First look at arc BLM activity before/after seed laser swap

Jay Benesch

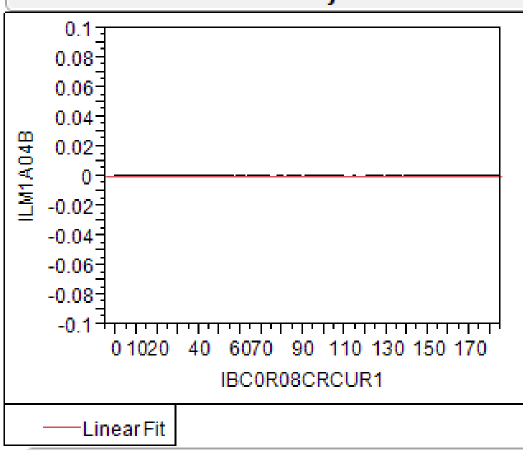
During the FY20 physics run, regions in the higher arcs have been activated in a manner never before seen. Chopper viewer images suggested a tail on the C beam was a cause of the difficulty. Accordingly, on March 19 while Hall C was down to switch experiments from a1n to d2n, the laser seeds for B and C were swapped. The B beam is defined by a narrow chopper slit and is low current so it it 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.

Fit Y by X Group

Bivariate Fit of ILM1A04B By IBC0R08CRCUR1



Linear Fit

ILM1A04B = 0 + 0*IBC0R08CRCUR1

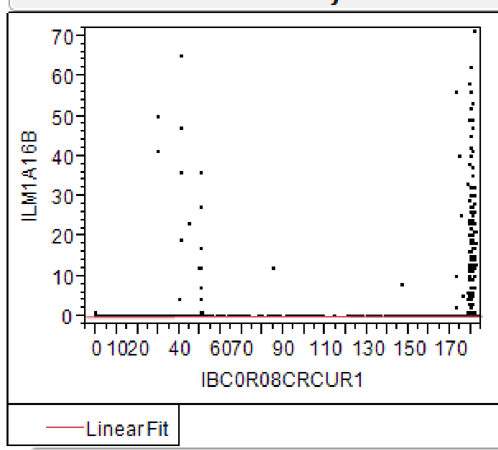
Summary of Fit

RSquare	.
RSquare Adj	.
Root Mean Square Error	0
Mean of Response	0
Observations (or Sum Wgts)	17268

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0	0	.	.
IBC0R08CRCUR1	0	0	.	.

Bivariate Fit of ILM1A16B By IBC0R08CRCUR1



Linear Fit

ILM1A16B = 0.0285057 + 0.001212*IBC0R08CRCUR1

Summary of Fit

RSquare	0.00183
RSquare Adj	0.001772
Root Mean Square Error	2.284086
Mean of Response	0.162729
Observations (or Sum Wgts)	17268

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0285057	0.029517	0.97	0.3342
IBC0R08CRCUR1	0.001212	0.000215	5.63	<.0001*

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

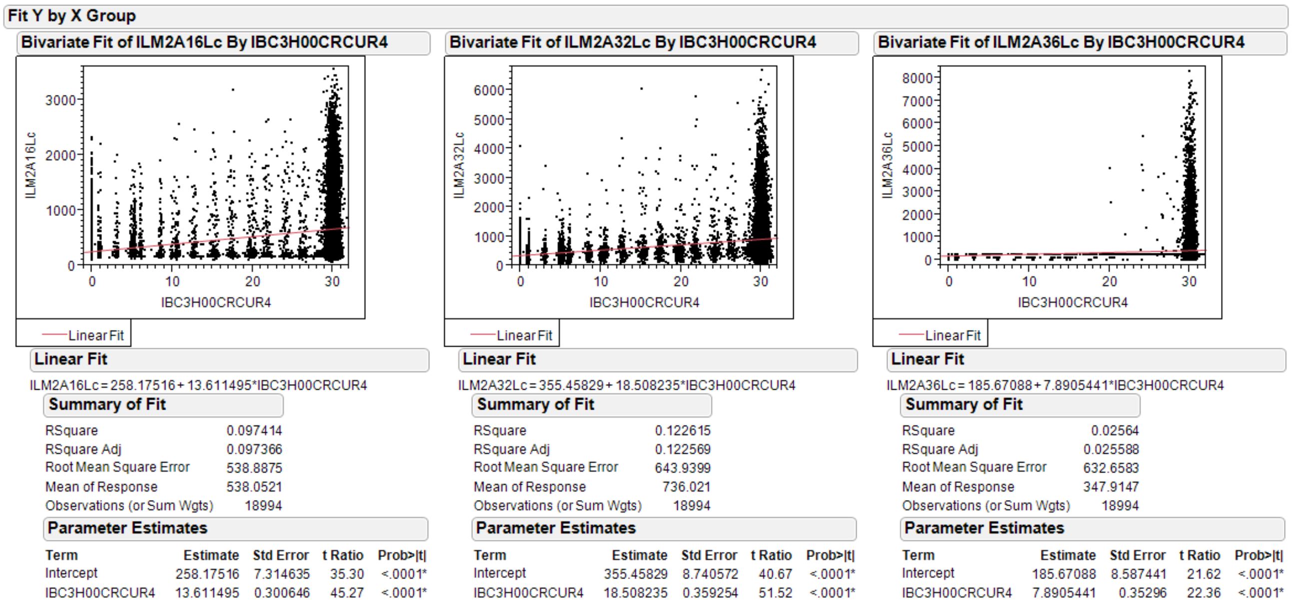


Figure 2. Arc 2 BLMs with little or no correlation to Hall C current. Period A, before seed change.

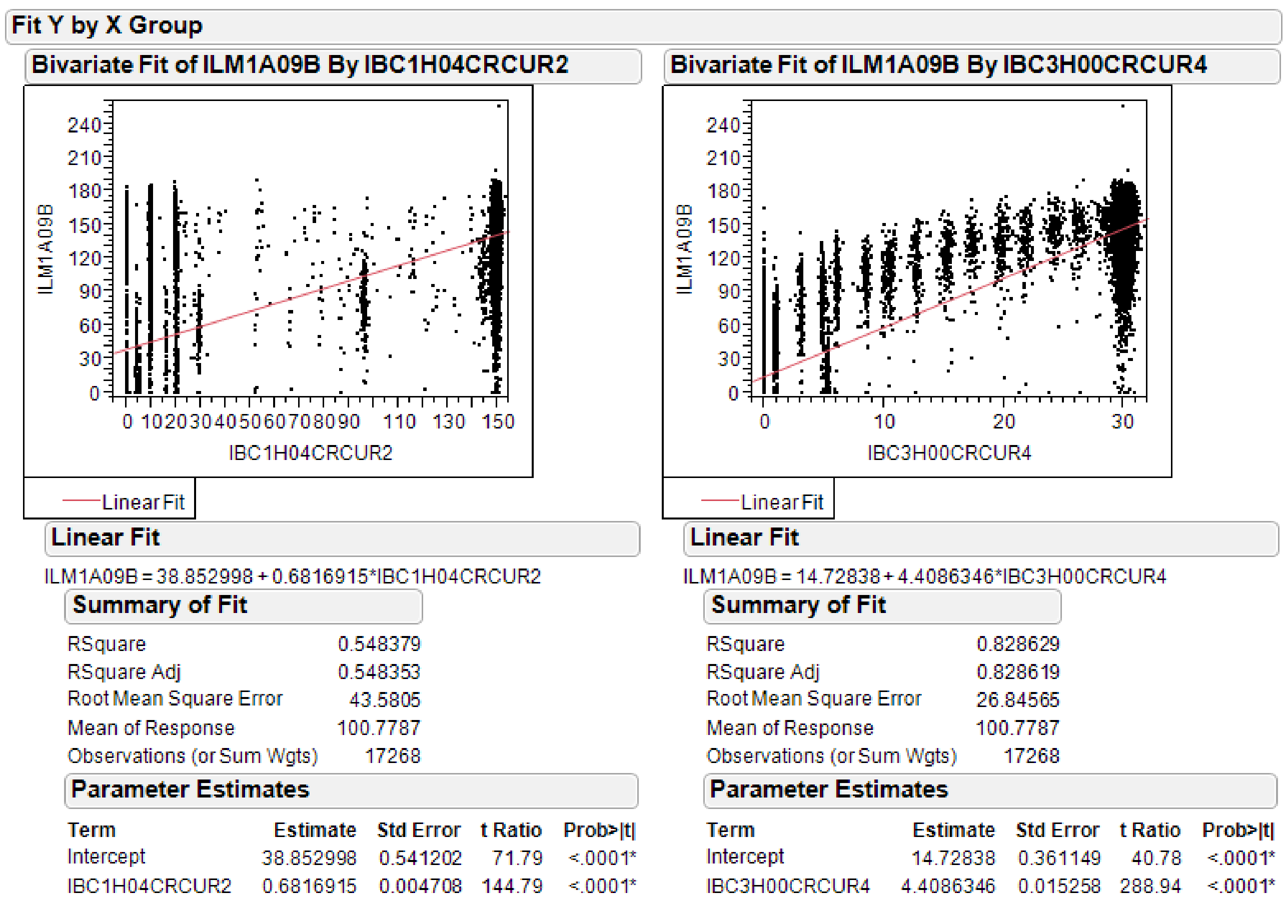
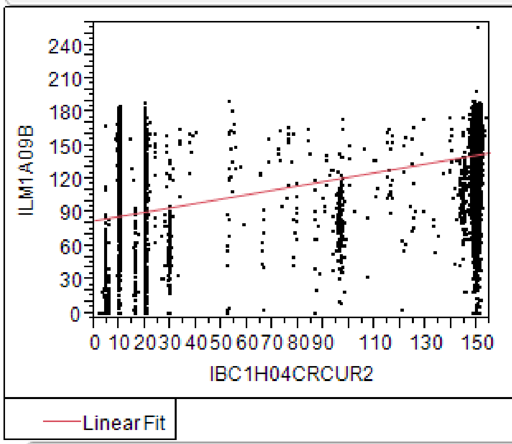


Figure 3. ILM1A09 vs Hall A and Hall C currents with both in the machine, before seed change. Correlation with Hall C (3H00) current is better than with Hall A, even though Hall A has five times the current for most of the period.

Fit Y by X Group

Bivariate Fit of ILM1A09B By IBC1H04CRCUR2



Linear Fit

ILM1A09B = 83.254394 + 0.39174*IBC1H04CRCUR2

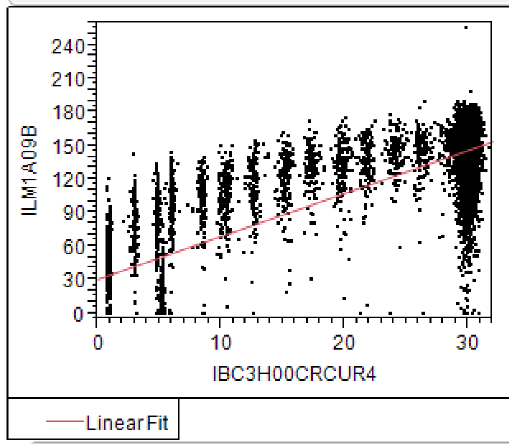
Summary of Fit

RSquare	0.265624
RSquare Adj	0.265568
Root Mean Square Error	37.78991
Mean of Response	129.133
Observations (or Sum Wgts)	12958

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	83.254394	0.747908	111.32	<.0001*
IBC1H04CRCUR2	0.39174	0.005723	68.46	<.0001*

Bivariate Fit of ILM1A09B By IBC3H00CRCUR4



Linear Fit

ILM1A09B = 30.828419 + 3.8470484*IBC3H00CRCUR4

Summary of Fit

RSquare	0.616505
RSquare Adj	0.616476
Root Mean Square Error	27.30841
Mean of Response	129.133
Observations (or Sum Wgts)	12958

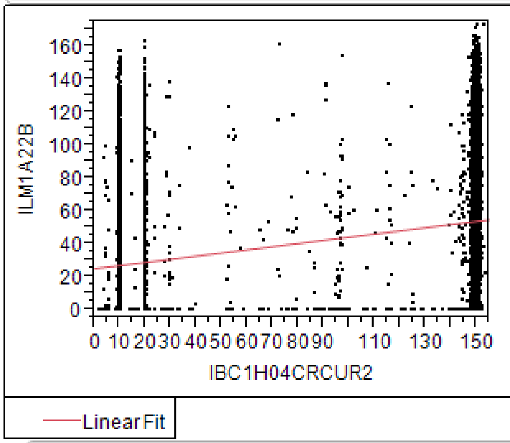
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	30.828419	0.722171	42.69	<.0001*
IBC3H00CRCUR4	3.8470484	0.026657	144.32	<.0001*

Figure 4. Same as figure 3 except points with both A and C currents under 1 μA 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

ILM1A22B = 25.117858 + 0.1912808*IBC1H04CRCUR2

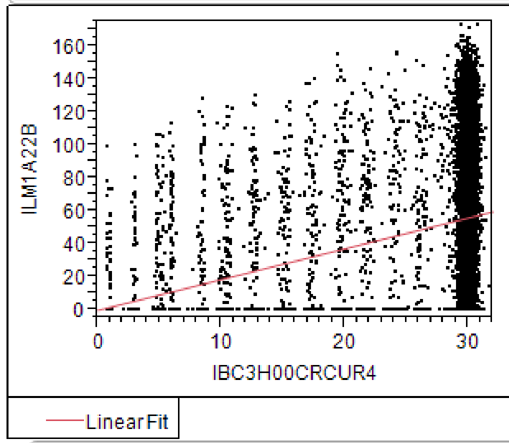
Summary of Fit

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

ILM1A22B = -0.238753 + 1.8689776*IBC3H00CRCUR4

Summary of Fit

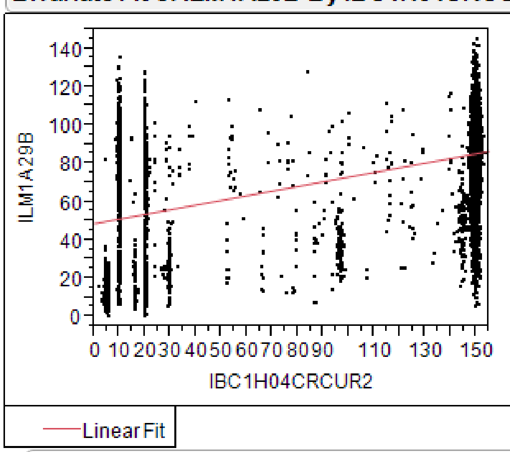
RSquare	0.127544
RSquare Adj	0.127477
Root Mean Square Error	43.99496
Mean of Response	47.51968
Observations (or Sum Wgts)	12958

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

ILM1A29B = 48.886997 + 0.2435606*IBC1H04CRCUR2

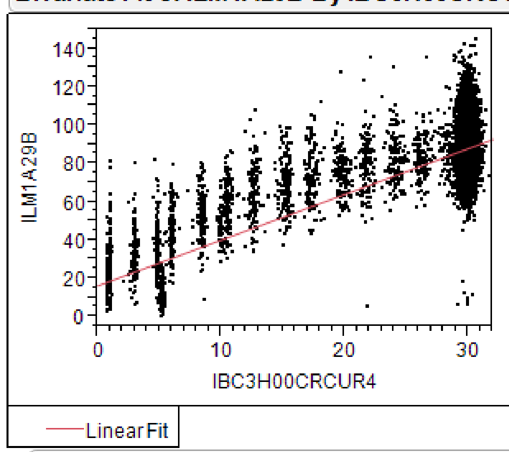
Summary of Fit

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

ILM1A29B = 16.420115 + 2.3868381*IBC3H00CRCUR4

Summary of Fit

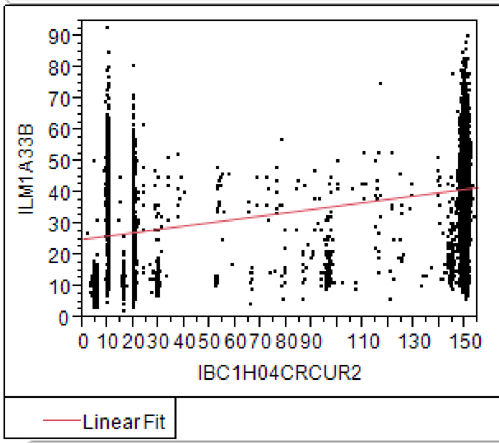
RSquare	0.705364
RSquare Adj	0.705341
Root Mean Square Error	13.88407
Mean of Response	77.41156
Observations (or Sum Wgts)	12958

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

ILM1A33B = 25.317656 + 0.106908*IBC1H04CRCUR2

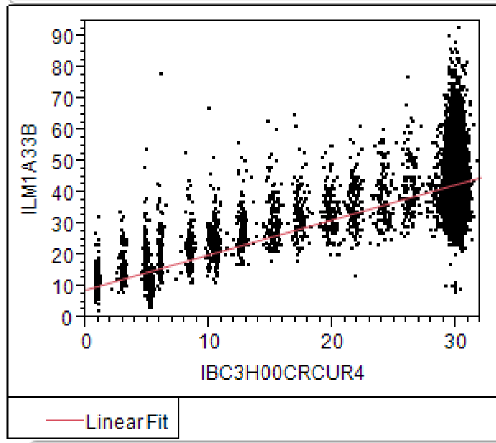
Summary of Fit

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

ILM1A33B = 9.103417 + 1.1245053*IBC3H00CRCUR4

Summary of Fit

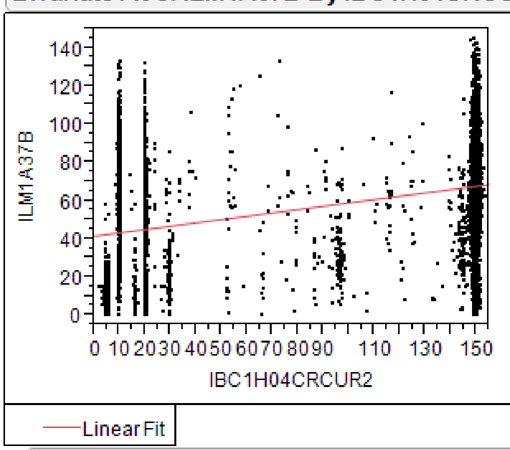
RSquare	0.581643
RSquare Adj	0.58161
Root Mean Square Error	8.583504
Mean of Response	37.83817
Observations (or Sum Wgts)	12958

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

ILM1A37B = 41.74789 + 0.1741027*IBC1H04CRCUR2

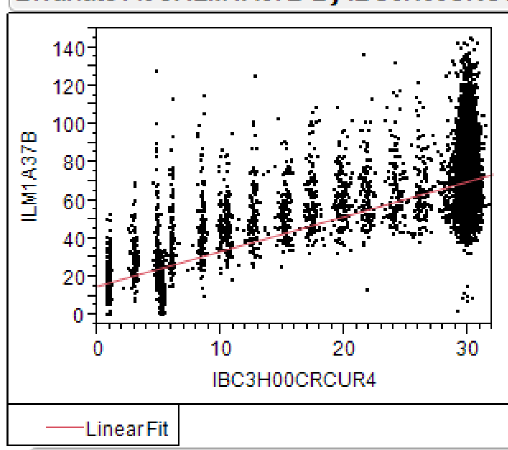
Summary of Fit

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

ILM1A37B = 15.49094 + 1.8254815*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

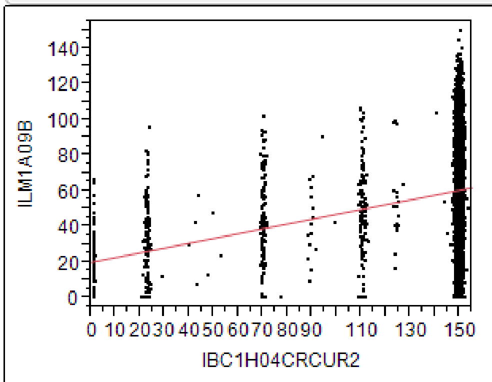
Parameter Estimates

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.

Bivariate Fit of ILM1A09B By IBC1H04CRCUR2



Linear Fit

Linear Fit

ILM1A09B = 20.299517 + 0.2694911*IBC1H04CRCUR2

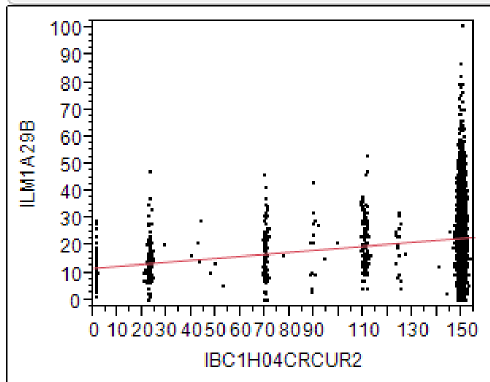
Summary of Fit

RSquare	0.037011
RSquare Adj	0.036941
Root Mean Square Error	27.41275
Mean of Response	59.76838
Observations (or Sum Wgts)	13885

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	20.299517	1.724444	11.77	<.0001*
IBC1H04CRCUR2	0.2694911	0.011667	23.10	<.0001*

Bivariate Fit of ILM1A29B By IBC1H04CRCUR2



Linear Fit

Linear Fit

ILM1A29B = 11.932074 + 0.0734173*IBC1H04CRCUR2

Summary of Fit

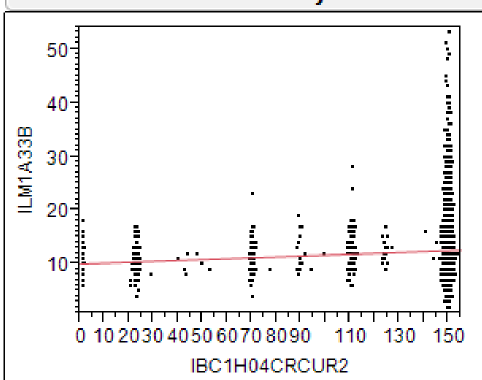
RSquare	0.020572
RSquare Adj	0.020501
Root Mean Square Error	10.1021
Mean of Response	22.68455
Observations (or Sum Wgts)	13885

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	11.932074	0.635489	18.78	<.0001*
IBC1H04CRCUR2	0.0734173	0.004299	17.08	<.0001*

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

Bivariate Fit of ILM1A33B By IBC1H04CRCUR2



Linear Fit

Linear Fit

ILM1A33B = 10.160844 + 0.016412*IBC1H04CRCUR2

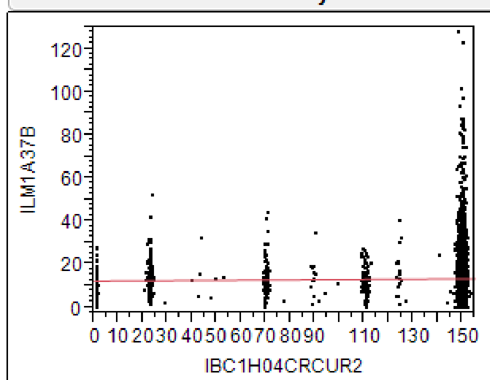
Summary of Fit

RSquare	0.007932
RSquare Adj	0.007861
Root Mean Square Error	3.660131
Mean of Response	12.56449
Observations (or Sum Wgts)	13885

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	10.160844	0.230247	44.13	<.0001*
IBC1H04CRCUR2	0.016412	0.001558	10.54	<.0001*

Bivariate Fit of ILM1A37B By IBC1H04CRCUR2



Linear Fit

Linear Fit

ILM1A37B = 12.374647 + 0.0071137*IBC1H04CRCUR2

Summary of Fit

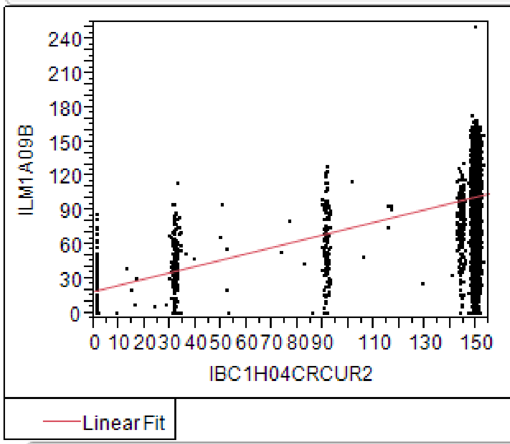
RSquare	0.000305
RSquare Adj	0.000233
Root Mean Square Error	8.123467
Mean of Response	13.41649
Observations (or Sum Wgts)	13885

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	12.374647	0.51102	24.22	<.0001*
IBC1H04CRCUR2	0.0071137	0.003457	2.06	0.0397*

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

ILM1A09B = 19.541228 + 0.5518795*IBC1H04CRCUR2

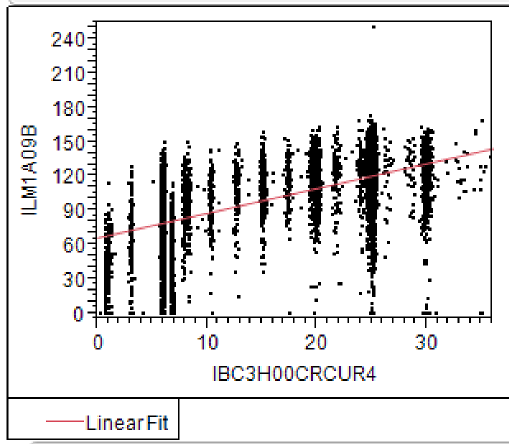
Summary of Fit

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

ILM1A09B = 66.282626 + 2.1709018*IBC3H00CRCUR4

Summary of Fit

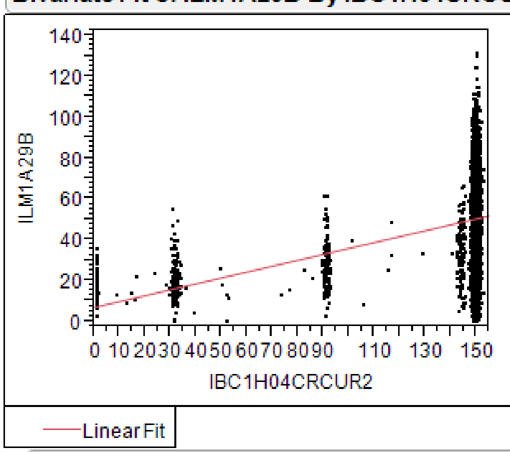
RSquare	0.403516
RSquare Adj	0.403469
Root Mean Square Error	25.05756
Mean of Response	101.1765
Observations (or Sum Wgts)	12586

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

ILM1A29B = 7.2654265 + 0.2884778*IBC1H04CRCUR2

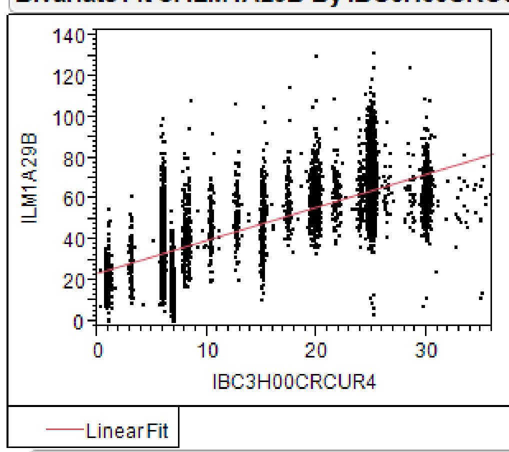
Summary of Fit

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

ILM1A29B = 23.91669 + 1.6188839*IBC3H00CRCUR4

Summary of Fit

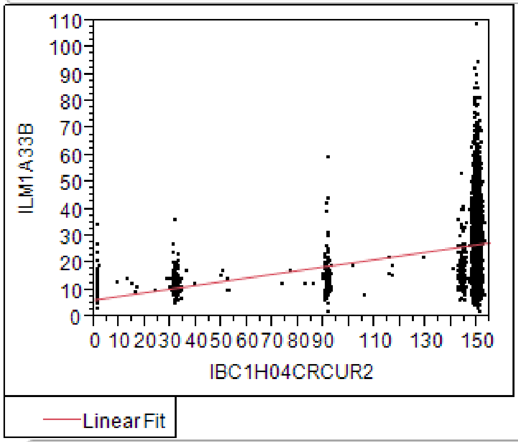
RSquare	0.616539
RSquare Adj	0.616508
Root Mean Square Error	12.12066
Mean of Response	49.93771
Observations (or Sum Wgts)	12586

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

ILM1A33B = 6.4614684 + 0.1368927*IBC1H04CRCUR2

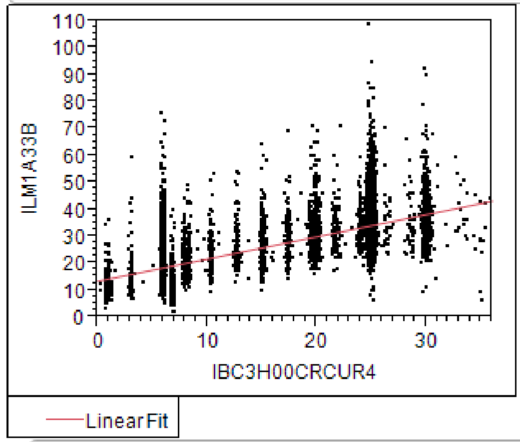
Summary of Fit

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

ILM1A33B = 13.441351 + 0.825561*IBC3H00CRCUR4

Summary of Fit

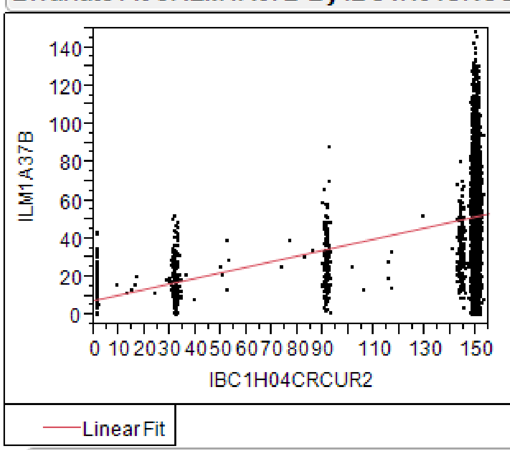
RSquare	0.493133
RSquare Adj	0.493092
Root Mean Square Error	7.945924
Mean of Response	26.71095
Observations (or Sum Wgts)	12586

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

ILM1A37B = 8.0690686 + 0.2925199*IBC1H04CRCUR2

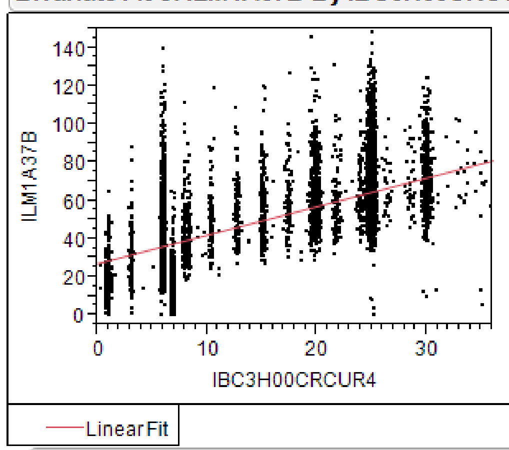
Summary of Fit

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

ILM1A37B = 27.297165 + 1.4957666*IBC3H00CRCUR4

Summary of Fit

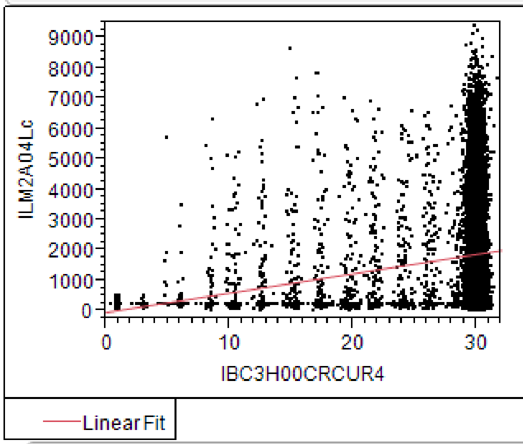
RSquare	0.444678
RSquare Adj	0.444634
Root Mean Square Error	15.86876
Mean of Response	51.33927
Observations (or Sum Wgts)	12586

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

ILM2A04Lc = -29.8276 + 63.768781*IBC3H00CRCUR4

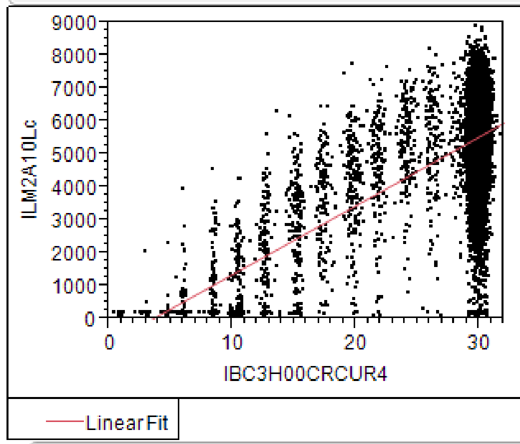
Summary of Fit

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

ILM2A10Lc = -731.4927 + 208.94058*IBC3H00CRCUR4

Summary of Fit

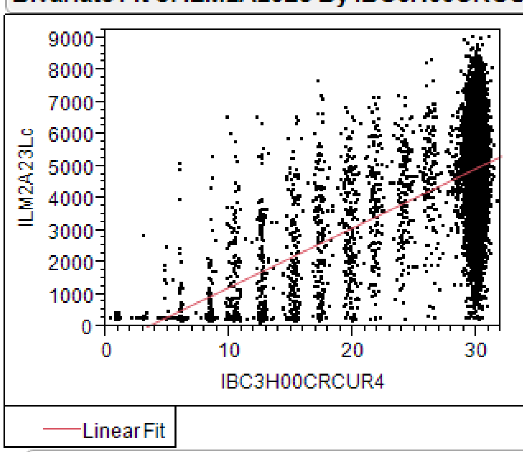
RSquare	0.689438
RSquare Adj	0.689417
Root Mean Square Error	1212.512
Mean of Response	4682.095
Observations (or Sum Wgts)	15070

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

ILM2A23Lc = -611.5163 + 185.65788*IBC3H00CRCUR4

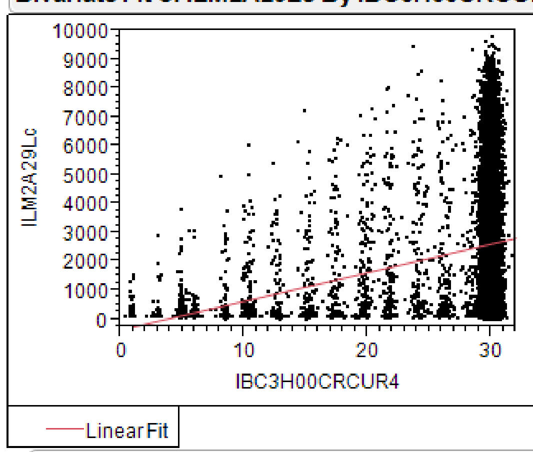
Summary of Fit

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

ILM2A29Lc = -349.11 + 99.010305*IBC3H00CRCUR4

Summary of Fit

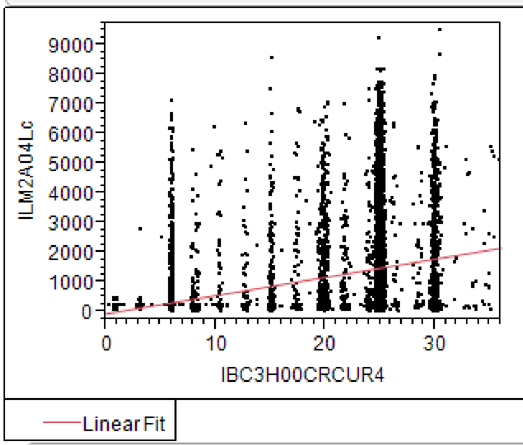
RSquare	0.141124
RSquare Adj	0.141067
Root Mean Square Error	2111.945
Mean of Response	2216.217
Observations (or Sum Wgts)	15070

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



Linear Fit

ILM2A04Lc = -32.93605 + 61.486685*IBC3H00CRCUR4

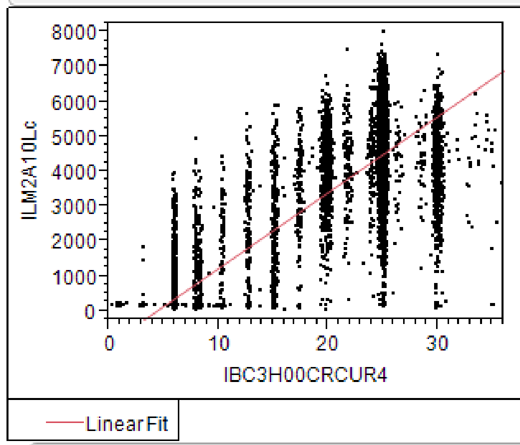
Summary of Fit

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



Linear Fit

ILM2A10Lc = -938.995 + 217.91905*IBC3H00CRCUR4

Summary of Fit

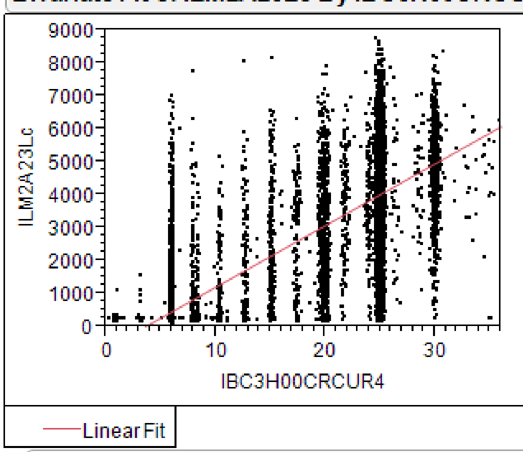
RSquare	0.812572
RSquare Adj	0.812559
Root Mean Square Error	990.074
Mean of Response	2567.099
Observations (or Sum Wgts)	14611

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



Linear Fit

ILM2A23Lc = -663.3052 + 187.40937*IBC3H00CRCUR4

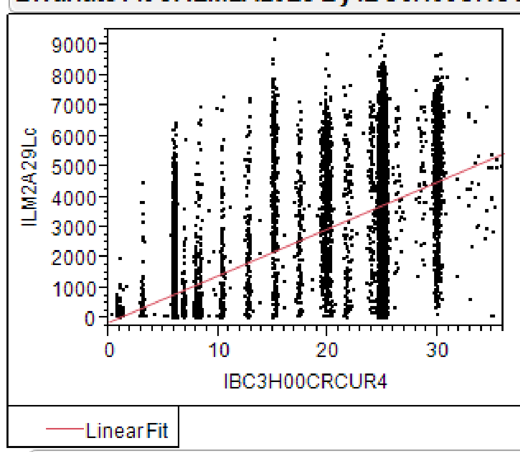
Summary of Fit

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



Linear Fit

ILM2A29Lc = -96.5539 + 154.0953*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*

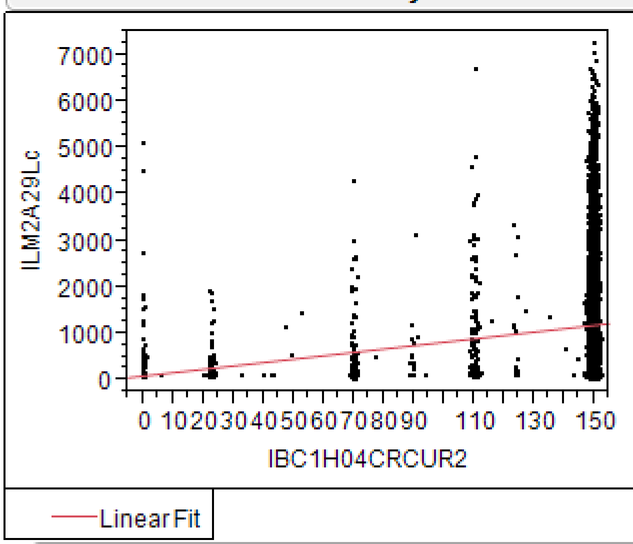
Figure 18. Arc 2 BLMs after seed change with Hall C > 1 μA.

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

Bivariate Fit of ILM2A29Lc By IBC1H04CRCUR2



Linear Fit

ILM2A29Lc = 106.03196 + 7.2647059*IBC1H04CRCUR2

Summary of Fit

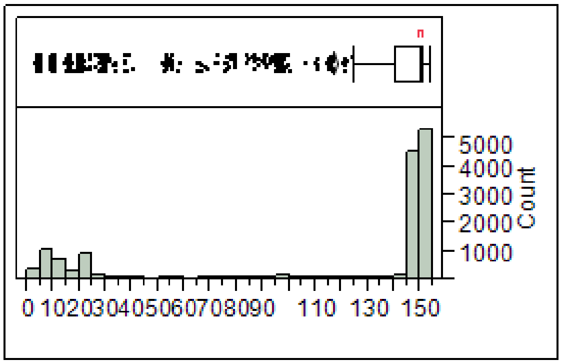
RSquare	0.135494
RSquare Adj	0.135447
Root Mean Square Error	1089.517
Mean of Response	976.0921
Observations (or Sum Wgts)	18218

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	106.03196	18.17439	5.83	<.0001*
IBC1H04CRCUR2	7.2647059	0.135961	53.43	<.0001*

Figure 19. In an attempt to understand the last line of the table, I plot response of 2A29 BLM against Hall A current while Hall C was down. It appears that about half the discrepancy can be explained by either B and D beam or signal leakage. Replace the PMT?

IBC1H04CRCUR2



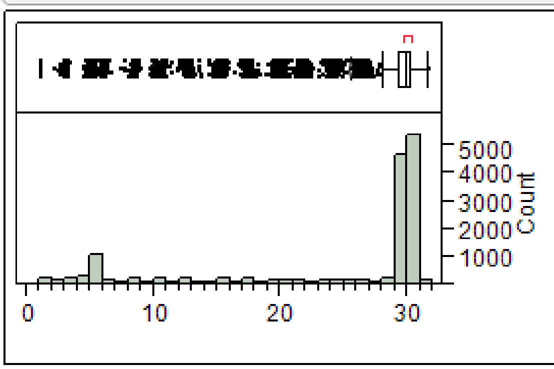
Quantiles

100.0%	maximum	153.42
99.5%		151.83
97.5%		151.38
90.0%		150.84
75.0%	quartile	150.36
50.0%	median	149.73
25.0%	quartile	139.935
10.0%		10.02
2.5%		5.46
0.5%		4.5
0.0%	minimum	3.36

Moments

Mean	117.11485
Std Dev	58.014416
Std Err Mean	0.509644
Upper 95% Mean	118.11382
Lower 95% Mean	116.11587
N	12958

IBC3H00CRCUR4



Quantiles

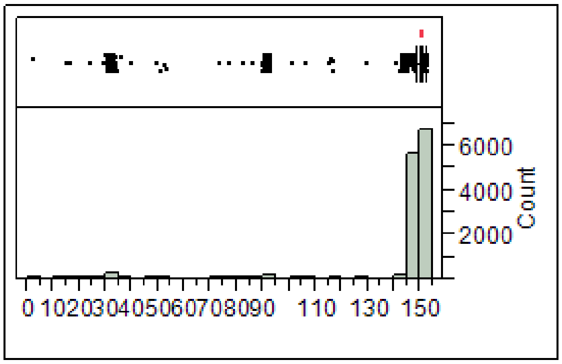
100.0%	maximum	31.71
99.5%		31.02
97.5%		30.72
90.0%		30.45
75.0%	quartile	30.18
50.0%	median	29.85
25.0%	quartile	29.28
10.0%		5.34
2.5%		4.71
0.5%		1.05
0.0%	minimum	1.02

Moments

Mean	25.55324
Std Dev	8.9999641
Std Err Mean	0.0790627
Upper 95% Mean	25.708214
Lower 95% Mean	25.398265
N	12958

Figure 20. Distributions of currents in period A, the "before" sample

IBC1H04CRCUR2



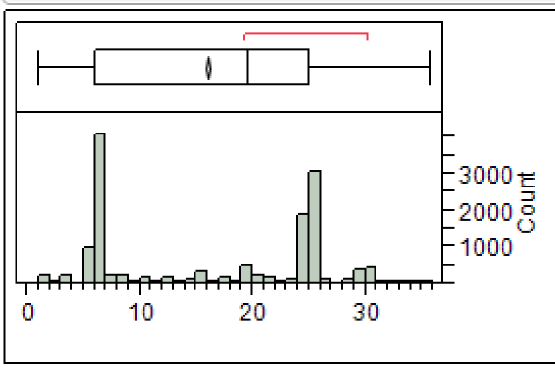
Quantiles

100.0%	maximum	153
99.5%		151.8
97.5%		151.35
90.0%		150.87
75.0%	quartile	150.48
50.0%	median	150.03
25.0%	quartile	149.55
10.0%		149.04
2.5%		143.58
0.5%		31.77
0.0%	minimum	1.08

Moments

Mean	147.92223
Std Dev	14.176288
Std Err Mean	0.1263626
Upper 95% Mean	148.16992
Lower 95% Mean	147.67454
N	12586

IBC3H00CRCUR4



Quantiles

100.0%	maximum	35.79
99.5%		30.36
97.5%		30.03
90.0%		25.26
75.0%	quartile	25.08
50.0%	median	19.59
25.0%	quartile	6.09
10.0%		6
2.5%		3.21
0.5%		1.05
0.0%	minimum	1.02

Moments

Mean	16.073431
Std Dev	9.4932024
Std Err Mean	0.0846192
Upper 95% Mean	16.239297
Lower 95% Mean	15.907564
N	12586

Figure 21. 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 $\geq 1\ \mu A$.

Conclusion: None

Second look at 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 it 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 24 0100-0700 with both high current halls, after the laser seed swap
C. April 13 0100-0700, twenty days after last beam

This second look begins with the arc 1 statistics with 0R08 = 0 in period C. Four of the BLMs show zero mean and standard deviations. The arc 1 BLMs have old electronics which do not allow both analog readback and MPS comparator operation. 1L04 and 1L06 are such BLMs. The others in the arc should read non-zero due to electronics noise.

Tabulate

	ILM1A04B	ILM1A06B	ILM1A09B	ILM1A16B	ILM1A19B	ILM1A22B	ILM1A24B	ILM1A26B	ILM1A27B	ILM1A29B	ILM1A32B	ILM1A33B	ILM1A35B	ILM1A36B	ILM1A37B
N	15251	15251	15251	15251	15251	15251	15251	15251	15251	15251	15251	15251	15251	15251	15251
Mean	0.000	0.000	0.437	0.000	0.000	0.495	4.502	10.50	7.910	9.747	10.44	8.630	9.207	8.367	9.964
Std Dev	0.000	0.000	1.990	0.008	0.008	5.190	4.643	2.257	3.727	3.199	1.968	1.511	7.125	4.436	5.377

Figure A1. April 13 data. Samples N, mean and standard deviation. 1L16 and 1L19 should not read zero but do. An OPS-PR has been filed.

Tabulate

	ILM1A09B	ILM1A22B	ILM1A24B	ILM1A26B	ILM1A27B	ILM1A29B	ILM1A32B	ILM1A33B	ILM1A35B	ILM1A36B	ILM1A37B
N	15251	15251	15251	15251	15251	15251	15251	15251	15251	15251	15251
Mean	0.437	0.495	4.502	10.50	7.910	9.747	10.44	8.630	9.207	8.367	9.964
Std Dev	1.990	5.190	4.643	2.257	3.727	3.199	1.968	1.511	7.125	4.436	5.377

Figure A2. April 13 stats with four BLMs eliminated: 1L04, 1L06, 1L16 and 1L19.

Tabulate

	ILM1A09B	ILM1A22B	ILM1A24B	ILM1A26B	ILM1A27B	ILM1A29B	ILM1A32B	ILM1A33B	ILM1A35B	ILM1A36B	ILM1A37B
N	3045	3045	3045	3045	3045	3045	3045	3045	3045	3045	3045
Mean	1.758	0.149	6.524	10.408	7.781	9.475	21.026	9.549	9.474	7.938	9.679
Std Dev	7.482	2.255	7.312	2.946	5.206	3.848	9.006	2.139	7.601	5.826	5.982

Figure A3. March 10 stats for samples with 0R08=0. One sees similar means for seven of eleven BLMs when compared to Figure A2. 1A32 is the only outlier. https://logbooks.jlab.org/entry/3809796 shows activation at 7A31 which may have contributed. The only other BLM near a warm region is 27, near a 9A27 hot spot with low whole body dose; standard deviation is up by half March 10 vs April 13.

I conclude that I can try to increase signal to noise ratio in examining dependence of BLM activity on beam current by subtracting the mean values in Figure 3 from all values in the data set. Only after I tried this did I realize that subtracting a constant from the data will affect only the intercept, not the slope, its t value (standard_error/parameter) or correlation coefficient. I tried subtracting a value from the normal distribution with mean and standard deviation in Figure A3 from the each of the 1L09 data points and checked the fit. That doesn't help either because the distributions of BLM response with 0R08=0 before the laser seed swap (the only data set I checked) are not normal: too many values ~1 and tails, which I truncated at 30, out to 100 in 12% of the data set. Rows excluded if ANY of the BLM signals in a given row were greater than 30. I'd have to extract eleven subsets from the full data sheet, one per BLM, to cut just the high values from each individually.

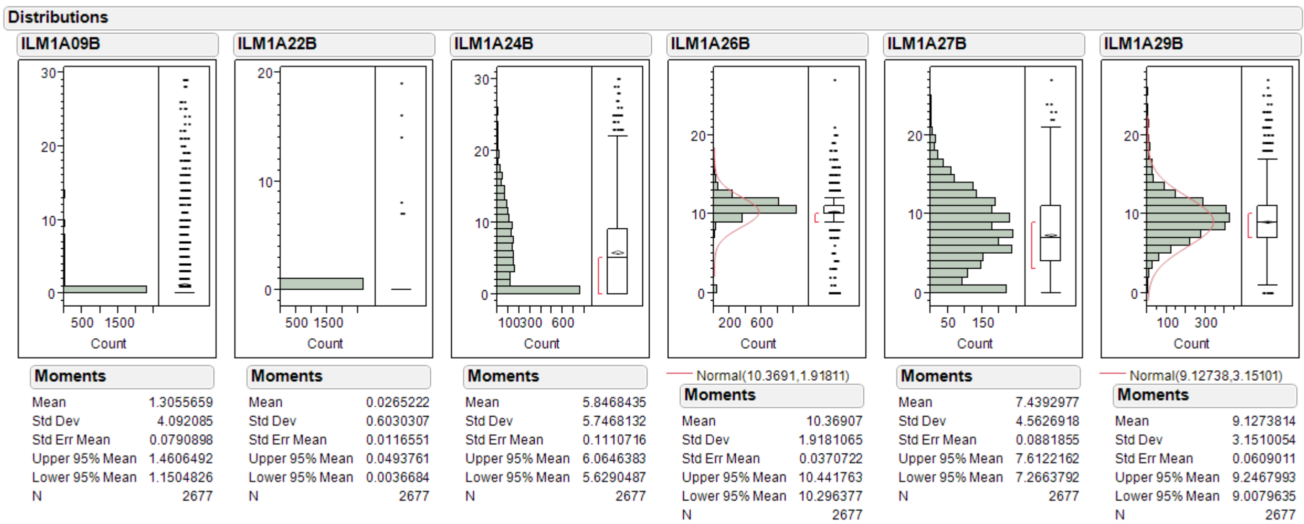


Figure A4. Response distributions of first six BLMs with 0R08=0 in period A, before the seed swap. Normal curves which are NOT significant are shown in fourth and sixth panels.

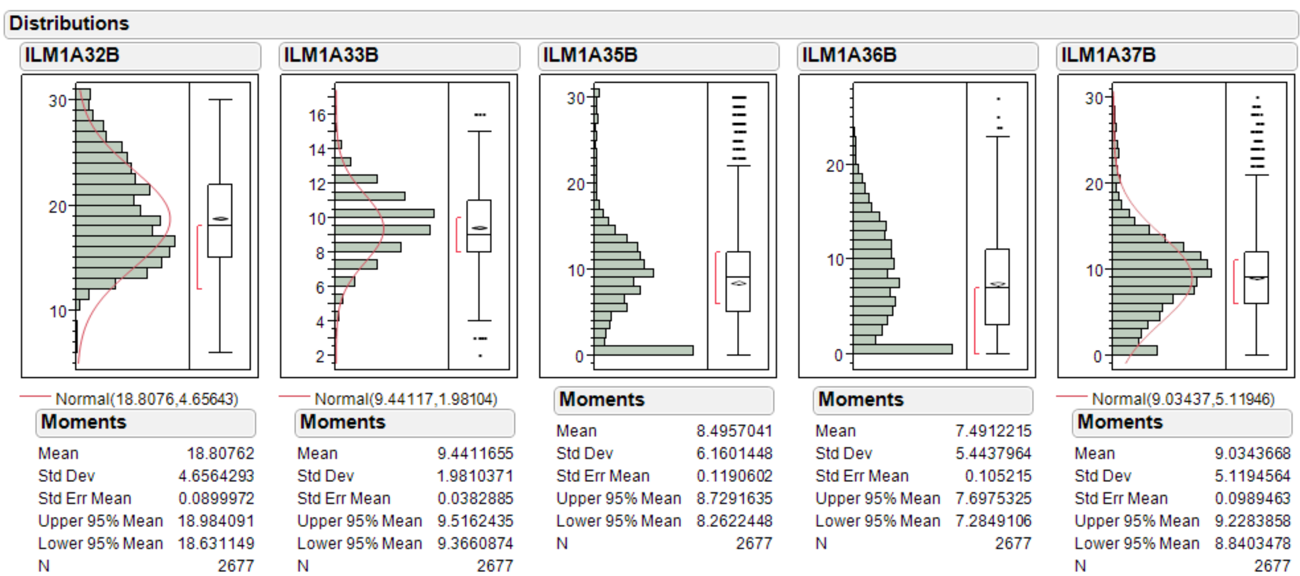


Figure A5. Response distributions of remaining BLMs with 0R08=0 in period A, before the seed swap. Normal curves which are NOT significant are shown in first, second and fifth panels.

Conclusion A1: A lot of very tedious work will be required to determine if the R^2 values in the previous look at arc1 BLM response versus Hall C current can be improved. I'll look at arc 2 before I try that as the signal should be cleaner.

Table A1. Correlation coefficients of arc 2 BLMs vs Hall C current before and after the seed swap

	2A04	2A06	2A10	2A14	2A16	2A19	2A23	2A26	2A29	2A32	2A36
before seed swap	0.100	0.452	0.713	0.050	0.518	0.096	0.616	0.189	0.151	0.058	0.014
after seed swap	0.068	0.228	0.467	0.014	0.030	0.059	0.402	0.078	0.335	0.049	0.002
after/before	*0.68*	*0.50*	*0.65*	*0.28*	*0.06*	*0.61*	*0.65*	*0.41*	*2.22*	*0.84*	*0.14*

The BLM correlation with Hall C current is lower after the seed swap with the exception of 2A29. Since this was shown to have a physically impossible but significant correlation to Hall A current in figure 19 of the first look, I discount this observation and again suggest this PMT be checked. The average R^2 value after/before is halved for the other ten BLMs. Mean 0.48, std dev 0.26 so mean is two sigma from null hypothesis. This suggests the seed swap helped.

Table A2. Linear regression of Hall C current against BLM response before and after laser seed swap

BLM	before_intercept	before_slope	after_intercept	after_slope	before@30uA	after@30uA	after/before
2A04	-38.55	64.58	14.41	61.26	1899	1852	0.975
2A06	2410.97	74.14	2789.82	54.38	4635	4421	0.954
2A10	-759.18	210.23	-305.73	140.59	5548	3912	0.705
2A14	-31.50	28.71	62.72	10.65	830	382	0.461
2A16	207.64	15.28	251.14	13.93	666	669	1.005
2A19	9.68	33.11	324.00	-2.86	1003	238	0.238
2A23	-607.81	185.38	-417.75	159.82	4954	4377	0.884
2A26	-130.53	65.31	-11.66	41.78	1829	1242	0.679
2A32	311.52	19.82	354.41	22.13	906	1018	1.124
2A36	143.37	9.54	206.39	2.24	430	273	0.637
					average after/before at 30 uA:		0.77

The reduction in regression prediction at 30 uA is only a fourth on average rather than half as with R^2 but is still reasonably consistent. Since the standard deviation of the ten values is 0.27 one can't formally draw any conclusions from this table but it is suggestive. 2A29 not considered.

Why does this second look come to a different conclusion than the first?

- All eleven BLMs were considered
- Only 2A29 was removed from set
- The "after" period is the last shift of beam delivery to Hall C, March 24, rather than a day earlier. More time was spent at 30 µA on March 24. "Before" is still March 10.