USE OF SEARCH METHODS AT OPTICAL ELEMENTS OF LINEAR ACCELERATOR SYSTEMS FOR IONS

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Abstract

The characteristics of the beam from the ion gun can change during an experiment at the acceleration system. These changes have their cause in the extraction process of the ion source and can be influenced only marginally. Therefore an once adjusted parameter set of the optical elements stays not optimal over the full time of the experiment. A procedure, searching and keeping the optimum of a quality value of the beam, is necessary. This procedure must run continuously during an experiment. Hence it follows that the beam characteristics must be influenced only in a limited way by such a search method. Such a procedure is presently tested at the Research Center (Forschungszentrum) Rossendorf e.V. (FZR). It is based on a correlation measurement between a test signal for each optical element and a quality signal describing the beam status.

1 BASIC PRINCIPLE

There are many optimization algorithms available (also called search algorithm). Most of them were developed for optimization of parameters. Those procedures have a high efficiency, i.e. few however exactly directed steps usher into the optimum. But from the view of control engineering these algorithms cause too large steps of the controlled values. In this case in the focal point is to be hold at the optimum. The algorithm must execute smallest steps around the optimum point.

One such a algorithm is called "Optimization with Synchronous Detecting". It is based on a correlation algorithm (Fig. 1) a detailed description can be found in [1]. A test signal is added to the control value from an integrator. A correlation operator analyses the difference between this signal and the difference of the quality value (see Fig. 2 and table in Fig. 1). This correlation operator executes a polarity correlation (sign correlation).

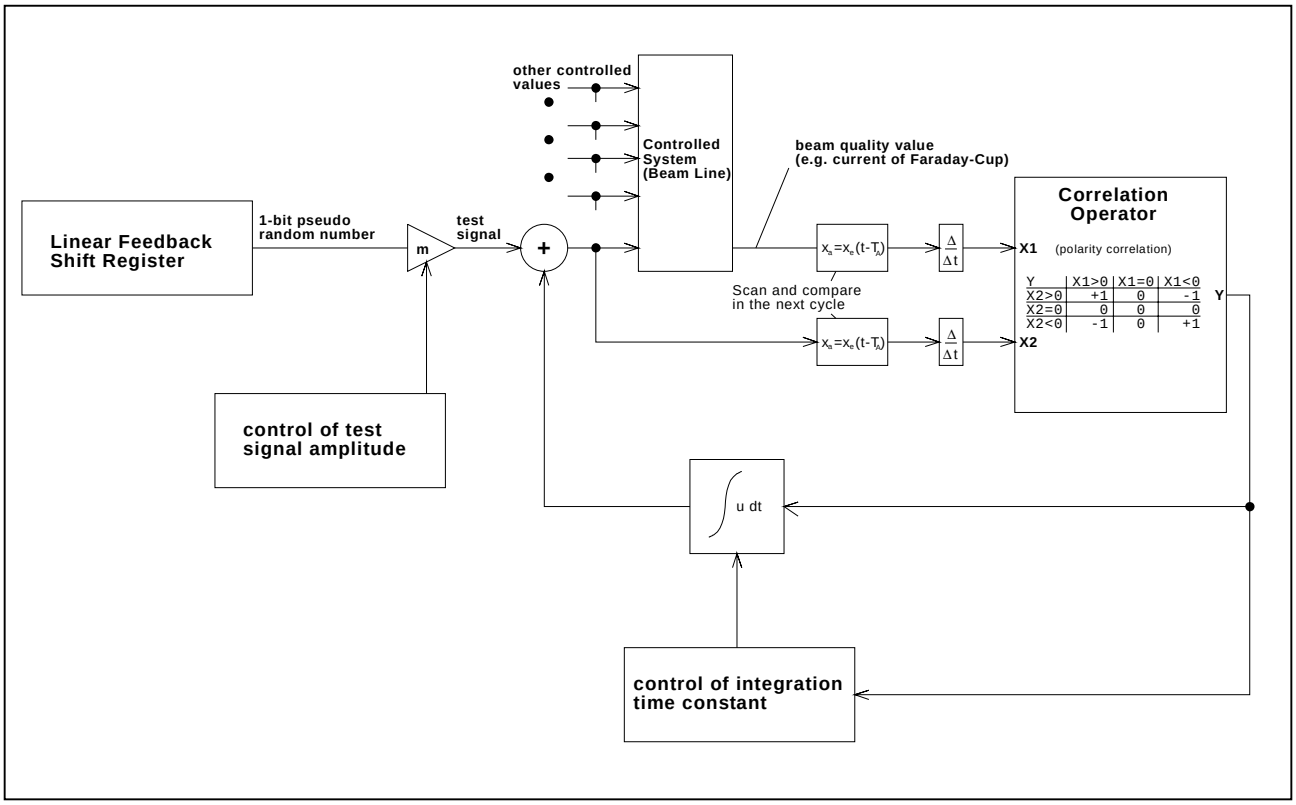

Figure 1: Search Algorithm

2 SIMULATION

The simulation of beam optics is executed in first order. The simulation tool is MATLAB. The following elements were used (Fig. 3):

- a source with Normal (Gaussian) Distribution of positions and angles
- two steerers per plane (xz- and yz-plane, K1a/K1b for position and K1b for angle)
- two quadrupol doublets
- two apertures with different aperture for each plane

The simulation starts with a symmetric beam source. In step 500 to step 1500 the center of the source is moved continuously to 0.4mm in x-direction (drift simulation). The quality value is the weighted sum of particles at the cup on the end and symmetry characteristics of beam loss on aperture segments.

Figure 3 shows the envelope at the end of the

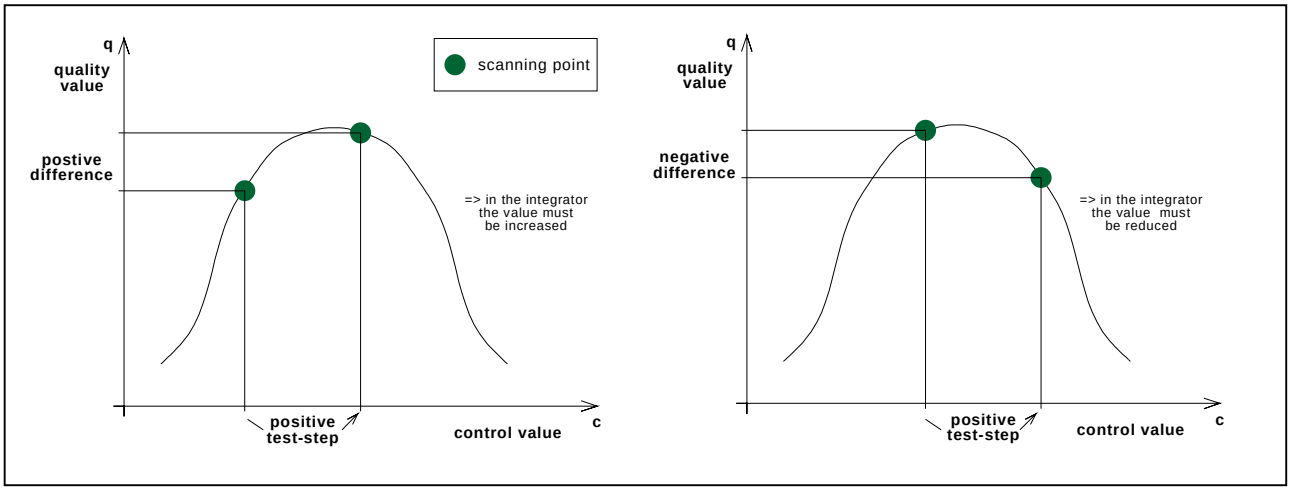

Figure 2: Two examples for correlation steps

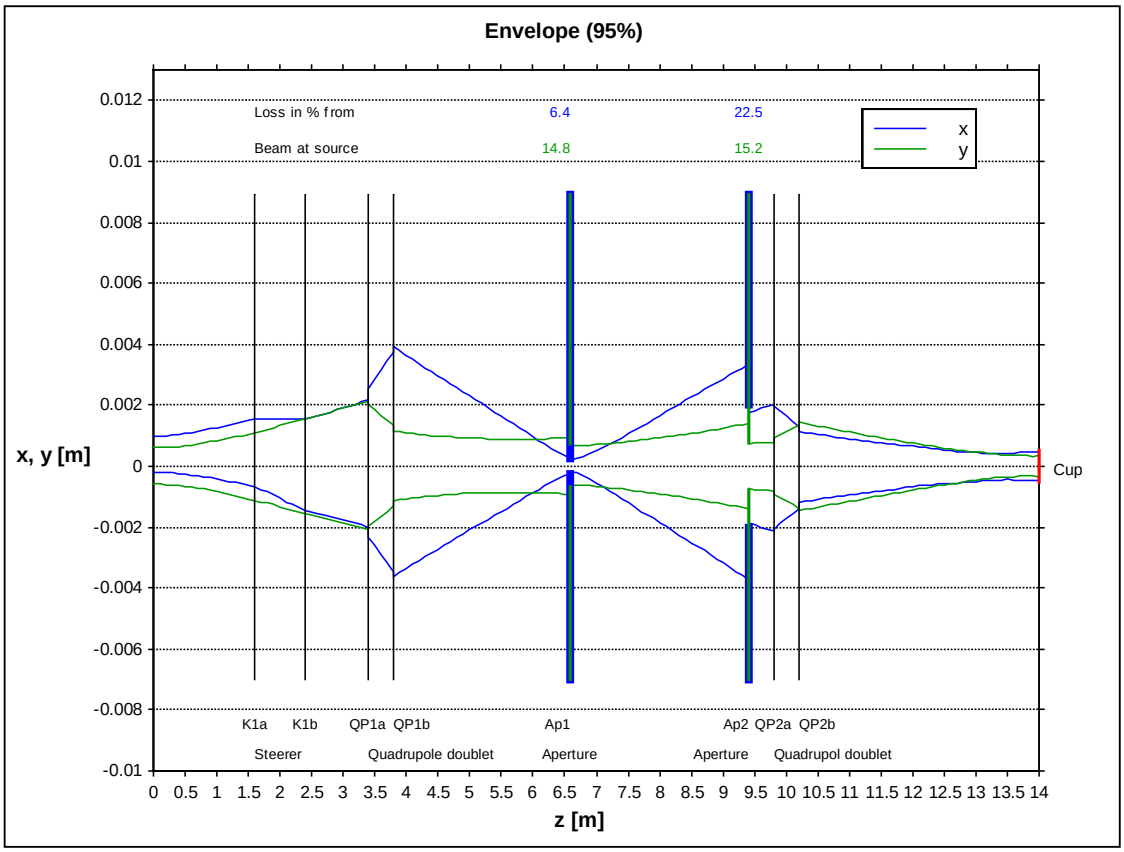

Figure 3: Envelope in xz- and yz-plane past 3000 simulation steps

simulation. The position-steerer corrects the displacement of the source in the xz-plane almost completely. Necessarily the loss values at apertures are selected relatively high in this simulation, so that the discretization with 2200 particles does not have a substantial effect on the simulation process. For comparison the red line in figure 4 shows the quality value if the search algorithm is stopped. If the search algorithm is running, the quality value is close to the maximum value (blue line). Figure 5 shows the controlled value for the position-steerer.

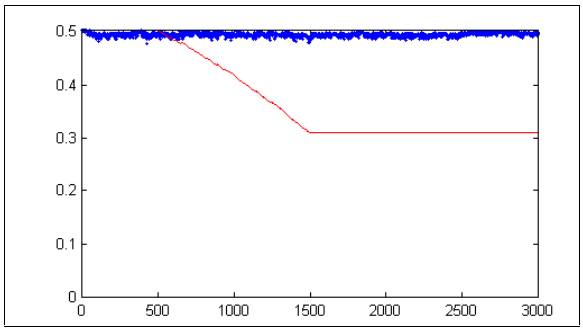

Figure 4: Quality value with search algorithm (blue, bold) and without search (fixed control values; red)

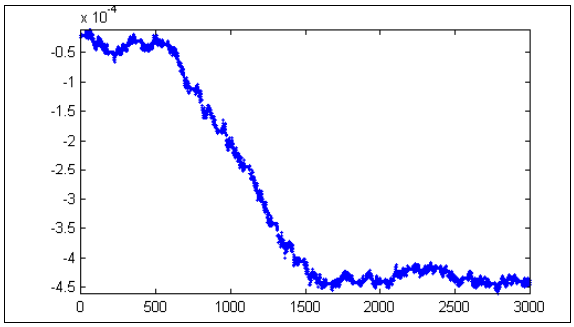

Figure 5: Value of position-steerer K1a/K1b

REFERENCES

[1] Hartmann, K.; Letzki, E.; Schäfer, W.: Statistische Versuchsplanung und –auswertung in der Stoffwirtschaft, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig 1974