1 Report of Work Carried out at DESY by Kate Voller

1.1 My Project

During my stay at DESY I have been helping carry out systematic analysis of testbeam data from a prototype Cherenkov detector. I looked at data from both 2009 and 2010. In the first few weeks I learnt some C++ by doing fits and creating plots in the ROOT framework of some data previously taken by my group. Initially I was using code that had already been written so as to familiarise myself with C++ and then I wrote a couple of my own scripts which collected data from a database, plotted relevant histograms and applied various fits. During the first few weeks I was looking at data from several photomultipliers, mainly the Hamamatsu R7400-06 single-anode photomultiplier (SAPM) and the Hamamatsu R7600U-03-M4 multi-anode photomultiplier (MAPM). Once I had written all the code to make the relevant plots and fits, I looked into the SAPM in a lot more detail and did a systematic analysis of pedestal poistion and pedestal width with time and with other varying parameters. Data from 2009 and 2010 was looked at and compared for the SAPM and the main results of my work are presented in the following.

1.2 Testbeam data 2009 (Gatelength:300ns Channel:7,'lo')

1.2.1 General Overview of Data

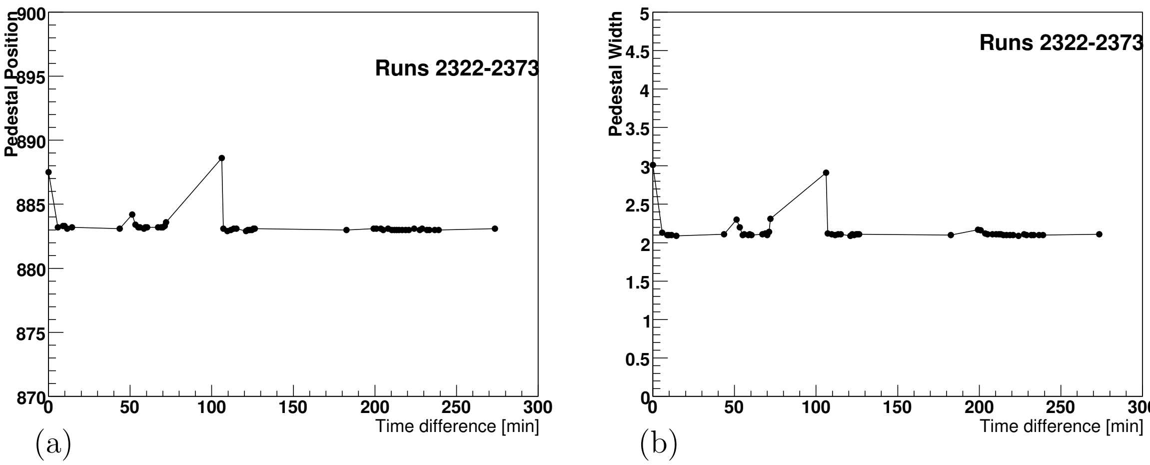


Figure 1: (a) Pedestal position changing with time, (b) Pedestal width changing with time

In Fig. 1(b) it can be seen that the pedestal width is constant apart from a few slight increases in width, causing peaks at run numbers 2322, 2328 and 2341. The first peak marks the start of the HV scans. The next block of runs (2328-2340) are the x-scans and the start of the y-scans are marked by the third peak at 2341. The final block are the bc-scans which have a very slight increase in width at the start but nowhere near as noticable as the other peaks. For now we will assume the peaks in the data appear at the channel edge and this will be proved later on when a more in depth look at the data is done.

Fig. 1(a) shows a near constant pedestal position with peaks occuring in the same places they did for the corresponding pedestal width graph (Fig. 1(b)). The first block of points corresponds to HV scans, with the next block being the x-scans. The start of the y-scans are again marked by the peak at run 2341 where the largest change in pedestal position occurs. The last block of bc scans don't seem to start with a peak.

1.2.2 X-scans

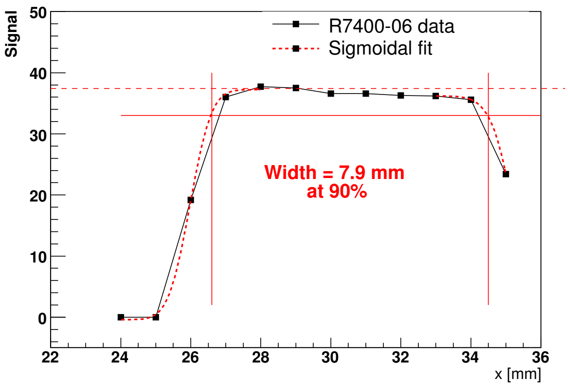
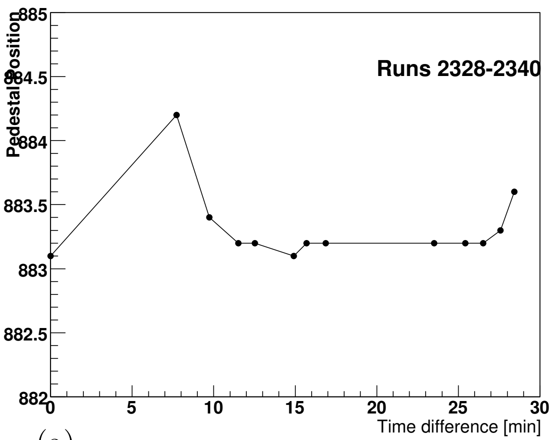
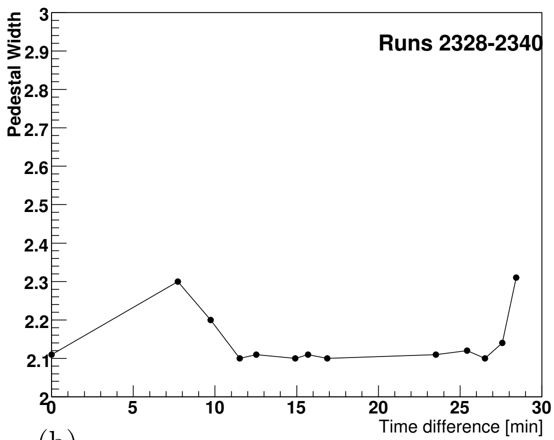


Figure 2: Signal for x-scans (runs 2328-2340)



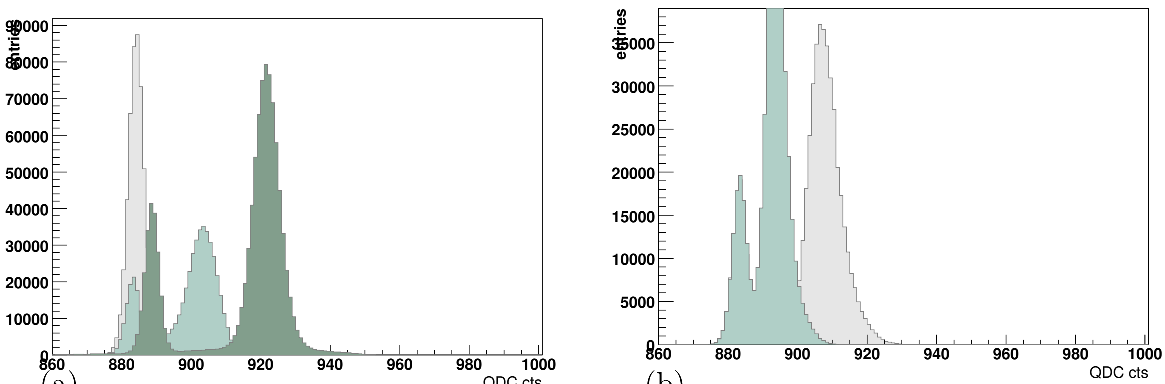
(a)



(b)

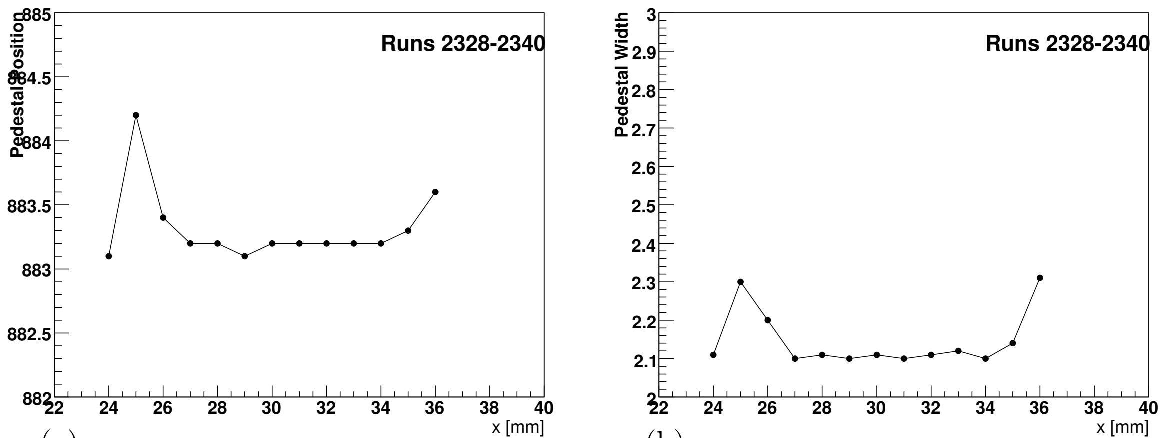
Figure 3: (a) Pedestal position and (b) pedestal width changing with time for x-scans

Fig. 3(a) and Fig. 3(b) show that the pedestal position and width for the 2009 x-scans remains almost constant. Between the first and second data points, there is the biggest change in pedestal position (increase of 1) and width (increase of 0.2) but after this point, it remains fairly constant for the remainder of the x-scans. The peaks at the start and end of the data occur at runs 2329 and 2340 and looking at the signal plot in Fig. 2 for this set of data it can be seen that these particular runs seem to be where the signal first starts to increase and at the end of the plateau where it starts to fall away. This means that the peaks in the pedestal position and width plots mark the edges of the channel. This can be confirmed by the plots in Fig. 4 where in plot (a) the grey represents run 2328, light green represents run 2329 and dark green represents 2330, clearly showing the edge of the channel is at 2329. In plot (b), the light green represents run 2339 and the grey represent run 2340, again clearly showing the signal disappearing and thus marking the channel edge. The plots in Fig. 5 also illustrate this fact nicely as you can see whereabouts in the x position the peaks in the position and width occur, confirming this is where the edge of the channel lies.



(a) (b)

Figure 4: Histograms illustrating (a) the left channel edge and (b) the right channel edge



(a) (b)

Figure 5: (a) Pedestal position and (b) pedestal width with x position

1.2.3 Y-scans

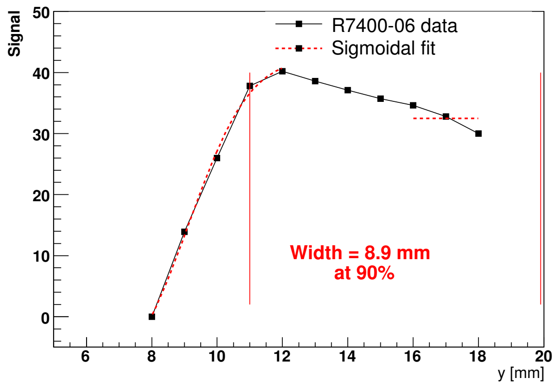
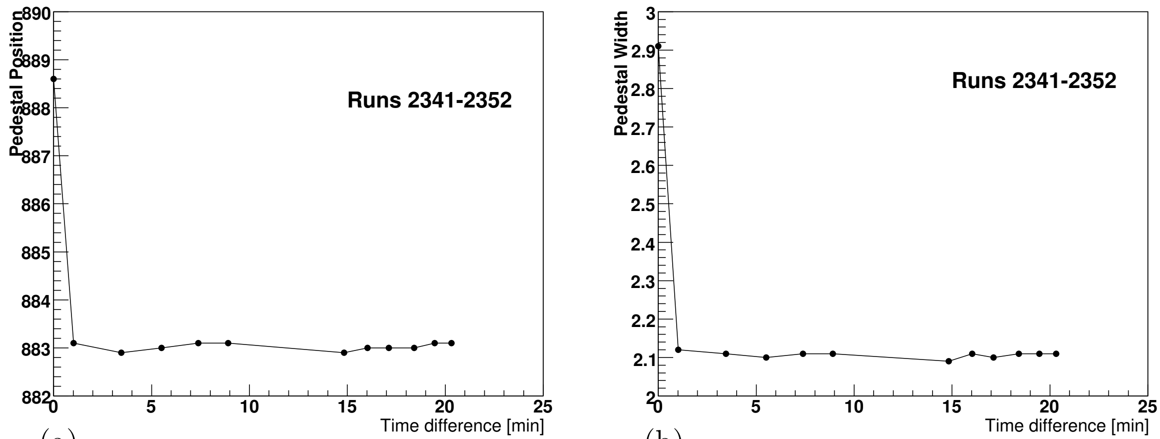


Figure 6: Signal for y-scans (runs 2341-2352)



(a) (b)

Figure 7: (a) Pedestal position and (b) pedestal width changing with time for y-scans

Fig. 7(a) shows the pedestal position for the 2009 y-scans. It can be seen form the plot that apart from the first run, the position remains almost constant throughout the set of y-scans. The first run has a difference in pedestal position of about 6 from the rest of the data. The pedestal width plot for these y-scans shown in Fig. 7(b) follows the same pattern as the pedestal position plot with an alomst constant pedestal width, bar the first run (2341) which has a pedestal width of 0.8 higher than the rest of the data which, like the x-scans, could represent one of the channel edges. This can be more easily seen by looking at the signal for the relevant run numbers. Fig. 7 shows that there is no signal for run number 2341 but there is for run 2342. The grey plot in Fig. 8 represents run 2341 where there is no signal while the green plot is run 2342 where signal clearly starts to appear, therefore the peak in the y-scan is the channel edge. Not enough data was taken to be able to see the other edge of the channel but the general results would be similar to those for the x-scans seen previously.

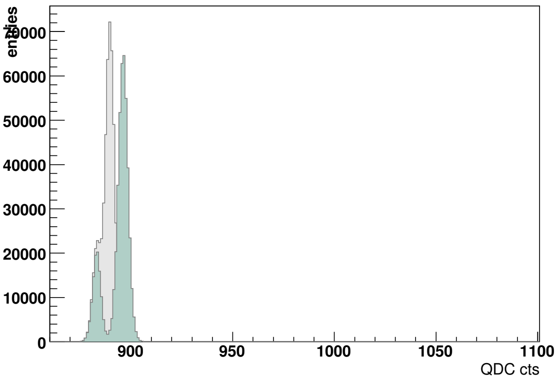
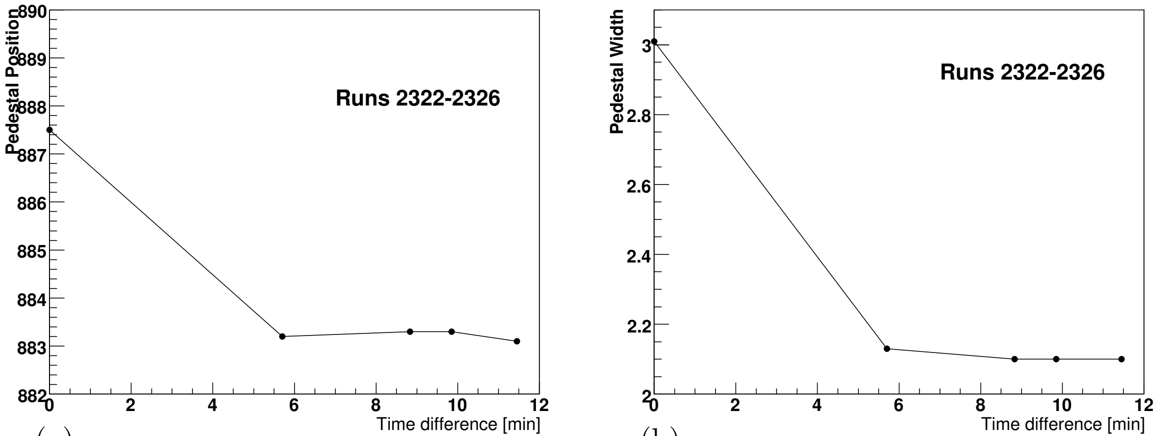


Figure 8: Histogram showing the edge of a channel

1.2.4 HV-scans



(a) (b)

Figure 9: (a) Pedestal position and (b) pedestal width changing with time for HV-scans

From Fig. 9(a), it can be seen that the pedestal position remains constant from the second HV-scan onwards. The first run of the HV-scan (run 2322) has a pedestal position of approximately 4.5 higher than the rest of the HV-scans. The pedestal width graph in Fig. 9(b) follows the same general pattern as the pedestal position graph, with the first HV scan having a width of 0.9 higher than the rest of the data, which seems to have a constant pedestal width.

Fig. 10 shows that both pedestal position and width remain fairly constant throughout the HV scan apart from the first point which is significantly higher than any of the other points. It is unclear so far why this point is significantly different from the others. Fig. 11 shows a steady linear increase in signal as the HV is increased.

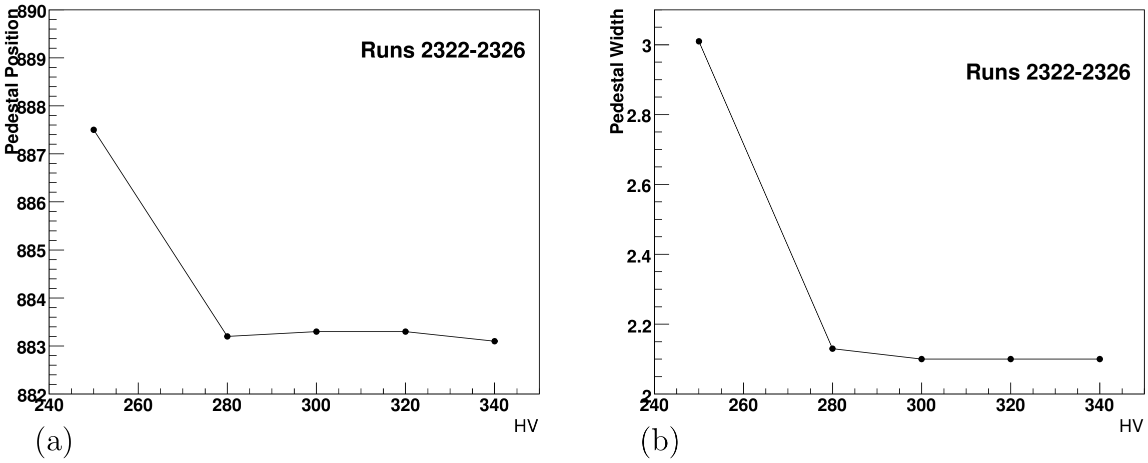


Figure 10: (a) Pedestal position and (b) pedestal width changing with HV. BC = 20

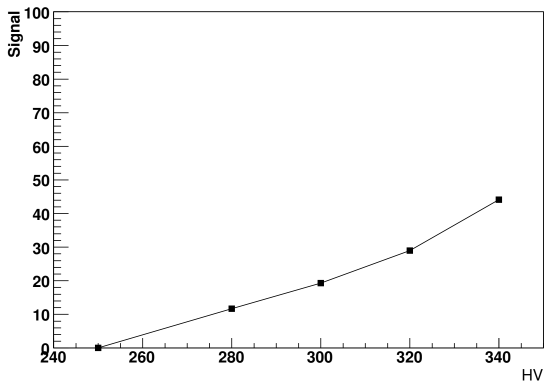
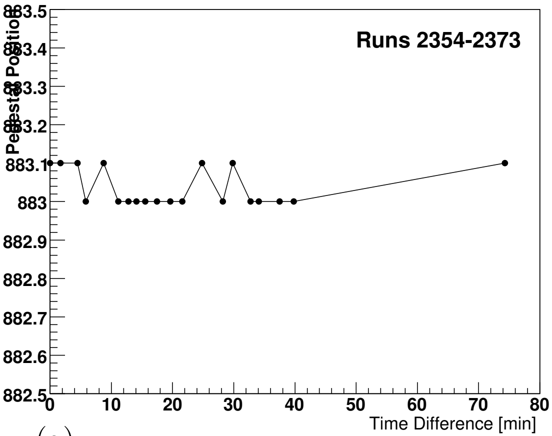


Figure 11: Signal-pedestal for HV-scans (runs 2322-2326), BC= 20

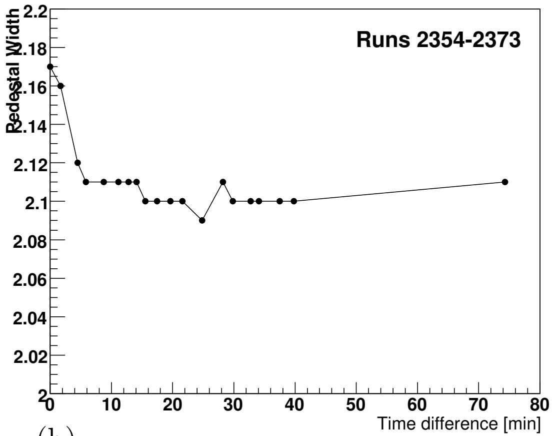
1.2.5 BC-scans

Fig. 12(a) shows that the pedestal position for the bc-scans seems to switch between 883.1 and 883.0. There are 5 peaks in the data where the pedestal position takes the higher value, and for the remaining runs it has the lower value. It is unclear why the peaks occur at the points where they do. Fig. 12(b) shows the pedestal width varies more than the pedestal position for the same set of runs. The first few sets of runs have a much greater pedestal width than the rest of the runs.

The plots in Fig. 13 show that the pedestal position is basically stable with resepect to bc. The pedestal width is also fairly stable apart from slightly higher values at the start. These plots follow the same general trends as those found in Fig. 12. Fig. 14 shows that generally there is a linear increase in signal as bc increases. There are two significant drops in signal at runs 2362 and 2372 respectively. It is unclear why these dramatic drops in signal have occured at these points.

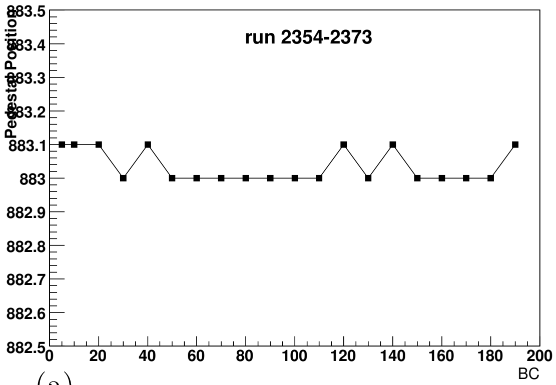


(a)

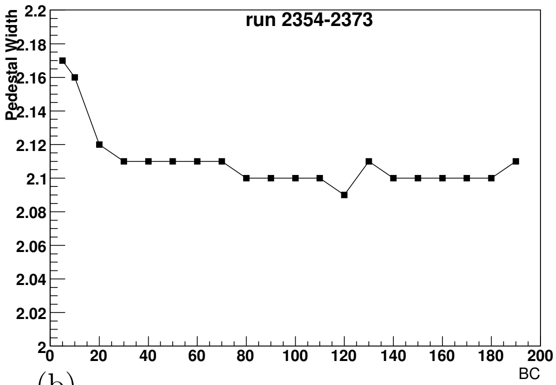


(b)

Figure 12: (a) Pedestal position and (b) pedestal width changing with time for bc-scans



(a)



(b)

Figure 13: (a) Pedestal position and (b) pedestal width changing with bc

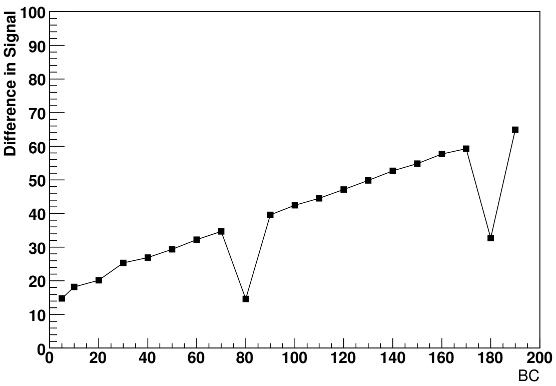
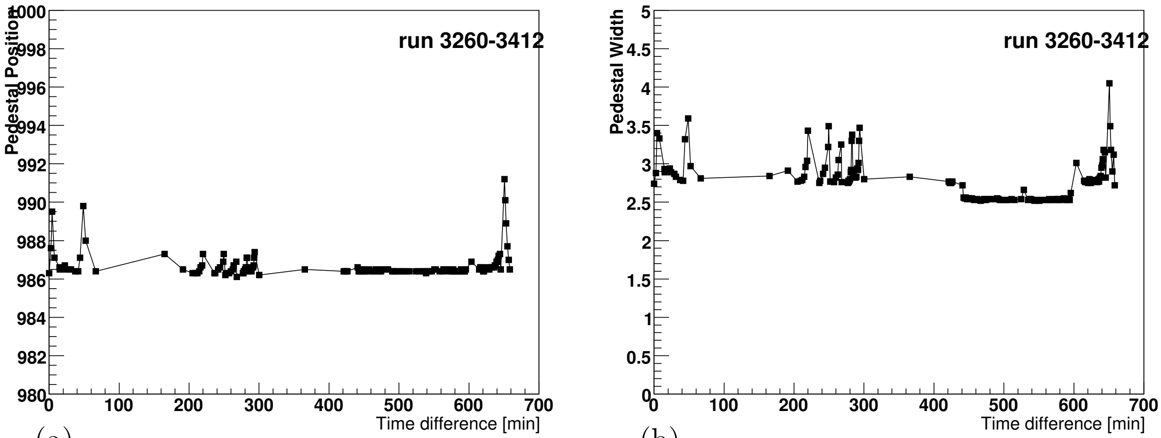


Figure 14: Signal-pedestal for BC-scans (runs 2354-2373), HV= 300

1.3 Testbeam data 2010 (Gatelength: 350ns Channel:6,'lo')

1.3.1 General Overview



(a) (b)

Figure 15: (a) Pedestal position changing with time, (b) pedestal width changing with time

Fig. 15(a) shows that the pedestal width is fairly constant with small periods of fluctuation in width. The first block of points, containing the first two peaks, represent the y-scans, followed by a reference scan. There is then one more y-scan and reference scan followed by a block of points containing several peaks, which are the HV scans. The peaks in this block seem to occur at the lowest HV in a particular run. The first peak at run number 3284 corresponds to a HV of 300, the peak at 3290 has a HV of 310, the peak at 3298 has a HV of 330, the peak at 3308 has a HV of 360 and the last peak at 3315 has a HV of 430. There is another reference scan about an hour later with a small blcok of dice-scans. The last long block of points are the bc-scans. The small bump in the middle indicates where the scans changed from bc-scans (scanning from low bc to high bc) to bc off-centre scans (scanning from high bc to low bc). The scans then return to just bc-scans but the HV was changed from 500 to 350 which could explain why the last block of bc-scans has a higher pedestal width. These scans are from high bc to low bc also.

In Fig. 15(b), runs 3260-3380 inclusive have a gate number of 350.75 ns while runs 3381-3412 inclusive have a gate length of 350 ns when the code is run. The runlist, however, shows that all these runs should have a gate length of 350 ns. The plot shows a near constant pedestal position aside from a few peaks occuring in the same runs as the peaks for the width graph (Fig. 15(a)). The first block of points are the y-scans followed by a reference scan. There is then the HV scans with another reference scan appearing about an hour later. The last block are the bc-scans, the first half of which have a HV of 500 and consist of bc and bc off-centre scans, whilst the second half have a HV of 350 and cosist only of bc-scans. The change between these two HV values causes a slight peak.

For comparison, channel 7 ie no signal present (Fig. 16(a)) has an almost completely constant pedestal position at a value of 1065 with only tiny flunctuations around this point. Fig. 16(b) shows the pedestal position for channel 7 and it can be seen that

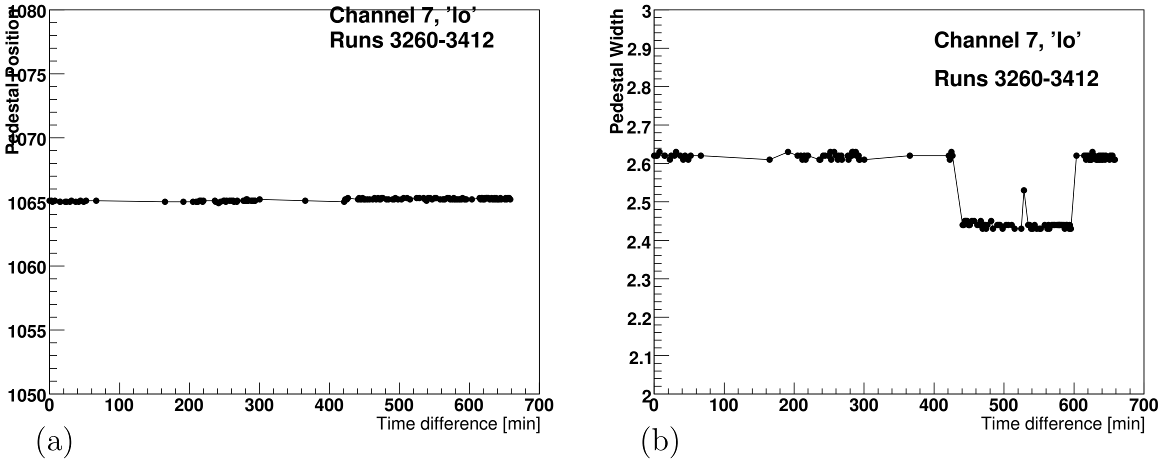


Figure 16: (a)Pedestal position and (b) pedestal width changing with time for channel 7

although the width does vary slightly, it is alot more constant than that for channel 6. However there is a sudden decrease in pedestal width when the first set of bc-scans are reached. The peak represents a reference scan followed by some off-centre bc-scans. The pedestal position then returns to its original position when the HV has been changed from 500ns to 350ns during the final set of bc-scans.

1.3.2 X-scans

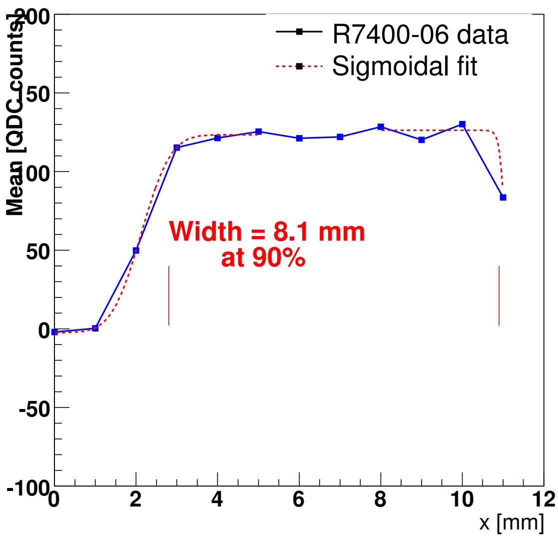
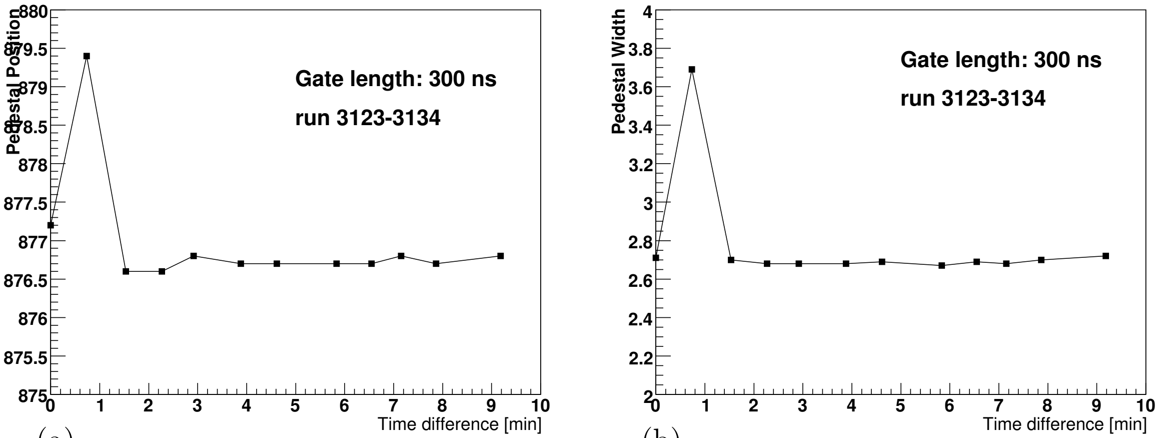


Figure 17: Signal for x-scans (runs 3123-3134)

Fig. 18(a) and Fig. 18(b) show pedestal position and width for a set of x-scans in the 2010 data. These set of scans show a very constant pedestal width and position apart from the one peak at the beginning of the run. Looking at the signal plot for this set of runs (Fig. 17) shows that this is where the signal starts to increase from 0 to a value. Fig. 19, where grey represents run 3124 and light green represents run 3125, also shows



(a) (b)

Figure 18: (a) Pedestal position and (b) pedestal width changing with time for x-scans. Note: gatelength is 300ns not 350ns.

that it is this run where signal first starts to appear (green plot) indicating this is the channel edge.

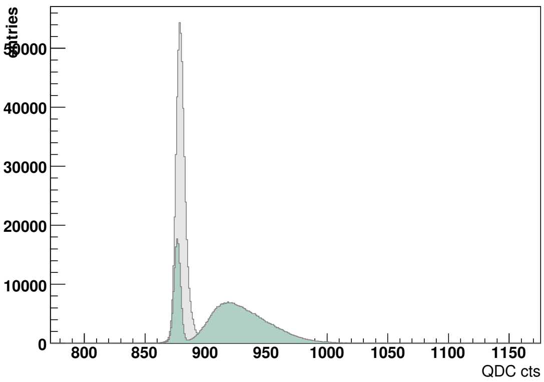


Figure 19: Histogram illustrating a channel edge

1.3.3 Y-scans

The pedestal position plot for the 2010 y-scans is shown in Fig. 21(a). The main part of the y-scan runs has a fairly constant pedestal position, varying only by about 0.5. However, at both the start and end of the runs there is a significant peak of approximately 3 higher than the rest of the data. The same applies for the pedestal width plot shown in Fig. 21(b) where there are two peaks of about 0.6 higher than the rest of the data at the start and end of the runs. Fig. 22(a) shows runs 3261-3263 (shown by grey, light green and dark green respectively) and it is clear that this peak (as in previous cases) is where the edge of the channel is (dark green plot has signal whereas light green run before hand has no signal peak present). Similarly Fig. 22(b) shows the channel edge for the other side (grey represents run 3727, light green is 3273 and dark green is 3274).

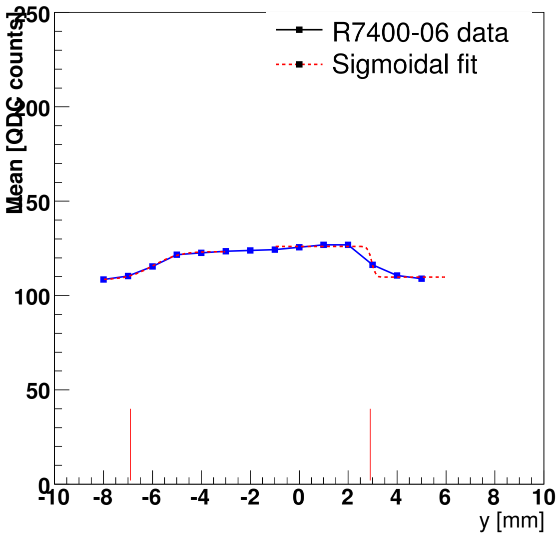


Figure 20: Signal for y-scans (runs 3261-3274)

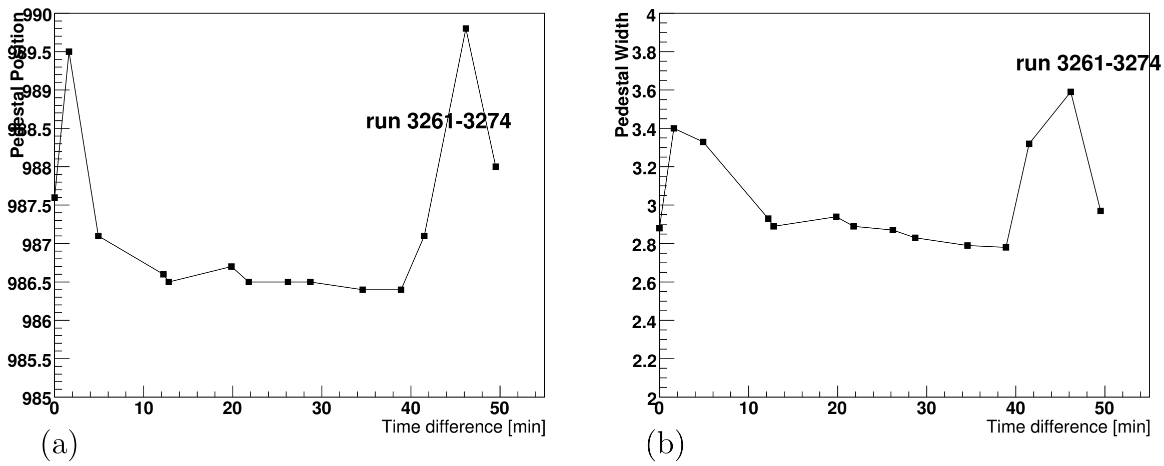
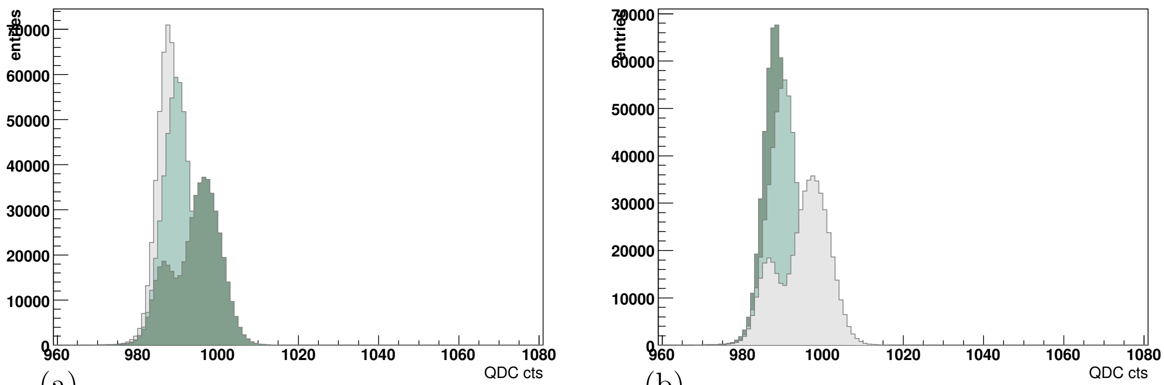


Figure 21: (a) Pedestal position and (b) pedestal width changing with time for y-scans

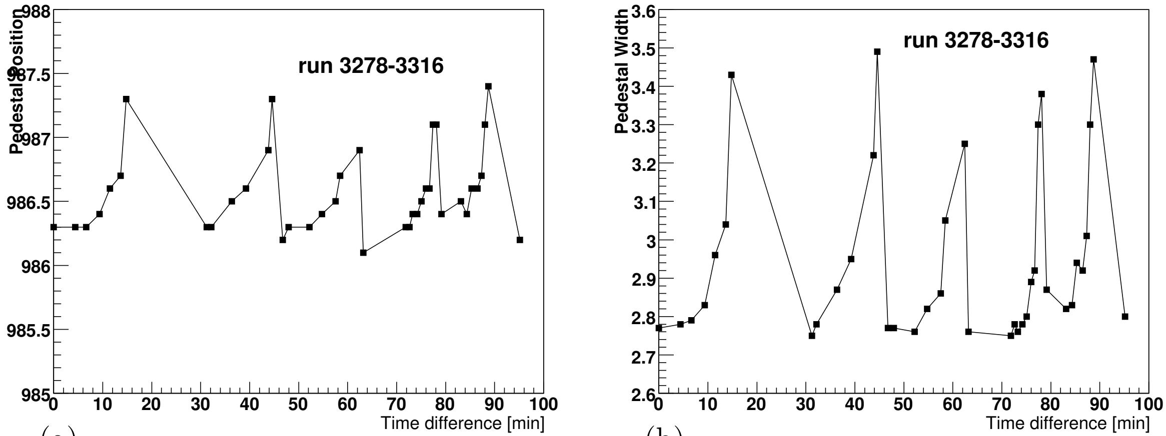
1.3.4 HV-scans

Fig. 23(a) shows that the pedestal position for the HV-scans fluctuates quite a lot. There are 5 main peaks and each peak seems to occur at the lowest HV in a particular run and the first point after the peak indicates where the HV has been reset to some higher value. The same pattern of peaks can be seen in the pedestal width graph (Fig. 23(b)) with each peak occuring at low HV values. Each set of HV scans was then plotted to see how pedestal position and width changed and the HV was increased shown in Fig. 24. In both casees, as the HV is increased, the pedestal position and width tend to decrease. The general shape of each plot is the same although the last three set of HV runs seem to begin with a peak due to the first point having a pedestal peak and width much lower than the rest of the points in that data run. A possible reason for the initial anomaly in these last three runs is the for runs 3298, 3308 and 3316 (the runs with the anomaly), the signal and pedestal seem to be overlapping so no separation of the two is possible,



(a) (b)

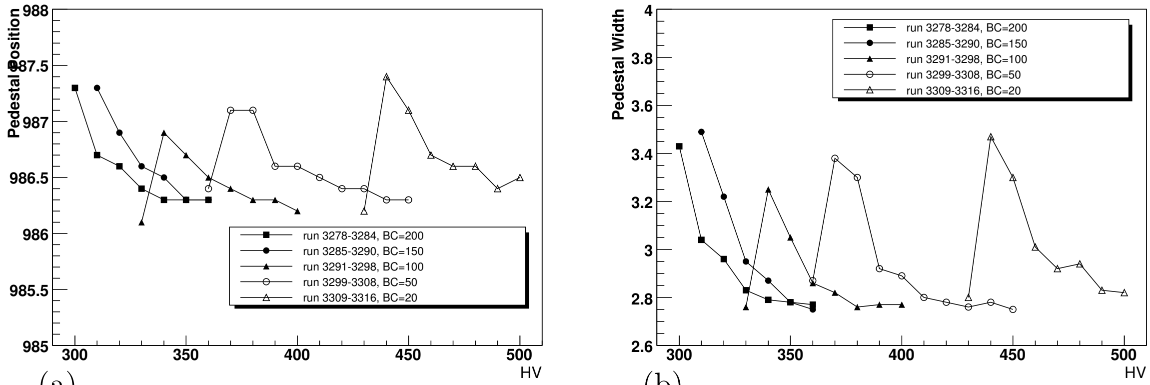
Figure 22: Histograms illustrating (a) the left channel edge and (b) the right channel edge



(a) (b)

Figure 23: (a) Pedestal position and (b) pedestal width changing with time for HV-scans

which could lead to inaccurate pedestal position adn width being calculated. The other two runs never have this occuring, suggesting this is the correct shape of the plot and not the shape of the plot with the peaks. Fig. 25 shows that the signal generally increases as the HV increases. A few of the HV runs have peaks in them which dont seem to fit the trend and it is unclear as to why these peaks have occured at these particular places.



(a) (b)

Figure 24: (a) Pedestal position and (b) pedestal width changing with HV-scans. Note: The lowest run number of each set corresponds to the highest HV value of each set

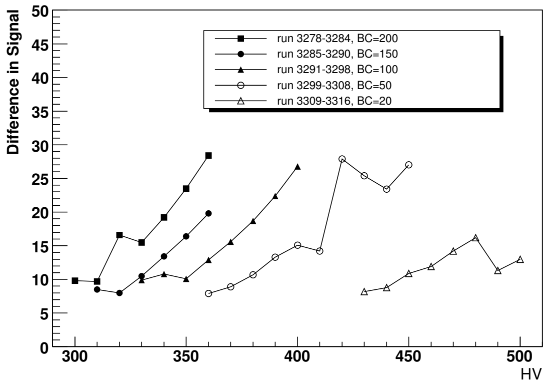


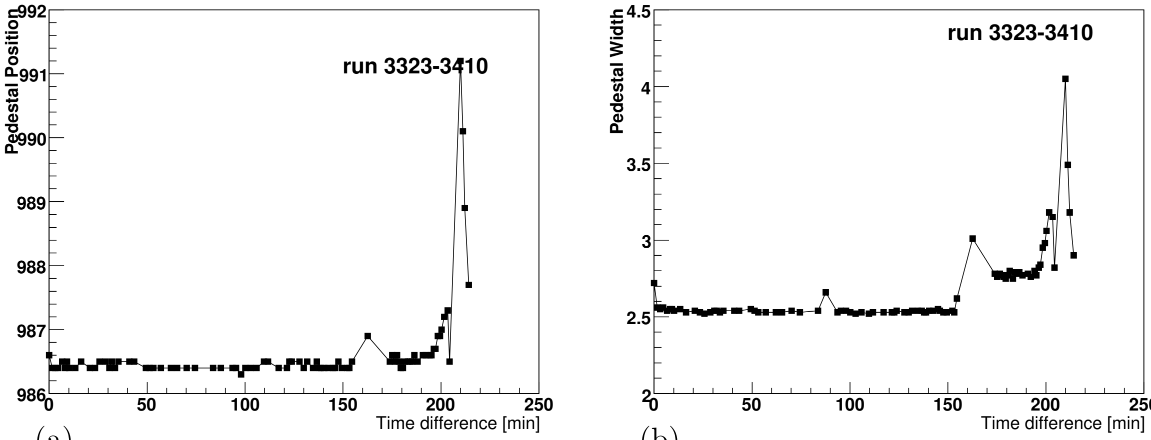
Figure 25: Signal-pedestal for different HV runs. Note: The lowest run number of each set corresponds to the highest HV value of each set

1.3.5 BC-scans

Fig. 26(a) shows that the pedestal position remains fairly constant throught the bc-scans apart from one significant peak at the end of the set of bc-scans. There is a small peak in the data occuring around a time difference of 160 mins which represents a reference scan amongst the bc-scans. Fig. 26(b) shows that the pedestal width is also fairly constant until the end of the set of bc-scans where there is more variation and the width seems to increase. This could be due to the HV changing from 500 to 350 for the later bc-scans.

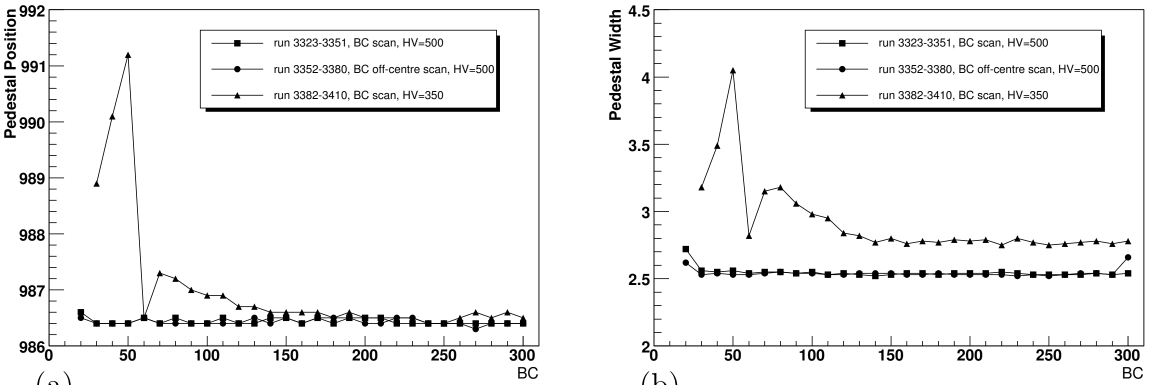
Fig. 27 shows that while the HV was kept at 500, the pedestal position and width remain constant regardless of whether the bc-scan was off-centre or not. When the HV was changed from 500 to 350 the pedestal position and width both increase. They are also less constant, with a peak towards the end of the runs at the lower bc values.

Fig. 28 shows that while the HV is kept at 500, there is a linear increase in signal with bc,



(a) (b)

Figure 26: (a) Pedestal position and (b) pedestal width changing with time for bc-scans



(a) (b)

Figure 27: (a) Pedestal position and (b) pedestal width changing with bc. Note: The lowest run number of the off-centre and 2nd bc set correpsond to the highest BC value of each set

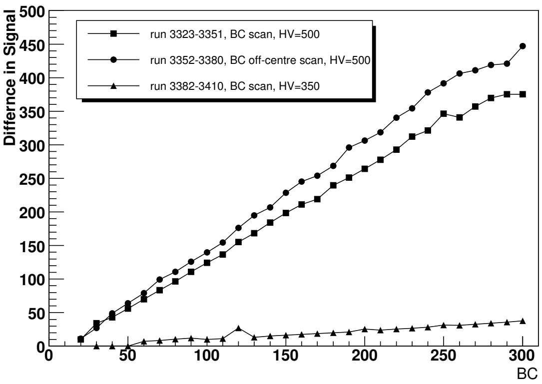


Figure 28: Signal-pedestal for different BC runs. Note: The lowest run number of the off-centre and 2nd bc set corresponds to the highest BC value of each set

regardless of whether it was a bc off-centre scan or simply a bc-scan. The two plots start off close together but diverge slightly at the higher bc values. When the HV is reduced to 350, the change in signal with bc is very small (less than 50).

1.4 Overall comparison

The pedestal position and width in 2009 and 2010 are pretty constant apart from some explainable peaks which appear at various points in the plots. Comparing the data from 2009 and 2010 shows that the pedestal position and width seem slightly more stable in the 2009 data as the peaks in position and width are less in the 2009 data than in the 2010 data. The set of x-scans in the 2010 data are the most stable as only one peak appears in the plots, compared to two peaks in the plots for the other scans. This peak is still a larger peak than that in the 2009 data however.

Comparing the 2009 and 2010 data for the y-scans shows that both the pedestal position and width are more stable in 2009 than they were in 2010 as the data from 2009 has only one peak whereas that from 2010 has two significant peaks in it.

The HV-scan plots for pedestal position and width are very different in 2010 compared to the 2009 data. in 2009 both position and width appeared to be a lot more stable than for 2010 where the data forms a series of peaks. However, a lot less HV-scans were done in 2009 so a true comparison between the two sets of data is not really possible.

The 2009 data for bc-scans seems to show that the pedestal psosition and width were both more stable in this year than in 2010. However, as with the HV-scans, a lot less bc-scans were done in 2009 than in 2010 so the plots can't be compared to closely.