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Linac-200: a new electron test beam facility

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The linear accelerator Linac-200 at JINR is a new facility, constructed to provide electron test beams to carry out particle detectors R&D, to perform studies of advanced methods of electron beam diagnostics, and for applied research. The core of the facility is a refurbished MEA accelerator from NIKHEF. The key accelerator subsystems including controls, vacuum, precise temperature regulation were completely redesigned or deeply modernized. Two test beam channels are available for users: the first one with electron energy in range 5–25 MeV and maximum pulse current 60 mA; and the second one with electron energy in range 40–200 MeV and maximum pulse current 40 mA. The pulse current varies smoothly from the maximum value down to almost zero (single electrons in a pulse). This report presents the status and operation parameters of the facility.

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1. Introduction

Linear electron accelerator Linac-200 is a unique facility intended for scientific and methodological research in the field of accelerator physics and technology, elementary particles detectors research and development, as well as fundamental and applied research in the fields of materials science and radiobiology. It is based on the MEA linear electron accelerator which was transferred to JINR from NIKHEF in the end of 90s.

Main accelerator structure unit is a station. The injector station A00 includes the electron gun, chopper, prebuncher and buncher. First accelerator station A01 includes one accelerating section and a klystron, which also feeds the RF equipment of the A00 station. All the rest stations include two accelerating sections and a klystron each.

Current setup (Fig. 1) consists of 5 stations, A00–A04, and allows generation of the 200 MeV electron beam. It is possible to install additional stations to increase the energy of the accelerator.

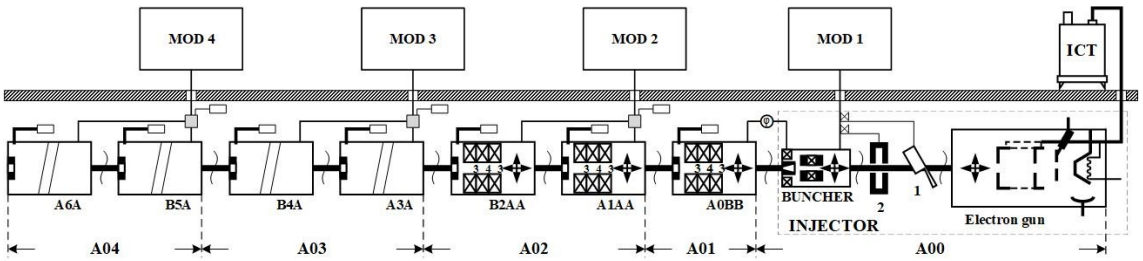

Figure 1: Linac-200 accelerator layout (1 – chopper, 2 – prebuncher).

2. General machine parameters

The electron beam is generated by the 400-kV DC triode-type electron gun with a thermionic cathode. The beam is available for users at two extraction points: after stations A01 (EP1) and A04 (EP2) (see Fig. 2). Parameters of the Linac-200 electron beam available for users are presented in the Table 1.

Figure 2: Beam extraction points at Linac-200: left – EP1, right – EP2.

Table 1: Parameters of the Linac-200 electron beam available for users

Parameter	Beam extraction point № 1 (EP1)	Beam extraction point № 2 (EP2)
Electron energy, MeV	5–25	40–200
Pulse duration, μs	0.2–3.5	
Max. pulse current, mA	60	40
Pulse repetition rate, Hz	1–50	1–25

Current values provided in the Table 1 are the maximum ones. If necessary, current can be changed from the specified value down to almost zero (by means of gun extractor and focusing electrodes voltage adjustment, and beam collimation). Maximum current can be obtained at energy ranges of 10–25 MeV at EP1 and 80–180 MeV at EP2.

Optimal pulse duration is 2 μs. Gun can produce pulses with the duration of up to 50 μs, but the duration of the accelerated pulse is limited to 3.5 μs by the RF pulse length. It's also possible to generate pulses with the duration below the specified range (i. e. 50 ns), but at the cost of the pulse quality (the lesser is the duration, the more non-rectangular is the pulse).

3. Overview of key accelerator systems

3.1 Acceleration & RF

Beam is accelerated by the iris-loaded travelling wave structures. RF power is provided by the 20-MW Thomson TH 2129 klystrons. Each klystron feeds two accelerating sections. The exception is the first one, which feeds one accelerating section and bunching devices. Due to the modulator limitations only half of the klystrons peak power is used (i.e. each accelerating section receives 5MW of RF power). Linac-200 key acceleration & RF parameters are given in Table 2.

Table 2: Linac-200 key acceleration & RF parameters

Total linac length, m	55
Number of short (3.7 m) sections	3
Number of long (7.3 m) sections	4
Frequency, MHz	2856
Wave type	TW
Field mode	2π/3
Filling time, μs	1.3
vg/c range	0.0093–0.0389
Shunt impedance, MΩ/m	56.5–48
Iris aperture: diameter, mm	32–17
thickness, mm	5.84
Number of klystrons	4
RF power: peak, MW	10
mean, kW	20

3.2 Beam Diagnostics

The following tools are used for diagnostics:

- Compton radiation monitors to detect major beam trajectory errors.
- Current transformers for current measurement in the operation mode.

- Traveling wave monitors allow to define both beam current and position.
- Beam viewers with scintillator screens and video cameras.

3.3 Control system

While the accelerator largely reuses refurbished parts of the MEA accelerator from NIKHEF, the accelerator control system is completely redesigned. A new distributed control system is being developed using the Tango toolkit. The accelerator subsystems (including focusing and steering magnets control, vacuum control system, synchronization system, electron gun control system, precise temperature regulation system) were redesigned or deeply modernized [1].

4. Research program at the Linac-200 facility in the near future

In the near future, research at the Linac-200 electron accelerator will be conducted in the following fields:

- Testzone for particle detectors R&D.
- Teraherz radiation source and beam diagnostics R&D.
- Material irradiation.
- Radiobiological studies.
- Education and training.

5. Next stages of the accelerator development

In the future it is planned to install 9 additional accelerating stations A05–A13, which will increase the energy of the accelerator up to 800 MeV. Accordingly, more extraction points will be added. Current plan is to make 2 new test beam channels: after stations A06 (350 MeV) and A08 (500 MeV). However other options are also available – in principle it is possible to extract the beam after any station.

A further increase in the accelerator energy is possible by developing a new klystron modulator with partial capacitance discharge and IGBT-based solid-state switches, as well as using the SLED (Stanford Linac Energy Doubler) energy compression system [2]. This upgrade of the accelerator will increase the energy to 2 GeV.

6. Conclusion

New Linac-200 electron test beam facility at the Joint Institute for Nuclear Research is nearing completion. Two test beam channels are available for users. The test beam facility is open for particle detectors and beam diagnostics R&D, material irradiation, radiobiological and other studies.

References

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