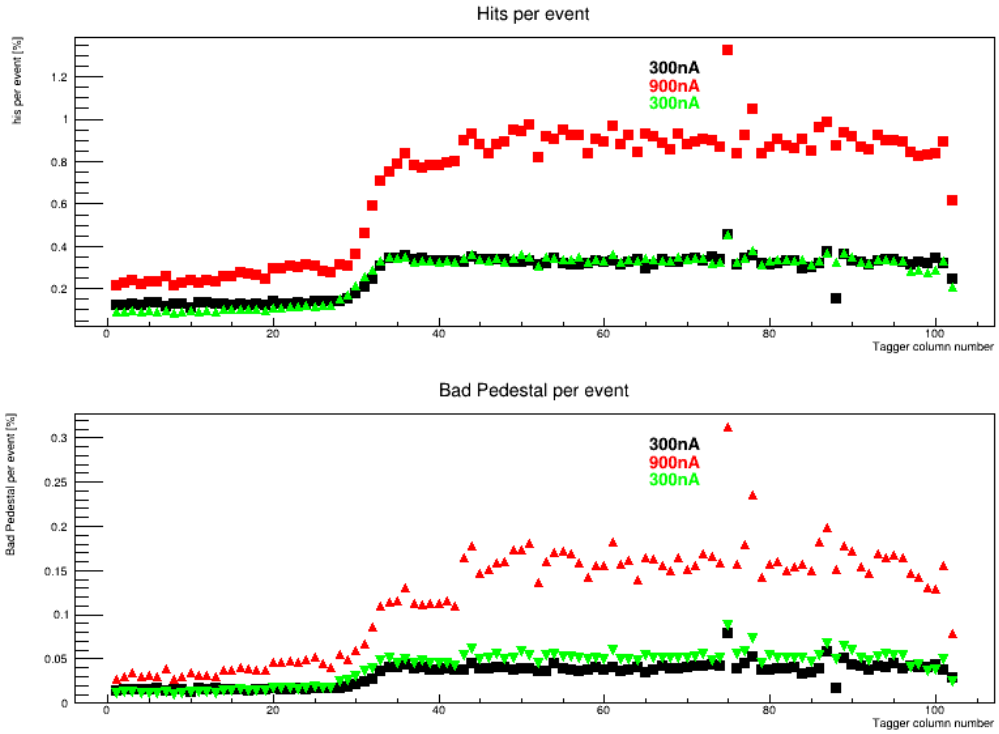
TAGGER HIGH RATE STUDIES

TAGGER microscope:

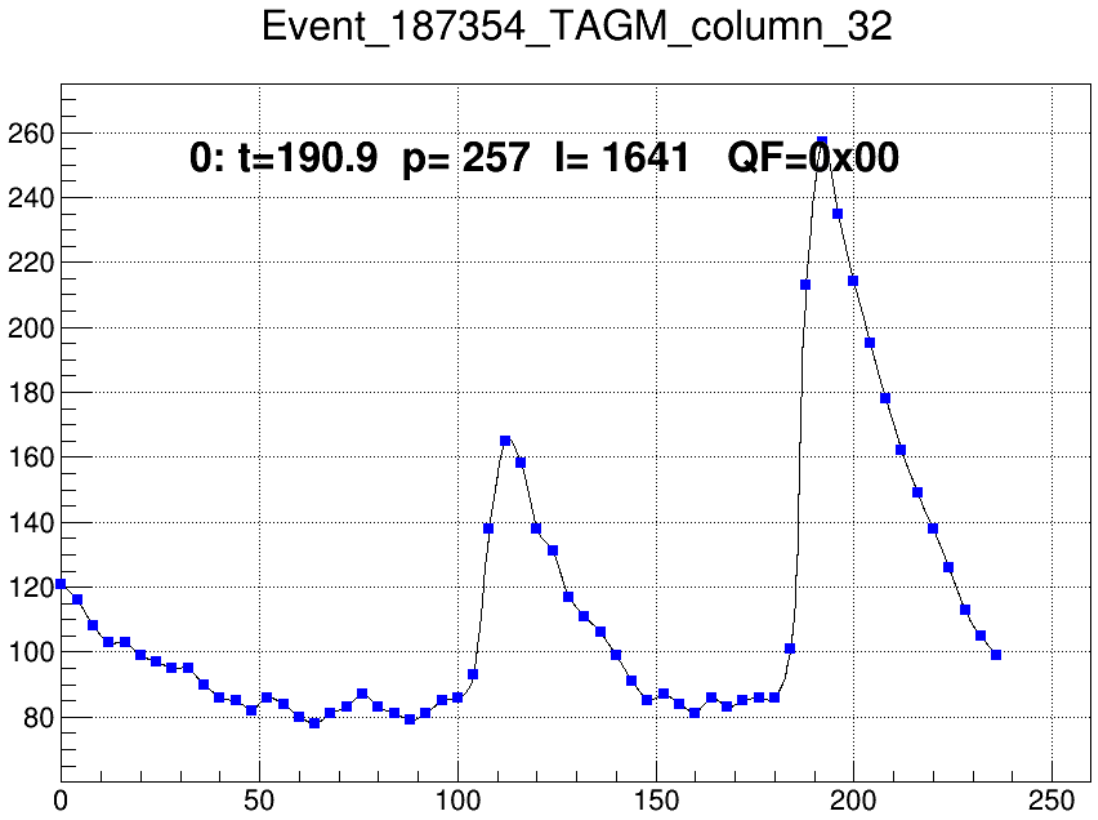
tagger microscope performace is studied by comparing the results from run 121039 with an electron beam current of 900nA to runs 121163 and 120847 with both an electron beam current of 300nA.
in all 3 case the 3rd file *_003.root is used in the analysis.

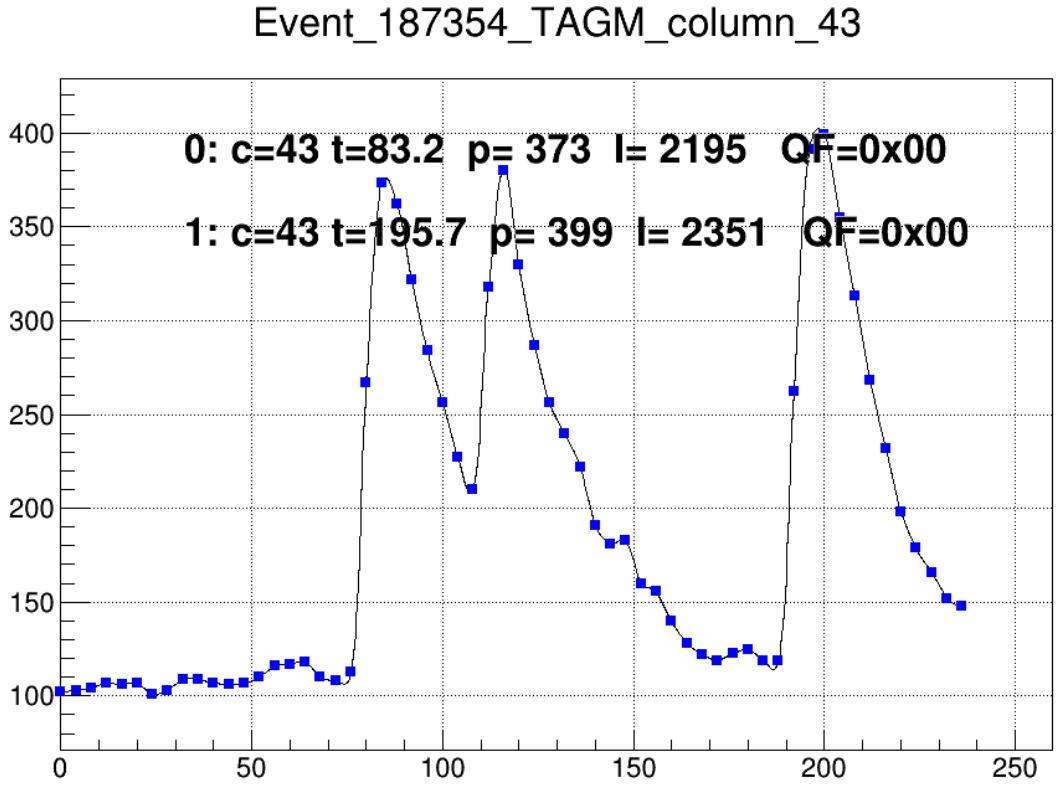
Hits in each column are counted separately for each event and filled into a histogram. A discrimination was applied if the pedestal determination failed. As a result one can determine the mean number of hits per event for each tagger microscope column given that the pedestal determination was succesfull. This is equivelent to stating that the start of the readout window is "flat" and no signal is present in that area.
At the same time one can determine the precentage of events where for a given column the online pedestal is not available and a "mean" pedestal would need to be used.



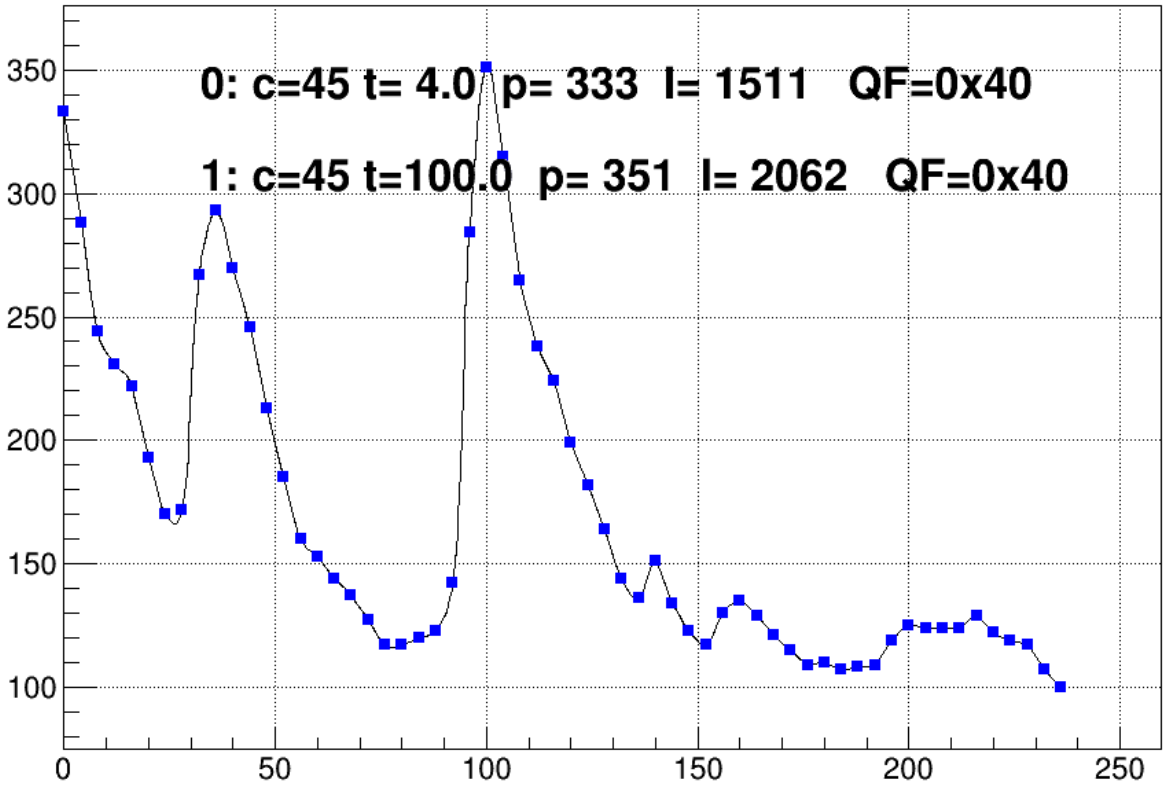
the "upper" graph shows the mean number of hits per tagger microscope column per event. The red color is for 900nA beam current while black and green are for 300nA.
Since this follows a "poisson" distribtuion means that for the columns in the coherent peak reagion with a mean close to unity or more the expected number of hits is more than one for a significant fraction of events.
Similarly the percentage of events where an online pedestal for a column is not valid and needs to be taken from the database is quite significant at current of 900nA in the coherent peak region.

To illustrate the issue in more detail we show several wave forms of the tagger microscope counters (column) all fromthe same event with an electron beam current of 900nA (Run 121039 file 003). Note that "from the same event" means the hit multiplicity within the tagger microscope as a whole for any even is already quite large. The horizontal scale is in units is in ns with a point each 4ns given by the fADC frequency of 250MHz, resulting in a total of 60 samples for each wave form.

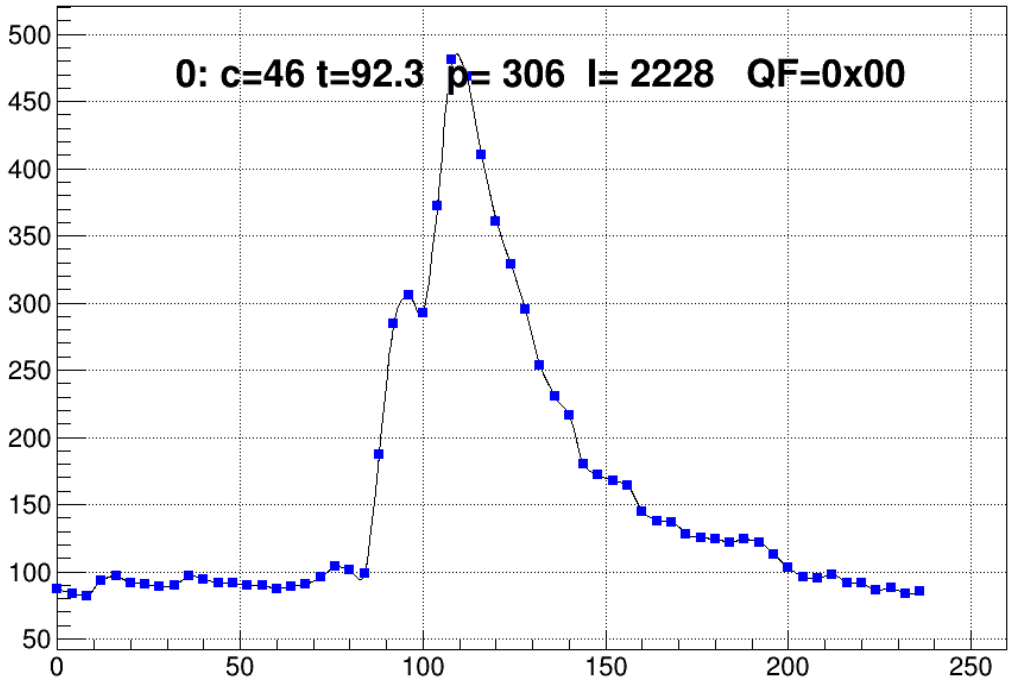


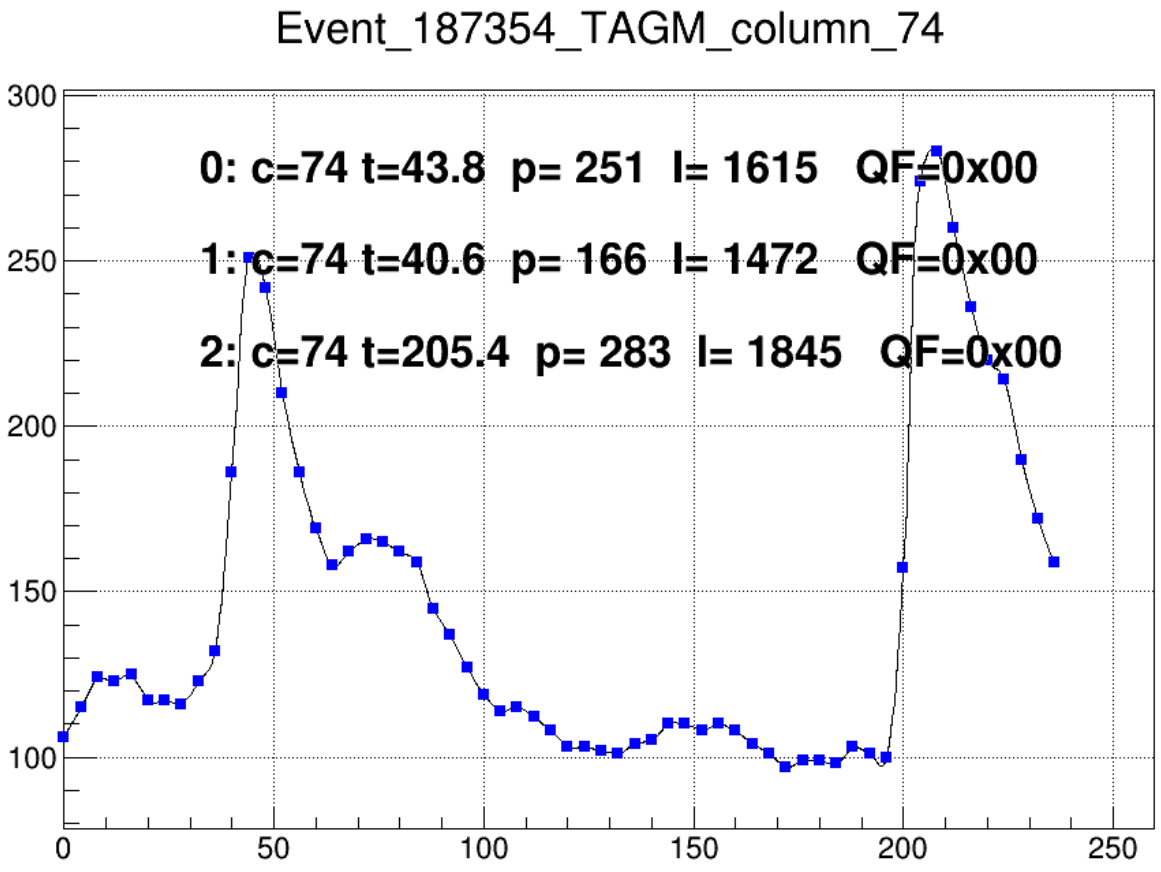


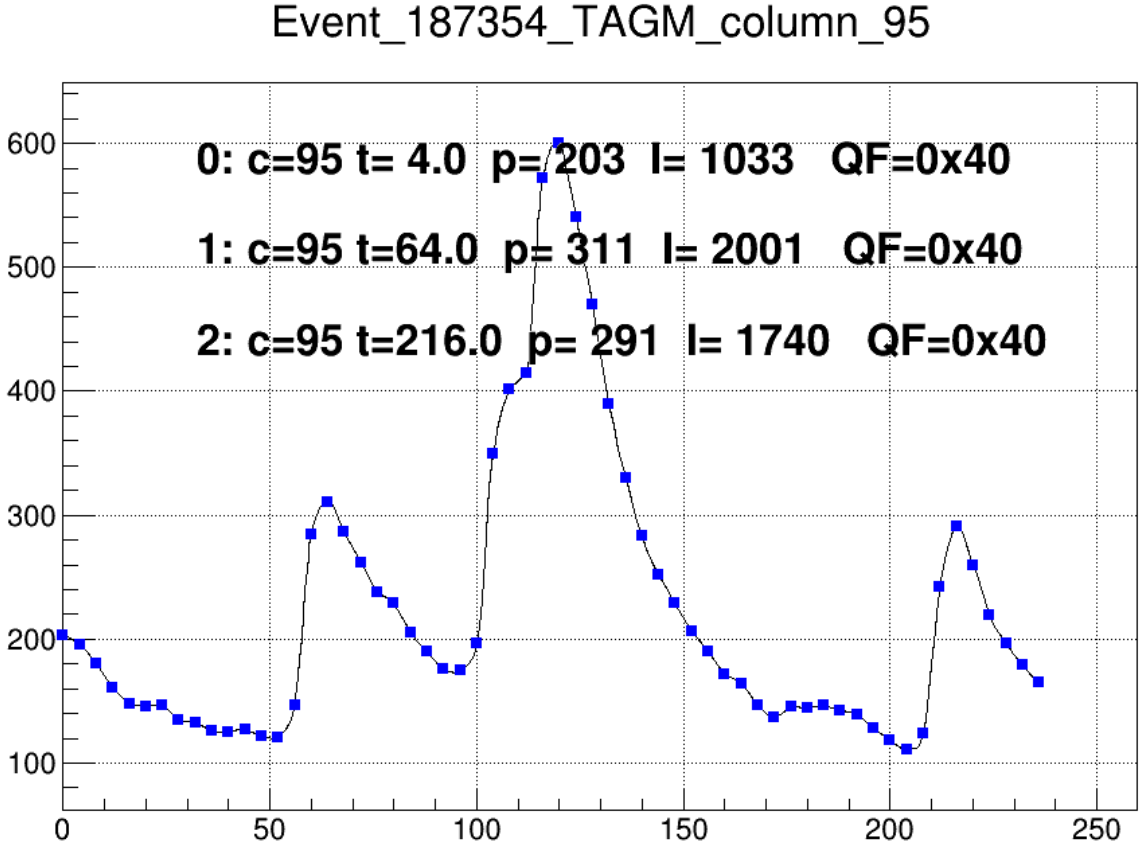
Event_187354_TAGM_column_45



Event_187354_TAGM_column_46




Event_187354_TAGM_column_74
0: c=74 t=43.8 p= 251 I= 1615 QF=0x00
1: c=74 t=40.6 p= 166 I= 1472 QF=0x00
2: c=74 t=205.4 p= 283 I= 1845 QF=0x00
300
250
200
150
100
0
50
100
150
200
250


Event_187354_TAGM_column_95
0: c=95 t= 4.0 p= 203 I= 1033 QF=0x40
1: c=95 t=64.0 p= 311 I= 2001 QF=0x40
2: c=95 t=216.0 p= 291 I= 1740 QF=0x40
600
500
400
300
200
100
0
50
100
150
200
250

Firstly, the rise time and decay time of the signal from the counters matter. In particular a long decay time with a large tail will manifest itself at high rates when a second signal occurs in the tail of the first signal. This is refer to as "pile-up" and may result in the second signal not to be detected. This behavor also depends on the algorithm on the FPGA that is designed to detect individual signals.

Secondly, at high rates the probaiblity of a hit occuring just before the start of the readout window causing the start of the readout window to lay in the "decay/tail" of a signal becomes much larger. Such a situation causes the pedestal determination part of the alorithm on the FPGA to fail and the algorithm will report QF = QF & 0x40 to indicate that the online pedestal can not be trusted.

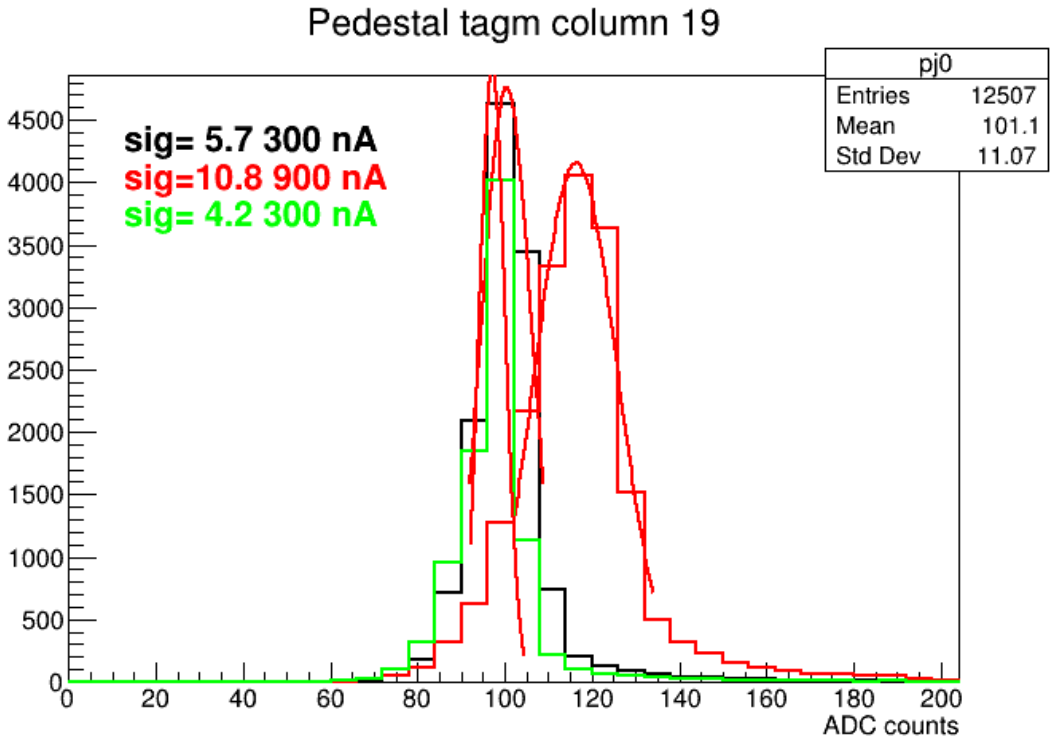
The fADC for this run 121039 for the readout of the tagger microscope are as follows:

```
FADC250_NSB          3
FADC250_NSA          6
FADC250_NPEAK        3
FADC250_NSAT         2
FADC250_READ_THR     150 # 1/14/18 by AEB/RTJ
```

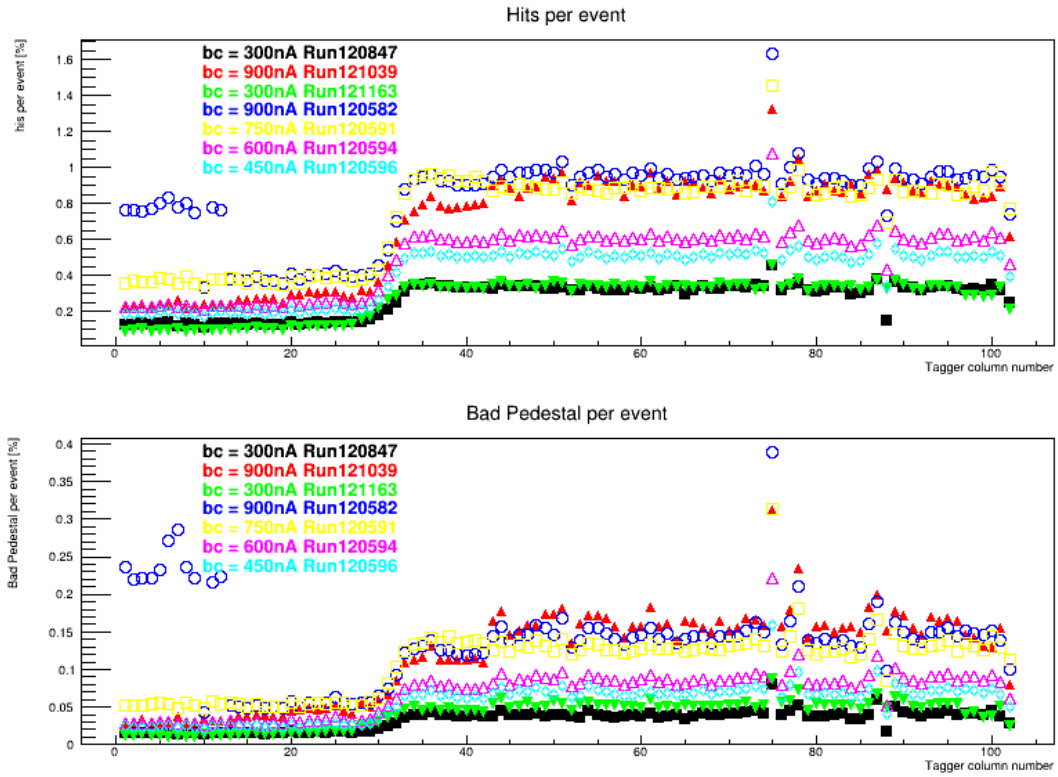
This means that a) only a maximum of 3 signal peaks are searched form, b) the minimum singal hight has to be 150 ADC counts (this INCLUDES the pedestal)

Waveform 1: the first signal peak is missed
Waveform 2: the second signal peak is missed

Regarding the base line, it turns out that the width of the pedstal significanlty increases with beam current. To illustrate this point the pedestal peak of each tagger hodocope is fit with gaussin in the peak reagion ony to determine the approximate width ignoring the tails. It turns out that for run 121039 with beam current 900nA all pedstals have a width that is a factor of 2 or even larger than for runs 121163 or 120847 where the beam current was the standard 300nA.
There may also be a base line shift happening but this can not be confirmed at this point.

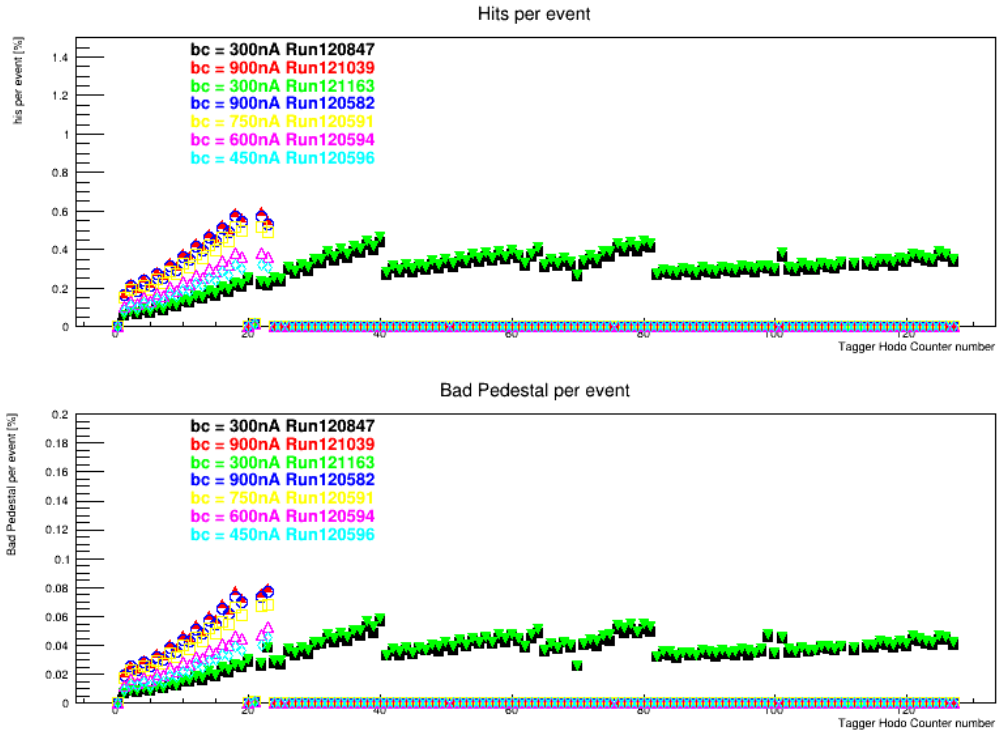


looking at other runs that expand on the e-beam current from 450nA to 900nA shows that while there is an increase of hit multiplicity with beam current there are additional effects that may change the expected linear dependance. There seems to be not much difference between 750nA beam current and 900nA beam current when looking at the number of hits found. This may be a result of saturation as the algorithm only looks for a maximum of 3 hits.
the fraction of events where the pedestal determination fails shows a linear increase up to 600nA but then does a jump when increasing to 750nA, also indicateive of some non linear effect.

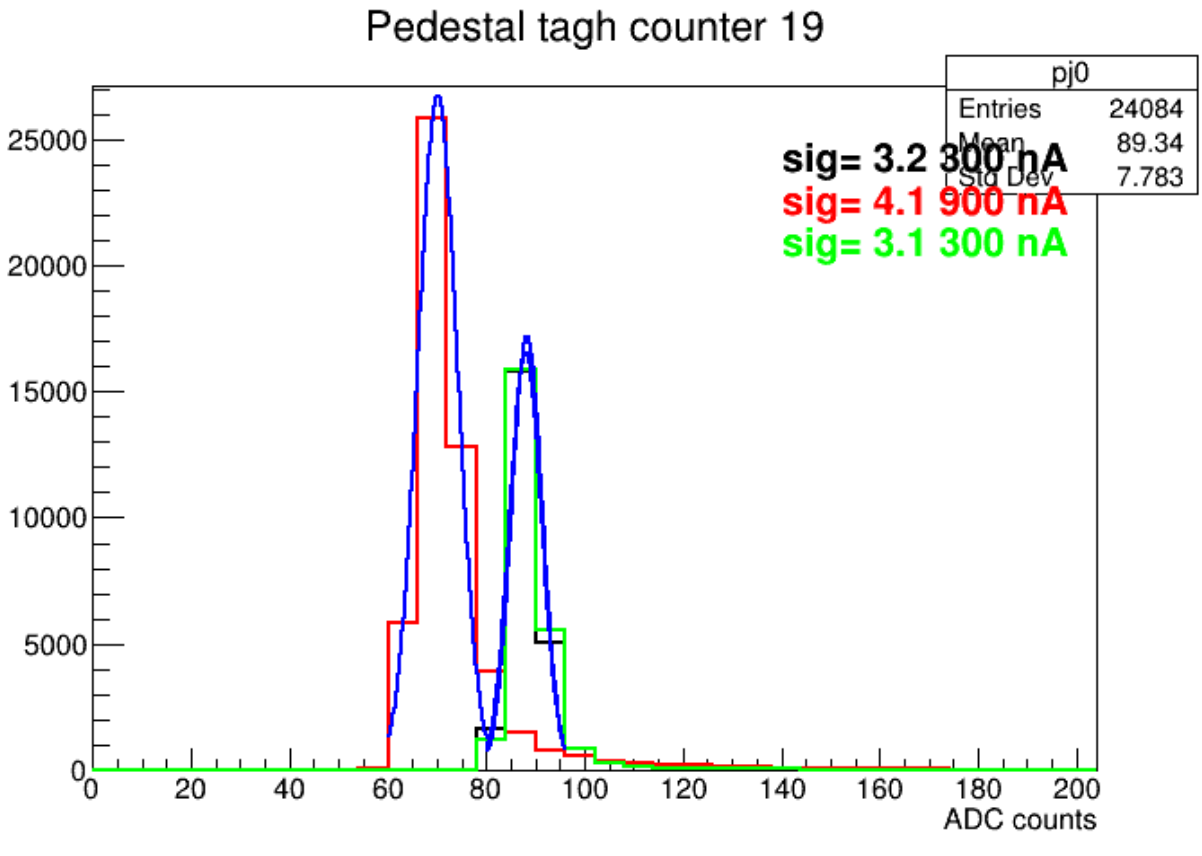


TAGGER hodoscope:

In case of the tagger hodoscope the situation regarding high rate studies is somewhat limited because for all high current runs all tagger hodscope counters larger than 21 were switched off. So only a limited range of counters can be studied.
Because the rise time and in particular the decay time of the signals from these counters are faster the effects of pile-up are less severe but still noticeable as can be seen in the picture below:

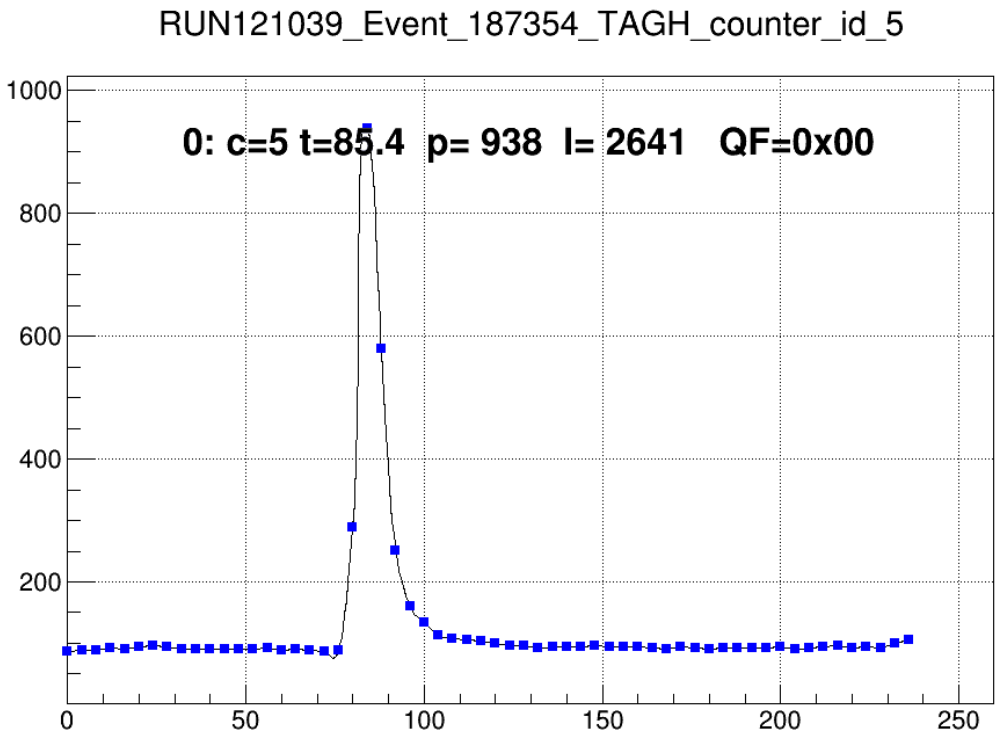


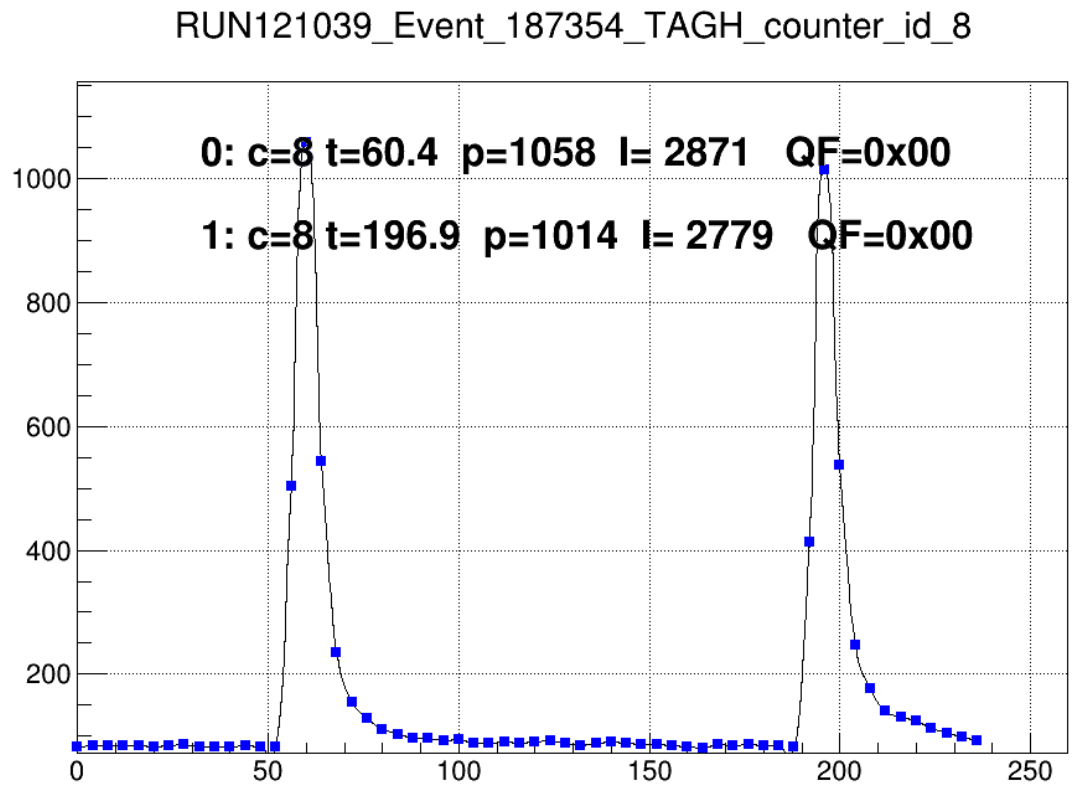
as can be seen the counters above #21 are turned off for beam currents larger than 300nA however one can still undestand the effect of higher currents. Similarly to the microscope there seems to be some non linear effect that are at play since the increse in hits/even and also bad pedestal rates seem to be not fully linear. In particulare the increase from 600nA to 750nA is much larger than from 450nA to 600nA.

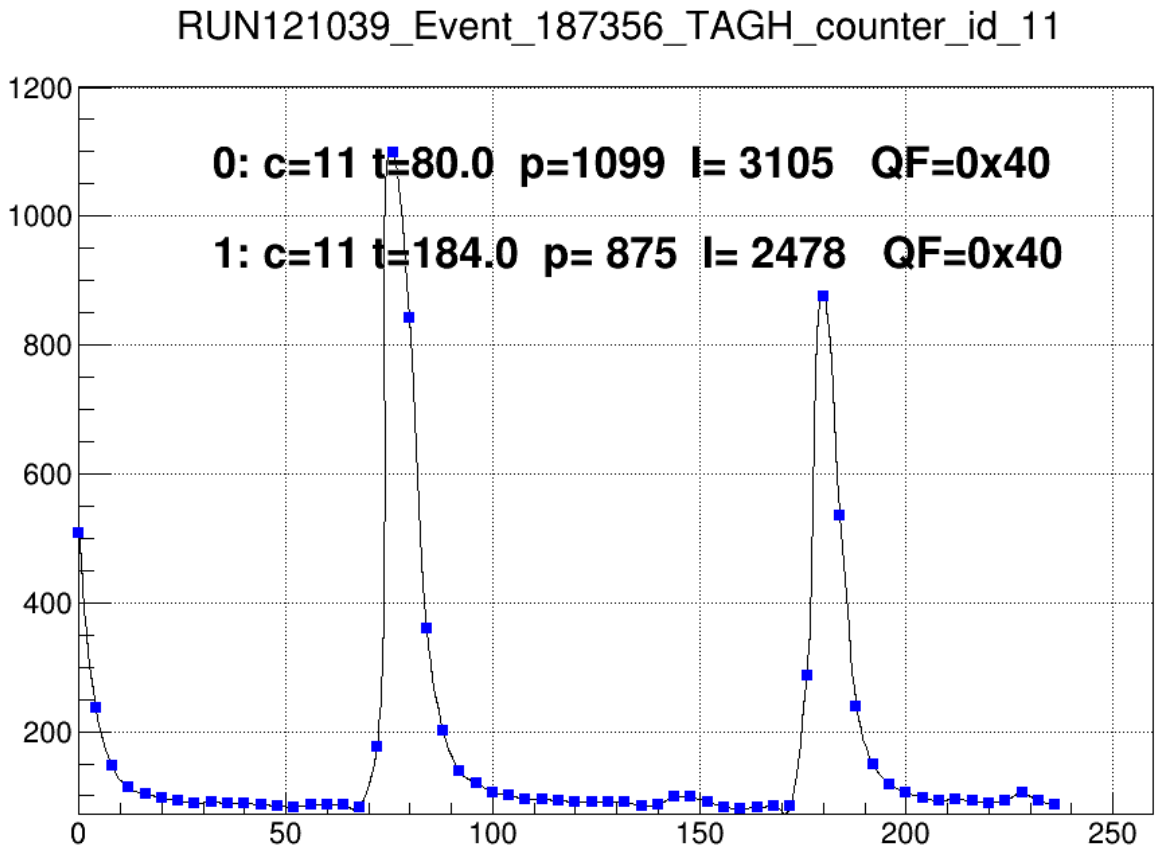


in contrast to the microscope there is a clear pedestal sag noticeable with increased rate. This is expected due to effect of the preamplifier on the PMT base that uses the same HV supply as the divider itself.
It is also evident that the base line itself becomes wider as the width of the pedestal becomes larger by about 30% between 300nA and 900nA beam current.

Below are a few examples of wave forms from run 121039 where the beam current was 900nA. The decay of the signals is of order 4 samples or 16ns which is rathe fast and very help full regarding pile-up. The rise time of the signals is rather fast with only one sample in the slope of the signal rise at best which makes it very difficult to determined good timeing by the flash ADC.






RUN121039_Event_187356_TAGH_counter_id_11
0: c=11 t=80.0 p=1099 I= 3105 QF=0x40
1: c=11 t=184.0 p= 875 I= 2478 QF=0x40
1200
1000
800
600
400
200
0
50
100
150
200
250