THE IASA 10 MeV CW-LINAC

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Abstract

The installation of a 10 MeV electron injector as a Project for the RaceTrack Microtron at the Institute of Accelerating Systems & Applications (IASA) [1] is presented. This Maquette line is composed by a 5 MeV injector linac with RF structures of the side-coupled type, followed by a 4m-booster section of the same type. This system will provide a realistic test facility for all subsystems (power station, klystron, wave-guiding, chiller, control, interlock and safety system), with exception of recirculations of the IASA cascade RTM facility. It is envisioned that its beams will be used for applied physics research.

1 INTRODUCTION

After the successful installation and operation of the 100-keV Line [1] [2], a new Maquette Project has been defined at IASA: the construction of a 10 MeV CW-Linac. This machine, seen as natural continuation towards the construction of the RaceTrack Microtron facility [3], comprises a 5 MeV electron injector linac with RF structures of the side-coupled type and a 4m-booster section of the same type. Both are powered with a 500 kW multi-cavity CW klystron amplifier at 2380 MHz. The 10 MeV CW-Linac provides a realistic test facility not only for the high power RF subsystems but also for the control, interlock and the safety system. It will be hosted in the basement of the IASA building, which is extended with a new experimental hall (Figure 1). All necessary building modifications for radiation protection has been completed. In the following sections a description of the electron injector, the high power RF drive system and the present status of the project will be given.

2 THE 10 MEV CW-LINAC

The 10 MeV CW-Linac is composed by a 5 MeV electron injector linac followed by a 4m booster section, both operated at the S-band (2380 MHz). The 5 MeV injector linac consists of two RF structures of the side-coupled type. The first is a 0.9 m long tapered-β capture section to accelerate the beam from 100 keV to approximately 1.2 MeV. This is followed by a 2.7 m long ”preaccelerator” section that has only a very slight β-taper (0.98 to 1.00). The preaccelerator section has an effective shunt impedance of $82.5 M\Omega/m$ with a power dissipation of 24 kW/m. The capture section attains its design field strength and distribution at a power level of 28 kW. For the booster section a 4 m long side-coupled structure (5.5 MeV) of the same type will be used.

The available RF power provided by the 500 kW klystron (VKS-8270) is enough to cover the injector requirements. A circulator directly after the klystron cavity serves as a protection system in case of strong RF reflections. The wave guiding system uses power splitters and phase shifters to distribute the power from the klystron to the three side-coupled accelerating structures. Space is also foreseen for a diagnostic line [1] for transverse emittance measurements. A well shielded Faraday Cup at the end of the line will be used for beam current measurements. Finally, the transport system to the experimental hall combined with a longitudinal emittance diagnostic and energy defining system is being currently designed. A schematic layout of the 10 MeV CW-Linac placed in the basement of the IASA building is shown in Figure 1.

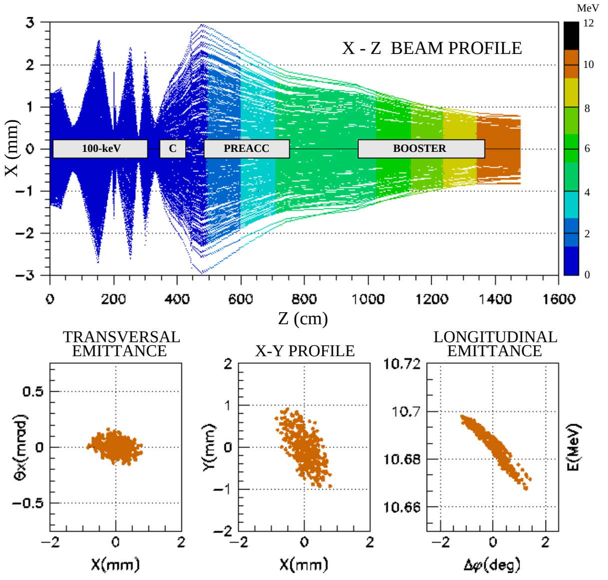

Figure 2: PARMELA simulation of the 10-MeV Linac

The functionality of the 10-MeV Linac is approached with with the simulation program PARMELA. In Figure 2 the x-beam profile along the linac for the different accelerating structures is shown. With conservative input variables ($\epsilon_x = \epsilon_y = 2\pi \ mm \ mrad$) the beam characteristics

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[1] Web-Address http://www.iasa.uoa.gr

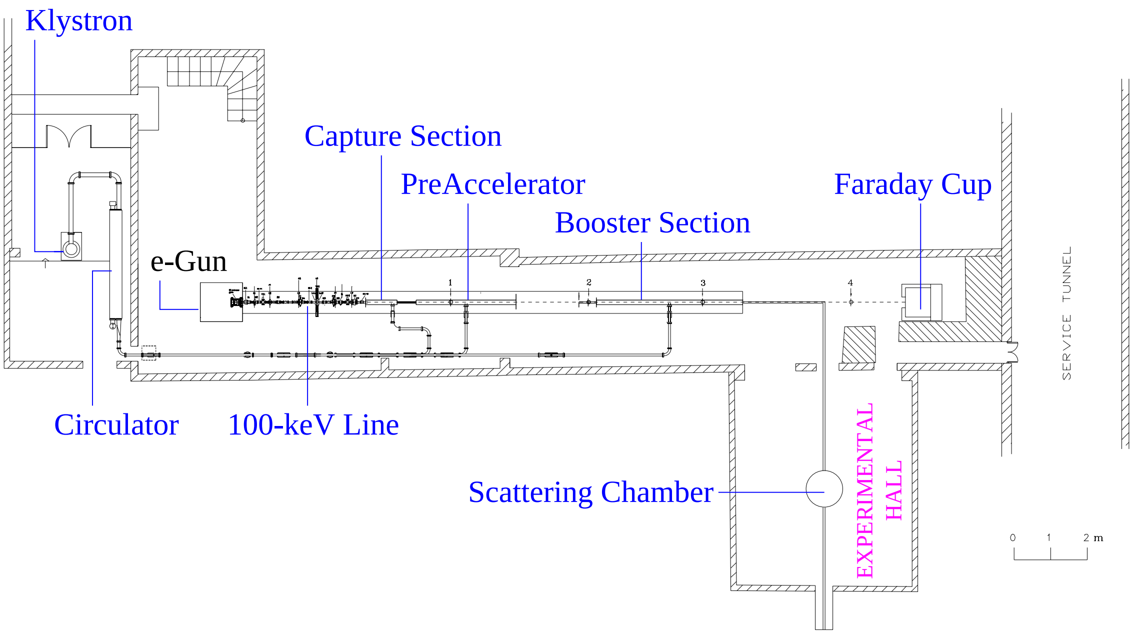

Figure 1: Layout of the 10 MeV CW-Linac located in the basement of the IASA building

at the line exit show a very promising x-y profile and emittances better than $\epsilon_t = 0.1\pi \ mm \ mrad$ transversally and $\epsilon_l = 6\pi \ keV \ deg$ longitudinally (lower part of Figure 2).

3 RF DRIVE SYSTEM

A high-power CW (continuous-wave) source, at 2380 MHz, for the IASA 10-MeV Linac is based on the CPI (Communications and Power Industries) type VKS-8270 multi-cavity klystron. The high-level DC power conditioning for the klystron uses an existing high-voltage transformer-rectifier (HVPS) and variable-voltage transformer (VVT), designed to operate from 60 Hz power, whereas the local power grid operates at 50 Hz. Other features include a new electronic crowbar system and high-speed primary-power disconnect.

3.1 High Power RF Requirements

The RF power requirements for the Capture, Preaccelerator, and the 4m Booster for the IASA Maquette project are presented below. The power dissipated on the cavity walls is given by:

$$P_{dis} = V_c^2/RL$$

where V_c is the cavity accelerating gradient, $R \approx 82.5 M\Omega/m$ is the shunt impedance of the structure, which is a geometry depended factor, and L is the electric length of the structure. The beam power is given by:

$$P_{beam} = I_0 V_a = I_0 V_c \cos\phi$$

where I_0 is the average beam current in the cavity, V_a is the accelerating gradient which is equal to the cavity gradient reduced by the cosine of the phase of the beam with respect to the RF crest.

The calculations are performed for Injector current equal to $100\mu A$. For this current, and $\beta = 1$, the reflected power is negligible, therefore the total required generated power is to a good approximation equal to the sum of the dissipated and beam power. Table 1 summarizes the RF-related parameters for the IASA Maquette. The beam phases w.r.t. rf crest are obtained from reference [4].

		Capture	**PreAcc**	**Booster**
Length (m)		0.9	2.7	4
Gradient (MV/m)		1.6	1.4	1.4
RF Power (kW)	Dissip.	27.9	64.1	95.0
	Beam	0.14	0.38	0.54
	TOTAL	28	65	96

Table 1: RF-related parameters for the IASA High-Power RF Maquette Project

3.2 AC to DC Converter

Variable-Voltage Transformer (VVT) and the High-Voltage AC-DC Converter (HVPS) The VVT is of dry construction, air cooled, and housed in an enclosure 8.8’ x 7.5’ x 9.1’, weighting 15,000 pounds. The E-18645 HVPS is oil-insulated, self-cooled, housed in a steel tank 5.25’ x 7.1’ x 8.8’, and weights 28,600 pounds. More details of these devices can be found in [5].

Electronic Crowbar It is considered prudent and it is standard practice to additionally protect the klystron by means of an electronically-triggered low impedance, such as another arc, shunting the high-voltage isolated by a portion of the series resistance. In this case a double ended

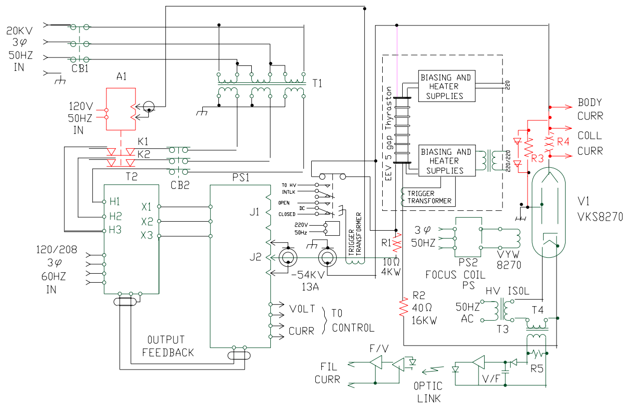

Figure 3: The RF Drive System

thyratron [6], which is able to conduct current in either direction is chosen. It remains conducting until virtually all stored energy as well as that from the follow on half cycle short circuit current is dissipated. The operating voltage of the IASA klystrons (max. 65 kV) depicts the use of a multigap thyratron. The model CX1194B made by EEV was chosen. The maximum voltage across each gap is thus 13kV almost half the maximum (25kV) specified value, and therefore voltage breakdowns should not occur or if so very rarely. The 50 Ohm series resistor is divided into two segments, one of 10 Ohms, R1, and one of 40 Ohms, R2. The high side of the crowbar is connected to their intersection. The 40 Ohms in series with the klystron is much higher in impedance than the fired crowbar, assuring that most of charge is diverted from the klystron. The maximum peak current through the crowbar is 54 kV/10 Ohms = 5400 A. Having a crowbar means that the 10-Ohm segment in series with the crowbar protects the remaining 40 Ohms as well as the klystron.

High-Speed Main Disconnect The 20 kV circuit breaker, shown as CB1, has an opening time of 3-5 line cycles, which is too long. At 20 kV line voltage, solid-state SCR-based relays are impractical. Vacuum relays, however, with close-spaced contacts, can achieve opening times as short as 2 milliseconds, or 1/5 cycle, giving 1/2-cycle clearing time, assuming the post-opening arc extinguishes at the current zero crossing. Only two such relays, Ross Engineering HBF-51-NC, K1 and K2 are required, with normally-closed contacts (Fig 3). They are driven open by the output of an SCR-switched stored-energy driver, type HCB, A1.

3.3 *Klystron RF Amplifier*

The VKS-8270 multi-cavity CW klystron amplifier has coaxial RF input, waveguide RF output, electromagnet beam focusing, and liquid cooling. Klystron tests, at 2380 MHz, with beam voltage of 65 kVDC and current of 15.1 A showed power output of 490 kW with 1 Watt RF input. With 50 Hz primary power, however, the DC beam voltage available is only 54 kV. At this rating the maximum output power should be appr. 320 kW.

4 CURRENT STATUS

The e-gun, 100-keV line, Capture Section and Preaccelerator has been installed and aligned to their final position (Fig 4). The new transformer 20/11.5kV to be used with the above mentioned HVPS has been already manufactured. Work on connecting the wave-guiding system with the klystron/circulator is under way. Additionally, the Electronic Crowbar has been built and tested at CERN. In parallel, progress has been done in preparing the chiller system for the cooling.

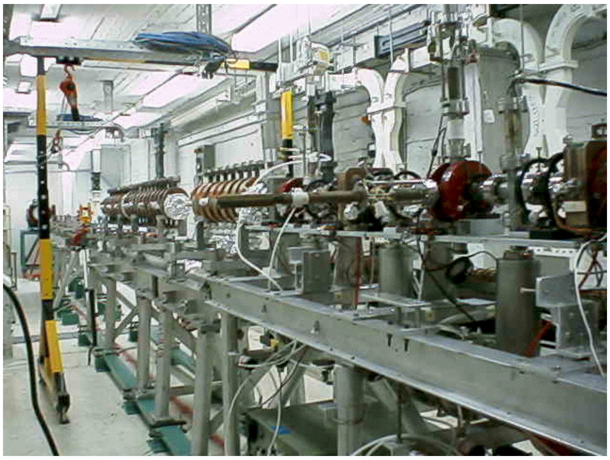

Figure 4: Capture/Preaccelerator View of the IASA 10-MeV Linac

The Control System based on EPICS has been extended in order to include the new process variables and a new Personnel Safety System has been designed and is being realized. First beams are expected to the end of this year.

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