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SOME ADDITIONAL EMITTANCE RESULTS WITH THE MARK II DUOPLASMATRON SOURCE

H. Wroe

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Collider Accelerator Department

Brookhaven National Laboratory

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Accelerator Department
BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, L.I., N.Y.

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1. Introduction

A recent internal report (AGS HW-2) described some emittance measurements with the Mark I duoplasmatron source, using the pin hole and copy paper technique and the importance of using very small pin holes was pointed out. Only a single measurement using 0.002-in. diameter pin holes was given, however, and the emittance value obtained was compared with those measured on the AGS preinjector for the same source in another internal report (AGS HW-3). This note reports some additional measurements obtained on the test stand, with small pin holes, which serve to check the earlier result.

2. Results

The method of measuring the emittance is exactly the same as that given in HW-2, and the emittance diagrams are like Fig. 12 of that report. The results, along with the relevant source parameters, are shown in Table I, two sets of values for emittance and brightness being given. One set is calculated from formulae appropriate to a rectangular phase space boundary and the other for an eliptical boundary. The latter are plotted as a function of beam current in Fig. 1.

Table I

Date of Measurement	Source Pressure	Filament Current	Discharge Current	Magnet Current	Extraction Voltage	Beam Current	Rectangular Phase Space Boundary		Eliptical Phase Space Boundary	
	microns	A	A	A	kV	mA	$\epsilon_2=\frac{\text{Area}\,\beta\gamma}{4}$	$B=\frac{I}{(\pi\epsilon_2)^2}$	$\epsilon_2=\frac{\text{Area}\,\beta\gamma}{\pi}$	$B=\frac{I}{\frac{1}{2}(\pi\epsilon_2)^2}$
							cm-mrad	$mA/cm^2 rad^2$	cm-mrad	$mA/cm^2 rad^2$
Jan. 6 1966	380	34	35	0.3	40	60	0.006	1.7×10^{11}	0.0076	2.1×10^{11}
March 25 1966	250	25	34	0.65	35	60	0.006	1.7×10^{11}	0.0076	2.1×10^{11}
March 25 1966	250	25	30	0.4	30	48	0.0059	1.4×10^{11}	0.0074	1.8×10^{11}
March 25 1966	250	25	27	0.3	25	32	0.0057	9.4×10^{10}	0.0072	1.2×10^{11}
March 29 1966	250	25.5	40	0.65	35	70	0.0076	1.2×10^{11}	0.0098	1.5×10^{11}

It will be seen that the earlier result (Jan. 6, 1966) has been confirmed.

An interesting phenomena was encountered in this work. It was observed that the discharge current varied in a cyclic manner, from pulse to pulse, by 10-20%, and the output current also varied in a similar way. This may be due to the magnetic field of the current in the filament, (alternating current at 60 cps) having an effect on the discharge in the arc chamber. When the waveform of the line voltage was displayed on a double beam oscilloscope along with the discharge current pulse, there was a clear correlation between the amplitude of the discharge pulse and its "phase" with respect to the line voltage. With the source in this state, it was observed that the copy paper images were elongated in a radial direction; the further the particular pin hole from the axis, the larger the elongation. A tentative explanation is offered.

The cyclic variation of discharge current produces a corresponding variation of ion density in the expansion cup and thus a variation of plasma boundary shape from pulse to pulse, i.e., the plasma boundary "breathes" in and out, taking several beam pulses to complete one cycle. This motion does not affect ions near the axis much, but those near the edges of the plasma boundary travel on slightly different trajectories on different pulses. Thus, the pin holes produce a series of round images side by side, which, during the half hour exposure of the copy paper, coalesce to form an elongated image.

At any rate, when the discharge pulse was synchronized with the power line, so that it always occurred at the same phase (and therefore, at the same value of magnetic field in the arc chamber) the instability disappeared and the copy paper images were once again all circular. It is not clear why this effect should show up at this time, because it has not been observed before with the Mark I source.

The results in Table I were obtained with the source in the stable mode. This serves to emphasize the need for very stable operation of the source when using this particular technique of emittance measurement.

3. Conclusions

The very low emittance value given in HW-2 has been confirmed and the need for stable source operation re-emphasized.

It should also be restated that the simple copy paper technique is at the very limits of its usefulness in these measurements which are only approximate.

4. Acknowledgements

The author wishes to thank R. Lockey, who very quickly arranged a circuit to synchronize the discharge current pulse.

Distribution: AGS Division Staff

HW/ah

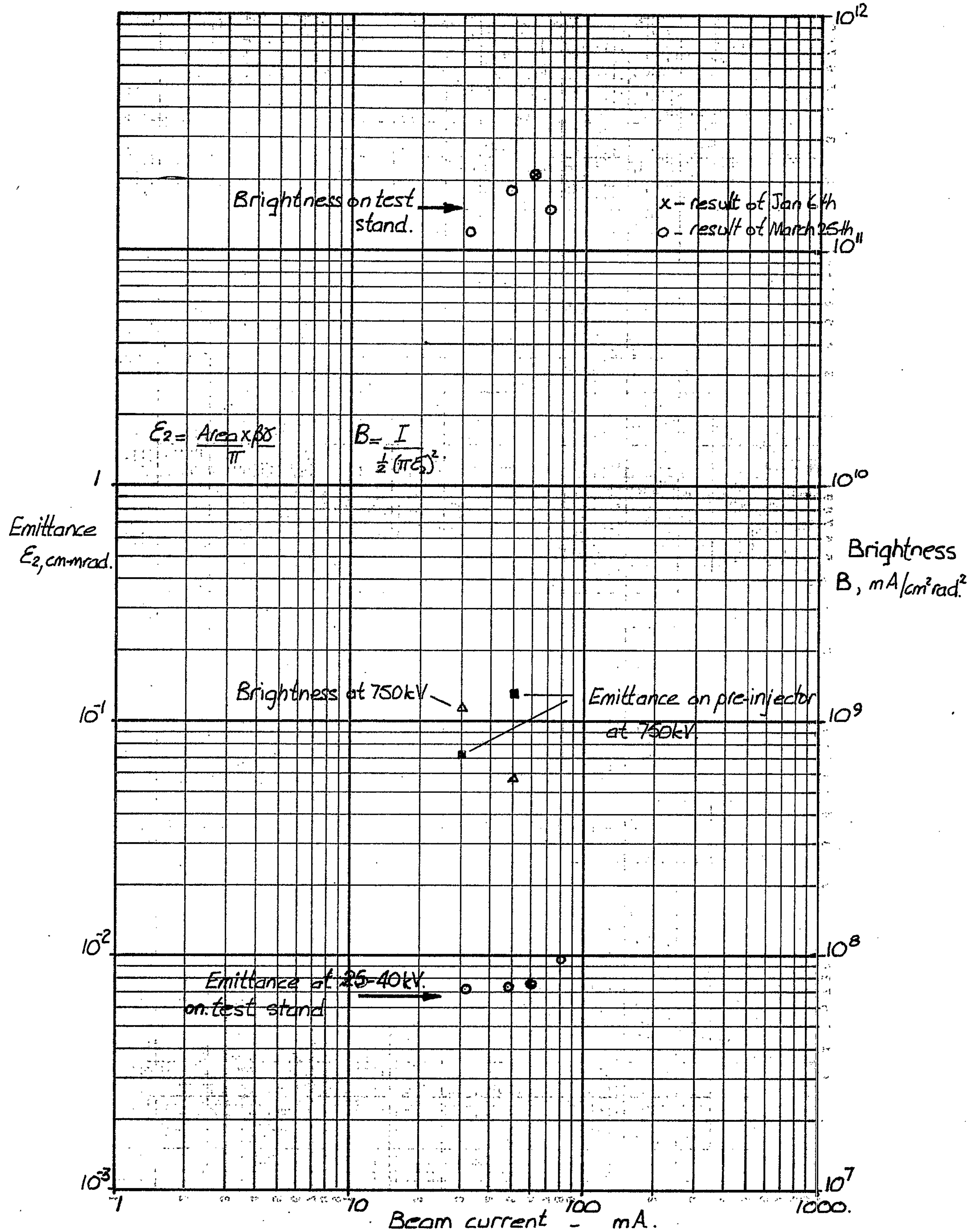

FIG 1 Plot of $\mathcal{E}_2$ & B against beam current for test stand & pre-injector