Orbit – drifts, noise/jitter, accuracy, slow feed-backs

Igor Pinayev

CeC X Retreat

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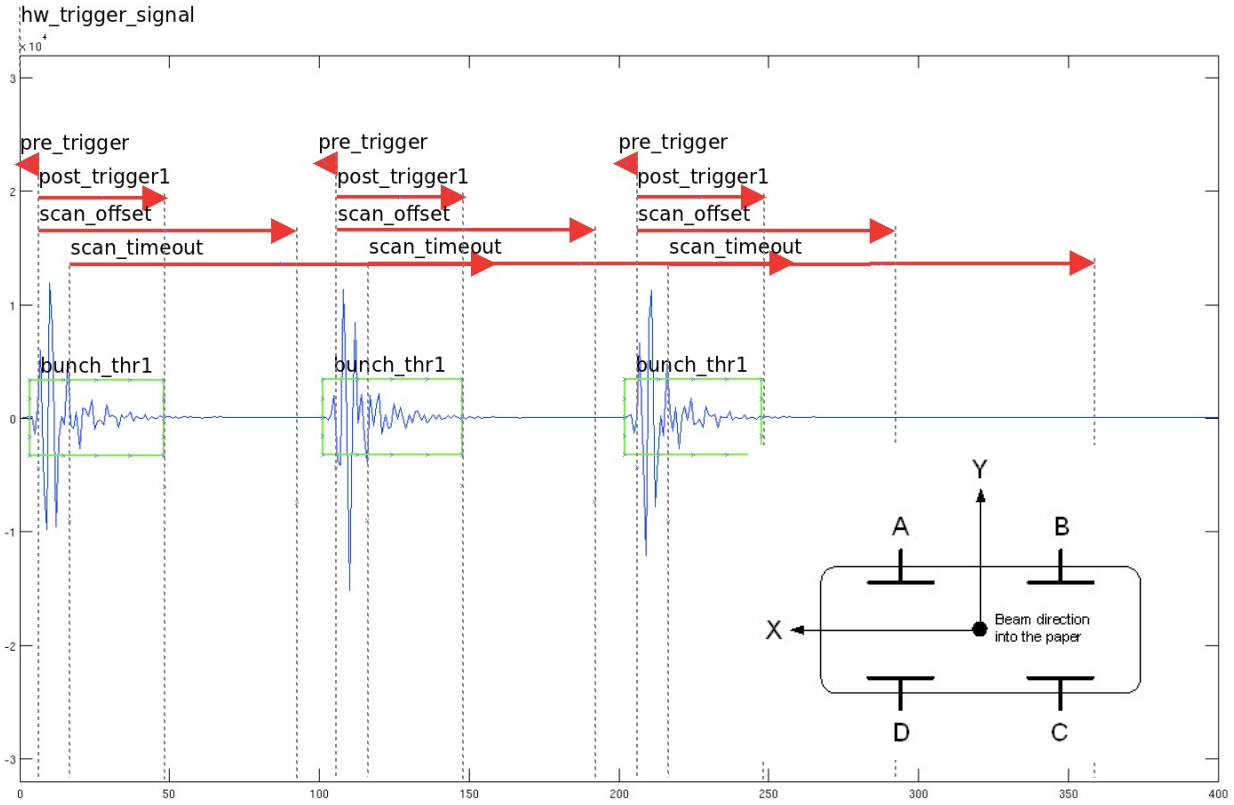
Outlook

- Means to measure orbit
- Orbit based applications
- Problems encountered
- Cause factors look up
- Possible solutions

Libera Single Pass Electron



We have three types units tuned to 350 and 500 MHz to observe the electrons, and tuned to the 9.3 MHz to observe hadrons.
Each unit is self-triggered from the incoming signal and calculates voltage for each channel

$$V = \sqrt{\sum u_i^2}$$

Conventional delta over sum calculations are used

$$r_X = \frac{V_A - V_B - V_C + V_D}{V_A + V_B + V_C + V_D}$$

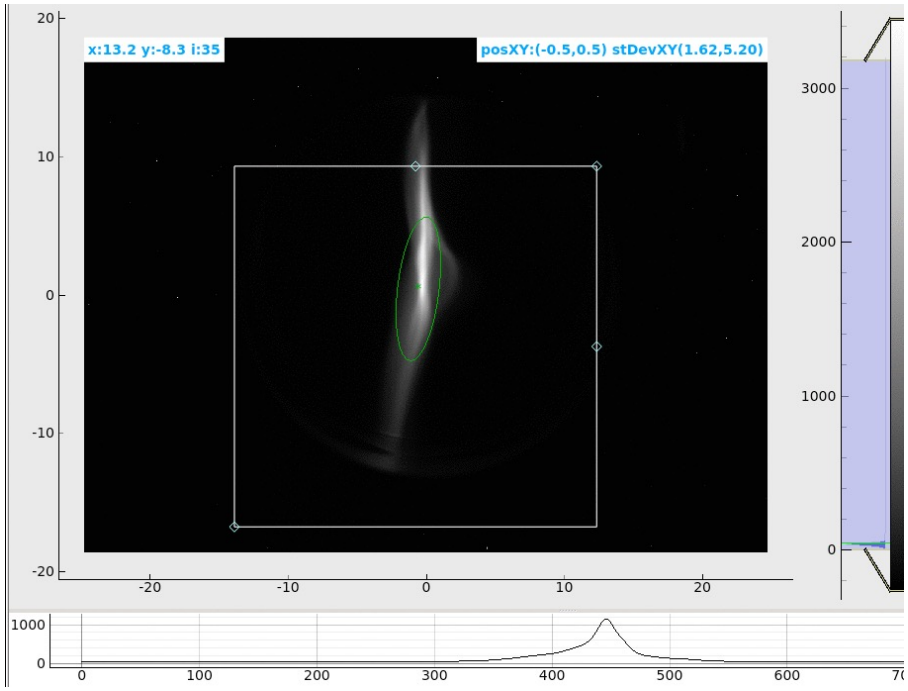
$$r_Y = \frac{V_A + V_B - V_C - V_D}{V_A + V_B + V_C + V_D}$$

$$q = \frac{V_A - V_B + V_C - V_D}{V_A + V_B + V_C + V_D} \approx 0$$

This value can be used for noise evaluation

We utilize the third order polynomic equation for calculating beam position

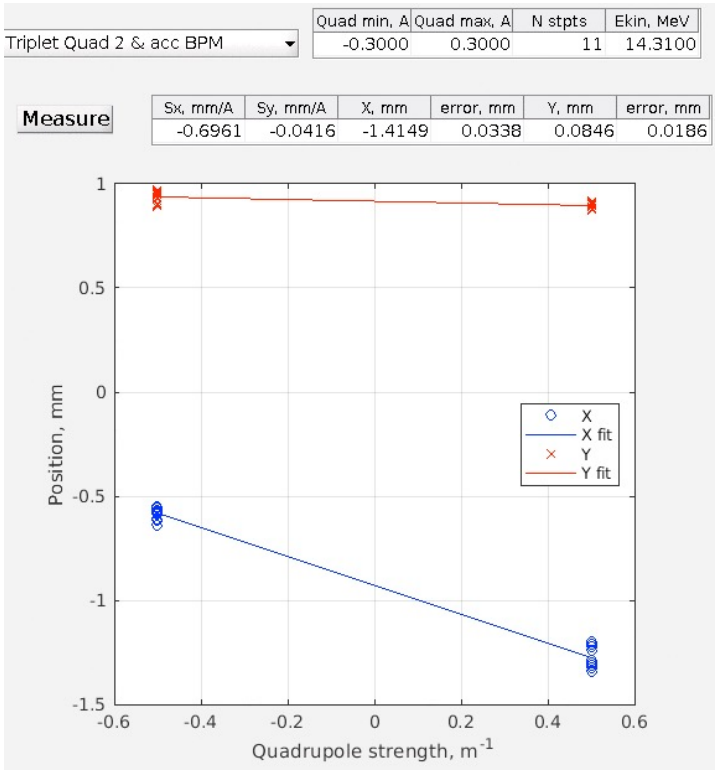
Profile Monitors



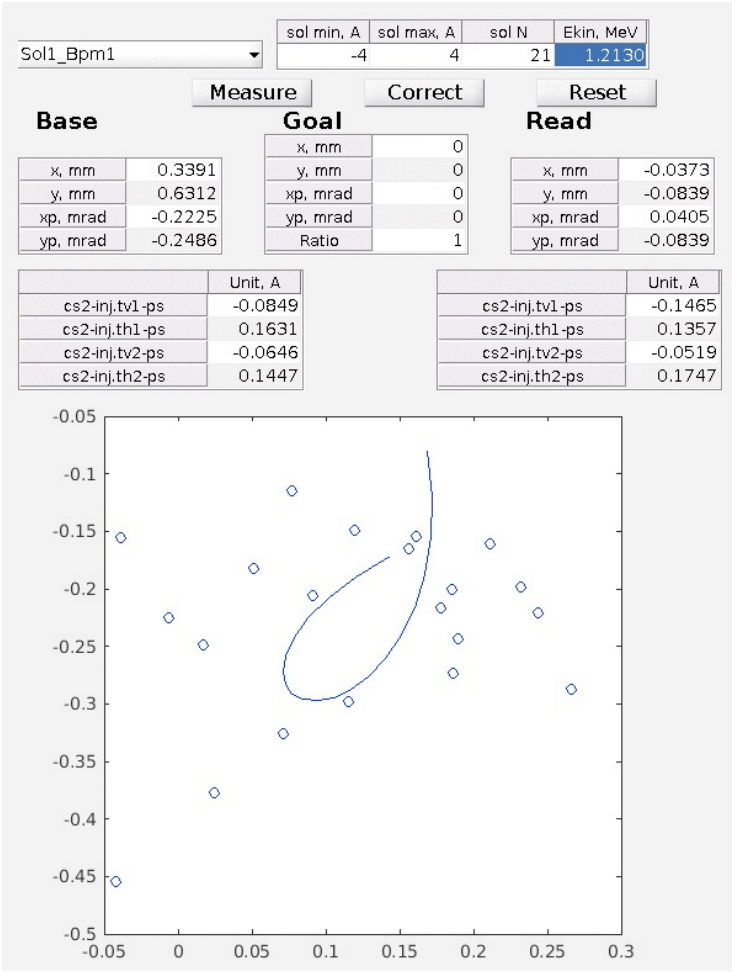
Beam position can be measured with profile monitor having 1” YAG:Ce screen. 2 Megapixel camera provides for 30 microns resolution.

It is intercepting diagnostics but can be used for the small charge beams and for absolute beam position measurement.

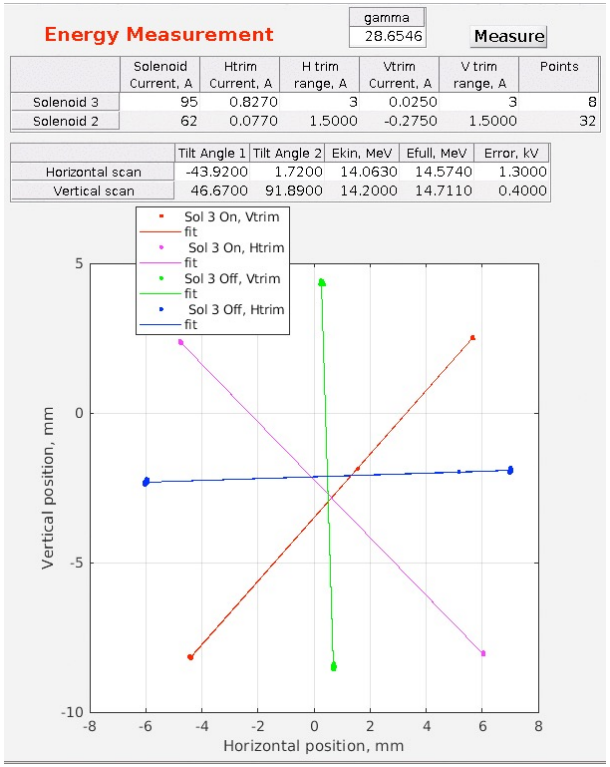
Applications for Position Measurements



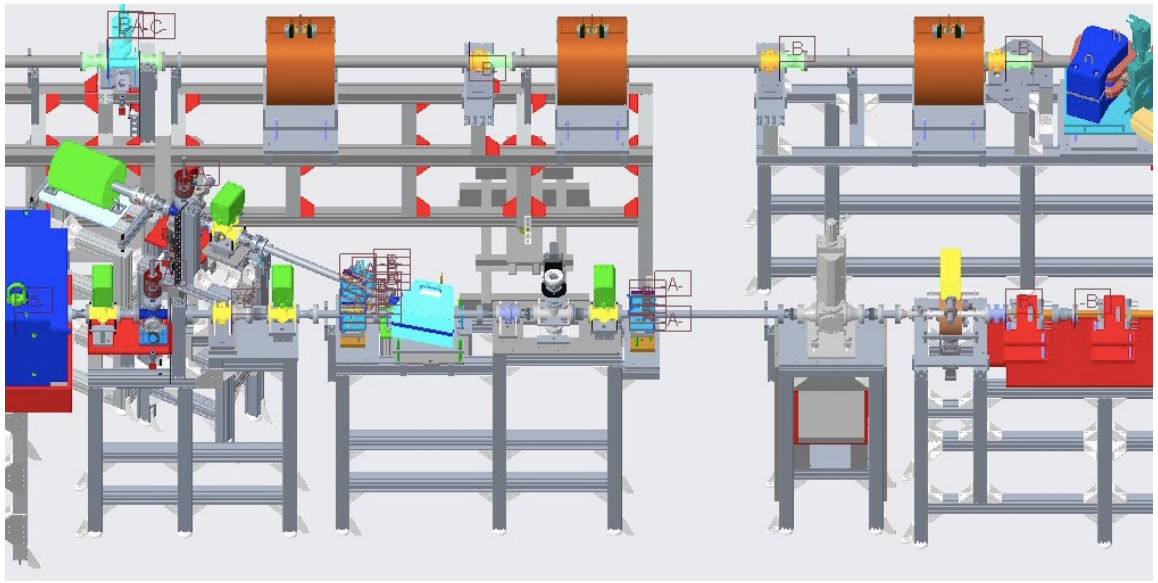
We can measure beam position vs. axis of the focusing element by analyzing beam motion caused by varying strength. Can be used for measuring of the very long drifts.



Energy Measurement and Monitoring



Using common section solenoid and profile monitor we can measure absolute beam energy. Position fluctuations introduce the statistical errors but drifts can be dangerous as well.



$$\frac{\delta E}{E} = -\frac{X_{yag} + 0.37X_1 + 0.735X_2}{D}$$

Uses BPM 1 and 2 in diagnostics line for measurement of the incoming beam trajectory

Uses profile monitor after the dipole for energy measurement (D=0.837 m)

Energy Monitoring during Operation

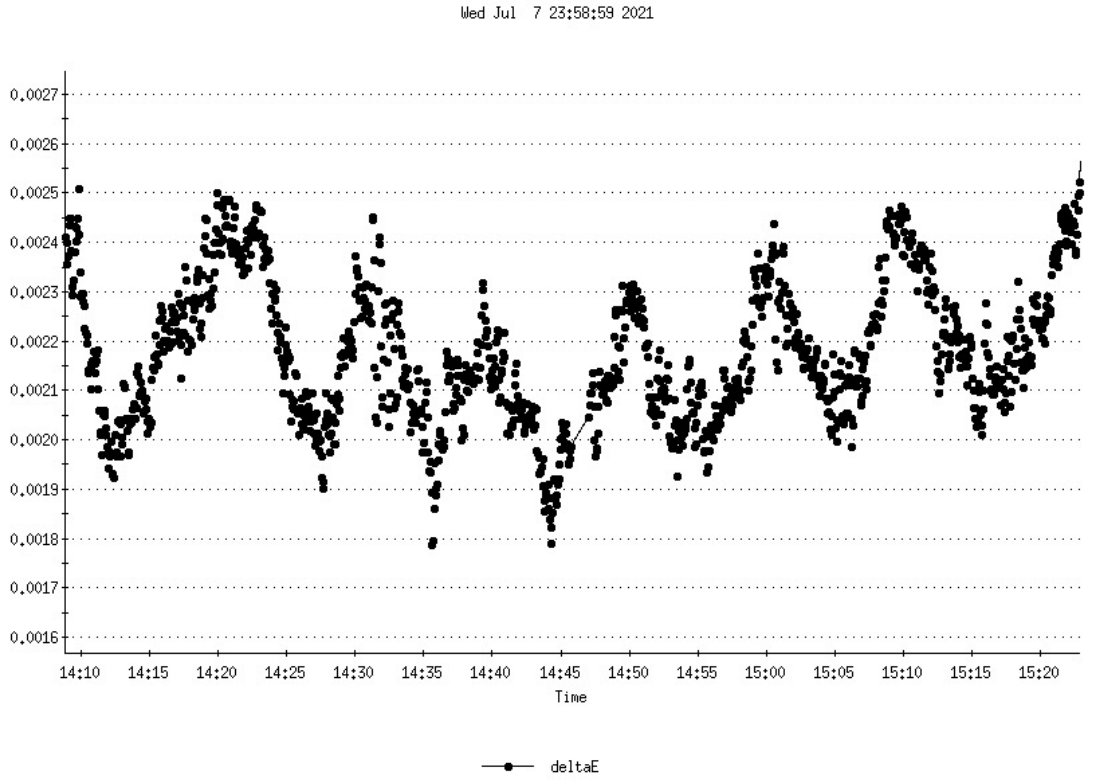
Uses triplet BPM and 1st modulator BPM for measurement of the incoming beam trajectory.

Uses dogleg BPM for energy measurement (D=0.295 m).

There are quadrupoles between the BPMs, therefore this method cannot be used for absolute energy measurement.

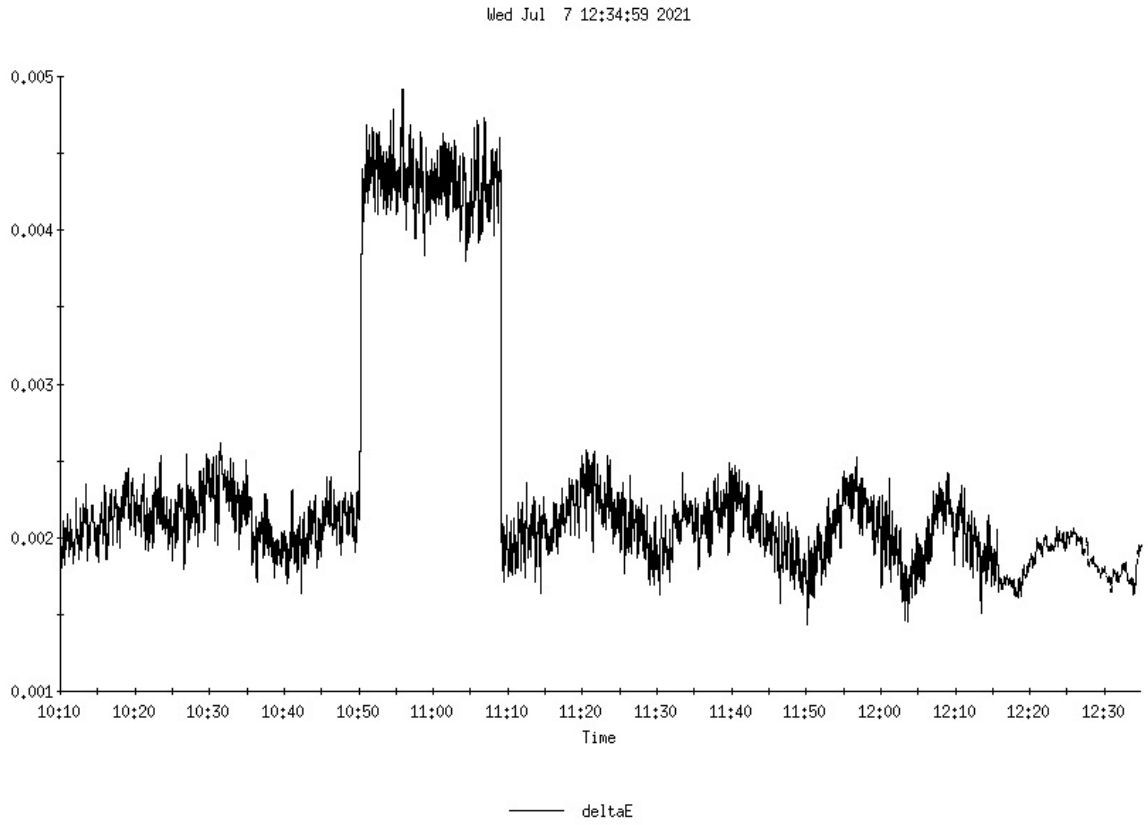
Coefficients k_1 and k_2 used for suppression of the betatron motion influence can be found using horizontal trims. They depend on the dogleg quadrupoles settings.

The dispersion in the common section should be close to zero.



$$\frac{\delta E}{E} = -\frac{X_{dglg} + k_1 X_{acc} + k_2 X_{mod1}}{D}$$

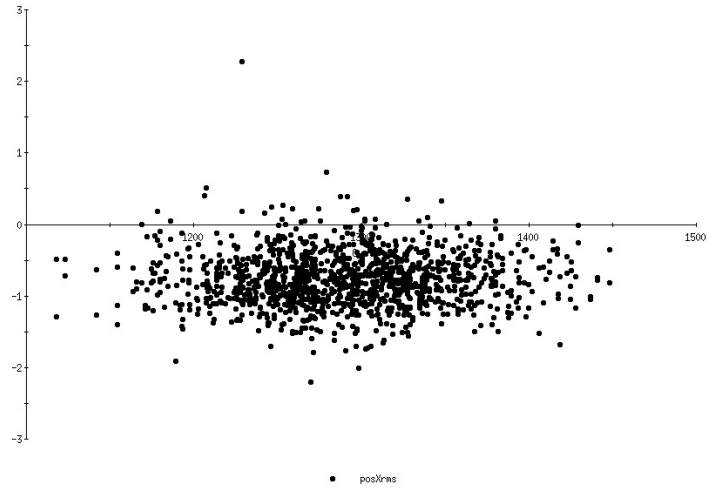
Effect of the Charge Change



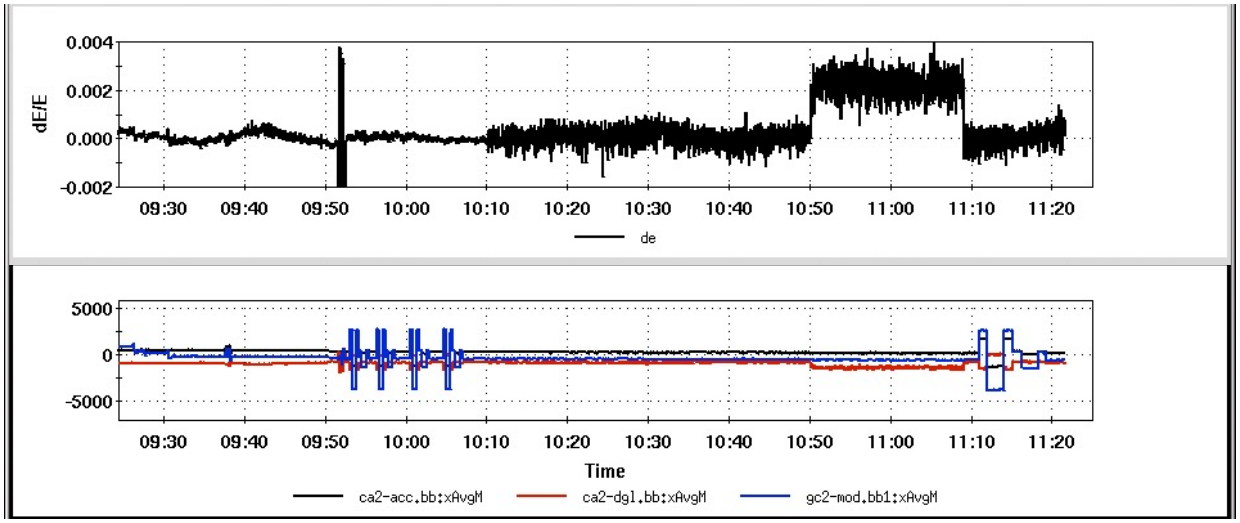
Charge was reduced from 1.5 nC to 500 pC between 10:50 and 11:09

Observed energy change is 2.5×10^{-3}

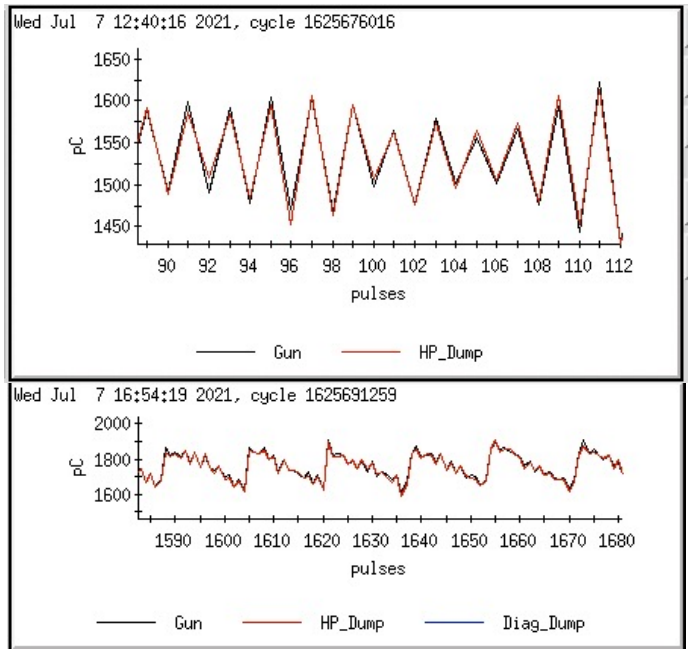
The solenoid based energy measurements did not show such large energy change. Neither we observed correlation with charge in the diagnostics line.



Sensitivity to Charge

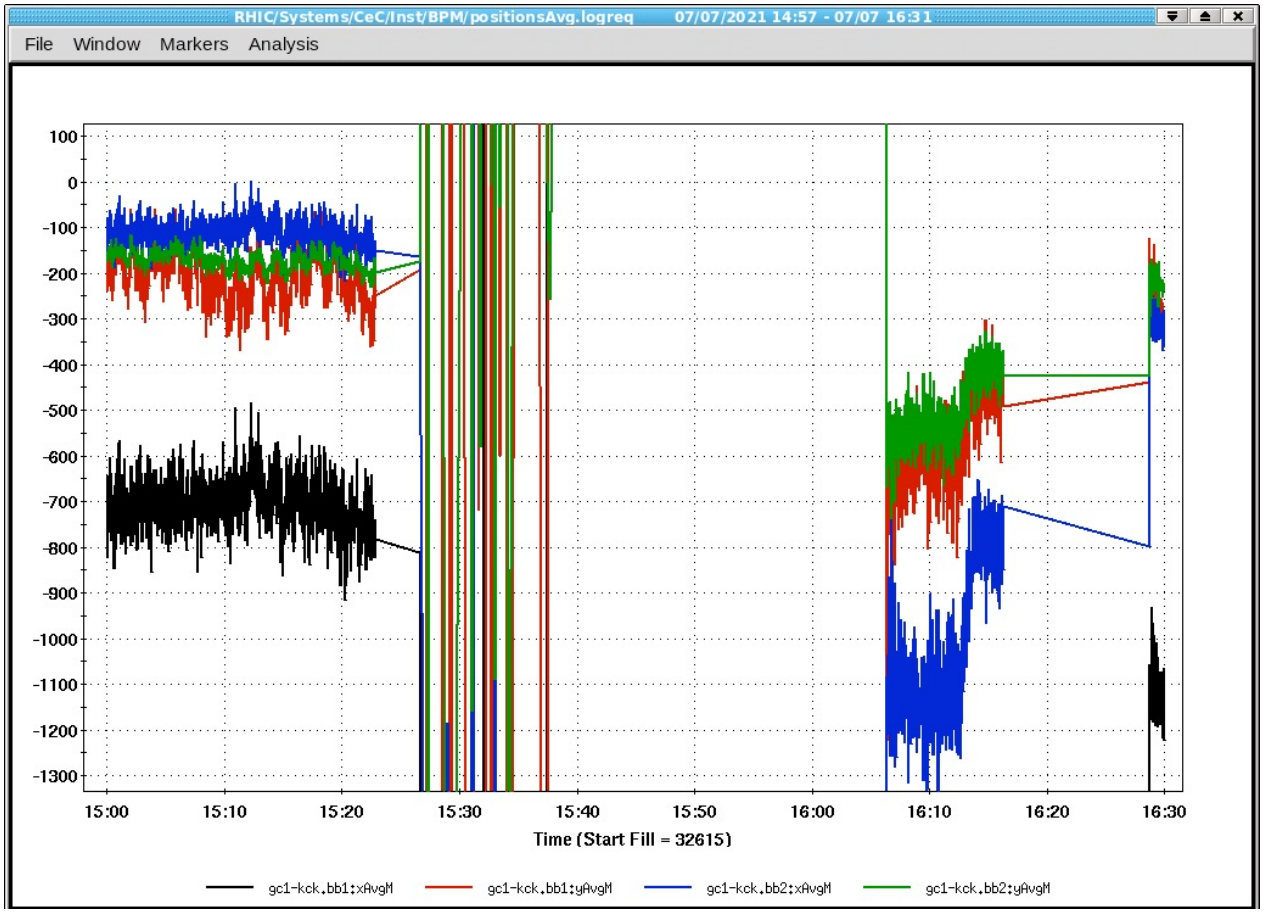


On July 7th the charge of the electron beam was reduced from 1.5 nC to 500 pC. System for energy monitoring observed 2×10^{-3} relative energy change. This were two absolute energy measurements performed with the common section solenoid. No such large energy change was observed. Most likely it was caused by beam overbunching affecting the dogleg BPM (red trace).



Fluctuations in laser power are the main source of the fluctuations of bunch charge. Besides uncorrelated fluctuations we have observed 39 kHz modulation due to the bifurcation in the regenerative amplifier and sawtooth modulation of unknown origin.

Electron Orbit Change after Reinjection



We have observed shift of the electron orbit after RHIC re-injection. No changes to the electron accelerator set-up were made (the laser was reset).

We have similar changes in orbit after breaks in CeC operation and restoring accelerator set-up. The changes are seen as early as on the first BPM just after the gun.

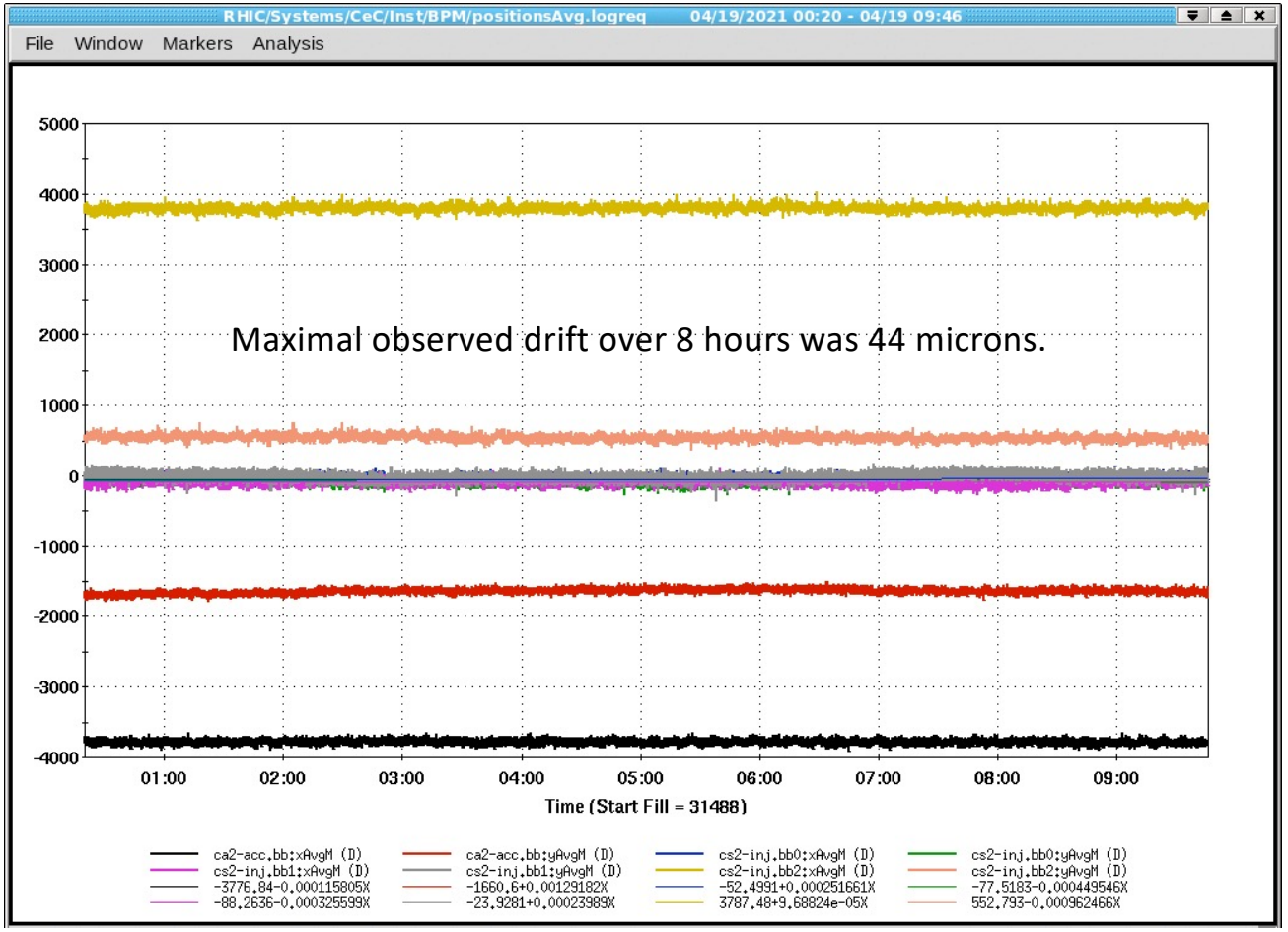
Possible causes: changes in the stray magnetic field from RHIC magnets (DX and D0) as well as from motor stage for gun FPC.

Orbit Drifts

BPM cs2-inj.bb1 readings after beam aligned on the first two LEBT solenoids. BPM is placed between the solenoids.

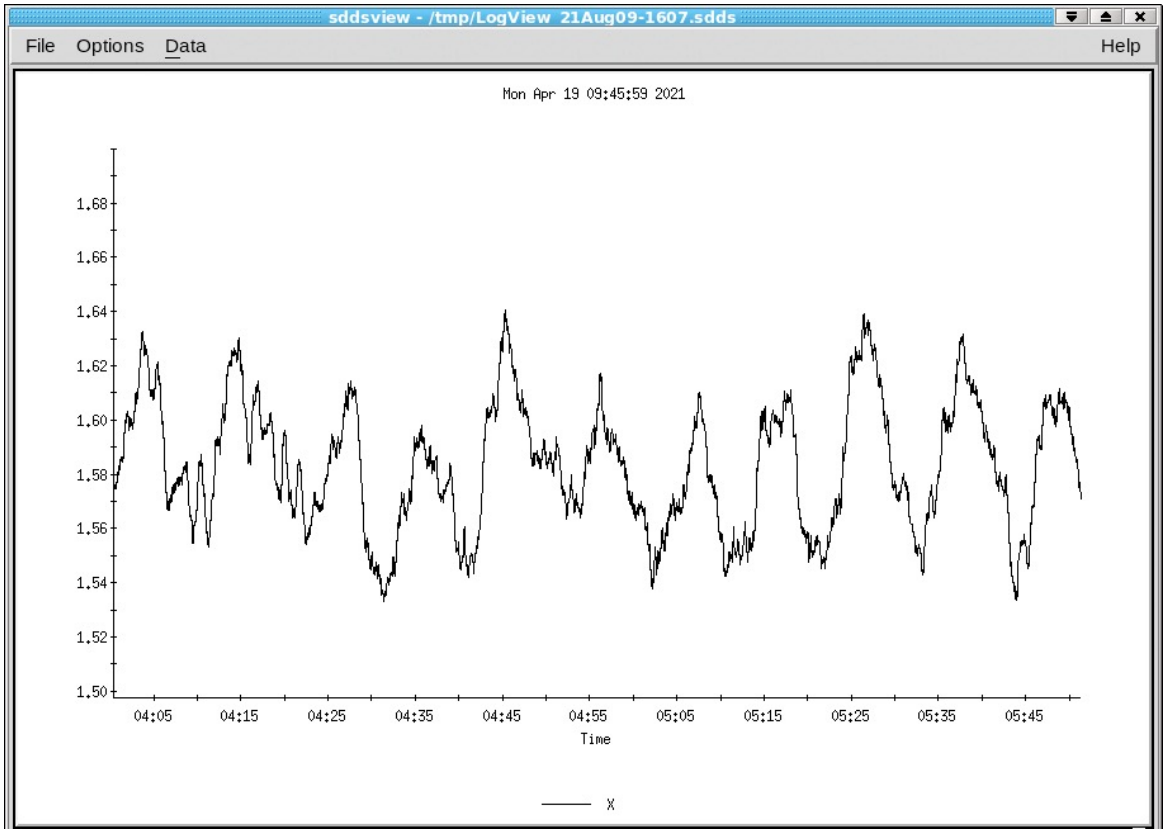
Date	Time	X_1, mm	Y_1, mm
March 22	20:44	1.86	-3.77
March 24	9:53	1.77	-3.60
March 25	17:09	1.68	-3.62
March 29	9:26	1.62	-3.80
April 2*	17:59	0.20	-0.25
April 4	16:03	0.20	-0.25
April 5	13:57	0.15	0.00

*The BPM offsets were changed



No noticeable drifts in the electronics

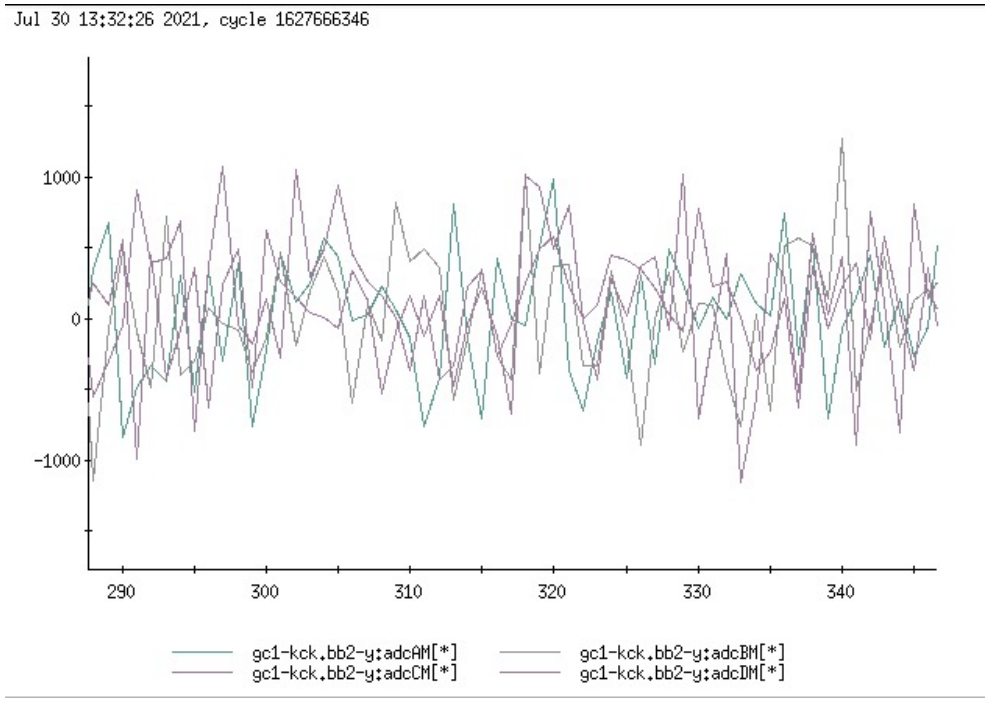
1002B A/C Cycle



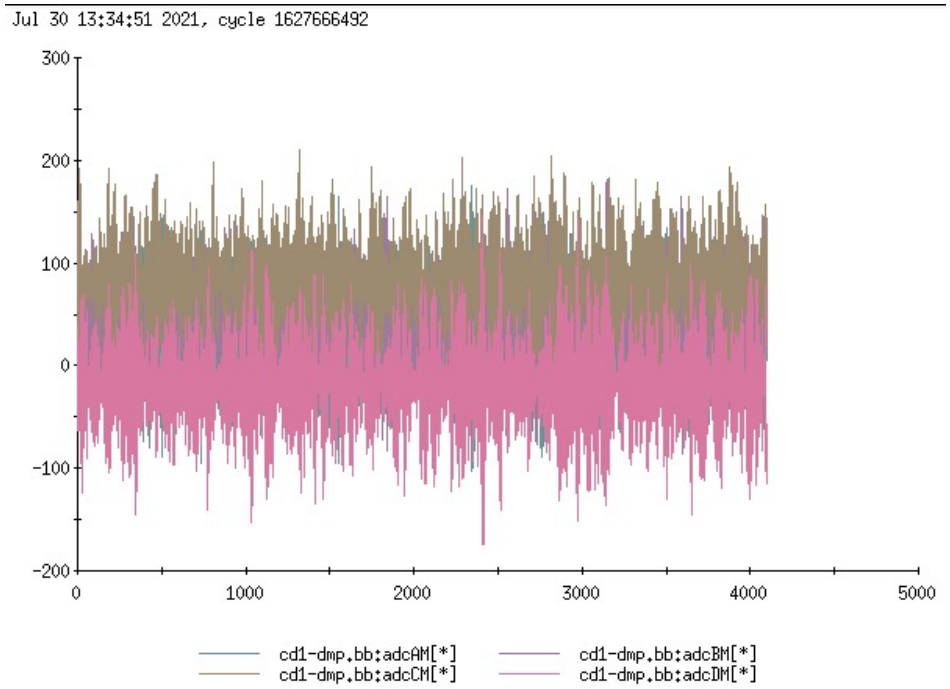
We have observed beam motion correlated with air conditioning cycle in the 1002B, which has characteristic 10 minutes period . We found that there is cycle in the current readback of power supplies. Five power supplies with high level of the current modulation were replaced.

Similar cycle was observed on RF systems.

External BPM Noise

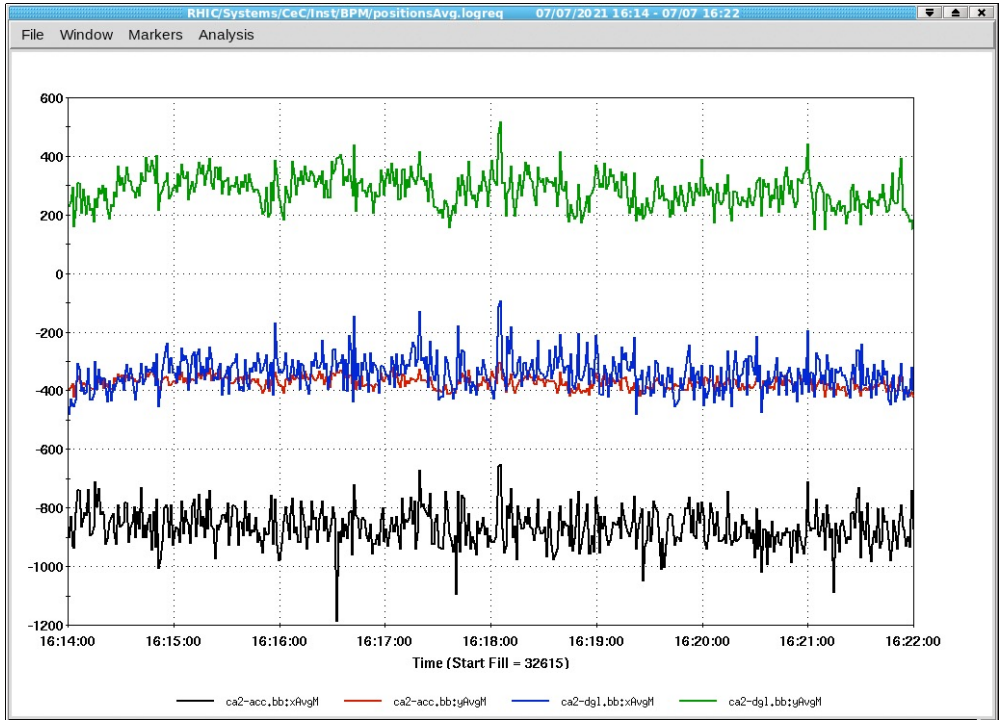


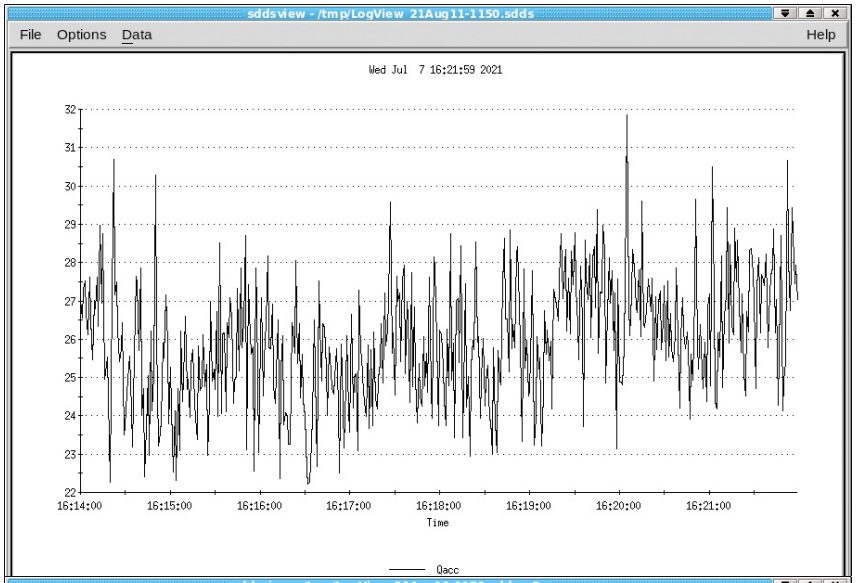
There is substantially more noise at 9.3 MHz. The noise is scaled with attenuators. The source is unknown (most likely some switchable power supply).

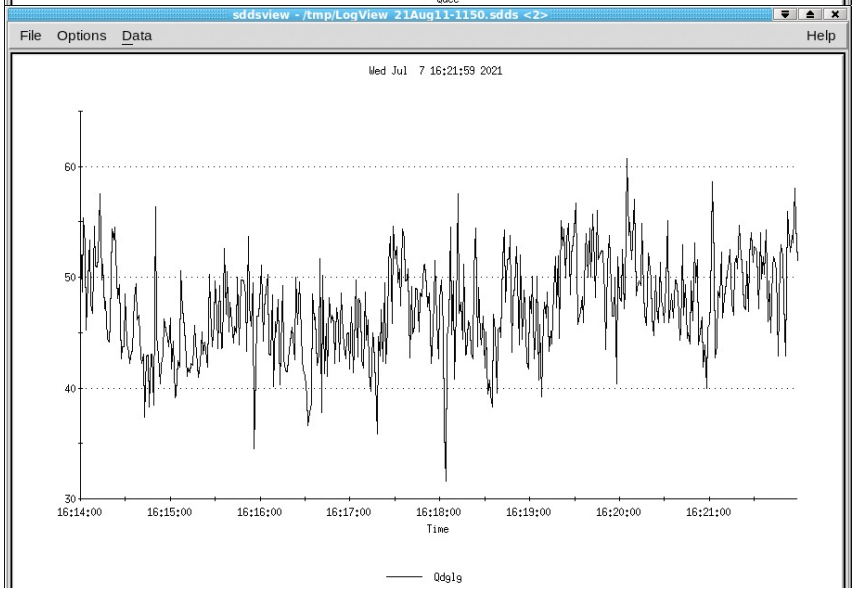


There is some external noise at 500 MHz but mostly it from BPM front end (does not scaled with attenuators).

Internal BPM Noise



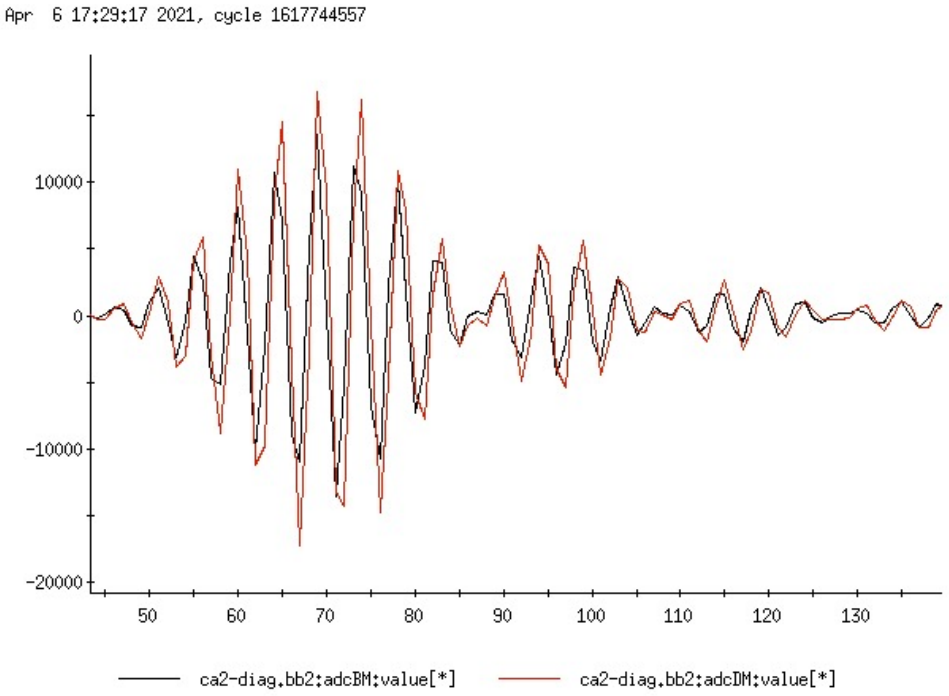




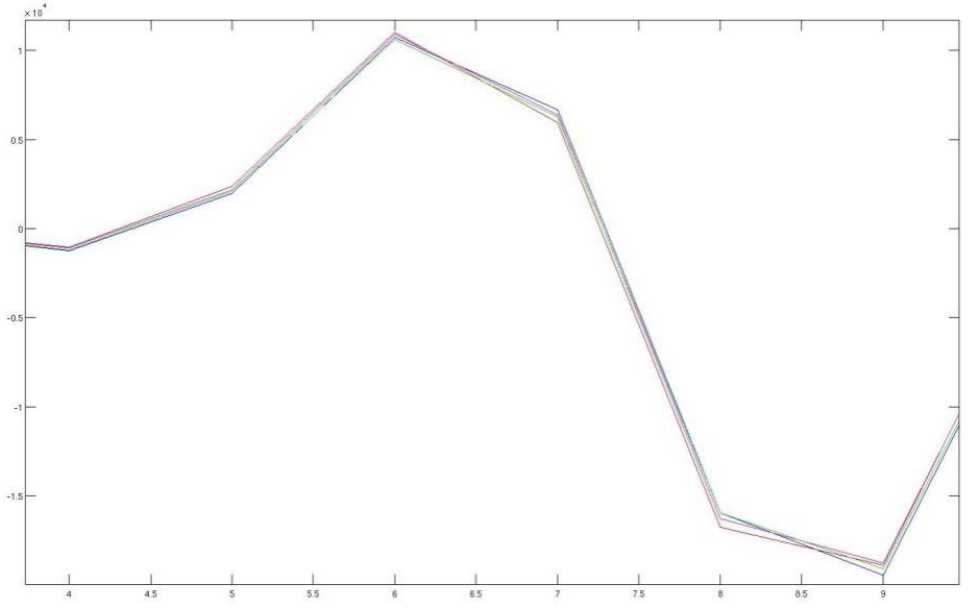
The variations of the triplet and dogleg BPM readings far exceed the properly scaled Q signal, indicating that this is most likely actual beam motion.

The beam position might be due to the laser spot center of gravity changes and magnets current changes

Adjusting Phases in Individual Channels



Raw signal from two channels in diagnostics BPM2



Phase aligned unit (from Libera manual).

Aligning phases in the individual channels can further reduce internal noise.

What Can Be Done

Laser

- Reduce number of passes through the regenerative amplifier
- Find and eliminate cause of saw-tooth modulation
- Increase laser spot size before the iris
- Add monitoring of the laser pulse energy (similar to the bunch charge measurements)
- Replace drive laser

Other systems

- Implement orbit feedback for the linac axis and common section
- Configure the RF loopback compensation for the best performance (diagnostics line can be used)
- Implement beam-based energy feedback
- Identify power supplies mostly affecting beam trajectory (swap them with spares or into the less critical location)
- Adjust phase correction in the BPM for minimal noise