Effect of Partial Discharge on Beam Dynamics

Eric F. Schmidt[1,2]

[1]Physics Department, Brookhaven National Laboratory, Upton, NY 11973
[2]Science Undergraduate Laboratory Internships (SULI); email: schmide2@my.erau.edu

October 26, 2016

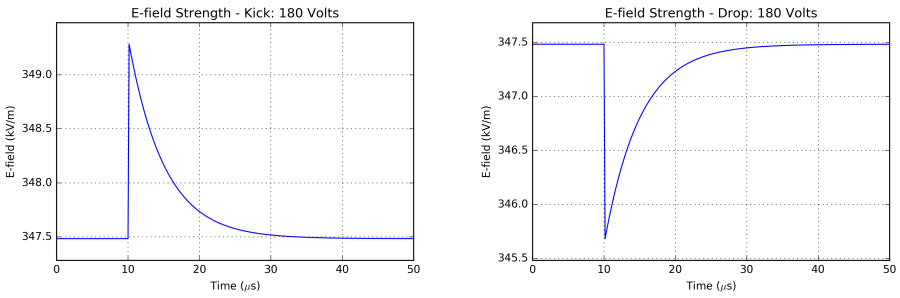
1 Introduction

A single muon was tracked around the ring and a voltage kick or drop of ±180 V was added to the bottom plate in the long quads [1]. The voltage drop or kick were each added in two places in the y, y' phase space: where y' was a maximum and where y' was a minimum (both at $y \approx 0$).

$$y' = \frac{dy}{ds} \tag{1}$$

where s is the distance the particle moves around the ring.

The particle was idealized: its momentum was set at the 'magic' momentum and it always remained at $x = 0$. The initial y-position was set at $y = 40$ mm. The muon was tracked in two different physical scenarios. First, it was tracked using the actual quad setup although the edge effects of the electric fields were not accounted for, the electric field was either 'on' inside a quad or 'off' ouside. In the second scenario it was tracked assuming quads covered the entire ring but the only locations that experienced a voltage kick/drop were where the long quads are actually located. The second tracking method was used because in the first scenario, the details of the muon reaction to the voltage change were lost in the data from the muon's movement in and out of E-fields and the drift when no E-field was present. Fig. 1 shows how the strength of the E-field changed during a kick, Fig. 1a and a drop, Fig. 1b. As the muon was being tracked, the maximum or minimum y-position was noted each time the muon made one revolution around the y, y' phase space at $y' \approx 0$. Histograms were then created from these extreme y values.



(a) E-field strength from the kick.

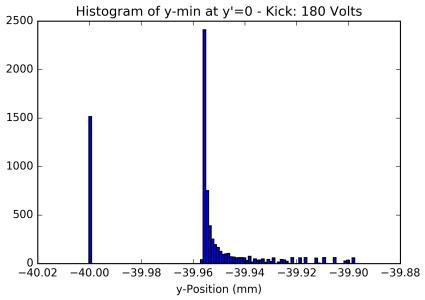
(b) E-field strength from the drop.

Figure 1: The strength of the electric field from a voltage kick/drop. The initial voltage change occurred in 156 ns. The recovery time constant is $\tau = 5\ \mu s$ [1].

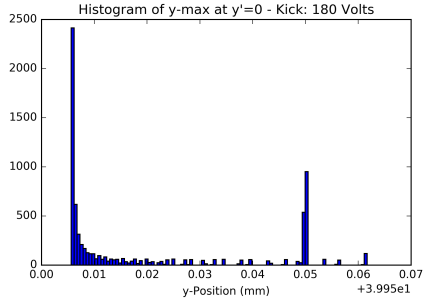
Results Tables 1,2 give the results. Figs. 2,3 show the histograms of the minimum and maximum positions from the voltage change. Only histograms of the scenario with full quad coverage around the rings are shown, in addition, as the histograms differ very little between minimum y' and maximum y', only maximum y' histograms are shown. We can see that after the recovery the min/max positions are different than before the voltage change. The maximum change of the extreme y-positions was only about $\Delta y \approx 0.1$ mm.

Table 2 shows us that other changes for a simplified, idealized system as was tracked here overwhelm the minor changes due to the voltage drop/kick.

Other locations for the voltage kick/drop in y, y' phase have a smaller effect on the min/max y-position values and are therefor not shown.

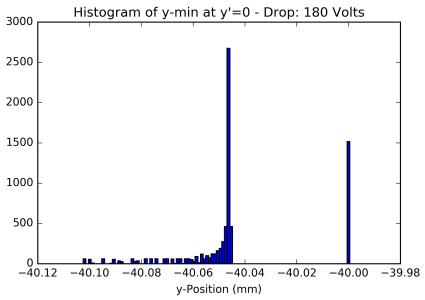


(a) Minimum y-position at $y' \approx 0$ due to the voltage kick.

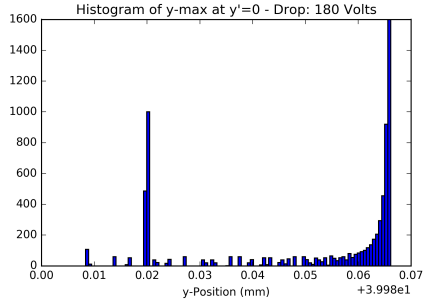


(b) Maximum y-position at $y' \approx 0$ due to the voltage kick.

Figure 2: The peaks at 40 mm are from before the voltage change. The ramp up to the larger peaks are the recovery phase and the large peaks are after the voltage recovered.



(a) Minimum y-position at $y' \approx 0$ due to the voltage drop.



(b) Maximum y-position at $y' \approx 0$ due to the voltage drop.

Figure 3: The peaks at 40 mm are from before the voltage change. The ramp up to the larger peaks are the recovery phase and the large peaks are after the voltage recovered.

2 Conclusion

A kick or drop of 180 V was added to the lower plate in the long quads around the ring. This change was added at various points around the y, y' phase space of a single tracked muon around the ring. The most extreme effect the voltage change had on the y-position of the muon was when the change occurred when y' was at a minimum or maximum. This change in the minimum or maximum values of the y-position were never more than ≈ 0.1 mm. These changes in the y-position are small compared to the effects of scraping.

Table 1: **Full quad coverage around the ring:** minimum and maximum values of y-position due to a voltage kick or drop of 180 V (at a minimum or maximum v') or no change. *The approximate recovered min/max values were read from the histograms produced.

v' (dy/ds)	Voltage Change (V)	Minimum y (mm)	Maximum y (mm)	Recovered Min y (mm)*	Recovered Max y (mm)*
max	+180	-40.000	40.012	-39.955	39.955
max	-180	-40.102	40.046	-40.045	40.045
min	+180	-40.04	40.101	-40.05	40.045
min	-180	-40.013	40.000	-39.955	39.955
-	0	-40.000	40.000	-	-

Table 2: **Actual quad coverage around the ring:** minimum and maximum values of y-position due to a voltage kick or drop of 180 V (at a minimum or maximum v') or no change.

Voltage Change (V)	Minimum y (mm)	Maximum y (mm)
+180	-40.456	40.480
-180	-40.517	40.401
0	-40.410	40.414

References

[1] V. Tishchenko, E989 docdb 4449 (2016)