# HCal Timing Calibration Quality Checks
## GMn, Config: 11, Prior to Pass 2

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# Contents

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# 1 How to Read this Document

This document details the timing calibration results for the above experiment, configuration, and replay pass. For information regarding the calibration process, see the overleaf.

Each kinematic has been calibrated separately for timing and the database will reflect this moving forward. All time vs energy plots used for this calibration are generated using updated ADC gain parameters and timing offsets for accuracy.

Each of the sections contains a brief description of the calibration results that follow. Any and all questions/concerns regarding these plots should be directed to the author at the email provided.

# 2 Special Considerations

- A significant time shift in ADC time data is evident on this kinematic and as such ADC time offsets are divided into two sets. All runs excluding 12450-12860 are **set 1** and runs 12450-12860 are **set 2**.

- Additionally, a significant time shift in TDC time data is evident on this kinematic and as such TDC time offsets are divided into two sets. All runs excluding 12314-12995 are **set 1** and runs 12996-13063 are **set 2**.

- Evaluation of various timewalk fits are presented here as a preliminary assessment of a new timewalk calibration added to SBS-offline. Changes to SBS-offline to add this timewalk calibration are commensurate with this calibration. It is recommended that future passes consider a $\Delta t = \alpha + \beta/E^N$ timewalk fit to the data where N is constrained to be very close to 0.5.

- Many of the fits to channels shown for set 1 demonstrate yellow or red coloring. If the histogram is red, there are not enough statistics in that channel to provide an offset. In this case, the offset implied by the aggregate of all channels is used. If the histogram is yellow, the fit is unreliable and the center of the bin in X corresponding to the maximum value is used. The second issue is generally caused by low statistics.

# 3   Timing

## 3.a   ADC Time Offsets, Set 1
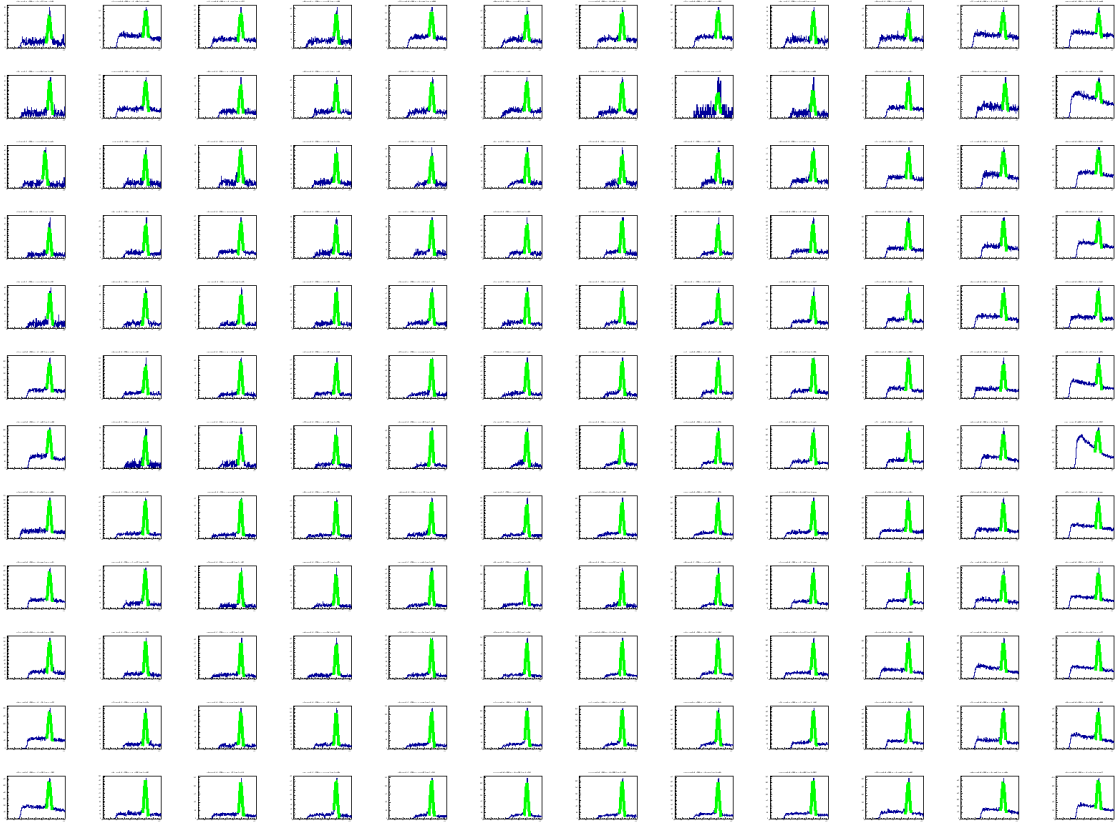
- Fits to ADC time spectra, by HCal Channel.



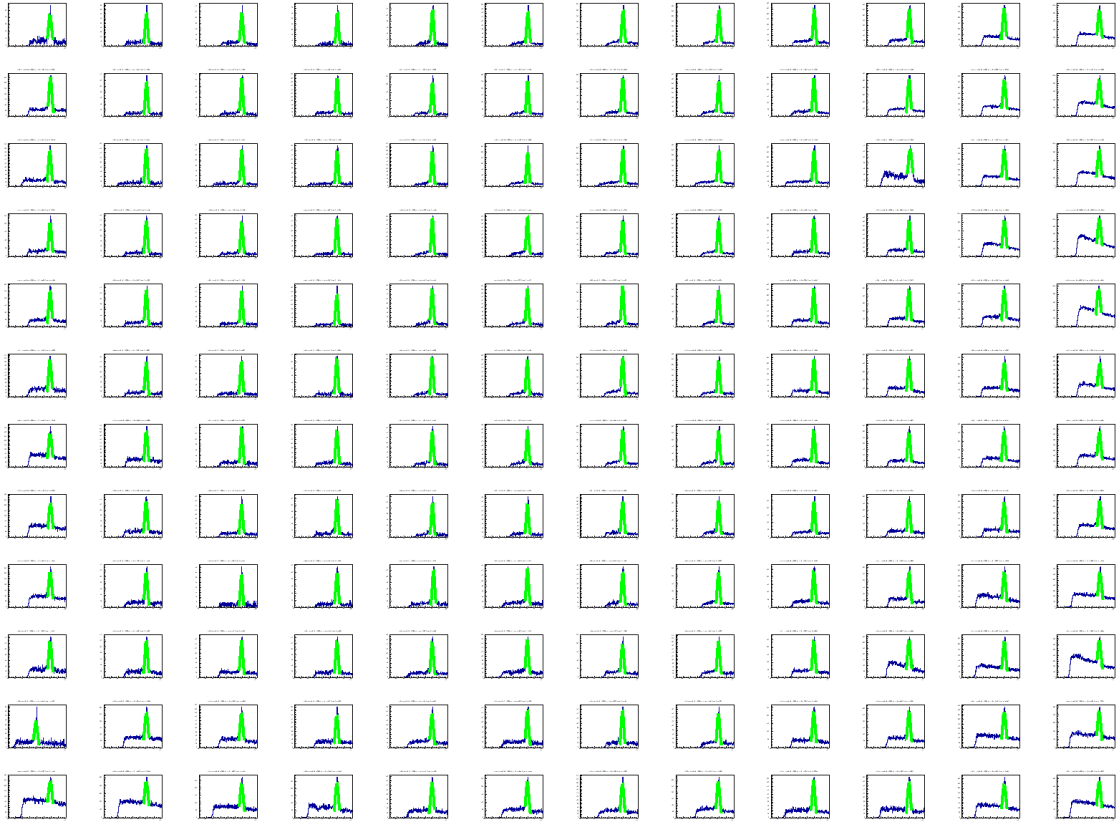Figure 1: ADCt Spectra Fits vs. Channel, Top Half, Set 1

Figure 2: ADCt Spectra Fits vs. Channel, Bottom Half, Set 1

- Mean/std. dev. comparisons before/after calibrations.

## 3.b   ADC Time Offsets, Set 2

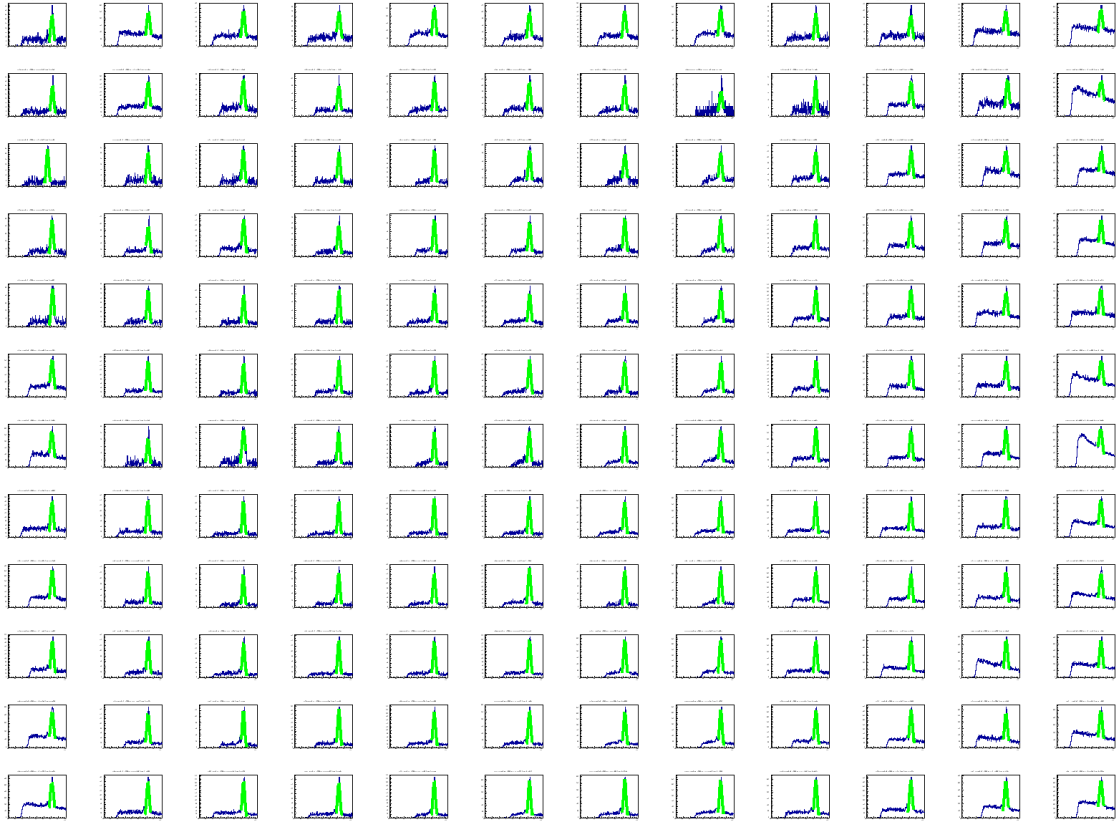- Fits to ADC time spectra, by HCal Channel.

Figure 3: ADCt Spectra Fits vs. Channel, Top Half, Set 2
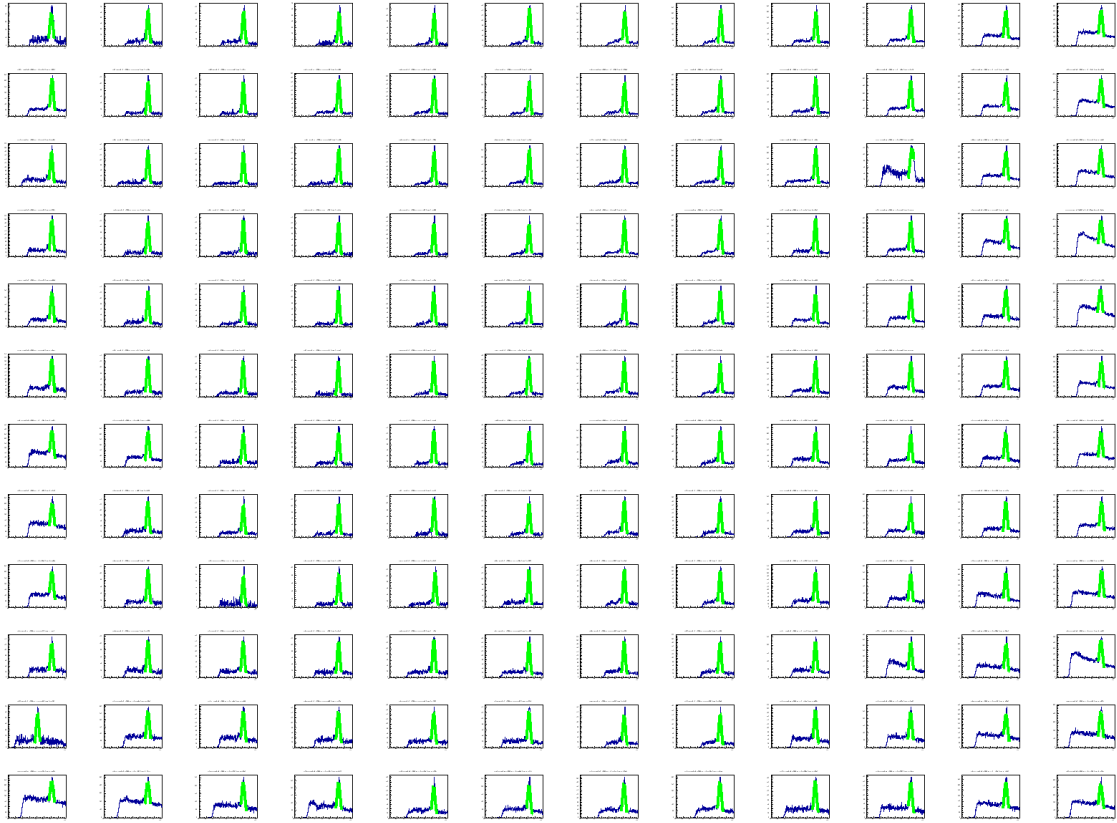
Figure 4: ADCt Spectra Fits vs. Channel, Bottom Half, Set 2

## 3.c   ADC Time Offsets, Both Sets

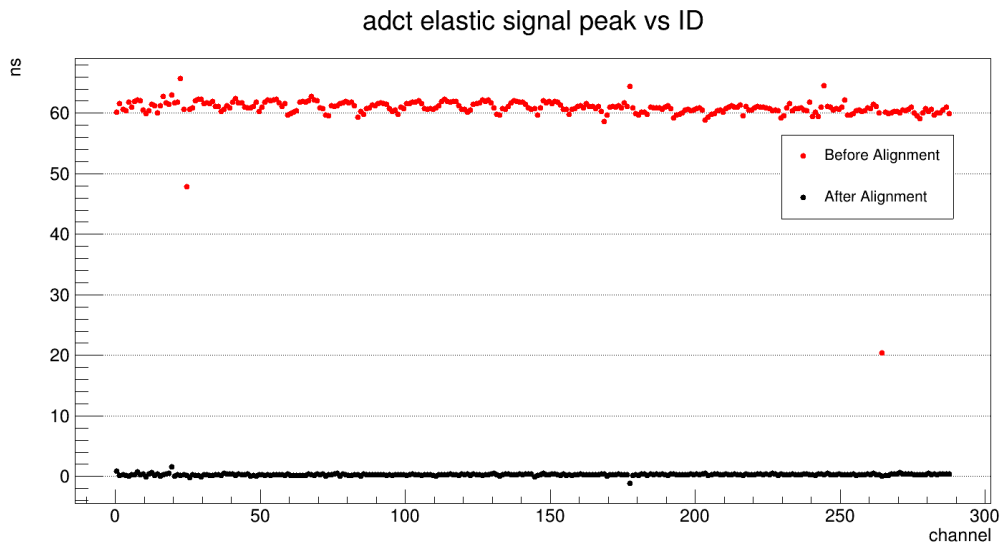Mean/std. dev. comparisons before/after calibrations.

Figure 5: ADCt Fit Comparison, Post-Cal in Black

## 3.d    TDC Offsets, Set 1

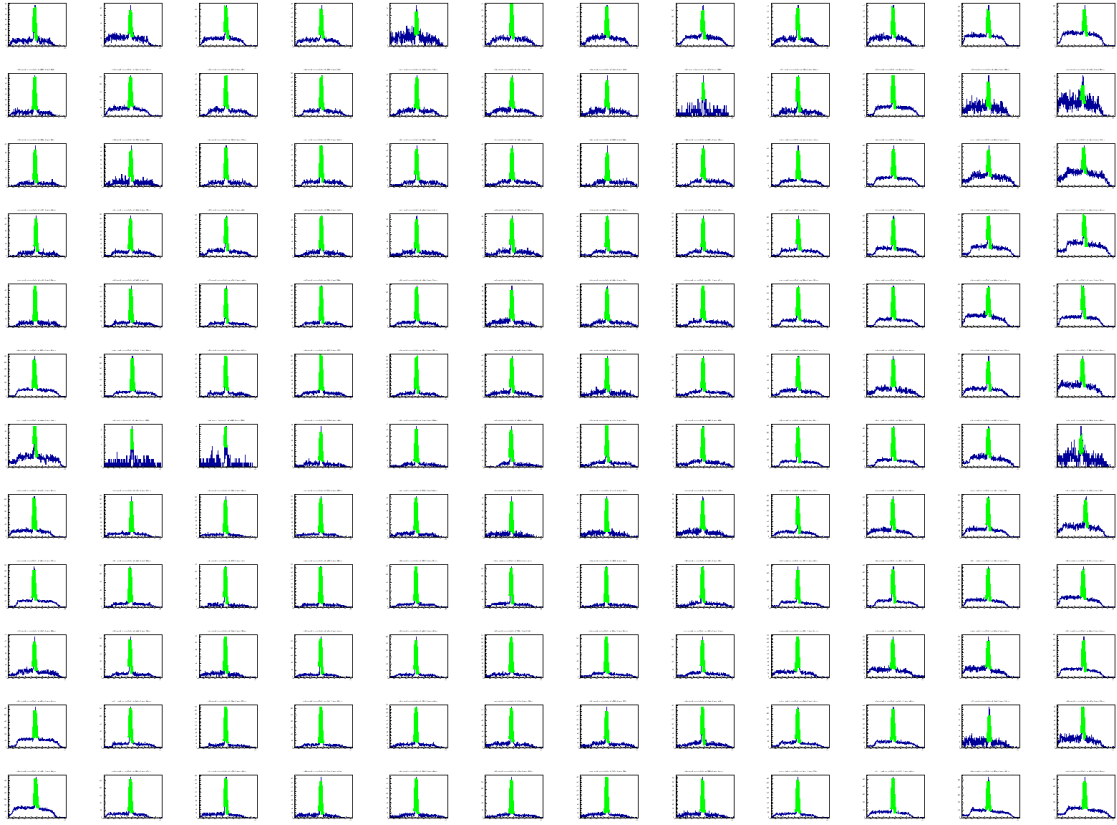- Fits to TDC spectra, by HCal Channel.

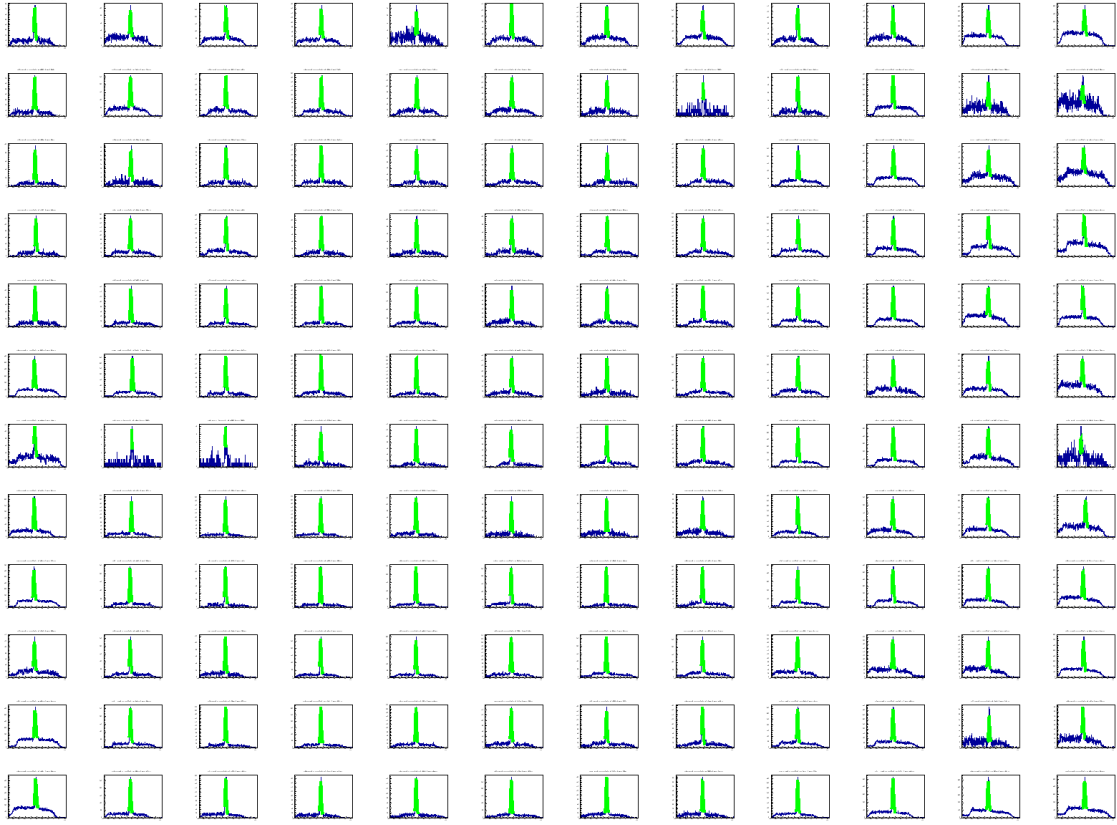Figure 6: TDC Spectra Fits vs. Channel, Top Half, Set 1

Figure 7: TDC Spectra Fits vs. Channel, Bottom Half, Set 1

## 3.e TDC Offsets, Set 2
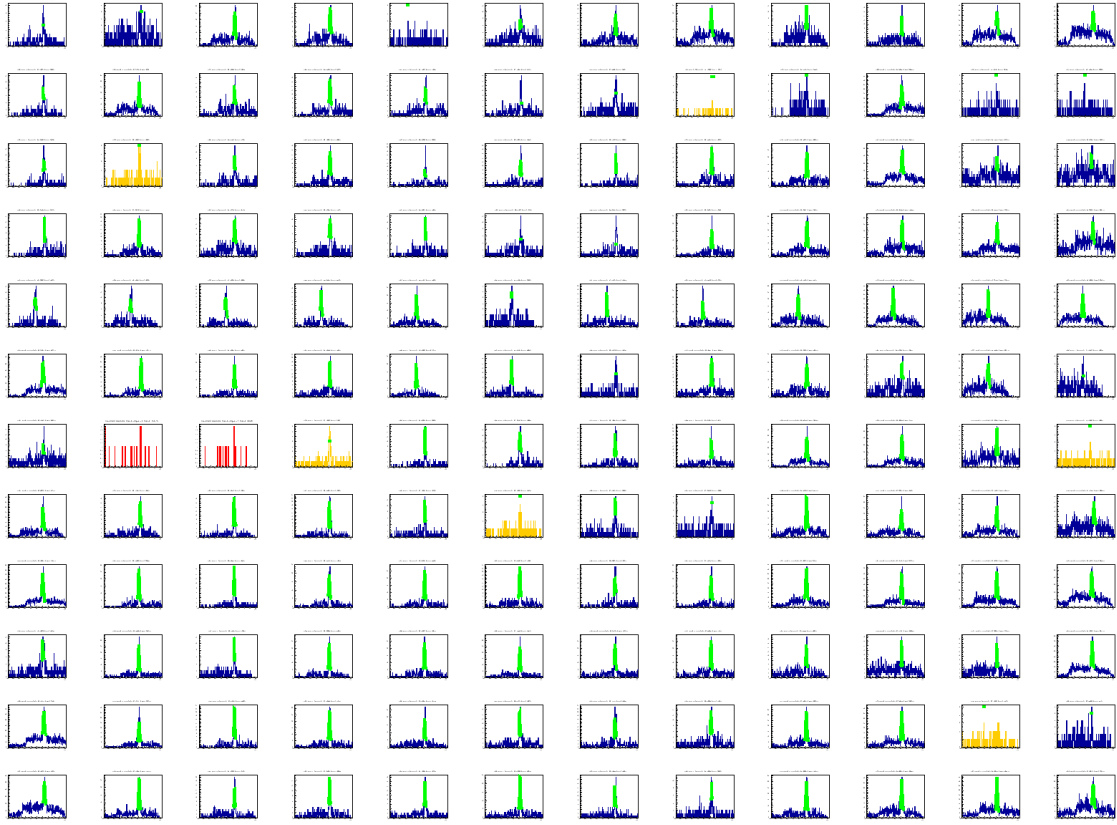
- Fits to TDC spectra, by HCal Channel.

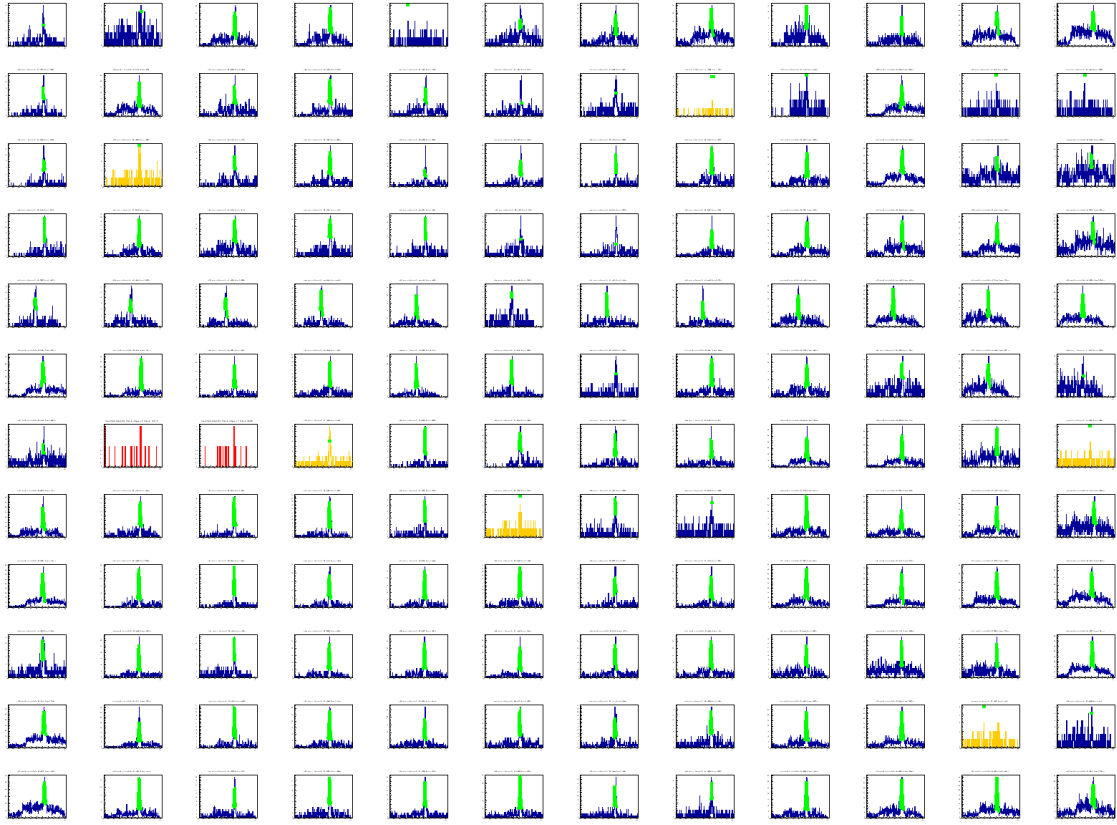Figure 8: TDC Spectra Fits vs. Channel, Top Half, Set 2

Figure 9: TDC Spectra Fits vs. Channel, Bottom Half, Set 2

## 3.f   TDC Offsets, Both Sets

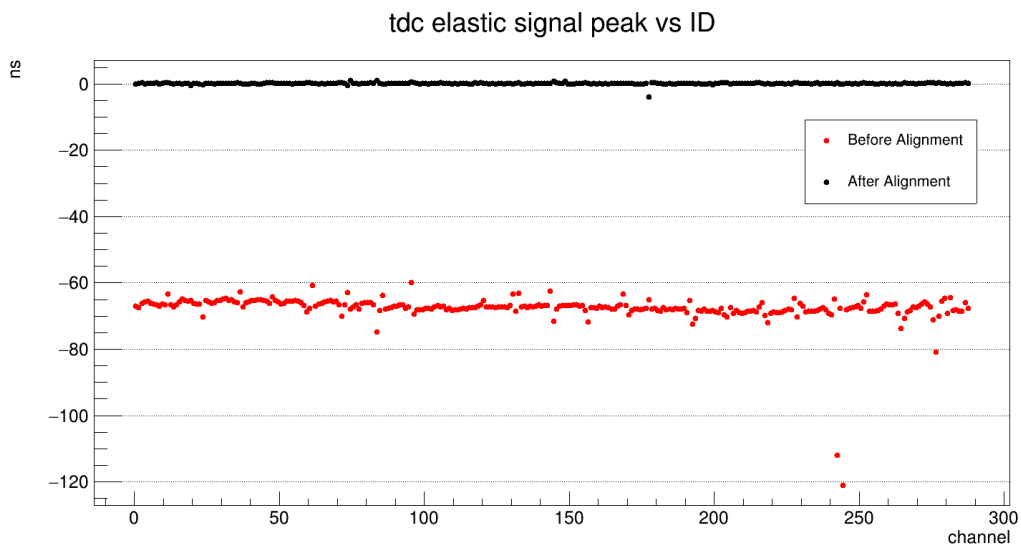Mean/std. dev. comparisons before/after calibrations.

Figure 10: TDC Fit Comparison, Post-Cal in Black

## 3.g   ADC Time Aggregate Comparison

All blocks post-alignment ADC time fit and comparison with ADC time from data before per-channel alignment.

adct-HODOtmean All Runs All Channels, After Alignment

| ht_allchan_allruns_before | |
|---|---|
| Entries | 1.03897e+07 |
| Mean | 55.88 |
| Std Dev | 36.69 |

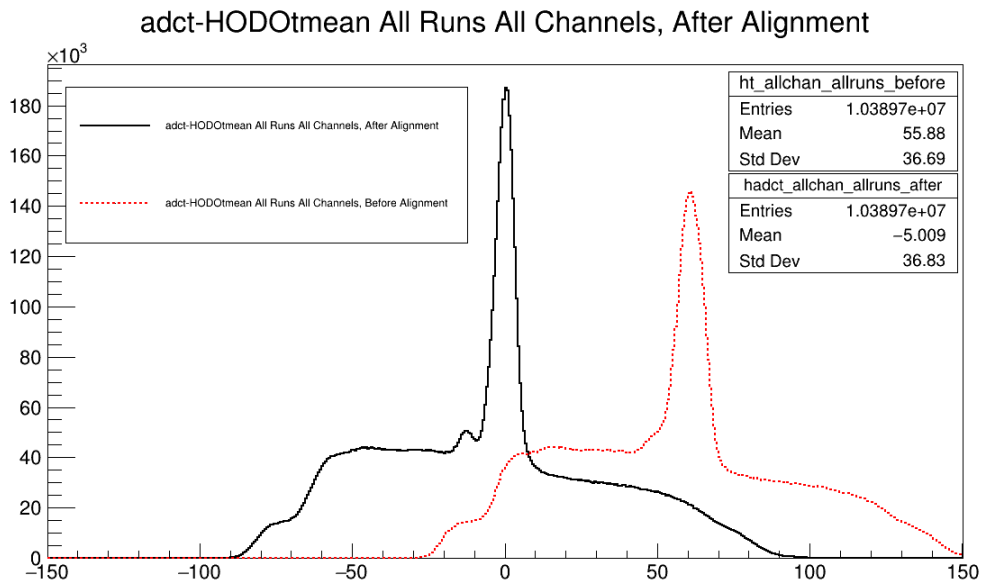| hadct_allchan_allruns_after | |
|---|---|
| Entries | 1.03897e+07 |
| Mean | −5.009 |
| Std Dev | 36.83 |

Figure 11: ADCt Comparison, All Channels. Post-alignment Mean: **0.27 ns**

# 4 Time vs Run

No significant deviations occur on either ADCt or TDC data as a function of run number.

## 4.a ADCt vs Run

HCal adc time (all blocks) vs run number, before and after. Includes direct comparison.
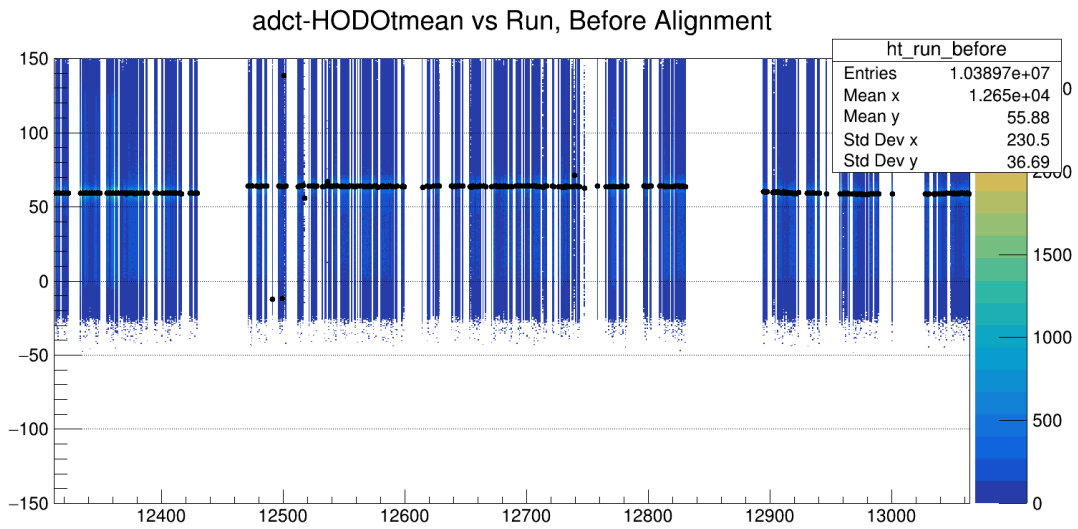
Figure 12: HCal ADCt vs Run Number All Channels, Before Alignment
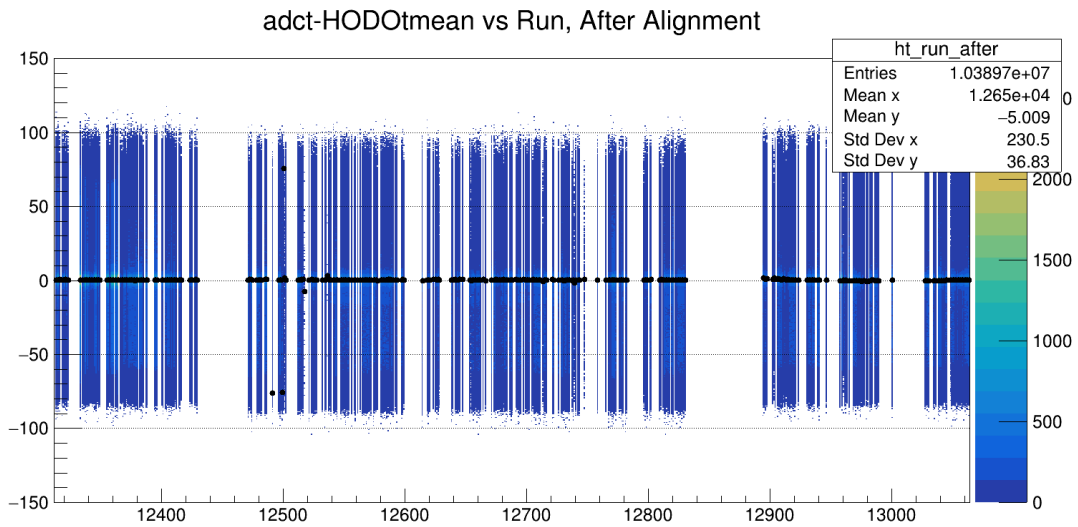


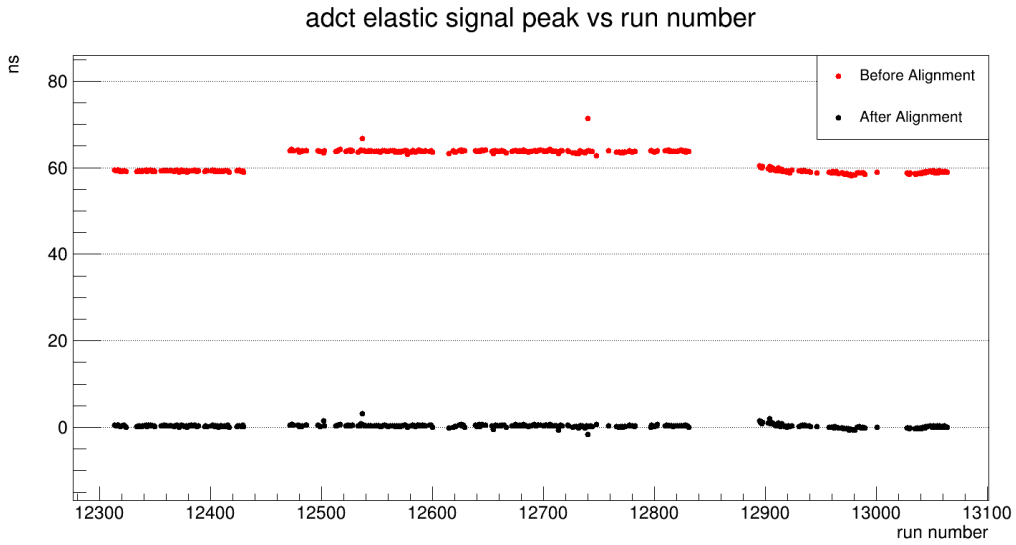Figure 13: HCal ADCt vs Run Number All Channels, After Alignment

Figure 14: HCal ADCt vs Run Number All Channels, Comparison

## 4.b TDC vs Run

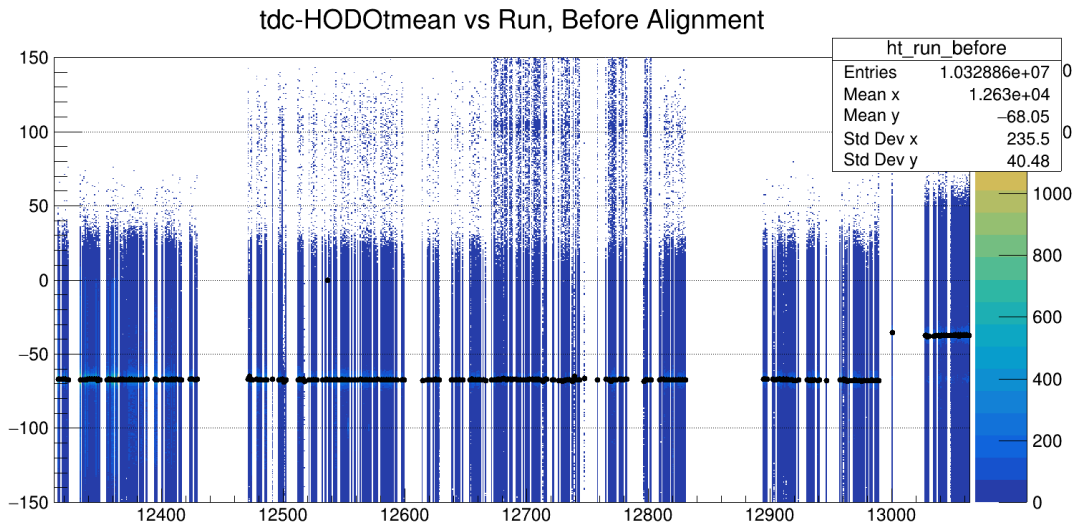HCal tdc time (all blocks) vs run number, before and after. Includes direct comparison.



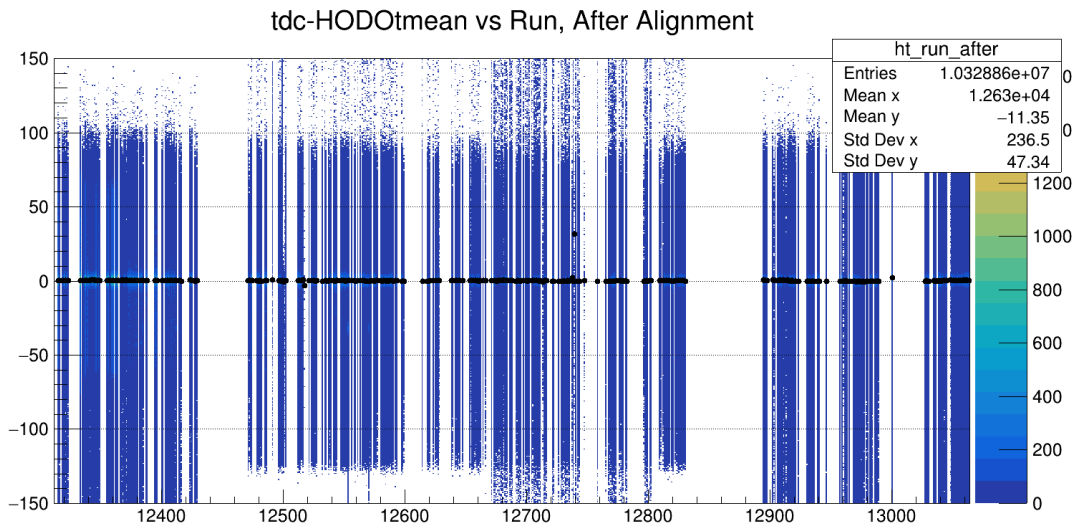Figure 15: HCal TDC vs Run Number All Channels, Before Alignment

Figure 16: HCal TDC vs Run Number All Channels, After Alignment
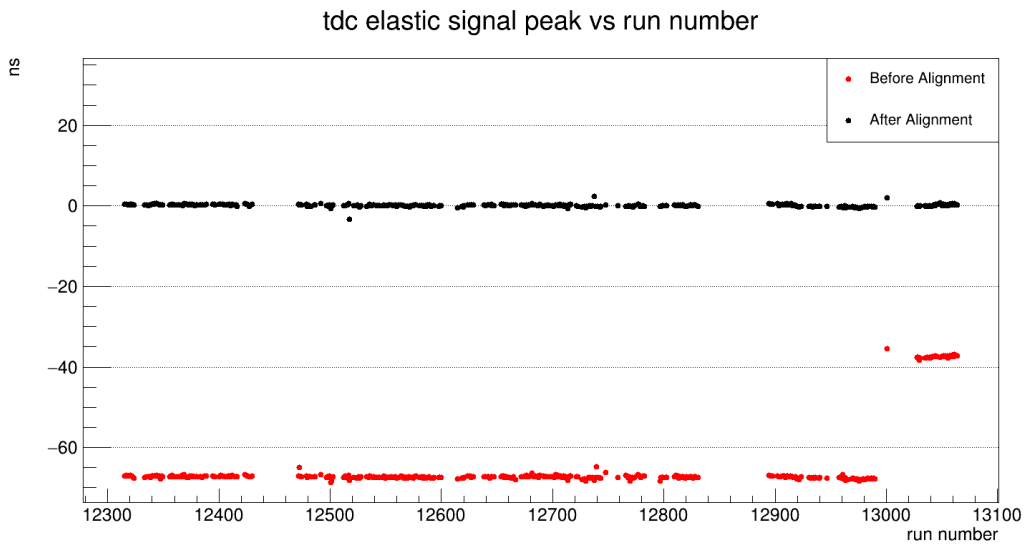


Figure 17: HCal TDC vs Run Number All Channels, Comparison

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# 5   Supplemental Timing

## 5.a   TDC Timewalk, Fits to Data

HCal tdc time (all blocks) vs energy, fit with $\Delta t = p0 + p1 \cdot E$. $p0$ is normal to the data and not passed to the calibration.
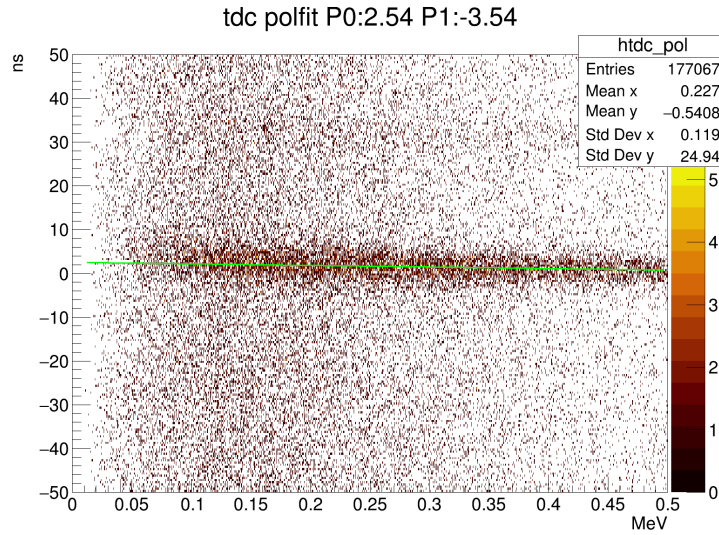


Figure 18: HCal TDC vs E

HCal tdc time (all blocks) vs energy, fit with $\Delta t = P0 \cdot exp(-P1 \cdot E) + p2$. $p2$ is normal to the data and not passed to the calibration.
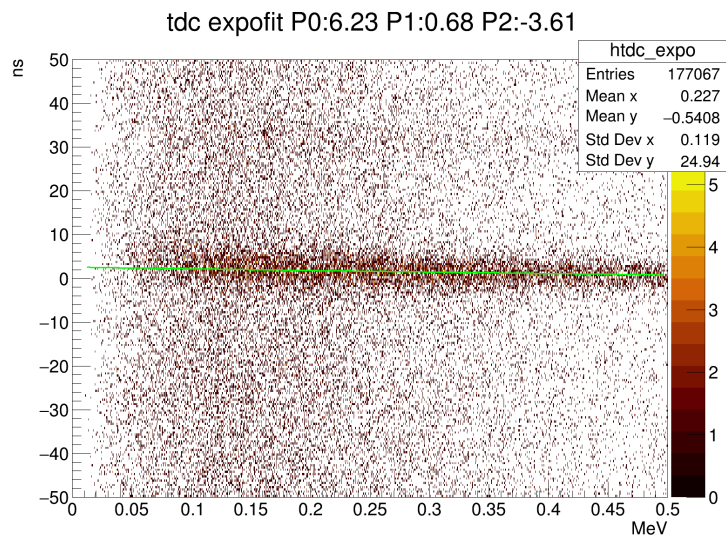
Figure 19: HCal TDC vs E

HCal tdc time (all blocks) vs energy, fit with $\Delta t = p0 + p1/E^{p2}$. $p0$ is normal to the data and not passed to the calibration.
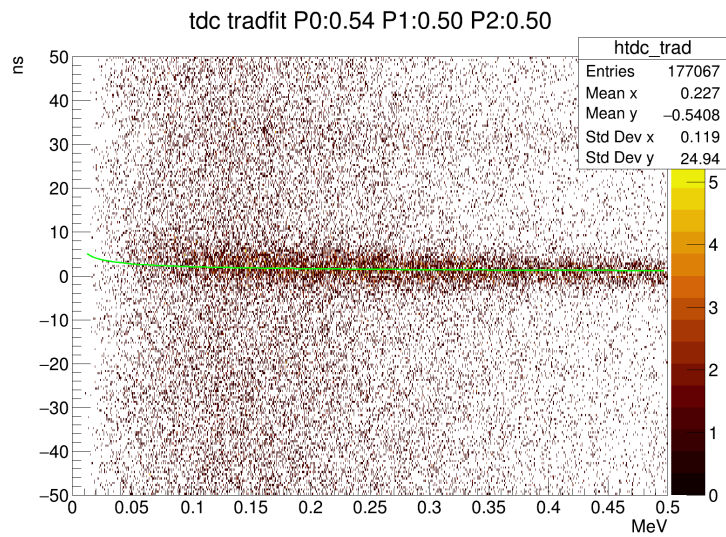


Figure 20: HCal TDC vs E,

## 5.b  ADCt Timewalk, Fit to Data

HCal adct time (all blocks) vs energy, fit with $\Delta t = p0 + p1 \cdot E$. $p0$ is normal to the data and not passed to the calibration.
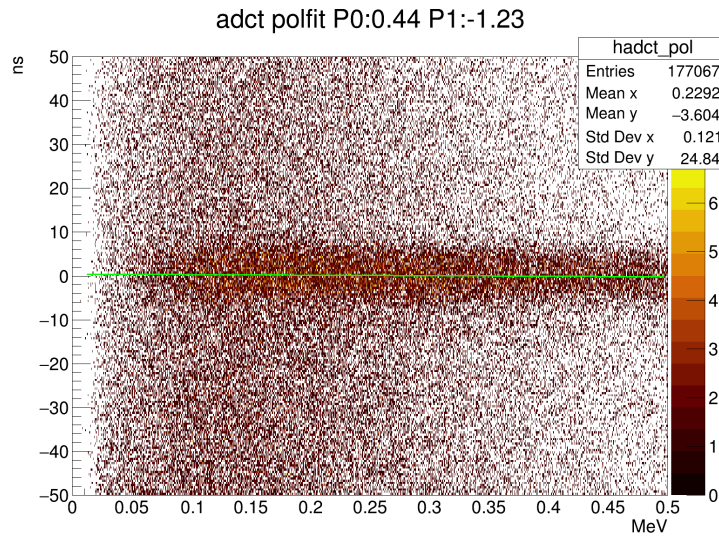


Figure 21: HCal ADCt vs E

# 6  SBS-offline check, ADCt set 1, TDC set 1

The following plots repeat checks above, but with a small replay of run 12369 data using replay_gmn.C with SBS-offline associated libraries updated with timewalk and with new offsets included in the database.

## 6.a  ADC Time All Channels



Figure 22: ADCt All Channels, Run 12369

## 6.b  TDC All Channels



Figure 23: TDC All Channels, Run 12369

# 7  SBS-offline check, ADCt set 2, TDC set 1

The following is over run 12674.

## 7.a ADC Time All Channels



Figure 24: ADCt All Channels, Run 12674

## 7.b TDC All Channels



Figure 25: TDC All Channels, Run 12674

# 8 SBS-offline check, ADCt set 1, TDC set 1 (second section)

The following is over run 12916.
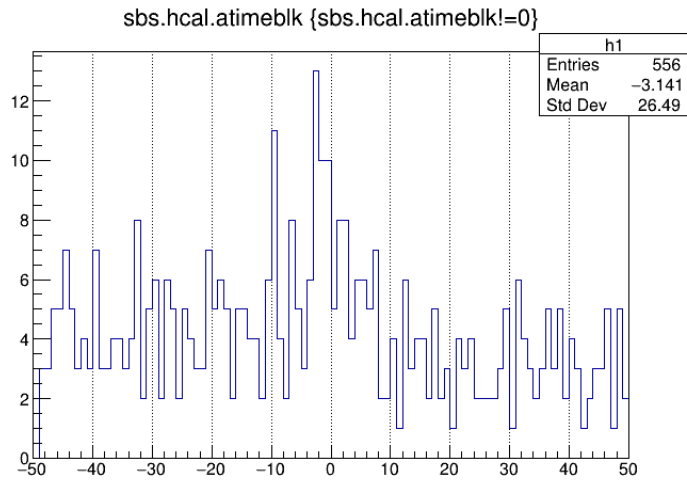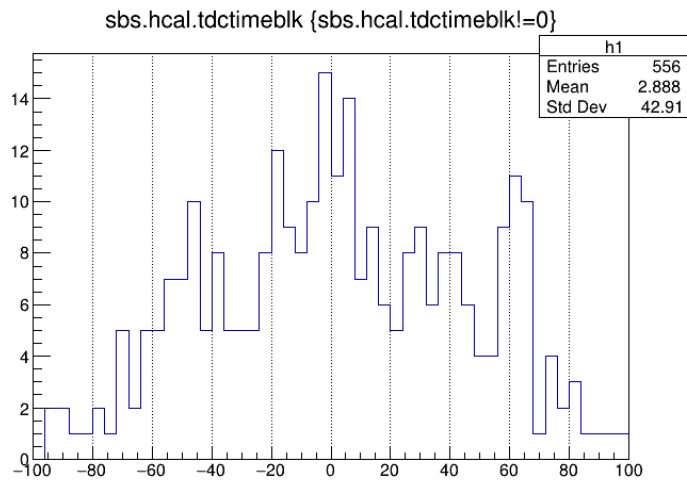
## 8.a ADC Time All Channels



Figure 26: ADCt All Channels, Run 12916

## 8.b TDC All Channels



Figure 27: TDC All Channels, Run 12916

# 9 SBS-offline check, ADCt set 2, TDC set 2

The following is over run 13057.
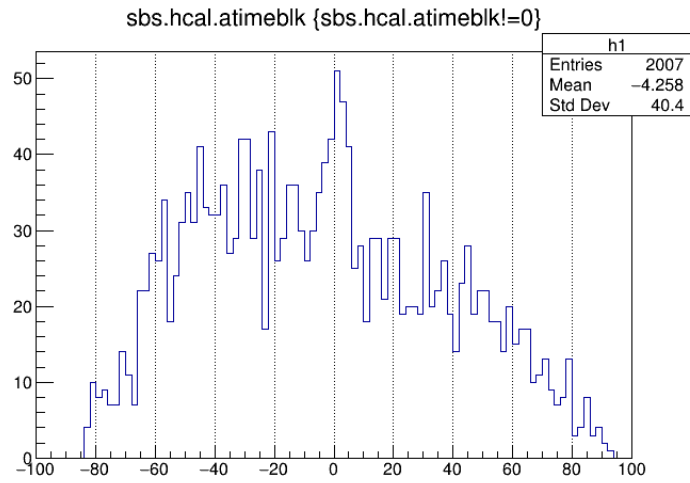
## 9.a  ADC Time All Channels



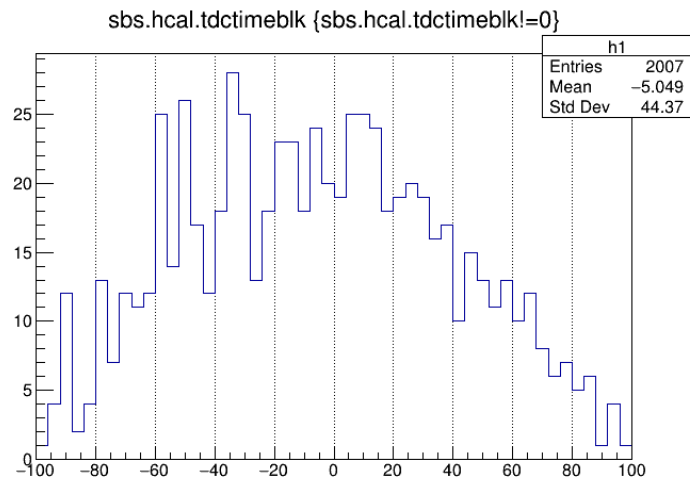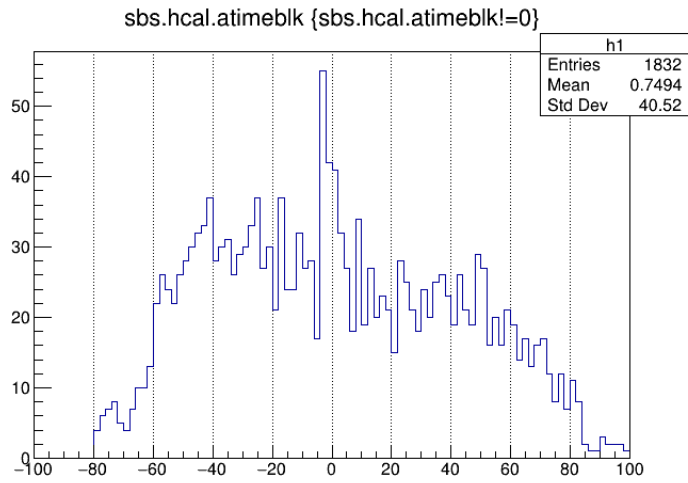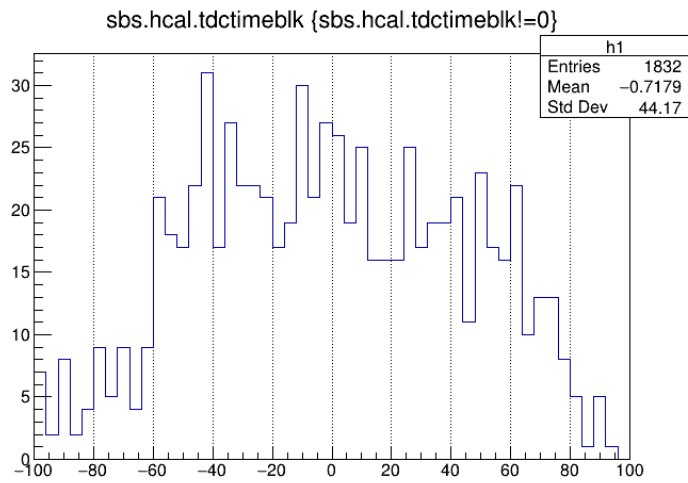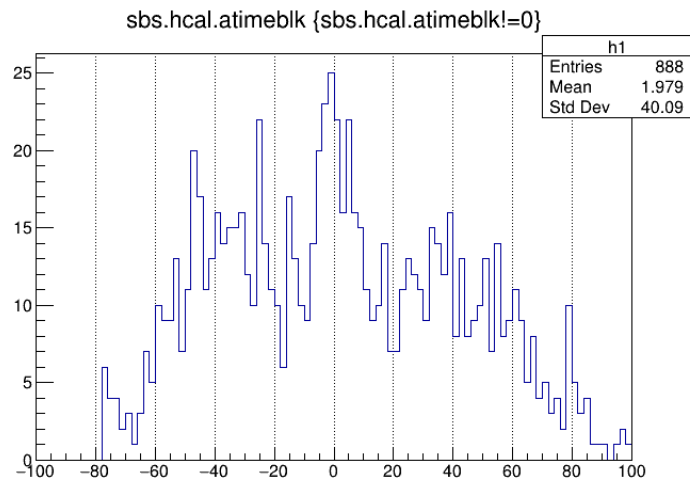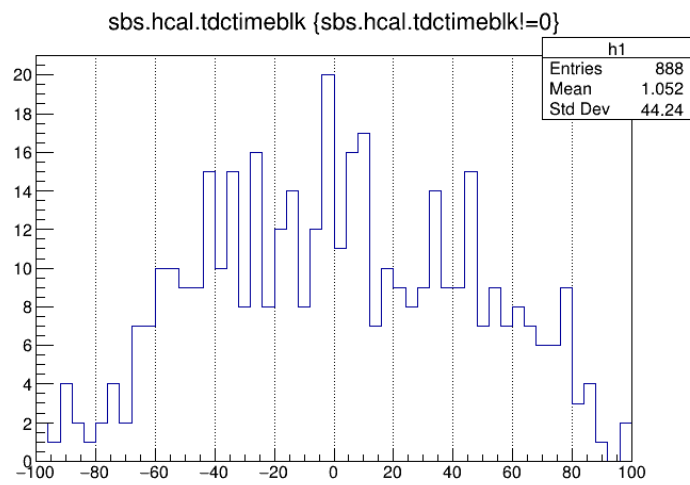Figure 28: ADCt All Channels, Run 13057

## 9.b  TDC All Channels



Figure 29: TDC All Channels, Run 13057

# 10    Supplemental

**General Set ADCt Alignment Info**

**Experiment: gmn, Configuration: 11, Pass: 1**

**Creation Date: 9_14_2023**

**Run range 0 - 0**

**Exclusion range 12450 - 12860**

**Target(s) Used: All Available**

**Calibration Set: none**

**Elastic Cuts**

**Global Elastic Cuts: bb.tr.n>0&&abs(bb.tr.vz[0])<0.08&&bb.gem.track.nhits>2&&bb.tr.p[0]>2.0&&sbs.hcal.e>0.03&&bb.ps.e>0.2**

**Other Cuts**

**Minimum Ev per Cell : 50**

**HCal Acceptance Match (Projected Nucleon Within HCal Acceptance)**

Figure 30: SBS11 set 1 adct timing cuts and experimental parameters.

**General Set ADCt Alignment Info**

**Experiment: gmn, Configuration: 11, Pass: 1**

**Creation Date: 9_19_2023**

**Run range 12450 - 12860**

**Exclusion range 0 - 0**

**Target(s) Used: All Available**

**Calibration Set: none**

**Elastic Cuts**

**Global Elastic Cuts: bb.tr.n>0&&abs(bb.tr.vz[0])<0.08&&bb.gem.track.nhits>2&&bb.tr.p[0]>2.0&&sbs.hcal.e>0.03&&bb.ps.e>0.2**

**Other Cuts**

**Minimum Ev per Cell : 50**

**HCal Acceptance Match (Projected Nucleon Within HCal Acceptance)**

Figure 31: SBS11 set 1 adct timing cuts and experimental parameters.

**General Set TDC Alignment Info**

**Experiment: gmn, Configuration: 11, Pass: 1**

**Creation Date: 9_13_2023**

**Run range 12314 - 12995**

**Target(s) Used: All Available**

**Calibration Set: none**

**Elastic Cuts**

**Global Elastic Cuts: bb.tr.n>0&&abs(bb.tr.vz[0])<0.08&&bb.gem.track.nhits>2&&bb.tr.p[0]>2.0&&sbs.hcal.e>0.03&&bb.ps.e>0.2**

**Other Cuts**

**Minimum Ev per Cell : 50**

**HCal Acceptance Match (Projected Nucleon Within HCal Acceptance)**

Figure 32: SBS11 set 2 tdc timing cuts and experimental parameters.

**General Set TDC Alignment Info**

**Experiment: gmn, Configuration: 11, Pass: 1**

**Creation Date: 9_14_2023**

**Run range 12996 - 13063**

**Target(s) Used: All Available**

**Calibration Set: none**

**Elastic Cuts**

**Global Elastic Cuts: bb.tr.n>0&&abs(bb.tr.vz[0])<0.08&&bb.gem.track.nhits>2&&bb.tr.p[0]>2.0&&sbs.hcal.e>0.03&&bb.ps.e>0.2**

**Other Cuts**

**Minimum Ev per Cell : 50**

**HCal Acceptance Match (Projected Nucleon Within HCal Acceptance)**

Figure 33: SBS11 set 2 tdc timing cuts and experimental parameters.