Penn Analysis of Cold ADC Long Term Performance

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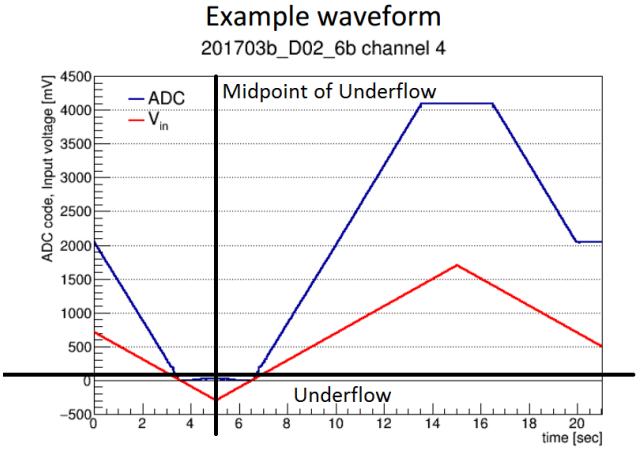
Table of Contents

Overview of Analysis

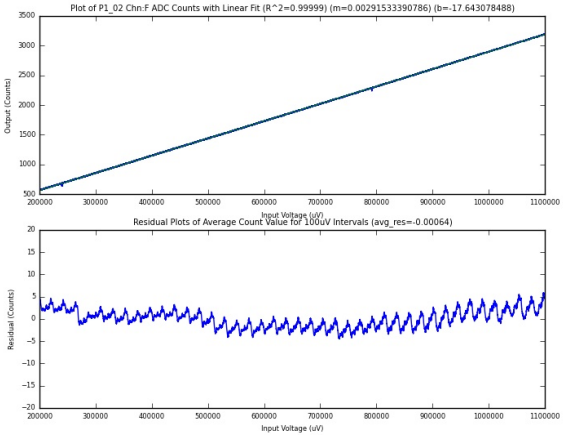
- Measure differential non-linearity (DNL) of BNL cold ADC for the January and March datasets and analyze for consistency.
- Apply a linear fit to each data file for January and March datasets and measure the differential non-linearity through residuals.

Methodology of ADC Analysis



Example plot of the DAC's output, the ADC's output, and the underflow. (Credit: David Adams)

Linearity and DNL of P1 Chip 2 Channel F



Linear fit and residuals of channel F for P1 chip 2 of dataset 1a

Table of Contents

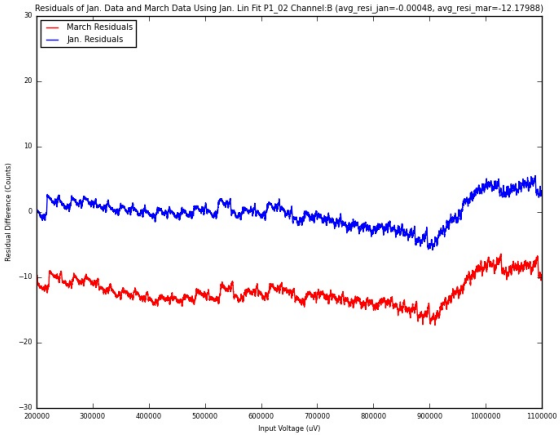
Linearity from March and January datasets

Channel	Slope (Count/uV)	y-intercept (Count)
Jan. B	0.002939	-6.10
Jan. F	0.002896	-5.97

Channel	Slope	y-int.	% Dev. Jan. Slope	Dev. Jan. y-int.
Mar. 1a B	0.002940	-18.85	0.034	12.75
Mar. 1a F	0.002915	-17.64	0.656	11.67

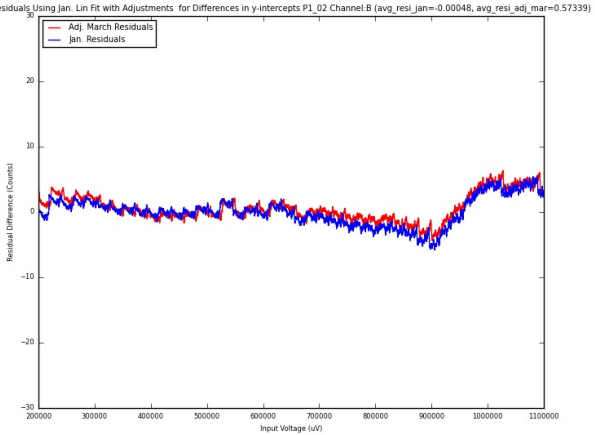
Linearity of chip 2 determined for the March dataset 1a and Jan.

Residuals for Channel B using Jan. Linear Fit



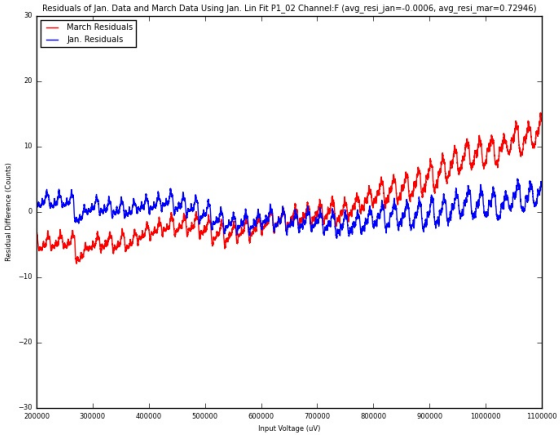
Overlay of the residuals generated using the January linearity fit with the January dataset and the March dataset 1a channel B.

Adjusted Residuals for Channel B using Jan. Linear Fit



Overlay of the adjusted residuals generated using the January linearity fit with the January dataset and the March dataset 1a for channel B.

Residuals for Channel F using Jan. Linear Fit



Overlay of the residuals generated using the January linearity fit with the January dataset and the March dataset 1a channel F.

Conclusion

- The January and March datasets appear inconsistent in the slope and residuals observed.
- Actual calibrations will require recording both the stimulus and the ADC output.

Table of Contents

Table of January Linear Fits Pt. 1

Channel	Slope (Count/uV)	y-intercept (Count)
0	0.003196	-24.29
1	0.003197	-12.76
2	0.003203	-5.43
3	0.003025	0.27
4	0.002922	-4.37
5	0.002963	-14.16
6	0.002981	-15.68
7	0.002947	-5.35
8	0.002903	-3.89

Linearity of chip 2 determined for the January dataset. Because the linear fit is over millions of data points, the uncertainties are unreasonably small (to the order of 10^{-9} for the slope and to the order of 10^{-3} for the y-intercept).

Table of January Linear Fits Pt. 2

Channel	Slope (Count/uV)	y-intercept (Count)
9	0.002870	-0.91
A	0.002882	-10.66
B	0.002939	-6.10
C	0.002907	-8.72
D	0.002902	-16.87
E	0.003144	-11.11
F	0.002896	-5.97

Linearity of chip 2 determined for the January dataset. Because the linear fit is over millions of data points, the uncertainties are unreasonably small (to the order of 10^{-9} for the slope and to the order of 10^{-3} for the y-intercept).

Table of March Linear Fits of 1a Pt. 1

Channel	Slope	y-int.	% Dev. Jan. Slope	Dev. Jan. y-int.
0	0.003187	-33.39	0.280	9.10
1	0.003183	-21.83	0.437	9.07
2	0.003192	-13.29	0.343	7.86
3	0.003018	-6.22	0.231	6.44
4	0.002918	-11.12	0.137	6.75
5	0.002962	-20.30	0.034	6.14
6	0.002958	-20.81	0.770	5.13
7	0.002933	-9.66	0.475	4.31
8	0.002900	-6.03	0.103	2.14

Linearity of chip 2 determined for the March dataset 1a with deviations from the January linear fits. Because the linear fit is over millions of data points, the uncertainties are unreasonably small (to the order of 10^{-9} for the slope and to the order of 10^{-3} for the y-intercept).

Table of March Linear Fits of 1a Pt. 2

Channel	Slope	y-int.	% Dev. Jan. Slope	Dev. Jan. y-int.
9	0.002858	-5.33	0.400	4.42
A	0.002864	-18.64	0.625	7.98
B	0.002940	-18.85	0.034	12.75
C	0.002913	-25.95	0.210	17.23
D	0.002900	-26.97	0.069	10.10
E	0.003136	-23.63	0.254	12.52
F	0.002915	-17.64	0.656	11.67

Linearity of chip 2 determined for the March dataset 1a with deviations from the January linear fits. Because the linear fit is over millions of data points, the uncertainties are unreasonably small (to the order of 10^{-9} for the slope and to the order of 10^{-3} for the y-intercept).

Table of Residuals Pt. 1

Channel	Avg. Jan. Resi.	Avg. 1a Resi.	1a y-int. Dev.
0	-0.00098	-15.28	9.10
1	-0.00123	-18.17	9.07
2	-0.00025	-14.83	7.86
3	-0.00129	-10.82	6.44
4	-0.00100	-9.14	6.75
5	-0.00044	-7.01	6.14
6	-0.00069	-20.13	5.13
7	-0.00059	-13.9	4.31
8	-0.00076	-4.09	2.14

Average residuals determined for the January dataset and March 1a dataset using the linear fits from January. All values are in the unit of ADC counts.

Table of Residuals Pt. 2

Channel	Avg. Jan. Resi.	Avg. 1a Resi.	1a y-int. Dev.
9	-0.00066	-12.39	4.42
A	-0.00097	-19.19	7.98
B	-0.00048	-12.18	12.75
C	-0.00075	-13.29	17.23
D	-0.00012	-11.90	10.10
E	-0.00034	-17.35	12.52
F	-0.00060	0.73	11.67

Average residuals determined for the January dataset and March 1a dataset using the linear fits from January. All values are in the unit of ADC counts.

Table of Adjusted Residuals Pt. 1

Channel	Adjusted Residuals 1a	Adjusted Residuals 12a	Classification
0	-6.18	-14.51	Very Inconsistent
1	-9.09	-10.43	Inconsistent
2	-6.97	-7.48	Inconsistent
3	-4.33	-4.72	Fairly Inconsistent
4	-2.38	-2.46	Consistent
5	0.87	-1.79	Consistent
6	-14.99	-15.19	Very Inconsistent
7	-9.62	-9.68	Inconsistent
8	-1.95	-2.07	Consistent

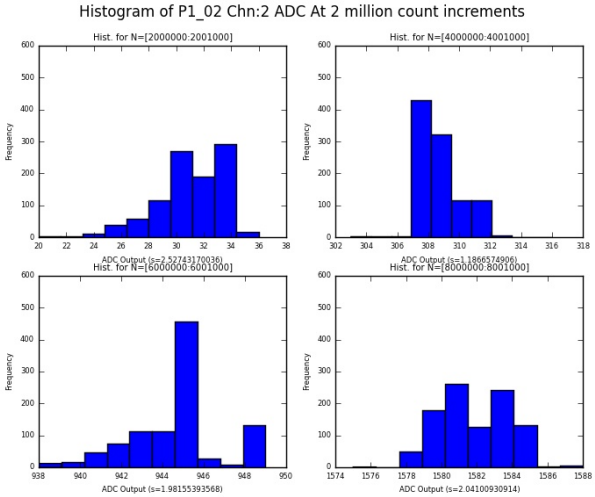
Adjusted average residuals determined for the January dataset and March 1a and 12a datasets using the linear fits from January determined by subtracting the difference of the found y-intercepts between the March and January linear fits.

Table of Adjusted Residuals Pt. 2

Channel	Adjusted Residuals 1a	Adjusted Residuals 12a	Classification
9	-7.97	-7.86	Inconsistent
A	-11.20	-11.98	Very Inconsistent
B	0.57	1.10	Consistent
C	3.93	4.87	Fairly Inconsistent
D	-1.82	-1.39	Consistent
E	-4.83	-3.99	Fairly Inconsistent
F	12.41	13.26	Very Inconsistent

Adjusted average residuals determined for the January dataset and March 1a and 12a datasets using the linear fits from January determined by subtracting the difference of the found y-intercepts between the March and January linear fits.

Histogram throughout Dynamic Range to Estimate RMS



Histograms of 1k points at different parts of dynamic range for March dataset 1a.