Clatterbridge 24th – 25th November 2016 Waveform Data Analysis

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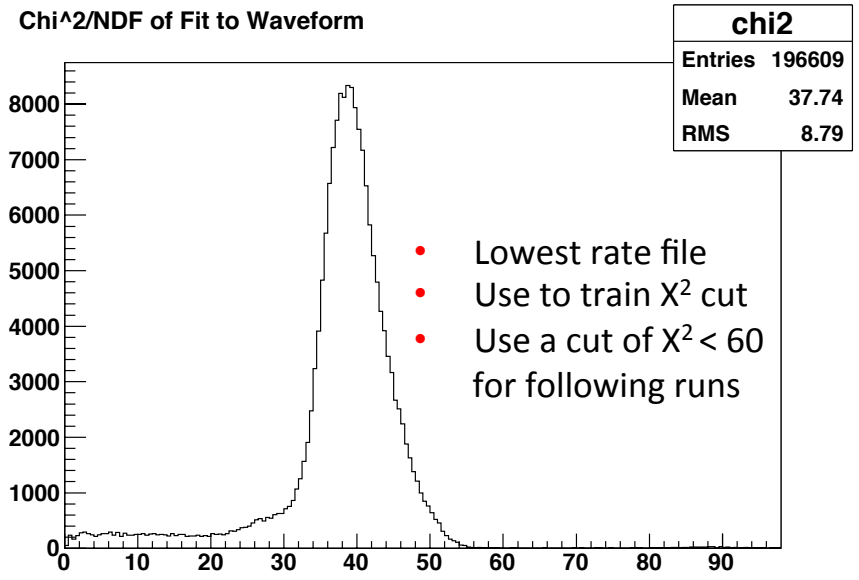
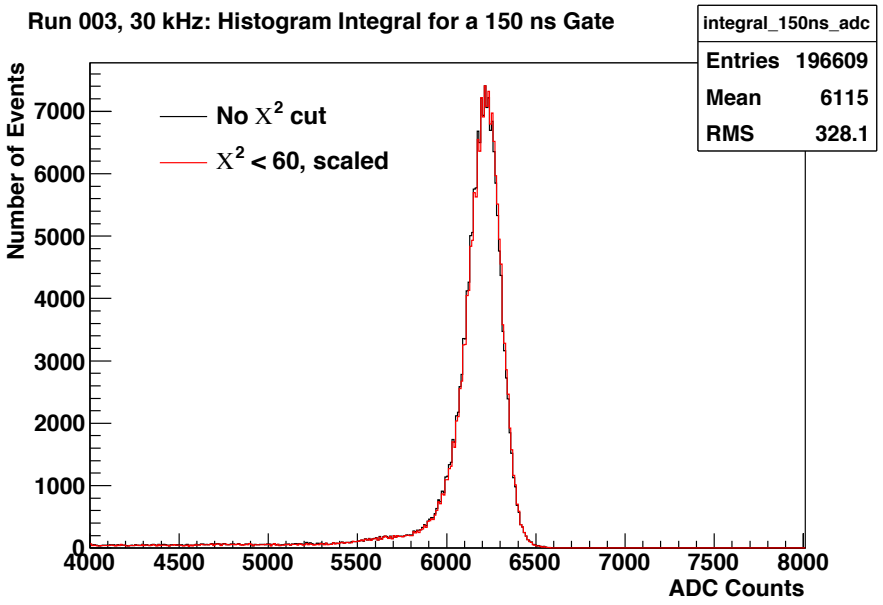
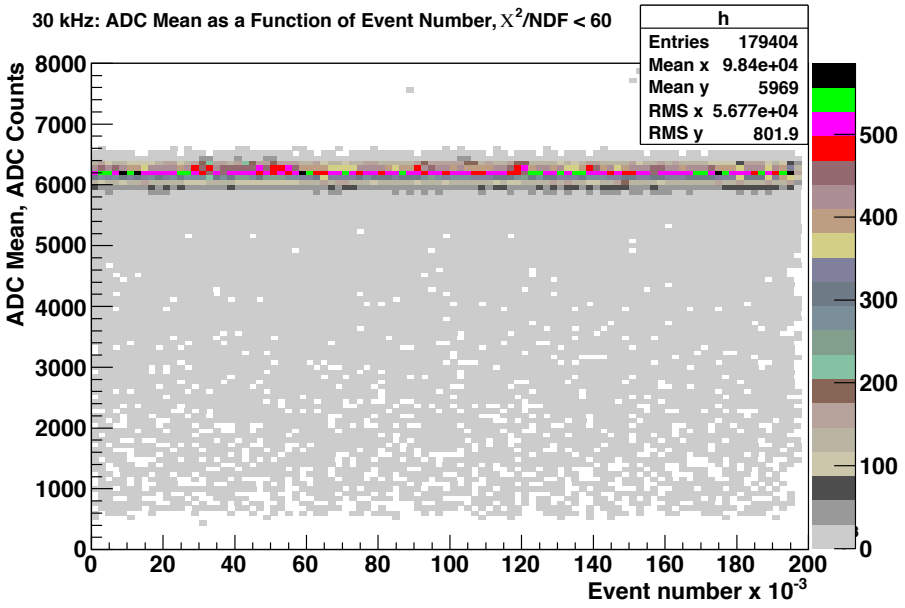
Thursday 24th of November 2016:
Rate Tests

Run 003: Rate - 30 kHz, No Absorbers

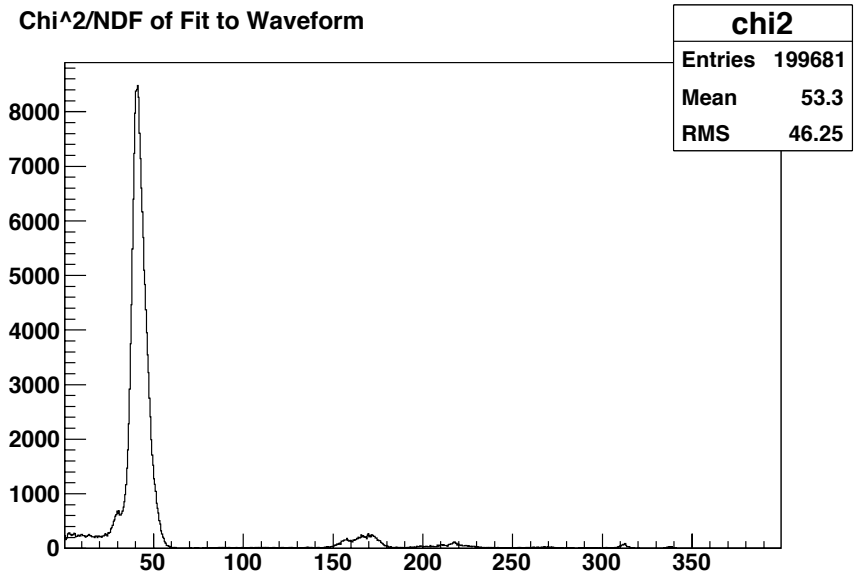


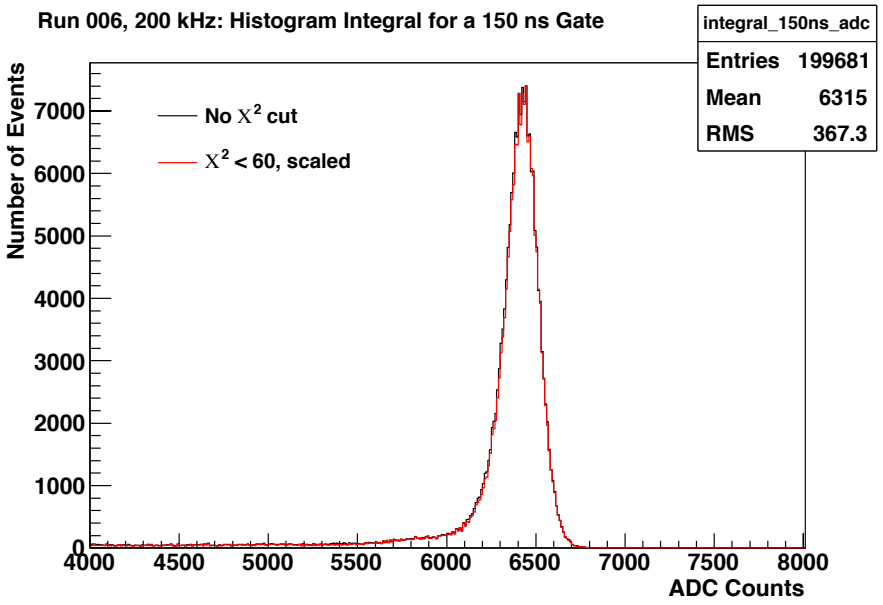


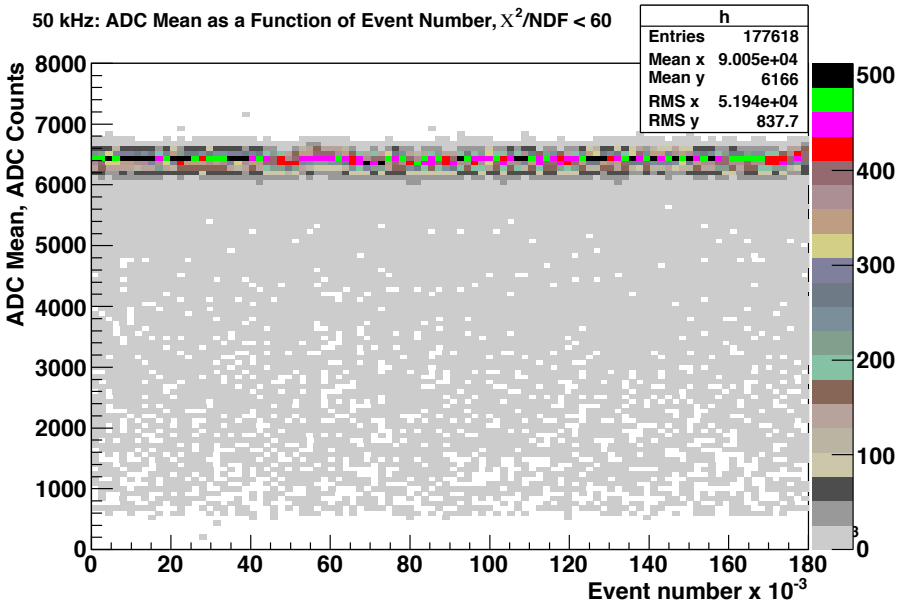


X²/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	196609	6231 ± 0.3	2.718 ± 0.015
< 60	179404	6234 ± 0.3	2.715 ± 0.015
ADC equivalent: run 001			
None	32768	6141 ± 0.1	2.544 ± 0.07

Run 006: Rate - 50 kHz, No Absorbers

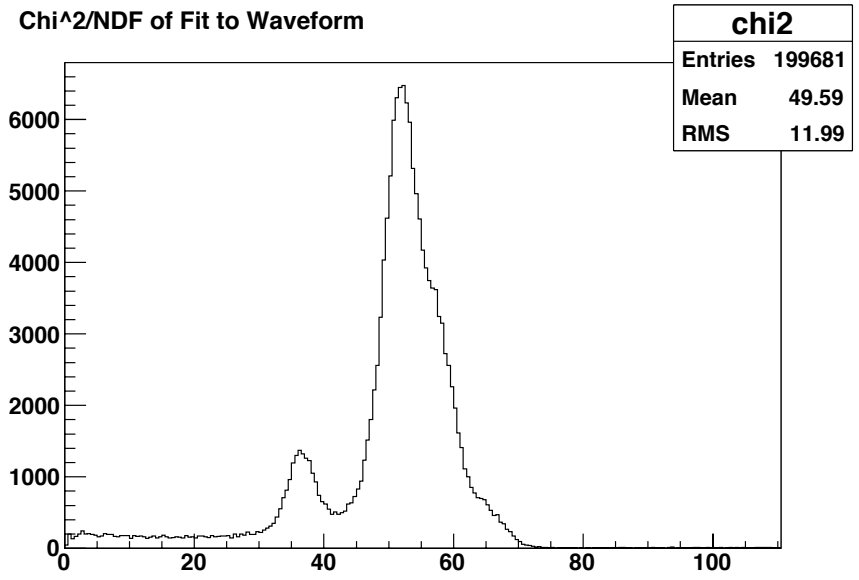


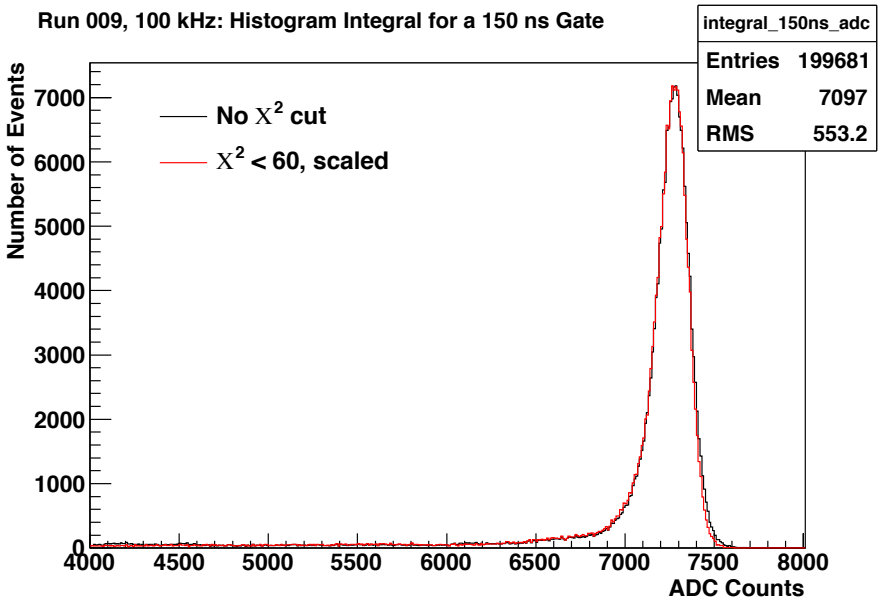


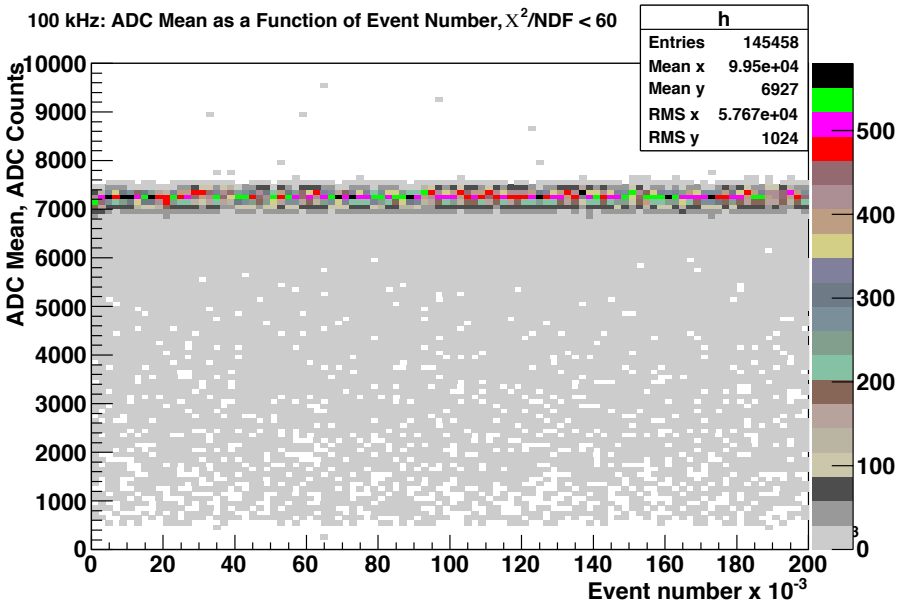


X²/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	199681	6441 ± 0.4	2.755 ± 0.015
< 60	177618	6442 ± 0.4	2.731 ± 0.014
ADC equivalent: run 004			
None		6345 ± 0.1	2.504 ± 0.006

Run 009: Rate - 100 kHz, No Absorbers

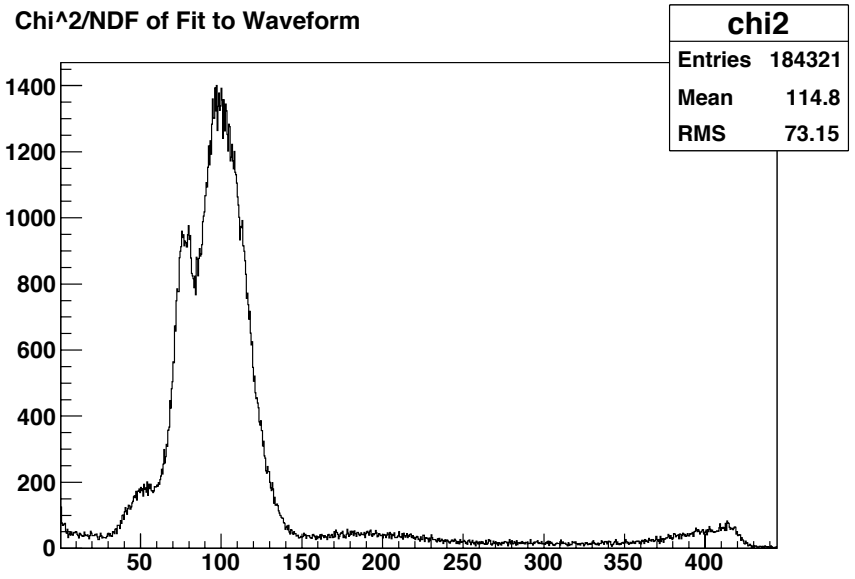


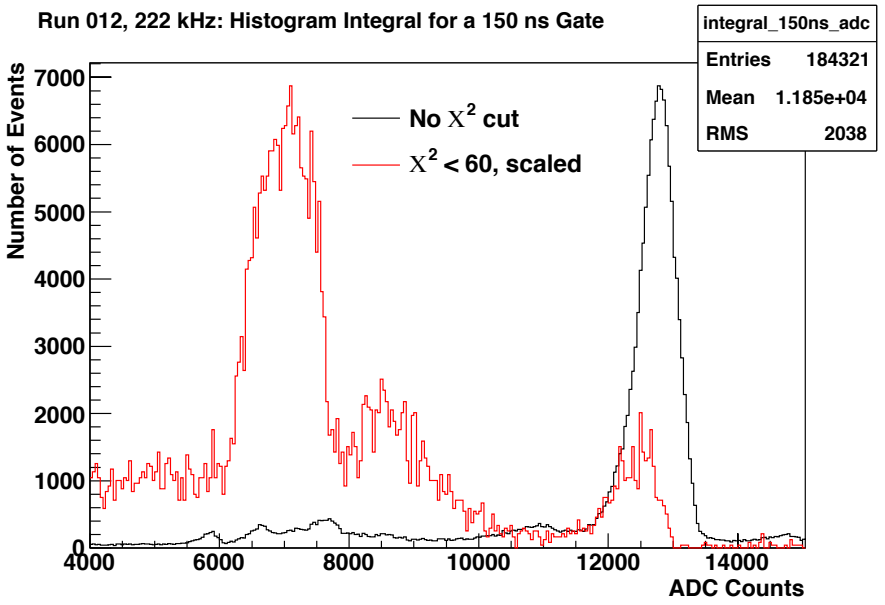


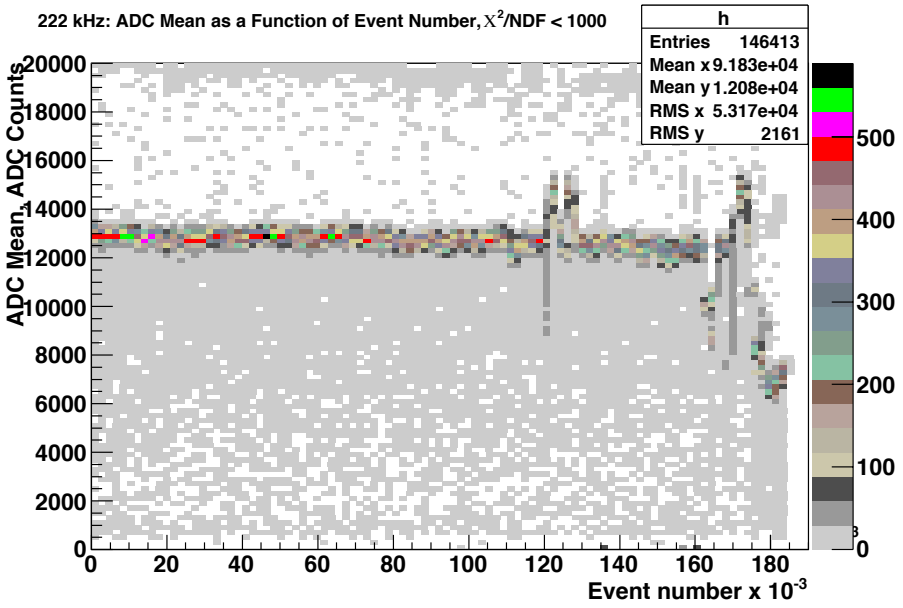


X²/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	199681	7291 ± 0.4	2.267 ± 0.014
< 60	145458	7289 ± 0.4	2.035 ± 0.014
ADC equivalent: run 007			
None		7155 ± 0.1	2.779 ± 0.006

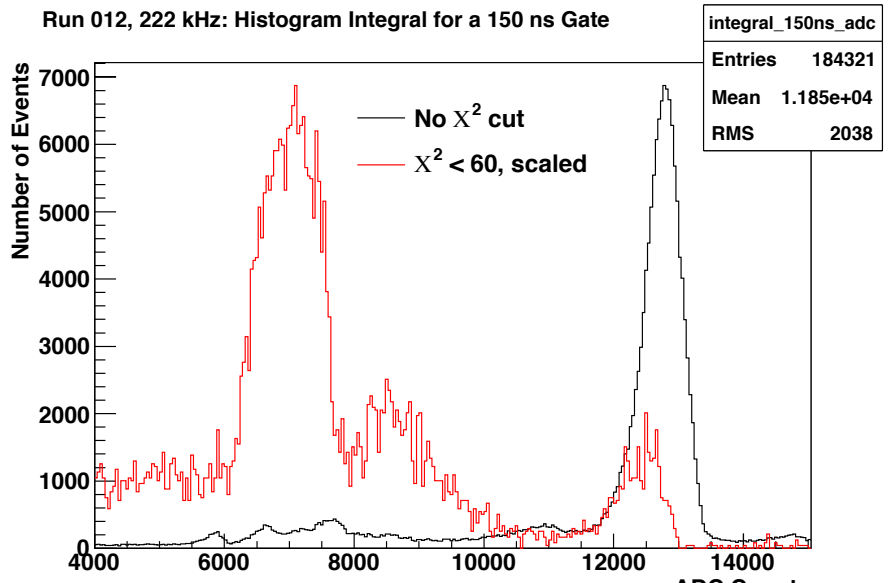
Run 012: Rate - 222 kHz, No Absorbers

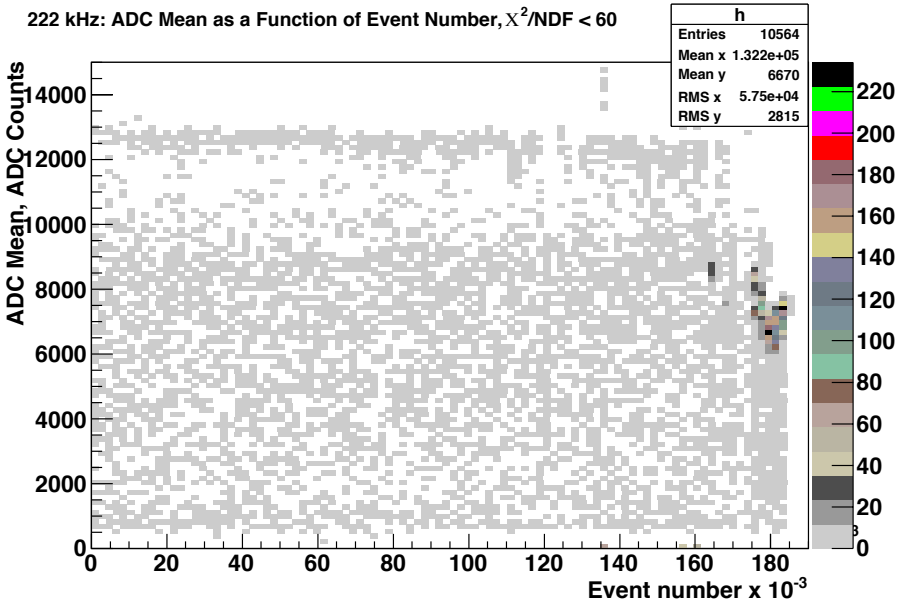






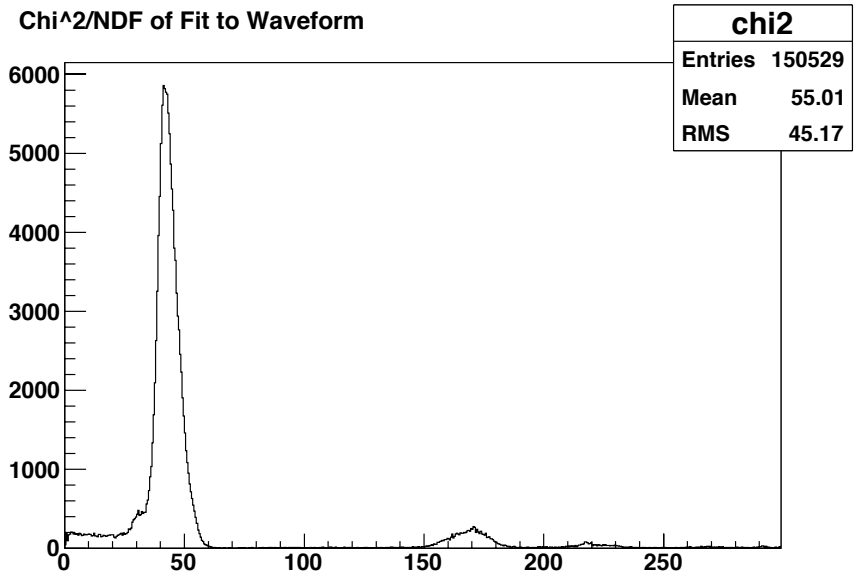
X²/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	184321	12828 ± 1.5	3.901 ± 0.036
< 60	10564	Unable to fit due to low statistics	
ADC equivalent: run 010			
None		13015 ± 0.2	1.853 ± 0.005

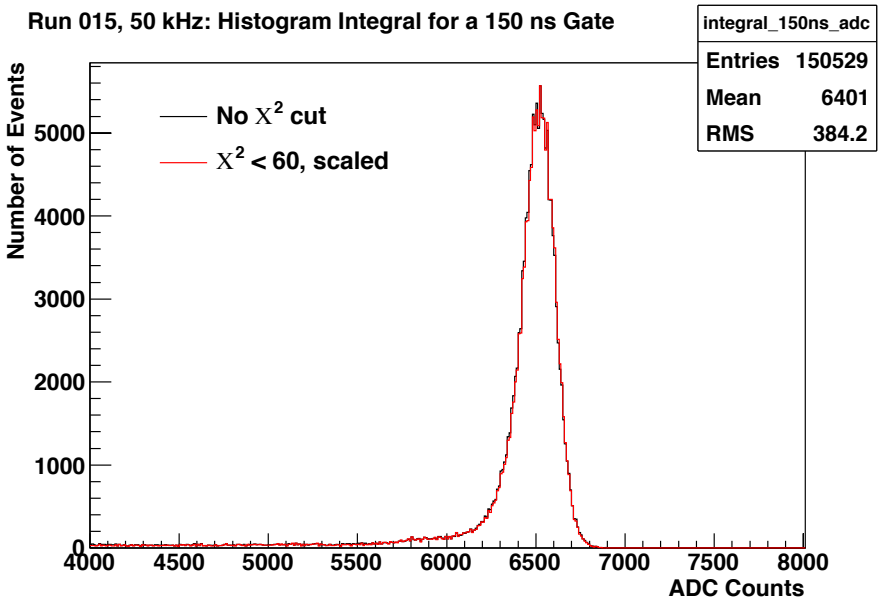


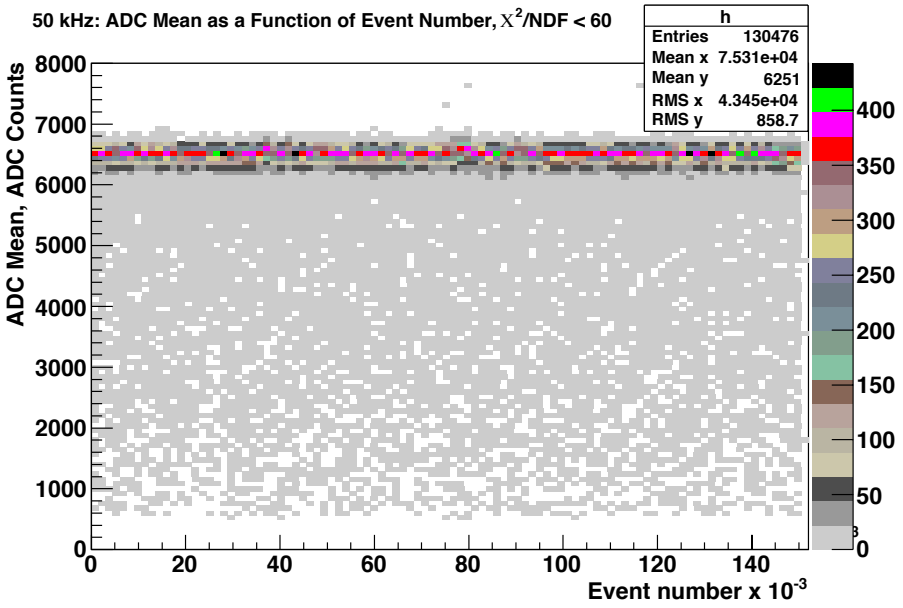


- For a proton beam rate of ~ 200 kHz the pulse height of the signal drastically increases, resulting in a higher mean of the ADC distribution
- Applying a cut of $X^2 < 60$ reduces the mean of the ADC distribution from ~ 13000 to ~ 7000, which is around the mean we see at rates < 200 kHz
- When looking at the ADC mean as a function of event number without applying a X^2 cut (Slide 6) some fluctuation is seen
- Looking at the ADC mean as a function of event number for $X^2 < 60$ (on this slide) shows that only events with an ADC mean of ~ 7000 are left
- Statistics are too low to fit the ADC spectrum with a $X^2 < 60$, but this is an interesting observation
- Similar observation in other 200 kHz runs, see later.

Run 015: Rate - 50 kHz, No Absorbers

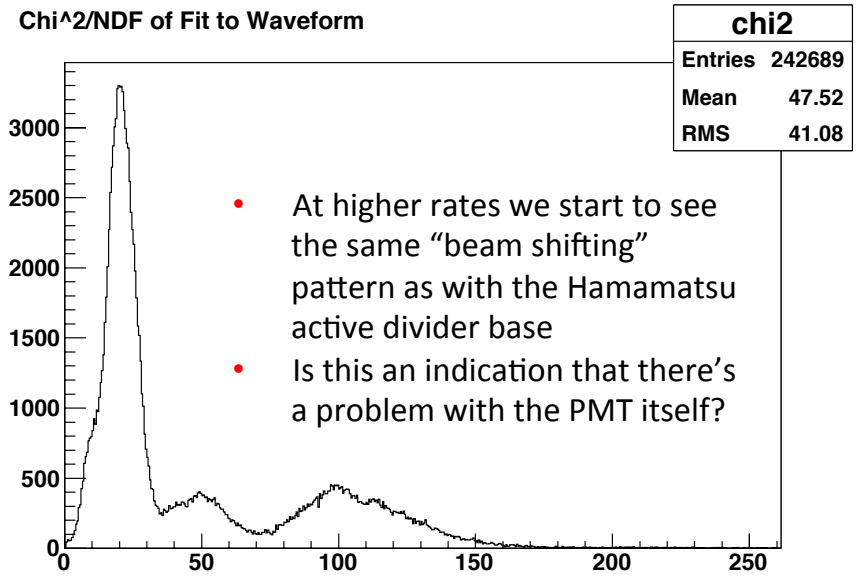


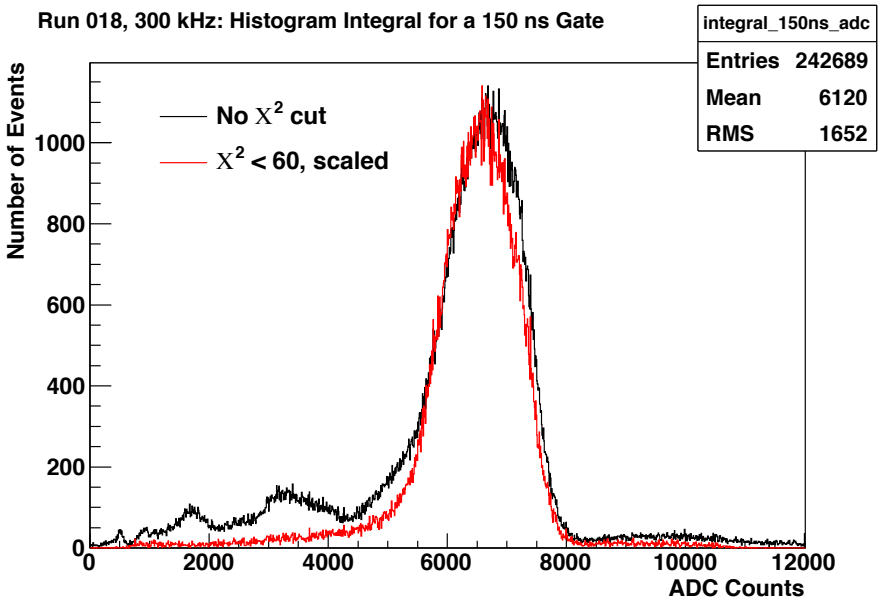


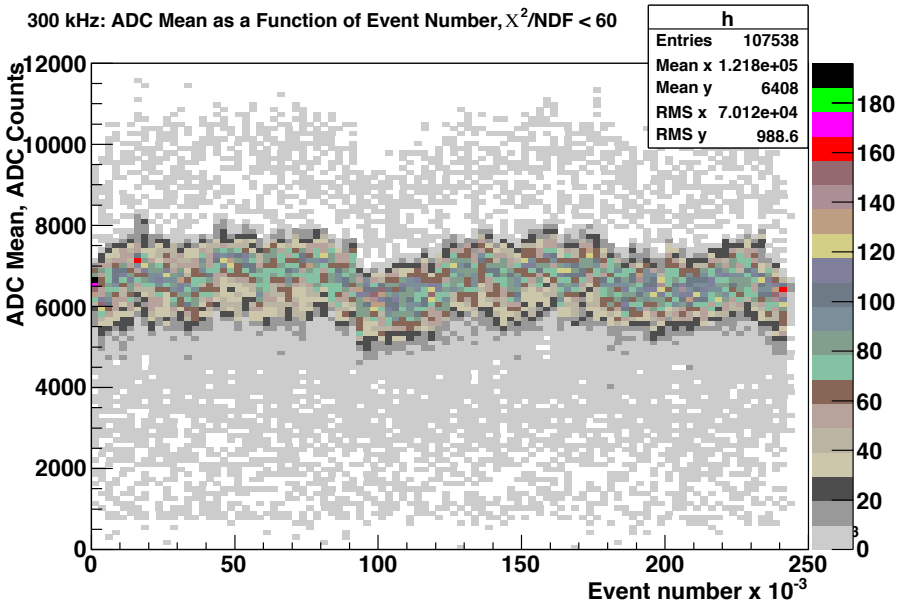


X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	150529	6536 ± 0.4	2.660 ± 0.016
< 60	130476	6538 ± 0.4	2.616 ± 0.018
ADC equivalent: run 013			
None		Unable to fit spectrum due to shifting during run	

Run 018: Rate - 300 kHz, No Absorbers

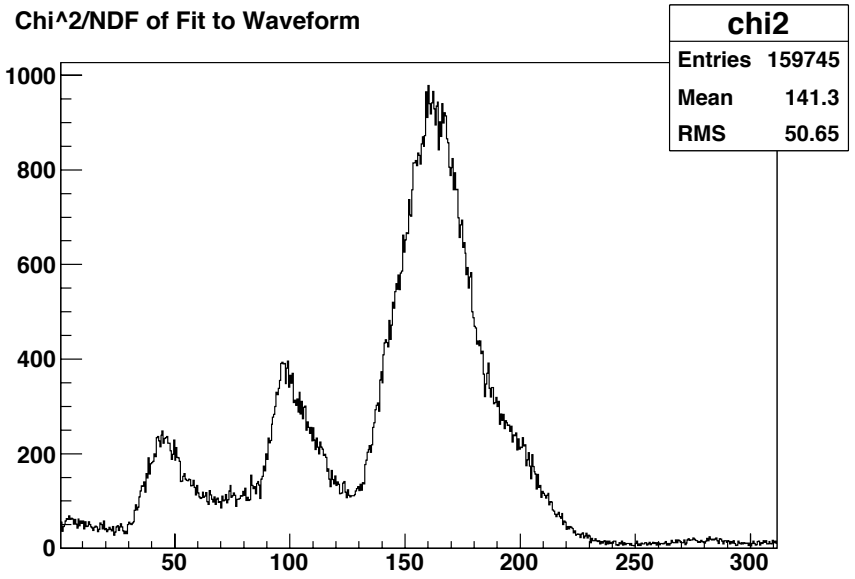


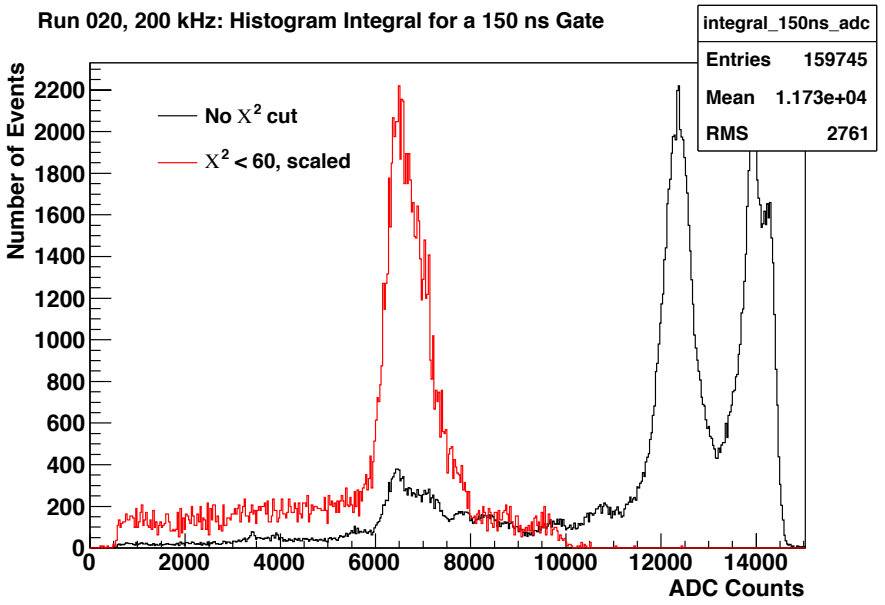


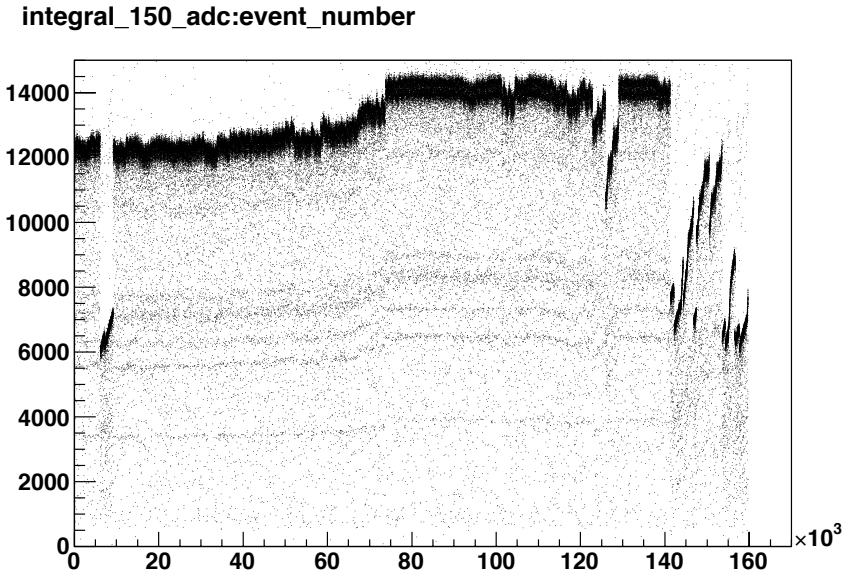


X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	242689	6789 ± 2.0	10.925 ± 0.120
< 60	10738	6709 ± 2.6	16.641± 0.082
ADC equivalent: run 016			
None		7155 ± 0.1	2.779 ± 0.006

Run 020: Rate - 200 kHz, No Absorbers

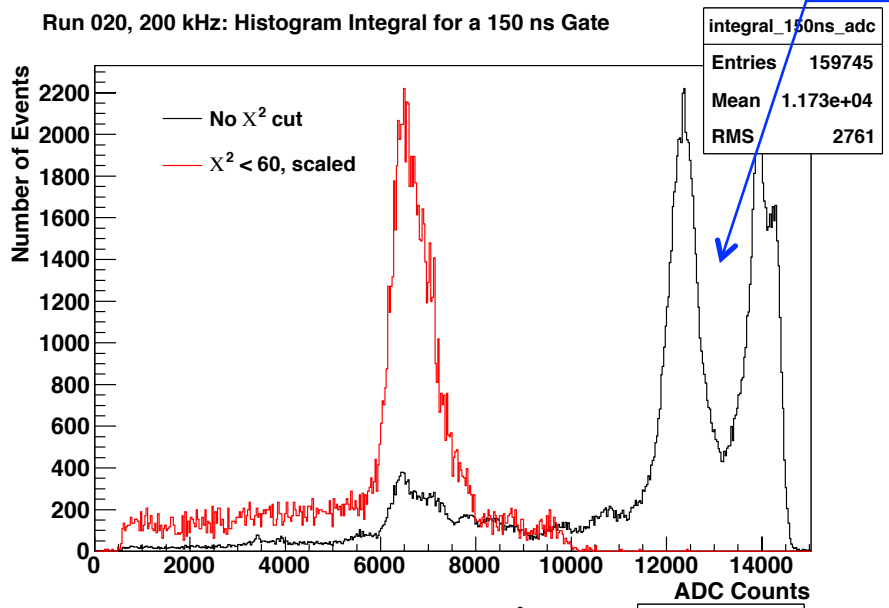


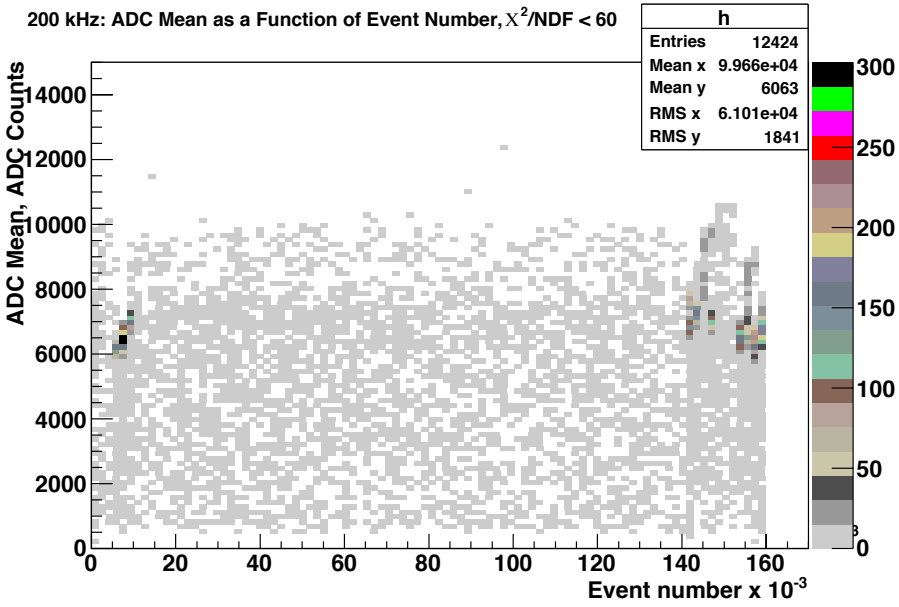




X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	159745	Unable to fit due to double peak	
< 60	12424	Unable to fit due to low statistics	
ADC equivalent: run 019			
None		12291 ± 0.5	4.006 ± 0.010

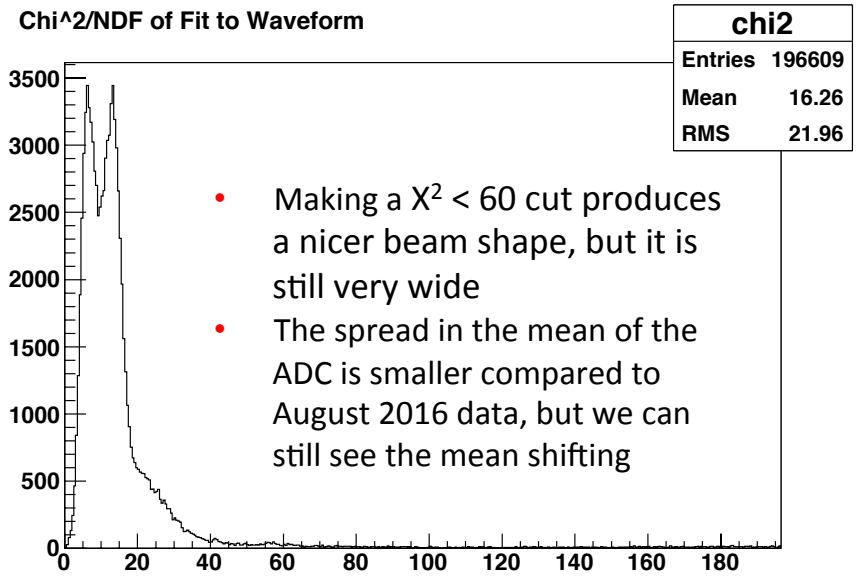
Why the double peak? According to my notes the scattering foil current started to drop towards the end of the run. Subsequent ADC mode spectra also showed beam shifting.



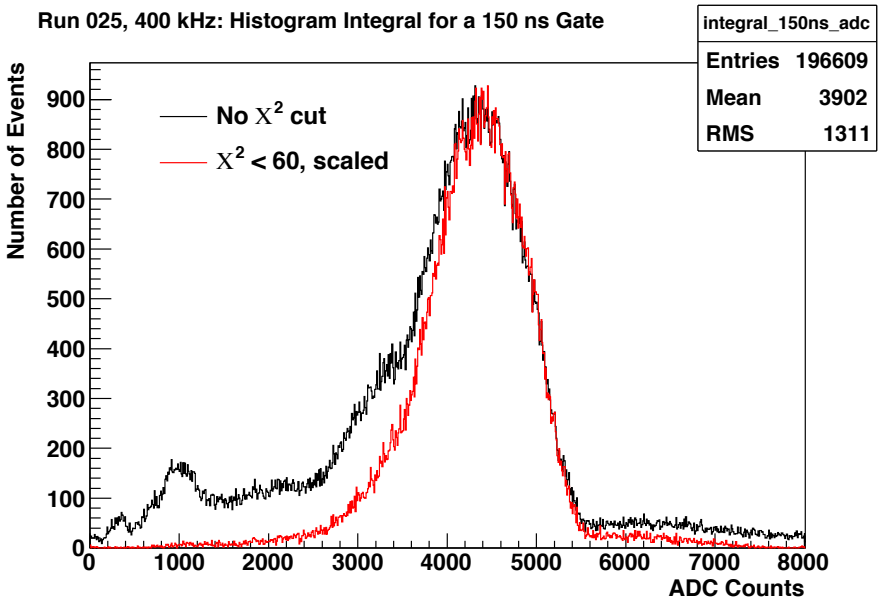


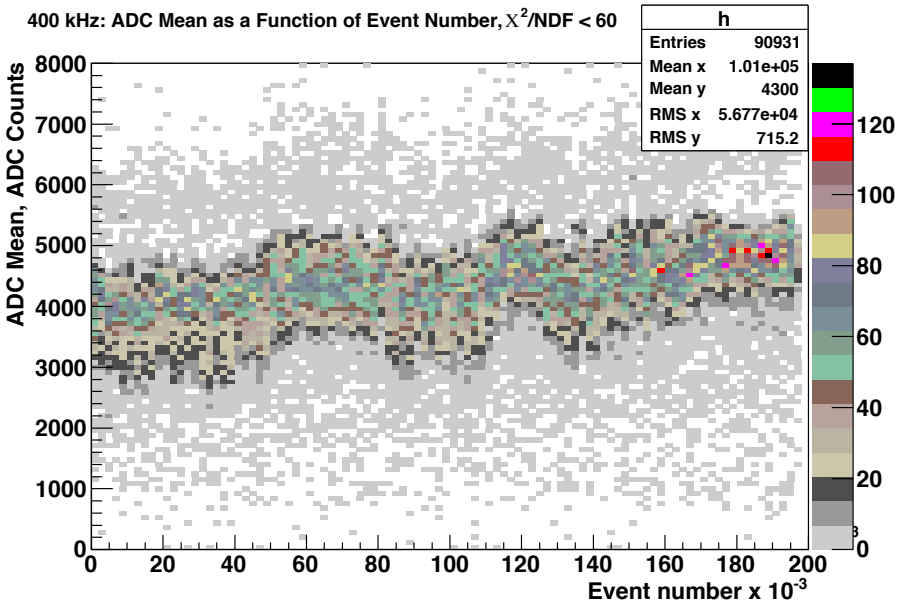
- For a proton beam rate of ~ 200 kHz the pulse height of the signal drastically increases, resulting in a higher mean of the ADC distribution
- Applying a cut of $X^2 < 60$ reduces the mean of the ADC distribution from ~ 13000 to ~ 7000, which is around the mean we see at rates < 200 kHz
- When looking at the ADC mean as a function of event number without applying a X^2 cut (Slide 10) some fluctuation is seen
- Looking at the ADC mean as a function of event number for $X^2 < 60$ (on this slide) shows that only events with an ADC mean of ~ 7000 are left
- Statistics are too low to fit the ADC spectrum with a $X^2 < 60$, but this is an interesting observation
- Similar observation in other 200 kHz runs, see earlier and later.

Run 025: Rate - 400 kHz, No Absorbers



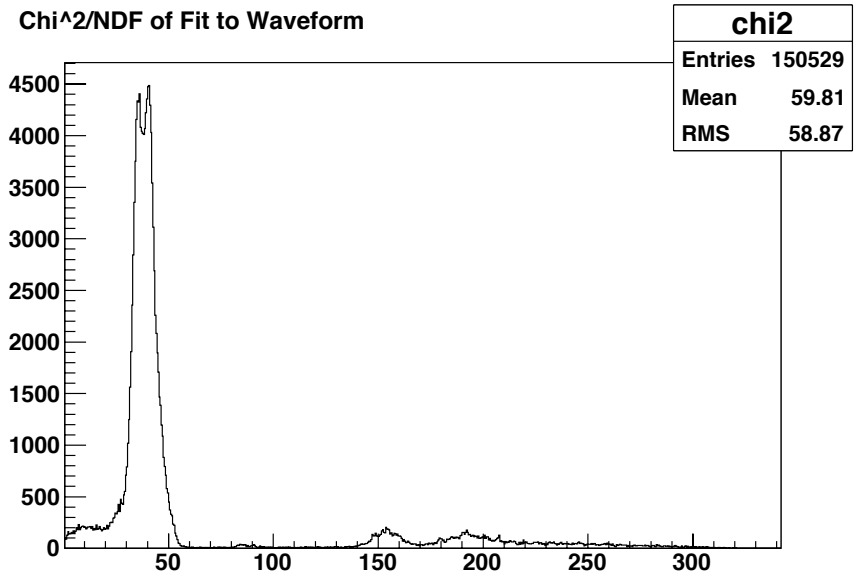
- Making a $X^2 < 60$ cut produces a nicer beam shape, but it is still very wide
- The spread in the mean of the ADC is smaller compared to August 2016 data, but we can still see the mean shifting

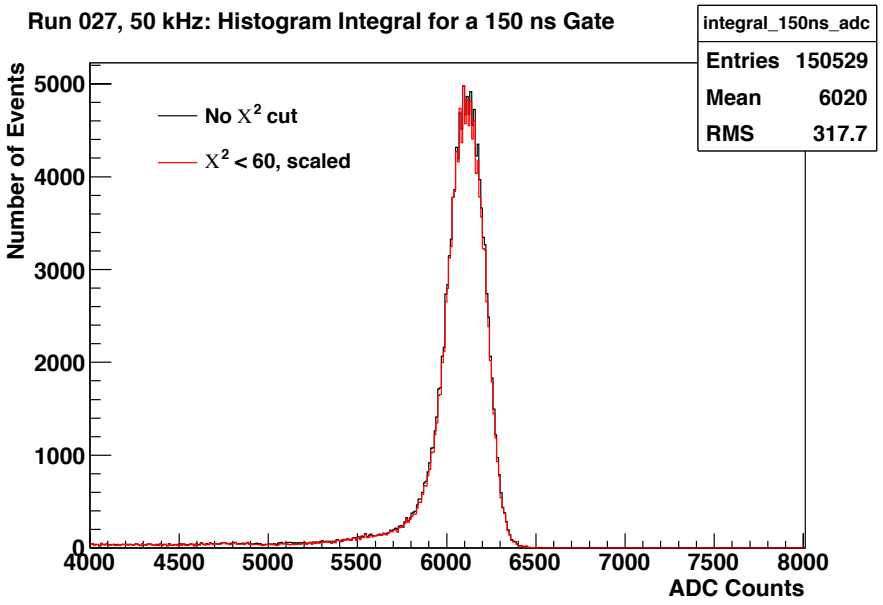


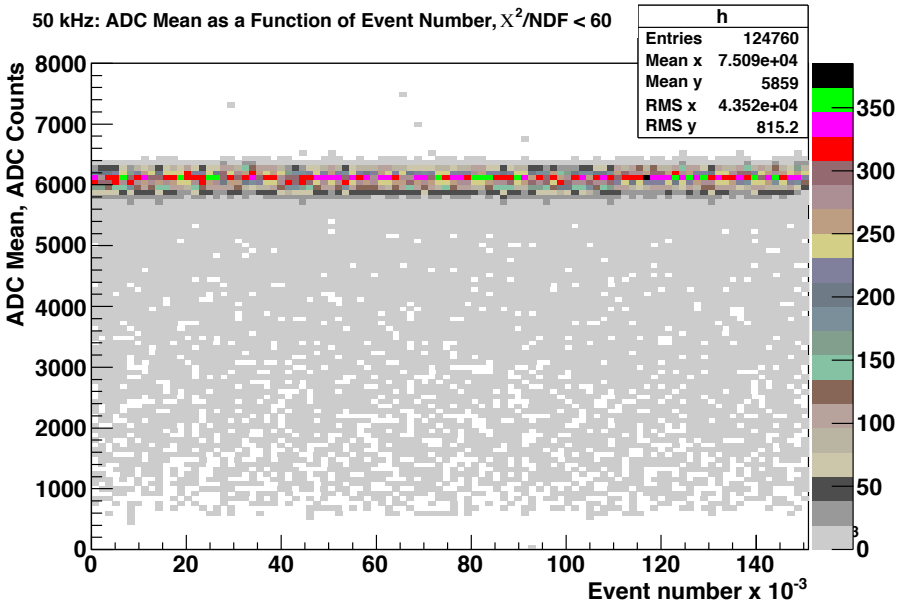


X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	196609	4346 ± 3.9	8.632 ± 0.425
< 60	90931	4500 ± 3.2	21.50 ± 0.16
ADC equivalent: run 024			
None		4676 ± 0.6	11.912 ± 0.037

Run 027: Rate - 50 kHz, No Absorbers



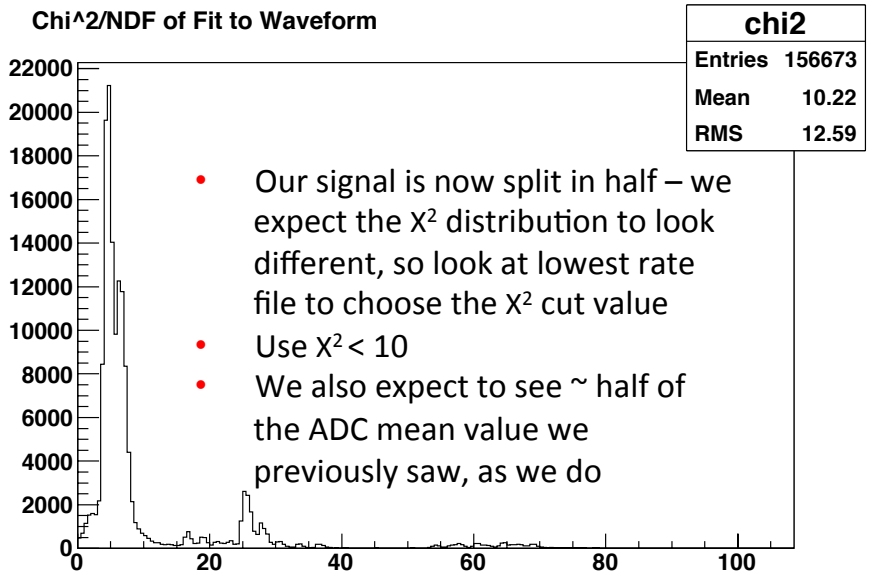




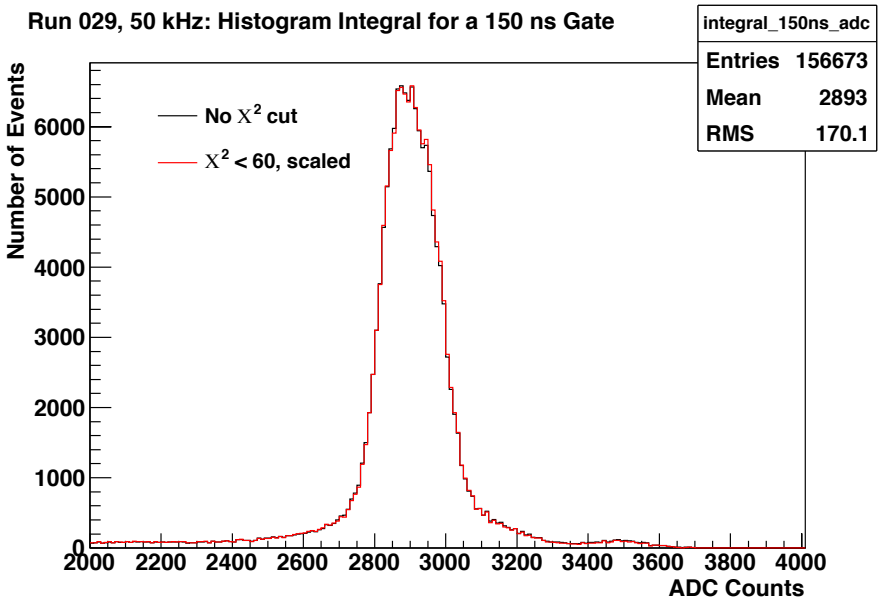
X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	150529	6138 ± 0.4	3.002 ± 0.014
< 60	124760	6137 ± 0.4	3.018 ± 0.015
ADC equivalent: run 026			
None		5981 ± 0.1	2.552 ± 0.005

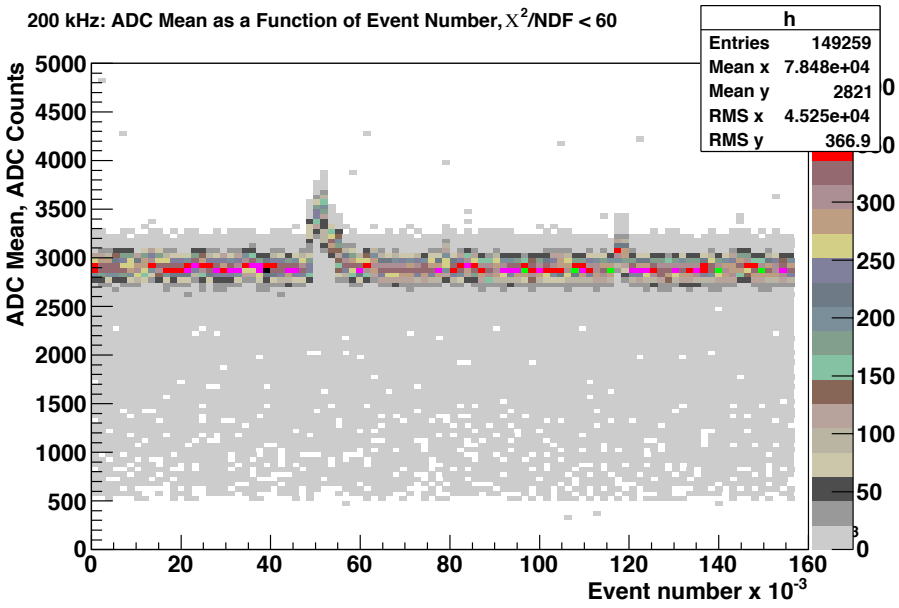
Thursday 24th of November 2016:
Scope and Digitiser 50 Ω LEMO Splitter Tests

Run 029: Rate - 50 kHz, No Absorbers



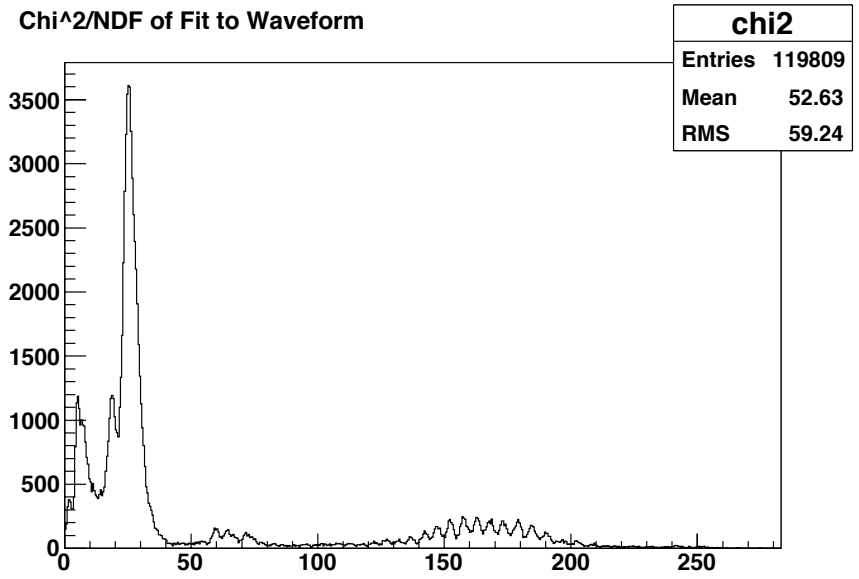
- Our signal is now split in half – we expect the X^2 distribution to look different, so look at lowest rate file to choose the X^2 cut value
- Use $X^2 < 10$
- We also expect to see ~ half of the ADC mean value we previously saw, as we do

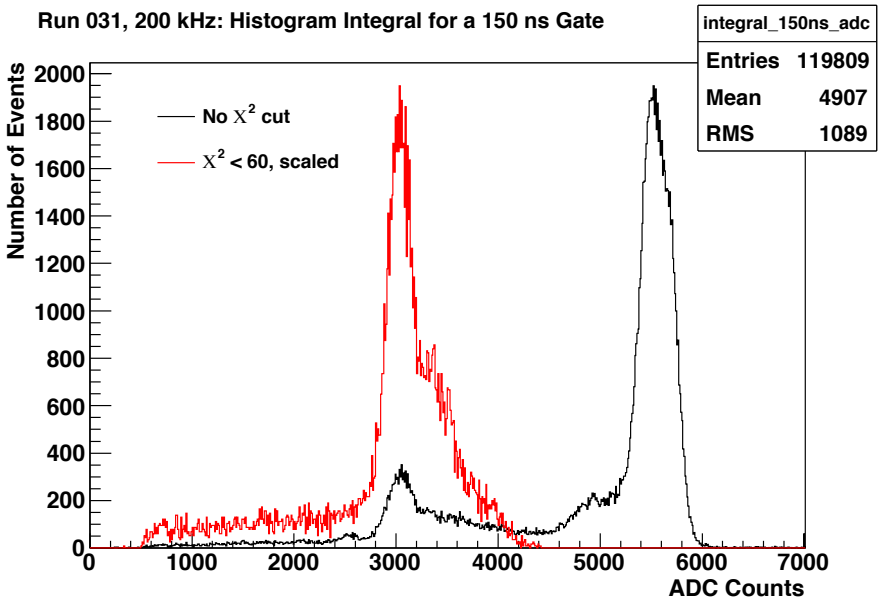


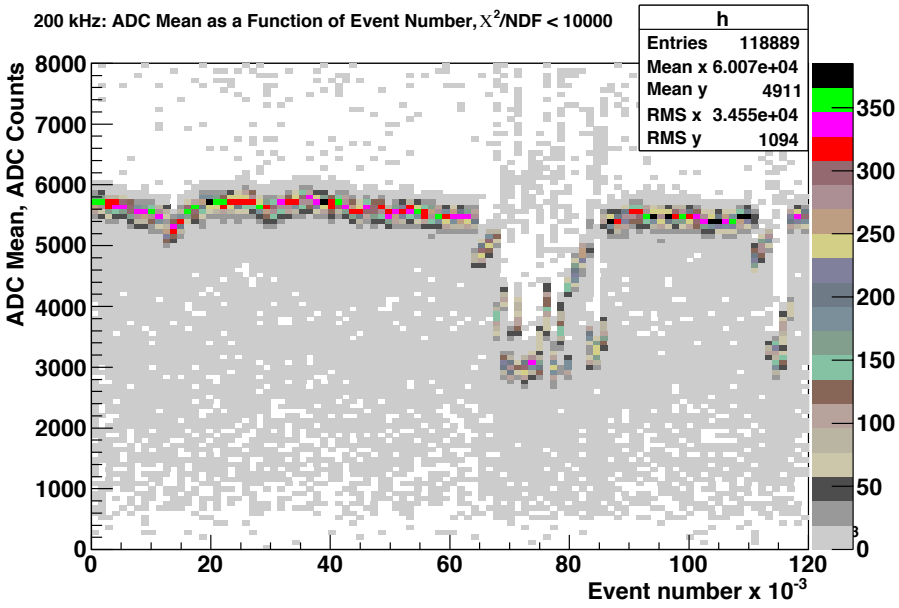


X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	156673	2914 ± 0.4	4.712 ± 0.029
< 10	149259	2916 ± 0.4	4.768 ± 0.029
ADC equivalent: run 028			
None		3046 ± 0.1	3.125 ± 0.008

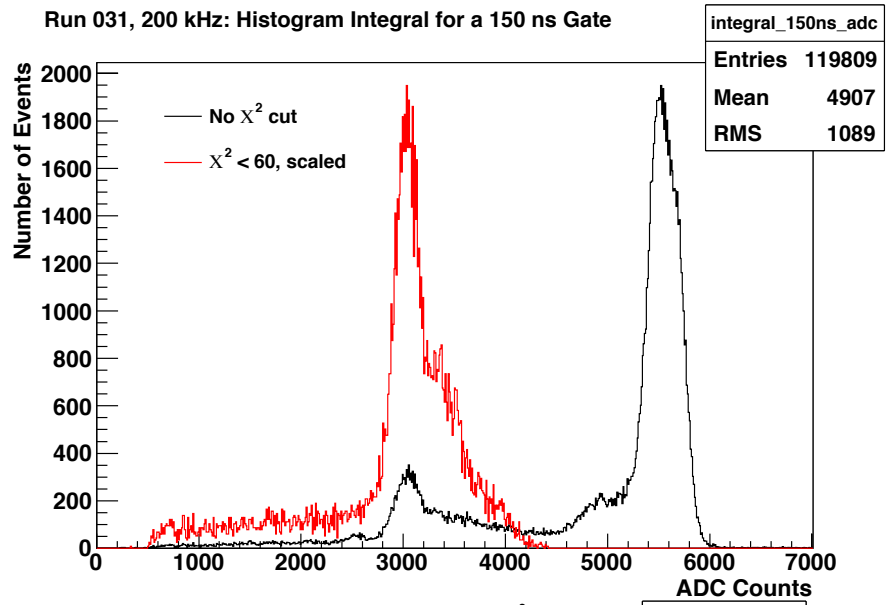
Run 031: Rate - 200 kHz, No Absorbers

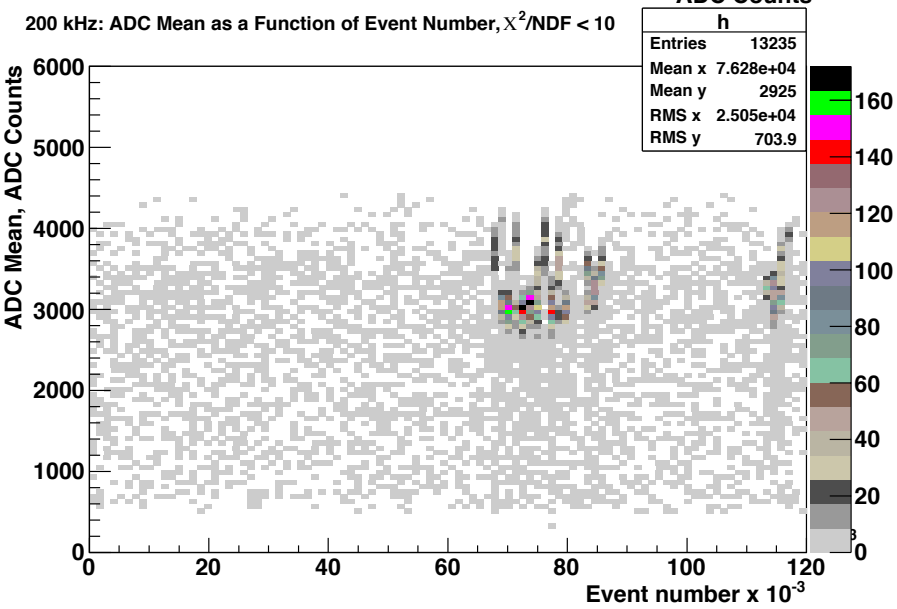






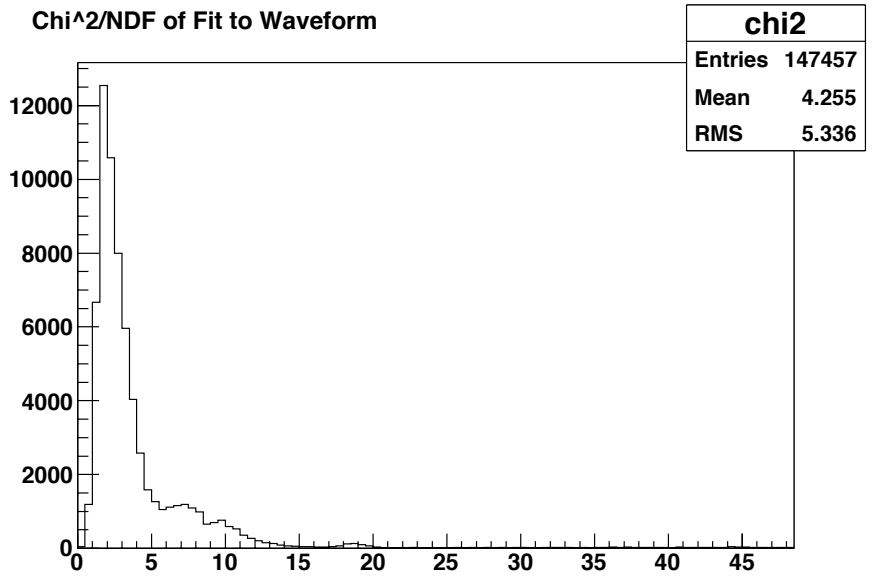
X²/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	119809	5599 ± 0.7	4.482 ± 0.032
< 10	13235	Unable to fit due to low statistics	
ADC equivalent: run 030			
None		5786 ± 0.1	2.815 ± 0.007

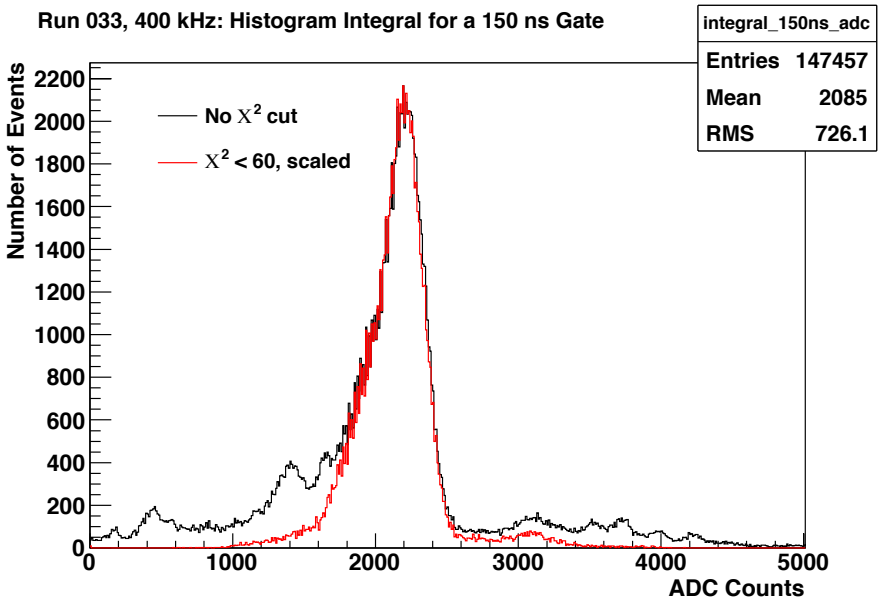


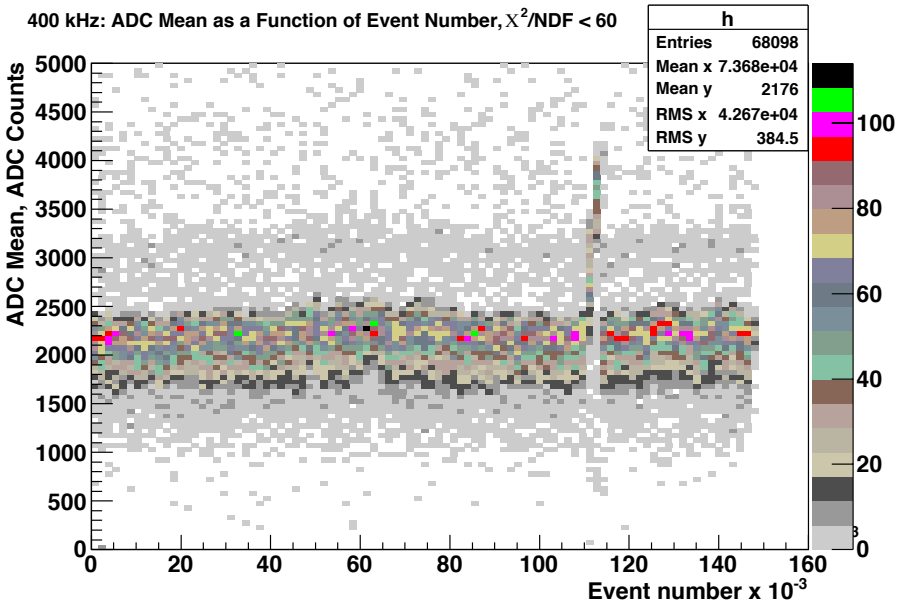


- For a proton beam rate of ~ 200 kHz the pulse height of the signal drastically increases, resulting in a higher mean of the ADC distribution
- Applying a cut of $X^2 < 10$ reduces the mean of the ADC distribution from ~ 5500 to ~ 3000, which is around half of the mean we see at rates < 200 kHz when using a splitter
- When looking at the ADC mean as a function of event number without applying a X^2 cut (Slide 16) some fluctuation is seen
- Looking at the ADC mean as a function of event number for $X^2 < 10$ (on this slide) shows that only events with an ADC mean of ~ 3000 are left
- Statistics are too low to fit the ADC spectrum with a $X^2 < 10$, but this is an interesting observation
- Similar observation in other 200 kHz runs, see earlier.

Run 033: Rate - 400 kHz, No Absorbers



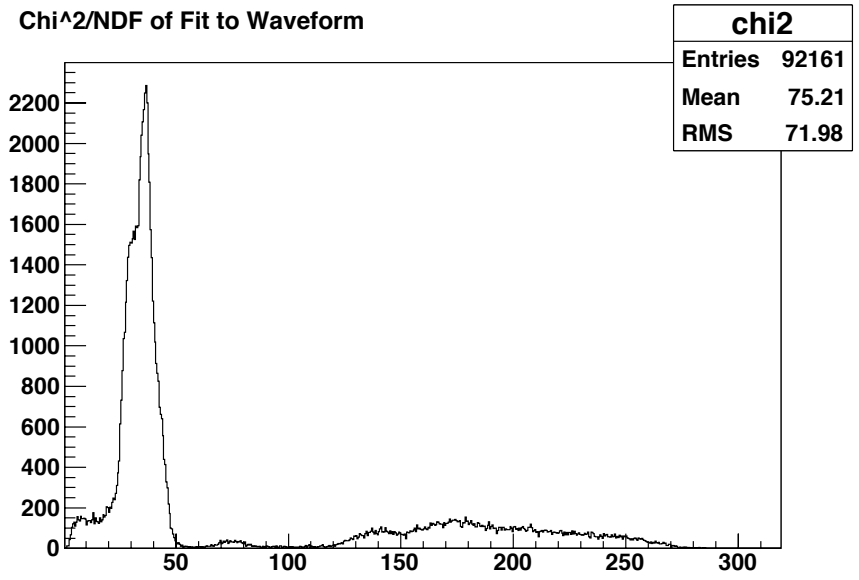


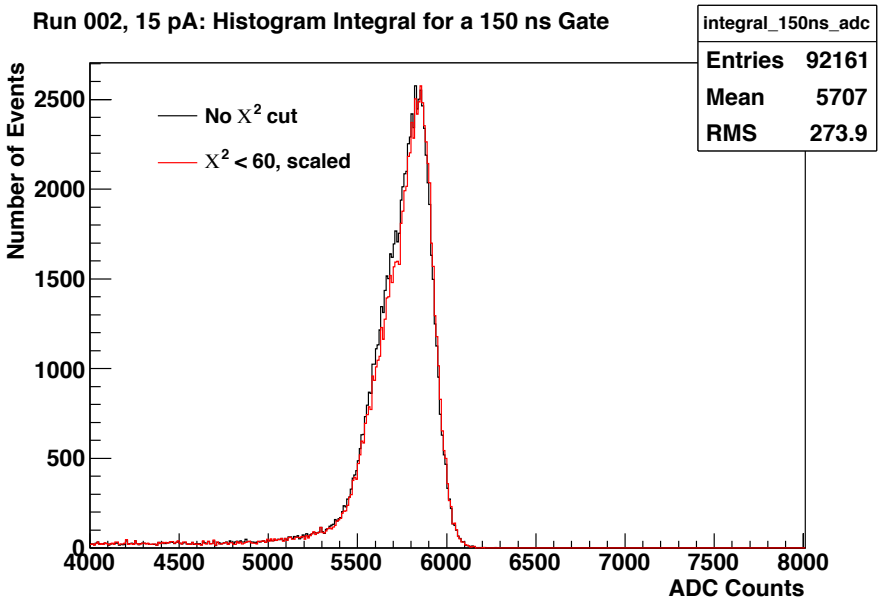


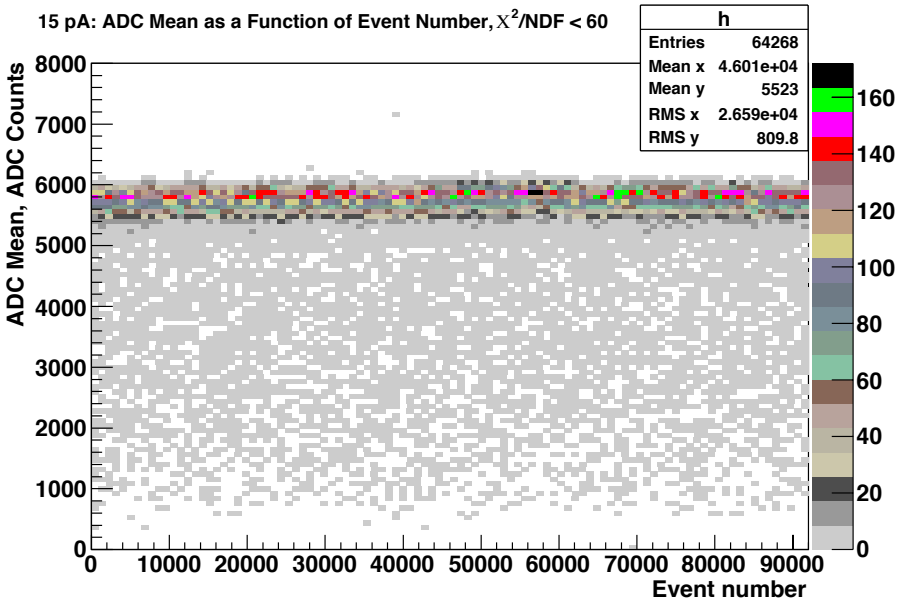
X²/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	147457	Unable to fit spectrum	
< 10	63152	2196 ± 1.2	14.064 ± 0.162
ADC equivalent: run 032 and 034			
None	Unable to fit spectrum due to shifting during running		

Friday 25th of November 2016:
Wheel Energy-Range Calibration Tests

Run 002: Rate - 50 kHz, Wheel Position 0/1.4 mm WE

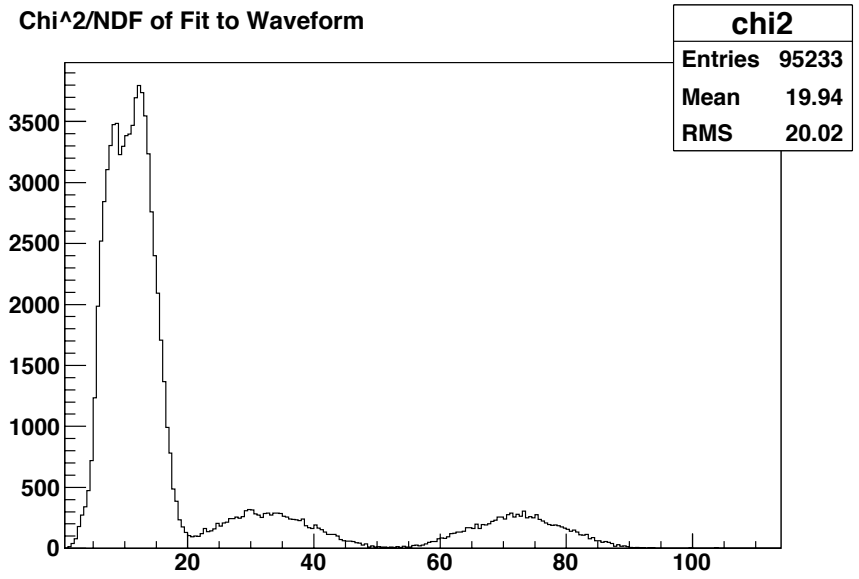


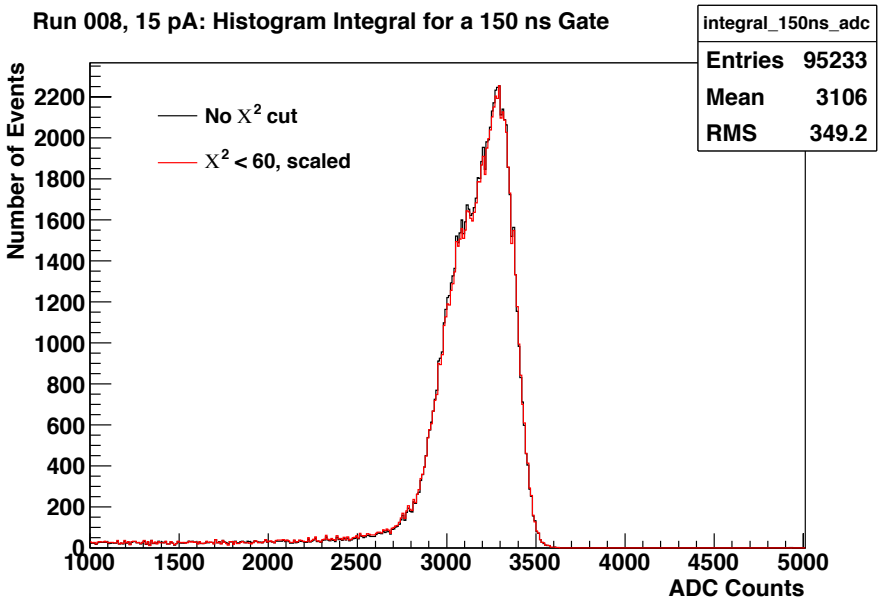


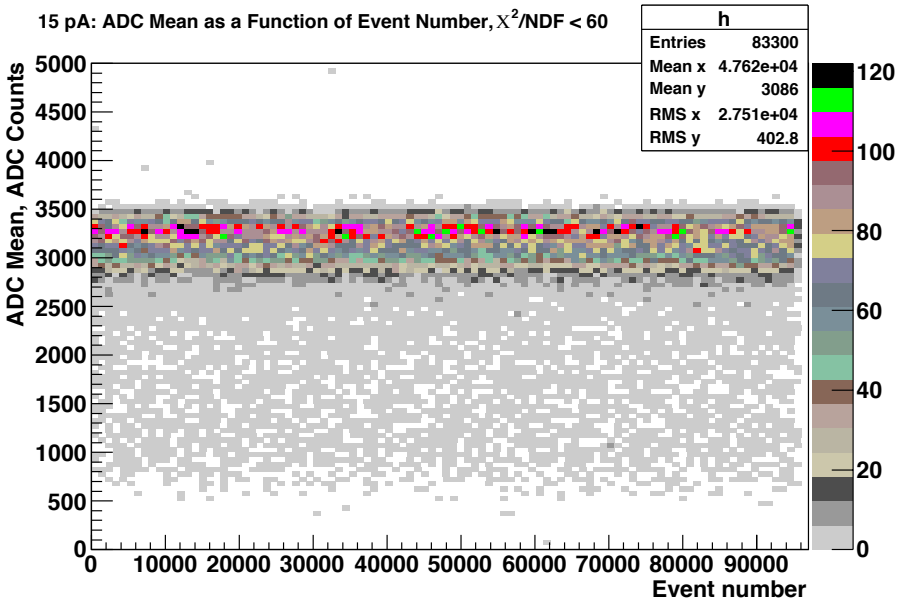


X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	92161	5818 ± 0.8	3.584 ± 0.032
< 60	64268	5830 ± 0.8	3,146 ± 0.041
ADC equivalent: run 001			
None		5672 ± 0.1	2.702 ± 0.007

Run 008: Rate - 50 kHz, Wheel Position 100/18.9 mm WE



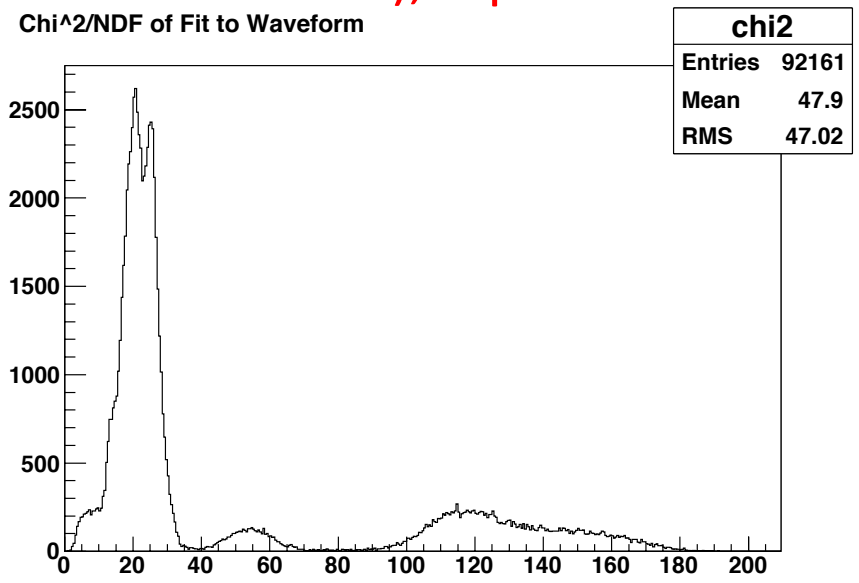


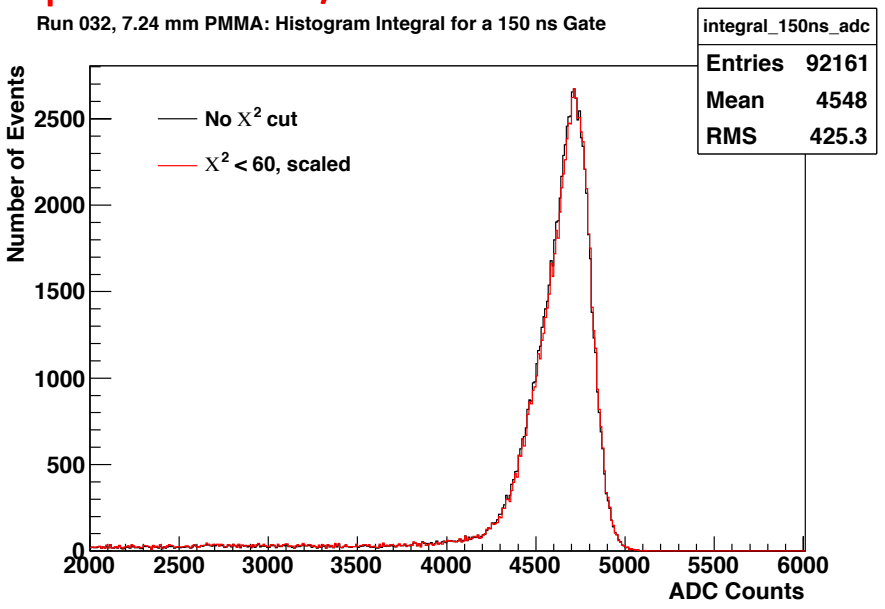


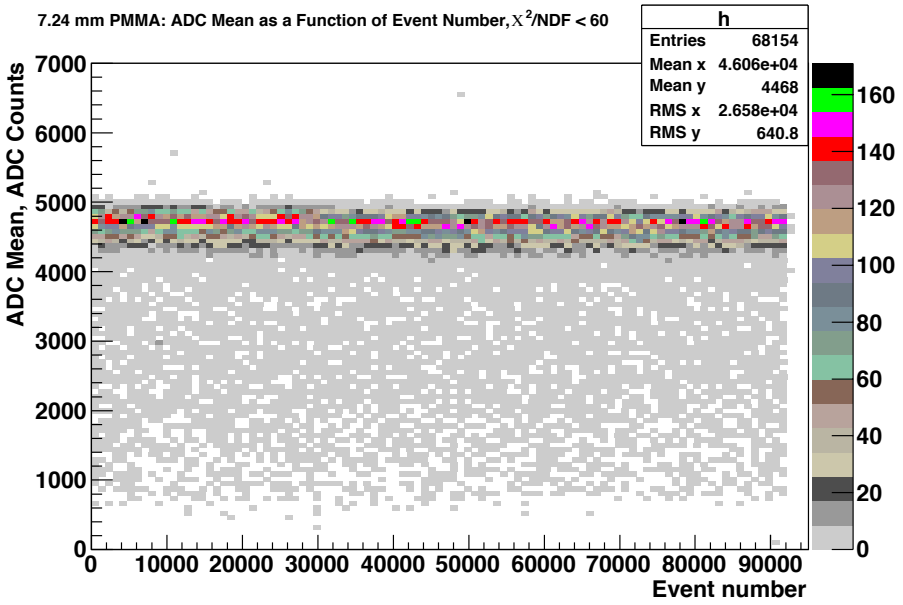
X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	95233	3234 ± 1.0	8.766 ± 0.059
< 60	83300	3235 ± 1.0	7.865 ± 0.014
ADC equivalent: run 007			
None		3139 ± 0.1	6.247 ± 0.012

Friday 25th of November 2016:
Wheel Equivalent PMMA Plates Tests

Run 032: Rate - 50 kHz, 7.2 mm PMMA Plate (placed in same position as wheel), equivalent to wheel position 40/8.4 mm WE

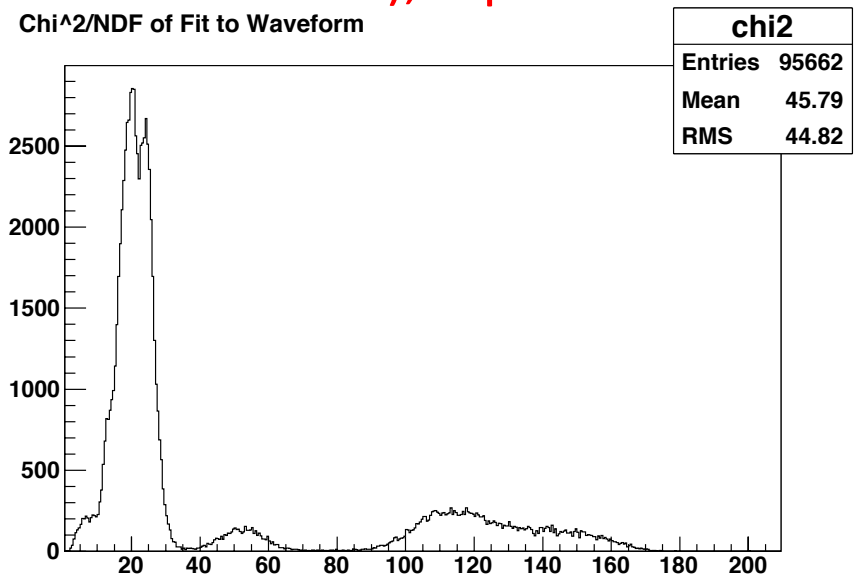


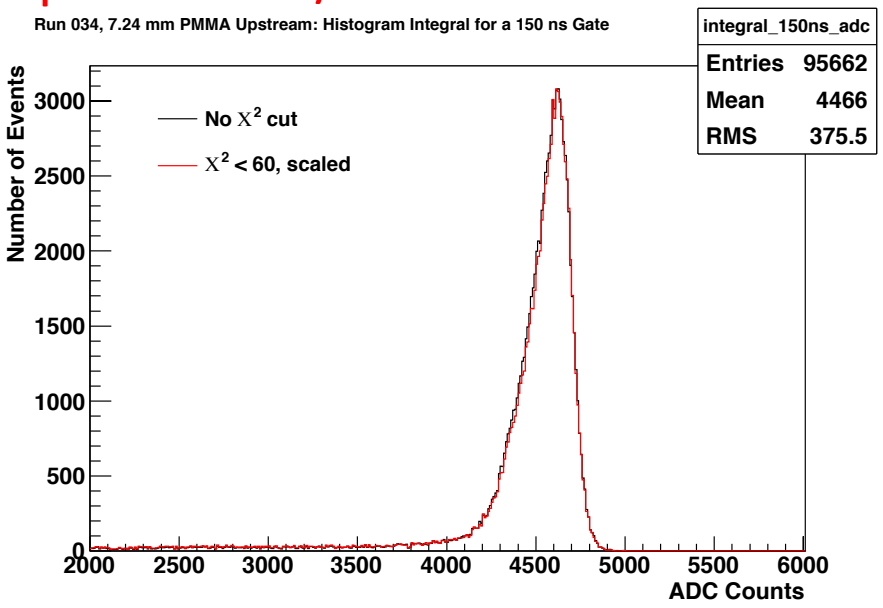


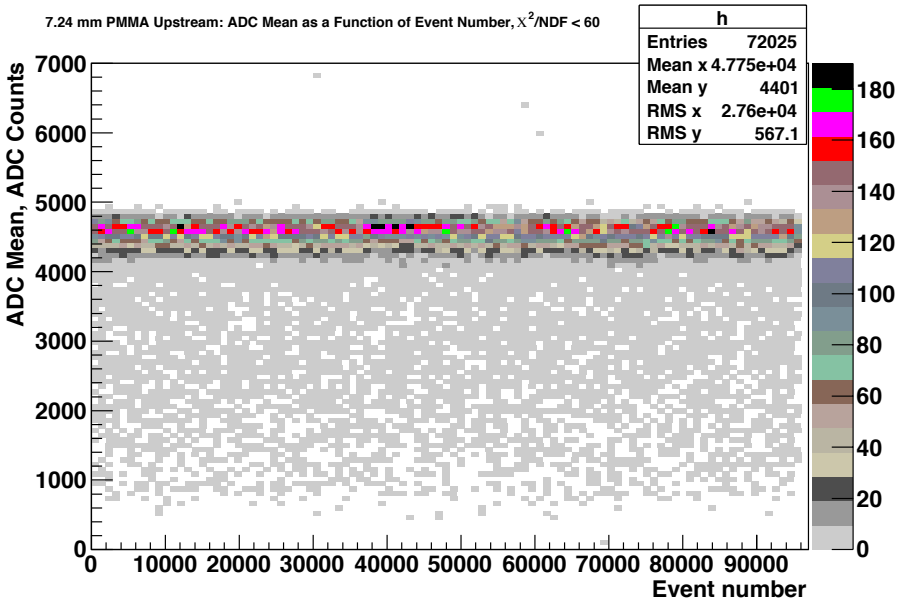


X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	92161	4714 ± 0.6	4.204 ± 0.035
< 60	68154	4718 ± 0.7	4.067 ± 0.042
ADC equivalent: run 031			
None		4609 ± 0.1	4.156 ± 0.008

Run 034: Rate - 50 kHz, 7.2 mm PMMA Plate (placed upstream of the beam), equivalent to wheel position 40/8.4 mm WE

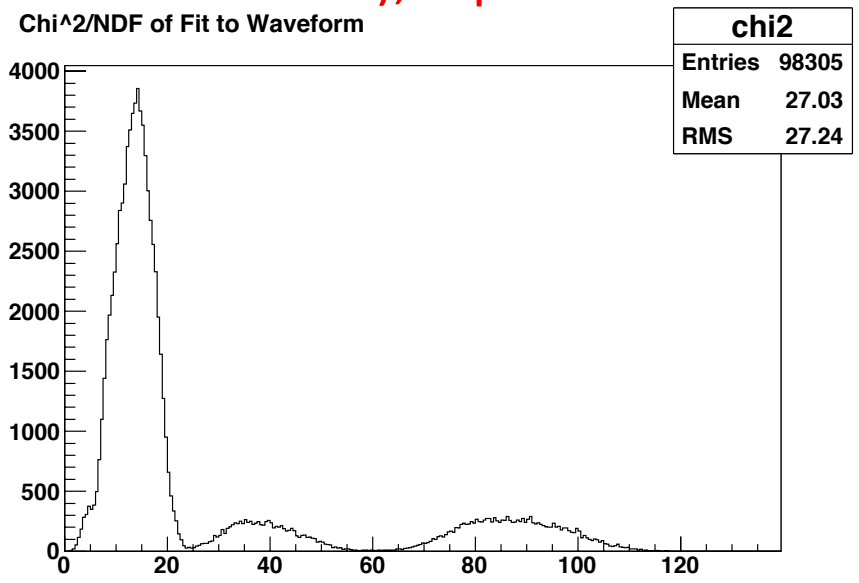


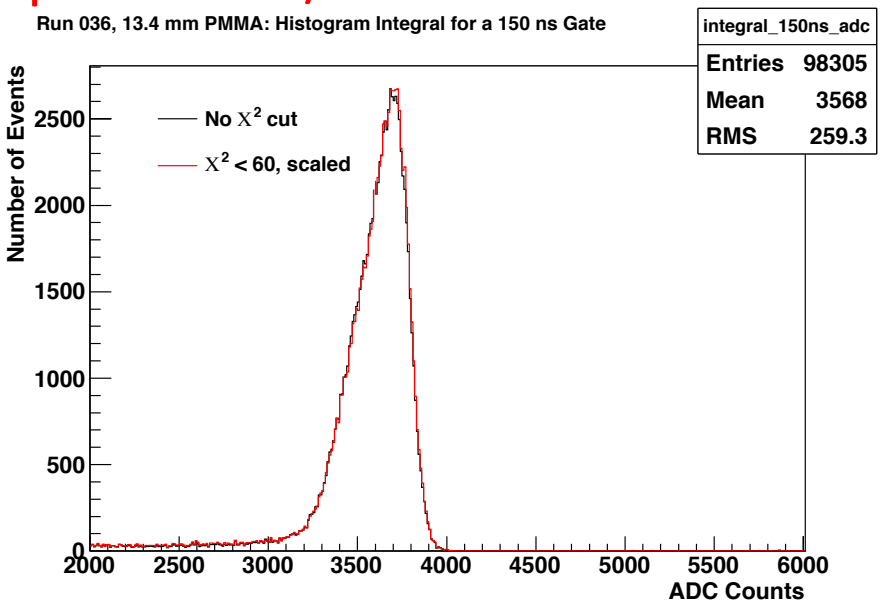


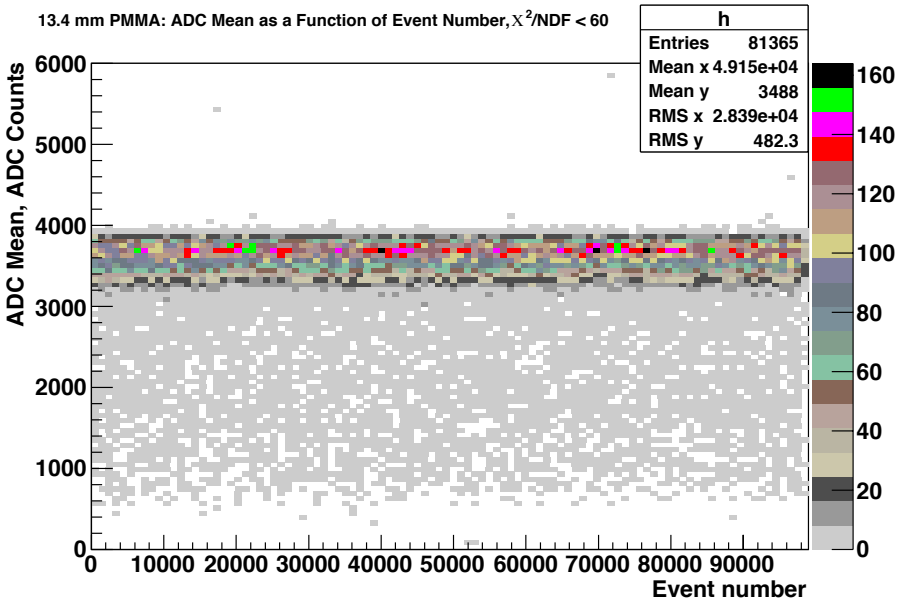


X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	95662	4614 ± 0.5	3.442 ± 0.035
< 60	72025	4617 ± 0.5	3.341 ± 0.038
ADC equivalent: run 033			
None		4495 ± 0.1	3.478 ± 0.009

Run 036: Rate - 50 kHz, 13.4 mm PMMA Plate (placed in same position as wheel), equivalent to wheel position 80/15.4 mm WE

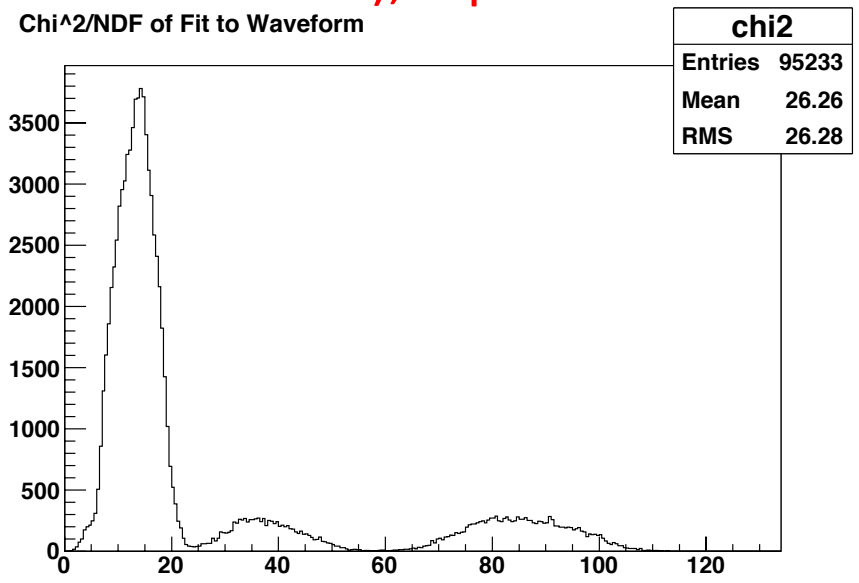


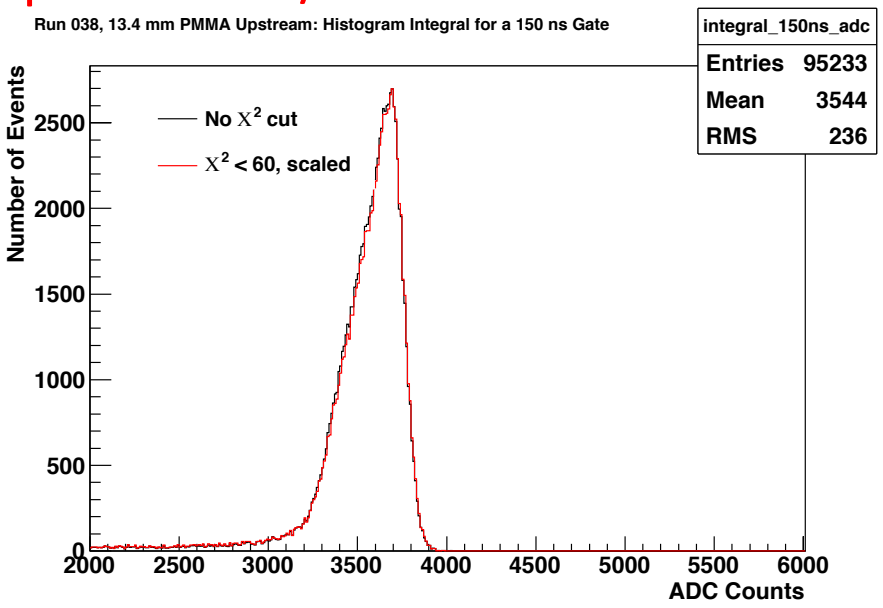


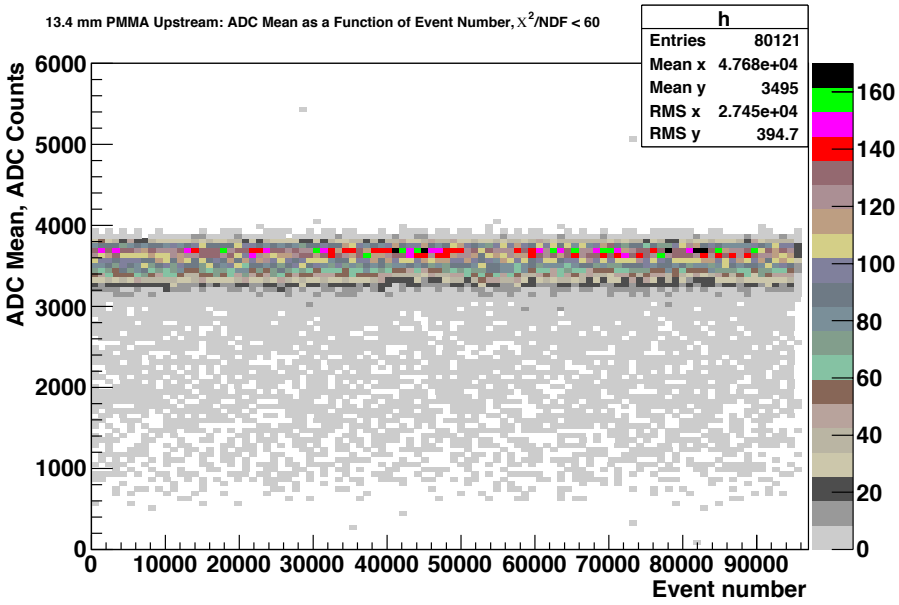


X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	98305	3679 ± 0.7	5.451 ± 0.045
< 60	81365	3684 ± 0.7	4.997 ± 0.057
ADC equivalent: run 035			
None		3570 ± 0.1	5.258 ± 0.010

Run 038: Rate - 50 kHz, 13.4 mm PMMA Plate (placed upstream of the beam), equivalent to wheel position 80/15.4 mm WE







X^2/NDF cut	Number of events	ADC mean, ADC counts	ΔE/E FWHM, %
None	95233	3653 ± 0.6	4.376 ± 0.059
< 60	80121	3657 ± 0.5	4.087 ± 0.055
ADC equivalent: run 037			
None		3539 ± 0.1	4.930 ± 0.011

Conclusions

- Although to somewhat a lesser extent we still see the “beam shifting” problem when running at higher rates

- In order to investigate this:

  - Use the detector emulator to test the detector at various rates in a controlled environment
  - Whilst getting to know the emulator we could pulse an LED at different rates and see whether we see any effects from this