

Arc BLM activity before/after seed laser swap Jay Benesch

During the FY20 physics run, regions in the higher arcs have been activated in a manner never before seen. Chopper viewer images suggested a tail on the C beam was a cause of the difficulty. Accordingly, on March 19 while Hall C was down to switch experiments from a1n to d2n, the laser seeds for B and C were swapped. The B beam is defined by a narrow chopper slit and is low current so it is less likely than C beam, which passes through an open slit, to contain a tail. Response of selected BLMs in arcs 1 and 2 as a function of A and C current were compared for three six hour periods:

- A. March 10 1400-2000 with both high current halls, before the laser seed swap
- B. March 20 0700-1300 with Hall A the only high current hall
- C. March 23 0100-0700 with both high current halls, after the laser seed swap

Arc 1 BLMs 04, 09, 16, 22, 29, 33 and 37 were downloaded for the six hour periods. Arc 2 BLMs 4, 10, 16, 23, 29, 32 and 36 were also downloaded. The less correlated BLMs are shown first and ignored thereafter.

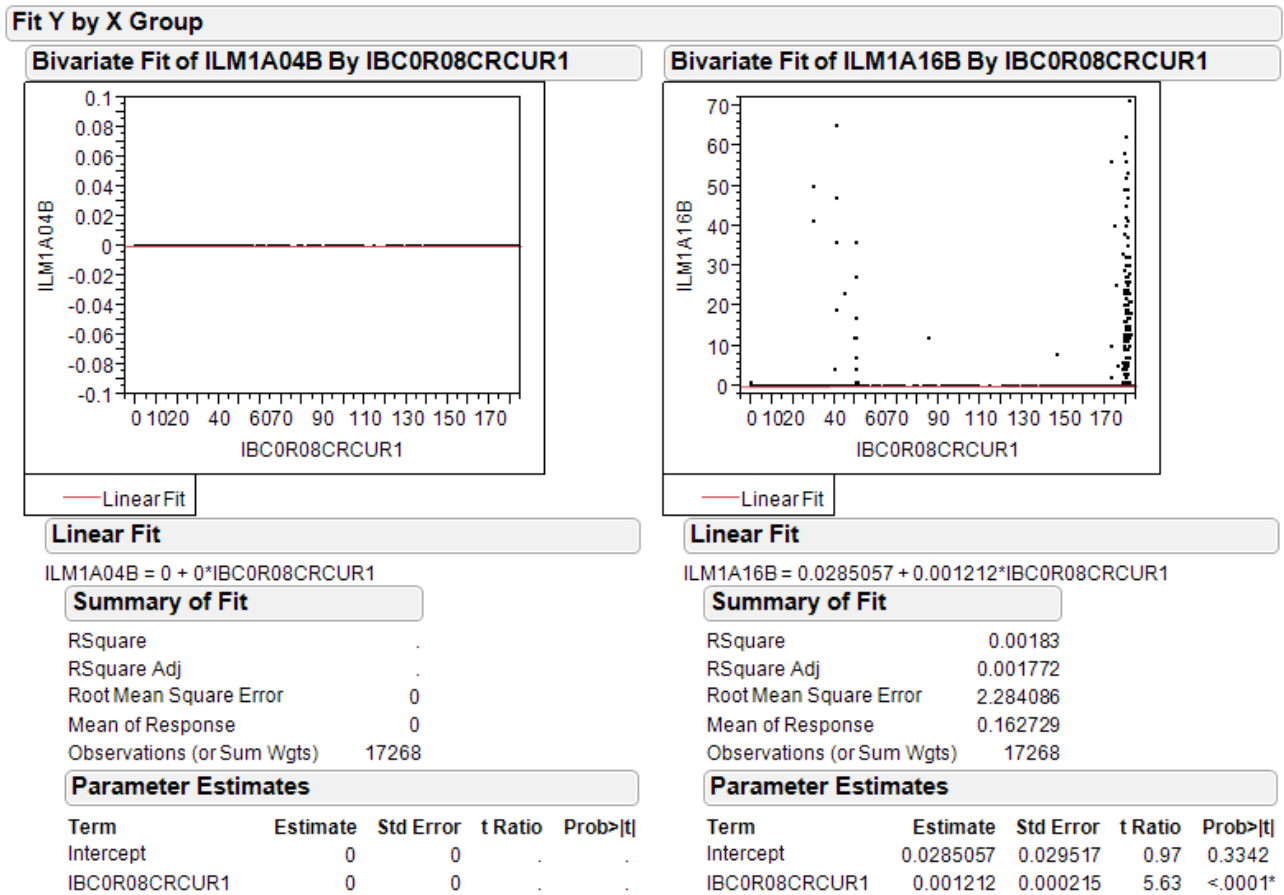


Figure 1. Arc 1 BLMs with no correlation to total current in arc. Period A, before seed change.

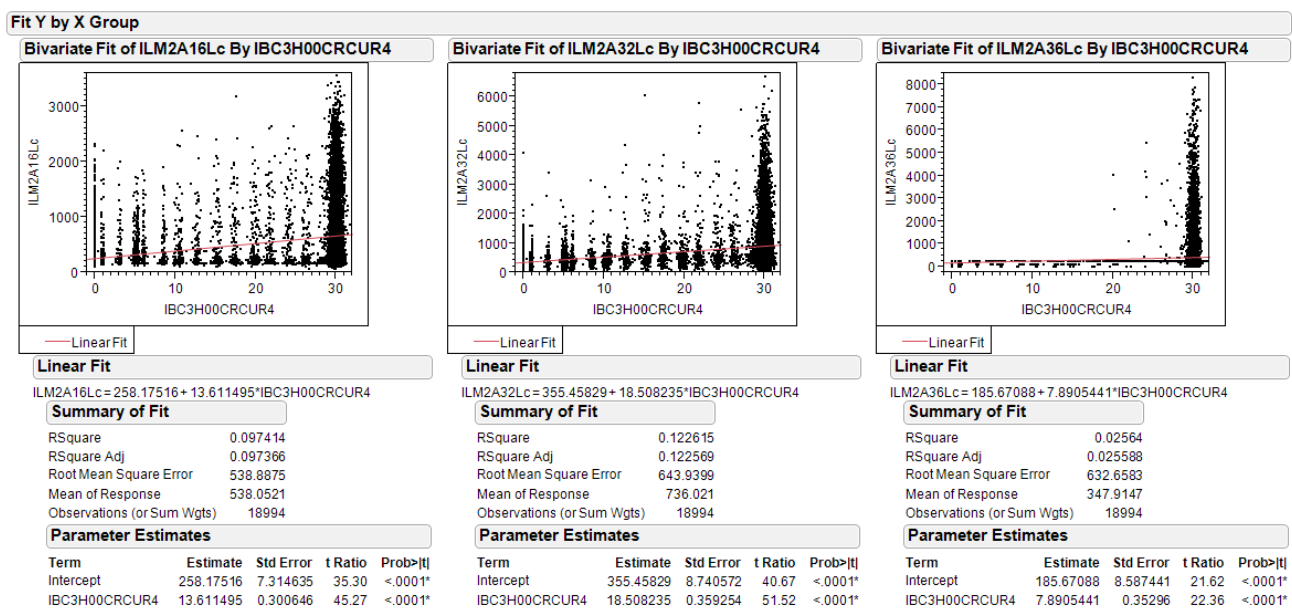


Figure 2. Arc 2 BLMs with little or no correlation to Hall C current. Period A, before seed change.

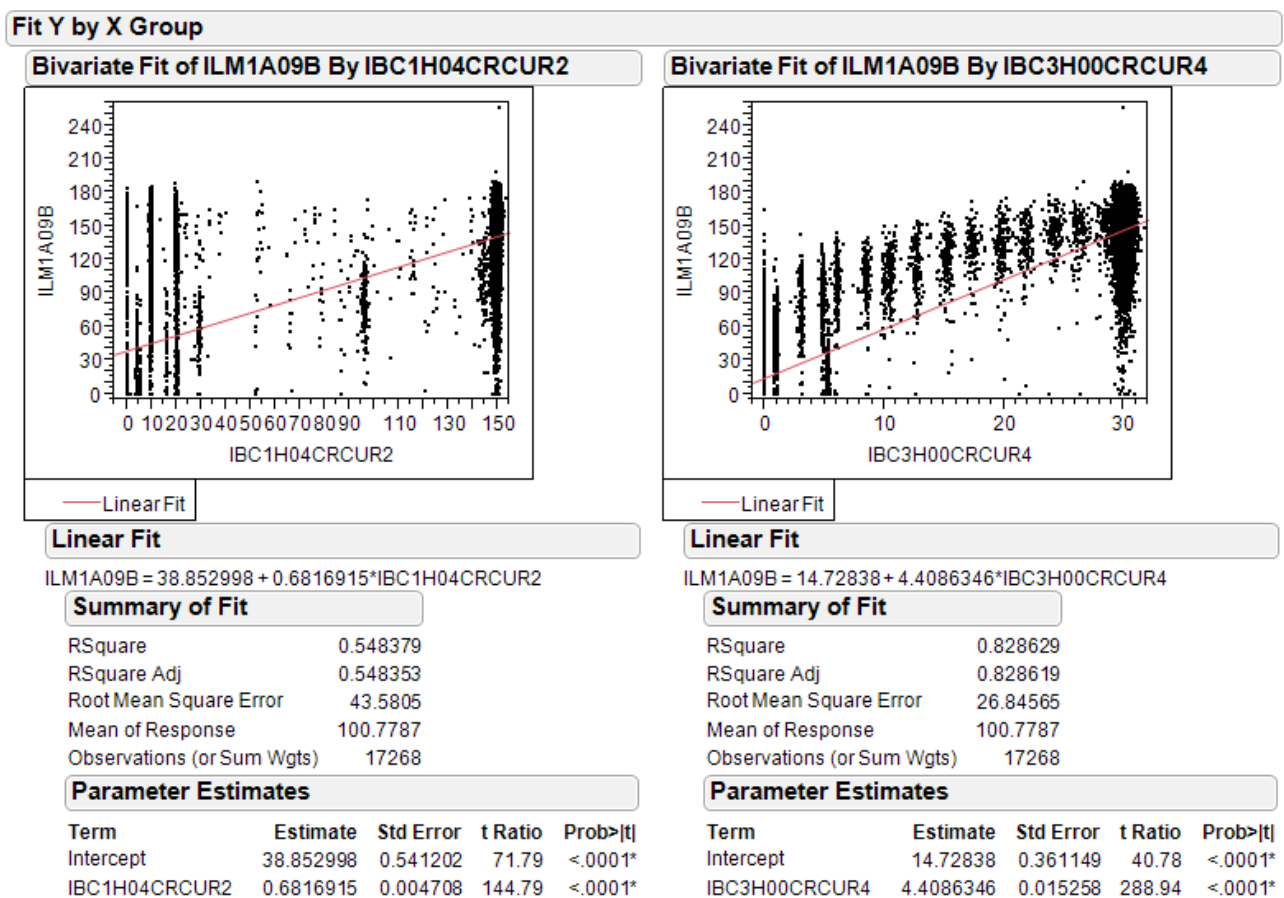


Figure 3. ILM1A09 vs Hall A and Hall C currents with both in the machine, before seed change. Correlation with Hall C (3H00) current is better than with Hall A, even though Hall A has five times the current for most of the period.

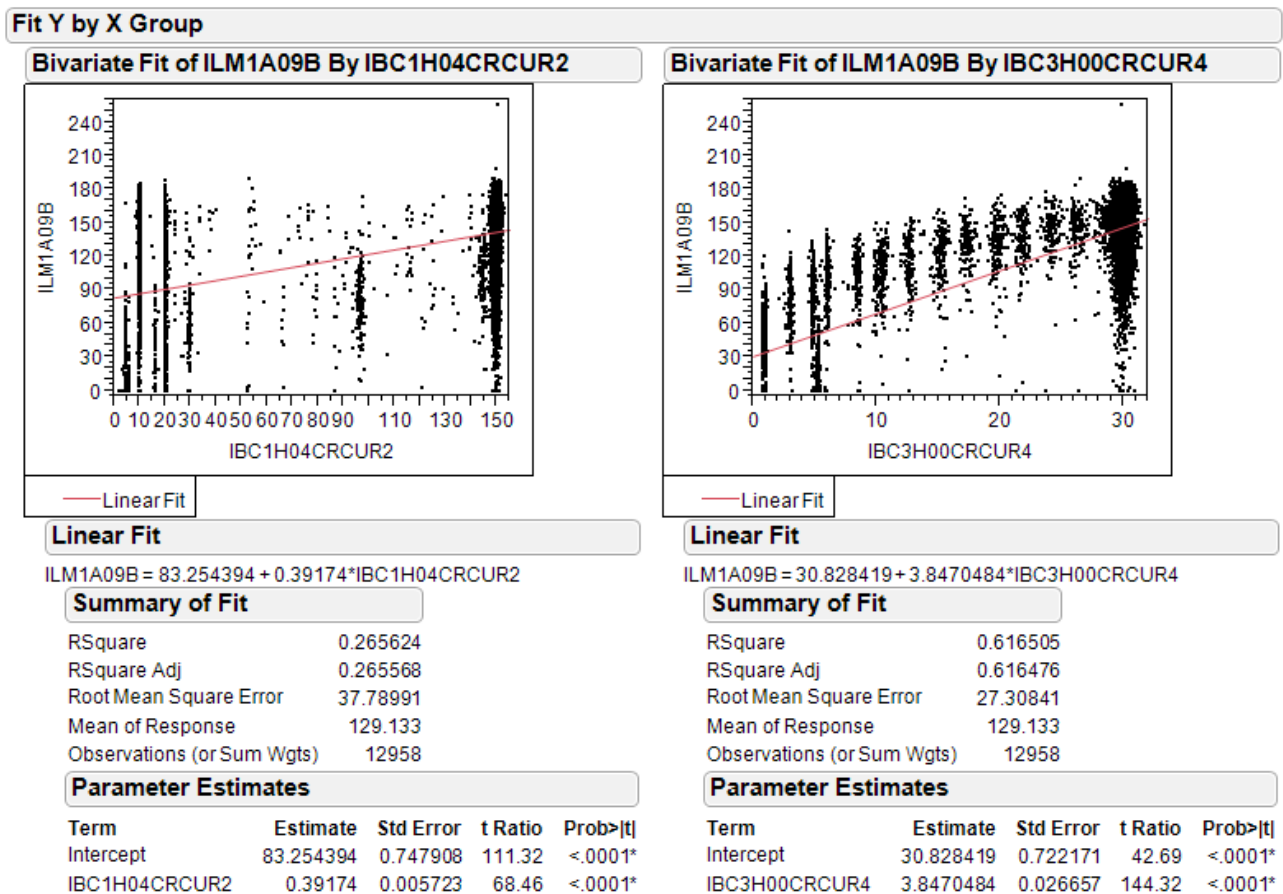
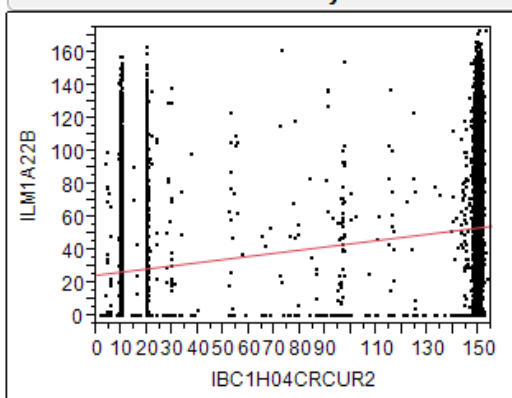


Figure 4. Same as figure 3 except points with both A and C currents under 1 μ A are removed. Cutting out the near-zero currents reduced R^2 for Hall A current by just over half while it reduced R^2 for Hall C current by only a fourth. This suggests that Hall C beam was responsible for the majority of the BLM activity even in arc 1 where Hall A current is five times as great.

I will now proceed to waste space by showing similar plots for the other four arc 1 BLMs whose data for period A I have on hand.

Bivariate Fit of ILM1A22B By IBC1H04CRCUR2



— Linear Fit

Linear Fit

$$\text{ILM1A22B} = 25.117858 + 0.1912808 \cdot \text{IBC1H04CRCUR2}$$

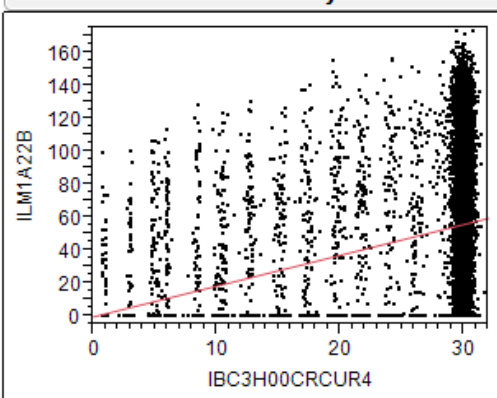
Summary of Fit

RSquare	0.055512
RSquare Adj	0.055439
Root Mean Square Error	45.77512
Mean of Response	47.51968
Observations (or Sum Wgts)	12958

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	25.117858	0.905945	27.73	<.0001*
IBC1H04CRCUR2	0.1912808	0.006932	27.59	<.0001*

Bivariate Fit of ILM1A22B By IBC3H00CRCUR4



— Linear Fit

Linear Fit

$$\text{ILM1A22B} = -0.238753 + 1.8689776 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

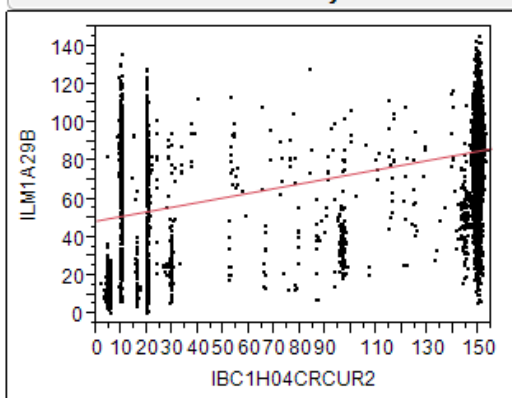
RSquare	0.127544
RSquare Adj	0.127477
Root Mean Square Error	43.99496
Mean of Response	47.51968
Observations (or Sum Wgts)	12958

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-0.238753	1.163447	-0.21	0.8374
IBC3H00CRCUR4	1.8689776	0.042945	43.52	<.0001*

Figure 5. ILM1A22 is almost useless, so I won't show it again.

Bivariate Fit of ILM1A29B By IBC1H04CRCUR2



— Linear Fit

Linear Fit

$$\text{ILM1A29B} = 48.886997 + 0.2435606 \cdot \text{IBC1H04CRCUR2}$$

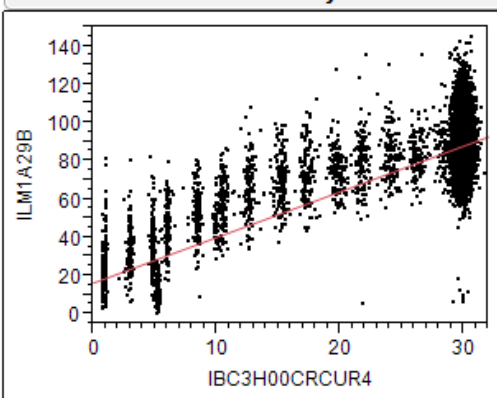
Summary of Fit

RSquare	0.305191
RSquare Adj	0.305137
Root Mean Square Error	21.32095
Mean of Response	77.41156
Observations (or Sum Wgts)	12958

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	48.886997	0.421967	115.85	<.0001*
IBC1H04CRCUR2	0.2435606	0.003229	75.44	<.0001*

Bivariate Fit of ILM1A29B By IBC3H00CRCUR4



— Linear Fit

Linear Fit

$$\text{ILM1A29B} = 16.420115 + 2.3868381 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

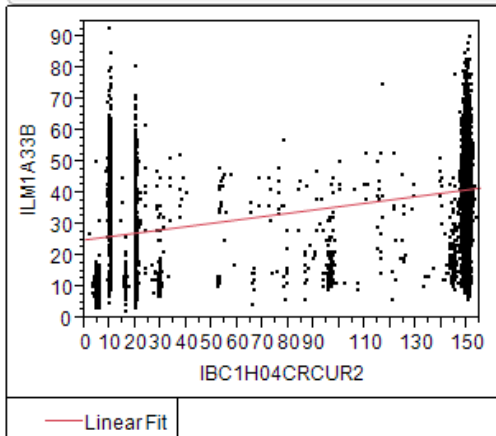
RSquare	0.705364
RSquare Adj	0.705341
Root Mean Square Error	13.88407
Mean of Response	77.41156
Observations (or Sum Wgts)	12958

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	16.420115	0.367164	44.72	<.0001*
IBC3H00CRCUR4	2.3868381	0.013553	176.12	<.0001*

Figure 6. ILM1A29 has much better correlation with current

Bivariate Fit of ILM1A33B By IBC1H04CRCUR2



Linear Fit

$$\text{ILM1A33B} = 25.317656 + 0.106908 \cdot \text{IBC1H04CRCUR2}$$

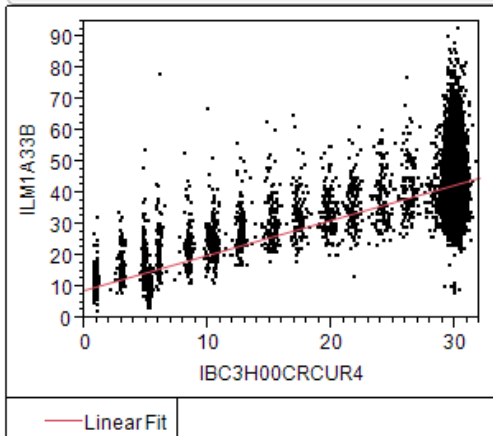
Summary of Fit

RSquare	0.218446
RSquare Adj	0.218386
Root Mean Square Error	11.73196
Mean of Response	37.83817
Observations (or Sum Wgts)	12958

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	25.317656	0.23219	109.04	<.0001*
IBC1H04CRCUR2	0.106908	0.001777	60.18	<.0001*

Bivariate Fit of ILM1A33B By IBC3H00CRCUR4



Linear Fit

$$\text{ILM1A33B} = 9.103417 + 1.1245053 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

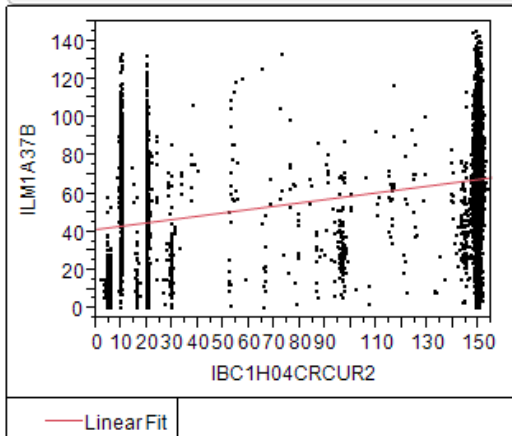
RSquare	0.581643
RSquare Adj	0.58161
Root Mean Square Error	8.583504
Mean of Response	37.83817
Observations (or Sum Wgts)	12958

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	9.103417	0.226991	40.10	<.0001*
IBC3H00CRCUR4	1.1245053	0.008379	134.21	<.0001*

Figure 7. ILM1A33 vs currents

Bivariate Fit of ILM1A37B By IBC1H04CRCUR2



Linear Fit

$$\text{ILM1A37B} = 41.74789 + 0.1741027 \cdot \text{IBC1H04CRCUR2}$$

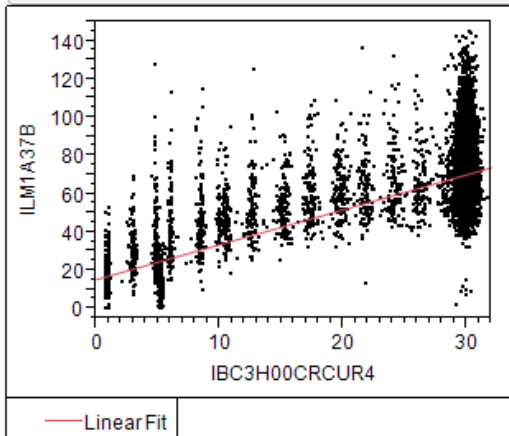
Summary of Fit

RSquare	0.187506
RSquare Adj	0.187443
Root Mean Square Error	21.02622
Mean of Response	62.13791
Observations (or Sum Wgts)	12958

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	41.74789	0.416134	100.32	<.0001*
IBC1H04CRCUR2	0.1741027	0.003184	54.68	<.0001*

Bivariate Fit of ILM1A37B By IBC3H00CRCUR4



Linear Fit

$$\text{ILM1A37B} = 15.49094 + 1.8254815 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

RSquare	0.496098
RSquare Adj	0.49606
Root Mean Square Error	16.55861
Mean of Response	62.13791
Observations (or Sum Wgts)	12958

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	15.49094	0.437892	35.38	<.0001*
IBC3H00CRCUR4	1.8254815	0.016163	112.94	<.0001*

Figure 8. ILM1A29 vs currents

I conclude that before the laser seed swap that the Hall C beam was the cause of perhaps two-thirds the arc 1 BLM activity. I will now examine period B when Hall C was off for ILMs 9, 29, 33 and 37.

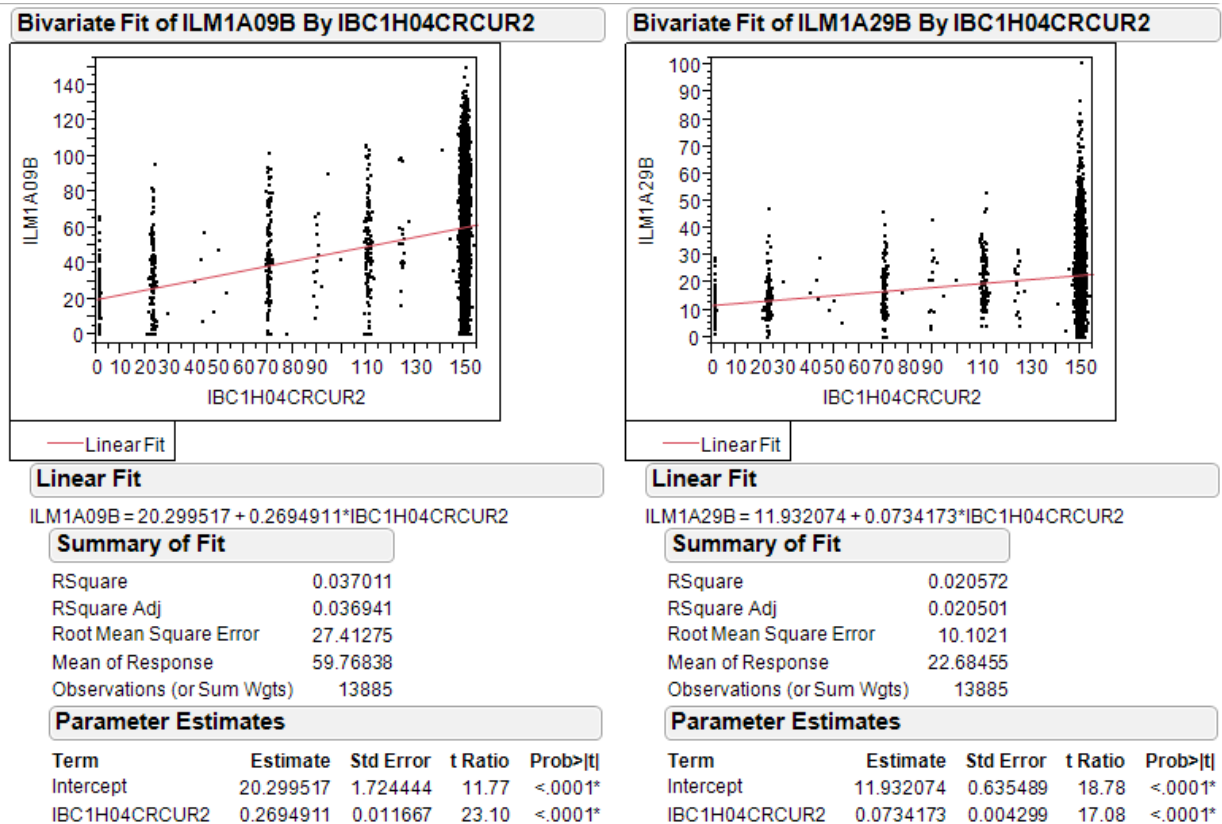


Figure 9: BLMs 9 and 29 with only Hall A, B and D beam in the machine.

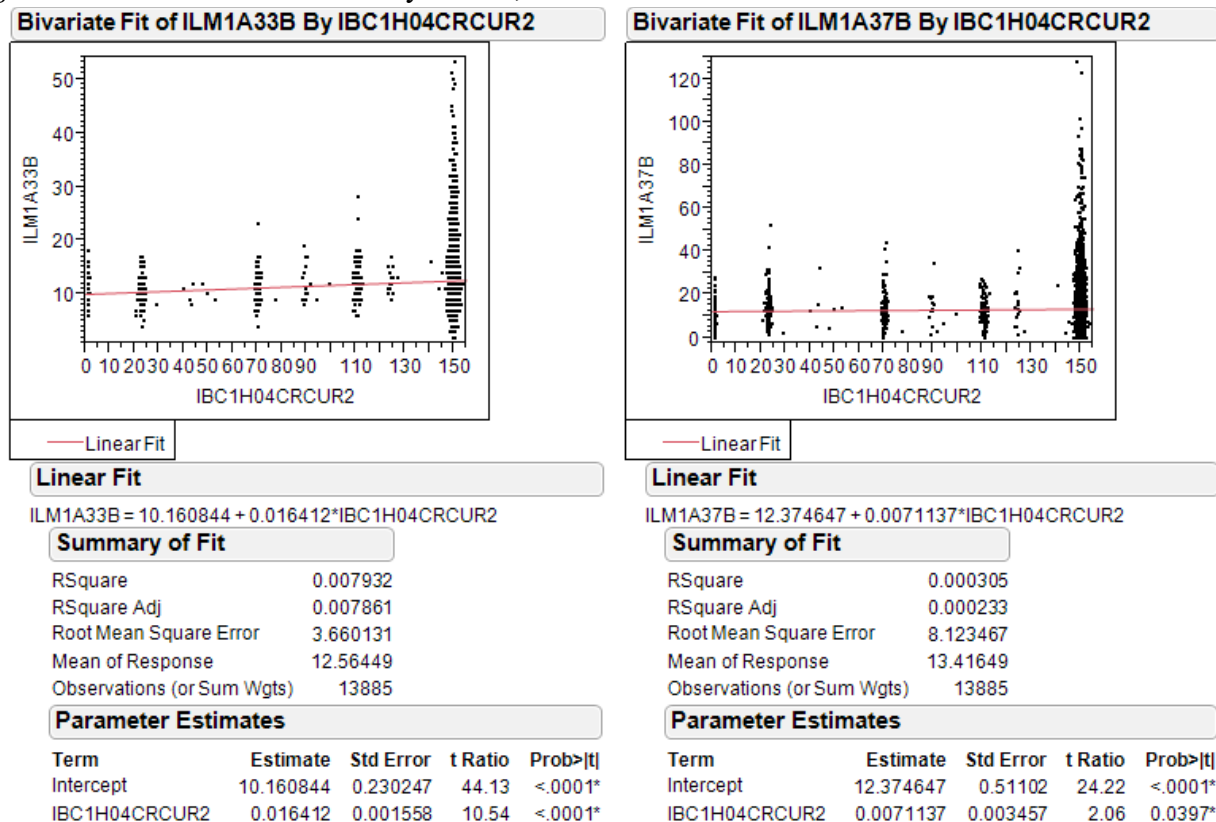
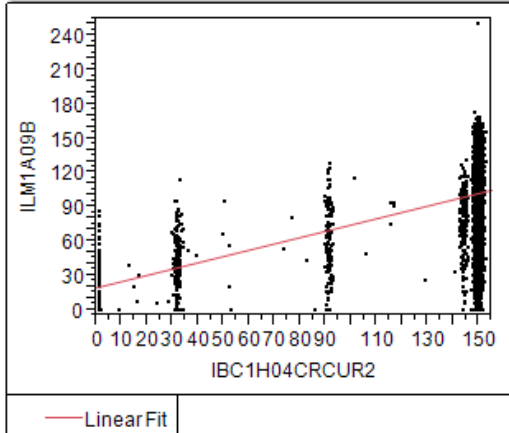


Figure 10. BLMs 33 and 37 with only Hall A, B and D beams in the machine

Bivariate Fit of ILM1A09B By IBC1H04CRCUR2



Linear Fit

$$\text{ILM1A09B} = 19.541228 + 0.5518795 \cdot \text{IBC1H04CRCUR2}$$

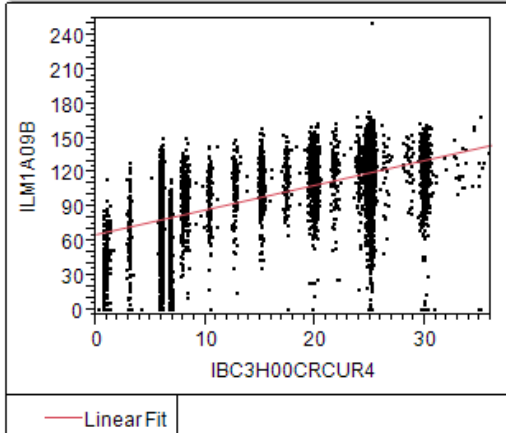
Summary of Fit

RSquare	0.058153
RSquare Adj	0.058078
Root Mean Square Error	31.4869
Mean of Response	101.1765
Observations (or Sum Wgts)	12586

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	19.541228	2.942113	6.64	<.0001*
IBC1H04CRCUR2	0.5518795	0.019799	27.87	<.0001*

Bivariate Fit of ILM1A09B By IBC3H00CRCUR4



Linear Fit

$$\text{ILM1A09B} = 66.282626 + 2.1709018 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

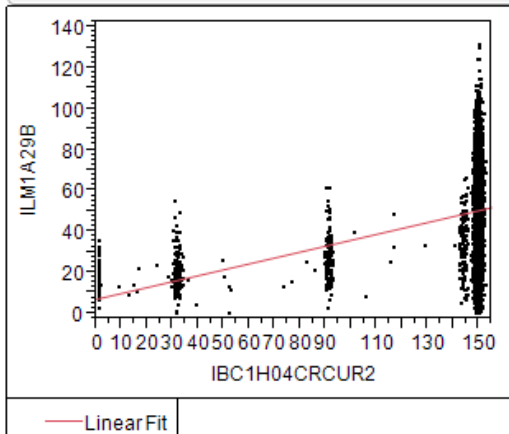
RSquare	0.403516
RSquare Adj	0.403469
Root Mean Square Error	25.05756
Mean of Response	101.1765
Observations (or Sum Wgts)	12586

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	66.282626	0.439219	150.91	<.0001*
IBC3H00CRCUR4	2.1709018	0.023529	92.27	<.0001*

Figure 11. BLM after seed swap with four halls operating, period C. Points removed if both A,C<1.

Bivariate Fit of ILM1A29B By IBC1H04CRCUR2



Linear Fit

$$\text{ILM1A29B} = 7.2654265 + 0.2884778 \cdot \text{IBC1H04CRCUR2}$$

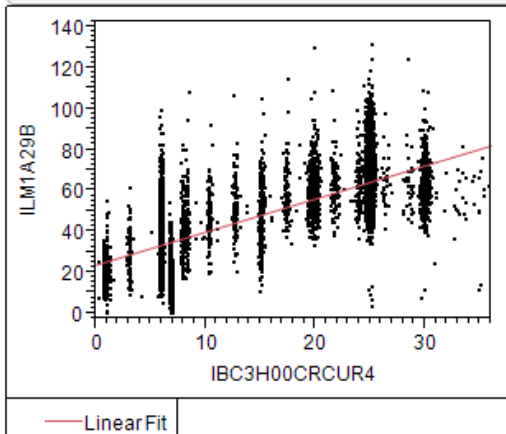
Summary of Fit

RSquare	0.043657
RSquare Adj	0.043581
Root Mean Square Error	19.14134
Mean of Response	49.93771
Observations (or Sum Wgts)	12586

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	7.2654265	1.788553	4.06	<.0001*
IBC1H04CRCUR2	0.2884778	0.012036	23.97	<.0001*

Bivariate Fit of ILM1A29B By IBC3H00CRCUR4



Linear Fit

$$\text{ILM1A29B} = 23.91669 + 1.6188839 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

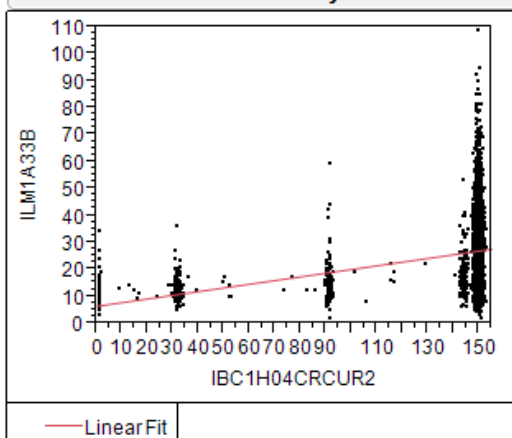
RSquare	0.616539
RSquare Adj	0.616508
Root Mean Square Error	12.12066
Mean of Response	49.93771
Observations (or Sum Wgts)	12586

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	23.91669	0.212456	112.57	<.0001*
IBC3H00CRCUR4	1.6188839	0.011381	142.24	<.0001*

Figure 12. BLM 1A29 after seed swap with four halls operating.

Bivariate Fit of ILM1A33B By IBC1H04CRCUR2



Linear Fit

$$\text{ILM1A33B} = 6.4614684 + 0.1368927 \cdot \text{IBC1H04CRCUR2}$$

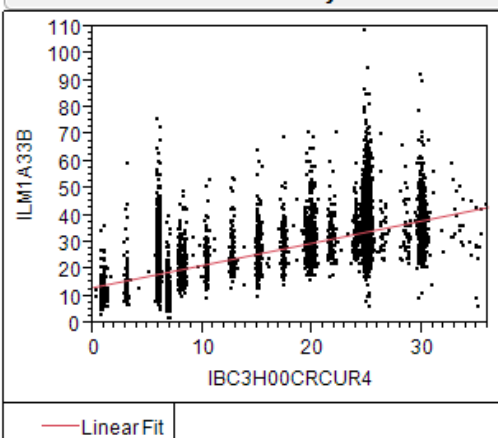
Summary of Fit

RSquare	0.030236
RSquare Adj	0.030159
Root Mean Square Error	10.99082
Mean of Response	26.71095
Observations (or Sum Wgts)	12586

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	6.4614684	1.026975	6.29	<.0001*
IBC1H04CRCUR2	0.1368927	0.006911	19.81	<.0001*

Bivariate Fit of ILM1A33B By IBC3H00CRCUR4



Linear Fit

$$\text{ILM1A33B} = 13.441351 + 0.825561 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

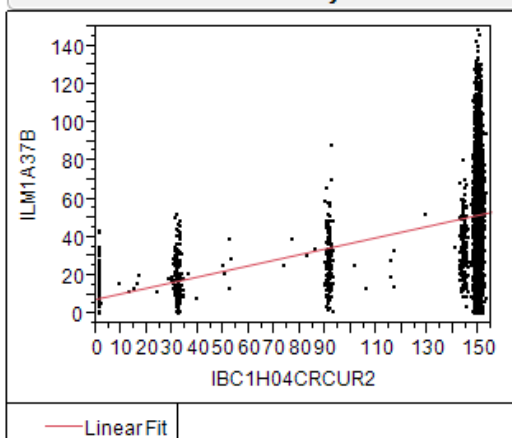
RSquare	0.493133
RSquare Adj	0.493092
Root Mean Square Error	7.945924
Mean of Response	26.71095
Observations (or Sum Wgts)	12586

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	13.441351	0.139279	96.51	<.0001*
IBC3H00CRCUR4	0.825561	0.007461	110.65	<.0001*

Figure 13. BLM 1A33 after seed swap with four halls operating.

Bivariate Fit of ILM1A37B By IBC1H04CRCUR2



Linear Fit

$$\text{ILM1A37B} = 8.0690686 + 0.2925199 \cdot \text{IBC1H04CRCUR2}$$

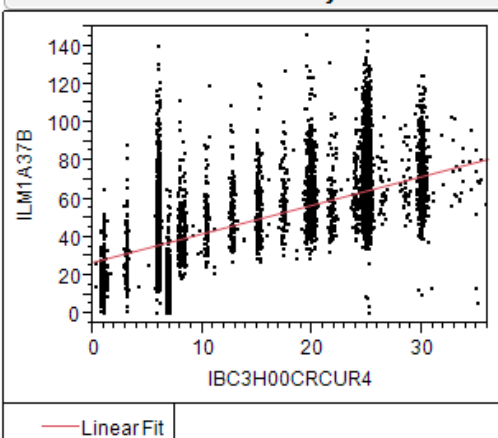
Summary of Fit

RSquare	0.037925
RSquare Adj	0.037849
Root Mean Square Error	20.88696
Mean of Response	51.33927
Observations (or Sum Wgts)	12586

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	8.0690686	1.951662	4.13	<.0001*
IBC1H04CRCUR2	0.2925199	0.013134	22.27	<.0001*

Bivariate Fit of ILM1A37B By IBC3H00CRCUR4



Linear Fit

$$\text{ILM1A37B} = 27.297165 + 1.4957666 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

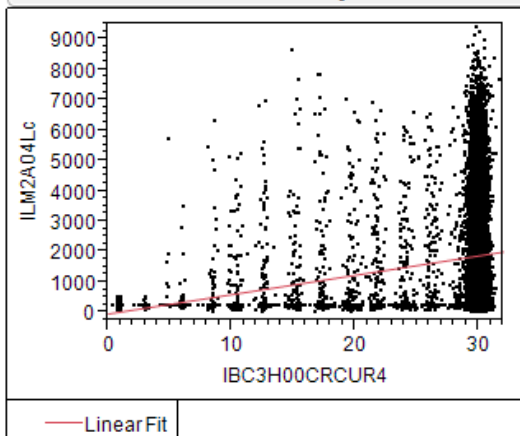
RSquare	0.444678
RSquare Adj	0.444634
Root Mean Square Error	15.86876
Mean of Response	51.33927
Observations (or Sum Wgts)	12586

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	27.297165	0.278154	98.14	<.0001*
IBC3H00CRCUR4	1.4957666	0.014901	100.38	<.0001*

Figure 14. BLM 1A37 after seed swap with four halls operating.

Bivariate Fit of ILM2A04Lc By IBC3H00CRCUR4



Linear Fit

$$\text{ILM2A04Lc} = -29.8276 + 63.768781 \cdot \text{IBC3H00CRCUR4}$$

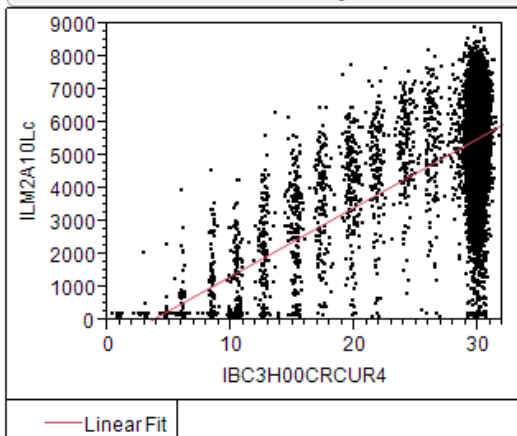
Summary of Fit

RSquare	0.09154
RSquare Adj	0.09148
Root Mean Square Error	1736.97
Mean of Response	1622.402
Observations (or Sum Wgts)	15070

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-29.8276	44.70081	-0.67	0.5046
IBC3H00CRCUR4	63.768781	1.636543	38.97	<.0001*

Bivariate Fit of ILM2A10Lc By IBC3H00CRCUR4



Linear Fit

$$\text{ILM2A10Lc} = -731.4927 + 208.94058 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

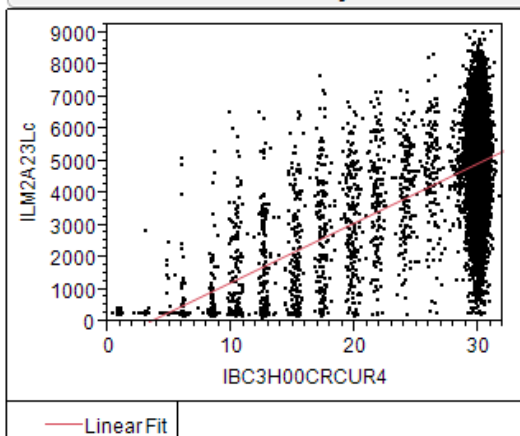
RSquare	0.689438
RSquare Adj	0.689417
Root Mean Square Error	1212.512
Mean of Response	4682.095
Observations (or Sum Wgts)	15070

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-731.4927	31.20394	-23.44	<.0001*
IBC3H00CRCUR4	208.94058	1.142409	182.89	<.0001*

Figure 15. Arc 2 BLMs with Hall C > 1 μA before seed change. Note scale difference vs arc 1.

Bivariate Fit of ILM2A23Lc By IBC3H00CRCUR4



Linear Fit

$$\text{ILM2A23Lc} = -611.5163 + 185.65788 \cdot \text{IBC3H00CRCUR4}$$

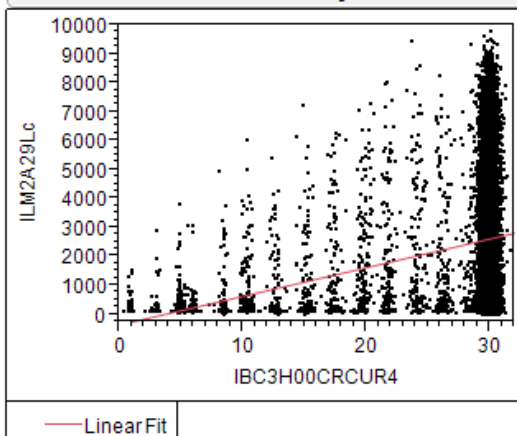
Summary of Fit

RSquare	0.608778
RSquare Adj	0.608752
Root Mean Square Error	1286.865
Mean of Response	4198.824
Observations (or Sum Wgts)	15070

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-611.5163	33.11738	-18.47	<.0001*
IBC3H00CRCUR4	185.65788	1.212462	153.12	<.0001*

Bivariate Fit of ILM2A29Lc By IBC3H00CRCUR4



Linear Fit

$$\text{ILM2A29Lc} = -349.11 + 99.010305 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

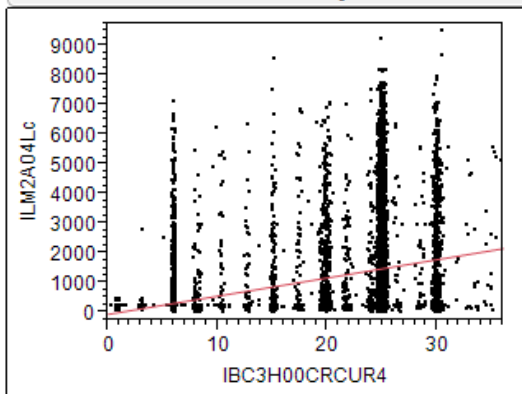
RSquare	0.141124
RSquare Adj	0.141067
Root Mean Square Error	2111.945
Mean of Response	2216.217
Observations (or Sum Wgts)	15070

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-349.11	54.35078	-6.42	<.0001*
IBC3H00CRCUR4	99.010305	1.989839	49.76	<.0001*

Figure 16. Arc 2 BLMs with Hall C > 1 μA before seed change.

Bivariate Fit of ILM2A04Lc By IBC3H00CRCUR4



— LinearFit

Linear Fit

$$\text{ILM2A04Lc} = -32.93605 + 61.486685 \cdot \text{IBC3H00CRCUR4}$$

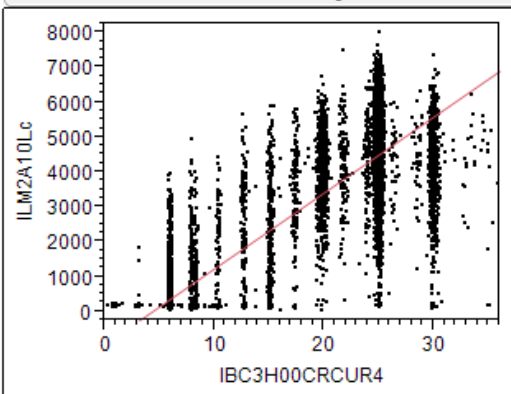
Summary of Fit

RSquare	0.164469
RSquare Adj	0.164411
Root Mean Square Error	1311.012
Mean of Response	956.3217
Observations (or Sum Wgts)	14611

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-32.93605	21.3997	-1.54	0.1238
IBC3H00CRCUR4	61.486685	1.146597	53.63	<.0001*

Bivariate Fit of ILM2A10Lc By IBC3H00CRCUR4



— LinearFit

Linear Fit

$$\text{ILM2A10Lc} = -938.995 + 217.91905 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

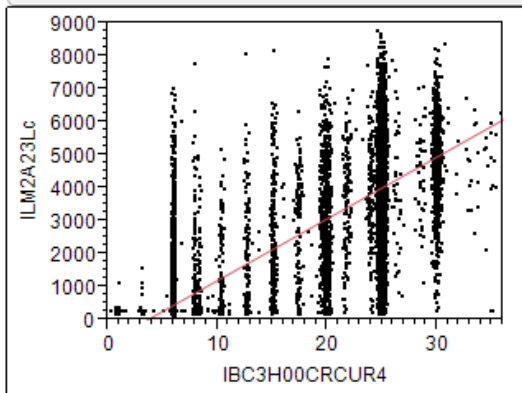
RSquare	0.812572
RSquare Adj	0.812559
Root Mean Square Error	990.074
Mean of Response	2567.099
Observations (or Sum Wgts)	14611

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-938.995	16.16101	-58.10	<.0001*
IBC3H00CRCUR4	217.91905	0.865908	251.67	<.0001*

Figure 17. Arc 2 BLMs after seed change with Hall C > 1 μA .

Bivariate Fit of ILM2A23Lc By IBC3H00CRCUR4



— LinearFit

Linear Fit

$$\text{ILM2A23Lc} = -663.3052 + 187.40937 \cdot \text{IBC3H00CRCUR4}$$

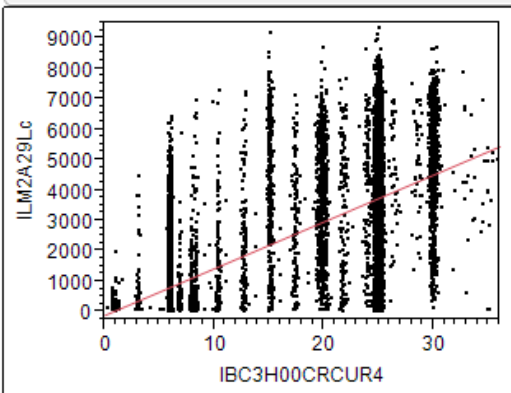
Summary of Fit

RSquare	0.658067
RSquare Adj	0.658044
Root Mean Square Error	1277.945
Mean of Response	2351.919
Observations (or Sum Wgts)	14611

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-663.3052	20.85994	-31.80	<.0001*
IBC3H00CRCUR4	187.40937	1.117677	167.68	<.0001*

Bivariate Fit of ILM2A29Lc By IBC3H00CRCUR4



— LinearFit

Linear Fit

$$\text{ILM2A29Lc} = -96.5539 + 154.0953 \cdot \text{IBC3H00CRCUR4}$$

Summary of Fit

RSquare	0.426369
RSquare Adj	0.426329
Root Mean Square Error	1690.826
Mean of Response	2382.681
Observations (or Sum Wgts)	14611

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-96.5539	27.59941	-3.50	0.0005*
IBC3H00CRCUR4	154.0953	1.478778	104.20	<.0001*

Figure 18. Arc 2 BLMs after seed change with Hall C > 1 μA .

Unfortunately, if I evaluate the linear fits at 30 uA I find that there is modestly less BLM activity attributable to Hall C beam in arc 1 and no significant change in arc 2 except doubling 2A29. Compare the last two columns in the table below. Scale of BLM response is very different in Arc 1 vs Arc 2.

Table 1. Linear fit coefficients and values at 30 uA before and after the laser seed change.

BLM	before_intercept	before_slope	after_intercept	after_slope	before@30uA	after@30uA
1A09	30.83	3.85	66.28	2.17	146	131
1A29	16.42	2.39	23.92	1.62	88	72
1A33	9.10	1.12	13.44	0.83	43	38
1A37	15.49	1.83	27.30	1.50	70	72
2A04	-29.83	63.77	-32.94	61.49	1883	1812
2A10	-731.49	208.94	-939.00	217.92	5537	5599
2A23	-611.52	185.66	-663.31	187.41	4958	4959
2A29	-349.11	99.01	-96.55	154.10	2621	4526

Conclusion: none

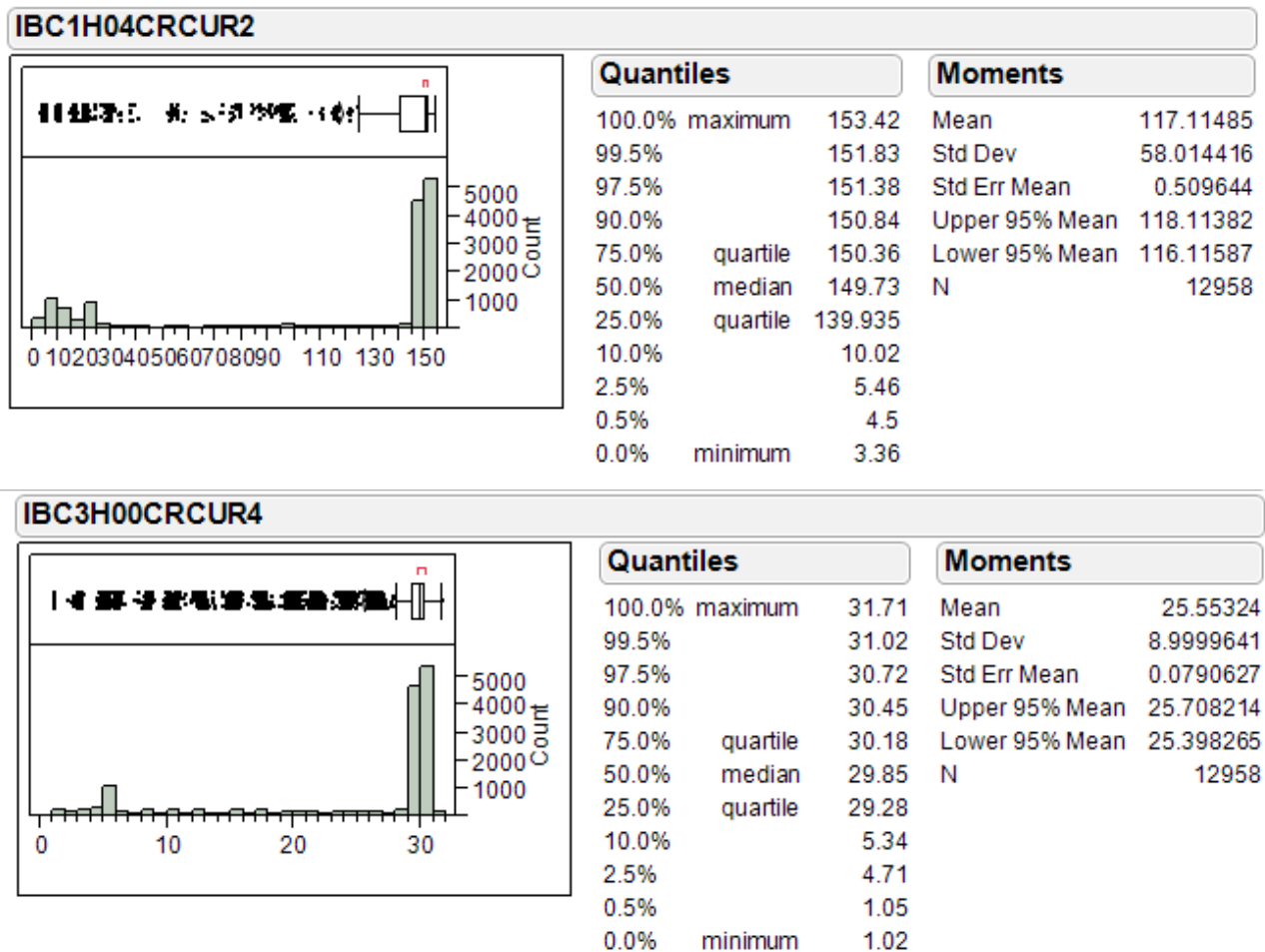


Figure 19. Distributions of currents in period A, the “before” sample

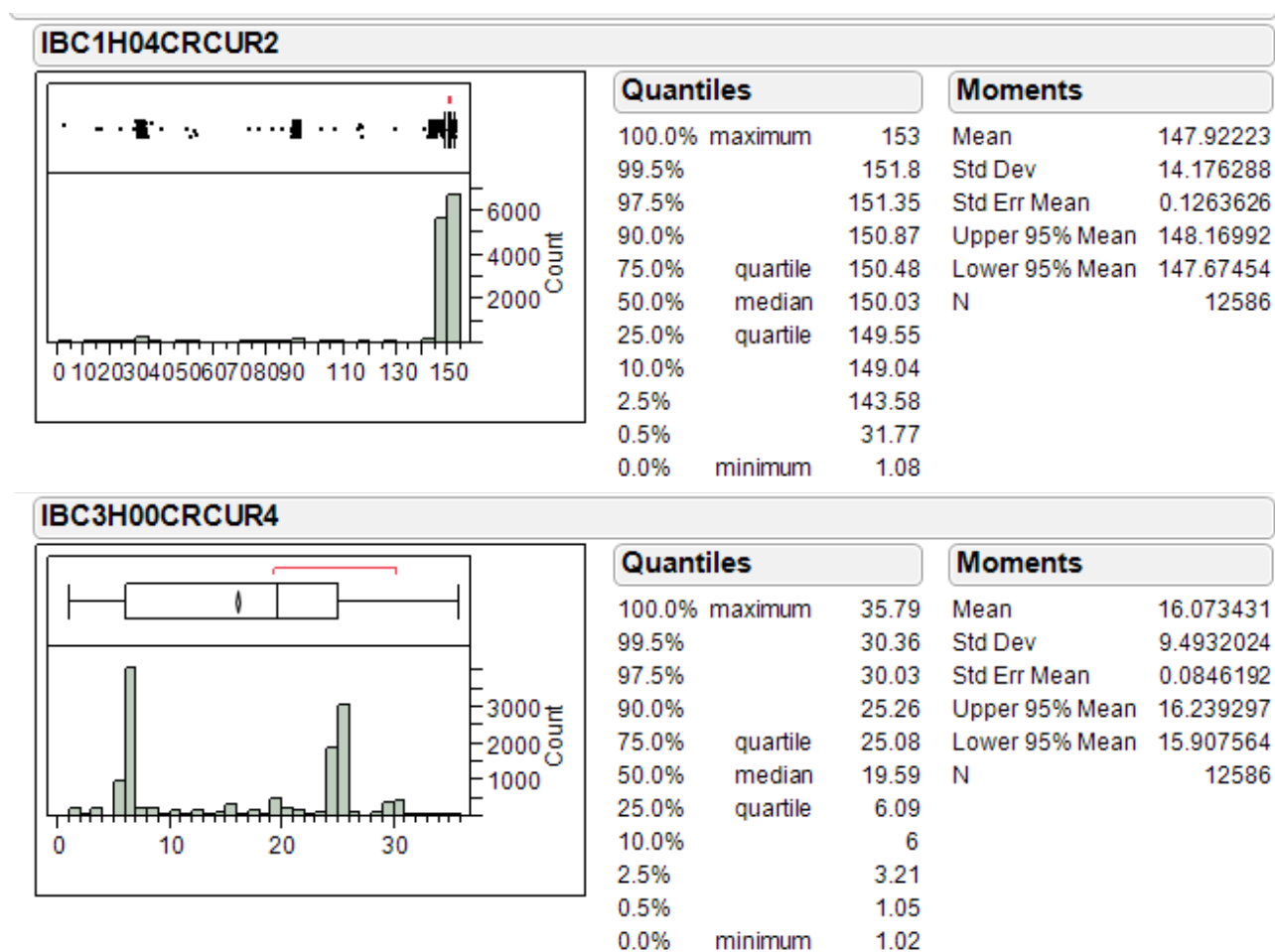


Figure 20. Distribution of currents in period C, the “after” sample.

This data is provided the readers so they may decide whether to ask the author to make additional cuts on the data. Recall that these sets have both A and C currents $\geq 1 \mu\text{A}$. Still no conclusion.