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Interpretation of the Barrel TRT gain map data from Duke X-ray scanner.

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As one of the quality control steps for the barrel TRT modules, the gain along the straws is measured at several points. Because the gain is related to the wire eccentricity inside straws, the gain mapping reveals how well straws are aligned inside a module, which is related to how well modules are constructed. Other than indicating the overall quality of modules, the gain map also selects out channels with unusually large gain variation. These channels have to be disabled (wires are removed) for a proper TRT operation.

The gain measurement can be done using Fe55 or an X-ray source. We have accumulated a fairly large amount of gain mapping data using the Duke X-ray scanner. In this paper, we attempt to classify and understand the features shown in the data. The proper understanding of the gain data is very important since some of the wires will be removed based on the degree of the gain variation. And removing wires is a permanent process.

Using the X-ray scanner, the gain is measured at 46 points equally spaced along a straw (23 points for each half). For the gain measurement, the signals from a sense wire are amplified and connected to an ADC. Figure 1 shows a typical charge distribution from the ADC (after subtracting out the pedestal). The distribution is fitted with Gaussian function to get the average. The average is related to the gas gain. The 46 averages are plotted as shown in Figure 2.

The statistical error for each point in Figure 2 is less than 0.5%. There are also errors due to the environmental factors such as pressure and temperature change, HV drift and gas composition change. The time constants for these factors are expected to be longer than ~10 minutes of one data taking period (23 points for one ASDBLR group, and there are 16 straws in the group). However one factor could have short time constant is the noise. Due to the activities around the module and in the building, the noise level fluctuates time to time. We have found that the noise level does shift the average ADC.

In Figure 3 through 10, we have collected plots with large gain variations. Most of the data with large gas variation falls in one of these categories. Because the data is taken front and back side separately, the x-axis of plots has 23 points rather than 46 points.

Class 1. Figure 3 and Figure 4

This is when a straw is bent between dividers. In a module there are five dividers. These are the locations where straws are supported and aligned. Including an endplate at each end, straws are aligned (supported) at seven locations. Or in a half of a module, there are four supporting locations. Figure 3 shows a case when a straw is bent between every supporting location and Figure 4 shows a case when a straw is bent between the last divider and the end plate. The straws with this behavior could be candidates for wire removal if the gain variation is out of specification. Typically, these channels are at the corners of a module of next to the shell. We suspect that these straws are pushed by the radiator sheets.

Class 2. Figure 5

This is when the sense wire is caught in the middle wire support or an end wire support. The typical behavior is continuous increase of the gain along the straw length. The channels with this behavior can be saved by re-stringing. Normally we remove ~6% of wires because of this problem during the stringing process because they fail HV test. However, it is not surprising that the HV test does not catch all the problem channels.

Class 3. Figure 6, Figure 7

We believe that the case 3 is due to the contamination on the wire. Figure 6 shows that the contaminated area is isolated (~ cm) while Figure 7 shows that the area could be as large as several cm. We note the X-ray beam width is about 5 mm and the distance between measurements is about 2.5 cm. We think that these features are due to the contamination on the wire for two reasons. First the gain in the dip region is lower than well centered wire. The gain should be minimum when the wire is perfectly centered. Second the dips disappear or get less pronounced after a ‘burning off’ process. In the figures, the gain map after the burning off process is also plotted. For the burning off process, a Sr90 source was position at the location of the contamination. Although we did not make careful measurement, we found that ~10 kHz/cm for one hour was sufficient to burn off some contaminant. Our measurement also shows that some modules exhibit less of this problem. This may be due to cleanness during the stringing. To reduce the problem due to contaminant, it is conceivable that a module undergoes a ‘burn off’ process before mapping.

Class 4. Figure 10

These are the cases not easily determined without looking at the data in detail. We found that some of them are due to bad fittings (to the ADC distribution) or bad measurements. Because the fits are done blindly (~25,000 fits for a type II module), it is quite often possible to have bad fits.
Another reason for the gain variation is the noise level change as discussed earlier. For these channels data has to be retaken. The sudden jump shown in Figure 10 may indicate

misaligned straw but further investigation shows that there are a few more straws within the same ASDBLR group with the same behavior. The data for the straws in the same ASDBLR group is taken at the same time. The sudden jump disappeared in the rescanned data.

Case 5. Figure 11, Figure 12

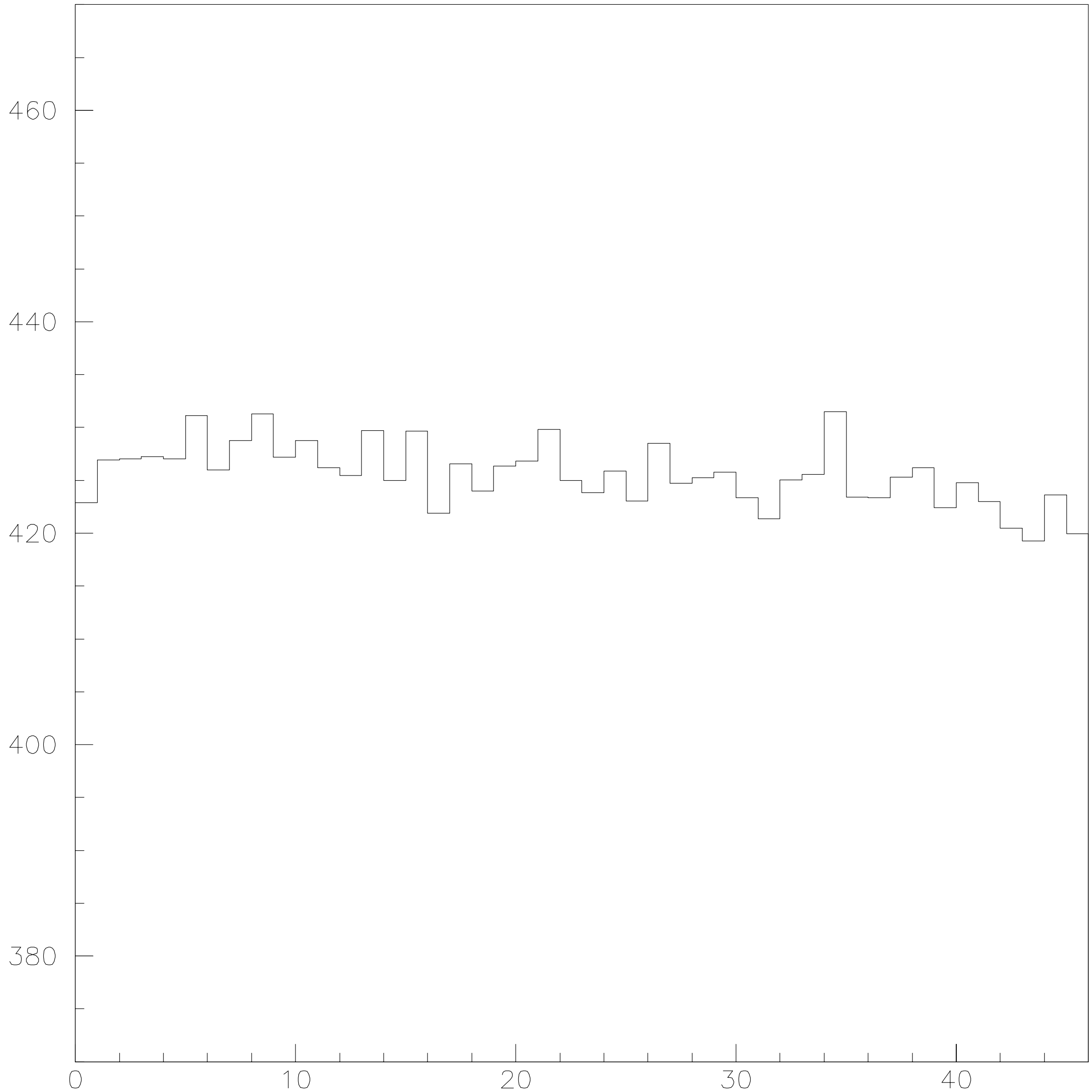
In some cases, the reason for the gain variation cannot be determined. The low gain in Figure 11 could be caused by a contaminated wire, but burning off process did not reduce the dip. It is possible that the contamination is bad and longer burning off period may be necessary. Figure 12 shows a case with sudden gain increase. Normally the increase is about ~5% and maybe ignored unless there are many other straws with this feature. This could be due to a sharp bending in a straw. Straws falls in Case 5 are hard cases and a set of guidelines has to be made to deal with these channels for removing wires.

Summary

As discussed at the beginning, some of the wires will be removed based on the gain map. Since this is a permanent process, utmost care has to be exercised to understand the data. Relying on a simple algorithm to decide to remove wires could be dangerous.

Experience shows that we have to have several filters. The first one would select out possible candidates for wire removal. For example, the plot of the ratio between the maximum gain minus minimum gain to the minimum gain (within 23 gain points) could be used for this purpose. (Figure 11 shows a plot of the ratio from the module 2.08). Once these channels are identified, they should be looked at individually. It may be also necessary to retake the data for some of the channels to make certain that we do not remove good wires. The channels belongs to Class 2 could be fixed by re-stringing.

In conclusion, a careful guideline has to be implemented for removing wires based on the X-ray gain mapping.



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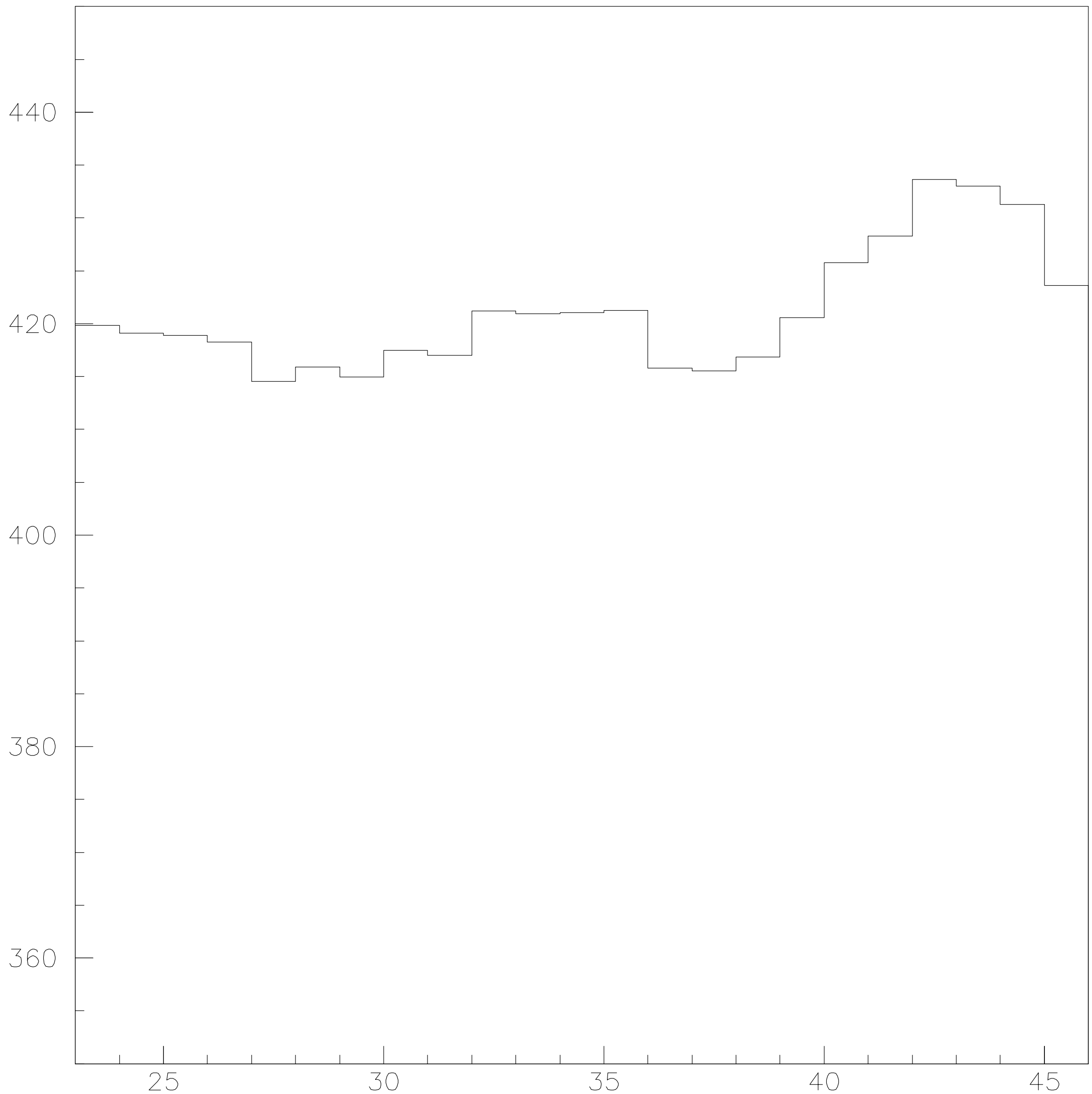

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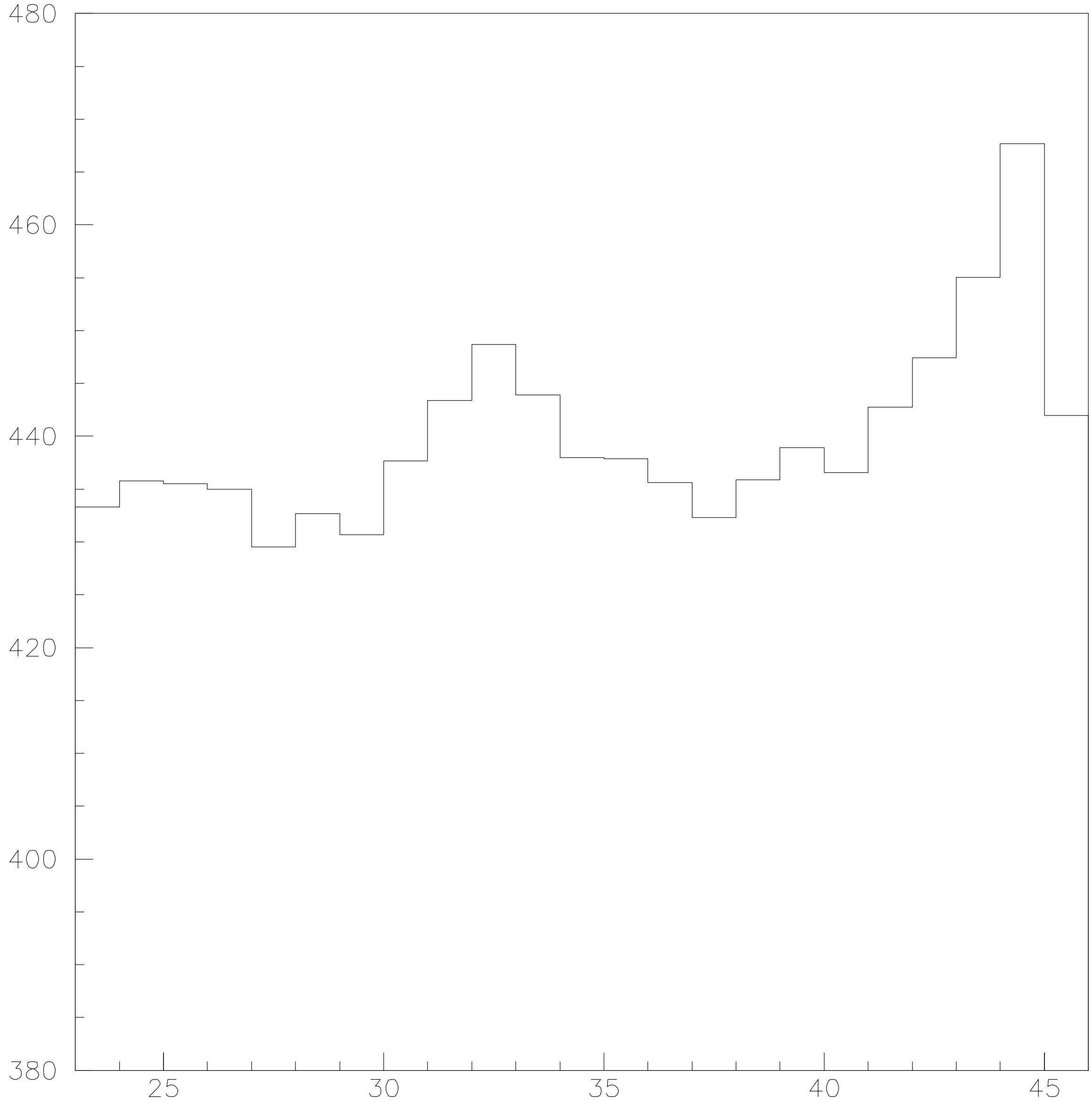

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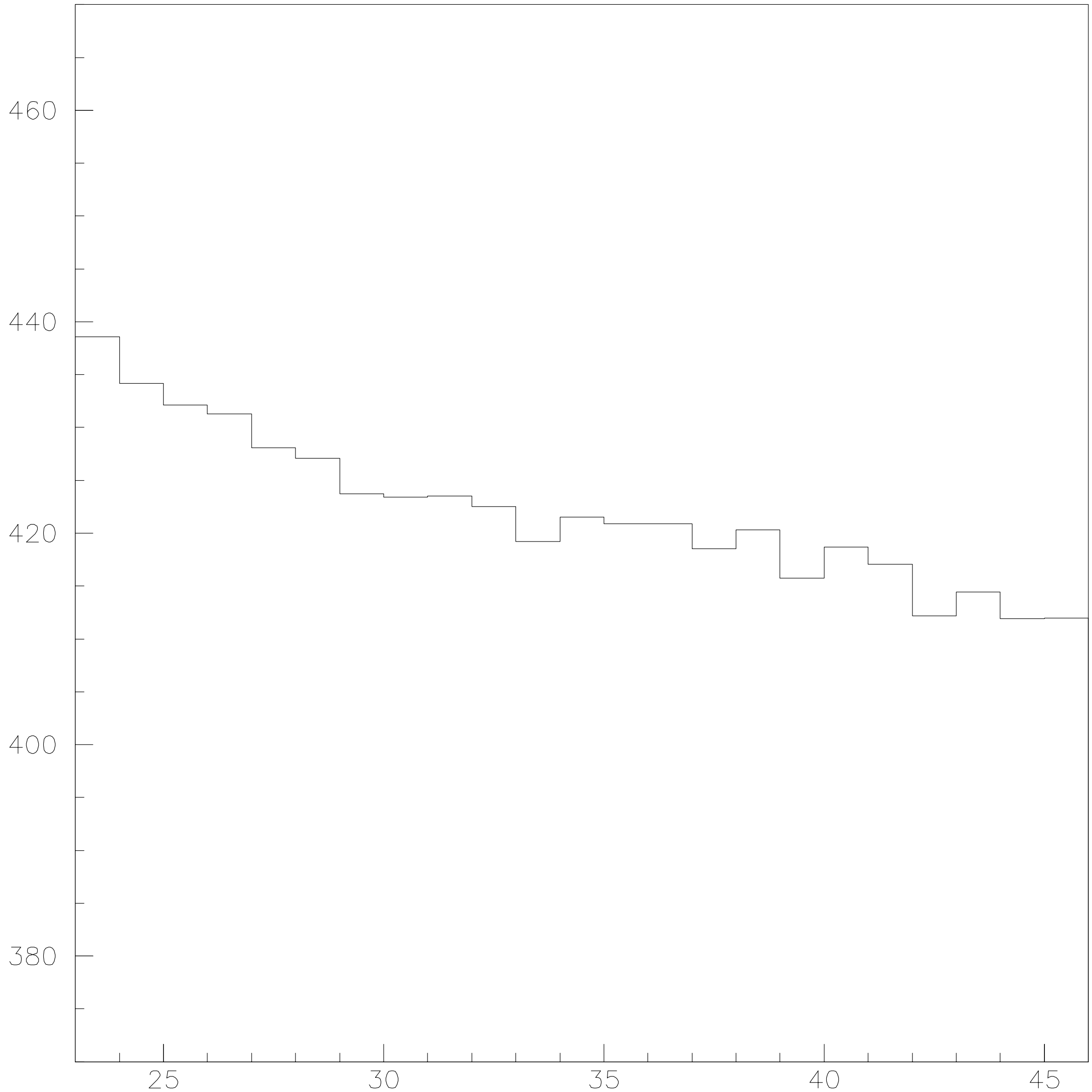

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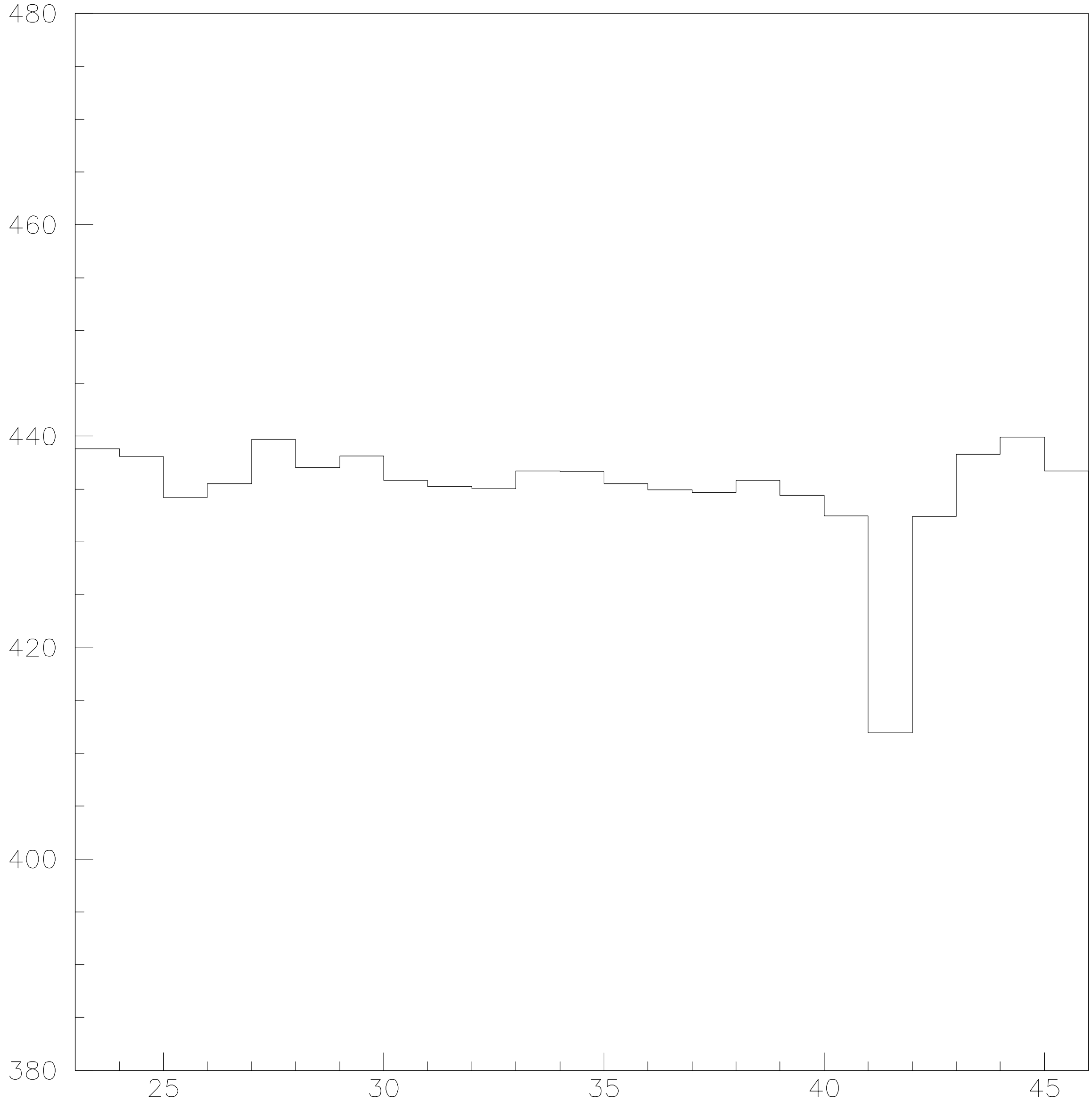

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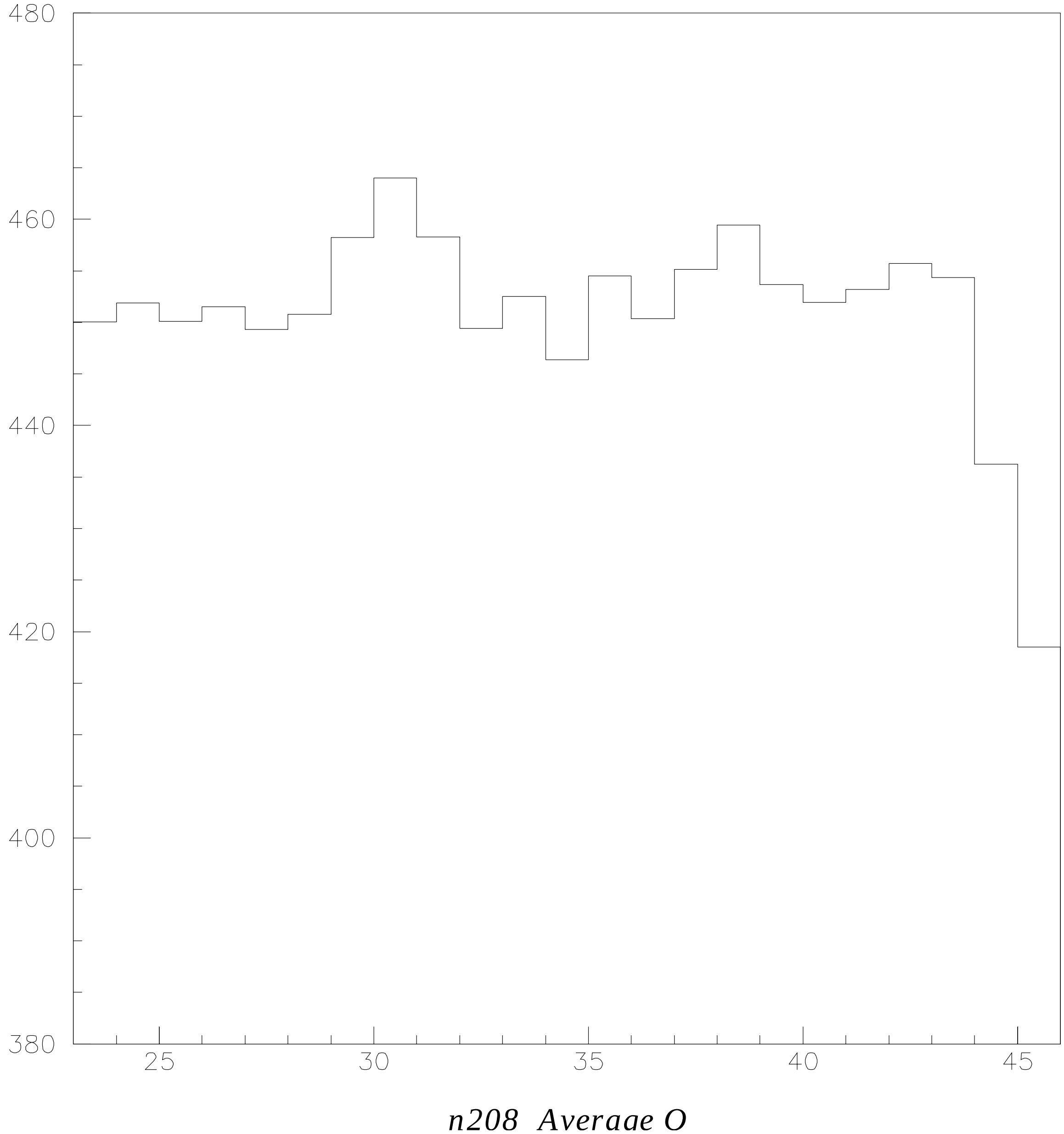
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