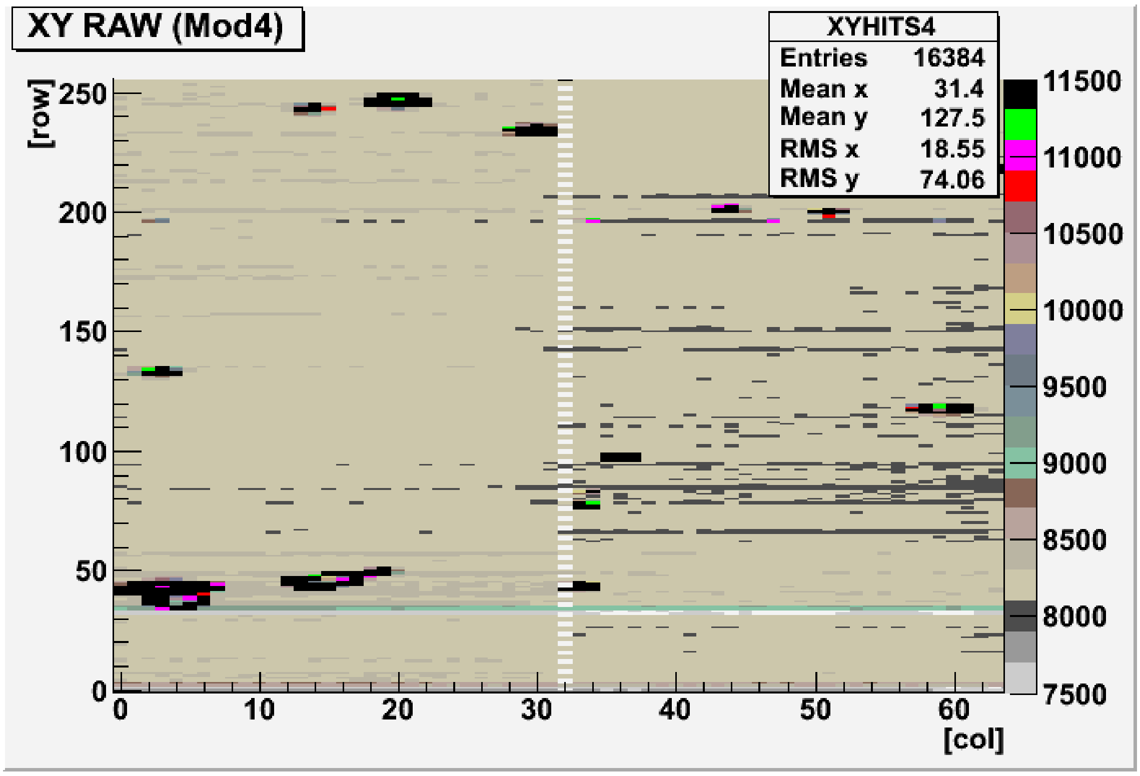
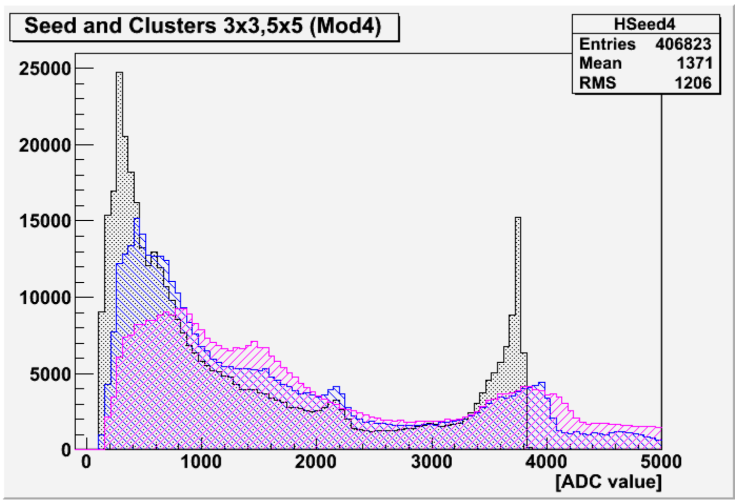
S3B System in Santiago

DEPFET matrix

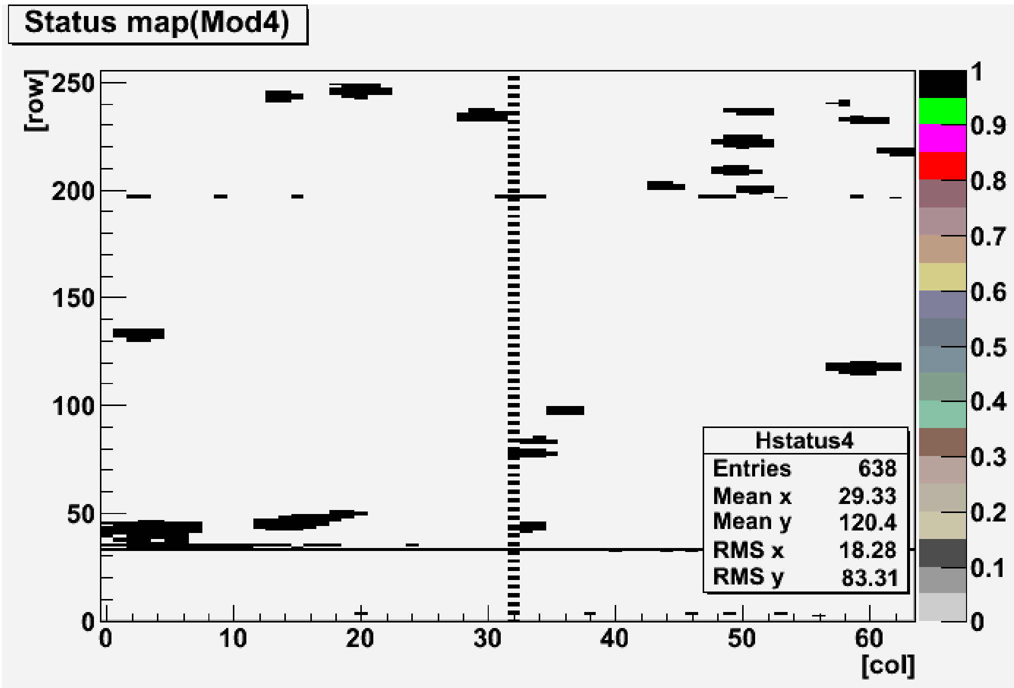
Raw data for the latest DEPFET matrix H 3.0.13 is shown in the following plot. Data was acquired without any kind of source or laser applied and it is using for the calculation of pedestals and for the system's noise evaluation. Number of entries/pixels is 16384 for 256 rows and 64 columns of pixels. Number of events for this run is 9355, that takes about 5 minutes of real time data acquisition.



There are many hot pixels on the matrix, which are distributed not only in single bad row or column, but also in rather big regions. All these pixels should be eliminated by monitoring program, but some of them can appear during the run. That is why it is necessary to evaluate bad areas manually and to calculate good pedestals with all bad pixels reckoned in. Seed and energy spectra without any additional masking are given in the next plot.

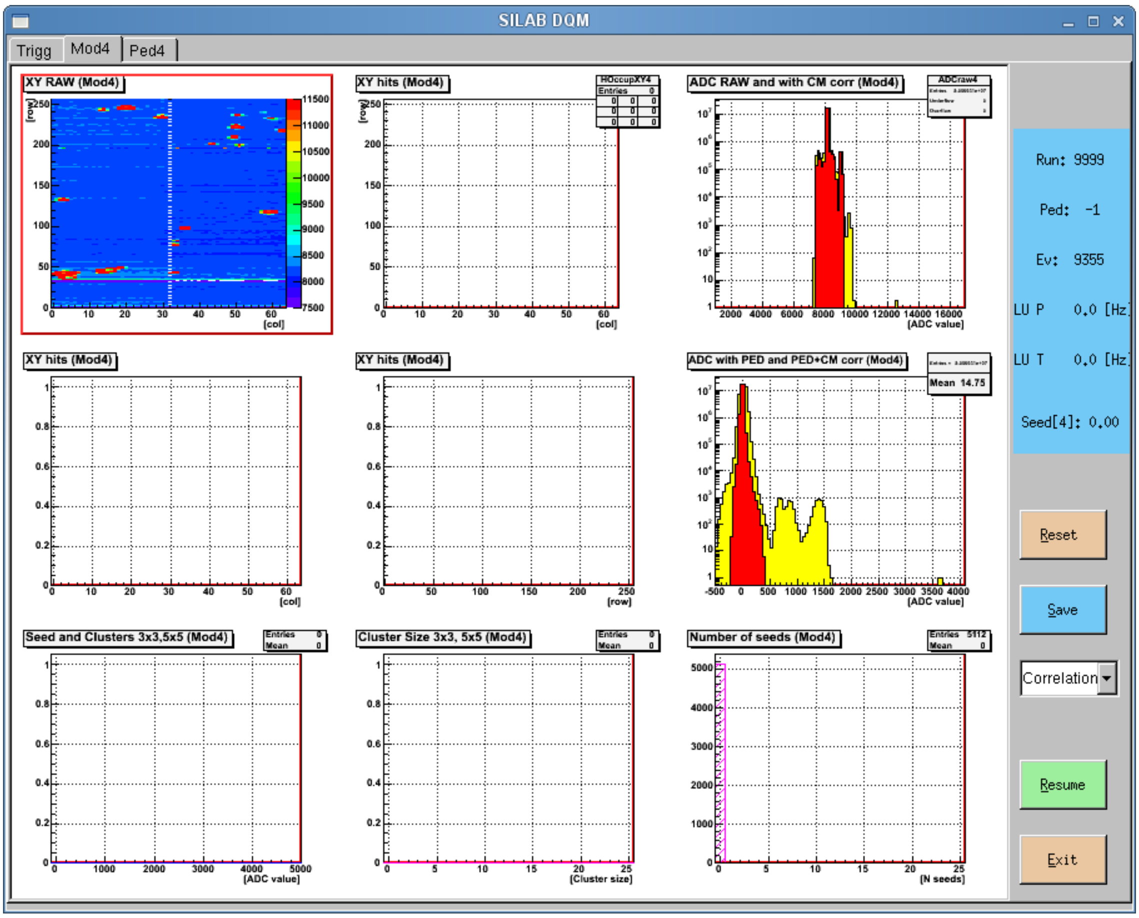


The hot pixels, whose have been calculated and eliminated by data monitoring program and also masked manually, are in 'Status map' plot. Total amount of such pixels are 638 in this particular case.



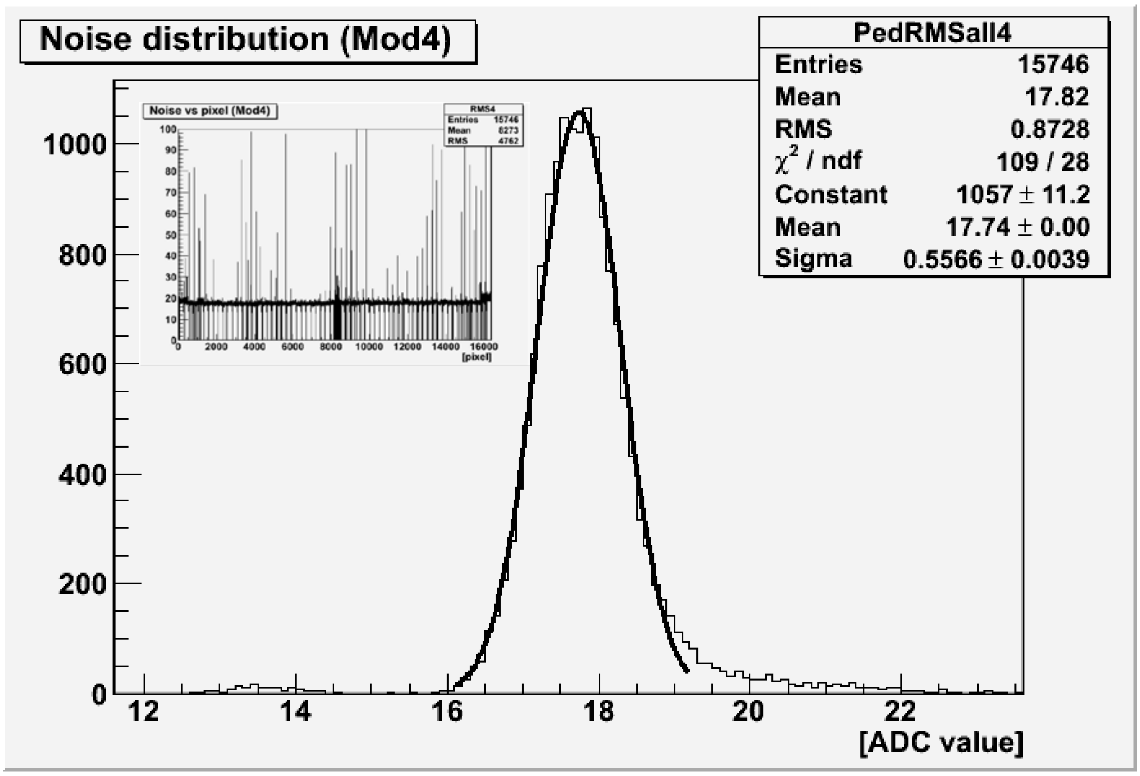
So this DEPFET matrix has around 3.9% of bad pixels, most of them are calculated by the software and also about 20% were selected during the test runs with further masking by hand.

Since all bad pixels were removed correctly the main monitoring window (next screen shot) shows zero activity in most plots.



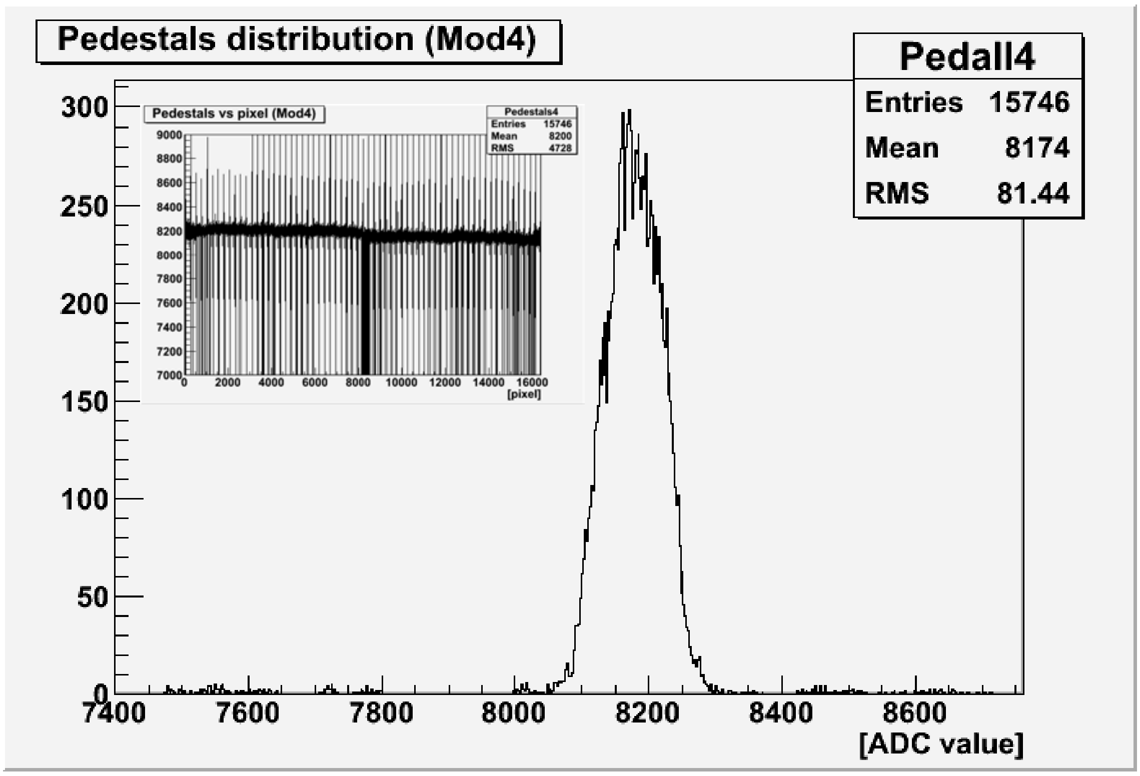
As there are no interactions of particles with the matrix, all 'XY hits' plots, plot of energy of one seed, 'Clusters' and 'Cluster Size' plots are empty. Also it can be seen 0 seeds in the 'Number of seeds' plot with 5112 entries.

System noise

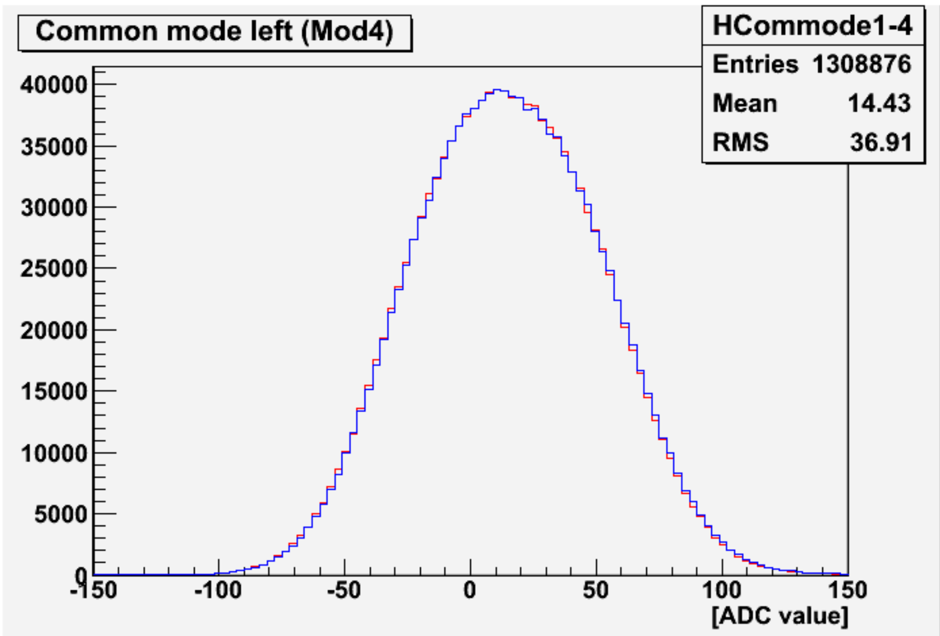


Mean value of the noise distribution is 17.74 ADC. All other same matrixes, those are at Bonn or Munich for the present moment, have mean value around 14-16 ADC units. Should be mentioned, that these matrixes are clean (there are no bad pixels) and only one single bad column of pixels can increase noise up to 17 ADC (matrix H 3.0.10).

The same situation with the pedestals: since the system has so many dead pixels, the mean value of the pedestals is almost 8200 ADC units with a broad distribution. Clean matrixes have two pedestals' peaks because of the two amplifies for the different sides of the matrix with average value about 8000 of the first one and a little bit more than 8000 ADC (8050-8100) for the second one.



Common mode is also awry a little, but it is ok. It should be around zero (mean value) in the range of -100÷100 ADC units.



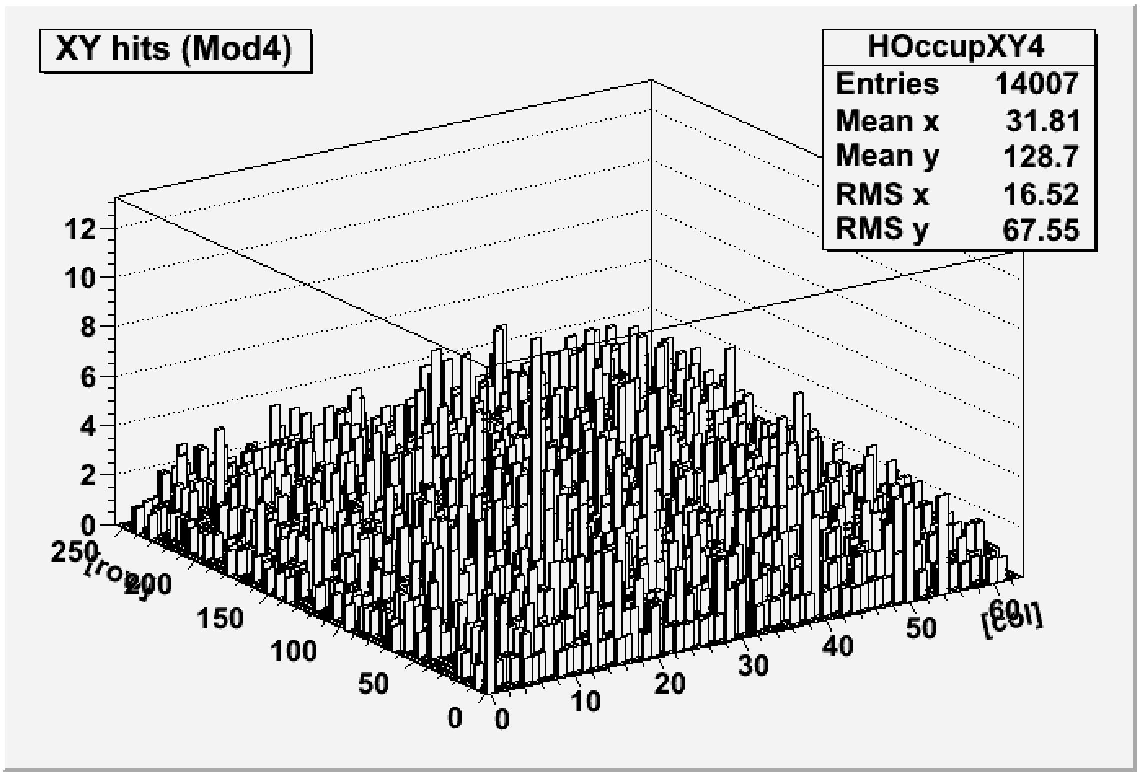
So, DEPFET matrix H 3.0.13 is suitable for data acquisition instead of many bad pixels. It has rather low noise, stable pedestals and content common mode. Pedestals, obtained during this run (run number 9999), are used and will be using for further runs with different radiation sources and laser.

Pedestals can be attached for selected run (XXXX) from the directory ~/depfet/DEPFET_DAQ/work_depfet by the command:

./Monitor.exe –file=DATA/RunXXXX-000.dat –lp=2 –pn=9999 –rn=(number)

Radiation source – Am-241

Radiation source – Americium-241 – was used for the data acquisition. The activity of this source is 0.34 MBq, good enough to see interactions of the particles with the DEPFET, as shown in figure below, even through the aluminum foil.



Radiation data for Am-241

Type	Energy	Percentage
Alpha	5485 keV	84.5
Alpha	5443 keV	13.0
Gamma	59.5 keV	35.9
Gamma	26.3 keV	2.4
Gamma	13.9 keV	42

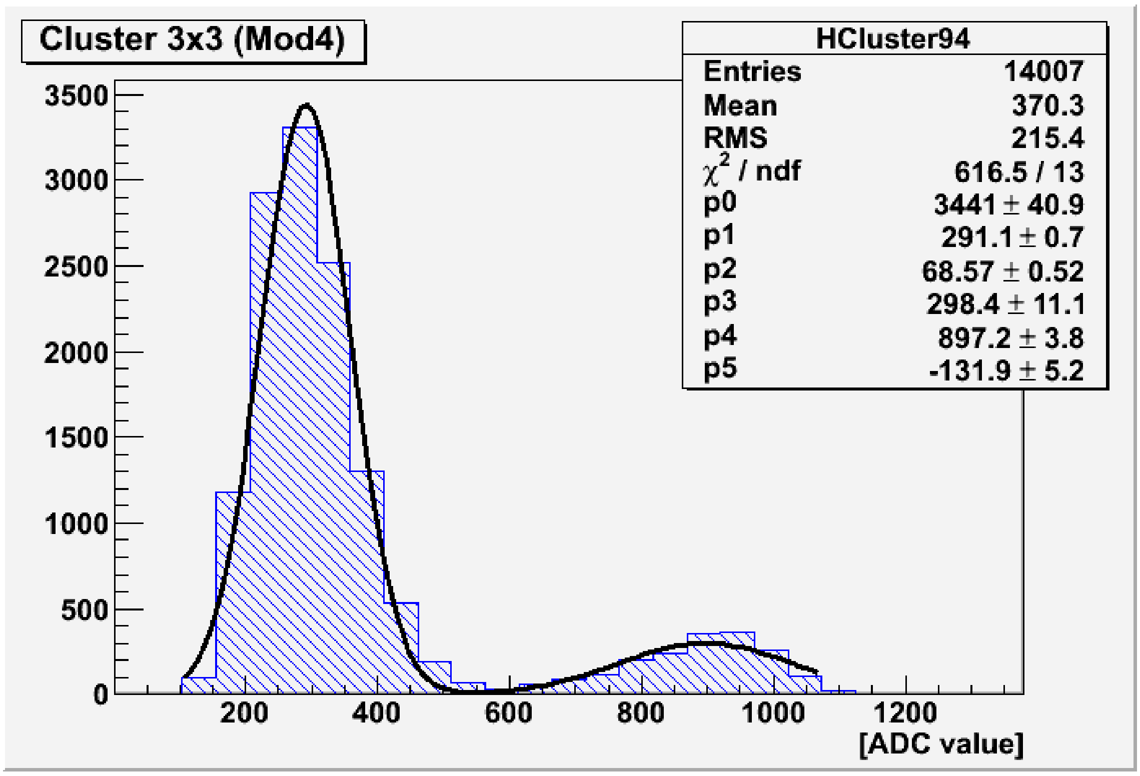
As it can be seen from radiation data table, Americium-241 decays by alpha emission with a by-product of gamma rays. Alfa particles should stop in any screening material (in this case - Al foil), because of the low penetration of alpha radiation.

The dose from the Am241 is partially absorbing in the 50 μm Al foil and the photons absorbed in the 450 μm Si are 25%, 0.6% and 1.2% for 15, 26 and 60 KeV respectively. Calculations have been done by Pablo and Javier.

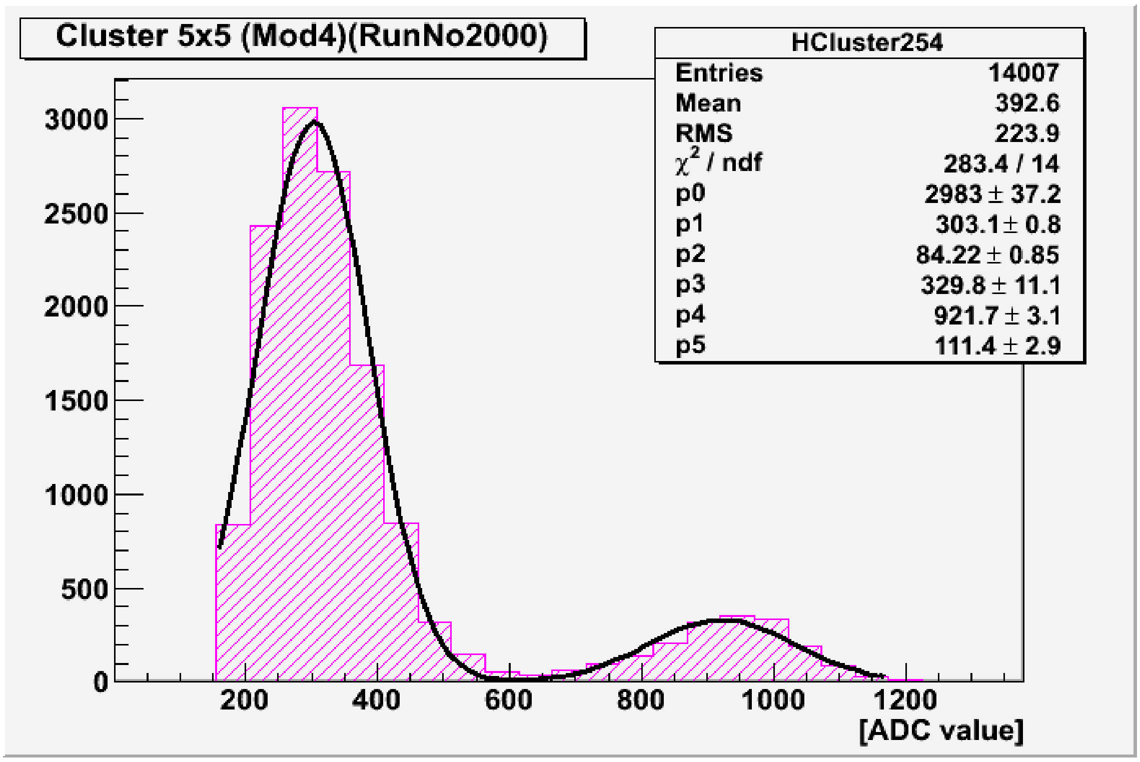
Energy, keV	Am 241. rate, %	Al. Absorbed, %	Si. Absorbed, %	Si after Al from Am241. Absorbed, %
15	42	10	66	25
26	2,4	2,8	25	0,6
60	35,9	0,3	3,3	1,2

It seems likely, that three peaks should appear in the energy distribution plot for the selected radiation source. The ratio between first and second energy peak is 1.73 and between second and third – 2.3.

Energy distributions for Am241 are shown in following plots as ‘Cluster 3x3’ and ‘Cluster 5x5’. Parameters p0 – p2, used for the first peak, and p3 – p5 for the second peak, are fitting values, where p0, p3 – constants of amplitude, p1, p4 – mean values and p2, p5 – sigmas.

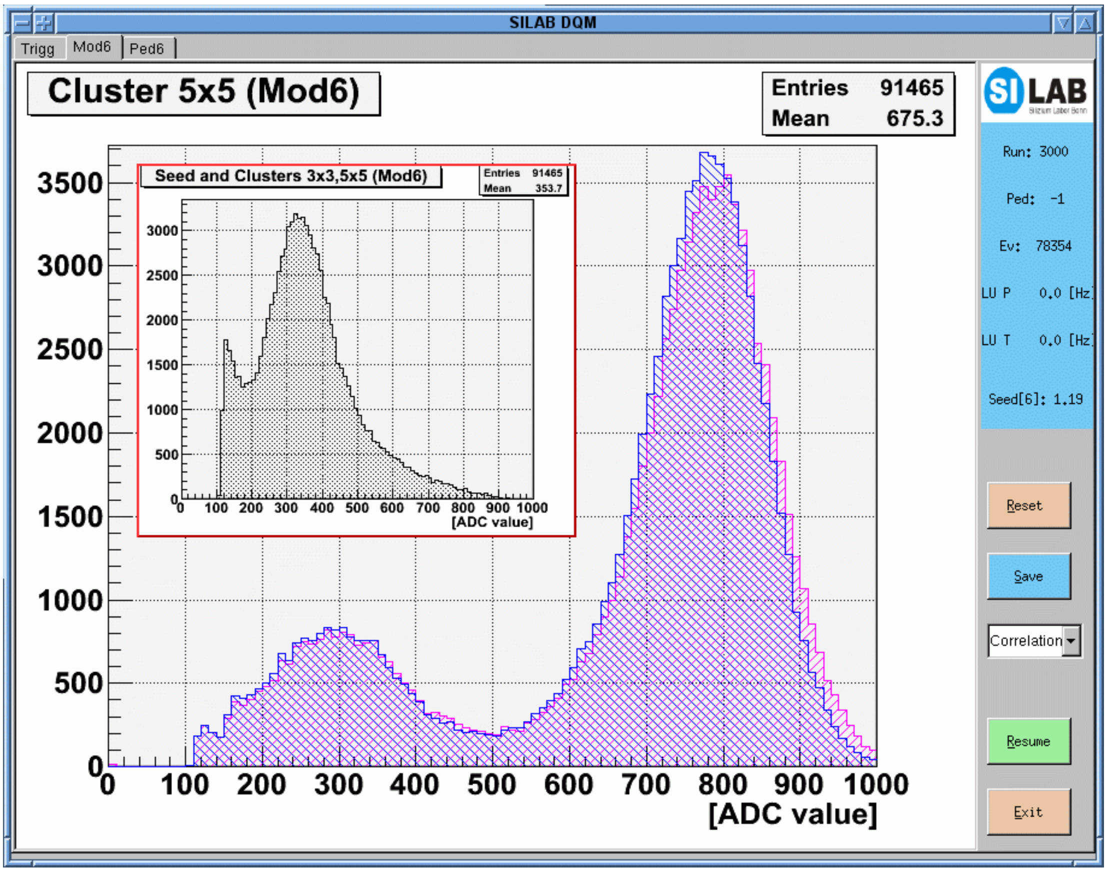


There are only two peaks. One peak couldn’t be seen (probably) because of the noise as 6σ cut was done and first ~108 ADC units were removed. Therefore, we can see only second and third peaks (???). Still the ratio p4/p1 is 3.08. Besides that, amplitude of the second peak is 11.5 times bigger than third one.



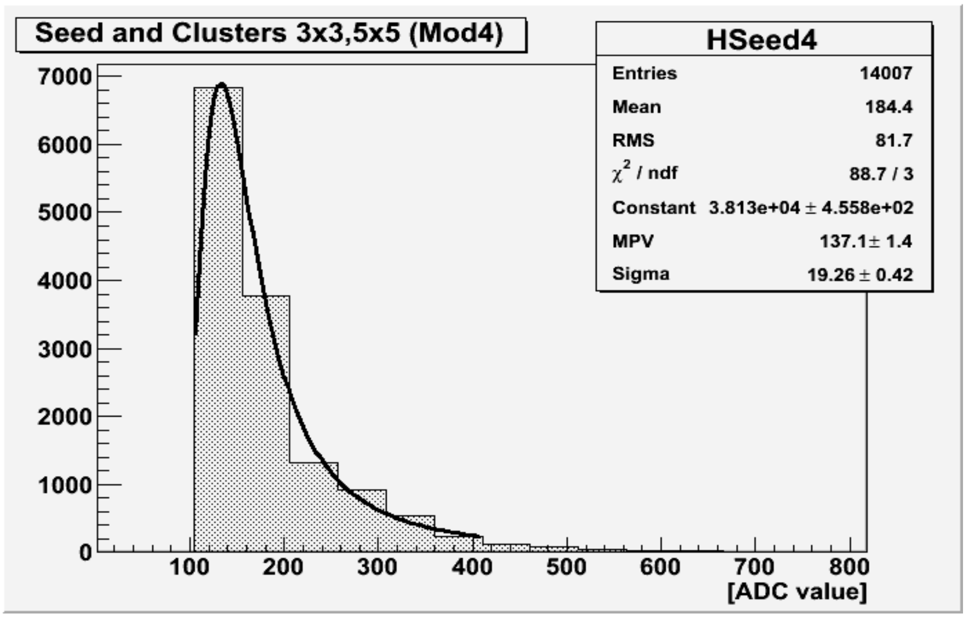
Ratio p4/p1 for the cluster 5x5 is almost the same – 3.04 (!!!) and p0/p3 is 9.

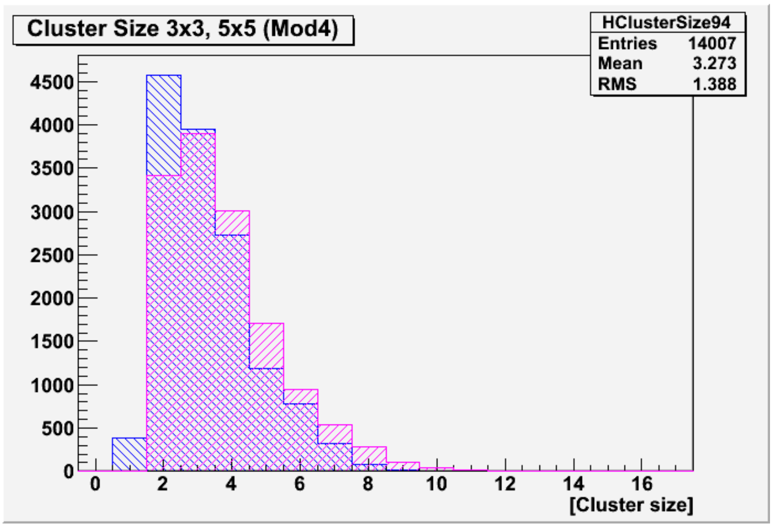
Sergej Furletov from Bonn has sent his own plots for the same radiation source (Am241) with his comments, that the plots are similar...



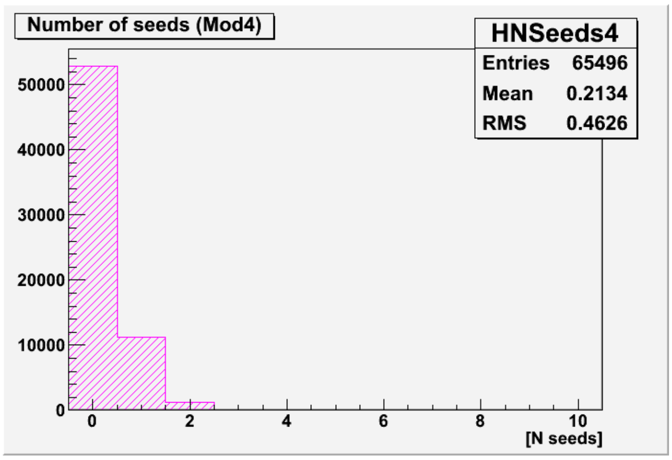
There are two big differences between our and Sergej's plots: ratio for the second and third peaks' mean value is ~770/300=2.56, that is more believable for the Am241, and his 3rd peak is bigger (ratio ~4.5)!

Also our ‘seed’ plot is completely different from the Sergej’s inserted one.





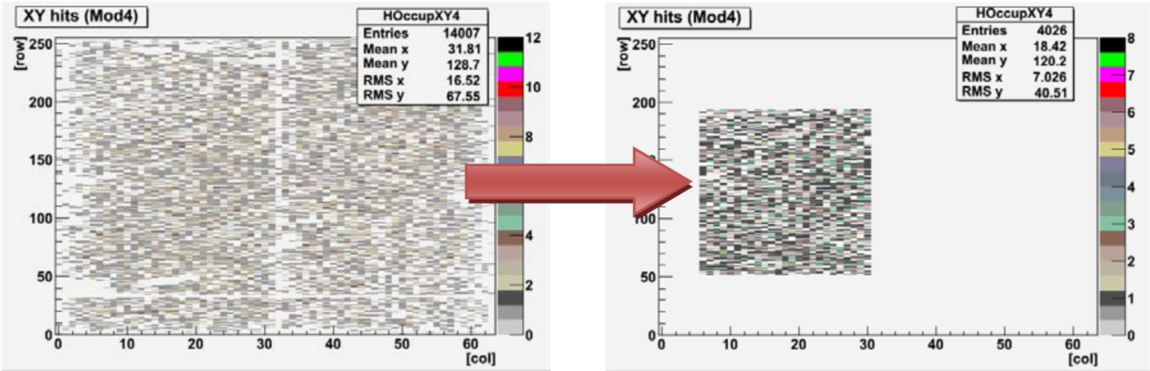
The largest count of pixels is 2 for cluster size 3x3 and 3 pixels for cluster 5x5 respectively. As it can be seen, cluster size 3x3 is enough to evaluate practically all seeds.



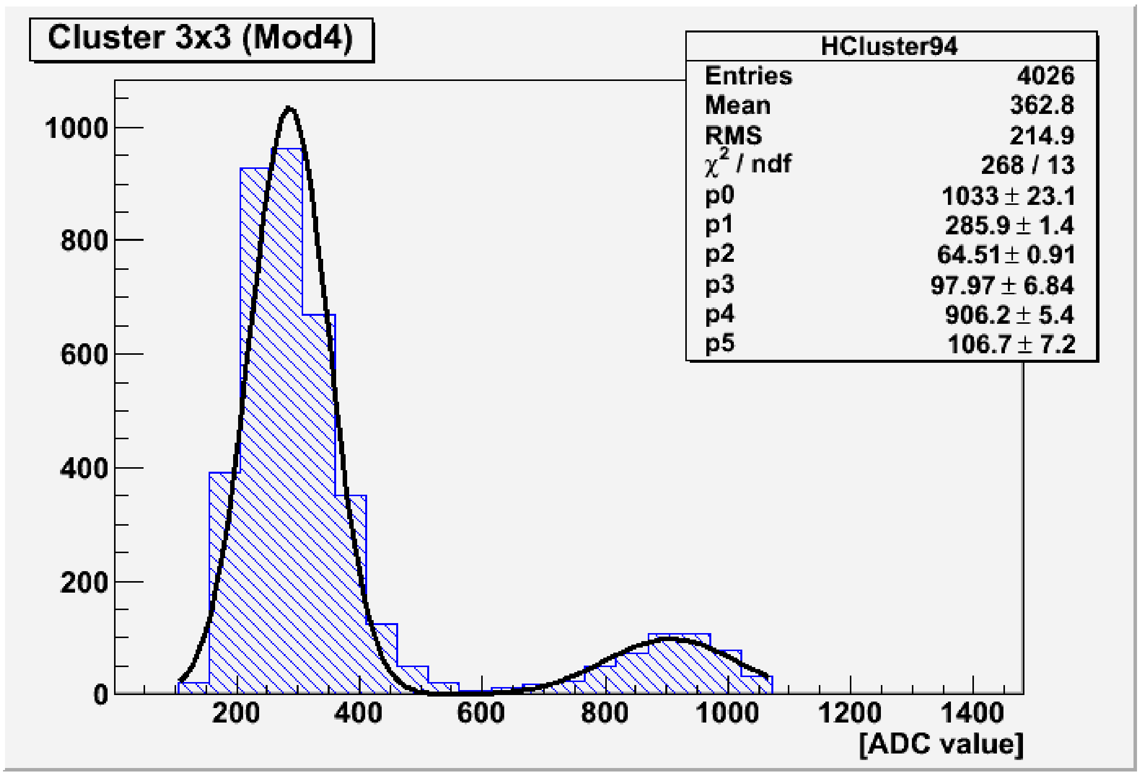
	Number of seeds						
	1	2	3	4	5	6	7
Entries	11280	1200	80	3	0	1	1

Masking

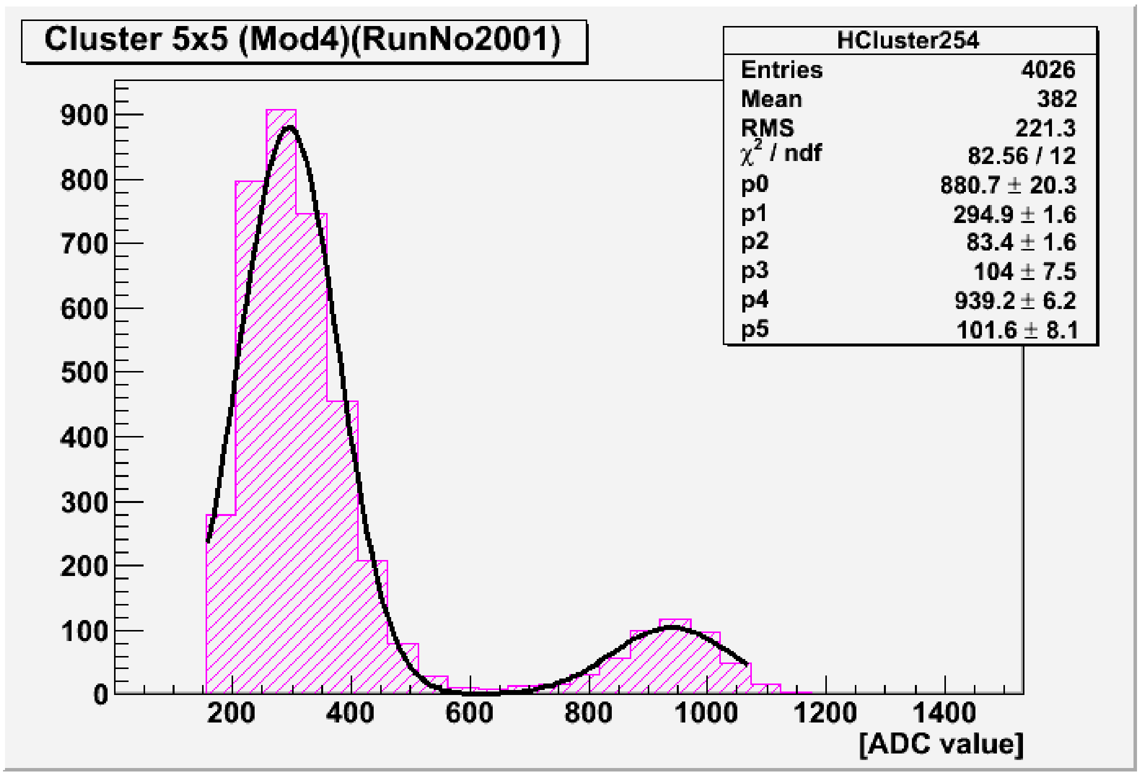
For corroboration of the results, the biggest part of the matrix was masked manually leaving only very clean region without bad or masked pixel on it.



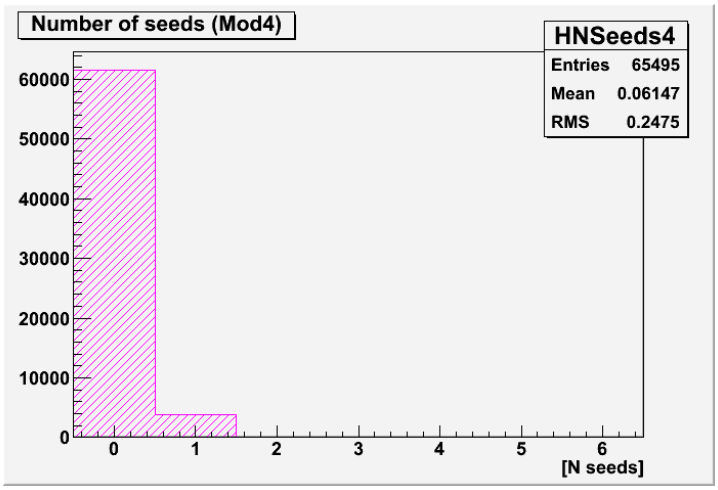
Masked rows: from 0 to 52 and from 194 to 255;
Masked columns: from 0 to 5 and from 31 to 63.



Ratio p4/p1 for the cluster 3x3 is 3.17 (even greater) and p0/p3 is 10.5.



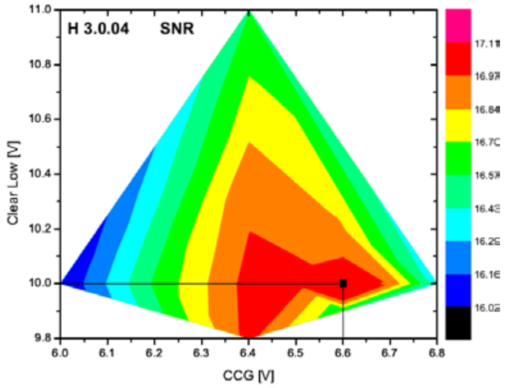
Ratio p4/p1 for the cluster 5x5 is 3.18 (the same) and p0/p3 is 8.5.



	Number of seeds		
	1	2	3
Entries	3797	113	1

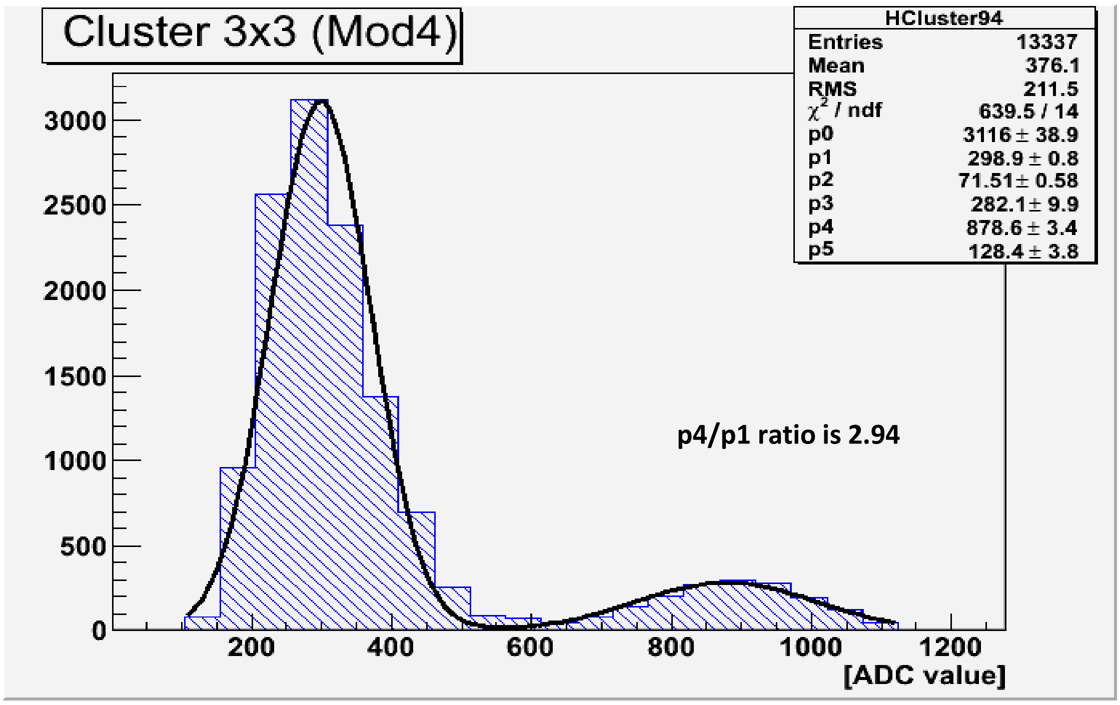
Operating point selection

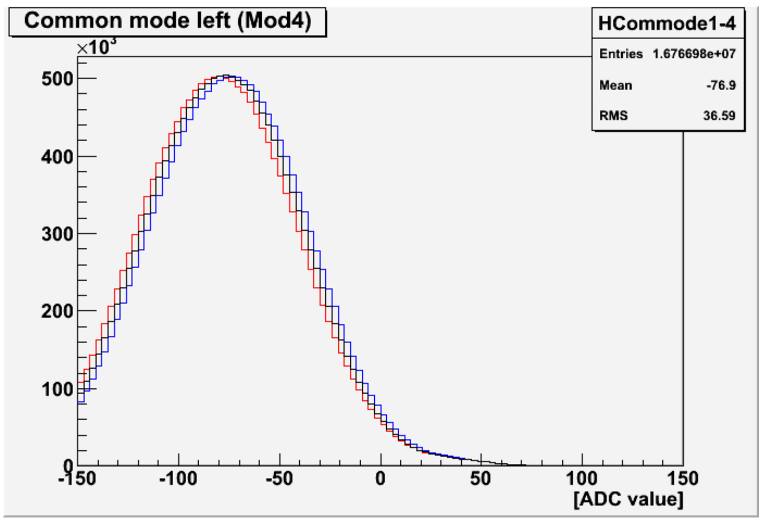
It's possible to shift spectra position with respect to ADC units by changing the system's gain. There are no interpolation results for best operating point indication of matrix H.3.0.13 (as it is in example for matrix H 3.0.04 in the following plot), so the voltages have been changed incidentally.



Standard value (for matrix H.3.0.13) for *Clear_low* voltage is 10V, for Common Clear Gate (*CCG*) – 6.4V. Don't forget, that there is no *Gate_on* voltage!

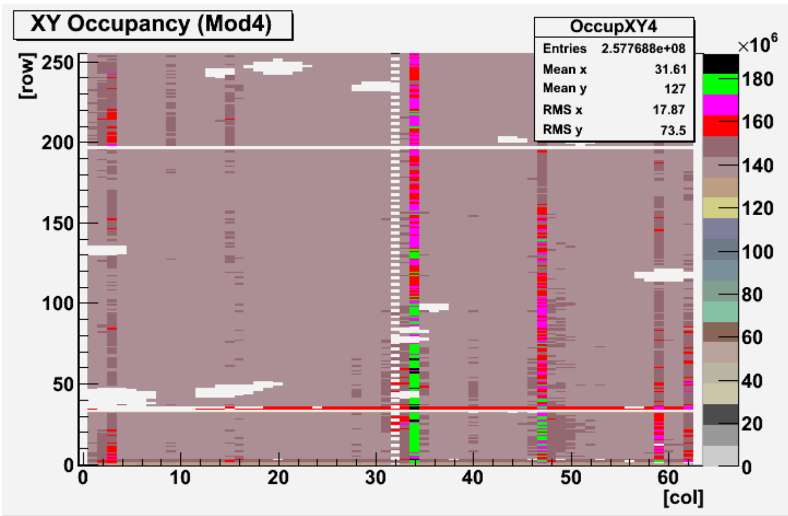
1st variant: *Clear_low* voltage is 9.5V (minimal available), *CCG* is 5.9V.



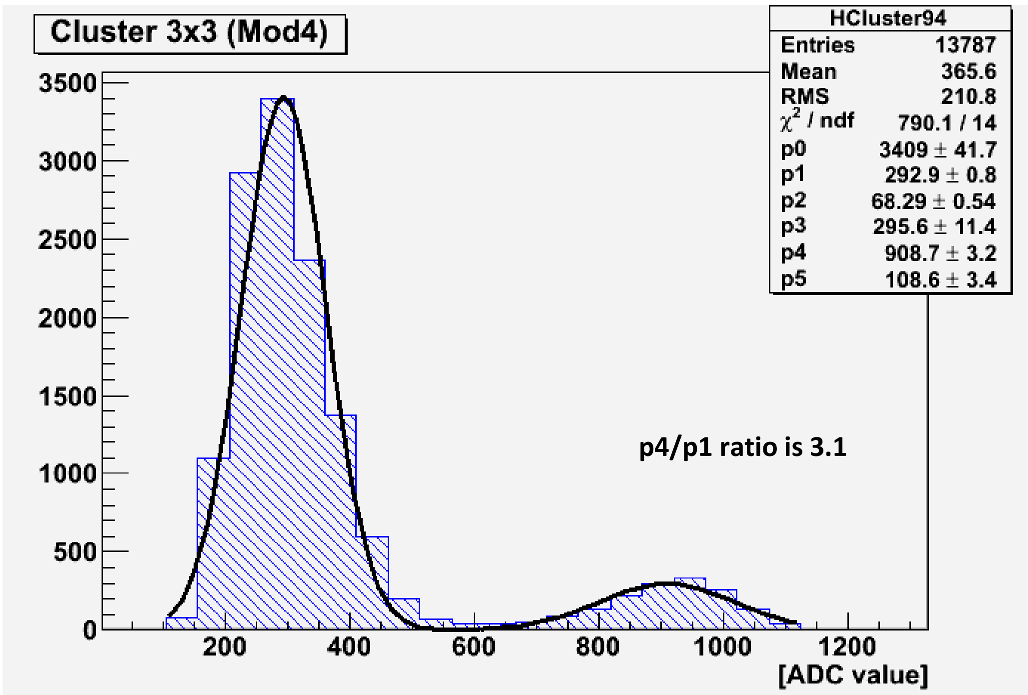


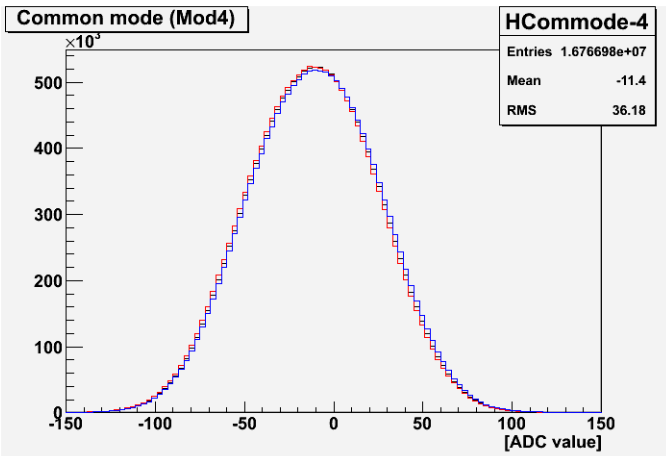
Common mode mean value is shifted to the left by 76.9 ADC.

Ratio is declined a little and common mode distribution is shifted around 77 ADC units to the left. Greater difference of *Clear_low* and *CCG* voltage is not desirable concerning the appearance of plenty noisy rows and columns even in previously clean areas. The same situation will be for the bigger than 7V *CCG* voltage.



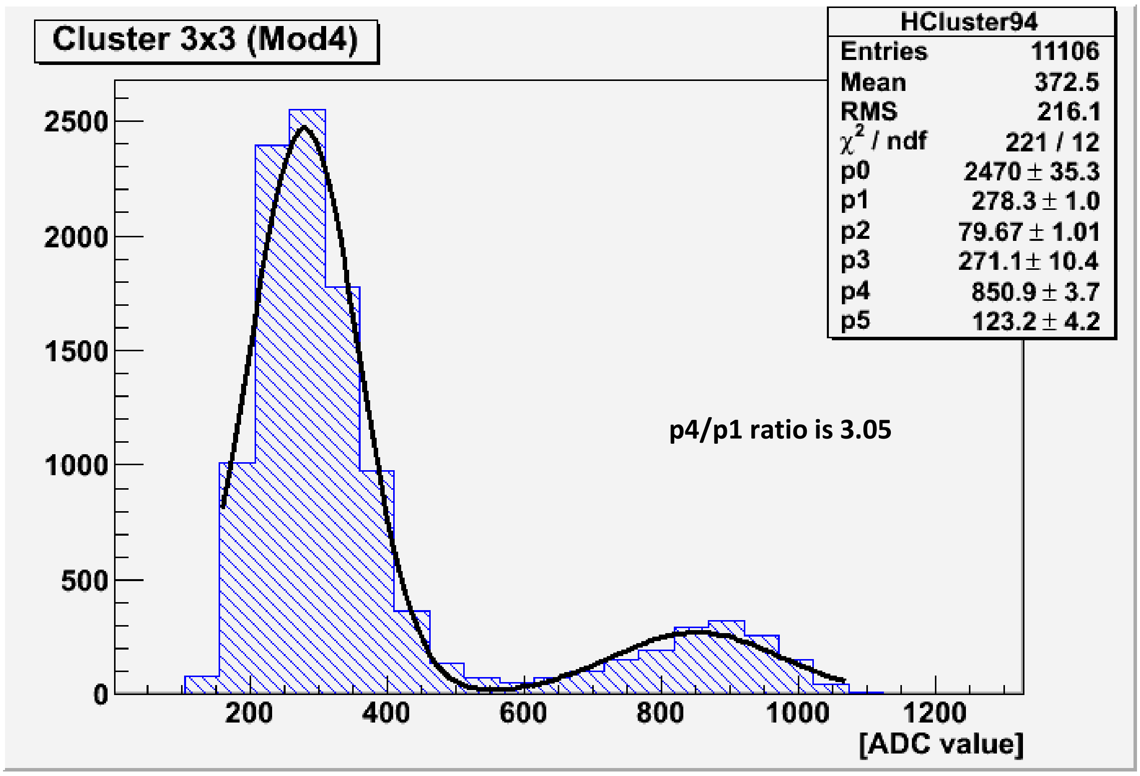
2nd variant: *Clear_low* voltage is 9.5V, *CCG* is 6.2V

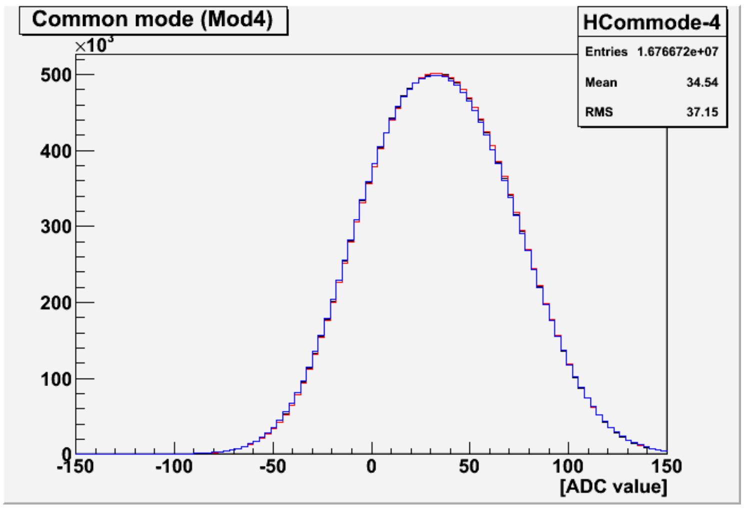




Common mode's mean value is around 0 (shifted to the left by 11.4 ADC) and the spectrum is similar to standard situation.

3rd variant: *Clear_low* voltage is 10.2V, *CCG* is 6.8V (The maximal available *Clear_high* voltage is 10.4V)





Still spectrum is almost the same and the common mode is shifted to the right (34.5 ADC). Maximum *Clear_high* voltage is 10.4V, so maximum reasonable *Clear_low* voltage is 10.2V. Also, it is not recommended to apply greater than 7V CCG voltage as it was mentioned previously.

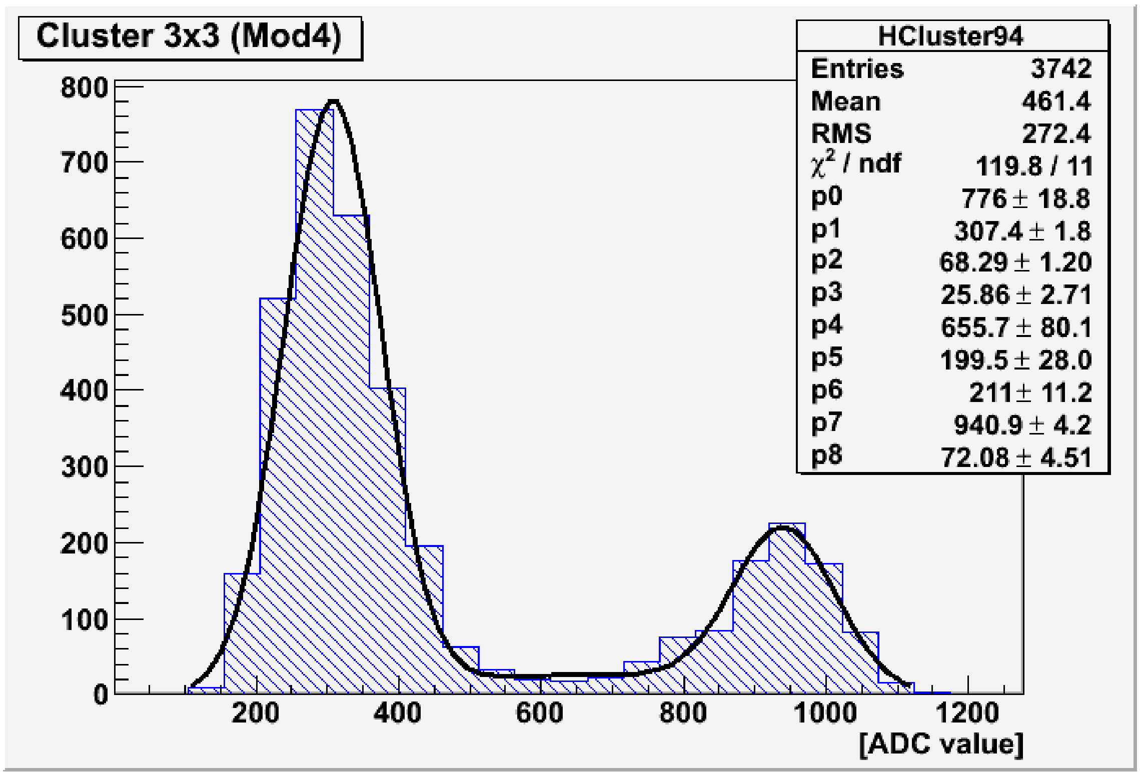
Covering the matrix

If the first visible peak corresponds to 14 keV, it should have the biggest amplitude/peak, as it is, because of the largest absorption (25 %). This peak can be easily reduced without essential changes in other energy distributions by covering the module window with Al.

Previous calculations were made for Al foil (50 μm). The first step is to apply additionally Al plate of 1 mm thickness:

E, keV	Absorption for different Al thickness, %			
	50 μm	1.05 mm	2.05 mm	3.05 mm
14	25	2.9		
26	0.6	0.34		
60	1.2	1.1		

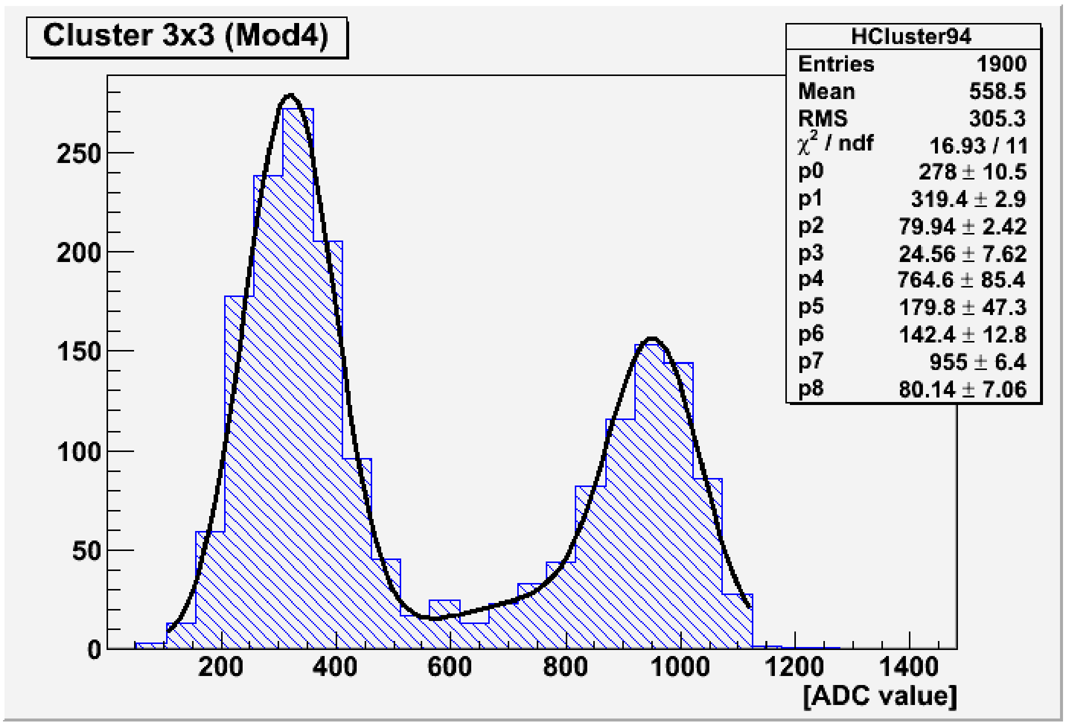
First peak should be decreased almost 10 times with 1mm of Al plate, second one – fall around twice and third – without strong change.



There is no significant reduction of the first peak, as it was expected from the calculations, but the constant of the peak is falling-off for several times. Also, it can be seen not well defined third peak in the middle.

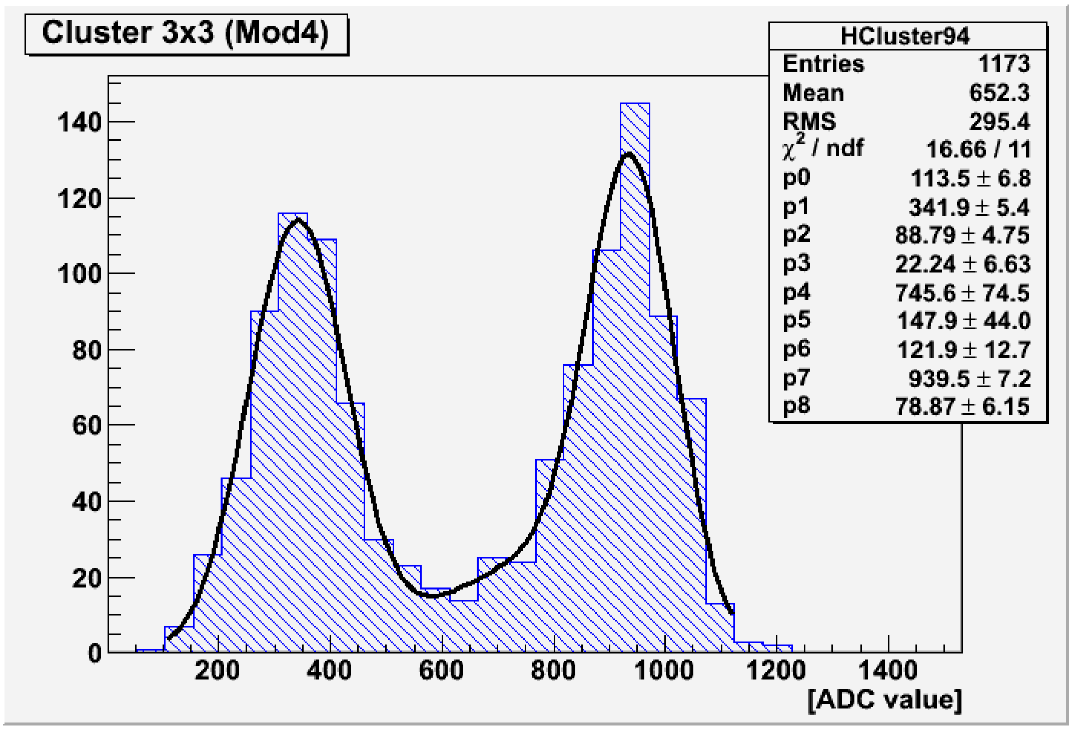
Second step is to apply 2 mm of Al:

E, keV	Absorption for different Al thickness, %			
	50 μm	1.05 mm	2.05 mm	3.05 mm
14	25	2.9	0.34	
26	0.6	0.34	0.2	
60	1.2	1.1	1.02	



And finally, third step is to cover matrix with 3 mm of Al:

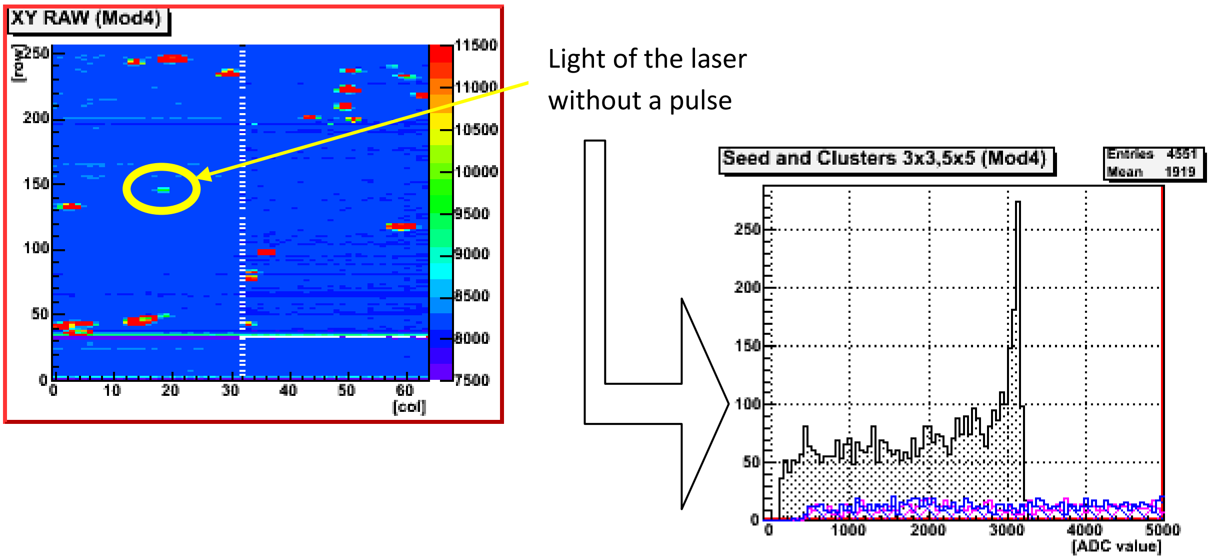
E, keV	Absorption for different Al thickness, %			
	50 µm	1.05 mm	2.05 mm	3.05 mm
14	25	2.9	0.34	0.04
26	0.6	0.34	0.2	0.11
60	1.2	1.1	1.02	0.94



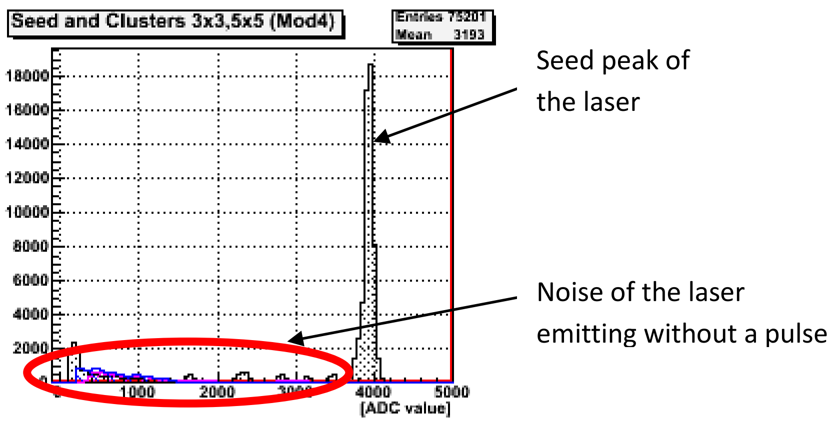
Eventually, the third peak is greater than the first one and it is possible to evaluate the second one: constant of amplitude is around 22 (p2), mean value 745 (p4) with sigma almost 150 (p5). The most important peak of 60 keV is at 939 ADC with the constant 122. Ratio between the first and the last peak is 2.75.

Laser

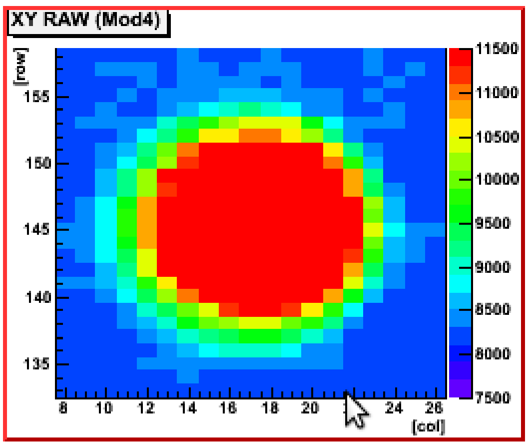
For analysis was used 1 mW laser with diode emitting wavelength of 1060nm. Powered laser emits some light even without applied pulse. In this way, noise of this light will appear in the system as a signal.



Right seed distribution of the laser appears at 4000 ADC after plugging in the pulse, together with fetched in noise from previous emitting. That is why, it is necessary to calculate the pedestals first and then run data acquisition with calculated pedestals after laser is powered and pulse is applied to it.

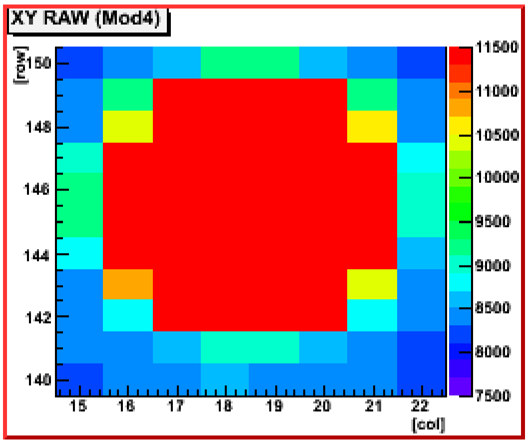


Next step is to focus the laser. It can be done by monitoring the 'XY RAW' plot and decreasing the number of active pixels marked in red. There are 108 pixels for 13 rows and 10 columns included in the red area in this particular plot.



The distance between DEPFET matrix and laser nozzle for such focus is in vicinity of 1.2 cm and it was changed step by step for the 50 µm interval to get the smallest area.

The best focusing have been done for 40 pixels (8 rows and 6 columns) for the motion stages positions (with the respect to home position):



X = -3.3 mm

Y = -18.29 mm

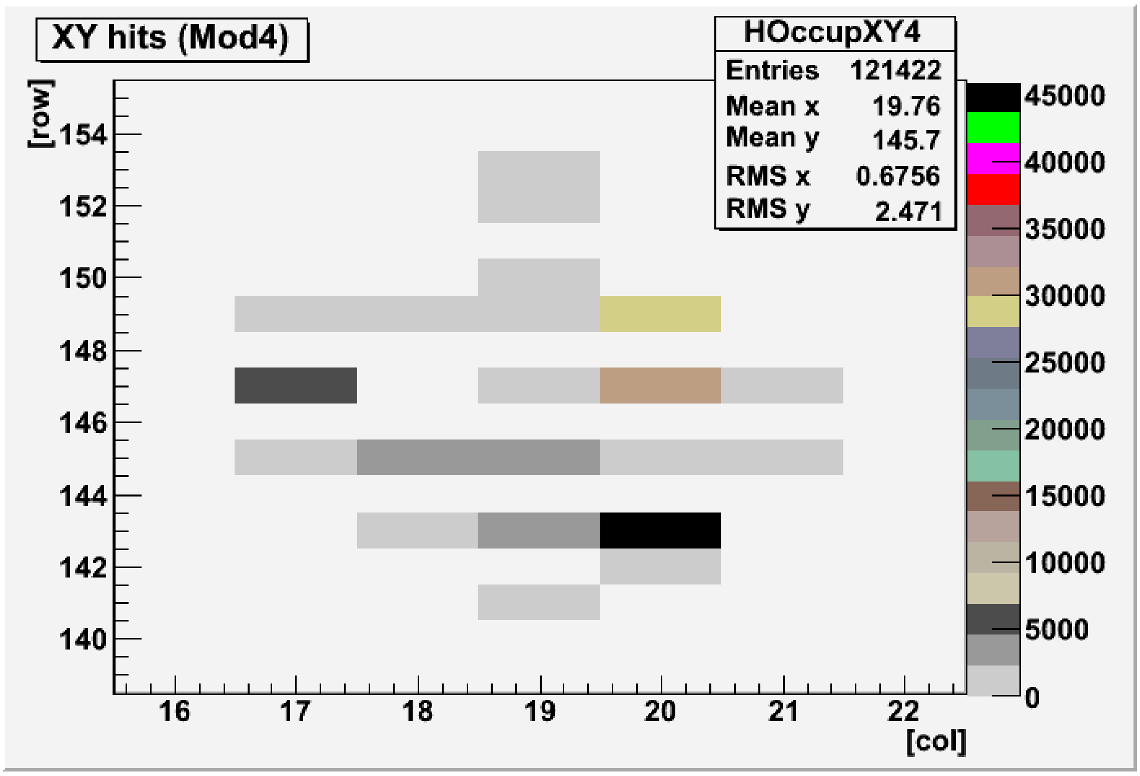
Z = 30.75 mm

This result is not good, because the beam width for the well focused laser at the working position (12 mm) should be 7.4÷9.4 μm. That corresponds only one pixel in the matrix.

There is fixed energy maximum (11500) and it is not possible to estimate the pixel with the biggest energy from investigated area. It is necessary to increase this value to see the expected focus of the laser or to reduce the laser power by changing the voltage of the pulse.

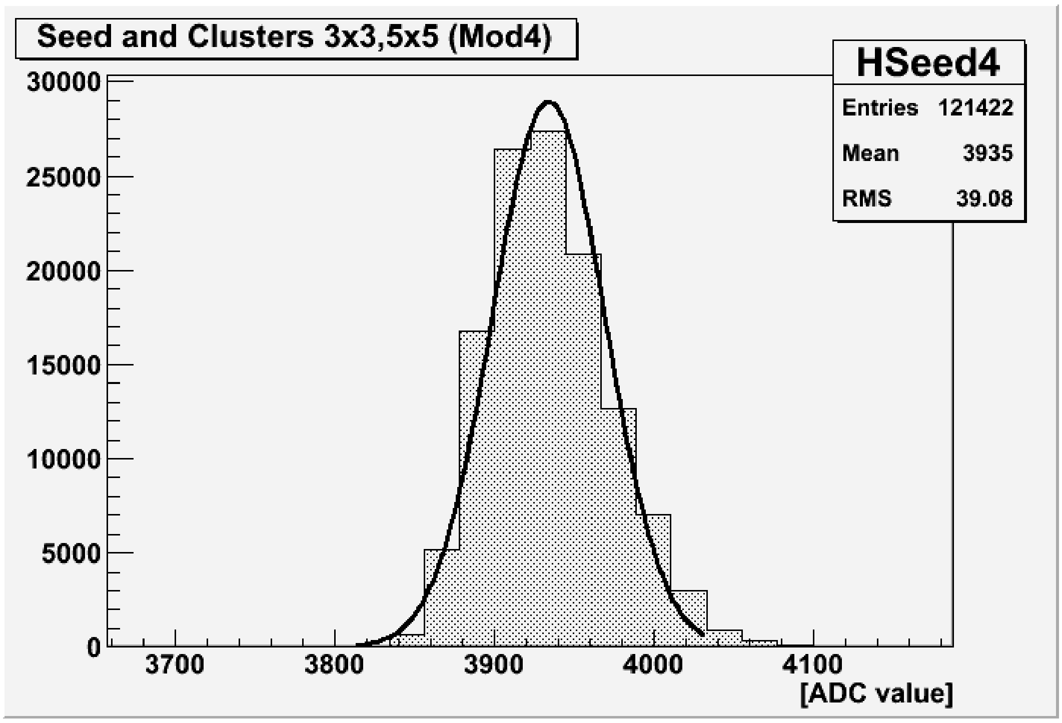
As it can be seen from the plot, the laser beam is perpendicular to the matrix, as this area is right square (6 columns × 32 μm = 192 μm and 8 rows × 24 μm = 192 μm).

'XY hits' plot shows that only one pixel has the greatest (45000) number of entries, there are two pixels with 30000 and all other – with sufficiently less number of entries.

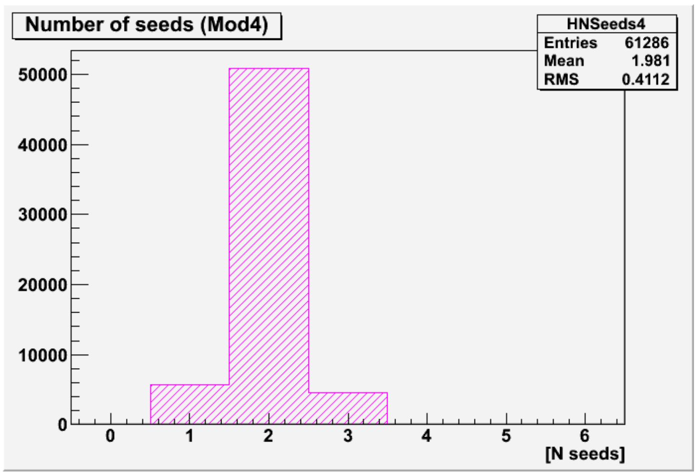


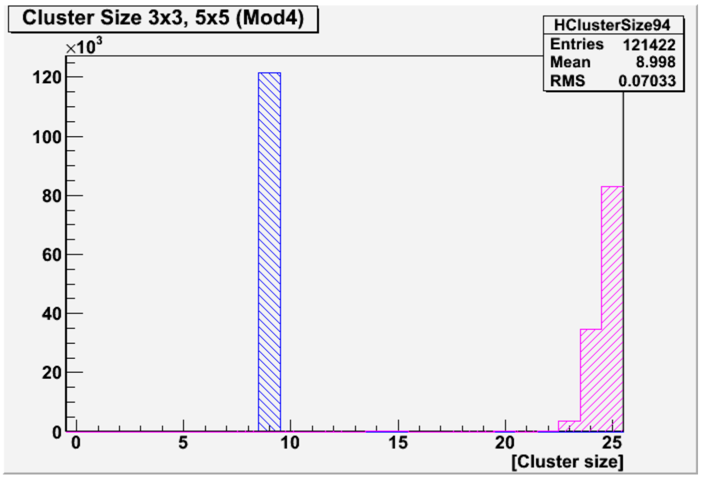
As it can be seen from 'XY hits' plot, laser beam is not perpendicular to the matrix and beam is not concentrated in one or few neighbor pixels!

Seed's mean value is 3935. It is not clear, how to fit it, but the Gaussian is most suitable.



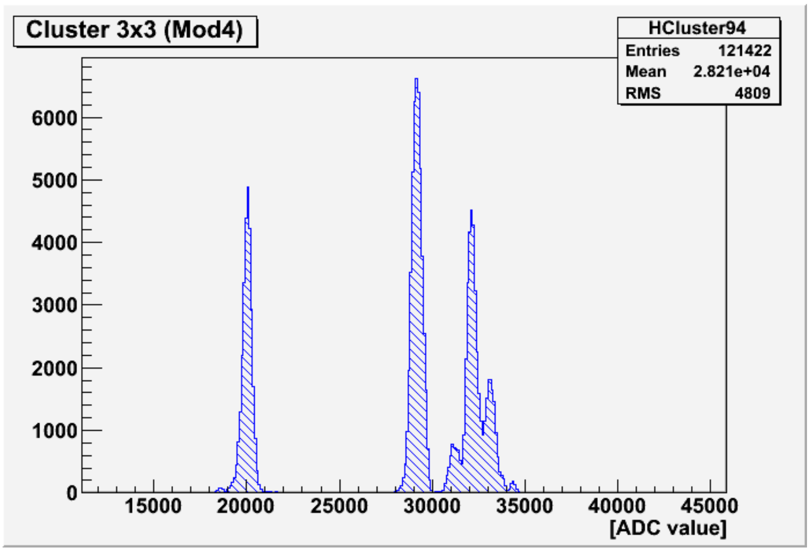
The number of seeds for the biggest part of entries is 2 (it should be 1 for right data).



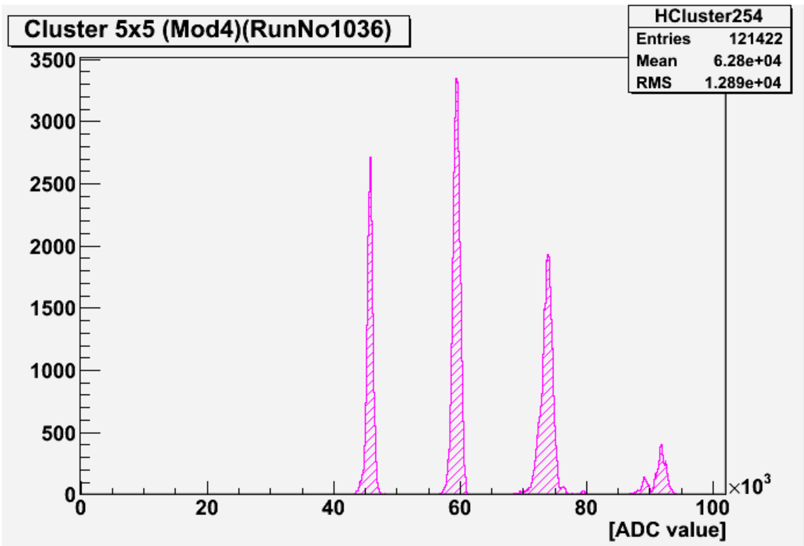


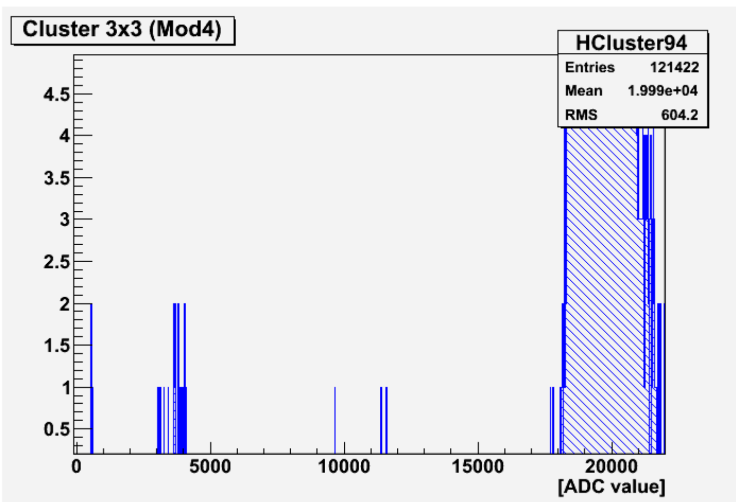
It is necessary to analyze cluster 10x10 for the present case, but cluster 3x3 should be enough after good focusing of the laser.

‘Cluster 3x3’ distribution has been found at several different energies. First peak is at $20 \cdot 10^3$ ADC, second – at $30 \cdot 10^3$ ADC and third is not well defined at $33 \cdot 10^3$ ADC. This data is not correct, as program finds many clusters at the interaction region and energy distributions appears for each of them. Again, it is necessary to focus the laser.



As it was expected, energies for cluster 5x5 are more than twice greater with the first peak at $45 \cdot 10^3$ ADC.





The lonely small peaks at cluster’s plots are considered to be noise, as single entries before the first 20000 ADC peak at plot ‘Cluster 3x3’.

Accordingly, not all pixels, obtained in ‘XY hits’, are containing signal.

Conclusions:

1. Well estimated pedestals should be applied each time together with masking out of additional hot pixels;

2. There are three peaks in Am-241 spectrum, but it doesn’t correspond to calculations, but rather well suits the data from other groups (Germans);

3. It is not possible to make significant shift of operating point selection by changing supplying voltages, because the matrix of class B;

4. Laser should be well focused with some changes in data acquisition software. And only after that we will be able to analyze data from the laser.