



# Simulation in Drift Chambers of the BM@N Experiment

D. Baranov, V. Palichik, M. Patsyuk, N. Voytishin  
JINR



AYSS-2020  
November 12, 2020



# Drift Chambers Reconstruction Chain

Hit reconstruction on a particular layer



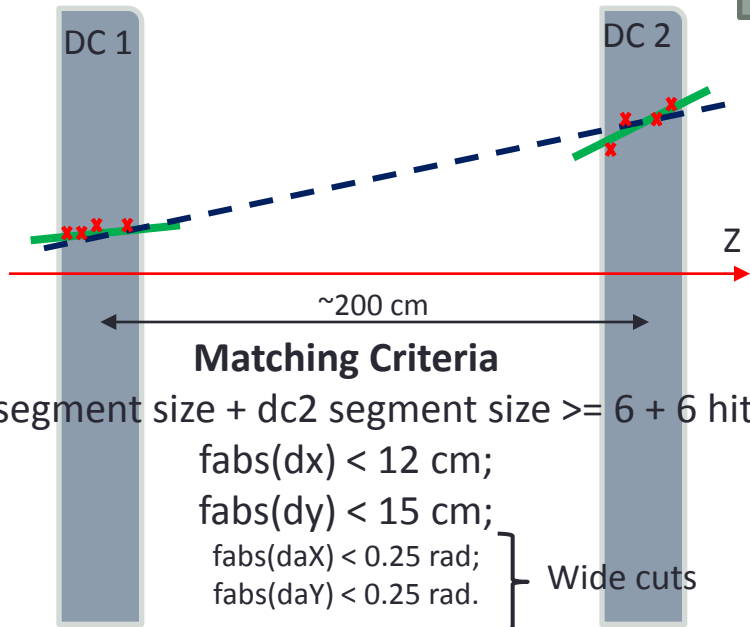
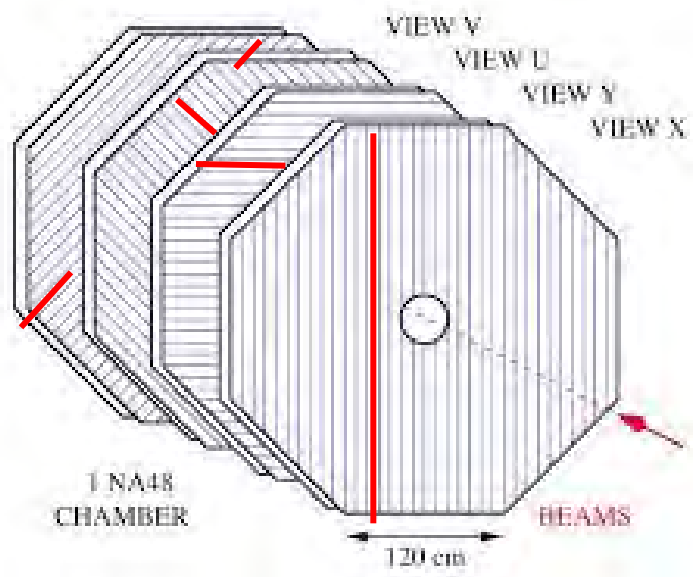
Pair hit assembly



DC1/2 Segment building



DC1+2 track reconstruction



MC Points

simulated coordinate smearing

data digis

time transformed into distance

input

MC DchHitProducer

data DchHitProducer

DchTrackFinder

DCH

Hits on layer;

Segments;

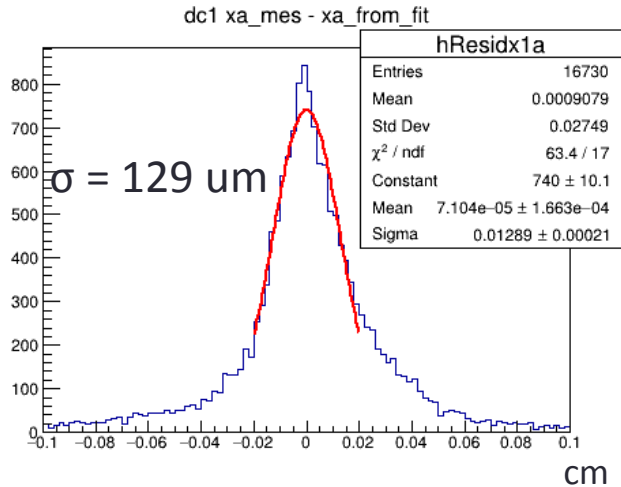
global tracks

output

# Some selected residuals [Measurement – segmentFit]

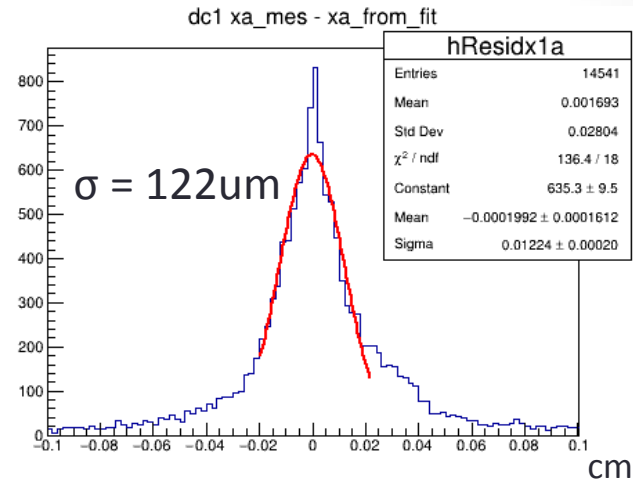
C beam, empty target, B = 1200A

### MC segments

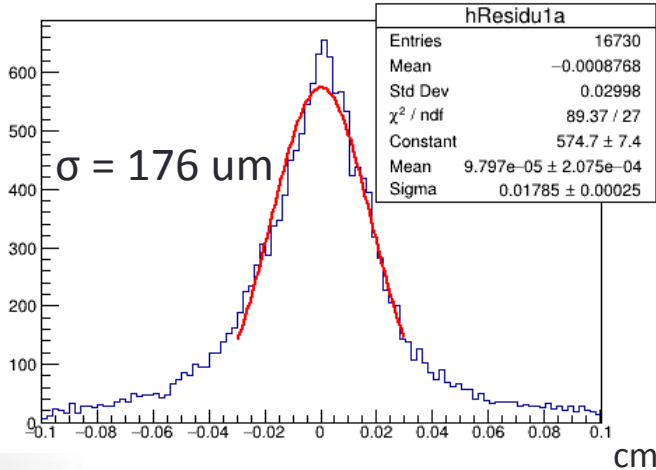


X - coordinate

### Data segments

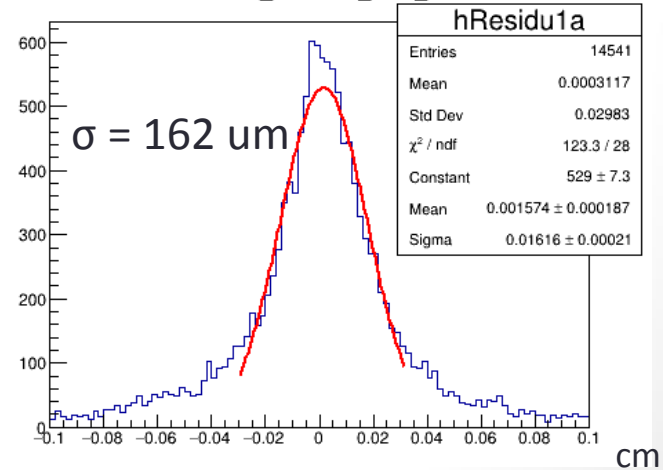


### MC segments



U - coordinate

### Data segments



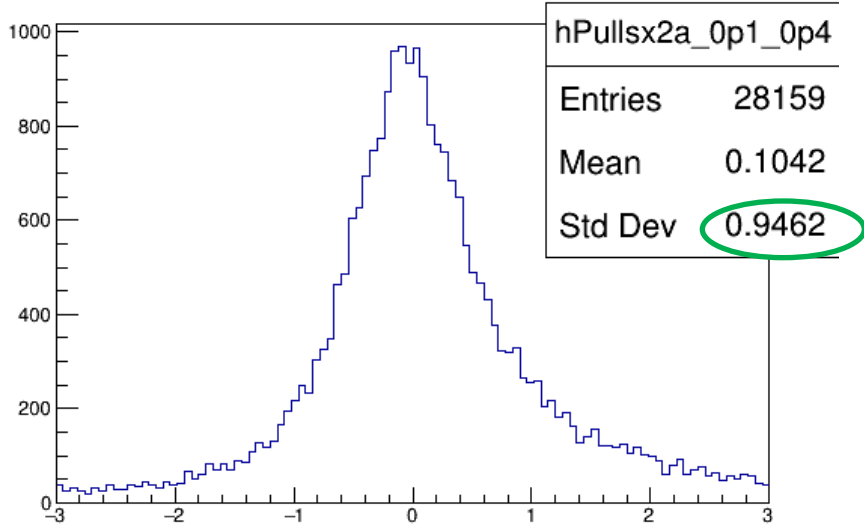
MC and data residuals are in agreement for all coordinates

# Pulls

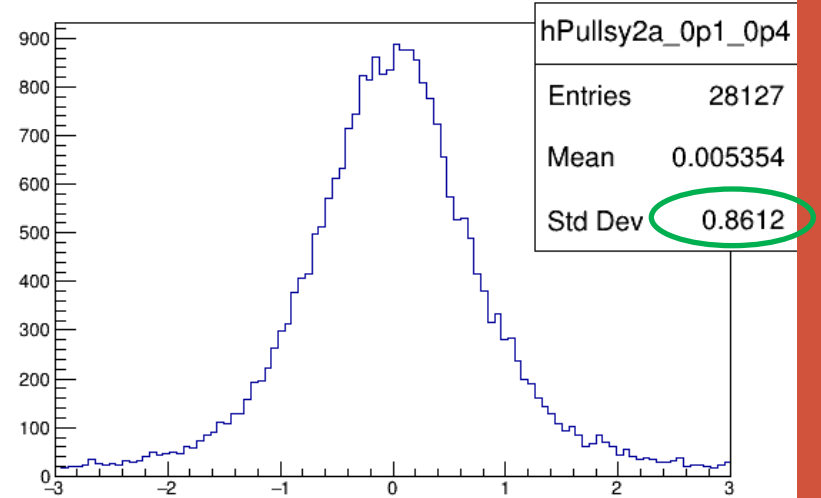
$$\frac{(X_{fit} - X_{measured})}{\sigma}$$

If  $\sigma$  for measurement is chosen correctly the pull's RMS  $\approx 1$

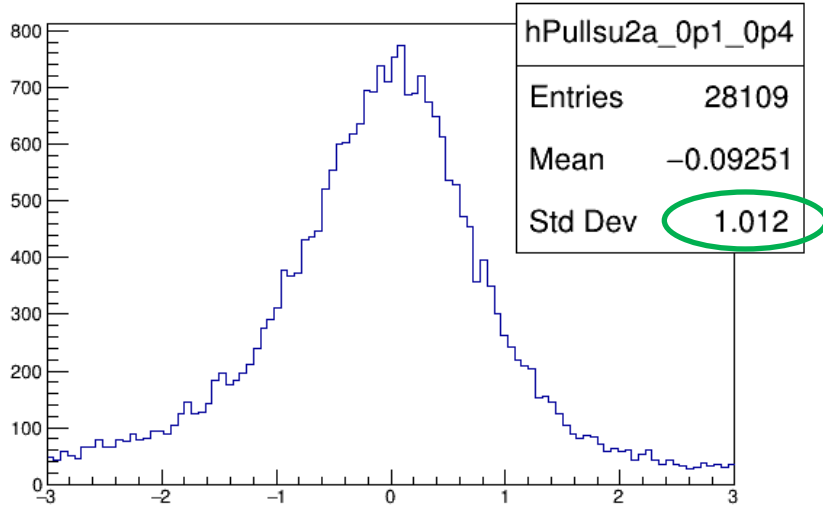
dc2 xa pull (0.1 - 0.4) away from wire



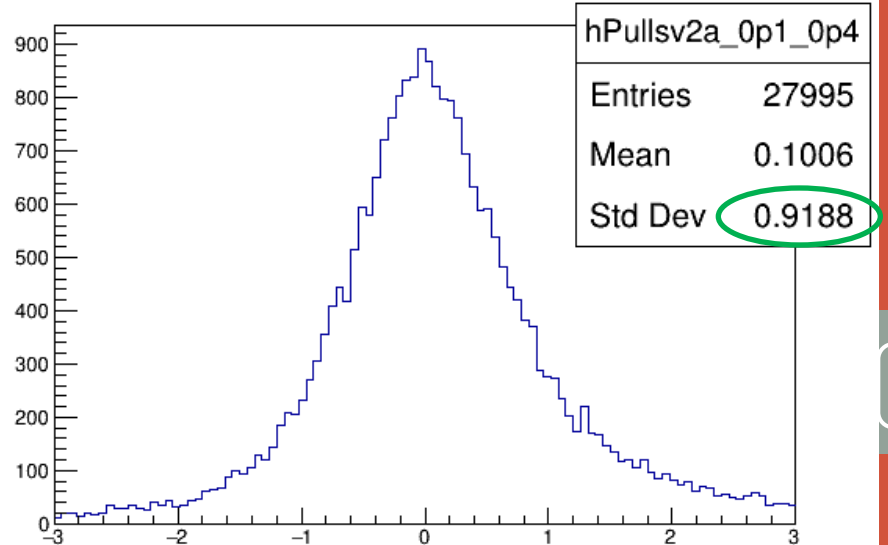
dc2 ya pull (0.1 - 0.4) away from wire



dc2 ua pull (0.1 - 0.4) away from wire



dc2 va pull (0.1 - 0.4) away from wire

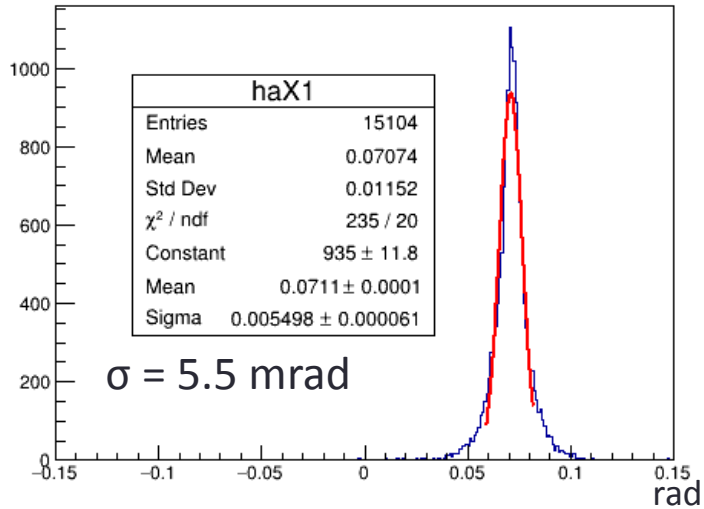


# Angle values and resolution

C beam, empty target, B = 1200A

MC segments

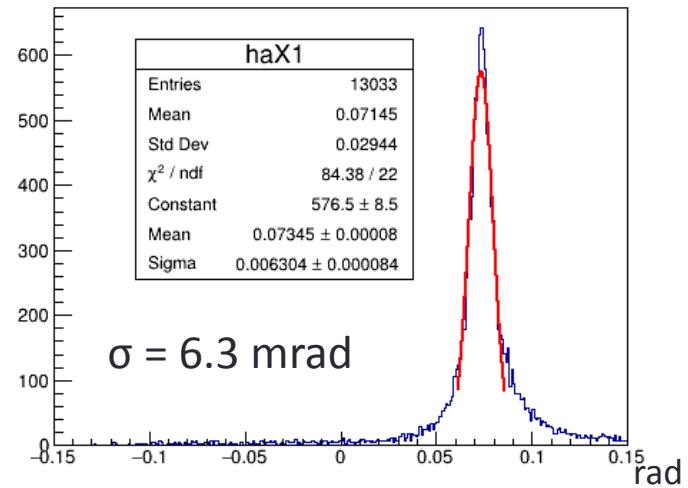
aX1



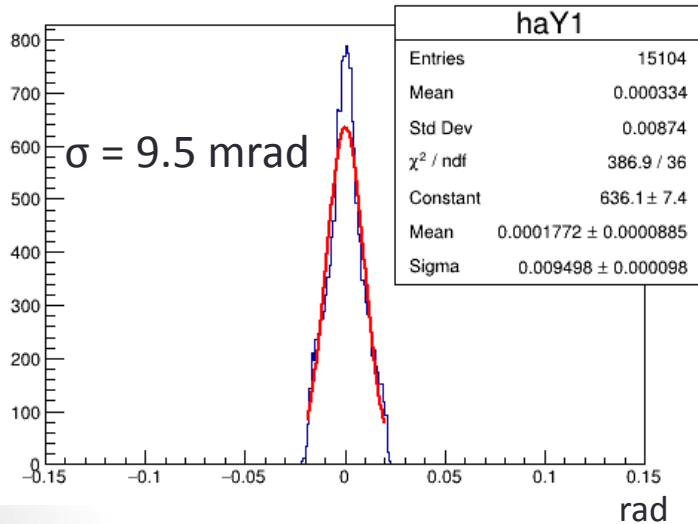
X slope

Data segments

aX1

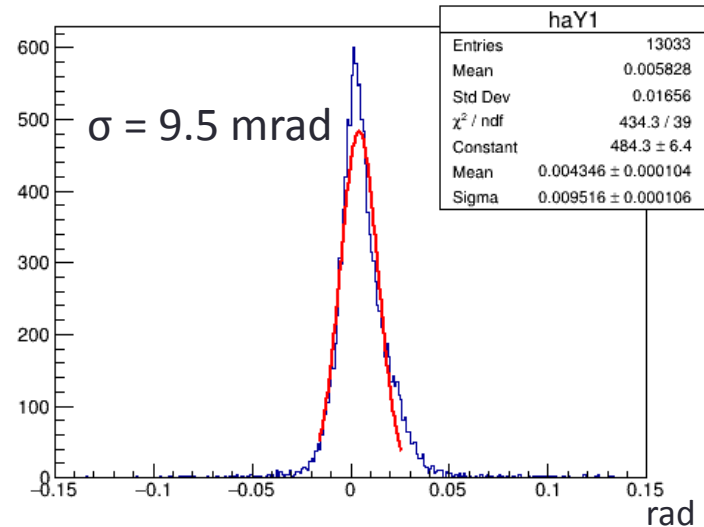


aY1



Y slope

aY1

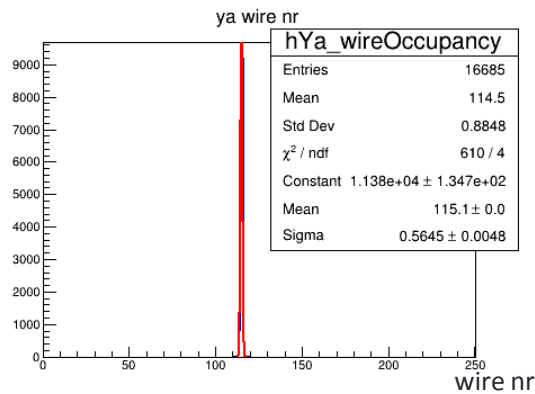
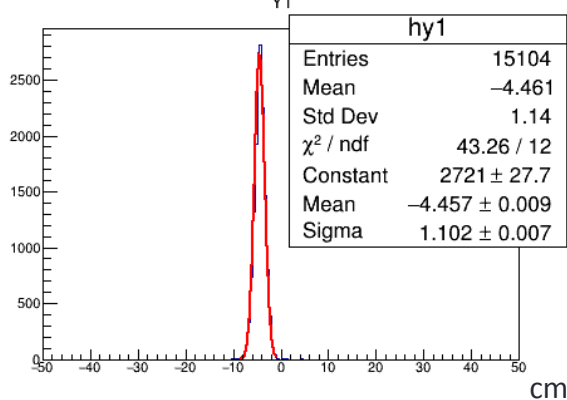
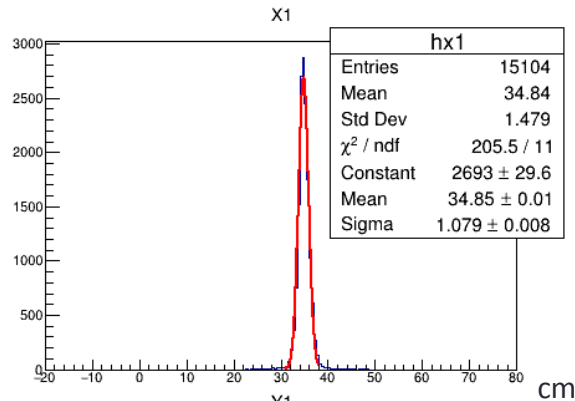


# Coordinates values and beam width

C beam, empty target, B = 1200A

MC segments

Data segments

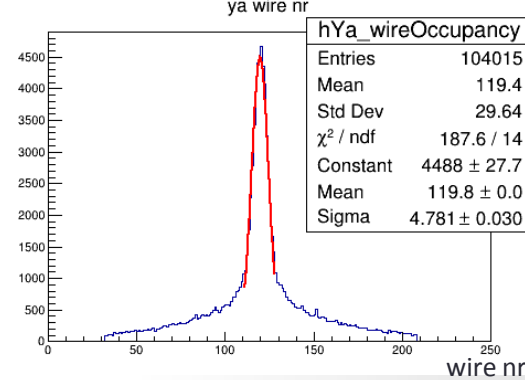
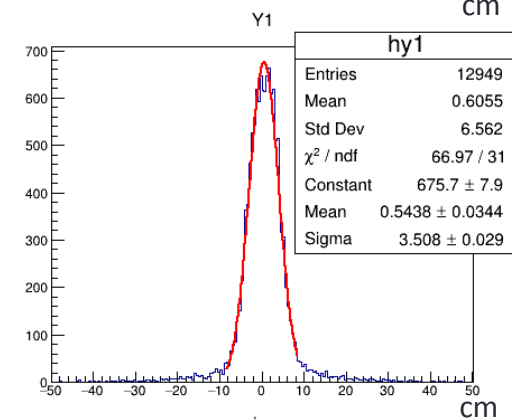
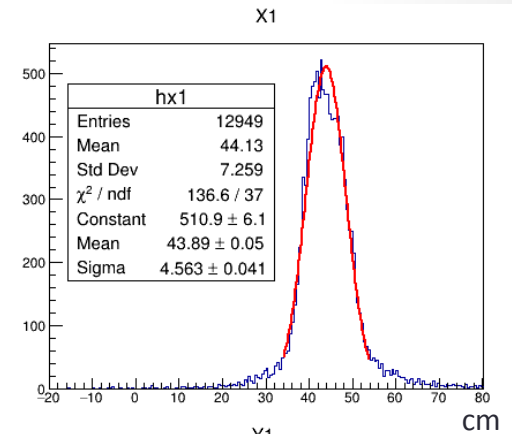


X segment coordinate

Y segment coordinate

Wire occupancy

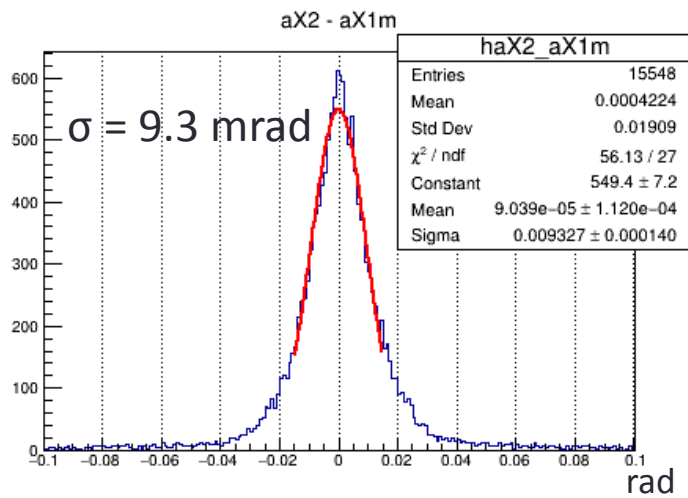
The difference is due to the width of the beam



# Difference in slopes between DC1 & DC2

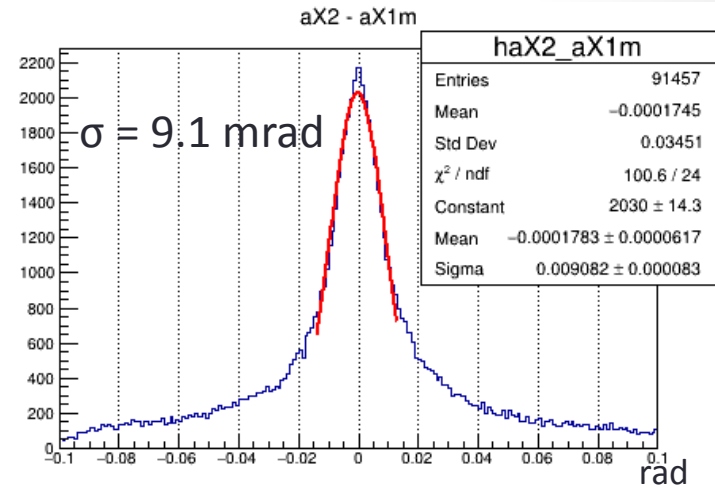
C beam, empty target, B = 1200A

MC reco

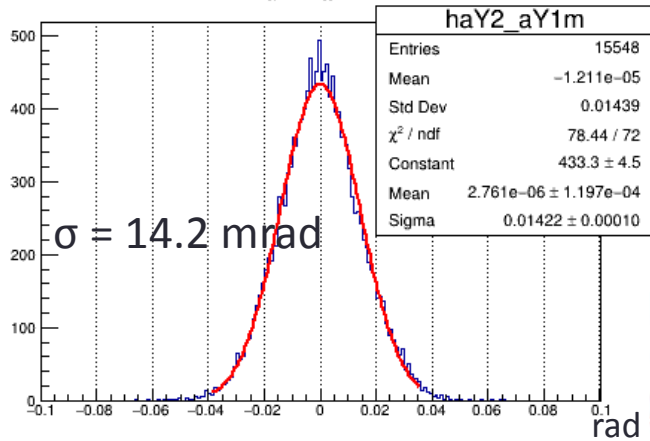


X slope

data reco

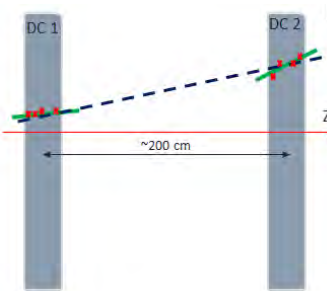
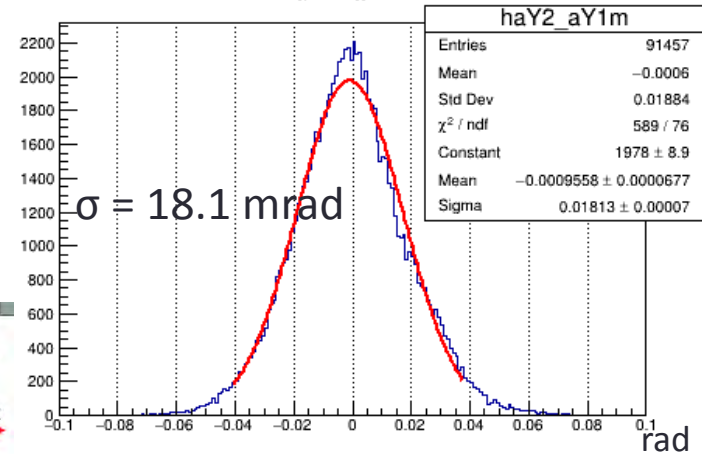


aY2 - aY1m



Y slope

aY2 - aY1m



MC slope difference distributions are adequate to SRC data

# Difference in coordinates for matching DC1 with DC2

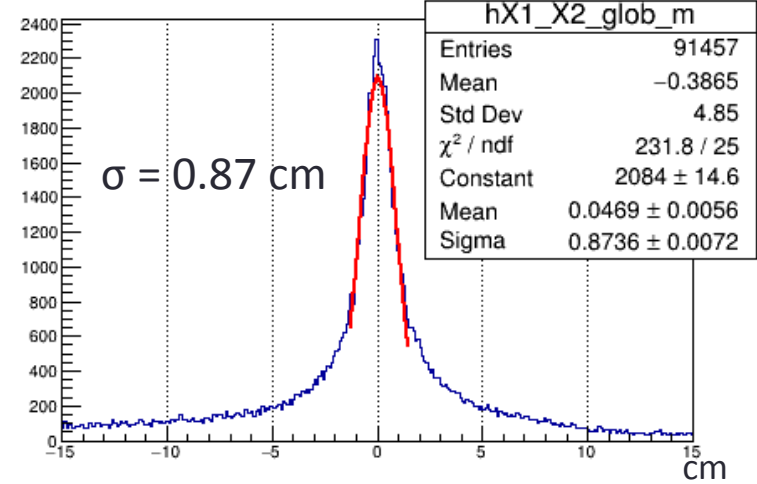
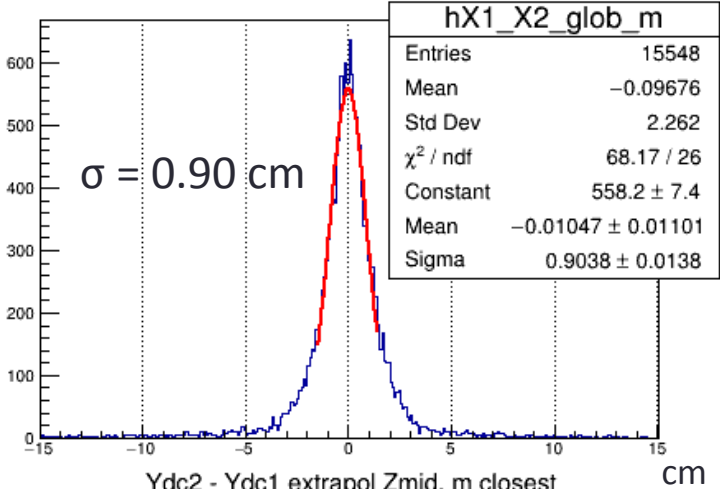
C beam, empty target, B = 1200A

MC reco

data reco

Xdc2 - Xdc1 extrapol Zmid, m closest

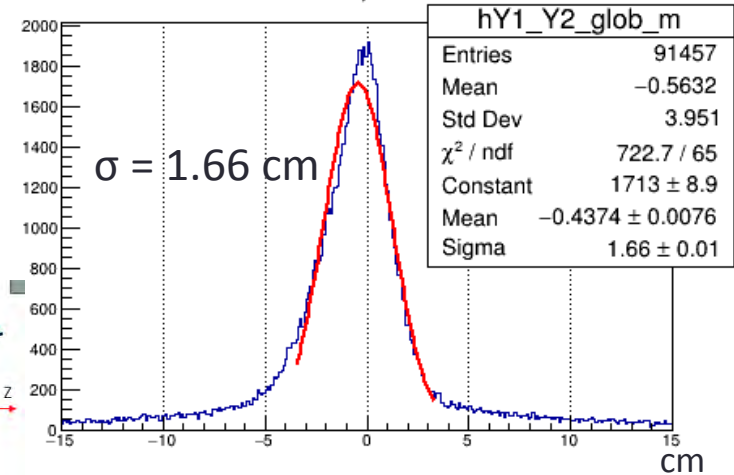
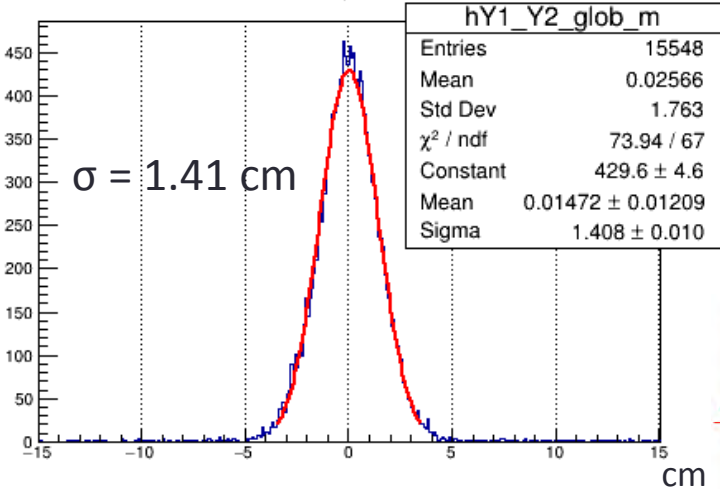
Xdc2 - Xdc1 extrapol Zmid, m closest



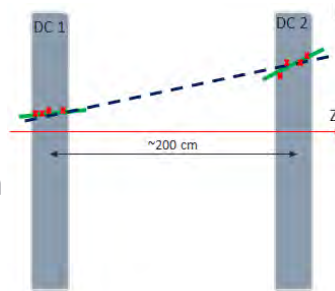
X

Ydc2 - Ydc1 extrapol Zmid, m closest

Ydc2 - Ydc1 extrapol Zmid, m closest



Y



Smearing for MC coordinates is adequate to SRC data

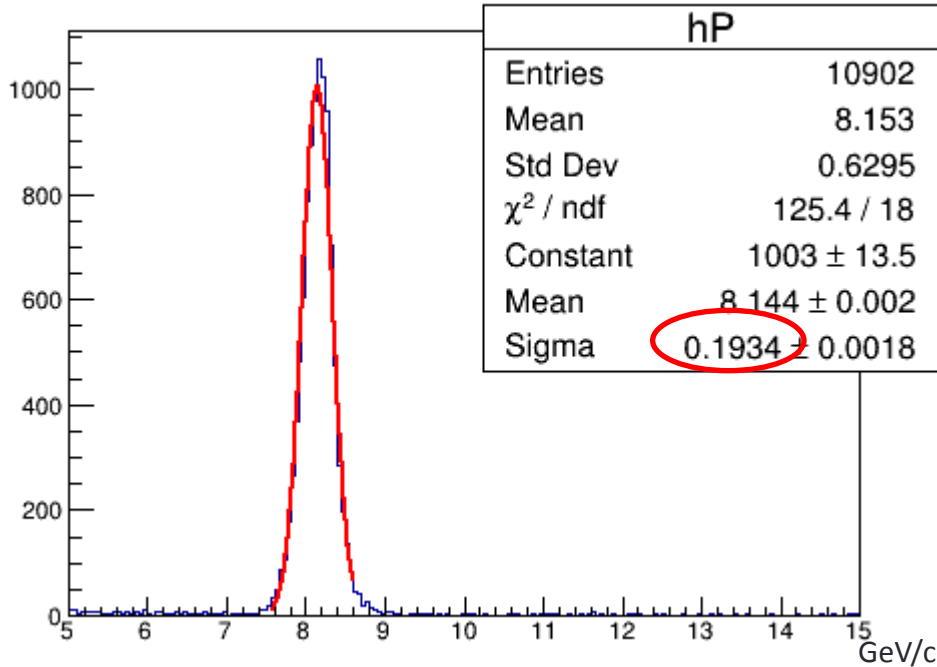


# C Beam momentum resolution

C Beam, empty target, B = 1200A

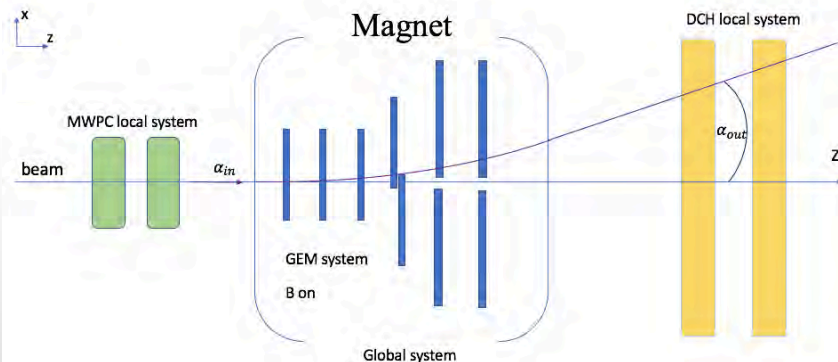
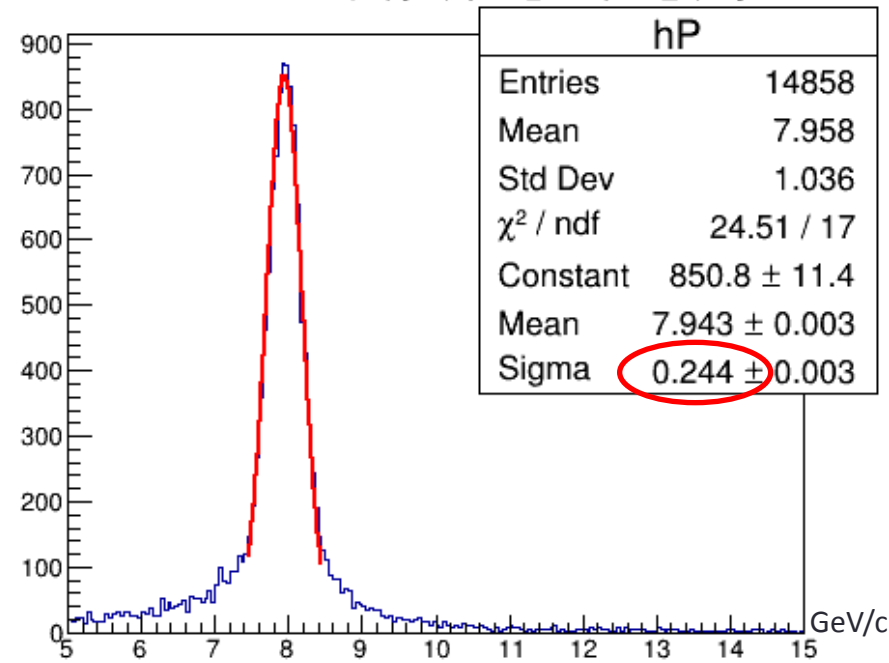
MC DCH global tracks

momentum =  $.3 * \text{Int}(BL) / [\sin(\alpha_{\text{out}} - \alpha_{\text{in}}) + C]$



RUN7 data DCH global tracks

momentum =  $.3 * \text{Int}(BL) / [\sin(\alpha_{\text{out}} - \alpha_{\text{in}}) + C]$



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

$\alpha_{\text{in}}$  - angle of beam before magnet (MWPC);  
 $\alpha_{\text{out}}$  - angles of beam after magnet (DCH);  
 $\int Bdl$  - magnet field integral [T\*m].

# Reconstruction Efficiency vs. MC hit probability

The probability that there is a detector response on layer corresponding to a particular MC point can be adjusted.

	dc1, %	dc2, %	dcGlobal, %
100% hit on layer probability	100	100	100
90% hit on layer probability	86.32	86.37	69.18

$$\text{Efficiency} = \frac{\text{number of reconstructed tracks}}{\text{number of MC tracks}} * 100\%$$

# Implementation into bmnroot

The screenshot displays the GitLab interface for the 'bmnroot' repository. The left sidebar shows navigation options: Project overview, Repository (Files, Commits, Branches, Tags, Contributors, Graph, Compare), Issues (29), and Merge Requests (0). The main content area shows the commit history for the 'dev' branch of the 'bmnroot / dch' directory. The history is organized by date, with a section for '23 Oct, 2020' containing four commits and a section for '22 Oct, 2020' containing one commit. Each commit entry includes a commit icon, the commit message, and the author's name and time since authored.

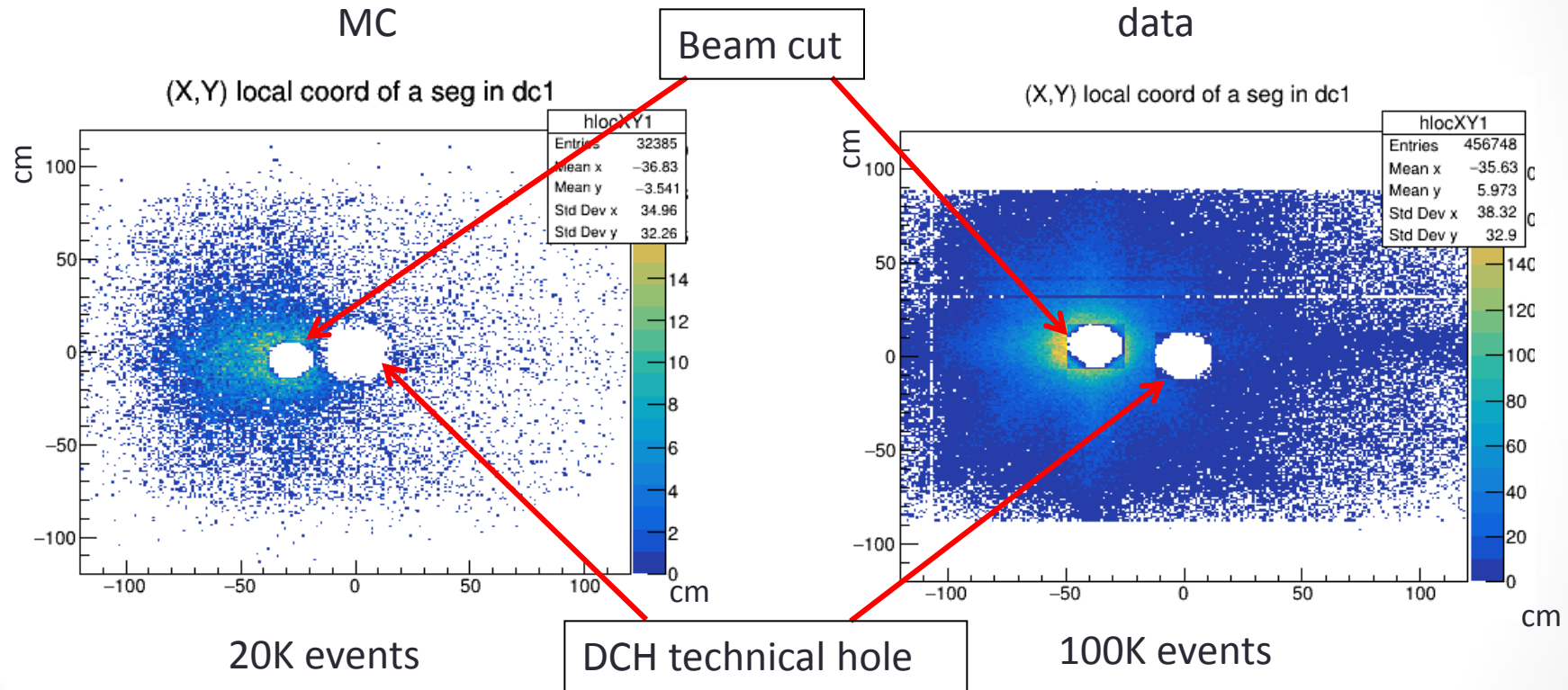
Date	Commit Message	Author
23 Oct, 2020	Update BmnDchHitProducer.cxx	Nikolay Voytishin
23 Oct, 2020	BmnDchTrackFinder.cxx adjusted for reconstruction of MC and experimental data	Nikolay Voytishin
23 Oct, 2020	BmnDchTrackFinder.h adjusted for reconstruction of MC and experimental data	Nikolay Voytishin
23 Oct, 2020	BmnDchHitProducer.cxx adjusted MC hit reconstruction	Nikolay Voytishin
22 Oct, 2020	adjusting simulation for DCH	Nikolay Voytishin

Unified DCH tracking for SRC/BM@N/MC/EXP was implemented into bmnroot.

# Ar beam e.m. contaminated MC data vs. Ar data

Ar beam, empty target, B = 1250A

DCH1 reconstructed segments local coordinates



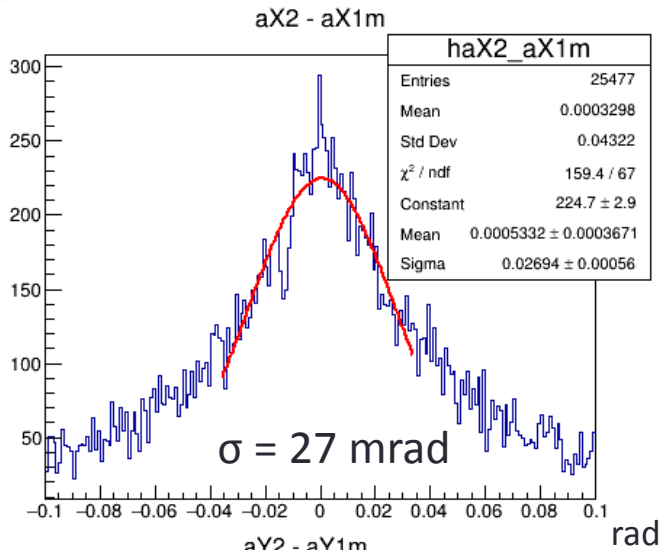
**Remark.** Cut on beam region applied in order for reconstruction to work properly

# Difference in slopes for DC1 & DC2

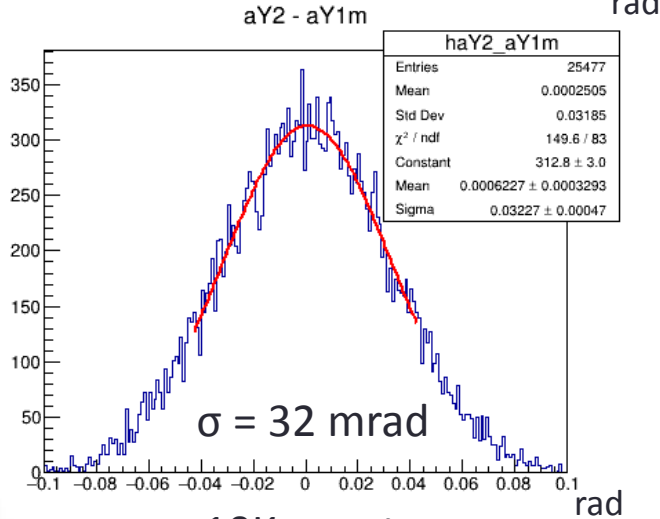
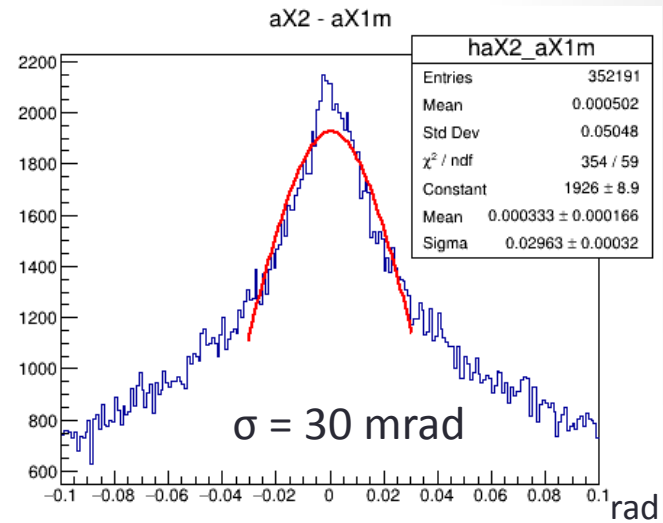
MC

Ar Beam, empty target, B = 1250A

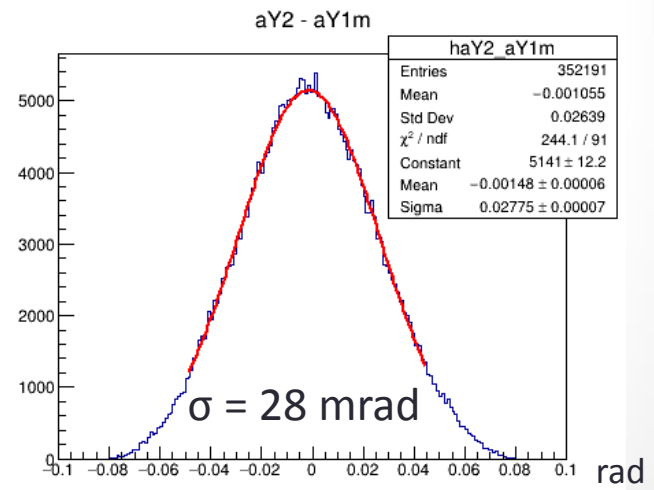
data



X slope



Y slope



10K events

100K events

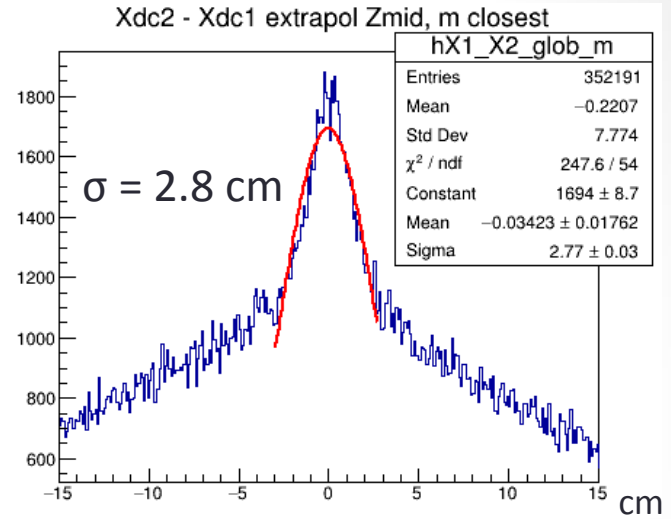
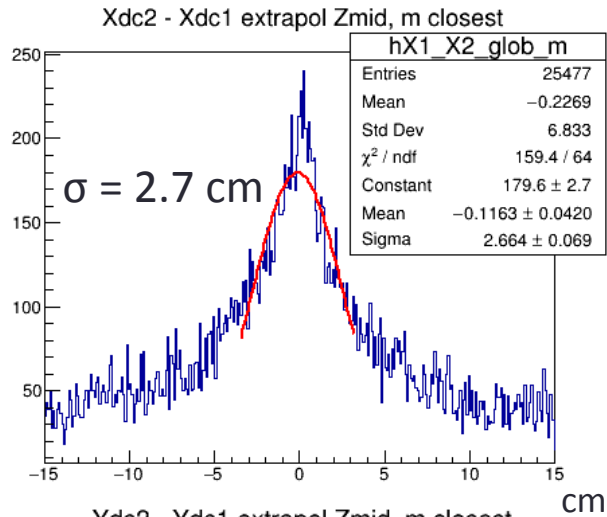
MC slope difference distributions are adequate to Ar data

# Difference in coordinates for matching DC1 with DC2

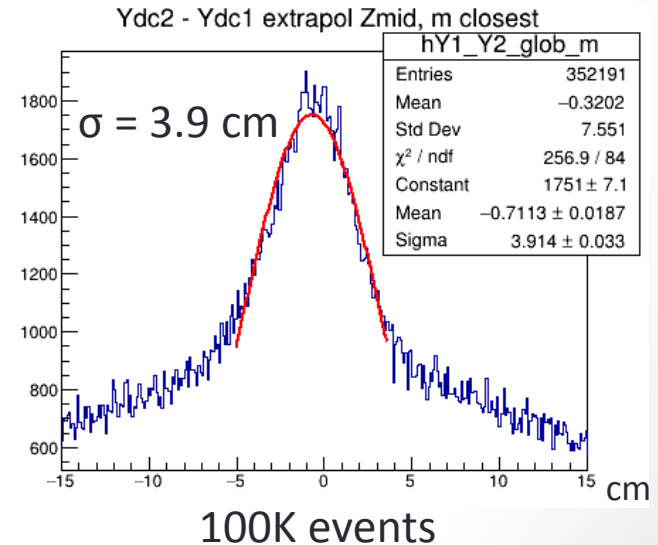
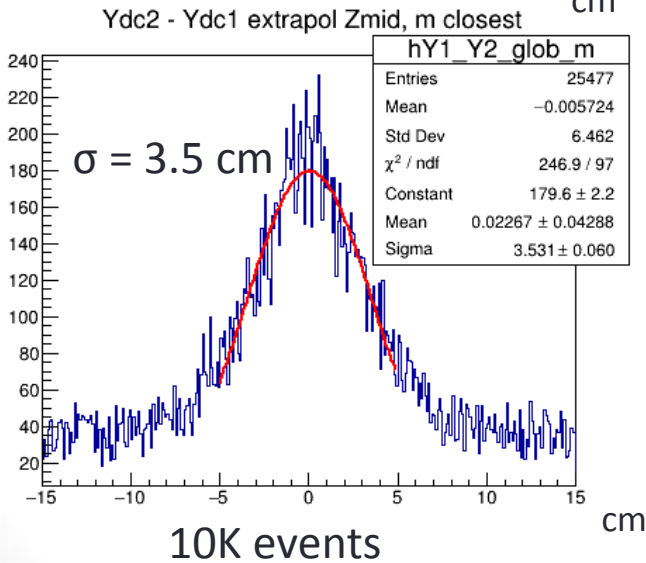
Ar Beam, empty target, B = 1250A

MC reco

data reco



X

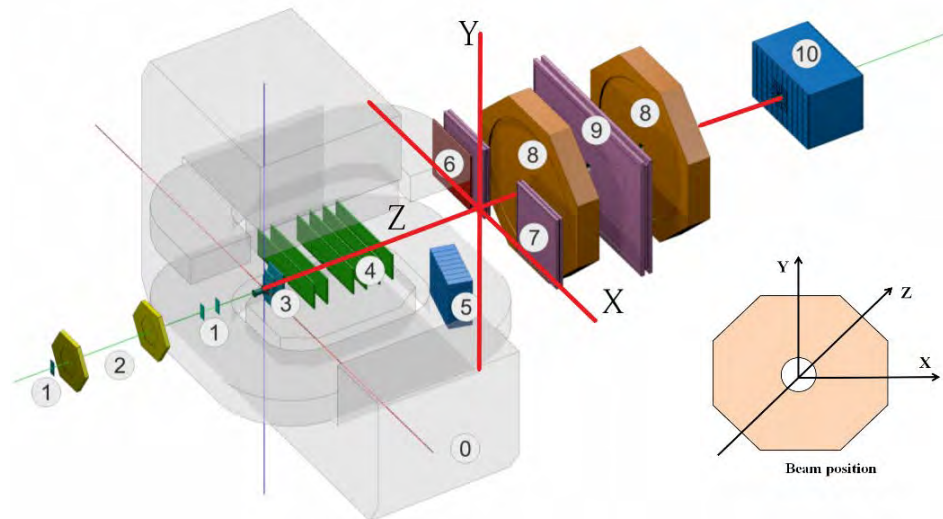


Y

Smearing for MC coordinates is adequate to Ar data

# Conclusions

- Realistic response of DCH added in simulation procedure
- Residuals and segment parameters are in agreement between MC and data
- The differences for matching between two DCH chambers in slopes and coordinates are quite similar for MC and data
- Tracking unified for SRC/BM@N/MC/EXP
- The full reconstruction chain for Dift Chambers is available in *bmnroot* package.

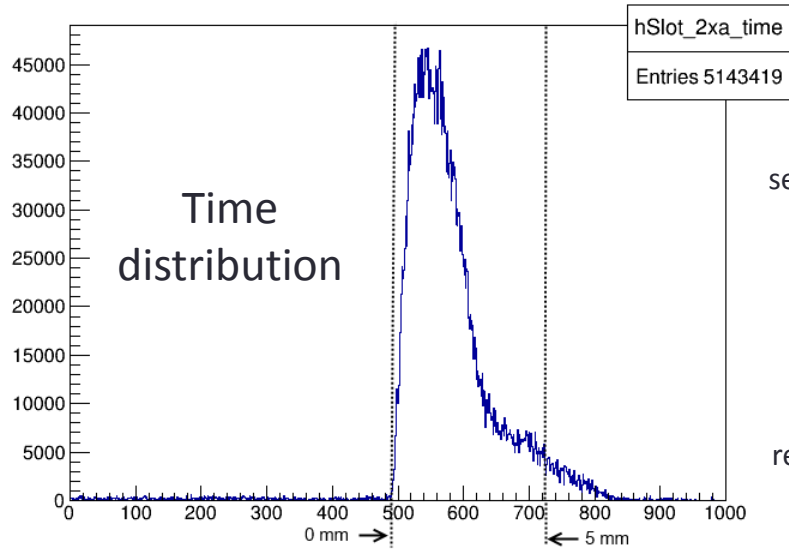


backup

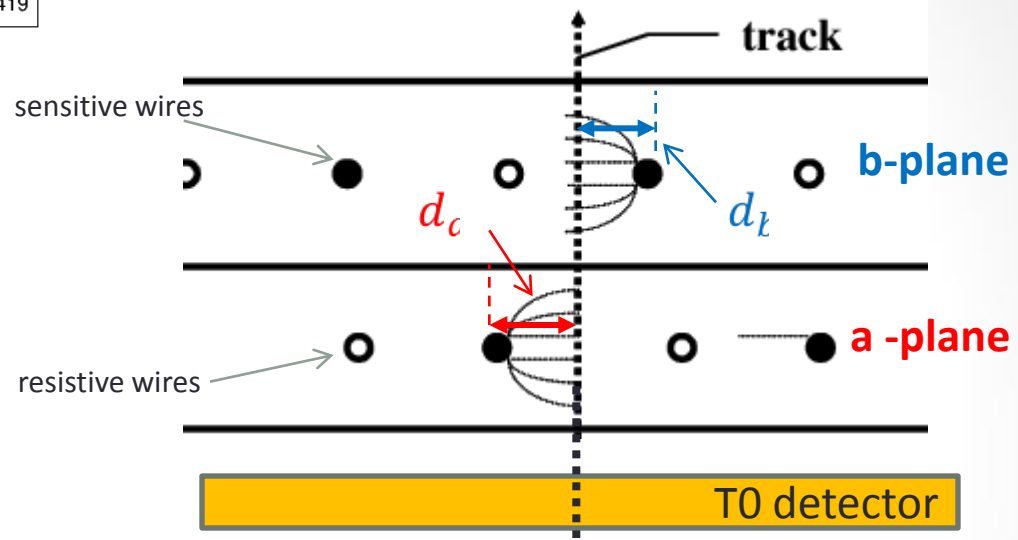


# Drift Chambers coordinate reconstruction on a layer

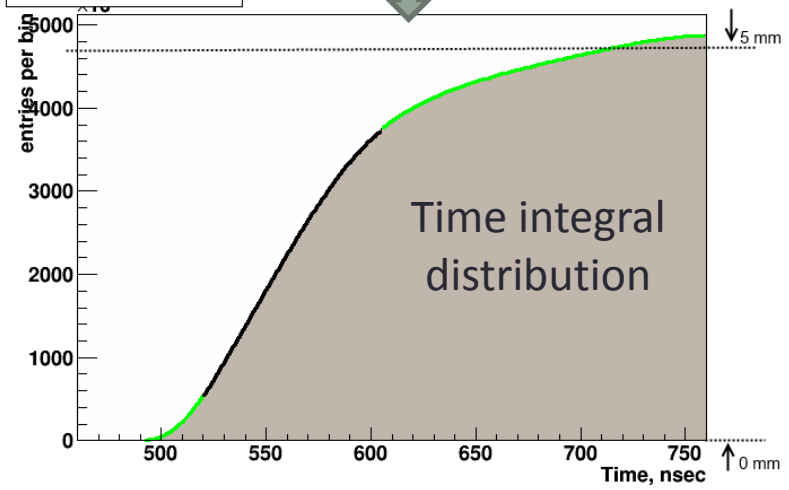
times\_for\_plane\_DC2\_xa



$$d_a + d_b - 5\text{mm} \rightarrow 0$$



time\_cs\_for\_plane\_DC2\_xa



- 4 double coordinate planes: 2x; 2y, 2u, 2v;
- wire angles  $0^\circ, 90^\circ, \pm 45^\circ$ ;
- wire pitch 10 mm;
- $Y_{out} \pm 1.35$  m,  $X_{out} \pm 1.35$  m;
- $R_{hole} = 10$  cm;
- 2048 wires per chamber.

# Drift Chambers Reconstruction & Performance

Hit reconstruction  
on a particular layer



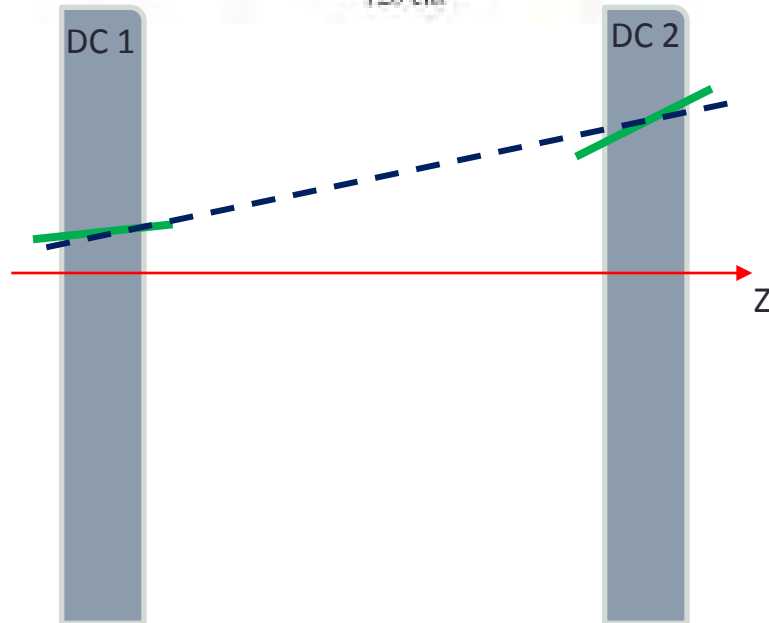
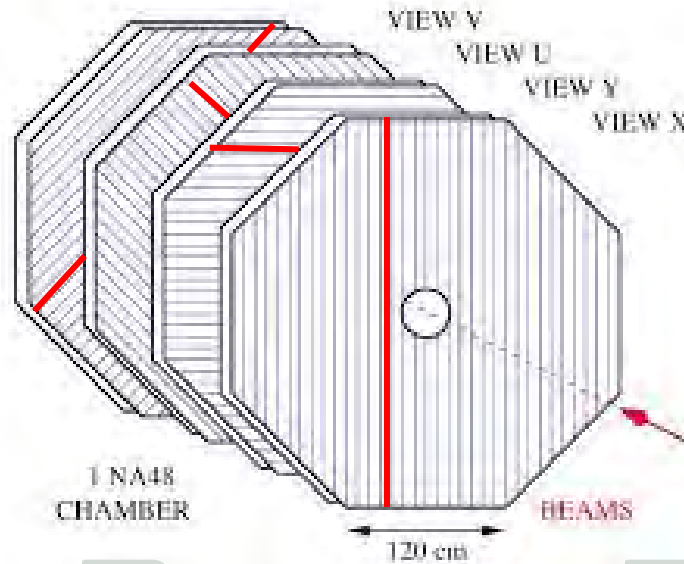
Pair hit  
assembly



Segment  
reconstruction



Global track  
reconstruction



$$X = \frac{V-U}{\sqrt{2}};$$
$$Y = \frac{V+U}{\sqrt{2}};$$

- 4 double coordinate planes;
- wire angles  $0^\circ, 90^\circ, \pm 45^\circ$ ;
- wire pitch 10 mm;
- $Y_{out} \pm 1.35$  m,  $X_{out} \pm 1.35$  m;
- $R_{hole} = 10$  cm;
- 2048 wires per chamber.