Septum Orbit Feedforward Correction At The AS

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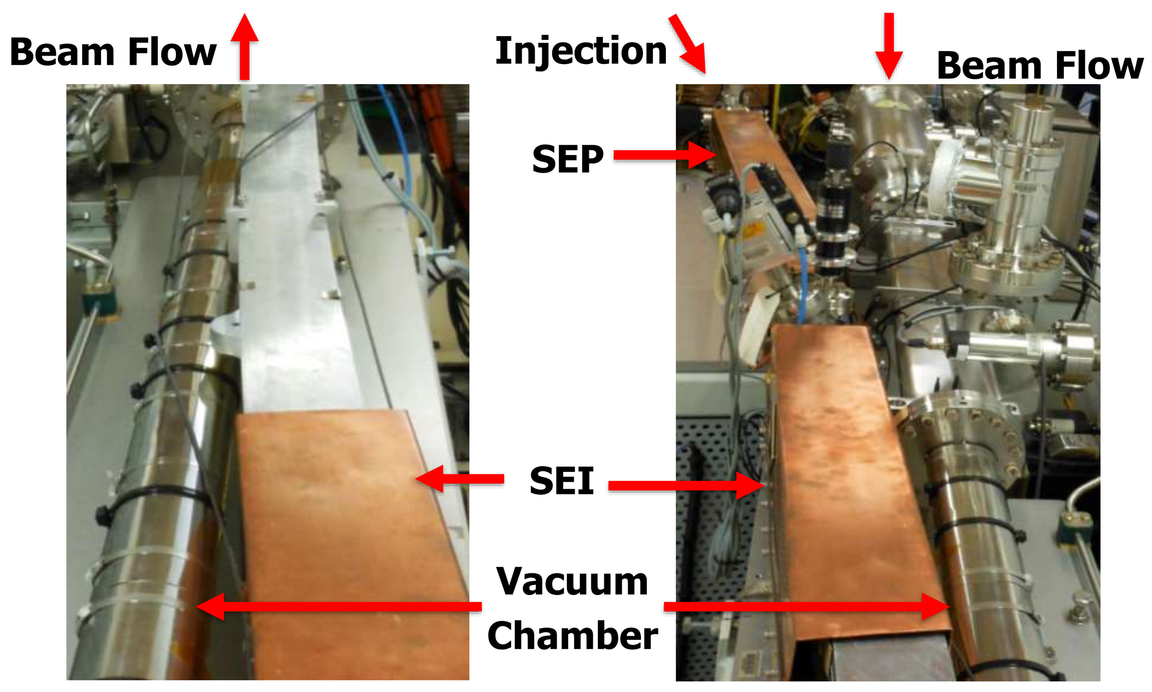
The leakage fields generated by the septum in the injection straight perturbs the beam by as much as 130 um horizontally and 80 um vertically during injection. This report will discuss the design and implementation of an active feedforward correction dipole and evaluate its effectiveness.

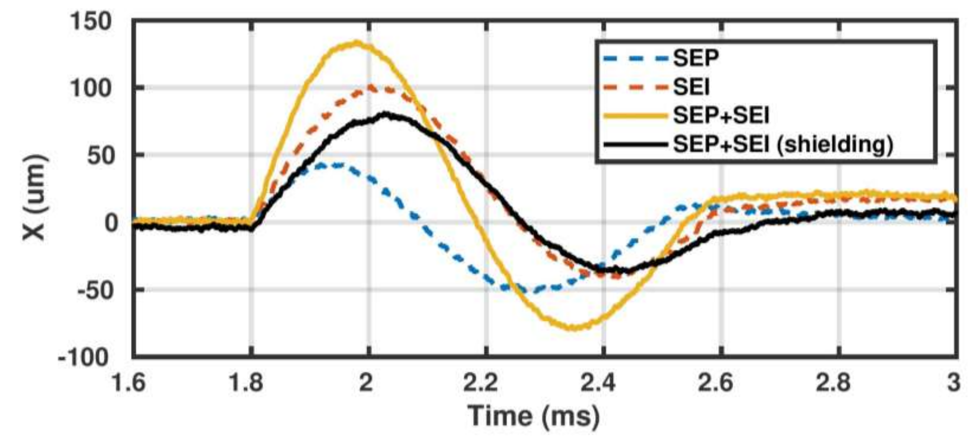
Introduction

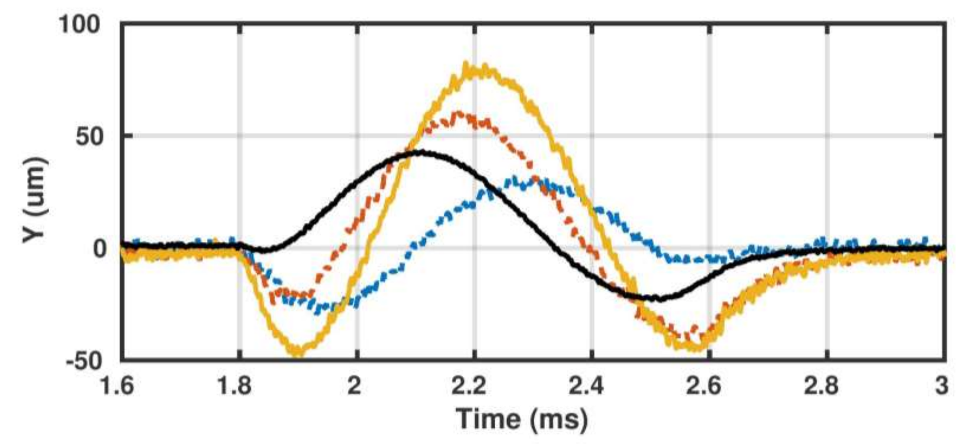
- Four injection kicker magnets and two horizontal septa (SEP and SEI) to guide the electrons from the injector system into the storage ring.
- Stray fields from the septa cause a perturbation in the beam around the full length of the storage ring each injection.

Passive Shielding

- 5 layers of 0.25 mm mu-metal are rolled around the vacuum chamber covering 1100 mm of the storage ring vacuum chamber. The mu-metal was rolled tight to maximise the inter-layer magnetic coupling with kapton tape wrapped around the vacuum chamber to insulate it from the mu-metal.
- Two copper boxes were installed to shield the septa themselves as some parts of the vacuum chamber did not lend themselves to shielding





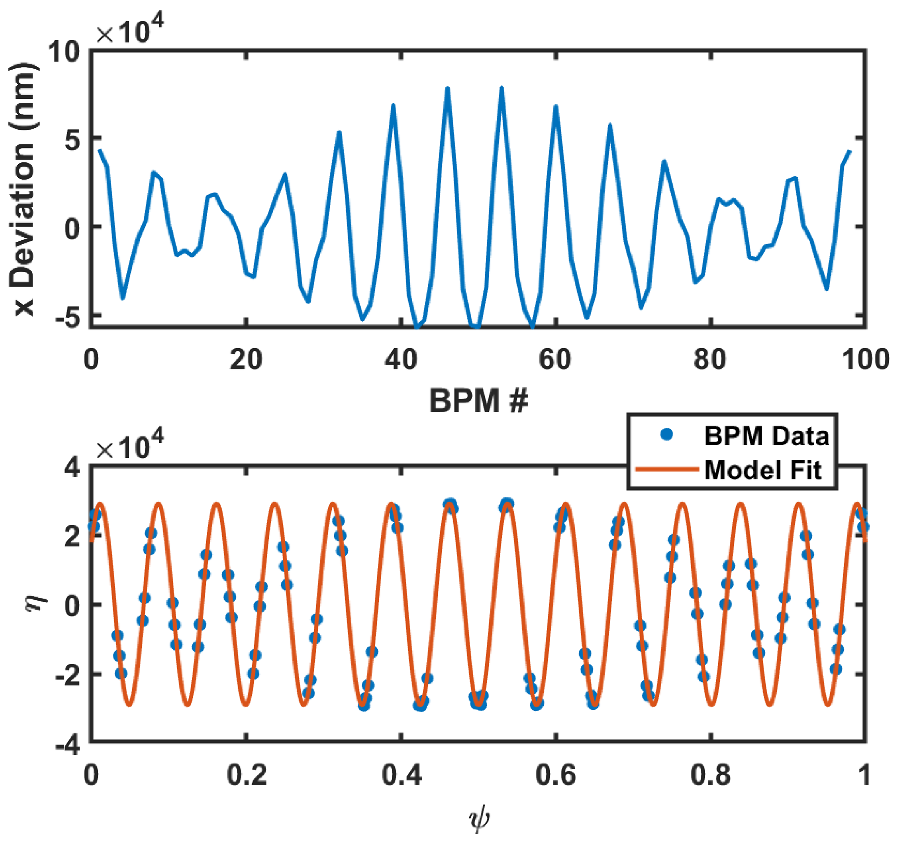


- Passive shielding reduced perturbation by ~44%
- Active methods will be used to remove remainder of the perturbation

Closed Orbit Perturbation Modelling

$$\eta = \eta_0 \cos(Q\psi + \lambda)$$

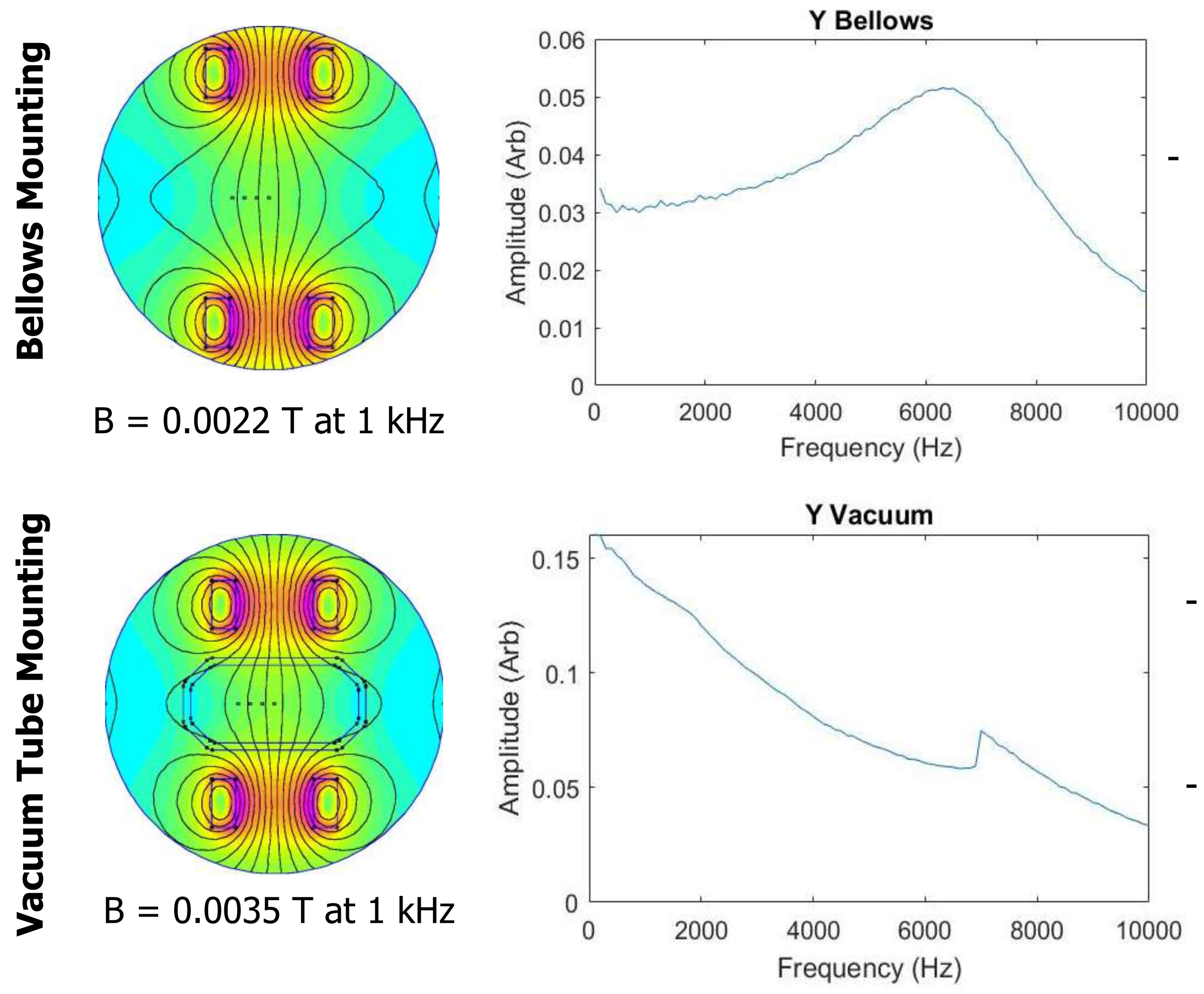
$$x(s) = \left(\frac{\sqrt{\beta_x(s)\beta_{kx}}}{2|\sin \pi Q_x|}\frac{\delta(Bl)}{B\rho}\right)\cos\left(Q_x|\psi(s) - \psi_k| - (Q_x - \lfloor Q_x \rfloor)\pi\right)$$



- Used to find optimal location for compensation dipole.
- Used to find optimal waveform for correction by iterative error minimization within each time frame.

- Kick amplitudes of 10 µrad and 6.5 µrad required on each axis.
- Initial testing achieved maximum kick amplitudes of 1.2 µrad at maximum capability of the 50V/2A power supplies.
- Larger kick amplitudes were achieved with the same power supply by comparing the mounting options and improving the coil design.
- Coil was optimized by reducing turns, increasing length and optimizing width using FEMM simulations.
- Frequency response of both mounting options was measured to verify results

Coil/Mounting Optimisation



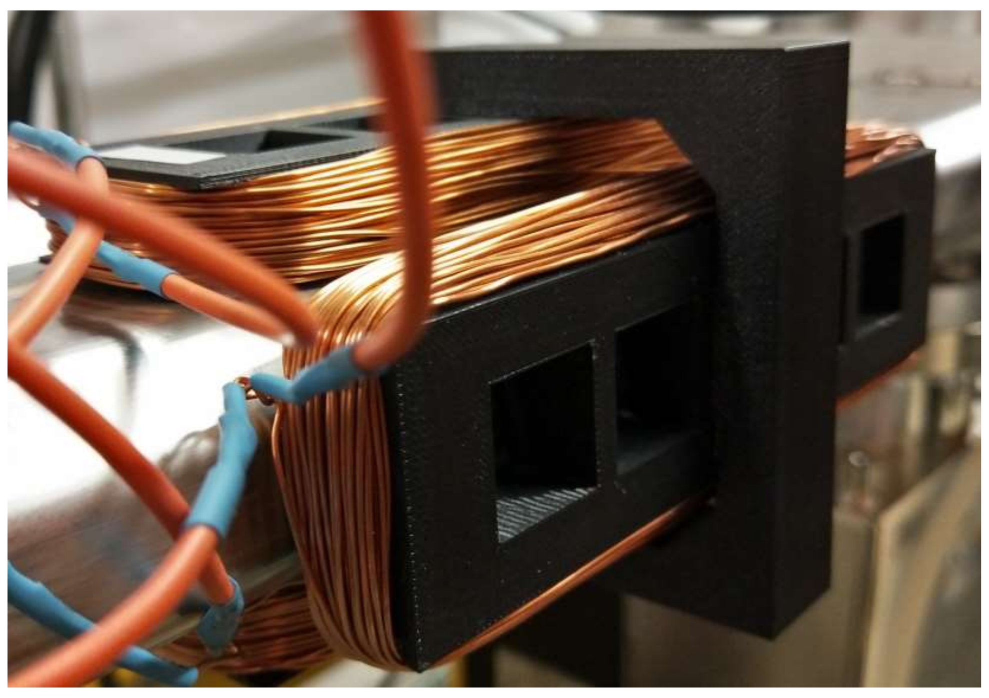
Observations

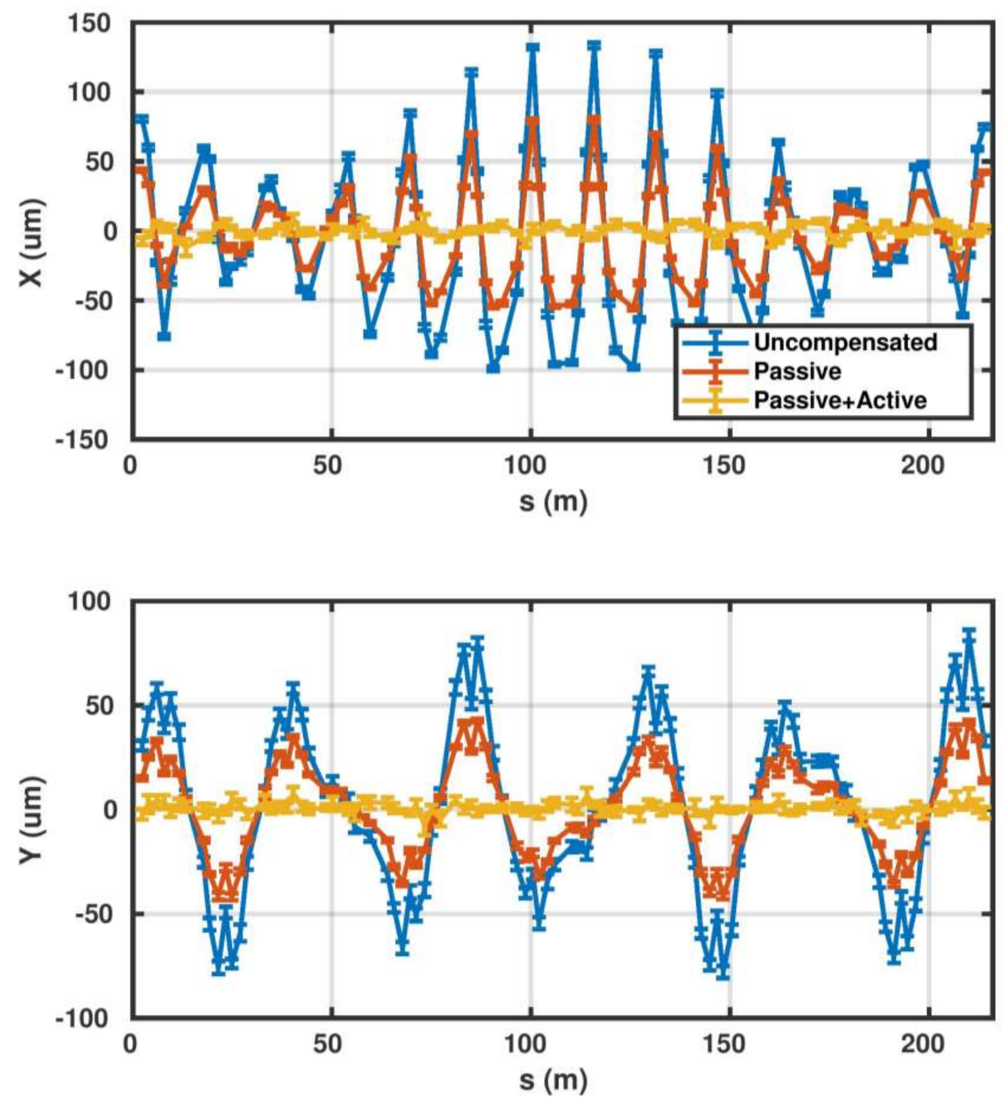
- Resonance at 6 kHz from power supply (LC circuit)
- Attenuation from vacuum tube dominating: $A \propto e^{-k\sqrt{f}}$
- Resonance at 7 kHz from power supply (LC circuit)

- FEMM simulations and experimental results agree that the Vacuum Tube provides larger kick amplitude at 1 kHz due to coil proximity despite frequency effects

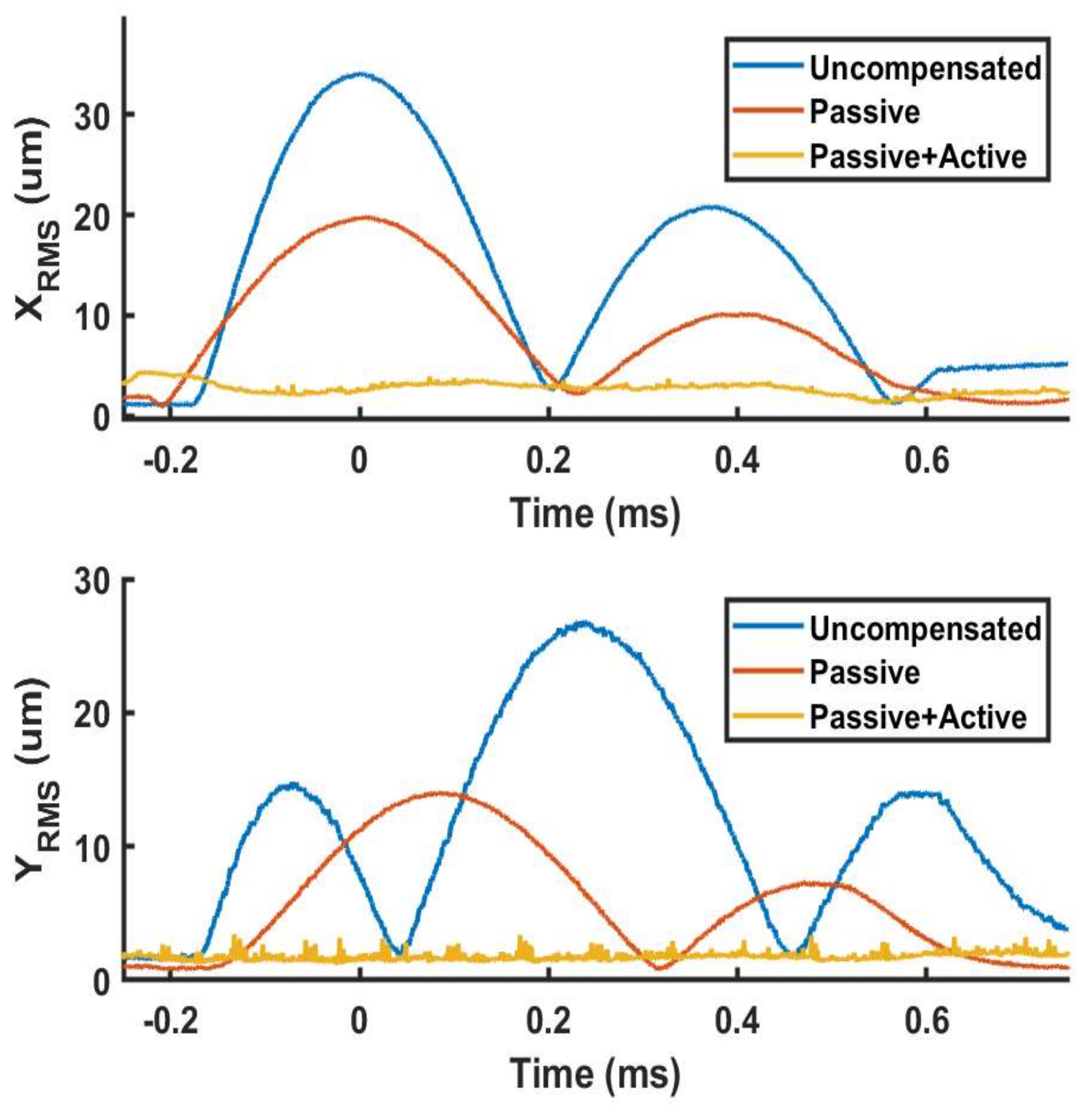
Results / Conclusion

- Custom coil mounted using a 3D printed holder, driven by 2x 50V/2A power supplies. On trigger each is sent a custom voltage waveform from a single RedPitaya.
- Active correction successfully reduced the maximum perturbation by a further ~75% on each axis, to a level close to the noise floor.
- More permanent version remains to be built.





Successful compensation over all Beam Position Monitors (BPMs)



Successful compensation over full duration of perturbation