Confusing behavior of big BPMs

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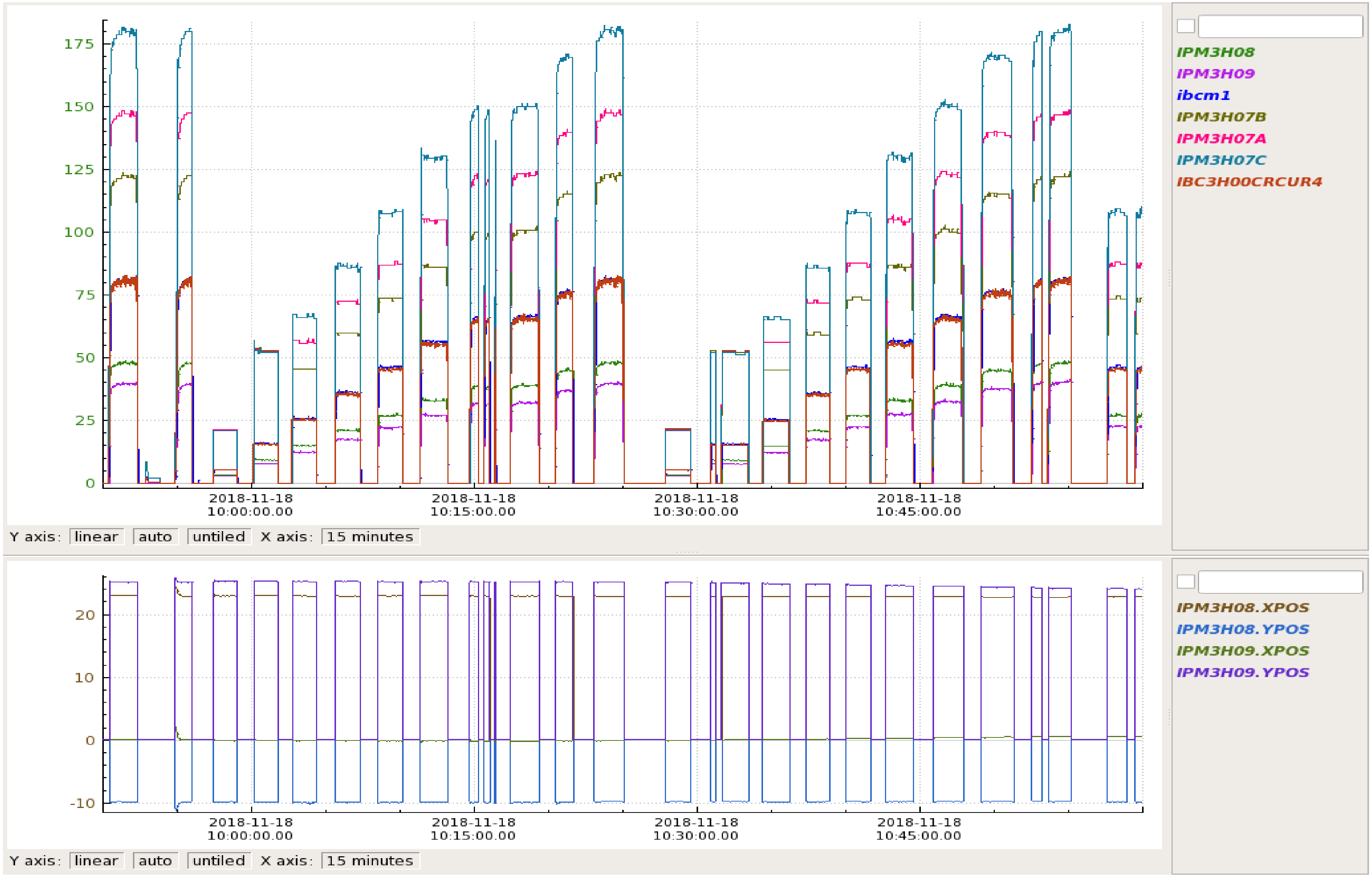
Big BPM

Background

- Big BPMs were designed and installed at the suggestion of Roger Carlini
- Stripline design for arc 10, Hall D scaled up
- 24” OD, 16” electrode D for 50 ohms
- Same receiver/software as other striplines
- Gain parameter, by scaling, should have been 60
- Gain doubled for tests reported here; more changes needed.
- Most data shown taken 12/17/2018

As current monitors 1

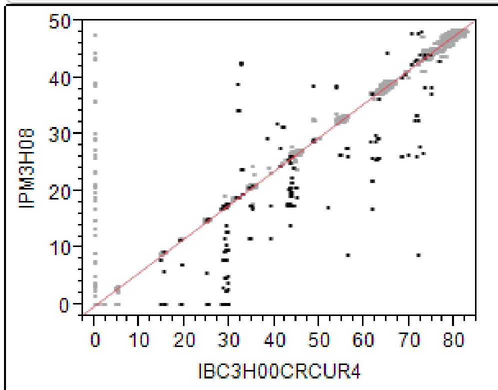


Wire sums tracks BCMs well

As current monitors 2

Fit Y by X Group

Bivariate Fit of IPM3H08 By IBC3H00CRCUR4



Linear Fit

Linear Fit

IPM3H08 = -0.064114 + 0.5949506*IBC3H00CRCUR4

Summary of Fit

RSquare	0.998866
RSquare Adj	0.998866
Root Mean Square Error	0.479184
Mean of Response	29.71868
Observations (or Sum Wgts)	4935

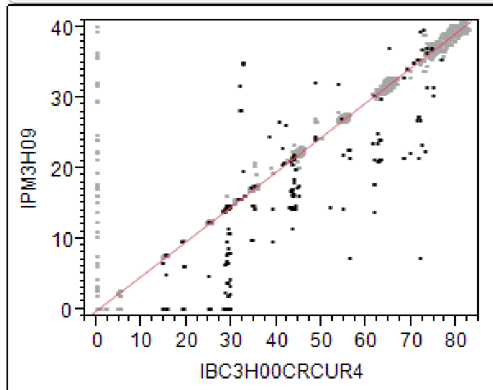
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	998160.93	998161	4347068
Error	4933	1132.70	0.229617	**Prob > F**
C. Total	4934	999293.63		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.064114	0.01583	-4.05	<.0001*
IBC3H00CRCUR4	0.5949506	0.000285	2085.0	<.0001*

Bivariate Fit of IPM3H09 By IBC3H00CRCUR4



Linear Fit

Linear Fit

IPM3H09 = -0.092615 + 0.4940894*IBC3H00CRCUR4

Summary of Fit

RSquare	0.998545
RSquare Adj	0.998545
Root Mean Square Error	0.450939
Mean of Response	24.64114
Observations (or Sum Wgts)	4935

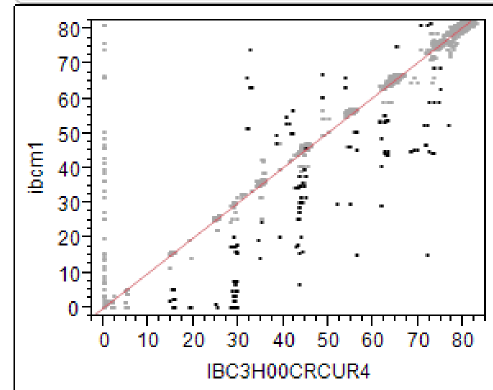
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	688414.22	688414	3385430
Error	4933	1003.11	0.203346	**Prob > F**
C. Total	4934	689417.33		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.092615	0.014897	-6.22	<.0001*
IBC3H00CRCUR4	0.4940894	0.000269	1840.0	<.0001*

Bivariate Fit of ibcm1 By IBC3H00CRCUR4



Linear Fit

Linear Fit

ibcm1 = 0.1822549 + 1.010998*IBC3H00CRCUR4

Summary of Fit

RSquare	0.996648
RSquare Adj	0.996648
Root Mean Square Error	1.401771
Mean of Response	50.79207
Observations (or Sum Wgts)	4935

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2882300.9	2882301	1466847
Error	4933	9693.2	1.964963	**Prob > F**
C. Total	4934	2891994.0		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.1822549	0.046307	3.94	<.0001*
IBC3H00CRCUR4	1.010998	0.000835	1211.1	<.0001*

Fits of wire sums and Hall C BCM against MPS BCM after outlier cuts (>5 sigma left two, >10 sigma right) Wire sums have (very slightly) better correlations than Hall C BCM.

As current monitors 3

- See TN-19-011for more information
- Roger Carlini suggests that wire sums before and after the target can give a measure of density change in fluid targets.
- It appears that the big BPMs can do this quite well.

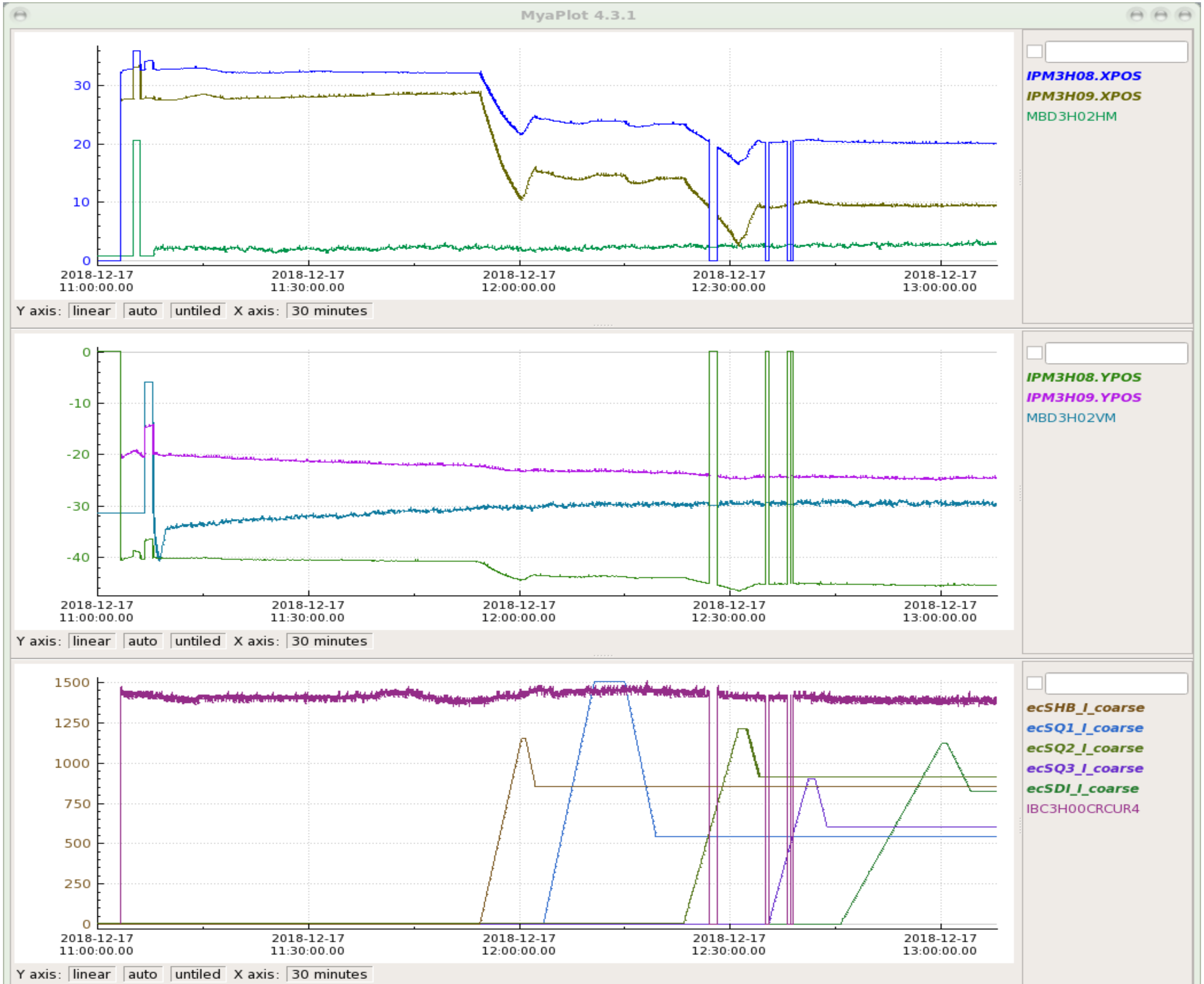
As Position Sensors 1

- All data and images hereafter taken from https://logbooks.jlab.org/entry/3639736
- A list of some sixty elogs on big BPM performance during the Fall 2018 run was also uploaded to indico

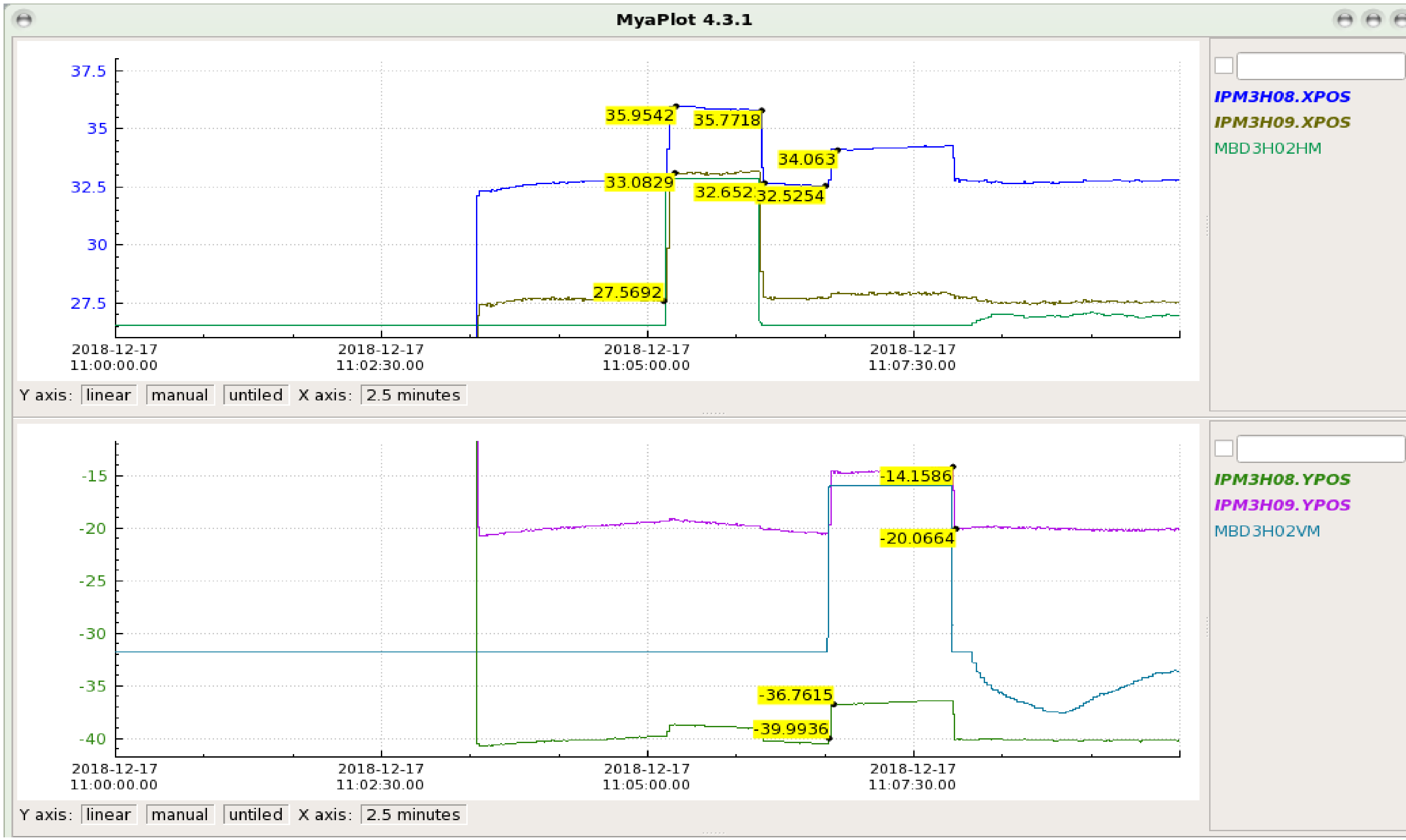
Position 2 - Full 12/17 test

Corrector changes at left

SHMS turn-on at center, right



Position 3: Corrector response

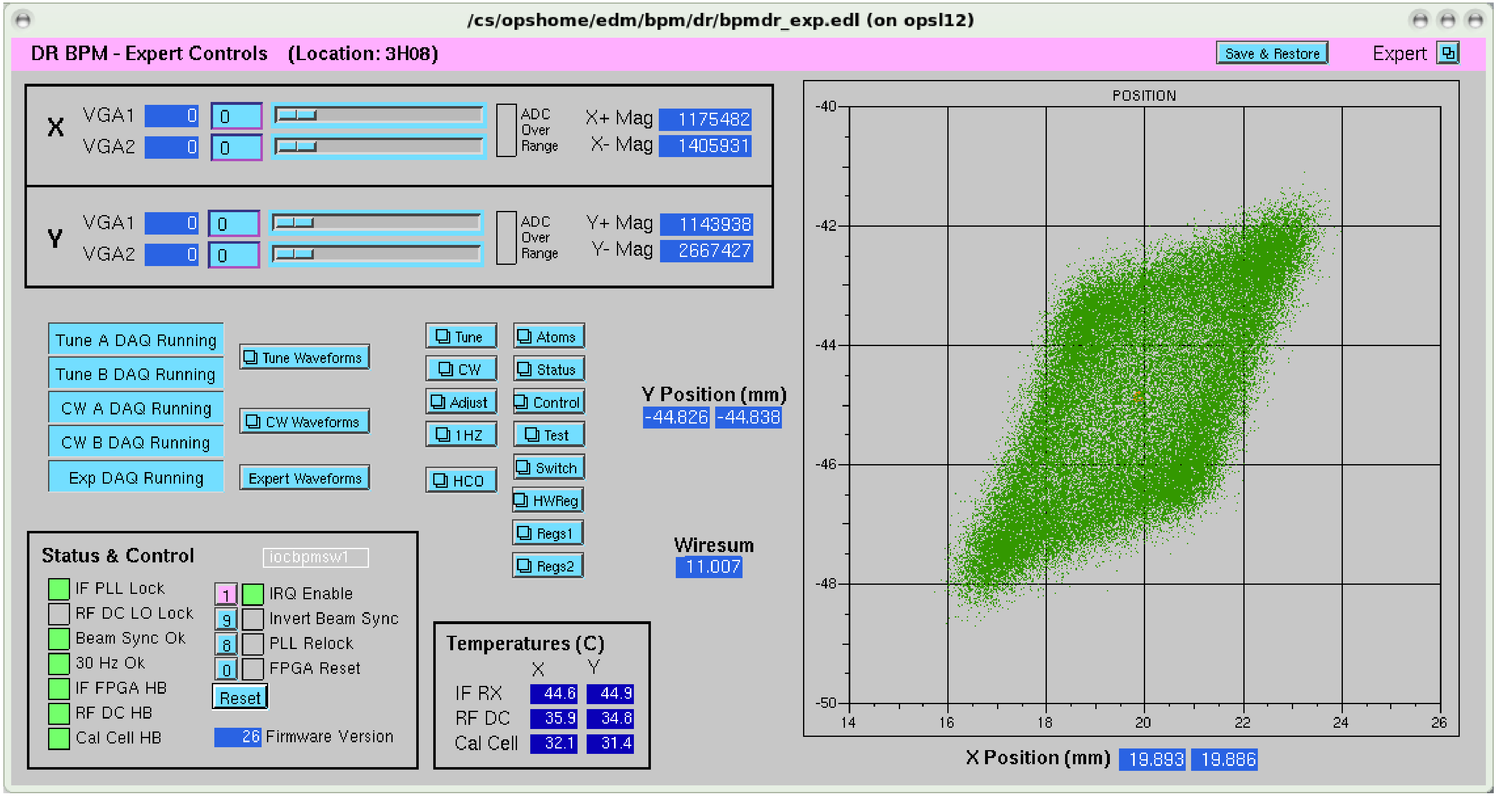


XPOS at top should only react to H corrector. 3H08 reacts to both, 3H09 OK
YPOS at bottom should only react to V corrector. 3H08 reacts to both, 3H09 OK
3H08 response about 3/4 of that expected, 3H09 about 1/7 more than expected.
Corrector variation after V peak due to resumption of orbit lock.

Position 4: long time response

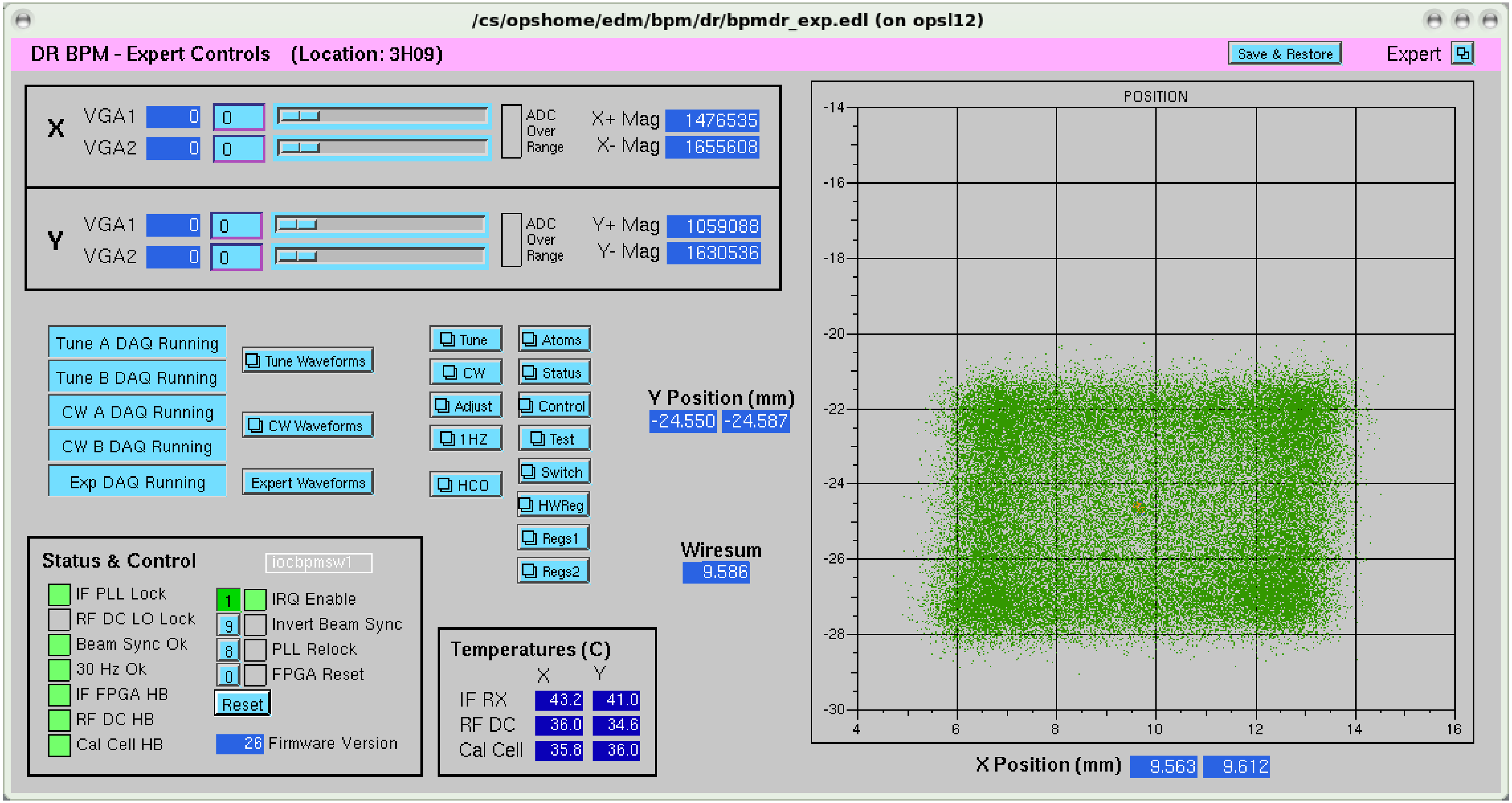
3H09YPOS cycles from positive (bad) to negative (good) with cause unfound. 3H09XPOS also changes, albeit not as much.

Position 5: 3H08 raster



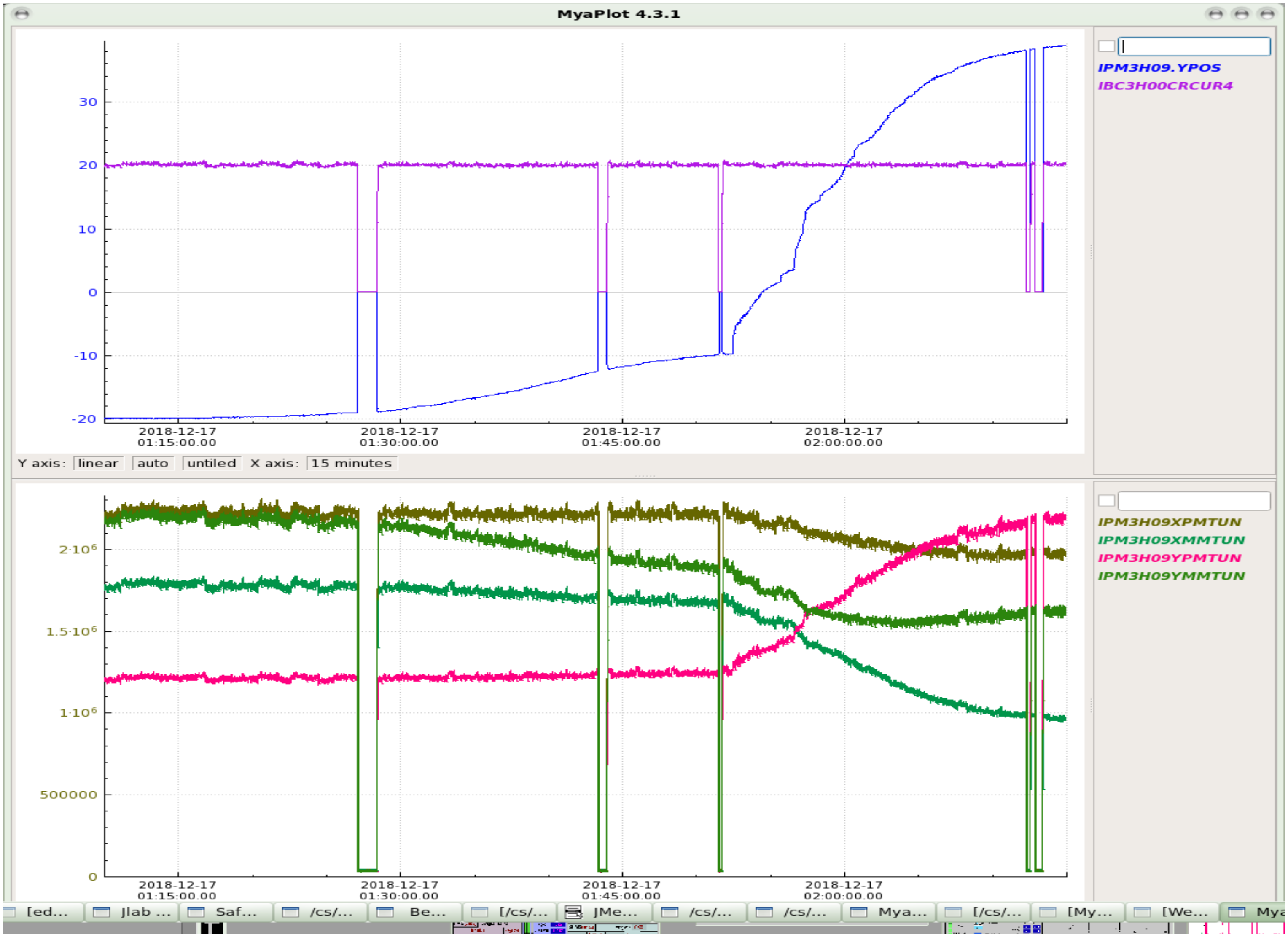
3H08 raster response is always rhomboid and about 3/4 of that expected, as with corrector response. Gain will be increased from 120 to 160 for next run.

Position 6: 3H09 raster



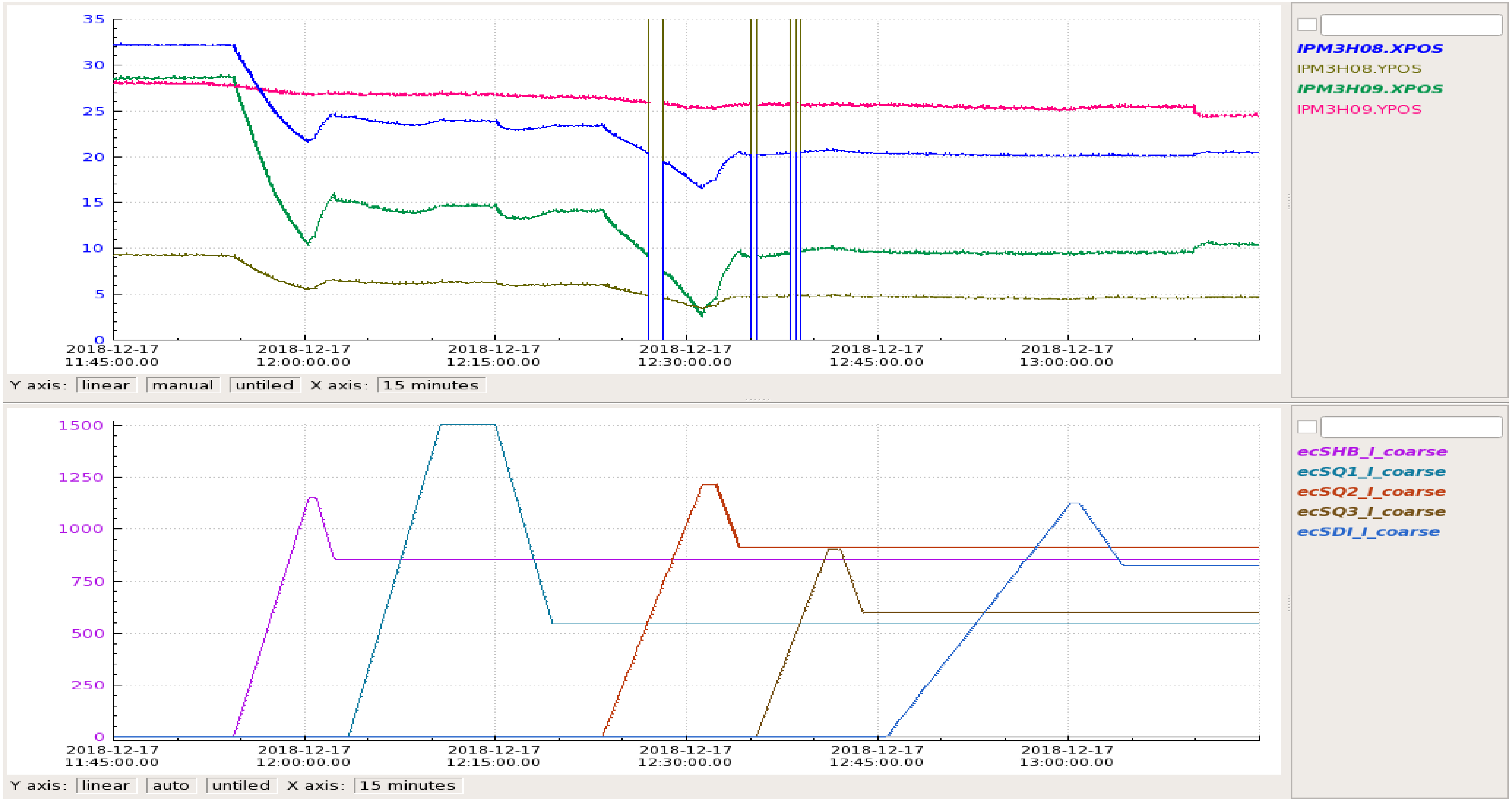
3H09 raster response is rectangular when Y position is negative and rhomboid when position is positive. Size is about 1/7 larger than expected, so gain will be reduced from 120 to 105. Picture frame perhaps due to sampling rate.

Position 7: 3H09 transition



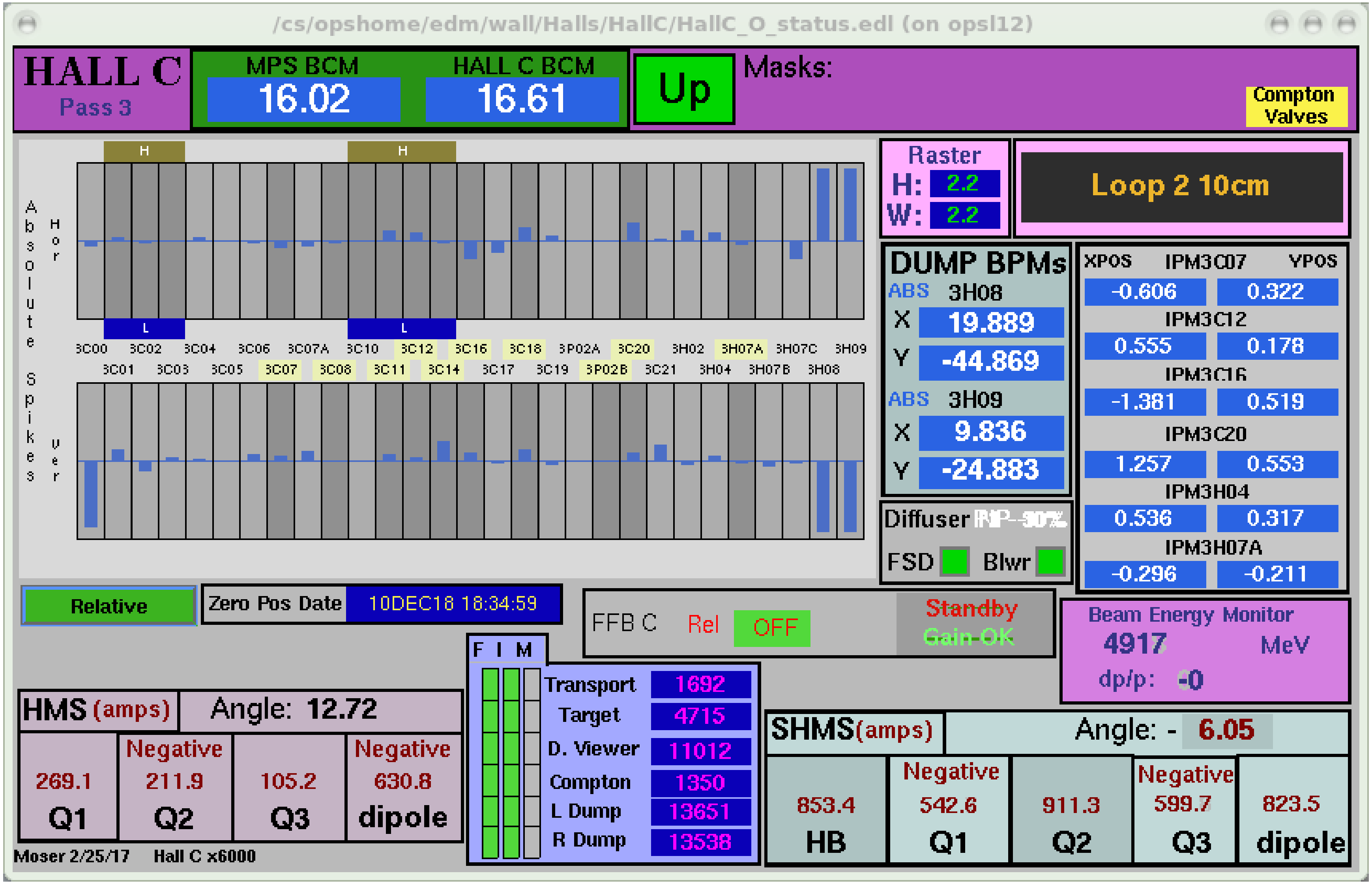
All four wires see change but bottom right (YM) and top left (YP) see more than the two X wires. Wires are labeled by position before 45 degree CCW rotation looking downstream. XP is top right and XM is lower left.

Position 8: SHMS response



In upper pane, vertical axis is for XPOs signals. For YPOS axis spans [-15,-50], also 35 mm. One sees the XPOS values respond strongly to HB and Q2 as expected. 3H08YPOS also responds, as it did to correctors. Gain corrections discussed above needed here too.

Position 9: wall screen at end of test



Position 10: Summary

- 3H09 responds as expected to raster a fraction of the time and YPOS agrees in sign with 3H08 then.
- 3H08 response is not orthogonal and varying rotation angle in spreadsheet or hardware doesn't help with that or raster rhombus.
- SOF values can be derived with beam for both BPMs when 3H09YPOS is negative and SHMS is off to make positions more meaningful - but 3H09 YPOS variation will still occur.
- Gains will be adjusted so response to upstream correctors and raster is as expected even with rhomboid raster.
- LO was separate box. Custom parts have arrived and are being installed on boards. Will this change anything?

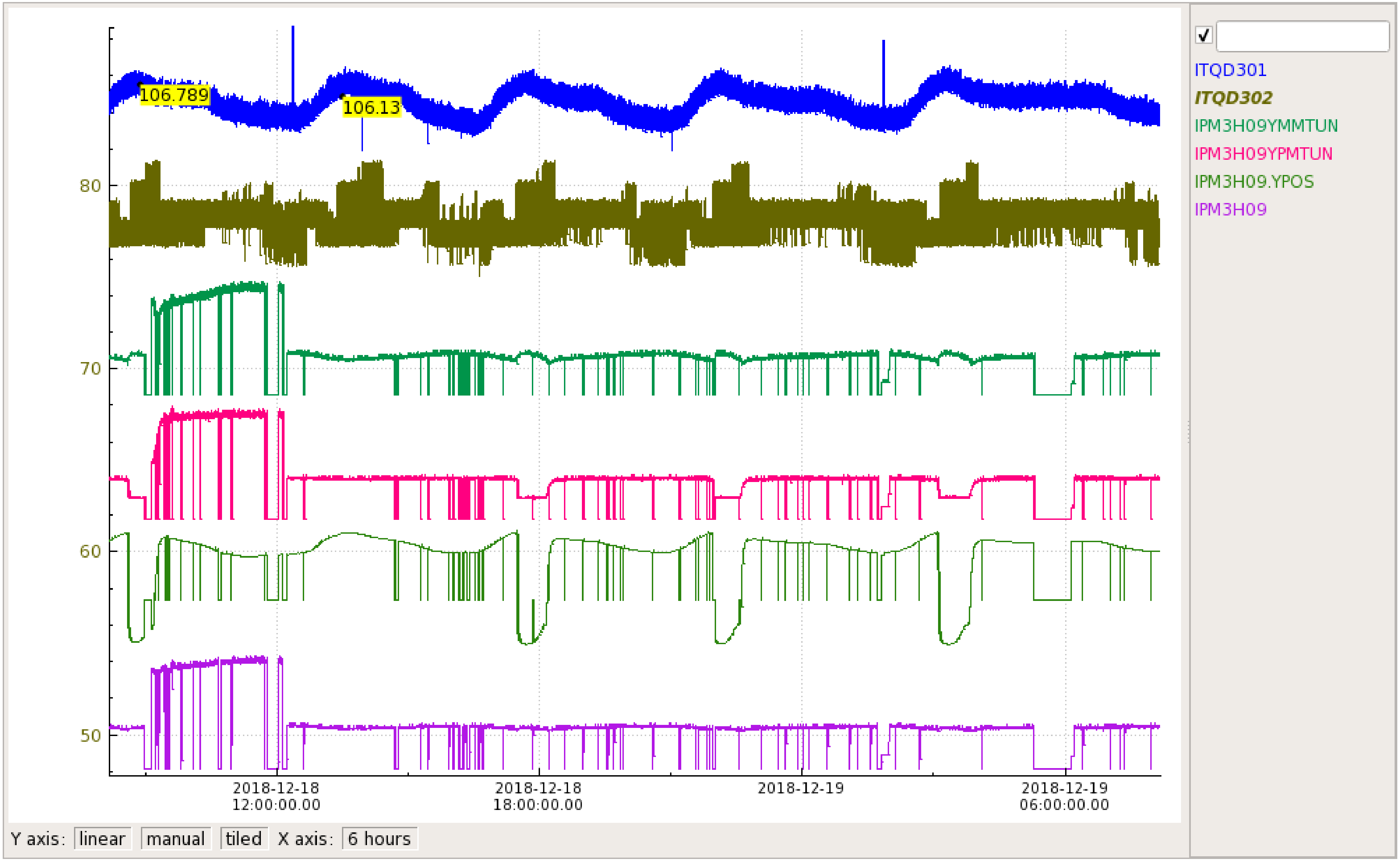
My Conclusions

- BPM wire sums are useful now
- 3H08 position will be useful when gains and SOFs are set early in run starting next week.
- 3H09 position will be useful some of the time.
- Engineering needs to concentrate more on the 3H09 position variation issue and the 3H08 rhombus.
- Four slides from John Musson follow.

John Musson comments on draft 1

- Extensive investigations while in access...we've swapped cables, muxes (which reside in lead vaults), receivers, local oscillator, and injected signals (long-term, upstairs and downstairs) only to conclude that the problem arises when the hall is locked with beam....AND, the problem follows the 3H09 sensor!
- The effect is absolutely correlated with ambient temperature (see next slide). The top is obtained via ambient probe at pivot, the brown is a thermocouple affixed to the can, and the remaining are the 2 Y-electrodes, Y-position, and current (4-wire).
- We have also instrumented the can with strain gauges as a method to rule out actual beam line motion.
- We have finished installing the individual 499 MHz LO components in each downconverter, which removes the common LO (but still utilizing the MO-derived 10 MHz reference for frequency lock).

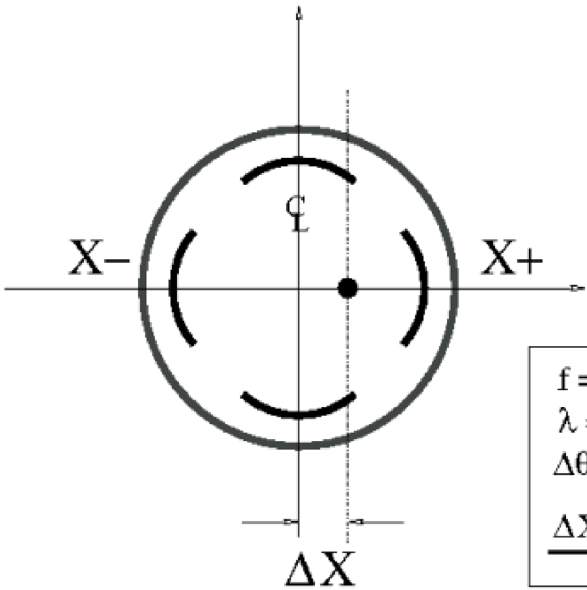
John Musson comments on draft 2



John Musson comments on draft 3

- The phase comparison of electrodes is only based on wavelength; we should be able to measure (or, use another fast X-Y plot) phase difference from edge to edge, thereby establishing the cal factor from measured data (next slide).
- Additional theories include backscatter from the dump, resonances produced by the downstream beamline into the dump, actual beamline motion (can't completely rule it out!!), internal mechanical deformation ....

Phase Method



$f = 499$ MHz

$\lambda = 60$ cm

$$\Delta\theta = \theta_{x+} - \theta_{x-} = \frac{2\Delta X * 360}{\lambda}$$

$\underline{\Delta X = 0.83\ \Delta\theta}$

- Dependent only on wavelength!
- Rastered beam provides derivation of constants (near-boresight / on axis)
- Intended as real-time calibration method
- Initial scans indicate 10-15% agreement