Quality control of ATLAS ITk stave alignment during assembly

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Abstract

The future of the LHC is the High Luminosity upgrade (HL-LHC), a project that will allow precision measurements of rare phenomena with much greater statistics than currently achievable. To maintain successful physics output in the challenging environment presented by the HL-LHC, the ATLAS detector will undergo major upgrades beginning in 2026. The most significant of these upgrades is the new all-silicon Inner Tracker (ITk) detector, which will provide robust tracking performance, an asset particularly in searches for new physics phenomena. BNL (Brookhaven National Laboratory) oversees building half of the barrel strip detector that includes about 200 staves, which are the units that provide mechanical support, cooling, electrical distribution and data connection to strip modules. This project aims at streamlining the calibration of the stave alignment, by facilitating the operator to identify faults in the assembly process. More specifically, an automated checks are performed in python scripts embedded in the LabView program that controls the assembly process. Such checks are performed on the pattern recognition software that is used aligns the stave and on the assessment of the residuals between the actual ad nominal positions of the module during and after mounting.

Introduction

One of the crucial steps in the stave assembly process is to position and align the locking points. This step, like all the others, is carried out using an Aerotech controlled by a LabVIEW program, during which the images and coordinates of the locking points are recorded. The coordinates of the locking points are then compiled in a csv file. In some cases, the pattern recognition algorithm may fail, and the program returns NaN in the file. For this reason, we have developed a program that tells the operator that the pattern recognition operation has failed. We have also developed Python code and LabVIEW diagrams to inform the operator of the position and alignment of the locking points in relation to the normal points.

1. Modules and staves for barrel at BNL

Staves barrel mounted at BNL are built with 14 modules. Modules will be loaded in a strip core which provides mechanical support using high stiffness and high thermal conductivity carbon fiber.

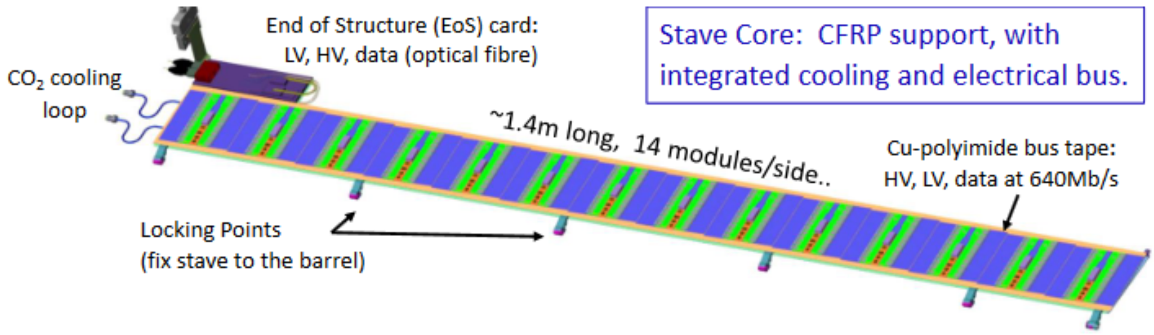

Figure1: completed stave with locking points essential for the insertion in ATLAS.

2. Failure to recognize the shape of the locking points.

Under certain conditions, such as poor lighting conditions, pattern recognition fails, and the locking point is not found. In this case, the software returns "Nan" in a file instead of the coordinate values of the locking point. We want to warn the operator with a button in the LabVIEW panel that will turn red when this happens, so he can act. To do this, we have created a python code that takes the path of the csv file as input and outputs a ‘Nan’ if the file contains any, or an ‘ok’ if it doesn't. The python code will be read by the LabVIEW diagram via the exec system interface, as shown in figure 2 and 3.

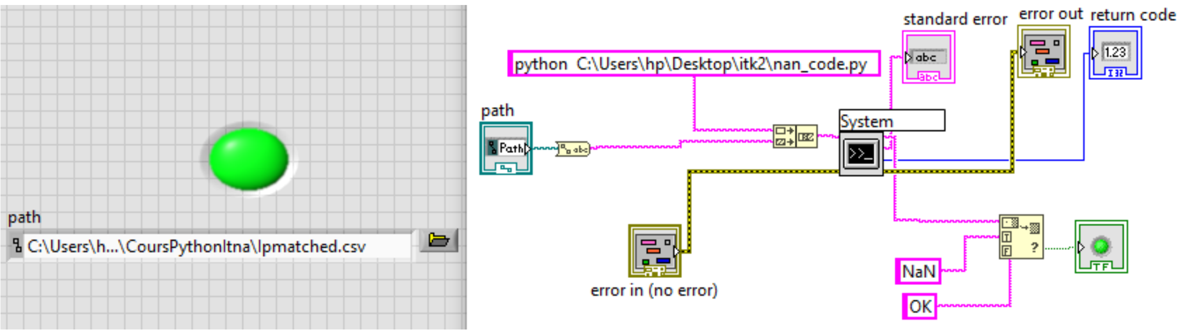

Figure2: in this image we have opened a file that does not contain Nan.

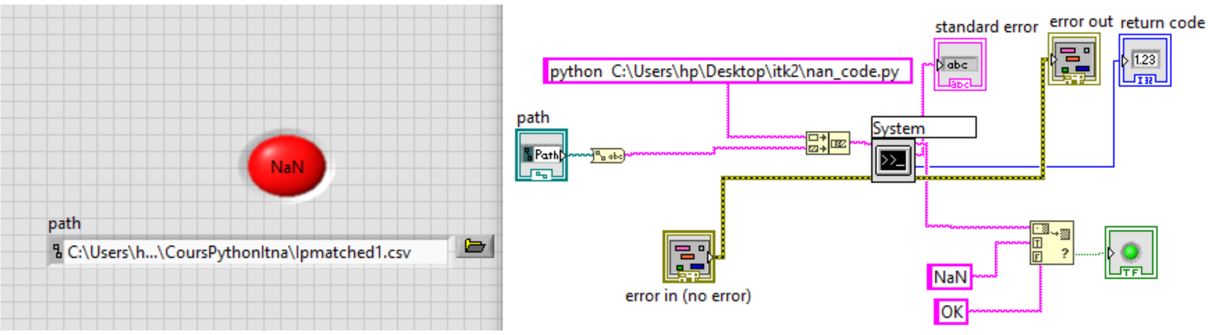

Figure3: in this image, we have opened a file containing Nan.

In this program, we have developed a way for the operator to be alerted to the existence of Nan in the csv file in the LabVIEW program panel.

3. quality control of locking point alignment

After positioning and collecting the coordinates of the locking points, the next step is to check their alignment. To achieve this, python code was developed to check their alignment and plot their positions in relation to the normal. In parallel, we developed a LabVIEW program that indicates the alignment of locking points with lights and displays the plots.

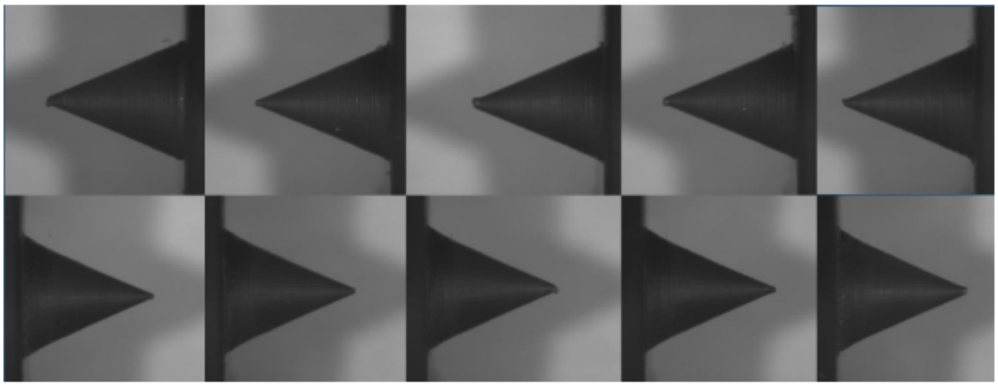

Figure4: the image of the locking points taken by the aerotech camera. in the stave, we have 5 locking points, each with two cones, so we need to make sure that the cones and centers of all the locking points are aligned.

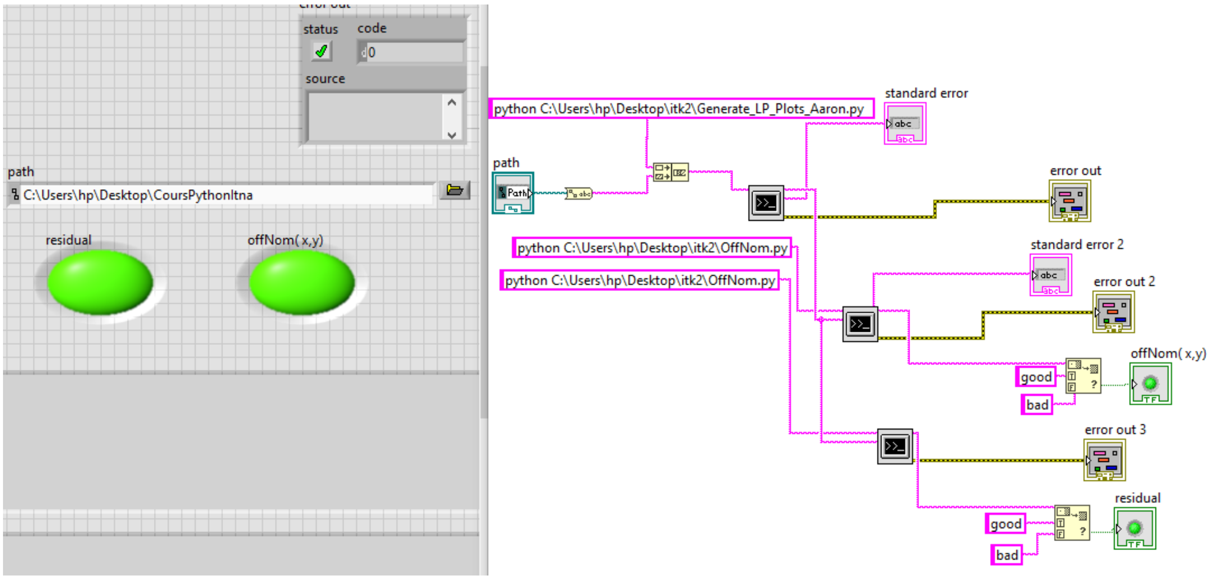

Figure 5:labview program for the light indicators

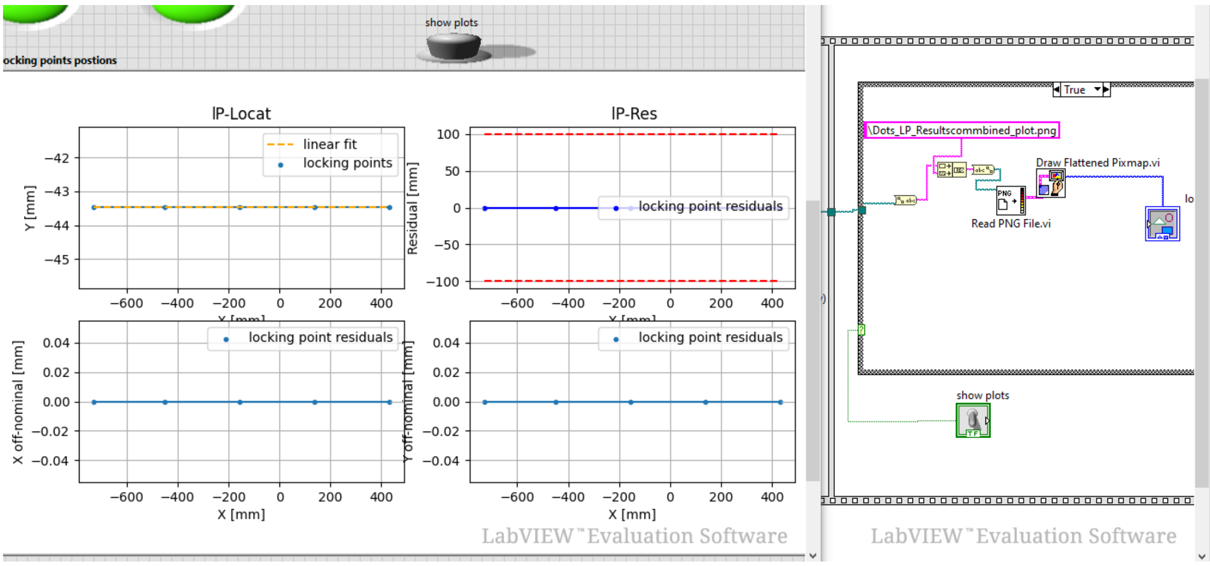

Figure 6: labview program for displaying plots by pressing the show plots button

In figure 5 of the labview program, we have two colored indicators: the one we call residual indicates the alignment of the centers of the locking points with respect to the x and y axes, and the second indicates the alignment of the locking points. when at least one of the locking points is out of range, one of the indicators will turn red.

We've created a python code that draws the alignment of the locking points with respect to the normal, making it easy to identify locking points that are not aligned with the normal in the case of red buttons. graphs will be displayed in the LabVIEW panel, as shown in figure 6.

Conclusion

This work was carried out to improve the quality control of the stave by adding a Nan indicator, adding two indicators, one for the alignment of the locking points and the other for the position of the center of the locking points in relation to the normal, and finally drawing curves showing the linearity of the locking points and displaying them in LabVIEW.

Acknowledgement

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