



# Reconstruction of simulated and experimental data in the Drift Chambers of the BM@N experiment

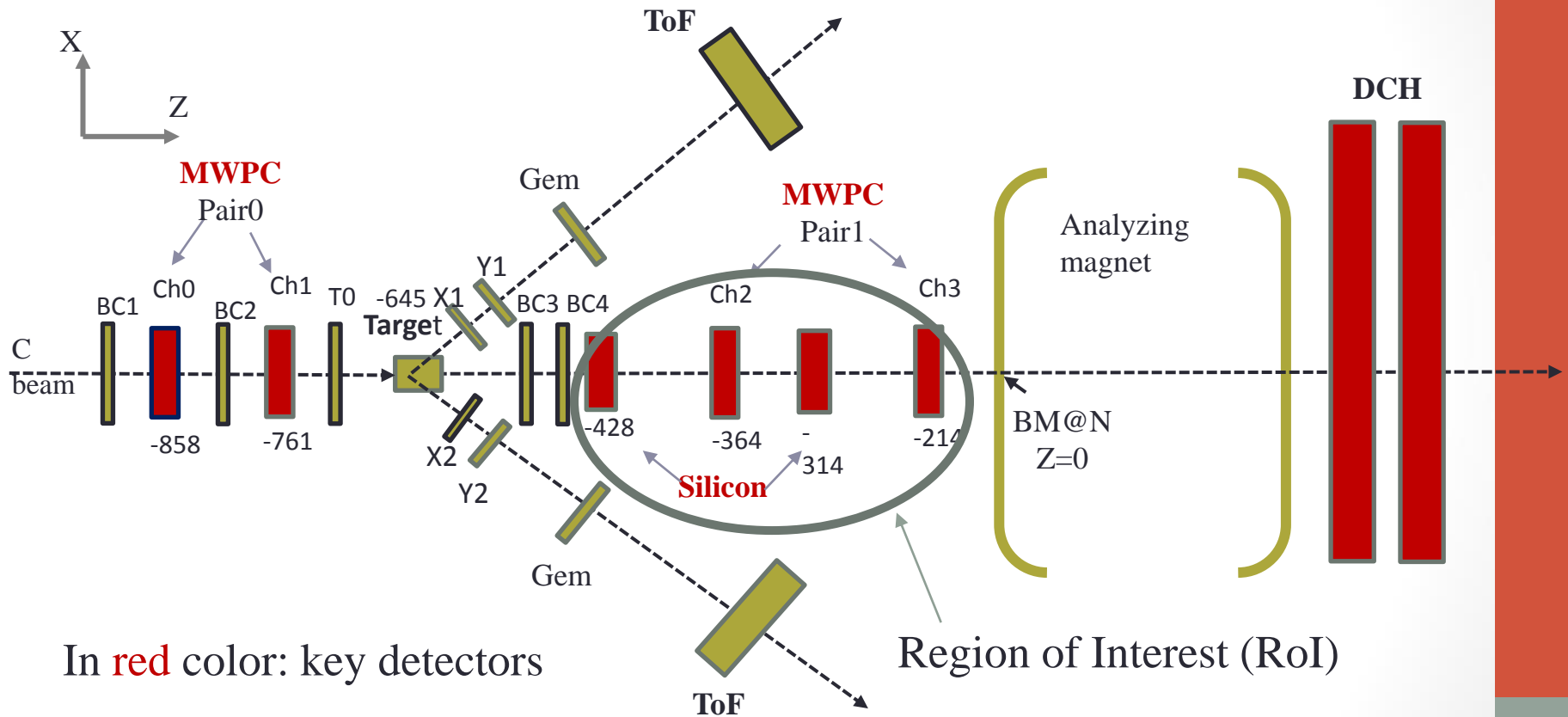
V. Lenivenko, V. Palichik, M. Patsyuk, N. Voytishin  
JINR



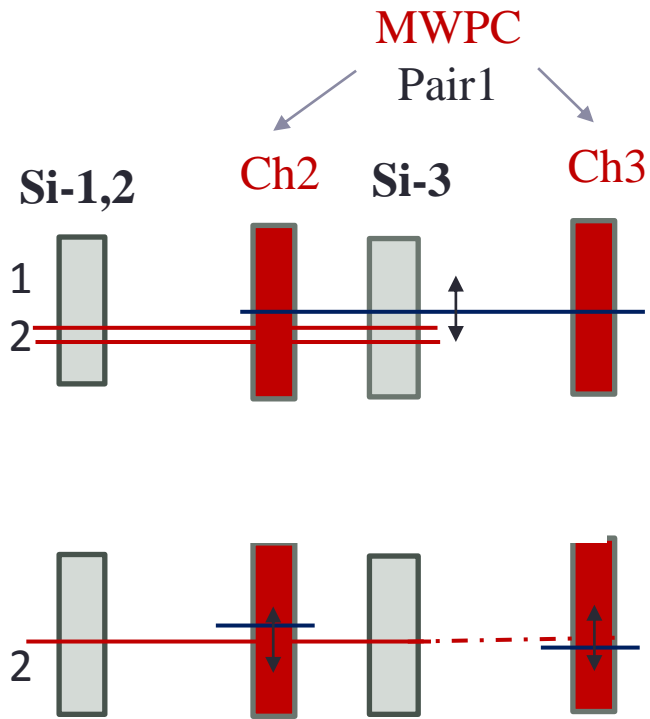
AYSS-2021  
2021-10-15



# SRC RUN7 CONFIGURATION (2018):



# Upstream (MWPC-Si) Track Algorithm



1. Si Tracks building in SiDets
2. MWPC Tracks (Pair1) building in Ch2 & Ch3
3. Si Tracks – MWPC Tracks (Pair1) matching
4. Matching of the rest Si Tracks with MWPC Segments separately (Ch2 or Ch3)
5. Track fitting by 2 systems => **Upstream track**

# MWPC Working Area is Increased (downstream the target)

MWPC has 6 planes:

U, V are rotated by  $\pm 60$  degrees to the X-axis

**Area3**

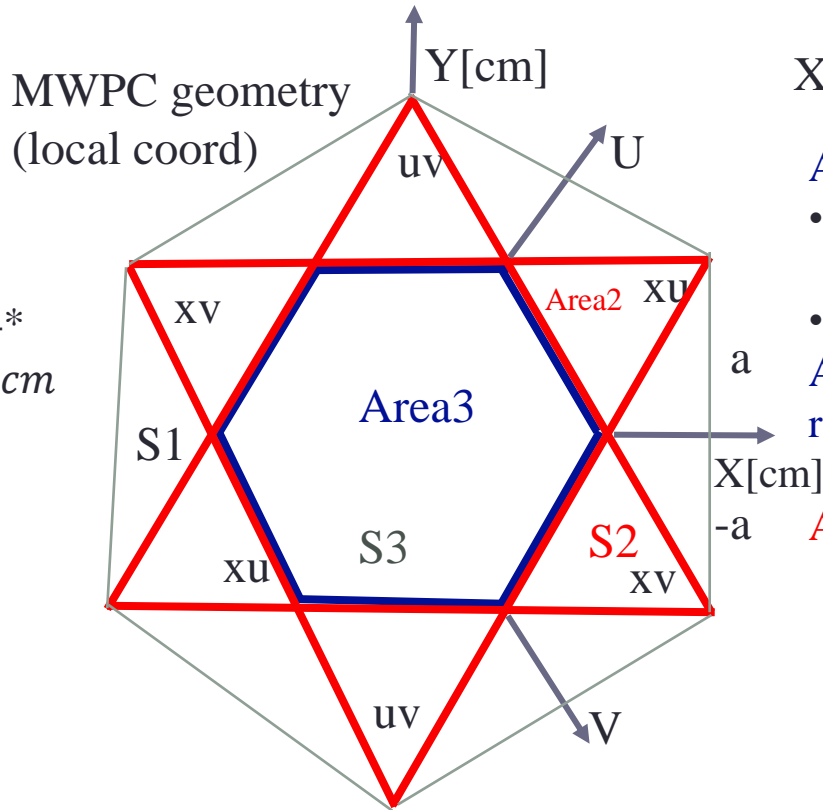
- is the area of intersection of 3 coordinates: XVU (6-planes segment possible)
- Area 3  $\approx$  beam area (it's basically 1 track)

**Area3** was used in old algorithm of MWPC track reconstruction

**Area2** is the area where 2 coordinates intersect:

- $U_1 U_2 V_1 V_2$  or  $X_1 X_2 V_1 V_2$  or  $X_1 X_2 U_1 U_2$   
(4- planes segment possible)

The adding of Area2(S2) doubles the working area!

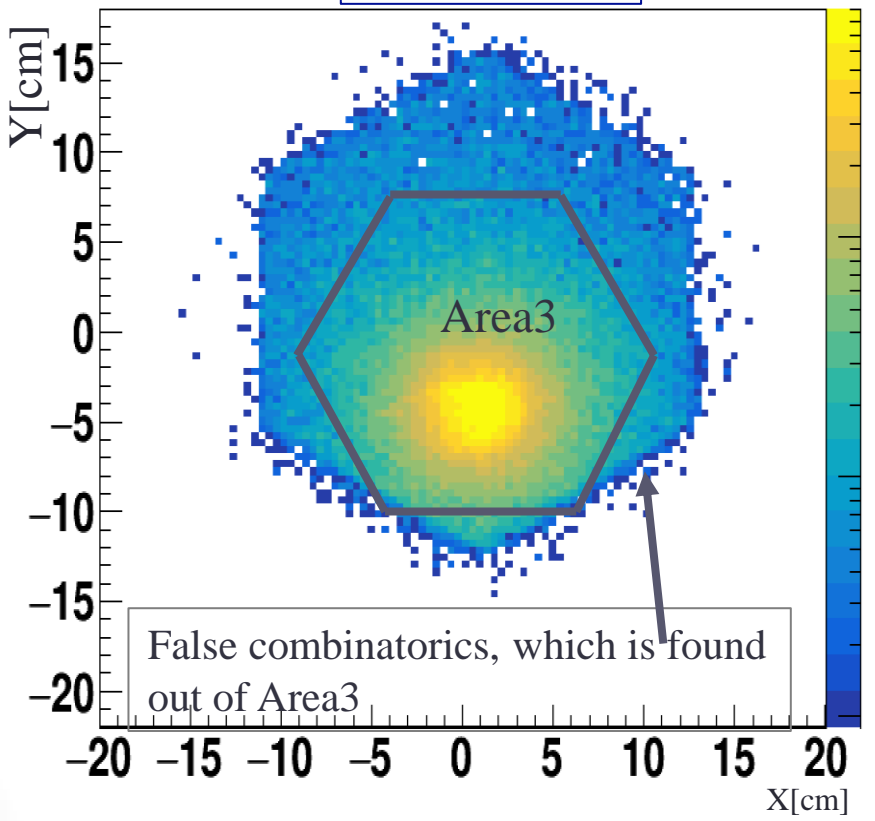


One-coordinate S1-area is not used

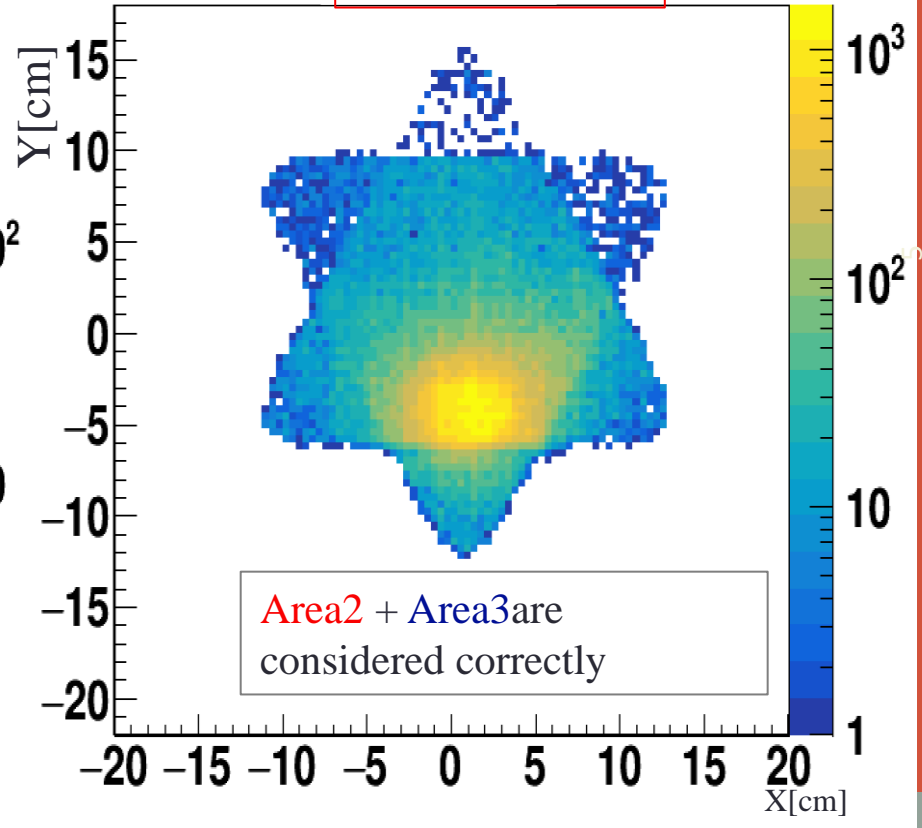
# Improvement in New Algo: False Combinatorics were Rejected

• Run 3338 (H2 target)

Old algo



New algo



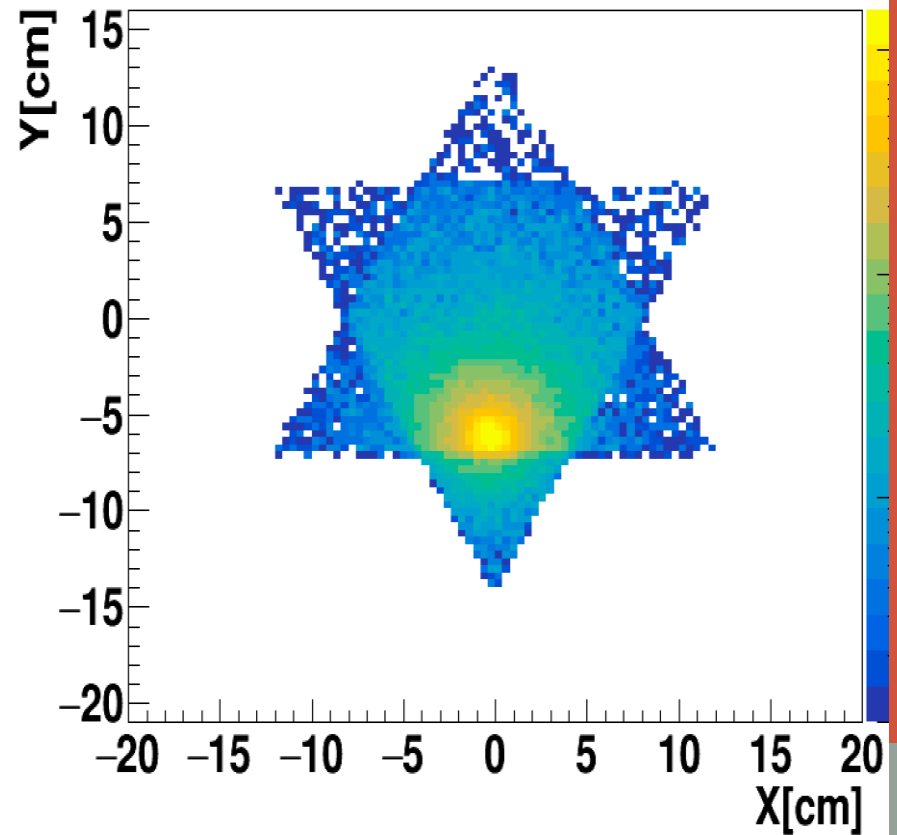
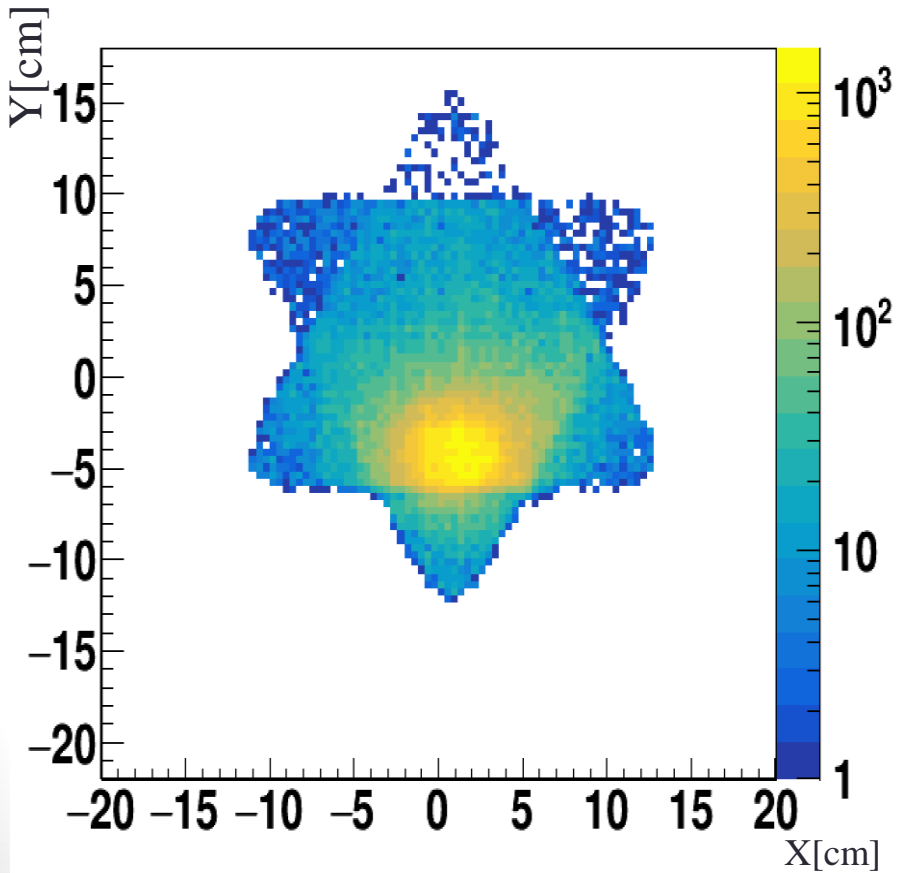
Ch2 segments coordinate plots. The same for Ch3 and Pair1

# Data vs MC: Coordinate Plots for Ch2 Segments

New algo

Data Run 3338 (H2 target)

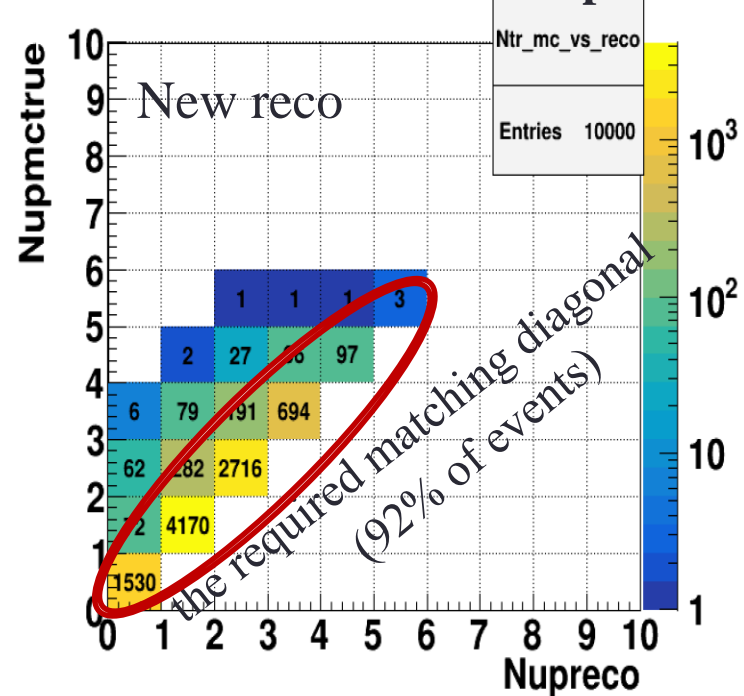
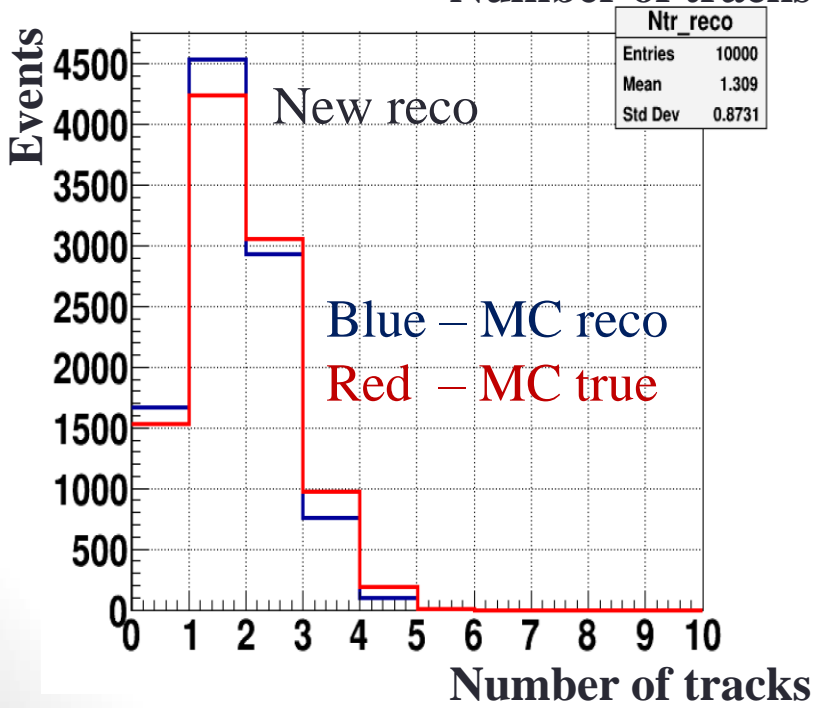
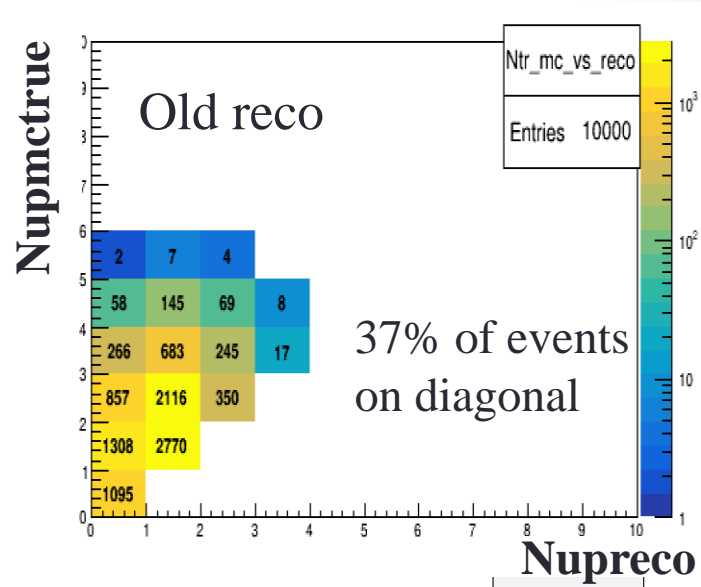
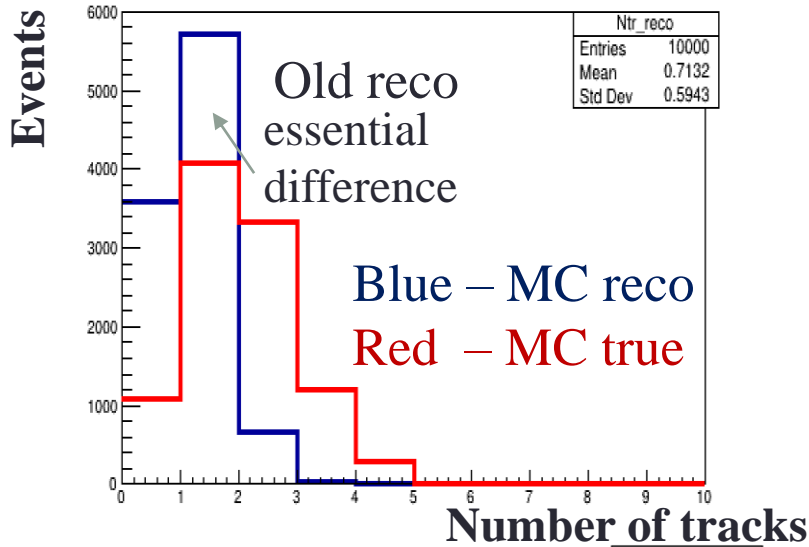
MC true (QGSM)



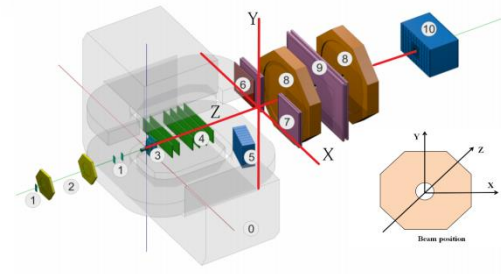
Good agreement between experimental and MC data is obtained

# MC reco vs MC true: Upstream Reco Algo Improvement

DCM-SMM



# Drift Chambers Reconstruction Chain



Hit reconstruction on a particular layer

↓

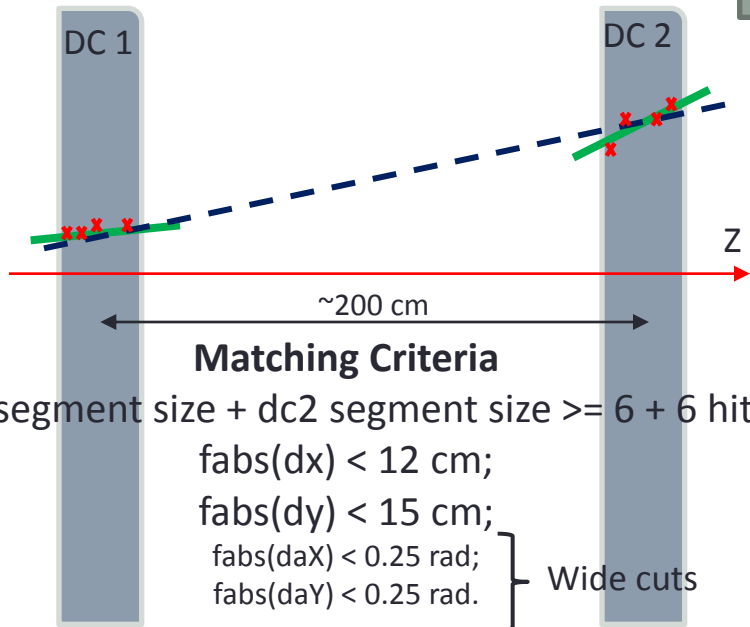
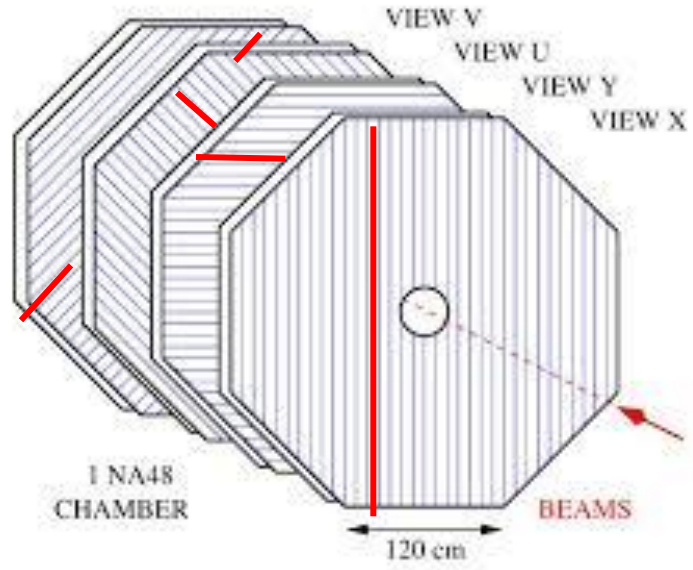
Pair hit assembly

↓

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

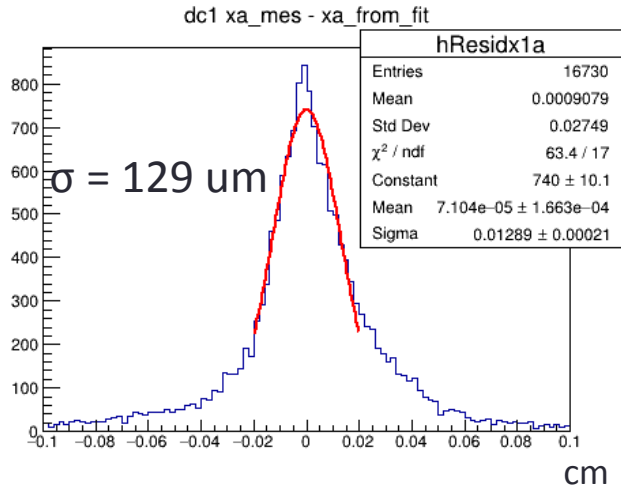
output



# Some selected residuals [Measurement – segmentFit]

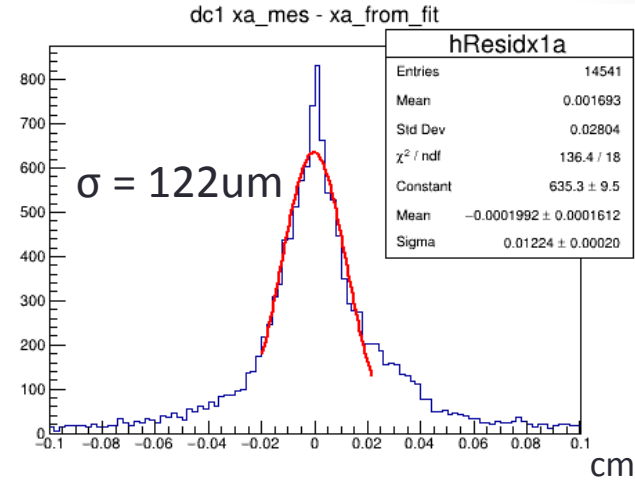
C beam, empty target, B = 1200A

MC segments

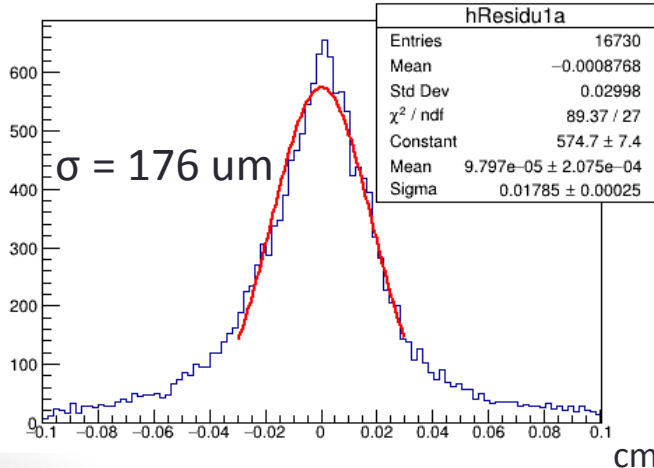


X - coordinate

Data segments

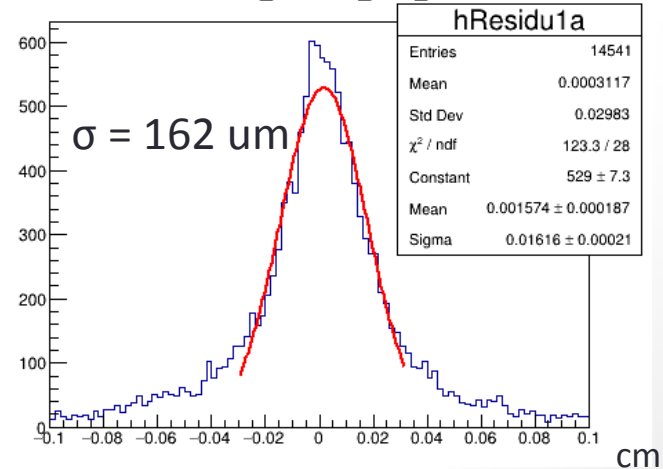


dc1 ua\_mes - ua\_from\_fit



U - coordinate

dc1 ua\_mes - ua\_from\_fit



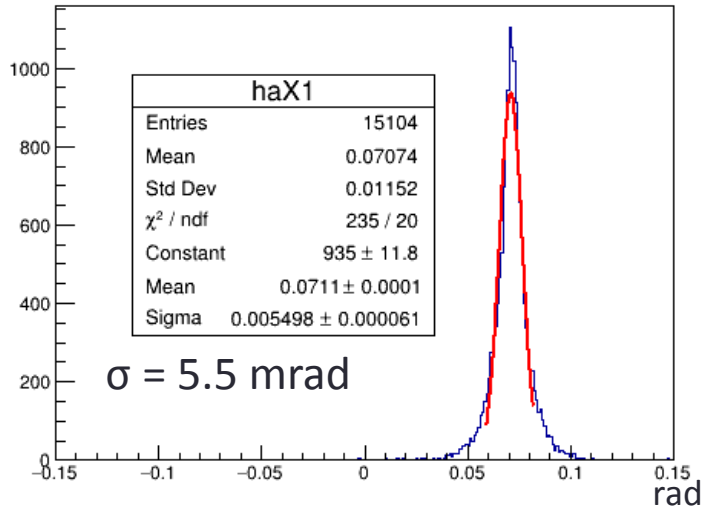
MC and data residuals are in agreement for all coordinates

# Angle values and resolution

C beam, empty target, B = 1200A

MC segments

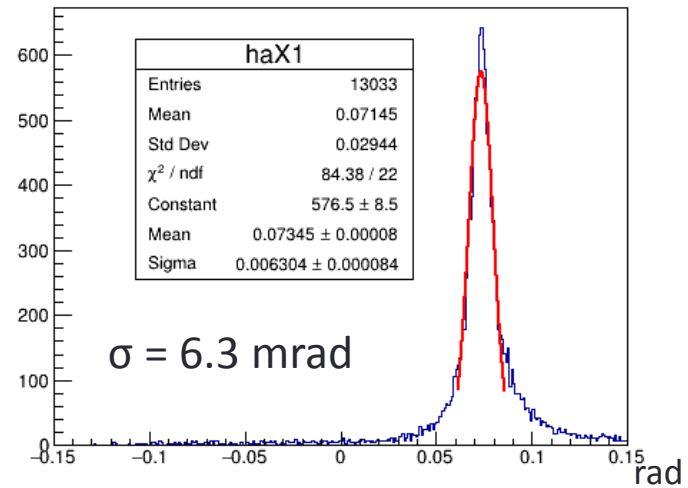
aX1



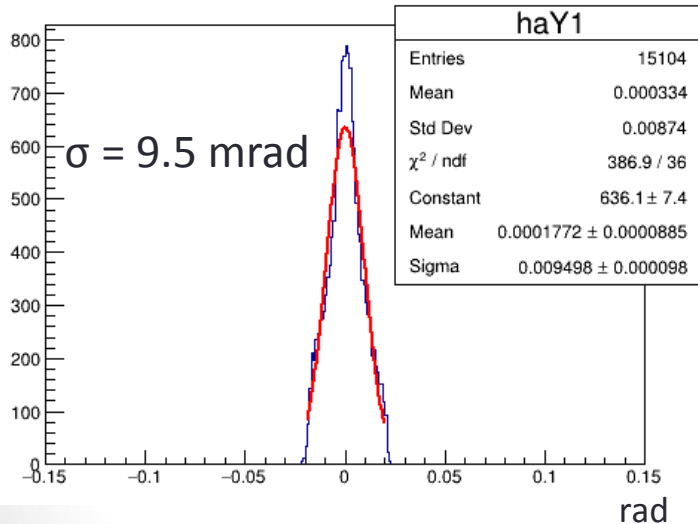
X slope

Data segments

aX1

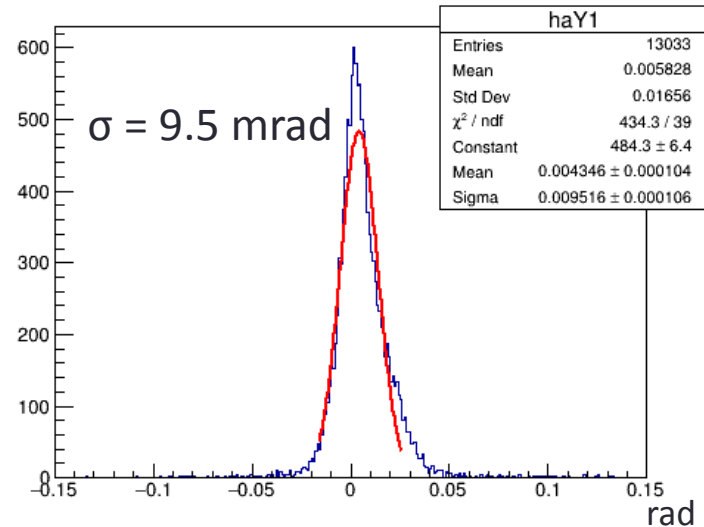


aY1



Y slope

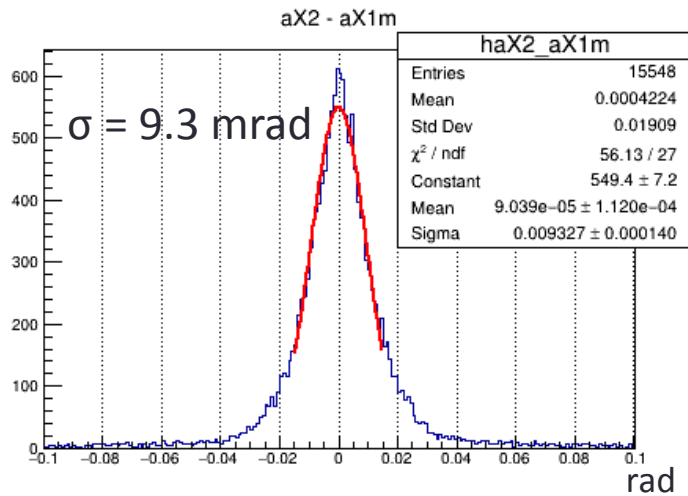
aY1



# Difference in slopes between DC1 & DC2

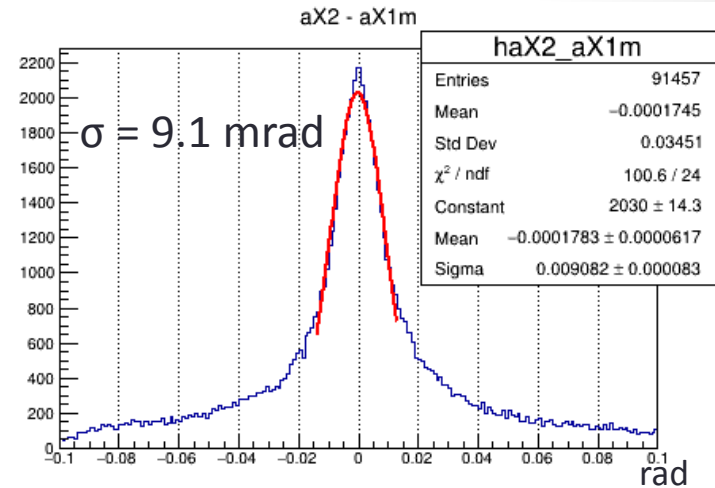
C beam, empty target, B = 1200A

MC reco

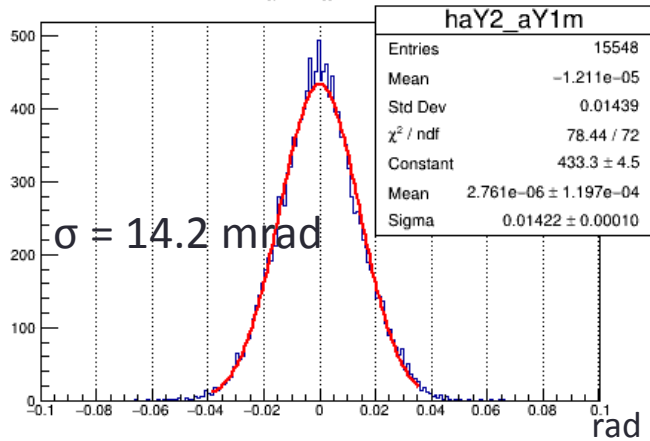


X slope

data reco

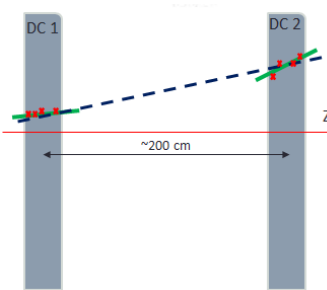
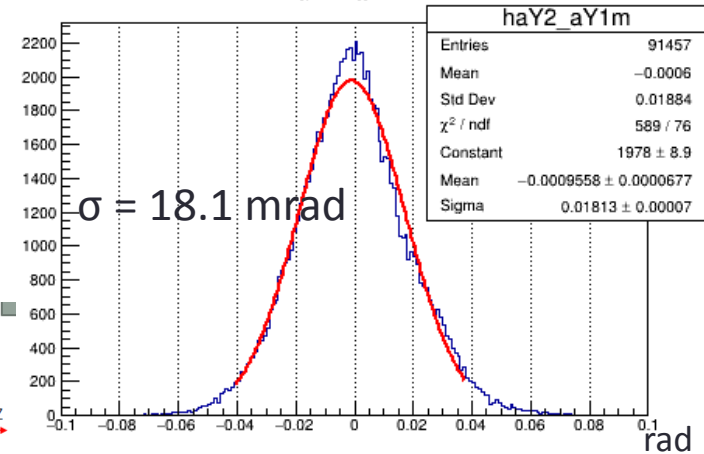


aY2 - aY1m



Y slope

aY2 - aY1m



MC slope difference distributions are adequate to SRC data

# Difference in coordinates for matching DC1 with DC2

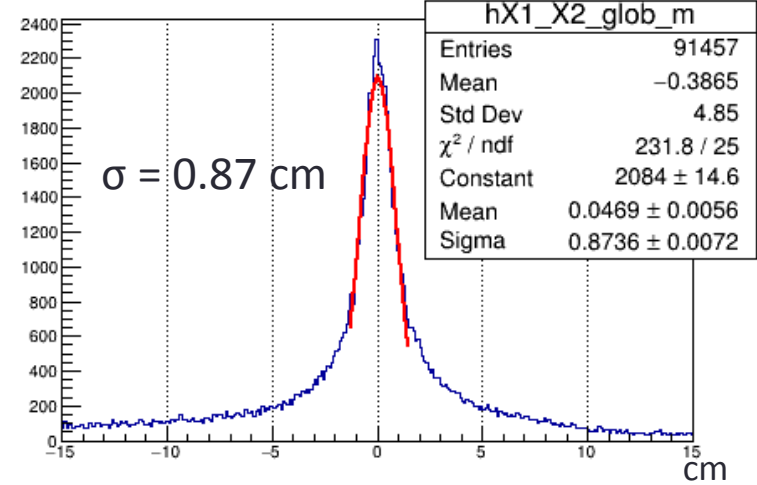
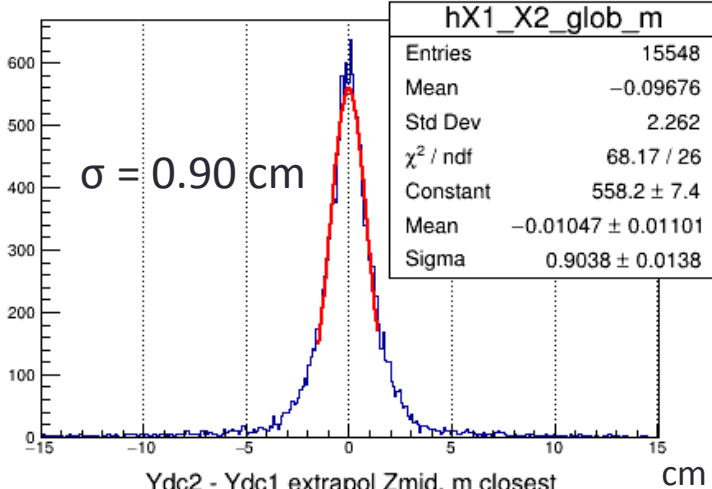
C beam, empty target, B = 1200A

MC reco

data reco

Xdc2 - Xdc1 extrapol Zmid, m closest

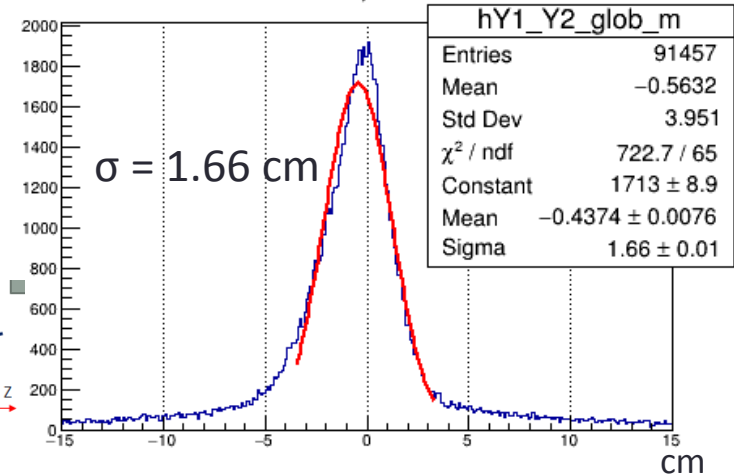
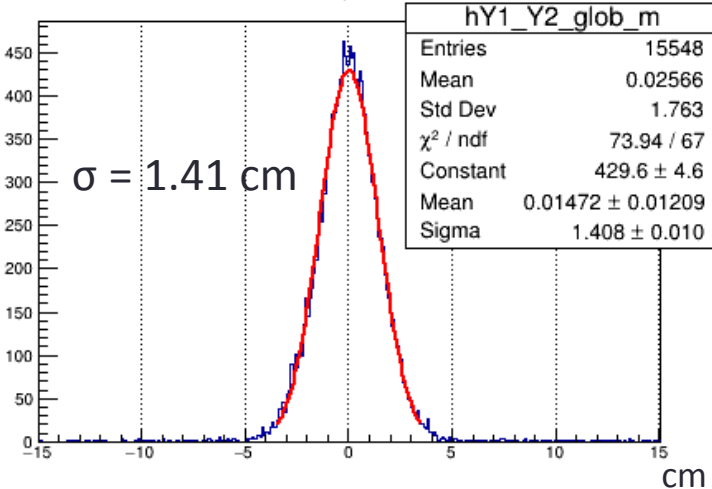
Xdc2 - Xdc1 extrapol Zmid, m closest



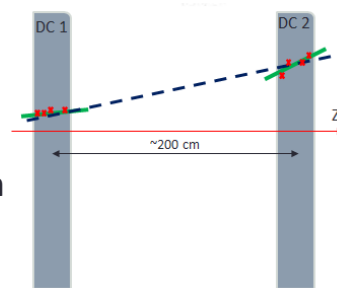
X

Ydc2 - Ydc1 extrapol Zmid, m closest

Ydc2 - Ydc1 extrapol Zmid, m closest



Y



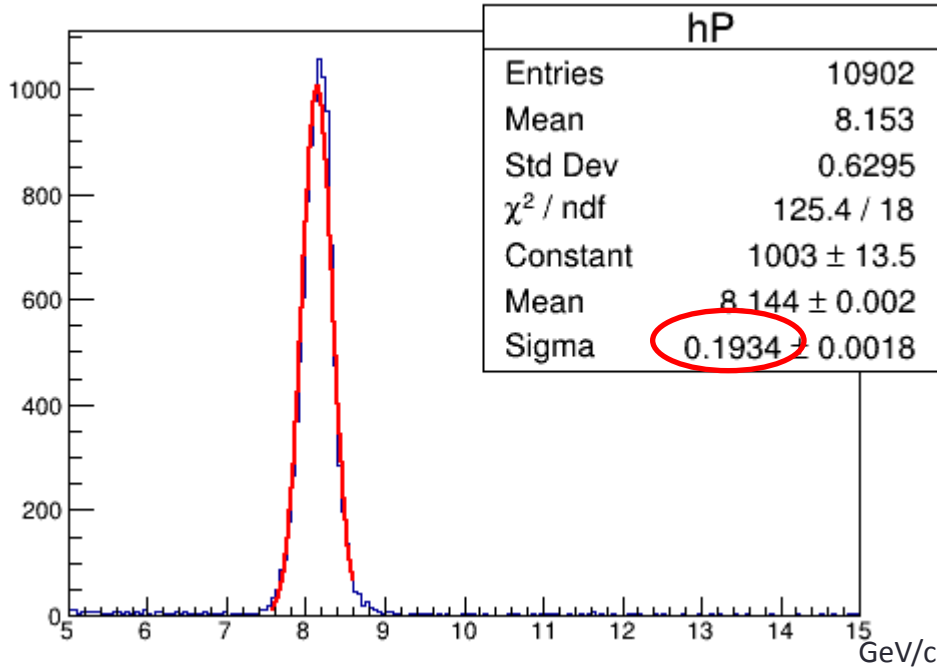
Smearing for MC coordinates is adequate to SRC data

# C Beam momentum resolution estimation

C Beam, empty target, B = 1200A

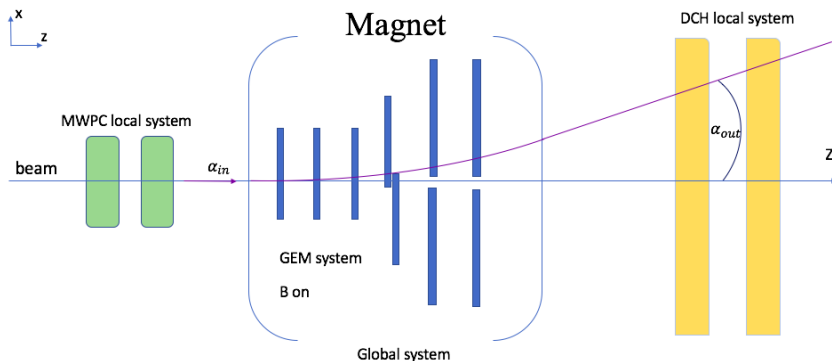
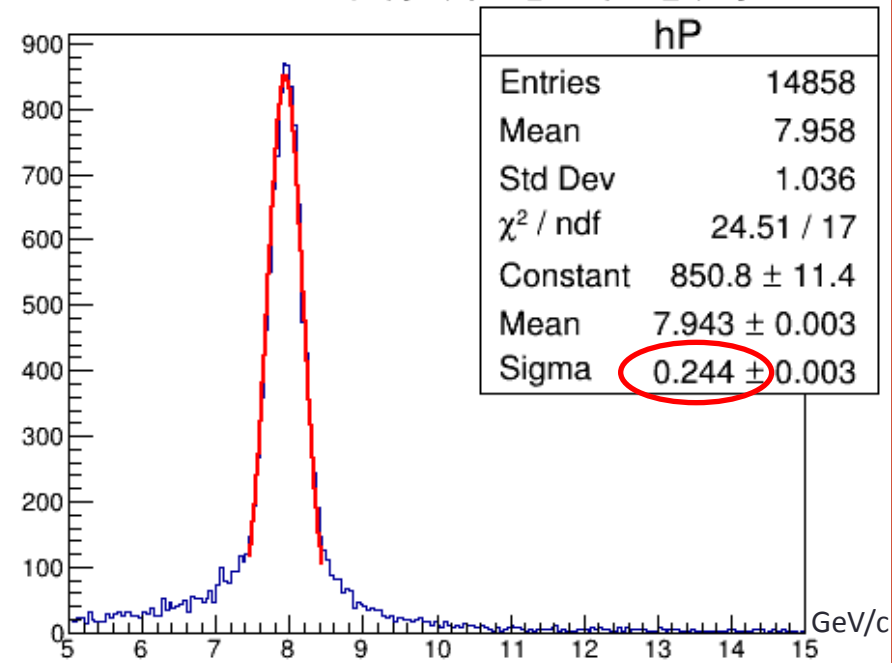
MC DCH global tracks

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



RUN7 data DCH global tracks

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



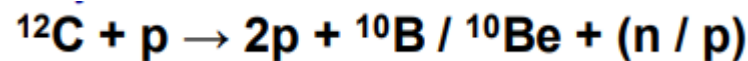
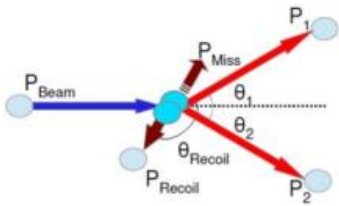
$$P_{\text{beam(est)}} = \frac{0.3 * \int B dl}{\sin(\alpha_{\text{out}} - \alpha_{\text{in}})}$$

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

# Reconstruction Efficiency vs. MC hit probability

ION generator (single particle in event)

	dc1, %	dc2, %	dcGlobal, %
100% hit on layer probability	100	100	100
92% hit on layer probability	86.32	86.37	69.18



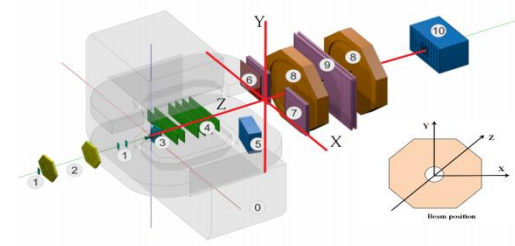
Dubna Cascade Model (DCM-QGSM)

Layer hit reconstruction probability	Particle type	dc1, %	dc2, %	dcGlobal, %
100% hit on layer probability	Ions( $^{12}\text{C}$ , $^{10}\text{B}$ , $^{10}\text{Be}$ )	95.6	96.6	91.5
	$\text{p}$ , $\text{e}$ , $\pi^+$ , $\pi^-$	96.1	98.3	91.3
92% hit on layer probability	Ions( $^{12}\text{C}$ , $^{10}\text{B}$ , $^{10}\text{Be}$ )	81.7	82.9	67.7
	$\text{p}$ , $\text{e}$ , $\pi^+$ , $\pi^-$	81.9	84.7	65.3

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

# Conclusions

- An algorithm for Upstream tracks reco based on MWPC and SiDet has been improved
- Number of MC true & MC reco tracks coincide in 92% of events (old reco 37%)
- 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.
- *Detailed investigation of reconstruction efficiency and resolution adjustments is ongoing.*



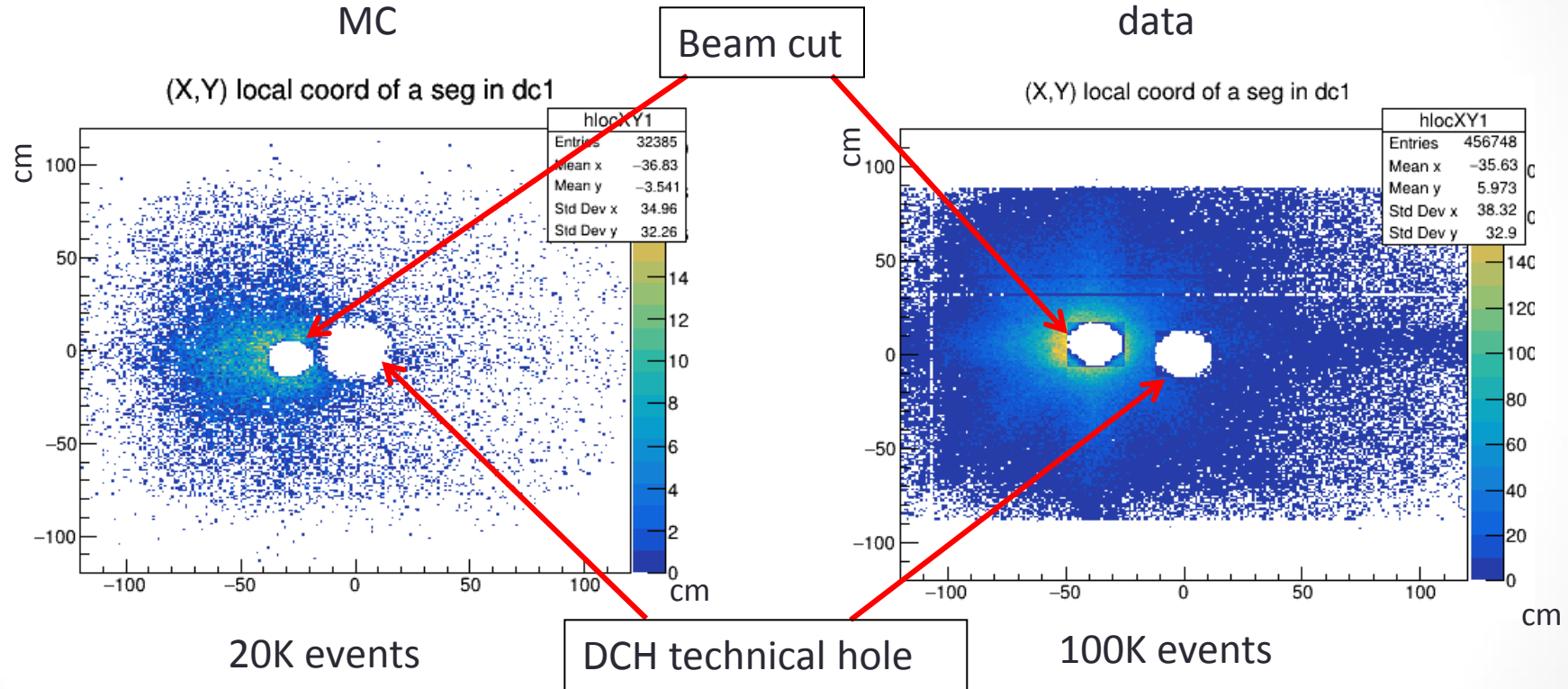
backup



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

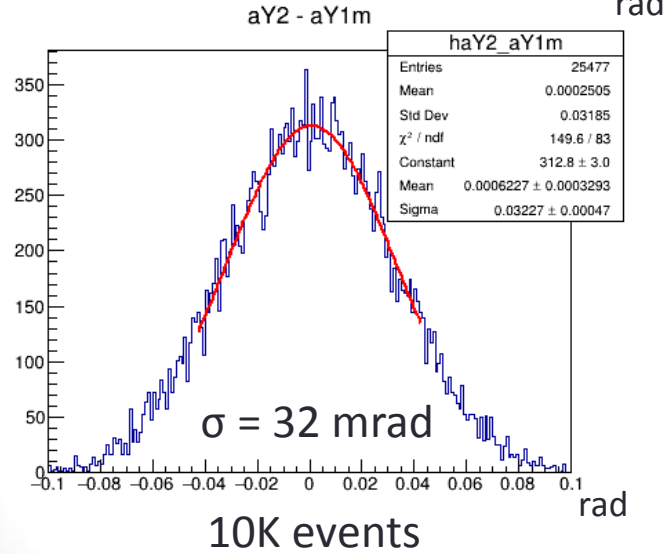
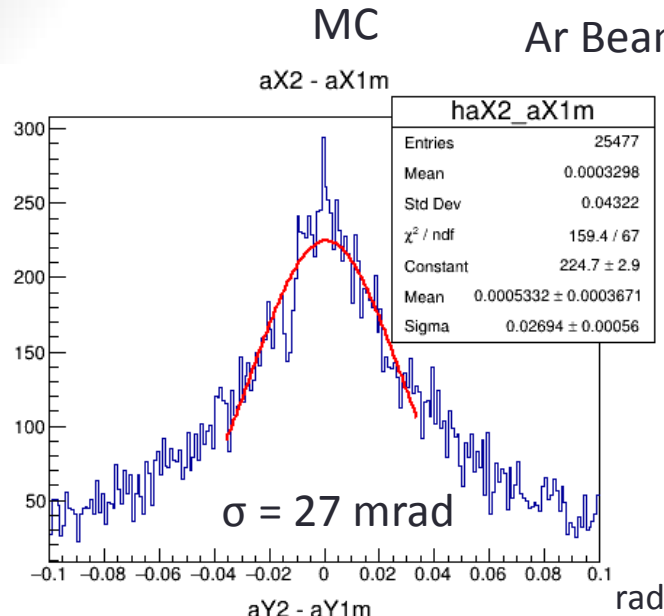
Ar beam, empty target, B = 1250A

DCH1 reconstructed segments local coordinates

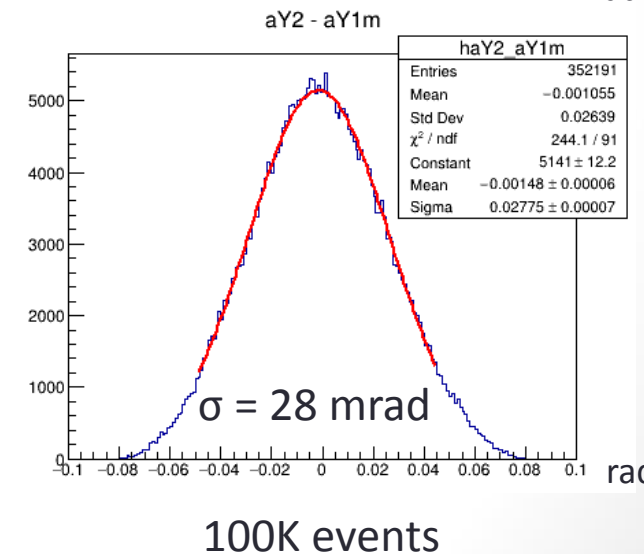
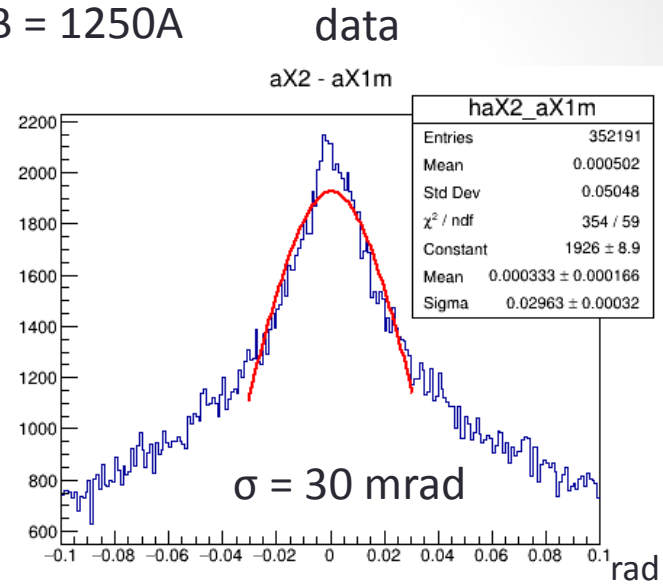


**Remark.** Cut on beam region applied in order for reconstruction to work properly

# Difference in slopes for DC1 & DC2



X slope



Y slope

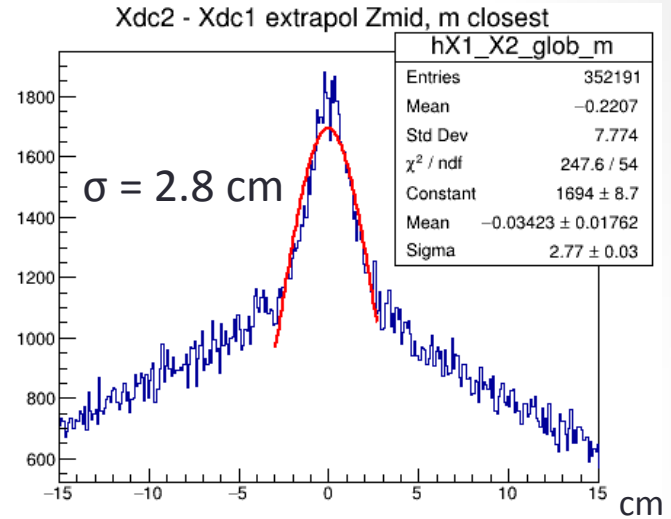
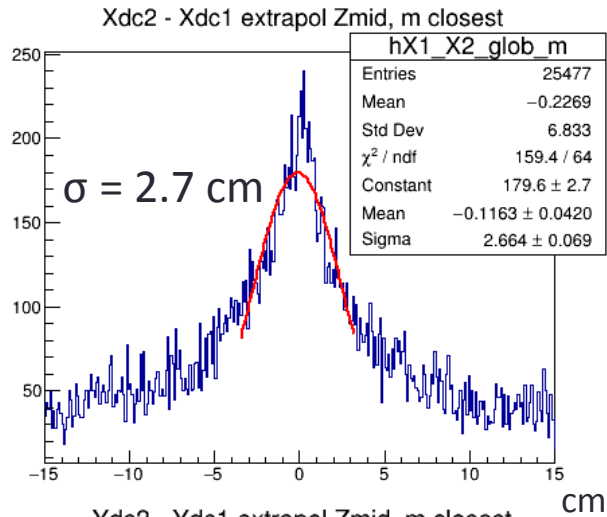
MC slope difference distributions are adequate to Ar data

# Difference in coordinates for matching DC1 with DC2

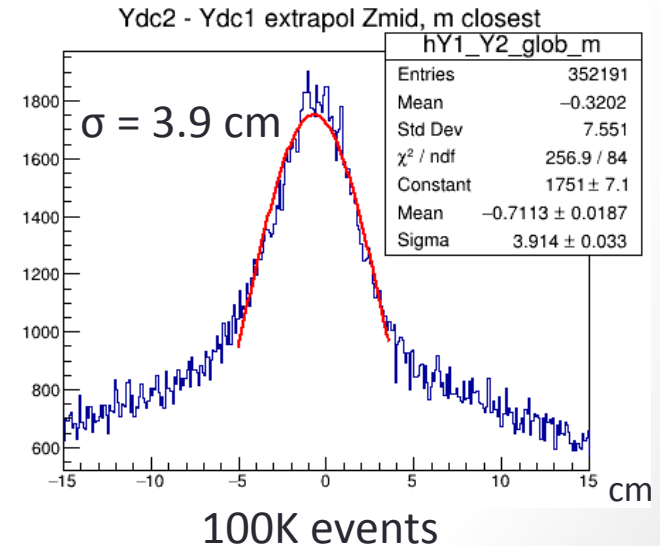
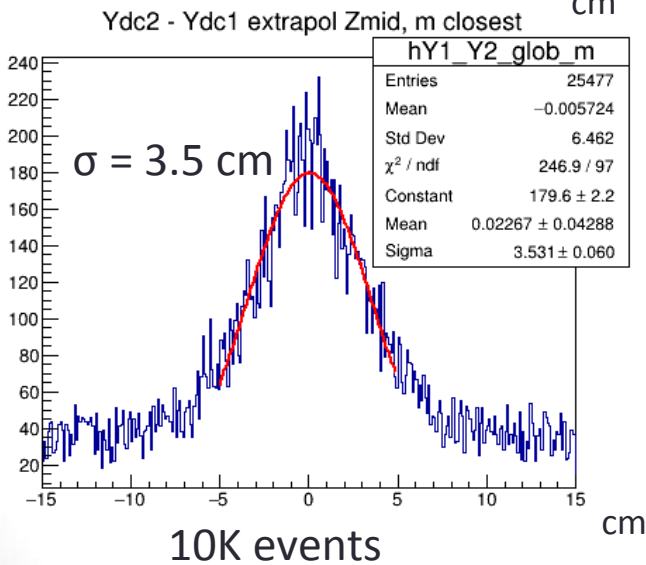
Ar Beam, empty target, B = 1250A

MC reco

data reco



X

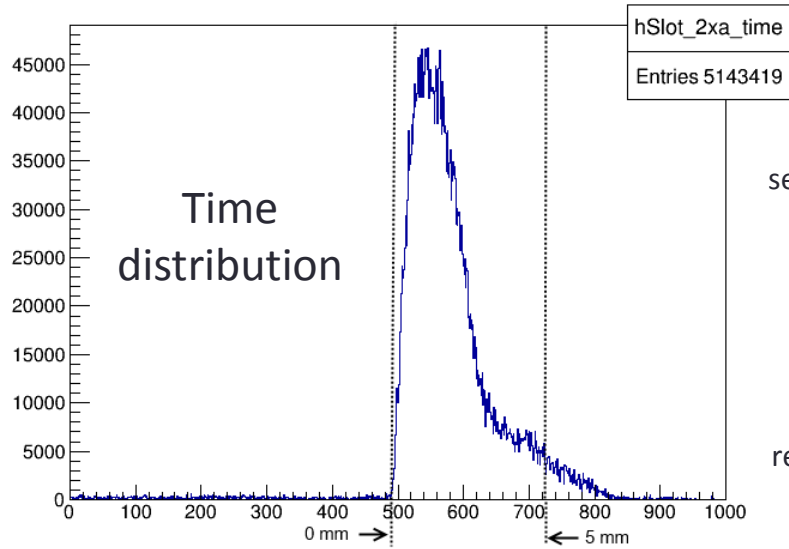


Y

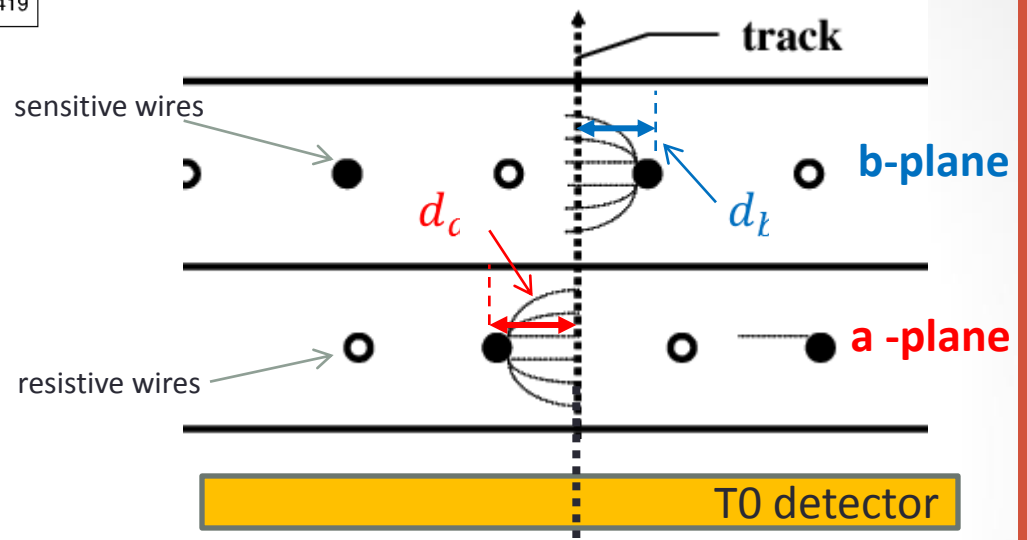
Smearing for MC coordinates is adequate to Ar data

# Drift Chambers coordinate reconstruction on a layer

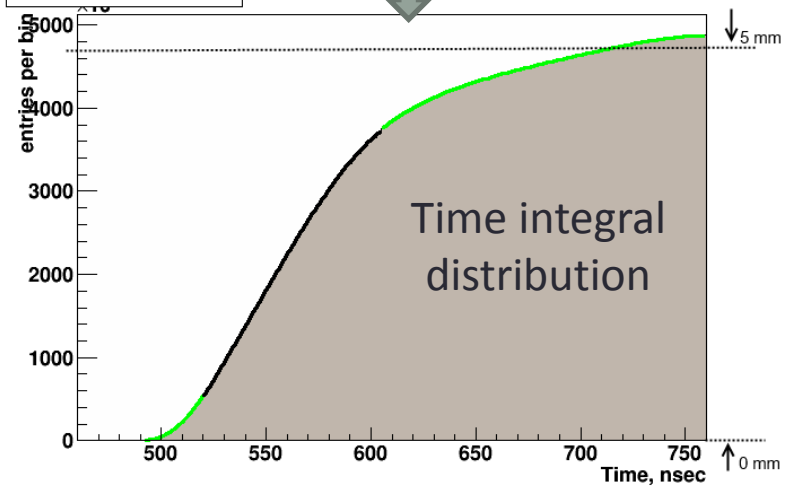
times\_for\_plane\_DC2\_xa



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



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



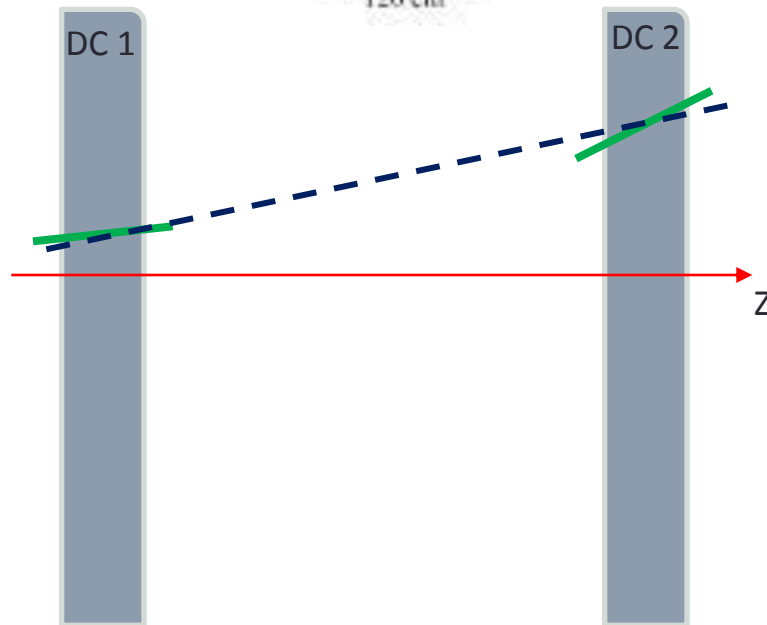
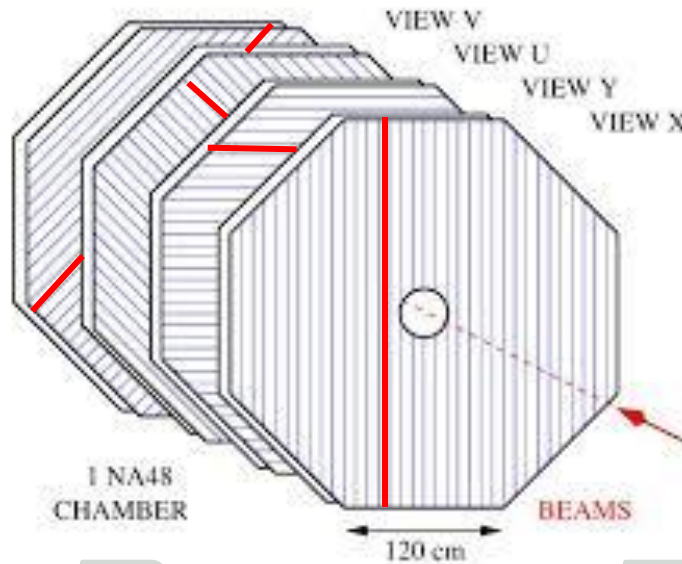
Pair hit  
assembly



Segment  
reconstruction



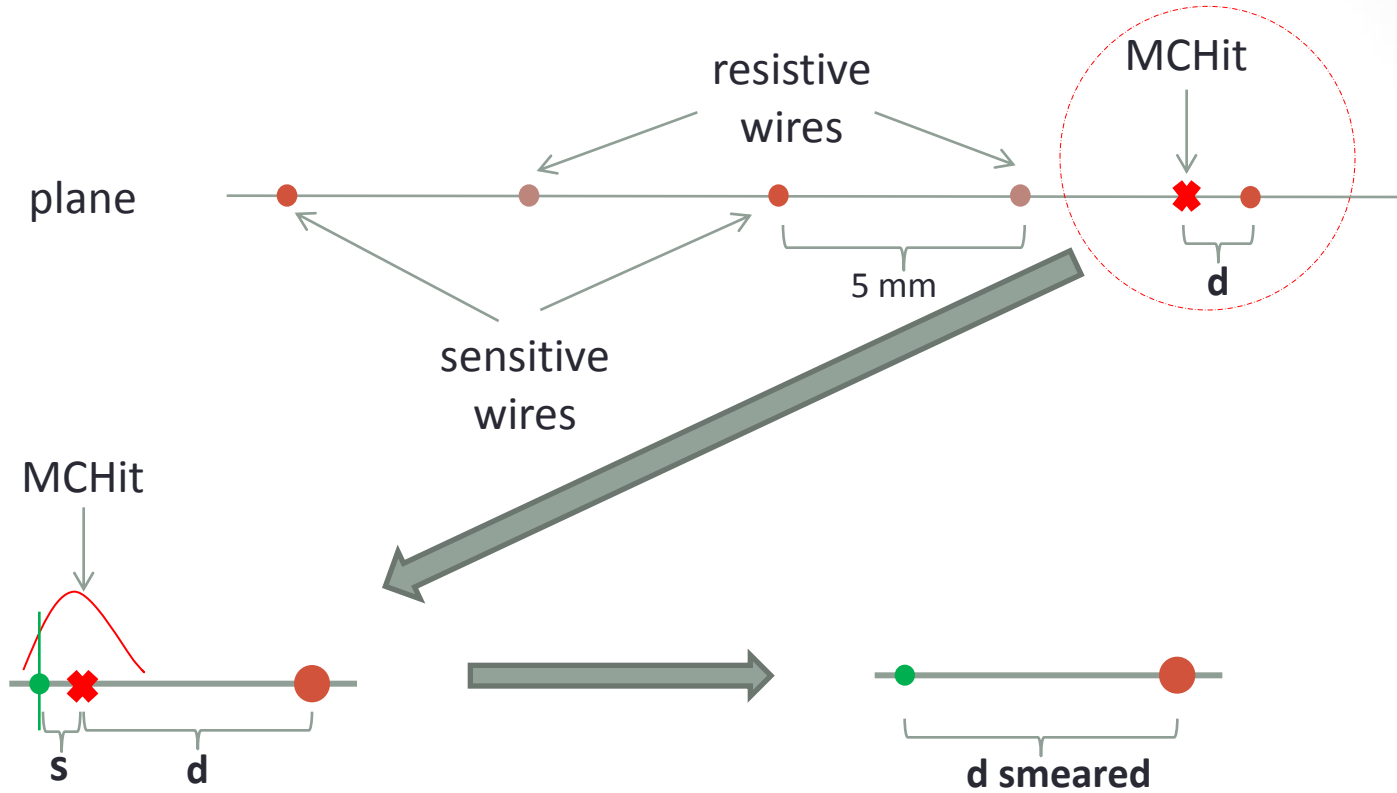
Global track  
reconstruction



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

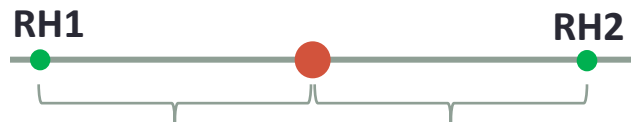
- 4 double coordinate planes;
- wire angles  $0^\circ, 90^\circ, \pm 45^\circ$ ;
- wire pitch 10 mm;
- $Y_{out} \pm 1.35$  m,  $X_{out} \pm 1.35$  m;
- $R_{hole} = 10$  cm;
- 2048 wires per chamber.

# MCHit -> smeared SimHit



According to  $d$  certain errors are used for Gauss smearing

If  $d\_smeared < 0$  ||  $d\_smeared > 5\text{ mm}$  the hit is reflected relative to the edge



2 RecHits are obtained from the smeared SimHit