Nuclotron beam momentum estimation using multiwire proportional chambers and drift chambers in BM@N experiment

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# BM@N - 2017 experimental setup

- Central tracker (GEM) - AA interactions reconstruction;

- Outer tracker (DCH, CPC) - link central tracks to ToF;

- ToF - hadrons and light nucleus identification;

- ZDC calorimeter - centrality of AA collisions measurement;

- Detectors to form T0, L1 centrality trigger and beam monitors;

- Electromagnetic calorimeter - γ,e+e- detection;

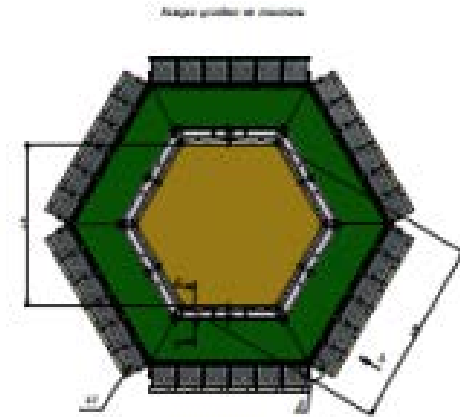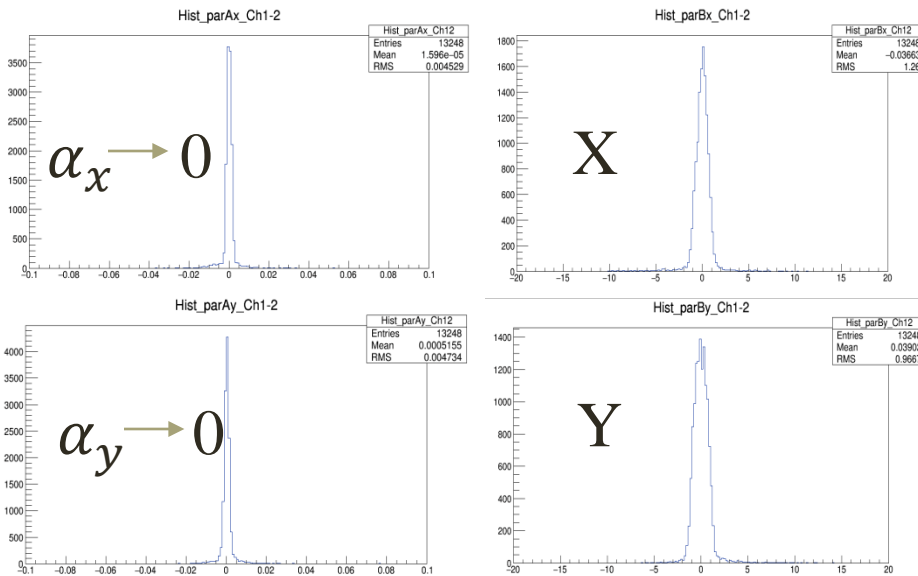- MWPC – alignment and incoming beam trajectory positioning.
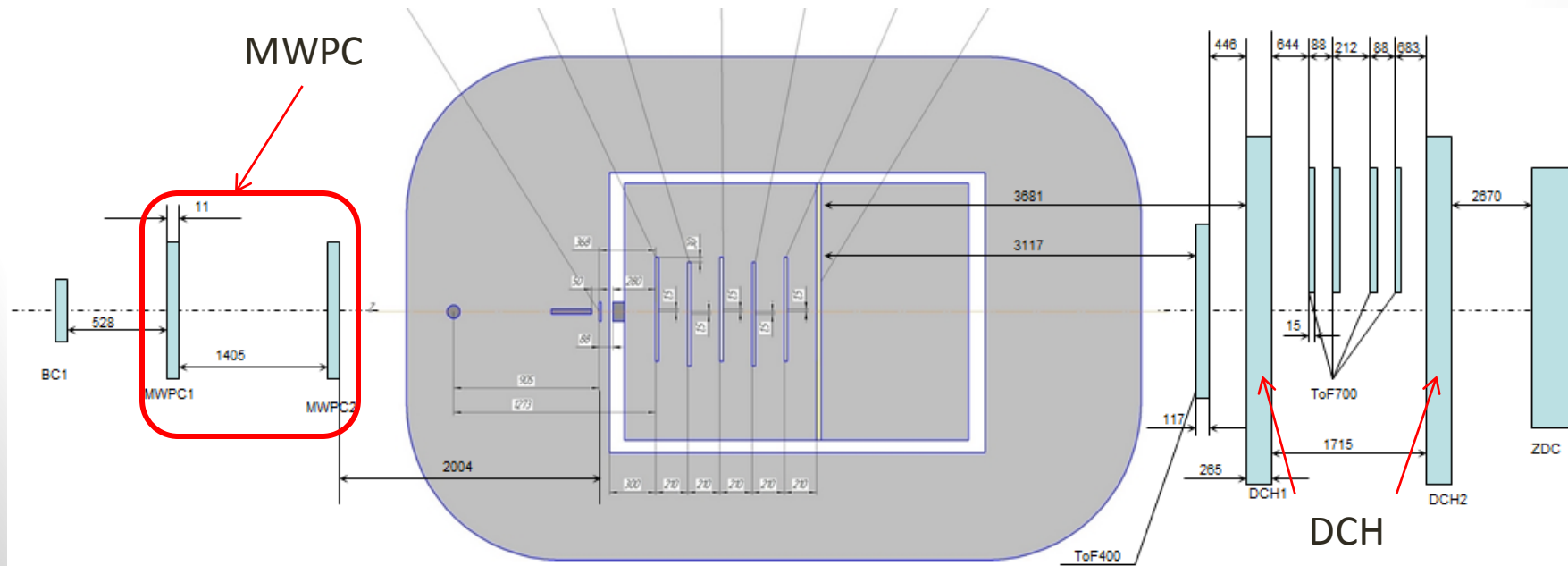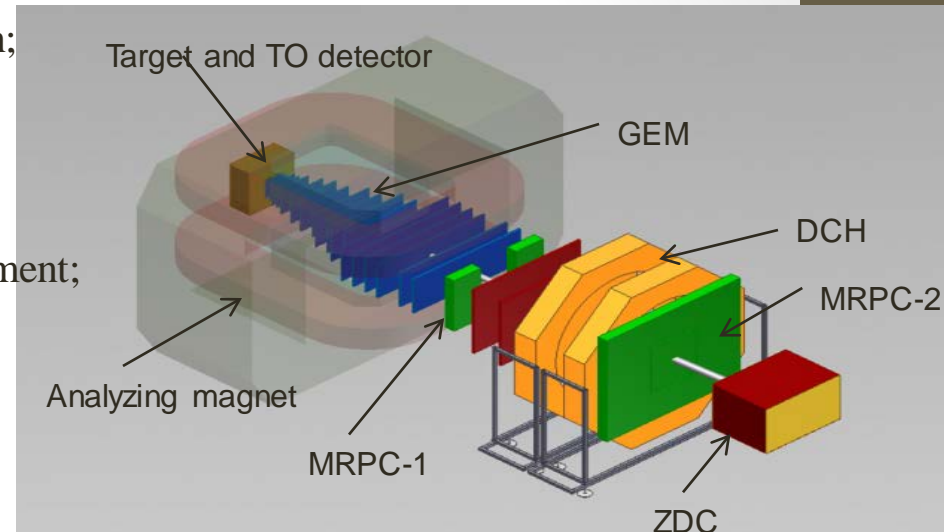
MWPC

- 6 planes in each chamber ;
- 3 double coordinate planes;
- wire angles $0°, \pm 60°$;
- wire pitch $d = 2.5$ mm ;
- Resolution $d/\sqrt{12} = 0.72$ mm;
- 576 wires per chamber.
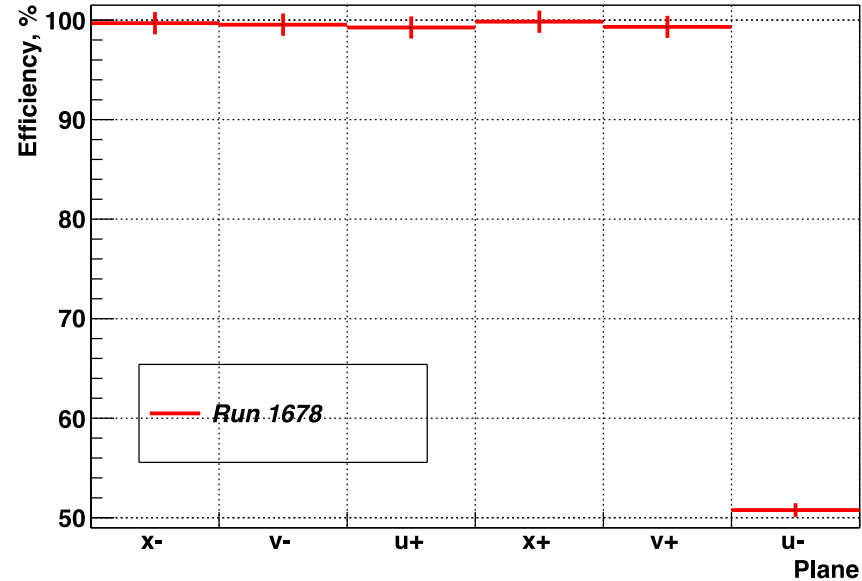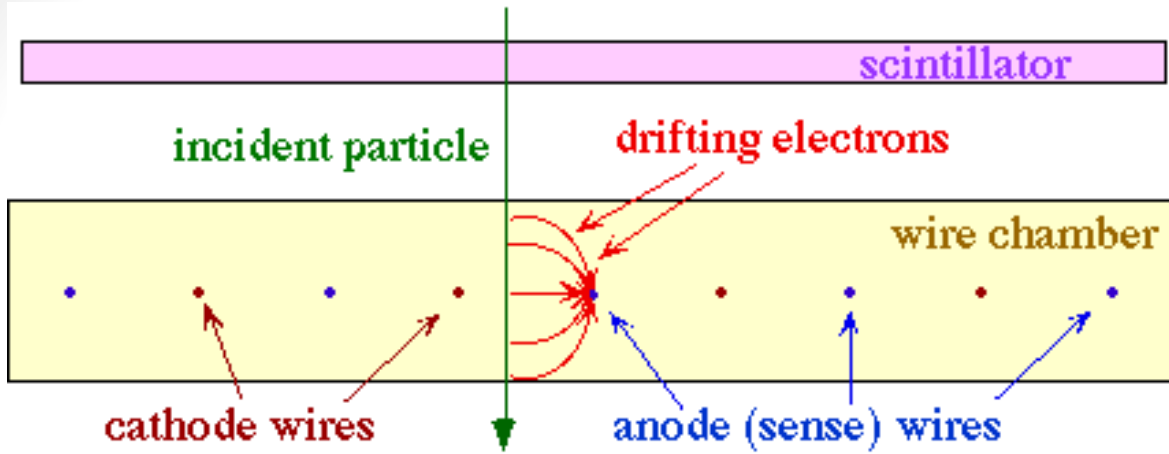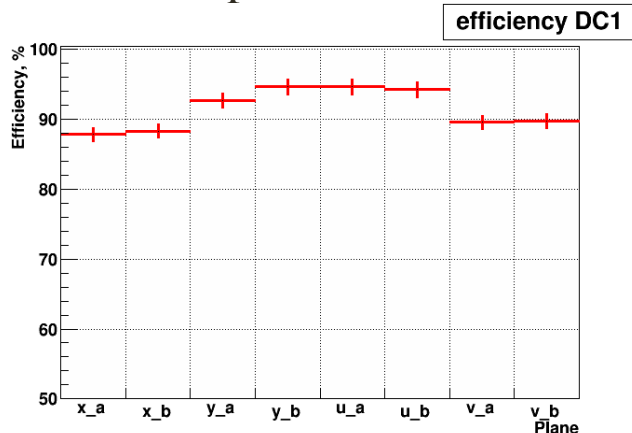
Detector beam parameters

Drift Chambers

Principle of working of a Drift Camber detector

- 4 double coordinate planes;
- wire angles 0°,90°,±45°;
- wire pitch 10 mm;
- Yout ± 1.35 m, Xout ± 1.35 m;
- R_hole = 10 cm;
- 2048 wires per chamber.

Spatial resolution

184 μm

Ya_Yb - 0.5cm	
hYa_Yb_0p5cm	
Entries	129707
Mean	0.008445
RMS	0.08404
χ^2 / ndf	795.4 / 22
Constant	8274 ± 33.5
Mean	0.00178 ± 0.00009
Sigma	0.02603 ± 0.00008

4
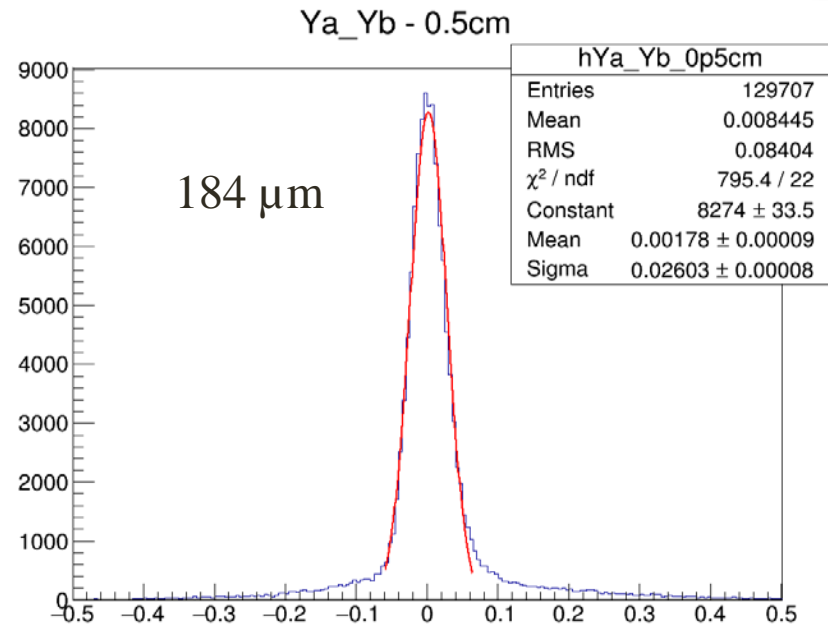
Beam momentum estimation procedure

$$P_{beam(est)} = \frac{0.3 * \int Bdl}{\sin(\alpha_{out} - \alpha_{in})}$$
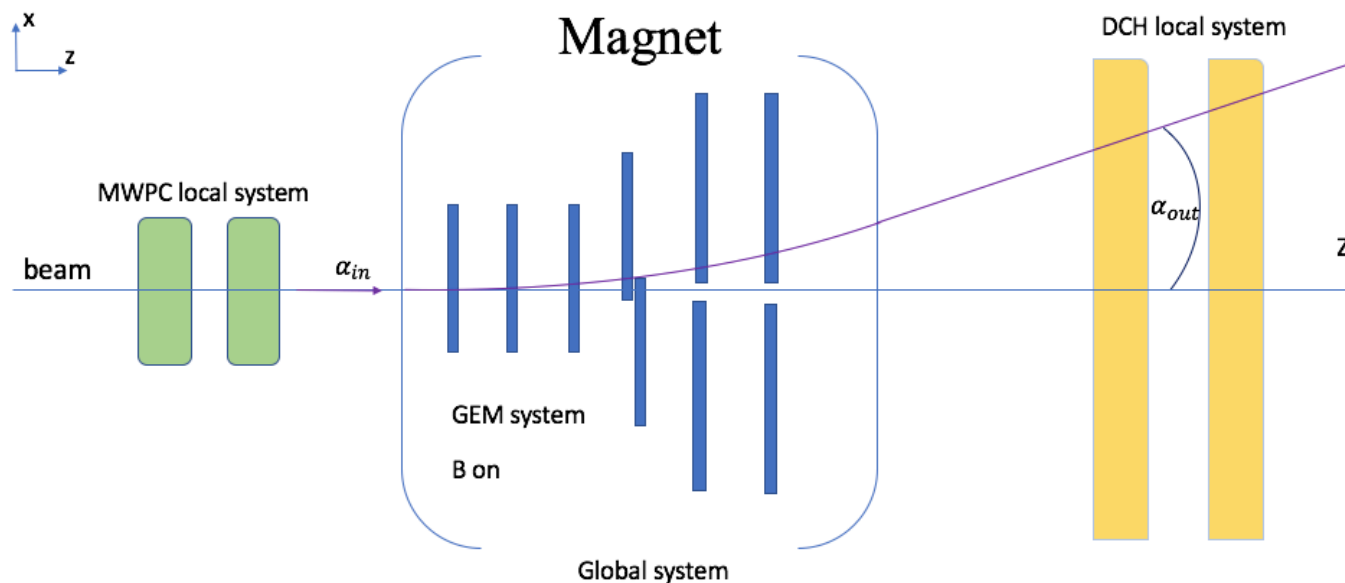
α_{in} - angle of beam before magnet (MWPC);
α_{out} - angles of beam after magnet (DCH);
$\int Bdl$ - magnet field integral [T*m].

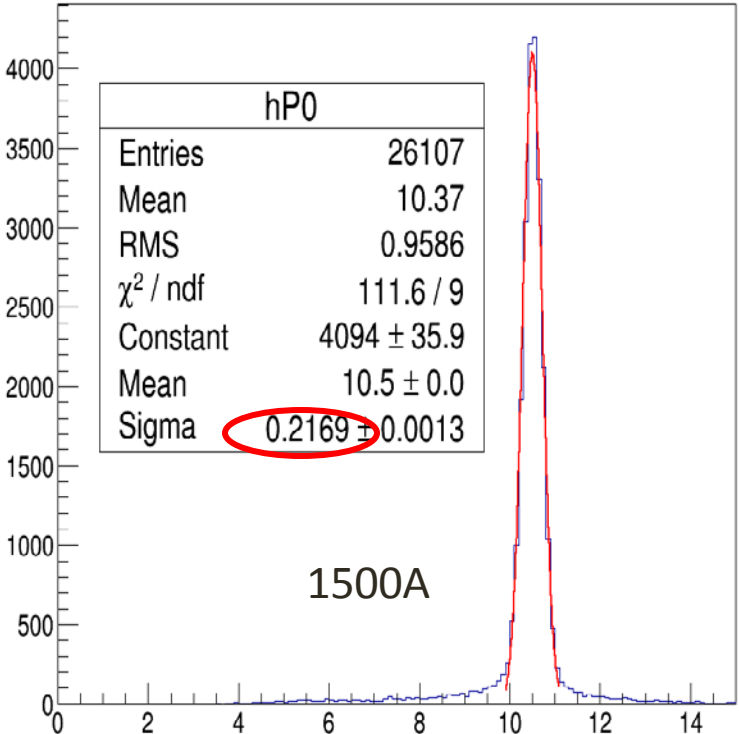$$P_{beam} = \frac{A}{Z} * \sqrt{\left(E/n + M_p\right)^2 - M_p^2}$$

A - mass number;
Z - number of protons;
E/n - beam energy per nucleon;
M_p - proton mass.

Momentum estimation for particular magnetic field values
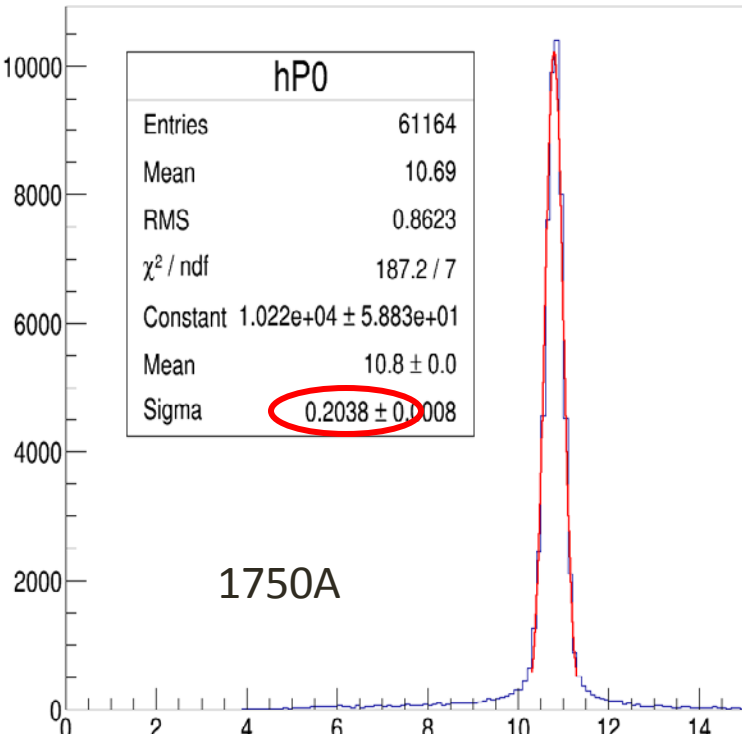
Momentum vs. Int(BdL)

C beam energy 4.5 GeV/nuclon;
Momentum 10.7 GeV/c;

Beam Momentum

$$P_{beam(est)} = \frac{0.3 * \int Bdl}{\sin(\alpha_{out} - \alpha_{in})}$$
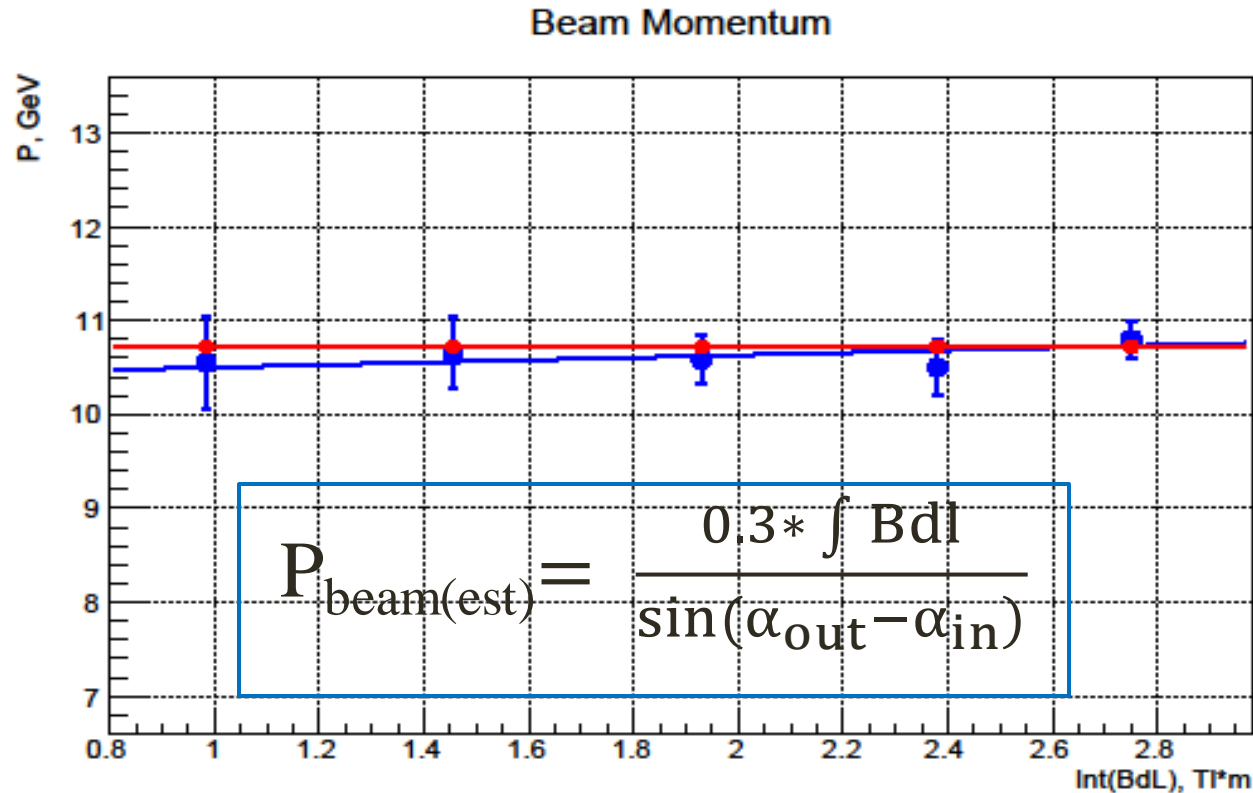
$$P_{beam} = \frac{A}{Z} * \sqrt{\left(E/n + M_p\right)^2 - M_p{}^2}$$

RED – Nuclotron beam momentum;
BLUE – estimated beam momentum.

Momentum vs. Int(BdL)

C beam energy 3.5 GeV/nuclon;
Momentum 8.7 GeV/c;

Beam Momentum

$$P_{beam(est)} = \frac{0.3 * \int Bdl}{\sin(\alpha_{out} - \alpha_{in})}$$

P, GeV — Int(BdL), Tl*m
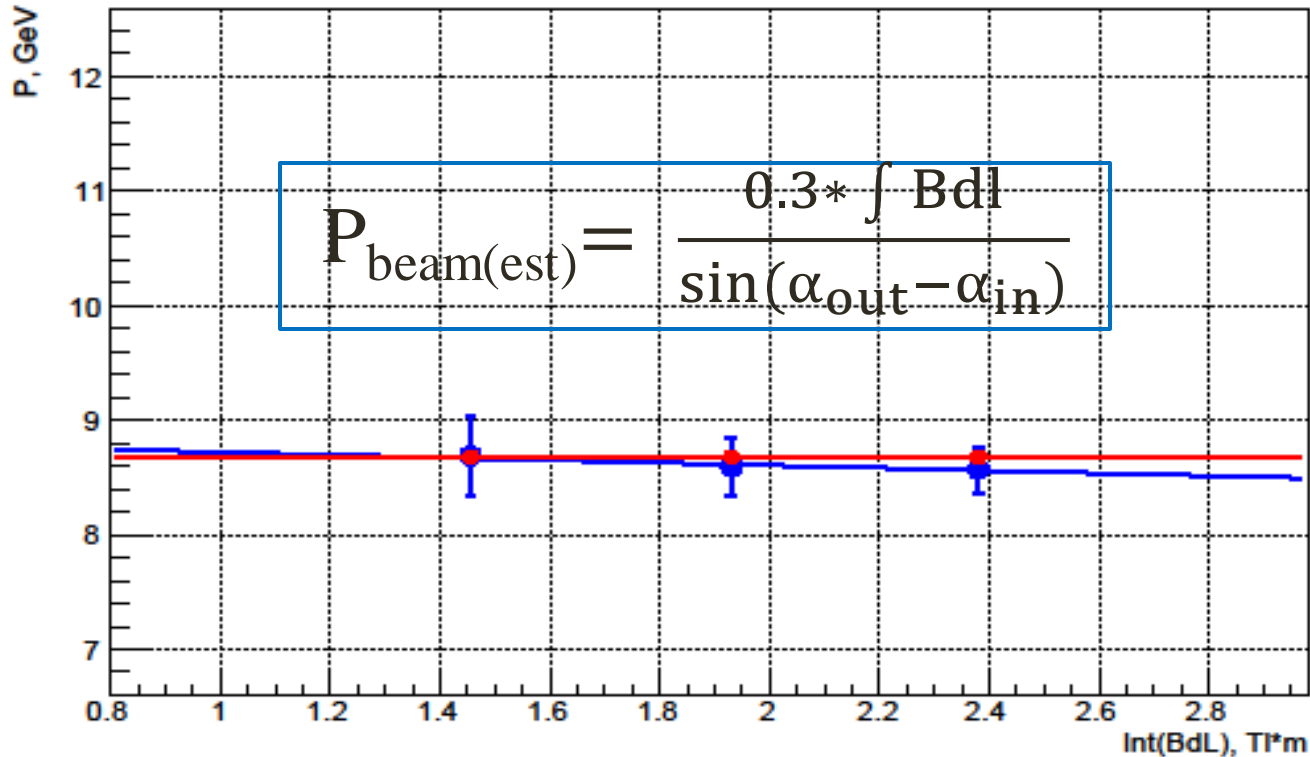
$$P_{beam} = \frac{A}{Z} * \sqrt{\left(E/n + M_p\right)^2 - M_p^{\,2}}$$

RED – Nuclotron beam momentum;
BLUE – estimated beam momentum.

Summary

- The BM@N experiment is the first part of the NICA project;
- The software for the MWPC and DCH detector systems was developed and implemented into the official experiment software;
- The spatial resolution for different layers of the DCH chambers varies within 150-200 μm;
- The global alignment procedure was performed in order to bring the detectors to a common coordinate system;
- The two systems give us the possibility to estimate the beam momentum value with a high precision ~2% for the working values of the magnetic field integral.

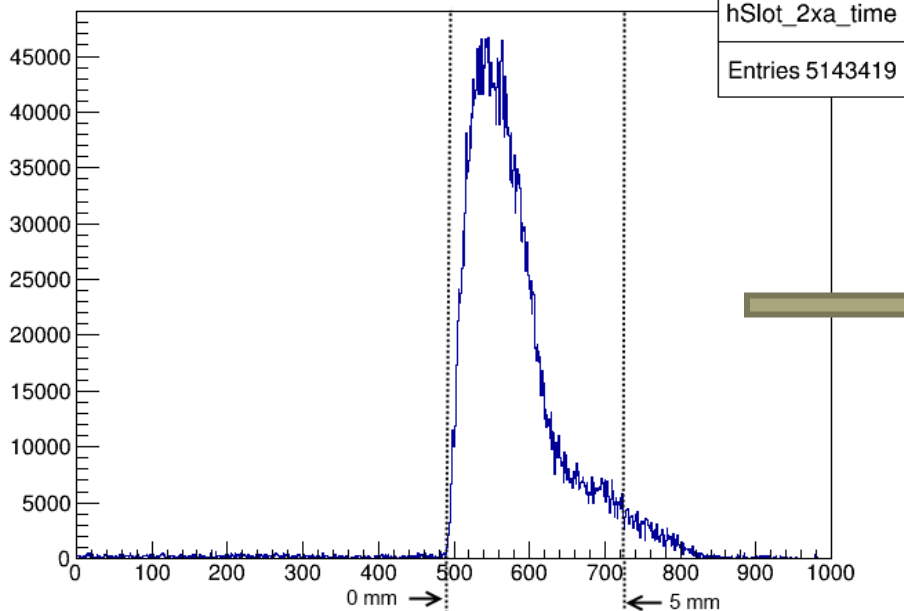# Thank you for your attention!

Backup slides
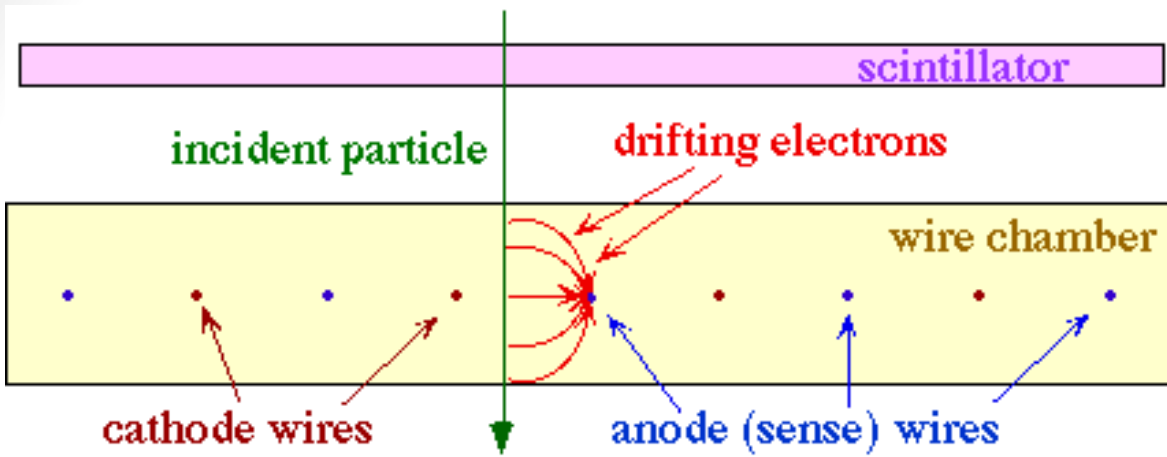
Principle of working of a Drift Camber detector

momentum = .3*Int(BL)/[sin(alphaX_out)+C]

600A

hP0	
Entries	48894
Mean	10.35
RMS	1.333
χ^2 / ndf	107.1 / 21
Constant	3505 ± 22.1
Mean	10.55 ± 0.00
Sigma	0.4957 ± 0.0023

momentum = .3*Int(BL)/[sin(alphaX_out)+C]

900A

hP0	
Entries	36649
Mean	10.47
RMS	1.248
χ^2 / ndf	55.97 / 15
Constant	3361 ± 24.4
Mean	10.66 ± 0.00
Sigma	0.3778 ± 0.0020

momentum = .3*Int(BL)/[sin(alphaX_out)+C]

1200A

hP0	
Entries	48936
Mean	10.46
RMS	1.029
χ^2 / ndf	77.42 / 9
Constant	6389 ± 41.1
Mean	10.58 ± 0.00
Sigma	0.2633 ± 0.0013
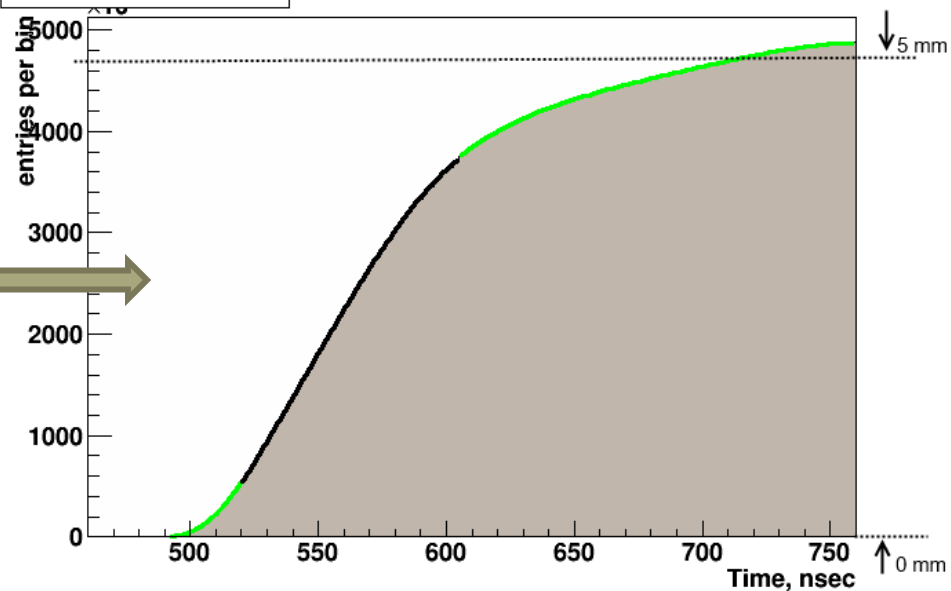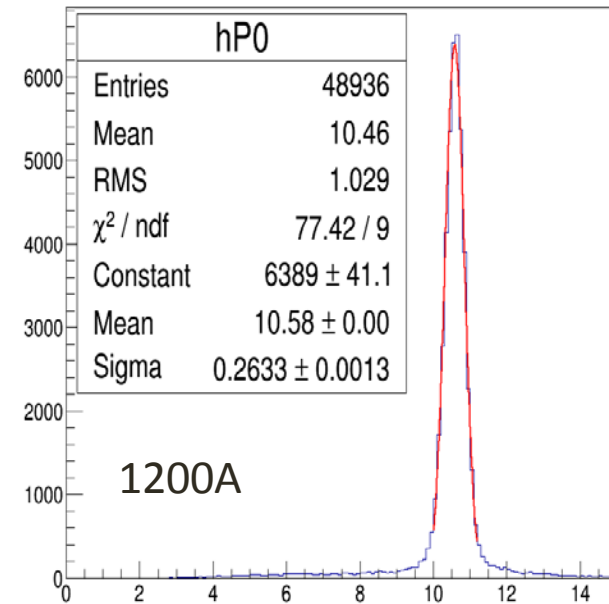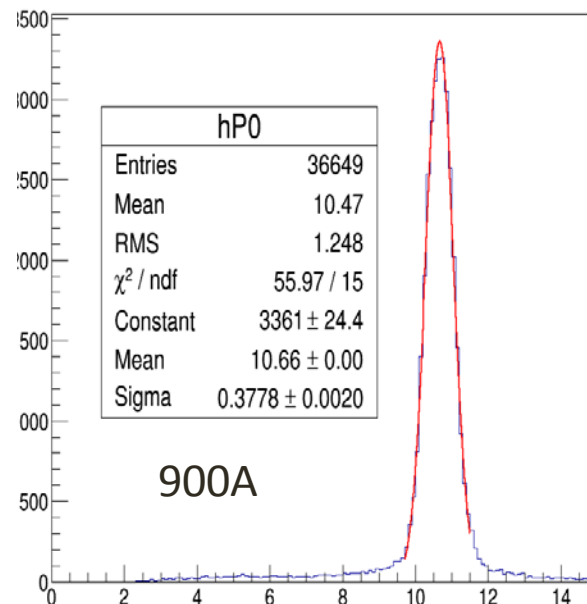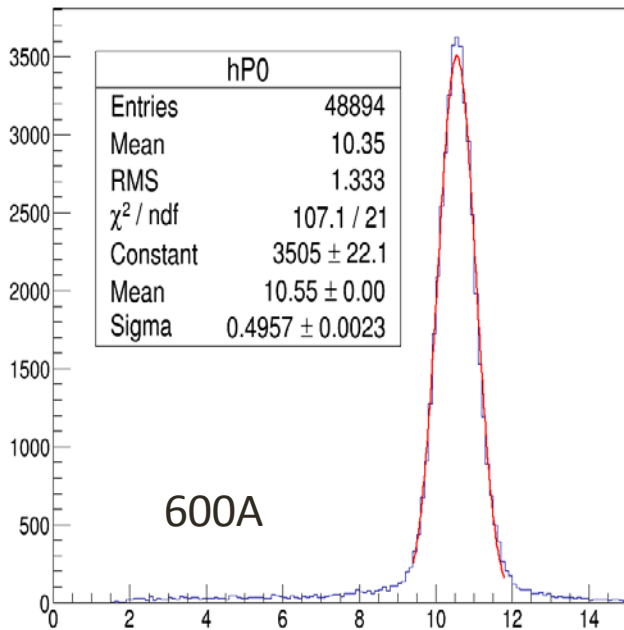
Beam - C 4.5 GeV/nucl

momentum = .3*Int(BL)/[sin(alphaX_out)+C]

1500A

hP0	
Entries	26107
Mean	10.37
RMS	0.9586
χ^2 / ndf	111.6 / 9
Constant	4094 ± 35.9
Mean	10.5 ± 0.0
Sigma	0.2169 ± 0.0013

momentum = .3*Int(BL)/[sin(alphaX_out)+C]

1750A

hP0	
Entries	61164
Mean	10.69
RMS	0.8623
χ^2 / ndf	187.2 / 7
Constant	1.022e+04 ± 5.883e+01
Mean	10.8 ± 0.0
Sigma	0.2038 ± 0.0008

13
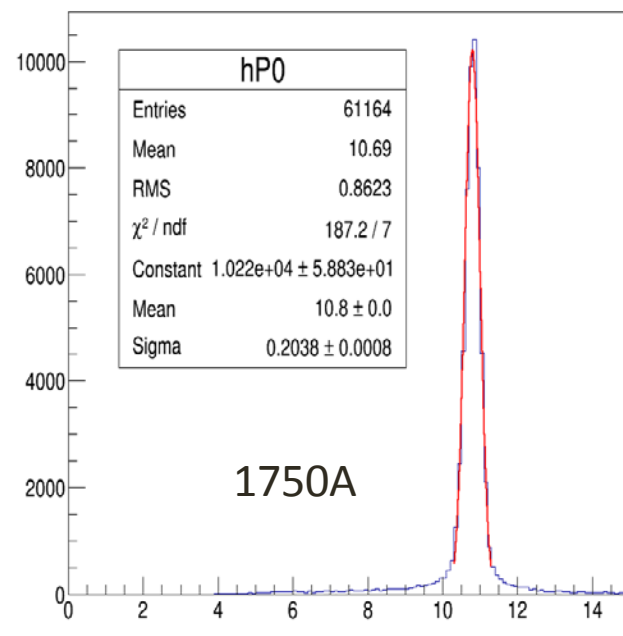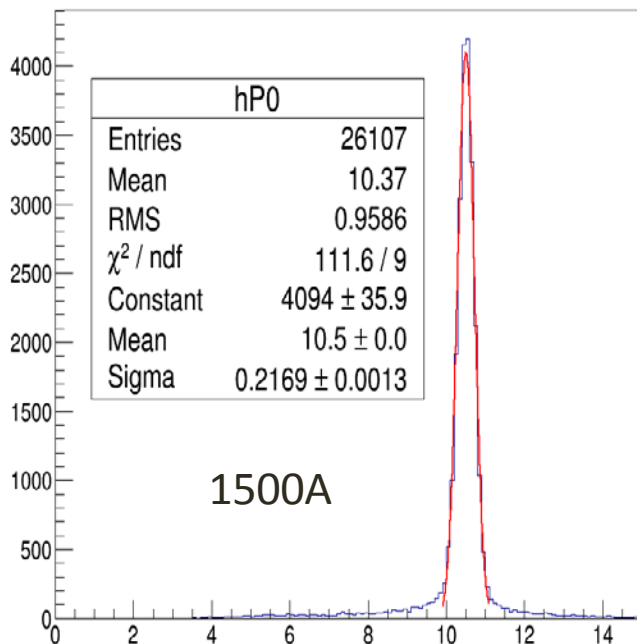
Momentum estimation for Beam - C 3.5 GeV/nucl

momentum = .3*Int(BL)/[sin(alphaX_out)+C]

900A

hP0	
Entries	45836
Mean	8.594
RMS	0.9125
χ^2 / ndf	81.06 / 12
Constant	4512 ± 30.5
Mean	8.689 ± 0.002
Sigma	0.3484 ± 0.0019

momentum = .3*Int(BL)/[sin(alphaX_out)+C]

1200A

hP0	
Entries	48007
Mean	8.585
RMS	0.713
χ^2 / ndf	286.6 / 9
Constant	6416 ± 42.1
Mean	8.587 ± 0.001
Sigma	0.2572 ± 0.0013

momentum = .3*Int(BL)/[sin(alphaX_out)+C]

1500A

hP0	
Entries	45776
Mean	8.656
RMS	0.5905
χ^2 / ndf	724.5 / 7
Constant	8238 ± 55.4
Mean	8.567 ± 0.001
Sigma	0.1963 ± 0.0010
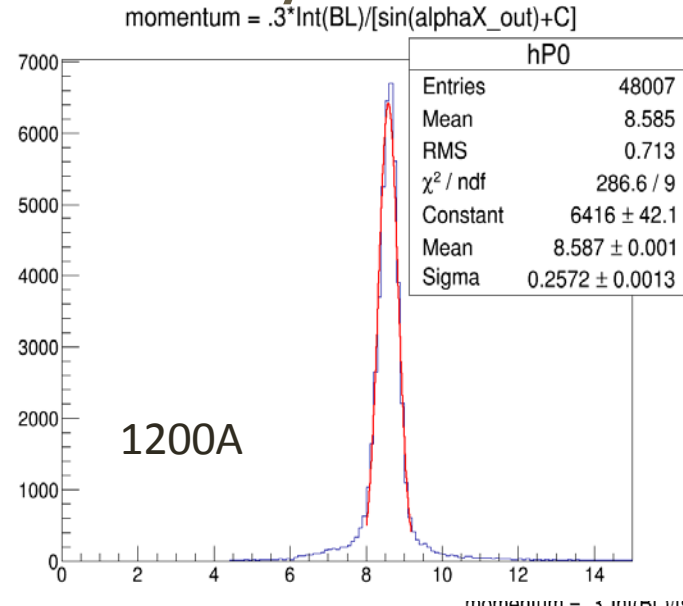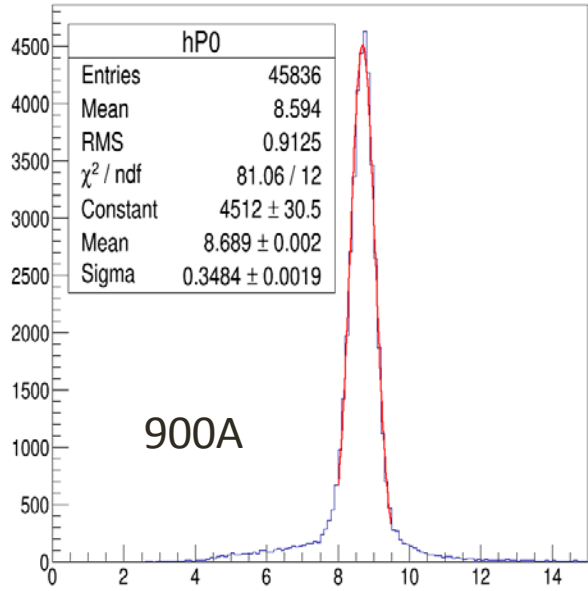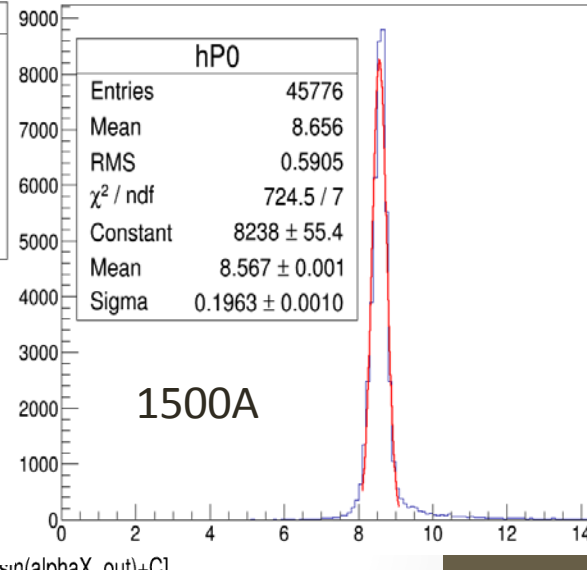
(X,Y) local coord of a seg in dc2

hlocXY2	
Entries	216973
Mean x	−43.15
Mean y	−0.3472
RMS x	9.126
RMS y	19.83
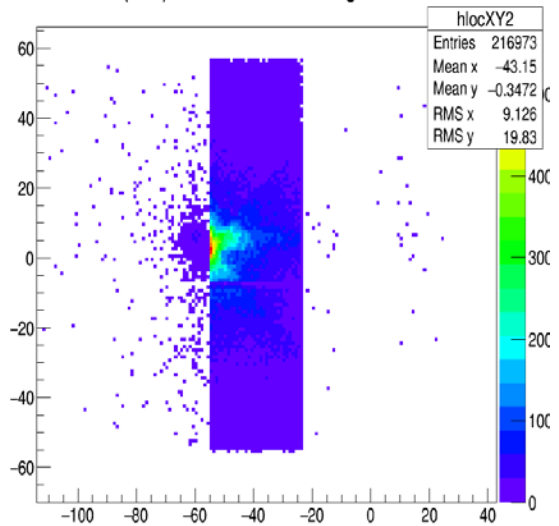
Missing two X amplifiers

momentum = .3*Int(BL)/[sin(alphaX_out)+C]

1800A

hP0	
Entries	1887
Mean	10.64
RMS	1.484
χ^2 / ndf	33.46 / 13
Constant	82.42 ± 3.72
Mean	9.827 ± 0.021
Sigma	0.4291 ± 0.0186

Expected value