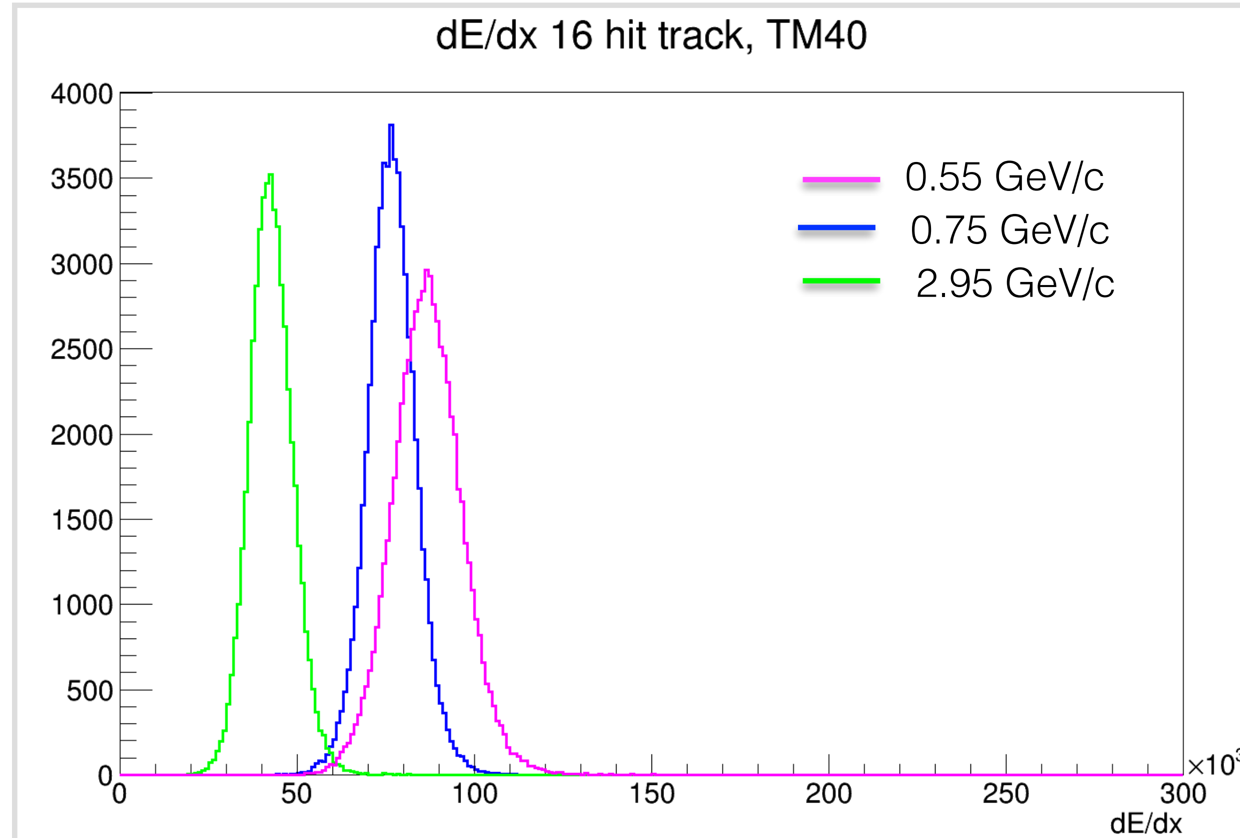
2.Energy loss measurement

- Energy loss spectra for reconstructed tracks
- Selective measurement of energy losses with Truncation mean(cut of largest energy losses per track)
- Calculation of path length for truncated events
- Calculation of specific energy losses per path length

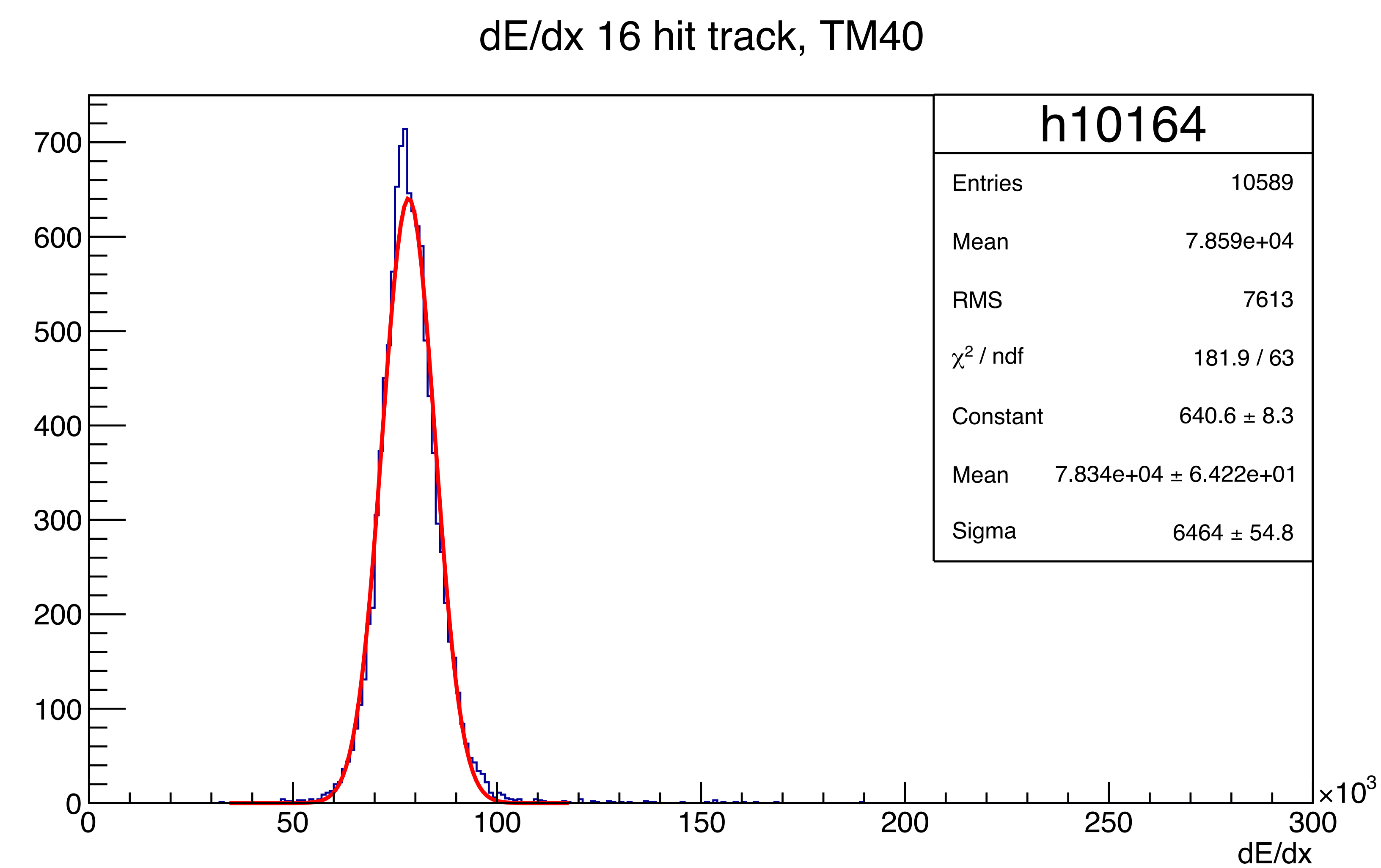
Energy loss for 16 straws at 1800V



Energy distribution for different momenta at 1800V



Results of the energy Resolution for example at 0.55 GeV/c

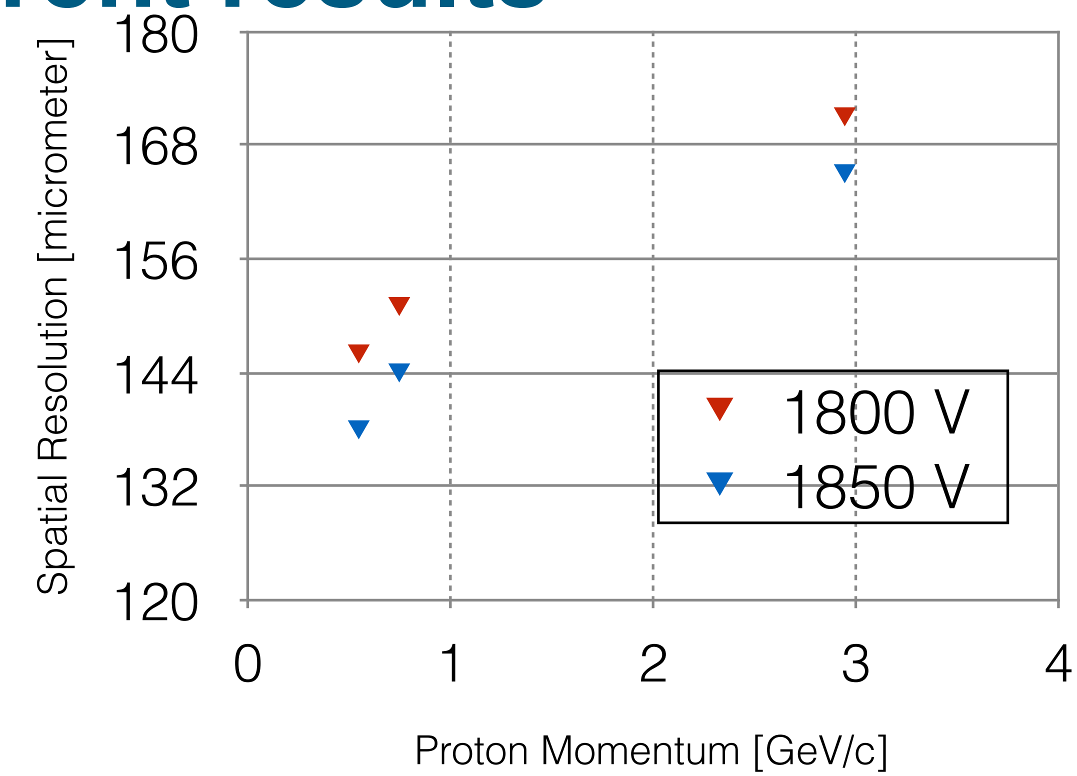


The best preliminary achieved energy resolution (with 16 straws and at 0.550 GeV/c proton momentum : $\sigma_{(dE/dx)} \sim 8.2\%$

Summary of current results

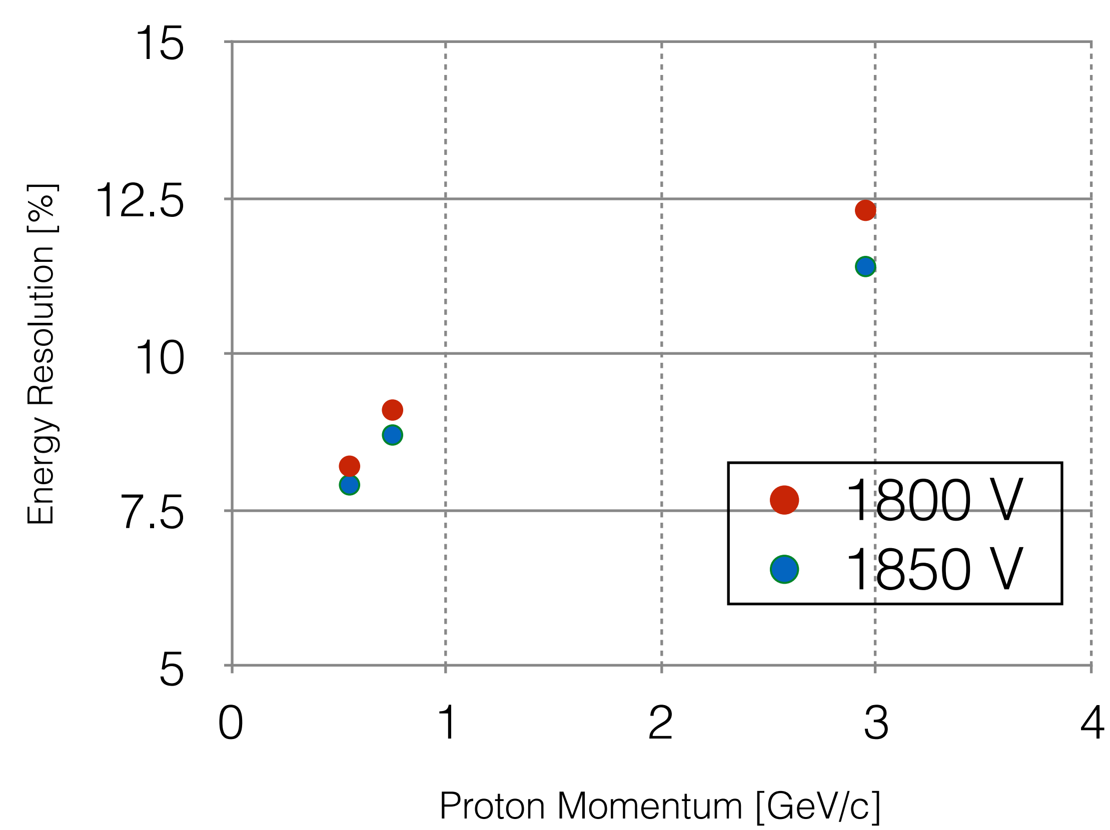
Summary of the results for reconstructed tracks of 16 hits

	Spatial resolution (μm) HV=1800 V	Spatial resolution (μm) HV=1850 V
0.550 GeV/c	146	138
0.750 GeV/c	151	145
2.95 GeV/c	171	165



For the energy resolution the truncation mean of 40% applied to initial dE/dx distributions

	Energy resolution [%] HV=1800 V	Energy resolution [%] HV=1850 V
0.550 GeV/c	8.2	7.9
0.750 GeV/c	9.1	8.7
2.95 GeV/c	12.3	11.4



Summary & Outlook

- The first beam test in COSY- TOF area was successful
- Clean beam condition, data taken for different intensities, low noise level smaller than 6 mV
- The results of the spatial and energy resolutions look good and promising
- Data analysis for is still in progress …
- New beam test (28 November till 04 December 2016) with deuteron beam in COSY-TOF area was successful and the new data analysis will be done in the near future.


Thank You!
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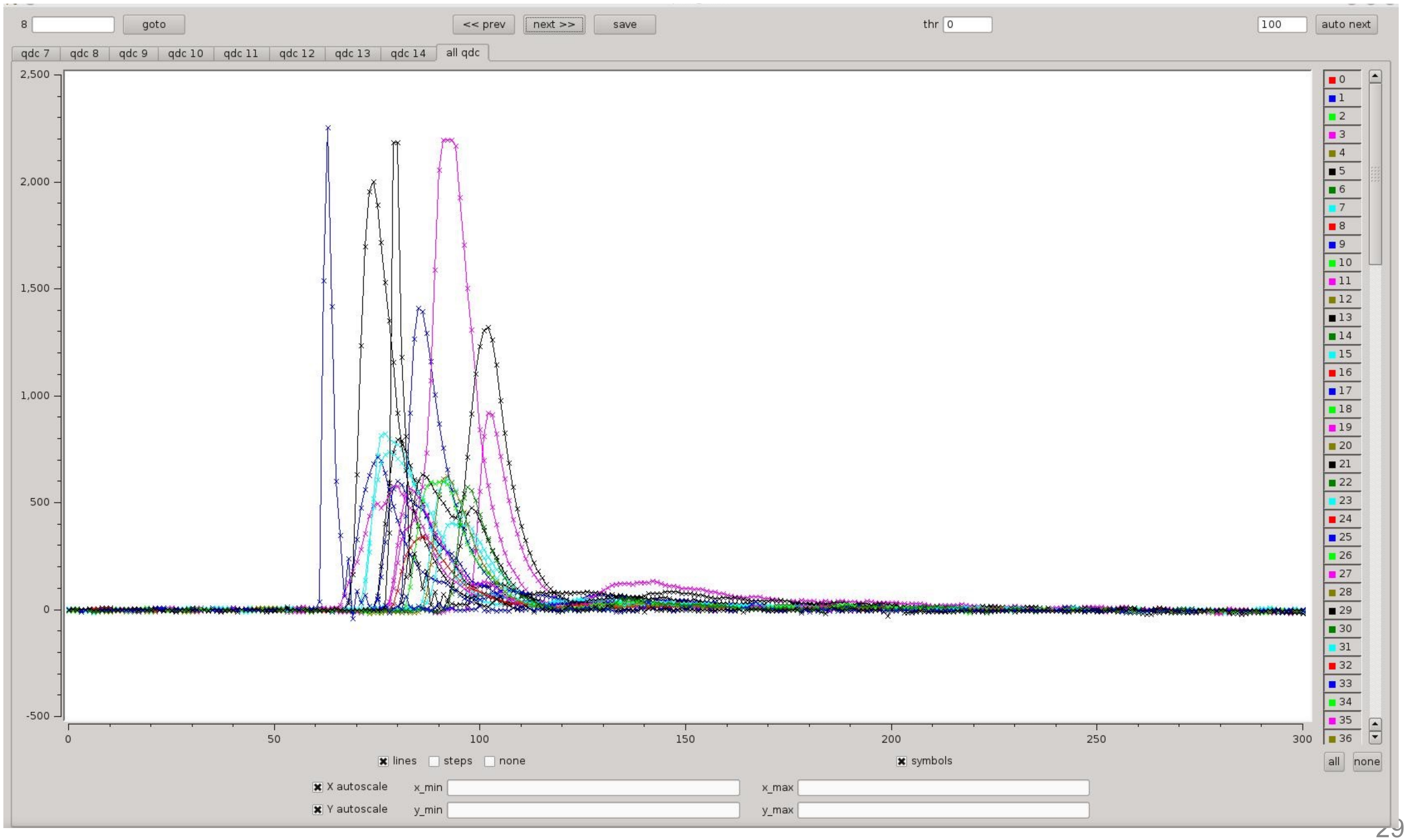
Back up

Analysis Method

1.Tracking

- Signal selection



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

The number of tracks *dn* traversing the tube within the time interval *dt*.
The minimum and the maximum drift times, t_0 and t_{max}
P_1 is the noise level
P_2 is a normalization factor
P_3 and P_4 are related to the shape of the distribution
P_5 and P_6 are the values of t_0 and t_{max}
P_7 and P_8 describe the slope of the leading and trailing edge of the distribution

where Δr_i is the residual of the i^{th} tube, defined as:

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

$r_{i,fit}$ is the distance of closest approach of the best fit line found in the center of tube i.

$r_{i,raw}$ indicates the radius computed using the r(t) relation

Zero crossing time calculated for highest steepness of leading edge