sTGC Single Point Resolution Analysis for the New Small Wheel (NSW)

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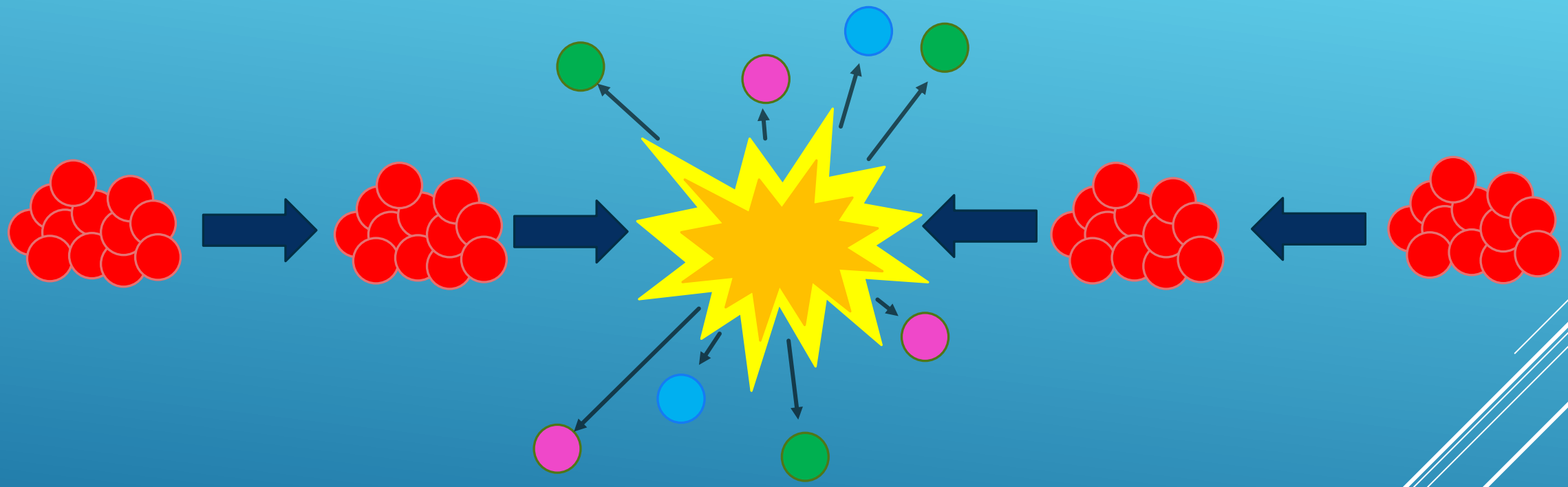
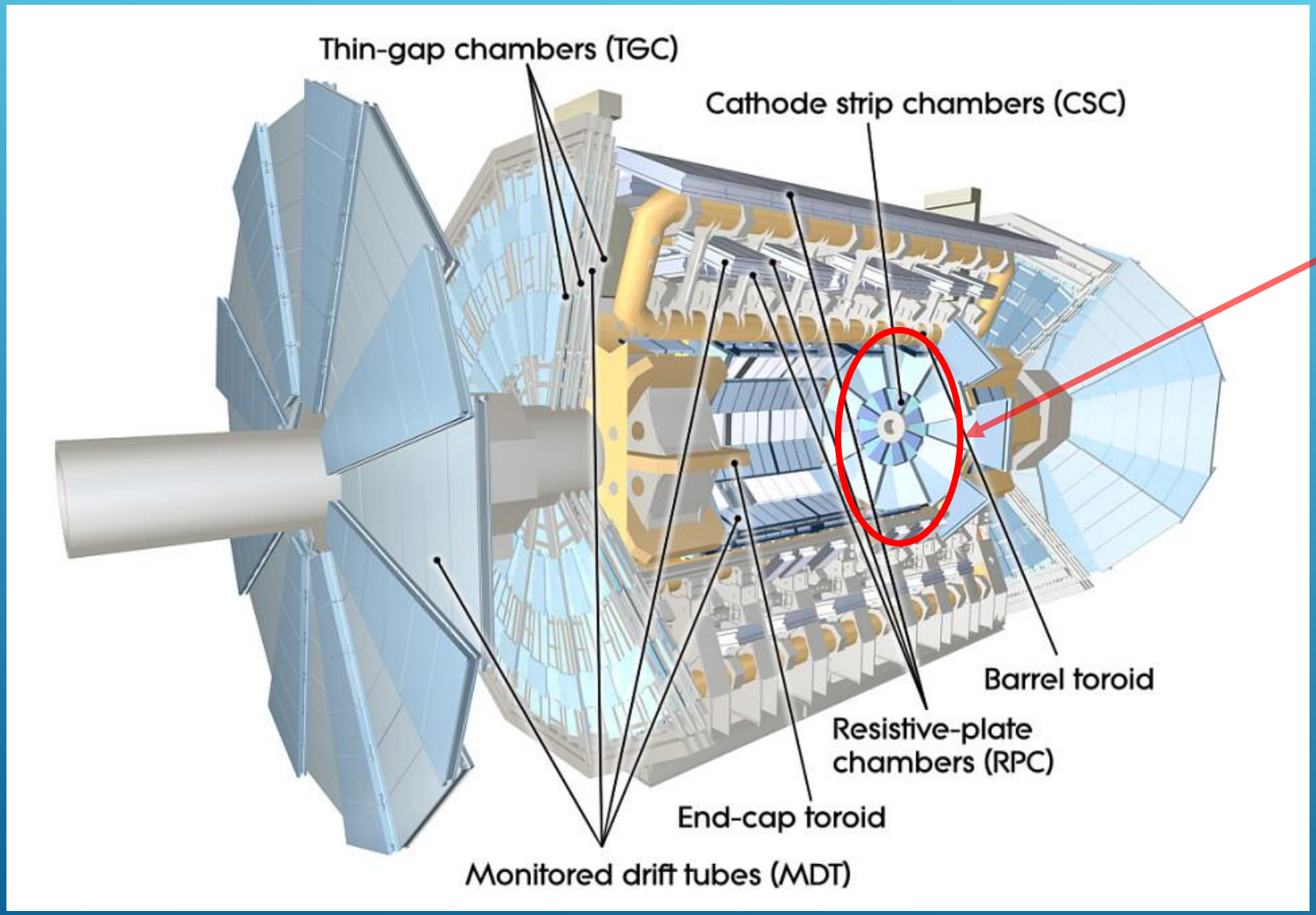
Inside the LHC



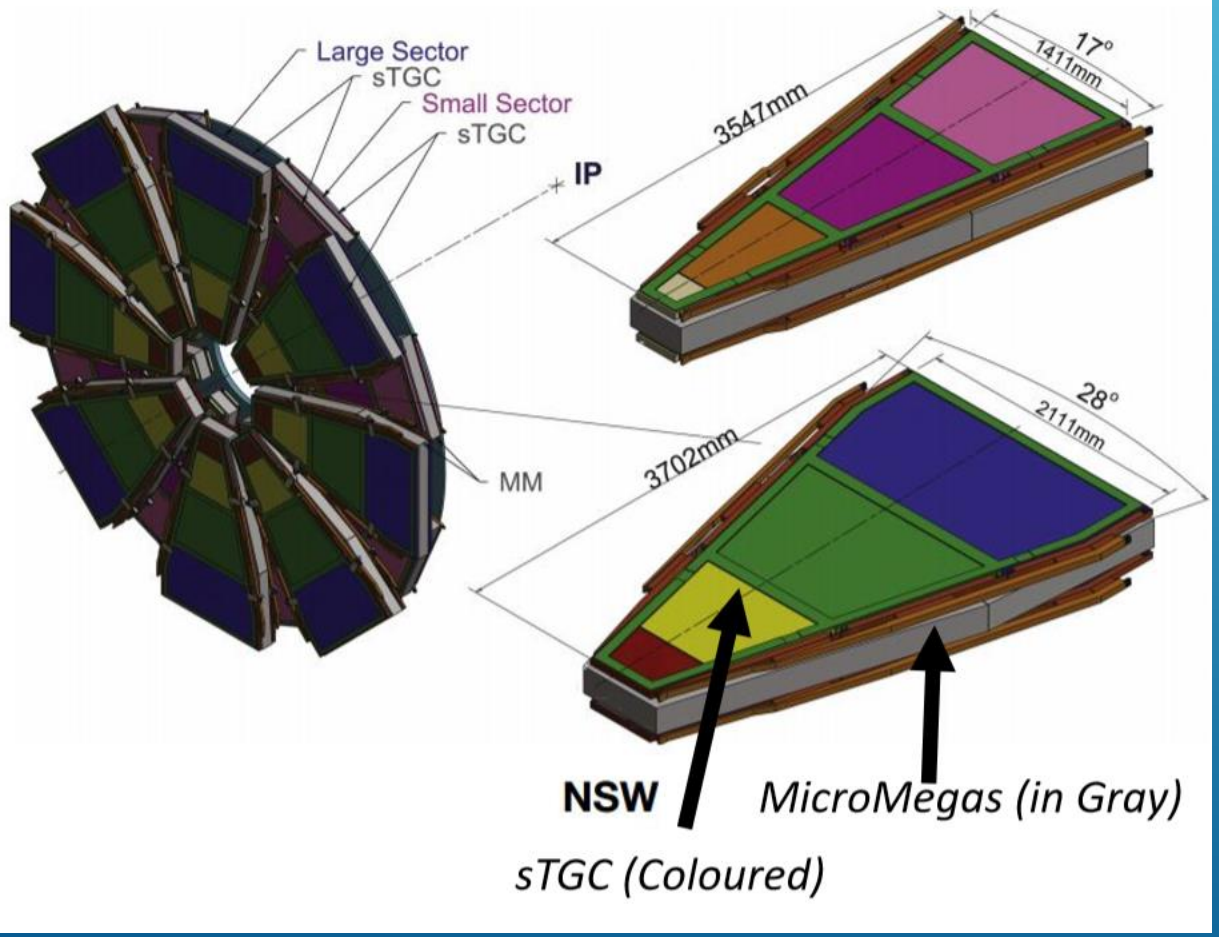
- During run 2, bunches of protons containing over 10^{11} protons per bunch are collided at a rate of 40MHz with a center point energy of 13TeV

ATLAS Detector at the LHC



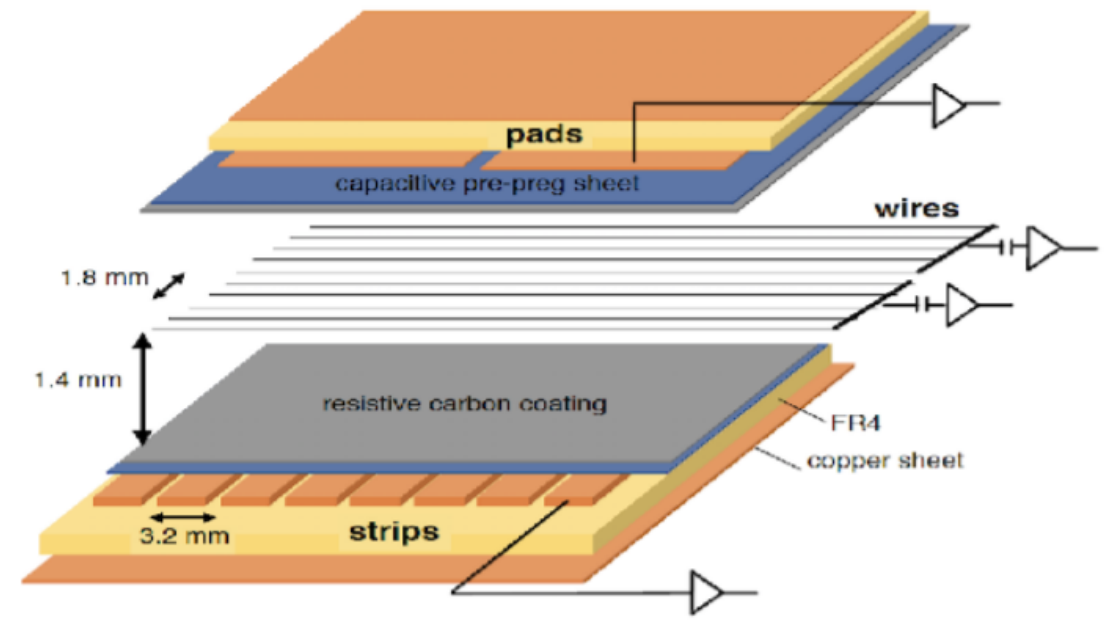
Current Small Wheel

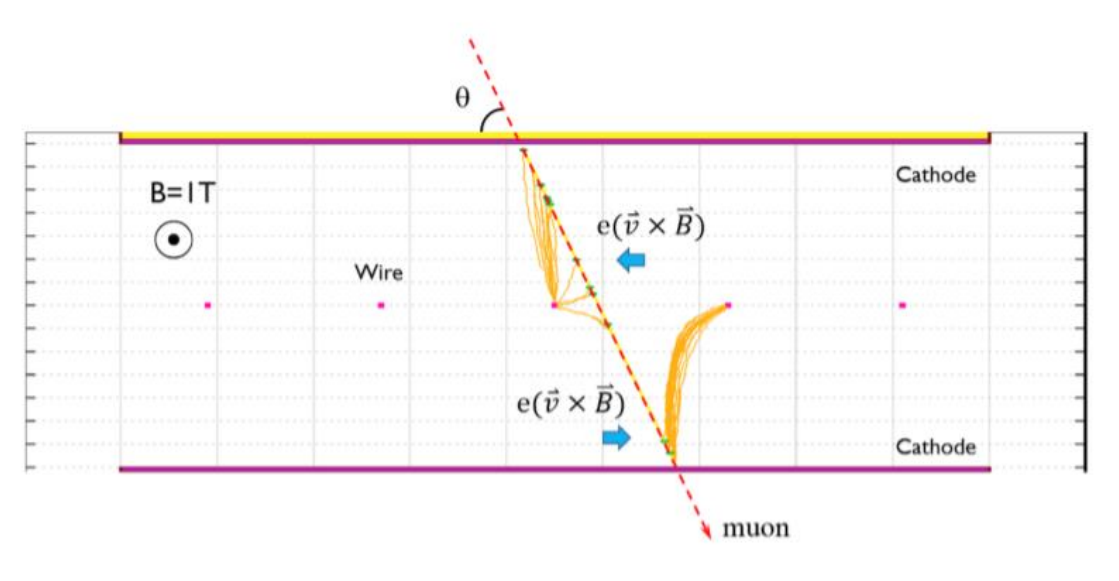
… which is now being replaced with the New Small Wheel



This together with the Big Wheel gives precision tracking of muons leaving the Interaction point (IP)

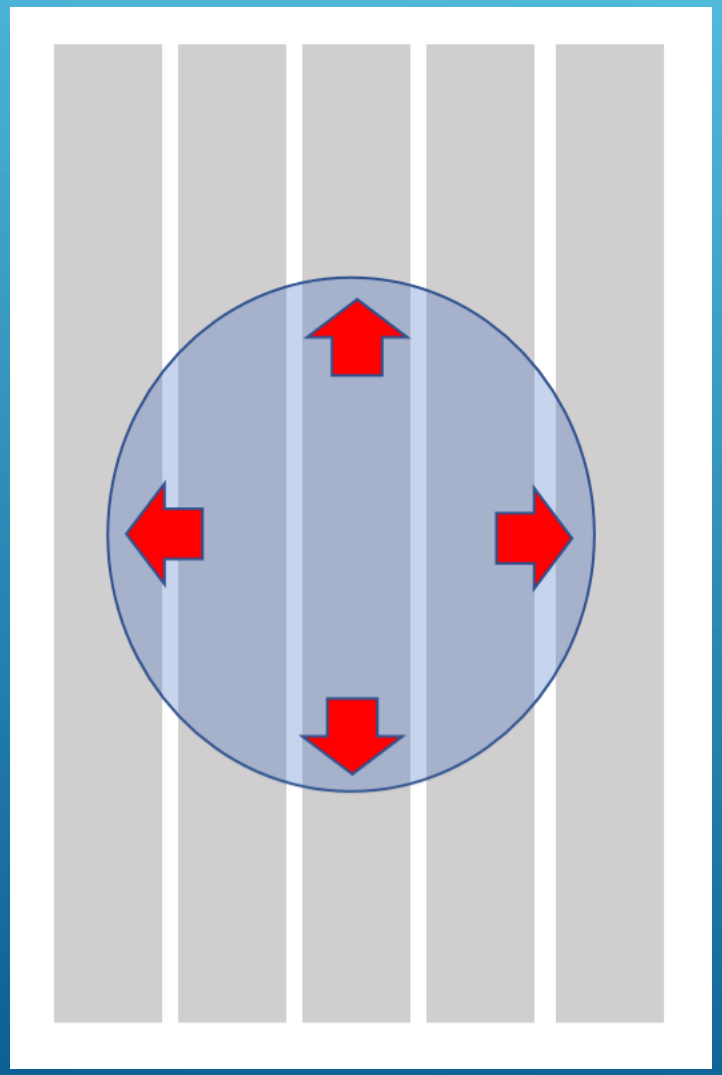
sTGC Design

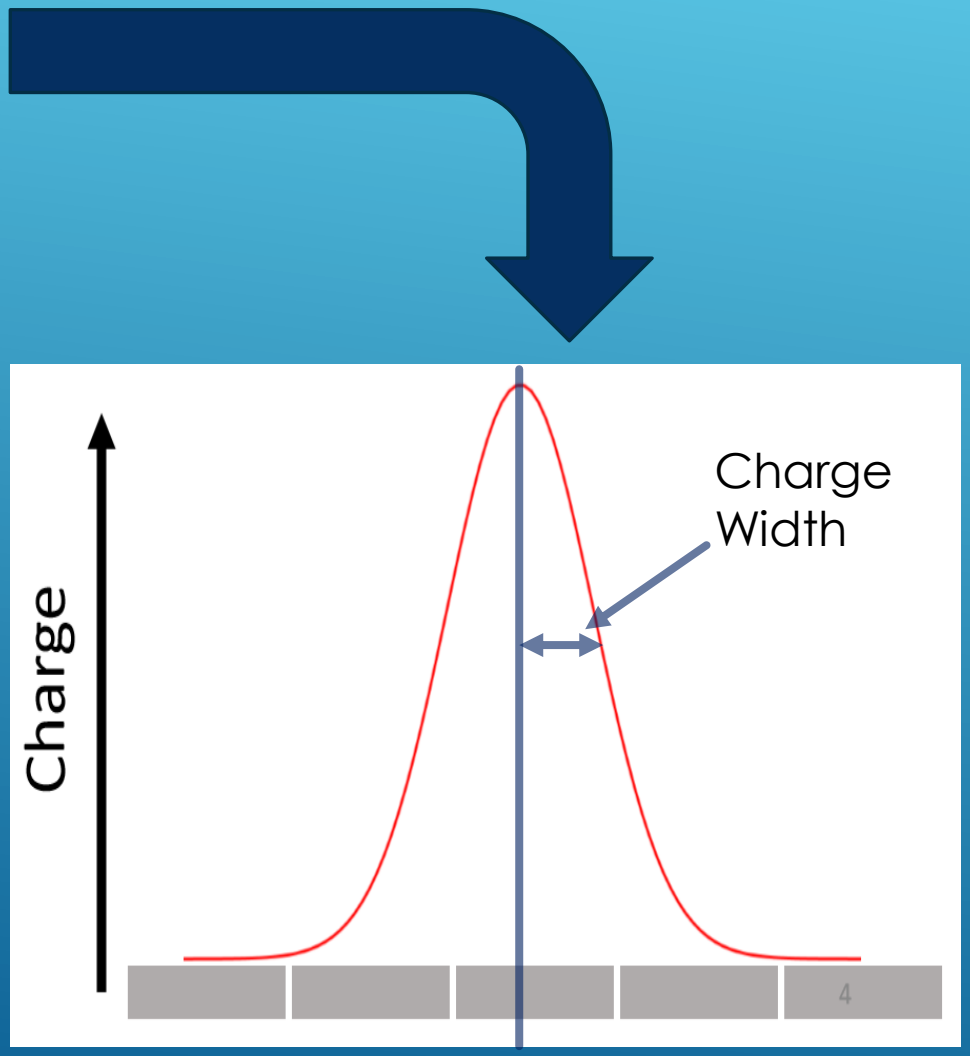




- The NSW's sTGC layers are Multiwire Proportional chambers.
- Strong electric fields guide ionized electrons to sTGC wires (anode).
- Increasing field strength near wire causes an avalanche of electrons.
- Charge on wires induce charge on the resistive layer and strips.
- Induced charge in strips are used to reconstruct the Y position of the hit, while the pads and wires are used to reconstruct the X position.

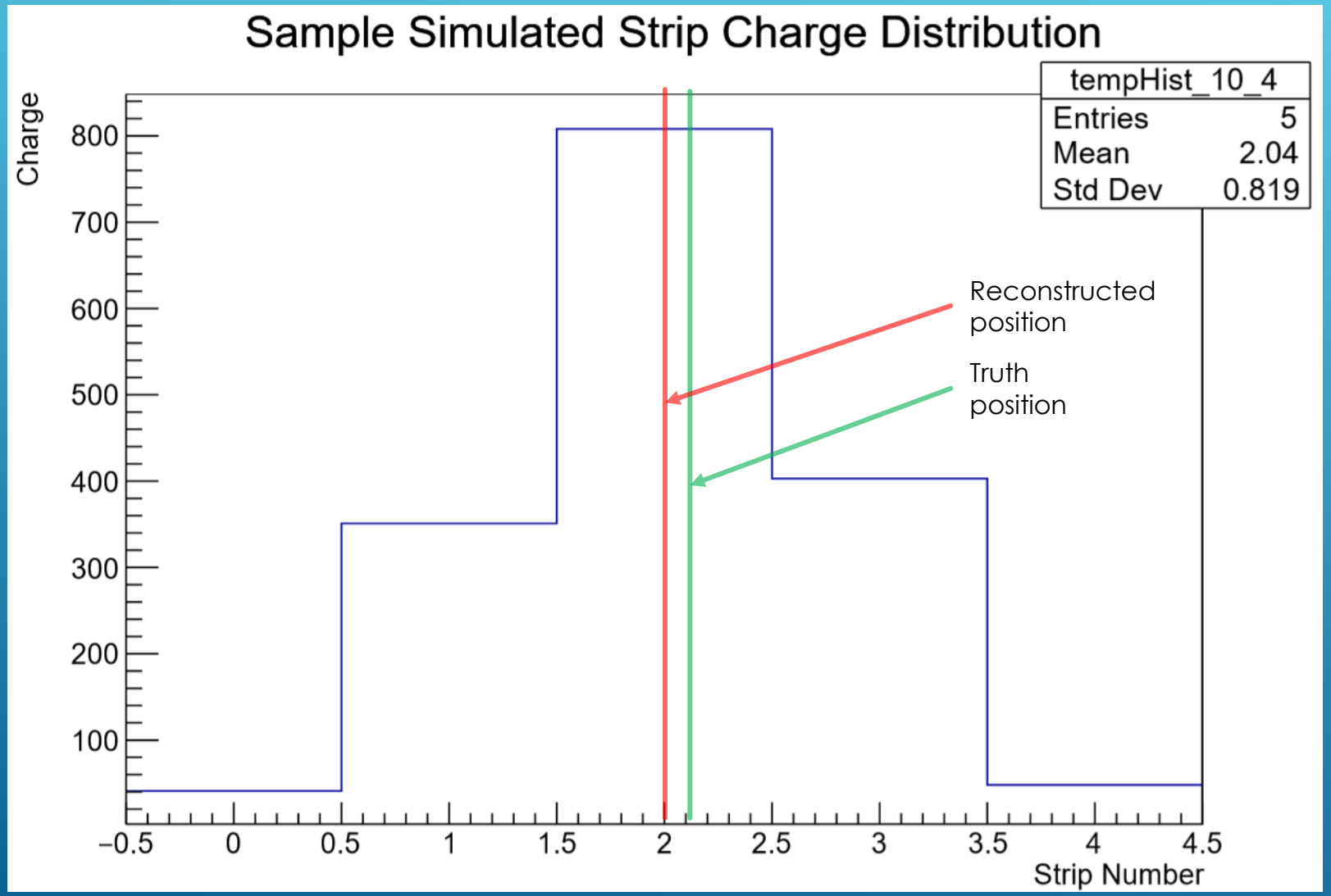
Tuning the sTGC Simulation





- Want to tune parameters of the simulation, such as charge width (a measure of how much the charge spreads over the strip surface) to better represent reality.
- Can do this using the single point resolution

What Does a Hit Look Like?

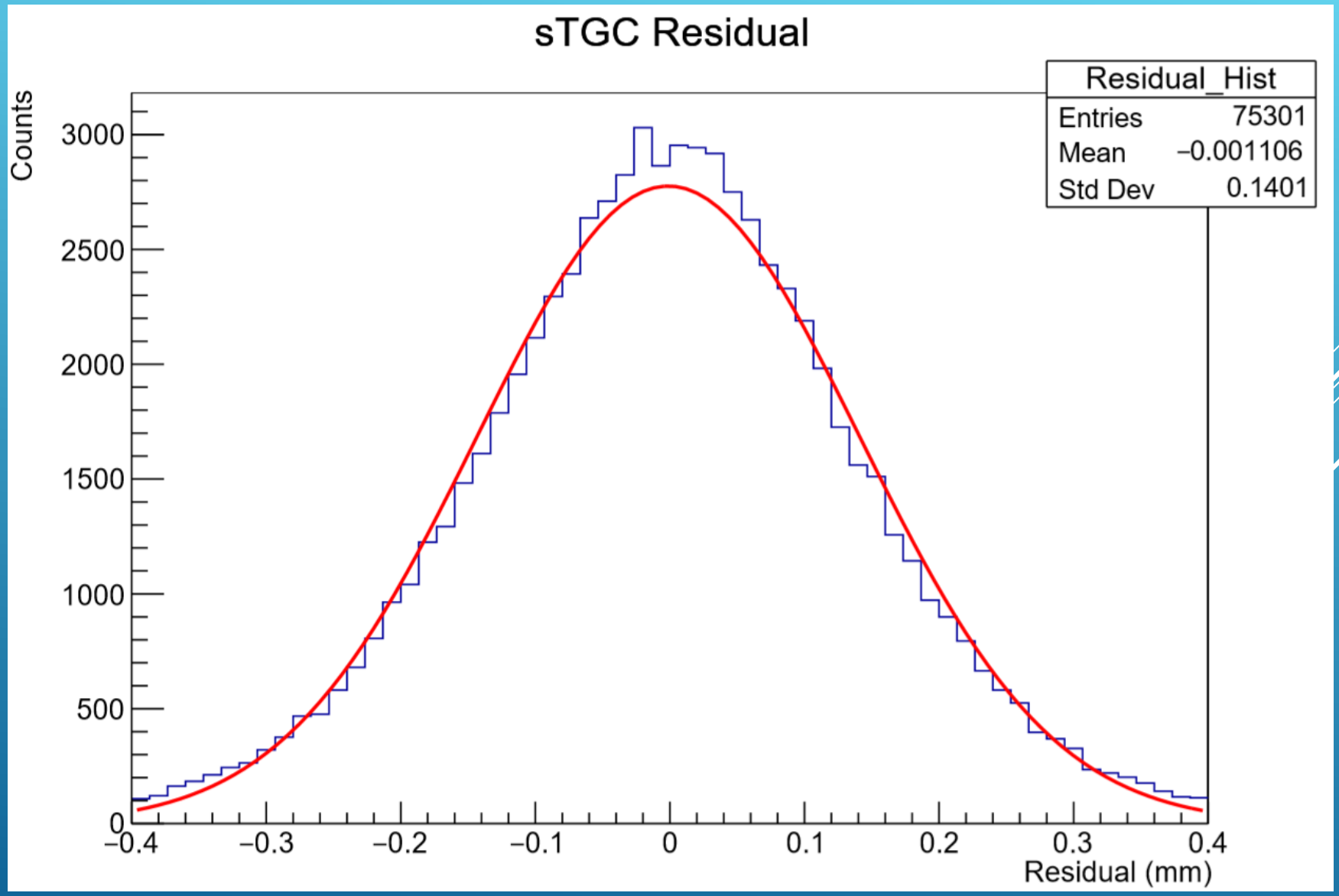


- Left is a sample charge distribution for a simulated muon event
- Strip Charge is used to reconstruct the hit position
- The Residual is the difference between the reconstructed position and the truth position of the hit:

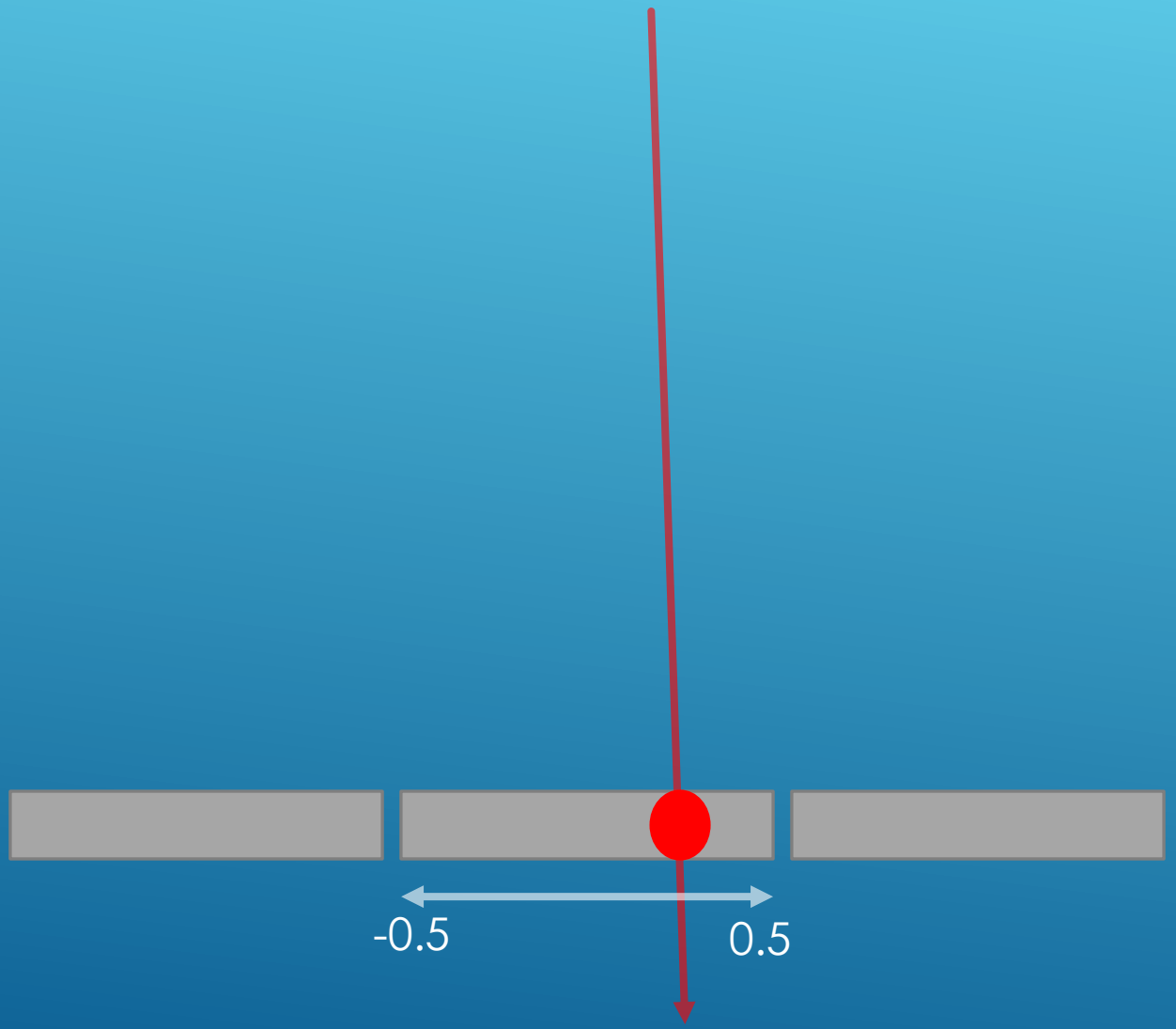
$$res = y_{reco} - y_{truth}$$

Resolution of the sTGC Layers

- The resolution of the sTGC measures how precisely we can determine the truth position of the hit using the reconstructed hit
- The resolution is defined as the standard deviation of the distribution of hit residuals.
- But is this the true single point resolution?



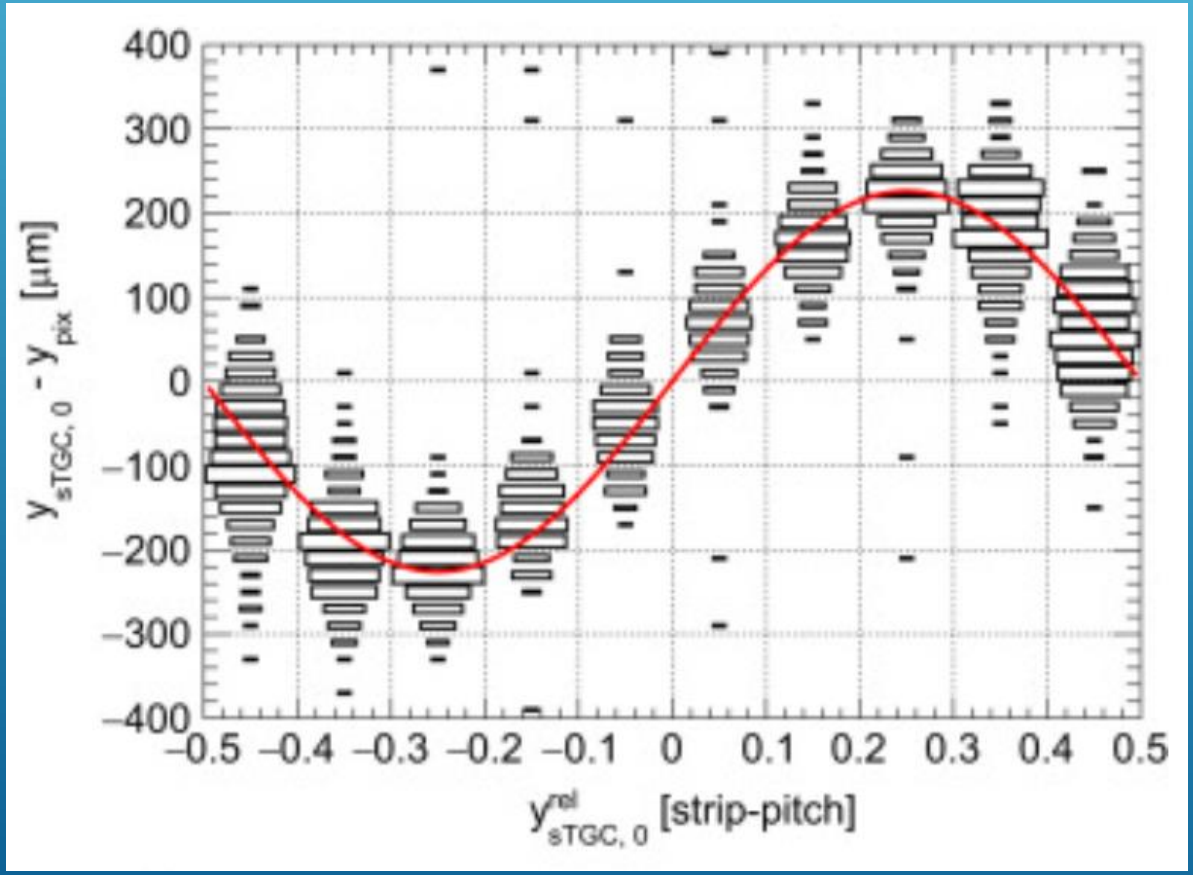
Dependence On Relative Strip Position



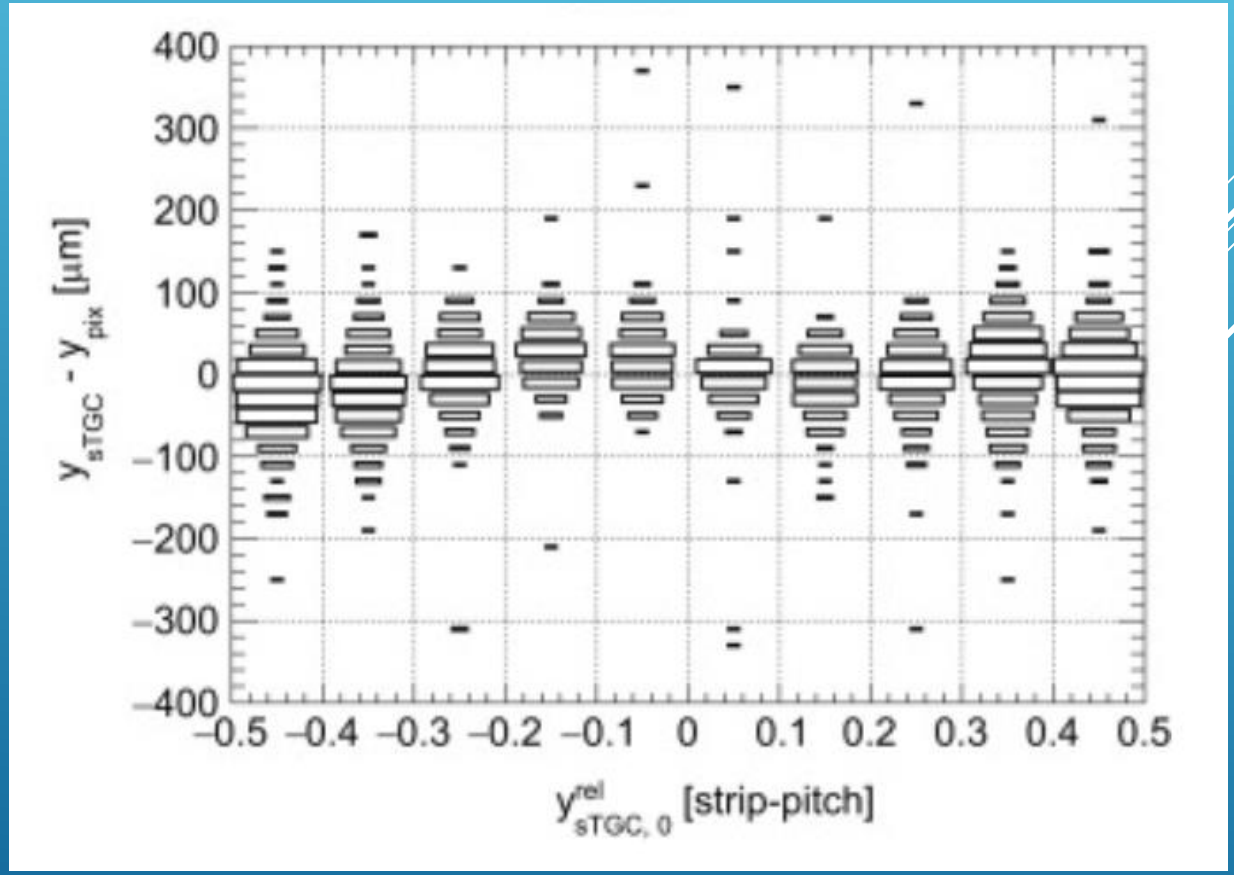
- Since the charge distribution registered by the detector is not continuous, we expect a bias on the residual based on the Relative Strip Position.
- Relative strip position is the truth position of a hit measured relative to the strip width. A relative position of -0.5 means the hit occurred at the bottom edge, while a relative position of 0.5 means the hit occurs at the top edge of the strip.

Dependence On Relative Strip Position

Observed Relative Strip Position Dependence, Test Beam Data 2014, Before Correction

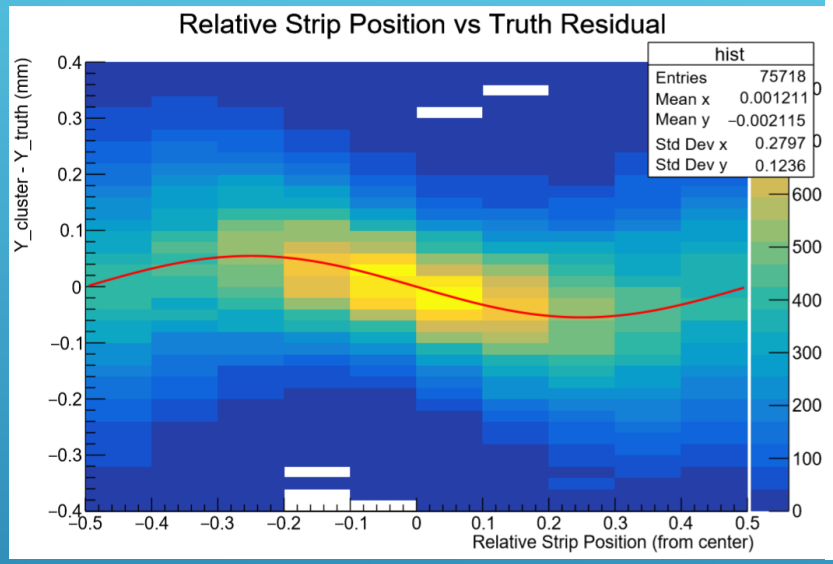


Observed Relative Strip Position Dependence, Test Beam Data 2014, After Correction

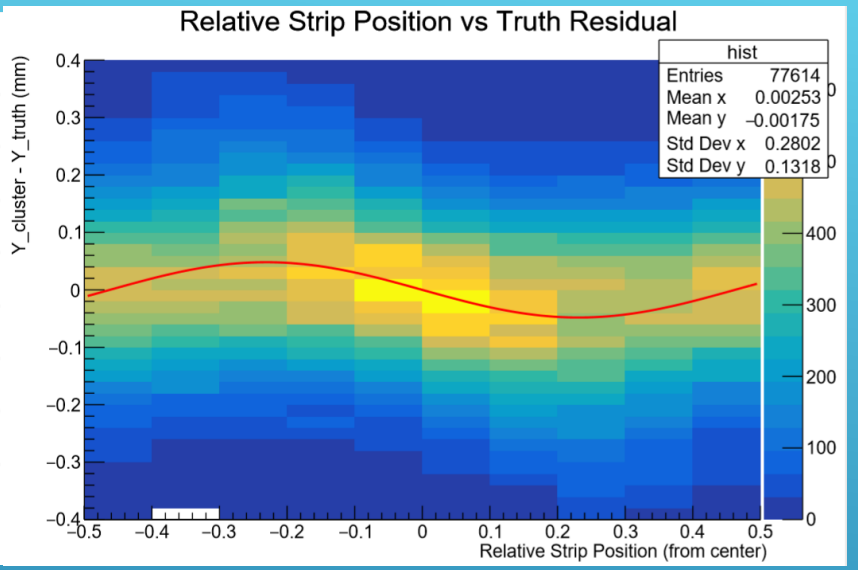


What Do We See In the Simulations?

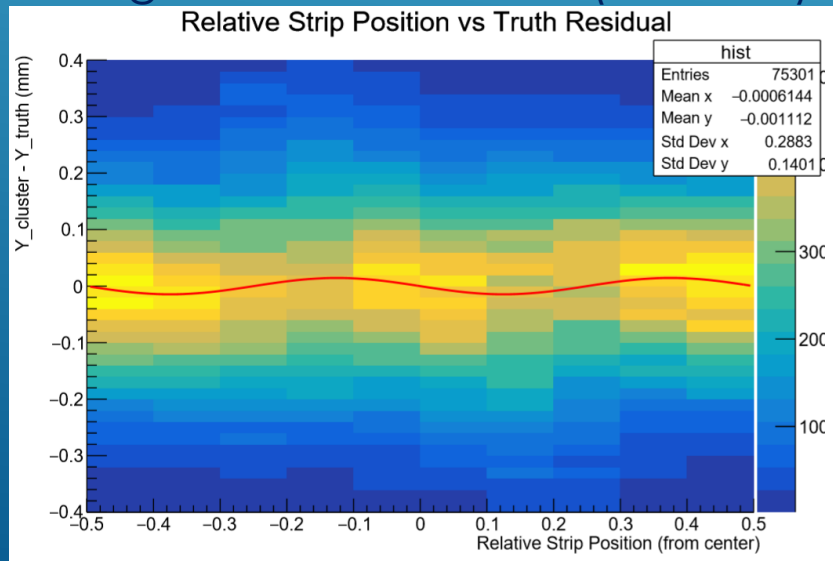
Charge Width = 1.6mm



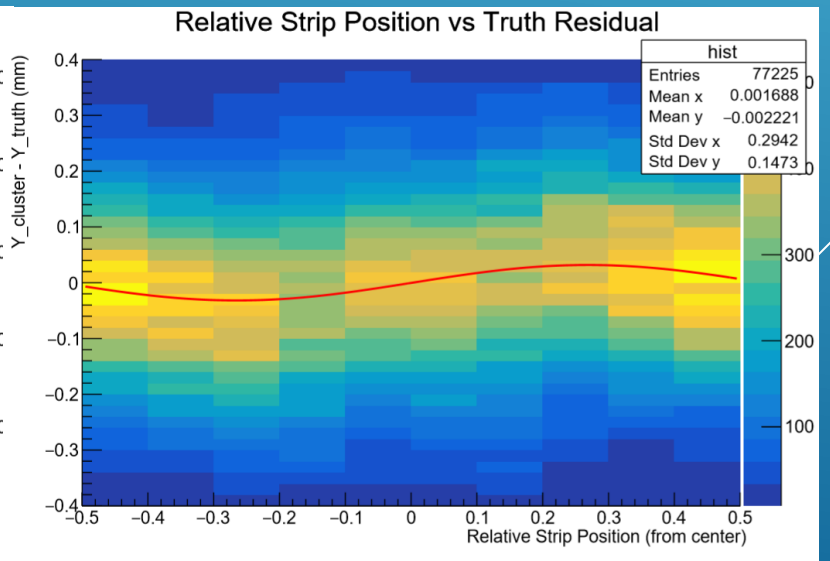
Charge Width = 1.9mm



Charge Width = 2.27mm (nominal)

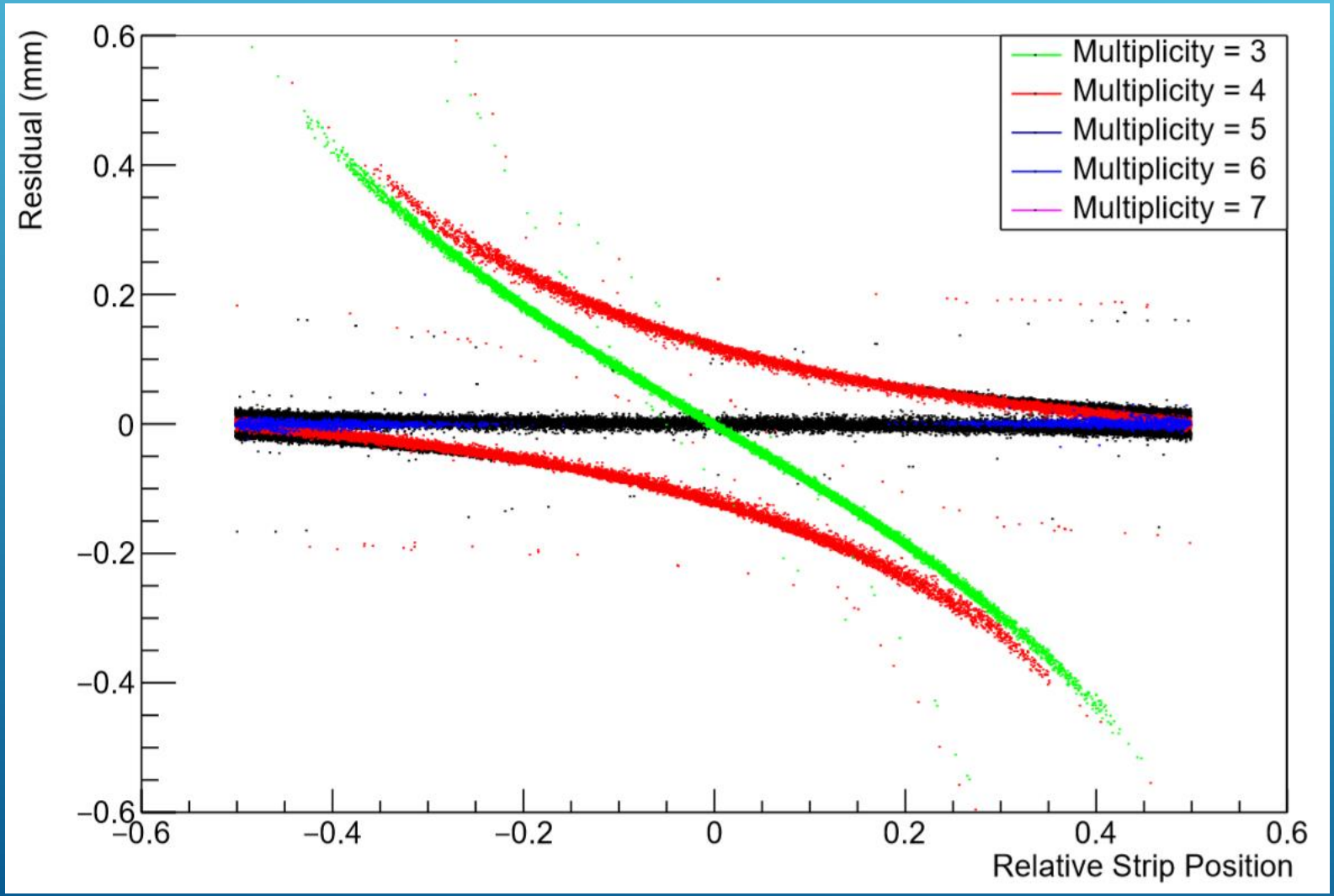


Charge Width = 2.5mm



What If We Take Out the Smearing in the Simulation?

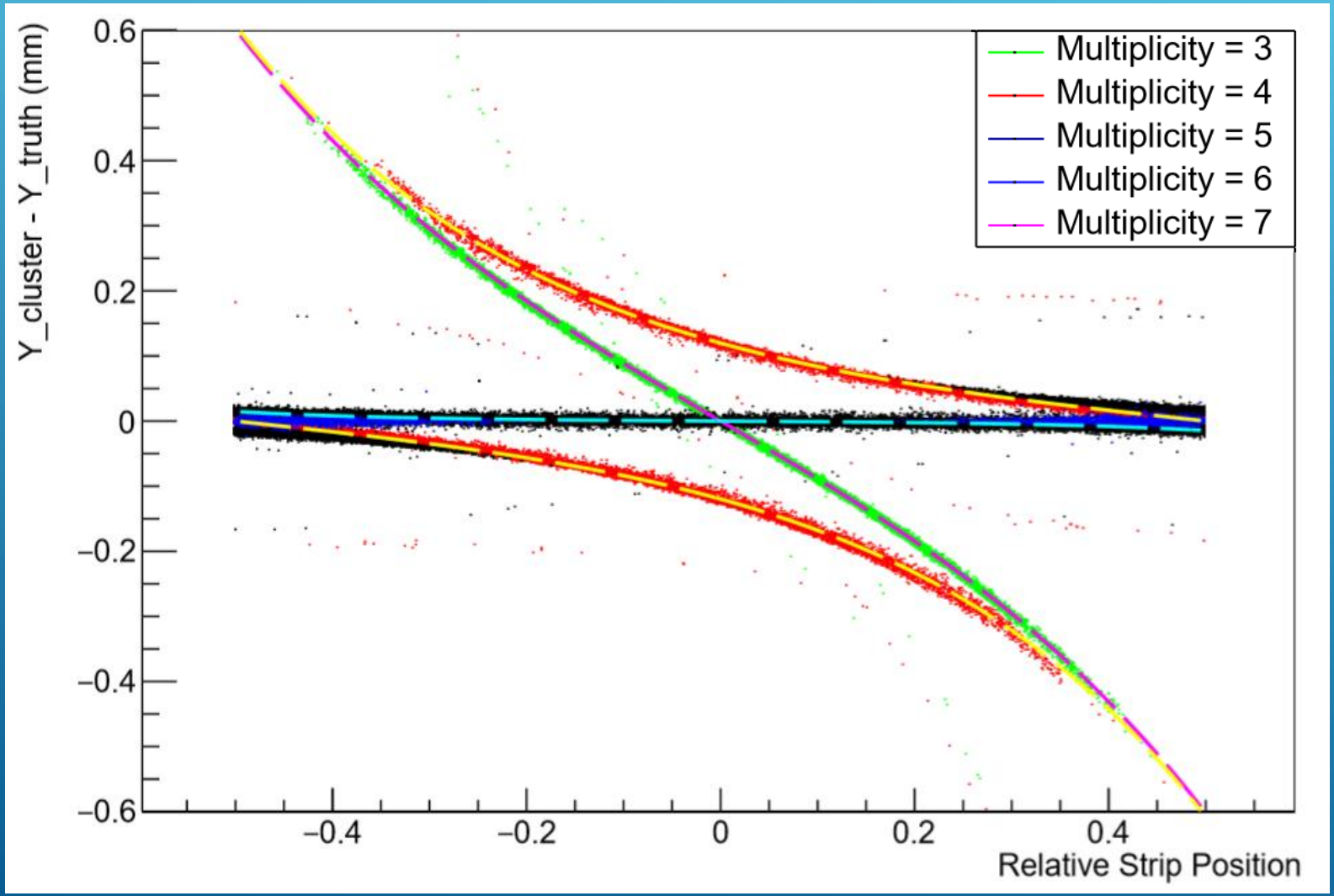
Simulated Relative Strip Position Dependence, 2.27mm (nominal) Charge Width, No Smearing



- During the simulation of an event, there is smearing of the charge width, smearing when charge is applied to the strip, an angular dependence on incidence angle, etc.
- Multiplicity refers to how many strips register a non-zero amount of charge

What If We Take Out the Smearing in the Simulation?

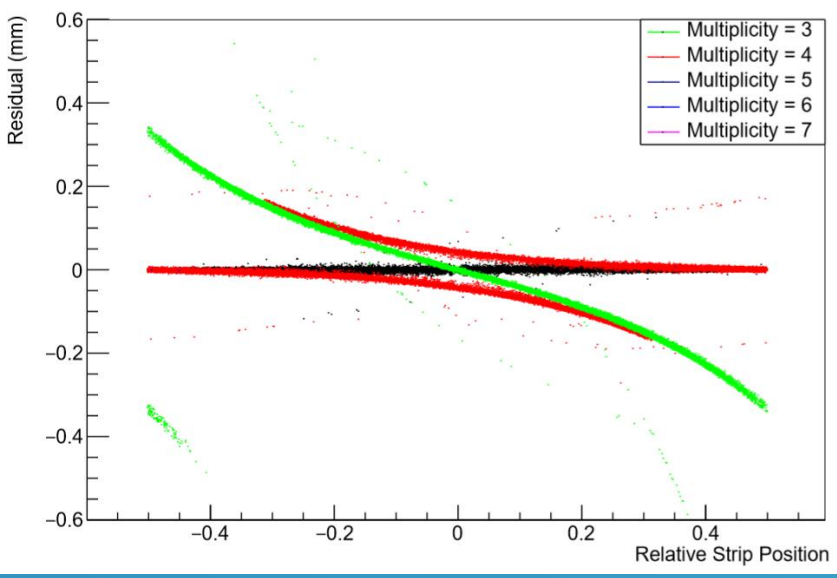
Simulated Relative Strip Position Dependence, 2.27mm (nominal) Charge Width, No Smearing



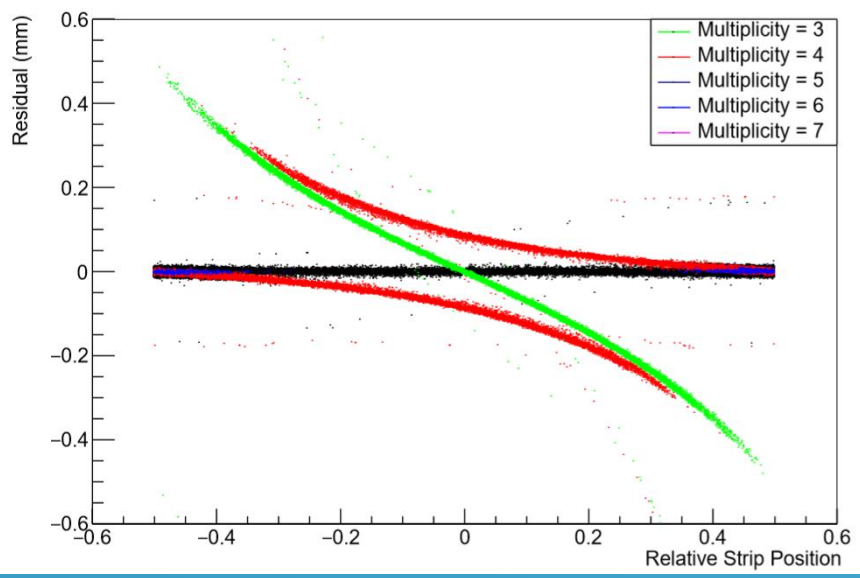
- All of the coloured bands can be parameterized by a hyperbolic sine function:
  $res = p_1 sinh(p_2 r)$
  Where r is the relative strip position and p_1 and p_2 are fitting parameters

Multiplicity	p_1	p_2
3	-0.306	2.86
4	-0.0513	3.17
5	-0.0017	5.70

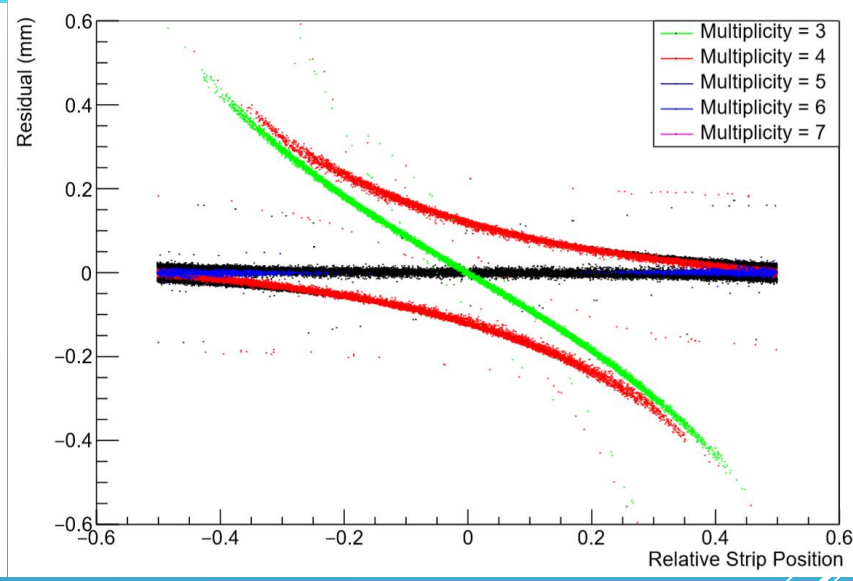
Charge Width = 1.95mm



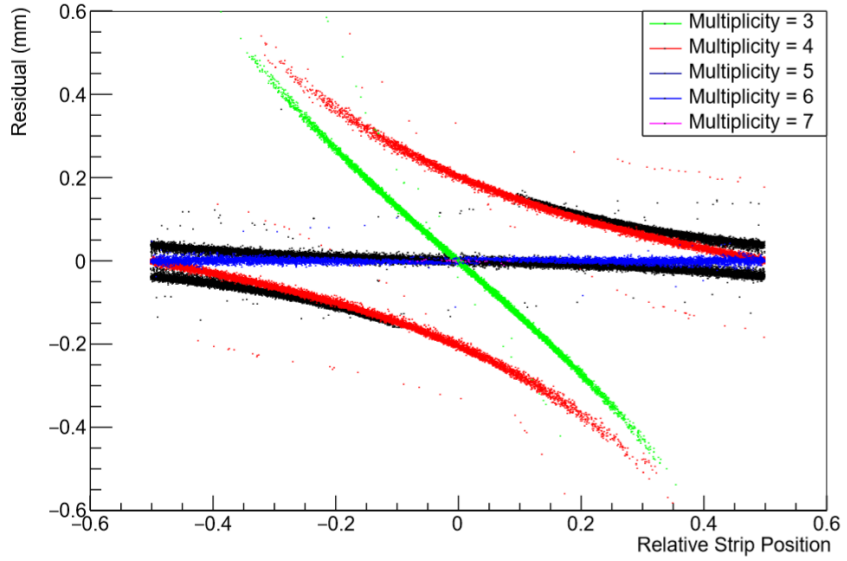
Charge Width = 2.15mm



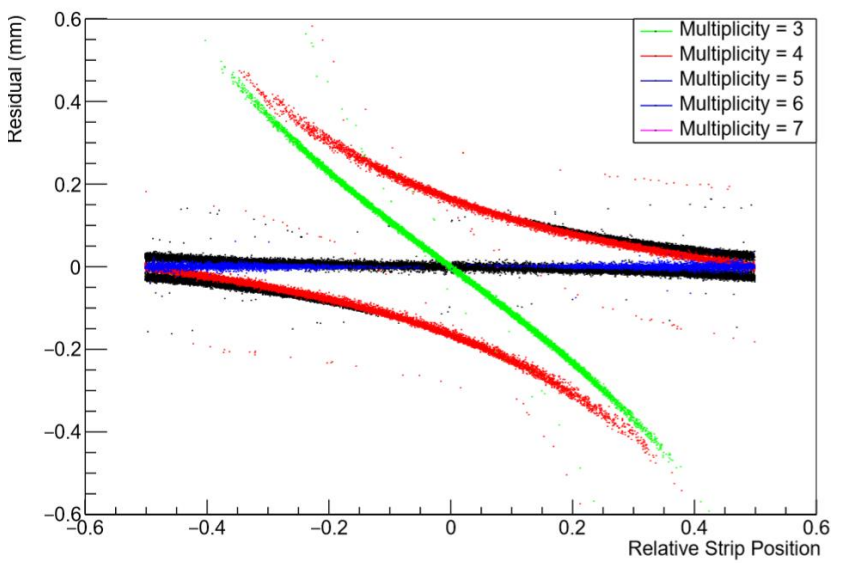
Charge Width = 2.27mm



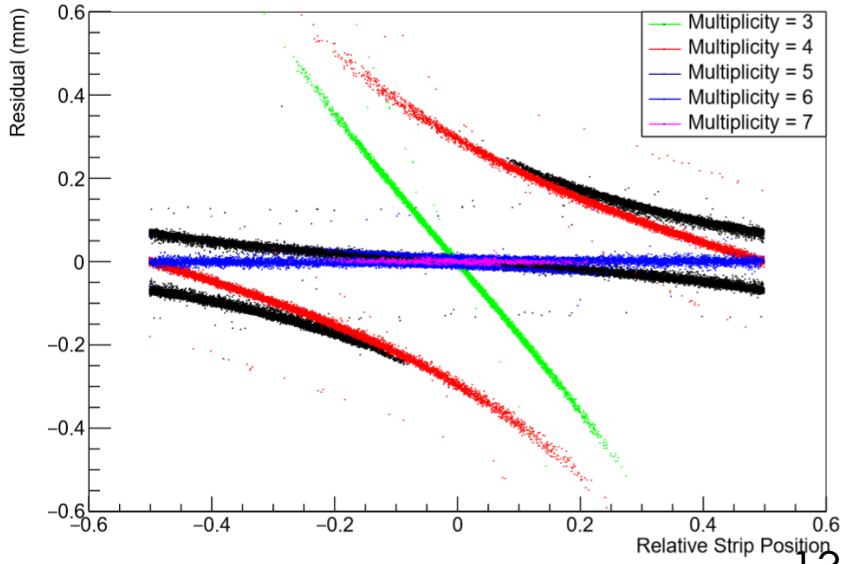
Charge Width = 2.4mm



Charge Width = 2.5mm



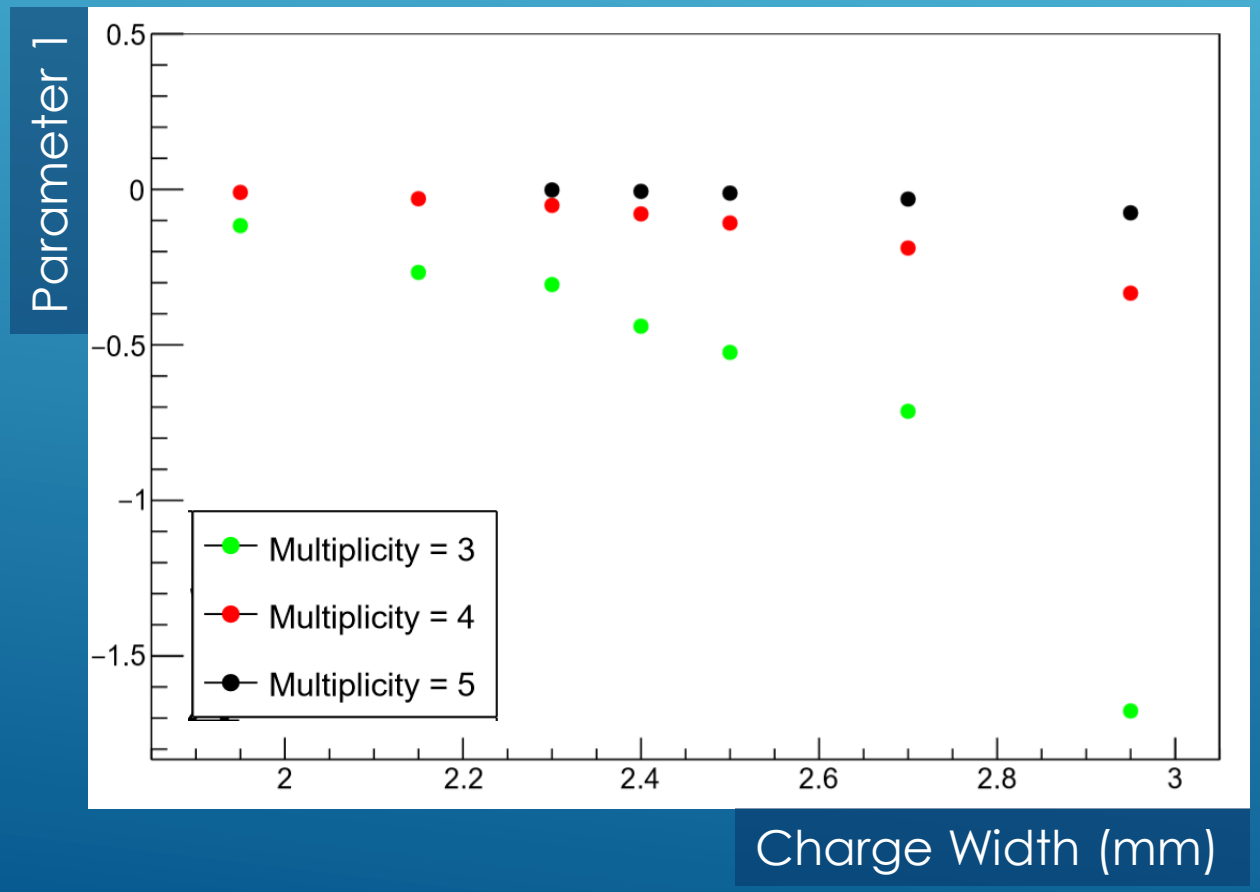
Charge Width = 2.7mm



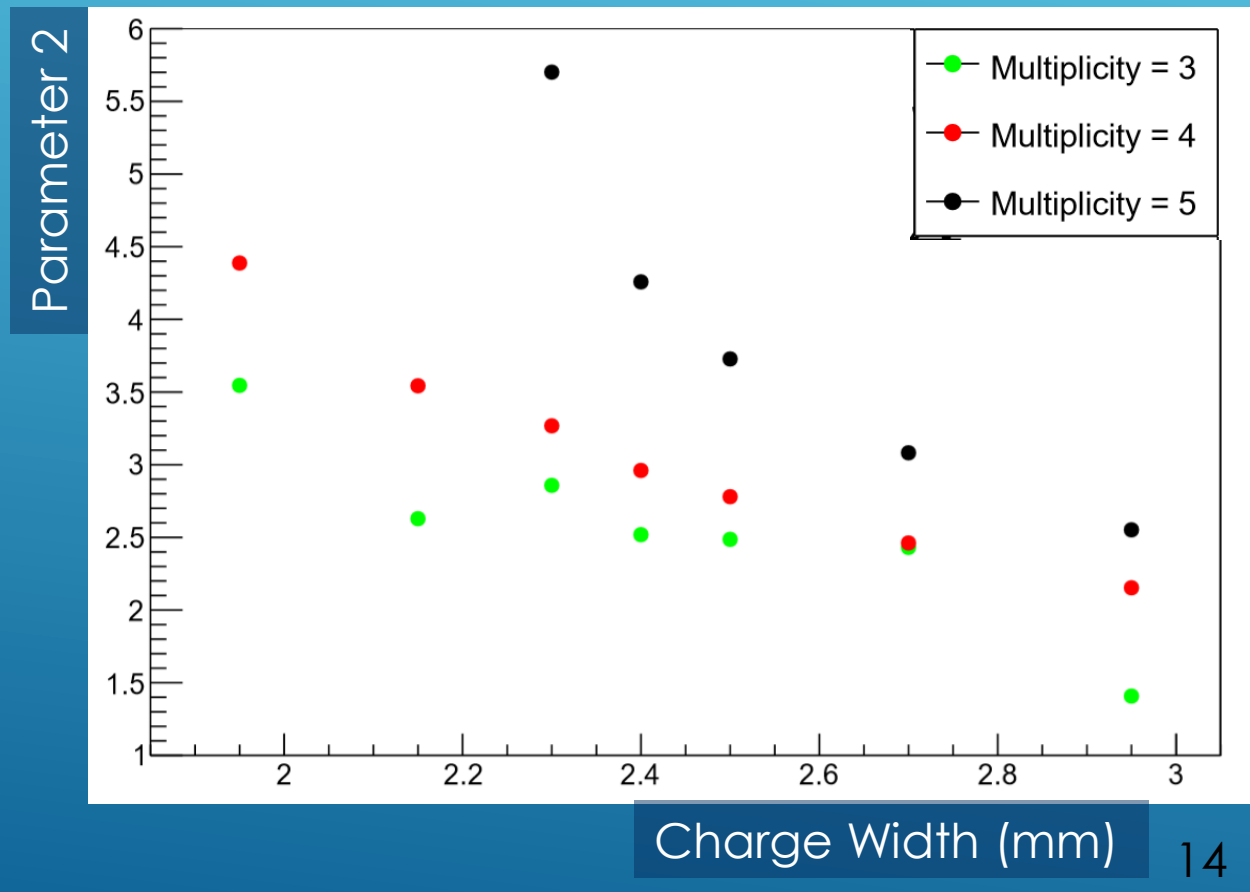
Dependence of charge Width on Fitting Parameters

Fitting Function: $res = p_1 sinh(p_2 r)$

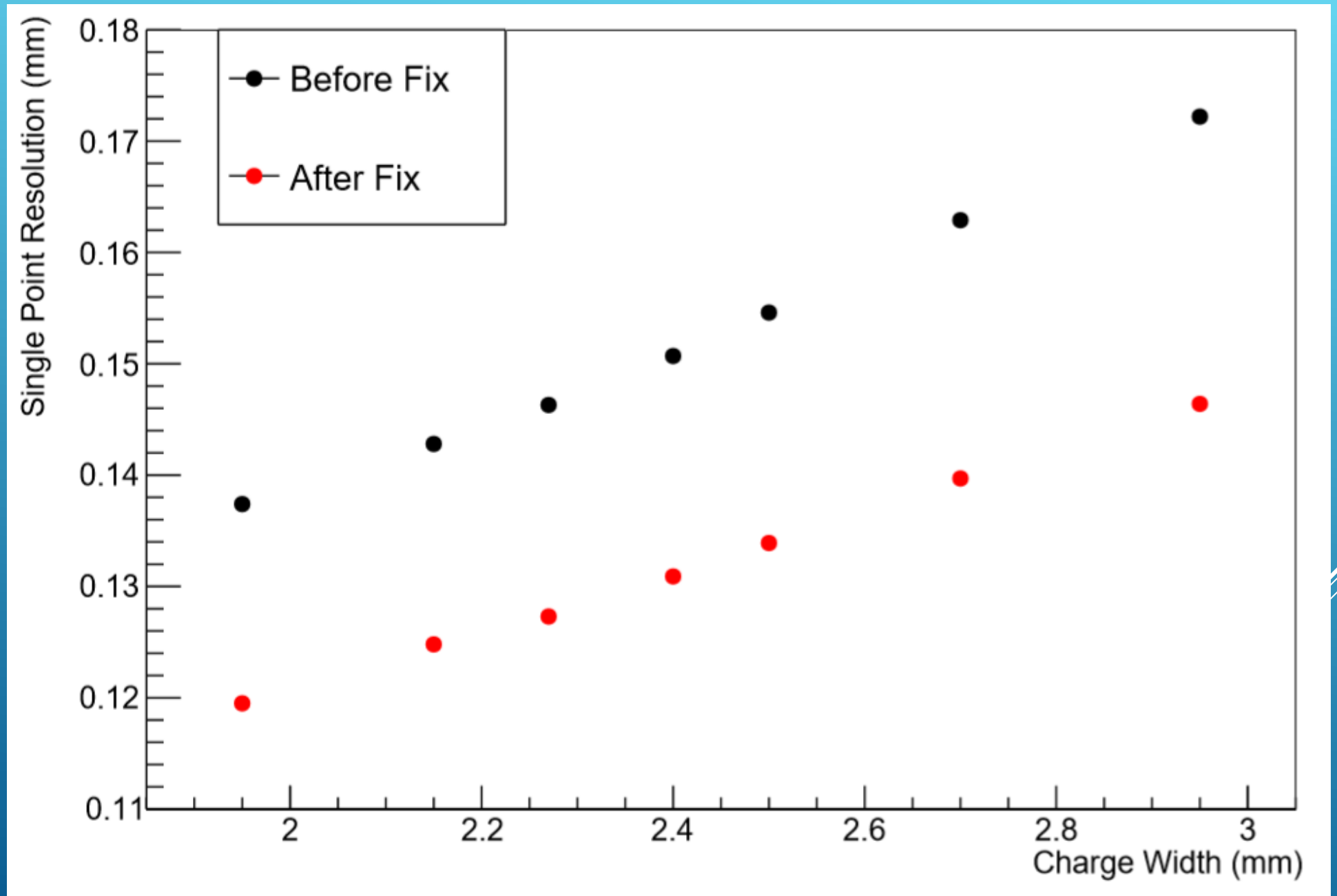
Charge Width Dependence on Fitting Parameter 1



Charge Width Dependence on Fitting Parameter 2



Single Point Resolution Before and After Relative Strip Dependence Fix

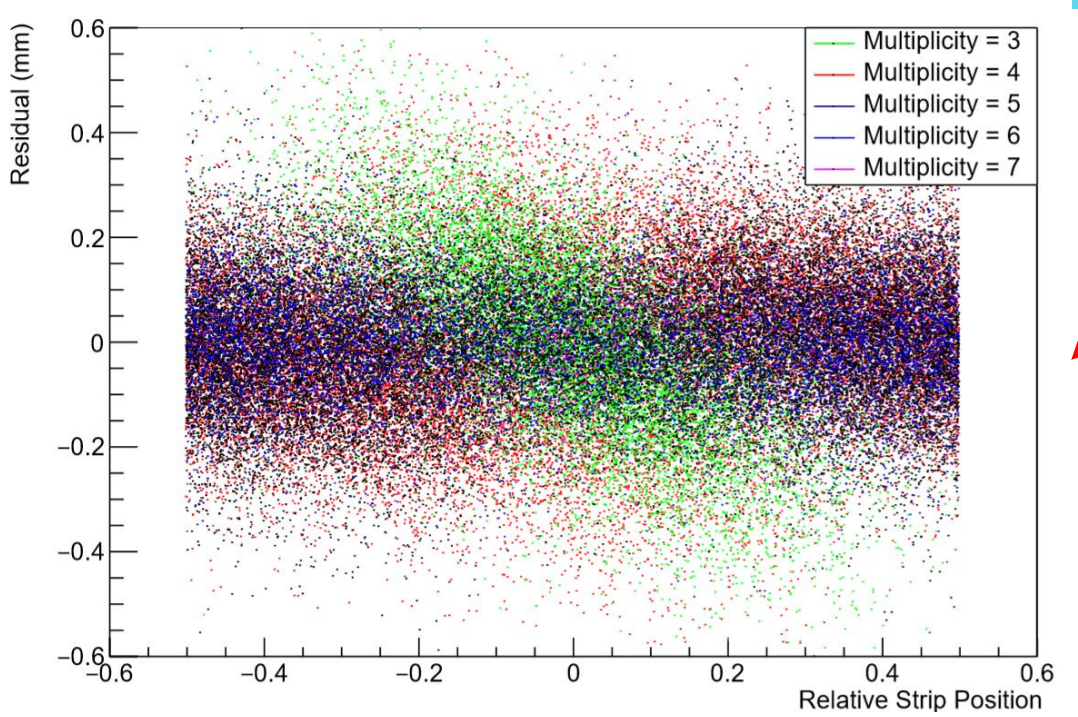


Conclusions and Next Steps

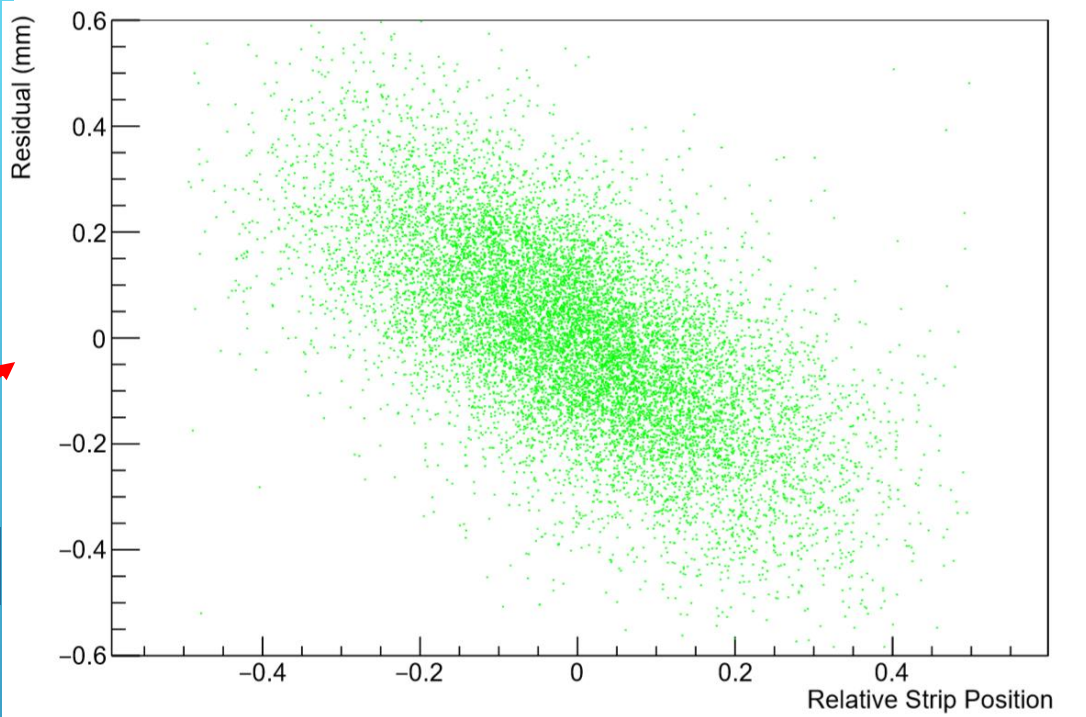
- Bias in hit residual found in sTGC simulation based on relative strip position.
- Progress has been made to implement a bias correction in ATHENA.

- Want to look to see if the same hyperbolic sine dependence is present in the test beam data for each multiplicity.
- Modify reconstruction algorithm to allow for reconstruction of normally incident muon, with sTGC only reconstruction to compare with test beam data.
- Compare the "fixed" single point resolution of the simulations to the single point resolution of the test beam data, and tune the relevant parameters of the simulation.

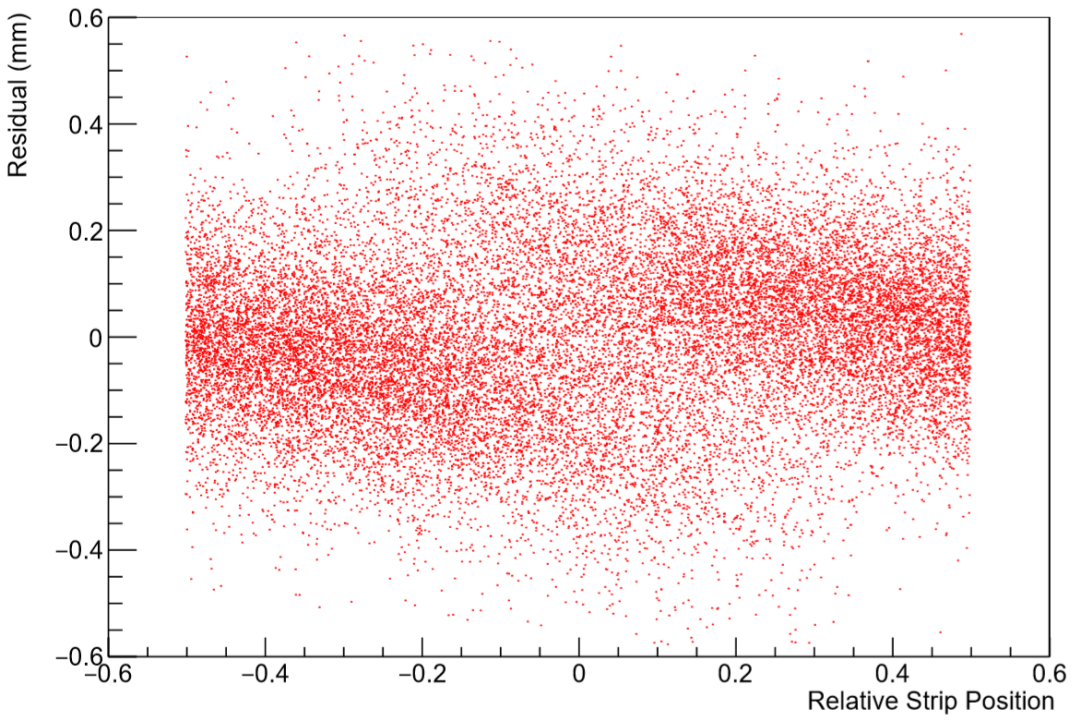
Back up Slides



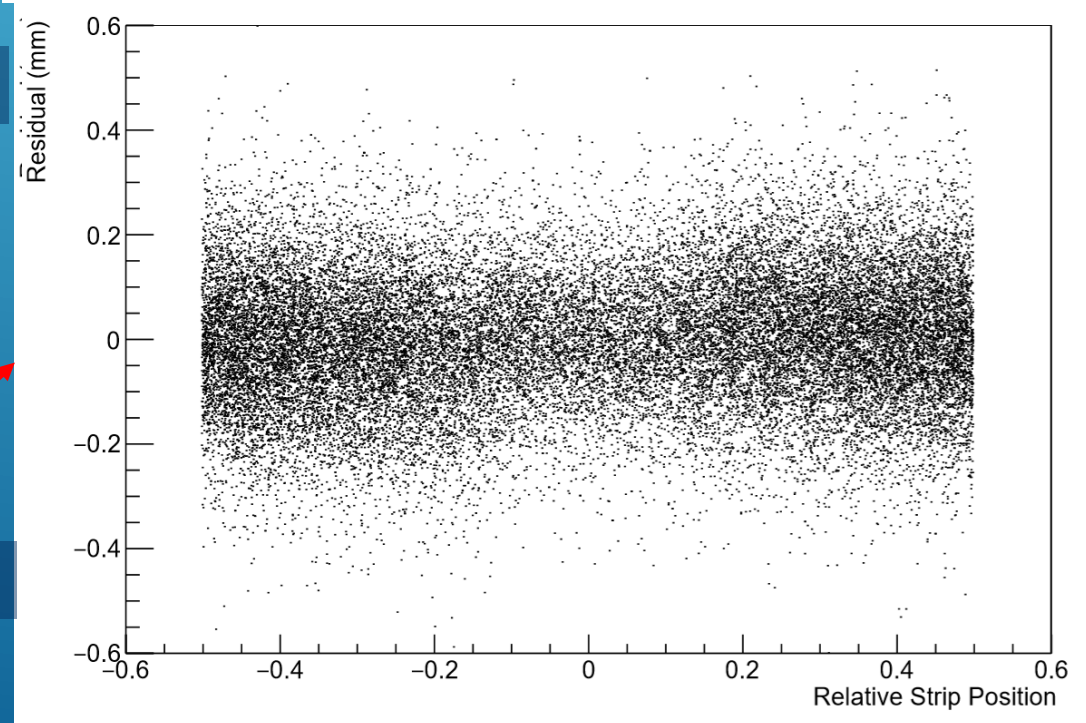
All Multiplicities



Multiplicity = 3

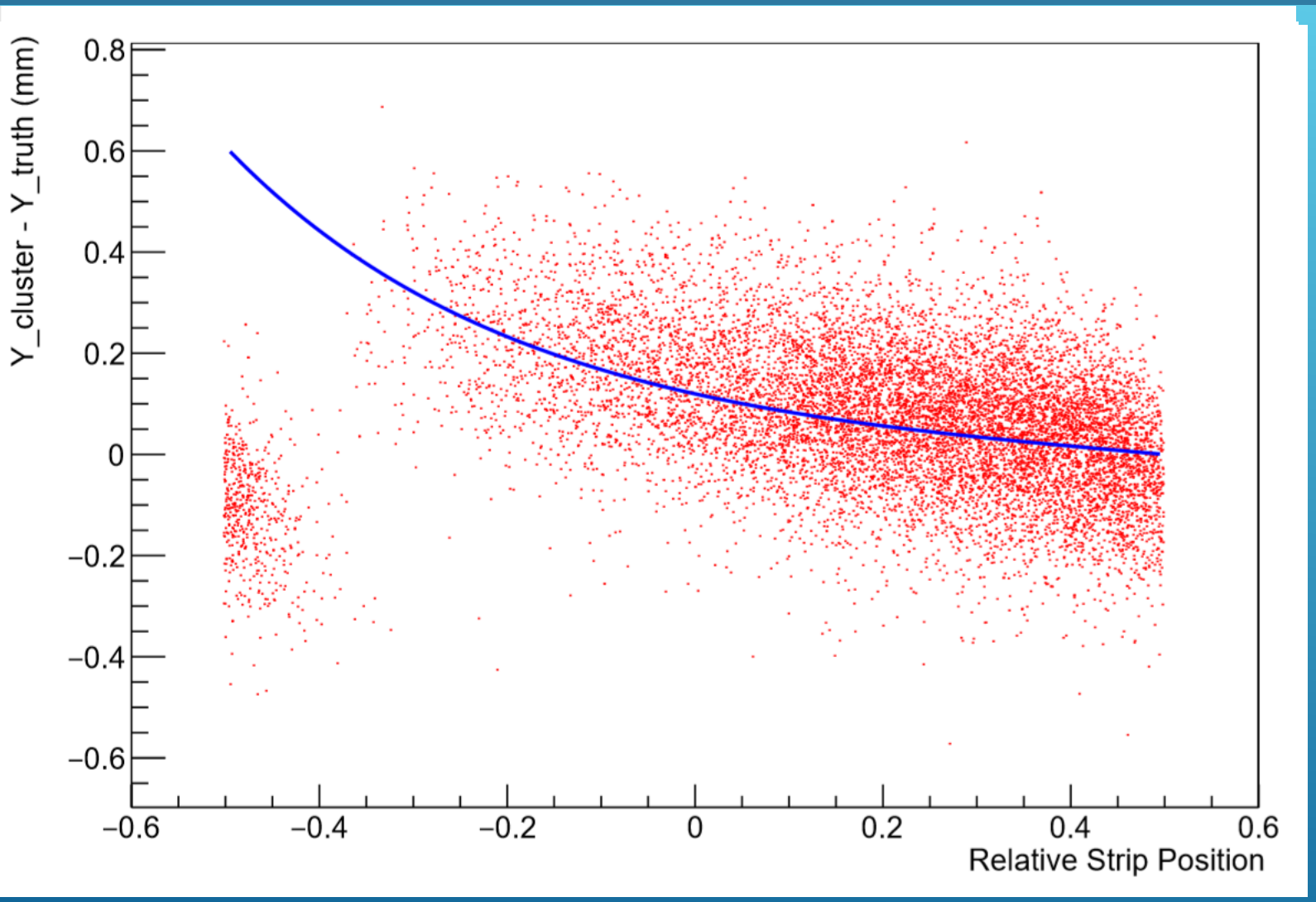


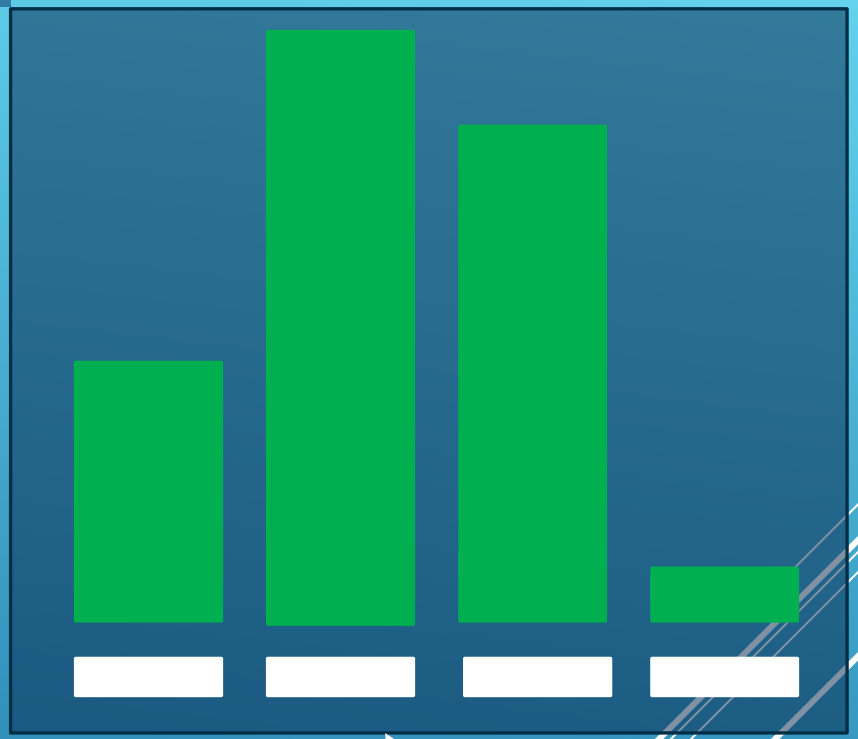
Multiplicity = 4



Multiplicity = 5

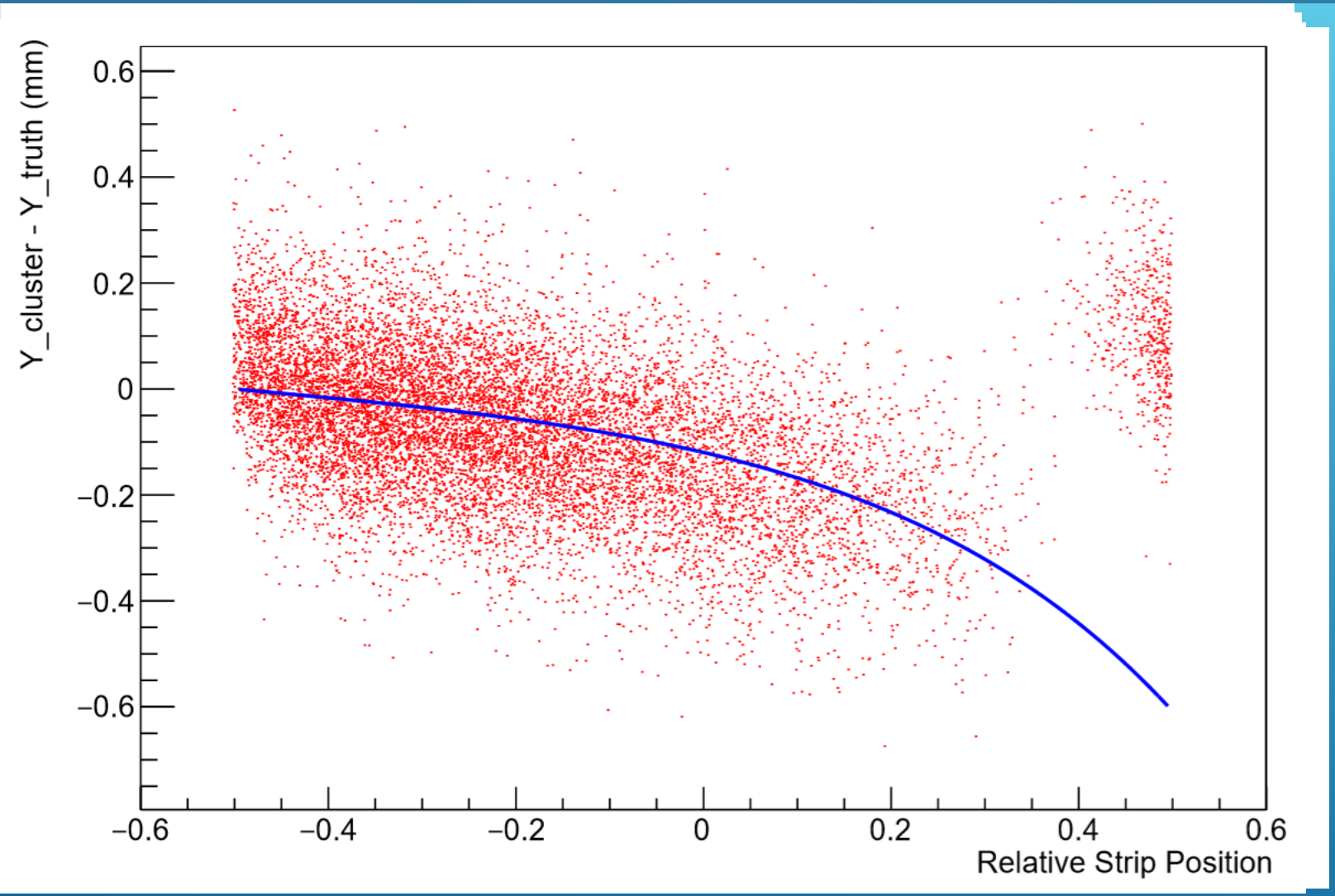
2.27mm Charge Width, With Smearing, Multiplicity = 4, Max Charge on 2nd Strip

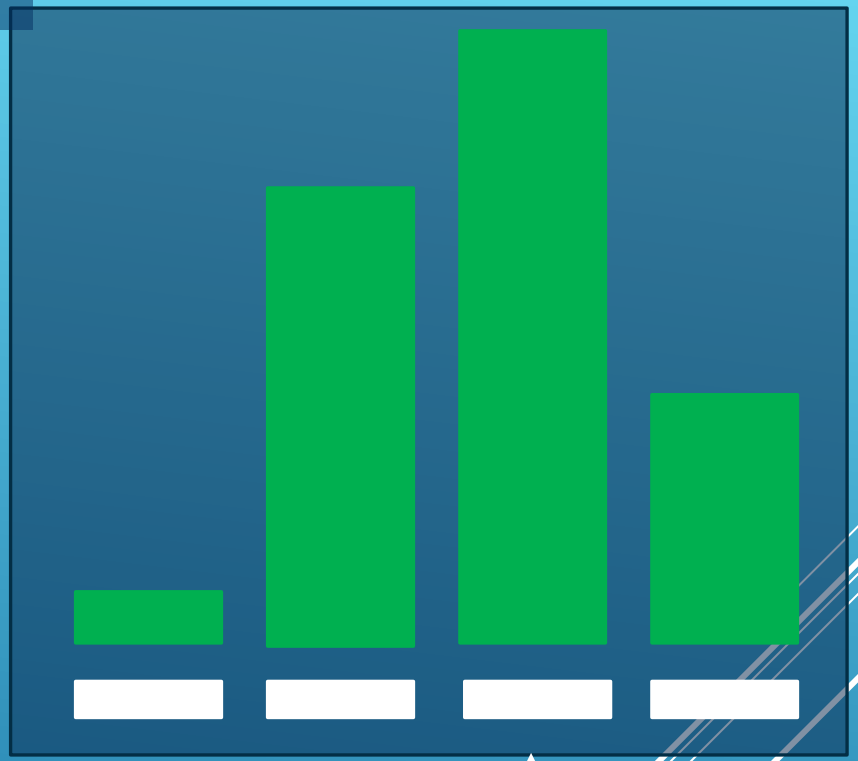




The strip with the most charge is the second strip.

2.27mm Charge Width, With Smearing, Multiplicity = 4, Max Charge on 3rd Strip





The strip with the most charge is the third strip.