FERMILAB-POSTER-24-0072-AD

Flattening the field during injection in the Fermilab booster using dipole corrector

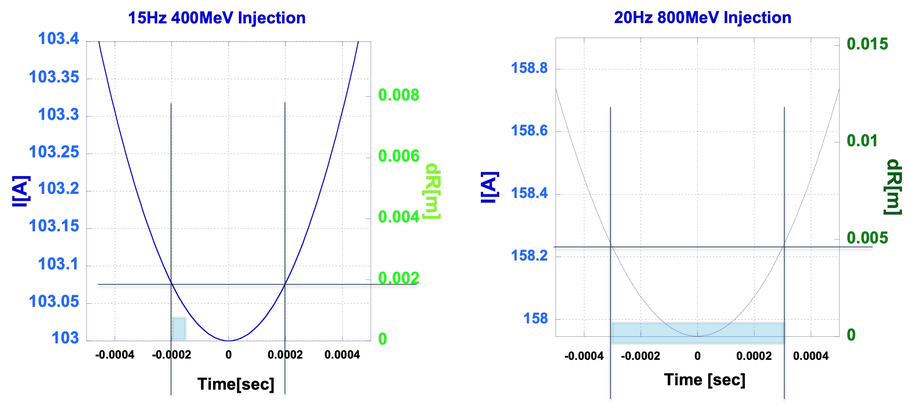
K. Seiya, D. Barak, C. Bhat, S. Chaurize, T. M. Omark, F. J. Ostiguy, H. Pfeffer, A. K. Triplett, B. Vaughn
Fermi National Accelerator Laboratory, Batavia, IL 60510

IPAC 24
NASHVILLE, TENNESSEE
USA
MAY 19-24, 2024

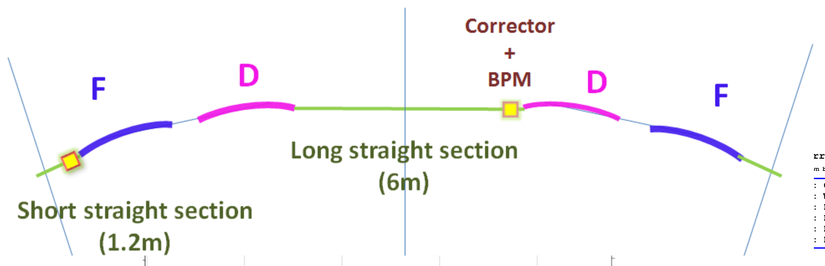
TUPC10

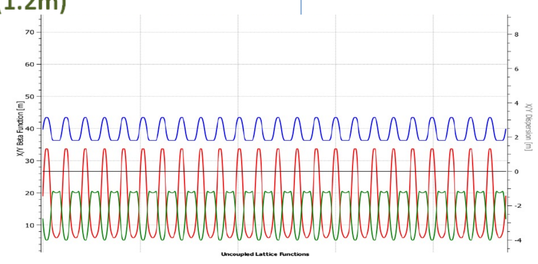
Goal

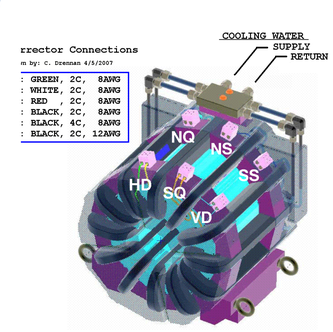
(1) Flattening of the net bending during injection using dipole correctors, and (2) Using a new system based on an Altera FPGA board, reduction of the cycle-to-cycle bending field variation caused by current jitter in the Gradient Magnet Power Supply (GMPS).



48 correctors in the Booster







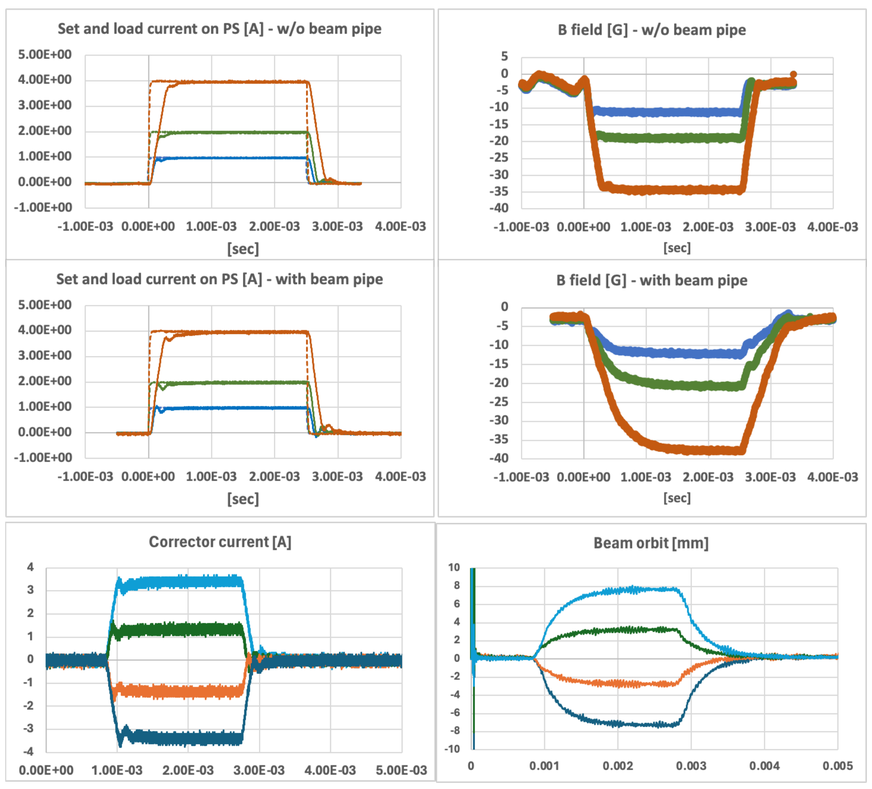
$$\frac{\Delta B\ell_{max}}{B \times 2\pi\rho} = \frac{0.009[T \cdot m] \times 48 \times 10[A]/24.4[A]}{0.042[T] \times 2\pi \times 75.75[m]}$$
$$= 0.0088$$

Corrector field with slew rate and Eddy current effect

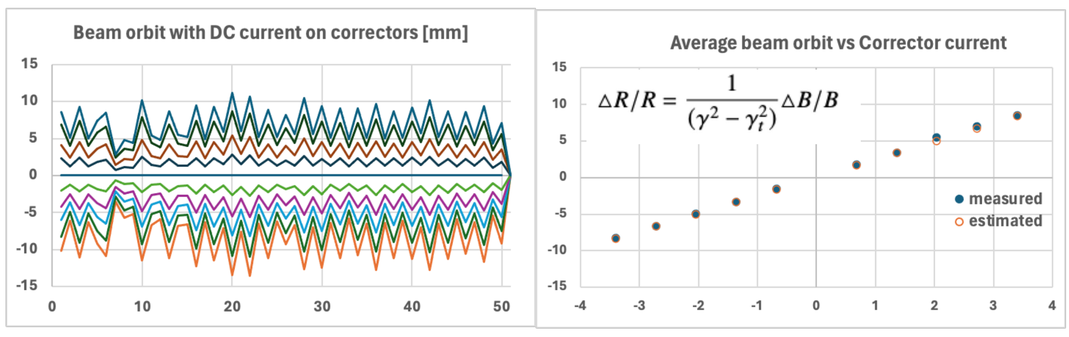
Corrector B field without beam pipe

Corrector B field With beam pipe

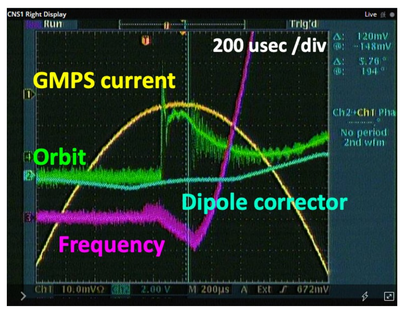
Beam orbit response



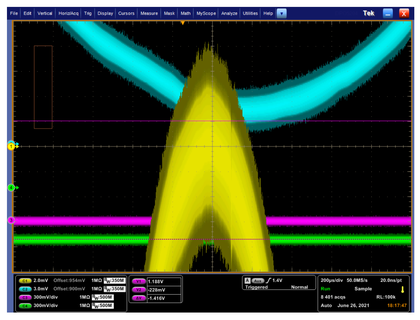
Dipole corrector current vs Beam position



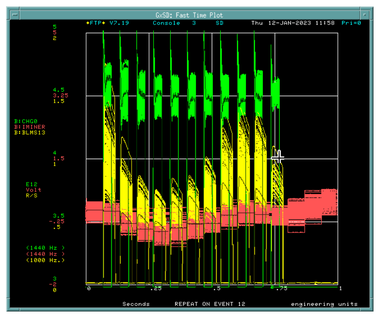
Beam at injection - other issues



Orbit shifts > 10 mm

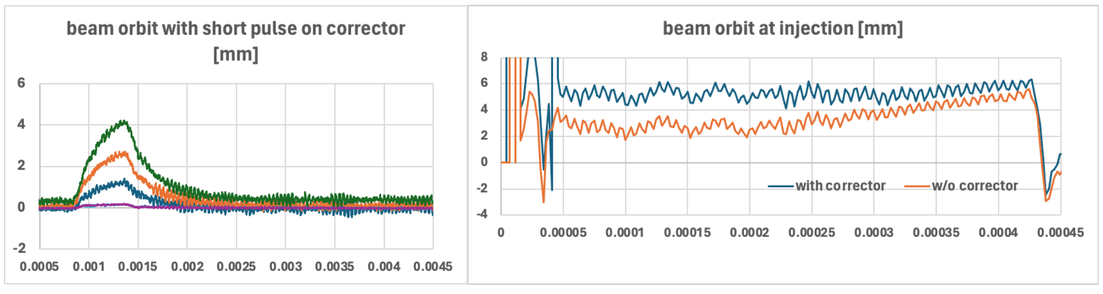


GMPS I jitter ~ 0.2%



Loss follows GMPS err.

Effective B field flatting with short pulse

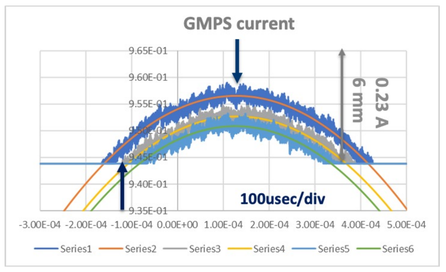


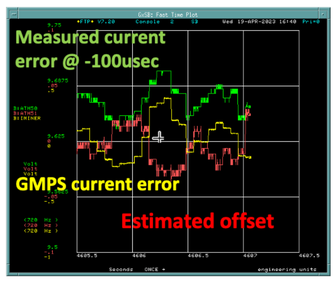
Bending field amplitude jitter and control with FF

1: Measure current 100 usec before injection

2: Estimate required offset

3: Send the offset to correctors

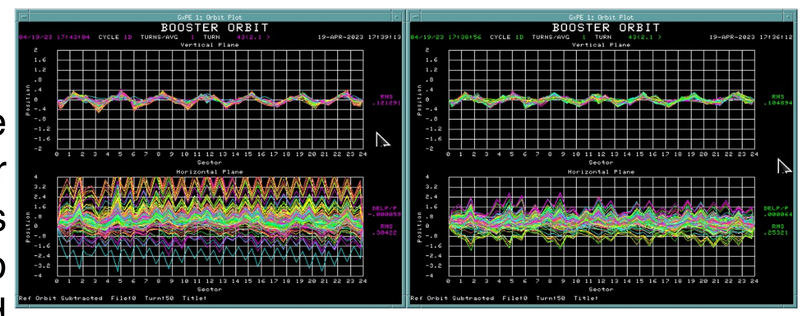




CONCLUSION

In preparation for the upcoming PIP-II operation, efforts were made to flatten the effective bending field at injection. During beam studies, the orbit response to the dipole corrector field was measured. Due to limitations in the power supply, the output voltage was restricted, thereby reducing the slew rate. Additionally, the corrector field was observed to be affected by the Eddy current effect. Using the limited field response, the bending field was canceled and resulting in a change in orbit execution of less than 1mm.

Further beam studies revealed two additional primary issues. Firstly, during normal operation, the beam orbit moved more than 10 mm within the first 1 millisecond of injection. Secondly, the bending fields exhibited jitter of more than 0.1%, causing the beam orbit to fluctuate beyond +/- 5mm. To address the field jitter, a feedforward approach utilizing an FPGA module was implemented, resulting in a reduction of jitter to less than half of its original magnitude.



ACKNOWLEDGEMENTS

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.