LINAC LUE-200 - STATUS OF THE PROJECT

W. Furman, V. Kobets, I. Meshkov. V. Piataev, G. Shirkov, V. Shvets, V. Shvetsov, A. Sumbaev
JINR, Dubna, Moscow region, 141980, Russia.

Abstract

In the report the status of the project of the S-band electron linear accelerator LUE-200 - the driver of the resonant neutron source IREN in the Joint Institute for Nuclear Research (Dubna) is presented.

INTRODUCTION

In 1960 in the Joint Institute for Nuclear Research (JINR) the first-ever reactor IBR of periodic action with a mechanical variation of reactance has been put into operation.

The IBR reactor has begun operation on the average power of 1 kW. Its design parameters have been reached at the end of 1960. TOF-spectrometer s on the basis of IBR was not the best for that time. Therefore at once after its creation the searches of ways to increase the resolution of IBR-spectrometer have begun. The solution was found in realization of the booster – scheme, in which the photoneutrons formed after interaction of electrons with the energy of several tens of MeV with heavy target, multiply in the reactor active zone. In the first variant the microtron with 30 MeV electrons was used as a booster. IBR with the microtron has started operation in 1964. Duration of a pulse in such mode has been reduced more, than by the order and has made up 3 - 4 mks. The modernized reactor IBR-30 has been put into operation in 1969, and in 1970 a new electron linac LUE-40 has been started. Since 1988 the neutron source IBR-30 operated only in the pulsed booster mode as a subcritical assembly, which is making multiple copies photoneutrons, born in W-target as an electron beam. Variation of the reactance of the reactor has been provided due to the mechanical rotation of a mobile part of the active zone. The injection of electron beam from the linac has been phased with the modulation of reactance of the zone (from K_{eff} = 0.944 between pulses up to K_{eff} = 0.995 in a pulse of fast neutrons). The source provided intensity of generation of neutrons up to 5 x 10^{14} s^{-1} in pulses duration 4.5 mks with frequency of 100 Hz. In such configuration the neutron source IBR-30 + LUE-40 has operated, having fulfilled on physical experiment almost 80 thousand hours till 2001.

The conceptual scheme of a new resonant neutron source (IREN) [1] is the direct development of the idea of the booster IBR-30 with fast duplication of the neutrons made by a pulse electron beam in the e-γ-n converter made of a heavy material. The driver of the source - the S-band travelling wave electron linac LUE-200 [1,2,3] will inject an electron beam with the energy 200 MeV and average power of 10 kW in a tungstic target, the converter, located in the center of the compact and fast active zone consisting of 108 fuel elements, made of high condition metallic plutonium ($_{239}$Pu). The zone should operate in the subcritical assembly mode with the factor of multiplication 32. The design of the zone with the $Ta^{10}B_2$ screen will allow one to receive minimal possible time of a neutron life time of a neutron in the active zone. Duration of a ulse of fast neutrons will be about 400 nanoseconds with the repetition rate of 150 Hz at the average intensity 10^{15} n/s. The experimental complex includes 8 neutron channels with the flying length from 50 m up to 1000 m. The Program of researches at the IREN source in the field of fundamental and applied nuclear physics is presented in [4].

The IREN project is realized in two stages. At the first stage, creation of the first turn of the linac LUE-200 with a non-multiplying neutron target is planned. At the second stage the development of the linac by increasing the electron beam power and replacement of non-multiplying target with a multiplying subcritical neutron target is planned. Parameters of the IREN facility in accordance with the stages of realization are presented in Table 1.

Table 1: Design parameters of the IREN facility.

	1-st turn	2-nd turn
Energy interval of the maximal neutron output	1 - 10^5 eV	
Duration of fast neutron pulse	150 ns	420 ns
Operation frequency	50 Hz	150 Hz
Total neutron yield	10^{13} s^{-1}	10^{15} s^{-1}

GENERAL DESCRIPTION OF THE LINAC

The concept of the S-band LUE-200 linac is designed at the Budker Institute of Nuclear Physics (BINP), Novosibirsk [2,3]. The basic scheme of the linac is presented Fig, 1. Its key parameters are shown in Table 2.

Table 2. Key parameters of the LUE-200 linac.

	1-st turn	2-nd turn
Maximal energy of electrons	100 MeV	200 MeV
Beam average power	2.25 kW	10 kW
Beam average pulse current	3 A	1.5 A
Beam pulse duration	≤ 150 ns	≤ 250 ns
Repetition rate	50 Hz	150 Hz
Number of accelerating sections	1	2
Operation frequency of the accelerating sections	2856 MHz	
Average accelerating gradient	~ 35 MeV/m	
RF power amplifier	1 klystron 5045 SLAC	2 klystrons 5045 SLAC

Distinctive feature of the accelerator is its vertical arrangement in two upper floors of a building, caused by the necessity to use the existing halls of the driver of the dismantled IBR-30 facility as a regular place for the new accelerator LUE-200.

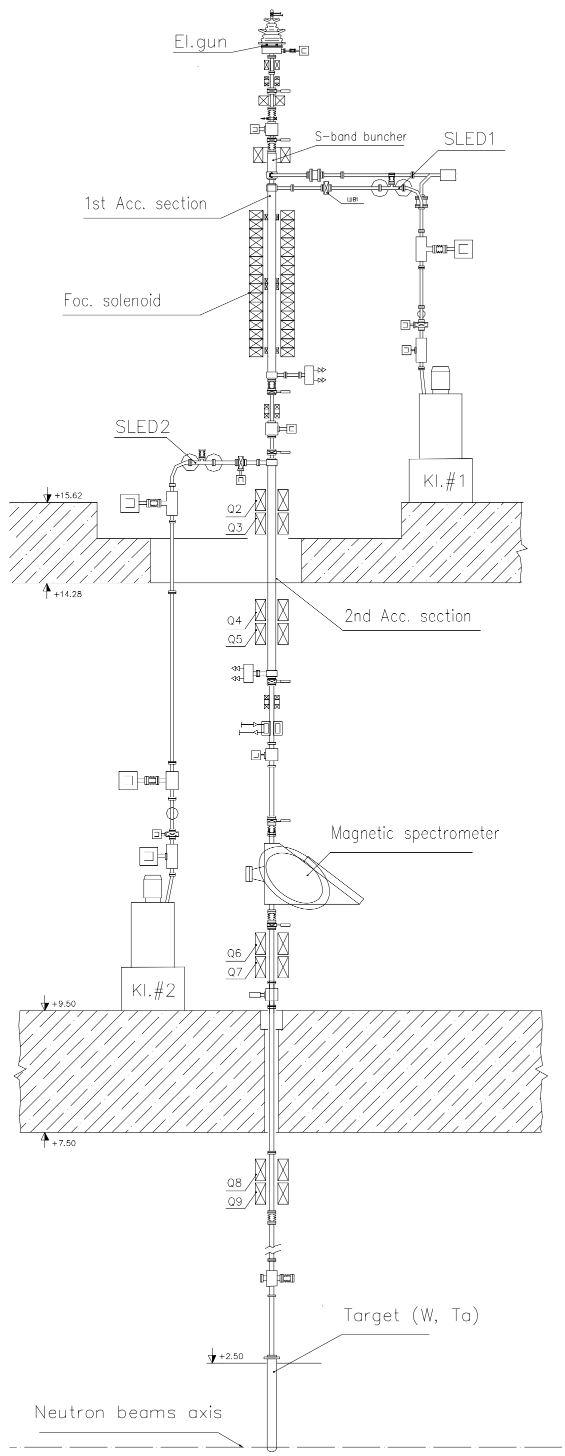

Figure 1: The basic scheme of LUE-200 linac.

The accelerator consists of the pulse electron gun, accelerating systems, two RF-power sources based on the klystron 5045 SLAC (Kl#1, Kl#2) with use of the SLED-type RF-power compression system (SLED1, SLED2), two modulators for a powering of the klystrons, beam focusing system, beam diagnostics system and a broadband magnetic spectrometer.

The electron gun [5] uses the 200 kV pulsed high voltage transformer and thermoionic cathode. The gun provide the beam pulsed current in a pulse up to 4.5 A with the pulse duration of 150 - 250 ns at a repetition rate of 150 Hz and an emittance of no more than 0.01 π·cm·rad.

The accelerating system consists of the S-band buncher and two travelling wave accelerating sections (operation frequency of 2856 MHz, produced in BINP). Each section is powered by a 5045 SLAC klystron. To support a beam in the first accelerating section, the solenoidal magnetic field of high uniformity for indemnify the influence of a space charge of the beam in the buncher and at the initial stage of acceleration is used. The focusing by Q-doublets is used in the 2nd accelerating section and in the transportation channel (Q2-Q3, Q4-Q5, Q6-Q7, Q8-Q9).

The second prominent feature of the linac is the use of short accelerating sections (L = 3 m) with extremely high acceleration rate. The accelerating system of the LUE-200 linac has been tested at the preinjector of the VEPP-5 complex mounted at BINP [6,7,8]. The facility has consisted of an electron gun, a magnetic focusing system and two accelerating sections of 3 m length powered by RF assembly on the basis of one of the 5045 SLAC klystron (1-st section has powered about 27.5 MW and 2-nd section has powered about 13.8 MW).

The following parameters of the electron beam were measured while testing the sections:

- gun beam pulse current,
- total charge of the accelerated beam, (total number of particles per one beam pulse),
- beam energy spectrum,
- beam energy content.

The energy spectra and energy contents of the accelerated beam were measured at the increase of a gun beam current from 1.63 A up to 3.48 A. Energy spectra of the beam after acceleration in two sections for three values of the gun beam current are shown in Fig. 2.

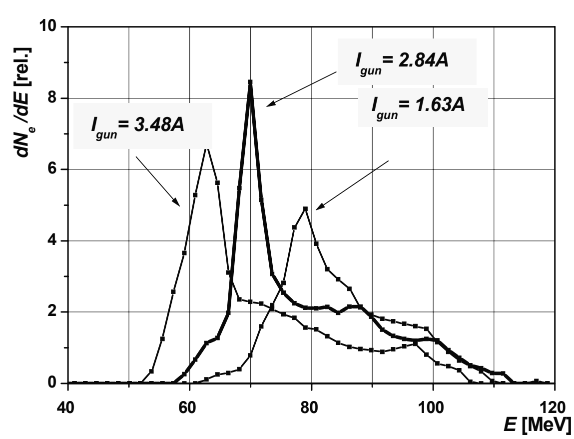

Figure 2: Energy spectra of the electron beam after acceleration in two sections for three values of gun beam current I_{gun}. The bold line shows the spectrum of the beam with maximum energy content.

It is seen from Fig. 2 that at the increase of the current of the beam injected in the accelerating system, the energy of the beam and mean accelerating rate are reducing.

As shown in a series of test experiments [6,7,8], in accelerating section powered by the power of about 55 MW RF the accelerating electrical field can reach more than 50 MV/m, and the average acceleration rate reaches more than 35 MeV/m.

These results, and also numerical modelling of the beam dynamics [9] give the basis to expect the opportunity of power increasing of an electron beam in the first turn due to increase in a beam current and reception of design parameters of the linac in the second turn of the accelerator.

STATUS OF THE PROJECT

Now the civil project of installation is executed regarding in the part, necessary for the coordination in the state control bodies of the Russian Federation, dismantling of the active zone of the IBR-30 reactor deduced from operation is finished (December 2005), deactivation and preparation of a target hall for installation of a target are made.

Among the immediate tasks of the project – the realization of its first stage - the first turn of installation in structure of the linear accelerator with one accelerating section and not multiplying neutron target.

The basic units of the linac systems are tested and prepared for installation. In halls of the accelerator the basic geodetic webs are created (vertically and horizontally). A carrying farm and service platforms at a regular place of the accelerator are mounted. The first klystron modulator is tested at the stand and is mounted in an accelerating hall. The electron source (an electron gun + a site of a beam formation) is completely ready to work. The beginning of works to install infrastructural systems (electrical power supplies, water supply, thermostabilization system, ventilation, the radiation control system, etc.) is planned. Rates and volumes of the performed works depend on rates of financing of the project from the JINR budget. In connection with transfer of the first turn of installation from the category of nuclear installations into the category of non-nuclear installations, procedure of the coordination and the statement of the project becomes considerably simpler, that allows one to plan the end of installation and physical start-up of the first turn of the accelerator in 2007.

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