IMPROVED MEASUREMENT OF ELECTRIC FIELD UNIFORMITY IN HORIZONTAL ELECTROSTATIC SEPARATORS *

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Abstract

An improved technique for measuring the uniformity of the electric field between the deflecting plates of a electrostatic separator was developed and applied to the measurement of a horizontal separator at CESR. The effect of stray charge was found to be limiting accuracy in previous measurements. Appropriate shielding has eliminated the problem.

1 INTRODUCTION

While magnetic field quality measurement techniques have advanced to a fine art for accelerator magnets, the measurement of the uniformity of electric fields is still in its infancy, perhaps because electrostatic elements are relatively uncommon [1]. Nevertheless, electrostatic separators are being employed at various accelerator laboratories and provide substantial kicks to the beams so as to obtain closed orbit distortions that are opposite for oppositely charged particles; i.e. beam separation. Nonuniformity of the electric field can cause unwanted tune shifts, coupling, etc. Such effects will have a different symmetry with respect to the charge of the beams than analogous effects from magnetic corrector elements. Also, magnetic correctors elements are usually used to correct for unavoidable errors in the closed orbit and so their strengths tend to be centered about zero, while separators are usually powered to obtain a constant effect on the beams and tend to be near maximum values. So it would seem worthwhile to try to obtain more information about the actual uniformity of the electric field in a separator than can be provided by a 2D design solution.

A measurement technique based on zeroing out the induced charge on a stretched wire held between the separator plates was discussed in [2]. The original measurement showed apparent nonlinearities whose origin was not understood. Since then we have improved the technique and the previously observed large nonlinearities are no longer observed.

2 DESCRIPTION OF METHOD

The basic technique we used was to stretch a long thin wire along a hypothetical particle trajectory between the deflecting plates and adjust the potential of the wire relative to the plate potentials to zero out the net induced charge on the wire. The induced charge is observed by varying the plate voltages so that the resulting induced currents can be seen on an oscilloscope. Once the wire potential is determined the wire can be translated a precise amount and the process repeated. The electric field is obtained by taking the derivative of the wire potential data with respect to the position of the wire. The theory supporting this technique worked out in [2].

Because only the total induced charge on the wire is observed, we need to avoid inducing any charge on the wire except due to electric field of the plates. However, as the wire is moved to measure the field off-axis, its potential becomes further from ground potential. So any grounded surfaces near the wire will induce charge on the wire and influence the measurement of the electric field due to the plates. The improvement we made to the basic technique is to add a shield which is at the wire potential which effectively prevents grounded surfaces from inducing charge on the wire.

3 MEASUREMENT DESCRIPTION

The measurement scheme is shown in figure 1. We used the following equipment:

- signal generator “Wavetek”,
- two precision voltmeters DVM1 and DVM2,
- potentiometers P1 and P2,
- digital oscilloscope “Scope”,
- switch SW,
- two linear translation stages PS1 and PS2.

The scheme worked in the following way: The Wavetek produced square-wave with voltage amplitude V_0, floating with respect to ground. This voltage was precisely measured by DVM1 and we applied it directly to separator’s plates. Potentiometer P2 was used to divide this voltage in half. The center tap of P2 was connected to the vacuum chamber (separator ground). This results in the plates having $\pm V_0/2$ voltage relative to the vacuum chamber as it is under normal operating condition. A stretched wire was strung through the separator and connected through the Scope to the central tap of the other potentiometer P1. The Scope indicated electric charge flowing through the wire caused by the voltage difference between wire and middle point of $P1$. The measuring procedure was the following. For a given wire position, say x, we adjusted potentiometer P2 to eliminate the signal seen on scope in at the beginning of the each pulse. The voltage measured with DVM2, V_w gave us the potential at the wire location while DVM1 gave us the voltage, V_0, between plates. The ratio V_w/V_0 as function of wire position gives the potential distribution. Taking the derivative with respect to wire position gave the electric field profile. In earlier measurements we found very strong disturbing factor. Near the separator’s

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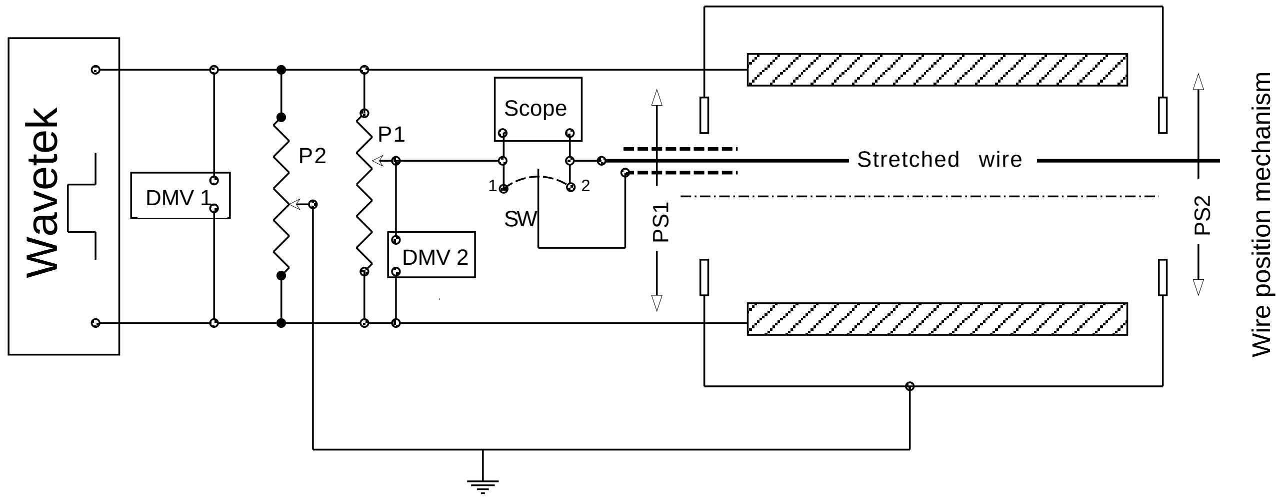

Figure 1: Schematic of electric field uniformity measurement setup.

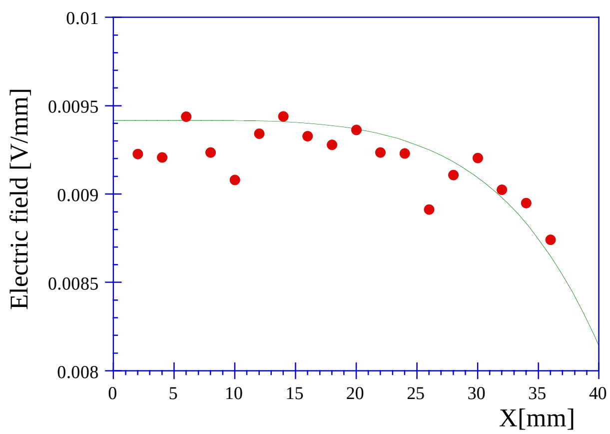

Figure 2: Measured and calculated with POISSON electric field distribution between plates.

ends the stretched wire was close to the vacuum chamber flanges. The voltage difference between wire and these flanges caused additional electrical charge flow which affected the measurement. To fix this problem we made the following improvement. One of the wire ends had been shielded with copper foil in the region close to one flange as shown in Figure 1. Shielding was connected either to point 1 or to point 2 shown on the schematic. In the first case, when the shielding was connected to point 2, we had two ends effect, in the second there was only one end effect. Combining these measurements we obtained end effect data and then using it we calculated the potential profile and excluded the end effects. The electric field was calculated as a difference in voltage measured at two adjacent wire positions divided by the distance. Figure 2 shows the measured electric field, corrected for end effects, in comparison with field calculated with the POISSON program. Here one can see quiet reasonable agreement between calculation and measurements.

4 REFERENCES

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[2] *Measurement of Electric Field Uniformity in a Electrostatic Separator*, Weiran Lou and James J. Welch, proc. Particle Accelerator Conference, PAC95, pp 2138, Houston TX, (1995)