

INJECTION SYSTEM OF CONTINUOUSLY WORKING RESONANCE ACCELERATOR WITH HIGH POWER OF ELECTRON BEAM

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Abstract

The paper presents a modified variant of injection channel for electron accelerator augmented by diagnostic equipment and additional magnetic optical elements.

To optimize operation modes of a new injection channel elements a computer simulation of electron dynamics was performed.

An experimental bench with a capability for electron beam diagnostics was developed on the basis of conducted calculations. Composition and geometry of the upgraded injection channel are fully reproduced on the experimental bench.

By the results of calculation and experimental studies an optimal variant of the injection channel is proposed. Such modified channel is supposed to be introduced into the acceleration complex.

INTRODUCTION

Designed resonance accelerator is intended for the electron beam production with discrete values of energy 1.5, 4.5 and 7.5 MeV and average power up to 300 kW [1]. The accelerator is based on the coaxial cavity, operating at the frequency 100 MHz.

Parameters of beam injection into the accelerating cavity possess a vital importance in approaching design characteristics of the output electron beam. Therefore, it is necessary to efficiently control the electron beam characteristics on the injection stage during accelerator operation. As of today there is lack of beam diagnostic devices in the existing injection channel. The presented paper proposes a variant of channel modification by diagnostic equipment and additional beam-focusing elements. The implemented equipment was tested on the experimental bench. Performed tests will also allow to optimize working parameters of RF injector and focusing elements.

ACCELERATOR INJECTION CHANNEL

The accelerator's electron injector is a grid-controlled hot-cathode gun based on the RF quarter-wavelength coaxial cavity (100 keV, 40 mA, 100 MHz) [2]. An advantage of such injector is a capability for longitudinal beam bunching by emission phase variation.

The external view of the active injection channel is shown in Fig. 1. A list of magnetic optical elements involves two focusing solenoids (2) and (4) and a magnetic quadrupole lens (5), required for compensating various effects of transverse components of electric field along of the beam trajectory in accelerating cavity [1].

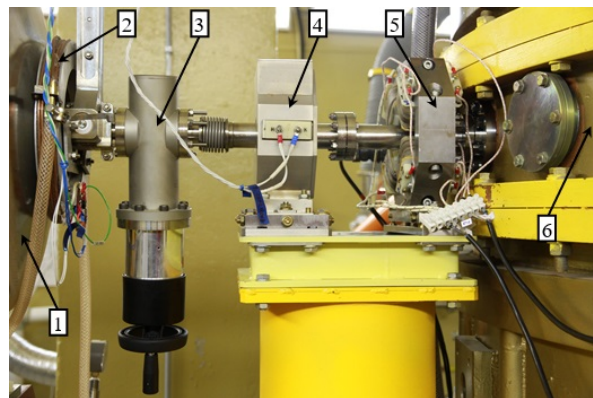


Figure 1: External view of injection channel: 1 – RF injector; 2 – focusing solenoid №1; 3 – high vacuum valve; 4 – focusing solenoid №2; 5 – magnetic quadrupole lens; 6 – accelerating cavity.

DIAGNOSTIC EQUIPMENT

Two space-divided resistive current pickups are planned to use in electron energy, pulse current and bunch length measurement (Fig. 2).

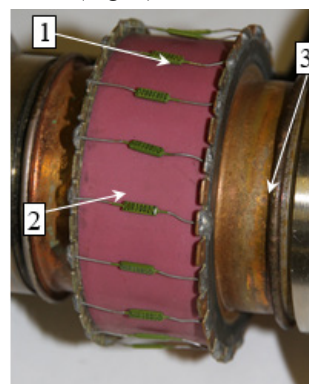


Figure 2: External view of resistive pickup: 1 – resistor 50 Ohm; 2 – ceramic insulator; 3 – beam transporting channel.

Diagnostic system based on the beam position monitor (BPM) and electromagnetic beam corrector (EBC) was developed to control a transverse beam position in the injection channel. BPM is a cylindrical chamber and four capacitive pickups in the form of disks, mounted

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diametrically opposite and electrically insulated from chamber walls (Fig. 3).

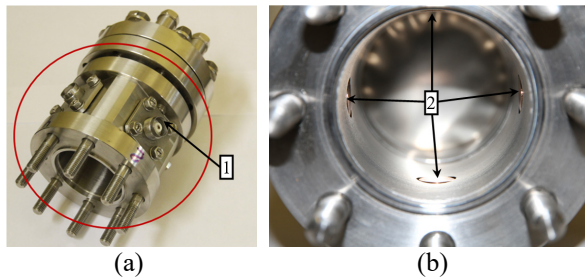


Figure 3: External view of BPM (a) and location of capacitive pickups (b): 1 – RF vacuum socket; 2 – capacitive pickups.

NUMERICAL CALCULATION OF BEAM DYNAMICS

To optimize operation modes of new injection channel elements electron dynamics calculation was performed in program ASTRA [3]. Simulation was carried out for the injection channel geometry, shown in Fig. 4.

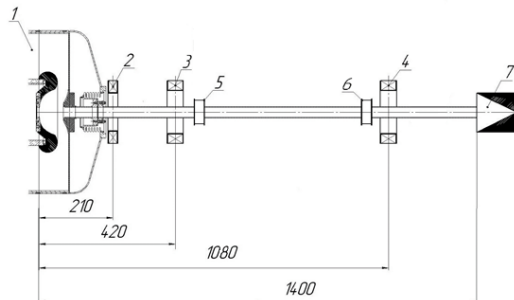


Figure 4: Diagram of injection channel: 1 – RF injector; 2, 3, 4 – focusing solenoids; 5, 6 – resistive current pickups; 7 – Faraday cup.

According to performed calculations, the operating range of electron emission phases is from 30° to 55° . Where boundary values correspond to a longitudinal electron bunching mode (30°) and maximal electron energy mode (55°).

As a result of simulation, the emission phase dependence of radial beam dimension is shown in Fig. 5. Peaks on the plot is caused by effect of focusing solenoid fields (Fig. 4, pos. 2, 3, 4).

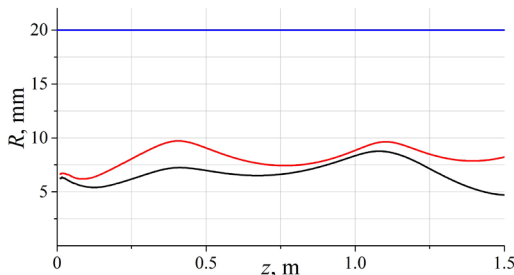


Figure 5: Calculated evolution of radial beam dimension on the drift section 1.5 m (red line – 30° , black line – 55° , blue line – channel aperture radius).

EXPERIMENTAL RESULTS

The experimental bench has been developed to test new diagnostic equipment (Fig. 6).

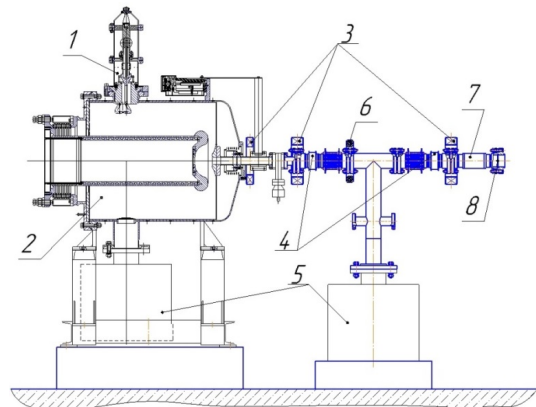


Figure 6: Scheme of experimental bench for electron beam diagnostics: 1 – RF power input unit; 2 – RF injector; 3 – focusing solenoid; 4 – resistive current pickups; 5 – vacuum pumps; 6 – EBC; 7 – BPM; 8 – vacuum-atmospheric window.

Electron energy was determined by a time-of-flight method with the aid of resistive current pickups (Fig. 6, pos. 4). The pulse beam current was measured and pulse widths at various emission phases were also estimated (Table 1). Typical signal oscillograms are given in Fig. 7.

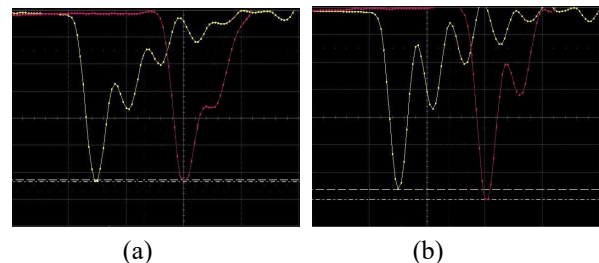


Figure 7: Typical signals from resistive current pickups (horizontal axis resolution 2 ns): (a) – 30° , (b) – 55° .

For equal signal amplitudes emission phase is about 55° (Fig. 7a). Otherwise if the second signal is larger and shorter than the first one the emission phase is 30° (Fig. 7b).

Transverse beam position relatively to the channel axis was defined by the BPM. Typical signals, obtained from capacitive pickups of BPM, is shown in Fig. 8.

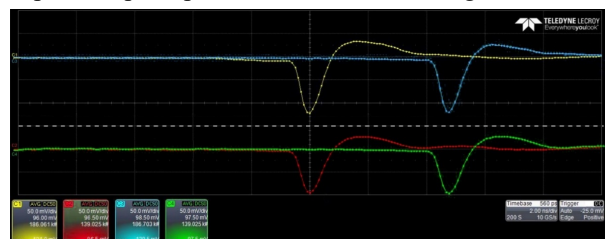


Figure 8: Typical signals from capacitive pickups of BPM.

