Analysis of experimental data measured by BM@N drift chambers

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BM@N - **B**aryonic **M**atter at **N**uclotron

The experiment is aimed at the study of hot compressed nuclear matter produced in collisions of heavy nuclei with emphasis put on strange matter production.

Physical program includes:

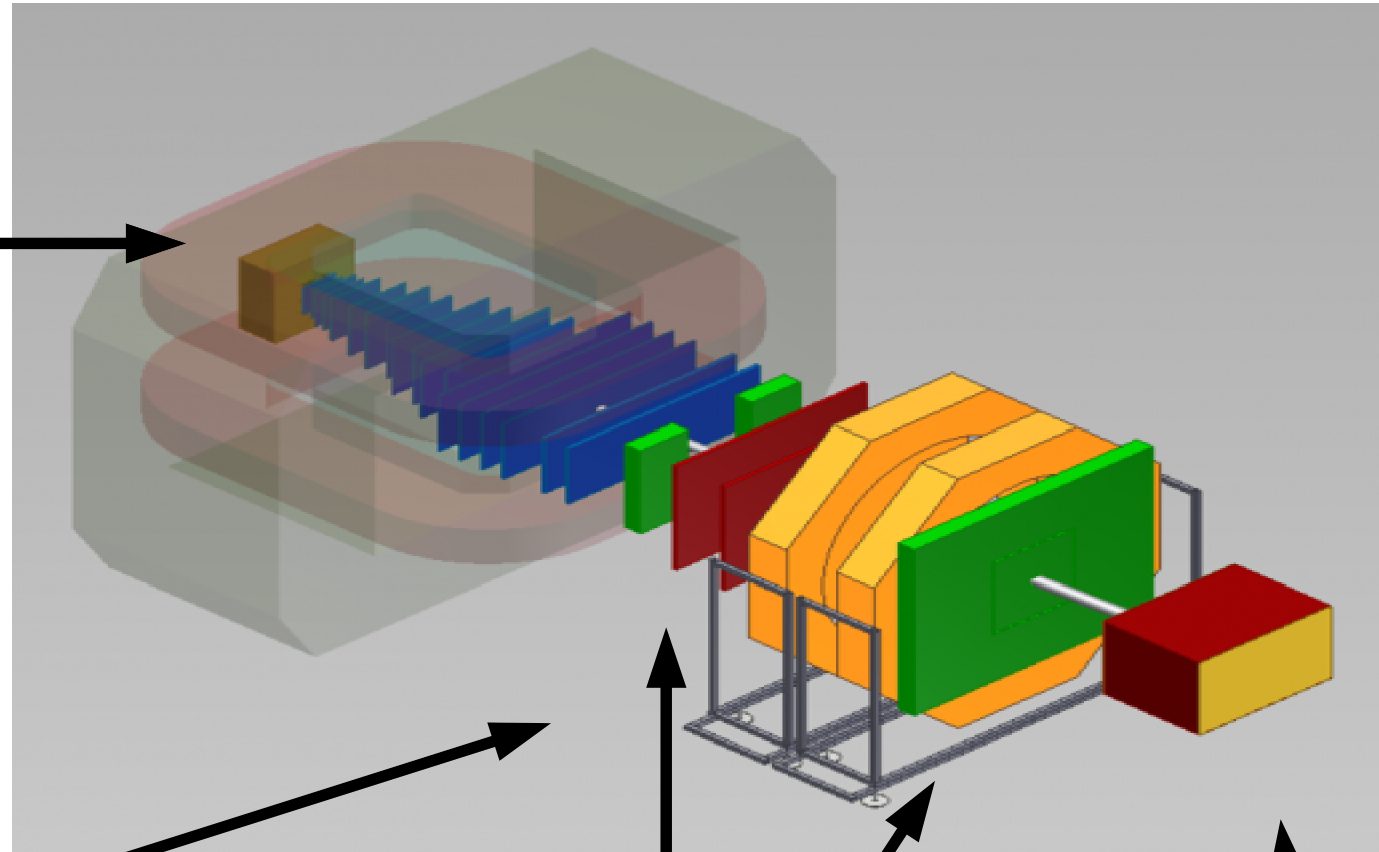
1) Study of strange and multistrange hadrons;
2) In-medium effects of vector mesons;
3) Strangeness in elementary p+p and proton induced reactions p+A;
4) Exotics: multistrange (hyper)nuclei, strange dibaryons, strangelets.

- Fixed target experiment;
- JINR Nuclotron is capable to accelerate heavy-ion beams with energies from 1 to 6 GeV per nucleon;
- Various nuclei up to Au are used as target or projectile nuclei – p, d, C, Ar, Cu, Xe, Au, etc.

BM@N experimental layout:

target

The GEM coordinate detectors are placed inside the analyzing magnet.



The Outer Tracker is based on two drift chambers and three MWPCs.

The two sets of TOF detectors are employed for particle identification.

ZDC is installed at the far end of the experiment setup to measure centrality of nucleus-nucleus collisions.

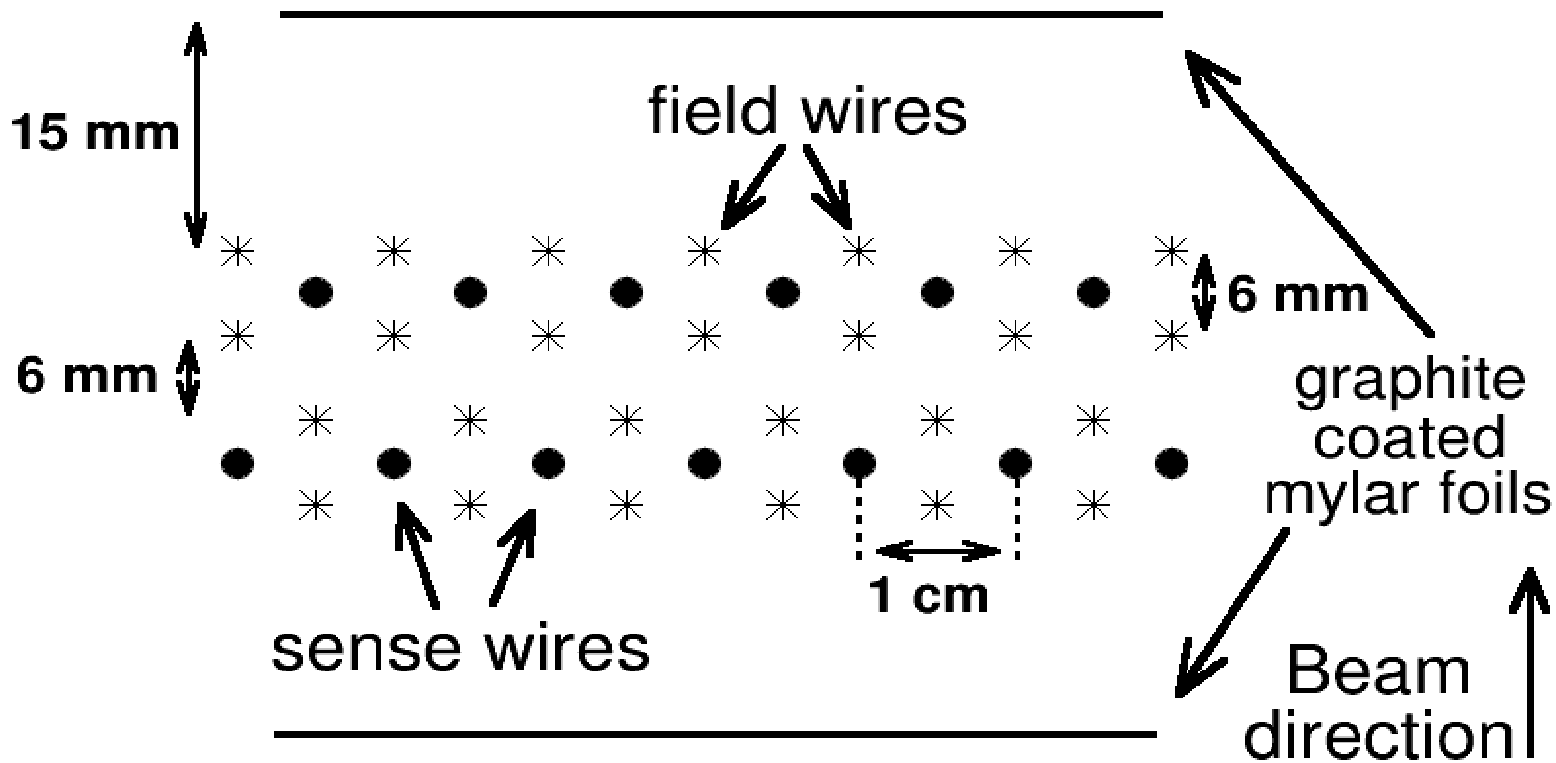
Drift chambers

Main characteristics:

- tracking detector;
- two identical chambers, placed outside the magnetic field;
- octagonal shape with edge length 120 cm, fiducial area about 4.5 m^2;
- central aperture with 24 cm diameter for the beam pipe;
- each chamber consists of 4 segments filled with working gas (70/30% mixture of Ar and CO_2);

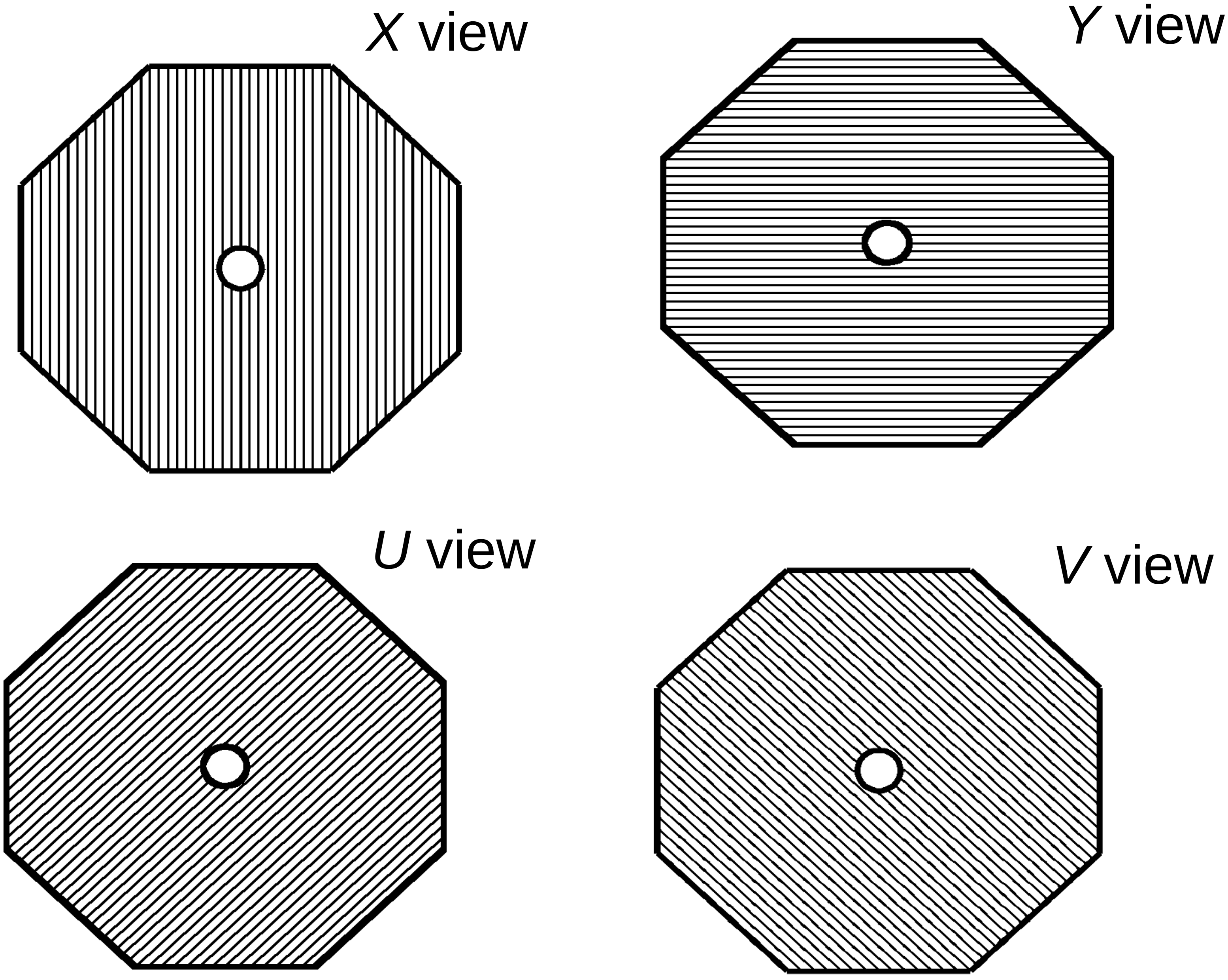
- there are two wire planes placed in each segment
- spacing between anode wires is 1 cm;

Structure of DCH segment:



Track signals (hits) are measured by the anode sense wires. The second wire plane is used to resolve left-right ambiguities of track hits measured by the first plane.

- each DCH segment measures different track transverse coordinate:,*x*,*y*,*u*,*v* (*u*,*v* are rotated Cartesian coordinates) depending on the anode wire plane azimuthal orientation: $\alpha=90^o$,0, $\pm45^o$.



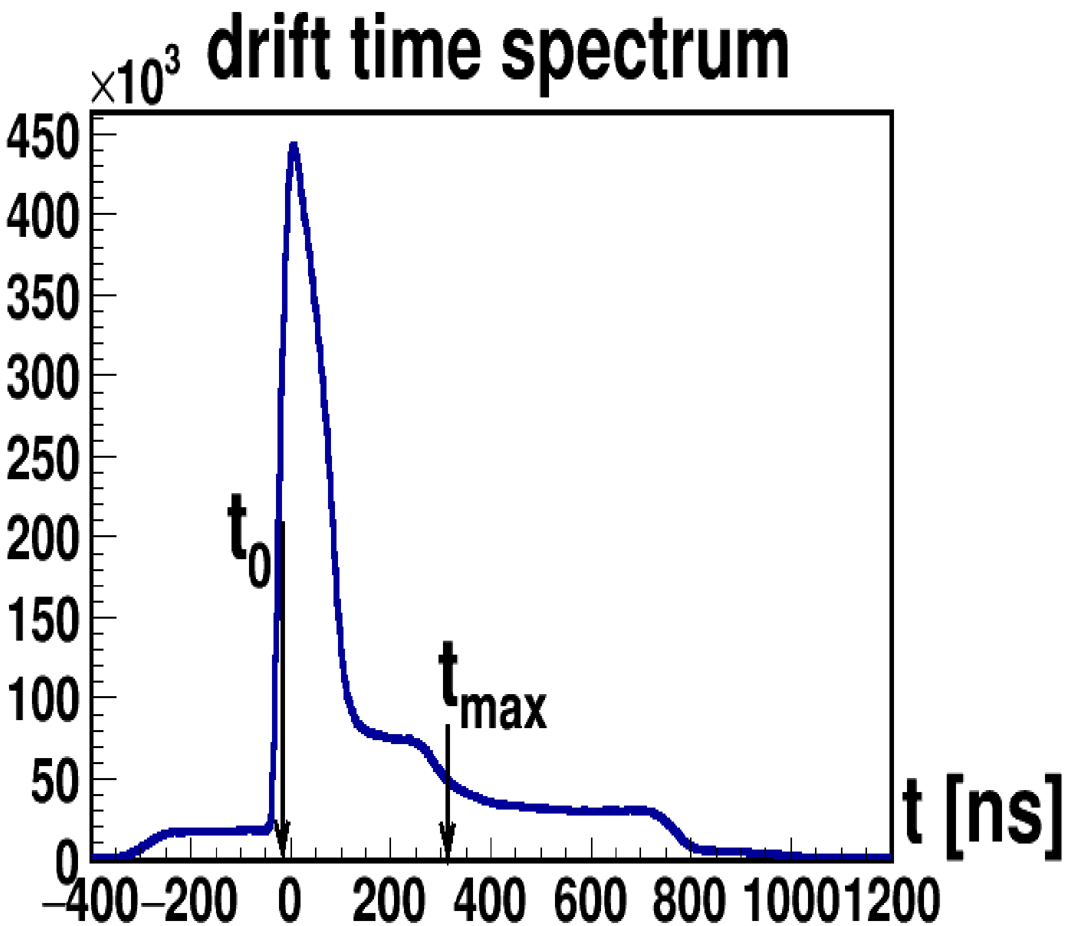
DCH wire planes

$\alpha=90^o$,0, $\pm45^o$

DCH calibration

In order to reconstruct the track coordinates, first we must estimate **distances of closest approach** of tracks to the anode wires (DCA) since DCA is not directly measured in the experiment. Instead, electron **drift time** is the available experimental observable.

The calibration converts the measured drift times to DCAs.



← typical drift time distribution (carbon beam data, run period 6)

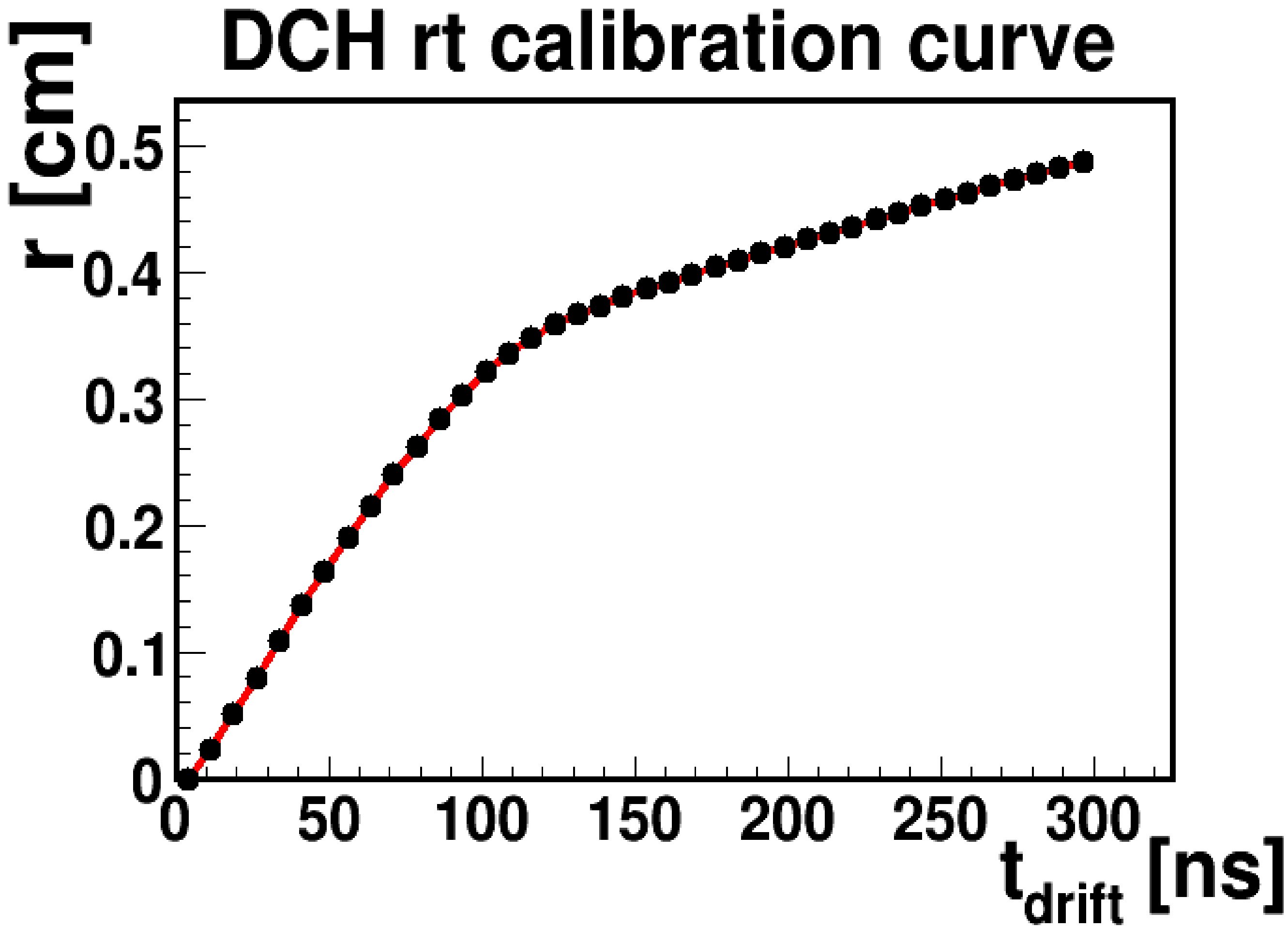
First, it is necessary to estimate the drift time limits (t_0 and t_{max}) corresponding to the minimal and maximal drift distances $r_0 \approx 0$ and $r_{max} \approx 0.5$ cm.

drift time $\boldsymbol{t_{drift} = t - t_0}$

Providing the DCA distribution is uniform, the isochronous radius-time relation is estimated by integrating the drift time spectrum:

$$r(t) = \frac{r_{max}}{N_{tot}} \int_0^t \frac{dN}{dt'} dt',$$

where N_{tot} is the total number of hits and time t gradually increases in equidistant steps from 0 to t_{max}-t_0.



Next step:
from 2 cordinates per hit to 3D points

Utilizing information on the shape of particle tracks.

Tracks are approximated by straight lines defined by points in four DCH planes:

$$x_1, y_1, z_1, \quad x_2, y_2, z_2, \quad u(x_3, y_3), z_3, \quad v(x_4, y_4), z_4,$$

where z_1, z_2, z_3, z_4 are defined by the DCH geometry and position, x_1, y_2, u, v are directly measured. Coordinates u,v of the rotated DCH planes are defined by equations:

$$u = y_3 \cos(\alpha) - x_3 \sin(\alpha), \qquad v = y_4 \cos(\alpha) + x_4 \sin(\alpha).$$

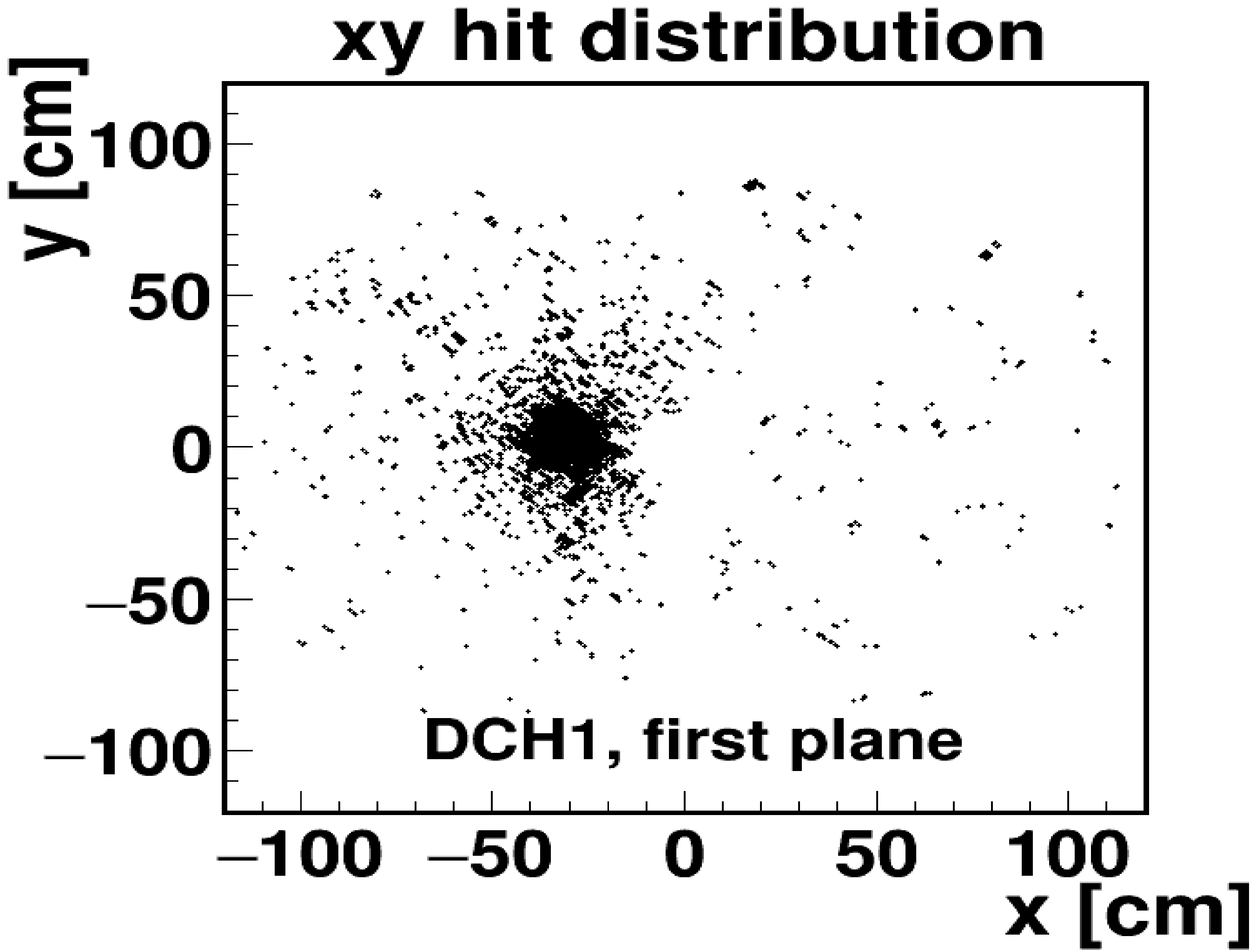
All the coordinates are tied up by the system of linear equations:

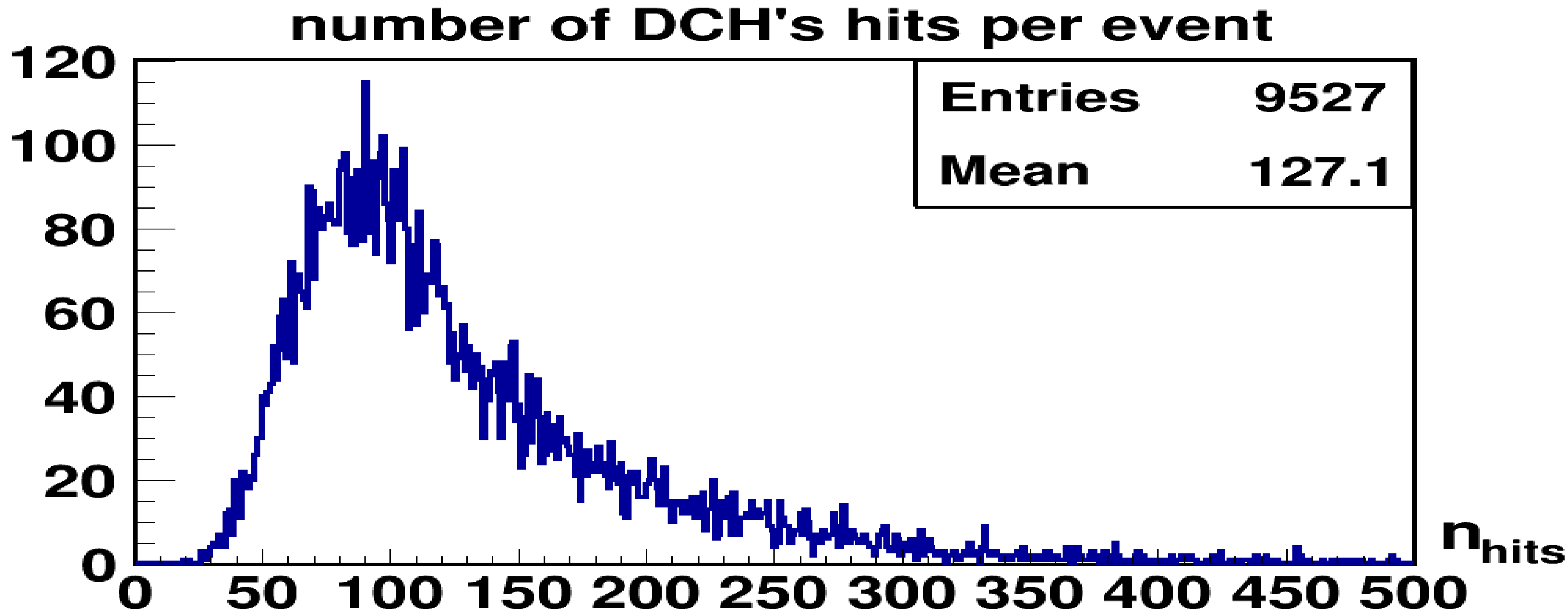
$$\frac{x_2 - x_1}{z_2 - z_1} = \frac{x_3 - x_1}{z_3 - z_1} = \frac{x_4 - x_1}{z_4 - z_1}, \qquad \frac{y_2 - y_1}{z_2 - z_1} = \frac{y_3 - y_1}{z_3 - z_1} = \frac{y_4 - y_1}{z_4 - z_1}.$$

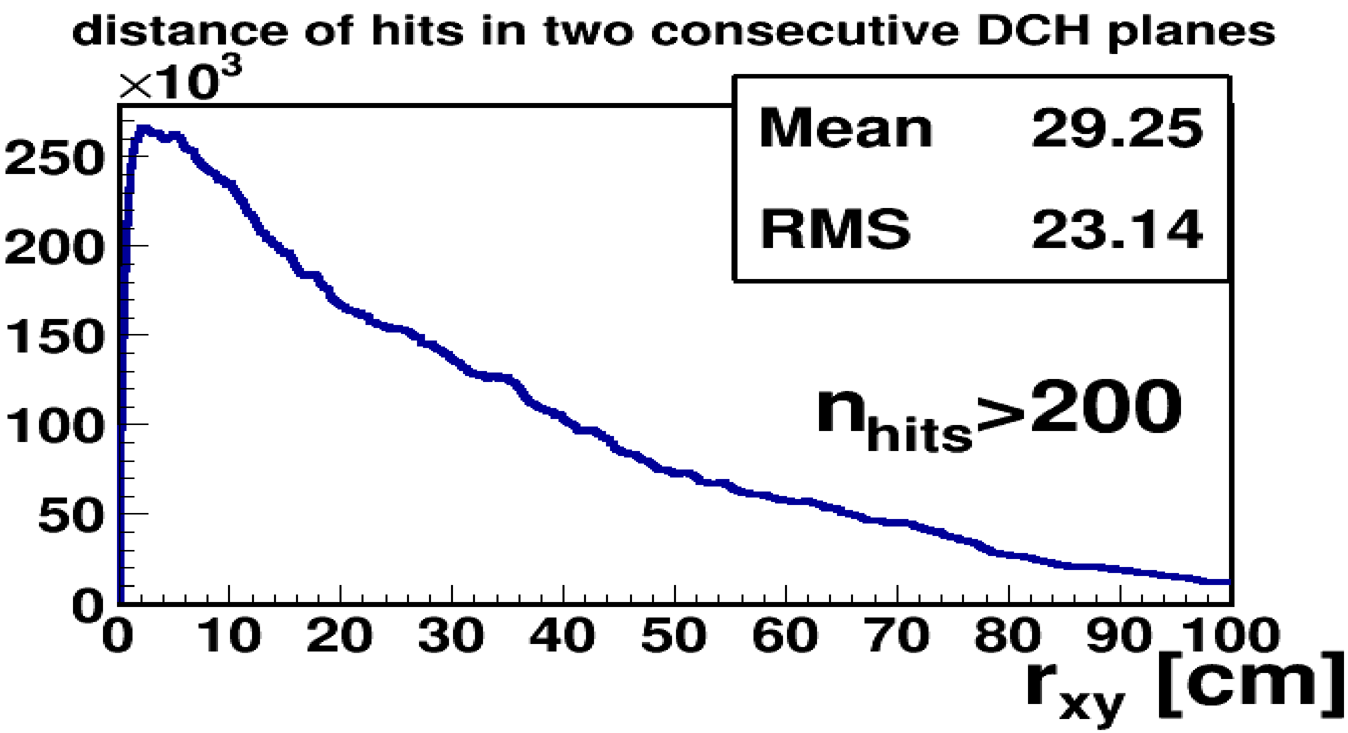
which is solved for the unknown coordinates.

Combining the linear track candidates from both DCH's, we obtain 8 points per track that are averaged to increase precision of track geometric parameters.

Profile of carbon beam at E_{kin}=4.5 AGeV:







High level of background

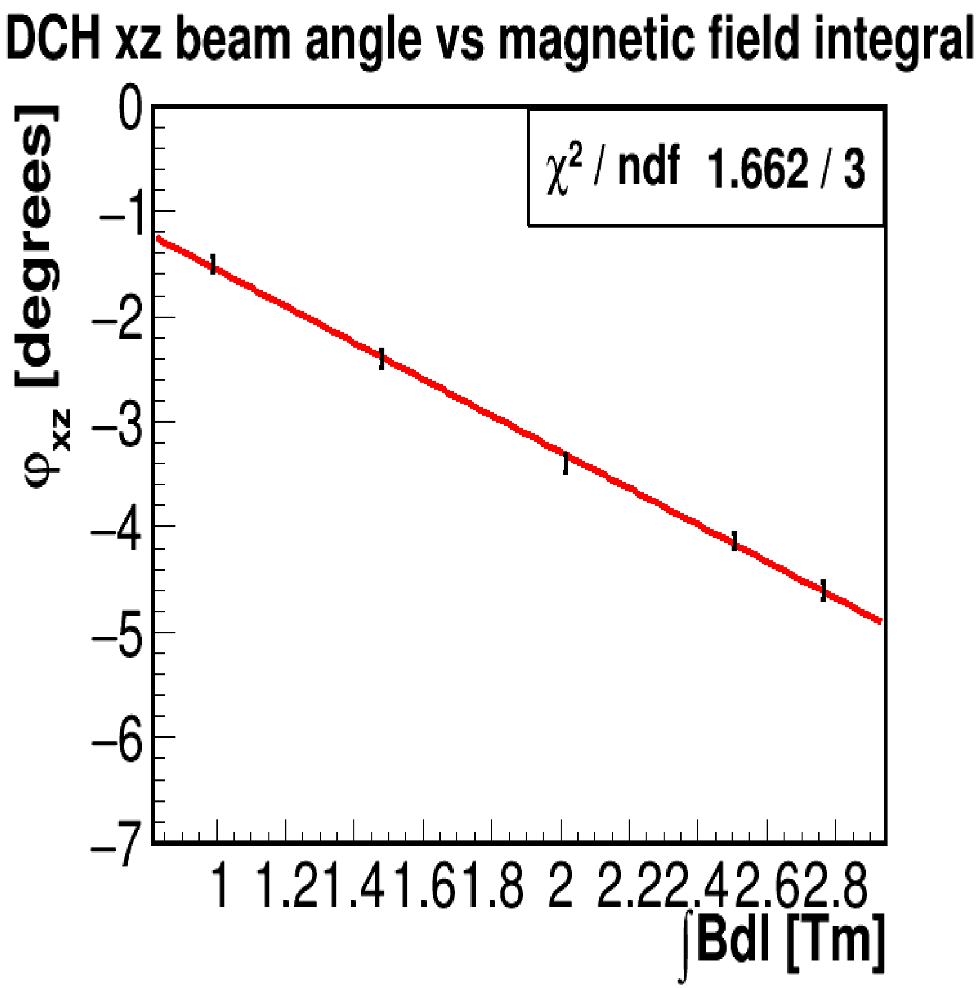
It would be desirable
to remove the background at the early stages of the data analysis.

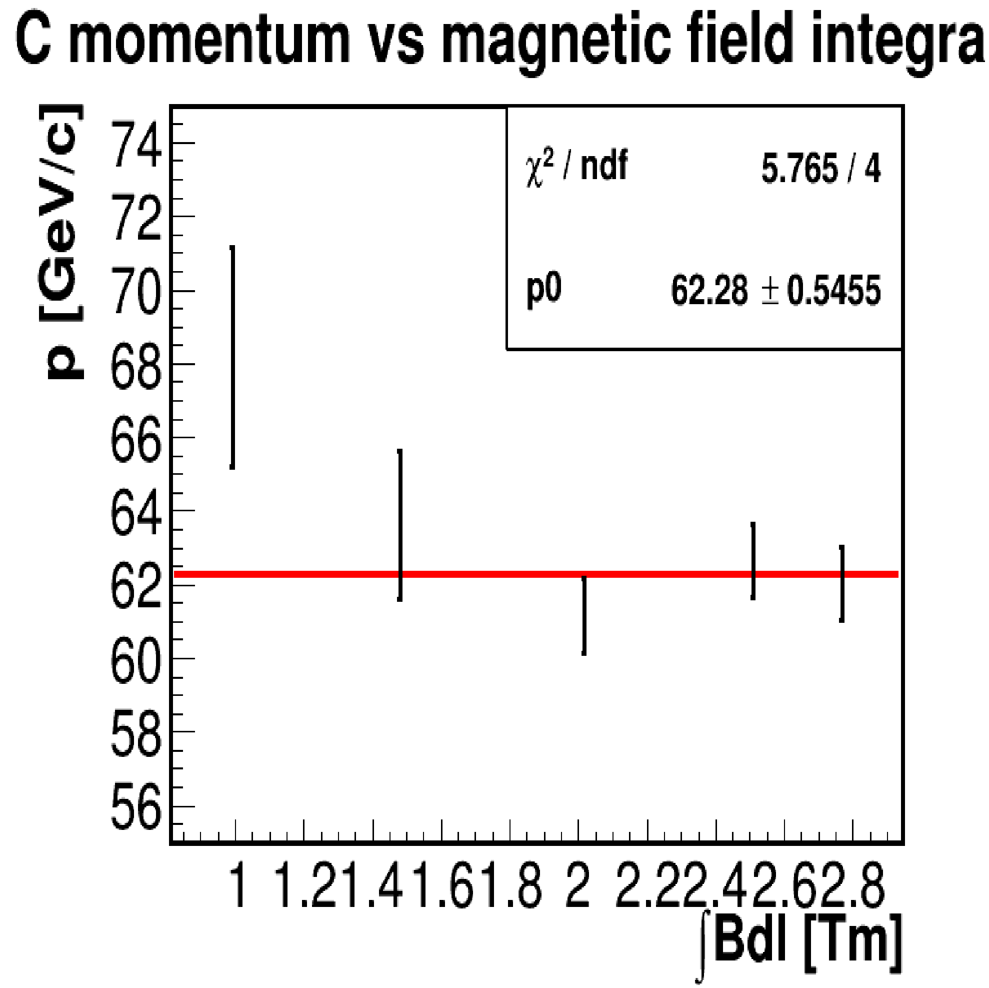
The method consistency check: momentum reconstruction of carbon beam at E_{kin}=4.5 AGeV.

Deflection of beam by magnetic field in *xz* plane is described by angle $\boldsymbol{\varphi_{xz}}$ which depends on magnetic field integral and beam momentum ***p***:

$$\varphi_{xz}(rad) = q\frac{\int Bdl}{p} \quad \Rightarrow \quad p = q\frac{\int Bdl}{\varphi_{xz}}$$

Dependences of angle φ_{xz} and beam momentum $\boldsymbol{p}$ on magnetic field integral. The analysis is done on a couple of investigated runs measured at diferent values of magnetic flux density *B.*





Nominal carbon beam momentum value: **64.21 GeV/c**, i.e. the reconstructed momentum value seems underestimated.

Summary:

1) The complex method of particle hit and track reconstruction in the drift chambers is tested on BM@N carbon beam data.
2) The *r-t* calibration curve is estimated and applied to calculate DCA coordinates of the DCH hits.
3) DCH track candidates are further estimated under the assumption of track linearity.
4) Track candidates in both the DCHs are aligned and averaged to produce global DCH track candidates.
5) The momentum of the carbon beam is reconstructed in order to test reliability of the applied method.
6) Although the preliminary results seem promising, some work still has to be done. Above all to make up an efficient algorithm capable to remove as much background as possible at the beginning of the analysis in order to avoid spending to much computing resources. The alignment procedure requires further improvements as well.