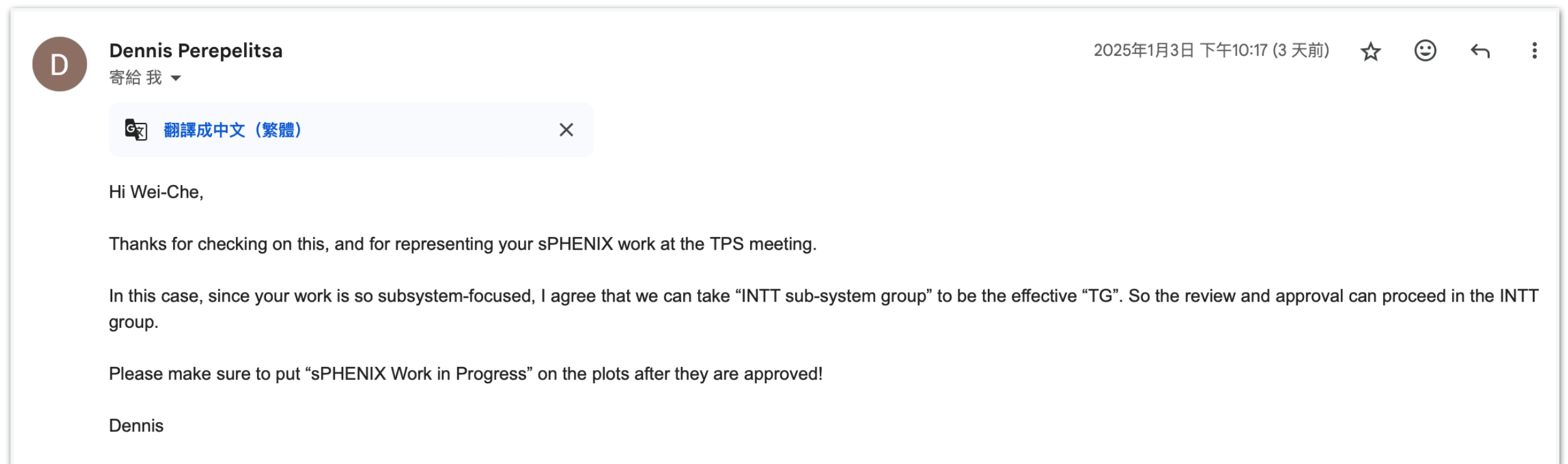# INTT cosmic analysis update

Wei-Che Tang, NCU

Aim for this presentation

- The TPS Annual Meeting (Annual Meeting of the Physical Society of Taiwan) is approaching on Jan. 14.

- I would like to present the current status of my comics analysis on the TPS meeting.

- I confirmed with Dennis that I could get the approval for "work in progress" plots within the INTT group.

Dennis Perepelitsa
寄給 我 ▾

2025年1月3日 下午10:17 (3 天前)

翻譯成中文（繁體）　✕

Hi Wei-Che,

Thanks for checking on this, and for representing your sPHENIX work at the TPS meeting.

In this case, since your work is so subsystem-focused, I agree that we can take "INTT sub-system group" to be the effective "TG". So the review and approval can proceed in the INTT group.

Please make sure to put "sPHENIX Work in Progress" on the plots after they are approved!
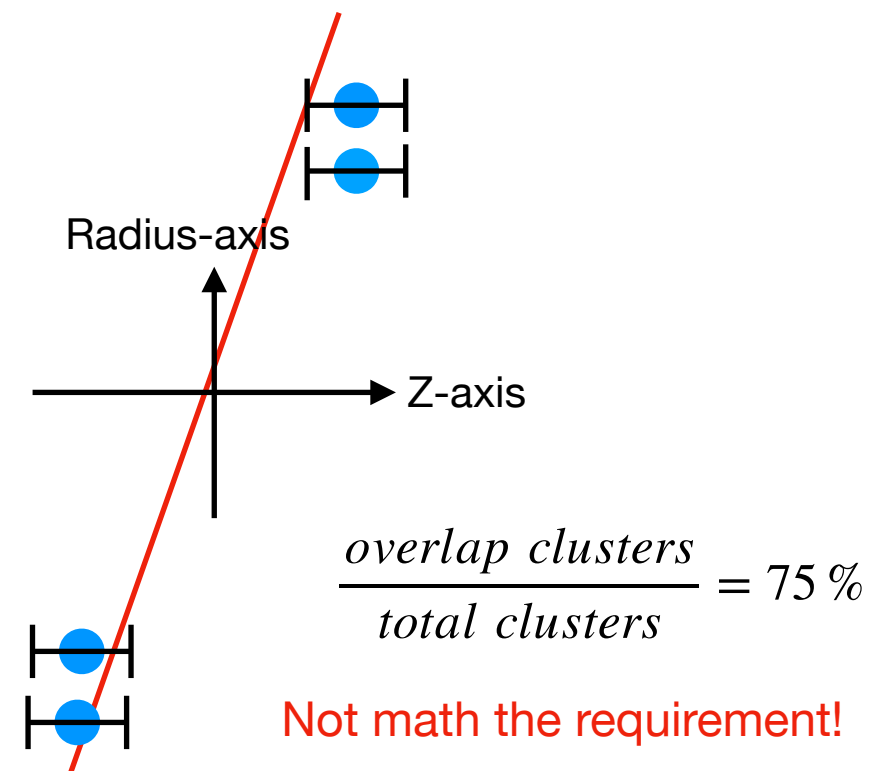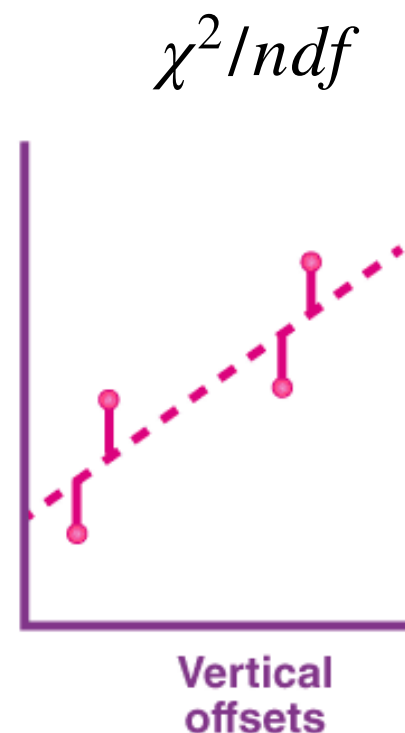
Dennis

Cosmic Analysis status

- Run number: 39365~39530, ~30 runs if not otherwise specified

  - Trigger: HCal Vertical trigger

  - Data taking with 0 magnetic field.

  - Total number of events: 4.2M

  - Threshold: 15

  - Data taking period: Apr. 12 ~ May. 1 (Run2024 cosmic data)

- INTTRawHit DSTs are from official production.

- INTTTrkrCluster DSTs are from private production using Fun4All framework.

  - To apply the private hot channel masking map.

- Good clusters required

  - *'cluster Adc > 15'* (Adc0 is set to be 15) & *'cluster phisize < 9'*

- Two approaches are used in this analysis.

  - 4 good clusters only.

    - Minimal requirement to reconstruct a pure cosmic track.

  - 4~7 good clusters included.

    - Find rare comic tracks with more ladders involved.

4 good clusters only

- Event selection: # of good clusters = 4

- Fit the clusters with a slope in X-Y and Z-Radius plane.

- Reduced residual is calculated in X-Y plane to evaluate the fitting quality.

  - To minimize the track angle dependence.

- Definition of a good track:

  - *X-Y* residual *< 0.02 cm*

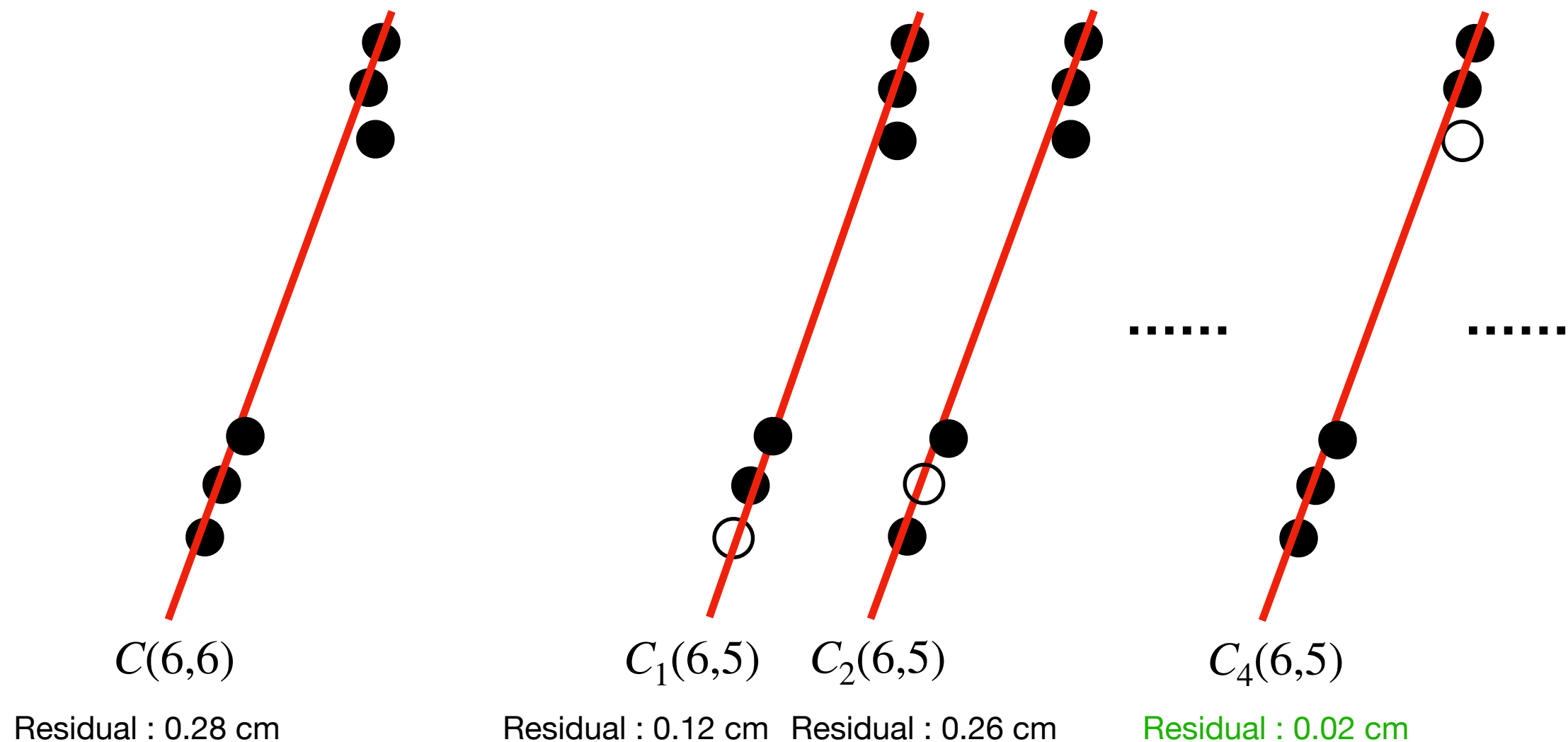 - Fitting line requires to overlap with each cluster (100% overlap) in Z-Radius plane.

χ^2/ndf

Residual

Radius-axis

Z-axis

$$\frac{overlap\ clusters}{total\ clusters} = 75\%$$

Not math the requirement!

Vertical offsets

Perpendicular offsets

4~7 good clusters

- Event selection: 4 ≤ # of good clusters ≤ 7

- Prepare all the combinations based on $C(n, k)$

  - n is total number of clusters in an event

  - k is the number of clusters involved in the fitting

  - i.e. if $n = 5$ → {4 x k=4} + {1 x k=5}

- Fit each combination with a slope in X-Y and Z-Radius plane.

- Reduced residual is calculated in X-Y plane to evaluate the fitting quality

  - To minimize the track angle dependence.

- Fitting line requires to overlap with each cluster in Z-Radius plane.

- In each k, pick up the one with the least reduced residual.

- Definition of a good track:

  - The combination with larger k whose reduced residual smaller than 0.02 cm is selected.

Clusters combination

- Prepare all the combinations based on $C(n, k)$

  - k ranges from 6 to 4, $n = 6$

  - The reduced residual smaller than 0.02 cm can be the candidate.

$C(6,6)$ $C_1(6,5)$ $C_2(6,5)$ $C_4(6,5)$

Residual : 0.28 cm   Residual : 0.12 cm   Residual : 0.26 cm   Residual : 0.02 cm

Clusters combination

- Prepare all the combinations based on $C(n, k)$

  - Although two combinations' residual is smaller than 0.02cm, the combination of larger clusters is selected.

Two candidates

$C_1(6,4)$ $C_2(6,4)$ $C_4(6,4)$ $C_4(6,5)$ $C_4(6,4)$

Residual : 0.21 cm Residual : 0.24 cm   Residual : 0.015 cm   Residual : 0.02 cm   Residual : 0.015 cm

Win!
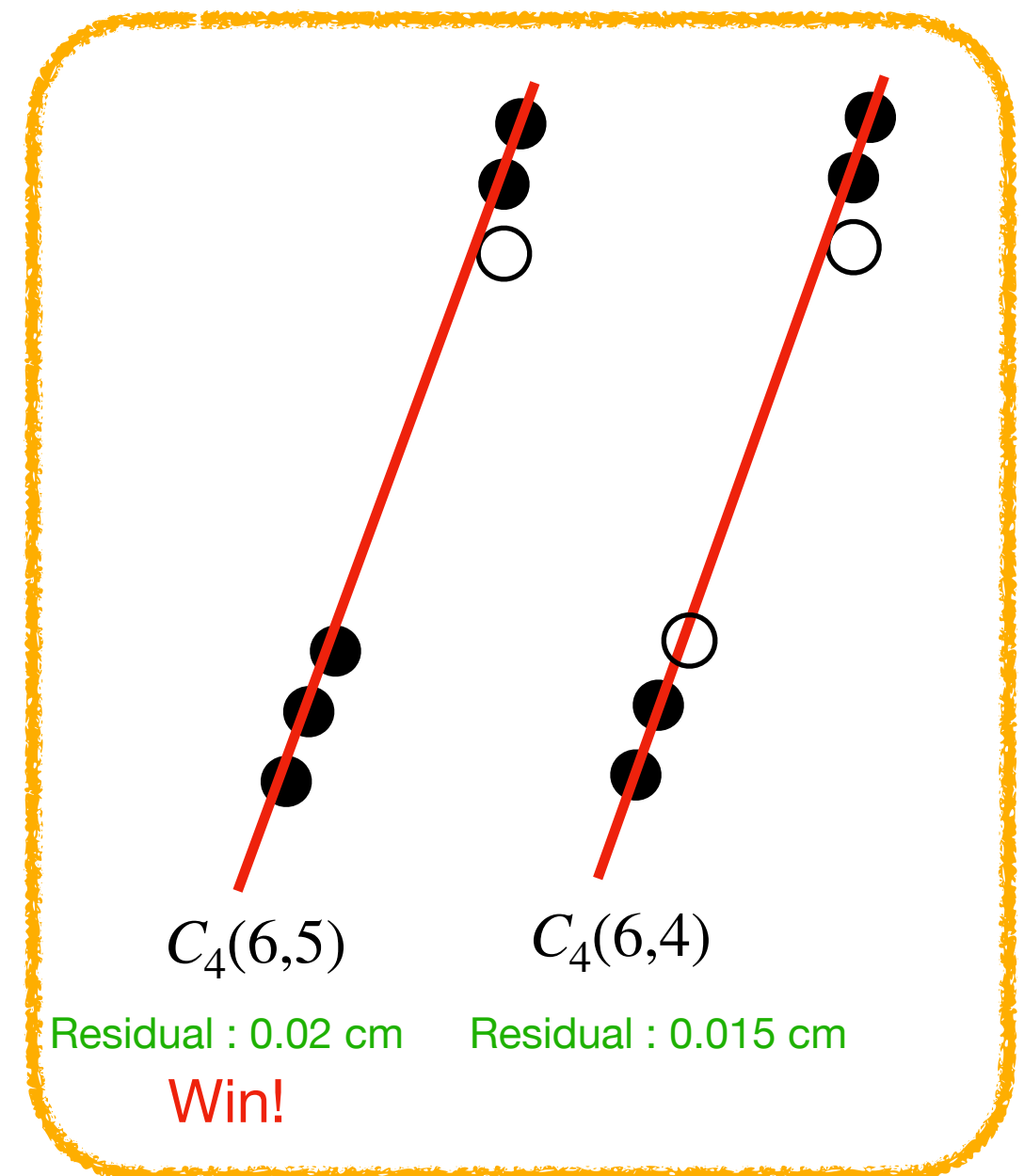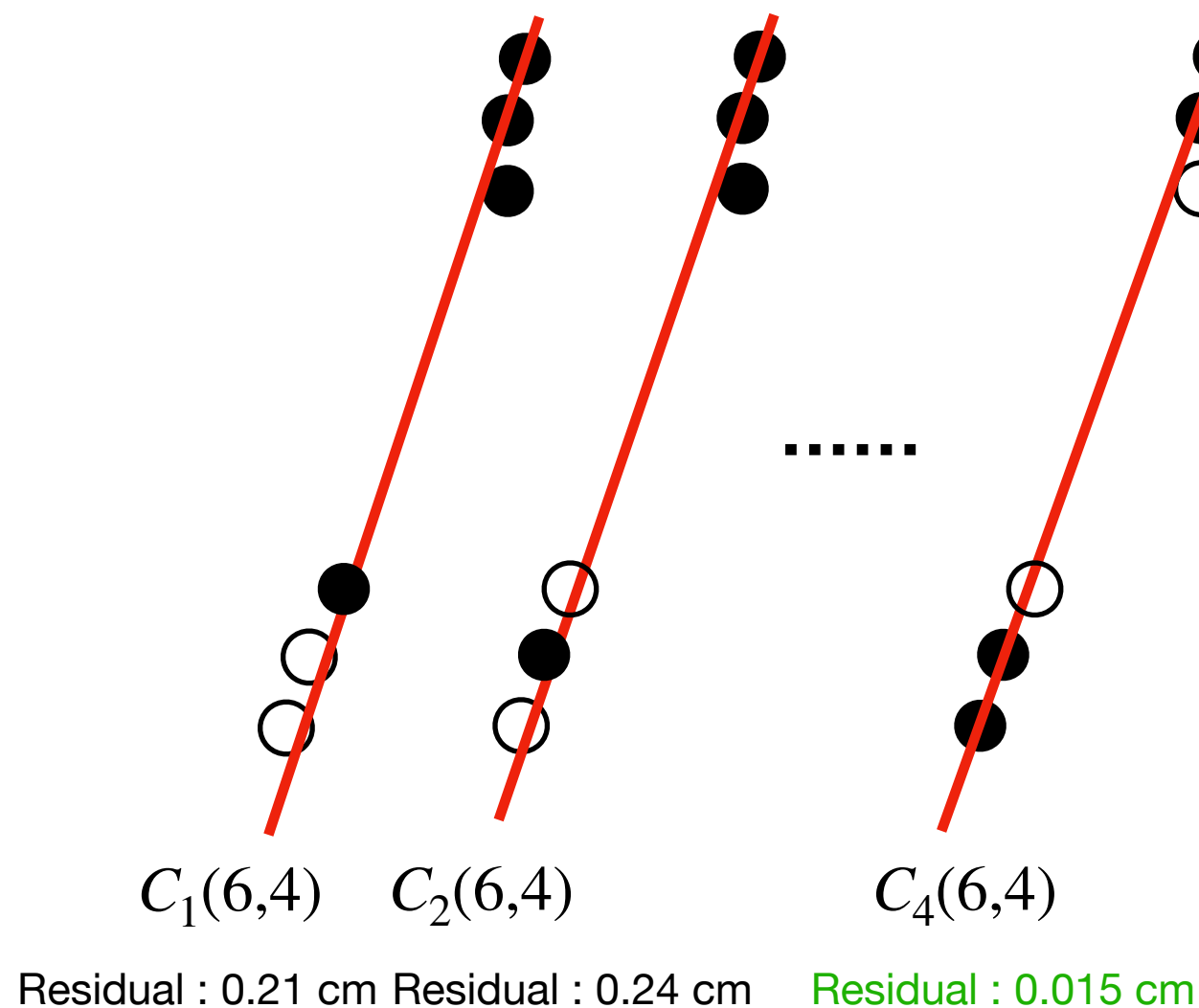
Good cluster required

- *'cluster Adc > 15' & 'cluster phisize < 9'*

- The plots use single run data.

Inclusive

Good cluster only

Cluster size = 1 && Adc = 15
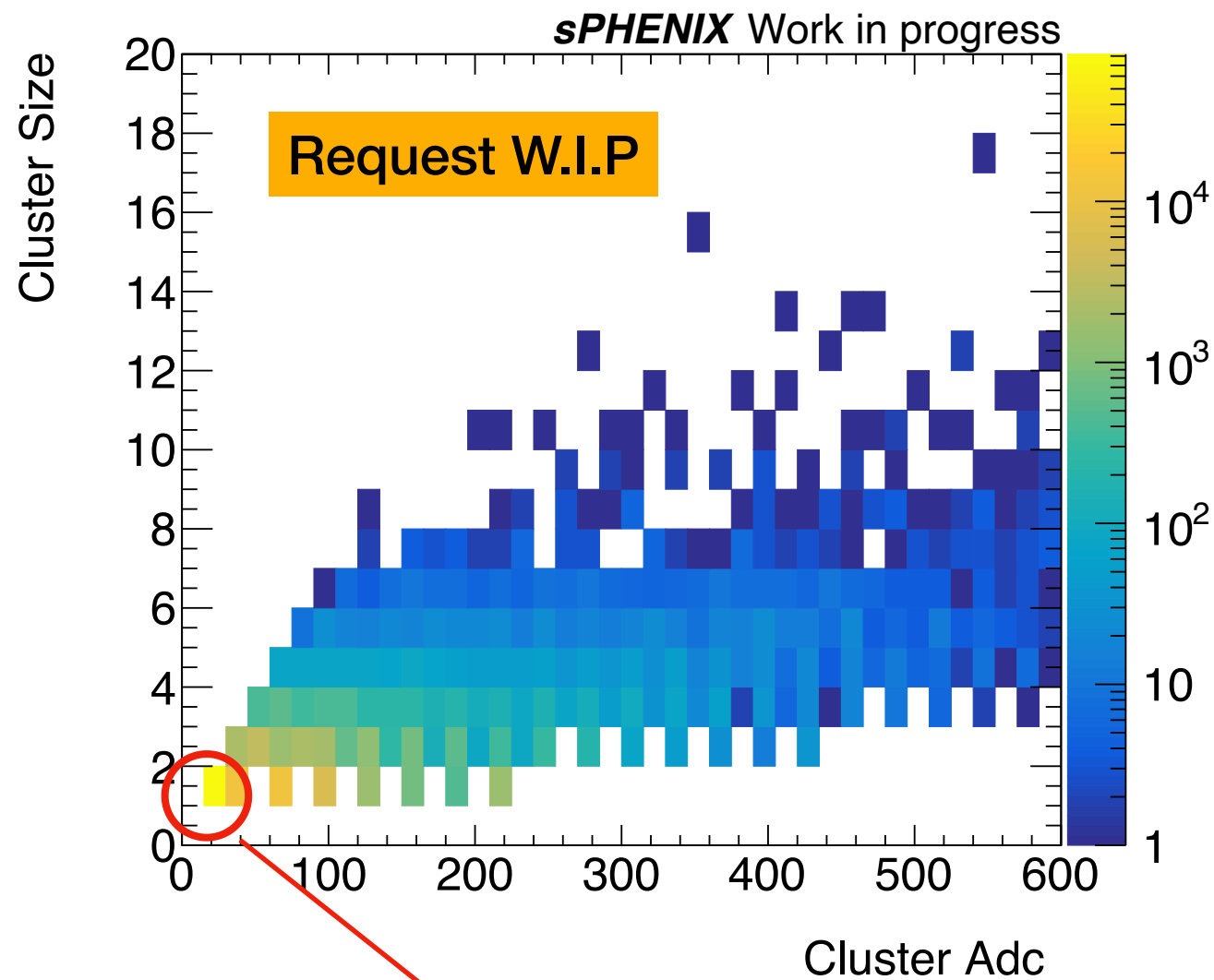
Absence of cluster size = 1 && Adc = 15

Good cluster required

- The plots use single run data.

- Empty events are excluded.

- A large fraction of '*cluster size = 1*' clusters are excluded.
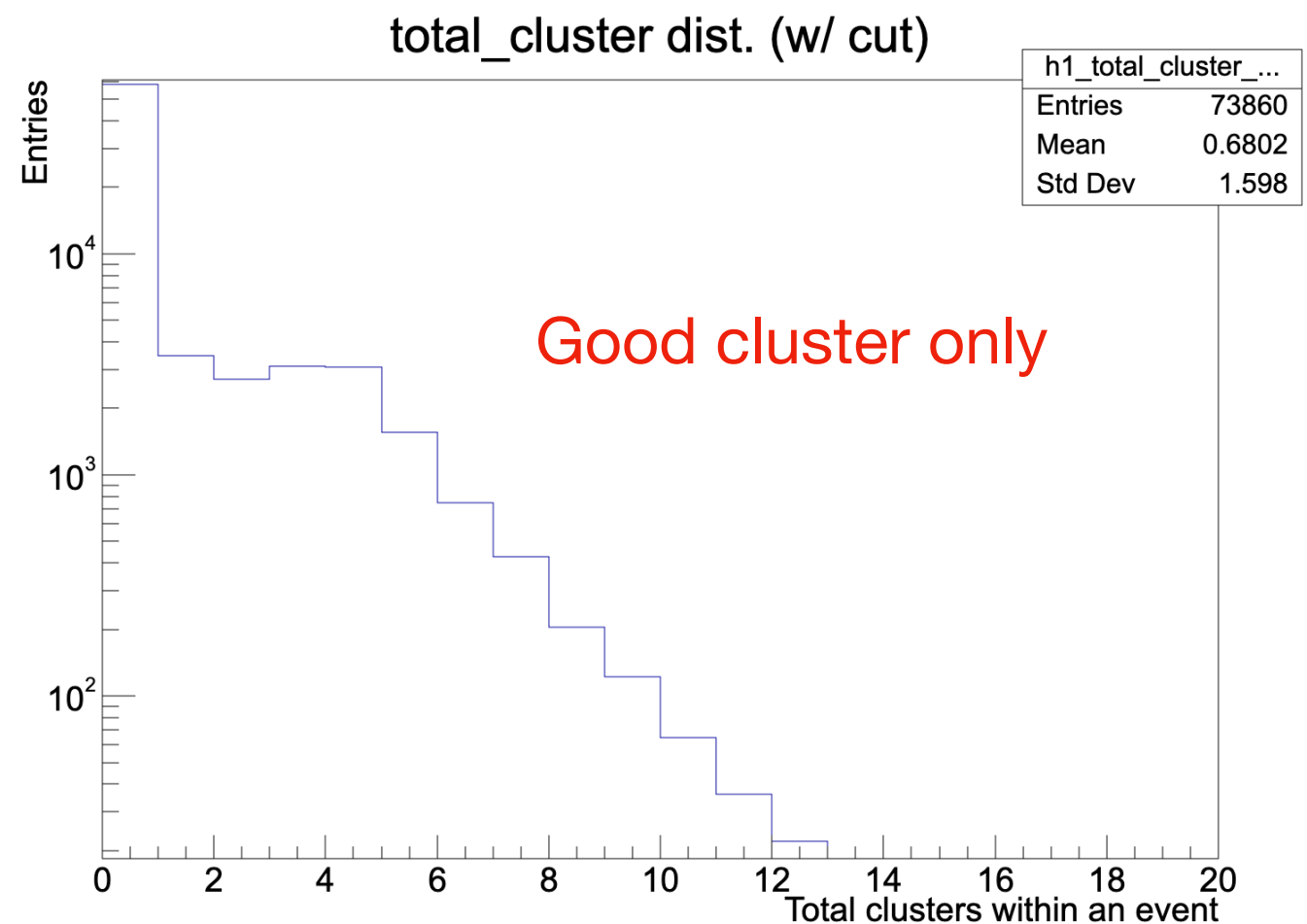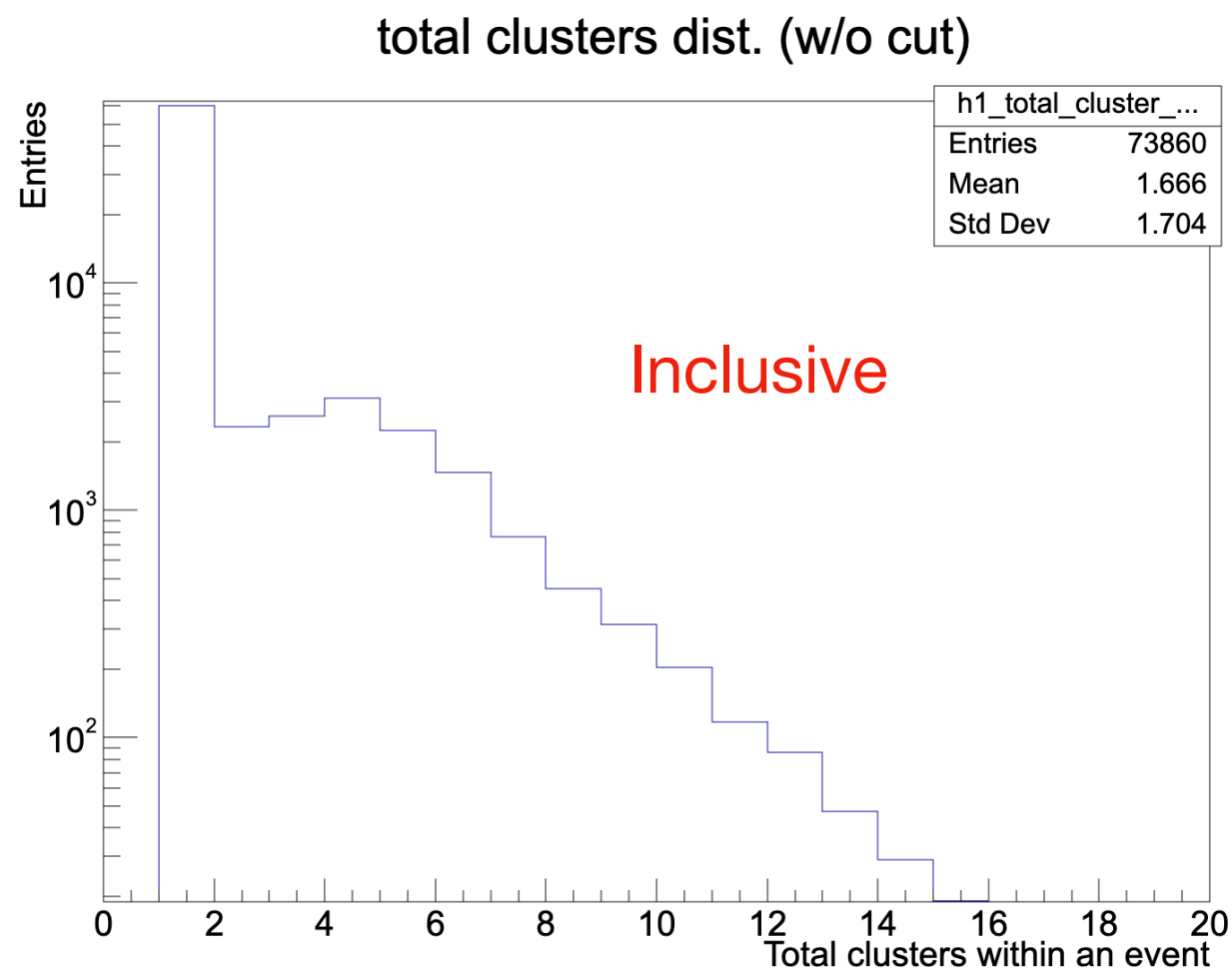
Reduced residual distribution

- The reduced residual distribution for **4 clusters only** in **X-Y plane.**
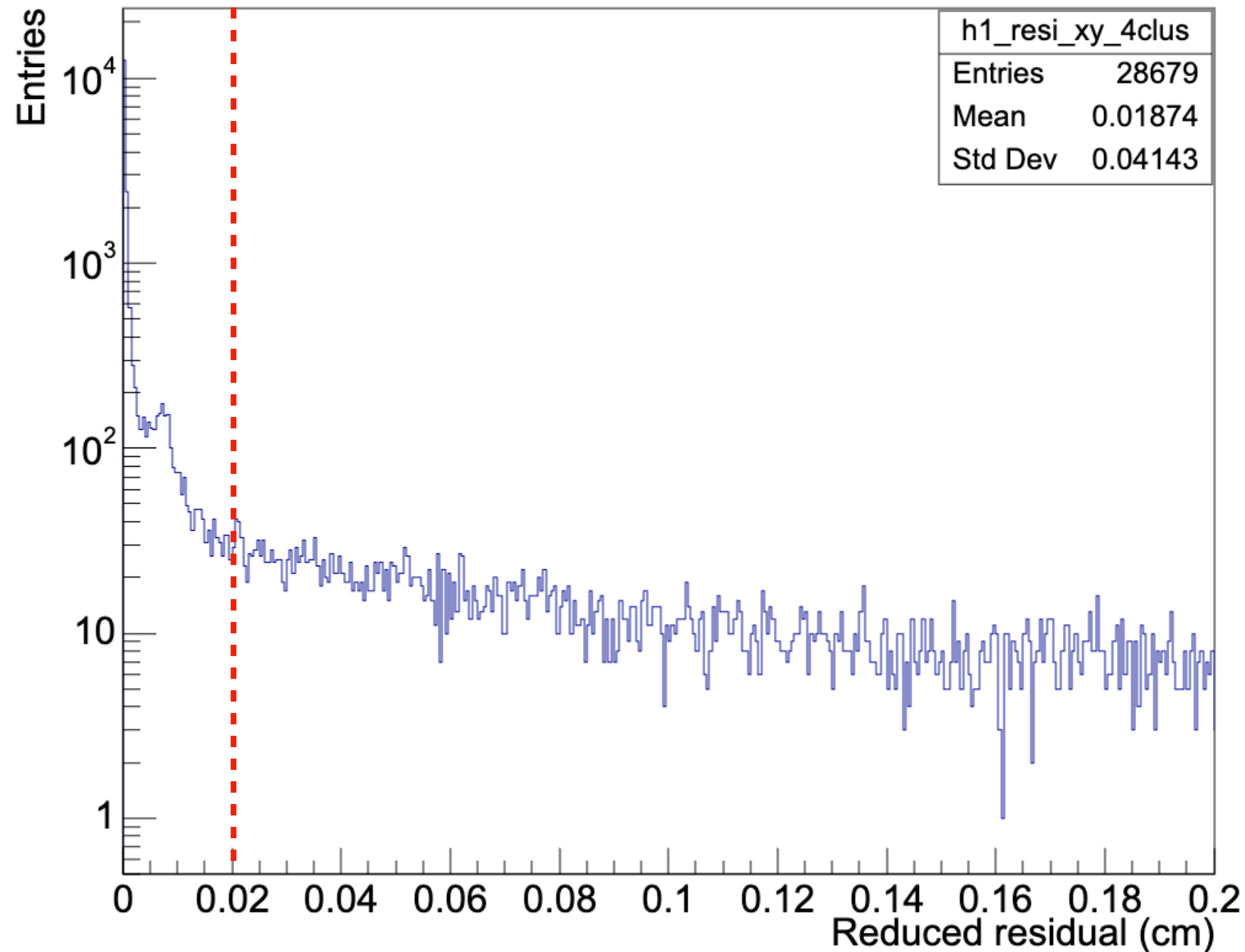
Event displays for 4 clusters only

- Good track!

- Reduced residual < 0.02 cm

Event : 23

sPHENIX **Work in progress**

Total clusters: 4

Selected clusters: 4

ϕ = 89.962°

Residual = 8.659e-06

Total clusters: 4

Selected clusters: 4

θ = 83.560°

- Bad track!
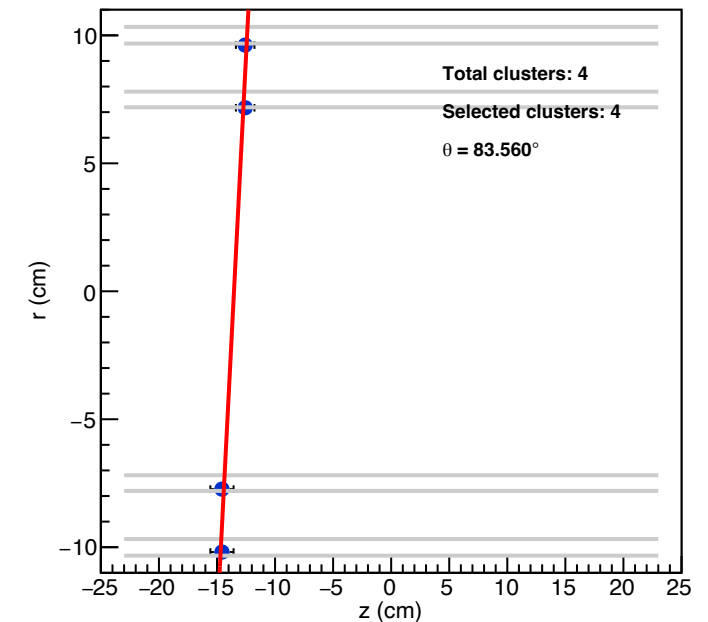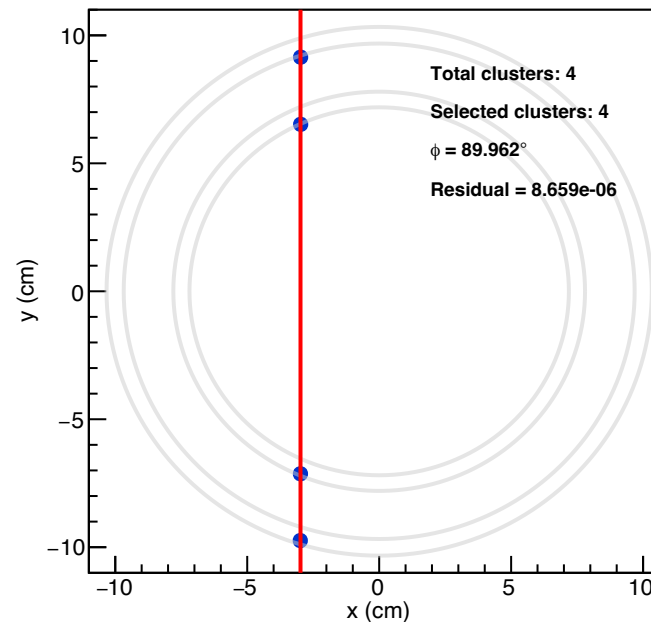
- Reduced residual > 0.02 cm

Event : 5270 (C(4,4) *combination 0*)

sPHENIX **Work in progress**

Total clusters: 4

Selected clusters: 4

ϕ = 89.201°

Residual = 8.639e-01

Total clusters: 4

Selected clusters: 4

θ = 94.068°

Residual = 4.652e+00

z vs y Event : 5270 (C(4,4) *combination 0*)   z vs x Event : 5270 (C(4,4) *combination 0*)
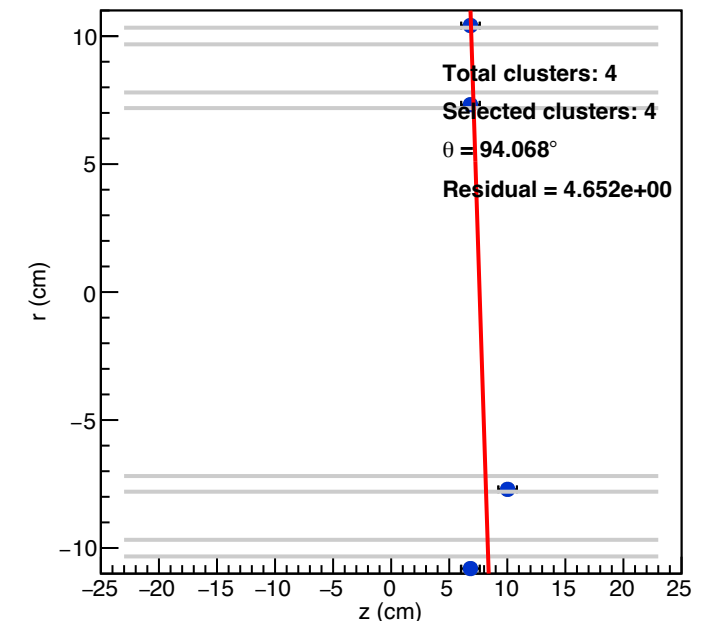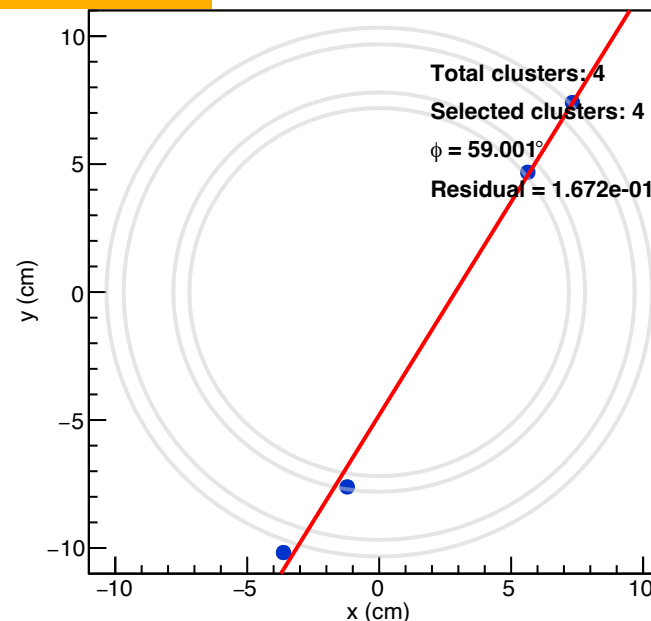
Angle distribution again
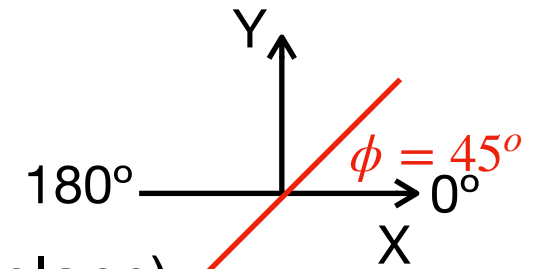
- The distribution of the ϕ angle (X-Y plane) and θ angle (Z-Radius plane)

- X-Y residual < 0.02cm, all 4 clusters cover the fitting line in Z-Radius plane.
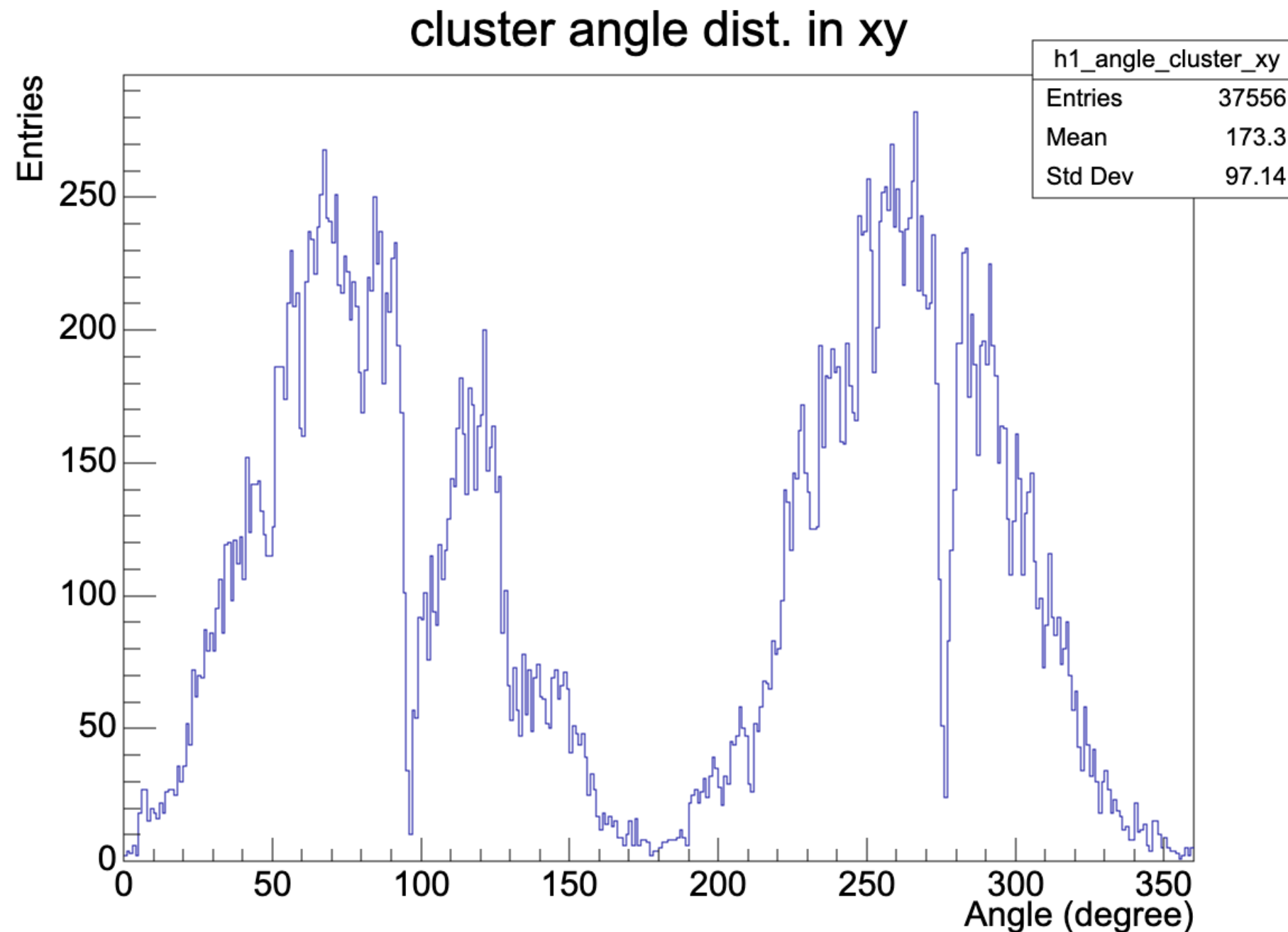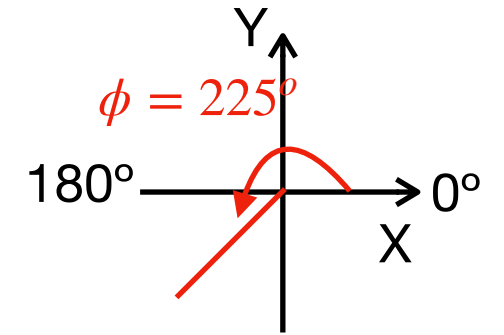
ϕ angle distribution in xy plane
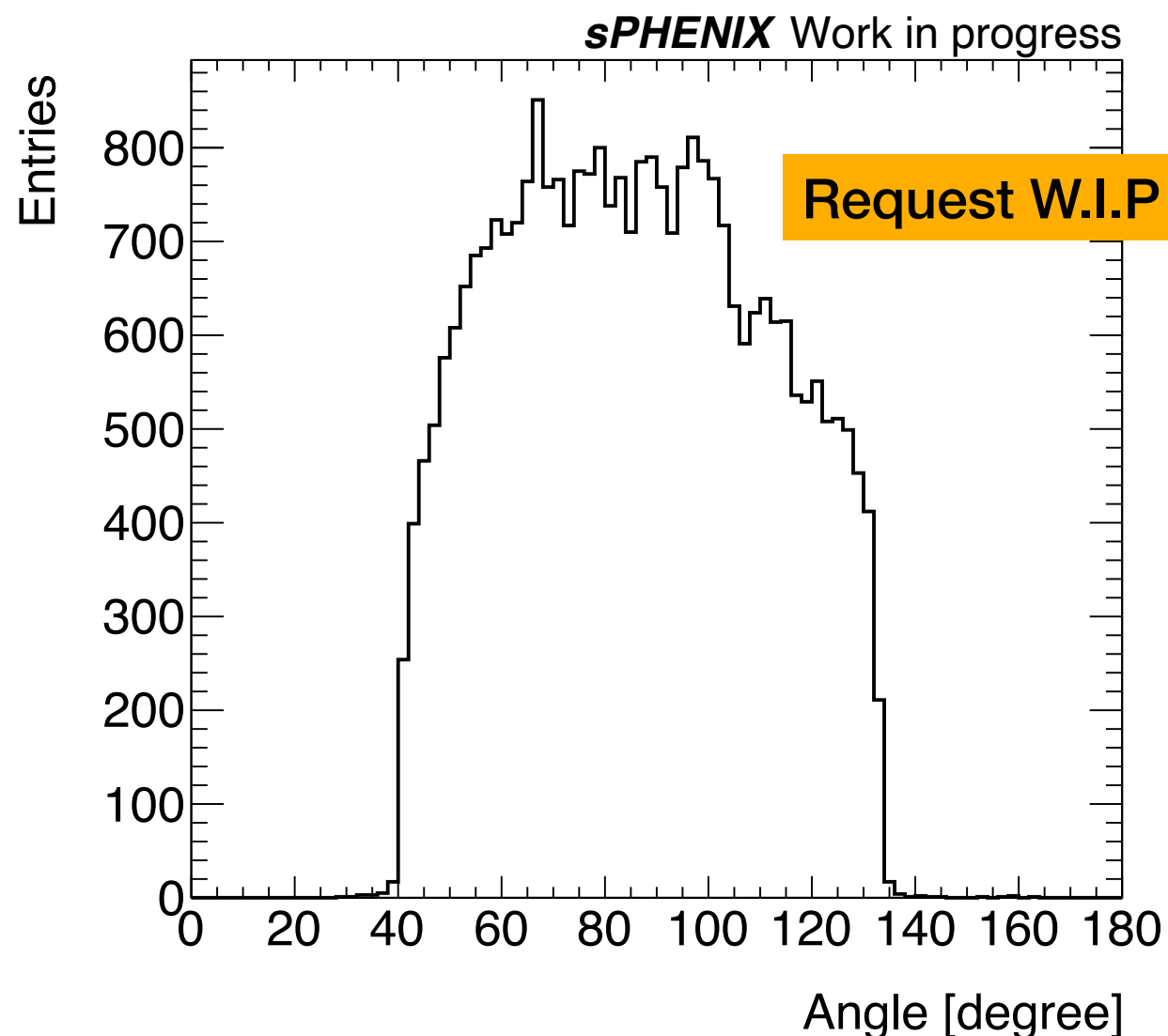
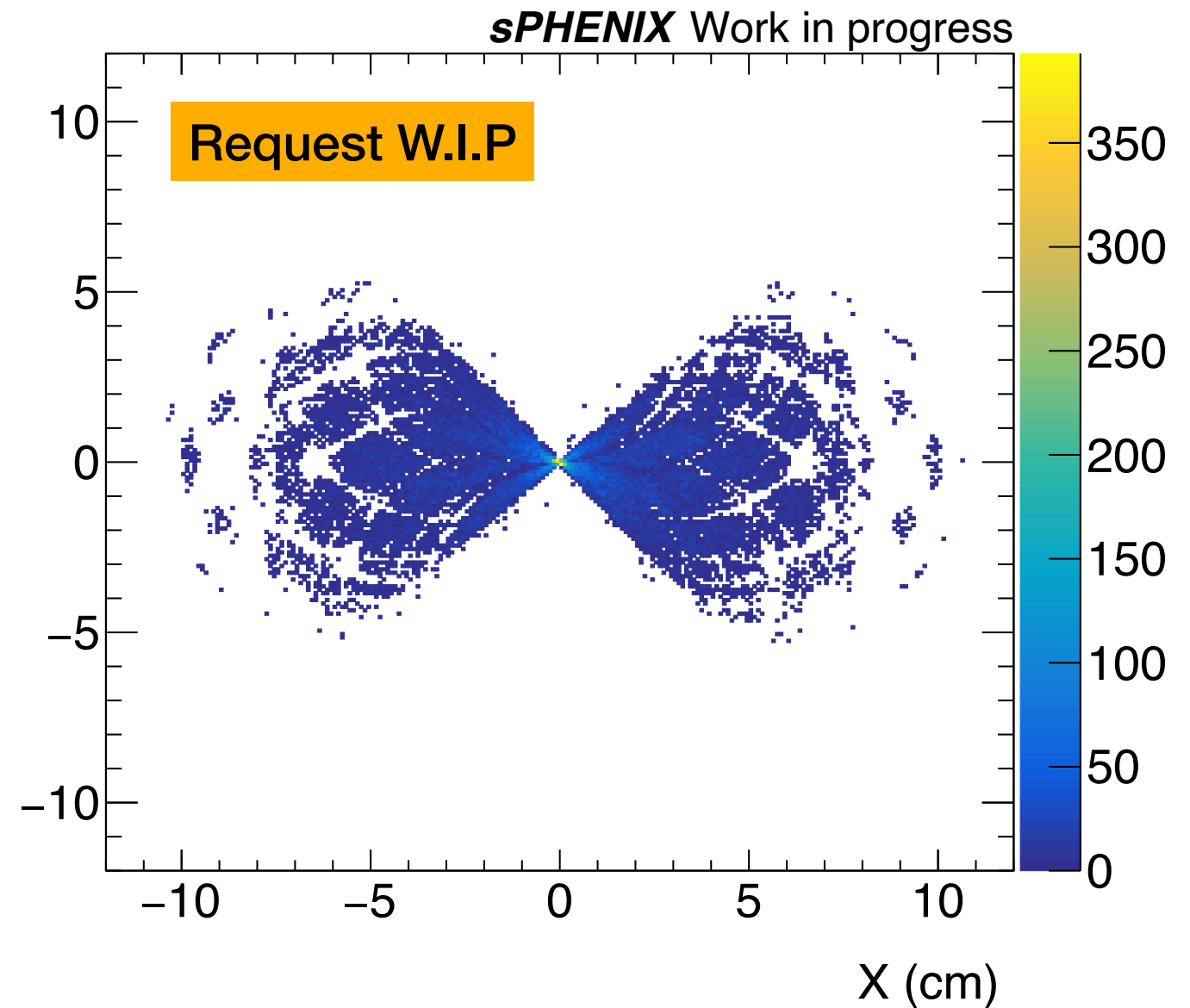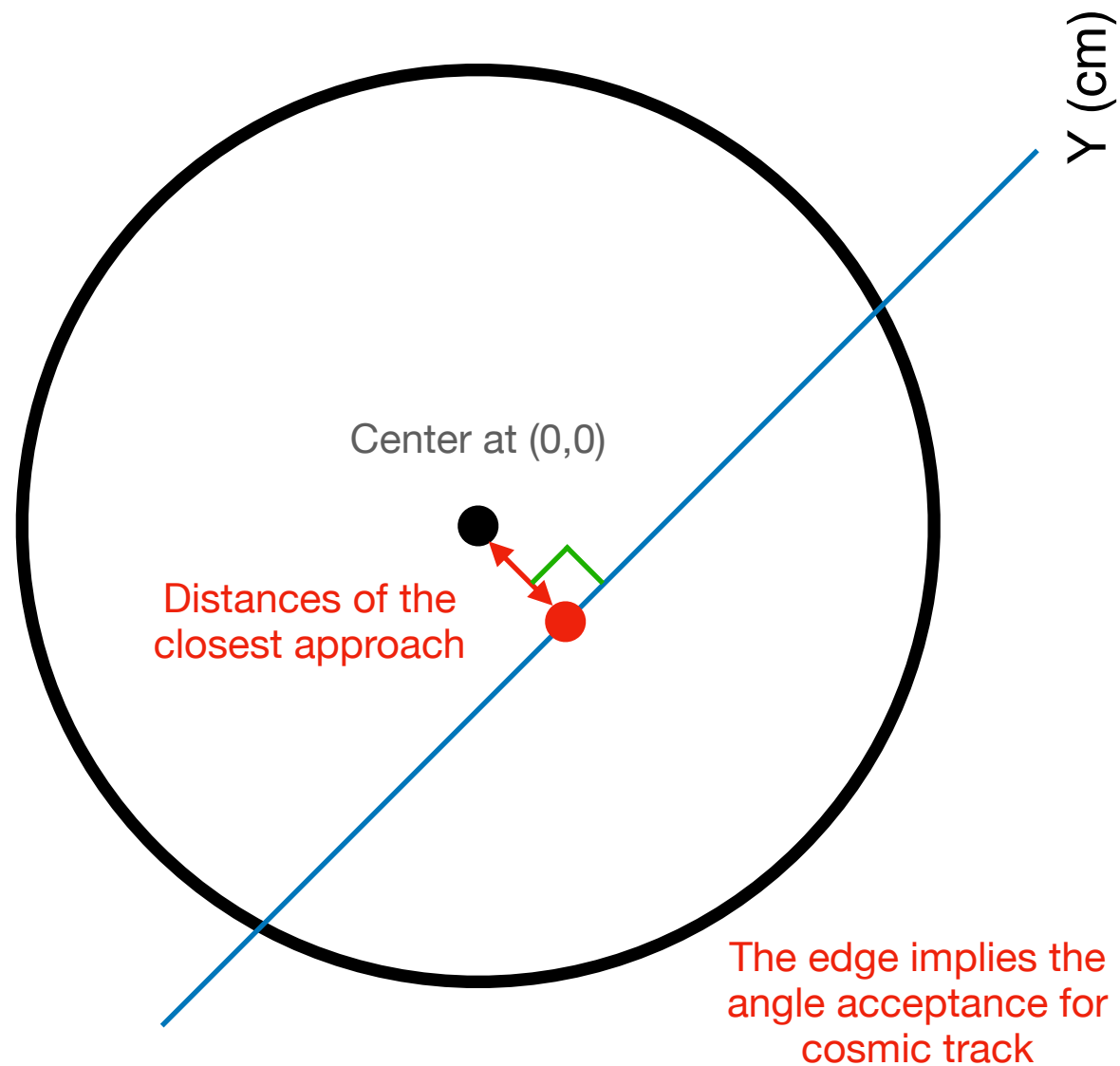θ angle distribution in zr plane
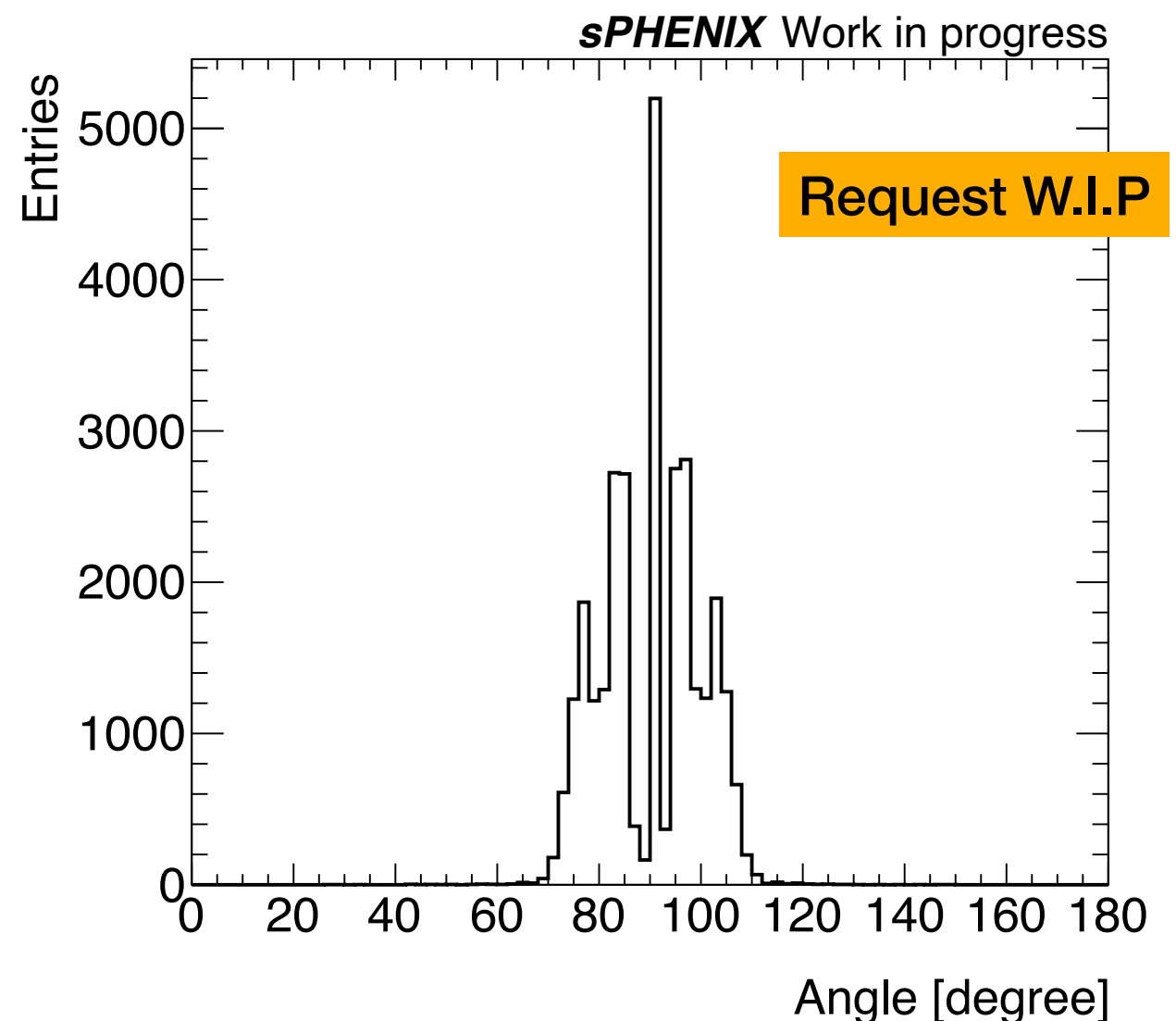
Cluster angle distribution

- The clusters of good tracks in ϕ angle distribution in X-Y plane.

- The distribution is in symmetry shape.

cluster angle dist. in xy

h1_angle_cluster_xy	
Entries	37556
Mean	173.3
Std Dev	97.14

The DCA points for tracks

- The plot also implies the acceptance angle of cosmic tracks.

Center at (0,0)

Distances of the closest approach

The edge implies the angle acceptance for cosmic track

sPHENIX Work in progress

Request W.I.P

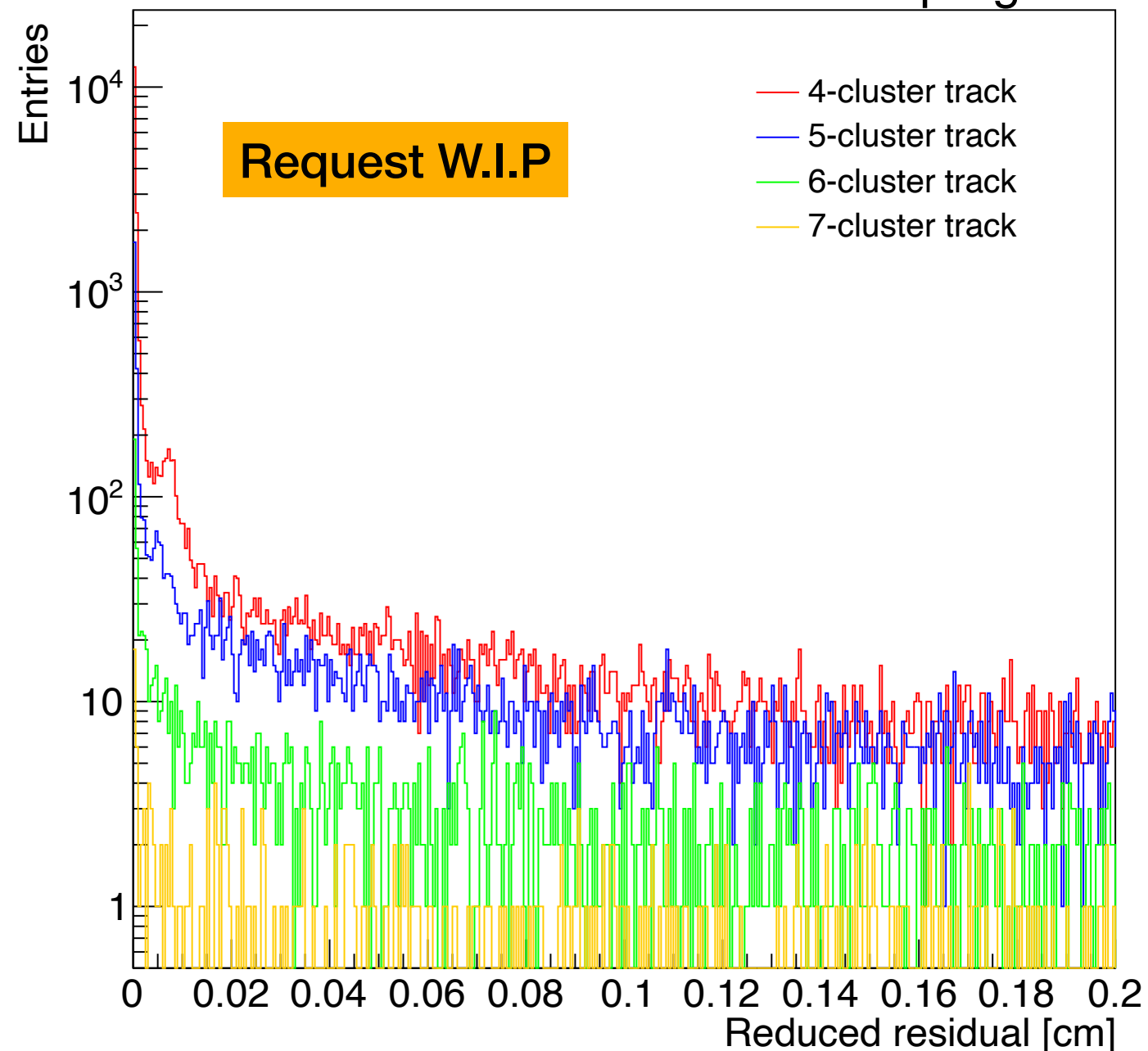# Reduced residual

- The reduced residual of different clusters tracks.
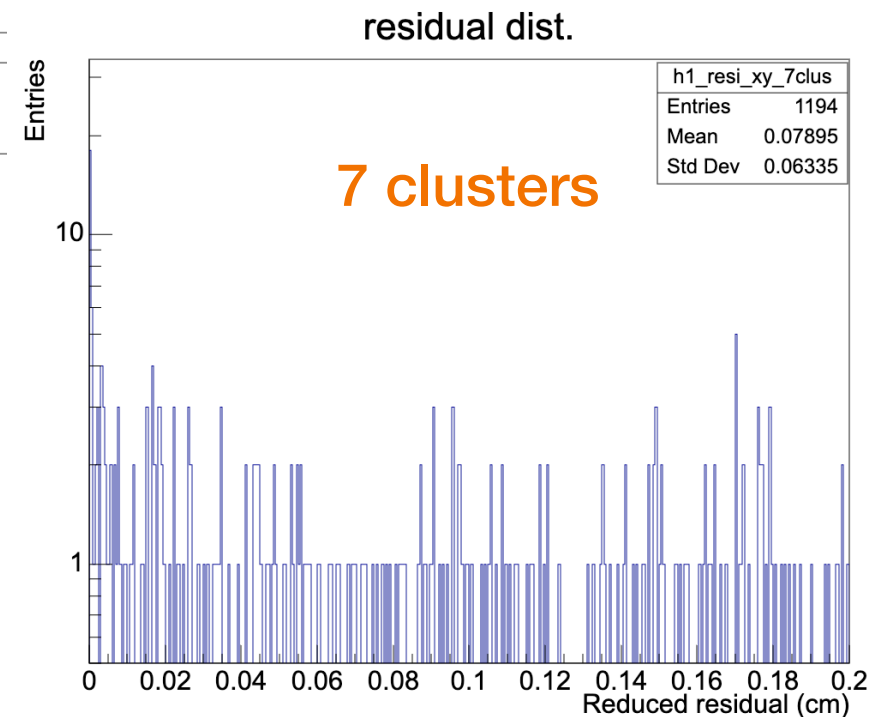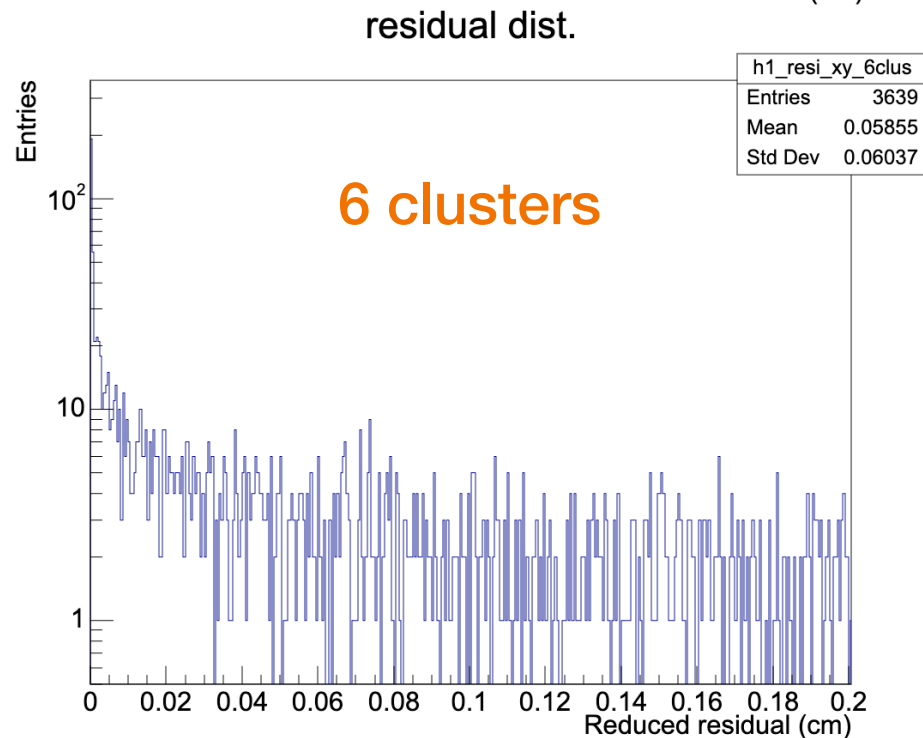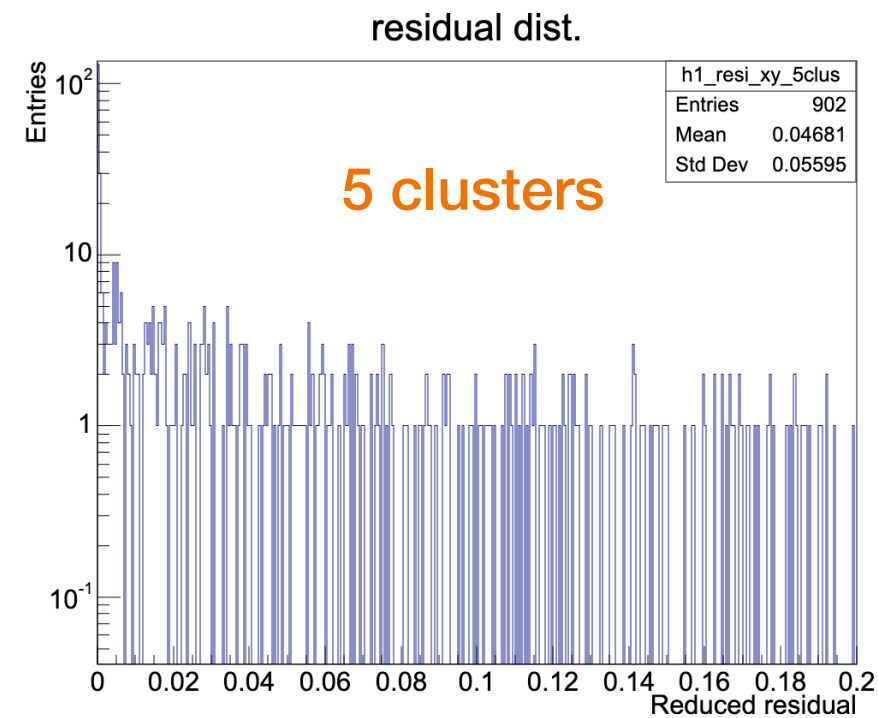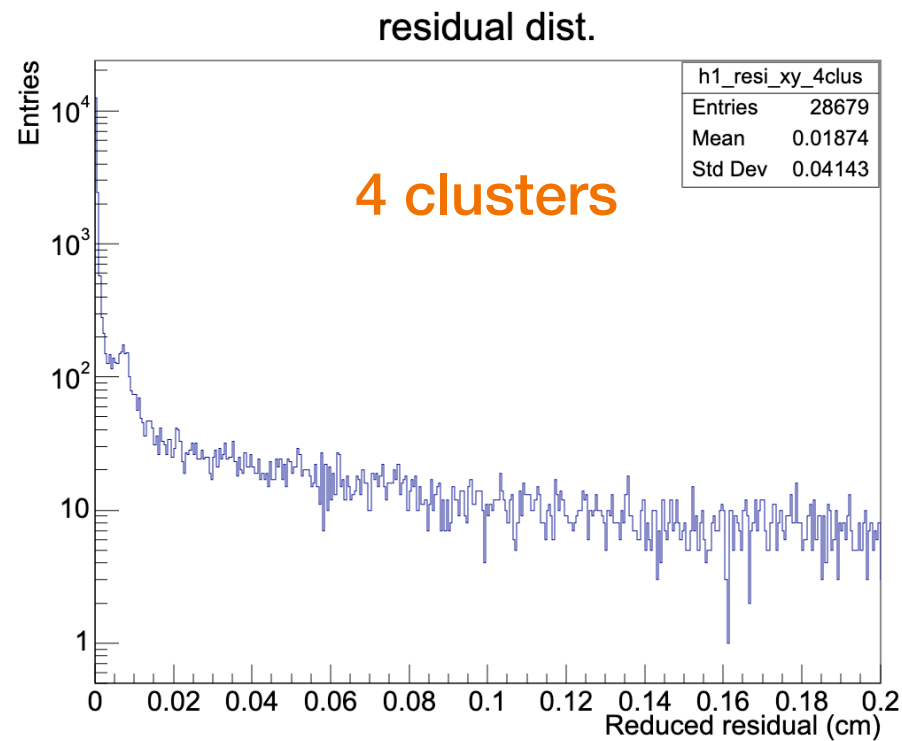
Reduced residual overlap

- No significant differences between the distributions of the clusters.

Reduced residual distribution

Event displays for good tracks
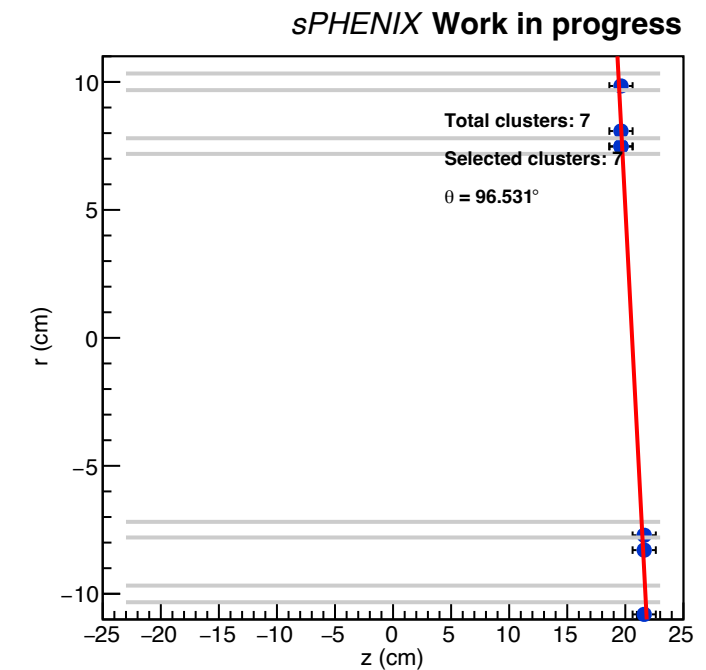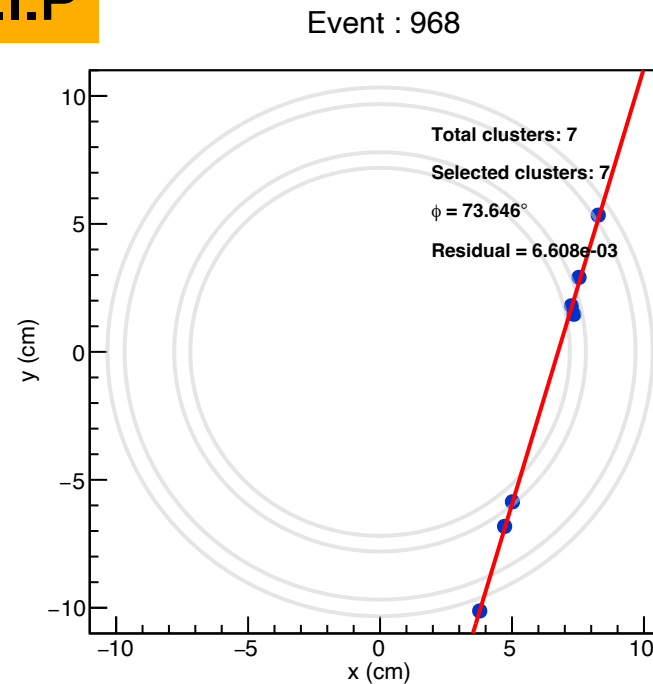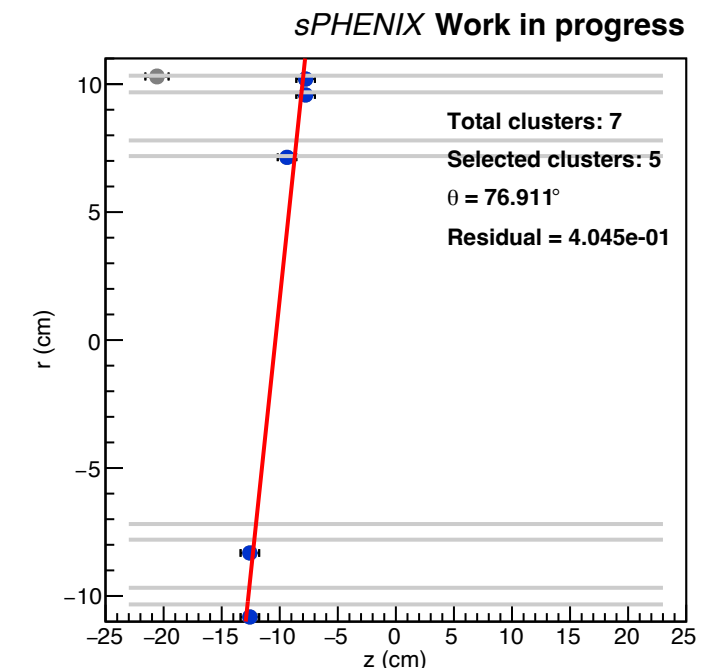
- Good track!

- Reduced residual < 0.02 cm with 5 clusters

Event : 968

Total clusters: 7

Selected clusters: 7

φ = 73.646°

Residual = 6.608e-03

sPHENIX **Work in progress**

Total clusters: 7

Selected clusters: 7

θ = 96.531°

- Good track!

- Reduced residual < 0.02 cm with 5 clusters (2 noise hits excluded)

x vs y Event : Event : 968 (Combination 0)

∠_zy= 99.823°

Residual = 0.000e+00

Total clusters: 7

Selected clusters: 5

φ = 78.068°

Residual = 6.608e-05

sPHENIX **Work in progress**

∠_zx = 120.660°

Residual = 0.000e+00

Total clusters: 7

Selected clusters: 5

θ = 76.911°

Residual = 4.045e-01
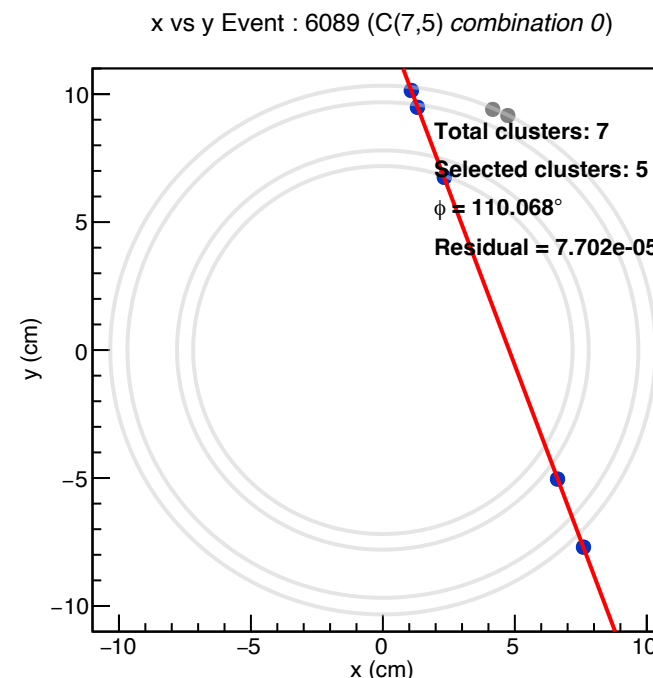
of clusters in a good track

- Reconstruction efficiency : $\frac{Good\ tracks}{Total\ events} = \frac{30K}{4200K} = 0.7\,\%$

  - $4\ clusters/total\ good\ clusters = 85\,\%$

  - $5\ clusters/total\ good\ clusters = 13\,\%$

  - $6\ clusters/total\ good\ clusters = 1.5\,\%$

  - $6\ clusters/total\ good\ clusters = 0.5\,\%$

sPHENIX Work in progress

Entries

Request W.I.P

# of Clusters in a good event
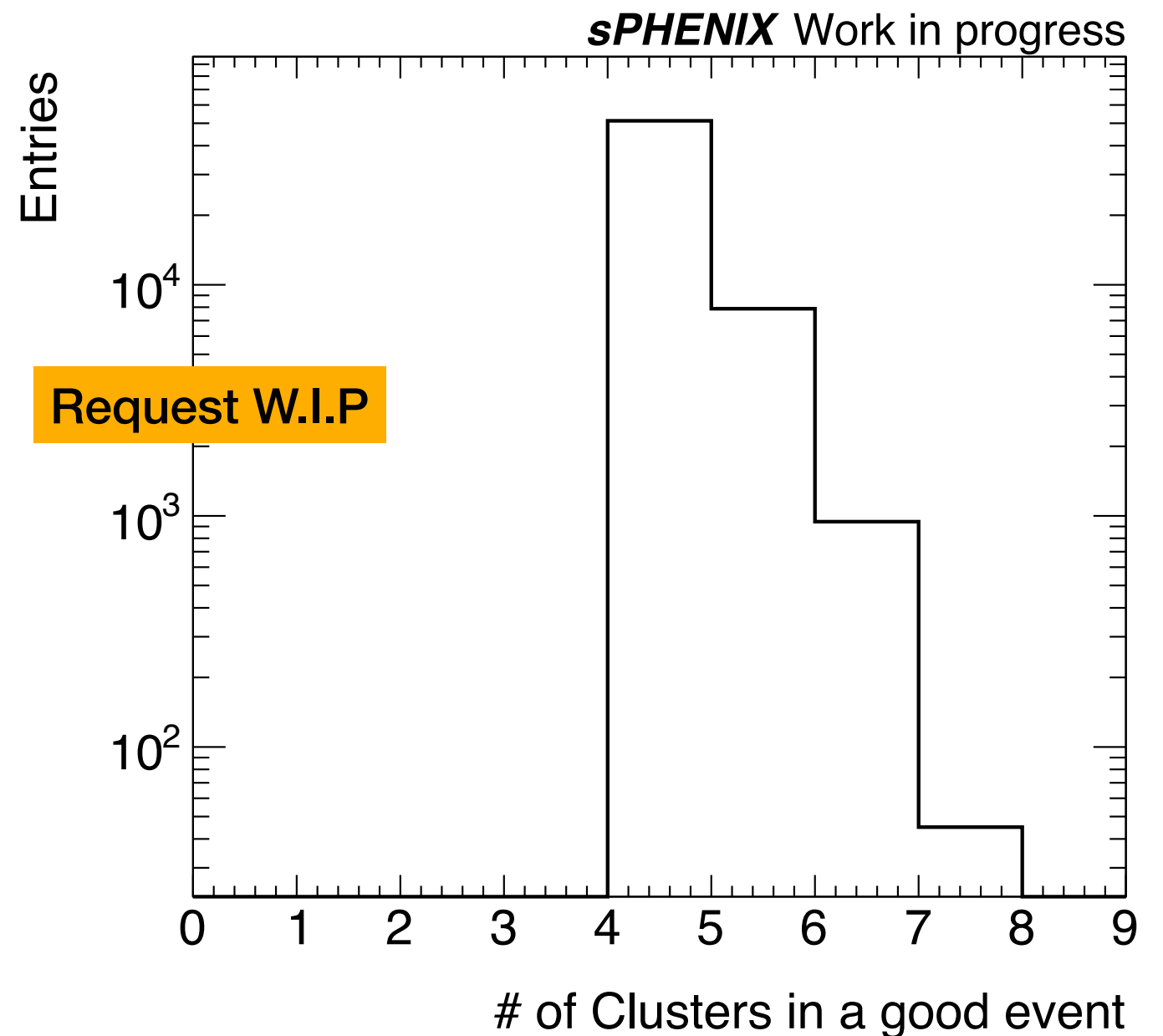
Angle distribution
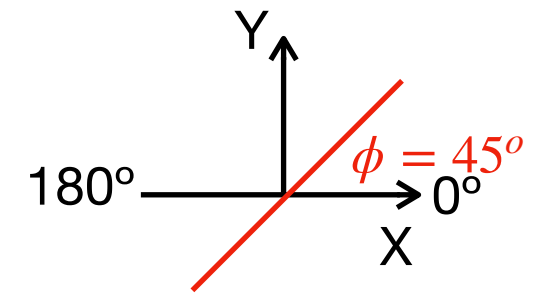
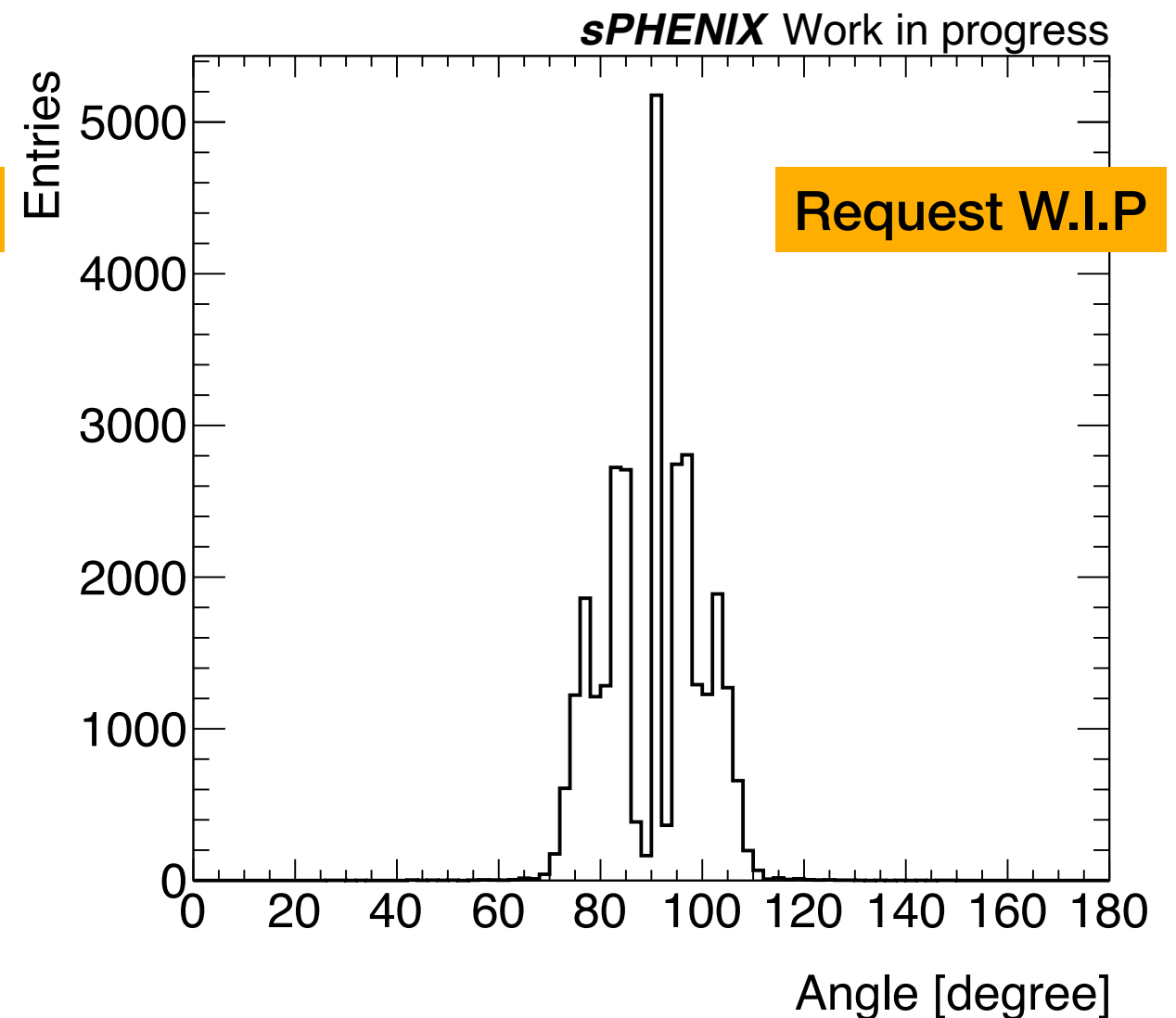- The distribution of the ϕ angle (in X-Y plane) and θ angle (in Z-Radius plane).

- X-Y residual < 0.02cm, full cluster coverage of the fitting line in Z-Radius plane.

ϕ angle distribution in xy plane
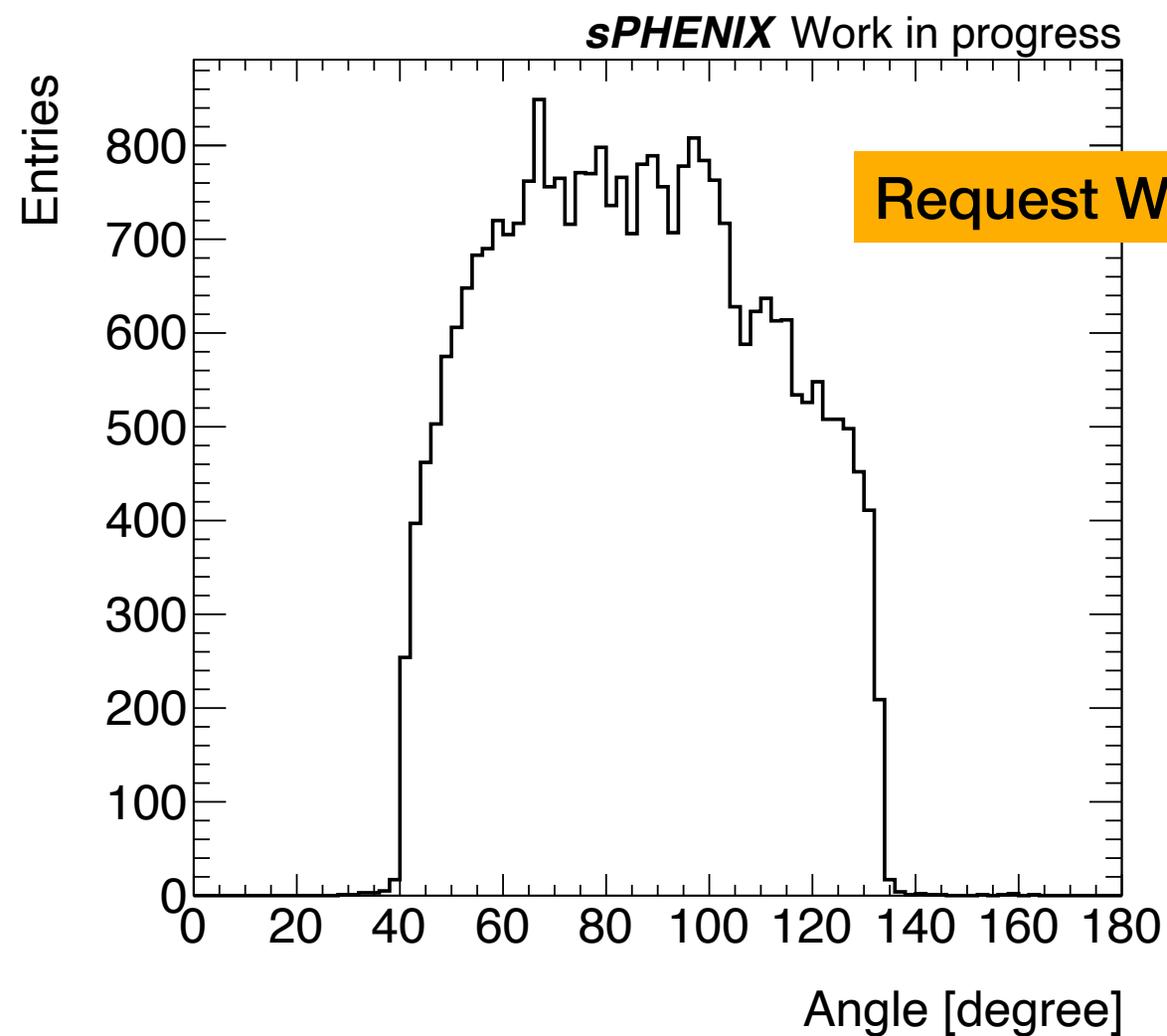
θ angle distribution in zr plane

Summary

- Roughly 25 runs from 2024 cosmic data is analyzed.

  - INTTRawHit DSTs are from official production.

  - INTTTrkrCluster DSTs are from private production using Fun4All framework.

  - Good cluster required.

  - Two different approaches are performed to this analysis.

- Look into the distribution of cluster size, cluster Adc and total clusters.

  - Compare the distribution before and after the cluster cut

    -> Those distributions seem to be normal.

- Residual distribution:

  - Distinguish good clusters with reduced residual smaller than 0.02cm.

  - Event displays support the choice of reduced residual cut.

- Angle distributions are presented.

Back up

Residual distribution check

- The cosmic tracks are fitted with a straight line, $y = c + mx$

- Residual distribution of the tracks. (instead of χ^2/ndf distribution)

- Because the cosmic tracks mostly come from vertically, calculating the residual by perpendicular way is a better method.
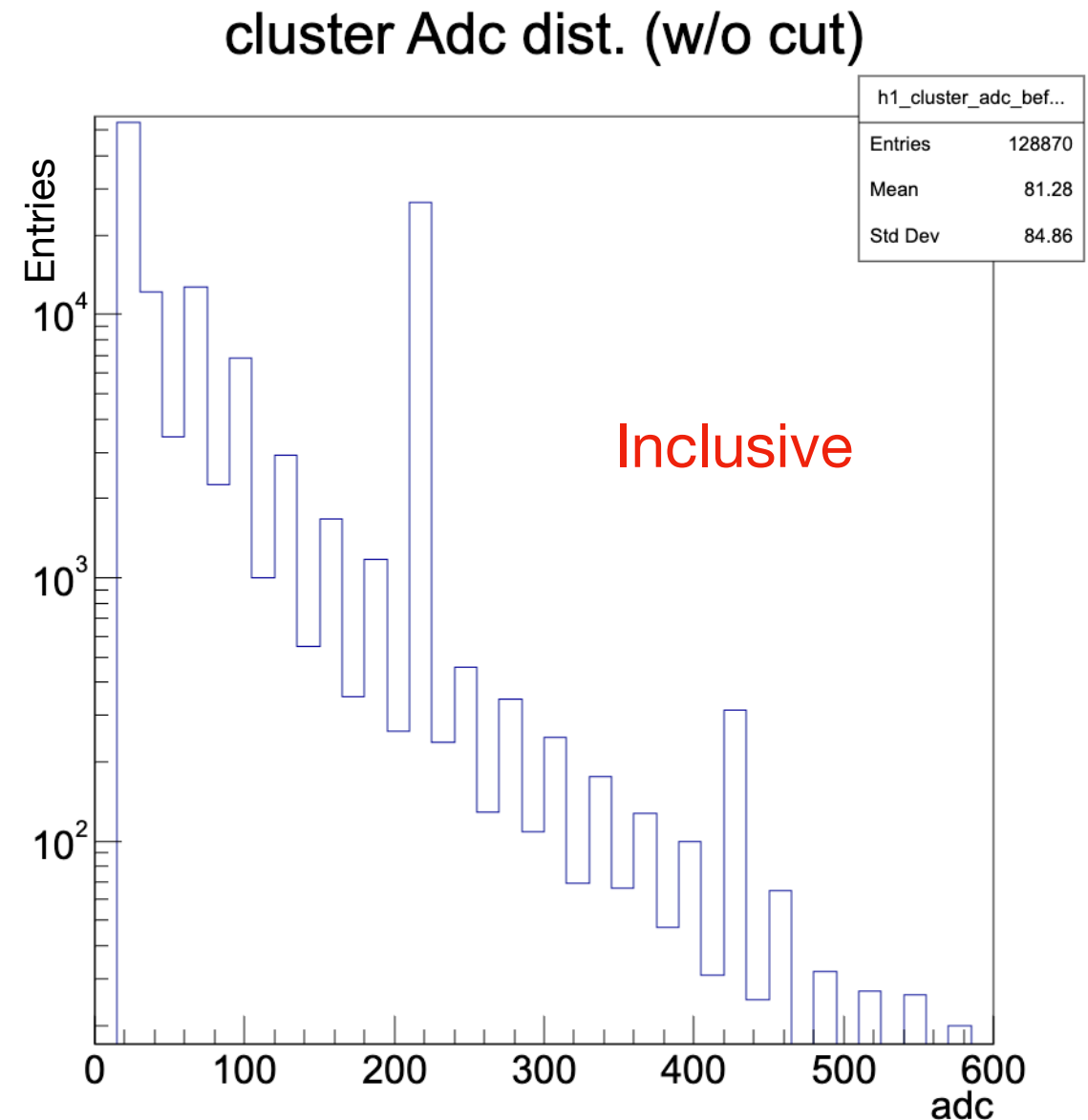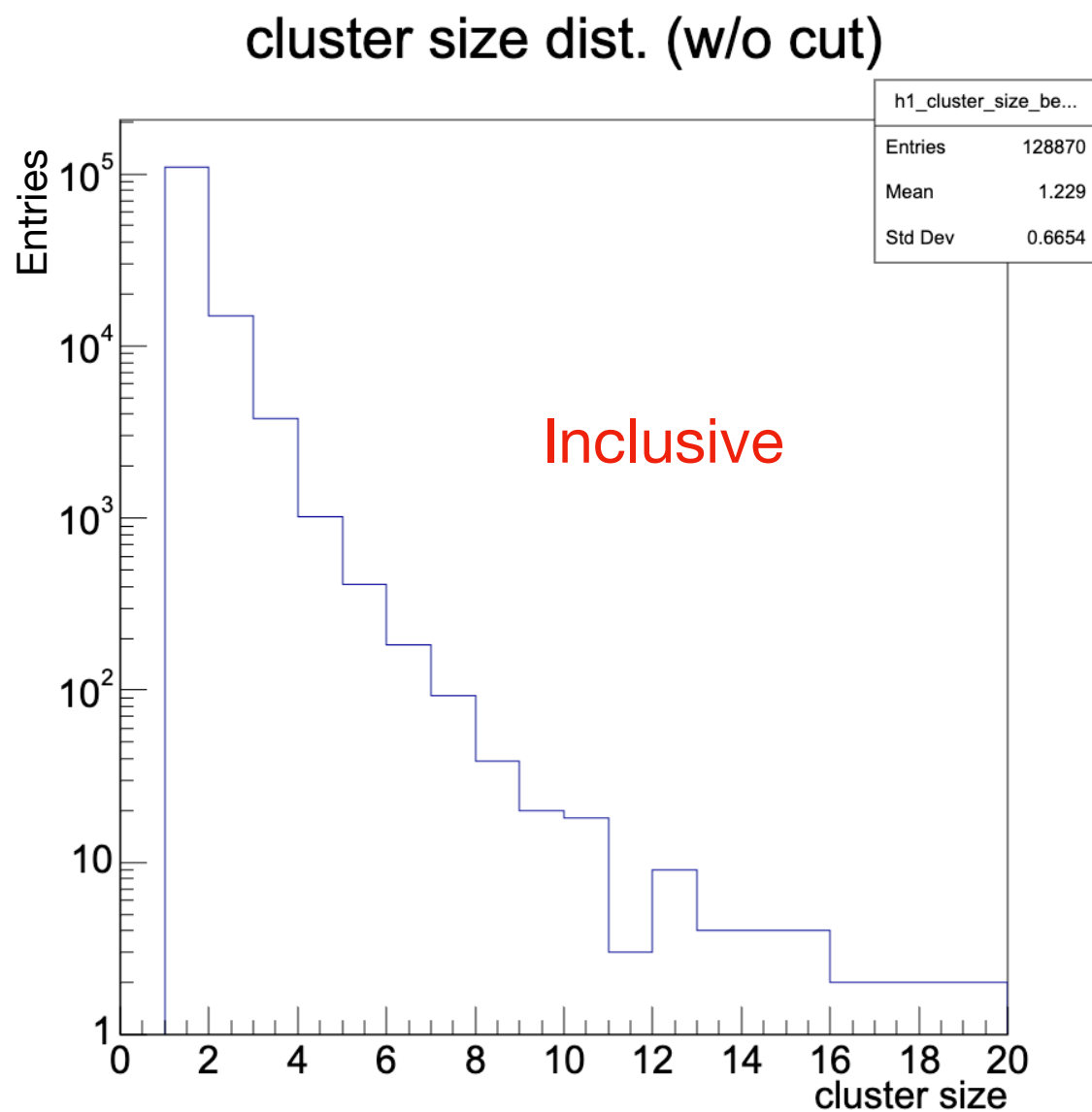
χ^2/ndf Residual

Vertical offsets   Perpendicular offsets
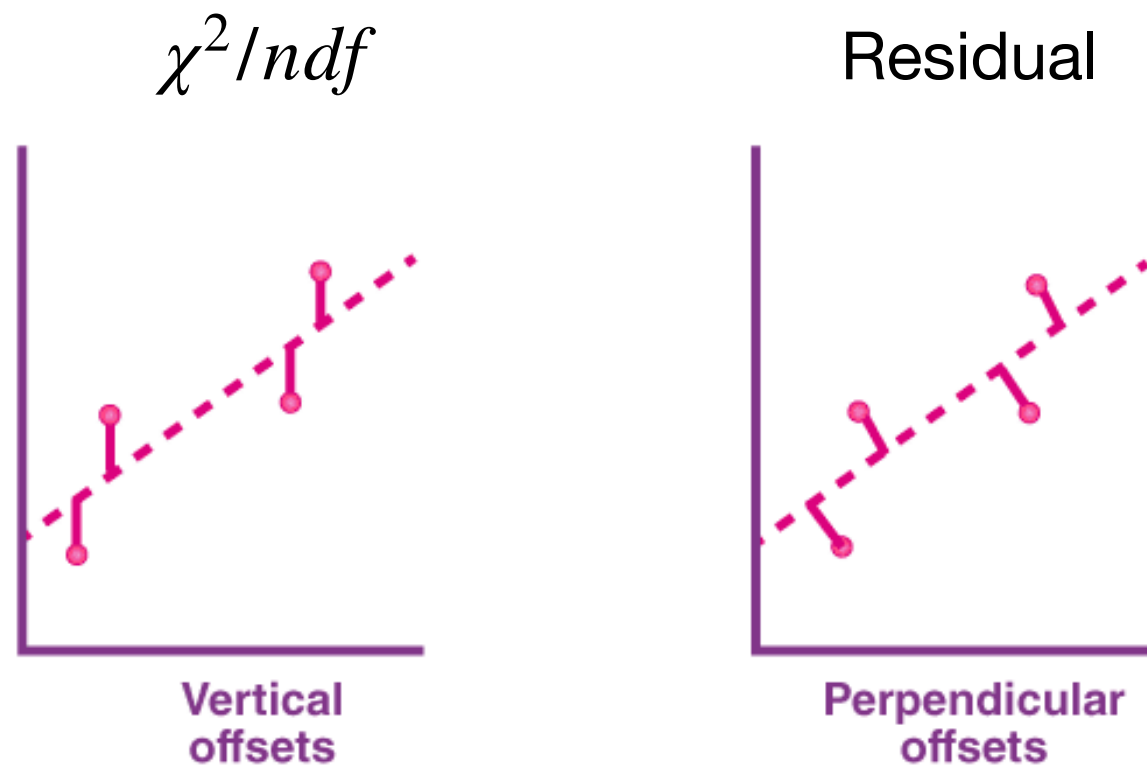
Residual distribution check

- There are some events are not only have 4 clusters, but even more.

- There are combinations of clusters $C(n, k)$ for those events.

- For the tracks that have more than 4 clusters, if the residual of them is similar or close to ones with 4 clusters, they may can be accepted.
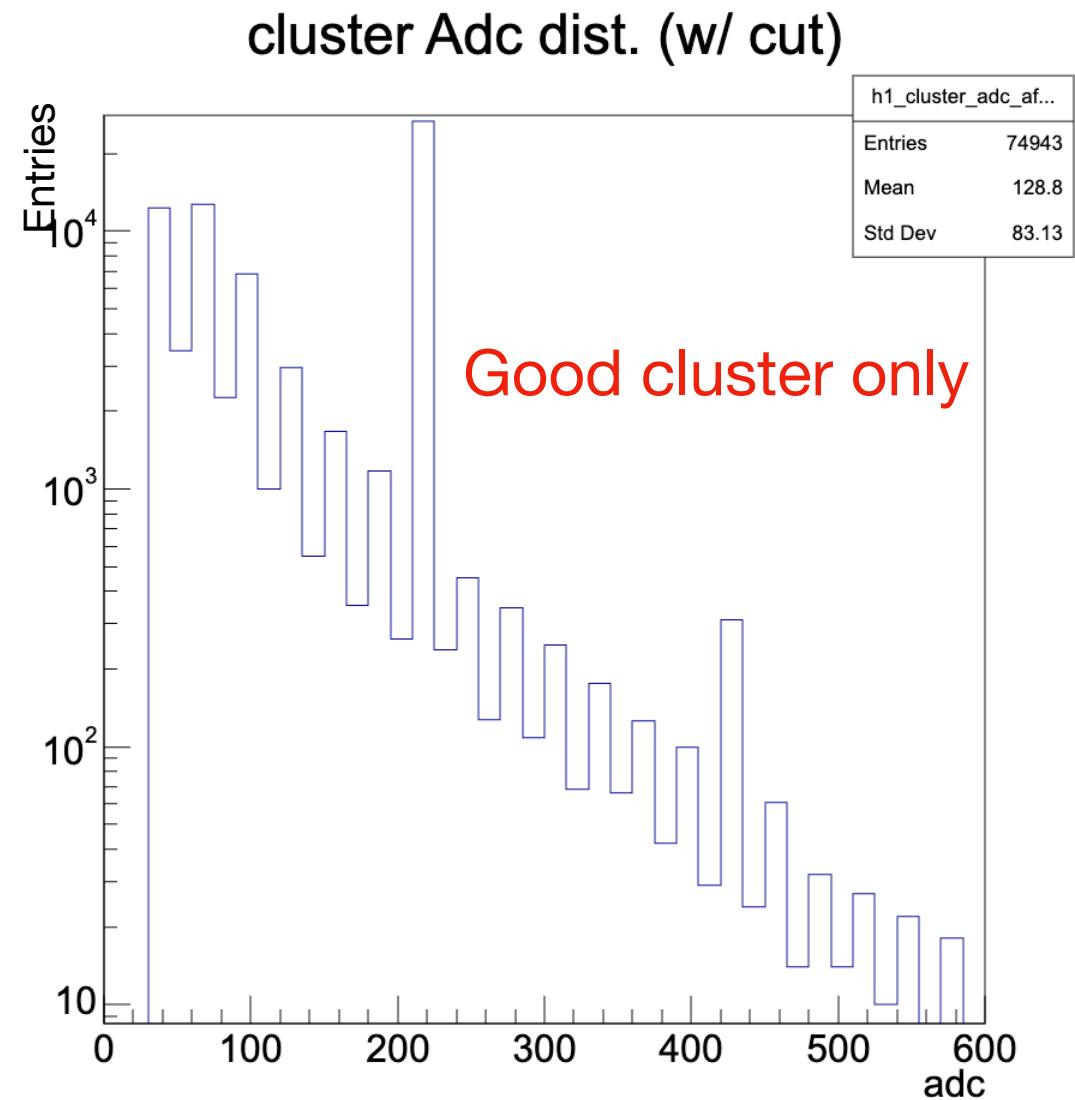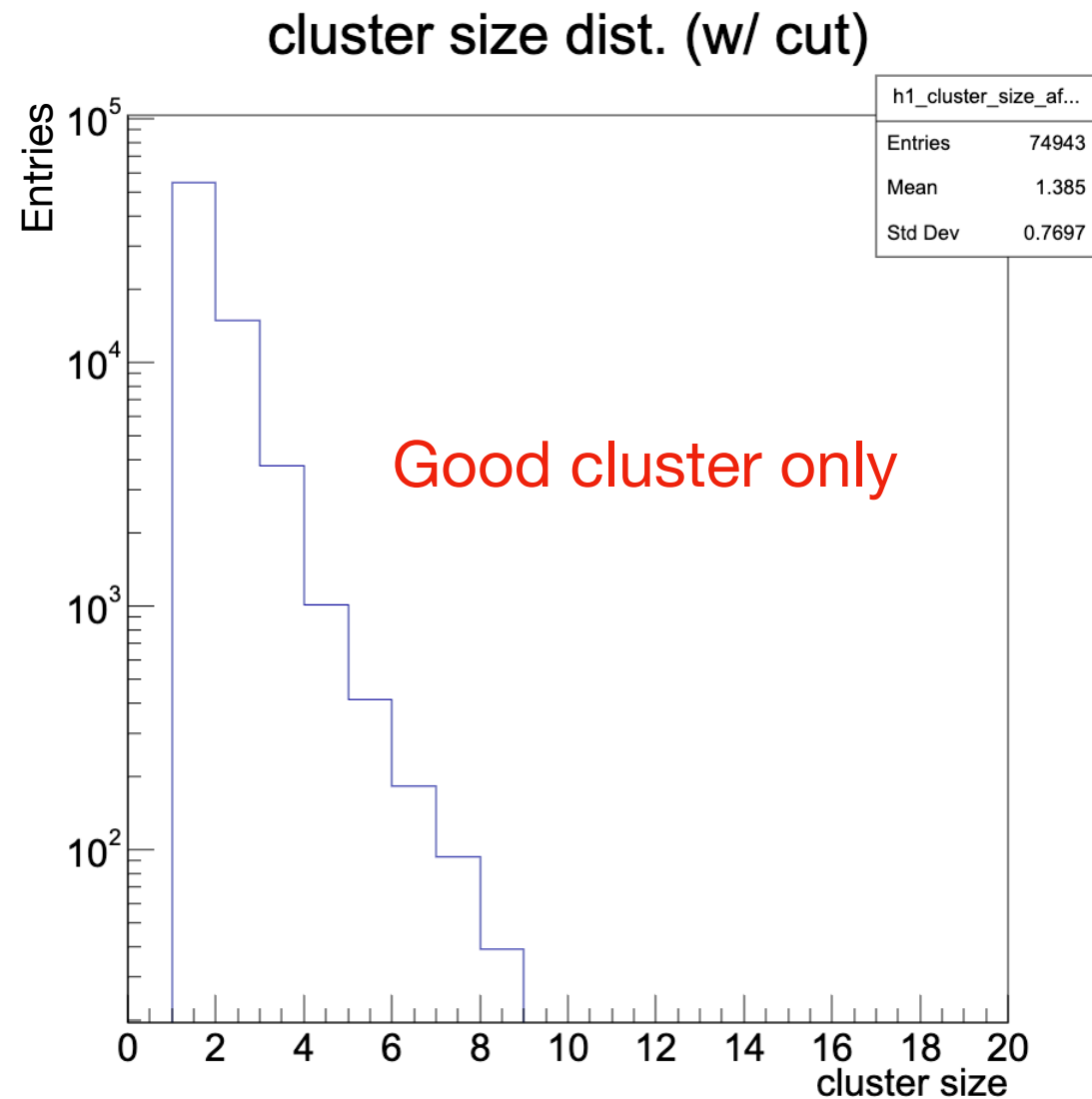
$C(6,4)$
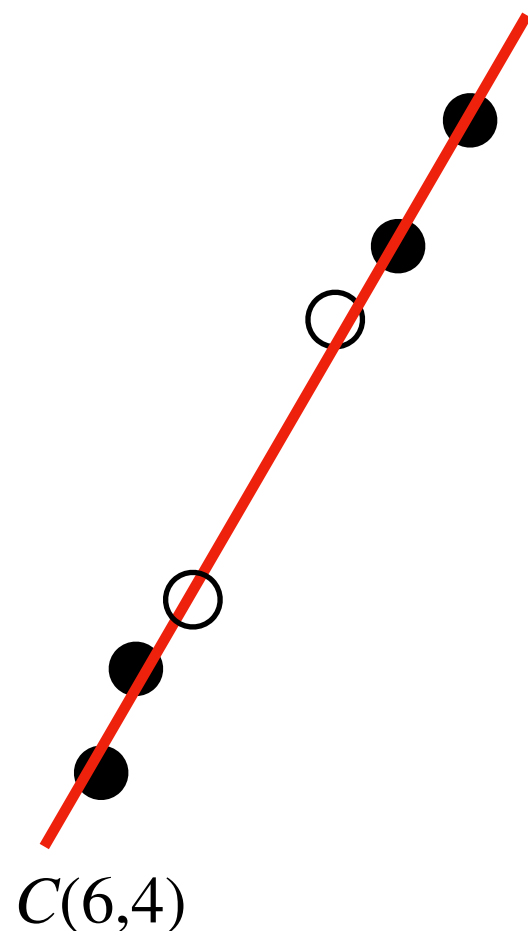
Run data check

- Without cluster cut:

  - Left: Cluster size distribution

  - Right: Cluster adc distribution

cluster size dist. (w/o cut)

h1_cluster_size_be...	
Entries	128870
Mean	1.229
Std Dev	0.6654

Inclusive

cluster Adc dist. (w/o cut)

h1_cluster_adc_bef...	
Entries	128870
Mean	81.28
Std Dev	84.86

Inclusive

Run data check

- Pre-selection comparison:
  - Left: Cluster size distribution
 - Right: Cluster adc distribution

cluster size dist. (w/ cut)

h1_cluster_size_af...	
Entries	74943
Mean	1.385
Std Dev	0.7697

Good cluster only

cluster Adc dist. (w/ cut)

h1_cluster_adc_af...	
Entries	74943
Mean	128.8
Std Dev	83.13

Good cluster only

Cosmic tracks event displays

Total clusters = 4, selected clusters = 4
Residual xy = 0.0046, residual zr = 0.0497

Total clusters = 7, selected clusters = 5
Residual xy = 0.0017, residual zr = 0.2849
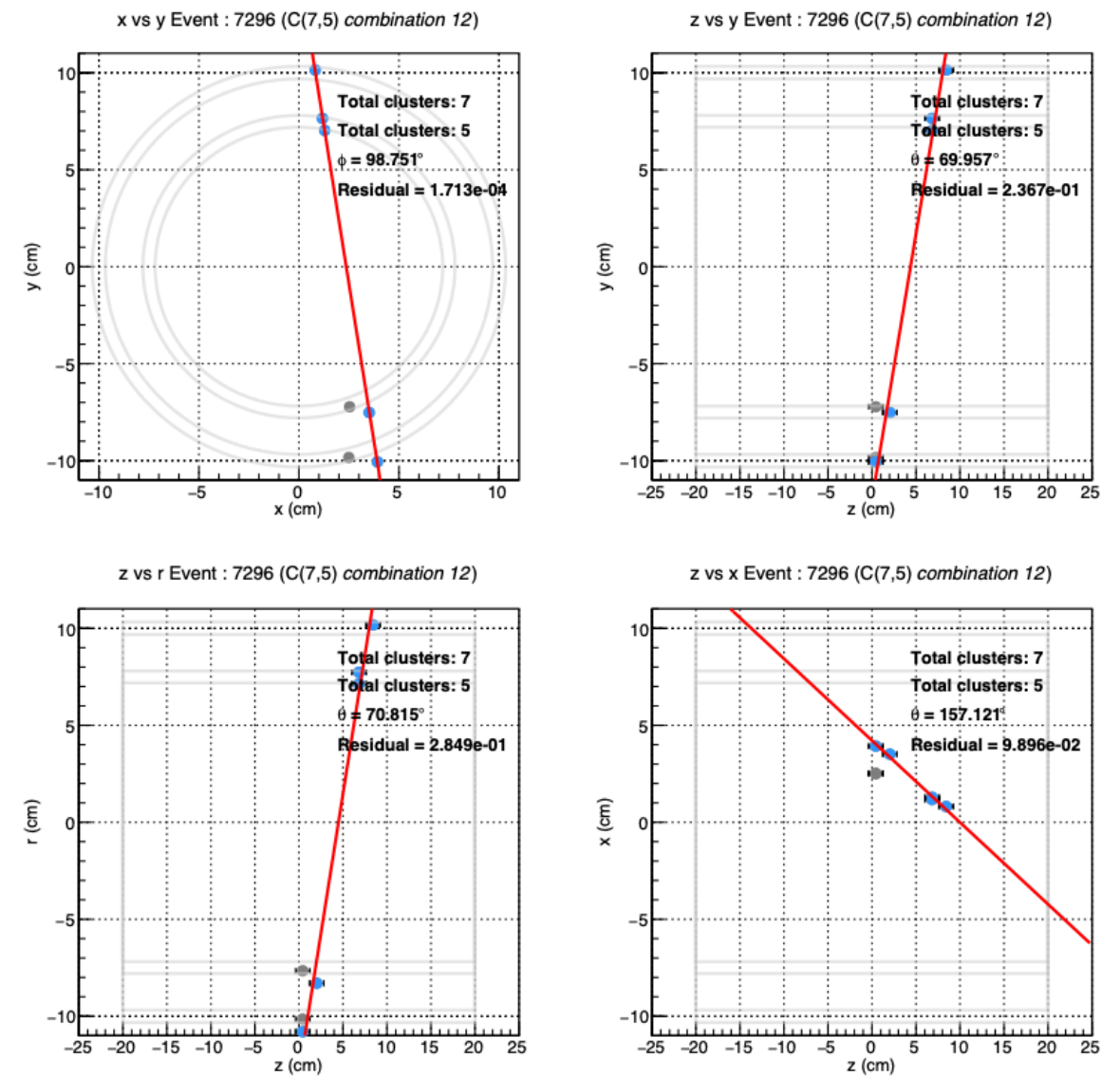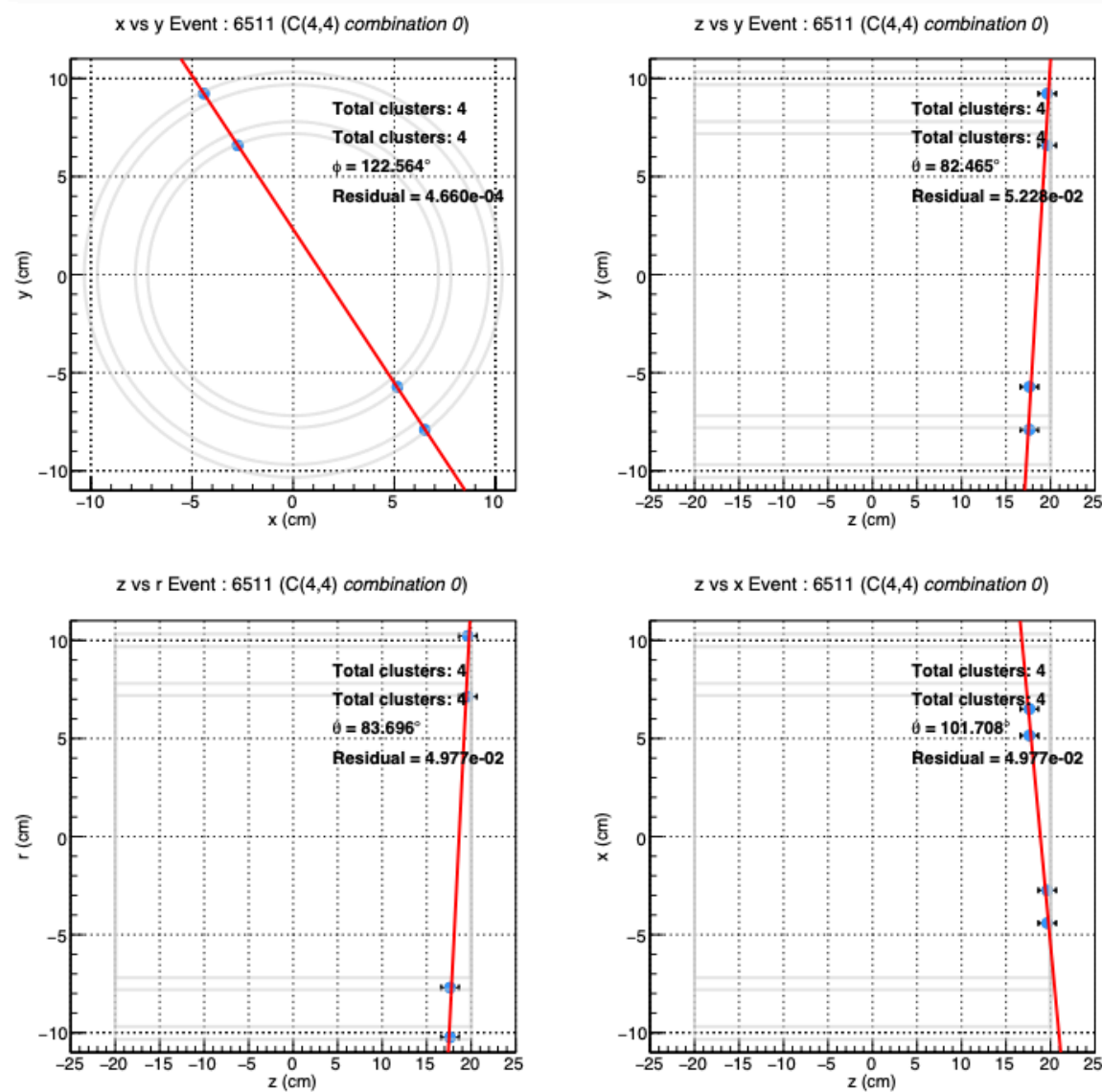
Fitting quality check

- The reduced residual distribution in **zr plane**.

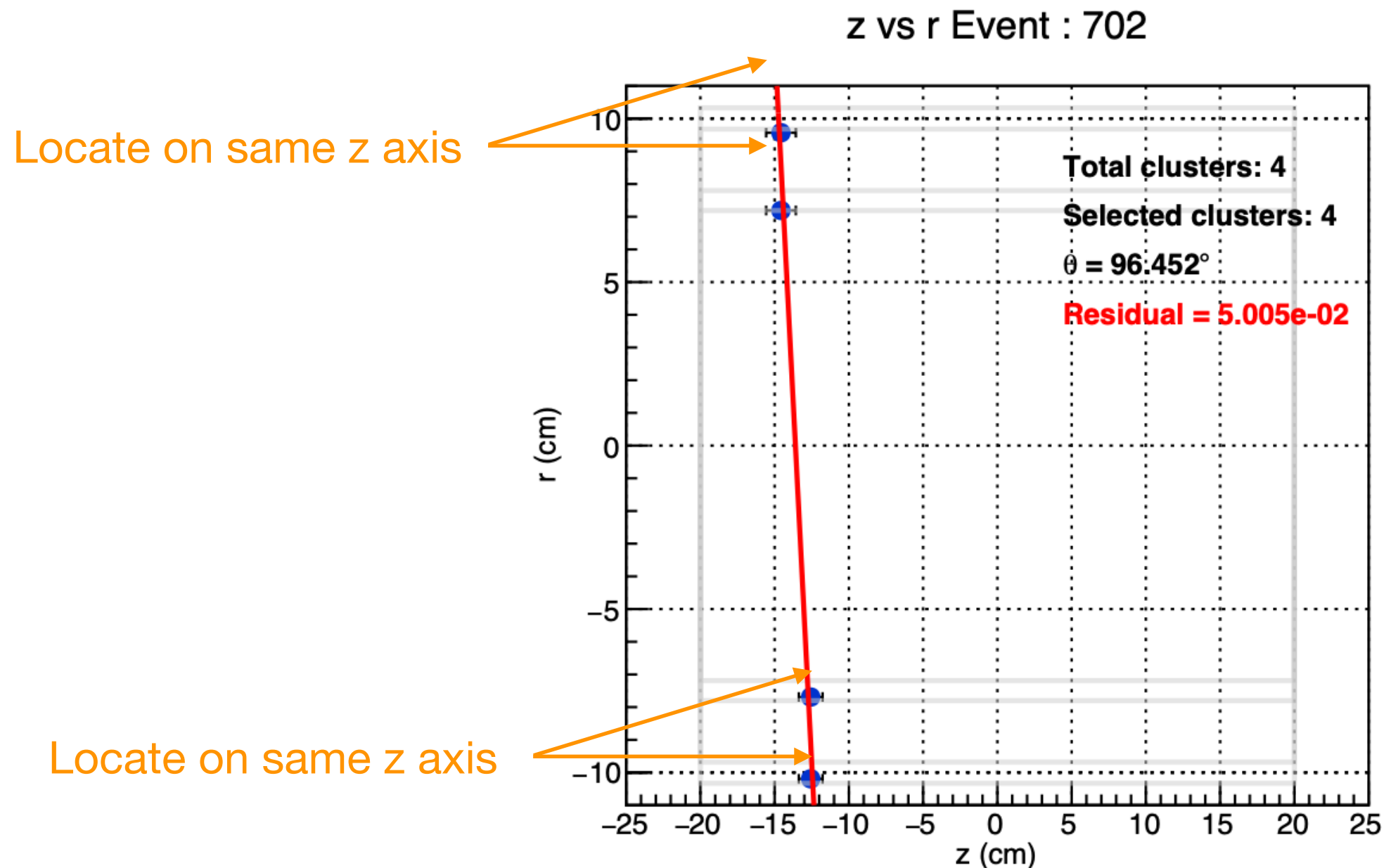- Selected the tracks whose reduced residual is smaller than 0.1 as a good track.
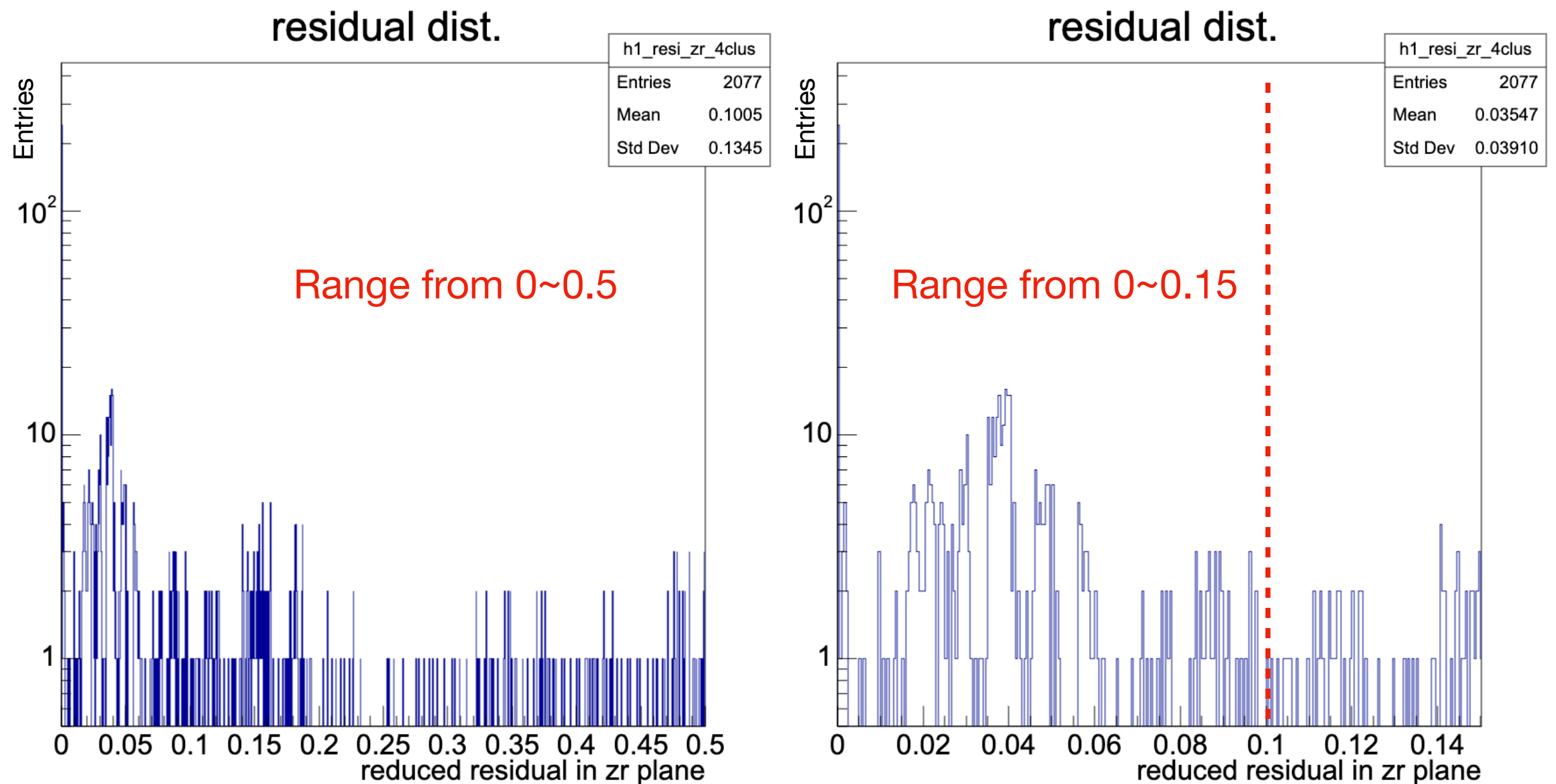
Fitting quality check (multi runs)

- The reduced residual distribution in **zr plane**.

- More peaks appear in zr residual distribution in combined run.

residual dist. (Single run)

residual dist. (Combined run)
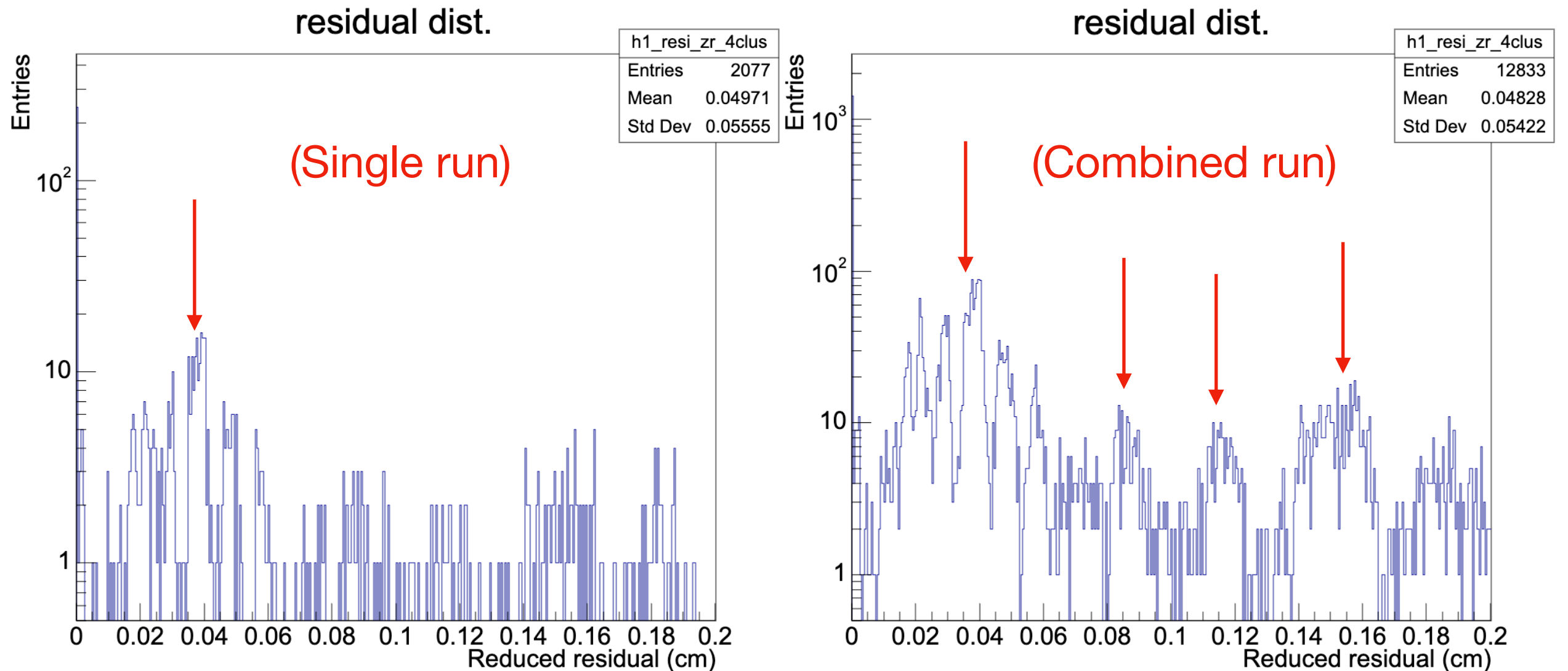
Run data check

- The event displays show that there is a pattern among those events.

- There is a z axis shift between upper hand clusters and lower hand clusters.

- The angle of these event is fix around 96° and 84°.

z vs r Event : 702

Total clusters: 4
Selected clusters: 4
$\theta = 96.452°$
Residual = 5.005e-02

Locate on same z axis

Locate on same z axis

Event display check

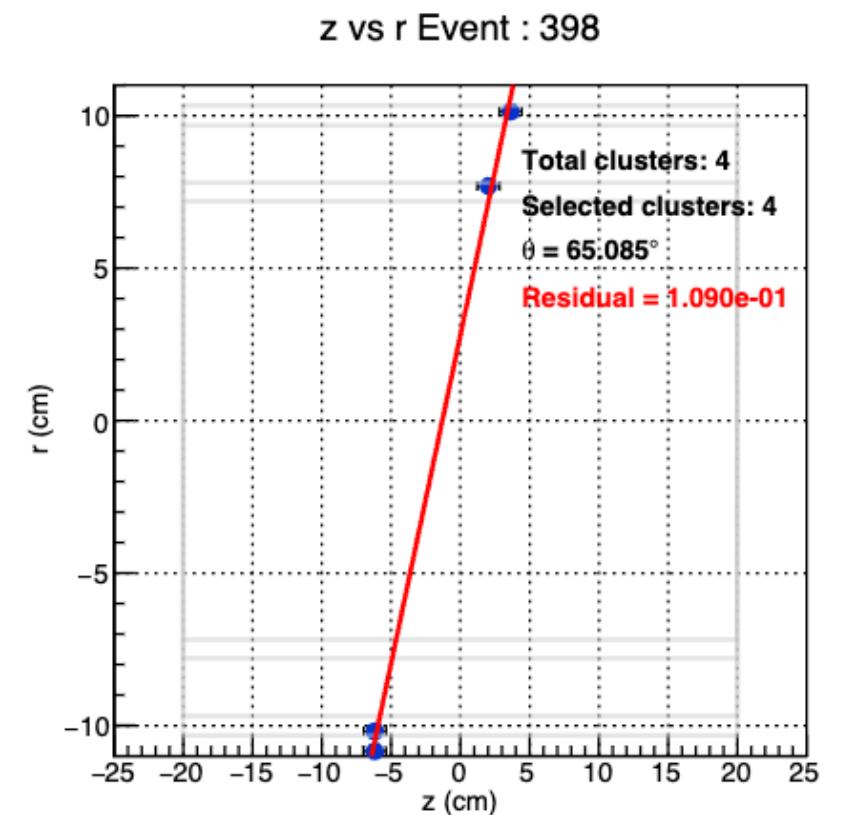- Take a look of event display where zr residual located at **0.02~0.06**.
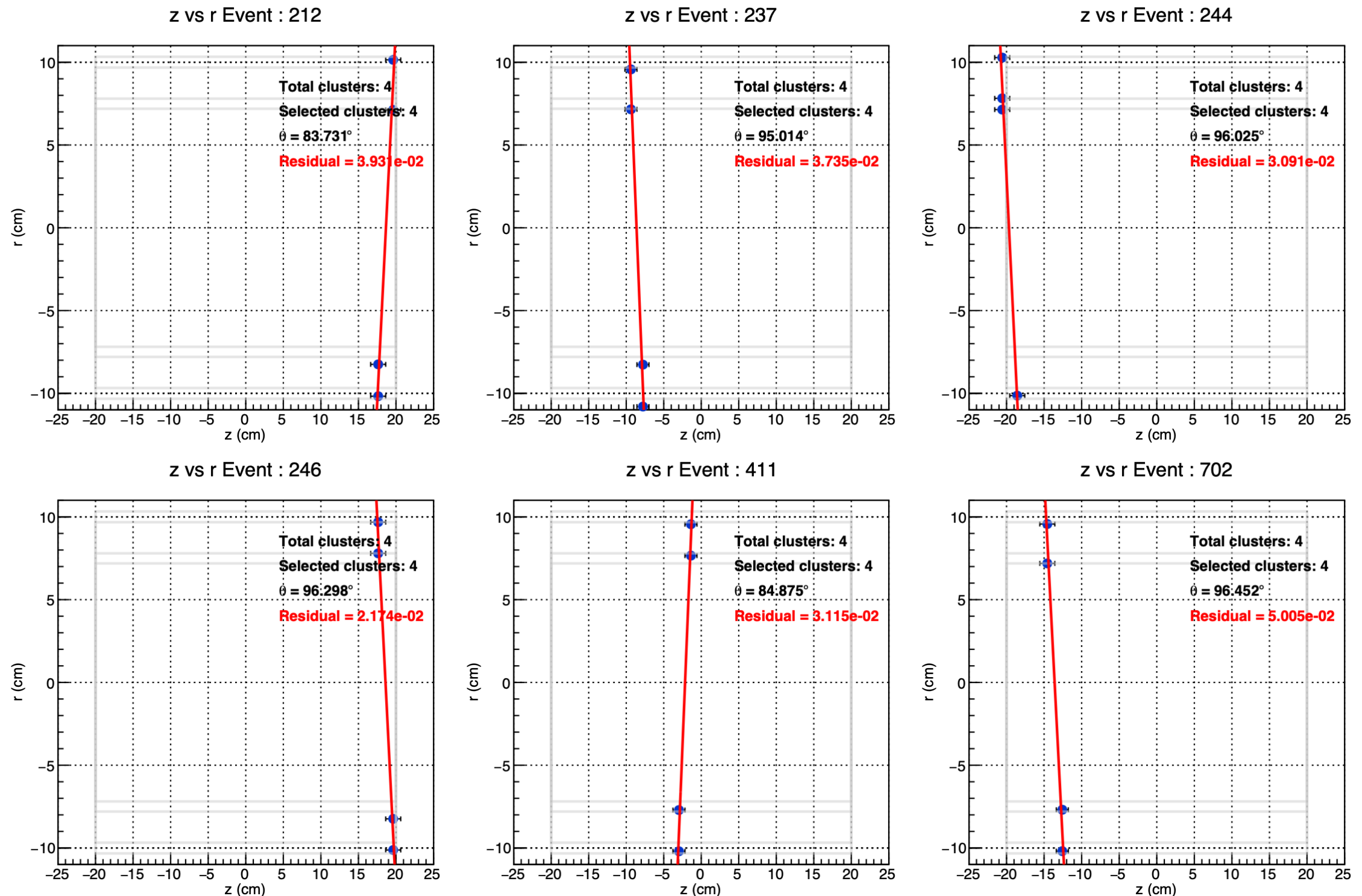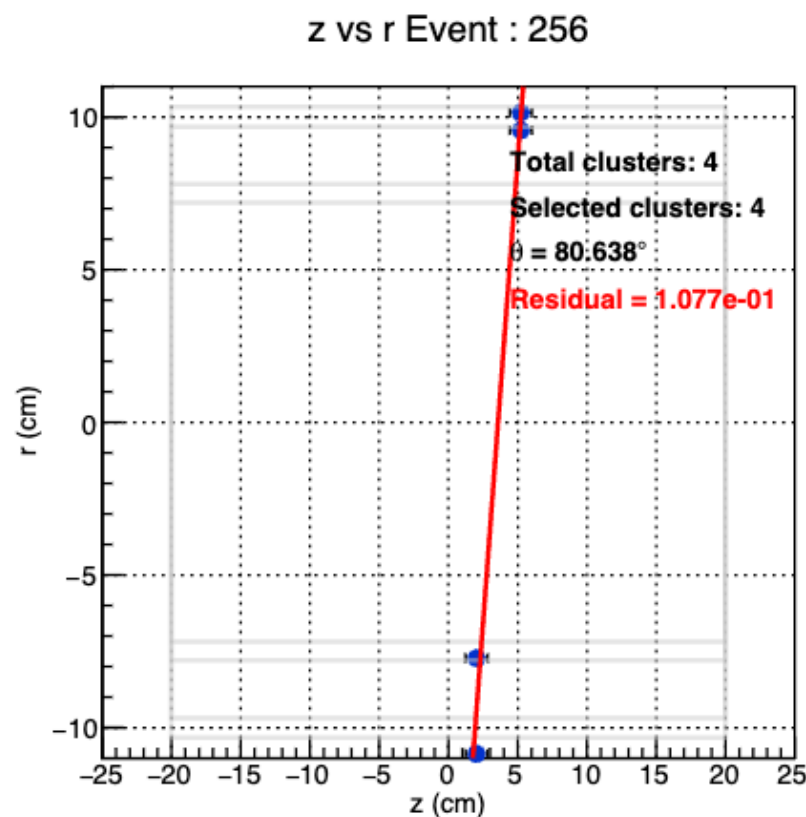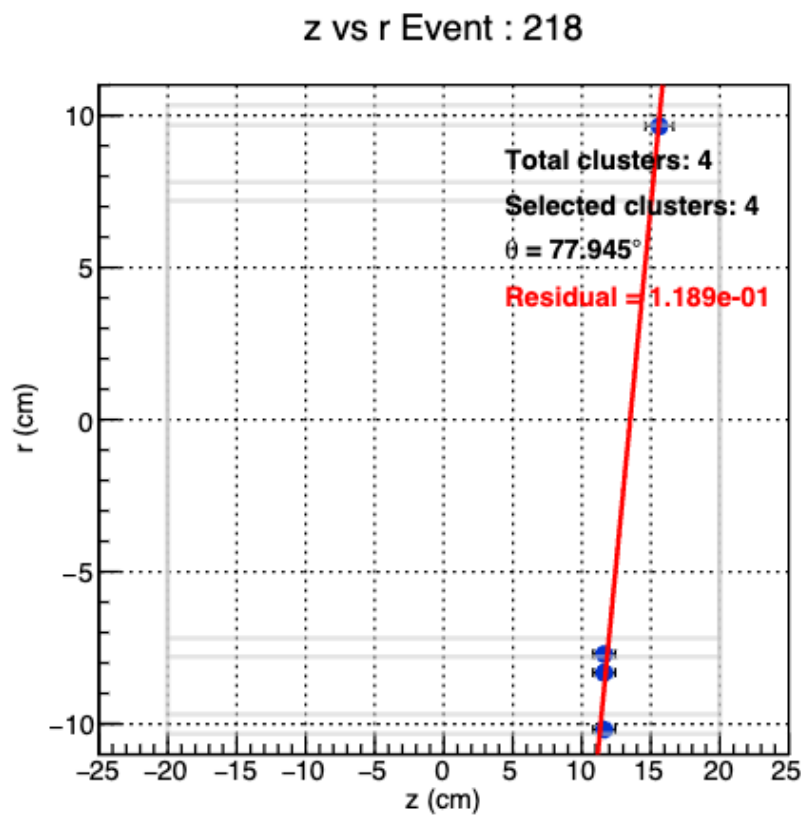
Event display check

- Another look of event display where zr residual located at 0.08~0.1.

- There is a z axis shift between upper hand clusters and lower hand clusters.

  -> The shift is bit larger comparing to the previous event display.
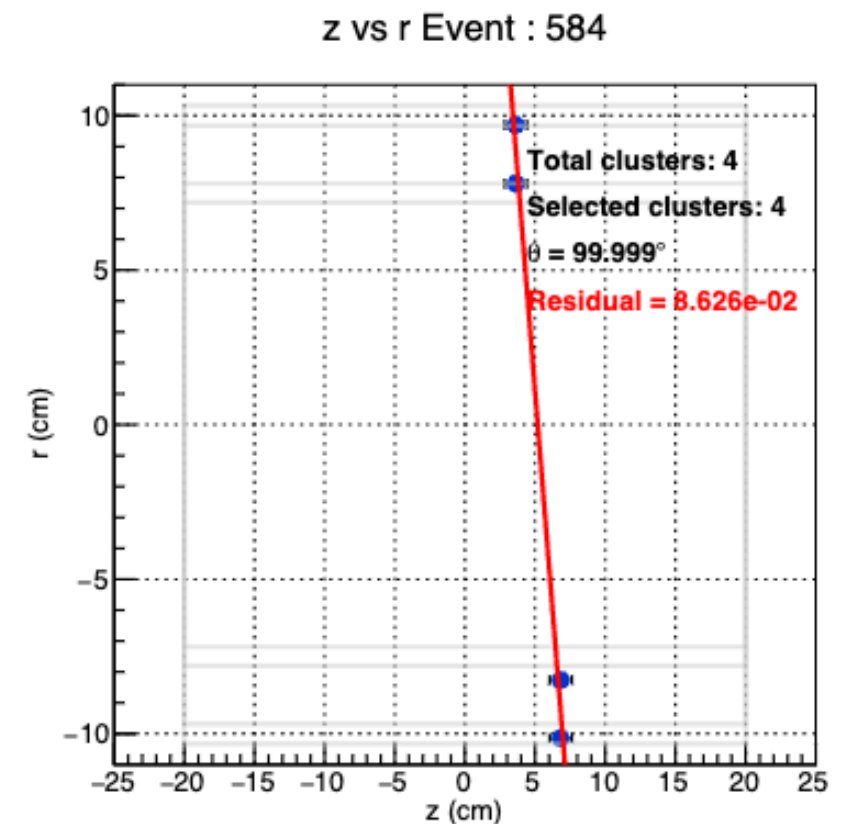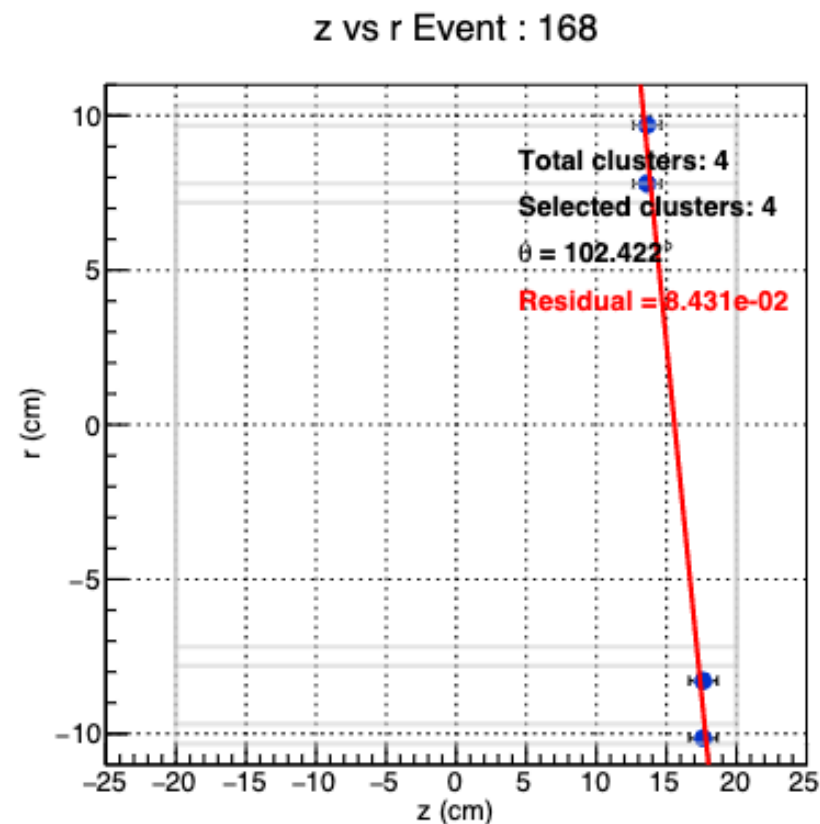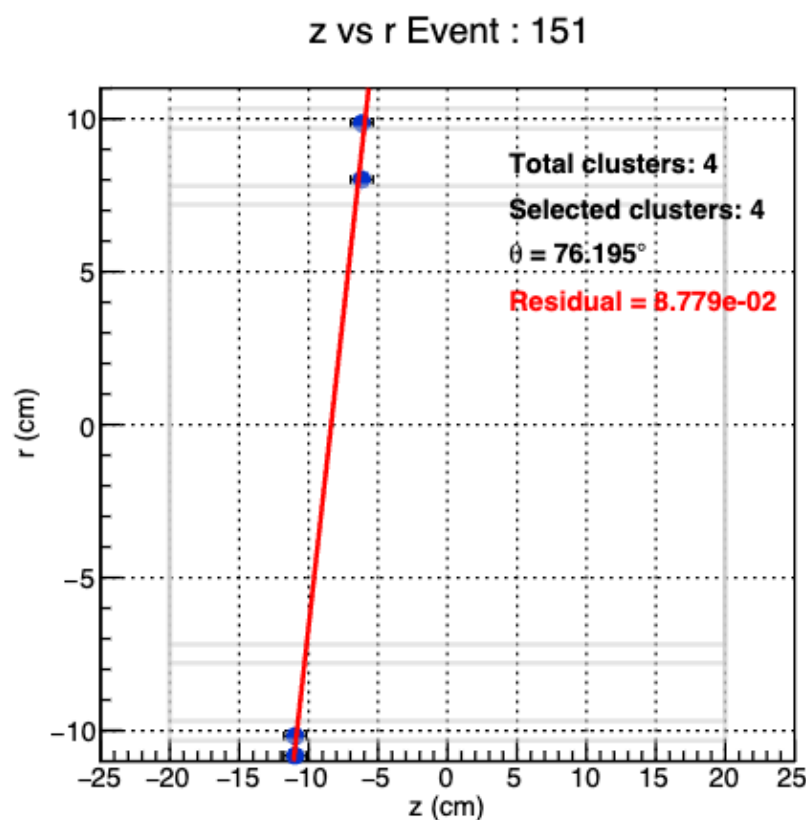
Event display check

- Another look of event display where zr residual located at 0.1~0.12.

- There is a z axis shift between upper hand clusters and lower hand clusters.

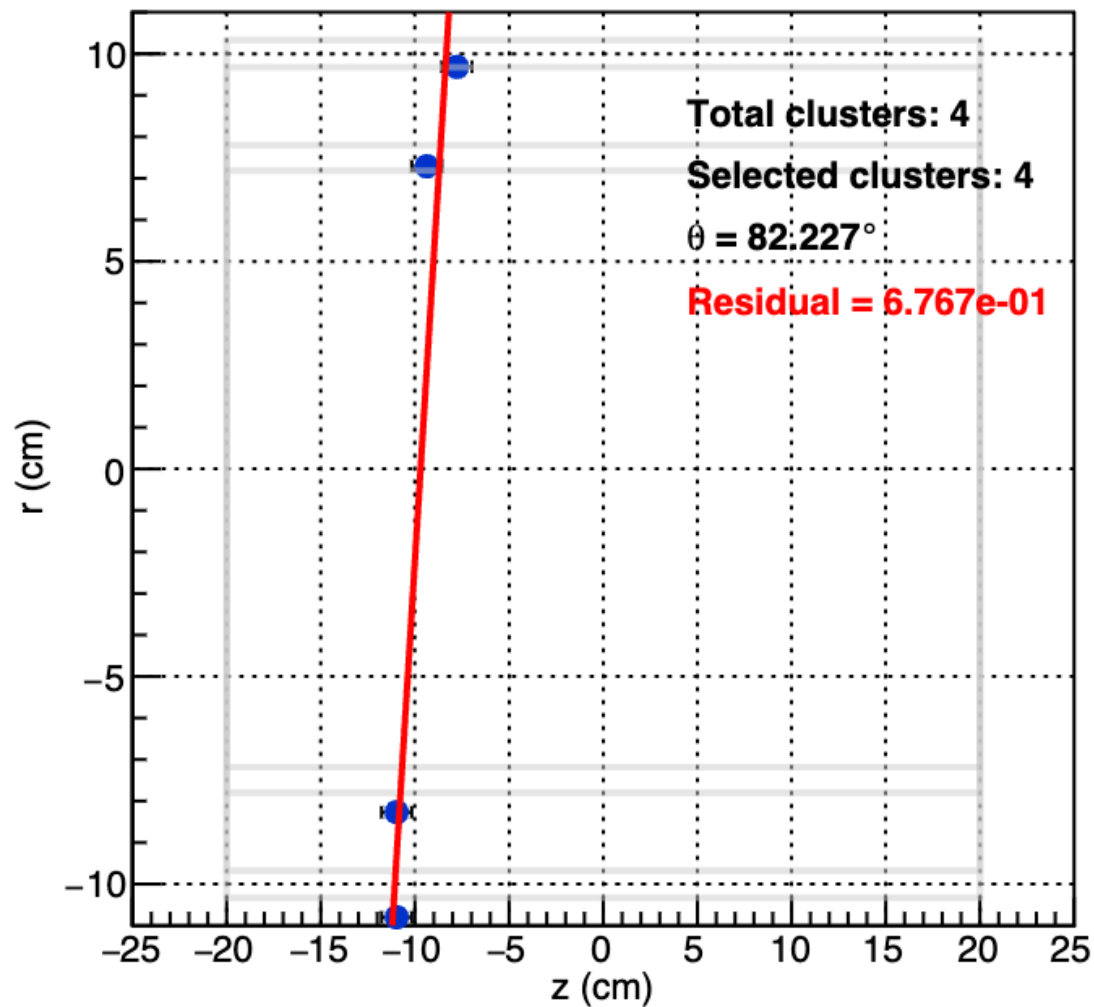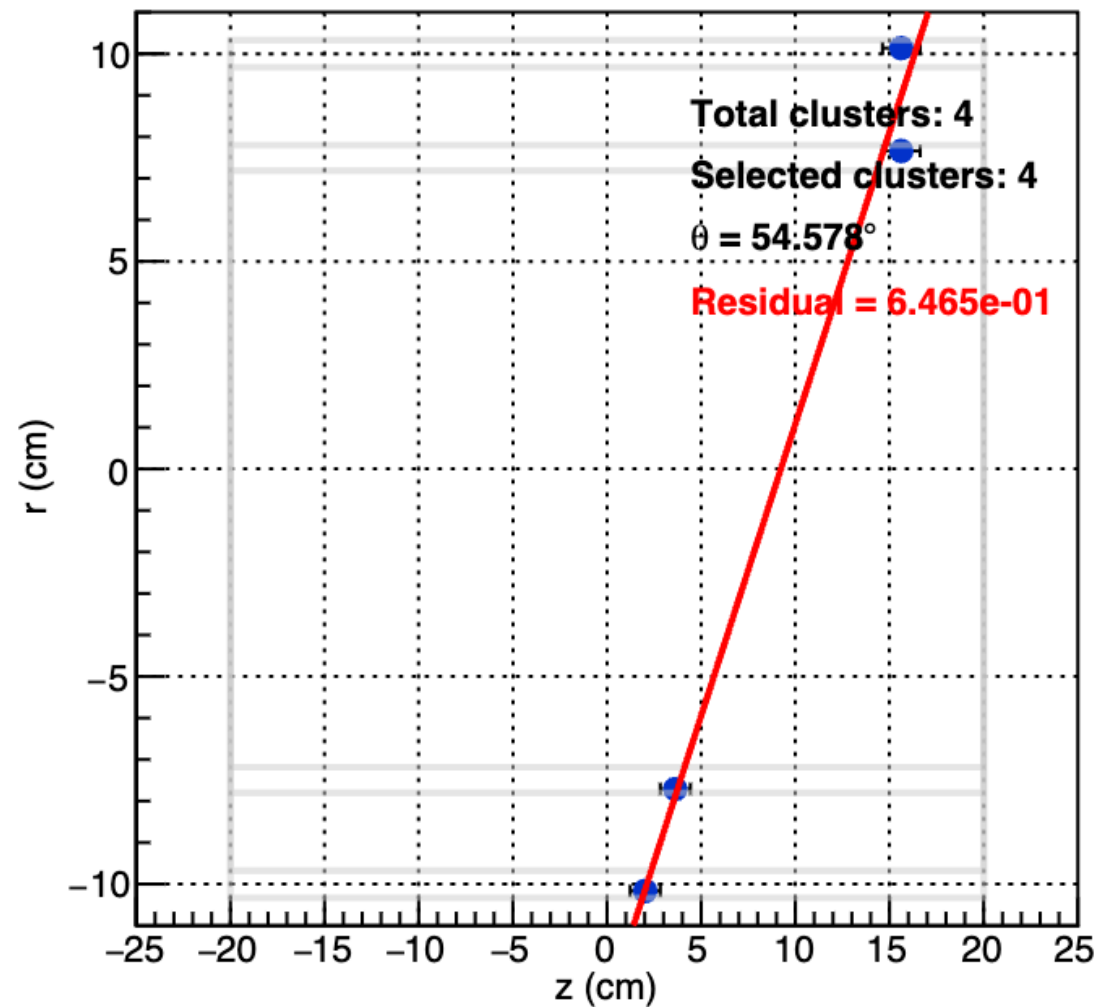 -> Although there is larger residual in zr plane, all the clusters are still within the z acceptance.

Event display check

- Another look of event display where zr residual located at 0.5~1.
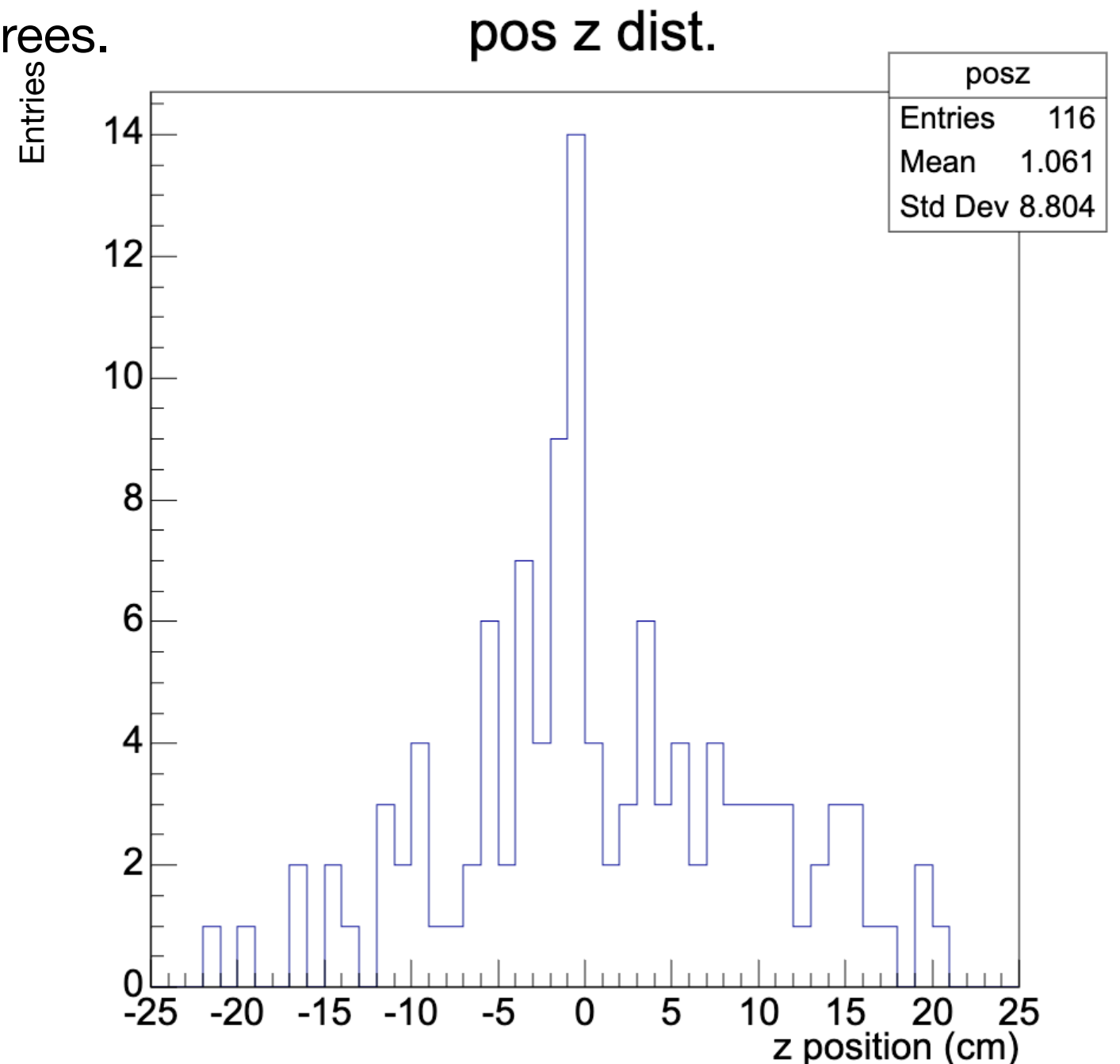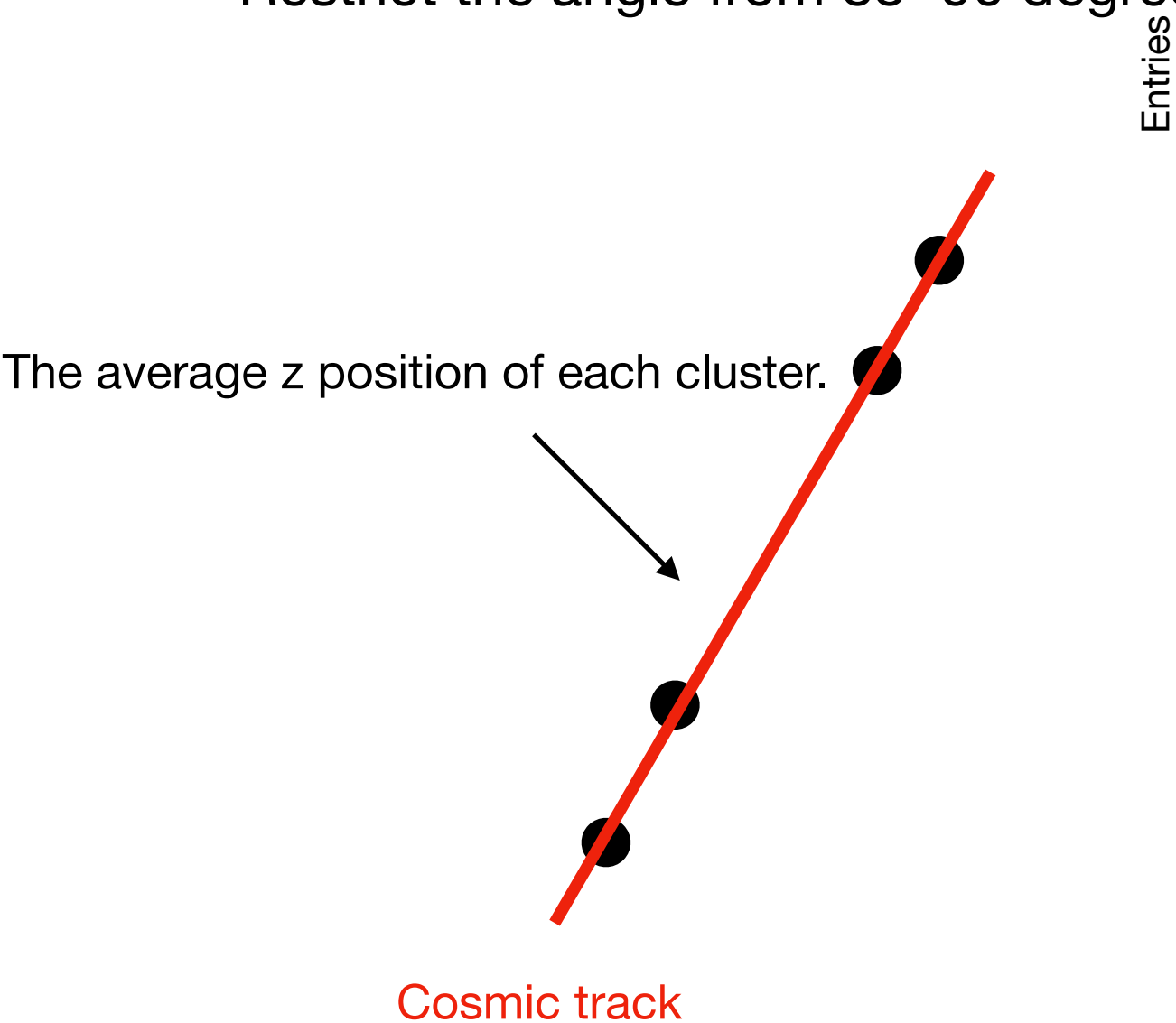

z vs r Event : 20

Total clusters: 4
Selected clusters: 4
θ = 82.227°
Residual = 6.767e-01

z vs r Event : 570

Total clusters: 4
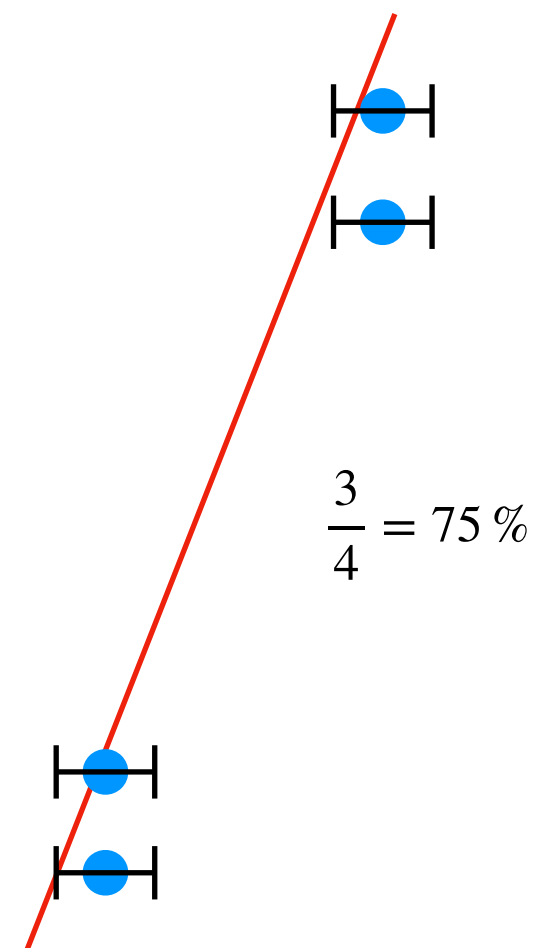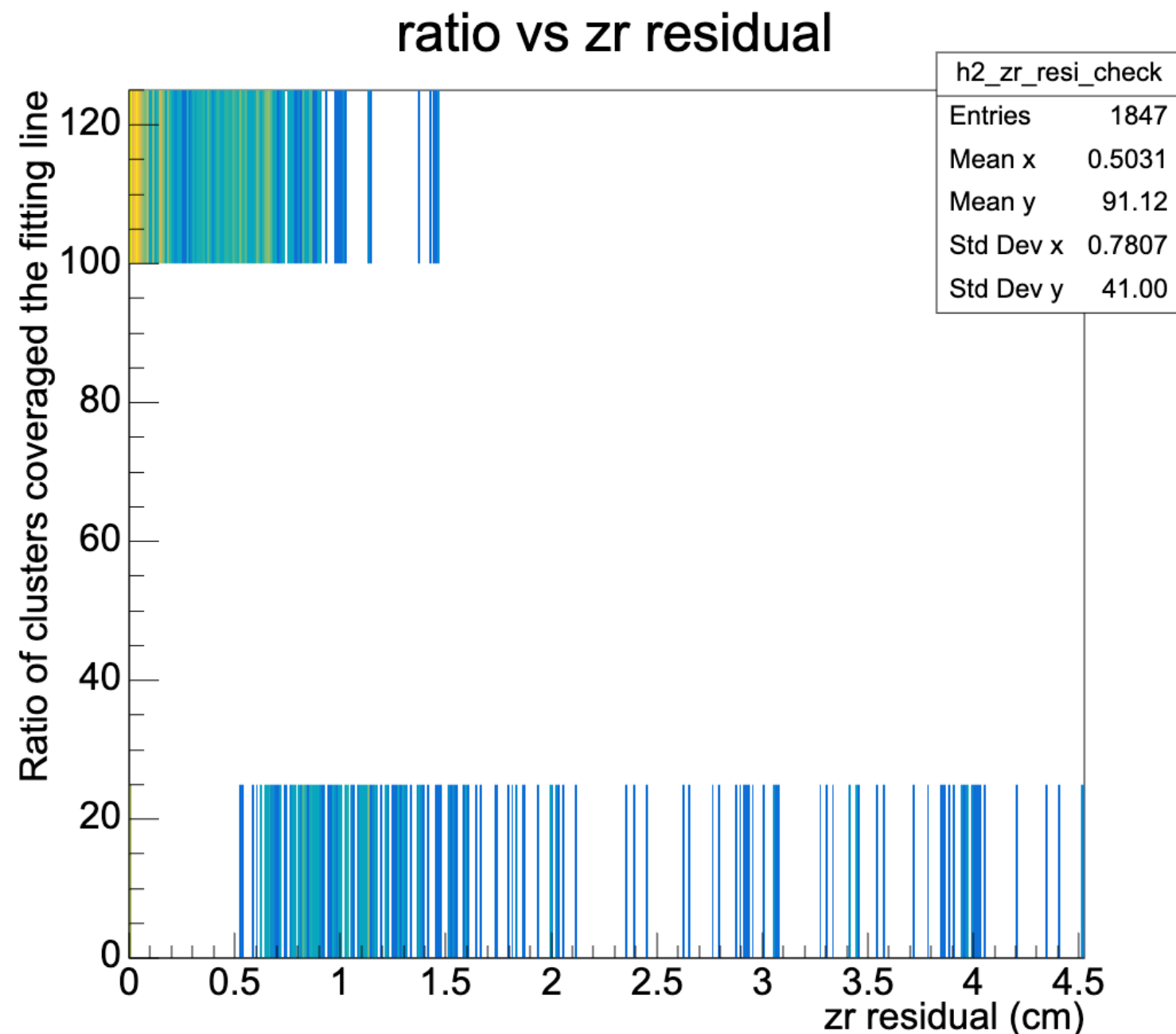Selected clusters: 4
θ = 54.578°
Residual = 6.465e-01

Z position distribution

- The position distribution along z axis.

- Residual cut applied.

- Restrict the angle from 88~90 degrees.

The average z position of each cluster.

Cosmic track

pos z dist.

posz	
Entries	116
Mean	1.061
Std Dev	8.804

z position (cm)

Entries

Clusters coverage

- The x axis is the zr residual.

- The Y axis is ratio of the number of clusters whose coverage is within the fitting line. (Ratio from 0% ~ 100%)

ratio vs zr residual

h2_zr_resi_check	
Entries	1847
Mean x	0.5031
Mean y	91.12
Std Dev x	0.7807
Std Dev y	41.00

$$\frac{3}{4} = 75\,\%$$

Cosmic tracks selection

- **Only focus on the event whose total good clusters equals to 4.**

- Track angle determined by reduced χ^2 method.

- Use the reduced residual to evaluate the fitting quality (to minimize the angle dependence).
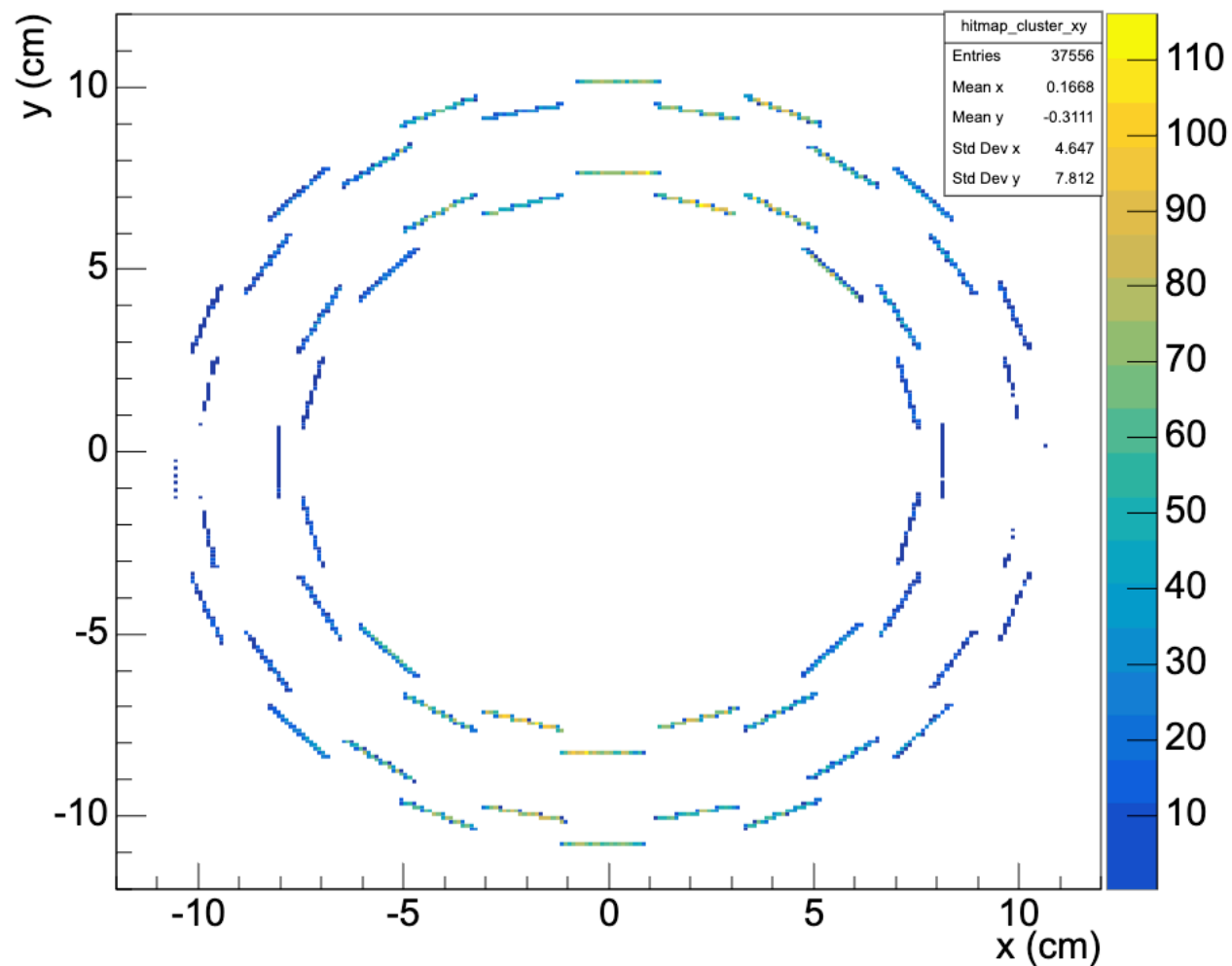
- The event display is shown in xy, zy, zx and zr planes. (The units are in cm)

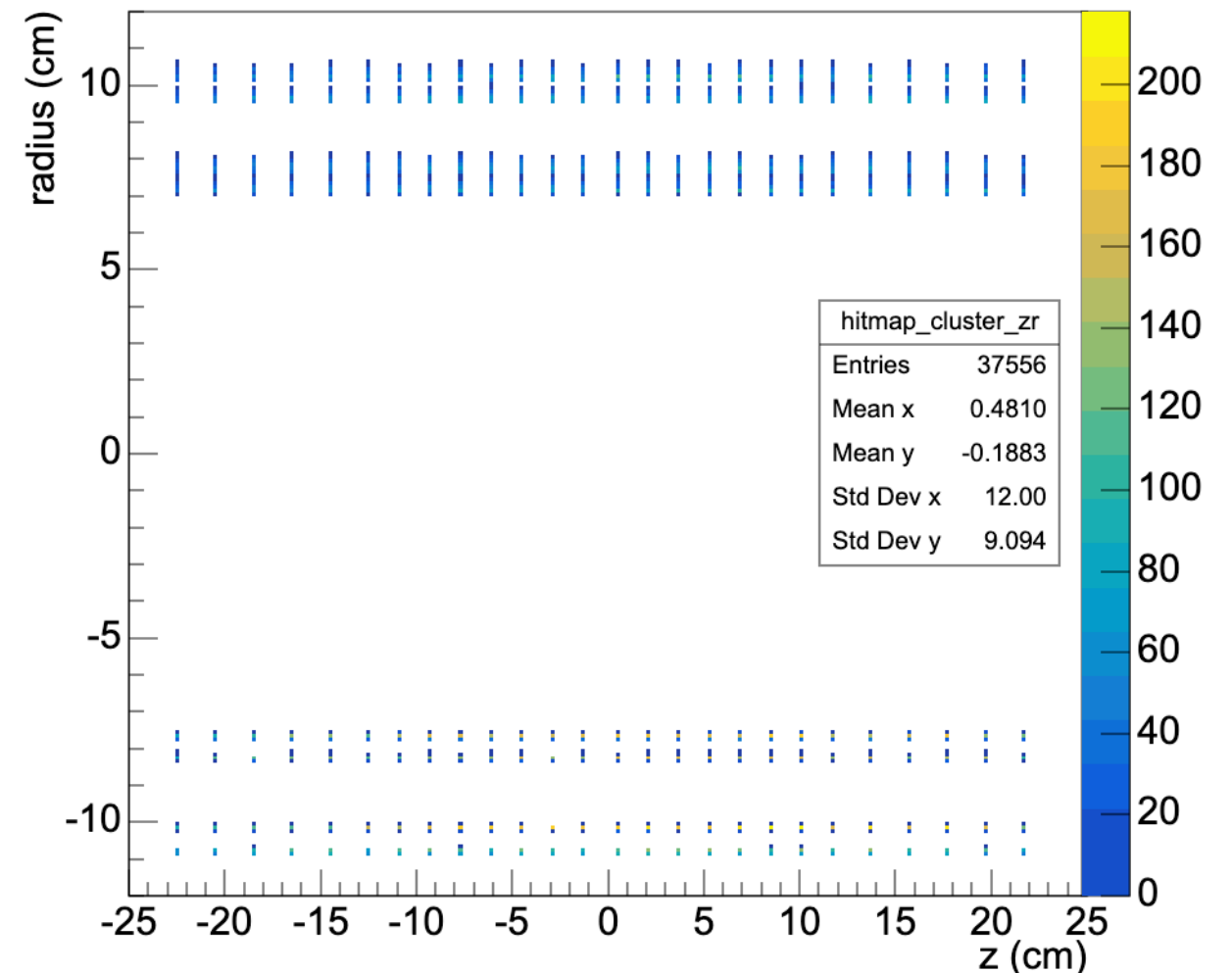- Mainly focus on the xy and zr planes in the analysis.
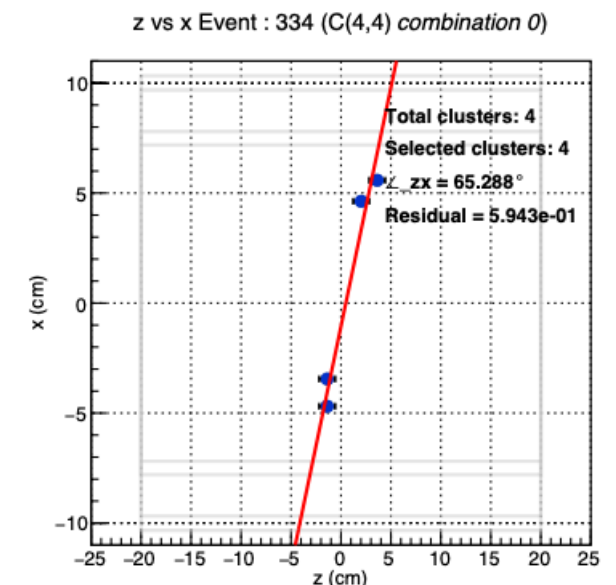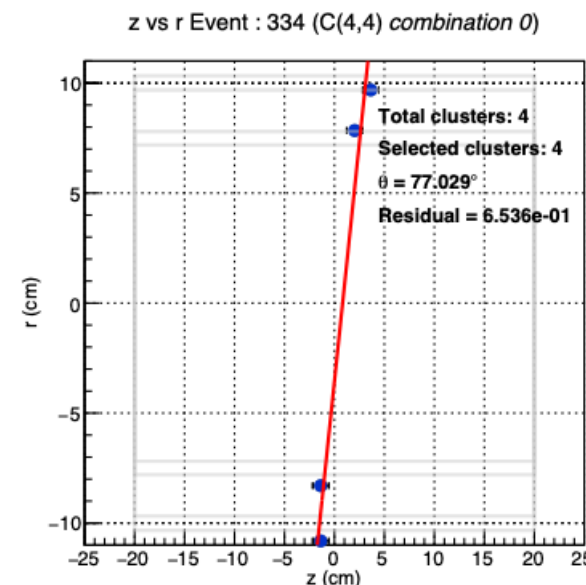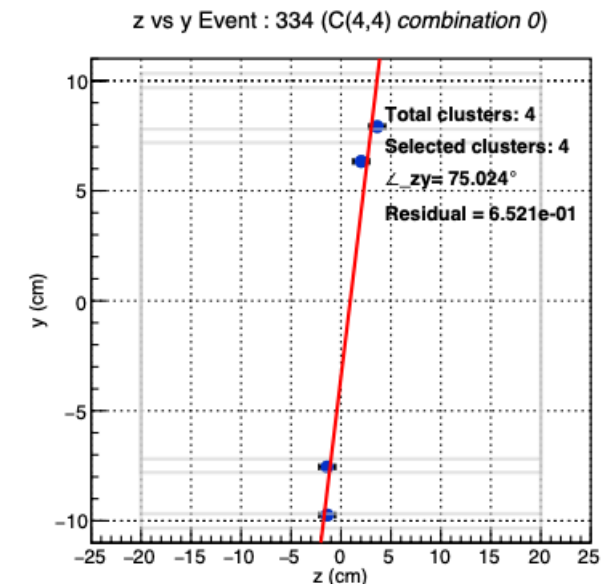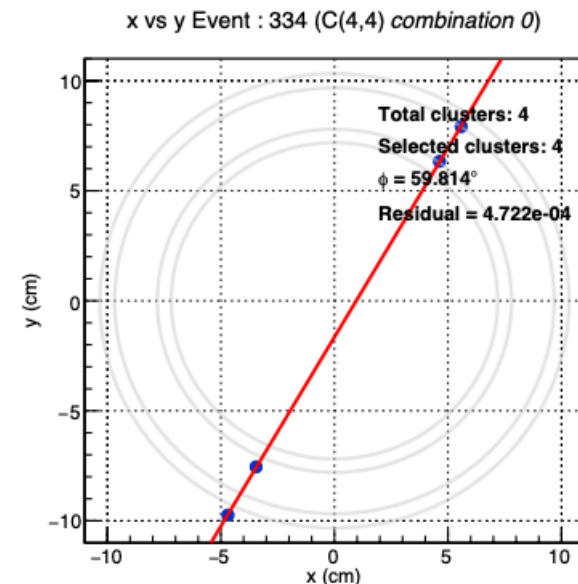
Clusters Hitmap

- The cluster hitmap in both xy and zr plane

  - There is a hot region on xy plane. → This also implies the track distribution.

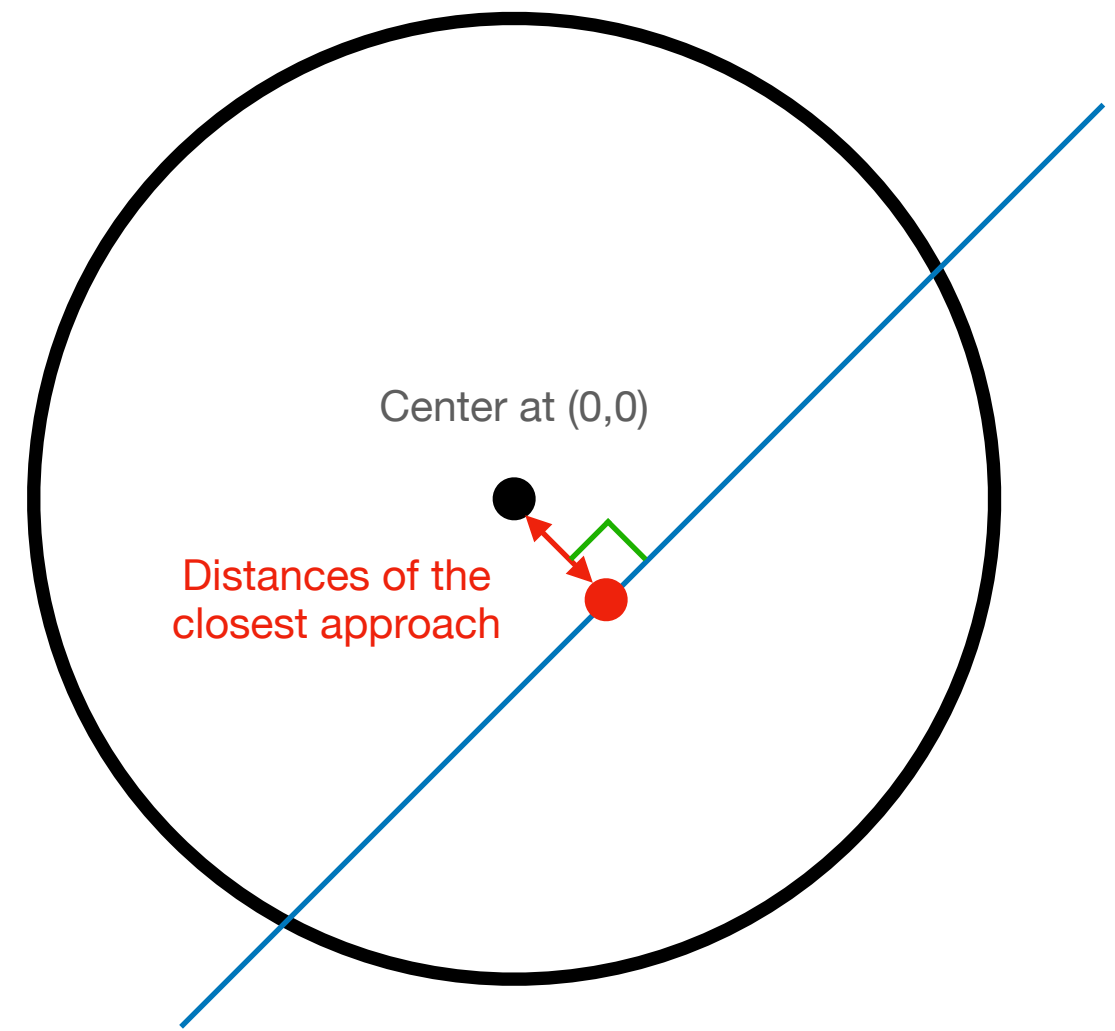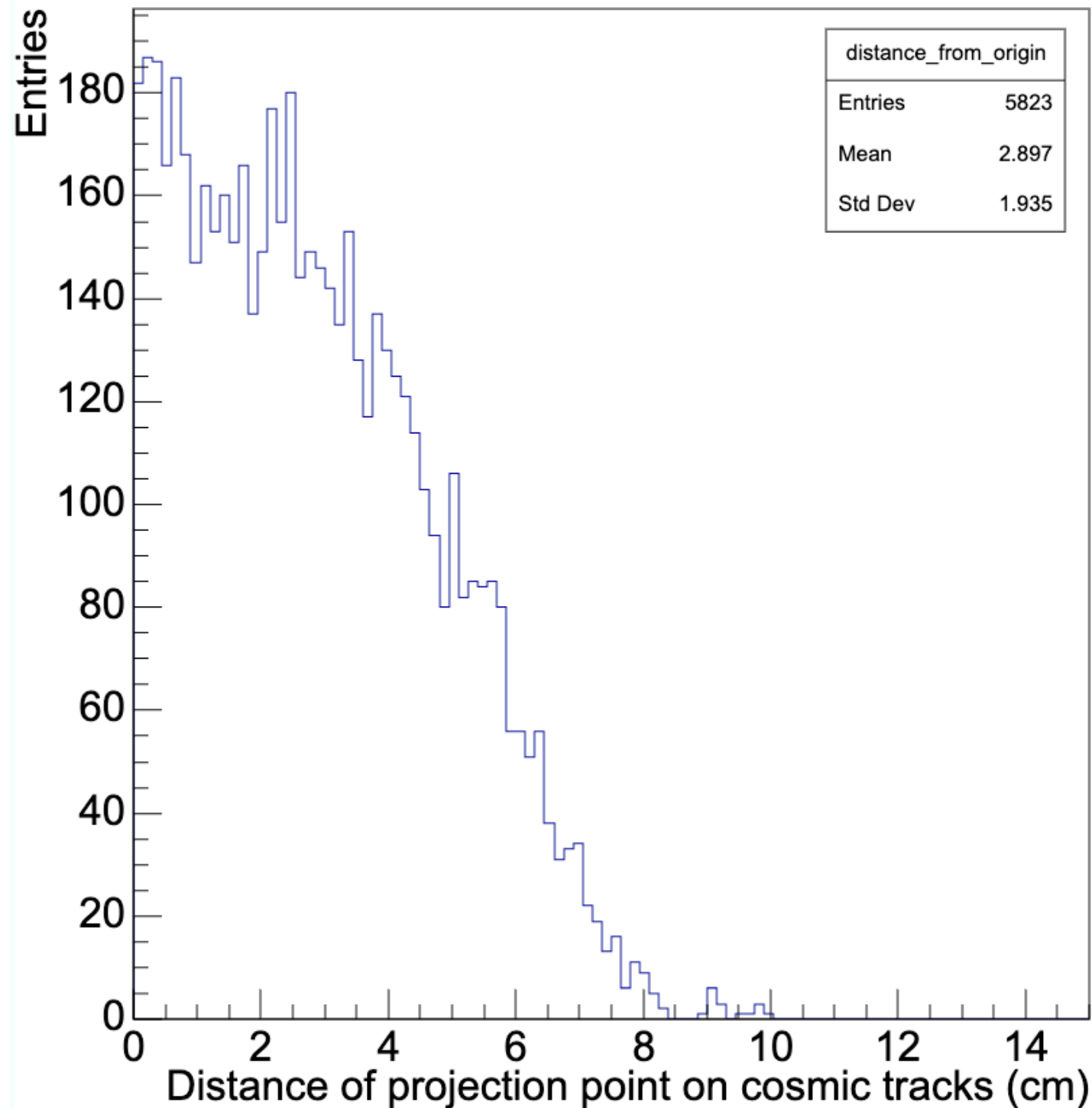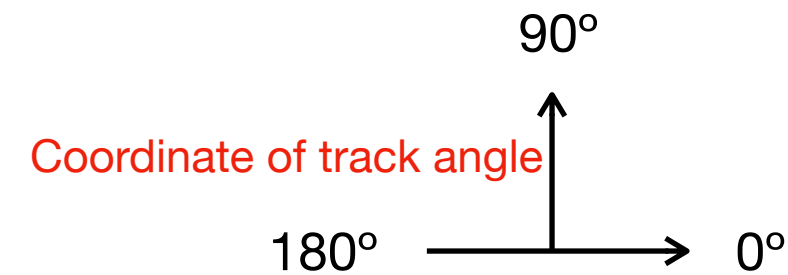 - No hot region on zr plane.

The distribution of the projection point of the origin on the cosmic tracks

The distance from the origin

distance_from_origin	
Entries	5823
Mean	2.897
Std Dev	1.935

Center at (0,0)

Distances of the closest approach

DCA point

Coordinate of track angle

90°
180° — 0°
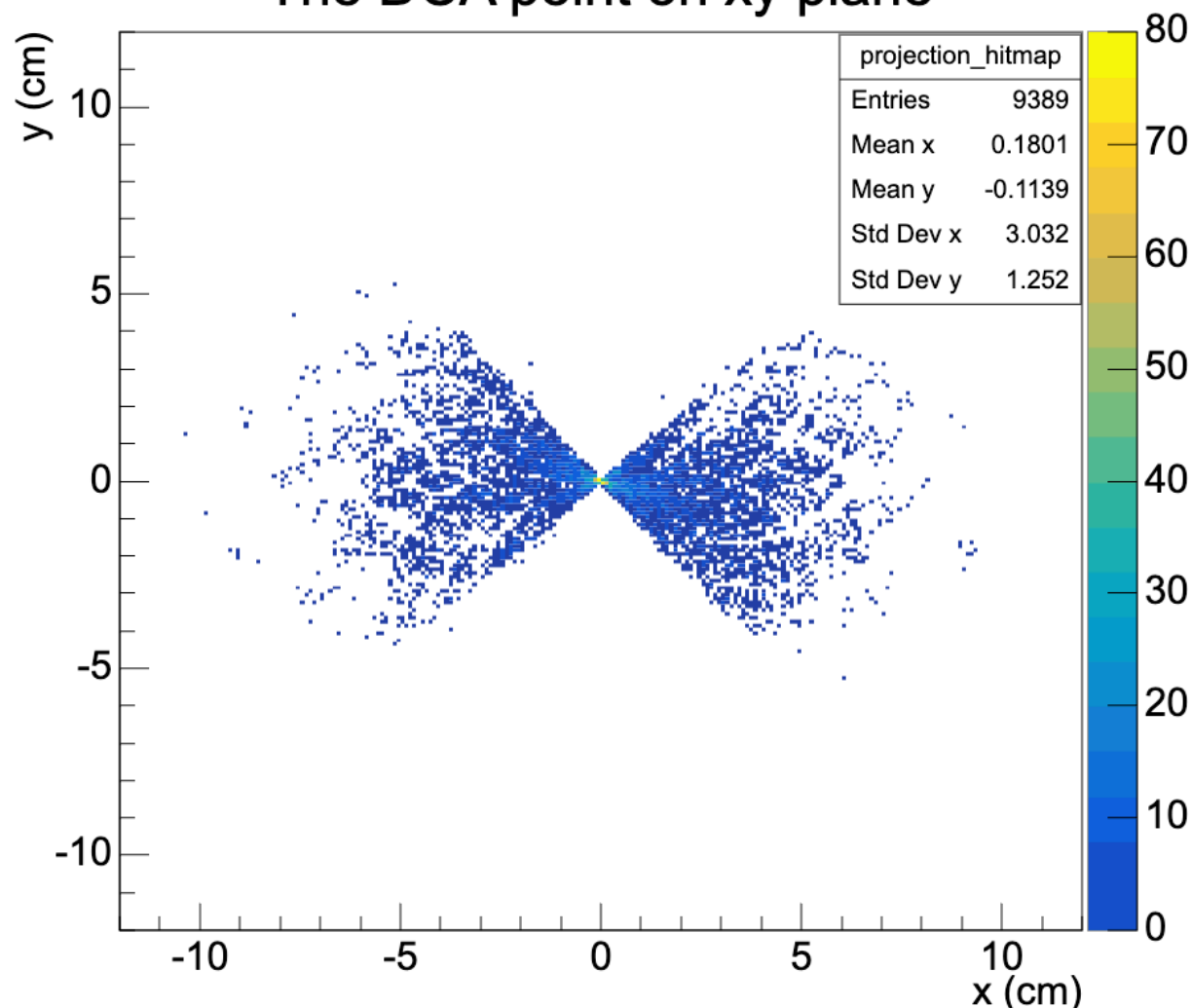
- The right figure shows the correlation between DCA and tracking angle.

  - Also shows the acceptance angle.

  - The more track angle close to 90 degrees, the larger DCA range can have.

  → Expected geometry. Those plots can check whether the trigger conditions (high correlation with track angle acceptance) have been changed or not.