Correction of 10 Hz Orbit Distortion From Diamond's I10 Fast Switching Chicane

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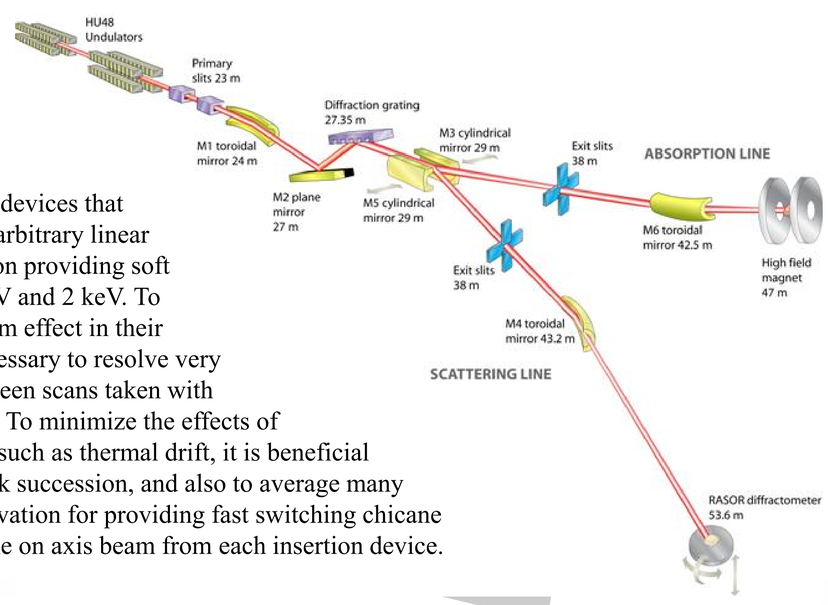
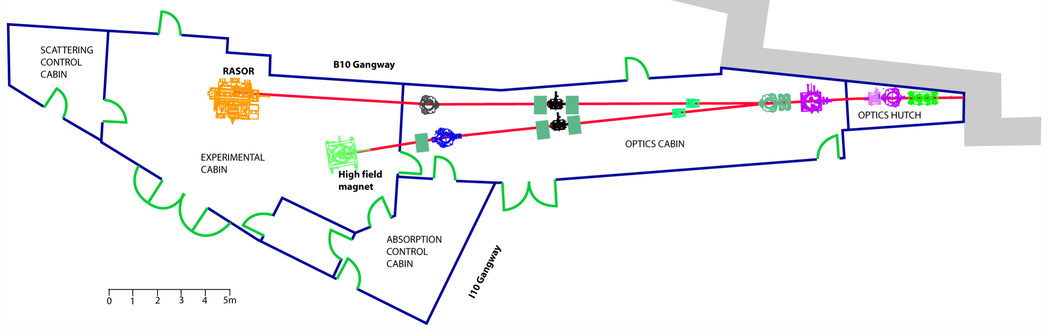
Diamond Light Source's I10 beamline is designed to perform advanced dichroism experiments. Samples are probed by circularly or linearly polarised x-rays which originate from either of two APPLE II insertion devices. In order to reduce noise on measurements it is beneficial to quickly switch between the two different beam polarisations. At Diamond Light Source this is achieved using five horizontal dipole 'chicane' magnets that sweep the beam on or off axis between each ID at 10 Hz.

I10 Beamline Configuration



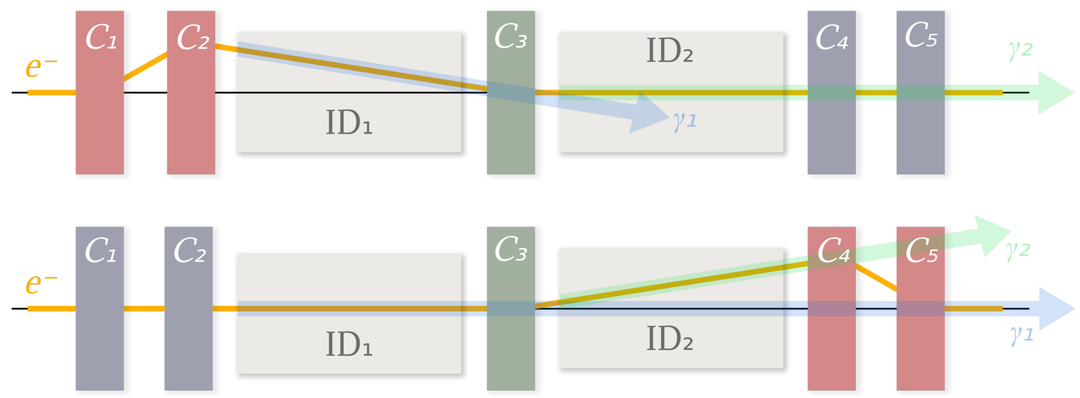
I10 uses two insertion devices that can be configured for arbitrary linear and circular polarisation providing soft x-rays between 0.4 keV and 2 keV. To determine the dichroism effect in their samples it is often necessary to resolve very small differences between scans taken with different polarisations. To minimize the effects of temporal based noise, such as thermal drift, it is beneficial to obtain scans in quick succession, and also to average many scans. This is the motivation for providing fast switching chicane magnets to alternate the on axis beam from each insertion device.



Chicane Magnets

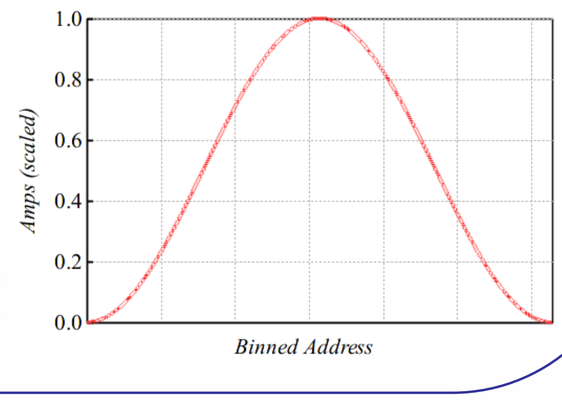
Arrangement of chicane magnets in their two extreme states.

C_1 and C_2 are at maximum field and pass the electron beam off axis through ID_1,
DC magnet C_3 provides a restoring kick and the on axis photon beam from ID_2 is generated.



C_1 and C_2 have zero field and pass the electron beam on axis generating a photon beam through ID_1,
DC magnet C_3 provides a kick that takes an off axis trajectory through ID_2,
C_4 and C_5 restore the nominal trajectory.

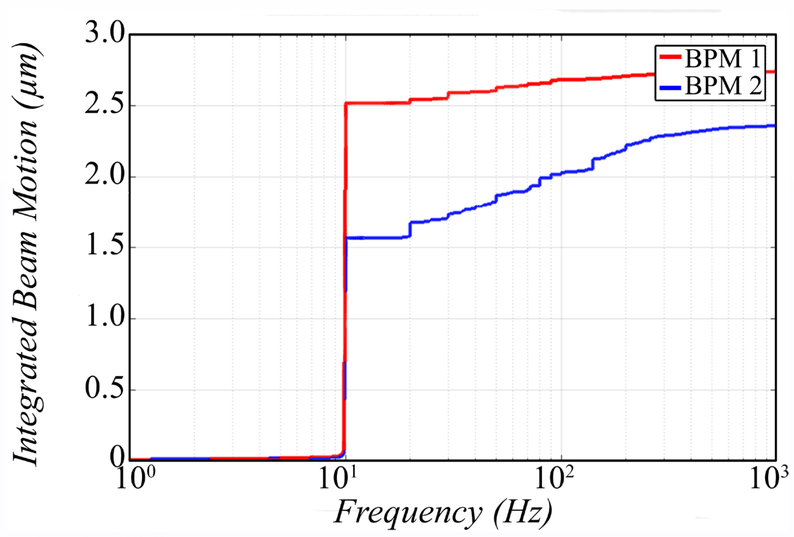
The AC waveform is cycled 180° out of phase between $\{C_1\ C_2\}$ and $\{C_4\ C_5\}$ to provide 10 Hz oscillations between the two on axis trajectories.



The offset sine waveform applied to chicane magnets by the power supply controllers.

The Problem with Switching

The switching scheme is designed to be transparent to other beamlines in Diamond, the electron trajectory should remain stable in the global storage ring. If the amplitude and phase used by the power supply controllers are not perfectly selected then there will be a residual component of the switching frequency that can be seen by all beamlines around the ring.



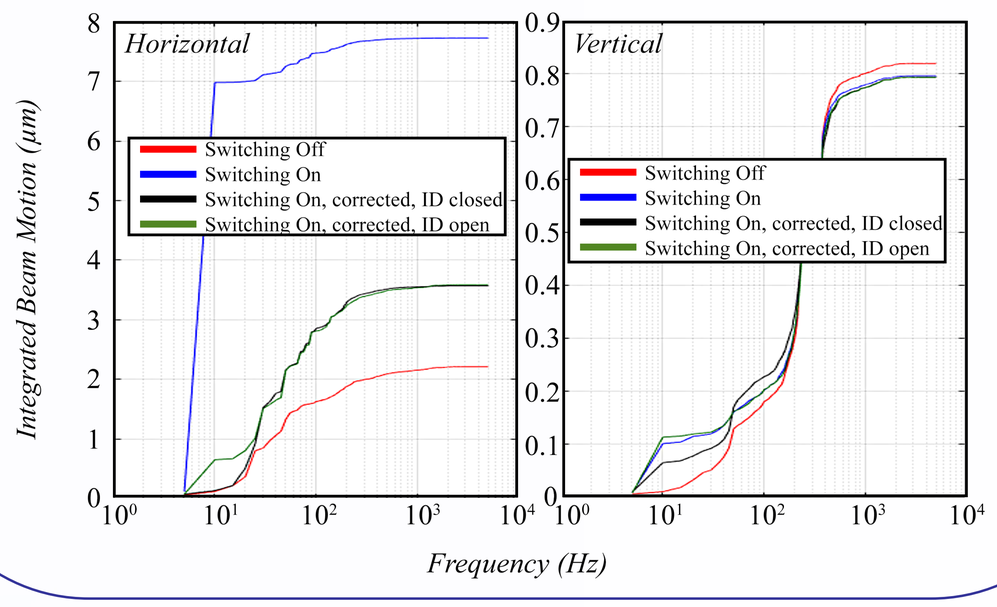
Effect of fast chicane switching on integrated beam noise.

For these example BPMs it is clear that there is significant noise being created at 10Hz and its harmonics, created by misalignments in the I10 chicane.

Correction Algorithm

Measuring a complex response matrix that maps changes in chicane amplitudes to BPM magnitude and phase at 10 Hz allows construction of a feedback routine to correct the residual beam noise. Inverting the response matrix and then forward multiplying by the measured 10Hz BPM vector gives a complex delta error vector. Mapping the current amplitude and phase of the chicane magnets into complex space, subtracting the error delta, then taking the magnitude and angle of the result gives new values for chicane amplitude and phase. Applying these new values removes the noise at 10 Hz.

Result of the correction. Under ideal conditions the 10 Hz component is completely removed.



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