# Studies Related to Improvements of Specific Ionization (dE/dx) Measurements in Belle II

Min Yeong Choi, Advisor: Dr. Roy A. Briere
Department of Physics, Carnegie Mellon University

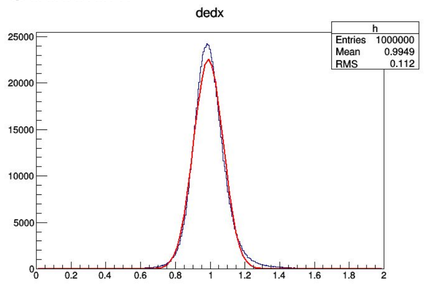
## Introduction

In the Belle II experiment at the High Energy Accelerator Research Organisation in Japan, we looked at several areas of improvement for measurements of the dE/dx in the Central Drift Chamber (CDC), which is used to help identify the particles passing through it.

We assess the calibration of the CDC by studying the resolution (width of the distribution) per mean of the dE/dx. We want to minimize it to make sure the experiments have the most accurate readings. We performed some studies on the resolution per mean to improve it

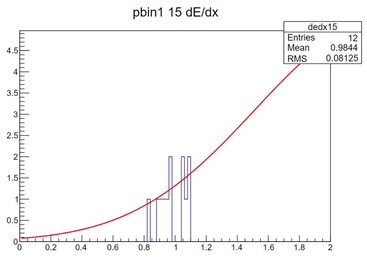
## Methods

- Truncation - The dE/dx distribution isn't exactly Gaussian.



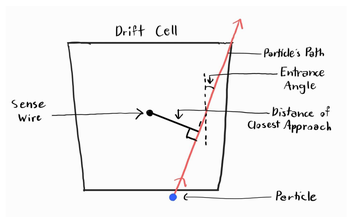

- Excess to the left of the peak and at the right tail.
- Want to see effect of removing dE/dx values at the ends

- Gaussian - The Gaussian fits are not accurate when the for low number of tracks.



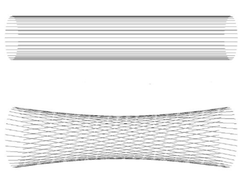

- Look at different methods of fitting to low statistics

- Notch - Bug in the code where a notch-like artifact - It's there when we plot particles' entrance angle vs distance of closest approach (DOCA)



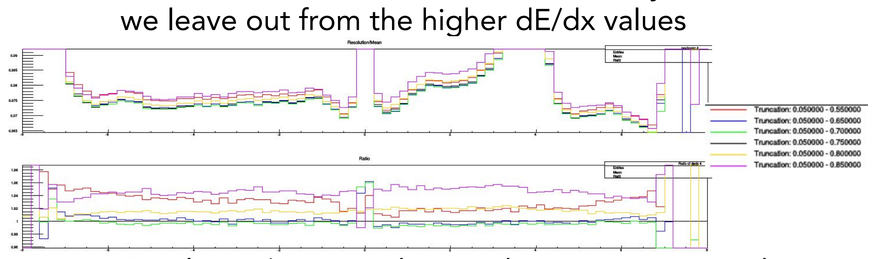

- Axial/Stereo - Resolution per mean should be the same no matter how the wires are slanted in the z direction.

Top: Axial Layer
Bottom: Stereo Layer
[1]

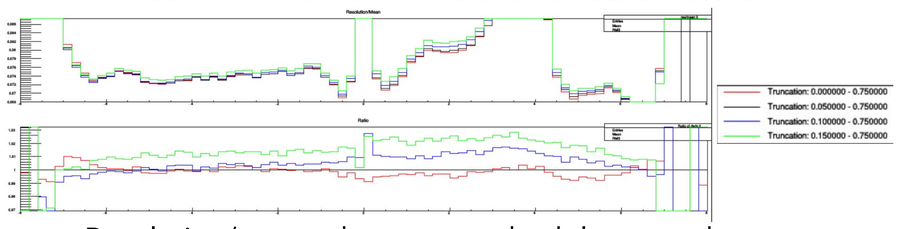


## Results

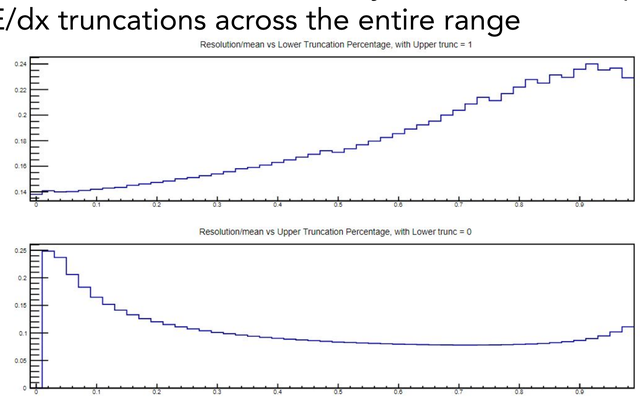
- Truncation
  - Default is keeping the middle 5% - 75% of the hits
  - Resolution/mean and ratio when we vary how much we leave out from the higher dE/dx values



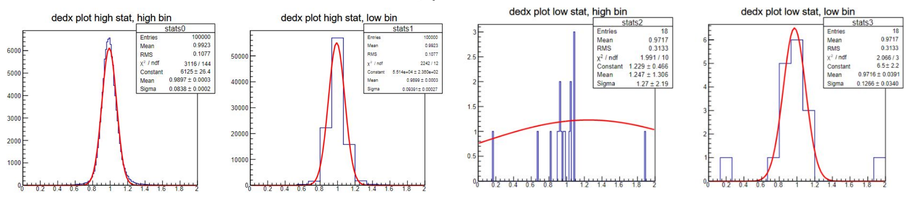

  - Resolution/mean and ratio when we vary upper how much we leave out from the lower dE/dx values



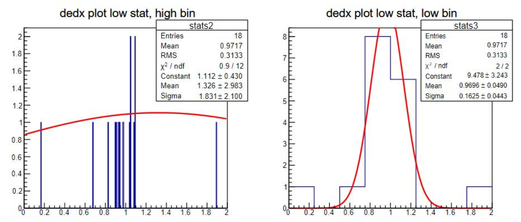

- Resolution/mean when we vary both lower and upper dE/dx truncations across the entire range

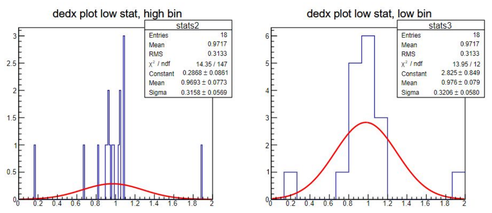



- Gaussian
  - Looked at 4 different types of data



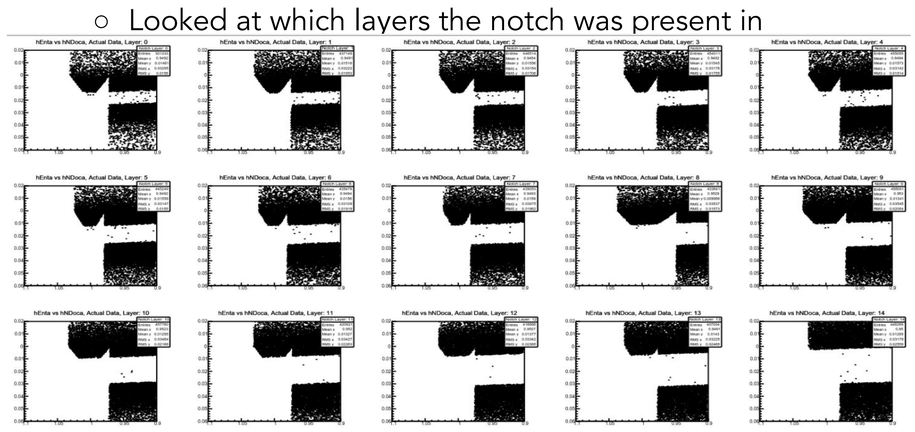

  - Want to fix the low statistics fitting.
  - Used initial parameters from the Root output to set the Gauss fitting



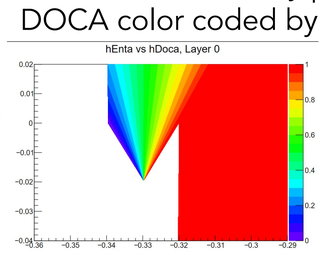

  - We also used Maximum likelihood fitting

- Notch
  - Looked at which layers the notch was present in

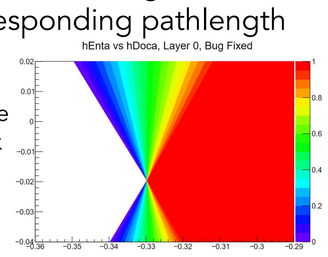


  - Cause of the notches - code that calculated the path length had unnecessary for-loop
  - We verified the fix by plotting entrance angle vs DOCA color coded by the corresponding pathlength

Before the bug fix




After the bug fix



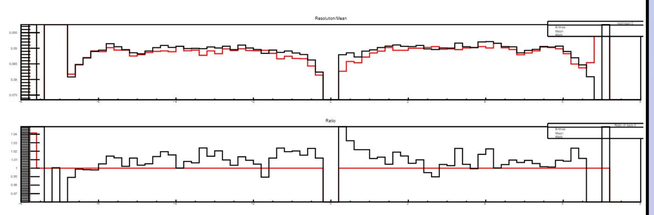

## Results (cont'd)

- Axial/Stereo
  - We want to compare the resolution/mean of the dE/dx of the axial and stereo layers
  - We compare the total amount of hits per particle path for each type of layer

Red - Axial layers
Black - Stereo layers

for both figures --->


  - Resolution/mean for axial and stereo layers including the first superlayer for both




## Results

- Truncation
  - We found that the optimal truncation was different from our historic values
  - 0% - 70% truncation produced lowest resolution/mean
  - Not too far from default values, and the local minima for both ends are very gradual
  - Not too noticeable of an impact on dE/dx
- Gaussian
  - Maximum likelihood fitting was able to fit better on low statistics data compared to initial parameters or standard Gaussian fitting.
  - Max Likelihood doesn't fit as well to the peaks of the data, but the mean and the standard deviation are accurate
- Notch
  - Able to successfully fix the notch bug in the code
  - Discovered that we were throwing out a lot more hits than just the notch itself
  - We were missing the smaller pathlength tracks as well
  - We have yet to test it on new data and compare the dE/dx resolution/mean
    - Future study!
- Axial/Stereo
  - Found out that the hits/track distribution for the axial layers was skewed to the lower end compared to stereo layers
  - Found that the stereo layers seemed to have noticeably worse resolution/mean than axial layers - Not sure why?

[1] - J. Bennett, US Belle II Summer School:Overview of the structure and uses of the Central Drift Chamber (CDC), 2016, Pg. 13. https://relativity.phy.olemiss.edu/indico/event/0/material/slides/0.pdf