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# Electron beam diagnosis on diadyn using a plasma source

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The aim of this paper is to report the results regarding electron beam diagnosis experiments performed with the DIADYN equipment. DIADYN is a laboratory installation used to realize non-destructive diagnosis and dynamics for low energy electron beams (10-50 keV). Its source, VES, (a hot filament vacuum electron source) has been replaced with a plasma source, PES_JT, and we have been able to make diagnosis using electron beams extracted from this plasma source. A comparison between experimental and calculated results will, also, be shown.

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*Keywords*: Electron, Beam, Diagnosis, Plasma

## 1. Introduction

The beam diagnosis in PES_JT regime was realized taking into account the pressure conditions in the electron beam channel, EBC, and the transmitted current $I_t$, through EBC for an extraction voltage Ui_ex. These conditions were the result of the discharge measurements in PES_JT, the current extraction from PES-JT and the transmission of this current through EBC. We synthetise the values of the three important parameters that characterised the beam extraction-transmision system, in the beam diagnosis process.

$$P = \sim 2.10^{-5}\ mbar\ ;\ I_t = 0.18\ A\ ;\ Ui\_ex = 12\ kV$$

## 2. Experimental setup

The beam system of DIADYN is presented in Fig. 1 and it consists of:

- The plasma source PES_JT
- The electron beam channel, EBC, made up of the magnetic lenses L1 and L2 and the field free spaces T1-T5
- A beam monitoring unit including two beam profile monitors M1 and M2 and the field free spaces T4, T5.

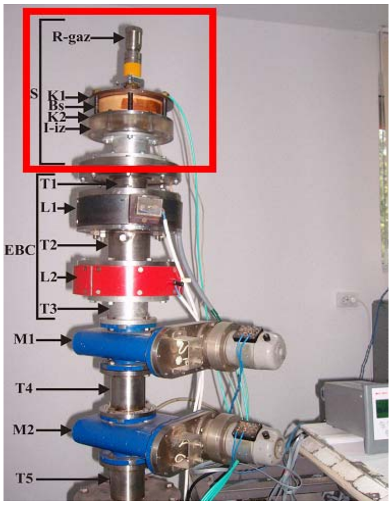
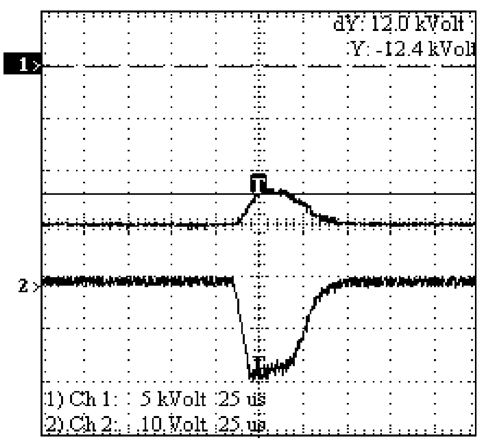



*Fig. 1. DIADIN equipped with a plasma source, PES_JT*

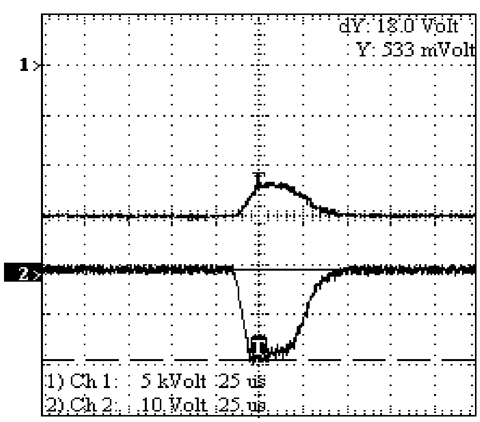
Fig. 1 represents the DIADYN installation, in which the vacuum electron source, VES, was replaced with an electron plasma source, S, with low voltage gas discharge, PES_JT, consisting of a discharge chamber vacuumed and in which there is a cylindrical anode, A. The chamber is , Bs, an electrostatic lens that generates an axial magnetic field and has at its two ends two cathodes K1, K2, shaped as disks and on the same voltage. Cathode K1 is provided with an orifice to allow gas admission in the source and K2 with an orifice that allows the particle extraction from the source. Between the two cathodes and the anode is applied the discharge voltage, Ua.

## 3. Results

We present in figure 2 the beam pulses extracted and transmitted through EBC. This corresponds to a polarization of the beam channel: UL1 = 1.8 V, UL2 = 0. In figures 2 one can see the parameters that characterize the extracted beam pulse: the high voltage on the extraction interval, Ui_ex = 12 kV, in 2_a and the extracted beam current, Iex = 0.18 A, in 2_b. We need to mention that PES_JT is functioning in a pulsed regime, the extraction voltage is continuous, and the measuring resistances for the extracted and the transmitted current are $R_M$_Iex = $R_M$_It = 100Ω. The measuring resistance is in concatenated connection with the Faraday cup that measures the two currents.




a




b

*Fig. 2. a - Beam pulse before lens L2: Ch1-Ui; Ch2 – It; Ui_ex; b – Beam pulse downstream from lens L2: Ch1-Ui; Ch2 – It; Iex.*

The PES_JT parameters shown above are similar with the ones of a beam regime we have studied with the hot filament electron source, VES, [3]. This resemblance allows us to use for non-destructive diagnosis of the beam extracted from the PES-JT source the same method and the same program MTGM [5], that we used in characterizing the VES sources.

The beam diagnosis for the PES_JT electron source was realized using the system made of the L1 lens and the two beam monitors M1 and M2 located after the EBC. We need to remind the electrical parameters of the L1 lens, the number of spires N_L1, and the resistance, R_L1: N_L1 = 710 Sp, R_L1 = 3.8 Ω, and for the power supply of the L1 lens with a current of I_L1 = 1 A, it has a number of ampere-spires, $(NI\_L1)_{et}$ = 710 As. The maximum field in the centre of the lens is Bc_L1 = 188 gauss for I_L1 = 1 A, U_L1 = 3.8 V. For realizing the field distribution in EBC in the beam diagnosis process as well as in the beam dynamics, the procedure applied for different polarizations of the L1 and L2 lenses is the same as the one used for the determination of the reference field for I_L1 = 1A, I_L2 = 1 A.

Regarding the discharge-extraction parameters of the PES_JT we emphasize that the emission orifice diameter is 2mm and the frontal orifice of the extraction electrode has a diameter of 5mm.

The pressure for the unlit source was 2.2 $10^{-5}$mbar and with the hot source was 2.5 $10^{-5}$mbar. The discharge parameters were Ua = 600 V, Ub = 100 V ~, Bc_PES = 900 gauss, fr = 90 Hz. The supply voltage of the L1 lens had different values as the L2 lens was not energy supplied.

The power supply was operated at Uî_a = 15 kV, the extraction voltage was Uî_ex =12 kV and under these conditions the extraction current obtained reached Iex, It = 0.18 A.

## 4. Disscusion

The determination of the beam parameters characterizing the spatial structure of the electron beam at the PES_JT exit are foregone by experimental measurements that consist of the determination of the experimental graphics RM1ex = f (UL1) şi RM2ex = f ( UL1). RM1ex şi RM2ex are determined with the beam profile monitors.

In table 1 we present the calculated radii for different voltages applied on the L1 lens for the registered pulses on the M1 monitor. It is, also, shown the beam radii read in “rms” sense (root mean square) [1] at 0,2h that is at 0,2 from the maximum pulse amplitude.

*Table 1. Experimental determinations with MTGM*

| U_L1 [V] | RM1ex_b [mm] | RM1ex_02b [mm] |
|---|---|---|
| 0.4 | 20.3 | 19 |
| 0.6 | 19.8 | 18.5 |
| 0.8 | 18.8 | 18 |
| 1 | 17.3 | 16.6 |
| 1.2 | 16.8 | 14.2 |
| 1.4 | 15.1 | 12.2 |
| 1.6 | 12.2 | 10.7 |
| 1.7 | 11.2 | 7.2 |
| 1.8 | 10.2 | 4.2 |
| 1.9 | - | - |
| 2 | 6 | 3.2 |
| 2.1 | - | - |
| 2.2 | - | - |

Similar readings have been made for M1 at 0,3h and for M2 at 0,0h, at 0,2h and 0,3h; all these readings were realized for the pulses of current extracted and transmitted through EBC, presented in Fig. 2.

*Table 2. Beam parameters determined with MTGM applied to the electron beam extracted from PES_JT*

| Experimental pulses read on M1 | Beam parameters at Ui_ex = 12 kV | | |
|---|---|---|---|
| | Eps [mm.mrad] | R0 [mm] | Z0 [mm] |
| "a", It=0.18A, RM1ex_base | 30.8 | 6.32 | 57.82 |
| "a1", It=0.18A, RM1ex_02h | 0.578 | 8.866 | 89.96 |
| "b", It=0.24A, RM1ex_base | 150.99 | 11.53 | 0.02 |
| "b1", It=0.24A, RM1ex_02h | 0.833 | 14.58 | 4.36 |

Table 2 shows the spatial parameters of the beam determined with the NAC_MTGM program, an improved numerical code [5], for different experimentally determined situations. We have to remind that these parameters are: beam emitance, Eps, beam radius in the object crossover, R0, object crossover position, Z0, related to the coordinate system origin, that, in the case of the electronic-optic assembly of DIADYN, it coincides with the position of the L1 lens centre.

The data in Table 2 were calculated taking into account only the beam parameters that were determined with the M1 monitor. The “a” cases correspond to the beam transmitted downstream from L2 that has an intensity of It_a = It_a1 = 0.18 A. The „b” cases are for a beam transmitted downstream from L2 that have the intensity It_b= It_b1 = 0.24 A. The difference in determining the beam characteristics is that in the “a” case the experimental radii determined with the M1 monitor are measured at the 0,0h (that is 0,0 from the pulse maximum amplitude) and for the “b1” case the experimental radii are measured at 0,2h from the pulse amplitude.

In Figs. 3 and 4 we present a comparison between the experimental curves and the curves determined by calculations using as input data in the dynamics equation the beam parameters from table 2. The parameters of the discharge-extraction regime are: Ua = 600 V, Ui_ex = 12 kV, a- It = 0.18 A, b - It = 0.24 A.

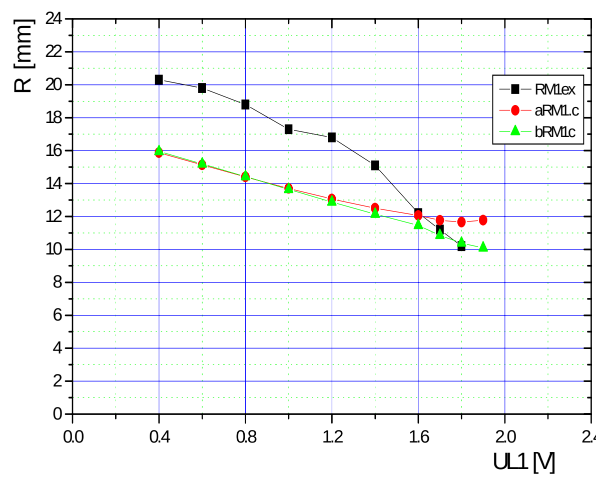



*Fig. 3. Experimental pulses measured at 0,0 from the pulse maximum amplitude.*

Figs. 3 and 4 show the diagnosis of the beam extracted from PES_JT, and the experiment – calculation comparisons.

In Fig. 4 we can observe that the best concordance between the experimental determinations and the theoretical calculations, regarding the non-destructive diagnosis of the beam extracted from PES_JT , made using MTGM, can be obtained for N=2. This case corresponds to a transmitted current downstream from the L2 lens, with the intensity It = 0.18 A and the energy W = 12 keV. The experimental pulses were determined in the “rms” sense with the M1 monitor and, particularly, for the case we discuss they were measured at 0.2 h.

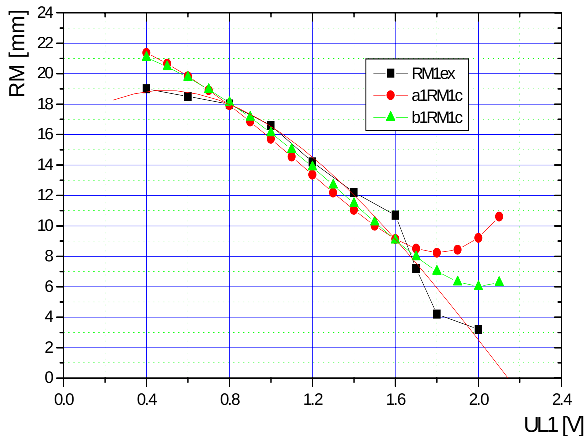



*Fig. 4. Experimental pulsed measured at la 0,2 from the maximum amplitude.*

## 5.Conclusions

This paper reports the results obtained from a non-destructive diagnosis made for an electron beam extracted from a plasma source, using the DIADYN equipment shown in Fig. 1. These results emphasize what we believed from the very begining of the experiments: that DIADYN can be adapted to functioning with a plasma source, PES_JT, instead of the hot filament source, SEV, that has been used untill now. We established the parameters for which there is a good agreement between the experimental determinations and the theoretical calculations for the beam diagnosis and this happens at a current of 0,18A. So, DIADYN can operate properly with a plsma source and we can make diagnosis with electron beams extracted from it.

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