



DCH in RUN7: MC vs. data

&

Gem + DCH + tof700 matching with MC data

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5th Collaboration Meeting of the BM@N
Experiment at the NICA Facility

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Part1: DCH in RUN7: MC vs. data

Drift Chambers Reconstruction Chain

Hit reconstruction on a particular layer



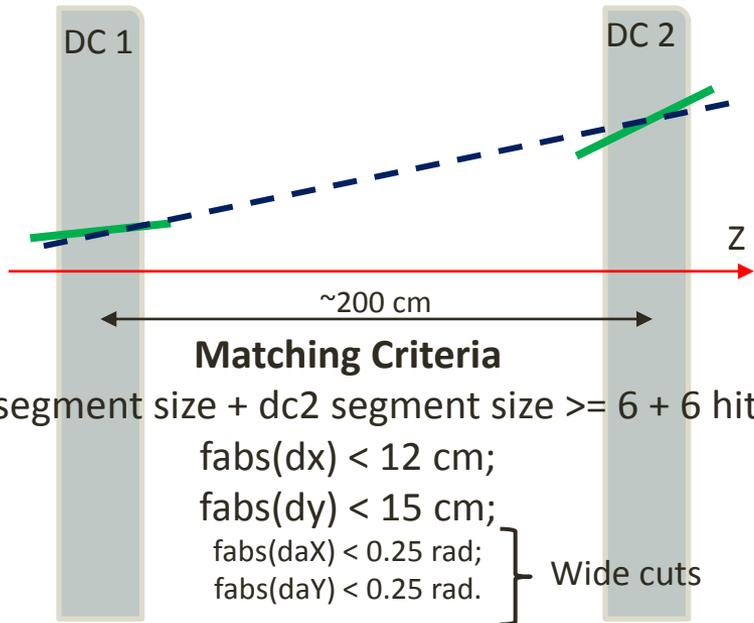
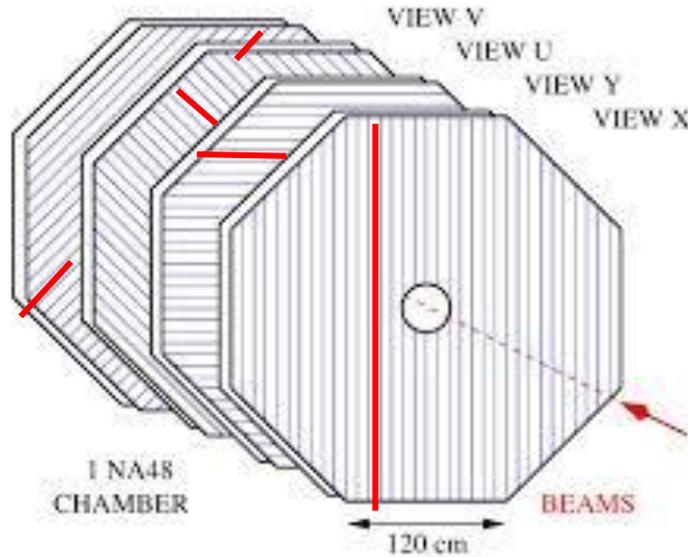
Pair hit assembly



DC1/2 Segment building



DC1+2 track reconstruction



MC Points

simulated coordinate smearing

MC DchHitProducer

input

data digis

time transformed into distance

data DchHitProducer

DchTrackFinder

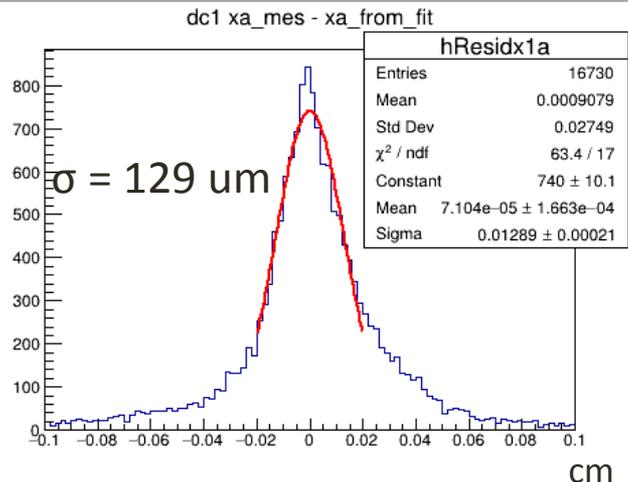
DCH hits on layer + segments + global tracks

output

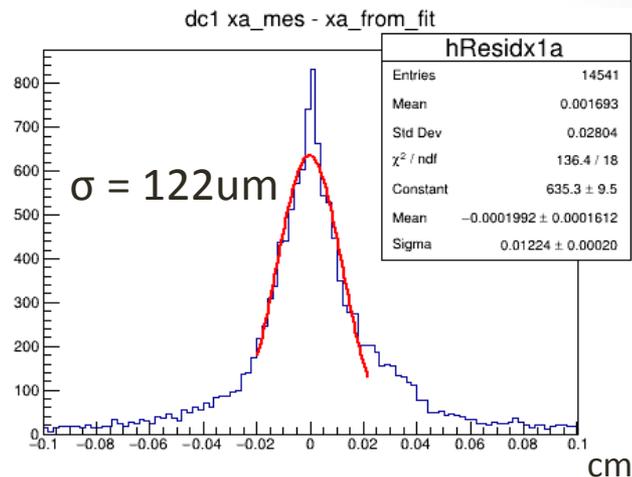
Some selected residuals [Measurement – segmentFit]

C beam, empty target, B = 1200A

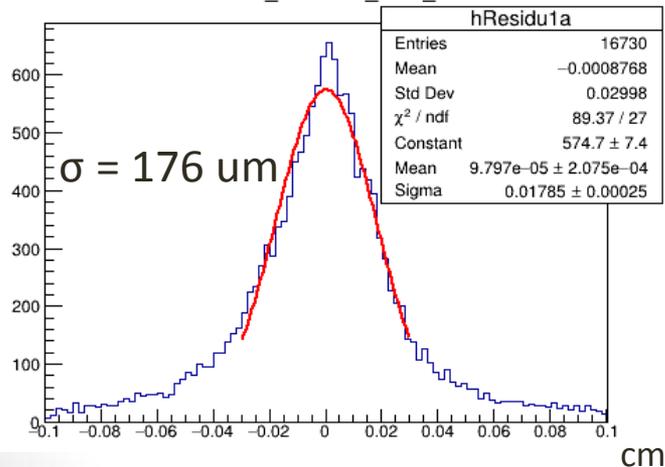
MC segments



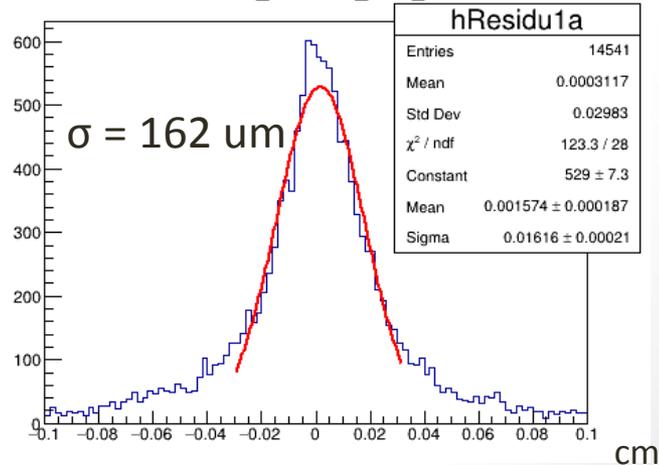
Data segments



dc1 ua_mes - ua_from_fit



dc1 ua_mes - ua_from_fit



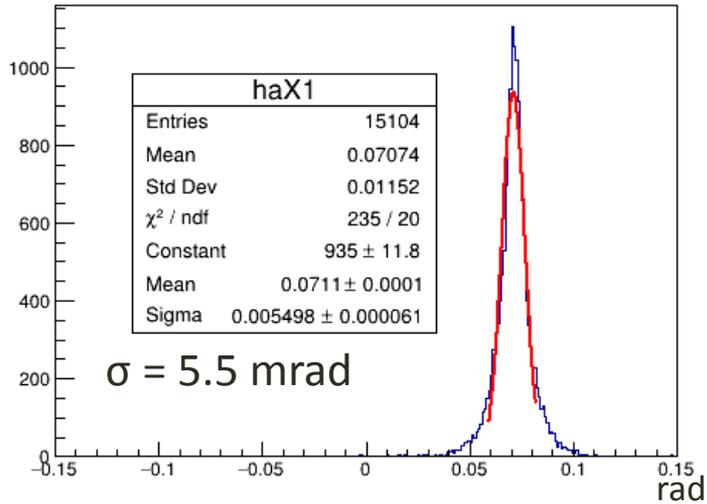
MC and data residuals are in agreement for all coordinates

Angle values and resolution

C beam, empty target, B = 1200A

MC segments

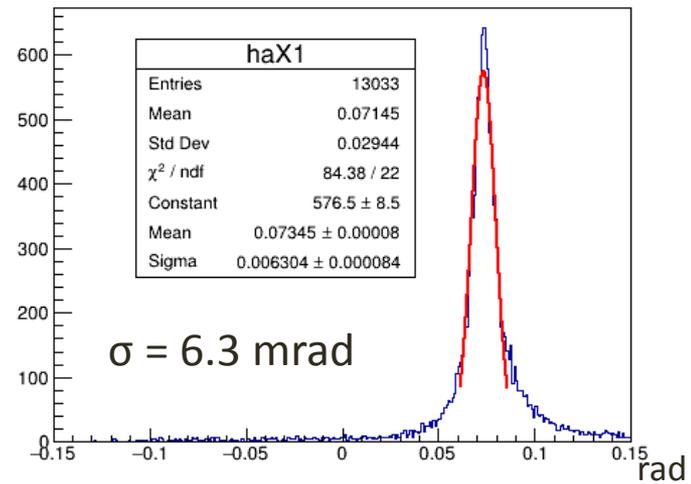
aX1



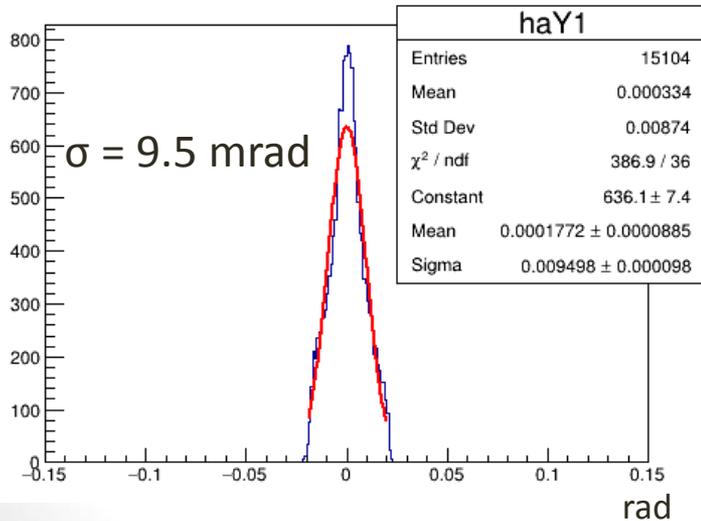
X slope

Data segments

aX1

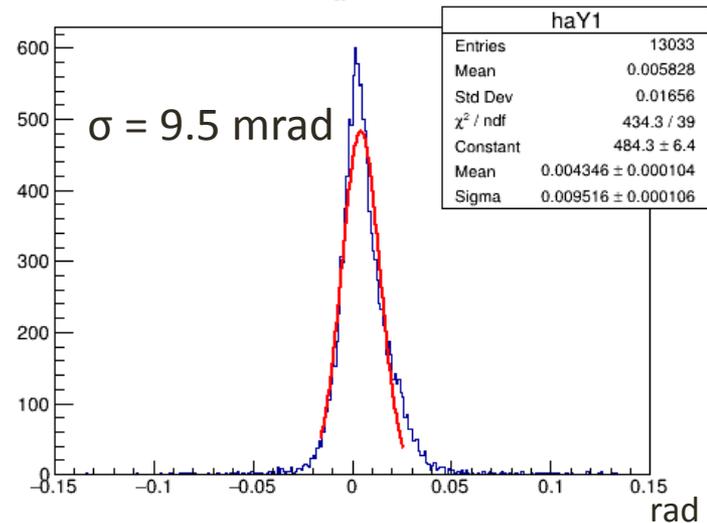


aY1



Y slope

aY1

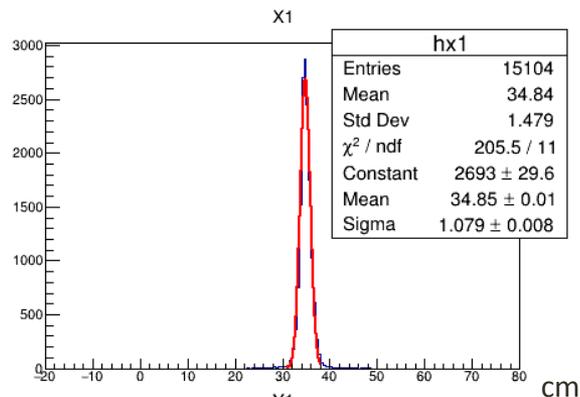


Coordinates values and beam width

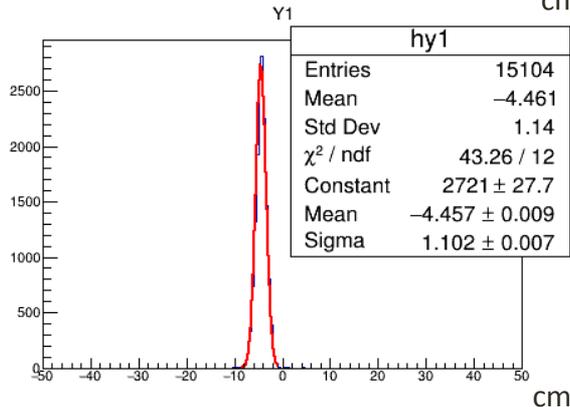
MC segments

C beam, empty target, B = 1200A

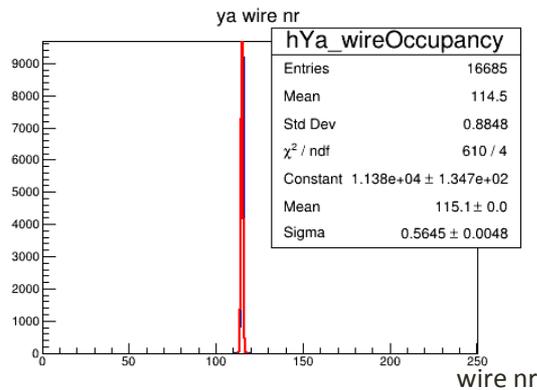
Data segments



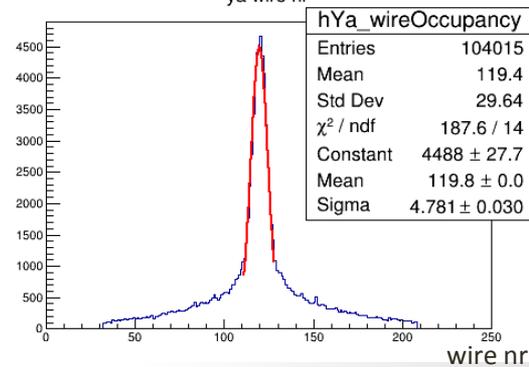
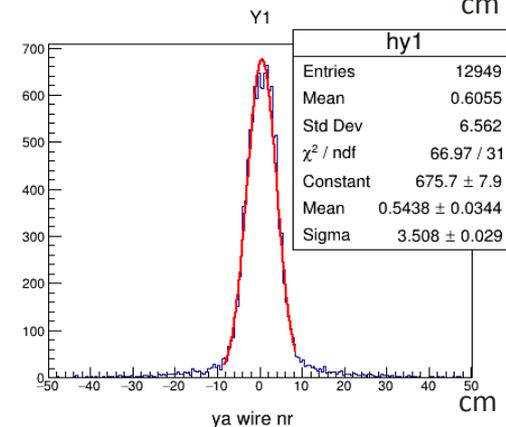
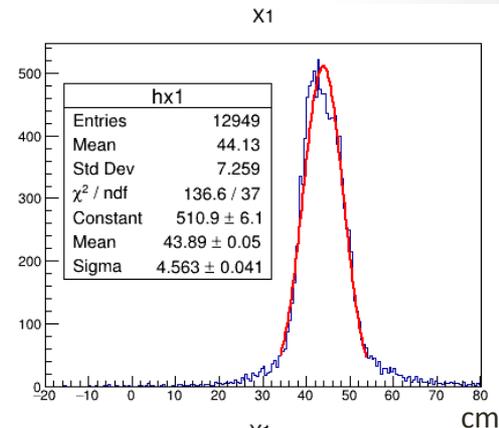
X segment
coordinate



Y segment
coordinate



Wire
occupancy

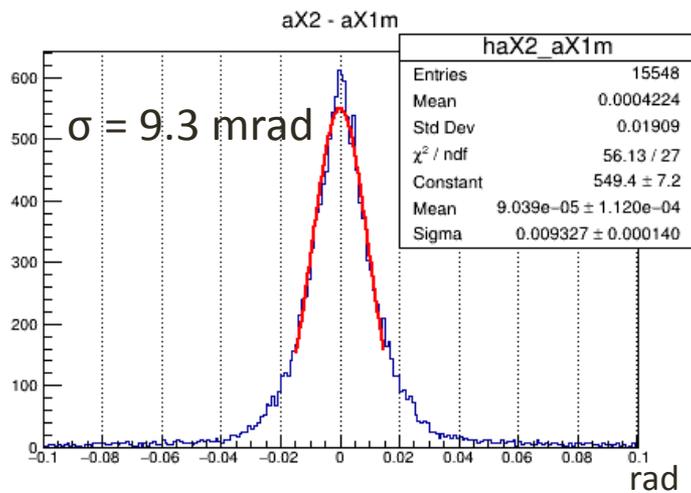


The difference is
due to the width of
the beam

Difference in slopes between DC1 & DC2

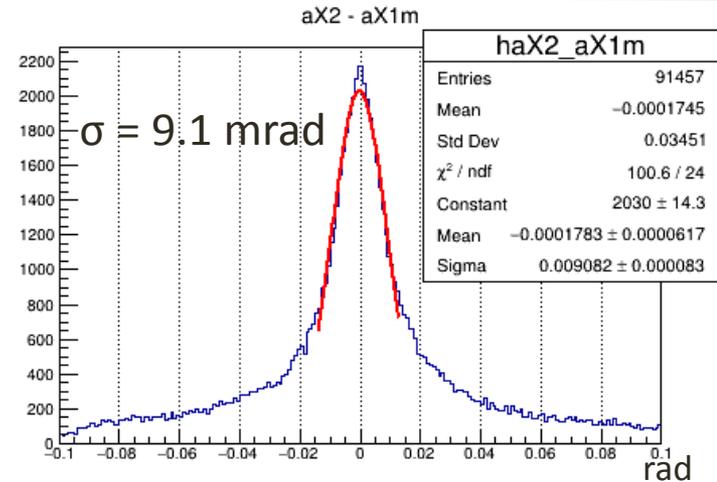
C beam, empty target, B = 1200A

MC reco

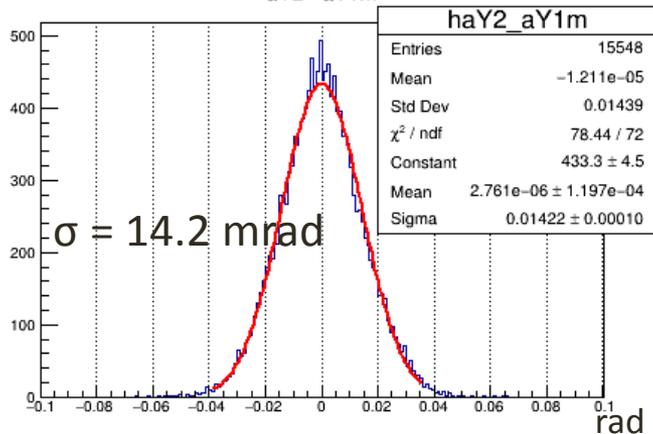


X slope

data reco

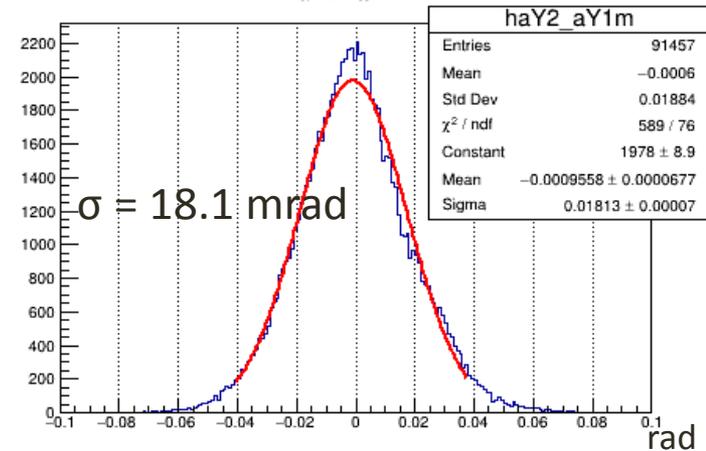


aY2 - aY1m



Y slope

aY2 - aY1m



20K events

100K events

MC slope difference distributions are adequate to SRC data

Difference in coordinates for matching DC1 with DC2

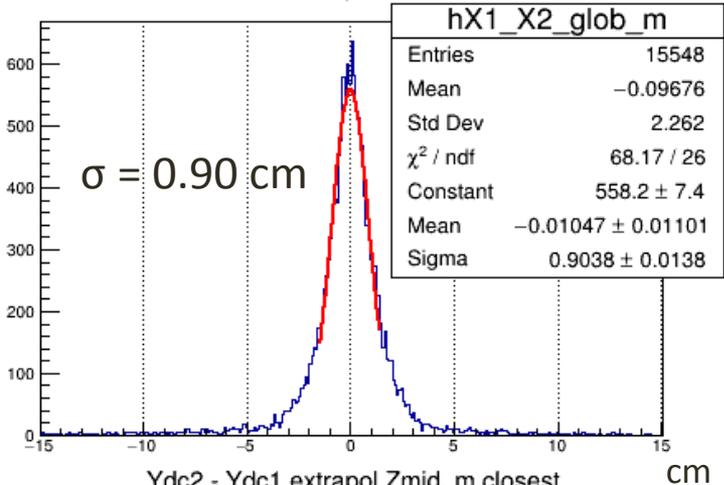
C beam, empty target, B = 1200A

MC reco

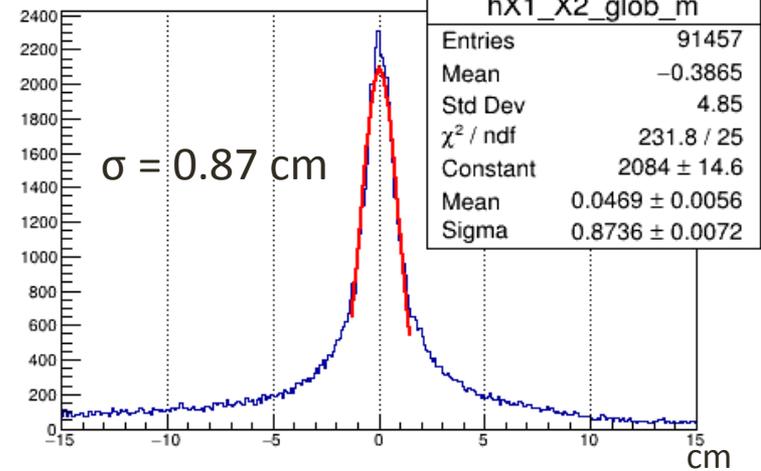
data reco

Xdc2 - Xdc1 extrapol Zmid, m closest

Xdc2 - Xdc1 extrapol Zmid, m closest

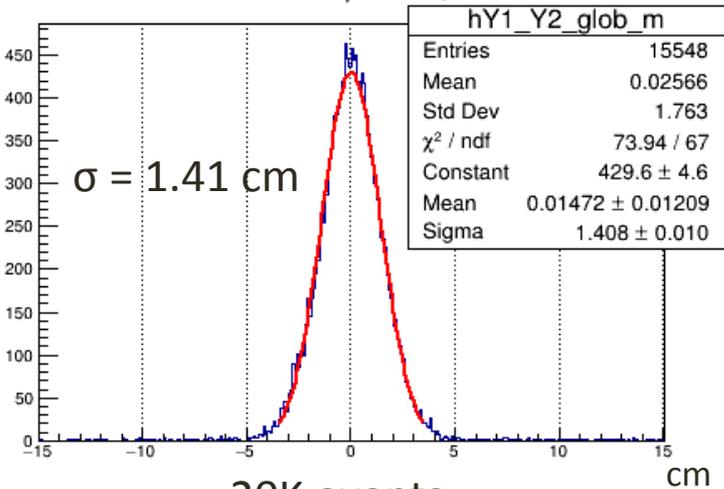


X

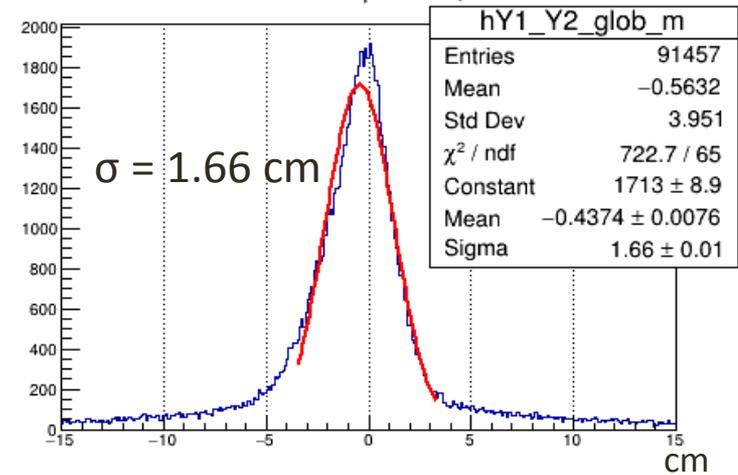


Ydc2 - Ydc1 extrapol Zmid, m closest

Ydc2 - Ydc1 extrapol Zmid, m closest



Y



20K events

100K events

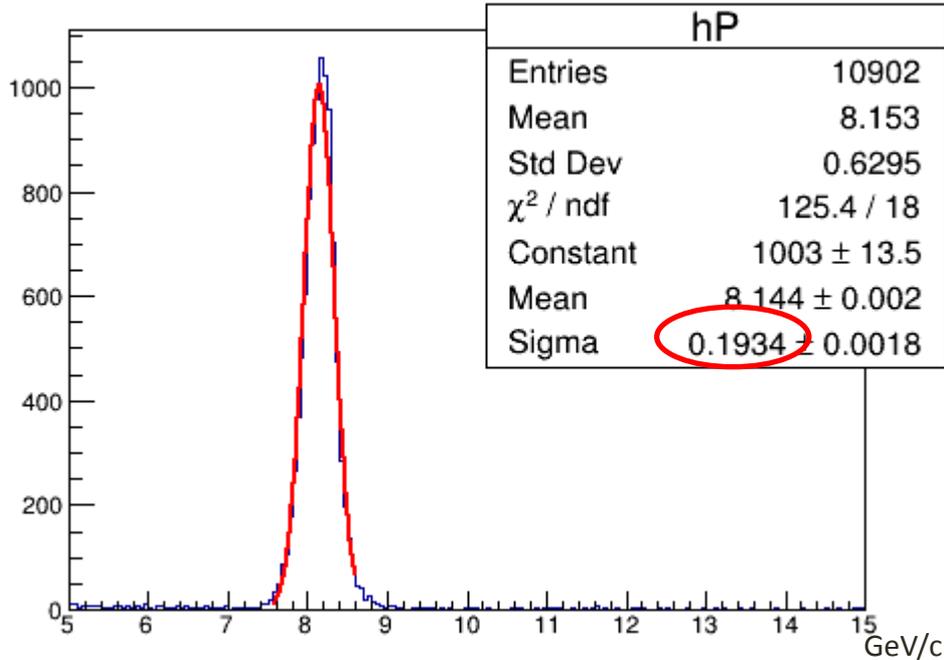
Smearing for MC coordinates is adequate to SRC data 8

C Beam momentum resolution

C Beam, empty target, B = 1200A

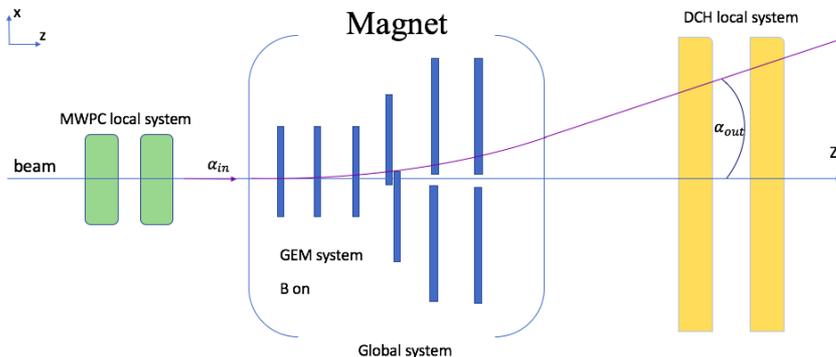
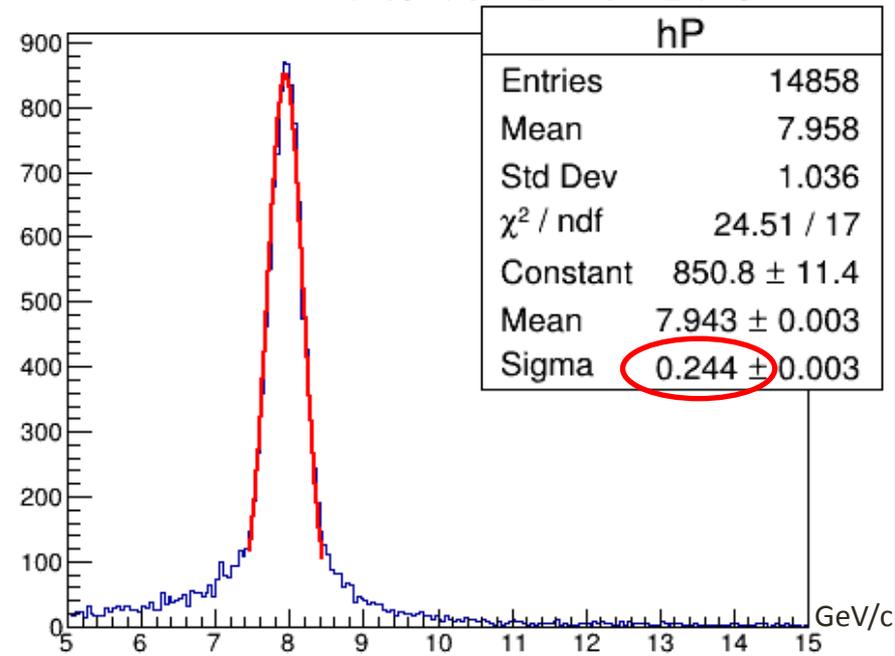
MC DCH global tracks

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



RUN7 data DCH global tracks

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



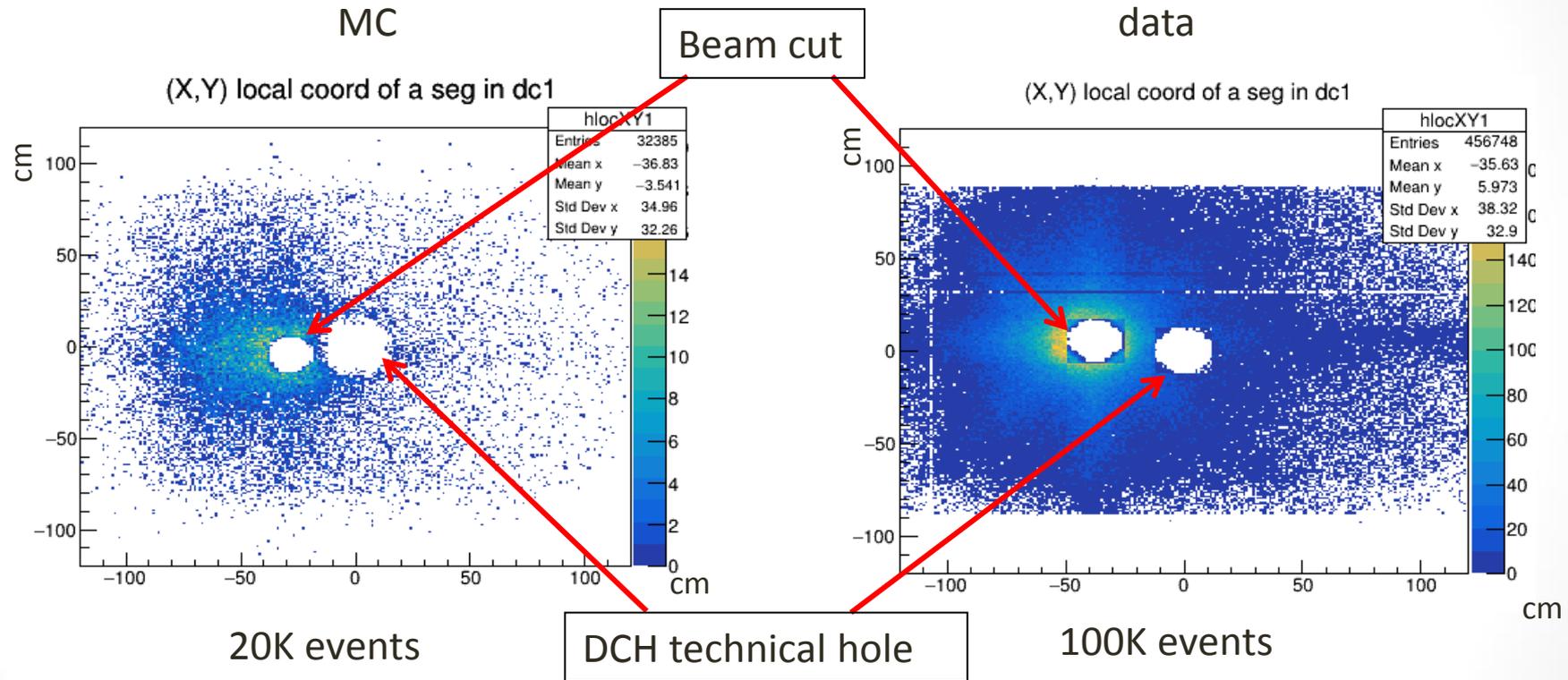
$$P_{\text{beam(est)}} = \frac{0.3 * \int B dl}{\sin(\alpha_{out} - \alpha_{in})}$$

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

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

Ar beam, empty target, B = 1250A

DCH1 reconstructed segments local coordinates



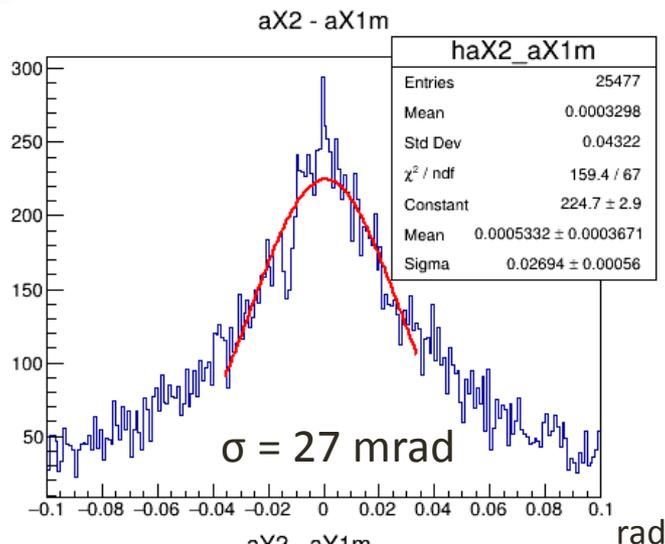
Remark. Cut on beam region applied in order for reconstruction to work properly

Difference in slopes for DC1 & DC2

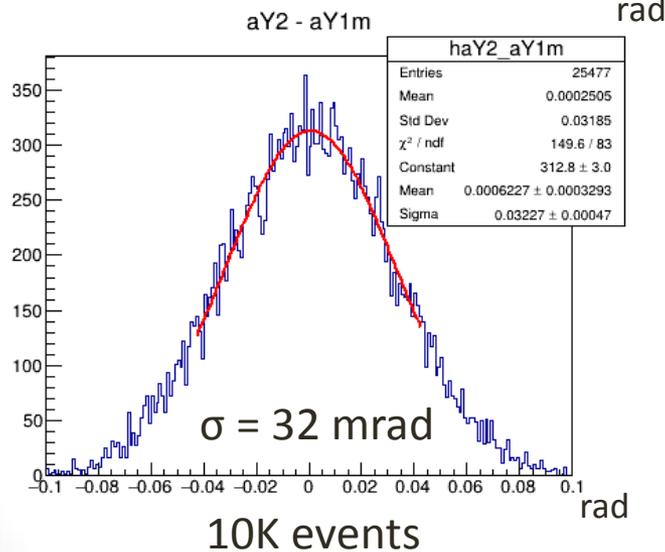
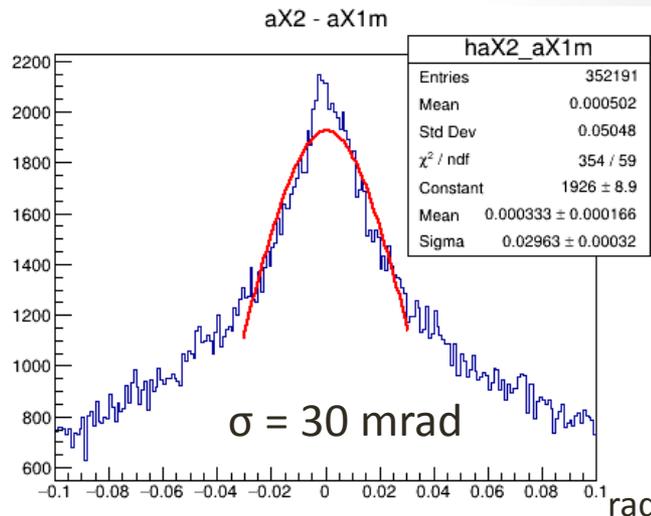
MC

Ar Beam, empty target, B = 1250A

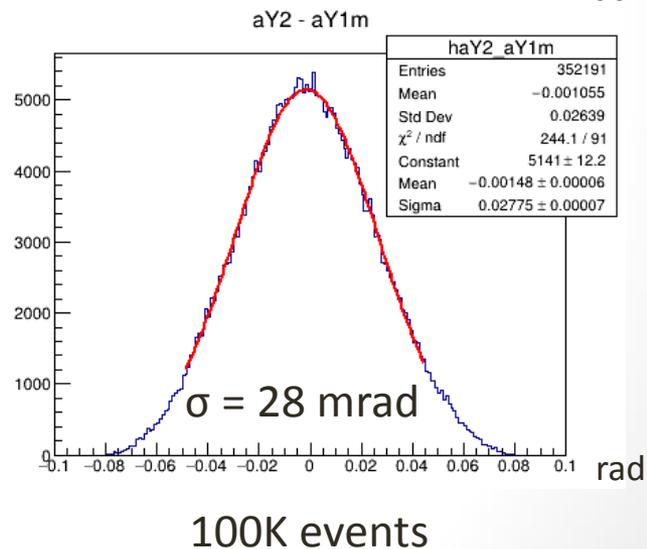
data



X slope



Y slope



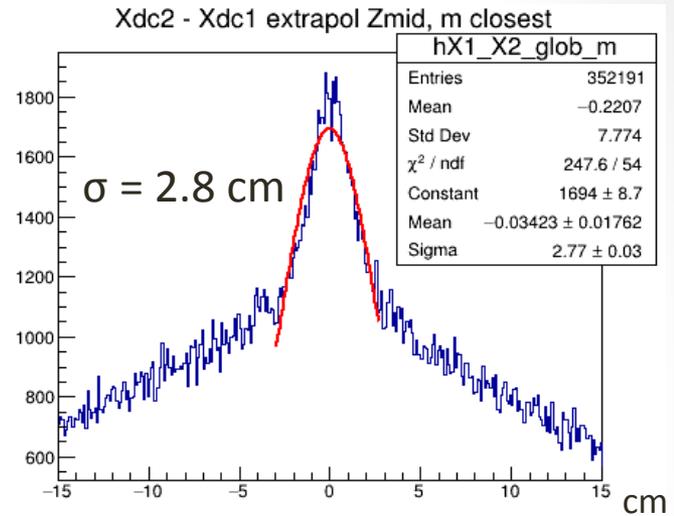
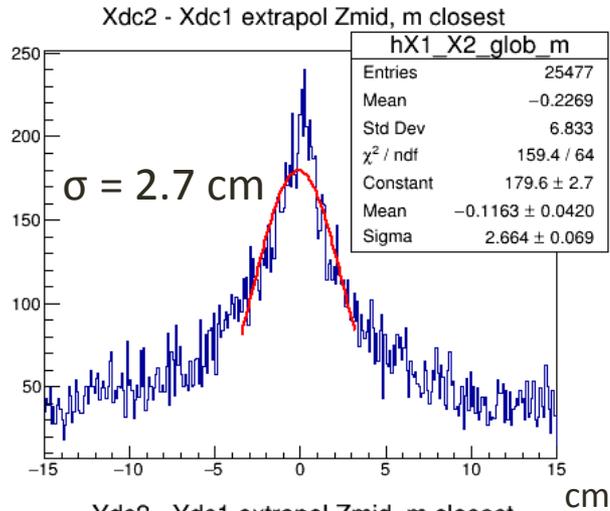
MC slope difference distributions are adequate to Ar data

Difference in coordinates for matching DC1 with DC2

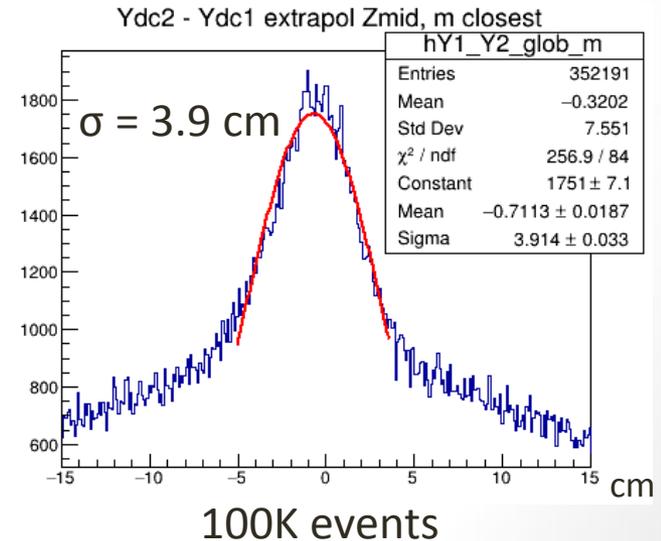
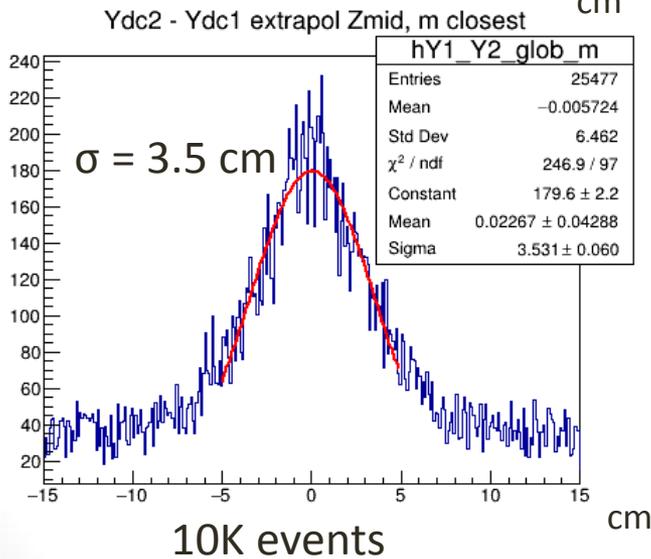
Ar Beam, empty target, B = 1250A

MC reco

data reco



X



Y

Smearing for MC coordinates is adequate to Ar data

Part2

Gem + DCH + tof700 matching with MC data

Criteria and Notations

“Good” GEM tracks – those which pass cut selection.

Yuri Petuhkov data cut

```
        if (nSiGemHits < 6 ||
            gemX < -140 || gemX > 240 ||
            gemY < -40 || gemY > 200 ||
            gemTx < -0.5 || gemTx > 1.0 ||
            gemTy < -0.1 || gemTy > 0.5 ||
            Xpv < -3.5 || Xpv > 4.0 ||
            Ypv < -1.0 || Ypv > 6.0 ||
            Qp == 0.0 || 1.0/TMath::Abs(Qp) > 15.0 || 1.0/TMath::Abs(Qp) < 0.15 ||
            gemZ < 500) continue;
```

Matching criteria:

“Good” GEM+DCH tracks – those which pass cut selection.

Abs(Dx) < 4 σ and Abs(Dy) < 4 σ

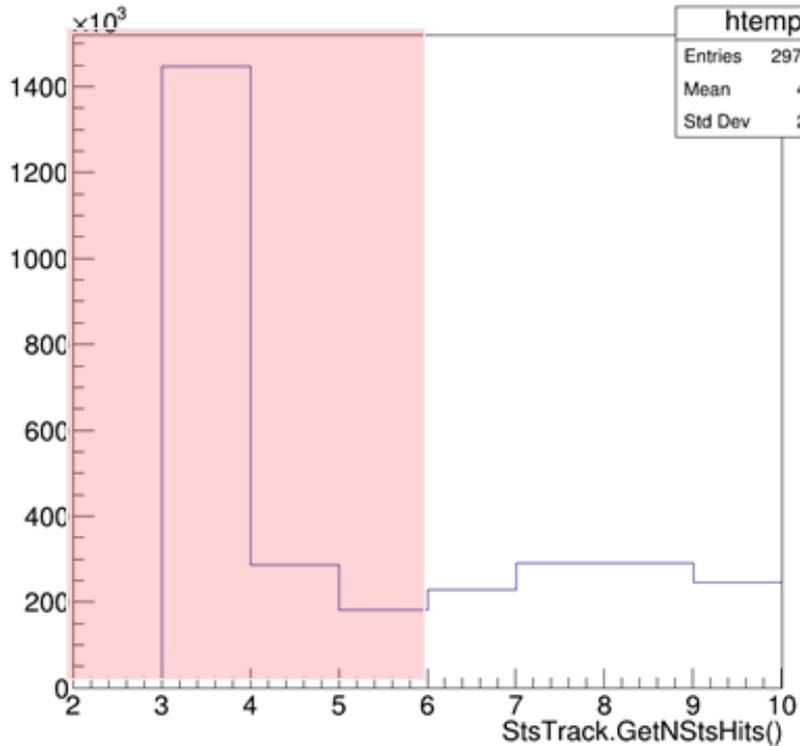
“Good” GEM+DCH tracks+TOF700 hits matching criteria:

track and hit pairs are sorted in a multimap by minimum distance,
unique pairs are selected **MAX distance (R) cut ~7 cm**

“Good” Gem Tracks

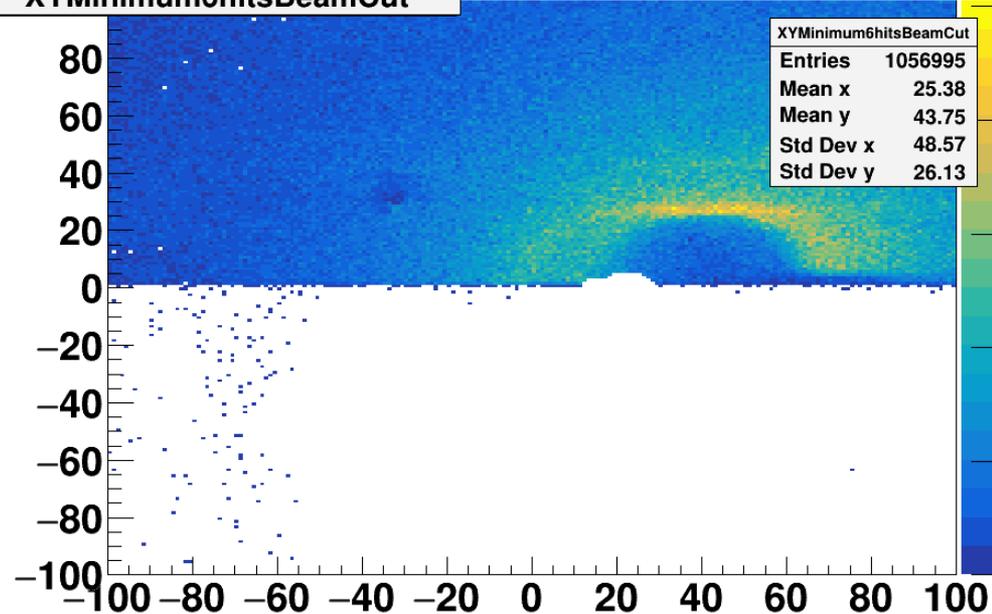
L1 tracking used for DCM-SMM Simulated Ar+target, B= 1250 A

StsTrack.GetNStsHits()



Minimum 6 SIGEM hits

XYMinimum6hitsBeamCut

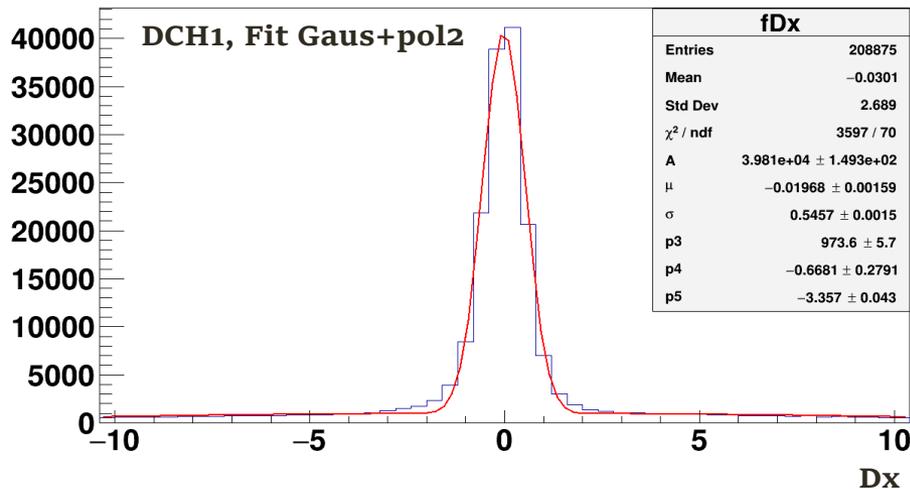


GEM to DCH extrapolation

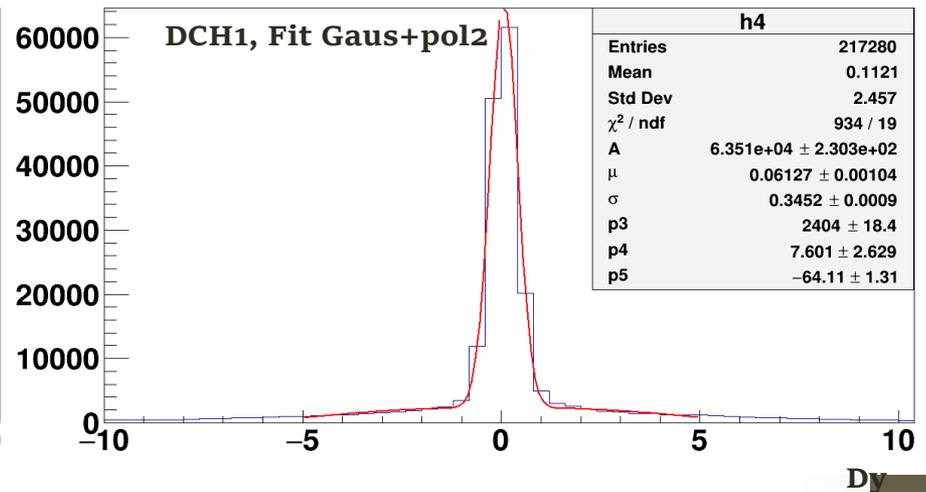
“Good” GEM tracks are 1/3 of all GEM tracks associated with MC Id

GEM-DCH1 Matching Criteria

GemDchTracks.fDx [GemDchTracks.fDchTrack.fParamFirst.fZ<530&& GemDchTracks.fDy>-1 && GemDchTracks.fDy<1]



GemDchTracks.fDy [GemDchTracks.fDchTrack.fParamFirst.fZ<530&& GemDchTracks.fDx>-2 && GemDchTracks.fDx<2]



Function: **Gaus + pol2**

Dx-peak is situated in interval of $\pm 2\text{cm}$

Dy-peak is between $\pm 1\text{cm}$

Dx $\sigma \sim 0.54$

Dy $\sigma \sim 0.34$

Matching criteria: **$\text{Abs}(\text{Dx}) < 4 \sigma$ and $\text{Abs}(\text{Dy}) < 4 \sigma$**

GEM-DCH Matching Efficiencies

$N_{\text{gem trs}} = 2\ 886\ 024$ all gem tracks associated with MC track

$N_{\text{good gem trs}} = 1\ 030\ 346$ gem tracks with minimum 6 si-gem hits and associated with MC track

$N_{\text{w. dch tr}} = 148\ 831$ dch tracks that are associated with a MC track and correspond to a good gem track

$N_{\text{matched trs}} = 124\ 511$ dch tracks that pass matching criteria with good gem

$N_{\text{true matched trs}} = 123\ 523$ matched dch tracks that coincide by associated MC track.

$$Eff_{MC_Id_matching} = \frac{N_{\text{truematchedtrs}}}{N_{\text{matchedtrs}}} = \frac{123\ 523}{124\ 511} = 99.2\ %$$

$$Eff_{\text{matching}} = \frac{N_{\text{truematchedtrs}}}{N_{\text{w.dchtr}}} = \frac{123\ 523}{148\ 831} = 82.99\ %$$

GEM-DCH-TOF700 Matching Efficiencies

$N_{\text{good gem dch trs}} = 124\,511$ good gem tracks that pass the matching criteria with dch

$N_{\text{w. tof hit}} = 107\,766$ tof hits that have MC Id corresponding to good gem dch track

$N_{\text{matched trs}} = 95\,838$, tof hits that pass the matching criteria with good gem dch track

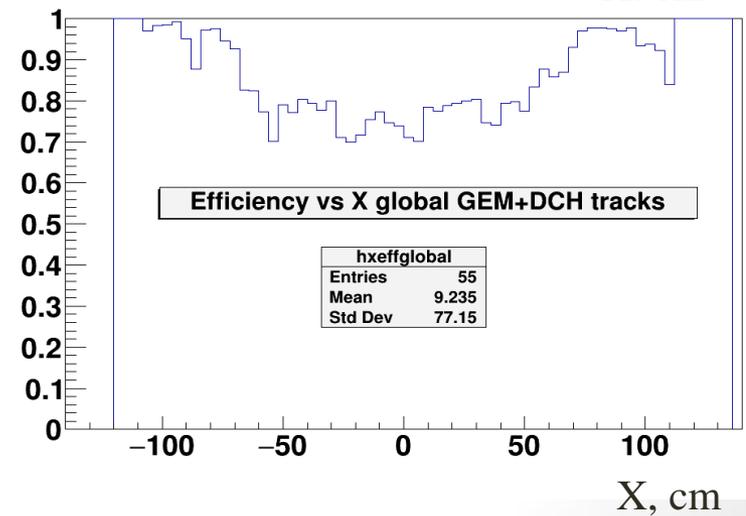
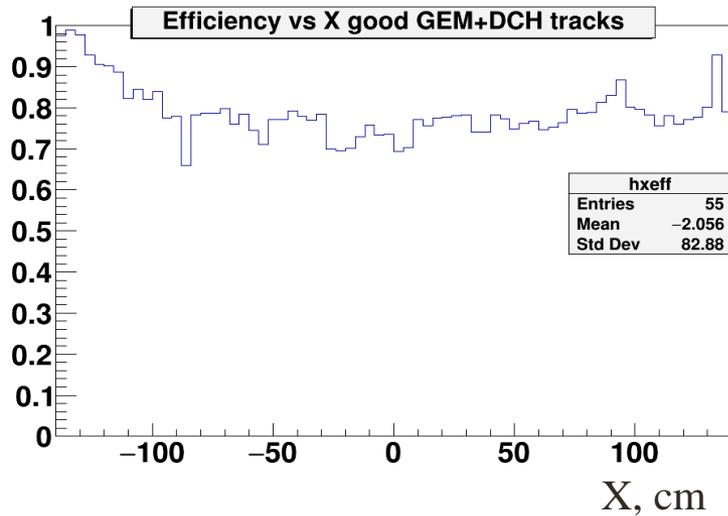
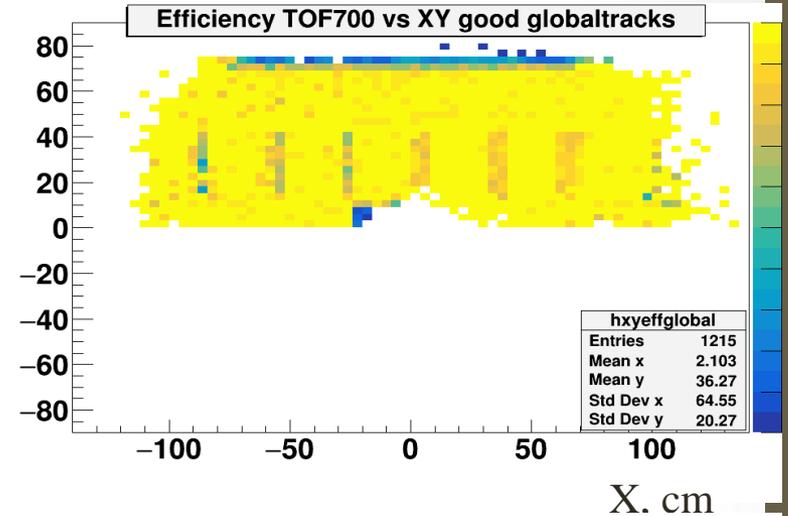
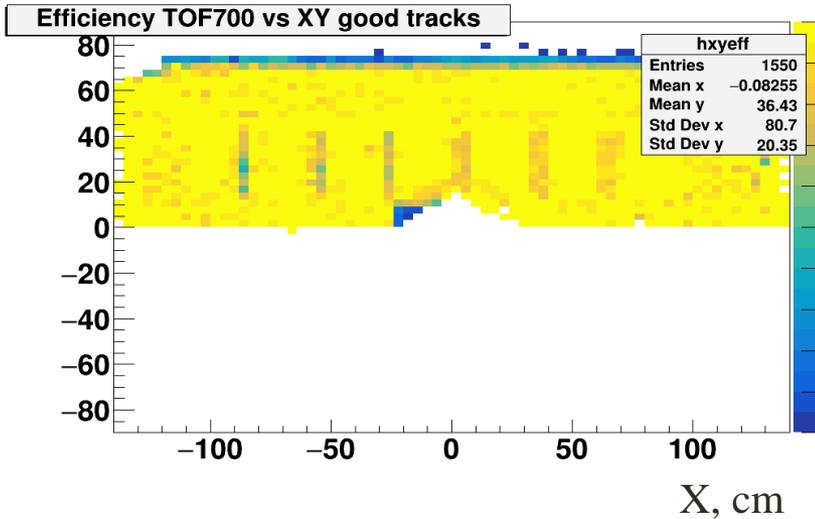
$N_{\text{true matched trs}} = 91\,218$ tof hits that pass the matching criteria and coincide by MC Id with good gem track

$$Eff_{MC_Id_matching} = \frac{N_{\text{truematchedtrs}}}{N_{\text{matchedtrs}}} = \frac{91\,218}{95\,838} = 95.17\%$$

$$Eff_{\text{matching}} = \frac{N_{\text{truematchedtrs}}}{N_{\text{w.tofhit}}} = \frac{91\,218}{107\,766} = 84.64\%$$

TOF700 Efficiency vs XY

Y, cm



Efficiency is good enough. Small **edge** effect.

Conclusions

1) DCH MC vs. data:

- MC with adequate DCH hit smearing was done
- 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

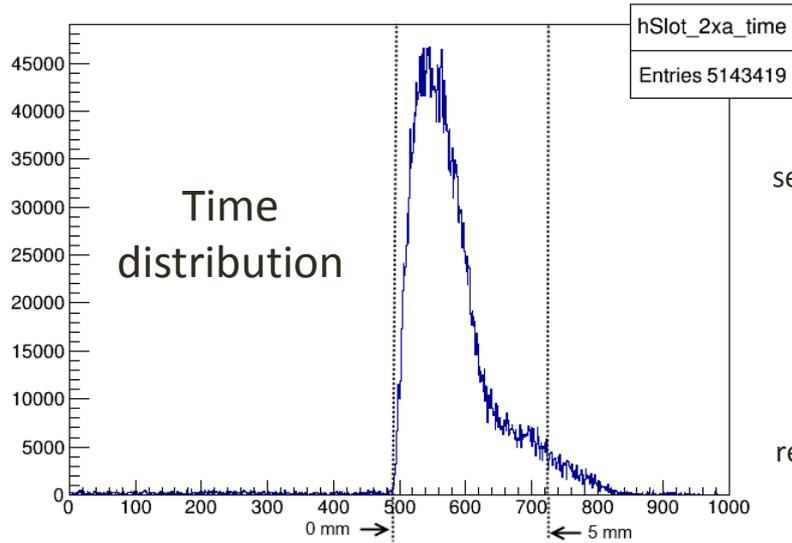
2) GEM-DCH-TOF700 matching for MC Ar+targets:

- GEM-DCH matching efficiency is 83% (tracking needs to be improved)
- MC Id matching efficiency is high - 99.2%
- GEM-DCH-TOF700 efficiency matching efficiency is high enough - 84.6%, while MC Id matching efficiency is 95.2%

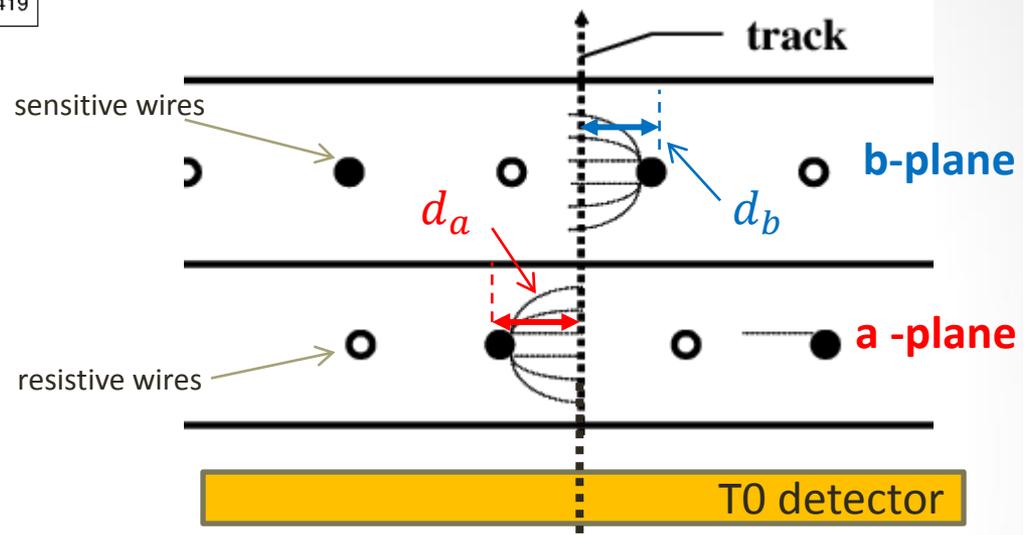
backup

Drift Chambers coordinate reconstruction on a layer

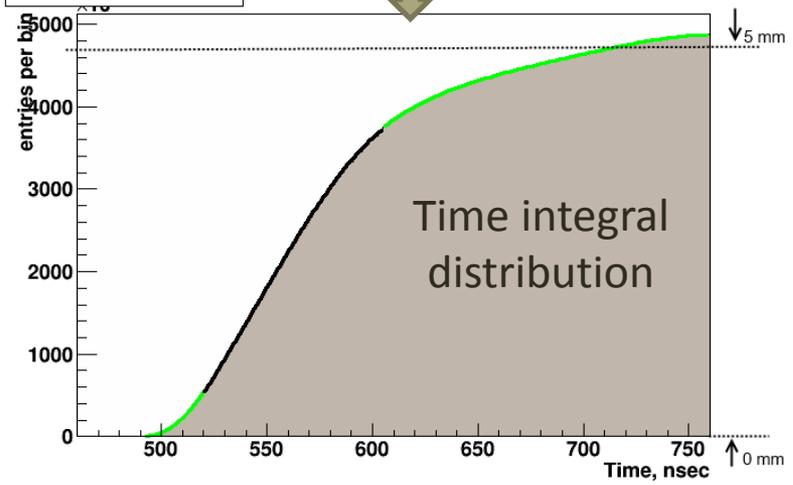
times_for_plane_DC2_xa



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



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



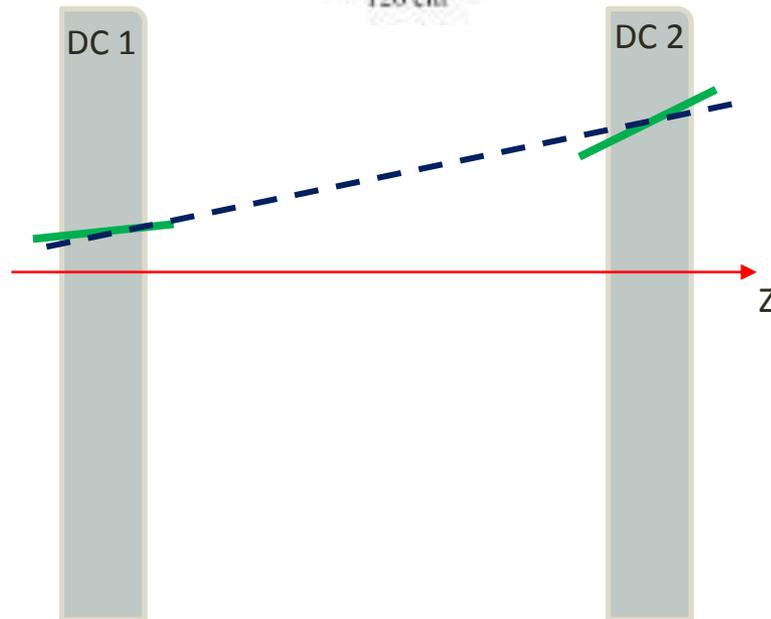
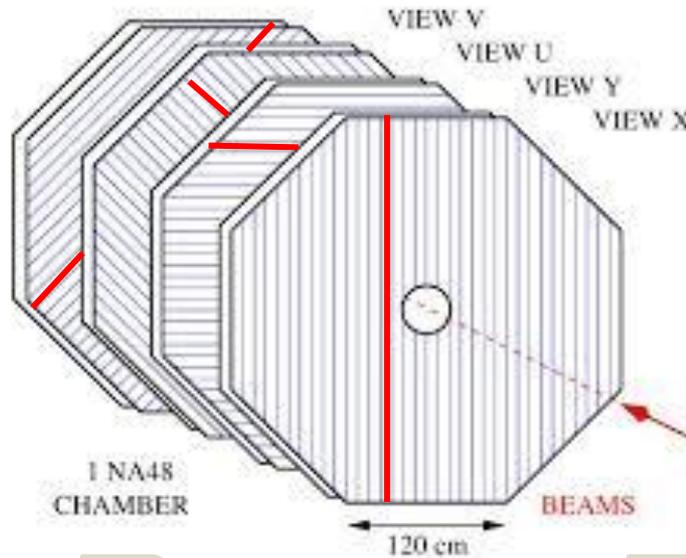
Pair hit
assembly



Segment
reconstruction



Global track
reconstruction

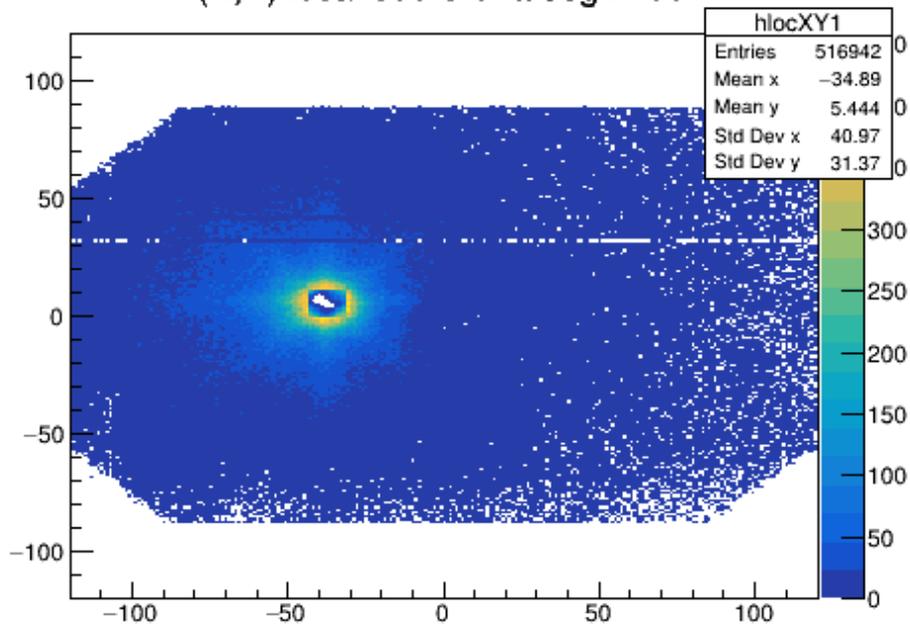


$$X = \frac{V-U}{\sqrt{2}};$$
$$Y = \frac{V+U}{\sqrt{2}};$$

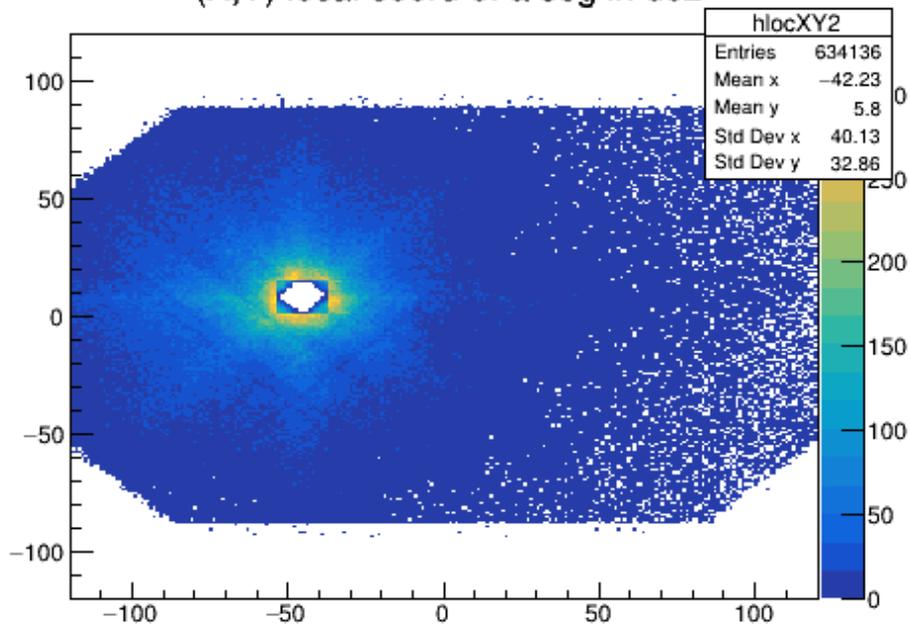
- 4 double coordinate planes;
- wire angles $0^\circ, 90^\circ, \pm 45^\circ$;
- wire pitch 10 mm;
- $Y_{out} \pm 1.35$ m, $X_{out} \pm 1.35$ m;
- $R_{hole} = 10$ cm;
- 2048 wires per chamber.

Beam cut

(X,Y) local coord of a seg in dc1

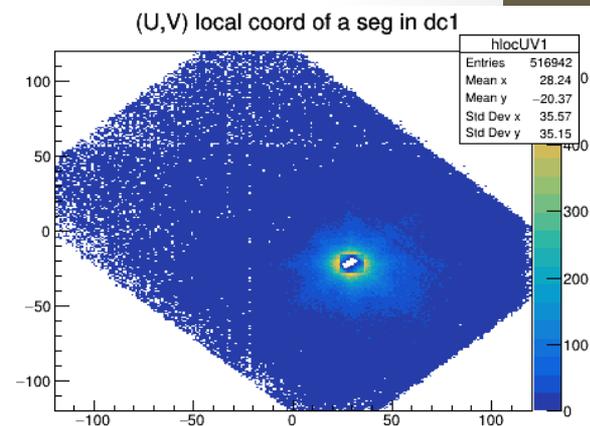


(X,Y) local coord of a seg in dc2



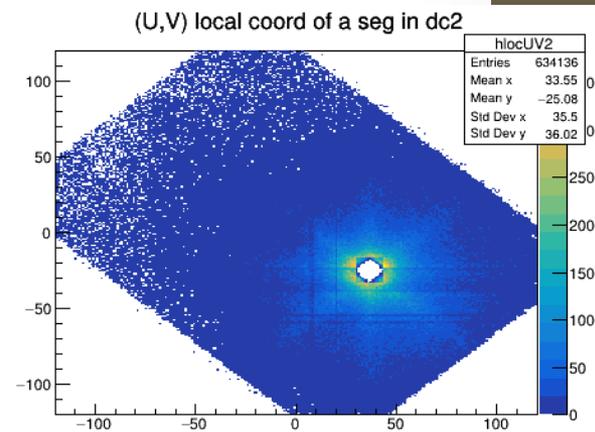
Run 4706, B = 1250A, empty target

DCH1



~10cm X 10cm cuts

DCH2



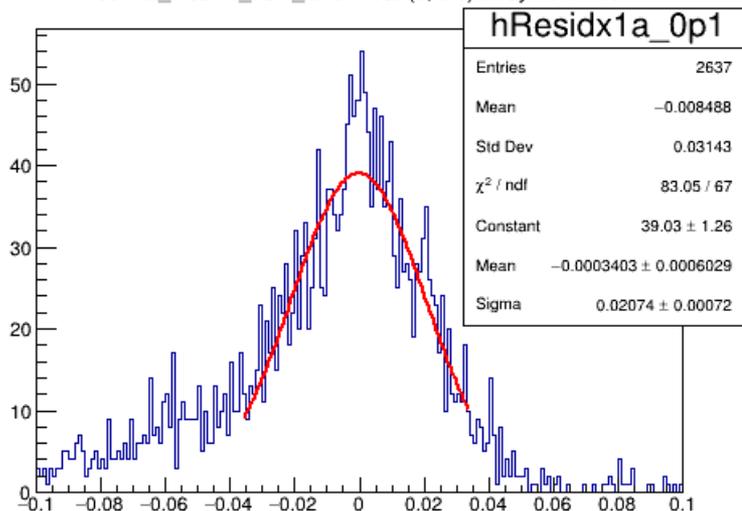
All in cm !!!

Residuals at edges

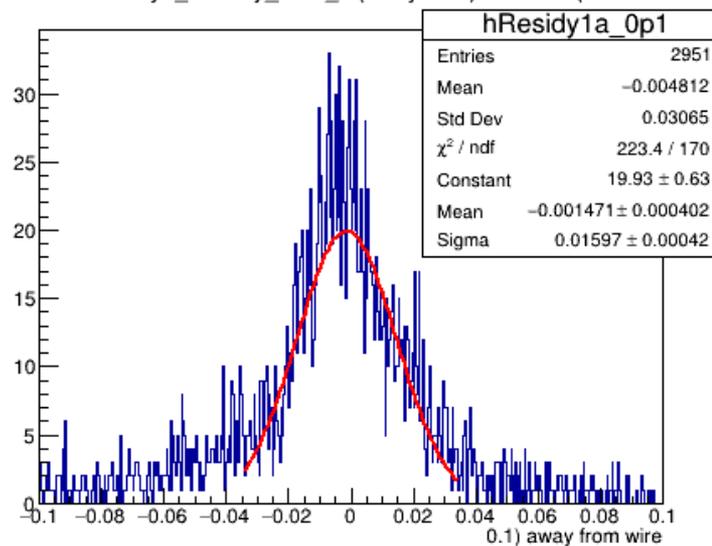
MC reco segs

Data reco segs

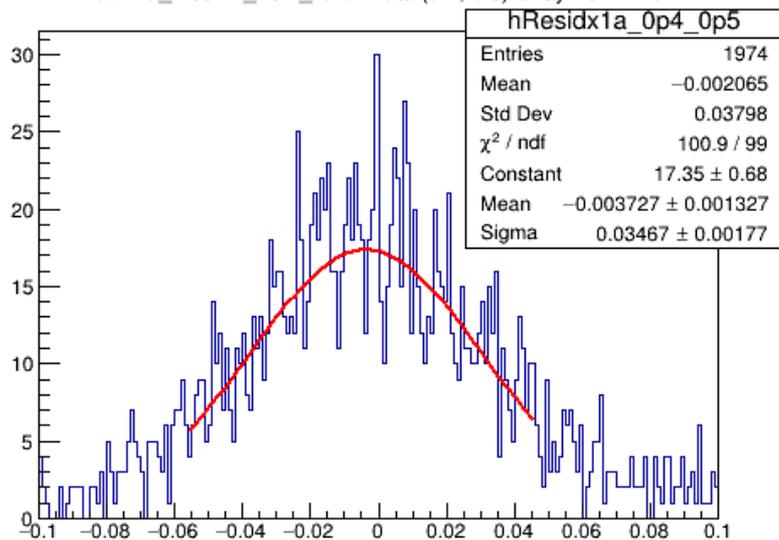
dc1 xa_mes - x_from_fit for hit at (0, 0.1) away from wire



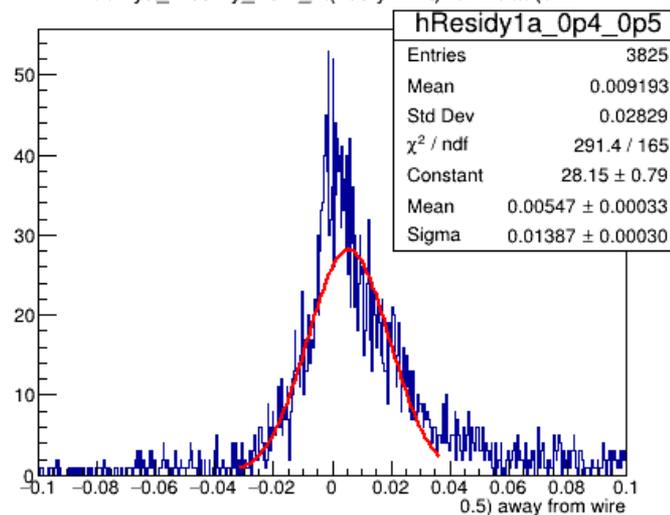
dc1 ya_mes - y_from_fit(w/o y in fit) for hit at (0



dc1 xa_mes - x_from_fit for hit at (0.4, 0.5) away from wire



dc1 ya_mes - y_from_fit(w/o y in fit) for hit at (0.4



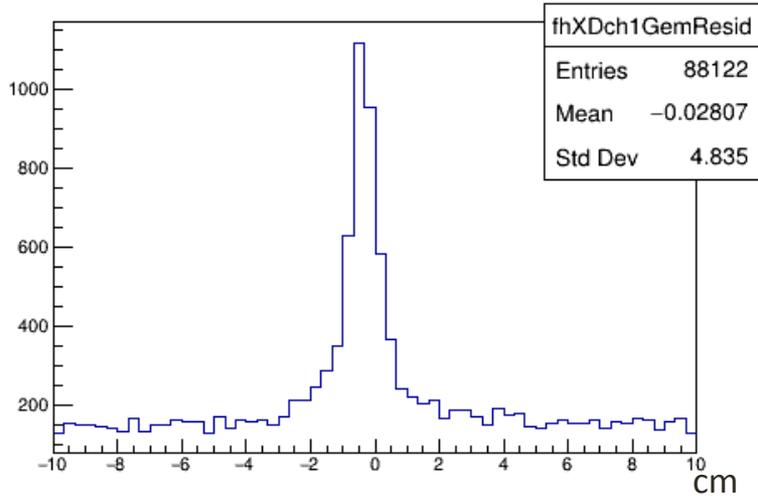
DCH - GEM matching

MC tracks

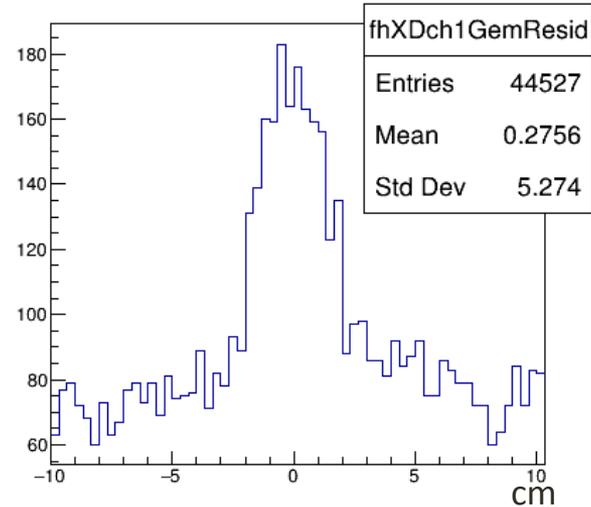
GEM(≥ 5 hits) + DCH

data tracks

fhXDch1GemResid

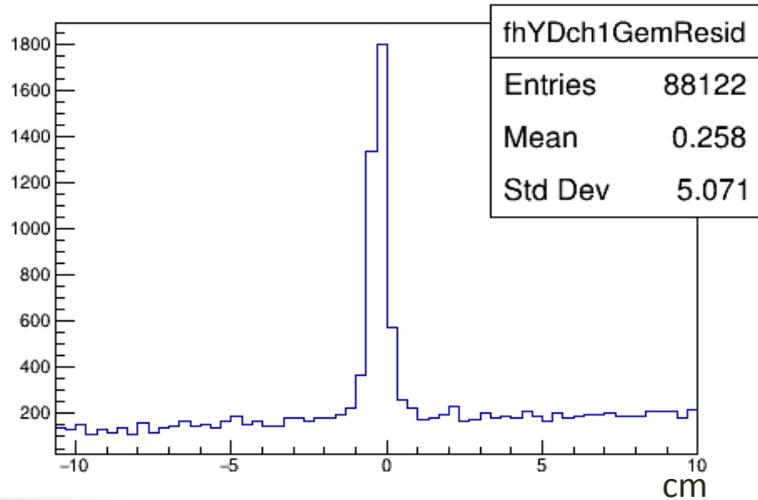


fhXDch1GemResid

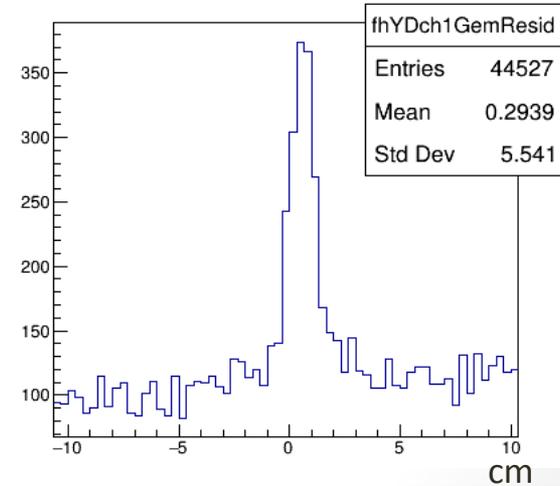


Ar beam, empty target, B = 1250A

fhYDch1GemResid



fhYDch1GemResid

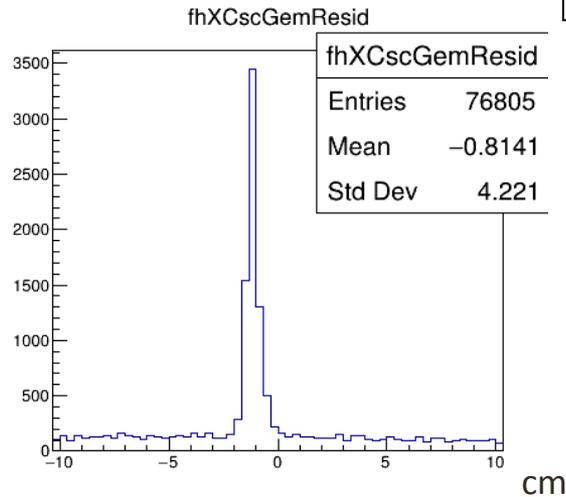


10K events

100K events

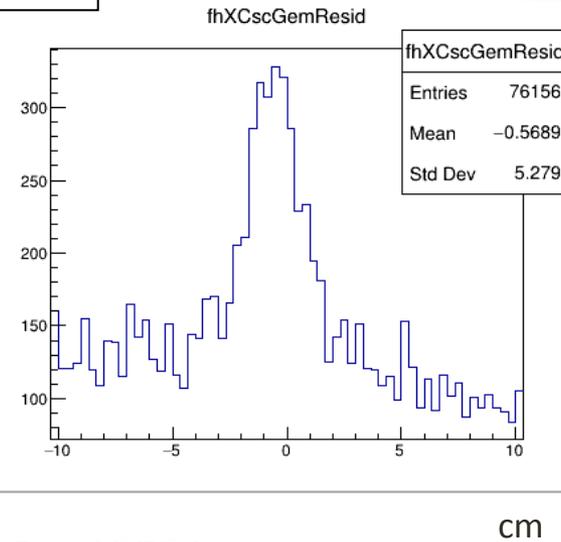
CSC – GEM matching

MC tracks

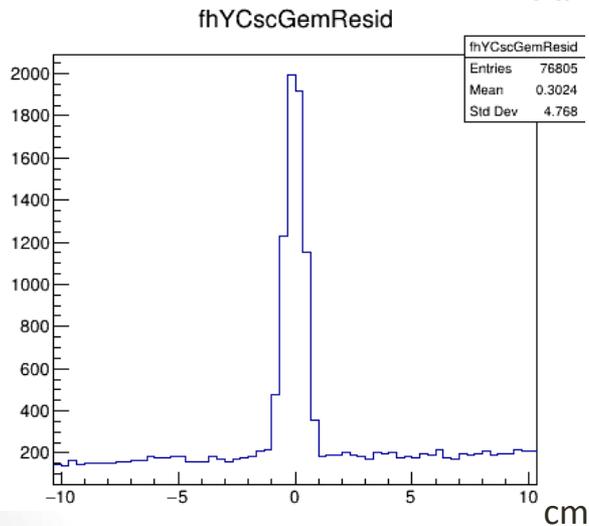


GEM(≥ 5 hits) + CSC

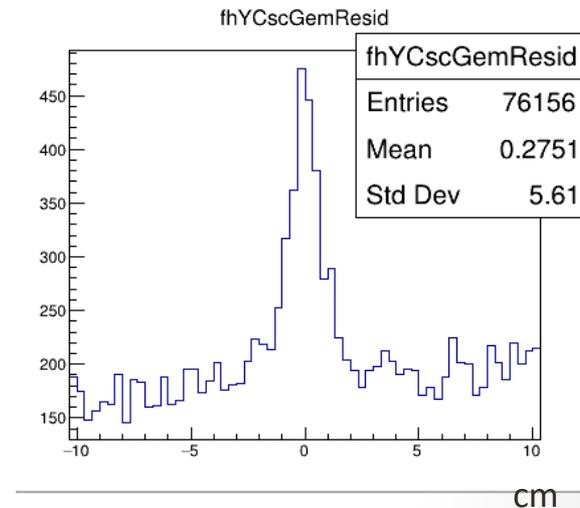
data tracks



Ar beam, empty target, B = 1250A



10K events



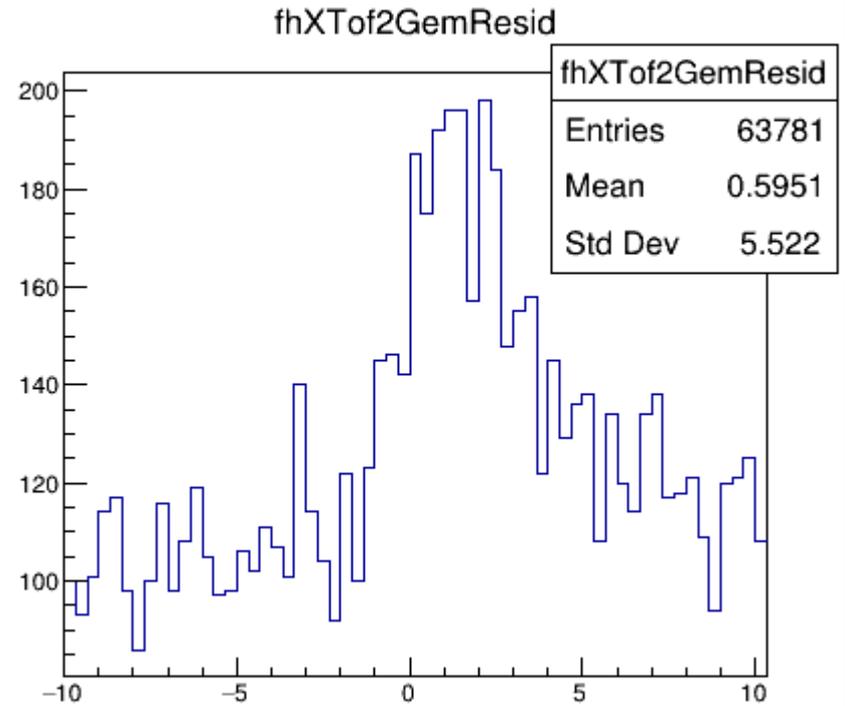
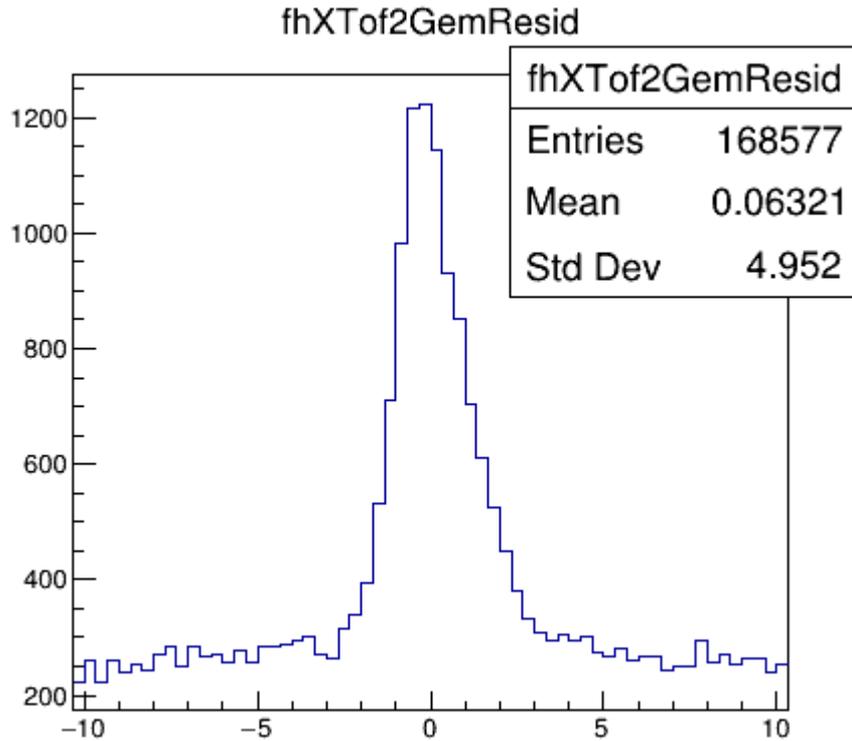
100K events

TOF700 – GEM matching

MC tracks

GEM(≥ 5 hits) + CSC

data tracks



Ar beam, empty target, B = 1250A

Notations

$N_{\text{gem trs}}$ **GEM** tracks (reconstructed MC gem tracks)

$N_{\text{good gem trs}}$ "Good" **GEM** tracks (those which pass cut selection)

$N_{\text{dch trs}}$ **DHC** tracks (reconstructed MC DCH1 tracks)

$N_{\text{w. all dch tr}}$ **GEM** tracks with a least 1 **DCH1** track

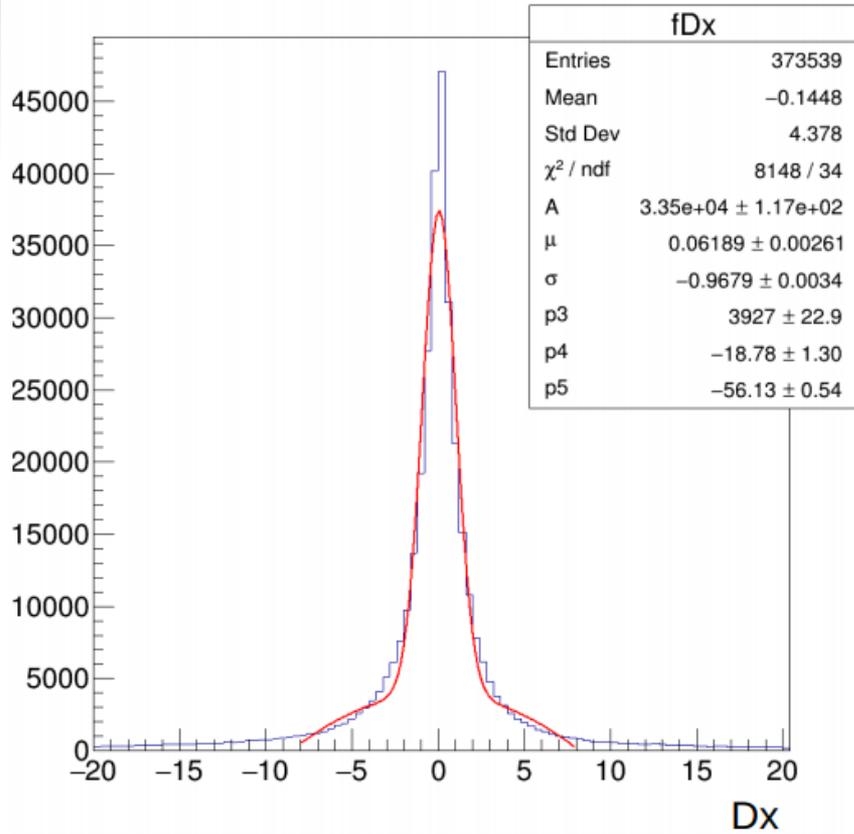
$N_{\text{w. dch tr}}$ "Good" **GEM** tracks with a least 1 **DCH1** track

$N_{\text{matched trs}}$ **GEM** tracks extrap. to **DCH1** and
matched to **DCH1** tracks

$N_{\text{true matched trs}}$ **GEM** tracks mathched to **DCH1** tracks and

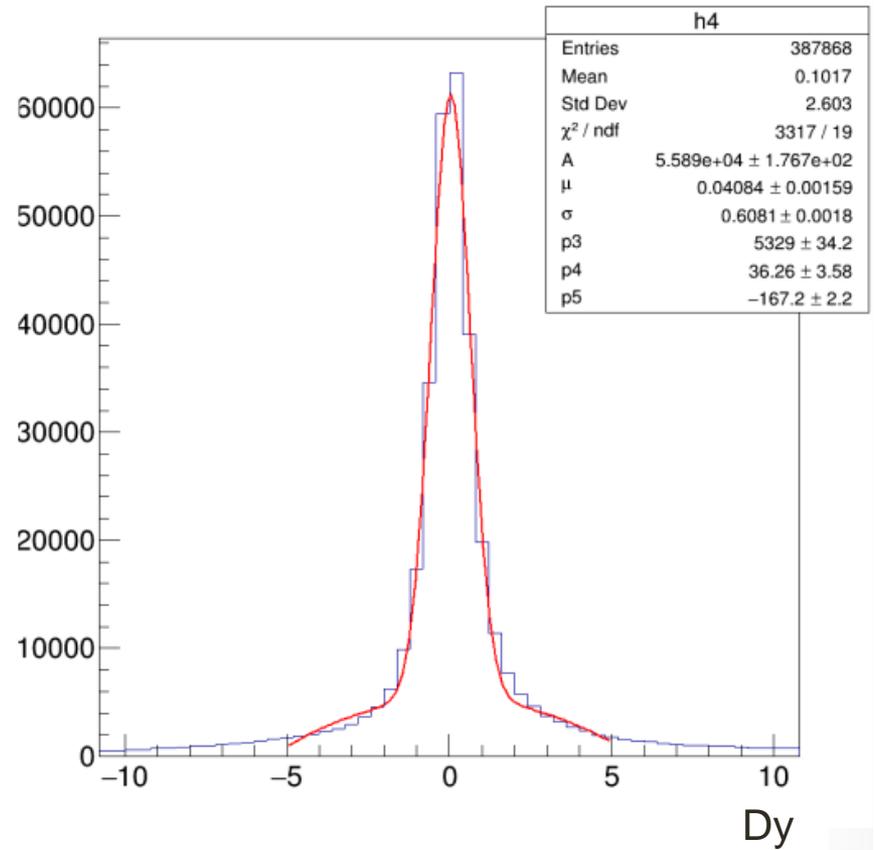
L1 Result

GemDchTracks.IDx (GemDchTracks.IDchTrack.IDParamFirst.Z=530&& GemDchTracks.IDy>= 2 && GemDchTracks.IDy<2)



L1 Result

GemDchTracks.IDy (GemDchTracks.IDchTrack.IDParamFirst.Z=530&& GemDchTracks.IDx>= 3 && GemDchTracks.IDx<3)



GEM-DCH matching on Run7 Ar data