Test Beam Data Analysis

Preliminary study of the performances of the TIGER-GEMROC and APV-SRS readout chains

Outline

- Aim and Datasets
- Pre-analysis and alignment
  - Strip occupancy and pathological areas
  - Alignment dataset selection
  - Alignment
  - Beam Profile Evaluation
- Analysis
  - Event Selection
  - Cluster Charge
  - Cluster Size
  - Charge Sharing
  - Resolution
- Conclusions

Aim and Datasets

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The aim of the analysis is to asses the performance of the **TIGER-GEMROC** readout chain and **compare** it with the one achievable using an **APV-SRS** readout chain under similar experimental conditions

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In both cases a **80 GeV muon** beam was used and the detectors were oriented to be perpendicular to the beam

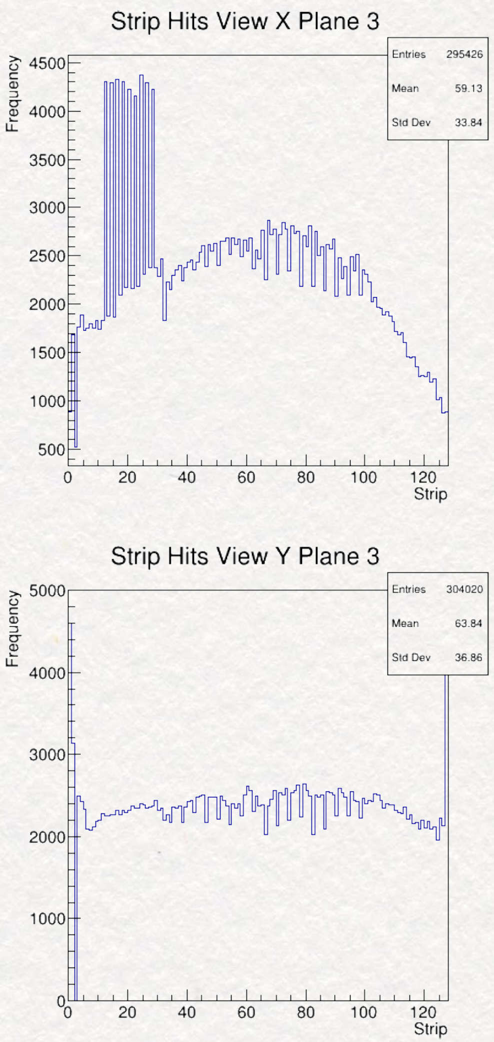
The positions of the hits are reconstructed using the **Charge Centroid** (CC) Algorithm

The gas mixture in the detectors is Ar-iC_4H_{10} (90/10) for both datasets

Pre-analysis and Alignment

Strip Occupancy and Pathological Areas

APV



Run 5273 825V

Run 563 825V

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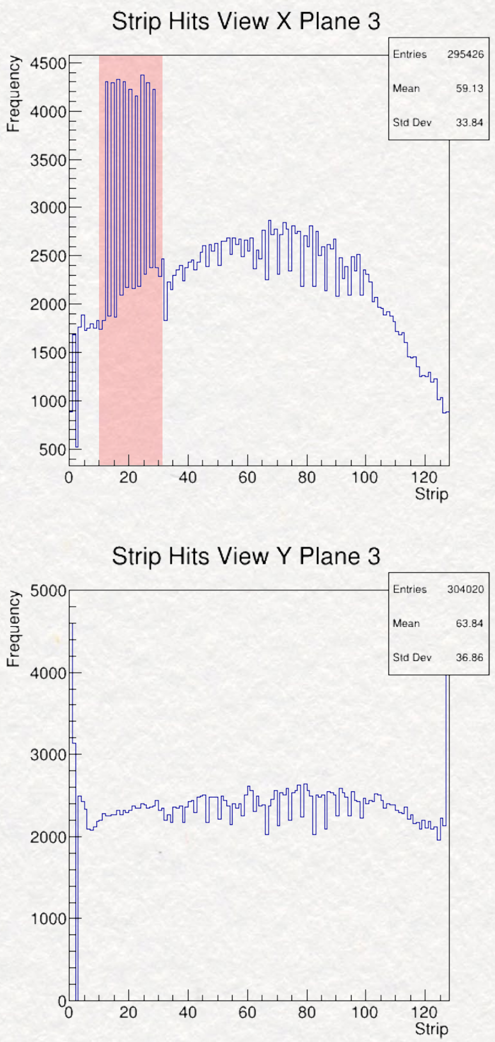

Noisy channels in this particular APV

Limited to view X of plane 3

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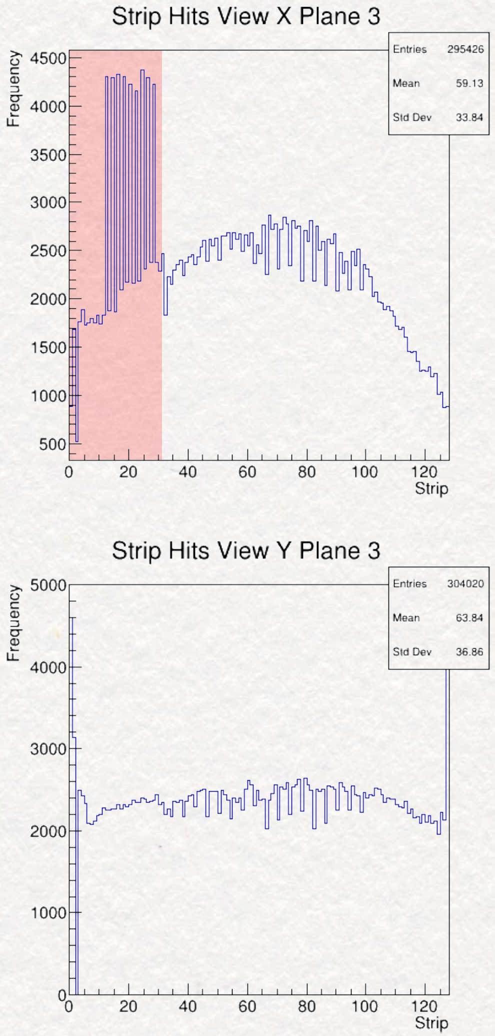

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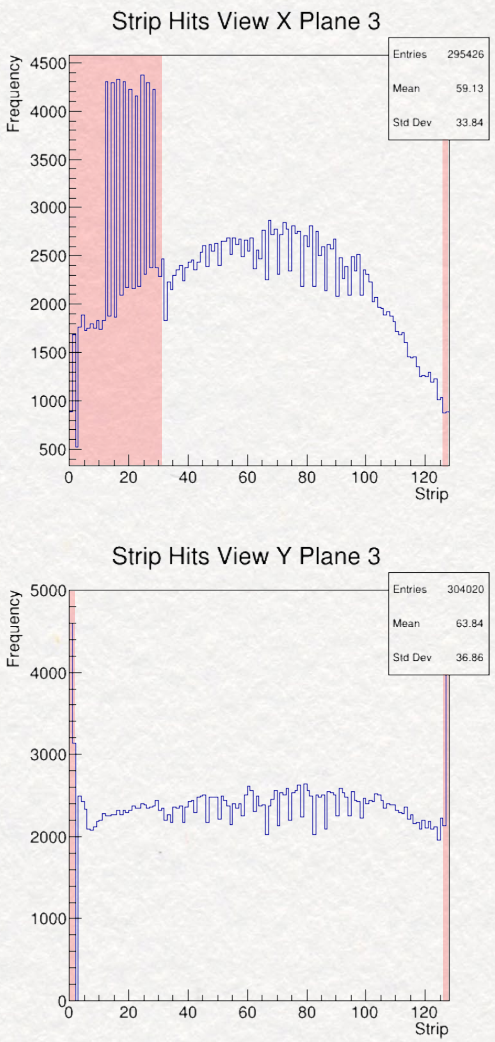

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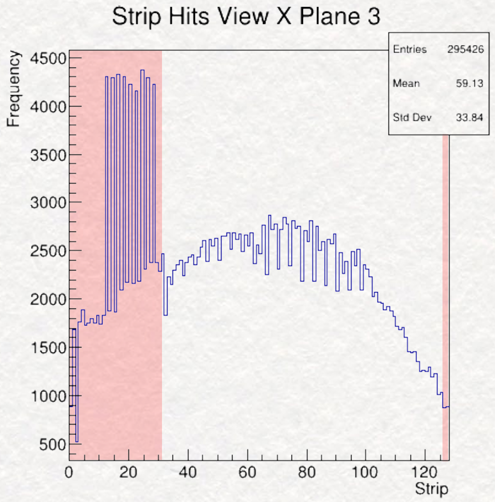

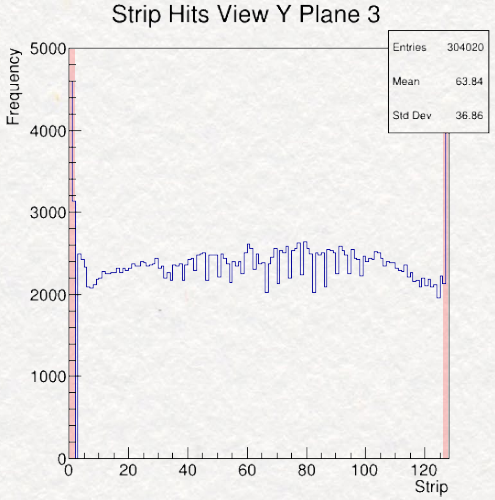

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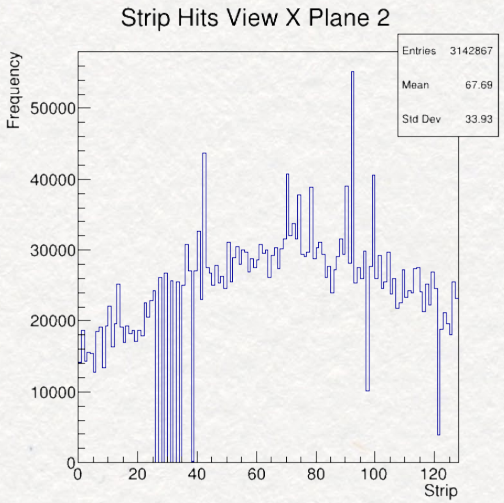

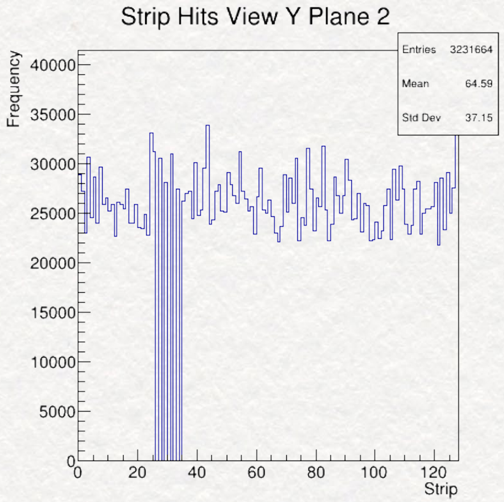

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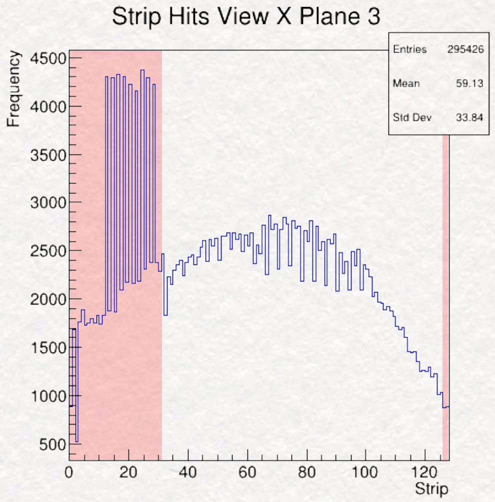

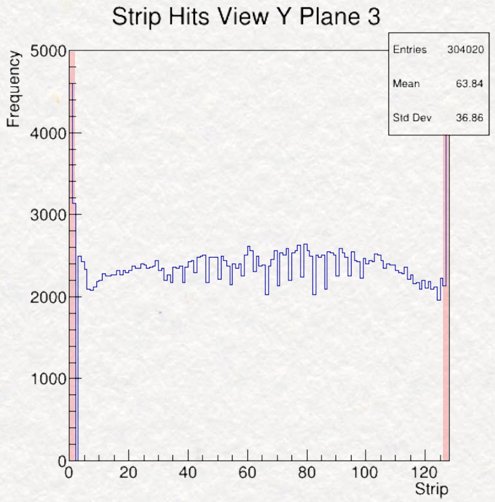

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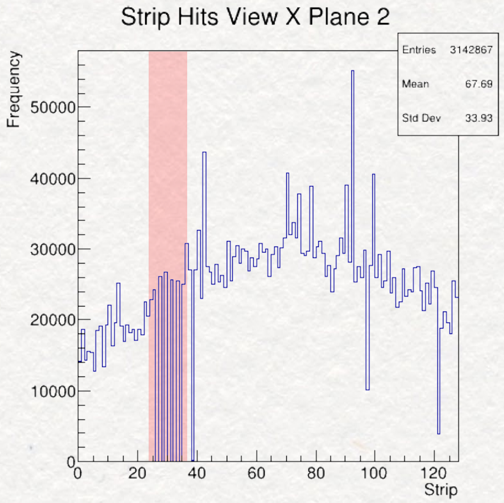

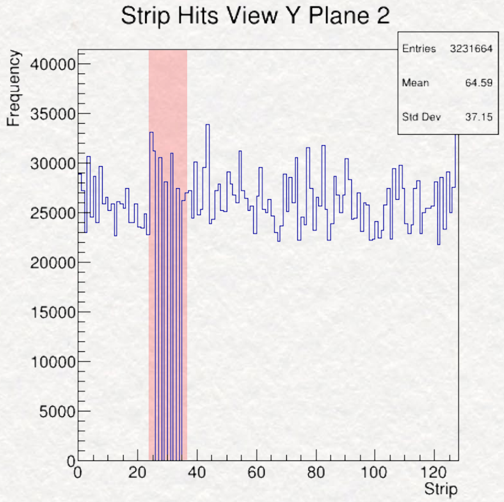

Channels disconnected due to non-matching FEB - Transition Board design

Present on all planes

Run 563 825V

Strip Occupancy and Pathological Areas

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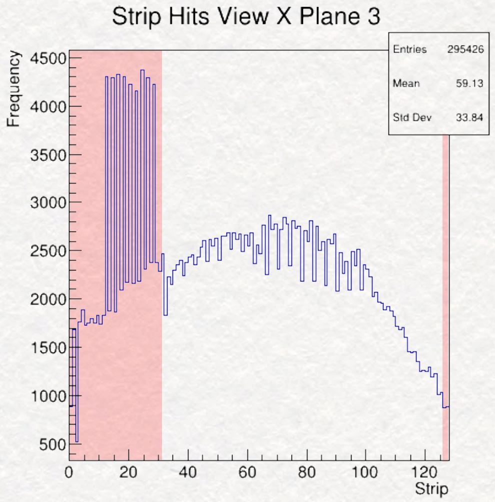

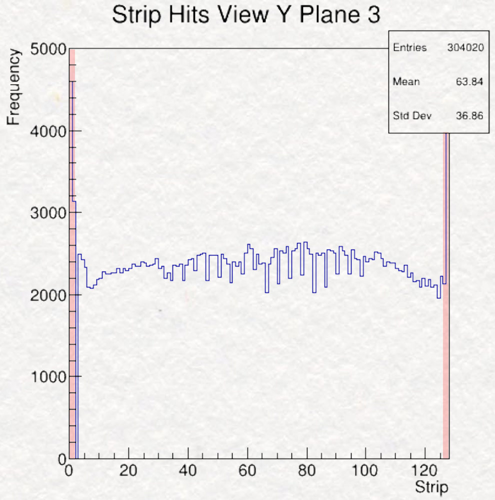

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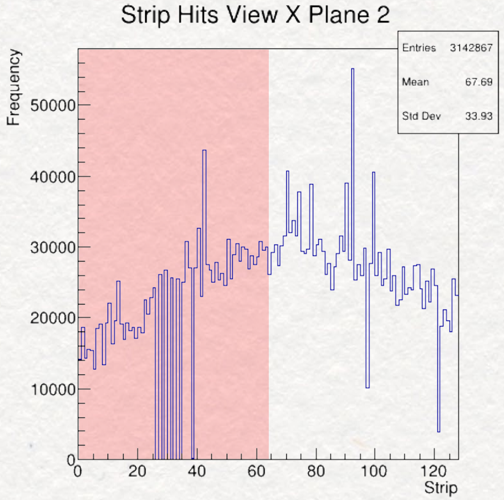

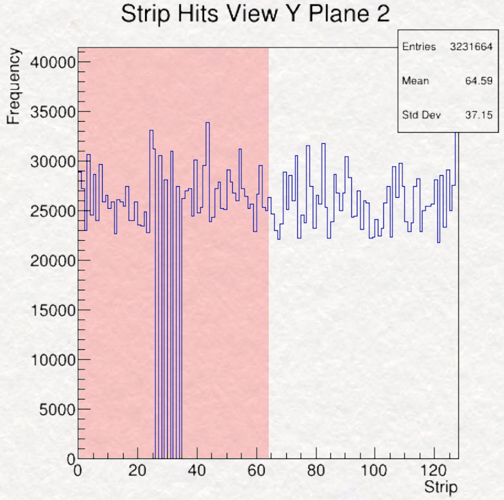

Channels disconnected due to non-matching FEB - Transition Board design

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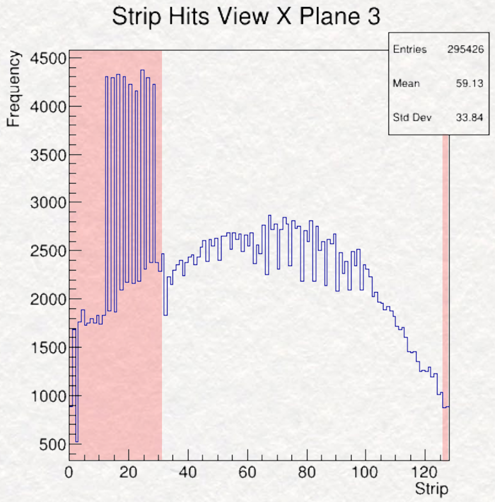

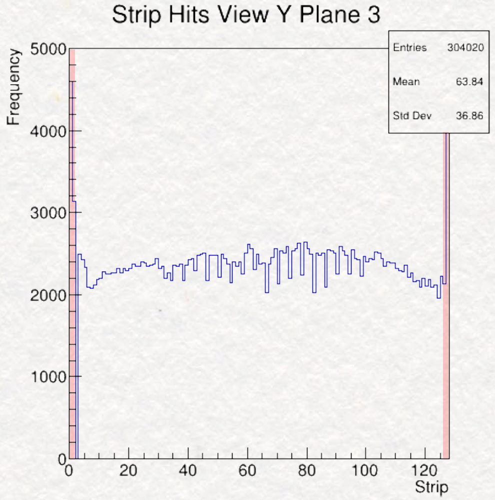

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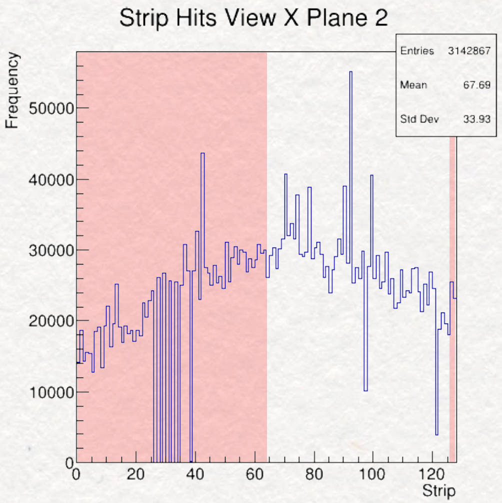

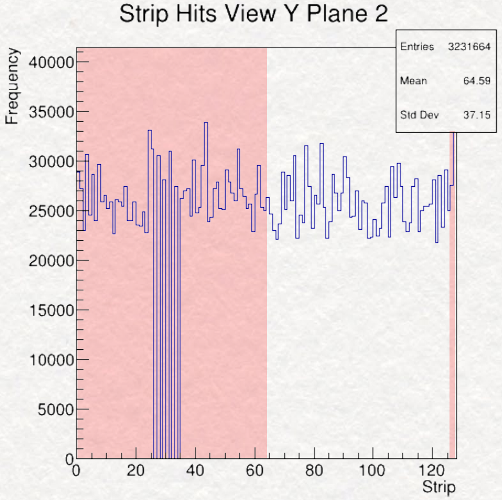

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The cut on the margins was maintained

Run 563 825V

Alignment Dataset Selection

The selection criteria have to be **safe**:

- Only events with a single cluster in each view of each plane
- All 8 clusters have to be above **10 fC** (TIGER) or **300 ADC counts** (APV)
- All 8 clusters have to be outside the pathological areas

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The two datasets:

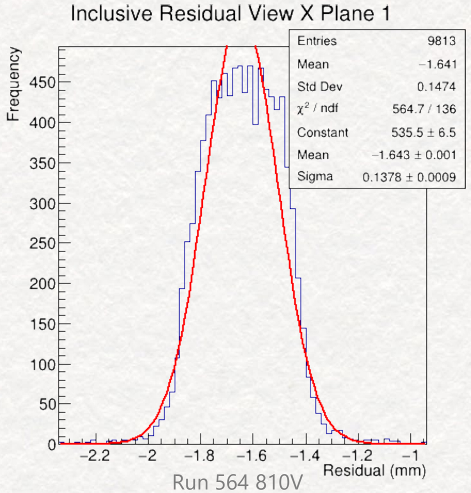
a mini HV scan (3 HV points) collected at 0° using APV-SRS readout

a fine HV scan (8 HV points) collected at 0° using TIGER-GEMROC readout

are aligned using the events selected in **a single run**

Readout Electronics	Run Number	HV (G1+G2+G3)	Selected Events	Total Events	Selection Efficiency	Effective Active Area
APV + SRS	5273	815 V	3690	100167 (≈100k)	3,68%	≈75%
TIGER + GEMROC	564	810 V	9813	993018 (≈1M)	0,99%	≈25%

Alignment



Run 564 810V

Not distributed as a gaussian

Not centered in 0

Run 564 810V

Alignment

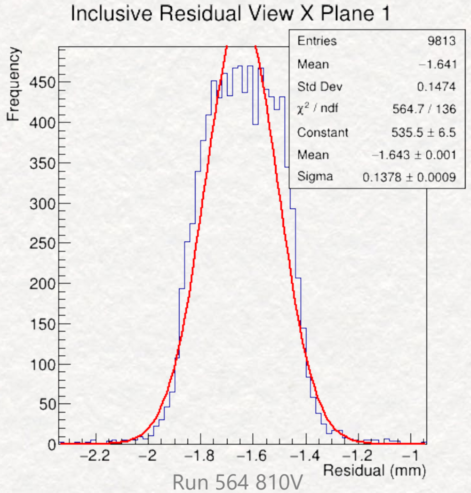
The alignment is performed in three steps:

1

XY Rotations

Corrects the dependence of the residual in one view from the position of the cluster in the other

Couples together X and Y coordinates



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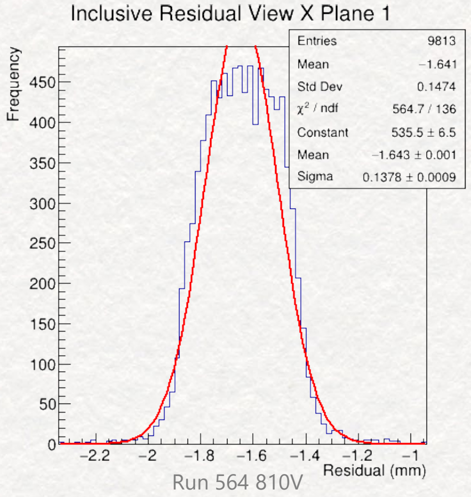
Shifts in 0 the mean values of the residuals distribution in both views

The shifts are calculated with respect to the fitted tracks



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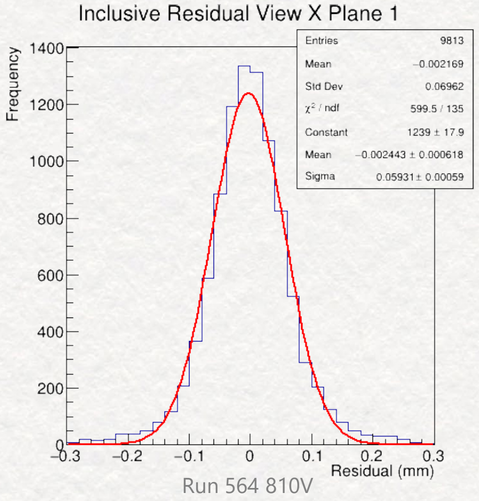

Better, but **they cannot become true gaussians**

Centered in 0

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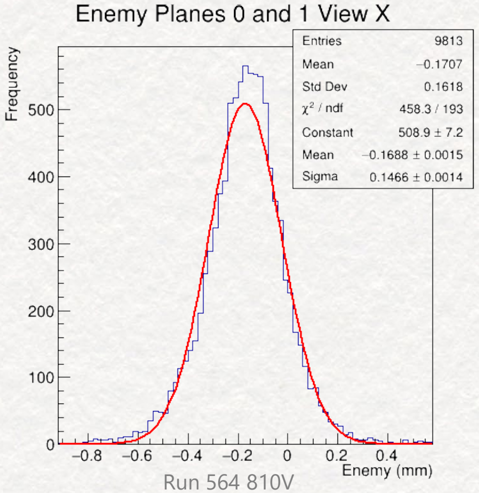
3 **Enemy Rotations**

Rotates the chambers with respect to one another until all are aligned with the first one

Orientation of the whole setup with respect to the beam is not corrected



Run 564 810V

Wider and sometimes deformed

Not centered in 0

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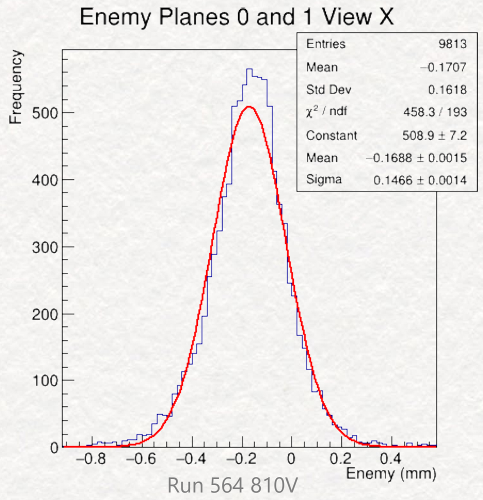
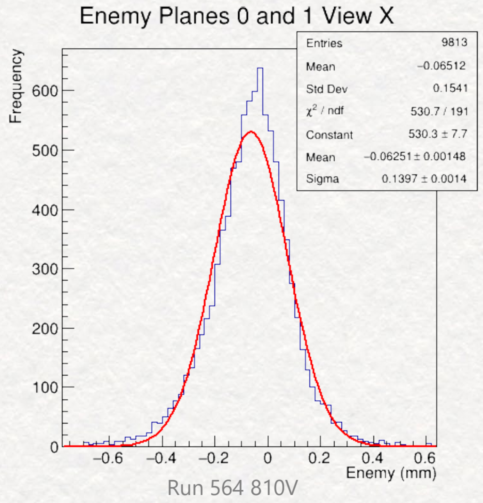


Wider and sometimes deformed

Not centered in 0

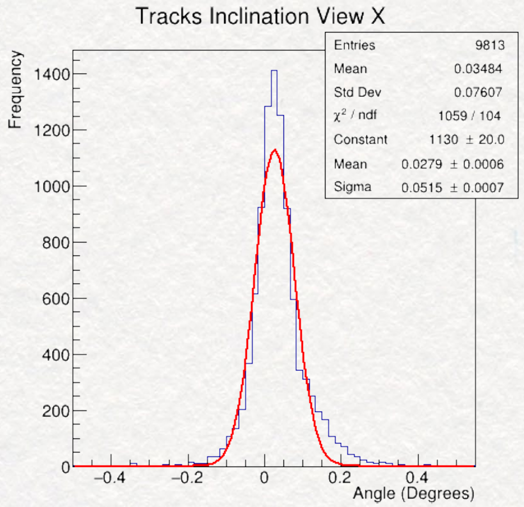
For more details check the backup

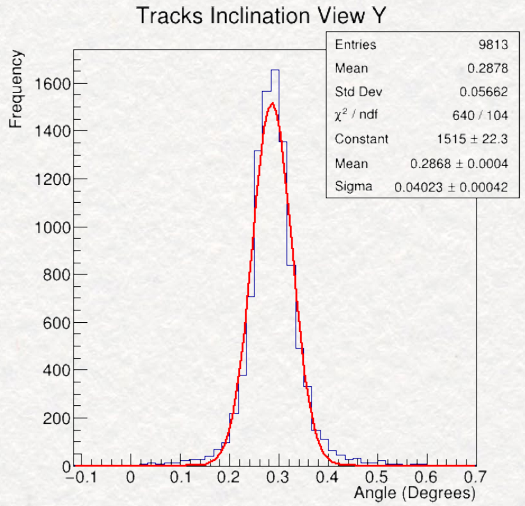


Narrower distribution

Still not centered in 0

Beam Profile Evaluation





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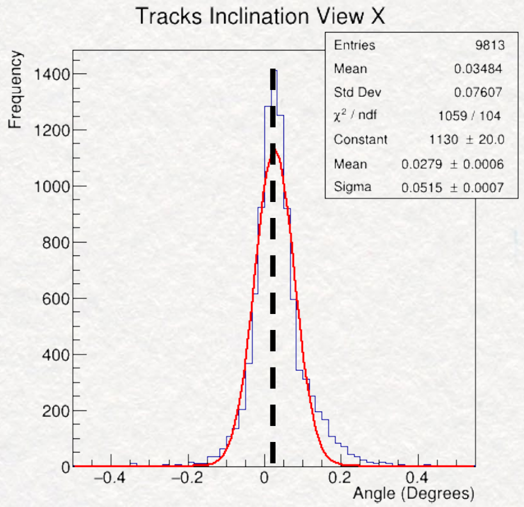

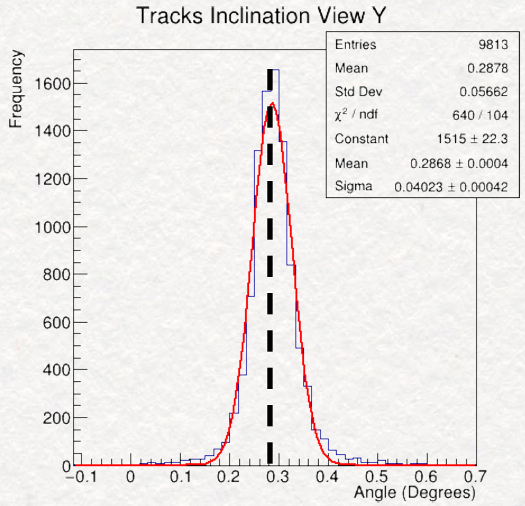

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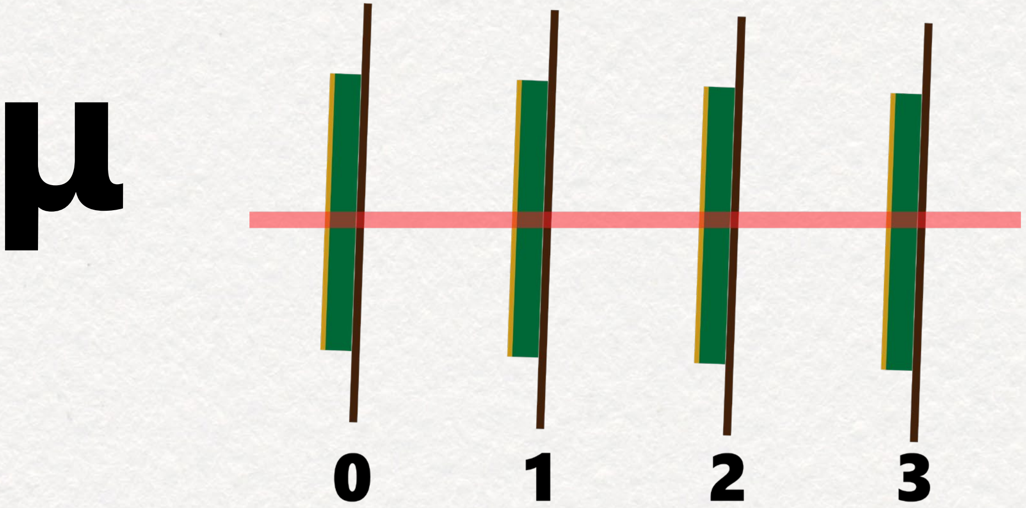

The **mean** of the distribution depends on the **orientation of the setup** with respect to the beam

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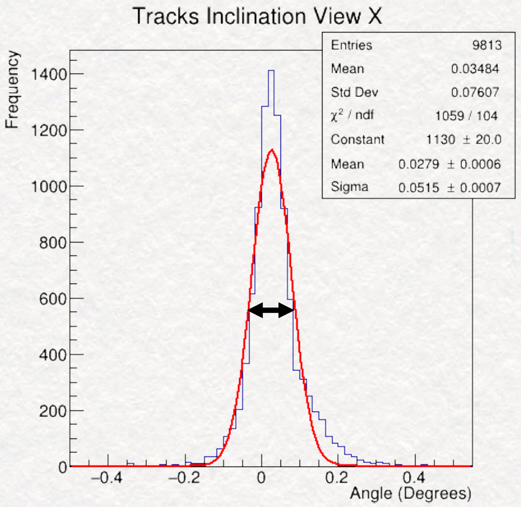
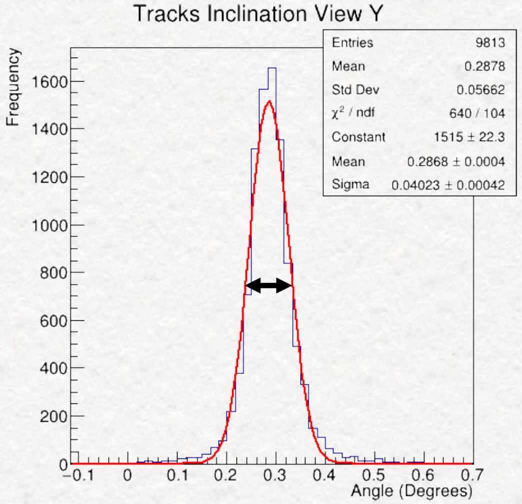
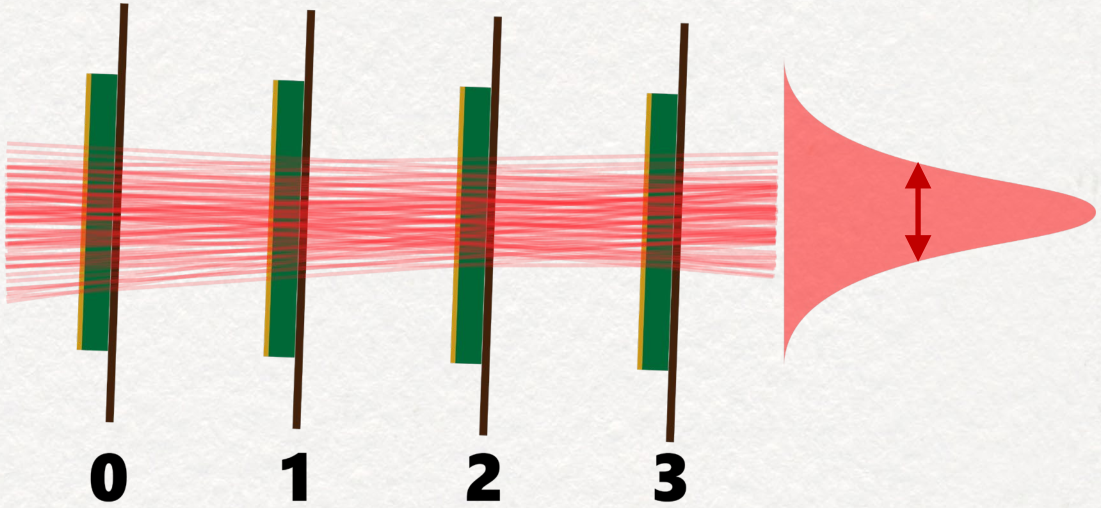




Run 564 810V

σ



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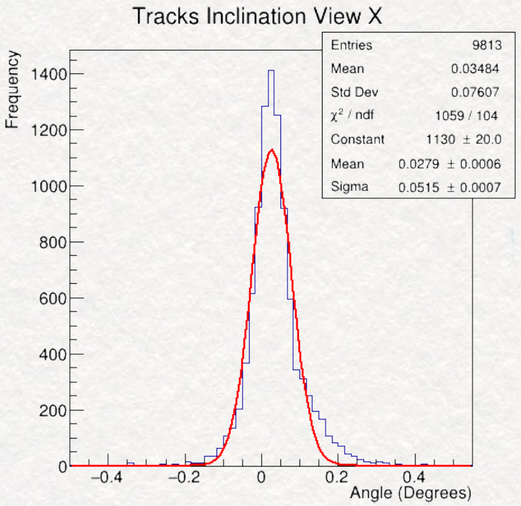
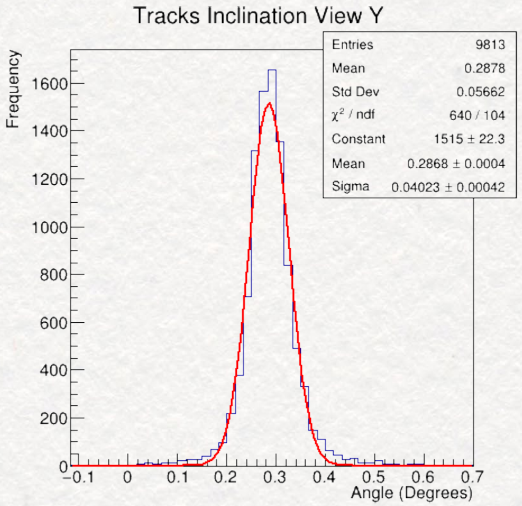
The **standard deviation** depends on the beam **divergence**

Beam Profile Evaluation





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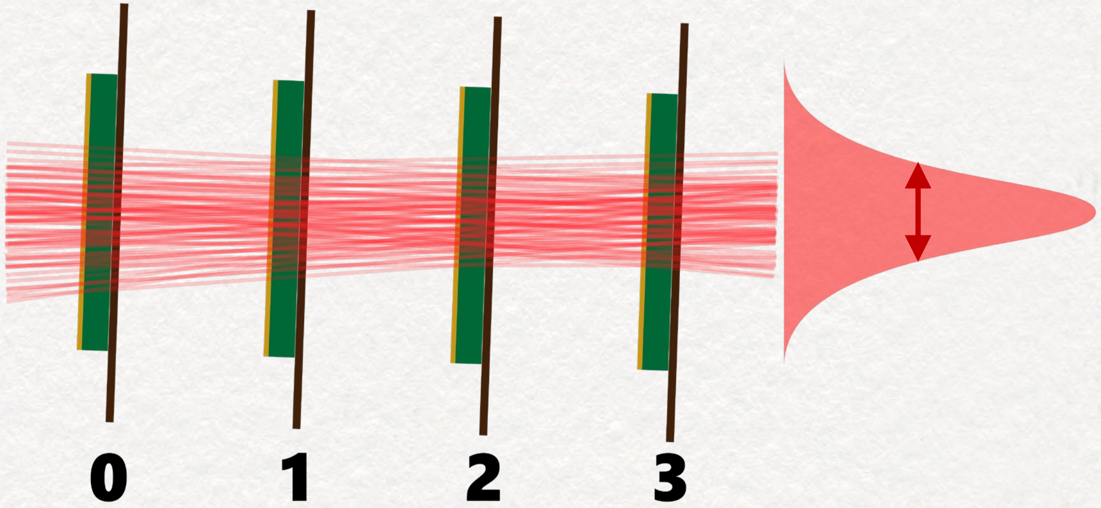

The **mean** of the distribution depends on the **orientation of the setup** with respect to the beam

The **standard deviation** depends on the beam **divergence**

Both these parameters are used for the **selection** of the events that will be studied in the analysis

Analysis

Event Selection

Philosophy of the Selection:

- For each trigger event we want to select **a single track**
- **The 2D clusters** that were **used in the fit of the selected track constitute the signal clusters**, which will then be used in the analysis for all the chambers

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For each trigger event:

If there are more than 5 1D clusters in any view on any plane the event is rejected

CUT

At least three chambers must have at least 1 2D cluster, otherwise the event is rejected

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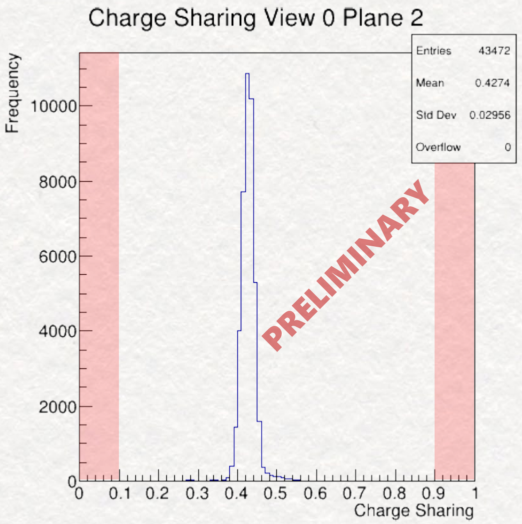
2D clusters having incompatible charge sharing are removed — CLEANUP

APV SRS



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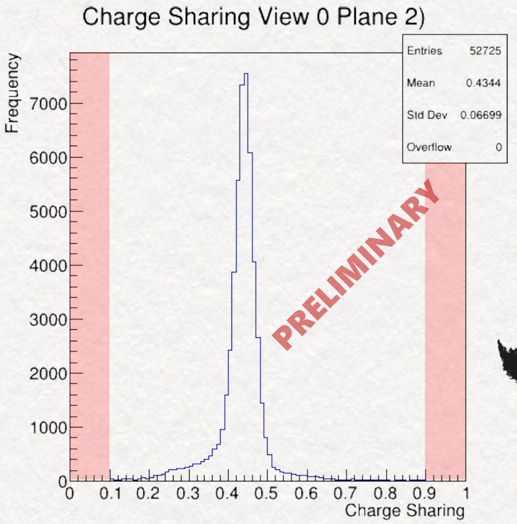

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TIGER GEMROC

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- After the charge sharing cleanup, at least three chambers must still have at least 1 2D cluster — CUT
- All possible tracks with three and/or four points are generated: — TRACK GENERATION
  - Tracks for which one chamber didn't fire
  - Tracks for which all chambers fired but none of the fits with four points pass a loose χ^2 cut (20)
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All tracks must match the beam profile within 5σ in order to be eligible for selection — CUT

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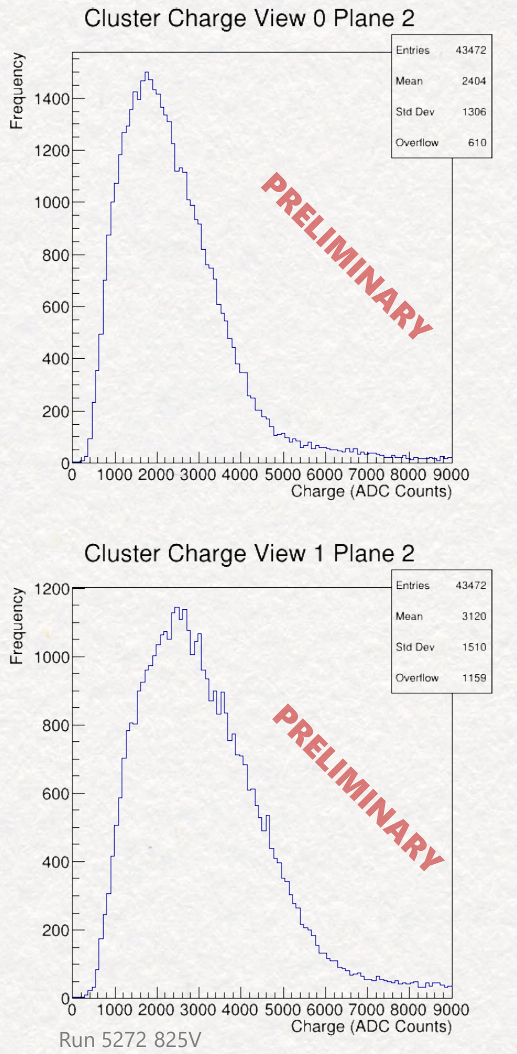
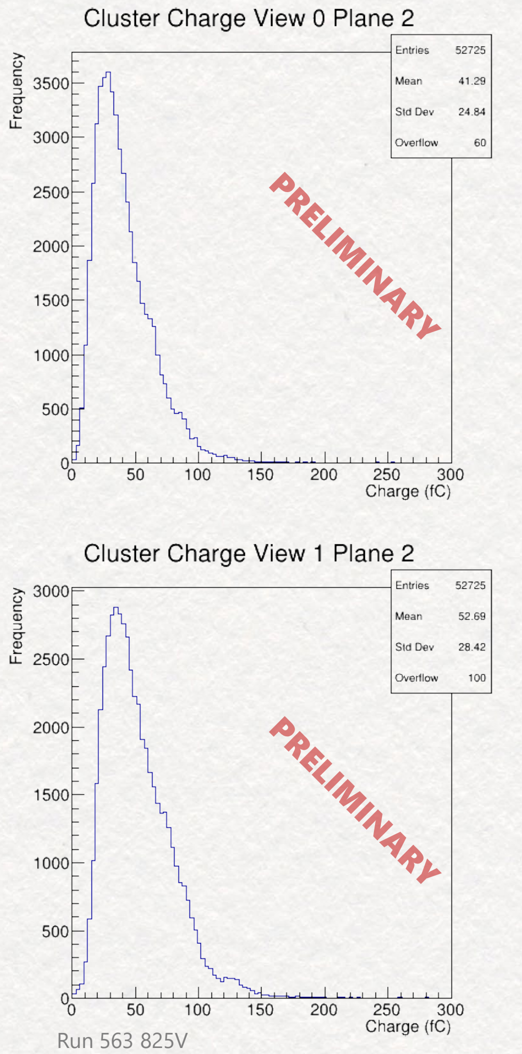
If no track survives the event is rejected — CUT

Cluster Charge

APV-SRS



TIGER-GEMROC



APV and TIGER measure charge differently

Cluster Charge

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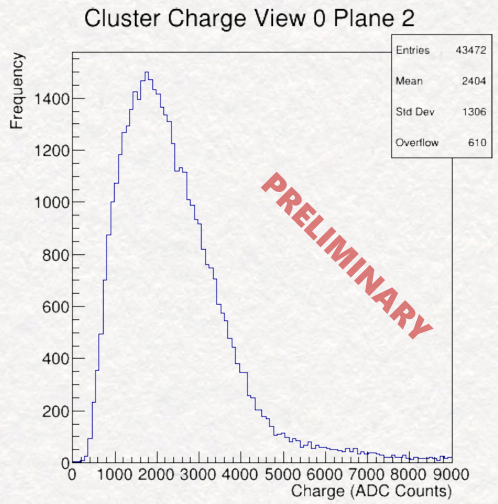
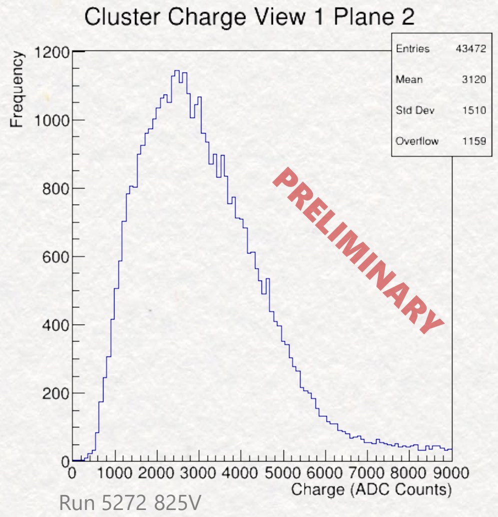
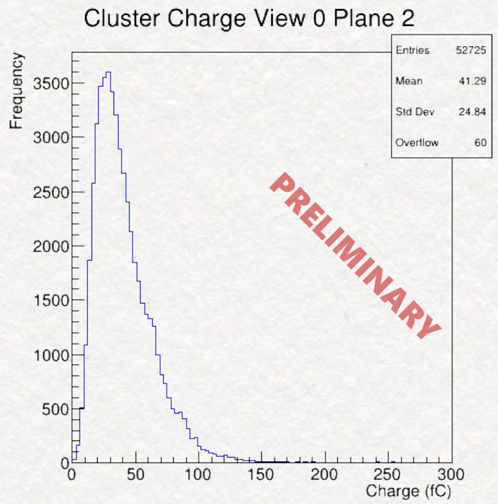
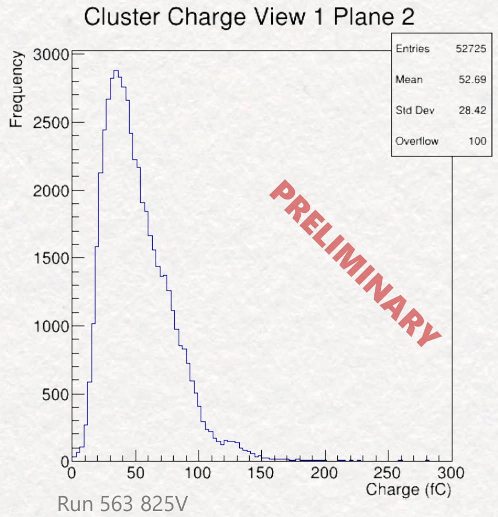




TIGER-GEMROC





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In the APV-SRS plots the charge is displayed in ADC counts

In the TIGER-GEMROC plots the charge is displayed in fC

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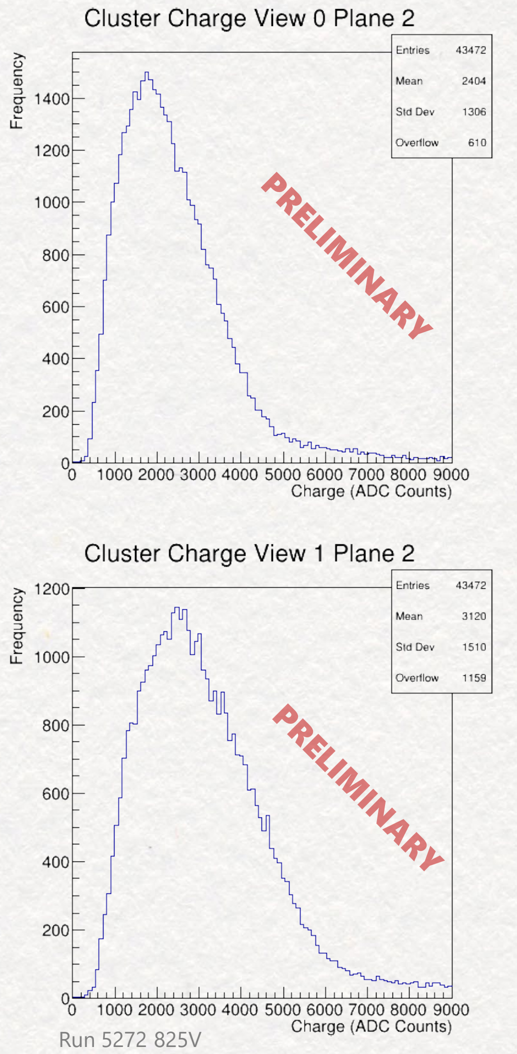
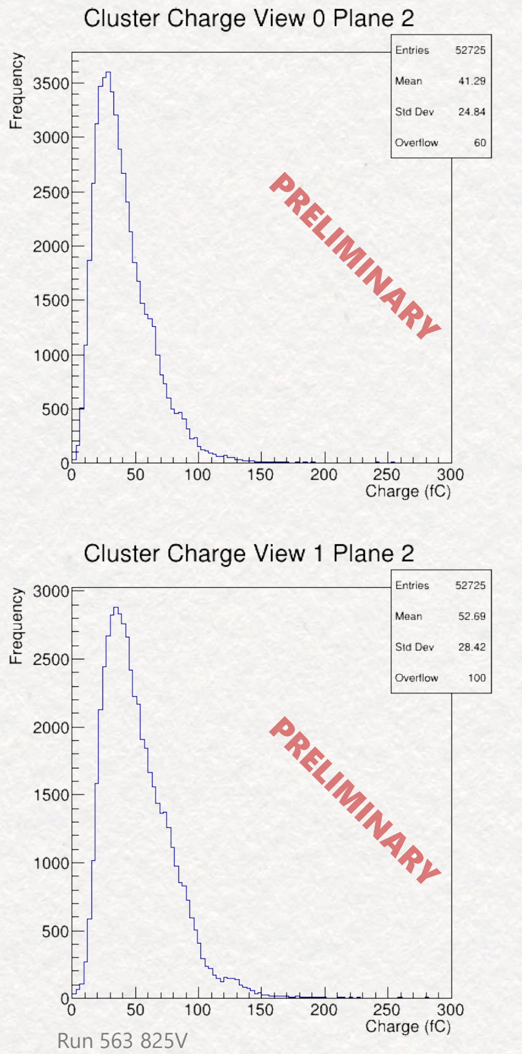


TIGER-GEMROC



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Assuming the conversion factor:

30 ADC counts = 1 fC

The plots shown have the same range

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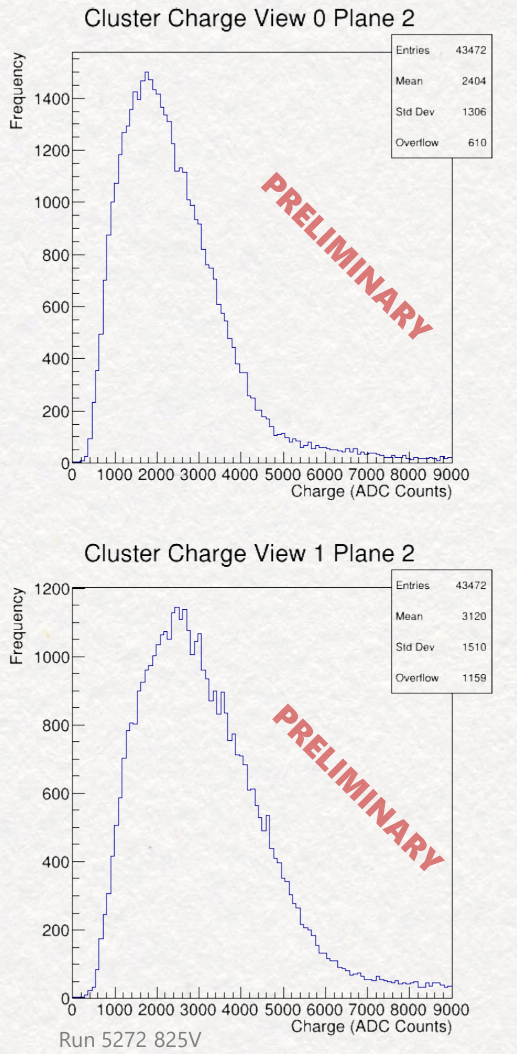
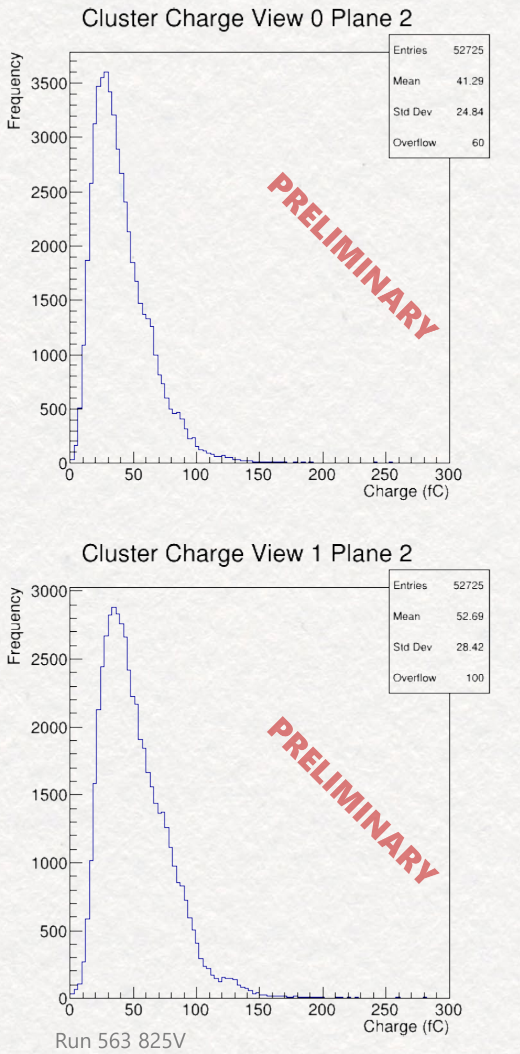


TIGER-GEMROC



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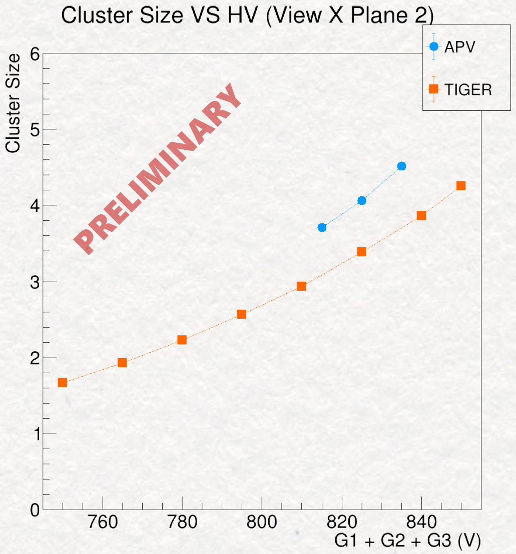
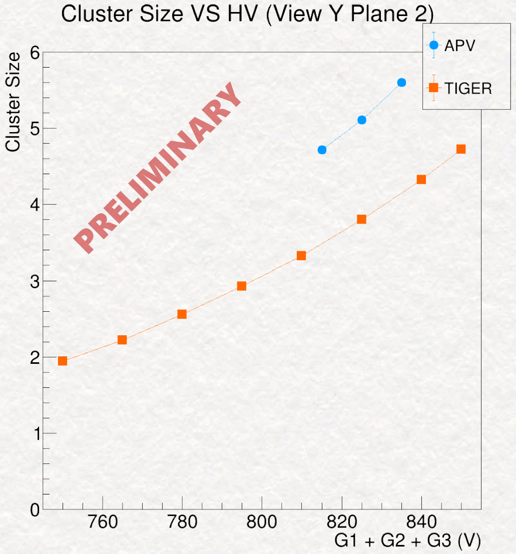
30 ADC counts = 1 fC

The plots shown have the same range

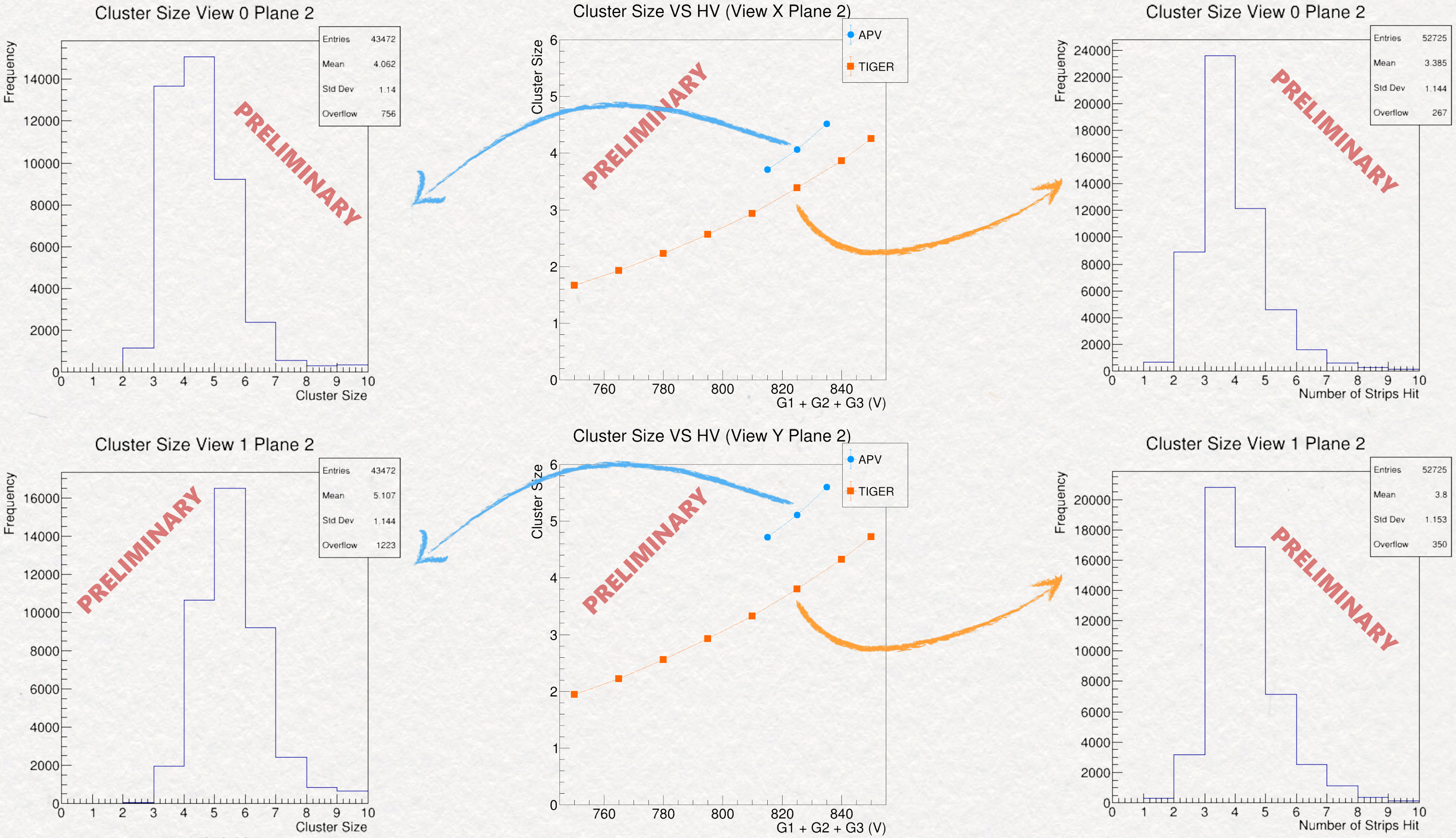
Bumps in the distributions are likely caused by channel saturation

Cluster Size





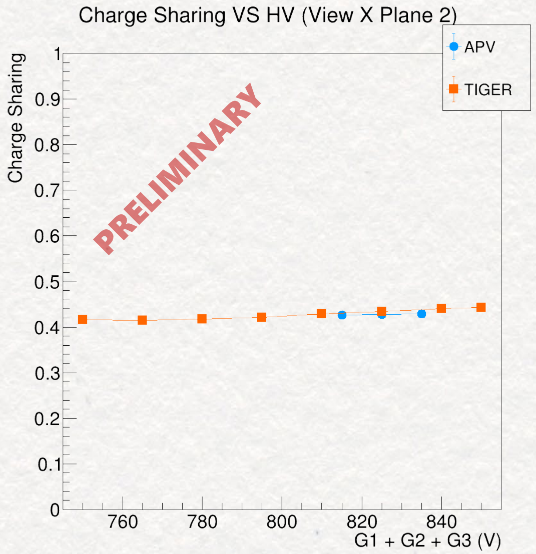
Cluster Size

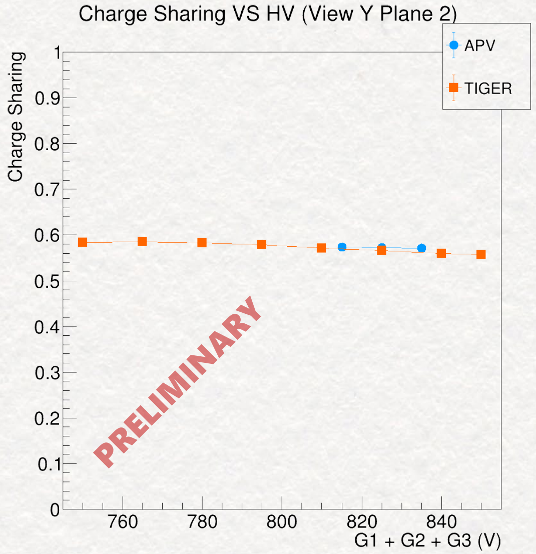


Run 5272 825V

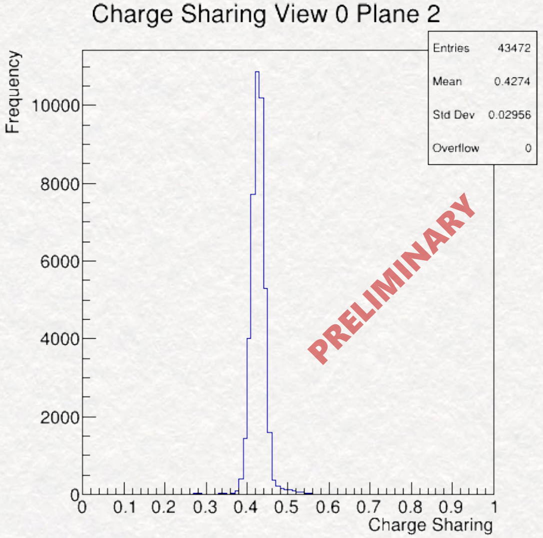
Run 563 825V

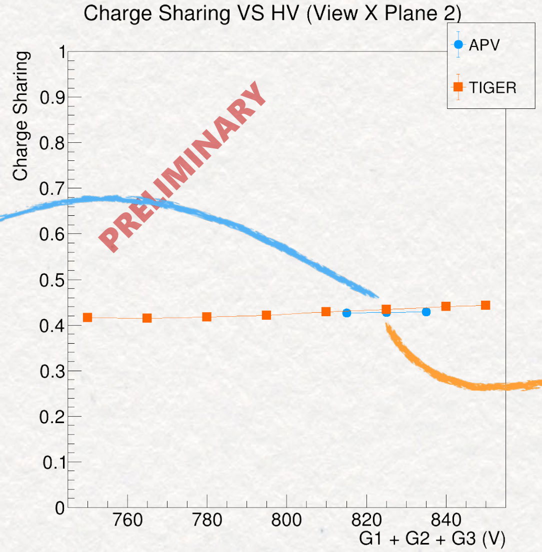
Charge Sharing

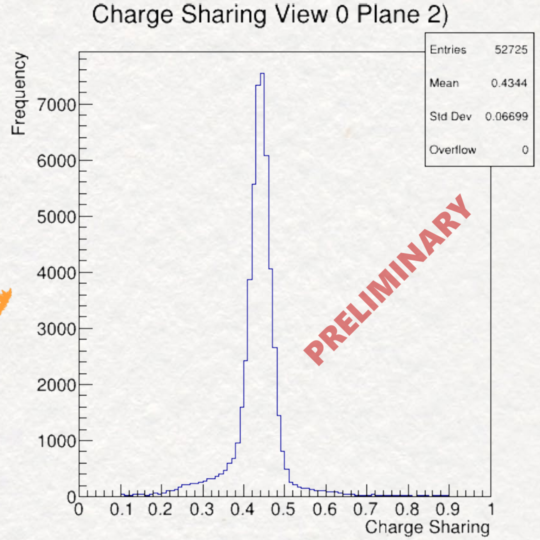


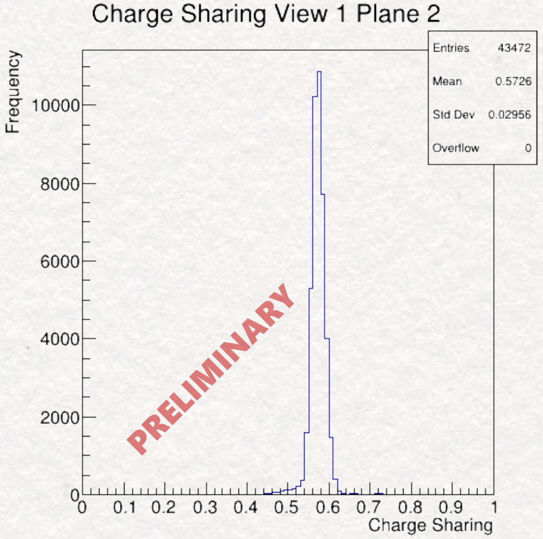


Charge Sharing









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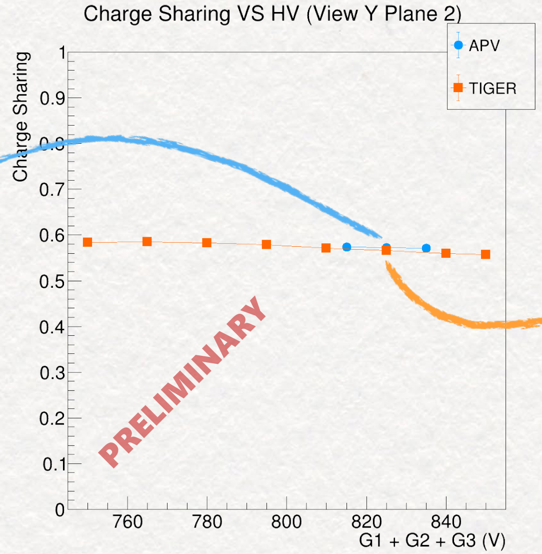

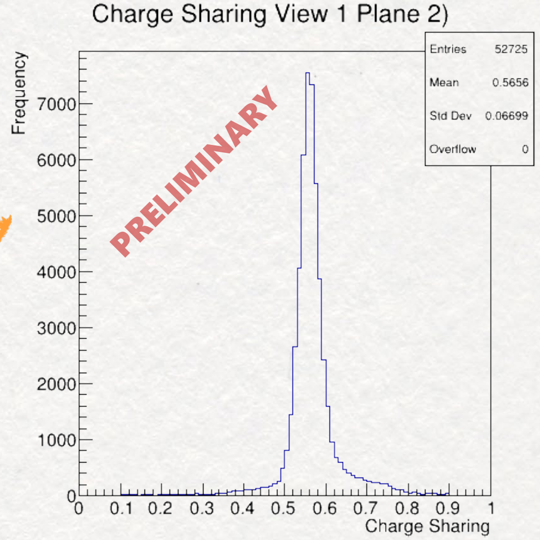

Run 563 825V

Resolution

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The postion measured by a chamber is evaluated against its **neighbouring** chambers

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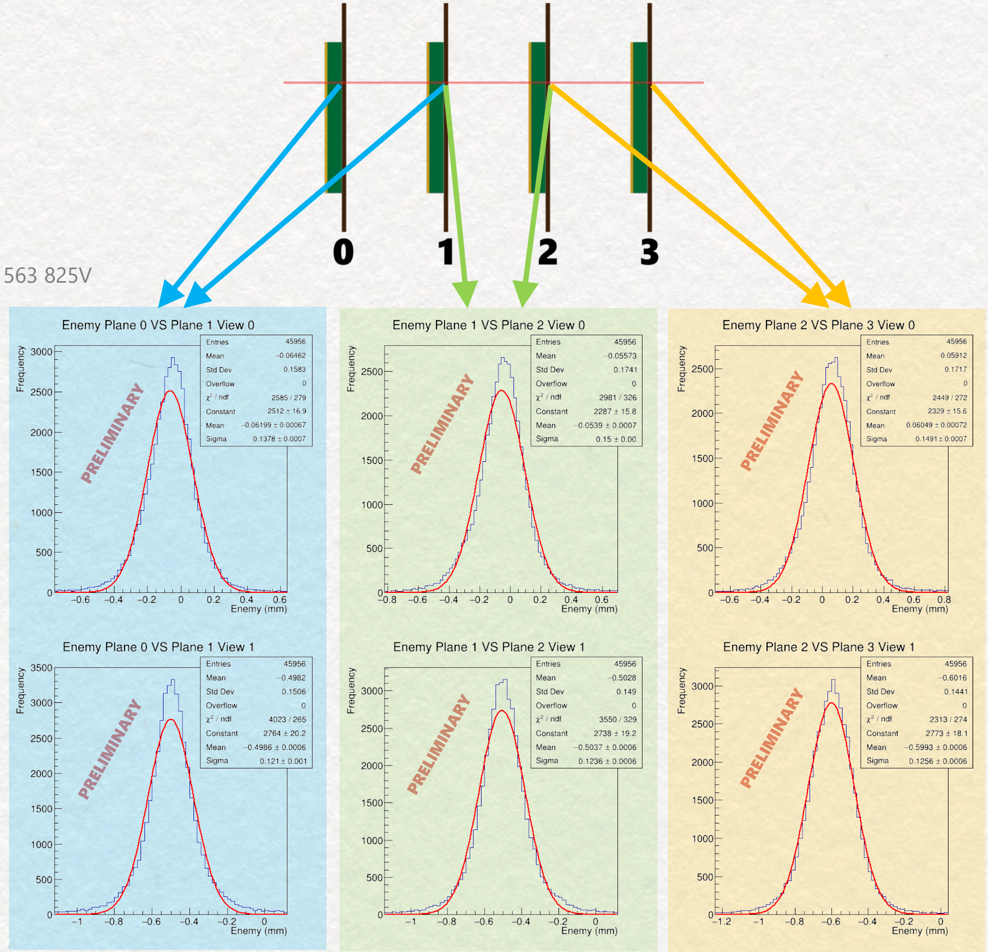

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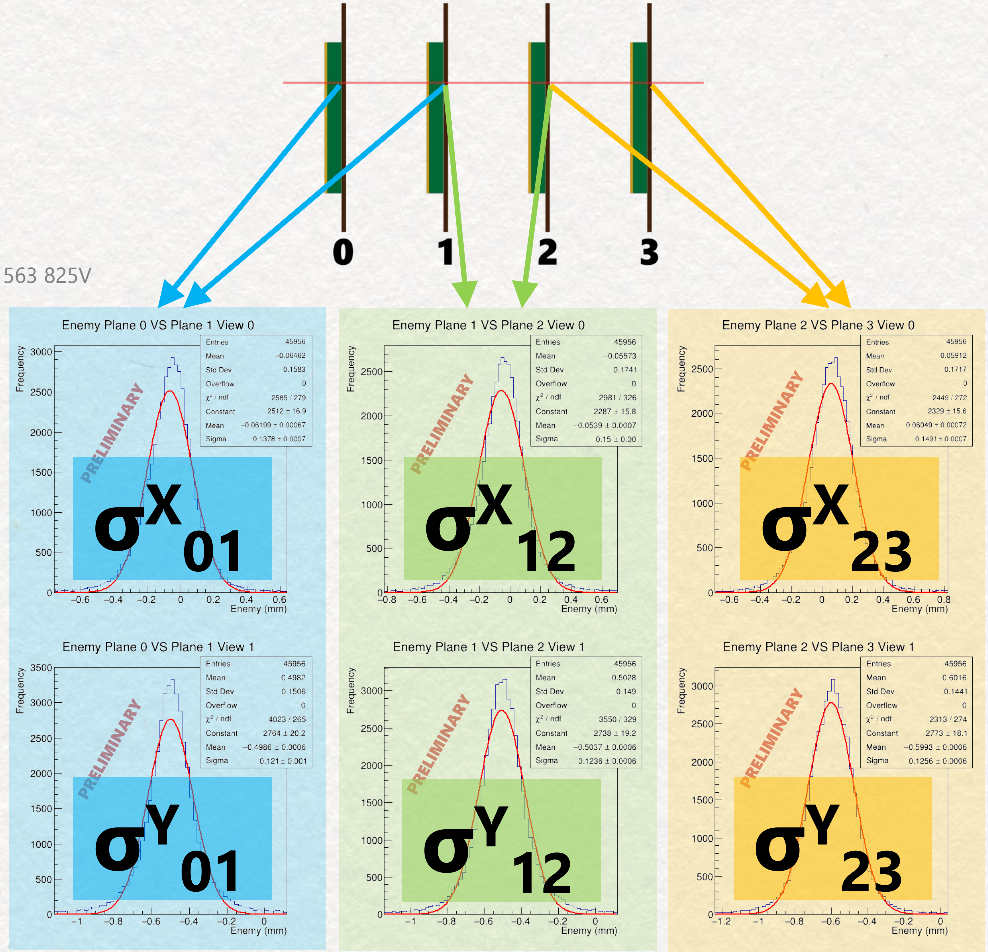

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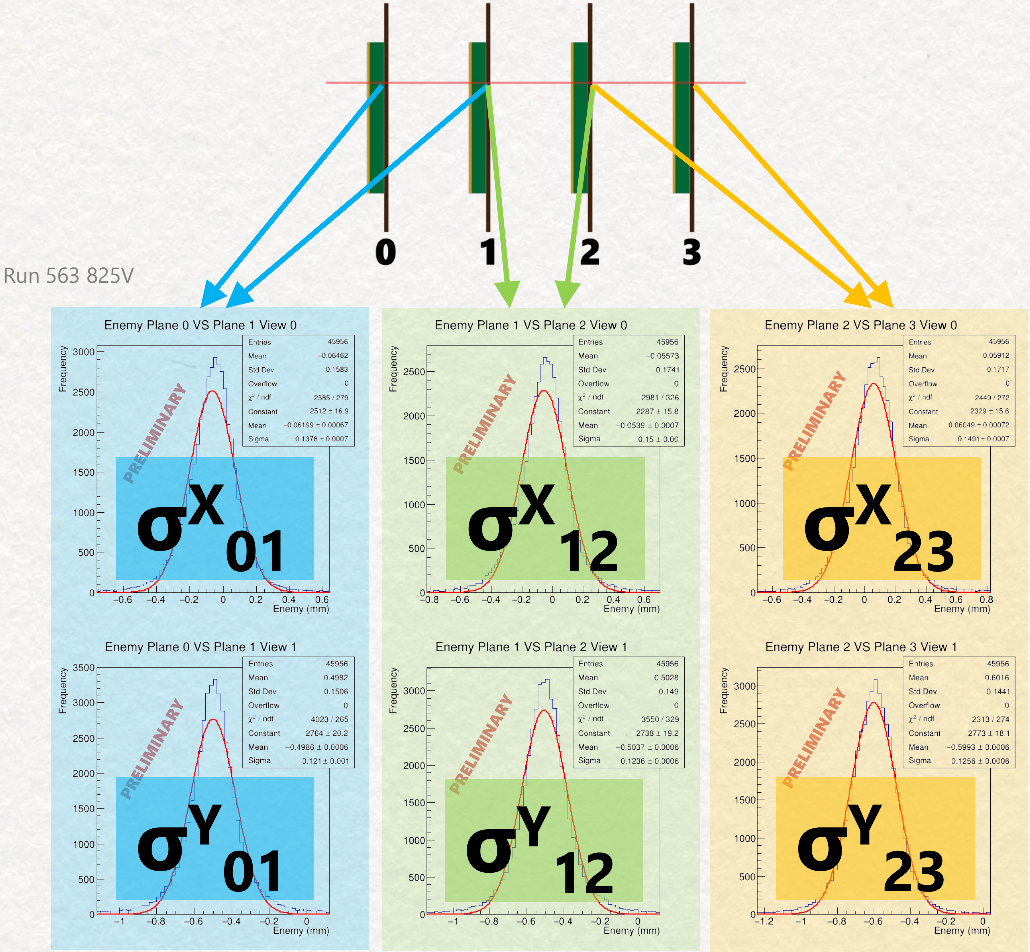

$$\sigma^X_{nm} = \sqrt{(\sigma^X_n)^2 + (\sigma^X_m)^2}$$

Assuming $\sigma^X_n \approx \sigma^X_m \approx \sigma^X$

$$\sigma^X_{nm} = \sqrt{(\sigma^X)^2 + (\sigma^X)^2} = \sqrt{2}\sigma^X$$

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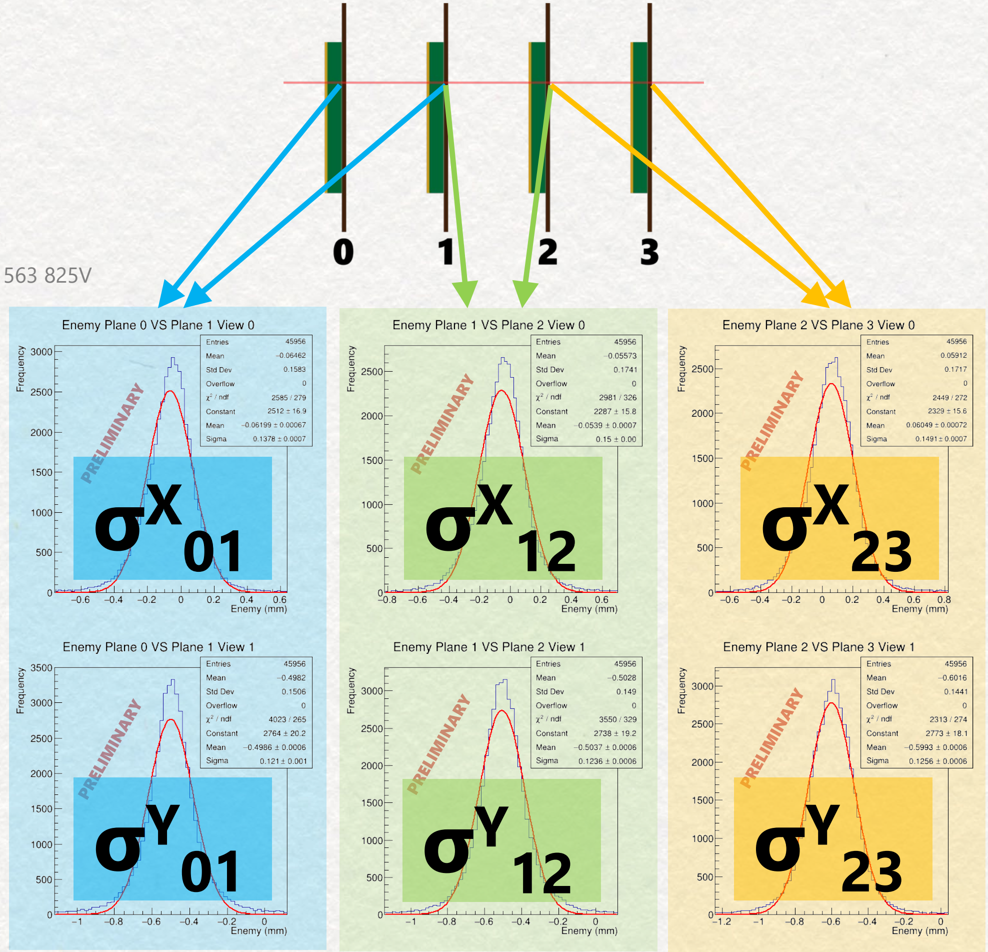

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$$\sigma^X_0 = \sigma^X_{01} / \sqrt{2}$$

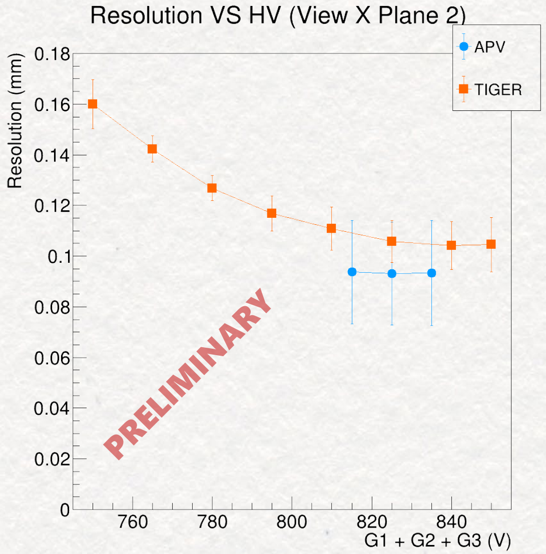
$$\sigma^X_1 = (\sigma^X_{01} + \sigma^X_{12}) / 2\sqrt{2}$$

$$\sigma^X_2 = (\sigma^X_{12} + \sigma^X_{23}) / 2\sqrt{2}$$

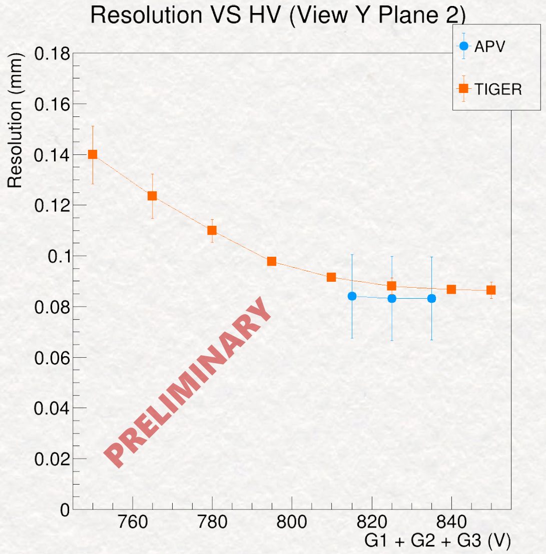
$$\sigma^X_3 = \sigma^X_{23} / \sqrt{2}$$

The error on the resolutions was assumed equal to their dispersion

Resolution



Resolution VS HV (View X Plane 2)
APV
TIGER
Resolution (mm)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
760
780
800
820
840
G1 + G2 + G3 (V)
PRELIMINARY



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PRELIMINARY

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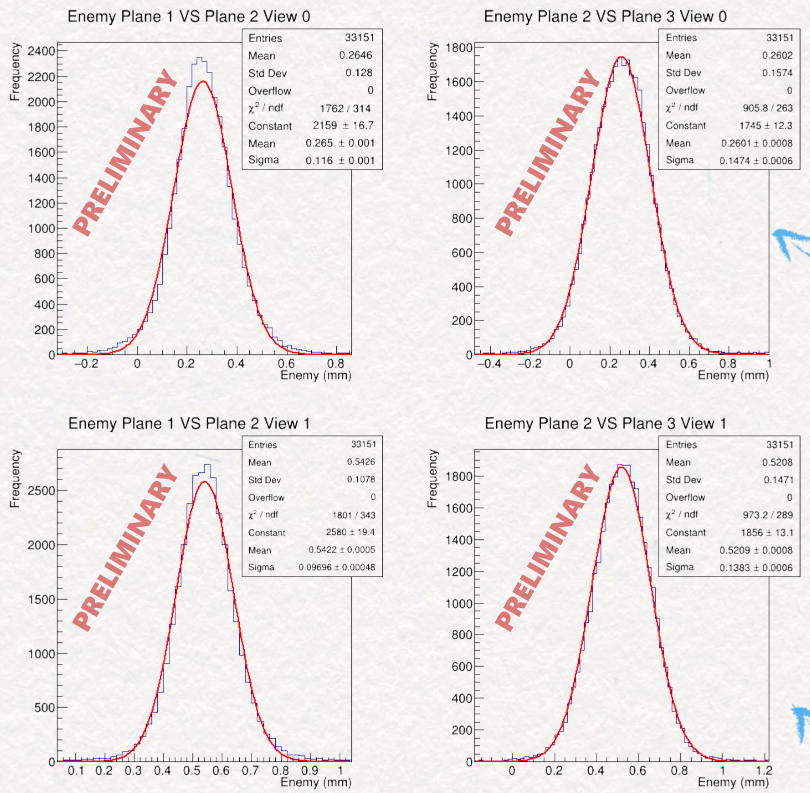

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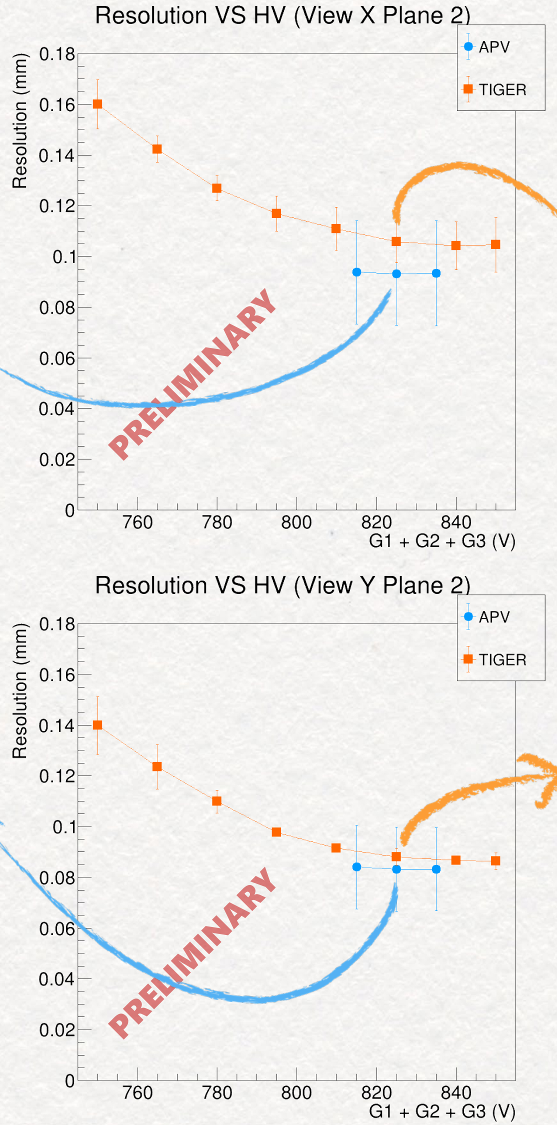

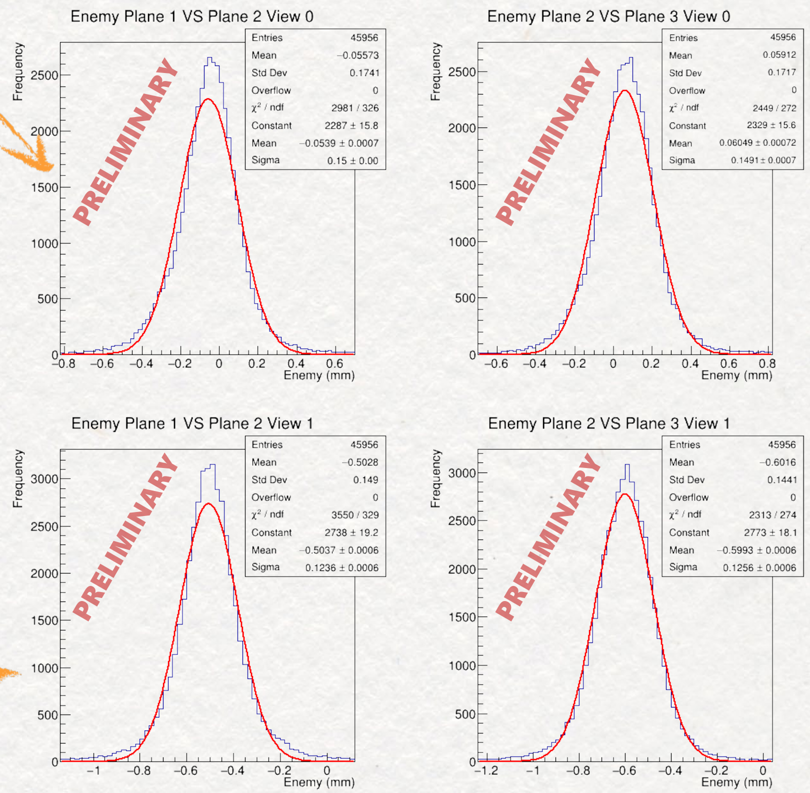

Run 563 825V

Simple gaussian fits of the **Enemy residuals distributions** are used to evaluate the resolution

A more accurate treatment may require the implementation of a **double gaussian fit**

Conclusions

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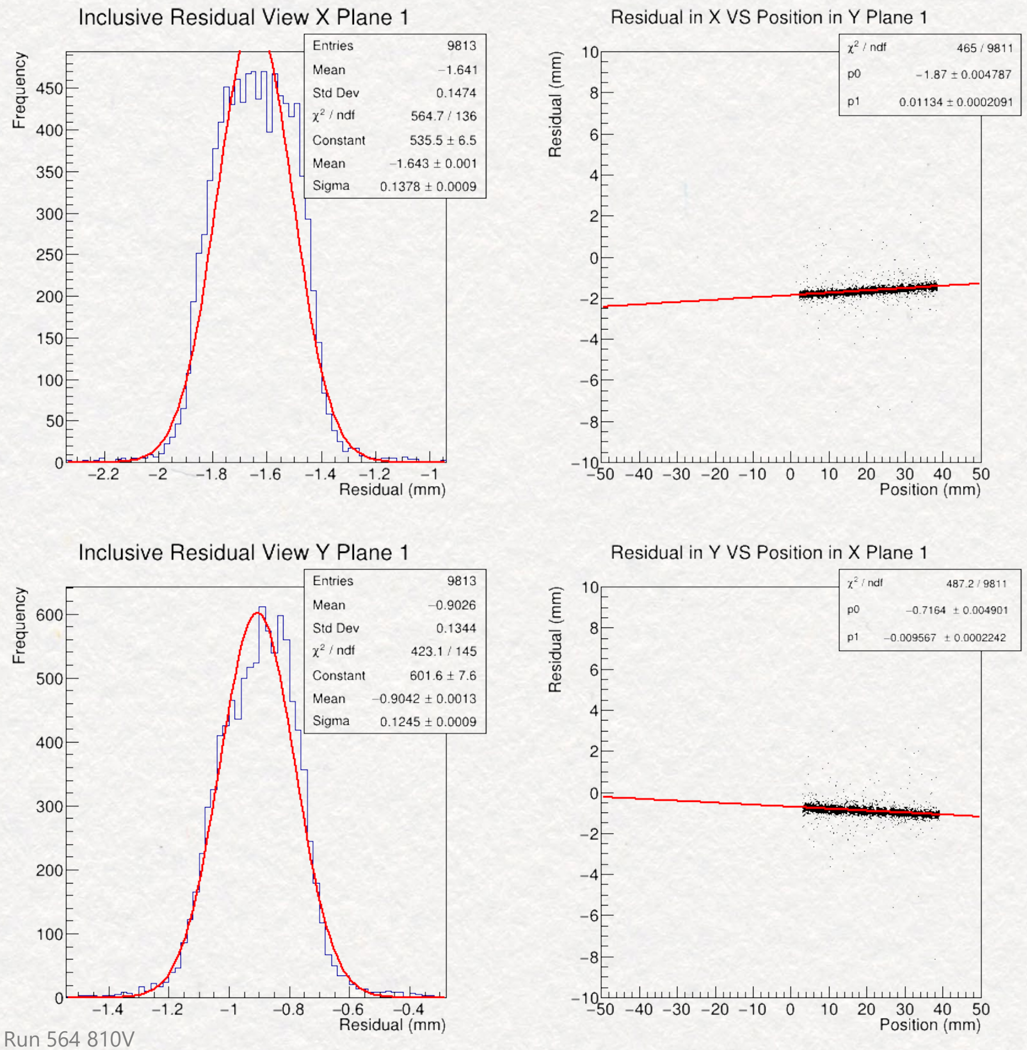
The study on the efficiency of the two readout chains is still at an early stage

Thanks for your attention

Backup

Alignment Phase 1: XY Rotations

BEFORE



Run 564 810V

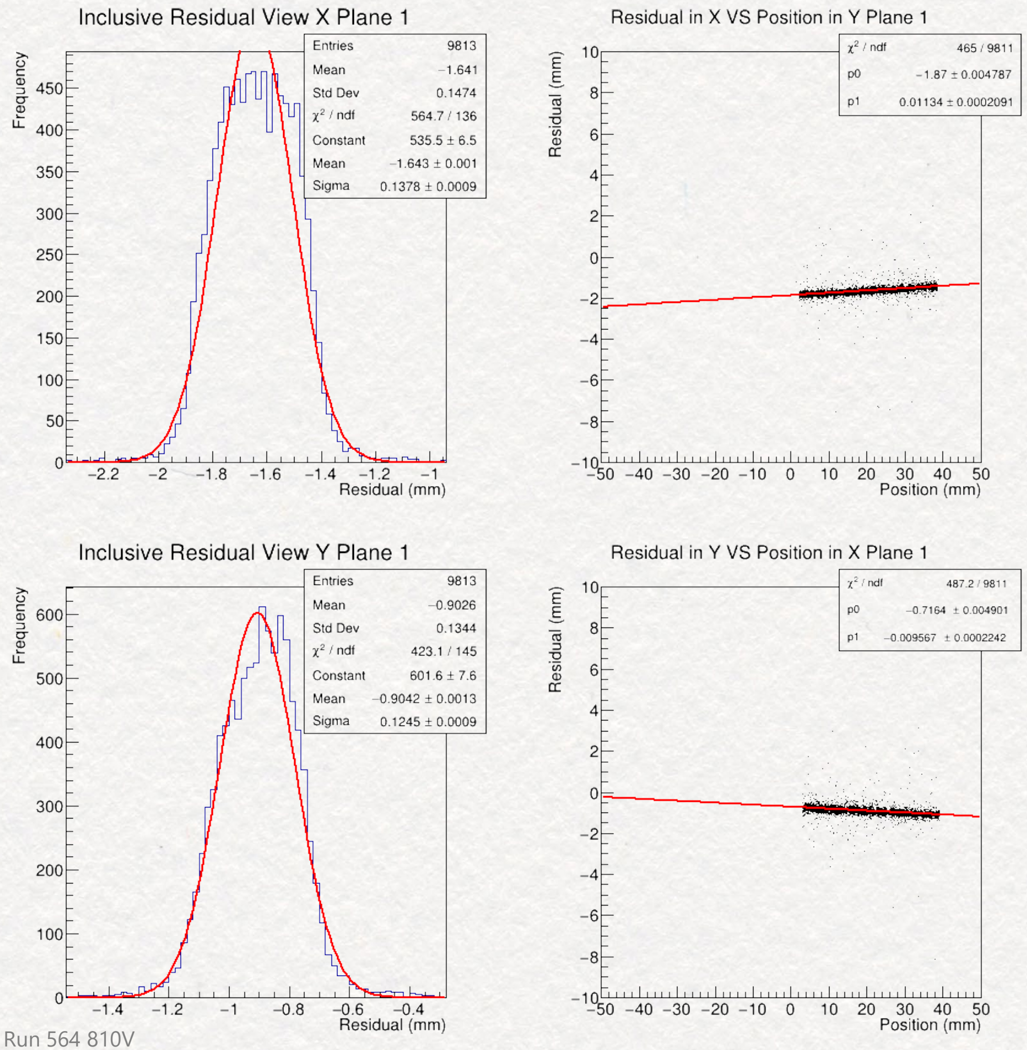
It is impossible to perfectly align the detectors during the installation of the setup

The two coordinates of a hit are collected separately and therefore uncoupled

This leads to some inconsistencies…

Alignment Phase 1: XY Rotations

BEFORE



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For an anode with X and Y strips perpendicular to each other **we expect the residual in one view to have no dependence on the position of the cluster in the other one**

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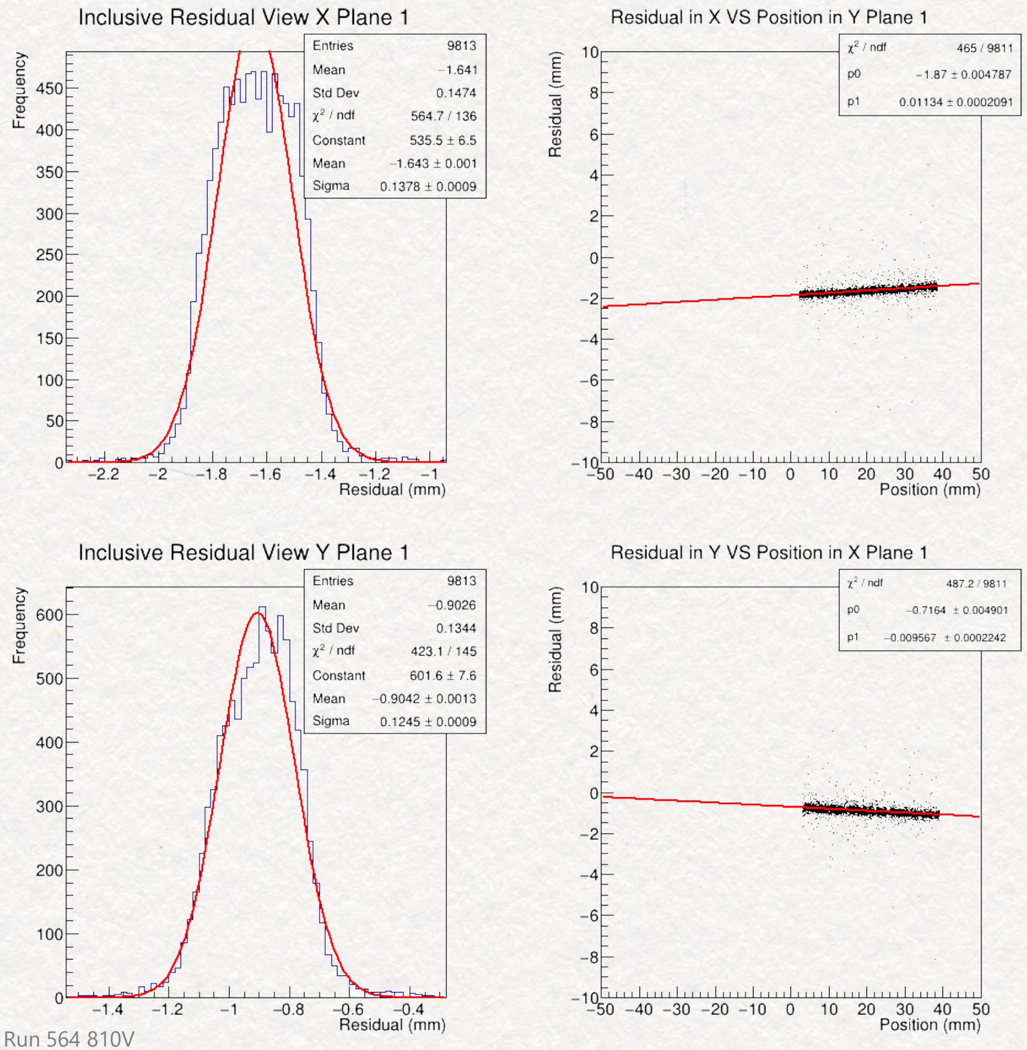

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Corrections must be applied to correctly interpret the data and provide reliable track reconstructions

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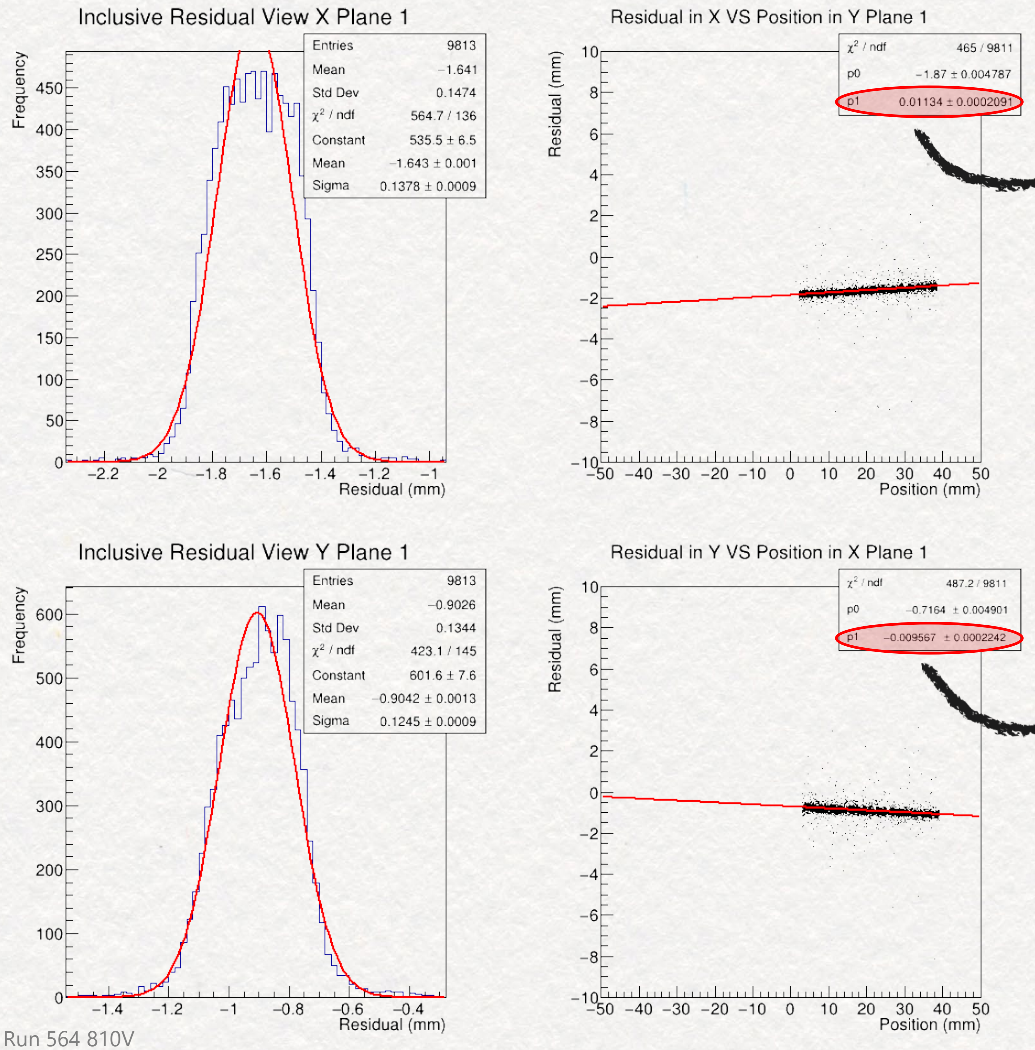


Run 564 810V

θ_{XY}

θ_{YX}

To correct for these we rotate of an angle:

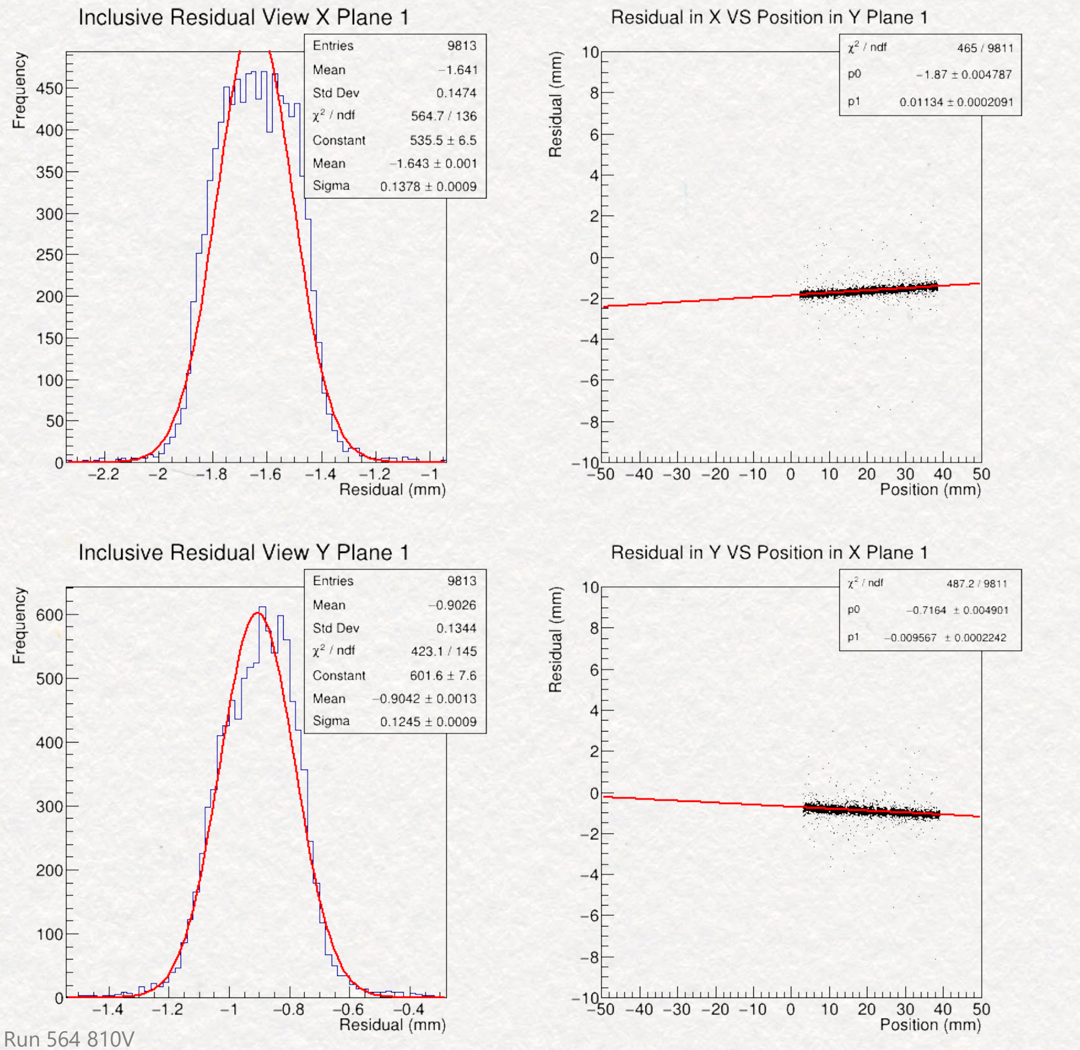
$$\theta = (\theta_{XY} - \theta_{YX})/2$$

Rotations couple together X and Y

They can only be applied to 2D clusters

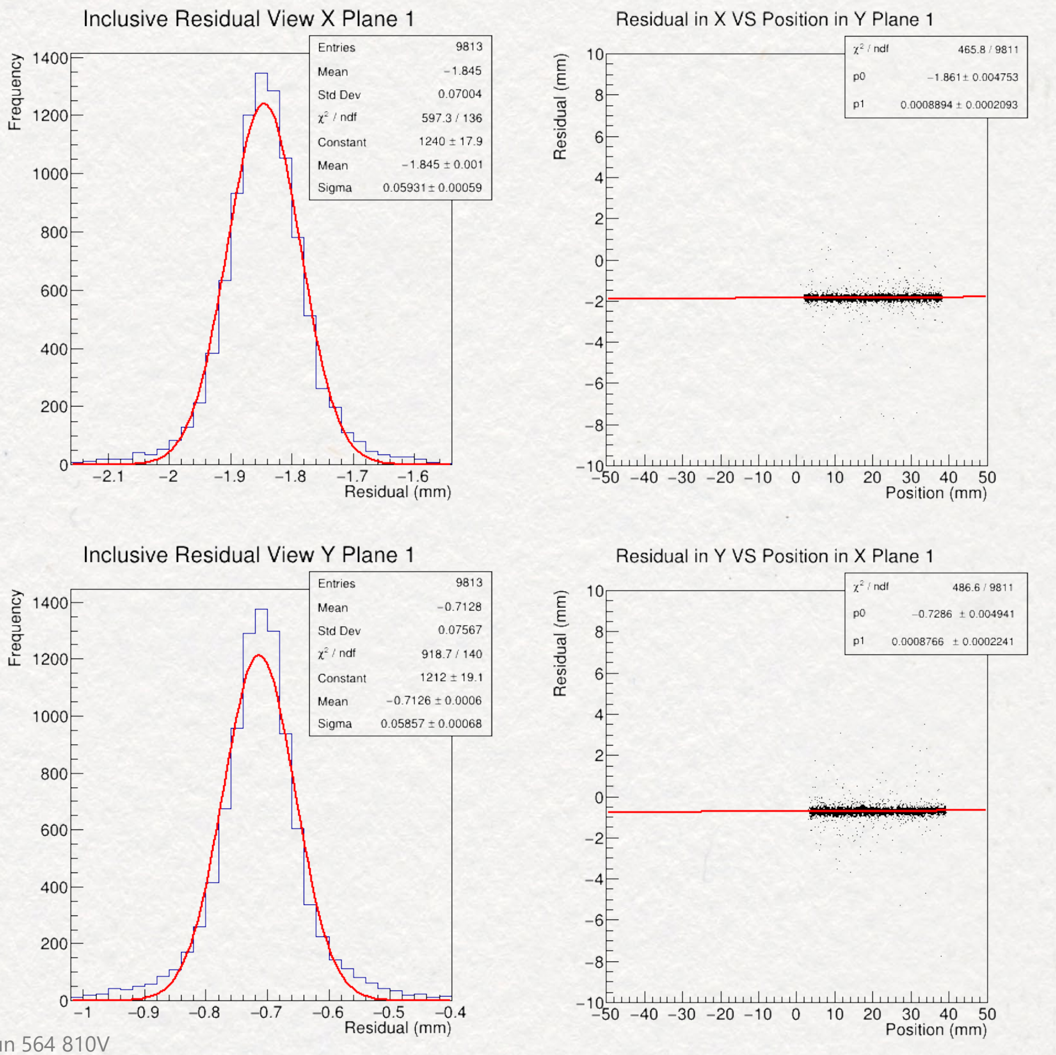
Alignment Phase 1: XY Rotations

BEFORE



Run 564 810V

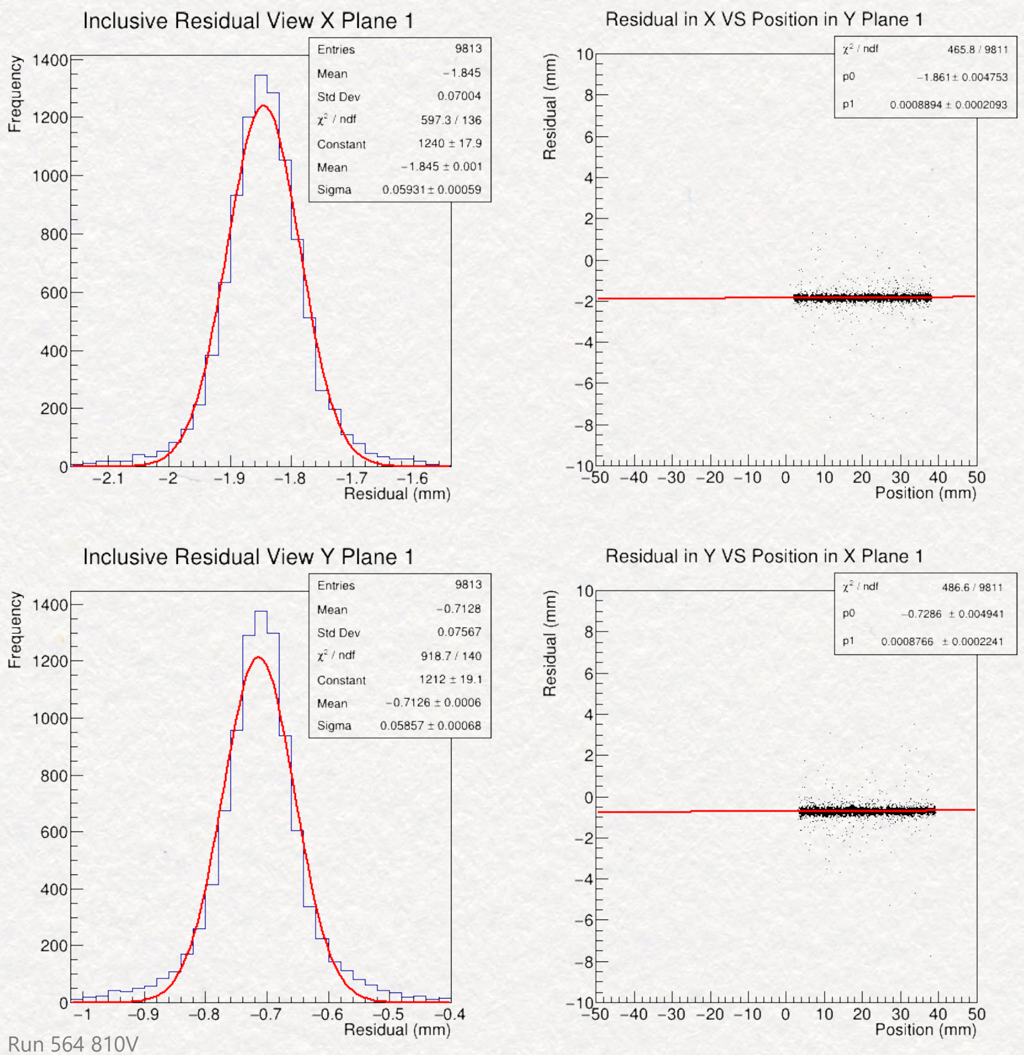
AFTER



Run 564 810V

Alignment Phase 2: XY Traslations

BEFORE



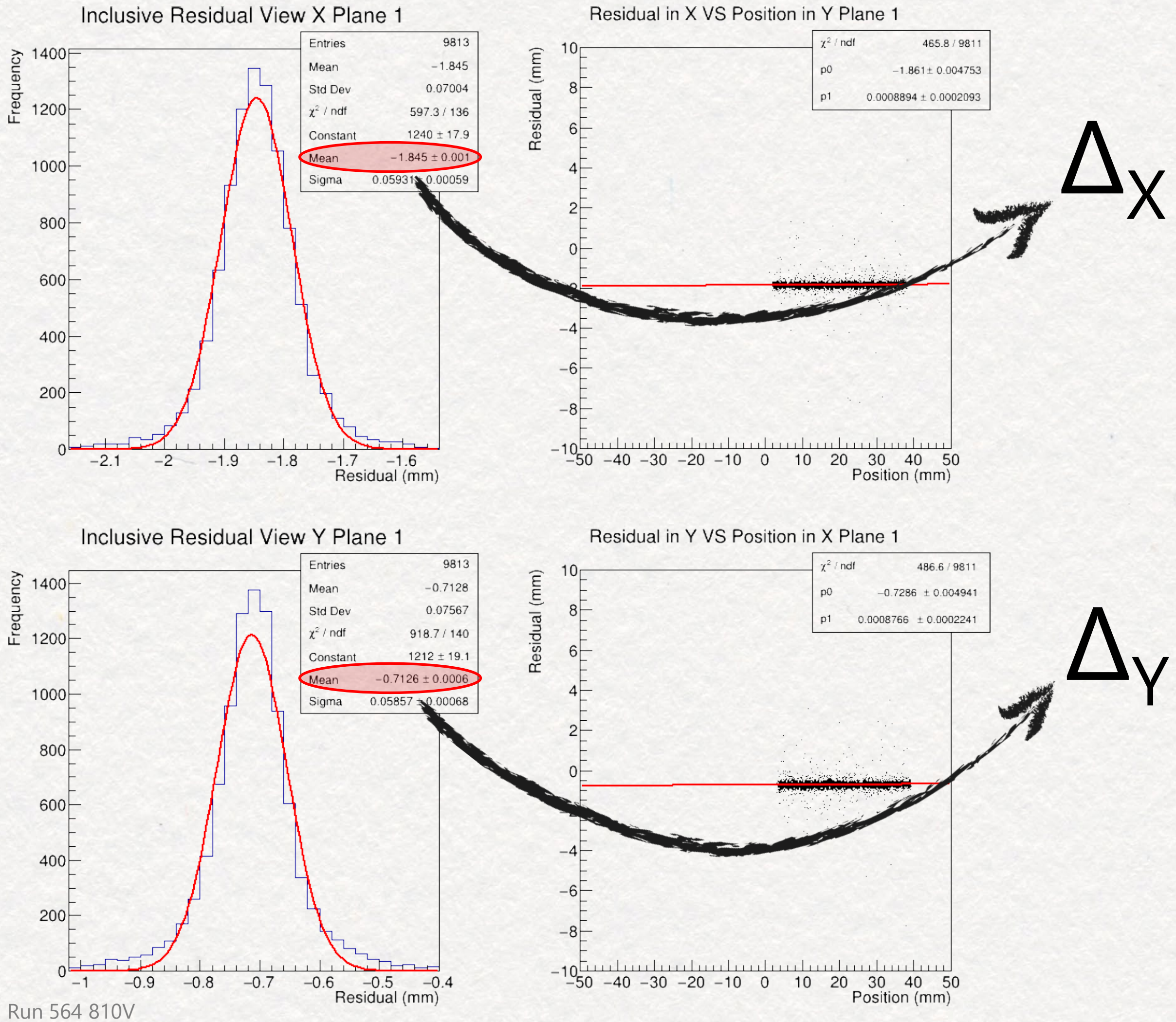
Run 564 810V

The shape of the distributions is greatly improved but they are **still not centered in 0**

To correct for this it is necesary to traslate both views

Alignment Phase 2: XY Traslations

BEFORE



Run 564 810V

Each view is shifted of an amount equal to the mean of the residuals distribution in that same view

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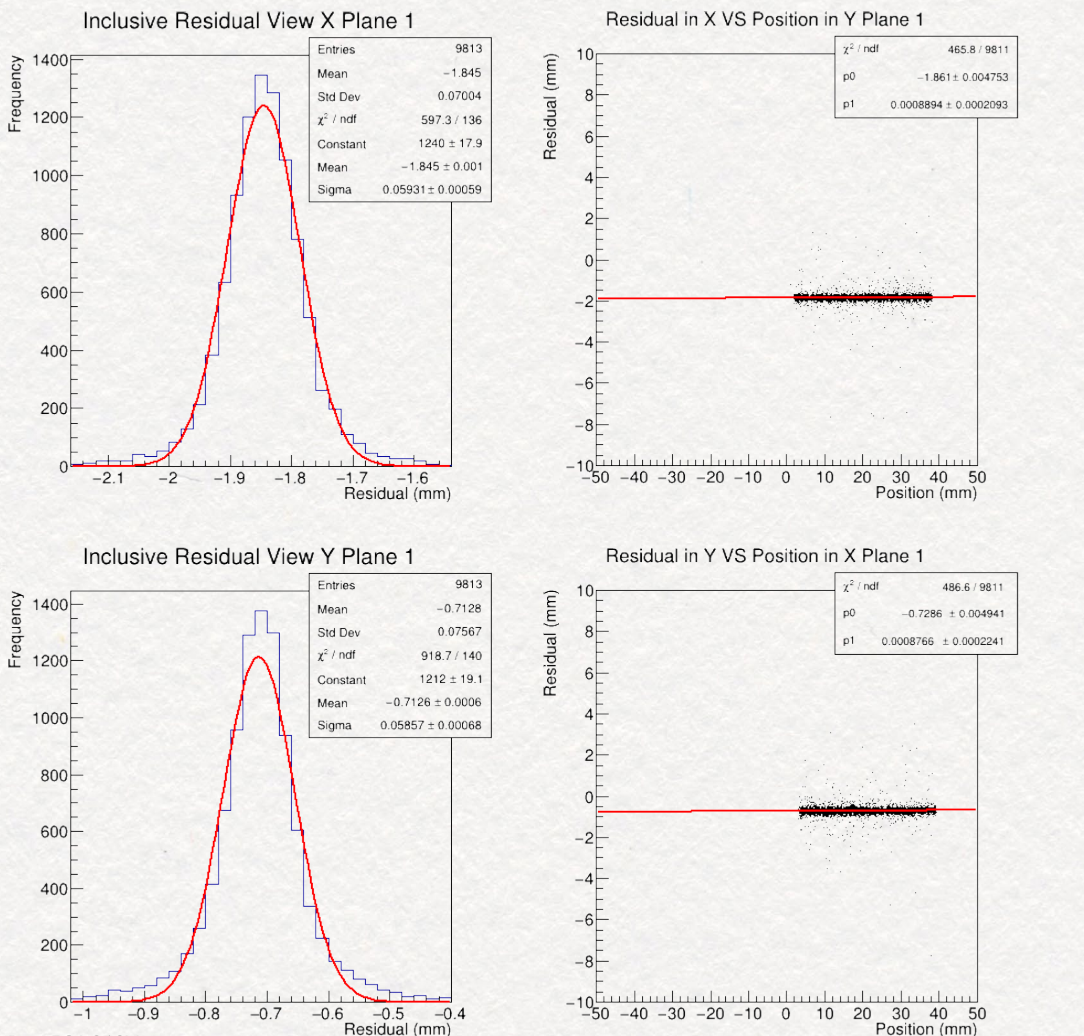
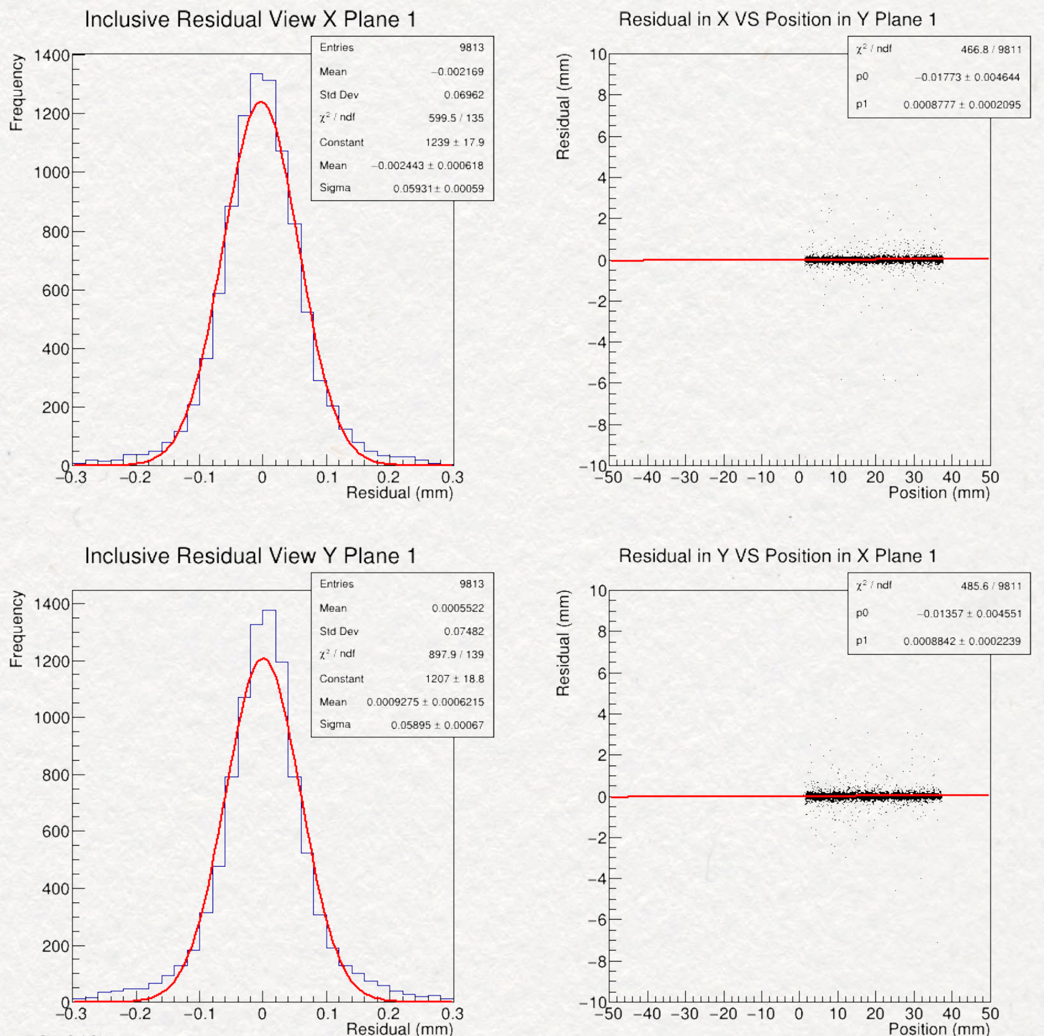


Run 564 810V

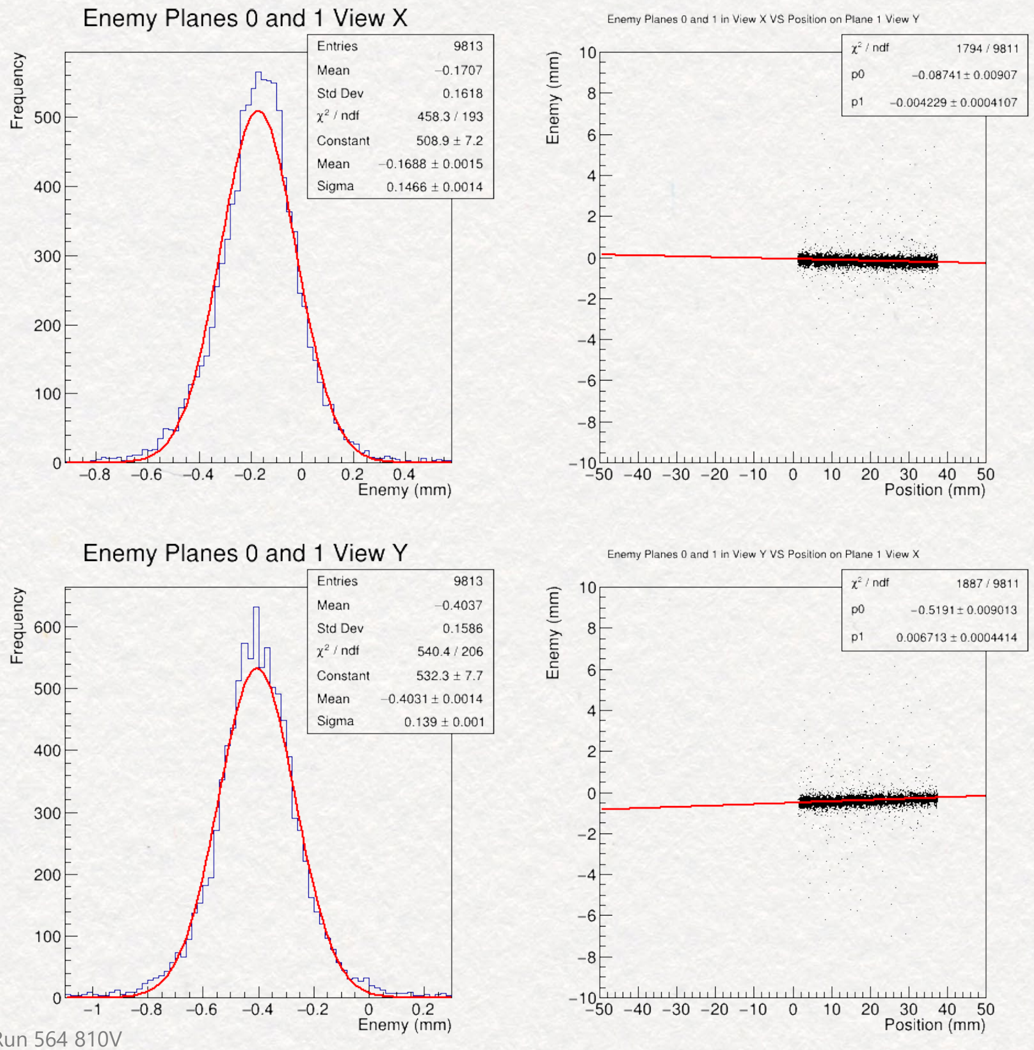
AFTER



Run 564 810V

Alignment Phase 3: Enemy Rotations

BEFORE



Run 564 810V

The resolution will later be evaluated using a technique called **''Enemy''**

The **difference between the position** of the hit **measured by a plane** in a certain view **and the one measured by the plane immediately downstream** on the same view is used to assess the resolution of the system without having to factor in the contribution of the tracking system

Alignment Phase 3: Enemy Rotations

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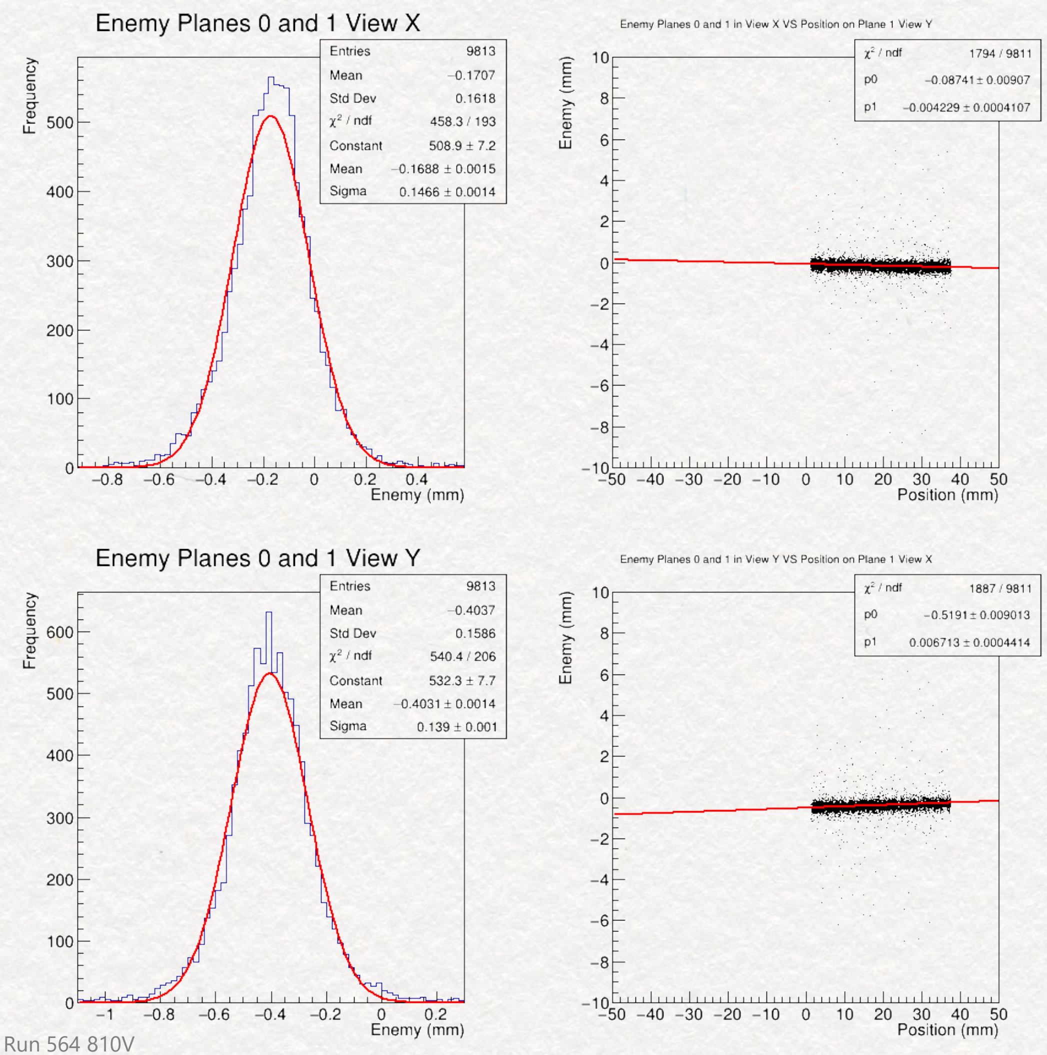

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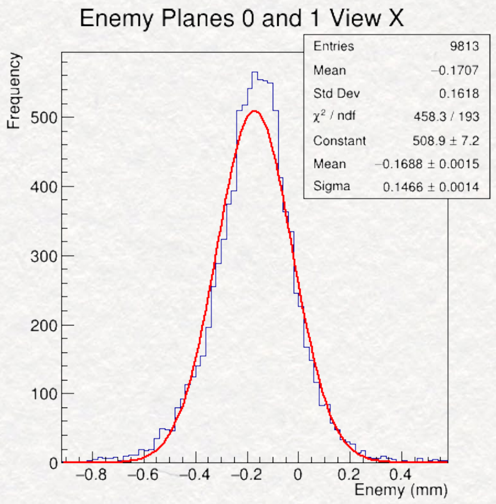
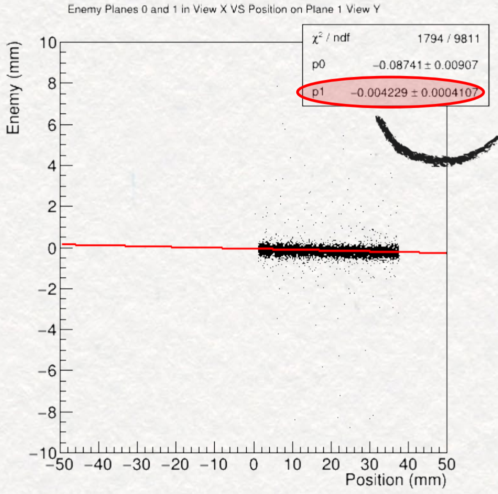
Assuming the chambers are not rotated with respect of each other, **this difference in one view should not depend on the position of the cluster in the other, on either of the two planes**

To correct this we rotate the last three chambers until they are aligned with the first

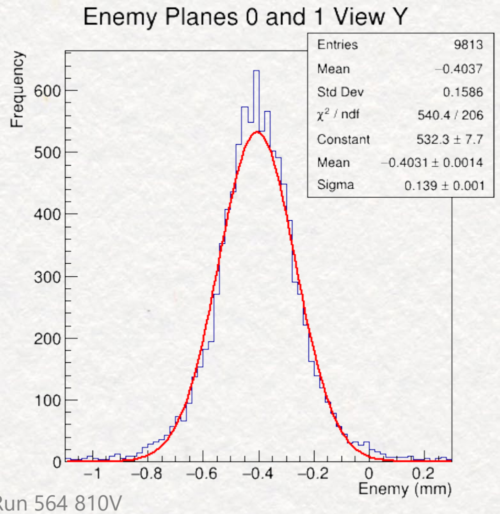
Alignment Phase 3: Enemy Rotations

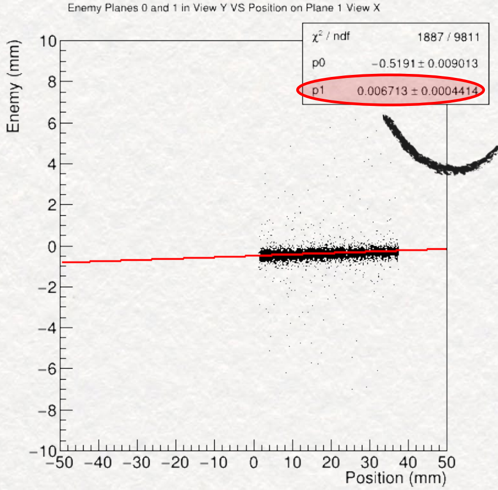
BEFORE





θ^e_{XY}





θ^e_{YX}

Run 564 810V

As for the residuals rotation angle is the average between the ones obtained from the two slopes

$$\theta^e = (\theta^e_{XY} - \theta^e_{YX})/2$$

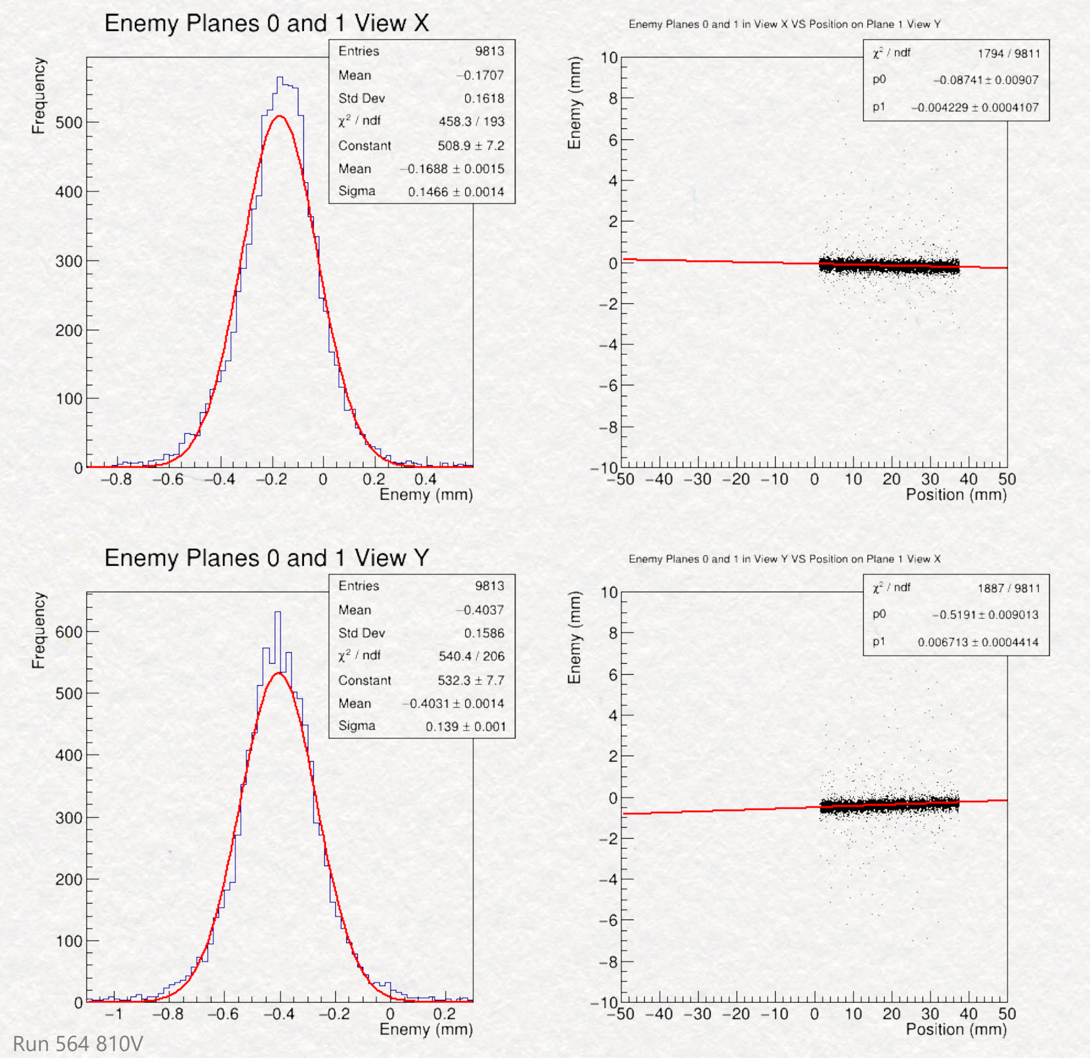
Each rotation is calculated with respect to the nearest chamber upstream

So the total rotation angles are:

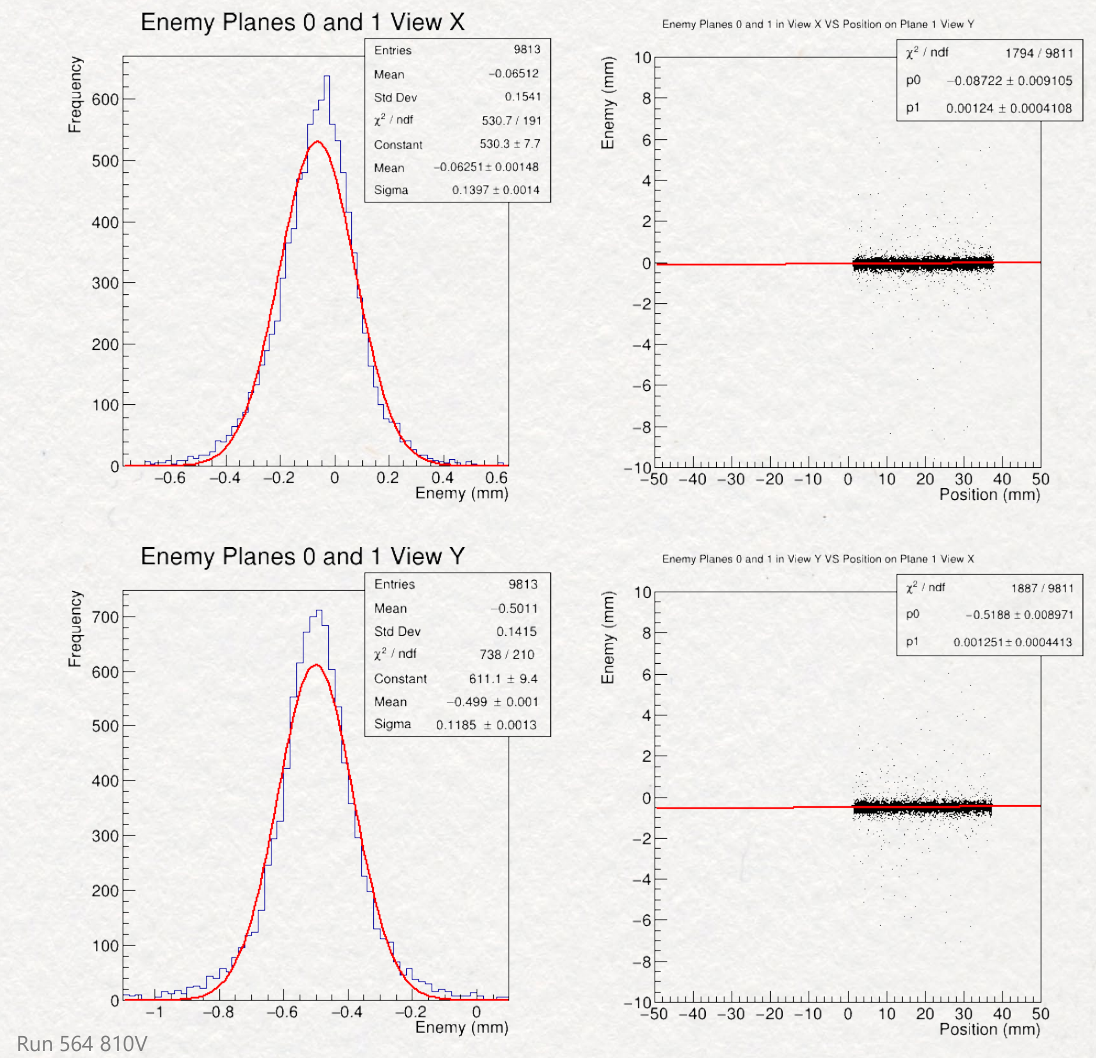
$$\theta^e_1 = \theta^e_{10}$$
$$\theta^e_2 = \theta^e_{10} + \theta^e_{21}$$
$$\theta^e_3 = \theta^e_{10} + \theta^e_{21} + \theta^e_{32}$$

Alignment Phase 3: Enemy Rotations

BEFORE



AFTER



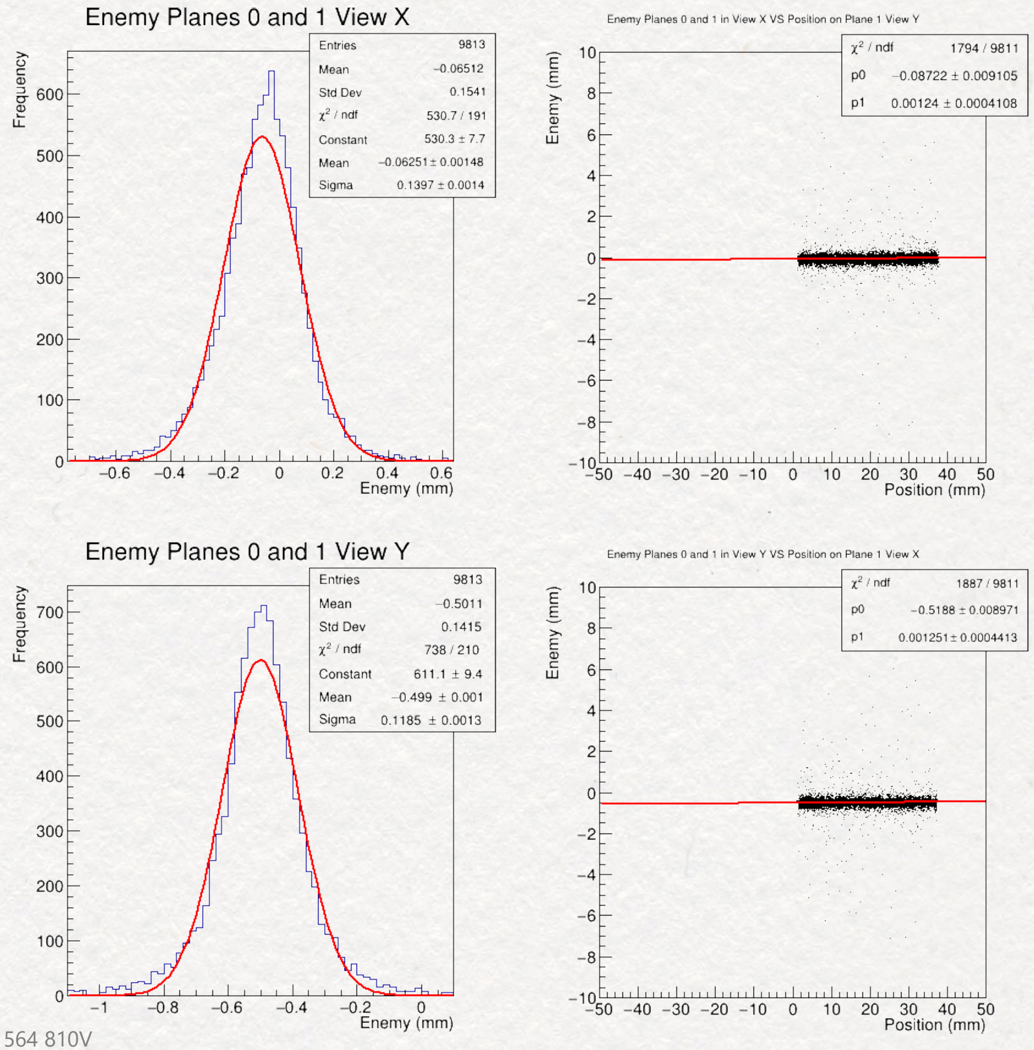
Alignment Phase 3: Enemy Rotations

AFTER

The mean of these distributions depends on the inclination of the tracks

As it does not affect the final result we do not correct this behavior

Moreover, it would require a rotation of the whole setup and so it would introduce an additional degree of uncertainty (errors in the fits, uncertainties in the spacing between the chambers)



Run 564 810V