A Short Analysis of run #07333

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1 Introduction

The purpose of this document is look over the data collected in MICE run #07333. This run was chosen because it was a recent run with good data.

The analysis code used to generate the plots here can be found in:
`https://github.com/e-overton/mice-analysis-scripts`.

2 Cluster Light Yield

The cluster light yield gives an idea of how well the calibration was performed, as well a measure of light yield from each passing particle. An interesting feature of the front end electronics is that some channels saturate at a low point (10-15 p.e.) and other channels saturate much higher (30+ p.e.). This feature is caused by the different gains of different cassettes of VLPC modules. Channels in saturation produce artefacts and should be discarded by the analysis, for completeness in this analysis a "saturated" histogram is shown, which contains the saturated channels.

A technique was employed in the tracker NIM paper which used the probability of a channel not being saturated to re-scale the bins in the histogram. This technique has been re-implemented here to produce the "unsaturated rescaled" histogram.

The clusters in this analysis were selected from tracks in order to reduce the noise of generating clusters. Figures 1 and 2 show the results of this analysis for the upstream and downstream detectors respectively.

In general the upstream light yield looks quite nice, however there is a long tail in the "unsaturated rescaled" histogram and could easily be an error in the implementation. There is a clear peak, centred on approximately 11 p.e., which is comparable to the 11.23 ± 0.01 p.e value presented in the NIM paper.

The downstream detector looks considerably different, which is probably caused by the sharp saturation at 11 p.e. shown in the right hand plot. This leads to a sharp spike and fall in the "saturated" data, and produces a sharp cut off in the "unsaturated" data. The "unsaturated rescaled" histogram displays an additional excess around 15 p.e., which could be related to this saturation.

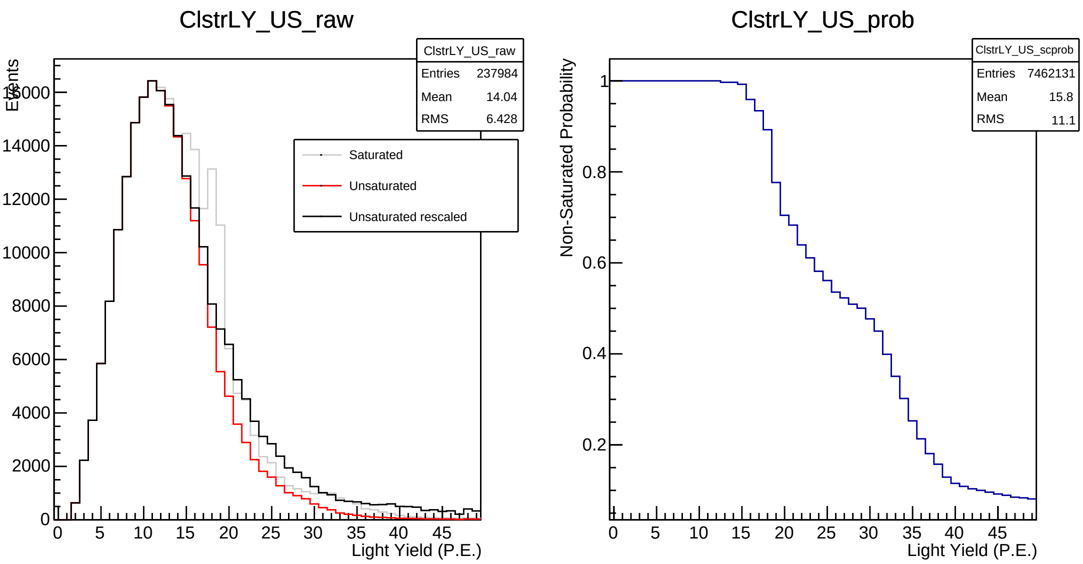

Figure 1: Cluster light yield of the upstream tracker

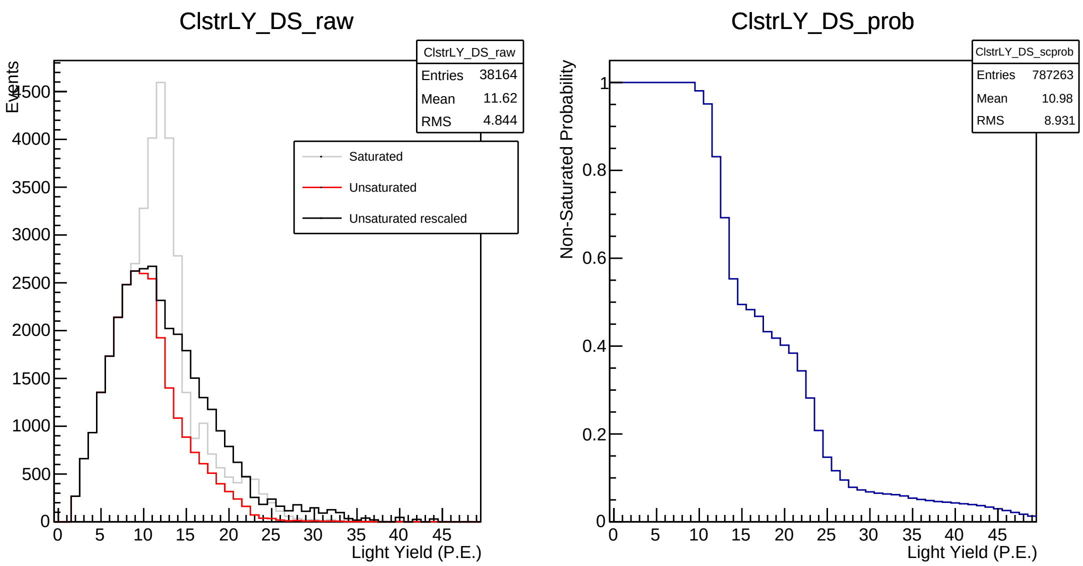

Figure 2: Cluster light yield of the downstream tracker

3 Station Plots

The analysis next studied each station inside the tracker, using space points. Lower level objects such as digits and clusters were again ignored due to their susceptibility to noise.

Each plot shows a histogram of the channels hit in each plane used to form a triplet space point which formed part of a track, note that gaps in the plane indicate a non-functioning channel. Complementary to this, the kuno conjecture was used with the duplet space points to indicate channels missing from the space point and is overlaid in red.

The final plot for consideration is the summary of all hits. A coincidence of horizontal and vertical slab hits were required of both TOF1 and TOF2. If no space point was observed in the station, then bin zero was filled. If a duplet was observed in the station, then bin 2 was filled and finally if a triplet was observed then bin 3 was filled. In the case of the "spacepoints in tracks" histogram, an extra constraint is applied which requires the space point to be part of a track, otherwise bin zero is filled.

Station 1 from the upstream detector is shown in figure 3, where plane 0 indicates at least 3 missing channels, and all planes look fairly respectable. The lower right "Hit Type" histogram shows some notable features:

1. There are a considerable fraction of triplet space points which were not associated to a track, and had a coincidence in TOF12.
2. There are approximately 100 of 3300 hits where no space point was formed for a TOF12 coincidence.
3. The ratio of duplets to triplets is comparable for both tracks and non-tracks, which indicates a low noise rate.

Station 1 from the downstream detector is shown in figure 4, again a few missing channels can be observed in planes 1 and 2. The "Hit Type" again indicates a number of things that can be compared to the upstream station:

1. There is a larger fraction of triplet space points which were not associated to a track, and had a coincidence in TOF12.
2. There are approximately 500 of 3300 hits where no space point was formed for a TOF12 coincidence, this is far worse than the upstream.
3. The ratio of duplets to triplets is lower for the space points requiring a track. This indicates the presence of background noise in the duplets.

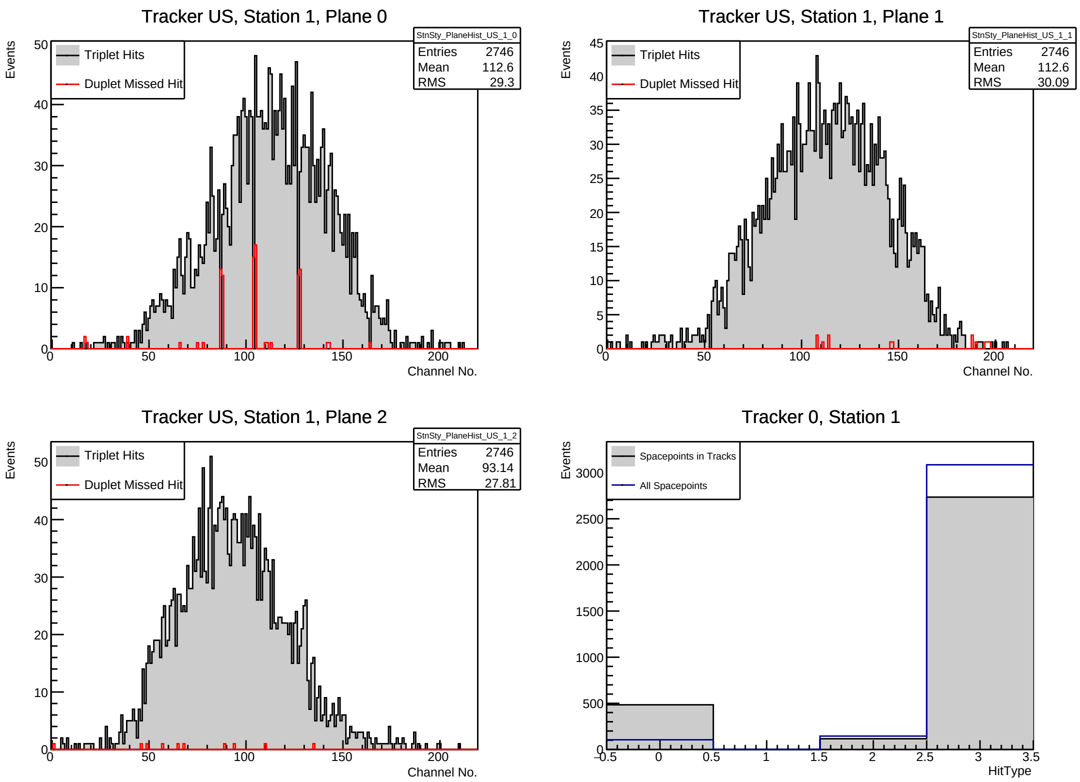

Figure 3: Single plane and hit efficiency plots from the station one in the upstream detector

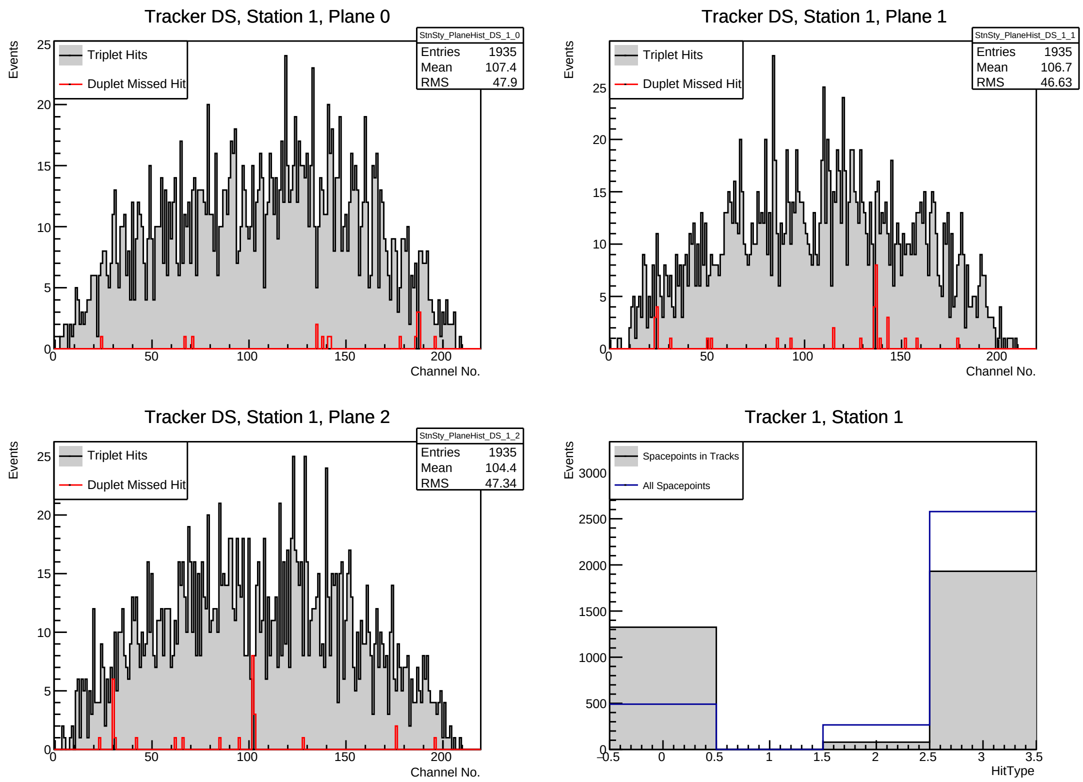

Figure 4: Single plane and hit efficiency plots from the station one in the downstream detector

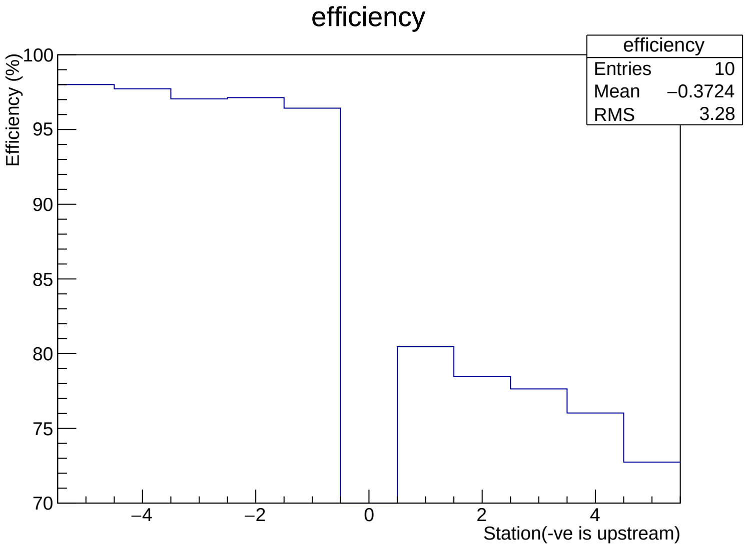

Figure 5: Efficiency for each tracker station, the upstream stations numbers are negative. eg: upstream station 3 = -3 on the plot.

4 Efficiency

From the station studies it is possible to make an estimate of the efficiency we have at each station. This is done by estimating the number of detector hits by:

$$\text{Hits} = \text{Triplets Observed}(1 + \frac{\text{Track Duplets}}{\text{Track Triplets}}) \qquad (1)$$

The purpose of this expression is to include duplets, without noise hits by using the ratio calculated from tracks. Triplets are assumed to be noise free, by their nature. The efficiency is then the number of hits to coincident TOF12 hits.

The plot indicates that the upstream detector is in good shape, with a 95% + efficiency, however the downstream detector is far less efficient, and has efficiency's between 70% and 80%. Both trackers have a slope in the efficiency, which is much more distinct in the downstream detector. This slope could be a hint that the timing of the integration and alive windows are incorrect.

5 Duplet Noise

The final study in this analysis was to investigate the rate of duplets from each station. This was completed by taking the duplet/triplet ratio for space points and subtracting the duplet/triplet ratio for space points which were contained within a track. The results are plotted in figure 6.

The upstream detector has a noise rate much lower than 1% on average, however the downstream detector has a noise rate as high as 10%. While this is still quite low, and the pattern recognition

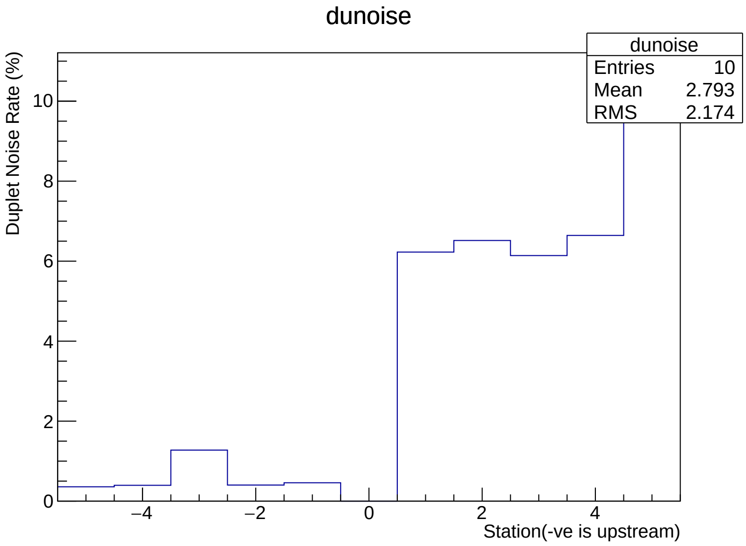

Figure 6: Duplet noise rate for each tracker station, the upstream stations numbers are negative. eg: upstream station 3 = -3 on the plot.

should filter out this, caution is required when looking at raw hits.

The higher noise rate in the downstream detector is most likely caused by the bias calibration, where the dark rate was set 50% higher than that on the upstream.

6 Conclusion

The upstream detector appears in very good shape, however the downstream detector is in less good shape, with both a higher noise rate and lower efficiency.

Indications point at a slight (<30ns) timing offset in the downstream detector. To fully understand this data is required from a reduced alive window in the DAQ.