

Photodetector Timing Resolution

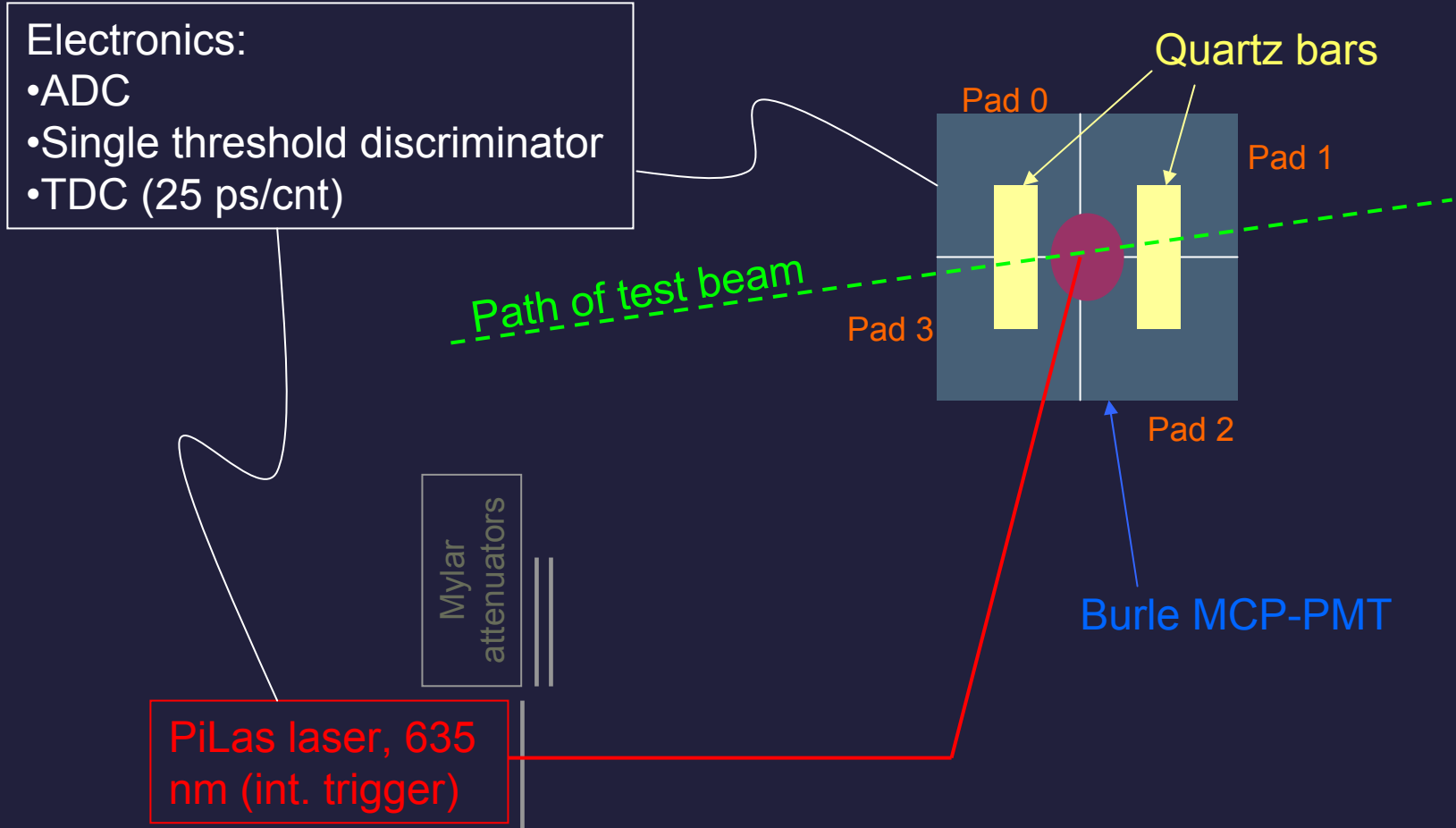
Burle Micro-Channel Plate Photo
Multiplier Tubes (MCP-PMTs)

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SLAC Group B
Winter 2005

Photo Multiplier Tube Specifications

	DIRC PMT	2x2 MCP-PMT
Pixel Size	~2.8 cm	~24 mm
Timing resolution (σ)	1.6 ns [single photo-electrons]	<ul style="list-style-type: none">•80-100 ps [single photoelectrons]•30-50 ps [test beam: ~60 photoelectrons]

End Station A Setup



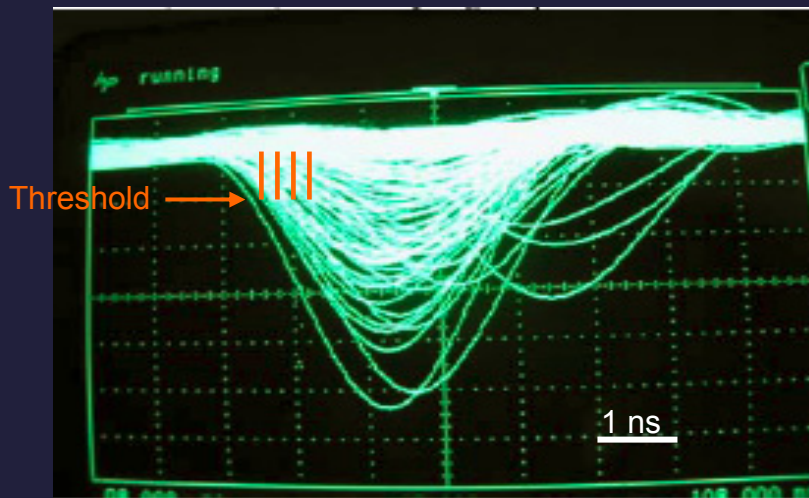
Limits to MCP Timing Resolution

- Cross-talk between channels
- Charge-sharing between pads
- Electronics noise
- Avalanche fluctuations [focus of this analysis]

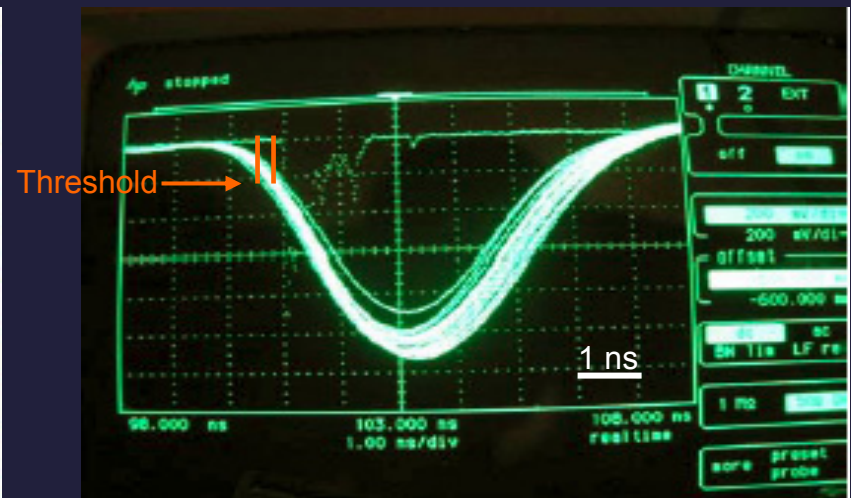
Timing resolution varies with ADC

- TDC measures hit time when pulse exceeds level set by single threshold discriminator.
- Size of pulse (# photoelectrons) affects the measured hit time.
- More photoelectrons reduce the variability of measured hit time (avalanche fluctuations have a smaller effect).

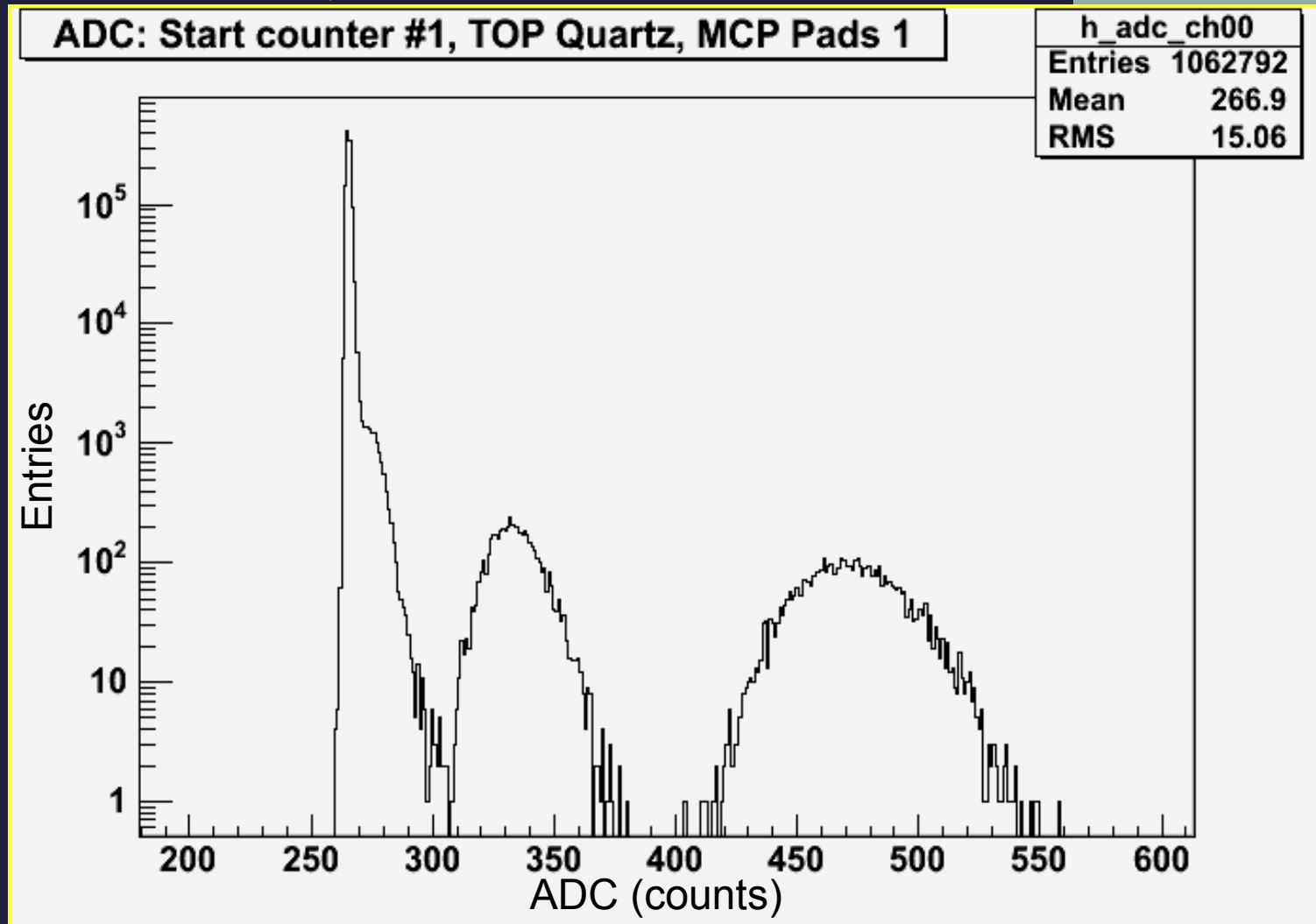
Single photoelectron pulses (2 mV/div)



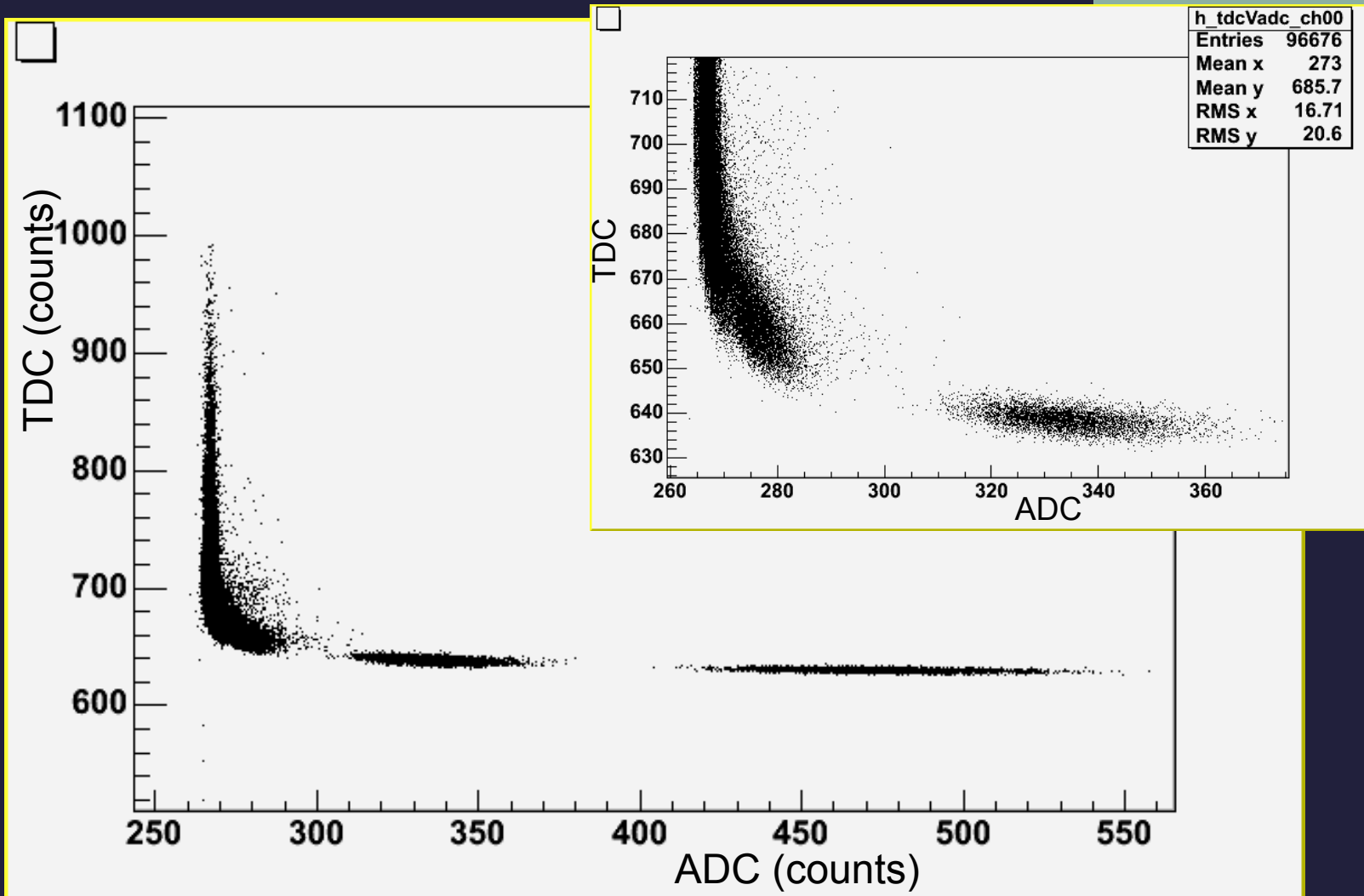
~300 photoelectrons / pulse (200 mV/div)



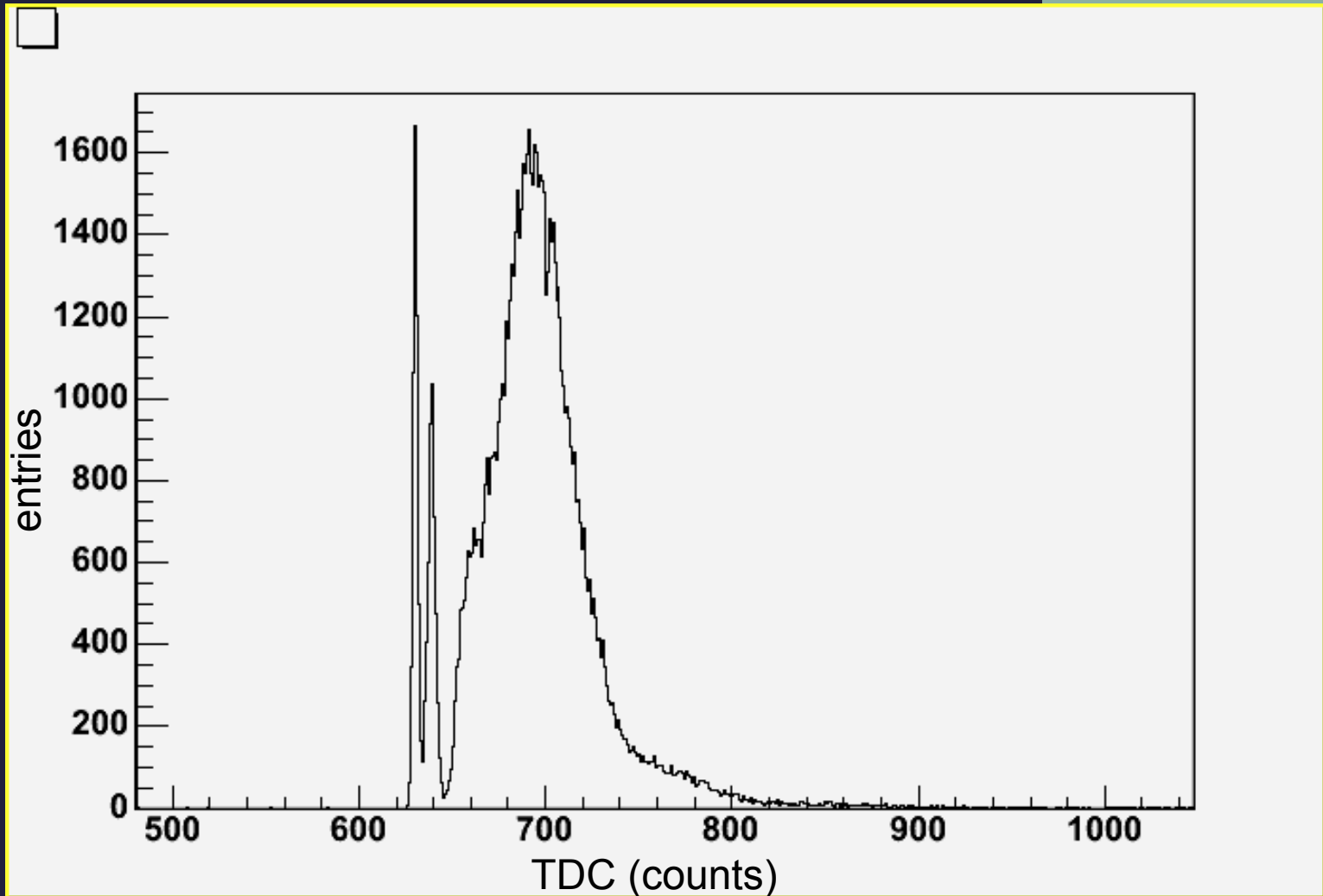
ADC Distribution of Runs 1-8, taken 11-22-04, 11-24-04



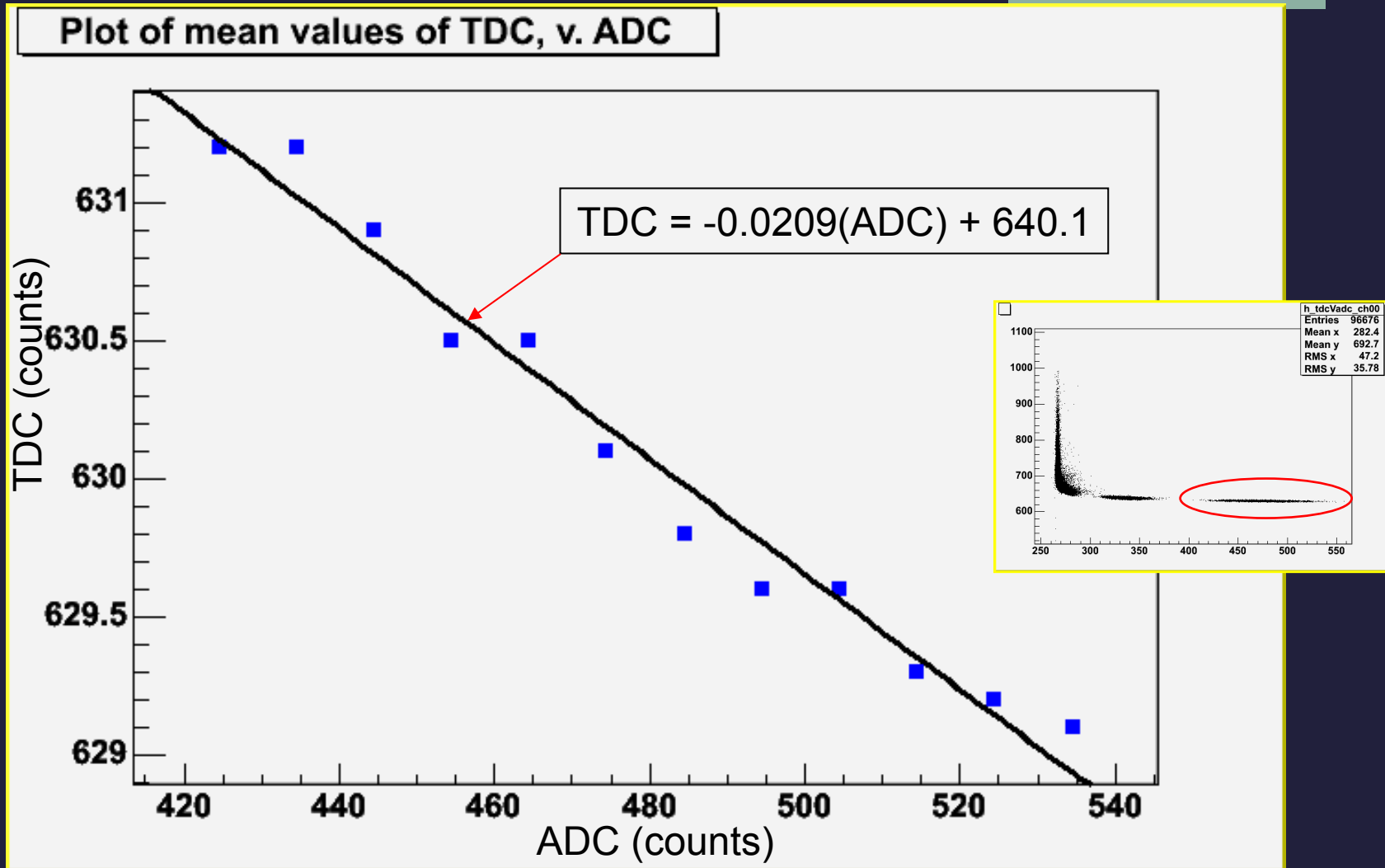
TDC v. ADC, Runs 1-8



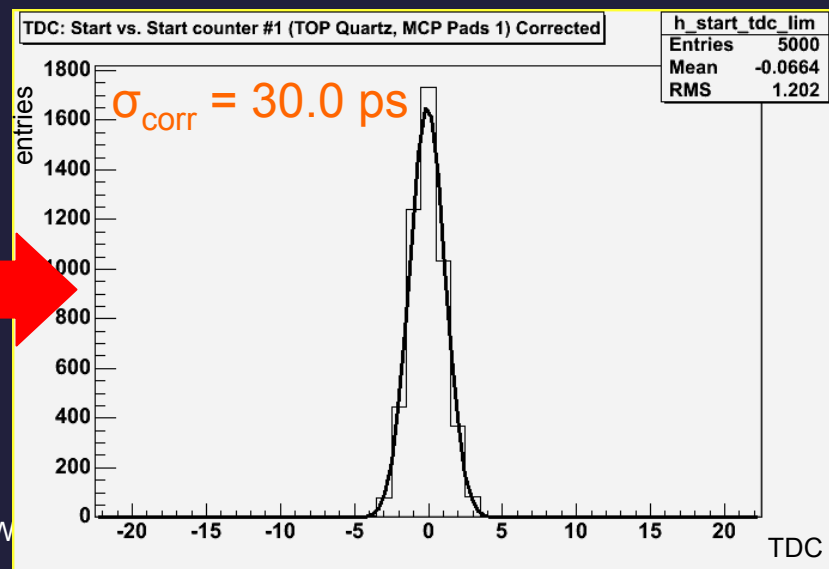
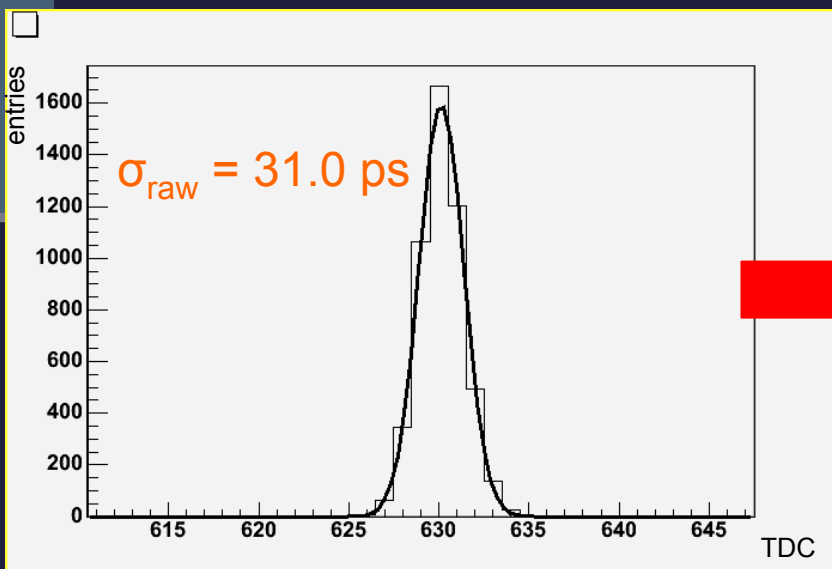
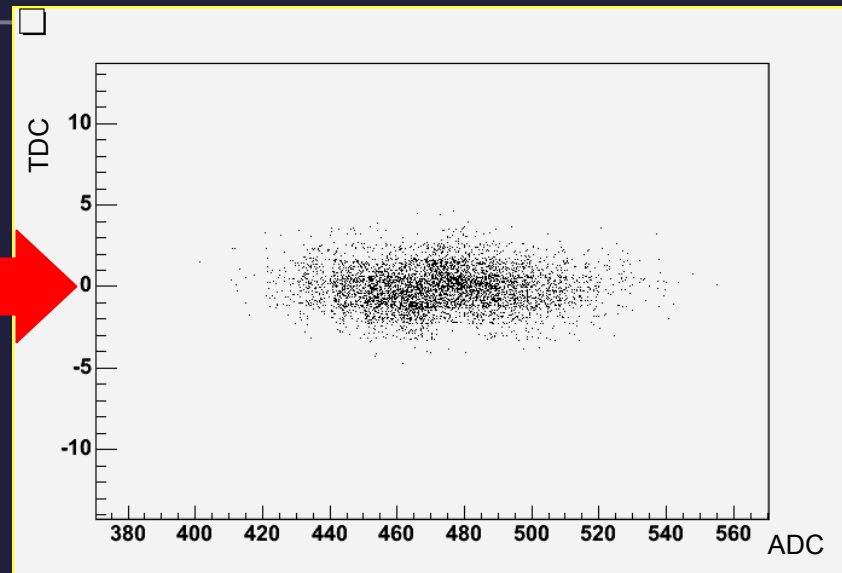
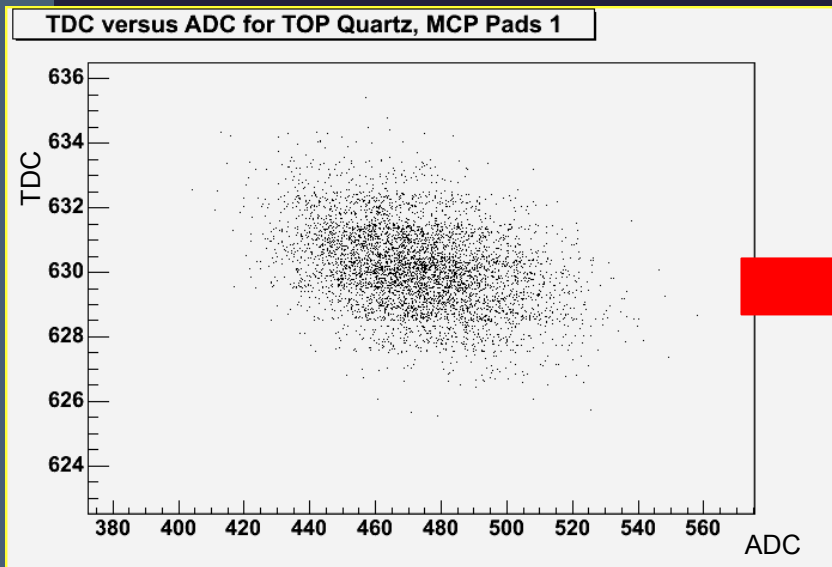
TDC Histogram, Runs 1-8



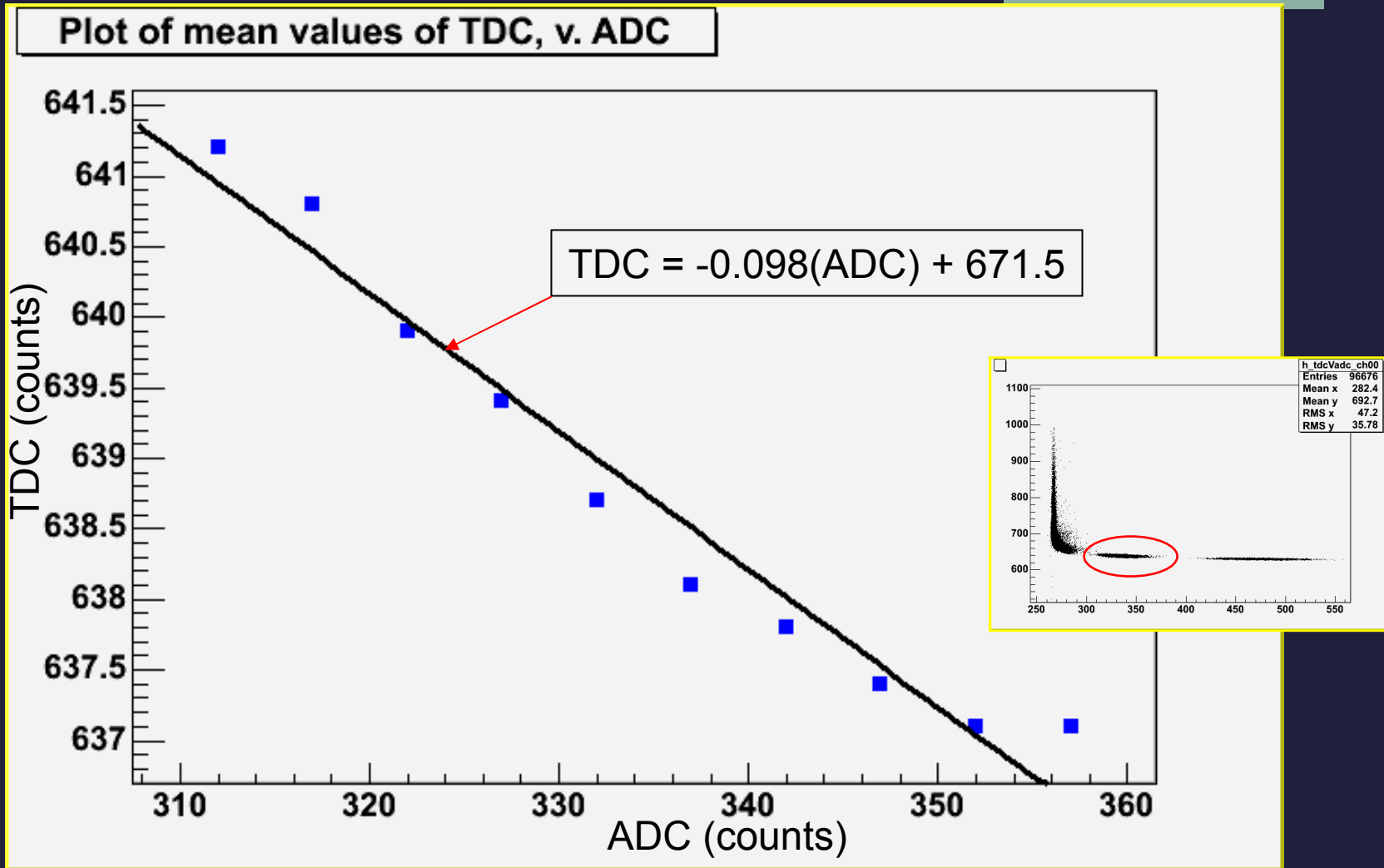
Linear fit to Run 8



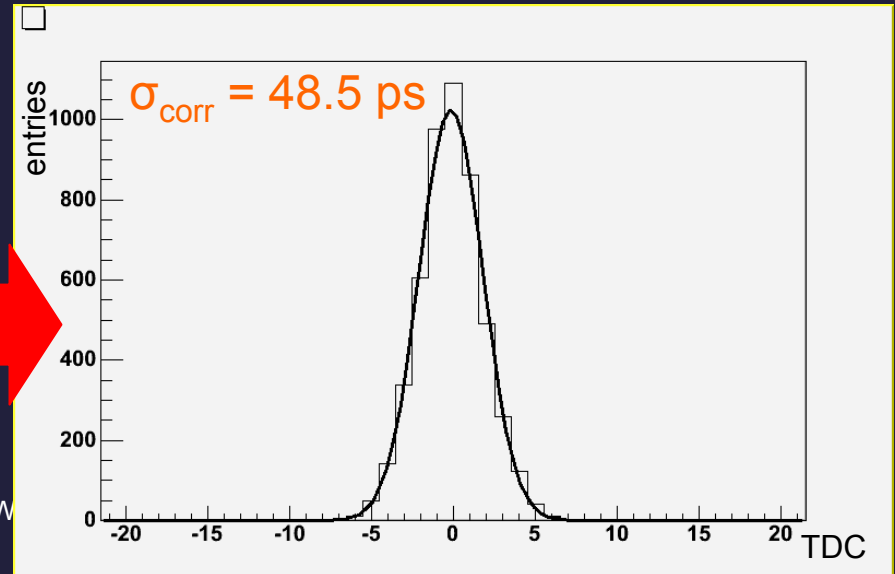
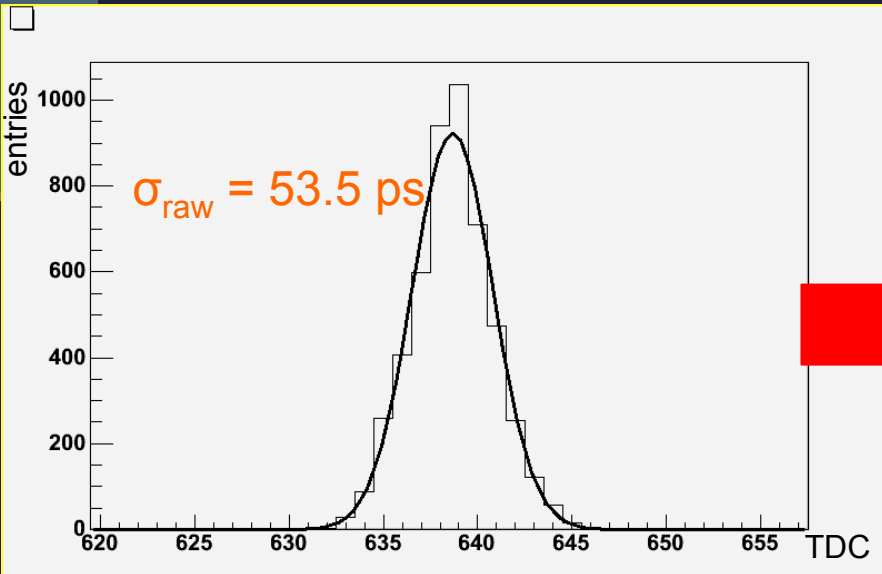
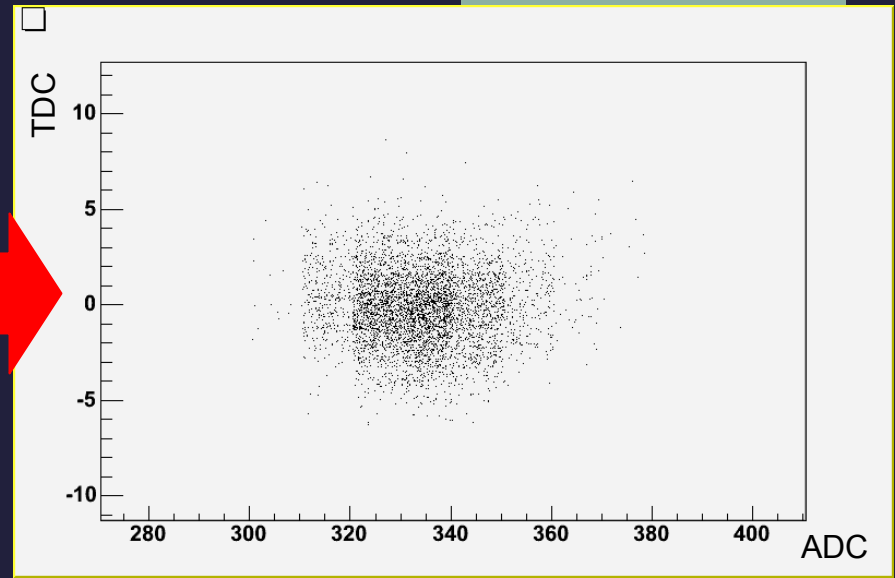
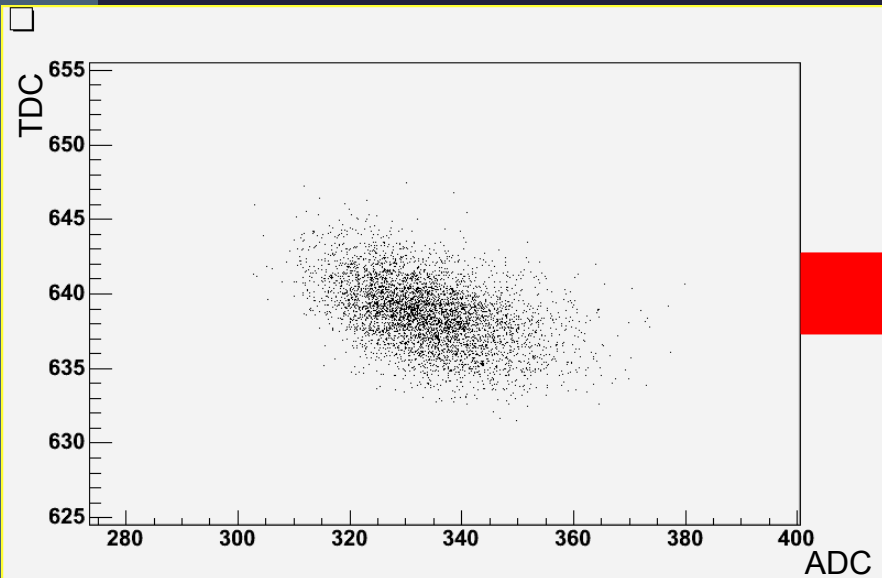
Linear correction to Run 8



Linear fit to Run 7

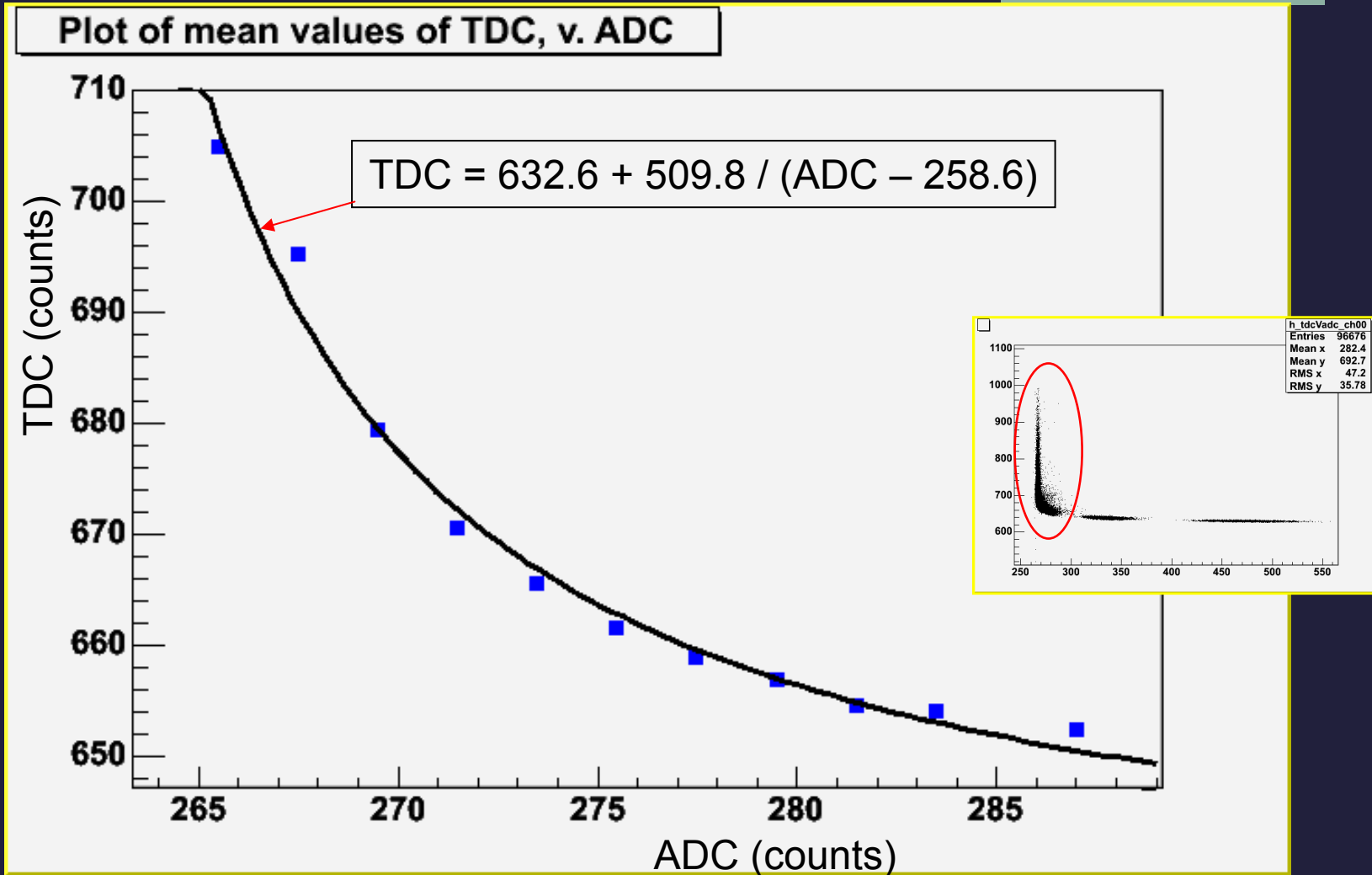


Linear correction to Run 7

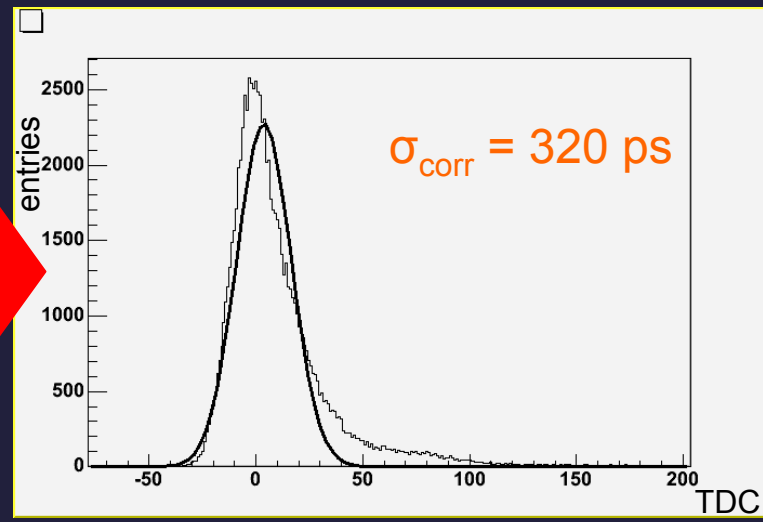
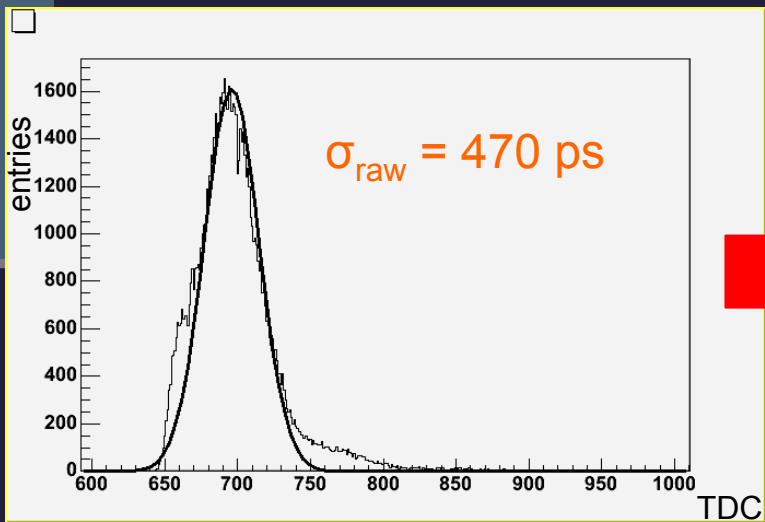
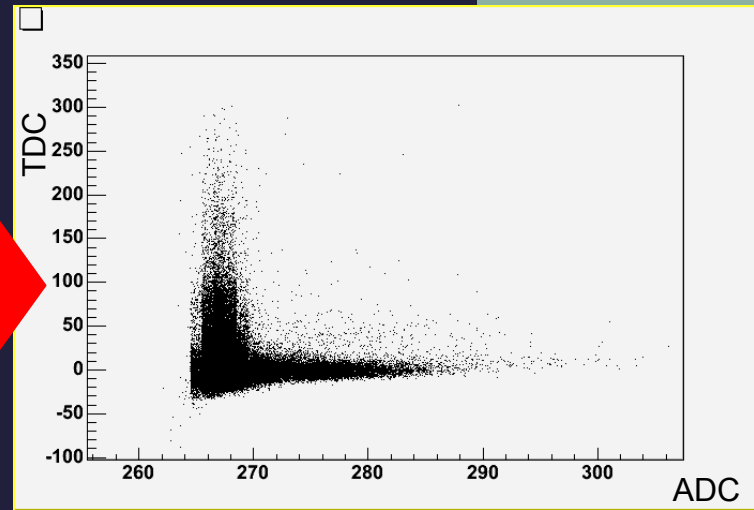
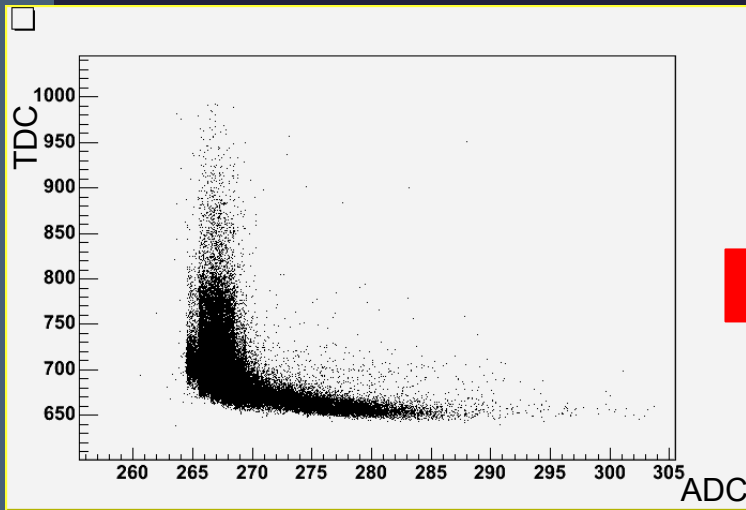


H.W

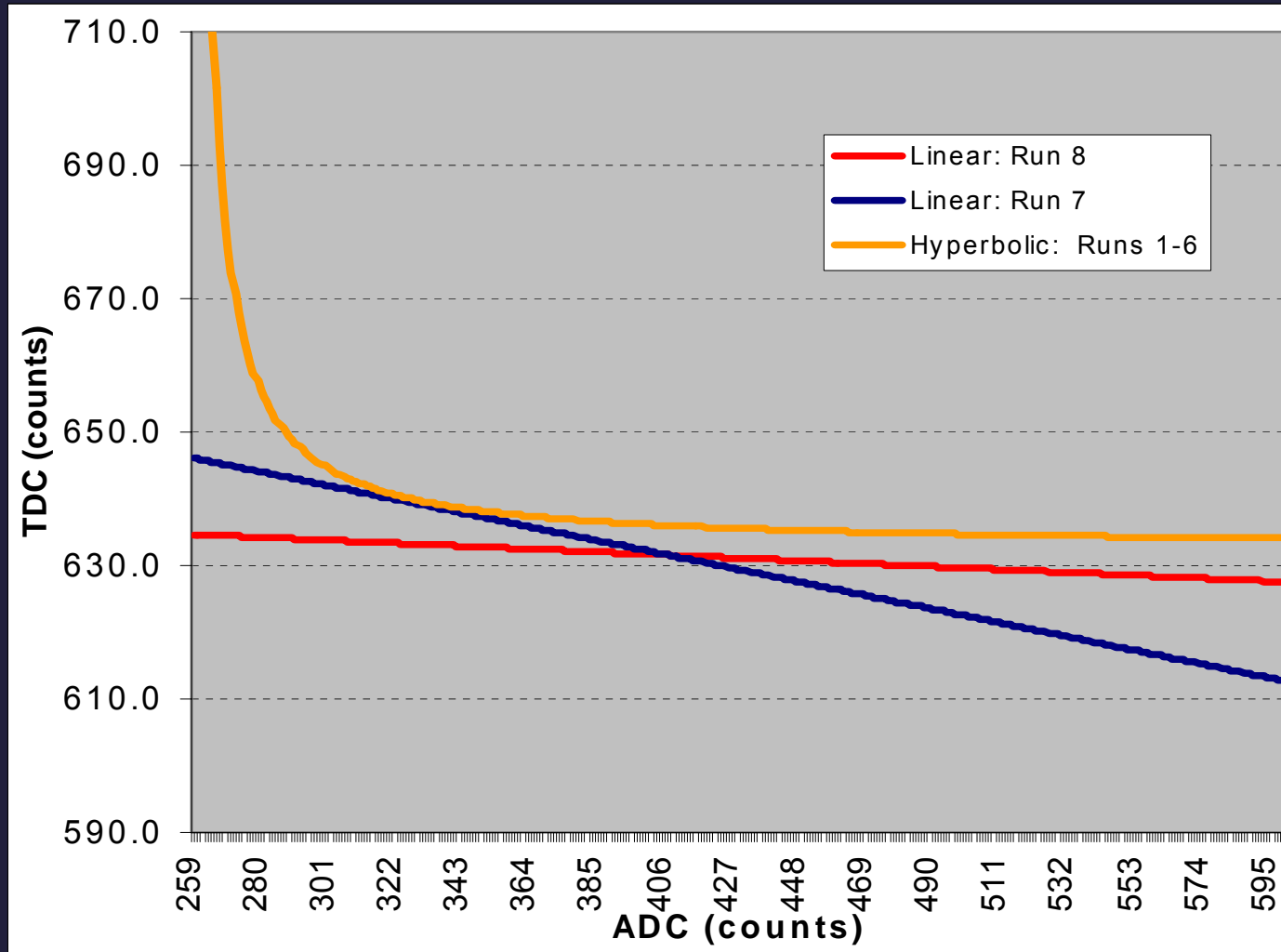
Hyperbolic fit to Runs 1-6



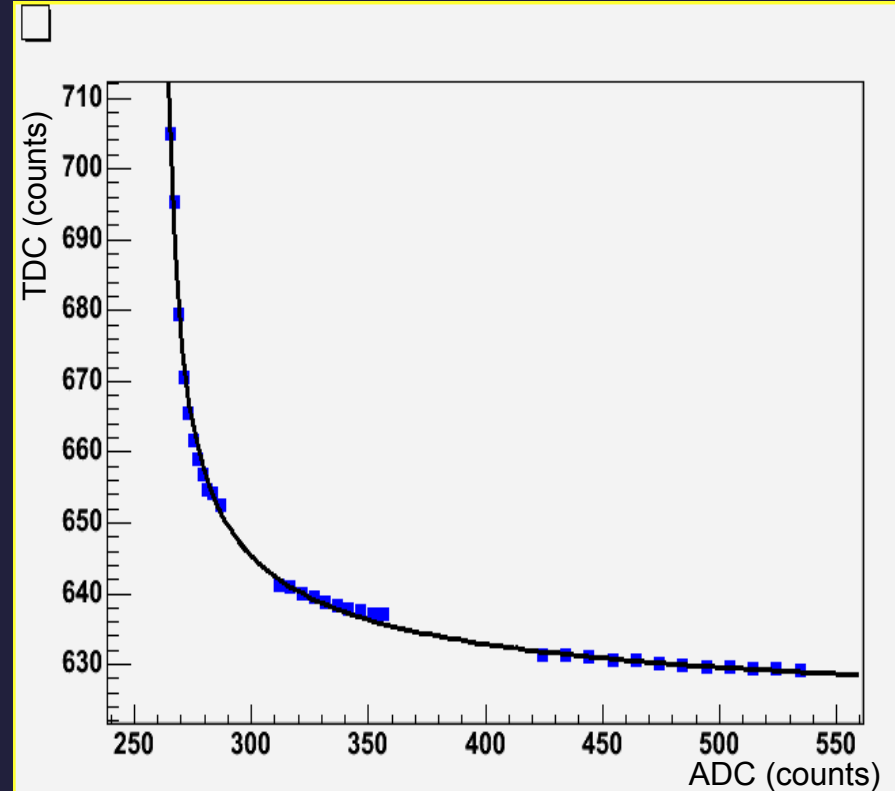
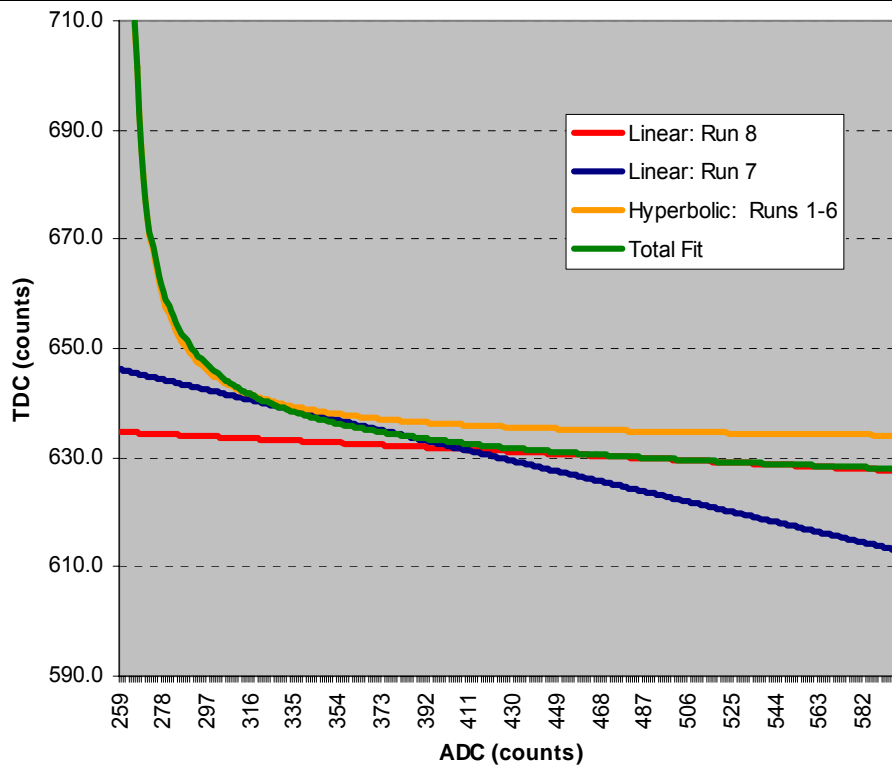
Hyperbolic correction to Runs 1-6



Independent fits to three data sets



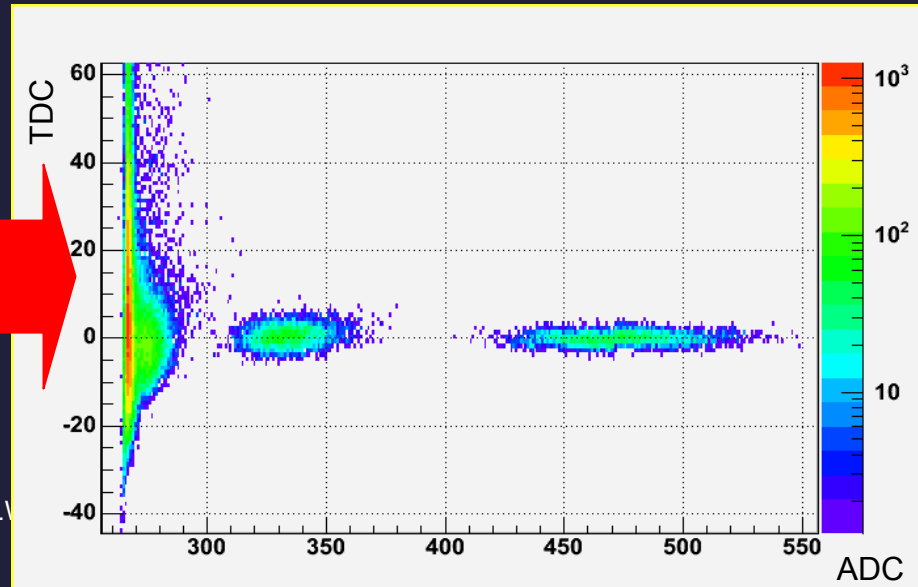
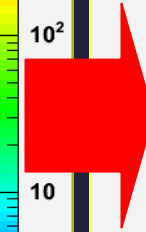
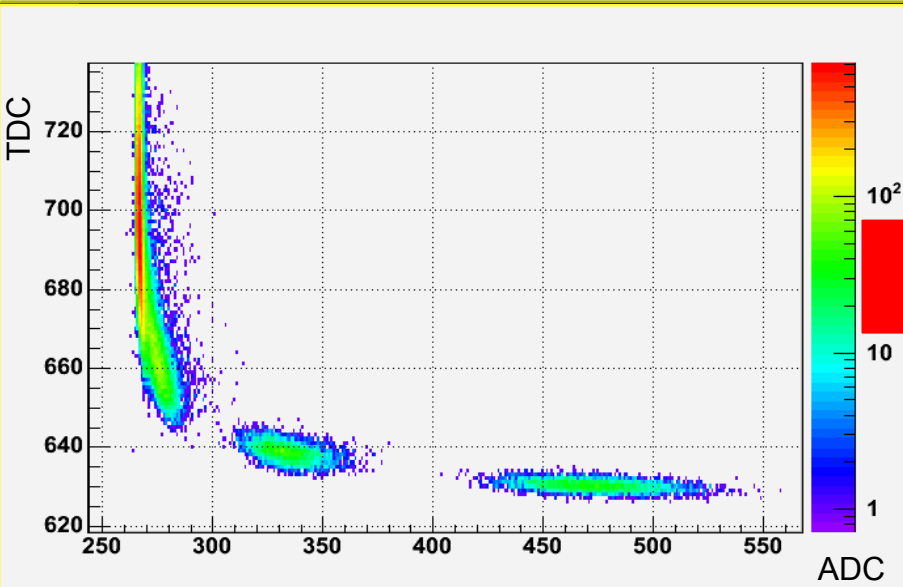
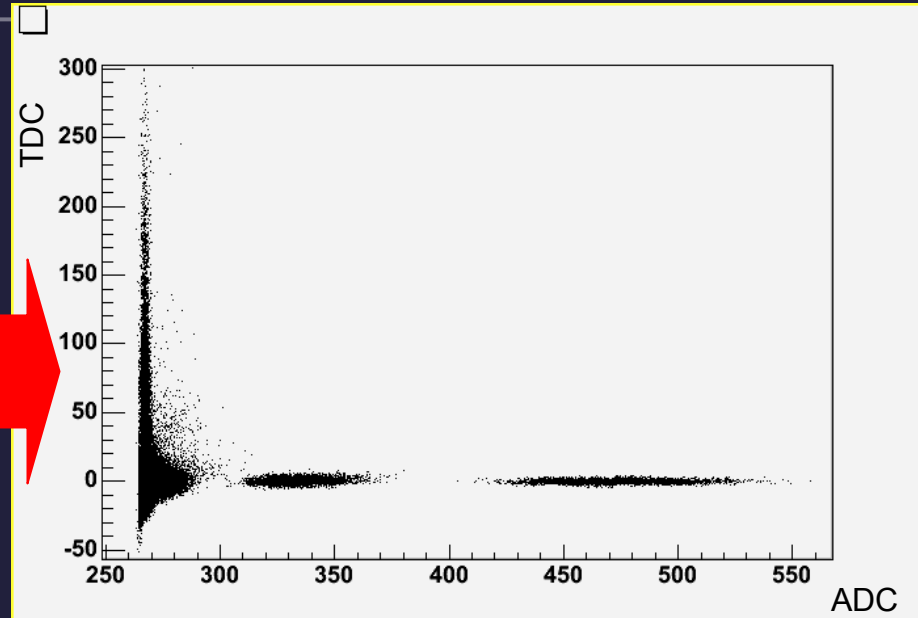
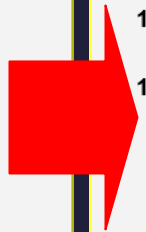
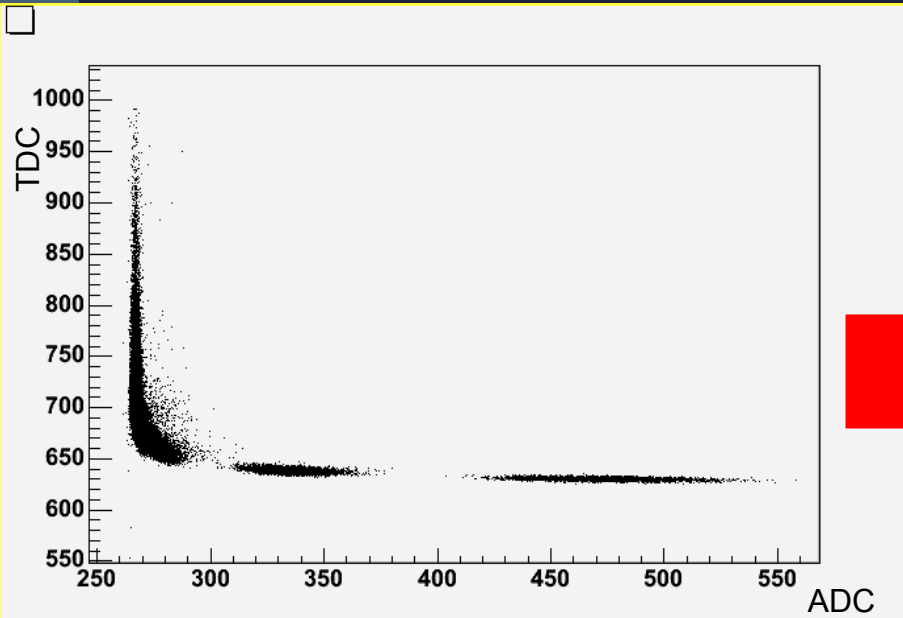
Optimized total fit



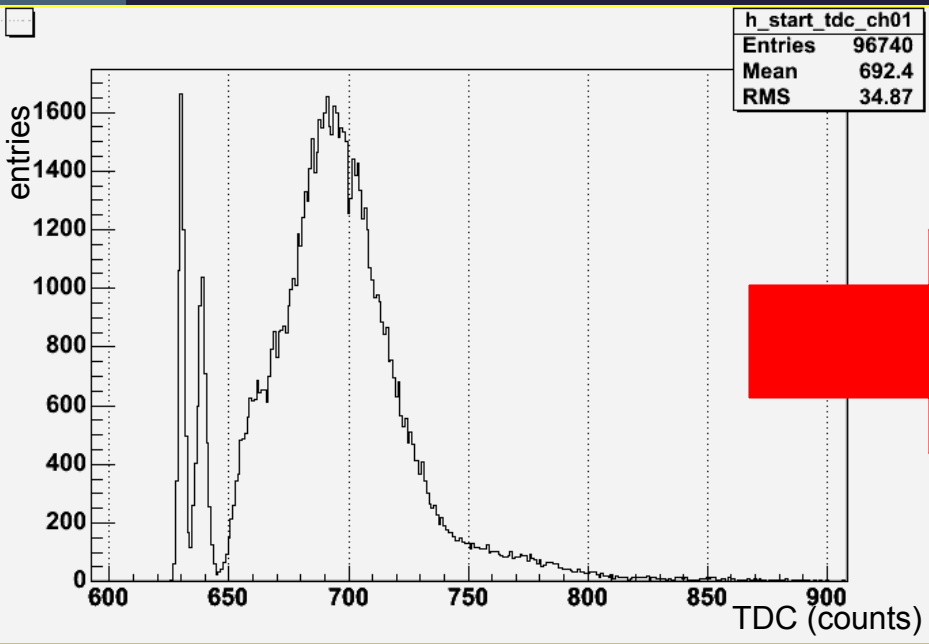
By Hand:
 $TDC = 619 + 165/\sqrt{(ADC - 262)}$

By Recursion:
 $TDC = 619.2 + 160.7/\sqrt{(ADC - 262.2)}$

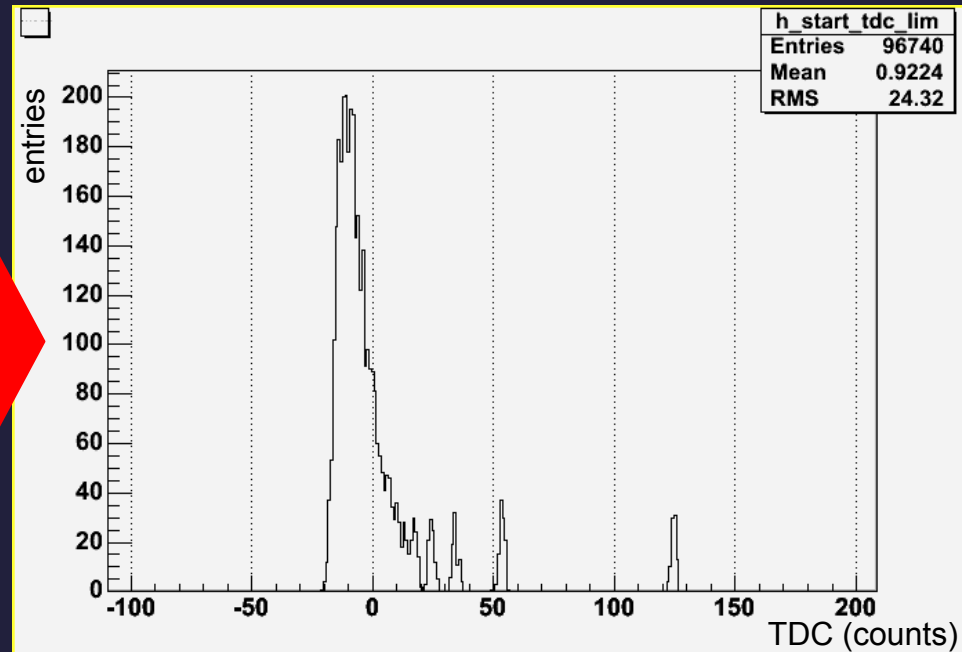
Total correction for Runs 1-8



Timing Resolution Correction: All Runs

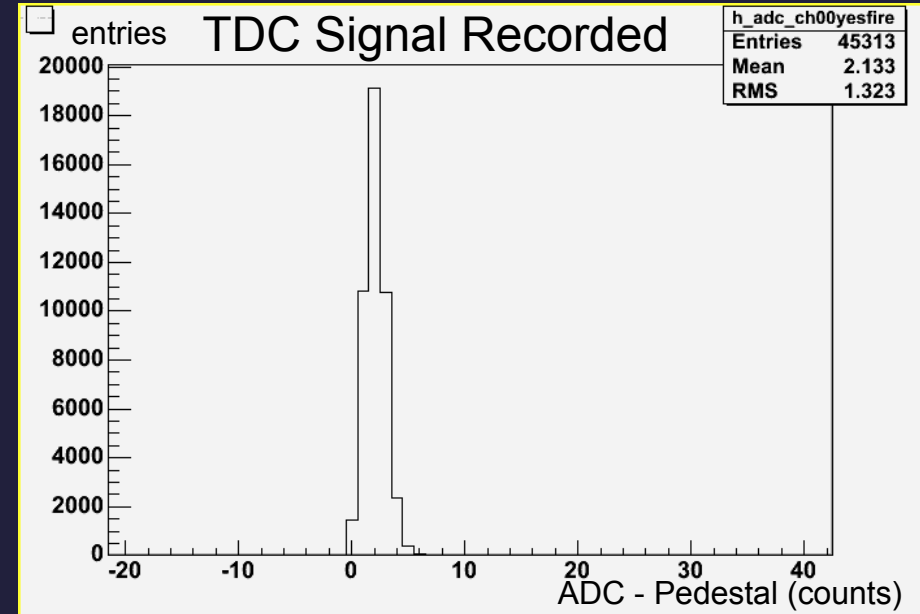
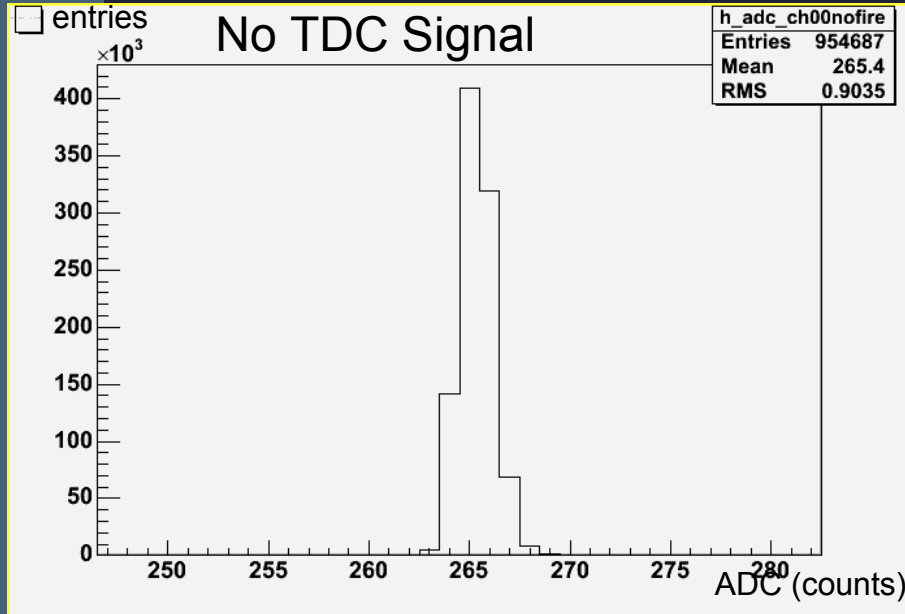


FWHM ~ 50 counts ADC



FWHM ~ 15 counts ADC

Use Run 1 (maximum attenuation): ADC counts \rightarrow photoelectrons

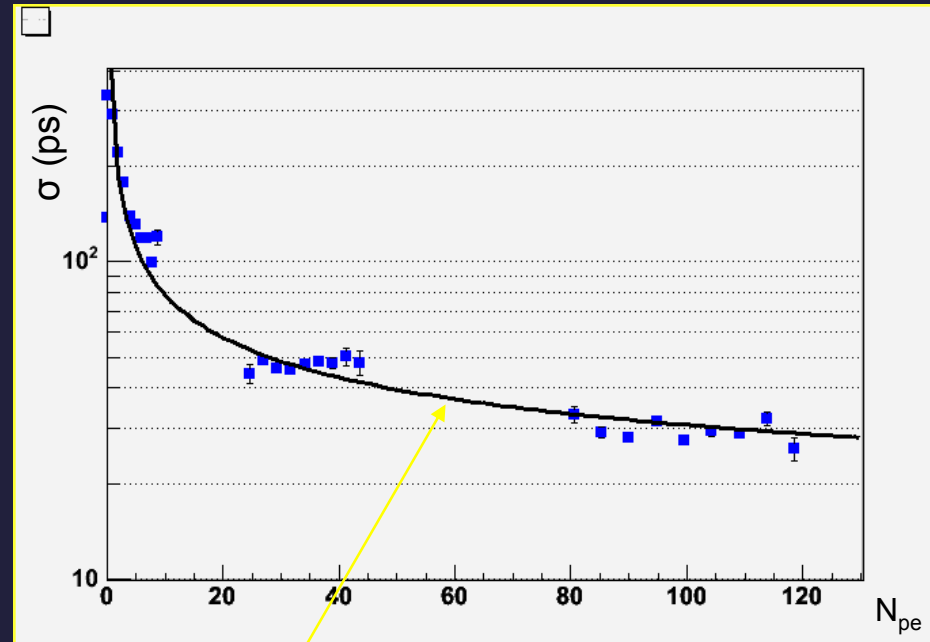
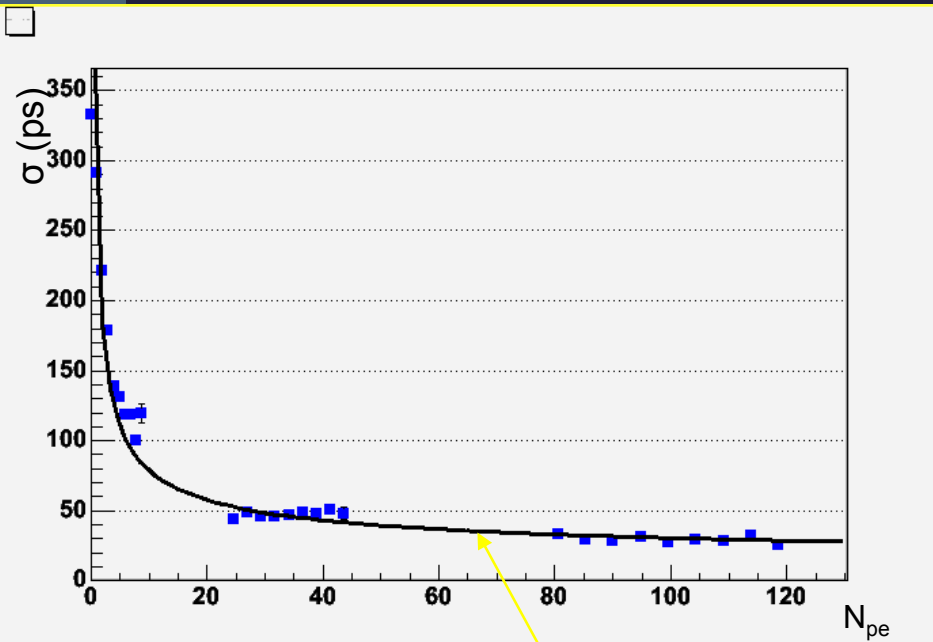


Pedestal value: 265.4 counts ADC

Single photoelectron mean ADC: 2.1 counts

1 photoelectron = 2.1 counts ADC

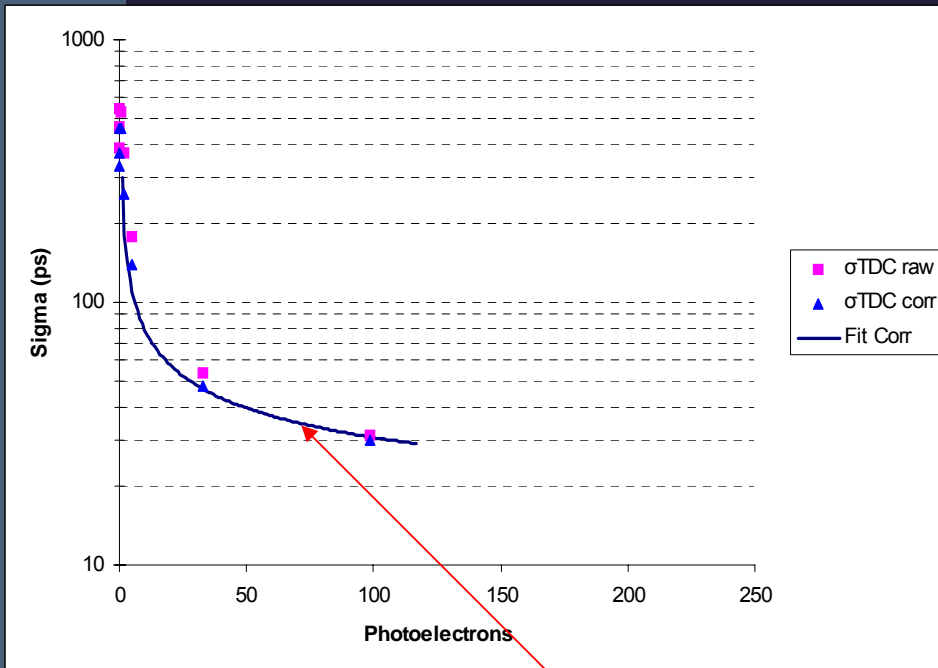
Timing Resolution vs. Photoelectrons



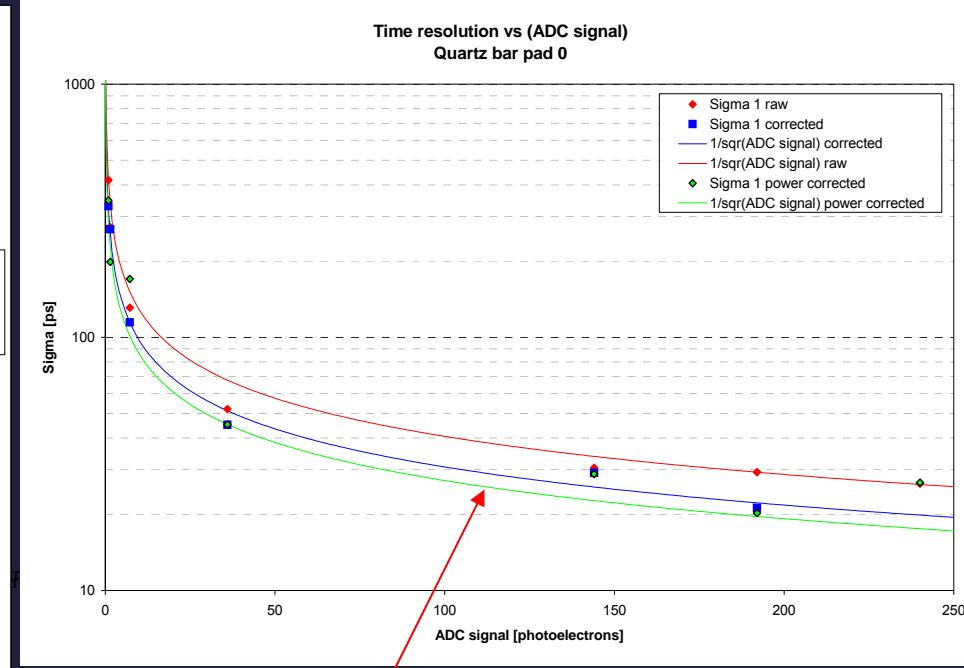
$$\sigma = 9.08 + 214.61 / \sqrt{(N_{pe} - 0.45)}$$

Comparison to Previous Analysis

Wells



Josef (different data runs)



Similar resolution spectrum

Conclusions

- Achieved timing resolution of 30 – 50 ps for ~100 photoelectrons (Run 8) down to ~30 photoelectrons (Run 7).
- Correction for timing – photon correlation most helpful in comparing disparate runs.
 - For constant number of photoelectrons, correction less useful.
- Further study:
 - Confirm # photoelectrons per ADC count.
 - Examine charge-sharing between pads.

Thanks to all Group B for lots of help this quarter!

