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A NEW EMITTANCE MEASURING DEVICE OF THE UNILAC

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Summary

For continuous monitoring of emittances and on-line calculation of beam envelopes during routine operation of the Unilac a fast measurement device was installed in the low energy beam transport line. Two orthogonal slit-collector systems are positioned parallel to the beam line. A microprocessor controlled electric deflecting system sweeps the beam by stepwise variation of the high voltage. The ratio between deflected and undeflected part of the pulsed beam can be varied within broad ranges. The minimum refresh rate for a complete emittance display in both transverse planes is 0.5 s. Although using fixed voltage steps the device can be adjusted to various charge to mass ratios. For comparison the slit-detector system can also be moved mechanically through the beam. Therefore the device combines a very fast nearly non-destructive emittance scan with a slow destructive system.

Introduction

At the Unilac facility improvements concerning beam diagnostics combined with the development of on-line optimization procedures are most effective in the low energy area. Frequent changes of the kind of ions to be accelerated or even changes of the ion sources on ground of limited source lifetimes tend to decrease the operational efficiency. Typical lifetimes of the Penning ion sources are rather short in comparison to typical run times of most of the experiments. In addition, emittance shows a time dependence due to erosion of source and extractor electrodes. Therefore, a continuous monitoring of emittances can be very efficient. The realization was performed by modification of one conventional emittance measuring device as used up to now at the Unilac.

General Description

Normally, at the Unilac emittances are measured by moving a slit detector system as shown in Fig. 1 step by step through the beam. Since there is no manipulation on the beam during the measurement and taking advantage of the high precision of the used feedthroughs and slit-detector system measured emittances can be very accurate[1]. Therefore it was decided that the conventional use of the system should be possible even with a modified fast measuring device. The solution results in an idea which is explained schematically in Fig. 2. In a new designed high vacuum chamber two sets of horizontal and vertical deflecting plates mounted on 4 double high vacuum feedthroughs were installed. Two orthogonal standard slit collector systems (comp. fig. 1) are positioned parallel to the beam line as shown in Fig. 2. A microprocessor controlled electric deflecting voltage sweeps the beam. In conventional use the slit-detector systems can also be moved mechanically through the beam. Fig. 3 shows the complete equipped new measurement chamber.

Characteristics of the System

Deflecting System:

The sweep over the slit-detector unit is performed by an electric field modulated by a staircase function. The high voltage generator produces a series of 32

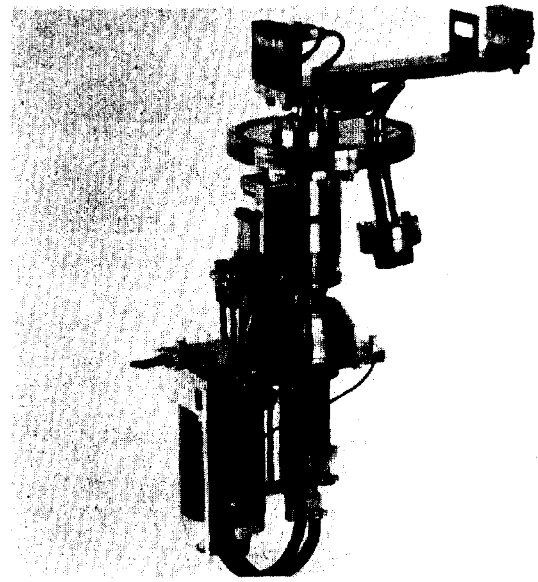

Fig. 1. Slit-detector system with feedthrough.

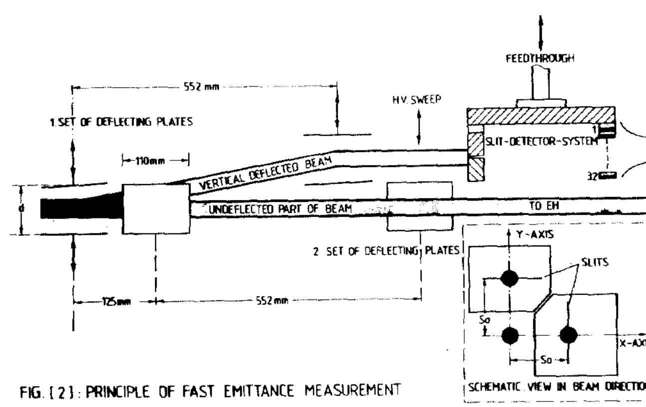

FIG. [2]: PRINCIPLE OF FAST EMITTANCE MEASUREMENT

rectangular steps, 300 Volts each, ranging from 9.2 kV up to 18.5 kV. Fig. 4 shows the functional diagram of the H.V. generator. The charging circuit loads a capacitor to approximately 10 kV. Voltage dependent resistors (V.D.R.) connected parallel to the capacitor can be short-circuited by switches. A block diagram of the complete device is given in Fig. 5. Since two circuits according to the basic diagram in Fig. 4 build up the H.V. generator, a non grounded high voltage output can be accomplished. The switching circuit contains 32 cells. Each cell includes V.D. resistors, Zener diodes and a thyristor switch which is triggered via an insulated pulse transformer by the µP-control electronics. Fig. 6 gives the timing diagram of the high voltage generator. From the µP the addresses of the switch cells to be fired and some other digital control signals are delivered and also shown in Fig. 6.

Although using fixed voltage steps of 300 Volts, the system can be adjusted to various charge to mass ratios ζ/A changing the electrical field strength on

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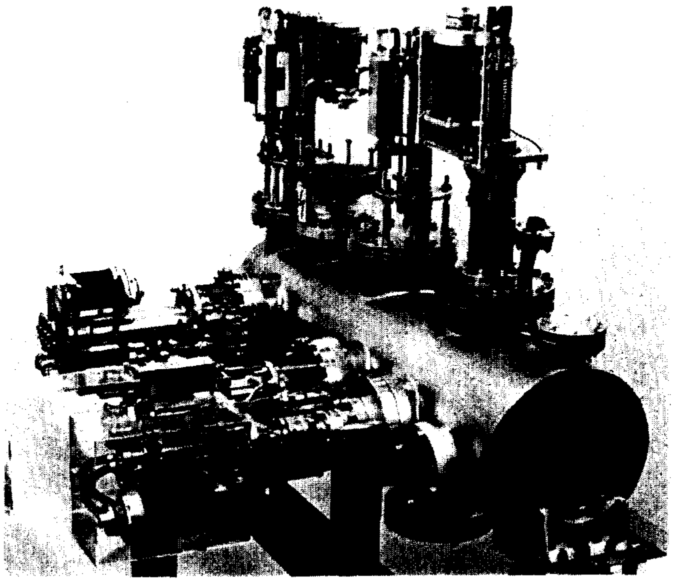

Fig. 3. Complete equipped emittance measuring chamber.

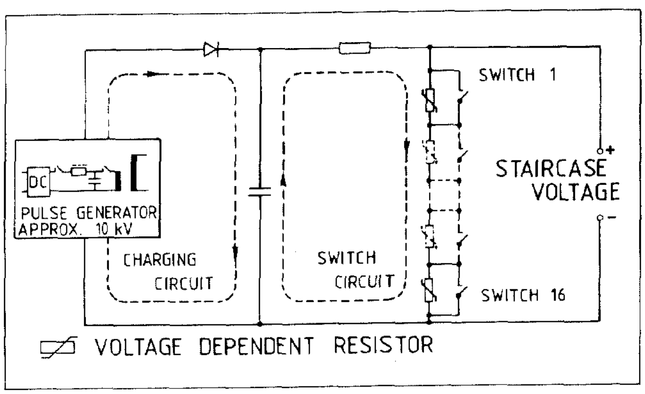

Fig. 4. Functional diagram of the high voltage generator.

the deflecting plates by means of the stepping motor driven feedthroughs. Adjusting the field strength and the position of the slit detector unit (variation of So, comp. fig. 2) even the step widths δx, δy can be optimized within given limits. With the parameters given in fig. 2 and taking into account that β=0.5% in the injection area the relation

$$So \cdot d = (\zeta/A) \cdot 361.13 \text{ cm}^2$$

holds. Since there are two free parameters So, d the displacement per step (δx, δy) can be optimized according to

$$\delta(\text{mm}) = (\zeta/A) \cdot 782.2 \; / \; d \; (\text{mm})$$

where δ stands for δx and δy respectively, Selected values So, d are limited by 40 mm $\leq$ So $\leq$ 75 mm and 31 mm $\leq$ d $\leq$ 60 mm.

The other device parameters are fixed and determined by the used slit-collector unit. Table 1 gives the relevant system parameters.

μP-Control Electronics:

The microprocessor modules consist of the standard GSI-85 system and control a part of the conventional emittance electronics, the high voltage sweep, the

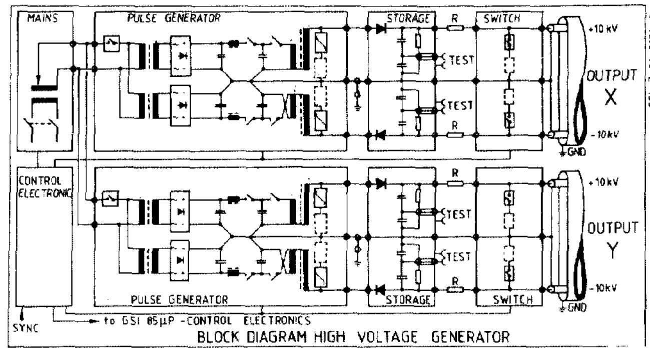

Fig. 5.

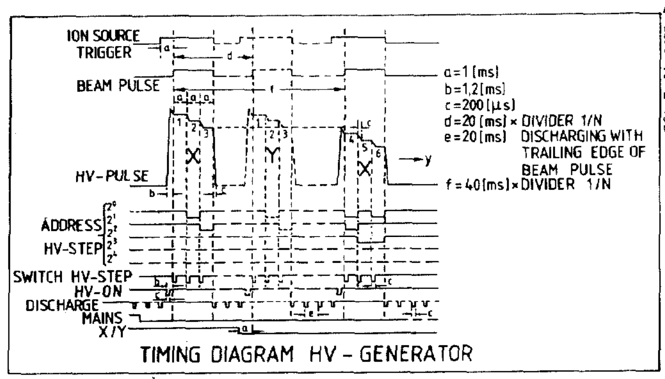

Fig. 6.

Table 1: Relevant System Parameters

Deflecting Voltage:		
Minimum	:	9.200 V
Maximum	:	18.500 V
Increments	:	300 V
Minimum time/increment	:	1 ms
Ranges:		
Position ($X_{max.}$, $Y_{max.}$)	:	±(7.5-25) mm
Angle ($X'_{max.}$, $Y'_{max.}$)	:	± 16 mrad
Current/detector strip	:	10 nA - 100 μA
Resolution:		
Position (Δx, Δy)	:	0.1 mm
Angle ($\Delta x'$, $\Delta y'$)	:	1 mrad
Step width in position	:	(0.5-1.6) mm

stepping motors and provides an interface to the main control computer for the evaluation of all relevant emittance parameters and display of on-line envelopes as discussed in Ref. 1. Fig. 7 shows a block diagram of the μP-electronics. Since even the high voltage sweep is controlled by digital signals it is possible to provide different modes for the time sequence of the deflected part of the beam: Three or one step of high voltage increments within one Unilac macropulse can be combined with a complete first scan for the horizontal plane and a complete scan afterwards for the vertical plane or a time shared measurement for both planes. The ratio between deflected and undeflected part of the pulsed beam can be varied within broad ranges. In addition to the planned activities of the main computer mentioned above, a rough display of measured emittances can be monitored on a television screen, using the μP-computing capability and a CRT-controller. Fig. 8 gives an example from first test measurements. The minimum refresh time for a complete emittance display as shown in Fig. 8 is 0.5 s.

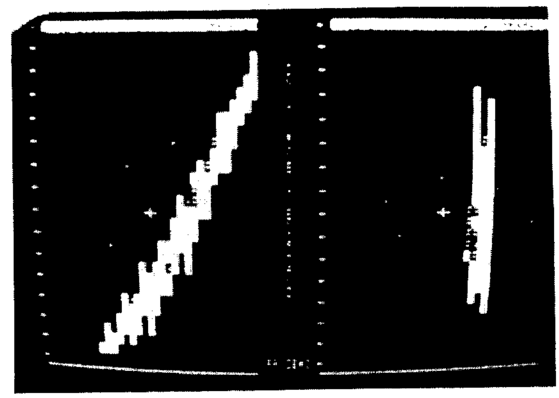

Fig. 8. Display of measured emittances on a television screen; left: horizontal plane, right: vertical plane.

Literature:

[1] J. Klabunde et al., proceedings of the 1979 Linear Accelerator Conference, Montauk, N.Y., page 291.

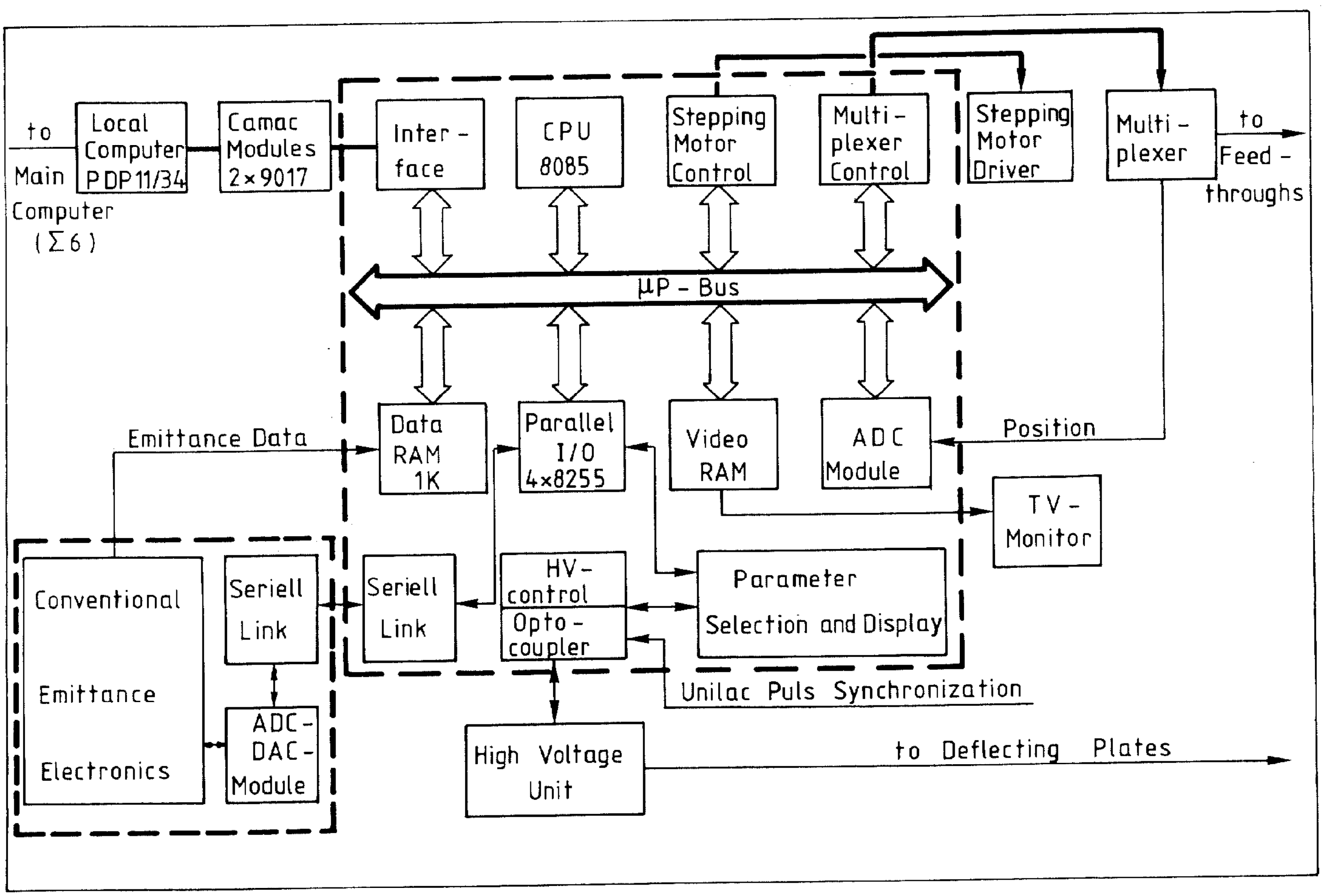

Fig. 7. Block diagram of the μP control electronics.