Alignment Correction of the Cathode Strip Chamber in ATLAS Detector

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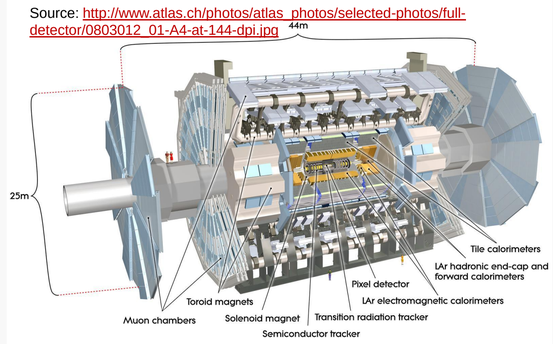
Abstract

The Cathode Strip Chamber (CSC) is a component within A Toroidal LHC Apparatus (ATLAS) detector, one of the four detectors located on the European Organization for Nuclear Research's (CERN) Large Hadron Collider. The team at Brookhaven National Laboratory, responsible for the proper alignment of the CSC, analyzes output produced through Monte Carlo simulations and actual collision events in order to confirm the CSC's alignment. The path of particles with low momentum can easily be deflected by magnetic fields and interaction with detector walls within the ATLAS. Therefore, by looking at the momentum change, the path a particle takes through the detector can be reconstructed. This information is stored in an n-tuple data structure holding the properties of the muons which were collected during the collisions. We iterate through the n-tuples to extract significant data that can be used for statistical analysis. To analyze the momentum differences, I generated histograms and graphs using ROOT libraries, a C++ framework created by CERN to study the results of physics simulations. These charts show the momentum statistics such as mean, standard deviation, and mode of a collision event. Comparing the statistics of theoretical values to actual values provides an insight into how much the CSC may be misaligned. We looked at the chambers individually in respect to one another by examining the statistics between each of the sixteen chambers. The datasets we looked at suggest there is a misalignment among the individual chambers. Furthermore, the chambers' shift of misalignment varies. Therefore, we have some difficulty in determining which of the sixteen chambers is misaligned. Research following my departure will focus on filtering out noise data to obtain consistent results which will dictate to us by how much certain chambers in the CSC need to be moved. If a repair is not feasible, then a statistical error correction will be taken into account in future calculations.

Introduction

Source: http://www.atlas.ch/photos/atlas_photos/selected-photos/full-detector/0803012_01-A4-at-144-dpi.jpg



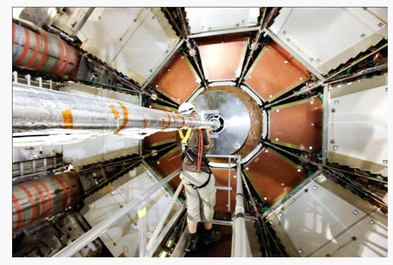
Top Image: ATLAS detector

Right Image: Installation of chambers in the CSC

Source: http://mediaarchive.cern.ch/MediaArchive/Photo/Public/2009/0905072/0905072_03/0905072_03-A4-at-144-dpi.jpg

The ATLAS Experiment collects data from detected collisions, in search of fundamental particles and energies, which existed at the birth of our universe. To ensure that all components of the ATLAS detector is correctly made and placed is a vital task for scientist and engineers on the project.

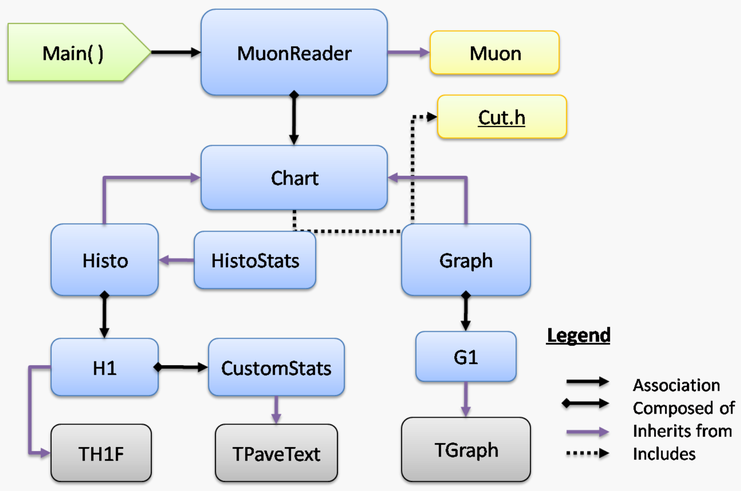
The CSC is one of the muon chambers in ATLAS, this project analyzes the alignment of its chambers, through data collected during the collision events.



Methods

The Program

The following is a UML diagram, which demonstrates the class hierarchy of the program used to analyze and graph the data:



Inclusion Classes and Headers
The TTree class in ROOT has an method called MakeClass(), which automatically creates a template class using the branches of the TTree as fields.

Control Flow
The Main() function creates an MuonReader object. A MuonReader, reads through the desired branches in the muon class. It contains a list of instantiated Charts, which have common function names to read tree values, create histograms and graphs, fill them with data, and draw the graphs. Implementation of each method will be defined by the user.

Extendibility
Histo holds a set of 1D histograms, and Graph holds a set of 2D (x vs. y) graphs. To create plots for new variables, user should create a class which inherits either Histo or Graph, and implement the functions, create(), execute(int i), draw(), fill(int sec), print(), and the constructor and destructor.

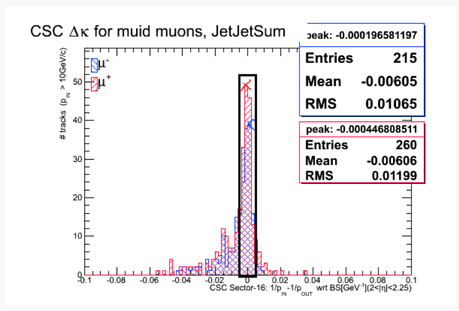
Collecting Statistics
CustomStats is a customized statistics display, which contain calculation for numerical values of mean, mode, and standard deviation.
HistoStat is useful when summary statistics is desired. It creates charts which will show the mean, mode, and standard deviation values individually. Independent variable: sixteen chambers, dependent variable: statistics calculated in each chamber chart.

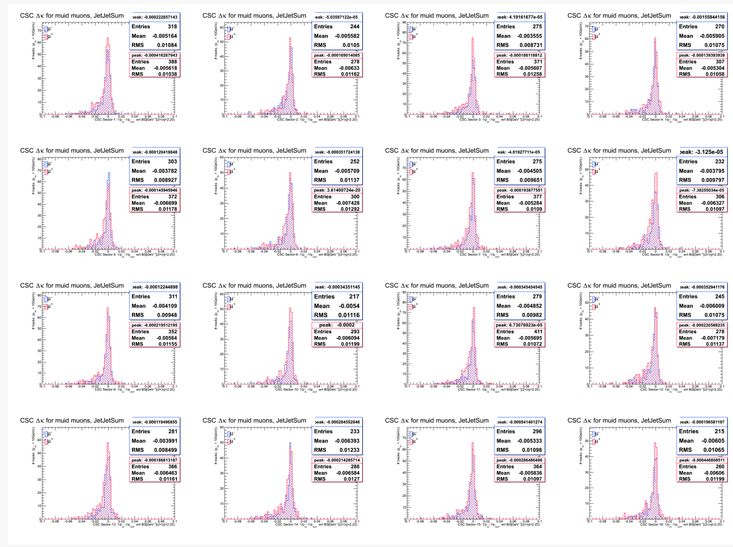
The Analysis

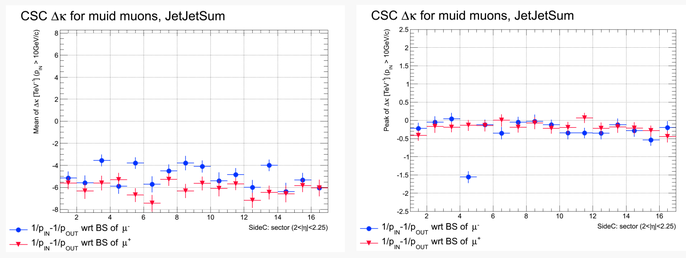
Mean vs. Peak

In both the actual and simulated data, there is an observable one sided tail, which will cause biased values when the mean of the points in the graph is calculated. Therefore instead of looking at the mean, we look at the peak shown on the plots.

The Peak Find Algorithm
The bins around 0, is [-x, 0] and [0, x], where x is the smallest unit of the bins (range/# of bins). Our results will always have either a negative or positive biased shift. We wish to get the peak value as close to 0 as possible, ROOT has a method called max value, which will return bin that has the most entries. Then we look at the two adjacent bins, and select the one that has the highest value. After we add two more bins, one from the left and the other to the right. Last we find the average position of these four bins.



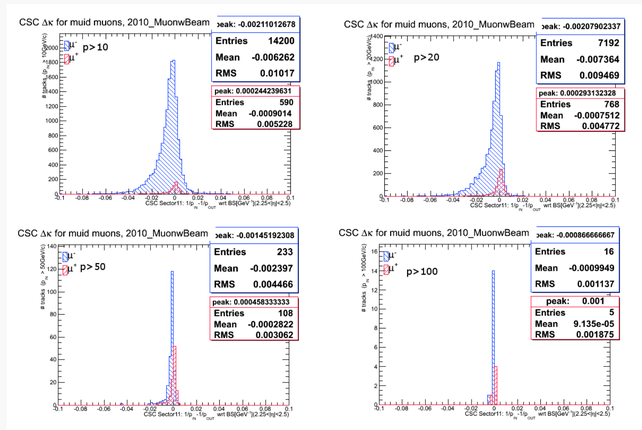




Cuts and Variables

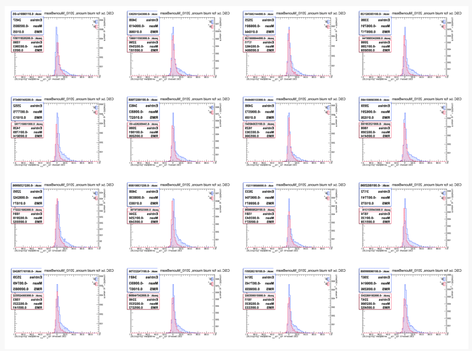
Momentum Cut [p>10, p>20, p>50, p>100]
As momentum cut goes up we lose very much to the background data, and only look at high energy events. However, if the momentum cut reduces data statistics by too much, much significant data will be lost, causing skewed statistics due to limited data points.

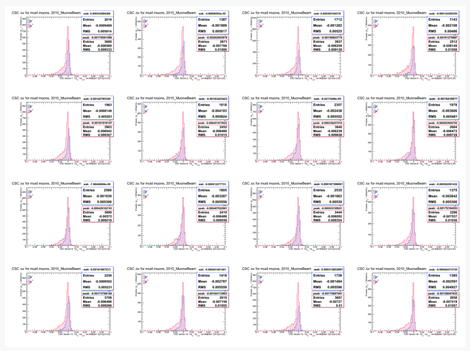
Eta isolation cut [etisol < 3000]
So far this has been our best method to reduce background noise. By limiting the radius of accepted eta values, making a cut at the isolation cone helps us get data closer to the theoretical values.

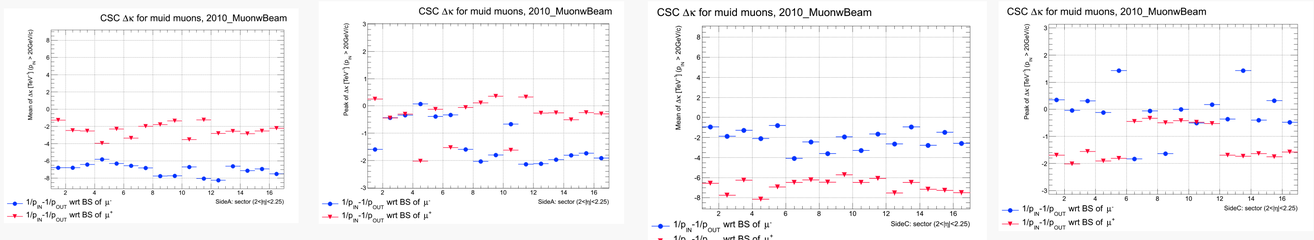


Results

The charts show collected data in 2010 of MuonwBeam collisions. Even with our best set of momentum and eta isolation cuts, there still exist great inconsistency.







Further Research

From the results, there suggest misalignment between the chambers. However to which degrees and by how many millimeters are they misaligned has yet to be determined. The on going research will focus on tracking down the exact measurements of misalignment.

Credits

ROOT | A Data Analysis Framework [Internet]
Geneva, Switzerland: European Organization for Nuclear Research; [updated 31 March 2010; cited 4 August 2010]
Available from: http://root.cern.ch

ALTAS Experiment
Geneva, Switzerland: European Organization for Nuclear Research; [updated 4 August 2010; cited 4 August 2010]
Available from: http://www.atlas.ch

MyAna04 [source code]
Yamamoto, Kyoko. Iowa State University, Ames, IA 50011

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